International Conference on New Photo-Detectors (PD15)

Monday 06 July 2015 - Thursday 09 July 2015

Moscow, Troitsk

Book of Abstracts

Contents

Morning Session 8 July/A / 0

Readout scheme for the Baby-MIND detector

Author(s): NOAH, Etam[1]
Co-author(s): Prof. KUDENKO, Yury [2] ; Prof. BLONDEL, Alain [1] ; FAVRE, Yannick [1] ; MINEEV, Oleg [3] ; Prof. TSENOV, Roumen [4]

[1] *University of Geneva*

[2] *INR*

[3] *INR RAS*

[4] *University of Sofia*

Corresponding Author(s): etam.noah@cern.ch

A readout scheme has been designed for the plastic scintillator bars of the Baby-MIND detector modules. This spectrometer will measure momentum and identify the charge of ˜1 GeV/c muons with magnetized iron plates interleaved with detector modules. One challenge the detector aims to address is that of keeping high charge identification efficiencies for momenta as low as ˜300 MeV/c where multiple scattering in the iron plates degrades momentum resolution. A front-end board has been developed, with 3 CITIROC readout chips per board and up to 96 channels. Functional prototypes of the front-end board are planned for April 2015. Hamamatsu MPPCs type S12571-025C were chosen following extensive comparisons, mapping of the light output from the wavelength shifting fiber and validation of the custom optical connector. Procurement of the MPPCs has been carried out to instrument 3000 channels in total. Design choices and first results of this readout scheme are presented, along with an outlook for potential applications.

Morning Session 9 July/A / 1

Random Number Hardware Generator Using Geiger-Mode Avalanche Photo Detector

Author(s): BEZNOSKO, Dmitriy[1]
Co-author(s): YESSENOV, Murat [1] ; DUSPAYEV, Alisher [1] ; BEREMKULOV, Timur [1] ; IAKOVLEV, Alexander [1] ; TAILAKOV, Arman [1]

[1] *Nazarbayev University*

Corresponding Author(s): dmitriy.beznosko@nu.edu.kz

The main problems with existing hardware random number generators today are either low speed and/or prohibitively high cost. This presentation shows the physical concept and test results of sample data of the high-speed hardware true random number generator design based Hamamatsu MPPC photo sensor. Main features of this concept are the high speed of the true random numbers generation (tens of Mbt/s), miniature size and estimated lower production cost. This allows the use of such a device not only in large companies and government offices but for the end-user data cryptography, in classrooms, in scientific Monte-Carlo simulations, computer games and any other place where large number of true random numbers is required. The physics of the operations principle of using a Geiger-mode avalanche photo detector is briefly discussed and the high quality of the data collected is demonstrated.

Poster Session / 2

The distributed particle detectors and data acquisition modules for Extensive Air Shower measurements at "Horizon-T_{KZ}" experiment

Author(s): Prof. BEZNOSKO, Dmitriy[1]
Co-author(s): DUSPAYEV, Alisher [1] ; YESSENOV, Murat [1] ; BEREMKULOV, Timur [1] ; IAKOVLEV, Alexander [1] ; BATYRKHANOV, Ayan [1]

[1] *Nazarbayev University*

Corresponding Author(s): dmitriy.beznosko@nu.edu.kz

"Horizon T" is a detector system of a new type is located at Tien Shan high-altitude Science Station of the Physical Institute of RSA at approximately 3340 meters above the sea level. It was constructed to register Extensive Air Showers (EAS) coming from a wide range of zenith angles ($0^o - 85^o$). The measurements of the time characteristics of the EAS are taken simultaneously at several registration points separated by the distance up to one kilometer. The poster presents the current system state, the R & D work of the system upgrade using the independent particle detection modules. The distributed DAQ system and event synchronization system progress will be presented as well.

Poster Session / 3

Beam profile measurement using Hamamatsu 64-channel PMT at DC-60 accelerator for cross-section of alpha-particle on carbon-13 scattering measurement.

Author(s): Prof. BEZNOSKO, Dmitriy[1]
Co-author(s): YESSENOV, Murat [1] ; DUSPAYEV, Alisher [1] ; IAKOVLEV, Alexander [1] ; NURMUKHAMBETOVA, Aliya [2]

[1] *Nazarbayev University*

[2] *Nazarbayev University Research and Innovations Center*

Corresponding Author(s): dmitriy.beznosko@nu.edu.kz

DC-60 is a heavy-ion accelerator (Li to Xe) with energy of 0.4-1.75 MeV/nucleon. It is used to accelerate 13C nuclei to measure the scattering cross-section of the helium on carbon-13 that is not known well and is important for the stellar astrophysics. For accurate measurements, it is important to know a beam profile within the test chamber. The poster describes preparations and setup for this measurement that would be carried out using a 64-channel Hamamatsu H7546B in conjuncture with the existing DAQ system of the experiment.

Afternoon Session 8 July/D / 4

Fully Automated Machine for Scanning SIMP detectors

RYCHTER, Andrzej[1]

[1] *Warsaw University of Technology*

Corresponding Author(s): arychter@ire.pw.edu.pl

A fully automated measurement setup for measuring SIPM detectors will be presented. Light source, positioning table, cooling system and data acquisition system will be described. Example results for MAPD-3N and MPPC S12572-010P will be shown.

Morning Session 7 July/A / 5

Recent development of vacuum photon detectors from Hamamatsu Photonics

YOSHIZAWA, Yuji[1]

[1] *Hamamatsu Photonics Japan*

Corresponding Author(s): yuji.yoshizawa@etd.hpk.co.jp

Hamamatsu Photonics has been providing several types of vacuum photon detectors for HEP experiments in many years. We have been making effort to develop new products accordingly. In this time, fast time response PMT series is shown as example. It includes 4 kinds of PMT sizes from 1-inch to 2-inch. T.T.S. of 170 ps was achieved in 1-1/8-inch PMT. This fast time response PMT series is suitable for TOF counter as well as PET in medical field. A new 20-inch PMT has

been also developed for Neutrino physics experiments. It has high C.E. and fast time response. The details of these PMTs and other developmental products will be shown in this presentation.

Afternoon Session 7 July/C / 6

Progress in the realization of a VSiPMT prototype

Author(s): BARBATO, Felicia Carla Tiziana[1]
Co-author(s): Prof. BARBARINO, Giancarlo [1] ; Dr. CAMPAJOLA, Luigi [2] ; Dr. DE ASMUNDIS, Riccardo [1] ; Dr. DE ROSA, Gianfranca [2] ; Dr. DI CAPUA, Francesco [2] ; Dr. MIGLIOZZI, Pasquale [1] ; Dr. MOLLO, Carlos Maximiliano [1] ; VIVOLO, Daniele [1]

[1] *INFN Naples*

[2] *University of Naples*

Corresponding Author(s): barbato@na.infn.it

The VSiPMT (Vacuum Silicon PhotoMultiplier Tube) is an innovative design for a revolutionary hybrid photodetector. The idea, born with the purpose to use a SiPM for large detection volumes, consists in replacing the classical dynode chain with a SiPM. In this configuration, we match the large sensitive area of a photocathode with the performances of the SiPM technology, which therefore acts like an electron detector and so like a current amplifier. The excellent photon counting capability, fast response, low power consumption and great stability are among the most attractive features of the VSiPMT. In order to realize such a device we first studied the feasibility of this detector both from theoretical and experimental point of view, by implementing a Geant4-based simulation and studying the response of a special non-windowed MPPC by Hamamatsu with an electron beam. Thanks to this result Hamamatsu realized two VSiPMT industrial prototypes with a photocathode of 3mm diameter. We now present the results of a full characterization of the VSiPMT industrial prototypes and the preliminary tests we are performing to realize a 2-inches and 3-inches VSiPMT prototype.

Afternoon Session 7 July/D / 7

Efficiency of modern fast photo detectors

IVANOV, Valentin[1]

[1] *Institute of Computational Technologies SB RAS*

Corresponding Author(s): vivanov.48@mail.ru

The original mathematical models and algorithms developed within the code “Monte Carlo Simulator 3D” (MCS-3D) are presented. These algorithms are devoted to model the photo-emission and cascades of secondary electron emission in micro-channel plate (MCP) amplifiers are widely used as photo detectors in accelerator physics, medical diagnostics, astrophysics etc. A theoretical method for calculation of secondary electron emission (SEE) yields has been developed. The method uses Monte Carlo simulation, empirical theories and close comparison to experimental data in order to parameterize the SEE yields of highly emissive materials for the MCPs. Numerical simulations were used to study the statistical properties for the prototype of large-area fast photo detectors which was developed at Argonne National Laboratory.

Morning Session 6 July/A / 8

Characterization of Silicon Photomultipliers for nEXO

OSTROVSKIY, Igor[1]

[1] *Stanford University*

Corresponding Author(s): ostrov@stanford.edu

Silicon Photomultipliers (SiPMs) are attractive candidates for light detectors for next generation liquid xenon double-beta decay experiments, like nEXO. One of the main requirements that the SiPMs must satisfy in order to be suitable for nEXO is high photon detection efficiency (PDE) at

175 nm, either directly or using a wavelength shifter. In addition, the devices should demonstrate sufficiently low levels of dark noise and correlated avalanche rates at liquid xenon temperature. We currently collaborate with several manufacturers for the development of SiPMs with high photon detection efficiency at 175nm. In parallel, we are also investigating new wavelength shifting materials produced by Luminotech (Moscow, Russia) that are coated on top of SiPMs and promise high performance, ease of handling, and compatibility with operation in liquid xenon. Devices produced by FBK, Hamamatsu, and other vendors have been characterized in details, measuring key SiPM parameters at cryogenic temperatures (-100C) in vacuum including absolute PDE at 175 nm, rates of dark noise, after-pulses, and cross-talk. A new test setup has recently been commissioned for measuring SiPMs performance in liquid xenon. Additionally, the nEXO collaboration is performing sensitive assessment of radioactivity content of the SiPMs to ensure that their pass our stringent radio-purity requirements. In this talk, we will describe the test setups, the measurement approaches, and present recent results obtained with the latest generations of SiPMs produced by FBK, Hamamatsu, and other vendors, including Hamamatsu MPPCs coated with wavelength shifters.

Afternoon Session 8 July/D / 9

Gamma Locator for the Sentinel Lymph Nodes Localization

Author(s): BERDNIKOVA, Anastasia[1]
Co-author(s): Prof. BOLOZDYNYA, Alexander [1] ; Dr. KANTSEROV, Vadim [1] ; Dr. SOSNOVTSEV, Valeriy [1]

[1] *National Research Nuclear University "MEPhI"*

Corresponding Author(s): akberdnikova@mephi.ru

Gamma locator is a handheld lightweight and compact gamma probe based on a scintillation crystal LaBr3:Ce and SensL MicroFB-30035-SMT silicone photomultiplier to be used for detection of gamma-radiation emitted by radionuclides such as Tc-99m, I-125, In-111, F-18. There are two main applications of gamma locator: intraoperative detection of sentinel lymph nodes and non-invasive scanning the surface of the body. In the first case, a radiotracer is injected into the patient preoperatively and surgeon checks the presence of metastasis in the lymph nodes after the removal of the tumor. In the second case, the gamma locator can detect tumors located superficially, and accurately determine their boundaries. When selecting the scintillator the following requirements should be considered: high relative light yield compared to NaI(Tl), the high value of the effective atomic number. The lanthanum cerium bromine has demonstrated the best features: the light yield higher than that of NaI(Tl) (130%), high density, high atomic number provide high efficiency of photoelectric absorption of gamma rays, and the decay time of the order of tens of nanoseconds provides high temporal resolution of the detector. Silicon photomultiplier is a device for detection of low intensive and very fast (several hundred nanosecond duration) light flashes. SiPM is used due to its high detection efficiency, low bias voltage, compact dimensions and high gain of signals. The scintillation crystal of 5 mm diameter and 10 mm length is optically connected with the SensL MicroFB-30035-SMT SiPM of 3x3 mm2 sensitive area. Experimental studies have shown that a scintillator packaged separately from the photodetector provides only 10.7% energy resolution at 662 keV (Cs-137) while being packed in a single enclosure with the SiPM it provides 6.9% FWHM energy resolution. Gamma probe can be constructed in corded or cordless configuration and equipped with a lithium-ion battery. Indication is performed by an acoustic signal and LED. Adjusting of the bias voltage of the photodetector and the thresholds of the discriminator is carried out by changing the resistance of the trimmers. The main technical characteristics of the prototype gamma locator were determined in the laboratory of NRNU MEPhI. Spatial resolution of gamma locator is the minimum distance between two point sources on which they can be resolved separately, or FWHM of the dependence of counting rate of the transverse distance between the detector and the source, and is measured to be 18 mm in the air and 20 mm in the scatter medium. Spatial selectivity is the polar angle, at which the count rate drops twice and it is measured to be 17 degrees in the air and 26 degrees in the scatter medium. Sensitivity is 191 cps/MBq in the air and 112 cps/MBq in the scatter medium. This work was supported in part by the Ministry of Education of the Russian Federation (State Contract with the NRNU MEPhI no. 11.G34.31.0049 of Oct. 19, 2011) and the Skolkovo Institute of Science and Technology (a part of the Skoltech/MIT Initiative project).

Afternoon Session 6 July/B / 10

Application and performance of Geiger-mode APDs in the First G-APD Cherenkov Telescope (FACT)

BRETZ, Thomas[1]

[1] *RWTH Aachen*

Corresponding Author(s): tbretz@physik.rwth-aachen.de

The First G-APD Cherenkov Telescope (FACT) has been operating since October 2011. Its construction was a major step forward in establishing solid state photon counters as detectors in focal plane instrumentations. The camera is comprised of 1440 sensor arrays of Geiger-mode avalanche photo diodes (G-APD), equipped with solid light guides to increase the light collection area of each sensor. Methods were successfully developed to overcome the temperature dependence of the gain of these sensors and to correct for the voltage drop induced during moonlit nights increasing the duty cycle of such instruments significantly. The availability of this number of sensors allowed for a detailed study of the dependence of their properties on overvoltage and temperature. High statistics featured the study of optical crosstalk up to high multiplicities. With its outstanding gain stability and its high duty cycle, the telescope is ideally suited for monitoring of bright TeV blazars. A technical overview of this novel type camera and a summary of the achieved sensor performance will be presented.

Afternoon Session 6 July/B / 11

Cherenkov light detection by PPDs

TAKESHITA, Tohru[1]

[1] *Shinshu University*

Corresponding Author(s): tohru@shinshu-u.ac.jp

In order to improve hadron energy measurement, we are investigating to utilize active absorber in the sampling hadron calorimeter. The active absorber consists of heavy transparent material such as Lead Glass and thin photo-sensors attached to form sampling calorimeter. The detection of Cherenkov lights needs to overcome the low light yield and to have enough sensitivity for short wave length region. We discuss our current study and further improvements at the conference.

Morning Session 8 July/B / 12

A Fast Avalanche Photodiode for the Readout of the 220nm Component of Barium Fluoride Scintillation Light

Author(s): HITLIN, David[1]
Co-author(s): Mr. KIM, Jae Hong [1] ; Mr. TREVOR, Jason [1] ; Dr. HOENK, Michael [2] ; Dr. HENNESSEY, John [2] ; Mr. MCCLISH, Mickel [3] ; Dr. FARRELL, Richard [4]

[1] *Caltech*

[2] *Jet Propulsion Laboratory, Caltech*

[3] *RMD Inc.*

[4] *RMD Inc*

Corresponding Author(s): hitlin@caltech.edu

An avalanche photodiode capable of detecting the fast component of the scintillation light of barium fluoride is being developed by a Caltech/JPL/RMD collaboration. The device has high quantum efficiency at 220nm, the wavelength of the fast scintillation component (0.9ns) and excellent discrimination against the 300nm slow scintillation component (650ns) of barium fluoride, as well as good rise and decay times. This device is intended for the calorimeter of the Mu2e experiment at Fermilab.

Afternoon Session 7 July/C / 13

The development and performance evaluation of a hybrid photo-detector for Hyper-Kamiokande

Author(s): JIANG, Miao[1]
Co-author(s): Dr. NISHIMURA, Yasuhiro [2] ; Mr. OKAJIMA, Yuji [3] ; Prof. KUZE, Masahiro [3] ; Mr. SUDA, Yusuke [4] ; Mr. AKUTSU, Ryosuke [4] ; Mr. FUKUDA, Daisuke [5] ; Ms. HIROTA, Seiko [1] ; Prof. YOKOYAMA, Masashi [4] ; Prof. NAKAHATA, Masayuki [4] ; Prof. SHIOZAWA, Masato [4] ; Prof. HAYATO, Yoshinari [4] ; Dr. NAKAYAMA, Shoei [6] ; Prof. TANAKA, Hidekazu [4] ; Prof. NAKAYA, Tsuyoshi [1] ; Dr. MINAMINO, Akihiro [1] ; Prof. TAKETA, Akimichi [4] ; Dr. KAWAI, Yoshihiko [7] ; Mr. OHMURA, Takayuki [7] ; Mr. SUZUKI, Masatoshi [7]

[1] *Kyoto University*

[2] *ICRR, The University of Tokyo*

[3] *Tokyo Institute of Technology*

[4] *The University of Tokyo*

[5] *Okayama University*

[6] *Kamioka Observatory, ICRR, University of Tokyo*

[7] *Hamamatsu Photonics K.K.*

Corresponding Author(s): mjiang@scphys.kyoto-u.ac.jp

Hyper-Kamiokande is a proposed next generation underground water Cherenkov detector capable of observing leptonic CP violation, nucleon decay, supernova neutrino and so on. Because of its large volume, 20(25) times larger than that of Super-Kamiokande for total (fiducial) mass, the total cost of photo-detectors will be expensive. Therefore cost-effective and high performance large-area photo-detectors are required to realize such a large detector. As one of photo-detector candidates, a hybrid photo-detector (HPD), which is made of a phototube and an avalanche diode (AD), is under development. Because of its simple structure, the manufacture cost is expected to be low. And a fast drift time of electron and large bombardment gain bring a good timing resolution and high photoelectron detection efficiency. The HPD with a diameter of 50 cm is expected to have a better performance than the existing photomultiplier tube with the same diameter. However, because of the large photoelectric surface, an AD with a diameter of 20mm is used in 50 cm HPD in order to ensure the collection efficiency. As a result, a new preamplifier for high parasitic capacitance is needed. Moreover, a new kind of HPD with a multi-channel AD is also under development to reduce the parasitic capacitance seen by preamplifier. In this presentation, we will report the development status of 50 cm HPD and the performance of two prototypes: one is the HPD with a single-channel AD and an improved preamplifier, the other one is the HPD with a multi-channel AD.

Morning Session 7 July/A / 15

Recent progress in the development of photomultiplier tubes

NAKAYAMA, Shoei[1]

[1] *Kamioka Observatory, ICRR, University of Tokyo*

Corresponding Author(s): shoei@suketto.icrr.u-tokyo.ac.jp

In this talk, recent progress in the development of photomultiplier tubes (mainly ones with a large aperture) will be reviewed. The status of the large aperture hybrid photodetector (HPD) development will also be covered.

Poster Session / 16

Development of radiation tolerant silicon photomultipliers using Synopsys TCAD

Author(s): PARYGIN, Pavel[1] ; POPOVA, Elena[1] ; BUZHAN, Pavel[1] ; GRACHEV, Viktor[1]
Co-author(s): GARUTTI, Erika [2] ; SCHWANDT, Joern [2]

[1] *NRNU MEPhI*

[2] *Hamburg University*

Corresponding Author(s): donkarloson@gmail.com

Silicon photomultipliers (SiPM) are semiconductor single photon sensitive devices with high internal gain. They have promising applications in such areas of science as high-energy physics, cosmophysics and nuclear medicine. However, the possibility of using SiPMs in some areas is limited by radiation tolerance.
Synopsys TCAD software allows developing and simulating technology of production microelectronic devices and their physical characteristics, significantly reducing the time and the cost of prototype manufacturing.
Simulating of manufacturing technology of SiPMs has been made. Based on this simulation, experimental samples were produced and then irradiated with different doses of X-rays with energy E≈12 keV. For the investigation of effects of radiation IV curves of devices were measured before and after irradiation and compared with results obtained from simulation.
Work has been partially supported by Megagrant 2013 program of Russia, agreement N14.A12.31.0006 from 24.06.2013.

Afternoon Session 7 July/C / 17

Peculiarities of the Hamamatsu R11410-20 photomultiplier tubes

Mr. KAPLIN, Vladimir[1] ; Mr. AKIMOV, Dmitry[2] ; Prof. BOLOZDYNYA, Alexander[1] ; Prof. EFREMENKO, Yury[3] ; Mr. KHROMOV, Alexander[1] ; MELIKYAN, Yury[1] ; Mr. SOSNOVTSEV, Valery[1]

[1] *NRNU MEPhI*

[2] *NRNU MEPhI, ITEP*

[3] *NRNU MEPhI, University of Tenesse*

Corresponding Author(s): velyour@yandex.ru

The RED100 double-phase emission detector is currently being prepared for the experiment aimed on the registration of the phenomenon of coherent neutrino scattering off xenon nuclei, having several dozens of Hamamatsu R11410-20 PMTs in its structure. Since the detector must be capable to detect rare events with small amount of the released energy, it is mandatory to evaluate the sensitivity and noise characteristics of the PMTs involved. For this purpose, a characterization procedure has been carried out for each PMT unit, including the study of its single photon response and noise characteristics. Among the systematic characteristics of 34 PMT samples, results of a special study of a number of non-standard features are presented. For example, observation of single photon emission of the PMT's internal structure is described, including the results of the photon emission intensity study as a function of the PMT bias voltage and temperature. Another important feature of the device concludes in an unusually big Cherenkov light yield of charged particles in the volume of the PMT quartz window. Properties of the window material together with high quantum efficiency for VUV light (>30%) lead to appearance of signals with amplitudes about 100 photoelectrons from atmospheric muons passing the horizontally placed PMT window. Such effect makes feasible the usage of a R11410-20 as a standalone particle detector. Special investigations were held concerning the value of 511 keV photons (among the atmospheric muons) Cherenkov light yield during their registration with the R11410-20 PMT window.

Afternoon Session 8 July/D / 18

Development of detectors with SiPM readout for nuclear medicine

PHILIPPOV, Dmitry[1] ; Mr. BUZHAN, Pavel[1] ; Dr. POPOVA, Elena[1] ; Mr. STIFUTKIN, Alexei[1] ; Mr. ILYIN, Andrei[1] ; Prof. BELYAEV, Vladimir[1]

[1] *NRNU MEPhI*

Corresponding Author(s): filippovdima@rambler.ru

Russian domestic medicine is suffering from a crippling deficit of modern equipment for diagnostics. Almost all of this equipment was imported. Most of them are operated for more than 10 years and are now needed to be either modernized or completely replaced.

Proof-of-principle prototype of the gamma-camera module was assembled. The prototype consists of 64-channel matrix of 6×6 mm^2 KETEK SiPMs (*www.ketek.com*), assembled at Scientific-Production Enterprise "Pulsar", Moscow. Front-end analogue readout and digitazing of the signals from the matrix is performed by 64-channel ASIC MAROC, which is commercial available and produced by French company WeeRoc (*www.weeroc.com*). Further processing of digitized signal is made on PC. The experimental measurements with NaI(Tl) $\oslash$ 30 $mm \times 20$ mm scintillator were carried out. The aim of the researching was to check an obtaining of necessary energy resolution since the signal is a sum of the eight center signals from the individual channels that operating under common bias voltage and having dark count rate, also integration time of MAROC3 is 150 ns and this time is less than decay time of scintillator, and as a consequence it leads to integrating at least half of the light. As result, energy spectrum of sum signal from the detectors with Cs-137 source has been built and energy resolution of 23.8% (for the 31-35 keV lines) has been obtained. In fact, this result is equal to 25.2% resolution obtained with PMT XP2020 with the full integration of the signal (all light has been collected) on digital oscilloscope LeCroy WaveRunner 620Zi with the same scintillator. It is assumed to make a tests with scintillator from the real gamma camera. The Monte-Carlo simulating of the full-size gamma camera is performed using Geant4 libraries (transportation of the photons), MATLAB (simulating of SiPM characteristics) and ROOT (fitting and histogramming) to obtain required energy and spatial resolution.

In parallel, we are developing the detector for dose monitoring in neutron capture therapy (NCT). It was suggested to utilize a LaBr3(Ce) scintillation crystal, that have the best energy resolution, using SiPM matrix for readout. The usage of SiPM matrix allows to create a dose detector, that capable not only to estimate the dose in the region of interests but also to restore a dose distribution shape in the real time during radiation process. To decrease a contribution of a background events it is suggested to use an active protection surrounding LaBr3(Ce) and operate in anti-coincidence mode. To perform the measurements the test prototype was assembled. LaBr3(Ce) cylindrical crystal made in Chernogolovka is surrounded by LYSO crystals, 64-channel matrix of $6 \times 6 mm^2$ KETEK SiPMs and the test board with MAROC3 electronics. The measurements with Cs-137 source were performed, resolution of 4.5% (662 keV) was obtained and result of using of the active protection was demonstrated. Currently, we have improved LaBr3(Ce) crystal with higher light output. The protection geometry is being optimized as well.

Also in collaboration with "POSITOM-PRO" company is related to the development of TOF-PET (time-of-flight PET) module using SiPM with the following requires: 10-15% energy resolution on 511 keV line, spatial resolution of about 3-4 mm FWHM, maximum count rate no less than 100 kHz and time resolution of about 300-400 ps, which is state-of-art commercial TOF-PET. Simultaneously, a module with the time resolution on 100 ps level for the next generation TOF-PET is being developed. One reason for worsening the time resolution is a slope of the leading front of the detector signal. The slope is higher, the time jitter related to the obtaining of the cut-off time is less. Thus, it is necessary to amplify the signal and not to change the slope of the front (to transmit the high frequencies without distortion). To do this, the selection of different high frequency amplifiers is being studied.

The latest obtained results will be presented.

Afternoon Session 8 July/C / 19

Development of a new positron counting system with SiPM readout for muon spin spectrometers

KANDA, Sohtaro[1]

[1] *The University of Tokyo*

Corresponding Author(s): kanda@post.kek.jp

A muon spin spectroscopy has been utilized for both of particle physics and material science. At J-PARC (Japan Proton Accelerator Research Complex), the world's highest-intensity pulsed muon beam has been realized. With the increase of the beam intensity, requirement for the detector's high-rate capability becomes essential.
Spectroscopy of muon spin is performed by measurement of positron angular asymmetry from muon decays. A new muon spin spectrometer with the silicon photomultiplier (SiPM) readout is under development for precision measurement of muonium hyperfine splitting [1]. The positron detector consists of tiled plastic scintillators, SiPMs (MPPC manufactured by Hamamatsu), and fast readout-circuits with ASIC based ASD and FPGA multi-hit TDC [2]
A prototype of the detector was developed and its performance was evaluated with the high intensity pulsed muon beam at J-PARC [3]. Based on an understanding of SiPM's characteristics and analog circuit response, a realistic event generator was developed for evaluation of systematic uncertainties of the measurement. Several methods of pileup correction were studied to minimize the systematic uncertainty. Characteristics of new types of SiPM were evaluated for further upgrade of the detector.
In this presentation, overview of the project and detail of the detector R&D will be discussed. As a major application of the detector, precision measurement of muonium hyperfine splitting will be introduced.
[1] : S. Kanda et al., Proceedings of the 2nd International Symposium on Science at J-PARC (to be published). [2] : K. M. Kojima et al., J. Phys. Conf. Ser. 551 012063 (2014). [3] : S. Kanda et al., JPS Conf. Proc. 2, 010404 (2014).

Morning Session 7 July/A / 20

A Test of New Large Aperture Photodetectors in a Water Čerenkov Detector

Author(s): NISHIMURA, Yasuhiro[1]
Co-author(s): Mr. OKAJIMA, Yuji [2] ; Mr. MIAO, Jiang [3] ; Mr. FUKUDA, Daisuke [4] ; Mr. AKUTSU, Ryosuke [1] ; Mr. SUDA, Yusuke [5] ; Mrs. HIROTA, Seiko [3] ; Dr. NAKAYAMA, Shoei [6] ; Prof. SHIOZAWA, Masato [6] ; Prof. YOKOYAMA, Masashi [5] ; Prof. HAYATO, Yoshinari [6] ; Dr. TANAKA, Hidekazu [6] ; Prof. NAKAHATA, Masayuki [6] ; Prof. NAKAYA, Tsuyoshi [3] ; Prof. KUZE, Masahiro [2] ; Prof. KOSHIO, Yusuke [4] ; Dr. TAKETA, Akimichi [7]

[1] *ICRR, The University of Tokyo*

[2] *Tokyo Institute of Technology*

[3] *Kyoto University*

[4] *Okayama University*

[5] *The University of Tokyo*

[6] *Kamioka Observatory, ICRR, University of Tokyo*

[7] *ERI, University of Tokyo*

Corresponding Author(s): ynisi@icrr.u-tokyo.ac.jp

A large-aperture photodetector is essential for a large-volume detector aiming at a neutrino physics and a nuclear decay search. Several new photodetectors with high resolution and efficiency have been developed for a one megaton water Čerenkov detector, Hyper-Kamiokande, planned in Japan. A proof test started in 2013 using a 200-ton water Čerenkov detector to evaluate feasibility of high quantum efficiency (HQE), a hybrid photodetector (HPD) and a photomultiplier tube (PMT) with a box-and-line (BL) dynode. Eight HPDs with a 20 cm diameter were installed to the 200-ton water tank in advance of a 50 cm HPD. A 50 cm Venetian-blind PMT used in Super-Kamiokande was improved with the HQE of 30% from 22%, and there were five PMTs attached as well in 2013. In addition, three 50 cm HQE BL PMTs joined in 2014, which showed high detection performance at a single photoelectron. In total in the 200-ton tank, 240 photodetectors including the 50 cm conventional Super-Kamiokande PMT have been tested over a year. Based on results in the proof test, the best candidate photodetector for Hyper-Kamiokande will be decided in 2016. A primary result on a calibration, long-term stability for a year and performance will be reported.

Poster Session / 21

Feasibility study of APD image sensor using Silicon-On-Insulator technology.

Author(s): HAMASAKI, Ryutaro[1]
Co-author(s): Prof. ARAI, Yasuo [2] ; Mr. KOYAMA, Akihiro [3] ; Dr. SHIMAZOE, Kenji [3]

[1] *SOKENDAI*

[2] *KEK,IPNS*

[3] *The University of Tokyo*

Corresponding Author(s): ryutaro@post.kek.jp

We are developing a new type of X-ray and optical imaging spectroscopy sensor using 0.2um FD-SOI CMOS process. The SOI technology is possible to connect between thick sensor layer of the high-resistivity substrates and circuit layer of low-resistivity substrates. This enables to fabricate monolithic pixel detectors with high-efficiency, high-speed,low-noise, low-power consumption characteristics.
To detect low-level signals, amplification mechanism to increase signal-to-noise ratio is need such as avalanche process. Thus we are studying linear mode avalanche process that operate in the high-field up to 200-500kV/cm.In this study, we will show results of feasibility study of realizing the sensor through HyENEXSS TCAD simulation and also show recent measurement results using SOI test devices.

Poster Session / 22

New type of scintillation detectors of thermal neutrons based on ZnS(Ag) /LiF and avalanche photodiodes.

Author(s): MARIN, Victor[1]
Co-author(s): NEDOREZOV, Vladymir [1] ; LITVIN, Vasyliy [1] ; AXENOV, Sergey [1] ; STOLYAROV, Andrey [1] ; Mr. TRUNOV, Dmitry [2] ; SADYKOV, Ravil [1]

[1] *INR RAS*

[2] *Institute for Nuclear Research of the Russian Academy of Sciences*

Corresponding Author(s): marin@inr.ru

Described high-efficiency scintillation detector of thermal neutrons on the basis of the scintillator ZnS(Ag)/LiF. The detector utilizes a new way of reading the light based on avalanche photodiodes which allows you to refuse the optical fibers and photomultipliers. The results of tests obtained on pulsed neutron source “RADEX” in INR. Using data detectors successfully obtained diffraction pattern of the test samples.

Morning Session 9 July/A / 23

Extraction of Activation Energies from Temperature Dependent Investigations of Dark Current and Dark Count Rate of Silicon Photomultipliers

Author(s): ENGELMANN, Eugen[1]
Co-author(s): Dr. POPOVA, Elena [2] ; Dr. VINOGRADOV, Sergey [3] ; Dr. WIEST, Florian [4] ; Dr. ISKRA, Peter [4] ; Mr. GEBAUER, Wolfgang [1] ; Ms. LOEBNER, Sabrina [1] ; Mr. GANKA, Thomas [4] ; Mr. DIETZINGER, Christoph [4] ; Prof. HANSCH, Walter [1] ; Dr. FOJT, Reinhard [4]

[1] *Universität der Bundeswehr, Munich*

[2] *Moscow Engineering and Physics Institute*

[3] *Cockcroft Institute, University of Liverpool*

[4] *KETEK GmbH, Munich*

Corresponding Author(s): eugen.engelmann@unibw.de

For several years Silicon Photomultipliers (SiPM) have been attractive candidates in order to replace conventional Photomultiplier Tubes (PMT) in many experiments. Besides several advantages of SiPM over PMT, like the increased photo detection efficiency (PDE), the compact design and the insensitivity to magnetic fields, the dark count rate (DCR) of SiPM is still a large drawback. Especially concerning applications with the need of a large photosensitive area or applications for which cooling of the detector is not an option. Reducing the dark count rate of SiPM would lead to an enormous enhancement of the application range of this promising photo-detector. As a first step towards the reduction of the DCR, the main mechanisms leading to dark breakdowns of the micro-cells have to be understood. By monitoring the dark current and the dark count rate as a function of temperature, an extraction of activation energies of mechanisms responsible for dark events is possible, using Arrhenius plots. The goal of the presented work is to develop a reliable method for the investigation of dark events and their origins.

Poster Session / 24

Development of a gamma camera based on silicon photomultipliers

Author(s): Mr. LAZARENKO, Evgeny[1] ; Mr. SKRYABIN, Alexandr[1]
Co-author(s): Dr. POPOVA, Elena [1] ; Mr. BUZHAN, Pavel [1]

[1] *National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)*

Corresponding Author(s): lazevg@mail.ru

The utilization of silicon photomultipliers (SiPM) in the detection module opens up a new possibilities of using a gamma camera. Two prototypes of gamma camera were developed. In the first prototype takes place a direct reading of monolithic scintillator NaI(Tl) using SiPM matrix and signal digitizing from this matrix utilizing a multichannel ASIC Maroc 3. This readout method allows to collect a large amount of light emitted from the scintillator volume, but makes it necessary to use a large number of photomultipliers and special multichannel electronics. In the second prototype between the scintillator NaI(Tl) and silicon photodetectors orthogonally related wavelength shifting fibers (WLS) are placed. They reduce the number of photodetectors but also they decrease the amount of light detected by the system.
Study of prototypes is essential to understanding the processes occurring inside the detecting section of the gamma camera, in consideration of the characteristics of silicon photomultipliers. The presence of dark count and optical crosstalk between SiPM pixels forms a excess noise factor (ENF) of the detector, which leads to decrease of the number of photoelectrons. Therefore, the number of initial triggered SiPM cells have to be determined using a statistical analysis based on the ENF of the silicon photomultiplier. The resulting experimental data for the both prototypes will be presented.
Work has been supported by Megagrant 2013 program of Russia, agreement N14.A12.31.0006 from 24.06.2013

Poster Session / 25

Nanostructured organosilicon luminophores as effective spectral shifters in a wide spectral region

Author(s): Dr. BORSHCHEV, Oleg[1]
Co-author(s): Mr. SKOROTETCKY, Maxim [2] ; Dr. SURIN, Nikolay [2] ; Prof. PONOMARENKO, Sergey [2]

[1] *Enikolopov Institute of Synthetic Polymeric Materials of Russian Academy of Sciences*

[2] *Institute of Synthetic Polymer Materials RAS*

Corresponding Author(s): borshchev@ispm.ru

During the last years, the number of light-harvesting luminescent dendritic molecules has increased rapidly. One of the most interesting features of these molecules is a possibility of incorporation of

different chromophores within one molecule that can lead to an intramolecular directional energy transfer from their peripheries to the center (a dendritic molecular antenna effect). It allows tuning the emission color of the core across the entire visible spectrum, which provides an efficient tool for controlling a wavelength of light emission in organic photonic and electronic devices. In this work we report investigation of the new nanostructured organosilicon luminophores (NOLs), where two different chromophores are connected to each other via silicon atoms, which brake the conjugation between them and fix them specifically in the space at the distance closer than 1-2 nm necessary for efficient Förster energy transfer [1,2,3]. NOLs possess several advantages: absorption in a wide optical spectral region; absorption cross-sections of the excitation light, which is 5–10 times higher as the cross-sections of the best low molar weight organic luminophores; very high photoluminescence quantum yield; luminescence spectra in the defined wavelength region; short luminescence lifetime as compared to the best inorganic luminophores. Photoluminescence study of the new molecules has shown an intramolecular energy transfer with the efficiency up to 99% and luminescence quantum yield up to 95% in different spectral regions. It should be noted that combination of different chromophores in NOLs allows tuning their emission wavelengths in a wide spectral region, which open possibilities for their wide application as spectral shifters – convertors of the emission with the energy of high frequency photons (140–400 nm) into emission in the visible spectral range (400–700 nm) [4,5].

This work was supported by Russian Foundation for Basic Research (N13-03-01315 and 13-03-12451), Foundation of President of the Russian Federation (project MK 6501.2015.3).

1 O.V. Borshchev, S.A. Ponomarenko, N.M. Surin, M.I. Buzin, A.P. Pleshkova, N.V. Demchenko, V.V. Myakushev, A.M. Muzafarov, Organometallics, 2007, 26, 5165.

2 Yu.N. Luponosov, S.A. Ponomarenko, N.M. Surin, O.V. Borshchev, E.A. Shumilkina, A.M. Muzafarov, Chem. Mater. 2009, 21, 447.

3 O.V. Borshchev, Y.N. Luponosov, E.A. Kleymyuk, N.M. Surin, S.A. Ponomarenko, A.M. Muzafarov Russ. Chem. Bull., 2010, 4, 781.

4 D.Y. Akimov, A.V. Akindinov, I.S. Alexandrov, V.A. Belov, O.V. Borshchev, A.A. Burenkov, M.V. Danilov, A.G. Kovalenko, Y.N. Luponosov, S.A. Ponomarenko, V.N. Stekhanov, N.M. Surin, S.A. Zav'yalov, M.Yu. Yablokov, NIM A, 2012, 695, 403-406.

5 S.A. Ponomarenko, N.M. Surin, O.V. Borshchev, Y.N. Luponosov, D.Y. Akimov, I.S. Alexandrov, A.A. Burenkov, A.G. Kovalenko, V.N. Stekhanov, E.A. Kleymyuk, O.T. Gritsenko, G.V. Cherkaev, A.S. Kechek'yan, O.A. Serenko, A.M. Muzafarov Scientific Reports 2014, 4, Article number: 6549.

Afternoon Session 7 July/C / 26

The VSiPMT (Vacuum Silicon PhotoMultiplier Tube): milestones and perspectives

Author(s): VIVOLO, Daniele[1]

Co-author(s): Prof. BARBARINO, Giancarlo [2] ; BARBATO, Felicia Carla Tiziana [1] ; Dr. DE ROSA, Gianfranca [2] ; Dr. DE ASMUNDIS, Riccardo [1] ; Dr. MIGLIOZZI, Pasquale [1] ; Dr. MOLLO, Carlos Maximiliano [1]

[1] *INFN Naples*

[2] *Università di Napoli Federico II*

Corresponding Author(s): vivolo@na.infn.it

The Vacuum Silicon PhotoMultiplier Tube (VSiPMT) is a new concept of photodetector based on the combination of the outstanding performances of SiPMs and the large sensitive surfaces of PMTs. Such device is made of a PMT standard envelope, with a photocathode for photon-electron conversion and an electrostatic focusing system that accelerates and focuses the generated photoelectrons towards a small focal area covered by a SiPM. The electron multiplication stage is the heart of the device and represents the real innovation with respect to the standard PMT technology. Therefore, a huge preliminary work aimed at the study of the performances of SiPMs as electron multipliers has been mandatory in order to investigate the feasibility of the VSiPMT. The extremely positive results achieved in this phase encouraged Hamamatsu Photonics to realize some prototypes of VSiPMT, that have been extensively characterized in the laboratories of INFN – Section of Naples. In this presentation some highlights about the main milestones of the

project will be provided. In particular, taking as a starting point the results of the prototype characterization, the so-called "phase 2" aimed at the realization of a new optimized generation of VSiPMT prototypes will be discussed.

Morning Session 8 July/A / 27

SiPM charge and recovery time for oversaturation conditions

Author(s): POPOVA, Elena[1]
Co-author(s): Mr. BUZHAN, Pavel [2] ; Mr. STIFUTKIN, Alexey [2] ; Mr. ILYIN, Andrey [2]

[1] *National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)*

[2] *NRNU MEPHI*

Corresponding Author(s): elena.popova@cern.ch

Amplitude, charge and recovery time for a single cell and real SiPMs for under- and oversaturation light intensities have been investigated. It has been shown that a SiPM illuminated by high intensity light flash (many photons/SiPM cell) is able to generate a signal with an amplitude that is higher then A1×N, where A1 – one-cell signal amplitude for low light conditions, N - total number of cells inside the SiPM. This effect can be explained by creation of multiple avalanche starting points inside of a SiPM cell which leads to the development of multiple avalanches inside of the cell and thus to a higher discharge current with shorter pulse duration when compared with a case of a single avalanche per cell. It will be shown that under strong oversaturation conditions even the charge from SiPM cell is not remaining a constant and increases with increasing intensity of light. The later effect leads to longer cell recovery times for higher light intensities. Work has been supported by Megagrant 2013 program of Russia, agreement N14.A12.31.0006 from 24.06.2013

Poster Session / 28

Study of the characteristics of SiPMs matrix as a photosensor for the scintillation detectors

Author(s): Mrs. DZAPAROVA, Irina[1]
Co-author(s): Dr. GANGAPSHEV, Albert [1] ; Mr. GAVRILYUK, Yuri [1] ; Dr. PETKOV, Valery [1] ; Dr. SERGEEV, Aleksandr [1] ; Dr. VOLCHENKO, Vladimir [1] ; Mr. YAKIMENKO, Sergey [1] ; Dr. YANIN, Alexey [1]

[1] *INR RAS*

Corresponding Author(s): dzaparova@yandex.ru

The matrices formed of silicon photomultipliers (SiPMs) are very promising photosensors for the scintillation detectors. We present preliminary results of characterization study of prototype of such detector. The matrix of 8x8 SiPMs from SensL company (ABL-ARRAYB64P-HDR) was chosen as photosensor. Each of the 64 SiPM has size of 6x6 mmˆ2 and consists of 18 980 micropixels. Measurements of the SiPM operation parameters were carried out for all individual SiPMs of the matrix. The relative change in the quantum efficiency of the SiPMs depending on the angle of incidence of the photon have been measured. Measurements of the proper gamma background of the matrix have been performed. The background count rate of the matrix due to proper radioactivity has been estimated.

Morning Session 9 July/A / 29

Performance test of new MPPC for a new neutrino detector WAGASCI

Author(s): HOSOMI, Fuminao[1]
Co-author(s): Mr. CHIKUMA, Naruhiro [1] ; Mr. KOGA, Taichiro [1] ; Dr. IZMAYLOV, Alexander [1] ; Prof. YOKOYAMA, Masashi [1] ; KARPIKOV, I. [2] ; Dr. KHABIBULLIN, Marat [3] ; KHOTJANTSEV,

A. [2] ; Prof. KUDENKO, Yury [4] ; MEFODIEV, A. [2] ; MINEEV, Oleg [3] ; OVSJANNIKOVA, T. [2] ; SUVOROV, S. [2] ; Mr. YERSHOV, Nikolay [4] ; BONNEMAISON, Alain [5] ; CORNAT, Remi [5] ; DRAPIER, Olivier [5] ; FERREIRA, Oscar [5] ; GASTALDI, Franck [5] ; GONIN, Michel [5] ; MUELLER, Thomas A. [5] ; Mr. HAYASHINO, Tatsuya [6] ; Prof. ICHIKAWA, Atsuko K. [6] ; Prof. MINAMINO, Akihiro [6] ; Mr. NAKAMURA, Keigo [6] ; Prof. NAKAYA, Tsuyoshi [6] ; Dr. QUILAIN, Benjamin [6] ; Mr. KIN, Ken'ichi [7] ; Prof. SEIYA, Yoshihiro [7] ; Prof. YAMAMOTO, Kazuhiro [7] ; Prof. HAYATO, Yoshinari [8] ; BLONDEL, Alain [9] ; CADOUX, Frank [9] ; FAVRE, Yannick [9] ; NOAH, Etam [9] ; RAYNER, Mark [9]

[1] *The University of Tokyo*

[2] *Institute for Nuclear Research of the Russian Academy of Sciences*

[3] *INR RAS*

[4] *INR*

[5] *Laboratoire Leprince-Ringuet Ecole Polytechnique*

[6] *Kyoto University*

[7] *Osaka City University*

[8] *Institute for Cosmic Ray Research*

[9] *University of Geneva*

Corresponding Author(s): hosomi@hep.phys.s.u-tokyo.ac.jp

In long baseline neutrino oscillation experiments, properties of neutrino are measured with neutrino interaction with the nucleus. Hence, understanding of the neutrino-nucleus interaction is critical for precise measurements of neutrino oscillation parameters. We have been developing a new neutrino detector named WAGASCI, to measure the cross section ratio of neutrino interaction with water and plastic targets with a large angular acceptance at J-PARC. In the T2K experiment, the far detector, Super-Kamiokande, uses water target while the near detectors use mainly plastic target. The uncertainty due to the difference of the target materials is one of major systematic uncertainties in T2K. The target of WAGASCI detector consists of 3-mm thick plastic scintillators assembled into a 3D grid-like structure. Multi-Pixel Photon Counters (MPPCs) are used to detect the light from scintillators. Because of the small light yield from thin scintillators, MPPCs are required to have low crosstalk rate and high photo detection efficiency (PDE).
We will use newly developed, crosstalk-suppression type MPPCs for WAGASCI detector. The new MPPC has an order of magnitude lower dark noise rate and crosstalk rate than old MPPC. We can operate the new MPPC with higher over voltage, which results in higher PDE. The total number of channels will be about 8,000. In order to realize a compact readout of large number of channels, we developed an array type MPPCs that have 32 MPPCs of 1.5 mm diameter active regions with 50 micron pixel size. A measurement system to test a large number of MPPCs is being developed. In this talk, the performance of new MPPC and the result of measurement with mass production will be presented.

Poster Session / 30

Response simulation for the scintillation detector with the silicon photomultiplier matrix as photosensor

Author(s): Dr. PETKOV, Valery[1]
Co-author(s): Mrs. DZAPAROVA, Irina [1] ; Dr. GANGAPSHEV, Albert [1] ; Dr. SERGEEV, Aleksandr [1] ; Dr. VOLCHENKO, Vladimir [1] ; Dr. YANIN, Aleksei [1]

[1] *INR RAS*

Corresponding Author(s): vpetkov@inr.ru

The use of the matrices formed of silicon photomultipliers (SiPMs) to collect light in scintillation detectors will allow obtaining an image (picture) of an event. The subsequent analysis of the images provides in principle the possibility to separate different classes of events in the detector. A program for simulation of the passage of muons through the prototype of such type of detector has been developed. The investigation of the response of the detector to the muons has been carried out.

Afternoon Session 6 July/B / 32

SiPM Based Focal Plane Instrumentation Prototype for the MAGIC Atmospheric Cherenkov Telescope

Author(s): FINK, David[1]
Co-author(s): Mr. HAHN, Alexander [1] ; Dr. MAZIN, Daniel [2] ; Dr. MIRZOYAN, Razmik [1]

[1] *Max Planck Institut fuer Physik*

[2] *Institute for Cosmic Ray Research, University of Tokyo*

Corresponding Author(s): fink@mpp.mpg.de

MAGIC is an imaging atmospheric telescope used for gamma ray astronomy. Both the original and the upgraded imaging telescope cameras in use rely on photomultipliers as the photon detectors. In preparation for their possible future use in MAGIC or subsequent telescopes, a camera module with silicon photomultiplier detectors has been developed for operation alongside the existing camera in the telescope. Front end imaging and electronics challenges and solutions are discussed, including the issues of fast analog pulse summation (˜4 nsec) of several devices, and the tradeoffs specific to this application's operating environment.

Morning Session 7 July/A / 33

Detailed performance evaluation of a new 20-inch photomultiplier tube with a Box and Line dynode

Author(s): OKAJIMA, Yuji[1]
Co-author(s): Dr. NISHIMURA, Yasuhiro [2] ; Mr. JIANG, Miao [3] ; Mr. AKUTSU, Ryosuke [4] ; Mr. SUDA, Yusuke [5] ; Ms. HIROTA, Seiko [6] ; Mr. FUKUDA, Daisuke [7] ; Dr. KUZE, Masahiro [8] ; Dr. ISHITSUKA, Masaki [8] ; Prof. NAKAHATA, Masayuki [4] ; Prof. SHIOZAWA, Masato [4] ; Dr. HAYATO, Yoshinari [4] ; Dr. NAKAYAMA, Shoei [4] ; Dr. TANAKA, Hidekazu [4] ; Dr. YOKOYAMA, Masashi [5] ; Prof. NAKAYA, Tsuyoshi [6] ; Dr. AKIHIRO, Minamino [6] ; Dr. TAKETA, Akimichi [9] ; Dr. KAWAI, Yoshihiko [10] ; Mr. SUZUKI, Masatoshi [10] ; Mr. OHMURA, Takayuki [10]

[1] *Tokyo Institute of Technology*

[2] *ICRR, The University of Tokyo*

[3] *Kyoto University*

[4] *Kamioka Observatory, Institute for Cosmic Ray Research, University of Tokyo*

[5] *Department of Physics, University of Tokyo*

[6] *Department of Physics, Kyoto University*

[7] *Department of Physics, Okayama University*

[8] *Department of Physics, Tokyo Institute of Technology*

[9] *Earthquake Research Institute, University of Tokyo*

[10] *Hamamatsu Photonics K.K.*

Corresponding Author(s): okajima@hep.phys.titech.ac.jp

Hyper-Kamiokande is a proposed future neutrino experiment with various physics goals such as the discovery of leptonic CP violation, nucleon decay, supernova neutrino, and so on, using a 1 Mton water Cherenkov detector. Because of the large volume, About 99000 of 20 inch photosensors are planed to set in the detector. (About 9 times as many as 20 inch photosensor in Super-Kamiokande) Considering a cost of photodetectors in Hyper-Kamiokande detector, more cost-effective and higher performance large-area photodetectors are desired.
A 20-inch diameter Box and Line PMT is a candidate photodetector for Hyper-Kamiokande, which has different type dynodes from PMTs in Super-Kamiokande (Hamamatsu R3600). Owing to an improvement on dynodes shape, a collection efficiency of photoelectrons becomes better than the R3600 PMT. In addition, a good timing resolution is obtained by a little variation of electrons' path during its multiplication. The first type of Box and Line PMT was developed in 2014 and the basic performances evaluation is ongoing to decide the photosensor for Hyper-Kamiokande.

In this presentation, I will describe the current evaluation status of the basic performance like 1 photoelectron charge distribution, timing resolution, gain, dark rate, and status of more detailed performance like after pulse rate measurement.

Morning Session 8 July/B / 34

Development of a WLS + SiPM system for UVC light detection.

BURENKOV, Alexander[1] ; Dr. AKIMOV, Dmitry[1] ; Mr. BELOV, Vladimir[1] ; Dr. BORSHCHEV, Oleg[2] ; Prof. DANILOV, Mikhail[1] ; Dr. DOLGOLENKO, Anatoli[1] ; Mr. KARELIN, Alexander[1] ; Mr. KOVALENKO, Aleksei[1] ; Mr. KUCHENKOV, Aleksei[1] ; Prof. PONOMARENKO, Sergey[3] ; Dr. POPOVA, Elena[4] ; STEKHANOV, Viktor[1] ; Dr. SURIN, Nikolay[3] ; Dr. ZELDOVICH, Olga[1]

[1] *ITEP*

[2] *Enikolopov Institute of Synthetic Polymeric Materials of Russian Academy of Sciences*

[3] *ISPM RAS*

[4] *National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)*

Corresponding Author(s): burenkov@itep.ru

The first studies of VUV detection by the SiPM have shown that it is necessary to use a WLS. Some manufacturers produce native VUV sensitive SiPMs at present. Collaborations Gerda, MEG, NEXT, nEXO plan to use these SiPMs in their detectors. The PDE of these SiPMs is lower than green or blue sensitive SiPMs. In our previous studies, it was obtained in the WLS + SiPM system about 50% of the sensitivity of the SiPM. We started to develop a WLS + SiPM system for use it in the nEXO prototype. In this study, we used the SiPMs developed at the MEPhI (MEPhI-KETEK) and Sensel and nanostructured organosilicon luminophores (NOL) as the WLS from the ISPM RAS.

Morning Session 8 July/B / 35

SiPM Readout Technique in a High Pressure Xenon Electroluminescent TPC for neutrinoless $\beta\beta$ decay

YAHLALI, Nadia[1]

[1] *INSTITUTO DE FÍSICA CORPUSCULAR*

Corresponding Author(s): nadia.yahlali@ific.uv.es

The NEXT-100 experiment aims at searching the neutrinoless double decay ($\beta\beta0\nu$) of the Xe-136 isotope, using a TPC filled with 100 kg of enriched and highly pressurized gaseous xenon. The key technological feature of NEXT TPC is the electroluminescence (EL), which requires the optical readout of the signals using Photomultiplier Tubes (PMT) and Silicon Photomultipliers (SiPMs) for energy and tracking measurements respectively. This technology has been implemented and extensively tested during the last years in the demonstrator prototype NEXT-DEMO, achieving high energy resolution ($< 1\%$ FWHM) and tracking capabilities required for a robust $\beta\beta$ decay experiment.

The interaction of the β particles in the xenon gas produces excitation and ionization signals that are both used in the TPC for the identification of the $\beta\beta0\nu$ events. The excitation signal is a prompt VUV scintillation, that is read out by an array of PMTs at the TPC cathode, providing a start-of-event signal. The ionization signal, which is proportional to the deposited energy in the gas, is amplified through the electroluminescence process that converts proportionally the charge signal to an optical signal, with very low statistical fluctuations. This optical signal known as the secondary scintillation, is of much larger amplitude and duration (few μs) than the primary scintillation signal. It builds up in the EL region at the TPC anode, several hundreds of μs after the starting of the event and is read out by the PMTs for the energy measurement. It is also read out by the array of SiPMs located right behind the EL region for the events topology measurement.

In the proposed talk, I will describe the NEXT concept and the signals induced by charged particles in the high-pressure xenon TPC read out by PMTs and SiPMs. I will especially address the SiPM readout technique implemented in the demonstrator prototype NEXT-DEMO, and its upgrade for the upcoming NEXT physics runs in the Canfranc Underground Laboratory (LSC) with the detectors NEXT-NEW and NEXT-100.

Morning Session 7 July/A / 36

Properties of New 50 cm Photodetectors in an Environment for Hyper-Kamiokande

Author(s): FUKUDA, Daisuke[1]
Co-author(s): Mr. YOSHINARI, Hayato [2] ; Mr. HIDEKAZU, Tanaka [2] ; Mr. YOKOYAMA, Masashi [2] ; Mr. TSUYOSHI, Nakaya [3] ; Mr. AKIMICHI, Taketa [2] ; Mr. TAKAYUKI, Ohmura [4] ; Mr. TAKAYUKI, Ohmura [4] ; Mr. MASATOSHI, suzuki [4] ; Dr. NISHIMURA, Yasuhiro [5] ; Mr. YUSUKE, suda [2] ; Mr. RYOSUKE, Akutsu [2] ; MIAO, Jiang [6] ; Ms. SIKO, Hirota [3] ; Mr. YUJI, Okajima [7] ; Dr. NAKAYAMA, Shoei [8] ; Mr. MASAYUKI, Nakahata [2] ; Mr. MASATO, Shiozawa [2]

[1] *Okayama University*

[2] *Tokyo University*

[3] *Kyoto University*

[4] *hamamatsu photonics*

[5] *ICRR, The University of Tokyo*

[6] *kyoto university*

[7] *Tokyo Institute of Technology*

[8] *Kamioka Observatory, ICRR, University of Tokyo*

Corresponding Author(s): fukudada@s.okayama-u.ac.jp

Hyper-Kamiokande is a next generation huge water Cherenkov detector proposed for a discovery of proton decay and neutrino observations. It is planed to have 20 times larger volume than Super-Kamiokande, with 100,000 next generation photo sensors. One candidate of the sensor is a 50 cm Box-and-Line dynode photomultiplier tube (BL PMT), which have excellent time resolution and energy resolution. However, the performance of the BL PMT is to be confirmed under a condition expected in Hyper-Kamikoande. For example, a response of the BL PMT is affected by a geomagnetic field especially in a certain direction. Since Hyper-Kamiokande is a large detector, the geomagnetic field cannot be completely canceled and the effect cannot be ignored. And the temperature in Hyper-Kamiokande is presumably different with usual environment, therefore, the temperature dependency has to be also checked. Such kind of a precise investigation in BL PMT has never been performed, though the design concept and the basic performance are established. In this presentation, several results of these specific characteristics will be reported, i.e., the effect of the magnetic field, the temperature, the incident point of photons, and the high-voltage value. The comparison of their effects to the original designed value will be also discussed.

Afternoon Session 6 July/C / 37

High granularity scintillating fiber trackers based on Silicon Photomultiplier

Dr. PAPA, Angela[1] ; Dr. RIPICCINI, Emanuele[2]

[1] *Paul Scherrer Institute*

[2] *infn roma*

Corresponding Author(s): angela.papa@psi.ch

Scintillating fibers coupled to photosensors provide flexible, fast and high granularity detectors which are able to work in a high rate environment. We will report about the performances obtained with several detector prototypes (single and multi-layers) based on 250 μm multi clad square scintillating fibers coupled to Hamamatsu silicon photomultiplier (SiPMs). Current

measurements show results never reached up to now: very high detection efficiency for minimum ionizing particles (m.i.p.) already for a single layer (95%, mean collected light/fiber 8 phe), and full efficiency for multilayer configurations. Spatial resolutions $< 100\mu$m are foreseen for single layer and much less for multilayer devices. Such spatial resolutions can be achieved by keeping the optical cross-talk between fibers at a negligible level ($< 1\%$), a level which we have proven to be obtainable when coating the fibers with aluminum. Finally, timing resolutions of the order of 500 ps have been achieved for m.i.p. (single layer configuration), resolutions that become better for multi hit events (multilayer configuration). A comparison between the detector performances for m.i.p. and highly ionizing particle (stopped muons) will also be given, showing the possibility of particle identification based on the large difference of the energy deposit on the scintillator by the two particles. Finally results as beam monitoring tool will be shown, with measurements performed along the Paul Scherrer Institute beam lines, which provide the most intense continuous muon beam in the world. All measurements have been supported with a Monte Carlo simulation based on Geant4 and a custom code, describing the response of the SiPMs.

Poster Session / 38

SiPM application for KL/muon detector at Belle-II

Dr. UGLOV, TImofey[1]

[1] *ITEP*

Corresponding Author(s): uglov@itep.ru

We report on a new KL and muon detector based on scintillators to be used for the endcap and inner barrel regions in the Belle II experiment. The increased luminosity of the e+ e- SuperKEKB collider entails challenging detector requirements. We demonstrate that 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. We also describe the simple technological methods used in the mass production for KL and muon detector modules, that allowed to increase significantly the light collection efficiency at SiPM, and the first experience of multichannel SiPM adjustment.

Morning Session 7 July/B / 39

Novel 1.5' Size PMTs of Outstanding Parameters for the CTA Project

Author(s): MIRZOYAN, Razmik[1]
Co-author(s): MÜLLER, Dominik [2] ; TOYAMA, Takeshi [2] ; Dr. NAKAJIMA, Daisuke [3] ; MENZEL, Uta [2] ; HOSE, Juergen [2] ; TAKAHASHI, Mitsunari [4] ; Dr. YAMAMOTO, Tokonatsu [5] ; Prof. TESHIMA, Masahiro [6]

[1] *Max-Planck-Institute for Physics*

[2] *MPI for Physics*

[3] *ICRR, Univ. Tokyo, Chiba, Japan*

[4] *ICRR Univ. Tokyo, Chiba, Japan*

[5] *Konan Univ., Japan*

[6] *MPI for Physics & ICRR, Univ. Tokyo, Chiba, Japan*

Corresponding Author(s): razmik.mirzoyan@mpp.mpg.de

Photomultiplier Tubes (PMT) are the most wide spread light detectors for measuring fast and faint signals. About six years ago we started an improvement program for the PMT candidates for the Cherenkov Telescope Array (CTA) project with the companies Hamamatsu Photonics K.K. (Japan) and Electron Tubes Enterprises Ltd. (England). CTA is the next major Imaging Atmospheric Cherenkov Telescopes array for high energy gamma-ray astrophysics, about 100 telescopes of sizes of 23m, 12m and 4m will be built in Northern and Southern hemispheres. For CTA we need PMTs with the highest quantum efficiency, maximized photo electron collection efficiency, short pulse width of a few ns, very low after-pulsing and transit time spread. The manufacturers were able to produce 1.5 ' PMTs of enhanced peak quantum efficiency of ˜ 40%.

These can collect up to 95-98% of photo electrons onto the first dynode for the wavelengths $\geq$ 400nm. A pulse width of $\leq$ 3ns has been achieved at the selected operational gain of 40k. The after-pulsing for a threshold of $\geq$ 4 photo electrons is reduced down to the level of 0.02%. We will report on the measurements of PMT R-12292-100 from Hamamatsu and the PMT D573KFLSB as the latest iteration from Electron Tubes Enterprises as candidate PMTs for the CTA project.

Morning Session 9 July/B / 40

LBNO-DEMO (WA105): a large demonstrator of the Liquid Argon double phase TPC

Author(s): TRZASKA, Wladyslaw Henryk[1]
Co-author(s): Prof. KUDENKO, Yury [2]

[1] *University of Jyväskylä*

[2] *INR*

Corresponding Author(s): wladyslaw.h.trzaska@jyu.fi

A giant (10-50 kt) liquid argon TPC has been proposed as the detector for an underground observatory for the study of neutrino oscillations, neutrino astrophysics and proton decay. This detector has excellent tracking and calorimetric capabilities much superior to currently operating neutrino detectors.
LBNO-DEMO (WA105) is a large demonstrator of the double phase liquid argon TPC based on the GLACIER design, with a $6\times6\times6$˜m^3 (appr. 300t) active volume. Its construction and operation test scalable solutions for the crucial aspects of this detector: ultra-high argon purity in non evacuable tanks, long drifts, very high drift voltages, large area MPGD, cold preamplifiers. The TPC will be built inside a tank based on industrial LNG technology. Electrons produced in the liquid argon are extracted in the gas phase. Here, a readout plane based on LEM detectors provides amplification before the charge collection onto an anode plane with strip readout. PMT located on the bottom of the tank containing the liquid argon provide the readout of the scintillation light.
This demonstrator is an industrial prototype of the design proposed for a large underground detector. WA105 is under construction at CERN and will be exposed to a charged particle beam (0.5-20 GeV/c) in the North Area in 2018. The data will provide necessary calibration of the detector performances and benchmark sophisticated reconstruction algorithms. This project is a crucial milestone providing feedback for the long baseline neutrino program, including projects like LBNO and DUNE.

Morning Session 9 July/B / 41

Study of scintillation counter consisting of a pure CsI crystal and APD.

EPIFANOV, Denis[1]

[1] *The University of Tokyo*

Corresponding Author(s): epifanov@hep.phys.s.u-tokyo.ac.jp

The Belle II detector at the SuperKEKB e+ e- collider is the only Super Flavor Factory in the nearest future. Electromagnetic calorimeter (ECL) is one of the most important subsystems of Belle II. To cope with extremely high luminosity and severe background conditions it was decided to upgrade the end cap ECL and utilize pure CsI scintillation crystals. We report about development and study of the counter based on the pure CsI crystal and APD(s) (Hamamatsu S8664-55, S8664-1010).

Morning Session 9 July/B / 42

Electromagnetic Calorimeter of the Belle II detector

SHWARTZ, Boris[1]

[1] *Budker Institute of Nuclear Physics, Novosibirsk State University*

Corresponding Author(s): shwartz@inp.nsk.su

The electromagnetic calorimeter of the BELLE II detector for experiments at SuperKEKB e^+e^- collider is described. A core part of the calorimeter, 8736 counters based on CsI(Tl) crystals read out by PIN photodiodes, is reused from the Belle detector which operated at the KEKB asymmetric energy collider from 1999 to 2010. Since the project luminosity of the SuperKEKB, 8×10^{35}, is 40 times higher than that of the previous collider, much more severe background conditions are expected. Therefore all readout electronics will be replaced to a new one that will be able to cope with high event rate. A second step of the upgrade when the crystals in the end caps are replaced to the fast pure CsI crystals is under study. Since the photon emission of undoped CsI crystal is roughly 10 times smaller than that of doped one, the photosensors with amplification should be used. Current baseline option is vacuum photopenthods, their characteristics and performance study is presented. An option of a read out with the large area APD is also under study.

Poster Session / 43

Soft photon registration at Nuclotron

Dr. KOKOULINA, Elena[1]

[1] *physicist*

Corresponding Author(s): kokoulin@sunse.jinr.ru

Collaboration SVD-2 has manufacturied electromagnetic calorimeter to register in nuclear interactions soft photons with energy smaller than 50 MeV. Detection of signal is carried out by SPM-PMPs. First results of soft photon yield in D+C, Li+C and C+ C are presented.

Afternoon Session 6 July/C / 44

Pixelated Positron Timing Counter with SiPM-readout Scintillator for MEG II experiment

Author(s): NISHIMURA, Miki[1]
Co-author(s): BOCA, Gianluigi [2] ; CATTANEO, Paolo Walter [3] ; DE GERONE, Matteo [4] ; GATTI, Flavio [5] ; OOTANI, Wataru [1] ; PIZZIGONI, Giulio [4] ; ROSSELLA, Massimo [3] ; SHIBATA, Naoya [1] ; SIMONETTA, Marcello [2] ; UCHIYAMA, Yusuke [1] ; YOSHIDA, Kohei [1]

[1] *The University of Tokyo*

[2] *INFN Pavia, Dipartimento di Fisicà dell'Università di Pavia*

[3] *INFN Pavia*

[4] *INFN Genova*

[5] *INFN Genova, Universitá degli Studi di Genova*

Corresponding Author(s): nmiki@icepp.s.u-tokyo.ac.jp

We have been developing a positron timing counter for the MEG II experiment which aims to search for $\mu^+ \to e^+\gamma$ decay with an unprecedented sensitivity. It is expected to have an ultimate time resolution of ∼30 ps in the high rate environment of the MEG II experiment. We employed a "pixelated" design with ∼500 small counters, each of which is based on a fast plastic scintillator plate readout by multiple SiPMs connected in series. This SiPM readout scheme provides a sharp signal waveform and a maximum light collection and thus, a good time resolution of each counter. Furthermore the overall time resolution can be significantly improved by simultaneous multiple timing measurements with several counters. We performed beam tests with a prototype detector and achieved an excellent overall time resolution of ∼35ps. In this talk the design and performance of the pixelated timing counter will be presented

Afternoon Session 8 July/C / 45

STUDIES OF SILICON PHOTOMULTIPLIERS FOR THE CMS HCAL UPGRADE

Author(s): MUSIENKO, Yuri[1]
Co-author(s): Mr. HEERING, Adriaan [2] ; Prof. WAYNE, Mitchell [2] ; Prof. RUCHTI, Randal [2] ; Mr. KARNEYEU, Anton [3] ; Mr. POSTOEV, Vladimir [3]

[1] *INR RAS (Moscow)/University of Notre Dame (Notre Dame)*

[2] *University of Notre Dame (Notre Dame)*

[3] *INR RAS (Moscow)*

Corresponding Author(s): iouri.musienko@cern.ch

The CMS Barrel (HB) and Endcap (HE) Hadron Calorimeters are scintillator sampling calorimeters with embedded wavelength shifting fibers (WLS) in scintillator tiles. The photo-sensors that are currently used are hybrid photodiodes (HPDs). In 2012 the HCAL Phase I upgrade was approved for the increased luminosity (5*1034) of SLHC. A key aspect of the HCAL upgrade is to add longitudinal segmentation to improve background rejection, energy resolution and scintillator radiation damage compensation. The increased segmentation can be achieved by replacing the HPDs with silicon photomultipliers (SiPMs)). The SiPMs for the CMS HCAL upgrade have to operate in a very hostile SLHC radiation environment (we expect a maximum total dose of 1012 n/cm2 for an integrated luminosity of 3000 fb-1). They should have good linearity for a wide range of scintillating signals and excellent reliability. During the last years we have successfully completed the R&D for instrumentation of SiPMs for the Phase 1 upgrade of HE/HB in 2017 and 2018. Here we report on the final SiPM parameters of two manufactures considered for the 2015 preproduction run. These candidates Hamamatsu (Japan) and KETEK (Germany) have developed state of the art custom large dynamic range SiPMs with large PDE and small ENC for the CMS HCAL Upgrade project. An overview of all results of our measurements of photon detection efficiency, spectral response, cell recovery time will be reported in this presentation. Results from a study on the radiation hardness of silicon photomultipliers (SiPMs) are also presented. The SiPMs were exposed to hadrons (protons and neutrons) at fluences up to 1*10ˆ12 hadrons/cm2. The SiPM's main parameters were measured before and after irradiation. The effects of the hadron radiation on breakdown voltage, quenching resistance value, gain, photon detection efficiency, dark current and dark count rate for these devices are shown and discussed.

Poster Session / 46

THE DESIGN, CONSTRUCTION AND TESTING OF TASD (TOTALLY ACTIVE SCINTILLATOR DETECTOR)

Author(s): Mr. MEFODIEV, Aleksandr[1]
Co-author(s): ANTONOVA, Maria [2] ; Prof. BLONDEL, Alain Paul Pascal [3] ; CADOUX, Frank Raphael [3] ; FAVRE, Yannick [3] ; FEDOTOV, Sergei [2] ; Mr. KHOTJANTSEV, Alexey [4] ; KLEIMENOVA, Alina [2] ; Prof. KUDENKO, Yury [5] ; MINEEV, Oleg [4] ; NOAH, Etam [6] ; OVSIANNIKOVA, Tatiana [2] ; YERSHOV, Nikolay [2] ; Dr. KHABIBULLIN, Marat [4]

[1] *INR RAS and MIPT*

[2] *Institute for Nuclear Research of the Russian Academy of Sciences*

[3] *Universite de Geneve*

[4] *INR RAS*

[5] *INR*

[6] *University of Geneva*

Corresponding Author(s): mefodiev@inr.ru

Under the project Advanced European Infrastructures for Detectors at Accelerators (AIDA), Institute of Nuclear Research (INR) and University of Geneva designed the Totally Active Scintillator Detector (TASD). The TASD detector consists of 50 modules of plastic scintillators. Each module is instrumented with one X and one Y plane, with 84 scintillator bars per plane readout using Hamamatsu MPPC's. The bar width, height and length are 1.0 cm, 0.7 cm and 90

cm respectively. The distance between modules can be varied from 0 to 2.5 cm. Other components such as active detectors or passive sheets of material can be inserted in these 2.5 cm gaps if required. The full detector depth can therefore be varied from 75 cm to 200 cm and in its compact form, it is 1 m3 in volume.
The results of tests of active elements (light yield, cross-talk, timing) with cosmic muons will be presented.

Morning Session 7 July/B / 47

Performance of large area PMTs at cryogenic temperatures for neutrino and rare event physics experiments

Author(s): FALCONE, Andrea[1]
Co-author(s): BOFFELLI, Fabrizio [2] ; ROSSELLA, Massimo [3] ; SPANU, Maura [1] ; TORTI, Marta [1] ; ZANI, Andrea [4] ; BONESINI, Maurizio [5] ; CERVI, Tommaso [2] ; MAZZA, Roberto [5] ; MENEGOLLI, Alessandro [1] ; MONTANARI, Claudio Saverio [4] ; PRATA, Marco Cesare [3] ; RAPPOLDI, Andrea [3] ; RASELLI, Gian Luca [3]

[1] *Universita' di Pavia - INFN Pavia*

[2] *Universita' di Pavia*

[3] *INFN Pavia*

[4] *INFN Pavia - CERN*

[5] *INFN Milano Bicocca*

Corresponding Author(s): andrea.falcone@pv.infn.it

Detectors, based on liquefied noble gases, are becoming more and more important in the field of neutrino and rare events physics. The measurement of scintillation light produced at the passage of an ionizing particle in the liquid medium plays a crucial role in these detectors and Photo-Multiplier Tubes (PMTs), directly immersed in liquid argon or xenon at cryogenic temperature, represent the most adopted devices, when working in absence of magnetic field. In view of future application, the behavior of a number of large cathode area (8 inches diameter) PMT models has been studied both at room and at cryogenic temperature. A complete characterization at cryogenic temperature has been performed in terms of gain, timing, signal shape, linearity, photo-cathode uniformity, dark counts and after-pulses rates and spectra. Moreover, an evaluation of the Quantum Efficiency of these devices, coated with wave-length shifter materials, has been carried out in the VUV region (from λ=120 nm to λ = 220 nm incident light).

Poster Session / 49

Characterization of 3×3 mm^2 SensL SiPM's for NewCHOD detector of NA62 experiment at CERN

Ms. KLEIMENOVA, Alina[1] ; Mr. FEDOTOV, Sergey[1]

[1] *INR, MEPhI*

Corresponding Author(s): fsa404@mail.ru

The main goal of NA62 experiment is to study extremely rare kaon decay $K^+ \to \pi^+\nu\bar{\nu}$ with 10% precision. This decay is strongly supressed in Standard Model (SM) and could be calculated with high precision BR($K^+ \to \pi^+\nu\bar{\nu}$) = 7.81×10^{-11} which makes it sensitive to New Physics beyond the Standard Model. One of the important detectors of NA62 trigger system is Charged-particle Hodoscope (CHOD) — system of scintillation counters with pad structure covering area around the beam pipe. CHOD is designed to define the aperture for charged particles for the level-0 trigger and to veto possible interactions in the RICH mirror plane ($\approx$ 20% of radiation length). New CHOD is scintillating hodoscope with a pad structure and a total number of 148 counters. Each pad readout with WLS fibers and two or four SensL SiPM's with a sensitive area of 3 × 3 mm2. This photosensor has 4774 pixels, each of 35×35 μm^2. The main parameters (photon detection efficiency, dark rate, cross-talk, and gain) of 500 SiPM's were measured. The results will be presented in the poster.

Poster Session / 50

A Spiral Fiber Tracker for the J-PARC E36 experiment

MINEEV, Oleg[1]

[1] *INR RAS*

Corresponding Author(s): oleg@inr.ru

A Spiral Fiber Tracker (SFT) was developed for use in E36 experiment at Japan Proton Accelerator Research Complex (J-PARC). SFT is designed for conducting high-precision measurement of charge particles from kaon decays and consists of four layers of flat ribbons made of 1 mm diameter plastic scintillating fibers. The fibers are read out by HAMAMATSU MPPCs connected to the scintillating fibers by clear fiber extensions. The ribbons are spirally wound around the kaon stopping target at the center of the detector setup and were tested in a beam in the spring 2015.

Morning Session 6 July/A / 51

Performance of Silicon Photomultipliers in photon number and time resolution

VINOGRADOV, Sergey[1]

[1] *Cockcroft Institute / University of Liverpool / Lebedev Physical Institute RAS*

Corresponding Author(s): sergey.vinogradov@liverpool.ac.uk

Silicon Photomultipliers (SiPMs) are a novel generation of photon detectors designed as an array of independently operated Geiger-mode APDs (pixels) with common output. SiPM provides proportional detection of low-level light pulses starting from single photons with remarkable photon number and time resolution at room temperature. Now they are worldwide recognized to be competitive with vacuum photomultiplier tubes (PMTs) and avalanche photodiodes (APDs) for scintillation and Cherenkov light detections in such areas as particle physics and nuclear medicine. Well-known specific drawbacks of SiPMs are excess noises caused by stochastic processes of crosstalk and afterpulsing as well as non-linearity and saturation of SiPM response to intense light pulses due to limited number of pixels and non-instant pixel recovery. This study presents an analysis of SiPM performance based on probability distributions of the key stochastic processes affecting SiPM response: photo-conversion, dark generation, avalanche multiplication, crosstalk and afterpulsing, non-linearity and saturation losses. SiPM performance in photon number resolution (energy) is represented in terms of specific excess noise factors of these processes identified as comparable metrics of their contributions. SiPM time resolution is shown to be defined by photon number resolution and by temporal profiles of photon arrival and photon detection time distributions, and a single electron response. Analytical results of this approach are applied to compare a performance of the modern SiPMs with each other and with conventional PMTs and APDs in typical scintillation and Cherenkov detection applications. The results also seem to be useful for SiPM characterization, selection, and application-specific optimization as well as for SiPM design improvements.

Morning Session 8 July/A / 52

Silicon Photomultiplier (SiPM): a flexible platform for the development of high-end instrumentation for nuclear and particle physics

Author(s): SANTORO, Romualdo[1]
Co-author(s): Prof. CACCIA, Massimo [1]

[1] *Università degli Studi dell'Insubria, Como (Italy)*

Corresponding Author(s): romualdo.santoro@uninsubria.it

Silicon Photomultipliers (SiPM) are a new class of photon sensors featuring single photon detection sensitivity, high photon detection efficiency, low excess noise factor, extended dynamic range and

magnetic field immunity. Operated at voltages not exceeding 100 V with a power consumption lower than 100 mW, SiPM benefit from the tremendous development of the Silicon technology in terms of cost production, design flexibility and performances.
They have been proven to be suitable for an increasing number of applications in science and industry and they are bound to open new perspectives in low light detection systems. This is the main reason why, few years ago, an R&D program was started in collaboration with CAEN S.p.A. to design a modular set-up that allows to easily operate SiPMs from different producers. The system, together with a dedicated simulation of the sensor response, is meant to be the base for the device characterization and the proof of concepts for new SiPM-based applications.
The main characteristics of the system will be presented together with a series of exemplary applications in medical dosimetry and homeland security, within projects funded by the European Commission with the Frameworks programs 6 and 7.

Poster Session / 53

Challenges of arbitrary waveform signal detection by Silicon Photomultipliers as readout for Cherenkov fibre based beam loss monitoring systems

Author(s): Dr. VINOGRADOV, Sergey[1]
Co-author(s): Mr. DEVLIN, Lee [2] ; Dr. NEBOT DEL BUSTO, Eduardo [3] ; Ms. KASTRIOTOU, Maria [3] ; Prof. WELSCH, Carsten [2]

[1] *Cockcroft Institute / University of Liverpool / Lebedev Physical Institute RAS*

[2] *Cockcroft Institute / University of Liverpool*

[3] *CERN / University of Liverpool*

Corresponding Author(s): sergey.vinogradov@liverpool.ac.uk

Silicon Photomultipliers (SiPMs) are well recognised as very competitive photodetectors due to their exceptional photon number and time resolution, room-temperature low-voltage operation, insensitivity to magnetic fields, compactness and robustness. Detection of weak light pulses of nanosecond time scale appears to be the best area for SiPM applications because in this case most of the SiPM drawbacks have a rather limited effect on its performance. In contrast with the more typical scintillation and Cherenkov detection applications which demand information on the number of photons and/or the arrival time of the light pulse only, beam loss monitoring (BLM) systems utilising Cherenkov fibres with photodetector readout have to precisely reconstruct the temporal profile of the light pulse. This is a rather challenging task for any photon detector especially taking into account the high dynamic range of incident signals (100K – 1M) from a few photons to a few percents of destructive losses in a beam line and presumably an arbitrary temporal distribution of photons (localisation of losses). Nevertheless, a number of advantages and ongoing improvements to the drawbacks of SiPM technology are considered to be a reasonable ground for this feasibility study of SiPM application in BLM systems. Transient SiPM responses on light pulses of a wide range of intensities have been measured and an analytical model has been applied to describe the results. Non-linearity of SiPMs due to the limited number of pixels and non-instant pixel recovery time is found to be a source of transient and history-dependent distortions of output signals. Discussion of the challenges and issues, possible measures to resolve the issues, and requirements for improvements of corresponding SiPM parameters is presented.

Afternoon Session 7 July/D / 54

The TORCH PMT:

MILNES, James[1]

[1] *Photek Ltd*

Corresponding Author(s): james.milnes@photek.co.uk

Photek are currently in a three year development program with CERN to produce a novel square PMT for the proposed TORCH detector which is aimed at the upgrade of the LHCb experiment.

The PMT will be MCP based for the inherent timing accuracy that this brings, and has three main novel features that need to be developed:

1. Long lifetime, it should be able to produce 5 C / cm^2 of accumulated anode charge without noticeable degradation in sensitivity.
2. Multi-anode output with a spatial resolution in the "y" direction of 0.4 mm and 6 mm in the "x" direction.
3. Close packing on 2 opposing sides with an active area fill factor target of 88% in the "x" direction. We will describe the work completed so far including the building and testing of lifetime prototypes, multi-anode prototypes and high fill factor (square) tube body shape developments. Previous work published by Photek has demonstrated a significant lifetime improvement in an MCP-PMT when the MCP is coated by Atomic layer Deposition (ALD). We believe that the ALD layer forms a barrier that prevents the outgassing of material from the MCP under heavy electron bombardment that, from an uncoated MCP, gets ionised and reacts with the photocathode, thus reducing the sensitivity. The front-end read-out of choice is currently the NINO ASIC and we will describe our developed method of efficiently coupling the PMT output pads to a PCB through an ACF film that minimises any parasitic input capacitance by allowing very close proximity between the NINO and the detector. We will also report on preliminary results from a charge sharing technique that enables position resolution that exceeds the granularity of the multi-anode.

Afternoon Session 6 July/B / 55

Muon tomography applied to active volcanoes

Author(s): MARTEAU, Jacques[1]
Co-author(s): Prof. GIBERT, Dominique [2] ; Dr. BREMOND, Jean [2] ; Mr. JOURDE, Kevin [3] ; Mr. IANIGRO, Jean-Christophe [4] ; Mr. CARLUS, Bruno [4]

[1] *IPN Lyon*
[2] *Géosciences Rennes*
[3] *Institut de Physique du Globe de Paris - UMR 7154*
[4] *IPNL - UMR 5822*

Corresponding Author(s): marteau.jacques@gmail.com

The DIAPHANE project is pluri-disciplinary collaboration between particle and ge o-physicists to perform the tomography of large geological structure mainly devoted to the study of active volcanoes. The detector used for this tomography, hereafter referred to as telescope, uses a standard, robust, cost-effective and well-known opto-electronics technology based on photomultipliers (either multichannel pixelized PM or silicon PM). The electronics system is built on the concept of autonomous, triggerless, smart sensor directly connected on a standard fast Ethernet network. In this talk the potential of the technique is detailed and discussed in the context of underground laboratories (long-term storage problems) and of active volcanoes. I will present recent results obtained on the Lesser Antilles volcanoes (Soufrière of Guadeloupe, Soufriere Hills of Montserrat), on the Etna in Sicily and on the Mayon in the Philippines. In particular I will show how the technique improved with time (embedding a sub-nanosecond resolution TDC within the existing programmable logic to reject background) and allows nowadays to monitor the activity of phreatic volcanoes and to constrain the geophysical models.

Poster Session / 56

Time resolution improvement of an electromagnetic calorimeter based on lead tungstate crystals

Author(s): Dr. IPPOLITOV, Mikhail[1]
Co-author(s): Dr. LEBEDEV, Valery [2] ; Prof. MANKO, Vladislav [3] ; Dr. SIBIRYAK, Iouri [3] ; Dr. AKINDINOV, Alexander [4] ; Dr. GORBUNOV, Nikolai [5] ; Dr. NOMOKONOV, Petr [5] ; Dr. RUFANOV, Igor [5] ; Prof. VODOPYANOV, Alexander [5] ; Dr. ZAPOROZHETS, Sergey [5]

[1] *NRC "Kurchatov Institute" and MEPhi*

[2] *NRC "Kurchatov Institute"*

[3] *NRC "Kurchatov Institute"*

[4] *ITEP*

[5] *JINR*

Corresponding Author(s): mikhail.ippolitov@cern.ch

Time resolution improvement of the electromagnetic calorimeter PHOS (CERN/ALICE experiment) is discussed. The existing channel consists of a scintillating crystal of PbWO4 viewed by APD (avalanche photo diode) HAMAMATSU S8664-55(S8148) coupled to the low noise charge sensitive preamplifier. For improvement of the timing resolution of the detecting channel it is proposed to enter one more photodetector SiPM (the silicon photo multiplier) in addition to the existing APD photodetector. APD signal is used for energy measurements and SiPM provides timing information. Laboratory tests and beam-test results are presented. We discuss energy and time resolutions of detecting channel with two very different photodetectors.

Morning Session 8 July/A / 57

Recent Enhancements of the KETEK SiPM Device Performance with regard to Timing, Cross Talk and CMOS Compatibility

Author(s): HARTINGER, Werner[1]
Co-author(s): WIEST, Florian [1] ; KNOBLOCH, Juergen [1] ; FOJT, Reinhard [1] ; Dr. POPOVA, Elena [2] ; DIETZINGER, Christoph [1] ; GANKA, Thomas [1] ; ISKRA, Peter [1] ; ENGELMANN, Eugen [1] ; LOEBNER, Sabrina [1] ; GEBAUER, Wolfgang [1] ; MÁRQUEZ SECO, Alicia [1] ; DÜSBERG, Felix [1]

[1] *KETEK*

[2] *National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)*

Corresponding Author(s): werner.hartinger@ketek.net

Silicon Photomultipliers (SiPM) are well-known low level light detectors and are potentially devices to replace Photomultiplier Tubes (PMT).
Essential technical key features for the sensors are the timing performance and the optical crosstalk probability. In order to achieve considerable improvements, KETEK has realized process modifications of its established SiPM technology:
The first modification is an optimized signal read-out for the micro pixel network, bringing down the single photon time resolution (SPTR) by a factor of 2.5.
Secondly, there is an improved optical trench isolation which leads to a further suppression of the optical cross talk down to a level of 3% in Geiger saturation regime, which corresponds to 5 V overvoltage (20% relative overvoltage) for the new KETEK device.
The processed devices will be presented and compared to the earlier established technology and an outlook on coming features will be given.
In addition KETEK has successfully transferred the SiPM production into a CMOS foundry. Beside cost advantages compared to a customized production process this also enables the integration of electronics on sensor level. In a close cooperation with MEPHI, KETEK has started R&D on analogue CMOS SiPM with integrated fast electronics.

Poster Session / 58

Two Models of Micropixel Avalanche Photodiode Response

Mr. ZHEZHER, Valeriy[1]

[1] *Joint Institute for Nuclear Research, Dubna, Russia*

Corresponding Author(s): vzhezher@gmail.com

Two simple models of response of the Micropixel avalanche photodiode (MAPD) are proposed. The first simple discrete model describes an avalanche development and quenching in time in a

single pixel. The time step is chosen as a ratio of depletion layer depth to the thermal velocity of charge carriers. Electric field and ionization coefficients for electrons and holes are recalculated before each step taking into account internal avalanche and external recharge currents and voltage drop between the pixel electrodes. The numbers of secondary carriers (electrons and holes) created within the depletion layer and collected at electrodes after each step are evaluated. One of important results is behavior of the avalanche after potential difference between cathode and anode of the pixel reaches a value of the breakdown voltage. The voltage keeps decreasing and new electron-hole pairs are being created with decreasing rate. The number of the charge carriers produced before and after the voltage reaches the breakdown voltage is approximately the same. As a result an effective pixel capacitance obtained from a slope of linear dependence of the pulse charge on bias voltage turns to be overestimated approximately twice.
In the second model the initial number of triggered pixels (or photoelectrons that initiated an avalanche process) is distributed according to Poisson law. This distribution then was distorted by optical crosstalk and dark noise counts. The crosstalk probability is assumed to follow the Poisson law. The dark noise was considered as a Poisson process. Simulation of resulting distribution of a number of triggered pixels was performed using Monte Carlo technique. Fitting results of the simulation gave simple formulae for extraction of parameters of initial distributions from the resulting distribution. The results of simulation are in good agreement with experimental data. Known fractions of events in the zeroth and first peaks of the experimental distribution and dark count rate allows one to extract the number of primary fired pixels and the crosstalk fraction.

Morning Session 9 July/B / 59

NICA/MPD Electromagnetic Calorimeter based on Multi-pixel Avalanche Photodetector

TYAPKIN, IGOR[1]

[1] *JINR*

Corresponding Author(s): igor5255@mail.ru

A Multi Purpose Detector (MPD) is being constructed for the Heavy-Ion Collider at Dubna (NICA). One of the important components of MPD setup is an Electromagnetic Calorimeter, which will operate in the magnetic field of MPD solenoid and provide good energy and space resolution to detect photons in the energy range from ˜100MeV to few GeV. For this purpose the, so-called, “shashlyk” sampling structure with the fiber readout to the silicon Multipixel Avalanche Photodetector is used. The genuine design is similar to the one developed by us for COMPASS experiment but a number of important modifications have been introduced to better meet MPD resolution, large volume thermo-stabilization and other requirements. These details are presented in the report along with the beam test results obtained with the MPD/NICA module prototypes.
Autors: N.Anfimov, V.Chalyshev, I.Chirikov-Zorin, Z.Krumshtein,B.Marinova, A.Olshevskiy, T.Rezinko, A.Rybnikov, A.Selyunin, I.Tyapkin

Morning Session 9 July/A / 60

High-Density-cell (HD) NUV Silicon Photomultipliers produced at FBK

Author(s): ACERBI, Fabio[1]
Co-author(s): Mr. FERRI, Alessandro [1] ; Mr. ZAPPALA, Gaetano [1] ; Dr. GOLA, Alberto [1] ; Dr. PATERNOSTER, Giovanni [1] ; Mr. ZORZI, Nicola [1] ; Mr. PIEMONTE, Claudio [1]

[1] *FBK*

Corresponding Author(s): acerbi@fbk.eu

In FBK we develop different custom SiPM technologies. The so called NUV-SiPM are based on a p-on-n junction type, on n-type epi/substrate. This configuration enhances the photon detection efficiency (PDE) in the blue-wavelength region (PDE typically peaked at 400 nm), thanks to the electron-triggered avalanche when incoming photons are absorbed near the surface. The electron

impact-ionization coefficient is higher than for holes and the trigger probability rises sharp already with few volts of excess bias (i.e. the difference between bias and breakdown voltage).
We recently developed a new high-density version of NUV-SiPM, called NUV-HD. Like RGB-HD technology, presented in [1], the devices feature a considerably high fill factor (FF) while reducing the correlated noise. This new NUV-HD technology combined all the benefits of the HD technology, i.e. high FF, increased photon detection efficiency, low correlated noise and high cell-density (thus high dynamic range), with the advantages of NUV approach (p-on-n junction) for light detection at short wavelength.
In the HD technology we use a small cell size (CS) and we implement trenches between cells. The reduction of cell size gives a lower gain of the cell, reducing both the afterpulsing and the amount of secondary-electrons, thus the optical crosstalk. Moreover, the trenches between cells provide optical isolation, further decreasing the crosstalk between cells. Thanks to this reduced correlated noise, it was possible to increase the FF to have a dead border region of about $1 \div 1.7\ \mu m$.
We produced different SiPM prototypes with cell size of $15\times15\ \mu m^2, 20\times20\ \mu m^2, 25\times25\ \mu m^2, 30\times30\ \mu m^2$. The fill factor is 77% for the bigger cell and about 55% for the $15 \times 15\ \mu m^2$. Thanks to the technology development, the HD technology shows the same low dark count rate (DCR) of "standard" NUV-SiPM, i.e. in the order of 100 kcps (kilo counts per second), for 1 mm^2 device. The direct crosstalk probability is ∼30% for the bigger cell and only ∼7.5% for the SiPM with the smaller one, at ∼6 V of excess bias, while the afterpulsing and the delayed crosstalk is only ∼1%. The PDE of the 30-μm cell SiPM is ∼40% already at low excess bias (as shown in the figure below), and it increases to ∼55% with 7 V. For the 15-μm cell PDE is ∼33% with 7 V.
[1] C. Piemonte, A. Ferri, A. Gola, T. Pro, N. Serra, A. Tarolli, N. Zorzi, "Characterization of the First FBK High-Density Cell Silicon Photomultiplier Technology," IEEE Trans. Electron Devices., vol. 60, no. 8, pp. 2567-2573, Aug. 2013.

Afternoon Session 6 July/B / 61

Implementation of silicon photomultipliers in scintillation detector systems of the GAMMA-400 space gamma-ray telescope

Author(s): RUNTSO, Mikhail[1]
Co-author(s): Mr. ARKHANGELSKYI, ANDREY [1] ; Mr. KUSHIN, VLADIMIR [1] ; Mr. MAKLYAEV, EVGENIY [1] ; Mr. MELIKYAN, YURIY [1] ; Mr. NAUMOV, PIOTR [1] ; Mr. NAUMOV, PAVEL [1] ; Mr. SHARAPOV, MIKHAIL [1] ; Mr. SOLODOVNIKOV, ARTIOM [1] ; Mr. YURKIN, YURIY [1] ; Mrs. ARKHANGELSKAYA, IRINA [1] ; Mr. GALPER, ARKADIY [1] ; Mr. FEDOTOV, SERGEY [1] ; Mr. KHEIMITZ, MAKSIM [1] ; Mr. KAPLIN, VLADIMIR [1] ; Mr. LEONOV, ALEXEY [1] ; Mr. LOGINOV, VITALIY [1] ; Mr. LAZAREV, SERGEY [1]

[1] *NRNU "MEPHI"*

Corresponding Author(s): mfruntso@mephi.ru

The scintillation detectors characteristics of GAMMA-400 gamma-ray space telescope constructed with the implementation of silicon photomultipliers manufactured by different manufacturers are reported. The measurements were carried out at the technological model of the gamma-ray telescope. The efficiency, amplitude ant timing properties of fast plastic large area scintillators and also calorimeter detectors based on non-organic CsI(Tl) scintillators were investigated. The detectors characteristics matching to the requirements for the systems of gamma-ray telescope is shown.

Morning Session 7 July/B / 62

Russian scintillation PMT for photon detectors developed and manufactured by MELZ

BELYANCHENKO, Sergey[1] ; Mr. ILIEVSKII, Valentin[2] ; SILAEV, Ilya[1] ; Dr. LUBSANDORZHIEV, Bayarto[3] ; RYKALIN, Vladimir[4]

[1] *"MELZ PMT" Ltd., Moscow*

[2] *Ltd "MELZ-PMT"*

[3] *Institute for Nuclear Research of the Russian Academy of Sciences*

[4] *IHEP, Protvino*

Corresponding Author(s): ilievskii@inbox.ru

Photomultiplier tubes (PMT) used as photodetectors, are of current importance nowadays. Wide application of photon detectors in high-energy physics, cosmic ray physics, astrophysics, security systems and medical diagnostics requires huge variety of photomultiplier tubes' types both by dimensions and parameters. "MELZ FEU" Ltd. is a leading Russian designer and manufacturer of various types of PMTs with high sensitivity, low noise level, high-speed impulse counting and excellent energy resolution.

One of the state-of-the-art developments of MELZ is PMT designed for registration of nanosecond luminous impulses, generated neutrino within operating volume of detector of deep-water neutrino telescope for KM3Net project. This photomultiplier is constructed in glass shell having 3 inches (76 mm) of photocathode useful diameter and 43,2 mm curvature radius. Overall length without pins is 105 mm, external diameter of the neck – 52 mm. In this PMT we use electro-optical system of linear type with 10 dynodes and underfocusing electrode on its input, which is mounted upon ceramics and has a mesh anode that works on reflection. Spectral response range of bialkali photocathode is 320-650 nm. Spectral sensitivity at 404 nm wavelength is not less than 130 mA/W. Gain is 5×10^6 at the least. Impulse duration at its half-altitude could be not more than 3 ns.

FEU-86U with potted voltage divider is also of interest to the consumer. It has 16 mm photocathode diameter with maximum 22 mm of overall diameter, weighting not more than 50 g. Luminous noise equivalent of the dark current of the anode is not more than $5 \times 10^{-13} lm/Hz^{1/2}$, and dark impulses counting rate at one-electron peak not is not greater than 300 1/s. All this parameters in the aggregate allow us to consider FEU-86U as the best threshold photomultiplier manufactured in Russia. It's been widely used in portable monitoring equipment for air environment in enclosed spaces.

Photomultipliers with 30 mm bulb diameter (photocathode diameter 25 mm) – FEU-85B, and FEU-115M8 are also commonly spread and well known. Their general feature is bialkali photocathode which considerably improves energy characteristics of the products. For example FEU-85B has not more than 800V voltage at the luminous sensitivity of anode 10 A/lm, and not more than 1000V at 100 A/lm. Energy resolution with crystal NaI (Tl) 25×25 mm, with ^{137}Cs – not more than 8.5%, and energetic equivalent of intrinsic noise doesn't exceed 1 keV. According to customer's request, this PMT can be issued with potted voltage divider encapsulated into bulb 30 mm diameter.

FEU-115M8 is used in the large area portals to detect radioactive objects in the traffic flow. Having 30 mm bulb diameter and not more than 67 mm length, its weight does not transcend 50g and, moreover, this PMT has at least 25 mm useful diameter of photocathode. By using fiber-optics it provides You an opportunity to collect light from a large volume of the scintillator very effectively. With operating voltage in the range 1300-1400 V, it has energetic equivalent of intrinsic noise less than 6 keV and energy resolution with crystal NaI (Tl) 25×25 mm, with ^{137}Cs - not more than 10%. In addition, it is a preferable alternative to the previously made by another manufacturer FEU-35 and FEU-35-1, since in comparison to them it has 2 times more spectral sensitivity at 410 nm wavelength of 5×10^{-2} A/W and lower operating voltage.

We can not ignore FEU-184, being manufactured by MELZ for many years and on the basis of which many modifications were developed. FEU-184 has 52 mm bulb diameter, 46 mm useful photocathode diameter, 110 mm length and weights not more than 120 g. With luminous sensitivity of anode 10 A/lm its operating voltage does not exceed 1350 V, and typical value is 650-750 V; energy resolution with crystal NaI (Tl) 40×40 mm, with ^{137}Cs - not less than 7%; with ^{57}Co - not less than 9.6% (typical value is 8.4 - 8.8%), energetic equivalent of intrinsic noise does not exceed 3 keV (typical value is 0.7 keV). The same parameters has a three-inch photomultiplier FEU-184TD. In addition to that, we have designed a heat-resistant modification FEU-184T, capable of working at ambient temperatures up to 150°C, having at the mentioned temperature energetic equivalent of intrinsic noise less than 40 keV, and not more than 50% decay of anode sensitivity. LLC "MELZ PMT" also serially produces heat-resistant PMT of 20 and 30 mm diameter with operating temperatures – 120, 150 and 200°C.

Poster Session / 63

Investigation of avalanche photodiodes after irradiation with neutrons up to 5×10^{14} n/cm^2

Mr. KARNEYEU, Anton[1] ; Dr. MUSIENKO, Yuri[2]

[1] *INR RAS*

[2] *INR RAS (Moscow)/University of Notre Dame (Notre Dame)*

Corresponding Author(s): anton.karneyeu@cern.ch

Results on the radiation hardness of avalanche photodiodes to fast neutrons are presented. APDs from Hamamatsu were irradiated with reactor neutrons up to 1 MeV equivalent fluence of 5×10^{14} n/cm^2 . The effects of this radiation on many parameters such as gain, intrinsic dark current, quantum efficiency, noise and capacitance for these devices are shown and discussed.

Poster Session / 64

Studies of vacuum photomultipliers at extremely low thresholds, photoelectron backscattering and photon detection efficiency

Author(s): Dr. LUBSANDORZHIEV, Bayarto[1]
Co-author(s): Mr. LUBSANDORZHIEV, Sultim [2] ; Dr. VYATCHIN, Evgeny [2]

[1] *Institute for Nuclear Research of the Russian Academy of Sciences*

[2] *Institute for Nuclear Research of RAS*

Corresponding Author(s): lubsand@rambler.ru

We present results of extensive studies of vacuum photomultipliers behavior at extremely low thresholds. Usually in case of low intensity light registration, like in Cherenkov and air fluorescent light detection experiments as well as in laboratory studies of single photoelectron response of photomultipliers, photomultipliers are operated at thresholds in the range of 0.1-0.5 photoelectrons (p.e.). But what will happen if to decrease threshold further down? For many years experimental physicists have been plagued by a sharp rise of the number of pulses with low charges in the charge distribution of pulses when they have been trying to decrease threshold. This part of spectrum is attributed to the noise and usually erroneously discarded. In our previous works [1, 2] it was shown that the part of the spectrum due to pulses with low charge are explained by photoelectrons inelastically backscattered on the first dynode. In present paper we show that this part of the spectrum is of crucially importancce for measurements and understanding of photon detection efficiency of vacuum photomultipliers.
Decreasing threshold working with some photomultipliers we managed to set a record threshold of as low as 0.002 p.e.. At such a low threshold beside main photoelectrons from photocathode we detected photoelectrons produced by direct photoemission at the first and even second dynodes, Fig.1 and 2. Although we reached such low threshold with photomultipliers of different types and sizes, from 1 cm to half a meter in photocathode's diameter, unfortunately not every photomultiplier is able to operate at such threshold. On the other hand photomultipliers able to work are more stable and have better single photoelectron response. So one can put forward a new criterion for photomultipliers quality – the ability to work at threshold lower than 0.01 p.e. The developed method to work with extremely low threshold will allow to trace the fate of each photoelectron produced on the photocathode and will improve the accuracy of photon detection efficiency with vacuum photomultipliers.
References.

1. B.K.Lubsandorzhiev et al. NIMA. 2000. V.A442. P.452.
2. B.K.Lubsandorzhiev et al. NIMA. 2006. V.567. P.12-16./ physics/0601157.

Afternoon Session 8 July/C / 65

"New" and "Old" ideas in photon detection.

LUBSANDORZHIEV, Bayarto[1]

[1] *Institute for Nuclear Research of the Russian Academy of Sciences*

Corresponding Author(s): lubsand@rambler.ru

We review some aspects of new and old developments in photon detection techniques. Particular emphasize is made on connections of "new" and "old" ideas in photon detection: quite often "new" ideas are well forgotten "old" ones. Comparisons are made for some "new" ideas claimed recently with "old" ideas discussed earlier, for some ideas – more than 40 years ago. Lessons learnt in studies of old developments will help to avoid not only "bicycle invention" but also give seeds for new genuine ideas as well.
The review covers different approaches in vacuum photodetectors developments including classical photomultipliers and hybrid phototubes pushed forward for the last 50 years. Some other issues concerning WLS and light guide techniques for increasing photodetectors sensitivity are discussed too. Rather detailed discussion of large area vacuum photodetectors (classical PMTs and Hybrid Phototubes) developments are presented.
Particular attention is paid to various applications by which photodetector developments have been driven by.

Poster Session / 66

Improved Performance and High Fill Factor TSV Packaged SiPM by SensL

Author(s): Mr. JACKSON, Carl[1]
Co-author(s): Mr. TIMOSHIN, Vyacheslav [2]

[1] *SensL*

[2] *AZIMUTH PHOTONICS*

Corresponding Author(s): timoshin@azimp.ru

SensL is undertaking continued development of silicon photomultiplier (SiPM) technology, both in performance and packaging. This poster presents some recent advances made in the packaging and performance of SensL SiPM sensors. We will show a better than order-of-magnitude reduction in the dark count rate resulting from process improvements. These ultra-low dark count rates are now available in SensL's current C-Series generation of SiPM sensors. Further gains are from the development of advanced through silicon via (TSV) technology that results in improved packaging solutions. An analysis of the various SensL packaging options is also presented, showing PDE measurements and the calculated fill factor of epoxy, micro leadframe package (MLP), and TSV packaging approaches. SensL will present improved core SiPM characteristics such as dark count rate and afterpulsing in its latest sensor which in turn enables leading CRT (Coincidence Resolving Time) for ToF-PET applications.

Poster Session / 67

Study of the MAPD performance for the electromagnetic calorimeter of the COMPASS-II experiment

Mr. SELYUNIN, Alexandr[1]

[1] *JINR*

Corresponding Author(s): selalsebog@gmail.com

ECAL0 is a new electromagnetic calorimeter designed for studying generalized parton distributions at the COMPASS II experiment at CERN. It will be located next to the target and will cover larger photon angles (up to 30 degrees). It is a modular high-granularity Shashlyk device with total number of individual channels are more than 1700. Since it operating in the magnetic

field the light readout is based on solid state photodetectors – micropixel avalance photodiodes (MAPD). To provide high linearity in a wide dynamic range of energies MAPD with high pixel density ($\sim 10^4 mm^{-2}$) can be used only. In this talk studying of the performance of the various types of MAPD with ECAL0 modules is presented.

Afternoon Session 7 July/D / 68

Performance of the MCP-PMT for the Belle II TOP counter

Author(s): MATSUOKA, Kodai[1]
Co-author(s): Mr. HIROSE, Shigeki [2] ; Prof. IIJIMA, Toru [1] ; Dr. INAMI, Kenji [2] ; Dr. KATO, Yuji [1] ; Dr. MAEDA, Yosuke [1] ; Mr. MIZUNO, Ryo [2] ; Dr. SATO, Yutaro [1] ; Dr. SUZUKI, Kazuhito [2]

[1] *KMI, Nagoya University*

[2] *Graduate School of Science, Nagoya University*

Corresponding Author(s): matsuoka@hepl.phys.nagoya-u.ac.jp

The time-of-propagation (TOP) counter is a novel ring imaging Cherenkov detector. It is a key device of particle identification in Belle II to extend the physics reach toward a new physics. The essence of the TOP counter is to detect the Cherenkov photons with a high efficiency and a better time resolution than 50 ps. Thus we developed the micro-channel-plate photomultiplier tube (MCP-PMT).
We succeeded in producing all the 512 MCP-PMTs used for the TOP counter. The photon detection efficiency and the response to single photons were measured systematically for every MCP-PMT: the average quantum efficiency is greater than 28% at 380 nm wavelength and the time resolution is 30-40 ps as expected. The detailed results will be presented including the high voltage dependence of the performance. In addition we measured the degradation of the gain, time resolution and collection efficiency in a 1.5 T magnetic field. These results will also be presented. In summary we would like to discuss that the systematic mass measurement showed not only the excellent performance of the MCP-PMTs for the TOP counter but also helped us to reveal the basic properties of the MCP-PMT.
Our R&D is now focused on upgrade of the MCP-PMT performance in terms of the lifetime, which we define as the total output charge where the quantum efficiency declines down to 80% of the beginning. We improved the production process of the MCP-PMT and succeeded in extending the lifetime longer than 10 C/cm^2 for all of four test samples. The lifetime test results as well as the R&D status will be included in the presentation.

Afternoon Session 6 July/C / 69

A Scintillating Fibre System Readout by SiPMs for Precise Time and Position Measurements

Author(s): DAMYANOVA, Antoaneta[1] ; Dr. BRAVAR, Alessandro[1]
Co-author(s): Mr. KAPTUR, Emil [2] ; Dr. KOWALSKI, Seweryn [2] ; Mr. PULAWSKI, Szymon [2] ; Mr. GREDIG, Roman [3] ; Mr. CORODI, Simon [4]

[1] *University of Geneva*

[2] *University of Silesia*

[3] *University of Zurich*

[4] *ETH Zurich*

Corresponding Author(s): antoaneta.damyanova@unige.ch

The compact size, fast response time and insensitivity to magnetic fields, turn the silicon photomultipliers (SiPM) into a suitable solution for experiments like Mu3e, where time information, with less than a nanosecond precision, is required. In the present talk we report on the performance of 250μm scintillating fibers staggered into ribbons and readout by Hamamatsu MPPCs. The analogue signals were first amplified and then fed to constant fraction discriminators, after which they were digitized through standard VME TDC and QDC modules. We have tested two

fiber-SiPM coupling configurations: one with individual fibers matched to single sensors, and another with whole ribbons attached to LHCb-type arrays. The time and position resolving capabilities of the systems were evaluated in conditions where either very low or extremely high number of photons were incident on the photodetectors.

Morning Session 7 July/B / 70

Optical modules and PMTs for the KM3NeT neutrino telescope

KALEKIN, Oleg[1]

[1] *Erlangen Centre for Astroparticle Physics*

Corresponding Author(s): oleg.kalekin@physik.uni-erlangen.de

KM3NeT is a multi-cubic-kilometer neutrino telescopes under construction in the Mediterranean Sea. KM3NeT will study of neutrinos of cosmic origin in the TeV-PeV energy range, and neutrino oscillation and mass hierarchy using atmospheric neutrinos in the GeV range. Both projects will use the same design of active elements to detect Cherenkov light of charged secondary particles – the optical modules. In the current first phase of the project, 31 detection units – a few hundred meters high vertical structures holding 18 Digital Optical Modules (DOMs) each – will be produced and deployed in the Mediterranean deep sea. The KM3NeT DOM consists of pressure resistant glass sphere encapsulating 31 photomultiplier tubes of 80 mm diameter produced by Hamamatsu, readout electronics and additional instrumentation for calibration and monitoring. The use of ˜3 inch diameter PMTs recently developed by ETL, HZC and MELZ is under investigation. This contribution describes the design and characteristics of the KM3NeT DOM and reviews suitable PMT types for this application.

Morning Session 9 July/A / 71

Characterization of the First Prototypes of Ultra-High-Density RGB Silicon Photomultipliers

Author(s): GOLA, Alberto[1]
Co-author(s): ACERBI, Fabio [1] ; FERRI, Alessandro [1] ; HEERING, Adriaan [2] ; Dr. MUSIENKO, Yuri [3] ; PATERNOSTER, Giovanni [1] ; PIEMONTE, Claudio [1] ; RUCHTI, Randal C. [2] ; ZORZI, Nicola [1]

[1] *Fondazione Bruno Kessler*

[2] *University of Notre Dame*

[3] *INR RAS / University of Notre Dame*

Corresponding Author(s): gola@fbk.eu

We characterized the first RGB SiPMs with Ultra-High-Density cells (RGB-UHD) manufactured at Fondazione Bruno Kessler (FBK), Trento. These devices employ narrow trenches to separate the SiPM microcells and feature extremely high cell density, very low gain and correlated noise and ultra-fast recovery time. Such characteristics are of great interest in applications that require high dynamic range and/or good resistance to radiation damage, such as the CMS ECAL/HCAL upgrade.
The devices have cell pitch of 7.5 μm, 10 μm and 12.5 μm, are arranged in a honeycomb configuration and have a circular active area with a 1.5 mm diameter. The cells have an hexagonal shape, thus, for example, the area of the 10 μm cell is 87 μm^2. The cell density is 20500, 11500 and 7400 cells/mm^2, for the three cell sizes, respectively. For each cell, there are four layout splits, differing in one very critical parameter, which is the distance of the active area from the cell border and from the isolating trenches. We call these split D1...D4, ordered from the most challenging layout, D1, to the most conservative one, D4. Depending on these splits, the fill factor (FF) of the cells varies between 57% and 33% and between 68% and 47%, for the 7.5 and 10 μm cells, respectively.
The automatic IV measurements showed that all cell sizes and layout splits were working in Geiger mode. We focused on the characterization of the cells with a 7.5 μm and a 10 μm pitch.

The measured Gain was very small, in the order of 3.5×10^4 and 4.5×10^4 per 1 V of over-voltage (V_{OV}), for the 7.5 μm and the 10 μm cells, respectively. These values correspond to a cell capacitance (C_T) of 4.5 fF and 5.7 fF for the two cell sizes. The low value of C_T allowed obtaining a very fast cell recovery time-constant, which was in the order of 3.5 ns and 4.5 ns, for the 7.5 μm and 10 μm cells. The primary, Poisson-distributed DCR measured at 20 °C with the D3 splits was 80 kHz/mm^2 and 200 kHz/mm^2, for the 7.5 μm and 10 μm cells, respectively.
Thanks to the low gain, we measured extremely low correlated noise probability (P_{CN}), which represents the sum of afterpulsing and optical crosstalk probabilities. For both cell sizes, P_{CN} was below 10% at 6 V over-voltage, resulting in ENF of ∼1.1. We also carried out a first PDE measurement at 515 nm on the 7.5 μm and 10 μm D1 cells, obtaining a PDE of 13.5% and 30% at 7 V_{OV}, which are remarkable values, considering the cell sizes. Finally, using a pulsed light source, we demonstrated single photon resolution at 20 °C for both cell sizes.
In conclusion, we demonstrated the functionality (with a pulsed light source) and characterized the properties (in the dark) of the RGB-UHD SiPM technology, featuring an ultra-high density of cells, extremely low gain, very fast recovery time constant and good PDE. We expect that the UHD characteristics will reduce the effects of radiation damage on SiPMs. The fast recovery time and the high cell density reduce the PDE loss due to cells busy because of the increased DCR, while the low gain reduces afterpulsing and power consumption. In the conference presentation, we will describe the RGB-UHD technology and we will report in detail on the experimental characterization of the different cell sizes and layout splits.

Poster Session / 72

A neutron detector with WLS-fibers readout and SiPM

Author(s): Mr. LITVIN, Vasily[1]
Co-author(s): KARAEVSKY, Sergey [2] ; Dr. SADYKOV, Ravil [2]

[1] *Institute for Nuclear Research RAS*

[2] *INR RAS*

Corresponding Author(s): vlitvin@inr.ru

A new neutron position sensitive detector was developed and tested. For neutron detection we uses LiF/ZnS-scintillation sheet. For light readout wavelength shifting (WLS) fibers used. Each end of these fibers connected with SiPM. The coordinate resolution of this detector is about 1 mm. Each scintillation sheets have efficiency 25 % for thermal neutrons. The detector can consist 2-3 sheets for more efficiency. A neutron coordinate determined by the position of the SiPM with pulse. The events was registered by gate pulses which generate by PMT mounted behind the scintillator sheets. This detector cam be useful for Small angle neutron spectrometers at continuous and at pulsed neutron sources.

Afternoon Session 8 July/D / 73

Development of start detector for ToF system of MPD/NICA experiment.

Author(s): Mr. YUREVICH, Vladimir[1] ; Mr. BATENKOV, Oleg[2]
Co-author(s): RUMYANTSEV, Mikhail [1] ; Mr. BABKIN, Vadim [1] ; Mr. LOBASTOV, Sergei [1]

[1] *JINR*

[2] *V.G. Khlopin Radium Institute*

Corresponding Author(s): mikhail.rumyantsev@yandex.ru

Project NICA/MPD is dedicated to study of hot and dense baryonic matter in collisions of heavy ions (up to Au^{+79}) in energy region $4 \leq \sqrt{S_{NN}} \leq 11$ GeV. The ToF system of MPD is the main detector for particles identification. It has to have time resolution better than 100 ps for separate pion/kaon in the momentum range 0-2.5 GeV/c and proton/kaon in the range 0-4.5 GeV/c. The stop signal for ToF measurments is given by barrel of Multigap Resistive Plat Chambers (MRPC).

The start signal for ToF measurements is given by stations of Cherenkov quartz counters (FFD - Fast Forward Detector).
A modular Cherenkov detector with picosecond time resolution is developed and created at LHEP/JINR in Dubna. The aim of this detector is production of start signal for ToF detector and fast triggering. This goal is achieved by registration of high-energy photons and charged pions in the detector modules based on MCP-PMTs XP85012/A1- Q from Photonis. The high-energy photons are detected via conversion to electrons in 10-mm lead layer in front of the 15-mm quartz radiator. The detector concept, module characteristics, and the detector performance studied by MC simulation and by using deuteron beam of Nuclotron are discussed. The time resolution of the detector module obtained in ToF measurements on deuteron beam is 24 ps for DRS4 digitizer readout and 37 ps for TDC (HPTDC chip) readout.

Afternoon Session 8 July/D / 74

Study of polystyrene scintillators-WLS fibers elements and scintillating tile-WLS prototypes for New CHOD detector of CERN NA-62 experiment

SEMENOV, Vitaliy[1]

[1] *IHEP, Protvino? RF*

Corresponding Author(s): vit.k.semenov@gmail.com

In the paper the light output and the time resolution of polystyrene scintillators-WLS samples have been measured with use wavelength shifting (WLS) fiber readout. The samples of different thickness (7-30 mm) have been made in the shape of bricks and plates with the areas of 25×80 and 108×134 (268) of mm^2 respectively. Besides samples of "ordinary" scintillator with additions of 2% p-Terphenyl + 0,05% POPOP, the rapid ultraviolet scintillator with one 2% additive PBD was used. For the light collection were used WLS-fibers BCF92, Y11 and scintillation fiber SCSF-78M as re-emitting. The fibers were glued into the grooves on the front surface of scintillators. As the photo detectors silicon photomultipliers (SiPM) were used, which were produced by CPTA (Russia) and SensL (Ireland). It is shown that the dependence of light output on the thickness of scintillator is nonlinear and close to the power function with $\frac{1}{2}$ index, which is also confirmed by the calculations carried out by Monte Carlo. The measured value of a light output makes it possible to obtain time resolution of about 0.5 ns. The best result (0.22 ns) of the time resolution with the MIP detection is obtained for the pair of ultraviolet scintillator and SCSF-78M fiber.

Poster Session / 75

Design of Large Scale Detectors Based on Polystyrene Solid State Scintillators Made of Granulated Polystyrene with WLS Fibers Light Collection

Dr. GORIN, Aleksandr[1]

[1] *SRC IHEP*

Corresponding Author(s): gorin@ihep.ru

Test results of parameters of $50 \times 50\ cm^2$ area scintillation detectors, produced of the commercial polystyrene granules with a technic of melting in a polished molding box are presented in a paper. The scintillators maximum emission spectrum is 425 nm and in comparison with block polymerized scintillators they have the same light yield in small samples, but significantly smaller volume transparency. The efficient scintillation light collection is realized with the help of 1 mm WLS fibers glued in grooves on the surface of the scintillator. An avalanche multipixel photodiode (SiPM) with $2.5 \times 2.5\ mm^2$ sensitive area is used as a photo receiver.
The counter light yield for MIP detection reaches 60 photoelectrons, light collection nonuniformity not exceed 30%. For example, calculated MIP detection efficiency is 99.9% at 15 pe discriminator threshold and in this case the peak-value ratio in an amplitude spectrum is equal to 1.2 and event rate is about 1000 1/s. The noise counts created by only SiPM do not observed at this threshold.

The small sizes of SiPM and preamplifier allow one to create detectors without geometrical inefficiency zones and to cover by them areas of any size. Such detectors may be used in cosmic ray researches, guard systems and other applications.

Poster Session / 76

Development of components for creation of the infrared module with the purpose of express analysis of motor-car fuel

Author(s): Dr. KIZHAYEV, Sergei[1]
Co-author(s): Dr. SALIKHOV, Khafiz [1] ; Dr. STOYANOV, Nikolay [1] ; Dr. CHERNYAEV, Anton [1] ; Dr. STOYANOVA, Tatiana [2]

[1] *LED Microsensor NT, LLC*

[2] *National Mineral Resources University (Mining University), Saint Petersburg, Russian Federation*

Corresponding Author(s): chernyaevav@yandex.ru

Creation of low-cost, portable sensors that can continuously provide information about the quality of the fuel for the tank is a very important task. Such sensors may be of interest both for car owners and manufacturers of automobile engines, as the life of an engine depends on fuel quality. One possible solution to this problem is the development of the infrared (IR) module to analyze the composition of gasoline and diesel fuel. In this paper transmission of IR radiation has been investigated in the range (1 - 4) μm for petrol of different brands and motor-car diesel fuel. The most substantial distinctions in the IR radiation transmission have been identified.
Fig. 1. Transmission spectra of gasoline (brand of the gasoline indicated on Fig.) and diesel fuel (dashed line).
Presence of light-emitting diodes and photodiodes with good operating parameters [1] is a necessary condition for creation of the smart IR module for the express analysis of petrol and diesel fuel. Previously we reported about creation of high-efficiency light-emitting diodes based on GaSb and InAs operating in the IR range [2, 3]. For the purpose specified above the photodiodes operating in the range of 2.0-3.6 μm at the temperatures up to 60 °C with the sensible area of 0.5 mm radius were developed. Two layers were deposited on the n-InAs substrate by the method of metalorganic vapour phase epitaxy. The active area of n-InAs was 2.5 μm thick and the barrier layer of p-InAsSbP was 1.5 μm in thickness with the using of Zn-containing source diethylzinc for p-n junction creation.For the improvement of operating parameters of photodiods the decline of concentration of charge carriers is needed in an active area, that was provided by the charge carriers compensation as diffusion of the acceptor impurity (Zn) proceeds. It was found out that distribution of concentration inside of the active area and of p-n junction position were influenced on the flux of diethylzinc which was varied within 0.20 μmol/min to 0.27 μmol/min. Experimentally C-U characteristics were measured at room temperature. The effective concentration of carriers in an active area was determined on the basis of the sharply asymmetrical p-n transition model. As the result the optimal growth conditions have been found from the point of view of flux value of diethylzinc FDeZn, namely: minimum concentration of charge carriers as much as 2.2×10^{16} cm^3 was obtained at FDeZn = 0.27 μmol/min. Thus the best operating parameters of photodiods were provided: responsivity R = 1.5 A/W, resistivity (at no bias) Ro = 1.1 kOhm, detectivity $D^* = 1.6 \times 10^{10}$ $cm\sqrt{Hz}/W$, dark currents I = 60 μA (at reverse bias 100 mV), capacity C = 0.6 nF.
Summarizing, in this work investigations have been carried out which were necessary for creation of the smart IR module with the purpose of express analysis of motor-car fuel, namely: 1) Transmission spectra for motor-car diesel fuel and petrols in the middle IR range have been obtained; 2) Epitaxial layers growth conditions have been optimized for improvement of photodiode operating parameters.
References

1. *www.lmsnt.com.*
2. N.D. Stoyanov, B.E. Zhurtanov, A.P. Astakhova, A.N. Imenkov and Yu.P. Yakovlev, High-efficiency LEDs of 1.6-2.4 μm spectral range for medical diagnostics and environment

monitoring, Semiconductors, 37, 8, 971-984, 2003.

3. N. Stoyanov, Kh. Salikhov , K. Kalinina, B. Zhurtanov, S. Kizhaev, Middle infrared LEDs: key element for new generation chemical sensors, Proceedings of the SPIE, 8257, 82571E-6, 2012.

Poster Session / 78

FIPSER a novel low cost and high performance readout for astrophysics

Author(s): OTTE, Nepomuk[1]
Co-author(s): CRESSLER, John [2] ; LIMYANSKY, Brent [2] ; REESE, Bobbey [2] ; TABOADA, Ignacio [2] ; ULUSOY, Cagri [2]

[1] *Georgia Tech*

[2] *Georgia Institute of Technology*

Corresponding Author(s): otte@gatech.edu

Low-cost and low-power digitization systems become increasingly important in particle-physics and particle-astrophysics experiments as the number of channels continuous to increase. Specialized readout concepts have been developed in the past that aimed at lower costs and made detector systems with many ten thousand channels feasible. As the number of channels in experiments is still on the rise new readout concepts are needed that meet upcoming demands.
We propose a novel readout system FIPSER (FIxed Pulse Shape Efficient Readout) that is primarily aimed for the digitization of detector signals that are a few nanoseconds long and vary in amplitude, but do not change their shape. FIPSER has the potential to lower the costs of the readout, including the front-end electronics, by an order of magnitude to less than $10 and power consumption to less than 50 mW per channel. FIPSER has the potential to be a key technology to make new groundbreaking experiments possible that have previously not been feasible due to conflicting power, thermal, and performance requirements.

Morning Session 8 July/B / 80

SiPM Readout of 128 nm Liquid Argon Scintillation Light Detectors

KUTTER, Thomas[1]

[1] *LSU*

Corresponding Author(s): kutter@phys.lsu.edu

Detection of neutrinos and the search for proton decay require large volume detectors. The electrical and optical properties of liquid argon (LAr), its affordability and its availability make LAr a suitable medium for detectors with masses up to several tens of kilotons.
After an introduction to the physics scope and a conceptual overview of LAr time projection chambers I will address the relevance, challenges and requirements of 128 nm LAr scintillation light detection in large volume cryogenic detectors. I describe work on large area VUV photon detector panels with a focus on the SiPM readout and associated cryogenic tests of SiPM properties in our laboratory.

Morning Session 6 July/A / 81

Review talk on SiPM's

OTTE, Nepomuk[1]

[1] *Georgia Tech*

Corresponding Author(s): pd15@inr.ru

Review talk on SiPM's

Morning Session 8 July/A / 82

Review talk on electronics

Mr. FLEURY, Julien[1]

[1] *WEEROC*

Corresponding Author(s): pd15@inr.ru

Review talk on electronics

Afternoon Session 6 July/C / 83

Highlights of Poster Session

YOKOYAMA, Masashi[1]

[1] *University of Tokyo*

Corresponding Author(s): pd15@inr.ru

Highlights of Poster Session

Summary and Announcements / 84

Summary talk

Prof. HABA, Junji[1]

[1] *KEK*

Corresponding Author(s): pd15@inr.ru

Summary talk of the PD15

Summary and Announcements / 85

Announcements from LOC/IPC

KUDENKO, Yury[1]

[1] *INR*

Corresponding Author(s): kudenko@inr.ru

Announcements from LOC/IPC