7th International Workshop on Ring Imaging Cherenkov detectors (RICH 2010)

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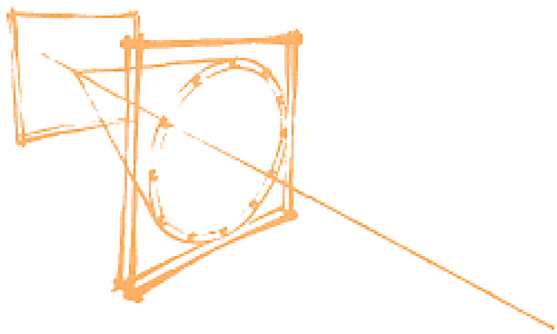

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GPUs for fast triggering and pattern matching at the CERN experiment NA62

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The NA62 experiment at the CERN SPS aims at measuring an ultra-rare decay of the charged kaon (K+ in pi nu nubar);The signal is very small with respect to the background then the trigger is a crucial part for such an experiment. The very innovative approach presented here aims at exploiting the parallel computing power of commercial GPUs (Graphics processing unit) to perform fast computations in software in the early trigger stages. With the steady reduction of GPU latencies, and the increase in link and memory throughputs, the use of such devices for real-time applications in high-energy physics data acquisition and trigger systems is becoming ripe. A pilot project within NA62 aims at integrating GPUs into the central L0 trigger processor, and also to use them as a fast online processors for computing trigger primitives. Several TDC-equipped sub-detectors with sub-nanosecond time resolution will participate to the first-level NA62 trigger (L0), fully integrated with the data-acquisition system, to reduce the readout rate of all sub-detectors to 1 MHz. The online use of GPUs would allow the computation of more complex trigger primitives already at this first trigger level. We describe the architecture of the proposed system and present the performances achieved to perform online recognition of rings from a RICH detector with sub-nanosecond time resolution. The challenges and the prospects of this promising idea will be discuss.

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The KM3NeT neutrino telescope

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KM3NeT denotes a research infrastructure in the Mediterranean deep sea, hosting a neutrino telescope with an instrumented volume of several cubic kilometres and interfaces for devices serving earth and sea science research. The technical design of the neutrino telescope will be presented, with particular focus on light detection and data acquisition. Its major physics objectives will be discussed in the light of its expected sensitivity.

Poster Session 2 (Summary) / 3

Design of a disc DIRC detector for the WASA experiment

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It is planned to install a disc DIRC counter in the WASA experiment at the COSY proton storage ring in Juelich. The purpose of this counter is to improve for 400 MeV to 800 MeV protons the kinetic energy measurement in the forward direction, measuring their speed at the few per mille level.
The disc DIRC is to be placed downstream of the WASA tracking counters in front of stacked plastic scintillator blocks that with a dE/dx profile continue to provide the particle identification.

The segmentation into four quarter-discs allows to incline the radiator relative to the incoming particles and thus lower the threshold velocity for light propagation inside the DIRC radiator.
It is planned to prototype two disc DIRC versions, a focussing DIRC and a time-of-propagation DIRC. The construction of two full-scale quarter disc prototypes is foreseen for 2010.
With the view of prototyping DIRC detectors in WASA for the upcoming PANDA experiment, we aim to validate the simulation results and gain experience in operating such a detector type in a hadron machine.

Technological aspects of Cherenkov detectors / 4

The use of saturated fluorocarbon fluids in high energy physics

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The excellent dielectric properties of saturated (CnF(2n+2)) fluorocarbons have allowed their use in direct immersion liquid cooling of electronics, for example in the Cray series supercomputers. They have also found extensive use as heat transfer media in vapour phase soldering. Their high density and optical transparency led to the suggestion by Seguinot and Ypsilantis for their use as liquid and gas radiator media for RICH detectors: such fluids have now been used in numerous particle physics and astroparticle physics experiments, some of which are highlighted. Systems to circulate and purify fluorocarbon Cerenkov radiator fluids rely on thermodynamic cycles similar to those of modern CFC-free refrigerants. Such new refrigerants - designed to disintegrate under UV in the atmosphere - are radiation-intolerant and cannot be used for direct cooling of particle detectors in demanding radiation environments such as at LHC. However pure saturated fluorocarbon molecules are extremely radiation resistant as well as being non-flammable and non-toxic. Their use as evaporative refrigerants was pioneered for the ATLAS pixel detector, leading to their choice for the cooling of the entire silicon tracker. Additionally they are used to evaporative coolants in ALICE and TOTEM and as liquid coolants in ATLAS and CMS. Ultrasonic techniques for vapour phase analysis of fluorocarbon Cerenkov radiators - developed at SLAC during the 1980s as an inexpensive and simple alternative to UV refractometry - have found use in the petro-chemical industry, in the MOCVD (metal organic chemical vapour deposition) manufacture of semiconductors and have been successfully demonstrated with gas mixtures used in clinical anaesthesia. Such techniques are again under development for the ATLAS tracker evaporative cooling system. Examples of the thermodynamics of fluorocarbon circulation systems, together with the ultrasonic analysis technique for these fluids will be described.

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The NA62 RICH detector

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The CERN NA62 experiment aims at a 10% measurement of the BR of the K+ into a pi+ and two neutrinos. The main background is the K+ decay into a muon and a neutrino, so pion-muon separation is a crucial ingredient. The RICH detector must separate pions from muons at 3 sigma level between 15 and 35 GeV/c momentum. The RICH must also measure the pion crossing time with a 100 ps resolution to avoid fake coincidences with an upstream beam spectrometer. To fufill these requirements a RICH filled with Neon at atmospheric pressure has been chosen, with a radiator length of 17 m. A mosaic of 20 hexagonal or semi-hexagonal mirrors with 17 m focal length, placed at the downstream end of the detector, will reflect the Cherenkov light onto two spots (to avoid the shadow induced by a beam pipe crossing the detector) located at the upstream end of the RICH where 2000 photomultipliers in total will be placed. Single anode photomultipliers, put at 18 mm minimum distance among each other have been chosen to match the required time resolution and Cherenkov angle sensitivity. A prototype was built to validate the project, with the same longitudinal dimensions (17 m) but reduced transverse size with respect to the final detector. In 2007 the prototype, equipped with 96 photomultipliers and exposed to a pion beam at CERN, showed a time resolution smaller than 100 ps. In 2009 in another test beam the prototype was equipped with 414 photomultipliers and demonstrated the capability to suppress by a factor 100 the muon background with respect to charged pions in a 15-35 GeV/c momentum range. The detector, approved and fully financed, is now in its construction phase with commissioning foreseen in 2012. The details of the project and the results of the test beams will be discussed.

Poster Session 2 (Summary) / 7

Silica Aerogel Cherenkov Counter for beta decay measurements

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A prototype to detect the highest energy fraction of electrons emitted by beta decays based on Cherenkov radiation in silica aerogel has been realized in order to be used in nuclear astrophysics target activation esperiments and environmental radioactive pollution survey. The prototype detects the high end-point of beta radiation: silica aerogel with refractive index of 1.056 corresponding to electrons threshold of 1 MeV was chosen. Silica aerogels have refractive index from 1.01 to 1.09, are materials transparent in the visible 380-780 nm and their low density (rho=0.10 – 0.35 g/cm3) results in a reduced absorption of gammas and a longer path on which beta particles radiate Cherenkov photons. Very good background reduction has been achieved. Background reduction relies not only on the threshold energy but also on the shape analysis of the Cherenkov pulse which strongly depends on charge ionization density. The counter has been tested with a 90Sr-90Y beta source (Emax= 2.27 MeV, t1/2=64 h for 90Y, Emax=0.546 MeV, t1/2=28.5 yr for 90Sr) and it can measure down to an activity of 1 Bq of 90Y. Because the ratio 90Y/90Sr is known, the activity of 90Sr (under the threshold) could be computed. 90Sr is a pure beta emitter as well as its daughter 90Y and this method is used to evaluate 90Sr activity in groundwater and soil samples. 90Sr is highly toxic because it can be exchanged with calcium in the bones structures, it could be spread in the environment by nuclear power plants and it cannot be detected by gamma techniques. Background reduction is achieved without decreasing too much the efficiency that would result in the increase of the cross sections uncertainties for nuclear astrophysics experiments. We plan to used the counter also in target activation measurements to study the cross section of two reactions of astrophysics interest: 8Be(d, 2p)9Li and 7Li(d,p)8Li. In both case the final products are beta emitters with electrons end-point energy of 13 around MeV.

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Comparison of Candidate Secondary Electron Emission Materials

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We have developed a theoretical method for calculating secondary electron emission (SEE) yields. The method uses Monte Carlo simulation, empirical theories, and close comparison to experiment,

in order to parameterize the SEE yields of highly emissive materials for microchannel plates. We have successfully applied this method to bulk Al2O3, a highly emissive material as well as to thinly deposited films of Al2O3. The simulation results will be used in the selection of emissive and resistive materials for the deposition and characterization experiments that will be conducted by a large-area fast detector project at Argonne National Laboratory.

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Gain and Time Resolution Simulations in Saturated MCP Pores

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Micro channel plate (MCP) amplifiers are commonly used in detectors of fast time signals with a pico-second resolution. The main parameters of the MCP amplifier, such as the gain factor and time resolution are strongly dependent on the work regime of the device. The saturation effects take place for a high-level input signal. In our paper these effects have been studied numerically for large area fast photo detectors. It was shown that the saturation effect for short pulses can be reduced by introducing a thin resistive layer between the bulk material and the emissive coating. The results were compared with the simulations of other authors and available experimental data.

Poster Session 2 (Summary) / 10

Correlation Phenomena in the Cherenkov Radiation of multiply charged Ions

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Correlation phenomena occurring in Cherenkov radiation are considered which are related to fluctuations of the charge states of multiply charged accelerated ions in a medium. The additional correlation contribution to the radiation is determined by the root-mean-square deviation of the ion charge from its equilibrium value and is responsible for the nonzero radiation yield in the event that the threshold condition is not fulfilled. Averaging the energy absorbed by the medium over the equilibrium charge state distribution will yield in this case correlation phenomena in the stopping power of an ion and in the generated electromagnetic radiation. The effect of these phenomena on Cherenkov radiation was considered for the first time by one of the authors in Ref. Physics Letters A, 372, 2133, 2008. The effect of charge exchange on Cherenkov radiation can be qualitatively described based on the Huygens principle. The field component with frequency ω of a particle moving in a medium can be represented as a superposition of the fields of oscillators of the same frequency arranged along the particle trajectory. If the particle charge is stepwise changed on some sections of the trajectory, this will change the energy of the particle interaction with the medium and the amplitudes of the oscillator fields. As a result, the interference of the oscillator fields within the coherence length from the trajectory sections corresponding to different charge states will incompletely damp the resulting field outside the Cherenkov radiation cone. If the charge fluctuations are random, this results in smearing of the radiation wave front and in transformation of the angular spectral density. Numerical estimates of the radiation yield of heavy ions in the optical and X-ray frequency ranges are given.

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GasToF: A picosecond resolution ToF detector at the LHC.

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The needs and the proposed solutions for extremely fast timing detectors were one of the main highlights of the FP420 R&D report recently published in JINST 4 (2009) T10001. The FP420 project studies feasibility of installing proton detectors at 420m from the ATLAS and/or CMS interaction point(s) at the LHC, allowing for precise measurements in high luminosity environment of the spatial position and arrival time of forward scattered protons. GasToF is one of two proposed ToF detectors and is the Cerenkov detector filled with the dense gas as C4F10 and readout by fast MCP-PMTs. Its prototyping is briefly described and supplemented by results of detailed simulations used for the design optimization. A number of the test beam results and cosmic ray measurements are presented showing that the GasToF detectors reach the time resolution of less than 10 ps, and high efficiency close to a mechanical edge. Operation of GasToF in high luminosity conditions requires running the MCP-PMTs at large event rates, more than 1 MHz per channel. Results of studies using a dedicated PiLas 408 nm laser setup and a 8 GHz bandwidth Agilent scope for testing two types of fast MCP-PMTs - the 6 um pore Hamamatsu R3809U-50 and the 3 um pore Photek 210 are discussed. These high rate tests were used both to understand performance of the MCP-PMTs and to find their optimal working point, including the effects of the fast amplifiers, constant fraction discriminators and cables.
New design of the GasToF detectors using the Photonis and Photek multi-anode MCP-PMTs is described and compared to the single channel design. The GasToF potential for resolving multihit events and for imaging the Cerenkov rings is then discussed.
Finally, the outlook for reaching the sub-picosecond resolutions and the posibility of using the GasToF detectors for particle ID are discussed.

Poster Session 2 (Summary) / 12

A Focussing Disc DIRC for PANDA

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The PANDA experiment, part of the planned FAIR upgrade to GSI, Darmstadt, will aim to study modern hadronic physics with unprecedented accuracy and precision. Excellent particle identification of both charged and neutral particles is necessitated to achieve PANDA's physics aims. Two Detection of Internally Reflected Cherenkov (DIRC) detectors are foreseen for charge particle identification, one in a barrel configuration for the the central region, and the second in a disc configuration for forward angles. The design of the forward disc centres around the novel application of passive chromatic dispersion correction elements, allied with focussing optics, to achieve superior resolution. A system of comprehensive prototype development will show the feasibility of the system.
Key to the success of the prototype is fully understanding the production, transport and detection of the Cherenkov photons within the detector. Initial test beam data giving the photon yield and its dependence on the polar angle of the detector will be shown. Observed photon yield is also the basis for subsequent studies into benefit of chromatic dispersion correction elements, the latest studies of which will also be shown.

Poster Session 2 (Summary) / 13

Tailoring the Radiation Hardness of Fused Silica

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Imaging Cherenkov detectors play an important role in modern particle and nuclear physics experiments. DIRC-type Cherenkov counters offer the advantage of a very compact detector design by employing solid radiator materials. The optical quality of such materials is paramount and has to withstand the radiation environment of modern high luminosity experiments without significant degradation.
The upcoming PANDA experiment at FAIR will rely on DIRC counters for precision particle identification over a wide momentum range. Synthetic fused silica is the radiator material of choice for these detectors. Investigations of the radiation hardness of different types of fused silica showed significant differences especially in the blue-UV region.
Radiation hardness studies on different types of Heraeus Suprasil fused silica led to the discovery of defect mechanisms that are well known for UV laser irradiation also being present for ionising radiation.
Evidence for these defect mechanisms and the relevant parameters that govern them will be presented. Using these results the composition of synthetic fused silica can be adjusted to improve its radiation hardness according to experimental requirements.

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Design, Construction, Operation and Performance of the Hadron Blind Detector for the PHENIX Experiment at RHIC

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A Hadron Blind Detector (HBD) has been developed for an upgrade of the PHENIX experiment at RHIC. The detector installed in 2008 was successfully operated during the p+p run of 2009 and is presently taking Au+Au data at [U+F0D6]sNN = 200 GeV. The HBD is a windowless Cherenkov detector, operated with pure CF4 in a special proximity focus configuration. The detector consists of a 50 cm long radiator directly coupled to a triple GEM detector which has a CsI photocathode evaporated on the top face of the first GEM foil and pad read out at the bottom of the GEM stack. A comprehensive report including, motivation, design, construction, and operation of the detector will be given. In particular detailed studies of the detector performance will be presented including position resolution, gain calibration and stability, hadron rejection factor, electron-hadron separation, single electron detection efficiency, figure of merit N0 and number of photoelectrons per electron and single vs double hit distinction.

Poster Session 2 (Summary) / 15

Results from first beam tests for the development of a RICH detector for CBM

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A key observable of the Compressed Baryonic Matter (CBM) physics program is a precise measurement of low-mass vector mesons and charmonium in their leptonic decay channel. In the CBM experiment at FAIR, electrons will be identified using a gaseous RICH detector combined with several TRD detectors positioned behind a system of silicon tracking stations. The concept of the RICH detector foresees an array of Multianode Photomultipliers (MAPMTs) as photodetector. First beam test data for Cherenkov light detection with a 64 channel Hamamatsu H8500 MAPMT recorded at GSI, will be presented. A 2 GeV proton beam was used to produce Cherenkov photons in a 8 mm thick plexiglass radiator. The signals of the MAPMT were attenuated by a factor of 40 in order to be compatible with the self triggered readout electronics based on the n-XYTER ADC chip which originally has been developed for signals from Silicon sensors. It offers 128 channels at a readout speed of 32 MHz, which will allow to cope with interaction rates up to 10 MHz foreseen for CBM. A very good separation of the ADC signals of uncorrelated, low amplitude noise events from signals of Cherenkov photons with higher amplitude can be achieved using a cut on the time difference between the beam counter coincidence and the hits in the MAPMT. The recorded number of MAPMT hits per beam event is compared with an estimate taking into account the number of produced Cherenkov photons, geometrical losses, transmission losses in the plexiglass and the quantum efficiency and collection efficiency of the MAPMT. The results of this beam test demonstrate that the self triggered n-XYTER ADC chip readout electronics is suited for the readout of the Hamamatsu H8500 MAPMT even with the currently needed attenuation of the primary PMT signals. It could be demonstrated that this MAPMT is able to detect single Cherenkov photons which can be well separated from noise using available timing information on the event.

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Development of a RICH detector for electron identification in CBM

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The Compressed Baryonic Matter (CBM) experiment at the Facility for Antiproton and Ion Research (FAIR) at Darmstadt will be a dedicated heavy-ion experiment exploring the intermediate range of the QCD phase diagram with A+A collisions from 10-45 AGeV beam energy. A key observable of the physics program is a precise measurement of low-mass vector mesons and charmonium in their leptonic decay channel. In CBM, electrons will be identified using a gaseous RICH detector combined with several TRD detectors positioned after a system of silicon tracking stations which are located inside a magnetic dipole field.
The concept of the RICH detector, results on R & D as well as feasibility studies in terms of electron efficiency, pion suppression and the invariant mass distributions of low-mass vector mesons and charmonium will be presented. For the RICH detector CO2 is foreseen as the radiator gas. Glass mirrors with a reflective Al+MgF2 coating are being developed in cooperation with industry. Reflectivity and surface homogenity results on first tested prototypes will be presented. For photodetection it ius planned to use MAPMTs coupled to fast, self triggered readout electronics. This readout electronics development is based on the so-called n-XYTER chip developed for the readout of Si detectors. This chip offers 128 channels at a readout speed of 32 MHz, and will allow the handling of interaction rates up to the 10 MHz foreseen for CBM. As an intermediate working solution a charge attenuator board for the readout of the Hamamatsu H8500 MAPMT was adopted. Successful operation for single photon counting and Cherenkov light detection was demonstrated in a testbeam. The usage of wavelengthshifter films is reinvestigated in order to increase the photon conversion efficiency for wavelengths below 300 nm. Wavelength dependent quantum efficiecy measurements will be presented. The preparation of RICH prototypes is ongoing.

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The VHMPID RICH upgrade project for ALICE at LHC

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The VHMPID RICH upgrade project for ALICE at LHC A. Di Mauro for the ALICE Collaboration RHIC results have shown the importance of high momentum particles as hard probes and the need for particle identification in a very large momentum range, in particular for protons. The ALICE detector has a unique capability to identify a wide variety of particles; however its momentum coverage for track-by-track identification should be extended to meet new physics challenges at LHC. The proposed Very High Momentum PID (VHMPID) detector is a focusing RICH with C4F10 gaseous radiator coupled to CsI-based photon detector, allowing track-by-track proton identification in the momentum range 12–30 GeV/c. The detector layout, the expected performance and trigger options will be discussed. Results from preliminary beam tests of a prototype of 60x40 cm2 equipped with CsI photocathode and MWPC will also be presented.

Poster Session 2 (Summary) / 19

VHMPID detector for the ALICE experiment upgrade at LHC: simulation results from mirror segmentation studies

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The Very High Momentum Charged Particle Identification (VHMPID) detector represents a possible upgrade for the ALICE experimental apparatus. It has been conceived to extend protons identification on a track-by-track basis up to p = 30 GeV/c. The VHMPID is a ring imaging Cherenkov with C4F10 gaseous radiator coupled to CsI-based photon detector. The focusing properties of a spherical mirror are exploited to focus Cherenkov photons on the photon detector, placed in its focal plane. Mirror segmentation is a critical parameter for the ring pattern recognition performances and for the capability to identify tracks close in the phase space. This feature is crucial for the contribution of VHMPID to the jets physics. We will present the results of detailed simulation studies that have been carried out in order to optimize the mirror segmentation.

Photon detection for Cherenkov Counters - gaseous devices / 20

R&D on CsI-TGEM based photodetector

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R&D on CsI-TGEM based photodetector

V. Peskov for the ALICE collaboration

The Very High Momentum PID (VHMPID) detector proposed for the ALICE upgrade is a focusing RICH using C4F10 gaseous radiator. For the detection of Cherenkov photons, one of the options currently under investigation is to use a CsI coated Triple-Thick-GEM (CsI-TTGEM). Extensive laboratory studies have been carried out to fully characterize this detector, showing a gain larger than 105 in Ne+10%CH4 and a quantum efficiency of 30% at 170 nm. We will present results from the laboratory studies and also first results of beam tests of a RICH detector consisting of a CaF2 radiator coupled to CsI-TTGEM equipped with a 10x10cm2 pad readout plane and GASSIPLEX-based front-end electronics. With such a prototype the detection of Cherenkov photons has been achieved for the first time, and simultaneously to MIPs, in a stable operation mode.

Poster Session 2 (Summary) / 22

Prototype tests for a DIRC detector at the WASA-at-COSY experiment

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The WASA-at-COSY experiment allows the study of production and decay of eta and eta' mesons in proton proton reactions with an almost full 4 pi covering detector including a forward spectrometer section. At the moment the Forward Range Hodoscope (FRH) in the forward angle spectrometer region determines the identity of the particles by measuring the energy loss dE-E. Simulations concerning the estimated background have shown, that an additional ring imaging Cherenkov detector in front of the Forward Range Hodoscope would significantly improve the particle identification and the energy resolution as well. Due to the very limited space, available at the intended detector position, the development of a DIRC (Detection of Internally Reflected Cherenkov light) detection system based on Plexiglas (PMMA) radiators is under discussion.
In order to show the feasibility, two different prototypes, consisting of a square PMMA radiatorbar and a PMMA focusing element were tested using the COSY proton beam. One focusing element is based on an internal reflecting polynomial shape surface, the other is based on a mirrored circular shape surface. The photon readout in the focal plane is done by Hamamatsu 64 channel multianode photomultipliertubes (MAPMT). In addition new MAPMTs with higher quantum efficiency were studied in order to increase the number of detected photons.
The results of the various test measurements will be discussed. Typical Cherenkov pattern obtained in the relevant proton energy range will be presented.
Supported by German BMBF and FZ Juelich

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New Focusing DIRC for Super B

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The BaBar DIRC is an innovative internally reflecting Ring Imaging Cherenkov Counter. It uses quartz bar radiator of Cherenkov light and the pinhole focusing onto an imaging device made up of individual conventional PMTs. Its success in the BaBar physics analysis motivated us to propose this concept again for the SuperB application. We plan to replace the BaBar stand-off box with a focusing optics (FBLOCK), which would be machined out the radiation hard solid piece Fused Silica. The major design constraints for the new camera are the following: (a) it has to be consistent with the existing BaBar bar box design; (b) it has to coexist with the BaBar magnet mechanical constraints; (c) it requires a very fine photon detector pixelization. The imaging is provided by a mirror structure focused onto an image plane containing highly pixilated photomultiplier tubes. The reduced volume of the new camera and different material alone reduces the sensitivity to background by about one order of magnitude compared to BaBar DIRC. The very fast timing of the new tubes will provide many additional advantages – (a) improving the Cherenkov resolution performance, (b) measuring the chromatic dispersion term in the radiator, (c) allowing the separation of ambiguous solutions in the folded optical system; and (d) providing another order of magnitude improvement in background rejection headroom. There are several important advantages of the new focused optical design made of solid Fused Silica: (a) the design is modular; (b) sensitivity to background, especially to neutrons, is significantly reduced; (c) the pinhole-size component of the angular resolution in the focusing plane can be removed, and timing can be used to measure the chromatic dispersion, improving performance; (d) the total number of MaPMT photon detectors is reduced by about one half compared to a non-focusing design with equivalent performance; (e) there is no risk of of water leaks.

Poster Session 2 (Summary) / 24

Development of a CBM-RICH prototype in Pusan

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In context of the R & D for the CBM-RICH detector [1], a prototype detector has been developed in Pusan, Korea. This RICH prototype detector with a spherical concave CBM-Mirror [2] and Multi-anode PMTs (H8500 & H8500C-03, Hamamatsu) is tested at an electron beam (p_e ˜60MeV/c) at the Test LINAC in the Pohang Accelerator Laboratory in Korea. This poster will present the preliminary detector performance with nitrogen gas as radiator and the operation of a gas monitoring and Control System (GCS) based on PVSSII.
Reference [1] C. Höhne et.al, NIM A 595 (2008) 187 [2] M. D¨urr, A. Braem and C. Höhne, FAIR-EXPERIMENTS-15, GSI Scientific Report 2008.

Photon detection for Cherenkov Counters - vacuum based devices / 25

Systematic Studies of Microchannel Plate PMTs

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The PANDA experiment at the FAIR facility at GSI in Darmstadt will use the DIRC technique to separate charged pions and kaons. Two devices are planned: a barrel DIRC and a forward disc DIRC detector covering together a polar angle range from 5 to 140 degrees. Since the PANDA detector was chosen to be very compact the image plane of both DIRCs is located inside the solenoid magnetic field of up to 2 T.
Thus the photosensors have to provide a good spatial resolution and have to detect single photons inside a high B-field. To correct for dispersion effects in the radiators a time resolution of better than 100 ps is desirable. Moreover, the interaction rate of 20 MHz inside PANDA leads to photon densities of up to several MHz/cm2 at the sensor's surface. This puts serious constraints on the rate stability and lifetime of these devices. Because of their excellent time resolution, high gain and B-field resistivity microchannel plate (MCP) PMTs are very appealing sensors for the PANDA DIRCs. As multi-anode devices they provide a good active area ratio while still being rather compact in size. In view of the harsh PANDA conditions the rate stability and the lifetime need to be thoroughly investigated.
In a systematic study we have measured the performance parameters of several types of MCP-PMTs. Among others the new Burle-Photonis Planacon 85012 with an improved vacuum and the latest Hamamatsu R10754-00-L4 were tested for their gain (in dependence of magnitude and orientation of a B-field), time resolution and rate stability. Surface scans were performed to investigate the response uniformity and the cross talk among the anode pixels. We have also started to do lifetime measurements: selected MCP-PMTs are illuminated with rate conditions similar to those in PANDA. Special focus is put on the quantum efficiency as a function of the integrated anode charge.
The results of these comprehensive studies will be presented and compared.
This work is supported by BMBF and GSI.

Research and Development for future detectors / 26

Focusing Aerogel RICH for particle identification and momentum measurement.

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Latest steps in the development of the Focusing Aerogel RICH (FARICH) in Novosibirsk are presented. Our group has developed the technique of multilayer aerogel production. Several multilayer aerogel samples were produced. Optical parameters were measured. A project of the Forward RICH for the SuperB experiment (Italy) is presented. It features a dual aerogel-water radiator and Photonis MCP PMTs. The detector will be able to perform pi/K separation at 3 sigma level from 0.2 to 7 GeV/c, mu/pi separation – from 0.13 to 1.4 GeV/c. FARICH precise velocity measurement gives the possibility to determine particle momentum with accuracy about 1%. An aerogel RICH for Super Tau-Charm factory project in Novosibirsk is proposed. It is shown that the detector will separate pions and kaons from 0.2 to 9 GeV/c momentum. Also mu/pi separation from 0.13 to 1.9 GeV/c momentum will be possible. A prototype of the FARICH is being built at BINP (Novosibirsk). It will be tested with a dedicated electron beam line. At the first stage MRS APDs (SiPM) produced by CPTA (Moscow) will be used as photon detectors. Gain, photon detection efficiency and noise rate were measured for several APDs.

Pattern recognition and data analysis / 27

Method of identification of rings in spectra from RICH detectors using the deconvolution based pattern recognition algorithm

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With the advancement of position sensitive low energy photon detectors with high quantum efficiency a ring imaging Cherenkov detector (RICH) becomes employed in increasing number of experiments. Trajectories of the particles with the momentum above Cherenkov photon emission threshold are in the RICH photon detector represented by rings. However, these rings are far from being ideal. Recognition of rings is therefore a serious problem, especially when fast decision is required, as it is usually the case when information from RICH detector is used in trigger. There exist several algorithms for the recognition of Cherenkov rings in experimental data. They are based e.g. on triangulation method, on a Metropolis-Hastings Markov chain Monte Carlo sampling, etc. Other pattern recognition techniques are used as well. In the talk we would like to present a new, alternative pattern recognition algorithm applied for determination of rings in two-dimensional spectra from RICH detectors. The method is based on boosted Gold deconvolution algorithm. This algorithm makes it possible to concentrate the contents of one ring into one point located in its centre. This allows us to automatically recognize rings in two-dimensional spectra. By choosing suitable input parameters for the deconvolution one can obtain an efficient tool for identification of rings in two-dimensional spectra. We will present examples of various properties of the proposed algorithm, e.g.: influence of the number of iterations, number of repetitions and boosting coefficient on the efficiency of the circle identification, behavior of deconvolution algorithm for noisy input data, resolution capabilities of the proposed method, robustness of the deconvolution method to the changes in radius and shape of the rings, the ability to identify the rings in experimental spectra.

Poster Session 2 (Summary) / 28

The CLAS12 large area RICH detector

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A large area RICH detector is being designed for the CLAS12 spectrometer as part of the the 12 GeV upgrade program of the Jefferson Lab Experimental Hall-B. This detector is intended to provide excellent hadron identification from 3 GeV/c up to momenta exceeding 8 GeV/c and to be able to work at the very high design luminosity - up to 10ˆ35 cmˆ2sˆ-1. Detailed feasibility studies are presented for two types of radiator, aerogel or liquid C6F14 freon, in conjunction with a highly segmented light detector in the visible wavelength range. The basic parameters of the RICH are outlined and the resulting performances, as defined by simulation studies, are reported.

Novel Cherenkov imaging techniques / 30

Particle Identification for the PANDA Detector

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The PANDA detector at the HESR of the future FAIR facility at GSI will measure the annihilation products of antiprotons impinging on a fixed target. The combination of a compact target spectrometer with a wide angle forward spectrometer was chosen for hermetic coverage of the full solid angle. Charged particle identification over a large momentum range is performed in the target spectrometer by two RICH detectors using the DIRC (Detection of Internally Reflected Cherenkov light) principle. Cherenkov photons are generated in synthetic fused silica radiators and transported by total internal reflection towards the photon detectors, placed outside the fiducial volume. The combination of a DIRC barrel and a forward endcap disk DIRC will cover the angular range between 5 and 140 degrees. We present the design of the barrel DIRC with three-dimensional readout capable of performing dispersion correction using fast timing. For the forward endcap disk two options are being considered: The "focussing disk DIRC," which includes LiF crystals for dispersion correction, and the "TOP disk DIRC" which uses the time of propagation of the photons for particle identification. Ongoing developments and the results of test beams for the various PANDA DIRC prototypes will be presented.

Poster Session 2 (Summary) / 32

The Barrel DIRC of the PANDA Experiment at FAIR

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Cooled antiproton beams of unprecedented intensities in the momentum range of 1.5-15 GeV/c will be used at the PANDA experiment at FAIR to perform QCD studies including searches for exotic states and high precision experiments in the charmed quark sector. Charged particle identification in the barrel region needs a thin detector operating in a strong magnetic field. Both requirements can be met by a Ring Imaging Cherenkov detector using the DIRC principle. Combining the time of arrival of the photons with their spatial image determines not only the particles velocity, but also the wavelength of the photons. Therefore, dispersion correction at the lower and upper detection threshold becomes possible. Long, rectangular bars made from synthetic fused silica are used as Cherenkov radiator and light guide. The optical properties, such as bulk transmission and surface reflectivity, are of critical importance to the DIRC performance. We developed a motion-controlled system using lasers wavelength from 266nm to 635nm to

measure the coefficient of total internal reflection which can be used to determine the quality of the surface polish with a precision of a few Angstrom. We present details of the design of a prototype for the Barrel DIRC detector of the PANDA experiment at FAIR and its performance in a proton test beam as well as measurements of the optical properties of prototype bars.

Poster Session 2 (Summary) / 33

Software Developement of PANDA barrel DIRC

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The PANDA experiment at the future facility for anti-proton and ion research (FAIR) at GSI, Darmstadt, aims at studying the strong interaction by precision spectroscopy. A detector system with excellent particle identification (PID) properties over a large range of solid angle and momentum is therefore mandatory. For the charged hadron identification in the barrel region, a compact ring imaging Cherenkov detector following the DIRC (Detection of Internally Reflected Cherenkov light) principle is foreseen. The realization of the barrel DIRC is done in PandaRoot framework. The result of simulation in barrel DIRC using Monte Carlo transport code (GEANT) and realistic digitization implementation using the information of photon detector will be presented. Possible reconstruction methods based on likelihood approaches and correction methods of chromatic dispersion using fast timing techniques will also be discussed.

Pattern recognition and data analysis / 34

Pattern recognition for TOP counter

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For the Belle II detector a time-of-propagation (TOP) counter is foreseen for particle identification in the barrel region. In this counter particle identity is determined from a complicated pattern in the time and position of Cherenkov photon detection. We will present an extended likelihood method for particle identification, which is based on an analytical construction of likelihood function. The method is adopted to various types of TOP counter, including those with a focusing mirror and an expansion volume at the quartz bar exit window. Using this method and a Geant based Monte Carlo simulation the performance of different TOP counter configurations has been studied. We will discuss these results.

Cherenkov Imaging in particle and in nuclear physics experiments / 35

The experience of building and operating COMPASS RICH-1

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COMPASS RICH-1 is a large gaseous Imaging Cherenkov Detector providing high quality hadron identification in the range from 3 to 60 GeV/c, in the wide acceptance spectrometer of the COMPASS Experiment at CERN SPS. It has been successfully operated since 2002 and its performances have increased in time thanks to progressive optimization and mostly to a major upgrade which was implemented in 2006. The main characteristics of its components are described in order to discuss the most critical problems which have been faced, of foreseen and unforeseen nature, and the solutions which have been found. The long term mastering of the challenges from radiator gas purity requirements, mirror alignment, photon detector instabilities, removal of

read-out heat, etc. are critically reviewed; delicate maintenance operations and some accidents are described too. The need to adapt COMPASS RICH-1 and its read-out for operating at higher and higher rates, to guarantee increasing efficiency and stability, and also to reduce the work load on the RICH experts during long runs is summarized; a brief overview of the upgrade results and of the most recent implementations is provided. Some highlights from COMPASS particle identification analysis and the overall RICH-1 performances are presented.

Cherenkov Imaging in particle and in nuclear physics experiments / 36

The ALICE High Momentum Particle Identification system:an overview after the first LHC run.

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The ALICE High Momentum Particle Identification RICH detector (HMPID), with its 10 m2 of Cesium Iodide (CsI) photo-cathodes is installed, in the ALICE solenoid since fall 2006. Since then, it has been thoroughly commissioned, together with its auxiliary systems, with cosmic rays and beam dump/splash events during various LHC injections tests in 2008 and 2009. Finally, the HMPID has successfully recorded events produced by the first proton-proton collisions at LHC in winter 2009. The present talk will review the experience gained during the commissioning phase and summarize the present status of the detector. Preliminary results, concerning the detector performance, will be shown.

Poster Session 2 (Summary) / 37

Performance of the FARICH-detector for the ALICE HMPID system at CERN

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An important experimental direction of the study in physics of heavy ion collisions is the measurement of the yield of high-Pt particles. The main problem is to study the dominant mechanism of parton energy loss in compressed nuclear matter. "Jet quenching effect" by RHIC STAR and PHENIX Collaborations gives the indication that there is a different loss of energy by quarks and gluons in a nuclear matter. Data show the effect of suppression of high-Pt particles up to a momentum $\geq$ 10 GeV/c. In order to extend the momentum interval of the identification of charged particles up to 10 GeV/c for pion-kaon separation and to 14 GeV/c for kaon-proton separation the focusing aerogel RICH (FARICH) detector (as the ALICE HMPID-system upgrade at CERN LHC) employing a multi-layer silica aerogel radiator has been proposed. The GEANT4 simulation package was used to estimate the performance of the FARICH detector. Results of the optimization of characteristics of the multilayer aerogel radiators, MRS APDs with and without Wave Length Shifter paint are discussed. The description of the main constructional and functional parts of the FARICH Prototype is presented. The Prototype consists of parts as followed: (1) light-isolating box, (2) thin carbon entrance window for beam particles, (3) radiator of the Cherenkov photons on the basis of 2- or 3-layer silica aerogel with gradually increasing indices, (4) light-collecting plane, (5) photo-sensitive coordinate matrix with MRS Avalanche Photodiodes (MRS APDs). A new FARICH detector option on the basis of the TGEM detector in a photo-sensitive plane (in a wavelength range of 500-600 nm) is discussed. FARICH preliminary test results obtained on test benches and CERN PS T10 channel are reported.

Photon detection for Cherenkov Counters - solid state and hybrid devices / 38

Module of Silicon Photomultipliers as a single photon detector of Cherenkov photons

Dr. PESTOTNIK, Rok[1] ; Prof. KORPAR, Samo[1] ; Prof. KRIŽAN, Peter[1] ; Mr. DOLENEC, Rok[1] ; Prof. STANOVNIK, Aleš[1] ; Dr. CHAGANI, Hassan[1]

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We have studied the possibility to use silicon photomultipliers as a single photon detector in a proximity focusing RICH with aerogel radiator; such as counter is considered for the Belle-2 detector. Their main advantage over conventional photomultiplier tubes is their operation in high magnetic fields. Their disadvantage is the relatively high dark noise count rate (~MHz/mm2) which can be overcome by using a narrow time window in the data acquisition. A module, consisting of 64 (8x8) Hamamatsu MPPC S10362-11-100P silicon photomultipliers, has been constructed and tested with Cerenkov photons emitted in an aerogel radiator by 120 GeV/c pions from the CERN T4-H6 beam. To increase the signal to noise ratio, i.e. to increase the effective surface on which light is detected, the light concentrators have been employed. In the beam test setup with 1 cm thick aerogel of n=1.03 we obtained 1.6 photons per ring. The light yield increased by a factor of 2.3 to 3.6 photons per ring when the light concentrators were used. With the final focusing radiator of thickness of 4 cm and n~1.05 and with the improved light guide production we expect to detect about 30 photons per ring.

Poster Session 2 (Summary) / 39

Status of aerogel production in Novosibirsk

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Silica aerogel blocks are produced for use in Cherenkov detectors by a collaboration of Boreskov Institute of Catalysis and Budker Institute of Nuclear Physics since 1986. Novosibirsk aerogel is used in several detectors. Among them are KEDR (BINP, Novosibirsk), LHCb (CERN, Geneva), AMS (for International Space Station mission) and others.
Currently our investigations are aimed at two directions: multilayer aerogels for Focusing RICH and aerogels with high index of refraction. We have synthesize two- and tetra-layer aerogel tiles with dimensions of 115x115 mm. We have modernized method of pin-hole drying for the preparation of aerogels with refractive index in the range from 1.07 to 1.20.

Photon detection for Cherenkov Counters - gaseous devices / 40

Progress towards a THGEM-based detector of single photons

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The novel and robust Thick GEM (THGEM) electron multiplier, coupled to a solid state photon converter, represents a promising option for covering, at affordable costs, large areas with photon detectors, in particular, in Cherenkov imaging counters where single photons must be detected with high efficiency. Multistage structures, where the first THGEM layer is coated with a photosensitive CsI film, guarantee UV light sensitivity, allow for gas multiplication factors >10^5 , for high rate operation, and provide fast pulses with a few nanosecond rise-time. The reduction of photon and ion feedback and of the related photocathode bombardment is obtained thanks to the closed geometry structure; this architecture can overcome the limitations affecting the present generation of gaseous photon detectors for RICH applications, based on open geometries. The main goal of our project is to demonstrate the feasibility of reliable gaseous detector of single photons based on the use of THGEM multipliers, able to stably operate at high gain and high rate, and to build and validate a large size prototype of such a detector. Project status and perspectives are reported; in particular attention is dedicated to the simulation and laboratory studies performed to understand the photoelectron extraction performance attainable using a solid photocathode coated onto a THGEM substrate.

Poster Session 2 (Summary) / 41

The Cherenkov radiator system of the High Momentum Particle IDentification detector of the ALICE experiment at CERN-LHC

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The aim of this talk is to present the design, the implementation and the operational modes of the Liquid Circulation System (LCS) built to circulate, purify and monitor the liquid perfluorohexane (C6F14) in the ALICE HMPID. The HMPID RICH uses C6F14 as Cherenkov radiator medium circulating in twenty-one quartz trays. The LCS features a pressure-regulated closed circuit, ensuring the C6F14 highest transparency to ultraviolet light. Intrinsically safe working conditions are obtained thanks to a novel liquid distribution “cascade” system. Moreover the system is protected against anomalous working conditions by a dedicated control system which operates it in both automatic and manual mode, locally and remotely, safeguarding the quartz radiator vessels. The LCS is isolated from the external environment by means of aerial lines where anhydrous argon flows in order to avoid the contact of the liquid with air, to allow pressure equilibrium between all elements and to convey the C6F14 vapour toward a cold trap station. The LCS has been fully commissioned over the last two years and proved to meet all requirements thus enabling HMPID to perform on cosmic ray data as by design and to successfully collect the first data during the start of the LHC operation in November 2009.

Poster Session 1 (Summary) / 42

Photonis MCP-PMT as a Light Sensor in the Belle II Aerogel Radiator RICH

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One of the candidates for the photon detector of the Belle II aerogel radiator RICH is the micro-channel plate photomultiplier tube (MCP-PMT). The MCP-PMT works very well in a high magnetic field of 1.5T. It shows a good performance to detect single photons with an excellent timing precision. In a 2GeV/c electron beam at KEK we have tested two tubes to investigate the photon yield and resolution. One of the two sensors had previously been exposed to an intense light flux resulting in an accumulated charge of 400mC/cm2 over a period of about two months. We will present the results of the measurements of the tubes as photon sensors of the RICH with aerogel radiator. Our tests of performance under an intense light flux and as a function of accumulated charge will be discussed. We will also present the timing performance of a common output signal from the last micro-channel plate.

Photon detection for Cherenkov Counters - gaseous devices / 43

Development of a gaseous PMT with micro-pattern gas detectors

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In the last few years, considerable effort has been devoted to the development of gaseous photomultiplier tubes (PMTs) with micro-pattern gas detectors (MPGD) which are sensitive to visible light. The potential advantage of such a gaseous PMT is that it can achieve a very large effective area with moderate position and timing resolutions. Besides it can be easily operated under a very high magnetic field (˜1.5 Tesla). Since photon and ion feedbacks cause faster degradation for the bi-alkali photocathode, the maximum achievable gain might be limited at a level 100. Several recent developments, however, have successfully achieved a long-term high sensitivity for a photon detection by using hole-type MPGDs such as a gas electron multiplier (GEM) and a glass capillary plate (CP). We constructed a double Micromegas detector with a bi-alkali photocathode. The gain of this device was studied by measuring the signal currents at the anode, first mesh, second mesh and the photocathode while varying the applied voltage of the first and second meshes. The gain reached 2×10ˆ3 without a large deviation from the exponential curve. However, at a gain above 2×10ˆ3 we observed a rapid gain rise due to secondary effects. In order to develop a gaseous PMT having no substantial secondary effects up to 10ˆ5 with a bi-alkali photocathode we tried some combinations of a hole-type MPGD and a Micromegas. We developed a hole-type MPGD with Pyrex glass by a micro-blasting method, which allows the problem-free production of bi-alkali photocathode while a kapton GEM reacts with the photocathode materials. Basic performance tests of the Pyrex CP gas detector were carried out with a gas mixture of Ne (90%) + CF4 (10%) at 1 atm. We successfully obtained a gain of up to 1.5×10ˆ4 and an energy resolution of 23% for 5.9 keV X-rays. Further tests are being curried out and results of them will be presented at the workshop.

Photon detection for Cherenkov Counters - solid state and hybrid devices / 44

Operating the Hybrid Photon Detectors in the LHCb RICH counters

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Over the last two years the LHCb experiment has commissioned over 500 Hybrid Photon Detectors (HPD) in its RICH detectors. Here we will report about results of the extensive monitoring programme for these novel photon sensitive devices. Recently the first Cherenkov photons produced by LHC beam particles were reconstructed. Data have been taken under a variety of different run conditions. HPDs have been regularly tested with and without external light sources. Dark runs facilitate identifying noisy pixels. Continuous-wave laser sources provide constant illumination on the photodetectors, and are used primarily for ion-feedback and image position measurements. Tests of the vacuum quality are regularly performed: most HPDs retain an excellent vacuum quality. However few show a linear increase in ion feedback over time - evidence of an intrinsic increase in residual gas concentration. Overall these data show an excellent performance of the HPDs with low dark count and noise rates. First results from data with LHC beams including detector occupancies and photon yield will also be reported.

Photon detection for Cherenkov Counters - solid state and hybrid devices / 45

Study of 144 Channel Multi-Anode Hybrid Avalanche Photo-Detector For the Belle-II RICH Counter

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For the Belle-II experiment, we have been developing a proximity focusing RICH counter with silica aerogel radiator as a new particle identifier in the forward endcap to extend the pi/K separation capability up to 4 $sigma$ at 4 GeV/c. Our requirements on a RICH photon detector are the following: (1) sensitivity to single photons, (2) immunity to magnetic field, (3) granularity of $sim5times5$ mm^2, (4) large effective area, (5) compact size due to the limited available space. To fulfill these conditions, R&D on a new hybrid avalanche photo-detector (HAPD) has been conducted with HPK for several years. In this device, vacuum tube with a bi-alkali photocathode is coupled to an avalanche photo-diode (APD), which is pixelated into $6times6$ pads, each of which is $5times5$ mm^2; 1 HAPD accommodates 4 APD chips, amounting to 144 pads total. More than 10 HAPDs have been newly produced since 2008. Fundamental features of HAPD samples were examined using a light source at the lab. Total gain was obtained to be about $5times10^4$ and a clear single photon signal was detected. Basic operations of HAPD under an axial magnetic field of 1.5 Tesla was also studied and the cross-talk due to electron back-scattering was very much suppressed and single photon sensitivity was improved. Recently, a new HAPD with high QE was successfully fabricated, and a QE exceeding 30 % could be confirmed. With these HAPD samples, a RICH prototype counter was built. In this set-up, a $2times3$ HAPDs were arranged with a custom-made ASIC readout system, by which signals were amplified and digitized. A test beam experiment was including the latest beam testcarried out in November 2009 at KEK. We obtained 2.5 times larger photoelectron yield with 40 mm-thick aerogel radiator compared to the previous beam test, and from these results the pi/K separation capability exceeding $5sigma$ at 4 GeV/c was demonstrated. In this report detail results of HAPD studies will be presented.

Poster Session 2 (Summary) / 46

Study of Transparent Silica Aerogel with High Refractive Index

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Highly transparent silica aerogel has been developed for Cherenkov radiator in a RICH counter to be installed in the Belle-II end-cap apparatus. In conjunction with necessity to use multiple aerogel radiator layers for the RICH focusing scheme pioneered by our group, the optical improvement of silica aerogel with higher refractive index range around n =$1.055sim1.070$ has been intensively carried out since the previous RICH workshop. Generally optical properties of aerogel tiles become poorer as refractive indices go higher, especially at $n > 1.055$. This was one of our concerns as the higher index radiator tile has to be located in the downstream in the focusing multiple aerogel radiator layers, where most of Cherenkov photons pass through and therefore higher transparency was required.
New aerogel fabrication method, known as “pin-hole drying(PD)” method, to keep its quality in the region of $n > 1.055$ was invented. In this method, special care is taken in the aging period of

alcogel tiles after the sol-gel process. Based on this technique, optical transparency for $n > 1.055$ sample was remarkably improved. For $n = 1.060$, we achieved a transmission length of about 50 mm at a wave-length of 400 nm, which is two times longer compared to the previous tiles.
The aerogel tile size is another important parameter for a realistic application. By optimizing various conditions, not only in the synthesis process but in the supercritical drying procedure, we have successfully produced a large sample with dimensions of $180 times 260 times 20$ mm^3, where optical properties are of the same level as in the case of the smaller ones.
New aerogel samples were used as radiators in a RICH prototype to evaluate performance in a test beam experiment done in November 2009 at KEK. The obtained photoelectron yield with new samples was 2.5 times higher than that with the old ones by the previous method.
In this contribution, our R&D on aerogel improvements will be given.

Poster Session 2 (Summary) / 47

The LHCb RICH upgrade plans

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The LHCb experiment plans to operate at an LHC luminosity of 2x10**32 /s cm2, or typically one collision per bunch crossing. After about five years it will have recorded a data sample of 10 fb-1. At this time LHCb plans an upgrade to operate the detectors at a significantly increased luminosity that will extend greatly its potential for discovery and study of new phenomena. The key to get such an improvement is to read out the full detector at the LHC crossing rate of 40MHz and to run the trigger in the data acquisition computer farm. Studies performed to optimise the design of the LHCb Upgrade are presented. The RICH detector will require new photon detectors as the current HPDs have encapsulated electronics which only supports reading out up to 1MHz data rate. Flat-panel Photo Multiplier Tubes (PMTs) are evaluated as a photon detector candidate and its properties including pulse height and shape and cross-talk are measured. The particle identification performance is studied as a function of luminosities ranging up to ten times the design as foreseen for the LHCb upgrade. Finally, the performance of flavour tagging using kaons, which strongly relies on RICH particle identification will also be presented

Cherenkov detectors in astroparticle physics / 48

The Major Atmospheric Gamma Ray Imaging Cherenkov Telescope

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MAGIC is a system of two Imaging Atmospheric Cherenkov Telescopes (IACTs). During the construction novel technologies have been developed, which nowadays represent the state of the art techniques on the market. The 17m diameter reflector is composed of light weight sandwich structured aluminium and glass mirrors, mounted on a carbon fiber tube dish structure. The overall focusing is kept at optimum by using the active mirror control system. These light-weight components allow repositioning times of less than 20s over 180deg in azimuth - one of the requirements to catch the high energy gamma ray radiation from gamma ray bursts. The large reflector, together with small diameter, high quantum efficiency photomultipliers in combination with improved triggering and readout system result in an energy threshold of 25 GeV, the lowest among current IACTs. MAGIC reached the energy range covered by satellite experiments and gives the unique opportunity to detect new, distant sources. The new techniques used in MAGIC as well as recent discoveries and scientific results will be discussed.

Research and Development for future detectors / 49

TOP counter prototype R&D

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We have been developing a Cherenkov ring-imaging counter, named TOP counter, as a particle identification device of Belle-II detector for super B-factory at KEK. In this presentation, we show the R&D status of TOP counter prototype development. We have performed the beam test using 2m long quartz radiator and MCP-PMTs, and evaluated the number of detected photons, time resolution and chromatic effects. We develop the square-shape MCP-PMT with Hamamatsu photonics, to obtain the enough lifetime under the Belle-II environment. We improved the lifetime of the quantum efficiency by changing the internal structure and production process.

Technological aspects of Cherenkov detectors / 50

Alignment and monitoring of the LHCb RICH detectors with data

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Hadron identification in the LHCb experiment is performed by Ring Imaging Cherenkov (RICH) detectors. The system is composed by two RICH detectors, three radiators, imaging optics and 484 Hybrid Photon Detectors (HPDs). The refractive index of the radiators (16 aerogel tiles, C4F10 and CF4) is calibrated using saturated (beta=1) tracks and expected changes due to atmospheric pressure variations are monitored with data and sensors. The 116 mirrors in the imaging system require alignment to an accuracy of 0.1 mrad and the position of the photon detectors needs to be accurate to 0.5 mm. Tools integrated in the system allowing to achieve this goal will be described. Once successfully commissioned the RICH detectors, they can be calibrated using the first collision data from the LHC. Their performance in particle identification will depend crucially on the accuracy with which the components will be aligned and the different corrections applied.

Poster Session 2 (Summary) / 51

Magnetic calibration of the LHCb RICH detectors

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The LHCb experiment will search for new physics in CP violation and rare decays of b hadrons at the LHC. Particle identification is provided by two RICH detectors, RICH-1 and RICH-2, equipped with 484 Hybrid Photon Detectors to read the Cherenkov light. The RICH detectors are located in the fringe field of the LHCb dipole magnet, and fields as large as 2.5 mT have been measured in some regions occupied by the RICH 1 photodetectors. Hence it is necessary to make corrections for the distortion of the ring-images measured by the HPDs. RICH 1 incorporates a magnetic calibration system comprising a series of collimated LEDs mounted on x-y stages which scan over the front-faces of the HPD arrays. The system allows mapping of the magnetic distortions to a precision better than 1 mm at each HPD photocathode level. The magnetic calibration procedure is performed in dedicated LED scans with dipole field on and off for both RICHes. Parameterizations for RICH-1 and RICH-2 are then computed and corrections applied to the LHC collision data. Cherenkov angular resolutions before and after magnetic corrections will be presented.

Technological aspects of Cherenkov detectors / 53

The ALICE HMPID Detector Control system, its evolution towards an expert and adaptative system

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The High Momentum Particle Identification Detector (HMPID) is a proximity focusing ring imaging Cherenkov (RICH) for charged hadrons identification at momenta 1< p < 3 GeV/c for pi and K and 1< p < 5 GeV/c for p.
The HMPID uses liquid C6F14 as radiator medium. The detection of the Cherenkov UV photons is carried out via CsI coated photocathodes and MWPCs.
To ensure a stable particle identification in the long term operation of LHC, this high technology detector requires a sophisticated control system responding to industrial standard for robustness, ensuring reliable remote operation. The HMPID Detector Control System (DCS) has been conceived and implemented in this perspective using the PVSS SCADA environment and Programmable Logic Controller (PLC) as control devices.
In this talk the DCS is presented highlighting its finite state machine structure. The evolution towards an 'Expert control system' providing error automatic recovering is discussed. Perspectives to integrate Adaptive features providing device feedback (e.g.: gas gain constant via MWPC HV correction) are also explored.

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The LHCb RICH silica aerogel performance with LHC data

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In the LHCb detector at the Large Hadron Collider, powerful charged particle identification is performed by Ring Imaging Cherenkov (RICH) technology. In order to cover the full geometric acceptance and the wide momentum range (1-100 GeV/c), two detectors with three Cherenkov radiators have been designed and installed. In the medium (10-40 GeV/c) and high (30-100 GeV/c) momentum range, gas radiators are used (C4F10 and CF4 respectively). In the low momentum range (1 to a few GeV/c) pion/kaon/proton separation will be done with photons produced in solid silica aerogel. A set of 16 tiles, with the large transverse dimensions ever (20x20 cmˆ2) and nominal refractive index 1.03 have been produced. The tiles have excellent optical properties and homogeneity of refractive index within the tile of ˜1%. The first data collected at LHC are used to understand the behaviour of the RICH: preliminary results will be presented and discussed on the performance of silica aerogel and of the gas radiators C4F10 and CF4.

Novel Cherenkov imaging techniques / 56

Detector concept combining Cherenkov and TOF information

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A detector concept is described that has been developed as a possible solution to the identification of low momentum hadrons in the proposed upgrade of the LHCb spectrometer. The detector consists of a DIRC-style quartz plate placed perpendicular to the beam axis, with photon detectors arranged around the periphery of the plate (outside the acceptance of the spectrometer). Cherenkov light produced by a charged particle traversing the plate is trapped within it by total internal reflection, and then focused onto the photodetectors. A combination of the precise measurement of the arrival time of the photons, and their position, should allow the time-of-flight of the particle to be reconstructed with a precision of ~10 ps, sufficient to satisfy the physics requirements. The expected performance from detailed simulation, and R&D that is underway to realize this concept, will be presented.

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Tools and Methods for simulation and evaluation of Very Large Volume Cherenkov Neutrino detectors

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We report on the structure and performance of the HOU Reconstruction & Simulation (HOURS) software package developed in order to study in detail the response of very large volume (km^3-scale) Cherenkov neutrino detectors. HOURS comprises a realistic simulation package of the detector response, including an accurate description of all the relevant physical processes, as well as several analysis strategies for event reconstruction. We also present results concerning the performance of several detector configurations of a Very Large Volume Cherenkov Neutrino detector. Our results refer to the evaluation of the detector sensitivity in observing cosmic neutrino fluxes from point-like and diffuse neutrino sources.

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Calibration and Optimization techniques for a Very Large Volume Cherenkov Neutrino Detector using Extensive Air Showers

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We report on a simulation study of the calibration potential offered by floating Extensive Air Shower (EAS) detector stations (HELYCON), operating in coincidence with a Very Large Volume Cherenkov Neutrino telescope. We describe strategies in order to investigate for possible systematic errors in reconstructing the direction of energetic muons as well as to determine the absolute position of the underwater detector.

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A new 1 km**2 EAS Cherenkov Array in the Tunka Valley

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A new EAS Cherenkov array has recently been put into the full operation in the Tunka Valley in Siberia, Russia. The main goal of the new detector is to study primary cosmic rays energy spectrum and mass composition in the energy range of 10**15 eV -10**18 eV. The array consists of 133 optical modules covering 1 km**2 area. The optical modules (OMs) are assembled in 19 clusters with 7 OMs in each cluster. The distance between OMs in a cluster is 85 m. The optical module is based on 8 in. hemispherical PMT. The array will locate EAS core with an accuracy of better than 6 m. The energy resolution of the array is ~15%. The detector will allow to measure EAS Cherenkov light lateral distribution and waveforms with high precision allowing to measure EAS maximum depth with**

an accuracy of ~25 g/cm2 which is in turn very important for primary cosmic rays mass composition studies. The array's smooth operation for several years will provide new important information on the primary cosmic rays in the energy range where, it is thought, there exists a transition between Galactic and extragalactic cosmic rays.

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Large area photodetectors for Astroparticle Physics Cherenkov arrays: PMTs vs HPDs

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We review large sensitive area photodetectors developed for Cherenkov neutrino arrays like neutrino telescopes - classical photomultipliers (PMTs) and hybrid phototubes (HPDs). We present results of studies of recently developed large sensitive area hemispherical PMTs including PMTs with high quantum efficiency photocathodes. We also present results of studies of new very fast scintillators like ZnO:Ga for use in large area HPDs. First pilot samples of HPD with ZnO:Ga scintillator has been recently developed and we present preliminary results of studies of their parameters. It's shown that the pilot samples have <1ns time resolution (fwhm) and a few ns pulse width (fwhm). Large sensitive area hybrid phototubes with such scintillators are very promising for new giant neutrino projects.

Poster Session 1 (Summary) / 61

Pinhole Camera for Observation of Transient Luminous Events in the Atmosphere.

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Abstract Recent measurements of the UV atmosphere glow have reported bright and fast Transient Luminous Events (TLE) in the atmosphere. Some of TLE features related with its space image and temporal characteristics remain unclear. The pinhole camera designed for observation of EAS Cherenkov light (Garipov & Khrenov, 1994) could be applied for TLE imaging with high frequency needed for revealing the TLE origin. In this work, we present a design and calibration of a pinhole camera aimed for TLE observations from the mountains. The TLE images are recorded by Multi Anode Photomultiplier (MAPM) tubes in two configurations. The electronic design of the camera including an automatic gain control for each MAPM tube is presented. The pinhole camera was calibrated by observing the moon light of various phases from the top of Sierra Negra Volcano (4300 m.a.s.l.).

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Cherenkov, Co-operation with International Scientific Community.

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Name Pavel Cherenkov is known in physics as the name of author who discovered new emission and proposed to use the emission for particles properties detection. At the same time Pavel Cherenkov took part actively in international scientific and scientifically-organizational projects, in international social life.
As international situation was changing, participation was held under variable circumstances. These aspects of Pavel Cherenkov activities can be of interest of scientific community dealing with Cherenkov detectors.

Poster Session 1 (Summary) / 63

Novel Large Format Sealed Tube Microchannel Plate Detectors for Cherenkov Timing and Imaging

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Microchannel plate devices are powerful detection devices for Cherenkov light, with good imaging and timing characteristics. However, currently the largest format devices available are of the order of 5cm, and these are expensive compared with photomultiplier tubes. One significant problem in covering large areas with such devices is both the cost, and the difficulty in fabricating large size microchannel plates. The packaging of a large sealed tube device, and producing a large area photocathode and imaging/timing readout are also of concern. As part of a collaborative program between university of California, Berkeley, the Argonne National Laboratory, University of Chicago, and several commercial companies, we are developing a 200mm square sealed tube microchannel plate detector scheme. One basis of the new device is the incorporation of a novel implementation of microchannel plates. We are developing comparatively low cost microchannel plates using borosilicate hollow core tubes. The resistive and photo-emissive surfaces are then applied by atomic layer deposition, eliminating the wet etch and thermal reduction processes for normal glass microchannel plates. Initial results on 25mm microchannel plates for gain, imaging performance and lifetime are very encouraging. Large 200mm microchannel plate substrates have been made and will be tested in the next few months. Designs for the sealed tube assembly, stripline anodes and entrance windows have been completed and are in fabrication. The overall device will be 220mm square and only about 10mm thick. The photocathode baseline is to use a bialkali material to match the Cherenkov spectrum, and to keep the overall background rate at an acceptable level. Stripline anodes are also being developed which will give less than 1mm spatial resolution using novel timing electronics. Based on data from existing designs, the new electronics should provide timing accuracy of a few picoseconds.

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Astrophysics with the H.E.S.S. Cherenkov Telescopes

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The High Energy Stereoscopic System (H.E.S.S.) is a system of four Cherenkov telescopes for GeV/TeV gamma-ray astronomy. By observing Cherenkov light emitted by particles in gamma-ray induced air showers the direction and energy of the primary gamma-ray can be reconstructed. A stereoscopic view of the air shower is achieved by combining the information from the four telescopes, allowing for an accurate reconstruction and a high rejection of background cosmic rays. The system has a sensitivity of 1% of the flux of the Crab nebula, the brightest steady source of gamma-rays in the sky, and a energy threshold of 100 GeV. The system is being upgraded with a new, 600 m2 telescope, currently being built in the center of the array. This will not only increase the sensitivity in the currently accessible energy regime, but also lower the energy threshold to about 30 GeV. H.E.S.S. has been operating since December 2003 and still continues to produce exciting results, including the recent detection of a VHE flare from the radio galaxy M87 and the detection of VHE emission from the starburst galaxy NGC 253. In this presentation, technical aspects of the system will be discussed and high-lights from resent results presented.

Novel Cherenkov imaging techniques / 65

The time-of-propagation counter for Belle II

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The Belle II detector operating at the future upgrade to the KEKB accelerator will perform high-statistics precision investigations into the flavor sector of the Standard Model. As charged hadron identification is a vital element of the experiment's success, the time-of-propagation (TOP) counter has been chosen as the primary particle identification device in the barrel region of Belle II. The TOP counter is a compact variant of the DIRC technique and relies heavily on exquisite single photon timing resolution with micro-channel plate photomultiplier tubes. We discuss the general principles of TOP operation and optimization of the Belle II TOP configuration, which is expected to provide 4 sigma or better separation of kaons and pions up to momenta of approximately 4 GeV/c.

Poster Session 1 (Summary) / 66

New Electronics for the Cherenkov Telescope Array

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The European astroparticle physics community aims to design and build the next generation array of Imaging Atmospheric Cherenkov Telescopes (IACTs), that will benefit from the experience of the existing H.E.S.S. and MAGIC detectors and further expand the very-high energy astronomy domain. In order to gain an order of magnitude in sensitivity in the 10 GeV to > 100 TeV range, the Cherenkov Telescope Array (CTA) will employ 50-100 mirrors of various sizes equipped with 1000 to 4000 channels per camera, to be compared with the 6000 channels of the final H.E.S.S. array. A 3-year programme started in 2009 and financed by the French ANR (Agence nationale de la Recherche) aims at building and testing a demonstrator module of a generic CTA camera. We present here the NECTAr design of front-end electronics for the CTA, adapted to the trigger and data acquisition of a large array, with simple production and maintenance operations. Cost and camera performances are optimised by maximising the integration of the front-end electronics (the amplifiers, fast analogue samplers, ADCs and first level buffering) in an ASIC, achieving several G-samples/s and a few microseconds eadout dead time. We present preliminary results and extrapolated performances from Monte Carlo simulations.

Poster Session 1 (Summary) / 67

Background radiation measurement with Water Cherenkov Detectors

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Water Cherenkov Detectors have the nice property of being mostly calorimeters for cosmic rays electrons and photons, while providing a clear signal for muons. At large energy deposited in the detector, they observe small extended air showers. This makes them interesting detectors to study the cosmic ray secondaries background. Using background histograms of the total energy deposited in detectors, or low threshold scaler counters, one can follow the flux of cosmic rays on top of the atmosphere at various energies, and/or study atmospheric effects on the cosmic ray showers development. Background data from the Pierre Auger Observatory will be presented, together with a reconstruction of the primary cosmic ray fluxes, showing modulation effects due to the Sun activity (Forbush decreases). Rapid changes in the background flux will be shown during the crossing of a storm over the 3000 km2 of the Pierre Auger ground array.

Cherenkov Imaging in particle and in nuclear physics experiments / 68

The Ring Imaging Cherenkov Detectors of the LHCb Experiment

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Particle identification is one of the fundamental requirement of the LHCb experiment. Hadron identification is performed by two Ring Imaging Cherenkov (RICH) detectors, comprising three radiators and 484 Hybrid Photon Detectors (HPDs) providing 500,000 channels of data. The particle identification system covers the full angular acceptance of the LHCb spectrometer and is designed to give positive identification from 1 up to 100 GeV/c. Specific readout electronics have been developed to readout and processing the data from the HPDs including data transmission and power distribution. A dedicated high voltage control system has been implemented in order to operate and monitor the RICH HPDs. Essential for RICH operation are the control and monitoring of low voltage and high voltage systems, the monitoring of gas quality, mirror alignment and environmental parameters, and finally detector safety. A well calibrated and aligned RICH system is essential for providing the particle identification performance necessary for the physics goals. The LHCb RICH Detector Control System ensures the efficient and safe operation of the two RICH detectors. A description of the LHCb RICH will be given, the experience to operate the detector at LHC, as well as preliminary performance, will be reported.

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The influence of gas refractive index to the RICH detector accuracy

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The radiator gas C4F10 at Compass RICH has two important characteristics of refractive index – absolute value at specific wavelength and material dispersion of this index. The influence of both characteristics, possibility of their measurement and compensation of it are presented. The refractive index of radiator gas varies with temperature, atmospheric pressure and gas purity. It is important to compensate effective refractive index changes in the process of particle identification. The modified Jamin interferometer was proposed, constructed and tested for on-line refractive index measurement. This interferometer will be connected in parallel to the Compass RICH vessel. It has 30 cm active length. It is very stable and very well vibration resistant instrument. It uses He-Ne laser so it measures refractive index at 633 nm with accuracy better than 10-6. The results can be applied to the all wavelengths of Cherenkov spectra. Only one value of effective refractive index of gas is used in general for gas characterization. But the dispersion must be taken into account. The simulation of Cerenkov angle distributions due refractive index dispersion of C4F10 for both PMT and CsI detectors was made. The spectrum of emitted Cherenkov photons depends on particle momentum especially in the case of momentum lower than 20 GeV/c. The photons of different wavelength have a different probability to be detected. There are two tendencies – photons from VIS range can fall to narrow angle and the number of detected photons is not so big. Photons from UV create wider rings and the number of detected UV photons is higher. We calculated angle distribution of detected photons, position and width of Cherenkov rings for both PMT and CsI detectors. Calculations were made for various values of particle momentum taken as parameters. It results that effective index is depending on particle momentum. This can be can be used at particle identification algorithm.

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Mirrors alignment control at Compass RICH-1 detector

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The COMPASS RICH-1 detector has been using two reflecting segmented spherical mirrors, constructed from 68 hexagonal and 48 pentagonal individual mirrors. All mirrors have three degrees of freedom per segment, i.e., piston, tip, and tilt. The influence of external vibrations, pressure and temperature fluctuation can change alignment of individual mirrors with respect to optimal spherical surface. The accuracy of Cerenkov angle measurement can be increased by monitoring and consequently by compensation of tilt of mirrors. The on-line measurement of individual mirrors misalignment was made by continues alignment of mirrors - CLAM method. The rectangular grid, made from reflecting continuous lines, is placed near the focal plane of mirror wall inside the detector vessel. The image of lines, reflected by the mirror wall, is observed by 4 cameras. Small misalignment of mirrors can change position of image of the lines at camera CMOS detector. The cameras were calibrated by using of calibrated plate to receive all information about lenses optical distortions. The developed algorithm enables compensation of these distortions. The photos of rectangular grid before, during and after Compass runs at different conditions were taken. Photogrammetric method was used to determine absolute camera's positions from images of photogrammetric targets, placed on mirror-wall frame. The absolute values of tilt of mirrors were determined by new algorithm from knowledge of both rectangular grid and photogrammetric targets positions and from localization of camera principal point. The tilts of individual mirrors were determined with a resolution of 0.1 mrad. These results demonstrate that the CLAM method can successfully sense the tilts of a segmented mirror.

Photon detection for Cherenkov Counters - vacuum based devices / 72

Development of Sub-Nanosecond, High Gain Structures for Time-Of-Flight Ring Imaging in Large Area Detectors

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Microchannel plate photomultiplier tubes (MCP-PMTs) are compact, imaging detectors, capable of micron-level spatial imaging and timing measurements with resolutions below 10 picoseconds. Conventional fabrication methods are too expensive for MCP-PMTs in the quantities and sizes necessary for large, time-of-flight ring-imaging Cherenkov detectors (TOF-RICH) and other fast-timing large-area photo-detector applications. The Large Area Picosecond Photodetector Collaboration (LAPPD) is developing new, commercializable methods to fabricate 20cm-square thin planar MCP-PMTs at costs comparable to those of traditional photo-multiplier tubes. Transmission-line readout with waveform sampling on both ends of each line allows the efficient coverage of large areas while maintaining excellent time and space resolution. Rather than

fabricating channel plates from active, high secondary electron emission materials, we produce plates from passive substrates, and coat them using atomic layer deposition (ALD), a well established industrial batch process. In addition to possible reductions in cost and conditioning time, this allows greater control to optimize the composition of active materials for performance. A cross-divisional effort within Argonne National Lab has been formed to fabricate and test ALD-activated channel plates, using a wide variety of chemistries. Work between the High Energy Physics Division and the Advanced Photon Source has produced an advanced channel-plate testing facility with particularly unique capabilities for testing the performance of ALD activated microchannel plates in the time-domain. We present details of the MCP fabrication method, and preliminary results from testing and characterization facilities at Argonne. Brief Preliminary results will also be presented on the reconstruction capabilities for neutrino events in future generations of water Cherenkov detectors using precision measurements of both the time and position for each radiated photon.

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Detector and Electronics R&D for picosecond resolution, single photon detection and imaging

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Photek, in collaboration with the University of Leicester space research centre, are pursuing a number of R&D projects aimed at developing systems for detection of single photon events with time resolution of the order of 10 ps. This involves the development of new detectors and accompanying electronics, utilising the HPTDC and NINO chips developed at CERN. An overview of R&D efforts will be presented, including results from a new multi-anode detector, jitter measurements on MCP-PMTs and current development progress on a benchtop HPTDC module.

Photon detection for Cherenkov Counters - gaseous devices / 74

THGEM/CsI: a potential UV-photon detector for RICH

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In view of their potential application in RICH, we report on the operation properties of single- and cascade-THGEM UV-photon detectors with reflective CsI photocathodes, under simultaneous irradiation of UV and X- or [U+F062]-rays. Our studies were carried out in neon/CH4 and Ne/CF4 mixtures, in which conditions were previously found for high photon detection efficiencies – similar to that in present CH4-operated MWPC/CsI UV-photon RICH detectors. In these mixtures THGEMs were also found to operate over higher dynamic range compared to argon mixtures. We focused here on the maximum achievable gain at various conditions, sparking probability, cathode-excitation effects and gain stability. The properties of a CH4-operated MWPC with reflective CsI photocathode, studied in similar conditions, are also reported – for comparison. We demonstrated that at low counting rates, the maximum achievable gain of the THGEM detector, similarly to most gas-avalanche multipliers, is determined by the Raether limit. At higher rates, the maximal gain continuously drops, though remaining significantly higher than that of the MWPC - under similar conditions; a triple-THGEM suffers much less from cathode excitation effects as compared to MWPC, which makes it suitable for high counting-rate applications. We will also recall other relevant properties of these detectors, and discuss their potential cryogenic operation in noble-gas scintillators.

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Particle identification with a track fit chi-square

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Tracker detectors can be used to identify charged particles based on their global chi value obtained during track fitting with the Kalman filter. The proposed method is independent of the traditional way of identification using deposited energy.
This approach builds upon the knowledge of detector material and local position resolution, using the known physics of multiple scattering and energy loss. The study using simplified models of present LHC experiments shows that pion-kaon and pion-proton unfolding is possible at low momentum. The separation is better than 1 sigma for $p < 0.9$ and 1.4 GeV/c, respectively.
Since the chi value of the filter is equivalent to that of a global fit, the method is suitable for any minimum chi^2 track fit that properly models energy-loss and scattering effects. In general, the performance of an experiment is determined by the number of good sensitivity split measurements, and it is also a strong function of particle momentum.
See recent preprint at http://arxiv.org/abs/0911.2624 [physics.ins-det], submitted to Nucl Inst Meth A.

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The AMS~02 RICH detector: performance during ground-based data taking at CERN

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The Alpha Magnetic Spectrometer (AMS), whose final version AMS 02 is to be installed on the International Space Station (ISS) later this year, is a detector designed to measure charged cosmic ray spectra with energies up to the TeV region and with high energy photon detection capability up to a few hundred GeV, using state-of-the art particle identification techniques.
Among several detector subsystems, AMS includes a proximity focusing RICH detector enabling precise measurements of particle electric charge (charge identification up to the iron region) and velocity (dbeta/beta ~ 10^-3 for Z=1, ~ 10^-4 for Z=10-20). The optimization of the RICH reconstruction efficiency imposed a dual radiator configuration with 16 NaF tiles (n=1.33) in the center and 92 aerogel tiles (n=1.050) surrounding, a pixelized detection matrix with 680 Hamamatsu R7600-M16 photomultipliers (4x4 pixels) and a highly reflective conical mirror to increase photon collection.
After the RICH detector assembly at CIEMAT (Madrid), it was taken to CERN where it was integrated in the full AMS 02 detector. AMS 02 underwent a pre-assembly in 2008 without its superconducting magnet before the final detector assembly which took place during 2009. Cosmic events were acquired in the context of the 2008 pre-assembly and final assembly, this time including the superconducting magnet, and a beam test from CERN SPS took place in February 2010. Results obtained with data from ground-based tests on the RICH performance are presented. A comparison with the aerogel light yield obtained on previous beam tests with a prototype detector is also discussed.

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Application of Geiger-mode photo sensors in Cherenkov detectors

Auteur(s): Dr. MARTON, Johann[1]
Co-auteur(s) Mr. AHMED, Gamal [2] ; Dr. BUEHLER, Paul [1] ; Dr. SUZUKI, Ken [1]

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Silicon-based photon sensors (SiPMs) working in the Geiger-mode represent an elegant solution for the the readout of particle detectors working at low-light levels like Cherenkov detectors. Especially the insensitivity for magnetic fields makes this kind of sensors suitable for modern detector systems in subatomic physics which are usually employing magnets for momentum resolution. On the other hand SiPMs are exhibiting fairly high noise levels which in priciple can be reduced by cooling. In our institute we are characterizing SiPMs of different manufacturers for selecting sensors and finding optimum operating conditions for given applications. Recently we built a timing detector with cooled and temperature-stabilized SiPM readout. The performance was tested in an accelerator environment using electrons with about 500 MeV at the beam test facility of Laboratori Nazionali di Frascati. This talk will present our results on sensor characterization and selected Cherenkov applications.

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Measuring the masses of the charged hadrons using a RICH as a precision velocity spectrometer

Auteur(s): COOPER, Peter[1]
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The Selex experiment measured several billion charged hadron tracks with a high precision magnetic momentum spectrometer and high precision RICH velocity spectrometer. We have analyzed these data to simultaneously measure the masses of all the long lived charged hadrons and anti-hadrons from the pion to the Omega- using the same detectors and techniques. The statistical precision achievable with this data sample is effectively unlimited.
We have used these measurements to develop and understand the systematic effects of a RICH as a precision velocity spectrometer with the goal of measuring all 16 masses with precision ranging from 100 KeV for the lightest to 1000 KeV for the heaviest. This requires controlling the radius measurement of RICH rings to the dR/R˜10ˆ-4 level.
Progress in the mass measurements and the required RICH analysis techniques developed will be discussed.

Research and Development for future detectors / 80

R&D towards the MEMPHYS detector

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MEMPHYS is a 0,5 Mton scale Water Cerenkov detector proposed for deep underground installation. Its performance with neutrino beams includes the possibility of measuring the mixing angle ϑ13, the CP violating phase δ and mass hierarchy. In addition, it would have an unprecedented reach for nucleon decay searches and for supernova neutrino detection. One R&D item currently being carried out is Memphyno, a small-scale prototype. Its main purpose is to serve as a test bench for new photodetection and data acquisition solutions, such the grouped readout and HV feeding system We will present the aims and status ofMemphyno.

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Gigaton Volume Detector in Lake Baikal

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We review the status of the Lake Baikal Neutrino Experiment. Preparation towards a km3-scale Gigaton Volume Detector (GVD) in Lake Baikal is currently a central activity. A prototype string for the future km3-scale Baikal neutrino telescope has been deployed and is fully integrated into the NT200+ telescope. We describe preliminary design and expected sensitivity of the GVD telescope, and discuss the experience of the GVD prototype string operation. We also present recent results from the long-term operation of NT200.

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The ANTARES Deep-Sea Neutrino Telescope: Operation and Calibration

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The ANTARES detector is the world's first operating deep-sea neutrino telescope. It is located at a depth of 2475m in the Mediterranean Sea, close to Toulon, France. ANTARES comprises a three dimensional array of 885 photomultipliers, designed to detect the Cherenkov light produced by neutrino-induced muons passing close to the detector. Since June 2008, the construction of the detector is complete.
Various aspects of the detector construction are described and the methods adopted to calibrate in-situ the efficiency, timing and positioning of the detector are presented.

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Thick-COBRA, a New Thick-Hole Concept for Ion Back Flow Reduction

Auteur(s): VELOSO, Joao[1]
Co-auteur(s) SANTOS, Carlos [1] ; AZEVEDO, Carlos [1] ; AMARO, Fernando [2] ; DOS SANTOS, Joaquim [2] ; BRESKIN, Amos [3] ; CHECHIK, Rachel [3]

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Ion Back Flow (IBF) in gaseous detectors presents a drawback in many applications, such as TPCs, RICH detectors and gaseous photosensors, among others. Following the success of the MHSP operating in flipped reverse mode, which reached an IBF reduction approaching 10ˆ-4, a new concept based on this one though with optimized geometry and aiming applications needing large detection areas, was developed in a "thick-hole" configuration, the Thick-COBRA. This new structure is produced in the same way as the Thick-GEM, but includes on one of its surfaces an extra electrode for trapping the ions from the multiplication stages. The extra electrode of the Thick-COBRA faces the electron drift region in such a way that not only ions flowing back from the cascade multiplication regions, but also those produced in the Thick-COBRA multiplication region can be trapped. In this work, experimental and simulation studies on IBF and electron collection/transmission efficiencies, are presented for the referred configuration. In addition, a discussion of its suitability for application to RICH and to gaseous photosensors will be presented.
This work was supported by project CERN/FP/109283/2009 under the FEDER and FCT (Lisbon) programs.

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FACT - the first Cherenkov Telescope using a G-APD Camera for TeV Gamma-ray Astronomy

Auteur(s): Mr. BACKES, Michael[1]
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Geiger-mode Avalanche Photo Diodes (G-APD) bear the potential to significantly improve the sensitivity of Imaging Air Cherenkov Telescopes (IACT). Therefore we are currently building the First G-APD Cherenkov Telescope (FACT) by refurbishing an old IACT with a mirror area of 9 square meters and construct a new, fine pixelized camera using novel G-APDs. The main goal is to evaluate the performance of a complete system. This is an important field test to check the feasibility of G-APD based cameras to replace at some time the PMT-based cameras of planned future IACTs like AGIS and CTA. In this talk, we present the basic design of such a camera as well as some important details to be taken into account. Additionally, we will make a critical comparison of PMTs and G-APDs concerning their use in IACTS.

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Results of the prototype camera for FACT

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The maximization of the photon detection efficiency (PDE) is a key issue in the development of cameras for Imaging Air Cherenkov Telescopes (IACT). Geiger-mode Avalanche Photodiodes (G-APD) are a promising candidate to replace the commonly used photomultiplier tubes by offering a larger PDE and a facilitated handling. The FACT project (First G-APD Cherenkov Telescope) evaluates the feasibility of this change by building a camera based on 1440 G-APDs for an existing small telescope. As a first step towards a full camera, a prototype camera module using 144 G-APDs was successfully built and tested. The experiences gained from its operation, including the observation of air showers, are presented. A method to compensate the strong signal variations due to the temperature dependence of the G-APDs gain is described.

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The Cerenkov Telescope Array

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The Cerenkov Telescope Array (CTA) is a project of building a High Energy (10 GeV to 100 TeV) gamma ray observatory. The CTA consortium is organized in workpackages dedicated to the electronics, the telescope structure, the focal plane instruments and other topics. In this talk, I will first give a brief overview of High Energy gamma ray astronomy. Next, I will describe the status of the work in the various workpackages. Then I will conclude by giving a tentative timeline for the CTA project.

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Cherenkov light imaging fundamentals and recent developments

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Recent advances in the development of gaseous detectors and MPGDs

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Other PID techniques

Dr. VAVRA, Jerry[1]

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Workshop highlights

Dr. RATCLIFF, Blair[1]

[1] *SLAC*

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Thanks, Closeout, announcement of location of next RICH workshop

Dr. NAPPI, Eugenio[1]

[1] *INFN*

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Poster overview (1 of 2)

Prof. KRIZAN, Peter[1]

[1] *University of Ljubljana*

Introduction to posters that will be visible today (Tuesday May 4) during coffee breaks

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Poster overview (2 of 2)

Prof. KRIZAN, Peter[1]

[1] *University of Ljubljana*

Posters that may be viewed in the coffee break this morning (Wednesday May 5) and tomorrow morning (Thursday May 6)

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PMT Characterisation for the KM3NeT Project

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The KM3NeT project aims to design and to construct at least a cubic kilometre scale neutrino telescope in the Mediterranean Sea. The main task is to instrument this deep-sea water volume with optical modules, each housing one or several photomultiplier tubes (PMTs). 3-, 8- and 10-inch PMTs from ET Enterprises, Hamamatsu and MELZ-FEU have been investigated as candidates for the telescope's optical modules. Various parameters of these photomultiplier tubes have been measured in a test bench at the Erlangen Centre for Astroparticle Physics. These results are presented.

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Status and perspectives of solid state photon detectors

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Status and perspectives of Vacuum-based photon detectors

Prof. IIJIMA, Toru[1]

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Status and perspectives of gaseous photon detectors

Dr. DALLA TORRE, Silvia[1]

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Technology issues in the Cherenkov light imaging

Prof. MATTEUZZI, Clara Matteuzzi[1]

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Reconstruction and Particle Identification Performance of the LHCb RICH detector

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Particle identification in the LHCb experiment is provided by two RICH detectors, covering a momentum range between 1 and 100 GeV/c. In order to maintain the integrity of the LHCb physics performance, it is essential to measure and monitor the particle identification efficiency and misidentification fraction over time. To achieve this, the unique kinematics associated with K-short, Lambda and D*decays are exploited to obtain high purity samples of pions, kaons and protons through the use of tracking information alone. Such calibration samples then allow for an unbiased assessment of the RICH detectors performance. Given the high production rates of K-short, Lambda and D* mesons at the LHC, monitoring of the RICH detectors performance is possible both "online" during running and "offline" after full-reconstruction of the data. Following analysis of the first LHC collisions, the performance of the LHCb RICH detectors will be presented. Efficiency and misidentification probabilities as a function of track momentum will be shown for each charged-particle type.

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Welcome (others)