

PoGOLite: a hard X-ray polarimeter

Elena Moretti KTH (OKC post-doc)
On behalf of the PoGOLite collaboration

The Protagonists:



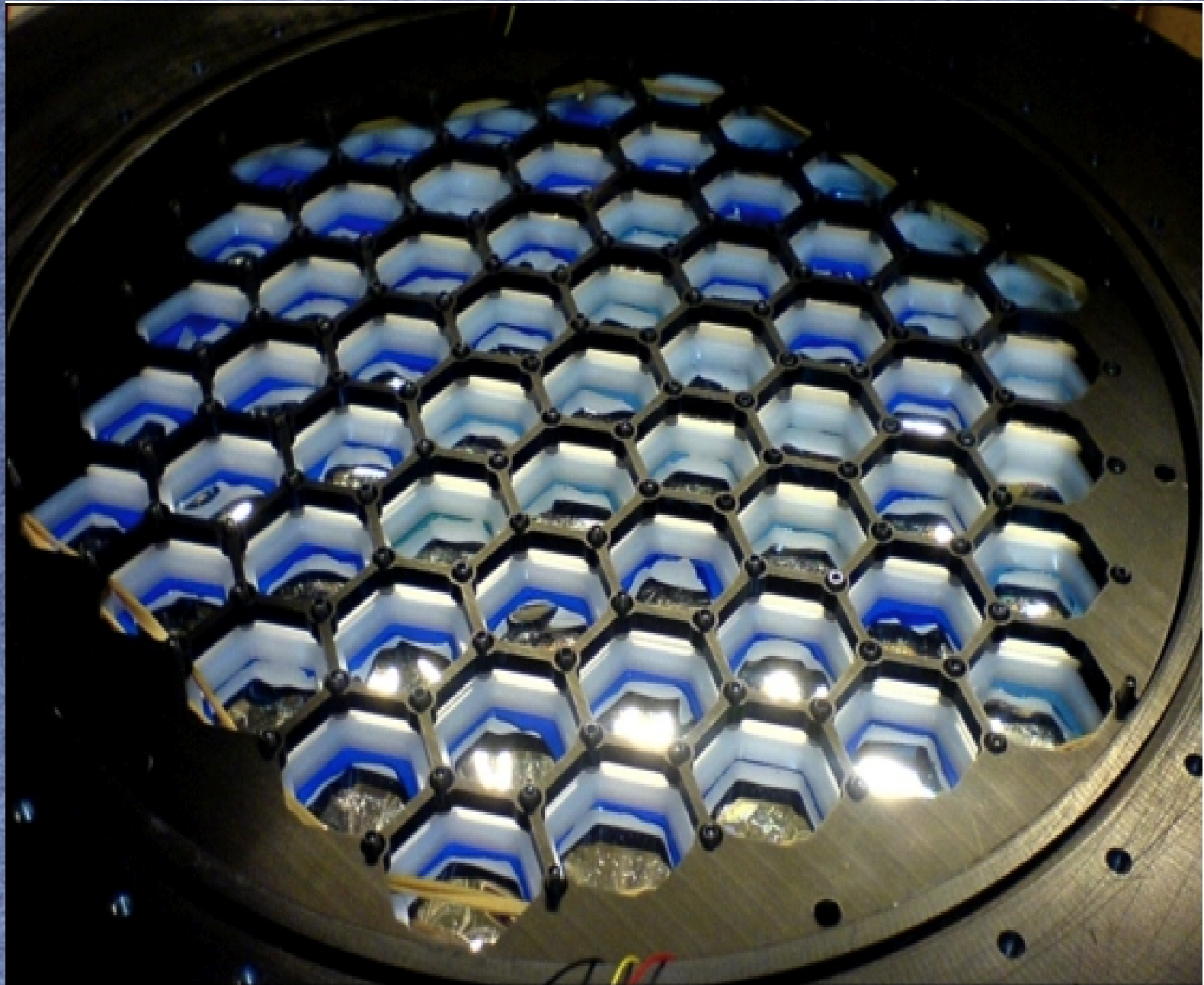
The collaboration:

- PI: Mark Pearce (KTH)
- Sweden: KTH & SU;
- Japan: Hiroshima University, ISAS, Waseda University, Tokyo Institute of Technology;
- USA: SLAC/KiPAC, University of Hawaii;
-
- External collaborators:
- DST Control in Linköping (attitude control system);
- SSC Erange (gondola, power and communication systems and campaign phase);
- KTH Alfvén Laboratory (Auroral monitor);

The collaboration:

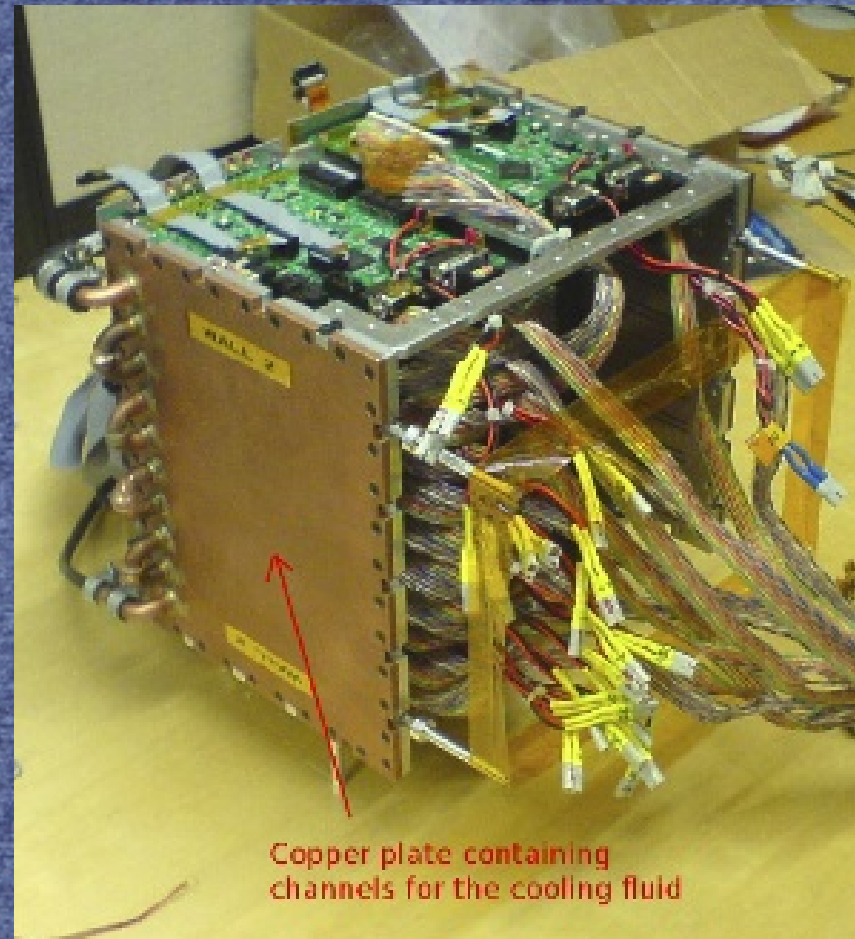
- KTH: Mark Pearce, Miranda Jackson, Stefan Rydström, Mozsi Kiss, Elena Moretti, Merlin Kole and many MCs students which gave important contributions;
- SU: Göran Olofsson, Hans-Gustav Floren;
- Japan: Tune Kamae, Hiromitsu Takahashi;
- External collaborators:
- DST Control: team led by Jan-Erik Strömberg;
- SSC Erange: team led by Torbjörn Eld;
- KTH Alfvén Laboratory: team led by Nickolay Ivchenko;

The subject



Preparing the polarimeter

The collaboration has worked on the preparation and development of the instrument: from the inner detector to the read out electronics, from the cooling system to the pressurised structure.



Preparing the Polarimeter



...not only advanced technology...

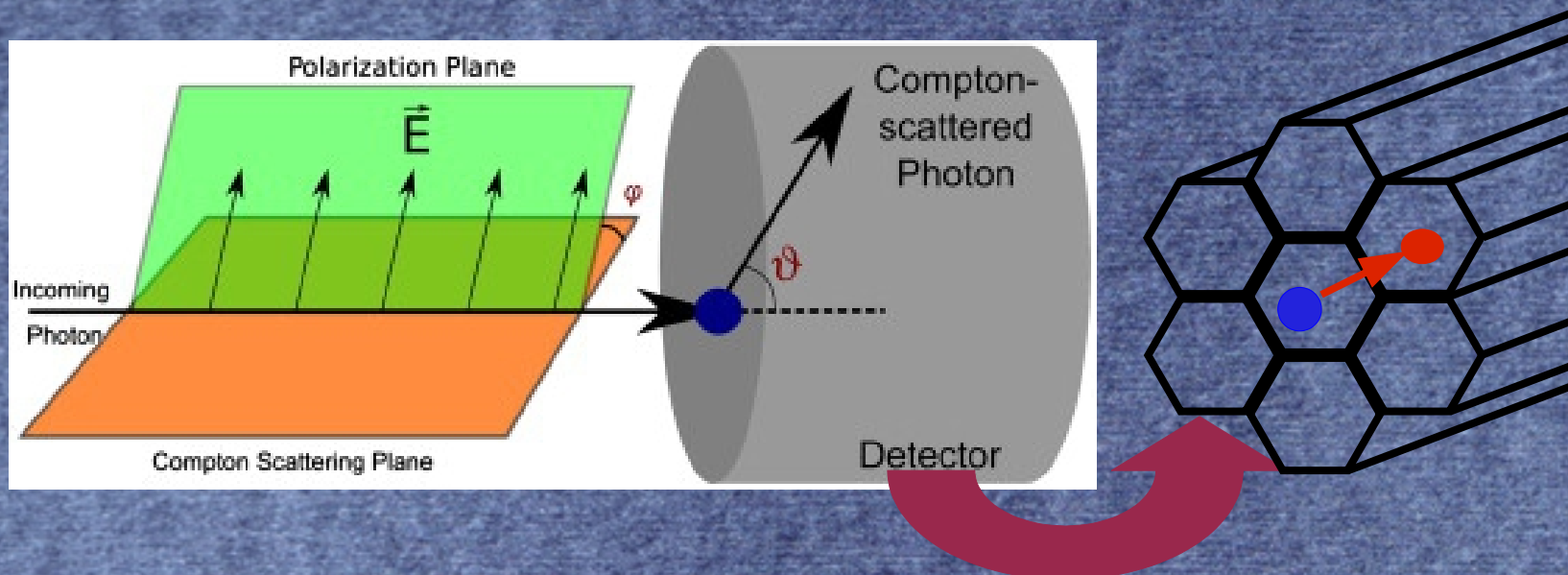


The detection idea

Klein-Nishina description of a Compton scattering for polarised photons:

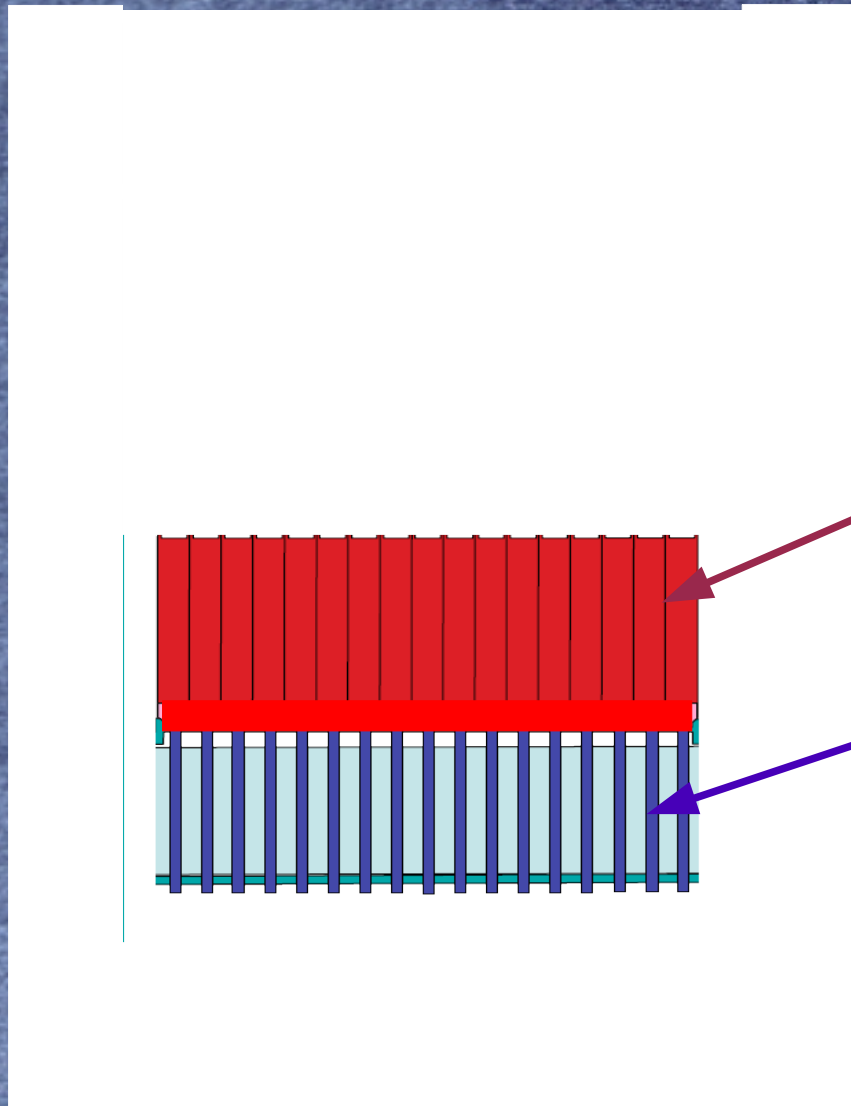
$$\frac{d\sigma}{d\Omega} = \frac{r_0^2}{2} \frac{E'^2}{E^2} \left(\frac{E'}{E} + \frac{E}{E'} - 2 \sin^2 \theta \cos^2 \phi \right)$$

=> the photon spatial distribution depends on the polarisation:



Angular resolution using a **segmented** detector

Detector tuning against bkg

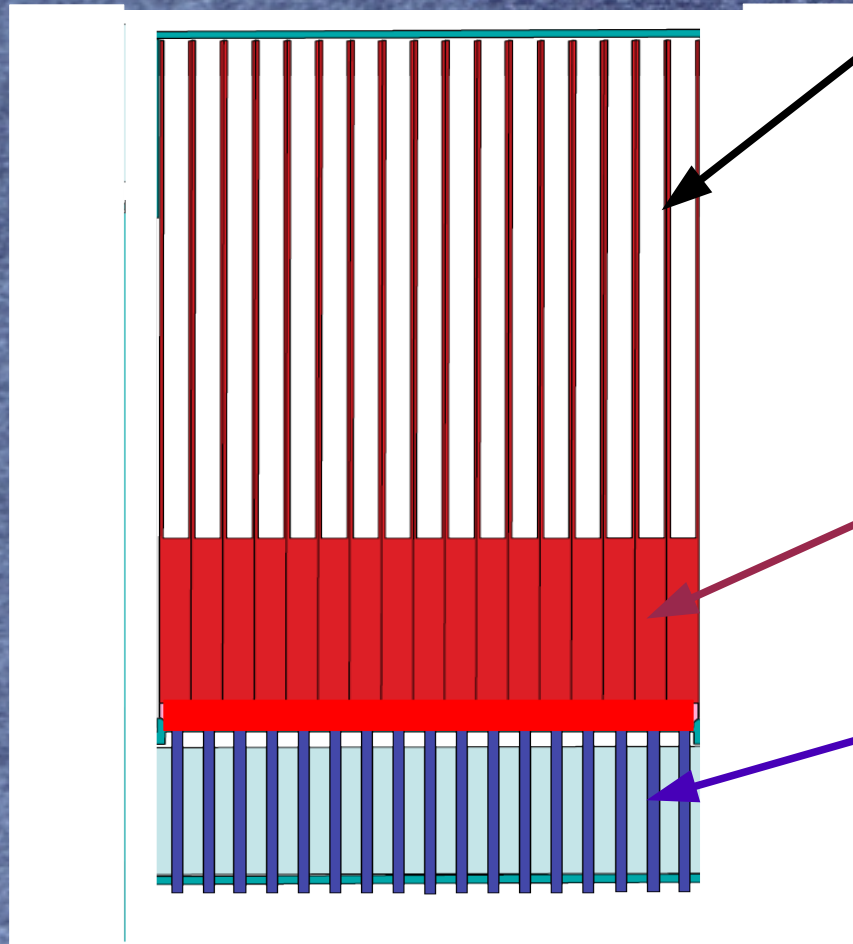


Applying the detection idea
with **fast scintillators** in a
hexagonal-geometry array.

The signal is amplified from
photomultiplier tubes.

Detector tuning against bkg

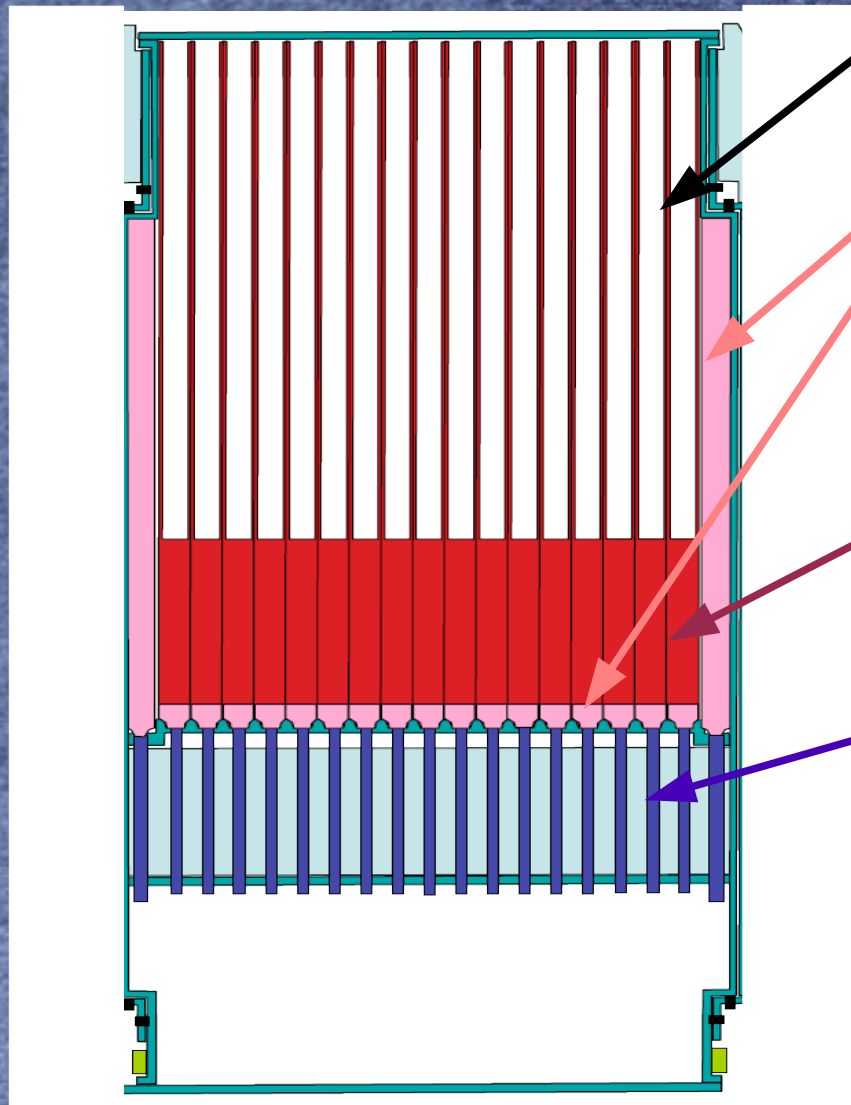
Slow scintillator tubes
collimate the received signal.



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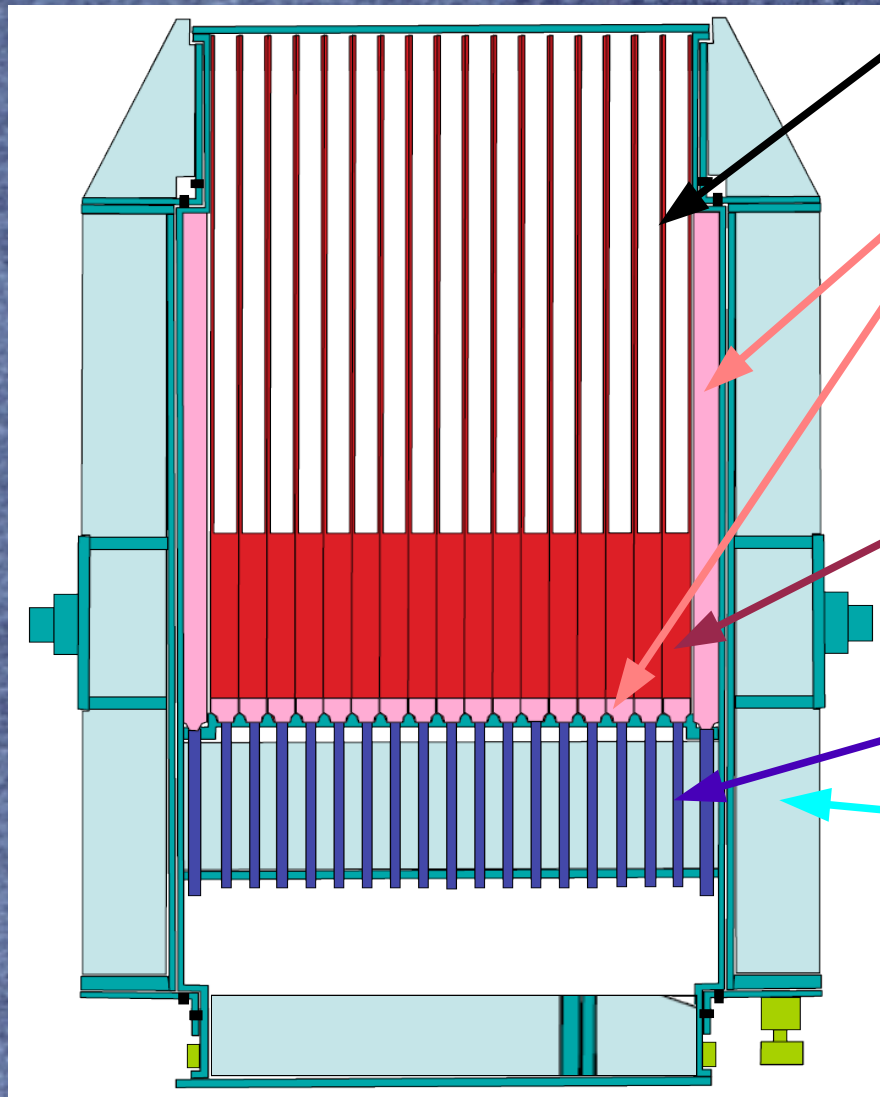
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BGO crystals create an
anti-coincidence shield

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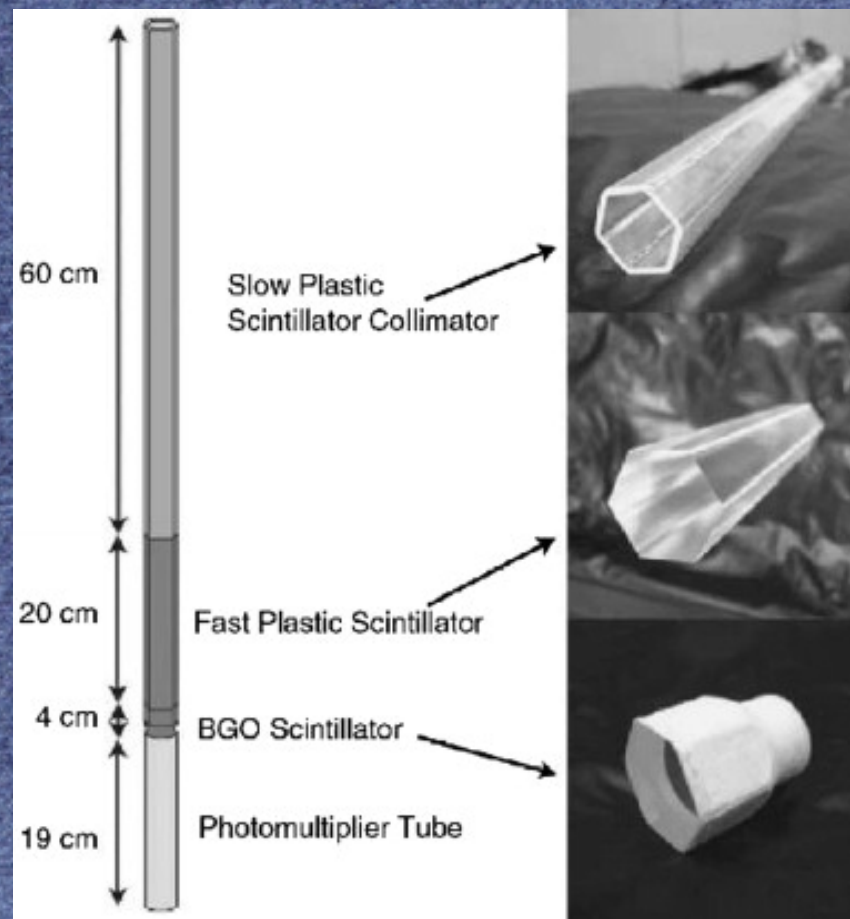
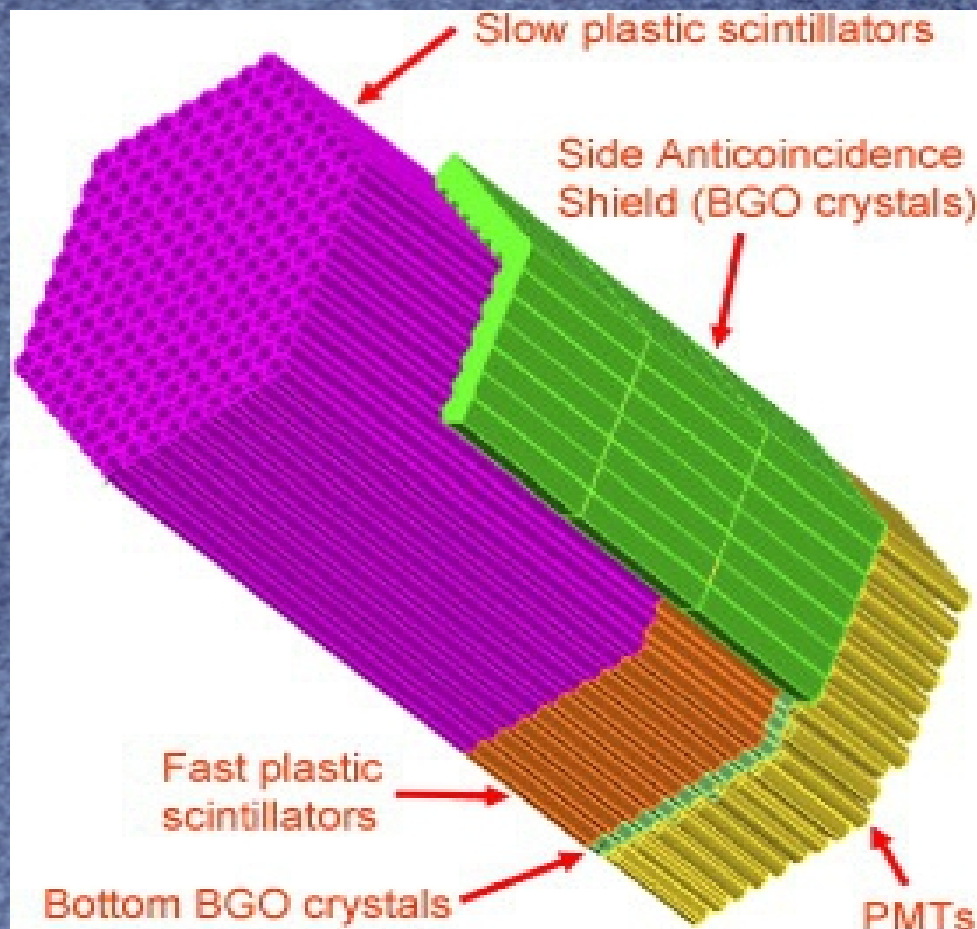
BGO crystals create an anti-coincidence shield

Applying the detection idea with fast scintillators in a hexagonal-geometry array.

The signal is amplified from photomultiplier tubes.

A passive neutron shield in polyethylene surrounds the detector

Detector facts



Energy range: 25 – 100 KeV

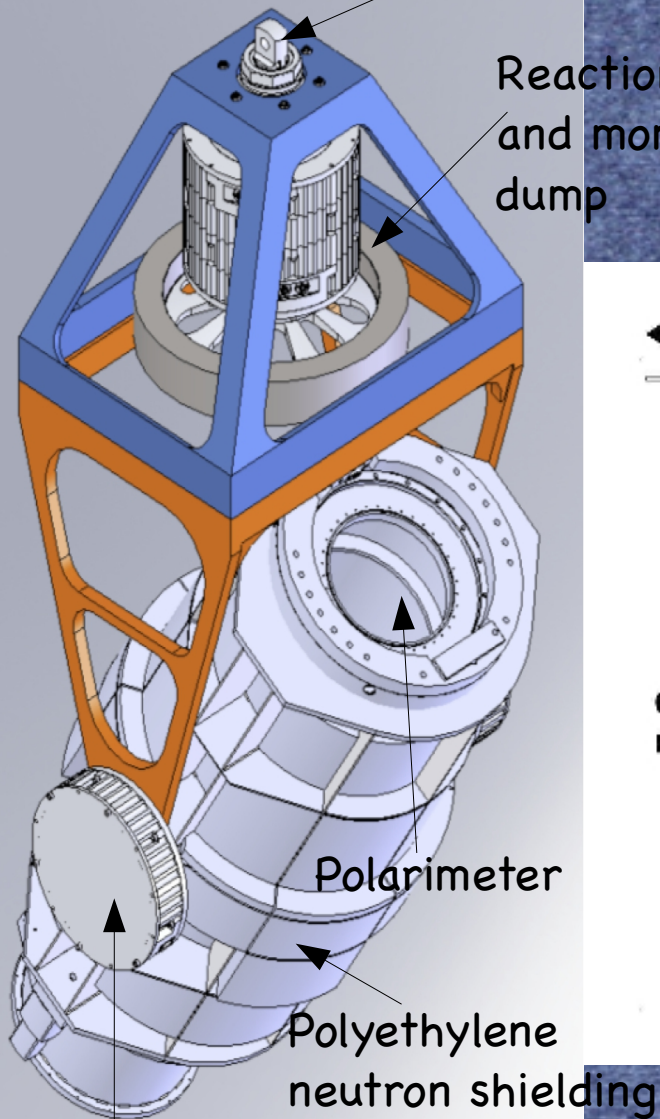
Effective area: 200cm^2 @ 50 keV

Field of view: 2.5 deg

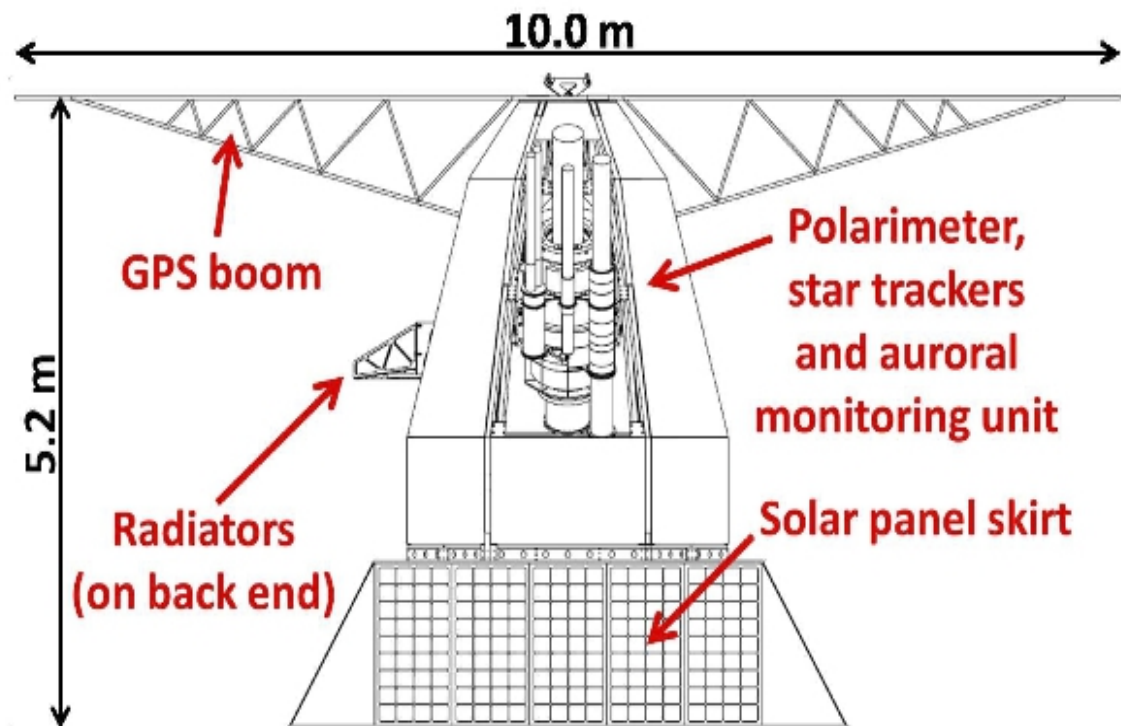
Attitude Control System and gondola

Flight train attaches here

Reaction flywheel
and momentum
dump



Elevation motor



The story

- 2003 → first idea;
- 2005 → proposal;
- 2006 – 2010 → development;
- 2010 → engineering flight planned but canceled;
- 2011 → 5 day long flight planned;



The story



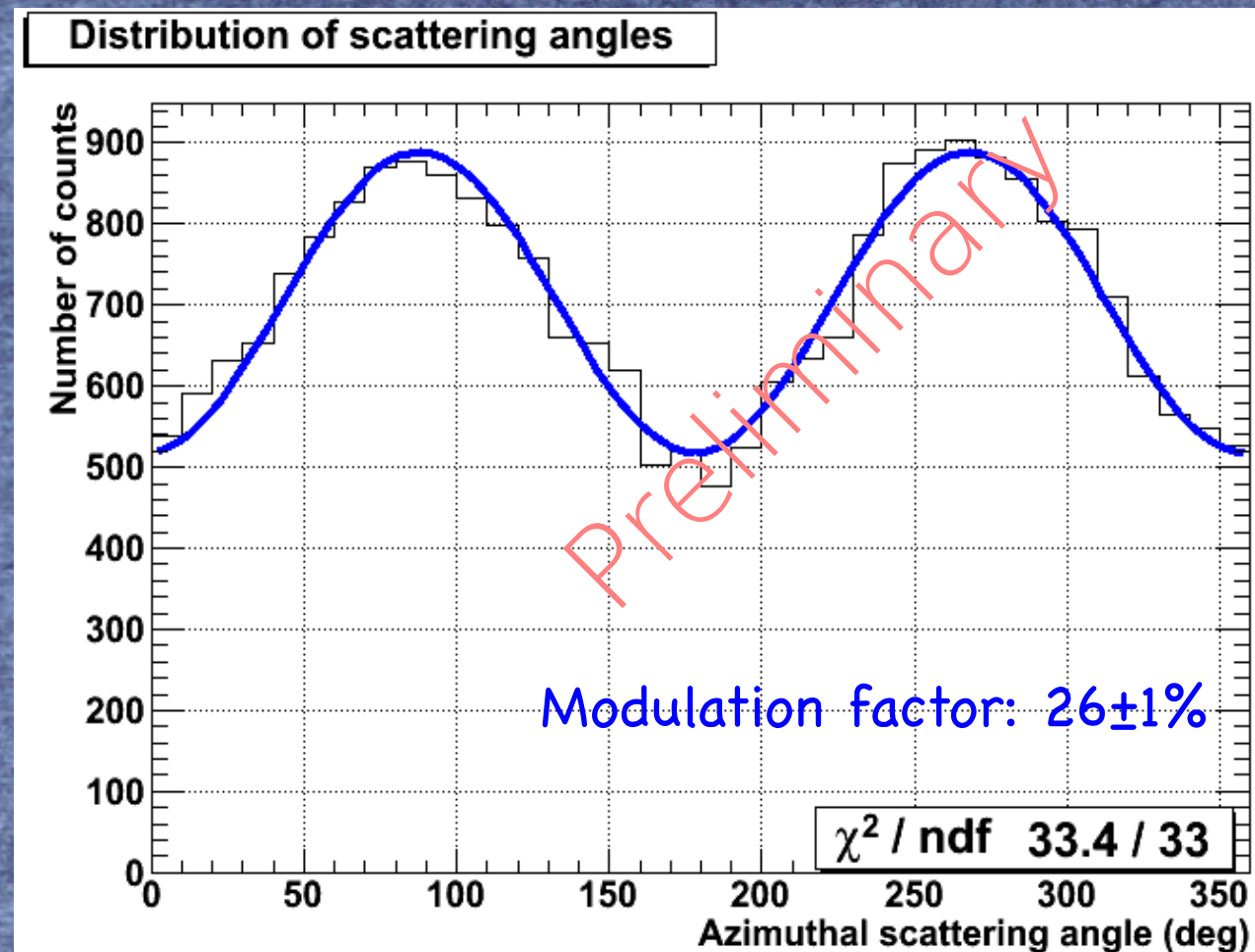
- 2011 → flight duration 5h;
- 2012 → 5 day long flight planned;
- 2012 → No launch opportunities due to weather;
- 2013 → new launch attempt for long⁷ flight;

Why do we keep
doing this after
all this bad
luck?

Answers!

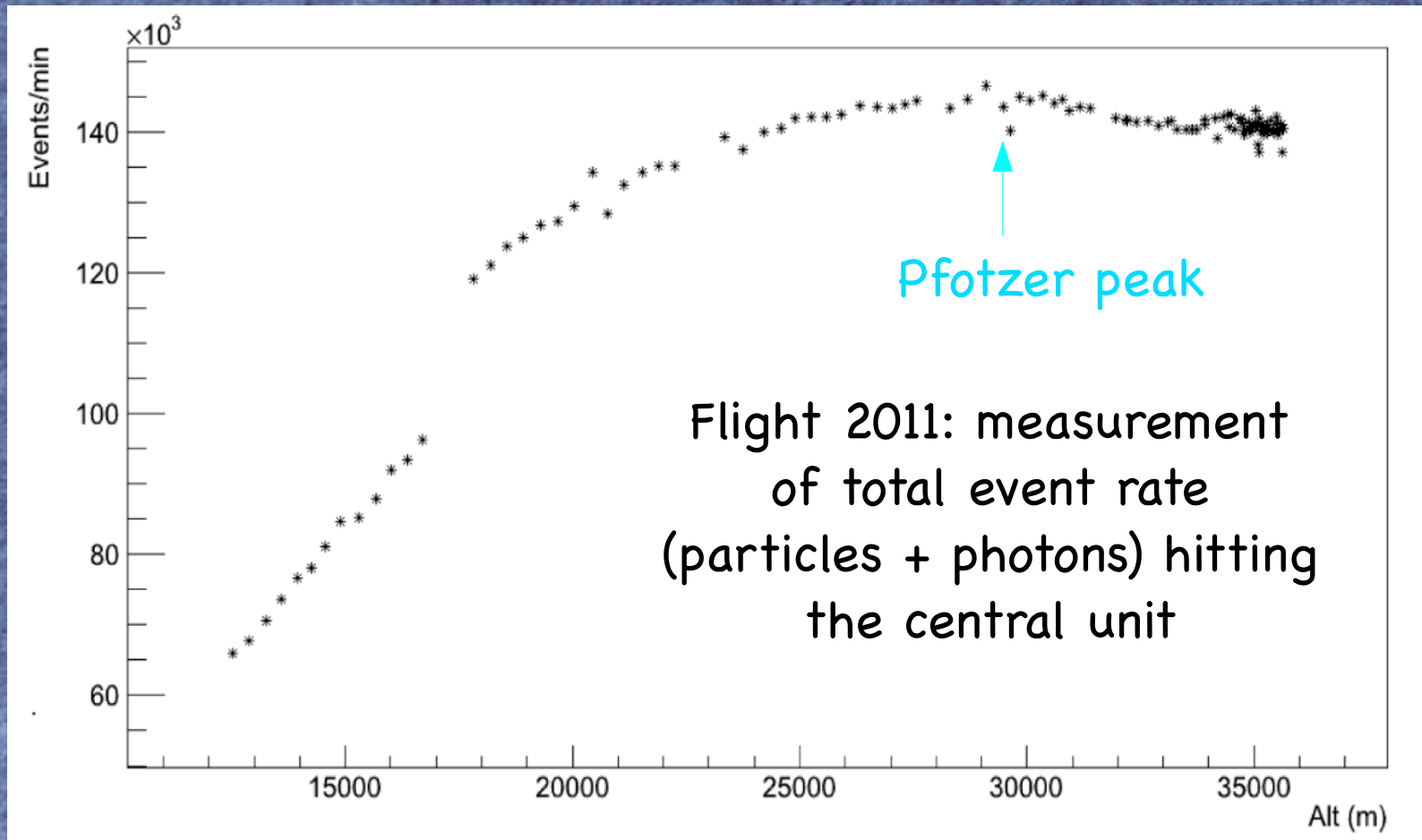
1. The instrument works as expected!

Ground
measurement of
a $\approx 100\%$
polarised source
(not bkg
subtracted)



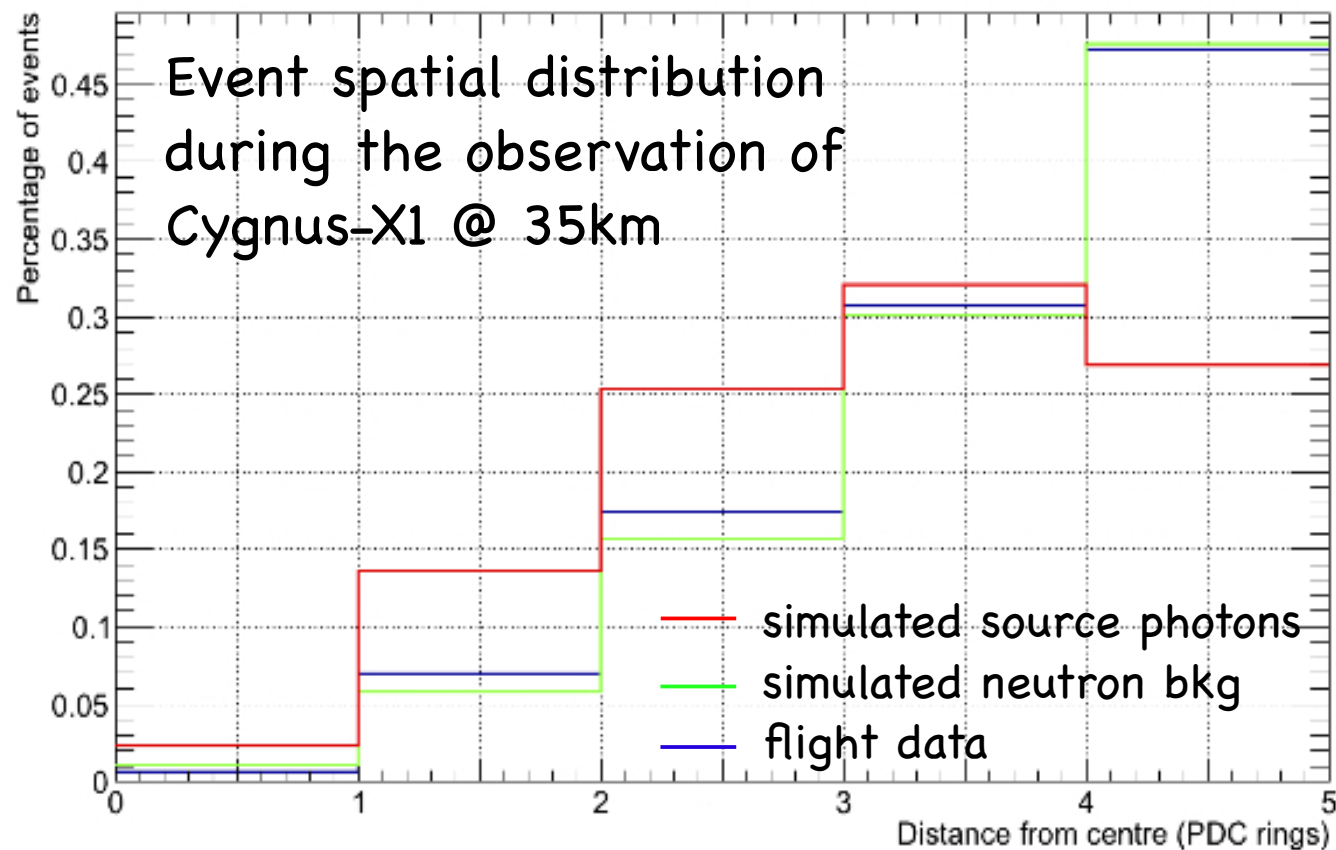
Answers!

1. The instrument works as expected!



Answers!

1. The instrument works as expected!



Answers!

2. The science is at the frontier

In the past:

- ✓ Good measurements in optical (450–950nm): pol degree and angle change with the phase;
- ✓ Old measurement (1976) @ 2.6keV, 5.2keV;
- ✓ Measurements at 200–800keV but not a “real” polarimeter
→ high systematics & bad timing resolution.

With PoGoLite:

- ✓ First measurement of the **Crab Nebula** in hard X-ray with a **dedicated polarimeter** (low systematics and good time resolution) ==> **Independent information** on the particle acceleration mechanisms and the geometry in the Nebula

Answers!

2. The science is at the frontier

- ✓ First measurement of the **Crab Nebula** in hard X-ray with a **dedicated polarimeter** (low systematics and good time resolution) ==> **Independent information** on the particle acceleration mechanisms in the Nebula
- ✓ Possible measurement of the Crab pulsar ==> complementary information to distinguish among acceleration-emission models
- ✓ Possible measurement of the polarisation of the binary system Cygnus-X1 ==> In which case this system emits polarised light? What is the geometry of the system?

Epilogue

Stay tuned!

I hope to see you next
year with the happy
ending

For references and more information check www.particle.kth.se/pogolite

Join us?

- Postdoctoral scholarship in astroparticle physics at KTH (2 years)

Application deadline: 2012-12-10.

- Ph.D. position in astroparticle physics at KTH in Stockholm.

Application deadline: 2012-12-17.

The positions concern polarised X-ray astrophysics – focussing on balloon-borne hard X-ray polarimetry (PoGOLite) and the development of new instrumentation.

*English: <http://www.kth.se/en/om/work-at-kth/vacancies>

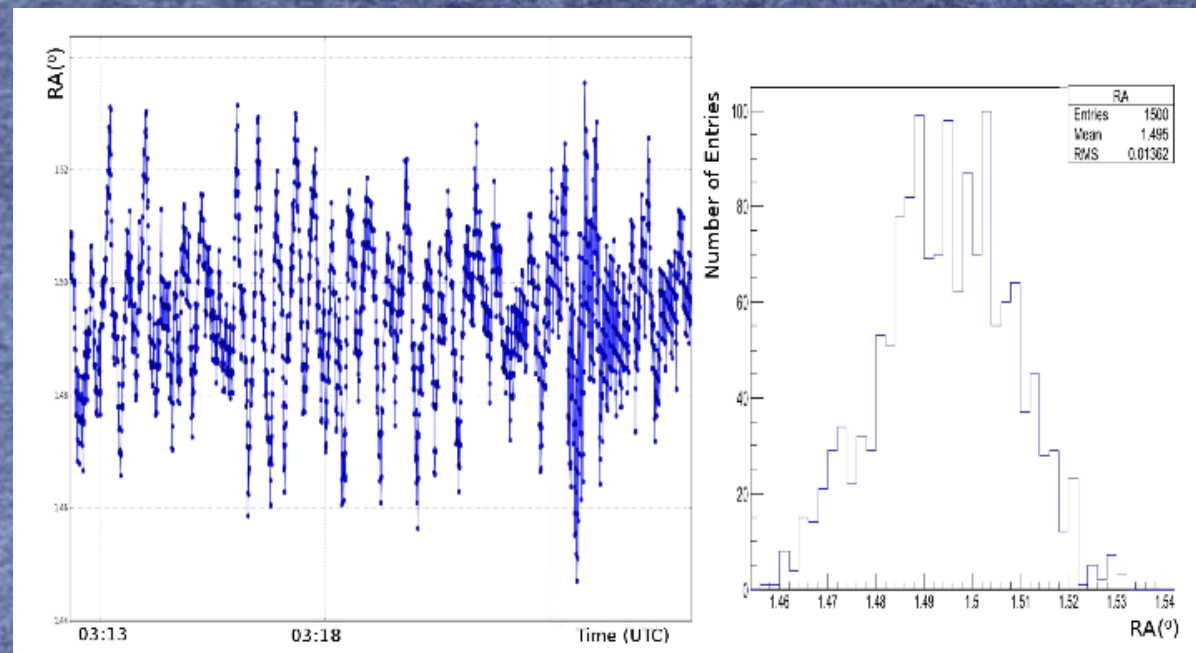
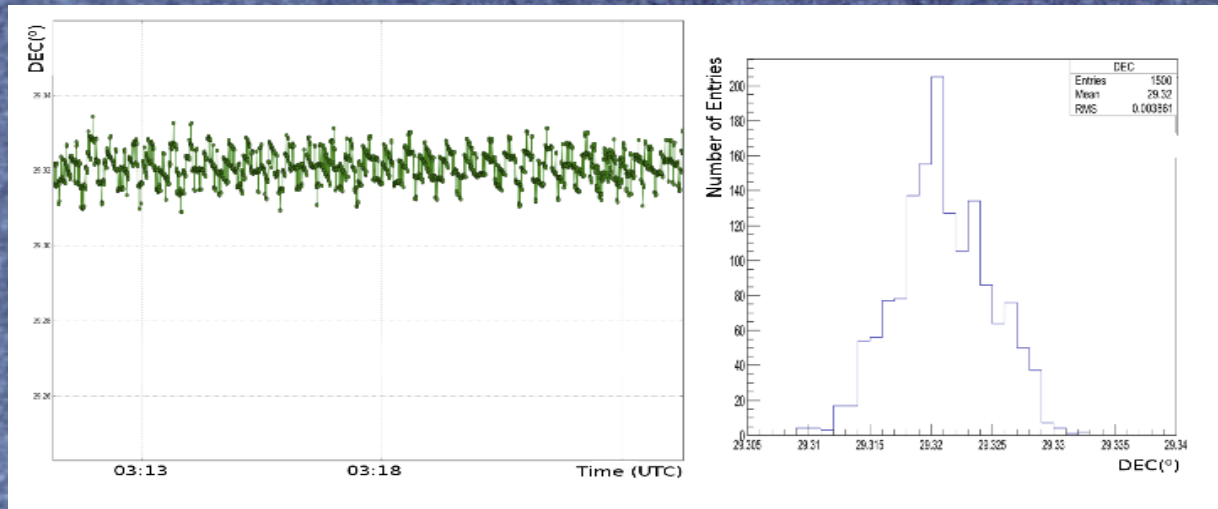
*Swedish: <http://www.kth.se/om/work-at-kth/lediga-anstallningar>

Thank you

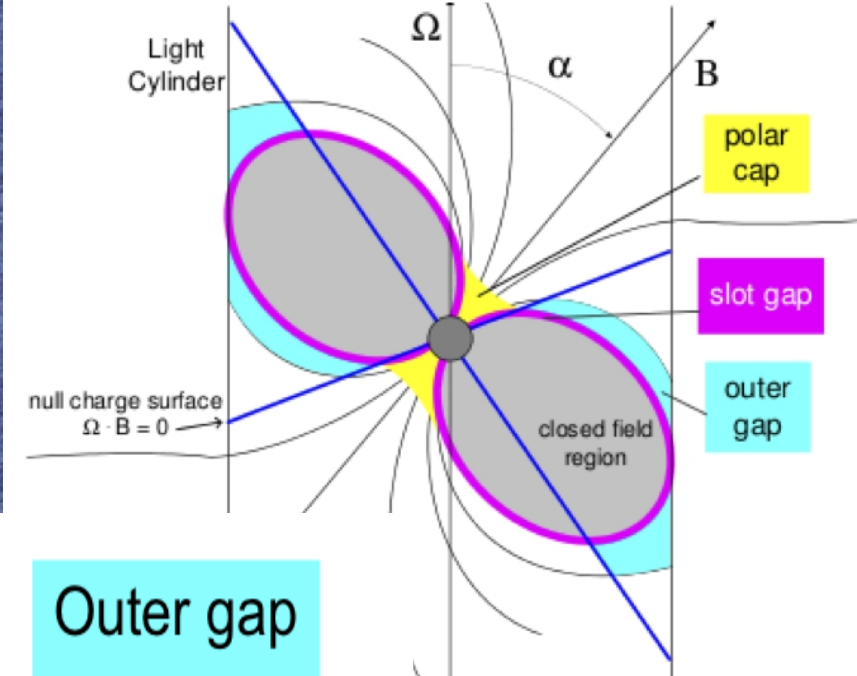
Crab nebula past measurements

Instrument	Energy	Pol. degree	Pol. angle
OPTIMA	450–950 nm, ~1–3 eV (Optical)	Peaks: low polarization, ~5–10%	Peaks: rapidly changing, ~70–170°
OSO-8	2.6 keV (X-rays) 5.2 keV (X-rays)	$(19.2 \pm 1.0)\%$ $(19.5 \pm 2.8)\%$	$(156.4 \pm 1.4)^\circ$ $(152.6 \pm 4.0)^\circ$
INTEGRAL (IBIS)	0.2–0.8 MeV (Gamma-rays)	Peaks: little or no polarization Off-pulse: >88% pol.	Peaks: N/A Off-pulse: $(122 \pm 7.7)^\circ$
INTEGRAL (SPI)	0.1–1 MeV (Gamma-rays)	Off-pulse: $(46 \pm 10)\%$	Off pulse: $(123 \pm 11)^\circ$

ACS performances

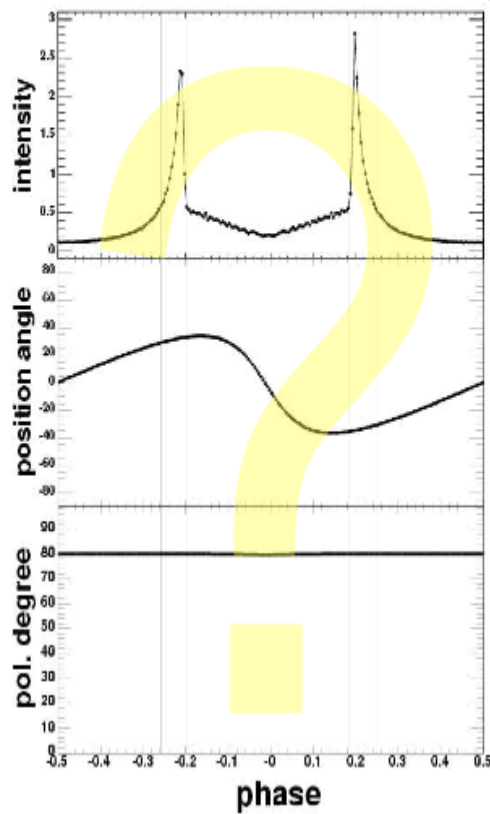


Pulsar models

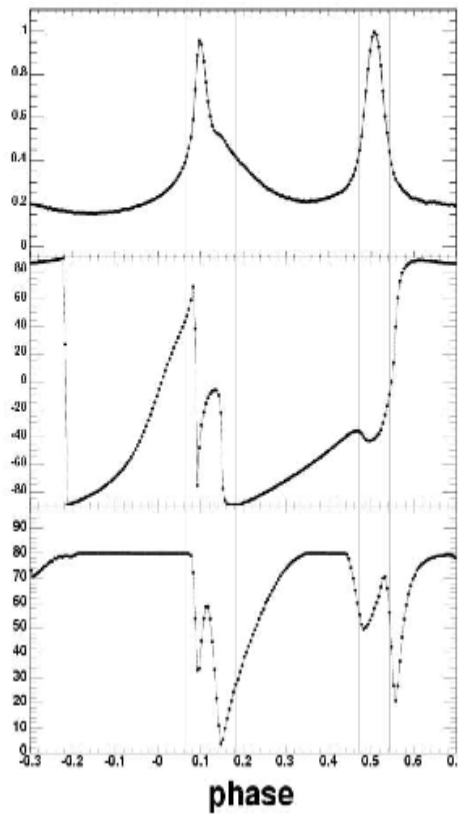


Polar cap

Numerical data: A. Harding



Caustic



Outer gap

