9th International Workshop on Ring Imaging Cherenkov Detectors (RICH 2016)

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Book of Abstracts

Contents

Cherenkov detectors in astroparticle physics / 58

The SNO Experiment

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The SNO experiment was a highly successful experiment that ran from 1999 until 2006. The use of heavy water as a neutrino detection material allowed for the measurement of solar neutrinos in both a charged current channel and a unique neutral current channel. Simultaneous measurements in both channels allowed SNO to demonstrate neutrino flavour change as the solution to the solar neutrino problem and provided a key signature for the discovery of neutrino oscillations. The 2015 Nobel prize was in part awarded to Arthur B. McDonald for his leadership of SNO as these measurements were made. Results from SNO and the varied methods used to obtain them will be reviewed and prospects for future SNO results will be discussed.

Registered:

Yes

Cherenkov detectors in astroparticle physics / 86

Performance Verification of the FlashCam Prototype Camera for the Cherenkov Telescope Array

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The gamma ray observatory Cherenkov Telescope Array (CTA) is planned to significantly improve upon the sensitivity and precision of the current generation of Cherenkov telescopes. The observatory will consist of several dozens of telescopes with varying sizes and different types of cameras. Of these, the FlashCam camera system is the first to implement a fully digital signal processing chain which allows for a traceable, configurable trigger scheme and flexible signal reconstruction. As of spring 2016, a prototype FlashCam camera for the middle-sized telescopes of CTA nears completion. The camera system and first results of the ongoing stability tests and performance verifications are presented.

Registered:

Yes

Cherenkov detectors in astroparticle physics / 63

The Tunka Cherenkov Experiment: Past, Present and Future

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We review Cherenkov experiments in the Tunka Valley. The experiments span nearly a quarter of a century. They started with a small "toy"array and are being presently evolved into a large scale experiment with a wide range of physics goals covering primary cosmic ray studies in the energy range of 1014-1018 eV and very high energy gamma-ray astronomy. We discuss future perspectives of the experiments as well.

Registered:

Yes

Cherenkov detectors in astroparticle physics / 59

The GCT Camera for the Cherenkov Telescope Array

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Jon Lapington for the CTA Consortium

The Gamma Cherenkov Telescope (GCT) is one of the designs proposed for the Small Sized Telescope (SST) section of the Cherenkov Telescope Array (CTA). The GCT uses dual-mirror optics, resulting in a compact telescope with good image quality and a large field of view with a smaller, more economical, camera than is achievable with conventional single mirror solutions. The photon counting GCT camera is designed to record the flashes of atmospheric Cherenkov light from gamma and cosmic ray initiated cascades, which last only a few tens of nanoseconds.

The GCT optics require that the camera detectors follow a convex surface with a radius of curvature of 1 m and a diameter of ˜35 cm, which is approximated by tiling the focal plane with 32 modules. The first camera prototype is equipped with multi-anode photomultipliers, each comprising an 8 × 8 array of 6 × 6 mm2 pixels to provide the required angular scale, adding up to 2048 pixels in total. Detector signals are shaped, amplified and digitized by electronics based on custom ASICs that provide digitisation at 1 GSample/s. The camera is self-triggering, retaining images where the focal plane light distribution matches predefined spatial and temporal criteria. The electronics are housed in the liquid-cooled, sealed camera enclosure. LED flashers at the corners of the focal plane provide a calibration source via reflection from the secondary mirror.

The first GCT camera prototype underwent preliminary laboratory tests last year. In November 2015 the camera was installed on a prototype GCT telescope (SST-GATE) in Paris and was used to successfully record the first Cherenkov light of any CTA prototype, and the first Cherenkov light seen with such a dual-mirror optical system. A second full-camera prototype based on Silicon Photomultipliers is under construction. Up to 35 GCTs are envisaged for CTA.

Registered:

Cherenkov detectors in astroparticle physics / 77

Results of the first detection units of KM3NeT

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The KM3NeT collaboration is building a km3-scale neutrino telescope in the Mediterranean Sea. The current phase of construction comprises the deep-sea and onshore infrastructures at two installation sites and the installation of the first detection units for the ARCA and ORCA detector. At the KM3NeT-It site, 100 km offshore Capo Passero, Italy, the first 32 detection units for the ARCA detector are being installed and at the KM3Net-Fr, 40 km offshore Toulon, France, 7 detection units for the ORCA detector. The second phase of KM3NeT foresees the completion of ARCA for neutrino astronomy at energies above TeV and ORCA for neutrino mass hierarchy studies at energies in the GeV range. The detection unit is the basic element of the KM3NeT detectors. In the ARCA geometry, the detection unit is a 700 meter long vertical structure hosting 18 optical modules. Each optical module comprises 31 3"photomultiplier tubes, instruments to monitor environmental parameters, and the electronic boards for the digitisation of the PMT-signals and the management of data acquisition. In their final configuration, both ARCA and ORCA will be composed of about 200 hundred detection units. The first detection unit was installed at the KM3NeT-It site in December 2015. It is active and taking data since its connection to the subsea network. The time of arrival and the duration of photon hits on each of the photomultipliers is measured with a time resolution of 1 ns and transferred onshore where the measurements are processed, triggered and stored on disk. A time calibration procedure, based on data recorded with flashing LED beacons during dedicated periods, allows for synchronisation of the time in the optical modules at the nanosecond level. In May 2016, the installation of two additional detection units at the KM3NeT-It site is foreseen. If successful, the first results with three active detection units will be presented. An update of the detector status and construction will be given.

Registered:

Yes

Cherenkov detectors in astroparticle physics / 75

Super-K upgrade and Hyper-Kamiokande

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Hyper-Kamiokande is proposed as a next-generation underground water Cherenkov detector having an enormous potential to discover proton decays and leptonic CP violation in neutrino oscillations. Two cylindrical tanks, each with a height of 60m and a diameter of 74m, will be filled with 520,000 metric tons of ultrapure water, a volume approximately 10 times larger than that of predecessor experiment Super-Kamiokande. The innermost main water volume of each tank will be viewed by 40,000 ultrasensitive 50cm diameter photosensors.

As an alternative to Hamamatsu R3600 50cm PMTs, which have been successfully used for 20 years in Super-Kamiokande, we have developed a new 50cm PMT having a high quantum efficiency photocathode and Box-and-Line type dynodes. The new PMT has twice higher single photon detection efficiency and much better timing and charge resolution than those of R3600. Characterization of the new PMT has mostly been completed and a long-term demonstration in a 200-ton water Cherenkov detector is ongoing. The mechanical characteristic of the new PMT will also be present, as well as the R&D status of the PMT protective cover to prevent a chain implosion.

We have also been developing another type of new 50cm photosensor, called hybrid photodetector (HPD). The HPD uses an avalanche diode (AD) for the electron multiplication, instead of metal dynodes, aiming to have far better timing and charge resolution than those of similarly-sized conventional PMTs. The 50cm HPD prototype using a small 5mm diameter AD has shown excellent

measurement performances. Towards the completion of the final design 50cm HPD using a 20mm diameter AD, we are trying to reduce the noises caused by the large junction capacitance of the AD.

The possibility to use "optical modules" instrumented with multiple small 3-inch PMTs is also being investigated. The increased granularity and directional information, which would highly benefit the reconstruction, are some of its advantages.

Registered:

Yes

Cherenkov detectors in astroparticle physics / 82

Neutrino astronomy at the South Pole: latest results from the IceCube neutrino observatory and its future development.

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The IceCube Neutrino Observatory is a cubic-kilometer neutrino telescope located at the Geographic South Pole. Buried deep under the Antarctic glacial, an array of 5160 Digital Optical Modules (DOMs) is used to capture the Cherenkov light emitted by relativistic particles generated from neutrino interactions. The main goal of IceCube is the detection of astrophysical neutrinos, and the identification of their sources. In 2013 the IceCube neutrino telescope detected a high-energy diffuse flux of neutrinos of cosmic origin with energy ranging from tens of TeV up to few PeV. Many analysis have been performed to confirm the discovery and to search for possible correlations with astrophysical sources. However, the sources of these neutrinos remain a mystery, since no counterparts have been identified yet.
In this talk I will give an overview of the detection principle of IceCube, the most recent results, and the plans for a next-generation neutrino detector, IceCube-Gen2.

Registered:

Yes

Cherenkov detectors in astroparticle physics / 80

Cherenkov light detection in underwater neutrino telescopes: technology and results of ANTARES and KM3NET

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Neutrino astronomy plays a key role in the exploration of the high-energy sky, due to excellent source pointing capabilities and an unrivaled field of view. Indeed, neutrinos can escape much denser celestial environments than light, thus behaving as tracers of the innermost processes occurring in astrophysical sources, hidden to traditional astronomy, without being deflected by the presence of magnetic fields on their path.

Neutrino telescopes are based on the detection of the Cherenkov light emitted by the secondary particles generated in high energy astrophysical neutrino interactions. The recent outstanding results achieved by IceCube have given a great boost to this field. In particular, the realization of a neutrino telescope in the boreal hemisphere will permit to cover a region of the sky complementary to the field of view of IceCube, including the Galactic Centre and a large part of the Galactic plane.
The ANTARES neutrino telescope has successfully demonstrated the feasibility of the undersea water Cherenkov technique, with ten years of data taking studded with a rich harvest of scientific results.
Building on the extensive experience gained in this project, the KM3NeT neutrino telescope will represent a big step forward in the field of neutrino astronomy. The KM3NeT research facility is currently under construction and will be realized as an installation distributed over two sites, with common detector technology and data handling. One telescope will be realized offshore CapoPassero, Italy, and will be dedicated to the high-energy neutrino sky, ARCA (Astroparticle Research with Cosmics in the Abyss). A denser detector, ORCA (Oscillation Research with Cosmics in the Abyss), will be built near Toulon (France) and will be dedicated to a lower neutrino energy range for the study of neutrino properties.
In this contribution, ANTARES and KM3NeT will be presented and compared in terms of technology, performances, scientific results and perspectives.

Registered:

Cherenkov detectors in astroparticle physics / 62

A digital FDIRC prototype for isotopic identification in astroparticle physics

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Experimental results obtained with a prototype of a Focused Internal Reflection Cherenkov, equipped with 16 high-granularity arrays of NUV-SiPM and tested at CERN SPS in March 2015, are discussed. The detector was exposed to relativistic ions of 13 and 30 GeV/n obtained from fragmentation of a primary Ar beam. The FDIRC included a single Fused Silica radiator bar optically connected to a cylindrical mirror and an imaging focal plane of dimensions ˜4 cm x 3 cm, covered with a total of 1024 SIPM photosensors. It was operated in photon counting mode thanks to the excellent performance of the SiPM arrays. The complete simulation of the detector was extended to the case of a planar device with multiple bars covering a sensitive area of the order of 1 m^2. Its operation inside a magnetic spectrometer (balloon or space-borne) was studied to evaluate its expected mass resolution for the identification of cosmic isotopes of astrophysical interest as ^{9}Be and ^{10}Be at energies of several GeV/amu with the goal to extend the energy reach of the present available data.

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Registered:

Yes

Cherenkov detectors in astroparticle physics / 42

Very high energy gamma-ray astronomy with HAWC

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The High-Altitude Water Cherenkov (HAWC) observatory was completed and began full operation on March 2015, collecting more than one year of data in its full configuration. The detector consists of an array of 300 water tanks, each containing 200 tons of purified water and instrumented with 4 PMTs. Located at an elevation of 4100 m a.s.l. near the Sierra Negra volcano in central Mexico, HAWC observes gamma rays in the 0.1-100 TeV range and has a sensitivity to TeV-scale gamma-ray sources an order of magnitude better than previous air-shower arrays. Its wide field-of-view and high duty cycle make HAWC an ideal instrument for surveying the very high energy gamma-ray sky. HAWC is currently undergoing an upgrade to improve the sensitivity at multi-TeV energies. It consists on the addition of an outrigger array of smaller tanks surrounding the main array. In this contribution, we will present the performance of the instrument, the latest results obtained with the full array, the status of the outrigger array and the expected performance of the full detector after the upgrade.

Registered:

Yes

Cherenkov detectors in astroparticle physics / 44

Research and Development Studies on a Silicon Photomultiplier based Camera for Imaging Atmospheric Cherenkov Telescopes

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The observation and study of faint signals at very high energy (E > 100 GeV) associated with cosmic phenomena constantly requires the development of advanced technologies and instruments to improve the sensitivity. Imaging Atmospheric Cherenkov Telescopes (IACTs) represent a class of instruments dedicated to the ground-based detection of cosmic VHE gamma ray emission based on the detection of the Cherenkov light produced in the interaction of gamma rays with the Earth atmosphere. One of the key elements of such instrument is a pixelized focal-plane camera consisting of photodetectors, each coupled to a light concentrator, commonly used to reduce the size of the dead area caused by the geometries of the photodetectors, as well as to reduce the amount of stray light entering at large field angles. To date, photomultiplier tubes (PMTs) have been the common choice given their high photon detection efficiency (PDE) and fast time response. Recently, silicon photomultipliers (SiPMs) are emerging as a an alternative. This technology is rapidly evolving. Currently, SiPMs have advantages, e.g., lower operating voltage and tolerance to high illumination levels and disadvantages, such as higher capacitance and cross talk rates. SiPM technology has a strong potential to become superior to that based on PMTs in terms of PDE, which would further improve the sensitivity of IACTs, and a reduced price per square mm of detector area. While the advantage of SiPMs has been proven for small IACTs and for IACTs based on a double-mirror Schwarzschild-Couder layout, it is yet to be demonstrated for large single mirrors designs. We are working to develop a SiPM-based module for the focal-plane cameras of the MAGIC telescopes, in view of a possible camera upgrade. We will describe the solutions we are exploring in order to balance a competitive performance with a minimal impact on the overall MAGIC camera design and present a comparison on the PDE based on ray tracing and Monte Carlo studies.

Registered:

Yes

Cherenkov detectors in astroparticle physics / 46

Upgrading the water Cherenkov tanks for atmospheric shower identification

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The nature and the sources of the cosmic rays of ultra-high energy are not yet elucidated. The cutoff of the spectrum around 50 EeV is now clearly established, but its interpretation is still ambiguous: it can be interpreted as the so-called GZK effect on a flux dominated by protons, or by an upper bound on the acceleration in the sources, or through a complex scenario implying a mixture of nuclei evolving with energy. To answer these questions the identification of the nature of the primaries is crucial. Present ground based detectors, especially water Cherenkov tanks, provide some indicators, in complement to the depth of maximum directly measured by fluorescence telescopes; but these indicators rely on models of the hadronic interactions at ultra-high energy, which cannot be observed in present colliders. One key feature to set more constraints on the development of atmospheric showers is a separate measurement of their electromagnetic and muonic components. Water Cherenkov tanks are sensitive to both, but cannot disentangle them in a clean and model-independent way. We present different options that have been studied to upgrade them, either by modifying their internal structure, or by adding above of below the tank another type of detector, with a different relative sensitivity to muons and photons/electrons. Another way of constraining the shower models, through the geomagnetic distortion of horizontal showers, will be presented.

Registered:

Yes

Cherenkov detectors in astroparticle physics / 47

THE RICH DETECTOR OF AMS-02: 5 YEARS OF OPERATION IN SPACE

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AMS-02 is a high-energy particle physics magnetic spectrometer installed on the International Space Station since May 2011, and operating continuously since then. By means of the simultaneous use of the Silicon Tracker, the AMS-02 RICH is able to investigate the isotopic composition of cosmic rays (CRs) in the kinetic energy range from few GeV/n to ˜10 GeV/n for elements with charge |Z| up to 4 with unprecedented statistics. The isotopes of light nuclei provide a unique tool to constrain the free parameters in the models for CR propagation in our Galaxy.

The performance of the AMS-02 RICH for the first 5 years of AMS operation in space will be shown. The long term stability of the system and the effect of varying environmental conditions will be addressed. The calibration procedures as well as the offline reconstruction of the velocity and charge will be described.

Finally, examples of the use of the RICH for the CRs isotopic composition measurement will be shown. The excellent simulation of the AMS detector provides the precise description needed for this analysis. Moreover, the use of the geomagnetic field for selecting control samples of CRs with enhanced abundances of heavy isotopes provides an independent tool for the study of the light nuclei isotopic composition with AMS.

Registered:

Yes

Cherenkov detectors in astroparticle physics / 49

FACT - Experience from more than 4.5 years of operation of the first SiPM camera

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When a high energetic particle or gamma-ray interacts with the atmosphere, it induces an air shower. Secondary particles of such showers emit dim and short duration flashes of Cherenkov light that can be measured with Imaging Atmospheric Cherenkov Telescopes (IACTs). For this task, very fast and sensitive photosensors are necessary. To be able to statistically distinguish between showers induced by hadrons and gamma-rays, the camera of an IACT typically contains more than 1000 pixels. In the past, all IACT cameras used Photomultiplier Tubes (PMTs) as photosensors. When the first generation of Geiger-mode operated Avalanche Photo Diodes (G-APD) became commercially available in the year 2007, the question raised if such solid-state photosensors could be a viable alternative for future IACTs. The FACT Collaboration was formed in 2008 with the goal to construct a novel camera and operate it in a refurbished 9.5mˆ2 IACT on the Canary Island La Palma. In October 2011, the camera was installed and data taking started within few hours. Since then, data are successfully taken almost every night.

One concern about using G-APDs is the strong dependence of their gain on the temperature, taking into account that the operation temperature at an IACTs can vary by more than 25 K. FACT has developed a method to self-calibrate the camera without the need of any external calibration device. This results in a very stable and reliable operation, allowing to operate FACT automatically without

the need of a shift
crew onsite. When weather conditions allow, the data taking efficiency of FACT exceeds 95%.

While PMTs can be damaged if illuminated by to much light, G-APDs are far more robust. This allows to operate the FACT camera also under strong moonlight conditions. In the past five years, each of the more than 1400 sensors of the FACT camera has collected an unprecedented amount of photons, without any indication of
aging or other problems related to the photo sensors.

Registered:

Yes

Cherenkov light imaging in particle and nuclear physics experiments / 36

Performance of the LHCb RICH detectors during the LHC Run II

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The LHCb RICH system, with the ability to provide hadron identification over a wide momentum range (2-100 GeV/c), is one of the big strengths of the LHCb experiment in the search for New Physics in decays of hadrons containing the charm and bottom quarks. Extensive maintenance took place during the Long Shutdown 1 of the LHC. A significant number of photon detectors (HPDs) were refurbished using new vacuum technologies, and the aerogel radiator was removed. The RICH information is also available for all lines in the High Level Trigger for the first time. The start of Run II of the LHC saw the beam energy increase to 6.5 TeV per beam and a new trigger strategy for LHCb with full online detector calibration. The challenges of the new conditions and the performance of the RICH detectors inferred from data collected in 2015 and 2016 will be presented.

Registered:

Yes

Cherenkov light imaging in particle and nuclear physics experiments / 85

Aerogel Ring Imaging Cherenkov at the Belle II spectrometer

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In the forward end-cap of the Belle II spectrometer, a proximity focusing Ring Imaging Cherenkov counter with an aerogel radiator will be installed. The detector will occupy a limited space inside solenoidal magnet with longitudinal field of 1.5 T. It consists of a double layer aerogel radiator, an expansion volume and a photon detector. 420 Hamamatsu hybrid avalanche photo detectors with 144 channels each will be used to read out single Cherenkov photons with high efficiency. More than 60000 analog signals will be digitized and processed in the front end electronics and send to the unified experiment data acquisition system.

The detector components have been successfully produced and tested and in the first half of 2016 installed in the spectrometer. We expect an excellent performance which will allow at least a 4σ separation of pions from kaons in the experiment kinematic region from 0.5 GeV/c to 4 GeV/c. In the presentation the requirements, the latest design challenges and the current performance will be shown. We will present the first data obtained during the cosmic tests of the final detector.

Registered:

Yes

Cherenkov light imaging in particle and nuclear physics experiments / 8

Construction and Performance of the NA62 RICH

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Co-authors: Andrea Bizzeti [1]; Enrico Iacopini [1]; Francesca Bucci [1]; Giuseppina Anzivino [2]; Mauro Piccini [3]; Monica Pepe [4]; Patrizia Cenci [4]; Riccardo Lollini [2]; Roberta Volpe [5]; Viacheslav Duk [4]

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The NA62 experiment at CERN has been constructed to measure the ultra rare charged Kaon decay into a charged pion and two neutrinos with a 10% uncertainty. The main background is made by the charged kaon decay into a muon and a neutrino which is suppressed by kinematic tools using a magnetic spectrometer and by the different stopping power of muons and pions in the calorimeters. A RICH detector is needed to further suppress the $\mu+$ contamination in the $\pi+$ sample by a factor of at least 100 between 15 and 35 GeV/c momentum, to measure the pion crossing time with a resolution of about 100 ps and to produce the trigger for a charged track. The detector consists of a 17 m long tank (vessel), filled with Neon gas at atmospheric pressure. Cherenkov light is reflected by a mosaic of 20 spherical mirrors with 17 m focal length, placed at the downstream end, and collected by 1952 photomultipliers (PMTs) placed at the upstream end.
The RICH detector installation was completed in the summer of 2014 and the detector was used for the first time during the pilot run at the end of 2014. The RICH was then operated during the NA62

Commissioning Run in 2015 and will be used in the 2016 Physics Run.
It must be noted that in 2014 and 2015 the RICH mirrors alignment was not optimal and the need of a better performance in the pion-muon separation was the main reason for the detector maintenance carried out in the 2015-2016 winter shutdown.
In this presentation the construction of the detector will be described and the performance reached during the 2014-2015 data-taking will be discussed. Some preliminary results of the 2016 data-taking will also be shown.

Registered:

Yes

Cherenkov light imaging in particle and nuclear physics experiments / **92**

The Belle II imaging Time-of-Propagation (iTOP) Detector

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High precision flavor physics measurements are an essential complement to the direct searches for new physics at the LHC. Such measurements will be performed using the upgraded Belle II detector that will take data at the SuperKEKB accelerator. With 40x the luminosity of KEKB, the detector systems must operate effciently at much higher rates than the original Belle detector. A central element of the upgrade is the barrel particle identification system. Belle II has built and installed an "imaging-Time-of-Propagation" (iTOP) detector. The iTOP uses quartz optics as Cerenkov radiators. The photons are transported down the quartz bars via total internally reflection with a spherical mirror at the forward end to reflect photons to the backward end where they are imaged onto an array of segmented Multi-Channel Plate Photo-Multiplier Tubes (MCP-PMTs). The system is readout using gigsample per second waveform sampling ASICs that provide precise photon timing. The combined timing and spatial distribution of the photons for each event are used to determine particle species. This presentation will provide an overview of the iTOP system.

Registered:

Yes

Cherenkov light imaging in particle and nuclear physics experiments / **16**

The PANDA Barrel DIRC Detector

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The PANDA detector at the international accelerator Facility for Antiproton and Ion Research in Europe (FAIR) near GSI, Darmstadt, Germany will address fundamental questions of hadron physics.

Excellent Particle Identification (PID) over a large range of solid angles and particle momenta will be essential to meet the objectives of the rich physics program,

which includes charmonium spectroscopy, the search for hybrids and glueballs, and the study of the interaction of hidden and open charm particles with nucleons and nuclei. Charged PID for the barrel section of the target spectrometer will be provided by a DIRC (Detection of Internally Reflected Cherenkov light) detector.
This counter will cover the angular range of 22-140 degrees and will need to cleanly separate charged pions from kaons for momenta between 0.5 GeV/c and 3.5 GeV/c with a separation power of at least 3 standard deviations.

The design of the PANDA Barrel DIRC detector is based on the successful BABAR DIRC and the SuperB FDIRC R&D with several important improvements to optimize the performance for PANDA, such as a focusing lens system, fast timing, and a compact fused silica prism as expansion region.

We will discuss the baseline design of the PANDA Barrel DIRC, based on narrow bars made of synthetic fused silica and a complex multi-layer spherical lens system, and the potentially cost-saving design option using wide fused silica plates and will present the result of tests of a large system prototype with a mixed hadron beam at CERN.

Registered:

Yes

Cherenkov light imaging in particle and nuclear physics experiments / 17

ALICE-HMPID performance at 13TeV √s during LHC Run2

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The High Momentum Particle IDentification (HMPID) detector installed in the ALICE experiment on the LHC at CERN consists of seven Ring Imaging Cherenkov (RICH) modules, 1.3x1.3 m2 each, having proximity focusing geometry. The Cherenkov photon detection is achieved by means of pad segmented photocathodes coated with 300 nm thick Caesium Iodide layer and installed in multi-wire proportional chambers operated with CH4. Liquid C6F14 (perfluorohexane) with n=1.2989 @ lambda=175nm is used as Cherenkov radiator. The HMPID identifies with three sigma separation charged pi and K in the momentum range 1-3 GeV/c, and protons in the range 1.5-5 GeV/c.
During 2015 (LHC Run2 period) and in the first half of 2016 LHC has delivered pp and Pb-Pb collisions respectively at 13 TeV √▯ and 5.02 TeV √▯▯▯ . After the good performance that HMPID has shown during Run1 (2010-2013), the study of the stability of the CsI photocathodes with respect to: the charge dose from ion bombardment, polluting gases, possible ageing effects ten years after the CsI evaporation and the C6F14 transparency, is presented. Some considerations on the future detector operation in the period 2019-2022 are also given.
Finally as overview of the detector performance, the scatter plots of the Cherenkov angle for both pp and Pb-Pb events are presented.

Registered:

Yes

Cherenkov light imaging in particle and nuclear physics experiments / 26

The GlueX DIRC Detector

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A focusing DIRC (FDIRC) detector is being developed to upgrade the particle identification capabilities in the forward region of the GlueX experiment at Jefferson Lab. The GlueX FDIRC will utilize four existing decommissioned BaBar DIRC bar boxes, which will be oriented to form a plane roughly 4 m from the fixed target of the experiment. A new photon camera has been designed that is based on the SuperB FDIRC prototype, but modified to reduce the cost while maintaining the physics performance. The full GlueX FDIRC system will consist of two such cameras, with the first expected to be built and installed by mid 2017. We present the current status of the design and R&D, along with the future plans of the GlueX FDIRC detector.

Registered:

Yes

Cherenkov light imaging in particle and nuclear physics experiments / 38

The new large-area hybrid-optics RICH detector for the CLAS12 spectrometer

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A large area Ring-Imaging Cherenkov detector has been designed to provide clean
hadron identification capability in the momentum range from 3 GeV/c up to 8 GeV/c for the CLAS12 experiments at the upgraded 12 GeV continuous electron beam
accelerator facility of Jefferson Lab, to study the 3D nucleon structure in the yet poorly explored valence region by deep-inelastic scattering, and to perform precision measurements in hadron spectroscopy.

The detector will exploit a novel hybrid configuration, in which the Cherenkov photons will either be detected directly for forward particles or after two mirror reflections for larger angle tracks.
The detector will include two layers of aerogel tiles as photon radiators, covering a total surface of about three squared meters, a system of planar and spherical mirrors and an array of 391 Hamamatsu H8500 and H12700 Multi-Anode Photomultiplier Tubes as photodetectors.
The readout of the 25000 electronic channels is provided by a compact system made by an ASIC front-end card based on the MAROC3 chip configured and controlled by an FPGA card.

The installation of the detector in the CLAS12 spectrometer is foreseen for the summer of 2017.
In the talk, the status of the detector will be presented and the results of the characterization of its main components and the expected performances will be discussed.

Registered:

Yes

Novel Cherenkov imaging techniques for future experiments / 69

The Future of RICH Detectors through the Light of the LHCb RICHes

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Co-authors: Alessandro Petrolini [2]; Olav Ullaland [1]; Roberta Cardinale [3]; Sajan Easo [4]

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The two RICH detectors of the LHCb experiment have been operational since 2008 and the data provided by them have been crucial for the physics program of LHCb. They have achieved an impressive performance for such complex detectors, one for all, its Cherenkov angle resolution of 0.67 mrad for single photons. The current system is expected to continue to take data until 2019, when a two year shutdown (LS1) is foreseen and LHCb will undergo a significant upgrade.

For this upgrade, a new RICH system configuration is in preparation (called Upg1a). Building on the present detector and strictly leaving intact the volumes already occupied in the experiment, it will feature a new optical system for RICH1, new photodetectors, and front-end and DAQ electronics capable of acquisition rates up to 40 MHz. It is planned to be operational at the start of year 2021.

With the advent of the High Luminosity LHC (HL-LHC) from 2027, there is opportunity for a 50-fold increase in the luminosity at LHCb compared to the present, which would further physics goals. To cope with this challenge, the RICH system needs to be redesigned to improve resolutions and reduce occupancies. In this scenario two new upgrade phases could be foreseen: phase 1b could be introduced in LS3 with a possible further upgrade in LS4, spanning a period between 2025 and 2035.

A proposal focused on the Phase 1b is presented. It shows how to overcome the challenges of the new conditions while still providing excellent particle identification within the constraints of the present LHCb experiment. The design makes use of latest and future technological advances in photodetection, electronics and optical materials. Details will be presented and the expected performance will be reported.

Although applied to specific circumstances, these ideas are used as a paradigm of what we think is achievable in the development and realization of high precision RICH detectors.

Registered:

Yes

Novel Cherenkov imaging techniques for future experiments / 39

The RICH detector of the CBM experiment

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[1] .

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CBM is a future heavy-ion experiment at the FAIR facility. It will explore the intermediate region of the QCD phase diagram with beam energies of up to 11 AGeV for the heaviest nucleus at SIS100. In CBM electrons with momenta of up to 8 GeV/c will be mainly identified with a RICH detector. It consists of a CO2 gaseous radiator, a spherical mirror system, and Multianode Photomultiplier Tubes (PMT) as photon detectors. The RICH concept and results of extensive R&D studies on its components were summarized in a TDR that was accepted by FAIR in Feb. 2014. Major open issues were defined in the TDR concerning the radiation hardness of the PMTs, shielding of a magnetic stray field in the PMT region, and the mirror holding structure. One major milestone achieved since then was the ordering of 1100 PMTs of type H12700 from Hamamatsu.

The sensor will be operated in a radiation high environment, thus its radiation hardness was tested in detail with thermal neutrons from a TRIGA reactor and gammas from a 60Co source. All components survive more than 20 years of CBM operation without major loss of performance. The PMTs are located close to the yokes of the CBM dipole magnet, where a stray field of up to 100 mT exists. To escape the field influence, the PMTs have been displaced outwards and a shielding box has been designed. This change of the RICH layout called for re-optimization of the primarily adapted detector geometry to assure minimal impact on the ring quality. With this change the close-to-final RICH geometry has been achieved. A mechanical design has been worked out which improves considerably the material budget of the mirror wall compared to earlier solutions while still keeping sufficient mechanical stability. A concept for correction for mirror misalignment is under development.
In this contribution an overview on the CBM RICH design with focus on the new developments described above will be given.

Registered:

Yes

Novel Cherenkov imaging techniques for future experiments / 7

The Endcap Disc DIRC of PANDA

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Co-authors: Albert Lehmann [2]; Anastasios Belias [3]; Avetik Hayrapetyan [4]; Concettina Sfienti ; Erik Etzelmüller [5]; Joachim Schwiening [6]; Julian Rieke [1]; Klaus Fohl [4]; Klaus Peters [7]; Mustafa Andre Schmidt [4]

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A 2 cm thick fused silica plate is the central part of the Endcap Disc DIRC, that has been designed to identify traversing pions, kaons and protons in the future PANDA experiment. The detector has a dodecagonal structure with a diameter of about 2 m. The radiator is segmented into 4 identical quadrants. Its acceptance covers the PANDA forward range of 5° to 22°. Cherenkov light produced by relativistic particles is internally reflected inside the highly polished radiator plates. Focusing optics is attached to the outer rim of the four plates outside of the acceptance of the experiment. It focuses the Cherenkov light onto MCP-PMTs with a pitch of about 0.5 mm. The detector will be able to provide a 4σ pion-kaon separation up to 4 GeV/c. A fast readout system will cope with the continuous antiproton beam of PANDA with interaction rates up to 20 MHz.

The current design is the product of a learning curve of several iterations of simulation, prototype development and test beam campaigns. We tested MA-PMTs, SiPMs and MCP- PMTs, using acrylic glass, float glass and fused silica for the optical elements. Considerations of radiation hardness, strong magnetic fields, tight spatial requirements and high count rates lead to the final design using fused silica as optical material and MCP-PMTs with high life time and good time and spatial resolution for single photon detection. A limited spectral acceptance reduces dispersion effects and extends the lifetime of the photo sensors. A compact and fast readout is realized by using ToFPET ASICs. Analytical reconstruction algorithms allow for fast particle identification.

The talk will explain the criteria that lead to the current design and will report on the quality control of the individual components on the test bench, as well as on the results of system tests using test beams and cosmic rays.

Registered:

Yes

Novel Cherenkov imaging techniques for future experiments / 76

The Forward RICH Detector for the PANDA Experiment

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The PANDA detector at the international accelerator Facility for Antiproton and Ion Research in Europe (FAIR) in Darmstadt, Germany will address fundamental questions of hadron physics. The PANDA Forward RICH (FRICH) is intended for identification of charged particles produced in antiproton collisions with a fixed hydrogen target that fly in the forward direction below 5°–10° of polar angle and with momentum between 3 GeV/c and 15 GeV/c.
The Forward RICH will employ a focusing aerogel radiator to achieve the required performance without use of gaseous Cherenkov radiator. Several precisely aligned flat mirrors will reflect light on the photon detector which is located outside of the detector's effective aperture. Photon detector consist of flat panel multianode photomultiplier tubes (MaPMT). The Forward RICH R&D relies on experience gained in developing RICH detectors for LHCb, CBM, Belle II and the Super Charm-Tau Factory project. A baseline design of the PANDA Forward RICH will be discussed including results from the full Monte-Carlo simulation and results of measurements and tests of the system's components.

Registered:

Yes

Novel Cherenkov imaging techniques for future experiments / 87

Cherenkov Detector work at Stony Brook University

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The Stony Brook University group has been involved with Cherenkov detector work for many years and our accomplishments include the RICH detector in PHENIX (photo-tube RICH) and the Hadron-Blind Detector (HBD), a windowless Cherenkov detector based upon CsI photocathodes directly placed upon the top surface a Gas Electron Multiplier (GEM). More recently, we have extended the work on CsI GEM photocathodes ion connection with the R&D program of leading to the future Electron-Ion Collider (EIC). These efforts include both a focused RICH detector and hybrid TPC/HBD tracking threshold-Cherenkov detector. The focused RICH featured a 5-layer GEM-stack coupled directly to a 1 meter-long radiator section. A commercial mirror with reflectivity in the deep UV focused rings onto the photocathode. The detector was tested both at SLAC (9 GeV/c electrons) and at Fermilab (mixed hadron beams with energies from 20 GeV/c to 32 GeV/c). Excellent pi/K/p separation was observed at all energies with 12 photo-electrons per ring. The TPC/HBD device combines Time-Projection Chamber tracking with threshold Cherenkov light detection using the same gas volume. The "exit side"of the field cage is made optically transparent using wire planes and the drift direction is set perpendicular to the track trajectory. This device was successfully tested in April 2016 at Fermilab and first results will be presented in this talk.

Registered:

Novel Cherenkov imaging techniques for future experiments / 15

The TORCH detector R&D: status and perspectives

Author: Thierry Gys[1]

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TORCH (Timing Of internally Reflected CHerenkov photons) is a time-of-flight detector for particle identification at low momentum. It has been originally proposed for the LHCb experiment to complement its particle identification capabilities provided by two gaseous ring-imaging Cherenkov detectors. TORCH is using 10mm-thick planes of quartz radiator in a modular design. A fraction of the Cherenkov photons produced by charged particles passing through this radiator propagate by total internal reflection, they emerge at the edges and are subsequently focused onto fast, position-sensitive single-photon detectors. The recorded positions and arrival times of the photons are used to precisely reconstruct their trajectory and propagation time in the quartz.
The TORCH design requires the development of photon detectors with asymmetric anode pads of typical size 0.4mmx6.4mm. The overall per-photon time precision must be better than 70ps after signal processing by dedicated fast electronics and appropriate reconstruction of the photon propagation time in the quartz. In addition, for use in a high-energy physics experiment, the photon detectors must survive a number of years in a high occupancy environment, corresponding to an anode current density of 1 to 5 C/cmˆ2 for 5 years.
The on-going R&D programme aims at demonstrating the TORCH basic concept through the realization of a full detector module and has been organized on the following main development lines: micro-channel plate photon detectors featuring the required granularity and lifetime, dedicated fast

front-end electronics preserving the picosecond timing information provided by single photons and high-quality quartz radiator and focussing optics minimizing photon losses.
This paper will report on the TORCH results successfully achieved in the laboratory and in charged particle beam tests. It will also introduce the latest developments towards a final full-scale module prototype.

Registered:

Yes

Novel Cherenkov imaging techniques for future experiments / 19

A study of the attainable Cherenkov angle resolution in cylindrical mirror-based Focusing DIRC designs using BaBar style radiators

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We have previously built and tested a full scale prototype of a Focusing DIRC (FDIRC) detector [1]. This device was based on the BaBar radiators and bar box enclosures attached to a new cylindrically focused camera, and intended for the upgrade of the BaBar detector for the SUPERB factory. Similar optical concepts are now being considered for the GLUEX experiment at JLAB, and possibly, the Electron-Ion collider PID detector at BNL. In this paper, we probe the Cherenkov angular resolutions attainable with similar radiator designs (which could make use of the available BaBar radiator bars) and FDIRC style focusing camera techniques. We compare four designs via Monte Carlo (MC): (a) the SuperB FDIRC with 6mm x 6mm pixels, (b) a similar device with smaller photodetector pixels(3mm x 12mm) as provided by the Hamamatsu H-9500 MaPMT and using the BaBar bar box without modification, (c) another device that again uses the BaBar bar box without modification, which is attached to a more compact camera with a much smaller FDIRC focusing block (FBLOCK) with photon detector pixel sizes of 1.6mm x 25.6 mm, as provided by the Photonis 1024-pixel XP-85022 MCP-PMT connected in this case as 1 x 16 small pixels, and (d) other possible concepts. The talk will compare and contrast the MC angular performance attained by each scheme.

[1] B. Dey et al., "Design and performance of the Focusing DIRC detector", NIMA 775(2015)112-131.

Registered:

Novel Cherenkov imaging techniques for future experiments / 28

Overview of LHCb-RICH upgrade

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The two RICH detectors in LHCb have successfully collected data corresponding to 3.3 /fb of integrated luminosity since 2010 and have been essential for most of the physics programme of LHCb. From 2021 onwards LHCb plans to collect data corresponding to 5 /fb of integrated luminosity per year in order to improve the statistical precision of the physics measurements and to search for very rare B-decays and D-decays. This will be achieved by removing the Level 0 hardware trigger running at 1 MHz and reading out the detectors at the full collision rate of 40 MHz.

In order to cope with the corresponding increase in the readout rate for the RICH detectors, the HPDs will be replaced by MaPMTs. The optics of the upstream RICH is modified so that the occupancy is reduced and the particle identification performance is improved. This requires rebuilding most parts of the upstream RICH where the arrays of MaPMTs and their readout would be installed in a tight space inside a magnetic shielding. New structures to hold MaPMTs and their readout boards will have to be designed. Following a technical design review in 2013, substantial advances in the mechanics have taken place and prototypes of MaPMTs and their readout electronics were tested. This includes testing these components in three test beams at CERN. A magnetic shielding system for the MaPMTs was designed and tested. Various readout components were tested for radiation hardness. New spherical mirrors made of carbon fibre composite are being developed and tested. An overview of these developments for RICH upgrade will be presented and the expected performance of the RICH system using LHCb simulations will be reported.

Registered:

Yes

Pattern recognition and data analysis / 34

Alignment and calibration methods for the Belle II TOP counter

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At the Belle II detector a Time-of-Propagation (TOP) counter will be used for particle identification in the barrel region. The Belle II TOP counter consists of sixteen 2.7 m long modules positioned in the space between the central drift chamber and the electromagnetic calorimeter. The counter is now under final installation into the Belle II detector. We will discuss the methods for the alignment and calibration of the TOP counter modules with measured data.

Registered:

Yes

Pattern recognition and data analysis / 60

Contribution of the High Momentum Particle Identification Detector (HMPID) to the ALICE physics program

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The ALICE apparatus is dedicated to collect data coming from pp, p-Pb and Pb-Pb collisions provided by LHC, to study the properties of strongly interacting matter under extremely high temperature and energy density conditions. For such a task, enhanced particle identification capabilities are requested. Among the other PID ALICE detectors, the ALICE-HMPID (High Momentum Particle Identification Detector) is devoted to the identification of charged hadrons, exploiting the Cherenkov effect. It consists of seven identical RICH counters, with liquid C_6F_{14} as Cherenkov radiator (n ≈ 1.298 at λ = 175 nm). Photons and charged particles detection is performed by a MWPC, coupled with a pads segmented CsI coated photo-cathode. HMPID provides 3 sigmas separation for pions and kaons up to p_T = 3 GeV/c and for kaons and protons up to p_T = 5 GeV/c. In this way HMPID is able to contribute to inclusive hadrons spectra measurement as well as to measurements where high purity PID is required, by means of statistical or track-by-track PID, respectively. A review of the contribution given, so far, by the HMPID to the physics measurements in ALICE, performed with LHC RUN1 (2010-2013) and RUN2 (2015) data, such as inclusive charged hadrons yields and ratios as a function of transverse momentum, deuterons identification and jets compositions, are shown.

Registered:

Yes

Pattern recognition and data analysis / 74

Recent developments in software for the Belle II proximity focusing RICH with aerogel as a radiator

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For the Belle II spectrometer a proximity focusing RICH counter with an aerogel radiator (ARICH) will be employed as a PID system in the forward end-cap region of the spectrometer. The detector

will provide about 4σ separation of pions and kaons up to momenta of 3.5 GeV/c, at the kinematic limits of the experiment. We present the up-to-date status of the ARICH simulation and reconstruction software, focusing on the recent improvements of the reconstruction algorithms and detector description in the Geant4 simulation. The effect of these on the detector performance is studied using the full Belle II detector simulation and the results of these studies will be presented. In addition, we will show the first reconstructed Cherenkov rings that will be collected during the detector cosmic-ray test, which is foreseen to start in the early summer. The analysis of these data will allow for the test of our full reconstruction chain, as well as for the validation of the Geant4 simulation, through the comparison of the measured and Monte Carlo data.

Registered:

Yes

Pattern recognition and data analysis / **25**

Real-time calibration and alignment of the LHCb RICH detectors

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The Ring Imaging Cherenkov (RICH) detectors of the LHCb experiment provide particle identification (PID) of charged particles in the momentum range of 2-100 GeV. This is essential for the LHCb core physics program. As the center-of-mass energy of the LHC has been increased from 8 TeV to 13 TeV, and the LHCb experiment will upgrade from 2021 and run at a 4-times higher luminosity than the current one, a new and unique software trigger strategy has been established at the LHCb experiment with the purpose of increasing the purity of the signal events by applying the same algorithms online and offline. This requires ultimate quality of vertexing, tracking, and PID. Real-time calibration and alignment of the RICH detectors is needed to provide the best PID for the online trigger, and will be reported in this talk. This includes the calibration of the refractive index of the RICH radiators, the calibration of the Hybrid Photon Detector (HPD) image, and the alignment of the RICH mirror system.

Registered:

Yes

Pattern recognition and data analysis / **35**

Real-time track-less Cherenkov ring fitting trigger system based on Graphics Processing Units

Authors: Gianluca Lamanna[1]; Massimiliano Fiorini[2]

Co-authors: Alberto Gianoli [2]; Alessandro Lonardo [3]; Andrea Biagioni [4]; Angelo Cotta Ramusino [2]; Davide Rossetti [5]; Elena Pastorelli [6]; F Simula [6]; Francesca Lo Cicero [6]; Ilaria Neri [2]; Luca Pontisso [7]; Marco Sozzi [7]; Mauro Piccini [8]; Michele Martinelli [4]; Ottorino Frezza [6]; Paolo Cretaro [6]; Pier Stanislao Paolucci [6]; Piero Vicini [9]; Riccardo Fantechi [10]; Roberto Ammendola [11]; Roberto Piandani [7]; Stefano Chiozzi [2]

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In rare decays experiments an effective online selection is mandatory for the data acquisition system in order to reduce data bandwidth and save storage resources. The NA62 experiment at CERN studies ultra-rare kaon decays and makes use of a three-levels trigger system to reduce the 10 MHz incoming events rate of about three orders of magnitude before storage. The first trigger stage (L0) is a hardware synchronous system that achieves a rejection factor of 10 within the maximum latency of 1ms. Two other triggers run at software level on a computer farm and perform further filtering and final event building.
The NA62 Ring Imaging Cherenkov (RICH) detector consists of a 17m long vessel, 3m in diameter, filled with Ne at 1atm, read out by 2000 photo-multiplier tubes (PMTs), that has been designed to separate pions from muons in the 15-35 GeV/c momentum range. According to the baseline design of the experiment, primitives from the RICH detector at L0 consist only of PMT multiplicities in a pre-defined time window.
A dedicated system for generating advanced trigger primitives for the RICH at L0 has been implemented on commercial Graphic Processing Unit (GPU), and relies on the enhanced computation capabilities and high parallelization available on such devices. A fast ring-fitting algorithm is fed with raw RICH data, with no track information from the spectrometer, and information on the particle speed and direction is provided for a more selective L0 trigger decision.
This system has been installed in parasitic mode during the 2015 NA62 experimental run and relies on direct GPU communication using a FPGA-based network interface card called NaNet that allows strong latency reduction. For the forthcoming 2016 run the system is being upgraded with an improved version of NaNet equipped with 10 Gigabit Ethernet link. The system performance will be described and results of multi-ring Cherenkov reconstruction obtained during the NA62 physics runs will be presented.

Registered:

Yes

Photon detection for Cherenkov counters / 57

Results from new Multi-Channel-Plate based Photon Detectors

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The Argonne MCP-based photo detector is an offshoot of the Large Area Pico-second Photo Detector (LAPPD) project, wherein
6 cm x 6 cm sized detectors are made at Argonne National Laboratory. We investigated these devices, which have pico-second timing and millimetre spatial resolution, in the laboratory. We will present

measurements of the properties of these detectors, including gain, time and spatial resolution, dark count rates, cross-talk and sensitivity to magnetic fields. We are also exploring ways to measure Cherenkov photons with these detectors using a cosmic ray telescope. In addition, we will discuss possible applications of these devices for neutrino and flavour physics experiments.

Registered:

Yes

Photon detection for Cherenkov counters / 68

Extension of the MCP-PMT lifetime

Author: Kodai Matsuoka[1]

Co-authors: Kazuhito Suzuki [2]; Kazuho Kobayashi [1]; Kenji Inami [3]; Raita Omori [1]; Shigeki Hirose [2]; Toru Iijima [1]; Yosuke Maeda [1]; Yuji Kato [1]

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emsp; A micro-channel-plate photomultiplier tube (MCP-PMT) has the best timing resolution
for single photon detection, which enabled us to realize the novel RICH detector,
the TOP counter, for particle identification in Belle II. A major concern about using MCP-PMTs under a high background environment like Belle II is a short lifetime of the photocathode because the quantum efficiency drops as a function of the integrated output charge of the MCP-PMT due to outgassing from the MCP.
emsp; We succeeded in extending the lifetime of the square-shaped MCP-PMT for the TOP counter step-by-step: from less than 0.1 C/cm^2 of the lifetime to about 1 C/cm^2 with a conventional MCP, about 9 C/cm^2 by applying atomic layer deposition (ALD) to the MCP, and more than 15 C/cm^2 by further improvement, while the estimated integrated
output charge in Belle II is about 3 C/cm^2. Especially more than 15 C/cm^2 was measured for all 10 samples.
emsp; This talk will also cover a difference of the performance between the conventional and
ALD-MCP-PMTs as well as a degradation of the performance under a high background.

Registered:

Yes

Photon detection for Cherenkov counters / 83

Planar microchannel plate photomultiplier with VUV-UV-Vis full range response for fast timing and imaging applications

Author: Junqi Xie[1]

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Planar microchannel plate photomultipliers (MCP-PMTs) with bialkali photocathodes are able to achieve single photon detection with excellent time (picosecond) and spatial (millimeter) resolution. They have recently drawn great interests in experiments requiring time of flight (TOF) measurement and/or Cherenkov imaging. Current MCP-PMTs have a response range of 300 nm –600 nm, limited by the window transmission and cathode materials. By replacing the glass window with fused silica, the detection range can be dramatically extended from 300 nm to 170 nm, providing much more efficient Cherenkov radiation detection.

The Argonne MCP-PMT detector group has recently designed and fabricated 6 cm x 6 cm MCP-PMTs with fused silica window. Initial characterization indicates that the fused silica window photomultipier exhibits a transit-time spread of 57 psec at single photoelectron detection mode and of 27 psec at multi photoelectron mode (100 photoelectrons). Currently, we are testing the MCP-PMTs at Fermilab test beam facility for its particle detection performance and rate capability. The progress on new window exploration and characterization of the new MCP-PMT in beamline particle test will also be reported and discussed.

Registered:

Yes

Photon detection for Cherenkov counters / 9

Recent Developments with Microchannel-Plate PMTs

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PANDA will be one of the pillar experiments at the new FAIR facility at GSI. With a high intensity antiproton beam its objectives will be, among others, charmonium spectroscopy and the search for gluonic excitations. These scientific goals require a high performance PID system which will consist of DIRC detectors residing inside a magnetic field of 2 Tesla.

Microchannel-plate (MCP) PMTs are very attractive photon sensors for low light level applications in B-fields. Until recently the main drawback of MCP-PMTs was aging. This causes a limited lifetime due to a rapidly decreasing quantum efficiency (QE) of the photo cathode (PC) as the integrated anode charge (IAC) increases. In the latest models of PHOTONIS, Hamamatsu, and BINP innovative techniques are applied to avoid aging which is mainly caused by ion backflow impinging on the PC and damaging it.

Since five years we are running an aging test for new lifetime-enhanced MCP-PMTs by simultaneously illuminating various PMT models with roughly the same photon rate. This allows a fair comparison of the lifetime of these MCP-PMTs and gave some insight in the best techniques for a lifetime enhancement. Also conclusions about the aging mechanisms may be possible.

In this presentation the results of comprehensive aging tests will be discussed. The QE dependent on the IAC was measured as a function of the wavelength and the position across the PC. For the best performing tubes the lifetime improvement in comparison to the older MCP-PMTs is a factor of 50 based on an IAC of meanwhile 10 C/cm2. This tremendous lifetime increase was accomplished by coating the MCP pores using an atomic layer deposition (ALD) technique.

In addition, we will present performance results of a new 2-inch lifetime-enhanced MCP-PMT with a very high position resolution (128x6 anode pixel) which was recently developed by Hamamatsu.

The effects of electron focussing on the position resolution inside a high magnetic field will also be discussed.

Registered:

Yes

Photon detection for Cherenkov counters / 10

The MPGD-based photon detectors for the upgrade of COMPASS RICH-1

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The RICH-1 Detector of the COMPASS Experiment at CERN SPS is undergoing an important upgrade for the physics run 2016 starting in April 2016: four new Photon Detectors, based on MPGD technology and
covering a total active area larger than 1.2 square meters will replace the actual MWPC-based photon detectors in order to cope with the challenging efficiency and stability requirements of the new COMPASS measurements. The new detector architecture consists in a hybrid MPGD combination: two layers of THGEMs, the first of which also acts as a reflective photocathode (a CsI layer is deposited on its top face) 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. The related R&D is shortly recalled.
All aspects of the COMPASS RICH-1 Photon Detectors upgrade are presented and large emphasis is dedicated to the engineering aspects, the mass production and the quality assessment of the MPGD componets.
In particular, the design and production of the detector components, the assembling and the validation tests of THGEMs and Micromegas and the engineering challenges of the detector installation are presented together with the expected performance of the upgraded COMPASS RICH-1. Preliminary performance figures are provided.

Talk on behalf of a the COMPASS RICH group.

Registered:

Yes

Photon detection for Cherenkov counters / 13

R&D of a pioneering system for a high resolution photodetector: the VSiPMT

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The VSiPMT (Vacuum Silicon PhotoMultiplier Tube) is an innovative design for a revolutionary hybrid photodetector.
The idea, born with the purpose to use a SiPM for large detection volumes, consists in replacing the classical dynode chain with a SiPM. In this conguration, we match the large sensitive area of a photocathode with the performances of the SiPM technology, which therefore acts like an electron detector and so like a current amplier.
The excellent photon counting capability, fast response, low power consumption and great stability are among the most attractive features of the VSiPMT. In order to realize such a device we rst studied the feasibility of this detector both from theoretical and experimental point of view, by implementing a Geant4-based simulation and studying the response of a special non-windowed MPPC by Hamamatsu with an electron beam.
Thanks to this result Hamamatsu realized two VSiPMT industrial prototypes with a photocathode of 3mm diameter.
We now present an overview of the full characterization of the VSiPMT industrial prototypes with their pro and contra. We also present the progress on the realization of a 1-inch prototype and the preliminary tests we are performing on it.

Registered:

Yes

Photon detection for Cherenkov counters / 21

The TORCH PMT, a close packing, long life MCP-PMT for Cherenkov applications with a novel high granularity multi-anode

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Photek are currently in a three year development program to produce a novel square PMT for the proposed TORCH detector which is being developed within an ERC project, with potential application in a future upgrade of the LHCb experiment around 2023. The PMT will be MCP based for the

inherent timing accuracy that this brings, and has three main novel features that need to be developed:
1. Long lifetime, it should be able to produce 5 C / cm2 of accumulated anode charge without noticeable degradation in sensitivity.
2. Multi-anode output with an effective spatial resolution of 128 × 8 pixels within a 53 mm x 53 mm working area.
3. Close packing on 2 opposing sides with an active width fill factor target of 88% in one direction.

We will present further evidence of the significant beneficial effect that an ALD (Atomic Layer Deposition) coating on the MCPs has on the life time of an MCP-PMT.

We have developed a novel anode design that combines the image charge technique with a patterned anode, and uses a charge sharing algorithm that produces an inter-pad position resolution beyond the granularity of the pads themselves: 0.225 mm FWHM (0.1 mm rms) derived from pads on a 0.83 mm pitch. We will also show initial results using the multi-channel NINO ASIC and the first multi-anode tube prototypes.

We will present results from the first square PMT prototypes demonstrating the required fill factor ratio.

Registered:

Yes

Photon detection for Cherenkov counters / 53

Test of the HAPD light sensors for the Belle II Aerogel RICH

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The Aerogel Ring-Imaging Cherenkov detector (ARICH) is being installed in the endcap region of Belle II spectrometer to identify particles from B meson decays by detecting the Cherenkov ring image from an aerogel radiator. To detect the single photons, a high-sensitive photon detector which

has wide effective area (∼70 mm × 70mm), a Hybrid Avalanche Photo Detector (HAPD), has been developed in a collaboration with Hamamatsu K.K. The HAPD consists of a hybrid structure of a vacuum tube and an avalanche photodiode (APD). It can be operated in the high magnetic field of the spectrometer (1.5 T) and withstands the radiation levels expected in the Belle II experiment. There are two steps of electric pulse amplification: acceleration by electric field in the vacuum tube part and electron avalanche in the APD part resulting in a total gain of about 10^5. In the ARICH we use 420 HAPDs in total. Before installing them, we performed quality assessment studies such as measurements of dark current, noise level, signal-to-noise ratio and a 2-dimensional scan with laser illumination. We also measured quantum efficiency of the photocathode. During the HAPD performance tests in the magnetic field, we observed very large signal pulses which cause long dead time for readout electronics in some samples. We have carried out a number of studies to understand this effect, and have found a way to mitigate it and suppress the degradation of ARICH performance. In this presentation, we will show a summary of the HAPD performance and quality assessment measurements including validation in the magnetic field for all of the HAPDs manufactured for the ARICH in the Belle II.

Registered:

Yes

Poster Session A - Board: 9 / **52**

Development of the ARICH monitor system for the Belle II experiment

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The Aerogel Ring Imaging Cherenkov (ARICH) counter takes the role in particle identification at the endcap region of the Belle II detector. ARICH discriminates charged pions from kaons using the difference in radiation angle of Cherenkov light. ARICH is composed of aerogel tiles and Hybrid Avalanche Photo-Detectors (HAPDs). To keep high photon detection efficiency of HAPDs, periodical check of the efficiency and in-situ calibration of HAPDs are necessary. We are developing the monitor system that checks performance of each channels.

The monitor system is required to be installed in limited space inside ARICH. Pulse light is injected into ARICH using the optical fiber and emitted at the end of the fiber towards aerogel tiles. Some of emitted photons are reflected by Rayleigh scattering in aerogel tiles. Using scattered photons that enter a HAPD window, the performance of HAPD checked. At early stage of the Belle II experiment, it is difficult to detect the possible change of the performance of HAPDs using the beam data, so the monitor system is useful to ensure the healthiness of HAPDs. In stable stage of the Belle II experiment, the system can be used as the in-situ calibration source for HAPDs and their front-end electronics.

We constructed prototype monitor system consisting of an HAPD, a pair of aerogel tiles and an optical fiber. To check how pulse light is scattered by aerogel tiles, scattered photons are detected with moving the HAPD. As a result, We find the photons are scattered about 30 cm away from the optical fiber. Using a scattered photon, We confirm that the monitor system can be used to judge if a channel is dead or alive. We also find that noise level and gain of each channels can be measured at the same time. We have tested the system for around 500 hours, and have confirmed the stability for long term operation.In this poster, a test using the partially constructed Belle II ARICH counter, will also be presented.

Registered:

Yes

Poster Session A - Board: 25 / **40**

Event reconstruction for the CBM-RICH prototype beamtest data in 2014

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The Compressed Baryonic Matter (CBM) experiment at the future FAIR facility will investigate the QCD phase diagram at high net baryon densities and moderate temperatures in A+A collisions from 2-11 AGeV (SIS100). Electron identification in CBM will be performed by a Ring Imaging Cherenkov (RICH) detector and Transition Radiation Detectors (TRD).
A real size prototype of the RICH detector was tested together with other CBM prototypes (TRD, Time of Flight) at the CERN PS/T9 beam line in 2014. For the first time the data format used the FLESnet protocol from CBM delivering free streaming data. The analysis was fully performed within the CBMROOT framework. In this contribution the event reconstruction methods which were used for obtained data are discussed. Rings were reconstructed using an algorithm based on the Hough Transform method and their parameters were derived with high accuracy by circle and ellipse fitting procedures. Results of the application of the presented algorithms will be also presented.

Registered:

Yes

Poster Session A - Board: 5 / **31**

Neutron detection using a Water Cherenkov Detector with pure water and a single PMT

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We present the performance of a novel neutron detection technique based on a Water Cherenkov Detector (WCD) employing pure water, an inner coating material acting as a light reflector and diffuser, and a single photomultiplier tube (PMT). The detector employed in this work is part of the Latin American Giant Observatory (LAGO) collaboration, that measures the low energy component of cosmic rays. The experiments presented in this work were performed in presence of ^{241}AmBe and ^{252}Cf neutron sources in different neutron moderator and shielding configurations. We show that fast neutrons from ^{241}AmBe and ^{241}Cf sources, as well as thermal neutrons from a neutron moderator, having different spectral characteristics, produce essentially the same pulse histogram shape. This characteristic pulse height histogram shape recorded is a clear signature of neutrons with energies lower than $\simeq$11\,MeV, and was verified in different experimental conditions. Using this experimental data we estimate the neutron detection efficiency for fast neutrons at the level of (15$\pm$5)\%.
Also we explain the physical process that produce Cherenkov light from an incoming neutron. Being the material employed as active volume pure water, a cheap and abundant material, the results obtained in this work are of great interest for the construction of low cost and large active volumes neutron detectors for different applications, specially those related with space weather phenomena monitoring as well as the detection of fisil or fusionable special nuclear material.

Registered:

Yes

Poster Session A - Board: `13 - Not presented` / **67**

Quartz Cherenkov Detectors for Calorimetry and Timing in LHC Forward Processes.

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Abstract submitted by Aldo PENZO

Due to extremely high rates near the intense LHC interacting beams, forward regions of LHC experiments are challenging for most detectors, that need to have superior time resolution and radiation

resistance. Detectors based on Cherenkov light produced in quartz elements meet these requirements and are ideal components for forward calorimeters.
For instance in CMS three calorimeters extend the pseudorapidity coverage of the central CMS detector (|eta| < 3) in the forward direction :

- HF (3 < |eta| < 5),
- Castor (5 < |eta| < 7),
- ZDC (8 <|eta| < 9).

All these calorimeters are based on the Cherenkov quartz technology. These detectors are undergoing important improvements, to make them compatible with the increasing LHC luminosity. This talk will present their status and recent evolution. Other applications of quartz Cherenkov detectors for high resolution timing will be discussed also.

Registered:

No

Poster Session A - Board: 21 / **56**

Measurements of Quantum Efficiency and Sensitivity to Magnetic Fields of the MaPMTs R13743 and R13742

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The performance of the photon detectors in the upgraded LHCb RICH counters will be critical to the charged particle identification efficiency and to the physics goals of the LHCb experiment. Quantum Efficiency (QE) and the closely related the Photon Detection Efficiency (PDE) are the most important properties for single photon counting detectors. In vacuum photon tubes, the PDE generally is reduced by external magnetic fields, either by a reduction of the intrinsic gain or by an increased probability of the photoelectron not arriving at the first dynode. Local shielding can recover parts of the losses introduced by magnetic fields. We report on measurements of the Quantum Efficiency in the wavelength range of 200 to 800 nm of the 64-channel MaPMTs for the upgraded LHCb RICH detectors: the 2-inch R13743 and the 1-inch R13742. We also present the relative PDE with respect to no magnetic field in external longitudinal and transverse magnetic fields up to 30 Gauss. To reduce this loss of efficiency, magnetic shielding will be required. An unconventional space-saving layout of a magnetic shield was designed and the relative PDE was measured with these shields. Simulations of the properties of this layout were found to be in agreement with measurements.

Registered:

Yes

Poster Session A - Board: 11 / **61**

Development of the CBM RICH readout electronics and DAQ. Prototype results, time resolution with and without WLS coverage, radiation hardness tests.

Author: Egor, for the CBM-RICH collaboration Ovcharenko[1]

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The CBM experiment at the future FAIR facility will investigate strongly interacting matter at high net-baryon densities but moderate temperatures in heavy-ion collisions with beam energies up to 11 AGeV (SIS 100). Electromagnetic radiation from the fireball is among the most sensitive probes for the created matter. In order to identify di-electrons in a momentum range up to 8 GeV/c, a RICH detector will be employed. The photodetector makes use of H12700 MAPMTs from Hamamatsu, in order to enhance the quantum efficiency in the UV WLS coatings with p-terphenyl will be used.
This contribution will present results from a prototype of the triggerless RICH readout electronics and DAQ chain used in a testbeam experiment with a RICH prototype at CERN-PS and independent tests in the lab. The MAPMTs were partially covered with p-terphenyl as WLS coating. The readout chain connects the H12700 MAPMT with the FPGA-based frontend board PADIWA consisting of a preamplifier and discriminator. Leading and trailing edges of the logical LVDS signal are then digitized by an FPGA-based TDC on the multifunctional TRB3 board. The CBM specific FLIB board was used as interface between the readout electronics and the PC, running DAQ and analysis software applications using CbmRoot. Necessary unpacking, calibration and analysis software modules have been developed. A versatile performance analysis of the readout and DAQ chain of this type has been conducted for the first time. First results on the time resolution of the readout will be shown, also including results from the WLS coated MAPMTs. The WLS decay time determined this way compares well with results known from literature. The time resolution achieved is well within the limits for running the CBM experiment at 10 MHz interaction rate.
In addition separate radiation hardness tests of the WLS coatings will be presented showing no degradation of the fluorescence intensity up to doses of 3x10ˆ12 neq/cmˆ2 or 100 Gy.

Registered:

Yes

Poster Session A - Board: 29 / **64**

New cameras for the H.E.S.S. experiment

Author: Gianluca Giavitto[1]

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The High Energy Stereoscopic System (H.E.S.S.) is an array of imaging atmospheric Cherenkov telescopes (IACTs) located in the Khomas highland in Namibia. It was built to detect Very High Energy (VHE, >100 GeV) cosmic gamma rays. Since 2003, H.E.S.S has discovered the majority of the known astrophysical VHE gamma-ray sources, opening a new observational window on the extreme non-thermal processes at work in our universe. H.E.S.S. consists of four 12-m diameter Cherenkov telescopes (CT1-4), built in 2003, and a larger 28-m telescope (CT5), built in 2012, which lowers the energy threshold of the array to 30 GeV. The cameras of CT1-4 are currently undergoing an extensive upgrade, with the goals of reducing their failure rate, reducing their readout dead time and improving the overall performance of the array. The entire camera electronics has been renewed from ground-up, as well as the power, ventilation and pneumatics systems, and the control and data acquisition software. The CT1 camera has been upgraded in July 2015 and is currently taking data; CT2-4 will upgraded in Fall 2016. Together they will assure continuous operation of H.E.S.S at its full sensitivity until and possibly beyond the advent of CTA. This contribution describes the design, the testing and the in-lab and on-site performance of all components of the newly upgraded H.E.S.S. camera.

Registered:

Yes

Poster Session A - Board: 23 / **84**

Silicon Photomultiplier as Photon Sensor for RICH Counter

Author: Elvedin Tahirovic[1]

Co-authors: Peter Krizan [2]; Rok Pestotnik [3]; Samo Korpar

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An array of 8×8 silicon photomultipliers (SiPMs) was characterised as a position sensitive single photon sensor for Ring Imaging Cherenkov (RICH) counter. To improve the geometric efficiency of the array, light concentrators were designed in a form of truncated pyramids and machined from borosilicate glass. A very high number of photons per Cherenkov ring, approximately 35, was detected with a prototype module in an electron beam at DESY. In this contribution, the losses introduced by the binary operation mode are estimated. The possibility of reducing optical cross-talk in the light concentrators array by employing the Teflon filler is considered and results of optical bench tests and ray tracing simulations are presented.

Registered:

Yes

Poster Session A - Board: 17 / **91**

Measurements of 511 keV annihilation photons with ultimate timing resolution

Author: Kazuho Kobayashi[1]

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We report on measurements of 511 keV annihilation photons with ultimate timing resolution via detection of Cherenkov radiation in
PbF2 crystals attached to an ultra-fast single-channel Micro-Channel PhotoMultiplier Tube (MCP-PMT). We have measured back-to-back timing resolution using a pair of such detectors, and compare the results with a Monte Carlo simulation. The study would provide useful benchmark in development of TOF-PET with Cherenkov light using an array of multi-anode MCP-PMT or solid-state photodetectors, such as MPPC or SiPM.

Registered:

Yes

Poster Session A - Board: 15 / **79**

The laser calibration system of the BelleII TOP detector

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The TOP detector of the Belle II Experiment at KEK is a particle
identification detector, devoted mainly to the separation of charged pions
and kaons.
Principle of operation of the TOP is the total internal reflection of
Cherenkov photons emitted by charged particles while crossing a quartz
radiator. The Cherenkov photons are then detected by an array of micro-cannel plate
photomultipliers, The position and time of arrival of the photoelectrons,
are used to reconstruct simultaneously both the
Cherenkov angle and the time of flight from the interaction vertex to the
detector.
In order to achieve a time resolution of less than 100 ps , necessary to
separate kaons from pions, the performance of electronics and PMTs must be continuously monitored by a high resolution laser calibration system.
This talk reports about the design, characterization, construction and
installation of this light distribution system
consisting of a picosecond laser source, a printed light circuit (PLC),
long single mode fibers coupled to bundles of multimode fibers terminated with graded
index microlenses, to provide illumination of all the PMT pixels with very small
time jitter (less than 50 ps).

Registered:

Yes

Poster Session A - Board: 1 / **12**

The high voltage supply system for the novel MPGD-based photon detectors for the upgrade of COMPASS RICH-1

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The detector architecture consists in a hybrid MPGD combination:
two layers of Thick-GEMs (THGEM), the first of which also acts
as a reflective photocathode thanks to a CsI film is deposited
on its top face, are coupled to a bulk MICROMEGAS with pad
segmented anode kept at positive high voltage (HV), while the
micromesh is grounded; the signals are read-out via capacitive
coupling from a second set of pads parallel to the anode ones.
The THGEMs are segmented in order to reduce the energy released
in case of occasional discharges. The power supply system is based
on commercial components by CAEN. Two original elements are
present in the architecture of the HV power supply system:
(i) The distribution to the THGEM segments and to the MICROMEGAS
anode pads has been optimized in order to minimize the propagation
of occasional discharges to other detector sectors.
(ii) The detector gain is kept stable in spite of the variation of the
environmental parameters, namely pressure P and temperature T,
compensating the HV according to the P and T evolution.
The HV system and its performance are described in detail.

Poster presented on behalf of the Trieste COMPASS group

Registered:

Poster Session A - Board: 3 / **23**

Conception and design of a control and monitoring system for the mirror alignment of the CBM RICH detector

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The Compressed Baryonic Matter (CBM) experiment at the future Facility for Antiproton and Ion Research (FAIR) complex will investigate the phase diagram of strongly interacting matter at high baryon density and moderate temperatures in nucleus-nucleus collisions. The beam energy will range from 2 up to 11 AGeV for the heaviest nuclei at the SIS 100 accelerator setup.
One of the key detector components foreseen to cope with the CBM physics program is the RICH detector, providing efficient and clean electron identification (for momenta up to 8 GeV). It will be made of a CO2 gaseous radiator, Multi-Anode Photo-Multipliers for photon detection and about 80 trapezoidal glass mirror tiles, equally distributed in two half-spheres and used as focusing elements with spectral reflectivity down to the UV range.
An important aspect to guarantee a stable operation of the RICH detector is the alignment of the mirrors. A qualitative alignment control procedure for the mirror system, CLAM (Continuous Line Alignment Monitoring method) originally developed by the COMPASS experiment, has been implemented in the CBM RICH prototype detector. It was tested under real conditions at the CERN PS/T9 beamline. Data and results of image processing will be reviewed and discussed.
In parallel a quantitative method using recorded data and originally developed and inspired by the HERA-B experiment has also been employed to compute mirror displacements of the RICH mirrors.

Results based on simulated events and the limits of the method are discussed as well.
If mirror misalignment is detected, it can be subsequently included and rectified by correction routines. A correction routine is presented and three geometries are compared, namely the misaligned, corrected and ideal ones. The improvements offered by the correction are also highlighted, using reconstruction efficiencies.

Registered:

Yes

Poster Session A - Board: 27 / **24**

Design and R&D of RICH detectors for EIC experiments

Authors: Alessio Del Dotto[1]; Cheuk-Ping Wong[2]; Douglas Fields[3]; Hubert van Hecke[4]; J. Matthew Durham[4]; Jin Huang[5]; Marco Contalbrigo[6]; Martin Lothar Purschke[7]; Maurizio Ungaro[8]; Sawaiz Syed[9]; Xiaochun He[2]; Zhiwen Zhao[10]

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An Electron-Ion Collider (EIC) has been proposed to further explore the strong force and QCD, focusing on the structure and the interaction of the gluon-dominated matter.
A generic detector R&D program (EIC PID consortium) for the particle identification in EIC experiments was formed to explore technologically advanced solutions for that scope.
In this context two Ring Imaging Cherenkov (RICH) have been proposed: a Modular RICH detector which consists of an aerogel radiator, a Fresnel lens, a mirrored box, and pixelated photon sensor; a dual-radiator RICH, consisting of an aerogel radiator and CF4 gas in a mirror-focused configuration.
We will present the simulation of the detector geometry configurations, together with an estimation of the expected performances.
A prototype of the Modular RICH detector is scheduled to be tested at Fermilab in April of 2016. The detector performance from this beam test and optimizations for the EIC environment will be also discussed in this presentation.

Registered:

Yes

Poster Session A - Board: 19 / **27**

Upgrade of the HADES RICH photon detector with H12700 MAPMTs
*

Author: Christian Pauly[1]

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The RICH detector of the HADES experiment is designed for efficient electron identification (electron momenta up to few hundred MeV/c) in relativistic heavy ion collisions, and successfully in operation since 1999 at the SIS18 accelerator facility, GSI, Darmstadt, Germany. It is based on a gaseous photon detector with a reflective CsI cathode deposited on the MWPC pad plane.
The CBM experiment at the future FAIR facility in Darmstadt will install a RICH detector utilizing 1100 Hamamatsu H12700 Multianode Photomultiplier tubes.
In a joint effort the HADES RICH photon detector will be replaced by a subset of these MAPMTs together with a new FPGA-TDC based readout chain resulting in a significant improvement of e+e-- pair reconstruction efficiency for near future measurement campaigns.
The talk will give an overview on the status and plans of the HADES RICH upgrade project, and show simulation results on the expected detector performance after the upgrade. The new readout chain based on the DiRICH front end module will be presented, and first results from prototype tests will be shown.

* supported by BMBF grants 05P15PXFCA, 05P15RGFCA, and GSI

Registered:

Yes

Poster Session A - Board: 7 / **41**

Beam test results for the upgraded LHCb RICH opto-electronic readout system

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The LHCb experiment is devoted to high-precision measurements of CP violation and search for New Physics by studying the decays of beauty and charmed hadrons produced at the Large Hadron Collider (LHC).

Two RICH detectors are currently installed and operating successfully, providing a crucial role in the particle identification system of the LHCb experiment.
Starting from 2019, the LHCb experiment will be upgraded to operate at higher luminosity, extending its potential for discovery and study of new phenomena. Both the RICH detectors will be upgraded and the entire opto-electronic system has been redesigned in order to cope with the new specifications, namely higher readout rates, and increased occupancies.
The new photodetectors, readout electronics, mechanical assembly and cooling system have reached the final phase of development and their performance was thoroughly and successfully validated during several beam test sessions in 2014 and 2015 at the SPS facility at CERN.
Details of the test setup and performance results of the opto-electronic readout system will be presented.

Registered:

Poster Session B - Board: `14 - Not presented` / **72**

The front-end electronics of the CLAS12-RICH detector

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The new aerogel radiator hybrid geometry CLAS12 RICH detector will be readout using 25000 single photon sensitive pixels on a 1 m^2 surface.
A modular on-detector electronics has been developed based on ASIC and FPGA.
It is capable of 100 % detection efficiency at 50 fC and 3D-binary reconstruction (hit position and time) with 1 ns resolution, 8 μs latency and negligible dead time up to 100 kHz.
In addition the system can work in self-trigger mode, offers linear analog measurements up to 30 pC thanks to embedded ramp ADCs and has an adjustable amplitude test pulser for complete onsite calibration and monitoring.
Boards are tailored to fit exactly Hamamatsu H8500 dimensions and come in two variants, 128 and 192 channels, to tessellate large surfaces or serving small setups with a very compact and lightweight look.
A user-friendly optical ethernet interface is available for high speed data transfer to the acquisition node.
The high configurability, the modular approach and the optical interface make it potentially interesting for many different imaging applications.
Stand alone test, laser test, irradiation test and real working conditions test results will be presented together with the system design.

Registered:

No

Poster Session B - Board: `12` / **65**

Ultrafast Detection in Particle Physics and Positron Emission Tomography Using SiPMs

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Silicon photomultiplier (SiPM) photodetectors perform well in many particle and medical physics applications, especially where good efficiency, insensitivity to magnetic field and precise timing are required. Recent developments in available devices and research which improved the understanding of SiPM response enable further improvement in the time resolution that can be achieved. We report on our recent research related to the use of SiPMs for very fast detection of Cherenkov photons in aerogel ring imaging Cherenkov counter (ARICH) and time-of-flight positron emission tomography (TOF PET).

Registered:

Poster Session B - Board: 26 / **22**

Performance simulation of BaBar DIRC bar boxes in TORCH

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TORCH is a large-area precision time-of-flight detector based on the DIRC principle, proposed to provide positive particle identification of low momentum kaons for the LHCb experiment at CERN. The DIRC bar boxes of the BaBar experiment at SLAC could possibly be reused to form a part of the TORCH detector time-of-flight wall area.

For the implementation of the BaBar bars, new imaging and readout optics are required. Several designs of readout optics have been worked out and their optical resolutions studied, a particular challenge being the design of a performant optics with sufficient angular resolution while keeping to a small volume and leaving the BaBar DIRC boxes unchanged up to and including the bar box exit windows.

The present paper will report on pion-kaon separation powers obtained from analysing simulated photon hit patterns. Different scenarios will be compared, among them the effect of optical imperfections on the detector and reconstruction performance.

Registered:

Yes

Poster Session B - Board: 18 / **94**

The Front End Readout Electronics for the Hybrid Avalanche Photo Detector of the Belle II ARICH

Author: Rok Pestotnik[1]

Co-authors: Haruki Kindo [2]; Hidekazu Kakuno [3]; Ichiro Adachi [4]; KOKI HATAYA [5]; Makoto Tabata ; Manca Mrvar [6]; Masanobu YONENAGA [7]; Peter Krizan [8]; Rok Dolenec [9]; Samo Korpar [1]; Satoru Ogawa [10]; Shohei Nishida [4]; Shuichi Iwata [11]; Takayuki SUMIYOSHI ; Yosuke Yusa

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In the forward end-cap of the Belle II spectrometer, the proximity focusing RICH with aerogel radiator will be installed for charged particle identification. At the back side of the Hybrid Avalanche Photo Detector (HAPD), a low power front end electronics board will be mounted. The board consists of a 11 layer PCB with four custom ASICs on the HAPD side and a FPGA on the other side. The front end board is designed to work in the 1.5 T magnetic field and withstand the 10 years of neutron irradiation. The 36 channel ASICs are responsible for amplification, shaping and discrimination of small (about 35000 e-) single photo-electron signals. The Xilinx Spartan-6 FPGA samples the digitized signals and sends the data via optical link to the experiment common data acquisition cards.
During the design, the functionality of the boards has been tested on the bench, in the test beam and during the neutron and gamma irradiation in the nuclear reactor.
420 front end boards were produced and tested prior the installation in the detector. In the presentation, we will present the module design, its functionality and the results of different tests.

Registered:

Yes

Poster Session B - Board: 30 / **70**

Design consideration for wide field-of-view gamma ray observatory on the Southern Hemisphere

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Gamma ray induced air showers can be observed by particle detector arrays at high altitudes. The water-Cherekov detection technique has proven to result in robust observations of the gamma-ray sky around TeV energies and has been applied in observatories like Milagro and more recently in HAWC. The biggest challenge for these kind of observatories is to effectively reject background events from proton induced air showers. The work presented here will give a detailed overview on the differences between photon and proton induced air showers by analysing the output of air shower simulations. The air shower particle footprint is studied as a function of detector altitude and incoming direction. In addition, the particle type, number and energy distributions are studied

together with the morphology particle footprint. The aim of this work is to establish the fundamental drivers for the design of a next generation wide field-of-view gamma ray observatory.

Registered:

Yes

Poster Session B - Board: 22 / **71**

Behaviour of HAPD for the Belle II experiment in magnetic field

Author: Haruki Kindo[1]

Co-authors: Hidekazu Kakuno [2]; Hideyuki Kawai [3]; Ichiro Adachi [4]; KOKI HATAYA [5]; Kazuya Ogawa [6]; Luka Santelj [7]; Makoto Tabata ; Manca Mrvar [8]; Masanobu YONENAGA [9]; Peter Križan [10]; Rok Dolenec [11]; Rok Pestotnik [12]; Ryusuke Kataura [6]; Samo Korpar [12]; Satoru Ogawa [13]; Shohei Nishida [4]; Shota Iori [14]; Shuichi Iwata [9]; Takayuki SUMIYOSHI [9]; Tetsuro Kumita [9]; Tetsuya Kobayashi [6]; Yosuke Yusa

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The proximity-focusing Aerogel Ring-Imaging Cherenkov detector (ARICH) has been designed to provide PID in the forward end-cap region of the Belle II spectrometer. As a photon detector a Hybrid Avalanche Photo- Detector (HAPD), which was developed in collaboration with Hamamatsu Photonics, will be used. As the ARICH will be placed in 1.5T magnetic field, the HAPD must be immune to it.
Recently the production of about 500 HAPDs was completed and their performance in the 1.5T magnetic field was tested. While from our early tests of prototype samples no adverse effects of magnetic field were expected, we observed that in about 20% of HAPDs abnormally large signals (about 5000 times a single photon signal), affecting the full APD surface, are generated when operating in the magnetic field. The main effect of these large signals on the HAPD performance is the short period of dead time following each large pulse. For the most problematic HAPDs, for which the rate of large pulses can reach up to a few per second, the induced dead time can be as high as 20%.
As a possible origin of large pulses we considered the surface flashover effect on the side-walls of the HAPD tube, which is known to depend on magnetic field. However, recently we found an unexpected dependence of the rate of pulses on the bias voltage applied to the APD, which hardly compatible with that mechanism. If we apply bias voltage to single APD pad with 10 V reduction, the frequency go down to near 0. On the other hand, when we apply 10 V reduction to all APD pads, the frequency does not decrease but sometimes increase. We also find the large pulse seems to be related to the vacuum inside HAPD.
In the poster, we report about the observation of large signals in the HAPD, our strategy to manage it, and our study to identify its mechanism behind it.

Registered:

Poster Session B - Board: 16 / **81**

MIP suppression with ThickGEM based Cherenkov detectors

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Micropattern Gaseous Detectors opened a novel way for
photon detection for RICH applications;
mostly using hole-type amplifiers like GEM and ThickGEM,
and hybrid structures based on the formers.
The main features are low ion backflow, high gain,
and possibility for suppressing the MIP signal.
Latter can enhance the dynamic range, and allow for high gain operation,
while using cost effective electronics.

A ThickGEM and wire chamber based hybrid was contructed,
and tested in particle beam for Cherenkov photon detection.
Its performance and main characteristics,
like high stabile gain, and small cluster size validated
its applicaiblity.

Systematic studies on the MIP suppression power
with the usage of ThickGEMs were carried out.
The dependence on field configuration
and applied ThichGEM-gain were measured and quantified.

The poster will focus on the detailed investigation of the latter,
while giving a brief description of the general performance
of the hybrid as a Cherenkov detector.

Registered:

Yes

Poster Session B - Board: 24 / **90**

Cherenkov light imaging with state-of-the-art solid state detectors

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A large area ring-imaging Cherenkov detector will be operated at the CLAS12 experiment at the upgraded continuous electron beam accelerator facility of Jefferson Lab for hadron identification.
With the new beam energy, the momentum range under study will range between 3 GeV/c and 8 GeV/c. The detector consist of areogel radiator, composite mirrors and photon detector and will be built with a hybrid optics design. Cherenkov light will be imaged in two different ways: forward tracks will be detected directly while large angles tracks will be detected after two mirror reflections. The active area has to be densely packed and highly segmented covering about 1 mˆ2 with pixels of 6 mmˆ2. A new technology that can offer a cost-effective solution and low material budget could be Silicon Photonmultipliers (SiPM). Their properties are very attractive: high gain at low bias voltage, fast timing, good single-photoelectron resolution, insensitivity to magnetic fields. The avalanche process in the SiPM micro-cell is initialized by a primary electron/hole pairs that can be generated by an incident photon or by thermal generation effects, after-pulses or optical cross-talk. These latter intrinsic effects are responsible for their high dark count rate.
Prototypes of 3 × 3 mmˆ2 SiPM from different companies and of different micro-cell size are under investigation to comprehend and minimize this dark counts effects and to study their response to the moderate radiation damage expected at CLAS12.
Prototypes of SiPM matrices (4x4 or 8x8) is being tested at test-beam facilities or cosmic stands in order to analyse the response to Cherenkov light and their performance with the CLAS12 RICH readout.
In this poster, a brief review of the latest and most interesting results from these studies will be shown.

Registered:

Yes

Poster Session B - Board: 10 / **54**

First results from Quality Assurance Testing of MaPMTs for the LHCb RICH Upgrade

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In 2019 the LHCb RICH detector will be upgraded to increase the read out rate from 1MHz to 40MHz. As a consequence, the current Hybrid Photon Detectors (HPDs) will have to be replaced. Multianode Photomultiplier Tubes (MaPMT) from Hamamatsu with 64-channels will be used: the 1-inch R13742 and the 2-inch R13743 MaPMTs (custom modifications of the MaPMTs R11625 and H12699). Quality assurance testing of these MaPMTs using custom developed readout electronics has started. We present the design and realisation of the test facilities to ensure consistency in testing and validation. A total of 3100 units of R13742 and 450 units of the R13743 will be tested requiring high efficiency and reliability from the test stations. We report on the test programme and protocols, characterising the units and assuring minimum specifications. First results of testing and detector characterisation will be presented, based on the pre-series production, comprising 50 units of R13742 and 28 units of R13743.

Registered:

Yes

Poster Session B - Board: 2 / **18**

Timing in a FLASH

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Very precise timing below the 100ps-mark is gaining importance in modern detector designs. Many technology demonstrators achieving this goal were based on the Cherenkov effect exploiting its prompt light emission. One common requirement is the necessity to compensate inherent walk effects to reach the sub-100ps timing precison.
In traditional approaches either the amplitude is measured in addition to the timestamp, which requires the signal to be split, or a constant fraction discriminator is used. More recent developments include sampling the signal and extracting the relevant features which requires powerful frontend electronics and is not suited for all experimental circumstances.

With the advent of high-precision TDCs another method becomes feasible: measuring the signal amplitude via Time-over-Threshold. In this case the frontend electronics can be kept simple by only using a discriminator circuit and, optionally, a wide-band amplifier.

A prototype detector, called FLASH (Fast Light Acquiring Start Hodoscope), was built based on QUARTIC's design ideas. The fused silica radiator bars were coupled to a 10 micron-pore type PLANACON MCP-PMT with 64 channels and readout with custom electronics based on the NINO ASIC. The TRB3 system, a high-precision TDC implemented in an FPGA, was used as data acquisition system.

The performance of the system was investigated at a dedicated test experiment at the Mainz Microtron (MAMI) accelerator and a combined PANDA Barrel DIRC test experiment at CERN's PS T9 beam line.
The validity of the Time-over-Threshold approach could be established and an overall timing resolution of approx 70 ps could be achieved. The intrinsic resolution of the frontend electronics including the TDC was measured to be less than 25 ps.

Registered:

Yes

Poster Session B - Board: 4 / **30**

Single photon test bench for series tests of HAMAMATSU H12700 MAPMTs*

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The CBM experiment at FAIR, Darmstadt, has recently bought 1100 HAMAMATSU H12700 photon sensors to equip the photon detection plane of the CBM RICH detector.
Delivery of these MAPMTs just started, and will continue until mid 2017.

This MAPMT features a clear single photon peak (PV $> 1.5 : 1$) at high efficiency (peak quantum efficiency (QE) $\geq 30\%$) whilst having relatively low noise (< 6.4˜kHz).

The H12700 was confirmed to be the best choice for these two Cherenkov detectors undergoing a longterm R&D phase also defining selection criteria for the bought MAPMTs.

An automatized single photon scanning test bench has been developed in order to efficiently test and characterize every single MAPMT soon after delivery, and to provide constant feedback to the manufacturer on quality and efficiency of the delivered tubes, allowing for further optimizations in the manufacturing process.
The test bench consists of a pulsed LED light source (460˜nm), connected to a XY stepper motor table, the MAPMTs are read out using a self triggered readout scheme based on the nXYter ASIC.

This setup allows to derive all important performance characteristics, like single photon efficiency, gain, dark noise, afterpulsing, cross talk, and gain deviation, from a single scan data set.
By September 2016, more than four hundred MAPMTs will be measured, providing interesting data on the stability and variances of the production process.

On the poster, we describe the design of the MAPMT test bench, and present results of all measured MAPMTs.

*Work supported by GSI and BMBF contract No. 05P15PXFCA

Registered:

Yes

Poster Session B - Board: 28 / **43**

LAGO: the Latin American Giant Observatory

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The Latin American Giant Observatory (LAGO) is an extended cosmic ray observatory composed by a network of water-Cherenkov detectors (WCD) spanning over different sites located at significantly different altitudes (from sea level up to more than 5000\,m a.s.l.) and latitudes across Latin America, covering a huge range of geomagnetic rigidity cut-offs and atmospheric absorption/reaction levels. The LAGO WCD is simple and robust, and incorporated several integrated devices to allow time synchronization, autonomous operation, on board data analysis, and even remote control and automated data transfer.

This detection network is designed to measure the temporal evolution of the radiation flux coming from outer space at ground level with extreme detail. LAGO is mainly oriented to perform basic research in three branches: high energy phenomena, space weather and atmospheric radiation at ground level. It is an observatory designed, built and operated by the LAGO Collaboration, a non-centralized collaborative union of more than 30 institutions from ten countries.

In this work we will describe the scientific and academic primary goals of our project, by showing its current results, present status and future perspectives. We will also include a brief description of the main characteristic that gives a unique perspective of scientific research in Latin America.

Registered:

Yes

Poster Session B - Board: 8 / **50**

Development of Slow Control System for the Belle II ARICH Counter

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The Aerogel Ring Imaging Cherenkov (ARICH) counter is the particle identification device covering the endcap region in the Belle II detector. As a Cherenkov photon sensor a position-sensitive Hybrid Avalanche Photo-Detector (HAPD) will be used. In total 420 HAPDs will be arranged to cover the endocarp area. To operate HAPD six power lines with different voltages are needed. Negative voltage of $\sim 7kV$ is applied to tube to accelerate photoelectrons, a different reverse voltage ($\sim 300V$) is applied to each of the four APD chips (to equalize their avalanche gains), and a voltage of $\sim 200V$ is needed for the APD guard ring. In total this result in 2520 voltage channels that must be controlled in a reliable manner. For this purpose, slow control system has been developed. This system is composed of two major functions, one is to control the power supplies, the other is for configuration of the readout electronics.

The control system of the power supply should communicate with the Belle II central data acquisition system (DAQ), and therefore some utility functions, which are widely used in the Belle II system, are employed. We implement a power supply control software as a network based remote system to set/get parameters and error messages via NSM2, a network IPC framework in the Belle II DAQ system.A prototype system corresponding to one-sixth scale of ARICH power supply was built and operations of this prototype have been studied in detail to establish the stable control. As a result, we concluded that it is possible to expand this system to operate all channels for the ARICH counter.

For the readout of the HAPD, front end board (FEB) is directly connected to an HAPD. Output data from five or six FEBs are sent to one merger board. The merger board is connected to Belle DAQ system via Belle2Link, the common framework of detector readout. All configuration for the FEBs and the merger boards can be controlled though the Belle2Link.

Registered:

Yes

Poster Session B - Board: 6 / **37**

Radiation hardness assurance of the CLARO8 front-end chip for the LHCb RICH detector upgrade

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The increase in luminosity planned for the next LHC experiments upgrade is such that even detectors far from the interaction region will be exposed to considerable amount of radiation. The LHCb experiment at CERN is preparing for an important upgrade to be achieved in the years 2019-2020 in order to sustain higher instantaneous luminosities and read out the detectors at 40 MHz. The LHCb electronics and trigger systems will be completely modified: in particular the RICH hybrid photo-detectors will be replaced by commercial multi-anode photomultiplier tubes using a new external front-end electronics based on the CLARO8 chip. The CLARO8 chip is an application specific integrated circuit designed for single-photon counting: it features 8 channels, a peaking time of 5 ns, a recovery time better than 25 ns and a configuration register protected against Single Event Upsets by triple modular redundancy. Each channel is made of a charge amplifier with 2-bit settable attenuation, plus a comparator with a 6-bit settable threshold, and exhibits a power consumption of about 1 mW.

A careful assessment of the CLARO8 performance under high radiation fields is fundamental to ensure stable operation of the upgraded RICH detectors over the expected lifetime of the experiment after the upgrade. According to FLUKA simulations, the photo-detectors region of the RICH detectors will be exposed to a total ionizing dose of 200 krad, a neutron fluence of 3×10ˆ12 1 MeV neq/cm2 and a high energy hadrons fluence of 1.2×10ˆ12 cm2. Systematic irradiation campaigns have been performed using ions, protons and mixed-field high-energy hadron beams, assuming a safety factor of more than 10 on the above radiation levels. This contribution describes the complete radiation hardness campaign of the CLARO8 chips and the results of its extensive characterization.

Registered:

Yes

Poster Session B - Board: 20 / **32**

Testing RICH Upgrade MaPMTs and Readout Electronics at High Rates

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One of the biggest challenges for the upgrade of the LHCb RICH detectors from 2020 is to readout the photon detectors at the full 40 MHz rate of the LHC proton-proton collisions. A test facility has been setup at CERN with the purpose to investigate the behaviour of the Multi Anode PMTs, which have been proposed for the upgrade, and their readout electronics at high trigger rates.

The MaPMTs are illuminated with a monochromatic laser that can be triggered independently of the readout electronics. A first series of tests, including threshold scans, is performed at low trigger rates (20 kHz) for both the readout and the laser with the purpose to characterise the behaviour of the system under test. Then the trigger rate is increased in two separate steps. First the MaPMTs are exposed to high illumination by triggering the pulsed laser at a high (20 MHz) repetition rate while the DAQ is readout at the same low rate as before. In this way the performance of the MaPMTs and the attached electronics can be evaluated at high laser exposure rate. In the second step both the laser and the DAQ are triggered at the high rate in order to evaluate the full readout chain.

Registered:

Yes

Review Talks / 103

Status and perspectives of gaseous photon detectors

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Registered:

Yes

Review Talks / 101

Status and perspectives of vacuum-based photon detectors

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Registered:

Yes

Review Talks / 102

Status and perspectives of solid state photon detectors

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Registered:

Yes

Review Talks / 99

Photonic crystals, graphene, and new effects in Cherenkov radiation

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Recent discoveries of new materials, combined with modern nanofabrication techniques, have revealed novel ways of manipulating and confining light on the nanoscale. These developments offer opportunities to control a variety of light-matter interactions, and in particular, manipulate radiation emission from charged particles. My talk will discuss novel phenomena that occur when charged particles interact with photons in such nanophotonic structures. These interactions can lead to novel physical phenomena including a new type of Compton scattering that can be used for compact x-ray sources, and new types of Čerenkov radiation that can potentially improve detectors for high-energy physics experiments.

In a conceptual breakthrough that is now more than 80 years old, Čerenkov showed how charged particles emit shockwaves of light when moving faster than the phase velocity of light in a medium. We predict new effects, occurring because of the quantum wave nature of a charged particle, that create unexpected deviations from the conventional Čerenkov theory. Despite the years that have passed since its discovery, and much interest in the Čerenkov effect, it remained inaccessible to most nanoscale electronic and photonic devices because of the relativistic velocities it requires. In a recent project, we have shown that a newly discovered material called graphene provides the means to overcome this limitation through the low phase velocity of light trapped on its surface. The interaction between the trapped light (called graphene plasmons) and the charge carriers flowing inside graphene presents a highly efficient 2D Čerenkov emission process, giving a versatile, tunable, and ultrafast conversion mechanism from electrical signal to photonic/plasmonic excitation.

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[2] V. Ginis, J. Danckaert, I. Veretennicoff, P. Tassin, "Controlling Cherenkov radiation with transformation-optical metamaterials."PRL 113, 167402 (2014).

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Registered:

Yes

Review Talks / 95

Cherenkov light imaging in particle and nuclear physics experiments

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Yes

Review Talks / 105

Waveform-sampling electronics for Cherenkov detectors

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Yes

Review Talks / 98

RICH-related data analysis, and its use for physics

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Yes

Review Talks / 100

Cherenkov radiation in medical imaging

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Yes

Review Talks / 97

Detectors for gamma and neutrino astronomy

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Yes

Review Talks / 96

Radio detection of air showers

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Yes

Review Talks / 104

Other PID techniques

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Registered:

Yes

Technological aspects and applications of Cherenkov detectors / 45

Aerogel mass production for the CLAS12 RICH: Novel characterization methods and Optical Performance

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A large area ring-imaging Cherenkov detector has been designed for the CLAS12 experiment, to achieve a pion vs kaon rejection power of 500:1 in the momentum range 3 - 8 GeV/c. The adopted solution foresees a novel hybrid optics design based on aerogel radiator, composite mirrors and multi-anode photon detectors. To minimize the instrumented area, a proximity imaging method will be used for forward scattered particles, whereas at larger angles the Cherenkov light will be focused by a mirror system and undergo two further passes through the radiator material before detection.

Good optical properties of the aerogel radiator are crucial for the performance of such a challenging RICH. In order to achieve the required separation power, the detector design foresees the use of large-area 20×20 cm^2 aerogel tiles, conjugating high refractive index n=1.05 and high-transmission in the 300-600 nm wavelength range. Each RICH module requires 120 tiles: the geometrical precision and the optical quality matching the stringent specifications are critical tasks of such an aerogel mass production.

Safety procedures to preserve the aerogel performance during characterization, storage and assembling of a large number of tiles and long term stability in different environmental conditions were studied. Light forward scattering in the aerogel volume or refraction at the aerogel surface represent potential significant contributions to the Cherenkov angle resolution, which may be enhanced

due to the peculiar reflected light path in the CLAS12 RICH. Not invasive methods were developed to study in details these effects with a dedicated laser test-bench. The chromatic dispersion was measured by two independent methods: in laboratory by the prism method and in a test-beam by selecting different wavelength ranges of the detected Cherenkov light with optical filters.

The procedures and the results of the detailed aerogel characterization will be discussed in the presentation.

Registered:

Technological aspects and applications of Cherenkov detectors / 66

Assembly and Installation of the Belle II TOP Detector

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The Belle II experiment will start up the detector commissioning from early 2017 and will carry out various physic programs from 2018, where good particle identification is demanded. The Time-of-Propagation (TOP) detector is responsible for $\pi\pm/K\pm$ separation in the barrel region of the Belle II spectrometer. It has 16 detector modules cylindrically arranged around the beam line at a radius of about 1.2 m. A single detector module mainly consists of a synthetic silica Cherenkov radiator and photo-detector arrays with readout electronics attached to a radiator end. The TOP detector identifies a particle species based on the propagation times and detected positions of the Cherenkov photons that are propagated through the radiator utilizing the total internal reflection.

The radiator has the approximate dimensions of 2700 mm (L) x 450 mm (W) x 20 mm (T), where four components are glued together. It is crucial to mechanically support such a "thin", glued radiator, managing the material budget, flat module attitude and limited installation space. Various efforts have been made for developing the mechanical structures and the assembly and installation procedures. Aluminum Honeycomb panels with curved shapes have been developed for the detector module container to achieve high rigidity with low material budget. The detector modules have been assembled with the precision alignment of the mechanical components, preventing from overstressing the radiator. Support structures have been developed to reinforce the single module rigidity, maintaining the flat module attitude from the assembly till the installation. The installation procedure has been established to maintain the detector module sag below 0.5 mm and to manage the tight installation clearance.

The assembly and installation of the detector modules has been and will be completed in April and May 2016, respectively, and will be discussed with the features of the mechanical structure.

Registered:

Yes

Technological aspects and applications of Cherenkov detectors / 73

From the speed of sound to the speed of light: ultrasonic Cherenkov refractometry.

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Despite its success in the SLD CRID at the SLAC Linear Collider, ultrasonic measurement of Cherenkov radiator refractive index has been less fully exploited in more recent Cherenkov detectors employing gaseous radiators. This is surprising, since it is ideally suited to monitoring hydrostatic variations in refractive index as well as its evolution during the replacement of a light radiator passivation gas (e.g. N2) with a heavier fluorocarbon (e.g. C4F10[CF4]; mol. Weight 188[88]). The technique exploits the dependence of sound velocity on the molar concentrations of the two components at known temperature and pressure. The SLD barrel CRID used an 87%C5F12/13%N2 blend, mixed before injection into the: blend control based on ultrasonic mixture analysis maintained the ⍰=1 Cherenkov ring angle to long term variation better than ± 0.3%, monitored ultrasonically at multiple points in the radiator vessel.
Recent advances using microcontroller-based electronics have led to ultrasonic instruments capable of simultaneously measuring gas flow and binary mixture composition in the fluorocarbon evaporative cooling systems of the ATLAS Inner Detector. Sound transit times are measured in opposite directions in flowing gas for simultaneous measurement of flow rate and sound velocity. Gas composition is evaluated in real-time by comparison with a sound velocity/composition database.
In the ATLAS application C3F8 fluorocarbon coolant leaks into the N2 anti-humidity envelopes of the silicon tracker are measured to a precision better than 5.10-5. Another instrument is configured as an angled path flowmeter to measure high returning C3F8 vapour flux (up to ˜1.2 kg.s-1) with a precision of < 2% F.S., and can also monitor C3F8/C2F6 blend composition to better than ±3.10-3.
These instruments, which could find their way back into new and upgraded gas Cherenkov detectors, have many other applications - including Xenon-based anaesthesia. These possibilities are discussed.

Registered:

Yes

Technological aspects and applications of Cherenkov detectors / **78**

Investigation of Cherenkov light scattering and refraction on aerogel surface.

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The work is devoted to the development of aerogel radiators for RICH detectors. The aerogel tiles with refractive index 1.05 and thickness of 30 mm were tested with RICH prototype on electrons beam at VEPP-4M collider.

The tile with cracks inside has been investigated. The experimental data show that the Cherenkov angle resolution for tracks in the crack area and for tracks in the normal area are the same.

Several tiles with polished surface were tested with RICH prototype. Earlier It was shown that polishing with silk tissue gives good surface quality, the amount of light lost at this surface is about 5-7%. The Cherenkov angle resolution was measured for the tile in two positions – clean outflow face and polished outflow face. The number
of detected photons are 11.5 for clean and 11.1 for polished surfaces.
The Cherenkov angle resolution for polished surface is 30% worse. This points
to forward scattering on the polished surface

These results are important for the development of aerogel radiators
for RICH detectors.

Registered:

Yes

Technological aspects and applications of Cherenkov detectors / 48

The new photodetectors for the LHCb RICH upgrade and their FE design

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The RICH detectors of the LHCb experiment provide particle identification, especially for hadrons, in high energy proton-proton collisions at the LHC at CERN over a wide momentum range (2 to 100 GeV/c). The Cherenkov light is collected on 2D photon detector planes sensitive to single photons. In order to make the detector capable to operate at 40 MHz event readout speed, matching the bunch crossing rate of the accelerator, a substantial upgrade is planned for deployment in 2019. The current hybrid photon detectors (HPD) will be replaced with Multi-Anode photomultiplier tubes (customisations of the Hamamatsu R11265 and the H12699 MaPMTs). These 8×8 pixel devices meet the experimental requirements thanks to their small pixel size (~3×3 mmˆ2 for the R11265 model), high gain (10ˆ6 electrons per photon), negligible dark counts rate (~ 50 Hz/cmˆ2) and moderate cross-talk. The measured performance of several tubes are shown, together with their long-term stability. A new 8-channel front-end chip, named CLARO8, has been specifically designed in 0.35 µm CMOS AMS technology for the MaPMT readout. The CLARO8 chip operates in binary mode and combines low power consumption (~ 1 mW/Ch), remarkable speed (baseline restored in ≤ 25 ns) and radiation hardness. A 12-bit digital register permits the optimisation of the dynamic range and the trigger level for each channel and provides tools for the on-site calibration. The design choices and the characterization of the electronics are presented.

Registered:

Yes

Technological aspects and applications of Cherenkov detectors / 11

Investigation of the properties of Thick-GEMs photocathodes by microscopic investigation with single photo-electrons

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Novel Cherenkov detector upgrades favour GEM and THick-GEM (THGEM) based MPGD systems. These detectors have reduced ion backflow, fast signal formation, high gain, and could suppress the MIP signals as well. Sources of concern are the possible inefficiencies of the photo-electron collection from the top of the THGEM and the local variation of the gain related to geometrical non-uniformity.
The developed high resolution scanner[1] using a focused UV light gave the possibility to study single photo-electron response of MPGDs in the submillimeter scale. Revealing the microstructure of photo-efficiency and local gain provides a new tool to quantitatively compare different THGEM geometries and field-configurations, and thus optimize the detector parameters. The presentation describes the key elements of the scanning system and focus, in particular, on the microstructure evolution of different Thick-GEM configurations providing optimization recipes.

Talk on behalf of a Budapest-Trieste Collaboration

Registered:

Yes

Technological aspects and applications of Cherenkov detectors / 20

Construction of Silica Aerogel Radiator System for Belle II RICH Counter

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We have developed a RICH counter as a new forward particle identification device for the Belle II experiment. In this RICH counter, the Cherenkov radiator consists of dual silica aerogel layers with different refractive indices in upstream and downstream. After intensive R&D on silica aerogel production and optical improvements, a refractive index combination of 1.045 and 1.055 was chosen for the radiator system. Each tile has square dimensions of 180 mm x 180 mm x 20 mm.
Mass-production of aerogel blocks started in November 2013, and it was completed in May 2014. More than 200 tiles for each refractive index were successfully manufactured, and were delivered to KEK. Their optical properties have been measured as a quality check. The average transmission length at 400 nm wave-length was obtained to be ˜45 mm and ˜35 mm for upstream and downstream tiles, respectively. These results demonstrate that high transparency was kept for all the tiles. The refractive index was also extracted using the Fraunhofer method, and the resultant values are consistent with our expectation.
After checking an optical quality, the aerogel tile is cut into the wedge shape to arrange the RICH radiator system. This was done using a water jet cutter device. It is emphasized that hydrophobic feature of aerogel tiles enables us to take this machining technique. Optical degradation in aerogel blocks due to this step was found to be quite small. The mechanical structure of the radiator container was fabricated in 2015. The wedge-shaped aerogel tiles was test-installed into one box in the container. It has been successfully done, and the procedures have been carefully examined. An installation work for the radiator system will begin shortly and will be completed by this summer.
In this contribution, details of Belle II radiator system will be reported with emphasis on our results of the optical quality measurements. The present status of the radiator system construction will be also described.

Registered:

Yes

Technological aspects and applications of Cherenkov detectors / 33

Looking inside volcanoes with the Imaging Atmospheric Cherenkov Telescopes

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Imaging Atmospheric Cherenkov Telescopes (IACT) are dedicated to the very high energy Astrophysics. An IACT consists of an optical system formed by high reflectivity mirrors that focus the Cherenkov light onto a multi-pixel focal camera with fast read-out electronics. IACT telescopes image the very short flash of Cherenkov radiation generated by the cascade of relativistic charged particles produced when a very high-energy gamma-ray strikes the atmosphere. In particular, the Cherenkov light emitted by muon is imaged by an IACT as an annular pattern that contains the

information needed to assess both direction and energy of the incident muon.
We present a new application of the IACT that could be used to perform the muon radiography of volcanoes. The quantitative understanding of the inner structure of a volcano is a key-point to forecast the dangerous stages of activity and mitigate volcanic hazards. Muon radiography shares the same principle as X-ray radiography: muons are attenuated by higher density regions inside the target so that, by measuring the differential attenuation of the muon flux along different directions, it is possible to determine the density distribution of the interior of a volcano. To date, muon imaging of volcanic structures has been mainly achieved with detectors made up of scintillator planes. The advantage of using Cherenkov telescopes is that they are negligibly affected by background noise and allow improved spatial resolution, compared to more widely used detectors.
This new approach will be tested by means of observations carried out by the ASTRI dual-mirror small-sized telescope (SST-2M), which is operative on the side slope of the Etna volcano (Italy). ASTRI SST-2M is a prototype telescope, developed by the Italian National Institute of Astrophysics, INAF, in the framework of the ambitious Cherenkov Telescope Array (CTA) project in order to verify the innovative technological solutions adopted on the CTA small-sized telescopes.

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106

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112

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