7th International Conference on
New Developments In Photodetection

Tours, France, June 30th to July 4th **2014**

NDIP

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CENTRE NATIONAL D'ÉTUDES SPATIALES

HIGLIGHT of Poster Session III

A. PENQUER (CNES/France)

Poster Session III: overview

- 24 contributions
- various detector technologies addressed and also electronics and system aspects
  - -CCD/CMOS (& Electron bombarded) detectors (4)
  - -CZT and Si Hard X-Ray specific detectors (2)
  - -Photocathodes/Gaseous detectors/Crystal detectors (7)
  - -Detector radiation tests (4)
  - -Front End Electronics and systems (7)
- aim is to have a quick look on the presented work; not possible to have a detailed focus on each poster

CCD/CMOS (& Electron bombarded) detectors

- CCD/CMOS : strong maturity visible detectors with various extended uses and applications:

  -CCD/CMOS for single photon detection with Electron Bombarding (2 posters)

  -CCD for X-Ray detection (1 poster)

  -CCD performances characterization by using X-Rays (1 poster)

- Electron Bombarded CCD/CMOS

-Single photon detection and localization accuracy with ebCMOS camera, A. Dominjon –P9

-Purpose

Comparison of LUSIPHER camera with other imaging system for single photon sensitivity and resolution

Simultaneous identification of hundreds of spot sources capability

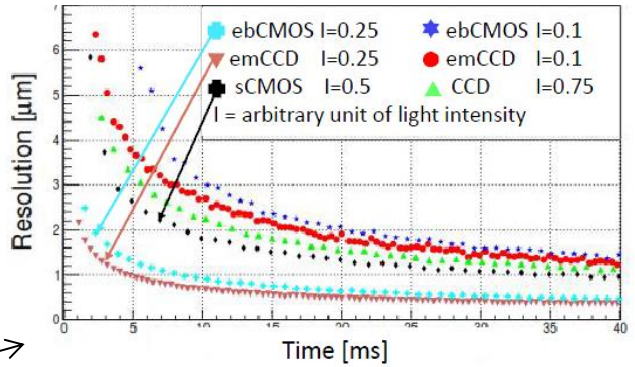
-Study results

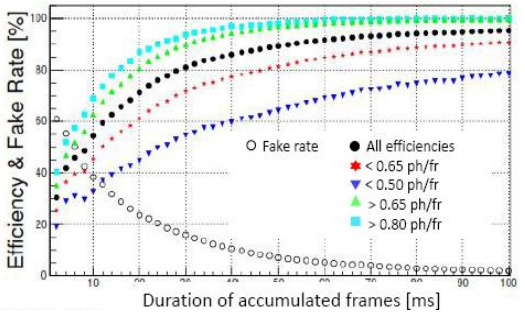
EbCMOS found to be well sensitive for single photon detection

Localization accuracy is close to emCCD detector one and less than 1μm resolution reached after 20ms

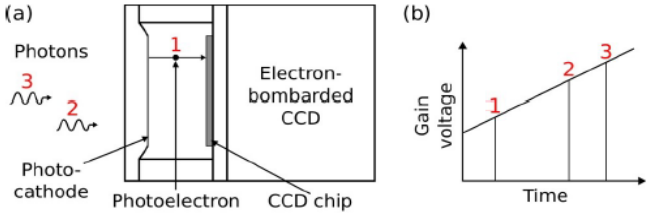
Identification of 700 source spots in only 20 frames (efficiency>90% after 60ms and false rate<5%)

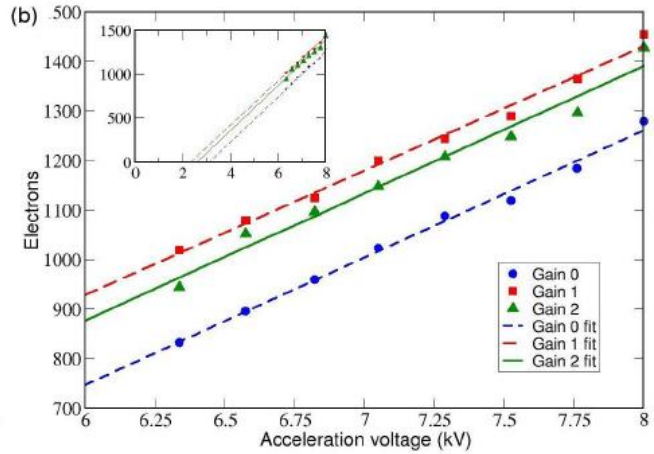
Electron-bombarded CMOS





- Electron Bombarded CCD/CMOS





-Electron-bombarded CCD as a parallel-processing photoelectronic time-to-amplitude converter, L. Hirvonen – P12

-Short description

New concept allowing to determine the arrival time

ebCCD gain depends on voltage

By varying voltage during integration time, pulse amplitude can be correlated to arrival time at photocathode

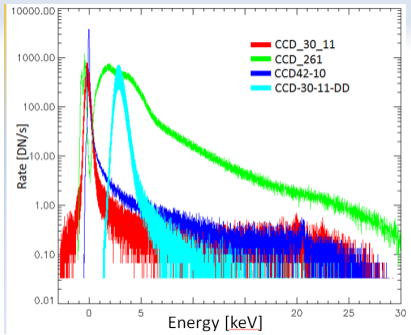
-First Measurements

First measurements performed with Hamamatsu ebCCD

Verification of gain dependency with acceleration voltage

Deduced Electron-hole generation Energy close to theory

CCD/CMOS



▪CCD & X-Rays

-Detection of X-Ray radiation in 1-30keV energy passband with the use of selected CCD detectors, S. Kuzin –P6

-Short description

Comparison of different CCD types for X-Ray detection capability

CCDs exposed to continuum and fluorescence line X-Ray

Focus on detection efficiency, dark current, linearity and split events pattern

Resolution of tested CCDs [keV]

Line	Mo K_α	Mo K_β	Cu K_α	Cu K_β
Energy [keV]	17.48	19.61	8.05	8.91
CCD-30-11	0.65	0.71	0.57	0.60
CCD261	1.13	1.19	×	×
CCD42-10	0.34	0.33	0.20	0.23
CCD30-11DD	×	×	×	×

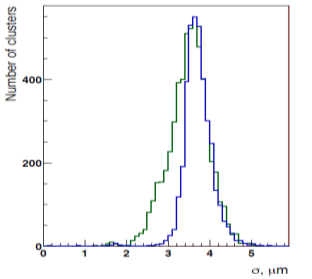


Figure 3. Measured sigma values are shown in green. The simulated X-rays with diffusion sigma value fixed at 3.55μm is shown in blue

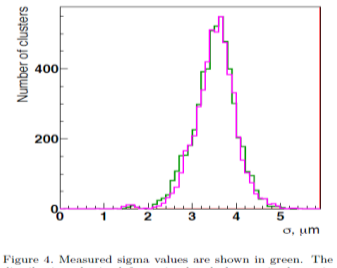
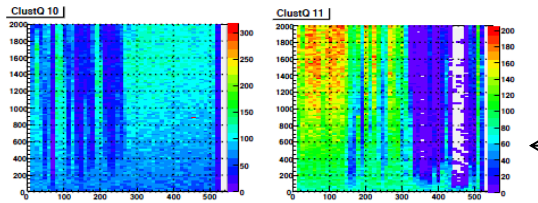


Figure 4. Measured sigma values are shown in green. The distribution obtained from simulated clusters is shown in pink.



-X-Ray analysis of fully depleted thick CCDs with small pixel size, I. Kotov– P3

-Short description

Small pixel size and fully depleted => diffusion

Use Fe X-Rays and clusters to determine diffusion and CTE

-Results

Diffusion measurement results in line with simulation

CTE measurements performed with aperture method which could be refined to avoid overestimating of CTE

Defects underlined by X-Ray analysis (large number of traps in some areas)

CZT and Si Hard X-Ray specific detectors

- CZT detectors (1 poster)

  Spectrometer applications

- Si double sided strip detector (1 poster)

  Compton wide field polarimeter application

CZT and Si Hard X-Ray specific detectors

- CZT spectrometers

-Caliste-SO, a CdTe-based spectrometer for bright solar event observation in hard X-Rays, A. Meuris –P18

-Short description

Hybrid for STIX/SOLAR ORBITER application

Low power consumption, high detector resistivity, small volume

Optimized interconnection process

CdTe schottky detector hybridized with IDEF-X ASIC

1cm2 anode: 2 bands divided into 2 large pixels (8mm2) and 1 small (1mm2)

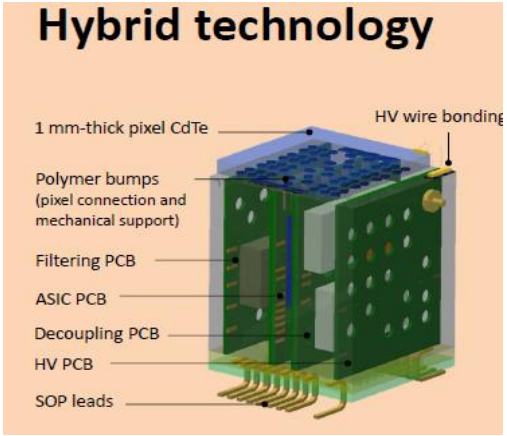
-Performances and development progress

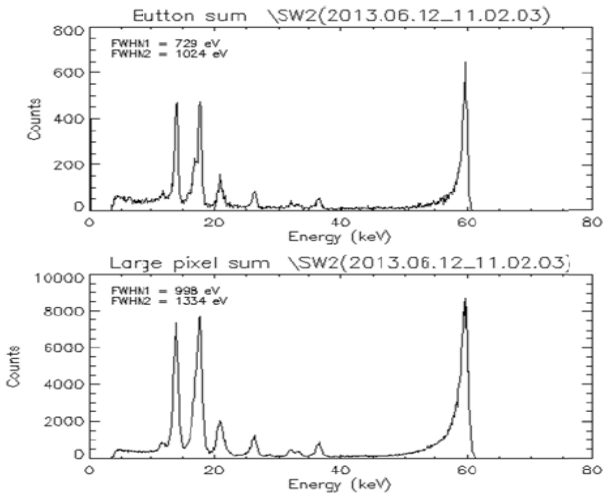
Spectroscopic measurement performed with excellent results

(resolution down to 0,7keV FWHM@6keV)

4 samples (engineering models) produced in 2013

15 QM in production





- Si double sided strip detector

-WPOL, a future space Compton wide field polarimeter: first light, M. Kahlil –P24

-Short description

Coded mask Imaging with two detection planes

Based on double sided strip Si detector

Mapping done on first plane (mask imaging)

Polarization measured by studying Compton scattering between the two planes

-Prototyping

Protoype of Compton camera with 2 DSSD undergoing

Readout by IDEF-X, (low noise space qualified ASIC)

Photocathodes/Gaseous detectors/Crystal detectors

- Various detector technologies using external photon amplifying
- Focus on:

  Photocathodes used to convert photon into electron (2 posters)

  Crystal photo-detector assembly (2 posters)

  Gaseous detectors: photomultipliers (2 posters) and gas properties improvement (1 poster)

Photocathodes

-Effect of humidity on photoemissive and structural properties of KBr thin film photocathode, N. Triloki –P54

-Problematic

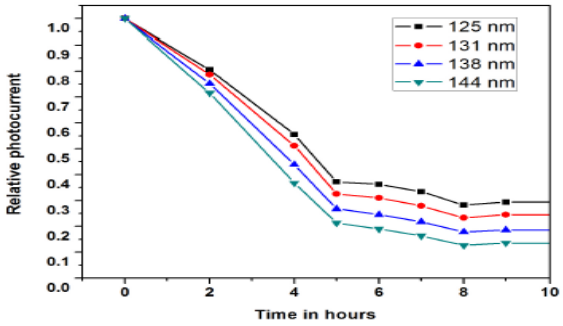
KBr good candidate for FUV/EUV or short X-rays

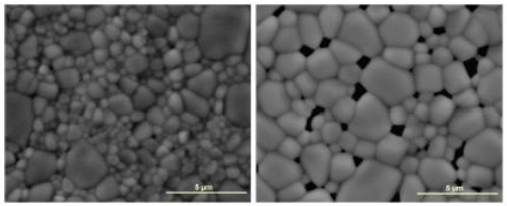
Aim is to investigate the possible moisture induced degradations

-Study results

Photocurrent decreased once moisture exposed

Crystallite size modified





-Photoemission and optical constant measurements of Cesium Iodide thin film photocathode, B. Singh – P45

-Problematic

Alkali pk very efficient in UV and soft X-rays; film thickness tunable from few nm to µm

Needs to know optical performances variations with λ

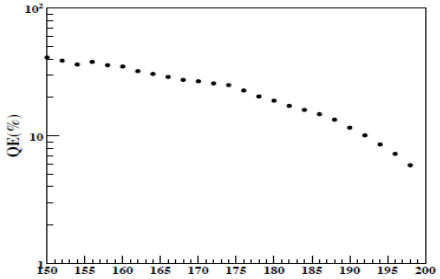
-Study results

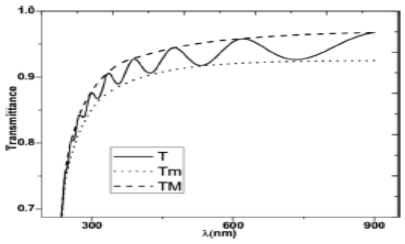
QE and absorbance of 500nm thick CsI film measured

QE in line with literature data for CsI pk

Transmittance, Energy bandgap and refraction index deduced from absorbance as function of wavelength

CsI film found to be homogeneous with dispersive behavior





- Crystal photodetector assembly

-Simulation studies of crystal photodector assemblies for the TAC-PF electromagnetic Calorimeter, F. Kocak –P42

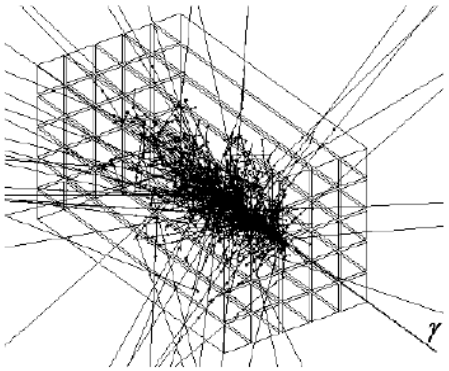
-Short description

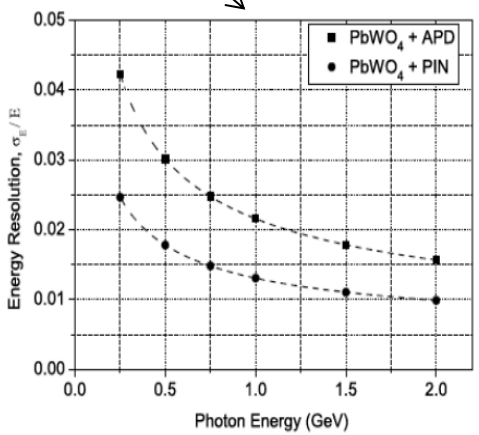
Colorimeter for Turkish Accelerator Center

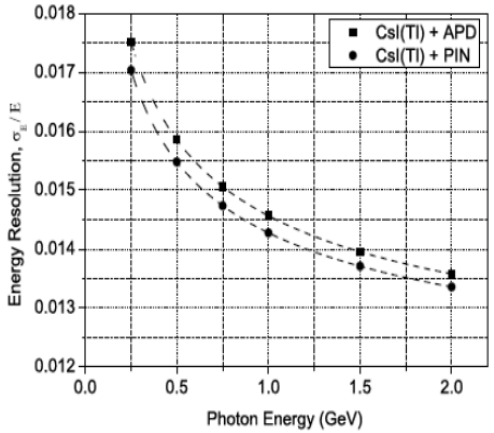
Comparison (by Geant4 simulation) of different crystal photodetector systems wrt the energy resolution

Shower fluctuations and leakage out the crystal volume taken into account

Focus on $PbWO_4$ and CsI crystals / PIN diode and APD Hamamatsu detectors







▪Crystal photodetector assembly

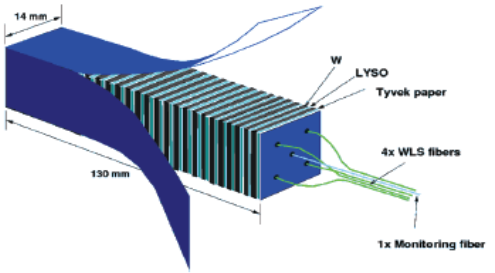
-Precision timing measurements for high energy photons, D. Anderson –P27

-Goal and System

Measure time of arrival of photons and electrons above 1GeV with precision of a few 10ps

Based on LYSO crystals (1.7cm cube and 2,5x2,5x 20cm3) and MCP-PMT

Further prospects will be done with other detection techniques (large area MCP, Silicon,…)



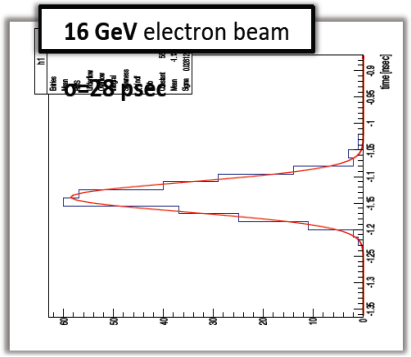
-Experimental setup and results

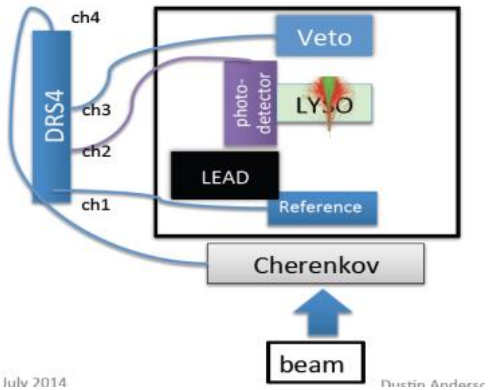
Readout: DRS4

Cherenkov counter tag electron events selection

TOF resolution ~30psec for 1.7cm cube

~60psec for 20cm





- Gas properties improvement for gaseous detectors

-Electroluminescence yield of xenon with small quantities of CH4/CF4 additives, E. D. Freitas –P57

-Short description

High-pressure chamber xenon gas time projection aimed on NEXT collaboration

But Xenon is a slow gas (=>very large electron diffusion)

Molecular gas additive will reduce diffusion (CH_4/CF_4)

Experimental studies are being performed with small driftless gas proportional scintillation counter to find out the most appropriated additive proportions

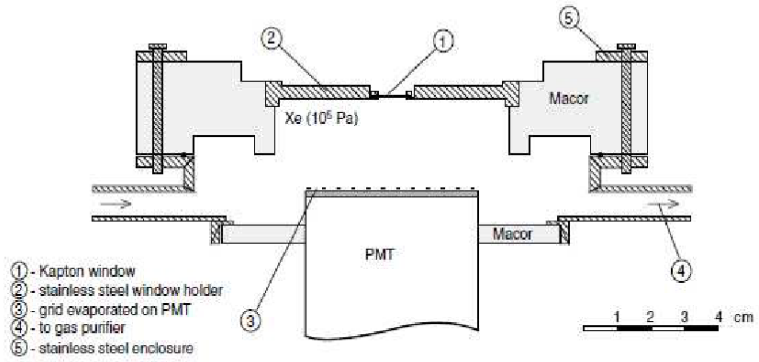


Fig. 1 – Schematic diagram of a driftless GPSC [3].

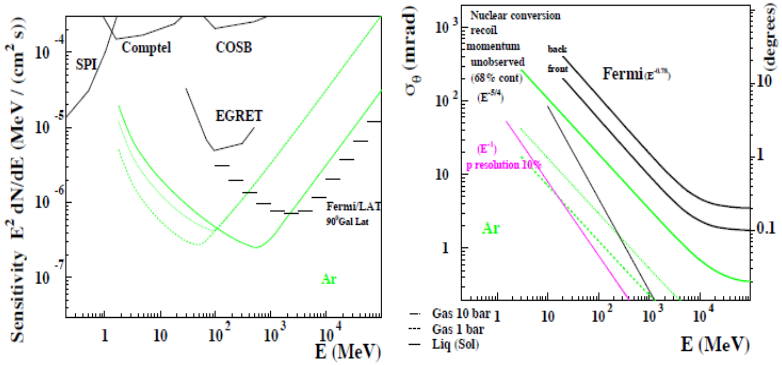
Gaseous detectors

-Harpo: a TPC concept for gamma ray polarimetry with high angular resolution in the MeV-GeV range, D. Attié –P48

-Short description

Detection and polarimetry of MeV-GeV Gamma rays for space application

Simulations show 1m^{3}Time Projection Chamber concept with Ar can provide improvement in sensitivity and angular resolution compared to actual systems
Polarization information can be extracted from conversions in the gas



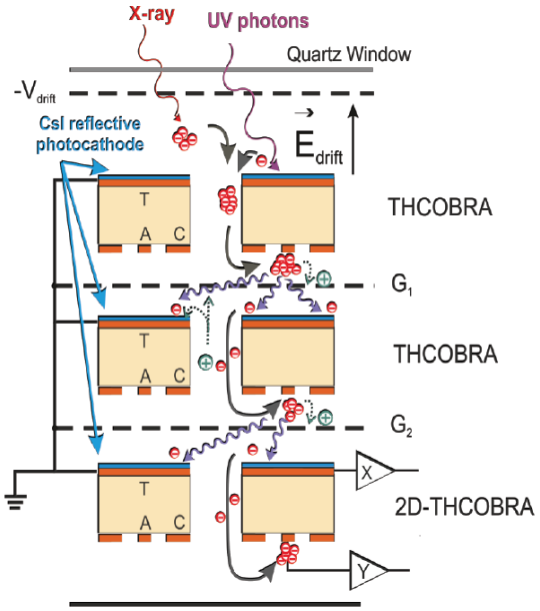
-Prototyping

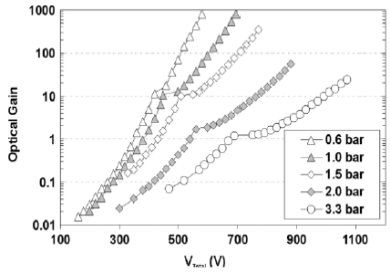
Prototype built and tested with cosmic muons

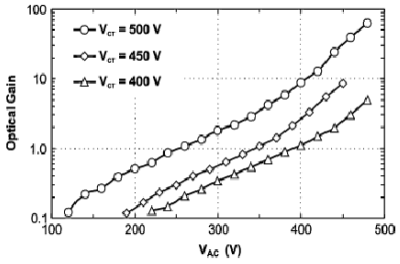
Tracking performances are being tested

Prototype will be used in test beam campaign at NewSUBARU in November

▪Gaseous detectors







-A new gaseous photomultiplier based on photon-assisted cascade electron multiplier using THCOBRA structure, A. Silva– P51

-Short description

Photon assisted cascade electron multiplier (PACEM)

3 THCOBRA elements; 2 charge blocking mesh electrodes

Avalanche on hole and anode of first THCOBRA generating VUV photons

Photoelectron extracted from pk and same process occurs on second stage; 2D THCOBRA as last element

-Study focuses on

Optical gain and ion back flow as a function of applied voltage and scintillating gases (XE on left figure and CF4 on right)

Position resolution capabilities

Detector radiation tests

- 4 contributions about detector radiation hardness tests:
  - APD detectors under neutrons (3 posters)
  - CdTe schottky detector under protons and secondary neutrons (1 poster)

Detector radiation tests

- APD under neutron irradiation

-Radiation hardness investigation of APD for PSD detector application at CBM, V. Mikhaylov, V. Kushpil –P60

-Context

High neutron field intensities, wide neutrons energy range

Investigation of detector candidates needed under neutron irradiation (2 KETEK and 1 ZECOTEK APDs irradiated)

-Method

Static/dynamic characteristics; single photon spectrum reconstitution

-Results

Noise rms and dark current increased dramatically; impossible use as single photon detection after irradiation

Based on C(V) and C(f) analyses, defects in Silicon volume is assumed to be responsible for high frequency noise

-Radiation damage study and characterization of Hamamatsu Silicon photo-multiplier, M. Fiorini – P63

-Short description

Three fluences steps: $5x10^8$, $5x10^9$ and $5x10^{10}$ 1MeV n_{eq} per cm^2

After each step: current voltage curves and dark noise analysis

Different devices under study, including "RadHard" one

Detector radiation tests

- APD under neutron irradiation (CMS ECAL APDs)

-Performance prospects for the CMS electromagnetic calorimeter barrel APDs for LHC Runs 2 and 3: radiation hardness and longevity, F. Addesa – P33

-Short description

In the frame of CMS ECAL at LHC: what will happen to the APDs performances under LHC irradiation (1,2 to 2,4.10^{14} N/cm2)?

-Results and mitigation solutions

Analysis done for 1,5.10^{14} N/cm2

Gain shift observed, can be corrected by rising bias voltage

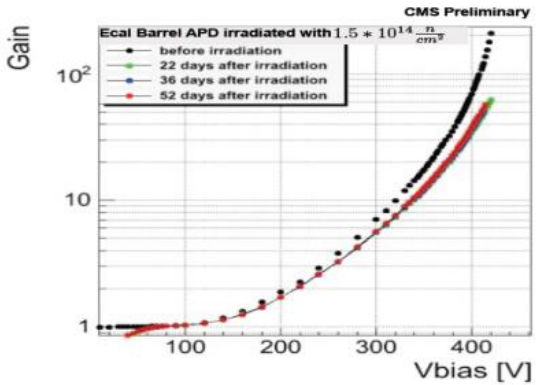
Dark current increase can be reduced by cooling from 18° C to 8° C

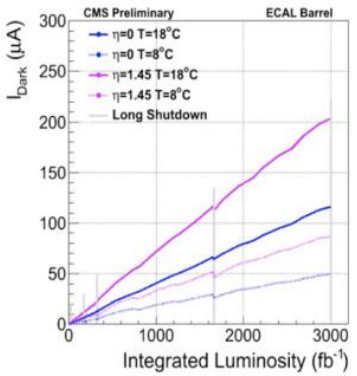
Noise increase can be mitigated by shorter signal shaping time

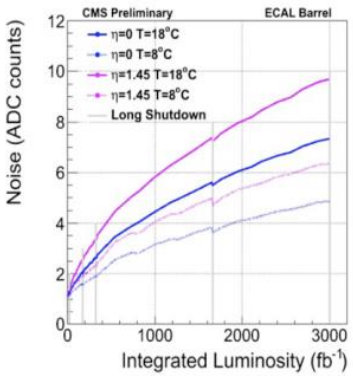
-Further Results

5 capsules irradiated up to 2,4.10^{14} N/cm2

Measurements undergoing







Detector radiation tests

- CdTe Schottky detectors under protons

-ASTRO-H CdTe detectors proton irradiation at PIF, D. Renaud – P21

-Short description

Schottky contacts CdTe detectors on SGD and HXI/ASTRO-H

Study of radiation effects on the detectors, focus on resolution and stability (wrt polarization effect)

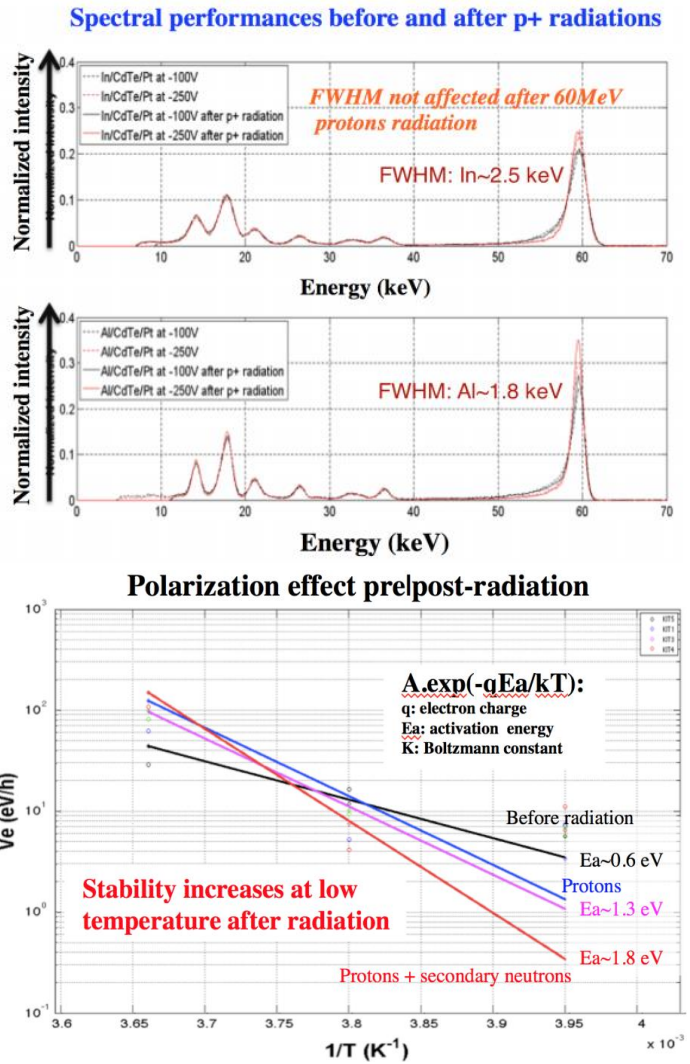
Radiation campaign in different configurations supported by GEANT 4 simulations

-Results

Spectral resolution not affected by protons

Proton induced improvement of stability; protons could be helpful to further understand polarization effects mechanisms

Secondary neutrons might be more active to reduce long run performances with significant degradation of resolution (factor of two)



Front End Electronics and systems

- 3 different topics addressed
  - Low noise Front End Electronics based on High Electron Mobility Transistors (HEMT) (2 posters)
  - Precision timing measurement chips (2 posters)
  - Systems (3 posters)

- Low noise Front End Electronics

-Cryogenic ultra low noise HEMT voltage amplifier, X. De La Broïse –P87

-Context

For detector operating at deep cryogenic temperature

Need of electronics working down to 1K to reduce interconnections,

For HEMT with 92pF input, equivalent noise of 0,46nV/Hz^{0,5} @1kHz demonstrated

-Development

HEMT using AlGaAs/GaAs heterojunctions

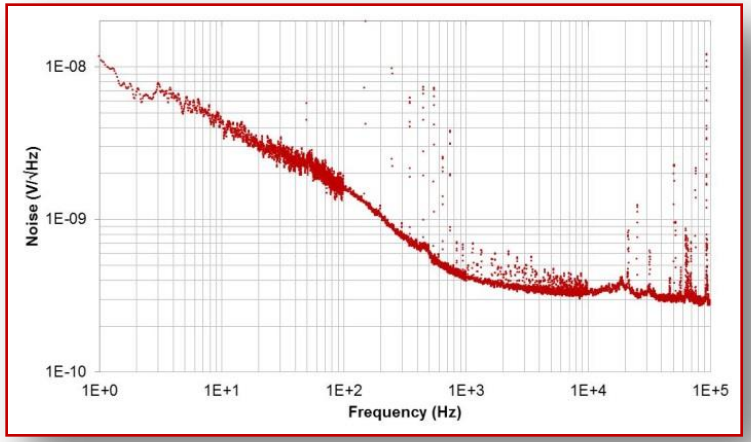
Electronic board with 6 amplification channels (gain 10 to 100)

4 different working modes; 2 different implementations

-Results

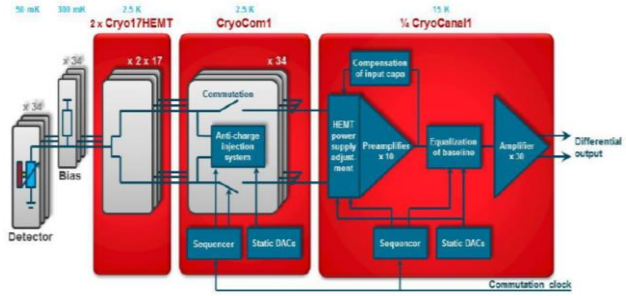
Tested @ 4,2K: gain of 50; 1,5mW per channel;

Noise less than 0,6nV/Hz^{0,5} @1kHz

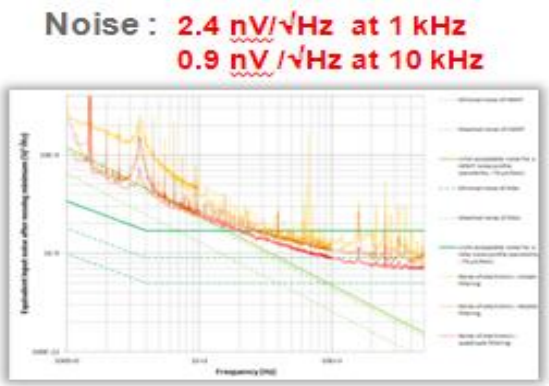


- Low noise Front End Electronics

-Low noise, low power dissipation multiplexing electronics using HEMT+SiGe ASICs for the readout of high impedance sensors, F. Lugiez –P81



Block diagram



-Context

High-Z fast detectors require close electronics in cryostat

Need of electronics with very low noise and low power dissipation

-Development

First stage with HEMT/ Second stage: multiplexing and amplifying

Input stage powered only when read=> anti-charge injection system needed to avoid perturbation when input stage commuted

First version developed successfully

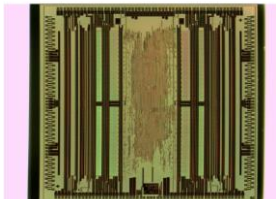
New version undergoing (tests in progress) with 34 channels and improvements (consumption, bandwidth, programming, integration,…)

- Precision timing measurement chips

-STIC3-silicon photomultiplier timing chip with picosecond resolution, V. Stankova –P72

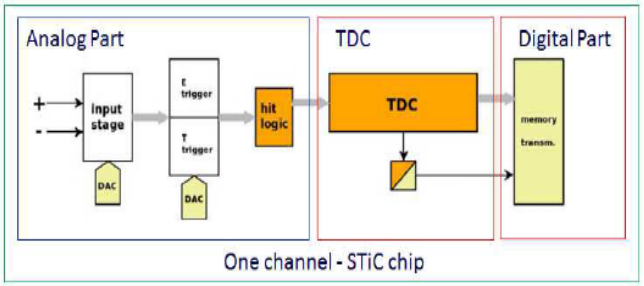
-Context

ASIC for SiPM with very high time resolution required
(200ps FWHM for 511 keV photons)



-Development

Updated of previous 16 channel ASIC;
64-channel in UMC CMOS 0,18µm technology
Analog part/TDC (less than 20ps resolution)/digital part
Differential readout structure (better noise rejection)
DAC controlled voltage for each channel
Consumption estimated to 25mW per channel
Characterizations under-going



-Triroc: 64-channel SiPM readout ASIC for PET/PET-ToF application, J. Fleury –P75

-Context

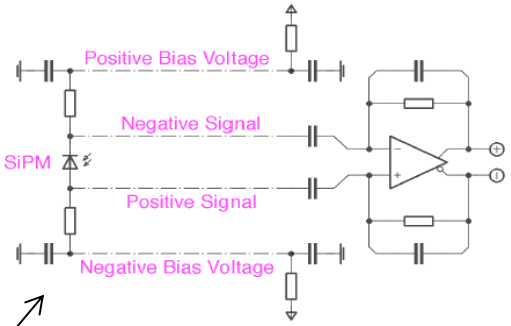
Latest Weeroc ASIC development, in the frame of TRIMAGE project
SiPM readout; high accuracy timing and charge measurement

-ASIC characteristics

64-channel in AMS 0,35µm Si-Ge technology
Low noise; DC coupled; both input polarity accepted; DC level adjustable per channel
High dynamic range 10-Bits ADC (up to 2500 photoelectrons)TDC fine time beginning of 40ps
ASIC submitted in March 2014

- Electronic systems

-A low noise fast pre-amplifier and readout system for SiPMs, P. Achenbach, M. Biroth –P78



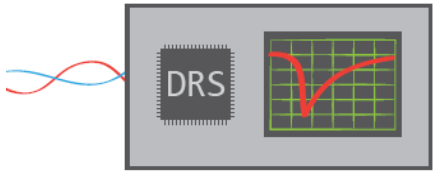
-Context

Zecotek SiPM readout; Large number of pixels @ 4K

Need to get fast SiPM signals over meters if electronics at Troom

-Proposed Electronics

Differential 4-wire pre-amplifier with passive filter close to detector

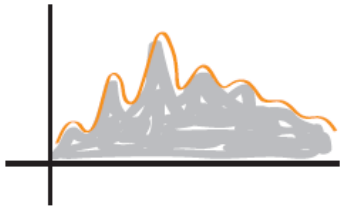


-System analysis and methods used

Fundamental parameters extracted of pulse shape to compare different amplifiers; pile-up detected while data acquisition is running

=>Use of switched capacitor array DRS4; Curve fitting of the pulse shape and online analysis concepts

Single cell gain, variation and crosstalk probability extracted of SiPM spectrum by derivation of an analytical curve-fitting function



- Electronic systems

-A 64ch readout module for PPD/MPPC using EASIROC ASIC, I. Nakamura –P84

-Short description

2 EASIROC ASICs, 64 sensors handling capacity

Module can adjust bias voltage, gains, shaping time trough EASIROC

Threshold adjustable with 1mV accuracy

On board power supply

12 Bits A/D converter

1ns TDC on Artix7 FPGA

Logic programmable to generate trigger signal

Communication can be done through TC/IP/UDP network

NIM standard form factor, only uses DC5V from NIM card

-Production

First production in September 2013

Noise, linearity, crosstalk measurement performed

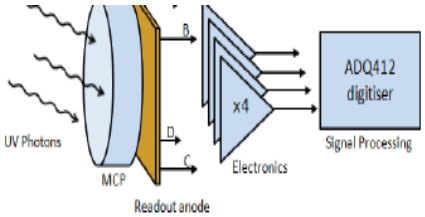
Front End Electronics and systems

-High performance detector readout for astrophysical and planetary instrumentation, S. Leach –P69

-Context and design challenges

MCP based photon counting device readout electronics

High image resolution needed



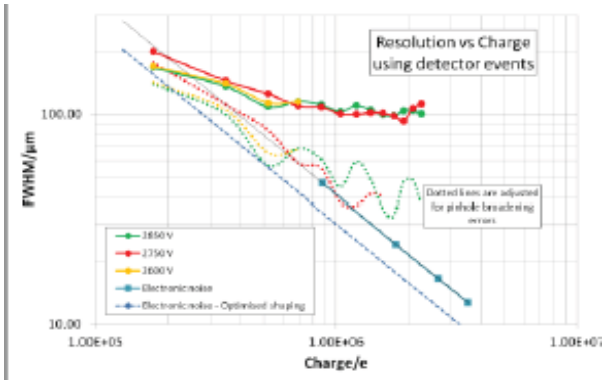
-Method

Spatial resolution improved by noise reduction

Capacitively coupled readout device; low noise FEE and adaptable digital pulse shaping techniques

-Imaging Results

Electronic noise predicts 7.7μm @ 4.3x10^{16} electrons



-Perspectives

Improvements, compare adaptive digital shaping techniques