Gamma Ray Burst polarimetry with a CubeSat mission

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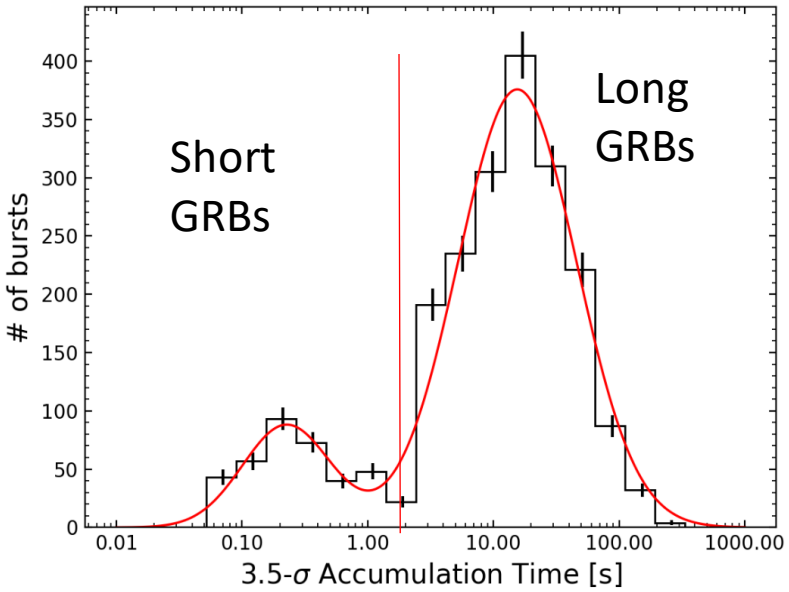
Transient Universe 2023 - Cargèse

COMCUBE Project

Quick reminder on GRBs :

GRB prompt emission duration from Fermi GBM data (Poolakkil et al., 2021)

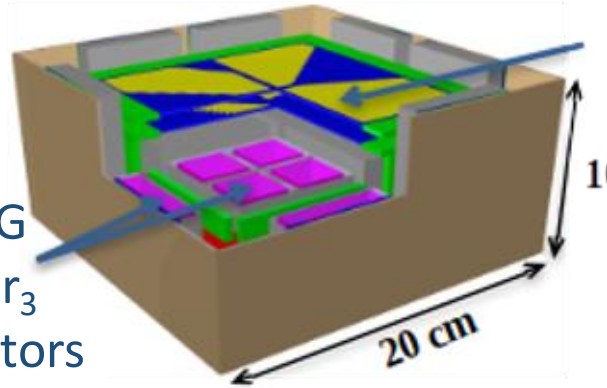


- Transient events composed of 2 phases :
  - Prompt emission : short (<2s) or long (>2s) GRBs
  - Afterglow emission
- Progenitors thought to be core collapse supernovae (lGRBs) or compact binary mergers (NS-NS or BH-NS for sGRBs)

COMCUBE :

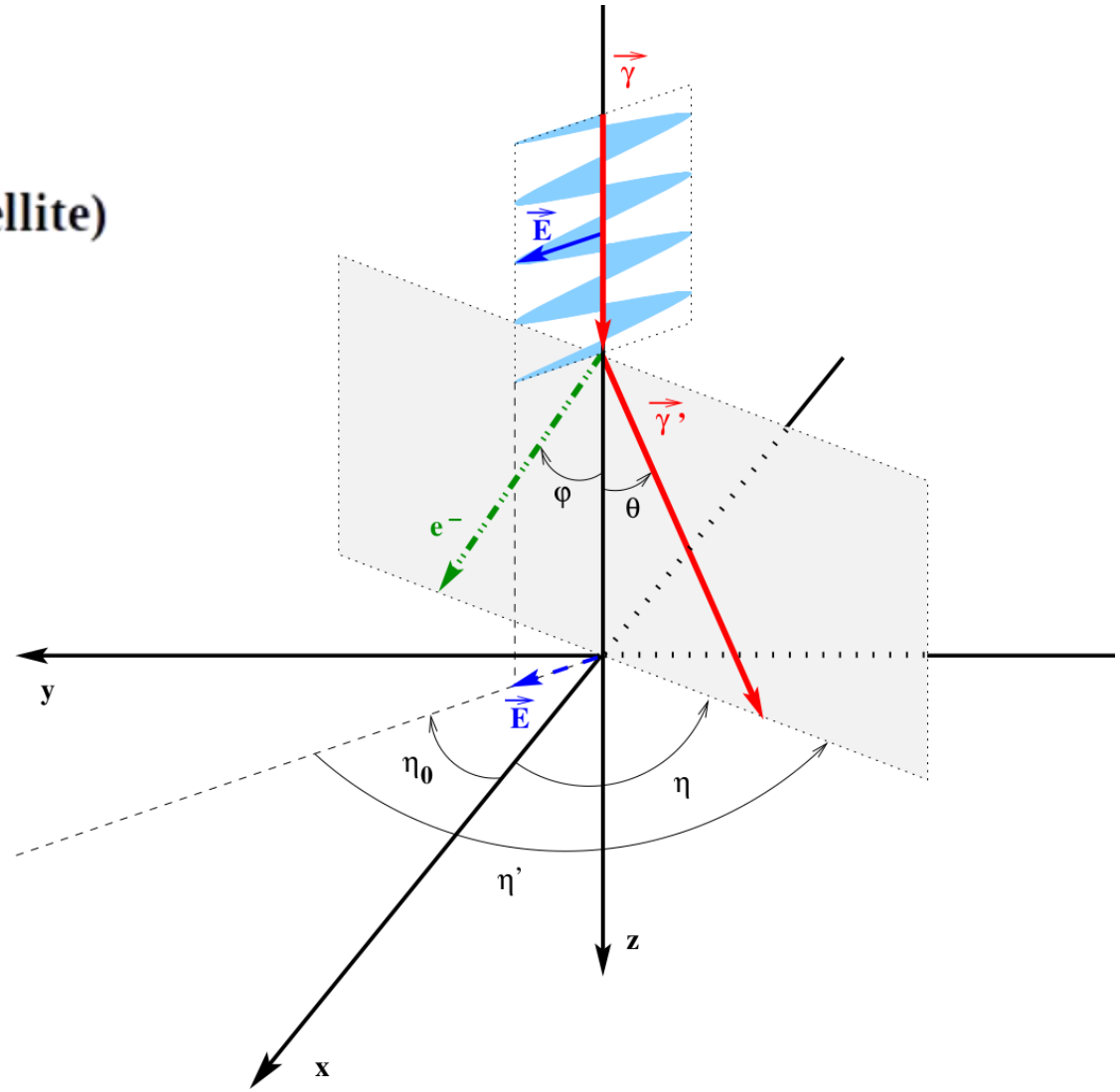
- GRB polarimetry using Compton scattering
- 1 detector : 6U CubeSat with 4U payload
- Constellation of several detectors
- Objectives :
  - Studying the prompt emission between 100keV and 1MeV
    - Both spectrometry and polarimetry
    - Constrain emission models of GRBs
  - Gamma-ray sky monitoring for multi-messenger astronomy
    - Participation to an ESA proposal as an *innovative mission concept enabled by a swarm of CubeSat*

Detector



Using Compton scattering :

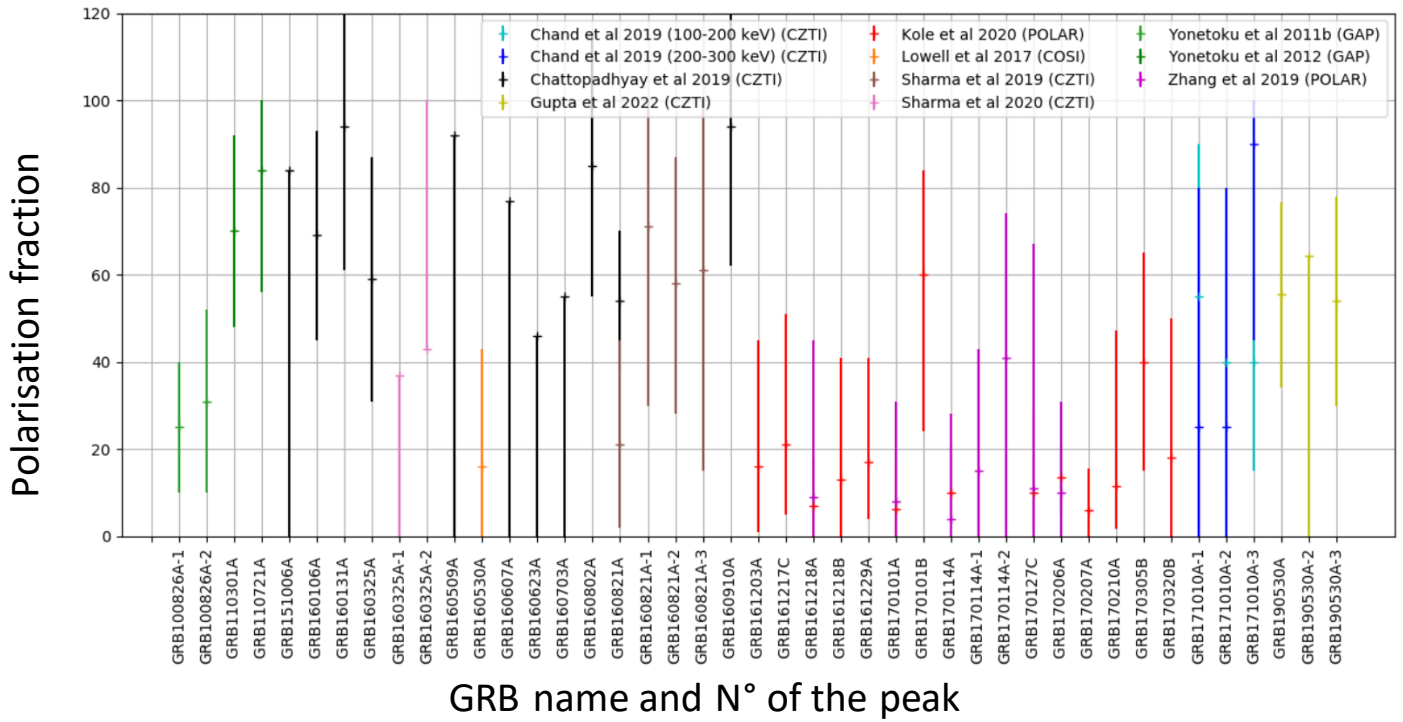
- First interaction in a DSSD (Double sided Silicon Strip Detector)
  - Compton scattering, a part of energy is deposited
- Second interaction in a GAGG or $CeBr_3$ scintillator
  - Photoelectric effect, the rest of the energy is absorbed
- Using the distribution of η' we calculate the polarisation fraction of the source



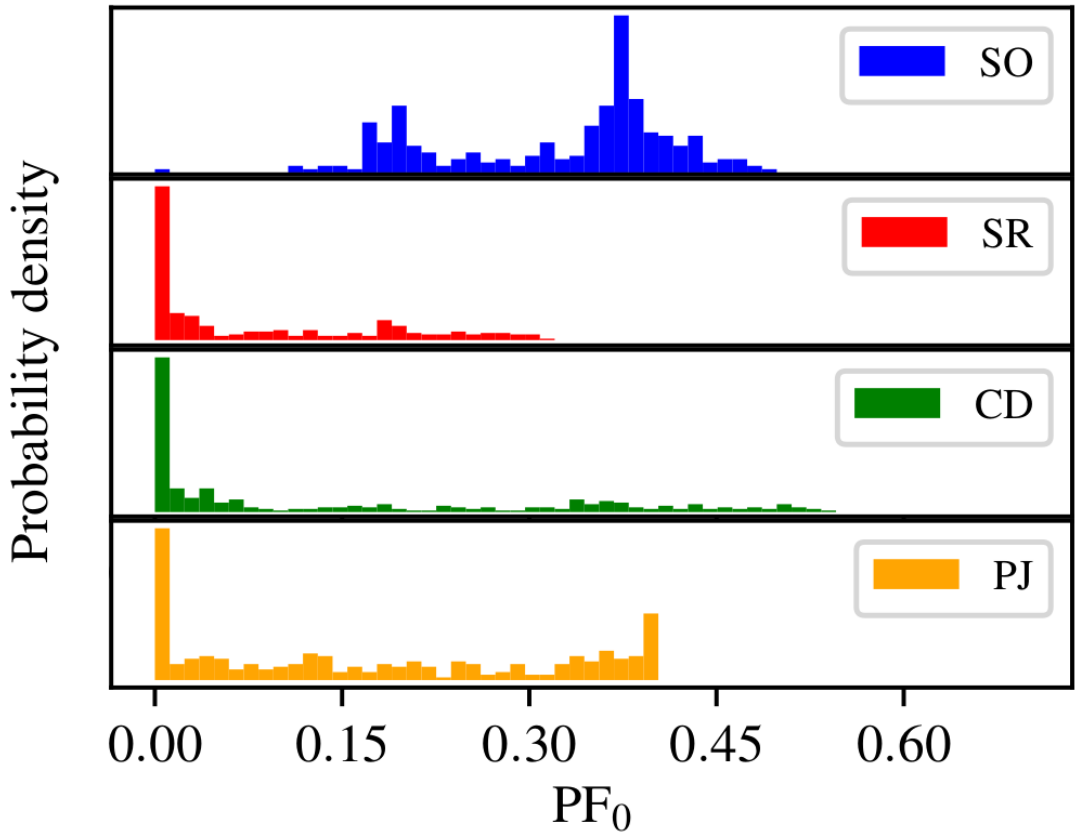
GRB Polarimetry

Large amount of spectrometric data but polarimetry is needed to constrain emission models

- Several polarimetric measurements
  - Statistical uncertainties are too large
  - May be a systematic effect



Pearce et al., 2019



Probability density of GRBs according to 4 different models :

- Synchrotron Ordered (SO)
- Synchrotron Random (SR)
- Compton Drag (CD)
- Photospheric Jet emission (PJ)

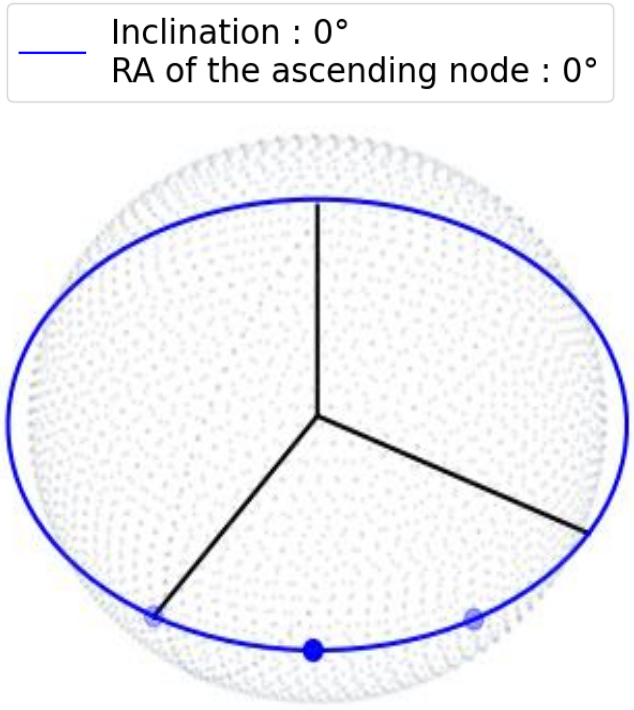
PhD objectives

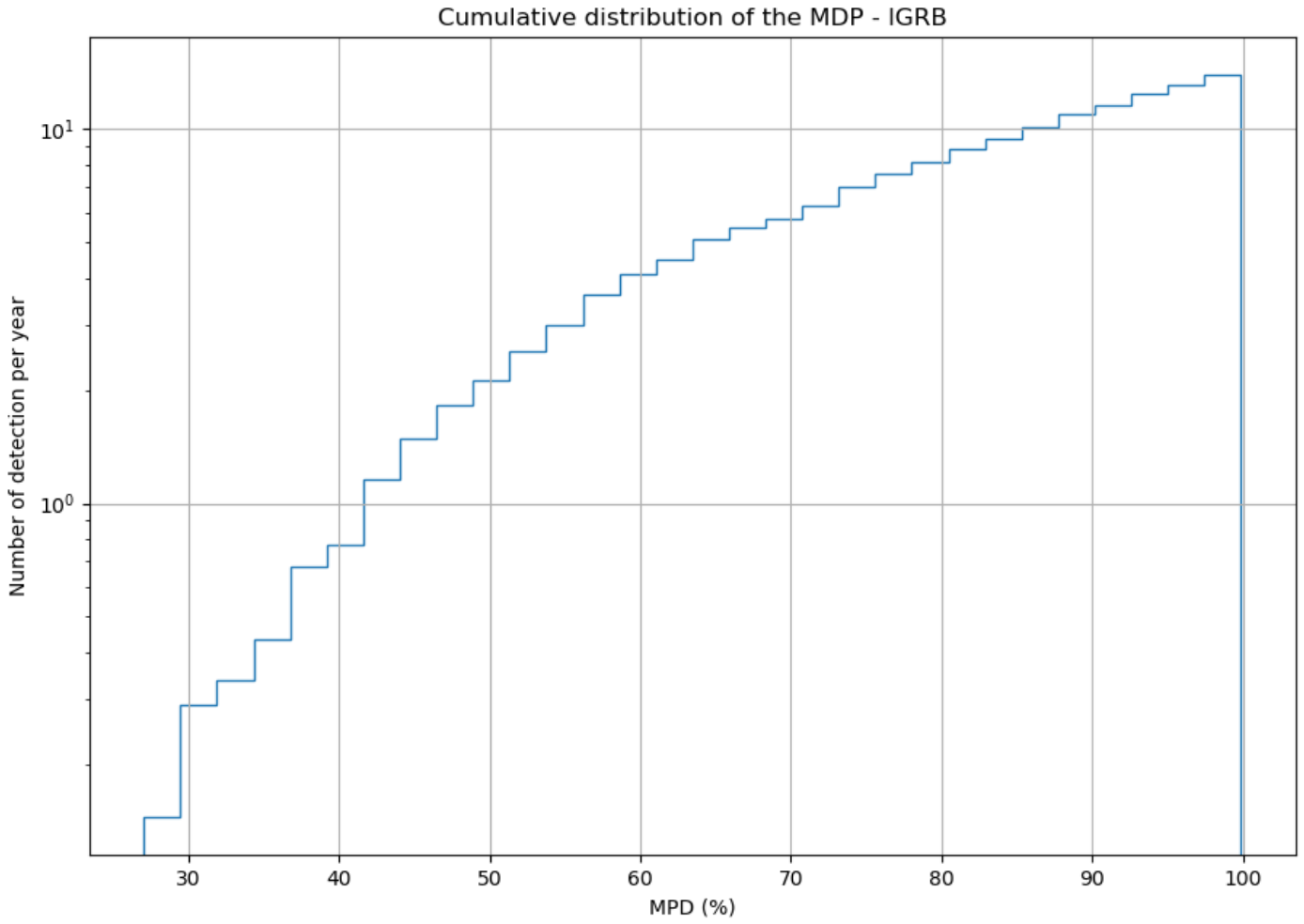
- Participate in the performance assessment of a 1U prototype
  - Stratospheric balloon flight in August
- Define mission objectives
  - Simulation of the constellation's performance
    - Detection of events : Signal to noise ratio (SNR)
    - Polarisation sensitivity : Minimum polarisation detectable by the telescope (MDP)
  - Estimate the number of detector and their orbit to :
    - Ensure a good sky monitoring
    - Obtain enough precise polarimetric measurement to constrain the emission models

Results

Polarisation sensibility

- Detection of 2 long GRBs with polarisation fraction of at least 50% per year
- More tests to come with new configurations

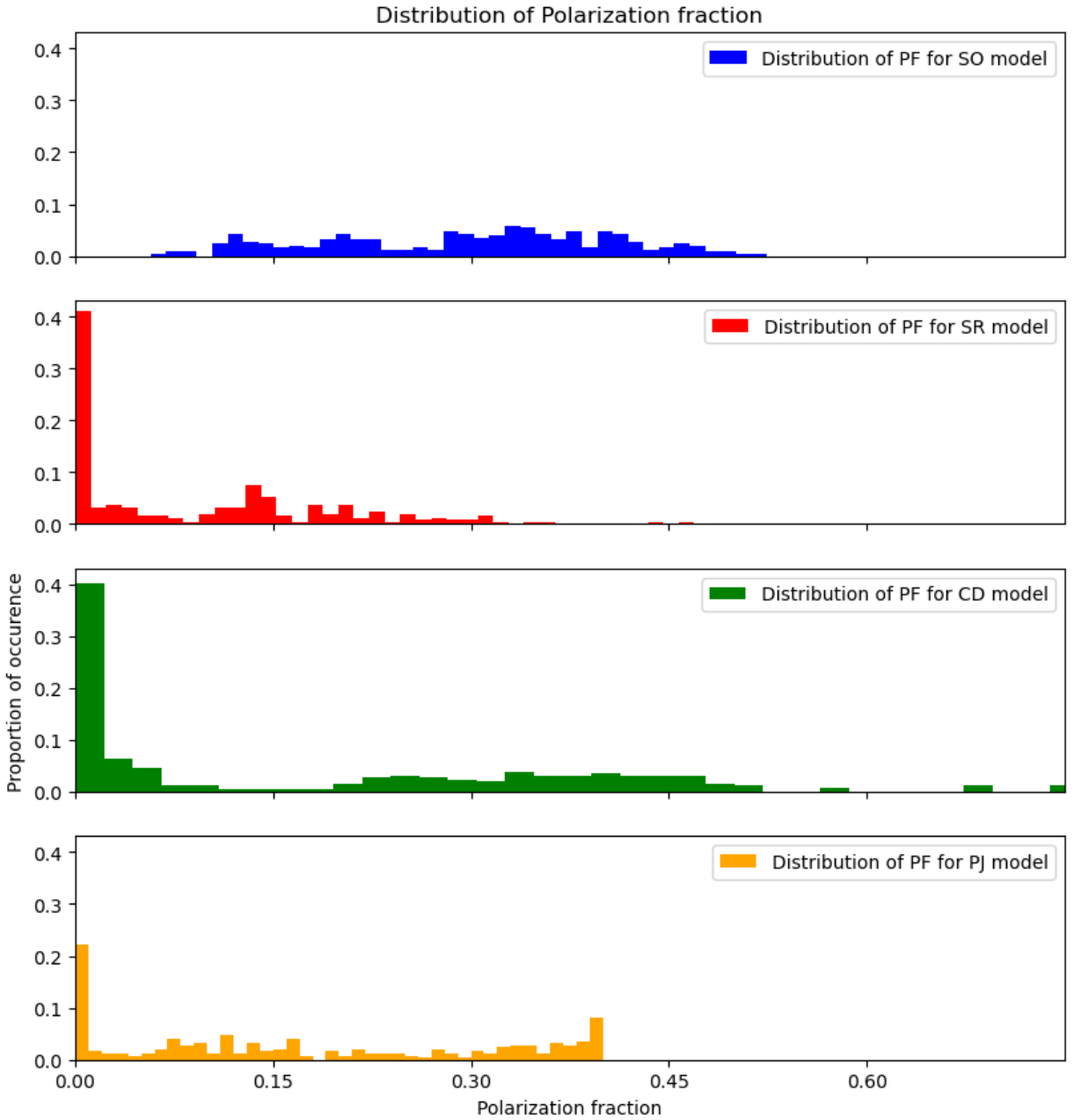




Based on data from Fermi GBM with a constellation of 3 satellites on an equatorial orbit, separated by an angle of 30°

Results

- Polarisation fraction calculated by Monte Carlo methods
  - Expected results for SR, CD and PJ models
  - PF values for SO model higher than for others models as expected
  - Values for SO more dispersed due to the distribution of viewing angle – only model really impacted by this parameter
- Next steps
  - Better understand the dispersion of the PF for SO model
  - Try more general models



Based on formula from Toma et al, 2009

Thank you for your attention