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 **~ 1%**
- South Atlantic anomaly **small**
- Lightning and TLEs **~ 2%**
- artificial sources (Anthropogenic / city light) **~ 9%**

Duty cycle estimation - Uncertainties

UV light sources

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

- sun
- moon

} **~ 21-22 %**

A) night on ISS – for which zenith angle start night at ISS ?

B) moon light formula verification

- transparency of atmosphere
- Eath's bond albedo

A)+B) MiniEUSO can help

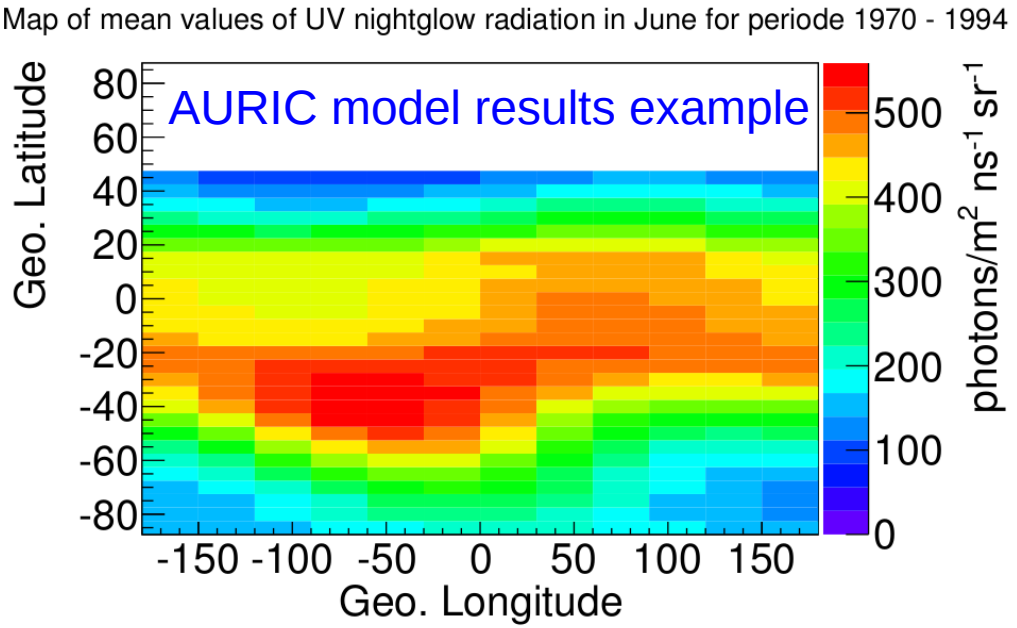
From Tatiana measurements dediced JEM-EUSO duty cycle reduction for different solar zenith angles night definition

Solar zenith angle (deg.)	Duty cycle (%)
108	22.2
109	22.1
110	21.9
111	21.7
112	21.5
113	21.3
114	21.0
115	20.6
116	20.3
117	19.9
118	19.5
119	19.0
120	18.4

Duty cycle estimation - Uncertainties

UV light sources

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



UV background is variable with position and time

- activities directed to UV BG model development and verification

A) AURIC model (ICRC 2013)

B) Tatiana 2 + ISUAL data analysis

Presentation : Latitudinal dependence of UV background in Tatiana 2 and ISUAL measurements

C) JEM-EUSO precursor experiments data will help

Duty cycle estimation

Auroras effect on JEM-EUSO operational efficiency

To estimate auroras effect we evaluate for every position of ISS additional parameters

- **Kp index** to describe geomagnetic activity
- geomagnetic latitude and longitude of ISS

The K-index quantifies disturbances in the horizontal component of earth's magnetic field with an integer in the range 0-9 with 1 being calm and 5 or more indicating a geomagnetic storm. The official planetary Kp index is derived by calculating a weighted average of K-indices from a network of geomagnetic observatories.

Following a Table from NOAA

- http://www.swpc.noaa.gov/Aurora/index.html

we exclude from duty cycle (observation efficiency) moments when Kp index for ISS geomagnetic latitude was equal or higher than auroral boundary

Comparison of Auroral Boundaries from Kp and Auroral Activity Level at Local Midnight

Magnetic Latitude	Kp	Magnetic Latitude	NOAA POES Auroral Activity Level
66.5	0	67.5	1
64.5	1	66.5	2
62.4	2	65.6	3
60.4	3	63.9	4
58.3	4	62.5	5
56.3	5	60.7	6
54.2	6	58.6	7
52.2	7	56.7	8
50.1	8	54.6	9
48.1	9	51.0	10
		48.5	10+
		45.0	10++

Duty cycle estimation

Auroras effect on JEM-EUSO operational efficiency

Verification of method

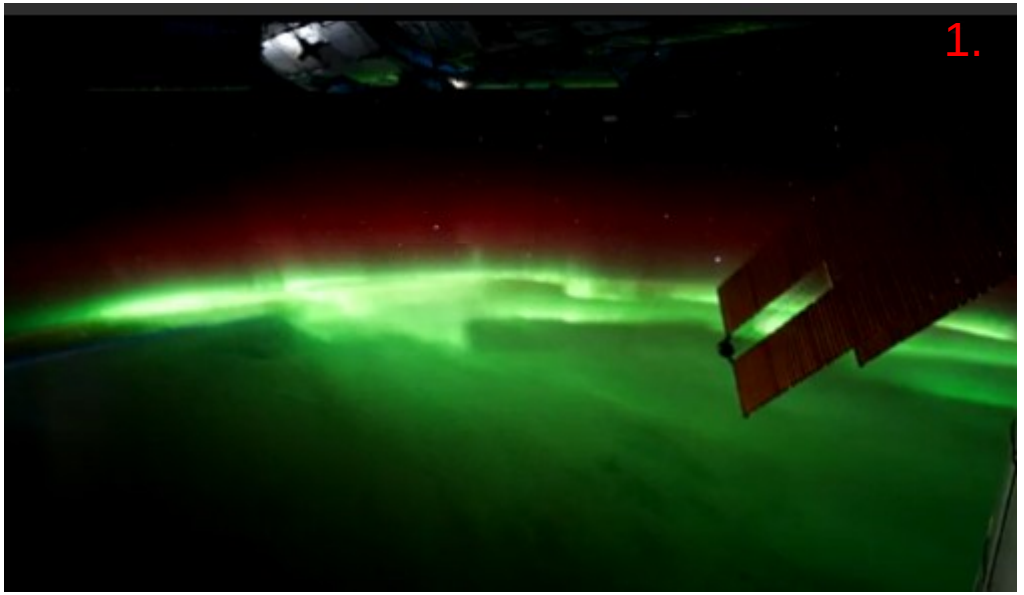
From few videos taken from ISS with auroras available at [1] we were able select one [2] in period 2000-2011 with clear aurora visible in nadir mode (directly under ISS).

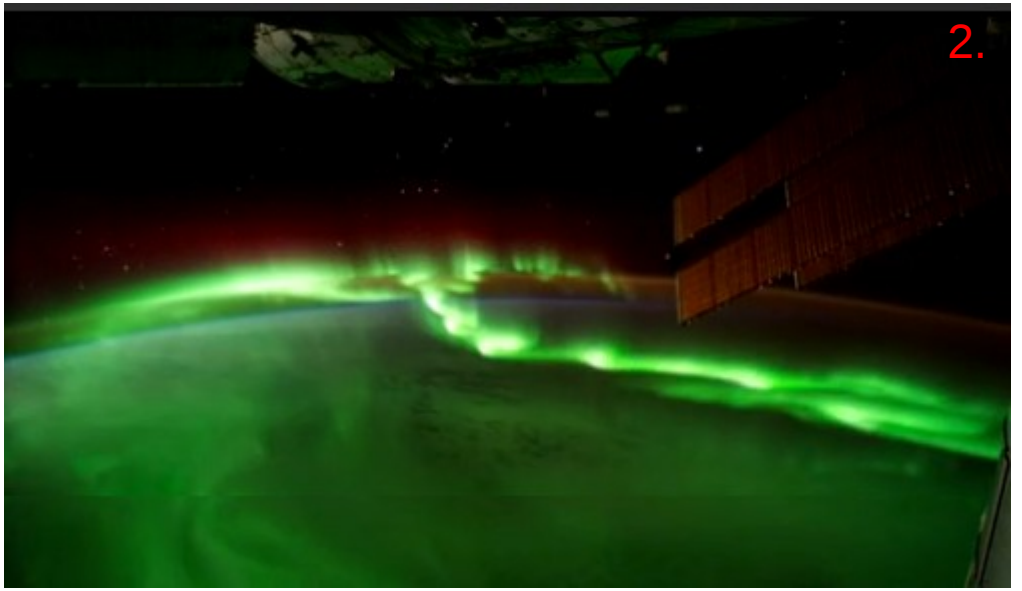
Video was taken when ISS flew from Madagascar to Australia between 17:22 and 17:45 GMT on 17. september 2011. Part of video shows ISS flight over aurora australis.

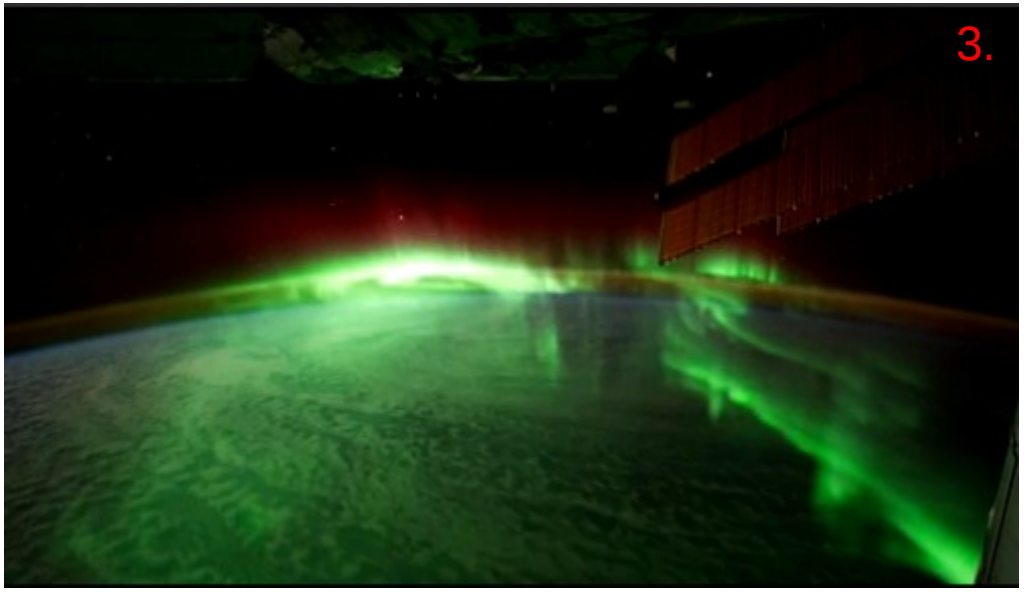
Coincidence between movie appearance of aurora and method identification of aurora in same time is a supporting argument to method validity.

References:

1. http://www.nasa.gov/multimedia/videogallery/index.html
2. http://www.nasa.gov/multimedia/videogallery/index.html?media_id=112491731







Duty cycle estimation

Auroras effect on JEM-EUSO operational efficiency

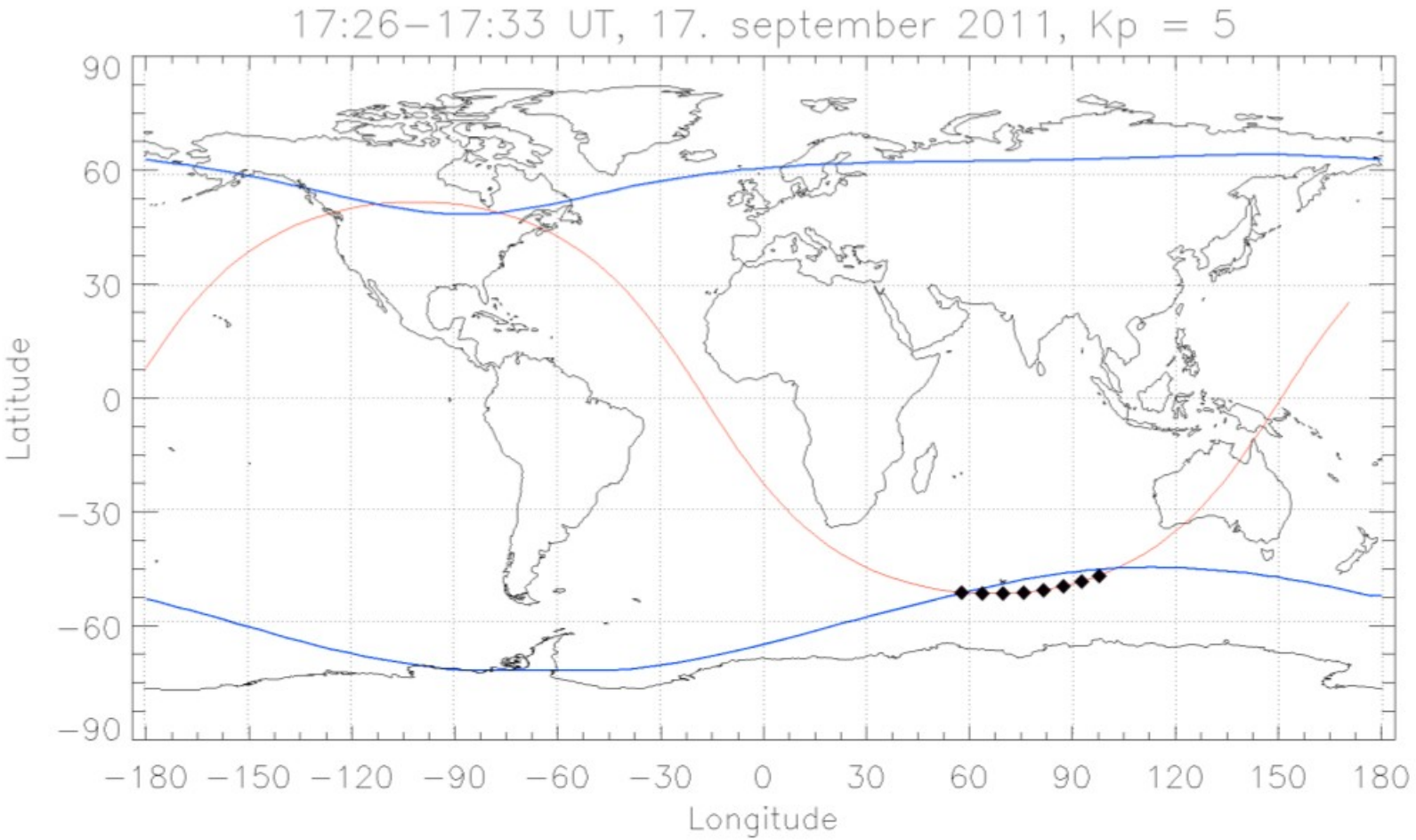
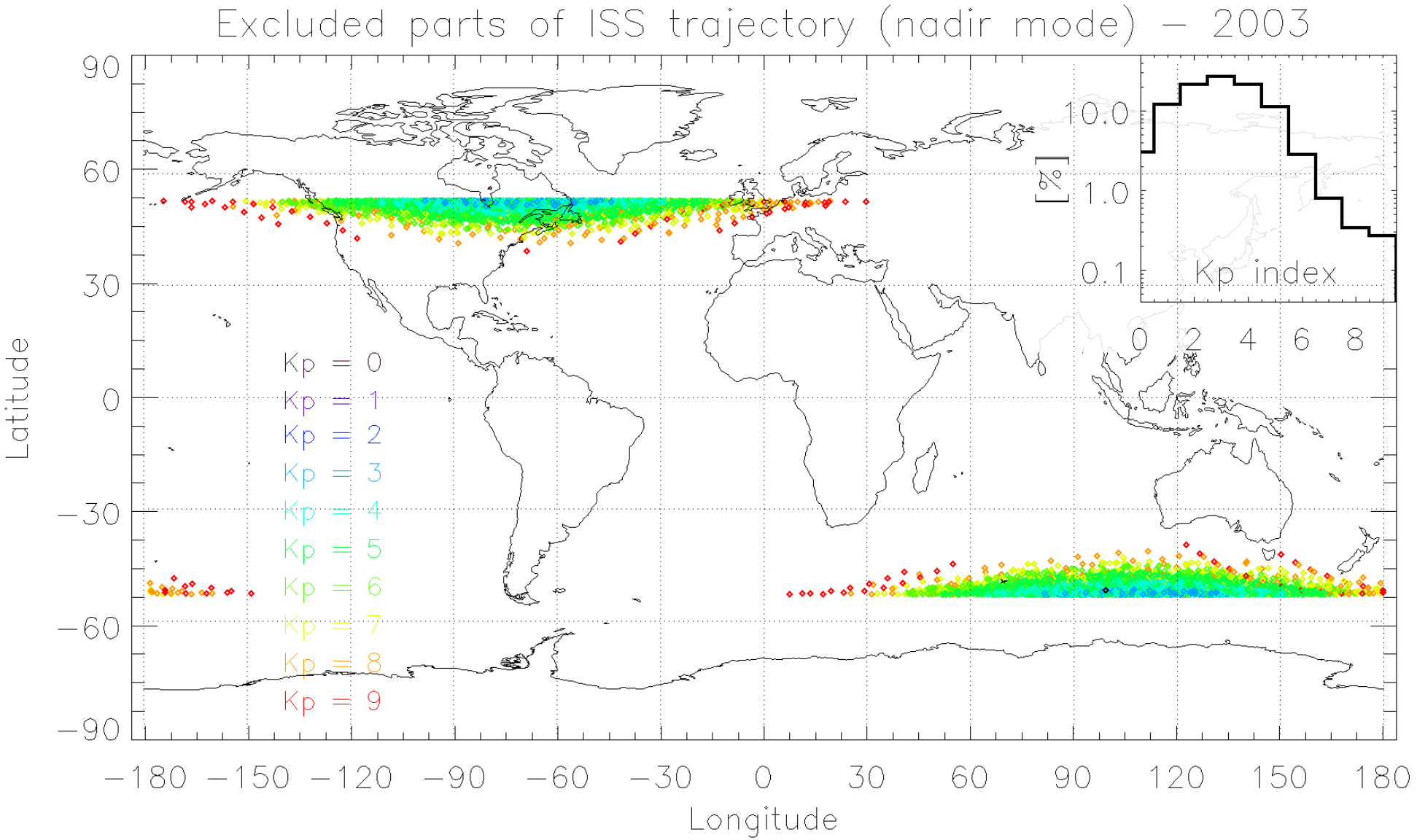


Figure A.17: Red line represent the trajectory of the ISS, blue lines are equator-ward boundaries of the auroral oval for magnetosphere disturbed at level Kp = 5. Diamonds on ISS trajectories are points on ISS trajectory with one minute step (from 17:26 till 17:33 GMT, 17 september 2011) excluded from EAS measurements visible on NASA video (NASA).

AdvSR article *Performances and air-shower reconstruction techniques for the JEM-EUSO mission*

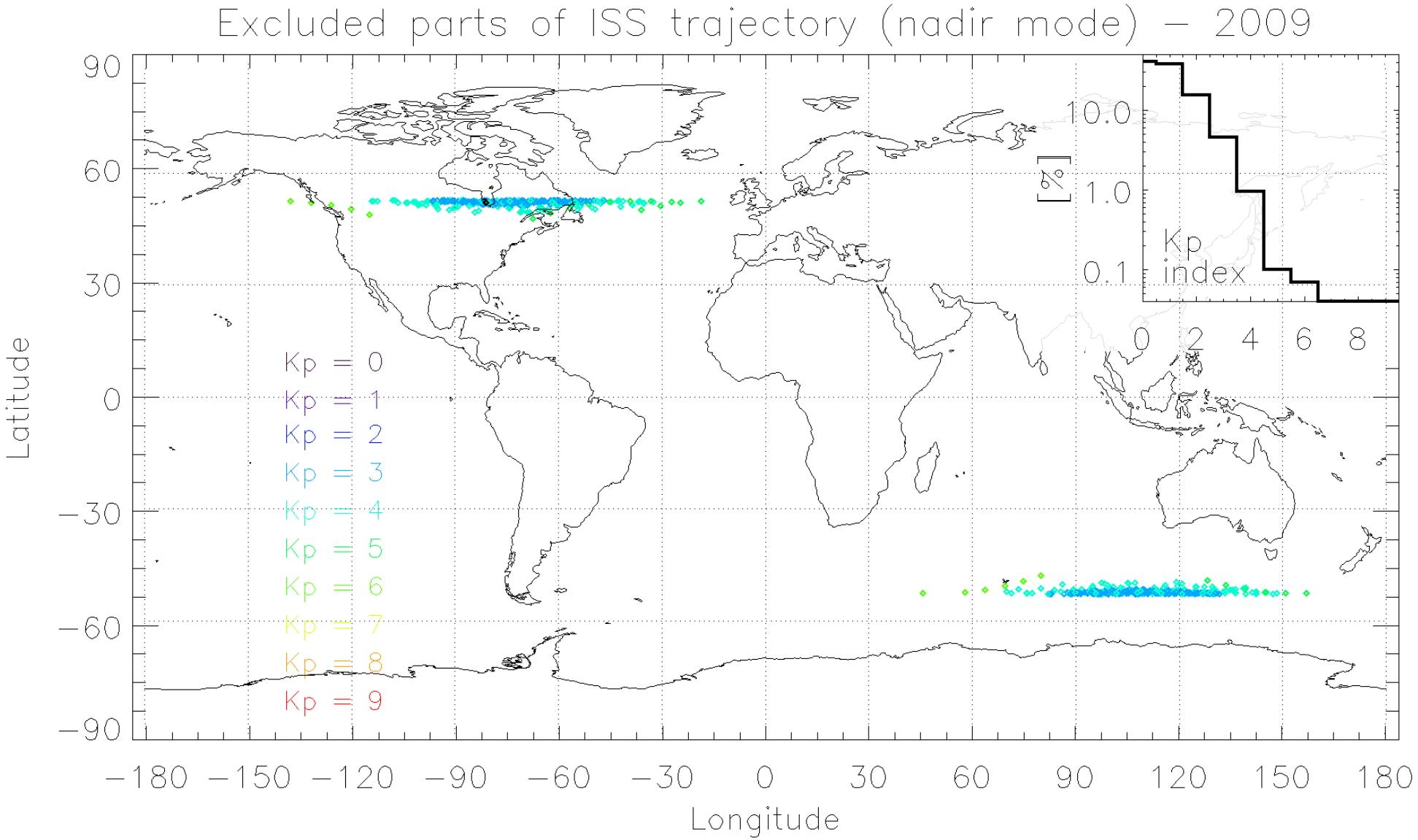
Duty cycle estimation

Auroras effect on JEM-EUSO operational efficiency



Duty cycle estimation

Auroras effect on JEM-EUSO operational efficiency



Duty cycle estimation

Auroras effect on JEM-EUSO operational efficiency

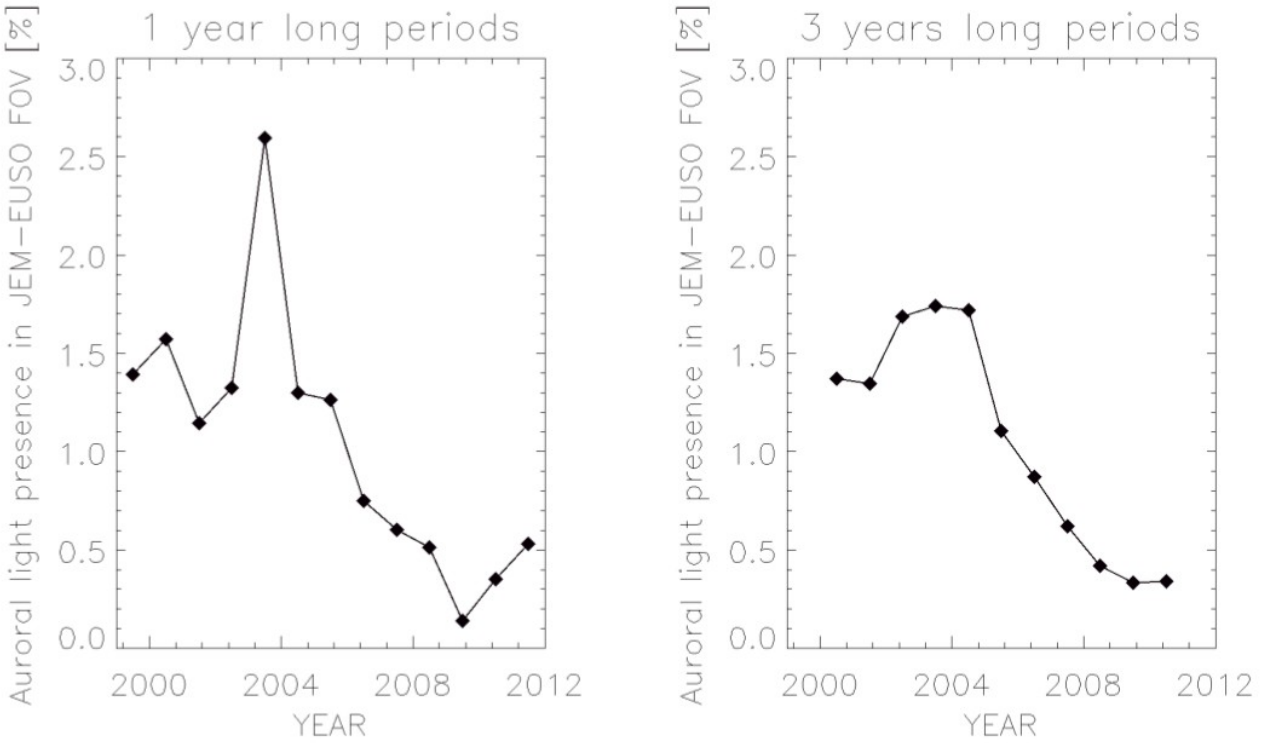


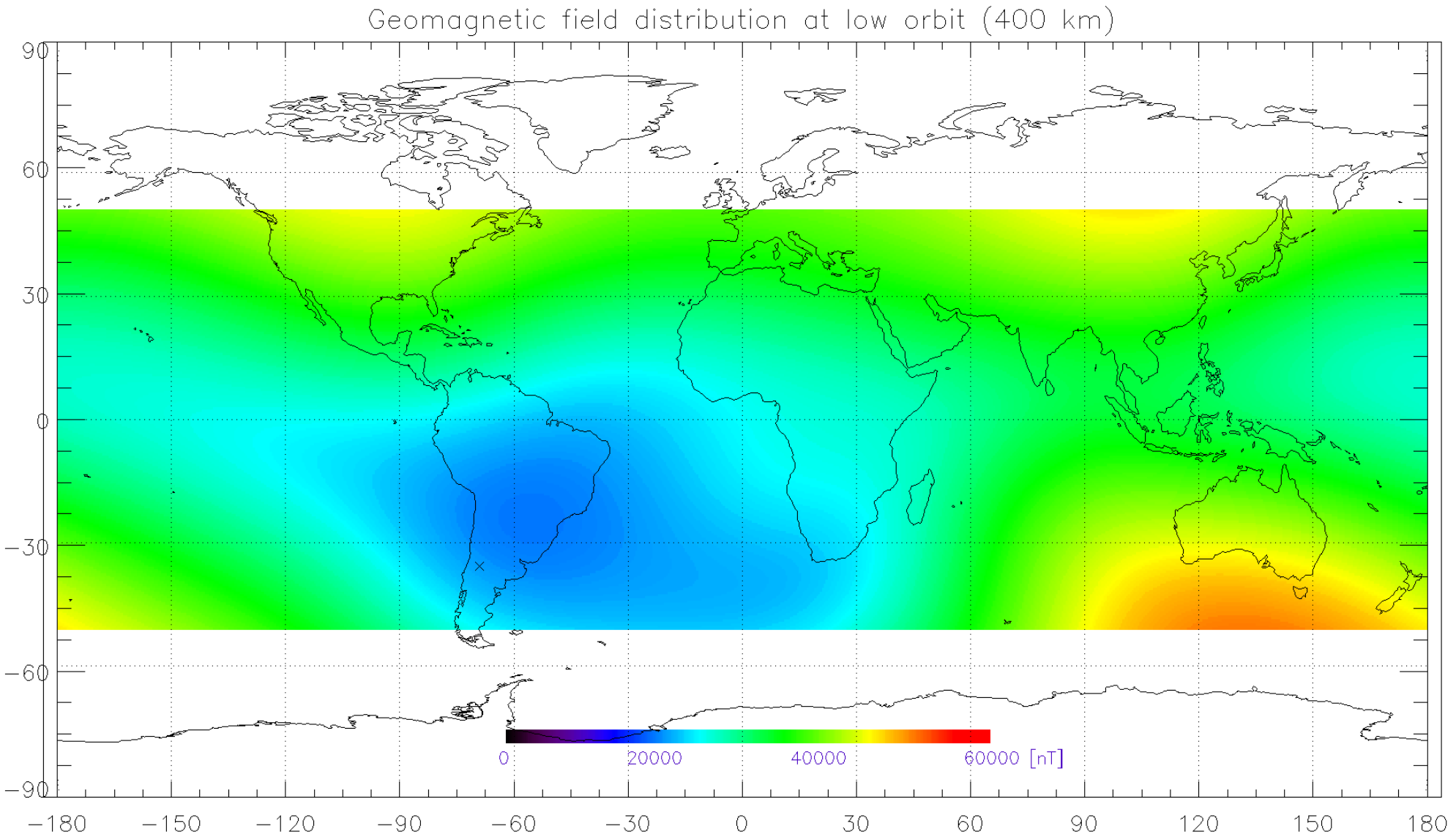
Figure 3: Left panel: Fraction of time f_{AL} in which auroral light restrain EAS measurements for one year long periods from 2000 to 2011. Right panel: Same as in the left panel, but integrating for 3-year periods.

To evaluate the influence in years 2017–2019 we should estimate geomagnetic conditions during such period. The conservative estimation is, that JEM-EUSO will face declining solar activity and solar minimum somewhere during measurement period. In that case we estimate an **effect of auroral light** to restrain the EAS measurement for **~1%** .

Duty cycle estimation

SAA effect on JEM-EUSO operational efficiency

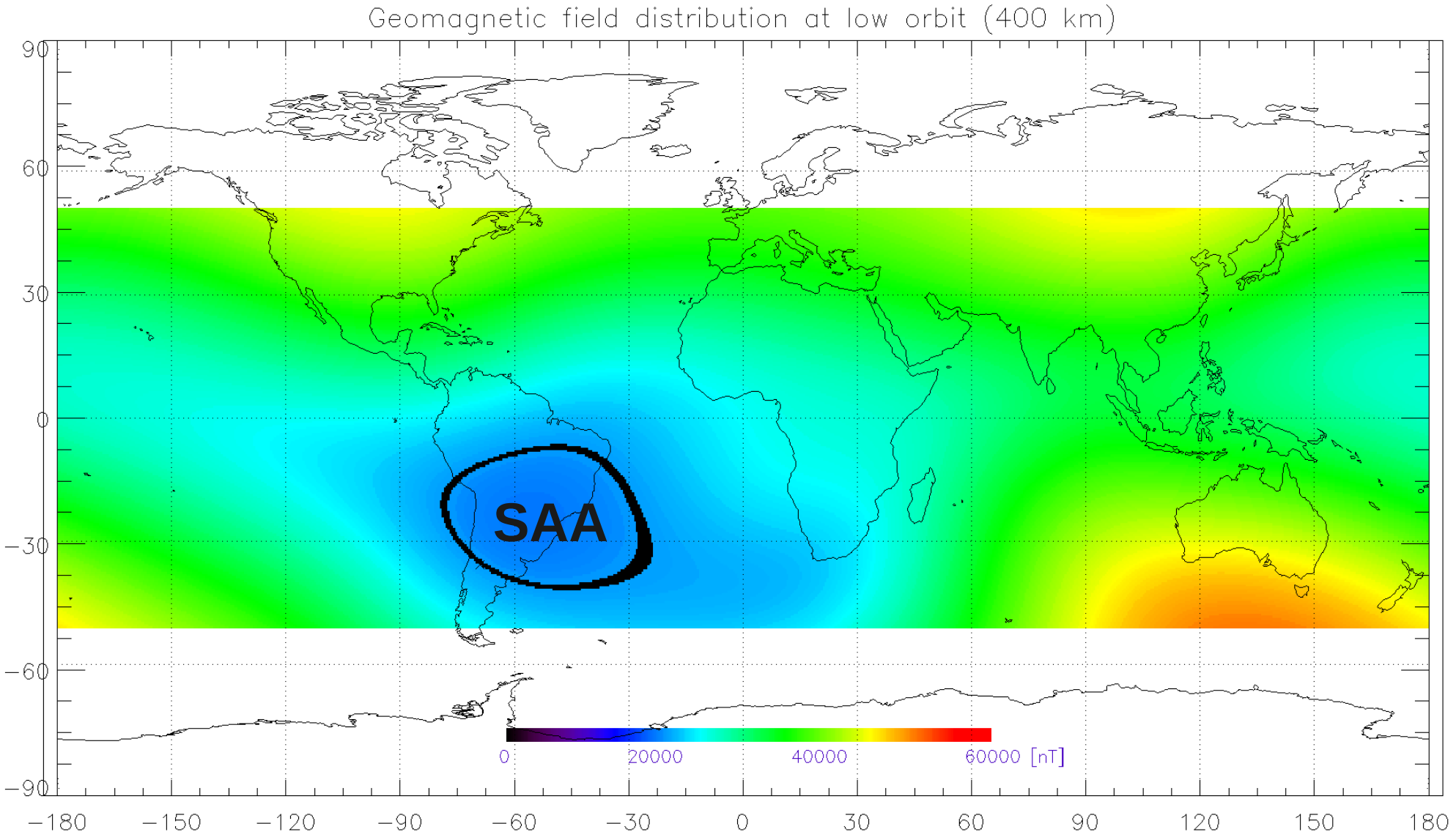
- IGRF field model – total magnetic field in *nT*



Duty cycle estimation

SAA effect on JEM-EUSO operational efficiency

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



Duty cycle estimation

SAA effect on JEM-EUSO operational efficiency

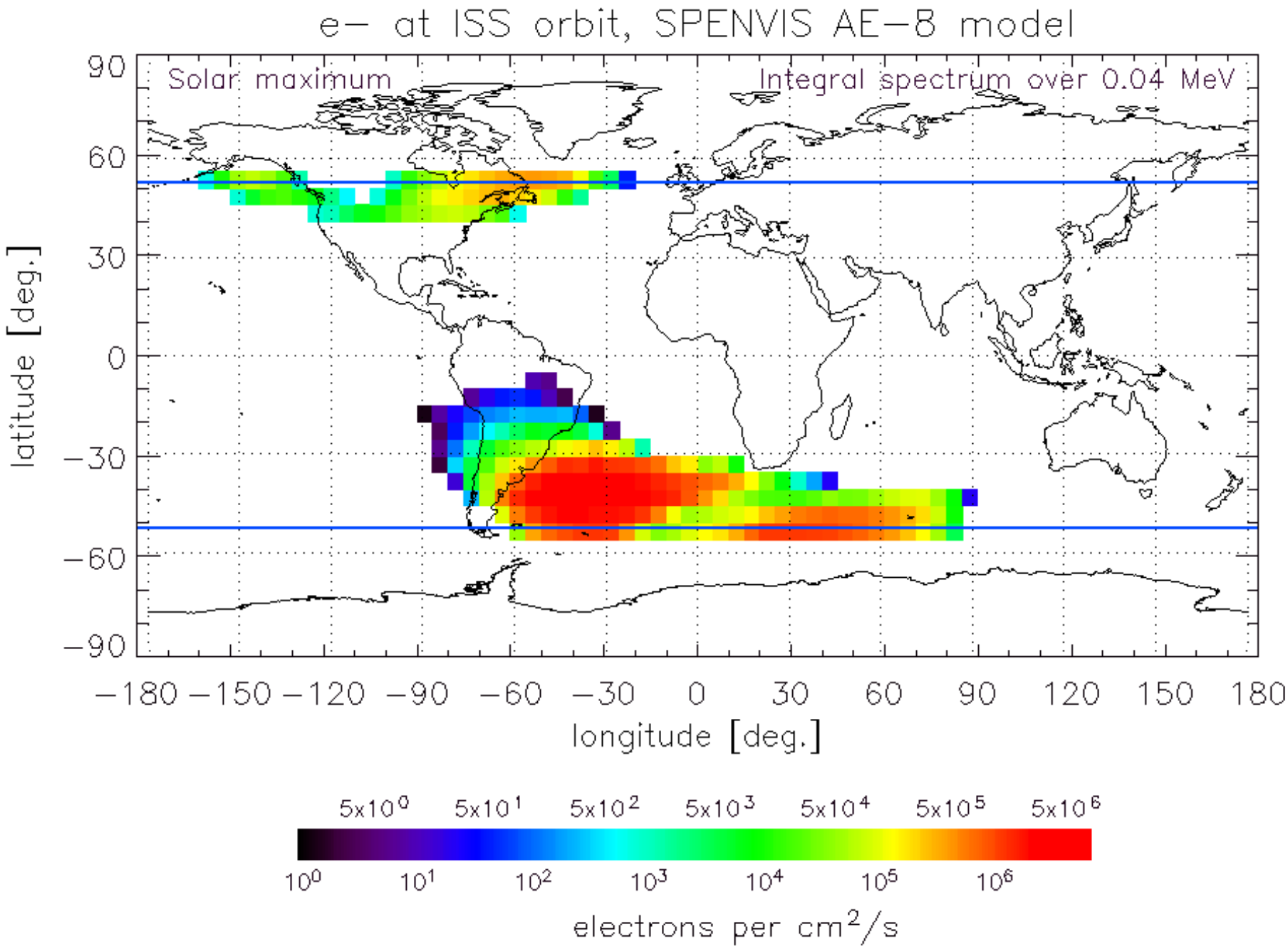
- Cosmic rays – negligible effect
- UV background emission (airglow) in SAA is in the range of values observed in the rest of the Earth
- Trapped electrons influence

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

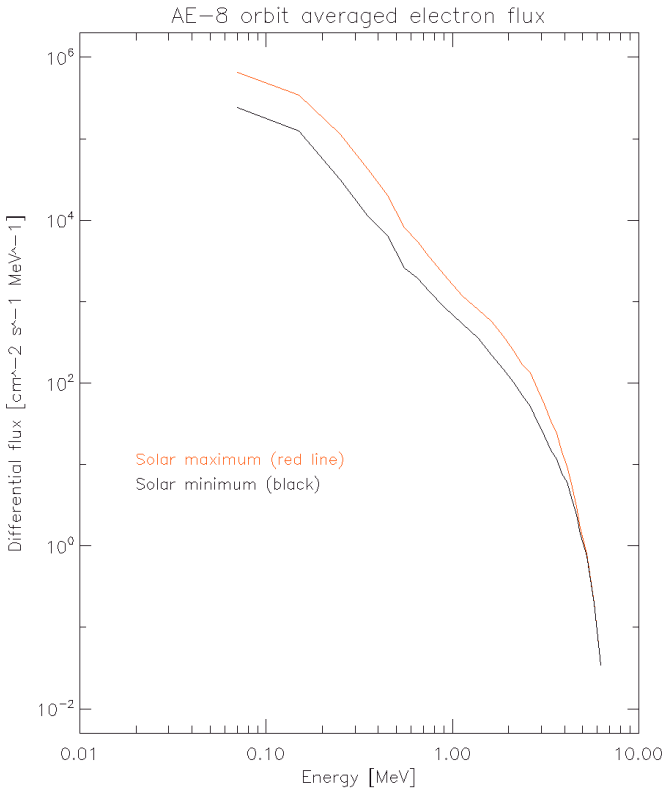
  - effect of those e^- to JEM-EUSO lenses :

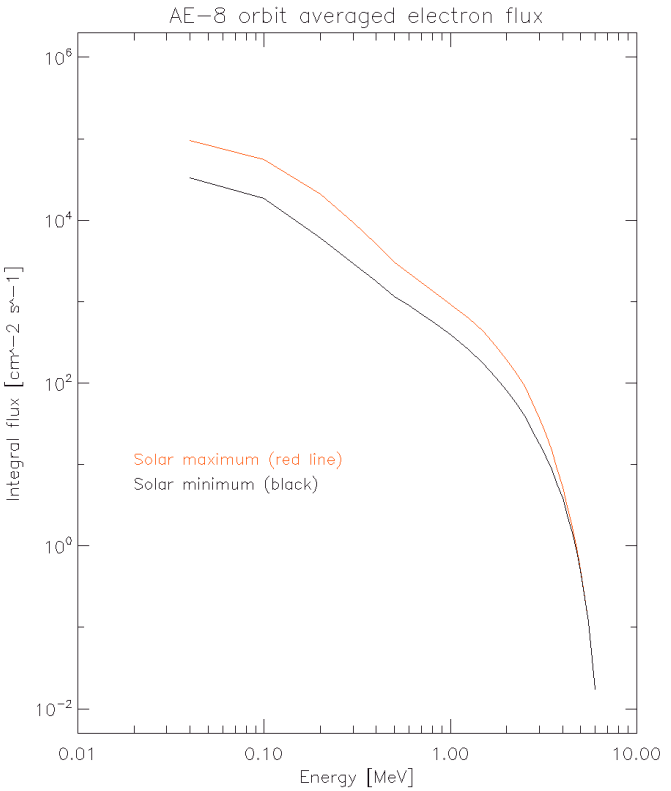
  - GEANT4 simulation

SPENVIS : traped electrons along orbit for 1 month



The maximum intensities in the center of SAA are of the orders of $\sim 10^6$ electrons $cm^{-2}\ s^{-1}$.



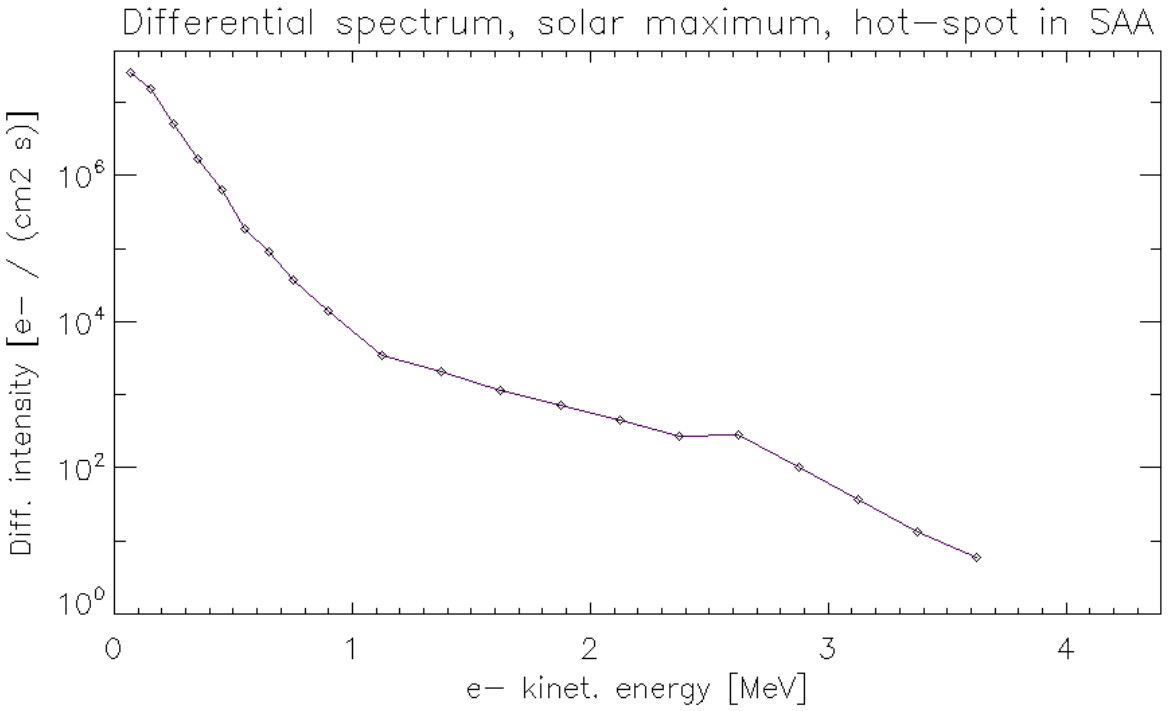


e⁻ spectra

- along ISS orbit for solar minimum and maximum

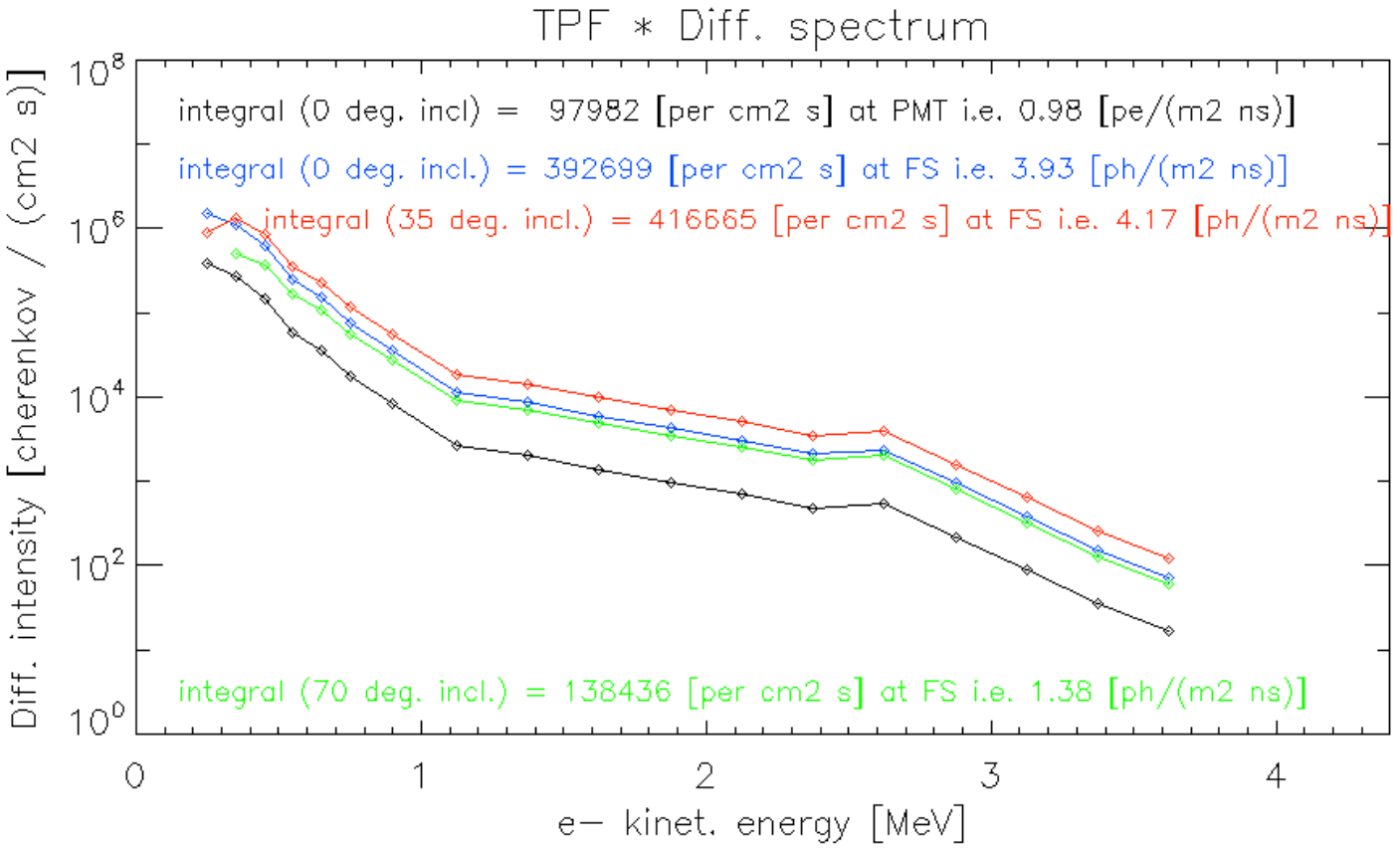
e⁻ spectrum

- in the SAA most “bright” region



Duty cycle estimation

SAA effect - 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**.

Duty cycle estimation

Anthropogenic / city light

Using DMSP (Defense Meteorological Satellite Program) database

– Annual average of cloudfree moonless intensity of '**Night Earth**' in 30 arcseconds grid on surface

- **Light pollution cities mainly consisting of visible range**

– Assuming UV intensity proportional to visible (data published for range 350 – 2000 nm in 63 levels scale)

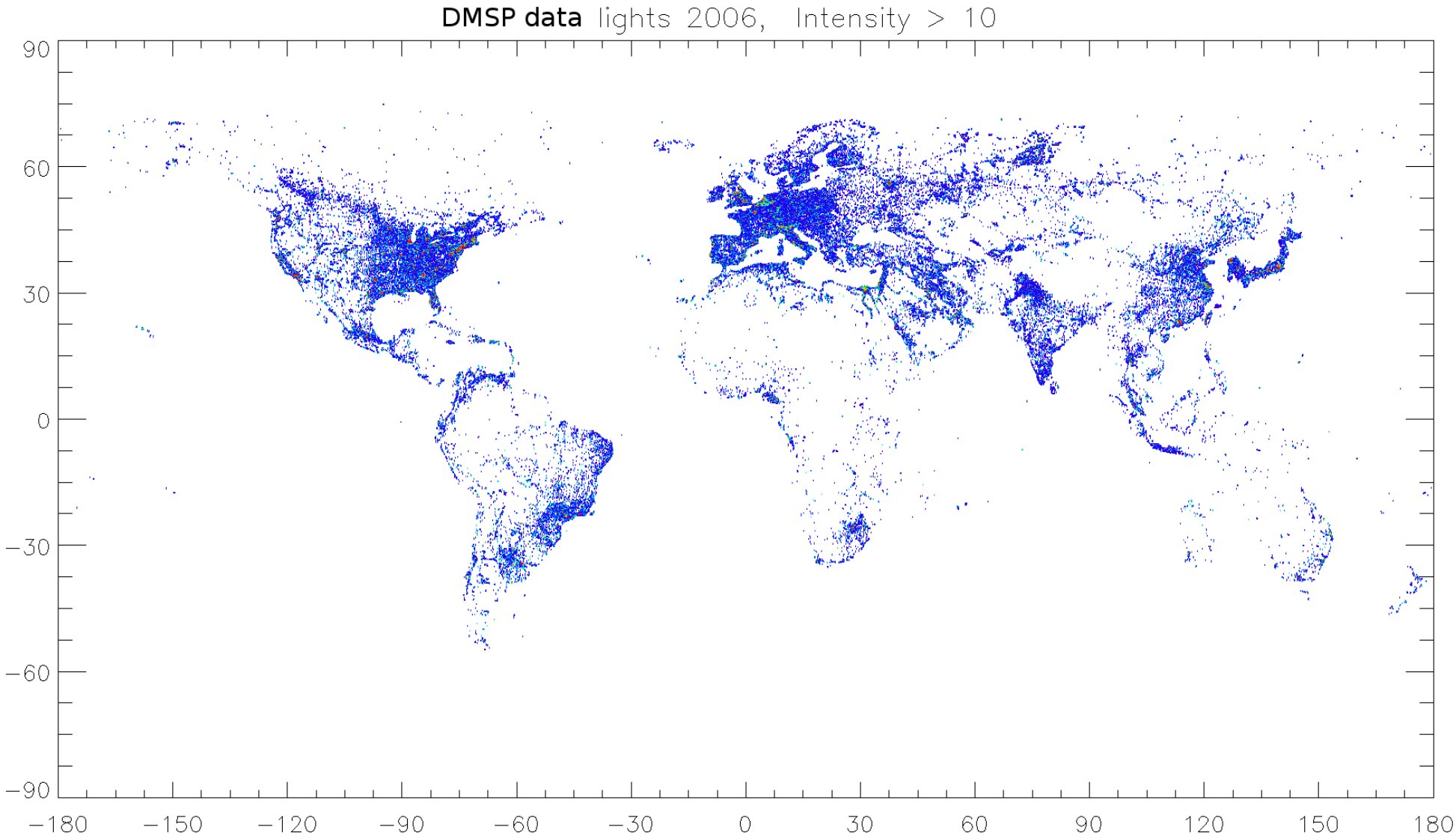
- **Estimating background intensity** in a unit of 'oceanequivalent'

– 'Oceanequivalent' background intensity

- assuming → 500 UVphotons / (m^2 sr ns)

Duty cycle estimation

City lights – selection from DMSP data



Condition to exclude measurements over cities from JEM-EUSO duty/operational cycle
– if we have 1 city in PDM = PDM is blind (DSMP resolution 1 km pixels). Zero PDM condition.

~ 9%

Duty cycle estimation

Conclusion - Outlook

- All main effect already included
- Verification and solutions of uncertainties in near future with help of JEM-EUSO precursor experiments data/results