South Atlantic Anomaly influence to JEM-EUSO measurements

Trapped protons effect

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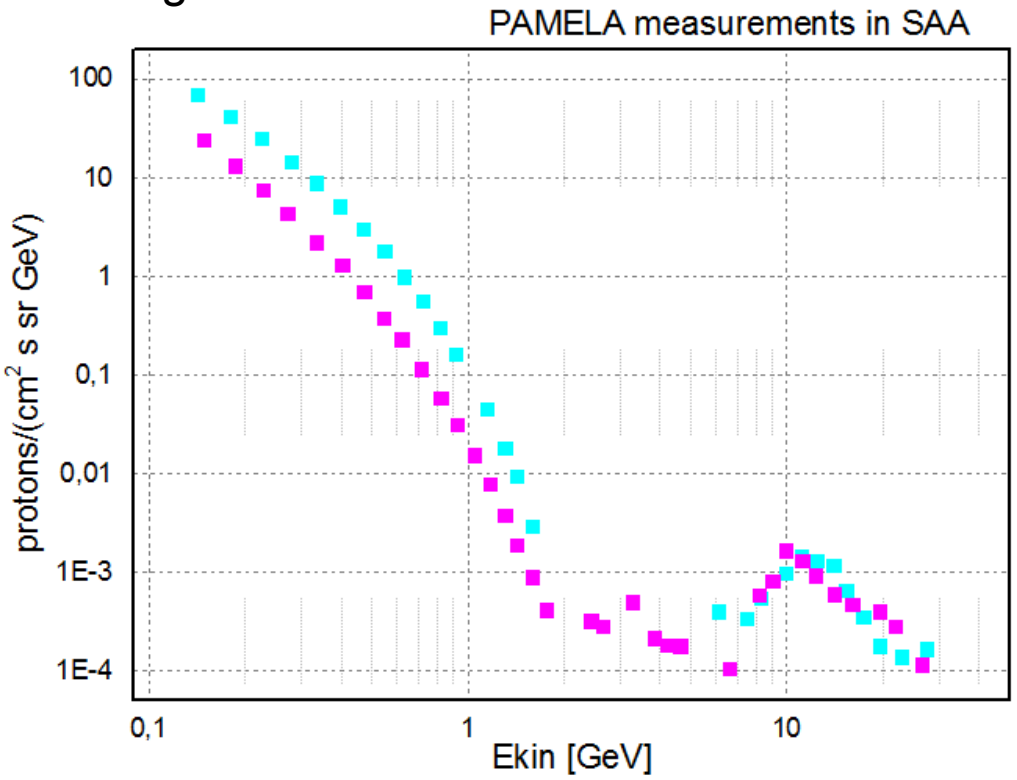
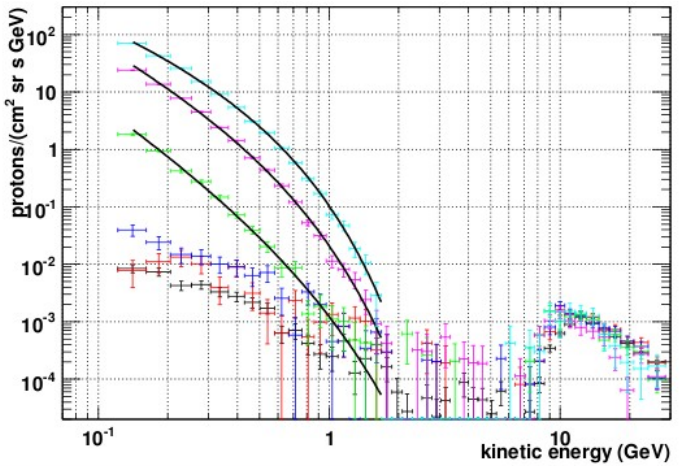
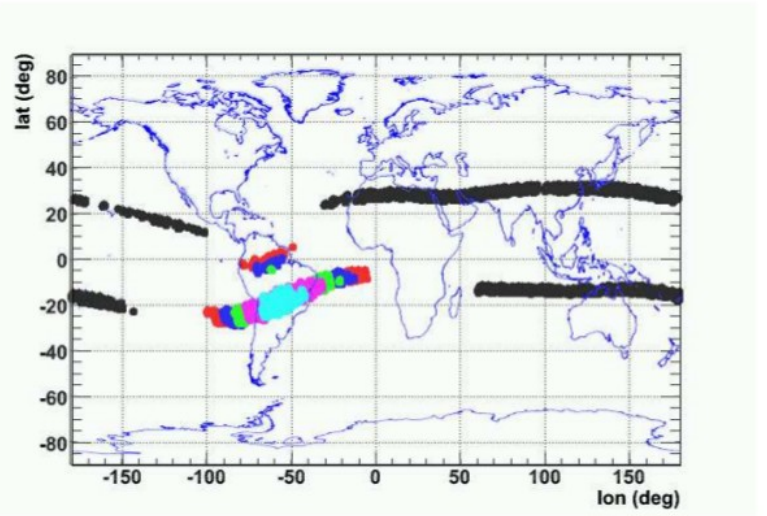
Two years of flight of the Pamela experiment: results and perspectives.
Marco Casolino et.al., arXiv:0810.4980, 2008

From figure in the article





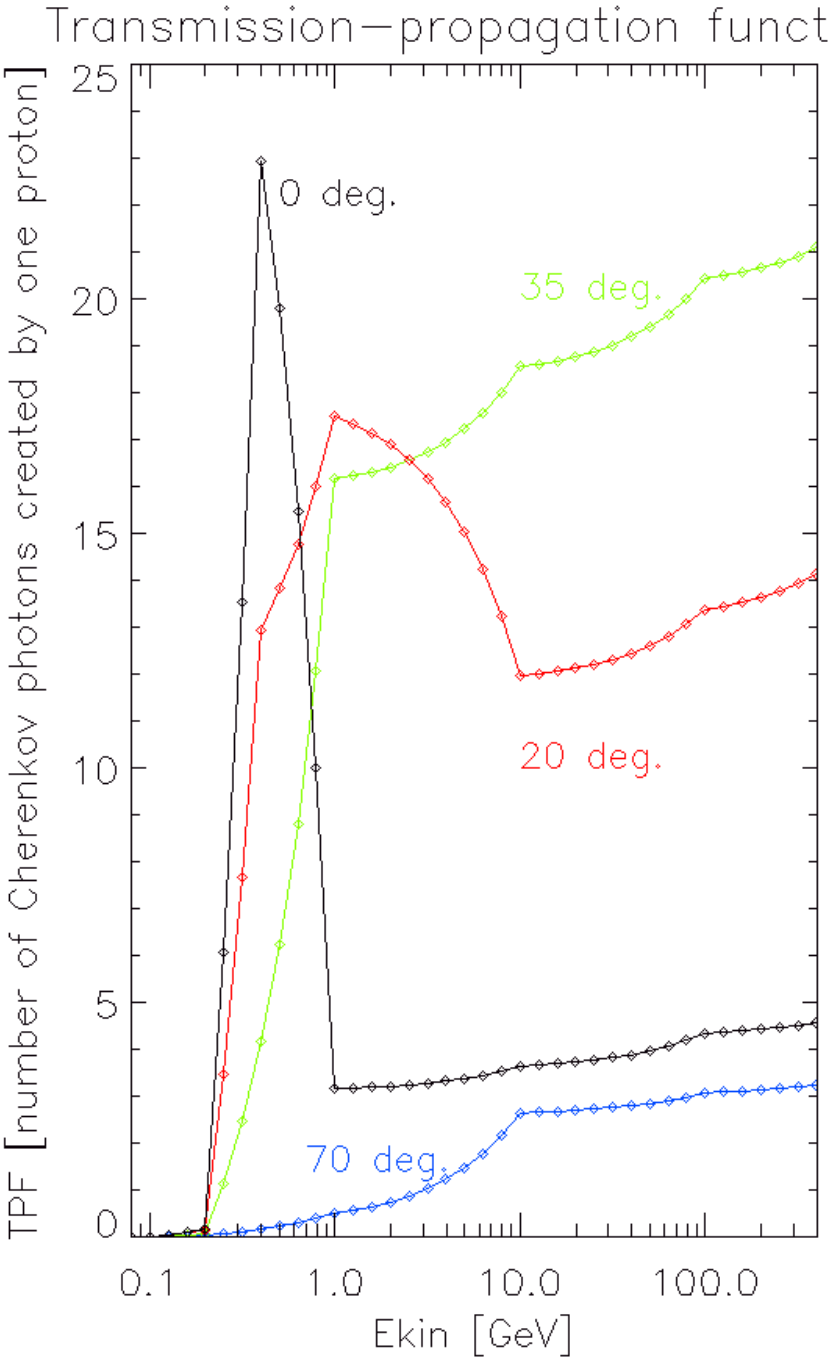


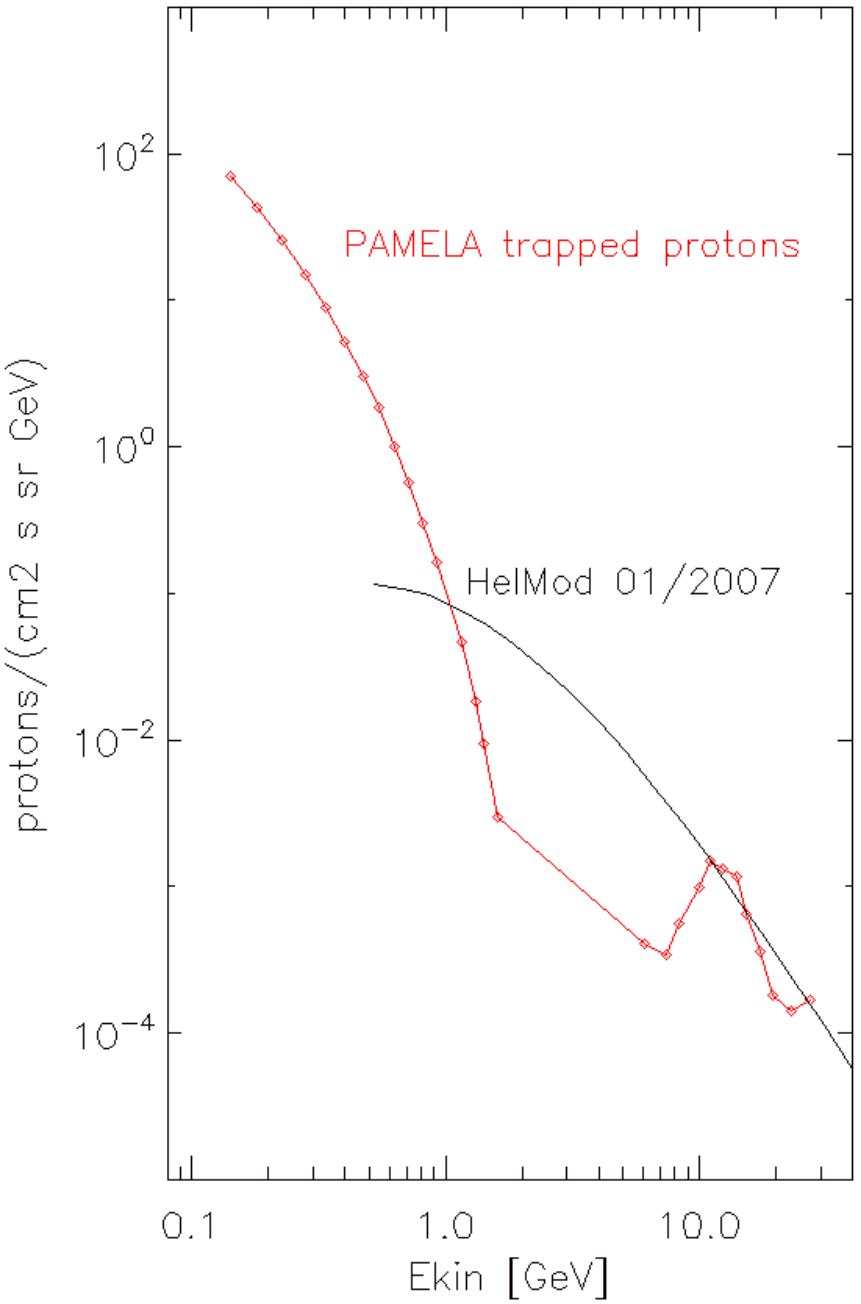
Situation for energies over ~20GeV ?

Over ~20GeV – Galactic cosmic rays

Fig. 3. Top: Plot of the differential energy spectrum of PAMELA in different regions of the South Atlantic Anomaly. Selection regions (shown in top bottom panel) are selected according to decreasing intensity of the magnetic field from bottom to top: Black $B > 0.3G$ - outside the SAA, Red 0.22 G $< B <$ 0.23 G, Blue 0.21 G $< B <$ 0.22 G, Green $0.20G$ ¡ B ¡ 0.21 G, *Pink* 0.19 G $< B <$ 0.20 G, Turquoise 0.19 G ¿ B) in the cutoff region 10.8 GV $< G <$ 11.5 GV. Flux of trapped particles can exceed the secondary particle flux in the same cutoff region outside the anomaly (black bands) of about four orders of magnitude at low energy.

Transmission-propagation function for protons





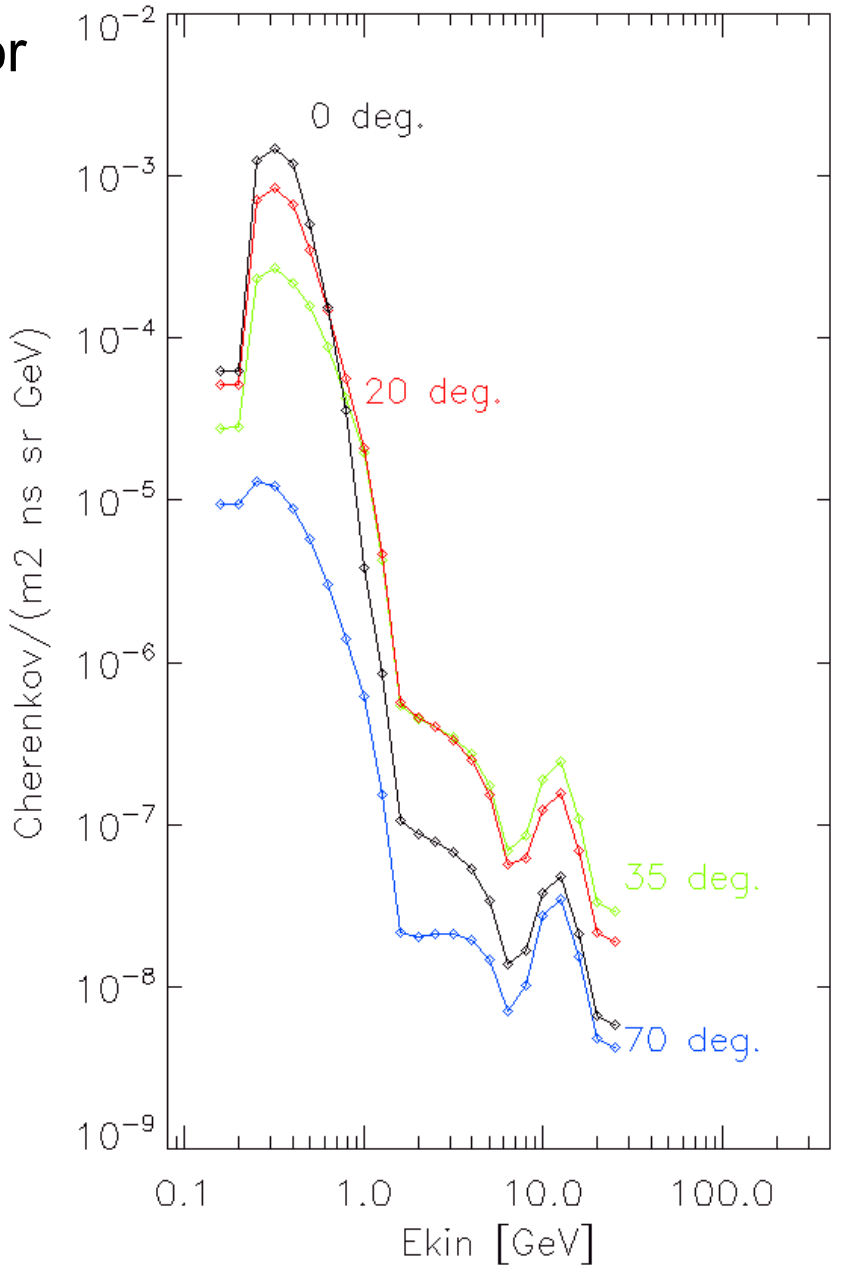
Svetlana Biktemerova calculation

P. Bobik, Trapped protons effect

Cherenkov photons

created by protons in JEM-EUSO detector

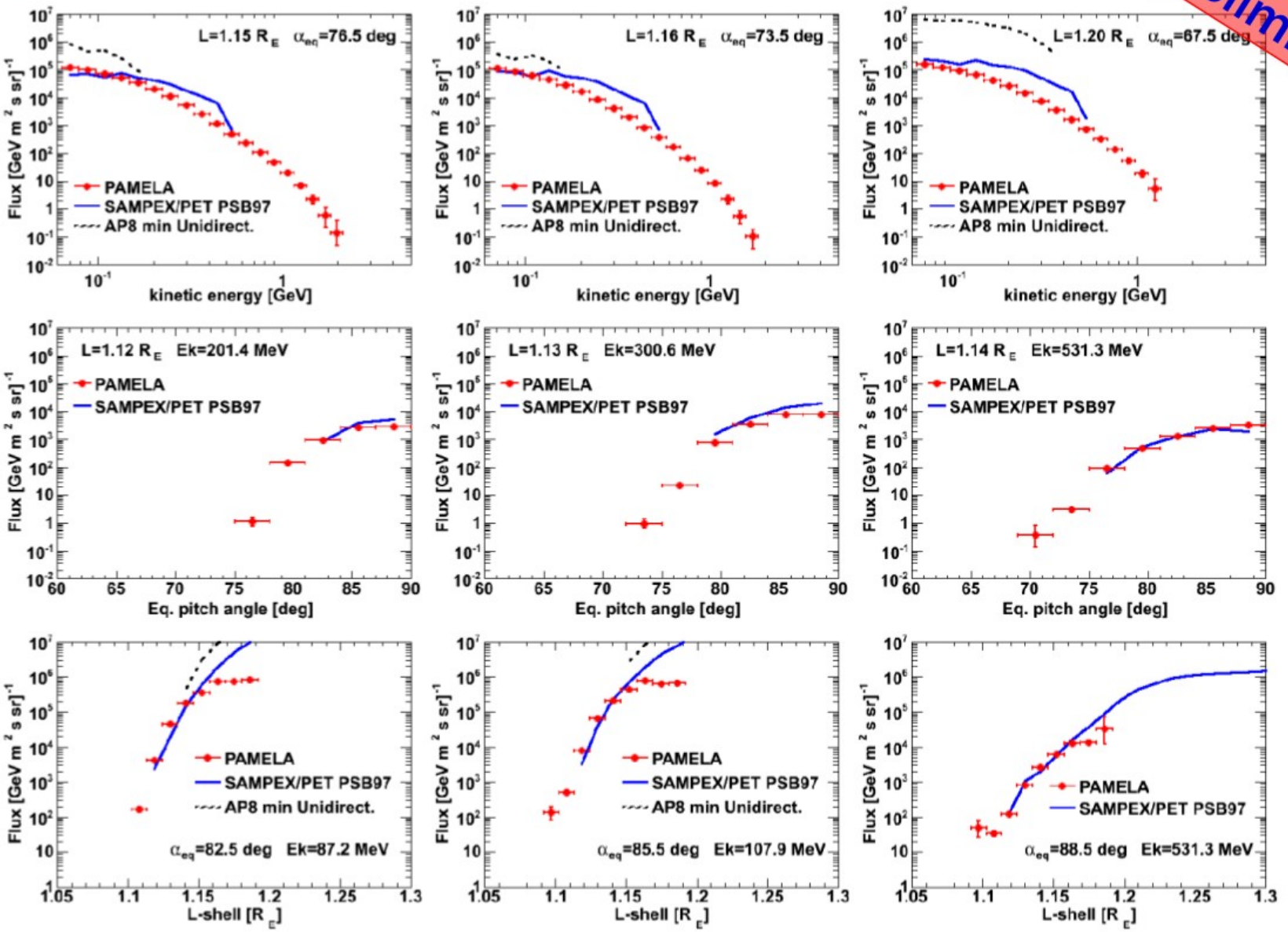
- For different protons incident angles we get:
- Incident angle / Intensity of Cherenkov ph
- 0^{O} / 0.000431 Cherenkov/(m^2 ns sr)
- 20^{o} / 0.000280 Cherenkov/(m^2 ns sr)
- 35^{o} / 0.000116 Cherenkov/(m^2 ns sr)
- 70^{o} / 0.0000058 Cherenkov/(m^2 ns sr)



Conclusion : **Negligible**

Stably-trapped proton differential fluxes
Comparison with semi-emphirical models

Preliminary



Alessandro Bruno, Francesco Cafagna, Under-cutoff proton fluxes measured by the PAMELA experiment, ICRC 2013

Trapped protons spectra

- Protons spectra
  - Intensity decreasing with energy
  - Intensity increasing with eq. pitch angle
    - Minimum angle between detector axis and direction of incoming particles
  - Intensity increasing with L-shell parameter
  - How is maximum spectrum during quiet period with non disturbed magnetosphere?

Trapped protons in SAA measured by the PAMELA experiment, A. BRUNO et.all ICRC 2011

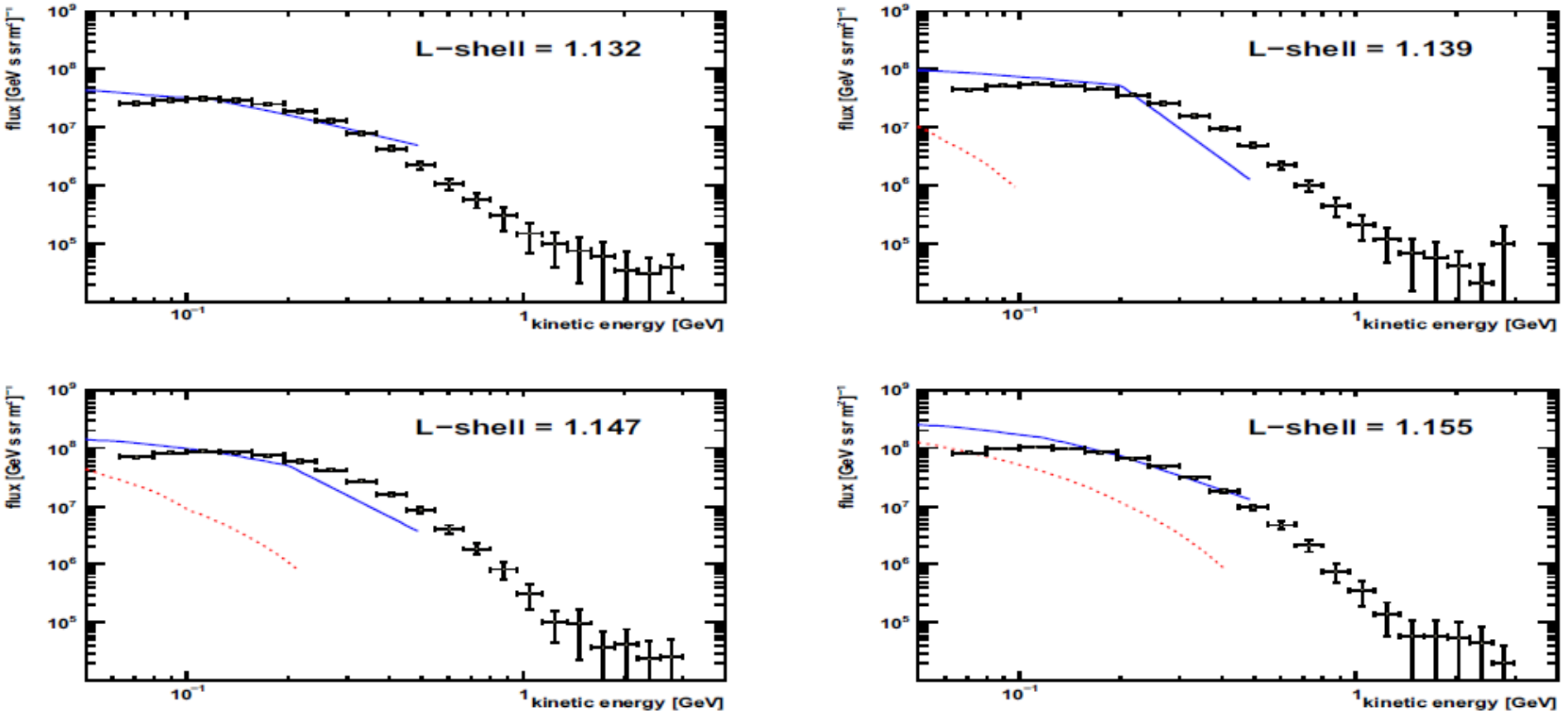
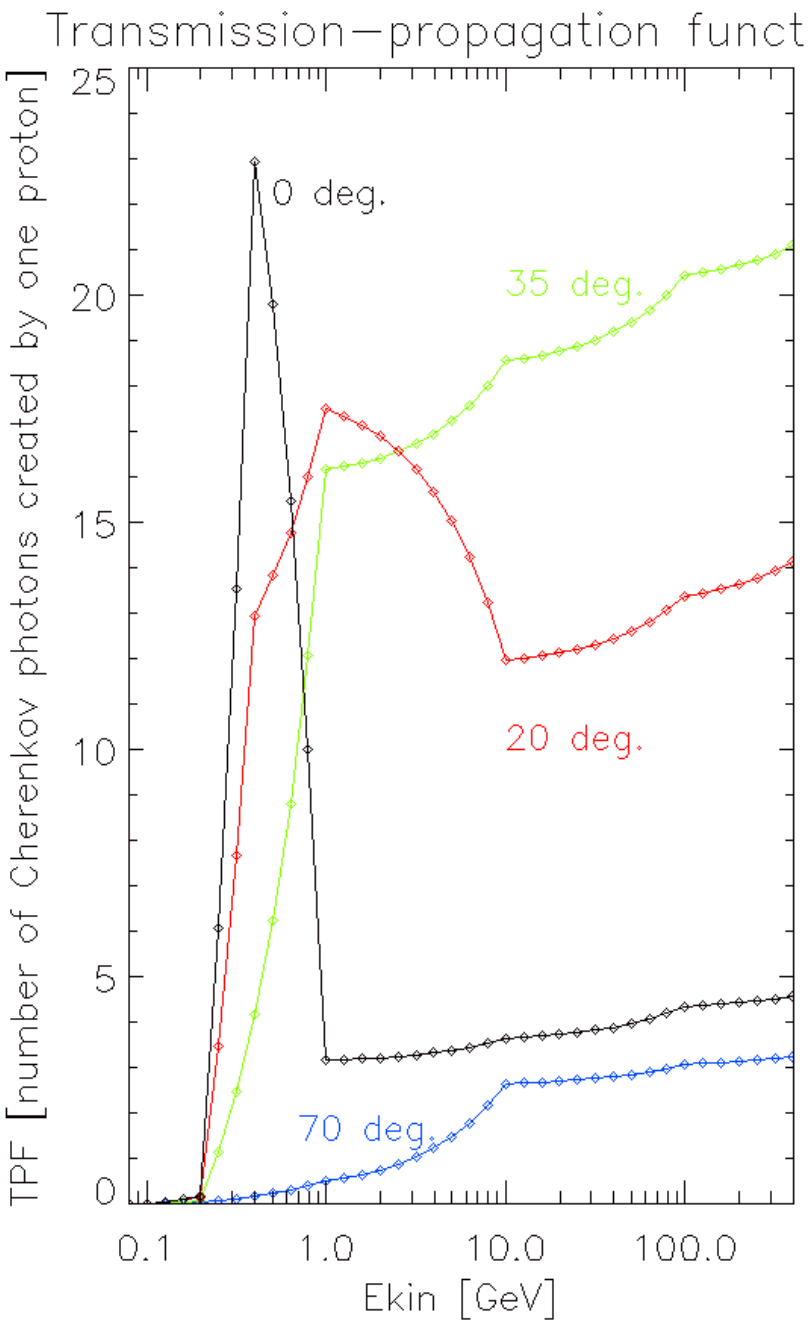
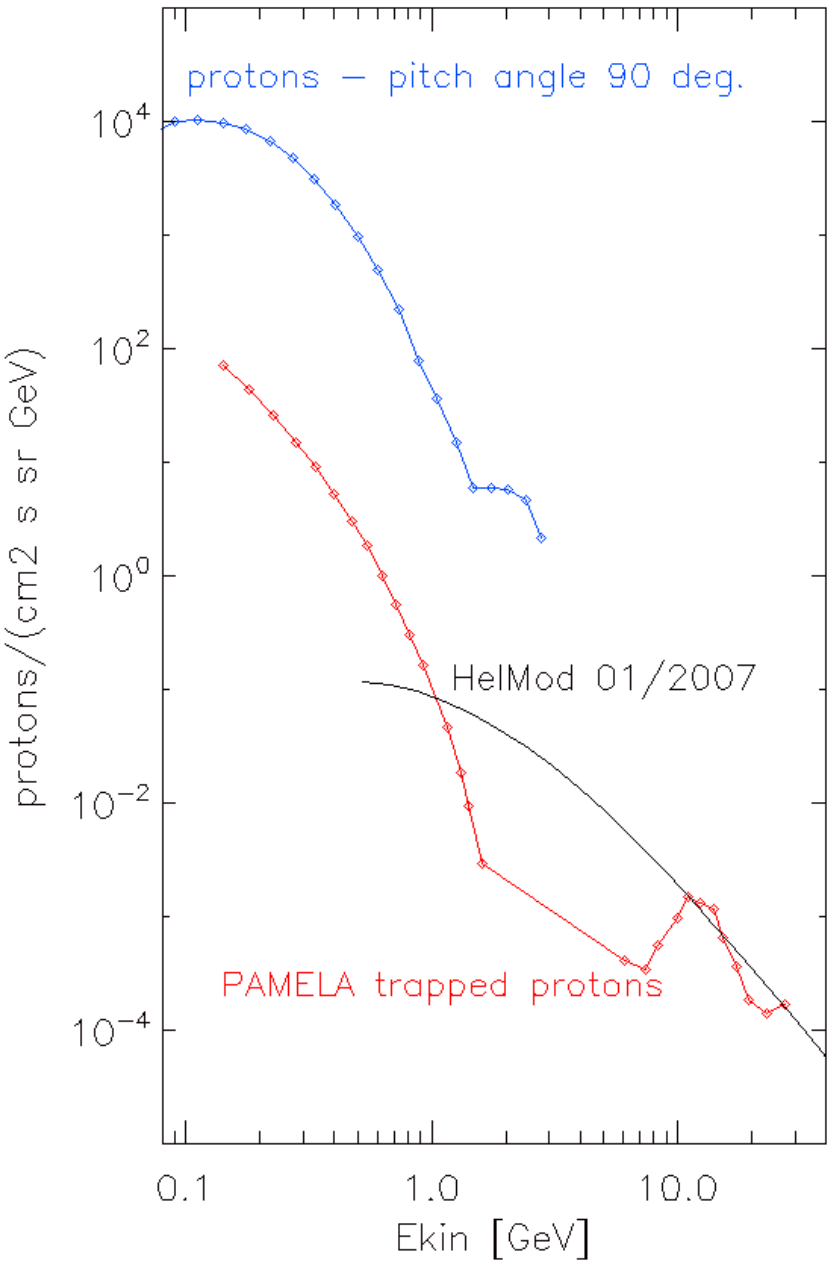


Figure 4: The trapped proton spectrum measured by PAMELA, at equatorial pitch angle α_{eq}=90°, for four different L-shell values. The error bars indicate statistical uncertainties. Predictions from AP-8min [10] (dotted red line) and from SAMPEX/PET PSB97 [11] (solid blue line) models are also reported.

Transmission-propagation function for protons





Svetlana Biktemerova calculation

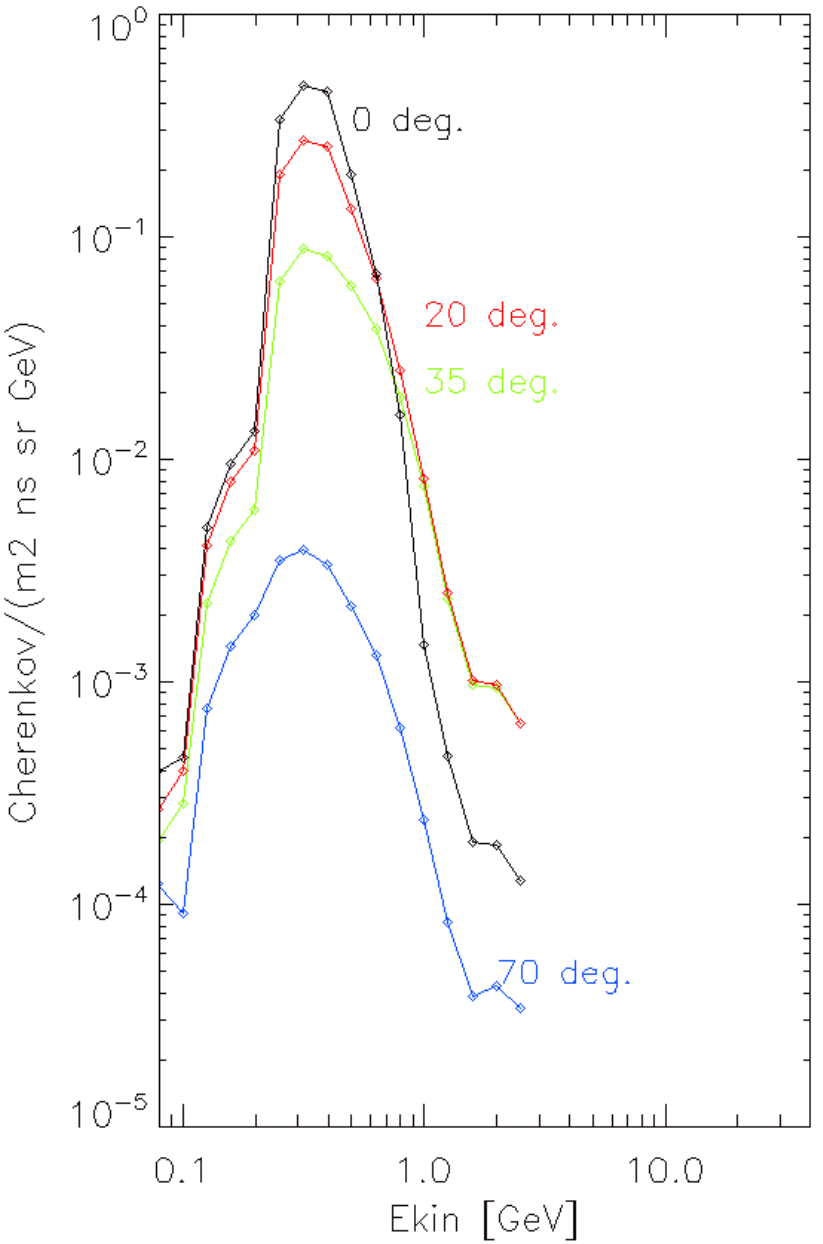
P. Bobik, Trapped protons effect

Cherenkov photons

created by protons in JEM-EUSO detector

- From proton intensities with 90º equatorial pitch angle
- For different protons incident angles todetector axis we get:
- Incident angle / Intensity of Cherenkov ph
- 0º / 0.1487 Cherenkov/(m^2 ns sr)
- 20º / 0.0992 Cherenkov/(m^2 ns sr)
- 35º / 0.0423 Cherenkov/(m^2 ns sr)
- 70º / 0.0019 Cherenkov/(m^2 ns sr)

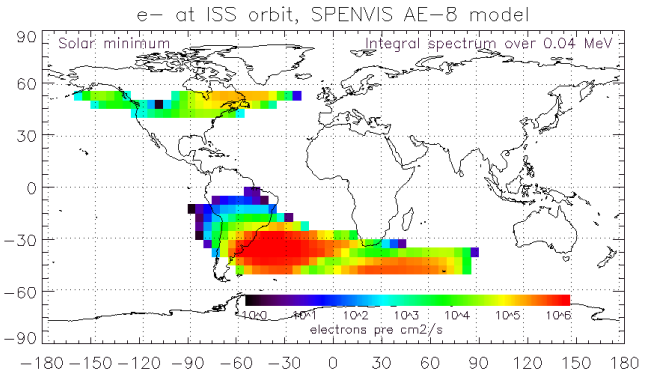
Conclusion : **Small**

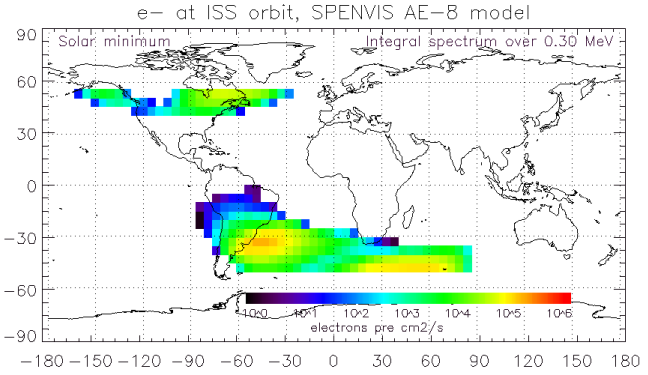


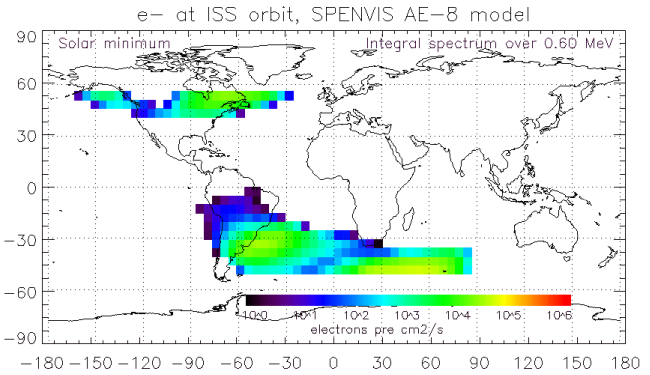
JEM-EUSO orbit - e^-

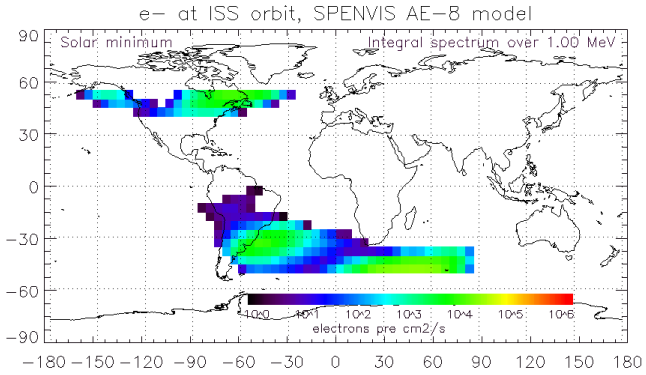
Solar maximum

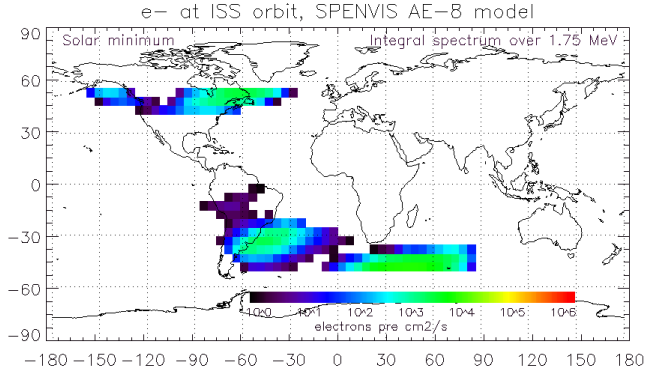
ICRC 2013 results

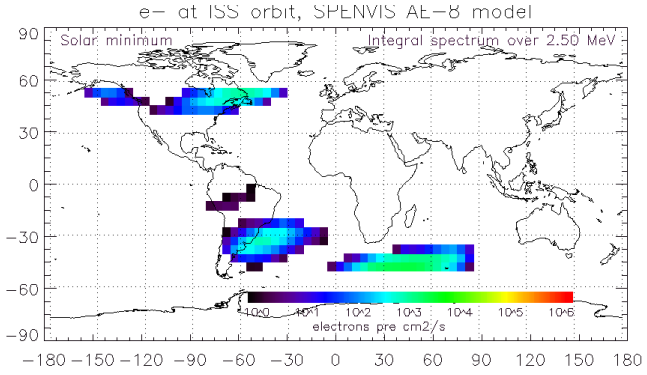


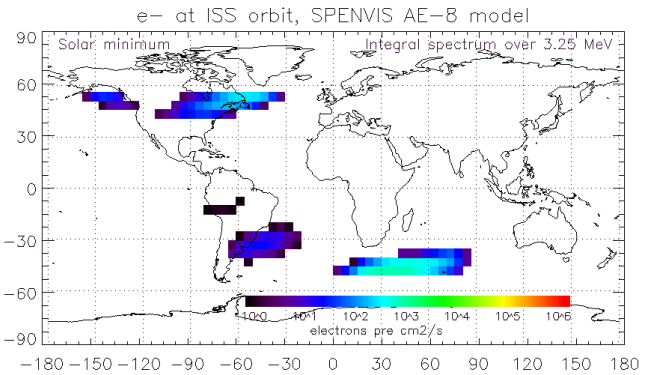


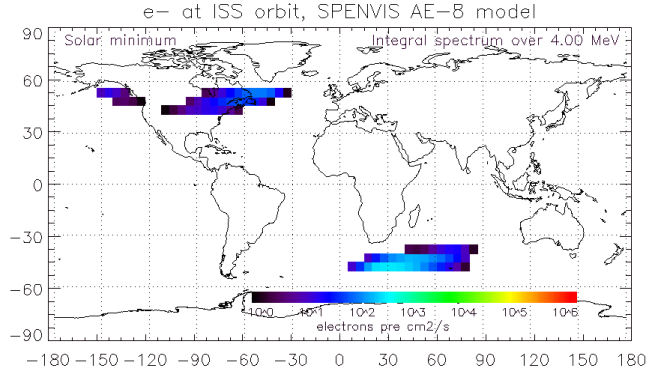


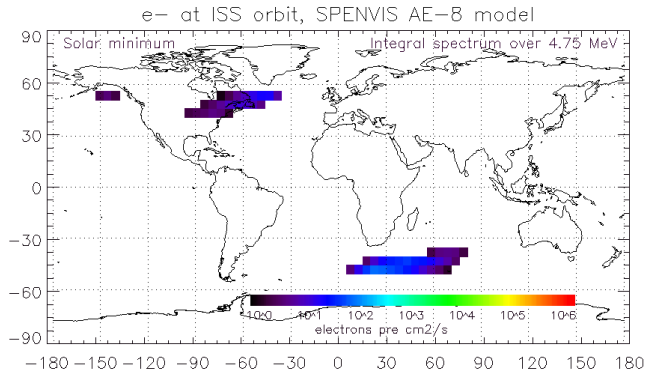


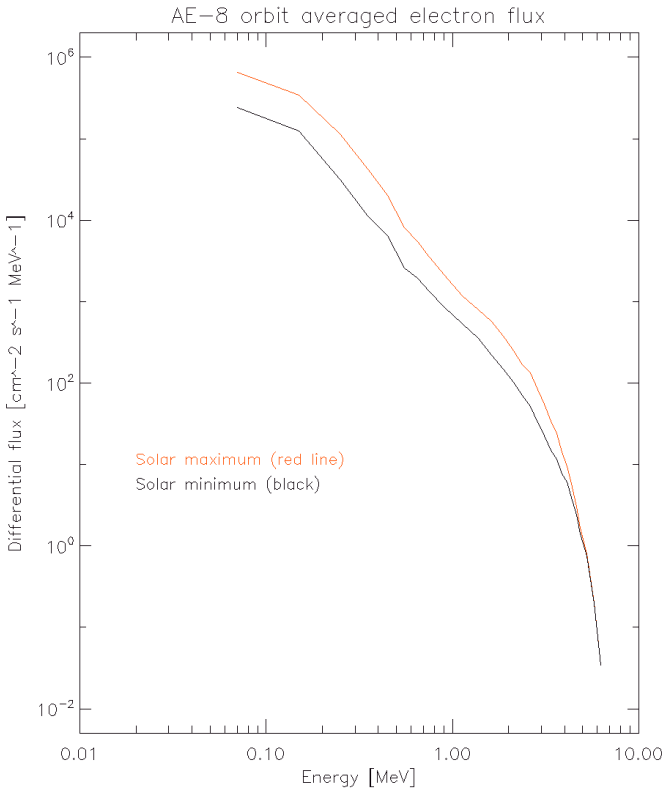


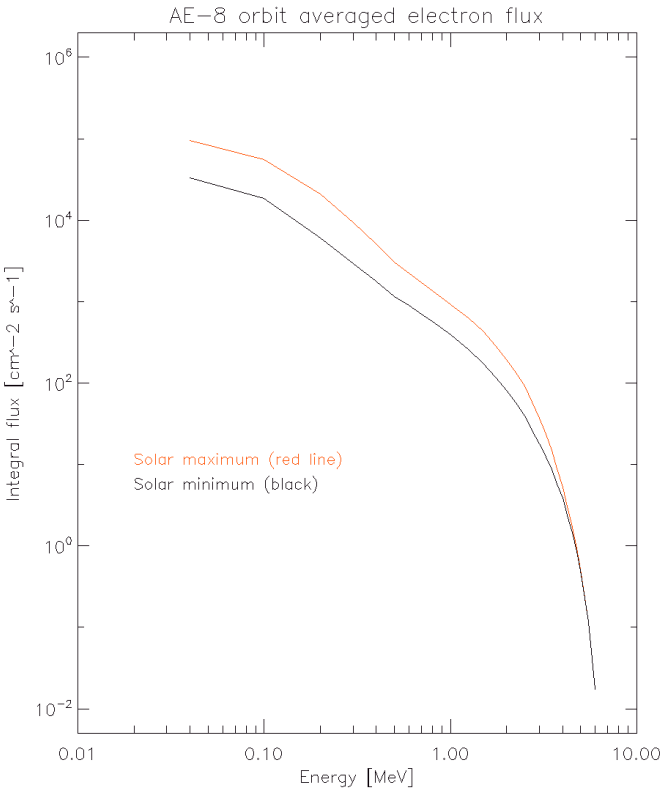












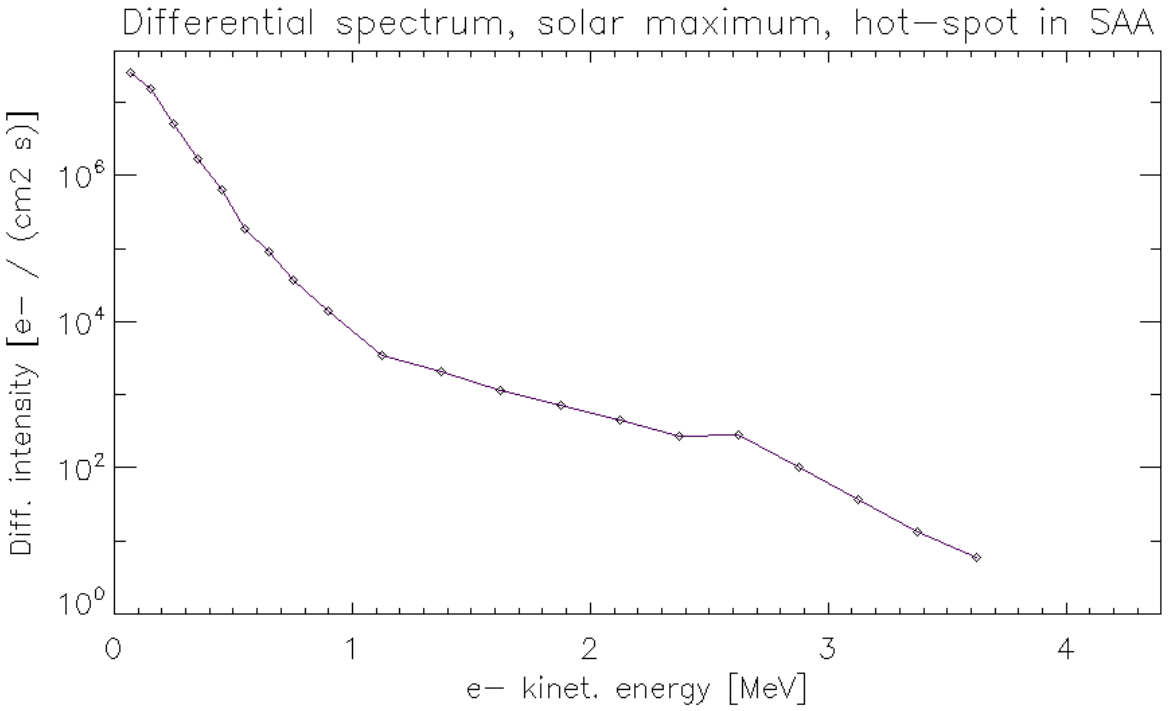
e⁻ spectra

- along ISS orbit for solar minimum and maximum

ICRC 2013 results

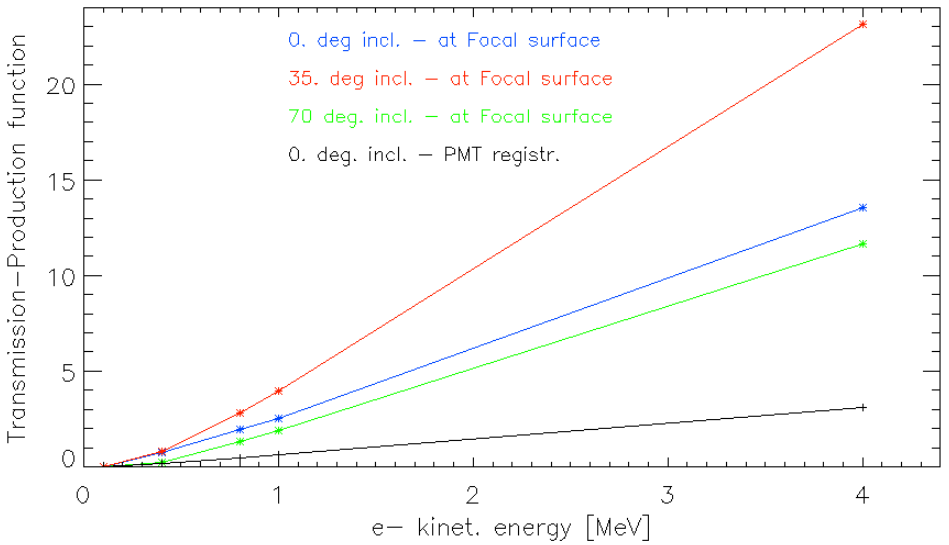
e⁻ spectrum

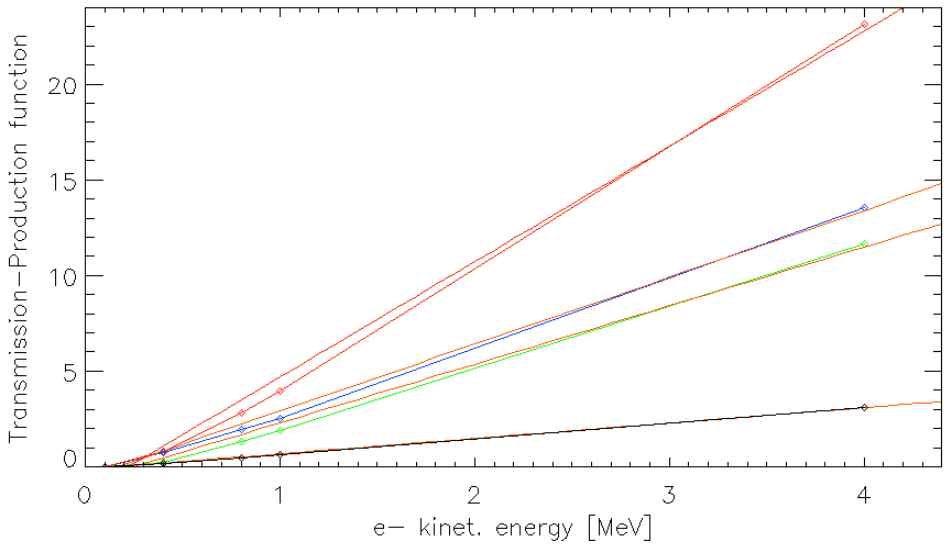
- in the SAA most “bright” region



Transmission-propagation function for e-

ICRC 2013 results





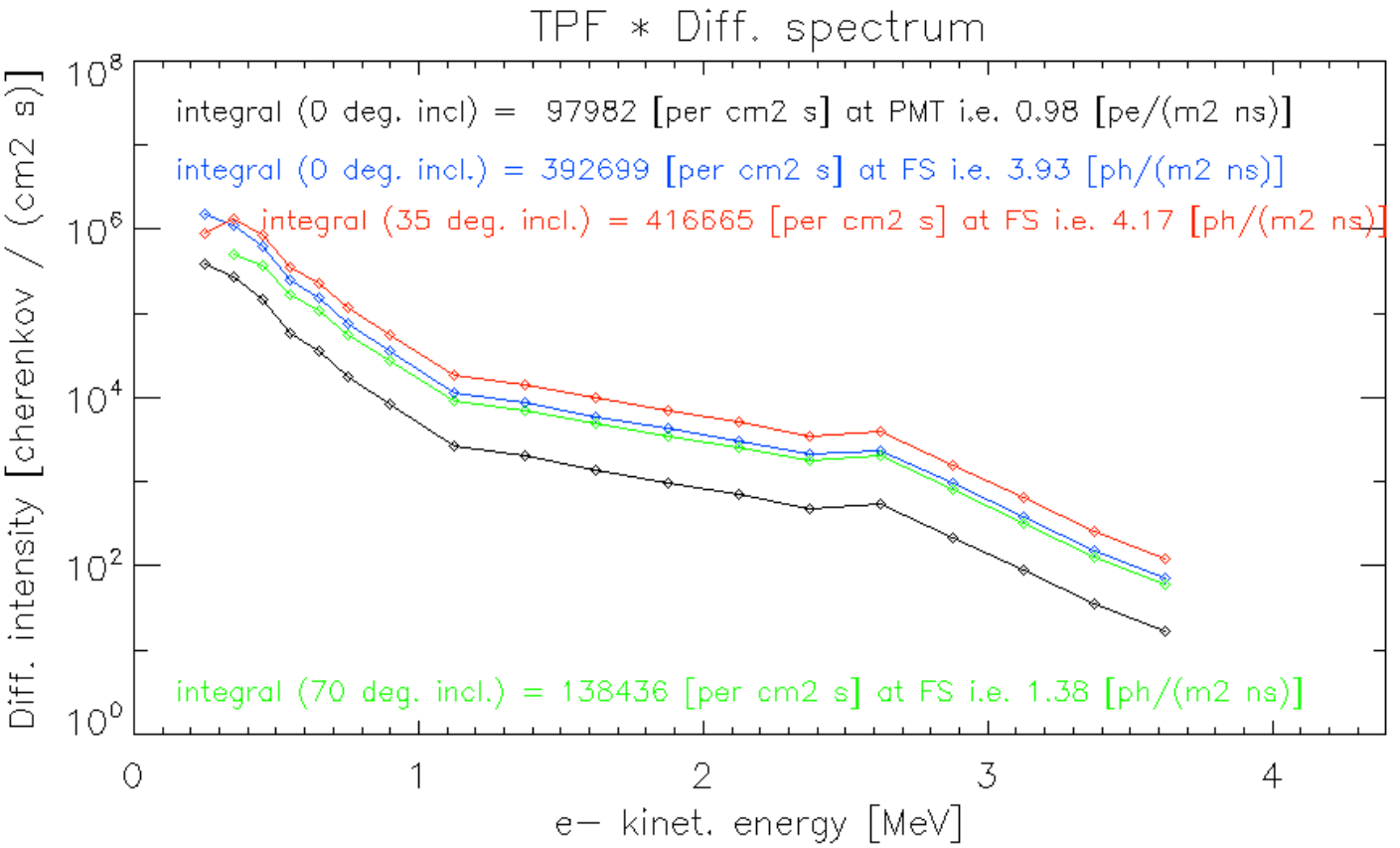
Simulation for 0º, 35º (close to max. production) and 70º. Inclination to main optics axis for

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
created by electrons in JEM-EUSO detector

ICRC 2013 results



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.

Conclusions

- Trapped e- in SAA ~ milions per cm^2 s
- Trapped protons in SAA ~ 10 - 1000 per cm^2 s
- In SAA we have protons with higher energies, but with comparable maximum values of TPF and spectrum extent
- Contribution from trapped protons - **Negligible/Small**
- Maximum of traped protons spectra around 100 MeV – because small creation of Cherenkov photons from part of spectra between 100MeV - 30GeV protons (i.e. spectrum from PAMELA measurements) and TPF shape for energies under 100MeV, conclusion stay same also with contribution of low energy protons.

Duty cycle estimation

UV light sources

If background 1500 ph/(m^2 ns sr) is allowed [in % of total time on orbit]

- sun
- moon

} ~ 21-22 %

- airglow/nightglow
- zodiacal light
- integrated faint star light

} ~ 20-21%

- Boreal/austral auroras ~99% (~ 1%)
- South Atlantic anomaly **small**
- Lightning and TLEs ~98% (~ 2%)
- artificial sources (city lights) ~91% (~ 9%)