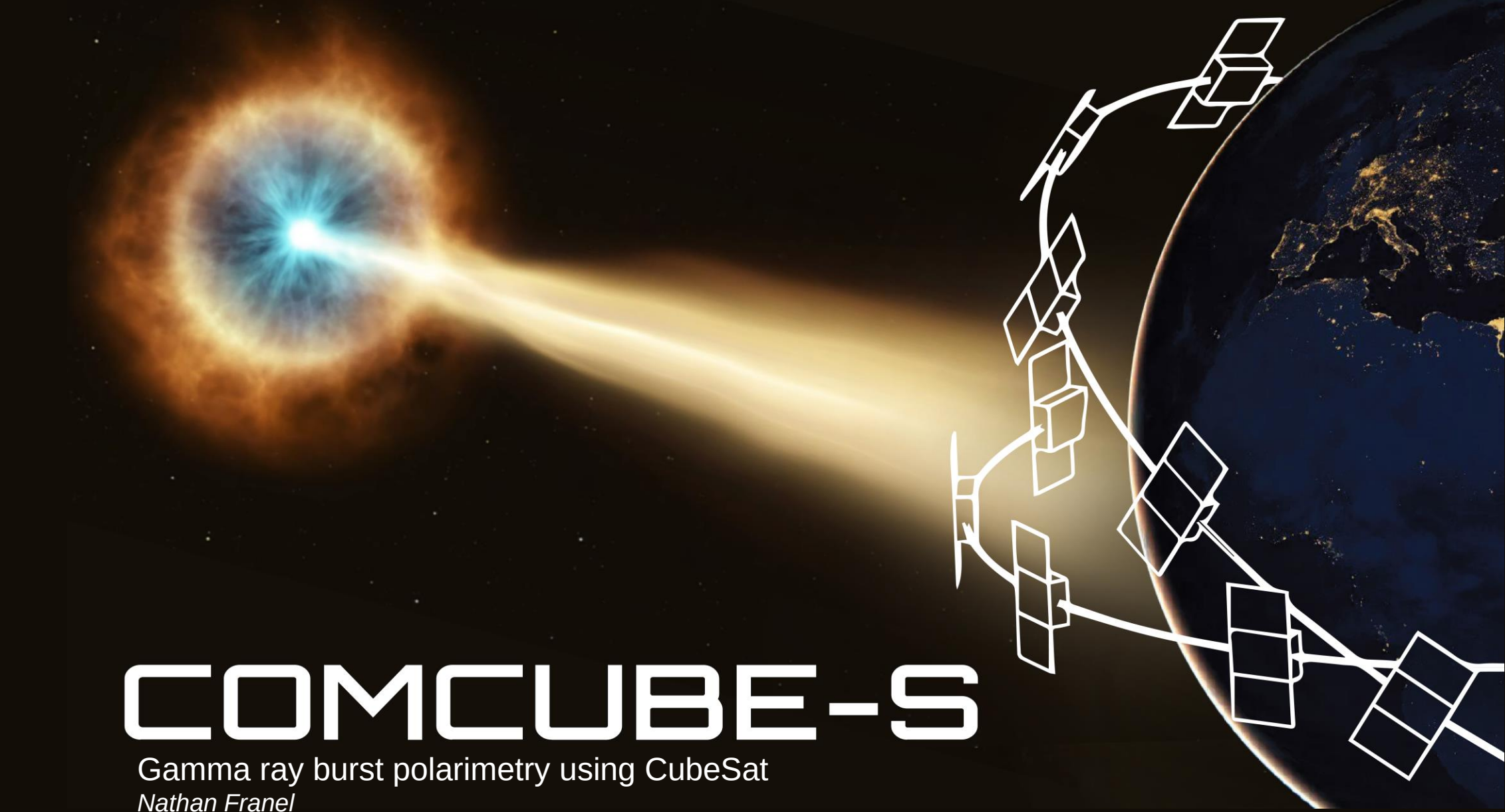


COMCUBE-S

Gamma ray burst polarimetry using CubeSat

Nathan Franel

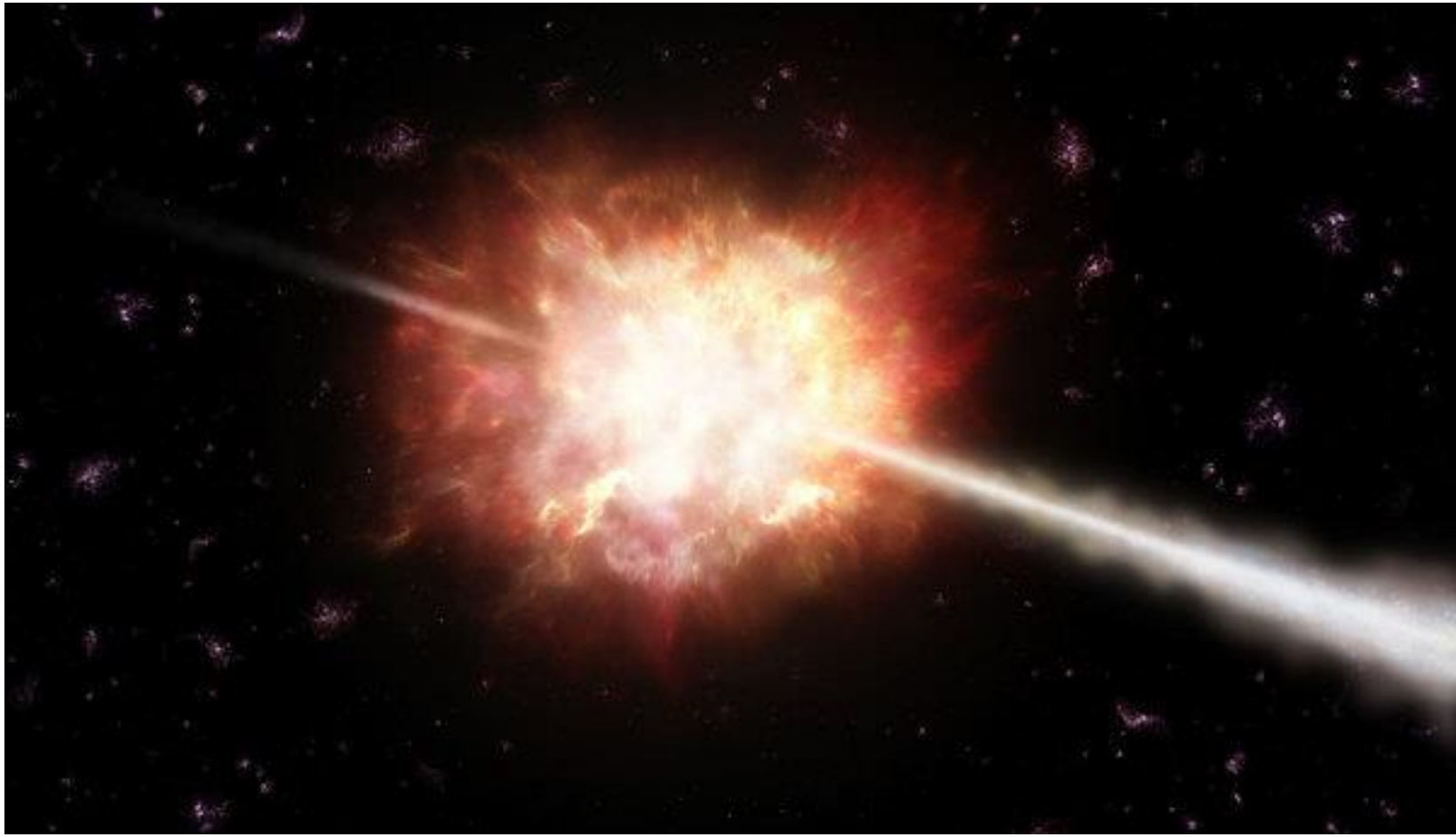
I. General Context

II. Simulations

III. Transatlantic balloon flight

IV. Perspectives

General context

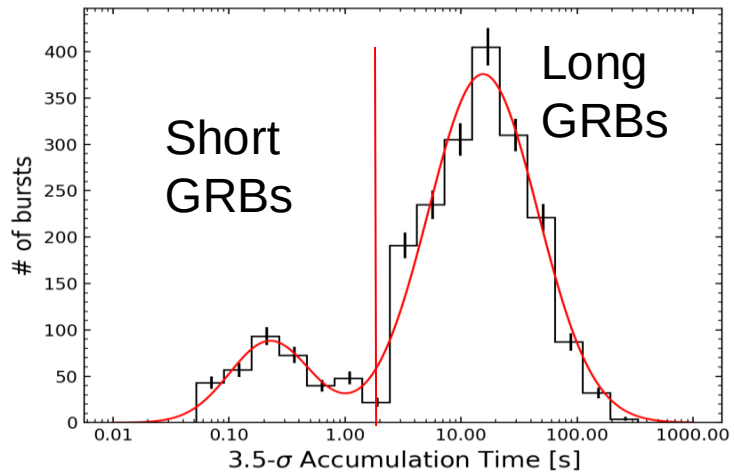


General Context

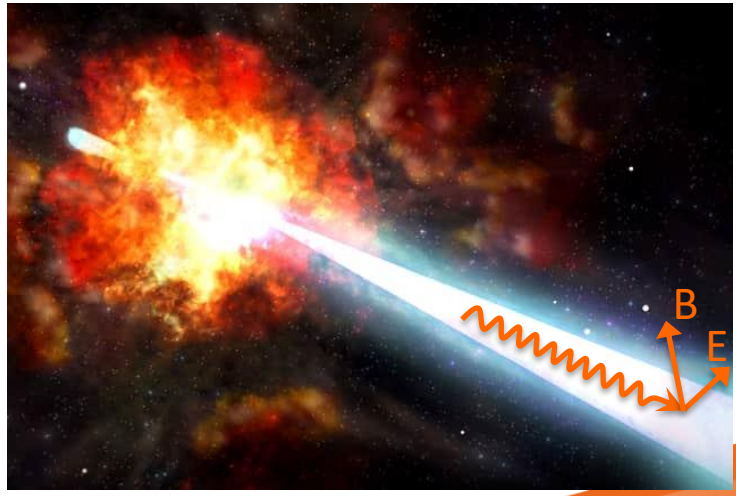
Prompt phase + Afterglow phase		
	Long bursts	Short bursts
Duration	> 2s	< 2s
Progenitor	Core collapse supernovae	Compact binary merger
Spectrum	Softer	Harder
	Spectrum peaking at ~100s of keV	

More and more **photometric** and **spectrometric** data on GRB :

SVOM, Fermi, Swift, CGRO

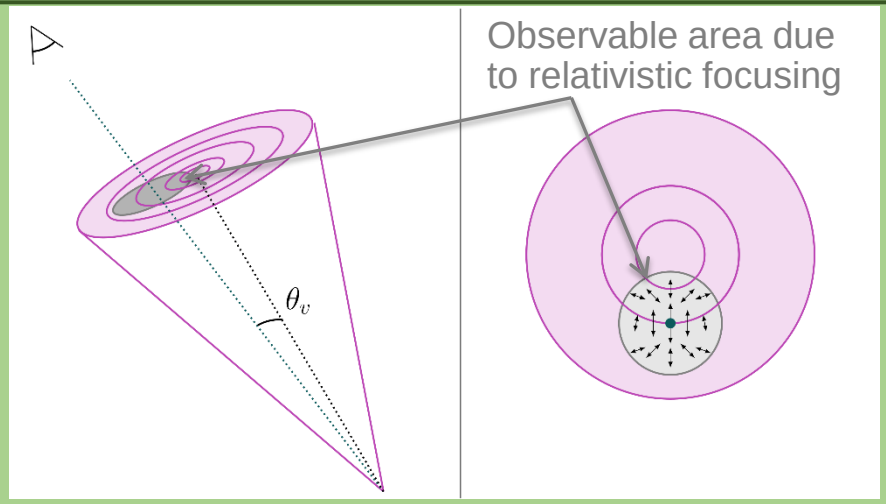


GRB duration obtained with Fermi GBM (Poolakkil et al., 2021)



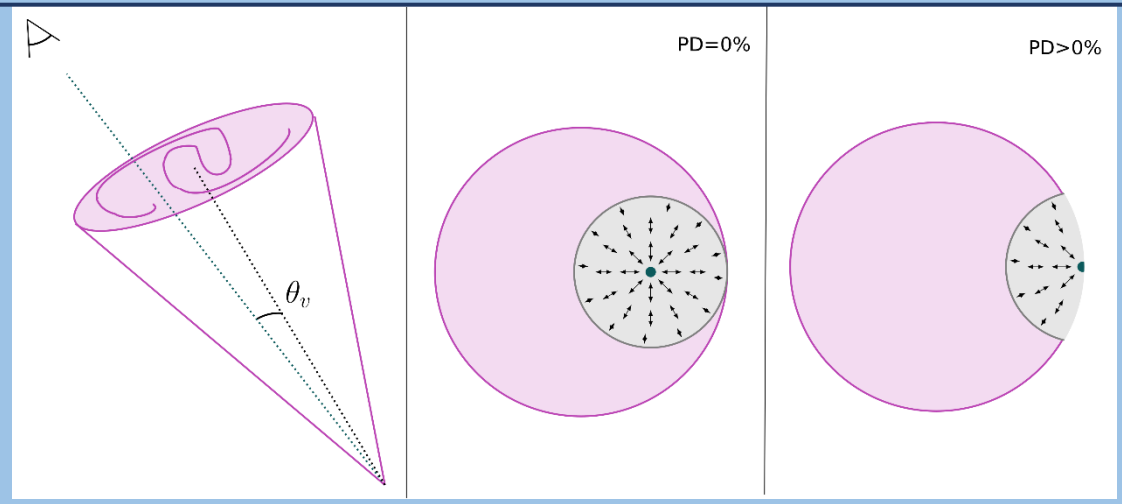
Poor knowledge of the jet physics

Jet energy **dominated by magnetic fields**



- Energy dissipation through **B-field reconnection**
- **Synchrotron** radiation in **ordered B-fields**

Matter-dominated outflow



- Energy dissipation through **internal shocks**
- **Synchrotron** radiation of electrons in **turbulent B-fields**

Different jet physics offer different polarisations of gamma rays

Polarisation could be a powerfull probe of the jet emission processes

ESA proposal : COMCUBE-S

COMCUBE-S

- **Project in phase A study at ESA** to measure polarisation of GRB prompt phase
- **European collaboration** : IJCLab (France), UCD (Ireland), Clyde Space (UK), CEA (France), KTH University (Sweden)

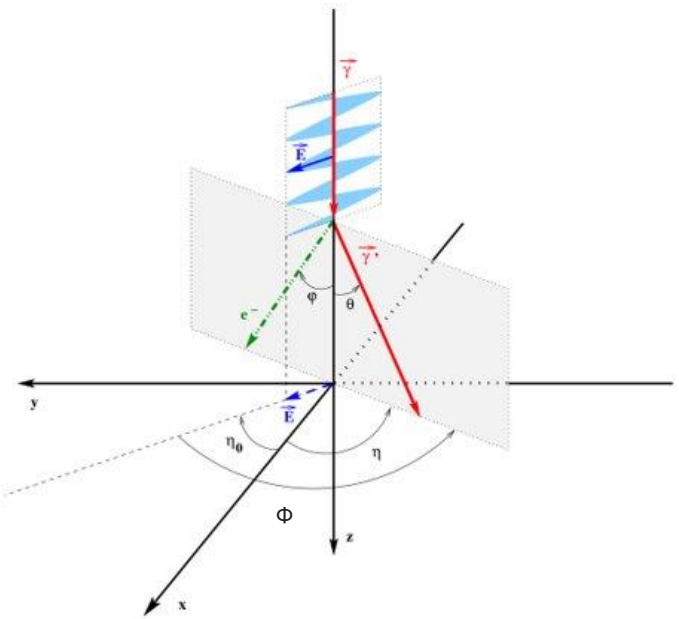
Baseline configuration :

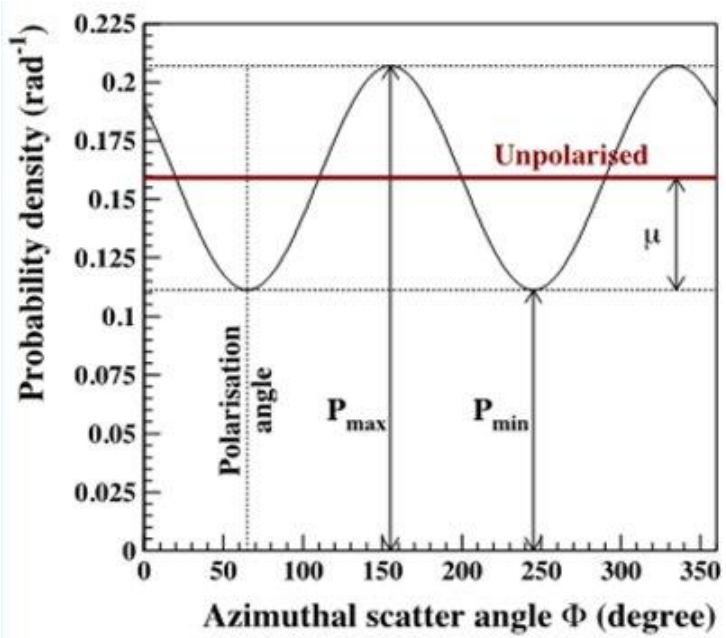
- Constellation of **27 Compton telescopes** equally spaced on an **equatorial orbit at 500km** of altitude.
- **16U spacecrafts** (20cm x 20cm x 40cm) including a **4U Compton polarimeter**
- Performs **polarimetric**, **spectrometric** and **photometric** measurements of **GRB prompt emission**.
- **Rapid follow-up** for multi-wavelength and multi-messenger astronomy with a **full sky field of view**.

Polarimetry is done using Compton scattering

- Photons' **scattering plan** is more likely to be **perpendicular to the polarisation vector**.
- We use a **histogram** (polarigram) to estimate the **fraction of light that is linearly polarized** :

➡ **Polarisation fraction**

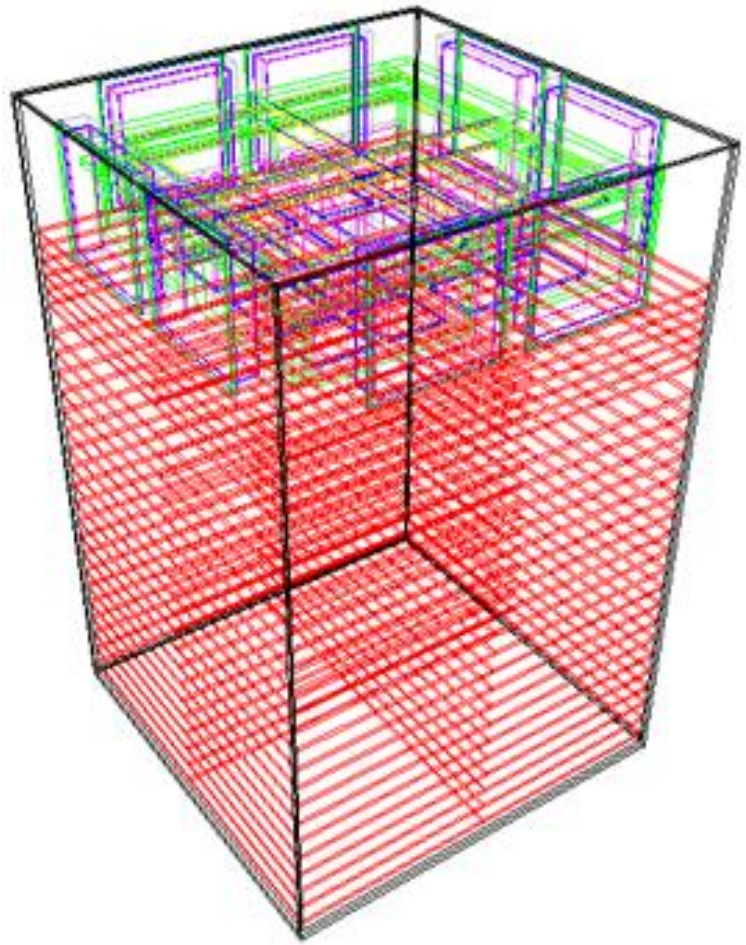




Polarimeter sensitivity

Minimum detectable polarisation (MDP)

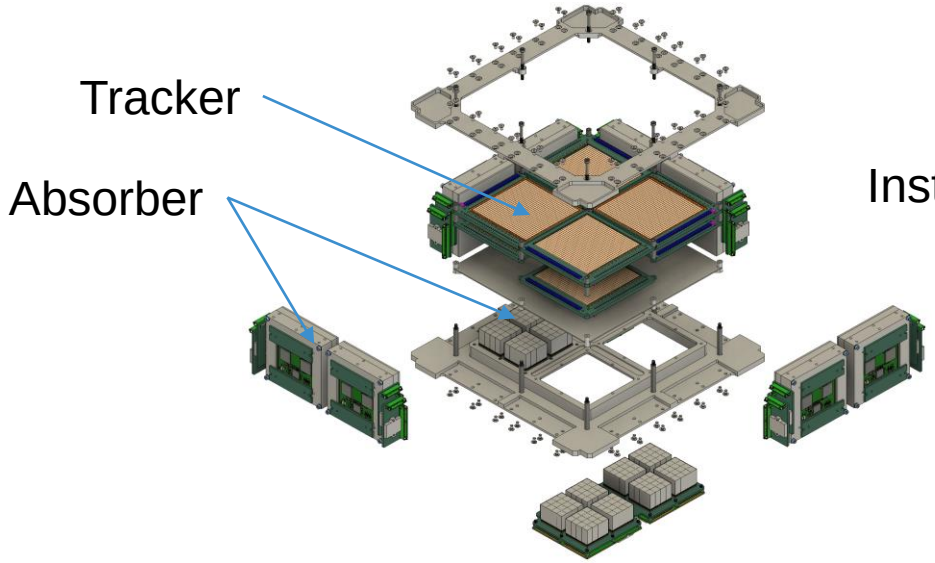
Simulation and estimation of the constellation performances



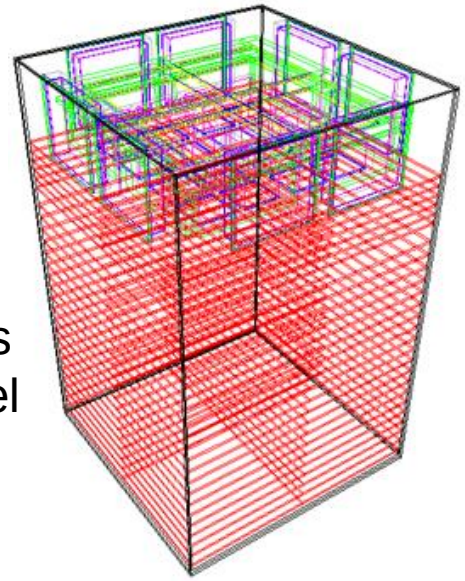
MEGAlib

MEGAlib simulations → Based on GEANT4

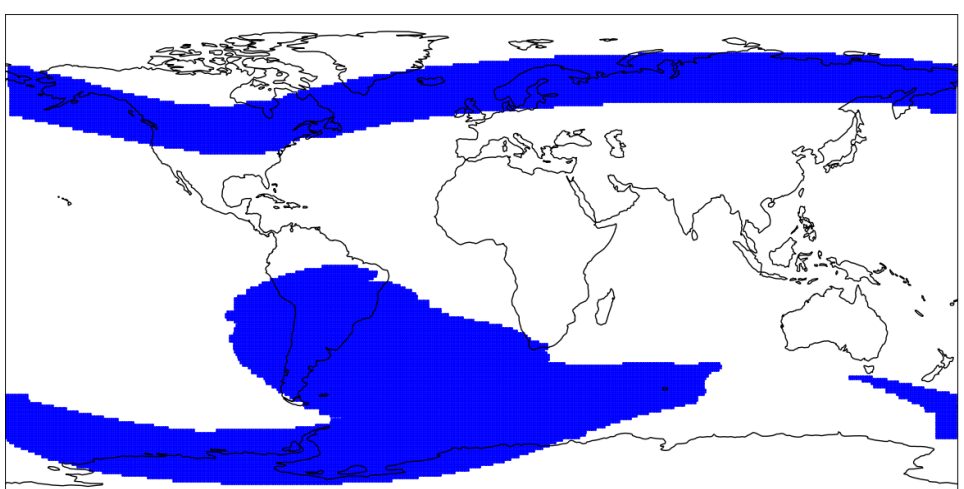
- Detector mass model
- Source spectrum
- Source duration and/or light curve



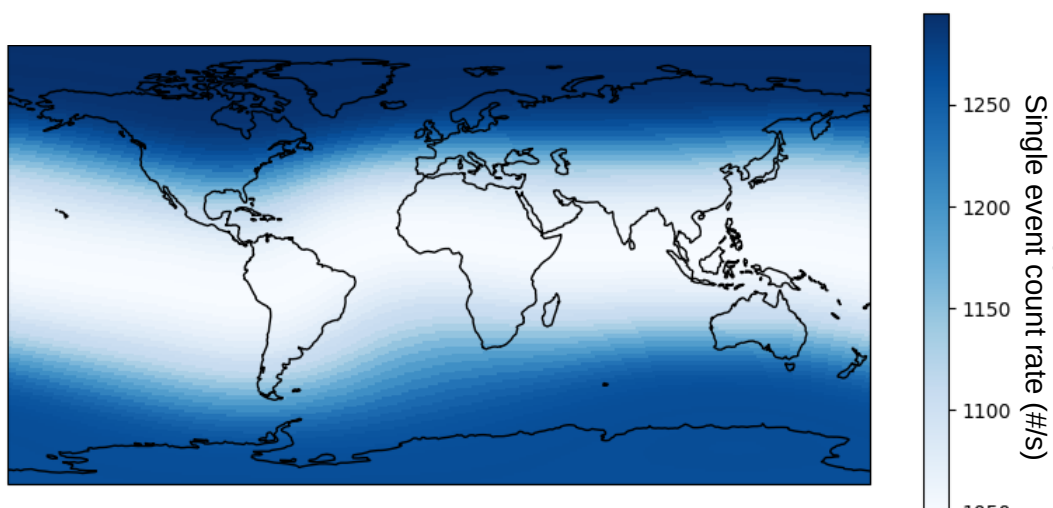
Instrument → Mass model



Van Allen radiation belts
Non operation area
From NASA's AP8min and AE8 max models

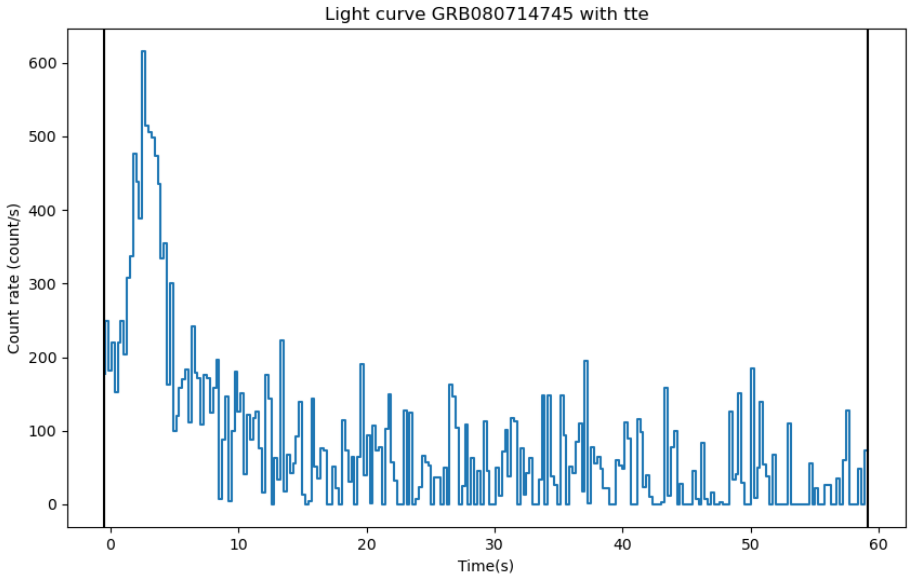


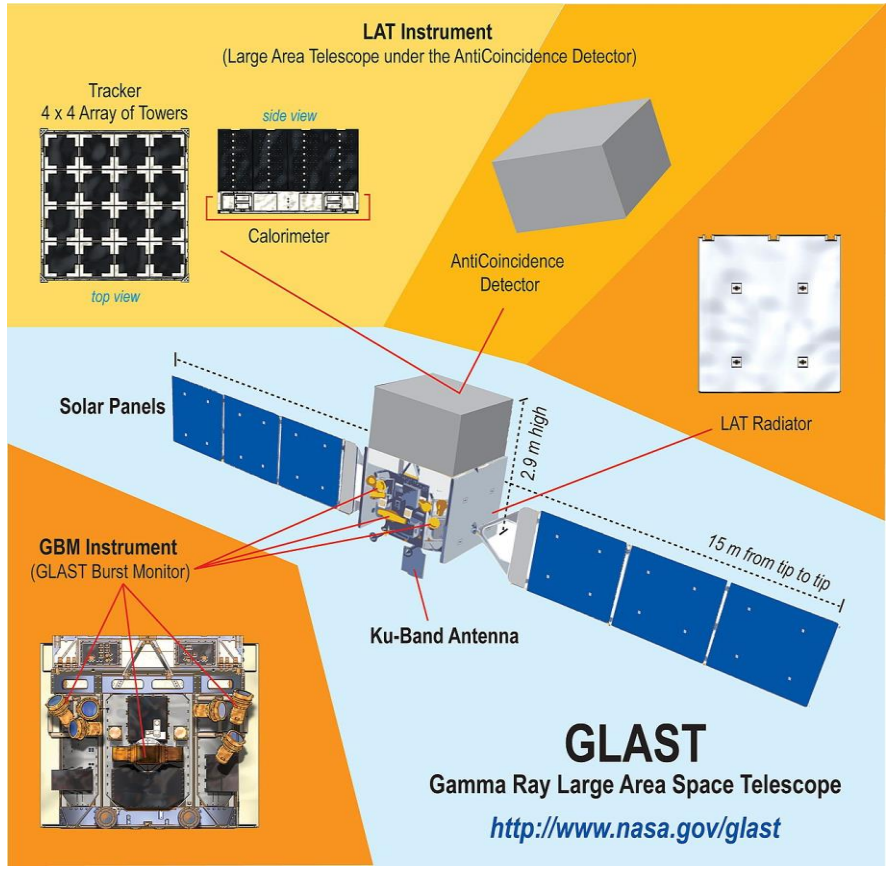
Background estimation
Particles spectra based on Cumani et al, 2019



Simulating GRBs

- Light curves and spectra are needed for simulations
  - **Taken from the Fermi GBM GRB data**
- The GRBs are simulated at a **random time** and a **random position** in the sky
- A simulation is done if a **GRB is in the field of view** of a satellite that is **not in a non operation area**





Results

Detection strategy based on SNR thresholds

GRB detection rate

380 GRB/year

Mean total effective area for single events

1536 cm²

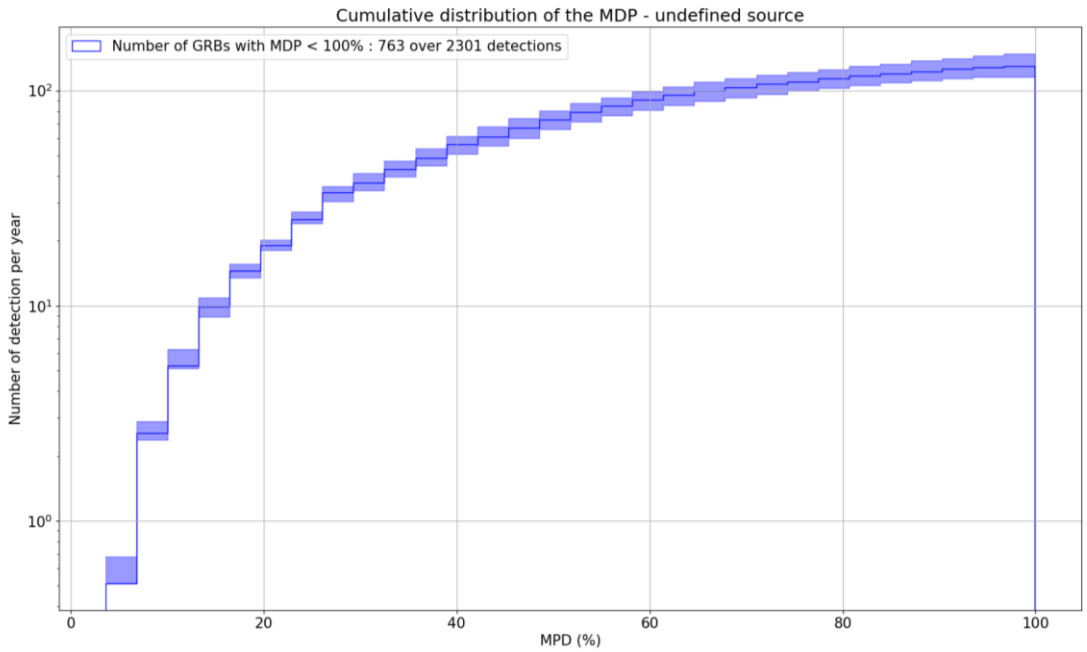
99.5% of GBM burst simulated detected

Effective area greater than that of GBM

→ **GRB fainter than those in GBM** catalogue are needed for a better estimation of the detection rate

GRB detected with MDP < 30%

35.6/year

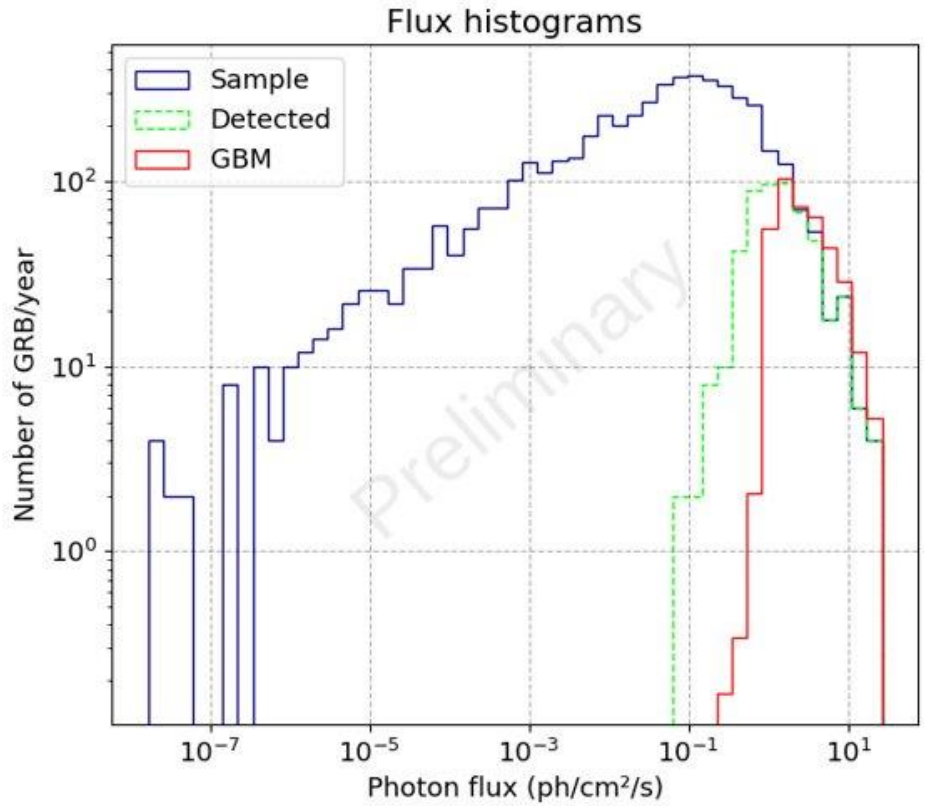


Simulating fainter GRBs

- Spectral **parameters** and time durations **from distributions**
  - **Duration, spectral index** : GBM
  - **Redshift** : *Lan et al. (2019), Lien et al. (2014), Ghirlanda et al. (2016)*
  - **Luminosity** : *Ghirlanda et al. (2016), Lien et al. (2014)*
  - **Correlations** : *Ghirlanda et al. (2016), Yonetoku et al. (2010)*

  These **distributions** are mostly power laws **obtained with observations**

- **Sample calibrated with Fermi GBM data**



Detection strategy based on SNR thresholds

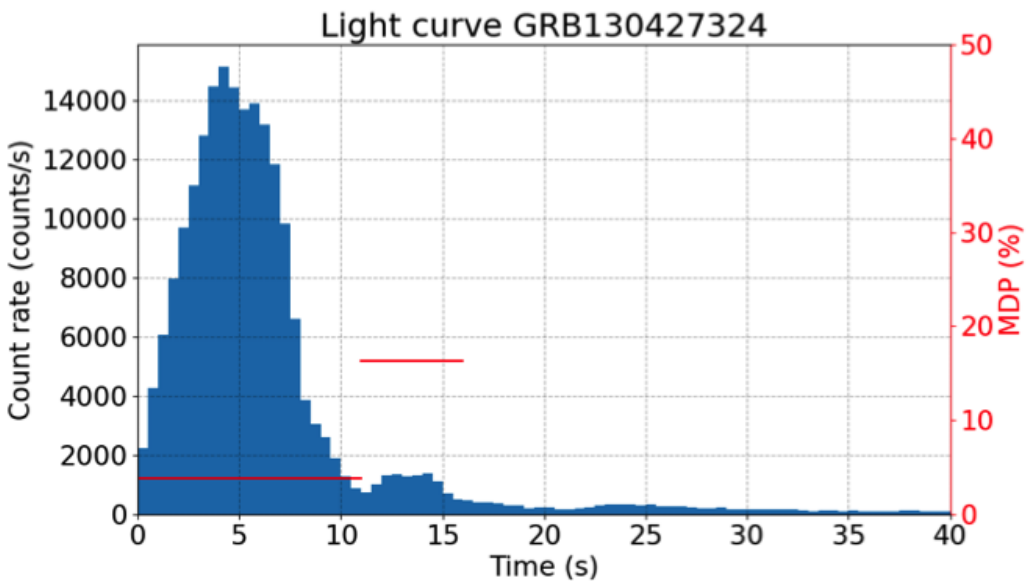
Detection rate

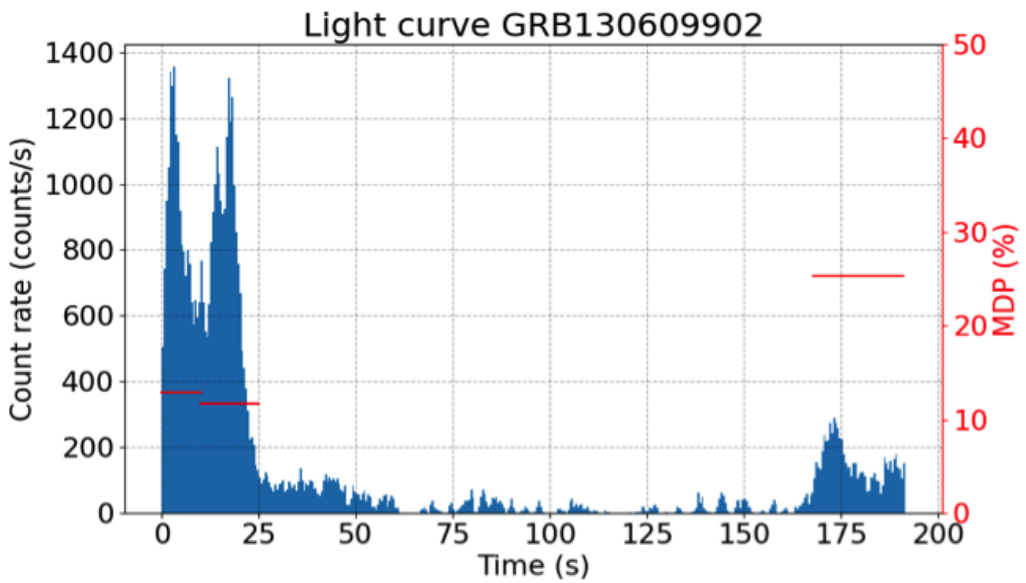
520 GRB/an

Time resolved polarimetry

Time resolved polarimetry possible for bright burst with a good sensitivity

~ 6 per year





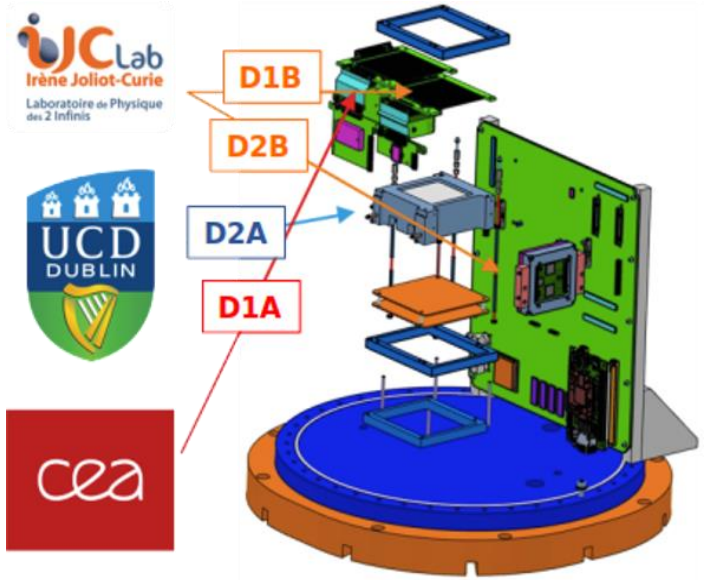
This could be a powerful probe of the jet structure

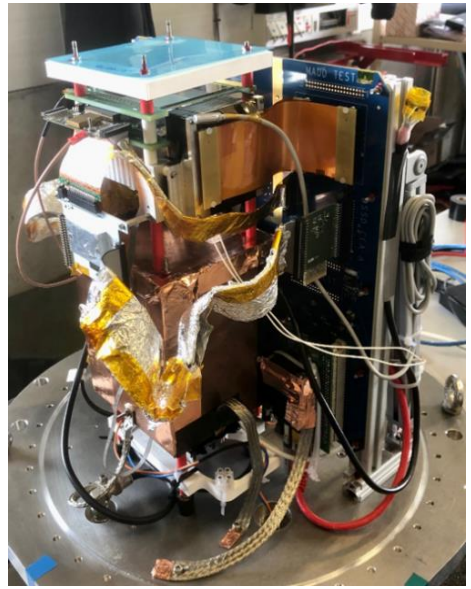
Prototype testing
-
Transatlantic stratospheric balloon flight

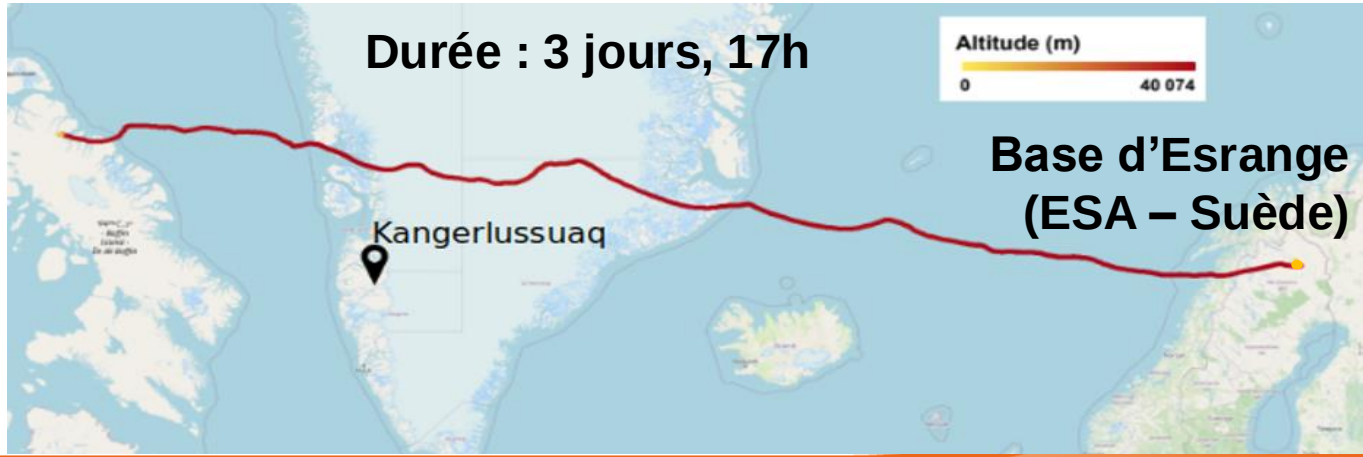
Stratospheric balloon flight

- **3 days and 17 hours flight** from Esrange, Sweden to Canada
- Launched June 23rd, 9:00PM local time
- Flight altitude : **40 km**
- Prototype :

  4 Detectors :
  - D1A : CEA silicium detector
  - D2A : UCD calorimeter
  - D1B : IJCLab silicium detector
  - D2B : IJCLab calorimeter

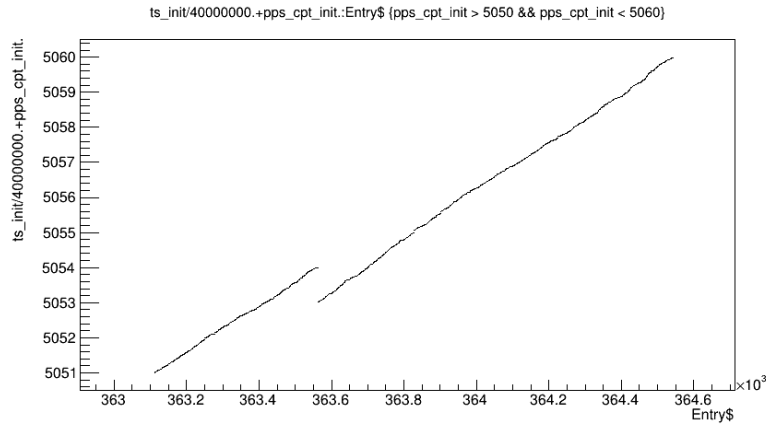


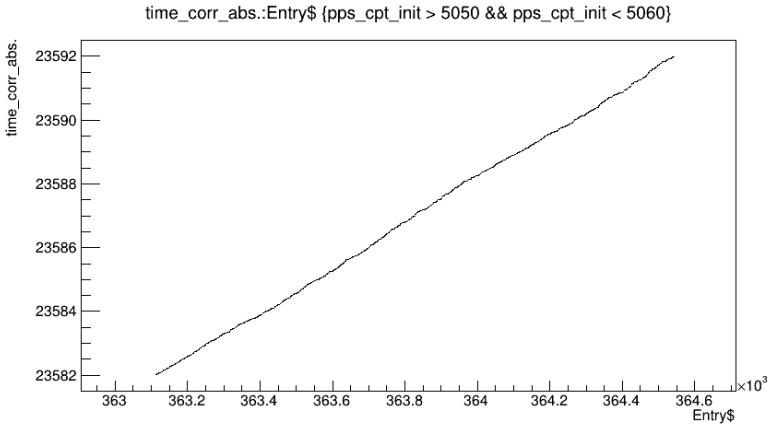




Coincidences between detectors

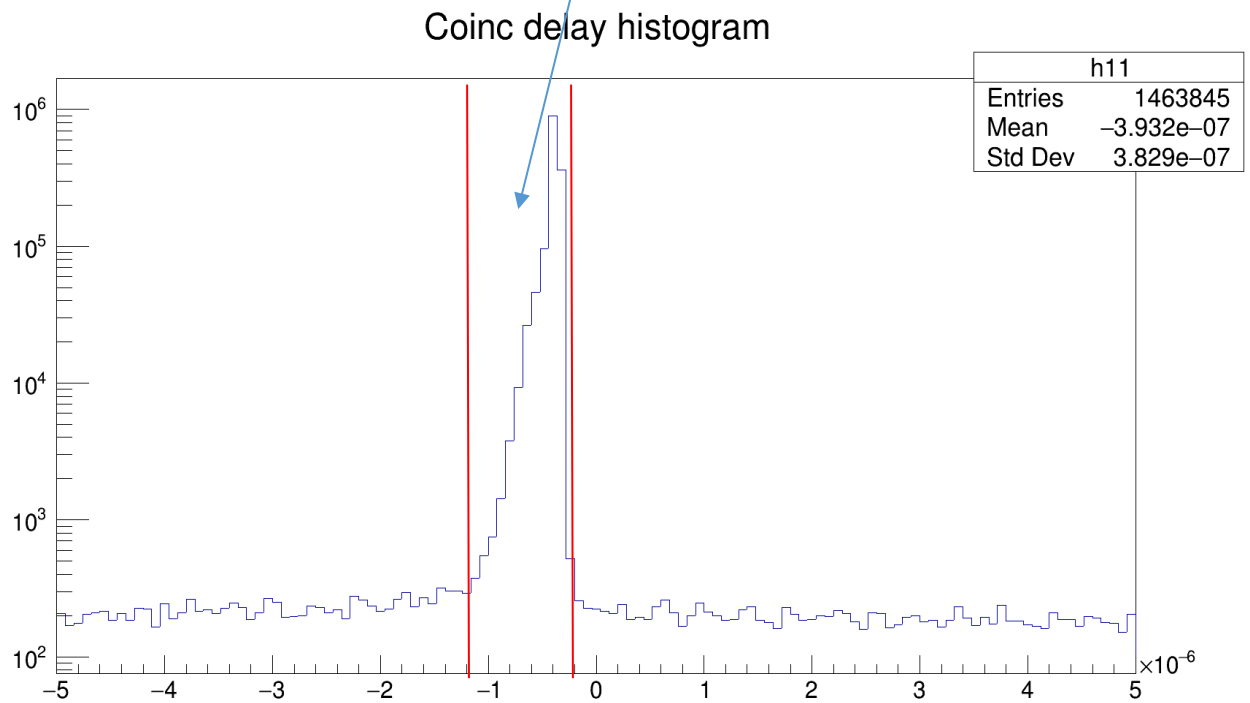
Timestamp correction





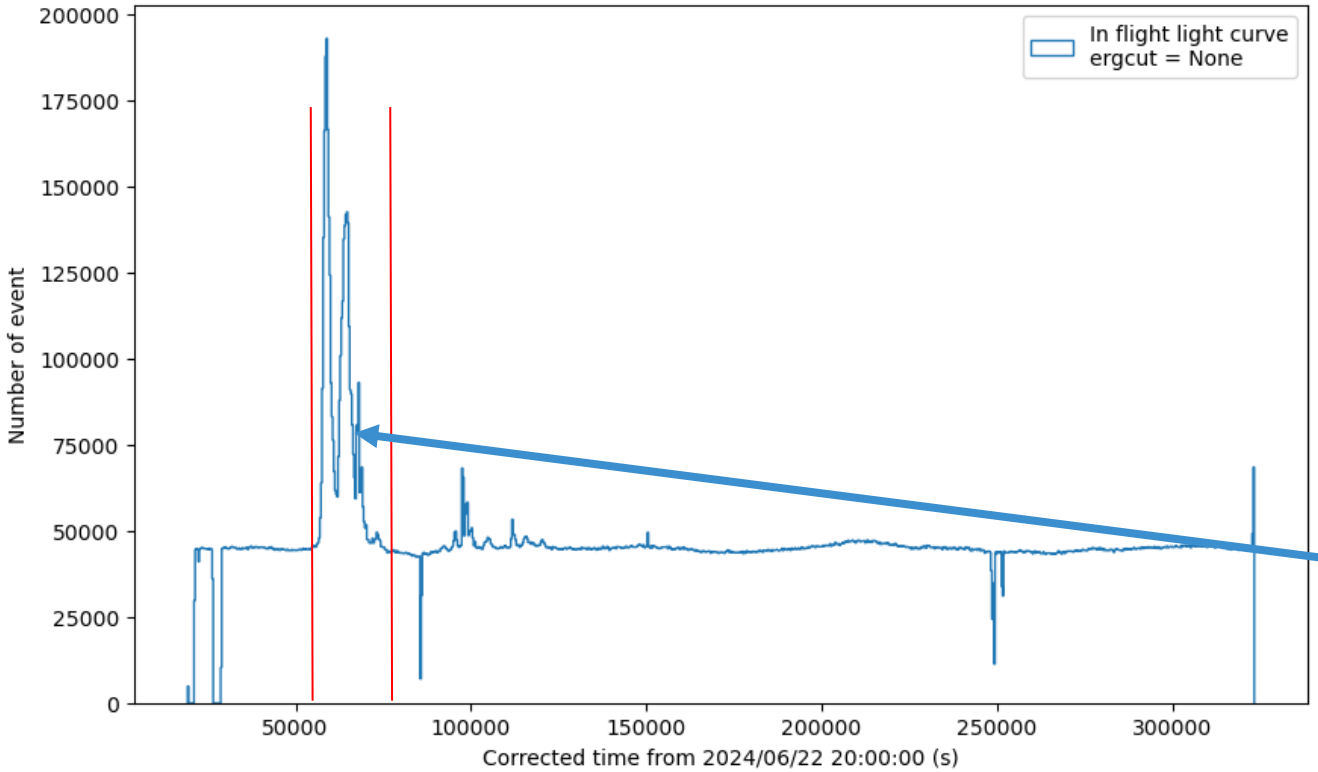
Delay between D1B and D2B for coincidences

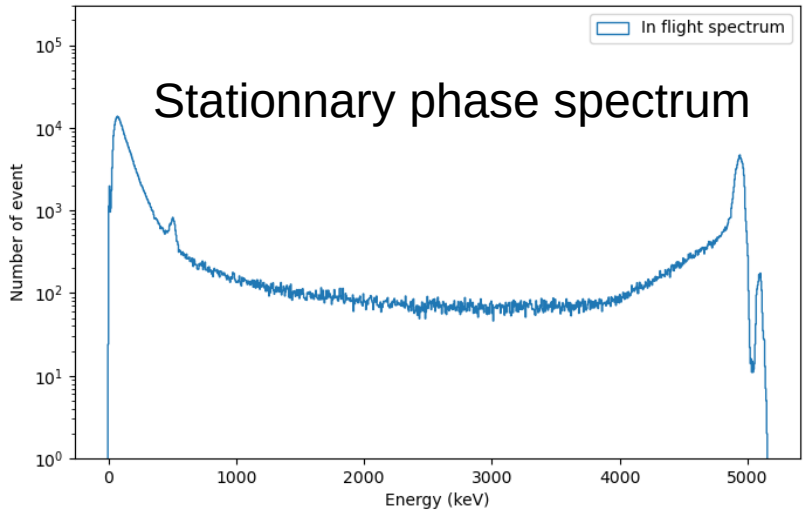
Real coincidences
1.44e6 vs 1.46e6 entries

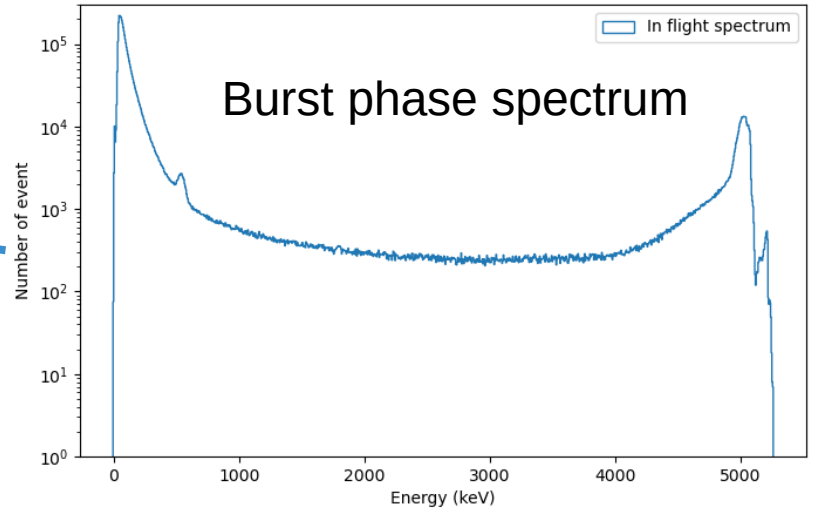


Light curves and spectra

Light curve while balloon is at 40 km







Perspectives

- Continue the **balloon flight analysis**
  - Refine the **energy calibration**
  - Make it work with **all detectors**
  - Reconstruct Compton events for **Compton imaging**
- **Phase A** starting January 2025
- **Coupling** the **GRB simulation** with simulation of different **astrophysical models**
  - Estimation of what should be detected according to different models