ABSTRACT BOOKLET

POSTER PRESENTATIONS

NDIP 20 – Troyes July 4th -8th , 2022

Poster Session - "Champagne Brut" - P01-01

Photon measurement and modeling instrumentation capacities developed for nuclear experiment and reactor monitoring

Speaker: DESTOUCHES

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Reliable and accurate measurements of gamma flux, energy and dose is a key stake in the field of the nuclear reactor science. Thus, in-core sensors and measurement systems have been developed to satisfy several severe criteria due to the harsh environment encountered, such as high gamma and neutron radiation flux levels (1E14n/cm²s) and doses/damages (1E21 n/cm², several GGy), high level and gradient of temperature (max 1600°C). This instrumentation have also to cope with constraining operational criteria, such as miniaturization, high reliability, remote operation, etc.
In response to these constraints, the CEA continuously develops innovative sensors and measurement systems both for on-line and a posteriori photonic measurements: Subminiature ionization gas chambers (3 mm in diameter), Gadolinium Self Powered Gamma Detector, Differential calorimeters (energy deposits up to 20 W/g), SiC, Thermo-luminescent detectors.
Besides that, the CEA MADERE platform allows to measure the specific radioactivity of solid samples emitting X or gamma rays on a range from 10 keV to 2 MeV in energy and from the Bq to beyond the MBq (1 – 5% uncertainty)
In addition, advanced modeling tools have been developed to design and optimize these measurement systems.
Main features and performances of these instrumentations will be presented and possible applications in other fields discussed.

Poster Session - "Champagne Brut" - P01-02

The Spid-X gamma camera: a miniature gamma ray integral field spectrometer for nuclear industry applications

Speaker: LE BRETON

R. LE BRETON[1], O. LIMOUSIN[2], G. TAUZIN[1], A. VANEL[2], P. SERRANO[3], V. MOGEAR[3], G. DANIEL[4], Y. GUTIERREZ[2], J. HULLO[3], M. VASSAL[3]

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In the framework of the ALB3DO joint laboratory, CEA/IRFU and the 3D PLUS French company are developing a gamma camera with embedded coded mask aperture and Compton imaging capabilities. This miniature (less than 3kg) integral-field spectrometer allows for spectro-identification and imaging in the nuclear domain from 2 keV up to 1 MeV. It is based on the Caliste technology, which uses finely pixelated CdTe semiconductor detectors and low noise ASICs, and which is originating from research and development for space astronomy and high-energy solar observation. The Caliste technology has been successfully launched on the STIX spectrometer onboard the Solar Orbiter satellite.
The aim of Spid-X is to perform in real time and thanks to a human portable device, the four following functions: automatic identification of radioisotopes, proportion measurement in case of multiple detections, imaging, and dosimetry at the camera level. This collection of features in only a single device makes Spid-X a very useful instrument for applications in the nuclear industry, such as monitoring, D&D and waste management. Indeed, thanks to a Convolutional Neural Network (CNN) trained on synthetic data, Spid-X only needs a few tens of photons to identify one or more radioactive sources in the same scene. Moreover, identified point or extended sources can be located in the 2D projection of the scene thanks to Coded Mask Aperture and Compton imaging and their corresponding algorithms. Finally, to enable the user to assess the safety of the scene, dosimetry is computed at the position of the device.
Along with a complete overview of the system, we present the first light of the first Spid-X prototype as well as performance results from first measurements.

Poster Session - "Champagne Brut" - P01-03

Demonstrative measurement of proton-nuclear reaction by deconvolving the prompt gamma-ray spectra

Speaker: OKAZAKI

M. HOSOBUCHI [1], F. NISHI [1], R. TANAKA [1], T. INANIWA [2], J. KATAOKA [1]

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In proton therapy, accurate measurement of dose distribution is required for improving the accuracy and quality of treatment.
One method of estimating radiation dose in real-time is to visualize the prompt gamma rays emitted during proton irradiation.
However, this is difficult without accurate measurements of nuclear cross sections, that cover a 10-100MeV energy range.
Herein, we propose a novel method for determining cross section by measuring the prompt gamma rays emitted from stacked slab phantoms placed along the proton path.
By applying an iterative inference using the response matrix, the contamination of various prompt gamma rays can be resolved; thus, the cross sections of various reactions were obtained at arbitrary proton energies.
In this study, we applied this method to measure the nuclear reaction of protons with 12C and 16O nuclei, which are the major elements constituting the human body.
The cross section of the 12C(p,p)12C* reaction, which produces a prominent gamma-ray peak at 4.4MeV, reproduced the one in literature well, supporting the validity of the proposed method.
Furthermore, we show that even weak prompt gamma rays can be resolved for a wide range of proton energies below 70MeV, for which no cross sectional data have been reported so far.

Poster Session - "Champagne Brut" - P01-04

Commissioning, Characterisation and Temperature Stabilisation of a 22000 SiPM-on-Tile Hadron Calorimeter System

Speaker: HEUCHEL

D. HEUCHEL [1], FOR THE CALICE COLLABORATION

[1] *Deutsches Elektronen-Synchrotron (DESY)*

With the successful construction and operation of a highly granular SiPM-on-tile calorimeter system, featuring ~22000 channels for individual read-out, the CALICE collaboration has set the next milestone in proving the scalability of this concept for a future high energy linear collider experiment.
For this large sample of photo-sensors a new approach of quality control was required to sufficiently monitor and characterise device parameters for both, test bench and in-situ beam test data. In the presence of temperature fluctuations during operation, it was possible to stabilise the SiPM responses with a fully automatic adaption of the bias voltage based on frequent temperature measurements, thanks to the excellent uniformity of the device parameters.
This talk will present results of SiPM parameter monitoring and characterisation studies during the construction and commissioning phase and report about the general system performance and the experience of automatic temperature compensation at system level during operation.

Poster Session - "Champagne Brut" - P01-06

In-depth study on the impact of proton irradiation on the dark current of two types of SiPM as part of a space qualification process.

Speaker: LACOMBE

K. LACOMBE[1], A. BARDOUX[2], I. BELKACEM[3], J. KNöDLSEDER[3], T. GIMENEZ[2], P. RAMON[4], B. THOMAS[5]

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In high-energy astrophysics domain, many space missions combined photomultiplier tubes (PMTs) with scintillators, for converting incoming high-energy photons into visible light, which is converted in an electrical pulse.
The silicon photomultipliers (SiPM), instead of PMTs which are bulky, fragile, and requiring a power supply of several thousand volts, are an encouraging alternative in the space field.
In this respect, we characterized SiPM detectors, coming from four manufacturers, to evaluate their use for space telescopes.
We first conducted a SiPMs characterization to study their performance in a representative space environment (a dedicated vacuum chamber), namely at low temperature and low pressure.
After studying measurements such as dark current, or Photon Detection Efficiency, we performed a first campaign of irradiation tests at UCL (Belgium) in order to analyze the susceptibility of SiPM to radiation damage on two selected detectors with a high level of fluence. Finally we led a new proton irradiation campaign based on several lower levels of fluence and two energies for further study.
Hereafter, we present the results of dark current measurements of irradiated detectors (SensL and FBK references) and, in addition, we show the impact of a heating stage on detectors performance.

Poster Session - "Champagne Brut" - P01-07

Innovative 3D coded aperture for imaging ionising radiations

Speaker: SUSAIEV

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Localization of ionizing radiation is an important issue in numerous applications in the nuclear industry and high-energy astrophysics. Aiming to improve current hard X-ray and low-energy gamma-ray imaging systems, which are usually based on flat coded apertures, a first version of the coded aperture in 3D was manufactured. It has a hemispherical shape with the Archimedean spiral pattern transparent to the incoming radiation. The prototype was tested in CEA List and CEA Irfu, and the first results show a notable improvement of the field of view in comparison with regular imaging systems based on flat coded apertures. A simulation code based on the ray-casting algorithm was also developed to consolidate the experimental results. This simulation code is planned to be used in the future to refine the next generations of aperture patterns in 3D.

Poster Session - "Champagne Brut" - P01-08

The scintillation light detection system of ICARUS T600: hardware implementation and initial results

Speaker: BONESINI

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ICARUS T600 detector is the largest Liquid Argon Time Projection Chamber (LAr-TPC) ever operated in a neutrino beam for oscillation studies.
After intense refurbishing operations carried out at CERN, the apparatus was transferred to Fermilab (IL, USA) to be used as a far detector within the Short Baseline Neutrino (SBN) program: three LAr-TPC detectors, placed along the Booster Neutrino Beam (BNB) line and operating at shallow depth, to investigate the possible presence of sterile neutrino states.
A brand new light detection system, based on large area Photo-Multiplier Tubes, has been realized for ICARUS T600 to detect VUV photons produced after the passage of ionizing particles in LAr. This system is fundamental for the T600 operation, providing an efficient trigger and contributing to the 3D reconstruction of events. Moreover, since the detector will be exposed to a huge flux of cosmic rays, the fast scintillation light signal is used to identify the neutrino interactions within the BNB and NuMI spill gates.
The main phases of the installation of the ICARUS T600 scintillation light detection system will be presented as well as initial results in terms of PMT gain and rates.

Poster Session - "Champagne Brut" - P01-09

Enhancing robustness of Deep Learning algorithms for spectral Identification of Radionuclides

Speaker: CHAOUAI

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Nuclear monitoring requires rapid, accurate and reliable diagnostic tools to characterize unknown radiological scenes. Recent studies have shown the potential of Deep Learning approaches to reach this goal for radionuclide spectral identification. These algorithms are capable of analyzing gamma-ray spectra to give a real-time answer with interesting performances, even for spectra with low-counting statistics. However, the scientific literature in Deep Learning has pointed out that models based on deep neural network show some lack of robustness, in the sense that small specific perturbations on the input data can change the prediction of the algorithm. In this study, we demonstrate that we are able to inject particular perturbations, small relative to the Poisson statistic, into gamma-ray spectra that mislead a neural network, which is otherwise highly accurate on unperturbed data. We apply a robust training procedure, called “adversarial learning” or “adversarial training”, to improve the robustness of our Deep Learning models. We evaluate this method using Caliste-HD, a CdTe detector for X- and gamma-ray photons. Our Deep Learning algorithm consists of a Convolutional Neural Network trained on a synthetic database of simulated spectra and tested on real data acquired with Caliste.

Poster Session - "Champagne Brut" - P01-11

An innovative detection system based on plastic scintillators, optical fibers, and fast photosensors for dosimetry in FLASH radiotherapy

Speaker: CASOLARO

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Ultra-high dose rate radiotherapy, also known as “FLASH”, is a potential breakthrough in cancer care. Beam monitors and dosimeters typically used in conventional radiotherapy fail under the FLASH conditions, making the clinical translation of FLASH challenging as it requires the development of new technologies. In this work, we propose an innovative detection system based on submillimeter polystyrene scintillators coupled to optical fibers and read-out by fast photosensors. The first beam tests have been performed at the 18 MeV medical cyclotron at the Bern University Hospital (Inselspital). The response of the new detection system has been found to be linear, within the experimental uncertainties, up to a dose rate of 110 Gy/s. The promising results reported in this work show the potentiality of high time- and spatial-resolution fast scintillators coupled to optical fibers as dosimeters and beam monitors for future FLASH radiation therapy clinical applications.

Poster Session - "Champagne Brut" - P01-12

Parametrisation of high light yield, energy resolution, and optical crosstalk in a SiPM-based liquid argon detector

Speaker: MOHARANA

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Light detection in low-energy experiments is of paramount importance. Silicon PhotoMultipliers (SIPMs) is a proven technology capable of detecting low-intensity light signals down to the single-photon level, with their performances improving year after year. At our lab in LNGS, we have been developing small scale single-phase liquid argon (LAr) detector prototypes equipped with high-performance SiPM photodetectors. We aim at achieving unprecedented levels of light yield in LAr setups utilizing a SiPM-based readout. In this talk, we will present the results of a 5 cm cubic chamber and a 4x3 cm cylindrical chamber, both instrumented with two 5x5 cm2 SiPM tiles of the FBK NUV-HD-Cryo family. We obtain gross light yield values of ~32 pe/keV in both setups at the maximum operating over-voltage, however, following our analysis involving the deconvolution of optical crosstalk (oCT) we estimate the true light yield to be around ~12 pe/keV. These oCT contributions are subject to fluctuations that can potentially affect the detector energy resolution, and should therefore be well understood. We present the full parametrisation of the light yield, energy resolution, and oCT components in the tested detectors, with a detailed discussion of the analytical model used.

Poster Session - "Champagne Brut" - P01-15

On-ground calibrations of XGRE: an ultrafast gamma-ray spectrometer onboard the TARANIS mission

Speaker: LAURENT

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XGRE (X-ray, Gamma-ray and Relativistic Electrons experiment) was one of the main instruments onboard the TARANIS satellite payload. It is an ultra-fast (350ns timing resolution) gamma-ray and electron detector built for measuring Terrestrial Gamma ray Flashes (TGFs). In this poster, we will present the TARANIS mission, discuss the design of the XGRE instrument and the measured performances during the instrument calibration at APC, LESIA and payload calibrations done onboard the satellite in CNES.

Poster Session - "Champagne Brut" - P01-16

Recent progress of the MCP-PMT development in the XIOPM

Speaker: CHEN

P. CHEN [1], J. TIAN

[1] XIOPM

Microchannel plate photomultiplier tubes (MCP-PMT) with high dynamic ranges and strong outputs are still challenges for applications in nuclear detection. We investigated the influence factors of gain nonlinearity causing high-linearity limits of the MCP-PMTs based on traditional MCP and the ALD coated MCP. Understanding how secondary electron emission (SEE) affects the performance of MCPs is crucial to choose the appropriate SEE materials and thickness correspondingly for the MCPs with different parameters. The dependence of the gain and timing performance on the SEE yield properties such as the backscattered, rediffuse and true SEEs were assessed by simulations. The results show that the backscattered and rediffused electrons in the SEE process have a greater effect on the gain of MCP. The gain of MCP does not completely depend on the highest SEE yield of the material.The effects of MCP structural parameters (aperture D, length-to-diameter ratio L/D, bias angle ?, and applied voltage U) on the magnetic field tolerance are also studied carefully. The efficient simulation work aided in both understanding the behavior of these devices and improving the performance. We also developed several types of MCP-PMTs with high dynamic range, fast gating function, position sensitive. All the progress will be presented.

Poster Session - "Champagne Brut" - P01-17

The modular front-end electronics for bolometer readout of the BINGO experiment.

Speaker: BAUDIN

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BINGO (Bi-Isotope 0?2? Next Generation Observatory) is a future experiment aiming in the study of double beta decay without neutrino emission. This experiment consists in the measurement of radioactive decay of scintillating crystals: Li2MoO4 enriched in 100Mo and TeO2 enriched in 130Te. A first prototype of the experiment named Mini-BINGO aims in the development of a specific structure with a total of 96 channels to be read out by a custom and dedicated electronics.
To cover the needs of readout of the experiment a modular front-end electronics has been designed for the readout of Neutron Transmutation Doped populated on crystal (for heat signal) or on germanium wafers (for scintillation light). This electronics consists in a resistance measurement of several hundreds of kOhms with small variation occurring when heat is developed in the sensors located in a cryostat at 15 mK. The electronics itself is located at room temperature and aims a thermal noise below 2nV/?Hz and an integrated noise below 20nV.rms between 1 and 100 Hz. In addition, the electronics provide a polarization voltage around 100 V for taking advantage of the so-called Neganov-Trofimov-Luke effect on sensors located on germanium wafer. We will describe the details and results of this electronics.

Poster Session - "Champagne Brut" - P01-18

Photo-Trap: a low-cost, low-noise solution for a large-area SiPM pixel

Speaker: WUNDERLIICH

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The lack of large-area Silicon photomultipliers (SiPMs) limits their use in many experiments and applications where large detection areas, low cost and power consumption are needed. Since capacitance, dark count rate and cost increase with the SiPM size, they are rarely found in sizes larger than 6 mm x 6 mm. Photo-Trap employs a wavelength-shifter plastic and a dichroic filter to build a SiPM pixel of a few cm^2. Light can be collected over a large area while keeping the noise, single-photoelectron resolution, power consumption and likely the cost of a single SiPM of 6 mm x 6 mm. We developed and characterized through laboratory measurements and simulations, four different proof-of concept pixels (the largest one being of 40 mm x 40 mm) sensitive in the near UV. These pixels achieve an optical gain ranging from ~5 to ~15, with trapping efficiencies going from ~10 to ~50% and a time resolution of ~3 ns. Photo-Trap could provide a solution to use SiPM technology in applications in which large collection areas and low noise are needed (e.g., optical wireless communication, free space quantum key distribution, Cherenkov radiators).

Poster Session - "Champagne Brut" - P01-19

Development of 64-channel LSI with ultrafast analog and digital signal processing dedicated for photon-counting computed tomography with multi-pixel photon counters

Speaker: ARIMOTO

M. ARIMOTO[1], D. SATO[1], K. YOSHIURA[1], J. KATAOKA[2], T. MARUHASHI[2], H. KIJI[2], T. TOYODA[2], H. IKEDA[3], H. KAWASHIMA[1], S. KOBAYASHI[1], S. TERAZAWA[4], S. SHIOTA[4], T. MIZUNO[1]

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X-ray computed tomography (CT) is an essential method for non-destructively visualizing the interior of the human body. Recently, photon-counting X-ray CT (PC-CT) has drawn attention for reducing a high dose for patients and acquiring spectral information to identify materials. To enable photon-counting imaging with a wide region (~60 mm long), we have developed a photon-counting system using a 64-channel multi-pixel photon counter (MPPC) array with a fast temporal response (a few nanoseconds) and a very large signal gain (~10^6), combined with a 64-channel YGAG scintillator array. In particular, to realize ultra-fast analog and digital signal processing (>100 MHz/channel), we developed a 64-channel large-scale integrated circuit (LSI, MPPC-CT64). We previously developed a 16-channel PC-CT system with a 16-channel LSI (MPPC-CT16). Although the MPPC-CT16 realized photon-counting imaging for a ~16-mm-long phantom, there were some energy uncertainties in the LSI, which degraded the obtained CT image quality. Thus, the MPPC-CT64 implements a function for correcting threshold energies and also increases the number of energy thresholds from four to six, which provides more precise measurements of CT values dependent on X-ray energy. In this paper, we briefly present the electric architecture and performance evaluation of the LSI combined with MPPCs.

Poster Session - "Champagne Brut" - P01-20

Radon-222 measurement by detection of alpha- radioluminescence of air with a triple-to-double coincidence ratio (TDCR) counter

Speaker: MITEV

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This work explores the applicability of the triple-to-double coincidence ratio counters (TDCR) as a suitable detector for 222Rn detection and measurement by the alpha- radio-luminescence of air. We developed a TDCR-based 222Rn measurement system which relies on the detection of 222Rn, 218Po and 214Po by air alpha- radio-luminescence of air. The system is connected to a 222Rn calibration facility and its response is studied by comparison to a reference 222Rn monitor that utilizes a PIPS detector. The linearity of the response of the system is verified with certified 239Pu sources in a large alpha emission rate range. The 222Rn response of the system is benchmarked against the reference PIPS detector under stable and varying 222Rn concentrations. An excellent agreement between the two systems is observed. It appears that the proposed method is feasible and has one very distinct advantage – the memory effect due to the deposition of 222Rn progeny can be eliminated entirely, by simply changing the vial in the TDCR counter. The proposed method is applicable for monitoring 222Rn concentrations during the calibration of radon detectors (e.g. solid state nuclear track detectors)

Poster Session - "Champagne Brut" - P01-21

The Image recovery methods for a portable Compton gamma camera with two scintillation detectors

Speaker: IVANOV

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The paper describes studies on modeling of image acquisition using a portable Compton-scattering gamma camera with two 3D scintillation detectors. New detectors are considered that make it possible to determine the coordinate and energy of interaction over the entire crystal volume. For research, a Monte Carlo model was developed to obtain a signal in such detectors. Using the model, numerical experiments can be performed to obtain the necessary data for different scintillation crystals, different geometry of the detectors and their relative positions. The data obtained using the model — modeling signals from sources of various energies and shapes — were used to reconstruct the distribution of sources. Various image recovery methods are considered. Images are reconstructed both for simulated calculated signals and for experimental data obtained with the Temporal delta Compton camera from Damavan Imaging.

Poster Session - "Champagne Brut" - P01-22

Monte Carlo study of a 3D CZT spectroscopic-imager for scattering polarimetry.

Speaker: CAROLI

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The measurement of the polarisation of the high-energy emission from cosmic sources has now become a key observational parameter for understanding the production mechanisms and the geometry of the active regions involved. Therefore, a mandatory requirement for the new instrumentation in this energy regime will be to provide high sensitivity for polarimetric measurements. For several years, our group has studied the performance of CdTe/CZT pixel spectrometer as scattering polarimeter. On the other hand, if you want to achieve the sensitivities required by the next generation instrumentation, in the 100 keV to MeV band, a promising solution is today offered by the development of spectrometers capable of three-dimensional spatial resolution (i.e. 3D spectroscopic imager). Herein, we report on the results of a Monte Carlo study devoted to optimize the configuration of a 3D CZT detector for scattering polarimetry and, in particular, to optimize its modulation factor (Q). Also, we present results on the dependence of Q from detector geometrical configurations (thickness and pixel/voxel scales), and from various filters that can be implemented. Furthermore, to assess the reliability of the implemented numerical model, we compare Monte Carlo results with experimental data obtained with 2D pixel spectrometers.

Poster Session - "Champagne Brut" - P01-24

Charge sharing in pixelated semiconductor sensors

Speaker: KOTOV

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The charge sharing between neighboring pixels in a pixelated sensor can be used to measure particle or x-ray coordinates with accuracy better than the pixel pitch.
The accurate model of the charge distribution shape is essential to achieve ultimate coordinate accuracy. The charge sharing is caused by charge carriers diffusion on the path from the generation point to pixels. This paper is focused on the diffusion of the initially compact charge distribution in the field free region.
The diffusion equation solutions are obtained for different initial conditions and resulting charge distributions are integrated over pixel areas.

Poster Session - "Champagne Brut" - P01-27

Design and fabrication of fast time resolution SOI-SiPM

Speaker: Kenji SHIMAZOE

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A prototype of a silicon photomultiplier (SiPM) was designed and fabricated by the 0.2 \mu\m 5-metal Silicon on Insulator (SOI) technology aiming at monolithic integration of a sensor and its readout electronics for medical radiation imaging. The SOI technology enables a very fine pixel size, the backside illumination, and the improved electronics performance. The SiPM's microcell design, such as the shape or size of electrodes or the quenching resistor, was modified for performance improvement, which was evaluated using a semiconductor analyzer or short-pule laser. The improvement in the PDE (Photon Detection Efficiency), time resolution, and recovery time was confirmed, and these results indicate that SOI-SiPM is applicable to photon-counting CT or TOF-PET.

Poster Session - "Champagne Brut" - P01-30

Characterisation of muon and proton beam monitors based on scintillating fibres with a SiPM read-out

Speaker: ROSSINI

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Beam hodoscopes based on 32x32 3 mm^2 or 1 mm^2 square polystyrene scintillating fibres along X/Y, have been designed and characterised for monitoring low-energy charged particle beams. Each fibre is read by a SiPM and the signal is digitised and analysed off-line.
Hodoscopes were exposed to the 60 Mev/c negative muon beam at Port 1 of the RIKEN-RAL muon facility (UK), where they proved to be good to determine the beam profile and its intensity, via a calibration with cosmic muons.
Furthermore, the exposition to the calibrated single-proton beam at CNAO (Italy), in the momentum range between 340 MeV/c and 690 MeV/c, provided further calibration in dE/dx and showed the feasibility of the detector as an instrument for proton beam characterisation too.
These hodoscopes will be used as negative muon beam monitors for the FAMU experiment at the Rutherford Appleton Laboratory, but the possibility of using them as a beam monitor in hadron therapy has also been investigated.

Poster Session - "Champagne Brut" - P01-31

Silicon avalanche photodiode quantum yield in the 114-170 nm and 210-1100 nm spectral ranges

Speaker: ZABRODSKII

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Back-illuminated “reach through” avalanche silicon precision detector (ASPD) with an active region of 1.0 mm was developed on the base of front-illuminated SPD photodiode. The results of the ASPD spectral measurements in the ranges of 114-170 nm and 210-1100 nm are presented. It is shown that the ASPD has a quantum yield up to 9300 electrons / photon at a reverse bias voltage of 315 V at 160 nm.

Poster Session - "Champagne Brut" - P01-32

Optical analysis of new scintillating compounds for fast neutrons detection

Speaker: GANDOLFO

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Neutron detection involves several issues regarding the intrinsic properties of the neutron itself, especially fast ones (E>0.5 eV). The latter, in fact, are low interacting with matter and their detection often goes hand in hand with gamma-ray's. This means that, for the development of a fast neutron detector, the key features to consider are the neutron detection efficiency and the capability of discriminating between different radiation, both depending on the particular material used for the detector. Despite there is a long tradition in the use of He-3 detectors, recent historical reasons have led to the need of new kind of fast neutron detectors. An alternative could be scintillation detectors, based on the conversion of neutron into ionizing particles via nuclear interaction. In this framework, this work is devoted to the study of the scintillation properties of a new, non-toxic, non-flammable scintillation liquid (1,5-tetraphenyltetramethyltrisiloxane TMTPS doped with 2,5-diphenyloxazole PPO), in order to be able to develop a full detector. In particular, the present work is focussed on the optical characterization of such compound by studying both fluorescence and Ion Beam Induced Luminescence (IBIL) spectrum at different dye percentage.

Poster Session - "Champagne Brut" - P01-33

Eu doped BaCl2/NaCl/KCl ternary eutectic grown by the Bridgman–Stockbarger method and its radiation imaging performance

Speaker: KAMADA

K. KAMADA[1]

[1] *Tohoku University*

2 inch diameter ternary eutectic of Eu doped BaCl2/NaCl/KCl scintillator was grown by the vertical Bridgman (VBS) methods. The BaCl2 phases were elon-gated along the growth direction, based on backscattered electron imaging (BEI) observations. The Tl:CsI scintil-lator phase grew as a matrix, which can be used to create optical waveguides for scintillation light. The expected Eu2+ 4f5d emission was observed at 400 nm by cathode luminescence (CL) measurement. The decay time of the eutectic was 428 ns, and its light output was estimated to be 7800 photons/MeV. An imaging test of the grown eu-tectuc using an gamma-ray was performed using a fiber optic plate, and an electron-multiplying CCD camera.

Poster Session - "Champagne Brut" - P01-34

Wide-band X-ray and gamma-ray imaging of living mouse to reveal pharmacokinetics of At-211

Speaker: MASUBUCHI

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Nuclear medicine therapy is a treatment method in which a radionuclide-labeled agent is selectively taken up by the lesion, and the tumor is directly irradiated. At-211, which is an alpha-ray emitting nuclide and is expected to be highly effective with few side effects, has attracted attention in recent years. In actual treatment, real-time monitoring is required to confirm the dynamics of drug accumulation in the correct location, and to estimate the exposure of normal tissues; therefore, accurate imaging technology is required. We developed a hybrid Compton camera (HCC), which is capable of broadband imaging from X rays to gamma rays, to image mouse treated with At-211 NaAt. Four HCCs were used to image At-211 NaAt-injected mouse under anesthesia. As a result, we were able to see 3D pharmacokinetics in the living mouse by using 79keV, and the accumulation of At-211 NaAt from the whole body to the stomach and thyroid. Furthermore, by implementing BGO active shield to HCC, we also succeeded in visualizing the drug distribution of At-211 NaAt in the mouse by nuclear gamma rays of 570 keV for the first time.
In this talk, I will also provide future perspective for quick and accurate imaging of drug delivery systems.

Poster Session - "Champagne Brut" - P01-35

Plastic Scintillator Detectors for beta-Gamma fast-timing

Speaker: ARICI

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The physical properties of a novel position sensitive fast plastic detector (bPlast detector), its timing performance and further work on the characterization of the position sensitivity capabilities are studied. The bPlast detector has been designed and built for measuring beta particles with energies of up to 8 MeV in decay spectroscopy experiments. In planned decay experiments, the exotic nuclei, produced by the GSI Fragment Separator, will be stopped in an active stopper detector. Shortly after the ion implantation a beta decay and emission of the gamma-rays will follow. The average time expected between implantations and decays is in the order of seconds to minutes, while the lifetimes of the excited states of interest are in the order of 100s ps. The detector consists of BC404 fast plastic scintillators with size of 80x80x3 mm. The scintillator is read out on each side by 16 3x3 mm2 SiPMs grouped in 4. That enables position resolution, locating the light emission point. The position sensitivity of the bPlast detector has been determined precisely, using charge particles by scanning of the detector surface in ?1cm steps. The time resolution of the detector has been tested and a 240ps (FWHM) has been obtained for ~1MeV gamma-rays.

Poster Session - "Champagne Brut" - P01-38

Registration of Laser Plasma Radiation with New Coded Aperture Imaging System

Speaker: IVANOV

O. IVANOV[1], I. STEPALIN[1], V. POTAPOV[1], A. KOLOGRIVOV[2]

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We present results of development system for imaging of radiation of hot spots of laser plasma with new coded aperture imaging system. System intended to increase angular resolution for shot time imaging of relatively week sources radiation. System includes fine code aperture based of random lines (similar to PNP coded aperture) with registration of coded flux of radiation with special x-ray sensitive films. Shadow-grams are processed with special iterative procedure. The procedure uses image of coded aperture as apparatus function of the system. Results of simulation of shadow-gram of sources of different shape and their image reconstruction are presented. The processing of some experimental shadow-rams obtained in laser plasma experiments are discussed also.

Poster Session - "Champagne Brut" - P01-39

Precession measurement of the perturbed angular correlation in double-photon emission nuclides with magnetic field

Speaker: UEKI

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Nuclear medical imaging, such as single photon emission computed tomography (SPECT) and positron emission tomography (PET), is one of important and highly sensitive diagnostic methods in medicine today, which measures and visualizes the accumulation of radiolabeled molecules with gamma rays. In our previous research, we have been investigating a novel method, double photon emission computed tomography (DPECT) utilizing cascade nuclides with cascade gamma-rays. This method can be used to extract the local micro-environment around a nucleus through the time-space correlation of emitted gamma-rays [1]. In this study, we used the magnetic field as the external field since nuclei have the property inducing Larmor precession by magnetic field. We have designed eight GAGG-MPPC 8 by 8 array detectors with individual time-over-threshold readout system to form a ring and characterize the angular correlation of an aqueous solution of 111In caused by the magnetic field. The effect of the existence and strength of the magnetic field on the angular correlation was measured and characterized.

Poster Session - "Champagne Brut" - P01-40

A light tracker based on scintillating fibers with SiPM readout

Speaker: PILLERA

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We present the concept of a novel compact and light tracker based on arrays of plastic scintillating fibers readout with Silicon Photomultipliers (SiPMs). The tracker will be composed of multiple planes, with the fibers in each plane oriented perpendicularly to those in the adjacent planes. Each plane will consist of two staggered layers of fibers, having a round cross section with 500 um diameter and arranged in a close-packed configuration. Scintillation photons produced in the fibers will be collected by SiPM arrays with 250 um strip pitch located at one end of the fibers.
This configuration will ensure an accurate spatial resolution and a fast response, while keeping a reduced material budget. Hence, this detector will be suitable to track low-energy particles and will be able to efficiently detect the Compton-scattered electrons produced by gamma rays with energies down to 100 keV.
We built a reduced scale tracker prototype, using Hamamatsu 128-channel SiPM arrays and 32-channel PETIROC2A front-end ASICs readout. The latter are controlled by a custom data acquisition board with self-triggering capabilities. We tested this prototype with cosmic rays, radioactive sources and accelerated particle beams.

Poster Session - "Champagne Brut" - P01-41

Improving the Performance of the TDC Module for Ghost Imaging System

Speaker: KIM

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The research is to develop a prototype capable of ghost image acquisition in an external environment using a silicon-based single photon detector. Development of optical system and single photon detector for quantum image measurement is carrying out at KAIST, and system for data acquisition is being developed at IRIS Co., Ltd. In order to obtain a ghost image, photons of long wavelengths traveling to the outer space and visible light regions traveling to the inner space will be measured by coincidence detection method. This measurement for ghost image experiments will be performed using a high-speed TDC module. Prototype TDCs were developed as single channel modules using Xilinx Spartan 3 and Spartan 7 FPGAs rather than using TDC commercialization chips such as the AS6501. The TDC module using FPGA board was estimated to be about 100 psec time resolution. This module uses the logic chain delay method to obtain the time information from the lookup table by encoding the flip-flops bits activated during the time delay between the start and stop signals.
From this research, TDC module using FPGA will not only be extended to 2 ~ 4 channels but also be optimized to have time resolution of less than 100psec using improved temperature compensation algorithm.

Poster Session - "Champagne Brut" - P01-42

3D-Printing of Transparent Granulate Materials for Light Guides and Scintillation Detectors

Speaker: WEITZEL

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Additive manufacturing techniques have advanced significantly and get more and more interesting also for the development of active parts of particle detectors. The main advantages are the flexibility in building 3D-forms, as well as fast prototyping cycles. For many detector applications it is crucial to use well-tested materials to avoid aging problems. Printers working with granulates allow the direct printing of original materials, including the usage of several different materials at the same time. This is very attractive, for example, for segmented and 3D-integrated detectors like calorimeters or trigger veto systems based on plastic scintillators coupled to photodetectors. In this work, we focus on the printing of transparent plastic granulates. We compare different thermoplastics as base material, particularly polymethylmethacrylate (PMMA) and polystyrene (PS). The printing process is ARBURG Plastic Freeforming featuring in-line drying, plasticizing with melting points up to 350°C and high-frequency droplet discharging. The main challenges are the transparency of the printed parts and their surface quality. The former is investigated using a UV/Vis spectrometer, the latter using a confocal 3D-microscope. We present a comparison to reference samples and discuss potential future applications of this technology.

Poster Session - "Champagne Brut" - P01-43

Integration of TECs on CMS Barrel Timing Layer SiPM arrays for very high SiPM irradiation

Speaker: HEERING

CMS COLLABORATION

The need for SiPM (Silicon Photomultiplier) operation after very high radiation in current HEP detectors is growing. The high intrinsic gain of SiPMs causes large power consumption after irradiation. We developed a 16 channel SiPM array package with integrated mini TECs (Thermal Electric Coolers) to improve the performance of the SiPMs after irradiation up to 2E14 n/cm2 (1 Mev eq.) for the CMS Barrel Timing Layer (BTL). This new CMS detector will be located just outside of the CMS Tracker and is already planned to be operating at a cryogenic temperature of -35C. By using TEC cooling, the SiPM DCR (Dark Count Rate) can be even further reduced by another factor of two for a ?T of -10 ºC. The extra power consumption can be almost entirely offset using TECs by dropping the power consumption of the SiPM itself by placing the TECs near to the heat source on the package. We also show that by using the TECs with reverse current, we can locally heat and anneal the SiPM's DCR by another factor of 3x during yearly LHC shutdowns. The integration of the TECs into the 16 channel SiPM packages by two manufactures and BTL modules, will be discussed.

Poster Session - "Champagne Brut" - P01-44

Minimizing power consumption for Time-of-Flight PET SiPM readout

Speaker: LATELLA / GONZALEZ MONTORO

R. LATELLA[1], G. KONSTANTINOU[1], A. GONZALEZ[2], J.M. BENLLOCH[2], P. LECOQ[1]

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Good energy and timing resolutions are key parameters for new generations of PET detectors. In particular, the implementation of detectors with minimum electronics, potentially only passive components, is desired. This will improve the cost but more importantly the power consumption of the final scanner, which will further reduce requirements for cooling and space.
In this work, we benchmark four circuit configurations with low power consumption. The tests were carried out using 3x3x5 mm3 LYSO:Ce:Ca crystals and FBK NUV SiPM. The two best scenarios provide a combination of 7% energy resolution and 96.7 ps CTR for 0.3 mW power consumption per detector, with two channels; and 115.1 ps and 12% energy resolution for a circuit without active components and a virtual zero power consumption, with one channel. We will further develop these solutions into system-level arrays with deployment potential.

Poster Session - "Champagne Brut" - P01-46

Performances of LIROC with SiPM: a Rad-Hard Front-End ASIC for Space LIDAR

Speaker: MORENAS

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LIDAR is a distance and speed measurement device using reflection characteristics of emitted light. In space applications, time-tagging LIDAR allows scanning planet surface before landing missions, formation flights by measuring distances between spacecrafts or atmospheric backscatter measurements. The main requirements for the read-out electronics are trifold: single-photon time-tagging capabilities for long range measurements, timing resolution better than LIDAR system (SiPM intrinsic resolution, laser pulse-width, etc.) and minimized dead time.
LIROC is a 64-channel front-end R&D ASIC designed to read silicon photomultipliers delivering charges in the range 50 fC - 10 pC. The ASIC is composed of a 1 GHz RF preamplifier followed by a fast discriminator and low swing LVDS fast driver with a power consumption of 3 mW per channel. The circuit exhibits also a fast return to baseline thanks to its tunable pole zero cancellation circuit prior to the preamplifier. The ASIC also embeds channel-wise DAC for SiPM overvoltage adjustment. Designed in TSMC 130nm, LIROC can furthermore withstand radiation environments up to multi-MRad radiation levels.1 LIROC configuration can be programmed using an I2C interface that has been triplicated for SEU tolerance.
LIROC architecture will be described, as well as foreseen spatial LIDAR with CERN PicoTDC enabling sub-centimeter resolution with picosecond TDC precision.

Poster Session - "Champagne Brut" - P01-47

Compol - a Cubesat Gamma ray polarimeter

Speaker: COJOCARI

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Compol is a proposed Cubesat mission dedicated to long-term study of gamma ray polarization of astrophysical objects. Besides spectral and timing measurements, polarization analysis can be a powerful tool in constraining current models of the geometry, magnetic field structure and acceleration mechanisms of different astrophysical sources. The Compol payload is a Compton telescope optimized for polarimetry and consists of a 2 layer stacked detector configuration. The top layer, the scatterer, is a Silicon Drift Detector matrix developed by the Max Planck Institute for Physics and Politecnico di Milano. The second layer is a calorimeter consisting of a CeBr3 scintillator read-out by silicon photo-multipliers developed at CEA Saclay. The latter is the subject of this talk, during which we will present calibration data and the performance of the calorimeter.

Poster Session - "Champagne Brut" - P01-49

FE electronics for the LEGEND-200 LAr veto

Speaker: ABRITTA COSTA

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The LEGEND-200 experiment is under commissioning at the Laboratori Nazionali del Gran Sasso in Italy. It will search for the hypothetical neutrino-less double beta decay process. It will need to attain an unprecedented background rejection efficiency to meet its physics goals. One mean of choice to do so is through an active veto based on scintillating liquid argon, light from which is collected by glass fibers and detected by arrays of KETEK PM33100T SiPM. Background rejection happens by time coincidence of several SiPM arrays. This translates into the need for very good signal-to-noise ratio and the ability to identify single photons by collected charge. Because of mechanical constraints on the array assembly, the SiPM are read out differentially on mini-coax cables, the signals are extracted from the cryostat through a Kapton band and are sent to the FE boards in-air. No amplification stage is allowed close to the SiPM due to radiopurity constraints.
In this talk we describe the FE system and how its design meets the demanding physics and electrical requirements, as confirmed in-situ in 2021-'22. We also present the integrated software-based slow control chain and its demonstrated stability in terms of the SiPM electrical parameters.

Poster Session - "Champagne Brut" - P01-50

Comparative study on existing and new optical fiber-based scintillation detector for spent fuel verification equipment

Speaker: KWAK

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The Wolsung Nuclear Power Plant is under IAEA safeguards. During IAEA PIV, the OFPS has been used as an official instrument for verification of a spent fuel since 2007. Some issues of the OFPS such as its low sensitivity, large and heavy structure lead to requiring more time and labor for IAEA safeguards activities and increasing an operator's load for preparing for a dangerous and time-consuming secondary inspection. The objective of this paper is to develop a new optical fiber-based scintillation detector to deal with such issues. To increase sensitivity of the instrument, a new optical fiber-based scintillation detector was developed by combining a P-terphenyl scintillator with an optical fiber of a 1.8 mm core diameter. A field test was carried out in Wolsung unit 1 Heavy Water Rector in Korea to characterize performance of the new OFPS. The results of the field test showed that the new instrument has at least 15 times higher sensitivity and also measured even very weak signal which could not be measured by the existing one. From the experimental results, we can conclude that the new OFPS would lower time and labor required for verification activities of spent fuels in wet storage pool.

Poster Session - "Champagne Brut" - P01-51

A Monte Carlo Model for Amorphous Silicon Based Microchannel Plates

Speaker: WYRSCH

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Amorphous silicon based microchannel plates are being developed to overcome performance limits of traditional glass-based microchannel plates. The two main attributes, bulk material and channel surface structure, differ from the usual case and determine the electron avalanche creation. A comprehensive 3D model is being developed to analyse the behavior of microchannel plates for various geometries. The model includes measurements of secondary electron emission energy distribution and Monte Carlo simulations of the electron yield as a function of energy and angles. We compute electron trajectories with a finite element analysis multi-physics software. The paper presents the results of Monte Carlo simulations and measurements of secondary emission functions of amorphous silicon and the high secondary emissive materials Al2O3 and MgO. We discuss discrepancies between these results and the expected secondary emission yield from gain measurements using the Eberhardt's model. The validity of this model for the analysis of amorphous silicon based microchannel plates is also addressed. Finally, we present model results for the gain, potential performance and timing properties as a function of the specific design of AMCPs.

Poster Session - "Champagne Grand Cru" - P02-03

A Low Noise Current-sensitive Preamplifier VIEC made from a Charge-sensitive Preamplifier

Speaker: KANNO

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For the decrease of dose exposure in X-ray computed tomography (CT), a low noise current-sensitive preamplifier, VIEC, was developed. The VIEC is made from a charge-sensitive preamplifier, which is immune to the dark current of an X-ray detector. With removing a feedback resistance from the charge-sensitive preamplifier, the voltage of a feedback capacitance is kept constant until the next X-ray deposits its energy into a detector. With measuring the voltage change of the feedback capacitance, the electric current induced by X-rays can be measured. Comparing with a conventional current-sensitive preamplifier IPA-6 which the authors have been using, the VIEC could measure the electric current about 1/750 of that the IPA-6 could.

In this paper, we report on CT measurements for 100 mm diameter acrylic phantom with using the VIEC and the IPA-6. The CT image qualities were compared in view of signal-to-noise ratio (SNR). For giving CT images with the same SNR, the VIEC requires 1/300 of X-ray tube current than the IPA-6 does.

Poster Session - "Champagne Grand Cru" - P02-04

Development of X-ray Ghost Imaging Simulation with GATE

Speaker: KIM

J. KIM[1], J. HWANG[1], K. KO[1], G. SONG[1], J. PARK[1], S. LEE[1], G. CHO[1]

[1] Korea Advanced Institute of Science and Technology

In this study, we firstly proposed a GATE simulation for x-ray ghost imaging (XGI) to preliminarily design some parameters and quantitatively predict its performance in terms of both the image quality and the absorbed dose of a sample. XGI was constructed with a computational GI scheme consisting of pre-recorded patterns. Pseudo-thermal x-ray was generated from the irradiation of a coherent x-ray beam (30 keV) on a scattering medium. The position and size of CuSn powder in the scattering medium was randomly changed at each measurement to acquire various speckle patterns. Under these conditions, a set of patterns were recorded by multi-pixel detector. After that, the bucket intensity signal was obtained by reproducing the corresponding patterns in the same sequence of frames. The total number of correlated data is ten thousand where the exposure time is 1 ?sec at each measurement. To quantitatively examine the absorbed dose of the sample, DoseActor was exploited into GATE code. The simulated XGI reconstructed several ghost images where the PSNR and SSIM were up to 9.37 dB and 0.58. Comparing with the direct imaging, XGI showed the poor images in the same exposure time, whereas the absorbed dose of the sample was slightly decreased.

Poster Session - "Champagne Grand Cru" - P02-05

Patterned Anodes with Sub-millimeter Spatial Resolution for Large-area MCP-based Photodetector Systems

Speaker: LI

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The development of large-area micro-channel-plate-based photodetectors (MCP-PMTs) such as the LAPPDTM with sub-mm space resolution and psec time resolution opens opportunities from high-precision 4D imaging. In such systems the electronic channel count is a major cost driver. Incorporating a capacitively coupled anode allows the use of external pickup electrodes with patterns of individual channels optimized for occupancy, rate, and time/space resolution applications while using a shared photodetector design. The signal pickup antenna can be economically implemented as a printed circuit card with a 2D array of pads for high-occupancy/high-rate applications, or a 1-dimensional array of strips for a lower channel count in low-occupancy/low-rate applications.

In 2021, we proposed pad patterns that enhanced signal-sharing between pads to substantially lower the channel count per unit area in large-area systems, while maintaining sub-millimeter spatial resolutions. Patterns that gang non-contiguous pads using multiple signal layers can lower the channel count even further, moving the scaling behavior in the number of pads from quadratic to linear. Several anode designs using strips and pads have been implemented as multi-layer PC boards and are under testing. We will present the designs and the results for presentation at NDIP20.

Poster Session - "Champagne Grand Cru" - P02-06

Neutron and beta imaging with Micromegas detectors with optical readout

Speaker: COOLS

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Recent developments have shown that coupling a Micromegas gaseous detector on a glass substrate with a transparent anode and a CMOS camera enables the optical readout of Micromegas detectors with an good spatial resolution demonstrating that the glass Micromegas detector is well-suited for imaging. This feasibility test has been effectuated with low-energy X-ray photons also permitting energy resolved imaging. This test opens the way to different applications. Here we will focus, on two applications. Namely, neutron imaging for non-destructive examination of highly gamma-ray emitting objects, such as irradiated nuclear fuel or radioactive waste. And secondly, we are developping a beta imager for the cell tagging in the field of anticancerous drug studies.

Both applications require gas simulations to optimization of photon yields and sensitive camera as well as design of the detectors in view of the specific constraints of reactor dismantling and medical applications: spatial resolution and strong gamma suppression for neutron imaging and precise rate and energy spectrum measurements for the beta.

A dedicated system consisting of a glass Micromegas detector and an ultrasensitive camera has been designed and assembled. First results from the characterization of the detectors will be shown as well as the first acquired images.

Poster Session - "Champagne Grand Cru" - P02-07

CATIROC, a multichannel front-end ASIC to readout array of PMTs in in large-scale experiments

Speaker: CONFORTI DI LORENZO

S. CONFORTI DI LORENZO[1]

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CATIROC (Charge And Time Integrated Read Out Chip) is a 16-channel front-end ASIC designed in AMS SiGe 0.35 µm technology to readout photomultiplier tubes (PMTs) in large-scale applications. It has been conceived such as a SoC (System on Chip) that processes analog signals up to the digitization to reduce the cost and cable number. It is an autonomous system operating in self-trigger mode, triggering on a single photoelectron (p.e. 160 fC @PMT gain 106) and providing a measurement of the arrival time and the integrated-charge for 16 input signals.

It provides a charge measurement over a dynamic range from 160 fC up to 70 pC and a time measurement with an accuracy of 500 ps (200 ps rms) per channel. CATIROC finds a valuable application in the context of the next-generation neutrino experiments, which are currently under design and deals with multi-tons targets and thousands of channels.

In particular it is currently implemented in the readout boards of the JUNO (Jiangmen Underground Neutrino Observatory) experiment, a liquid scintillator antineutrino detector, and a total of 2000 ASICs have been produced for the front-end board mass production. The ASIC architecture, the performance measurements for applications to neutrino experiments will be detailed in the talk.

Poster Session - "Champagne Grand Cru" - P02-08

Near infrared photosensor module for LIDAR applications

Speaker: TAVERNIER

S. TAVERNIER[1], R. BEN-MICHAEL[2], R. BUGALHO[3], D.S. JOSE CARLOS[3], L. FERRAMACHO[3], C. LEONG[3], R. SILVA[3], M.S. MIGUEL SILVEIRA[3], J. VARELA[3]

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There are many advantages in using near infrared light for LIDAR. The laser power can be larger because the human eye is less affected by light in this wavelength region, the sunlight is less intense in certain parts is this wavelength region, and the Laser beam is less diffused by small particles in the atmosphere such as tiny water droplets or dust particles.
In this contribution we will present results obtained with a LIDAR detector using a Discrete-Amplification Photon Detector (DAPD) sensitive to photons in the range of 950nm to 1650nm range, combined with a digital readout using an ASIC suitable for LIDAR.
We will present an study the performance of this device using dark counts and LASER pulses at 1538.2 nm. and demonstrated that the system can detect pulses of a few photons in typical LIDAR applications.

Poster Session - "Champagne Grand Cru" - P02-09

Monte-Carlo model for calculating SiPM noise in measuring systems

Speaker: MUSIENKO

Y. MUSIENKO[1], A. HEERING[2], A. KARNEYEU[3], M. WAYNE[2]

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We developed a Monte-Carlo model to calculate noise produced by SiPMs in measuring systems with charge integration. This model
takes into account SiPM dark count rate (DCR), cross-talk between cells, signal pulse shape. Results of noise calculation in dependence
on SiPM parameters (DCR, X-talk, cell recovery time, quenching resistor) as well as on parameters of the measuring system (input resistance,charge integration time) will be shown and discussed.

Poster Session - "Champagne Grand Cru" - P02-10

A scintillator and SiPM based mini-array facility for basic and applied cosmic ray investigations

Speaker: LA ROCCA

F. RIGGI[1], P. LA ROCCA[1], O. PARASOLE[1], C. PINTO[1]

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Coincidence measurements between cosmic ray detectors placed some distance apart are the standard way to detect the arrival of extensive air showers created in the Earth atmosphere by the interaction of a high energy primary particle. In this project we tried to exploit the potential of a detector array based on the use of several small area individual detectors, which could be easily re-configured in different detection geometries and employed in basic and applied physics investigations. Such low cost facility is also intended as an educational tool for master and PhD students in a cosmic ray physics laboratory. Each module is based on a small size scintillator tile, with a Wavelength Shifter bar and a Silicon photomultiplier for light collection and readout. Individual signals from SiPMs are sent to an Arduino MEGA board for trigger, data acquisition, GPS time stamping and storage. This contribution will report the design of the project and a few physics cases, resulting from the outcome of several measurements campaigns carried out with different geometrical configurations.

Poster Session - "Champagne Grand Cru" - P02-11

Development of the housing system with cooling for SiPM for the LHCb RICH future upgrades

Speaker: CARDINALE

R. CARDINALE[1], A. PETROLINI [1], S. MINUTOLI[2], F. FONTANELLI[1], A. SERGI[1]

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The RICH detectors of the LHCb experiment need several improvements to be able to operate with an excellent performance in the foreseen Large Hadron Collider high-luminosity phase. Silicon Photomultipliers (SiPM) are good photo-sensor candidates to be used in the future upgrades of the RICH detectors. The main limitation is due to the high noise after irradiation (including both dark count rate and correlated noise) which could prevent to use them in single-photon mode unless operated at low-enough temperatures.
A module housing the SiPM sensors and the readout front-end electronics, which provides also ancillary services, is under development. The starting point is the housing module currently used for Upgrade I detector, called the Elementary Cell (EC). The EC houses the photo-sensors (MultiAnode PMT) and the front-end readout electronics providing mechanical structure, electrical and power connections and passive thermal dissipation. The main challenge for the new EC will be the implementation of active cooling. Different cooling possibilities are currently under investigation . Mechanical, electrical and thermal challenges will be presented together with the preliminary tests on thermal behaviour of prototypes.

Poster Session - "Champagne Grand Cru" - P02-12

Doublesided strip sensors formed by concatenated drift structures

Speaker: SCHOPPER

F. SCHOPPER[1], R. RICHTER[1]

[1] Semiconductor Laboratory of the Max-Planck Society

Doublesided silicon strip detectors (DSSD) have been used and are forseen as scatter sensors for ?-ray imagers making use of Compton scattering events. The requirements for this application are different from the usual application of DSSDs in particle tracking. A rough position resolution of about a mm can be accepted. A Timing resolution much better than 1µs and autonomous trigger capabiliy is also mandatory but particularly spectroscopic energy resolution is required.

To improve spectroscopic performance, the first choice would be Silicon Drift Detectors (SDD), but facing the large areas to be covered individual SDDs would require too much power. To solve this problem many small SDDs could be concatenated in a strip-like manner keeping the summed anode capacitance in a reasonable range. P-strips deliver position and prompt trigger signals, but in SDDs the drift rings push the potential minimum for signal electrons towards the p-side. Holes generated above this minimum drift into the drift rings and the p-side signal is significantly diminished. This effect can be suppressed by a deep phosphorus implant.

We propose a sensor with concatenated SDDs, deep phosphorus implant and structured p-side which can be operated like a double-sided strip detector. A small prototype is in production.

Poster Session - "Champagne Grand Cru" - P02-13

Characterization of the focal plane of the Microchannel X-ray Telescope on the Metrology beamline of the SOLEIL synchrotron for the space astronomy mission SVOM

Speaker: SCHNEIDER

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The Microchannel X-Ray Telescope will be implemented on board the SVOM Sino-French space mission to observe the early afterglow of gamma-ray bursts in the 0.2-10 keV energy range and localize them within 2 arcmin. Inside the 9 kg camera, the detection chain consists of a detector assembly equipped with a fully depleted 256 x 256 pixel pnCCD and two CAMEX front-end ASIC, and a full-custom "US-free" front-end electronics box to control the focal plane and extract photon events. The flight spare model was tested on the Metrology beamline of SOLEIL synchrotron to measure the quantum efficiency up to 1.8 keV and characterize the spectral response, i.e. the energy calibration, the charge transfer efficiency and the energy resolution at different positions on the detector. This implied the development of a full-custom cryostat to interface with the beamline and a special tuning of the beamline to get extra low photon flux for single photon counting in the pixels of 75 ?m size without pile-up. The paper presents the configuration, the test plan, the test results and the modeling of the detector response.

Poster Session - "Champagne Grand Cru" - P02-14

The upgraded readout electronics of the CMS ECAL barrel featuring the CATIA APD readout ASIC

Speaker: GUILLOUX

CMS COLLABORATION

The CMS electromagnetic calorimeter (ECAL) will be upgraded to maintain detector performance in the challenging environment of the High Luminosity LHC, and in particular to meet the Level-1 trigger requirements. In the barrel region, the existing PbWO4 crystals and avalanche photodiodes (APDs) will be maintained. The very front-end (VFE) ECAL barrel electronics will be replaced in order to mitigate the increasing noise from the APDs, discriminate against anomalous APD signals, provide the extra bandwidth needed to maintain the integrity of the detector signal shape, and optimize the timing resolution of the system. The new front-end electronics consists of two cascading ASICs: a fast, dual gain trans-impedance amplifier (CATIA) and a dual ADC, designed in 130 nm and 65 nm CMOS, respectively. The front-end (FE) card will provide the streaming of data from VFE to back-end electronics, which will have increased granularity (tower-level to single crystal-level). The design of the full ECAL barrel readout chain and the status of the component R&D will be presented, along with the latest test beam and laboratory test results for CATIA coupled with an ADC.

Poster Session - "Champagne Grand Cru" - P02-15

A new gaseous flame detector

Speaker: KALKAN

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A new gaseous photoionization flame detector is described with a long sensing distance, wide detection angle and short detection time in two different geometry. EF (Ethylferrocene) and TEA (Triethylamine) are used in the detector as photocathode vapour. Cylindrical and dome type quartz windows performed with silver nano-tube transparent conductive inner coating as the cathode surface. The optimization of parameters and the results of the first tests are discussed.

Poster Session - "Champagne Grand Cru" - P02-16

Experiment of in-vivo imaging with third-generation setup using Photon-Counting CT with 64ch Multi-Pixel Photon Counter

Speaker: SAGISAKA

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X-ray computed tomography (CT) is widely used for non-invasive diagnostic imaging. However, high radiation dose is required to obtain clear contrast image, which leads to a loss of energy information owing to severe pile-up of each X-ray pulses. In this context, the photon-counting CT (PCCT) provides multi-color images with significantly low radiation dose. We are developing the photon-counting system composed of Multi-Pixel Photon Counter (MPPC) optically coupled with high-speed ceramic scintillator. Our system is easy to fabricate and cost-effective compared to other approach of using CdZnTe sensors. Specifically, we propose a novel method of material decomposition by comparing CT values of multiple energy X-ray bands, that is generally applicable even without K-edge information. Furthermore, we succeeded in the world's first attempt of in-vivo imaging of a mouse using the horizontal 64ch MPPC-based PCCT system, that substantially reduce the measurement time for the imaging. We confirmed accumulation of Iodine and Gadolinium as contrast agents and were able to see bones, lung, kidney, and bladder in the CT images. As a future prospect, we will visualize pharmacokinetics in mouse using various nano-particles.

Poster Session - "Champagne Grand Cru" - P02-17

First-steps in Deep Learning algorithms for photon interaction reconstruction in fast scintillator detectors for PET medical imaging

Speaker: YAHIAOUI

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The principle of positron emission tomography relies on the detection in coincidence of two 511-keV gamma-ray photons emitted by a positron-electron annihilation in the organ to image. The use of the time difference between the detection of the two photons allows for the improvement of the signal to noise ratio in PET imaging. This improvement is directly related to the coincidence timing resolution. The objective of the ClearMind project is to significantly improve the timing resolution of PET detectors. Fast scintillator $PbWO_4$ detectors are developed to use the detection of scintillation and Cherenkov photons to reconstruct gamma interaction position, time and energy. This study is focused on the signal analysis for the reconstruction of the gamma interaction properties. The complexity of this processing comes from different levels, from the randomness of the phenomenon in the creation and path of the optical photons and photoelectrons, to the signal measurement given by a Transmission Line Readout Board.

We develop a Deep Learning approach to perform this signal analysis. We use Geant4 simulation data to train and test our model and we show the potential of this method to reconstruct gamma interaction properties with an estimation of the uncertainty on the reconstruction.

Poster Session - "Champagne Grand Cru" - P02-19

Nanoscale structurized plastic scintillators

Speaker: ZONGO SITROUGNE / CERNA

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Scintillating polymers are widely used in nuclear and particle physics detectors as well as for numerical industrial applications. In their solid state, i.e. plastic matrix, their cost, mechanical properties and industrial scale manufacturing make them extensively employed. On the other hand, the light output is limited due to the low amount of photons produced in the bulk (roughly 7,000 to 10,000 photons/MeV) and losses through reflections and optical coupling.

To improve the light extraction, we propose to pattern the scintillating polymer at the micro or nanometric scale. The expected outcome are i/ increasing the radiative emission rate by creating resonant cavities (Purcell effect) and/or ii/ improving photon extraction at the polymer interface by suppressing the total internal reflection. The scientific is to understand the photonics at the nanometric scale after the interaction of ionizing radiations in a patterned scintillating polymer. The applicative objective is to develop new polymer structuring processes.

Recently, our consortium fabricated and characterized several empirical methods to pattern commercial organic scintillators. More than 50% additional light was measured compared to the standard commercial sample for specific pattern confirming the interest of the approach.

Poster Session - "Champagne Grand Cru" - P02-20

Large area picosecond photodetector (LAPPD) performance and applications update

Speaker: MINOT

M. MINOT[1], F. MICHAEL[1], H. COLE[1], L. ALEXEY[1], P. MARK[1], S. MICHAEL[1], S. CLARKE[1], S. SHIN[1], S. CWIK[1], M. AVILES[1]

[1] *Incom Inc.*

The Large Area Picosecond Photodetector (LAPPDTM) is an economic MCP photomultiplier (MCP-PMT) offering good timing and position resolution, and high gain in an evacuated 203mm x 203mm package with an active area 350cm2. Two LAPPD design versions are currently available. Gen-I LAPPD offers direct signal read-out from 28 internal strip line anodes; The baseline (V1.0) product is in pilot production and available for test and evaluation. Gen-II LAPPD amplified signals are collected on a resistive interior anode capacitively couple to a patterned external printed circuit signal board that can be customized for different application specific anode patterns. The enabling technology for both versions is a pair large area microchannel plates (MCPs) formed by atomic layer deposition (ALD) of resistive and emissive coating applied to bare glass capillary arrays. “ALD-GCA-MCPs” offer unique performances not achieved with conventional lead oxide (PbO) MCPs. A blue-sensitive photocathode (K2NaSb) applied offers quantum efficiencies (QE) of 20-30% at 365 nm. Both GEN I and II devices perform with gain ~10^7, mean QE ~ 25±2 @ ~90% uniformity, time resolution of 50-70 Psec for single photoelectrons, with spatial resolutions (X, Y) of 2.4 & 0.76 mm. An update of LAPPD results for nuclear and particle physics, beam line applications will be provided.

Poster Session - "Champagne Grand Cru" - P02-21

Development of new method to measure SiPM saturation

Speaker: MURATA

T. MURATA[1], W. OOTANI[1], N. TSUJI[1]

[1] *The University of Tokyo*

The saturation of SiPM can be an issue for scintillation detectors with SiPM readout. When many photons are injected to a SiPM, the output can be saturated due to the limited number of pixels. To convert the output of the SiPM into the number of incident photons correctly, it is necessary to understand the behavior of the saturation. The saturation of the SiPM is usually measured by directly injecting fast visible-light pulse to a SiPM. However, this method does not include the effect of the time constant of the scintillation light emission, which is not negligible compared to the recovery time of SiPM pixels and hence mitigates the saturation. A new method to measure the SiPM saturation including all the relevant effects has been developed. The saturation of the SiPM coupled to a scintillator is directly measured with the scintillation light excited by injecting fast UV-light pulse to the scintillator. A large recovery of SiPM is observed. A new model of the SiPM saturation has also been developed. The new model includes the effect of the properties of SiPMs such as crosstalk, after-pulse, and pixel recovery. It is found that the new model well describes the measured saturation.

Poster Session - "Champagne Grand Cru" - P02-22

Prospects for X-HPDs as photodetectors of next generation astroparticle physics experiments

Speaker: LUBSANDORZHIEV

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We review prospects for X-HPDs for use as photodetectors of next generation of astroparticle physics experiments. We discuss their performances and perspectives of their new developments with new scintillator materials and small compact photodetectors like SiPMs.
X-HPDs are hybrid phototubes using fast scintillators (monocrystals or phosphors) as parts of photoelectron multiplier systems. Scintillators are coupled with compact photodetectors (small PMTs or SiPMs) for final photoelectrom multiplication. Newly developed fast and effective scintillator materials and high sensitive compact photodetectors open very good perspectives for X-HPDs development for future experiments.
Indeed, X-HPDs are fast with ~1-2 ns TTS (FWHM), even faster with scintillators with 1 ns or sub-ns decay time. They have excellent SER (FWHM) – 30% or less. Their performances are immune to the terrestrial magnetic field. They are free from aftrepulses.

Poster Session - "Champagne Grand Cru" - P02-25

Translating and Rotating Volume Computed Tomography (TRVCT)

Speaker: PARK

S. PARK[1], H. KIM[2], Y. YI[1], J.B. PARK[3]

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We describe a novel system named TRVCT (Translating and Rotating Volume Computed Tomography), developed for computed tomography image from large object with simple method and low price. Tomogram images can be acquired when the object is translating and rotating simultaneously with vertical linear array detector. This method is different from the normal X-ray CT completely. We used fan-beam X-ray, and the direction of the detector and rotating axis are in parallel. Because a hundred or thousand tomograms with Z-axis from just one scanning, it has excellent Z-axis resolution and has an advantage that can improve the resolution in X-Y plane with changing translating speed and frequency of data acquisition. There is no ring artifact that is generated frequently in the third generation CT scanner. So, we can have high resolution tomograms from this TRVCT system. The TRVCT can be used to acquire images for large object like tire, engine, or whole car, and it can remove the scattering from X-ray for high resolution images.

Poster Session - "Champagne Grand Cru" - P02-26

3D Compton imaging: A promising modality for imaging electron bremsstrahlung or protons beams

Speaker: HMISSI

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Flash X-ray radiography using electron beams and Hadron-therapy are increasingly studied as an alternative to gamma ray radiotherapy. For those treatments a 3D imaging of dose deposition would be highly desirable. Imaging modalities used for nuclear medicine (PET, SPECT) are poorly tailored for this task as they both require a large number of observations to reconstruct a tomographic image of an object. To populate all those observations in a reasonable time a wide angle around the source should be covered by the detectors. The wide angular acceptance of Compton cameras allows, as we have shown by imaging nuclear waste in 3D, to obtain real 3D images of complex objects with only three views at right angle to the object, using low dose of radiation. We have obtained images using bremsstrahlung radiation from 90Y, 234Pa and 208Tl in both nuclear industry and healthcare context. We have also obtained 2D images of a proton beam energy deposition in a polycarbonate cube. The results are very promising as it seems possible with this technology to obtain 3D tomographic images with a voxel size < 1 cm3 in human patients from hard (>400 keV) and wide gamma ray spectrum with a quite simple Compton camera.

Poster Session - "Champagne Grand Cru" - P02-27

Evaluation of large area photomultipliers for use in a new Baksan Large Neutrino Telescope project

Speaker: USHAKOV

N. USHAKOV[1]

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

We present results of advance studies of large area photomultipliers (PMTs) of different types from several manufacturers for use in a new Baksan Large Neutrino telescope. First requirements for photodetectors to be used in the telescope were formulated. Parameters of 8-inch, 10-inch and 20-inch PMTs were thoroughly studied; 8-inch PMTs under studies were R5912-20 and R5912-100 from Hamamatsu Photonics; 10-nch PMTs – R7081-20 and R7081-100 from Hamamatsu Photonics; 20-inch PMTs – R12860 from Hamamatsu Photonics and MCP-PMT from NNVT. Particular emphasis was done on measurements of photocathode sensitivity, single photoelectron response, TTS , dark current counting rate and afterpulses rate.

Poster Session - "Champagne Grand Cru" - P02-31

Study of the time resolution of multi-anode photodetectors in single photon regime with high photon rates

Speaker: CAPELLI

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In this work the time resolution of two Hamamatsu photodetectors has been studied: the MCP-PMT R10754 and the MaPMT R11265. The timing performance has been investigated illuminating different portions of detector surface with a pulsed laser. Various photon rates have been tested and the acquired signal output has been analyzed to compute the FWHM time resolution in single photon regime. The MaPMT time resolution results nearly independent from the photon rate. It depends mainly on the portion of illuminated pixel area. A FWHM time resolution below 100 ps is obtained with the MCP-PMT, regardless of the illuminated area. However, this device exhibits a saturation effect that degrades the time resolution rapidly at high photon rate. A different MCP-PMT produced by Photek is currently under study to assess its timing performance in single photon regime with high photon rates.

Poster Session - "Champagne Grand Cru" - P02-33

Characterization of different semi-monolithic detectors with DOI and TOF capabilities suitable for TB-PET

Speaker: BARRIO

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The i3M is currently involved in the development of a clinical Total Body PET (TB-PET) scanner of approximately 80 cm diameter and 70 cm axial coverage. At this moment, different detectors based on semi-monolithic blocks with different surface treatments and read out by different SiPM arrays are being characterized, in order to assess how the different parameters affect the detector performance. In all cases, the external dimensions of the detector block are 25.8x25.8x20 mm3. The materials employed in the surfaces are Enhanced Specular Reflector (ESR), black painting and retroreflector. The two photodetectors employed belong to the series 13 and 14 from Hamamatsu Photonics. The results obtained for the four detectors under characterization show an energy resolution ranging from 10% up to 13% at 511 keV, a spatial and DOI resolution better than 3 mm and 4 mm, respectively, for all cases and a Detector Time Resolution (DTR) ranging from 195 ps up to 346 ps when energy-weighted averaging of the different timestamps belonging to the same event is applied.

Poster Session - "Champagne Grand Cru" - P02-36

A high-pressure, optical Time Projection Chamber

Speaker: AMARINEI

R.M. AMARINEI[1], F. SANCHEZ NIETO[1], S. BORDONI[1], T. LUX[1], E. ROE[1]

[1] *University of Geneva*

A high-pressure, optical Time Projection Chamber (TPC) is proposed for future neutrino experiments. Its excellent particle detection momentum threshold, together with costeffective
scale-up prospects, make the TPC a strong candidate for reducing systematic errors due to neutrino-nucleus interactions. In order to produce thousands of photons per primary electrons, the TPC is equipped with a thick gas electron multiplier. This is followed by a mesh, capable of producing further photons through the process of electroluminescence (EL). The photons, normally in the UV range, are shifted to visible using a PEN wavelength shifter. Confirming our simulation predictions, using a simple photo-multiplier tube, data show that hundreds of photons can be detected. Further, measurements suggest that the EL mesh can increase the photon yield if needed. The test phase being successfully passed, full tracking is going to be done using an SiPM array, already set up for data acquisition.

Poster Session - "Champagne Grand Cru" - P02-37

Monitoring Space Weather by Tracking Extensive Air Shower Particles with a Novel Compact Ground-Based Cherenkov Detector

Speaker: LEACH

S. LEACH[1], J. LAPINGTON[1]

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Solar activity continuously influences the near-Earth space environment, known as space weather. Fluctuations in radiation, background particles and magnetic field disruptions are monitored by several active spacecraft. From the ground, neutron monitoring stations record rate changes in cosmic ray background, influenced by space weather, through detection of nuclei from Extensive Air Showers (EAS). Composed of millions of fast-moving secondary particles, an EAS is triggered in Earth’s atmosphere when an incident cosmic ray particle interacts with air molecules. A cascade of violent collisions begins and continues deeper into the atmosphere with many constituents showering a large area of the surface. By measuring EAS particles at ground level, scientists can monitor and record space weather fluctuations.
Using the Cherenkov radiation detection technique, we have developed a novel, compact, EAS particle tracking method and have collated live event data for over a year. Built around Cherenkov-optimised silicon photomultipliers we monitor muon event rate and track incident angle.
We describe our hardware design, including updated instrument simulations, and present one year of EAS particle monitoring analysis identifying structure and key features in the data. Correlations are illustrated between our background event rate monitoring, independent space weather reports and correspondence with official recorded solar activity.

Poster Session - "Champagne Grand Cru" - P02-40

Study of the Non-uniformity of the PMT Photocathode Response and its Influence on the Results Obtained in Different Scintillation Counting Experiments

Speaker: TODOROV

V. TODOROV[1], P. CASSETTE[1], C. DUTSOV[1], B. SABOT[2], S. GEORGIEV[1], K. MITEV[1]

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We investigated the non-uniformity of the response of the photocathodes of some PMTs and their potential influence on the results of scintillation measurements. We have developed an experimental system which allows studies of the photocathode response non-uniformity and its influence on the shape of alpha spectra obtained after pulse-shape discrimination. The system is presented together with the first tests of a Hamamatsu R7600U-200 PMT. A degradation of the counting efficiency and a shift of the peak position towards small values was identified in the measurements near the edges of the photocathode where the energy resolution is significantly worse compared to the central region of the PMT. Such non-uniformity also affects absolute activity measurements based on the free parameter model, i.e., the Triple to Double coincidence Ratio (TDCR) and the CIEMAT/NIST efficiency tracing methods. A significant non-uniformity in a PMT would interfere with the assumption of the traditional free parameter model of a Poisson distribution of the number of emitted photons. This introduces an extra variance of the calculated detection efficiency which should be considered in the measurement uncertainty budget. Experimental results are presented in the paper, together with their practical influence in scintillation measurements and absolute calibration of radionuclides.

Poster Session - "Champagne Grand Cru" - P02-42

Development of Photo-–Diode for Pohang Accelerator Laboratory X-–ray Free-–Electron Laser

Speaker: BAEK

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Pohang Accelerator Laboratory X-ray free-electron laser (PAL-XFEL) has exploited the self-amplified spontaneous emission (SASE) process to provide intense ultrashort X-ray pulses. The XFEL beam fluctuates pulse by pulse unpredictably because the characteristics of the SASE process are intrinsically stochastic [1~4]. Therefore, diagnostic devices are very important to optimize the XFEL beam, monitor the XFEL beam status during the scientific experiments, and normalize experimental data. Photo-diodes (PDs) have been used in various diagnostic devices as shown in Fig. 1. The PDs at quadrant beam position monitor detect backscattered X-rays from a transparent thin film placed in the beam path [5], and the signals from the four PDs are used to calculate the intensity and position of the beam [6]. The PD at pop-in monitor [7] is used for the X-ray energy, beam size scans, and intensity measurement by changing solid attenuator's thickness. PDs used until recently at the beamline of the PAL-XFEL are commercial products, so it has been difficult to find proper types of the PDs depending on applications or purchase at times due to political issue with the selling country. For this reason we design PDs and they are fabricated at foundry of institutes in Korea. This PD is called PAL-PD hereafter. The size of the fabricated PAL-PD is 10 mm × 10mm (PAD1), 20 mm × 20 mm (PAD4), and 30 mm × 30 mm (PAD9). Target performances of the PAL-PD are as follows: leakage current at an operating voltage to be <10 nA/cm2, and the signal to noise ratio for the Fe-55 radioactive source to be >5. The junction and ohmic sides of the PAL-PD are used for signal readout and beam entrance, respectively. The PAD1 design is classified into four types depending on its metal structure, and the PAD4 and PAD9 are classified into three types depending on its guarding structure. They are shown in Fig. 2. All of four types in PAD1 have a single guarding structure, on the other hand, ones in PAD4 and PAD9 have ring-shaped metal structure on the ohmic side. A total of six wafers are manufactured, and they are splitted by the fabrication process for making different aluminum metal and anti-reflective coating (ARC) thickness. Figure 3 shows the cross-sectional views of two types among various PAL-PDs. The performance dependence on the types – metal shape and thickness – is investigated, and we present the results of the performance comparison between the PAL-PDs and commercial PDs.

Poster Session - "Champagne Grand Cru" - P02-43

Silicon Photomultipliers and light readout for the Demonstrator of the ENUBET instrumented decay tunnel

Speaker: IACOB

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The NP06/ENUBET project is designing a facility with unprecedented control on the neutrino flux for high precision (O(1%)) cross section measurements. The key part of the facility is an instrumented decay tunnel that measures large angle charged leptons from kaon decays, thus constraining the associated neutrino fluxes. It is based on a sampling calorimeter for e/?/? separation complemented with rings of plastic scintillator doublets for the rejection of photons. An intense prototyping activity led to the final configuration of the calorimeter readout: WLS fibers running on the frontal faces of the tiles bring the light to SiPMs placed above a borated polyethylene layer, providing a shielding against radiation damage of the sensors. A 1.65 m long section of the instrumentation will be built to demonstrate the viability and effectiveness of this approach and will be tested in the East Area at CERN-PS. An azimuthal sector of the instrumentation (ENUBINO) has been built as a benchmark for the Demonstrator and has been exposed to charged particles at CERN-PS in November 2021. This contribution will report a summary of the photosensors characterization and of the prototyping activities, an overview of the Demonstrator design and construction and preliminary results of the ENUBINO test beam campaign.

Poster Session - "Champagne Grand Cru" - P02-45

Development of a gamma-ray detector onboard a radiation source imager under high-dose environments

Speaker: MIZUNO

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Since the accident at the Fukushima Daiichi Nuclear Power Plant occurred 10 years ago, various studies have been conducted to decontaminate radioactive materials and to decommission the remains of the reactor. It is essential to identify the locations of radioactive materials for decontamination in a building under high radiation doses. One of the important methods is visualization by a gamma camera, but the existing imagers are difficult to be used in FDNPP due to limited functionality. We developed a pinhole gamma camera consisting of multi-pixel photon counters (MPPCs) combined with fast scintillators processed by a fast signal-processing analog and digital LSI under high-dose environments. In this paper we report on the developed imaging system. In addition, we present the performance estimate of spectral and temporal responses.

Poster Session - "Champagne Grand Cru" - P02-46

Time Resolution Analysis of Simulated MCPs

Speaker: BALDWIN

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Photon counting detectors are used for many applications, within many fields such as astronomy, high energy physics and medical physics. Microchannel Plates (MCPs) are thin electron multiplication devices that are used in many of these applications.

Manufacturing of MCPs is a complex process and there are several variables that affect their performance. Therefore, being able to simulate an MCP is beneficial and allows additional flexibility for the designers and manufacturers. Accurate simulations allow design changes to improve the gain and timing characteristics to be iterated prior to manufacture, reducing development time.

Using Computer Simulation Technology (CST) Studio Suite particle tracking software, a model of an MCP has been developed. The model consists of seven hexagonally arranged pores, a simple cathode and anode, and electrode coatings at both ends of the MCP. The model has been used to simulate the gain and time distributions for different MCP geometries and bias voltages, as well as the radial distribution of electrons colliding with the anode.

We present simulation results from the modelled MCPs and demonstrate the time resolution analysis that can be performed. Our goal is to identify the optimum MCP parameters for particular timing requirements in specific applications.

Poster Session - "Champagne Grand Cru" - P02-48

Comparison of new SiPM models for applications in High-Energy physics

Speaker: ROSSINI

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Silicon Photo-Multipliers (SiPMs) are widely used as light detectors for the new generation of experiments dedicated to high energy physics. For these reason, we tested several recent devices from different manufacturers: Hamamatsu 13xxx and 14xxx series; Ketek; SensL ONsemiconductors; AdvanSid; Broadcom. Particular emphasis has been put on measurements of breakdown voltage, dark counts and dark current and gain, performed at different temperatures by means of a climatic chamber (F.lli Galli model Genviro-030LC) with a temperature range from ?60 ?C to +60 ?C, housing the SiPM under test and of a cryo-pump with a cold head, allowing to scan the temperature from 300 K down to 50 K. In this way it was also possible evaluating the temperature coefficient of all models. Moreover, all devices have been successfully tested in a Liquid Nitrogen bath (77K), having in mind possible applications to detectors for neutrino and dark matter searches using liquefied noble gases such as Xenon and Argon as a target medium. In this case, the thermal component of the noise decreases at low temperature, thus allowing the use of the device at higher overvoltage.

Poster Session - "Champagne Grand Cru" - P02-49

Development of multi-element monolithic Germanium detectors for X-ray detection at synchrotron facilities

Speaker: MANZANILLAS VELEZ

L. MANZANILLAS VELEZ[1]

[1] *Synchrotron SOLEIL*

In past years efforts have concentrated to the developments of arrays of Silicon Drift Detectors for X-ray spectroscopy. This is in stark contrast to the little effort that has been devoted to the improvement of germanium detectors. Germanium detectors enable to detect with better energy resolution and more efficiently photons of considerable higher energy with respect to silicon detectors. In this context, the detector consortium of the European project LEAPS-INNOV has set an ambitious R&D program devoted to the development of a new generation of multi-element monolithic germanium detectors for X-ray detection. In order to improve the performance of the detector under development, physics simulations of the different detector designs under consideration are performed. In this contribution, the efforts in terms of R&D will be outlined with on-going modelization of detector geometry under study with first performance results.

Poster Session - "Champagne Grand Cru" - P02-51

Towards precise temporal resolution using highly multiplexed readout schemes for gamma-ray detectors

Speaker: GONZALEZ MONTORO

SANCHEZ David[1]

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Nowadays, the performance in Time-of-Flight (TOF) for PET detectors, which boosts the effective sensitivity of the system, is reaching the technological limit imposed by the scintillator crystal and photosensors used. Increasing the axial length of a PET scanner improves the solid angle coverage, thus allowing to boost the sensitivity. This are the so-called Total Body PET (TB-PET) scanners. Recently, the TB-PET systems for human use called Biograph Vision from Siemens and the uExplorer from United Imaging are commercially available and first clinical studies have been shown. The Biograph Vision has remarkable TOF capabilities of 217 ps. Nevertheless, from the technical perspective, there is still room for further improving these systems with depth of interaction (DOI), and/or readout channel reduction as it is major concern to develop a long axial scanner. In this work, we will show the preliminary results addressing these two major concerns on a TB-PET system, both the reduction of readout channels as well as the DOI capabilities of the system by using a semi-monolithic scintillator crystal approach, thus allowing to have <300 ps TOF as well as sub-3mm spatial resolution and DOI.

Poster Session - "Champagne Demi Bulles" - P03-01

Flame Detector based on a Novel UV Sensor

Speaker: NIEMELA

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We have developed a novel gaseous detector for Ultra-Violet single-photon counting applications. We make use of a diamond-coated photocathode with high QE for UV radiation, and integrate it with the well-known and familiar proportional-counter structure. Each UV photon releases an electron from the photocathode surface that is then accelerated towards the anode wire with high enough electric field to enable avalanche and gas amplification. Thus, each UV photon generates a large voltage pulse at the output of the low-noise charge-sensitive preamplifier. These pulses can easily be counted with suitable read-out electronics, and based on the count rate, the strength of the UV radiation source can be determined.

By employing a large area photocathode of 2000 mm2, we have built a highly sensitive flame detector that is able to detect a small candle flame from more than 50 meters distance.

The future applications include detection of flames from far away in fire-hazard areas like oil refineries and oil tankers, and early detection of forest fires and other wildfires with drone-mounted operation. Also, spark and discharge detection in electric power lines and transformers can be carried out with drone operations.

Poster Session - "Champagne Demi Bulles" - P03-02

SMARTENT - Active tent to detect and locate radioactivvity

Speaker: LONGHITANO

P. FINOCCHIARO[1], L. COSENTINO[1], S. LO MEO[2], F. LONGHITANO[3], G.E. POMA[1], A. RIZZO[2], G. VECCHIO[1]

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We propose an active tent to be used during nuclear inspection campaigns by officers of international organizations e.g. IAEA, CTBTO, EURATOM, ESARDA. In such campaigns field tents are usually employed, with one or more central tables delimiting an "internal" and an "external" zone and used as a material interchange space between the two. Whenever entering the tent or there is a passage of people and/or material from the internal to the external zone and vice versa, a verification of non-contamination has to be done.
The proposed tent will feature a set of gamma ray counters which can detect the presence of radiation and provide a reasonable indication of its location and activity. Each counter, an 80 cm long scintillating fiber readout at each end by a Silicon Photo Multiplier (SiPM), is embedded in the tent texture/frame and possibly under the tent floor. Moreover, an array of 1 cm3 spectroscopic scintillators can be installed as part of the exchange table, capable of detecting position and rough shape of a gamma emitting object on the table itself and to quickly provide a preliminary spectroscopic indication. Geant4 Monte Carlo simulations have shown the feasibility of the system.

Poster Session - "Champagne Demi Bulles" - P03-04

Front End Electronics Module Design for the Schwarzschild-Couder Telescope (SCT) Camera

Speaker: BONESINI

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The Schwarzschild-Couder Telescope (SCT) is a Medium-Sized Telescope proposed for the Cherenkov Telescope Array (CTA). The current prototype is installed at the Fred Lawrence Whipple Observatory (FLWO) in Arizona , USA. The camera is only partially equipped and is being upgraded with improved SiPM sensors and a new Front End Electronics Module (FEEM) for the full focal plane. The new FEEMs aim to read-out and digitize the SiPM pre-amplified signals down to the single photoelectron (phe). This phe signal is assumed equivalent to a signal with 2 mV peak amplitude and 500 MHz maximum bandwidth. The FEEM should have a linear response up to 2 V for a required dynamic range of about 1000 phe. A noise equivalent of 0.5 phe is an acceptable value. Due to the severe mechanical constraints to have compact electronics and low noise performances, the FEEM consists of two stacked-up submodules, one dedicated to the power supplies and the other to house the FPGA which reads-out and sends digitized data to the main backplane. The new FEEM is capable of digitizing 64 analog channels with a sampling frequency of 1 GSamples/s.
A first prototype of the FEEM has been produced. In this contribution we will present the performance of these FEEM prototypes.

Poster Session - "Champagne Demi Bulles" - P03-05

Large-Area SiPM Pixels (LASiPs) in SPECT

Speaker: WUNDERLICH

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A standard camera for Single Photon Emission Computed Tomography (SPECT) contains 50-100 photomultiplier tubes (PMTs). It is shielded by a thick layer of lead which makes it heavy and bulky. Its weight and size could be significantly reduced if replacing the PMTs by silicon photomultipliers (SiPMs). However, one would need a few thousands channels to fill a camera with SiPMs due to their small senstive area. Alternatively, we propose to use Large-Area SiPM Pixels (LASiPs), built by summing individual currents of several SiPMs into a single output. We developed a LASiP prototype that sums 8 SiPMs of 6 x 6 mm2 and built a proof-of-concept micro-camera holding 4 of those prototypes coupled to a NaI(Tl) crystal. We measured an energy resolution of ? 11.6 % at 140 keV and were able to reconstruct simple images of a 99mTc capillary of 0.5 mm diameter with an intrinsic spatial resolution of ?2 mm. The micro-camera was also simulated with Geant4 and validated with experimental measurements. An extension of these simulations allowed us to study the feasibility of using larger LASiPs in a full-body SPECT camera. We present the results of this study.

Poster Session - "Champagne Demi Bulles" - P03-06

The large and innovative PMT array of the JUNO experiment

Speaker: BORDEREAU

C. BORDEREAU[1]

[1] *CENBG / Université de Bordeaux*

The Jiangmen Underground Neutrino Observatory (JUNO) is a large 20 kton liquid scintillator detector, under construction in southern China, with the primary goal of determining the neutrino mass hierarchy through the measurement of reactor antineutrinos at a 53 km baseline. This requires an unprecedented energy resolution for such a large detector (~35 m radius) of 3% at 1 MeV. The detector will be equipped with the largest array of photodetectors ever built, combining large and small PMTs (~45,000 in total), achieving a 77% photocathode coverage.
5,000 Dynode PMTs and 15,000 new Micro-Channel Plate PMTs, developed and produced for JUNO, will make up the 20,000 high quantum efficiency 20-inch PMTs (LPMTs). To reduce the systematic uncertainties of the energy resolution and energy scale, a second PMT array consisting of 25,000 3-inch PMTs (SPMTs) has also been custom-built and produced for JUNO. They will be installed between the gaps of the LPMTs and will work in the photo-counting mode for energies of a few MeVs. Severe quality constraints have been placed on the PMT performances, controlled by both the producing companies and the JUNO collaboration using dedicated test benches. My talk will cover the development and production of the two PMT systems and the validation of their performances for neutrino physics with JUNO.

Poster Session - "Champagne Demi Bulles" - P03-07

Characterization of solid state detectors for MIR radiation around 7 micron

Speaker: BONESINI

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Mid-Infrared (MIR) radiation around 6-7 micron has important applications for biomedical diagnostics, environmental monitoring, isotope analysis.
A relevant issue is the transport of this radiation over distances up to 1-2 meters with special fibers and its detection with specialized detectors. Two complementary setups one based on pulsed QCL laser from Alpes laser and one based on a DFG laser, both working around 6.8 micron, have been used at INFN Milano Bicocca and Elettra Sincrotrone, Trieste for these studies. While the former system attains a certain value of power by high repetition rates and low energy per pulse, the last one gets it by a low repetition rate and a high energy per pulse.
Tests have been done to study performances of solid state detectors from Thorlabs, Hamamatsu, Asai Kasei and other producers in the MIR region around 6.8 micron. These are mainly IR sensors developed for detecting human presence. Results on their response as a function of the incoming laser power will be presented.
These results will help to set up the problem of injection of pulsed MIR light around 6.78 micron into the cryogenic target of the FAMU experiment at RIKEN-RAL devoted to the high precision measurement of the proton Zemach radius.

Poster Session - "Champagne Demi Bulles" - P03-08

NUV and VUV sensitive Silicon Photomultipliers technologies optimized for operation at cryogenic temperatures

Speaker: ACERBI

F. ACERBI[1], S. MERZI[1], G. PATERNOSTER[1], N. ZORZI[1], A. GOLA[1]

[1] *FBK*

The silicon photomultipliers (SiPMs) emerged as a promising solution in many applications, like high-energy physics experiments and recently, they are the detector of choice for the readout of liquid noble gases scintillators (e,g, liquid Xenon and Argon) in very-large-area physics experiments. Here the SiPMs are operated at cryogenic temperatures. Important studies have been done to optimize SiPM performance for such conditions and we developed the new NUV-HD-cryo technology and the VUV-HD-cryo tecnology. Important technological improvements have been demonstrated: i) reduction of electric field, to reduce band-to-band tunneling, ii) doping profiles modifications to reduce afterpulsing at low temperatures and iii) reduction of quenching resistor variation over temperature.
In this work we show and compare the recent characterization results of primary noise, correlated noise, photon detection efficiency (PDE) and photon-number resolution of these SiPM technologies, measured at FBK between 300 K and 60 K.
Primary DCR reduces to few counts per second already at 200 K, and even more going toward LN temperature, afterpulsing increment is mitigated, being less than 15% at 125 K (Vex=4V). PDE maintain good values (>50%) down to 75 K, and good photon number resolution is preserved.

Poster Session - "Champagne Demi Bulles" - P03-09

Research on Scintillating Glass Hadronic Calorimetry

Speaker: MA Lishuang

L. MA[1], S. QIAN[1]

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The Circular Electron Positron Collider (CEPC) is a new generation collider for the precise measurement of Higgs bosons. The Hadronic Calorimeter (HCAL) is an important component of CEPC aim to measure precisely the energy, position, time and other information of final hadrons. There are a lot of options of HCAL, a new HCAL based on glass scintillator and Silicon Photomultiplier (SiPM) is proposed in this manuscript. Glass scintillator is a new kind of scintillator material, who has high density, adjustable performance and controllable cost. A HCAL simulation model based on glass scintillator and SiPM was set up in Geant4, and simulations of the effects of glass composition, thickness, light yield, bubbles, etc. on HCAL energy resolution have been performed. The single tile simulation and cosmic ray experiment were also proceeding. Compared with plastic scintillator and crystal, glass scintillator composed with SiPM are good candidate for the next generation of HCAL.

Poster Session - "Champagne Demi Bulles" - P03-10

Characterization of PMTs for the FlashCam project

Speaker: KALEKIN

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High quantum efficiency Photomultiplier Tubes (PMTs) of type R12199-100-5 from Hamamatsu have been selected for the cameras of the large plate scale telescopes of the Cherenkov Telescope Array (CTA). The FlashCam group has developed a camera design suitable for installation in Medium-Sized Telescopes of CTA.
Using PMTs delivered in 2017, an advanced FlashCam prototype was produced and installed in the central CT5 telescope of the H.E.S.S. experiment in Namibia in fall 2019. Since then the PMTs are in field operation for more than 2 years already, and provide very stable performance. To control quality of PMTs, sub-samples delivered in 2017 and 2021-2022 have been characterized in laboratory for timing parameters, gain, afterpulsing and Quantum Efficiency (QE). The results on spectral shape of QE and homogeneity of QE over photocathode area are presented.

Poster Session - "Champagne Demi Bulles" - P03-11

Development of a fast Cherenkov detector for prompt gamma ray imaging in particle therapy

Speaker: MOREL

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We are conceiving a detector for the real time monitoring of particle therapy treatments. Its goal is to reconstruct the vertex distribution of Prompt Gamma rays (PG) emitted from the patient, through the exclusive measurement of particle Time-Of-Flight (TOF). PGs are detected in coincidence with a diamond-based beam monitor measuring the proton arrival time. The Time-of-flight gamma-ray Imaging detector ArRAy (TIARA), will be composed of ~30 detector pixels. Each pixel is built from a 1*1*1 cm3 Cherenkov crystal read out by a SiPM. Our goal is to achieve a 100 ps rms TOF resolution with a high sensitivity to obtain a millimetric precision on the proton range measurement, in a few seconds.

The pixel time resolution was estimated at 105 ps rms for gamma rays of 1.25 MeV using a dedicated preamplifier. The pixel detector was also tested with PGs produced at a proton therapy facility using non-dedicated electronics: we obtained a 135 ps rms TOF resolution, and a 4 mm proton range precision at 2 sigma with only 600 events, thus paving the way to the 100 ps rms detection of PGs.

We will present the characterization experiments and simulations carried out for the development of the pixel prototype.

Poster Session - "Champagne Demi Bulles" - P03-12

First step in quasi-physical data of gamma ray spectra simulation using Generative Adversarial Networks

Speaker: FERNANDES DE OLIVEIRA

F.M. FERNANDES DE OLIVEIRA[1], G. DANIEL[2], O. LIMOUSIN[2], Y. GUTIERREZ[2]

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In the field of X-ray and gamma-ray detection, the design and optimization of detection systems require the use of radiation simulation of the material and instrumental response. The usual approach consists of defining a mathematical model of an instrument in a stable and constant environment. However, when the operating conditions are varied or even unstable, or when the instrument has multiple configurations, it becomes extremely difficult to make accurate and adaptable models. In order to train models for nuclear, medical and astrophysical applications, it is utterly important to have high quality and representative simulated data. It may be too costly, in terms of computation time, to produce the data, whether by laboratory tests or by computer simulations based on physical models using Monte Carlo methods. In this paper, we address this issue by presenting a deep neural network model based on Generative Adversarial Networks (GANs). Once the network is trained, we are able to generate, in less than a second, realistic spectral signatures of different radioelements and mixtures following the Caliste detection system. Due to the promising first results we obtained, we keep improving this method to generate spectral signature corresponding to complex environmental situations.

Poster Session - "Champagne Demi Bulles" - P03-13

Development of SiPMs for the CMS HGCAL at HL-LHC

Speaker: CHEN Yi-Mu

CMS COLLABORATION

The High Luminosity LHC (HL-LHC) will deliver 3000/fb of integrated luminosity at an average pileup of 140-200 collisions per bunch crossing. The high luminosities result in a significant radiation dose to the detectors, especially in the endcaps. In order to cope with this challenging experimental environment, a High Granularity Calorimeter (HGCAL) is being constructed to replace the existing endcap calorimeters of CMS. Silicon photomultipliers (SiPMs) are used in HGCAL to detect the light from about 240,000 individual scintillating tiles. We describe recent developments for the HGCAL SiPMs, including quantification of the SiPM radiation hardness, modeling of SiPM noise and its evolution with time, production testing and quality control plans, as well as expectations for the combined system performance.

Poster Session - "Champagne Demi Bulles" - P03-14

Readout Studies for the Future ECAL at High-Luminosity LHCb

Speaker: MAZORRA DE COS

J. MAZORRA DE COS[1], D. GASCóN FORA[2], E. PICATOSTE OLLOQUI[2]

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The increase of occupancy and radiation damage expected in LHCb, after the upgrade of the LHC machine to the High Luminosity era, challenges the capacity of the shashlik technology currently employed in the Electromagnetic Calorimeter (ECAL). A new design with enhanced spatial and timing resolution is under development using different configurations (shashlik/spaghetti), absorber materials (W/Pb) and scintillating materials (garnet/polystyrene). The project aims towards a consistent readout system based on fast photomultiplier tubes and a fast waveform sampling ASIC. Several different prototypes have been evaluated under an electron beam at DESY facility (1-5GeV) and in the SPS at CERN (20-100GeV). The light was detected with PMTs that had been characterized in laboratory to assure their gain, linearity and timing performance. The resulting data was used to evaluate the required specifications of the readout electronics to preserve the performance, specifically the 20ps time resolution required for interaction discrimination.

Poster Session - "Champagne Demi Bulles" - P03-15

Beam test characterization of SiPMs reading a a Plastic Scintillator Prototype for the space-based cosmic ray experiment HERD.

Speaker: ROSSINI

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The High Energy cosmic-Radiation Detector (HERD) detector, planned to go onboard Chinas Space Station, will employ a Plastic Scintillator Detector (PSD) as for gamma-ray veto and Z measurement of charged Cosmic Rays.
The requirement of hermeticity of the detector suggests to position the SiPMs on the large face housed on long Printed Circuit Board (PCB) capable to host 5 tiles in order to have no gaps between tiles. The signals are extracted via the PCB.
A PSD prototype consisting of a PCB with two scintillator tiles equipped the SiPMs has been tested with proton and C ion beam at the CNAO (Centro Nazionale Adroterapia Oncologica) in Pavia (Italy).
Varying the kinetic energy of the beam energy losses and therefore light productions comparable to those due to high Z relativistic ions are obtained. The SiPMs detect signals on a broad dynamic range. Results on charge resolution and uniformity of collection are presented.
Some preliminaty results on time resolution are also presented.

Poster Session - "Champagne Demi Bulles" - P03-16

Studies and Optimization of Scintillation Light Measurements in XEMIS2 Liquid Xenon Compton Camera for Small Animal 3-Gamma Medical Imaging

Speaker: ZHU

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We report on the studies of scintillation light measurements in an innovative XEnon Medical Imaging System, named XEMIS2, consisting of a liquid xenon Compton camera, designed for low activity small animal 3-gamma imaging, conceived and developed at the SUBATECH laboratory. It mainly aims to localize a radiopharmaceutical labeled with a specific radionuclide, such as Scandium-44, and reduce the administered activity while preserving the image quality. XEMIS2 combines the measurement of scintillation light and ionization electrons produced from the gamma-rays interactions. In XEMIS2, the scintillation light provides the gamma-rays interaction time. A set of photomultiplier tubes are distributed around the active volume to measure it. Besides, a self-triggered scintillation light measurement system has been designed for XEMIS2 to reduce the electronics dead-time during continuous data taking. The data acquisition prototype has been implemented and qualified in XEMIS1, whose results show a good performance in scintillation light measurement. Furthermore, it is possible to spatially pre-localize the gamma-rays interactions and achieve the virtual fiducialization of the active volume by matching the scintillation signals with the ionization signals through an algorithm based on the light collection map. XEMIS2 is recently under construction in a small animal medical imaging center CIMA for further preclinical studies.

Poster Session - "Champagne Demi Bulles" - P03-17

Feasibility of skewness-based characterization of SiPMs with unresolved spectra

Speaker: VINOGRADOV

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Conventional methods of SiPM characterization are mostly based on a resolved spectrum of photoelectron or dark electron detection which represents a random number of fired SiPM cells. However, such methods do not apply for radiation-degraded SiPMs of a high dark count rate with unresolved spectra. Developments of radiation-intense facilities with SiPM-based detectors like high-luminosity particle calorimeters, e.g., CERN CMS HGCAL, are faced with this challenge.

The method of statistical moments is a well-known technique for the estimation of parameters of a random variable distribution using sample moments of raw data. The first two moments have already been used for estimation of a gain and number of photoelectrons by a mean and variance of detected charges relying on a priori known Excess Noise Factor (ENF) of the SiPM or PMT (also known as ENF method).

In this study, the third moment or skewness of the measured charge is proposed to extend the approach up to the estimation of the third unknown – crosstalk-originated ENF. The skewness-based characterization presumes Generalized Poisson distribution of fired cells which was found to be in good agreement with many experiments. Theoretical and experimental evaluations of the method show promising preliminary results including high dark count rate conditions.

Poster Session - "Champagne Demi Bulles" - P03-18

Water Luminescence Imaging for Visualization of Therapeutic Effects of Proton Therapy and Radiosensitizers

Speaker: OKAZAKI

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Recently, chemoradiation therapy, a treatment method in which drugs in the body undergo various reactions upon irradiation, and further therapeutic effects can be expected owing to synergistic effects has attracted attention. Particularly, research on various sensitizers that accentuate the characteristics of the particle beams: high dose concentration, to minimize damage to the healthy cells, and increase the therapeutic effect have been conducted. We focused on a technique proposed by Yamamoto et al. to image new luminescence phenomena that occur even with radiation energies below the Cherenkov threshold. In this study, we verified the characteristics of luminescence imaging in terms of wavelength components and depth distribution to confirm its usefulness as a real-time monitor of the sensitization mechanism and therapeutic effects of the radiosensitizer. Consequently, we established that luminescence exhibited a spectral distribution that gradually decreased from short to long wavelengths. Moreover, we found complex structures such as peaks and dents in the spectral distribution which suggests that luminescence may be a combination of multiple luminescence origins. Investigating the relationship between radiolysis products and the luminescence will lead to provided a clue for the use of water luminescence as a new therapeutic effect monitor.

Poster Session - "Champagne Demi Bulles" - P03-19

Novel Positron Emission Tomography with Opaque Liquid Scintillator Detection Technology

Speaker: VERDIER

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The main experimental challenges in positron emission tomography (PET) are focusing on improving the sensitivity either by pushing the time of flight (ToF) performances or extending the axial field of view. Also the use of 3? detection capability enables several extra advantages, including the possible enhancement of the ToF information to better locate the annihilation vertex or enabling tissue probing through positonium study. We present the design and the projected performances of LiquidO-PET (LPET), a demonstrator to explore our ability to meet the aforementioned capabilities through a novel PET system paradigm. It is based on opaque scintillation of a liquid medium. The light scattering forces the emission photons to stay around its source into a stochastically confined “light ball”, collected and mapped through an embedded lattice of wavelength-shifting fibers and read out by silicon-photomultipliers coupled to sub-100 ps readout electronics. The low density medium, causes a 511 keV ? to create a sequence of several Compton scatters, each leading to a point-like measurable light ball. Expected performances range from a radial spatial resolution of a few mm to a few cm in the axial direction, a ToF resolution of 100-300 ps and a sensitivity of 200-700 kcps/MBq for an axial FoV in the 50-200 cm range.

Poster Session - "Champagne Demi Bulles" - P03-20

Development of optical fiber scintillator plate for X-ray imaging

Speaker: YAJIMA

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In this study, a novel optical scintillator fiber plate and the fabrication method was developed. It consists of plenty of scintillator fibers covered glass tube with 35 ?m diam-eter. The refractive index of the scintillator is higher than the glass in this system. Generated scintillation light above the critical angle is totally reflected at the interface with the glass and optically waveguided like an optical fiber. Owing to light guiding system, optical fiber scintil-lator plate can show high spatial resolution. Sensitivity can be improved by increasing the thickness of the plate while ensuring its transparency. In imaging test, optical fiber scintillator plate shows FWHM (spatial resolution) = 37.2 µm.

Poster Session - "Champagne Demi Bulles" - P03-21

Long term aging test of the new PMTs for the HL-LHC ATLAS hadron calorimeter upgrade

Speaker: SCURI

S. LEONE[1]

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The central hadron calorimeter of the ATLAS experiment at the Large Hadron Collider (LHC) is readout by about 10,000 photomultipliers (PMTs). Earlier studies of performance showed a degradation in PMT's response as a function of the integrated anode charge. A model of the time evolution of the PMT response was made, with a projected loss exceeding 25% for the fraction of the PMTs (about 8% of the total) that will integrate an anode charge of 600 C, expected at the end of the High-Luminosity LHC program. These PMTs will be replaced with a newer version, in order to keep the global detector performance at an optimal level. A local test setup is being used in the Pisa laboratory to study the long term response of a new PMT model considered for replacement in the hadron calorimeter readout of most active cells. For the first time this new PMT model has been tested after integrating more than 250 C of anode charge. Preliminary results obtained from data collected in the Pisa laboratory are shown in this presentation.

Poster Session - "Champagne Demi Bulles" - P03-22

XGRE-NG, a multi-mission space gamma-ray spectrometer: design optimisation and first results

Speaker: LAURENT

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XGRE-NG is a fast gamma-ray modular spectrometer that may be implemented in different space missions. After a first phase 0 study in 2021, its realization and qualification for space is currently under way through a dedicated R&D program, funded by CNES, and lead by the APC and LESIA laboratories (France). Scientific objectives of this module are, among others, study of Terrestrial Gamma-ray Flashes (TGFs), in follow-up of the TARANIS satellite, Gamma-Ray Bursts (GRB) and Solar flares. In this poster, we will describe the module design optimisation and present its first measured performances.

Poster Session - "Champagne Demi Bulles" - P03-23

Large area LaBr3:Ce crystals read by SiPM array with improved timing and temperature gain drift control

Speaker: BONESINI

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Compact detectors, based on 1/2" or 1" LaBr3:Ce crystals and 4x4 SiPM arrays, have been developed to detect low energy X-rays (~ 100 keV). Applications are foreseen inside the FAMU experiment at RAL to study the ``proton radius puzzle'' and radiation imaging in medical physics. Solutions were studied to reduce the typical drawbacks connected with SiPMs' gain drift with temperature and the worse timing, as compared to PMTs.
By developing a custom 8-channels NIM module based on CAEN A7585D chips, the gain drift effect in the range 10-40 C, was reduced by a factor ten.
Timing was also studied, using an hybrid ganging solution for SiPM array cells.
Groups of four cells of a 4x4 SiPM array are connected in series with decoupling capacitors in between (``hybrid connection''). In this way the load capacitance is reduced, giving a faster signal. The connection acts as a series connection for the signal readout and a parallel connection for the SiPM bias.
Signals from four groups of SiPM are then summed up.
FWHM energy resolutions up to 3% at the Cs137 peak (662 keV) were obtained. These values compare well with the best resolutions obtained with a PMT readout. An increase in timing up to a factor two was observed.

Poster Session - "Champagne Demi Bulles" - P03-24

Simulation and Event Reconstruction in Monolithic PbWO4 Crystal Detector for ClearMind Project

Speaker: SUNG

C. SUNG, V. SHARYY, D. YVON

ClearMind project aims to develop the TOF PET detection module providing a short coincidence resolving time, good spatial resolution, and high detection efficiency. ClearMind project uses monolithic PbWO4 scintillating crystal for the position-sensitive detector, and the bialkali photo-electric layer is directly deposited on the crystal. The 511 keV photon conversion produces both scintillating and Cherenkov photons. Photoelectrons generated at the photocathode, are amplified by the micro-channel-plate, and signals induced on the pixelized anode are collected through the transmission lines readout and digitized by the SAMPIC module. In this work, we present a Geant4 simulation of such module and estimate the detection performances: spatial and DOI resolution, time resolution, and efficiency. The reconstruction of the gamma interaction in the detector volume is performed from the photoelectrons map of 2D-position and time registered by the readout. We compare the precision of the simple statistical algorithms using mean and RMS with machine learning techniques developed using TVMA package.

Poster Session - "Champagne Demi Bulles" - P03-25

Characterization of the radiation-induced damage in a Polyethylene Naphthalate (PEN) scintillator

Speaker: GANDOLFO

M. CAMPAJOLA, F. DI CAPUA

Polyethylene naphthalate (PEN) is a common plastic material recently recognized as a good scintillator. To prove its applicability in nuclear and high energy physics experiments, we characterize its scintillation and transmission properties by stimulation with UV light and alpha and beta sources. Several key-parameter of the scintillator have been investigated, namely, the emission spectrum, the optical transmittance, the pulse decay time constants, and the light yield. Furthermore, we tested its tolerance to radiation damage by performing two irradiation test campaigns with an 11 MeV proton beam and with a 1 MeV electron beam, with doses up to 15 Mrad and 80 Mrad, respectively. Results showed remarkable scintillation properties and good radiation-hardness behaviours: a light yield loss of ~15% at 10 Mrad and ~35% at the maximum delivered dose of 80 Mrad was observed.

Poster Session - "Champagne Demi Bulles" - P03-27

Gate dielectric for the DoTpIX pixel devices: preliminary results

Speaker: FOURCHES

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The development of pixel arrays close to the interaction point in large detector systems used in high energy physics require high radiation hardness for the pixels and their readout. The DoTPiX is based on q n-channel MOS device, which will require the possibility of operation with a positive and negative voltage applied on the up control gate. The voltage magnitude may reach a five V value, which will ensure the depletion of the DoTPIX device as a whole. The DotPIX comprises a buried Ge gate obtained by low temperature epitaxial growth of Ge on Si. We have started to study the different ways to achieve these prerequisites, both radiation hardness up to the Megarad range, and the need for a low temperature budget to reduce the Ge and Si intermixing, which may be detrimental to the DoTPIx operation. The use of Si thermal oxide is investigated together with that of deposited oxide (Hafnium Oxide for example), which differs from the Silicon Dioxide. The possibility of a combination of thermal silicon dioxide and deposited oxides opens another possibility in this study. We will also make Ionizing radiation experiments on specific samples and analyze them.

Poster Session - "Champagne Demi Bulles" - P03-28

Simultaneous Multi-nuclide Double Photon Coincidence Imaging with Parallel and Slit Collimators

Speaker: UENOMACHI

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Single photon emission computed tomography (SPECT) provides a distribution image of radionuclide that emits low energy gamma-rays (typically up to 400 keV). The position of radionuclide is estimated using mechanical collimators made of heavy material such as lead and tungsten. The conventional method that utilizes only the energy information requires to rotate detectors. On the other hands, some nuclides emit successive photons with a short time duration—called as cascade photons, which can be assumed to be come from the same nucleus. Therefore, taking the coincidence detection between cascade photons can determine the location. Recently, we have demonstrated the double photon coincidence imaging with parallel hole collimators. In this study, we demonstrated the double photon coincidence imaging with parallel and slit collimators for higher detection efficiency. 111In (SPECT nuclide) and 67Cu (therapeutic nuclide) were succeeded to be visualized simultaneously.

Poster Session - "Champagne Demi Bulles" - P03-29

X-ray Imaging Polarimetry using a Fine Pixel CMOS Imager

Speaker: ODAKA

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Polarization is a basic property of a photon as well as its energy. In astrophysics, polarization tells us anisotropy of an emitting source, providing us with key information on the structure of a celestial object that can not be resolved by direct imaging. However, polarimetry in the energy bands above X-rays is still on a technological frontier though there should be plenty of interesting objects including accreted plasmas onto black holes and emitting nebulae powered by relativistic particles flown from rapidly rotating neutron stars. We present a new approach to X-ray polarimetry using a CMOS imager with a pixel size of 2.5 micrometers, its performance evaluation, and effective analysis methods of imaging polarimetry. By using the synchrotron photon facility SPring-8, we obtained modulation factors of 4% (10 keV), 12% (16 keV), and 15% (24 keV), which are consistent with those values reported by Asakura et al. (2019), for simple event selection. Other event selection criteria to improve the polarimetric performance are also studied. We demonstrate imaging polarimetry using the combination of a fine-pixel CMOS sensor and a fine-pitch coded aperture mask, which can be installed in a small satellite such as a CubeSat.

Poster Session - "Champagne Demi Bulles" - P03-30

SiPM module for the ACME III electron EDM search

Speaker: HIRAMOTO

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This presentation shows the design and performance of a SiPM module developed for the ACME III electron electric dipole moment (eEDM) search. A measurement of the eEDM is a powerful probe for the existence of physics beyond the Standard Model of particle physics. The ACME experiment searched for eEDM with the world's highest sensitivity using cold ThO polar molecules (ACME II: Nature, 562 (2018) 355-360). In the next generation of the ACME experiment, SiPMs are used for signal readout instead of PMTs used in the previous measurement. We have developed a dedicated SiPM module, which includes a 16-channel SiPM array and a signal amplifier. The SiPM dark count rate, background light sensitivity, and optical crosstalk are well suppressed. The light from the ThO molecules, and the SiPM module shows about 2.5 times higher detection efficiency than the ACME II PMTs. We have completed the development of the SiPM module, and eight modules will be installed to the next-generation ACME apparatus.

Poster Session - "Champagne Demi Bulles" - P03-32

Anomalously long delayed afterpulses in classical vacuum photomultipliers

Speaker: LUBSANDORZHIEV

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We report results of extensive studies of afterpulses with anomalously long delay time registered in classical vacuum photomultipliers. Such a type of afterpulses with delayed times of 70-200 microseconds has been observed firstly only in 8 inch PMTs produced by Electron Tubes almost 20 years ago. It took some time (due mostly to their unusualness) to publish the results of the first observation [1]. Now we observed such anomalously delayed afterpulses in PMTs of different types and sizes starting form small ¾” (XP1911B) and intermediate 3” and 5” (XP72B22 and ET 9390B respectively) to large area 10” and 20” PMTs (R7801 and R12860 respectively). In case of 20” PMTs delay times of afterpulses are in the range of 200-500 microseconds. Probability of such aftrepulses is less than 0.05% per photoelectron. Their amplitudes are strongly at a single photoelectron level. So far there is no still any reasonable explanation of the effect. There is no pronounced dependence of their rate on the value of PMT’s high voltage supply. There is only strong dependence of delay time on the size of PMTs: the bigger PMTs the longer delay time. Despite their low rate and small amplitude they can play important role in experiments searching rare events like dark matter experiments.

Poster Session - "Champagne Demi Bulles" - P03-33

PET detector based on pixelated crystals with single-side readout enabling TOF and DOI capabilities

Speaker: BARRIO

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The main disadvantage of traditional PET detectors based on pixelated scintillation crystals single-sided read out is the absence of depth of interaction (DOI) information. In this contribution, we propose a PET detector with single-side readout and 1:1 coupling, based on arrays of pixelated crystals that are naked and glued in one direction, and optically separated in the other one. In this configuration, some of the optical photons will propagate in the glued direction, generating a light distribution from which DOI information can be retrieved. We have characterized four different detector configurations, all of them consisting of a linear array of 1x8 naked LYSO crystals of approximately 3x3x20 mm3 each, with the top and bottom faces polished, and with a different number of grinded lateral surfaces (2 versus 4) and also different crystal wrapping (ESR versus BaSO4). The results obtained for the four detector configurations show energy resolutions ranging from 8.4% to 9.8% and timing resolutions below 290 ps for all cases with the fastest timestamp and close to 230 ps when energy-weighted averaging of different timestamps is applied. Regarding DOI performance, all configurations provide some DOI information, which improves with the number of grinded faces and also with the use of BaSO4 as a reflector.

Poster Session - "Champagne Demi Bulles" - P03-34

CAMBIO: An Astronomical Camera for Medical and BIOlogical applications

Speaker: TALVARD

C. GENNET[1]

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In Biomedical science, Terahertz (THz) technologies have been identified since several years as promising candidates to better understanding the fundamental processes involved in living tissues. At CEA/Saclay, we have developed high detectivity bolometers for Astrophysical purposes in the THz domain. Then it was naturally motivating to assess the capabilities of the astronomical imagers in the field of biomedical science. This is the main objective of the CAMBIO project, which has been supported by an internal research tool at CEA.
Taking advantage of the strong dependence of the THz emission with the water content of tissues, we proposed an experimental set-up capable of detecting emissivity contrasts in biological samples. We report in this paper the results obtained with several acquisition modes for various biological models. These results have been obtained with a preliminary fore-optics adapted to the existing camera. We discuss and propose in conclusion some possible improvements of the present study.

MACACO III Compton camera assessment for hadron therapy treatment monitoring and radiotracer imaging

Speaker: LLOSA

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The IRIS group has completed the development of MACACO III, a third prototype of a Compton camera. The system is composed of three planes of LaBr3 crystals coupled to SiPM arrays. New photodetectors from Hammatsu photonics have been tested, achieving improved energy resolution (4.8% FWHM at 511 keV) and higher stability with voltage and temperature variations. The readout system has also been upgraded with the use of the AliVATA DAQ board, which allows to operate the three detectors with a single board. Neural Networks are being employed for event selection, in order to increase the signal-to-noise ratio.
The system has been characterized in the laboratory and the results compared to GATE simulations achieving excellent agreement.
As a system for treatment monitoring in hadron therapy, tests have been carried out in beam facilities, at CNA (Sevilla) with 18 MeV protons impinging a graphite target, detecting 1 mm target steps, and also at the clinical gantry of the protontherapy centre in Krakow, detecting range variations of 2 mm. Moreover, background reduction strategies based on the use of silicon detectors are being tested.
In addition, the system is being assessed for radiotracer imaging. A Derenzo-like phantom filled with 18F-FDG has been imaged and further tests are ongoing.

Poster Session - "Champagne Demi Bulles" - P03-37

SINGLE - PHOTON SPECTROSCOPY WITH A FLEXIBLE FRONT-END READOUT SYSTEM FOR THE RADIOACTIVE WASTE MONITORING

Speaker: POMA

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In the framework of the MICADO project we developed gamma counters as a solution for radioactive waste monitoring. Each counter consists of a scintillating fiber (SciFi) coupled two Silicon photomultipliers (SiPM). Thanks to its optimized single photon sensitivity, the left-right coincidence constraint and a good S/B ratio, the SciFi counter can be employed for long-term monitoring of radioactive waste drums.

In order to obtain a compact optimized data acquisition system, a new CAEN Front-End board has been employed, as it can easily and efficiently handle up to 64 SiPM signals at the same time.

The spectroscopic modality of the SciFi has been investigated by using a gamma source. The resulting multi photon spectra have been analysed by using a multi Gaussian peak fit convoluted with a Poisson behaviour. Due to its improved discrimination capacity to detect signal events above the environmental background and thanks to the optimal single photon resolution, the new DAQ system is proved to be well suited for the project.

Poster Session - "Champagne Demi Bulles" - P03-39

XAFS-DET: a new high throughout X-ray spectroscopy detector system developed for synchrotron applications

Speaker: ORSINI

F. ORSINI[1]

[1] *SOLEIL Synchrotron*

With continuous improvements and upgrade of photon sources and X-ray beamlines, detection technologies beyond current capabilities are essential. In this framework, lot of effort has to be devoted to the improvement germanium detectors, which represent a very important class of instruments for X-ray spectroscopy because they enable to detect efficiently photons of considerable higher energy with respect to silicon detectors. In synchrotron applications such as fluorescence detectors for absorption spectroscopy (XAFS), germanium detectors do not show artefacts due to features such as the escape peak interfering with interesting peaks being measured. The detector workpackage of the European project LEAPS-INNOV, also named XAFS-DET, aims at pushing germanium detector performance beyond the state-of-the-art in the energy range from 5 to 100 keV, and for instance, enhance the throughput per unit area for X-ray spectroscopy by developing new multi-element monolithic detectors with reduced element size. Shrinking the element size entails challenges such as the development of new miniaturized front-end electronics and the use of advanced digital pulse processors to avoid collimators in front of the sensing elements. Preliminary layout and main choices for the design of the detector will be presented at the conference.

Poster Session - "Champagne Demi Bulles" - P03-41

Photon Detection Probability >60% from 430 to 480 nm at 0.85 V Excess Bias on SPAD in CMOS Technology

Speaker: PELLION

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This paper discusses Single photon avalanche photodiode (SPAD) detectors built in a standard CMOS technology. The SPAD is fabricated as n+/p-(epi)/p well junction with octagonal shape mitigating corner effects. A guard ring of n-well (with 40V breakdown voltage) around the n+ cathode (with about 12V breakdown voltage) is used to prevent premature discharge [Ref 1]. In this paper, we compare performances obtained with SPAD sizes ranging from 10µm to 24µm side, for 8 photodiodes. We investigate the optimal photodiode size and we found that the 16µm provides less noise by µm2 (for this technology: AMS 0.35µm). We measured, the breakdown voltage, the Dark Count Rate (DCR), and the Photon Detection Probability (PDP), with a -40°C to +20°C temperature range, for these 8 photodiodes. The sensitivity of the SPADs structures has been measured over the visible range at different over-voltages, by means of a dedicated test bench a measured Photon Detection Probability (PDP) as high as 66% at 460nm is reported for an excess bias of 6,8% (0,85V) whatever the size or the temperature. A Dark Count Rate (DCR) as low as 140Hz at -40°C with a 0.6V excess bias is also reported for a 10µm photodiode size. This DCR increase up to 1400Hz at 20°C.

Poster Session - "Champagne Demi Bulles" - P03-46

Development of hybrid position-sensitive silicon photomultipliers for high-resolution brain PET

Speaker: HWANG

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In this work, we present a new Position-Sensitive Silicon Photomultiplier (PS-SiPM) based on both light sharing and charge sharing architectures, which we call Hybrid PS-SiPM. We produced 1.5x1.5 mm2 and 3.0x3.0 mm2 Hybrid PS-SiPM prototypes. They were fabricated with the 180 nm Complementary Metal-Oxide Semiconductor (CMOS) process technology with an 8 um p-epi wafer. The breakdown voltage of the device is 28.5 V and the microcells have a size of 50x50 ?m2. The photon detection efficiency at 450 nm was 10 % on 11 over-voltage. The Hybrid PS-SiPM can compensate for each of the disadvantages of light sharing and charge sharing architectures. The proposed PS-SiPM provides low complexity of the readout electronics, high spatial resolution, and a fast output signal. These characteristics are fundamental for obtaining a good performance in the application of small-size positron emission tomography. Using Na-22 (511 keV) source, we verified that the spatial resolution of the device is 16 % with coupling the 3.0x3.0 mm2 Hybrid PS-SiPM prototype to a 3x3 pixelated LYSO crystal.

Poster Session - "Champagne Demi Bulles" - P03-47

Detailed analysis of a previously uninvestigated feature in lanthanum bromide scintillation crystal intrinsic background

Speaker: MARCER

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Lanthanum halide scintillation crystals represent the state of the art of the scintillators technology for gamma ray spectroscopy. They feature a short decaying time (< 30 ns), high light yield, good detection efficiency and an optimal energy resolution (< 5% at 662 keV). Lanthanum halides also present an intense intrinsic background caused by the radioactive decay of 13?La and 22?Ac contaminations, which cover all the lower energies up to 3 MeV.

Despite being a limitation in low counting rate experiments, this intrinsic background can be exploited to perform energy calibration of the pulse height spectra, refraining from the employment of dedicated external sources. The intense electron capture peak of 13?La at 1471 keV, which is the most relevant feature for this purpose, has been deeply characterised in literature in many aspects.

In this work, a detailed analysis of the lanthanum bromide intrinsic background was performed on several scintillation crystals, unveiling a feature with an average energy of 1515 keV not yet described in the current literature.

Poster Session - "Champagne Demi Bulles" - P03-48

High resolution imaging and timing using capacitive division

Speaker: LAPINGTON

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The capacitive division image readout (C-DIR) is a mechanically and electronically simple charge centroiding readout for single photon imaging detectors such as microchannel plate (MCP) detectors. Its purely capacitive nature endows it with a) very high signal bandwidth allowing MCP-limited time resolution, and b) low capacitance measurement nodes, allowing improved signal to noise charge measurement and correspondingly finer spatial resolution at high throughput. We describe an implementation of an MCP detector with C-DIR, optimised to provide combined high spatial and temporal resolution in single photon counting operation. The C-DIR is instrumented with high-speed front-end electronics utilising a fast waveform digitizer with a sample rate in excess of 1Gsample/s. We present results of the spatial and temporal resolution, and throughput of the detector system, and discuss the possible design variations which trade off performance parameters against each other.

Poster Session - "Champagne Demi Bulles" - P03-49

Spectral identification and quantification of radioactive species in gamma ray spectra by means of Bayesian Convolutional Neural Network

Speaker: DANIEL

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In the nuclear field, the characterization of radiological scenes is a major issue to achieve for different and various domains, from nuclear safety and security, to medical applications or also decommissioning and dismantling topics. Therefore, the identification and the quantification of radioactive species is one of the main information to obtain. We present here a method of spectral analysis based on Bayesian Convolutional Neural Network (BCNN), trained only with a synthetic dataset composed by simulated spectra, which aims to identify radioelements and quantify their intensity in the recorded spectrum. This method is tested with real data acquisition of radioelements mixtures recorded by Caliste, a CdTe semi-conductor detector for high-energy photons, whose high resolution is about 1 % at 60 keV and 0.7 % at 662 keV. We demonstrate that our BCNN is able to achieve an identification accuracy of 90 % from only one thousand of recorded photons, to give the proportion of each identified source and to associate an accuracy on each result, with a computing time of less than 0.5 seconds using a standard computer system.