Study of the impact of dead time and computation of the ECLAIRs detection plane spectral response

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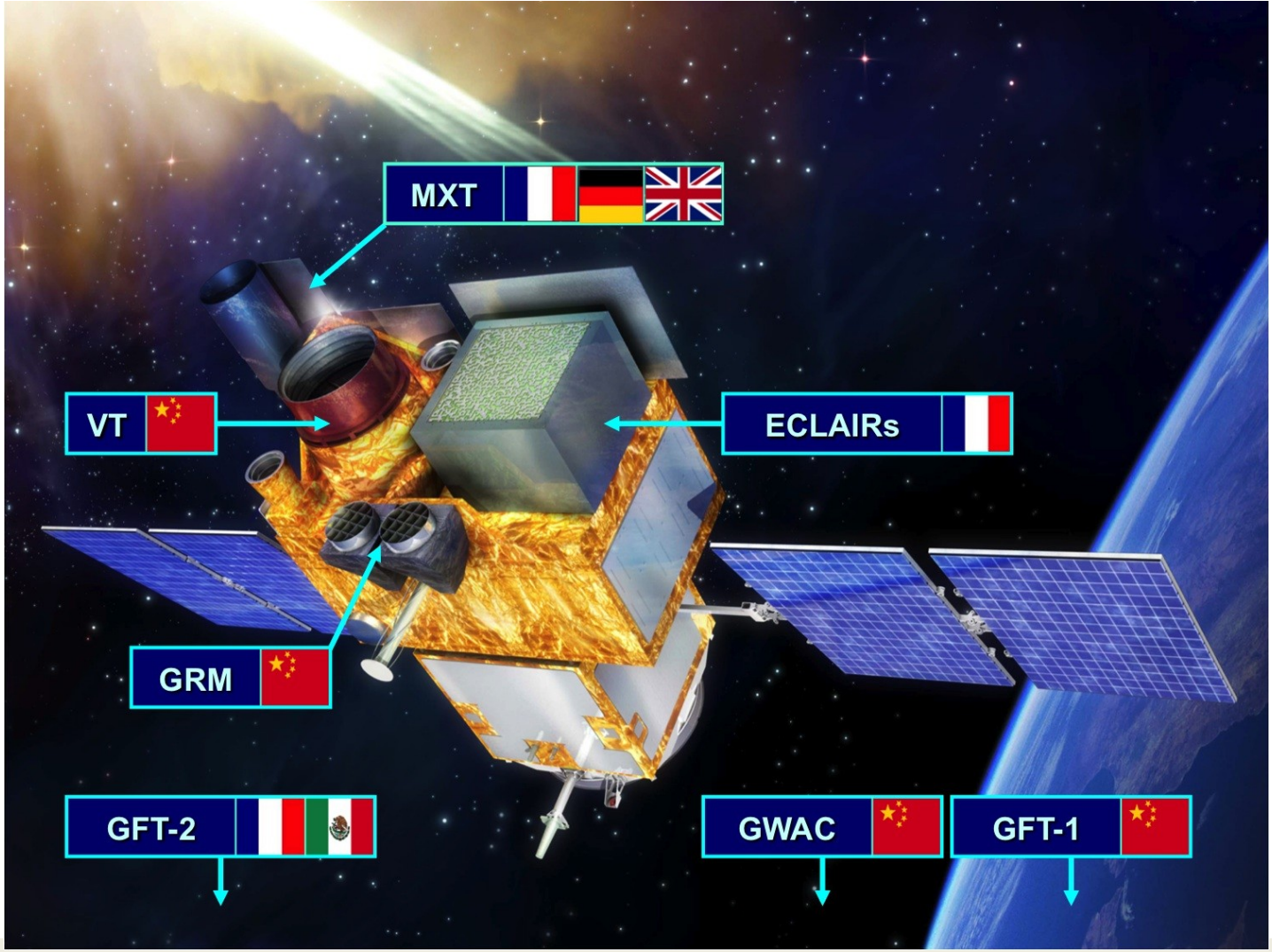
MXT
VT
ECLAIRs
GRM
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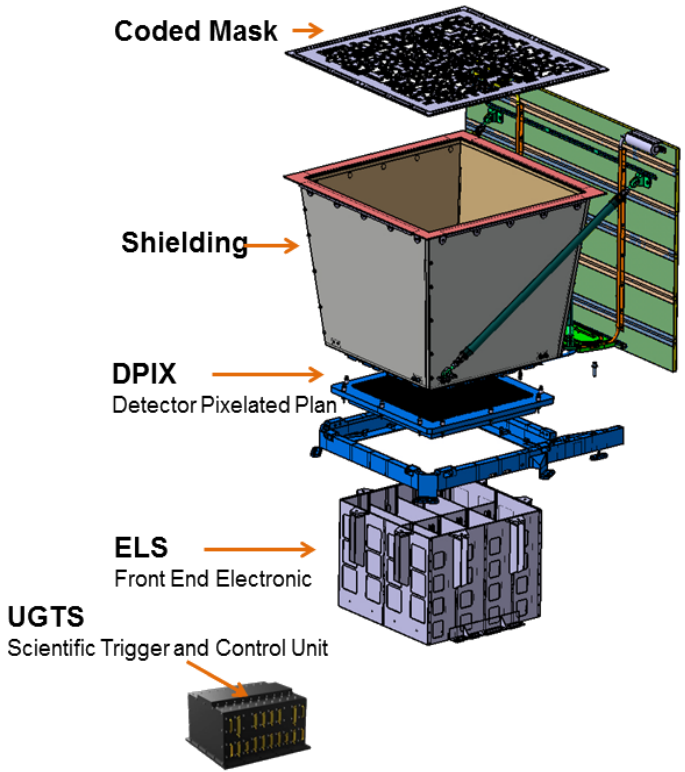
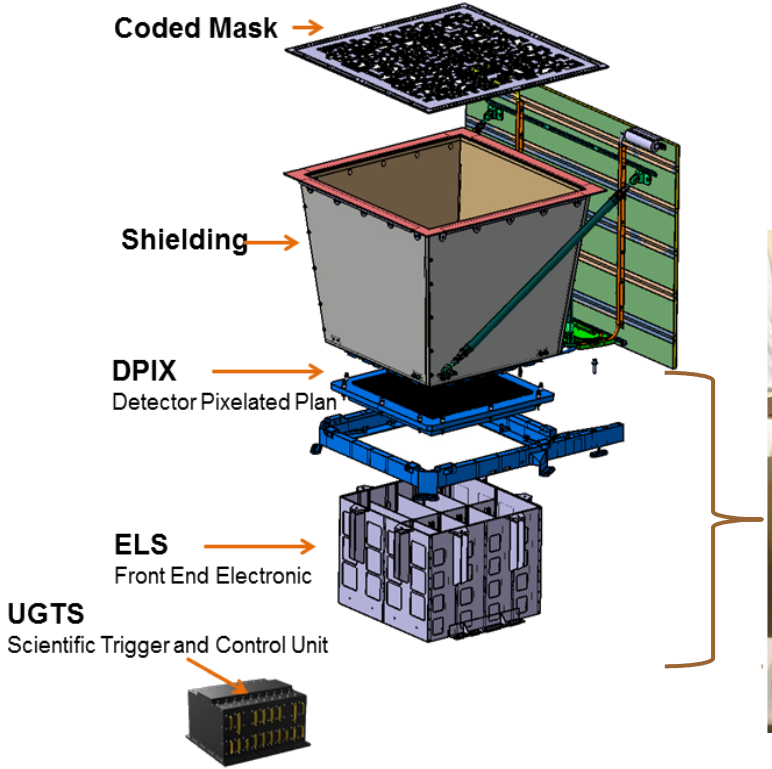
ECLAIRs presentation - Scientific performances

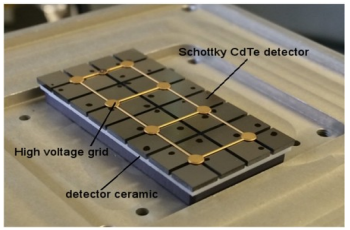


Energy Band	4 - 150 keV
Active surface of the plane	1024 cm^2
Energy resolution @ 60keV	< 1.5 keV
Time resolution	10 µs
Dead Time	< 5%
Field of view	2.02 sr
localisation error box	< 12 arcmin

- Precise and fast localisation
- Photons counting with an adapted sensitivity and resolution in time
- Measuring the temporal and spectral properties of the emission

ECLAIRs presentation - modules and electronics

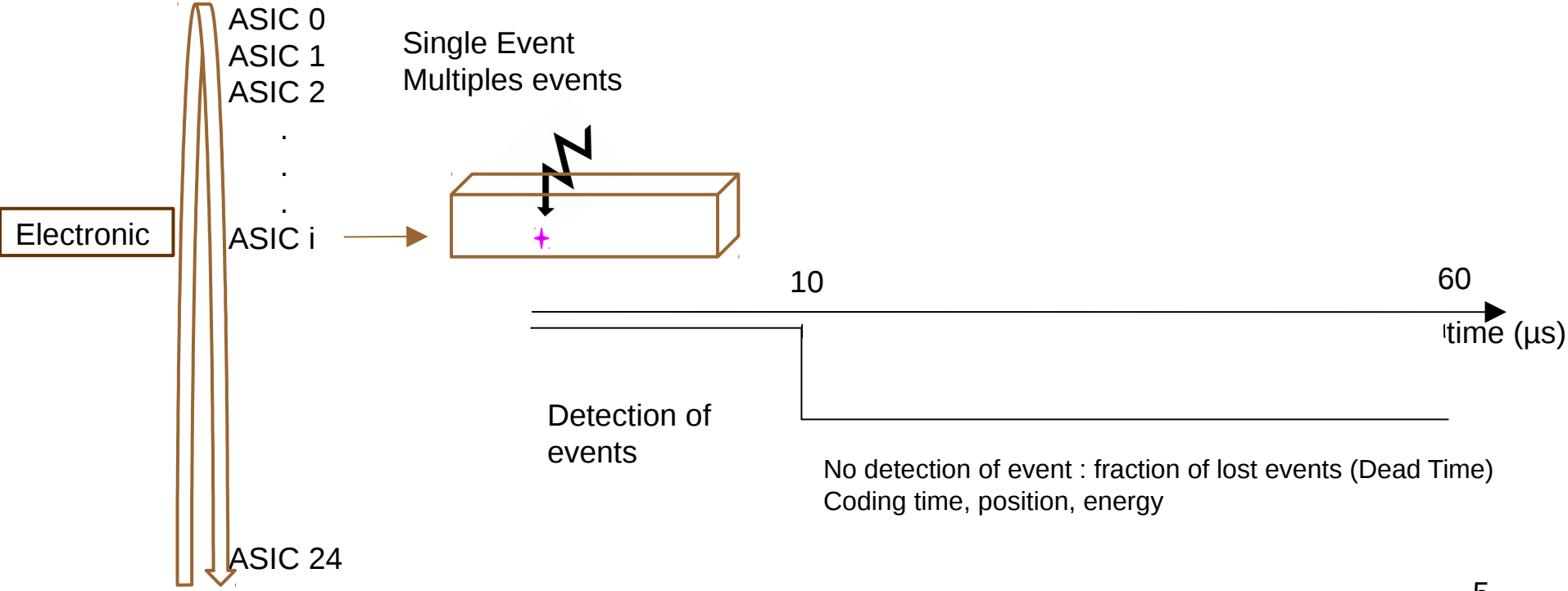




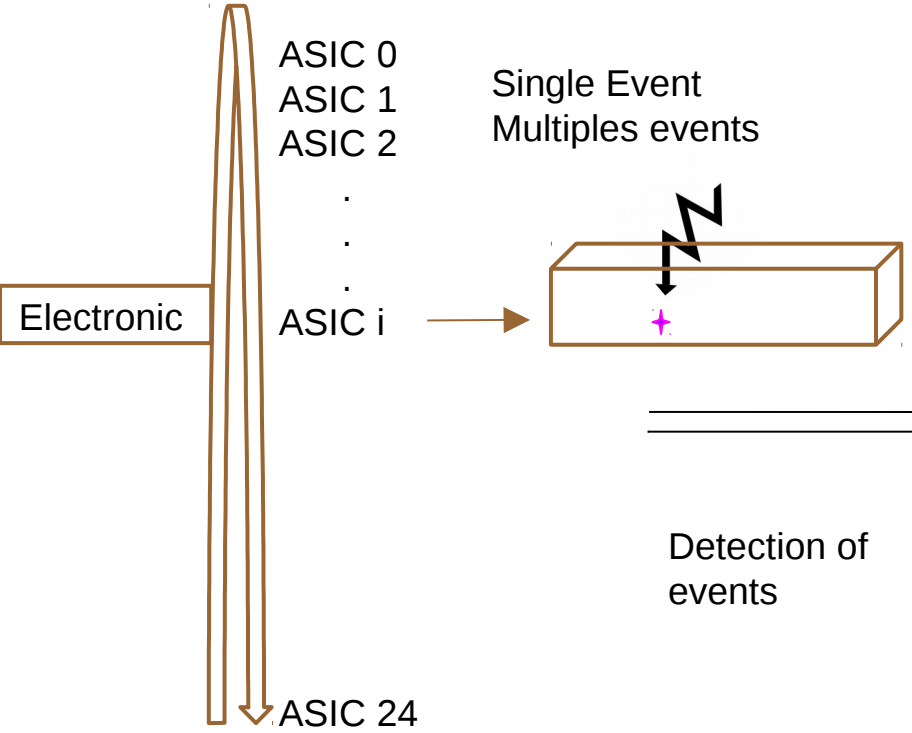
- 6400 pixels
- 4x4x1 mm^3 in CdTe
- 32 pixels per modules
- 25 modules per sector
- 8 independant sectors

- Readout Electronic Sector
- Coding :
  - Time
  - Position
  - Energy
  - Multiplicity
- Computation of the energy onboard
- Detection of events with saturate energy

ECLAIRs presentation - electronic readout operations



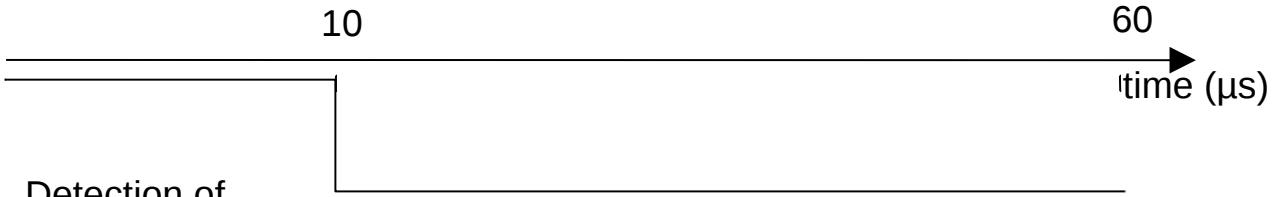
ECLAIRs presentation - electronic readout operations



Single Event
Multiples events

2 Types of Dead Time :

1- Pure Dead time : lost events
2 - Total Dead time : lost events + multiples



Detection of events

No detection of event : fraction of lost events (Dead Time)
Coding time, position, energy

DEAD TIME - Method used

SOFTWARE ANALYSIS

- Use of a code simulating the operation of the electronic chain
- Estimation of dead time for 2 cases
  - 12500 cps/s/ELS
  - 5% of dead time

HARDWARE ANALYSIS

- Test bench
- Input files with random position energies and time
- Analysis output files
- Estimation of the dead time for 2 cases
- Comparison with the software analysis

EXPERIMENTAL PART

- Prototype
- Different sources heights for differents counts rates
- Comparison with previous part

DEAD TIME - Method used

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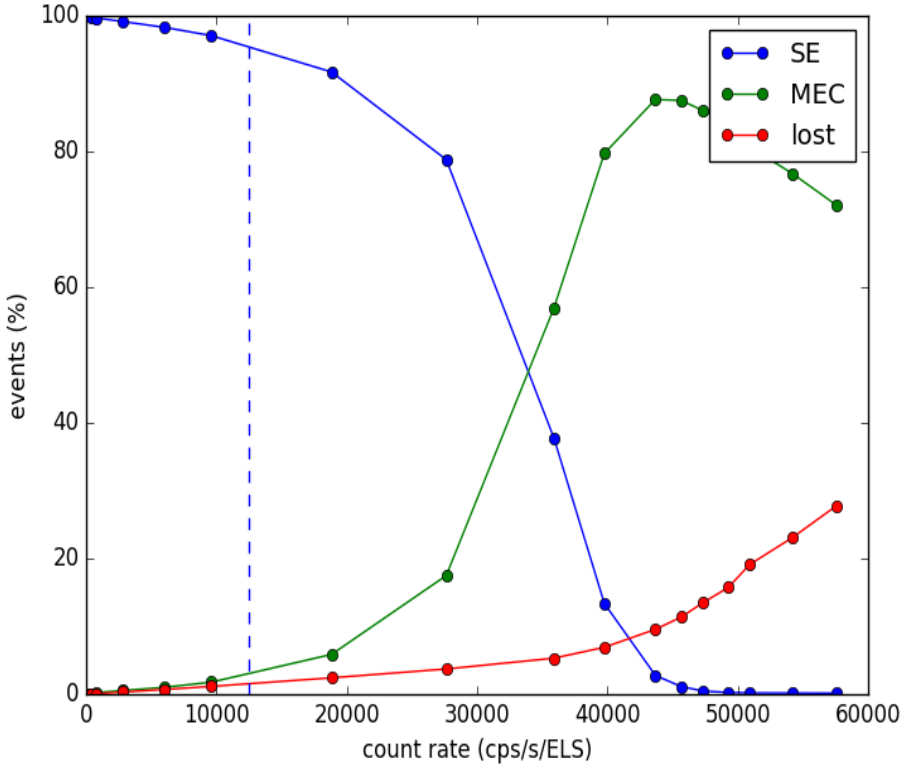
DEAD TIME - Software Analysis



HYPOTHESES

- Input generated automatically
- All events are coded
- 12000 events uniformly distributed over the sector without the mask
- Constant source count rate from 200 to 140000 cps/s/ELS

RESULTS

For 12500 cps/s/ELS :

Pure Dead Time : 1.5%

Total Dead Time : 4.5 %

DEAD TIME - Method used

SOFTWARE ANALYSIS

- Use of a code simulating the operation of the electronic chain
- Estimation of dead time for 2 cases
  - 12500 cps/s/ELS
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HARDWARE ANALYSIS

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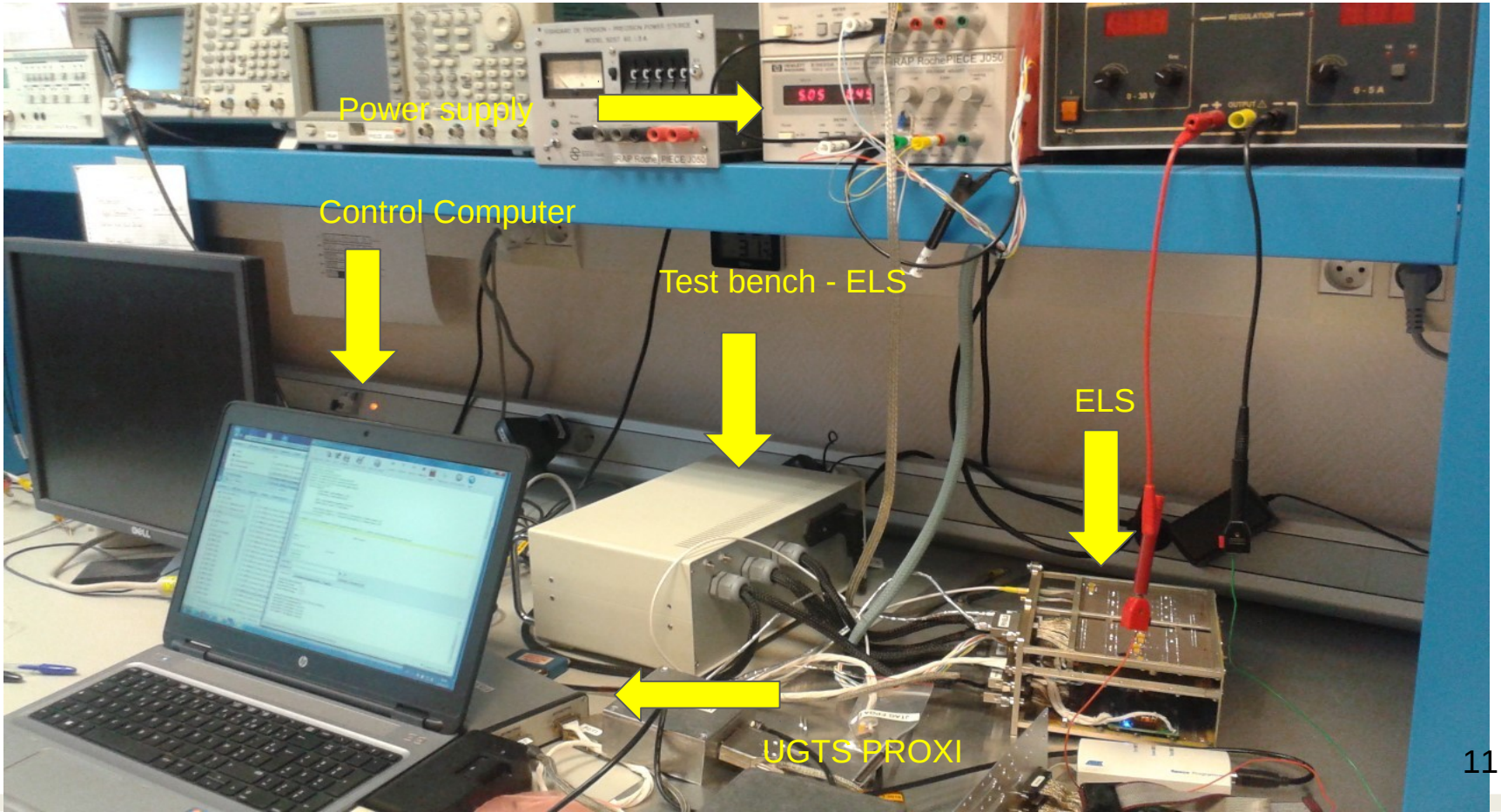
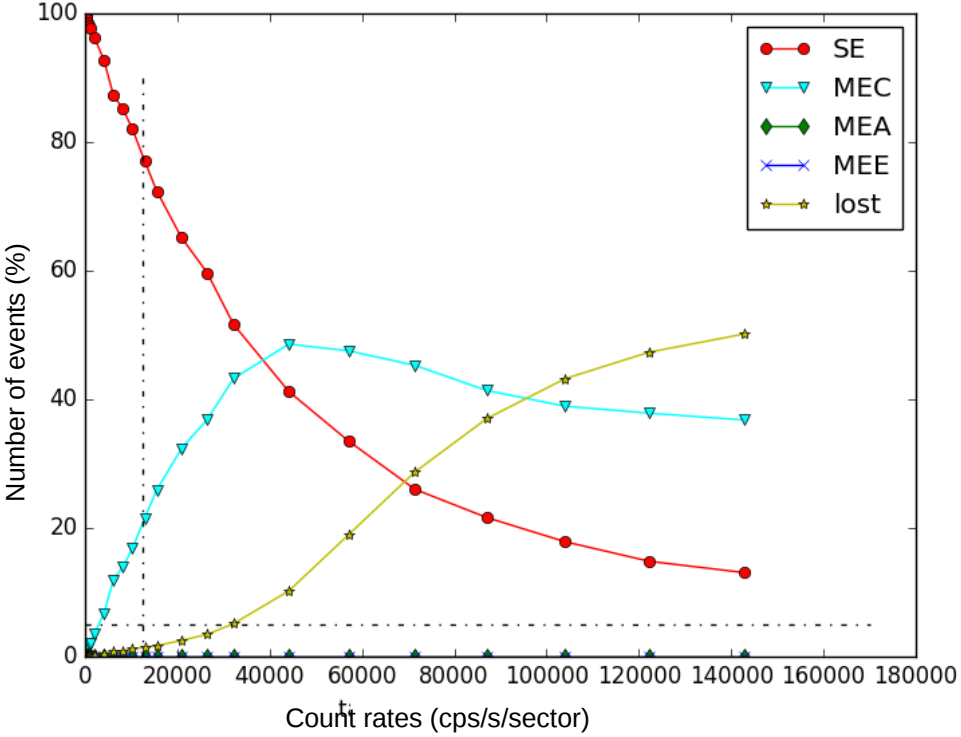
DEAD TIME - Hardware Analysis



DEAD TIME – Hardware analysis



HYPOTHESES

- choice of intputs (Poisson distribution for time)
- All multiples are coded
- 10000 events uniformly distributed over the sector
- differents count rates (200- 140000 cps/s/ELS)

RESULTS

For 12500 cps/s/ELS :

Pure Dead Time : 1.3%

Total Dead Time : 26.7%

DEAD TIME - Method used

SOFTWARE ANALYSIS

- Use of a code simulating the operation of the electronic chain
- Estimation of dead time for 2 cases
  - 12500 cps/s/ELS
  - 5% of dead time

HARDWARE ANALYSIS

- Test bench
- Input files with random position energies and time
- Analysis output files
- Estimation of the dead time for 2 cases
- Comparison with the software analysis

EXPERIMENTAL PART

- Prototype
- Different sources heights for differents counts rates
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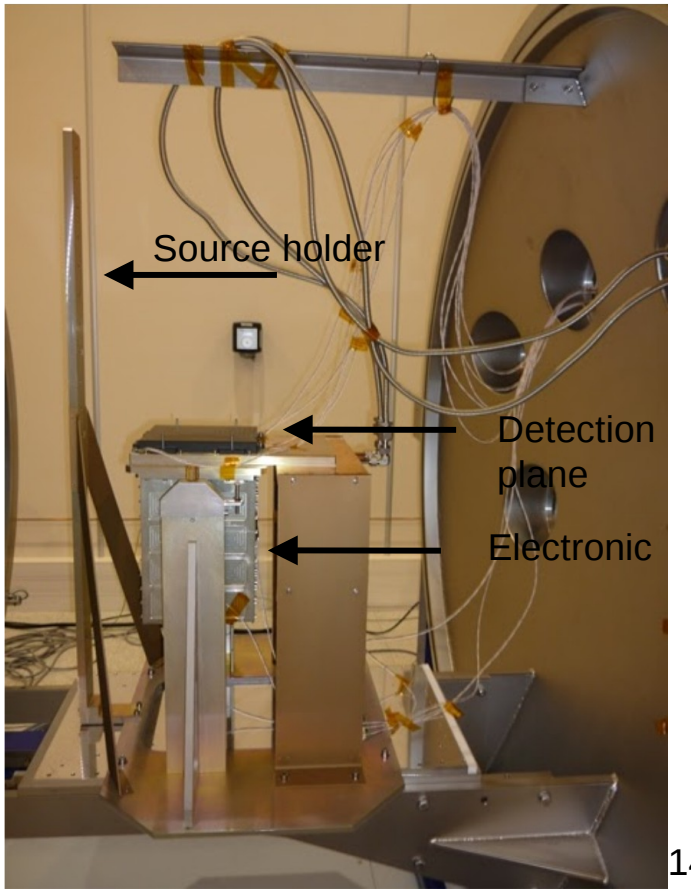
DEAD TIME - Experimental Part

Sources :
^{241}Am : 10-60 keV
^{55}Fe : 6 keV
^{57}Co : 6keV, 122-136keV
^{60}Co : (MeV)



DEAD TIME SYNTHESIS

The Pure dead time corresponds to the scientific requirement
Hardware results under investigation

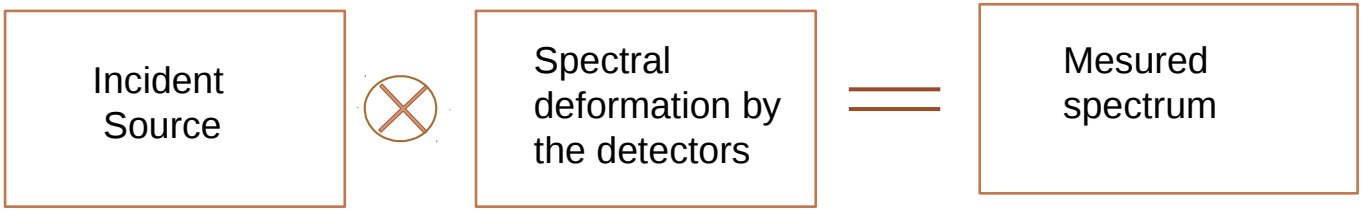
In process :

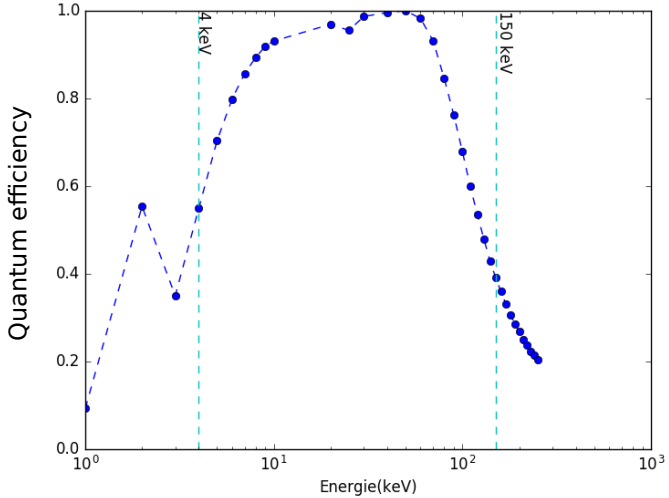
- Application to astrophysical sources
- Impact of the mask shadow on the results
- Experimental part

Bajat et al. In prep (sept. 2017)

Spectral response

- Spectral response : energies redistribution
- the detector on the incident spectrum stamp

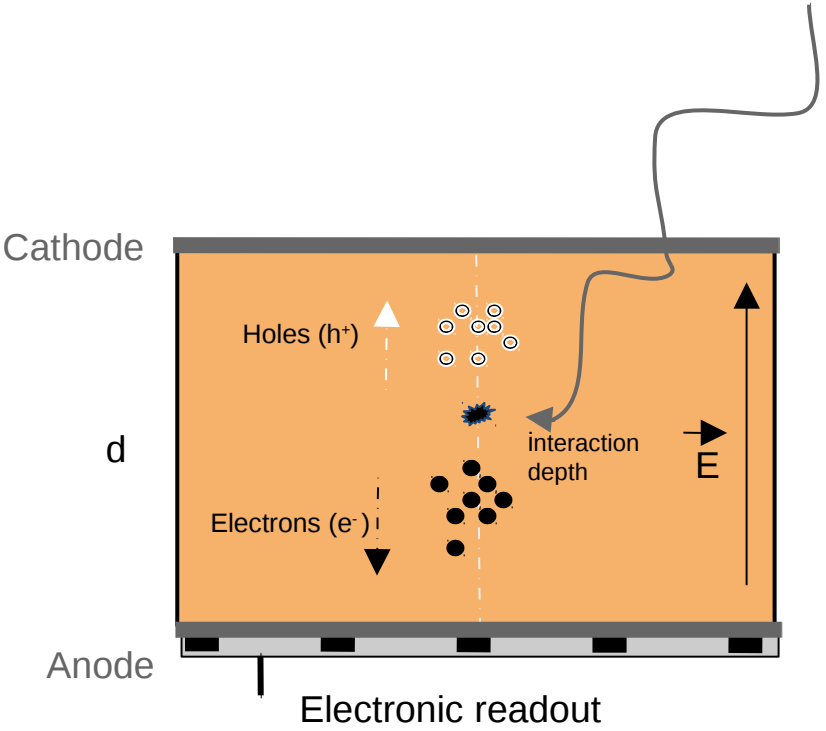




REDISTRIBUTION OF ENERGIES

- Charge collection
- Noise
- Physics process
- ...

Detection plane response - Principle of detection

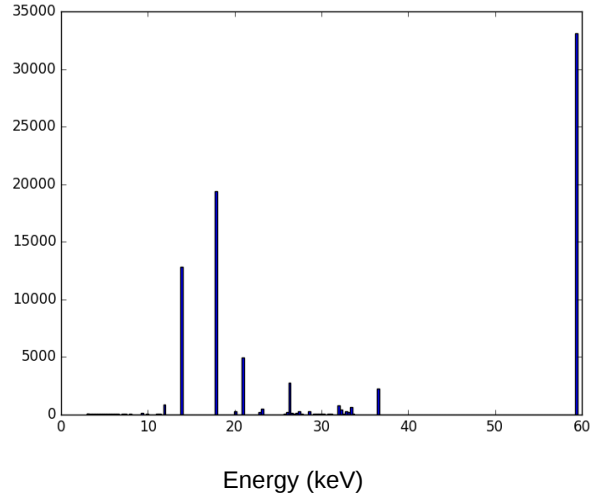


- Incomplete charge collection
- $\mu\tau_e$ and $\mu\tau_h$ with μ the mobility and τ time life for electrons and hole

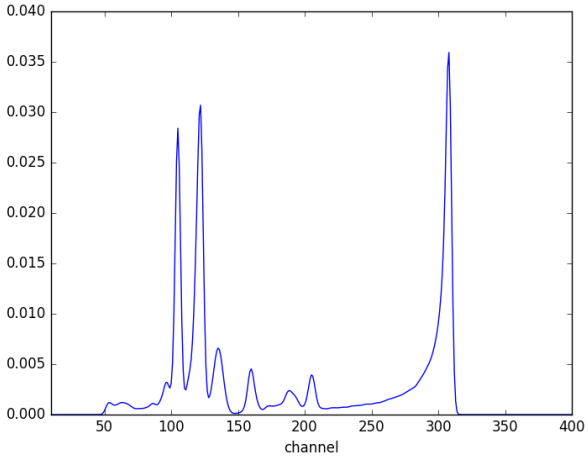
METHOD

- Physical model for the energy reconstruction
- Calibration
- Table of parameters

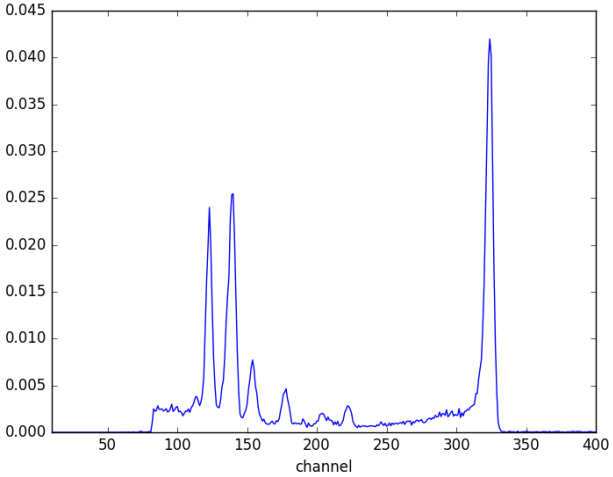
Spectral response : Model



GEANT4 Model



Spectral Model

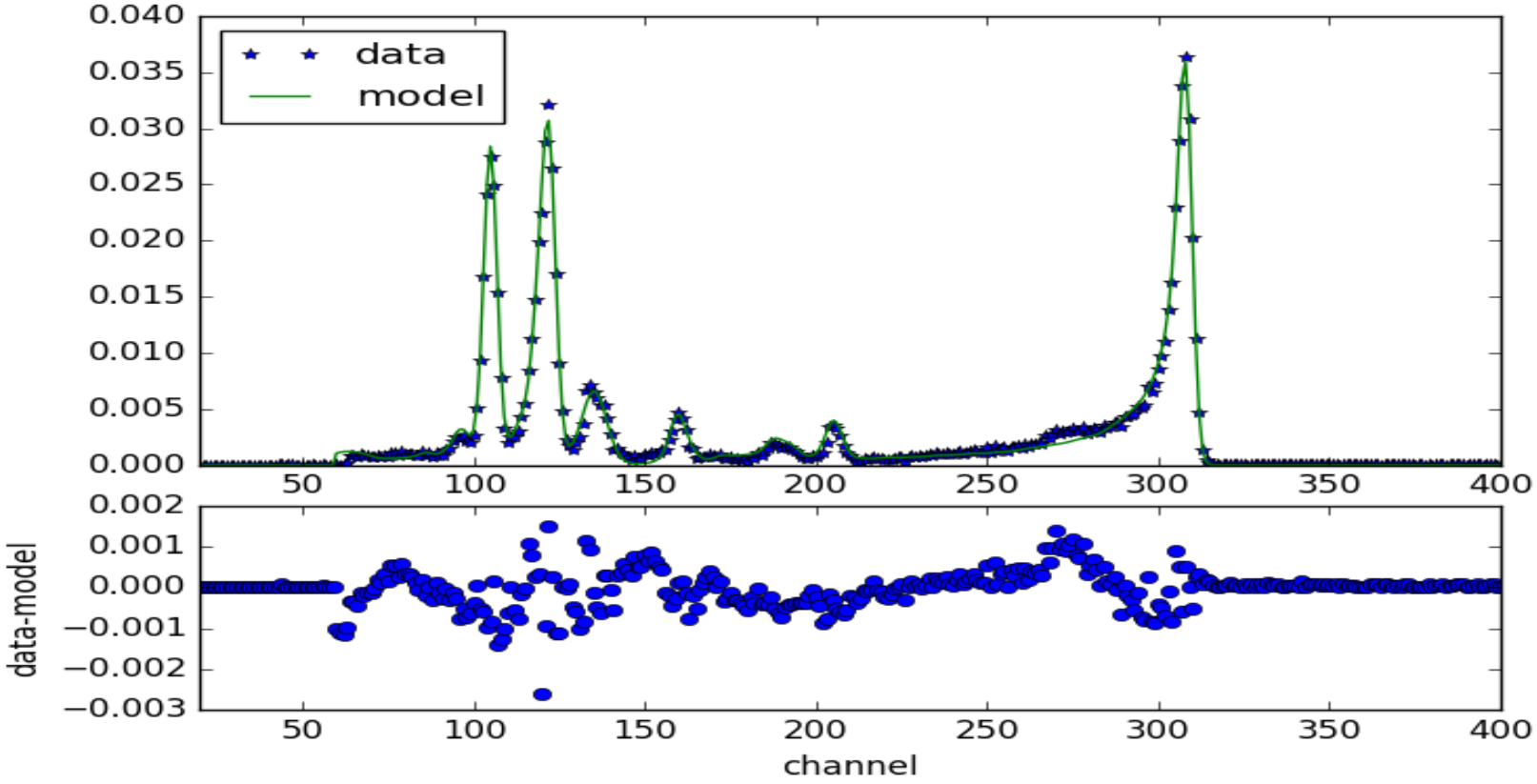


Experimental Model

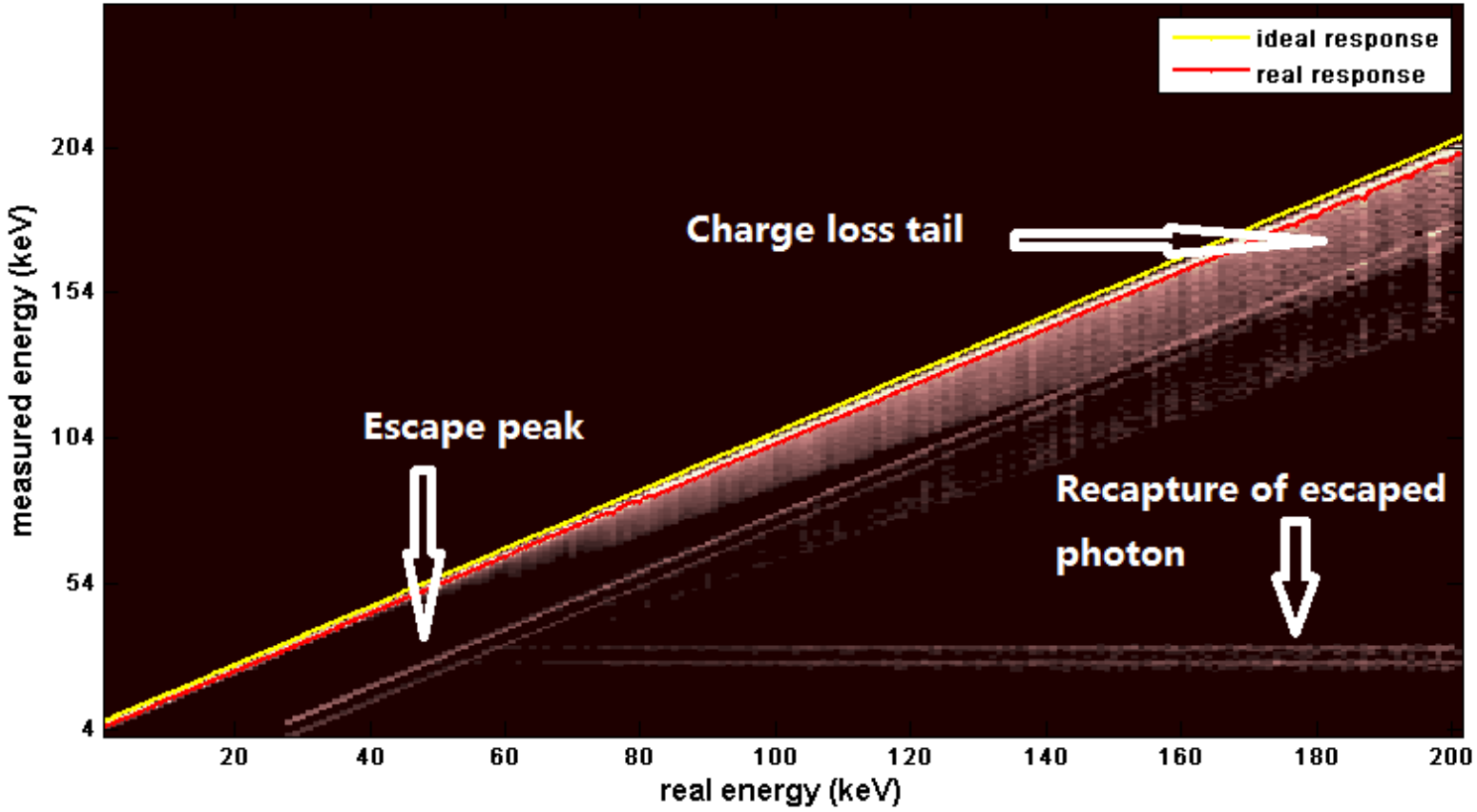
ECLAIRs detection plane response - First Results

^{241}Am

Temp = -20°C



ECLAIRs detection plane response



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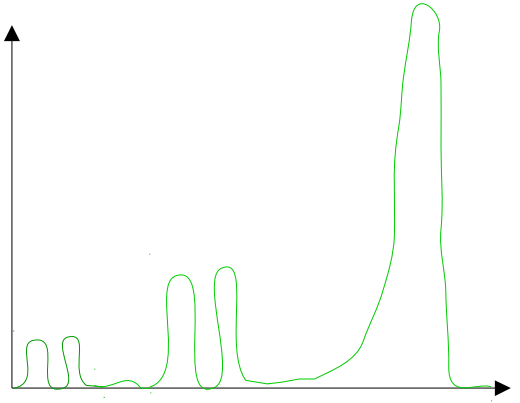

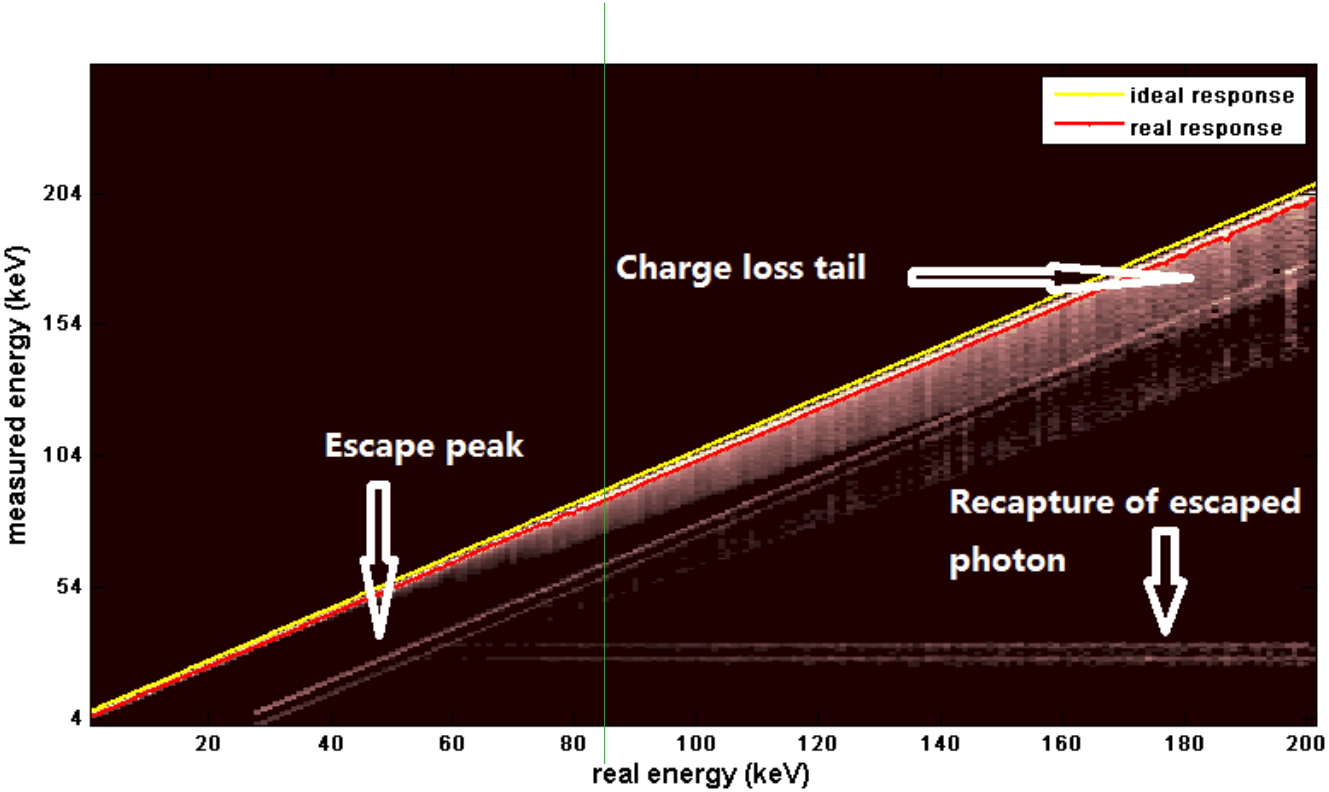

ECLAIRs detection plane response - Synthesis

Improvement of the response model
First study of statistics parameters

In process :

- Geant4 Model with the environment of the prototype
- Calibration with the Prototype data : extraction of parameters for all detectors
- Incidence angle Impact
- Application to astrophysics sources