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BOOK OF ABSTRACTS

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Laser backscattering for beam energy calibration in collider experiments. Recent results.

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The report is devoted to the beam energy measurement systems which are now in operation at the BEPC-II and the VEPP-2000 colliders. After brief histrorical overview, it describes the principles of operation, interesting options, present performance and accuracy achievments of the approach.

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Beam energy measurement system at BEPCII

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The beam energy measurement system (BEMS) for Beijing electron positron collider (BEPCII) is introduced. It is based on the measurement of Compton back scattered photons. The relative systematic uncertainty of beam energy measurement is estimated as $2 * 10^{-5}$. Some upgradations for BEMS are also introduced.

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Luminosity measurements at LHCb

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Luminosity measurements at LHCb are of pivotal importance. They have been used in about 50 LHCb publications of production cross section results. The interaction rate at LHCb is continuously monitored by several luminosity counters (like the number of reconstructed tracks) measuring the fraction of "empty" events, i.e. events which fall below a chosen threshold of a given luminosity counter. Using the law of Poisson statistics, an average interaction rate per bunch crossing is derived from the "empty" events fraction. The absolute calibration of the luminosity counters is performed a few times per year (typically for each new beam energy and beam types), mostly in dedicated LHC fills. Two techniques are employed for the direct luminosity measurement. The first one is the classic van der Meer scan method which is used by all four LHC experiments. The second one is unique to LHCb. Here, the beam profiles and their overlap integral are determined from the beam "images" recorded with beam-gas interactions. Both techniques give similar accuracy but have different systematics. Their combination has allowed us to obtain in LHC Run I the most precise luminosity measurement ever achieved at a bunched hadron collider. In this talk, we give an overview of the LHCb experience with the luminosity calibration, present several recent calibration results and outline the developments which are being pursued to obtain a better understanding of the calibrations.

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Beam background detection at SuperKEKB/Belle II

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The SuperKEKB energy-asymmetric e+e- collider has completed its first phase of commissioning and is working towards its design luminosity of 8x10^{35}cm^{-2}s^{-1}. The collisions will be recorded and analyzed with the Belle II spectrometer whose construction is on-going at the roll-out position. Last spring, SuperKEKB circulated beams in both rings during the first phase of commissioning. In this time, beam conditions were monitored around the interaction point with an array of sensors collectively called BEAST II. I will report on the results of BEAST II during this commissioning phase as well as plans to upgrade this detector for the second phase of SuperKEKB commissioniong.

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The KLOE-2 High Energy Taggers

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The precision measurement of the $\pi^0 \to \gamma\gamma$ width allows to gain insights into the strong QCD dynamics. A way to achieve the precision needed (1%) in order to test Theory predictions is to study the π^0 production trough $\gamma\gamma$ fusion in the $e^+e^- \to e^+e^-\gamma^\star\gamma^\star \to e^+e^-\pi^0$ reaction. The KLOE-2 experiment, currently running at the DAΦNE facility in Frascati, aims to perform this measurement. For this reason, new detectors, which allow to tag final state leptons, have been installed along the DAΦNE beam line in order to reduce the huge background coming from ϕ-meson decays. The High Energy Tagger (HET) detector measures the deviation of leptons from their main orbit by determining their position and timing. The HET detectors are placed in roman pots just at the exit of the DAΦNE dipole magnets, 11 m away from the IP, both on positron and electron sides. The HET sensitive area is made up of a set of 28 plastic scintillators. A dedicated DAQ electronic board, based on a Xilinx Virtex-5 FPGA, has been developed for this detector. It provides a MultiHit TDC with a time resolution of 550(1) ps and the possibility to clearly identify the correct bunch crossing ($\Delta T_{bunch} \sim$ 2.7 ns). The most relevant features of the KLOE-2 tagging system operation as time performance, stability, efficiency, and the techniques used to determine the time overlap between the KLOE and HET asynchronous DAQs will be presented.

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The LHCb upgrades overview

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Optimization of the beam crossing angle at the ILC for e+e- and gamma-gamma collisons

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In the present ILC design the beam crossing angle for e+e- collisions is 14 mrad. The photon collider needs the angle about 25 mrad due to larger beam disruption angle. The solution is suggested which decreases the required crossing angle for the photon collider down to 20 mrad and allows to work in both modes of collisions without any degradation of performance.

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BigData challenges and processing at present and future High Energy Physics and Nuclear Physics experiments

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In this contribution I discuss the various aspects of the computing resource needs experiments in High Energy and Nuclear Physics, in particular at the Large Hadron Collider, have encountered so far and how this will evolve in the future when moving from LHC to HL-LHC ten years from now, when the already Exa-scale levels of data we are processing could increase by a further order of magnitude. The distributed computing environment has been a great success and the inclusion of new super-computing facilities, cloud computing and volunteering computing for the future a big challenge, which we are successfully mastering with a considerable contribution from many super-computing centres around the world, academic and commercial cloud providers and in particular with support of RF Ministry and Education and Science mega-grant program for BigData Technologies Laboratory hosted at National Research Center Kurchatov Institute.

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Trigger systems of the LHC experiments

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Interaction rates at the LHC increase with the collider's luminosity and collision energy. All LHC experiments and in particular their trigger systems have to take this fact into account in order to ensure efficient physics data taking while at the same time keeping data rates at an acceptable level. This talk will present an overview of the most important trigger upgrades that have happened since the end of LHC Run 1 in 2012, describe work currently underway and present an outlook on major improvements planned for the medium-term future.

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Computing challenges of the CMS experiment

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The success of the LHC experiments is due to the magnificent performance of the detector systems and the excellent operating computing systems. The CMS offline software and computing system is successfully fulfilling the LHC Run 2 requirements. For the increased data rate, together with high pileup interactions, improvements of the usage of the current computing facilities and new technologies became necessary. Especially for the challenge of the future HL-LHC a more flexible and sophisticated computing model is needed. In this presentation, I will discuss the current computing system used in the LHC Run 2 and future computing facilities for the HL-LHC Runs using flexible computing technologies like commercial and academic computing clouds. The cloud resources are highly virtualized and can be deployed for a variety of computing tasks providing the capacities for the increasing needs of large scale scientific computing.

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The Belle II Software - From Detector Signals to Physics Results

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The Tracking and Calorimeter Systems of the Mu2e Experiment

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The Mu2e experiment at Fermilab is a search for muon-to-electron conversion in the field of an aluminum nucleus with a sensitivity improvement of four orders of magnitude over existing limits. The low mass straw tube tracker system and the pure cesium iodide crystal calorimeter system of the experiment will be discussed in detail.

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The MEGII detector

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An overview of the conceptual design and construction status of the detector for the MEGII experiment, the upgrade of MEG, is presented. MEGII is designed to search for the $\mu^+ \to e^+$ decay with a sensitivity an order of magnitude better than MEG down to 5×10^{-14}. To achieve this sensitivity a muon decay rate a factor of two higher is required. The detector resolution on all physical parameters is expected to improve of a factor of two. The detector has been substantially redesigned to cope with the highest muon decay rate expected. Some detector components have been upgraded (calorimetry, beam line, calibration), others redesigned completely (drift chamber, timing counter), others added (Radiative decay counter). All main detector components are presented emphasizing the improvements with MEG. An estimate of the expected final sensitivity is presented.

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The construction technique of high granularity and high transparency Drift Chambers for the MEG II upgrade

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The MEG experiment searches for the charged lepton flavor violating decay, $\mu^+ \to e^+\gamma$. MEG has already determined the world best upper limit on the branching ratio $BR < 4.2 \times 10^{-13}$@90%CL. An upgrade of the whole detector has been approved to obtain a substantial increase in sensitivity. Currently MEG is in upgrade phases, this phase involves all the detectors. The new positron

tracker is a single volume, full stereo, small cells drift chamber(DC) co-axial to the beam line. It is composed of 10 concentric layers and each single drift cell is approximately square 7 mm side, with a 20 μm gold plated W sense wire surrounded by 40 μm and 50 μm silver plated Al field wires in a ratio of 5:1, about $12,000$ wires. Due to the high wire density ($12 wires/cm^2$), the use of the classical feed-through technique as wire anchoring system could hardly be implemented and therefore it was necessary to develop new wiring strategies. The number of wires and the stringent requirements on the precision of their position and on the uniformity of the wire mechanical tension impose the use of an automatic system to operate the wiring procedures. This wiring robot, designed and built at the INFN Lecce and University of Salento laboratories, consists of:

- a semiautomatic wiring machine with a high precision on wire mechanical tensioning (better than 0.5 g) and on wire positioning (20 μm) for simultaneous wiring of multiwire layers;
- a contact-less infrared laser soldering tool;
- an automatic handling system for storing and transporting the multi-wire layers.

The drift chamber is currently under construction at INFN and should be completed by the end of summer 2017 to be then delivered to PSI for commissioning.

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Cylindrical drift chamber and tracking in COMET

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The cylindrical drift chamber (CDC) of COMET Phase-I experiment aims to search 105MeV electrons from muon-e conversion. To achieve the target sensitivity and high momentum resolution, CDC is designed and constructed to be a low-mass detector with alternating stereo layers. And a multi-track fitting method is introduced to meet the challenge of multi-turn track reconstruction in CDC.

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Central Drift Chamber for Belle-II

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The Central Drift Chamber (CDC) is the main device for tracking and identification of charged particles for Belle-II experiment. The Belle-II CDC is cylindrical wire chamber with 14336 sense wires, 2.3m-length and 2.2m-diameter. The wire chamber and readout electronics have been completely replaced from the Belle CDC. The new readout electronics system must handle higher trigger rate of 30kHz with less dead time at the design luminosity of $8 \times 10^{35}\mathrm{cm}^{-2}\mathrm{s}^{-1}$. The front-end electronics are located close to detector and send digitized signal through optical fibers. The Amp-Shaper-Discriminator chips, FADC and FPGA are assembled on a single board. Belle-II CDC with readout electronics has been installed successfully in Belle structure in October 2016. We will present overview of the Belle-II CDC and status of commissioning with cosmic ray.

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NA62 Straw Tracker

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The NA62 experiment at CERN is aimed at measuring the ultra-rare decay K+→π+$\nu\nu^{-}$ with 10% accuracy. The spectrometer contains 7168 straw tubes operating in vacuum. The detector was successfully installed and commissioned in 2014 - 2015. The goal of this report is to give a general overview of the straw tracker.

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Status of the Precision Drift Tube Chambers for the ATLAS Muon Spectrometer

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The Muon Drift Tube (MDT) chambers provide very precise and reliable muon tracking and momentum measurement in the ATLAS muon spectrometer. Already in run 2 of the LHC they have to cope with very high background counting rates up to 500 Hz/cm2 in the inner endcap layers. At High-Luminosity LHC (HL-LHC), the background rates are expected to increase by almost a factor of 10. New small (15 mm)-diameter Muon Drift Tube (sMDT) chambers have been developed for upgrades of the muon spectrometer. They provide an about an order of magnitude higher rate capability and allow for the installation of additional RPC trigger chambers in the barrel inner layer of the muon detector for HL-LHC. They have been designed for mass production and achieve a sense wire positioning accuracy of 5 microns. A pilot project for the barrel inner layer upgrade is on the way for the 2019/20 LHC shutdown. Several sMDT chambers have already been installed and operated in the ATLAS detector.

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Design of the forward straw tube tracker for the PANDA experiment

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In the PANDA experiment, for momentum analysis of forward scattered charged particles, a large gap dipole magnet and the Forward Tracker (FT) will be used. The main requirements for the FT include a high rate capability corresponding to particle fluxes reaching up to $2.5x10^4cm^{-2}s^{-1}$ close to the beam pipe and a total counting rate of about $5x10^7s^{-1}$. A momentum acceptance extending down to at least 3% of the beam momentum and a momentum resolution better than 1.5% is expected. To meet these requirements, a tracking system based on 10 mm in diameter straw tubes, made of a thin (27 um) aluminized Mylar film, has been designed. It consists of 6 tracking stations, each comprising 4 planar double-layers of the straws with a total material budget of only 2% X0. The straws are made self-supporting by a 1 bar over-pressure of the working gas mixture (Ar/CO2). This allows to use lightweight and compact rectangular support

frames for the double-layers and to split the frames into pairs of C-shaped half-frames for an easier installation on the beam line. The double-layers are built of separate modules consisting of 32 straws arranged in two staggered layers. The modular construction allows for fast repair and/or replacement of the modules suffering from aging effects or broken straws during the detector lifetime. The read out of the FT is based on the newly developed PASTTREC ASIC (0.35 um CMOS) providing configurable gain and shaping time, an ion tail cancelation and a baseline holder circuits appropriate for the high rate applications. The drift time as well as a Time-Over-Threshold (TOT) of the detector signals is measured using Trigger Readout Boards v3 (TRBv3) containing 64 TDC channels implemented in FPGA and serving also as nodes of the readout platform and data processing. Tests of prototype modules, performed with proton beams at high counting rates of up to 1 MHz/straw, demonstrated a tracking capability with a good spatial resolution of 150 um per straw and the applicability of the TOT technique for the identification of the particles species by means of their specific energy losses.

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TPC status for MPD experiment at NICA project

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This report presents: - MPD and TPC configurations; - the main geometrical parameters and features of TPC; - tooling for TPC assembly; - design of readout chamber based on MWPC and frontend electronics; - description of TPC subsystems (gas, cooling, laser calibrarion) and its status; - status of jobs on integration of TPC into MPD.

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A TPC for the International Linear Collider

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Significant R&D on detectors for the future International Linear Collider (ILC) has been carried out during the last few years. The ILD central tracker includes a Time Projection Chamber (TPC) embedded in a 3.5 T solenoidal field. Within the framework of the LCTPC collaboration, a Large Prototype (LP) TPC has been built as a demonstrator. Its endplate can accommodate up to seven modules of MPGD representative of the proposed design for ILD. The MPGD technologies being developed are Gas ElectronMultiplier (GEM), Micromegas and GridPix. In these technologies, two solutions for the gas amplification (GEM and Micromegas) are combined with either a traditional pad-based or a digital chip readout.
A large prototype of TPC, equipped with up to seven identical modules in a 1 T magnetic field has been tested with a 6 GeV electron beam at DESY. Track reconstruction performance was measured for three different detector technologies: Gas Electron Multiplier, Resistive Micromegas and GridPix. Recent results of these tests will be given. They address realistically implementation questions. Also, together with the ILD collaboration, a detailed study of the field configuration in the interaction region and its effects on the background is started, and plans for calibration and alignment are drawn up. The current status of these will be reported.
It was demonstrated that current technologies allow us to meet the ILD tracker requirements.

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MWPC prototyping and testing for STAR Inner TPC Upgrade

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STAR is upgrading the inner sectors of the STAR Time Projection Chamber(iTPC) to increase the segmentation on the inner pad plane from 13 to 40 pad rows and to renew the inner sector wire chambers. The upgrade will expand the TPC's acceptance out to pseudo-rapidity |eta| ≤ 1.5, compared to the current limitation of |eta|≤ 1. Furthermore, the detector will have better acceptance for tracks with low momentum, as well as better resolution in both momentum and dE/dx for tracks of all momenta. The enhanced measurement capabilities of STAR-iTPC upgrade are critical to the physics program of the Beam Energy Scan II at RHIC during 2019˜2020, in particular the QCD phase transition study. In this talk, I will discuss the iTPC MWPC module fabrication and testing results from the first full size prototype made at Shandong University.

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Silicon Technologies for the CLIC Vertex Detector

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CLIC is a proposed linear e^+e^- collider providing particle collisions at center-of-mass energies of up to 3 TeV. The physics objectives of precise top quark, Higgs boson and Beyond Standard Model physics require a superior performance of the CLIC detector. In particular the vertex detector faces the challenges of providing a single point resolution of only a few micrometers while not exceeding the envisaged material budget of around 0.2% X_0 per layer. Beam-beam interactions and beamstrahlung processes impose an additional requirement on the timestamping capabilities of the vertex detector of about 10 ns.
These goals can only be met by employing novel techniques in the sensor and ASIC design as well as in the detector construction. The mass of the overall detector is reduced by using forced air-flow cooling. To enable this, the detector will be operated in a power pulsing scheme, limiting the power dissipation to the minimum and making use of the beam structure of the CLIC accelerator.
The R&D program for the CLIC vertex detector comprises various technologies which are explored in order to meet the above demands. The feasibility of planar sensors with a thickness of 50-150μm, including different active edge designs, are evaluated using Timepix3 ASICs. First prototypes of the CLICpix readout ASIC, implemented in 65 nm CMOS technology and with a pixel pitch of $25 \times 25 \mu m^2$, have been produced and tested in particle beams. An updated version of the ASIC with larger pixel matrix and improved precision of the time-over-threshold and time-of-arrival measurements has been submitted. Different hybridization concepts have been developed for the interconnection between the sensor and readout ASIC, ranging from small-pitch bump bonding of planar sensors to capacitive coupling of active HV-CMOS sensors. Furthermore, a through-silicon via (TSV) interconnect process has been developed, allowing for seamless tiling of detectors in large areas. Detector simulations based on Geant4 and TCAD allow the comparison with experimental results and are used to assess and optimize the performance of the various designs.
This contribution gives an overview of the R&D program undertaken for the CLIC vertex detector and presents performance measurements of the prototype detectors currently under investigation.

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The Phase-1 Upgrade of the CMS Pixel Detector

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The CMS experiment features as its innermost component a silicon pixel detector which provides high precision space point measurements of charged particle trajectories. The original detector was designed for an instantaneous luminosity of $1.0x10^{34}cm^{-2}s^{-1}$. Due to improvements of the LHC this luminosity was already exceeded in 2016 and it is foreseen that it will be further increased up to two times the design value before 2018. This will lead to more interactions per bunch crossing and also the inefficiencies caused by the readout electronics will rise.
To maintain the excellent tracking efficiency, the CMS collaboration has built a new pixel detector with the plan to install it in an extended technical shutdown at the beginning of 2017. The Phase I pixel detector features an additional fourth layer in the barrel part and an additional third layer in the endcaps. The material budget could still be reduced by a lightweight carbon fiber support structure and a new cooling system using a two-phase CO2 cooling. To reduce data losses, new readout chips with larger buffers and a digital readout have been developed and the readout electronics was upgraded. Furthermore the new detector features a novel powering scheme using DC-DC converters.
This contribution will motivate the design choices for the new pixel detector and their impact on the tracking performance. With a special focus on the barrel detector, the production and qualification of pixel modules and the power system components will be discussed and final results will be presented. The results of system tests that were carried out with the DC-DC power system will be shown. The status of the mounting of components onto the support structures, the associated test procedures including results, and the status of the installation of the whole detector into CMS will be discussed.

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ATLAS Forward Proton detector – status and future plans

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In 2016 the ATLAS collaboration successfully installed a part of the ATLAS Forward Proton (AFP) detector to measure diffractive protons leaving under very small angles (hundreds of micro radians) the ATLAS proton-proton interaction point. The AFP aims to tag and measure forward protons scattered in single diffraction or hard central diffraction, where two protons are emitted and a central system is created. In addition, the AFP has a potential to measure two-photon exchange processes, and be sensitive to eventual anomalous quartic couplings of Vector Bosons: $\gamma\gamma W^+W^-$, $\gamma\gamma ZZ$, and $\gamma\gamma\gamma\gamma$. Such measurements at high luminosities will be possible only due the combination of high resolution tracking detectors and ultra-high precision time-of-flight (ToF) detectors at both sides of the ATLAS detector. In its first, current, phase the AFP detector consists of one arm with two semi-edgeless 3D Silicon pixel detectors, each placed in a horizontal Roman Pot. Both Pots are placed at one ATLAS side, 205 and 217 meters away from the ATLAS interaction point, very close (2-3 mm during data taking) to the LHC beams. The detector system construction, its installation in the LHC tunnel and commissioning (including full integration of the AFP into the ATLAS detector control system and trigger and data acquisition) will be presented together with the detector performance plots based on the data taking during the standard LHC running. The second phase of the AFP realization, planned to the beginning of 2017 and including the installation of the AFP second arm together with ToF Quartz-Cherenkov subdetectors (housed in both farther Roman Pots) will be described in the second part of the talk.

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Tracking Detector for Luminosity Measurement at PANDA

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The PANDA experiment will be part of the new FAIR accelerator center at Darmstadt, Germany. It is a fixed target experiment in the antiproton storage ring HESR. Main topics of the PANDA physics program are the search for new and predicted states and the precise measurement of the line shape by the energy scan method. Crucial for these measurements is the precise determination of the luminosity at each energy point for normalization of the data taken.
To determine the luminosity with a precision of better than 3 %, PANDA will implement a tracking device to reconstruct elastically scattered antiprotons near the non interacting antiproton beam. It will consist of four planes of thinned silicon sensors (HV-MAPS) for the reconstruction of the tracks. HV-MAPS (High Voltage Monolithic Active Pixel Sensor) is a pixel sensor combining frontend electronics with the actual sensitive material on one chip. To increase the signal speed and the radiation tolerance a reverse bias voltage of 60 V is applied. The whole detector system will be operated in vacuum in order to reduce the systematic uncertainty due to multiple scattering. In addition the setup has to have a very low material budget. Therefore the 50 μm thick sensors are glued on both sides of a 200 μm CVD diamond. These modules are clamped in a holding and cooling structure.
This presentation will discuss the technical design of the tracking detector for the luminosity measurement and its challenges like cooling, mechanical support structures, differential pumped vacuum system, and the sensors themselves. All topics are completed by existing prototype results.

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On the Development of Large Area Silicon Tracking Systems for the NICA/MPD, NICA/BM@N and FAIR/CBM experiments

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Status of the development of the large area fast Silicon Tracking Systems for experiments with stationary targets with the BM@N (NICA) and CBM(FAIR) setups are reviewed. A talk is concluded by a brief report on plans for building the Internal Tracking System for the NICA/MPD setup based on a novel MAPS technology.

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Status of the Mu3e detector

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Mu3e is an experiment searching for charged lepton flavor violation in the rare decay $\mu \rightarrow$ eee. Decay vertex position, decay time and particle momenta have to be precisely measured in order to reject both combinatorial and physics background. A silicon pixel tracker based on 50 μm thin high voltage monolithic active pixel sensors (HV-MAPS) in a 1T magnetic field will deliver precise vertex and momentum information. A scintillating fibre detector and a scintillating tile detector will provide sub ns time information. The status of the Mu3e detector will be presented, summarizing the development of HV-MAPS chips, the pixel detector modules and the timing detectors as well as the front-end electronics.

Tracking and vertex detectors / **147**

A new Scintillating Fibre Tracker for LHCb experiment

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The LHCb detector will be upgraded during the Long Shutdown 2 (LS2) of the LHC in order to cope with higher luminosities and to read out the data at 40MHz using a trigger-less read-out system. Several sub-detectors must be either redesigned or completely replaced to cope with higher occupancy. The current tracking detectors downstream of the LHCb dipole magnet will be replaced by the Scintillating Fibre (SciFi) Tracker. Concept, design and operational parameters are driven by the challenging LHC environment including significant ionizing and neutron radiation levels. Over a total active surface of 360 m2 the SciFi Tracker will use scintillating fibres (Ø 0.25 mm) read out by Silicon Photomultipliers (SiPMs). The SciFI tracker project is now at the transition from R&D to series production. We will present its design, the production technology, and the latest lab and test beam results.

Posters - Board: 59 / **151**

Cherenkov gamma-ray telescope of TAIGA experiment. Status of work

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The main characteristics of gamma-ray telescope IACT (Image Armospheric Cherenkov Telescope) are presented. IACT is one of main parts of the TAIGA experiment, located in Tunka valley, 50 km from Lake Baikal. The telescope will measure gamma-rays from point sources up to PeV energies and will work in conjunction with an array of wide-angle optical Cherenkov detectors HiSCORE, and the muon detectors. The hybrid installation, which consists of IACT, HiSCORE and other TAIGA detectots allows to enhance significantly the sensitivity and to extend the range of available for detection and study cosmic rays and gamma rays measured energies. Wherein it allows to keep a sufficiently high angular resolution. It is planned to build up to 16 telescopes

IACT. Working in complex, an array of three species of detectors can fix all stages of formation and the development of Extensive Air Showers with high accuracy.

Posters - Board: 58 / **150**

Developing of muon system for TAIGA experiment

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One of experimental methods of astrophysics at energies from 10 TeV and higher is the registration of extensive air showers (EAS). Herewith, one of the main objectives, appearing during EAS registration, is primary particle identification. EAS, produced by proton or nucleus, content 30-50 times more muons than EAS, produced by gamma-quanta with the same energy. This way, muon component of shower registration can give extra information about primary particle. Muon registration is performed by scintillation detectors. Within the TAIGA experiment (Tunka Advanced Instrument for cosmic-ray physics and Gamma Astronomy), it is suggested to construct the EAS's muon component registration system on the area of about 5 sq.km. Muon system must include two layers of detectors, which will be placed on a surface and underground for separation of the muon component of a shower. The total detection area must cover more than 0.1% of the total area of the observatory. That means that one of the main requirements to the developed detector is a low cost. The design of a scintillation counter with wavelength shifters was developed. The use of wavelength shifters for collection of a scintillation light allows using of PMT's with small photocathode diameter, that decreases counter's price. For technology verification, counter prototype with scintillator area of 0.25 sq.m., was created. Prototype was successfully tested with nature muon background, what proved applicability of chosen design. At present, assembly of a counter with scintillator area of 1 sq.m, placed in sealed container made from stainless steel, is in progress.

Posters - Board: 44 / **153**

Recent progress in oxide scintillation crystals development by low-thermal gradient Chozchralski technique for particle experiments

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Modern experiments in high energy, astroparticle and astrophysics experiments call for high performance scintillation detectors with unique properties: radiation-resistant in high energy physics and astrophysics, highly radiopure, containing certain elements or enriched isotopes in astroparticle physics applications. The low-thermal gradient Chozchralski (LTG CZ) crystal growth technique provide excellent quality large volume crystal scintillators thanks to absence of thermoelastic stress in the crystal and overheating of the melt. The features are particularly significant in production of crystalline materials with strong thermal anisotropy properties and low mechanical strength. Another advantage of the LTG CZ method is a much lower level

of the melt evaporation. It allows to improve the melt stoichiometry and minimize losses of the charge, crucially important in production of crystal scintillators from enriched isotopes. The LTG CZ is especially efficient in large volume scintillators production. Radiation-resistant high optical properties bismuth germanate crystals with mass up to 75 kg were produced for high energy physics and astrophysical experiments. Production of high performance cadmium tungstate crystals with mass 20 kg is well established too. The LTG CZ technique looks an out-of-competition approach to produce crystal scintillators from enriched isotopes for double beta decay experiments. Excellent quality cadmium tungstate crystal scintillators from enriched 106Cd and 116Cd with a yield of crystal boule up to 85% of initial charge, and very low irrecoverable losses less than 1%, were obtained. Similar specifications were also achieved in R&D of zinc and lithium molybdenum crystals from enriched 100Mo for cryogenic double beta experiments. It should be stressed that the LTG CZ method opens a possibility to obtain deeply radiopure crystal scintillators by using double crystallization with reasonable amount of starting material thanks to the very large yield of crystalline boules. An R&D is in progress to produce highly radiopure zinc tungstate crystal scintillators for the ADAMO dark matter project aiming at search for the directionality of Dark Matter candidate particles. R&D of large volume sodium molybdate (Na2Mo2O7), calcium molybdate (CaMoO4), and lead molybdate (PbMoO4) for double beta decay experiments will be reported too.

Posters - Board: 11 / **56**

Numerical simulation of fast photo detectors based on microchannel plates

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Description of mathematical models for fast photo detectors based on microchannel plates (MCP) in three-dimensional formulation is given. The models include calculations of photoelectron collection efficiency in the gap photo cathode - MCP, gain factor of secondary electron cascades in the channels, the particle scattering in the gaps between the plates, taking into account the edge fields and strong external magnetic fields. For end-to-end modeling through microchannel amplifier the original algorithms and the code "MCS3D" (Monte-Carlo Simulator) were developed, which allow to calculate the gain and the parameters of spatial and temporal resolution of the device.

Posters - Board: 21 / **155**

Application of the Cluster Counting and Timing techniques to improve the performance of the high transparency Drift Chambers for modern High Energy Physics experiments

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The ultra-low mass and high granularity Drift Chambers can fulfill the requirements of tracking systems for modern High Energy Physics experiments, like the experiments for the search of extremely rare processes (as MEG-II) and the experiments at the future high intensity accelerators (as FCC). For the firsts a high resolutions (order of 50-200 keV/c) for particle momenta in the range of 50-300 MeV/c, which is totally dominated by multiple scattering contributions, is required; for the seconds to the ability of reaching the expected resolution and rate performances the use of the Cluster Counting and Timing technique can add a valuable PID performance impossible to reach with the dE/dx technique. We present how, in Helium based gas mixtures, by counting and measuring the arrival times of each individual ionization cluster and by using statistical tools it is possible to have a bias free estimate of the impact parameter and a better PID discrimination. Since typical time separations between consecutive ionization acts range from a few ns, at small impact parameters, to a few tens of ns, at large impact parameters, in order to efficiently applying the cluster timing technique, it is necessary to have read-out interfaces capable of processing high speed signals, in which one can easily isolate pulses due to different ionization clusters. We present a full front-end chain, needed to apply the Cluster Counting/Timing technique, able to manage the low signals (˜few mV) at a high bandwidth (˜1 GHz) coming form the drift chamber cells. In particular we developed a digitization board, based on a 12bit FADC and on a Virtex-6 FPGA, able to efficiently digitize the signals and to perform an on-line processing. We wrote, and implemented in the FPGA, a fast algorithm able to efficiently extract the cluster information in an on-line processing otherwise it couldn't be possible to use the Cluster Counting/Timing technique on a large detector. We show the firsts results obtained on the application of the techniques on small prototypes.

Posters - Board: 54 / **66**

Development of scintillator detector for detection of cosmic ray shower

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We are building an array of active detectors to detect cosmic ray air showers at an altitude of about 2200 meter above sea level in the Himalayas. Each of the elements of this array is a 1m x 1m plastic scintillator coupled with WLS and photomultiplier tube. These scintillators are fabricated indigenously in Cosmic Ray Laboratory (CRL), Tata Institute of Fundamental Research (TIFR), Ooty, India.
All 1m x 1m scintillators are made of four 0.5m x 0.5m blocks. All four scintillator blocks are connected to a single photomultiplier tube (PMT) by using wavelength shifting (WLS) optical fiber. The PMT is mechanically fixed and connected to the base circuit. The negative high voltage (HV) to the PMTs is applied using MHV cable and the signal is collected by BNC cable. Initially all the PMTs are calibrated and their individual efficiencies are measured using other scintillator blocks of same kind.
Three such scintillator detectors are completed and tested. To detect the cosmic ray shower (as a preliminary test) three scintillator detectors are placed on a horizontal plane. The centers of the scintillator detector made a triangle of sides 1.9 m, 3 m and 3.5 m respectively. The three-fold coincidence from this horizontal stack of three detectors, which mimics a cosmic ray shower, is measured for about 1 month period. It is found that the shower rate reaching the detector varies with time between ˜ 0.25-0.35 Hz.

Posters - Board: 72 / **159**

The 32-channel TDC based on Altera Cyclone III FPGA.

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The number of read-out channels in modern experiments can reach very high values. This requires the use of electronics at a low cost per channel. Such result could be achieved through the use of widely available commercial electronic components. In this work we present newly developed TDC (Time-to-Digital Converter) block in the VME-32 standard. The 32-channel block is based on a single FPGA Altera Cyclone III chip. The block captures the events – rising and falling edges of input signal at a sample rate of 840 MHz. Maximum event rate is 210 MHz, until FIFO buffer for 512 events is not overflowed. Data from channel FIFO buffer is going to the shift register and then stored in shared memory, where it can be read on the VME bus. Main parameters of the TDC are: Resolution: 1.19 ns (1/840 MHz) Minimum time interval: 4.76 ns (1/210 MHz, 4 samples) Maximal time interval: 3440 ns (12 bit) It is supposed to use such TDCs in the developed Focusing Aerogel RICH for Super Charm-Tau Factory (BINP, Novosibirsk) and muon detectors read-out of TAIGA gamma-observatory (Tunka valley, Buryatia, Russia).

Posters - Board: 34 / **51**

Hadron calorimeters for the experiment of tensor-polarized deuteron photodisintegration at the VEPP-3 storage ring.

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Tensor analysing power T20 of the two-body deuteron photodisintegration reaction will be measured in an unexplored region of the photon energy upto 1.5 GeV. The particle detector will be comprised of two identical arms placed symmetrically with respect to the storage ring median plane for detecting of the proton-neutron pairs in coincidence. The main role of two hadron calorimeters, as the important elements of the partical detector, is to provide high detection efficiency of the neutrons and determination of their trackers positions. Description of calorimeters and their construction status will be presented.

Posters - Board: 17 / **98**

Development of a silicon micro-strip detector with single photon sensitivity for fast dynamic diffraction experiments at a synchrotron radiation beam.

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Time resolved experiments on the diffraction of synchrotron radiation (SR) from crystalline materials give information on the evolution of a material structure after a heat, electron beam or plasma interaction with the material. Changes in the material structure happen within a microsecond scale and a detector with corresponding parameters is needed. SR channel 8 of the VEPP-4M storage ring provides radiation from the 7-pole wiggler that allows to get up to several tens photons within 1 μs from a W crystal for the most intensive diffraction peak. In order to perform experiments that allow to measure the evolution of W crystalline structure under the impact of powerful laser beam, a new detector is developed, that can provide information about the distribution of scattered SR flux in space and its evolution in time at a microsecond scale. The detector based on the silicon p-on-n micro-strip sensor with DC metal strips. The sensor contains 1024 30 mm long strips with 50 micron pitch. 64 strips are bonded to the front-end electronics based on APC128 ASICs. The APC128 ASIC contains 128 channels that consist of low noise integrator with 32 analogue memory cells. The integrator equivalent noise charge is about 2000 electrons and thus the signal from individual photons with energy above 40 keV can be observed. The analogue memory can be readout with 10 MHz rate. The first measurements with the beam scattered from W crystal with energy near 60 keV demonstrated the capability of

this prototype to observe spatial distribution of the photon flux with the intensity from below one photon per channel up to ~100 photons per channel with frame rate from 1 MHz up to 10 kHz. The future development of full-size detector will be discussed in the presentation.

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Proposal for VEPP-4M beam energy measurement using magnetic spectrometer with Compton calibration and photon detector

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A method for circular e^-/e^+ accelerator beam energy measurement is proposed. Coordinate of an electron (or positron) in a focussing magnetic spectrometer built in a circular accelerator depends on its energy E, spectrometer parameters A, B, and circulating beam energy E_0: $X = AE_0/E+B$. To define parameter A, Compton backscattering with two wavelengths can be applied, which produces two scattered electron energies strictly coupled with the beam energy. Parameter B is defined using coordinate detector for Compton backscattered photons. This detector should be calibrated in the coordinate frame of the spectrometer electron detector using precisely measured beam energy or precision geometry measurements. Thus, the beam energy can be defined with expected uncertainty better than 10^{-4}. Built-in focussing magnetic spectrometer is an essential part of VEPP-4M collider, it is intended for two-photon processes study at KEDR detector. It has Compton calibration system with two lasers. Also photons scattered from interaction point can be registered by coordinate detector. Thus, the the technique proposed could be implemented here with minimum efforts, test of the technique is planned with the present equipment. To measure VEPP-4M beam energy in whole energy range 1.5-5.0 GeV (which is essential for future precision experiments at KEDR detector in Υ mesons energy range) the installation needs an extra equipment and optimisation, they are also planned after the test.

Posters - Board: 56 / **114**

Testing methods for 20-inches PMTs of the JUNO experiment

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The 20kt Liquid Scintillator (LS) JUNO detector is under construction by the International Collaboration in China with the primary goal to address the question of neutrino mass ordering (hierarchy). The main JUNO challenge is to achieve a record energy resolution, ~3% at 1MeV of energy released in the LS, which is required to perform the neutrino mass hierarchy determination. About 20'000 large 20" PMTs with high Photon Detection Efficiency (PDE) and good photocathode uniformity ensure about 80% surface coverage of JUNO detector. The JUNO collaboration is preparing equipment for the mass tests of all PMTs using 4 dedicated containers. Each container consists of 36 drawers. Each drawer will test a single PMT. This approach allows us to test 144 PMTs in parallel. The basic measurement in the container will be the PMT response during illumination of its photocathode by the uniform light of a small intensity. All of the 20000 PMTs will undergo the container test. For sampled tests of PMTs also a dedicated scanning system was constructed that allows us to study a variation of the PDE over the whole PMT photocathode surface. Recently a sophisticated laboratory for the PMT testing was built. It has a dark room where the scanning station is housed. The core of the scanning station is a rotating frame with 6 LED sources of calibrated short light flashes that are placed along the photocathode surface covering zenith angles from the top of a PMT to its equator. It allows testing of individual PMTs in all relevant aspects by scanning the photocathode and identifying any potential problem. The

collection efficiency of a large PMT is known to be very sensitive to the Earth Magnetic Field (EMF), therefore, understanding the necessary level of EMF suppression is crucial for the JUNO Experiment. A dark room with Helmholtz coils compensating the EMF components is available for these tests as a JUNO facility. Hamamatsu R12860 20" PMT is a candidate for the JUNO experiment. In this talk the container design and mass-testing method, the scanning setup and scanning method are described and preliminary results for performance test of this PMT are reported.

Posters - Board: 29 / **116**

First using of the particle identification system based on dense aerogel in data analysis of the e+e- -> K+K- process

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The threshold Čerenkov counter based on dense aerogel with refraction index n =1.13 is described. This counter is used for π/K separation at SND detector at VEPP-2000 e^+e^- collider in the particle energy range up to 1 GeV. The results on separation efficiency for hadrons produced in e^+e^- annihilation are presented. New results on the $e^+e^- \to K^+K^-$ process cross section has been obtained in the energy range $1.05 \div 2.0$ GeV with using the Čerenkov counters. The cross section value was found to be consistent with previous measurements.

Posters - Board: 20 / **137**

First results from the ATLAS-GaAsPix radiation monitoring system

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The ATLAS-GaAsPix system is a network of GaAs:Cr-based Timepix pixel detectors installed in various points of the ATLAS detector in the framework of the collaboration between JINR, IEAP CTU, CERN and Tomsk State University. The ATLAS-GaAsPix project provides installation of 10 Timepix detectors (5 singles, 5 twins) with GaAs:Cr sensors nearby Timepix detectors of the ATLAS-TPX system. First three detectors of the system were installed during YETS 2015-2016 and have successfully functioned during the LHC operation in 2016.
In this work we present the first results obtained with ATLAS-GaAsPix detectors including the estimation of radiation fluxes in the ATLAS cavern for different particles. This is made possible by the use of developed procedure of the particle identification based on the shape of the particle track and deposited energy. Experimental results are consistent with numerical simulations.

Posters - Board: 12 / **65**

Z - chamber of the CMD-3 detector in the reconstruction of the track longitudinal coordinate

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Since 2010 the CMD-3 detector has been collecting data at the e+e- collider VEPP-2000 in the Budker Institute of Nuclear Physics. One of the main goals of experiments with CMD-3 detector is the precise measurement of the cross sections of the e+e- anihilation into hadrons. One of the main source of systematic uncertainty is determination of polar angles of tracks. Z-chamber is

used for the reconstruction of the tracks longitudinal coordinate with low systematic uncertainty. The measurement of longitudinal coordinates is performed by the collecting of the charge which is induced on the strip cathodes. The algorithms of the reconstruction of cathodes clusters and calibration procedure are presented. The estimation of systematic errors is discussed too.

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TUNKA-GRANDE experiment

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The Tunka- Grande array is a part of a single experimental complex TAIGA, which is located in the Tunka Valley (Republic of Buryatia, Russia) about 50 km from Lake Baikal. The purpose of this complex is the study of cosmic rays and gamma-ray of ultra-high energies by detecting extensive air showers. The Tunka-Grande array consists of 380 scintillation detectors distributed over 1 km^2 area. A description of the Tunka-Grande array is provided. The first results of the operation is presented. The prospects of studying the primary cosmic rays in the energy range 10 -1000 PeV during simultaneous registration of the radio emission, Cherenkov and charged particle components of extensive air showers are discussed.

Posters - Board: 19 / **129**

Optimizing The Performance of V0+ Detector of the Fast Interaction Trigger (FIT) for the Upgrade of the ALICE Detector

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The ALICE Collaboration is preparing a major detector upgrade for the second LHC shutdown (2019-2020). The LHC luminosity and collision rate from 2021 onwards will considerably exceed the design parameters of the present ALICE forward trigger detectors. Furthermore, the introduction of a new Muon Forward Tracker will significantly reduce the space available for the upgraded trigger detectors. To comply with these conditions a Fast Interaction Trigger (FIT) has been designed. The FIT will be the primary forward trigger and will provide minimum bias trigger, multiplicity trigger, centrality, beam-gas event rejection, collision time for the Time of Flight detector (TOF), offline multiplicity and event plane determination. The FIT detector comprises of two subdetector systems, T0+ and V0+. The T0+ consists of two arrays of quartz radiators coupled to MCP-PMT sensors facing the interaction point. The V0+ detector is composed of a

disk of plastic scintillator segments, optical fiber bundles, and photosensors. In this contribution, we will focus on the V0+ detector. The V0+ detector requires high efficiency, high dynamic range (1 – 500) particles, radiation hardness and must be compatible with 25 ns bunch spacing and ~ 1-2 MHz interaction rate for pp collisions of the new LHC operation while keeping the time resolution of about 200 ps for a single particle. In order to fulfill these technical challenges, a rigorous R&D work is ongoing. In this talk, we will present the latest status of the R&D, an optimization of scintillator material, the choice of photosensors (SiPM, Finemesh PMT, and MCP-PMT), the design of the optical fiber bundles and the readout electronics as well as an outlook.

Posters - Board: 15 / **82**

Characterization of GaAs:Cr Timepix hybrid pixel detectors

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High resistivity gallium arsenide compensated by chromium fabricated by Tomsk State University has demonstrated a good suitability as sensor material for hybrid pixel detectors used in X-ray imaging systems with photon energies up to 60 keV. The material is available with thickness up to 1 mm and thanks to its Z number and fully active volume of the sensor high absorption efficiency in this energy region is provided.
In this work we report the recent results of characterization of the Timepix detectors hybridized with GaAs:Cr sensors of various thickness using synchrotron radiation and gamma sources. The energy and spatial resolution, mu-tau distribution over sensor area have been determined. By means of scanning the detector with pencil photon beam generated by synchrotron facility the geometrical mapping of pixel sensitivity is obtained as well as the energy resolution of a single pixel. The long-term stability of the detector has been evaluated based on the measurements performed over one year. Also the radiation hardness of GaAs:Cr sensors was investigated by means of irradiation with 20 MeV electrons and the results will be presented in comparison with Si sensors.

Posters - Board: 38 / **83**

The Crystal Zero Degree Detector at BESIII

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The BESIII experiment at the BEPCII electron positron collider at IHEP (Beijing) is collecting data in the charm-τ mass region. Electron positron collisions are a very well suited environment for the study of initial state radiation (ISR). However, the photons from ISR are strongly peaked towards small polar angles and are currently detected with limited efficiency.
In order to increase the detection efficiency of ISR photons, we are developing small-size calorimeters to be placed in the very forward and backward regions. Each detector will consist of two 4×3 arrays of $1 \times 1 \times 14\,cm^3$ LYSO crystals. A $1\,cm$ gap separating each of the two arrays will reduce the contamination from background at very low angles. The scintillation light will be collected by silicon photomultipliers (SiPMs). The expected event rate in the MHz range requires flash ADCs recording the preamplified SiPM outputs.The digitized waveforms will be analyzed in realtime yielding data reduction and pile-up detection. This high bandwidth data stream will be transmitted via optical fibers to FPGA-based hardware performing sub-event building, buffering, and event correlation with the BESIII trigger. The sub-events with a corresponding trigger will be sent to the BESIII event builder via TCP/IP.
The performance of the detectors and the impact of the beam pipe material in front of the detectors are currently studied in Geant4-based simulations. A single crystal equipped with a

SiPM was instrumented as a prototype detector. Tests with sources and in electron beam at the MAMI facility were performed successfully.

Posters - Board: 42 / **139**

Radiation damage in silicon photomultipliers exposed to neutron radiation

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We report on the measurement of the radiation hardness of newly developed silicon photomultipliers (SiPMs) manufactured by Hamamatsu Corporation (Japan). The SiPMs were irradiated with neutrons up to 1 MeV equivalent fluence of $2 * 10^{12} n/cm^2$ at TRIGA Marc II research reactor in Ljubljana. The SiPM's main parameters were measured before and after irradiation. The effects of the radiation on many parameters such as gain, intrinsic dark current, photon detection efficiency and noise for these devices are shown and discussed.

Posters - Board: 4 / **53**

Novel Fast Response and Radiation-resistant Scintillator Detector for Beam Loss Monitor

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At high luminosity era, beam loss monitor with fast response and good radiation resistance is crucial for smooth and safe operation of collider. Due to high intensity of the beam, even a small amount of beam loss may cause cooling issue and serious damage to accelerator components and radiation sensitive equipment. The ultimate goal of a beam loss monitor system at a high intensity beam is to identify the loss level and, if possible, the loss location and time structure and to be able to protect the machine at uncontrolled loss (detect the uncontrolled loss as soon as possible and shut down the accelerator in microsecond level). This requires the beam loss monitor has fast response and excellent radiation resistance. The traditional ionization chamber, plastic (liquid) scintillator+PMT, PIN diodes etc has difficulties to satisfy all of the requirements.
In this talk, we will report the design and test results of a fast response and radiation-resistant scintillator detector as the beam loss monitor of high intensity beam at low energy part such as RFQ. The detector is consistent of a 2cm x 2cm x 0.5 cm LYSO crystal readout by a 0.6 cm x 0.6 cm Silicon photomultiplier (SiPM). LYSO features high light yield, short decay time, relative dense and very good radiation resistance (2 orders of magnate higher than plastic scintillator). And SiPM has many advantages compared to PMT. It is compact, economy, insensitive to magnetic field and has low working voltage, good charge resolution and broad spectra response. The detectors we constructed have been tested with various radioactive sources. The test results show that the detector has good sensitivity to photon at energy range of a few keV to tens of MeV and charged particles with good linearity and energy resolution (23% for 60 keV X-ray). Two detectors (one parallel to and the other perpendicular to the beam) are installed outside of the vacuum chamber shell of a 800 MeV electron storage ring and tested. The detail of the test and results will also be reported. Furthermore, the implication in the electromagnetic calorimeter based on fast response crystal and SiPM readout for the high intensity electron positron accelerator facility in China will be discussed.

Posters - Board: 60 / **171**

Antihydrogen experiments: addressing the challenges of ultra-low temperatures

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Antimatter experiments conducted at the Antiproton Decelerator (AD) at CERN address the fundamental questions why primordial antimatter is not observed in the present Universe. The weak equivalent principle (WEP) can be tested measuring the gravitational acceleration of antihydrogen atoms in the Earth's gravitational field that are horizontally emitted from a Penning trap. The antihydrogen atoms can be produced via resonant charge exchange of Rydberg positronium and antiprotons at temperatures potentially determined by the recoil limit of the constituents. To prepare an ensemble of cold antihydrogen with a narrow velocity spread we plan to extend the existing electron cooling mechanism of antiprotons by laser-cooling techniques of negative C2- molecules in a Penning trap in order to sympathetically cool antiprotons to the mK regime. The generation of cold antihydrogen atoms can ultimately also be used for precision spectroscopy experiments of electromagnetic interaction as a test of CPT symmetry. In this presentation the status of the experiment at CERN and the feasibility of sympathetic cooling of antiprotons using photo-detachment and AC Stark Sisyphus cooling of C2- will be reviewed.

Posters - Board: 3 / **24**

Measurement of the luminosity at the CMD-3 detector.

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Since December 2010 the CMD-3 detector has taken data at the electron-positron collider VEPP-2000. The collected data sample corresponds to an integrated luminosity of 60 1/pb in the c.m. energy range from 0.32 up to 2 GeV. Preise luminosity measurement is a key issue for many experiments whih study the hadronic cross sections at e+e− colliders. The integrated luminosity of the collider was measured using two well known QED processes e+e−→e+e−, $\gamma\gamma$. The preliminary results of the luminosity measurement are presented in the various energy range. The current accuracy of the luminosity determination is estimated to be 1%. The study of the different systematics is in progress now and in forthcoming future we hope to reduce it to the level of ˜0.5%.

Posters - Board: 47 / **25**

The array of scintillation detectors with natural boron for EAS neutrons investigations

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In MEPhI, the URAN array, consisting of detectors based on scintillator with natural boron, to study neutron EAS has been created. The array consists of 72 en-detectors, in which the recording material is an inorganic scintillator which represents a silicon plate with an alloy granules of mixture of scintillator ZnS (Ag) and B2O3. Thermal neutrons are recorded due to the isotope 10B (main reaction 10B + n → 7Li + α + 2.792 MeV) whose content in natural boron is about

20%. The area of each detector is 0.36 sq. m. Detectors are located on two roofs of the laboratory buildings and are combined into cluster structures of 12 detectors. The URAN setup is aimed at studying of primary cosmic rays in the "knee" region by means of the detection of neutrons produced as a result of interactions of EAS particles with nuclei of atmosphere or matter near the installation. The structure and the main elements of the installation are describes and the first recorded events are demonstrates.

Posters - Board: 48 / **26**

The detector on the basis of drift chambers for inclined muon bundle investigations

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The large-scale coordinate-tracking detector TREK for registration of inclined EAS is being developed in MEPhI. The use of large drift chambers (4000x508x112 mm^3) developed in IHEP for experiments at the neutrino channel of U-70 accelerator will allow to create a unique large-scale detector of 270 m^2 area for registration of multi-particle events at large zenith angles generated by ultrahigh-energy cosmic ray particles. The key advantages of these chambers are a large effective area (1.85 m^2), a good coordinate and angular resolution with a small number of measuring channels. Detector will be operated as a part of the experimental complex NEVOD, in particular, jointly with Cherenkov water detector (CWD) with volume of 2000 m^2 and coordinate detector DECOR. The first part of the detector named Coordinate-Tracking Unit based on the Drift Chambers (CTUDC) representing two coordinate planes of 8 drift chambers in each has been developed and mounted on the opposite sides of the CWD. It has the same principle of joint operation with NEVOD-DECOR triggering system so the main features of the TREK detector will be examined. Results of an examination of drift chambers and their electronics with new test benches, a calibration of the CTUDC and the first results of its joint operation with NEVOD-DECOR complex are presented.

Posters - Board: 46 / **21**

Study of proportional electroluminescence in two-phase argon

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This work was performed in the course of the development of a two-phase Cryogenic Avalanche Detector (CRAD) in Ar for dark matter search and low energy neutrino experiments. The detector included EL gap located directly above the liquid-gas interface, which was optically read out using cryogenic PMTs located on the perimeter of the gap and matrix of Geiger-mode APD (GAPD). The results of the measurements of detector sensitivity to X-ray-induced signals and EL gap yield are presented.

Posters - Board: 33 / **46**

The Mu2e crystal calorimeter

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The Mu2e experiment aims to measure the charged-lepton flavour violating (CLFV) neutrino-less conversion of a negative muon into an electron in the field of a nucleus. The conversion process results in a monochromatic electron with an energy slightly below the muon rest mass (104.97 MeV). Goal of the experiment is to improve of four orders of magnitude the previous measurement with similar technique and reach a single event sensitivity of 2.5 x 10^{-17} on the conversion rate with respect to the muon capture rate.
Although the SM is very well tested in many regimes, it appears likely to be incomplete. In many of the Beyond the Standard Model (BSM) scenarios, rates for CLFV processes are within the reach of the next generation of experiments. In particular, if SUSY particles have masses and couplings within the discovery reach of the LHC, CLFV rates will be observable. On the contrary, many CLFV searches have a sensitivity to new physics that exceeds the LHC reach bringing the reach of new mass scale up to 10^4 TeV. In this contest indirected measurements of CLFV will be crucial evidence of new physics. Complementarity of Mu2e and MEG upgrade is relevant in this respect.
The experiment goal is obtained with a very intense (20 GHz) pulsed negative muon beam sent to an Aluminium target for a total number of 10^{18} stopped muons in three years of running. Production and transport of the muons is done with a complicated and sophisticated magnetic systems composed by a production, a transport and a detector solenoid. The magnetic systems allows to bring this very intense beam to target with a low request on power. Description and status of the magnetic system will be reported.
The improvement with respect to previous conversion experiments is based on four elements: the muon intensity, the beam structure layout, the extinction of out of time particles and the precise electron identification in the detector solenoid. The conversion electron will be reconstructed and separated by the Decay in Orbit (DIO) background by a very high resolution (120 keV) tracking system based on straw technology. The crystal calorimeter system will confirm that the candidates are indeed electrons by performing a powerful mu/e rejection while granting a tracking independent HLT filter. A Cosmic Ray Veto system surrounds the detector solenoid and contributes to make the cosmic based background negligible.
The Mu2e experiment is under design and construction at the Muon Campus of Fermilab and has obtained CD-3 approval in July 2016. In the current schedule, the experiment start is foreseen for the end of 2019 with 3 years of running from 2020 to 2022. A second phase with a x 10 improvement on muon intensity is being discussed and could start after 2025 at the completion of the PIP-2 machine.

Posters - Board: 39 / **106**

Prototype of vacuum phototriode for SND detector

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The design of prototype of vacuum phototriodes for SND detector is presented. Diameter of devise is 52 mm. The meshes pitch of 100 μm are used as anode. Multialkali or bialkali photocathodes of photodetectors will be adapted for NaI (Tl) crystals. It is supposed to increase the lifetime of the phototriodes for this dimensions.

Posters - Board: 64 / **42**

The first results of the processing module prototype of the Liquid Xenon Calorimeter's for timing measurements

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One of the goals of the Cryogenic Magnetic Detector at Budker Institute of Nuclear Physics SB RAS (Novosibirsk, Russia) is a study of hadron production in electron-positron collisions near threshold. The neutron-antineutron pair production events can be detected only by the calorimeters. In the barrel calorimeter the antineutron annihilation typically occurs about 5 ns or later after the beams crossing. For identification of such events it is necessary to measure the time of flight of particles to the LXe-calorimeter with an accuracy of about a few nanoseconds. The LXe-calorimeter consists of 14 layers of ionization chambers with two readout: anode and cathode. The duration of charge collection to the anodes is about 4.5 μs, while the required accuracy of measuring of the signal arrival time is less than 1/1000 of that (i.e. 4.5 ns). Besides, the signals' shapes differ substantially from event to event, so the signal arrival time is measured in two stages. In the paper we describ the development of the special electronics which performs waveform digitization and the on-line measurement of signals' arrival times and amplitudes and results of the first tests on the detectors.

Posters - Board: 63 / **40**

Development of high resolution GEM-based detector for the extracted electron beam facility at the VEPP-4M collider.

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Budker Institute of Nuclear Physics has a special installation for generation of extracted beams of electrons and photons in a wide range of energies at the VEPP-4M collider. This facility requires high resolution low-mass coordinate detectors to precisely determine particles trajectories.
The specialized detectors with high spatial resolution and low material content were developed and during 2016 the first detector was manufactured (GEMs, flexible readout structures and electronics PCBs made at CERN Workshop, assembly finalized at the BINP).
The detector consists of three cascades of gaseous electron multiplier (GEM), the X-Y readout structure and detector electronics. Electronics is based on the APC128 ASIC (analog pipeline chip, 128 channels), six of these chips are used covering 768 channels in total. These channels are connected to the readout structure, which has two layers: 512 vertical strips and 256 horizontal strips, both directions have 0.25 mm pitch of the readout strips. Other key features are the following:

- sensitive area 128x64 mm with expected resolution better than 50 um,
- Altera Cyclone III FPGA with 40K logic elements and 1.16Mbit of internal RAM,
- 1GBit and separate 100MBit ethernet for data transfer and detector management,
- internal 4kV high voltage source.

The latest results obtained will be reported at the conference.

Posters - Board: 65 / **68**

New method for determining avalanche breakdown voltage of silicon photomultipliers

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The avalanche breakdown and Geiger mode of the silicon p-n junction is considered. A precise method is proposed for determining the avalanche breakdown voltage of silicon photomultipliers (Si PM). The method is based on measuring the dependence of the photon detection efficiency on the bias voltage when one type of carriers (electron or hole) is injected into the depleted region of the p-n junction. The injection of electrons or holes from the base region of the Si PM semiconductor structure is performed using short-wave or long-wave light. At low overvoltage detection efficiency is linearly dependent on the overvoltage, and extrapolation to zero values determines the Si PM avalanche breakdown voltage.

Posters - Board: 25 / **10**

Separation of e+e- to e+e- and e+e- to pi+pi- events based on the difference in the energy deposition profiles in SND detector calorimeter.

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The technique of discrimination of the $e^+e^- \to e^+e^-$ and $e^+e^- \to \pi^+\pi^-$ events in energy range $0.5 < \sqrt{s} < 1$ GeV based on the difference in the energy deposition in calorimeter of SND detector was developed by applying machine learning method. In particular the following parameters are used: ${}^0E_j$ is the energy deposition in jth layer of the tower with the maximal energy deposition, ${}^1E_j$ is the sum of energy depositions in jth layer of eight towers that surround the tower with the maximal energy deposition, ${}^2E_j$ is the sum of energy depositions in jth layer of the other towers of the cluster ($j = 1, 2, 3$).Identification efficiency for $e^+e^- \to e^+e^-$ and $e^+e^- \to \pi^+\pi^-$ events is estimated to be in the range from 99.3 to 99.8 %. Contribution of the identification efficiencies errors to the total error of $e^+e^- \to \pi^+\pi^-$ cross section is less than 0.2% for the most energy points.

Posters - Board: 37 / **75**

The geometric alignment of the CMD-3 endcap electromagnetic calorimeter using events of two-quantum annihilation

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Since 2010 the electromagnetic endcap calorimeter based on BGO crystals is taking part in experiments as one of the system of CMD-3 detector. The spacial resolution is one of crucial parameters of the calorimeter. The inaccurate knowledge of real calorimeter position can limit the resolution. In this work the alignment of the center of the calorimeter with respect to the tracking system of the CMD-3 detector has been performed using events of two-quantium annihilation. The alignment technique that has been used to determine the real position of the calorimeter is described. Finally, the improvement in spacial resolution of the calorimeter after application the correction on the real calorimeter position is shown.

Posters - Board: 31 / **144**

Simulation of the ASHIPH Cherenkov counters of the KEDR detector

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The particle identification system of the KEDR detector is based on aerogel threshold Cherenkov counters ASHIPH (Aerogel, SHifter, PHotomultiplier). The simulation program of the ASHIPH counters was developed based on the Geant3.21 package. The Geant3.21 description of the ASHIPH counters is integrated into the KEDR full detector simulation. The simulation of the ASHIPH system includes a realistic geometry description of all 160 counters (three active media - aerogel, shifter, teflon; electronics boxes and HV outputs). For all counters a realistic refractive index of materials was used. The measured inhomogeneities of the light collection in aerogel was taken into account for calculating the number of photo-electrons from the particles. The digitized amplitudes from calibrated single-photo-electron spectrum and Poisson distribution are generated. The amplitude spectra obtained in the simulation are in a agreement with experimental data.

Posters - Board: 43 / **141**

New empirical expression for APD gain versus voltage dependence

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We propose new empirical formula describing gain vs. voltage dependence for thick p-n junction avalanche photodiodes (APDs). Good agreement between this formula and real gain on the voltage dependence was found for several APDs used in HEP and medical applications.

Posters - Board: 13 / **77**

GEM tracking system of the BM@N experiment

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BM@N experiment (Baryonic Matter at Nuclotron) is aimed to study core-core (up to "gold-gold") collisions in extreme conditions. High intensity of interactions and large multiplicity of charged

particles in each event cause special requirements to detectors: high spatial and time resolution, radiation loadings up to $10^6/cm^2$. As soon as triple GEM (Gas Electron Multipliers) posses all above-mentioned characteristics, they were chosen as the main track detector. Integration of GEM detectors into the experimental setup structure and study of their characteristics are the topics of the report.

Posters - Board: 27 / **76**

Microchannel plates phototubes in high magnetic field

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Microchannel plate photomultiplier tubes (MCP PMT) have good immunity to magnetic field and excellent time resolution. The influence of magnetic fields up to 4.5 T on the parameters of several MCP PMT designs was studied. PMTs with two, three and four MCPs were tested in magnetic fields. The tested samples have different diameters of MCP pores: 3.5, 6, 8 and 10 microns. Dependencies of the time resolution, the gain and the photoelectron collection efficiency on magnetic field are presented.

Posters - Board: 7 / **108**

Radiation Hardness tests with neutron flux on different Silicon photomultiplier devices

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Radiation hardness is an important requirement for solid state readout elements operating in high radiation environments common in particle physics experiments. The MEG II experiment at PSI, Switzerland, investigates the forbidden decay $\mu+ \to$ e+ γ. exploiting the most intense muon beam of the world. A significant flux of non-thermal neutrons (kinetic energy Ek $\geq$ 0.5 MeV) is present in the experimental hall produced along the beamline and in the hall itself. We present the effects of neutron fluences comparable to the MEG2 expected doses on several Silicon PhotoMulitipliers (SiPMs). The tested models are: AdvanSiD ASD-NUV3S-P (the same model used in MEG II), AdvanSiD ASD-RGB3S-P, Hamamtsu s12571-050P and Excelitas C30742-33-050-x. The neutron source is the thermal Sub-critical Multiplication complex (SM1) moderated with water, located at the Department of Chemistry University of Pavia (Italy). We report the change of SiPMs most important electric parameters: dark current, dark pulse frequency, gain, direct bias resistance, as a function of the integrated neutron fluence.

Posters - Board: 36 / **72**

ATLAS jet and missing energy reconstruction, calibration and performance in LHC Run-2

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The performance of the reconstruction and calibration of the jet energy scale and missing transverse energy scale with the ATLAS detector at the LHC is a key component to realize the ATLAS

full physics potential, both in the searches for new physics and in precision measurements. New algorithms used for the reconstruction and calibration of jets and missing energy with the ATLAS detector during LHC run 2 are presented. Measurements of the performance and uncertainties are derived from data. The results from the 2016 pp collision data set at $\sqrt{s}$=13 TeV are reported.

Posters - Board: 6 / **71**

Calibration of the KEDR detector Tagging System with two-photon lepton pair production

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Two-photon events $e^+e^- \to e^+e^- + l^+l^-$ selected with the central part of KEDR detector were used for Tagging System energy calibration check and for single- and double-tag efficiency determination.

Posters - Board: 35 / **70**

Radiation hardness study of CsI(Tl) scintillation crystals for the Belle II calorimeter

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The electromagnetic calorimeter of the Belle II detector contains CsI(Tl) crystals of 30 cm length which have been used at the Belle experiment. We measure the light output degradation of CsI(Tl) crystals exposed to uniformly distributed absorbed dose. Four Belle typical crystals with known scintillation characteristics are irradiated with photons at a total dose of about 35 krad. Results show acceptable radiation hardness for the Belle II experiment conditions where the accumulated dose in crystals could reach 10 krad.

Posters - Board: 57 / **128**

CaloCube: a highly segmented calorimeter for space based observation of high energy cosmic rays.

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Future research in High Energy Cosmic Ray Physics concerns fundamental questions on their origin, acceleration mechanism,and composition.Unambiguous measurements of the energy spectra and of composition of cosmic rays at the "knee" region are expected to answer the above questions. Ground based experiments have systematic limitations to the precision of the measurement and thus they must be complemented by space-based experiemtns. A calorimeter based space experiment can provide not only flux measurements but also energy thus overcoming some of the limitations of the ground based experiments. Large acceptance is required, but this contrasts with the limitations in weight and size of space based experiments. A novel idea in calorimetry is discussed here which addresses these issues compatibly with the constraints. Simulation and beam test results with prototypes are reported.

Posters - Board: 66 / **90**

The low energy beam profile monitor for the muon g-2/EDM experiment at J-PARC

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The muon g-2/EDM experiment at J-PARC aims to measure the muon's anomalous magnetic moment and electric dipole moment with high precision by utilizing an ultra-cold muon beam. Current muon g-2 discrepancy between Standard Model prediction and average experimental value is about 3 standard deviation. This experiment requires a development of the muon LINAC to accelerate thermal muons to 300 MeV/c momentum. Along with this, beam diagnostic detectors play a key role. The beam profile monitoring system is designed to measure the profile of the low energy muon beam. It was tested during two beam tests in 2016 at MLF D2 line at J-PARC. The detector was used with positive muons, Mu-, p and H-, e- and UV light. The system overview and preliminary results are given. Special attention is paid to the beam profile monitor spatial resolution and online monitor software used during data taking.

Posters - Board: 67 / **100**

A 64-channel integrated circuit for signal readout from coordinate detectors.

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A specialized integrated circuit is developed for the readout of signal from coordinate detectors of different types, including gas micro-pattern detectors and silicon micro-strip detectors. The ASIC includes 64 channels, each of those containing low-noise charge sensitive amplifier with connectable feedback capacitor and/or resistor and fast reset of the feedback capacitor. Each channel of the ASIC contains also 100 cells of the analogue memory that can be readout with 10 MHz rate through the analogue multiplexer. The pitch of input pads is 50 μm and the chip size is 5x5 mm^2. Equivalent noise charge of the ASIC channel is about 2000 electrons with 10 pF capacitance at the input and maximal signal before saturation corresponds to 2x10^6 electrons. The first application for this ASIC is the detector for imaging if explosions at a synchrotron radiation beam (DIMEX), where it have to substitute old and slower APC128 ASIC. The full size electronics including 8 chips for 512 channels was assembled and tested. The results of the tests with SR beam will be shown in the presentation.

Posters - Board: 45 / **160**

The Fermilab Muon g-2 experiment: laser calibration system

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The anomalous muon dipole magnetic moment can be measured (and calculated) with great precision thus providing insight on the Standard Model and new physics. Currently an experiment is under construction at Fermilab (USA) which is expected to measure the anomalous muon dipole magnetic moment with unprecedented precision. One of the improvements with respect to the previous experiments is expected to come from the laser calibration system which has been designed and constructed by Italian part of the collaboration (INFN). An emphasis of this talk will be on the calibration system that is in the final stages of construction as well as the experiment which is expected to start data taking this year.

Posters - Board: 69 / **107**

Development of the new spectrometric channel for the SND electromagnetic calorimeter

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The Spherical Neutral Detector (SND) is one of the two detectors operating at VEPP-2000 e+e- collider, which is located at Novosibirsk, Russia. The main part of the SND is a three-layer electromagnetic calorimeter (EMC), which consists of 1640 NaI(Tl) counters. Each counter includes NaI(Tl) crystal, vacuum phototriode, and charge-sensitive preamplifier.
It is planned to improve the EMC spectrometric channel. There are two goals. The first one is to provide each channel with 1 ns or better time resolution measurement (now 5 ns) while preserving current amplitude resolution. It's useful for reliable detection of low-speed anti-neutrons, producing in e+e–>n anti-n reaction near threshold. This new channel is also needed for increasing the operation rate of the EMC electronics. Higher operation rate is important due to increase of the VEPP-2000 luminosity by about 5 times after its recommissioning. To achieve that, new modules for shaping and digitizing signal were designed, manufactured and tested.
The new shaping module F12M is developed to achieve optimal signal shape for best time and amplitude resolution.
The new Z24 module based on the Xilinx SoC Zynq digitizes and processes the signal waveforms oscillogram for calculation its time and amplitude with the specially developed algorithm.
Detailed overview of the F12M and Z24 electronic designs, special algorithm for signal processing and current measurement results are presented in the report.

Posters - Board: 14 / **79**

The upgrade of the CMS Outer Tracker detector

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The era of High Luminosity LHC (HL-LHC) will pose unprecedented challenges for detector design and operation. The planned luminosity of the upgraded machine is $5 * 10^{34} cm^{-2} s^{-1}$, possibly reaching an integrated luminosity of 3000fb^{-1} by the end of 2037. CMS Tracker detector will have to be replaced in order to fully exploit demanding operating conditions and delivered luminosity. The new detector will provide robust tracking as well as information for the first level trigger. The focus of this talk is the replacement of the CMS outer tracker system, describing new layout and technological choices together with some highlights of R&D activities.

Posters - Board: 28 / **115**

Measurement of absolute photon detection efficiency of different silicon photomultipliers.

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Silicon photomultipliers (SiPM) is a photon detector consists of a micro-cells matrix. Each micro-cell is a Geiger-Mode avalanche photo-diode working beyond the breakdown voltage. SiPM are used in tasks that require registration UV, Visible and Near-infrared weak light signals. Silicon photomultipliers have high photon detection efficiency, gain, good time resolution, compact size, and insensitivity to the magnetic field. We have compared the photon detection efficiency of the light of several detectors: MRS-APD (CPTA), MPPC S10931-100P, S13360-6050PE (Hamamatsu), MicroFC-60035-SMT, MicroFC-30035-SMT (SensL) at several wavelengths of light.

Posters - Board: 9 / **13**

Status of the KEDR new drift chamber

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For further implementation of physical research program at the KEDR detector and for accompanying equipment upgrade the new drift chamber is currently being developed. This main tracking and momentum-measuring system represents gas multilayer wire chamber operating in proportional mode. Design features and modifications versus existing chamber are described. Using prototype the spatial resolution in various gas mixtures is studied and results of spatial resolution measurements are presented.

Posters - Board: 51 / **38**

After-pulsing and cross-talk comparison for KETEK PM1125NS-SB0, Hamamatsu S10362-11-100C and Hamamatsu S13360-3050CS at room temperature

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Silicon photomultipliers (SiPMs) have become extensive used recently. They exceed photomultiplier tubes on quantum efficiency, size and resistance to the magnetic field. However, due to the features of the structure they have a greater value of dark noise rate, as well as they have additional sources of noise: cross-talk and after-pulsing. In addition, these parameters may have a temperature dependence.
In this article we present results of a evaluation dark noise rate, probabilities of cross-talk and after-pulses at different voltages and temperatures for two modern SiPM: Hamamatsu S13360-3050CS and KETEK PM1125NS-SB0 and Hamamatsu S10362-11- 100C SiPM from the previous generation. An offline signal processing was performed by a pulse approximation with reconstruction of amplitudes and start times to find these parameters. As a result, we found

that at achieved measurement accuracy the dark noise rate has a temperature and a voltage dependence, but cross-talk and after-pulses probabilities have only the latter.

Posters - Board: 1 / **15**

Energy Scale Calibration of KEDR Detector Tagging System

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Tagging system of KEDR detector is a symmetrical focussing magnetic spectrometer for scattered at small angles electrons and positrons, which is embedded into the lattice of VEPP-4M collider. It is intended for two-photon processes study and measures scattered electron/positron energy with resolution $\Delta E/E_0 = 0.03\% \ldots 0.6\%$ (E_0 is the beam energy). For precise energy scale calibration two methods are used: tagging of bremsstrahlung electron/positron by the photon energy measured by BGO calorimeter, and direct calibration using Compton backscattering spectrum edges. Also the energy scale is defined using the model of TS magnetic system with accuracy comparable to energy resolution. This report covers the design and current status of the calibration system.

Posters - Board: 30 / **121**

Development of MCP based particle detector

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A time-of-flight detector based on microchannel plates (MCP) is under development. The main goal of this work is the creation of a radiation hard large area detector providing 10 ps time resolution in strong magnetic field. The conceptual detector design consists of

- VUV transparent Cherenkov radiator placed inside a vacuum tight metal-ceramic volume,
- semitransparent CsI photocathode evaporated onto radiator surface,
- an array of small pore MCPs arranged in chevron configuration,
- segmented anode with 1 cm pitch.

The details of the detector design and the status of the development are reported.

Posters - Board: 52 / **55**

Study of cryogenic photomultiplier tubes for the future double-phase cryogenic avalanche detector.

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We report the results of characterization study of several types of cryogenic photo-multipliers manufactured by Hamamatsu Photonics, namely: compact 2 inch R6041-506MOD tubes, 3 inch R11065-10 and R11065-MOD tubes for operation in liquid Ar and 3 inch R11410-20 tubes for operation in liquid Xe. These types of PMT are proposed for installation into the future double-phase cryogenic avalanche detector that is developed in the Laboratory of Cosmology and Particle Physics of the Novosibirsk State University jointly with the Budker Institute of Nuclear Physics. Compact PMTs are planned to be installed at the side of the cryogenic vessel and they will detect electroluminescense in a high field region above liquid. 3 inch PMTs will be installed at the bottom of the cryogenic vessel in liquid Ar and they will detect primary scintillations from recoil nuclei as well as secondary scintillations. Main task of both PMT systems is to provide fast trigger signal. Therefore the PMTs have to distinguish between single electron and double electron signals to suppress effectively the background. Eight R11065 PMTs and eight R11410-20 tubes were tested and they all demonstrated excellent performance in terms of gain and relative single electron efficiency. All 3 inch PMTs showed maximal gain in liquid Ar above $5x10^6$ and relative single electron efficiency above 95%. Compact R6041-506MOD tubes have different dynode system and thus their single electron energy resolution and relative efficiency is much worse than that of 3 inch tubes. From 21 two inch PMTs only 12 tubes were selected with acceptable relative single electron efficiency higher than 70% at the maximal gain higher than $5x10^6$. However these PMTs are very attractive because these are the only compact type of tubes that can operate in liquid Ar.

Posters - Board: 2 / **18**

Laser polarimeter at VEPP-4M

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A new high precision measurement of the masses of Υ mesons with KEDR detector at VEPP-4M collider requires beam energy calibration. The most accurate method of beam energy calibration is resonant depolarization technique. It is based on measurement of spin precession frequency which is connected to Lorentz factor of the beam and well known normal and anomalous part of magnetic moment of electron due to Thomas precession. Spin precession frequency is determined from frequency of resonant destruction of beam polarization. Intra-beam (Touschek) scattering is used for polarization measurement at the energies below $E = 2.0$GeV. At higher energies $E = 5$GeV around Υ production Touschek intensity is rather small. This report describes a new polarization measurement system developing at VEPP-4M. It is based on up-down asymmetry of Compton backscattering of circular polarized photons on vertical polarized electrons. A pulse 527nm laser with 0.3W average power is used. Polarization is controlled by Pockels cell or by rotated $\lambda/4$ phase plate. Scattered photons are registered by two-coordinate GEM based detector based with 12mm lead photon converter.

Posters - Board: 61 / **31**

Concept of data storage prototype for Super-C-Tau factory detector

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Detector data storage is one of the key component of the detector infrastructure, so it must be reliable, highly available and fault tolerant shared storage. It is mostly oriented (from end user point of view) for sequential but mixed read and write operations and is planed to store large data blocks (files). According to CDR of Super-C-Tau factory detector data storage must have very high performance (several Tbps in both directions simultaneously) and significant volume (tens of Petabytes). It is decided to build a series of growing prototypes to investigate storage and neighboring technologies. First prototype of data storage is aimed to develop and test basic components of detector data storage system such as storage devices, networks and software. This prototype is designed to be capable to work with data rate of order 10 Gbps. It is estimated that about 5 computers with about 50 disks in total should be enough to archive required performance. The prototype will be based on Ceph storage technology. Ceph is a distributed storage system which allows to create storage solutions with very flexible design, high availability and scalability.

Posters - Board: 49 / **30**

Multisector scintillation detector with fiber-optical light collection

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Abstrat
A new type of scintillation detector for the use in high energy physics is described. The detector consists of eight octagonal scintillator sectors with total area 1 sq.m. Each sector represents two plates of plastic scintillator with 2 cm thickness. Between the plates, eleven 1 mm thick WLS fibers are laid evenly over the surface. The space between the fibers is filled with silicone compound to provide better light collection. Fiber ends from all eight sectors are gathered in the central part of the detector into a bunch and dock to the cathode of a FEU-115m photomultiplier. The read-out of the counter signals is carried out from 9th and 12th dynodes for providing a wide dynamic range of about 10,000 particles. The front-end electronics of the detector is based on the flash-ADC with a sampling frequency of 200 MHz. The features of detecting and recording systems of the scintillation detector and the results of its testing are discussed.

Posters - Board: 62 / **37**

Design and fabrication of a data logger for atmospheric pressure, temperature and relative humidity for gas-filled detector development

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A novel instrument has been developed to monitor and record the ambient parameters such as temperature, atmospheric pressure and relative humidity. With this data logger continuous recording of temperature, atmospheric pressure, relative humidity and the time stamp can be done with a programmable sampling interval. The device is interfaced with computer by Lab-view software. This instrument is very cheap and these parameters are very essential for understanding the characteristics such as gain of gas filled detectors like Gas Electron Multiplier (GEM) and Multi Wire Proportional Counter (MWPC). In the second version, the data can be monitored remotely through Ethernet. In this article the details of the design, fabrication and operation processes of the device has been presented.

Posters - Board: 10 / **36**

Tracking chamber made of 15-mm mylar drift tubes

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We are presenting a drift chamber composed from three layers of mylar drift tubes with outer diameter 15 mm. The tubes are made of mylar film 125 micrometers thickness covered with aluminium from both sides. Length of tubes is 560 mm. A ingle tube is self-supported structure withstanding 350 g wire tinsion without supports an internal overpressure. It was assembled 350 such tubes. Disign, quality control procedures of drift tubess is preented. Seven chambers were glued from these tubes. Each chamber consists of 3 layers, 16 tubes per layer. A few chambers were tested with cosmic rays. Results of the tests, counting rate plateau and coordinate resolution are presented as well.

Posters - Board: 50 / **35**

JUNO PMT system

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The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose underground experiment and the largest liquid scintillator (LS) detector going for neutrino mass hierarchy, precise neutrino oscillation parameter measurement and studies of other rare processes which include but not limited to solar neutrino, geo-neutrino, supernova neutrinos and the diffuse supernova neutrinos background. The 20” PMT system with ˜17000 high quantum efficiency tubes, where including Hamamatsu 20” and newly developed MCP 20” tubes, is one of the keys of JUNO experiment for better energy resolution, good detector response etc. We are doing

prototypes for PMTs, detectors to study/understand more detailed characters of the future detector. With this poster, I plan to give you a full view about the JUNO PMT system, including PMT system layout, PMT testing system design, PMT water proof potting with electronics, implosion protection.

Posters - Board: 18 / **99**

Silicon micro-strip detector for imaging of fast processes at high intensity synchrotron radiation beam

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The technique of imaging of fast processes at high intensity synchrotron radiation (SR) beam is developed in the Budker Institute of Nuclear Physics since the beginning of 2000s. The DIMEX (Detector for Imaging of Explosions) based on gas ionization chamber is working at the channel 0 at the VEPP-3 storage ring and at the channel 8 at the VEPP-4M storage ring. However, the gaseous detector can not provide the necessary parameters for the experiments at the channel 8 at the VEPP-4M, where photon flux is up to 100 times higher than at the channel 0 at the VEPP-3. In particular the rate capability of gaseous detector is far not enough due to the space charge effects induced by slow positive ions. The Si micro-strip detector is proposed for high rate experiments at the VEPP-4M storage ring. The first Si sensors were produced by Hamamatsu Photonics and included 1024 p-strips on n substrate with DC metal strips. The strip pitch is 50 μm and the strips length is 30 mm. Each metal strip is connected to the guard ring through ˜400 Ohm polysilicon resistor in order to drain high current from the sensor to ground. The front-end electronics will measure the voltage drop on such resistor. A dedicated ASIC is developed for this detector that is able to measure signals from each strip in the range equivalent to 1000 to 10^6 photons with 30 keV energy and store them in the analogue memory with the frame rate up to 50 MHz. The first prototype of such detector that will include 120 channels equipped with the prototype ASICs is assembled now and the first results of the measurements will be shown in the presentation.

Posters - Board: 53 / **59**

Developing of the segmented neutrino detector Baby-MIND

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The T2K (Tokai-to-Kamioka) is a long baseline neutrino experiment designed to study various parameters that rule neutrino oscillations, with an intense beam of muon neutrinos. A near detector complex (ND280) is used to constrain non-oscillated flux and hence predict the expected number of events in the far detector (Super-Kamiokande). The difference in the target material between the far (water) and near (scintillator, hydrocarbon) detectors leads to the main non-cancelling systematic uncertainty for the oscillation analysis. In order to reduce this uncertainty a new water grid and scintillator detector, WAGASCI, has been proposed.
Magnetized Iron Neutrino Detector (Baby-MIND) is Muon Range Detector (MRD) for WAGASCI experiment in T2K. The Baby-MIND modules are composed of magnetized iron and the long plastic scintillators bars which are read out with wavelength shifting (WLS) fibers. Event reconstruction resides in selecting tracks above the certain threshold in length. Analyzing the vertex allow us to reconstruct the hadronic component of interactions.

New frontend board CITIROC was created for readout of Baby-MIND. The bar elements and frontend board were tested with cosmic rays and on with beam at T9 CERN the results are reported.

Posters - Board: 26 / **16**

Charged particle identification using the liquid Xenon calorimeter of the CMD-3 detector

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This report describes a currently being developed procedure of the charged particle identification for CMD-3 detector, installed at the VEPP-2000 collider. The procedure is based on the application of the boosted decision trees classification method, and uses as input variables, among others, the specific energy losses of charged particle in the layers of the liquid Xenon calorimeter. The efficiency of the procedure is demonstrated by an example of the extraction of events of $e^+e^- \to K^+K^-$ process in the centre of mass energy range from 1.8 to 2.0GeV.

Posters - Board: 41 / **135**

Development and production of high purity raw materials for scintillators for experiments in particle physics

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Experiments in fundamental particle physics push forward frontiers of what could be possibly measured, so they imply high requirements on performance of measurement instrumentation. In case scintillation detectors are used, this often means such applications require scintillators with unique characteristics, at least on one or two parameters. Examples of such requirements are: high transparency and radiation hardness of PbWO4 crystals for LHS CMS and ALICE detectors and isotopic purity and extra-low natural radioactivity background of CaMoO4 crystals for Y2L AMoRE detector.
To reach the necessary scintillator performance special attention should be paid to chemical composition of raw materials. Development of a pure substance technology includes such components, as finding suitable analytical techniques, development of purification procedures, scaling these procedures to technological processes and establishing control methods. There are some common approaches, however, every raw material compound purification is a special task. Developing a raw material specification is a separate problem as well, and it usually takes extended experimental work. In this report we summarize our experience on a development and production of high purity raw materials for high performance scintillators, such as PbWO4, CaMoO4 and polycrystalline garnet-based scintillators.

Posters - Board: 32 / **32**

Laboratory tests of the response stability of the ATLAS Tile Calorimeter photomultipliers

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High performance stability of the ATLAS Tile Calorimeter is achieved with a set of calibration procedures. One step of the calibration procedure is based on measurements of response stability to laser excitation of the PMTs that are used to read out the calorimeter cells. A facility to study the performance of the PMT stability response has been operating in the PISA-INFN laboratories since 2015. Goals of the tests are to study the time evolution of the PMT response in order to reproduce and understand the origin of the response drifts observed with the Tile Calorimeter PMTs during LHC Run I and Run II. A new statistical approach was used to measure the drift of the absolute PMT gain. A new procedure which combines studies of the time evolution of the global PMT responses and of the individual PMT gains was adopted to derive the evolution of the cathode quantum efficiency. The experimental setup of the Pisa facility and the first results obtained by testing about 30 PMTs are presented.

Posters - Board: 40 / **111**

Energy and time reconstruction algorithm of Belle II electromagnetic calorimeter

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The design luminosity of the SuperKEKB collider in the BelleII experiment at KEK is 8×10^{35} cm^{-2}s^{-1} or 40 times larger than that of the previous KEKB collider with the Belle detector. Correspondingly, one expects larger beam background. also increased. To keep performance of the electromagnetic calorimeter at the high level, a new readout scheme has been developed and implemented in new detector electronics. The new scheme provides continuous digitization of shaped signal followed by wave form analysis with determination both amplitude and time of the signal. Time allows essential suppressions of background hits. We performed study of hits reconstruction algorithm and developed calibration tools for Belle-II calorimeter using background simulation data and cosmic rays events.

Posters - Board: 68 / **103**

Status of the electromagnetic calorimeter trigger system at the Belle II

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The Belle II experiment at the SuperKEKB collider in Japan has been under the construction toward a physics run in 2017 with 40 times higher instantaneous luminosity than the KEKB collider. The main physics motivation is to search for the New Physics from heavy flavor decays. In order to select an event of interest efficiently from much higher luminosity and beam background conditions than the KEKB, we have upgraded the Electromagnetic Calorimeter (ECL) hardware trigger system. It will be realized by improving ECL trigger logic based on two main triggers, the total energy and the number of clusters, with a FPGA-based flexible architecture and a high speed serial link for the data transfer. We report the current hardware, software, and firmware status that has been achieved so far. The overall scheme of the system will be presented as well.

Posters - Board: 71 / **126**

Data acquisition for the PANDA luminosity detector with online track reconstruction

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PANDA is an experiment for hadron spectroscopy which will be build in Darmstadt at the future site of FAIR. Main goals of the experiment are the search for new states and the precise measurement of the line shapes of known charmonium states with the energy scan method. To normalize measured data, precise knowledge of the luminosity is vital. At the PANDA experiment the luminosity will be measured via the angular distribution of antiproton-proton elastic scattering. The luminosity detector will consist of 4 planes of silicon-pixel-sensors (HV-MAPS) to measure the track distribution of antiprotons depending on the scattering angle. The online reconstruction of the tracks will be performed on GPUs. After the tracks are reconstructed, only the data containing tracks will be saved for further processing while the rest gets discarded. In this talk the status of the online track reconstruction and the data acquisition of the luminosity detector will be presented.

Posters - Board: 23 / **33**

Limits of a spatial resolution of the cascaded GEM based detectors

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Micro-pattern gaseous coordinate detectors possess a spatial resolution in ten micron scale together with high rate capability up to 10^7 cm^{-2} s^{-1}. Another advantage of these detectors is an essentially lower cost per unit area in comparison with the semiconductor detectors. Cascaded Gas Electron Multiplier (GEM) based detectors belong to the micro-pattern gaseous detector class. They are widely used in numerous collider experiments and in particular, at the Budker Institute of Nuclear Physics (BINP). Thus, limit values of spatial resolution, achieved by these detectors, are of significant interest. In order to determine the limit spatial resolution the simulation of charged particle registration process was accomplished. The simulation of applied detector configurations include HEED based transport of 1 GeV energy electrons through the detector and Garfield++ based tracking of avalanche evolution inside working volume, filled with the gas mixture Ar(75%)–CO_2(25%), as well as obtaining of signal distribution on the readout strips with electronics noise being taken into account. The experimental part of the work is devoted to the operability tests of the designed detectors and the measurements of their characteristics including the registration efficiency, the material budget and the spatial resolution. The material budget measurements of GEM based detectors are important for the DEUTERON facility at the VEPP-3 storage ring, where these detectors are planned to be installed. The experiments for the measurements of the detector parameters were carried out with the extracted beam facility of VEPP-4M collider at the BINP.

Posters - Board: 70 / **110**

Management system for the SND experiments

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Management system for the SND detector experiments is being remade. There are some features to implement and some UI solutions to refine. One important part of the system is interaction between the SND databases and the user (where experiment configuration, conditions and metadata are stored).
A new system is designed in client-server architecture. It includes web-interface for user interaction. There are logical layers that separate roles of a user or developer: user interface templates, template variables description and initialization, implementation details. The template layer mentioned should introduce as simple as possible terms to be easily adjusted by physicists. The web interface should be convenient to use (display the most important parameters; provide easy configuration editing).
The system is implemented using Node.JS, a modern JavaScript framework. A new template engine is designed. The important feature of the engine is asynchronous computations hiding with heterogeneous expression style.
Although development has not finished yet, the current version of the system is put into production. At the moment it includes a number of informational pages and configuration editing templates (ones for dealing with the first level trigger configuration, equipment configuration, experiment metadata, experiment conditions, relevant information for the SND operators).

Posters - Board: 73 / **174**

Next generation FPGA application on the ATLAS calorimeter trigger board dedicated to jet identification

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To cope with the enhanced luminosity delivered by the Large Hadron Collider (LHC) in 2021, the ATLAS experiment has planned a major upgrade. As part of this, the first level trigger based on calorimeter data will be upgraded to exploit fine-granularity readout using a new system of Feature EXtractors (FEXs), which each use different physics objects for the trigger selection. The three FEXs are: the electromagnetic FEX (eFEX), the jet FEX (jFEX) and the global FEX (gFEX) that identify electron/photon and tau signatures, (large area) jets and global variables, respectively. The main difference between the jFEX and the gFEX is the granularity of the data received from the calorimeters. This presentation describes the general upgrade concept of the first level calorimeter trigger and focusses then on the design and tests of the jFEX prototype. Up to 2 Tb/s have to be processed to provide jet identification (including large area jets) and measurements of global variables within a few hundred nanoseconds latency budget. This requires the use of large Field Programmable Gate Arrays (FPGAs) with the largest number of Multi Gigabit Transceivers (MGTs) available on the market. The jFEX board prototype hosts four large FPGAs from the Xilinx Ultrascale family with 120 MGTs each, connected to 24 opto-electrical devices, resulting in a densely populated high speed signal board. MEGTRON6 was chosen as the material for the 24 layers jFEX board stack-up because of its property of low transmission loss with high frequency signals (GHz range) and to further preserve the signal integrity. Special care has been put into the design accompanied by simulation to optimise the voltage drop and minimise the current density over the power planes. The first results from numerous tests on the prototype are reported with special emphasis on high- speed signal quality.

Posters - Board: 24 / **176**

Development of large scale focal plane detectors for MAGIX

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MAGIX is a planned experiment that will be implemented at the upcoming accelerator MESA in Mainz. Due to its location in the energy-recovering lane of the accelerator beam-currents up to 1 mA with a maximum energy of 105 MeV will be provided for precision experiments.MAGIX itself consists of a jet-target and two magnet-spectrometers. Inside the spectrometers GEM-based detectors will be used in the focal plane. The design goals for the detector modules are a spatial resolution of 50 μm, a size of 1,20 x 0,30 m^2 and a minimal material budget. To accomplish these goals we started developing several GEM-prototypes to study different behaviors and techniques for the final detector. The GEMs used are provided by CERN and are trained, stretched and framed in our laboratory. In this contribution the requirements, ongoing development and achieved measurements are presented.

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Development of the internal Gas-Jet-Target for MAGIX

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MAGIX is a planned experiment that will be implemented at the upcoming accelerator MESA in Mainz. Due to its location in the energy-recovering lane of the accelerator beam currents up to 1 mA with a maximum energy of 105 MeV will be provided for precision experiments.
MAGIX itself consists of a Jet Target and two magnet-spectrometers. The Jet-Target consists of a Laval-Nozzle and a catcher which is mounted in a high performance pumping system. This contribution is about the hydrodynamics and the technical implementation of the target system.

Posters - Board: 16 / **96**

The Phase-2 ATLAS ITk Pixel Upgrade

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The entire tracking system of the ATLAS experiment will be replaced during the LHC Phase II shutdown (foreseen to take place around 2025) by an all-silicon detector called the "ITk" (Inner Tracker).
The innermost portion of ITk will consist of a pixel detector with five layers in the barrel region and and ring-shaped supports in the endcap regions. It will be instrumented with new sensor and readout electronics technologies to improve the tracking performance and cope with the HL-LHC environment, which will be severe in terms of occupancy and radiation. The total surface area of silicon in the new pixel system could measure up to 14 m2, depending on the final layout choice, which is expected to take place in early 2017.
Several layout options are being investigated at the moment, including some with novel inclined support structures in the barrel-endcap overlap region and others with very long innermost barrel layers. Forward coverage could be as high as |eta| < 4. Supporting structures will be based on low mass, highly stable and highly thermally conductive carbon-based materials cooled by evaporative carbon dioxide circulated in thin-walled titanium pipes embedded in the structures. Planar, 3D, and CMOS sensors are being investigated to identify the optimal technology, which may be different for the various layers. The RD53 Collaboration is developing the new readout chip. Ideally the readout chips will be quite thin (100-150 μm) to save material; this presents a challenge for sensor-chip interconnection and options are being evaluated in collaboration with industrial partners to identify reliable processing technologies.
The pixel off-detector readout electronics will be implemented in the framework of the general ATLAS trigger and DAQ system. A readout speed of up to 5 Gb/s per data link will be needed in the innermost layers going down to 640 Mb/s for the outermost. Because of the very high

radiation level inside the detector, the first part of the transmission has to be implemented electrically, with signals converted for optical transmission at larger radii.
Extensive tests are being carried out to prove the feasibility of implementing serial powering, which has been chosen as the baseline for the ITK pixel system due to the reduced material in the servicing cables foreseen for this option.

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Central Tracking for experiment BM&N based on double side silicon detectors.

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Double side silicon micro-strip detector invented, designed and assembled for BM@N experiment is considered. Each plane of detector with common square 250x250mm consists of eight modules. Each module is a 1280ch. 300μm double side DC detector with 90μm pitch for P+ and 103 μm pitch and 2.5° for N+ side. Strips ate bonded to the front-end electronics based on VATAGA7.1 ASICs from IDEAS company. VATAGP7.1 ASIC is a 128ch multiplexed analogue readout and calibration facilities chip . In addition, each channel has a fast shaper that gives a trigger signal.

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The electronic for TOF system of the CMD-3 detector

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The time-of-flight system now is installed at the CMD-3 detector of the VEPP-2000 electron-positron collider at the Budker Institute of Nuclear Physics. It is based on the strips of organic scintillator with shifter fibers readout and silicon photomultiplier (SiPM) photodetectors. The new electronics for TOF subsystem is designed at the Budker Institute of Nuclear Physics. The main feature of the new electronic is using ripple-free technology to provide bias voltage for SiPM photodetectors. Also this design has very low power consumption. It allows the individual controlled bias voltage generator to be integrated to front-end electronics, near the photodetectors. In this paper the structure of the TOF electronic hardware is described.

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Limits of Scintillation Materials For Future Experiments at High Luminosity LHC and FCC

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This report gives of a review the last results of the radiation damage effects in scintillation materials used in high energy physics experiments, that are caused by γ-quanta and high energy hadrons, and neutrons the three main causes of irradiation in the High Luminosity LHC and future FCC. The creation and recovery of color centers, induced radioactivity and harmful radio-luminescence in organic and inorganic materials under hadron irradiation are described. An approach to select scintillation materials suitable to operate in the different parts of the detectors, particularly in the forward part of calorimeters will be proposed. Report also considers approaches to construct detection modules capable to survive during the full operation period of the High Luminosity LHC.

Calorimetry / 12

Performance of the ATLAS Tile Calorimeter

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The Tile Calorimeter (TileCal) is the central scintillator-steel sampling hadronic calorimeter of the ATLAS experiment at the LHC. Jointly with other calorimeters it is designed for energy reconstruction of hadrons, jets, tau-particles and missing transverse energy. The scintillation light produced in the scintillator tiles is transmitted by wavelength shifting fibers to photomultiplier tubes (PMTs). The analog signals from the PMTs are amplified, shaped and digitized by sampling the signal every 25 ns. The TileCal frontend electronics reads out the signals produced by about 10000 channels measuring energies ranging from ~30 MeV to ~2 TeV. Each stage of the signal production from scintillation light to the signal reconstruction is monitored and calibrated.
The performance of the calorimeter has been established with cosmic ray muons and the large sample of the proton-proton collisions. The response of high momentum isolated muons is used to study the energy response at the electromagnetic scale, isolated hadrons are used as a probe of the hadronic response and its modelling by the Monte Carlo simulations. The calorimeter time resolution is studied with multijet events.
Results on the calorimeter operation and performance are presented, including the calibration, stability, absolute energy scale, uniformity and time resolution. These results show that the TileCal performance is within the design requirements and has given essential contribution to reconstructed objects and physics results.

Calorimetry / 140

The Phase II upgrade of the CMS Barrel Electromagnetic Calorimeter

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The High Luminosity LHC (HL-LHC) will provide unprecedented instantaneous and integrated luminosities. The lead tungstate ($PbWO_4$) crystals forming the barrel part of the Electromagnetic Calorimeter (ECAL) of the Compact Muon Solenoid (CMS) will still perform well, even after the expected integrated luminosity of 3000fb-1 at the end of HL-LHC. The avalanche photodiodes (APDs) used to detect the scintillation light will also continue to be operational, although there will be some increase in electronics noise due to radiation-induced APD dark currents.
During the third long shutdown of the LHC (LS3), the barrel ECAL will undergo extensive changes in order to prepare for the next decade of operation under the more challenging conditions of the HL-LHC. The barrel operating temperature will be reduced, to mitigate the increasing APD-induced noise. The most significant change will be the replacement of a majority of the on-detector and off-detector readout. This will remove existing constraints on trigger rate and latency, and will provide additional functionality to exploit the higher luminosity delivered by the HL-LHC.
We start with the comparison of the legacy detector design goals and the real detector performance. Then we review the design and R&D studies for the barrel calorimeter upgrade and present results from test beam studies of the first prototype readout electronics. We present test beam results on hadron irradiated $PbWO_4$ crystals up to fluences expected at HL-LHC and detail the status of the new readout and trigger electronics R&D. The mitigation of the larger number of concurrent interactions per bunch crossing (pileup) expected at HL-LHC may be substantially improved by means of precision time tagging of calorimeter clusters, by associating them to primary vertices via 4D triangulation. We present recent test beam results on the precision timing potential of the CMS lead tungstate calorimeter and discuss how the readout electronics may be adapted to exploit this performance in CMS.

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The LHCb Calorimeter system: design, performance and upgrade

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The LHCb Calorimeter system consists of four subdetectors: a Scintillating Pad Detector (SPD) and a Pre-Shower detector (PS) in front of an electromagnetic calorimeter (ECAL) which is followed by a hadron calorimeter (HCAL). They are used to select high transverse momentum hadron, electron and photon candidates for the L0 trigger, and provide the identification of electrons, photons and hadrons, as well as the measurement of their energies and positions.

The first part of this talk will be devoted to the design and operation of the present system. This will include monitoring and calibration procedures for LHC Run I (2010-2012) and Run II (2015-2018), the detector performance figures and measurement of radiation degradation of various detector components. The achieved performance will be illustrated by distributions for selected B decays.

Finally, the plans for the LHCb Calorimeter system upgrade will be discussed. The Phase I upgrade during LHC LS2 (2019-2020) will consist mainly in removal of the PS and SPD subdetectors and full replacement of the ECAL and HCAL frontend electronics, in order to enable 40 MHz detector operation without L0 trigger. The options for further upgrades, planned for LHC LS3 (2024-2026) and beyond, imply essential revision of the ECAL detector.

Calorimetry / 11

Upgrade of the ATLAS hadronic Tile calorimeter for the High luminosity LHC

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The Tile Calorimeter (TileCal) is the hadronic calorimeter of ATLAS covering the central region of the ATLAS experiment. TileCal is a sampling calorimeter with steel as absorber and scintillators as active medium. The scintillators are read-out by wavelength shifting fibers coupled to photomultiplier tubes (PMT). The analogue signals from the PMTs are amplified, shaped and digitized by sampling the signal every 25 ns.

The High Luminosity Large Hadron Collider (HL-LHC) will have a peak luminosity of $5x10^{34}cm^{-2}s^{-1}$, five times higher than the design luminosity of the LHC. TileCal will undergo a major replacement of its on- and off-detector electronics for the high luminosity programme of the LHC starting in 2026. All signals will be digitized and then transferred directly to the off-detector electronics, where the signals will be reconstructed, stored, and sent to the first level of trigger at a rate of 40 MHz. This will provide better precision of the calorimeter signals used by the trigger system and will allow the development of more complex trigger algorithms. Changes to the electronics will also contribute to the reliability and redundancy of the system.

Three different frontend options are presently being investigated for the upgrade and a final solution will be chosen after extensive laboratory and test beam studies that are in progress. A hybrid demonstrator module was developed using the new electronics while conserving compatibility with the current system. The demonstrator undergoes extensive testing and will be installed during one of the next winter maintenance period.

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Development of ATLAS Liquid Argon Calorimeter Readout Electronics for the HL-LHC

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The LHC high-luminosity upgrade in 2024-2026 requires the associated detectors to operate at luminosities about 5-7 times larger than assumed in their original design. The pile-up is expected to increase to up to 200 events per proton bunch-crossing. To be able to retain interesting physics events even at rather low transverse energy scales, increased trigger rates are foreseen for the ATLAS detector. At the hardware selection stage acceptance rates of 1 MHz are planned, combined with longer latencies up to 60 micro-seconds in order to read out the necessary data from all detector channels. Under these conditions, the current readout of the ATLAS Liquid Argon (LAr) Calorimeters does not provide sufficient buffering and bandwidth capabilities. Furthermore, the expected total radiation doses are beyond the qualification range of the current front-end electronics. For these reasons a replacement of the LAr front-end and back-end readout system is foreseen for all 182,500 readout channels, with the exception of the cold pre-amplifier and summing devices of the hadronic LAr Calorimeter. The new low-power electronics must be able to capture the triangular detector pulses of about 400-600 nano-seconds length with signal currents up to 10 mA and a dynamic range of 16 bit. Different technologies to meet these requirements are under evaluation: A preamplifier in 130nm CMOS technology with two gain stages can cover the desired dynamic range while meeting the required noise levels and non-linearity values. Alternatively, developments of pre-amplifier, shaper as well as ADCs are performed in 65 nm CMOS technology. Due to the lower voltage range, 2-gain and 4-gain designs of the analog part are studied with programmable peaking time to optimize the noise level in presence of signal pile-up. Radiation-hard, 14 bit ADC operating at 40 or 80 MHz are also being studied. Results from performance-simulation of the calorimeter readout system for the different options and results from design studies and first tests of the components will be presented.

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The Upgrade of the ECL forward calorimeter of the BelleII experiment at SuperKEKB.

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The new SuperKEKB collider will be an upgrade of the existing KEKB electron-positron asymmetric collider, with a target luminosity of $8\times10^{35}\mathrm{cm}^{-2}\mathrm{s}^{-1}$, about 40 times greater than the previous one. The accelerator upgrade is based on the novel low-emittance "nanobeams" scheme. The detector will also be upgraded to cope with the higher luminosity, pile-up and occupancy. We report on the development of the new pure CsI calorimeter for the forward region. An intensive R&D has been carried out to study the performance of pure CsI crystals with Avalanche Photodiodes readout. Results on the signal to noise ratio for different sensors and front end electronics configurations will be presented as well as the use of filters and wavelength shifters. Measurements with a source, simulating the background machine, have been performed and will also be presented.

Calorimetry / 157

Gain stabilization of SiPMs

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The gain of SiPMs increases with bias voltage and decreases with temperature. To operate SiPMs at stable gain, the bias voltage can be adjusted to compensate temperature changes. We have tested this concept with 30 SiPMs from three manufacturers (Hamamatsu, KETEK, CPTA) in a climate chamber at CERN varying the temperature from 1°C to 50°C. We built an adaptive power supply that used a linear temperature dependence of the bias voltage readjustment. With one selected bias voltage readjustment, we stabilized four SiPMs simultaneously. We fulfilled our goal of limiting the deviation from gain stability in the 20°C-30°C temperature range to less than ±0.5% for most of the tested SiPMs.

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Polycrystalline Scintillators for Large Area Detectors in HEP Experiments

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Further physical programs at the LHC will require a significant increase of the accelerator luminosity throughout the High Luminosity phase of LHC. During this period, charged hadrons and neutrons with fluences higher than 1014 p/cm2 per year in the largest pseudo-rapidity regions of the detectors will have a non-negligible influence on the radiation damage of materials. Moreover, with the increasing activation of the experimental equipment, it will become more difficult to periodically replace and maintain the detector components. Therefore, the selection of materials for new detectors to be used at the upgrade of experimental setup requires a more reliable assessment of the risks of detector failures due to severe radiation damage. Y3Al5O12:Ce (YAG:Ce) crystal was found to be one of the most radiation hard scintillation materials. However, production of YAG:Ce in a single crystalline form is costly because crystal growth is performed at temperature near 1900 °C with a very low rate of transformation of a raw material into a crystal. As an alternative solution to the single crystalline option we propose YAG:Ce based polycrystalline scintillation materials, obtained by cheaper chemical routes. We have prepared and tested two variants: 1) a composite material, composed of large sized grains, packed and glued together into a translucent body with density up to 50% of the single crystal; 2) sintered translucent ceramic body with density ˜98% of the theoretical density. As all components of composite modules are selected to be radiation hard, such technology can be considered a suitable option to replace plastic scintillators in a region of a detector where high radiation hardness is mandatory. Here we report the results of a comparative tests of the YAG:Ce single crystals and composite modules obtained by different approaches. Work was supported by Ministry of Science and Education of Russian Federation, subsidy agreement № 14.625.21.0033 dated 27.10.2015, project identifier RFMEFI62515X0033.

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Highly Granular Calorimeters: Technologies and Results

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The CALICE collaboration is developing highly granular calorimeters for experiments at a future lepton collider primarily to establish technologies for particle flow event reconstruction. These technologies are now also finding applications elsewhere, such as upgrades for the LHC. At the same time, the large data sets collected in an extensive series of beam tests have enabled detailed studies of the properties of hadronic showers in calorimeter systems, resulting in improved simulation

models and development of sophisticated reconstruction techniques. In this presentation, we will discuss current R&D activities within CALICE, focusing on technological prototypes that address system issues relevant for full detector systems and production techniques amenable to mass production for silicon, scintillator, and gas detector based electromagnetic and hadronic calorimeters. We will also present highlights from studies of the structure of hadronic showers and selected results on reconstruction techniques for imaging calorimeters.

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Silicon-tungsten calorimetry for future high energy e+e- collider

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Particle Flow Algorithms (PFA) aimed at the jet reconstruction at the particle level, yield the most precise jet energy resolution, up to a factor of two better than the traditional calorimetry. For the precise jet "pattern recognition", highly granular calorimeters are required. They have being developed by the CALICE collaboration starting from the beginning of 2000's. The most demanding requirements are for the electromagnetic calorimeter (ECAL). The silicon-tungsten (SiW) ECAL technology, though expensive, provides the best performance with an excellent granularity. We shall discuss the R&D and the recent results in this field in the talk.
In 2005-2012, CALICE collaboration has built and tested the "physical prototypes" of highly granular calorimeters to test PFA approach. We report the recent studies performed in 2016-17 on the recognition of two close by electromagnetic and electromagnetic-hadronic showers obtained with the event mixing, and also on the tests of the hadronic interaction models with SiW ECAL physical prototype.
From 2012 until present, the SiW ECAL group develops the new generation of the prototypes, called "technological", with fully embedded electronics. It should be suitable for the future e+e- high energy collider like ILC. A similar technology has been approved for the phase II CMS calorimeter endcaps upgrade (HGCAL project) and is also considered for the ATLAS preshower upgrade (HGTD project) and the LHCb inner ECAL upgrade. Although the LHC upgrade projects will be briefly mentioned, the main focus in the talk will be on the development and the optimization for ILC. The recent test beam results at SPS in CERN will be discussed in detail.

Calorimetry / 34

Calibration of the LHCb calorimetric system

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LHCb experiment is one of the four main spectrometers at the Large Hadron Collider. The primary goal of LHCb experiment is the search for indirect evidence of new physics in CP violation and rare decays of hadrons, which contain heavy quarks. The calorimeter system of LHCb consists of four sub-detectors: Scintillator Pad Detector followed by a Preshower detector and then an electromagnetic (ECAL) and hadronic (HCAL) calorimeters. The main purpose of the calorimeter system is the identification of hadrons, photons and electrons, and the measurement their energies and positions. This information is the basis of the Level-0 trigger, which is required for initial event selection. The LHCb ECAL is a «shashlik» type calorimeter of 25 X_0 thickness. A number of calibration techniques are applied sequentially. The final calibration method is based on reconstruction of the π^0 meson invariant mass, which allows to achieve the accuracy of measuring the electron and photon energies of 2%. The Hadron Calorimeter is a sampling iron-scintillator calorimeter of 5.6 nuclear interaction lengths thickness with structure arranged along the collider beam direction. HCAL calibration is based on hydraulic movement of $\sim$ 10 mCi radioactive ^{137}Cs source through every cell. This method provides very detailed information about the calorimeter and allows to measure the response of every individual scintillating tile. The layout of the LHCb calorimeters and these calibration systems and details of the calibration procedures are reported. Special emphasis is put on the data analysis procedure and visualization software. The latest results on the HCAL performance are presented.

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Monitoring and Correcting for Response Changes in the CMS Lead-tungstate Electromagnetic Calorimeter in LHC Run2

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The CMS Electromagnetic Calorimeter (ECAL) is made of 75848 lead-tungstate scintillating crystals. The LHC has delivered excellent performance in Run2, allowing CMS to record data corresponding to an integrated luminosity of more than 40 fb-1 at 13 TeV. The Run2 luminosity increase has caused higher radiation doses in the ECAL crystals and photodetectors, affecting the light output. The excellent intrinsic energy resolution of the CMS ECAL is preserved with the aid of a precise monitoring system. Crystal and photodetector response changes are monitored in real time by a sophisticated apparatus using lasers and LEDs. Soon after data are taken, a computer farm processes the laser and LED monitoring events and computes precise corrections to be used in the event reconstruction within 48 hours of data-taking. Similar corrections must also be applied at the trigger level. This talk describes the evolution of the crystal response, the components of the CMS ECAL monitoring system, and how it is operated in Run2.

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Sensors for the CMS High Granularity Calorimeter

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The Particle Flow Algorithm (PFA) is increasingly used in particle physics as a powerful tool to improve jet energy resolution. Recent technology advances allow to fully exploit PFA by combining precise tracking with fine-grained calorimetry. The CMS experiment is currently developing high granularity calorimeter endcaps for its HL-LHC upgrade (CMS HGCAL). The electromagnetic part, as well as the first layers of the hadronic part, foresees silicon sensors as the active material. This technology is similar to the silicon-based ECAL developed in the framework of the Linear Collider by the CALICE collaboration. In this talk the current status of the HGCAL silicon sensor development is presented. First results of single diode measurements are shown, as well as tests of full 6-inch hexagonal sensor wafers with 135 cells in the laboratory and in beam tests.

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A High-Granularity Timing Detector for the Phase-II upgrade of the ATLAS Calorimeter system

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The expected increase of the particle flux at the high luminosity phase of the LHC (HL-LHC) with instantaneous luminosities up to L $\simeq 7.5\times10^{34}$ cm^{-2}s^{-1} will have a severe impact on pile-up. The pile-up is expected to increase on average to 200 interactions per bunch crossing. The reconstruction and trigger performance for electrons, photons as well as jets and transverse missing energy will be severely degraded in the end-cap and forward region, where the liquid Argon based electromagnetic calorimeter has coarser granularity compared to the central region. A High Granular Timing Detector (HGTD) is proposed in front of the liquid Argon end-cap calorimeters for pile-up mitigation at Level-0 (L0) trigger level and in offline reconstruction. This device should cover the pseudo-rapidity range of 2.4 to about 4.2. Four layers of Silicon sensors, possibly interleaved with Tungsten, are foreseen to provide precision timing information for charged and neutral particles with a time resolution of the order of 50 pico-seconds per readout cell in order to assign the energy deposits in the calorimeter to different proton-proton collision vertices. Each readout cell has a transverse size of only a few mm, leading to a highly granular detector with several hundred thousand readout cells. Using the information provided by the detector, the contribution from pile-up jets can be reduced significantly while preserving high efficiency for hard-scatter jets. The expected improvements in performance are in particular relevant for physics processes with forward jets, like vector-boson fusion and vector-boson scattering processes, and for physics signatures with large missing transverse energy. Silicon sensor technologies under investigation are Low Gain Avalanche Detectors (LGAD), pin diodes, and HV-CMOS sensors. The physics motivations and expected performance of the High Granular Timing Detector at the HL-LHC are summarized. The proposed detector layout and Front End readout, laboratory and beam test characterization of sensors and the results of radiation tests are presented.

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Simulation of Secondary Emission Calorimeter for Future Colliders

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Ever increasing collision energies in current and future colliders demand for radiation hard calorimeters. Calorimeters based on secondary electron emission process from dynode metals was proposed in 1990s as radiation hard alternative to overcome this difficulty. Since the discovery of secondary emission of electrons from metal surfaces, there has been many approaches to quantify this process by using semi-empirical models, including Monte Carlo studies. These Monte Carlo studies, however, usually do not include secondary emission process as a part of physics, governing the shower development and the probabilistic nature of the emission process. In this study we present a Geant4 calorimeter simulation based on a newly developed physics class, which was derived from a probabilistic approach found in the literature. By developing this physics class inside Geant4 we were able to determine the yield and energy spectrum of secondary emission electrons from metal surfaces. We were also able to determine the calorimeter response to energetic particles by using the showers they create inside the calorimeter layers consisting of dynode structures. We first provide a comparison between data and simulation of a thin foil for the yield and secondary electron energy spectrum. We then give response, linearity, and resolution for a generic sampling calorimeter based on a secondary emission electron process together with results from a scintillating sampling calorimeter for comparison.

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Neutrino detectors for oscillation experiments

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Recent progress in the development of the detectors for neutrino oscillation experiments will be presented. The near and far detectors in current accelerator (T2K, NOVA) and reactor experiments will be described. An emphasis will be put on the neutrino detectors for the next generation oscillation experiments: a huge water Cherenkov detector HyperKamiokande, large volume liquid argon detectors for the DUNE experiment, large volume scintillator detectors for the reactor experiment JUNO. New detector ideas, technique and future prospects for measurements of neutrino cross sections will be also discussed.

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WA105 experiment at CERN: large demonstrator of Dual Phase Liquid Argon TPC detector for DUNE

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Deep Underground Neutrino Experiment (DUNE) has chosen liquid argon (LAr) technology for the detection of neutrinos produced with proton beams at Fermilab and transmitted 1300 km through the Earth towards the Sanford Underground Research Facility (SURF) in South Dakota. Two basic configurations for LAr TPC are considered: a single phase and a dual phase. The former has already worked as a 300 ton unit (ICARUS) but more R&D is needed to reach the desired module size of 10 kton. The later has many benefits in terms of signal to noise ratio, imaging capabilities, scalability, and cost reduction but has not yet been proven on a large scale. The task of WA105 is to build ProtoDUNE DP – a large dual phase (DP) demonstrator – and to test it with charged particle beams (0.5-20 GeV/c) at CERN in 2018. The data will provide the necessary calibration of the detector and benchmark reconstruction algorithms. This project is a crucial milestone for DUNE. If successful, DP is likely to become the second 10 kton module to be installed at SURF.
The key advantage of DP TPC is the benefit of charge amplification in the gas phase using Large Electron Multipliers (LEM). Electrons produced by energetic charged particles in the active volume of liquid argon drift along the z-axis towards the top anode and enter the gas layer. Here, a readout plane with LEM tiles provides amplification and charge collection yielding equal charge sharing in the x and y direction. PMTs located on the bottom of the tank provide trigger for non-beam events by registering the scintillation light generated by charged particles in liquid argon.
The active volume of ProtoDUNE DP will be 6 x 6 x 6 m3 (˜300 t of LAr). Both the size and the construction details were chosen to test scalable solutions for the crucial aspects of this detector: ultra-high argon purity in a non-evacuable tank, long drifts, very high drift voltages, large area Charge Readout Plane, cold preamplifiers, etc. The TPC will be installed inside of a tank based on industrial LNG technology.

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The Instrumentation of JUNO

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Jiangmen Underground Neutrino Observatory (JUNO) is under construction in southern China which aims to measure the neutrino mass hierarchy and neutrino oscillation parameters using the reactor neutrinos from two nearby nuclear power plants 53km away. JUNO also has good capabilities of researches such as supernova neutrinos, geo-neutrinos, solar neutrinos and so on. Here the instrumentation of JUNO is introduced and its central detector is designed to measure neutrinos with huge target of liquid scintillator of 20k tons and with the precise energy resolution

to reach (3%)/√(E(MeV)) . To satisfy the above requirements, the new MCP-PMT with 20 inches diameter and with high detection efficiency is developed in China and its performances are reported. Also the R&Ds of PMT readout electronics, the liquid scintillator, the calibration system and the veto system are introduced.

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The Hyper-Kamiokande detector: R&D studies of a new generation of Photosensors

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Hyper-Kamiokande is a Large water Cherenkov detectors, such as the successful Super-Kamiokande, and the forthcoming Hyper-Kamiokande requires large aperture, high sensitivity photosensors able to detect the weak Cherenkov light generated by neutrino interactions or proton decay. As a consequence, the capability of a water Cherenkov detector largely relies on the performance of its photosensors. Currently the photosensors used in Super-Kamiokande, equipped with a 50 cm diameter photocathode, are the world's largest photomultiplier tubes. In this communication the current status of development of Hyper-K detector will be reviewed.

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The RED-100 experiment

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The experiment on first observation of the elastic coherent scattering of neutrino off atomic nuclei is proposed with the use of the RED-100 emission two-phase xenon detector. This process was theoretically predicted more than 40 years ago by the Standard model of particle physics but has not been observed yet because of lack of the detection technique of the events with the low energy deposition in massive (more than several dozens of kg) targets: the energy of nuclear recoil from the neutrino scattering in detector is in the keV- and sub-keV- energy ranges. This can be done with a technology of particle detection by means of a two-phase emission detector proposed in Russia and well worked out in the experiments on search for dark matter. The RED-100 two-phase xenon emission detector and proposed experiment with it at the Kalinin nuclear power plant (KNPP) is described in this talk. The perspective of the use of such type detectors for neutrino monitoring of nuclear power reactors is considered.

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Measurement of ionization yields of nuclear recoils in liquid argon using two-phase detector

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Direct search for dark matter particles (WIMP - Weakly Interacting Massive Particle) is produced in the detectors of recoil nuclei through observation of WIMP elastic scattering on atomic nuclei of detector matter. The current situation with the observation signals from dark matter particles is quite confusing. Some authors believe that one of the reasons for these differences among different experiments is the problem of reliable calibration of energy scales for recoil nuclei. In this regard, particularly relevant is the problem of calibration of detectors for dark matter, and low-energy neutrinos, especially in the field of low energy of the recoil nuclei - less than 10 keV. In Budker Institute of Nuclear Physics we measured ionization yields of nuclear recoils in liquid argon using a two-phase Cryogenic Avalanche Detector (CRAD) with electroluminescence (EL) gap, operated in argon doped with a minor (49 ± 7 ppm) admixture of nitrogen at 87 K and 1.00 atm. The EL gap was optically read out using cryogenic PMTs located on the perimeter of the gap. We used DD generator to produce neutrons with 2.45 MeV energy.

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TAIGA experiment: present status and perspectives.

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The TAIGA observatory addresses ground-based gamma-ray astronomy at energies from a few TeV to several PeV, as well as cosmic ray physics from 100 TeV to several EeV. TAIGA will be located in the Tunka valley, ˜50 km West from Lake Baikal. The different detectors of the TAIGA will be grouped in 6 arrays to measure Cherenkov and radio emission as well as electron and muon components of atmospheric showers. The combination of the wide angle Cherenkov detectors of the TAIGA-HiSCORE array and the 4-m Imaging Atmospheric Cherenkov Telescopes of the TAIGA-IACT array with their FoV of 10x10 degrees and underground muon detectors offers a very cost effective way to construct a 10 km2 array for gamma-ray astronomy.

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archPbMoO4 scintillating bolometers as detectors to search for the neutrinoless double beta decay of 100Mo

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To effectively detect elusive particles the use of a detector with high efficiency and enhanced sensitivity is required. Cryogenic scintillating bolometers are among the most promising detectors used for the investigation of rare nuclear processes due to their excellent background rejection capabilities thanks to the simultaneous and independent, double readout of heat and scintillation light induced by particle interaction in the crystal. The main goal of the CUPID-0 experiment is to demonstrate the feasibility of using scintillating bolometers to search for the neutrinoless double beta decay of several perspective isotopes (82Se, 100Mo, 116Cd and 130Te). 100Mo is among them due to its high energy transition (Qbb = 3035 keV), comparably high natural isotopic abundance (9.67%), possibility to be highly enriched by the ultra-speed gases centrifuges technology (up to 99.5%) and a reasonable price for such type of enrichment. Different molybdenum-based crystals were tested in the last decade for their potential application as scintillating bolometers. Among them, the most promising are Li2MoO4, CaMoO4 and ZnMoO4. Despite of a significant progress in their development, there are a number of challenges to be met, mainly caused by the high internal

radioactive contamination and difficulties in the high quality large volume crystal production. However, many of these problems can be omitted in case of PbMoO4 crystal produced from archaeological lead. Here we present results on the archPbMoO4 crystal performance produced from archaeological lead, as a promising scintillating bolometer to search for the neutrinoless double beta decay of 100Mo. For this purpose the archPbMoO4 crystal has been characterized by chemical and optical methods, and by means of cryogenic measurements.

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Design of the Photomultiplier Tube Base with High Dynamic Range for LHAASO

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The Large High Altitude Air Shower Observatory (LHAASO) project is scheduled to be built at Sichuan province in China. As a large scale complex of various detectors, its primary scientific goals are exploring the origin of the galactic cosmic ray, searching for very high energy gamma ray sources, and the precise measurement of the components at the knee region. To accomplish these tasks, the proposed project consists of three detector arrays: 1 km^2 extensive air shower array (KM2A, including ED and MD), 75000 m^2 Water Cherenkov Detector Array (WCDA) and Wide Field of view Cherenkov Telescope Array (WFCTA). Among them, WCDA and MD will employ the large area photomultiplier tube (PMT) as the readout of its cell detector.
WCDA is proposed to target gamma astronomy at energies between 100 GeV and 30 TeV. The WCDA covers an area 75000 m^2, configured as 3120 small ponds (5 $m \times 5$ $m \times 4$ m depth). A $8-9$ inch hemispherical PMT is located at the bottom-center of each cell, facing upward, to collect the Cherenkov light produced by shower particles in water. The PMTs require not only good single photoelectron (SPE) resolution and small transit time spread (TTS), but also a large charge dynamic range from 1 to 4000 photoelectrons (PE) at the inciting light pulse width of 6.4 ns. Bases for the candidate PMTs Hamamatsu R5912, Beijing Hamamatsu CR365 and HZC Photonics XP1805 are designed, respectively. The voltage divider is a purely resistive chain and the base comprises two different outputs obtained by using the anode and the dynode. The results show that at the working gain of 3×10^6, the characteristics of all the three PMTs satisfy the demands of WCDA.
Additionally, a high dynamic range photomultiplier tube base for Hamamatsu R5912 and HZC XP1805 are designed for the underground Muon Detector (MD), which is another major detector in LHAASO and used to detect the muon components in the extensive air shower. The cell detector of MD requires the dynamic range up to 15000 muons which means output current of 1.8 A from the PMT. For R5912 as an example, the divider is designed to extract the signals from the 7th dynode (DY7) and the anode. The charge ratio between the anode and DY7 is around 160 and the equivalent anode peak current non-linearity of DY7 within 5% is up to 1.87 A, which satisfies the dynamic range requirement in the MD.

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Cluster type EAS array of the NEVOD experimental complex

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A new NEVOD-EAS array for detection of extensive air showers (EAS) in the energy range $10^{15} - 10^{17} eV$ is being created in MEPhI (Moscow, Russia) on the basis of the Experimental Complex NEVOD. It will operate in conjunction with the Cherenkov Water Detector NEVOD and coordinate detector DECOR, as well as with detectors URAN and TREK which are now being constructed. The array will allow determining of the size, axis position and arrival direction of EAS registered by aforementioned installations of the experimental complex.
Since the NEVOD-EAS array is being created at the densely built territory and detecting elements cannot be deployed in the same plane like in usual shower arrays, its registering system is organized in a cluster principle, and a newly developed cluster approach is used for experimental data analysis. Each cluster of the shower array is an independent system which includes 16 scintillation counters of EAS electron-photon component combined in 4 detector stations (DS) and registering electronics. Cluster electronics performs digitizing of analog signals, selection of local events according to intra-cluster triggering conditions, time-stamping of local events and monitoring of cluster operational parameters. Information on local events and operational parameters is transferred to the central DAQ post of control and synchronization of all clusters. Local events from different clusters are then combined according to their timestamps.
In 2015-2016, the central part of the NEVOD-EAS array was created and launched into operation. It includes 4 clusters located at different altitudes at area of $10^4 m^2$ around the complex. Test and experimental runs carried out at the central part of the array have proved the possibility of using such cluster approach to registering system organization and experimental data analysis.
The features of the distributed cluster type registering system of the NEVOD-EAS shower array, as well as the cluster approach to experimental data analysis are discussed. The main characteristics of clusters and their elements are presented.

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The new Cylindrical GEM Inner Tracker of the BESIII experiment: test beam results of two prototypes.

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A cylindrical GEM detector is under development, to serve as an upgraded inner tracker at the BESIII spectrometer. It will consist of three layers of cylindrically-shaped triple GEMs surrounding the interaction point. The experiment is taking data at the e^+e^- collider BEPCII in Beijing (China) and the GEM tracker will be installed in 2018. Tests on the performances of triple GEMs in strong magnetic field have been run by means of the muon beam available in the H4 line of SPS (CERN) with both planar chambers and the first cylindrical prototype. Efficiencies and resolutions have been evaluated using different gains, gas mixtures, with and without magnetic field. The obtained efficiency is larger than 95%, in many operational arrangements. The spatial resolution for planar GEMs has been evaluated with two different algorithms for the position determination: the charge centroid and the micro time projection chamber (TPC) methods. The two modes are complementary and are able to cope with the asymmetry of the electron avalanche when running in magnetic field, and with non-orthogonal incident tracks. With the charge centroid, a resolution lower than 100 microns has been reached without magnetic field and lower than 200 microns with a magnetic field up to 1 T. The micro TPC mode showed to be able to improve those results. In the first beam test with the cylindrical prototype, the detector had a very good stability under different voltage configurations and particle intensities. The resolution evaluation is in progress.

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Study on a new design of a GEM-based technology detector for the CMS experiment

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The muon system of the Compact Muon Solenoid (CMS) experiment at the LHC is currently uninstrumented at pseudorapidity higher than $|\eta|= 2.4$. Therefore, the installation of a chamber in that position would allow track reconstruction beyond the calorimeter at higher pseudorapidity, increasing the muon system's acceptance and improving the tagging of high-eta muons, besides improving muon trigger. Main challenges to such installation are the high particle flux to be substained, high radiation tolerance, and fitting a multi-layered detector in a reduced available space (less than 30 cm). Micropattern Gaseous Detectors (MPGDs) show promising performances responding to the most severe constraints posed by High Energy Physics (HEP) experiments. They use small amplification regions - of the order of tens of microns - allowing for a high rate capability, a very good spatial resolution and radiation tolerance. Lots of MPGDs with different geometries have been developed and tested. An example is the Gas Electron Multiplier (GEM) detector, using copper clad kapton foils on which microscopic holes, hundreds microns apart, have been chemically etched. The cathode and the anode electrodes close the foils that are conveniently spaced to create drift, transfer and induction gaps. A new configuration β" back to back - of such a device is presented with the aim of developing a compact size multi-GEM detector. It is composed by two independent stacked triple GEM detectors, positioned with the anodes toward the outside. In this way, they can share the same cathode, placed at the center of the system, allowing to reduce the total detector's thickness since a single cathode and a single external frame are used. A first prototype has been produced and characterized with an X-Ray source and muon beams. First results on its performance will be presented.

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High resolution micro-pattern gas detectors for particle physics, developments at the Budker INP

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Micro-pattern gaseous detectors (MPGDs) allow operation at very high background particle flux with high efficiency and spatial resolution. This combination of parameters determines the main application of these detectors in particle physics experiments: precise tracking in the areas close to the beam and in the end-cap regions of general purpose detectors. MPGDs of different configurations have been developed and are under development for several experiments in the Budker INP. The system of 8 two-coordinate detectors based on cascade of Gas Electron Multipliers (GEM) is working at the KEDR experiment at the VEPP-4M collider in the tagging system that detects electrons and positrons, lost their energy in two-photon interactions and taken out of the equilibrium orbit by a dedicated magnetic system. Another set of cascaded GEM detectors is developed for the almost-real Photons Tagging System (PTS) of the DEUTRON facility at the VEPP-3 storage ring. The PTS contains 3 very light detectors (material content is about 0.2% of radiation length) with very high spatial resolution (below 50 um). At present the system is completed and the detectors are under tests at the extracted electron beam facility at the VEPP-4M collider. Dedicated detectors based on cascaded GEMs are developed for the extracted electron beam facility at the VEPP-4M collider. These devices will allow precise particle tracking with minimal multiple scattering having very low material content (about 0.2% of radiation length). The readout structure of these detectors has 0.25 mm strip pitch in X and Y directions, and spatial resolution below 50 um is expected from them according to the simulation studies. The last results from the first detector of this series will be presented at the Conference. An upgrade of the coordinate system of the CMD-3 detector at the VEPP-2000

collider is proposed on the basis of the resistive micro-WELL (mu-rWELL). This structure is in fact the GEM lying at the resistive surface that have readout structure below the resistive layer. If a high voltage is applied between the top GEM electrode and the resistive layer, the gas amplification occurs in the GEM holes (wells) and such structure works as a surface with distributed amplification. An advantage of such approach in comparison with cascaded GEMs system is that there is only one active surface and, thus, a detector with curved (i.e. cylindrical) surface can be easier to manufacture. We propose to make a thin cylindrical chamber based on mu-rWELL and thin end-cap disc detectors based on the same technology. A research activity on this subject is starting.

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A new technique for assembling large-size GEM detectors and its experimental results

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GEM detectors have been successfully used in modern nuclear and particle physics experiments. The key to the GEM application at large-scale experiments is cost-effective realization of large-size detectors, in which development of GEM detector assembly techniques plays a key role. The detector group at the University of Science and Technology of China (USTC) has been conducting intensive R&D on large-size GEM detectors, particularly on assembly techniques of GEM detectors, since 2013. The main aim is to build up technology for constructing the tracking detector at the SoLID experiment proposed for the 12-GeV upgrade program at JLab.
We started large-size GEM R&D by implementing the self-stretching GEM assembly technique developed at CERN for the CMS Muon GEM upgrade project, and gained a great deal of experience with the self-stretching technique through large-size GEM detector prototyping.
From our implementation and practice of the self-stretching technique, we found a major disadvantage of the technique in application for very large GEM detectors with size larger than 1m. When GEM foil size reaches over 1m, the overall foil extension of a triple-GEM under tension of ˜ 5N/cm can be as large as ˜2.5mm. This was precisely measured by a dedicated GEM stretching test station. The screws used to stretch foils would then be pulled by the inner frames and tilted towards the GEM stretching direction, and finally exceed the tolerance of the screw hole size and get blocked. This would result in partial application of stretching force to the foils and improper setting of O rings in the screw holes which could further cause gas leakage. In view of these problems, we have developed a new GEM stretching technique called "sliding self-stretching" based upon the original self-stretching technique. In this new technique, the nuts are fixed by the main frame which forces the stretching screws to keep vertical to the side-plane of the mainframe, and the GEM foils can move freely up to 5mm with respect to the main frame. With this sliding self-stretching technique, GEM foils as large as ˜1m can still be stretched very uniformly while gas tightness is ensured. A large-size GEM prototype (1m×0.5m) has been successfully built with this new technique, demonstrating the advantage of the sliding self-stretching technique over the original one in large-size GEM assembly. The GEM prototype was thoroughly tested in terms of uniformity and effective gain. In order to test the spatial resolution of the prototype, we have built a GEM readout system based on APV25. As the first step, we tested a 30 cm×30 cm GEM detector with the readout system, and obtained a good result.
This report presents the details of the sliding self-stretching technique for large-size GEM assembly and test results of a large-size GEM prototypes built with the technique. The performance of the GEM prototypes is also compared to that of large-size GEM detectors built with other techniques.

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Discharge and stability studies for the new readout chambers of the upgraded ALICE TPC

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ALICE (A Large Ion Collider Experiment), taking data at the CERN Large Hadron Collider (LHC), uses a Time Projection Chamber (TPC) to provide tracking and particle identification of charged particles in the central barrel. This TPC is the largest TPC built so far (almost 90m^3 volume) and - while operated in a 0.5T magnetic field - provides a momentum resolution of d$p/p = 1\%$ (at the multiple scattering limit) as well as a dE/dx resolution of 5-7%. The readout chambers are Multi Wire Proportional Chambers (MWPCs), employing a gating grid to prevent ions, which are produced during the gas amplification, from moving into the drift volume. Hence there is a maximal readout rate of about 3kHz - given by the closing time of the grid ($\sim$ 250ms) and the electron drift time through the whole TPC ($\sim$ 90ms).
After the long shut-down 2 (from 2021 onwards) the LHC will provide lead-lead collisions at interaction rates of 50kHz. In order to cope with these rates the TPC needs to be upgraded with new readout chambers, which allow for continuous read-out and preserve the energy and momentum resolution of the current MWPCs. Therefore the amount of ions in the drift volume can only be as big as 1% of the ions produced during the gas amplification. Hence the ion back flow from the chambers has to be small. It was found that chambers with a stack of four Gas Electron Multipliers (GEMs) fulfil these requirements, if the voltages applied to all the GEMs are tuned properly. In addition the chambers must be stable while being operated at the LHC. Hence studies of the discharge behaviour with small prototypes (equipped with only one or two GEMs) as well as stability studies with full readout chambers have been performed. During these studies the phenomenon of "secondary discharges" was observed. This special kind of discharge occurs after an initial discharge in a time between 0 to several 10ms, if the electric field above or below the GEM is high enough.
In this talk we will give an overview of the ALICE TPC upgrade and of the current design status of the GEM based readout chambers. We will focus on the studies of the chamber stability and present our current knowledge on the observed "secondary discharges" and our measures on how to avoid them. This includes our considerations of the high voltage supply schema. In addition we'll give a short outlook on the challenges of the mass production of the new readout chambers.

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The micro-RWELL detector

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The R&D on the micro-Resistive-WELL (μ-RWELL) detector technology aims in developing a new scalable, compact, spark-protected, single amplification stage Micro-Pattern Gas Detectors (MPGD) for large area HEP applications as tracking and calorimeter device as well as for industrial and medical applications as X-ray and neutron imaging gas pixel detector. The novel micro-structure, exploiting several solutions and improvements achieved in the last years for MPGDs, in particular for GEMs and Micromegas, is an extremely simple detector allowing an easy engineering with consequent technological transfer toward the photolithography industry. Large area detectors (up 1x2 m2) can be realized splicing μ-RWELL_PCB tiles of smaller size (about 0.5x1 m2 – typical PCB industrial size). The detector, composed by few basic elements such as the readout-PCB embedded with the amplification stage (through the resistive layer) and the cathode defining the gas drift-conversion gap has been largely characterized on test bench with X-ray and with beam test

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Large Area Resistive Micromegas for the Upgrade of the ATLAS Muon Spectrometer

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Large size resistive Micromegas (MM) detectors will be employed for the first time in high-energy physics experiments for the phase-1 Muon Spectrometer upgrade of the ATLAS experiment at CERN / LHC. The current innermost stations of the muon endcap system, the Small Wheel, will be upgraded in 2019 to retain the good precision tracking and trigger capabilities in the high background environment expected with the upcoming luminosity increase of the LHC. Along with the small-strip Thin Gap Chambers (sTGC) the "New Small Wheel" will be equipped with eight layers of MM detectors arranged in multilayers of two quadruplets, for a total of about 1200 m^2 detection planes. All quadruplets have trapezoidal shapes with surface areas between 2 and 3 m^2. The MM system will provide both trigger and tracking capabilities. A transverse momentum resolution of about 15% for 1 TeV muon is required, as a consequence, each MM plane must achieve a spatial resolution of the order of 100 μm independent of the track incidence angle. To keep systematics under control a challenging mechanical precision is required in the construction; the position of the readout elements (the strips) of the assembled module must be known with an accuracy of 30 μm along the precision coordinate and 80 μm perpendicular to the plane. The detector will operate in a very challenging environment: an inhomogeneous magnetic field (B < 0.3 T), and a background rate up to ˜15 kHz/cm^2 In the recent years, the achievement of the required performance has been demonstrated with dedicated test-beams performed on small (10×10 cm^2) resistive MM detectors. This talk will review all the work done to move from the small (with bulk technology) prototypes to the large final detector with the same resistive scheme but using a mechanical floating mesh. In May 2016 the first full size prototype (modules-0) has been completed and studied on a dedicated test beam at Cern, then used to perform mechanical studies for the detector assembly in the wheel and for the performances under deformation. Results of these tests will be shown.

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Precise Calibration of Large Area Micromegas Detectors Using Cosmic Rays

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Currently m^2-sized micropattern detectors with spatial resolution better than 100 μm and online trigger capability are of big interest for many experiments. Large size in combination with superb spatial resolution and trigger capability implicates that the construction of these detectors is highly sophisticated and imposes strict mechanical tolerances. We developed a method to survey assembled and working detectors on potential deviations of the micro pattern readout structures from design value as well as deformations of the whole detector, using cosmic muons in a tracking facility.
The LMU Cosmic Ray Facility consists of two 8 m^2 ATLAS Monitored Drift Tube chambers (MDT) for precision muon reference tracking and two segmented trigger hodoscopes with sub-ns time-resolution and additional 10 cm position information along the wires of the MDTs. It provides information on homogeneity in efficiency and pulse height of one or several micropattern detectors installed in between the MDTs. With an angular acceptance of $-30°$ to $+30°$ the comparison of the reference muon tracking with centroidal position determination or time projection chamber like track reconstruction in the micropattern detector allows for calibration in three dimensions. We present results of a m^2-sized one-dimensional resistive strip Micromegas detector consisting of two readout boards with in total 2048 strips, read out by 16 APV25 front-end boards. This 16-fold segmentation along the precision direction in combination with a 10-fold segmentation in orthogonal direction by the resolution of the trigger hodoscope, allows for very detailed analysis of the 1 m^2 detector under study by subdivision into 160 partitions, each being analyzed separately.

We are able to disentangle deviations from the readout strip straightness and global deformation due to the small overpressure caused by the Ar:CO_2 gas flux.
We introduce the alignment and calibration procedure, report on homogeneity in efficiency and pulse height and present results on deformation and performance of the m^2-sized Micromegas.

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Construction and Quality Assurance of Large Area Resistive Strip Micromegas for the Upgrade of the ATLAS Muon Spectrometer

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To cope with the increased background induced hit rate of up to ˜15 kHz/cm^2 in the innermost stations of the muon endcap system of the ATLAS experiment after the high-luminosity upgrade of the LHC, the currently used precision detectors will be replaced by resistive strip Micromegas in 2019. In the "New Small Wheel" the Micromegas will be arranged in two times four detection layers built of trapezoidally shaped quadruplets of four different sizes.The Micromegas quadruplets will consist of 5 panels, 3 drift panels and 2 readout panels, made of aluminum honeycomb core sandwiched by printed circuit boards (PCBs).
To achieve 15% transverse momentum resolution for 1 TeV muons and thus a spatial resolution in a single plane of about 100 μm, each active plane has to have an accuracy of 80 μm perpendicular to the plane and the alignment of the readout strips on the individual PCBs and particularly the alignment within a quadruplet must fulfill a challenging precision of 30 μm. The required mechanical precision for the production of the components and their assembly is a key point and must be controlled during construction and integration. The readout strips are etched on PCB boards using classical photolithographic processes accompanied by comprehensive quality control. Depending on the type of the module 3 or 5 PCB boards need to be joined and precisely aligned to form a full readout plane. The precision in the alignment is reached either by use of precision mechanical holes as reference for precision pins or by optical alignment of masks, both referenced to the strip pattern. Assembly procedures have been developed to build the single panels with the required mechanical precision. The assembly of a quadruplet includes exact stretching and mounting on very accurate frames of the four stainless steel micro-meshes. Methods to confirm the precision of components and assembly are based on precise optical devices and X-ray or cosmic muon investigations.
We will report on the construction procedures for the Micromegas quadruplets, on the quality control procedures and results, and on the assembly and calibration methods

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Study of some aspects of straw tube detectors for CBM-MuCh

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The Compressed Baryonic Matter (CBM) experiment at the future Facility for Antiproton and Ion Research (FAIR) in Darmstadt, Germany is designed to explore the QCD phase diagram in the region of moderate baryon densities. This will only be possible with the application of advanced instrumentation, including highly segmented and fast gaseous detectors. Keeping in mind the high interaction rate at FAIR, the Muon Chamber (MuCh) detector in CBM will use Gas Electron Multiplier (GEM) chambers in the first two stations and straw tubes are the candidates for the 3rd and 4th stations.
We have carried out R&D with one small straw tube detector and the efficiency and gain have been studied with premixed gas of Ar/CO2 70/30. The count rates are measured with different radioactive sources. The attenuation of signal and the variation of gain with rate are also measured. The details of the measurement process and the experimental results will be presented.

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The cylindrical GEM detector of the KLOE-2 experiment

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The KLOE-2 experiment started its data taking campaign in November 2014 with an upgraded tracking system at the DAΦNE electron-positron collider at the Frascati National Laboratory of INFN. The new tracking device, the Inner Tracker, operated together with the KLOE-2 Drift Chamber, has been installed to improve track and vertex reconstruction capabilities of the experimental apparatus.
The Inner Tracker is a cylindrical GEM detector composed of four cylindrical triple-GEM detectors, each provided with an X-V strips-pads stereo readout. Although GEM detectors are already used in high energy physics experiments, this device is considered a frontier detector due to its fully-cylindrical geometry: KLOE-2 is the first experiment benefiting of this novel detector technology.
Alignment and calibration of this novel detector will be presented together with its operating performance and reconstruction capabilities.

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Cherenkov detectors with aerogel radiators

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This review discusses the application of the aerogel as radiator in Cherenkov detectors. The talk gives the view on the history of use of aerogel in detectors for particle physics experiments. Physical principles of such detectors construction and operation are described. Data on threshold Cherenkov counters with direct light collection and on those using wavelength shifters are presented. Also presented are data on Ring Image Cherenkov detectors with single and multilayer focusing aerogel radiators.

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Aerogel RICH counter for the Belle II forward PID

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The Belle II spectrometer, a follow up of the very successful Belle experiment, is in the last stages of construction at the SuperKEKB electron-positron collider at KEK in Japan. For the PID

system in the forward region of the spectrometer, a proximity focusing RICH counter with aerogel radiator (ARICH) will be employed. The detector will provide a 4σ separation of pions and kaons up to momenta of 3.5 GeV/c, at the kinematic limits of the experiment. ARICH consists of ring-shaped radiator and photon-detector planes, separated by ~20 cm of expansion volume and covering an area of ~3m^2. The radiator plane is covered by aerogel tiles and the detector plane is formed by an arrangement of 420 Hybrid Avalanche Photo-Detector (HAPD) modules. HAPD provides high efficiency single photon detection in the high magnetic field of the spectrometer (1.5 T) and withstands high radiation levels expected at the experiment.
The production and quality assurance tests of all detector components were finished in 2016, and their installation into ARICH is largely completed. One sector of fully equipped ARICH is being used for the detector cosmic test. In the talk we will report on the ARICH design, current construction status and recent results from the cosmic test and detector simulation studies.

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AMS-02 RICH detector in space: status and results

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AMS-02 is a high-energy particle physics magnetic spectrometer installed on the International Space Station (ISS) in May 2011, succesfully operating and taking data since then. The goal of the experiment is to carry out precise measurements of cosmic rays in the energy range from GeV/n to TeV/n by means of specialized sub-detectors. The Ring Imaging Cherenkov (RICH) provides AMS with a precise measurement of the particle velocity and charge. The AMS-02 RICH layout follows a proximity focusing design with two radiators. The central part of the radiator is formed by 16 sodium fluoride (NaF) tiles with a refractive index n = 1.33, surrounded by 92 tiles of silica aerogel with a refractive index n = 1.05. The challenges and the experience gained operating the detector in space for 5 years will be presented. RICH critical parameters are constantly monitored to ensure detector integrity and optimal performance. The long term stability of the system and the effect of varying environmental conditions will be addressed with special focus on the aerogel radiator. Finally, examples of the use of the RICH detector for the measurement of the isotopic composition of light elements in CR will be shown.

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R&D of Focusing Aerogel RICH detectors

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Focusing Aerogel RICH (FARICH) is a novel type of Cherenkov detector that employs radiator of multi-layer or inhomogenious aerogel to get focussed Cherenkov rings in the photon detector plane. This tehnique allows one to achieve an excellent Cherenkov angle resolution that allows one, for example, to separate muons and pions up to 2 GeV/c momentum that is neeeded for the Super Charm-Tau factory project in Novosibirsk. FARICH R&D started in 2004 is followed. Applications of the FARICH detectors in the forthcoming and future experiments are described, including the Forward RICH detector for the PANDA experiment. Beam tests results of FARICH prototypes are reported.

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Status of installation and commissioning for the Belle II time-of-propagation counter

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The Time-Of-Propagation (TOP) counter in the Belle II experiment is a novel device for particle identification (PID), where a Cherenkov ring image is reconstructed based on timing information of each photon. This can provide better performance of PID than the PID detectors of the former Belle experiment, while compact and low-mass detector system is realized at the same time. We started detector construction at the beginning of 2015 and installation was successfully finished in the middle of 2016. Commissioning of the installed detector with laser calibration system and cosmic ray muons is now in progress toward the physics data taking, which shows reasonable performance of this detector. In this presentation, processes of detector production and initial performance check as well as status of commissioning after installation are reported.

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The PANDA DIRC detectors at FAIR

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The PANDA experiment at the FAIR facility will use antiproton beams on a fixed target to investigate open questions in hadron physics in the momentum range of 1.5-15 GeV/c. Two DIRC detectors in the target spectrometer will provide charged particle identification (PID) for pions and kaons. The Barrel DIRC covers polar angles between 22○ and 140○ and momenta between 0.5 GeV/c and 3.5 GeV/c. It is based on the successful BaBar DIRC detector, but with several key improvements to perform π/K separation better than 3σ. In the (forward) endcap region, for polar angles between 5○ to 22○, the Disc DIRC will cleanly separate π from K for momenta up to 4 GeV/c. Both DIRC counters will use lifetime-enhanced microchannel plate PMTs for photon detection in combination with fast readout electronics. The radiators are made from highly polished synthetic fused silica to minimize the loss of photons propagating through the radiators by total internal reflection and to ensure that the Cherenkov is conserved. Geant4 simulations and tests with several prototypes at various test beam facilities have been used to evaluate the designs and validate the expected PID performance of both PANDA DIRC counters.

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Advances in Solid State Photon Detectors

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This presentation reviews the latest developments in solid state photo-detectors, discusses the SiPM properties and problems and gives a speculative outlook on their future evolution. A special attention is paid to new developments in the field of radiation-hard SiPMs.

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MPGD-based photon detector upgrade for COMPASS RICH

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The RICH detector of the COMPASS Experiment at CERN SPS is undergoing an important upgrade: the central MWPC-based photon detectors have been replaced with novel Micropattern detectors, to cope with the challenging efficiency and stability requirements of the new COMPASS measurements.
The new hybrid MPGD detector consists of two layers of ThickGEMs and capacitive bulk Micromegas. Photoconversion takes place on the CsI layer deposited onto the first ThickGEM; while position information and signals are read out from the pad-segmented anode via capacitive coupling by analog FEE based on APV25 chips.
The presentation focuses on the main issues of production, detailed quality assessment technique, and the commissioning status of the first in-experiment MPGD-based RICH. The talk will be given on behalf of a the COMPASS RICH Group.

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The PANDA barrel-TOF detector at FAIR

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The triggerless detector system $\bar{P}$ANDA which is being built at the FAIR facility. The versatile detector system will enable us to study open questions in hadron physics, by doing charmonium spectroscopy with precision measurements of mass, width and decay branches, investigating possible exotic states, search for modifications of charmed hadrons in nuclear matter and gamma-ray spectroscopy of hypernuclei by using antiprotons on a cluster jet or a pellet target in the momentum range of 1.5 to 15 GeV/c.
The barrel-TOF subdetector is one of the outer layers of the multi-layer design of the PANDA barrel. It is designed with a minimal material budget in mind mainly consisting of 90x30x5 mm^3 thin plastic scintillator tiles read out on each end by a serial connection of 4 SiPMs. 120 such tiles are placed on 16 2460 x 180 mm^2 PCB boards forming a barrel covering an azimuthal angle from 22.5° to 150°. The detector is designed to achieve a time resolution below 100 ps (sigma) which allows for good event separation as well as particle identification below the Cherenkov threshold via the time-of-flight, simultaniously providing the interaction times of events. The current prototype achieved ˜60 ps, well below the design goal.
The R&D is in a matured stage and a technical design report is currently being reviewed by the collaboration. In this contribution the whole project from the design concept to the latest result of test beamtime as well as the future outlook will be presented.

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Micro-channel plates in ionisation mode as a fast timing device for future hadron colliders

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Future high rate hadron colliders are expected to have hundreds of concurrent proton-proton interactions in the same bunch crossing, deteriorating the reconstruction of the hard scattering event and the identification of calorimeters. The possibility to distinguish neutral particles coming from different interaction vertices is being pursued as a tool to reduce pile-up contamination in calorimeters, and restore optimal performance. At the high luminosity LHC (HL-LHC) about 200 concurrent interactions are expected, with a spread between the interaction vertices of few centimeters in the beam direction and 200ps in the collision time. A time of flight resolution of the order of 30 ps would be able to reduce neutral particles pile-up contamination at the calorimeter level of about one order of magnitude, restoring pile-up conditions similar to what is routinely sustained in the current run of the LHC. Micro-channel plates have been used in PMT configuration as fast charged particles detector (resolution of better than 20 ps have been achieved with commercial devices), however they are not particularly radiation tolerant, mostly due to the ion feedback on the photocathode. The possibility of using micro-channel plates without a photocathode (i-MCP) has been studied in several test beams. Different MCP geometries are compared with the goal to identify the optimal configuration. Efficiency of more then 70% with a time resolution of better than 40 ps are achieved for single charged particles, leading to an efficiency close to 100% for EM shower after few radiation lengths. This open the possibility to use i-MCPs as a timing layer in a sampling calorimeter or to use it in a pre-shower device independent from the calorimeter technology.

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K long and muon system for the Belle II experiment

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A new K0L and muon detector based on scintillators will be used in the Belle II experiment, currently at the final stages of construction. The increased luminosity of the e+e- SuperKEKB collider entails challenging detector requirements. Relatively inexpensive polystyrene scintillator strips with wavelength shifting fibers ensure a sufficient light yield at the Silicon PhotoMultiplier (SiPM) photodetector, are robust and provide improved physics performance for the Belle II experiment compared to its predecessor, Belle.

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Charged Particle Hodoscope for NA62 experiment and it's performance in 2016 run

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A new Charged Particle Hodoscope (CHOD) detector for the NA62 experiment has been designed, constructed, installed and integrated with NA62 data acquisition system.Main purpose of the new detector are: to identify trigger topologies with charged particles in the fiducial volume and to detect conversion and hadron interactions of particles in the material upstream. The design features and performance of the NA62 CHOD in 2016 run are presented.

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A custom readout electronics for the BESIII CGEM detector

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The design of a custom front-end electronics for the readout of the new inner tracker of the BESIII experiment, carried out at BEPCII in Beijing, is presented. For the upgrade of the inner detector, planned for 2018, a lightweight tracker based on an innovative Gas Electron Multiplier (GEM) cylindrical detector is now under development. The analogue readout of the CGEM enables the use of a charge centroid algorithm to improve the spatial resolution to better than 130 μm while loosening the pitch strip to 650 μm, which allows to reduce the total number of channels to about 10 000. The channels are readout by 160 dedicated integrated 64-channel front-end ASICs, providing a time and charge measurement and featuring a fully-digital output.
The energy measurement is extracted either from the time-over-threshold (ToT) or the 10-bit digitisation of the peak amplitude of the signal. The time of the event is generated by quad-buffered low-power TDCs, allowing for rates up to 60 kHz per channel. The TDCs are based on analogue interpolation techniques and produce a time stamp (or two, if working in ToT mode) of the event with a time resolution better than 100 ps. The front-end noise, based on a CSA and a two-stage complex conjugated pole shapers, dominate the channel intrinsic time jitter, which is less than 5 ns r.m.s.. The time information of the hit can be used to reconstruct the track path, operating the detector as a small TPC and hence improving the position resolution when the distribution of the cloud, due to large incident angle or magnetic field, is very broad.
Event data is collected by an off-detector motherboard, where each GEM-ROC readout card handles 4 ASIC carrier PCBs (512 channels). Configuration upload and data readout between the off-detector electronics and the VME-based data collector cards are managed by bi-directional fibre optical links.
This talk will cover the relevant design aspects of the detector electronics and the front-end ASIC for the CGEM readout, and review the first silicon results of the chip prototype.

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Phase-I Trigger Readout Electronics Upgrade for the ATLAS Liquid-Argon Calorimeters

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The upgrade of the Large Hadron Collider (LHC) scheduled for shut-down period of 2018-2019, referred to as Phase-I upgrade, will increase the instantaneous luminosity to about three times the design value. Since the current ATLAS trigger system does not allow sufficient increase of the trigger rate, an improvement of the trigger system is required. The Liquid Argon (LAr) Calorimeter read-out will therefore be modified to use digital trigger signals with a higher spatial granularity in order to improve the identification efficiencies of electrons, photons, tau, jets and missing energy, at high background rejection rates at the Level-1 trigger. The new trigger signals will be arranged in 34000 so-called Super Cells which achieves 5-10 times better granularity than the trigger towers currently used and allows an improved background rejection. The readout of the trigger signals will process the signal of the Super Cells at every LHC bunch-crossing at 12-bit precision and a frequency of 40 MHz. The data will be transmitted to the back-end using a custom serializer and optical converter and 5.44 Gb/s optical links. In order to verify the full functionality of the future Liquid Argon trigger system, a demonstrator set-up has been installed on the ATLAS detector and is operated in parallel to the regular ATLAS data taking during the LHC Run-2. Noise level and linearity on the energy measurement have been verified to be within our requirements. In addition, we have collected data from 13 TeV proton collisions during the LHC 2015 run, and have observed real pulse from the detector through the demonstrator system. The talk will give an overview of the Phase-I Upgrade of the ATLAS Liquid Argon Calorimeter readout and present the custom developed hardware including their role in real-time data processing and fast data transfer. This contribution will also report on the performance of the newly developed ASICs including their radiation tolerance and on the performance of the prototype boards in the demonstrator system based on various measurements with the 13 TeV collision data. Results of the high-speed link test with the prototypes of the final electronic boards will be also reported.

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Electronics for CMS Endcap Muon Level-1 Trigger System Phase-1 and HL LHC Upgrades

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To accommodate high-luminosity LHC operation at 13 TeV collision energy, the CMS Endcap Muon Level-1 Trigger system had to be significantly modified. To provide the best track reconstruction, the trigger system must now import all available trigger primitives generated by Cathode Strip Chambers and by certain other subsystems, such as Resistive Plate Chambers (RPC). In addition to massive input bandwidth, this also required significant increase in logic and memory resources. To satisfy these requirements, a new Sector Processor unit has been designed. It consists of three modules. The Core Logic module houses the large FPGA that contains the track-finding logic and multi-gigabit serial links for data exchange. The Optical module contains optical receivers and transmitters; it communicates with the Core Logic module via a custom backplane section. The Pt Lookup Table (PTLUT) module contains 1 GB of low-latency memory that is used to assign the final Pt to reconstructed muon tracks. The μTCA architecture (adopted by CMS) was used for this design. The talk presents the details of the hardware and firmware design of the production system based on Xilinx Virtex-7 FPGA family. The next round of LHC and CMS upgrades starts in 2019, followed by a major High-Luminosity (HL) LHC upgrade starting in 2024. In the course of these upgrades, the new Gas Electron Multiplier (GEM) detector and more RPC chambers will be added to the Endcap Muon system. In order to keep up with all these changes, a new Advanced Processor unit is being designed. This device will be based on Xilinx UltraScale+ FPGAs. It will be able to accommodate up to 100 serial links with bit rates of up to 25 Gb/s, and provide up to 2.5 times more logic resources than the device used currently. The amount of PTLUT memory will be significantly increased to provide more flexibility for Pt assignment algorithm. The talk presents preliminary details of the hardware design program.

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Front-End Electronics development status for TPC detector of MPD/NICA project

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The TPC is placed in the center of a Multi Purpose Detector comprising the interaction point of colliding beams together with other central detectors that provides the recovery and identification of charged particle tracks in the pseudorapidity's range $|\eta| \leq 1.2$ in future NICA collider experiments. The readout system is one of the most complex parts of the TPC. The electronics of each readout chambers is an independent system. The whole system contains 95232 channels, 1488 64-ch. front-end cards (FEC), 24 readout control units (RCU). The front-end electronics (FEE) based on modern ASICs, FPGA and high-speed serial links. Development status, measurement results and possible design improvements of the TPC front-end electronics presented.

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Precision Timing concepts in large scale distributed astroparticle experiments

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Time synchronization to sub-nsec precision of detector systems distributed over large areas is requested in modern astroparticle experiments, like upcoming Gamma-Ray and Cosmic-Ray detector arrays, to ensure optimal pattern recognition and background rejection.
White-Rabbit (WR), a new ethernet-based technology for time and frequency transfer, is well suited for this purpose. It allows clock-synchronziation and trigger-time stamping to sub-nanosecond precision over multi-km scale distances. This technology also supports new complex and flexible topological trigger strategies, based on ethernet-routed timestamps.
We present design and results from the White-Rabbit installation in the TAIGA-HiSCORE array, gained over several years; and discuss upcoming applications like e.g. the Cherenkov-Telescope-Array (CTA) and high energy neutrino telescopes.
Excellent field performance, design flexibility at timing and triggering level, open soft- and hardware approach with strong community support and documentation, commercial availability, easy integration into modern system monitoring architectures, and the striking cost-efficiency make White-Rabbit a new de-facto experimental standard, and advantageous over custom-made solutions.

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Monitoring Single Event Upsets in SRAM-based FPGAs at the SuperKEKB Interaction Point

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Static RAM-based Field Programmable Gate Arrays (SRAM-based FPGAs) [1, 2] are widely adopted in Trigger and Data Acquisition (TDAQ) systems of High-Energy Physics (HEP) experiments for implementing fast logic due to their re-configurability, large real-time processing capabilities and embedded high-speed serial IOs. However, these devices are sensitive to radiation effects such as single event upsets (SEUs) or multiple bit upsets (MBUs) in the configuration memory, which may alter the functionality of the implemented circuit. Therefore, they are normally employed only in off-detector regions, where no radiation is present. Special families of SRAM-based FPGAs (e.g. the Xilinx Virtex-5QV) have been designed for applications in radiation environments, but their excessive cost (few 10k USD), with respect to their standard counterpart ($\sim$ 500 USD), usually forbids their usage in many applications, including HEP. Therefore, there is a strong interest in finding solutions for enabling the usage of standard SRAM-based FPGAs also on-detector. Methods based on modular redundancy and periodic refresh of the configuration, i.e. configuration scrubbing, are used in order to mitigate single event effects, which become more significant as the technological scaling proceeds towards smaller feature sizes. In fact, latest devices also include dedicated circuitry implementing error correcting codes for mitigating configuration errors. The expected bit configuration upset rate is valuable information for choosing which protection strategy, or which mixture of strategies, to adopt. Typically, test campaigns are carried out at dedicated irradiation facilities by means of heavy ions, proton and neutron beams [3,4,5] and they permit to determine the particle to bit error

cross section. However, a reliable prediction of the upset rate, and of radiation effects in general, requires the knowledge of the cross section as function of the particle species and their spectra and it depends on a detailed knowledge of the radiation fluxes. Often such information is not available with sufficient precision, and when possible an in situ (or in flight for space applications) measurement of the upset rate is highly recommended. For instance, experiments at the Large Hadron Collider have been monitoring SEUs in readout control FPGAs [6], experiments in space have been launched in order to measure single event effects rates and compare them to predictions based on cross sections [7]. Furthermore, over the last decade, FPGA vendors have been carrying out experiments aimed at measuring SEUs induced by atmospheric neutrons in their devices [8].
In February 2016, the SuperKEKB [9] e^+e^- high-luminosity ($8 \cdot 10^{35} cm^{-2} s^{-1}$) collider of the KEK laboratory (Tsukuba, Japan) started being commissioned. A dedicated commissioning detector, named BEAST2, has been being used to characterize beam backgrounds prior to the Belle2 detector roll into the beams and to provide tuning parameters for Monte Carlo simulations. BEAST2 consists of a fiberglass support structure and several subdetectors mounted onto it, including time projection chambers (TPCs) and He-3 tubes.
In this work, we present direct measurements of radiation-induced soft-errors on a SRAM-based FPGA device installed on the BEAST2 frame at a distance of $\sim$ 1 m from the beam interaction point. Our goal is to provide experimental results of the expected FPGA configuration error rate and power consumption variation at Belle2 and at other experiments operating in similar radiation conditions. For this study, we designed a dedicated board hosting a Xilinx Kintex-7 325T device without additional active components, in such a way to be able to decouple FPGA failures from those of other devices. The board receives power and clock from dedicated remote generators installed in a counting room. The configuration and read back are performed via a JTAG connection and they are managed by a dedicated single board computer . During the commissioning of the collider, we periodically read back the FPGA configuration in order to detect errors and we logged the power consumption on the different power domains of the device. Currents for both electron and positron rings spanned a range between 50 and 500 mA, therefore providing data about the FPGA in different radiation conditions. Even if the machine is not providing collisions yet, as the beams are not focused to the interaction point, our results show a rate of 0.02 upsets/day averaged over the whole commissioning time frame. BEAST2 subdetectors provided valuable information about the radiation environment. This work is part of the ROAL SIR project funded by the Italian Ministry of Research (MIUR).
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Monitoring complex detectors: the uSOP approach in Belle II experiment

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uSOP is a general purpose single board computer designed for deep embedded applications in control and monitoring of detectors, sensors, and complex laboratory equipment. In this work we present and discuss the main aspects of the hardware and software design and the expandable peripheral architecture built around field busses. We show the tests done with state-of-art DS 24-bit ADC acquisition modules, in order to assess the achievable noise floor in a typical application. We report on the deployment of uSOP in the monitoring system framework of the ECL endcap calorimeter of the Belle2 experiment, presently under construction at the KEK Laboratory (Tsukuba, J).

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The Belle II Pixel Detector Data Aquisition and Background Suppression System

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The Belle II experiment, at the future SuperKEKB collider in Tsukuba, Japan, features a design luminosity of $8 \cdot 10^{35}$ cm^{-2}s^{-1}, which is a factor of 40 larger than its predecessor KEKB. The pixel detector (PXD) with about 8 million pixels is based on the DEPFET technology and will improve the vertex resolution in beam direction by a factor of 2. With an estimated trigger rate of 30 kHz, the PXD is expected to generate a data rate of 20 GBytes/s, which is about 10 times larger than the amount of data generated by all other Belle II subdetectors.
Due to the large beam-related background, the PXD needs a data acquisition system with high-bandwidth data links and realtime background reduction by a factor of 10 as otherwise the event builder will be saturated. To achieve this, the Belle II pixel DAQ uses an FPGA-based computing platform with high speed serial links implemented in the ATCA (Advanced Telecommunications Computing Architecture) standard.
The architecture and performance of the data acquisition system and data reduction of the PXD will be presented.
In April 2016 a prototype PXD-DAQ system, which was operated in a test beam campaign, delivered first data with the whole readout chain under realistic, high rate conditions. Final results from the test beam will be presented.

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Electronic readout system for Belle II imaging Time of Propagation detector

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The imaging Time of Propagation (iTOP) detector is a new quartz Cherenkov radiation detector to work at the Belle II experiment. The iTOP will identify, with high precision, charged hardons created in electron-positron collisions at the SuperKEKB collider. With its timing resolution of less than 50 ps, the iTOP will help searching for rare and previously unobserved physics events while minimizing effects of SuperKEKB beam backgrounds on the reconstructed data. The iTOP is built as a 16-module barrel detector placed at Belle II between the Central Drift Chamber and the Electromagnetic Calorimeter. In the iTOP, Cherenkov photon signals are collected by microchannel plate photomultiplier tubes. Sixty four (four per each iTOP module) 128-channel electronic Subdetector Readout Modules (SRMs) sample the collected photon signals, digitize them, read out the digitized data, and then forward them to the Belle II back-end data acquisition system. Every SRM is composed of five boards. Four of those boards carry application-specific integrated circuits (ASICs) that perform sampling and digitization; every board (the ASIC carrier board) has four 8-channel ASICs mounted on it. Sampling and digitization in each channel is done by a 16 x 32 (x 64) switched capacitor array using Wilkinson method. The ASIC carrier board, in addition, has a field-programmable gate array that reads out the digitized data from the on-board ASICs. The fifth board of the SRM, named as Standard Control Readout Data (SCROD) board, collects data from the four ASIC carrier boards, then buffer and forward them through an optical link to the back-end data acquisition system. The field-programmable gate array mounted on the SCROD board formats the data collected from the ASIC carrier boards. The iTOP 8192-channel front-end electronic readout system was built and integrated at Belle II. In situ commissioning of the system is underway. Performance studies of the calibration laser data acquisition, with and without magnetic field of 1.5 T, demonstrate that the iTOP channels collect data with the timing resolution of less than 50 ps.

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Data Aquisition System for the PENeLOPE Experiment using the Unified Communication Framework

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PENeLOPE is a neutron-lifetime experiment aiming for high precision by counting neutrons and decay protons. The proton detector consists of about 1250 Avalanche Photodiodes (APDs) with a total active area of 1225 cm^2. The detector and electronics will be operated on a high electrostatic potential of -30 kV, in a magnetic field of 0.6 T and at a temperature of 77 K. The electronics include low-noise preamplifiers, CR-RC shapers, ADCs and FPGAs. Each FPGA reads out 96 12-bit SAR-ADCs with 1 MSps in parallel. We developed a firmware for the FPGAs including a self-triggering readout with continuous pedestal calculation and configurable trigger threshold. The data transmission and configuration is done via the Unified Communication Framework (UCF) we developed at the Technical University of Munich. UCF is a unified network protocol developed for FPGAs with built-in high-speed serial interfaces. It provides up to 64 different communication channels via a single serial link. One channel is reserved for timing and trigger information, the other channels can be used for slow-control interfaces and data transmission. All channels are bidirectional and share network bandwidth according to assigned priority. The timing channel distributes messages with fixed latency and low jitter (about 20 ps) in one direction. From this point of view the protocol implementation is asymmetrical. The framework supports point-to-point connections and star-like 1:n topologies. The star-like topology can be used for front-ends with low data rates and time-distribution systems. In this topology, the master broadcasts information according to assigned priorities, the slaves communicate in a time-sharing manner to the master.
The project is supported by the Maier-Leibnitz-Laboratorium (Garching), the Deutsche Forschungsgemeinschaft and the Excellence Cluster "Origin and structure of the Universe".

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Plans and Status of the SuperKEKB and BelleII Project

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Characterisation of novel prototypes of monolithic HV-CMOS pixel detectors for high energy physics experiments

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An upgrade of the ATLAS experiment for the High Luminosity phase of LHC is planned for 2024 and foresees the replacement of the present Inner Detector with a new Inner Tracker completely made of silicon devices.
Depleted Monolithic Active Pixel Sensors (DMAPS) built with High Voltage CMOS (HV-CMOS) technology are investigated as an option to cover large areas in the outermost layers of the pixel detector and are especially interesting for the development of monolithic devices which will reduce the production costs and the material budget with respect to the present hybrid assemblies. For this purpose the H35Demo, a large area HV-CMOS demonstrator chip, was designed by KIT, IFAE and University of Liverpool, and produced in AMS 350 nm CMOS technology. It consists of four pixel matrices and additional test structures. Two of the matrices include both amplifiers and discriminator stages and are thus designed to be operated as monolithic detectors.
In these devices the signal is mainly produced by charge drift in a small depleted volume obtained increasing the bias voltage to the order of 100 V or more. Moreover, this technology allows to enclose the electronics in the same deep n-wells also used as collecting electrodes to enhance the radiation hardness of the chip.
In this contribution the characterisation of H35Demo chips and results of the very first test beam measurements of the monolithic matrices with high energetic pions at CERN SpS will be presented.

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Scintillating Fibre Detector for the Mu3e Experiment

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Mu3e is a dedicated experiment for the rare lepton flavour violating decay $\mu^+ \to e^+e^-e^+$. Its ultimate goal is to find or exclude this process if it occurs more than once in 10^{16} muon decays. This constitutes four orders of magnitude improvement with respect to the predecessor. A thin multi-layer scintillating fibre detector consisting of 250 μm thick fibres read out on both sides with silicon photomultiplier arrays provides an excellent time measurement with $\sigma < 500$ ps in order to reject combinatorial background at a muon stopping rate around 10^8 muon/s, concurrently minimizing the material budget to $X/X_0 < 0.3\%$. The design, performance and readout concept, including the dedicated readout chip MuTRiG, is presented.

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Inner Detector Track Reconstruction and Alignment at the ATLAS Experiment

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The Inner Detector of the ATLAS experiment at the LHC is responsible for reconstructing the trajectories of charged particles ('tracks') with high efficiency and accuracy. It consists of three subdetectors, each using a different technology to provide measurements points. An overview of the use of each of these subdetectors in track reconstruction, as well as the algorithmic approaches taken to the specific tasks of pattern recognition and track fitting, is given. The performance of the Inner Detector tracking will be summarised. Of crucial importance for optimal tracking performance is precise knowledge of the relative positions of the detector elements. ATLAS uses a sophisticated, highly granular software alignment procedure to determine and correct for the positions of the sensors, including time-dependent effects appearing within single data runs. This alignment procedure will be discussed in detail, and its effect on Inner Detector tracking for LHC Run 2 proton-proton collision data highlighted.

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A T0/Trigger Detector for the External Target Experiment at CSR

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A new T0/Trigger detector based on multi-gap resistive plate chamber (MRPC) technology has been constructed and tested for the exteranl target experiment (ETE) at CSR. It measures the multiplicity and timing information of particles produced in heavy-ion collisions at the target region, providing necessary event collision time (T0) and collision centrality with high precision. Monte-Carlo simulation shows a time resolution of several tens of picosecond can be achieved at central collisions. The experimental tests have been performed for this detector at both IHEP-E3 beam line and the CSR-ETE. The preliminary results will be shown to clarify the performance of the T0/Trigger detector.

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Pulse-shape discrimination with Cs2HfCl6 crystal scintillator

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Very recently, significant interest in crystal scintillators with $KPtCl_6$ structure has been renewed since they possess a high light yield, linear response at low energies, and good energy resolution. Cs_2HfCl_6 (CHC), in particular, a crystal belonging to the same structure group, is one of the most promising scintillator for gamma spectroscopy giving almost 54000 ph/MeV light yield

and 3.3% energy resolution at 662 keV. In addition, the CHC crystal is the first scintillating material containing a high fraction of Hf in mass (of about 25%). This opens new opportunities to search for a rare nuclear processes occurring in Hf isotopes applying the "source = detector" experimental approach with high sensitivity.
Here we report the results of our investigation into a 3 cm^3 CHC crystal as a promising detector of search for rare nuclear processes occurring in Hf isotopes. For this reason, the response of the crystal to irradiation by alpha particle was studied. The quenching factor for 5 MeV alpha particles is 0.28, showing that alpha particles produce almost a third of the light produced by gamma quanta. This crystal has also shown the ability to discriminate between different types of radiation by applying pulse-shape discrimination techniques. For example, using the optimal filter method we determined the separation between signals with a Factor of Merit (FOM) = 6.08 for energy at 1 MeV. This means we can fully separate signals induced by alpha particles from those of gamma quanta. Similar results were obtained using the mean time method.
The internal radioactive contamination of our 3 cm^3 CHC was also studied. Using low-background measurements with germanium gamma-spectrometer at Gran Sasso Underground Laboratory (Italy). The resulting analysis concluded that the crystal is free from nuclides of U/Th natural decay chains, only limits were set of their activities at the level of few mBq/kg were seen after 500 hours of measurements. However, the crystal contains artificial ^{137}Cs nuclide (0.8 Bq/kg) and ^{134}Cs at levels of tens of mBq/kg. Also observed nuclides produced by cosmic ray irradiation ^{132}Cs and ^{181}Hf with activities at the level of tens of mBq/Kg.
The prospects of the CHC scintillating crystal as a detector to search for rare nuclear decay of Hf isotopes is discussed.