# VCI2019 - The 15th Vienna Conference on Instrumentation

# Report of Contributions

Contribution ID: **455** Type: **Talk**

# The ultra light Drift Chamber of the MEGII experiment

*Wednesday, February 20, 2019 11:30 AM (20 minutes)*

The MEG experiment, at the PSI, aims at searching the charged lepton flavor violating decay $\mu^+ \rightarrow e^+\gamma$. MEG has already determined the world best upper limit on the branching ratio: BR<4.2$\times 10^{-13}$@90\%CL.
The new positron tracker is a high transparency single volume, full stereo cylindrical Drift Chamber (DC), immersed in a non uniform longitudinal B-field, with length of $1.93\ m$ , internal radius of $17\ cm$ and external radius of $30\ cm$. It is composed of 9 concentric layers, divided in 12 identical sector of 16 drift cells. The single drift cell is approximately square, with a 20 $\mu$m gold plated W sense wire surrounded by $40\ \mu$m silver plated Al field wires in a ratio of 5:1. The total number of wires amounts to 12288 for an equivalent radiation length per track turn of about 1.45x$10^{-3}$ $X_0$ when the chamber is filled with a gas mixture of helium and iso-butane. Due to the high wire density ($12 wires/cm^2$), the use of the classical feed-through technique as wire anchoring system could hardly be implemented and therefore it was necessary to develop new wiring strategies. The number of wires and the stringent requirements impose the use of an automatic system (wiring robot) to operate the wiring procedures. Several tests have been performed in different prototypes of the drift chamber, exposed to cosmic rays, test beams and radioactive sources, to fulfill the requirement on the spatial resolution to be less than $110\ \mu$m.

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**Session Classification:** Gas Detectors

**Track Classification:** Gaseous Detectors

Contribution ID: **456** Type: **Poster**

# A First Look At the Timepix2 in Heavy Ion Beams

The long awaited Timepix2 from the Medipix2 Collaboration is due to be available this fall (2018), and plans are in place to expose it to the Heavy Ion beams at the HIMAC facility in Japan this December (2018). The initial goal is to evaluate the extended dynamic range of its' novel pre-amplifier design, and to exercise its' overall performance in a wide range of heavy ion beams. The Timepix2 has a number of additional capabilities over the venerable Timepix detector including the capability to record simultaneously both the charge deposited per pixel and time of arrival. As a frame based device, it also has suppression for events occurring prior to the frame opening, as well as provisions to allow continuation of digitization of events cutoff by the frame closing. Finally, the Timepix2 has the novel feature of 8 full auxiliary digital pixels for use in coupling external detector devices (e.g.SiPMs) for coincident readout within the Timepix2's data stream, avoiding having to synchronize multiple data acquisition systems.

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**Session Classification:** Poster Session B

**Track Classification:** Astroparticle Detectors

Contribution ID: **459** Type: **Poster**

# Beam-Loss Damage Experiment on ATLAS-like Silicon Strip Modules Using an Intense Proton Beam

The ATLAS silicon tracker detectors are designed to sustain high dose integrated over several years of operation. This very substantial radiation hardness should also favour the survival of the detector in case of accidental beam losses.
An experiment performed in 2006 showed that ATLAS Pixel detector modules (silicon planar hybridly coupled with FE-I3 electronics) could survive to beam losses up 1.5 1010 protons/cm2 in a single bunch with minimal or no deterioration of performance.
The upgrade of LHC to even higher luminosity (HL-LHC) calls for a new test of these properties.
Two test beam campaigns have been done in 2017 and 2018 at the High-Radiation to Materials (HiRadMat) Facility of the CERN Super Proton Synchrotron in order to establish for the first time the damage threshold of different types of ATLAS IBL pixel and strip detectors under very intense proton beam irradiation.

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**Session Classification:** Poster Session B

**Track Classification:** Semiconductor Detectors

Contribution ID: **461** Type: **Poster**

# Sub-nanosecond synchronization node for high-energy astrophysics: The KM3NeT White Rabbit Node

The first Detection Units of the KM3NeT infrastructure, whose main goal is the detection of cosmic neutrinos, are currently being deployed on the Mediterranean sea bed. The collaboration has chosen White Rabbit technology for providing sub-nanosecond synchronization between the Digital Optical Modules, the functional detection units of the detector. White Rabbit functionality is provided by the main front-end electronics board, the so-called Central Logic Board, that embeds both, the White Rabbit firmware, as an IP core on a XILINX Kintex 7 FPGA, and the tunable oscillators, the hardware needed by the White Rabbit technology. The Central Logic Board also digitizes the data provided by 31 photomultiplier, which detect the Cherenkov radiation produced by neutrinos, it controls the acoustic signals and the rest of the instrumentation and it provides all the communications interfaces. The present paper describes the Central Logic Board of KM3NeT and the network topology focusing on how it provides synchronization functionalities.

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**Session Classification:** Poster Session A

**Track Classification:** Astroparticle Detectors

Contribution ID: **462** Type: **Talk**

# Performance of Large Area Picosecond Photo-Detectors – LAPPD

*Friday, February 22, 2019 3:15 PM (20 minutes)*

The Large Area Picosecond Photo-Detector (LAPPD™) is a microchannel plate (MCP) based planar geometry photodetector featuring single-photon sensitivity, semitransparent bi-alkali photocathode, millimeter spatial and picosecond temporal resolutions and an active area of to 350 square centimeters. The "baseline" LAPPD™ employs a borosilicate float glass hermetic package. Photoelectrons are amplified with a stacked chevron pair of "next generation" large area MCPs produced by applying resistive and emissive Atomic Layer Deposition (ALD) coatings to glass capillary array (GCA) substrates. Signals are collected on microstrip anodes applied to the bottom plate. We report performance results achieved for fully functional sealed LAPPDs™. These results include electron gains of up to 1E7, low dark noise rates (15-30 Hz/cm2), single photoelectron (PE) timing resolution of 64 picoseconds RMS (electronics limited), and single photoelectron spatial resolution along and across strips of 2.4 mm and 0.8 mm RMS respectively and high (up to 25%) QE uniform bi-alkali photocathodes.

While not fully optimized, these tiles are usable for applications by early adopters. Optimized LAPPDs can be employed in neutrino experiments (e.g. ANNIE, WATCHMAN, DUNE), particle collider experiments (e.g. EIC), neutrinoless double-beta decay experiments (e.g. THEIA), medical and nuclear non-proliferation applications. We will also discuss future prospects of the project and new developments in LAPPDs.

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**Session Classification:** Plenary 5

Contribution ID: **468** Type: **Talk**

# SiPM single photon time resolution measured via bi-luminescence

*Thursday, February 21, 2019 4:30 PM (20 minutes)*

We present results on measurements of the single photon time resolution on silicon photomultipliers using bi-luminescence. When a silicon photomultipler is biased passed breakdown, each avalanche produces a number of photons as electron-hole pairs recombine. If these photons enter a neighboring cell and trigger an additional avalanche, the process is referred to as optical cross-talk. We refer to bi-luminescence as the process in which one or more of these spontaneously emitted photons escape the device and triggers an avalanche in a different device. Thus, measuring the time difference between the avalanche of the emitter and the absorber results in a measurement of the single photon time resolution each device. For the emitter and absorber, we use identical type SiPMs biased to the same over voltage. The time difference between coincident events in each SiPM gives rise to a double peaked structure, with each peak being fitted with a convolution of a gaussian and exponential distribution, corresponding to the single photon time resolution and afterpulse components, respectively. Measurements are carried out for a range of temperatures to measure the activation energy of the afterpulse component. The extracted single photon time resolution is compared to literature values on comparable devices.

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**Session Classification:** SiPM

**Track Classification:** SiPM

Contribution ID: **469** Type: **Poster**

# Active doping profile of silicon detectors using innovative TLM scan method

Improvements of silicon detector technology for high energy physics applications demand the introduction of doping carriers into the sensor material to optimize the charge collection efficiency of the detecting devices. Total doping profile of any silicon sensor device can be measured with very high precision using secondary ions mass spectrometry (SIMS). In this work new 3D SIMS scannig method has been used for phosphorus implantation and total doping map will be shown. The focus is to present an alternative scanning technique based on Transmission Line Method, mainly used in Integrated Circuit and nanotechnology developments. We deduce from TLM method measurements, active doping profiles of planar pixel sensors used for LHC experiment; further target is also to evaluate how active dopants profile changes when pixel sensors are heavily irradiated and how TCAD models can reproduce the data obtained from TLM method.

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**Session Classification:** Poster Session A

**Track Classification:** Semiconductor Detectors

Contribution ID: **473** Type: **Talk**

# CUORE: the first bolometric experiment at the ton scale for the search for neutrino-less double beta decay

*Friday, February 22, 2019 11:20 AM (20 minutes)*

The Cryogenic Underground Observatory for Rare Events (CUORE) is the most massive bolometric experiment searching for neutrino-less double beta ($0\nu\beta\beta$) decay. The detector consists of an array of 988 $TeO_2$ crystals (742 kg active mass) arranged in a compact cylindrical structure of 19 towers. The construction of the experiment and, in particular, the installation of the towers in the cryostat was completed under clean room conditions in August 2016, and data taking began in spring 2017. In this talk, we will describe the CUORE experiment, including the cryostat, the front-end electronics, the data acquisition system and the data processing chain, and present the detector performance during the first year of running. We will emphasize the effort made in improving the energy resolution in the $^{130}$Te $0\nu\beta\beta$ decay of region of interest and the suppression of backgrounds. We also describe the work to lower the energy threshold that will give CUORE the sensitivity to search for other rare events such as dark matter.

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**Session Classification:** Plenary 4

Contribution ID: **474** Type: **Talk**

# The MEV project: an innovative high-resolution telescope for Muography of Etna Volcano

*Thursday, February 21, 2019 2:00 PM (20 minutes)*

The MEV project started in 2016 the construction of an innovative muon tracking telescope expressly designed for the muography of the Etna Volcano, in particular one of the active craters in its summit area. The telescope is a tracker based on extruded scintillating bars with WLS fibers and featuring an innovative read-out architecture. It is composed of 3×1 m2 XY planes; the angular resolution does not exceeds 0.4 msr and the total angular aperture is about ±45°. A special effort concerned the design of mechanics and electronics in order to meet the requirements of a detector capable to work in a hostile environment such as the top of a tall volcano, at a far distance from any facility. The telescope was powered by solar panels in order to make it completely independent from external power source. The whole electronic chain was custom designed for this application in order to reduce the power consumption, which is about 20 W, including the wireless data transmission system. The test phase started in January 2017 and ended successfully at the end of July 2017. An extinct volcanic crater (the Monti Rossi, in the village of Nicolosi, about 15 km from Catania) was the target of the measurement, of which was acquired the first muographic image with a promising quality. Then, the telescope was moved to the summit zone of the Etna Volcano, with the aim of imaging the active North-East crater.

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**Session Classification:** Astroparticle Detectors

**Track Classification:** Astroparticle Detectors

Contribution ID: **477** Type: **Talk**

# Design and status of the Mu2e CsI + SiPMs calorimeter

*Tuesday, February 19, 2019 3:15 PM (20 minutes)*

The Mu2e experiment at Fermilab will search for the charged-lepton flavour violating neutrinoless conversion of a negative muon into an electron in the field of an aluminum nucleus.
The Mu2e detector is composed of a tracker and an electromagnetic
calorimeter and an external veto for cosmic rays.
The calorimeter plays an important role in providing excellent particle identification capabilities, a fast online trigger filter while aiding the track reconstruction capabilities.
The calorimeter requirements are to provide a large acceptance for ~100 MeV electrons and reach:
1) a time resolution better than 0.5 ns @ 100 MeV;
2) an energy resolution O(10%) @ 100 MeV;
3) a position resolution of 1 cm.
The calorimeter consists of two disks, each one made of 674 pure CsI
crystals readout by two large area 2x3 array of UV-extended
Silicon Photomultipliers (SiPMs) of 6x6 mm^2 dimensions.
A large scale prototype has also been constructed and tested at the beam test facility in Frascati. It consists of 51 pre-production crystals readout by a Mu2e SiPM.
We will present all the test and progresses done on crystals and SiPMs to define the calorimeter design as well as the satisfying results obtained with the test beam of the prototype.

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**Session Classification:** Calorimeter

**Track Classification:** Calorimeters

Contribution ID: **480** Type: **Talk**

# Upgrade of the KamLAND-Zen Mini-balloon and Future Prospects

*Wednesday, February 20, 2019 9:00 AM (20 minutes)*

The observation of a neutrino-less double-beta ($0\nu\beta\beta$) decay would be evidence of neutrino's Majorana nature, and it might be a clue to explain the baryon asymmetry and the extremely light neutrino masses. The half-life of $0\nu\beta\beta$ decay is more than $10^{26}$ year in case of $^{136}$Xe, thus it is important to make radiopure detector to find the very rare decay.
KamLAND-Zen is a $0\nu\beta\beta$ decay search experiment with Xe loaded liquid scintillator (XeLS) containing 90.77\% enriched $^{136}$Xe.
The mini-balloon is a container for holding XeLS at the center of the KamLAND detector without impairing the extremely low radiation environment.
We have installed a new mini-balloon with a thickness of 25 $\mu$m and a radius of 1.92 m, which was made in a class 1 clean room and is almost twice as large as the last one. The mini-balloon is going to hold about 750 kg of Xe gas in the XeLS and $0\nu\beta\beta$ decay search will start soon.

After the KamLAND-Zen experiment, it is planned to do a $0\nu\beta\beta$ decay search experiment with a remodeled KamLAND detector to improve the energy resolution (KamLAND2-Zen).
I will also talk about novel hardware improvements to collect data without loss just after a large light yield event such as a cosmic ray muon spallation at KamLAND2-Zen.

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**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **484** Type: **Poster**

# MPGD hole-by-hole gain scanning by UV excited single photoelectron detection

The developed high resolution scanner using focused UV light gave the possibility to study single photoelectron response of MPGDs on the sub-millimeter scale. This technology reveals the microstructure of photo-efficiency and local gain to quantitatively compare different GEM geometries and thus provides a powerful tool for GEM quality assurance.

The readout detector uses a single GEM with the combination of an asymmetric MWPC (Close Cathode Chamber) as post-amplification stage. A pulsed UV LED source with emission at 240 nm is focused to 0.03 mm diameter on the GEM surface, while a single photoelectron charge spectra is recorded over a selected 2D region. As opposed to continuous illumination, here the GEM gain and photoelectron detection efficiency is clearly separated. Both the photoelectron yield and gain map fluctuates from hole to hole. The gain appears constant taking a hexagonal shape around each hole, pointing to the fact that the gain depends more on hole geometry and less on the position where the electron enters. High resolution gain map allows us to measure edge-effect, chargeup and the effect of GEM faults amongst others. The single photoelectron spectra provides valuable information on the avalanche formation in GEM detectors.

The presentation will introduce the scanning system and share results from photoelectron yield and gain maps from different types of GEMs.

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**Session Classification:** Poster Session B

**Track Classification:** Gaseous Detectors

Contribution ID: **486** Type: **Talk**

# Neutral bremsstrahlung in two-phase argon electroluminescence: first results and possible applications

*Wednesday, February 20, 2019 9:25 AM (20 minutes)*

A new mechanism of proportional electroluminescence (EL) in two-phase Ar has been revealed, namely that of neutral bremsstrahlung (NBrS), that quantitatively describes the photon emission below the Ar excitation threshold and non-VUV component above the threshold. This paves the way for direct readout of electroluminescence (S2) signals in two-phase TPCs, using PMT and SiPM matrices, in particular in dark matter two-phase detectors. In addition, this mechanism predicts the enhanced contribution of the fast component to S2 signal, which can affect the correct determination of diffusion coefficients and z-coordinate fiducialization in liquid Ar detectors. The NBrS effect has a universal character: it should be present in all noble and molecular gases. It may also explain the non-VUV components observed earlier in various light emission processes, in particular the primary and secondary scintillations in noble liquids in the visible and NIR range.

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**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **487** Type: **Poster**

# Low-pressure TPC with THGEM readout for ion identification in Accelerator Mass Spectrometry

A new technique for ion identification in Accelerator Mass Spectrometry (AMS) has been proposed based on measuring the ion track ranges using a low-pressure time projection chamber (TPC). As a proof of principle, the low-pressure TPC with charge readout using a THGEM multiplier was developed. The tracks of alpha-particles from various radioactive sources were successfully recorded in the TPC. The track ranges were measured with a rather high accuracy, reaching 3%. Using these results and SRIM code simulation, it is shown that the isobaric boron and beryllium ions can be effectively separated at the 10 sigma level. This technique is expected to be applied in the AMS facility in Novosibirsk for dating geological objects, in particular for geochronology of Cenozoic Era.

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**Session Classification:** Poster Session A

**Track Classification:** Gaseous Detectors

Contribution ID: **488** Type: **Poster**

# Calibration of a polycrystalline 3D diamond detector fabricated for small field dosimetry

In medical radiation dosimetry, the use of small photon fields is almost a prerequisite for high precision localized dose delivery to delineated target volume. The accurate measurement of standard dosimetric quantities in such situations depends on the size of the detector with respect to the field dimensions. Thanks to a new technology, polycrystalline diamond devices with 3-dimensional structures are produced by using laser pulses to create graphitic paths in the diamond bulk. By fabricating very narrow and close by columnar electrodes perpendicular to the detector surface, it is possible to create arrays of 3D-cells with very small sensitive volume. In order to present a solution to the problem of the detector size for small field dosimetry the 3D technology aims to a new highly segmented larger polycrystalline diamond dosimeter to obtain field profiles in a single shot measurement, reducing the uncertainty of the delivered dose. To this purpose a 3D all carbon detector with an array of 9 3D cells have been produced. Due to the heterogeneous structure of the polycrystalline diamond substrate, it was necessary to study the response of each 3D cell under a standard field photon beam. It was demonstrated that each single cell of the array has a different sensitivity to the radiation beam,but the response is linear, stable and repeatable hence different calibration factors can be applied to obtain an overall detector response and reduce the uncertainty of the delivered dose.

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**Session Classification:** Poster Session B

**Track Classification:** Semiconductor Detectors

Contribution ID: **490** Type: **Talk**

# PETALO: Time-of-Flight PET with liquid xenon

*Thursday, February 21, 2019 11:30 AM (20 minutes)*

Liquid xenon has several attractive features, which make it suitable for applications to nuclear medicine, such as high scintillation yield and fast scintillation decay time. Moreover, being a continuous medium with a uniform response, liquid xenon allows one to avoid most of the geometrical distortions of conventional detectors based on scintillating crystals. In this paper, we describe how these properties have motivated the development of a novel concept for positron emission tomography scanners with Time-Of-Flight measurement, which combines a liquid xenon scintillating volume and silicon photomultipliers for the readout. A first Monte Carlo investigation has pointed out that this technology would provide an excellent intrinsic time resolution, down to 70 ps, which makes it possible to measure the Time-Of-Flight with high efficiency. Also, the transparency of liquid xenon to UV and blue wavelengths opens the possibility of exploiting both scintillation and Cherenkov light for a high-sensitivity positron emission tomography scanner with Time-Of-Flight capabilities. Monte Carlo simulations point to a time resolution of 30-50 ps obtained using Cherenkov light. A first prototype is being built to demonstrate the high energy, spatial and time resolution of this concept, using a ring of 30 cm of internal diameter and a depth of 3 cm instrumented with VUV–sensitive silicon photomultipliers.

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**Session Classification:** Medical Applications

**Track Classification:** Medical Applications

Contribution ID: **493** Type: **Talk**

# Innovative $\gamma$ detector filled with high-density liquid for brain PET imaging

*Thursday, February 21, 2019 11:55 AM (20 minutes)*

CaLIPSO is an innovative $\gamma$ detector designed for high precision cerebral PET imaging. For the first time, liquid trimethylbismuth is used as sensitive medium. The detector operates as a time-projection chamber and detects both Cherenkov light and charge signal. Indeed, each 511-keV photon releases a single primary electron that triggers a Cherenkov radiation and ionizes the medium. As trimethylbismuth has never been studied before, we measured its free ion yield that represents the number of electron-ion pairs released by the primary electron. To do so, we developed a low-noise measuring system to determine the weak current induced by a $^{60}$Co source in the liquid with an accuracy better than 5 fA for a strong electric field up to 7 kV/cm. We used tetramethylsilane as benchmark liquid to validate the apparatus and we measured a zero-field free ion yield of $0.53 \pm 0.03$ in agreement with measurements in literature. However, we found a zero-field free ion yield of $0.083 \pm 0.003$ for trimethylbismuth, which is a factor 7 lower than the typical values for similar dielectric liquids. Quantum chemistry computations on heavy atoms tend to demonstrate the high ability of trimethylbismuth to capture electrons, which could explain this weak value. This recombination mechanism marks a new step in understanding charge transport in liquid detectors.

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**Session Classification:** Medical Applications

**Track Classification:** Medical Applications

Contribution ID: **495** Type: **Talk**

# Measurements and Simulations of Surface Radiation Damage Effects on IFX and HPK Test Structures

*Thursday, February 21, 2019 2:50 PM (20 minutes)*

Radiation damage effects at High Luminosity LHC expected fluences (2×10<sup>16</sup> n/cm<sup>2</sup> 1 MeV) and total ionising doses (TID) (1 Grad) will impose very stringent constraints in terms of radiation resistance of solid-state detectors. The complex physical phenomena related to radiation damage effects can be addressed by means of TCAD tools aiming at evaluate the most suitable technological options to be adopted for the fabrication of radiation-resistant, long-term operating detectors. In particular, surface damage effects can be investigated with TCAD tools in order to study their macroscopic, device-level effects, e.g. the inter-electrode isolation and charge collection properties of different design options. Aiming at the generality of the approach, in this work, we address the effects of surface damage on detectors fabricated on p-type substrates by two different foundries. Actually, starting from standard test structure measurements the interface trap state density (NIT) and the oxide charge (QOX) can be extracted and used as input parameters to the simulation tools. Moreover, a detailed TCAD parametric analysis has been carried out, aiming at evaluating the effects of oxide charge density and interface trap density variation with the dose. The good agreement between simulation results and measurements would support the use of the model as a predictive tool to optimize the design and the operation of novel solid-state detectors in the HL-LHC scenario.

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**Presenter:** MOSCATELLI, Francesco (Universita e INFN, Perugia (IT))

**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **497** Type: **Poster**

# Detector developments for high performance muography applications

Imaging with cosmic muons dates back by decades, initiated by searching for hidden structures in the Chephren pyramid by Alvarez. Since then, the term "muography" was coined for this possibility offered by nature's highly penetrating particles, and can be applied for imaging various large scale objects. As the observation point needs to be below the object of interest, either the detector is placed underground, and can reveal density structures, or, the detector can be on the surface and look sideways, capturing muons closer to the horizon.

In both cases, long term operation must be achieved with high efficiency and at good angular resolution. The presentation introduces the technological possibilities and solutions. The relevance of the out-of-laboratory environment is demonstrated on the example of a 4 square meter telescope targeting the Sakurajima volcano in Japan, and various underground applications including natural caves.

For open air detectors, the suppression of the low energy (non penetrating) muon background can be reached with a telescope using absorber (scatterer) layers between detector layers with good position resolution. The resulting Muography Observation System, using MWPC-s with contemporary solutions, allows muographic imaging through 2 km of rock, with 10 m resolution from a distance of 3 km.

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**Session Classification:** Poster Session B

**Track Classification:** Astroparticle Detectors

Contribution ID: **500** Type: **Poster**

# Instrumentation and optimization studies for a Beam Dump Experiment (BDX) at MESA

At the Institute for Nuclear Physics in Mainz the new electron accelerator MESA will go into operation within the next years. In the extracted beam operation (155 MeV, 150 μA) the P2 experiment will measure the weak mixing angle in electron-proton scattering in 10,000 hours operation time. Therefore the high-power beam dump of this experiment is ideally suited for a parasitic dark sector experiment.

Currently, the experiment is studied with a simulation based on MadGraph and Geant4. Theoretically dark photons γ' are generated in the beam dump by a process analog to electromagnetic bremsstrahlung and decay invisibly to pairs of dark matter particles. In a calorimeter behind the beam dump, electrons scattered off by dark matter particles can be detected. For maximizing the experimental sensitivity, the probability of detecting dark matter particles has to be optimized.

The Geant4 simulation was extended by an optical photon study, where the response of possible calorimeter materials - $PbF_2$, BGO, the lead glasses SF5, SF6 and SF57HTultra - was examined. In this contribution the simulation outcomes are compared with the results of first prototypes tested at MAMI with 14 MeV electrons.

In a first phase we will use more than 1,000 $PbF_2$ crystals from a previous experiment. The exclusion limits for this and a lead glass calorimeter with 11 $m^3$ active volume for a second phase are shown, and the current status of a prototype detector array including a veto system will be presented.

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**Session Classification:** Poster Session A

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **502** Type: **Poster**

# Study of metal contacts on Cd1-xZnxTe and Cd1-xMnxTe crystals for radiation detector applications

This work describes a comprehensive study of metal contacts on single crystals of II-VI group semiconductors, Cd1-xZnxTe and Cd1-xMnxTe. Both materials are candidates for numerous detector applications, while the former is more established, the latter has potential advantages. In this work we formed metal contacts on high resistivity Bridgman grown Cd1-xZnxTe and Cd1-xMnxTe crystals by thermal evaporation method. Usage of different contact materials and various surface preparation processes of the Me-Semiconductor interface allowed a comprehensive comparison of the resulting performance of obtained devices. The characterization of the detectors included varied techniques such: I-V measurements, noise PSD (Power Spectral Density), determination of the activation energy (temperature behavior), etc. The results of comparison reveal the advantages and drawbacks of produced detectors. This work emphasizes the pronounced potential of Cd1-xMnxTe crystals for radiation detectors.

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**Session Classification:** Poster Session A

**Track Classification:** Semiconductor Detectors

Contribution ID: **503** Type: **Talk**

# Science and technology of the DARWIN observatory

*Friday, February 22, 2019 11:45 AM (20 minutes)*

DARWIN is a next-generation dark matter and neutrino observatory based on 50 tons of xenon. Its central TPC of 2.6 m diameter and height is operated as dual-phase detector with optimized light and charge read-out. It will allow to search for WIMPs at the GeV-TeV mass scale down to the “neutrino floor” where coherent interactions of astrophysical neutrinos start to dominate the interaction rate. The experiment will also hunt for solar axions, galactic ALPs and sterile neutrinos in the keV mass range. This is complemented by a high-sensitivity search for neutrinoless double beta decay of Xe-136 and a high-precision measurement of the solar pp-neutrino flux.
This requires excellent signal-background discrimination while maintaining an extrordinary low level of background. A key challenge therein is the efficient purification of the LXe target from the radioisotopes Kr-85 and Rn-222 by cryodistillation and other means, as well as identification and suppression of neutron-induced reaction. Finally, an efficient charge read-out requires electron lifetimes in LXe on the ms-scale. The talk describes the physics reach and design of DARWIN, and focuses on ongoing R&D works on background suppression and improvements of the light and charge read-out in the very large TPC.

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**Presenter:** Prof. DREXLIN, Guido (Karlsruhe Institute of Technology)

**Session Classification:** Plenary 4

Contribution ID: **504** Type: **Talk**

# Novel charged particles monitor of light ions PT treatments: results of preliminary tests using a RANDO® phantom

*Thursday, February 21, 2019 12:20 PM (20 minutes)*

In Particle Therapy, the use of C, He and O ions as beam particles is being pursued to fully profit from their interaction with matter resulting into an improved efficacy in killing the cancer cells. An accurate on-line control of the dose release spatial distribution, currently missing in clinical practice, is required to ensure that the healthy tissues surrounding the tumor are spared, preventing undesired damages caused by, for example, morphological changes occurred in the patient during the treatment with respect to the initial CT scan. Charged secondary particles, produced by the projectile fragmentation in the collisions with the patient tissues, represent a valid option for light ions treatments monitoring since they are also emitted at large angles with respect to the beam direction and they can be detected with high efficiency in a nearly background free environment. The Dose Profiler detector, based on 8 pairs of orthogonal layers ($19.2 \times 19.2\ cm^2$) composed by squared plastic scintillating fibres, allows the online charged fragments reconstruction and backtracking at the clinical high rates (∼100 kHz). Preliminary tests performed on the DP, using the $^{12}$C ion beams of the CNAO treatment centre and an anthropomorphic phantom as a target, will be reviewed in this contribution. The results implications in view of a first clinical trial, scheduled to start at the CNAO in 2019, will be discussed in the framework of the upcoming clinical routine test.

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**Session Classification:** Medical Applications

**Track Classification:** Medical Applications

Contribution ID: **505** Type: **Talk**

# High space resolution μ-RWELL for high rate applications

*Tuesday, February 19, 2019 12:10 PM (20 minutes)*

The micro-Resistive-WELL (μ-RWELL) is a compact, simple and robust Micro-Pattern Gaseous Detector (MPGD) developed for large area HEP applications requiring the operation in harsh environment.
The detector amplification stage, similar to a GEM foil, is realized with a polyimide structure micro-patterned with a blind-hole matrix, embedded through a thin Diamond Like Carbon (DLC) resistive layer with the readout PCB. The introduction of a resistive layer (ρ~50÷200 MΩ/square) mitigating the transition from streamer to spark gives the possibility to achieve large gains (>10^4), while affecting the detector performance in terms of rate capability. Different detector layouts have been studied: the most simple one based on a single-resistive layer with edge grounding has been designed for low-rate applications (few tens of kHz/cm2); more sophisticated schemes are under study for high-rate purposes (O( MHz/cm2)).
The single-resistive layer scheme, extensively tested and validated, it is mature for the technology transfer towards the industry working into the rigid and flexible PCB photolithography.
The high-rate version of the detector has been developed in the framework of the phase-2 upgrade of the LHCB muon system, where strong requirements on the robustness and rate capability are required.
An overview of the different architectures studied for the high-rate version of the detector, together with their performance measured at the high intensity PiM1 beam of the PSI will be presented.
The presence of the resistive layer also affects the charge spread on the strips and consequently the spatial resolution of the detector: the results of a systematic study of the spatial resolution obtained with the charge centroid (CC) method for orthogonal tracks as a function of the DLC resistivity will be discussed.
For non-orthogonal tracks the spatial resolution with CC method is compared with the performance obtained with the micro-TPC mode: a readout approach that exploiting the combined measurement of the time of arrival and the amplitude of the signals on the strips allows a fine estimation of the position of the track for a wide incident angular range.
The excellent performance together with the high flexibility of the technology suggests the use of such a detector as a high space resolution inner tracker in HEP. The possibility to exploit the μ-RWELL technology to build a full Cylindrical detector will be eventually discussed.

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**Presenter:** BENCIVENNI, Giovanni (Istituto Nazionale Fisica Nucleare Frascati (IT))

**Session Classification:** Plenary 3

**Track Classification:** Gaseous Detectors

Contribution ID: **507** Type: **Talk**

# Upgrade of the CMS Muon System with GEM Detectors: recent progress on construction, certification, Slice Test, and Long-term Operation

*Wednesday, February 20, 2019 11:55 AM (20 minutes)*

The CMS Muon Spectrometer is being upgraded (the GE1/1 project) during the LS2 shutdown (2019-2020) using large-area, trapezoidal-shaped triple-GEM detectors in the forward region, 1.6 < eta < 2.2. We present the chamber assembly and qualification procedure, as well as an overview of the results obtained during detector qualification. We report preliminary results on system integration and tests of the production version of the chambers with their digital electronics. Results from the pre-production chambers installed during 2017-2018 (Slice Test) are presented together with details of the detector control system. Slice Test results are presented on front-end electronic channel loss and a solution to mitigate the problem. We present an overview and recent results on classical aging studies and longevity tests and their impact for the use of triple-GEM detector systems in CMS.

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**Presenter:** FALLAVOLLITA, Francesco (Università e INFN Pavia)

**Session Classification:** Gas Detectors

**Track Classification:** Gaseous Detectors

Contribution ID: **508** Type: **Poster**

# Transverse and longitudinal segmented forward hadron calorimeters with SiPMs light readout for future fixed target heavy ion experiments

Forward hadron calorimeters with transverse and longitudinal segmentation are developed for upgraded heavy ion NA61 and BM@N experiments and future CBM experiment at FAIR. The main purpose of these calorimeters is to provide an experimental event-by-event measurements of centrality and orientation of reaction plane in heavy-ion collisions at high beam rates. One of the features of these modular calorimeters is the presence of a beam hole in the centre, which is necessary for the operation at high beam rates. Hadron calorimeters in all these experiments are composed of sampling lead/scintillator modules with longitudinal segmentation. Light collection in the modules is provided by WLS fibers glued in each scintillator plate. The light from 6 consecutive scintillator plates in module is detected by one SIPM with an active area of 3x3mm2 placed at the end of module. Light readout from 10 longitudinal sections in each module for NA61 and CBM calorimeters is provided by 10 Hamamatsu MPPCs. Central modules in BM@N calorimeter are more compact and have only 7 longitudinal sections. The light yield measured with muons beam for CBM modules is about 40-50 ph.e./section. The response of supermodule (array 3x3 assembled from 9 CBM modules) has been studied on CERN T9, T10 and NA61 with proton beams in the energy range 1.5-150 GeV. The details of calorimeters, measured response of the supermodule and radiation conditions simulated for these calorimeters will be presented.

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**Session Classification:** Poster Session B

**Track Classification:** Calorimeters

Contribution ID: **510** Type: **Poster**

# Compact segmented hadron calorimeter for detection of low energy spectators at MPD/NICA facility.

The forward hadron calorimeter (FHCal) for the detection of the protons and neutrons in energy range of 1-5 GeV is discussed. Since the calorimeter will operate inside the superconductive magnet with limited available space its length is about one meter only. A single FHCal module consists of 42 lead/scintillator sandwiches arranging in overall 4 interaction lengths. However, it works well for the low energy hadrons below 10 GeV. The FHCal module consists of 7 longitudinal sections that allow the measurements of the hadron shower profile in the calorimeter. Also, longitudinal segmentation makes possible to select the tracks of the muons with different geometry to perform the energy calibration. The deposited energy from hadrons at such low energies are comparable with that from the minimum ionizing particles. Therefore, the attention was payed to increase the light yield in each longitudinal section. The use of WLS-fiber light readout and advanced photodetectors (Hamamatsu MPPCs) allows the reliable detection in each section of the cosmic muons with the different tracks. The beam tests of the calorimeter modules with 10 longitudinal sections at CERN PS with the proton momenta below 10 GeV/c confirmed the expected performance. As was shown, 4 interaction lengths are enough to contain the hadron shower and to ensure the energy resolution with the stochastic term of about 55%. The energy depositions in different sections and the shower profile are discussed.

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**Presenter:** IVASHKIN, Alesandr (Russian Academy of Sciences (RU))

**Session Classification:** Poster Session A

**Track Classification:** Calorimeters

Contribution ID: **511** Type: **Talk**

# A SiPM-based dual-readout calorimeter for future leptonic colliders

*Tuesday, February 19, 2019 2:50 PM (20 minutes)*

Calorimeters for future leptonic collider experiments have to provide extreme precision in reconstructing energies of both isolated particles and jets springing off the colliding beams. Thanks to the expected energy resolution and the excellent particle ID capability, the dual-readout fibre calorimeter could be a possible solution. This calorimetric technique reconstructs the electromagnetic fraction (fem) by simultaneously measuring the scintillation and the Cherenkov light produced by the showers in the fibres of the calorimeter. In 2017, a first module readout with Silicon PhotoMultipliers (SiPM) was designed, constructed and tested on beam at CERN. The results of this first test completed the proof-of-concept but also pointed out some crucial points to be addressed to make SiPM a reliable solution for dual-readout. Among these it is worth mentioning: the sensor non-linearity response, the optical crosstalk between fibres and the very large number of readout channels required for a full scale module. In 2018, an upgrade of the SiPM-based calorimeter was tested in another beam test. This talk reports the test beam results on the module performance, highlighting as well the key and potentially critical parameters and the adopted solutions. This is including electrical grouping of signals by single sensors, aimed at reducing the number of channels. Finally, the R&D program targeted to the design and construction of the building block of a full scale detector will be presented

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**Session Classification:** Calorimeter

**Track Classification:** Calorimeters

Contribution ID: **514** Type: **Poster**

# Luminometers for Future Linear Collider Experiments

The FCAL collaboration develops fast, compact calorimeters to measure the luminosity of electron-positron collisions with high precision using small angle Bhabha scattering, and bunch-by-bunch using beamstrahlung pairs. Searches for new physics also require the detection of high energy electrons at low angles. Several sensor options, such as GaAs or single crystal sapphire, are under consideration in addition to conventional silicon diode sensors, all of which are being assessed for radiation tolerance.

A small Moliere radius facilitates the measurement of Bhabha events in the presence of background and allows the detection of single high energy electrons on top of the diffuse pair background. A multi-plane prototype compact luminometer was studied in a 5 GeV electron beam at DESY. The results for the longitudinal and transverse shower profiles are compared with Geant4 simulations and used to determine the effective Moliere radius of the prototype, which approaches the technological limit.

A multi-channel low-power readout ASIC is under development in 130nm CMOS, comprising an analog front-end and fast 10-bit ADC in each channel, followed by fast serialization and data transmission. In addition, an ASIC with a dual readout scheme for BeamCal allowing for a fast feedback to the accelerator and simultaneous data taking and calibration is under development.

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**Session Classification:** Poster Session B

**Track Classification:** Calorimeters

Contribution ID: **515** Type: **Poster**

# TAIGA - a hybrid array for high energy gamma astronomy and cosmic ray physics

The TAIGA (Tunka Advanced Instrument for cosmic ray physics and Gamma Astronomy) facilities aims at gamma-ray astronomy at energies from a few TeV to several PeV, as well as cosmic ray physics from 100 TeV to several EeV. Combination of the wide angle Cherenkov timing detector TAIGA-HiSCORE with the 4-m class Imaging Atmospheric Cherenkov Telescopes (TAIGA-IACT) of FoV of 10x10 degrees offers a cost effective-way to construct a 10 km^2 array with the expected integral sensitivity about 2,5 10^{-14}erg cm^{-2} sec^{-1} for detecting gamma rays with an energy of 100 TeV for the 300-hour observation of a local source. Reconstruction of a given EAS energy with an accuracy about 15%, incoming direction with an accuracy about 0,1 degree and its core position with an accuracy about 5 -6 m, based on the TAIGA-HiSCORE data allow one to increase a distance between the IACTs up to 600-1000 m. At present the TAIGA first stage has been constructed in Tunka valley, ~50 km West from the Lake Baikal. Now it consists of 60 TAIGA-HiSCORE Cherenkov stations distributed over an area of.0,6 km2 and the first IACT of the TAIGA-IACT array. Before the end of 2019; it will include 110–120 wide-angle Cherenkov detectors on an area of 1 km^2, three IACT. This complex will allows one to prove experimental potential and advantage of the joint operation of the timing and imaging Cherenkov arrays and to star the search for Galactic PeVatrons.

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**Presenter:** Prof. BUDNEV, Nikolay (Irkutsk State University)

**Session Classification:** Poster Session A

**Track Classification:** Astroparticle Detectors

Contribution ID: **518** Type: **Poster**

# Operation of a silicon microstrip detector prototype for ultra-fast imaging at a synchrotron radiation beam.

A method of imaging of ultra-fast processes, like explosion or fast combustion, at a synchrotron radiation beam is being developed at the Siberian Synchrotron and Teraherz Radiation Center (SSTRC). Two stations are operating at beam line 0 at the VEPP-3 storage ring and at beam line 8 at the VEPP-4M storage ring. Both stations are equipped with the detector for imaging of explosions DIMEX, based on high pressure ionization chamber, and allowing to record up to 100 one dimensional images with the frame rate of 8 MHz. However the maximum flux that DIMEX can detect is limited as well as spatial resolution and frame rate because of gas technology used. In view of significant increase of SR flux at the VEPP-4M beam line due to the new 9-pole 2 T wiggler, a new detector is being developed for this beam line, based on Si microstrip sensor. The first Si microstrip detector prototype has been mounted with new specially developed front-end ASIC that allows to record data with the rate of 50 MFrames/s. The first measurements with this prototype demonstrated significant improvement of all critical parameters of the detector compared to the gaseous version. The maximum detected photon rate before saturation is increased to 20000 photons/(chan x bunch) compared to 1500 photons/(chan x bunch) (Si detector has 50 um channel pitch while gaseous detector has 100 um channel pitch). Spatial resolution is improved from 240 um to 130 um and frame rate is increased by a factor more than 6.

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**Session Classification:** Poster Session B

**Track Classification:** Semiconductor Detectors

Contribution ID: **519** Type: **Talk**

# Evaluation of a novel photon-counting CT system using a 16-channel MPPC array for multicolor 3-D imaging

*Thursday, February 21, 2019 2:00 PM (20 minutes)*

X-ray computed tomography (CT) is widely used in diagnostic imaging of the interior of the human body; however, the radiation dose of conventional CT typically amounts to 10 mSv. Under such environments, X-ray photons are severely piled-up; therefore, the CT images are monochromatic and various artifacts are present due to beam hardening effects. In contrast, photon counting CT (PC-CT) offers a low dose and multicolor CT system. At present, PC-CT systems based on CdZnTe devices are widely studied. This system is yet far from being an established clinical technique, owing to the high-cost and complexity of huge number of read out channels; the pixel size of CdZnTe must be as small as ~0.1-0.2 mm to withstand high counting rate due to the slow mobility of electron-hole pairs. In this paper, we propose a cost-effective, novel PC-CT system consisting of 16-ch multipixel photon counter (MPPC) coupled with a high-speed scintillator array. As a proof of concept, we show 3-D color images of a lighter phantom taken in a sufficiently low-dose environment. Material identification is possible by setting multiple energy windows. Next, we applied our PC-CT system for K-edge imaging, which can improve blood-tissue contrast using a specific contrast agent. By setting appropriate energy windows, our PC-CT system accurately reconstructed absolute concentration of iodine and gadolinium. Finally, we discuss the prospects and possible future clinical applications of the developed PC-CT system.

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**Session Classification:** Medical Applications

**Track Classification:** Medical Applications

Contribution ID: **520** Type: **Poster**

# First demonstration of portable Compton camera to visualize 223-Ra concentration for radionuclide therapy

Radionuclide therapy (RNT) is an internal radiation therapy that can selectively damage cancer cells. Recently, the use of alpha-emitting radionuclides was initiated in RNT owing to its dose concentration and short range. In particular, 223-Ra is widely used for bone metastasis cancer. Despite its potential for clinical applications, it is difficult to know whether the drug has been properly delivered to the target lesion. As such, we propose a new method of monitoring nuclear gamma rays promptly/simultaneously emitted from 223-Ra in alpha-decay by using a high-sensitivity Compton camera. We first observed a small bottle of 223-Ra solution that had a total radio-activity of 0.56 MBq. The reconstructed image converged at the correct position with a position resolution of ~20 mm at a plane 10 cm ahead of the camera. Next, we observed a phantom consisting of three spheres, with diameters ranging from 13 to 37 mm, filled with 223-Ra solution (9 kBq/ml) and then surrounded by a ~20-cm layer of water. A 3D image was constructed by rotating the Compton camera around the phantom. Then, images were taken from eight directions at 30-min intervals, respectively. Although the image resolution remains limited at 351 keV, three spheres were resolved at the correct position in the 3D image with their relative intensities. Finally, we discuss current problems and plans for improving the sensitivity and angular resolution for future clinical applications.

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**Session Classification:** Poster Session B

**Track Classification:** Medical Applications

Contribution ID: **527** Type: **Talk**

# Pixel-detector R&D for CLIC

*Monday, February 18, 2019 2:25 PM (20 minutes)*

The physics aims at the proposed future CLIC high-energy linear e+e- collider pose challenging demands on the performance of the detector system. In particular the vertex and tracking detectors have to combine precision measurements with robustness against the expected high rates of beam-induced backgrounds. A spatial resolution of a few microns and a material budget down to 0.2% of a radiation length per vertex-detector layer have to be achieved together with a few nanoseconds time stamping accuracy. These requirements are addressed with innovative technologies in an ambitious detector R&D programme, comprising hardware developments as well as detailed device and Monte Carlo simulations. Various fine pitch hybrid silicon pixel detector technologies are under investigation for the CLIC vertex detector. The CLICpix and CLICpix2 readout ASICs with 25 micron pixel pitch have been produced in a 65 nm commercial CMOS process and bump-bonded to planar active edge sensors as well as capacitively coupled to High-Voltage (HV) CMOS sensors. Monolithic silicon tracking detectors are foreseen for the large surface (~140 square meters) CLIC tracker. Fully monolithic prototypes are currently under development in High-Resistivity (HR) CMOS, HV-CMOS and Silicon on Insulator (SOI) technologies. This talk presents an overview of the CLIC pixel-detector R&D programme, focussing on recent test-beam and simulation results.

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**Presenter:** DANNHEIM, Dominik (CERN)

**Session Classification:** Plenary 2

**Track Classification:** Semiconductor Detectors

Contribution ID: **529** Type: **Talk**

# AXEL: High-pressure Xe gas TPC for BG-free 0v2b search

*Wednesday, February 20, 2019 12:20 PM (20 minutes)*

Observation of the neutrinoless double-beta decay (0v2b) is a key to solve the neutrino absolute mass and the Majorana nature. Recent 0v2b search experiments will test the neutrino mass region allowed in case of the inverted mass ordering, but oscillation experiments favor the normal ordering. For 0v2b search in the normal ordering region, a background-free search with a 1-ton scale large detector is essential. To realize such search, we are developing a new detector AXEL.
The AXEL is a high-pressure 136Xe gas TPC with using the electroluminescence (EL) process as a signal readout for good energy-resolution. The event topology is reconstructed by our unique tracking-plane of ELCC. The ELCC consists of four layers: anode Cu plate, rigid PTFE structure, ground mesh electrode, and photosensor array, with a cell structure. Drift electrons produced in the gas region are collected into each cell along the electric field, and they are linearly amplified by EL process. The ELCC promise high energy resolution and the scalability for the large volume. With a 10 L size prototype chamber, we evaluated the feasibility study of ELCC; we achieved 0.8 - 1.0% of energy resolution with extrapolation to Q-value. For a precise measurement, we are constructing next prototype with 180 L size.
In this presentation, we will report the performance obtained with the 10 L prototype chamber, the latest upgrade status of a 180L-size prototype construction, and future prospect including deep learning.

**Primary author:** Dr OBARA, Shuhei (Kyoto University)

**Co-author:** FOR THE AXEL COLLABORATION

**Presenter:** Dr OBARA, Shuhei (Kyoto University)

**Session Classification:** Gas Detectors

**Track Classification:** Gaseous Detectors

Contribution ID: **531** Type: **Poster**

# Particle detectors in Rare-gas crystals

Low energy threshold detectors are necessary in many frontier fields of the experimental physics. In particular these are extremely important for probing Dark Matter (DM) possible candidates. We present the activity of the AXIOMA matrix R&D project, a novel detection approach that exploits Rare gases crystals both undoped and doped maintained at low temperature. In the undoped matrices, the direct ionization of the incident particle creates free charges that could be extracted through the solid-vacuum interface and then detected. In the doped crystals scheme we probe the energy levels of atoms embedded into the crystals. We exploit laser-assisted transitions that are triggered by the absorption of the incident particle in the material and leads in the emission of a fluorescent photon or in an electron. Two possible schemes are thus possible: one is based on a light signal while the other takes advantage of high efficiency-in vacuum charge detection. The second approach offers the advantage of single-electron detection combined with a very low dark count rate using microchannel plate or channeltron sensors. However, to ensure electrons' drift, we needs high quality crystals with an impurity level lower than ppb especially for high electronegativity atoms. Through these schemes, we could be able to detect low energy release in the range [sub eV-tens of eV] in large volume crystals opening thus the possibility to investigate lighter DM candidates.

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**Presenter:** Dr GUARISE, Marco (University of Ferrara and INFN)

**Session Classification:** Poster Session B

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **532** Type: **Poster**

# Latest Improvements of Microchannel-Plate PMTs

Microchannel-plate (MCP) PMTs were identified as the only suitable photon sensors for the DIRC detectors of the PANDA experiment at FAIR. PANDA is a hadron physics experiment which employs a high intensity antiproton beam of up to 15 GeV/c to perform high precision measurements of, among others, objectives like charmonium spectroscopy and search for gluonic excitations. As the long-standing aging problems of MCP-PMTs were recently overcome by coating the MCP pores with an atomic layer deposition (ALD) technique, we have investigated further improved 2-inch MCP-PMTs. The latest PHOTONIS devices reach a DQE = QE*CE > 25% and lifetimes of >20 C/cm$^2$ IAC without any sign of aging. Also the newly developed 2-inch MCP-PMTs of Hamamatsu are maturing and now usable in high rate environments. In this talk the status of our long-term lifetime measurements and the performance of the currently most advanced ALD-coated MCP-PMTs will be presented. In addition, first results obtained with a new quality assurance setup for MCP-PMTs will be discussed. This setup consists of a modular PADIWA/TRB DAQ system to measure the response of up to 300 anode pixels simultaneously. The system is very flexible and allows a glance "inside the MCP-PMT": background parameters like position dependent dark count rates and ion afterpulsing will be accessible as well as temporal and spacial distributions of recoil electrons and the effects of electronic and charge-sharing crosstalk among the anode pixels.

**Primary author:** Dr LEHMANN, Albert (Universität Erlangen-Nürnberg)

**Presenter:** Dr LEHMANN, Albert (Universität Erlangen-Nürnberg)

**Session Classification:** Poster Session A

**Track Classification:** Photon Detectors

Contribution ID: **533** Type: **Poster**

# NONINVASIVE METHOD OF RECOVERY OF GAS PARTICLE DETECTORS UNDER OPERATION IN HIGH-INTENSITY FIELDS OF RADIATION

Aging effects result in a surface degradation of both the anode and cathode electrodes, which occur in different forms. Anode type of aging is associated with silicon deposits formed on the surface of the anode wires. This effect is manifested even with small accumulated charges in the range of (0.1–1.0) Coulomb per cm of the anode wire length. If there would be no silicon contamination in the detector, it could operate at higher doses with the accumulated charge exceeding 1 Coulomb/cm. In this case, the main mechanism of aging would be swelling of the wire caused by chemical interaction of the oxygen, which is coming from the gas avalanche, with the tungsten that is the main material of the anode wire. Cathode aging is associated with formation of dielectric films at the cathode, which usually cause the Malter effect. We describe a method of noninvasive recovery of gas-discharge detectors, which have been degraded due to operation in intense radiation fields, by cleaning the cathode and anode wire surface from organic compounds, silicon, and tungsten compositions (swelling effects). It has been shown that the method of plasma-chemical etching in a gas discharge increases the detector lifetime in several times. Recovery of the main technical characteristics of the detector after its aging without disassembling and repairing is actual for many physical experiments, since the development of a detector operating with an accumulated charge of about 10–20 C/cm is still a problem.

**Primary author:** Prof. KRIVSHICH, Anatoly

**Presenter:** Prof. KRIVSHICH, Anatoly

**Session Classification:** Poster Session B

**Track Classification:** Gaseous Detectors

Contribution ID: **539** Type: **Talk**

# The PreProcessor modules for the ATLAS Tile Calorimeter at the HL-LHC

*Tuesday, February 19, 2019 5:20 PM (20 minutes)*

The Tile Calorimeter (TileCal) is the central hadronic calorimeter of the ATLAS experiment at the Large Hadron Collider (LHC). It is a sampling calorimeter made of steel plates and plastic scintillators, read out by approximately 10,000 photomultipliers. In 2024, the LHC will be upgraded to the High Luminosity LHC (HL-LHC) allowing it to deliver up to 7 times the nominal instantaneous design luminosity. The Phase-II TileCal Upgrade will accommodate the detector and data acquisition system to the HL-LHC requirements. The on- and off-detector electronics will be completely redesigned, using a new readout architecture with a full-digital trigger system.
The upgraded on-detector electronics will transfer digitized data for every bunch crossing (~25 ns) to the Tile PreProcessor system (TilePPr) in the counting rooms, with a total data bandwidth of 40 Tbps. The TilePPr will store the detector data in pipeline memories to accommodate the new ATLAS Trigger and Data Acquisition architecture requirements, and will interface with the FELIX system and the first trigger level. A total of 32 TilePPr modules will be needed to read out the entire detector. The TilePPr module is composed of a full-size ATCA carrier blade equipped with four FPGA- based Compact Processing Modules with single-width AMC form factor.
This contribution presents the hardware and firmware developments, results and experiences for the final design of the Tile PreProcessor for the ATLAS Phase II Upgrade.

**Primary author:** CARRIO ARGOS, Fernando (Univ. of Valencia and CSIC (ES))

**Presenter:** CARRIO ARGOS, Fernando (Univ. of Valencia and CSIC (ES))

**Session Classification:** Calorimeter

**Track Classification:** Calorimeters

Contribution ID: **542** Type: **Talk**

# Bulk engineering for enhanced lateral drift sensors

*Thursday, February 21, 2019 3:15 PM (20 minutes)*

Future experiments in particle physics foresee few-micrometer single-point position resolution in their vertex detectors, motivated by e.g. b/light-quark-tagging capabilities. Silicon is today's material of choice for high-precision detectors and offers a high grade of engineering possibilities. Instead of scaling down pitch sizes, which comes at a high price for an increased number of channels, our new sensor concept seeks to improve the position resolution by increasing the lateral size of the charge distribution already during the drift in the sensor material. To this end, it is necessary to carefully engineer the electric field in the bulk of this so-called enhanced lateral drift (ELAD) sensor. This is achieved by implants deep inside the bulk which allows for a modification of the charge carriers' drift paths.

In order to engineer the sensor bulk, we chose to combine epitaxial growth with ion beam implantation in an alternating approach. Test samples are analysed with spreading resistance profiling (SRP) and electrochemical capacitance-voltage (ECV) profiling and are compared to TCAD optimisation studies.

Results of the ECV and SRP measurements are presented and discussed. The feasibility of bulk engineering through the combination of epitaxial growth and ion beam implantation is discussed. Additionally, we demonstrate the potential of ELAD sensors, which make use of bulk engineering, in comparison to conventional planar hybrids based on test beam simulation studies.

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**Presenter:** JANSEN, Hendrik (Deutsches Elektronen-Synchrotron (DE))

**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **546** Type: **Talk**

# The EUSO-SPB2 mission

*Wednesday, February 20, 2019 9:00 AM (20 minutes)*

EUSO-SPB2 is a second generation Extreme Universe Space Observatory (EUSO) on a Super-Pressure Balloon (SPB). The mission broadens the scientific objectives of the EUSO program and constitutes the first step towards the study of neutrino signals from the high atmosphere and space.
The EUSO-SPB2 science payload will be equipped with three detectors designed for a long duration mission. One is a fluorescence telescope developed to detect Ultra High Energy Cosmic Rays via the UV fluorescence emission of the particle showers generated in the atmosphere. The other two telescopes will measure Cherenkov light emission from showers of lower energy cosmic rays to study and measure the background contribution for detecting cosmogenic neutrinos.
These specific techniques and detection methods are performed in light of the realization of POEMMA (Probe of Extreme Multi Messenger Astronomy), a space mission, currently under NASA funded conceptual design studies. The EUSO-SPB2 mission has been approved by NASA and foreseen to be launched in 2021.
In this paper we will give a description of the payload, including details on the detection techniques and the telescopes design.

**Primary authors:** SCOTTI, Valentina; OSTERIA, Giuseppe (INFN)

**Presenter:** SCOTTI, Valentina

**Session Classification:** Semiconductor Detectors

**Track Classification:** Astroparticle Detectors

Contribution ID: **547** Type: **Talk**

# Detectors for direct Dark Matter search at KamLAND

*Wednesday, February 20, 2019 9:50 AM (20 minutes)*

Nature and properties of the Dark Matter (DM) in the Universe are among the most fundamental questions of the modern particle physics and astrophysics. So far, the only experiment that claimed detection of a signal from the DM is the DAMA/LIBRA NaI(Tl) experiment located at the Gran Sasso underground laboratory in Italy. Until the recent time, the main obstacle in repeating the DAMA/LIBRA experiment was insufficient radio-purity of NaI(Tl) crystals developed by other collaborations. However, we successfully developed an ultra-low background NaI(Tl) crystals of required purity and prepare for independent verification of the DAMA/LIBRA result. In addition, we study sources of alternative explanation for modulation of the background in detectors located at deep underground laboratories.

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**Presenter:** Dr KOZLOV, Alexandre (The University of Tokyo)

**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **548** Type: **Poster**

# Feasibility study of the use of CMOS image sensors in radioguided surgery with $\beta^-$ emitters

A feasibility study about the employment of widely and commercially avaliable CMOS imager sensors in a radioguided surgery probe for $\beta^-$ detection is presented.
The radioguided surgery is a medical technique, which involves the use of a manageable probe for the intraoperative detection of the radiation emission of radiopharmaceuticals. The probe support the visual inspection of the surgeon, helping him to localize the tumor tissue extension with the highest possible resolution.
The use of $\beta^-$-emitters as tracers, instead of the more commonly employed $\gamma$-emitters, increases the ratio between the signal from diseased tissue and the background from the surrounding healty tissues. This is due to the shorter means free path of the electrons if compared to photons.
CMOS imager sensors have shown suitable features to be employed as active elements in a pen-shape probe for $\beta^-$ direct detection.
The performances of several CMOS sensor (Aptina products) have been tested in terms of stability of response as a funcion of time, temperature, and radiation exposure. Campaigns of measurement have been performed under the emission of sources of $^{90}Y$ diluted in agar agar, featuring different activities, dimensions, and shapes, in order to estimate the detection relative efficiency, the spatial resolution, and the attainable sensitivity during an acquisition time of a few seconds.

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**Session Classification:** Poster Session A

**Track Classification:** Medical Applications

Contribution ID: **549** Type: **Poster**

# Discharge behavior of resistive Micromegas

We performed detailed studies to measure the effect of the mesh geometry and gas mixtures on the discharge behavior of resistive Micromegas.
A Micromegas detector has been built at CERN with a special design allowing to easily replacing the mesh. It has 1028 readout strips with a pitch of 400 μm, an active area of 40x50 cm2 and 128 μm high pillar spacers. The resistive strips, screen-printed on an insulating foil, have the same size as the readout ones. Meshes of different geometries have been stretched on iron frames fitting the detector structure.
The test procedure consisted in measuring current, gain and counting rate from 55Fe gamma source, as function of the amplification voltage up to the discharge limit.
The systematic analysis of the data allowed to conclude on the stability interval of the six different types of mesh we tested, consistent with the expectations based on the values for the average and maximum electrical field created by the mesh geometry.
With the same experimental setup, test and analysis procedure we have studied the discharge behavior of different Argon-based gas mixtures; results of the gas study will be also reported.

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**Session Classification:** Poster Session A

**Track Classification:** Gaseous Detectors

Contribution ID: **550** Type: **Poster**

# Time-projection chamber development for Multi-Purpose Detector of NICA project

Under the JINR scientific program on study of hot and dense baryonic matter, a new accelerator complex the Nuclotron-based Ion Collider fAcility (NICA) is under construction. The Multi-Purpose Detector (MPD) will operate at one of the collider interaction point and it is optimized for investigations of heavy-ion collisions in energy range from 4 to 11A GeV.
TPC is proposed as central part of tracking system of the MPD detector. It is the natural choice for three-dimensional imaging of complex events in heavy-ion experiment. In conjunction with the time of flight and inner tracker detectors TPC is providing tracking, pattern recognition, vertex reconstruction and charged particles identification. The TPC has cylindrical body with diameter of 2.8 m and length of 3.4 m and placed in magnet with solenoidal field 0.5 T. Sensitive volume contains 17.6 $m^3$ of argon-methane mixture. Detector will register charged products of heavy ions collisions and providing events registration with trigger rate up to 7 kHz.
Report presents parameters of the TPC and development status of its sub-systems such as: field cage and high-voltage electrode, readout chambers, laser calibration system, temperature stabilization system, gas system, front-end electronics and others. TPC assembling procedure and infrastructure are presented in the report as well.

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**Presenter:** VERESCHAGIN, Stepan (Joint Institute for Nuclear Research)

**Session Classification:** Poster Session B

**Track Classification:** Gaseous Detectors

Contribution ID: **551** Type: **Poster**

# DEPFET Detector development for the Wide Field Imager of ATHENA

The ATHENA X-ray observatory was selected as ESA's second large-class mission, scheduled to launch in the early 2030s. To enable detailed explorations of the hot and energetic universe, two complementary focal-plane instruments are coupled to a high-performance X-ray telescope. As one of these, the WFI (Wide Field Imager) features an unprecedented survey power by combining an excellent count rate capability (≥ 1 Crab) with a large field of view of 40x40 arcmin2. In order to achieve the required energy (< 170 eV at 7 keV) and time resolution (5 ms) with monolithic sensors of 512x512 pixels, dedicated DEPFET detectors have been developed.
In the course of the detector development, a dedicated production of prototype sensors has been fabricated and tested. The studies of those devices resulted in the selection of one sensor variant, which will be used at the pre-flight fabrication. The excellent spectroscopic performance of the selected detector variant will be demonstrated with recent results of a large size detector with 256x256 pixels. The energy response of the device was evaluated by illuminating the detector with characteristic X-ray radiation. Due to the large sensor area, the homogeneity of the entrance window and between individual pixels can be evaluated.

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**Session Classification:** Poster Session A

**Track Classification:** Semiconductor Detectors

Contribution ID: **553** Type: **Talk**

# The CMS ECAL Phase-2 Upgrade for High Precision Timing and Energy Measurements

*Tuesday, February 19, 2019 5:45 PM (20 minutes)*

The CMS electromagnetic calorimeter (ECAL) is a homogeneous calorimeter made of about 75000 lead tungstate scintillating crystals. In view of the high-luminosity phase of the LHC, the ECAL electronics must be upgraded to cope with the more stringent requirements in terms of trigger latency and rate. The new electronics will transmit the data in streaming mode from the front-end electronics to the off-detector electronics, where the trigger primitives will be formed in powerful FPGAs. The front-end electronics will feature two new radiation-hard chips: a dual gain trans-impedance amplifier (TIA) and a sampling ADC with loss-less data compression. The TIA choice allows preserving the fast pulse shape of the lead tungstate coupled to Avalanche Photodiodes (APD), and it is more resilient to the noise increase due to the radiation-induced APD leakage current. An important characteristic of the new design will be the capability to provide precision timing measurements, of the order of 30 ps, for photons and electrons above 50 GeV. The excellent time resolution will improve the overall CMS physics performance by mitigating the high pile-up effects. First characterization results of the TIA chip will be shown, and studies of energy and timing resolution performed in beam tests with the electronic prototypes will be presented.

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**Presenter:** FERRI, Federico (Université Paris-Saclay (FR))

**Session Classification:** Calorimeter

**Track Classification:** Calorimeters

Contribution ID: **554** Type: **Poster**

# Instrumentation concepts for Neganov-Luke assisted mK-temperature Germanium detectors in dark matter search

In direct searches for dark matter, the signature is a recoiling nucleus being hit by a massive dark matter particle, a so-called WIMP. A viable technology to search for such recoil signatures are detector arrays of Ge mono-crystals operated at a few mK temperature and equipped with electrodes and thermal sensors. Applying a small (few V/cm) external field, a simultaneous measurement of ionization and heat signals allows efficient discrimination of nuclear (signal) against electron recoils (background). Applying a larger bias leads to a so-called Neganov-Luke assisted amplification of the heat signal, lowering the effective threshold and thus opening a search for low mass WIMPs. The electronics and DAQ system for such a cryogenic low-threshold setup will be presented and discussed, with special emphasis on the realisation in the EDELWEISS experiment as well as in currently ongoing R&D projects.

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**Presenter:** Dr SIEBENBORN, Bernhard (Karlsruhe Institute of Technology (KIT))

**Session Classification:** Poster Session A

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **555** Type: **Talk**

# EIGER: High frame rate pixel detector for synchrotron and electron microscopy applications

*Friday, February 22, 2019 4:20 PM (20 minutes)*

The hybrid pixel detector EIGER, featuring 75×75 $\mu$m$^2$ pixel size, is a photon counter designed for use at synchrotrons. The chip and the complete readout system were designed at the Paul Scherrer Institut, Switzerland. A single chip consists of 256×256 pixels and can acquire data at 22000~frame/s with 4-bit counter depth. In a full module, 4×2 chips are bonded to a single 320 $\mu$m thin Si sensor. The readout electronics of a module has been specifically developed to preserve the high frame rate capability of the chip. Larger modules systems, up to 9 Mpixels, have been built tiling modules together and preserving the high frame rate capability.
EIGER has been tested also as a detector for electrons both at low energies (8−20 keV targeting photo-emission electron microscopy) and higher energies (100−300~keV, typical for transmission electron microscopes). The stopping power of electrons varies a lot at these energies and the multiple scattering can be substantial. Up to 20 keV, the Si sensor needs to be optimized to reduce its entrance window, where low energy electrons stop or scatter. For higher energies up to 100 keV, EIGER shows single pixel resolution. At 200 or 300 keV, the multiple scattering of the electron in the sensor spoils the spatial resolution and a cluster of pixels is recorded per electron. However, EIGER is still suitable for diffraction applications at these energies thanks to the high frame rate capability.

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**Presenter:** FRÖJDH, Erik (Paul Scherrer Institut)

**Session Classification:** Plenary 5

Contribution ID: **556** Type: **Talk**

# Analysis methods for highly radiation-damaged SiPMs

*Thursday, February 21, 2019 4:55 PM (20 minutes)*

Measurements and analysis methods are presented with the aim to determine the SiPM performance after irradiation by neutrons to fluences between 10^9 and 5x10^14 neq/cm^2. SiPMs with 4384 pixels of 15x15 μm2 produced by KETEK are used.
Following measurements and analyses will be presented to determine the fluence dependence of the SiPM parameters given in the list.
1. Y–f from which the pixel capacitance, quenching capacitance and quenching resistance are determined.
2. C–Vreverse for determining the doping profile and the electric field.
3. Idark–Vforward for determining the quenching resistance.
4. Idark–Vreverse for determining the breakdown voltage and estimating the dark-count rate (DCR), the pixel occupancy and saturation effects at high DCR values.
5. Iphoto-Vreverse for determining the breakdown voltage and the reduction of the photo-detection-efficiency (pde).
6. Transient_dark–Vreverse from the rms-spread of the Transient_dark integrrated over different time intervals the SiPM pulse decay time, the DCR and saturation effects due to high DCR are determined.
7. Transient_light–Vreverse from the mean and rms-spread of the Transient_light integrated over different time intervals, the SiPM gain and the pde are determined.
The assumptions and limitations of the analyses and ways how to minimise the loss of pde for a given radiation fluence, will be presented. If a parameter can be determined in several ways, the differences will be discussed.

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**Presenter:** Prof. KLANNER, Robert (University of Hamburg)

**Session Classification:** SiPM

**Track Classification:** SiPM

Contribution ID: **557** Type: **Poster**

# Lynkeos MIS: A Muon Imaging System for Nuclear Waste Containers

The Lynkeos Muon Imaging System (MIS) uses cosmic-ray muons for the 3D-imaging of the contents of shielded nuclear waste containers. The detector system consists of four scintillating fibre tracker modules using 64 channel MPAMTs as readout, two above and two below the object to track the muons. Complex imaging algorithms then reconstruct a 3D image of the object and its contents.

The Lynkeos MIS is the result of a 7 year joint research project between UK National Nuclear Laboratory and the University of Glasgow, funded by the Nuclear Decommissioning Authority with £4.8 million from 2009 to 2016. Lynkeos Technology Ltd. was founded in 2016 and in 2017 was awarded a £1.6 million contract from Innovate UK for the First-of-a-kind deployment of the Lynkeos MIS on the Sellafield site. The Lynkeos MIS is operating on the Sellafield site since October 2018 as the worldwide first muon imaging system that is deployed on a nuclear site. It also is the first CE-marked large-scale particle tracking detector.

This talk will present the detector itself, the steps towards commercialisation of the technology, especially the CE-marking process, and present results from the imaging of two different waste containers - 500 l Intermediate Level Waste (ILW) drums and GeoMelt containers with vitrified waste.

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**Presenter:** Prof. KAISER, Ralf (University of Glasgow & Lynkeos Technology Ltd.)

**Session Classification:** Poster Session B

**Track Classification:** Miscellaneous

Contribution ID: **561** Type: **Talk**

# Development of resistive Micromegas TPCs for the T2K experiment

*Wednesday, February 20, 2019 9:00 AM (20 minutes)*

The long baseline neutrino experiment T2K has launched the upgrade project of its near detector ND280, crucial to reduce the systematic uncertainty to less than 4%. An essential component of this upgrade consists of the resistive Micromegas TPCs, for 3D track reconstruction, momentum measurement and particle identification. These TPC, with overall dimensions of 2x2x0.8 m3, will be equipped with 32 resistive bulk Micromegas.
The thin field cage (3cm thickness, 4% rad. length) will be realized with laminated panels of Aramid and honeycomb covered with a kapton foil with copper strips. The 34x42 cm2 Micromegas will use a 500 kOhm/square DLC foil to spread the charge over the pad plane, each pad being appr. 1 cm2 . The front-end cards, based on the AFTER chip, will be mounted on the back of the Micromegas and parallel to its plane.
In Summer 2018 we have tested one resistive Micromegas detector on the ex-Harp TPC field cage in the CERN PS test beam (electrons, pions and protons with momenta between 0.5 and 2 GeV/c) with excellent results both for the space point resolution and for dE/dx. In particular we have tuned the charge spreading by varying the electronics shaping time from 100 to 600 ns.
In November 2018 we will release the detailed TDR describing all the components of this device (the installation is planned in 2021). In this talk we will report on the design of this detector, its performance, the results of the test beam and the plan for its construction.

**Primary author:** DELBART, Alain (CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette (FR))

**Presenter:** DELBART, Alain (CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette (FR))

**Session Classification:** Gas Detectors

**Track Classification:** Gaseous Detectors

Contribution ID: **564** Type: **Poster**

# MIMOSIS, a CMOS sensor for the CBM Micro Vertex Detector

The Compressed Baryonic Matter Experiment (CBM) is one of the core experiments of the future FAIR facility at Darmstadt/Germany. This experiment will explore the phase diagram of strongly interacting matter in the regime of high net baryon densities with numerous rare probes. The Micro Vertex Detector (MVD) will determine the secondary decay vertex of open charm particles with $\sim 50\ \mu\mathrm{m}$ precision, contribute to the background rejection in di-electron spectroscopy and help to reconstruct neutral decay products of strange particles by means of missing mass identification.

The MVD will be placed between 5 and $20\ \mathrm{cm}$ downstream the target and inside vacuum and operate at average collision rates of 100 kHz Au-Au and of 10 MHz p-Au. It will be operated with a dedicated CMOS Monolithic Active Pixel Sensor named MIMOSIS. Its design relies on the pixel array read-out architecture of the ALPIDE sensor developed for the ALICE ITS upgrade and extends its rate capability by more than one order of magnitude. Moreover, the fixed target geometry of the MVD creates specific challenges including strong gradients in the track density and radiation load, a bombardment with direct beam ions and substantial beam intensity fluctuations.

We will discuss those challenges, introduce the requirements for the detector technology and show the solutions foreseen in the MIMOSIS sensor. Moreover, the status of the tests of the first sensor prototype MIMOSIS-0 will be given.

**Primary authors:** Dr DEVEAUX, Michael (Goethe University Frankfurt); Dr KOZIEL, Michal (Goethe University Frankfurt)

**Presenter:** Dr DEVEAUX, Michael (Goethe University Frankfurt)

**Session Classification:** Poster Session B

**Track Classification:** Semiconductor Detectors

Contribution ID: **566** Type: **Talk**

# Development of a 3D highly granular scintillator neutrino detector for the T2K experiment

*Wednesday, February 20, 2019 10:15 AM (20 minutes)*

The long baseline neutrino experiment T2K has launched the upgrade project of its near detector ND280, crucial to reduce the systematic uncertainty in the prediction of number of events at the far detector to less than 4%. An essential component of this upgrade is a highly segmented scintillator detector, acting as a fully active target for the neutrino interactions.
The baseline concept for it is a novel device, called SuperFGD (arXiv:1707.01785, 2018_JINST_13_P02006), with dimensions of ~200x180x60 cm3 and a total mass of about 2 tons. It consists of about 2x106 small scintillator cubes each of 1 cm3. The signal readout from each cube is provided by wavelength shifting fibers inserted in these holes and connected to micro-pixel avalanche photodiodes MPPCs. The total number of channels will be ~60,000. We have demonstrated that this detector, providing three 2D projections, has excellent tracking performance, including a $4\pi$ angular acceptance, especially important for short proton and pion tracks.
Prototypes of this detector have been tested in a beam of charged particles at CERN in 2017-2018. The detector response of these prototypes, including the light yield, the cross-talk, and the time resolution has been measured.
In November 2018 we will release the detailed TDR describing all the components of this device (the installation is planned in 2021). The progress in the R&D of this detector, future plans and results of simulations will be also reported.

**Primary author:** PARSA, Saba (Universite de Geneve (CH))

**Presenter:** PARSA, Saba (Universite de Geneve (CH))

**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **567** Type: **Poster**

# The performances of photomultiplier tube of WCDA++ in LHAASO experiment

In order to extend the dynamic range of Water Cherenkov Detector Array (WCDA) in Larger High Altitude Air Shower Observatory (LHAASO), another 1.5-inch photomultiplier tube (PMT) is placed aside the 8–inch PMT in each cell of WCDA. All these 1.5-inch PMTs, total 900, consist of the WCDA++ system. The performances of these 1.5-inch PMTs, with special designed di-output voltage divider, are test by using the PMT test system of Shandong University. Especially, the working voltage and signal width effect on the dynamic range of these PMTs is studied. The results show that: the dynamic range, within 5% charge non-linearity under signal width of 5.5ns, is up to 200 kPEs (PhotoElectrons); the dark noise count rate is less than 200Hz under the 1mV threshold at PMT gain of 2e+05 ; the transit time spread (TTS) is less than 4ns. 3 adjacent PMTs' working voltage are difference within 2V , and can share one high voltage power supply. These results confirmed that PMT performance meet the WCDA++ requirements.

**Primary author:** Ms ZHANG, Hengying (Shandong University)

**Co-authors:** Ms YU, Yanhong (Shandong University); Mr LIU, Dong (Shandong University); Mr LIU, Cheng (Institute of High Energy Physics, Chinese Academy of Sciences ); Prof. FENG, Cunfeng (Shandong University)

**Presenter:** Ms ZHANG, Hengying (Shandong University)

**Session Classification:** Poster Session B

**Track Classification:** Cherenkov Detectors

Contribution ID: **569** Type: **Talk**

# Performance studies of RPC detectors with new environmentally friendly gas mixtures in presence of LHC-like radiation background

*Thursday, February 21, 2019 11:30 AM (20 minutes)*

Resistive Plate Chamber (RPC) detectors are widely used at the CERN LHC experiments as muon trigger thanks to their excellent time resolution. They are operated with a Freon-based gas mixture containing C2H2F4 and SF6, both greenhouse gases (GHG) with a very high global warming potential (GWP). The search of new environmentally friendly gas mixtures is necessary to reduce GHG emissions and costs as well as to optimize RPC performance.
Several recently available gases with low GWP have been identified as possible replacements for C2H2F4 and SF6. More than 60 environmentally friendly gas mixtures have been investigated on 2 mm single-gap RPCs. The RPC detectors have been tested in laboratory conditions and at the CERN Gamma Irradiation Facility (GIF++), which provides a high energy muon beam combined with an intense gamma source allowing to simulate the background expected at HL-LHC.
RPCs performance have been studied at different gamma rates with the new environmentally friendly gases by measuring efficiency, streamer probability, rate capability, induced charge, cluster size and time resolution. A complete overview of the results obtained at GIF++ will be presented.
To finalize the studies, the RPCs are now operated under gas recirculation with the selected new gas mixture and exposed to the intense gamma radiation of GIF++ for evaluating possible long-term aging effects, gas damage due to radiation and compatibility of LHC gas system with new gases.

**Primary authors:** MANDELLI, Beatrice (CERN); GUIDA, Roberto (CERN); RIGOLETTI, Gianluca (Universita & INFN, Milano-Bicocca (IT))

**Presenter:** MANDELLI, Beatrice (CERN)

**Session Classification:** Gas Detectors

**Track Classification:** Gaseous Detectors

Contribution ID: **570** Type: **Poster**

# The ENUBET ERC project for an instrumented decay tunnel for future neutrino beams

The ENUBET ERC project (2016-2021) is studying a narrow band neutrino beam where lepton production could be monitored at single particle level in an instrumented decay tunnel. For this purpose we have developed a specialized shashlik calorimeter with a compact readout. The modules are composed of 1.5 cm thick steel absorbers coupled to 5 mm thick plastic scintillators. A matrix of 3 x 3 fibers run transversely with a density of one fiber/cm2 and an overall surface of about 10cm^2. Fibers are coupled individually to HD SiPM mounted on a custom PCB allowing reduce the dead zones between adjacent modules to an extremely small level compared to "fiber bundling" configurations. This setup allows a very effective longitudinal segmentation or e/pi separation. We will present the results of test beams performed in 2016-2018 at the CERN-PS East Area. We will also discuss the characterization of SiPM of different cell size (12μm and 15 μm) before and after being exposed to neutron fluxes up to 10^{12}/cm^2 at the INFN-LNL CN accelerator facility in June 2017. We have also successfully characterized at CERN a (12 X0) shashlik calorimeter based on polysiloxane scintillators. These are scintillators which come in liquid form, are poured around the fiber arrays and finally made solid with a thermal treatment.

JINST 13 (2018) P01028
IEEE Trans. Nucl. Sci. 64 (2017) no.4, 1056-1061
Nucl. Instrum. Meth. A845 (2017) 511-514
JINST 11 (2016) no.12, C12040
CERN-SPSC-2016-036 / SPSC-EOI-014

**Primary author:** PAROZZI, Elisabetta (Milano Bicocca University)

**Presenter:** PAROZZI, Elisabetta (Milano Bicocca University)

**Session Classification:** Poster Session A

**Track Classification:** Calorimeters

Contribution ID: **572** Type: **Poster**

# New insights on boiling carbon dioxide flow in mini- and micro-channels for optimal silicon detector cooling

Whilst the thermal management needs of future silicon detectors are increasing, the mass and volume minimization of all ancillaries gets more demanding. This requires highly effective active cooling in very small channels. Due to its favourable thermo-physical properties, evaporative CO2 is used as refrigerant for the future generations of silicon detectors at LHC. However, available data on CO2 boiling in channels of small hydraulic diameter (< 3 mm) are too limited, often affected by large uncertainties, to allow for developing reliable predictive models for heat transfer coefficient and pressure drop. This raises the need for long iterative phases of experimental tests, which will be reduced by the availability of reliable models. In the context of the AIDA-2020 project, a new test stand has been developed to characterize, with unprecedented level of accuracy, boiling flows of CO2 in mini- and micro-channels with hydraulic diameter ranging from 2 down to 0.1 mm. Results from this long term campaign will be presented and discussed. We will show the heat transfer coefficient and pressure drop behaviour in stainless steel tubular evaporators for saturation temperatures from +20 to -25 ℃, mass fluxes from 1200 to 100 kgm-2s-1 and heat fluxes from 5 to 35 kWm-2. High speed camera observations of CO2 flow patterns recorded on micro-structured silicon cold plates are used to help with the interpretation of the heat transfer coefficient and pressure drop trends reported.

**Primary authors:** HELLENSCHMIDT, Desiree (Universität Bonn (DE)); BOMBEN, Marco (LPNHE & Université Paris Diderot, Paris (FR)); CALDERINI, Giovanni (Centre National de la Recherche Scientifique (FR)); PETAGNA, Paolo (CERN)

**Presenter:** HELLENSCHMIDT, Desiree (Universität Bonn (DE))

**Session Classification:** Poster Session A

**Track Classification:** Semiconductor Detectors

Contribution ID: **573** Type: **Poster**

# Status and Performance of CBM-TOF systems

The Compressed Baryonic Matter (CBM) experiment aims at exploring the QCD phase diagram at large baryon densities with heavy ion beams in the beam energy range from 2 A GeV to 11 A GeV at the SIS100 accelerator of FAIR/GSI. For charged particle identification that is required by many observables that are sensitive to the phase structure like collective flow, phase space population of rare hyperons, fluctuations of conserved quantities, … a high performance Time-of-Flight (TOF) wall with a granularity of about 100.000 channels and a system timing resolution of better than 80 ps is being built.. The system comprises Multi-gap Resistive Plate Chambers (MRPCs) in multi-strip configuration with free-streaming readout enabling the measurement up to a flux of 20 kHz/cm$^2$ on the detector surface.
As part of the CBM-FAIR phase 0 program about 8% of the CBM TOF wall has been installed in the forward hemisphere ($1.0 < \eta < 1.5$) of the STAR experiment at RHIC/BNL (called eTOF) during the beam energy scan (BES II) campaign planned for 2019/2020. Another 5 modules (1600 channels) are installed at miniCBM at SIS18/GSI (also part of FAIR phase 0).
The status, performance and QA of both TOF detector systems will be presented.

**Primary authors:** DEPPNER, Ingo-Martin (Physikalisches Institut der Universität Heidelberg); HERRMANN, Norbert (Univ. Heidelberg)

**Presenter:** DEPPNER, Ingo-Martin (Physikalisches Institut der Universität Heidelberg)

**Session Classification:** Poster Session A

**Track Classification:** Gaseous Detectors

Contribution ID: **574** Type: **Poster**

# Flavour Physics at the High Luminosity LHC: LHCb Upgrade II

The LHCb Collaboration is planning an Upgrade II, a flavour physics experiment for the high luminosity era. This will be installed in LS4 (2030) and targets an instantaneous luminosity of 1 to 2x10 34 cm-2 s-1, and an integrated luminosity of at least 300fb-1. Modest consolidation of the current experiment will also be introduced in LS3 (2025).
This talk will present an overview of the LHCb plans for Upgrade II and highlight the physics reach of the upgraded experiment for selected physics topics.

**Primary author:** DENYSENKO, Vadym (Universitaet Zuerich (CH))

**Presenter:** DENYSENKO, Vadym (Universitaet Zuerich (CH))

**Session Classification:** Poster Session A

**Track Classification:** Miscellaneous

Contribution ID: **575** Type: **Talk**

# SciFi – Upgrading LHCb with a Scintillating Fibre Tracker

*Thursday, February 21, 2019 11:30 AM (20 minutes)*

LHCb will undergo a major upgrade during the LHC long shutdown in 2019/2020 to cope with increased instantaneous luminosities and to implement a trigger-less 40 MHz readout. The current inner and outer tracking detectors will be replaced by a single homogeneous detector based on plastic scintillating fibres (SciFi). The SciFi tracker covers an area of 340 m2 by using more than 10,000 km of scintillating fibre with 250 μm diameter, enabling a spatial resolution of better than 100 μm for charged particles. Six-layer fibre mats of 2.4 m length are assembled to form individual detector modules (0.5 × 4.8 m 2) consisting of 8 mats each. Linear arrays of Silicon Photomultipliers cooled to -40℃ are placed at the fibre ends. The readout of 524k channels occurs through custom-designed front-end electronics.

The LHCb requirements and environment impose stringent demands on the performance of the fibres. A R&D program aiming at the development of very fast and efficient scintillating fibres, based on a novel type of luminophores (NOL), has been launched in parallel to the SciFi production. The performance of the prototype NOL fibres is competitive, in particular the decay time constant is close to 1 ns, i.e. about 50% shorter than the best standard fibre.

The talk will give a brief overview of the SciFi detector design, production and performance of various components and status of the detector assembly. Furthermore, we will report on the latest results of the NOL fibre development.

**Primary author:** GRUBER, Lukas (CERN)

**Presenter:** GRUBER, Lukas (CERN)

**Session Classification:** Photon Detectors

**Track Classification:** Photon Detectors

Contribution ID: **577** Type: **Talk**

# Operational Experience of the Phase-1 CMS Pixel Detector

*Tuesday, February 19, 2019 4:55 PM (20 minutes)*

In 2017, CMS has installed a new pixel detector with 124M channels that features full 4-hit coverage in the tracking volume and is capable to withstand instantaneous luminosities of $2 \times 10^{34} cm^{-2} s^{-1}$ and beyond. Many of the key technologies of modern particle detectors are applied in this detector, like efficient DCDC low-voltage powering, high-bandwidth $\mu$TCA backend electronics, and light-weight CO2 cooling. By now the detector has been successfully operated for two years in p-p and heavy ion collisions and very valuable experience has been collected with the afore mentioned components. During the long shutdown of LHC from 2019 to 2021 the CMS pixel detector will be extracted and the modules of the inner most layer that suffered the most from radiation damage will be replaced. For that reason, a better readout chip as well as a new token bit manager chip will be used for these modules that fixes problems observed during operation.
This talk gives an overview of the detector performance in 2018 and describes the improvements made and challenges faced in the last two years of the detector operation.

**Primary author:** VORMWALD, Benedikt (Hamburg University (DE))

**Presenter:** VORMWALD, Benedikt (Hamburg University (DE))

**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **578** Type: **Poster**

# Comparison of TCAD simulations of irradiated Si-sensors with beam-test measurements

The aim of the work is to develop a model which allows reliably predicting the effects of radiation damage by hadrons in segmented silicon sensors up to 1 MeV equivalent neutron fluences of $2 \cdot 10^{16}\mathrm{n/cm^2}$, which are expected at the High-Luminosity LHC for an integrated luminosity of 3000 $\mathrm{fb}^{-1}$. Recently we presented a model with five effective traps (Hamburg Penta-Trap Model, HPTM) which provides a good and consistent description of the effects by 24 GeV/c proton irradiation on pad diodes. The Optimiser of SYNOPSYS-TCAD has been used to determine the parameters of the five traps by minimisation of the differences between simulated and measured I-V, C-V and $\mathrm{CCE}_{IR}$-V (Charge-Collection-Efficiency with infrared light). However, the I-V, C-V and $\mathrm{CCE}_{IR}$-V data have only a limited sensitivity to the depth dependence of charge trapping, which is essential to predict the response of radiation-damaged segmented sensors, because of highly non-uniform weighting fields. Therefore we developed a simple method to incorporate the information gained by edge-on beam data of irradiated pixel sensor into the TCAD optimisation.
In the talk we will present the method how the position dependent induced charge is implemented in the TCAD optimisation, the results of the fits and the predictions are compared to the test beam results.

**Primary authors:** Dr SCHWANDT, Joern (University of Hamburg); EBRAHIMI, Aliakbar (Hamburg University (DE)); FEINDT, Finn (Hamburg University (DE)); Dr FRETWURST, Eckhart (University of Hamburg); Prof. GARUTTI, Erika (University of Hamburg); Prof. KLANNER, Robert (University of Hamburg); NIEMEYER, Caroline (Hamburg University (DE)); Dr PITZL, Daniel (DESY); STEINBRUECK, Georg (Hamburg University (DE))

**Presenter:** Dr SCHWANDT, Joern (University of Hamburg)

**Session Classification:** Poster Session B

**Track Classification:** Semiconductor Detectors

Contribution ID: **582** Type: **Poster**

# Longevity studies and Phase 2 electronics upgrade for CMS Cathode Strip Chambers in preparation of HL-LHC

The muon system of the CMS experiment includes 540 Cathode Strip Chambers (CSCs) that serve as the primary source for muon detection and triggering in the end cap region. The CSCs are intended to operate throughout the life of the CMS experiment, including the challenging environment of the HL-LHC era. To access the longevity of CSCs over the HL-LHC lifespan, a new campaign of accelerated irradiation studies has been performed at the CERN GIF++ facility. Afterwards, additional irradiation tests of both standard and prototype CSCs with reduced concentration of CF4 in the gas mixture have also been conducted, as part of the CERN-wide program to minimise greenhouse gas consumption. In addition, the increased CMS level-1 trigger rate, latency, and data volume foreseen at the HL-LHC will exceed the design specification of the existing CSC detector electronics. Upgrades to electronics target the inner rings of the CSCs in each station, which have the highest particle flux. In this poster we present the results of CSC longevity studies, as well as the capabilities of the newly designed electronics.

**Primary author:** WANG, Bingran (Northeastern University (US))

**Presenter:** WANG, Bingran (Northeastern University (US))

**Session Classification:** Poster Session B

**Track Classification:** Gaseous Detectors

Contribution ID: **583** Type: **Poster**

# Real-Time Dose-Verification in Particle Therapy Using an Electron-Tracking Compton Camera

Dose verification in situ is highly required in proton therapy. We have developed an electron-tracking Compton camera (ETCC) which consists of gaseous time projection chamber (TPC) and a position-sensitive scintillator. Since the TPC performs the electron-tracking, the ETCC is able to reconstruct Compton scattering event-by-event, and to reject the back ground strongly. In this presentation, we demonstrate the feasibility of dose verification using the ETCC, and the gamma-ray images are compared between the annihilation gammas and prompt gamma rays of higher energy.
Using the ETCC, we obtained the gamma-ray image for the Polymethyl methacrylate (PMMA) phantom irradiated with 290-MeV/u carbon beam at Heavy Ion Medical Accelerator in Chiba (HIMAC), Japan, with a particle (carbon) rate of up to 5 x 10<sup>6</sup> cps. We succeeded in obtaining gamma-ray imaging (0.4 – 2.0 MeV) in beam, and gamma-ray imaging peak was consistent with simulation data using the PHITS code.
In this experiment, we used Gd<sub>2</sub>SiO<sub>5</sub>(Ce) scintillator as the absorber. Here, angular resolution of the Compton camera is related to be energy resolution of the scintillator. Recently, we have developed novel scintillation material, (Gd, La)<sub>2</sub>Si<sub>2</sub>O<sub>7</sub>(Ce) with better energy resolution than Gd<sub>2</sub>SiO<sub>5</sub>(Ce). To improve the angular resolution of the ETCC, we also show the scintillation properties of the novel scintillator in this paper.

**Primary authors:** KUROSAWA, Shunsuke (Tohoku Universtiy); Dr KAMADA, Kei (Tohoku University)

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**Presenter:** Dr KAMADA, Kei (Tohoku University)

**Session Classification:** Poster Session B

**Track Classification:** Medical Applications

Contribution ID: **585** Type: **Poster**

# Silicon on Insulator Silicon Photomultiplier (SOI-SiPM) Array for Use in Photon counting CT

Photon counting computed tomography (PCCT) based on indirect conversion detectors took great interests from its low fabrication cost and easy handling. In order to satisfy both count rate requirements of over 2 Mcps/mm<sup>2</sup> and spatial resolution requirements in PCCT, sub-mm pitch silicon photomultiplier array using silicon on insulator technology (SOI-SiPM) was fabricated and evaluated in this study. All SiPMs were formed in the bulk substrate layer and readout electronics was integrated on SOI layer. In this study, the basic performance of SOI-SiPM array prototype was investigated. Several sensor features, such as a fast recovery time around 16 ns and a gain of 1 × 10<sup>5</sup> were within requirements to realize Photon counting computed tomography. More detailed performance including electronics will be presented in conference.

**Primary authors:** Mr KOYAMA, Akihiro (The University of Tokyo); Mr HAMASAKI, Ryutaro (The Graduate University for Advanced Studies); Prof. SHIMAZOE, Kenji (The University of Tokyo); Prof. TAKAHASHI, Hiroyuki (The University of Tokyo); Prof. TAKESHITA, Tohru (Shinshu University); Prof. KURACHI, Ikuo (High Energy Accelerator Research Organization); Prof. MIYOSHI, Toshinobu (High Energy Accelerator Research Organization); Prof. NAKAMURA, Isamu (High Energy Accelerator Research Organization); Prof. KISHIMOTO, Shunji (High Energy Accelerator Research Organization); Dr HASHIMOTO, Ryo (High Energy Accelerator Research Organization); Dr ONO, Shun (High Energy Accelerator Research Organization); Prof. ARAI, Yasuo (High Energy Accelerator Research Organization)

**Presenter:** Mr KOYAMA, Akihiro (The University of Tokyo)

**Session Classification:** Poster Session B

**Track Classification:** SiPM

Contribution ID: **587** Type: **Poster**

# Construction of Vacuum-compatible Straw Tracker for COMET Phase-I

The COMET experiment at J-PARC aims to search for a lepton-flavour violating process of muon to electron conversion in a muonic atom, $\mu$-e conversion, with a branching-ratio sensitivity of $<10^{-16}$, 4 orders of magnitude better than the present limit, in order to explore the parameter region predicted by most of well-motivated theoretical models beyond the Standard Model.

The need for such an excellent sensitivity places several stringent requirements on the detector;
i) good momentum resolution, <2%, for 100 MeV/$c$ electron, which is primarily limited by multiple scattering effect for this momentum region,
and
ii) high rate capability, up to $5 \times 10^9 \mu^-$/s muon beam by J-PARC.

In order to fulfill such requirements, we decided to develop the straw-base planar tracker which is **operational in vacuum** and made of an **extremely light material**. The COMET straw tracker consists of 10 mm diameter straw tube, longer than 1 m length, with 20$\mu$m-thick Mylar foil and 70nm-thick aluminum cathode.

In the previous conference VCI2016, the R&D for this vacuum-compatible straw tracker was reported. After that, two big milestones, detector-performance verification by the full-scale prototype with 100 MeV/$c$ $e^-$ beam, and start the assembly of final straw tracker for COMET Phase-I, were achieved.

In VCI2019, we report these two big milestones, **result of beam test** and **status of final assembly**, and **some prospects towards the COMET Phase-II**.

**Primary author:** Prof. NISHIGUCHI, Hajime (KEK)

**Co-authors:** Dr VOLKOV, Alexander (JINR); Mr HAMADA, Eitaro (KEK); Mr SUZUKI, Junichi (KEK); Prof. TOJO, Junji (Kyushu University); Dr UENO, Kazuki (KEK); Mr OISHI, Kou (Kyushu University); Mr KAMEI, Naoya (KEK); Mr TSVERAVA, Nikolozi (JINR); Dr EVTOUKHOVITCH, Peter (JINR); Prof. MIHARA, Satoshi (KEK); Dr FUJII, Yuki (Monash University); Dr TSAMALAIDZE, Zviadi (JINR)

**Presenter:** Prof. NISHIGUCHI, Hajime (KEK)

**Session Classification:** Poster Session A

**Track Classification:** Gaseous Detectors

Contribution ID: **588** Type: **Poster**

# Particle Identification with DIRCs at PANDA

The DIRC technology (Detection of Internally Reflected Cherenkov light) offers an excellent possibility to minimize the form factor of Cherenkov detectors in hermetic high energy detectors. The PANDA experiment at FAIR in Germany will combine a barrel-shaped DIRC with a disc-shaped DIRC to cover an angular range of 5 to 140 degrees. Particle identification for pions and kaons with a separation power of 3 standard deviations or more will be provided for momenta between 0.5 GeV/c and 3.5 GeV in the barrel region and up to 4 GeV/c in the forward region.
Even though the concept is simple, the design and construction of a DIRC is challenging. High precision optics and mechanics are required to maintain the angular information of the Cherenkov photons during multiple internal reflections and to focus the individual photons onto position sensitive photon detectors. These sensors must combine high efficiencies for single photons with low dark count rates and good timing resolution at high rates. The choice of radiation hard fused silica for the optical material and of MCP-PMT photon sensors is essential for DIRC detectors to survive in an environment of radiation and strong magnetic field. The two DIRC detectors differ in the focusing optics, in the treatment of chromatic dispersion and in the electronic readout systems.
The technical design of the two DIRC detectors and their validation by testing prototypes in particle beams at DESY and CERN are presented.

**Primary author:** Prof. DUEREN, Michael Johannes (Justus-Liebig-Universitaet Giessen (DE))

**Presenter:** Prof. DUEREN, Michael Johannes (Justus-Liebig-Universitaet Giessen (DE))

**Session Classification:** Poster Session A

**Track Classification:** Cherenkov Detectors

Contribution ID: **591** Type: **Talk**

# First fragmentation measurements with the ΔE-TOF detector of the FOOT experiment

*Thursday, February 21, 2019 2:50 PM (20 minutes)*

The FOOT experiment was designed to identify the fragments produced in the human body during hadrontherapy and to measure their production cross-section. The ΔE-TOF detector of the FOOT apparatus estimates the atomic number Z and velocity β of the fragments by measuring the energy deposited (ΔE) in two layers of orthogonal plastic scintillator bars and the time-of-flight (TOF) with respect to a trigger detector. The detector performances have been already evaluated in a previous study at the CNAO hadrontherapy center of Pavia, obtaining 50 ps time resolution and 6% energy resolution, for 100-400 MeV/u carbon ions. In this work, the results of the first fragment identification measurements performed at CNAO are presented. A plastic target was irradiated with carbon ions of 330 MeV/u. Two plastic scintillator bars coupled to silicon photomultipliers were placed at a ~8° angle with respect to the beam line to remove the primary beam component and measure fragments interactions only. Events that triggered both bars were recorded with a WaveDAQ-based electronics. The energy deposited in the two bars and the TOF between them were measured. The atomic number of the detected fragments was determined, indicating that particles with Z=1 and Z=2 were detected at a ~8° angle. Currently, we are reproducing the experimental set-up with Monte Carlo simulations, and a preliminary comparison confirms these results.

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**Presenter:** KRAAN, Aafke

**Session Classification:** Medical Applications

**Track Classification:** Medical Applications

Contribution ID: **592** Type: **Talk**

# Measurement results of the MALTA monolithic pixel detector

*Thursday, February 21, 2019 4:30 PM (20 minutes)*

MALTA is a full scale monolithic pixel detector implemented in ToweJazz 180nm CMOS technology. The small pixel electrode allowed for the implementation of a fast, low noise and low power front-end, which is sensitive to the charge released by ionizing radiation in a 20-25 um deep depleted region. The novel asynchronous matrix architecture is designed to ensure low power consumption and high rate capability. Such features make MALTA a possible candidate for the outer layer of ATLAS Inner Tracker (ITk) upgrade.
Unirradiated MALTA sensors, as well as chips irradiated with neutrons and X-rays, have been extensively tested in laboratory measurements and with high energy particle beams. This contribution will discuss the results of this measurements campaign and will address the further improvements that are being implemented in the next versions of the chip.

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**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **593** Type: **Talk**

# Verification of Monolithic CMOS Pixel Sensor Chip with Ion Beams for Application in proton Computed Tomography

*Thursday, February 21, 2019 3:15 PM (20 minutes)*

proton Computed Tomography (pCT) is an emerging imaging modality useful in treatment of cancer using protons and heavy ions. The pCT collaboration in Bergen is building a prototype Digital Tracking Calorimeter (DTC) for proton therapy application. The DTC is a 41 layers of Si-Al sandwich structure where CMOS pixel sensors are used as the active element and aluminum is the absorbing material. The pixel sensor used was developed for upgrade of the ALICE Inner Tracking System at the Large Hadron Collider, CERN. The pixel sensor is a CMOS Monolithic Active Pixel Sensor (MAPS) consisting of almost half-million pixels each of the size of 29.24 x 26.88 $\mu m^2$.

In the pCT context two ion-beam test experiments were performed. The first experiment was carried out to test dependence of the cluster size on the beam position. For this a micro-beam of 10 MeV Helium-4 was used and a few pixels of the chip were scanned. The test results show that the cluster size changes with the beam position. The second experiment was carried out to study the cluster sizes for different beam energies and to obtain the tracking efficiency for Proton and He4 ions going through a stack of three chips. In the presentation, early results of both the ion-beam test experiment of MAPS will be reported.

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**Session Classification:** Medical Applications

**Track Classification:** Medical Applications

Contribution ID: **596** Type: **Poster**

# Timing and Synchronization of the DUNE Neutrino Detector

Synchronizing the different parts of a Particle Physics detector is an essential part of its operation. We describe the system being planned for the DUNE liquid argon neutrino detector and experience from the single phase protoDUNE detector currently operating at CERN.

DUNE is will have four caverns, each of which can house a detector with 10kT fiducial mass. The first caverns is planned to house a single phase module and the second a dual phase module. In both systems the time-stamps are locked to timing provided by GPS/GLONASS antennae.

Due to the different readout architectures of the single phase dual phase different timing distribution methods are used: The dual phase module will use IEEE1588 (White Rabbit). The single phase will use a simpler protocol designed to be easy to implement in the readout elements receiving timing and clock.

The timing distribution system for the single phase detectors can use passive optical fan-outs which reduces cost and allows for the use of redundant timing masters.

Measurements on the single phase protoDUNE system indicate that the timing distribution system adds ~ 15ps RMS per hop.

We describe the measures taken to reduce the risk of "silent failures" where synchronisation is lost with GPS without being detected. This is achieved using separate, spatially separated, antennae together with independent GPS receivers.

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**Presenter:** CUSSANS, David (University of Bristol (GB))

**Session Classification:** Poster Session B

**Track Classification:** Electronics

Contribution ID: **597** Type: **Poster**

# High-purity scintillating $CaWO_4$ crystals for the direct dark matter search experiment CRESST

The direct dark matter search experiment CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) uses scintillating $CaWO_4$ single crystals as targets for possible nuclear recoils induced by Dark Matter particles. An intrinsic radioactive contamination of the crystals as low as possible is crucial for the sensitivity of the detectors. In the past $CaWO_4$ crystals operated in CRESST were produced by institutes in Russia and Ukraine. Since 2011 $CaWO_4$ crystals have also been grown at the crystal laboratory of the Technische Universität München (TUM) to better meet the requirements of the CRESST experiment. The radiopurity of the raw materials and of first TUM-grown crystals was measured by ultra-low background γ-spectrometry. TUM-grown crystals were also operated as low-temperature detectors at a test setup in the Gran Sasso underground laboratory as well as in the CRESST experiment itself. These measurements were used to determine the crystals' intrinsic α-activities. The total α-activities of TUM-grown crystals as low as 1.23±0.06 mBq/kg were found to be significantly smaller compared to those of crystals grown at other institutes. The new generation of TUM-grown crystals is produced using recrystallization and low-speed growing.

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**Session Classification:** Poster Session B

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **600** Type: **Talk**

# Strategies for reducing the greenhouse gas emissions from particle detectors operation at the CERN LHC experiments

*Tuesday, February 19, 2019 11:20 AM (20 minutes)*

A wide range of gas mixtures is used for the operation of different gaseous detectors at the CERN LHC experiments. Some gases, as C2H2F4, CF4, C4F10 and SF6, are greenhouse gases (GHG) with high global warming potential and therefore subject to a phase down policy affecting the market with price increase and reduced availability.
The reduction of GHG emissions is an objective of paramount importance for CERN: four different strategies have been identified to achieve it.
The first strategy is based on the use of gas mixture recirculation plants. This solution is used in all plants suppling gaseous mixture to the CERN LHC detector systems. The approach and the development of such technology made at CERN will be presented. Furthermore, to protect detectors against their intrinsic fragility, the development of additional modules is ongoing to achieve a pressure and flow stability which goes beyond original design.
The second approach is based on recuperation of used gas mixtures followed by separation of the most critical GHG for its re-use. As state-of-the-art example, the CF4 recuperation plant and the prototype for C2H2F4 recuperation will be reviewed.
A third approach is making use of industrially available solutions for disposal of GHG.
Finally, the use of new eco-friendly gases is object of many R&D programs by the particle research community.
The four strategies will be compared by considering investment required, potential return benefit and technological readiness.

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**Presenter:** GUIDA, Roberto (CERN)

**Session Classification:** Plenary 3

Contribution ID: **602** Type: **Poster**

# Performance of four CVD diamond radiation sensors at high-temperature

Ionising radiation detectors based on wide band-gap materials have the potential to operate at temperatures greater than 200 ℃. Such detectors are important in applications such as monitoring near reactors and in deep oil and gas well bore-hole logging. We discuss the development of alpha particle detectors, based on CVD diamond, which operate with good charge collection efficiency and energy resolution at temperatures up to 225 ℃. Four nominally identical commercial, electronic grade, CVD diamond sensors have been coated with a thin metal conductive layer in our laboratory and then attached to ceramic PCB. We present the I-V characteristics, the CCE and the energy resolution for alpha particles from a mixed Pu-Am-Cm source, for the four sensors operating at temperatures from 20 to 250 ℃. A comparison of Monte Carlo simulations of the energy spectra is made with experimental data.

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**Session Classification:** Poster Session A

**Track Classification:** Semiconductor Detectors

Contribution ID: **603** Type: **Poster**

# A long slab prototype for ILD SiW-Ecal

The long slab is a new prototype for the SiW-Ecal, a silicon tungsten electromagnetic calorimeter for the ILD detector of the future International Linear Collider. This new prototype has been designed to demonstrate the ability to build a full length detecting layer (1.60m for the ILD barrel). Indeed, this length induces difficulties for clock and signal propagation and data integrity. The design used for short length slabs had to be adapted on the basis of a simulation study. The long slab performance has been tested with cosmics, radioactive source and with 3 GeV electrons in the beam tests at DESY, Hamburg. The results of the per-channel calibration of the detector will be presented. In DESY beam tests we have accumulated data for both normal and inclined incidence of the beam. With the latter one particle can sometimes traverse two pixels and deposit less energy per pixel. We'll show how this can be used to measure the position of the trigger threshold. This new prototype gives us a lot of hints on how to improve the design of the front-end electronics. It is also a convenient tool to estimate the key characteristics of ILD SiW-Ecal (like power consumption, cooling, readout time etc.) and to optimize the future design of the detector.

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**Session Classification:** Poster Session B

**Track Classification:** Calorimeters

Contribution ID: **605** Type: **Talk**

# Micro Pattern Gas Detector Optical Readout for Directional Dark Matter Searches

*Thursday, February 21, 2019 9:00 AM (20 minutes)*

The Time Projection method is ideal to track low kinetic energy charged particles. Large volumes can be readout with a moderate number of channels providing a complete 3D reconstruction of the tracks within the sensitive volume.
The total released energy and the energy density along the tracks can be both measured allowing for particle identification and to solve the head-tail ambiguity of the track. Moreover, gas represents a very interesting target to study Dark Matter interactions. In gas, nuclear recoils induced by a Dark Matter particle scattering can yield tracks long enough to be detected.
We describe here a prototype TPC with a GEM amplification stage. The readout is based on the detection of the light produced in the GEM with a high granularity CMOS sensor in conjunction with a photomultiplier. The prototype was exposed to $\gamma$, neutron source and minimum ionizing particles, obtaining very promising results in terms of detection efficiency, energy resolution and particle identification.

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**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **606** Type: **Talk**

# GRAPES-3 Detector System

*Thursday, February 21, 2019 2:50 PM (15 minutes)*

The Gamma Ray Astronomy at Pev Energies phase-3 (GRAPES-3), experiment located in beautiful slopes of Nilgiris hills ,Ooty, India, consist of world class indigenously developed detector system. The core elements of the experiment are plastic scintillator (Sc) detector and proportional counter (PRC). A large array of 400 Sc detectors each having sensitive area of 1m2 are spread in field with inter-detector separation of 8m covering an effective area of 25000m2 [1]. The design of these detectors are unique for a high energy cosmic ray experiment with extended dynamic range and wavelength shifting (WLS) fiber readout.The 3712 sealed PRC's each made of 600*10*10cm hollow mild steel square tube are used as muon detector. These PRC's are arranged in a grid of 4-layers with each layer having 58 PRC's covering a total area of 560m2 making it as the most sensitive tracking muon telescope[2].The near maintenance free detector system is very rugged with failure rate of less than 2%. The signal processing for both Sc and PRC's are done with indigenously developed front end and back end electronics modules.The recent discovery of Transient Weakening of Earth's Magnetic Shield Probed by a Cosmic Ray Burst[3] using GRAPES-3 tracking muon telescope at Ooty has demonstrated that a unique instrument can make a major discovery.
[1] S K Gupta et al Nucl Phys A 540 (2005) 311–323
[2] Y Hayashi et al Nucl Phys A 545 (2005) 643–657
[3] P K Mohanty et al Phys Rev Lett 117, 171101 (2016)

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**Session Classification:** Astroparticle Detectors

**Track Classification:** Astroparticle Detectors

Contribution ID: **607** Type: **Talk**

# Full System of Positron Timing Counter Having Time Resolution under 40 psec with Fast Plastic Scintillator Readout by SiPMs

*Monday, February 18, 2019 5:30 PM (20 minutes)*

A positron timing counter (TC) required 30-40 ps time resolution for ~50 MeV/c positron by the MEG II experiment has been developed. We employed the high segmented design with 512 scintillator plates ($120 \times 40 \times 5$ mm$^3$ and $120 \times 50 \times 5$ mm$^3$) attached 6-SiPM-array at the both ends. Pile up is reduced by the segmented design, and multi-counter measurement improves the overall timing resolution.

All the single counters were assembled and their resolutions were under 100 psec in pre-test with Sr source. The construction and installation was also completed in 2017. An engineering run was performed in the end of 2017 at the $\pi$E5 muon beam line in PSI, which supplies most intense muon beam ($7 \times 10^7$ stops/s on a target) in the world. We successfully operated the full system of TC in the MEG II environment and achieved the time resolution under 40 ps with more than 8 counter hits.

The overall resolution for the signal positrons is estimated to be 38.5 ps by weighting with the number of hits distribution of the signal positrons obtained by MC. The time resolution of TC is improved by a factor of 2 from the MEG experiment.

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**Session Classification:** Plenary 2

Contribution ID: **608** Type: **Talk**

# Deep Diffused Avalanche Photodiodes for Charged Particle Timing

*Tuesday, February 19, 2019 2:25 PM (20 minutes)*

The upgrades ATLAS and CMS for the High Luminosity LHC (HL-LHC) highlighted physics objects timing as a tool to resolve primary interactions within a bunch crossing. Since the expected pile-up is around 200, with an rms time spread of 170ps, a time resolution of about 30ps is needed. The timing detectors will experience a 1-MeV neutron equivalent fluence of $\Phi_{eq} = 10^{14}$ and $10^{15}\text{cm}^{-2}$ for the barrel and end-cap regions, respectively.
In this contribution, deep diffused Avalanche Photo Diodes (APDs) produced by Radiation Monitoring Devices are examined as candidate timing detectors for HL-LHC applications. To improve the detector's timing performance, the APDs are used to directly detect the traversing particles, without a radiator medium where light is produced.
Devices with an active area of $8 \times 8\text{mm}^2$ were characterized in beam tests. Two readout schemes were investigated: 1) a direct coupling to the APD with off-sensor capacitive coupling and 2) a capacitive coupling on the sensor realized by means of a metallic mesh isolated from the detector by a kapton layer. The timing performance and signal properties were measured as a function of position on the detector using a beam telescope and an MCP.
Devices with an active area of $2 \times 2\text{mm}^2$ were used to determine the effects of radiation damage on current, signal amplitude, noise, and timing using a ps pulsed laser. These detectors were irradiated with neutrons up to $\Phi_{eq} = 10^{15}\text{cm}^{-2}$.

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**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **609** Type: **Poster**

# Positron tracking detector for J-PARC muon g-2/EDM experiment

The muon anomalous magnetic moment (g-2) and the electric dipole moment (EDM) are calculated with high precisions in the Standard Model (SM) and are suitable to search for new physics beyond the SM. J-PARC muon g−2/EDM (E34) experiment aims to measure g−2 with a precision of 0.1 ppm and search for EDM with a sensitivity of $10^{-21}$ e·cm with a different method from the muon g−2/EDM experiments at BNL and FNAL. We utilize high intensity proton beam at J-PARC and a newly developed technique of reaccelerated thermal muon beam. This muon beam is accelerated to 300 MeV/c and is injected to the storage magnet with a 3 T magnetic field using a newly developed 3-D spiral injection scheme. Positrons from muon decays are detected by the silicon strip tracking detector.

The positron tracking detector consists of 40 modules called vanes. Each vane consists of 16 silicon strip sensors. The data from the silicon strip sensors are transferred to the front-end readout system via flexible printed circuits (FPCs) glued on the sensors. Front-end readout consists of ASICs on other FPCs and the FPGA-based readout board. Heat of ASICs is transferred to cooling plates via the FPCs.

Mass production of silicon strip sensors has been started. Designs of FPCs for sensors and readout ASICs are fixed and mass production will start soon. Developments of other detector components are ongoing. The status of these fabrications and developments will be presented.

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**Session Classification:** Poster Session B

**Track Classification:** Semiconductor Detectors

Contribution ID: **610** Type: **Talk**

# Development of a novel neutron tracker for the characterisation of secondary neutrons emitted in Particle Therapy.

*Thursday, February 21, 2019 4:30 PM (20 minutes)*

The MONDO (MOnitor for Neutron Dose in hadrOntherapy) project addresses the technical challenges posed by a neutron tracker detector: high detection efficiency and good backtracking precision. The project main goal is to develop a tracking device capable of fully reconstruct the four-momentum of the ultra-fast secondary neutrons produced in Particle Therapy treatments via double elastic scattering interactions.
The tracker - $10 \times 10 \times 20\ cm^3$ - is made by a matrix of thin squared scintillating fibres ($250\ \mu m$) arranged in layers orthogonally oriented. A tailored readout silicon sensor based - SBAM (SPAD-Based Acquisition readout for MONDO experiment) - matched to the MONDO needs of single photon detection capability, high spatial resolution and compactness - has been developed in collaboration with Fondazione Bruno Kessler (FBK).
A small detector prototype ($4 \times 4 \times 4.8\ cm^3$) has been built and tested with a sensor prototype, *SPADnet-I*, in order to experimentally evaluate the light output expected and consequently optimise the final readout.
The simulation characterisation of the detector response with monochromatic neutrons in the [20-300] MeV will be presented together with the expected performances of MONDO as neutron beam monitor.
The preliminary measurements at electron and proton beams of the prototype with the SPAD array readout and the first SBAM chip test results will be reported.

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**Session Classification:** Medical Applications

**Track Classification:** Medical Applications

Contribution ID: **612** Type: **Talk**

# Recent results of the technological prototypes of the CALICE highly granular calorimeters

*Friday, February 22, 2019 2:50 PM (20 minutes)*

The CALICE Collaboration has been conducting R&D for highly granular calorimeters since more than 15 years with an emphasis on detectors for Linear Colliders. This contribution will describe the commissioning, including beam tests, of large scale technological prototypes of a silicon tungsten electromagnetic calorimeter and hadron calorimeters featuring either a gaseous medium or scintillator with SiPM as an active material. Where applicable, raw performances of the calorimeter such as energy resolution and linearity will be presented but also studies exploiting the distinct features of granular calorimeters regarding pattern recognition. Meanwhile, the technology of granular calorimeters has been established, and the principle is part of nearly every design of detectors of energy frontier projects and beyond.
In addition to a summary of the state of the art of the CALICE prototypes, the contribution will also outline adaptations of the current design to meet the needs of calorimeters for applications beyond linear colliders.

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**Session Classification:** Plenary 5

**Track Classification:** Calorimeters

Contribution ID: **613** Type: **Talk**

# Development of new large calorimeter prototypes based on Lanthanum Bromide and LYSO crystals coupled to silicon photomultipliers: A direct comparison

*Tuesday, February 19, 2019 4:55 PM (20 minutes)*

The challenges for new calorimetry for incoming experiments at intensity frontiers is to provide detectors with ultra-precise time resolution and supreme energy resolution.

Two very promising materials on the market are BrilLanCe (Cerium doped Lanthanum Bromide, LaBr3 (Ce)) and LYSO (Lutetium Yttrium OxyorthoSilicate, Lu2(1-x) Y2x SiO5 (Ce)), supported by recent developments aiming at providing new relative large crystals.

The response of both LaBr3 (Ce) and LYSO prototypes fired with gammas at an energy of 55 MeV have been studied. Very promising results have been obtained.
For the (R = 4.45 cm, L = 20.3 cm) LaBr3 (Ce) crystal an energy resolution of σE /E ~ 2.3(1)% and a timing resolution of σt ~ 35(1) ps have been predicted. The energy resolution can be further improved by using larger crystals (either R = 6.35 cm or R = 7.6 cm, L = 20.3 cm) approaching respectively a σE/E ~ 1.20(3)% and a σE /E ~ 0.91(1)%.
Competitive results can be obtained with (R = 3.5 cm, L = 16 cm) LYSO crystal with an energy resolution of σE /E ~ 1.48(4)%, that can be further improved ( R = 6.5 cm, L = 25 cm, σE /E ~ 7.37(1)% ). A timing resolution less performing than the LaBr3 (Ce) one but better than any available nowadays calorimeter working at this energy can be obtaiend, σt ~ 49(1) ps, ultimately improved to σt ~ 40(1) ps with optimal photosensors.
Such results put these future high energy calorimeters at the detector forefront at intensity frontiers.

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**Session Classification:** Calorimeter

**Track Classification:** Calorimeters

Contribution ID: **614** Type: **Talk**

# Single layer Compton detectors for measurement of polarization correlations of annihilation quanta

*Thursday, February 21, 2019 2:25 PM (20 minutes)*

Measurement of gamma ray polarization can provide valuable insight in different areas of physics research: nuclear, particle and astrophysics. Also, since the polarizations of gamma quanta from positron annihilation are perpendicular, there have been studies to use these polarization correlations in Positron Emission Tomography (PET). The polarization of gammas can be determined from Compton scattering. We have set up two compact, position and energy-sensitive Compton scattering detectors in coincidence mode. Each consists of a single-layer array of Lutetium Fine Silicate scintillation pixels (3x3x20 mm3) in a 4x4 matrix read out on one side by SiPM array with matching elements size. Signals from all elements are acquired and processed by fast pulse digitizers. The coincidence time resolution of typically <0.5 ns (FWHM) allows a clear identification of coincident events, while the energy resolution of 11% (at 511 keV) and the detector granularity allow the reconstruction of the polar and the azimuthal scattering angles. We will present the evidence of the observed polarization correlations of the gamma quanta from positron annihilation and discuss the possible applications of this feature in PET and other experiments where measurement of gamma polarization is of interest. A system of such single-layer Compton detectors would significantly reduce the number of electronic channels compared to typical two layer (scatter-absorber) systems used for Compton scattering detection.

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**Session Classification:** Medical Applications

**Track Classification:** Medical Applications

Contribution ID: **616** Type: **Talk**

# Improving the CTR of a PET module using the DOI

*Thursday, February 21, 2019 4:55 PM (20 minutes)*

In a PET scanner, the probability of early stage detection of cancer is increased by high spatial resolution and sensitivity. Depth Of Interaction (DOI) is an important quantity both in small PET scanners and also in whole-body PET machines.
The module we developed is a pixellated scintillator of LYSO crystals with single side readout and allows light recirculation thanks to a light and a guide reflector on the side of the matrix opposite to the photodetector. The DOI information is extracted from the ratio between the light seen by the single SiPM channel coupled to the crystal hit and all the light collected by the photodetector.
To improve the timing performances of the module, the idea is to use the DOI information to correct for the time jitter caused by the various point of interaction of the gamma photons along the main axis of the crystal pixel. This correlation between the DOI and time of arrival of the optical photons can be exploited and the CTR is therefore corrected by properly combining the information of the multiple timestamps read out by a 4x4 SiPM array in order to obtain a more precise estimation of the time of interaction.
Using a small tagging crystal in coincidence with our matrix and a Na22 source, the CTR of the module was shown to improve beyond 200 ps FWHM after the correction; this was demonstrated for pixellated modules of different size and with different levels of depolishing of the lateral faces of the scintillators.

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**Session Classification:** Medical Applications

**Track Classification:** Medical Applications

Contribution ID: **619** Type: **Talk**

# The ATLAS ITk Strip Detector System for the Phase-II LHC Upgrade

*Thursday, February 21, 2019 9:00 AM (20 minutes)*

The ATLAS experiment at the Large Hadron Collider is currently preparing for a major upgrade of the Inner Tracking for the Phase-II LHC operation, scheduled to start in 2026. The radiation damage at the maximum integrated luminosity of 4000/fb implies integrated hadron fluencies over 2x10^16 neq/cm2 requiring a completed replacement of the existing Inner Detector. An all-silicon Inner Tracker (ITk) is under development with a pixel detector surrounded by a strip detector. The current prototyping phase, targeting an ITk Strip Detector system consisting of four barrel layers in the centre and forward regions composed of six disks at each end, is described in the ATLAS Inner Tracker Strip Detector Technical Design Report (TDR). With the recent final approval of the ITk strip TDR by the CERN Research Board, the pre-production readiness phase has started at the institutes involved. In this contribution we present the design of the ITk Strip Detector, and outline the current status of R&D and prototyping on various detector components, with a particular emphasis on the radiation-hard sensors, ASICs and front-end electronics under development. We will also discuss the status of preparations and the plans for the forth-coming pre-production and production phase.

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**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **621** Type: **Talk**

# Module and System test Development for the Phase-2 ATLAS ITk Pixel Upgrade

*Tuesday, February 19, 2019 10:15 AM (20 minutes)*

In the high-luminosity era of the Large Hadron Collider, the instantaneous luminosity is expected to reach unprecedented values, resulting in about 200 proton-proton interactions in a typical bunch crossing. To cope with the resulting increase in occupancy, bandwidth and radiation damage, the ATLAS Inner Detector will be replaced by an all-silicon system, the Inner Tracker (ITk). The innermost part of ITk will consist of a pixel detector, with an active area of about 14 $m^2$. In order to cope with the changing requirements in terms of radiation hardness, power dissipation and production yield, several different silicon sensor technologies will be employed in the five barrel and endcap layers. With the arrival of the first readout chip prototype, the RD53A chip, the development of hybrid detector modules is starting to address numerous production issues, understanding of which will be crucial for the layout and production of the final ITk pixel detector modules. In addition, the new powering scheme is serial which gives further challenges. A large prototyping programme on system test level is ongoing. Components for larger structures with multiple modules based on the FE-I4 front-end chips were produced and are in assembly and evaluation. The paper will present latest results from the assembly and characterization of prototype modules as well as the latest evaluation and results of thermo-mechanical prototypes and fully electrical prototypes.

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**Session Classification:** Plenary 3

**Track Classification:** Semiconductor Detectors

Contribution ID: **623** Type: **Poster**

# Comparison of transition radiation measurements with a Si and GaAs pixel sensor on a TimePix3 chip

Growing energies of particles at modern or planned particle accelerator experiments as well as various cosmic ray experiments require particle identification at gamma factors of up to $\approx 10^5$. At present there are no detectors capable of identifying single charged particles with reliable efficiency in this range of gamma-factors.
New developments in pixel detectors allow to perform simultaneous measurements of the energies and the emission angles of generated Transition Radiation X-rays and to identify particles on the basis of maximum available information about generated TR photons.
Preliminary results of studies of TR energy-angular distributions using Si and GaAs sensors bonded to TimePix3 chips are presented.
Studies were carried out at the CERN SPS facility with 20 $GeV/c$ electrons and muons from 120 to 290 $GeV/c$ using different types of radiators.
This talk will discuss the measurement and analysis techniques used for this experiments as well as comparison of efficiencies of TR registration for both types of sensors.

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**Session Classification:** Poster Session A

**Track Classification:** Semiconductor Detectors

Contribution ID: **625** Type: **Poster**

# Design, Construction and Test of Small-Diameter Drift Tube Chambers for the Phase-1 Upgrade of the ATLAS Muon Spectrometer

The ATLAS muon spectrometer comprises an efficient muon trigger system and high muon momentum resolution up to the TeV scale. In the regions at both ends of the inner barrel layer of the muon spectrometer the trigger coverage in combination with the endcap muon spectrometer is limited. In order to improve the muon trigger capabilities at higher luminosities, additional resistive plate chambers (RPCs) will be installed in these regions in the next long shutdown of the LHC in 2019-2020 (Phase-1 upgrade). Given very tight spatial constraints, the present muon drift tube (MDT) chambers will be replaced by an integrated system of thin-gap RPCs and small-diameter muon drift tube (sMDT) chambers. Due to their 8 times higher background rate capabilites, the new sMDT cham- bers are also suitable precision muon tracking detectors at future hadron colliders. A comprehensive overview of the production of the sMDT chambers will be given, covering the construction of the drift tubes, the evaluation of the wire positioning accuracy required to be better than 20µm, deformation measurements using optical alignment systems and the installation and test of the gas distribution system and electronics. The evaluation of the sMDT chamber geometry with a coordinate measuring machine yields a wire positioning accuracy of better than 10µm for the 1.5×1.5 m2 chambers with up to 744 drift tubes. Test results of sMDT chambers with cosmic rays and in a high-energy muon beam at CERN are presented.

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**Session Classification:** Poster Session B

**Track Classification:** Gaseous Detectors

Contribution ID: **626** Type: **Talk**

# The Cylindrical-GEM Inner Tracker Detector of the KLOE-2 Experiment

*Thursday, February 21, 2019 9:00 AM (20 minutes)*

The KLOE-2 experiment represents the continuation of KLOE and acquired 5.5 $fb^{-1}$ data from November 2014 to March 2018 with the aim of collecting the largest sample of $\phi$ mesons at the DA$\Phi$NE $e^+e^-$ collider at the Frascati National Laboratory of INFN.
A new tracking device, the Inner Tracker, was installed at the interaction region of KLOE-2 and it was operated together with the Drift Chamber to improve track and vertex reconstruction capabilities of the new experimental apparatus.
The Inner Tracker is a four-layer cylindrical triple-GEM detector with each layer equipped with an X-V strips-pads stereo readout.
Although GEM detectors have been extensively used in high energy physics experiments, the IT, with its fully-cylindrical geometry, is a frontier detector and KLOE-2 is the first experiment which benefited of this novel detector technology operated at a collider.
The operation of the Inner Tracker will be presented,together with the results of the alignment and calibration and tracking-verexing performance of such a unique detector.

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**Session Classification:** Gas Detectors

**Track Classification:** Gaseous Detectors

Contribution ID: **629** Type: **Talk**

# EDET DH80k - Characterization of a DePFET based sensors for TEM Direct Electron Imaging

*Tuesday, February 19, 2019 2:00 PM (20 minutes)*

The EDET DH80k is a 1 MPixel camera system, optimized for the direct detection of 300 keV electrons from a TEM equipped with a pulsed, high intensity electron source. It was designed to record stroboscopic movies of dynamic processes with unprecedented temporal and spatial resolution. The camera consists of four identical modules with the complete set of frontend and peripheral electronics required for standalone operation. The sensitive part of each module is a sensor array with 512 x 512 pixels of 60 µm x 60 µm each, which yields an overall sensitive area of 3 cm x 3 cm. The same area is back thinned to either 50 µm or 30 µm to minimize the multiple scattering of electrons. In combination with a beam-stop optimized for low backscattering of electrons, this results in an optimized line spread function. The sensor array is based on the DePFET pixel design, which is a highly modifiable combined sensor-amplifier structure, with an inherently high peak to background ratio and high speed readout capability. For the EDET DH80k camera a DePFET design with

- a nonlinear in-pixel signal compression,
- large (~$10^6$ electrons) dynamic range,
- and a specialized readout scheme that allows for an 80 kHz frame rate

was developed.
Detailed results from the first measurements on pixel level with low noise measurement setup (SPIX) will be presented.

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**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **630** Type: **Talk**

# First Production Modules of the ATLAS Micromegas and Performance Studies

*Wednesday, February 20, 2019 9:25 AM (20 minutes)*

The ATLAS collaboration at LHC has endorsed the resistive Micromegas technology, along with the small-strip Thin Gap Chambers (sTGC), for the high luminosity upgrade of the first muon station in the high-rapidity region, the so called New Small Wheel (NSW) project. After the R&D, design and prototyping phase, the first series production Micromegas quadruplets have been constructed at all involved construction sites: in France, Germany, Italy, Russia and Greece. The achievement of the requirements for these detectors revealed to be even more challenging than expected, when scaling from the small prototypes to the large dimensions. We will describe the construction and relevant problems, to a large extent common to other micro-pattern gaseous detectors, and the adopted solutions. Final validation results on the achieved mechanical precision and on the stability during operation will be presented, along with the main results of the modules certification with cosmic rays. Additionally, one of the first series modules, equipped with a prototype of the final front-end electronics based on VMM chip, was tested in muon/pion beam at the H8 line of SPS at CERN during the summer of 2018. We present the test setup and performance results on efficiency and resolution for perpendicular and inclined tracks. These studies were focused to establish and determine the working point of the ATLAS Micromegas detectors. Comparison to initial requirements for operation in ATLAS is also discussed, namely spatial resolution of 100 μm at high background hit rate of up to 20 kHz/cm2. Studies with several gas mixtures were also carried out and will be presented. In addition, we will report on results from the exposure of the Micromegas detector under X-ray irradiation environment at GIF++ facility of CERN.

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**Session Classification:** Gas Detectors

**Track Classification:** Gaseous Detectors

Contribution ID: **632** Type: **Talk**

# Upgrade of the ATLAS Muon Spectrometer Thin Gap Chambers and their electronics for the HL-LHC phase

*Thursday, February 21, 2019 9:50 AM (20 minutes)*

The instantaneous luminosity of the LHC will be increased by almost an order of magnitude with respect to the design value by undergoing an extensive upgrade program for the High-Luminosity LHC (HL-LHC). Many upgrades are foreseen for the thin gap chambers (TGC) of the ATLAS Muon System. A Phase-I upgrade project is the replacement of the present first station in the forward regions with the New Small Wheels (NSWs). Along with Micromegas, the NSWs are equipped with 8 layers of small-strip thin gap chambers (sTGC) arranged in multilayers of two quadruplets, for a total active surface of more than 2500 $m^2$. The spatial resolution has to be better than 100 μm per sTGC plane to allow the trigger track segments to be reconstructed with an angular resolution of 1 mrad. At Phase-II, the TGC at larger radius from the beam line than the NSW will also be replaced with triplet chambers with finer granularity. Another Phase-II upgrade project is the replacement of the TGC trigger and readout electronics. The first prototype of the frontend board has been developed and tested at the CERN SPS with functions required for the HL-LHC including data transfer of 256 channels at 16 Gbps. The new trigger algorithm has been validated with data, and was found to reduce the event rate by 30% while increasing the efficiency by a few percent. The design, performance and status of the ATLAS TGC upgrade projects will be discussed, along with results from tests of the chambers or prototypes with beams.

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**Session Classification:** Gas Detectors

**Track Classification:** Gaseous Detectors

Contribution ID: **633** Type: **Talk**

# The Mu3e Scintillating Fiber Timing Detector

*Thursday, February 21, 2019 11:55 AM (20 minutes)*

The Mu3e experiment will search for the rare neutrinoless lepton flavor violating mu+ -> e+e+e- decay and it aims at reaching an ultimate sensitivity of 10^-16 on this branching ratio. The experiment will be performed at PSI using the most intense continuous surface muon beam in the world (presently ~1x10^8 mu/s). In order to reach this sensitivity all backgrounds must be rejected below this level. The Mu3e detector is based on thin monolithic active silicon pixel sensors (HV-MAPS) for very precise tracking in conjunction with scintillating fibers and tiles coupled to Si-PMs for accurate timing measurements and is designed to operate at very high intensities.

To suppress all forms of combinatorial background a very thin (thickness < 0.2% of radiation length) Scintillating Fiber (SciFi) detector with few 100 ps time resolution, efficiency in excess of 96%, and spatial resolution of ~100 um has been developed. Moreover the SciFi detector will help to determine the charge of the recurling tracks in the central region of the apparatus. The SciFi arrays are coupled at both ends to Si-PM arrays and are read out with a dedicated mixed mode ASIC, the MuTRiG.

We will report in detail the development of the SciFi detector, from the scintillating fiber through the Si-PM array photo-sensors up to the front end electronics and the data acquisition. We will discuss the performance of the SciFi detector prototypes as observed in our studies.

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**Session Classification:** Photon Detectors

**Track Classification:** Photon Detectors

Contribution ID: **640** Type: **Talk**

# Operational Experience and Performance with the ATLAS Pixel detector at the Large Hadron Collider

*Tuesday, February 19, 2019 4:30 PM (20 minutes)*

The tracking performance of the ATLAS detector relies critically on its 4-layer Pixel Detector, that has undergone significant hardware and readout upgrades to meet the challenges imposed by the higher collision energy, pileup and luminosity that are being delivered by the Large Hadron Collider (LHC), with record breaking instantaneous luminosities of 2 x 1034 cm-2 s-1 recently surpassed.
The key status and performance metrics of the ATLAS Pixel Detector are summarised, and the operational experience and requirements to ensure optimum data quality and data taking efficiency will be described, with special emphasis to radiation damage experience.

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**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **643** Type: **Talk**

# Commissioning and beam test a high pressure time projection chamber

*Wednesday, February 20, 2019 10:15 AM (20 minutes)*

Due to their large active volume and low energy threshold for particle detection Time Projection Chambers (TPCs) are promising candidates to characterise neutrino beams at the next generation long baseline neutrino oscillation experiments such as DUNE and Hyper-K, the successor of the T2K experiment. The higher target density for the incoming neutrino beam of a TPC filled with gas at High Pressure (HPTPC), will potentially allow a better neutrino-nucleus interaction measurements as compared to a TPCs at 1 atm.

Our HPTPC has about $0.5\,\mathrm{m}^3$ active volume which is embedded into a pressure vessel rated up to $5$ barA. A cascade of meshes amplifies the primary ionisations. The induced charge on each mesh is read out. In addition the photons emitted during the gas amplification are read out by four CCD cameras focused on the readout plane, which thus image the 2D projection of particle's tracks on the transverse plane. The third coordinate is reconstructed from the charge signal.

We report on the commissioning of the HPTPC and on its performance during a four week long beam test at the CERN PS, measuring low momentum protons ($\leq 0.5\,\mathrm{GeV}$) interactions with the counting gas. Several mixtures with Argon predominance have been tested for their light yield and gas gain. Eventually, the proton Ar cross section will be calculated from the data sample, which will enter the calculations of final state interactions in neutrino Ar scattering.

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**Session Classification:** Gas Detectors

**Track Classification:** Gaseous Detectors

Contribution ID: **644** Type: **Talk**

# ATLAS LAr Calorimeter Performance in LHC Run-2 and Electronics Upgrades for next Runs

*Friday, February 22, 2019 9:50 AM (20 minutes)*

Liquid argon (LAr) sampling calorimeters are employed by ATLAS for all electromagnetic calorimetry in the pseudo-rapidity region $|\eta| < 3.2$, and for hadronic and forward calorimetry in the region from $|\eta| = 1.5$ to $|\eta| = 4.9$. In the LHC Run-2 about 150fb-1 of data at a center- of-mass energy of 13 TeV have been recorded. The well calibrated and highly granular LAr Calorimeter reached its design values both in energy measurement as well as in direction resolution.
Electronics developments are pursued for the trigger readout of the ATLAS Liquid-Argon Calorimeter towards the Phase-I upgrade scheduled in the LHC shut-down period of 2019- 2020.Trigger signals with higher spatial granularity and higher precision are needed in order to improve the identification efficiencies of electrons, photons, tau, jets and missing energy, at high background rejection rates, already at the Level-1 trigger.
Following new TDAQ buffering requirements and high expected radiation doses in the pileup conditions of the high-luminosity LHC, the ATLAS Liquid Argon Calorimeter electronics will be upgraded (Phase-II) to readout the 182,500 calorimeter cells at 40 MHz with 16 bit dynamic range. Developments of low-power preamplifiers and shapers to meet these requirements are ongoing in CMOS 130nm. In order to digitize the analogue signals on two gains after shaping, radiation-hard, low-power 40 MHz 14-bit ADCs are developed using a SAR architecture in 65 nm CMOS.
This contribution will give an overview of the detector operation, changes in the monitoring and data quality procedures, to cope with increased pileup, as well as the achieved performance, including the calibration and stability of the electromagnetic scale, noise level, response uniformity and time resolution. Results of ASIC developments including QA/QC and radiation hardness evaluations, performances of the pre-production boards and results of the system integration tests, progress of QA/QC of final production boards will be presented along with the overall system design for the Phase-I upgrade. Results of tests of the first prototypes of front-end components will be presented, along with design studies on the performance of the off-detector readout system for the Phase-II upgrade.

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**Session Classification:** Plenary 4

**Track Classification:** Calorimeters

Contribution ID: **647** Type: **Poster**

# A novel 4D fast track finding system on FPGA

We present a novel 4D fast track finding system capable of reconstructing four dimensional particle trajectories in real time using precise space and time information of the hits. The fast track finding device that we are proposing is designed for the high-luminosity phase of LHC and it is based on a massively parallel algorithm to be implemented in commercial field-programmable gate array using a pipelined architecture. We will present studies of expected tracking performance for a possible pixel detector of a future upgrade of the LHCb experiment and first results based on a hardware prototype.

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**Presenter:** PETRUZZO, Marco (Università degli Studi e INFN Milano (IT))

**Session Classification:** Poster Session A

**Track Classification:** Electronics

Contribution ID: **648** Type: **Talk**

# A High-Granularity Timing Detector for the Phase-II upgrade of the ATLAS Calorimeter system: detector concept, description and R&D and first beam test results

*Thursday, February 21, 2019 9:50 AM (20 minutes)*

The increase of the particle flux (pile-up) at the HL-LHC with luminosities of L ⊠ 7.5 × 10^34 cm−2 s-1 will have a severe impact on the ATLAS detector reconstruction and trigger performance. The end-cap and forward region where the liquid Argon calorimeter has coarser granularity and the inner tracker has poorer momentum resolution will be particularly affected. A High Granularity Timing Detector (HGTD) is proposed in front of the LAr end-cap calorimeters for pile-up mitigation and for luminosity measurement.
It will cover the pseudo-rapidity range from 2.4 to 4.0. Two Silicon sensors double sided layers will provide precision timing information for MIPs with a resolution better than 30 ps per track in order to assign each particle to the correct vertex. Readout cells have a size of 1.3 mm × 1.3 mm, leading to a highly granular detector with 3 millions of channels. Low Gain Avalanche Detectors (LGAD) technology has been chosen as it provides enough gain to reach the large signal over noise ratio needed.

The requirements and overall specifications of the HGTD will be presented as well as the technical proposal. LGAD R&D campaigns are carried out to study the sensors, the related ASICs, and the radiation hardness. Laboratory and test beam results will be presented.

**Co-author:** ATLAS COLLABORATION

**Presenter:** LUND-JENSEN, Bengt (KTH Royal Institute of Technology (SE))

**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **653** Type: **Poster**

# Development of Hafnium STJ for cosmic neutrino background search

The COBAND experiment searches for far infra red photons from decays of cosmic neutrino background. In order to achieve sensitivity for neutrino lifetime predicted by some theoretical model, 2% energy resolution is required for the detector. We are developing a superconducting tunnel junction detector (STJ) using Hafnium superconductor (Hf) that have very small bandgap. Bandgap of Hf is 0.021 meV that is 1/8 of aluminum generally used as a superconducting material. Therefore Hf-STJ gives eight times larger signal output and better sensitivity may be possible compared to other current STJ detectors. So far, quality of Hf-STJ is limited by leak current caused by ununiformity of insulator layer.

We fabricated 10 micron square and 200 micron square Hf-STJs with photolithographic techniques and measured its I-V characteristic by four-terminal sensing at temperature below 150 mK in a dilution refrigerator at University of Tsukuba. The leak current of 10 micron Hf-STJ is smaller than before, but it is still 100 - 1000 times larger compared to our goal. I-V curve looks similar to general STJ's characteristic feature and Josephson current was also seen. In this measurement, it was not possible to study I-V curve in detail or to check response to photons due to large leak current coming from thermal excitation at 150 mK close to critical temperature. We plan to measure this Hf-STJ at 50 mK by using an adiabatic demagnetization refrigerator in Korea in 2018 to reduce thermal noise.

**Primary authors:** Dr IIDA, Takashi (University of Tsukuba); Dr TAKEMASA, Kenichi (University of Tsukuba)

**Presenter:** Dr IIDA, Takashi (University of Tsukuba)

**Session Classification:** Poster Session B

**Track Classification:** Astroparticle Detectors

Contribution ID: **654** Type: **Poster**

# Development of Spherical Proportional Counter for Light WIMP search

The Spherical gaseous detector (or Spherical Proportional Counter, SPC) is a novel type of particle detector, with a broad range of applications. Its main features include a very low capacitance, a potential low energy threshold independent of the volume, a good energy resolution, robustness and a single detection readout channel. Applications range are from radon emanation gas monitoring, neutron flux and gamma counting and spectroscopy, neutrinos physic, Light WIMP searches and coherent neutrino scattering measurement. Laboratories interested in these various applications share expertise within the NEWS-G (New Experiments With Sphere) Collaboration. NEWS-G_LSM, a low background SPC installed at Modane underground laboratory (LSM) has been used with Neon gas to search for dark matter particles thanks to a very low energy threshold, around 100 eV. To reach better performances, the next generation of SPC (140cm), NEWS-G_SNO, is under construction. We will present the fabrication method for NEWS_G detectors, low energy calibration with 37Ar and X generator, cleaning methods to remove the surface contamination, measurement of detector background and its interpretation.

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**Session Classification:** Poster Session A

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **656** Type: **Poster**

# Production and performance study of Diamond-Like Carbon for the resistive electrode in MPGD application

Diamond-like Carbon (DLC), a newly recognized resistive material, is a kind of metastable amorphous carbon material. DLC has recently received considerable attention and is increasingly exploited in resistive electrodes to suppress discharges in Micro-Pattern Gaseous Detector (MPGD). DLC coating provided a new method to produce high-quality resistive electrodes for MGPDs owing to it's low dielectric constant, wide band gap, good chemical and thermal stability. Many studies and optimizations on DLC production process is carried out with Magnetron Sputtering Technology to get applicable DLC resistive electrodes. Two different electrode structures (DLC/APICAL and Cu/DLC/APICAL) have been produced and tested in Micro-Resistive WELL (μRWELL) detectors. The design, farbrication and test of a standard μRWELL detector using DLC/APICAL structure were performed. A spatial resolution of better than 70 μm in both dimensions was achieved while maintaining the detection efficiency higher than 95%. The rate capability (measured with 8 keV copper target X-rays) reaches 100 kHz/cm2 when the gas gain is 8000. More studies to further improve rate capability with multi-point grounding method by using Cu covered DLC (Cu/DLC/APICAL) are also presented.

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**Session Classification:** Poster Session A

**Track Classification:** Gaseous Detectors

Contribution ID: **657** Type: **Talk**

# A new Transition Radiation detector based on GEM technology

*Thursday, February 21, 2019 9:25 AM (20 minutes)*

Transition Radiation Detectors (TRD) has the attractive features of being able to separate particles by their gamma factor. The classical TRDs are based on Multi-Wire Proportional Chambers (MWPC) or straw tubes, filled with Xenon based gas mixture to efficiently absorb transition radiation photons. While it works for experiments with relatively low particle multiplicity, the performance of MWPC-TRD in experiments with luminosity of order $10^{34} cm^2 s^{-1}$ and above, is significantly deteriorated due to the high particle multiplicity and hence the channel occupancy. Replacing MWPC or straw tubes with a high granularity Micro Pattern Gas Detectors (MPGD) like GEM, could improve the performance of TRD. In addition, GEM technology allows to combine a high precision tracker with TRD identificator. This report presents a new TRD development based on GEM technology for the future Electron Ion Collider (EIC). First beam test was performed at Jefferson Lab (Hall-D) using 3-6 GeV electrons. GEM-TRD module has been exposed to electrons with fiber radiator and without. The first results of test beam measurements and comparison with Geant4 Monte Carlo will be presented.

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**Presenter:** FURLETOV, Sergey (Jefferson Lab)

**Session Classification:** Gas Detectors

**Track Classification:** Gaseous Detectors

Contribution ID: **658** Type: **Poster**

# HEPS-BPIX2: the Hybrid Pixel Detector with TSV Processing for High Energy Photon Source in China

HEPS-BPIX2 is the second prototype of single-photon counting pixel detector with 1 million pixels developed for applications of synchrotron light sources. It follows the first prototype, HEPS-BPIX, with a pixel size of 150 μm x 150 μm and frame rate up to 1.2 kHz at 20-bit dynamic range. This paper contains a detailed description of HEPS-BPIX2 upgrade with a recently launched Through Silicon Via (TSV) processing to reduce the insensitive gap between modules. From the 60k-pixel single-module detector to large-area multi-modules systems, the transmission control protocol (TCP) hardware stack on 10 Gigabit Ethernet (10GbE) is adopted for high speed data transfer to DAQ. The calibration and images are taken at X-ray and synchrotron light, and the performance is also presented.

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**Session Classification:** Poster Session B

**Track Classification:** Semiconductor Detectors

Contribution ID: **659** Type: **Talk**

# New test beam results of 3D detectors constructed with poly-crystalline CVD diamond

*Tuesday, February 19, 2019 2:50 PM (20 minutes)*

The latest test beam results of 3D detectors fabricated with poly-crystalline chemical vapor deposition (CVD) diamonds will be shown. The devices have 50$\mu$m $\times$ 50$\mu$m cells with columns 2.6$\mu$m in diameter. In one of the devices the cells were ganged in a 3$\times$2 cell pattern and in the other the cells were ganged in a 5$\times$1 cell pattern to match the layouts of the pixel read-out chips currently used in the CMS and ATLAS experiments at the LHC, respectively. In beam tests, using tracks reconstructed with a high precision tracking telescope, both devices achieved tracking efficiencies greater than 97\%. In the same beam tests, the first pulse height distributions from poly-crystalline CVD diamond 3D pixel devices were measured and will be presented. Finally, the latest test beam results of irradiated poly-crystalline CVD diamond pad and pixel detectors will be presented.

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**Presenter:** REICHMANN, Michael Philipp (ETH Zurich (CH))

**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **661** Type: **Poster**

# Development of a prototype of intraoperative PET-laparoscope system for surgical navigation in cancer surgery

PET (positron emission tomography) is used to preoperatively identify lymph node metastasis. However it is difficult to locate those lymph node metastasis during surgery. Intraoperative PET-laparoscope system consisting of an external fixed detector array and a movable detector which can be inserted into a patient's stomach has been proposed to identify lymph node metastasis during gastric cancer surgery. This study presents the development of prototype detectors for PET-laparoscope system. A 7 × 7 array of 10 × 10 × 20 mm GAGG crystals coupled with SiPMs (Silicon photomultipliers) was used in the fixed detector. The movable detector used a single 10 × 10 × 5 mm GAGG crystal coupled with an SiPM for achieving the required spatial resolution around 10 mm. An optical tracking system was used to track the movable detector. SiPM outputs were read out by time-over-threshold (TOT) ASICs for converting the charge to digital pulses. An FPGA based DAQ system was used to determine the arrival time, pulse width carrying the energy information and channel number of each TOT output. During the first stage image reconstruction experiments the detector prototype could reconstruct images of a Na-22 point source with better than 10 mm spatial resolution in coronal and longitudinal directions although the resolution in sagittal (depth) direction was limited due to inadequate projections. The prototype detector performance with position tracking system will be presented at the conference.

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**Presenter:** Ms LIYANAARACHCHI, Madhushanka Rukshani (The University of Tokyo)

**Session Classification:** Poster Session A

**Track Classification:** Medical Applications

Contribution ID: **664** Type: **Talk**

# FoCal: a highly granular digital calorimeter

*Tuesday, February 19, 2019 2:25 PM (20 minutes)*

In light of the upgrade program of the ALICE detector a calorimeter at forward rapidities (FoCal) is being considered. This detector would measure photons, electrons, positrons and jets for rapidities eta > 3 offering a wealth of physics possibilities.
Its main focus is on measurements related to the structure of nucleons and nuclei at very low Bjorken-x and possible effects of gluon saturation.
The FoCal electromagnetic calorimeter must be able to discriminate decay photons from direct photons at very high energy, which requires extremely high granularity.
A dedicated R&D program is ongoing to develop the technology needed for such a high-granularity device. Within this program we have constructed a unique prototype of a digital electromagnetic calorimeter based on CMOS monolithic active pixel sensors (MAPS).
This prototype has has demonstrated the unique capabilities of such a highly granular digital calorimeter, providing unique shower profile measurements and good linearity and energy resolution. The prototype calorimeter was based on the MIMOSA chip, which is however not fast enough for application in a full detector at LHC. As a next step, the ALPIDE chip developed for the ALICE Inner Tracker Upgrade is being investigated for performance with high occupancy. We will present results from the current prototype, the performance of the ALPIDE and plans for the next prototype.

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**Presenter:** VAN DER KOLK, Naomi (Nikhef National institute for subatomic physics (NL))

**Session Classification:** Calorimeter

**Track Classification:** Calorimeters

Contribution ID: **667** Type: **Talk**

# Lumped element kinetic inductance detectors on CaF2 for neutrino-less double-beta decay and spin-dependent dark matter search

*Thursday, February 21, 2019 9:25 AM (20 minutes)*

Superconducting detectors (SCDs) are widely used in astroparticle physics experiments such as dark matter search and cosmic microwave background experiments. Kinetic Inductance Detector (KID) is one of the promising SDCs since KID has several technical advantages: very low fundamental noise, easy fabrication, and high scalability with frequency domain multiplexing. KID consists of microwave resonance circuit with superconducting film on substrate. Any energy deposit will break apart Cooper pairs in the superconducting film, resulting in an excess quasi-particle population. The change in the population increases kinetic inductance in the resonance circuit. The signal is readout from the change of the resonance.
Generally, silicon is used as substrate. We implement lumped element KIDs (LEKIDs) in CaF2 crystal which is used as substrate. CaF2 is a novel target for neutrino-less double-beta decay and spin-dependent dark matter studies, since 48Ca is one of the double-beta decay nuclei and 19F is sensitive to spin-dependent elastic scattering with dark matter.

LEKID on CaF2 is cooled to 300mK with 3He sorption cryocooler. The resonance is found in O(1GHz). Thus, we confirmed that LEKID on CaF2 worked well. This result opens a new possibility in the next generation of astroparticle physics experiments

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**Presenter:** ISHIDOSHIRO, Koji (Tohoku University)

**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **670** Type: **Talk**

# Development of the CMS Mip Timing Detector

*Monday, February 18, 2019 2:50 PM (20 minutes)*

The Compact Muon Solenoid (CMS) detector at the CERN Large Hadron Collider (LHC) is undergoing an extensive Phase II upgrade program to prepare for the challenging conditions of the High-Luminosity LHC (HL-LHC). In particular, a new timing layer will measure minimum ionizing particles (MIPs) with a time resolution of ~30ps and hermetic coverage up to a pseudo-rapidity of |η|=3. This MIP Timing Detector (MTD) will consist of a central barrel region based on L(Y)SO:Ce crystals read out with SiPMs and two end-caps instrumented with radiation-tolerant Low Gain Avalanche Detectors. The precision time information from the MTD will reduce the effects of the high levels of pile-up expected at the HL-LHC and will bring new and unique capabilities to the CMS detector. The time information assigned to each track will enable the use of 4D reconstruction algorithms and will further discriminate interaction vertices within the same bunch crossing to recover the track purity of vertices in current LHC conditions. We present motivations for precision timing at the HL-LHC and the ongoing MTD R&D targeting enhanced timing performance and radiation tolerance, including test beam results.

**Primary author:** LUCCHINI, Marco Toliman (Princeton University (US))

**Presenter:** LUCCHINI, Marco Toliman (Princeton University (US))

**Session Classification:** Plenary 2

**Track Classification:** Semiconductor Detectors

Contribution ID: **674** Type: **Poster**

# High light yield calcium iodide (CaI2) scintillator for astroparticle physics

Large light yield of scintillator can be a key to develop a good detector for astroprticle physics. Calcium Iodide (CaI2) crystal is discovered by Hoftadter et al. in 1960s and known to have large light yield. University of Tsukuba and IMR, Tohoku University are jointly developing CaI2 crystal from 2016 using updated facilities and leading-edge techniques. At first, vaporization of CaI2 material was problem because of its close melting point and boiling point. We overcame this problem by sealing off a quartz tube to prevent evaporation and finally we succeeded to grew 1 inch CaI2 crystal by Bridgman method. Small piece of CaI2 crystal was sliced off and polished in a dry room whose humidity is less than 1 %. Energy response of CaI2 coupled with photomultiplier tubes was measured using 137Cs gamma-ray source. Photoelectric peak of 662 keV gamma-ray of CaI2 was 2.7 times higher than that of NaI(Tl) and light yield of CaI2 was estimated to be 107,000 ph./MeV. While CaI2 showed good scintillation property, it also showed very strong cleavability and deliquescent. Since these characteristics makes it difficult to cut and polish CaI2 crystal, we tried to grow CaBr2-xIx crystal by replacing iodine (I) with bromine (Br) to reduce cleavability. We found larger bromine fraction gives smaller cleavability and smaller light yield. A crystal with 2 % europium (Eu) and quarter bromine (Eu2%: Br0.5I1.5) gave 95,400 ph./MeV. We plan to optimize fraction of Eu and Br next.

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**Presenter:** Dr YOSHINO, Masao (Tohoku University)

**Session Classification:** Poster Session A

**Track Classification:** Astroparticle Detectors

Contribution ID: **678** Type: **Talk**

# New ALICE detectors for Run 3 and 4 at the CERN LHC

*Monday, February 18, 2019 2:00 PM (20 minutes)*

During Run 3 and 4 ALICE (A Large Ion Collider Experiment) will gain two orders of magnitude in the statistics over the combined data collected during Run 1 and Run 2 at the LHC. ALICE will also conduct high-precision measurements of rare probes over a broad range of transverse momenta with particular focus on low signal-to-background probes at low pT values. To achieve that goal a sustained Pb-Pb readout rate of up to 50 kHz must be maintained while operating either continuously or with a minimum bias trigger. To cope with that challenge, ALICE is implementing new hardware and software solutions. In particular, three new detectors are being installed: the Inner Tracking System (ITS), the Muon Forward Tracker (MFT) and the Fast Interaction Trigger (FIT) detector. The new trackers are based on ALIPIDE (ALICE Pixel Detector), a custom designed sensor incorporating the requirements imposed by the physics program including a high-granularity and low material budget of the non-active elements. The new sensor will improve vertexing and tracking, especially at low pT values. The use of ALIPIDE by the Muon Forward Tracker will add vertexing capabilities to the Muon Spectrometer covering a broad range of transverse momenta and allowing ALICE to measure beauty down to pT~0 from displaced J/Psi vertices and to have an improved precision for the Psi(2S) measurement. It will also add high-granularity data to the forward multiplicity information acquired by FIT. In addition to providing inputs for the new Central Trigger Processor, FIT will serve as the main
luminometer, collision time, multiplicity, centrality, and reaction plane detector for the ALICE experiment.

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**Presenter:** TRZASKA, Wladyslaw Henryk (University of Jyvaskyla (FI))

**Session Classification:** Plenary 2

**Track Classification:** Semiconductor Detectors

Contribution ID: **681** Type: **Talk**

# Status of the NEXT project

*Tuesday, February 19, 2019 4:30 PM (20 minutes)*

Status of the NEXT project
The NEXT program is developing the technology of high-pressure Xe gas TPCs with electroluminescent amplification (HPXe-EL) for neutrinoless double beta decay searches. The first phase of the program included the operation of two small prototypes, NEXT-DEMO and NEXT-DBDM, which demonstrated the robustness of the technology, its excellent energy resolution and its unique topological signature. The NEXT-White radiopure demonstrator (50 cm diameter and length) is the second phase of the program and has been operating in Canfranc underground laboratory since October 2016 with 5 kg of depleted Xe (to be replaced by Xe enriched to 90% 136Xe). NEXT-100 constitutes the third phase of the program. It will deploy 100 kg of enriched Xe at 15 bar and is a scale-up of NEXT-White by ~2:1 in linear dimensions. In addition to a physics potential which is competitive with the best current experiments in the field, NEXT-100 can be considered as a large scale demonstrator of the suitability of the HPXe-EL technology for detector masses in the ton-scale. In this talk we will describe the NEXT-White detector and its latest results on energy resolution, topology and background rate, discuss the expected physics reach of NEXT-100 and outline ongoing R&D activities towards a ton-scale HPXe-EL detector. These include, in particular, the use of low-diffusion Xe gas mixtures for better imaging, cryogenic operation of the TPC and the development of barium tagging techniques.

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**Presenter:** Dr ARAZI, Lior (Ben-Gurion University of the Negev (IL))

**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **683** Type: **Poster**

# Test Measurements with the Technical Prototype for the Mu3e Tile Detector

The Tile Detector is a dedicated timing detector system developed for the Mu3e experiment, which is designed to search for the lepton-flavour violating (LFV) decay $\mu \rightarrow eee$ with a target sensitivity of $10^{-16}$. In order to determine the vertex of the three decay electrons, precise spatial and timing measurements are necessary, resulting in the requirement of a time resolution below 100 ps for the Tile Detector.
The Tile Detector, which is currently under development, employs plastic scintillator tiles and silicon photomultipliers, which are read out by dedicated 32-channel ASICs. Measurements using the first technical prototype of the Tile Detector in two testbeam campaigns, undertaken at the Deutsches Elektron-Synchrotron (DESY) in Hamburg, Germany in February and June 2018, show a preliminary single channel timing resolution of the order of 40 ps, which is well below the required resolution of 100 ps.
Furthermore, the production and assembly procedures for the final detector system were defined and finalised based on the experience gained from the construction of the prototype. Thermal simulation and measurement studies using the prototype provided additional input for the finalisation of the detector structure.

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**Session Classification:** Poster Session B

**Track Classification:** Photon Detectors

Contribution ID: **685** Type: **Poster**

# Fabrication and Testing of a 1024-pixel SiPM Camera

Abstract: We have fabricated the 1024-pixel SiPM sensor and the associated electronics. We integrated the SiPM sensor and the electronics to build a pinhole camera. In this paper, we present the fabrication and assembly procedure of the SiPM sensor and the readout electronics, and the preliminary result of testing the pinhole camera. This camera can be readily used as an X-ray detector with an array of the scintillator pixels placed in front of the SiPM sensor. The application of such an X-ray detector includes the X-ray or gamma-ray imaging in the medical field and the detection of astronomical or astrophysical X-ray sources in space. This camera also can be used as a detector that counts photons in low light environment.

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**Presenter:** Dr LEE, Jik (The Center for High Energy Physics, Kyungpook National University)

**Session Classification:** Poster Session A

**Track Classification:** SiPM

Contribution ID: **689** Type: **Talk**

# Beam tests of a large-scale TORCH time-of-flight demonstrator

*Wednesday, February 20, 2019 12:20 PM (20 minutes)*

The TORCH time-of-flight detector is designed to provide particle identification over the momentum range 2–10 GeV/c over large areas. The detector exploits prompt Cherenkov light produced by charge particles traversing a 10 mm thick quartz plate. The photons propagate via total-internal reflection and are focussed onto a detector plane comprising position-sensitive micro-channel plate (MCP) detectors. The goal is to achieve a single-photon timing resolution of around 70 ps, giving a timing precision of 15 ps per charged particle by combining the information from around 30 detected photons. The MCP-PMT detectors have been developed with a commercial partner (Photek), leading to the delivery of a square tube of active area 53 x 53mm^2 with 8 x 128 pixels equivalent. A large-scale demonstrator of TORCH with a quartz plate of dimensions 660 x 1250 mm^2, read out by a pair of MCP-PMTs with custom readout electronics, has been verified in beam tests at the CERN PS. Preliminary results indicate that excellent single-photon timing resolution can be achieved by employing a data-driven calibration. The projected performance of a full-scale TORCH detector at the LHCb experiment will also be presented.

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**Session Classification:** Cherenkov

**Track Classification:** Cherenkov Detectors

Contribution ID: **690** Type: **Talk**

# Progress on the PICOSEC-Micromegas Detector Development: towards a precise timing, radiation hard, large-scale particle detector with segmented readout

*Wednesday, February 20, 2019 9:50 AM (20 minutes)*

Detectors with a time resolution of a few 10ps and robustness in high particle fluxes are necessary for precise 4D track reconstruction in future, high luminosity HEP experiments. In the context of the RD51 collaboration, the PICOSEC detector concept has been developed, which is a two-stage Micromegas detector with a photocathode coupled to a Cherenkov radiator. Single channel PICOSEC prototypes equipped with a CsI photocathode have demonstrated an excellent resolution, of 24 ps, for timing the arrival of MIPs. The PICOSEC timing characteristics have been extensively studied with laser beams and have been understood in terms of detailed simulations and phenomenological models.

Due to the fact that ion back-flow in the drift region damages the CsI photocathode, alternative photocathode materials (e.g., pure metallic and Diamond-Like Carbon) have been investigated. Comparison of the charge distribution of the PICOSEC response signal to UV light and muons, allows to consistently estimate the photoelectron yield of the photocathode, a parameter which affects critically the PICOSEC performance. Different resistive anode layers have also been tested for stable operation in a high intensity pion beam.

Towards developing PICOSEC detectors for practical applications, multi-channel PICOSEC prototypes with CsI photocathodes and anodes segmented in hexagonal pads (5 mm side) have been tested in UV light and muon beams. After correcting for systematic errors due to imperfections on the anode planarity, a uniform timing resolution of 25 ps for each pad is achieved. Furthermore, a similar timing resolution has been measured for signals shared across multiple pads.

This conference contribution will present the progress and developments towards a well understood, robust, large-area, PICOSEC detector offering precise timing in the HL-LHC era and beyond.

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**Presenter:** KORDAS, Kostas (Aristotle University of Thessaloniki (GR))

**Session Classification:** Gas Detectors

**Track Classification:** Gaseous Detectors

Contribution ID: **691** Type: **Poster**

# Prospects for Silicon, Diamond and Silicon Carbide detectors as fast neutron spectrometers

The range of application of high band-gap solid state detectors is expanding in those environments where the high neutron flux is an issue, such as the high-flux spallation neutron sources and the thermonuclear fusion experiments. In particular, Diamond and Silicon Carbide are considered an interesting alternative to Silicon thanks to their high resistance to neutron damage. In this work we present measurements, performed at the neutron Time-Of-Flight facility at CERN (n_TOF), of the response function to neutron of three different detectors, namely a Single-crystal Diamond, a pure Silicon and a Silicon Carbide. At n_TOF neutrons are generated via spallation process in a lead target, making use of the pulsed proton beam delivered by CERN PS accelerator (E=20 GeV, pulse width 6 ns r.m.s, max frequency 0.8 Hz). Neutrons from the target are collimated and travel in vacuum along a beam pipe towards the n_TOF experimental area where they are detected. Neutron detection is based on the collection of the electron-hole (e-h) pairs produced by neutron interaction with Carbon and Silicon atoms. By storing, for each neutron event, both the Time of Flight (univocally related to the neutron kinetic energy) and the deposited energy, the response to quasi-monoenergetic neutrons was measured for each detector in the energy range from 1 to 50 MeV. The results found for the three detectors are compared and discussed in view of their use at spallation neutron sources and at fusion experiments.

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**Session Classification:** Poster Session A

**Track Classification:** Semiconductor Detectors

Contribution ID: **693** Type: **Poster**

# Proton Irradiation Hardness Investigations of 60 GHz Transceiver Chips for High Energy Physics Experimentations

The replacement of wired readout systems with the broadband wireless links will significantly reduce the number of cables and their connectors at the LHC. These cables notably contribute in the active detector volume and cause multiple scattering. The availability of 60 GHz license free band (57-66 GHz) provides the opportunity to achieve 10's of Gbps wireless data rate for a single link. This paper presents the experimental results of 17 MeV proton irradiation on 60 GHz wireless transceiver (TRX) chips. These are low power, half duplex chips implemented in 65 nm CMOS technology and support the short range point-to-point data rate up to 6 Gbps by employing OOK modulation scheme. To investigate the irradiation hardness for high energy physics applications, two TRX chips were irradiated in turn with total ionizing dose (TID) of 74 kGy and 42 kGy and fluence of $1.38\times10^{14}$ $N_{eq}/cm^2$ and $0.78\times10^{14}$ $N_{eq}/cm^2$ for RX and TX modes, respectively. The chips were characterized by the pre and post-irradiation analog voltage measurements for different circuit blocks as well as through the analysis of wireless transmission parameters like BER, eye diagram, jitter etc. Post irradiation measurements have shown 1 dB reduction in the TX output power, while 4.5 dB fall in RX gain but both TRX chips are found functional through over the air measurements at 5 Gbps. Moreover, no shift in the operational frequency has been observed during the experimentation.

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**Presenter:** Mr AZIZ, Imran (Uppsala University)

**Session Classification:** Poster Session B

**Track Classification:** Electronics

Contribution ID: **702** Type: **Talk**

# The RICH detector of the NA62 experiment at CERN

*Wednesday, February 20, 2019 11:55 AM (20 minutes)*

NA62 is the last generation kaon experiment at the CERN SPS aiming to study the ultra-rare $K^+ \to \pi^+\nu\overline{\nu}$ decay. The main goal of the NA62 experiment is the measurement of this BR with 10% accuracy. This is achieved by collecting about 100 $K^+ \to \pi^+\nu\overline{\nu}$ events.
The challenging aspect of NA62 is the suppression of background decay channels with BR up to 10 orders of magnitude higher than the signal and with similar experimental signature, such as $K^+ \to \mu^+\nu$.
To this purpose, the NA62 experimental strategy requires, among other conditions, good particle identification (PID) capability and rejection power of the kinematic selection.
A key element of PID in NA62 is the Ring-Imaging Cherenkov (RICH) detector, exploiting neon gas at atmospheric pressure as radiator medium. According to the NA62 requirements, the RICH identifies $\mu^+$ and $\pi^+$ in the momentum range between 15 and 35 GeV/c with a muon rejection factor of $10^{-2}$.
It also measures the arrival time of charged particles with a precision better than 100 ps and is one of the main components of the NA62 trigger system.
The RICH detector has been successfully operated during the 2016, 2017 and 2018 data taking periods of NA62. The main design aspects and operational characteristics of the detector will be described in detail and a detailed report of its performance, directly measured with the data collected, will be presented.

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**Presenter:** PEPE, Monica (INFN Perugia (IT))

**Session Classification:** Cherenkov

**Track Classification:** Cherenkov Detectors

Contribution ID: **703** Type: **Poster**

# Coincident Detection of Cherenkov Photons from Compton Scattered Electrons for Medical Applications

Throughout the last decade there has been an increasing interest in an efficient gamma ray detector for medical applications. Especially proton beam therapy and nuclear medicine could benefit from the ability to detect higher energetic gamma-radiation above 1 MeV. One possible detector would be a dual-plane Compton Camera.
Coincident detection of energy and position of both the electron and the scattered gamma allows for a reconstruction of the incoming gamma momentum to lie on the surface of a cone.Intersection of many cones yields information on the gamma source location.
A novel concept for the detection of the high energetic Compton-Scattered electron is proposed. Using coincident detection of Cherenkov photons generated by the electron in an optically transparent radiator material an estimation of the scattering vertex, the electron energy and momentum is possible. A proof of principle is presented showing the coincident detection of Cherenkov photons created by electrons in PMMA on a 8-by-8 Silicon-Photomultiplier array. A coincidence timing resolution in the order of 250 ps is achieved. Spatial sensitivity for the electron source location from accumulated events will be demonstrated as well as the ability to reconstruction information on the electron from single coincident events. The influence of radiator material and thickness has been investigated and will be presented together with a comparison of obtained results with theoretical estimations and simulations.

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**Session Classification:** Poster Session B

**Track Classification:** Medical Applications

Contribution ID: **704** Type: **Poster**

# Run and Slow Control System of the Belle II Silicon Vertex Detector

The Belle II Silicon Vertex Detector (SVD) is currently being finalized and commissioned at the SuperKEKB factory, Tsukuba, Japan. For a reliable operation and data taking of the SVD a sophisticated and robust run and slow control system has been implemented, which utilizes the Experimental Physics and Industrial Control System (EPICS) framework.
EPICS uses client/server and publish/subscribe techniques to communicate between the various sub-systems and computers. The information exchange between the different pieces of software and computers is done by process variables (PVs).
These PVs are provided by input/output controllers (IOCs), which communicate and interface with the hardware components.

The Belle II SVD slow and run control comprises of five groups of subsystems, which are SVD DAQ controller, Flash ADC controller, environmental monitors and interlocks, power supplies and EPICS infrastructure services.
In this presentation we describe tasks and implementation of the individual sub-systems, the interaction between them and the global Belle II run and slow control as well as first experiences from commissioning and initial operation of the SuperKEKB accelerator.

**Primary authors:** IRMLER, Christian (Austrian Academy of Sciences (AT)); Mr YIN, Hao (HEPHY Vienna)

**Presenters:** IRMLER, Christian (Austrian Academy of Sciences (AT)); Mr YIN, Hao (HEPHY Vienna)

**Session Classification:** Poster Session A

**Track Classification:** Electronics

Contribution ID: **705** Type: **Talk**

# Using Quantum Entangled Photons to Measure the Absolute PDE of a Multi-Pixel SiPM Array

*Thursday, February 21, 2019 5:20 PM (20 minutes)*

Spontaneous parametric down-conversion (SPDC) of a visible pump photon is the generation of two less energetic, quantum entangled photons (QEPs), often in the near infrared (NIR), using a non-linear crystal such as beta barium borate (BBO). Since the detection of one QEP predicates the existence of its entangled twin, QEPs have previously been used to measure the absolute photon detection efficiency (PDE), η(λ), of a detector under test (DUT) by measuring time-coincident events with an additional trigger detector, allowing evaluation of $_{DUT}$ (λ) without recourse to a calibrated reference detector.
We propose an extension of this technique to measure η(λ) for pixels on a multi-pixel array where each pixel provides an individual signal output, and we model this using Monte Carlo simulations. By treating all pixels in a multi-pixel array as indistinguishable, we show that the symmetry of the measurement allows the mean η(λ) of the array to be evaluated.
We describe the QEP absolute PDE measurement technique, and present the first experimental results showing the measurement of η(λ) for a 64-pixel SiPM array utilising a 64-channel waveform digitiser module to provide photon timing and coincidence measurements. We consider the feasibility of using QEPs for η(λ) measurements across the visible spectrum by using higher energy pump photons and considering coincident events in non-symmetric pixels, with the goal of developing an instrument for in-situ absolute PDE calibration.

**Primary authors:** Dr WILLIAMS, Jamie (University of Leicester); Prof. LAPINGTON, Jon (University of Leicester); Dr LEACH, Steven (University of Leicester); Mr DUFFY, Connor (University of Leicester)

**Presenter:** Dr WILLIAMS, Jamie (University of Leicester)

**Session Classification:** SiPM

**Track Classification:** SiPM

Contribution ID: **706** Type: **Talk**

# Belle II electromagnetic calorimeter.

*Tuesday, February 19, 2019 4:30 PM (20 minutes)*

The electromagnetic calorimeter of the Belle II detector and its performance in the first KEKB run during 2018 are described. It is a high-granularity homogeneous calorimeter based on 8736 CsI(Tl) scintillating crystals. The scintillation light is detected by two PIN photodiodes. Electronics of the calorimeter provides signal readout with 2 MHz digitization followed by wave form analysis (WFA) in FPGA resulting in both amplitude and time reconstruction. Usage of the WFA reduces a contribution of the pile-up noise, the time information allows to suppress the beam background. The information from the calorimeter is used for particle energy measurement, particle idetification as well as for the collider luminosity measurement. The figure shows the reconstructed energy for photons from $e^+e^- \to \gamma\gamma$. Red and blue points correspond to data and MC, respectively.

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**Session Classification:** Calorimeter

**Track Classification:** Calorimeters

Contribution ID: **708** Type: **Talk**

# Upgrade of the ALICE Time Projection Chamber

*Tuesday, February 19, 2019 11:45 AM (20 minutes)*

The Time Projection Chamber (TPC) of the ALICE experiment is being upgraded with new readout chambers based on Gas Electron Multiplier (GEM) technology during the second long shutdown of the CERN Large Hadron Collider. The upgraded detector will operate continuously and triggerless without the use of a gating grid. It will thus be able to read out all minimum bias Pb-Pb events that the LHC will deliver at the anticipated peak interaction rate of 50 kHz for the high-luminosity heavy-ion era. After several years of R&D, the last two years were devoted to the production of 80 quadruple-GEM chambers in several institutes and countries utilizing 640 GEM foils. The chambers underwent a detailed quality control procedure in order to ensure the highest standard as required for the installation in the ALICE TPC.To guarantee optimal operational safety, a careful design of the HV configuration, employing so-called cascaded power supplies, was developed. Continuous readout of the TPC data with rates up to 3 TByte/s into the online data farm will be accomplished by a new front-end scheme, utilizing the newly developed SAMPA readout ASIC, and the GBT readout system developed at CERN. The presentation will give an overview on the overall production process, with special focus on the results of the completed assembly of the new GEM-based read-out chambers and the production of the new readout electronics. Furthermore, an outlook on the forthcoming installation activities will be presented.

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**Presenter:** MUNZER, Robert Helmut (Johann-Wolfgang-Goethe Univ. (DE))

**Session Classification:** Plenary 3

Contribution ID: **713** Type: **Poster**

# Series Production Testing, Commissioning and Initial Operation of the Belle II Silicon Vertex Detector Readout System

The Silicon Vertex Detector (SVD) of the Belle II experiment at the High Energy Accelerator Research Organization (KEK) in Tsukuba, Japan, consists of 172 double-sided microstrip technology silicon sensors arranged cylindrically in four layers around the interaction point. A total of 1748 readout chips (APV25) process and send the analog signals over 2.5 meter long copper cables to 48 Junction Boards (JBs) located inside the detector housing which provide an interface for connecting the cables on the inside of the detector with those of the outer world, and to power the detector with radiation-hard and magnetic insensitive DC-DC converters. From there the analog data are sent over 13 meter long copper cables to 48 A/D Converter boards (FADCs) located in crates on top of the Belle II detector structure. They control the detector, convert the SVD data into digital domain, and perform first data processing using powerful FPGAs. From the FADC boards the data are then sent out to the central DAQ by optical fibers.
This paper shows hardware and procedures to test all components of the SVD data readout system (Cables, FADC boards, JBs) individually after the series production, the findings of the commissioning of the whole readout chain using final hardware in two test setups, and the first results of the initial operation of the final detector.

**Primary author:** THALMEIER, Richard

**Co-author:** BELLE II SVD COLLABORATION

**Presenter:** THALMEIER, Richard

**Session Classification:** Poster Session B

**Track Classification:** Electronics

Contribution ID: **716** Type: **Poster**

# Long-term and efficient operation of the MWPC muon detector at LHCb

With its ~1650 mˆ2 of MWPCs, the muon detector of LHCb is one of the largest instrument of this kind worldwide, and one of the most irradiated.
Currently we run at the relatively low instantaneous luminosity of 4x10ˆ32 cm-2s-1, nevertheless the most irradiated MWPCs already integrated ~0.7 C/cm of accumulated charge per wire. The statistics of gas gaps affected by high voltage trips in the proportional chambers is presented for the whole period of operation.
Most of the problematic chambers were successfully recovered in situ during data taking, under the nominal LHC beam conditions, by means of a long-term HV training
(with the working gas mixture). The appearing of self-sustained currents in one of the MWPC gaps and the effectiveness of the recovery procedures put in place, indicate that the large majority of the trips are due to Malter effect.
The method has proven to be very effective, allowing to keep the muon detector efficiency very close 100%, as it was initially designed. In parallel, a test has been performed of a systematic addition of a small amount of oxygen to the nominal gas mixture: results of this test will be discussed.

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**Presenter:** KOTRIAKHOVA, Sofia (Petersburg Nuclear Physics Institut (RU))

**Session Classification:** Poster Session B

**Track Classification:** Gaseous Detectors

Contribution ID: **721** Type: **Talk**

# Towards wafer-scale monolithic CMOS integrated pixel detectors for X-ray photon counting

*Thursday, February 21, 2019 5:20 PM (20 minutes)*

A new semiconductor process is being developed for manufacturing monolithic CMOS pixel detectors. The technology is based on direct bonding of 200 mm CMOS wafers to an absorber in a low-temperature, oxide-free, covalent wafer bonding process. It is applicable to any material such as Si, GaAs and epitaxial SiGe. The latter are realized by means of space-filling arrays of SiGe crystals which can be grown up to at least 100 μm by a plasma-enhanced chemical vapor deposition process on patterned Si substrates. The absorber enables ~ 100% detector fill factor, direct conversion of X-rays, and charge collection at the CMOS readout pixels.
To demonstrate the technology, a chip was designed in 150 nm CMOS process featuring 240 x 300 pixels of 100 μm pitch. Each analog pixel has a charge sensitive amplifier, leakage current compensation and a shaper. On the digital side, two threshold-programmable discriminators feed the output to 12-bit asynchronous counters. The counters can work in parallel, or in cascade-mode by using the second counter as register for simultaneous acquisition/ reading. A data acquisition system was developed to readout the front-end board hosting the CMOS chip. The board integrates an FPGA for hardware control and software processing, it handles the image acquisition protocols and assembles data frames to a computer.
In this conference, we shall discuss the first experimental tests and X-ray characterization measurements obtained on the novel kind of detector.

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**Presenter:** NEVES, Jorge (G-ray Medical)

**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **724** Type: **Talk**

# The Large Enriched Germanium Experiment for Neutrinoless $\beta\beta$ Decay (LEGEND)

*Tuesday, February 19, 2019 4:55 PM (20 minutes)*

The use of high-purity germanium (HPGe) detectors enriched in the isotope $^{76}$Ge is one of the most promising techniques to search for neutrinoless double-beta decay, a process forbidden in the Standard Model of particle physics. A discovery of this lepton number violating process might answer the question of why the universe consists of matter (but not antimatter) and consequently, why matter exists at all.

The Large Enriched Germanium Experiment for Neutrinoless Double Beta Decay (LEGEND) Collaboration has been formed to pursue a tonne-scale $^{76}$Ge experiment with the discovery potential at a half-life beyond $10^{28}$ years. To achieve this, increased detector mass, improved background rejection, as well as a further reduction in intrinsic radioactive backgrounds with respect to current-generation experiments, are required. The LEGEND Collaboration develops a phased neutrinoless double-beta decay experimental program based on the approaches pursued by Majorana Demonstrator and GERDA - the two $^{76}$Ge experiments that lead the field in both the background level in the signal region of interest as well as energy resolution and spectroscopic performance achieved. A first phase - expected to start by 2020 - with ~ 200 kg of HPGe detectors will be operated at the Gran Sasso Underground Laboratory.

In this talk, I will discuss the plans and physics reach of LEGEND as well as the combination of R&D efforts and existing resources employed to expedite physics results.

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**Presenter:** Dr WILLERS, Michael (Lawrence Berkeley National Laboratory)

**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **725** Type: **Talk**

# Performance of the Belle II imaging Time-Of-Propagation (iTOP) detector in first collisions

*Friday, February 22, 2019 10:15 AM (20 minutes)*

The iTOP detector is a novel Cherenkov detector developed for particle identification at Belle II, an upgrade of the previous Belle experiment at KEK. The SuperKEKB accelerator, an upgrade of KEKB, collides electrons and positrons with a design luminosity of 8*10^(35)/(cm^2 s). In order to exploit the high collision rate Belle II has a trigger rate of up to 30 kHz.
The iTOP detector uses quartz bars as source of Cherenkov photons. The photons are reflected inside the bars until they hit photomultipliers at one end. The spatial distribution and precise arrival times of the detected photons are used to reconstruct the Cherenkov angle. To achieve a good pion-kaon separation the photon arrival times have to be measured with a resolution better than 100 ps. Microchannel plate photomultipliers together with dedicated high-speed electronics for 2.7 GSa/s waveform sampling are used to achieve this timing resolution. The iTOP detector consists of 16 modules with 512 channels each, in total the detector has 8192 channels.
First collisions were recorded in Spring 2018. A phase of physics operation with a ramp up to full luminosity starts March 2019. In this talk the design of the iTOP detector will be shown and experience and results from initial operation will be discussed together with an outlook on future running conditions.

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**Presenter:** BESSNER, Martin (Deutsches Elektronen-Synchrotron (DE))

**Session Classification:** Plenary 4

Contribution ID: **726** Type: **Talk**

# Optical readout of gaseous detectors: new developments and perspectives

*Thursday, February 21, 2019 11:55 AM (20 minutes)*

Scintillation light detection by imaging sensors presents a versatile and intuitive readout modality for gaseous radiation detectors. Based on visible scintillation light emission from gas mixtures such as Ar/CF4, optical readout provides images with high spatial resolution.
We present novel readout approaches including ultra-fast imaging for beam monitoring in addition to studies of optically read out detector concepts demonstrating suitability for a number of applications ranging from X-ray radiography and fluorescence to 3D track reconstruction in an optically read out Time Projection Chamber (TPC) based on Gaseous Electron Multipliers (GEMs). Furthermore, optical readout of Micromegas on a transparent substrate was shown to be well-suited for X-ray imaging and single X-ray photon detection.
A novel readout approach combining optical and electronic readout for 3D track reconstruction based on transparent anodes was developed to allow reconstruction of intricate track trajectories. Furthermore, beam monitoring capabilities of optically read out GEM-based low material budget detectors were tested in a clinical proton beam facility.
Ultra-fast CMOS imaging sensors capable of frames rates of tens of thousands of frames per second enable high speed X-ray fluoroscopy and real-time beam monitoring at megapixel resolution. At reduced resolution, a million frames per second acquisition rates were used for 3D track reconstruction from image sequences recorded in a TPC.

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**Presenter:** Dr BRUNBAUER, Florian Maximilian (CERN, Vienna University of Technology (AT))

**Session Classification:** Gas Detectors

**Track Classification:** Gaseous Detectors

Contribution ID: **727** Type: **Poster**

# Investigating Microchannel Plate PMTs with TOFPET2 multichannel picosecond timing electronics

TOFPET2 is the second-generation design of a high-performance multichannel picosecond timing readout electronics ASIC produced by PETsys Electronics SA, Portugal. Originally developed for time-of-flight positron emission tomography using silicon photomultipliers, in this work we describe an experimental programme to evaluate the performance of TOFPET2 with pixelated microchannel plate photomultiplier tube (PMT) detectors.

Investigations were performed using various signal input methods; injected electronic stim signals, SiPMs photodetectors, single anode MCP photomultiplier detector and finally imaging with a Photek MAPMT228 multi-anode MCP-PMT detector using a 16 x 16 pixelated multi-layer ceramic readout.

Measurements were undertaken using the PETsys Time-of-Flight ASIC evaluation kit (mark2) operating in single photon counting mode. We present performance results for time resolution, cross channel coincidence time resolution and energy resolution using internal pulse amplitude measurement and time-over-threshold signal paths.

Photodetector timing performance was evaluated using a 40 ps wide pulsed laser, operating at single photon level using a temperature stabilised setup within a dark enclosure. Amplitude walk correction was applied using the in-built time-over-threshold output from the TOFPET2 system. Single photon timing resolution of better than 110 FWHM was demonstrated and further results are presented.

**Primary authors:** Dr LEACH, Steven (University of Leicester); Prof. LAPINGTON, Jon (University of Leicester); Mr SUDJAI, Thawatchai; Mr CONNEELY, Thomas (Photek LTD); HINK, Paul (i2 innovation); MILNES, James (Photek Ltd); DURAN, Ayse (Photek)

**Presenter:** Prof. LAPINGTON, Jon (University of Leicester)

**Session Classification:** Poster Session A

**Track Classification:** Medical Applications

Contribution ID: **729** Type: **Talk**

# Commissioning of the Belle II Silicon Vertex Detector

*Thursday, February 21, 2019 9:25 AM (20 minutes)*

The Belle II experiment at the SuperKEKB collider of KEK (Japan) will accumulate $e^+e^-$ collision data at an unprecedented instantaneous luminosity of $8 \times 10^{35}$ cm$^{-2}$s$^{-1}$, about 40 times larger than its predecessor experiment. The Belle II vertex detector consists of two layers of DEPFET based pixels (PXD) and four layers of double sided silicon strip detectors (SVD). The SVD sensors are assembled into oblong modules called the ladders, which are arranged cylindrically around the beam direction. Most of the ladders have a kinked shape giving the SVD its characteristic lantern structure.

From April to July 2018 a reduced scale version of the SVD was installed in Belle II and has collected $e^+e^-$ collision data during an initial commissioning run of SuperKEKB. From July to September 2018 the completed SVD was operated outside of the experiment and cosmic ray muon data has been accumulated. The full vertex detector, SVD with the pixel detector, will be finally installed in Belle II by the end of this year and SuperKEKB operation with the full experiment in place will restart in spring 2019. In this talk we summarize the studies performed with the first data sets and the results obtained on the performance of the device.

**Presenter:** CASAROSA, Giulia (INFN - National Institute for Nuclear Physics)

**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **730** Type: **Poster**

# Design of large area MCP-PMT and a novel bowl-shape MCP

The Jiangmen Underground Neutrino Observatory (JUNO) is a multipurpose neutrino experiment designed to determine neutrino mass hierarchy and precisely measure oscillation parameters. The R&D of large area microchannel plate photomultiplier tube (MCP-PMT) for JUNO started in 2011. In the last 3 years, much progress has been achieved. The high performance 8-inch and 20-inch prototypes were developed and 15,000 20-inch MCP-PMTs were ordered by JUNO. In the large area MCP-PMT, the small MCPs replace the bulky dynode chain of the traditional large PMTs. Photoelectrons from the large area photocathode are electrostatically focused to the MCPs. We will present the design of the 20-inch MCP-PMTs.

We will also present the study of photoelectron backscattering on the MCP surface. Finally, A novel bowl-shape MCP with an open area ratio greater than 90% is proposed. The planar area of the electrode is enormously cut down. An additional thin film with a high secondary electron emission yield is deposited on its nickel-chromium electrode. The side surfaces of the input electrode are specially curved to guide secondaries from the electrode into the nearest channel. Results predict that collection efficiency of the bowl-shape MCP is higher than 98% and the delayed pulse is less than 2%. This indicates that good detection efficiency, temporal and spatial resolution can be achieved simultaneously with the novel MCP.

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**Presenter:** Ms CHEN, Ping (Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences)

**Session Classification:** Poster Session B

**Track Classification:** Cherenkov Detectors

Contribution ID: **732** Type: **Talk**

# The gaseous QUAD pixel detector

*Thursday, February 21, 2019 12:20 PM (20 minutes)*

We have developed a gaseous pixel detector based on four Timepix3 chips that can serve as a building block for a large detector plane. To provide the required gas amplification a fine grid has been deposited on the chip surface by wafer postprocessing (GridPix technology). The precisely aligned grid holes and chip pixels having a pitch of 55 μm and the high time resolution of 1.56 ns of the Timepix3 chip enable the reconstruction of each individual ionization electron where the accuracy is dominated by diffusion. The QUAD is designed to have minimum electrical field inhomogenities and distortions, achieving a tracking precision in the pixel plane with systematics of better than 10 microns. Due to the high efficiency to detect the ionization electrons a precise measurement of the energy loss dE/dx can be performed.
The QUAD detector has all services located under the detection surface. In this way multiple QUADs can be simply put together to create a detection surface of arbitrary dimensions. A possible application is in the readout modules of a large TPC.
In the presentation we show details about the construction of the QUAD and the results from a recent test beam experiment performed at the ELSA electron beam in Bonn where a silicon telescope was used to provide accurate tracking.

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**Session Classification:** Gas Detectors

**Track Classification:** Gaseous Detectors

Contribution ID: **734** Type: **Talk**

# Experimental advances of photon detection time resolution limits in SiPMs and scintillator based detectors

*Monday, February 18, 2019 5:05 PM (20 minutes)*

Scintillator based radiation detectors readout by SiPMs successively break records in their reached time resolution. Nevertheless, new challenges in time of flight positron emission tomography (TOF-PET) and high energy physics are setting unmatched goals in the 10ps range. Recently we have shown that high frequency (HF) readout of SiPMs significantly improves the measured single photon time resolution (SPTR), allowing to evaluate the intrinsic performance of large area devices; e.g. we measured 90ps FWHM with FBK NUV-HD SiPMs of 4x4mm$^2$ area and 40$\mu$m SPAD size. In this contribution we will summarize the intrinsic SPTR for different producers, e.g. FBK, HPK, Ketek, SensL etc. In TOF-PET such readout allows to lower the leading edge detection threshold, so that the fastest photons produced in the crystal can be utilized. This is of utmost importance if a high SPTR and prompt Cherenkov light generated by the hot-recoil electron upon 511keV photoabsorption should improve timing. In this context we measured a CTR of 150$\pm$3ps FWHM with 2x2x3mm$^3$ BGO crystals coupled to FBK SiPMs. This faint Cherenkov signal is as well present in standard LSO scintillators, improving the CTR of 2x2x3mm$^3$ LSO:Ce:Ca coupled to FBK NUV-HD 4x4mm$^2$ with 25$\mu$m SPAD size to 61$\pm$2ps FWHM using HF-electronics, as compared to 73$\pm$2ps when readout by the NINO front-end ASIC. This new experimental data will allow us to evaluate further the timing limits in scintillator-based detectors.

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**Presenter:** GUNDACKER, Stefan (CERN)

**Session Classification:** Plenary 2

Contribution ID: **735** Type: **Poster**

# Large acceptance high rate GEM detectors for muon tracking in heavy ion collisions of CBM experiment at FAIR

The Compressed Baryonic Matter(CBM) experiment at the upcoming FAIR facility will explore the phase diagram of hadronic matter in the region of highest baryon densities with various rare probes including light vector mesons and charmonium decaying into di-muon pairs. Unprecedented interaction rates of 10 MHz Au+Au collisions in an energy range (upto 11 AgeV) is a unique feature in CBM. The Muon Chamber (MUCH) system of CBM will perform the task of dimuon detection. The novel layout of MUCH comprising of alternating absorber and detector stations will be discussed. Harsh radiation environment and high particle rates(upto 400 kHz/cm2) impose severe constrains on the detector design for the first few stations, where large triple GEM modules covering 2л acceptance will be implemented. Readout plane is segmented into pads of progressively increasing sizes(3-17mm). The readout coupled to self-triggered electronics, is another unique feature in CBM. Such real size prototypes(~2000 sq. cm.) have been built and tested. These prototypes were tested with Pb+Pb collisions at CERN SPS for the first time in a free-streaming mode. The challenging task of event and track-reconstruction based on time-stamps of the detector hits has been performed. All these along with the details of the detector design, data acquisition, intricate mechanical integration issues in CBM, radiation issues, cooling-schematic and production readiness will be presented and discussed.

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**Session Classification:** Poster Session A

**Track Classification:** Gaseous Detectors

Contribution ID: **737** Type: **Poster**

# Development of a large active area beam telescope based on the SiD micro-strip sensor

A new beam telescope, Lycoris, is currently being installed as an improvement for the DESY test beam infrastructure within the EU Horizon2020 AIDA-2020 project. Lycoris telescope is designed to cover a large area for providing a reference momentum measurement to beam users in an 1 T solenoid magnet. It consists of six layers of the 10×10 cm2 surface, 25 μm(50 μm) sensor(readout) pitch, single-sided silicon strip sensor, giving a spatial resolution better than 10 μm along the bending direction. The micro-strip sensor is designed for the SiD tracker, readout by two bump-bonded, KPiX ASICs, which digitizes and serializes signals from all connected strips, then sends out via one single wirebonded data trace. This hybrid-less arrangement enbales Lycoris to accomodate 3 layers of the hybrid-less SiD sensor in 3.2 cm space. The presentation will first introduce the telescope with its components, then characterization results of the sensor modules will be given based on the beam tests in August and September 2018. At the end, the first beam test results of the Lycoris telescope prototype will be shown with a comparison to the simulation.

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**Session Classification:** Poster Session B

**Track Classification:** Semiconductor Detectors

Contribution ID: **738** Type: **Talk**

# Belle II Pixel Detector – Performance of final DEPFET Modules

*Tuesday, February 19, 2019 5:45 PM (20 minutes)*

In spring 2018 the SuperKEKB accelerator in Tsukuba, Japan, provided first e+e- -collisions to the upgraded Belle II experiment. During this commissioning phase the volume of the innermost vertex detector was equipped with dedicated detectors for measuring the radiation environment as well as downsized versions of the final Belle II silicon strip (SVD) and pixel (PXD) detectors.
The PXD is the sub-detector closest to the interaction point. It is made from all-silicon modules integrating support structure and sensor. The sensors are pixel matrices of DEpleted P-channel Field Effect Transistors (DEPFET) which are steered and read out by 14 ASICs bump-bonded to each module.
Four of the first available PXD modules of the final iteration were set up in the commissioning PXD detector. They were operated with close-to-final services and their data used to help evaluate accelerator operation.
Final PXD modules were also characterized in the laboratory and at beam tests at DESY. This talk will highlight the results of these performance measurements and the long term tests during accelerator commissioning.
Furthermore a short status and outlook of the final Belle II PXD that will be included in the first physics run is given.

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**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **739** Type: **Talk**

# A multi-PMT photodetector system for the Hyper-Kamiokande experiment

*Wednesday, February 20, 2019 11:30 AM (20 minutes)*

Hyper-Kamiokande (Hyper-K) is the next upgrade of the currently operating Super-Kamiokande experiment. Hyper-K is a large water Cherenkov detector with a fiducial volume which will be approximately 10 times larger than its precursor. Its broad physics program includes neutrinos from astronomical sources, nucleon decay, with the main focus the determination of leptonic CP violation.
To detect the weak Cherenkov light generated by neutrino interactions or proton decay, the employment of the multi-PMT concept, first introduced in the KM3NeT detector, is considered as a possible solution. A multi-PMT Optical Module - a pressure vessel instrumented with multiple small diameter photosensors, readout electronics and all required power supplies (incl. high voltage) - offers several advantages, such as weaker sensitivity to Earth's magnetic field, increased granularity and directional information with an almost isotropic field of view. In this contribution the development of a multi-PMT module for Hyper-K is
discussed.

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**Presenter:** DE ROSA, Gianfranca (INFN)

**Session Classification:** Miscellaneous

**Track Classification:** Photon Detectors

Contribution ID: **740** Type: **Poster**

# Beam test results of two shashlyk ECAL modules for NICA-MPD

Electromagnetic calorimeter (ECal) is an important detector of the Multi Purpose Detector (MPD) at the NICA collider. A shashlyk-type electromagnetic calorimeter is selected as MPD ECal. The particular goals of the MPD ECal are to measure of spatial positions and energy of photons and electrons. The whole ECal consists of 43008 shashlyk tower and each tower consists of 220 layers of 1.5mm scitillator +0.3mm lead plates. 16 wavelength-shifted fibers are used to collect light signals. The SiPM detector is used to read out the signals. After being amplified, the signal was sent to a waveform sampling circuit to obtain the waveform of each incident particle. Two ECal prototype modules were developed in Tsinghua University and they were tested with cosmic ray and electron beam. In the cosmic ray test, the distribution of NPE, which is the number of photoelectrons collected by the detector, is obtained. The average NPE is around 450. The beam test was carried out at DESY on August of 2018. MPD ROOT is used to analysis the test data and a well-fit energy linear relationship between NPE and electron energy together with a good energy resolution around 3% were achieved. All these results show that the prototype of ECal is fully capable of the requirement of the NICA-MPD. In this article, we described the structure of the shashlyk module and its performance in beam test.

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**Presenter:** Mr LI, Yulei (Tsinghua University )

**Session Classification:** Poster Session A

**Track Classification:** Calorimeters

Contribution ID: **743** Type: **Talk**

# The NA64 experiment for searches of rare events at CERN

We report on the recent activity of the NA64 experiment at the SPS of CERN. The NA64 experiment uses a beam dump setup to conduct missing energy searches with a high intensity electron beam.

In 2016 - 2018 separate dedicated searches for two mediators between standard model and dark sector, a new light vector boson A' and a new short-lived neutral boson X, were performed. The A' was proposed as a possible explanation for magnetic moment anomalies of muons. It could be created in electron on target reactions $e^-Z \rightarrow e^-ZA'$ and supposedly decay invisible into lighter dark sector particles ($A' \rightarrow \chi\bar{\chi}$). The X is motivated by an excess of $e^+e^-$-pairs in $^8$Be* excited state nuclear transitions. It could be produced in bremstrahlung interactions $e^-Z \rightarrow e^-ZX$ and decay into standard model leptons ($X \rightarrow e^+e^-$).

We show the experimental setup and the analysis strategies of the searches for both bosons. We present the data recorded in 2016 and 2017 and show near and distant future plans of NA64.

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**Presenters:** Mr HÖSGEN, Michael (HISKP); HOSGEN, Michael (University of Bonn (DE))

**Session Classification:** Miscellaneous

**Track Classification:** Miscellaneous

Contribution ID: **748** Type: **Poster**

# New Large Aperture Photodetectors for a Water Cherenkov Detector

Three types of 50 cm-diameter photo-detectors were newly developed for a future large water Cherenkov detector, Hyper-Kamiokande. These detection performance was largely improved by adopting different amplification systems from a conventional 50-cm photomultiplier tube (PMT) in Super-Kamiokande.
A new PMT with a box-and-line dynode was completed by optimizing the surface curvature, alignment inside and circuit to maximize the performance with a detailed evaluation of the response, as R12860 by Hamamatsu Photonics K.K. (Hamamatsu). Compared with the conventional 50 cm PMT, it achieved a double detection efficiency and half resolutions for both timing and charge with a high pressure tolerance up to 1.25 MPa.
Another type is a 50 cm hybrid photo-detector using an avalanche diode (Hamamatsu, R12850). High eight kilovolts are applied, therefore a built-in power supply and cable with a water tight connector were developed accordingly. The preamplifier for the large junction capacitance was also developed. It showed the highest resolutions in the 50-cm photodetectors.
In addition, a 50-cm micro-channel plate PMT was developed for Hyper-Kamiokande as GDB-6203 by North Night Vision Technology Co., LTD in China based on a PMT for the Juno experiment. The timing resolution was improved for a use in water Cherenkov detectors.
A lot of progress to realize three photodetectors is reported including various studies such as a cover for the photodetector, the dark count rate, tests in water.

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**Presenter:** NISHIMURA, Yasuhiro (The University of Tokyo)

**Session Classification:** Poster Session A

**Track Classification:** Cherenkov Detectors

Contribution ID: **750** Type: **Poster**

# 3D silicon sensor optimisation for high resolution time measurements

Looking forward to future High Luminosity LHC experiments, efforts to develop new tracking detectors are increasing. A common approach to improve track reconstruction efficiency in high pile-up conditions is to add time measurement per pixel with resolution smaller than 50 ps. Different sensor technologies are under development in order to achieve those performances, like low gain avalanche diodes and 3D sensors. 3D sensors are characterized by very fast charge collection times, but present some critical issues in timing due to their electrode configurations. The presence of zero electric field volumes inside the electrodes themselves and low electric field regions between same sign electrodes causes that the 3D sensor technology presents potentially a large time walk contribution which negatively affects time resolution. In order to reduce drastically this error, a detailed study based mostly on simulation has been done with main focus on the exploration for a timing optimised 3D sensor electrode configuration. To have a more detailed view of the timing performances, sensor operation was also simulated, using TCAD and other simulation tools developed specific for this application, and the results analysed. In this presentation a detailed overview of the modeling and simulation activity as well as their results, including also future steps will be presented. The output of this studies defines the optimal sensor layout for timing applications.

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**Presenter:** LOI, Angelo (Universita e INFN, Cagliari (IT))

**Session Classification:** Poster Session A

**Track Classification:** Semiconductor Detectors

Contribution ID: **763** Type: **Poster**

# A particle detector system that exploits liquid argon scintillation light

This paper describes a particle detection system that exploits the prompt signals from the scintillation light produced by ionizing particles in liquid argon. The system includes 10 R5912 Hamamatsu photomultipliers (PMTs) coated with TPB for the detection of the VUV scintillation light. A laser calibration system is used to set the gains and determine the relative timing of the PMTs. The setup is installed in a double-wall, vacuum-insulated 1500 liters liquid argon cryostat. The cryostat is approximately 2 m high and has 105 cm external diameter, 96 cm internal diameter.
The PMTs DAQ system is realized with 500 MS/s digitizers read out by means of 1.25 Gb/s bandwidth optical links. The system allows the recording of the whole waveform of each PMT in order to associate the interaction time of each event occurring in the volume with high timing resolution. The digitizers also provide logic signals when the PMT signals exceed a defined threshold. The logic signals are processed by FPGA modules in order to generate the trigger.
The detector has been exposed to cosmic rays. The system performance in terms of trigger efficiency and timing resolution, with a view to its application in neutrino detectors, will be presented.

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**Session Classification:** Poster Session A

**Track Classification:** Photon Detectors

Contribution ID: **764** Type: **Poster**

# Operation and performance of the PADME active target

Large size and thin high-quality polycrystalline diamond were used to build the full carbon active target of the PADME experiment, at the Beam Test Facility (BTF) of the Laboratori Nazionali di Frascati, searching for a dark photon of mass up to about 23.7 MeV.

The diamond sensors were ordered from a US commercial firm and graphitic electrodes on the surfaces were produced by a UV excimer laser at the University of Salento.

The full carbon active target has a size of 2x2 cm2 and a thickness of 100 microns. Both sensor surfaces host strip electrodes with a pitch of about 1 mm, oriented in orthogonal directions in the two planes. It is intended to acts as a beam and luminosity monitor by reconstructing at each bunch the beam intensity and profile in two orthogonal projections.

The detector is in operation since the beginning of September 2018. We review the status, the operation experience, and the performance of this device in the PADME experiment as measured so far.

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**Session Classification:** Poster Session B

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **765** Type: **Talk**

# Searching for neutrinoless double-beta decay with GERDA

*Tuesday, February 19, 2019 5:20 PM (20 minutes)*

The GERDA experiment searches for the lepton number violating neutrinoless double-beta decay of 76Ge operating bare, enriched Ge diodes in liquid argon. The BEGe detectors feature an excellent background discrimination from the analysis of the time profile of the detector signals, while the instrumentation of the cryogenic liquid volume surrounding the germanium detectors acts as an active veto to further suppress the external background. With a total exposure of 82.4 kg · yr we remain in the background free regime and have achieved a median sensitivity on the half-life of T1/2>1.1 x 10^26 yr (90% C.L.). We observed no signal and derive a lower limit of T1/2>0.9 x 10^26 yr (90% C.L.). In this talk we will summarize the basic concept of the GERDA design, the data taking and the physics results obtained in Phase II. We will then present the last upgrade performed and the expected performances for the full 100 kg · yr exposure.

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**Presenter:** DI MARCO, Natalia (LNGS - INFN)

**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **766** Type: **Poster**

# Level-1 track finding with an all-FPGA system at CMS for the HL-LHC

The CMS experiment at the LHC is designed to study a wide range of high energy physics phenomena. It employs a large all-silicon tracker within a 3.8T magnetic solenoid, which allows precise measurements of transverse momentum (pT) and vertex position.

This tracking detector will be upgraded to coincide with the installation of the High-Luminosity LHC, which will provide luminosities of up to about 10^35 cm^2 /s to CMS, or 200 collisions per 25 ns bunch crossing. This new tracker must maintain the nominal physics performance in this more challenging environment. Novel tracking modules that utilise closely spaced silicon sensors to discriminate on track pT have been developed and allow the readout of only hits compatible with pT > 2-3 GeV tracks to off-detector trigger electronics. This would allow the use of tracking information at the Level-1 trigger of the experiment, a requirement to keep the Level-1 triggering rate below the 750 kHz target, while maintaining physics sensitivity.

This talk presents a concept for an all FPGA based track finder using a fully time-multiplexed architecture. Hardware demonstrators have been assembled to prove the feasibility and capability of such a system. The performance for a variety of physics scenarios will be presented, as well as the proposed scaling of the demonstrators to the final system and new technologies.

**Primary author:** HAHN, Kristian (Northwestern University (US))

**Presenter:** HAHN, Kristian (Northwestern University (US))

**Session Classification:** Poster Session A

**Track Classification:** Electronics

Contribution ID: **768** Type: **Talk**

# Radiation characterization of two large and fully depleted CMOS pixel matrices fabricated in 150 nm and 180 nm technologies

*Thursday, February 21, 2019 4:55 PM (20 minutes)*

Two different design concepts of the depleted monolithic CMOS active sensor (DMAPS) are realized in the large scale pixel matrixes, named LF-Monopix and TJ-Monopix. They are realized in so-called large and small electrode design in a pixel. In the large electrode DMAPS, a high bias voltage of 300 V is applied to the highly resistive wafer without damaging the readout electronics. Full depletion of the sensor was observed at 20 V and at 120 V for 100 µm or 200 µm thinned wafer, respectively. In contrast, the small fill factor DMAPS has analog front end circuit that achieves low noise (19 e-) and low power (110 mW/cm$^2$) thanks to its small detector capacitance. The sensing volume is modified 25 µm p-epi layer, and it is also fully depleted. Both of prototypes are fully monolithic DMAPS equipped with a fast readout in column drain architecture. To investigate the radiation hardness of both pixel matrixes, they are irradiated with neutrons and protons up to the fluence of $1\times10^15\mathrm{n}_{eq}/\mathrm{cm}^2$. Results of electrical and beam tests performed on un-irradiated and irradiated chips will be shown in this presentation.

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**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **772** Type: **Poster**

# Detection of epithermal and fast neutrons with Ce doped GAGG and LYSO scintillation materials. New advantages for TOF techniques.

Recently, we demonstrated that epithermal and fast neutrons produce distinct γ-quanta in the energy range bellow 1 MeV in Gd containing media. These soft quanta can be detected in the scintillation material, containing Gd ions. One of the promising candidates for this purpose is gadolinium-gallium-aluminum garnet Gd3Al2Ga3O12 (GAGG) doped with Ce, having high light yield and excellent energy and time resolution. In addition to Gd, another atom, namely Lu, has large neutron cross section for epithermal and fast neutrons. Hence, lutetium silicate Lu2SiO5 (LSO-LYSO) scintillation crystal's family can be used for this purpose as well.
This report presents results on the comparative study of the response of GAGG and LYSO based scintillation detectors to different neutron sources. Time resolution to detect neutrons with SiPM based detectors is evaluated. Detecting units for TOF neutron spectrometers are described.
Acknowledgements

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**Session Classification:** Poster Session B

**Track Classification:** Miscellaneous

Contribution ID: **773** Type: **Talk**

# Direction-Sensitive Dark Matter Search Using Tungstate Scintillator

*Thursday, February 21, 2019 9:50 AM (20 minutes)*

Ones of the candidates for the Dark Matters are weakly interacting massive particles (WIMPs), and we expect that the Earth should experience a "wind" (named 'WIMP wind') against the direction of the rotation, where is direction to Cygnus.
In this study, we propose a new type Dark matter detector using single crystals in order to have higher detection efficiency than gaseous ones. Some team reported that $ZnWO_4$ can detect the direction of incident particles due to anisotropic. However, the mechanism has been not revealed. A Mg-admix $ZnWO_4$ crystal is expected to have different lattice constant from normal $ZnWO_4$, and anisotropic properties can be changed. Thus, we compare scintillation and anisotropic properties for $ZnWO_4$ and Mg-admix $ZnWO_4$ in this paper.
We grew $ZnWO_4$ and (Zn, Mg)$WO_4$ single crystals with diameters of ~0.5 inch grown by the Czochralski process. We checked the crystal phase and structure using the powder X-ray diffraction.
Light outputs of the crystals irradiated with 5.5 MeV alpha rays and 59.5 keV X-rays were estimated for each surface (orientation) for $ZnWO_4$ and (Zn, Mg)$WO_4$ using a photo multiplier and an $^{241}$Am source, and the light output ratios ($\alpha$ /$\beta$ ratio), defined as peak channel of 5.5-MeV alpha-ray absorption peak over that of 59.5-keV X-ray, were evaluated.The results show we find anisotropic for both samples, while anisotropic effect for Mg-admix made smaller than Mg-free one.

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**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **778** Type: **Talk**

# High resolution three dimensional characterization of irradiated silicon detectors using a Two Photon Absorption-TCT

*Thursday, February 21, 2019 2:25 PM (20 minutes)*

The Transient Current Technique (TCT) has been instrumental in the characterization of silicon radiation detectors over the last 20 years. Using visible or infrared lasers, excess carriers can be produced continuously along the beam propagation direction, the penetration depth of the light determining the length of the trail of charges. No spatial resolution is therefore obtained along this direction. However, a new technique called Two Photon Absorption-TCT (TPA-TCT) allows to produce charge carriers in a confined three dimensional volume.

TPA-TCT was successfully tested in non-irradiated diodes. For this conference we present results on diodes irradiated to various fluences between 1e13 and 1e16 neq/cm2. We show that radiation induced crystal defects lead to a linear increasing single photon absorption (SPA) of the 1.3 μm photons used for TPA, thus compromising the method for highly irradiated sensors. However this contamination can be suppressed because the SPA process is independent of the position of the focus of the laser inside the detector. Thus, the resolution along beam propagation direction can be retrieved back by taking a single measurement with the focus outside of the detector and then subtracting this contribution from the total induced current. TPA-TCT is therefore a powerful three dimensional technique that can also be successfully applied to irradiated detectors. TPA-TCT shows for instance the formation of double junction in diodes and LGADs.

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**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **779** Type: **Poster**

# Small-Pads Resistive Micromegas Prototype

Detectors at future accelerators will require operation at rates up to three orders of magnitude higher than 15 kHz/cm$^2$, the hit rates expected in the current upgrades forward muon detectors of LHC experiments. A resistive Micromegas detectors with modified readout system can achieve rate capability up to few MHz/cm$^2$ and low occupancy, thanks to few mm$^2$ readout pads. We present the development of small-pad Micromegas detectors built with the spark protection resistive layer realised with different techniques: a pad-patterned embedded resistor with screen printing, and a uniform DLC (Diamond Like Carbon structure) layer by sputtering. All detectors consist of a matrix of 48x16 rectangular pads, with 1 and 3 mm pitch. The active surface is 48x48 mm$^2$ with a total number of 768 channels, routed off-detector for readout. Characterization and performance studies of the detectors have been carried out by means of radioactive sources, X-Rays guns, cosmic rays and high energy particle beam. A comparison of performance with different resistivity values will be presented. A new prototype with integrated electronics readout is currently under assembly, the final configuration will guarantee full scalability to large size detectors, overcoming the challenging problem, unsolvable for large size, of routing off detector the pad readout lines. The design, the construction and preliminary data of this new detector, will also be reported.

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**Session Classification:** Poster Session B

**Track Classification:** Gaseous Detectors

Contribution ID: **782** Type: **Talk**

# The Gigatracker, the silicon beam tracker for the NA62 experiment at CERN.

*Thursday, February 21, 2019 10:15 AM (20 minutes)*

The Gigatracker is the NA62 beam tracker. It is made of three $63.1mm \times 29.3mm$ stations of $300\mu m \times 300\mu m$hybrid silicon pixel detectors installed in vacuum ($\sim 10^{-6}mbar$).
The beam particles, flowing at 750 MHz, are traced in 4-dimensions by means of time-stamping pixels with a design resolution of $200ps$. This performance has to be maintained despite the beam irradiation amounting to a yearly fluence of $2 \times 10^{14}$ 1 MeV eq. n/cm$^2$.
The detector material minimization is paramount, as the detector faces the full beam. The station material budget is reduced to $0.5\%X_0$ by using (HEP world first) microchannels cooling.
We will describe the detector design and performances during the NA62 runs.

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**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **784** Type: **Talk**

# The CMS Outer Tracker for the High Luminosity LHC

*Tuesday, February 19, 2019 9:50 AM (20 minutes)*

The era of High Luminosity Large Hadron Collider will pose unprecedented challenges for detector design and operation. The planned luminosity of the upgraded machine is $5 - 7.5 \times 10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$, reaching an integrated luminosity of 3000-4000 $\mathrm{fb}^{-1}$ by the end of 2039. CMS Tracker detector will have to be replaced in order to fully exploit the delivered luminosity and cope with the demanding operating conditions. The new detector will provide robust tracking as well as input for the first level trigger. This report is focusing on the replacement of the CMS Outer Tracker system, describing new layout and technological choices together with some highlights of research and development activities.

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**Session Classification:** Plenary 3

**Track Classification:** Semiconductor Detectors

Contribution ID: **785** Type: **Talk**

# In-depth study of Inverse-Low Gain Avalanche Detectors (ILGAD) for 4-dimensional tracking and radiation tolerance assessment of thin LGAD

*Tuesday, February 19, 2019 3:15 PM (20 minutes)*

For the high-luminosity LHC upgrade, the ATLAS and CMS experiments are planning to include dedicated detector systems to measure the arrival time of Minimum Ionising Particles (MIPs). Such systems should provide a timing resolution of 30 ps per MIP. State-of-the-art timing technologies integrating Silicon photo-multipliers and plastic scintillators do not tolerate the hadron fluences expected at the end-cap detector regions (up to 3×10^15 neq/cm2). To cope with these requirements, a Silicon sensor with integrated signal amplification, the Low Gain Avalanche Detector (LGAD) is the baseline sensing technology of the end-cap timing detector systems at HL-LHC. A comprehensive radiation tolerance study of LGAD pad-like sensors manufactured at IMB-CNM and irradiated at CERN's PS-IRRAD proton facility up to a fluence of 3×10^15 neq/cm2 is presented here. Two different active thicknesses were studied: 35-microns and 50-microns; the effect of carbon co-implantation on the radiation tolerance was also investigated. The building block LGAD sensor of the above mentioned timing detector systems is designed as a pad diode matrix. The timing resolution of this LGAD sensor is severely degraded when the MIP particle hits the inter-pad region since there is no amplification in this region. This limitation is named as the LGAD fill-factor problem. To overcome the fill factor problem, a p-in-p LGAD (Inverse LGAD) was introduced. Contrary to the conventional LGAD, the ILGAD has a non-segmented deep p-well (the multiplication layer). Timing and tracking performance of the first ILGAD prototype is presented. ILGADs should ideally present a constant timing performance over all the sensitive region of the device without timing degradation between the signal collecting electrodes.These studies were performed within the context of the RD50 collaboration and partially funded by the H2020 EU project AIDA-2020.

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**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **787** Type: **Poster**

# First test beam results obtained with IDEA, a detector concept designed for future lepton colliders

IDEA (International Detector for Electron-positron Accelerators) is a detector concept designed for a future leptonic collider operating as a Higgs factory. It is based on innovative detector technologies developed over years of R&D. In September 2018, prototypes of the proposed subdetectors have been tested for the first time on a beam line at CERN, setting a milestone for the detector design and test for future Higgs boson factory collider machines, like FCC-ee or CepC. The preliminary results from this test of a full slice of the IDEA detector will be presented. The talk will include results of standalone subdetector measurements and on their combined performance.

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**Session Classification:** Poster Session A

**Track Classification:** Miscellaneous

Contribution ID: **789** Type: **Poster**

# Thick, silicon CCDs to search for dark matter within the DAMIC-M Experiment

The DAMIC (Dark Matter in CCDs) Experiment employs the active silicon of low-noise charge-coupled devices (CCDs) as a target to search for a variety of dark matter candidates with masses below 10 GeV. An array of seven 675-$\mu$m thick CCDs with a target mass of ~40 grams has been collecting data at SNOLAB since early 2017 and the next stage of the experiment, DAMIC-M, will be an array of CCDs with a total mass of 1 kg to be located in France at the Laboratoire Souterrain de Modane. The collaboration has engaged in an extensive campaign of characterization efforts to understand the response of these CCDs to low-energy nuclear recoils and their unique capabilities, including the use of high spatial resolution for both the rejection and study of backgrounds. This talk will address the general features of DAMIC CCDs and include some results of early characterization efforts of the improved DAMIC-M devices which feature skipper-style readout capable of single-electron resolution. Potential alternative applications of CCDs in rare-event searches will be also be discussed.

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**Session Classification:** Poster Session A

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **790** Type: **Talk**

# NU-CLEUS: Exploring coherent neutrino-nucleus scattering with cryogenic detectors

*Tuesday, February 19, 2019 5:45 PM (20 minutes)*

The detection of coherent-neutrino nucleus scattering (CEνNS) opens the door for new physics within and beyond the Standard Model of Particle Physics. NU-CLEUS is a novel neutrino experiment at a nuclear power reactor which allows for precision measurements with a novel cryogenic gram-scale detector design based on CRESST technology. A recent prototype detector has achieved an ultra-low energy threshold of 20eV for nuclear recoils, one order of magnitude lower than previous devices. The NU-CLEUS experimental concept contains a fiducial-volume cryogenic detector concept, which is expected to significantly reduce backgrounds. The NU-CLEUS experiment aims to operate at close distance to a power reactor; a promising site at the CHOOZ power plant in France is currently being investigated. In this talk we present in detail the cryogenic detector technology of NU-CLEUS and report about the strategy of the new experiment which has recently been fully funded.

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**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **792** Type: **Poster**

# Performance of the CMS RPC upgrade using 2D fast timing readout system

A new generation of RPC chambers capable to withstand high particle fluxes (up to 2000 Hz/cm2) and instrumented with a precise timing readout electronics is proposed to equip two of the four high eta stations of the CMS muon system.

Doublet RPC detectors each made of two 1.4 mm HPL electrodes and separated by a gas gap of the same thickness are proposed. The new scheme reduces the amount of the avalanche charge produced by the passage of a charged particle through the detector. This improves the RPC rate capability by reducing the needed time to absorb this charge. To keep the RPC efficiency high a sensitive, low-noise and high time resolution Front-End Electronics is needed to cope with the low charge signal. An ASICS called PETIROC that has all these characteristics is proposed to read out the new chambers.

Thin (0.6 mm) Printed Circuit Board (PCB), 160 cm long, equipped with pickup strips of 0.75 cm pitch will be inserted between the two RPC detectors. The strips will be read out from both ends, using the arrival time difference to determine the Y position. The absolute time measurement will be also used with the aim to reduce the data ambiguity due to the expected high pileup at the future HL-LHC.

The results from RPC chamber equipped with the new readout system will be presented based on a complete set of laboratory electronic measurements and test beams. An excellent time and position resolution is obtained with the new chamber thanks to the new readout system.

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**Session Classification:** Poster Session B

**Track Classification:** Gaseous Detectors

Contribution ID: **793** Type: **Poster**

# Study on garnet scintillators for TOF-PET detectors and HEP exeriments

Scintillation crystals are widely used in detectors for high energy physics and medical physics. For positron emission tomography (PET), a major approach to improve the signal to noise ratio and image quality is the time-of-flight technique, where fast scintillators with high stopping power are needed. Particle detectors in future high energy physics experiments will operate at high collision rate in a harsh radiation environment. Coupling radiation tolerant scintillating crystals to silicon photomultiplier provide a flexible option for a precise timing layer in particle detectors, helping in the reconstruction of physics events.

Gadolinium Aluminum Gallium Garnet (GAGG:Ce) scintillators feature high scintillation yield, high density and fast decay time to be competitive with LSO or LYSO. Codoping with divalent ions like $Mg^{2+}$ ions decreases rise and decay time significantly leading to better time resolution.

In this contribution we discuss the timing performance of different codoped GAGG:Ce crystals and the influence of crystal properties, such as density, light yield, decay kinetics and geometry on the timing performance. Samples of LYSO:Ce have also been used as reference time device. Coupled to HPK with 50 $\mu$m SPAD size a CTR of 165 $\pm$ 5 ps (FWHM) for 3x3x5 mm$^3$ GAGG:Ce,Mg,Ti and 130 ps for 2x2x3 mm$^3$ for GAGG:Ce,Mg was measured at E=511 keV.
Timing performance for 100 GeV charged pions traversing pairs of crystals will also be presented.

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**Presenter:** KRATOCHWIL, Nicolaus (CERN)

**Session Classification:** Poster Session B

**Track Classification:** Medical Applications

Contribution ID: **797** Type: **Poster**

# Processing of AC-coupled n-in-p pixel detectors on MCz silicon using atomic layer deposition (ALD) grown aluminium oxide

We report on the fabrication of capacitively-coupled (AC) n+-in-p pixel detectors on magnetic Czochralski silicon substrates. In our devices, we employ a layer of aluminium oxide ($Al_2O_3$) grown by atomic layer deposition (ALD) as dielectric and field insulator, instead of the commonly used $SiO_2$. As shown in earlier research, $Al_2O_3$ thin films exhibit high negative oxide charge, and can thus serve as a substitute for p-stop/p-spray insulation implants between pixels. In addition, they provide far higher capacitance densities than $SiO_2$ due to their high dielectric constant, permitting more efficient capacitive coupling of pixels. Furthermore, metallic titanium nitride (TiN) bias resistors are presented as an alternative to punch-through or poly-Si resistors.

Devices obtained by the abovementioned process are characterized by CV, IV, and TCT measurements, and by 2 MeV proton microprobe. Results show the expected high negative charge of the $Al_2O_3$ dielectric, uniform charge collection efficiency over large areas of pixels, and acceptable leakage current densities.

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**Session Classification:** Poster Session B

**Track Classification:** Semiconductor Detectors

Contribution ID: **798** Type: **Poster**

# The Transition Radiation Detector in the CBM Experiment at FAIR

The Compressed Baryonic Matter (CBM) experiment will be one of the research pillars of FAIR (Darmstadt, Germany), which is currently under construction. High-intensity heavy-ions beams delivered by the SIS100 accelerator (FAIR Phase 1) will be used to explore the QCD phase diagram at high baryon densities. Interaction rates of up to 10 MHz on a fixed target will enable measurements at an unprecedented level of precision and will allow access to rare probes like, e.g., multi-strange hyperons and hyper-nuclei. The in-medium mass modification of vector mesons can be measured via lepton pairs, and excitation functions of various observables will serve as sensitive probes for phase transitions.

At the planned interaction rates, the CBM experiment has to meet the challenge of very high hit rates in the detectors. This poster will focus on the Transition Radiation Detector in CBM, which is foreseen as a a 4-layer design with thin Xe-filled MWPCs (3.5+3.5 mm amplification and 5 mm drift volume) and PE-foam based radiators. To cope with the high hit densities in the inner detector region, detector modules with high readout granularity in 2D are being developed. High-rate tests of the default MWPCs at the CERN Gamma Irradiation Facility (GIF) will be covered as well as measurements of the MWPC and radiator response to electron beams provided by DESY. The TRD readout concept which interfaces to a newly developed performant, self-triggered and free-streaming DAQ system will be sketched.

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**Session Classification:** Poster Session A

**Track Classification:** Gaseous Detectors

Contribution ID: **800** Type: **Talk**

# The LHCb Upgrade Programme and the VELO

*Monday, February 18, 2019 3:15 PM (20 minutes)*

The LHCb Upgrade I, currently under construction and scheduled to start data taking in Run 3, will transform the experiment to a triggerless system reading out the full detector at 40 MHz event rate. The increased luminosity and trigger efficiency anticipated at the upgrade will allow a huge increase in precision, in many cases to the theoretical limit, and the ability to perform studies beyond the reach of the current detector. In order to allow the triggerless readout the front end electronics of all subdetectors will be changed, and many subdetectors will be upgraded to cope with the increased occupancy and radiation levels. The Vertex Locator (VELO) is the detector surrounding the interaction region, and will be a hybrid pixel system, featuring silicon pixel sensors with 55x55 μm pitch, read out by the VeloPix ASIC. The sensors and ASICs will approach the interaction point to within 5.1 mm and be exposed to a radiation dose of up to 370 MRad or 8.1015 1MeV neqcm−2. The ASICs must sustain pixel hit rates of over 800 Mhits/s with an output data rate of 15 Gbit/s. The pixel modules are coooled via evaporative CO2 circulating in microchannels embedded within a silicon substrate. In parallel to the construction efforts for the Upgrade I, LHCb has recently submitted a physics case for a an Upgrade II detector to begin operation in 2031. Here major parts of the detector will be replaced and functionality added to enable the detector to run at a futher luminosity step of up to 2×1034 cm−2 s−1. It is anticipated to collect approximately 300 fb−1 at Upgrade II. In the case of the VELO further enhancements will be needed to address the problems of real time pattern recognition and increased radiation doses. The current status of the VELO Upgrade I construction will be described and concepts for a future Upgrade II VELO presented.

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**Session Classification:** Plenary 2

**Track Classification:** Semiconductor Detectors

Contribution ID: **803** Type: **Talk**

# Construction, operation and performance of the novel MPGD-based photon detectors of COMPASS RICH-1

*Thursday, February 21, 2019 12:20 PM (20 minutes)*

The RICH-1 Detector of the COMPASS Experiment at CERN SPS has been upgraded in 2016: four new Photon Detectors, based on MPGD technology and covering an active area of 1.4 square meters replace the previously used photon detectors (MWPCs with CsI photocathodes). The new detector architecture consists in a hybrid MPGD combination: two layers of THGEMs, the first of which also acts as a reflective photocathode (its top face is coated with a CsI film) are coupled to a bulk Micromegas on a pad segmented anode; the signals are read-out via capacitive coupling by analog F-E based on the APV25 chip. All aspects of the COMPASS RICH-1 Photon Detectors upgrade are presented. The design, the engineering aspects, the mass production and the quality assessment of the MPGD components are recalled. The assembling and the validation tests of the detectors are described. The operating conditions and the on-line monitoring of the detector response are illustrated. The characterization of the novel photon detectors is presented in detail. With a typical gain approaching 20000, a signal formation time of 100 ns, a single photon angular resolution of 1.8 mrad and about 10 detected photons per ring at saturation the novel MPGD-based detectors of single photons of COMPASS RICH-1 meet the required specifications and open the way for interesting future applications.

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**Session Classification:** Photon Detectors

**Track Classification:** Photon Detectors

Contribution ID: **804** Type: **Talk**

# Dual-readout calorimetry, an integrate high-resolution solution for energy measurements at future electron-positron colliders

*Wednesday, February 20, 2019 11:55 AM (20 minutes)*

Traditional energy measurements in hadron detection have always been spoiled by the non-compensation problem. Hadronic showers develop an electromagnetic component, from neutral mesons' decays, over-imposed on the non electromagnetic component. As the two are typically sampled with very different responses, fluctuations between them directly spoil the hadronic energy resolution. Dual-readout calorimetry allows to reconstruct the electromagnetic component on an event-by-event basis and correct the energy measurements for its fluctuations, thus providing a significant step towards the ultimate energy resolution in hadron and jet detection. The IDEA detector proposal for the CepC and FCC-ee future collider, devises a single dual-readout calorimeter, for electromagnetic, hadronic and jet energy measurements. In this talk, the main developments required to bring the technique to an effective solution will be presented. Results from full simulations of a standalone calorimeter indicates that an energy resolution in hadron detection of $\frac{\sigma}{E} = \frac{30\%}{\sqrt{E}}$ is reachable. A possible full-coverage $4\pi$ geometry is under development, with full simulations, as well. From the hardware side, results from a new dual-readout prototype optimized for electron/hadron identification in a multi particle environment and tested at the recent IDEA vertical slice test beam will be presented as well.

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**Presenter:** PEZZOTTI, Lorenzo (Universita and INFN (IT))

**Session Classification:** Miscellaneous

**Track Classification:** Calorimeters

Contribution ID: **805** Type: **Poster**

# Investigations on the radiation damage of the LHCb VELO: a full review

The LHCb Vertex Locator (VELO) is a silicon micro-strip detector operating extremely close to the LHC proton beams. During nominal data-taking the innermost active strips are as close as ~8 mm to the beams.
This proximity makes the LHCb VELO
an ideal laboratory to study radiation damage effects in silicon detectors.

The analysis of charge collection efficiency (CCE) data showed that there is a correlation of cluster finding efficiency (CFE) with the distance of strip to a second metal layer routing line. The detectors are constructed with two metal layers to cover the R/$\phi$ strips and route the signal to the front-end chips.
A loss of signal amplitude is observed with a dependency on the distance to the routing lines. Using the Perugia n-type bulk model and the
Peltola surface damage model it is shown that up to 60\% of the charge is collected by routing lines. This is caused by trapping of the otherwise mobile electron accumulation layer at the oxide-silicon interface, causing the shielding effect on the routing lines to be reduced. The observed drop in CFE can be explained by the angular dependence of charge loss to the second metal layer. The efficiency drop as function of track radius and angle is reproduced combining 2D and 3D TCAD simulations.

A complete review of the whole history of the LHCb VELO radiation damage studies will be presented with results of run 1 and 2, as well as comparisons to TCAD simulations.

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**Session Classification:** Poster Session A

**Track Classification:** Semiconductor Detectors

Contribution ID: **808** Type: **Talk**

# The 2 inches VSiPMT industrial prototype

*Thursday, February 21, 2019 5:45 PM (20 minutes)*

Photon detection is a key factor to study many physical processes in several areas of fundamental physics research. Focusing the attention on photodetectors for particle astrophysics, we understand that we are very close to new discoveries and new results. In order to push the progress in the study of very high-energy or extremely rare phenomena (e.g. dark matter, proton decay, neutrinos from astrophysical sources) the current and future experiments require additional improvements in linearity, gain, quantum efficiency and single photon counting capability. To meet the requirements of these classes of experiments, we propose a new design for a modern hybrid photodetector: the VSiPMT (Vacuum
Silicon PhotoMultiplier Tube).
The idea is to replace the classical dynode chain of a PMT with a SiPM, which therefore acts as an electron detector and amplier. The aim is to match the large sensitive area of a photocathode with the performances of the SiPM technology. The previous VSiPMT prototypes already showed many attractive features such as low power consumption, weak sensitivity to magnetic fields, excellent photon counting capability and so on.
We now present the results of the full characterization of the latest and largest version achieved up to now, a 2-inches VSiPMT manufactured by Hamamatsu.

**Primary authors:** BARBATO, Felicia Carla Tiziana (INFN - National Institute for Nuclear Physics); Prof. BARBARINO, Giancarlo (University of Naples "Federico II"); MOLLO, Carlos Maximiliano (INFN); VIVOLO, Daniele; Dr FUKASAWA, Atshuito (Hamamatsu Photonics KK)

**Presenter:** BARBATO, Felicia Carla Tiziana (INFN - National Institute for Nuclear Physics)

**Session Classification:** SiPM

**Track Classification:** SiPM

Contribution ID: **812** Type: **Talk**

# The CMS Pixel Detector for the High Luminosity LHC

*Tuesday, February 19, 2019 5:20 PM (20 minutes)*

The High Luminosity Large Hadron Collider (HL-LHC) at CERN is expected to collide protons at a centre-of-mass energy of 14 TeV and to reach the unprecedented peak instantaneous luminosity of $5 - 7.5x10^{34}cm^{-2}s^{-1}$ with an average number of pileup events of 140-200. This will allow the ATLAS and CMS experiments to collect integrated luminosities up to 3000-4500 $fb^{-1}$ during the project lifetime. To cope with this extreme scenario the CMS detector will be substantially upgraded before starting the HL-LHC, a plan known as CMS Phase-2 upgrade. The entire CMS silicon pixel detector will be replaced and the new detector will feature increased radiation hardness, higher granularity and capability to handle higher data rate and longer trigger latency. In this talk the Phase-2 upgrade of the CMS silicon pixel detector will be reviewed, focusing on the features of the detector layout and on developments of new pixel devices.

**Primary authors:** SGUAZZONI, Giacomo (INFN (IT)); CMS TRACKER COLLABORATION

**Presenter:** SGUAZZONI, Giacomo (INFN (IT))

**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **815** Type: **Poster**

# Deep Machine Learning on FPGAs for L1 trigger and Data Acquisition

Machine learning is becoming ubiquitous across HEP. There is great potential to improve trigger and DAQ performances with it. However, the exploration of such techniques within the field in low latency/power FPGAs has just begun. We present HLS4ML, a user-friendly software, based on High-Level Synthesis (HLS), designed to deploy network architectures on FPGAs. As a case study, we use HLS4ML for boosted-jet tagging with deep networks at the LHC. We map out resource usage and latency versus network architectures, to identify the typical problem complexity that HLS4ML could deal with. We discuss possible applications in current and future HEP experiments.

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**Session Classification:** Poster Session B

**Track Classification:** Electronics

Contribution ID: **818** Type: **Talk**

# Novel Resistive-Plate WELL sampling elements for (S)DHCAL

*Thursday, February 21, 2019 10:15 AM (20 minutes)*

Digital and Semi-Digital Hadronic Calorimeters (S)DHCAL were suggested for future Colliders as part of the particle-flow concept. Though studied mostly with RPC-based techniques, studies have shown that MPGD-based sampling elements could outperform. An attractive, industry-produced, robust, particle-tracking detector for large-area coverage, e.g. in (S)DHCAL, could be the novel single-stage Resistive Plate WELL (RPWELL). It is a single-sided THGEM coupled to the segmented readout electrode through a sheet of large bulk resistivity. Past laboratory and accelerator studies were performed in moderate-size RPWELL prototypes in Ne- and Ar-based gas mixtures. These demonstrated large dynamic range (from single electrons to thousand-times MIPS), stable operation under high gains (> 105) also in hadronic beams; MIP detection efficiency>98% was reached at <1.2 pad multiplicity. We will present recent studies carried out with 6.5 mm thick (incl. electronics) 50x50 cm2 RPWELL-based sampling elements, equipped with a Semi Digital readout electronics based on the MICROROC chip. They were performed at the CERN-SPS with 150 GeV muons and high-rate pions. Results will be shown on detection efficiency, pad multiplicity, gain and efficiency uniformity and detector stability. We will further present the preliminary performance of an RPWELL-based (S)DHCAL small prototype exposed to low-energy electrons at CERN-PS. Other applications in noble-liquid and UV detectors will be discussed.

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**Presenter:** Dr BRESSLER, Shikma (Weizmann Institute of Science (IL))

**Session Classification:** Gas Detectors

**Track Classification:** Gaseous Detectors

Contribution ID: **819** Type: **Poster**

# Radiation damage in p-type EPI silicon pad diodes irradiated with different particle types and fluences

In view of the HL-LHC upgrade, radiation tolerant silicon sensors that contain low-resistivity p-type implants or substrates, like LGAD or HVCMOS devices, are being developed in the framework of ATLAS, CMS, RD50 and other sensor R&D projects. The devices are facing a particular problem - the apparent deactivation of the doping due to the irradiation, the so-called acceptor removal effect.

In the present work proton- and neutron-fluence dependent radiation damage effects, including change in leakage current and effective doping concentration, space charge sign inversion, but also introduction and annealing of point- and cluster-defects have been studied in Si pad diodes fabricated from p-type EPI material of different resistivity (10-1000 ohm·cm). Standard electrical characterizations (I-V, C-V), TCT (Transient Current Technique) and TSC (Thermally Stimulated Current) techniques were applied.

A correlation between effective doping concentration obtained from C-V measurements and defect concentration Nc extracted from TSC measurements for both neutron and proton irradiation is observed and pointing towards the microscopic origin of the acceptor-removal.

A detailed analysis of the dominant TSC peaks - E(30K), BiOi and three main deep acceptor levels H(116K), H(140K) and H(152K) - responsible for the changes in the effective space charge is performed. The origin and annealing behavior of E(30) and H(40) and other cluster-related defects are discussed as well.

**Primary authors:** GURIMSKAYA, Yana (CERN); MATEU, Isidre (CERN); DIAS DE ALMEIDA, Pedro (Universidad de Cantabria (ES)); FERNANDEZ GARCIA, Marcos (Universidad de Cantabria (ES)); MOLL, Michael (CERN)

**Presenter:** GURIMSKAYA, Yana (CERN)

**Session Classification:** Poster Session B

**Track Classification:** Semiconductor Detectors

Contribution ID: **821** Type: **Poster**

# Development of a Resistive Plate Device with micro-pattern technique.

We present an RPC built with techniques developed for micro-pattern gaseous detectors. It consists in two equal electrode plates made of FR4 substrate with 250 Cu readout strips. A 50 um insulating foil, carrying resistive lines, is glued on top of the substrate. Both the Cu and the resistive strips have a pitch of 400 um and width of 300 um.
The plates are spaced by a 2 mm gap and rotated by 90 deg., providing a 2D tracking capability. With such a device the surface resistivity can be tuned to values below the ones of existing RPC (either glass or phenolic-melamine). The thin separation layer between the electrodes and the readout strips provides a better capacitive coupling of the signal, allowing to operate the detector at lower gain. Moreover, the strip-shaped resistive pattern reduces the induced charge size in the direction perpendicular to the strips. All these features go in the direction of improving the rate capability.
The basic concept of this new device will be presented together with preliminary results of ongoing tests at CERN.

**Primary author:** IENGO, Paolo (CERN)

**Presenter:** IENGO, Paolo (CERN)

**Session Classification:** Poster Session B

**Track Classification:** Gaseous Detectors

Contribution ID: **822** Type: **Talk**

# Silicon Detectors for the LHC Phase-II Upgrade and Beyond – RD50 Status Report

*Thursday, February 21, 2019 2:00 PM (20 minutes)*

The inner tracking layers of all LHC experiments were designed and developed to cope with the environment of the present Large Hadron Collider (LHC). At the LHC Phase-II Upgrade foreseen for 2026, the particle densities and radiation levels will increase by roughly an order of magnitude compared to the present LHC conditions. Therefore, the inner tracking layers will need to be replaced. The new inner tracking layers, which will all be based on silicon detectors, must be significantly more radiation hard.
Within the RD50 Collaboration, a large R&D program has been underway for more than a decade across experimental boundaries to develop silicon sensors with sufficient radiation tolerance for HL-LHC trackers. Key areas of detectors R&D include HV CMOS sensors, detectors made in the 3D technology and Low Gain Avalanche Detectors (LGADs). We will present the state of the R&D in several silicon detector domains, in particular 3D and LGAD detectors. We will also comment on the options for detector choices experiments beyond the LHC, using the FCC as an example.

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**Presenters:** SZUMLAK, Tomasz (AGH University of Science and Technology (PL)); ON BEHALF OF THE RD50 COLLABORATION

**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **824** Type: **Poster**

# CEvNS detection with CONUS

Coherent elastic neutrino nucleus scattering (CEvNS) has been predicted since 1973, but eluded detection for more than 4 decades mainly due to a lack of technology able to detect small nuclear recoils. The process was first observed in August 2017 using a spallation neutron source [1].
Complementary to it, new projects like CONUS try to detect CEvNS using reactor anti-neutrinos. CONUS is based on a novel Ge detector technology and a shield technique designed for operation at shallow depth close to a reactor core. For data acquisition in the initial phase of the experiment, a custom-made software framework has been developed. For a second phase, a new electronics based on the FlashCam DAQ [2] is in preparation.
This talk sheds light on the instrumentation, operation and upgrades of the CONUS setup and presents challenges and latest results from the experiment. An outlook will further summarize the physics potential of CEvNS-based detectors.

[1] Observation of Coherent Elastic Neutrino-Nucleus Scattering, Science 357 (2017) no.6356, 1123-1126
[2] A Trigger and Readout Scheme for future Cherenkov Telescope Arrays, arXiv:0812.0762

**Primary author:** SCHIERHUBER, Tobias (Max-Planck-Institut für Kernphysik)

**Presenter:** SCHIERHUBER, Tobias (Max-Planck-Institut für Kernphysik)

**Session Classification:** Poster Session B

**Track Classification:** Miscellaneous

Contribution ID: **828** Type: **Talk**

# APiX: a two-tier avalanche pixel sensor for charged particle detection and timing.

*Wednesday, February 20, 2019 9:25 AM (20 minutes)*

A novel pixelated charged particle detector with fast timing capabilities is under development. It addresses two important requirements for the next generation of position sensitive detectors: minimization of material budget and power consumption, while providing high granularity and excellent timing. It is a "thin" (tens of micron), window-less, vertically integrated, CMOS detector. Internal gain and fast timing (tens of ps) are provided by operating the sensor in quenched Geiger mode. Each pixel on the upper tier is vertically integrated with its corresponding partner on the second tier and operated in coincidence. This dramatically reduces the dark count rate and allows digital mode operation. A proof-of-principle prototype was implemented in a 150 nm CMOS process and tested with high energy particle beams at CERN. The device radiation tolerance was investigated, via irradiation, at Legnaro National Laboratory (LNL). A second prototype featuring a larger fill-factor has been manufactured and characterized. Potential applications include high resolution tracking and radiation monitoring in space-borne experiments and radiation imaging in nuclear medicine. A small hand-held demonstrator is under construction for radio-guided surgery.

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**Presenter:** Dr BROGI, Paolo (Univ. of Siena and INFN Pisa, IT)

**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **829** Type: **Talk**

# GAPS: a balloon-borne cosmic-ray antimatter experiment

*Thursday, February 21, 2019 2:25 PM (20 minutes)*

Novel theories beyond the Standard Model predict dark matter candidates that could provide a significant enhancement of the antideuteron and antiproton flux, in particular at low energies. The General Antiparticle Spectrometer (GAPS) experiment is the first antimatter search experiment designed specifically for low-energy cosmic ray antideuterons and antiprotons.
GAPS identifies antideuterons and antiprotons using a technique based on exotic atom capture and decay. This novel detection technique allows GAPS to have unprecedented sensitivity in the low energy range (<0.25 GeV/n) for antiprotons and antideuterons. The apparatus consists of 10 planes of lithium-drifted Si (Si(Li)) detectors, surrounded on all sides by a plastic scintillator time-of-flight.
GAPS is designed to carry out its science program using long-duration balloon flights in Antarctica and is currently scheduled by NASA for its first flight in late 2020.
This presentation will describe the design, status, and discovery potential of the GAPS scientific program.

**Primary authors:** OSTERIA, Giuseppe (INFN - National Institute for Nuclear Physics); SCOTTI, Valentina; FOR THE GAPS COLLABORATION

**Presenter:** OSTERIA, Giuseppe (INFN - National Institute for Nuclear Physics)

**Session Classification:** Astroparticle Detectors

**Track Classification:** Astroparticle Detectors

Contribution ID: **831** Type: **Talk**

# Radiation hard active pixel sensor with 25µm x 50µm pixel size designed for capacitive readout with RD53 ASIC

*Thursday, February 21, 2019 5:45 PM (20 minutes)*

We will present a sensor chip for a capacitively coupled particle detector (CCPD). CCPDs have been proposed for several experiments and it has been demonstrated that the signals from the sensor to the readout chip can be transmitted when the chips are glued. However, it is still not proven whether gluing can be done fast on a large number of devices. Therefore, we are investigating a new concept. The readout chip and the sensor chip are mechanically connected with a small number of large bump bonds. The signals from pixels are still transmitted capacitively. No glue is used. The benefit of this concept is that a conventional flip chip technique can be used to build the detector. Since the bumps can be large, an industrial bumping process can be used which assures low cost. The sensor chip is based on HVCMOS structure. A special design is used to ensure large output signals that are needed because the gap between the sensor and the readout chip is large. The pixel size is 25µm x 50µm and the transmitting electrode pitch is 50µm x 50µm. Therefore for the readout of the sensor, a standard HL-LHC readout chip developed by RD53 collaboration can be used. The CCPD sensor chip has been produced. Measurement results and design details will be presented in this contribution.

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**Presenter:** ZHANG, Hui (Karlsruhe Institute of Technology (KIT))

**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **837** Type: **Talk**

# The Jiangmen Underground Neutrino Observatory (JUNO)

*Friday, February 22, 2019 12:10 PM (20 minutes)*

The Jiangmen Underground Neutrino Observatory (JUNO) is an experiment under construction in China with the primary goal of determining the neutrino mass hierarchy (MH) with reactor antineutrinos. The JUNO detector system consists of a central detector, an active veto system and a calibration system. The central detector is a 35 meter diameter transparent acrylic sphere containing a 20 kton liquid scintillator neutrino target. A primary photodetection system consisting of 18 000 large (20" diameter) dynode and microchannel plate photomultipliers surrounds the central detector. A second interlaced photodetection system is made of 25 000 small (3" diameter) photomultipliers working in the single photoelectron regime for the reactor antineutrino detection. The detector is designed to achieve an unprecedented energy resolution of 3% @1MeV and an absolute energy scale uncertainty better than 1%. A veto system, consisting of a water Cherenkov detector and a top tracker, is used to to help maximally remove cosmogenic backgrounds. Due to its unprecedented scale and precision, JUNO will be an exceptional multipurpose detector with a rich physics program in neutrino oscillation, geo-neutrinos, astrophysical neutrinos and the search for physics beyond the Standard Model (sterile neutrinos, dark matter, proton decay and others).

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**Presenter:** CERNA, Cedric (CENBG/CNRS)

**Session Classification:** Plenary 4

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **838** Type: **Talk**

# The SuperNEMO Demonstrator double beta experiment

*Thursday, February 21, 2019 10:15 AM (20 minutes)*

The SuperNEMO experiment will study decays of 82Se in order to look for neutrinoless double beta decays (0νββ), interactions that, if observed, would prove the Majorana nature of neutrinos. SuperNEMO inherits the tracking-calorimetry technology of NEMO-3, which allows for a clear determination of event kinematics, while aiming for an improved background suppression and 0νββ sensitivity. A demonstrator module will start operating in 2019. The double beta emitting source, 7 kg of 82Se, is shaped in thin foils (20 squared meters), and surrounded by a half meter long helium tracking chamber composed of 2000 Geiger cells. A 4 PI gamma catcher and electron calorimeter, made of plastic scintillators with an energy resolution of 7% (FWHM) at 1 MeV, surrounds the whole. The demonstrator is constructed in ultra low radioactivity materials and is installed in the Modane Underground Laboratory in the Frejus Tunnel under the French-Italian Alps.

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**Presenter:** JEREMIE, Andrea (Laboratoire d'Annecy-le-Vieux de Physique des Particules (LAPP))

**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **843** Type: **Poster**

# Neutron Gas Scintillation Imager with Glass Capillary Plate

A glass capillary plate (CP) is a thin glass plate of 300 $\mu$m thickness with a large number of through holes (50 $\mu$m diameter with 64 $\mu$m pitch). The CP is one of a device for a hole-type micropattern gaseous detectors (MPGD) as represented by gas electron multiplier (GEM). We have been developing a neutron gas scintillation imager (n-GSI) consisting of a thin layer of $^{10}$B, a CP gas detector, mirror and lens optics, and a cooled CMOS camera system. The performance of the neutron imager was investigated using a thermal neutron beam at the Kyoto University Accelerator-driven Neutron Source (KUANS) and Kyoto University Reactor (KUR). Owing to the high imaging capability the n-GSI, the practical position resolution of 200 $\mu$m was obtained for the neutron beam. The tracks of $\alpha$-rays or $^{7}$Li produced by the interaction between neutrons and 10B were also clearly observed. We report on the properties of the neutron imager and describe the outlook for future developments on the basis of the results of Monte Carlo simulations using a particle and heavy ion transport code system (PHITS).

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**Session Classification:** Poster Session A

**Track Classification:** Gaseous Detectors

Contribution ID: **849** Type: **Talk**

# CUPID-0: a double-readout cryogenic detector for Double Beta Decay search

*Tuesday, February 19, 2019 2:00 PM (20 minutes)*

CUPID-0 is the first large mass neutrinoless double beta decay (0νDBD) experiment based on cryogenic calorimeters with dual read-out of light and heat for background rejection. The detector, consisting of 26 ZnSe crystals, 2 natural and 24 enriched at 95% in Se82, coupled with bolometric light detectors, has been constructed respecting very strict protocols and procedures, from the material selection during crystal growth to the new and innovative detector structure for the assembly in a bid to achieve the best performance of the array. The successful construction of the detector lead to promising preliminary detector results, that will be presented. The array is in fact taking data underground at LNGS (Italy) since March 2017 and the particle identification, enabled by the heat and light simultaneous read-out, provides an unprecedented background level, for cryogenic calorimeters, of only 3.2×10-3 counts/keV/kg/y in the region of interest (ROI) of the 0νDBD search for Se82, namely around 3 MeV.

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**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **850** Type: **Talk**

# Quantum Dots for Rare Decays: the ESQUIRE Project

*Tuesday, February 19, 2019 3:15 PM (20 minutes)*

The future Neutrinoless Double Beta Decay (0νDBD) experiments will require a particle detector easily scalable in mass and able to reach good energy resolution (around 2% or better) in the region of interest for the study of these rare decays, at about 3 MeV.
The ESQUIRE (Experiment with Scintillating QUantum dots for Ionizing Radiation Events) project aims at the development of a new category of scintillating materials, based on nano-crystals (Quantum Dots) containing a 0νDBD candidate isotope. These scintillators would be coupled to high quantum efficiency optical photon sensors (SDDs) with high quantum efficiency (up to 80% in the 450-1000 nm λ region) and low electronic noise, thus solving in one fell swoop the scalability and the good energy resolution requests.
We will report on the first results of the optical characterization measurements of the samples containing the nano-crystals and on the first scintillation measurements collected so far.

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**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **852** Type: **Talk**

# PandaX-III high pressure xenon TPC for neutrinoless double beta decay search

*Tuesday, February 19, 2019 2:25 PM (20 minutes)*

**Abstract:**
The PandaX-III experiment uses high pressure Time Projection Chambers (TPCs) to search for neutrinoless double-beta decay of Xe-136 with high energy resolution and sensitivity at the China Jin-Ping underground Laboratory II (CJPL-II). Fine-pitch Microbulk Micromegas will be used for charge amplification and readout in order to reconstruct both the energy and track of the neutrinoless double-beta decay event. In the first phase of the experiment, the detector, which contains 200 kg of 90% Xe-136 enriched gas operated at 10 bar, will be immersed in a large water tank to ensure 5 m of water shielding. For the second phase, a ton-scale experiment with multiple TPCs will be constructed to improve the detection probability and sensitivity. A 20-kg scale prototype TPC with 7 Micromegas modules has been built to optimize the design of Micromegas readout module, study the energy calibration of TPC and develop algorithm of 3D track reconstruction. The preliminary results of the PandaX-III prototype TPC will be also presented in this talk.

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**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **863** Type: **Poster**

# PID system for Super C-$\tau$ Factory at Novosibirsk

The Super C-$\tau$ Factory at Novosibirsk is a new experiment with $e^+e^-$ - collider with energy W=2÷6 GeV and luminosity up to $10^{35}cm^{-1}s^{-1}$ (in 100 times higher than in operated today experiments in this energy region). For successful execution of the broad experimental program development of universal detector with excellent parameters is needed. R&D activities on all detector subsystems are carrying out today. The main requirements for PID system are following: good $\pi/K$-separation in whole operational momentum range and good $\mu/\pi$-separation up to 1.2 GeV/c. Few options are under consideration today: FARICH (Focusing Aerogel RICH) based on 4-layer aerogel tiles and more than 1 million channels photon detection pixels, threshold ASHIPH ( Aerogel SHifter PHotomultiplier) counters with 6000 liters of aerogel of two refractive indexes and TOF technique with time resolution better than 30 ps. All these options are described. Results of simulation, preliminary calculations and some results of prototypes tests are presented.

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**Session Classification:** Poster Session B

**Track Classification:** Cherenkov Detectors

Contribution ID: **865** Type: **Talk**

# The CMS High Granularity Calorimeter for the High Luminosity LHC

*Tuesday, February 19, 2019 2:00 PM (20 minutes)*

The CMS experiment at CERN will undergo significant improvements during the so-called Phase-II Upgrade to cope with a 10-fold increase in luminosity of the High Luminosity LHC (HL-LHC) era. Especially the forward calorimetry will then suffer from very high radiation levels and intensified pile-ups in the detectors. Thus, the CMS collaboration is designing a High Granularity Calorimeter (HGCal) to replace the existing endcap calorimeters. It features unprecedented transverse and longitudinal segmentation for both electromagnetic (ECAL) and hadronic (HCAL) compartments. This will facilitate particle-flow calorimetry, where the fine structure of showers can be measured and used to enhance pileup rejection and particle identification, whilst still achieving good energy resolution. The ECAL, and a large fraction of HCAL, will be based on hexagonal silicon sensors produced from 8-inch wafers, each with several hundreds of individual cells of 0.5 - 1 $cm^2$ cell size. The remainder of the HCAL will be based on highly-segmented scintillators with SiPM readout. An overview of the HGCAL project is presented in this talk with a focus on the silicon sensors; covering motivation, engineering design, expected performance and the current status of prototypes: from lab measurements to beam tests.

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**Session Classification:** Calorimeter

**Track Classification:** Calorimeters

Contribution ID: **866** Type: **Talk**

# Imaging with ion beams at MedAustron

*Thursday, February 21, 2019 5:20 PM (20 minutes)*

MedAustron is an Austrian cancer treatment center for proton and carbon therapy. For clinical use protons are accelerated up to 250 MeV, whereas carbon ions will be available up to 400 MeV/u. The facility also features a unique beam line exclusively for non-clinical research. This research beam line will be commissioned for even higher proton energies of up to 800 MeV.

In this contribution, development efforts towards an ion beam computed tomography system suitable for clinical use at MedAustron will be discussed, as well as general possibilities for performing beam tests at MedAustron.

Results from first test beams using silicon strip detectors in a tracking telescope as required in a proton computed tomography system will be presented. Additionally, findings from Geant4 simulations to optimize the set-up will be discussed along with first approaches to image reconstruction.

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**Session Classification:** Medical Applications

**Track Classification:** Medical Applications

Contribution ID: **867** Type: **Talk**

# Belle II aerogel RICH detector

*Wednesday, February 20, 2019 11:30 AM (20 minutes)*

Aerogel Ring Imaging CHerenkov counter (ARICH) - is the particle identification device installed in the forward region of the Belle II detector at SuperKEKB accelerator facility in Japan. The first electron – positron collisions at SuperKEKB took place 26 of April in 2018 during so called phase 2 run. Measured performance of the ARICH detector based on recorded bhabha events during phase 2 are presented.

To focus Cherenkov light ARICH use two 20 mm thick layers of silica aerogel radiator with 1.045 and 1.055 refractive index for upstream and downstream layer respectively. The photon detector plane consist of 420 Hybrid Avalanche Photo Detectors (HAPD) which conceived to operate in 1.5 T magnetic field. Each HAPD has 144 channels with size of 4.9 mm x 4.9 mm. ARICH is located two meters far from the iteration point. Its main goal is to separate kaons from pions in 0.5 - 4.0 GeV/c momentum range.

The particle identification algorithm based on ratios of log likelihood which takes into account Cherenkov angle and number of Cherenkov and background photons for given particle hypothesis. We measure 16 mrad angular resolution per photon and 10 photons per bhabha electron within 6 – 8 GeV/c momentum range which is in agreement with simulation within 10 % while measured number of background photons per track is 1.3 which is 30 % more than seen from simulation.

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**Session Classification:** Cherenkov

**Track Classification:** Cherenkov Detectors

Contribution ID: **868** Type: **Poster**

# Energy deposition of protons in silicon sensors at MedAustron

MedAustron is a hadron synchrotron primarily designed and built for cancer tumor treatment. Besides its clinical purpose, it is equipped with a dedicated beam line for non-clinical research. This beam line can be used for beam tests utilizing protons with an energy of up to 252 MeV at the moment, but 800 MeV will be available through 2019 as well as Carbon ions.
In order to understand the usability of this beam line for testing Silicon detectors we conducted first beam tests at MedAustron. This includes the design and commissioning of a trigger setup based on scintillators and PMTs, which is meant to stay permanently there. Moreover, the beam intensity had to be reduced from the nominal rate for clinical treatments of up to 10^10 particles per second down to 10^4. This allowed us to measure the beam profile utilizing silicon strip sensors read out by the ALiBaVa system. The nominal beam energy was varied between 52 and 252 MeV and was verified by determining the specific energy loss of protons in Silicon. As these energies are rather low compared to the typical HEP beam tests, the proton beam through the setup was simulated to determine necessary energy correction caused by losses through matter and air in front of the Si sensor. These approaches yielded good agreement with reference data from NIST, so MedAustron is considered as a reliable facility for future beam tests.

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**Session Classification:** Poster Session A

**Track Classification:** Semiconductor Detectors

Contribution ID: **870** Type: **Poster**

# Field effect transistor test structures for studies of inter-strip isolation in silicon strip detectors

Because of its radiation resilience, p-type silicon has been established as baseline material for tracking detectors in upcoming high-luminosity physics experiments. When deciding on the quality of p-type silicon strip sensors, strip isolation is crucial. Regions of highly doped p+ implant (p-stop) are introduced between n+ strips to interrupt the electron accumulation layer that forms at the interface to the overlying oxide. Doping concentration, implantation depth and geometry of the p-stop regions determine the achieved inter-strip resistance. Typically, inter-strip resistance is measured directly on the strip sensors. The measurement, however, is prone to substantial errors. Large resistances on the order of 100 GΩ require precise, low-noise measurement setups, which are influenced strongly by parasitic currents.
To provide a comparably simple alternative to measurements on strip sensors, this contribution aims to relate the threshold voltage and inter-channel resistance of field effect transistors (FET) to the inter-strip resistance of silicon strip sensors. We compare measurements of dedicated test structures to measurements on strip sensors with different n- and p-spray implantations and present comparative TCAD simulations. The FET test structures could present a fast and reliable option to judge inter-strip resistance and strip isolation properties on silicon sensors. This would be especially valuable for process quality control during future series productions.

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**Session Classification:** Poster Session B

**Track Classification:** Semiconductor Detectors

Contribution ID: **873** Type: **Poster**

# Development of a Time Projection Chamber for Ion Transmission Imaging

At the LMU Department of Medical Physics a portable platform for proton irradiation of small animals is under development for pre-clinical research with tumor bearing mouse models. The platform intends to use beams available at clinical facilities. It consists of a custom beamline to produce particle beams of the needed energy range and focus and several beam monitoring and imaging systems, used for pre-treatment animal imaging, positioning control and range verification during treatment.
In this context, we are developing an ion transmission tomography system, which combines particle position information from tracking detectors with a residual energy measurement of the transmitted particles with energies between few and 80MeV. To ensure precise tracking even of the lowest energy particles and to measure their residual energy with high precision, we are developing a small-size Time Projection Chamber (TPC) as rear detector of the imaging system with a discharge insensitive floating strip Micromegas readout structure. It features a tracking region and a range detection region, in which transmitted particles are stopped by a set of 0.5mm thick Mylar absorbers, alternating with few mm wide gas layers.
We will outline the construction of a working prototype and present detailed results from a testbeam with 22MeV protons. We will discuss the behavior of field-shaping and of insulating absorbers and present the imaging capabilities of the complete system as simulated by FLUKA.

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**Session Classification:** Poster Session A

**Track Classification:** Gaseous Detectors

Contribution ID: **875** Type: **Poster**

# Calibration and Performance of the Compact High Energy Camera SiPM Prototype Front-End Electronics proposed for the Cherenkov Telescope Array

The Compact High Energy Camera (CHEC) is a full-waveform camera, designed and proposed for the dual mirror Schwarzschild-Couder small sized telescope of the Cherenkov Telescope Array. CHEC-S is the second prototype and is based upon silicon photomultiplier (SiPM) photodetectors optimised for single photon counting and nanosecond timing. The camera water-cooled focal plane plate comprises a total of 2048 SiPM pixels organised as 32 independent sensor and front-end electronics (FEE) modules providing event detection and signal digitisation of Cherenkov light flashes. Each module comprises an 8 x 8 tile arrangement of SiPM pixels, coupled to a 64-channel preamplifier-buffer followed by an FEE module based around the TARGET chipset, which combines triggering and waveform capture functionality.

We describe test and calibration procedures performed at single module level focusing on characterising the SiPM photodetectors, optimised preamp-buffer and updated CHEC-S FEE readout module. We present end-to-end performance results for the readout chain from photodetector through to calibrated image data. Analysis results include; gain-matching, dynamic range, trigger efficiency, night-sky-background effects, event waveform characteristics, electronic channel crosstalk, SiPM angular dependency and optical crosstalk, and dependence on operating temperature.

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**Session Classification:** Poster Session A

**Track Classification:** Electronics

Contribution ID: **876** Type: **Poster**

# RADEM, a Radiation Hard Electron Monitor for the JUICE mission

The ESA next class-L mission to the Jovian system, JUICE, the Jupiter Icy Moons Explorer, will collect valuable data while orbiting Jupiter and three its moons for a period of three and a half years. RADEM, the Radiation Hard Electron Monitor is being developed to provide housekeeping information. It will also provide valuable scientific data on the energetic radiation environment of the Jovian system for the full mission duration. The Jovian radiation environment, dominated by electrons, results from Jupiter's gigantic magnetic field and its interaction with its moons and it is extremely hazardous and complex. So far, only the Galileo spacecraft performed long-term measurements of the Jovian radiation environment.
RADEM features three detector heads: the Proton and Ion Stack Detector with two copper collimators. The first one is surrounded by 8 Si sensors separated by increasingly thicker aluminum and tantalum absorbers, to measure protons from 5 to 250 MeV and the second by 2 Si sensors to measure ion species; the Electron Stack Detector consists of a single copper collimator surrounding 8 Si sensors tailored to measure electrons from 0.3 to 40 MeV; and a Directionality Detector , in which a single copper torus with 28 apertures, each leading to an individual Si sensor, to measure 28 directions with a field-of-view close to 2π str to correct for electron flux angular dependences. In this work, RADEM overall properties and Engineering Model calibration results are shown.

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**Session Classification:** Poster Session A

**Track Classification:** Semiconductor Detectors

Contribution ID: **881** Type: **Poster**

# First tests of a reconfigurable depleted MAPS sensor for Digital Electromagnetic Calorimetry

Digital calorimetry relies on a highly granular detector where the cell size is sufficiently small so that only a single particle in a shower enters each cell within a single readout cycle. The DECAL sensor, a depleted monolithic active pixel sensor (DMAPS), has been proposed as a possible technology for future digital calorimeters. A DECAL sensor prototype has been designed and fabricated in the TowerJazz 180 nm CMOS imaging process, using high resistivity 18 μm epitaxial layer. The prototype has a pixel matrix of 64x64 pixels with a pitch of 55x55 μm, and reads out using fast logic at 40 MHz. Each pixel contains four collection electrodes, trimming logic, pre-amplifier, shaper and discriminator with digital output. The pixel configuration logic provides a 5 bit calibration DAC and a mask flag. It can be reconfigured to function as either a strip sensor, for particle tracking, or a pad sensor, counting the number of pixels above threshold for digital calorimetry. The sensor is mounted on a custom designed PCB and read out using an Ethernet based readout system.

The talk will present results of chip characterisation, including digital summing logic, analogue pixel performance and threshold scans under laser illumination. Measurements will be compared to expected results from simulation.

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**Session Classification:** Poster Session B

**Track Classification:** Semiconductor Detectors

Contribution ID: **882** Type: **Poster**

# Thin, Double-Sided Radiation Detectors Using Alternative Implantation Techniques

The CiS Forschungsinstitut fuer Mikrosensorik is engaged in developments of radiation detector technologies on several different fields. Current projects are dealing with large area thinned sensors, active edge sensors and 3D-sensors.

The challenge of producing cost-efficient, thin and large-sized sensors for High Energy Physics experiments is approached by a wet etching technology. Cavities are etched with KOH to the sensors' back side to reduce their thickness to the order of 150…50 µm. The technology was successfully applied on single-sided processes on 4" and 6" wafers. It is now transferred to a double-sided process which makes high demands on the wafer process, especially the photolithography. Further focus is set on the thickness homogeneity and very shallow doping profiles. One goal is to realize a thin, double-sided Delta-E strip sensor for an upgraded TRex detector (Miniball experiment at ISOLDE).

In order to reduce the inactive area of planar sensors to a minimum, an active edge technology can be used. A corresponding pixel sensor run was finished successfully. It showed that the vertical DRIE trenches worked in combination with different side wall doping methods. N- and p-substrates with two wafer thicknesses have been produced. A good yield was achieved for sensors with inactive edges down to 50 µm. The experiences gained within this run are currently used to develop two different 3D-sensor processes.

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**Session Classification:** Poster Session A

**Track Classification:** Semiconductor Detectors

Contribution ID: **883** Type: **Poster**

# Neutron detector based on a layer of LiI:Eu

Neutron detectors based on gas-discharge tubes filled with 3He have a high thermal neutron registration efficiency and are not sensitive to others ionizing radiation. But the main disadvantage of such detectors is the high cost of a very rare isotope 3He.
One of the effective elements for the registration of thermal neutrons is the isotope of lithium 6Li, which nature contamination is much more (about 7.5% of the total lithium) than 3He-content. LiI:Eu scintillation material enriched with 6Li has a good neutron/gamma discrimination (more than 0.8).
The purpose of this work was to develop a new design of a thermal neutron detector, based on a LiI:Eu scintillation material.
Due to possibility of easy installation a new detector instead of 3He a tubular design of detector was used. The detector was made by applying a crystalline thin layer of LiI:Eu on the inner wall of an ampoule. The registration efficiency of thermal neutrons obtained by a tubular detector with a natural isotopic composition of Li with a total thickness of 3.2 mm deposited is 23.47%. Improving of detector efficiency may achieved by increasing the thickness of the scintillation layer and/or additional enrichment of the material with the 6Li.

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**Session Classification:** Poster Session A

**Track Classification:** Miscellaneous

Contribution ID: **886** Type: **Poster**

# Measurements of Beam Backgrounds at SuperKEKB

The Belle II experiment at the SuperKEKB asymmetric energy $e^+e^-$ collider in Tsukuba, Japan, finished its commissioning phase in 2018. In the years to follow the SuperKEKB will deliver an instantaneous luminosity of $8 \cdot 10^{35}\mathrm{cm}^{-2}\mathrm{s}^{-1}$, which is 40 times higher than the record luminosity of its predecessor, KEKB. In order to exploit the physics potential of this new generation flavor factory it is crucial for the Belle II detector to be able to cope with high beam induced background levels. These are critical from the point of detectors radiation hardness, data throughput capabilities, and performance of event reconstruction algorithms. During the early phase of Belle II and SuperKEKB operation the background levels were measured at different accelerator conditions by the Belle II detector systems and by a set of dedicated beam background detectors (collectively called BEAST II). These measurements enable us to disentangle backgrounds originating from different sources and help us to predict the behavior of background levels with further increase of SuperKEKB instantaneous luminosity. In the talk we present the first results of mentioned measurements, comparison with the background levels expected from the simulation, and discuss the impact of obtained results on the Belle II performance.

**Primary author:** SANTELJ, Luka (Jozef Stefan Institute)

**Presenter:** SANTELJ, Luka (Jozef Stefan Institute)

**Session Classification:** Poster Session B

**Track Classification:** Miscellaneous

Contribution ID: **890** Type: **Poster**

# CMOS based SPAD Arrays for the Detection of Rare Photon Events at Cold Temperatures

We have operated a 2D array of $88 \times 88$ Single Avalanche Photo Diodes fabricated in a CMOS technology in liquid nitrogen to evaluate its dark count rate at low temperatures. We found a rate of <20 dark counts per second and per $mm^2$ equivalent active area and observed an additional background at the edge of the array, which we attribute to photons emitted in the peripheral circuitry. The low dark count rate in combination with good timing information and excellent spatial resolution may lead to novel applications of such chips, like for instance search experiments using liquid Argon or Xenon. As a next step, we have therefore developed a 2D array with high fill factor and with a very low power, data-driven readout architecture.

**Primary authors:** FISCHER, Peter (Heidelberg University); KELLER, Michael (Heidelberg University)

**Presenter:** KELLER, Michael (Heidelberg University)

**Session Classification:** Poster Session B

**Track Classification:** SiPM

Contribution ID: **891** Type: **Talk**

# RD53A: a large-scale prototype chip for the phase II upgrade in the serially powered HL-LHC pixel detectors

*Wednesday, February 20, 2019 10:15 AM (20 minutes)*

The phase II upgrade of the HL-LHC experiments within the LHC intends to deepen the studies of the Higgs boson and to allow the discovery of further particles by adding an integrated luminosity of about $4000 fb^{-1}$ over 10 years of operation. This upgrade would overwhelm the installed pixel detector readout chips with higher hit rates and radiation levels than ever before. To match these extreme requirements the RD53 collaboration, a joint effort between ATLAS and CMS, developed RD53A, a new generation pixel detector readout chip prototype manufactured in a $65nm$ CMOS technology. It is half the size of the final pixel chips and designed to meet requirements in the face of $3GHz/cm^2$ hit rate after irradiation to $500Mrad$. The detector is capable to use $50x50\mu m^2$ or $25x100\mu m^2$ pixels with high readout speed of up to 4 links per chip with $1.28Gbit/s$ each. Shunt-LDO regulators integrated on the bottom of the chip provide the required voltages to the two power domains, analog and digital. These regulators enable serially powering of the pixel modules, which is the only feasible, radiation hard scheme to ensure acceptable power cable losses and to stay within the material budget for the future pixel detectors. An overview of the status and challenges of serial powering and the shunt-LDO regulator development will be given.

**Co-authors:** RD53 COLLABORATION; Mr STILLER, Andreas (Fachhochschule Dortmund)

**Presenter:** DIMITRIEVSKA, Aleksandra (Lawrence Berkeley National Lab. (US))

**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **893** Type: **Poster**

# Vacuum ultra-violet SiPM development for nEXO

nEXO is an experiment being designed to search for neutrino-less double beta decay in liquid Xenon. Excellent energy resolution is required for background rejection which in turns require excellent efficiency for the detection of scintillation photons. At the same time, the intrinsic radioactive background of component must be minimize which rules out using photo-multiplier tube (PMTs). Silicon photo-multipliers (SiPMs) appear ideally suited for nEXO providing single photon sensitivity, low dark noise at the liquid Xenon temperature and very low radioactive material content. The main challenge of the R&D effort within nEXO had been to achieve good photo-detection efficiency between 165 and 190nm (Vacuum Ultra-Violet, VUV). The current best SiPM from Fondazione Bruno Kessler achieves about 25% efficiency at 175nm, which is sufficient for nEXO. Nevertheless the nEXO collaboration is investigating solutions for enhancing the efficiency by using anti-reflective coating. In this talk we will show the development of VUV SiPM within the nEXO collaboration.

**Primary author:** RETIERE, Fabrice (TRIUMF)

**Presenter:** RETIERE, Fabrice (TRIUMF)

**Session Classification:** Poster Session A

**Track Classification:** SiPM

Contribution ID: **897** Type: **Poster**

# ArgonCube: A Modular LArTPC with Pixelated Charge Readout

ArgonCube is a novel, modular approach to Liquid Argon Time Projection Chambers (LArTPCs). ArgonCube segments the total detector volume into an number of electrically and optically isolated TPCs sharing a common cryostat, providing improved performance while also mitigating technical risks with LAr purity and electric field. The field shaping uses a continuous resistive plane, field-shell, instead of mechanical cage, minimising dead material near the active volume and reducing power dissipation in the case of HV breakdown. For the charge readout a pixelated anode plane is employed, with bespoke readout electronics providing cold amplification and digitisation, enabaling unambiguous true 3D event reconstruction with a flat efficiency as function of track angle. The light readout is achieved with large dielectric planes inside the field-shell, this minimises effects of Rayleigh scattering, allowing for the efficient detection of contained prompt scintillation, thus improving trigger efficiency. ArgonCube has already found application in the high multiplicity environment of the Deep Underground Neutrino Experiment (DUNE) Near Detector (ND). An ArgonCube prototype will be deployed as the core component of ProtoDUNE-ND at Fermilab in 2020.

**Primary author:** METTLER, Thomas Josua (Universitaet Bern (CH))

**Co-author:** SINCLAIR, James Robert (Universitaet Bern (CH))

**Presenter:** METTLER, Thomas Josua (Universitaet Bern (CH))

**Session Classification:** Poster Session A

**Track Classification:** Gaseous Detectors

Contribution ID: **898** Type: **Talk**

# Microfabricated silicon substrates for pixel detectors assembly and thermal management

*Wednesday, February 20, 2019 9:50 AM (20 minutes)*

At CERN, the Detector Technologies (DT) group of the Experimental Physics (EP) department is actively investigating a number of innovative solutions for heat management and detector module assembly in HEP experiments. Among these, recent research carried out at EP-DT has focused on the development of microfluidic devices to cool silicon pixel detectors. In this respect, continuous advances in microengineering have opened the door to smaller and more efficient cooling devices capable of handling increasing power densities with a minimum mass penalty.
In 2014, the NA62 experiment has pioneered the use of a silicon microfluidic system with single-phase liquid $C_6F_{14}$ for the thermal management of its GigaTracKer (GTK) pixel detectors. Following the NA62 success, LHCb became the first LHC experiment to adopt a similar solution. The future upgrade of the LHCb's Vertex Locator (VeLo) will combine multiple silicon plates with embedded microchannels with an evaporative $CO_2$ system to cool fifty-two pixel detector modules dissipating a total of about 2 kW.
This paper will present the implementation of this novel approach for the construction and thermal management of the NA62 GTK and LHCb VeLo pixel detectors. Future developments such as 3D-printed microfluidics and microchannels embedded into monolithic pixel detectors will also be discussed.

**Primary author:** MAPELLI, Alessandro (CERN)

**Presenter:** MAPELLI, Alessandro (CERN)

**Session Classification:** Semiconductor Detectors

**Track Classification:** Semiconductor Detectors

Contribution ID: **899** Type: **Poster**

# First results on 3D pixel sensors interconnected to RD53A readout chip after high energy proton irradiation

In this presentation results obtained in beam test experiments with 3D columnar pixel sensors interconnected with the RD53A readout chip are reported. RD53A is the first prototype in 65nm technology issued from RD53 collaboration for the future readout chip to be used in the upgraded pixel detectors. The interconnected modules have been tested on hadron beam at CERN before and after irradiation, in the CERN IRRAD facility, to an equivalent fluence of 1E16 neq/cm2 (1MeV equivalent neutrons). All results are obtained in the framework of the CMS R&D activities in view of the pixel detector upgrade for the High Luminosity phase of the LHC at CERN (HL-LHC). The sensors were made in FBK foundry in Trento, Italy, and their development was done in collaboration with INFN (Istituto Nazionale di Fisica Nucleare, Italy). Preliminary analysis of collected data shows hit detection efficiencies around 97% measured after high energy proton irradiation.

**Co-author:** MESCHINI, Marco (Universita e INFN, Firenze (IT))

**Presenter:** DUARTE CAMPDERROS, Jordi (Universidad de Cantabria (ES))

**Session Classification:** Poster Session B

**Track Classification:** Semiconductor Detectors

Contribution ID: **904** Type: **Talk**

# Development of the thin TOF-PET scanner based on fast monolithic silicon pixel sensors

*Thursday, February 21, 2019 5:45 PM (20 minutes)*

The Thin-TOF PET (TT-PET) project aims at the construction of a small-animal PET scanner based on silicon monolithic pixel sensors with 30 ps time resolution for 511 keV photons, equivalent to 100 ps time resolution for minimum ionizing particles. The high time resolution of the pixel sensor allows for precise time of flight measurement of the two photons and a significant improvement in the signal-to-noise ratio of reconstructed images. The TT-PET scanner will also have sensitivity for photon depth of interaction, thus improving the spatial resolution across its whole field of view. The detectors, developed for this application, are monolithic silicon pixel sensors in SiGe BiCMOS technology. The prototype chip, comprising a $3 \times 10$ pixel matrix and a 50 ps binning TDC, has been recently tested at the CERN SPS beam test facility. The detector shows an efficiency greater than 99% and a time resolution for minimum ionizing particles of approximately 130 ps for $500 \times 500\mu m^2$ pixels with 600 fF capacitance.

**Primary authors:** HAYAKAWA, Daiki (Universite de Geneve (CH)); IACOBUCCI, Giuseppe (Universite de Geneve (CH)); PAOLOZZI, Lorenzo (Universite de Geneve (CH)); VALERIO, Pierpaolo (CERN); RIPICCINI, Emanuele (UNIGE); FERRERE, Didier (Universite de Geneve (CH)); RATIB, Osman (University of Geneva); FORSHAW, Dean Charles (Universitaet Bern (CH)); WEBER, Michele (Universitaet Bern (CH)); MIUCCI, Antonio (Universitaet Bern (CH)); BANDI, Yves (Universitaet Bern (CH)); CARDARELLI, Roberto (INFN e Universita Roma Tor Vergata (IT)); Dr RÜCKER, Holger (IHP Microelectronics); Dr KAYNAK, Mehmet (IHP Microelectronics)

**Presenter:** HAYAKAWA, Daiki (Universite de Geneve (CH))

**Session Classification:** Medical Applications

**Track Classification:** Medical Applications

Contribution ID: **906** Type: **Poster**

# Novel monolithic array of Silicon Drift Detector systems designed for X-ray absorption fluorescence and low energy X-ray fluorescence

In recent decades, new and better detectors for X-ray spectroscopy have been developed, and, among these, many are based on Silicon Drift Detectors (SDD). We present a further improvement resulting from the dedicated optimization of the whole detector system: SDD detector design and production technology, ultra-low noise front-end electronics, dedicated acquisition system and digital filtering.
Two new detector systems based on monolithic arrays of SDD have been developed.
The first detector system is designed for Low Energy X-Ray Fluorescence (LEXRF), in particular for the TwinMic beamline at Elettra Sincrotrone Trieste. It is composed of 4 trapezoidal monolithic arrays of SDDs, each having 8 square cells; the system has a total non-collimated area of 1230 mm<SUP>2</SUP> and it is optimized to work in vacuum in an energy range of 200-4000 eV.
The second detector system, designed for the Jordan's synchrotron light source SESAME, is optimized for X-Ray Fluorescence (XRF) and X-ray Absorption Fine Structure (XAFS). It is composed of 8 rectangular monolithic arrays of SDDs, each having 8 square cells. This system has a total non-collimated area of 576 mm<SUP>2</SUP> and it is optimized to work in an energy range of 3-30 keV.
The two detector systems were tested at the Elettra Sincrotrone Trieste on the TwinMic and XAFS beamlines. The results of the latest characterization tests carried out with the two systems will be presented.

**Primary author:** CIRRINCIONE, Daniela (INFN-Ts)

**Co-authors:** ALTISSIMO, Matteo (Elettra Sincrotrone Trieste); ANTONELLI, Matias (Elettra Sincrotrone Trieste); AQUILANTI, Giuliana (Elettra Sincrotrone Trieste); BELLUTTI, Pierluigi (FBK); BERTUCCIO, Giuseppe (Politecnico di Milano); BORGHI, Giacomo (TERA Foundation (IT)); BUFON, Jernej (Elettra Sincrotrone Trieste); CAUTERO, Giuseppe (Elettra Sincrotrone Trieste); FICORELLA, Francesco (FBK - Fondazione Bruno Kessler); GANDOLA, Massimo (Politecnico di Milano); GIANONCELLI, Alessandra (Elettra Sincrotrone Trieste); GIURESSI, Dario (Elettra Sincrotrone Trieste); KOUROUSIAS, George (Elettra Sincrotrone Trieste); MELE, Filippo (Politecnico di Milano); MENK, Ralf Hendrik (Elettra Sincrotrone Trieste); OLIVI, Luca (Elettra Sincrotrone Trieste); ORZAN, Giulio (INFN Trieste); PICCIOTTO, Antonino (Fondazione Bruno Kessler - FBK); RASHEVSKAYA, Irina (Universita e INFN, Trieste (IT)); Dr RASHEVSKY, Alexander (INFN di Trieste); SAMMARTINI, Martina (Politecnico di Milano); SCHILLANI, Stefano (Elettra Sincrotrone Trieste); STEBEL, Luigi (Elettra Sincrotrone Trieste); Dr ZAMPA, Gianluigi (INFN di Trieste); Dr ZAMPA, Nicola (INFN di Trieste); ZORZI, Nicola (Fondazione Bruno Kessler - FBK); Dr VACCHI, Andrea (INFN di Trieste)

**Presenter:** CIRRINCIONE, Daniela (INFN-Ts)

**Session Classification:** Poster Session A

**Track Classification:** Semiconductor Detectors

Contribution ID: **907** Type: **Poster**

# Fast Beam-Beam Collisions Monitor for experiments at NICA

Two interaction points are foreseen for beam intersections of NICA collider at JINR. The event-by-event monitoring of collisions is required both for the beam tuning and for event selection using the precise timing (T0) of the events for MPD and SPD experiments at NICA. Data on the reaction plane and on the event centrality of nucleus-nucleus collisions should be also obtained for physics analysis.

The Fast Beam-Beam Collisions (FBBC) monitor based on the Micro Channel Plates (MCPs) is proposed. New MCPs with the improved characteristics, such as small diameter (6μ) channels, low resistivity (100-500 MOhm), high gain (~107), short fast rise-time (~0.8ns) signals, will be used. The ultra-high vacuum (UHV) compatibility and low-mass compact design allow the application inside the vacuum beam line. The FBBC is also considered for the local polarimetry at the SPD to monitor the beam polarization during data taking.

The FBBC uses the concept of the isochronous multi-pad readout and summation of short (~1ns) signals. The prototypes were developed and tested previously using the beams of MIPs both at JINR and CERN. Results of model simulations and tests of new prototypes of the fast MCP readout setups are presented and discussed.

**Primary authors:** Dr FEOFILOV, Grigory (Saint-Petersburg State University); Prof. VALIEV, Farrhat (Saint-Petersburg State University); Dr BALDIN, Anton (JINR andInstitute for Advanced Studies ”OMEGA”, Dubna, RF); Dr HAR’YUZOV, Pavel (JINR and Institute for Advanced Studies ”OMEGA”, Dubna, RF)

**Presenter:** Dr FEOFILOV, Grigory (Saint-Petersburg State University)

**Session Classification:** Poster Session A

**Track Classification:** Miscellaneous

Contribution ID: **911** Type: **Talk**

# DANAE – A new effort to directly search for Dark Matter with DEPFET-RNDR detectors

*Tuesday, February 19, 2019 2:50 PM (20 minutes)*

The direct search for dark matter (DM) at the sub-GeV/c² mass scale gained special interest during the last years, mainly motivated by various theoretical models. To search for individual DM-electron interactions in Si-semiconductor devices a readout noise level of less than 1e- RMS is required.

One possible technique which promise a sub-electron noise level is the *Depleted P-channel Field Effect Transistor* (DEPFET) with *Repetitive Non Destructive Readout* (RNDR). Such a low noise level was successfully demonstrated with a single pixel DEPFET-RNDR prototype [1]. The follow-up project DANAE aims to apply the DEPFET-RNDR technique to the direct search for DM-electron interactions. The assembly of a setup with a detector matrix of 64x64 pixels is envisaged. Currently, a dedicated test stand for the optimization of the dark current and the detector characterization is under construction.

In this contribution we will introduce the DEPFET-RNDR technique and the DANAE project. Afterwards, the status of the ongoing R&D work will be reported which is currently focused on the setup construction and the investigation of the temperature dependence of the dark current. Finally we will discuss future prospects of DANAE.

[1] A. Bähr, H. Kluck, J. Ninkovic, J. Schieck and J. Treis, Eur. Phys. J. C77 (2017) 905, arXiv:1706.08666

**Primary author:** Dr KLUCK, Holger (HEPHY)

**Co-authors:** TREIS, Johannes (MPG Semiconductor Laboratory); SHI, Hexi (HEPHY); NINKOVIC, Jelena (MPG Halbleiterlabor); Prof. SCHIECK, Jochen (Institut für Hochenergiephysik der Österreichischen Akademie der Wissenschaften, 1050 Wien, Austria); BÄHR, Alexander (MPG-HLL)

**Presenter:** Dr KLUCK, Holger (HEPHY)

**Session Classification:** Dark matter and other low-background experiments

**Track Classification:** Dark matter and other low-background experiments

Contribution ID: **916** Type: **Talk**

# The LHAASO Experiment

*Thursday, February 21, 2019 3:10 PM (20 minutes)*

The Large High Altitude Air Shower Observatory (LHAASO) plans to build a hybrid extensive air shower (EAS) array with an area of about 1 km2 at an altitude of 4410 m a.s.l. in Sichuan province, China, aiming for very high energy gamma ray astronomy and cosmic ray physics around the spectrum knees. With an extensive air shower array covering an area of 1.3 km2 equipped with >40,000 m2 muon detectors and a 78,000 m2 water Cherenkov detector array, a sensitivity of about 1% Crab unit to gamma ray sources is achieved. Thus LHAASO will survey the entire northern sky for gamma ray sources with a full duty cycle and high sensitivity. The spectra of all sources in its field of view will be measured simultaneously over a wide energy range from 300 GeV to 1 PeV. This measurement will offer a great opportunity for identifying cosmic ray origins among the sources. The LHAASO is also equipped with 12 Cherenkov/fluorescence telescopes, so it will serve as an effective detector for energy spectrum measurements of different mass groups of cosmic rays.

**Primary author:** HE, Huihai (Institute of High Energy Physics, CAS)

**Presenter:** HE, Huihai (Institute of High Energy Physics, CAS)

**Session Classification:** Astroparticle Detectors

**Track Classification:** Astroparticle Detectors

Contribution ID: **918** Type: **Invited Talk**

# Searches for Gravitational Waves by LIGO and Virgo: Recent Results and Future Plans

*Monday, February 18, 2019 10:20 AM (45 minutes)*

The first discoveries by LIGO and Virgo have established gravitational wave detectors as a powerful new tool for probing the highest energy astrophysical events in the universe. In this talk, I'll give an overview of the detectors and present the most recent results on the searches for binary black hole/binary neutron star mergers as well as searches for other classes of gravitational wave events. In addition, I'll give a preview of plans for the emerging global network of detectors in the next decade and beyond.

**Presenter:** REITZE, David

**Session Classification:** Plenary 1

Contribution ID: **919** Type: **Invited Talk**

# From particle physics technologies to society

*Monday, February 18, 2019 11:10 AM (45 minutes)*

Particle physics has revolutionized our understanding of the Universe, and it is the epitome of basic research: seeking answers to fundamental questions. In its pursuit of knowledge, particle has also played a role in developing innovative technologies: frontier instruments like the Tevatron at Fermilab or the Large Hadron Collider (LHC) at CERN, and their detectors, require frontier technologies, well beyond the industrial know-how at the time the accelerators and the experiments were conceived. The tools of the trade of particle physicists – accelerators, detectors, computing and simulations – have found applications in a variety of fields outside physics research. In some cases, these software and hardware tools have been adopted by scientists working in entirely different research areas: Geant4, Scientific Linux, synchrotron light sources. Innovations such as the World Wide Web have profoundly changed society, and there are many prominent examples in healthcare, from accelerator-based cancer therapy to medical imaging instrumentation. But there is also a myriad of lesser-known applications that have an impact in aerospace, cultural heritage, industry 4.0, food safety. This talk will explain how advances in particle physics-related technologies have had a positive impact in many fields of society, and in particular in medical and biomedical technologies and research.

**Presenter:** FRISCH, Benjamin (CERN)

**Session Classification:** Plenary 1

Contribution ID: **920** Type: **Invited Talk**

# The Silicon Photomultiplier Status and Perspectives

*Monday, February 18, 2019 4:15 PM (45 minutes)*

The Silicon Photomultiplier (SiPM) is a solid-state device capable of sensing, timing and quantifying with high accuracy light signals down to the single-photon level. Featuring large internal gain with negligible fluctuations, high intrinsic timing resolution, low-voltage operation, insensitivity to magnetic fields, high degree of radio-purity, mechanical robustness and excellent uniformity of response, the SiPM is a very attractive alternative to Vacuum and Hybrid Photomultiplier Tube devices.

This review talk summarizes the present status of the SiPM development and put it in future perspective by examining the four following subjects:
1) Device Physics and Technology
2) SiPM properties and performance
3) New developments and trends
4) Selected applications examples

After a short introduction aiming at presenting the two main families of SiPM (namely the Analog and the Digital SiPM) the review will illustrate the Physics of the device. In particular the main working principles of the Single Photon Avalanche Diode (SPAD), which is the building block of any SiPM, will be discussed in order to clarify both intrinsic benefits and issues related to the solid-state sensor and to introduce the technology challenges that in the last 15 years have been addressed and gradually solved. Key Technology points will be then shown to be mostly related to the constraints (1) of building the SiPM device as a closely packed array of thousands of SPADs working in parallel and (2) of providing effective feedback mechanisms for controlling the SPADs discharge and recharge. Custom and CMOS silicon technologies will be discussed while illustrating the main technological differences between the Analog and the Digital SiPM families.

In the second part of the review the SiPM properties will be discussed in terms of main parameters characterization. Gain and dynamic range , Noise (both of uncorrelated and correlated type), Phodo-Detection Efficiency (PDE), Timing properties, stability and radiation hardness will be addressed, providing also the occasion for a performance comparison with respect to other types of high-sensitivity light sensors.

Despite the SiPM technology is quite mature there is still large room for improvement. Thus in the third part of the review the most challenging new developments and trends will be instanced by showing how noise (for example single photo-electron equivalent noise or correlated after-pulsing noise) can be mitigated, how the sensitivity spectra are being extended towards very short or long wavelengths (respectively VUV and NIR regions) and how radiation hardness can be improved.

Eventually, selected application examples will illustrate how, in addition to straightforward applications, like for instance high energy calorimetry or medical imaging, the SiPM is becoming the baseline option also for low-light intensity applications, for fast timing applications and, by exploiting their excellent performances at cryogenic temperatures, even for very large area applications. Illustrations of options and clever solutions concerning the related Front-End electronics will be also provided.

**Presenter:** COLLAZUOL, Gianmaria (University of Padova and INFN Padova)

**Session Classification:** Plenary 2

Contribution ID: **921** Type: **Invited Talk**

# CMOS Active Pixel Sensors for High Energy Physics

*Friday, February 22, 2019 9:00 AM (45 minutes)*

CMOS technology, which fueled the rapid growth of the information technology industry in the past 50 years, has also played and continues to play a crucial role in the remarkable development of detectors for High-Energy Physics (HEP) experiments. The amazing evolution of CMOS transistors in terms of speed, integration and cost decrease, allowed a continuous increase of density, complexity and performance of the front-end and readout circuits for HEP detectors. With the advent of CMOS Active Pixel Sensors (APS), where the sensing layer and its readout circuitry are combined in a single silicon device, CMOS became also the technology for a new generation of vertex and tracking detectors. After a brief historical excursus on the development of CMOS APS, their most recent developments and applications in HEP, as well as some examples in other scientific domains, will be presented. Novel developments and prospects for further improvement of these devices in terms of integration scale, timing and radiation hardness will be discussed.

**Presenter:** MUSA, Luciano (CERN)

**Session Classification:** Plenary 4

Contribution ID: **922** Type: **Invited Talk**

# Quantum Sensors in High-Energy Physics

*Tuesday, February 19, 2019 9:00 AM (45 minutes)*

I will discuss recent efforts in applying quantum information science (QIS) technology to High Energy Physics experiments, in particular efforts using quantum sensors in the search for low mass dark matter, and axion-line particles. I will also discuss the possible applications in QIS for technologies developed for HEP experiments.

**Presenter:** ESTRADA, Juan (fermilab)

**Session Classification:** Plenary 3

Contribution ID: **923** Type: **Invited Talk**

# Large Liquid Argon TPCs and the search for CP Violation in the lepton sector with long baseline experiments

*Friday, February 22, 2019 2:00 PM (45 minutes)*

With three-neutrino-families mixing firmly established in recent years, and the relatively large value of theta_13 observed, the race is on to discover CP Violation in neutrino mixing in accelerator-driven long baseline neutrino oscillation experiments. NOvA and T2K will continue to provide increasingly precise measurements of the PMNS mixing matrix parameters into the next decade. DUNE will use giant Large TPCs deep underground in South Dakota to detect neutrinos from Fermilab starting early in the second half of the next decade. Hyper-K in Japan intend to use a giant underground water Cerenkov to detect the neutrino beam from J-PARC. Both experiments would resolve the neutrino mass ordering question and achieve excellent CP Violation sensitivity. The kiloton-scale single phase ProtoDUNE (NP04) at the CERN Neutrino Platform has demonstrated the LAr TPC design for the DUNE Far Detector. Construction, operation and performance of this detector will be the main focus of this contribution.

**Presenter:** TOURAMANIS, Christos (University of Liverpool (GB))

**Session Classification:** Plenary 5

Contribution ID: **924** Type: **Invited Talk**

# Instrumentation – state of the art and a look into the future

*Friday, February 22, 2019 5:10 PM (45 minutes)*

Progress in experimental physics relies often on advances and breakthroughs in instrumentation, leading to substantial gains in measurement accuracy, efficiency and speed, or even opening completely new approaches and methods. At a time when the R&D for the upgrade of the large LHC experiments is still in full swing, the Experimental Physics Department of CERN has proposed a new technological R&D programme from 2020 onwards that will rely on a sustained cooperation with the HEP community. The programme covers the domains detectors, electronics, software and intimately connected domains like mechanics, cooling and experimental magnets.

This talk will try to highlight new ideas, advances and breakthroughs presented at this conference and, whenever possible and meaningful, put them in relation to the planned R&D programme.

**Presenter:** JORAM, Christian (CERN)

**Session Classification:** Summary

Contribution ID: **925** Type: **not specified**

# Award Ceremony

*Friday, February 22, 2019 4:45 PM (25 minutes)*

**Presenter:** Prof. KLANNER, Robert (University of Hamburg)

Contribution ID: **926** Type: **not specified**

# Closing

*Friday, February 22, 2019 6:00 PM (5 minutes)*

**Presenter:** KRAMMER, Manfred (CERN)

Contribution ID: **929** Type: **Talk**

# Information from the Organizers

*Monday, February 18, 2019 10:10 AM (10 minutes)*

**Presenter:** BERGAUER, Thomas (Austrian Academy of Sciences (AT))

**Session Classification:** Opening

Contribution ID: **930** Type: **Invited Talk**

# Art and History of Vienna

*Monday, February 18, 2019 6:00 PM (45 minutes)*

The city of Vienna was essentially founded by the ancient Romans. In the late middle ages, it became the capital of the Habsburg Empire, and consequently grew in size and importance. Even though there are some Roman excavations, most of the architectural heritage originates from the monarchy. In particular, the turn of the 19th to 20th centuries was undoubtedly a peak in many aspects of arts and culture, and even the population of Vienna was then higher than today. Nonetheless, the monarchy terminated almost hundred years ago and gave way to modernism. All periods of fine arts are represented in Vienna, by architecture as well as in museums. In addition, performing arts and classical music are offered in various places. This presentation will provide an overview of the history of Vienna, the periods of art and where to spot them, with a particular focus on the locations where social events will take place during this conference.

**Presenter:** FRIEDL, Markus (Austrian Academy of Sciences (AT))

**Session Classification:** Art and History of Vienna

Contribution ID: **931** Type: **not specified**

# Single layer Compton detectors for measurement of polarization correlations of annihilation quanta

**Presenter:** MAKEK, Mihael (Faculty of Science, University of Zagreb)

**Session Classification:** Medical Applications

Contribution ID: **932** Type: **Talk**

# Opening

*Monday, February 18, 2019 10:00 AM (1 minute)*

**Presenter:** KRAMMER, Manfred (Chairman OC VCI)

**Session Classification:** Opening

Contribution ID: **933** Type: **Talk**

# Welcome

*Monday, February 18, 2019 10:01 AM (3 minutes)*

**Presenter:** BRASSEUR, Georg (OeAW - President of the Division of Mathematics and Natural Sciences)

**Session Classification:** Opening

Contribution ID: **934** Type: **Talk**

# Welcome

*Monday, February 18, 2019 10:04 AM (3 minutes)*

**Presenter:** SCHIECK, Jochen (TU and HEPHY - Director of HEPHY)

**Session Classification:** Opening

Contribution ID: **935** Type: **Talk**

# Welcome

*Monday, February 18, 2019 10:07 AM (3 minutes)*

**Presenter:** RIDIKAS, Danas (IAEA - Head of Physics Section)

**Session Classification:** Opening