

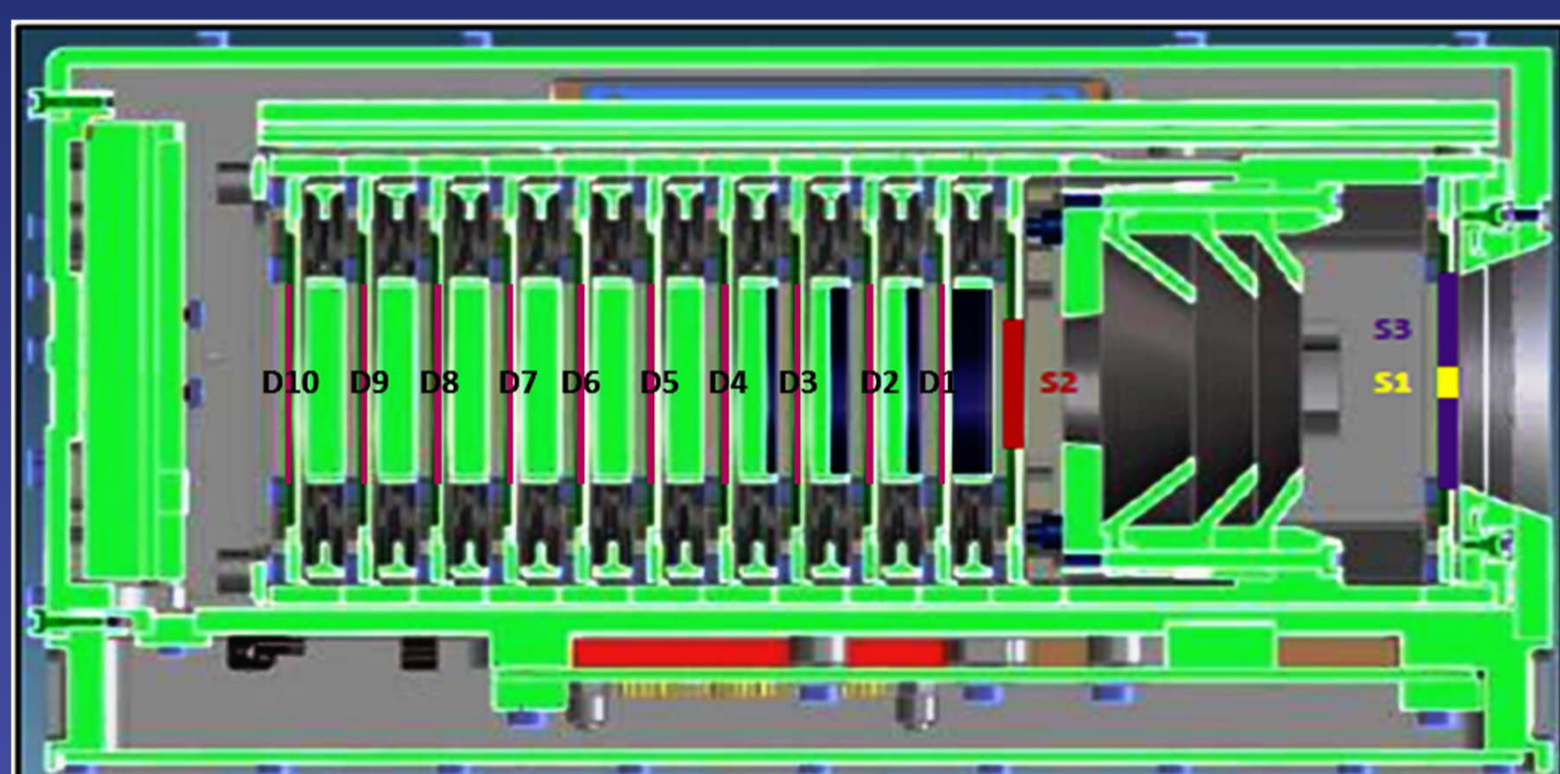
# The Proba-V/EPT data products within the ESA-SSA Space Weather Services.

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## 1. Introduction

The EPT is a modular, low mass (4.6 kg), low power (5.6 W), compact (211 x 162 x 128 mm<sup>3</sup>) charged particle spectrometer, designed to perform high-fidelity space radiation flux measurements [1]. EPT was launched on May 7<sup>th</sup>, 2013 on-board PROBA-V on a polar LEO at 820 km altitude where it measures fluxes of electrons, protons and  $\alpha$ -particles.



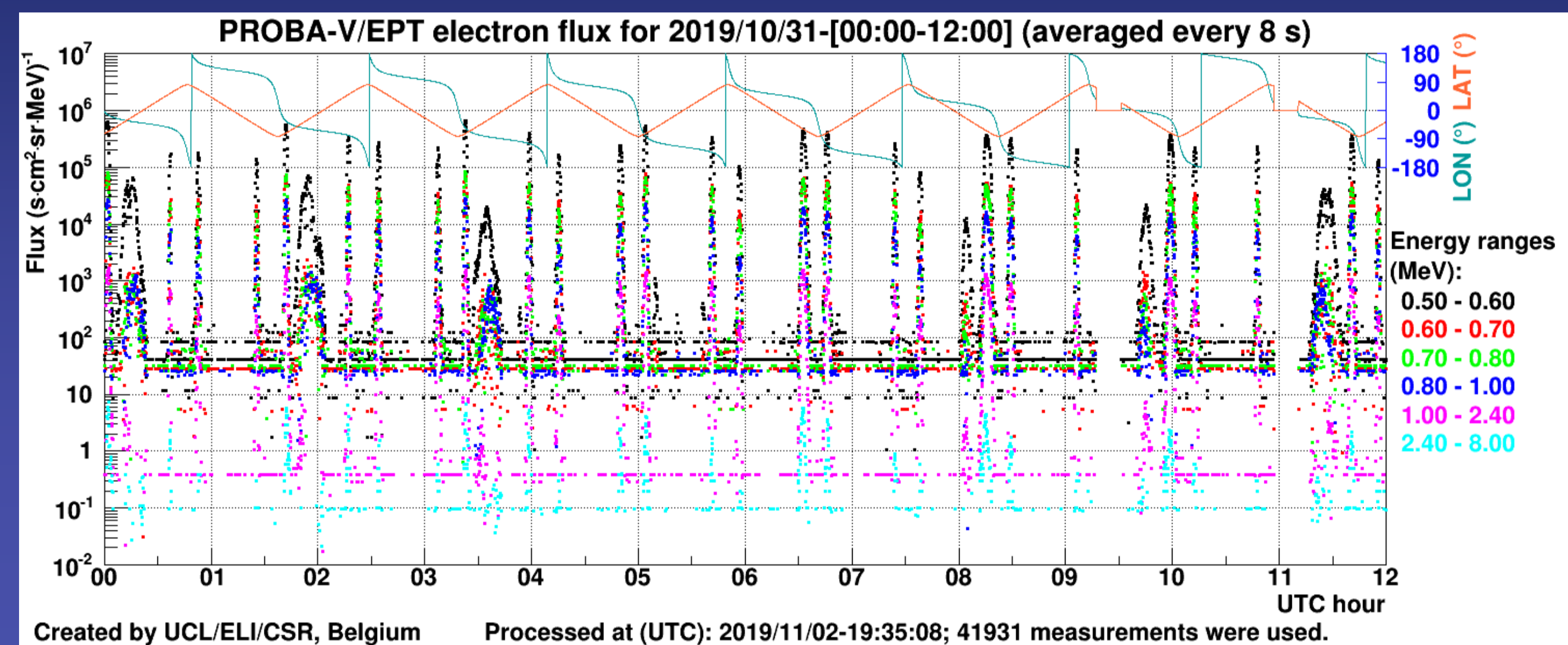
Cross section view of the EPT: the S1, S2 and S3 analog sensors as well as the 10 DAM detectors are highlighted.

| VC | Electrons | Protons | He-ions |
|----|-----------|---------|---------|
| 1  | 0.5-0.6   | 9.5-13  | 38-51   |
| 2  | 0.6-0.7   | 13-29   | 51-116  |
| 3  | 0.7-0.8   | 29-61   | 116-245 |
| 4  | 0.8-1.0   | 61-92   | 245-365 |
| 5  | 1.0-2.0   | 92-126  | 365-500 |
| 6  | 2.0-8.0   | 126-155 | 500-615 |
| 7  | 8.0-20    | 155-182 | 615-720 |
| 8  |           | 182-205 | 720-815 |
| 9  |           | 205-227 | 815-900 |
| 10 |           | 227-248 | 900-980 |
| 11 |           | >248    | >980    |

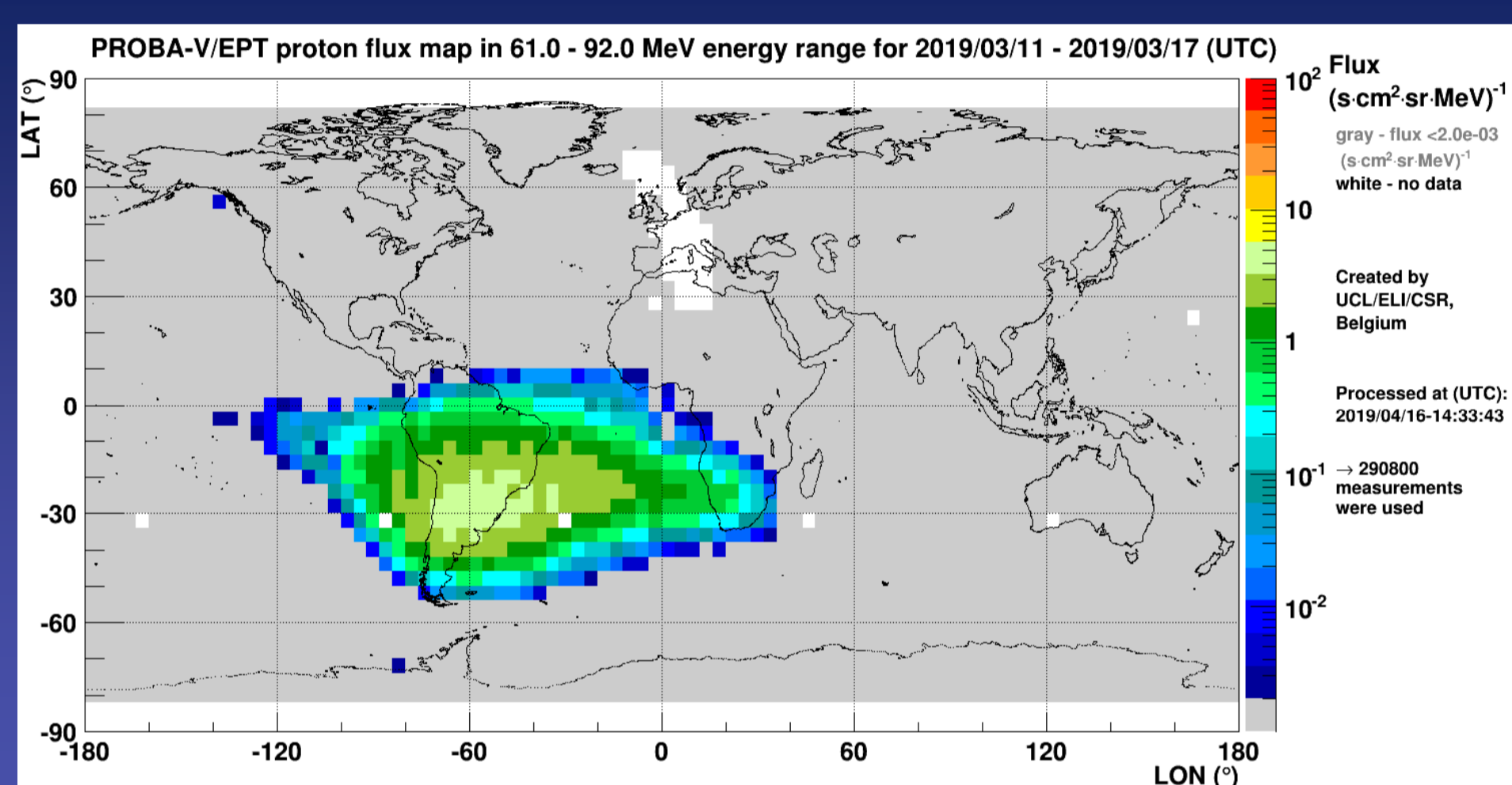
## 2. Data Products

Within the ESA – SSA Space Weather programme (SSA – SWE – P2 and – P3), the UCLouvain - CSR, acting as an Expert Group within the “Expert Service Centre (ESC) – Radiation”, has delivered the following data products for electrons, protons and helium (**Available at <http://swe.ssa.esa.int/space-radiation>**):

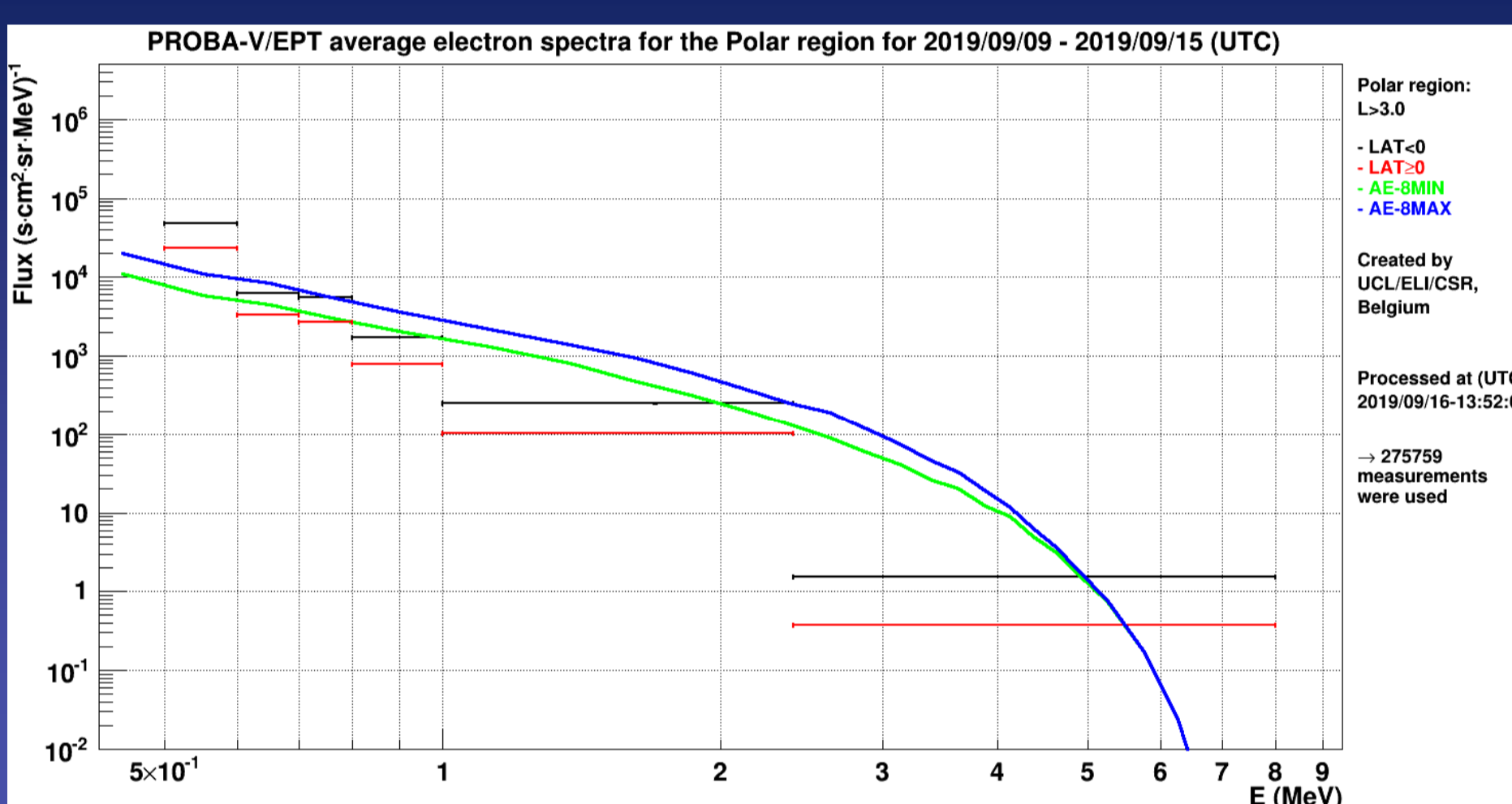
- Daily flux time-series along the orbit at 2s step (mainly).



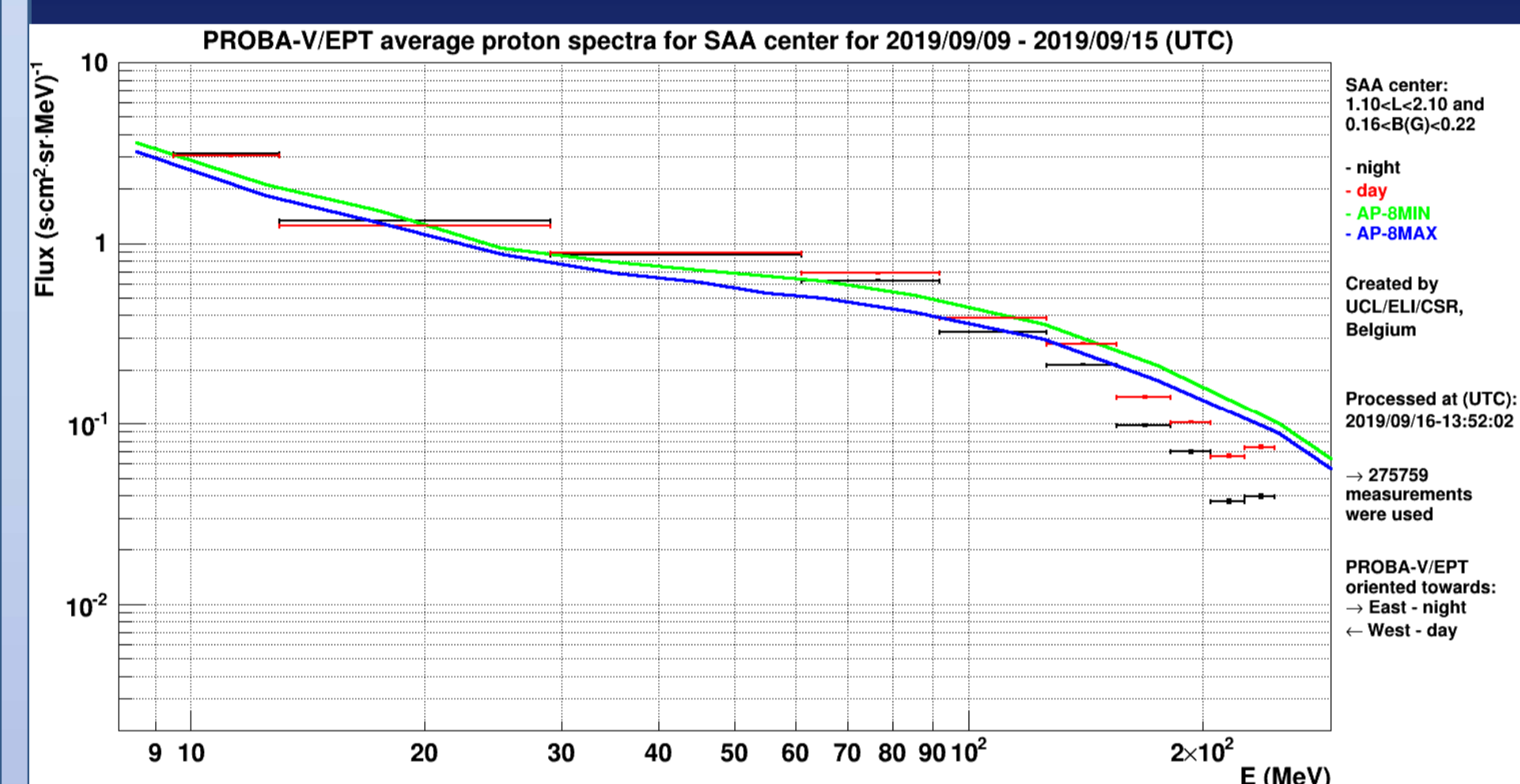
- Weekly averaged flux maps on regular geographical grid with 4° step.



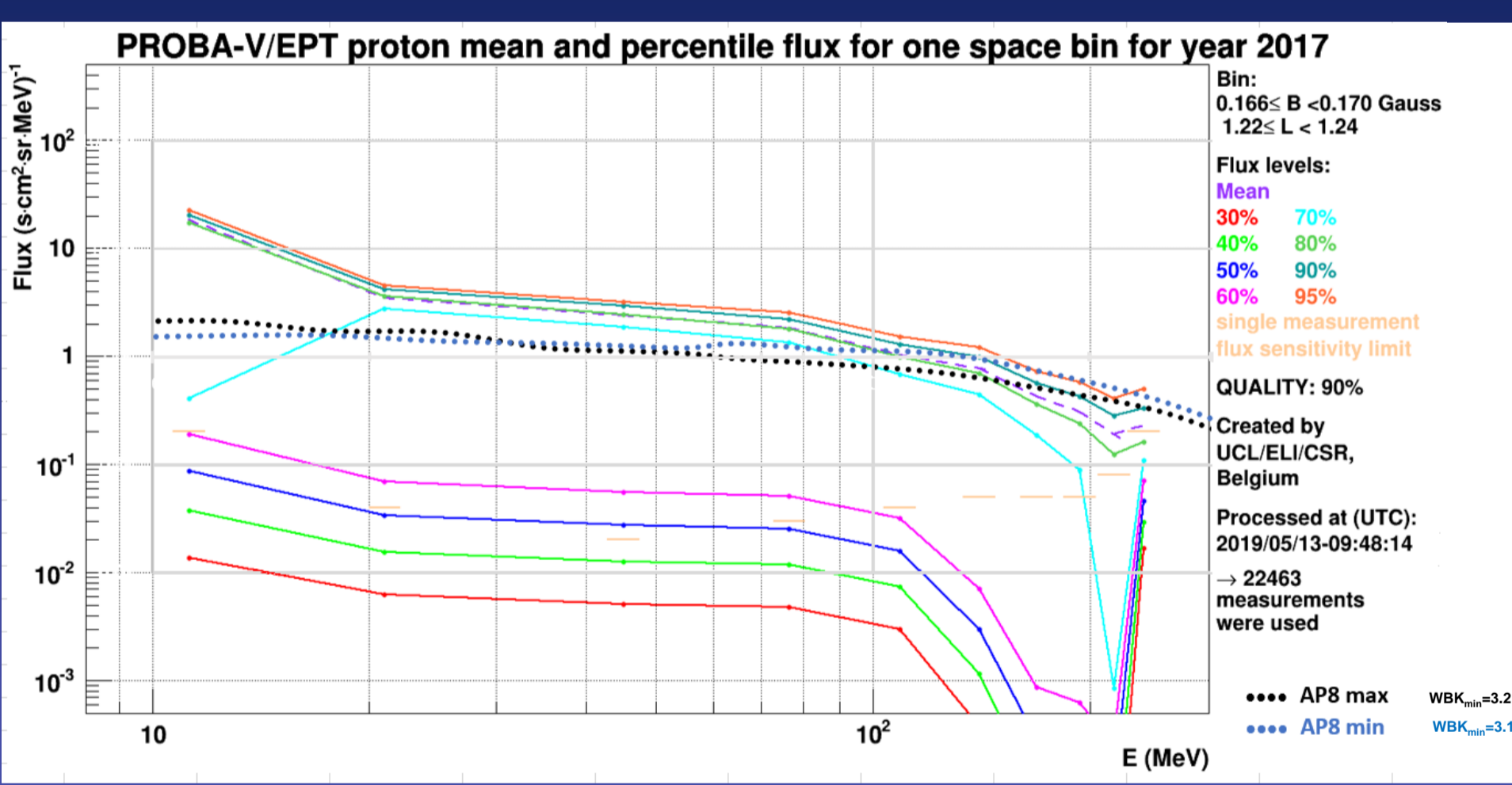
- Weekly averaged auroral electron energy spectra (>3)



- Weekly averaged SAA (1.1<L<2.1 and 0.16<B(G)<0.22) proton and helium energy spectra;

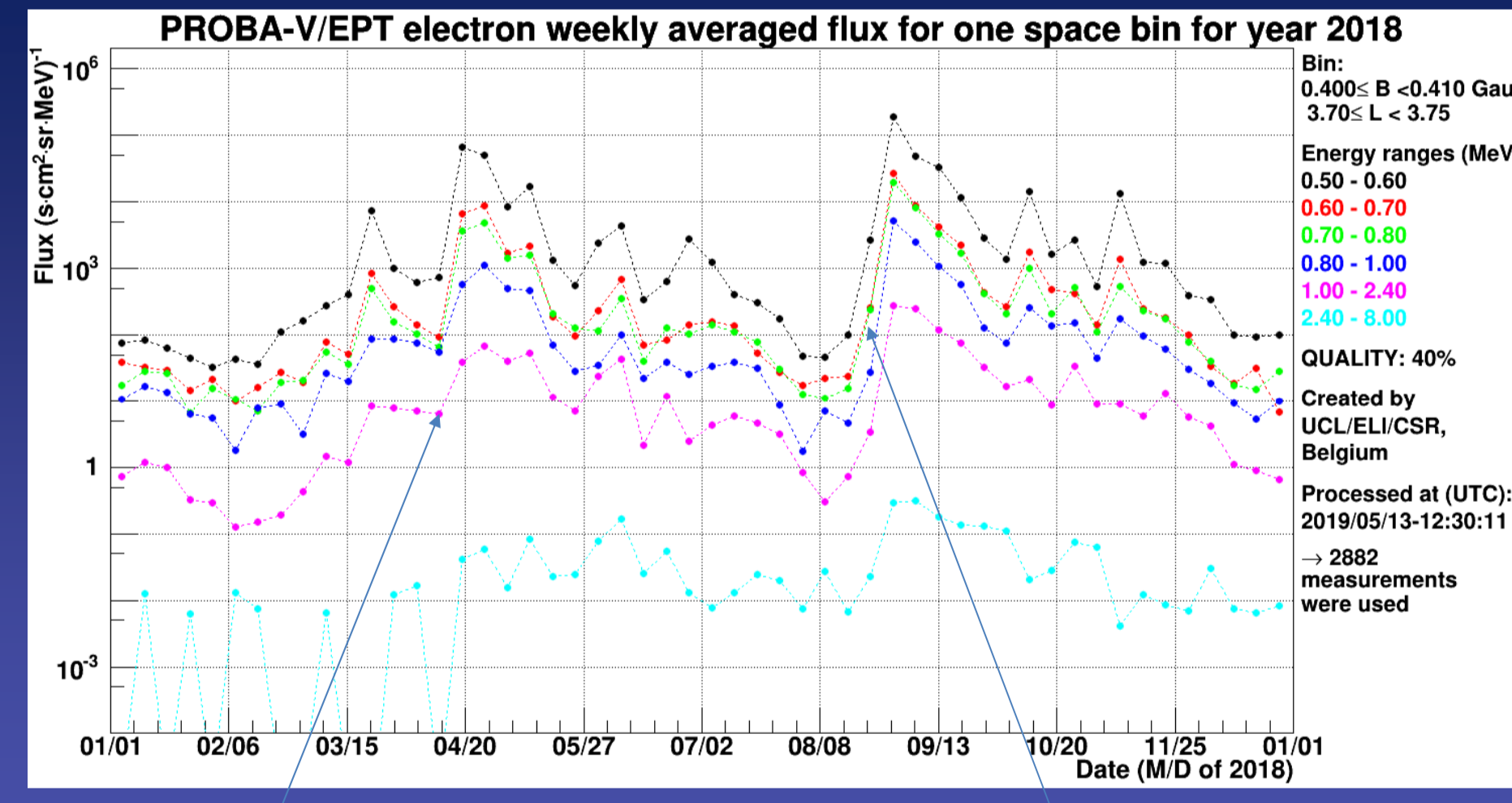


- Yearly static radiation model of the three energetic particles, ...



Coming soon!

...including flux time series on a regular B-L grid (L2)



Coming soon!

## 3. Caveats

| EPT Life                |                                      |
|-------------------------|--------------------------------------|
| Time Period             | Phase                                |
| 2013/05/13              | Launch                               |
| 2013/05/21 – 2013/06/23 | Commissioning Phase                  |
| 2013/06/24 – 2014/06/27 | Nominal Period                       |
| 2014/06/28 – 2014/07/30 | Calibration Period                   |
| 2014/07/31 – 2014/09/14 | Test Period                          |
| 2014/09/15 – 2014/11/13 | Electron channel refinement (<1 MeV) |
| 2014/11/14 – now        | Recovered Period                     |

**For the Nominal Period:**

Very rare saturation in electron channels in high flux region (outer radiation belts).

Agreement between proton flux data of EPT, GOES-15 and SREM during SEP and between proton spectrum measured by the EPT and VAP/RPS in the SAA [2].

Prompt noise increase and gain loss on front sensors S1 and especially S3

**For the Recovered Period:**

The data starting on 15 September 2014 should be used with care. They are good for study of dynamics in the outer belt but precautions should be taken when drawing conclusions regarding absolute flux values.

Issues:

Protons in SAA:

- ♣ For E>92 MeV, fluxes within 20% (renormalization)
- ♣ For E<92 MeV: FOV deterioration
- ♣ For all E: flux underestimation under extreme conditions (increased electron flux inducing count rate decrease in S3: super pile-up)

Auroral protons during SEP:

- ♣ For E<92 MeV: strong flux underestimation
- ♣ Electron contamination in proton channel 2 [13-29 MeV] and 3 [29-61 MeV] for 3<L<5 when electron fluxes >1 MeV are high (estimation > 2·10<sup>3</sup> #/cm<sup>2</sup>/s/sr)

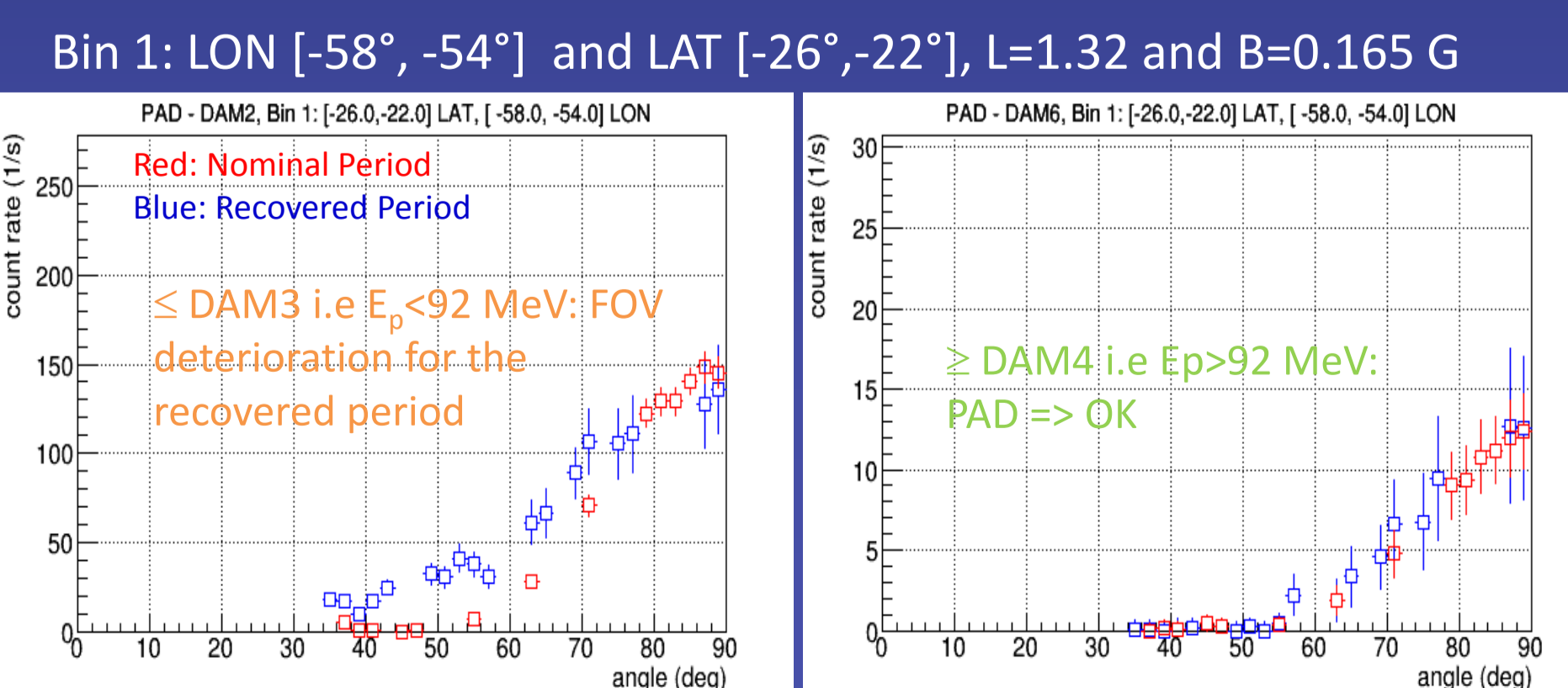
Electron in the SAA:

- ♣ Electron fluxes acquired at 1.3<L<1.8 and B<0.185 G is suspected to be affected by pile-up for which it will not be corrected (issue observed also during nominal period).

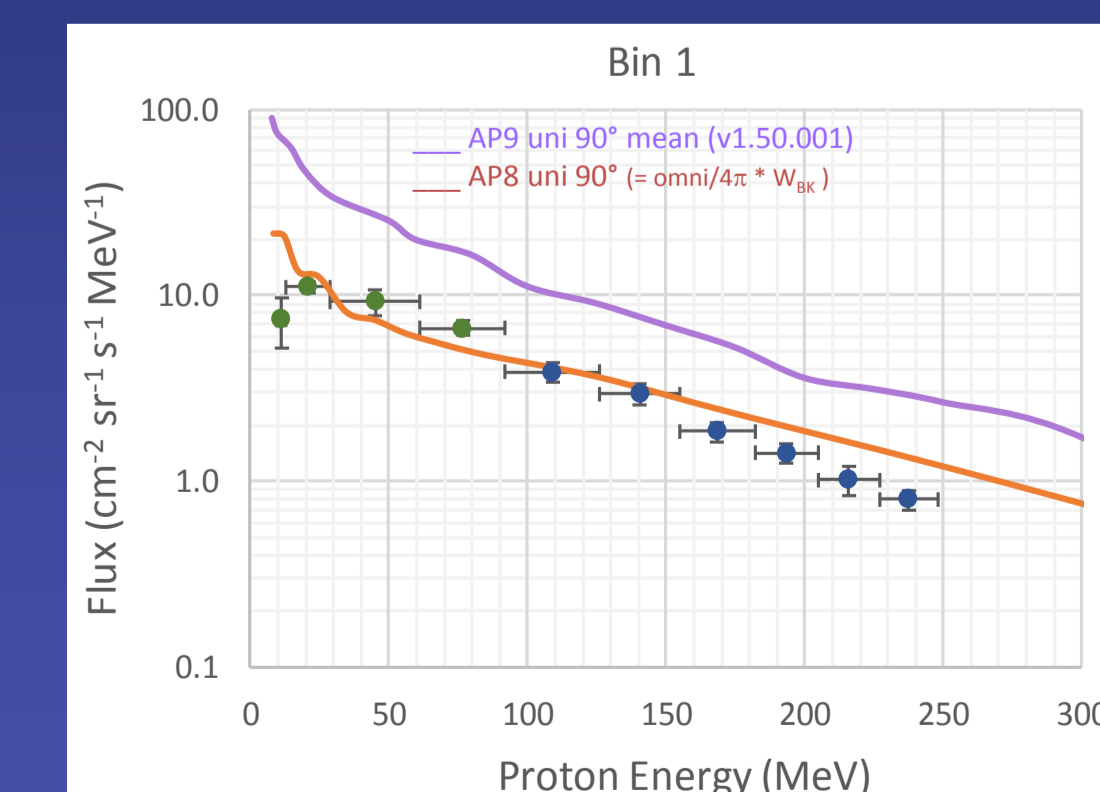
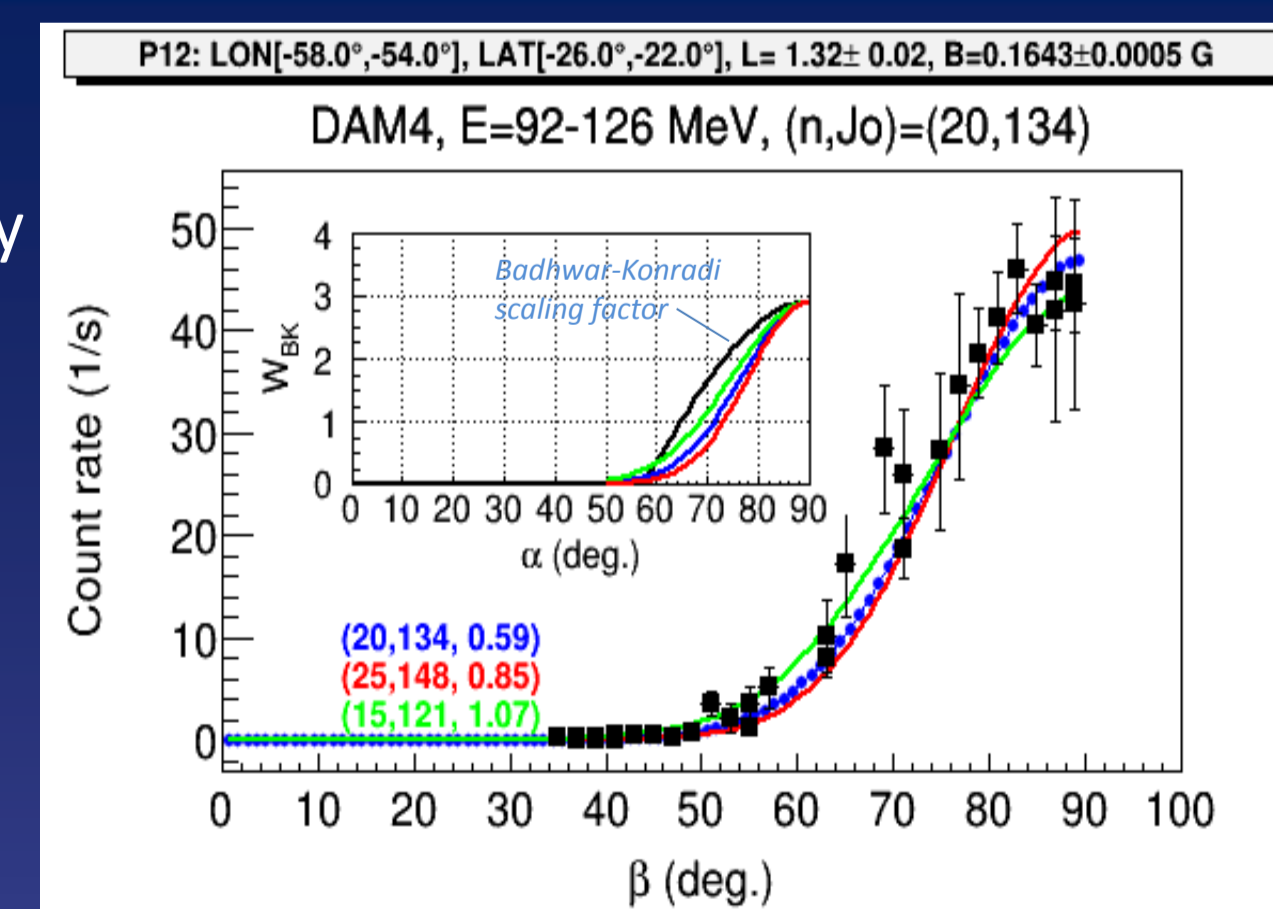
Solutions (included in the new data set (release 2020/01):

- ♣ use of S1-based data for p channel 9.5-13 MeV in SAA
  - ♣ use of S1-based data for p channel 9.5-13, 13-29, 29-61, 61-92 MeV for L>3 regions
  - ♣ Renormalisation by x1.22 for all p channels when S1+S3 data used
  - ♣ Correction of proton data for “super pile-up” in S3
  - ♣ Include new filtering algorithm: !!! new flag system
- Also, it is suggested to use only data with Chi2<2 which guarantees that the observations are compatible with the efficiency matrix used. This is mandatory for electron data.

## 4. Proton pitch angle distributions



Fit of the data with simulated efficiency matrices to find anisotropy factor n and flux at 90° J<sub>0</sub>:  
 $J(\alpha) = J_0 \sin^n(\alpha)$



Comparison with AP9 and AP8:  
The discrepancy with AP9 comes from the overestimation of the AP9 omnidirectional flux.

## 5. Future actions

- Release of updated data set with the best filtering and correction techniques applied (January 2020).

### References

- Cyamukungu et al., The Energetic Particle Telescope (EPT) on Board PROBA-V: Description of a New Science-Class Instrument for Particle Detection in Space, IEEE TNS, vol. 61 Issue: 6, pp3667-3681, 2014.
- Borisov et al., Angular Distribution of Protons Measured by the Energetic Particle Telescope on PROBA-V, IEEE TNS, vol. 61 Issue: 6, pp3371-3379, 2014
- Benck et al., Characterization of Solar Energetic H and He Spectra Measured by the Energetic Particle Telescope (EPT) On-Board PROBA-V During the January 2014 SEP Event, IEEE TNS, vol. 63, issue 6, pp2941-2949, 2016

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