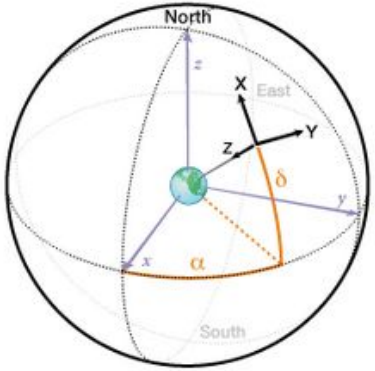
New MEGAlib's features and DC3 background simulations

COSI Germany meeting

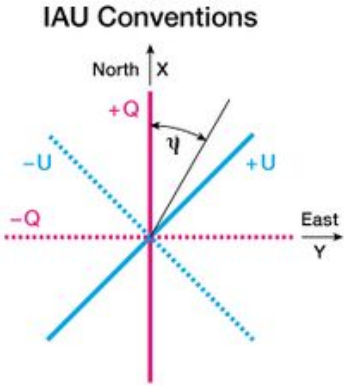
Savitri Gallego

MEGAlib’s new features

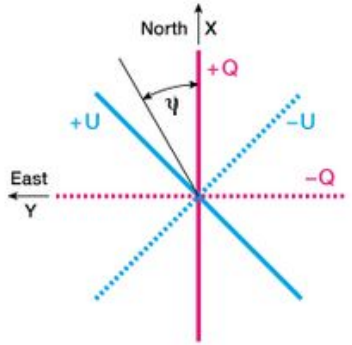
Polarisation in Galactic coordinates



Coordinate Sphere



Tangent plane, looking inward



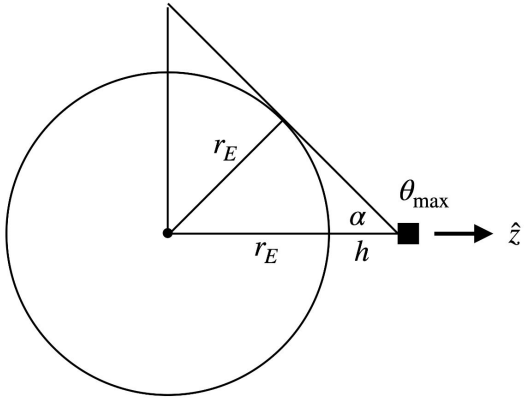
Tangent plane, looking outward

- By default MEGAlib is simulating the polarization relative to spacecraft coordinates
- But science papers usually uses the IAU convention to publish polarization angle and fraction
- Now MEGAlib can handle polarization in galactic coordinates (branch “develop-cosi”)
- There is a source file example here

Earth Occultation

$r_E = 6378$ km

$h = 550$ km



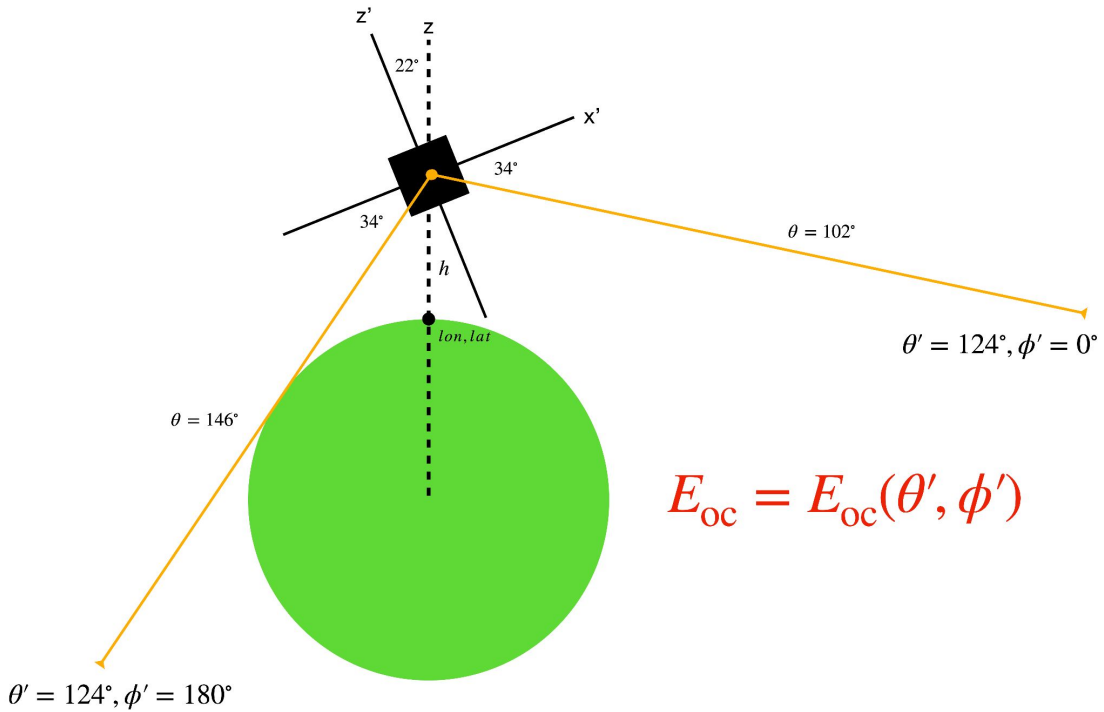
$$\theta_{\max} = \pi - \alpha$$

$$\sin(\alpha) = \frac{r_E}{r_E + h}$$

$$\therefore\ \theta_{\max} = \pi - sin^{-1}\left(\frac{r_E}{r_E + h}\right) = 112.98^{\circ}$$

- DC2 was using zenith pointing
- Easy to handle Earth occultation : only generates particle with theta bigger than thetamax

Earth Occultation



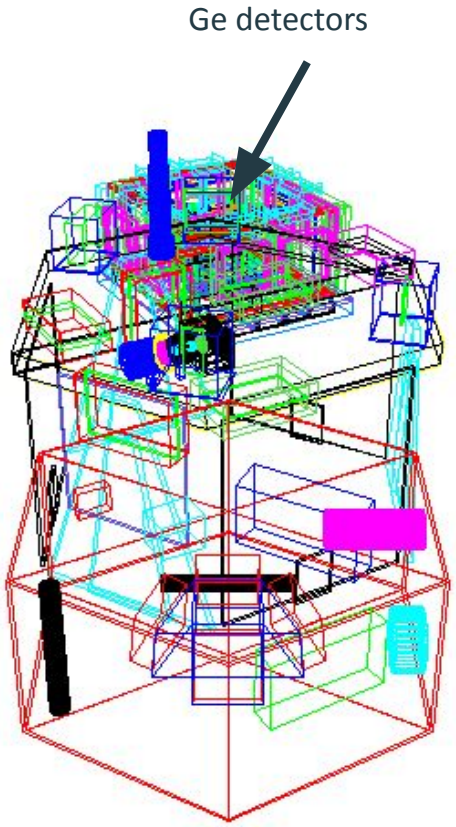
$$E_{oc} = E_{oc}(\theta', \phi')$$

- The angle between the incident photon and the Earth zenith in Galactic coordinates is calculated at time t,
- All events with an incident angle > the maximum angle are rejected
- More explanation and example are shown in DC3 page

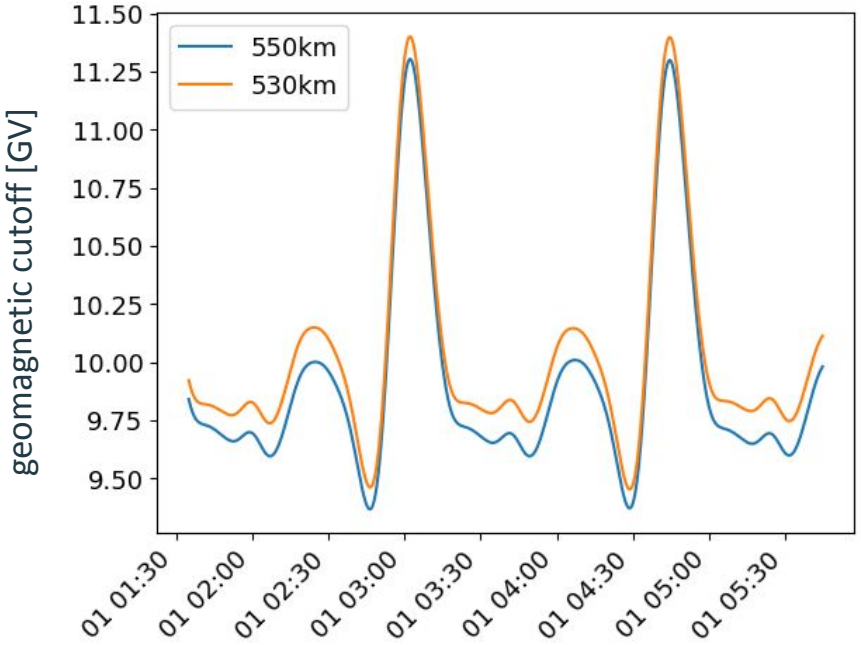
DC3 background simulations

What is new compare to DC2 ?

- DC2 methodology
- DC3 new features :
  - 530km instead of 550km
  - pdr mass model
  - use geant4 v11.2
  - Build-up of the activation (no more extrapolation)
  - 22 degree rocking implemented in the orientation file
  - Earth Occultation done in cosima
  - SAA passages with trapped protons component
  - solar modulation (extrapolated to 2027)
  - BGO hits will be saved (24h of orbit)



altitude change



- GC will vary in the range [9-11.5] GV for a equatorial orbit at 530km of altitude

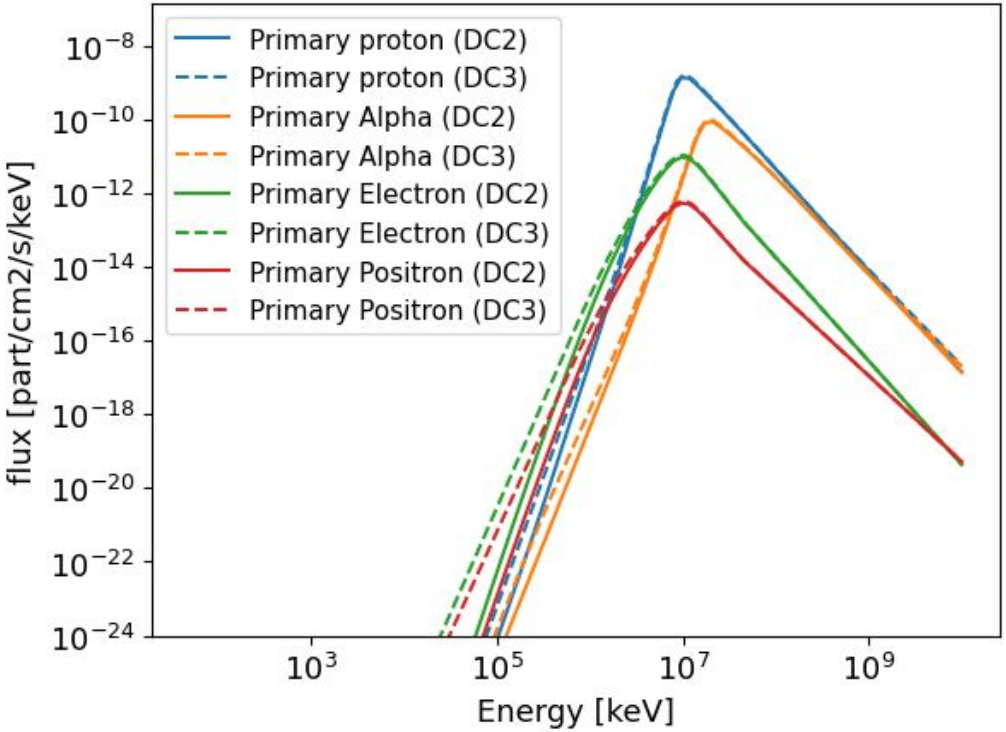
- Dipole approximation (Smart et al. 2005) using IGRF value for g10 extrapolated to 2027

$$GC = \frac{g_0^1 \cdot R_{Earth}}{4} \cdot \left(1 + \frac{h}{R_{Earth}}\right)^{-2} \cos^4(\lambda)$$

Change with DC2 input

- We use now a more up to date Cumani code version
  - Primary Proton/alpha are from hellmod
- Primary Electron/Positron from more up-to-date AMS data extrapolate to 2027 solar activity (see Francesco slides)
- Expected solar modulation : 520 MV

geomagnetic cut-off 10GV



Atmosphere 511 line

- We added the 511 keV line to the Albedo photons
- 28.207e-3 ph/cm2/s
- should we add 4.44 MeV line ?

Table 1. Comparison of Average Fluxes in Selected γ-Ray Lines During Periods of High and Low Solar Activity as Defined by the Alma Ata B Neutron Monitor

Line or Quantity Averaged	Spectrum (Rigidity)	Interval	Low Activity Average Flux[a] (1980–1983, 1989)	High Activity Average Flux[a] (1984–1988)	Ratio High:Low
4.44 MeV	<7 GV	6 month	11.1 ± 0.2	12.8 ± 0.2	1.16 ± 0.03
	7–11 GV	6 month	6.4 ± 0.1	7.4 ± 0.2	1.14 ± 0.03
	>11 GV	6 month	3.9 ± 0.1	4.1 ± 0.1	1.03 ± 0.03
1.6 + 2.3 MeV	<7 GV	6 month	4.2 ± 0.1	4.9 ± 0.1	1.16 ± 0.05
	7–11 GV	6 month	2.4 ± 0.1	2.6 ± 0.1	1.09 ± 0.05
	>11 GV	6 month	1.6 ± 0.1	1.5 ± 0.1	0.92 ± 0.09
0.511 MeV	<7 GV	48 day	41.3 ± 0.1	45.7 ± 0.1	1.104 ± 0.004
	7–11 GV	48 day	29.9 ± 0.1	31.6 ± 0.1	1.056 ± 0.004
	>11 GV	48 day	23.3 ± 0.1	22.2 ± 0.1	1.051 ± 0.005
Alma Ata B neutrons	6.6 GV	6 month	8709	9385	1.08
Tsumeb neutrons	9.2 GV	6 month	11290	11865	1.05
Huancayo neutrons	13 GV	6 month	1711	1760	1.03

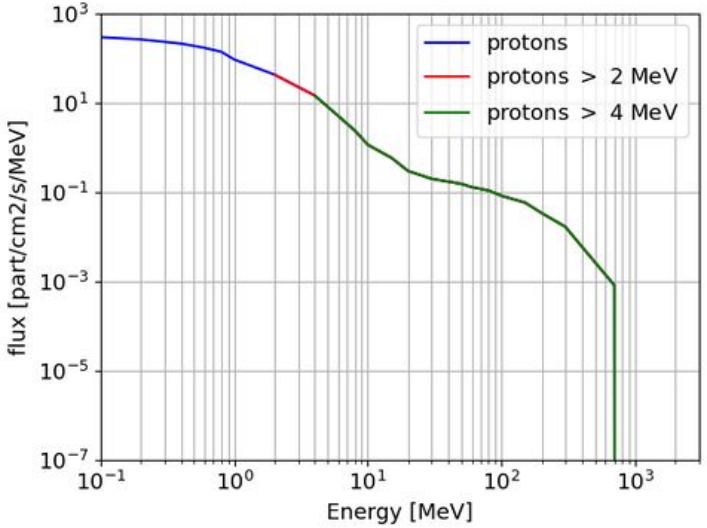
[a]Compare Figures 4 and 5. Gamma-ray line fluxes in units of 10^{-3} photon cm^{-2} s^{-1}. The low and high cosmic ray activity periods were defined by the Alma Ata B count rates being either above or below the mean for the period 1980–1989.

Harris et al. 2003 doi:10.1029/2003JA009958

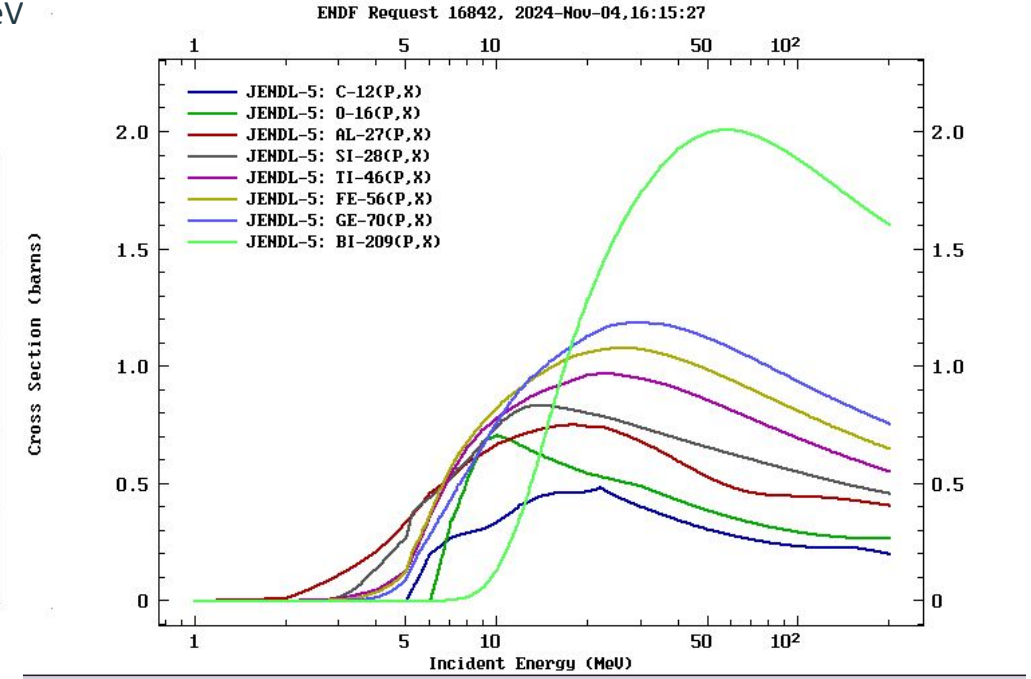
Scale flux with altitude : 29.9 * (500/530) = 28.207
SMM average altitude 500km

SAA Input

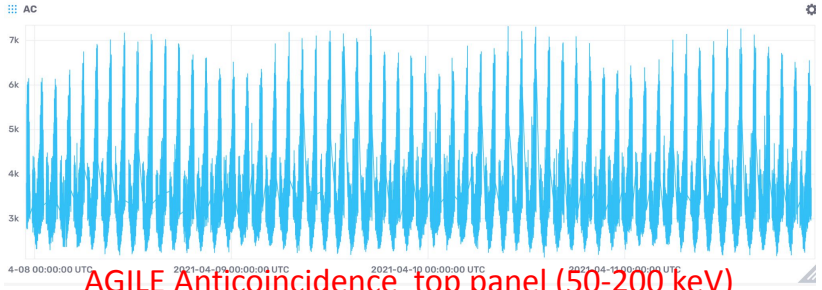
- Input flux and LC produce by AP9
- We are only interested into activation induced by the protons so we will use spectrum and flux with Emin = 4MeV
  - improve the simulation time



proton cross section for different elements

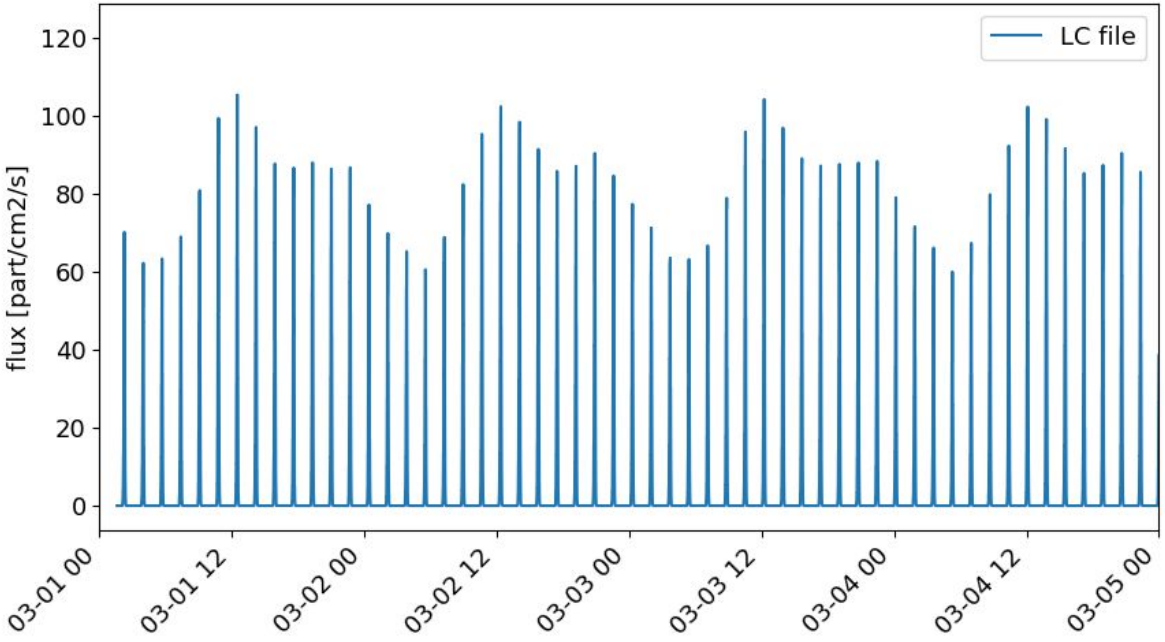


SAA Input



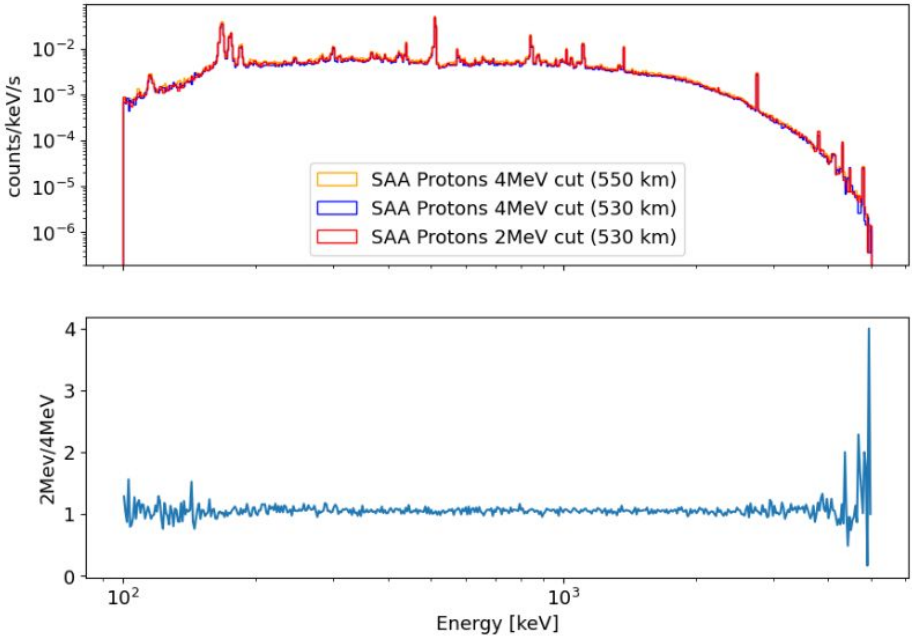
AGILE Anticoincidence top panel (50-200 keV)

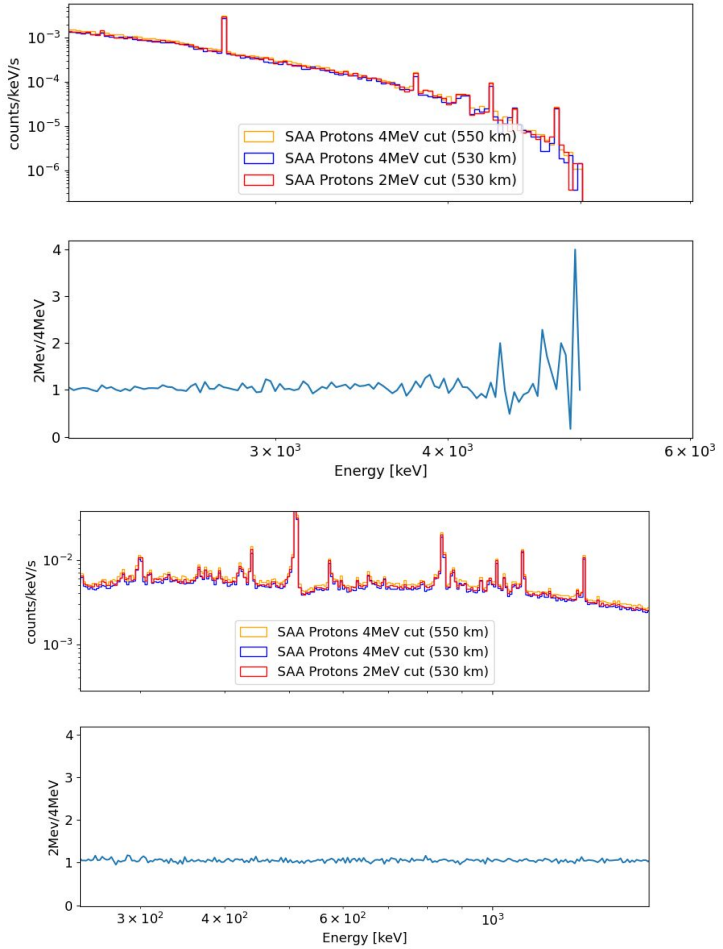
trapped protons



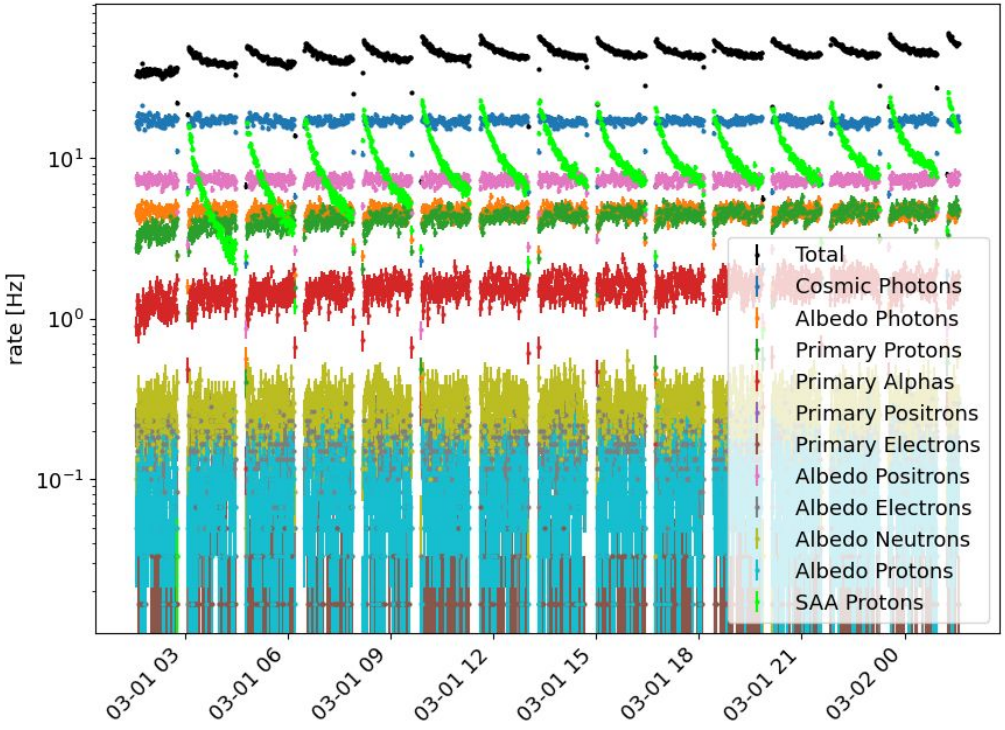
- IRENE AP9 v1.57.004
- use 3 months of COSI orbit and compute the diff flux for each position
- integrate along the energy to get the LC

SAA cut at 2 or 4 MeV





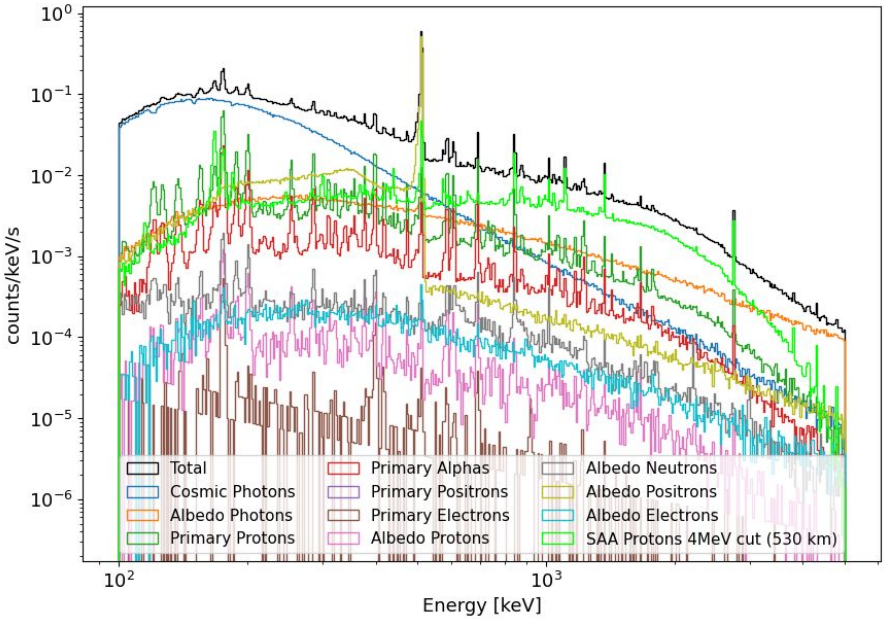
24h total rate for reco+select CO evt



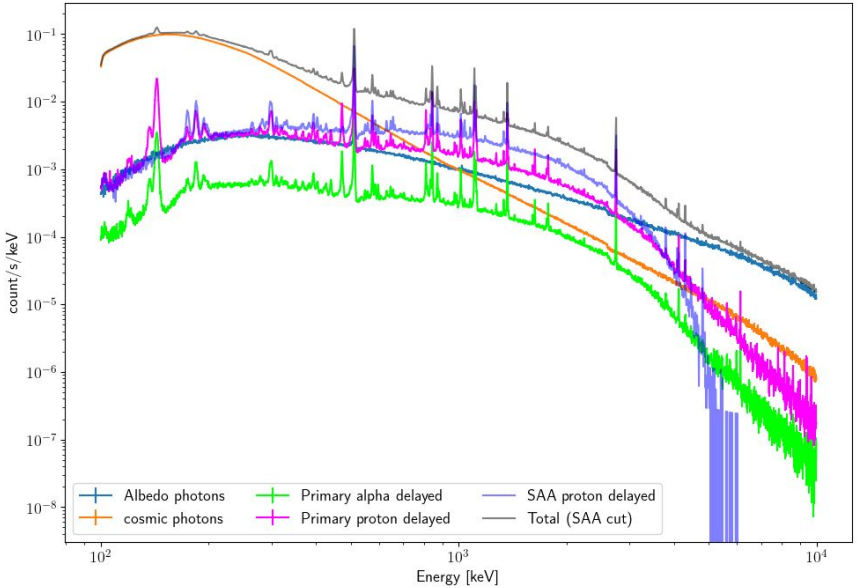
- The shape of the rate is dominated by the SAA activation
- No clear differences between the 2 rocking when we look all the Ged

24h Spectrum for reco+select CO evt

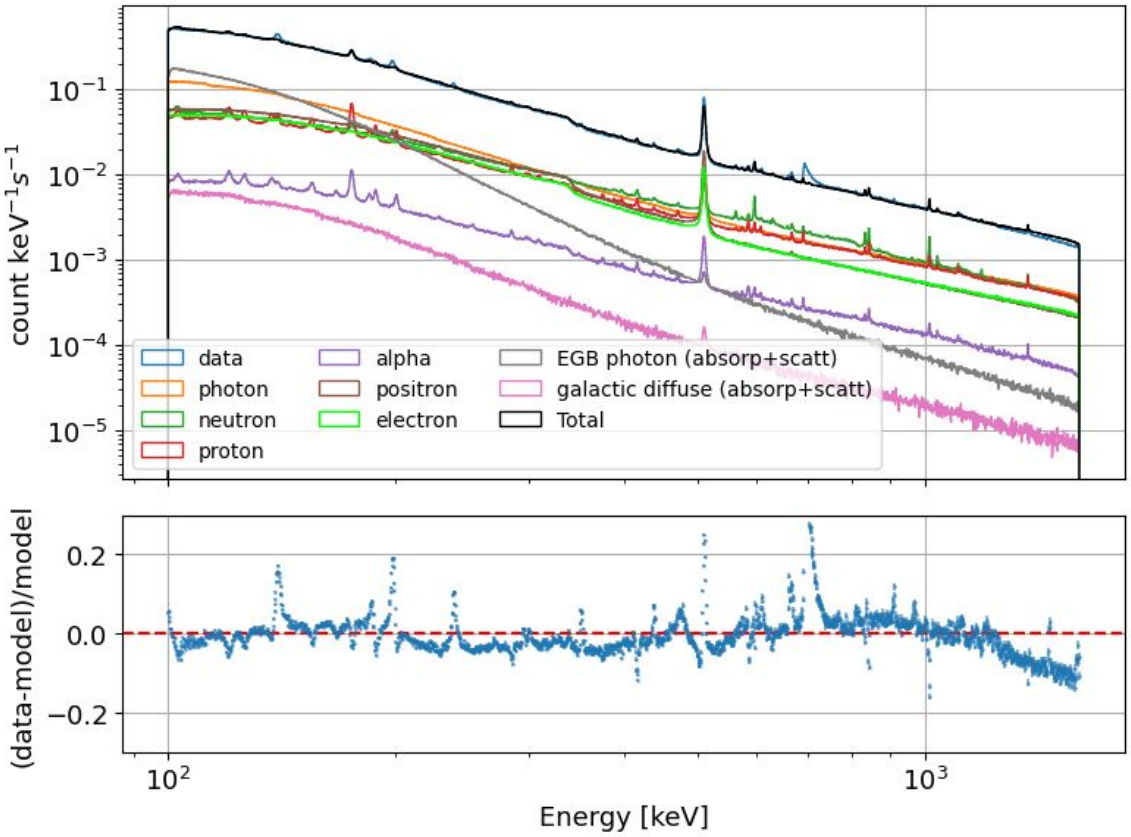
24h DC3



3 months DC2



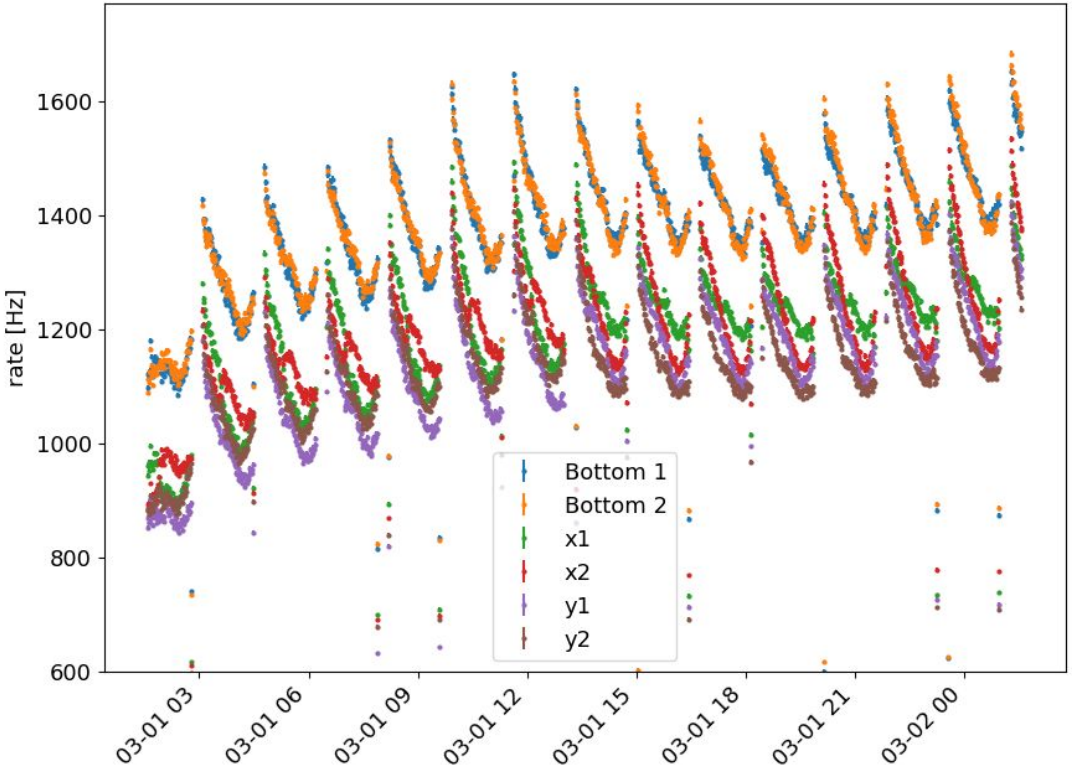
How good the simulations could be ?



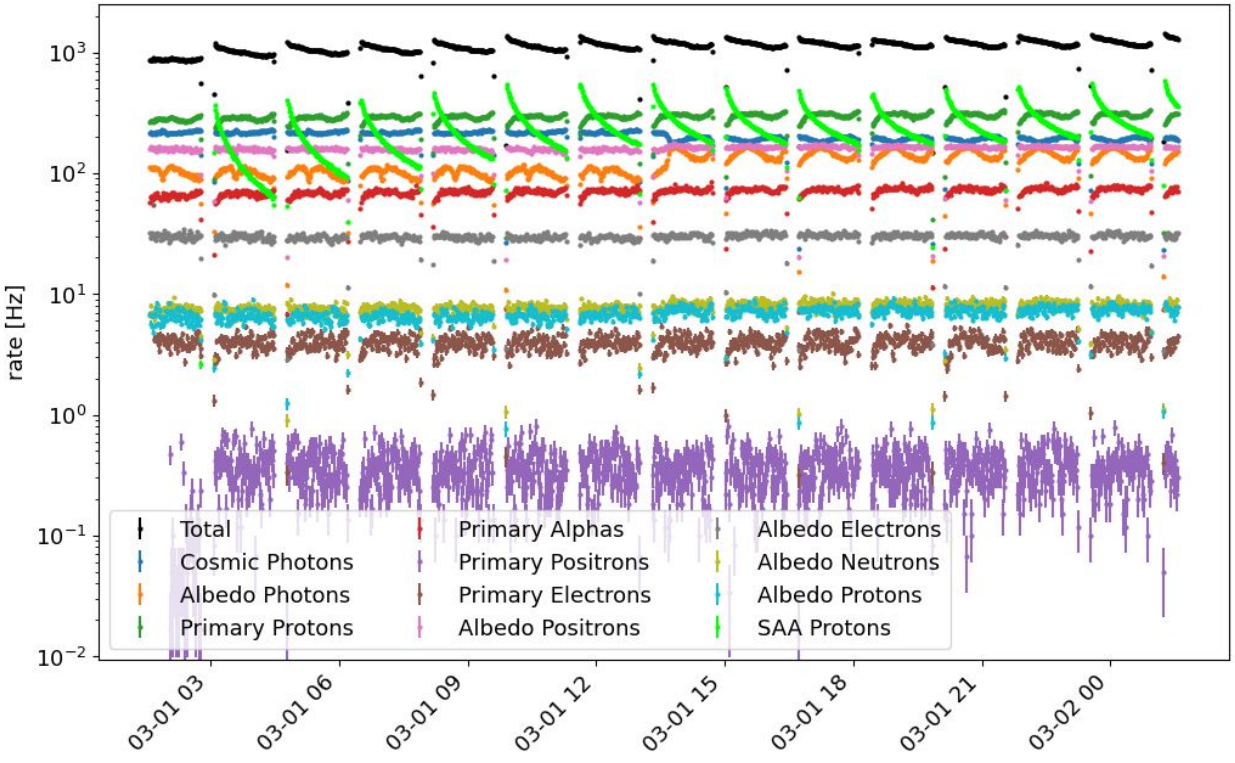
- no scaling : 50% comparison with data
- With scaling : 10-20%
- Lines quiet well reproduce

Back-up

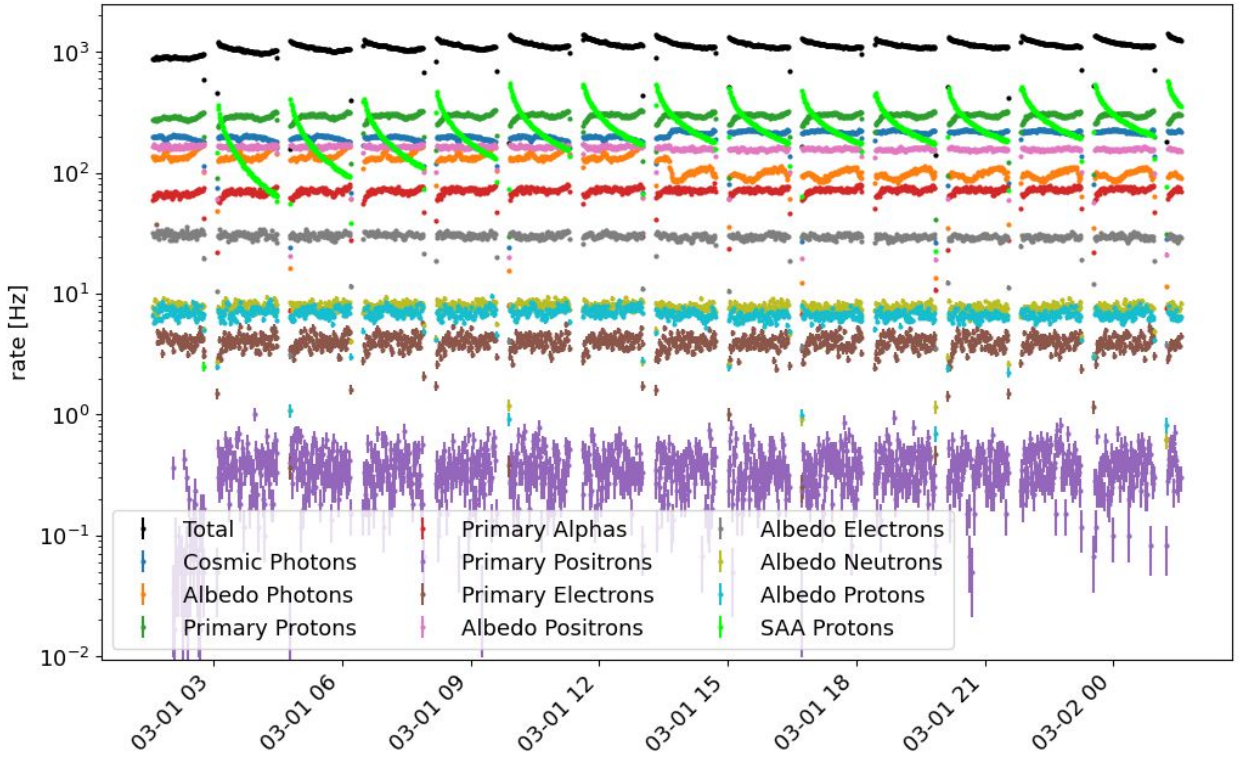
BGO all panels



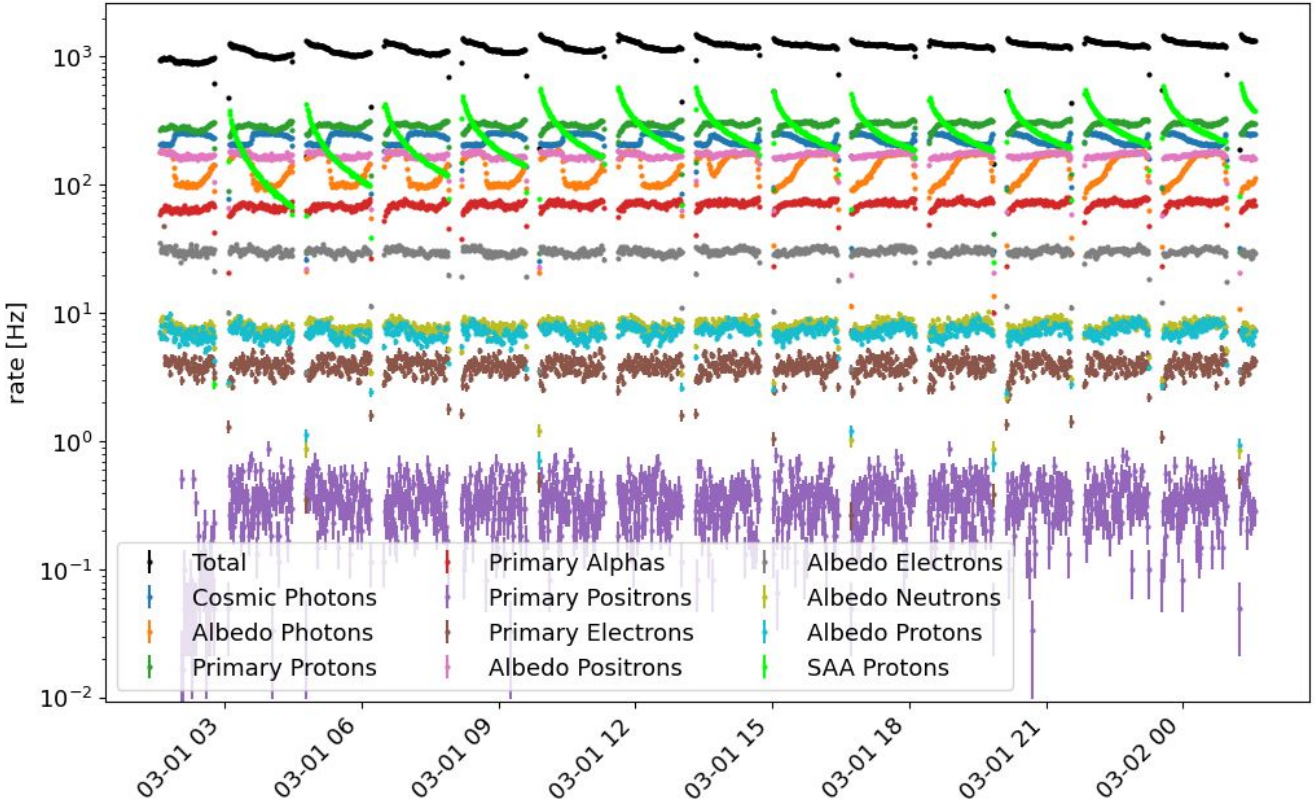
BGO panel y1


rate [Hz]
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
03-01 03
03-01 06
03-01 09
03-01 12
03-01 15
03-01 18
03-01 21
03-02 00
Total
Cosmic Photons
Albedo Photons
Primary Protons
Primary Alphas
Primary Positrons
Primary Electrons
Albedo Positrons
Albedo Electrons
Albedo Neutrons
Albedo Protons
SAA Protons

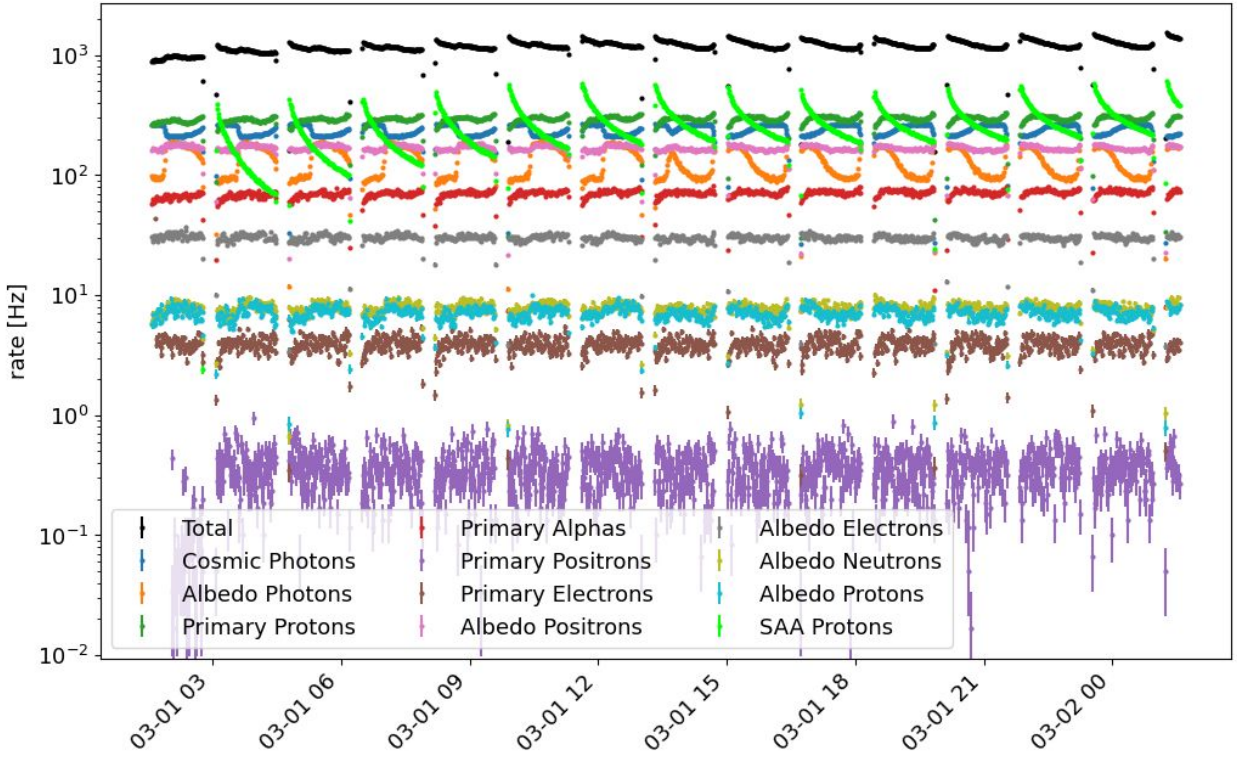
BGO panel y2


rate [Hz]
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
03-01 03
03-01 06
03-01 09
03-01 12
03-01 15
03-01 18
03-01 21
03-02 00
Total
Cosmic Photons
Albedo Photons
Primary Protons
Primary Alphas
Primary Positrons
Primary Electrons
Albedo Positrons
Albedo Electrons
Albedo Neutrons
Albedo Protons
SAA Protons

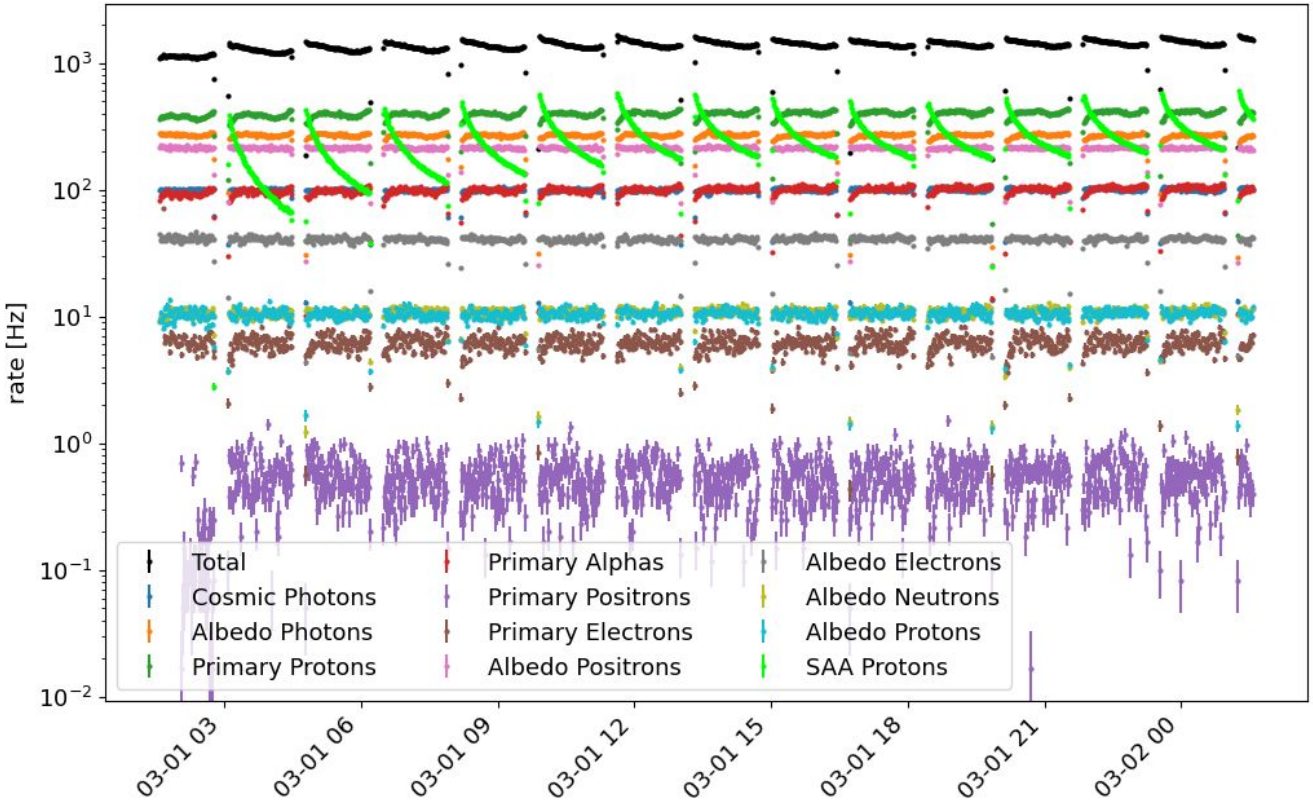
BGO panel x1


rate [Hz]
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
03-01 03
03-01 06
03-01 09
03-01 12
03-01 15
03-01 18
03-01 21
03-02 00
Total
Cosmic Photons
Albedo Photons
Primary Protons
Primary Alphas
Primary Positrons
Primary Electrons
Albedo Positrons
Albedo Electrons
Albedo Neutrons
Albedo Protons
SAA Protons

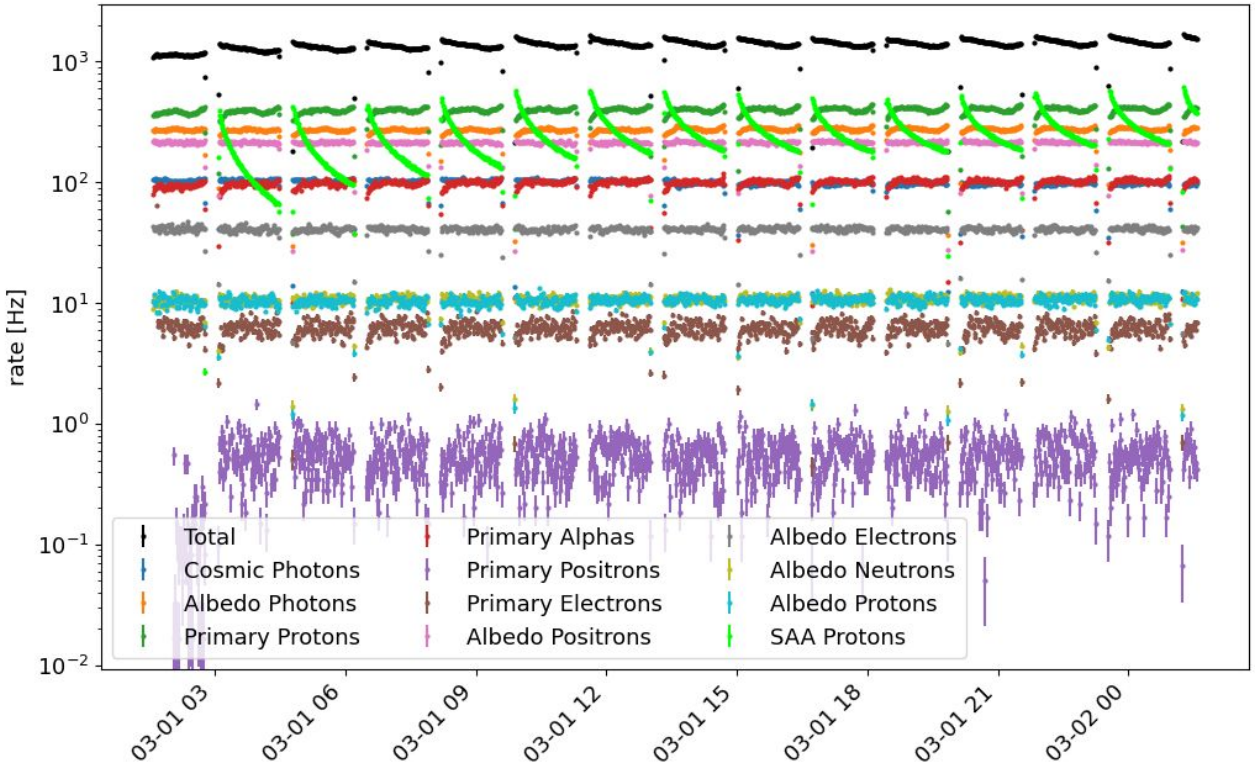
BGO panel x2


rate [Hz]
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
Total
Cosmic Photons
Albedo Photons
Primary Protons
Primary Alphas
Primary Positrons
Primary Electrons
Albedo Positrons
Albedo Electrons
Albedo Neutrons
Albedo Protons
SAA Protons
03-01 03
03-01 06
03-01 09
03-01 12
03-01 15
03-01 18
03-01 21
03-02 00

BGO panel bot 1



BGO panel bot 2



DC3 background input models