South Atlantic Anomaly influence to JEM-EUSO measurements

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South Atlantic Anomaly (SAA)

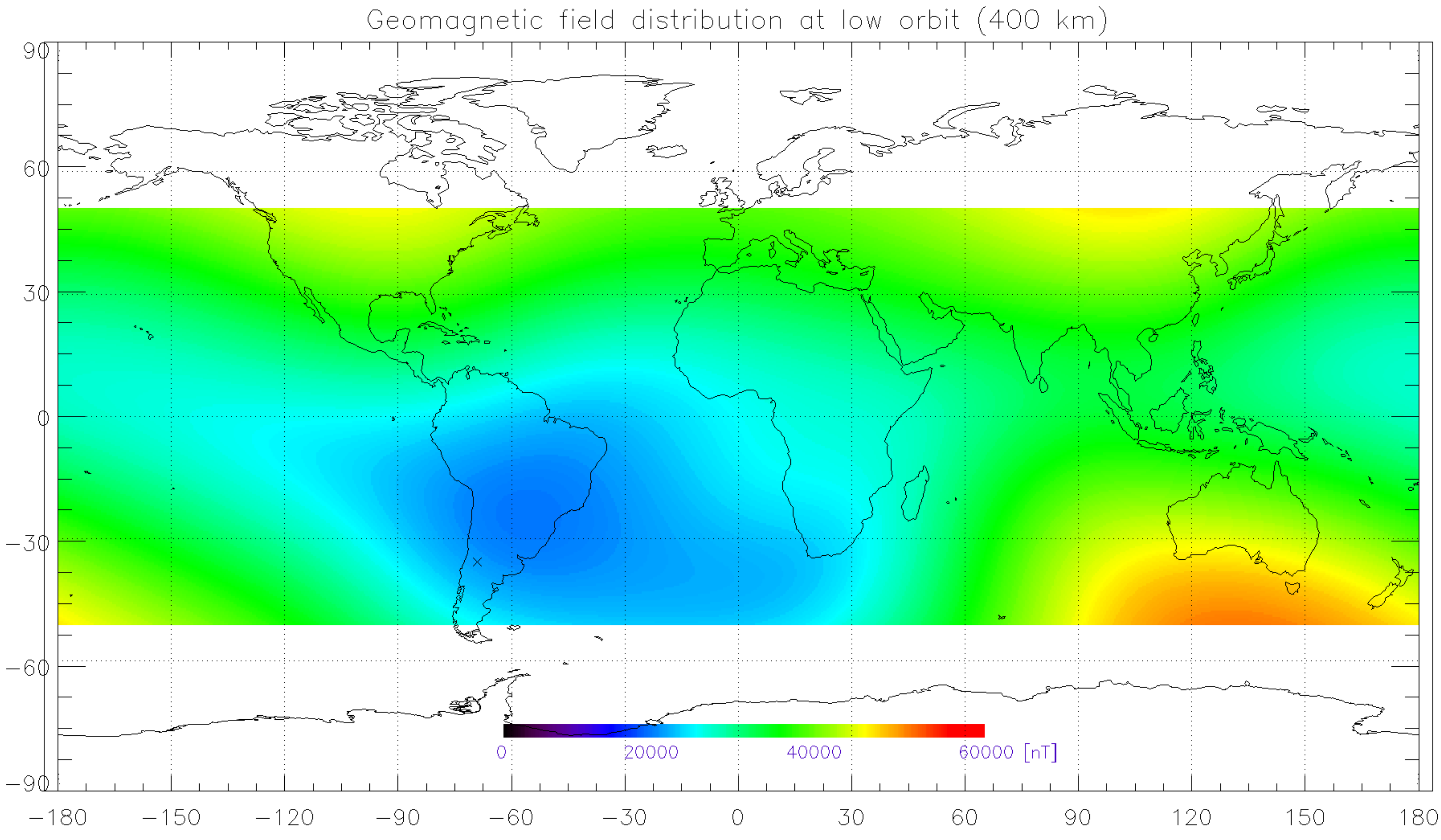
- two different effects

a) production of higher UV background in atmosphere
b) trapped particles (e^-) passes through lenses, creating additional UV background in SAA

Previous simple estimation of SAA influence
- based on evaluation of total geomagnetic field (IGRF) and Tatiana 1 measurements

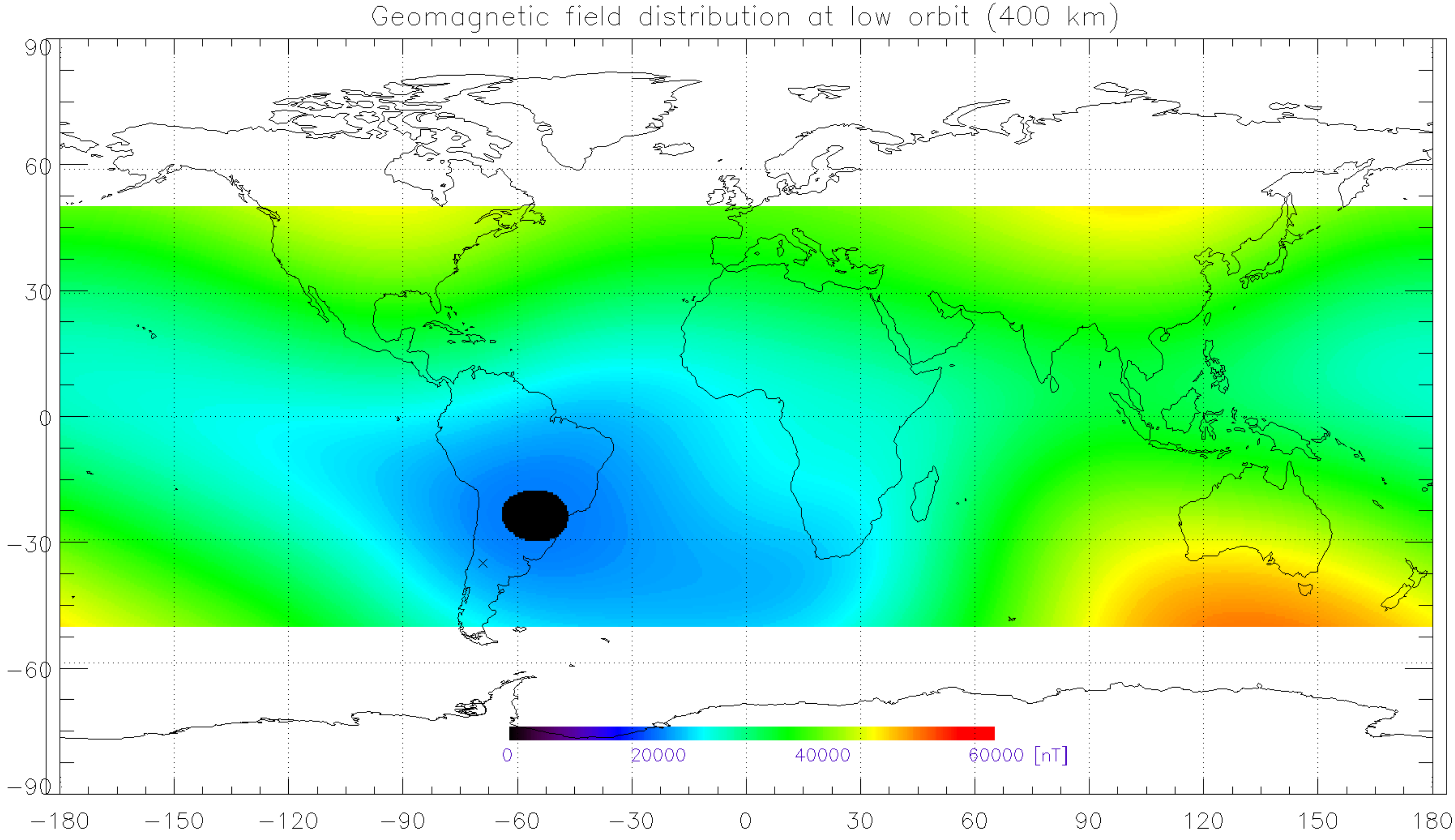
SAA effect on JEM-EUSO operational efficiency

- IGRF field model – total magnetic field in *nT*



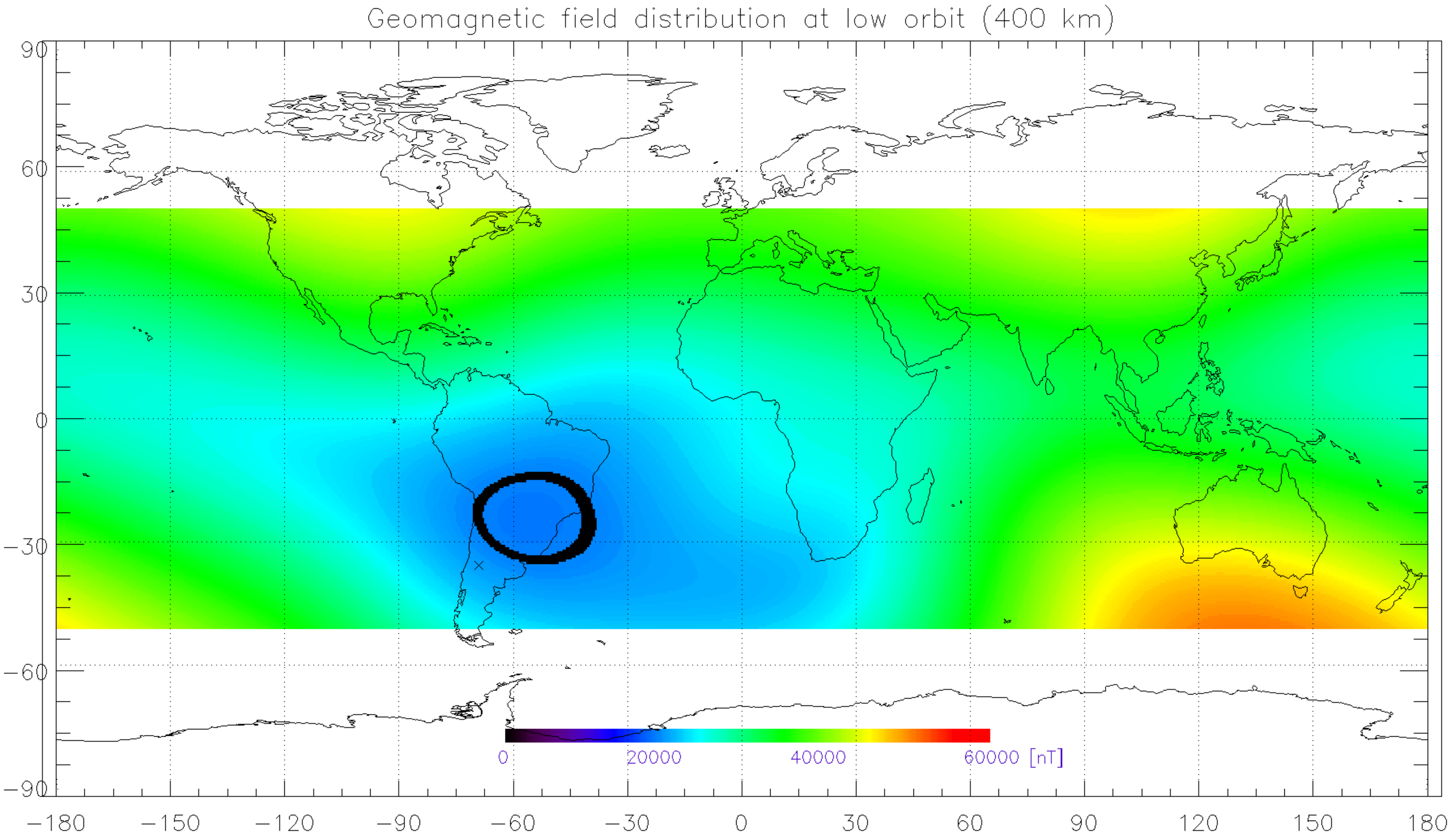
SAA effect on JEM-EUSO operational efficiency

- IGRF field model – total magnetic field in *nT* :: *black circle area with* $B_{total} < 19500$ *nT*



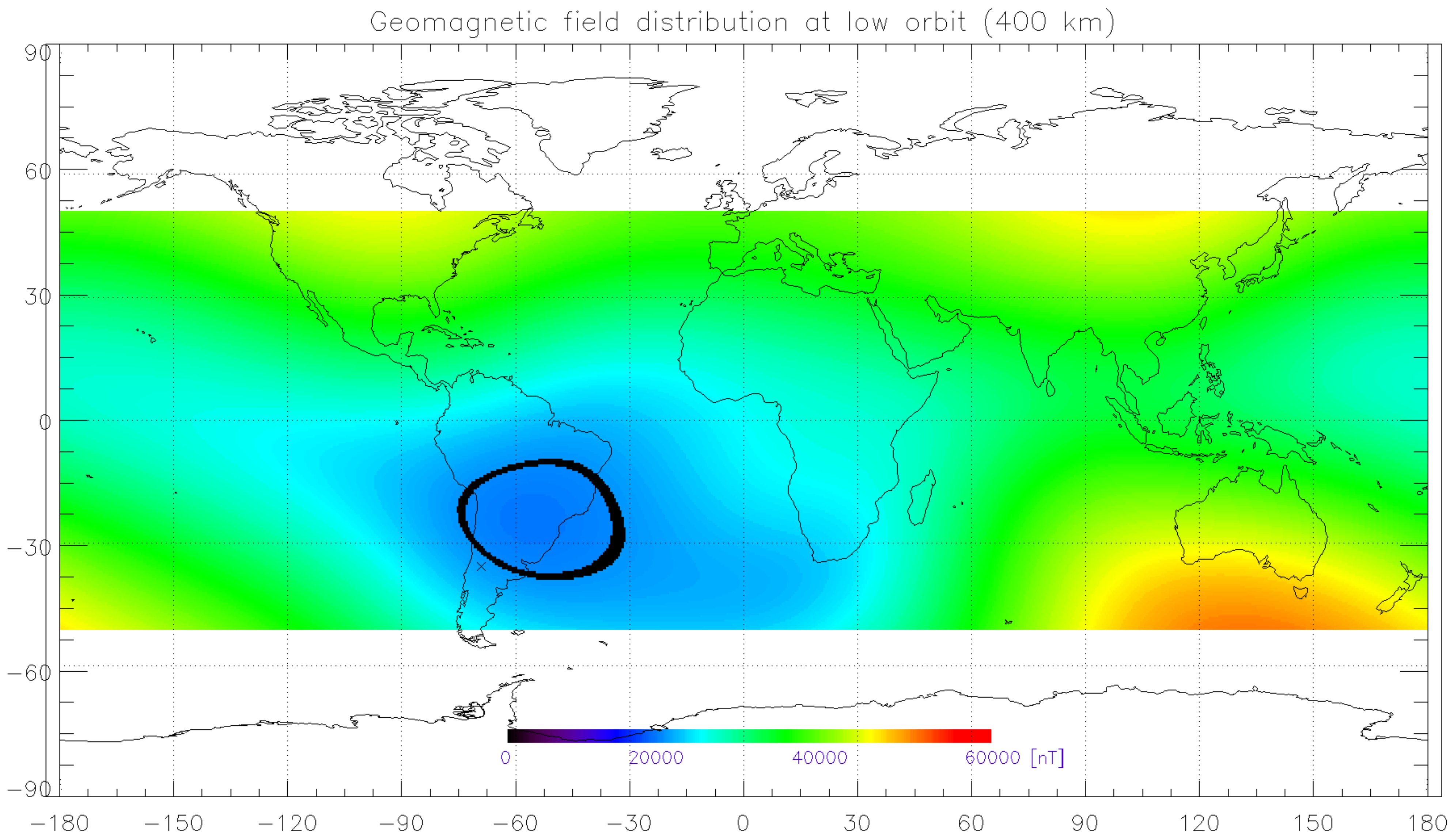
SAA effect on JEM-EUSO operational efficiency

- IGFR field model – total magnetic field in *nT* :: *black circle area with* $B_{total} < 20000\ nT$



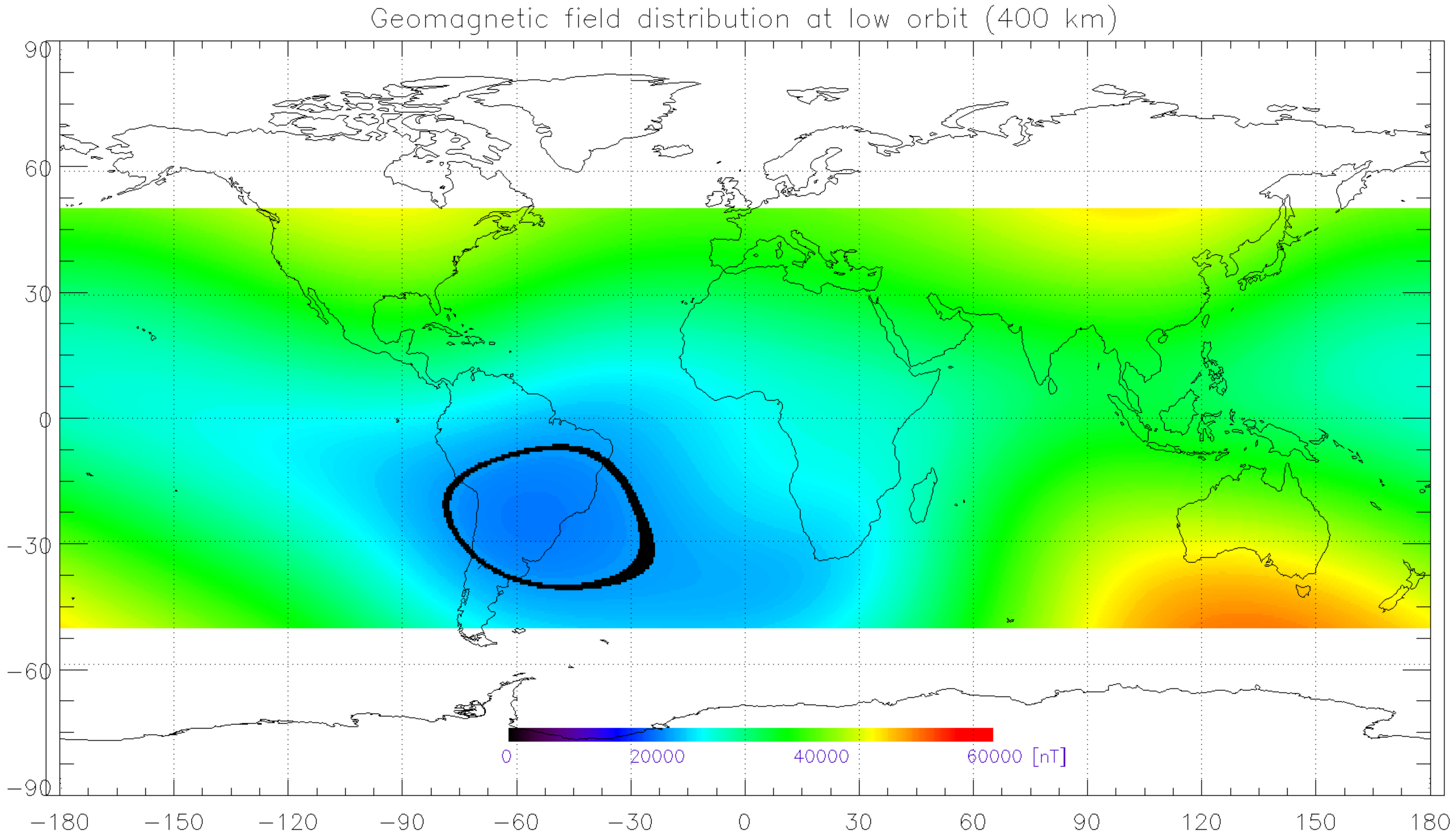
SAA effect on JEM-EUSO operational efficiency

- IGRF field model – total magnetic field in *nT* :: *black circle area with* $B_{total} < 20500\ nT$



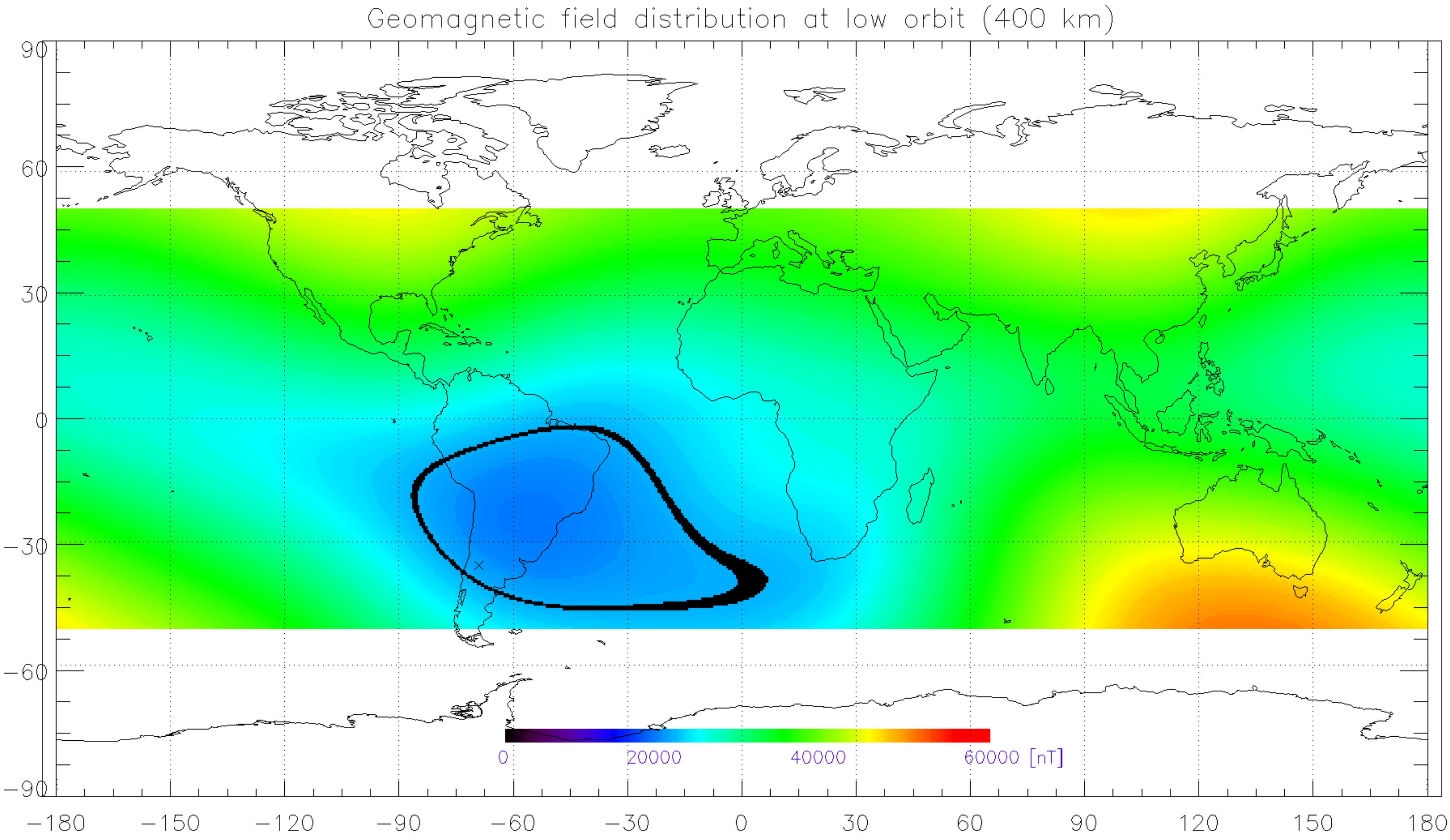
SAA effect on JEM-EUSO operational efficiency

- IGRF field model – total magnetic field in *nT* :: *black circle area with B_{total} < 21000 nT*



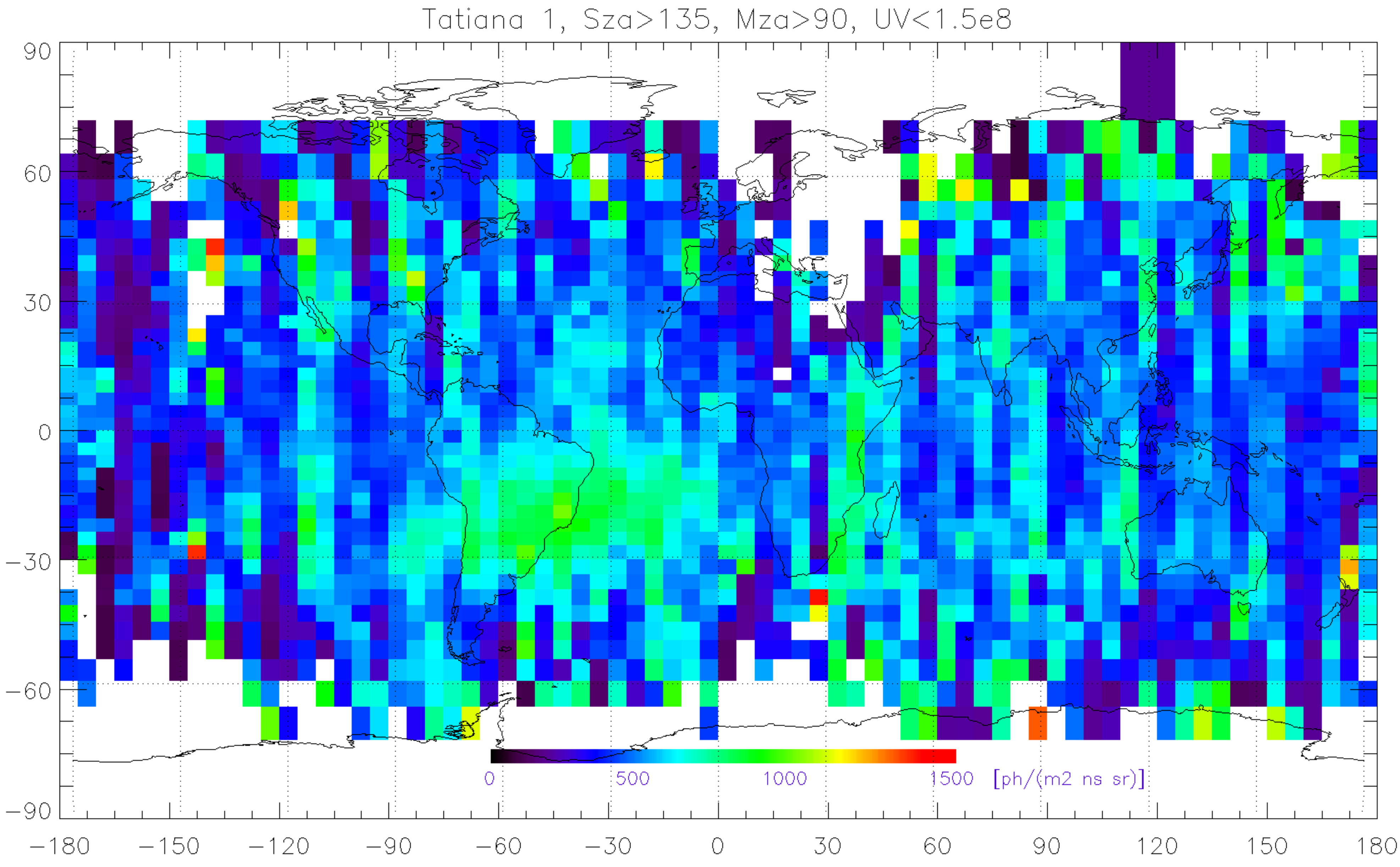
SAA effect on JEM-EUSO operational efficiency

- IGRF field model – total magnetic field in *nT* :: *black circle area with* $B_{total} < 22000\ nT$



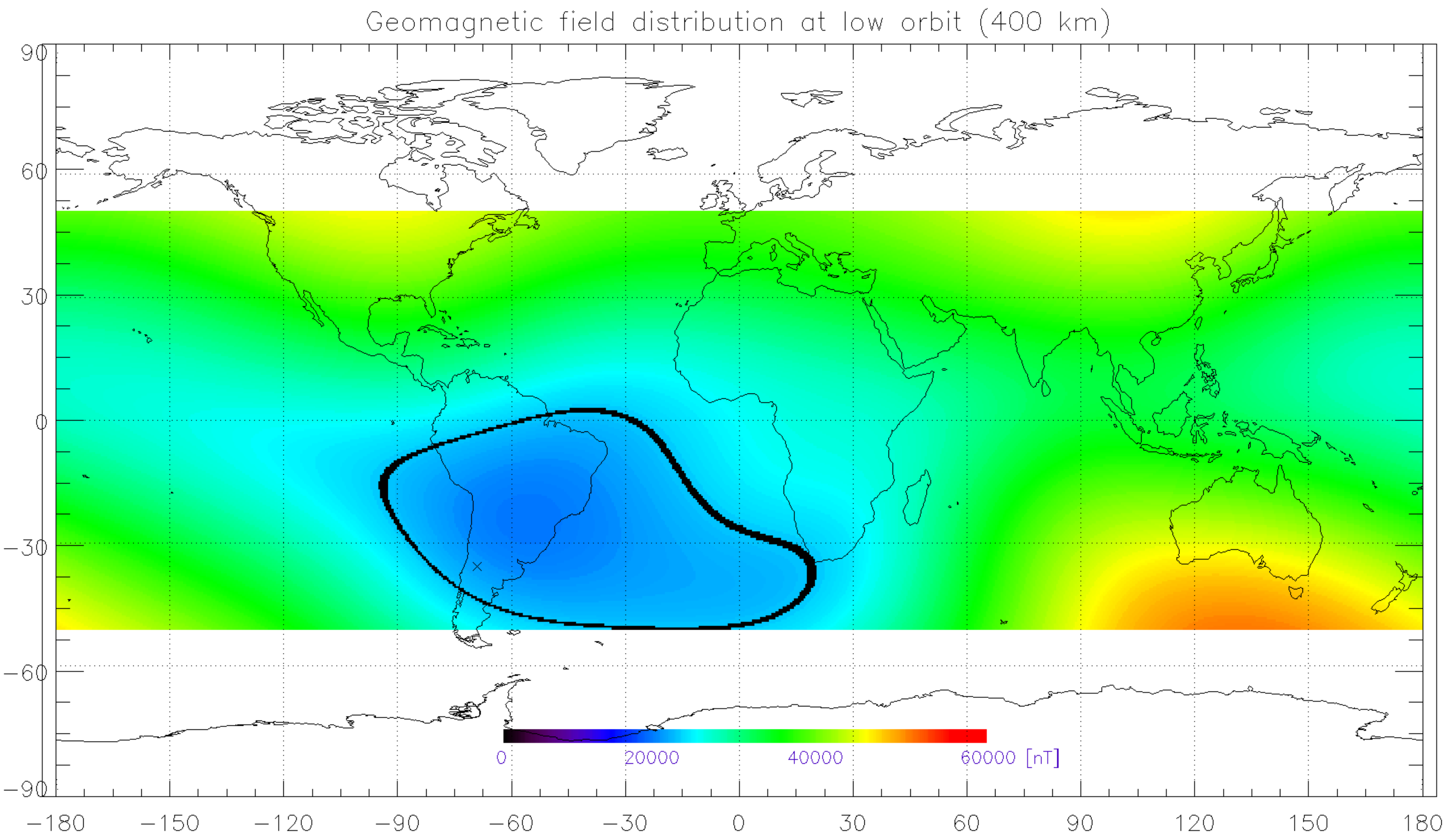
SAA effect on JEM-EUSO operational efficiency

Tatiana 1 UV BG measurements



SAA effect on JEM-EUSO operational efficiency

- IGRF field model – total magnetic field in *nT* :: *black circle area with B_{total} < 23000 nT*



SAA effect on JEM-EUSO operational efficiency

- To which energies / particles we (instrument) are sensitive?

- Effect is partly due to additional/higher UV BG created in SAA
- Conservative estimation – we are not measure inside SAA, measurements inside SAA are excluded

SAA effect on JEM-EUSO operational efficiency

B_{total} < 19500 nT

$I_{Allowed}$ [ph/(m^2 ns sr)]	$I_{SUN} + I_{BG} + I_{MOON}$ [%]	$I_{SUN} + I_{BG} + I_{MOON} + I_{SAA}$ [%]
1000	19.26	19.22
1500	20.42	20.38
2000	21.43	21.38
5000	26.07	26.02
10000	32.21	32.14
15000	34.81	34.73
30000	34.84	34.77

B_{total} < 21000 nT

$I_{Allowed}$ [ph/(m^2 ns sr)]	$I_{SUN} + I_{BG} + I_{MOON}$ [%]	$I_{SUN} + I_{BG} + I_{MOON} + I_{SAA}$ [%]
1000	19.26	18.63
1500	20.42	19.75
2000	21.43	20.73
5000	26.07	25.23
10000	32.21	31.16
15000	34.81	33.67
30000	34.84	33.70

B_{total} < 22500 nT

$I_{Allowed}$ [ph/(m^2 ns sr)]	$I_{SUN} + I_{BG} + I_{MOON}$ [%]	$I_{SUN} + I_{BG} + I_{MOON} + I_{SAA}$ [%]
1000	19.26	17.70
1500	20.42	18.77
2000	21.43	19.69
5000	26.07	23.97
10000	32.21	29.60
15000	34.81	32.00
30000	34.84	32.03

B_{total} < 20000 nT

$I_{Allowed}$ [ph/(m^2 ns sr)]	$I_{SUN} + I_{BG} + I_{MOON}$ [%]	$I_{SUN} + I_{BG} + I_{MOON} + I_{SAA}$ [%]
1000	19.26	19.04
1500	20.42	20.19
2000	21.43	21.18
5000	26.07	25.78
10000	32.21	31.84
15000	34.81	34.41
30000	34.84	34.44

B_{total} < 21500 nT

$I_{Allowed}$ [ph/(m^2 ns sr)]	$I_{SUN} + I_{BG} + I_{MOON}$ [%]	$I_{SUN} + I_{BG} + I_{MOON} + I_{SAA}$ [%]
1000	19.26	18.38
1500	20.42	19.49
2000	21.43	20.46
5000	26.07	24.90
10000	32.21	30.75
15000	34.81	33.22
30000	34.84	33.26

B_{total} < 23000 nT

$I_{Allowed}$ [ph/(m^2 ns sr)]	$I_{SUN} + I_{BG} + I_{MOON}$ [%]	$I_{SUN} + I_{BG} + I_{MOON} + I_{SAA}$ [%]
1000	19.26	17.36
1500	20.42	18.41
2000	21.43	19.32
5000	26.07	23.52
10000	32.21	29.04
15000	34.81	31.39
30000	34.84	31.42

B_{total} < 20500 nT

$I_{Allowed}$ [ph/(m^2 ns sr)]	$I_{SUN} + I_{BG} + I_{MOON}$ [%]	$I_{SUN} + I_{BG} + I_{MOON} + I_{SAA}$ [%]
1000	19.26	18.85
1500	20.42	19.99
2000	21.43	20.97
5000	26.07	25.52
10000	32.21	31.52
15000	34.81	34.06
30000	34.84	34.10

B_{total} < 22000 nT

$I_{Allowed}$ [ph/(m^2 ns sr)]	$I_{SUN} + I_{BG} + I_{MOON}$ [%]	$I_{SUN} + I_{BG} + I_{MOON} + I_{SAA}$ [%]
1000	19.26	18.04
1500	20.42	19.13
2000	21.43	20.07
5000	26.07	24.44
10000	32.21	30.18
15000	34.81	32.61
30000	34.84	32.64

B_{total} < 24000 nT

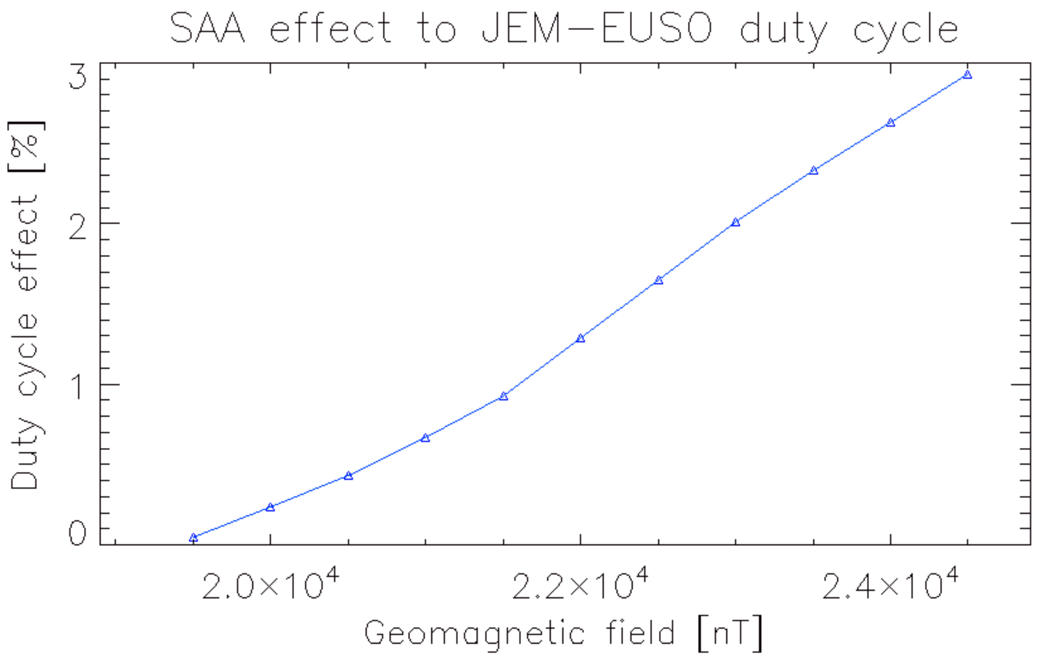
$I_{Allowed}$ [ph/(m^2 ns sr)]	$I_{SUN} + I_{BG} + I_{MOON}$ [%]	$I_{SUN} + I_{BG} + I_{MOON} + I_{SAA}$ [%]
1000	19.26	16.77
1500	20.42	17.79
2000	21.43	18.66
5000	26.07	22.73
10000	32.21	28.07
15000	34.81	30.33
30000	34.84	30.36

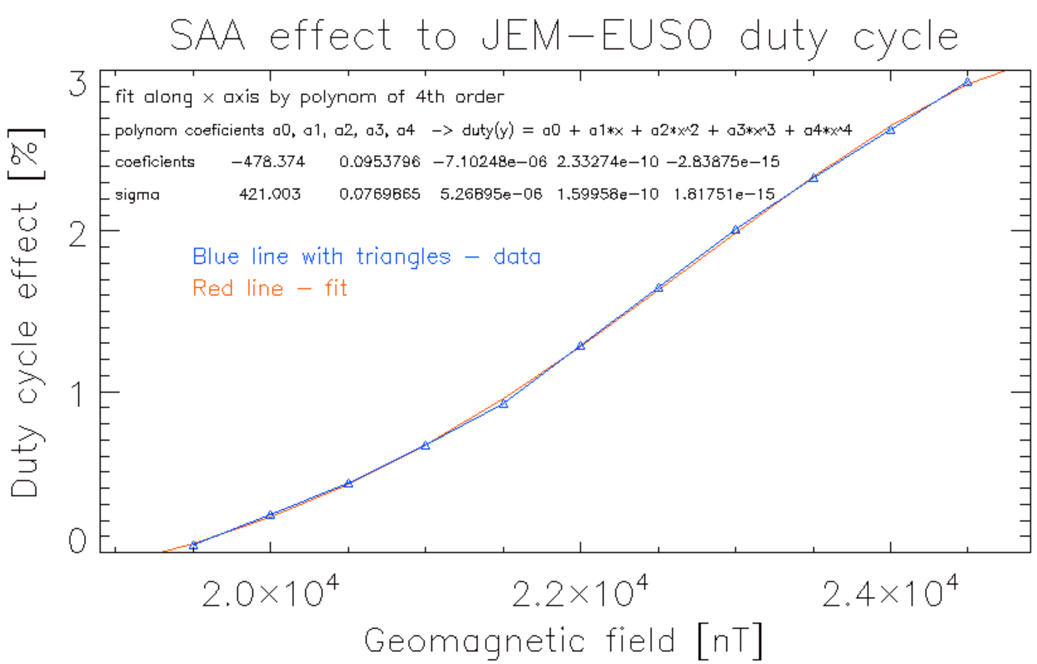
SAA effect on JEM-EUSO operational efficiency

- From Tatiana 1

21000 – 21500 nT

0.67% - 0.93%





SAA effect on JEM-EUSO operational efficiency

Conclusion for SAA effect to DC from simple approach

- Conservative estimation of South Atlantic Anomaly effect to JEM-ESUO operational efficiency lead to reduction of allowed time of measurements by 0.7%-0.9%.

- To verify SAA effect we need to know/estimate to which particles (energies) we are sensitive

  - **Galactic cosmic rays?**

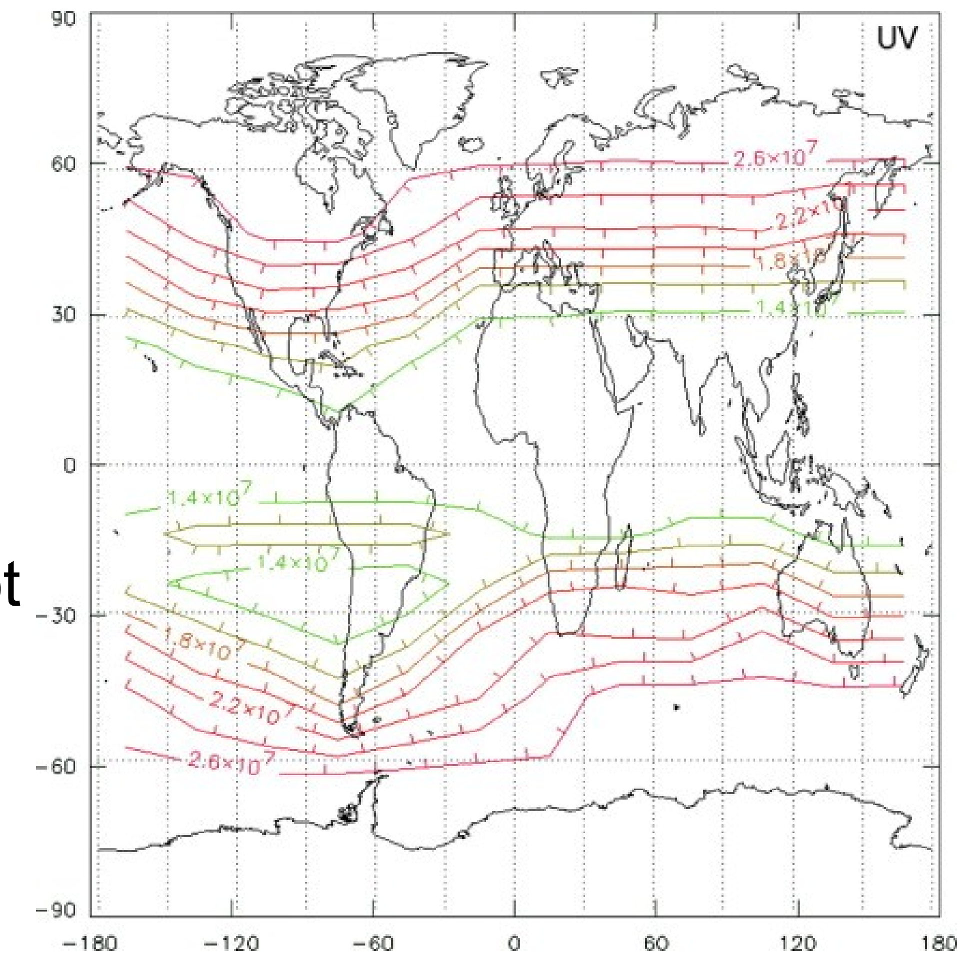
Galactic cosmic rays

- Hypothesis: GCR create additional UV BG

  - was already tested in Advances in Space Research [1] article for all Earth surface except SAA

  - now simulation also for SAA

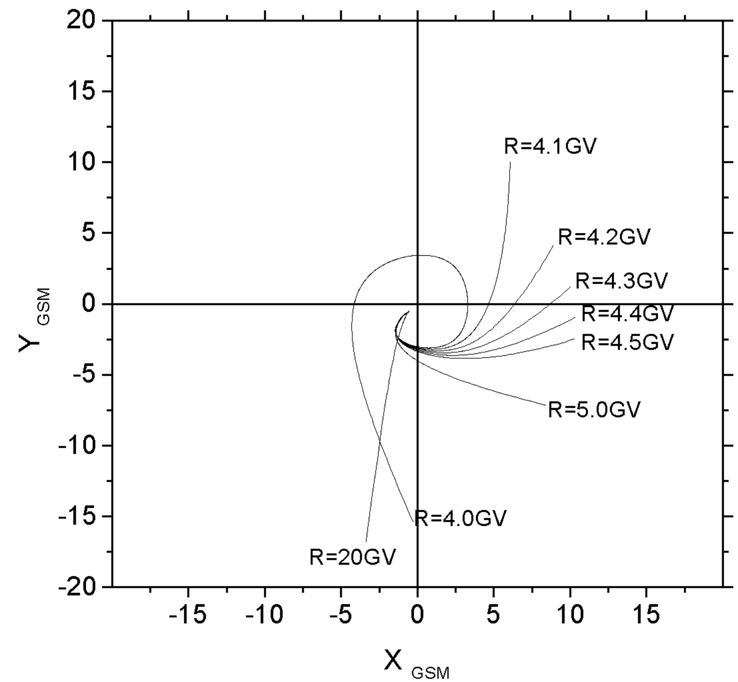
  - even we think that this will be not main/big effect, we provide simulation in SAA



UV light intensity at the top of the atmosphere for albedo 100%. For albedo 0% UV light in 300–400 nm (number of photons in $(m^2\ s\ sr)^{-1}$) will have half values.

[1] Distribution of secondary particles intensities over Earth's surface: Effect of the geomagnetic field, Advances in Space Research, 50, 7,986-996, 2012

Galactic cosmic rays



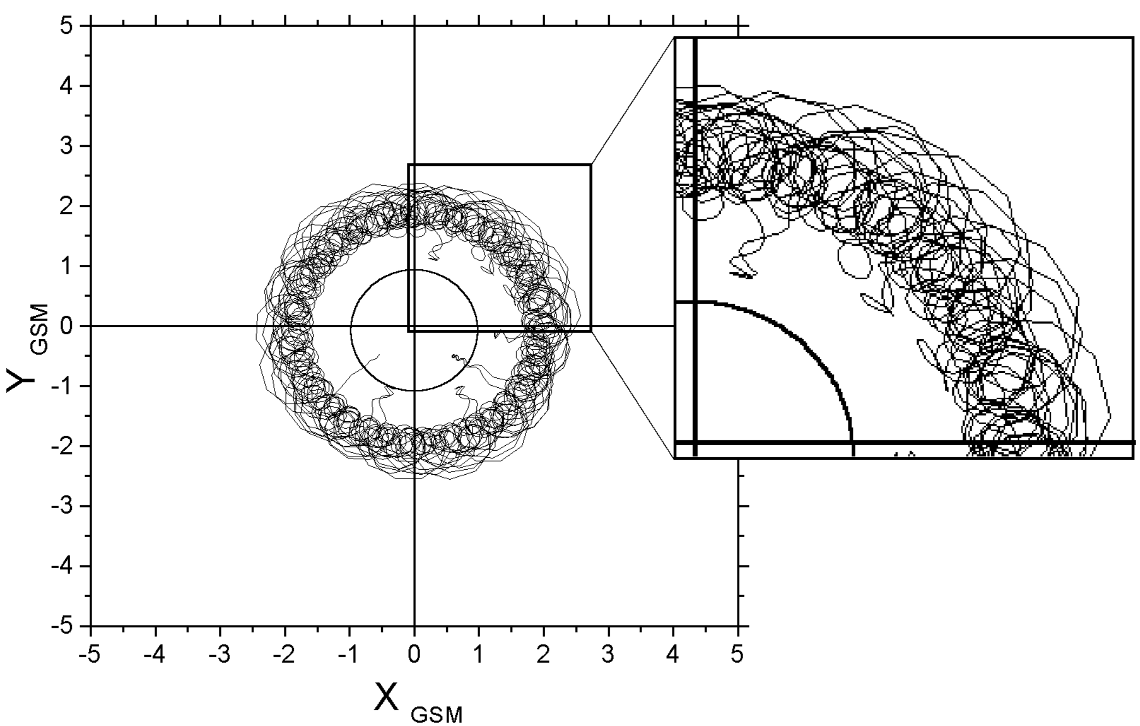
Simulation

- for every point (geographical place) on latitude "line" crossing a SAA and we evaluate

  - 576 directions

  - for every directions 20 000 energies

  - ~10 million trajectories for one point

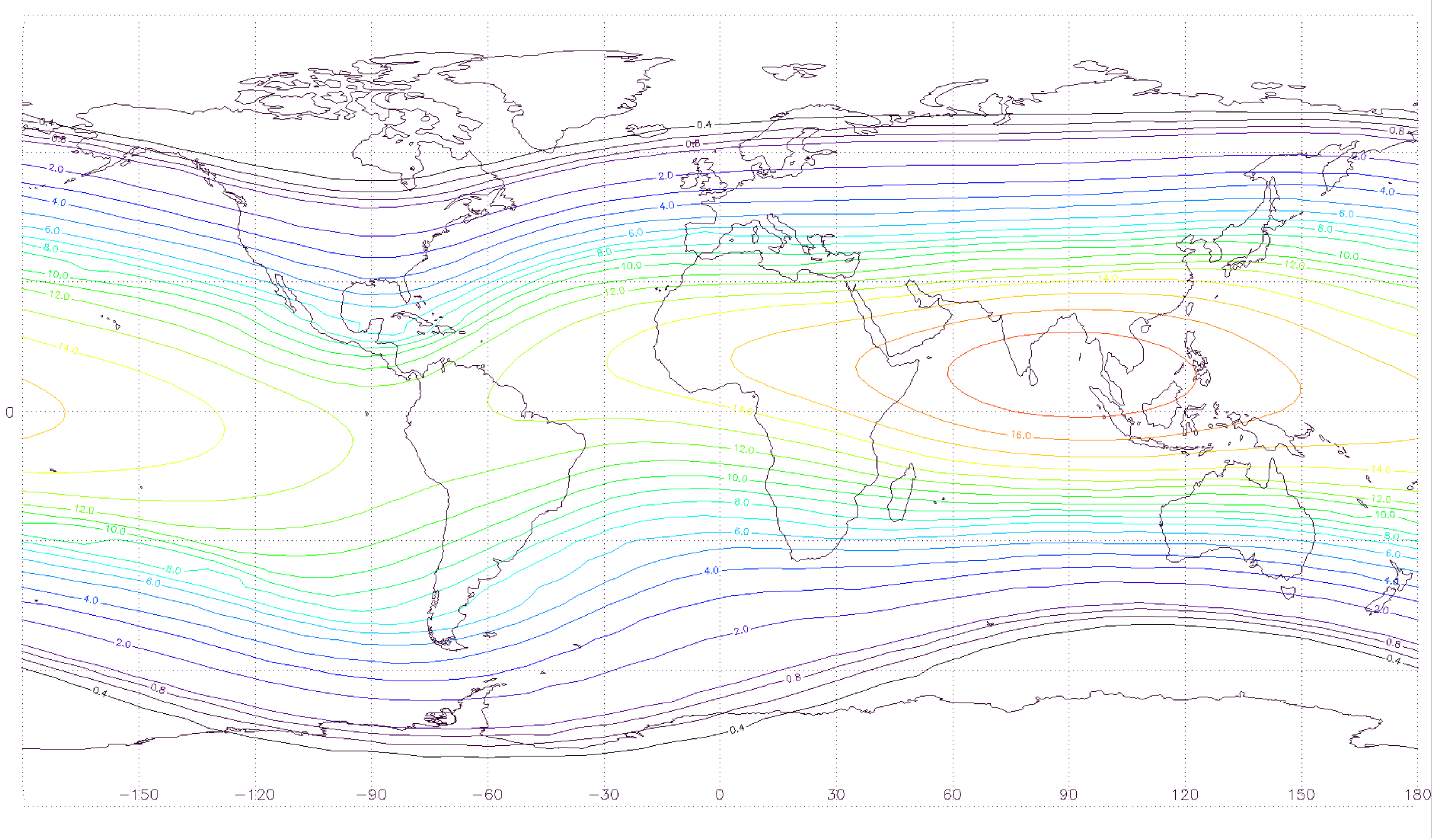


- longitudes 0^o and 300^o

- Model **GeoMag**

www.geomagsphere.org

Vertical cutoff rigidities



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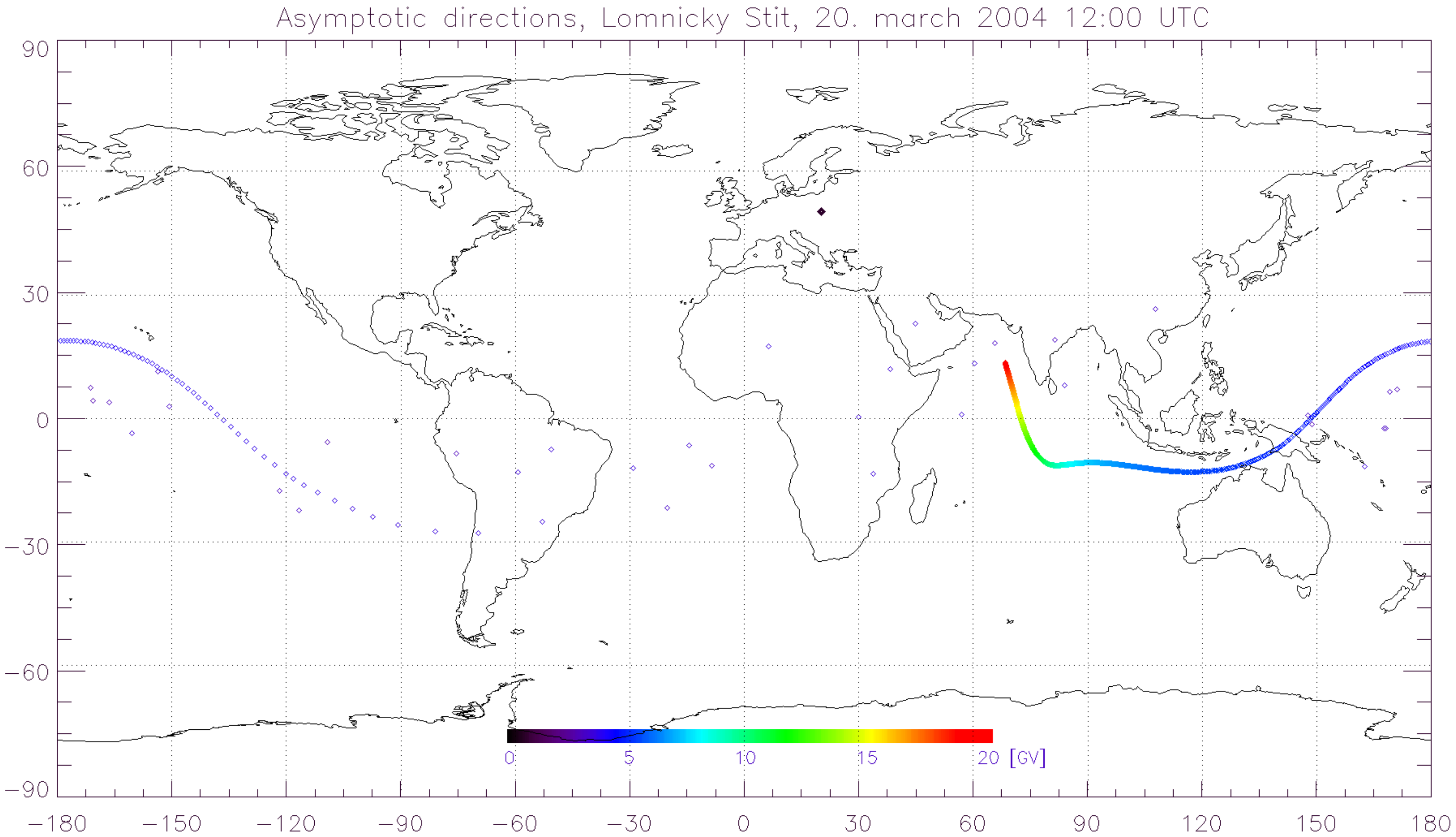
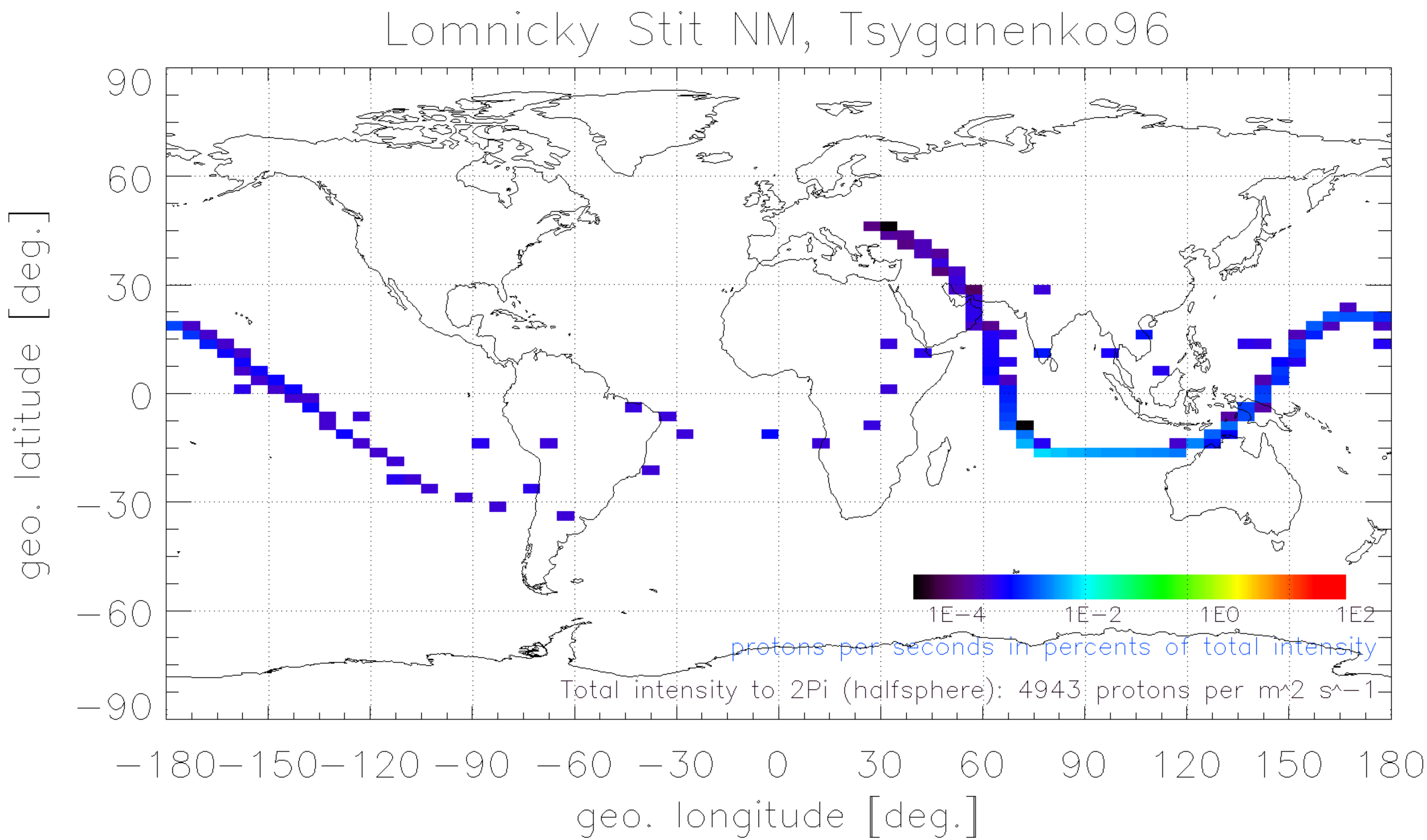
Vertical cutoff rigidities

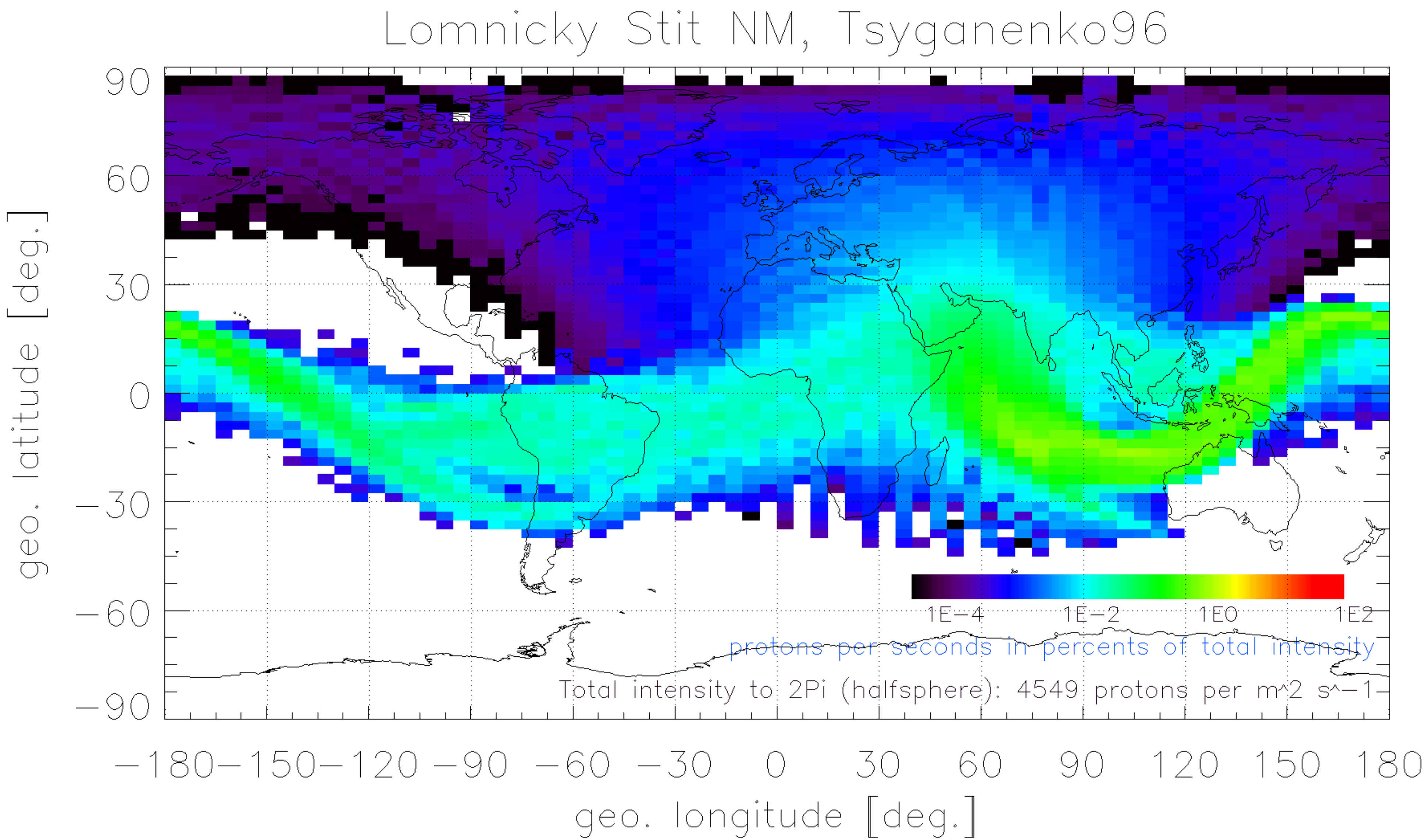


www.geomagsphere.org

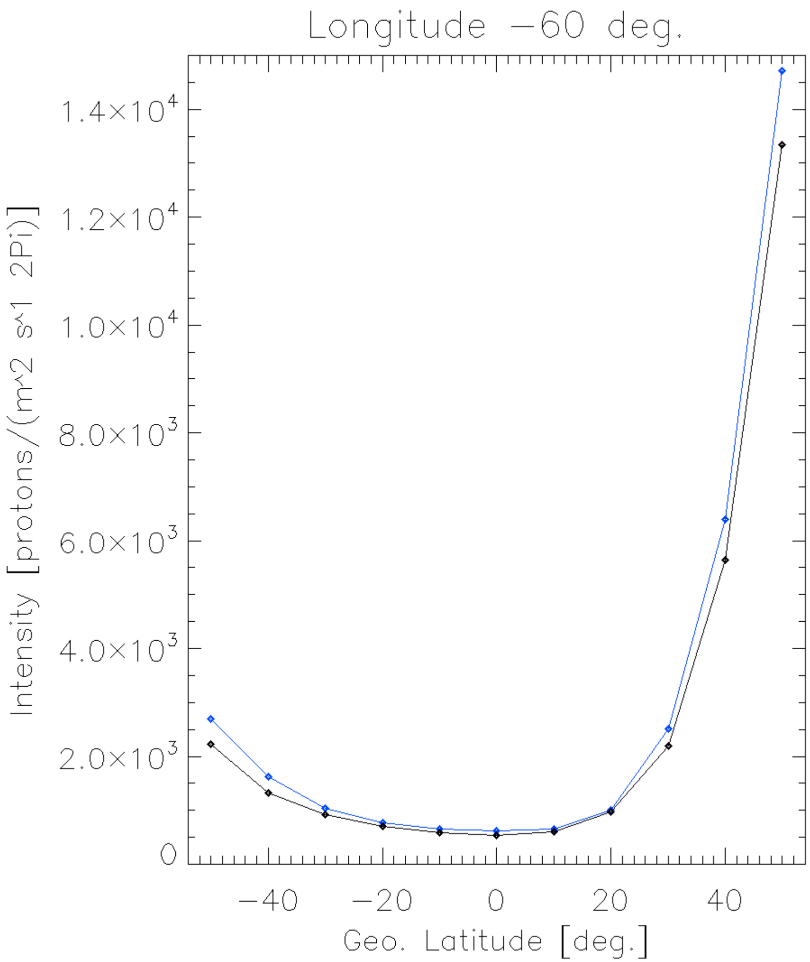
Intensities from asymptotic directions
(vertical approach)

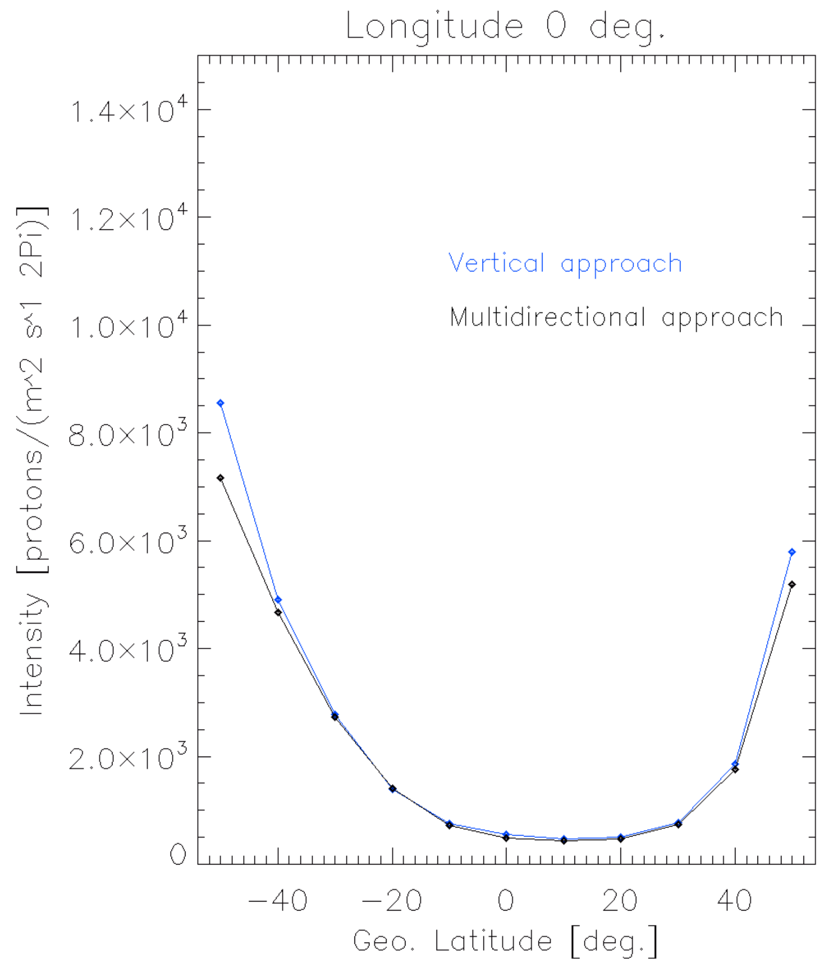


Intensities from asymptotic directions
(multidirectional approach)



Vertical vs. All directions





Conclusion : Not reasonable influence from GCR

- Airglow UV BG production is higher in SAA - AURIC presentation
- dynamical : intensity change in time and border of SAA change

Trapped particles : e^-

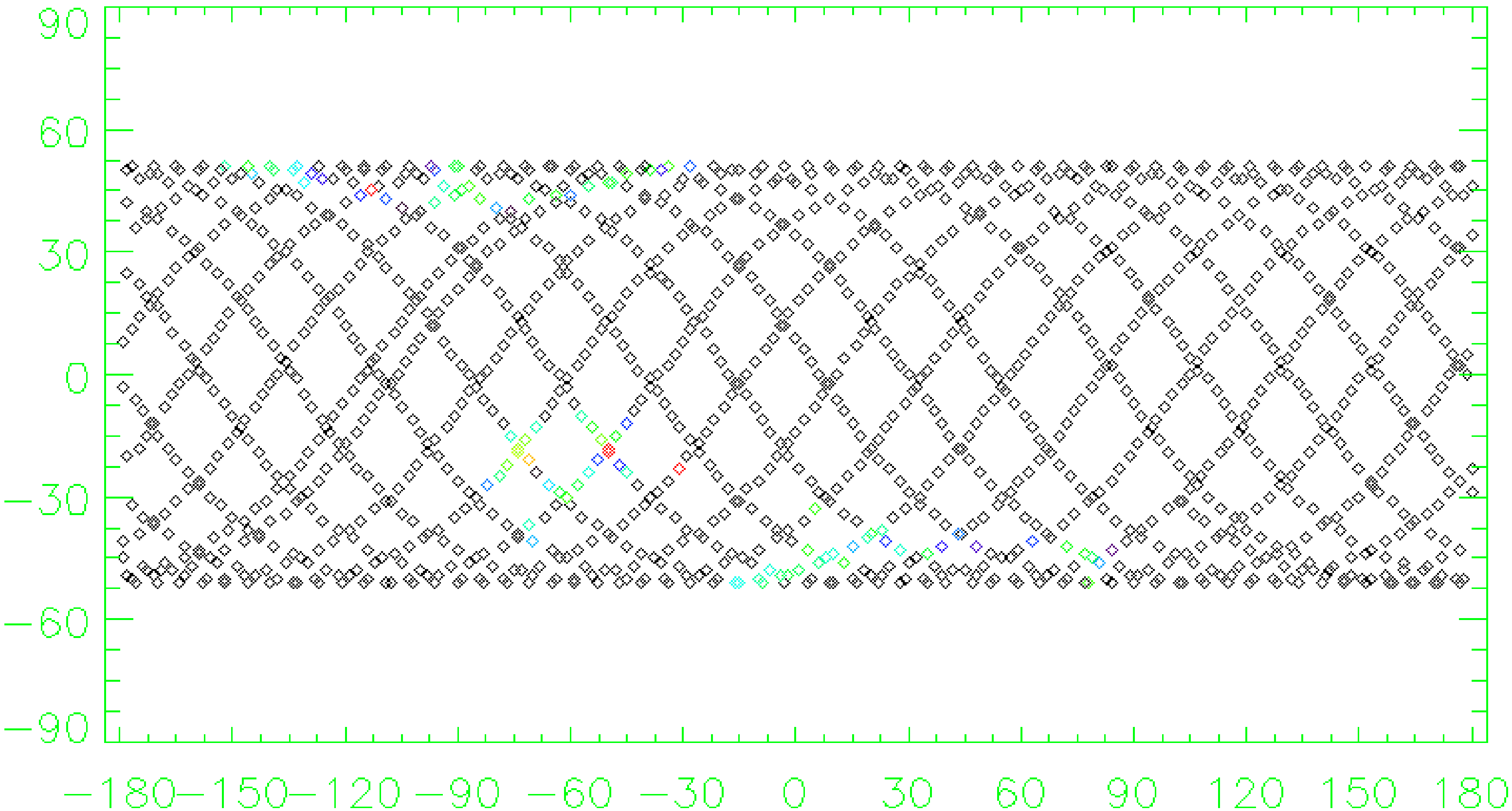
Trapped electrons influence

- SPENVIS AE-8 model : producing a data (trapped e^- intensities) for generated ISS orbit

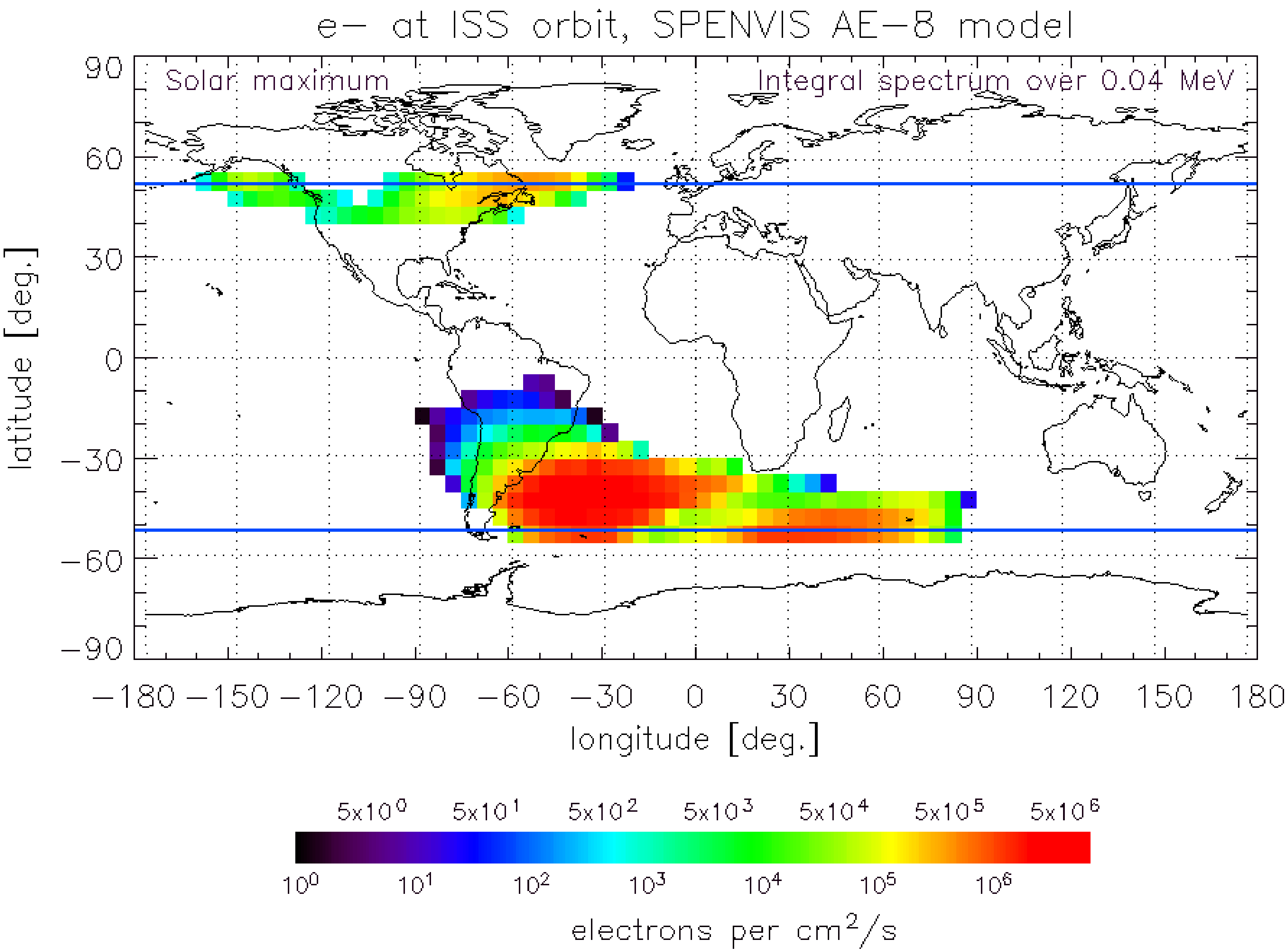
- effect of those e^- to JEM-EUSO lenses :
  How many UV photons are created ?

- GEANT4 simulation

SPENVIS : generated ISS like orbit

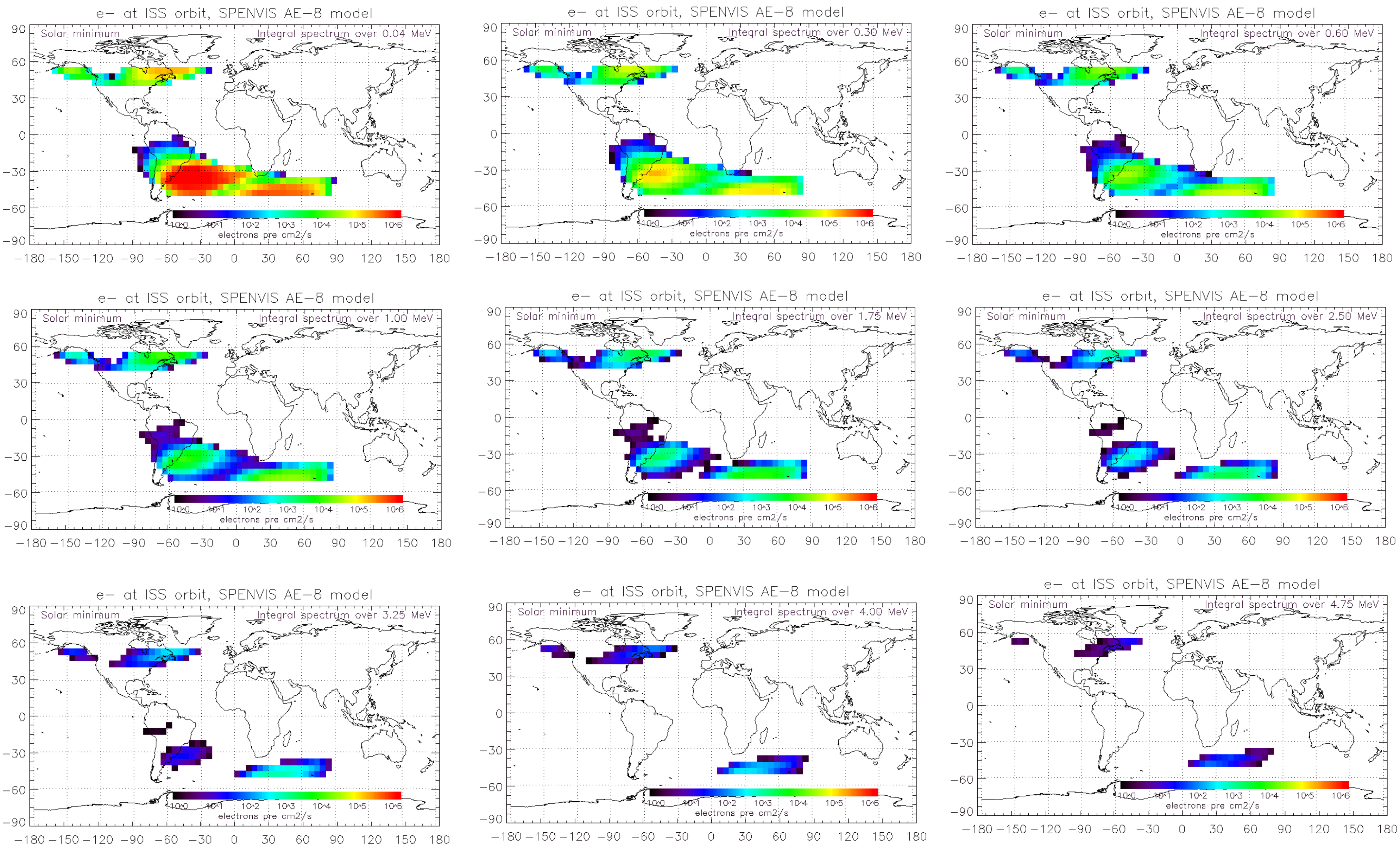


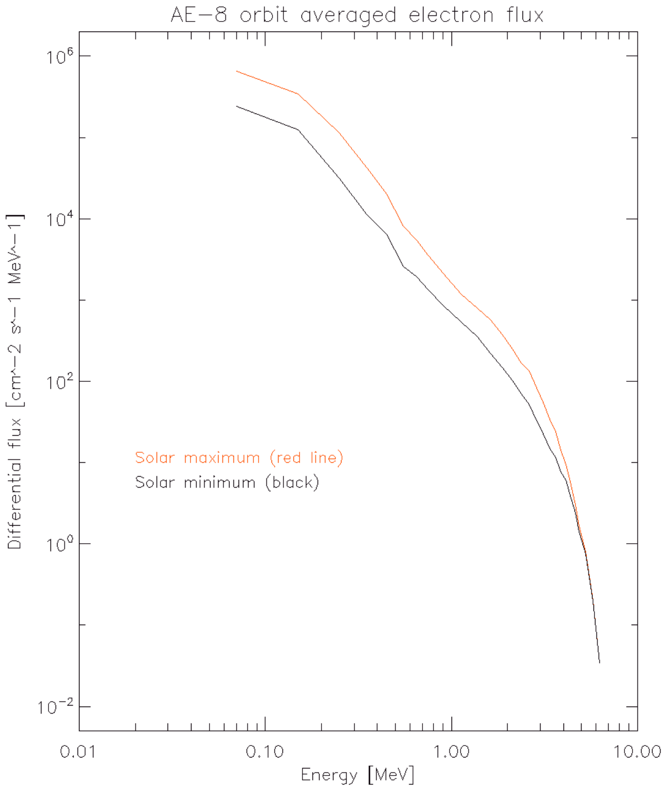
SPENVIS : traped electrons along orbit for 1 month

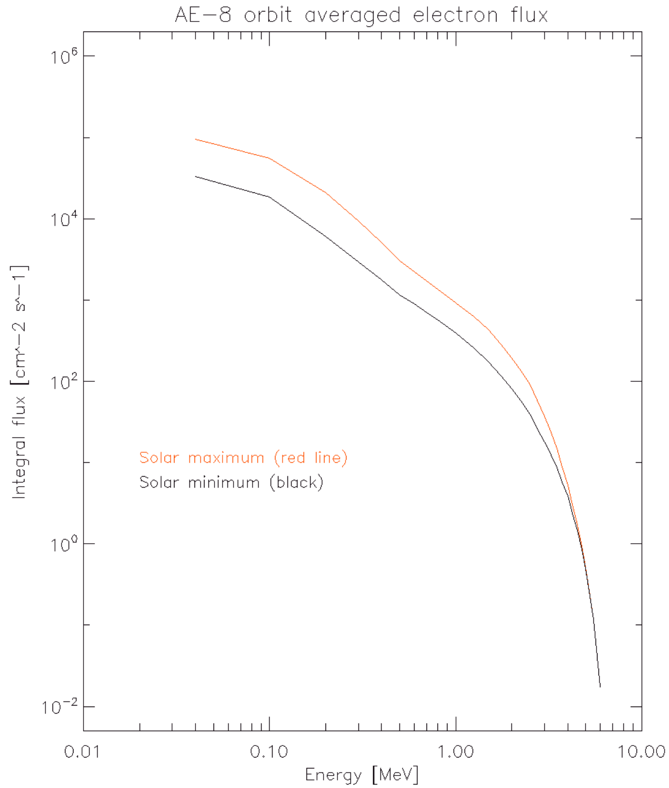


JEM-EUSO orbit - e⁻

Solar maximum

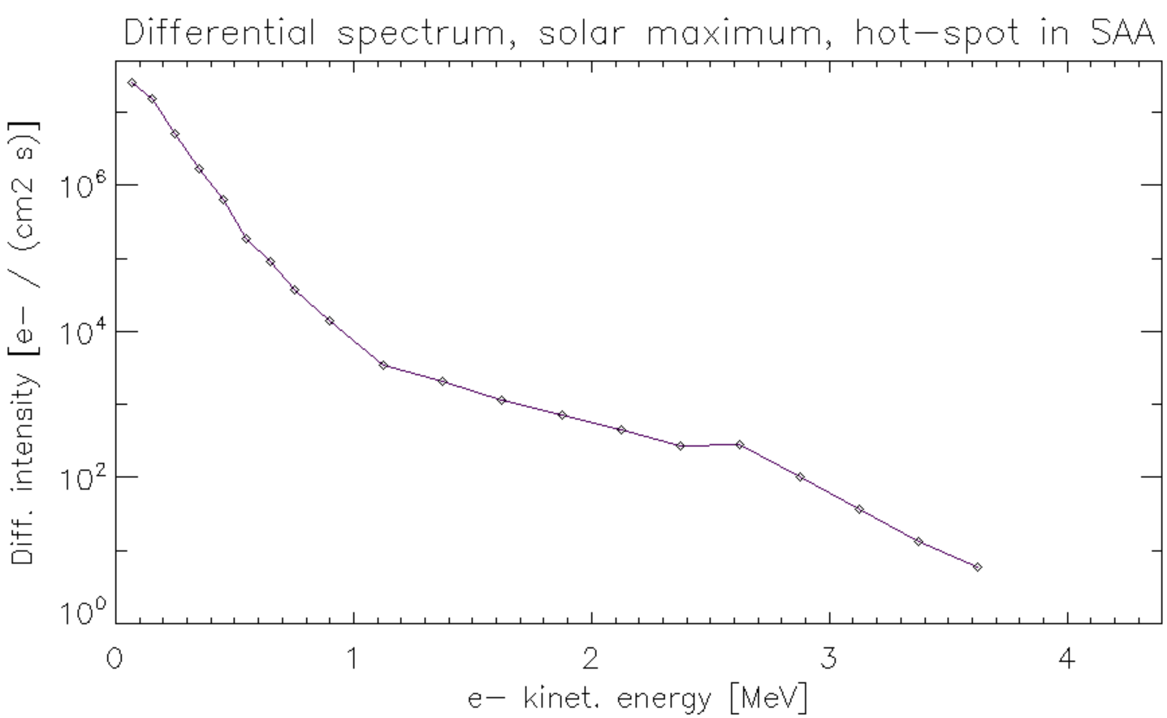






e^- spectra

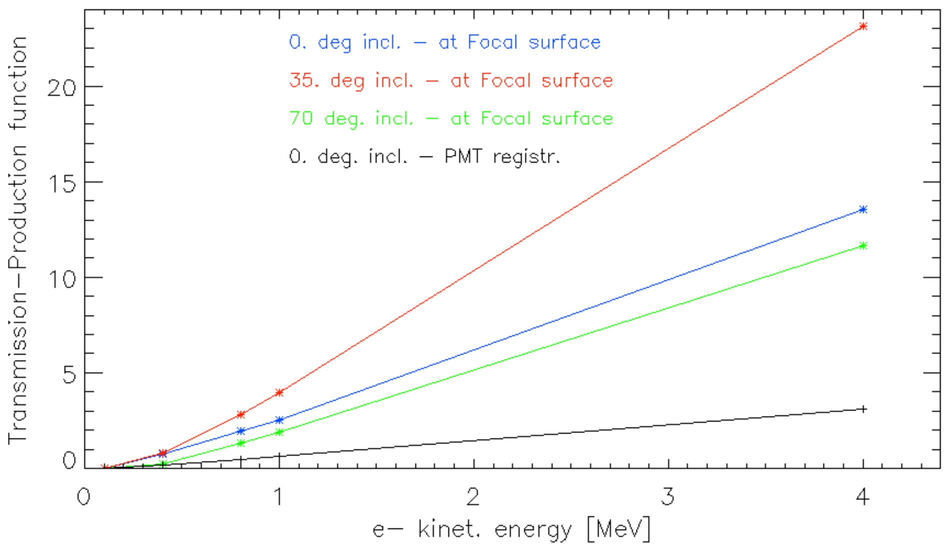
- along ISS orbit for solar minimum and maximum

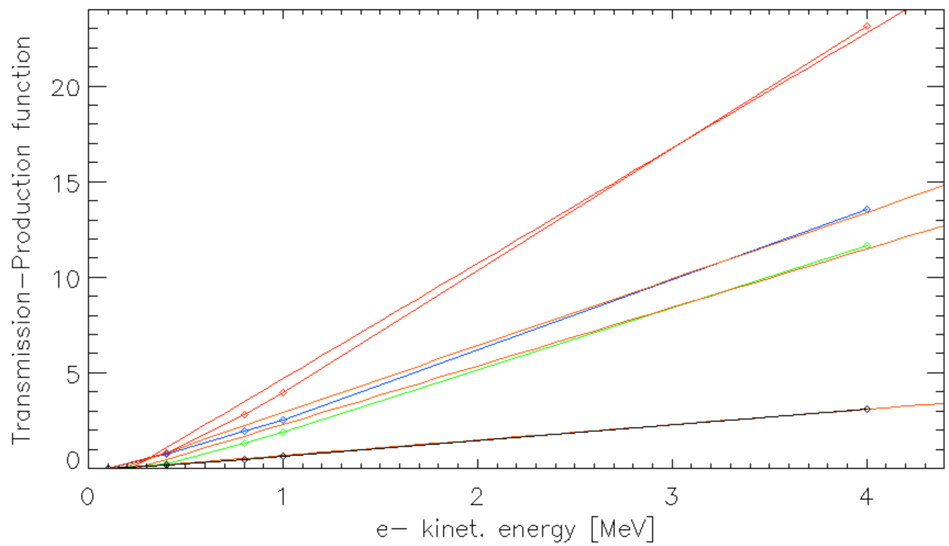


e^- spectrum

- in the SAA most "bright" region

Transmission-propagation function



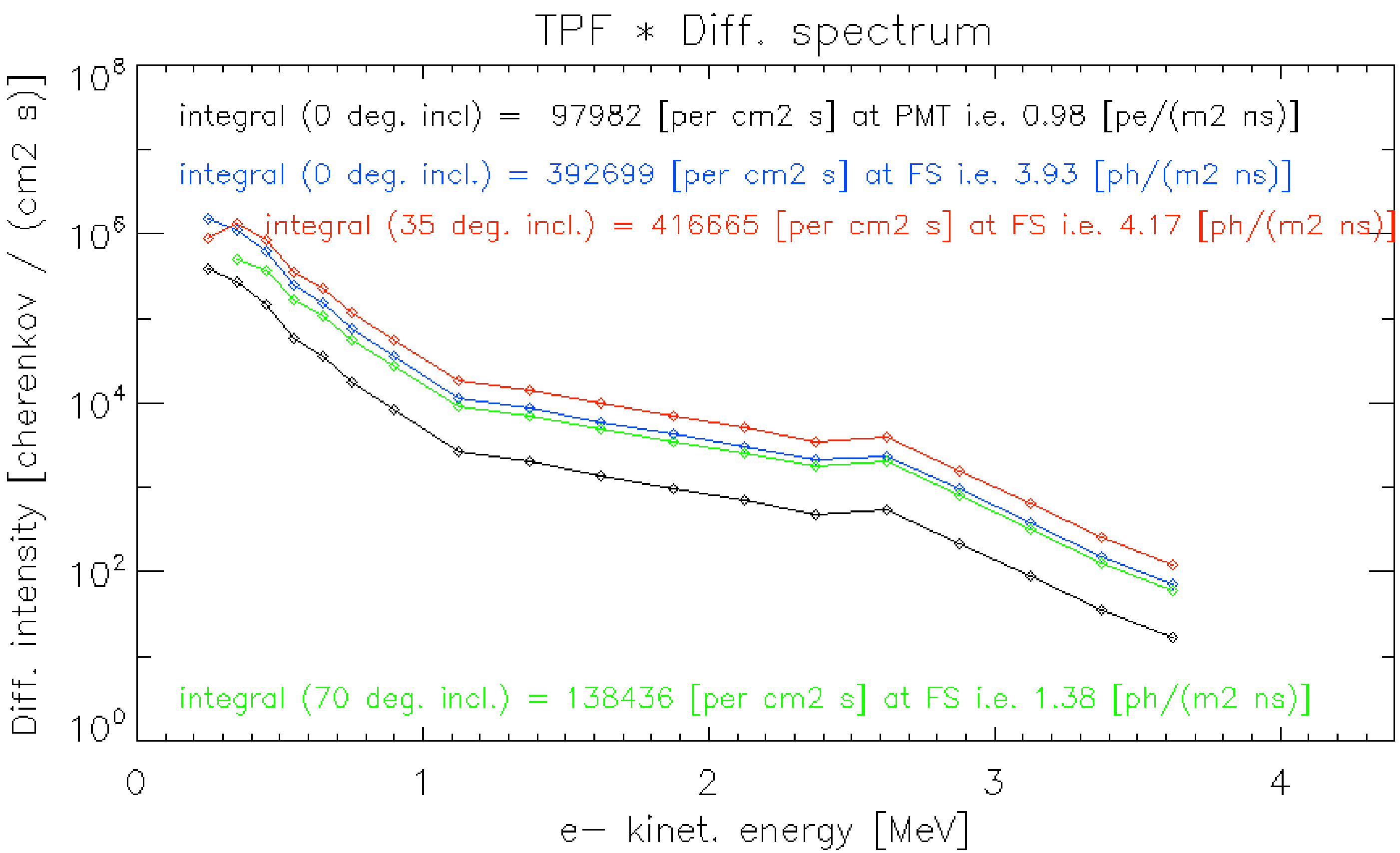


Simulation for 0º, 35º (close to max. production) and 70º. Inclination to main optics axis for

10^4 electrons 0.1 MeV
10^4 electrons 0.4 MeV
10^4 electrons 0.8 MeV
10^4 electrons 1 MeV
10^4 electrons 4 MeV

in GEANT4 by Sveta Biktemerova

Photons reaching FS



Evaluated upper limit ~4 ph/(m^2 ns) is approximatelly in order of 1% in comparison to photons which pass the detector and reach the FS from the standard UV BG of 500 ph/(m^2 ns sr). This leads to conclusion that electrons trapped in non disturbed magnetosphere do not affect the JEM-EUSO operational duty cycle significantly.

Disturbed magnetosphere case
effect of trapped electrons

Preliminary conservative estimation

- based on increase of electrons Intensities estimation at different L-shells for different Kp indexes along ISS trajectory

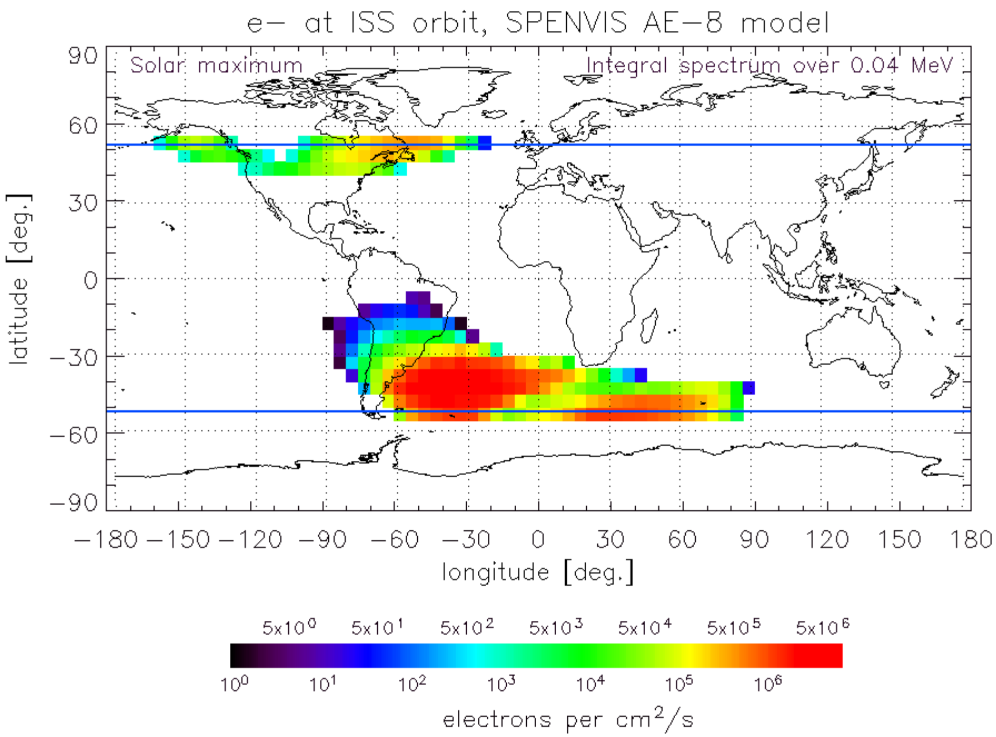
Year	Total influence [%][1]
1999	1.2
2000	1.4.
2001	0.9
2002	1.0
2003	2.7
2004	1.1
2005	1.1
2006	0.6
2007	0.4
2008	0.4
2009	0.1
2010	0.3
2011	0.5

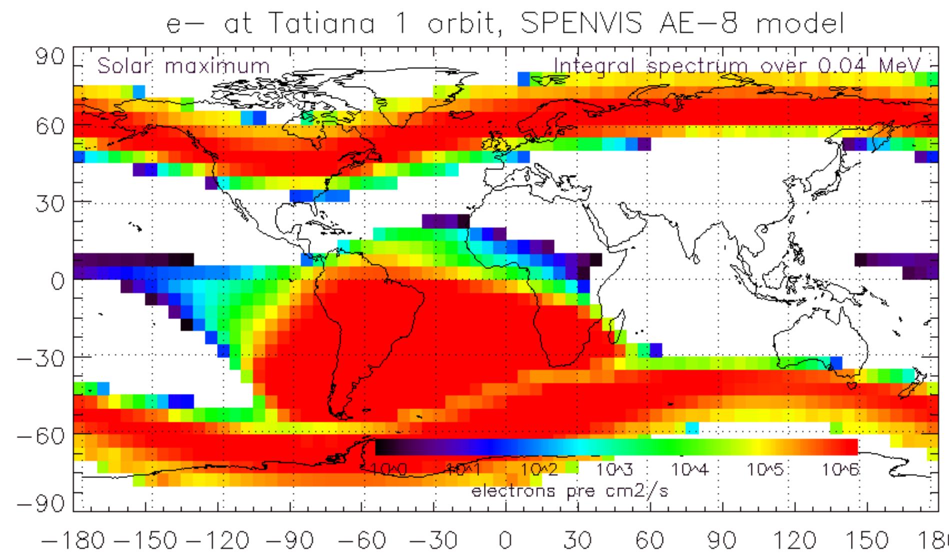
(1) percents from all time on orbit

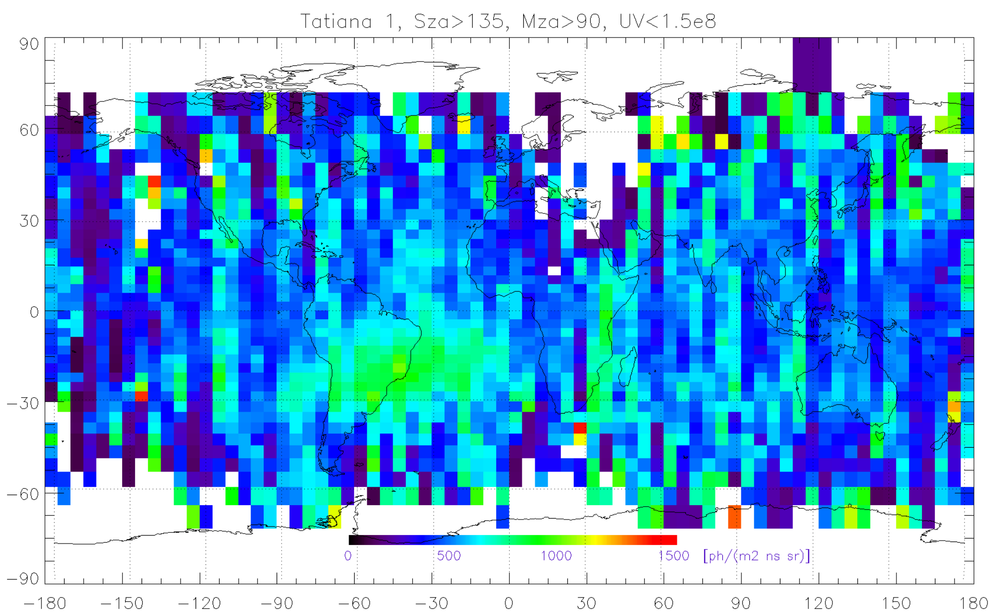
Conclusions

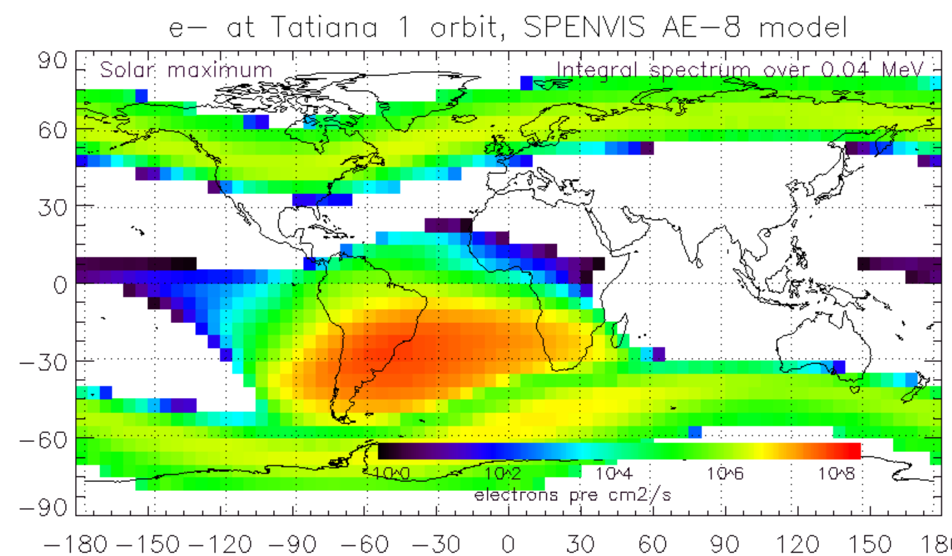
- GCR has not influence duty cycle/UV BG
- e^- influence to duty cycle in non disturbed magnetosphere is in order of few percents
- Disturbed magnetosphere till now preliminary conservative estimation, less than 1 percent

ISS vs. Tatiana 1 orbit - trapped e^-









Tatiana 1 orbit - e⁻

Solar maximum