WORKSHOP ON PICO-SECOND TIMING DETECTORS FOR PHYSICS

Report of Contributions

https://indico.cern.ch/e/861104

Contribution ID: **1** Type: **not specified**

Ultimate resolution of ToF-PET detectors –open questions and ways forward

An overview will be given of the recent progress towards achieving an ultimate 10 ps CRT resolution for the ToF-PET detectors. Emphasis will be put on understanding of the obtained results, and on the status of advanced Monte Carlo simulations in this filed. The open issues will be discussed in this context and ways of attacking this challenge will be proposed for discussion.

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Presenter: PIOTRZKOWSKI, Krzysztof

Contribution ID: **2** Type: **not specified**

picoTDC: A 3ps bin bize 64 channel TDC for HEP experiments

We present the ASIC development and test results of the picoTDC, a 64 channel time tagging Time-to-Digital Converter (TDC) with 3ps bin size. The ASIC runs from a single 40MHz reference clock, can be configured very flexible. Reference clock is fed to a PLL generating an internal 1.28GHz, then split into 256 phases through a 64 element DLL and a resistive interpolation resulting in the 3.05ps bin size. These clock phases then drive the capture registers of the 64 channels. To reduce the power consumption, the resistive interpolation can be disabled resulting in a bin size of 12.2ps. The digital logic of the ASIC is clocked at 320 MHZ thus it supports hit rates of up to 320MHz per channel, internal buffering and trigger matching as well as TOT measurements. The readout interface consists of four eight bit parallel interfaces with up to 320MHz data rate, resulting in a maximum readout rate of 10GBit/s or 320 million hits per second for the whole ASIC. In order to reduce the required readout bandwidth, a trigger functionality is implemented to read out only the interesting hits. Where this is not feasible, the data can also be read out triggerless. The TDC has been prototyped in a 65nm CMOS technology. First test results show an effective single-shot RMS resolution better than the bin size (3ps, including measurement jitter), but a higher mismatch between bins than expected. For the submission of the final production version the mismatch will be improved. Detailed measurements and functional tests of the final version will be available at the time of the conference.

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Co-authors: CHRISTIANSEN, Jorgen (CERN); HORSTMANN, Moritz

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Contribution ID: **3** Type: **not specified**

PicoTDC: 64channel TDC with ps resolution

The PicoTDC is a 64channel TDC ASIC with 12 and 3 ps time binning implemented in a 65nm CMOS technology. It is available in its final production version that have been extensively characterized to have an effective RMS resolution better than 3ps across all channels. ˜1ps rms time resolution has been demonstrated when tuned for a specific channel. Hit digitization is done at 1.28GHz with a 4 bit derandomizer buffer before further hit processing per channel is performed at 320MHz.
A flexible data flow architecture with extensive date buffering (512 hits per channel) allows the chip to be used in a continuous time tagging mode with or without triggering. Readout is performed via 4 or 1 readout ports of 8bits at a maximum rate of 320MHz.

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Contribution ID: **4** Type: **not specified**

Picosecond timing resolution with scintillators

The future generation of radiation detectors is more and more demanding on timing performance for a wide range of applications, such as particle identification in nuclear physics and high energy physics detectors, high resolution hadronic calorimetry in finely segmented detectors, precise event time tagging in high luminosity accelerators, time of flight (TOF) techniques for PET cameras and a number of photonic applications based on single photon detection.
There is in particular a consensus for gathering the multidisciplinary academic and industrial excellence around the ambitious challenge to develop a 10ps TOF PET scanner (TOFPET). The goal is to reduce the radiation dose (currently 5-25 mSv for whole-body PET/CT), scan time (currently > 10 minutes), and costs per patient (currently > 1000 € per scan), all by an order of magnitude.
To achieve this very ambitious goal it is essential to significantly improve the performance of each component of the detection chain: light production, light transport, photodetection, readout electronics. Speeding up progress in this direction is the goal of the challenge and will have an important impact on the development of a new generation of ionization radiation detectors.
It will be shown that the possibility to reach 10ps time-of-flight resolution at small energies, as required in finely granulated calorimeters and PET scanners, although extremely challenging, is not limited by physical barriers and that a number of disruptive technologies, such as multifunctional heterostructures, combining the high stopping power of well know scintillators with the ultrafast photon emission resulting from the 1D, 2D or 3D quantum confinement of the excitons in nanocrystals, photonic crystals, photonic fibers, as well as new concepts of 3D digital SiPM structures, open the way to new radiation detector concepts with unprecedented performance.

Primary author: Prof. LECOQ, Paul

Presenter: Prof. LECOQ, Paul

Contribution ID: **5** Type: **not specified**

The ATLAS Forward Proton Time-of-Flight detector: results, experiences and plans

The Time-of-Flight (ToF) detectors of the ATLAS Forward Proton (AFP) system are designed to measure the primary vertex z-position of the pp -> pXp processes by comparing the arrival times measured in the ToF of the two intact protons in the final state. We present the results obtained from a performance study of the AFP ToF detector operation in 2017 and discuss plans for LHC Run 3 as well as for an eventual future upgrade of the ToF detectors.

In 2017, time resolutions of individual channels ranging between 20 ps and 40 ps were extracted. Even though the AFP ToF efficiency is below 10%, the overall time resolution of each ToF detector is found to be 20(26) +- 4(5) ps for side A(C). This represents a superb time resolution for a detector operating at few milimeters from the LHC beams.

Events from ATLAS physics runs at moderate pile-up taken at the end of 2017 are selected with signals in ToF stations at both sides of ATLAS. The difference of the primary vertex z-position measured by ATLAS and the value obtained by the AFP ToFs is studied. The distribution of the time difference constitutes of a background component from combinatorics due to non-negligible pile-up, and significantly narrower signal component from events where protons from the same interaction are detected in ToF. The fits performed to the distribution of the reconstructed time difference yield the vertex position resolution (of about 6 mm +- 1 mm at best) that is in agreement with the expectation based on single-ToF channel resolutions.

Primary author: BERESFORD, Lydia Audrey (CERN)

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Contribution ID: **6** Type: **not specified**

Overview oOverview of CNM LGAD results with B, Ga and C diffused Si-on-Si and epitaxial wafers

Low Gain Avalanche Detectors (LGADs) are n-on-p silicon sensors with an extra doped p-layer below the n-p junction which provides signal amplification. When the primary electrons reach the amplification region new electron-hole pairs are created that drift towards the p+ region increasing the generated signal. The moderate gain of these sensors, together with the relatively thin active region, provide excellent time performance for minimum ionization particles. To mitigate the effect of pile-up at the HL-LHC by both the ATLAS and CMS experiments have chosen the LGAD technology for their High Granularity Timing Detector (HGTD) and for the End-Cap Timing Layer (ETL) respectively. A full characterization of LGAD sensors fabricated at CNM before and after neutron irradiation up to 2.5E15 neq/cm2 will be presented. Sensors produced in epitaxial and Si-on-Si wafers and doped with Boron and Gallium and also diffused with Carbon have been studied. The results include their electrically characterization (IV, CV and bias voltage stability) and performance studies with a Sr-90 radioactive source setup. Also the behaviour of the Inter-Pad region for 2x2 LGAD arrays with Transient Current Technique (TCT) at different fluences will be shown.

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Contribution ID: **7** Type: **not specified**

Performance of a low gain avalanche detector in a medical linac and characterisation of the beam profile

Low gain avalanche detectors can measure charged particle fluences with high speed and spatial precision, and are a promising technology for radiation monitoring and dosimetry. A detector has been tested in a medical linac where single particles were observed with a time resolution of 50 ps. The integrated response is similar to a standard ionising chamber but with a spatial precision twenty times finer, and a temporal precision over 100 million times better, with the capability to measure the charge deposited by a single linac pulse. The unprecedented resolving power allows the structure of the ~3 μs linac pulses to be viewed and the 350 ps sub-pulses in the train to be observed.

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Contribution ID: **8** Type: **not specified**

Overview of CNM LGAD results with B, Ga and C diffused Si-on-Si and epitaxial wafers

Low Gain Avalanche Detectors (LGADs) are n-on-p silicon sensors with an extra doped p-layer below the n-p junction which provides signal amplification. When the primary electrons reach the amplification region new electron-hole pairs are created that drift towards the p+ region increasing the generated signal. The moderate gain of these sensors, together with the relatively thin active region, provide excellent time performance for minimum ionization particles. To mitigate the effect of pile-up at the HL-LHC by both the ATLAS and CMS experiments have chosen the LGAD technology for their High Granularity Timing Detector (HGTD) and for the End-Cap Timing Layer (ETL) respectively. A full characterization of LGAD sensors fabricated at CNM before and after neutron irradiation up to 2.5E15 neq/cm2 will be presented. Sensors produced in epitaxial and Si-on-Si wafers and doped with Boron and Gallium and also diffused with Carbon have been studied. The results include their electrically characterization (IV, CV and bias voltage stability) and performance studies with a Sr-90 radioactive source setup. Also the behaviour of the Inter-Pad region for 2x2 LGAD arrays with Transient Current Technique (TCT) at different fluences will be shown.

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Contribution ID: **9** Type: **not specified**

Development of SiPM based fast time of flight for the AMS-100 in space

AMS-100 is one of the next generation high energy cosmic-ray experiment in space as a successor of AMS-02 and has a potential of improving the sensitivity by a factor of 1000 for the cosmic anti-matter particles AMS-100.
It is designed as a magnetic spectrometer with a large geometrical acceptance of 100m2 sr and to be operated for ten years at Sun-Earth Lagrange Point 2.
It consists of a TOF, a thin solenoid Magnet based on HTS tapes, SciFi- and Si-Trackers, an EM Calorimeter with a Preshower in the cylindrical shell structure.
The TOF is a crucial sub-detector for the main trigger. It requires a fast timing measurement with a time resolution better than 20 ps in the 2 x 4 thin layers of TOF along the particle trajectory.
A test setup of TOF is designed based on small size (Kuraray 87mm x 30mm x 5 mm) of fast plastic scintillator tile and multi arrays of SiPM (Hamamatsu S14161-6050HS-04).
An amplifier board is built to merge 16 SiPM arrays into 4 readout channels in Hybrid connection and has single HV module communicated with a SPI protocol via onboard USB controller. The amplified signals are readout by the fast waveform digitizer (DRS4).
We have studied the timing performace using UV LED pulses and investigated time resolution with beta rays from a radioactive source (90Sr).
We will report on time resolution measured better than 50 ps and timing effects in various conditions of scintillator, SiPM and readout electronics.

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Contribution ID: **10** Type: **not specified**

Performance measurements of the Large Area Picosecond PhotoDetector (LAPPD) as a timing layer for the LHCb UpgradeII electromagnetic calorimeter

The increase in instantaneous luminosity during the high-lumi phase of the LHC represents a significant challenge for future detectors. In order to cope with high-pileup conditions, a promising strategy is to add a fourth dimension to the measurements of the hits, by exploiting the time separation of the various proton-proton primary collisions. Such a strategy requires to achieve time resolutions of the order of 10-20 picoseconds, at least an order of magnitude shorter than the average time span between primary interactions. Microchannel plate (MCP) photomultipliers (PMTs) are compact devices capable of measuring time and position of charged particles with the required resolutions.

A campaign of feasibility studies to exploit MCP-based devices for the upgrade of the LHCb electromagnetic calorimeter (ECAL) has started in these last two years. The technology of large area picosecond photodetectors (LAPPD) is under investigation to implement a timing layer to be placed within a sampling calorimeter module with the purpose of measuring the arrival time of electromagnetic showers. Off-the-shelf, the device is the largest MCP-PMT ever built (20x20 cmˆ2 of active area), all made using inexpensive materials, capable of time resolutions of a few ten picoseconds per single photoelectron.

Performances of the LAPPD, either Gen-I tiles with internal stripline readout or Gen-II tiles with external pixelated readout, have been measured thoroughly both with a laser beam and with an electron beam at DESY. In particular, time resolutions as good as 30 ps with single photoelectrons and a few ps with multiple photoelectrons have been demonstrated by our studies. Details of the various experimental setups that have been used and of the relevant results will be shown and discussed.

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Contribution ID: **11** Type: **not specified**

SoLID and ATHENA TOF systems

I will present the detectors systems, requirements and expected performance of the SOLID and ATHENA detectors time of flight systems.

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Presenter: Dr CAMSONNE, Alexandre (Jefferson Laboratory)

Contribution ID: **12** Type: **not specified**

Development of AC-LGADs for high-rate Particle Detection

We present here an evaluation of the high-rate suitability of AC-LGADs (also named Resistive Silicon Detectors RSD) that can be made with great segmentation for the charge collection while maintaining a 100% fill factor. This is achieved by employing un-segmented (p-type) gain layer and (n-type) N-layer, and a di-electric layer separating the metal readout pads. The design allows great flexibility in the choice of the geometry of the metal readout pads, both in terms of pitch and size. The high spatial precision is achieved by using the information from multiple pads, exploiting the intrinsic charge sharing capabilities of the AC-LGAD provided by the common N-layer. It depends on the location, and the pitch and size of the pads.

We tested the performance of AC-LGAD of several manufacturers with focused IR-Laser scans directed alternatively at the read-out side on the front and the bias side on the back of the AC-LGAD, and in charged particle beam tests. This allows to investigate the performance as a function of the following detector parameters: sheet resistance and termination resistance of the n-layer, thickness of the isolation di-electric, doping profile of the gain layer, pitch and size of the readout pads and the bulk thickness. TCAD simulations of the sensors are compared with the experimental results.

We use the data to evaluate the limitations high-speed readout ASICs can expect from high-flux charged particles and X-rays and from constraints of power consumption in the readout chain.

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Presenter: SADROZINSKI, Hartmut (University of California,Santa Cruz (US))

Contribution ID: **13** Type: **not specified**

AGILE: Development of a compact, low power, low cost and on-board detector for ion identification and energy measurement.

AGILE (Advanced enerGetic Ion eLectron tEle- scope) instrument is being developed at KU and NASA Goddard Space Flight Center to be launched on board a CubeSat in 2022. AGILE instrument aims at identifying a large variety of ions (H-Fe) in a wide energy range (1-100 MeV/nucl) in real-time using fast silicon detectors, and fast read-out electronics. This can be achieved by the first use of real-time pulse shape discrimination in space instrumentation. This method of discrimination relies on specific amplitude and time characteristics of the signals sampled every 100ps and produced by ions that stop in the detector medium. AGILE will be able to observe, in-situ, the fluxes of a large variety of particles in a wide energy range to advance our knowledge of the fundamental processes in the Universe. We will present the current stage of development of the instrument, the discrimination method used, and the first result from lab tests using an Am-241 source.

Primary authors: GAUTIER, florian; ROYON, Christophe (The University of Kansas (US)); KANEKAL, Shrikanth (NASA Goddard); MINAFRA, Nicola (The University of Kansas (US)); NOVIKOV, Alexander; ISIDORI, Tommaso (The University of Kansas (US)); GREELEY, Ashley (NASA Goddard); SCHILLER, Quintin (NASA Goddard)

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Contribution ID: **14** Type: **not specified**

Front-end integrated circuit to read out the thin UFSD achieving ps time resolution and its future developments

We present the experimental results obtained with the FAST2 ASIC. It is a picosecond resolution front-end electronics to read out Ultra-Fast Silicon detectors (UFSD). It has been optimized to achieve a combined time resolution below 45 ps. The ASIC implements the standard 110 nm CMOS technology and 20 readout channels. The ASIC power rail is at +1.2 V, achieving a power consumption of 2.4 mW/ch. Each FAST2 readout channel presents an amplifier, a comparator stage, and an LVDS driver as the output stage.

The experimental tests include a Large Scanning-TCT with a 1060 nm wavelength laser diode. Here, the FAST2 ASIC, couples to a UFDS with a capacitance of 3.4 pF, achieves a timing jitter lower than 12 ps at 15 fC of input charge. The successive experimental tests measure the full temporal resolution of the UFSD-ASIC system using a beta telescope. The Sr90 beta source on the UFSD adds a new uncertainty source due to the MIP non-uniform energy depositions. The Landau noise adds an uncertainty of 30 ps, achieving a combined time resolution around 40-45 ps for a bias voltage equal to 200 V.

The future prototype to readout UFSD will implement a structure of 32 readout channels. Each channel occupies an area of 500x500 ⊠2. 2/3 of the space is for the analog circuits, such as an amplifier, discriminator, and 4-blocks of time to digital converter (TDC). The remaining area will be for the digital circuit for pixel control logic and data transmission. The readout channel can operate at the maximum system clock frequency of 320 MHz, achieving a time resolution, for the TDC, around 25-50 ps LSB, and a conversion rate around 700-350 ns depending on the TDC configuration. Then, considering there is no additional noise contribution in the TDC, its uncertainty contribution to the combined time resolution is around (25 ps)/$\sqrt{12}$.

The new IC prototype can operate in 3 modes. Primarily the Time of Arrival (ToA) operation, which provides the time of the particle arrival with a time resolution of 25 ps, and a conversion rate of 750 ns. However, the ToA operation only occupies 1 TDC, then we can work with the rest of TDC simultaneously, reducing the conversion rate by 4 (175 ns). Secondly, the Time of Threshold (ToT) operation measures the time of an event amplitude is over a specific threshold. The ToT operation requires 2 TDCs to compute the leading and trailing edge. Then, the conversion rate is reduced by 2 in this case (350 ns). The last operation mode is the ToA and amplitude. Here, the readout channel output measures the ToA and the event amplitude, with an operation rate equal to 350 ns.

The new FAST2 version will be submitted to the foundry at the end of the year, and we might test it in the early spring.

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Co-authors: ; ARCIDIACONO, Roberta (Universita e INFN Torino (IT)); CARTIGLIA, Nicolo (INFN Torino (IT)); Dr MARCO, Ferrero (Università di Torino); SIVIERO, Federico (Universita e INFN Torino (IT))

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Contribution ID: **15** Type: **not specified**

Timing performance of the Timepix3 and Timepix4 pixel ASICs

Precise timing will be an important part of future detector upgrades in order to prepare particle physics experiments for the High-Luminosity LHC. The higher luminosity, which is essential to observe rare phenomena, is obtained through higher pile-up rates making it more difficult to distinguish between collisions. Precise time measurements will help tracking algorithms separate spatially overlapping tracks. In this presentation we will show detailed studies of the temporal performance of the Timepix3 ASIC, and the first detailed timing measurements with Timepix4, which is the latest generation fine-pitch pixel ASIC that is used for the characterisation of sensors that will be used in future upgrades.

The Timepix3 ASIC has 256×256 pixels with a pitch of 55×55 µm², and uses 640 MHz oscillators (one per group of 2×4 pixels) to timestamp hits with a granularity of 1.56 ns. Recently, an elaborate time calibration of the LHCb VELO Timepix3 telescope has been performed in order to assess the feasibility of future large scale 4D trackers consisting of many readout channels. In this study, a detailed understanding of the timing systematics of the Timepix3 ASIC was obtained, and the track-time resolution was improved from 438(16) ps to 236(4) ps by applying per-pixel corrections to the time measurement. The knowledge obtained in this study has been used to carefully characterise the timing performance of both a 3D sensor and a thin planar sensor, which were bonded to Timepix3 ASICs. Using test-beam measurements, the timing performance was determined as a function of both the deposited charge and the track intercept location within a pixel (˜2 µm resolution). For a perpendicularly incident beam, the 3D detector reaches an overall resolution of 567(6) ps compared to an overall resolution of 683(8) ps for the thin-planar detector. The results were compared to lab measurements of their respective analog- and digital front-ends using externally timed test pulses. For a perpendicularly incident beam, the resolution of the 3D detector is dominated by the digitisation whereas the resolution of the thin-planar detector also has an important contribution from jitter in the analog front-end due to its smaller typical signal size.

Timepix4 will be used to further study fast sensor technologies for future 4D trackers. It has, among other improvements, a bigger matrix consisting of 448×512 pixels with a pitch of 55×55 µm², a higher maximum hit rate of 358 Mhits/s/cm², and an improved timestamp granularity of 195 ps. Detailed timing measurements of the analog and digital front-ends have been performed, and will be presented.

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Contribution ID: **16** Type: **not specified**

Time resolution of an irradiated 3D silicon pixel detector

We report on the measurements of time resolution for double-sided 3D pixel sensors with a single cell of 50 μm × 50 μm and thickness of 285 μm, fabricated at IMB-CNM and irradiated with reactorn neutrons to different radiation doses up to 1e16 MeV neq/cm2.

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Contribution ID: **17** Type: **not specified**

Fast timing with Cherenkov photons and analog SiPMs

Time of flight positron emission tomography can strongly benefit from a very accurate time estimator, eg. due to prompt Cherenkov emission produced upon 511 keV gamma interaction in heavy inorganic scintillators. Recently it was demonstrated that coincidence time resolution (CTR) values as good as 200 ps FWHM are possible for 20 mm long BGO crystals when selecting on events with high Cherenkov photon number, coupled to FBK NUV-HD SiPMs and high frequency electronics.

Harvesting solely Cherenkov photons as it is the case in PbF2 and considering all events independently of the deposited energy and number of detected Cherenkov photons, this quantity is improved to 142 ps (215 ps) FWHM for 2x2x3(20) mm^3 crystal geometry. When black painting the crystal to reduce the photon time spread and selecting on one detected Cherenkov photon only, the measured time resolution is solely determined by SiPM properties and depth-of-interaction contribution with CTR values ranging from 113 ps to 167ps FWHM for 3 mm and 30 mm crystal length.

Beside those classical detector approaches, the combination of semiconductor detectors such as TlBr or TlCl with the possibility of utilizing prompt Chernekov photons for the time information and charge induction for precise energy and DOI identification, can lead to an outstanding detector performance with superior sensitivity, challenging the figure of merit of current used Lutetium-based materials.

We present measured and simulated CTR values for various Cherenkov radiators coupled to analog Silicon Photomultipliers and discuss current limits and paths for future detector improvements toward 100 ps CTR.

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Presenter: KRATOCHWIL, Nicolaus (CERN)

Contribution ID: **18** Type: **not specified**

Ultra Fast timing detectors with applications in cosmic ray physics, medical science and other domains

In this talk, we will describe the use of fast Silicon detectors and the fast sampling method in high energy physics and applications in medicine and cosmic ray physics.

Primary author: ROYON, Christophe (The University of Kansas (US))

Presenter: ROYON, Christophe (The University of Kansas (US))

Contribution ID: **19** Type: **not specified**

TPA setup for temporal characterisation of silicon detectors

Historically, transient current measurements mainly used single-photon absorption (SPA). In contrast, two-photon absorption (TPA) is limited to a small voxel and allows for three-dimensional imaging of the detector volume. TPA requires strong focusing optics to achieve beam waists of the order of micrometers. This small voxel enables the characterisation of the detector volume in detail. Using the advantage of a fast pulsed laser, also the temporal characteristics of hybrid pixel detectors can be studied in detail

In this talk, the commissioning of a TPA setup at Nikhef is presented. A first estimate of the temporal resolution of the system is derived using a reference diode. Preliminary measurements indicate a temporal resolution of 43 ps, in the time difference measurement between the laser diode-based trigger system and a reference diode. If these two contributions are approximately equal, the laser system component resolution is estimated at 30 ps. In addition to evaluating the temporal performance of the laser setup, timing measurements of planar silicon sensors bonded to Timepix3 ASICs will be shown, indicating the viability of characterising hybrid pixel detectors in both space and time.

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Contribution ID: **20** Type: **not specified**

Recent results on fast 3D-trench silicon sensors and related electronics

In the last three years the TimeSPOT Collaboration has developed innovative silicon pixels allowing to reach a time resolution better than 20˜ps on minimum ionizing particles. Such new devices are 3D silicon pixels with trench-shaped electrodes. They achieve such an outstanding time resolution thanks to both a highly uniform electric field inside the pixel and electrons and holes drift velocities close to saturation.
Tests performed under particle beams at accelerator facilities and with radioactive sources in laboratory have routinely shown time resolutions of about 20 ps per hit on 55 μm pitch pixels.
In the last year accurate laboratory tests, both with a pulsed laser-based setup, able to precisely measure the sensor response throughout its active area, and with radioactive sources, emulating a test beam setup in the more controlled laboratory environment, have shown that these 3D pixel sensors intrinsically possess a time resolution close to 10 ps, and the available front-end electronics represents the real limit to their timing performance. A dedicated ASIC, developed in CMOS 28-nm technology and capable to readout a matrix of 1024 pixels of 55 μm pitch, has been produced and is presently under characterization in our laboratory. THE ASIC integrates a full readout chain and a high-resolution TDC per single pixel. First test results on such last developments will be presented at the workshop.

Primary author: LAI, Adriano (Universita e INFN, Cagliari (IT))

Presenter: LAI, Adriano (Universita e INFN, Cagliari (IT))

Contribution ID: **21** Type: **not specified**

6 µm pore microchannel plates in a square photomultiplier tube and the integration of TOFPET2 electronics

We present the recently developed 2-inch square multi-anode PMT using 6 µm pore microchannel plates with results on single photon timing accuracy, gain, uniformity, magnetic field susceptibility, and count rate capability. We also discuss the development combining multi-anode PMTs with the TOFPET2 front-end ASIC; demonstrators of a 256 channel demo system with < 100 ps single photon timing are now built and available with a new commercialized system available in early 2022.

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Presenter: MILNES, James (Photek Ltd)

Contribution ID: **22** Type: **not specified**

Fabrication and first full characterisation of timing properties of 3D diamond detectors

Very high luminosity experiments at future accelerators will need a new generation of vertex detectors able to stand exceptionally high levels of radiation and to provide precise spatial and time reconstruction of tracks. Diamond sensors may provide a promising radiation hard solution to these challenges posed by future hadron machines.
A 3D geometry with thin columnar resistive electrodes orthogonal to the diamond surface is expected to have enhanced radiation hardness, providing at the same time significantly better space and time resolution with respect to the extensively studied planar diamond sensors.
We report on the development, production, and characterisation of innovative 3D diamond sensors with electrodes obtained by laser nanofabrication, achieving 30% improvement in both space and time resolution with respect to sensors from the previous generation.
This is the first complete characterisation of the time resolution of 3D diamond sensors and combines results from tests with laser, β rays and high energy particle beams.
Plans and strategies for further improvement in the fabrication technology and readout systems as well as results from detailed sensor simulations are also discussed.

Primary authors: PASSALEVA, Giovanni (INFN Florence (IT)); ANDERLINI, Lucio (Universita e INFN, Firenze (IT))

Co-authors: LUCARELLI, Chiara (Universita e INFN, Firenze (IT)); SCIORTINO, Silvio (Universita e INFN, Firenze (IT)); VELTRI, Michele (Universita e INFN, Firenze (IT)); Dr CORSI, Chiara (Laboratorio Europeo Spettroscopie Non Lineari); Dr BELLINI, Marco (INO-CNR)

Presenter: ANDERLINI, Lucio (Universita e INFN, Firenze (IT))

Contribution ID: **23** Type: **not specified**

An LGAD-based full active target for the PiENuX experiment

PIENUX is a next-generation experiment to measure the charged-pion branching ratios to electrons vs muons, Re/μ and pion beta decay (Pib) π+⟶π0eν. Re/μ provides the best test of e-μ universality and is extremely sensitive to new physics at high mass scales; Pib could provide a clean high precision value for Vud. Order of magnitude improvements in precision to these reactions will probe lepton universality at an unprecedented level, determine ⊠⊠⊠ in a theoretically pristine manner and test CKM unitarity at the quantum loop level. The pion to muon decay (π⟶μ⟶e) has four orders of magnitude higher probability than the pion to electron decay (π⟶eν). To achieve the necessary branching-ratio precision it is crucial to suppress the π⟶μ⟶e energy spectrum that overlaps with the low energy tail of π⟶eν. The high-acceptance and high-resolution design of the PIENUX calorimeter allows to reduce the tail correction to be < 0.01%.

A high granularity active target (ATAR) is being designed to suppress the muon decay background sufficiently so that this tail can be directly measured. In addition, ATAR will provide detailed 4D tracking information to suppress other significant systematic uncertainties (pulse pile-up, decay in flight of slow pions) to < 0.01%, allowing the overall uncertainty in Re/μ to be reduced to O(0.01%). The high precision 4D tracking would allow to separate the energy deposits of the pion decay products in both position and time. The chosen technology for the ATAR is Low Gain Avalanche Detector (LGAD). These are thin silicon detectors (down to 50 μm in thickness or less) with moderate internal signal amplification (up to a gain of ˜50). LGADs are capable of providing measurements of minimum-ionizing particles (MiP) with time resolution as good as 17 ps. In addition, LGADs have fast rise time and short full charge collection time. The ATAR would be made of 48 planes of 2×2 cm strip LGADs with 120 μm of active thickness. To achieve a ˜100% active region several technologies still under research are being evaluated, such as AC-LGADs and TI-LGADs. A dynamic range from MiP (positron) to several MeV (pion/muon) of deposited charge is expected, the detection and separation of close-by hits in such a wide dynamic range will be a main challenge. Furthermore the compactness and the requirement of low inactive material of the ATAR present challenges for the readout system, forcing the amplification chip and digitization to be positioned away from active region.

Primary author: Dr MAZZA, Simone Michele (University of California,Santa Cruz (US))

Presenter: Dr MAZZA, Simone Michele (University of California,Santa Cruz (US))

Contribution ID: **24** Type: **not specified**

Performance of the FASTPIX sub-nanosecond CMOS pixel sensor demonstrator

Within the ATTRACT FASTpix project, a monolithic pixel sensor demonstrator chip has been developed in a modified 180 nm imaging CMOS process technology, targeting sub-nanosecond timing measurements for single ionising particles. It features a small collection-electrode design on a 30 micron deep epitaxial layer and contains 32 mini matrices of 68 hexagonal pixels each, 4 transmitting an analog output signal and 64 transmitting binary hit information, with pixel pitches ranging from 8.66 to 20 micron. Various process- and design variations are explored, aiming at accelerating the charge collection and making it uniform over the pixel area. Signal treatment of the analog waveforms as well as reconstruction of Time-of-Arrival and Time-over-Threshold information is carried out off-chip. This contribution introduces the design of the sensor and readout system, and presents first performance results achieved in measurements with radioactive sources, laser-light injection and particle beams.

Primary authors: DANNHEIM, Dominik (CERN); BUSCHMANN, Eric (CERN); BRAACH, Justus (Hamburg University (DE)); DORT, Katharina (CERN, Justus-Liebig-Universitaet Giessen (DE)); MUNKER, Magdalena (CERN); VICENTE BARRETO PINTO, Mateus (Universite de Geneve (CH)); KUGATHASAN, Thanushan (CERN); SNOEYS, Walter (CERN)

Presenter: BUSCHMANN, Eric (CERN)

Contribution ID: **25** Type: **not specified**

Quartz Cherenkov Timing Detectors Revisited

In the selective category of timing detectors with few picoseconds precision, quartz (fused silica) Cherenkov radiators associated with fast photodetectors, hold a well-established position.
Such detectors satisfy criteria for timing measurements at picosecond level, such as an instantaneous production of almost isochronous photons, relatively small geometrical dimensions, giving time spread of few picoseconds, and photodetectors with negligible transit time spread (TTS) and high gain.
A time resolution of 5 picoseconds has been obtained for charged particles traversing a quartz radiator block directly attached to the face of a Micro-Channel Plate Photomultiplier (MCP-PMT); different geometries of quartz radiators (bars) can be used, providing results in the range of few picoseconds. Another useful feature of such detectors is a remarkable resistance of quartz to radiation damage, up to few Grads.
Compared to this kind of detectors, other timing techniques reach relatively larger resolutions that can be reduced however by multiple simultaneous measurements; the quartz-radiator+MCP-PMT detector involves a non-negligible material budget that may be incompatible with multiple measurements. The radiator dimensions may condition the time-of-flight measurement precision, introducing correlations preventing a simple statistical treatment of the individual detectors'resolutions. These effects have been studied experimentally with different test beams. A QUARTIC module (with bars in the form of L) has been used for some of the beam tests with hadrons at CERN.
Other tests have been performed with straight bars disposed at different angles with respect to the beam direction. A configuration with 3 quartz counters has been extensively studied with electron beams at DESY, providing permanently calibrated time reference signals with precision below 10 picoseconds, and also giving a test bench for a rigorous treatment of statistical correlations in timing resolution measurements. The experimental results are in satisfactory agreement with GEANT4 simulation studies. The excellent timing response of quartz bars for charged minimum Ionizing particles (MIP) is typical also of quartz optical fiber bundles, which are extensively employed for calorimetry in the forward regions of LHC experiments, due to their high radiation resistance. Therefore high precision timing can be achieved also for particle showers developing in calorimeters.

Primary author: PENZO, Aldo (University of Iowa (US))

Presenter: PENZO, Aldo (University of Iowa (US))

Contribution ID: **26** Type: **not specified**

Recents advancements in UFSD performances

This presentation focuses on 2 aspects of UFSD performances: the improved temporal resolution obtained with thinner sensors and the higher radiation resistance of sensors with deep gain implants.
Using sensors produced by FBK, the temporal resolution of sensors with an active thickness of 25, 35, 45, and 55 microns will be shown and the radiation hardness of gain implants position at 0.5 - 1.5 micron will be presented.

Primary authors: MARTINEZ ROJAS, Alejandro David (INFN - National Institute for Nuclear Physics); SIVIERO, Federico (INFN - National Institute for Nuclear Physics); FERRERO, Marco (Universita e INFN Torino (IT)); CARTIGLIA, Nicolo (INFN Torino (IT)); BORGHI, Giacomo (Fondazione Bruno Kessler); DALLA BETTA, Gian-Franco (INFN and University of Trento); PATERNOSTER, Giovanni (Fondazione Bruno KEssler); MENZIO, Luca (Universita e INFN Torino (IT)); PANCHERI, Lucio (University of Trento and TIFPA-INFN); MANDURRINO, Marco (INFN); TORNAGO, Marta (Universita e INFN Torino (IT)); CENTIS VIGNALI, Matteo (FBK); BOSCARDIN, Maurizio (FBK Trento); ARCIDIACONO, Roberta (Universita e INFN Torino (IT)); SOLA, Valentina (Universita e INFN Torino (IT))

Presenter: CARTIGLIA, Nicolo (INFN Torino (IT))

Contribution ID: **27** Type: **not specified**

Welcome

Presenter: BETANCOURT, Christopher (Universitaet Zuerich (CH))

Contribution ID: **28** Type: **not specified**

Fabrication and first full characterisation of timing properties of 3D diamond detectors

Thursday, 9 September 2021 13:30 (25 minutes)

Presenter: PASSALEVA, Giovanni (INFN Florence (IT))

Session Classification: Detector session III

Contribution ID: **29** Type: **not specified**

Time resolution of an irradiated 3D silicon pixel detector

Thursday, 9 September 2021 13:55 (25 minutes)

Presenter: DE SIMONE, Dario (Universitaet Zuerich (CH))

Session Classification: Detector session III

Contribution ID: **30** Type: **not specified**

Fast timing with Cherenkov photons and analog SiPMs

Thursday, 9 September 2021 14:20 (25 minutes)

Presenter: KRATOCHWIL, Nicolaus (CERN)

Session Classification: Detector session III

Contribution ID: **31** Type: **not specified**

TPA setup for temporal characterisation of silicon detectors

Friday, 10 September 2021 10:15 (25 minutes)

Presenter: GEERTSEMA, Robbert Erik (Nikhef National institute for subatomic physics (NL))

Session Classification: Detector session III

Contribution ID: **32** Type: **not specified**

6 µm pore microchannel plates in a square photomultiplier tube and the integration of TOFPET2 electronics

Thursday, 9 September 2021 15:30 (25 minutes)

Presenter: MILNES, James (Photek Ltd)

Session Classification: Detector session IV

Contribution ID: **33** Type: **not specified**

Performance of the FASTPIX sub-nanosecond CMOS pixel sensor demonstrator

Thursday, 9 September 2021 15:55 (25 minutes)

Presenter: BUSCHMANN, Eric (CERN)

Session Classification: Detector session IV

Contribution ID: **34** Type: **not specified**

Overview of CNM LGAD results with B, Ga and C diffused Si-on-Si and epitaxial wafers

Thursday, 9 September 2021 16:20 (25 minutes)

Presenter: CASTILLO GARCIA, Lucia (IFAE - Barcelona (ES))

Session Classification: Detector session IV

Contribution ID: **35** Type: **not specified**

Recent results on fast 3D-trench silicon sensors and related electronics

Thursday, 9 September 2021 14:45 (25 minutes)

Presenter: LAI, Adriano (Universita e INFN, Cagliari (IT))

Session Classification: Detector session III

Contribution ID: **36** Type: **not specified**

Discussion session

Thursday, 9 September 2021 17:10 (30 minutes)

Session Classification: Detector session IV

Contribution ID: **37** Type: **not specified**

Picosecond timing resolution with scintillators

Friday, 10 September 2021 09:00 (25 minutes)

Presenter: LECOQ, Paul Rene Michel

Session Classification: Detector session III

Contribution ID: **38** Type: **not specified**

Performance measurements of the Large Area Picosecond PhotoDetector (LAPPD) as a timing layer for the LHCb UpgradeII electromagnetic calorimeter

Friday, 10 September 2021 09:25 (25 minutes)

Presenter: PERAZZINI, Stefano (Universita e INFN, Bologna (IT))

Session Classification: Detector session III

Contribution ID: **39** Type: **not specified**

SoLID and ATHENA TOF systems

Friday, 10 September 2021 09:50 (25 minutes)

Presenter: CAMSONNE, Alexandre (Jefferson Laboratory)

Session Classification: Detector session III

Contribution ID: **40** Type: **not specified**

Development of AC-LGADs for high-rate Particle Detection

Thursday, 9 September 2021 16:45 (25 minutes)

Presenters: SADROZINSKI, Hartmut (University of California,Santa Cruz (US)); SADROZINSKI, Hartmut (SCIPP, UC santa Cruz)

Session Classification: Detector session IV

Contribution ID: **41** Type: **not specified**

Recent advancements in UFSD performances

Friday, 10 September 2021 11:10 (25 minutes)

Presenter: CARTIGLIA, Nicolo (INFN Torino (IT))

Session Classification: Detector session IV

Contribution ID: **42** Type: **not specified**

Discussion

Friday, 10 September 2021 12:00 (30 minutes)

Session Classification: Detector session IV

Contribution ID: **43** Type: **not specified**

An LGAD-based full active target for the PiENuX experiment

Friday, 10 September 2021 14:00 (25 minutes)

Presenter: MAZZA, Simone Michele (University of California,Santa Cruz (US))

Session Classification: Detector session V

Contribution ID: **44** Type: **not specified**

Quartz Cherenkov Timing Detectors Revisited

Friday, 10 September 2021 14:25 (25 minutes)

Presenters: PENZO, Aldo (infn); PENZO, Aldo (University of Iowa (US))

Session Classification: Detector session V

Contribution ID: **45** Type: **not specified**

Status of development of SAMPIC chips and modules.

Friday, 10 September 2021 15:15 (25 minutes)

Presenter: BRETON, Dominique Robert (Université Paris-Saclay (FR))

Session Classification: Electronics session I

Contribution ID: **46** Type: **not specified**

picoTDC: A 3ps bin bize 64 channel TDC for HEP experiments

Friday, 10 September 2021 15:40 (25 minutes)

Presenters: ALTRUDA, Samuele; ALTRUDA, Samuele (Ministere des affaires etrangeres et europeennes (FR))

Session Classification: Electronics session I

Contribution ID: **47** Type: **not specified**

Front-end integrated circuit to read out the thin UFSD achieving ps time resolution and its future developments

Friday, 10 September 2021 16:35 (25 minutes)

Presenter: MARTINEZ ROJAS, Alejandro David (INFN - National Institute for Nuclear Physics)

Session Classification: Electronics session II

Contribution ID: **48** Type: **not specified**

Timing performance of the Timepix3 and Timepix4 pixel ASICs

Friday, 10 September 2021 17:00 (25 minutes)

Presenter: HEIJHOFF, Kevin (Nikhef National institute for subatomic physics (NL))

Session Classification: Electronics session II

Contribution ID: **49** Type: **not specified**

MCP-PMT development

Friday, 10 September 2021 17:25 (25 minutes)

Presenter: DUARTE PINTO, Serge (Photonis)

Session Classification: Electronics session II

Contribution ID: **50** Type: **not specified**

Discussion session

Friday, 10 September 2021 17:50 (30 minutes)

Session Classification: Electronics session II

Contribution ID: **51** Type: **not specified**

Ultimate resolution of ToF-PET detectors –open questions and ways forward

Saturday, 11 September 2021 09:00 (25 minutes)

Presenters: PIOTRZKOWSKI, Krzysztof (Universite Catholique de Louvain (UCL) (BE)); PIOTRZKOWSKI, Krzysztof (Universite Catholique de Louvain (UCL) (BE))

Session Classification: Application session I

Contribution ID: **52** Type: **not specified**

Ultra Fast timing detectors with applications in cosmic ray physics, medical science and other domains

Saturday, 11 September 2021 09:25 (25 minutes)

Presenter: ROYON, Christophe (The University of Kansas (US))

Session Classification: Application session I

Contribution ID: **53** Type: **not specified**

Performance of a low gain avalanche detector in a medical linac and characterisation of the beam profile

Saturday, 11 September 2021 09:50 (25 minutes)

Presenter: MCNULTY, Ronan (University College Dublin (IE))

Session Classification: Application session I

Contribution ID: **54** Type: **not specified**

AGILE: Development of a compact, low power, low cost and on-board detector for ion identification and energy measurement

Saturday, 11 September 2021 10:15 (25 minutes)

Presenter: GAUTIER, florian

Session Classification: Application session I

Contribution ID: **55** Type: **not specified**

The ATLAS Forward Proton Time-of-Flight detector: results, experiences and plans

Saturday, 11 September 2021 11:10 (25 minutes)

Presenter: SYKORA, Tomas (Charles University (CZ))

Session Classification: Application session II

Contribution ID: **56** Type: **not specified**

Development of SiPM based fast time of flight for the AMS-100 in space

Saturday, 11 September 2021 11:35 (25 minutes)

Presenter: CHUNG, Chan Hoon (Rheinisch Westfaelische Tech. Hoch. (DE))

Session Classification: Application session II

Contribution ID: **57** Type: **not specified**

Discussion session

Saturday, 11 September 2021 12:25 (30 minutes)

Session Classification: Application session II

Contribution ID: **58** Type: **not specified**

Workshop Conclusion

Saturday, 11 September 2021 12:55 (10 minutes)

Presenters: ROYON, Christophe (The University of Kansas (US)); BETANCOURT, Christopher (Universitaet Zuerich (CH))

Contribution ID: **59** Type: **not specified**

A comparative study of LGAD radiation damage mechanisms

Aiming to a sub 30 psec time resolution at fluences in excess of 6×10^{15} 1 MeV n_{eq}/cm^2, several dopants are explored to improve radiation tolerance of intrinsic gain sensors. Using a common mask, CNM produced LGADs with boron, boron + carbon and gallium implanted gain layers are subjected to neutron and proton irradiation ranging from 10^{14} to 6×10^{15} 1 MeV n_{eq}/cm^2 on both particle species. A systematic study of acceptor removal, gain reduction and timing performance is presented at different temperatures (-10^oC, -20^oC, -30^oC). Charge collection, relative efficiency, signal shape and noise analysis are also addressed, using charged particles in a laboratory setup. Three different approaches are used to individually evaluate different mechanisms of radiation damage and their effect on sensor performance, with a distinction between bulk and gain layer effects. Finally, stability is evaluated via dark count rate, which combined with efficiency, determines the sensor's operatable region and it's evolution with radiation.

Primary authors: Dr GKOUGKOUSIS, Vagelis (CERN); CASTILLO GARCIA, Lucia (IFAE - Barcelona (ES)); COCO, Victor (CERN)

Presenter: Dr GKOUGKOUSIS, Vagelis (CERN)

Contribution ID: **60** Type: **not specified**

Characterization of Novel Trench-Isolated LGADs for 4D tracking

Silicon detectors are crucial for charged particle trajectory measurements with high precision. They provide high spatial granularity using pixels, strips and are ubiquitous in High Energy Physics (HEP) experiments. In recent years, Low Gain Avalanche Detectors (LGADs) have shown the capability of timing measurements in the tens of ps range, giving a possibility to make ultra-fast silicon detectors (UFSD). The low gain is sufficient to perform precise particle time measurement. However, the segmentation still provides hindrance in achieving 100% fill factor (FF) for many applications and to use LGADs as 4-dimensional (4D) tracking devices. The new LGAD design based on trench isolation technique (TI-LGAD) is very promising in reducing the inter-pixel distance and hence increased FF which in turn makes them capable of 4D tracking. This contribution describes the features of a new TI-LGAD sensors production by FBK, in which the no gain region is reduced significantly by replacing Junction Termination Extension (JTE) and p-stop implant with slender trenches. A new R&D batch was produced in FBK within the RD50 collaboration, in which several structures and process splits are implemented. This batch enables a systematic study to select the best process and layout. In this work, we will present the isolation between pixels, and the dead area between pixels for various structures. We characterized the structures using pulsed IR/Red laser and measured the Inter-Pixel Distance (IPD) for different border geometry. We achieved an IPD of about 3 microns which is significantly lower than any previous LGAD technology. The main aim of this contribution will be laser characterization to look for enhanced FF for 4D tracking.

Primary author: BISHT, Ashish (University of Trento, Fondazione Bruno Kessler)

Co-authors: BORGHI, Giacomo (Fondazione Bruno Kessler); BOSCARDIN, Maurizio (Fondazione Bruno Kessler); CENTIS VIGNALI, Matteo (Fondazione Bruno Kessler); FICORELLA, Francesco (Fondazione Bruno Kessler); HAMMAD ALI, Omar (Fondazione Bruno Kessler); PATERNOSTER, Giovanni (Fondazione Bruno Kessler)

Presenter: BISHT, Ashish (University of Trento, Fondazione Bruno Kessler)

Contribution ID: **61** Type: **not specified**

Systematic study of heavily irradiated LGAD stability using the Fermilab Test Beam Facility

LGAD sensors will be employed in the ATLAS High-Granularity Timing Detector and the CMS MIP Timing Detector upgrades to mitigate the high levels of pileup expected in the High-Luminosity phase of the LHC. Over the last several years, much attention has focused on designing radiation-tolerant gain implants to ensure these sensors survive the fluences expected, in excess of 1–2E15 n_{eq}/cm^2. As verified with beta source measurements, the latest sensor prototypes are able to provide adequate gain for precision timing even at the end of life. However, in beam tests, highly irradiated LGADs operated at high voltage have been seen to exhibit violent burn-out events that render the sensors non-operational. We present the results of the first systematic study of heavily irradiated LGAD mortality using data collected at the Fermilab Test Beam Facility. In the present campaign, 30 sensors have been exposed to the 120 GeV proton beam in a highly controlled environment. We demonstrate that rare, highly-ionizing proton interactions can lead to single-event burnout. Sensors with diverse characteristics and treatments are included to study which properties affect the mortality risk and understand potential mitigation strategies. With proper operational mitigation, we expect sensor mortality can be avoided with minimal impact on the performance of the final detectors.

Primary authors: CMS COLLABORATION; SOLA, Valentina (Universita e INFN Torino (IT))

Presenter: SOLA, Valentina (Universita e INFN Torino (IT))

Contribution ID: **62** Type: **not specified**

The CMS MTD Endcap Timing Layer: Precision Timing with Low Gain Avalanche Detectors

The MIP Timing Detector (MTD) of the Compact Muon Solenoid (CMS) will provide precision timestamps with 40 ps resolution for all charged particles up to a pseudo-rapidity of $|\eta|=3$. This upgrade will mitigate the effects of pile-up expected under the High-Luminosity LHC running conditions and bring new and unique capabilities to the CMS detector. The endcap region of the MTD, called the Endcap Timing Layer (ETL), will be instrumented with silicon low gain avalanche detectors (LGADs), covering the high-radiation pseudo-rapidity region $1.6 < |\eta| < 3.0$. The LGADs will be read out with the ETROC readout chip, which is being designed for precision timing measurements. We present recent progress in the characterization of LGAD sensors for the ETL and the development of ETROC, including test beam and bench measurements.

Primary authors: CMS COLLABORATION; FERRERO, Marco (Universita e INFN Torino (IT))

Presenter: FERRERO, Marco (Universita e INFN Torino (IT))

Contribution ID: **63** Type: **not specified**

Precision Timing with the CMS Barrel MIP Timing Detector

The MIP Timing Detector (MTD) is a new sub-detector planned for the Compact Muon Solenoid (CMS) experiment at CERN, aimed at maintaining the excellent particle identification and reconstruction efficiency of the CMS detector during the High Luminosity LHC (HL-LHC) era. The MTD will provide new and unique capabilities to CMS by measuring the time-of-arrival of minimum ionizing particles with a resolution of 30 - 40 ps at the beginning of HL-LHC operation. The information provided by the MTD will help disentangle ˜200 nearly simultaneous pileup interactions occurring in each bunch crossing at LHC by enabling the use of 4D reconstruction algorithms. The central Barrel Timing Layer (BTL) of the MTD uses a sensor technology consisting of LYSO:Ce crystal bars readout by SiPMs, one at each end of the bar. In this talk, we present an overview of the MTD BTL design and the recent test beam results demonstrating the achievement of the target time resolution of about 30 ps.

Primary authors: BORNHEIM, Adi (California Institute of Technology (US)); ON BEHALF OF THE CMS COLLABORATION

Presenter: BORNHEIM, Adi (California Institute of Technology (US))

Contribution ID: **64** Type: **not specified**

Scintillating sampling technologies with precision timing capabilities for the Upgrade II electromagnetic calorimeter of LHCb

The aim of the LHCb Upgrade II is to operate at a luminosity in the range of 1 to 2 x 10^{34} cm^{-2} s^{-1} to collect a data set of 300 fb^{-1}. This will require a substantial modification of the current LHCb ECAL due to high radiation doses in the central region and increased particle densities. Timing capabilities with O(10) ps precision for neutral electromagnetic particles and increased granularity with denser absorber in the central region are crucial for pile-up mitigation.

Several scintillating sampling ECAL technologies are currently being investigated for this purpose: Spaghetti Calorimeter (SpaCal) with garnet scintillating crystals and tungsten absorber, SpaCal with scintillating plastic fibres and tungsten or lead absorber, and Shashlik with polystyrene tiles, lead absorber and fast WLS fibres. The aim is to optimise each technology for timing performance, radiation hardness as well as spatial and energy resolution.

The presentation focusses on results for the time resolution from test beam measurements at DESY and the CERN SPS in 2021 using prototypes for all technologies mentioned above. It also includes an overview of the overall R&D programme towards the Upgrade II of the LHCb ECAL.

Primary author: ROLOFF, Philipp (CERN)

Presenter: ROLOFF, Philipp (CERN)

Contribution ID: **65** Type: **not specified**

Status of the TORCH time-of-flight detector

The TORCH time-of-flight detector is designed to provide a 15 ps timing resolution for charged particles, resulting in pi/K particle identification up to 10 GeV/c momentum over a 10 m flight path. Cherenkov photons, produced in a quartz plate of 10 mm thickness, are focused onto an array of micro-channel plate photomultipliers (MCP-PMTs) which measure the photon arrival times and spatial positions. A half-scale (660 x 1250 x 10 mmˆ3) TORCH demonstrator module has been tested in a 5 GeV/c mixed proton-pion beam at the CERN PS. Customised MCP-PMTs of active area 5 cmˆ2 and granularity 64 x 64 pixels have been employed, which have been developed in collaboration with industrial partner, Photek (UK). The single-photon timing performance and photon yields have been measured as a function of beam position in the radiator, giving measurements which are consistent with expectations. The expected performance of TORCH for high luminosity running of the LHCb upgraded experiment has been simulated.

Primary author: HARNEW, Neville (University of Oxford (GB))

Presenter: HARNEW, Neville (University of Oxford (GB))

Contribution ID: **66** Type: **not specified**

Single event effect study on LGAD: Present status and future prospects of femtosecond laser studies at ELI

Currently, a majority of the research has been focused on LGAD stability and irreversible breakdown. Single event effect has been extensively researched in femtosecond laser studies at ELI Beamlines. In this presentation we will mainly focus on future activities aiming to aid us in bettering our understanding of the underlying mechanism causing the destruction. An overview of the present status and up to now accumulated knowledge will be reported. Unique TCT-SPA/TPA set up at ELI Beamlines will be explained as well as future upgrades.

Primary author: LASTOVICKA MEDIN, Gordana (University of Montenegro (ME))

Co-authors: KRAMBERGER, Gregor (Jozef Stefan Institute (SI)); Dr REBARZ, Mateusz (Extreme Light Infrastructure); Dr ANDREASSON, Jakob (Extreme Light Infrastructure); Mr KROPIELNICZKI, Kamil (Extreme Light Infrastructure); KROLL, Jiri (Czech Academy of Sciences (CZ)); LASTOVICKA, Tomas (Czech Academy of Sciences (CZ)); TOMASEK, Michal (Acad. of Sciences of the Czech Rep. (CZ)); CARTIGLIA, Nicolo (INFN Torino (IT)); SOLA, Valentina (Universita e INFN Torino (IT))

Presenter: LASTOVICKA MEDIN, Gordana (University of Montenegro (ME))

Contribution ID: **67** Type: **not specified**

Tracking and Vertexing in 4D

LHCb has recently submitted a physics case to upgrade the detector to be able to run at instantaneous luminosities of $2\times10^{34}cm^{-2}s^{-1}$, an order of magnitude above Upgrade I, and accumulate a sample of more than 300 fb^{-1}. At this intensity, the mean number of interactions per crossing would be 56, producing around 2500 charged particles within the LHCb acceptance. The LHCb physics programme relies on an efficient and precise vertex detector (VELO) to correctly identify the origin point of the b/c decays. To meet this challenge it is necessary to use temporal precision on each hit at the pixel detector region. To achieve this goal a new 4D hybrid pixel detector with enhanced rate and timing capabilities in the ASIC and sensor will be developed. Improvements in the mechanical design will be needed to allow periodic module replacement and lower detector material.

The early stages of R\&D and conceptual design of a 4D VELO will be presented, together with extensive simulation studies showing the prospects of the 4D-tracking approach on physics measurements, compared to typical 3D and timing plane alternatives$p

Primary author: CARVALHO AKIBA, Kazuyoshi (Nikhef)

Presenter: CARVALHO AKIBA, Kazuyoshi (Nikhef)

Contribution ID: **68** Type: **not specified**

Status of the TORCH time-of-flight detector

Saturday, 11 September 2021 12:00 (25 minutes)

Presenters: HARNEW, Neville (University of Oxford (GB)); HARNEW, Neville (University of Oxford (GB))

Session Classification: Application session II

Contribution ID: **69** Type: **not specified**

Tracking and Vertexing in 4D

Friday, 10 September 2021 11:35 (25 minutes)

Presenter: JOHNSON, Daniel (Massachusetts Inst. of Technology (US))

Session Classification: Detector session IV

Contribution ID: **70** Type: **not specified**

Single event effect study on LGAD: Present status and future prospects of femtosecond laser studies at ELI

Friday, 10 September 2021 14:50 (25 minutes)

Presenters: LASTOVICKA MEDIN, Gordana (University of Montenegro (ME)); LASTOVICKA MEDIN, Gordana (University of Montenegro (ME))

Session Classification: Detector session V

Contribution ID: **71** Type: **not specified**

Characterization of Novel Trench-Isolated LGADs for 4D tracking

Thursday, 9 September 2021 09:10 (25 minutes)

Presenter: BISHT, Ashish (Fondazione Bruno Kessler)

Session Classification: Detector Session I

Contribution ID: **72** Type: **not specified**

A comparative study of LGAD radiation damage mechanisms

Thursday, 9 September 2021 09:35 (25 minutes)

Presenter: GKOUGKOUSIS, Vagelis (CERN)

Session Classification: Detector Session I

Contribution ID: **73** Type: **not specified**

Systematic study of heavily irradiated LGAD stability using the Fermilab Test Beam Facility

Thursday, 9 September 2021 10:00 (25 minutes)

Presenter: SOLA, Valentina (Universita e INFN Torino (IT))

Session Classification: Detector Session I

Contribution ID: **74** Type: **not specified**

The CMS MTD Endcap Timing Layer: Precision Timing with Low Gain Avalanche Detectors

Thursday, 9 September 2021 10:45 (25 minutes)

Presenter: FERRERO, Marco (Universita e INFN Torino (IT))

Session Classification: Detector session II

Contribution ID: **75** Type: **not specified**

Precision Timing with the CMS Barrel MIP Timing Detector

Thursday, 9 September 2021 11:10 (25 minutes)

Presenters: BORNHEIM, Adi (California Institute of Technology (US)); BORNHEIM, Adolf (California Institute of Technology (US)); BORNHEIM, Adolf (Charles C. Lauritsen Laboratory of High Energy Physics)

Session Classification: Detector session II

Contribution ID: **76** Type: **not specified**

Scintillating sampling technologies with precision timing capabilities for the Upgrade II electromagnetic calorimeter of LHCb

Thursday, 9 September 2021 11:35 (25 minutes)

Presenters: MARTINAZZOLI, Loris (Universita & INFN, Milano-Bicocca (IT)); ROLOFF, Philipp (DESY); ROLOFF, Philipp (Deutsches Elektronen-Synchrotron (DESY)); ROLOFF, Philipp (CERN)

Session Classification: Detector session II

Contribution ID: **77** Type: **not specified**

Discussion

Session Classification: Detector session II

Contribution ID: **78** Type: **not specified**

Welcome

Thursday, 9 September 2021 09:00 (10 minutes)

Presenters: ROYON, Christophe (The University of Kansas (US)); BETANCOURT, Christopher (Universitaet Zuerich (CH))