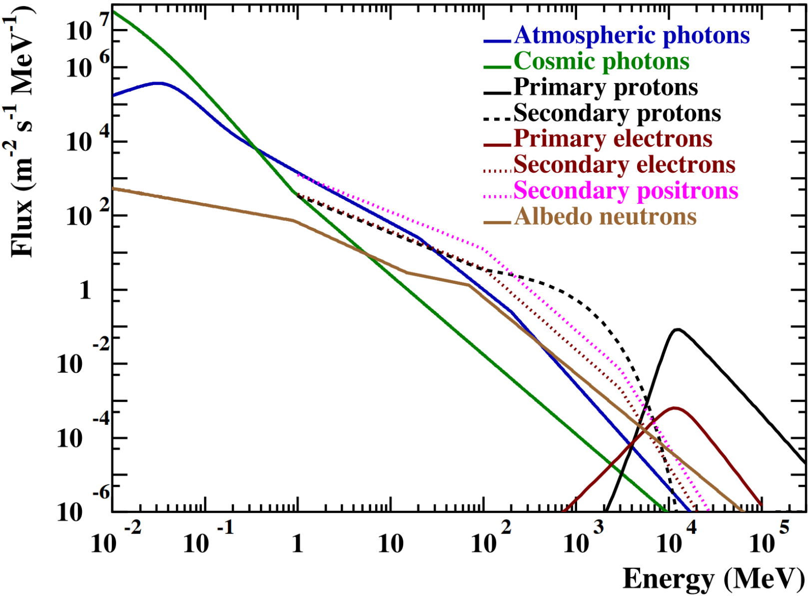
SWG 2nd progress meeting

Background environment in an equatorial low-Earth orbit & updates on the performance

P. Cumani, M. Hernanz, V. Tatischeff



Flux (m^{-2} s^{-1} MeV^{-1})
Energy (MeV)
Atmospheric photons
Cosmic photons
Primary protons
Secondary protons
Primary electrons
Secondary electrons
Secondary positrons
Albedo neutrons
10^{7}
10^{6}
10^{4}
10^{2}
1
10^{-2}
10^{-4}
10^{-6}
10^{-2}
10^{-1}
1
10
10^{2}
10^{3}
10^{4}
10^{5}

General Parameters

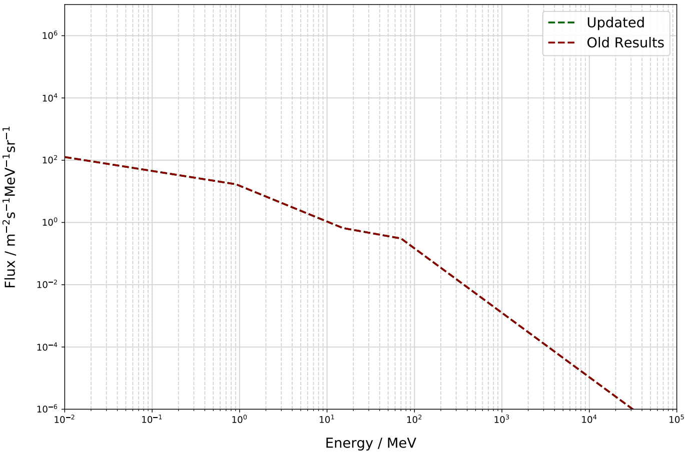
If not differently specified, the spectrum (in $m^{-2}s^{-1}MeV^{-1}sr^{-1}$) is calculated for:

- Altitude $h = 550$ km
- Inclination $i = 0^\circ$
- Medium solar activity

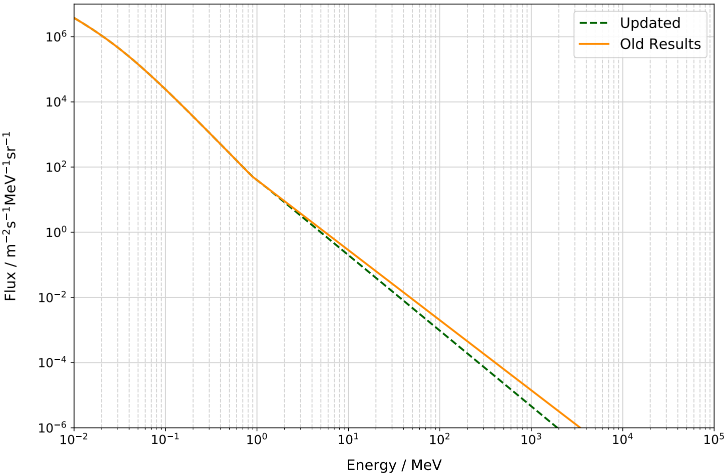
Albedo Neutrons

Only the upward component by Kole et al. (2015): 4 power-laws

$x_i \cdot E^{-y_i}$

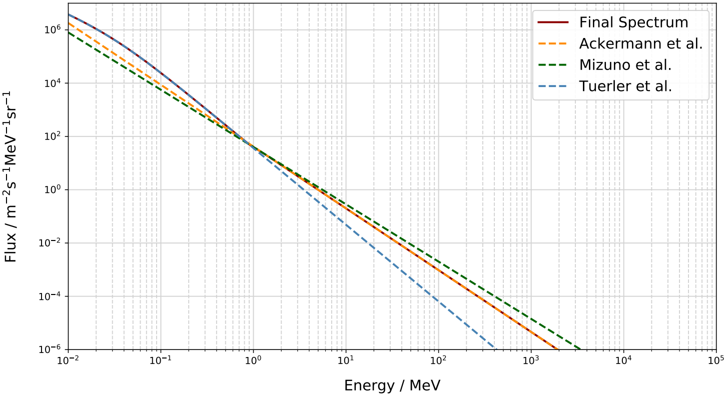


Cosmic Photons



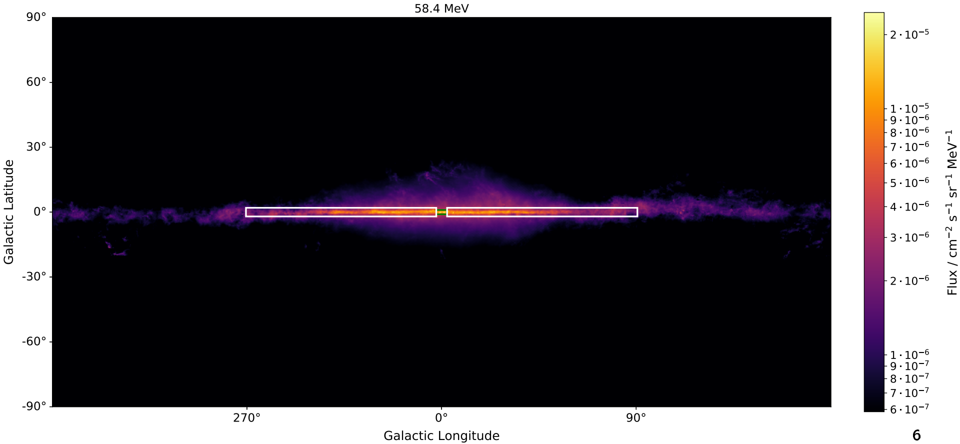
Cosmic Photons

- E<890 keV: INTEGRAL (Türler et al. (2010))
- 890 keV< E <∼ 1.2 MeV: EGRET (Mizuno et al. (2004))
- E > ∼ 1.2 MeV: Fermi-LAT (Ackermann et al. (2015))

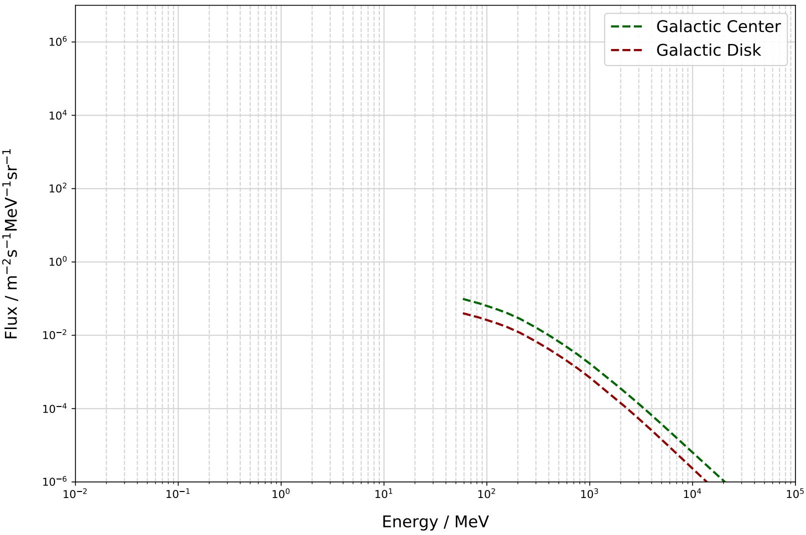


Cosmic Photons: Galactic Disk

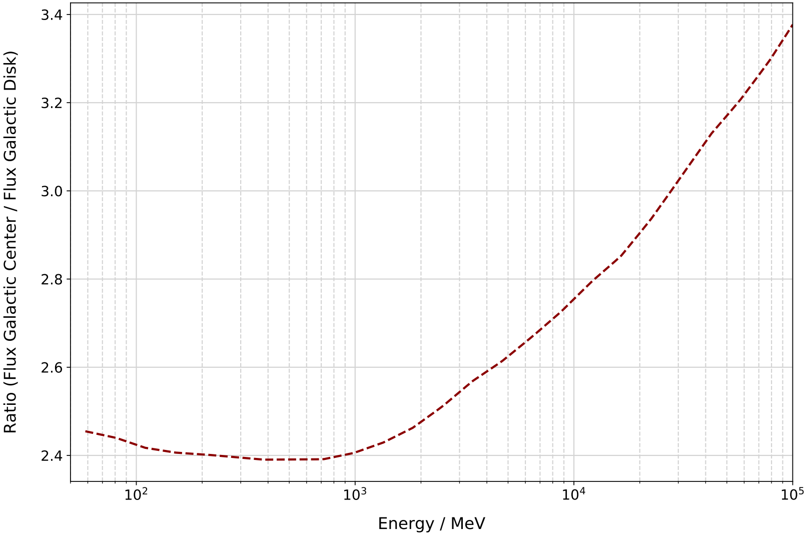
Publicly available LAT Galactic interstellar emission model: average of the two regions ($b = \pm 1°$, $l = \pm 2.5°$ and $b = \pm 2°$, $l = \pm 90°$)



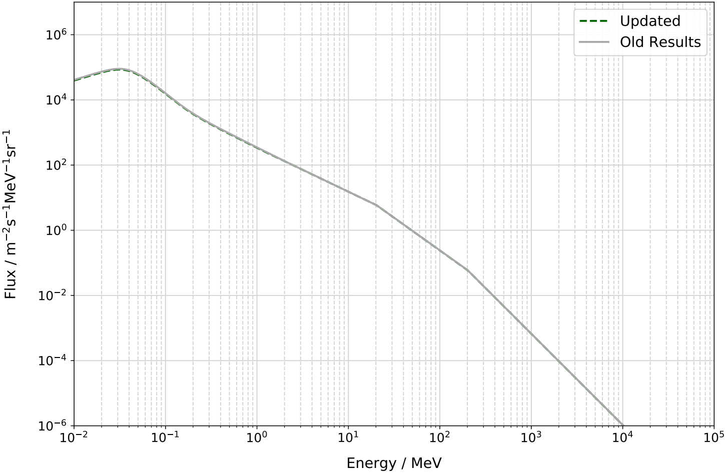
Cosmic Photons: Galactic Disk



Cosmic Photons: Galactic Disk



Albedo Photons

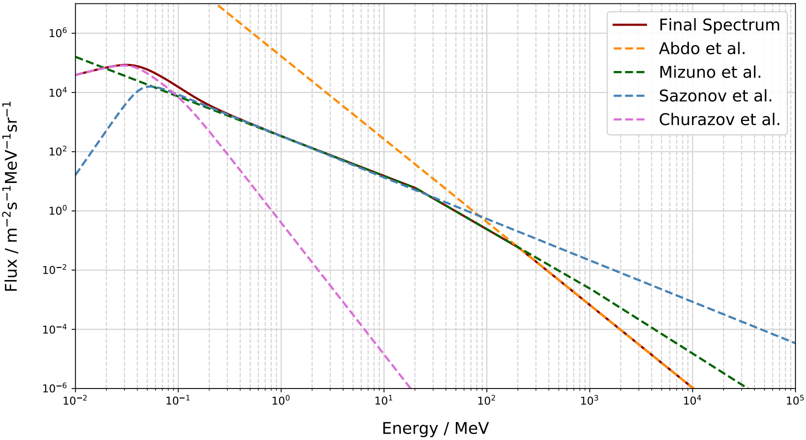


Albedo Photons

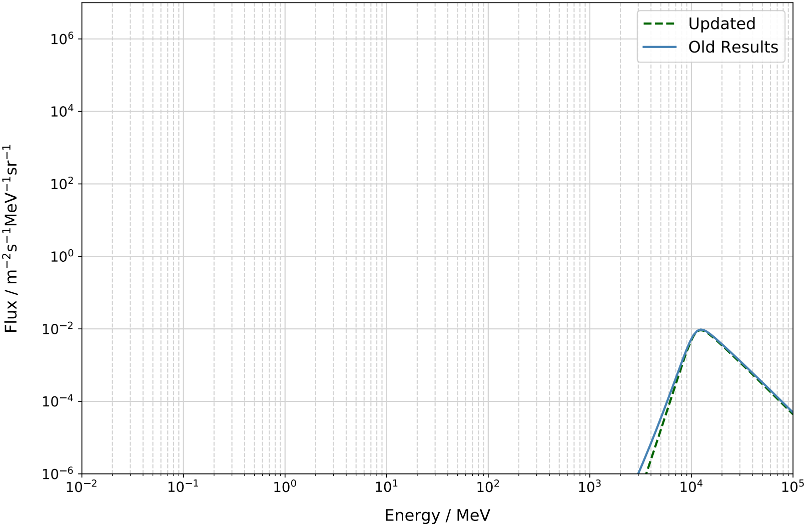
- E<1.85 MeV: The sum of:
  - Hard X-ray surface brightness of the Earth's atmosphere Sazonov et al. (2007)
  - Reflected cosmic X-ray background from Churazov et al. (2006)
- 1.85 MeV $<$ E $<$ 200 MeV: From Mizuno et al. (2004)
- E>200 MeV: From Abdo et al. (2009):

All the results are normalized to the Mizuno et al. (2004) ones

Albedo Photons



Primary Protons



Primary Protons

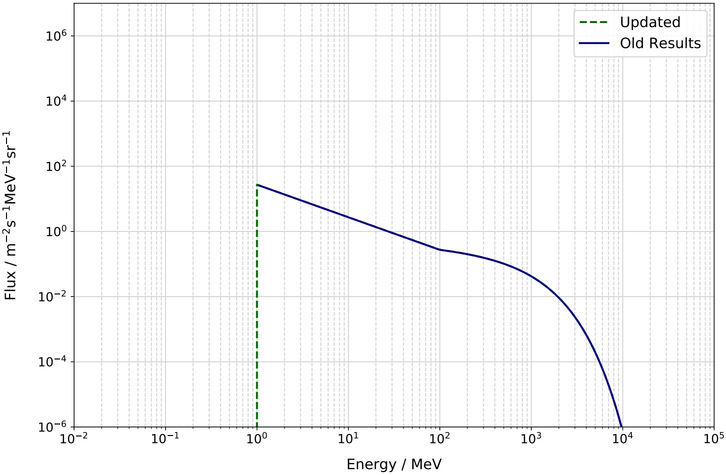
AMS data (Aguilar et al. (2015a)) plus solar modulation and reduction factor from the geomagnetic cutoff.

Why not SPENVIS?

- Not rely on an external tool
- Consistency with primary electrons/positrons spectra (that can not be calculated using SPENVIS)

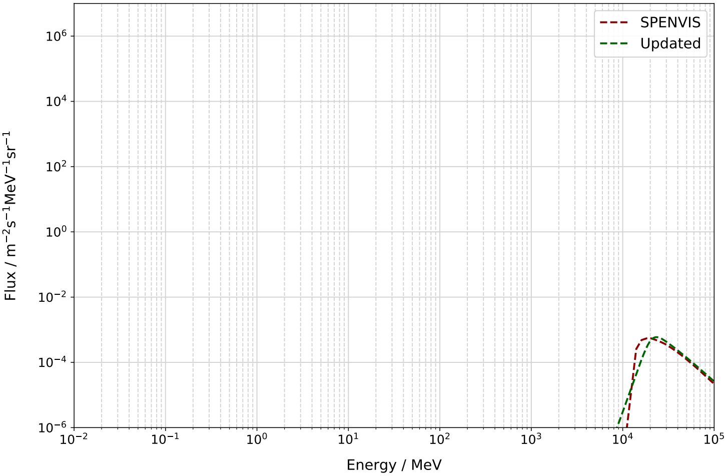
Secondary Protons

From Mizuno et al. (2004)



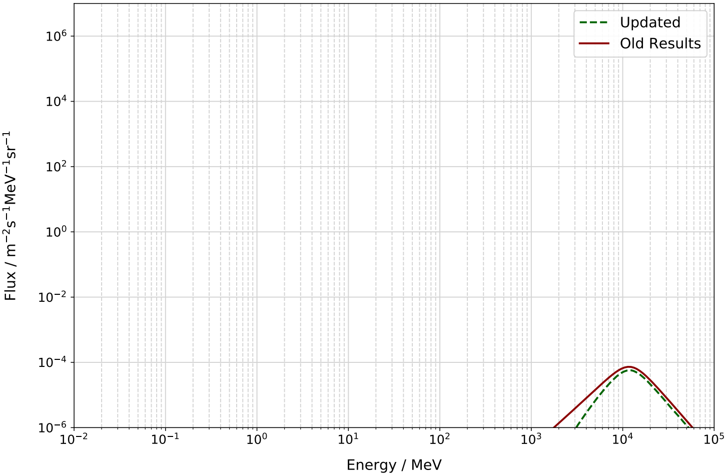
Primary Alphas

AMS data (Aguilar et al. (2015b)) plus modulations



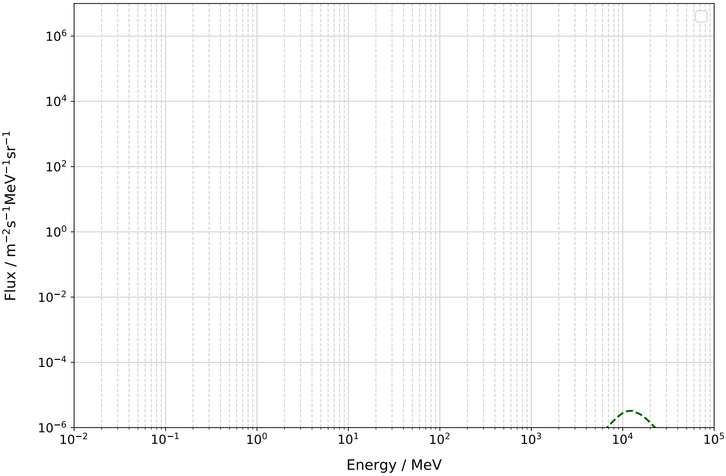
Primary Electrons

AMS data (Aguilar et al. (2014)) plus modulations



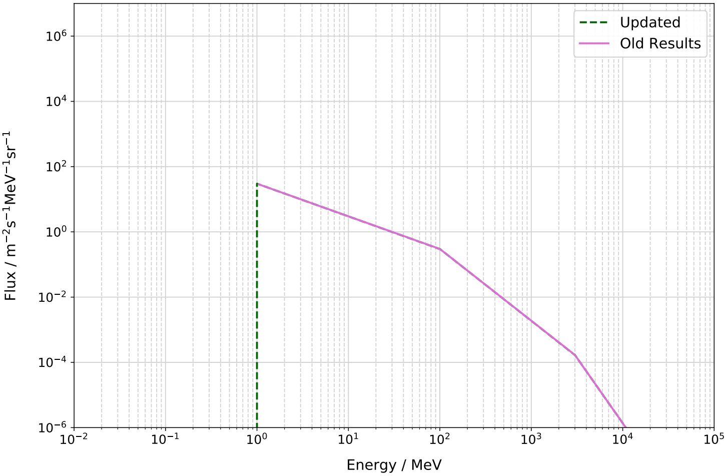
Primary Positrons

AMS data (Aguilar et al. (2014)) plus modulations



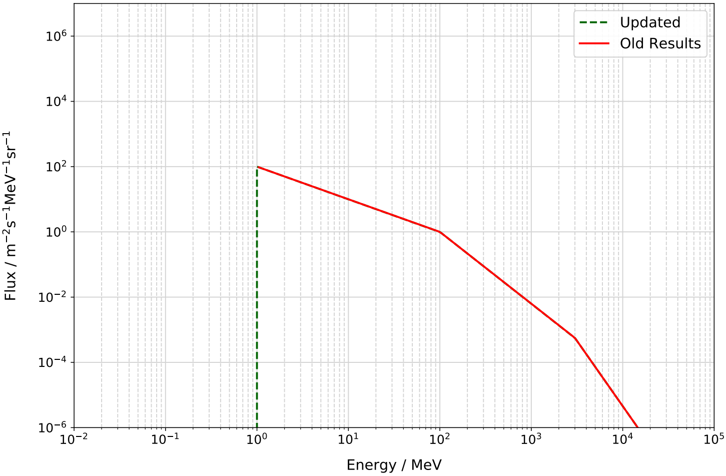
Secondary Electrons & Positrons

From Mizuno et al. (2004)

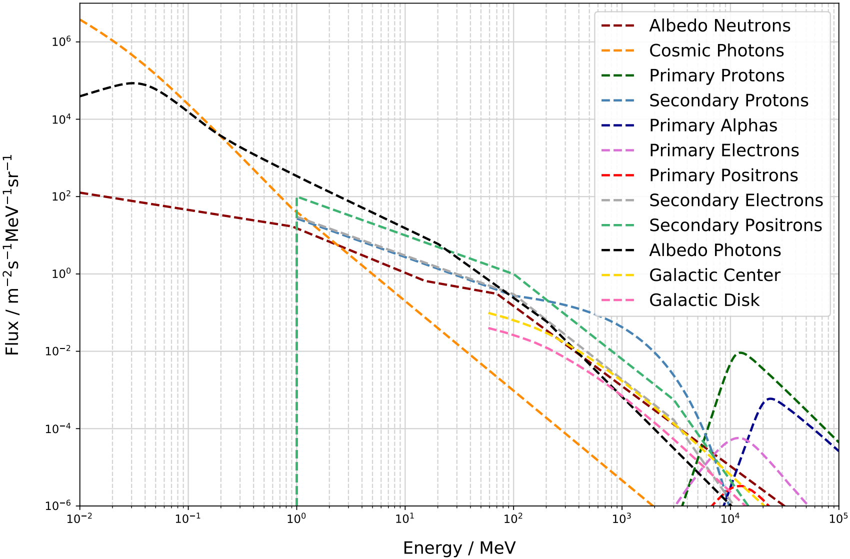


Secondary Electrons & Positrons

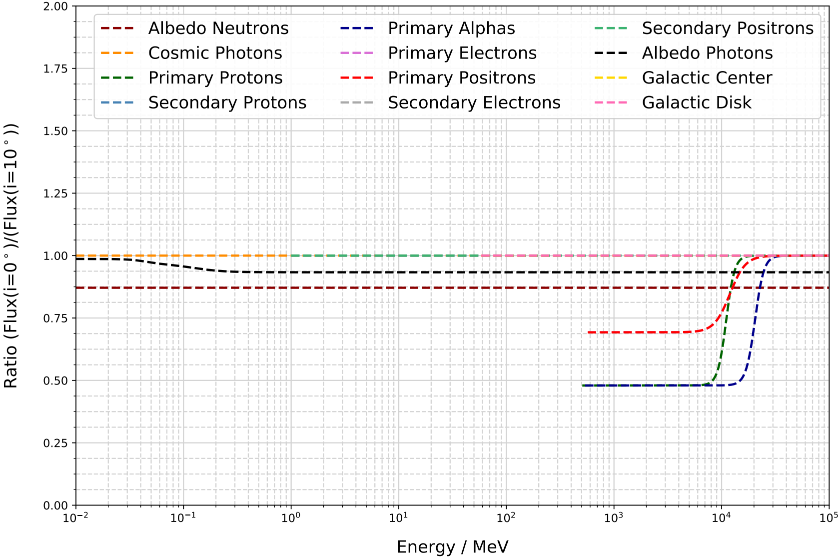
From Mizuno et al. (2004)



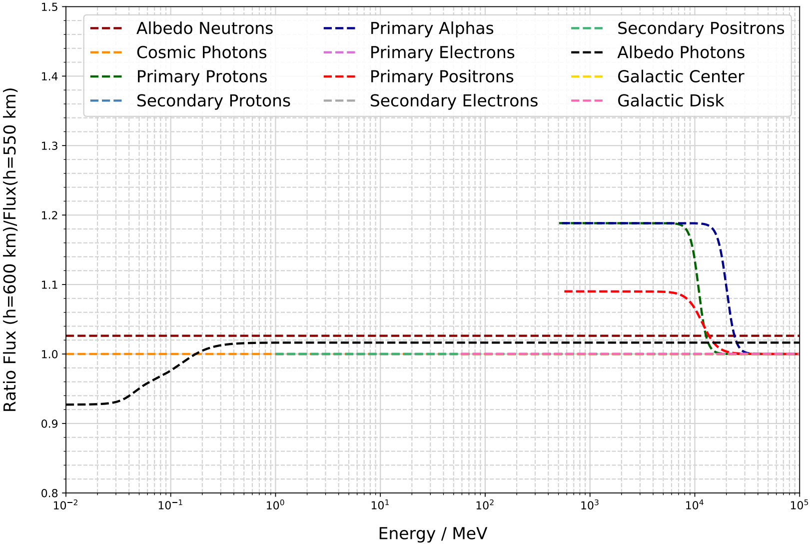
General Background



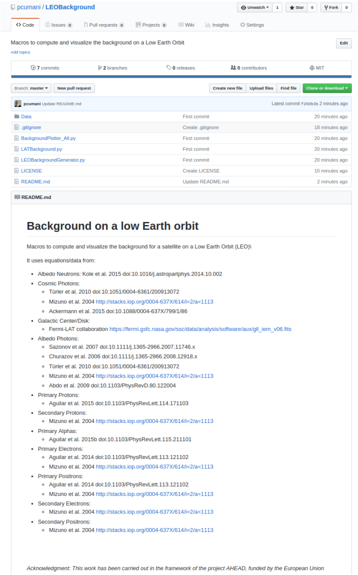
General Background



General Background



General Background: Github



pcumani / LEOBackground

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Code | Issues 0 | Pull requests 0 | Projects 0 | Wiki | Insights | Settings

Macros to compute and visualize the background on a Low Earth Orbit

Edit

Add topics

7 commits | 2 branches | 0 releases | 0 contributors | MIT

Branch: master | New pull request | Create new file | Upload files | Find file | Clone or download

pcumani Update README.md — Latest commit f269b3b 2 minutes ago

Data	First commit	20 minutes ago
.gitignore	Create .gitignore	18 minutes ago
BackgroundPlotter_All.py	First commit	20 minutes ago
LATBackground.py	First commit	20 minutes ago
LEOBackgroundGenerator.py	First commit	20 minutes ago
LICENSE	Create LICENSE	10 minutes ago
README.md	Update README.md	2 minutes ago

README.md

Background on a low Earth orbit

Macros to compute and visualize the background for a satellite on a Low Earth Orbit (LEO)\

It uses equations/data from:

- Albedo Neutrons: Kole et al. 2015 doi:10.1016/j.astropartphys.2014.10.002
- Cosmic Photons:
  - Türler et al. 2010 doi:10.1051/0004-6361/200913072
  - Mizuno et al. 2004 http://stacks.iop.org/0004-637X/614/i=2/a=1113
  - Ackermann et al. 2015 doi:10.1088/0004-637X/799/1/86
- Galactic Center/Disk:
  - Fermi-LAT collaboration https://fermi.gsfc.nasa.gov/ssc/data/analysis/software/aux/gll_iem_v06.fits
- Albedo Photons:
  - Sazonov et al. 2007 doi:10.1111/j.1365-2966.2007.11746.x
  - Churazov et al. 2006 doi:10.1111/j.1365-2966.2008.12918.x
  - Türler et al. 2010 doi:10.1051/0004-6361/200913072
  - Mizuno et al. 2004 http://stacks.iop.org/0004-637X/614/i=2/a=1113
  - Abdo et al. 2009 doi:10.1103/PhysRevD.80.122004
- Primary Protons:
  - Aguilar et al. 2015 doi:10.1103/PhysRevLett.114.171103
- Secondary Protons:
  - Mizuno et al. 2004 http://stacks.iop.org/0004-637X/614/i=2/a=1113
- Primary Alphas:
  - Aguilar et al. 2015b doi:10.1103/PhysRevLett.115.211101
- Primary Electrons:
  - Aguilar et al. 2014 doi:10.1103/PhysRevLett.113.121102
  - Mizuno et al. 2004 http://stacks.iop.org/0004-637X/614/i=2/a=1113
- Primary Positrons:
  - Aguilar et al. 2014 doi:10.1103/PhysRevLett.113.121102
  - Mizuno et al. 2004 http://stacks.iop.org/0004-637X/614/i=2/a=1113
- Secondary Electrons:
  - Mizuno et al. 2004 http://stacks.iop.org/0004-637X/614/i=2/a=1113
- Secondary Positrons:
  - Mizuno et al. 2004 http://stacks.iop.org/0004-637X/614/i=2/a=1113

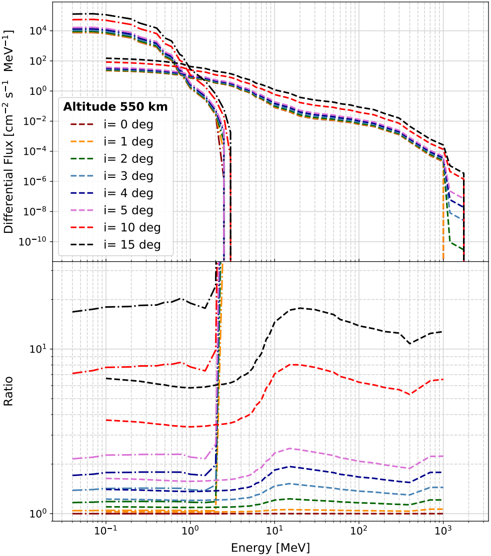
Acknowledgment: This work has been carried out in the framework of the project AHEAD, funded by the European Union

South Atlantic Anomaly: Model Update

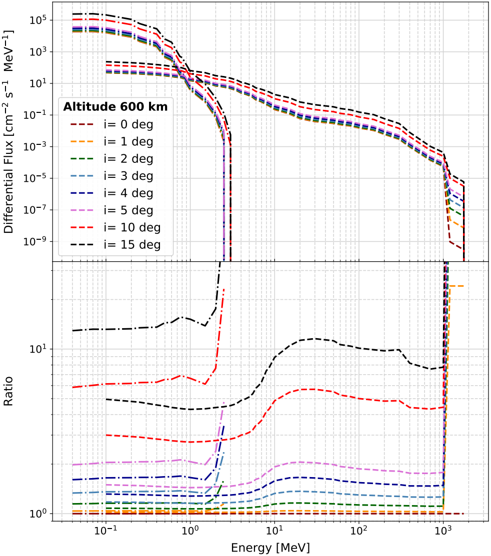
AE9/AP9 have been updated to version 1.5

- More data from experiments
- Absolute results changed (softer spectrum)
- Relative results remained the same (550 km, low inclination orbit still favored)

South Atlantic Anomaly: Model Update

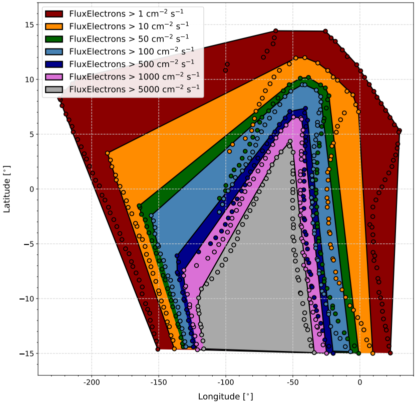


South Atlantic Anomaly: Model Update

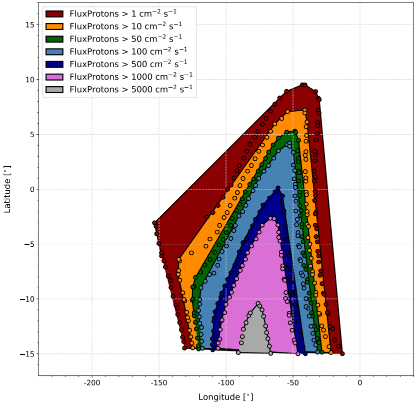


South Atlantic Anomaly: Model Update

Electrons

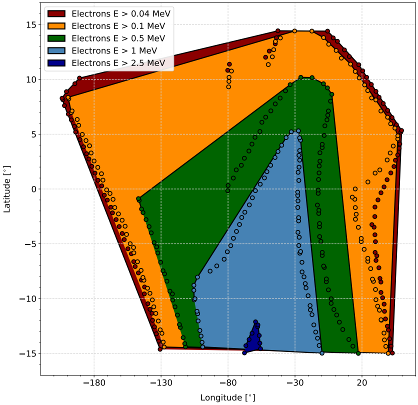


Protons

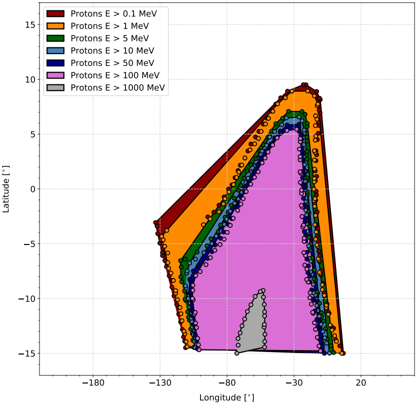


South Atlantic Anomaly: Model Update

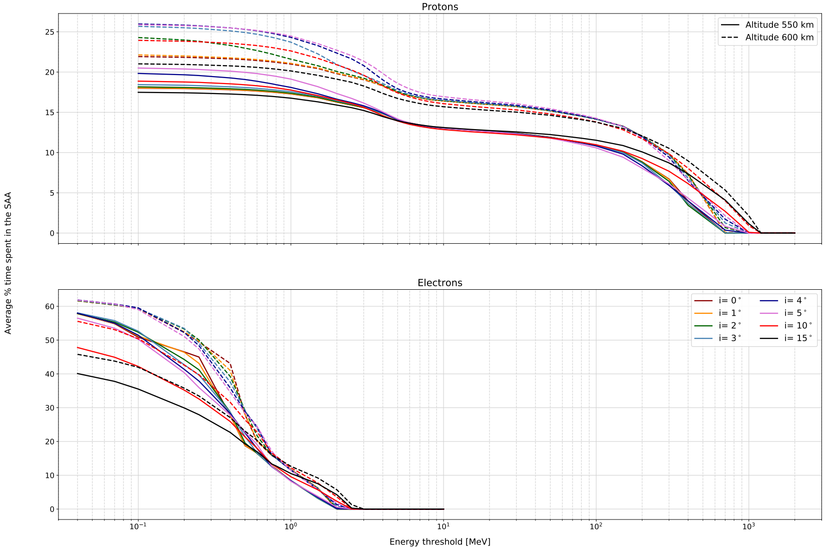
Electrons



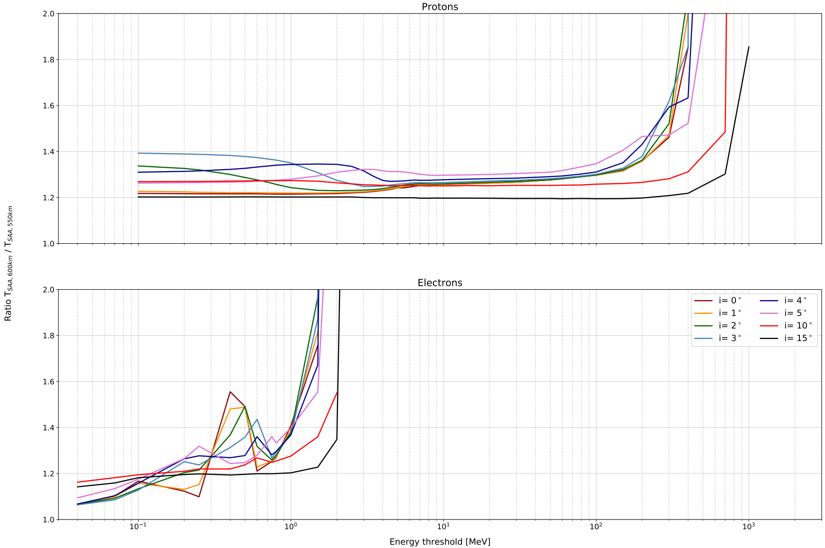
Protons



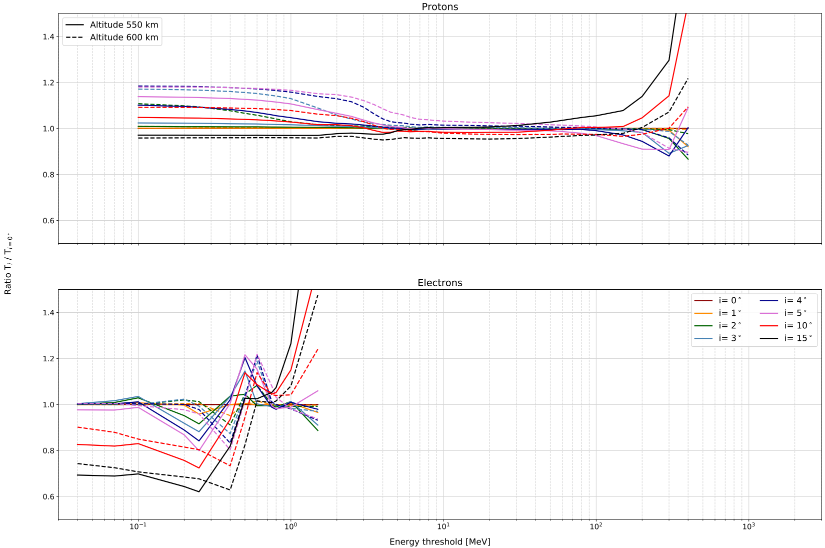
South Atlantic Anomaly: Model Update



South Atlantic Anomaly: Model Update



South Atlantic Anomaly: Model Update

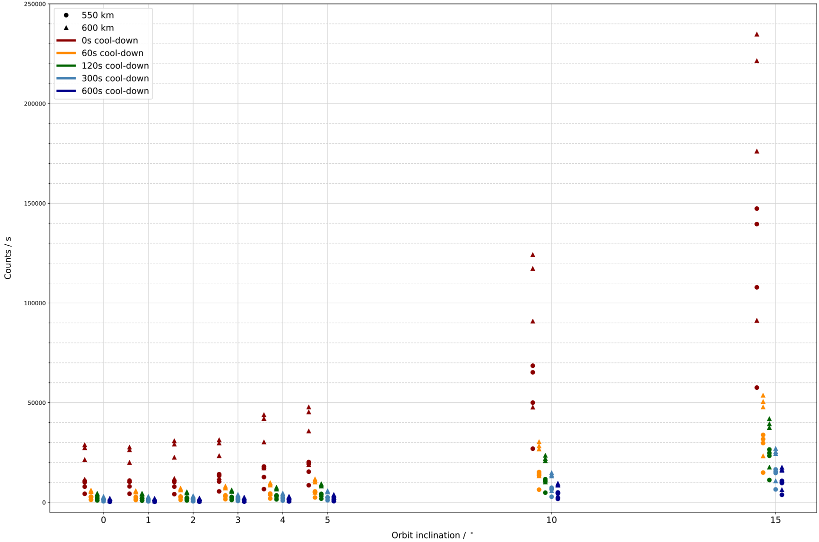


South Atlantic Anomaly: Activation Simulations

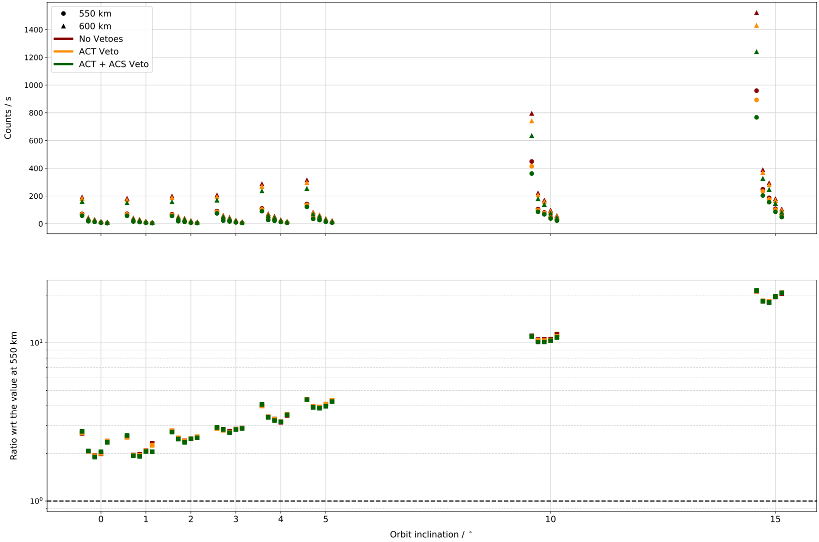
Divided in 3 steps:

- Calculation of the created isotopes: 10^6 events, AP9 differential spectrum
- Costant irradiation with cool-down: 0, 60, 120, 300, 600 s
- Activation: 60 s observation after cool-down
- Reconstruction

South Atlantic Anomaly: Activation Simulations



South Atlantic Anomaly: Activation Simulations

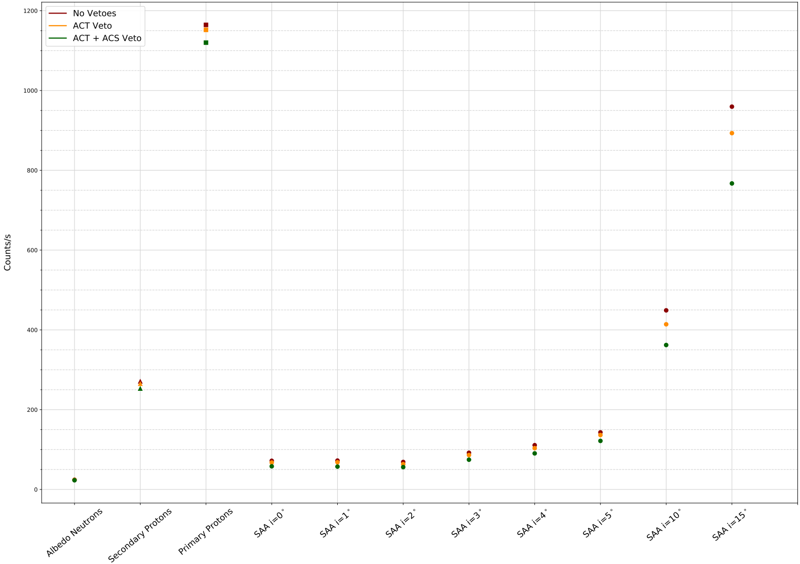


General Background: Activation Simulations

Calculated for:

- Albedo neutrons, primary and secondary protons
- 1 year of costant irradiation
- 550 km, 0° inclination

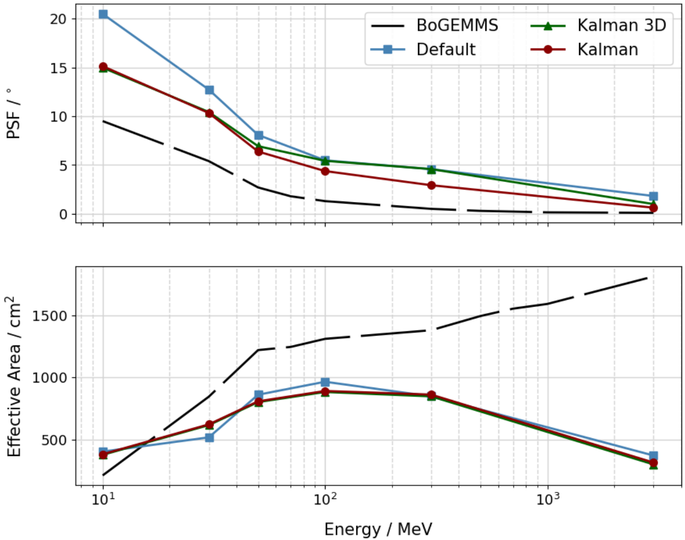
General Background: Activation Simulations



Conclusions

- The description of the different background components has been updated
- Python macros are already available on github
- Activation simulations for the SAA confirms choice of 550 km, $i < 5^\circ$ orbits
- SAA (for $i < 5^\circ$) and albedo neutrons activation negligible wrt primary/secondary protons
- Paper comprising LEO general background plus e-ASTROGAM activation

Performance: where we left



Performance: Vertex Finder Algorithm

MEGAlib (used also as Compton/Pair discriminator):

- One layer with exactly one hit
- Below: at least two layers with exactly two hits
- Above: no hits

AGILE:

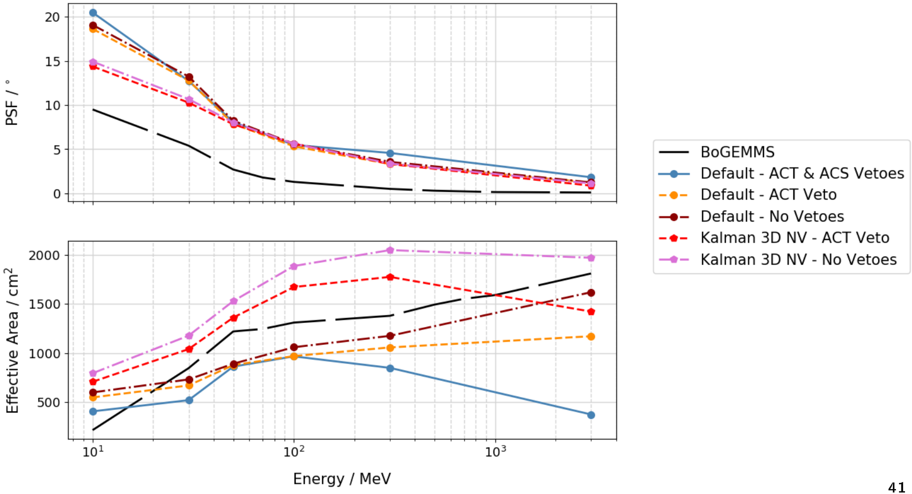
- Kalman Filter used on every possible combination of hits on the first two planes
- The couple of hits whose track has the least χ^2 is chosen as the vertex

Performance: New Vertex Finder Algorithm

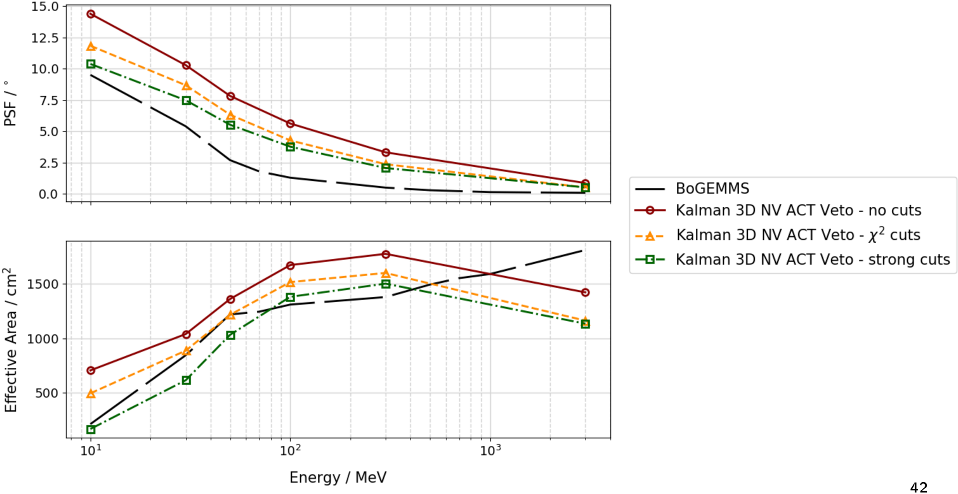
New approach

1. Default MEGAlib search is performed. If a vertex is found it is used, as previously.
2. If the search fails, the approach used in AGILE is implemented.
3. If the Kalman Filter fails or succeed but with too high χ^2 (ensure a good quality of the search and minimize the number of mislabeled events), the event is not considered as created by a pair.

Performance: New Vertex Finder Algorithm



Performance: New Vertex Finder Algorithm



Performance: New Vertex Finder Algorithm

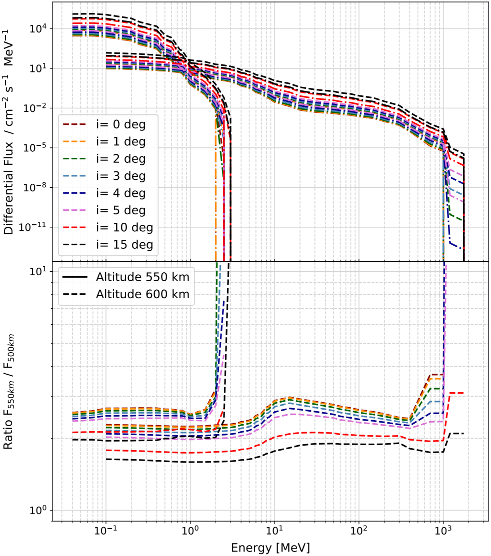
Percent difference in the number of events with the two vertex finder algorithm

		Percentage					
		10 MeV	30 MeV	50 MeV	100 MeV	300 MeV	3000 MeV
Identifiable		0.33	0.03	0	0.02	-0.01	0.05
Reconstructed	Single site	0	0.1	0	0	-0.09	0.11
	Compton	0.53	-0.3	-0.19	0.04	-0.04	0.49
	Pair	32.57	61	71.54	78.08	74.36	21.66
	Muon	-14.5	-34.27	-41.11	-42.39	-37.23	-25.89

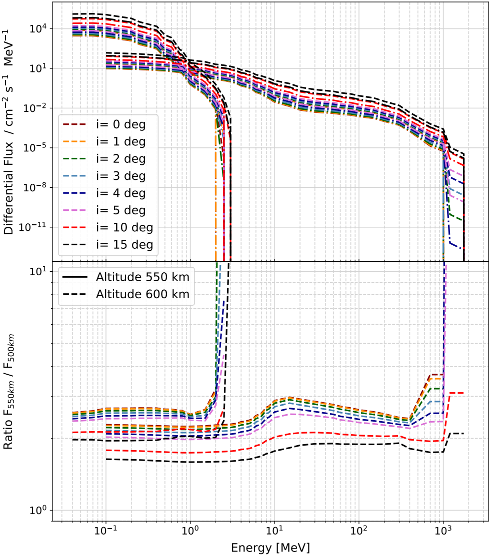
Conclusions

- A new vertex algorithm was implemented
- Effective area now comparable to the paper results
- Compton performance seems to be unaffected by the change
- A non-disruptive veto using the segmentation of the side AC needs to be implemented

South Atlantic Anomaly: Model Update



South Atlantic Anomaly: Model Update



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A. A. Abdo et al. Fermi large area telescope observations of the cosmic-ray induced γ-ray emission of the Earth's atmosphere. Phys. Rev. D, 80(12):122004, December 2009. doi: 10.1103/PhysRevD.80.122004.

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