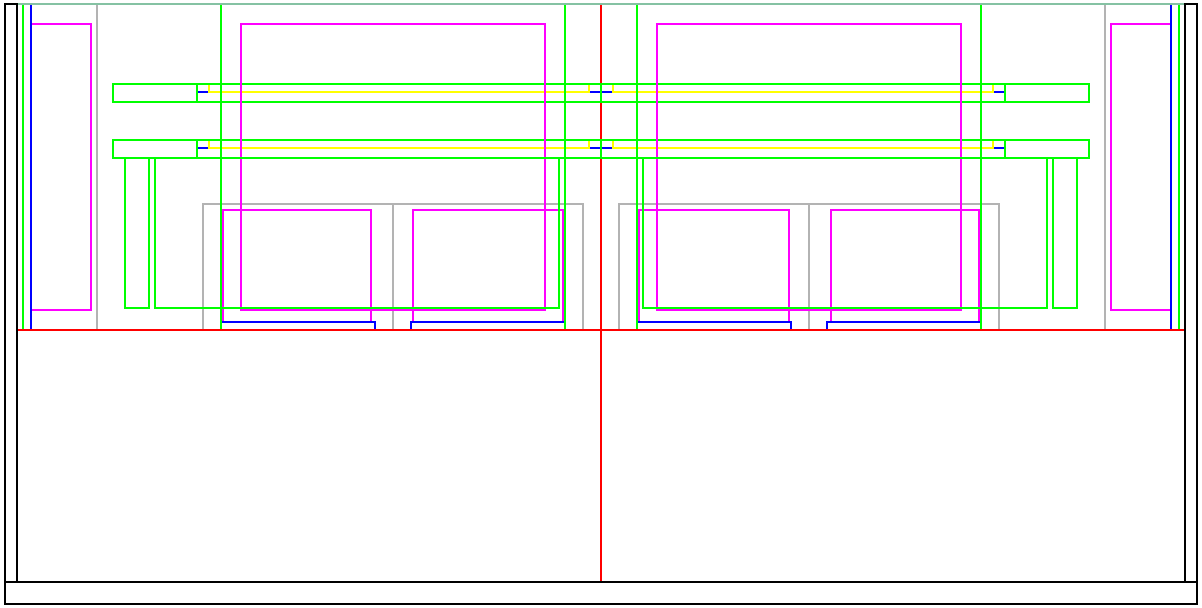
COMCUBE:
GRB polarization sensitivity

Alexey Uliyanov
University College Dublin

Coimbra AHEAD2020 Progress Meeting on Space Experiments
for HE Astrophysics & Multi-messenger Astronomy
1-2 October 2020

MEGAlib model

- COMCUBE_v1.3.2 model by Adrien Laviron:
  - 4U satellite
  - 2 DSSD layers
  - 16 bottom CeBr3 detectors
  - 8 side CeBr3 detectors



GRB response

- Assume zenith pointing and divide the full sky into ten θ-bins of equal solid angle.
- For each bin, simulate a reference GRB using the average θ of the bin and phi=22° and a Band spectrum with α=-1.1, β=-2.3, Epeak=300keV, Fluence=1e-2 erg/cm^2 above 100 keV
- For polarization analysis select Compton events in 100-1000 keV range and with a 30° ARM cut
- Background: cosmic and atmospheric photons generated with the MEGAlib BackgroundGenerator using 5 GV cutoff rigidity

θ (°)	25.8	45.6	60.0	72.5	84.3	95.7	107.5
Selected events	59166	58596	52614	42588	29632	26091	23272
Modulation μ_{100}	0.48	0.43	0.41	0.36	0.30	0.28	0.35
Background (s^{-1})	6.4	6.1	5.8	5.6	5.5	5.5	5.8

MDP calculation for arbitrary bursts

$$\mathrm{MDP}_{99} = \frac{4.29}{\mu_{100} S}\sqrt{S + B}$$

(Weisskopf 2010)

Use T_{90} and 90% of the GRB fluence F to estimate the number of background and signal events for each burst in the catalog:

$$B = T_{90} \times \mathrm{BgRate}$$

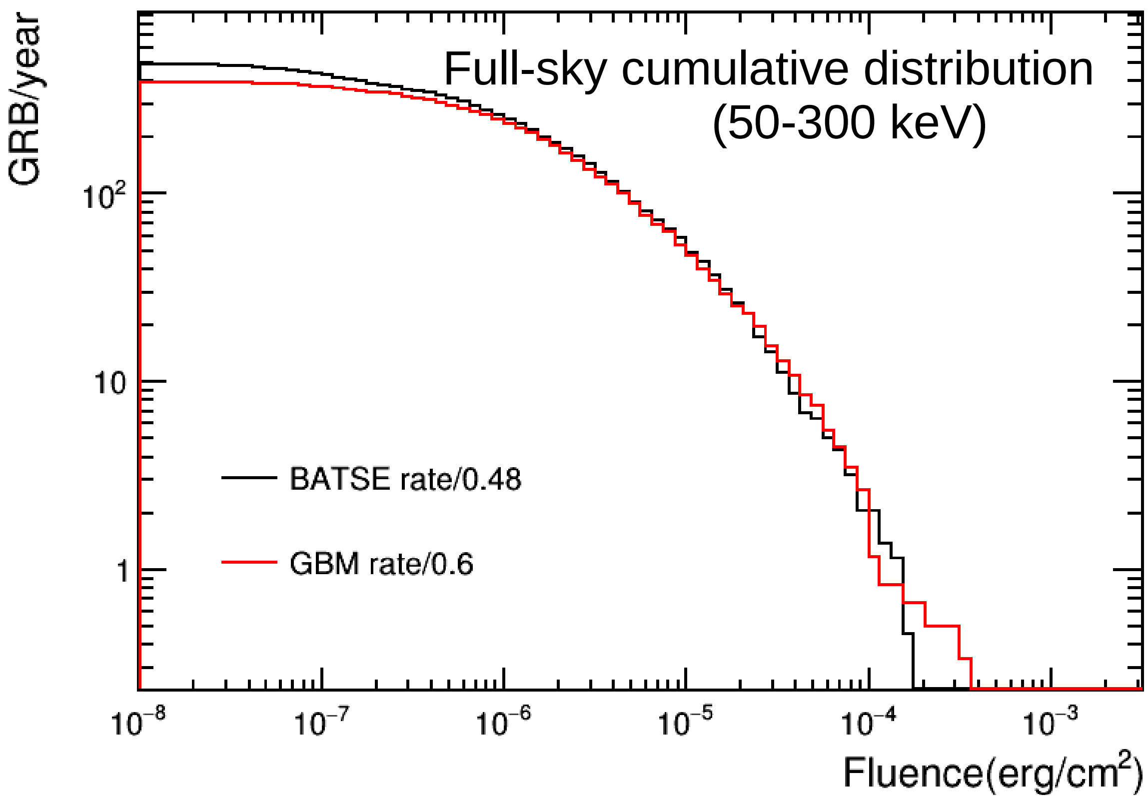
$$S = 0.9 \times \frac{F}{F_0} \times S_0$$

The fluence ratio F/F_0 needs to be calculated in an energy range relevant for polarisation analysis.

BATSE catalogue: using energy fluence in the 100-300 keV range. F_0=2.18e-3 erg/cm2 for the reference GRB above.

GBM catalogue: using photon fluence in 140-700 keV range calculated from the provided GRB spectra. F_0=7470 ph/cm2

GRB fluence distribution



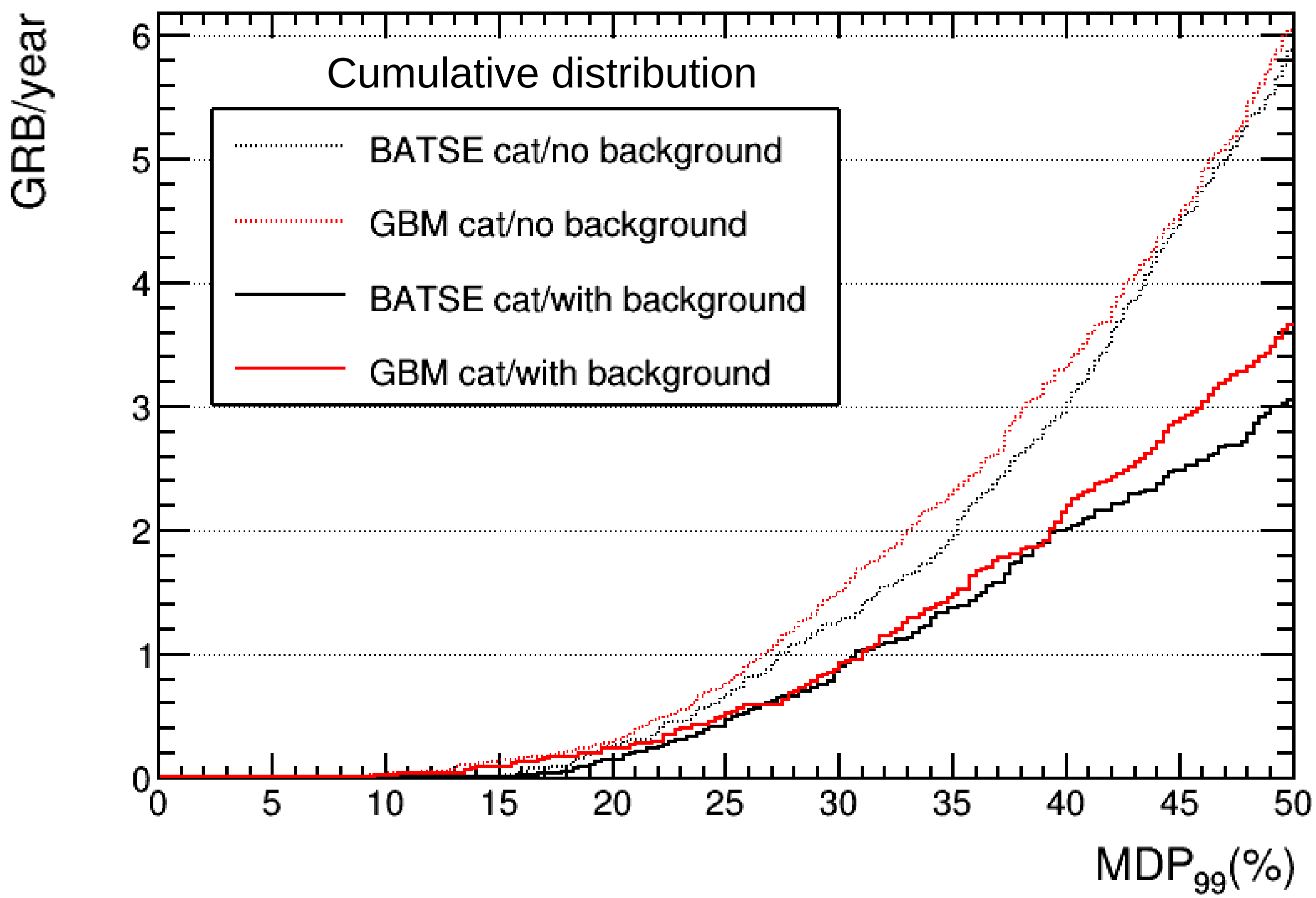
BATSE sky exposure factor = 0.48:
- 0.67 due to Earth occultation
- 0.71 due to trigger downtime

Assume GBM exposure factor = 0.60 to match the BATSE rate:
- 0.69 due to Earth occultation
- 0.87 due to trigger downtime

Assume 20% trigger downtime for COMCUBE

MDP with 1 satellite

For each GRB in the catalogue, MDP is calculated 7 times (once for each θ-bin to account for uniform distribution of GRBs over sky) and each value is added to the distribution with a sampling weight of 1/7.



Similar results from the BATSE and GBM catalogues

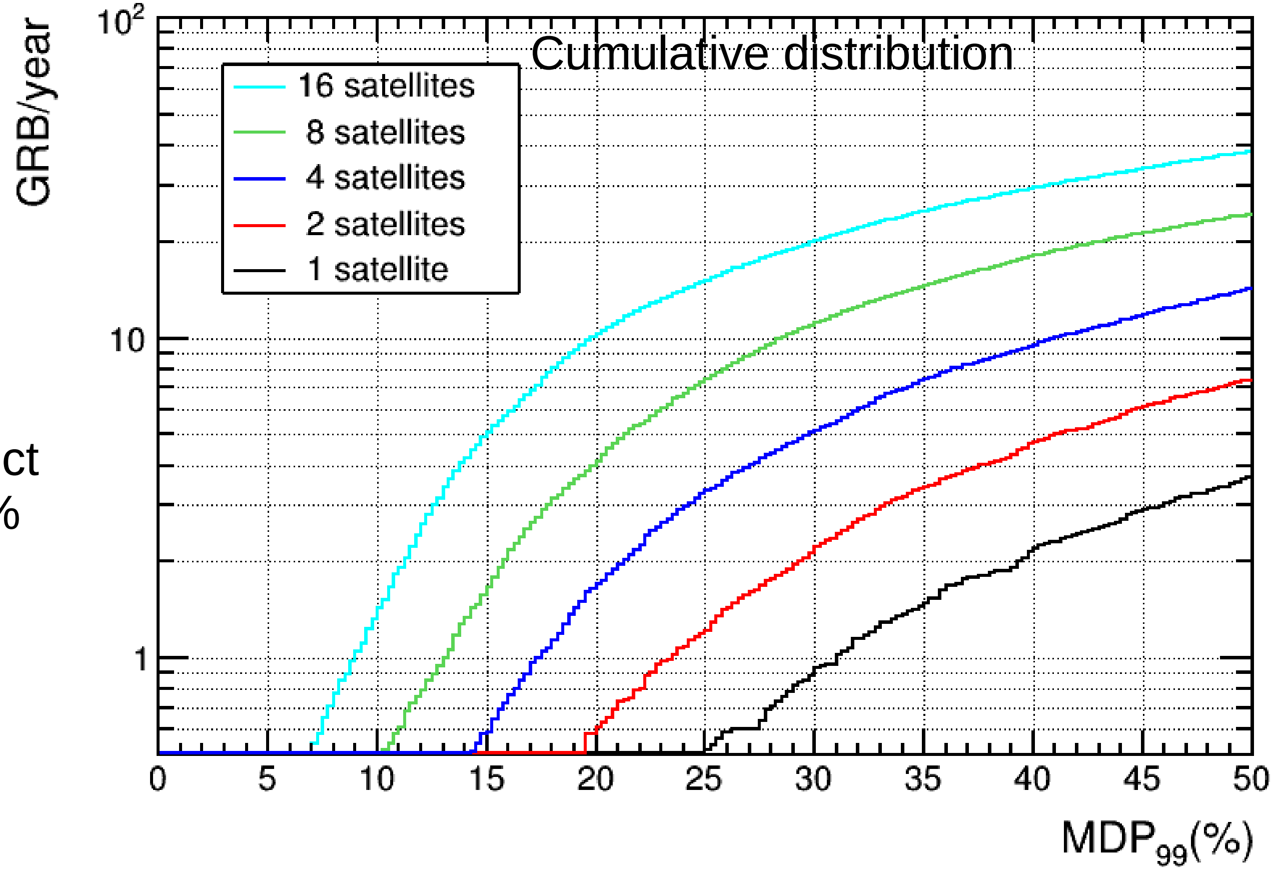
Background has a significant effect on GRB polarization measurements

One satellite is expected to detect, on average, 1 GRB/year with MDP<31%

MDP with multiple satellites

For each GRB in the GBM catalogue:
- generate the number of enabled satellites (assuming 20% downtime)
- generate θ angle (bin) for each enabled satellite and calculate MDP
- combine MDP from multiple satellites: $\frac{1}{MDP^2} = \sum \frac{1}{MDP_i^2}$

- repeat the procedure N=30 times and add each MDP sample to the distribution with 1/N weight



4 satellites in orbit would detect ~ 5 GRB/yr with MDP_{99} < 30%