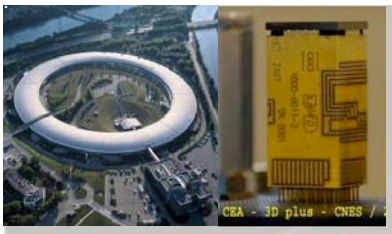
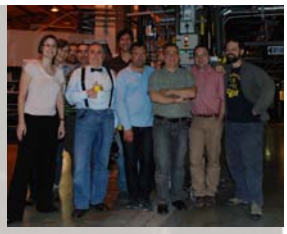


LaPolCaliste

Polarisation Performance of the CdTe/CZT Caliste Detector Modules



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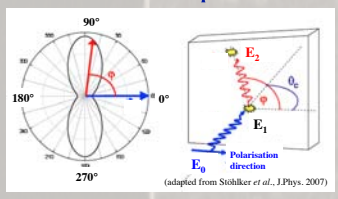
Scientific Drivers and Rationale

Polarimetric measurements in X and hard X-rays offer a powerful diagnostic to identify the emission mechanisms at play in astrophysical sources, as e.g. synchrotron in comparison with thermal processes, as well as the geometry of systems for which the hard X-ray emission is due to reflection of photons from a primary source, as e.g. accretion disks in binary systems or the molecular clouds in the Galactic Centre.

However very few astrophysical measurements have been performed so far due to the lack of efficient space instrumentation. We are exploring here the use of pixellated CdTe/CZT detectors, space qualified and with extremely good spectro-imaging performance, for polarisation measurements via Compton interaction.

Measurement principle

Measure the azimuthal angle distribution of the diffused photon in a Compton interaction. For a 100 % polarised incident radiation, this is given by :



(adapted from Stöhlker *et al.*, J.Phys. 2007)

$$\frac{d\sigma}{d\Omega} \propto \left(\frac{E_2}{E_0}\right)^2 \left(\frac{E_2}{E_0} + \frac{E_0}{E_2} - 2\sin^2\theta\cos^2\varphi\right)$$

$$with \;\; E_2 = \frac{E_0}{1 + \frac{E_0}{m_e c^2}(1-\cos\theta)}$$

$$and \;\; E_0 = E_1 + E_2$$

The two interactions, depositing E_1 and E_2, are measured in the same crystal, oriented at θ = 90° from the beam direction.

Data analysis

- **Energy calibration of each pixel (data from a detector scan with the beam)**
- **Selection of Compton events very close to 90° scattering (θ), from the energy E_2 (E_2 from 139 to 148 keV for the 200 keV beam)**
- **Measurement of the angular distribution from the image of selected events, in sectors as defined in figure below.**
- **Fit of the data with the theoretical distribution, with parameters being the polarisation fraction and the polarisation angle w.r.t. the Caliste axis.**

At this stage only the 200 keV runs with the CdTe crystal have been analysed.

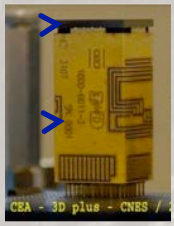
Caliste Module

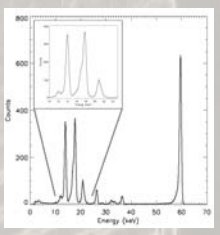
Each detector is made of a single, 1 cm², pixellated crystal with its front end electronics hybridized, forming a Caliste module

- **2 crystals have been used: 1 mm thick CdTe Schottky & 2 mm thick CdZnTe**
- **Each crystal has 16 × 16 pixels with 580 µm pitch (pixel area of 0.336 mm²)**

Crystal

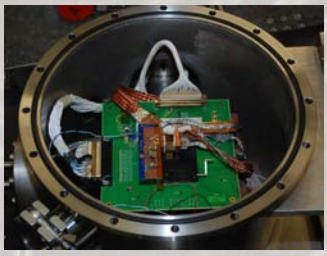
Front End Electronics 8 vertical ASICS in the module





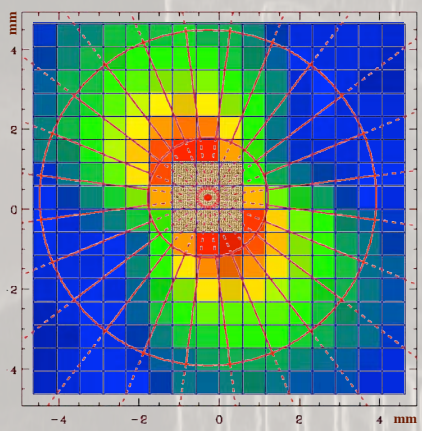
Spectral resolution 0.85 keV @ 60 keV

Set up and beams at ESRF line ID15



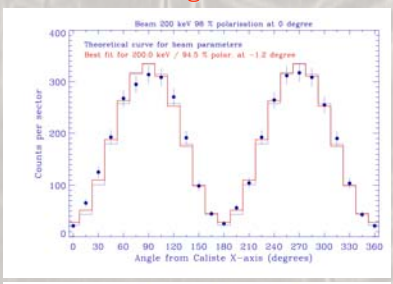
- **Data taken from May 11 to 16, 2011**
- **Energies 200 keV & 300 keV – Sub-pixel beam size (<~ 100 µm)**
- **Polarisation from 80 to 98 %, detector angles from 0 to 30° relatively to the beam polarisation direction**

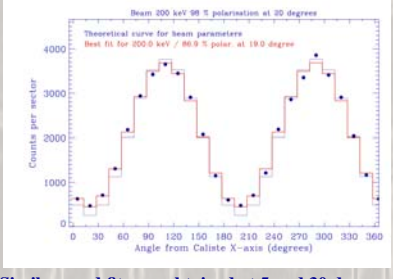
Compton photons distribution



CdTe detector, 200 keV with 98 % polarisation at 30°. The image (centre part excluded) shows the number of energy selected events per pixel (from 1 to 2579). The x and y scales are mm from the crystal centre. The 15° wide sector definition is superimposed. Only events located between 1.5 and 4 mm (full circles) are counted in the angular distribution measurement (as in the examples on the right panels)

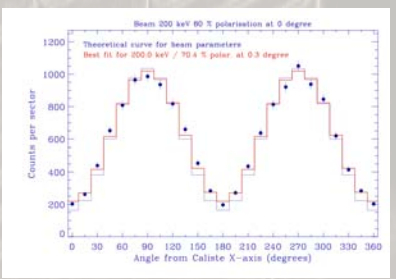
Polarisation angle measurement

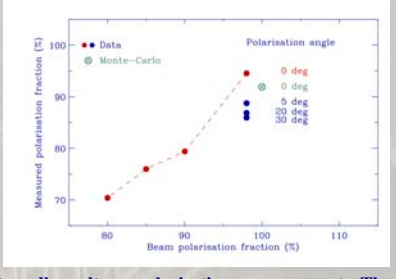




Similar good fits are obtained at 5 and 30 degrees with best fits of 88.8 % polarisation at 4.6° and 86.0 % at 28.6° respectively

Polarisation fraction measurement





Overall results on polarisation measurements. They are fully consistent with Monte-Carlo simulations in the same geometry at this stage of analysis.