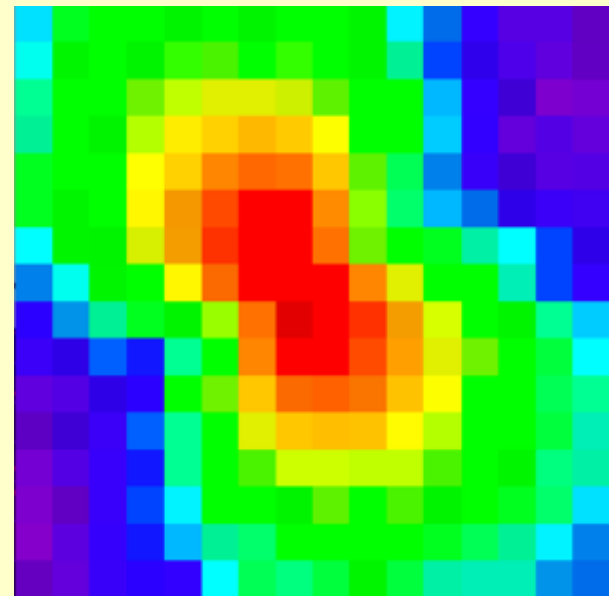
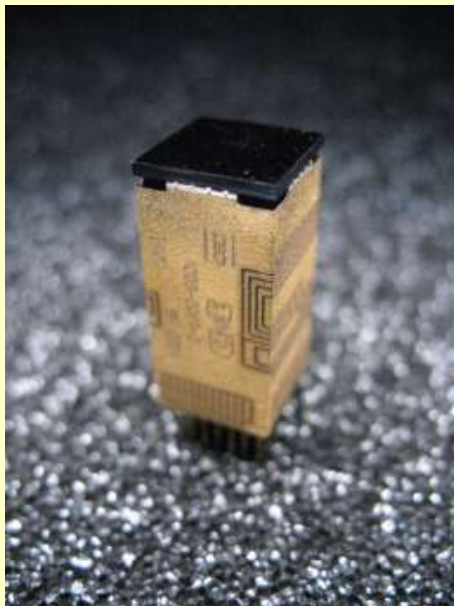


FINE PITCH CDTE-BASED HARD-X-RAY POLARIMETER PERFORMANCE FOR SPACE SCIENCE

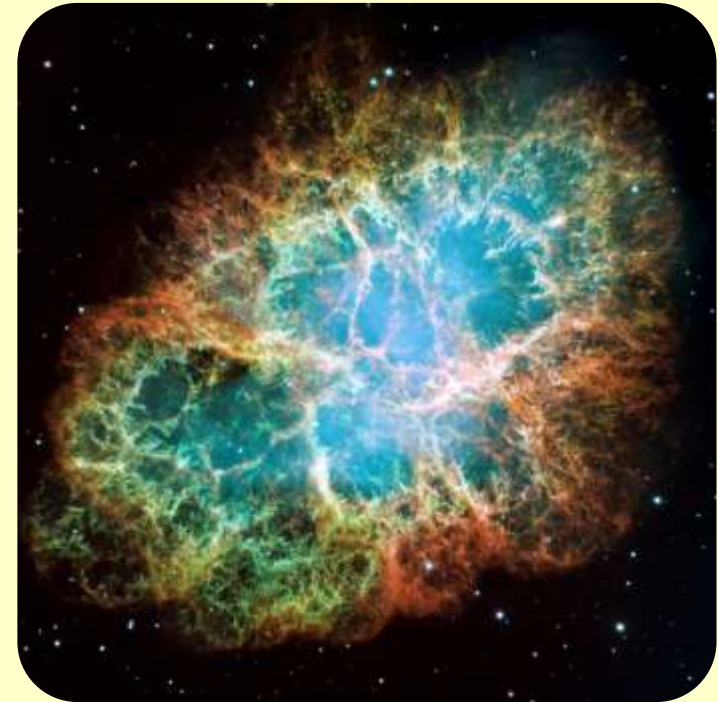
Sarah Antier – Philippe Ferrando – Olivier Limousin – Ezio Caroli – Rui Curado Silva



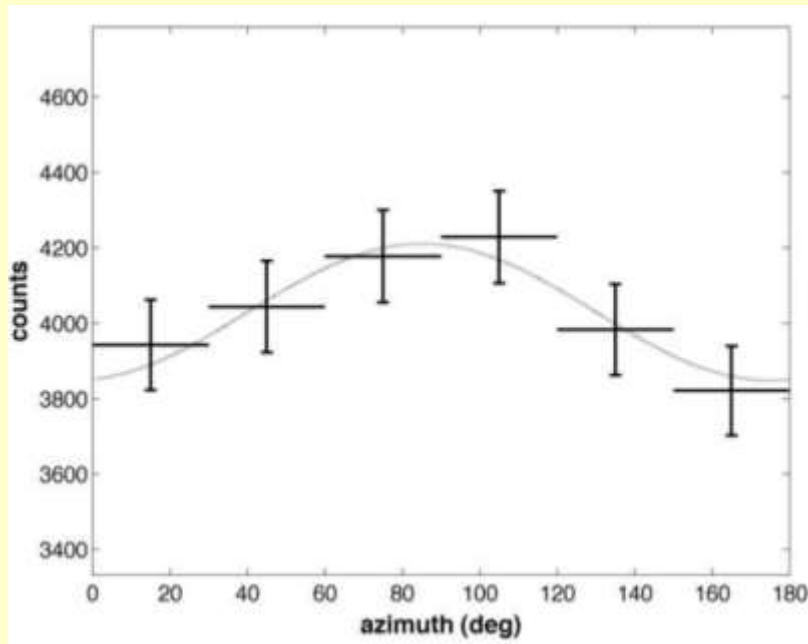
Raise of the X-ray astronomy: 20th
With satellites
With specific technology
and methods

X-ray sources Polarization benefits:

- Emission mechanisms
- Emission region geometry
- Structure of the magnetic field



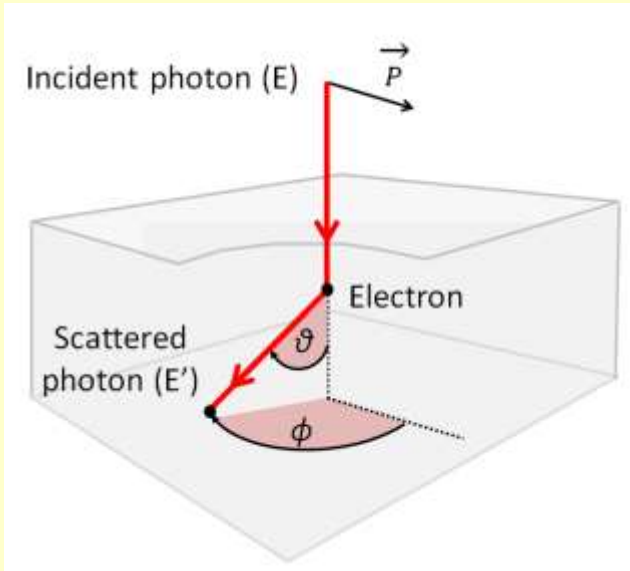
With SPI and Ibis on INTEGRAL, First measurement of polarization of the Crab pulsar [Forot et al.2008]



Selection energies: [200- 800 keV]
Angle of pol. = $122.0^\circ \pm 7.7$
Degree of pol.= $46 \% \pm 10 \%$

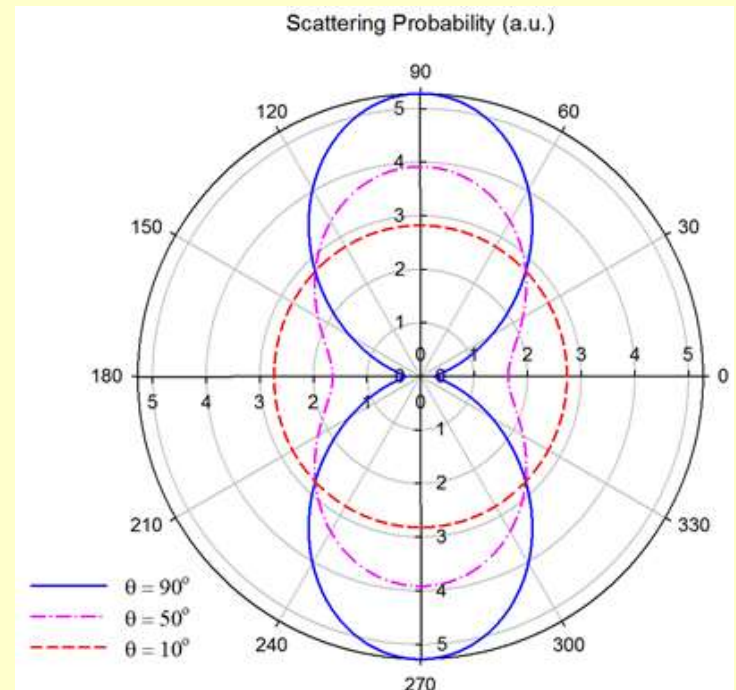
Lack of efficient X-ray space instrumentation
dedicated to polarization

MEASUREMENT OF POLARIZATION IN X-RAY ASTRONOMY



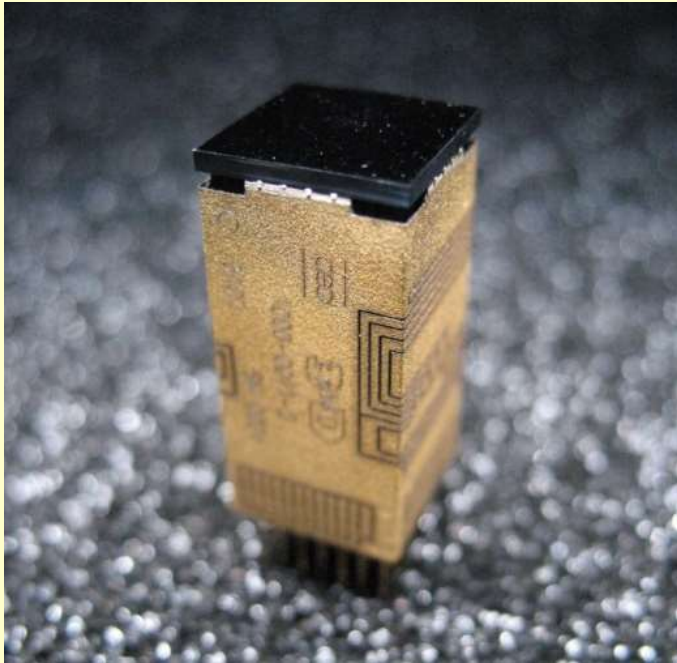
Polarization measured with Compton properties
Azimuthal distribution of the scattered photons

90° scattering angle
max. Polarization information



Detector design:
Small pixel size
Multiple event detection
Excellent energy resolution

Our proposal: Polarization with Caliste Technology CdTe base fine pitch imaging spectrometers by CEA-Irfu



Caliste 256

Especially designed for space mission
CdTe

16 x 16 pixels

1 cm x 1cm

580 μ m x 580 μ m

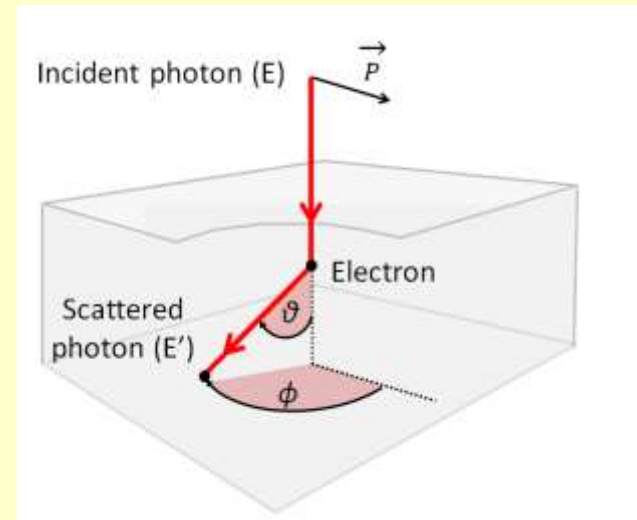
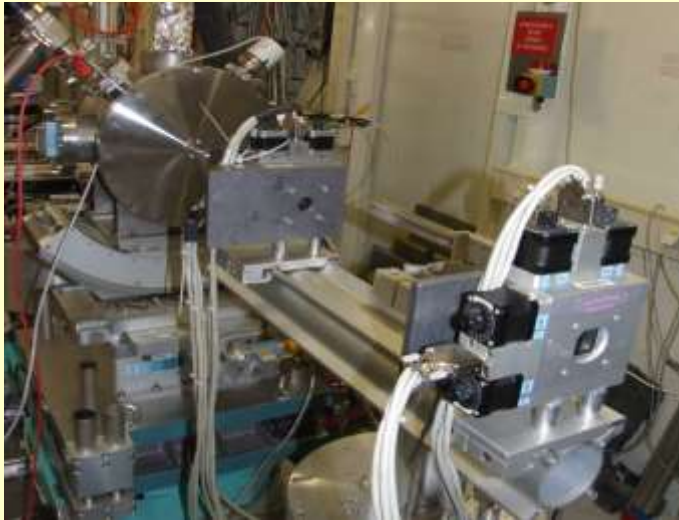
0.85 keV resolution at 60 keV

Range: 2 - 250 keV

Multiple events

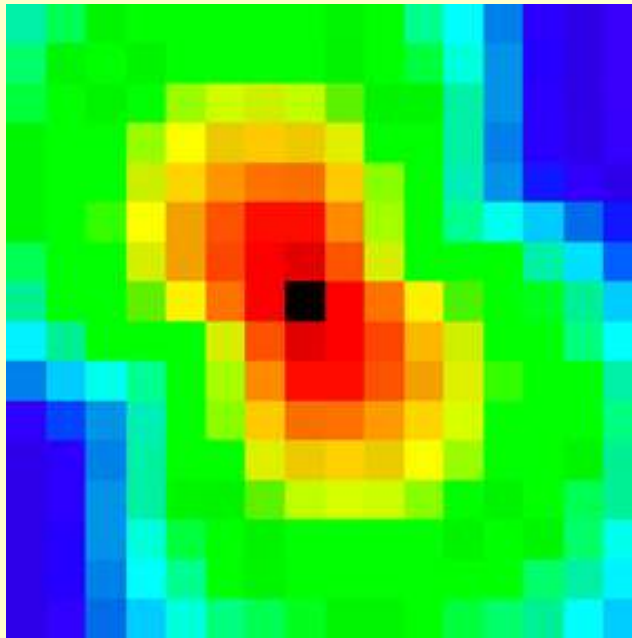
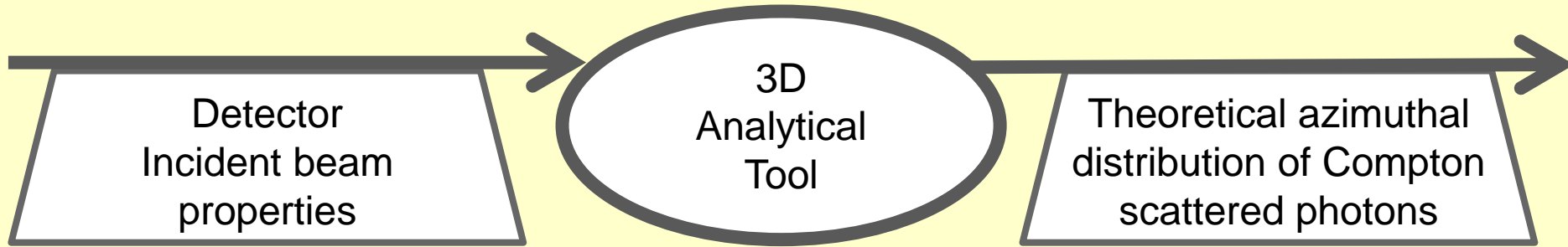
- Experimental set-up**
- Simulation tool**
- Polarization measurement procedure**
- Caliste Polarization Performances**

EXPERIMENTAL SET UP AT ESRF

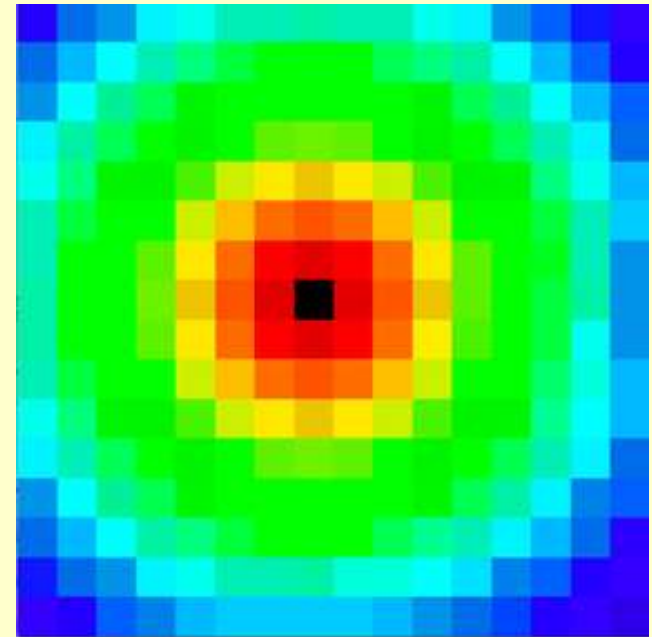


Type of detector	CdTe	CZT
Thickness (mm)	1	2
Trigger configuration	Optimized for double events	
Incident beam Energy (keV)	69.5 (scan)-200-300	
Degree of polarisation (%)	80-85-88-89-90-98	
Angle of polarisation (°)	0-5-10-20-30	

SIMULATIONS: CALCULATION OF EXPECTED PERFORMANCES OF A DETECTOR IN A SPECIFIC ENERGY RANGE



100 % linearly polarized beam with $\Phi = 30^\circ$
 (200 keV)

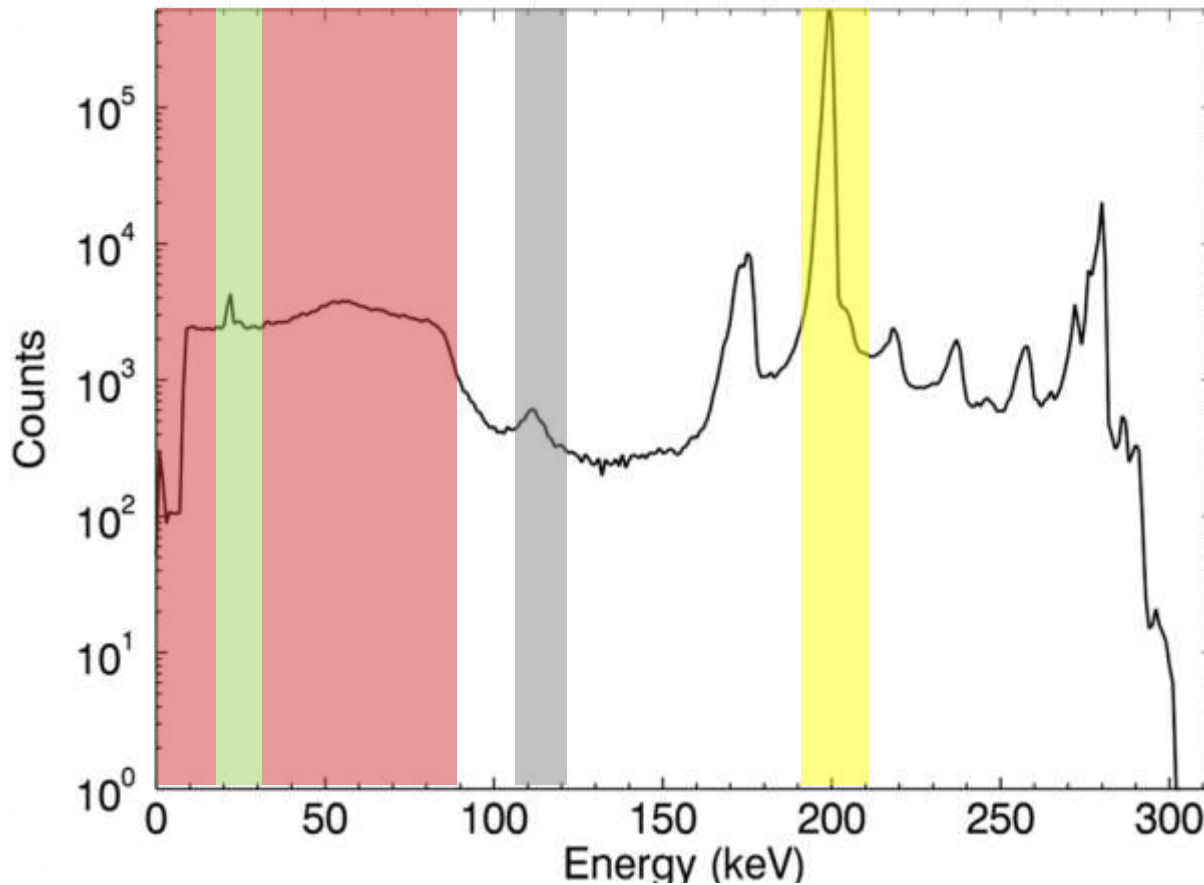


un-polarized photon beam
 (200 keV)

POLARIZATION PARAMETERS METHOD: DATA SPECTROSCOPIC ANALYSIS

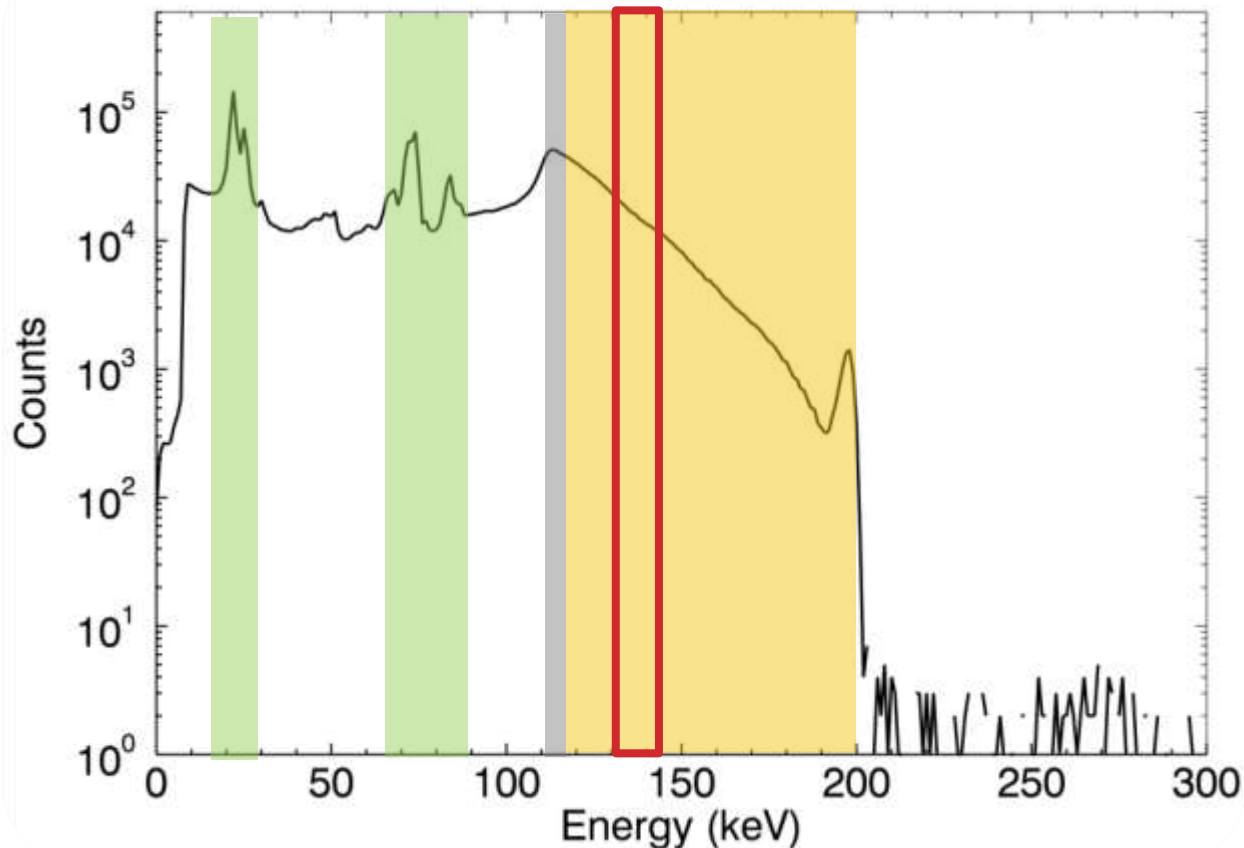
Spectrum of the central pixel
200 keV

Selection Energy
90° scattering angle



Spectrum of the pixels around

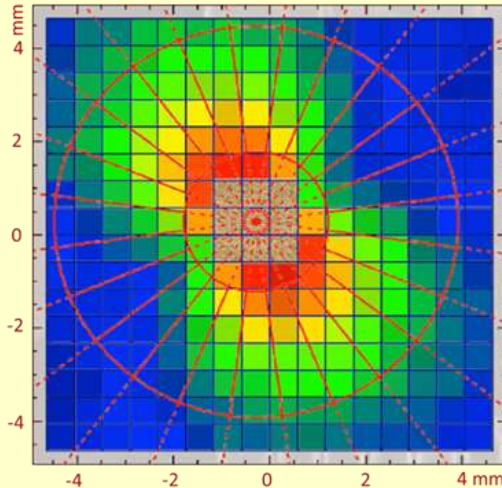
Selection Energy
90° scattering angle



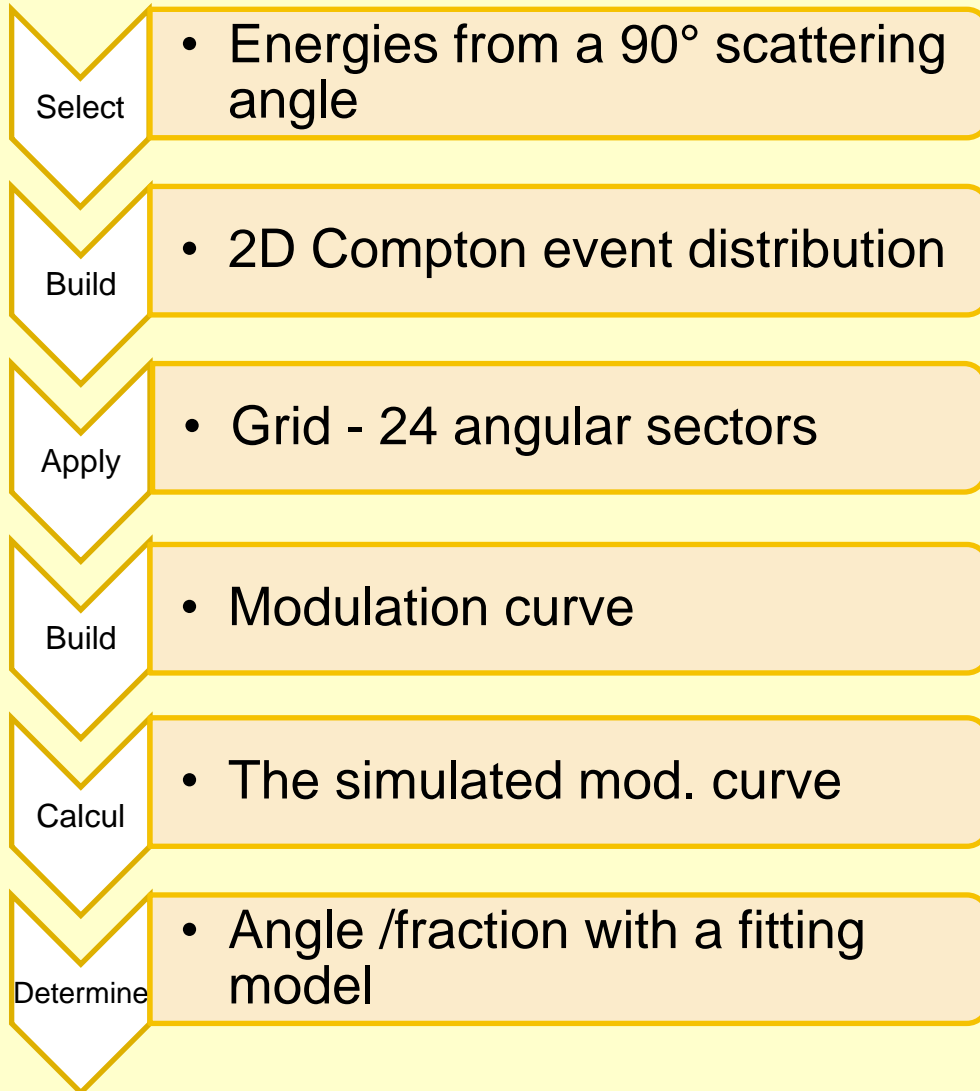
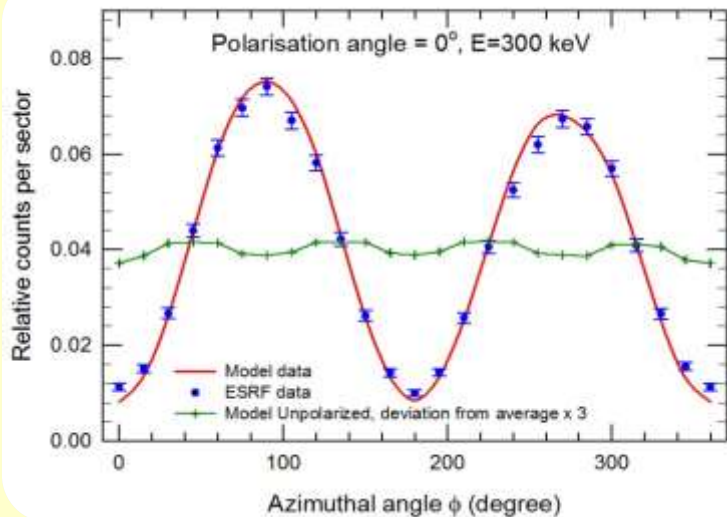
POLARIZATION PARAMETERS MEASUREMENTS PROCEDURE

200 keV photon beam, 98 % polarized, $\phi = 30^\circ$.

REAL DATA



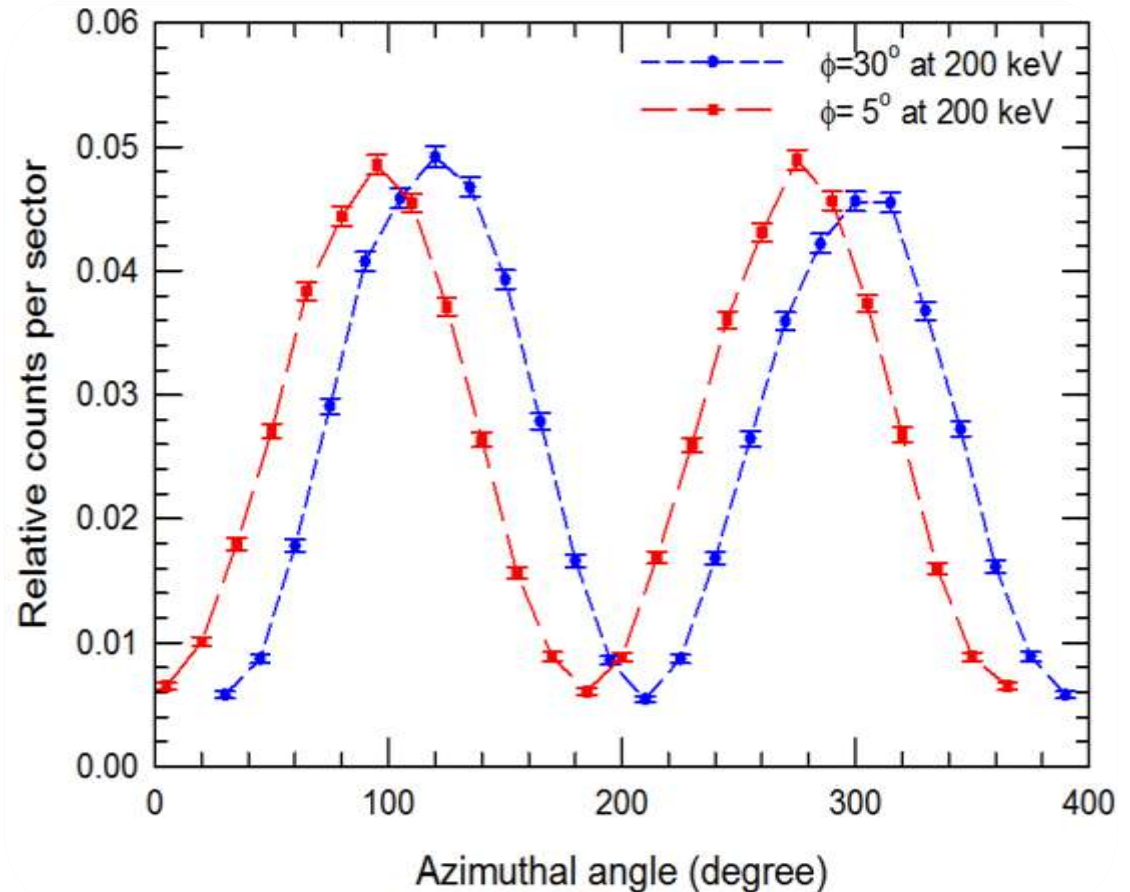
$$Q = \frac{Max - Min}{Max + Min}$$



RESULTS HIGH ENERGY: Q FACTOR

1. 200-300 keV beam
2. CZT and CdTe
3. [80%-98%] fraction of polarization
4. [0-30°] angle of polarization

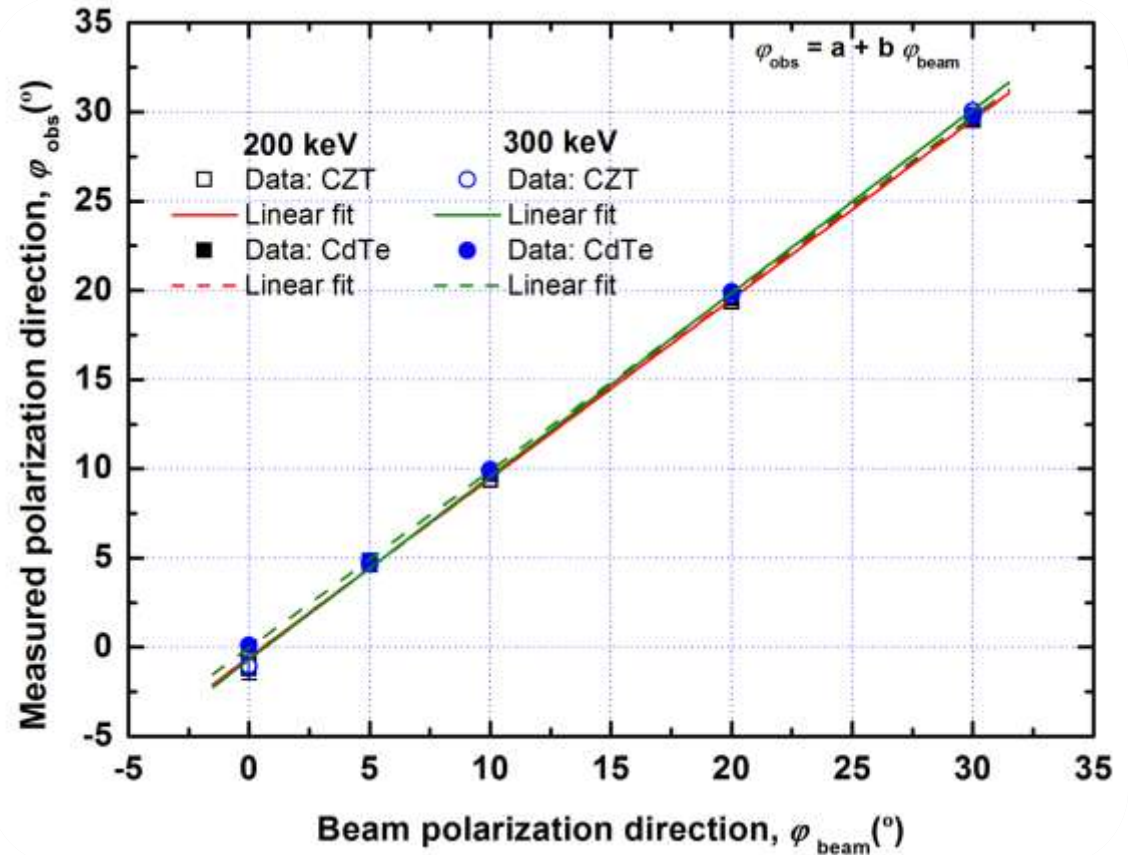
Caliste
Q factor = 0.75



RESULTS HIGH ENERGY: ANGLE OF POLARIZATION

1. 200-300 keV beam
2. CZT and CdTe
3. [80%-98%] fraction of polarization
4. [0-30°] angle of polarization

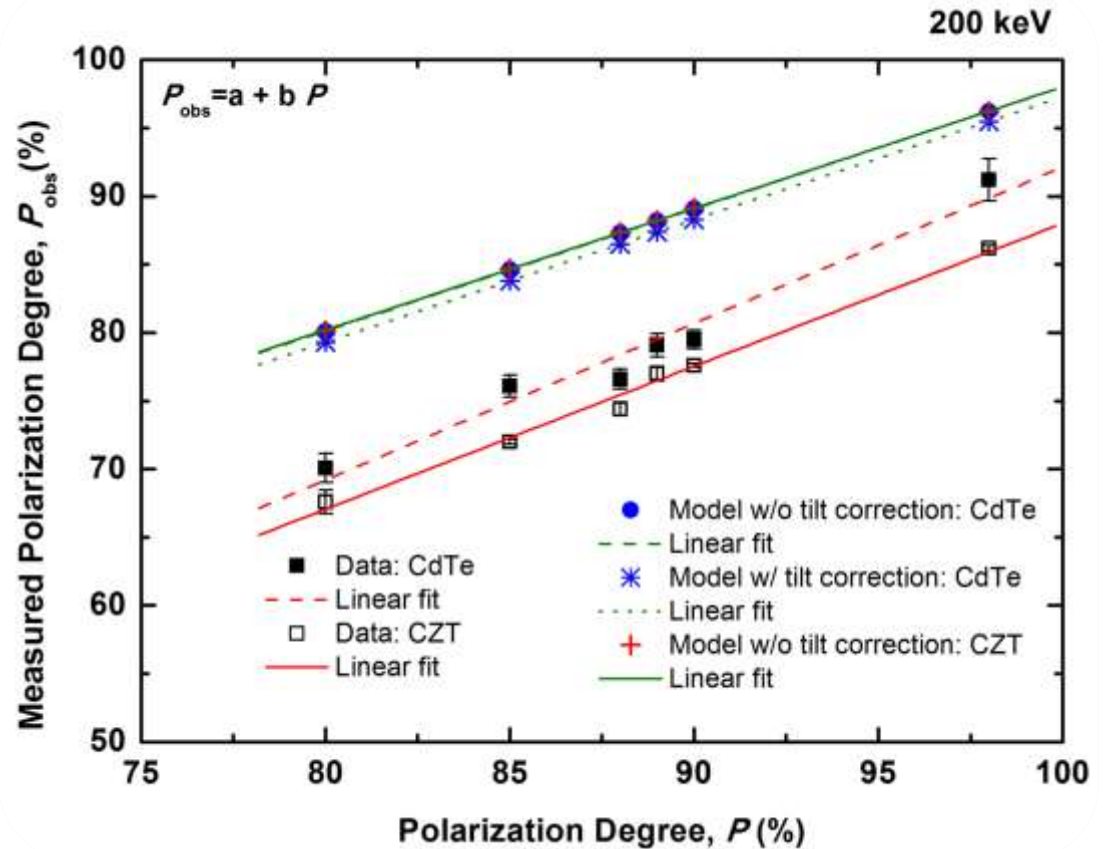
**Caliste Direction
Precision < 1°**



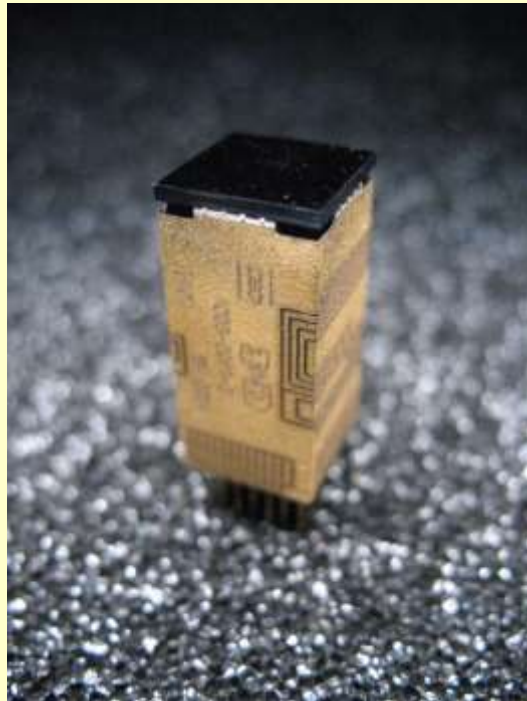
RESULTS HIGH ENERGY: DEGREE OF POLARIZATION

1. 200-300 keV beam
2. CZT and CdTe
3. [80%-98%] fraction of polarization
4. [0-30°] angle of polarization

Caliste Degree Accuracy < 5%



Calise 256 Polarization Performances (Energies > 150 keV):



$Q = 0.75$

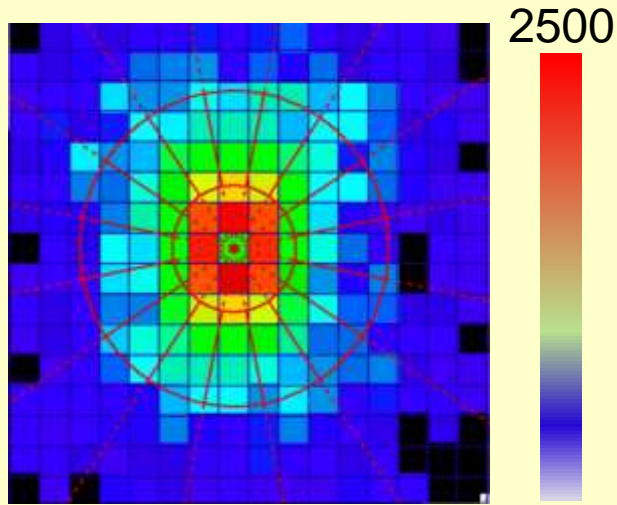
Angle Accuracy $< 1^\circ$

Degree Accuracy $< 5\%$

**POLARIZATION
PERFORMANCE
IN SPACE ?**



CALISTE RESULTS LOW ENERGY

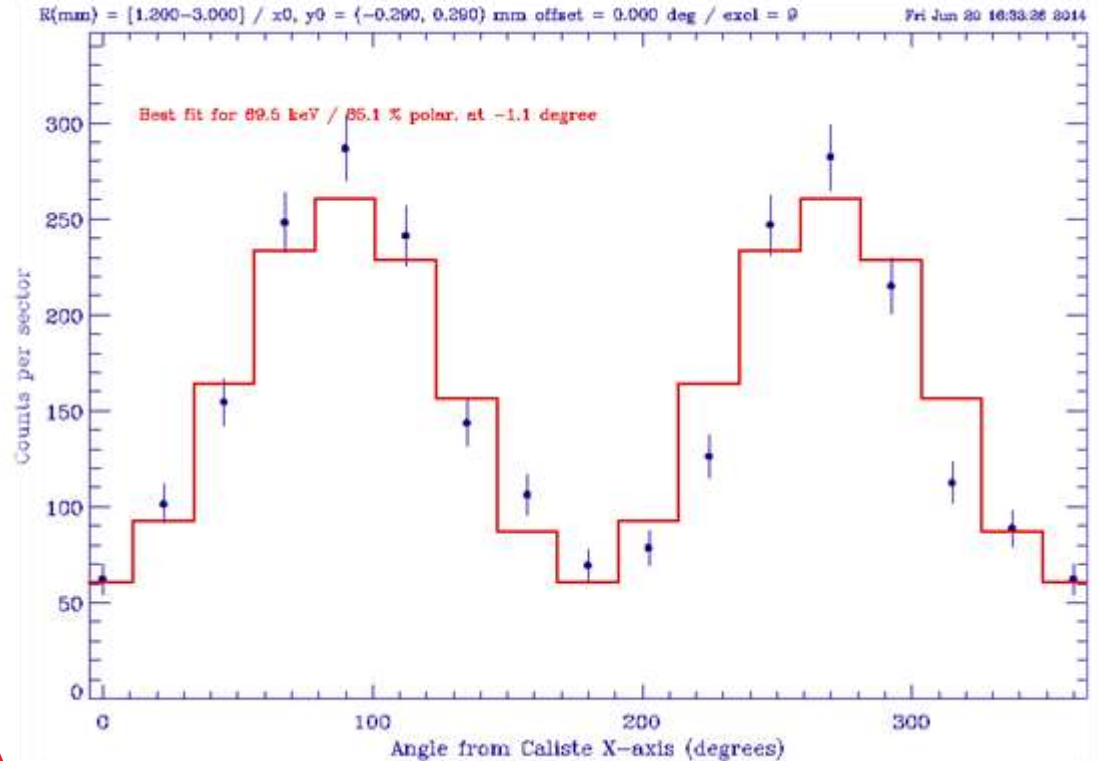


Total = 38 00 events

11

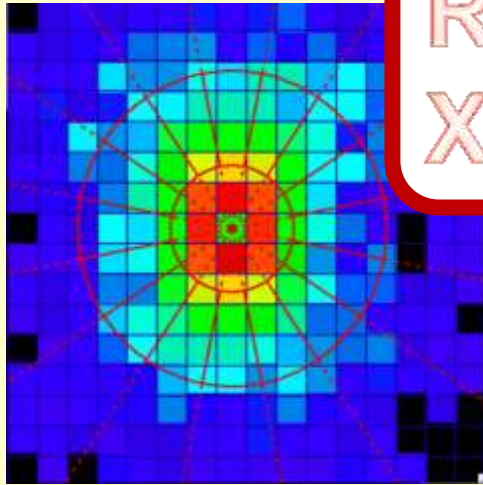
$Q=0.64 \pm 0.04$
Error degree < 15%
Error angle < 1°

69.5 keV



CALISTE RESULTS LOW ENERGY

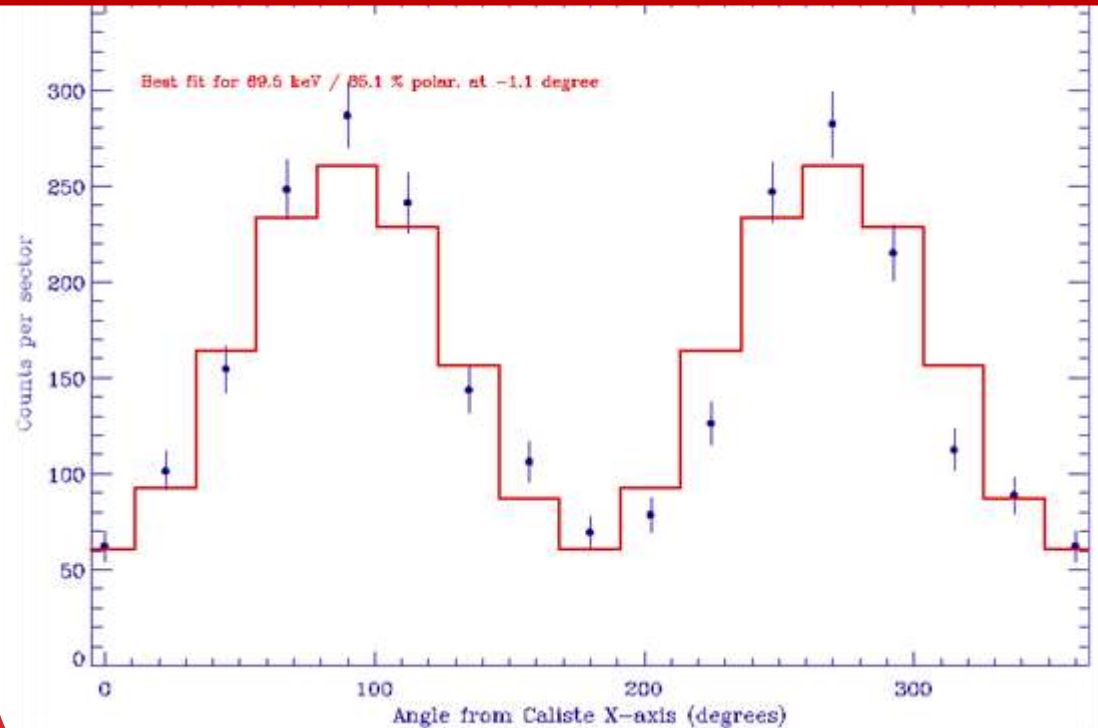
Results in adequation with X-ray focusing optics

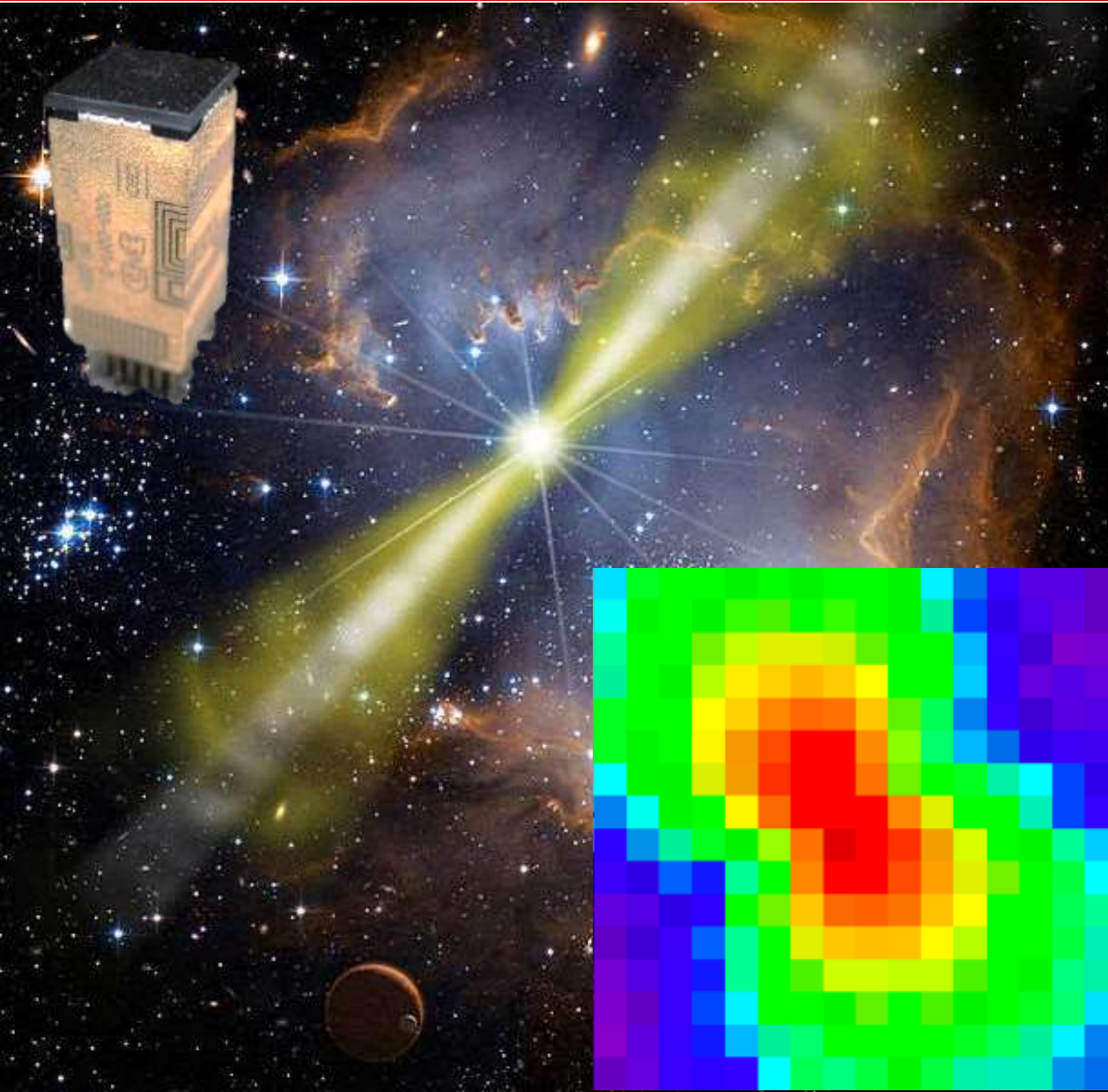


11

Total = 38 00 events

$Q=0.64 \pm 0.04$
Error degree < 15%
Error angle < 1°





Aknowledgements

P.Ferrando
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