Highlights of Poster Session II

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Poster Session II
Details

- 13 contributions (originally 22 - 9 withdrawn)
- Covered technologies and fields are:
  - XRay detectors: 6 contributions
  - Camera: 2 contributions
  - Avalanche Photo-diode: 1 contribution
  - Hybrid detectors: 1 contribution
  - Solid State detectors: 1 contribution
  - Other detectors: 2 contributions
Acknowledgments and disclaimer

- Many thanks to all contributors for their highlight slides
- Order of presentation is « random » – no preference!
- Apologies for possible inconsistencies – be tolerant!
XRay detectors

6 contributions
Motivation: Computed Tomography (CT) is a wonderful method to detect cancers but when cancers are marked by iodine it becomes difficult to be observed with high tube voltage diagnosis.

The idea: to exploit the energy information of X-rays in transmission measurements.

This work: a novel detector which measures X-rays as current and gives energy distribution of incident X-rays called transXend detector.

Method to deduce energy information with flat panel detector is shown on Poster 14.

1st → 3rd Generation CT:
- For measurement time reduction (human diagnostic)
- With CdTe flat panel detector + Al absorbers
Photon detection by an InSb compound semiconductor detector with reduced leakage current

Yuki Sato et al. – Kyoto University, Japan

Motivation: photon detector with compound semiconductor InSb in order to detect hazardous elements such as Li, Be and Pb (environmental preservation)

Why InSb? High detection efficiency
- High atomic numbers (In:49, Sb:51) and high density (5.78 g/cm³): Photon absorption efficiency
- Smallest band gap energy 0.6 ev (at room temperature): Energy resolution

This work: reducing leakage current by cooling and with changing the electrode design

Current-voltage curves
- This work: 24 K (●) and 73 K (▲)
- Leakage current was decreased

137Cs-gamma-ray measurement
- @ 4.5 K
- Gamma-ray was measured by the InSb detector

Details shown on Poster 25
Synchrotron radiation studies of spectral features caused by Te inclusions in CdZnTe

Conny Hansson et al. - European Space Agency/ESTEC, the Netherlands

- **CdZnTe (CZT):** recognised as a high energy X-ray and γ-ray detection medium due to its high stopping power and wide band gap.

- **Problem:**
  - detector perf. limited by defects in the crystal structure
  - spectroscopic performances are limited by Te inclusions

- **This study:** 10 mm thick CZT coplanar grid detector having large Te inclusions exposed to pencil beam synchrotron radiation in order to study spectroscopic features introduced by Te inclusions at different X-ray energies

- **Results:**
  - small inclusions <3µm: compensated by depth sensing techniques
  - larger inclusions: variation in collected charge carrier number
    - introducing trapping levels
    - affecting the electric field profile inside the detector
  - Explanations on Poster 95

- **Problem:** Spectral performance evaluated as a function of inclusion size

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Caliste-SO X-ray micro-camera for the STIX instrument on-board Solar Orbiter mission

Aline Meuris et al. - CEA / Irfu, France

- STIX (Spectrometer Telescope for Imaging X-rays): will provide information on the timing, location, intensity and spectra of accelerated electrons near the sun

- Caliste-SO: an hybrid component integrating the sensor material and dedicated front-end electronics for high resolution X-ray spectroscopy

- Applications: Hard X-ray astronomy: see Talk Caliste-256, session S14 Thursday PM → use advantages of small pixels and possibility to place several units side by side for a large focal plane
  - Solar physics: Caliste-SO on board Solar Orbiter ESA mission (phase B) → use advantages of a compact design, low power (new ASIC version: IDeF-X HD)

- Challenges for this device:
  - High count rate of solar flares (up to 10^5 counts/s/detector)
  - 1 keV FWHM @ 6 keV with large pixels (8 mm^2) moderate cooling (−20°C) and strong radiation level (10^{11} 10 MeV equivalent protons/cm^2 during the whole mission)
This work: study CdTe and Cd$_x$Zn$_{1-x}$Te radiation detectors with a non-destructive optical method which uses the effect of non-steady-state photoelectromotive force (photo-EMF).

Method: the non-steady-state photocurrents can be excited in widegap semiconductors illuminated by an oscillating light pattern. Such illumination is created by 2 coherent light beams one of which is phase modulated with frequency $\omega$. This technique allows the direct transformation of phase modulated optical signals into the electrical current. A lot of photoelectric parameters can be measured: carriers' lifetime $\tau$ and mobility $\mu$, diffusion $L_D$ and drift lengths $L_0$, concentration of trapping centers $N_D$.

Experimental results:
- characterization of transport parameters of CdTe and CdZnTe
- $\mu\tau$-product calculated using experimental data

More results on Poster 153

<table>
<thead>
<tr>
<th></th>
<th>Dark conductivity</th>
<th>Photoconductivity</th>
<th>Diffusion length of holes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CdTe</td>
<td>0.83x10$^{-9}$ $\Omega^{-1}cm^{-1}$</td>
<td>(1.1-2.5)x10$^{-9}$ $\Omega^{-1}cm^{-1}$</td>
<td>&gt;18 $\mu$m</td>
</tr>
<tr>
<td>CdZnTe</td>
<td>0.64x10$^{-9}$ $\Omega^{-1}cm^{-1}$</td>
<td>(0.8-2.8)x10$^{-9}$ $\Omega^{-1}cm^{-1}$</td>
<td>5.9 $\mu$m</td>
</tr>
</tbody>
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GaN detector development for particle and X-ray detection

Alan Owens et al. - European Space Agency/ESTEC, The Netherlands

- **GaN**: widely used in optoelectronics area, little work on its particle and X-ray detection properties

- **Properties**: 
  - wide band gap = 3.39 eV
  - high density = 6.15 g cm⁻³
  - large displacement energy = 20 eV
  - thermal stability

  Should be an ideal radiation detection medium operating in extreme thermal and radiation environments

- **Devices**: Si-GaN PIN diodes
  - 2 µm thick epitaxial layer on p-type 4H-SiC substrate
  - 400, 500, 600, 700 µm diameter diodes tested
  - full depletion for biases 20-60 Volts
  - tests carried out from -40°C to +20°C

- **Spectroscopy measurements**:
  - Alpha response
  - Energy resolution ~ 10% FWHM
  - Hard X-ray response
  - 60 keV
  - No response!

Let's see on Poster 179
Camera

2 contributions
Wide-Field Single Photon Counting Imaging with an Ultrafast CMOS-Camera and an Image Intensifier
Gianmarco Zanda et al. – King’s College London

- **Aim:** to design a system with positional, temporal information and high sensitivity (single photon)

- **Setup:** Ultra-Fast CMOS camera coupled with a photon counting Image Intensifier (3-stage)
  - Acquisition with a pulsed laser allows luminescence decay measurements
  - Phosphor decay can be exploited for photon arrival timing below camera exposure time

- **Advantages:**
  - Ultra high frame rate
  - Single photon sensitivity, photon event is amplified BEFORE accumulation
  - Wide Field technique (positional information and faster than PMT scanning: parallel processing of all pixels)
  - High signal to noise ratio (yes/no in the event localization)
  - Temporal Information - photon arrival time with Microsecond Resolution
  - Centroiding techniques to improve spatial resolution but introduces fixed pattern noise (FPN)

**Discussion on centroiding, timing of the events and FPN on Poster 181**
Charge Diffusion Measurement in Fully Depleted CCD using X-rays
Ivan Kotov et al. - Brookhaven National Laboratory, USA

- **Context:** specialized CCD sensors are being developed for the Large Synoptic Survey Telescope. LSST requires sensor contribution to Point Spread function (PSF) to be small and well characterized.

- **Setup:** sensor PSF is determined by the lateral charge diffusion on the drift path from the CCD window to the gate. Use of an X-ray source (\(^{55}\text{Fe}\)) to measure charge diffusion.

- **Method:** charge distribution described by 4 parameters:
  - x- and y-position
  - sigma
  - total amplitude

  **Criterion:** parameters are determined if the cluster contains at least 4 pixels with amplitude above the noise.

  Clusters with sufficient signal to noise ratio selected as pixel “fired”.

- **Results:** distribution of sigma values measured:
  - with a prototype device (green)
  - with simulated X-rays (blue)

  Good agreement for the “window” peak.

More explanations on Poster 138
Avalanche Photo-Diode (APD)

1 contribution
Anomalous APD signals in the CMS ECAL

David Petyt et al. - STFC Rutherford Appleton Lab.

Setup: The main component of the Compact Muon Solenoid (CMS) to detect and measure the energies of electrons and photons from proton-proton collisions is the Electromagnetic Calorimeter (ECAL).
- ECAL consists of 75848 PbWO4 crystals, organized into a barrel and 2 endcap detectors
- Scintillation light emitted by the crystal is converted into electrical signals by Avalanche Photo-diodes (APDs) glued to the rear face of the crystal.

Problem: Anomalous signals, consisting of isolated large signal, have been observed during LHC 2009-11 data taking. “ECAL spikes” are observed to be proportional to the proton beam intensity.

Understanding: Spikes are ascribed to direct energy deposition by particles striking the APDs and causing occasionally large signals through direct ionization of the silicon.
- spike properties and rates
- Monte Carlo simulations
- laboratory and test beam

Used to understand the spikes origin

A method to reject these signals in the trigger has been founded

Revised method presented on Poster 109
Hybrid Photodetector

1 contribution
Use of Hybrid Photon Detectors in scintillations studies and imagin applications

Jiri A. Mares et al. - Institute of Physics, AS CR, Czech Republic

- **Detector**: HPMT = a photocathode + one Si-PIN diode used as an anode. Photoelectrons electrostatically focused on Si-PIN diode

- **Aim**: HPMT used in characterization of scintillating materials
  - energy resolution
  - non linearity
  - reliable photoelectron calibration
  - less noise respect to classical PMT's

- **Applications**:
  - largest use: at LHCb experiment at CERN at the RICH detectors for particle identification (500 HPD's used)
  - imaging application: γ-ray optoelectronic camera
    ISPA tube = YAP:Ce photocathode + array of Si-diode pixels

More details on Poster 37

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Solid State Detectors

1 contribution
Single photon avalanche diode radiation tests

Josef Blazej et al. – CTU Prague, Czech Republic

- Single Photon Avalanche Diode (SPAD): provided by Czech Technical University (structure on Silicon)
- Context: generally used in lidar or various ranging experiments recently planned for applications in deep space missions that is why radiation damage tests were carried out.
  - Expected source of radiation = trapped and solar protons and electrons and gamma ray
  - Expected to change after radiation = SPAD effective dark count rate (increasing)
  - Not expected to change = other parameters such as QE, breakdown voltage, speed...
- Tests using 2 radiations: proton radiation and gamma ray

1 - Indiana University Cyclotron Facility: 54 MeV energy protons

- low proton flux: no changes in DC rate
- high proton flux: DC increases from 0.3Mc/s to 1.6Mc/s
  - DC rate depends on the radiation flux
- slow annealing effects in time: decrease slope of 0.8Mc/s in 100 days after irradiation.

2 - Nuclear Research institute in Rez: $^{60}$Co source

- Gamma ray radiation did not caused any significant changes in diodes performance:
  - DC rate = 0.2Mc/s before and after irradiation

Measurements results on Poster 184
Other Photodetectors

2 contributions
First steps towards small prototype gamma camera based on wavelength shifting fibers
I.F.C. Castro and L.M. Moutinho et al. - i3n, Physics Dept, Univ. of Aveiro, Portugal

- **Context:** development of higher resolution gamma cameras is interesting in cancer diagnosis

- **Setup:**
  - Gamma camera:
    - based on optical fibers (1mm ø)
    - coupled to both sides of inorganic scintillation crystals (CsI-Na)
    - readout of the scintillation light by means of light guides, namely Wavelength Shifting Fibers
  - Spatial resolution = 1-2 mm FWHM

- **Test of small prototypes using collimated Co$^{57}$ (122 keV)**
  - 12 fibers prototype with MaPMT: $V(MaPMT)= -800V$
  - 10 fibers prototype with SiPMs: $T \sim 20^°C, V_b$(common to all)$= -70.5V$

Position of maximum output signal for different collimator hole positions
New Micromesh Gas Detector for Gaseous Photomultiplier

F Tokanai et al. - Dept of Physics, Yamagata University, Japan

- **Gaseous PMT**: can achieve a very large effective area but moderate position and timing resolutions

- **Development of a New Micro Mesh Gas (Micromegas) detector**
  - fabricated by chemical etching in conical holes on the metal of 46 μm thickness
  - holes diameters = 80 and 120 μm - Pitch = 250 μm
  - drift and absorption region for X-rays = 5 mm
  - amplification region (between mesh and anode) where a high electric field is formed to induce electron avalanches = 150 to 200 μm

- **Performance test using X-rays (6keV)**
  - For Ne (90%) + CF4(10%) gaz mixture at 1 atm
    - Gain up to 2x10^4 for V_{applied} = 500V
    - Energy resolution of 18%

- **Performance test using UV light**
  - Development of a gaseous PMT composed of a CsI photocathode and the Micromegas detector
  - Gain up to 2x10^4 for V_{applied} = 500V
  - Encouraging results to develop a gaseous PMT with a bialkali photocathode sensitive to visible light!

[Poster ID 45]
Conclusions and perspectives

WELCOME TO POSTER SESSION II!

All contributors are looking forward to seeing you in the Poster and Exhibition Hall