



Jupiter Radiation Model: New results & Review

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r e t u r n o n i n n o v a t i o n

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JOSE model: Magnetic parameters used to construct JOSE

✓ Magnetic parameters used to develop JOSE model

- Very close to the planet, $L < 10$

Salamambo model, based on L and B/B_{eq} parameters will be used

- Close to the planet, $10 < L < 20$

According to the data analyzed until now (P10, P11, V1 and V2), L and B/B_{eq} parameters allow to well organized the particles until $L=20$ and will be used to construct the new model (based on in-situ data)

- Far from the planet, $L > 20$

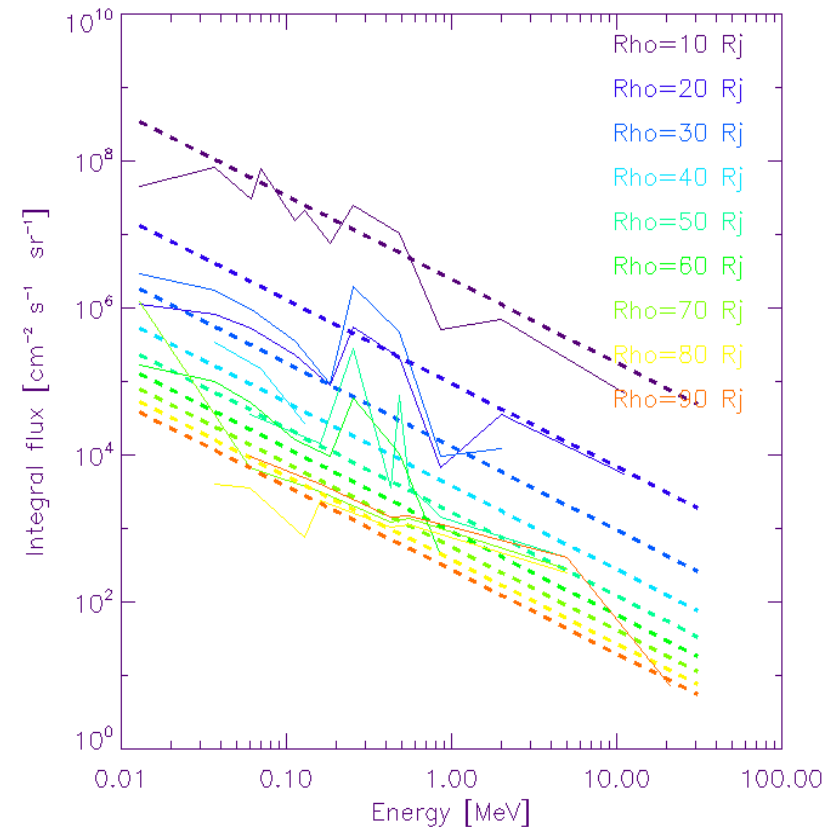
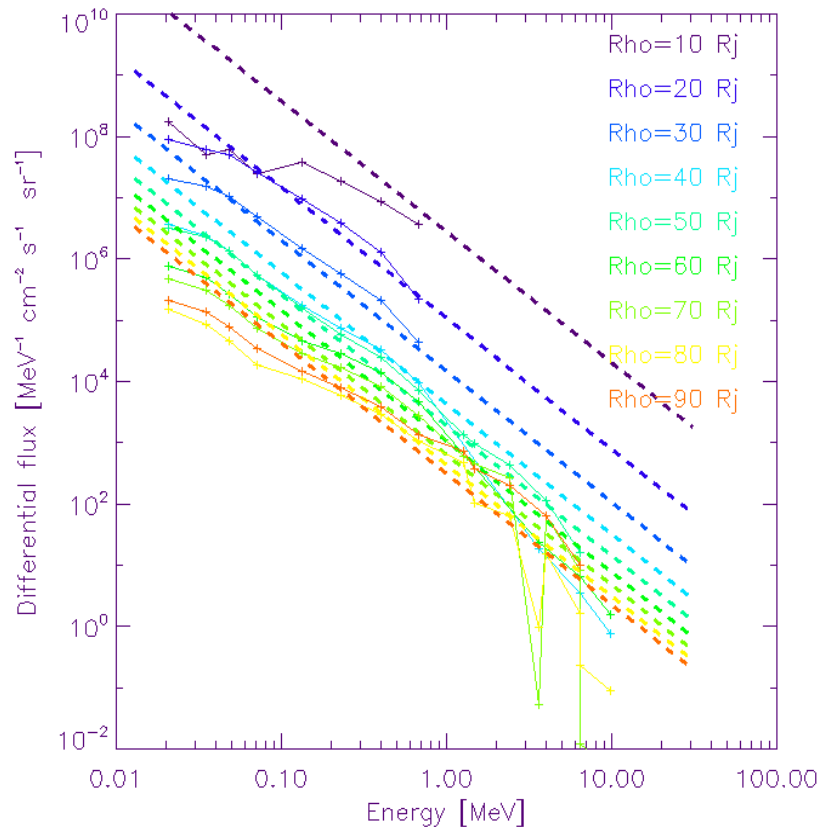
Being given that far from the planet, the real magnetic equator cannot be represented by the dipole magnetic equator, the L parameter cannot be used.

A new parameter, nd_{cs} (distance from the current sheet or real magnetic equator) and the radial distance ρ will be used to construct the new model based on in-situ data.

JOSE model: Electron model development (ρ , ndcs) > 16 Rj

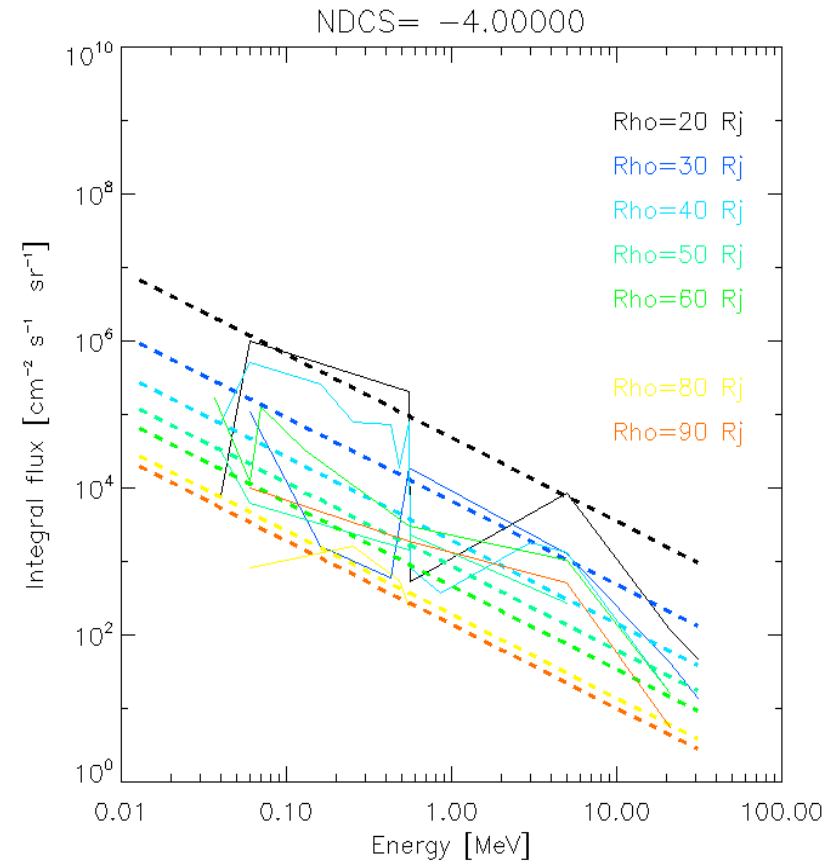
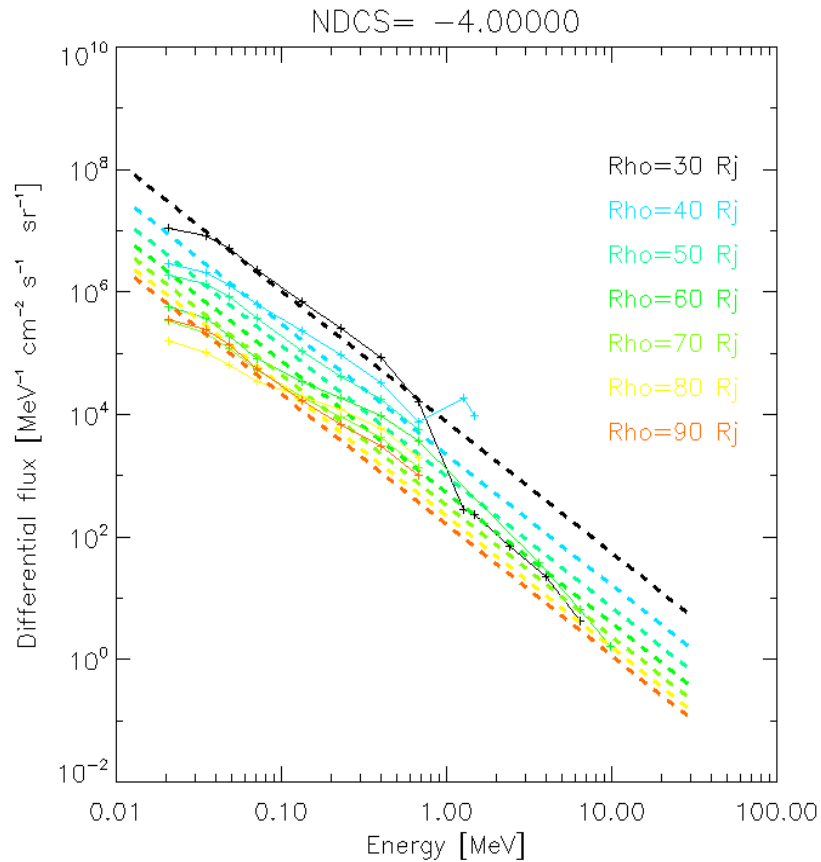
Spectrum is fitted with a single power law

Comparison with data (solid line) @ magnetic equator



JOSE model: Electron model development (ρ , ndcs) > 16 Rj

Comparison with data outside magnetic equator

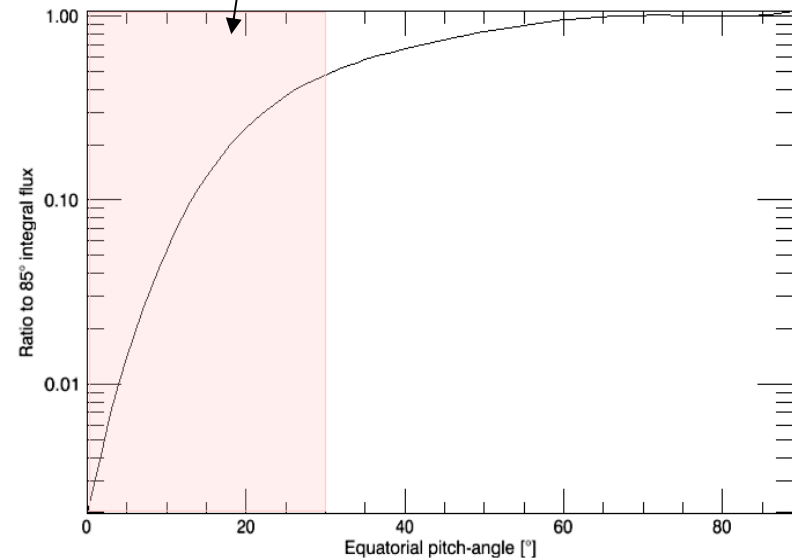
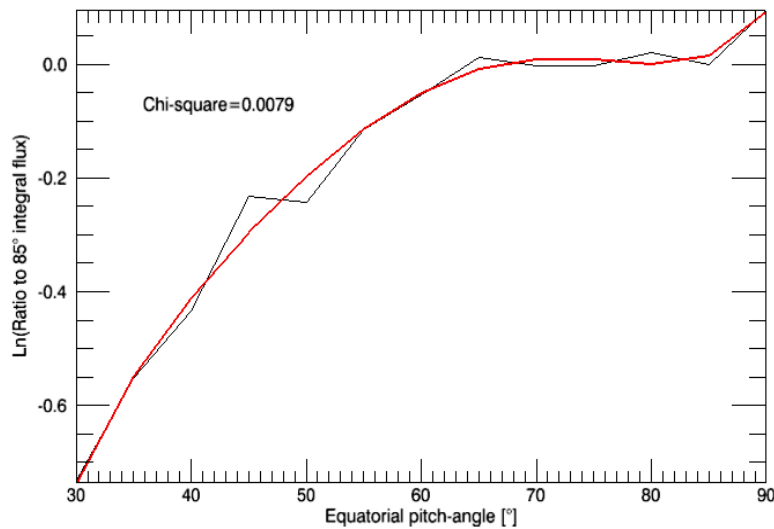


JOSE model: Electron model development (L, α_{eq}) $L < 20$

B/Beq profile: $\sin(\alpha_{eq}) = B/B_{eq}$

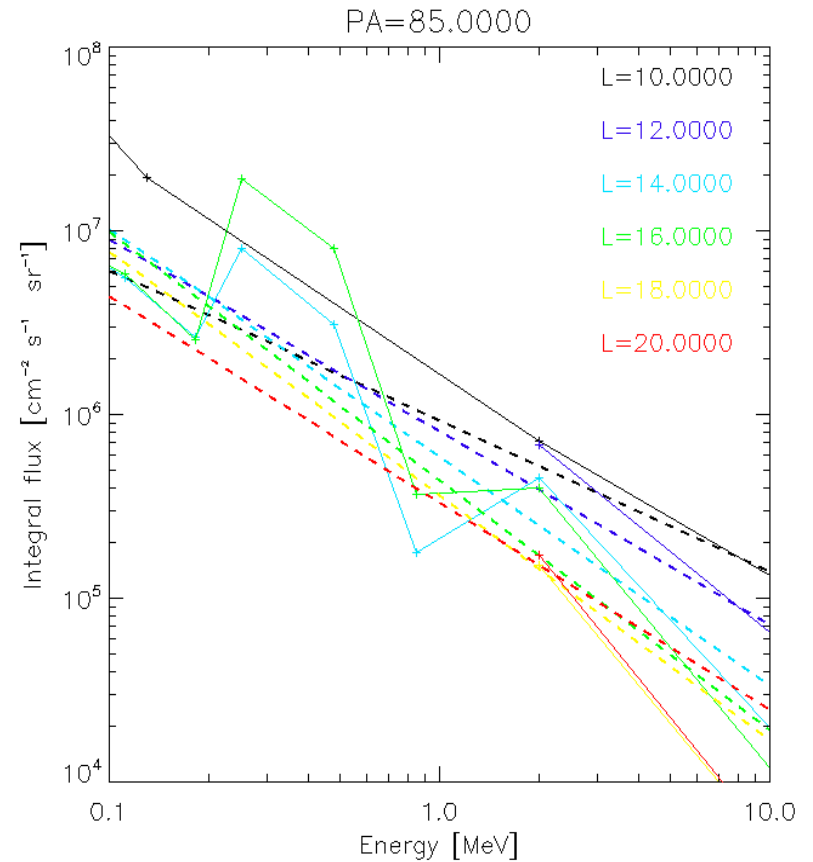
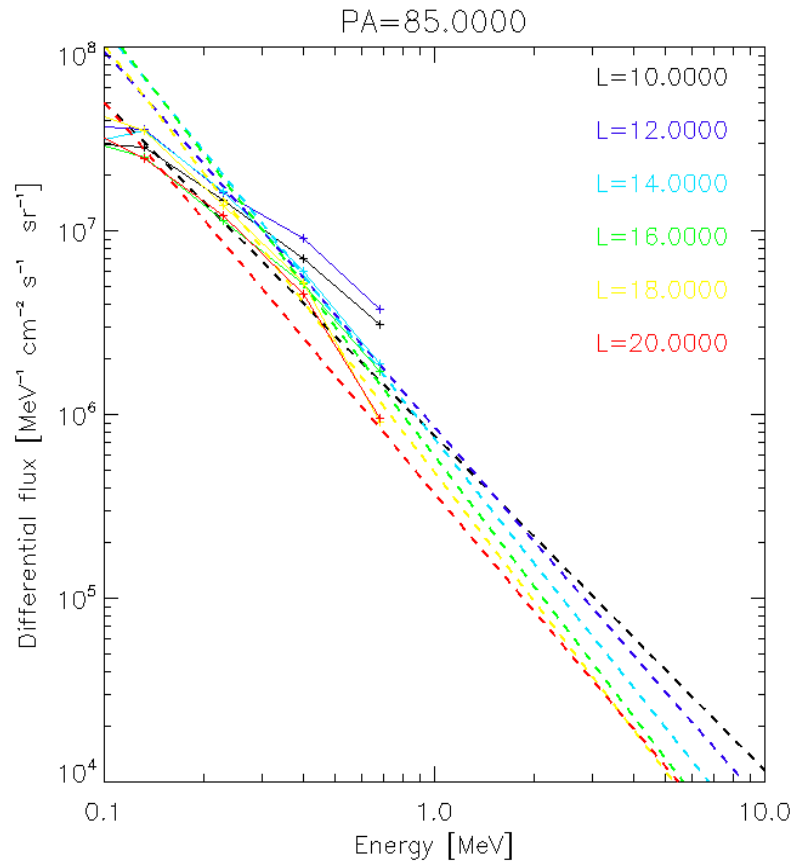
No data at small pitch angle (high latitude) = extrapolation
Extrapolation (no data there)

$$y = -6.2262735 + 0.46165538 \cdot PA - 0.015757436 \cdot PA^2 + 0.00028488797 \cdot PA^3 - 2.5816144e-06 \cdot PA^4 + 9.1619539e-09 \cdot PA^5$$



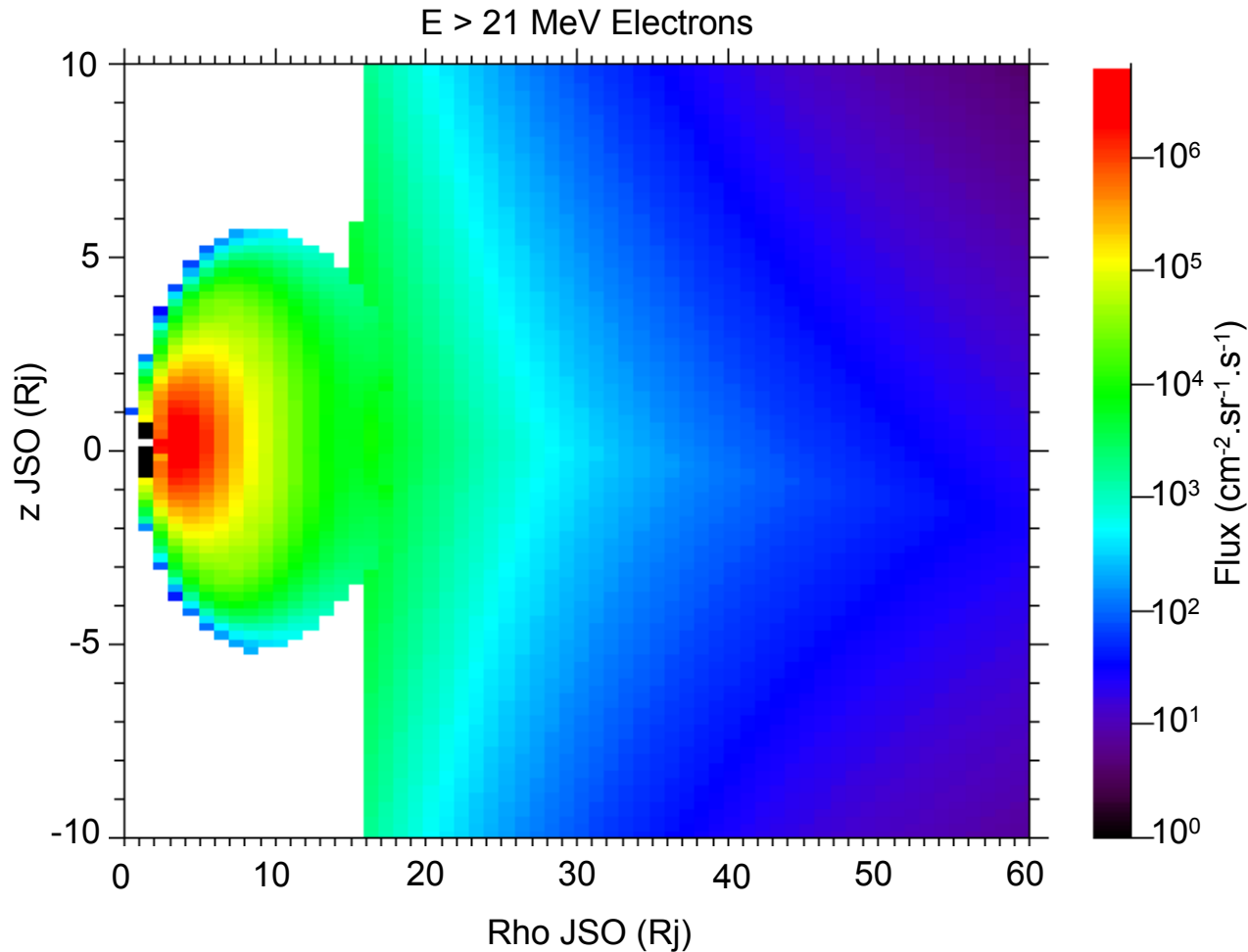
JOSE model: Electron model development (L, α_{eq}) $L < 20$

Comparison with data near magnetic equator



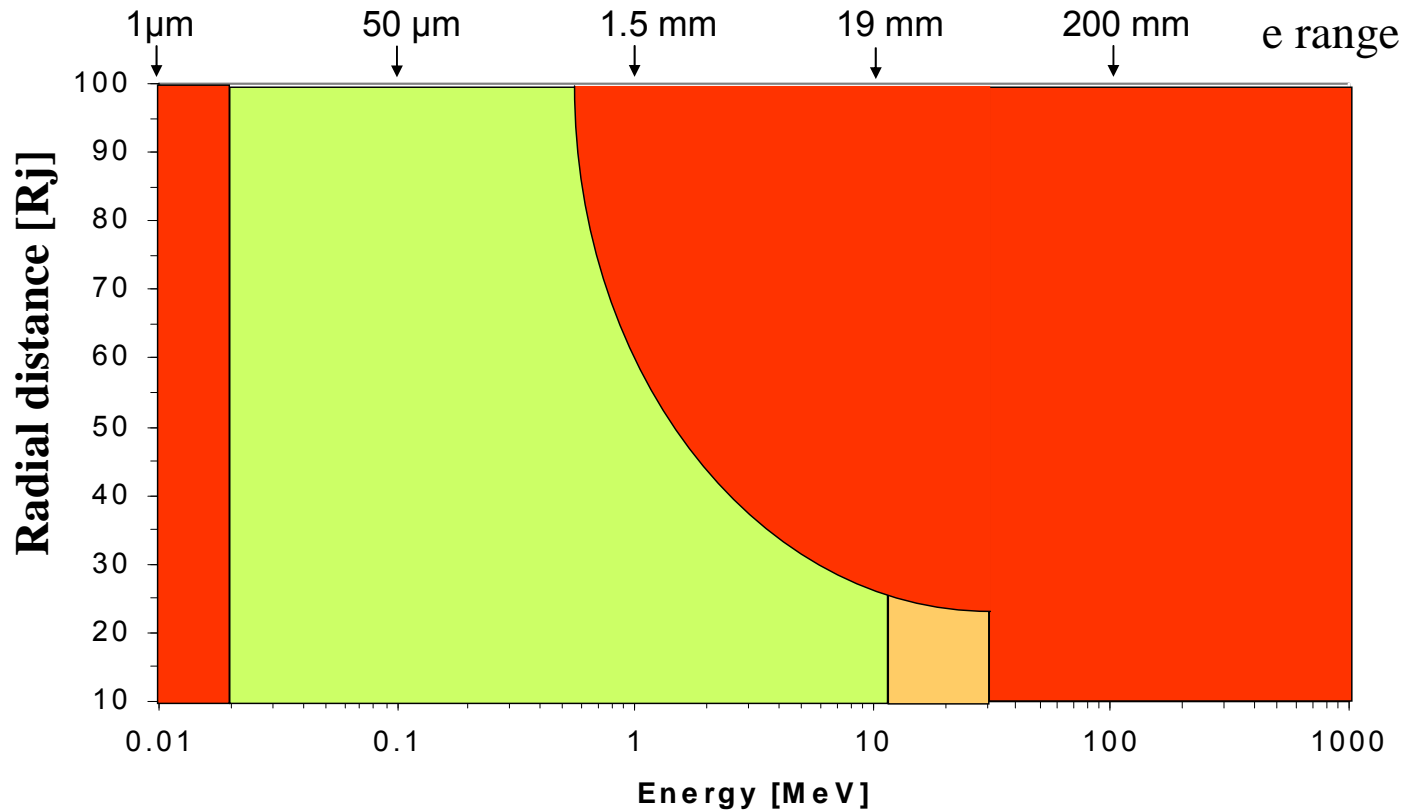
JOSE model: Electron model results

✓ Exemple of results



JOSE model: Region of validity of JOSE electron

✓ Energy coverage and region of validity of electron model



no constraints at all

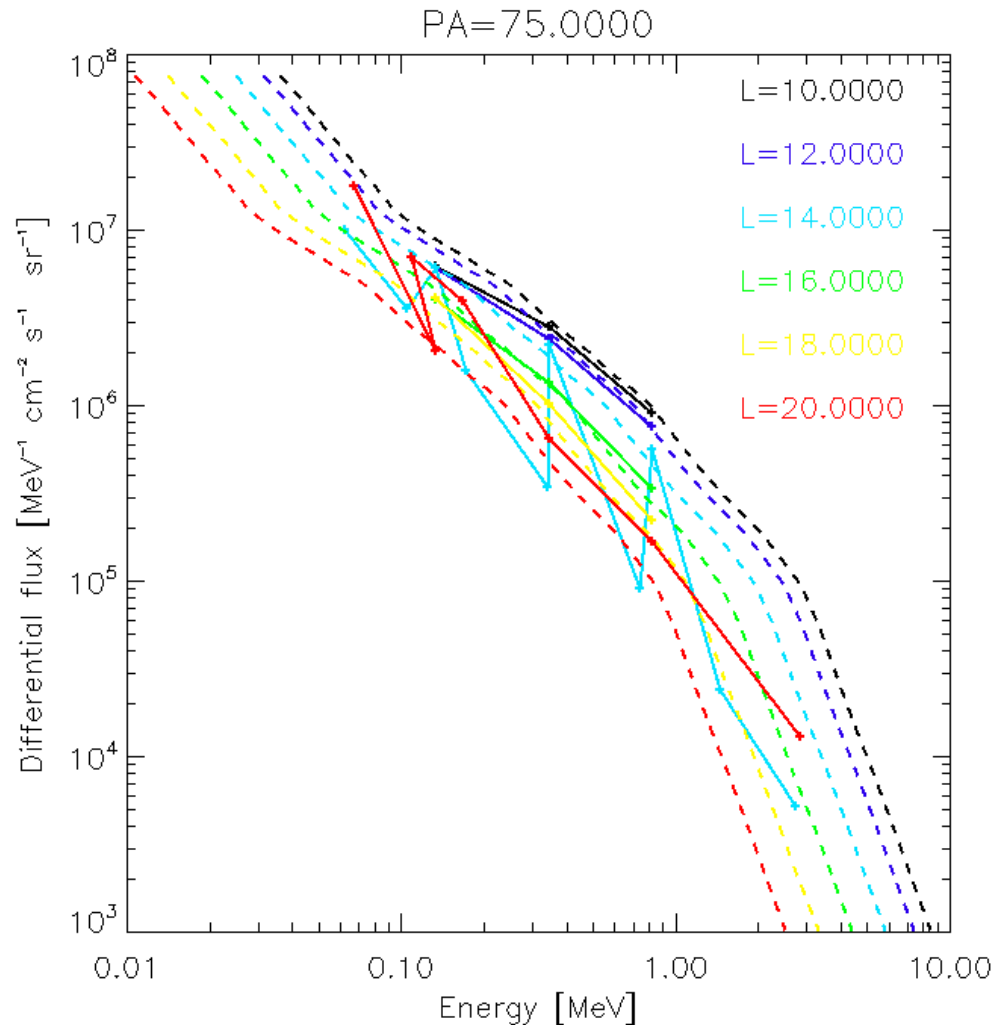
poor constraints

good constraints

JOSE model: Proton model development (L, α_{eq}) $L < 20$

✓ Presentation of proton model

$L < 20$

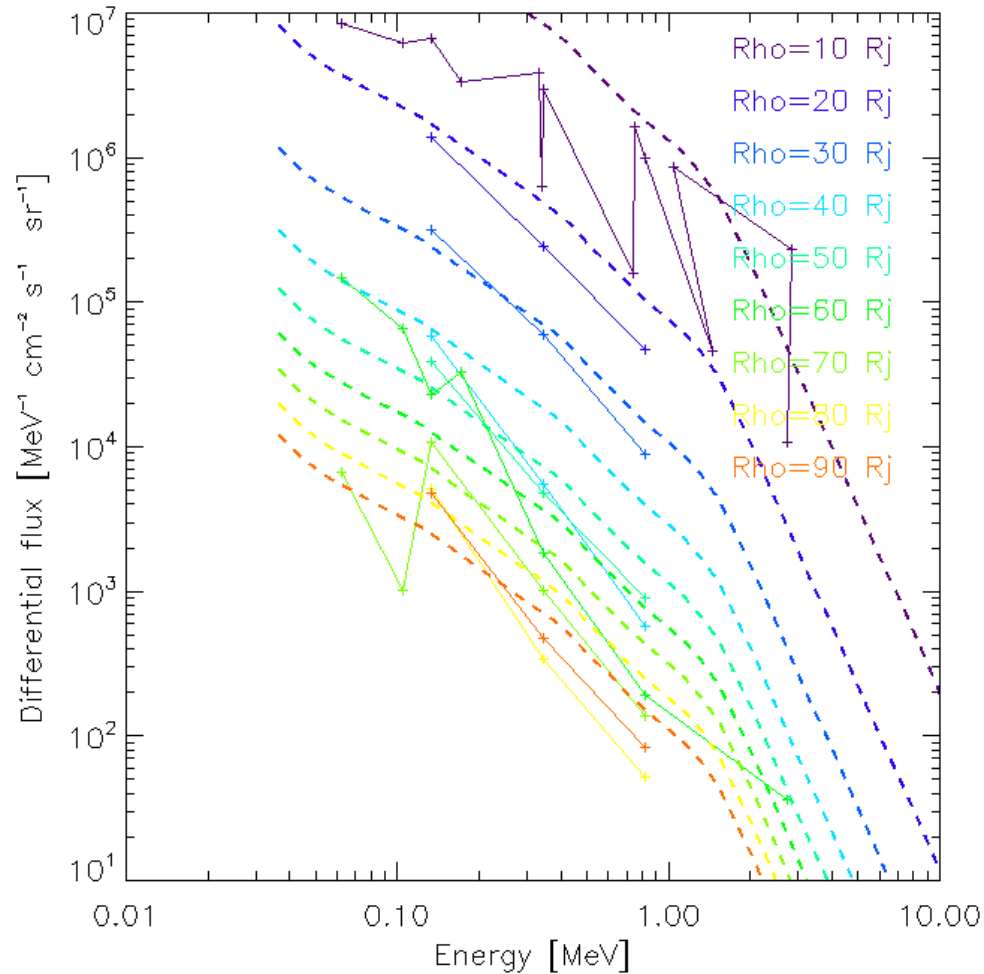


Data:solid line
JOSE:dashed line

JOSE model: Electron model development (ρ , ndcs) > 16 Rj

✓ Presentation of proton model

$\rho > 20$ Rj at magnetic equator

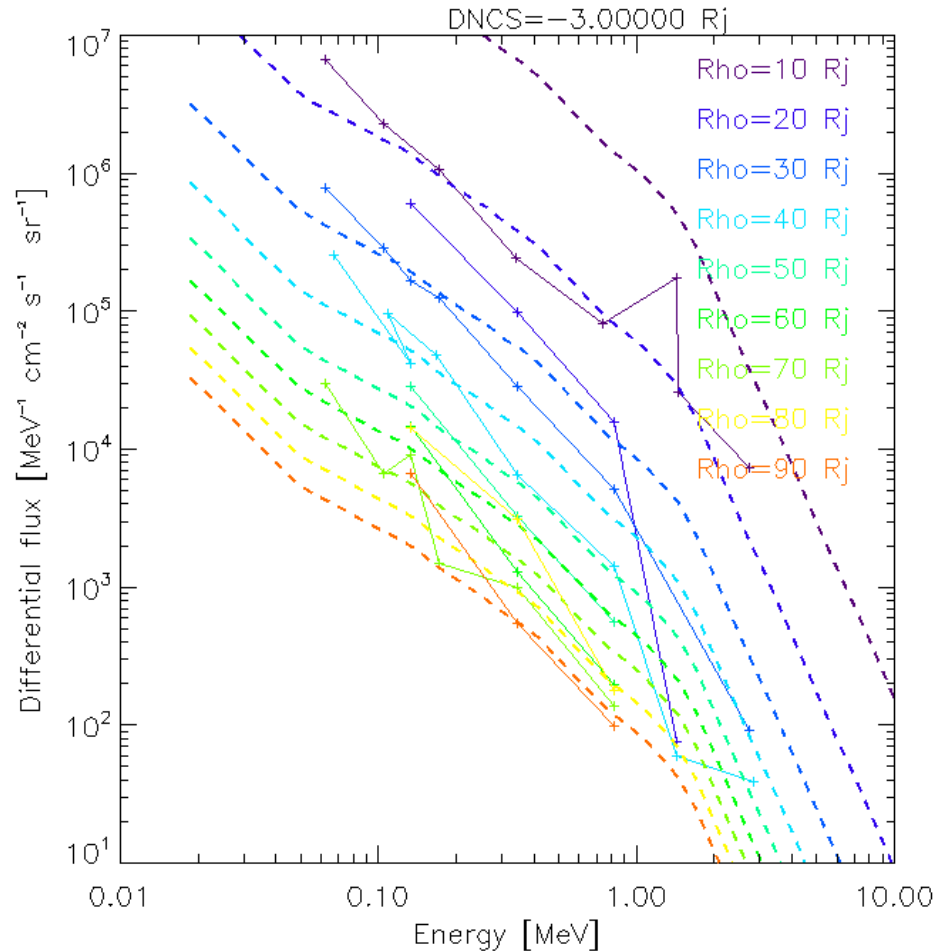


Data:solid line
JOSE:dashed line

JOSE model: Electron model development (ρ , ndcs) > 16 Rj

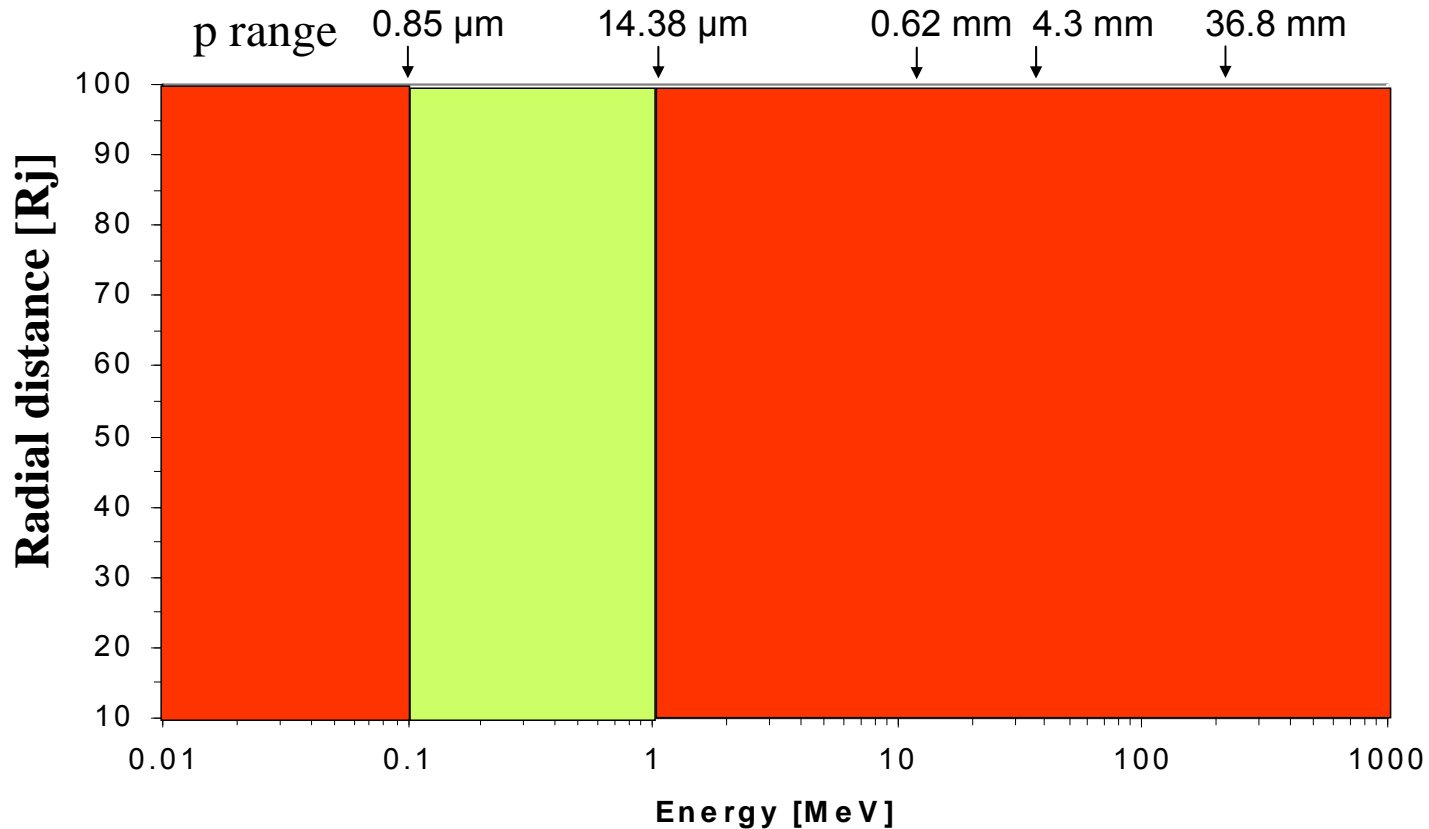
✓ Presentation of proton model

$\rho > 20$ Rj, outside magnetic equator



JOSE model: Region of validity of JOSE proton

✓ Energy coverage and region of validity of proton model



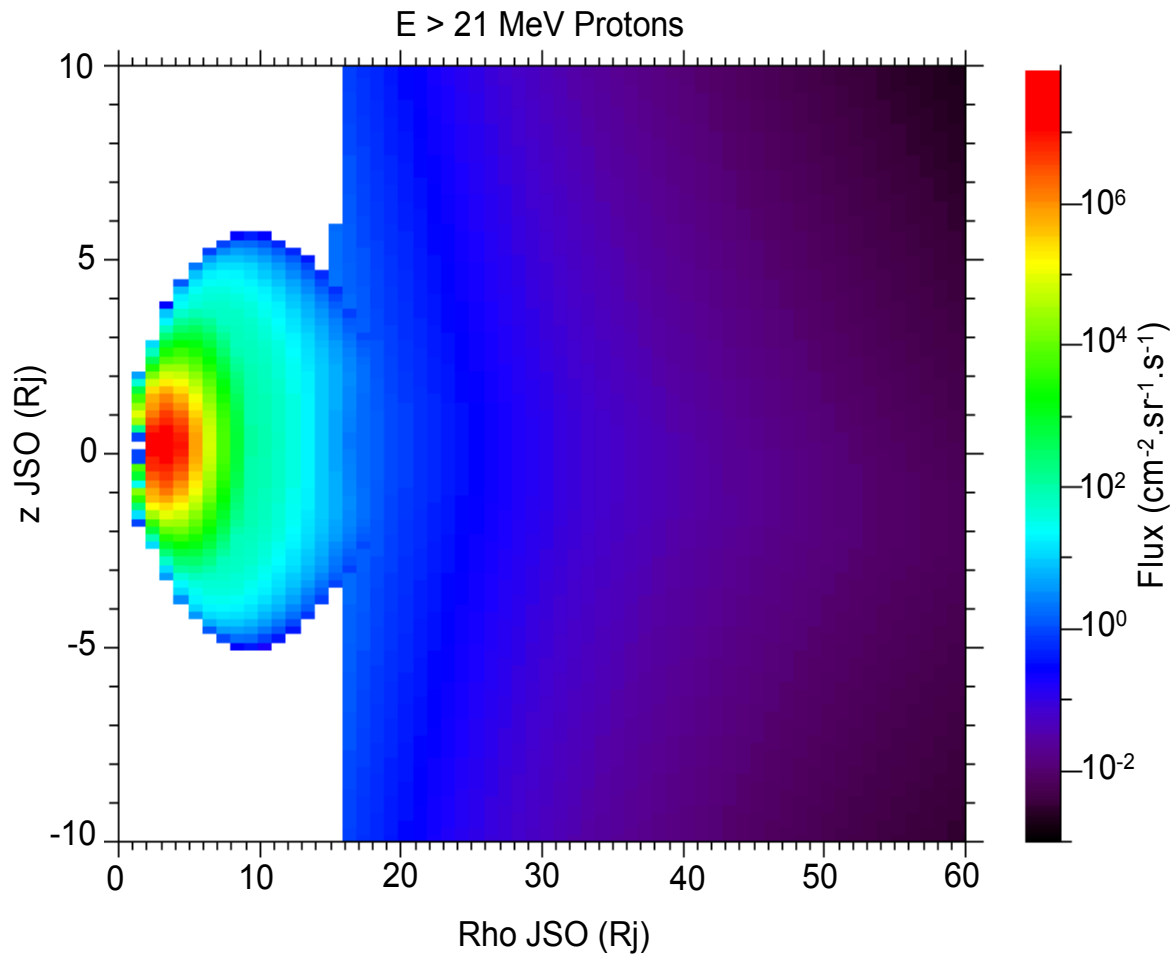
no constraints at all

poor constraints

good constraints

JOSE model: Proton model results

✓ Exemple of results



JOSE model: Inputs and outputs of the model

Fortran 90 source code:

INPUTS:

- **species** : 1-electron, 2-proton, 3-carbon, 4-oxygen, 5-sulphur
- **whatf** : 1-differential flux ($\text{MeV}^{-1} \cdot \text{cm}^{-2} \cdot \text{sr}^{-1} \cdot \text{s}^{-1}$), 3-integrated flux ($\text{cm}^{-2} \cdot \text{sr}^{-1} \cdot \text{s}^{-1}$)
- **sysaxesIN** : coordinate system used: -1-S3(1957)RH, 0-JDZ, 1-S3(1965)LH, 2-S3(1965)RH, 3-MAG, 4-RLL, 5-JSO, 6-JSM, 7-JSE
- **xIN** : cartesian coordinates (*array of (3,100000)*)
- **year** : year of the selected date (*array of 100000*)
- **doy** : day of year of the selected date (*array of 100000*)
- **UT** : seconds in the day of the selected date (*array of 100000*)
- **energy** : array of 25 energy values in MeV (for electron and proton) or MeV/Nuc (for other species)
- **byte_path** : path for the input files
- **strlen** : length of the byte_path variable
- **conflevel** : **confidence level** (*-1. for no confidence level and $0 < \text{conflevel} < 1$ otherwise*)

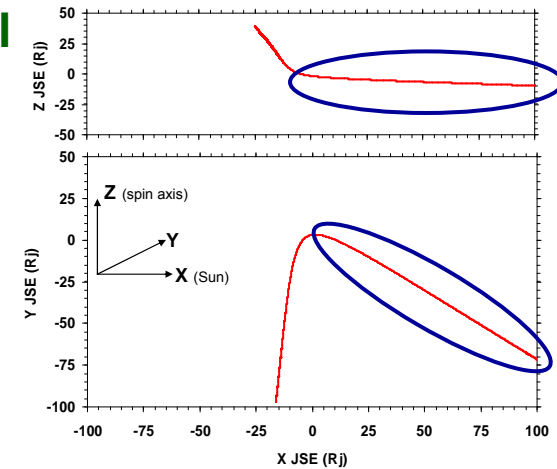
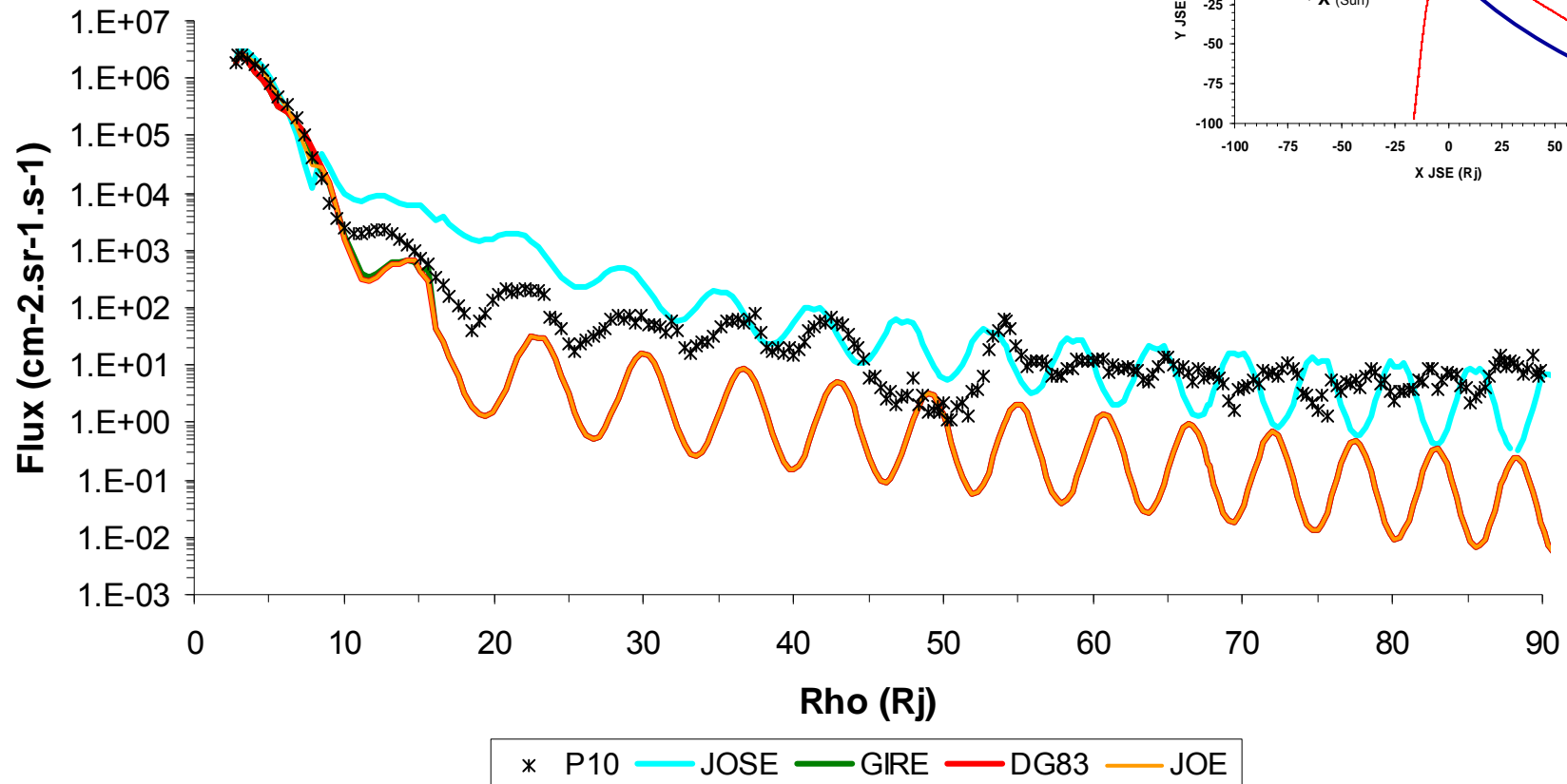
OUTPUTS:

- **flux** : Differential [$\text{cm}^{-2} \cdot \text{s}^{-1} \cdot \text{sr}^{-1} \cdot \text{MeV}^{-1}$] or integral [$\text{cm}^{-2} \cdot \text{sr}^{-1} \cdot \text{s}^{-1}$] flux for the specie and the energies selected (*array of (25,100000)*)
- **L** : L parameter (*array of 100000*)
- **B** : Magnetic field (nT) (*array of 100000*)

JOSE model: Comparison of JOSE with in-situ data

➤ Comparison of JOSE with P10 data and other model

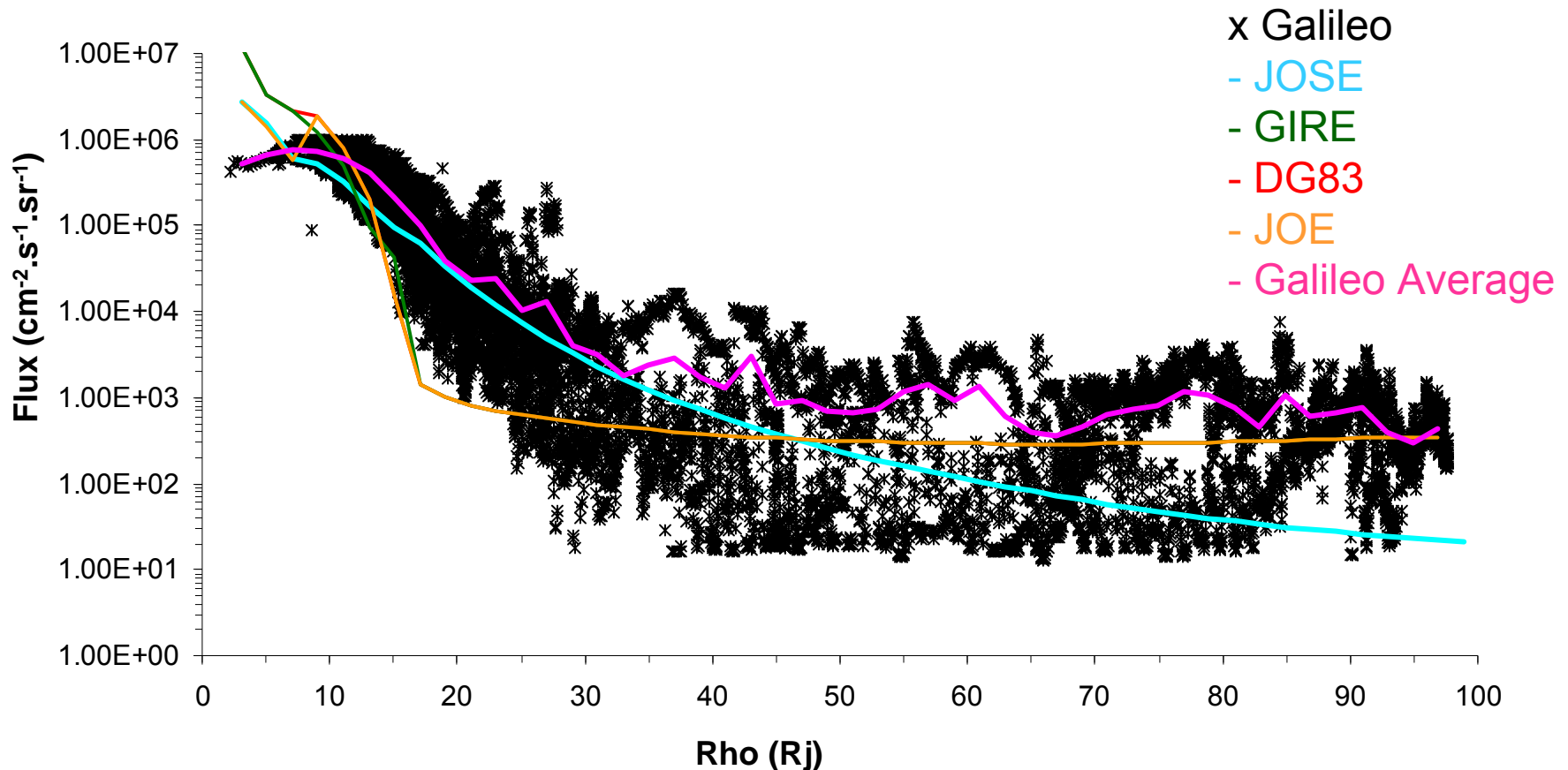
Electrons flux > 21 MeV
along the inbound trajectory of Pioneer 10



JOSE model: Comparison of JOSE with in-situ data

➤ Comparison of JOSE with Galileo Orbiter data and other model

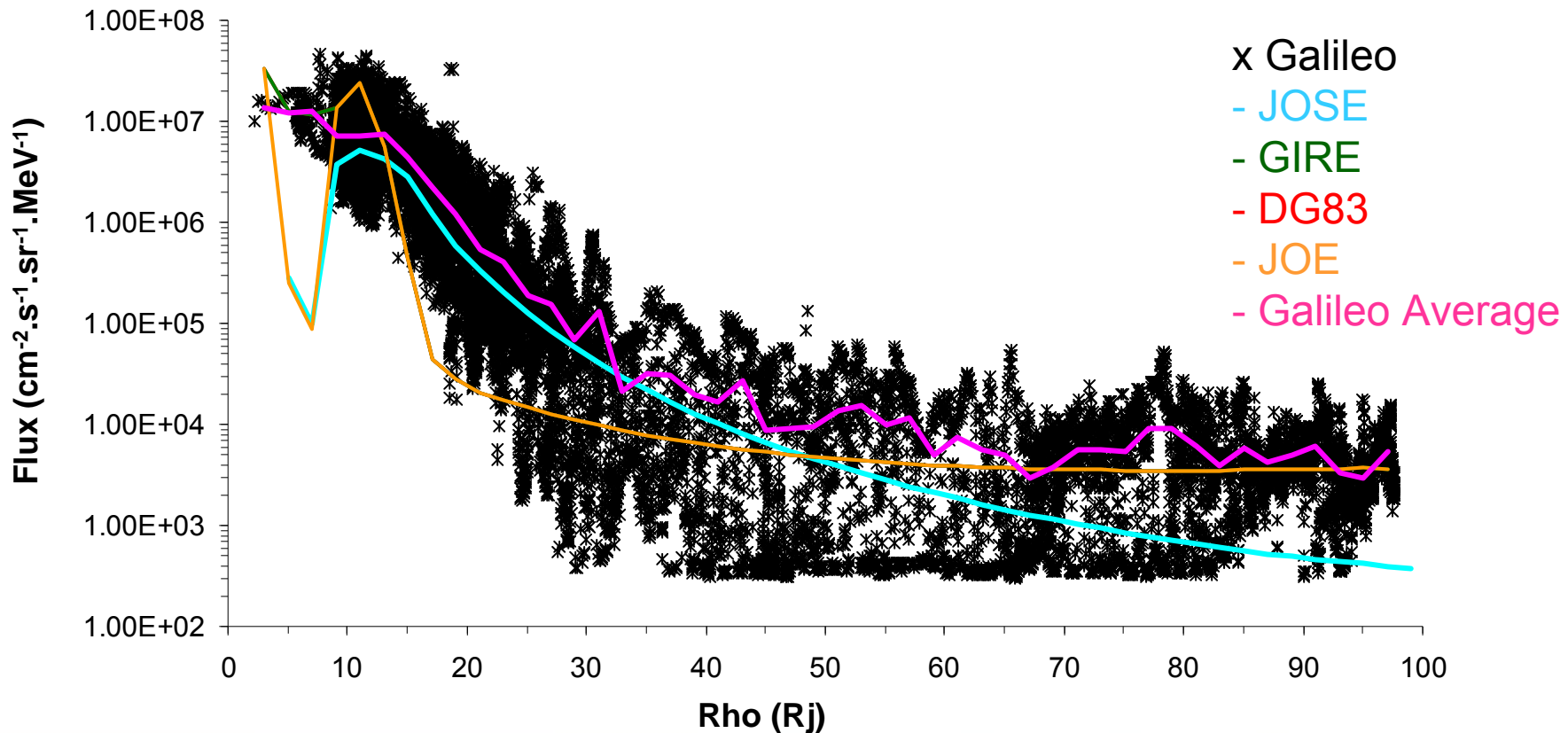
Electrons flux > 2 MeV at jovigraphic equator measured by Galileo and resulting from models



JOSE model: Comparison of JOSE with in-situ data

➤ Comparison of JOSE with Galileo Orbiter data and other model

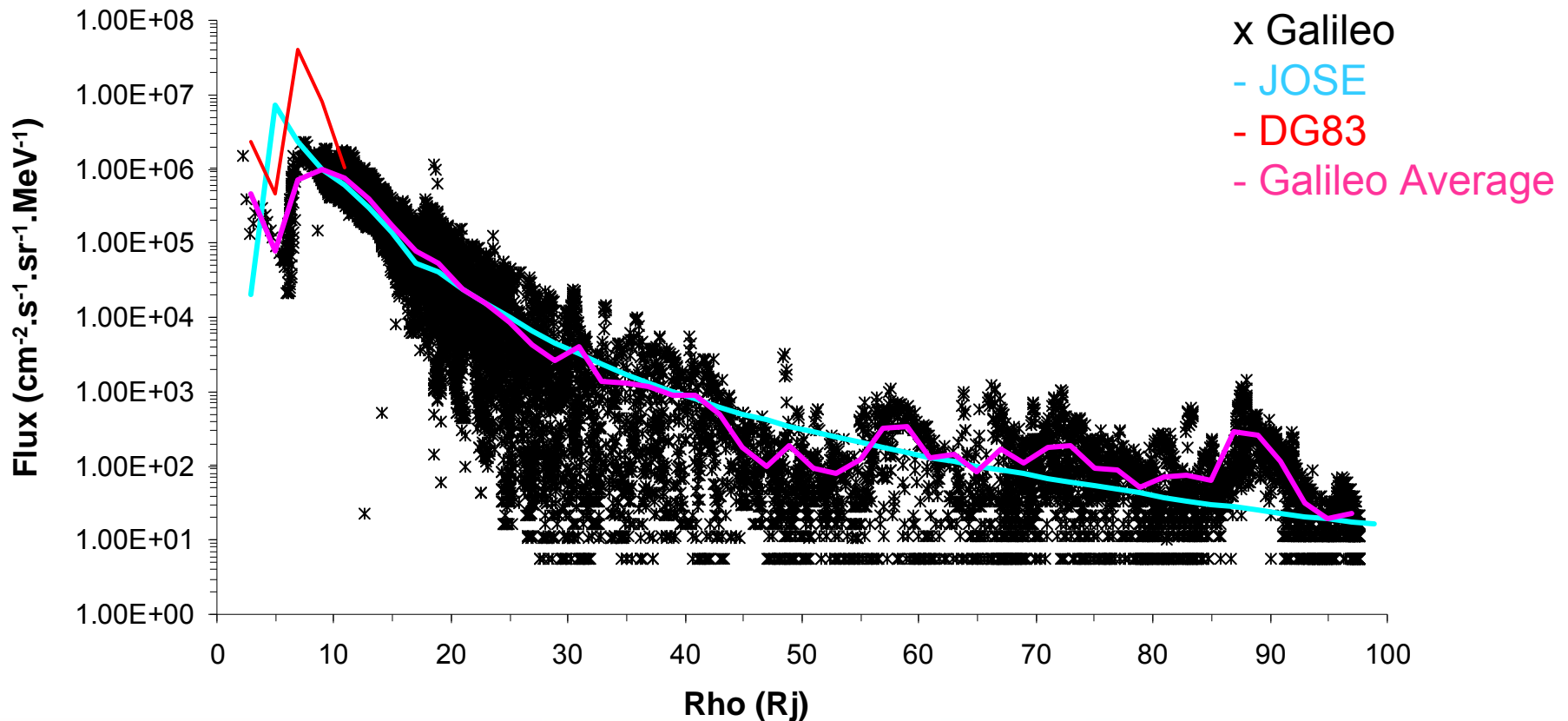
0.304-0.527 MeV **electrons** flux at jovigraphic equator measured by Galileo and resulting for models



JOSE model: Comparison of JOSE with in-situ data

➤ Comparison of JOSE with Galileo Orbiter data and other model

0.54-1.25 MeV **protons** flux at jovigraphic equator measured by Galileo and resulting from models



JOSE model: Confidence Level

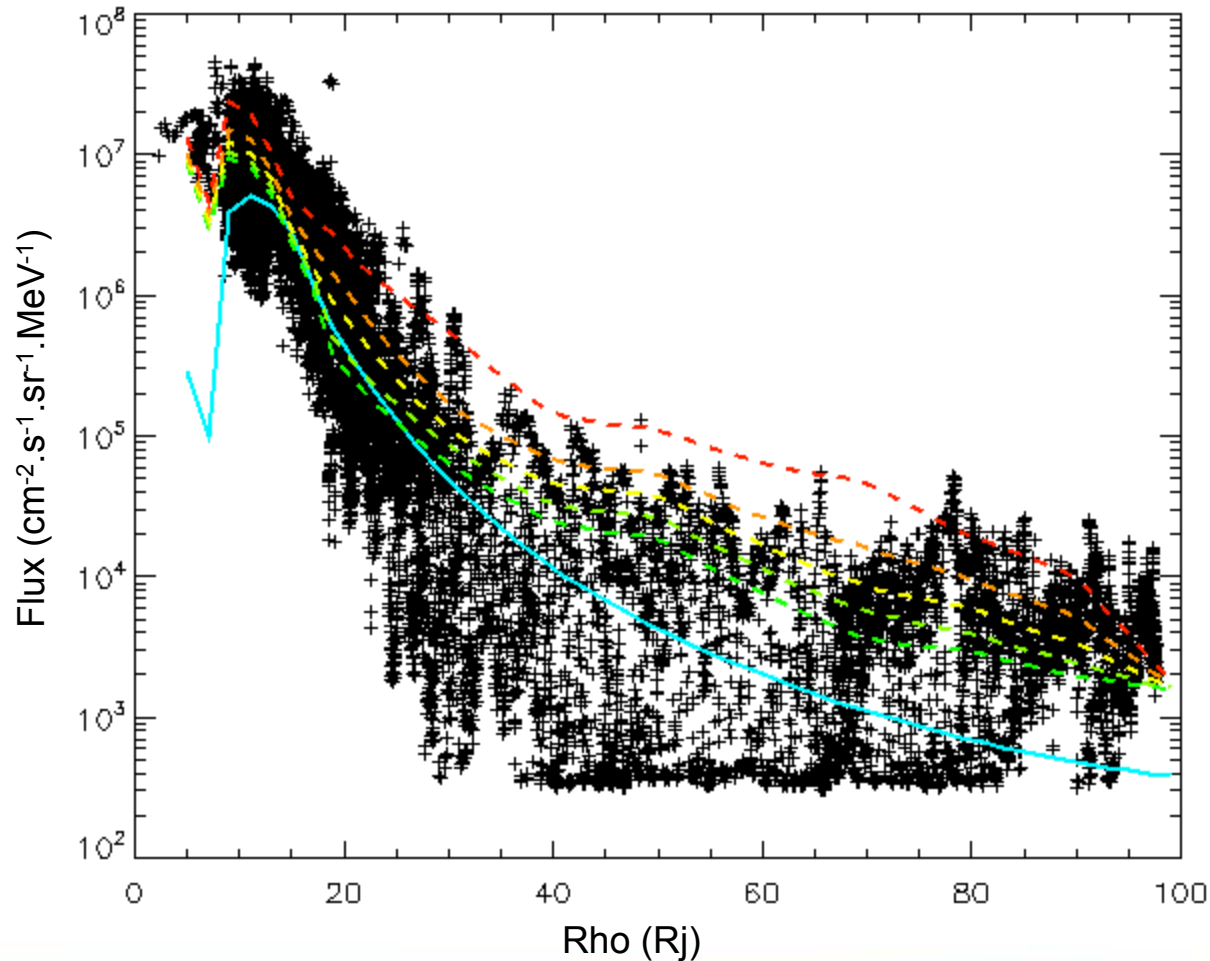
A refined model has been developed including confidence level.

- It uses JOSE average as a baseline (Energy, L, B/Beq profiles)
- It provides flux intensities for confidence levels between 0.5 and 0.9999
- It is mainly based on Galileo EPD data
- It is extrapolated for energies higher than the highest available in data base following JOSE averaged model profiles
- This model substantiate the JOSE average model and is a net improvement

JOSE model: Confidence Level

➤ Comparison with Galileo Electron 0.304-0.527 MeV

At jovigraphic equator ($-0.1 < z < 0.1 R_j$)

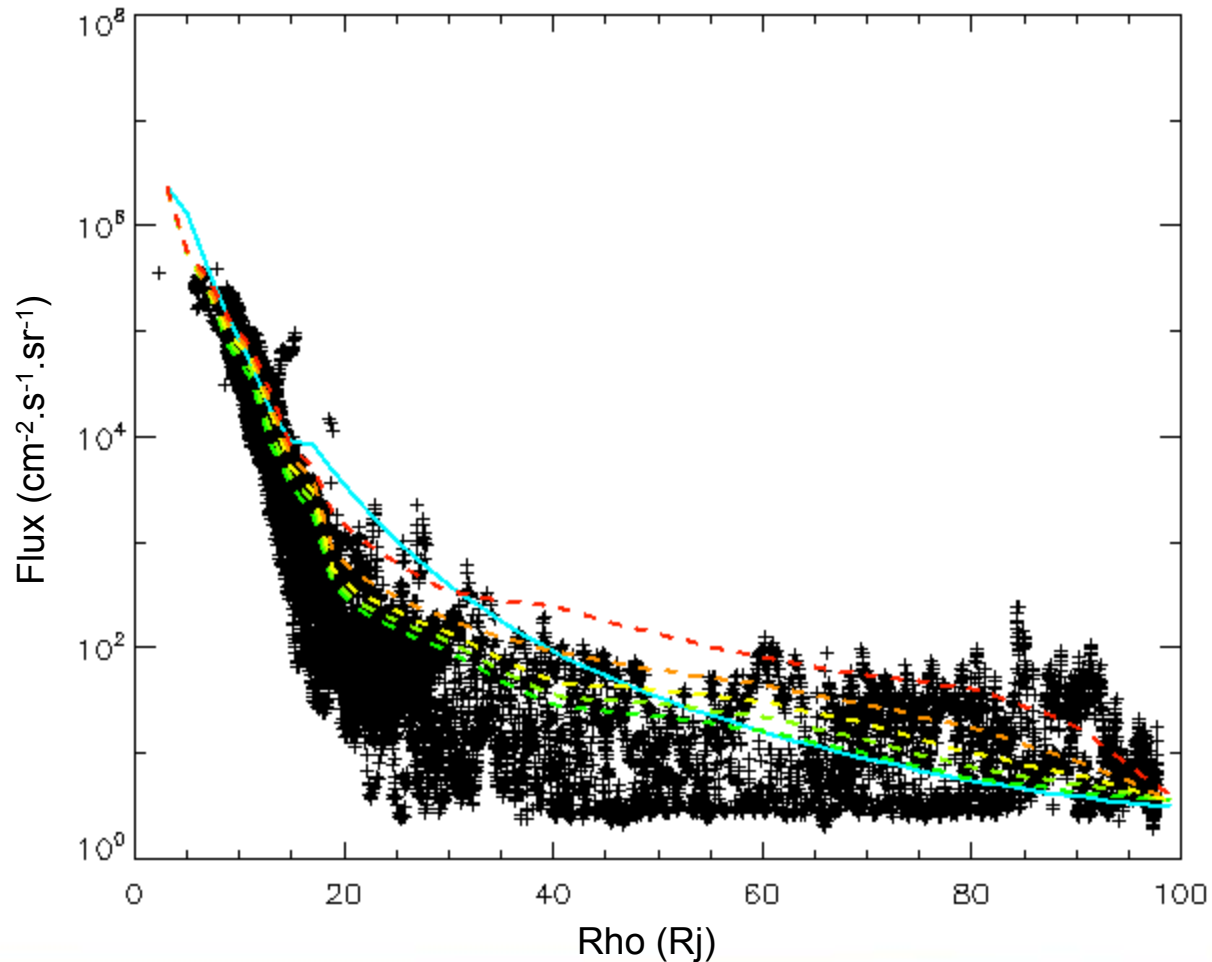


- x Galileo
- JOSE Average
- Conf level 0.8
- Conf level 0.85
- Conf level 0.9
- Conf level 0.95
- Conf level 0.99

JOSE model: Confidence Level

➤ Comparison with Galileo Electron >11 MeV

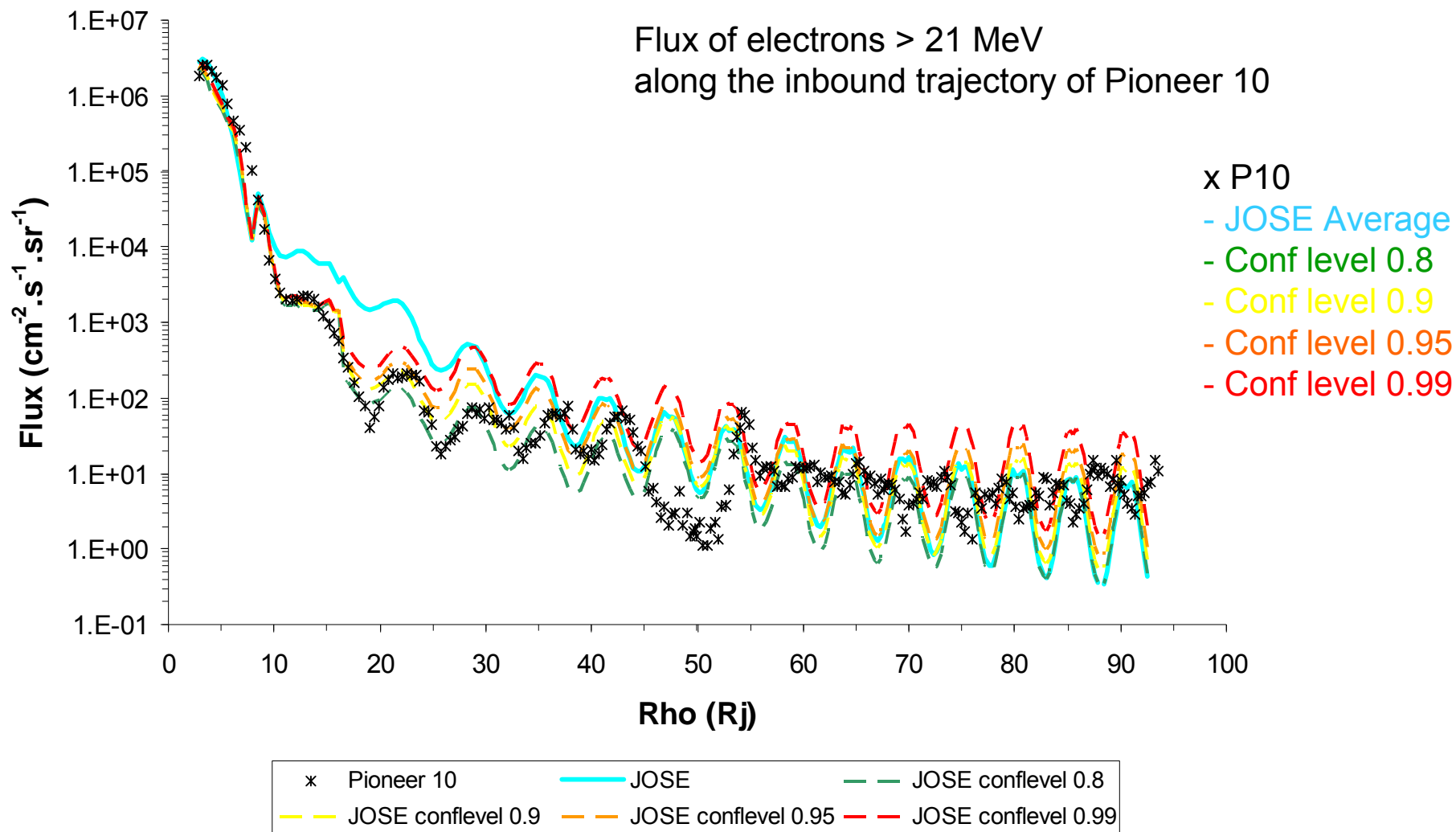
At jovigraphic equator ($-0.1 < z < 0.1 R_J$)



- x Galileo
- JOSE Average
- Conf level 0.8
- Conf level 0.85
- Conf level 0.9
- Conf level 0.95
- Conf level 0.99

JOSE model: Confidence Level

➤ Comparison with Pioneer 10 Electron >21 MeV



Conclusions

- A new Jovian radiation environment has been developed under ESA fundings part of the JOREM study
- The model provides outputs for any confidence levels (for risk assesment analysis)
- The JOSE model including confidence levels exhibits good comparisons with in-situ data for a confidence level of 0.85