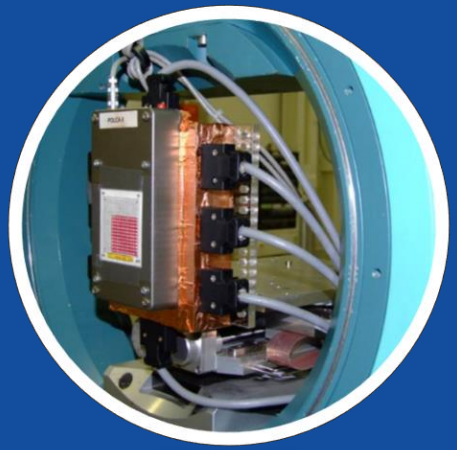
LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia

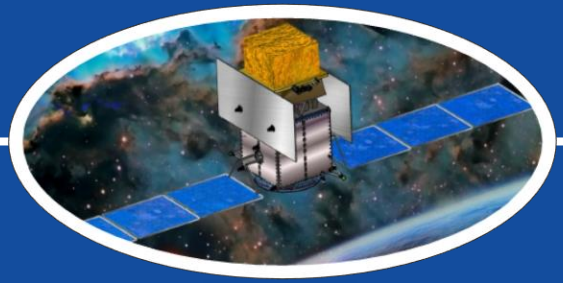


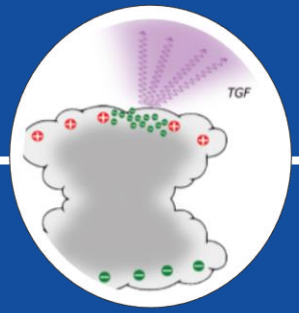
High-Energy Space Observatories in the New Era of Multi-Messenger Astrophysics

R. M. Curado da Silva

2019/03/06

i-Astro activities





Scientific

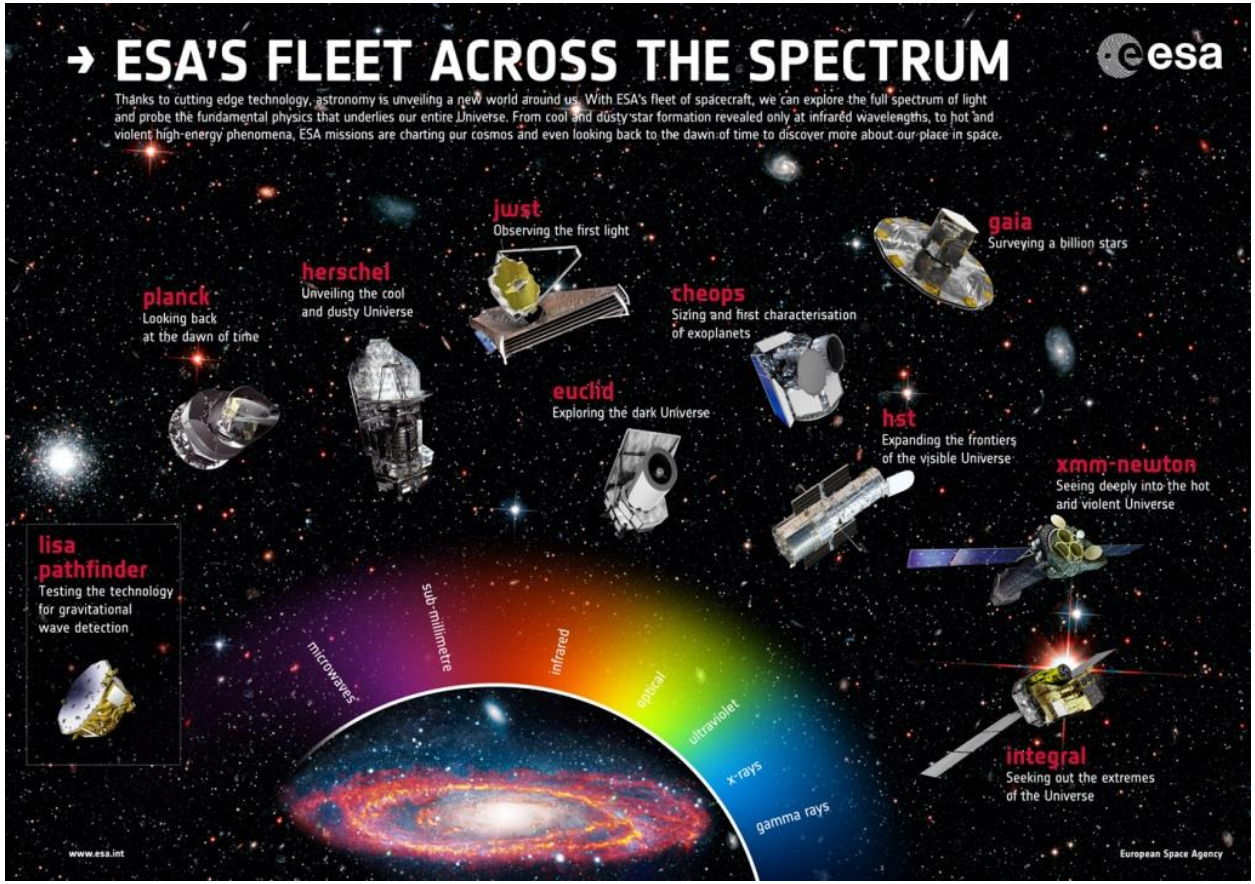
- All-Sky-ASTROGAM
- AMEGO
- CUBECOM
- IXPE

Spin-off

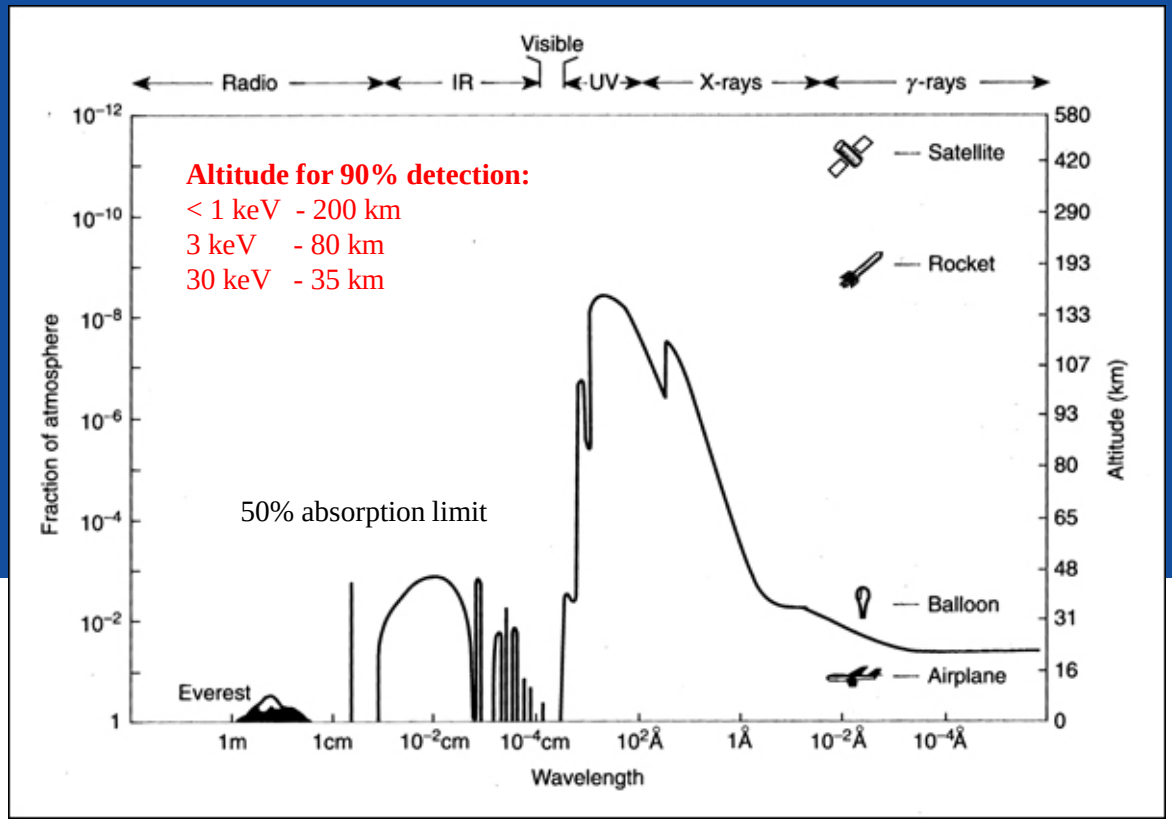
- TGF Flight Security
- Orbital Radiation Damage

Outreach & Dissemination

- Astronaut Summer School
- Space Summer School
- Balloon/CubeSat for student teams


ESA'S FLEET ACROSS THE SPECTRUM
esa
Thanks to cutting edge technology, astronomy is unveiling a new world around us. With ESA's fleet of spacecraft, we can explore the full spectrum of light and probe the fundamental physics that underlies our entire Universe. From cool and dusty star formation revealed only at infrared wavelengths, to hot and violent high-energy phenomena, ESA missions are charting our cosmos and even looking back to the dawn of time to discover more about our place in space.
jwst
Observing the first light
gaia
Surveying a billion stars
herschel
Unveiling the cool and dusty Universe
planck
Looking back at the dawn of time
cheops
Sizing and first characterisation of exoplanets
euclid
Exploring the dark Universe
hst
Expanding the frontiers of the visible Universe
xmm-newton
Seeing deeply into the hot and violent Universe
lisa pathfinder
Testing the technology for gravitational wave detection
microwaves
sub-millimetre
infrared
optical
ultraviolet
x-rays
gamma rays
integral
Seeking out the extremes of the Universe
www.esa.int
European Space Agency

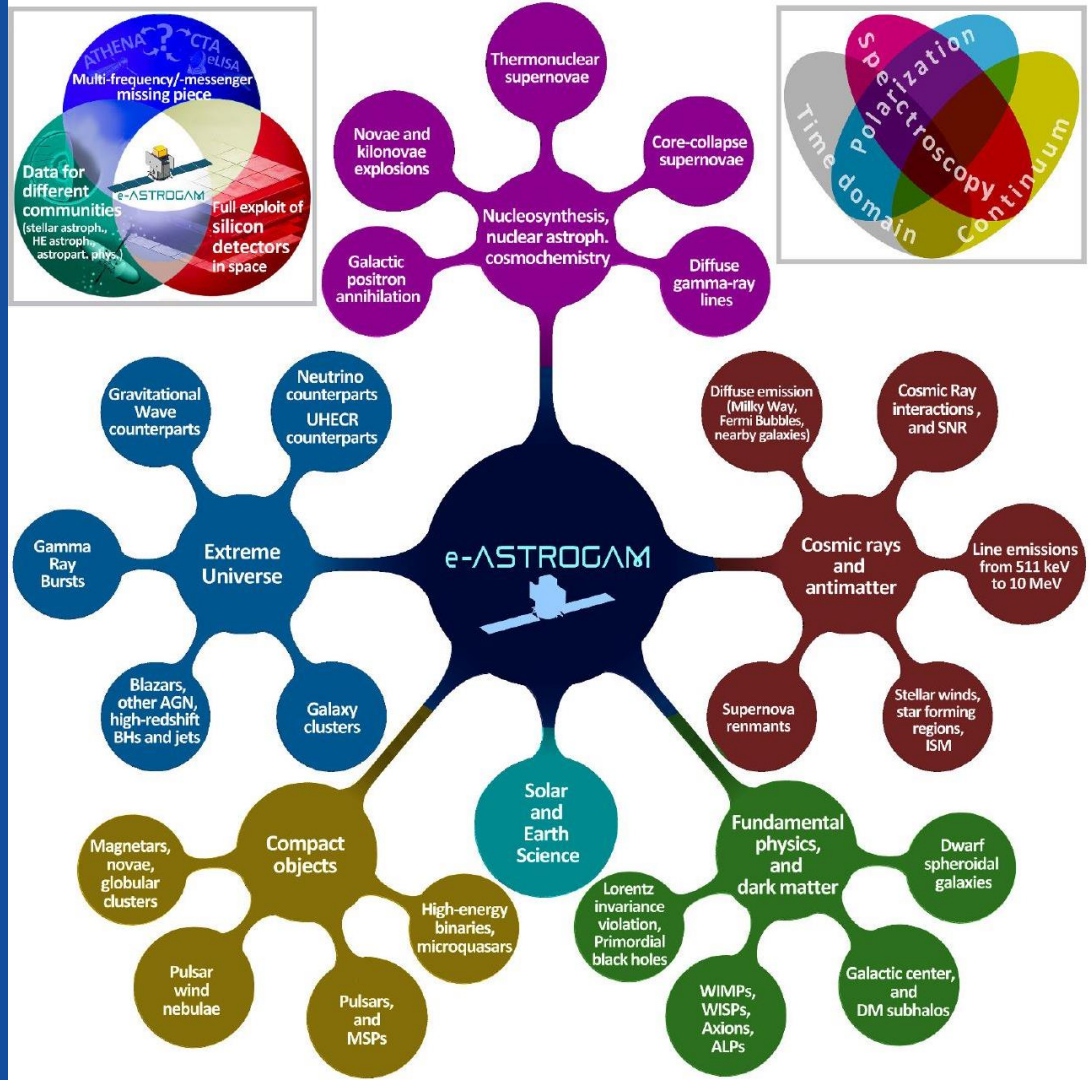
Space Missions are essential to observe the whole electromagnetic spectrum



High energy astrophysics (0.1 – 100 MeV)

Polarimetry

- 2 extra parameters (angle and degree);
- emission production mechanism and object geometry.

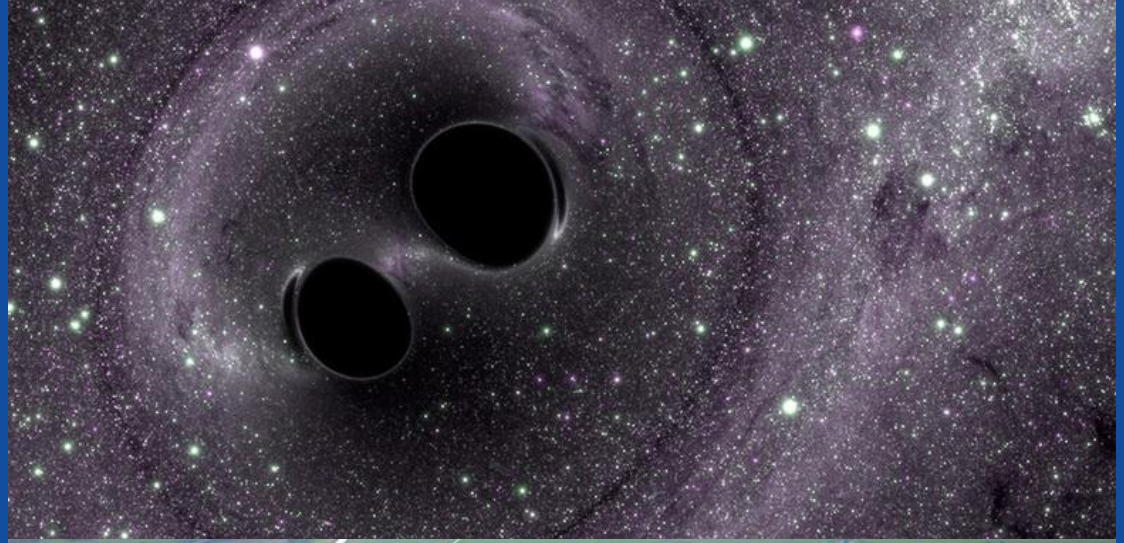


High energy astrophysics (0.1 – 100 MeV)

Multi-messenger astrophysics
Gravitational waves + Gamma-rays

LIGO-Virgo + INTEGRAL

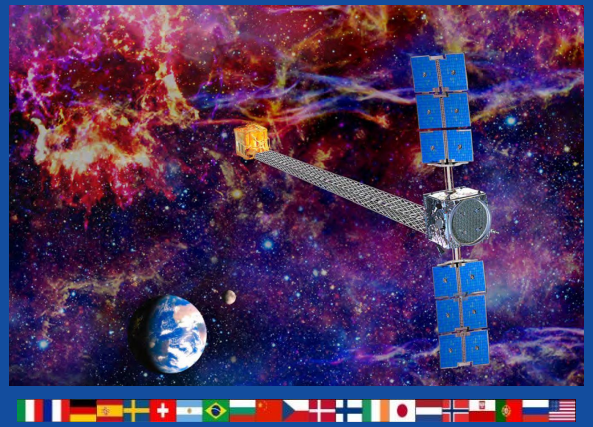
- supernova explosions;
- stellar mergers.



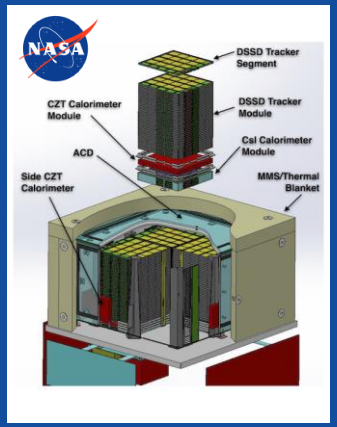
High-energy astrophysics missions

Ongoing missions: INTEGRAL, SWIFT, Fermi

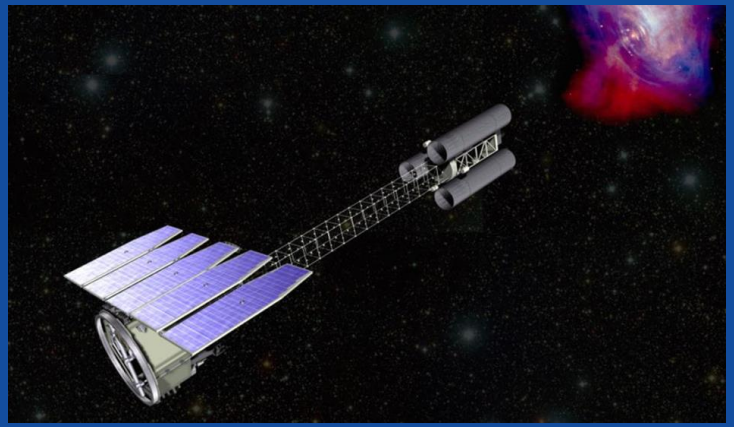
Past consortia: GRI (2007), DUAL (2010), ASTROGAM (2014)



All-Sky-ASTROGAM (ESA F mission)



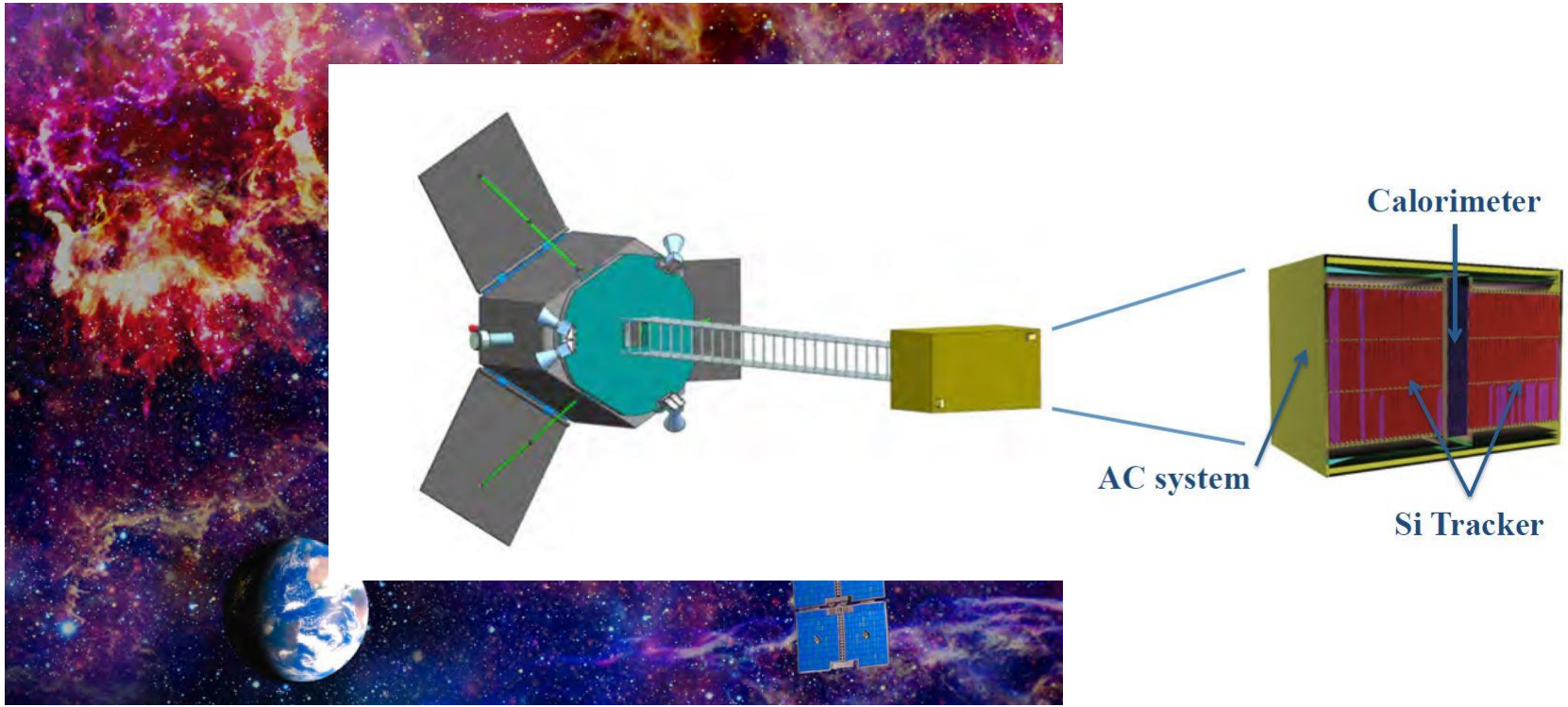
NASA AMEGO



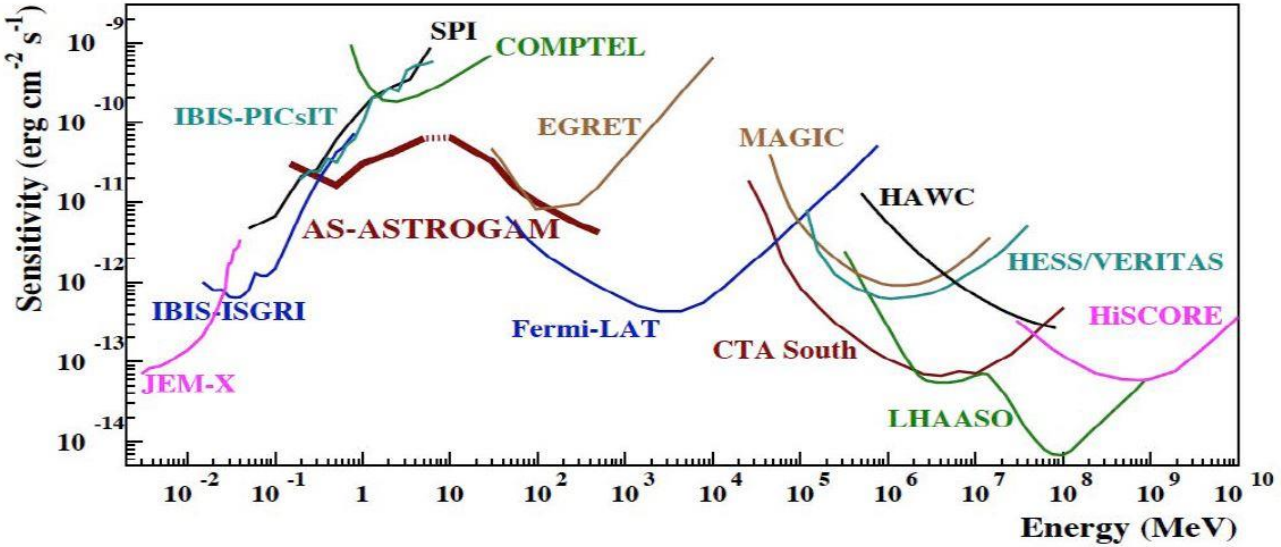
NASA IXPE

All-Sky-ASTROGAM

ESA F mission call



All-Sky-ASTROGAM
Sensitivity



MDP

(Minimum Detectable Polarization)

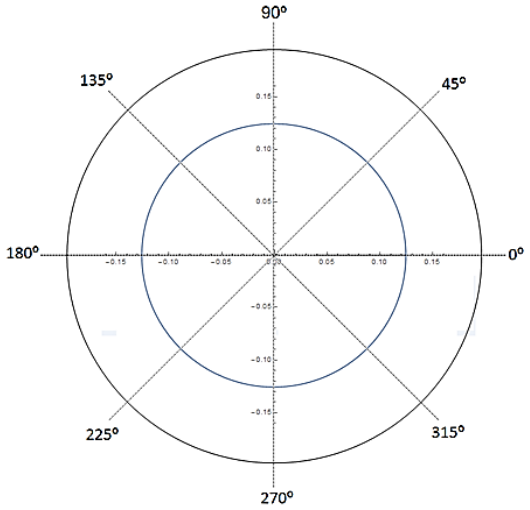
< 20 %

100 mCrab, 0.3-2.0 MeV
1 year obs. Time

Compton Polarimetry

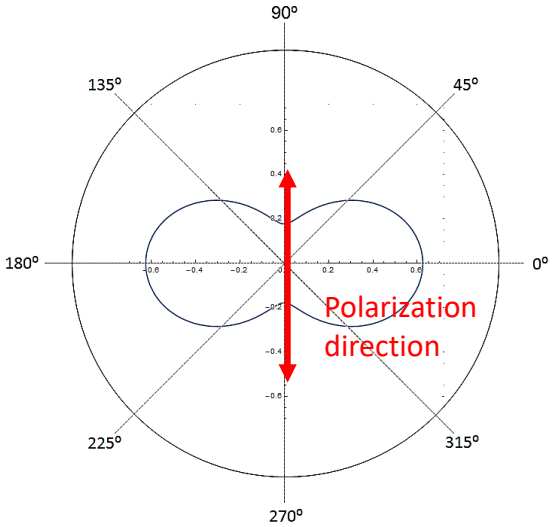
Unpolarized Beam

$$\frac{d\sigma_{KN,U}}{d\Omega} = \frac{1}{2} r_0^2 \varepsilon^2 [\varepsilon + \varepsilon^{-1} - \sin^2\theta]$$



Polarized Beam

$$\frac{d\sigma_{KN,P}}{d\Omega} = \frac{1}{2} r_0^2 \varepsilon^2 [\varepsilon + \varepsilon^{-1} - 2\sin^2\theta\cos^2\eta]$$

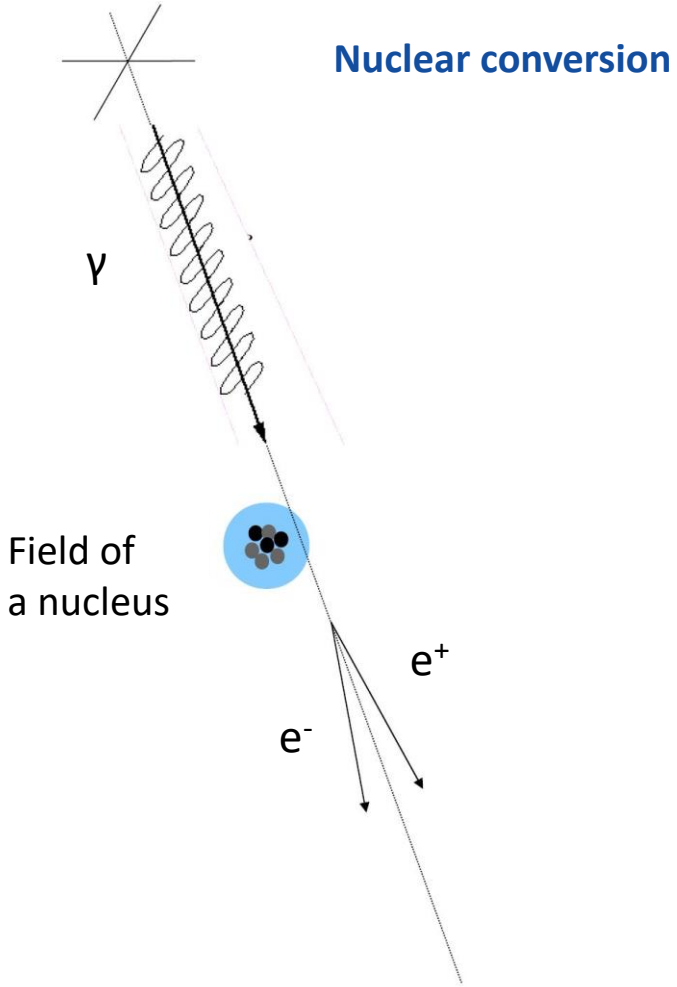


100%

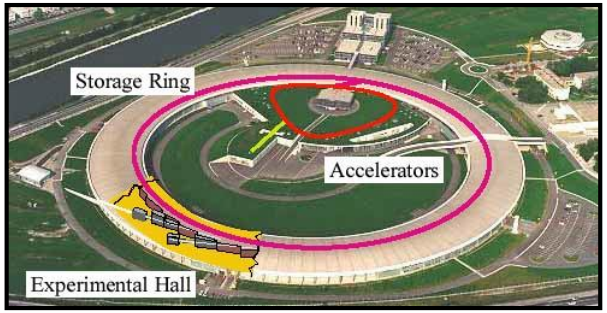
Pair Production Polarimetry

- e-/e+ pair is emitted in the plane of polarization of the photon;
- The pair distribution modulation amplitude and maxima phase depend on polarization degree and angle, respectively;

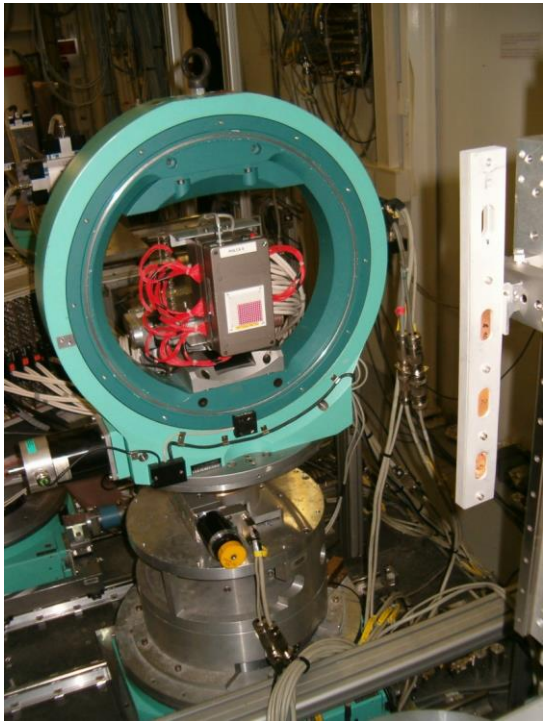
- Simulation code based on MEGAlib and BoGEMMS (Bologna Geant4 Multi-Mission Simulator) for pair production regime;
- Experimental: 1) MEGA prototype data; 2) NewSUBARU polarized beam (1 to 74MeV); 3) Balloon prototype testing (HEMERA?).



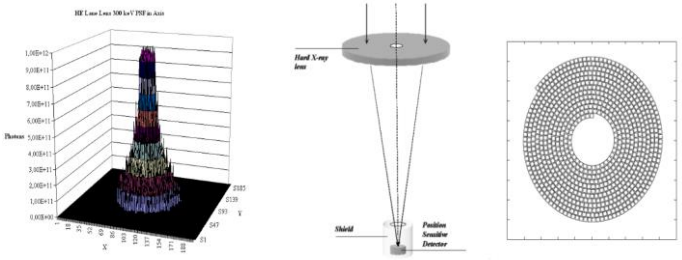
Previous polarimetric studies



ESRF, Grenoble, France ~ 99 % polarized radiation

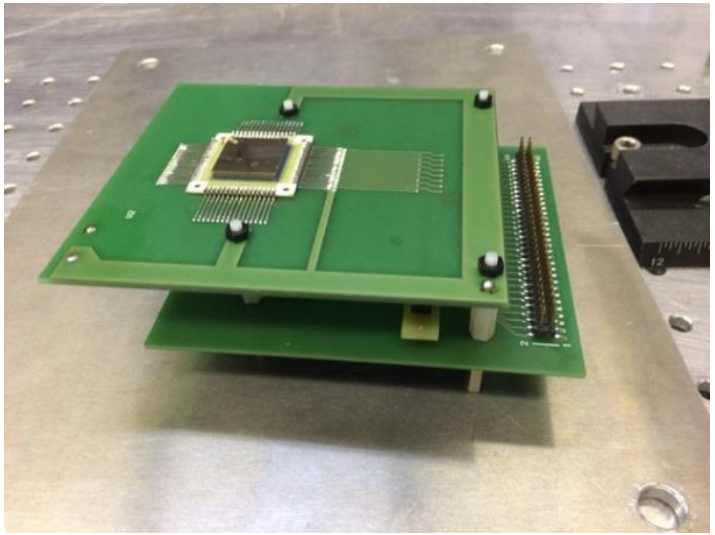


Laue lens sample Cu crystals + CdTe detector →

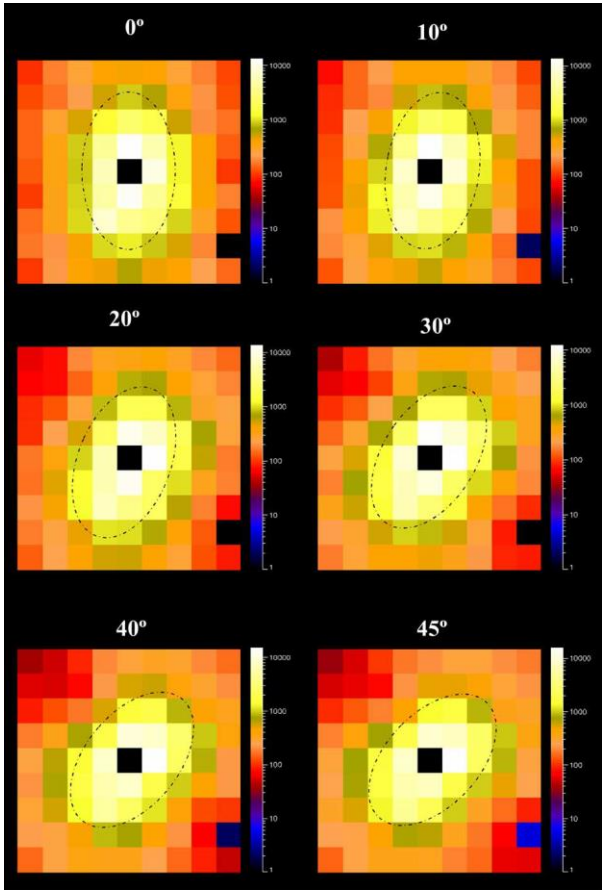


Modulation Q and Polarization direction

Detectors: 2 x CdTe; 18x18 mm^2; 2 mm thick 8x8 pixels; 2 mm pitch



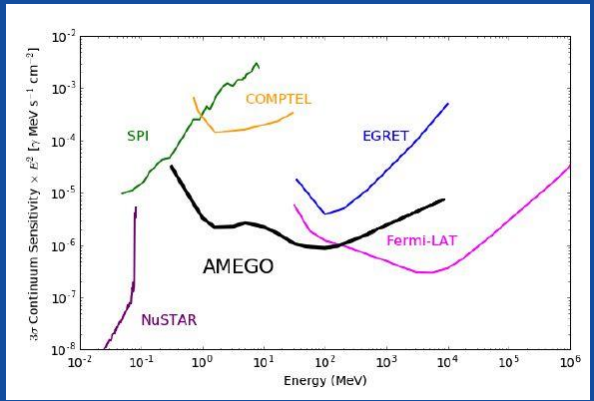
Distance between planes	Modulation factor
6 mm	0.287
10 mm	0.192

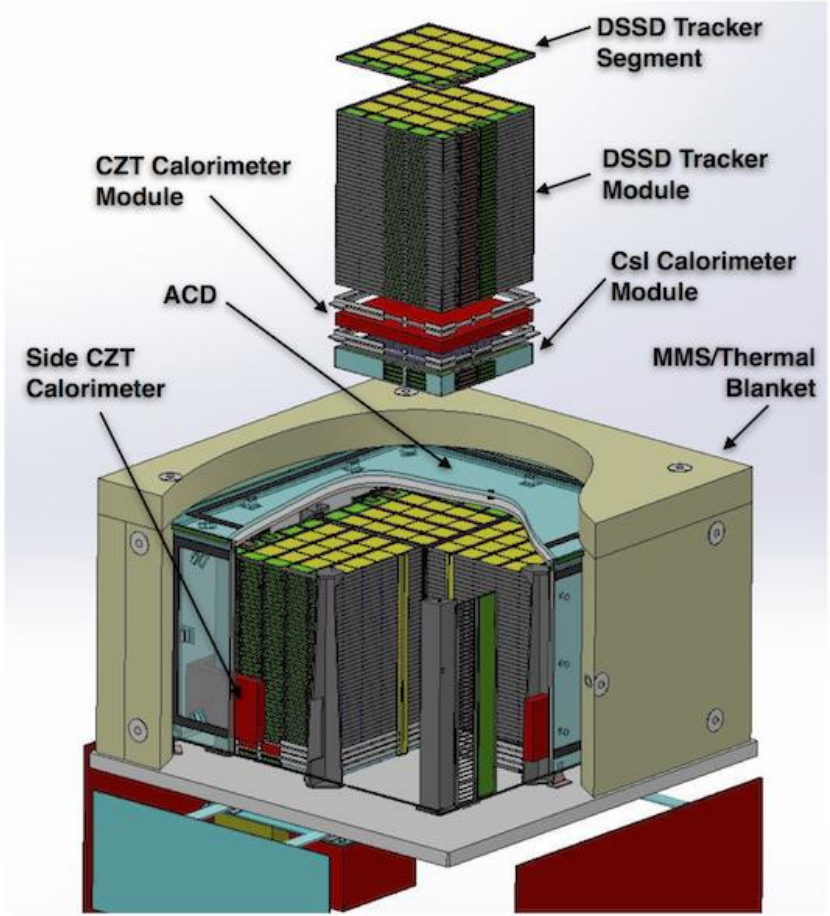


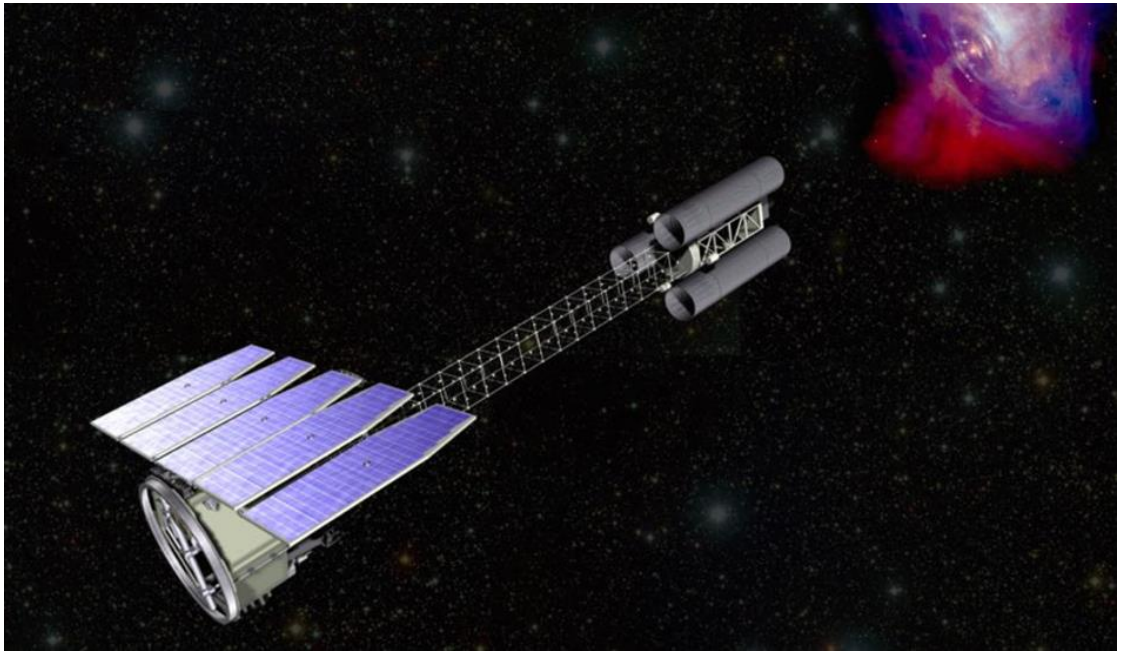
AMEGO NASA

All-sky Medium Energy Gamma-ray Observatory

- NASA Probe Class Call
- Energy Range: 0.2 MeV -> 10 GeV;
- Angular Resolution: 3° (1 MeV), 10° (10 MeV);
- Energy Resolution: <1% below 2 MeV; 1-5% at 2-100 MeV; ~10% at 1 GeV
- Sensitivity:



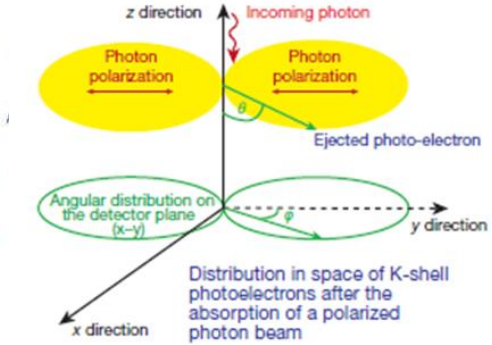


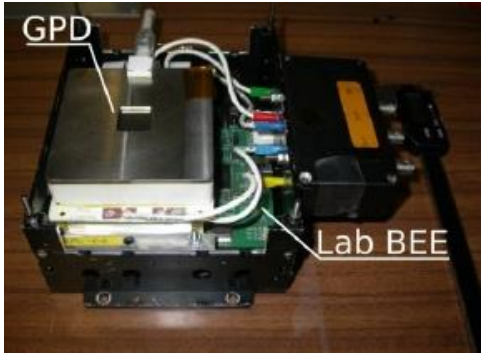


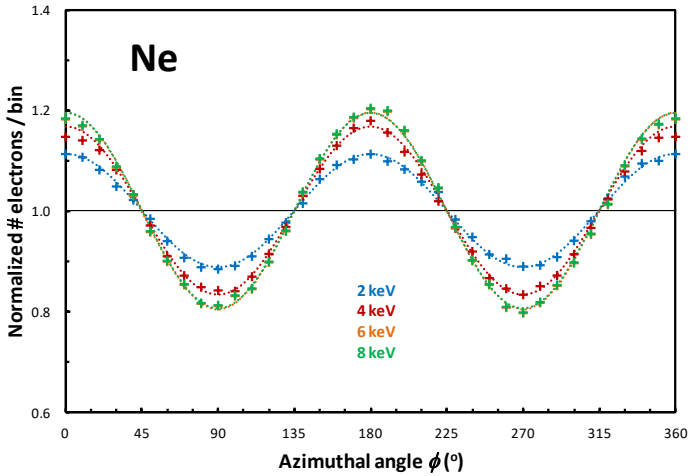
IXPE
Imaging X-ray Polarimeter Explorer

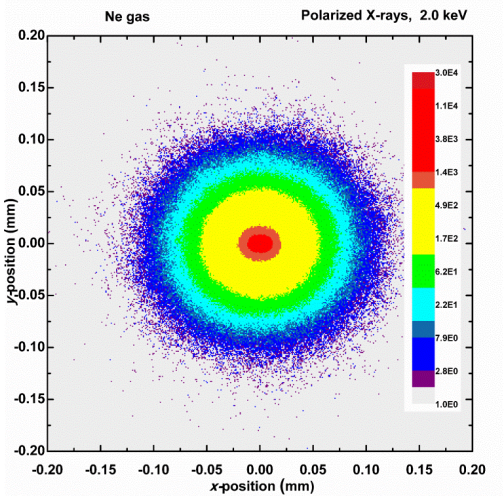
- XIPE: X-ray Imaging Polarimetry Explorer (PI: Enrico Costa, INAF/IAPS, Roma);
- LIP part of XIPE Instrument Team;
- Selection for M4 Call Phase A in 2015;
- Not selected for Phase B;
- Moved to NASA IXPE (Imaging X-ray Polarimeter Explorer) with INAF/IAPS Roma team.

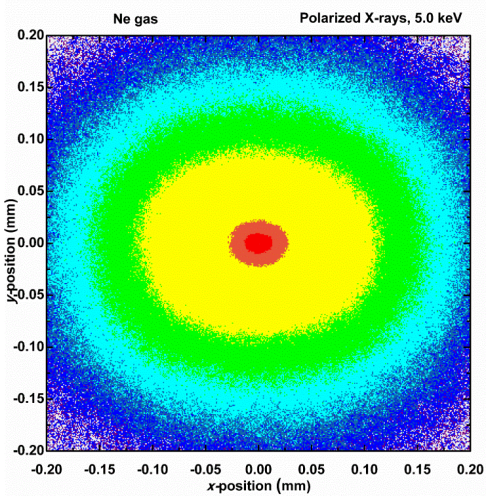
Gas Pixelized Dectetor



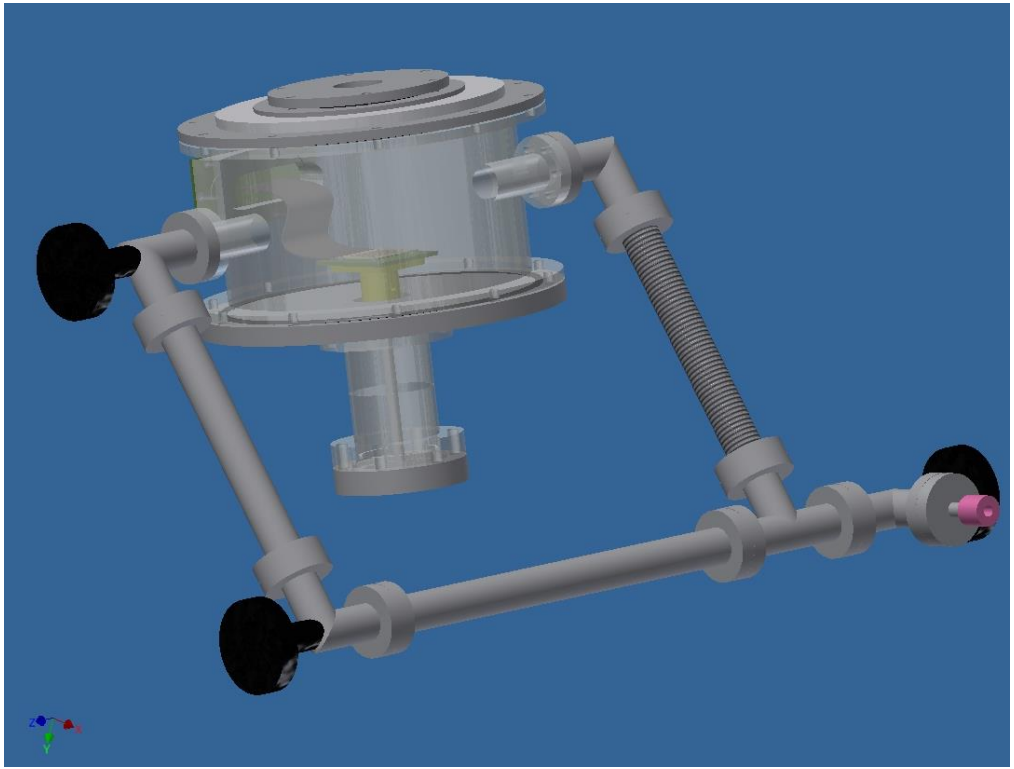






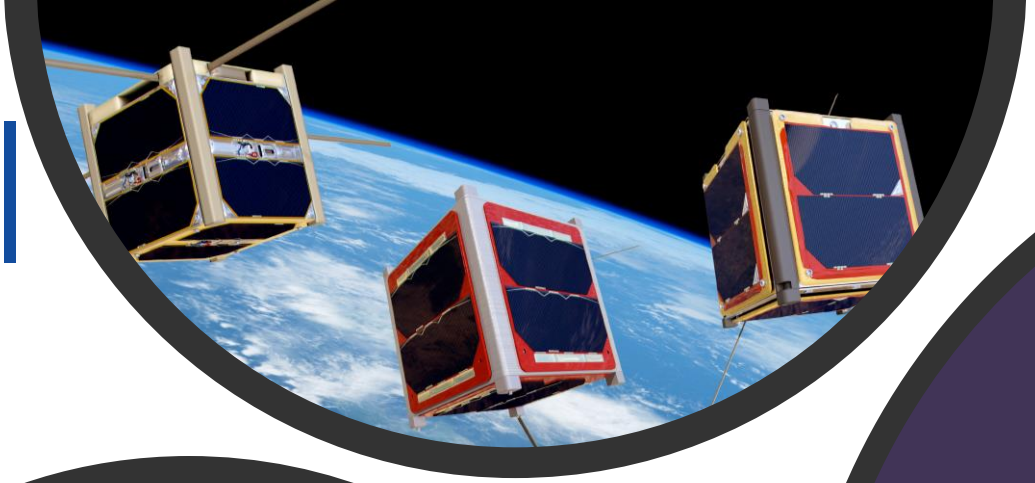


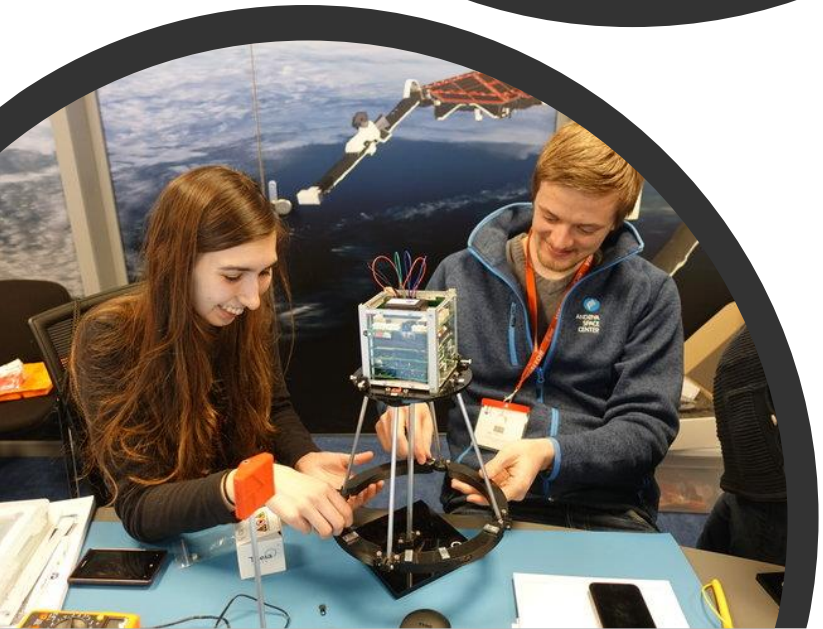
Polarimetry with
Ne, Ar and Xe



Under development

- Experimental system for transverse measurement of electron clouds generated by X-rays;
- Electron distributions for several gas mixtures and for different absorption regions, electric fields and depths.



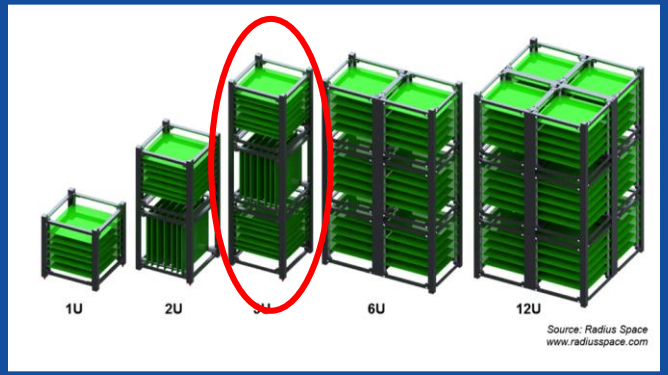


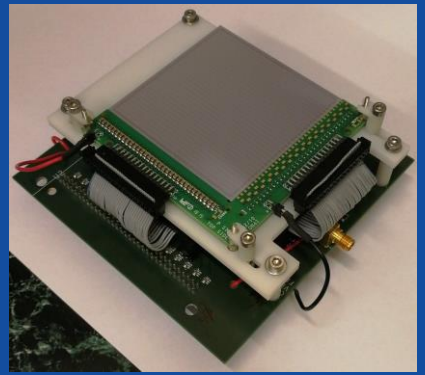
Cubesat Scientific Constellations

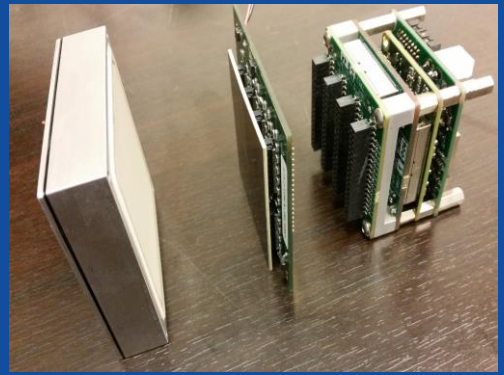
Use of Cubesat technology is a priority of H2020 EU recent calls for scientific applications

COMCUBE Nanosat sub-WP

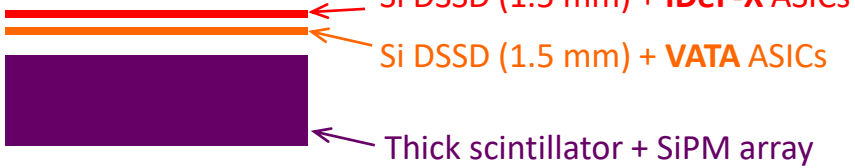
Development of a 3U Compton nanosat for the polarimetry of GRBs + qualification of the e-ASTROGAM technologies



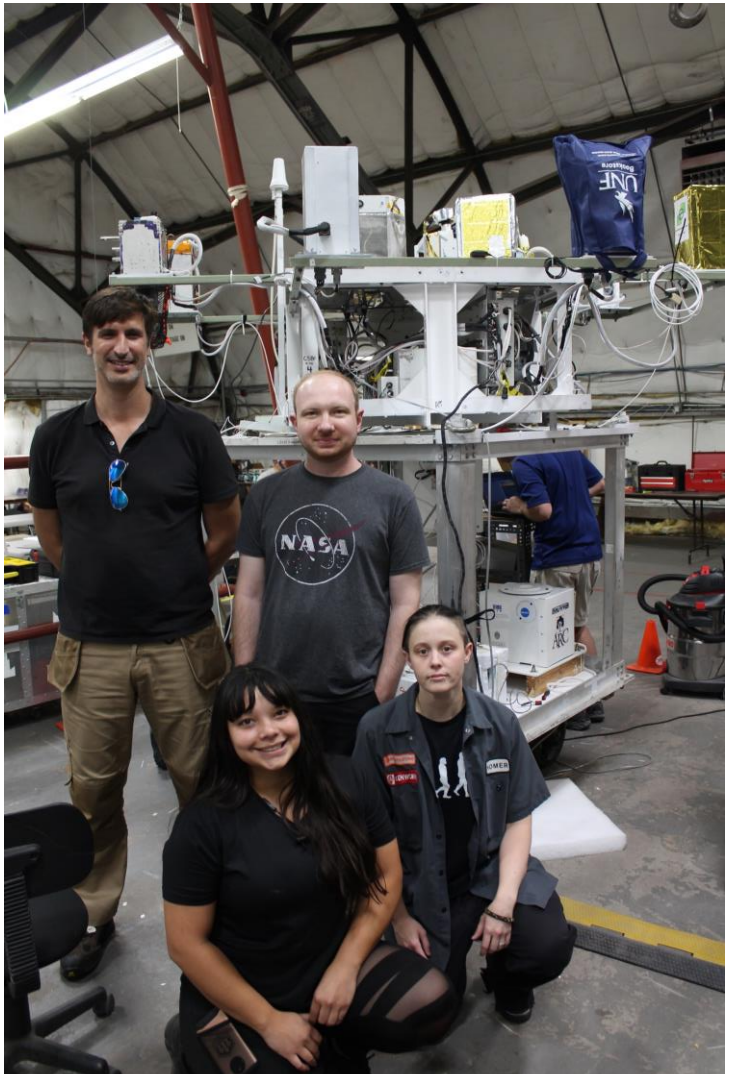




- Cubesat : standard unit ⇒ 1U
- Size : 10 x 10 x 10 cm
- Weight : 1kg
- Power : ~ 1.3 W



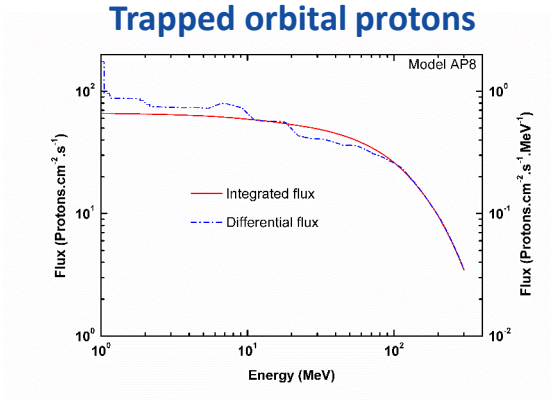
NASA Ballon
Polarimetric Experiment

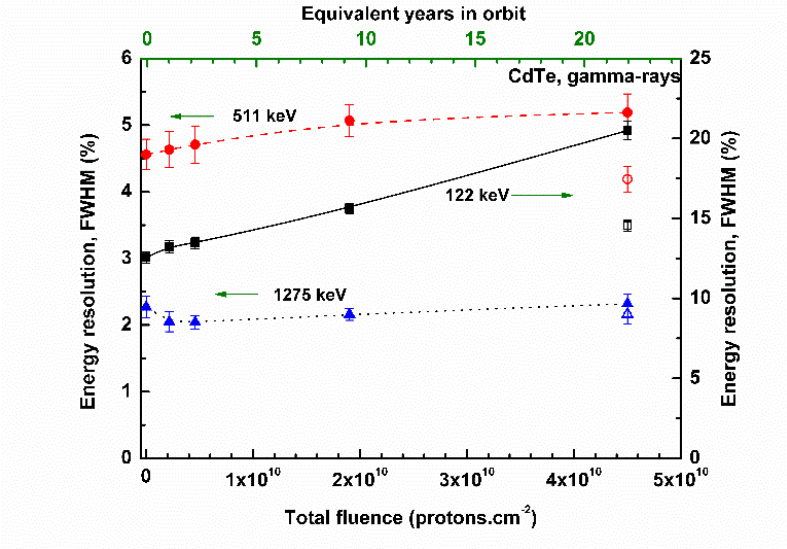


Orbital Proton

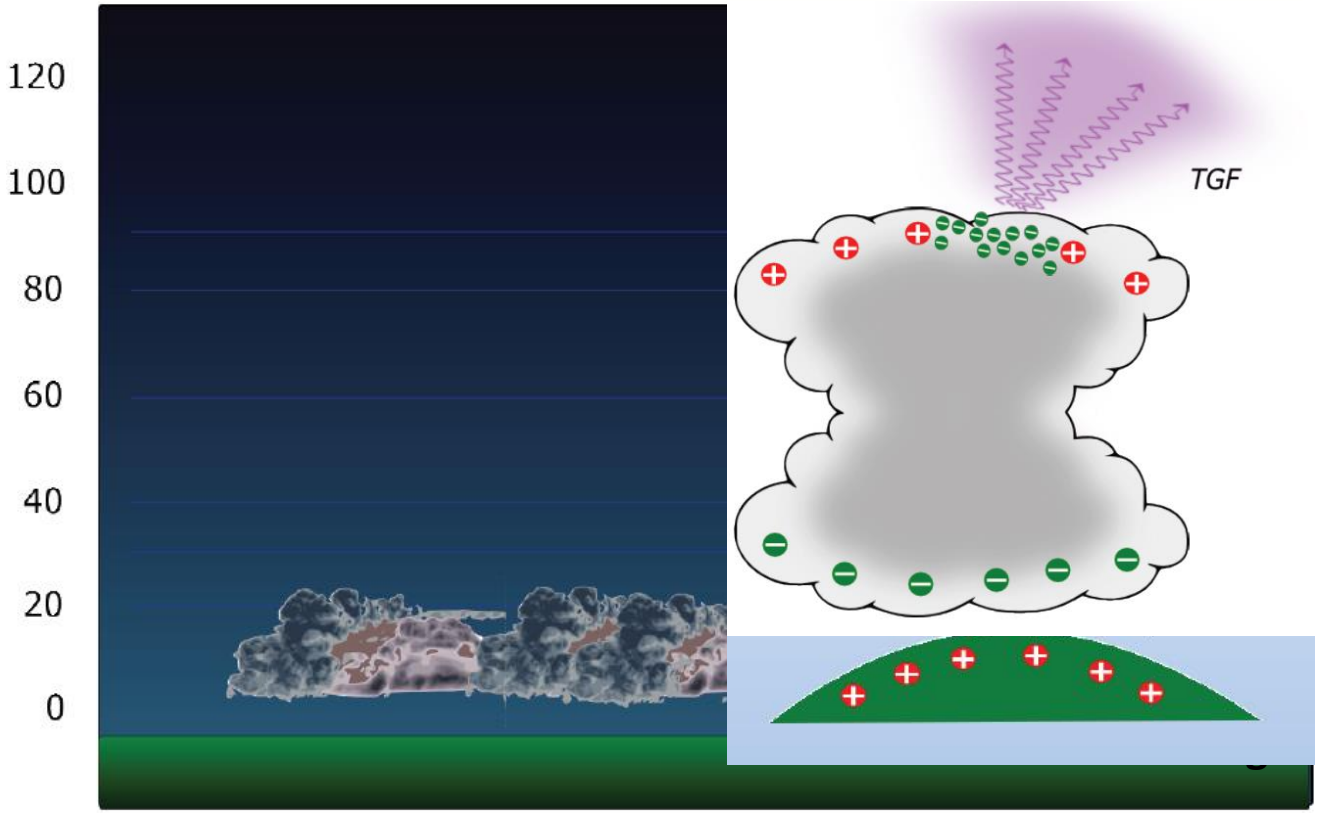
Radiation Damage and Activation

Acrorad and EURORAD CdTe detectors tested at ICNAS, Coimbra, cyclotron proton beamline.





Spin-off: Flight Security



Dissemination and Outreach

Portugal Space Summer School

Astronaut Summer School

Future Steps

- All-Sky-ASTROGAM selection for launch by 2026.
  - Mass model simulation;
  - Calorimeter development (PRODEX ?);
  - Experimental instrument characterization and radiation damage.

- AHEAD 2 activities: Development of CUBECOM demonstrator.
  - Next H2020 Scientific Space Instrumentation Call by 2020.

- AMEGO
  - Pair production polarization and scientific case;
  - Instruments' characterization and eventually more (PRODEX ?);

- IXPE mission:
  - Study mixtures of noble and quenching additive gases (DME or isobutane);
  - Development of gas testing system to measure the transverse spreading of the electron clouds produced by X-rays;