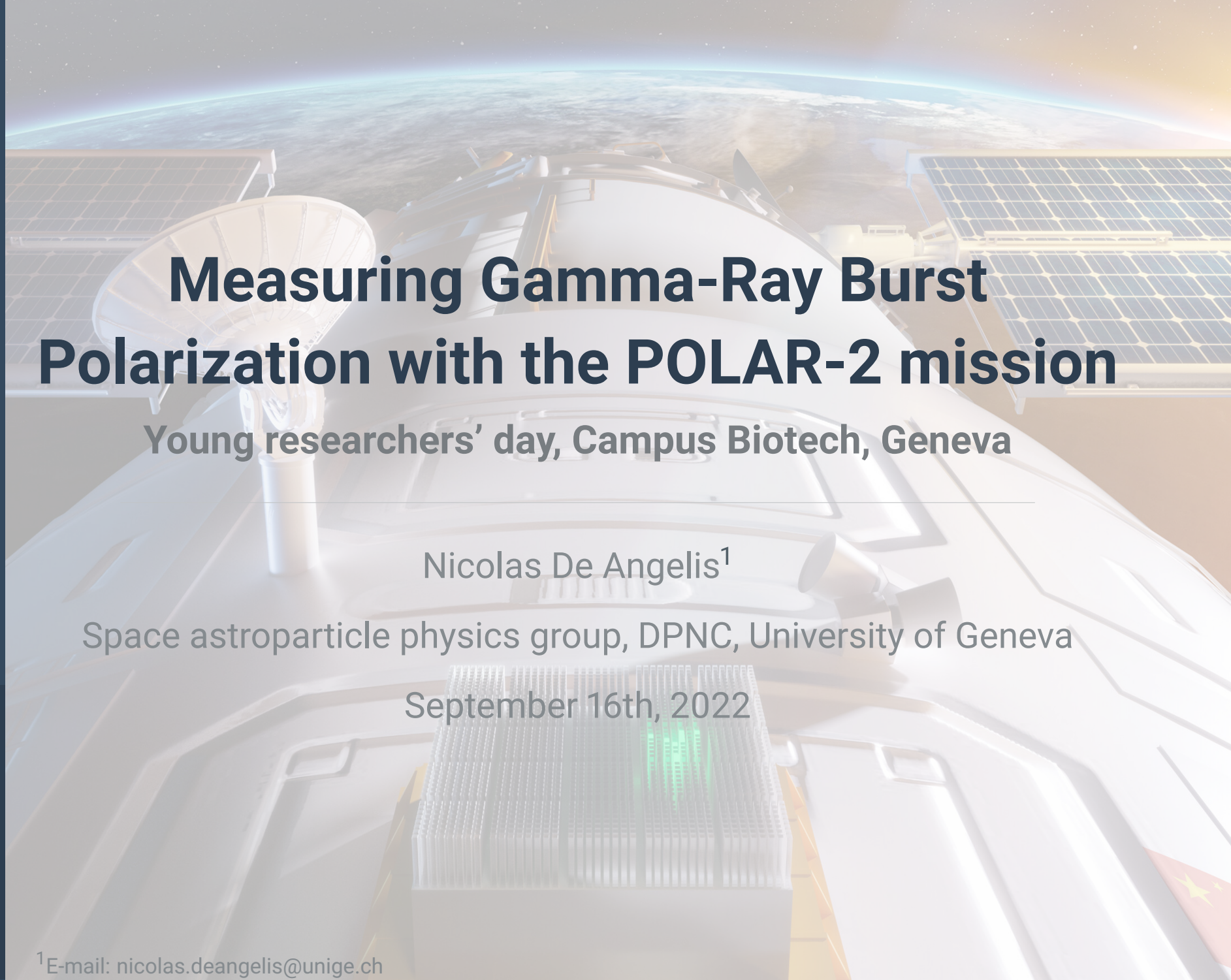

Measuring Gamma-Ray Burst Polarization with the POLAR-2 mission

Young researchers' day, Campus Biotech, Geneva

Nicolas De Angelis[1]

Space astroparticle physics group, DPNC, University of Geneva

September 16th, 2022

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Gamma-Ray Bursts paradigm

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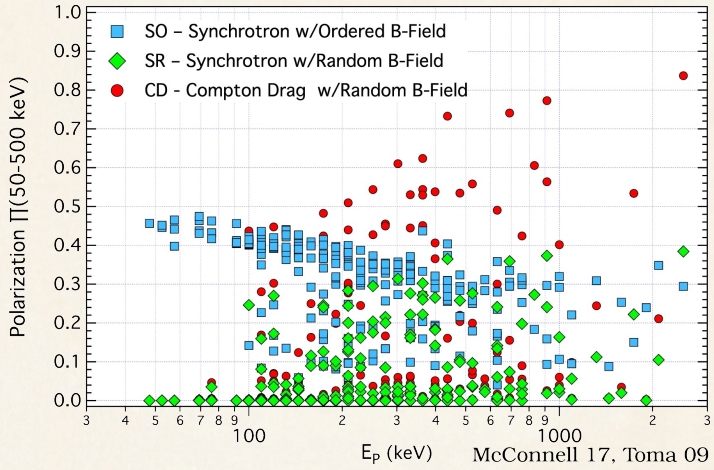
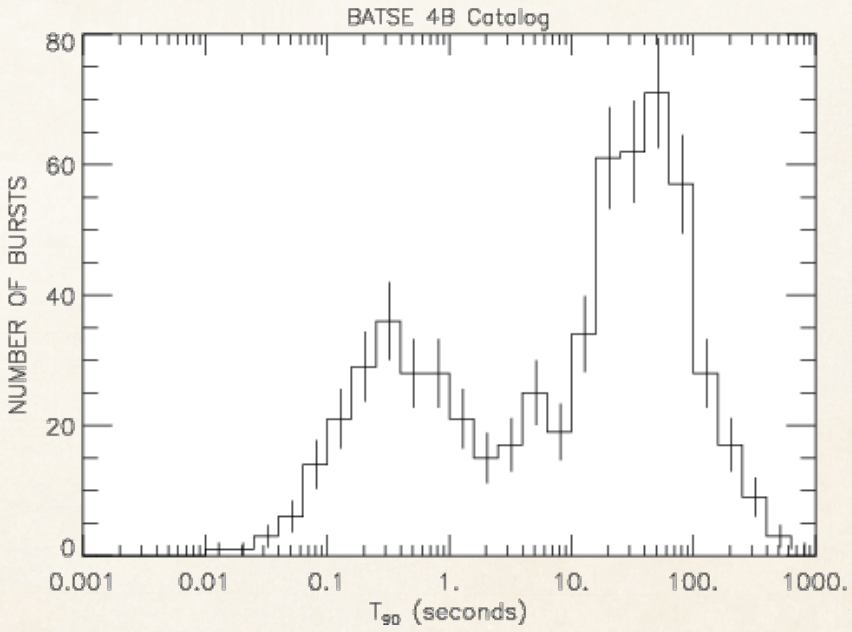
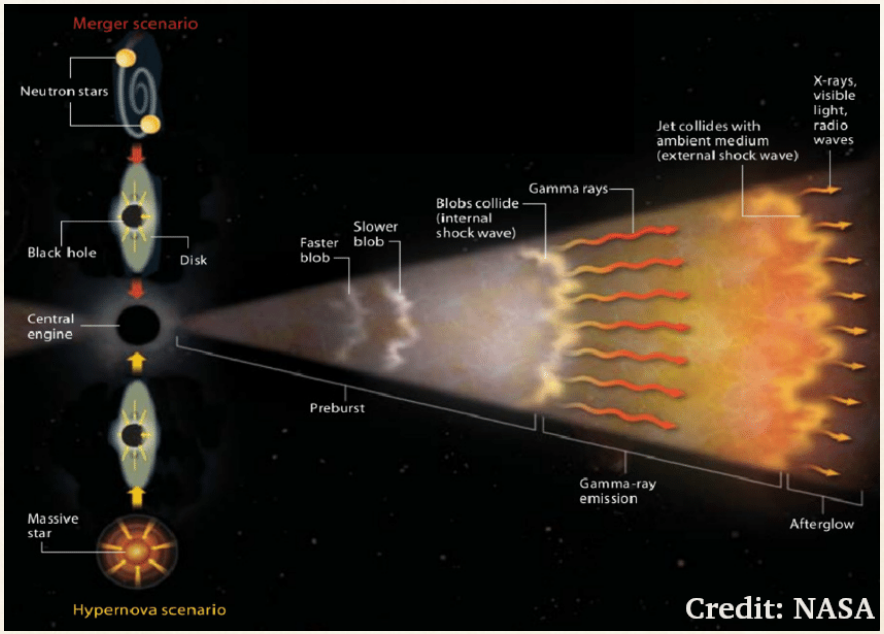
- Bright and short transient event in γ-ray (prompt emission) followed by an afterglow (from X-ray to radio)
- Extragalactic sources, 2 types: short (from BNS) and long (from SN)
- Polarization brings a better understanding of the jet and magnetic field structures







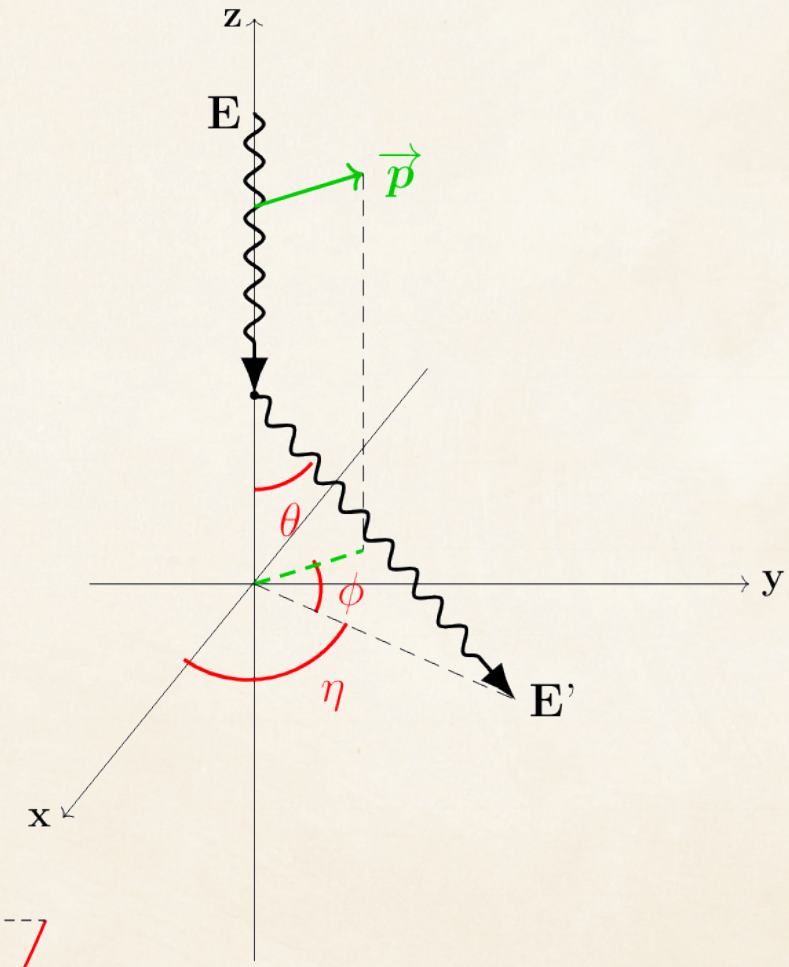
Polarimetry with the Compton scattering

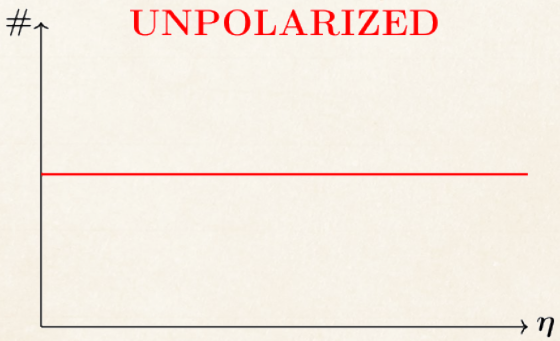
Compton scattering can be used to determine the polarization of a source:

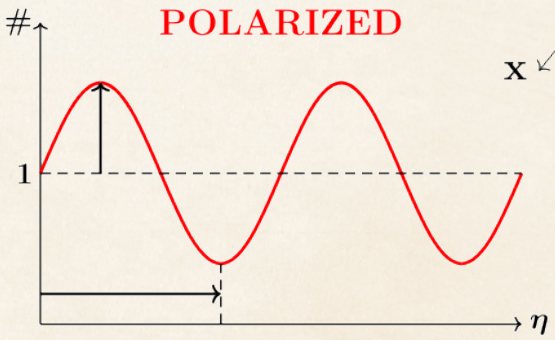
- Azimuthal scattering angle distribution provides information on polarization degree and angle
- So called modulation curved, parametrized by the Klein-Nishina cross-section:

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

- Relative amplitude $\leftrightarrow$ PD, phase $\leftrightarrow$ PA







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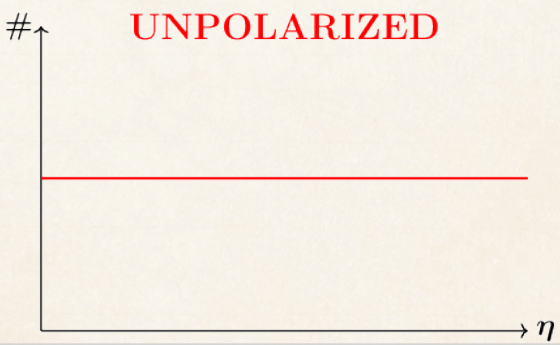
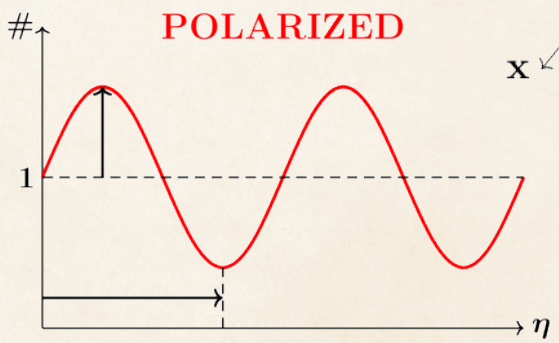
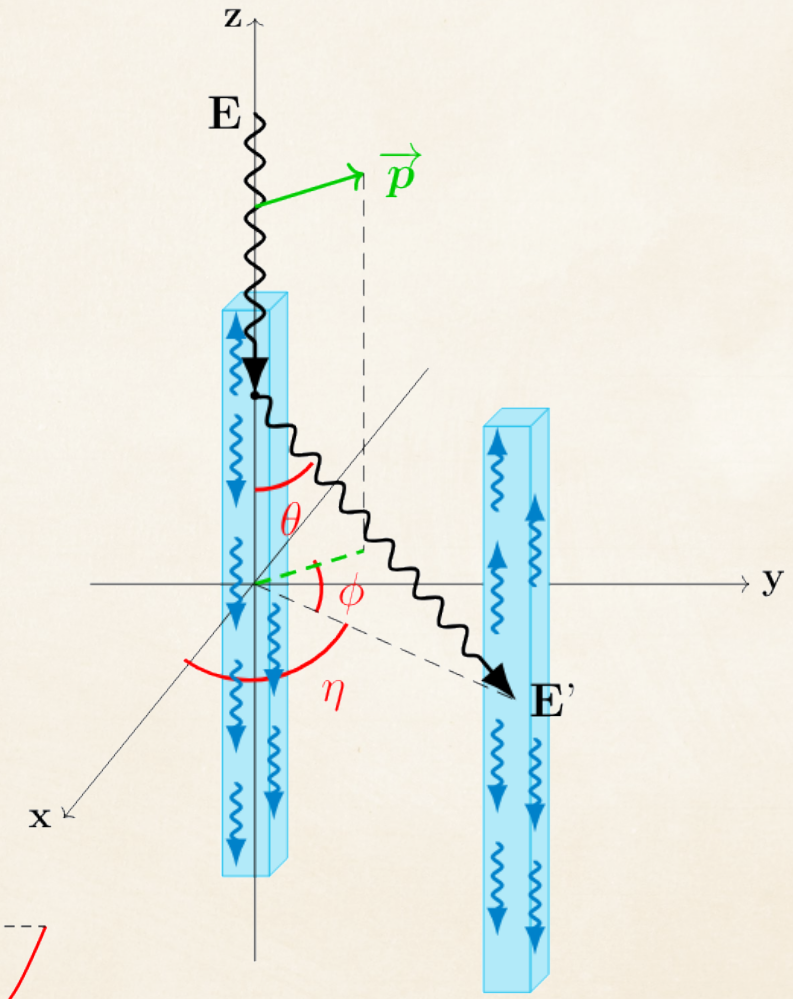
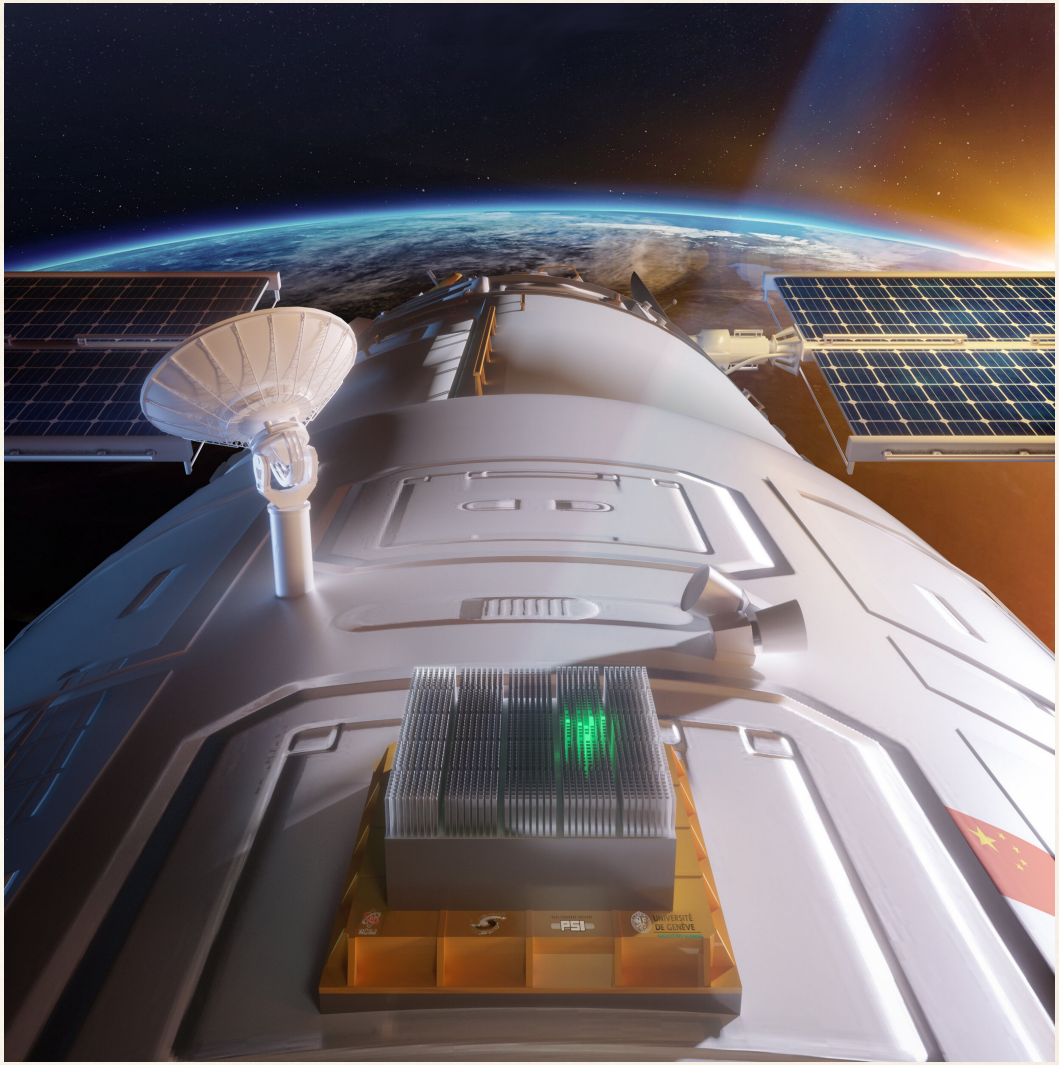
- Relative amplitude $\leftrightarrow$ PD, phase $\leftrightarrow$ PA
- **A segmented array of scintillators can be used to measure the scattering angle distribution (aka modulation curve)**







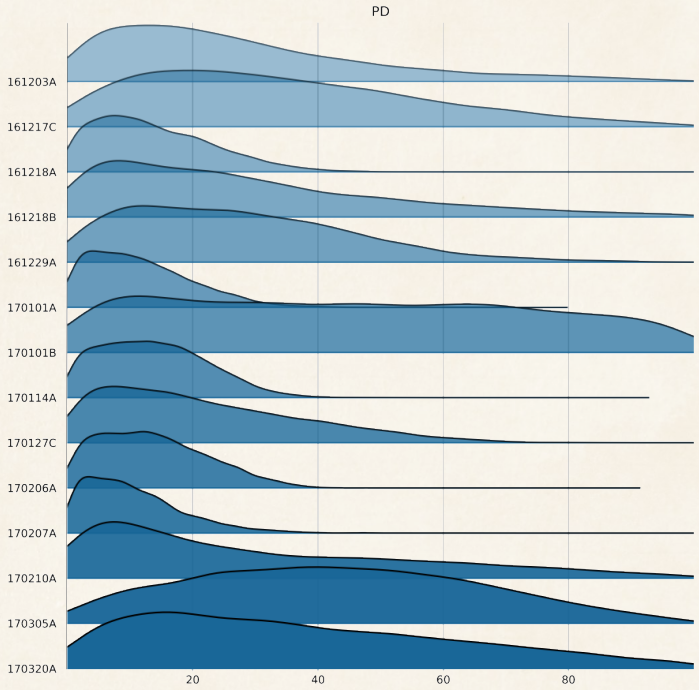
The POLAR instrument



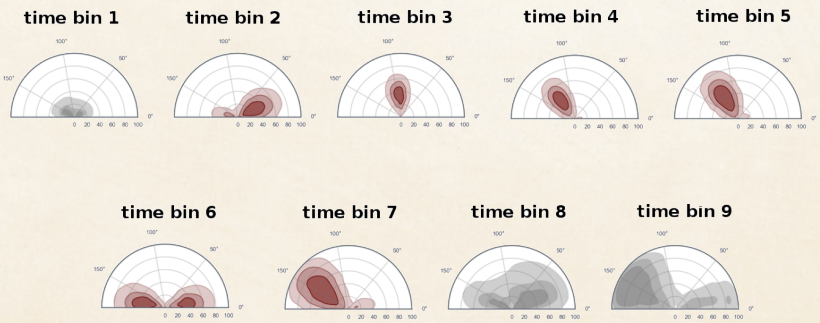
- Array of 40×40 scintillator bars divided into 5×5 modules
- Each bar individually read out by light sensor (so called Multi-Anode PMTs)
- 30kg instrument, half-sky FoV, sensitive in the range 50-500 keV
- Launched in Sept 2016 on the Tiangong-2 Chinese space lab for 6 months of operation

What we learned from POLAR

- 55 GRBs detected, catalog of 14 GRBs analysed, results show a low or null polarization degree (excluding synchrotron emission models from toroidal magnetic field, compatible with photospheric emission model and other synchrotron models)
- Time resolved analysis show a hint of quickly evolving polarization angle that washes out polarization degree on time integrated analysis $\Longrightarrow$ need more statistics to make proper time resolved analysis $\rightarrow$ **the POLAR-2 mission**



A&A 644, A124 (2020)



A&A 627, A105 (2019)

The POLAR-2 mission

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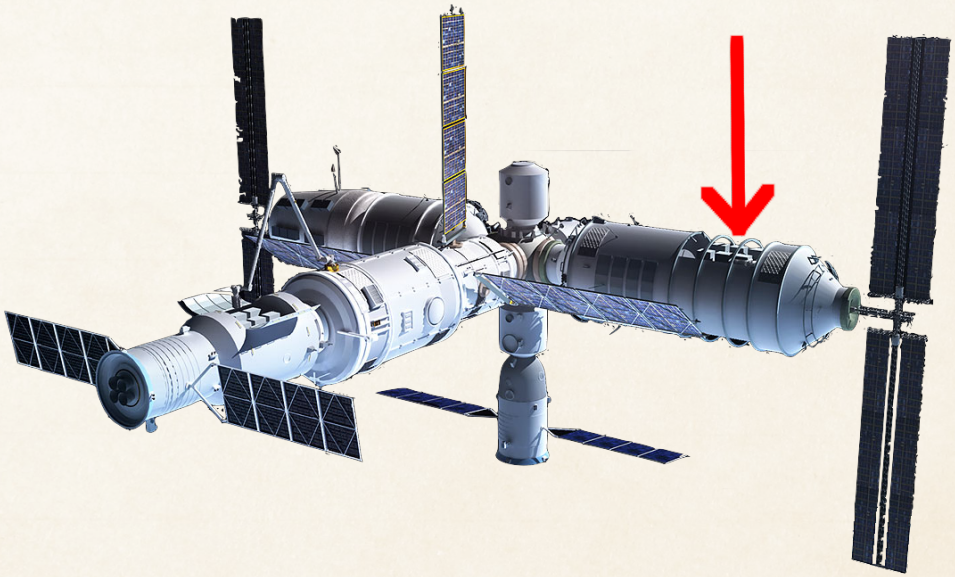
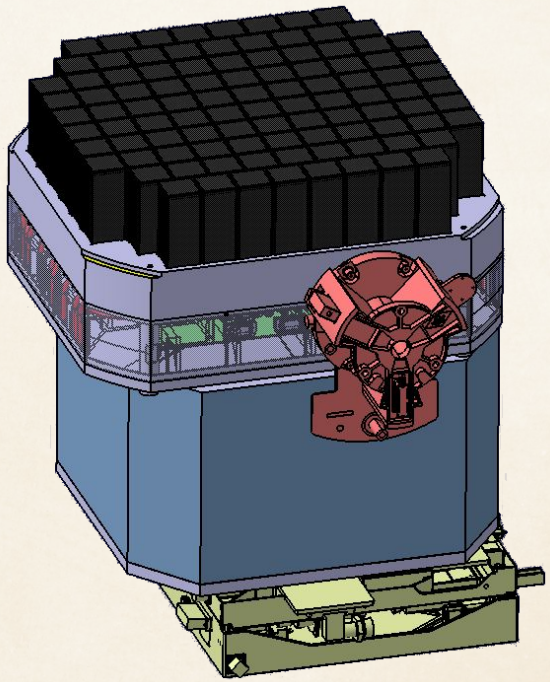
- Large scale GRB polarimeter based on POLAR legacy
- 4 times bigger than POLAR (from 25 to 100 polarimeter modules), 10 times more efficient (thanks to an improved design of the polarimeter modules)
- Lowered energy threshold to a few keV
- Equipped with spectrometer modules (CeBr3 or LaBr3) for joint spectral, localization, and polarization analysis
- Launch on China Space Station early 2025 (matches LIGO/VIRGO O5 run, possibility of joint observations with GW)



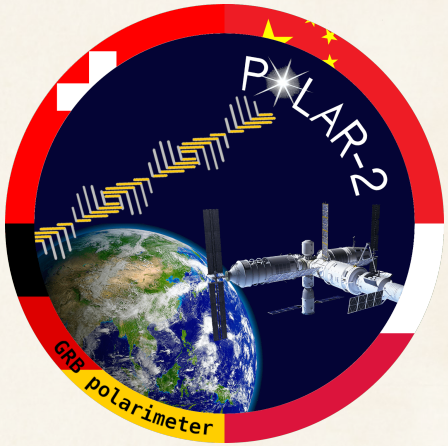


The POLAR-2 collaboration

About 20 people working on POLAR-2 from 4 countries:

- UniGe (DPNC), Switzerland: Management, polarimeter modules, instrument thermal and mechanical integration
- UniGe (DA), Switzerland: Online software system
- NCBJ, Poland: Back-End Electronics, Power Supply
- IHEP, China: Flight Model Acceptance, Spectrometers
- MPE, Germany: Qualification & Verification, Spectrometers

More info on `https://www.unige.ch/dpnc/polar-2`.



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Narodowe Centrum Badań Jądrowych
National Centre for Nuclear Research
ŚWIERK

中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

MPE
Max-Planck-Institut für extraterrestrische Physik

Anticipated performances and status of POLAR-2

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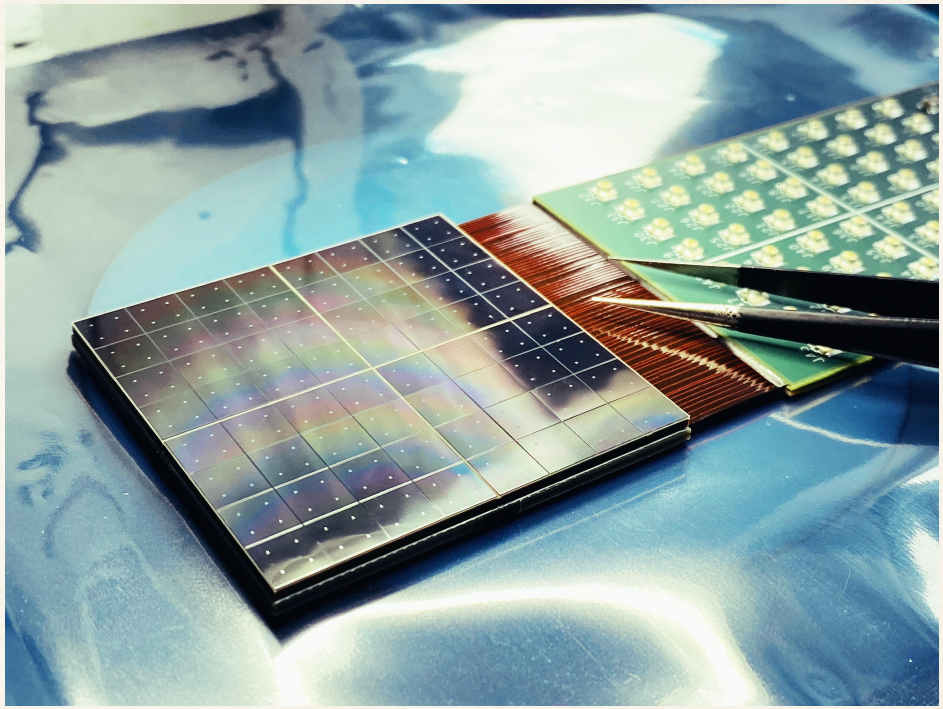
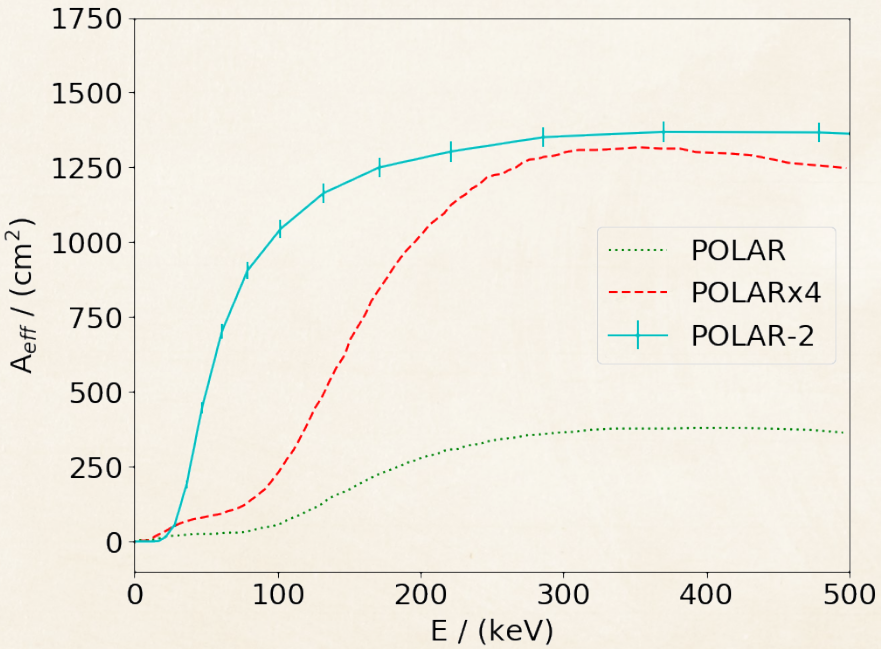
- Several technological/design improvement, the main one being the upgrade from MA-PMTs to SiPMs (Silicon PhotoMultipliers)
- POLAR-2 is 4 times bigger, but its effective area will be 10 times better (e.g. for GRB170114A, 26.4° off-axis in POLAR FoV)





- Polarimeter module design finalized, several prototypes built, already qualified for vibration/thermal/vacuum on single module level

Thank you for your attention !

unige.ch/dpnc/polar-2