SEP Identification Algorithm on AMS low latency data

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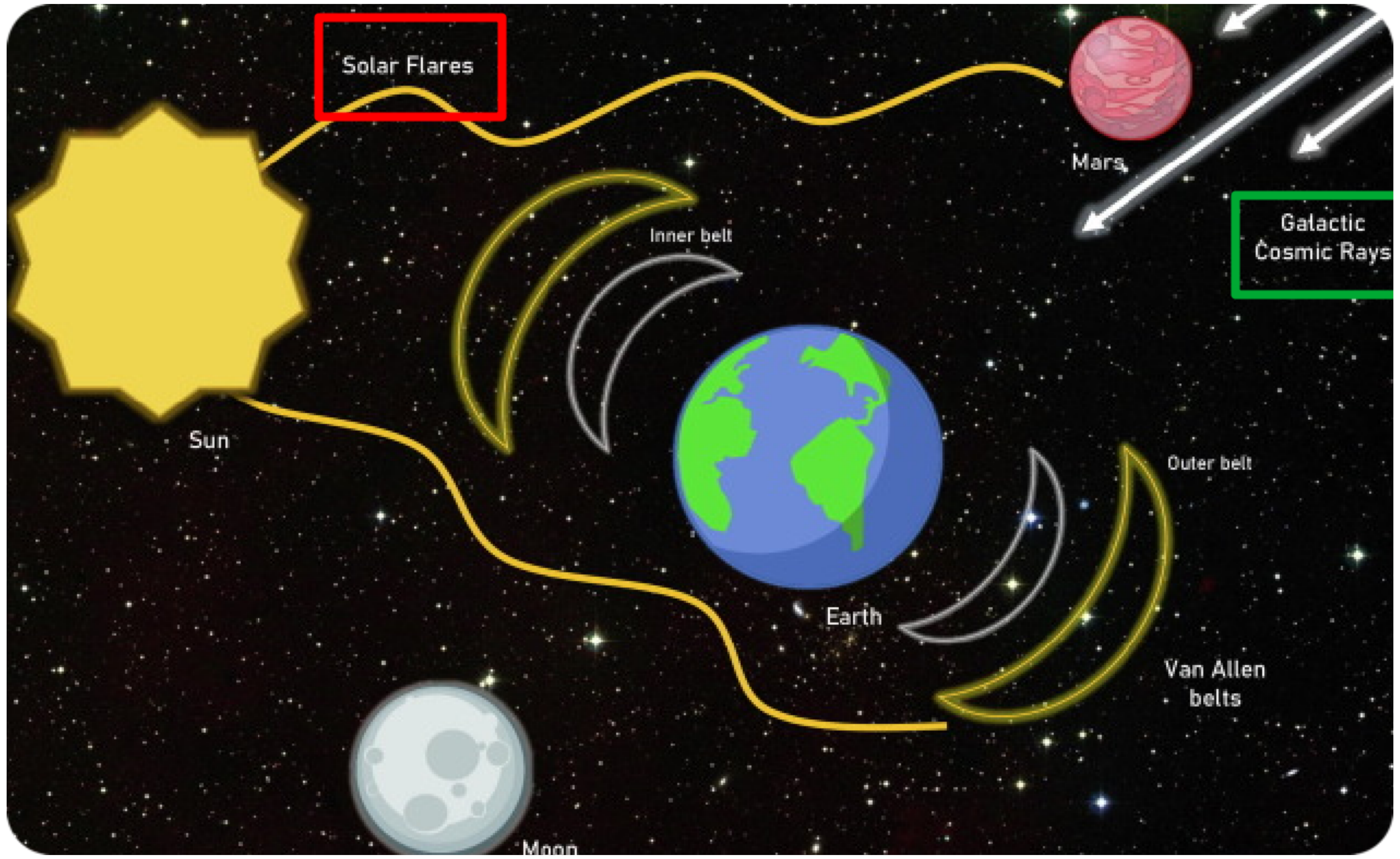
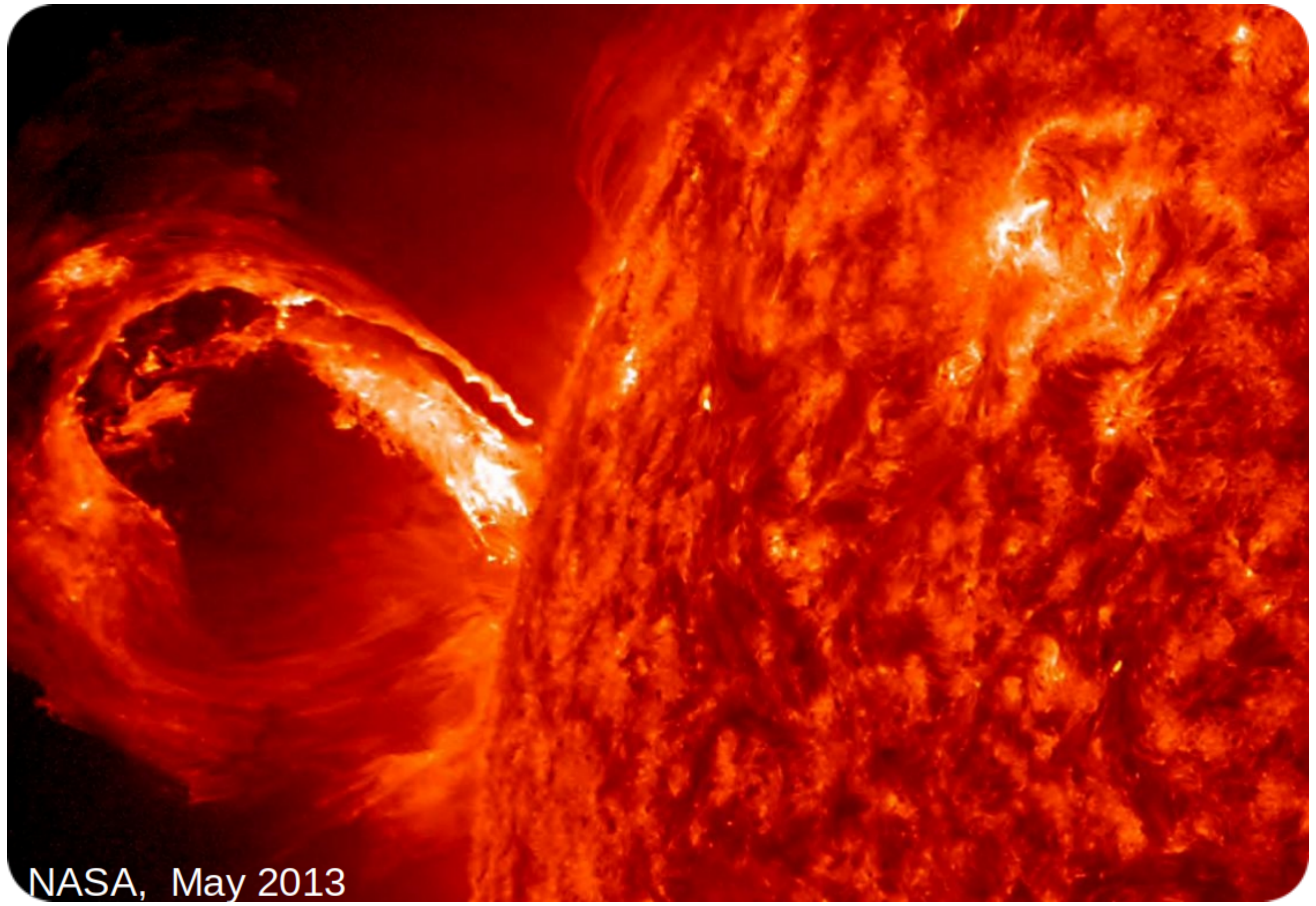
SOLAR ACTIVITY AND SPACE WEATHER

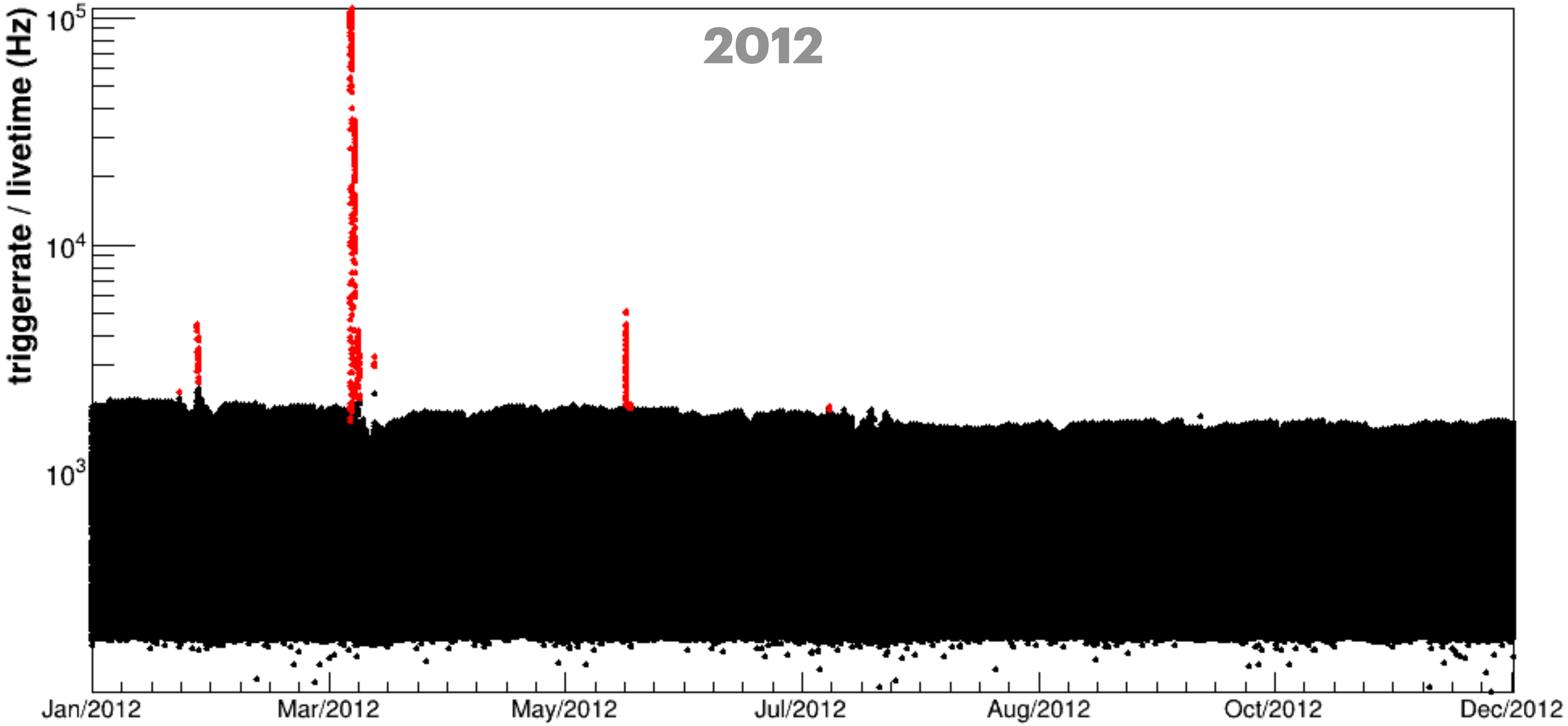
- The solar **activity cycle** has a period of 11 years, alternating between solar **minimum** and **maximum**.
- On the Sun's surface **occasional** and **short duration** phenomena take place: **solar flares** and **CMEs**.
- **Solar Energetic Particles (SEPs)** can be emitted in these events.
- **Space Weather** studies the effects of solar phenomena and their interactions with the environment.





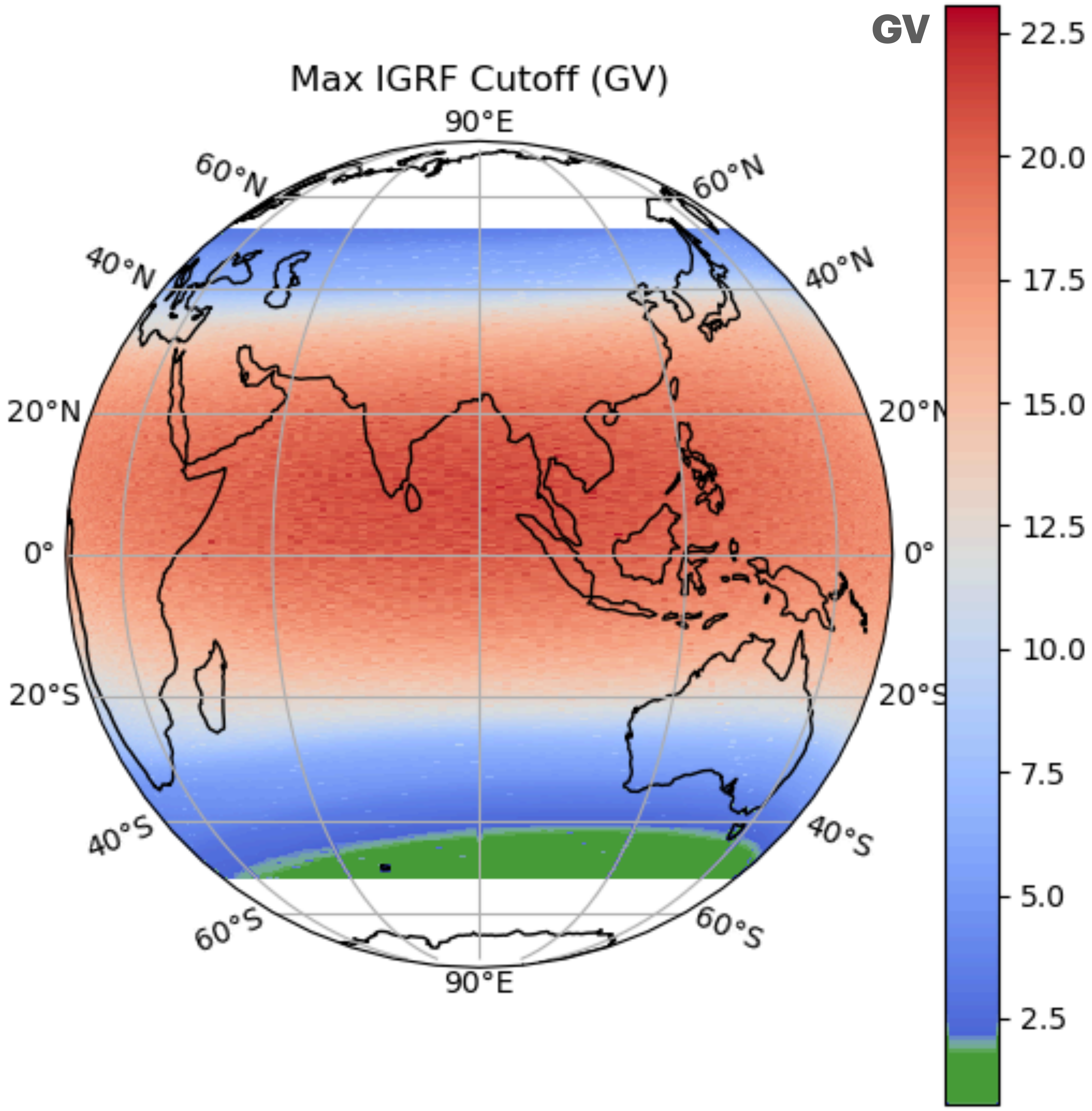
SPACE WEATHER WITH AMS

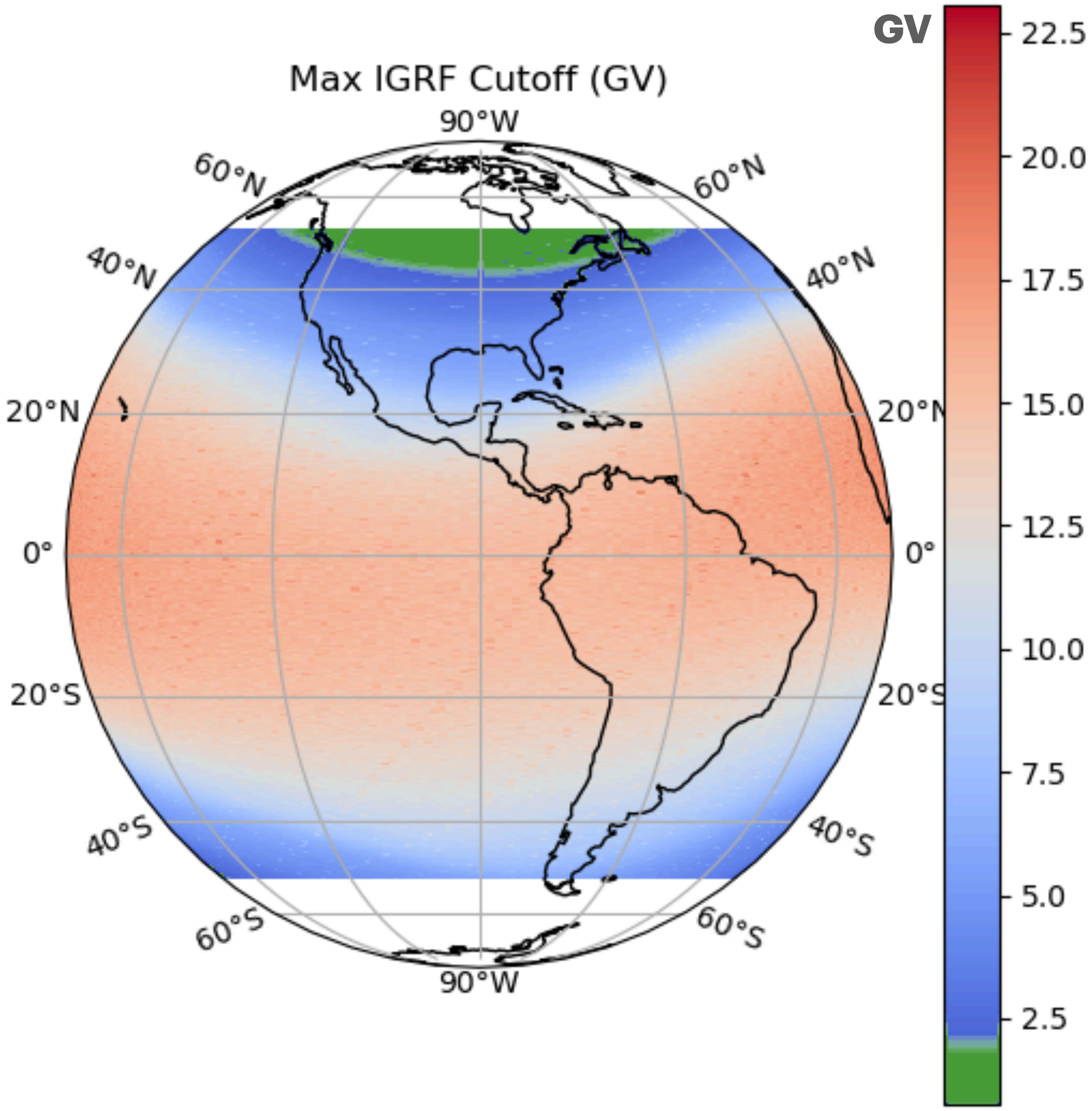
- The **SEP Identification Algorithm**, based on AMS **low latency data**, could be used to monitor in **real time** the ionizing radiation conditions outside the ISS.
- Each **data point** is the average **trigger rate in one minute**, normalized by the livetime.
- **Red data points** correspond to **SEP intervals**, according to the algorithm.



THE IGRF GEOMAGNETIC RIGIDITY CUTOFF

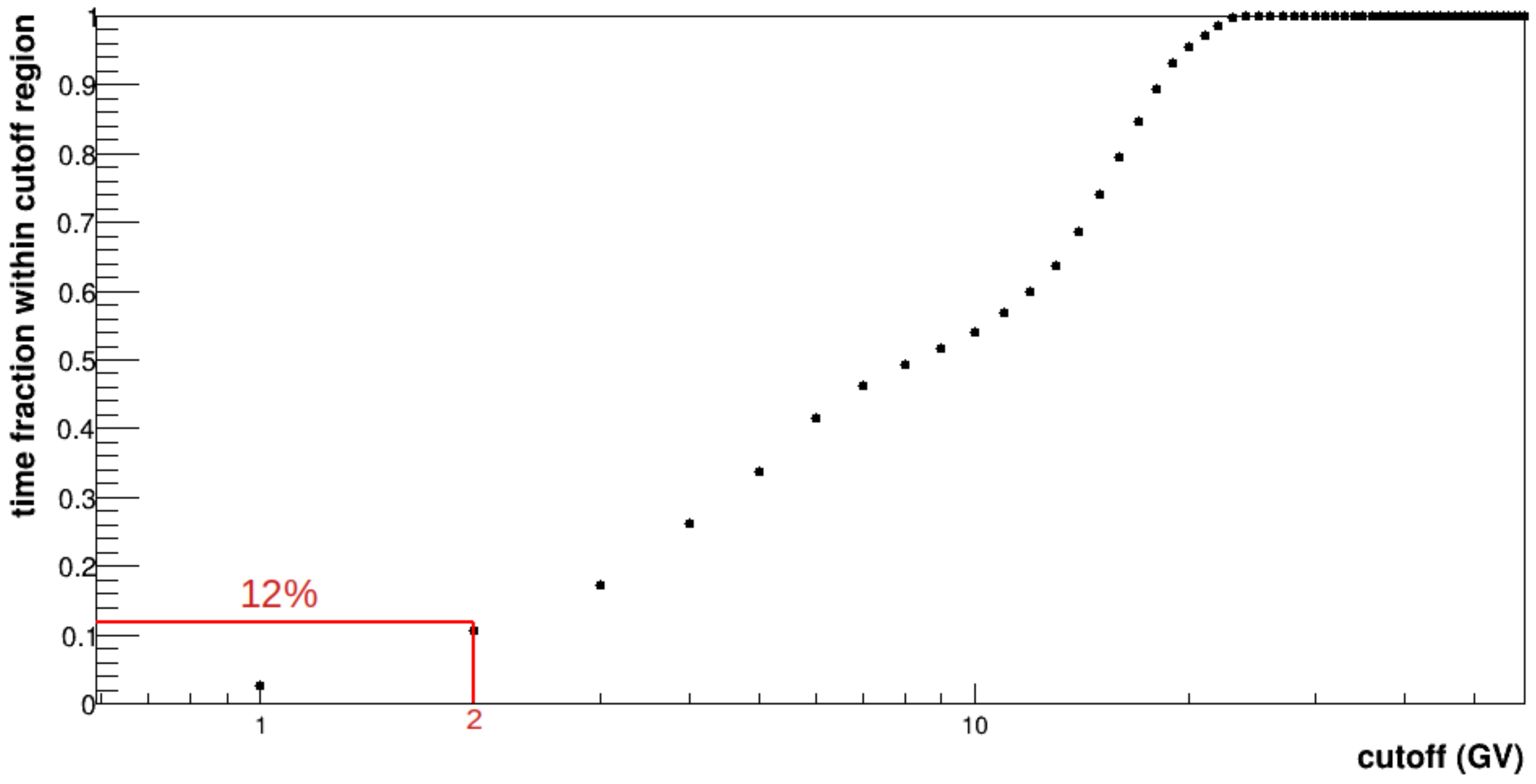
- **Rigidity Cutoff** lower near magnetic poles —> **low energy** particles (solar component) can reach Earth
- The **[cutoff < 2GV]** region defines the **SEP Sensitivity Zone**, in which AMS can detect O[GeV] energy particles, corresponding to SEP events.

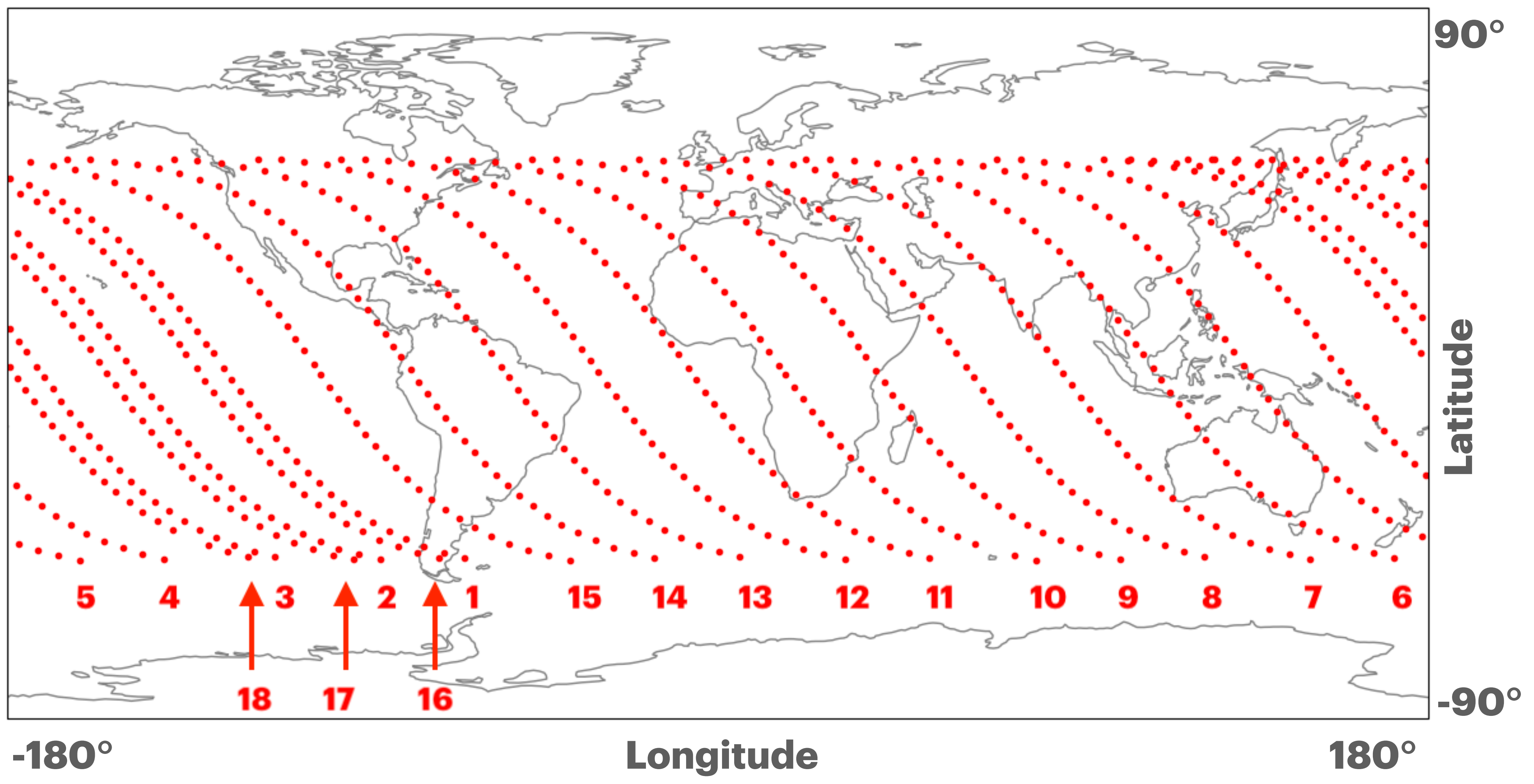




THE IGRF GEOMAGNETIC RIGIDITY CUTOFF

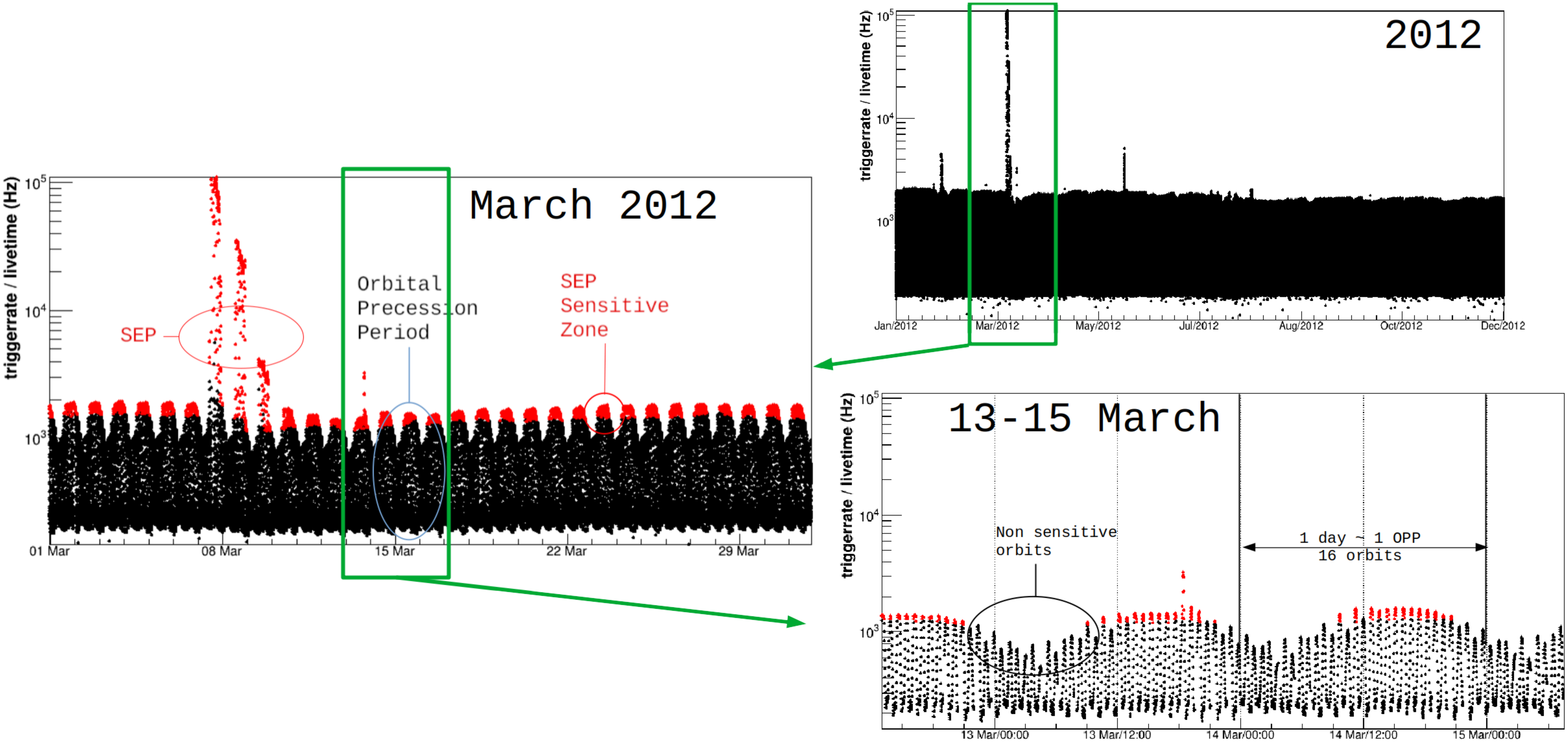
- The **time fraction** spent by AMS within the **Sep Sensitive Zone** is about **12%** of the total exposure time.
- AMS is **sensitive** to SEP events during **~6-7** ISS orbits per day and only in polar regions.





OPP - Orbital Precession Period: time to complete one full precession (~ 1 day, 16 orbits)

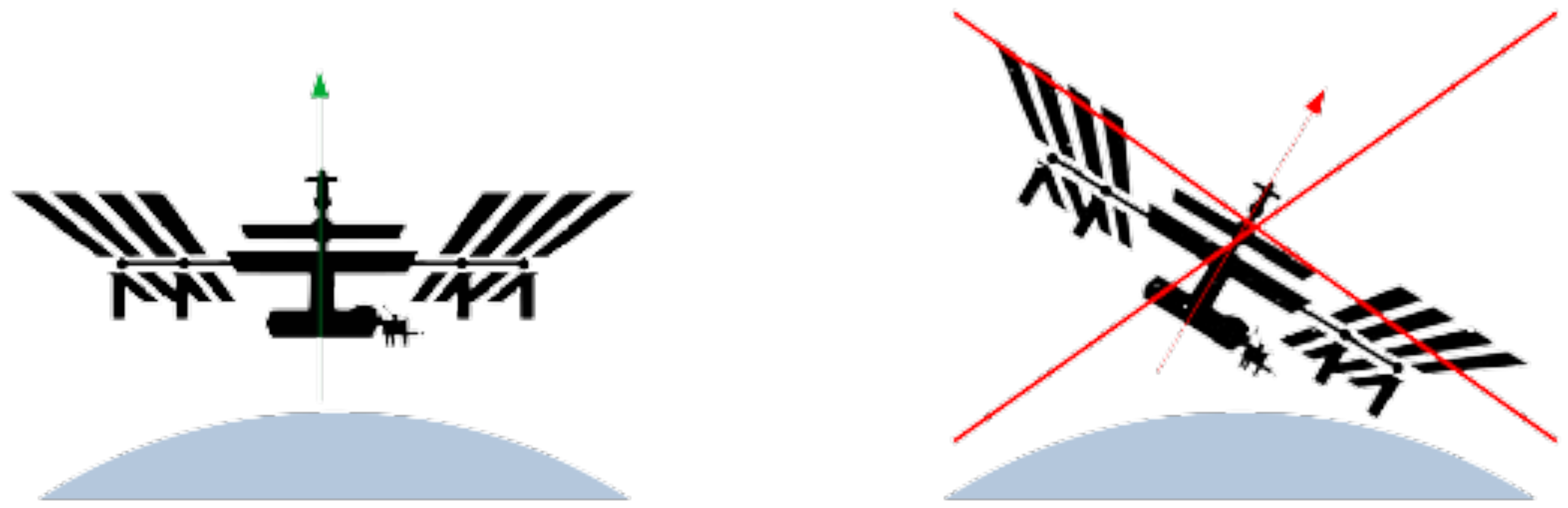
TRIGGER RATE OVERVIEW



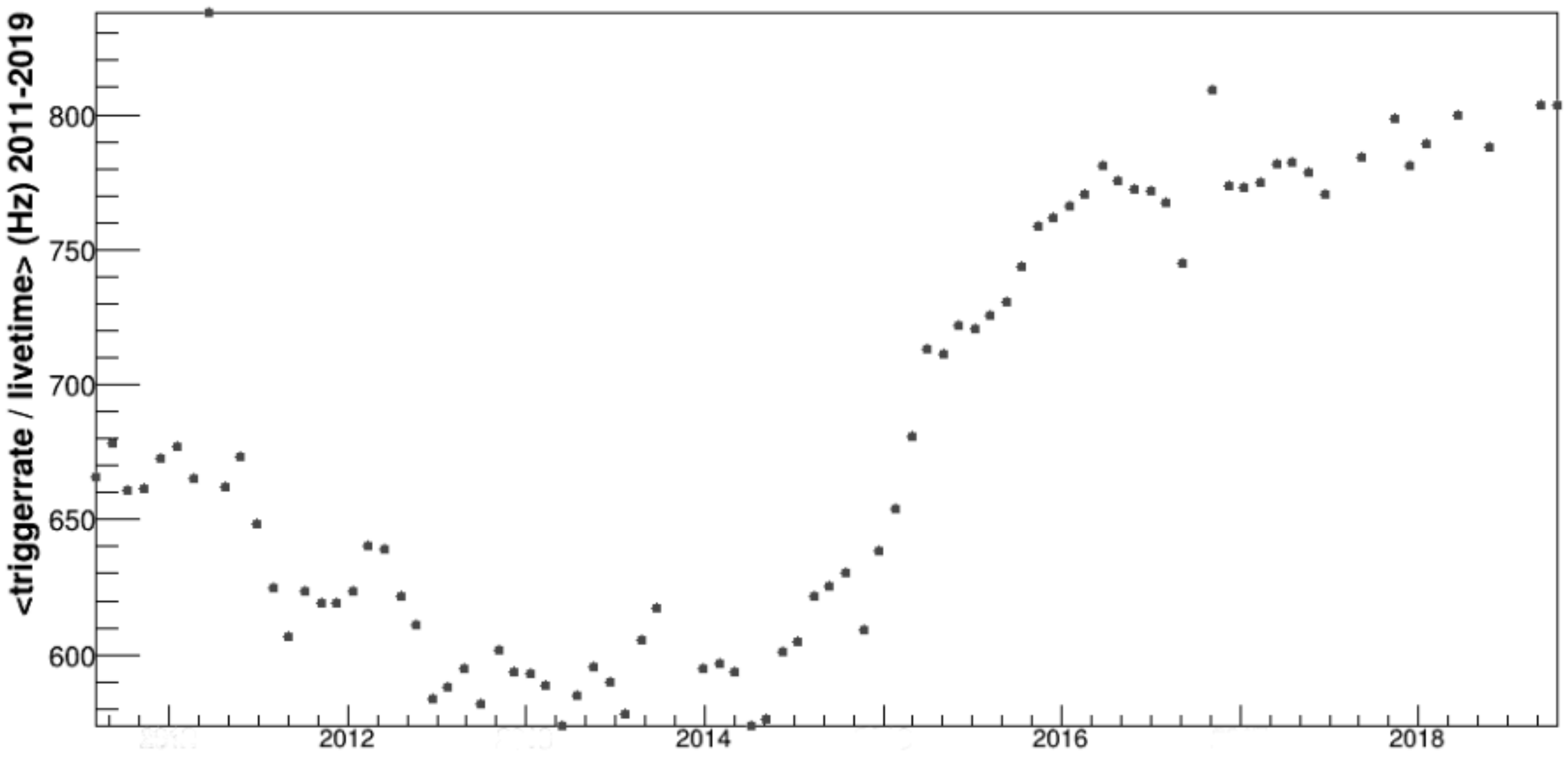
DATA PRESELECTION

Preselection Cuts:

- Intervals containing corrupted data
- Intervals associated with the SAA
- Intervals with ISS not in nominal status

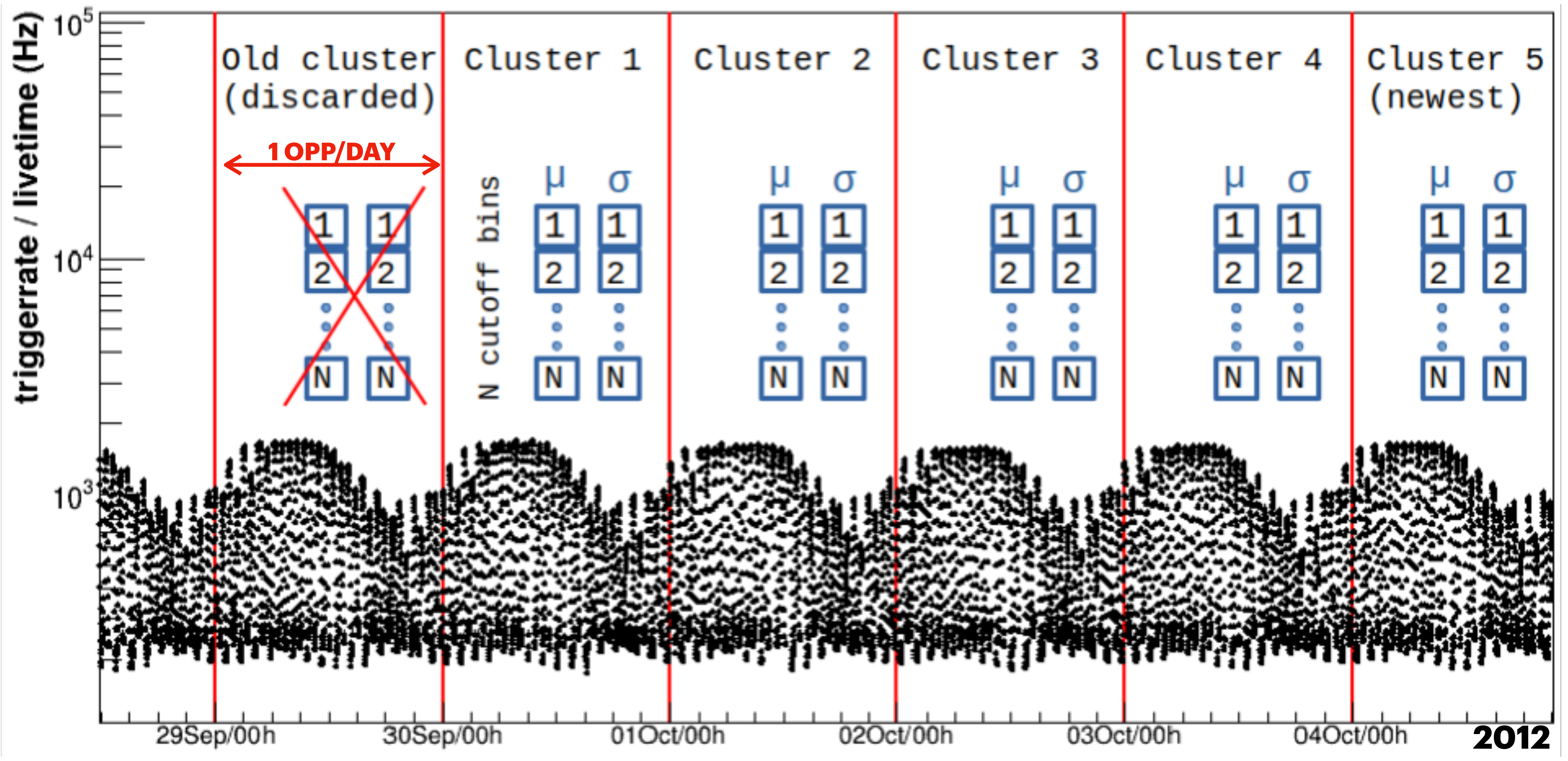


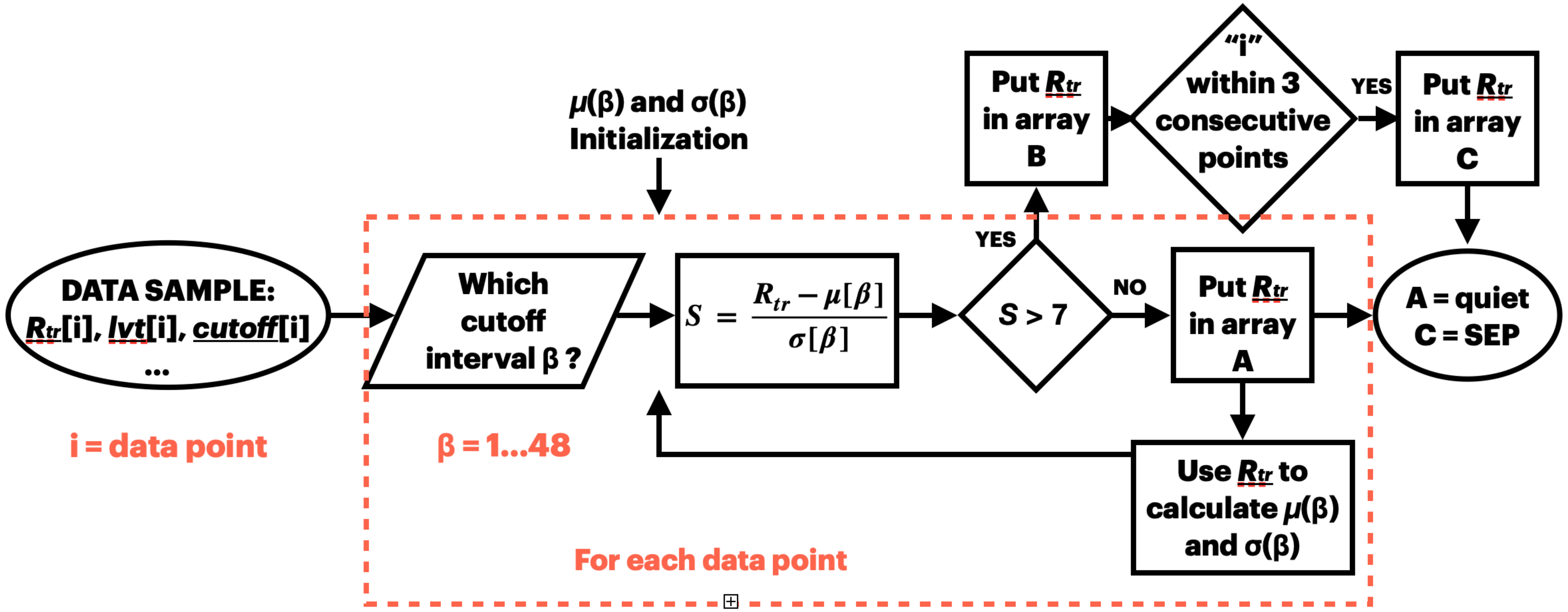
Solar activity cycle —> high variability of trigger rate, even on quiet periods —> **dynamic SEP-ID threshold**



SEP IDENTIFICATION ALGORITHM

- The [0,∞]GV **cutoff interval** is subdivided in **N bins**.
- **Trigger rate quiet level**: mean and standard deviation, for each point, on the previous 5 days.
- The quiet level is calculated separately for each cutoff bin and used to determine the **significance (S)**.

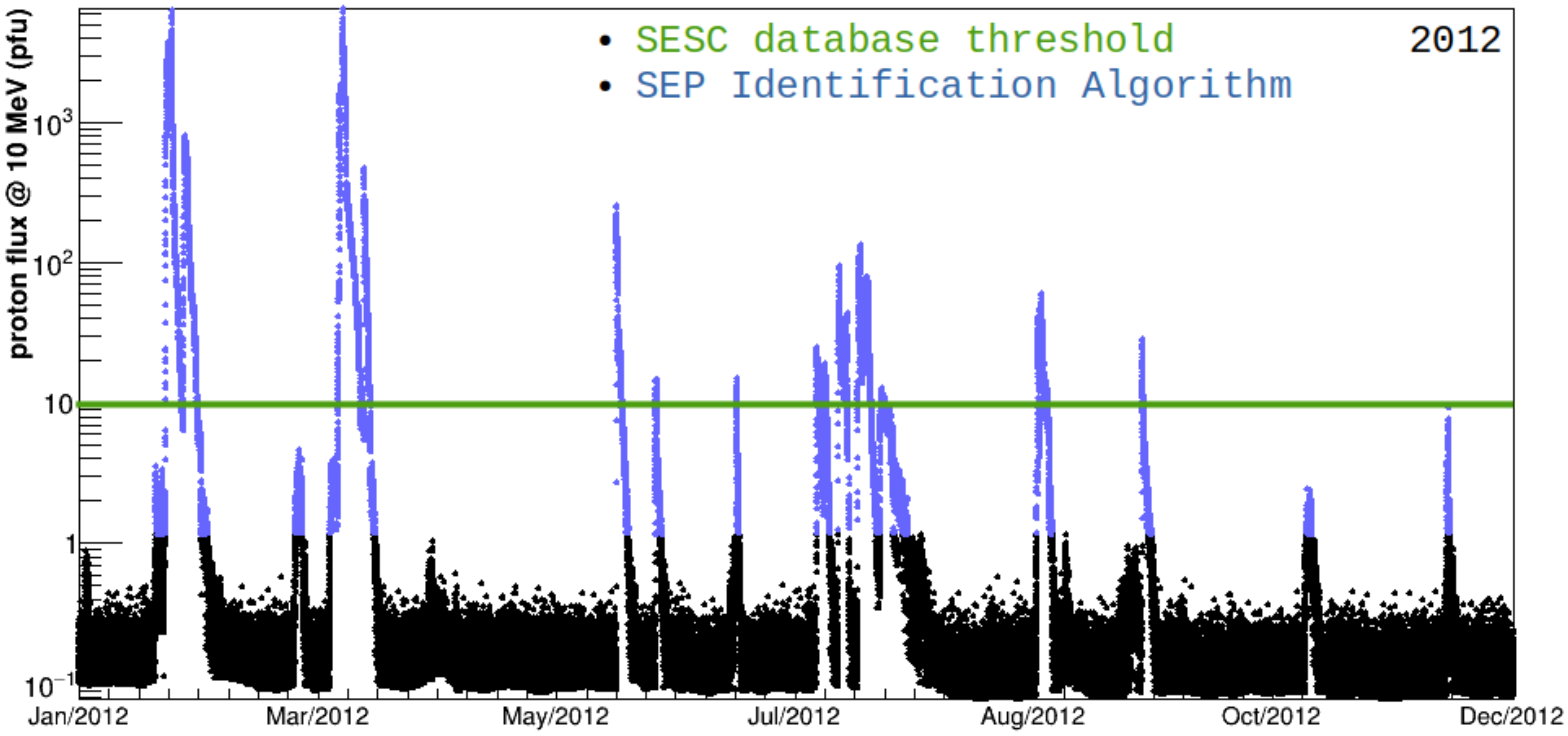




SEP IDENTIFICATION ALGORITHM

The same algorithm was applied to GOES data. NOAA has a database of SEP events based on the same data, using a constant threshold.

- NOAA threshold: flux > 10 pfu
- Our SEP-ID algorithm: flux with S > 7



SEP IDENTIFICATION ALGORITHM

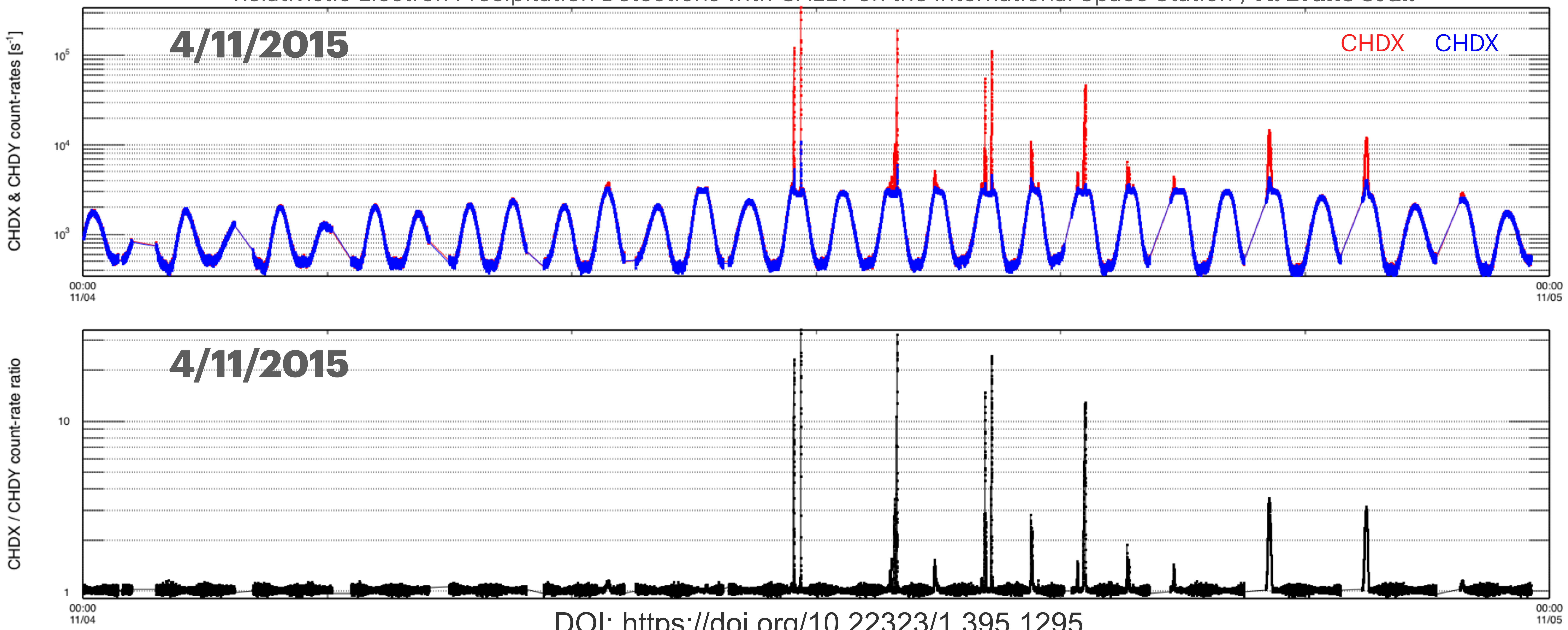
SEP events found by our algorithm on AMS and GOES data are matched with events on the NOAA database

2012							
NOAA Start Time	NOAA P-Flux (pfu)	AMS Interval	AMS Max	AMS Max tr.rate (Hz)	GOES Interval	GOES Max	GOES Max Flux (pfu)
Jan 23	6310	Jan 23-	Jan 28	4453	Jan 22 -	Jan 24	6310
Jan 27	796	-Jan 28	same	same	- Feb 3	same	same
Mar 07	6530	Mar 7-9	Mar 7	110893	Mar 5-	Mar 8	6350
Mar 13	469	Mar 13	Mar 13	3234	-Mar 17	same	same
May 17	255	May 17-18	May 17	5111	May 17-20	May 17	255
May 27	14				May 27-28	May 27	14.8
Jun 16	14				Jun 16-17	Jun 17	14.9
Jul 07	25	Jul 8	Jul 8	1963	Jul 7-11	Jul 7	25.2
Jul 12	96				Jul 12-15	Jul 13	96.1
Jul 17	136				Jul 17-	Jul 18	136
Jul 23	12				-Jul 30	same	same
Sep 01	59				Sep 1-5	Sep 2	59.9
Sep 28	28				Sep 28-30	Sep 28	28.4
					Nov 9-10	Nov 9	2.4
					Dec 14-15	Dec 15	9.4

REP IDENTIFICATION WITH CALET

- **Relativistic Electron Precipitation (REP)**: trapped electrons in the geomagnetic field lost into the upper or middle atmosphere.
- **CHD**: CALET "CHarge Detector", composed by two hodoscope layers of plastic scintillators.

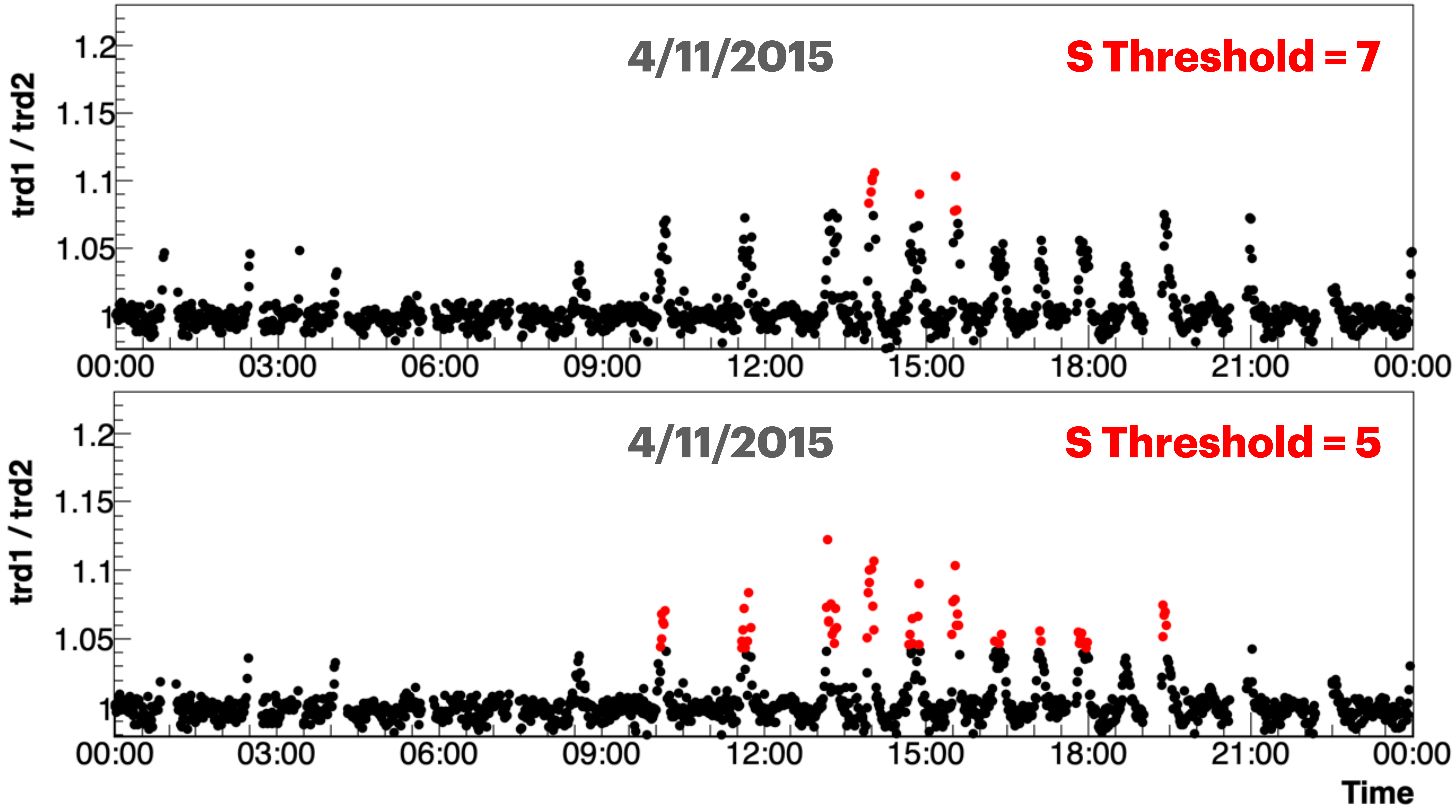
"Relativistic Electron Precipitation Detections with CALET on the International Space Station", **A. Bruno et al.**



DOI: https://doi.org/10.22323/1.395.1295

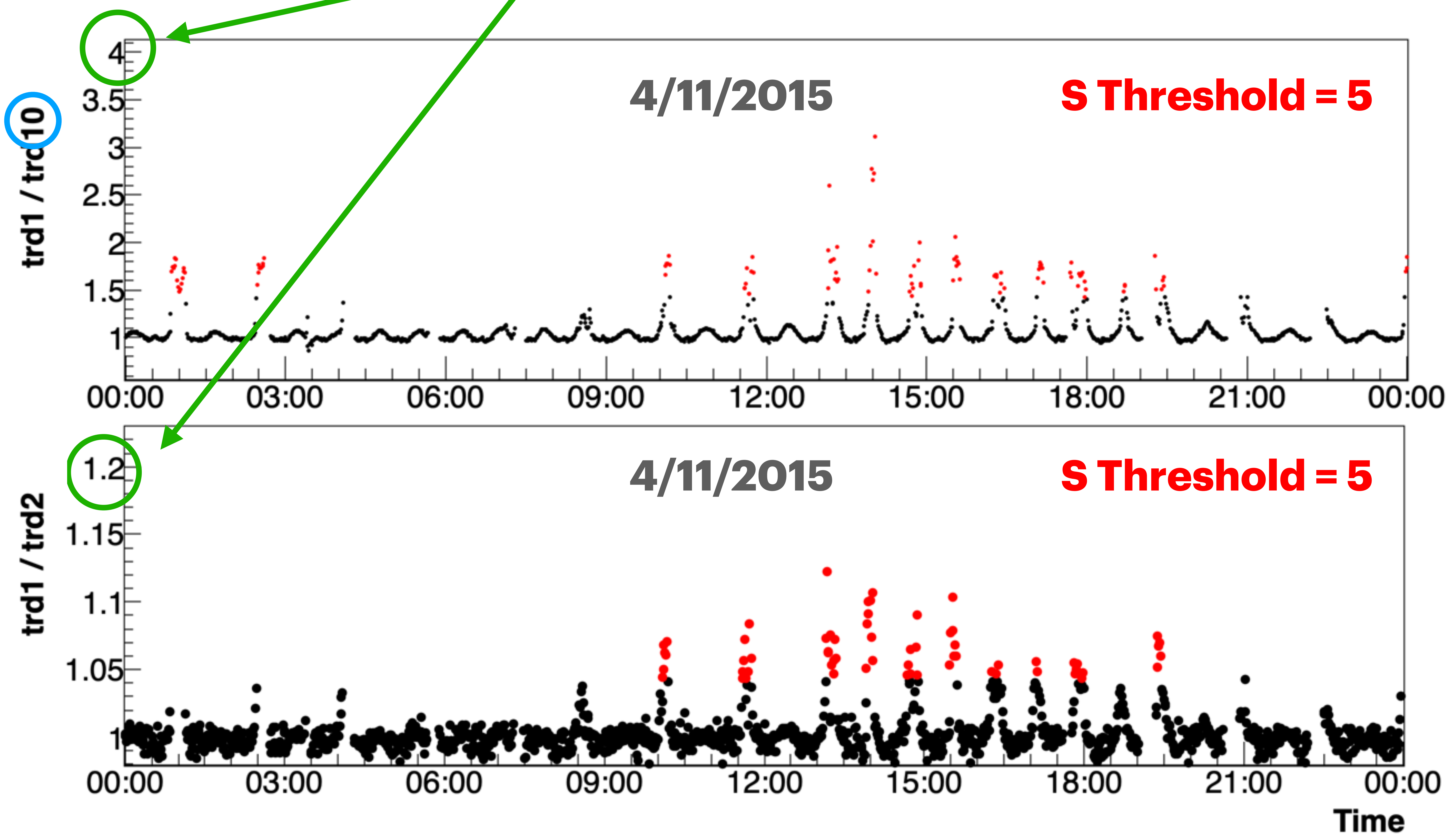
REP IDENTIFICATION WITH AMS

- The **SEP-ID Algorithm** was adapted for the **REP analysis**, using the **TRD layers** count rates.
- We first used the **ratio** between the **top two TRD layers**, selecting a **significance threshold equal to 5**.

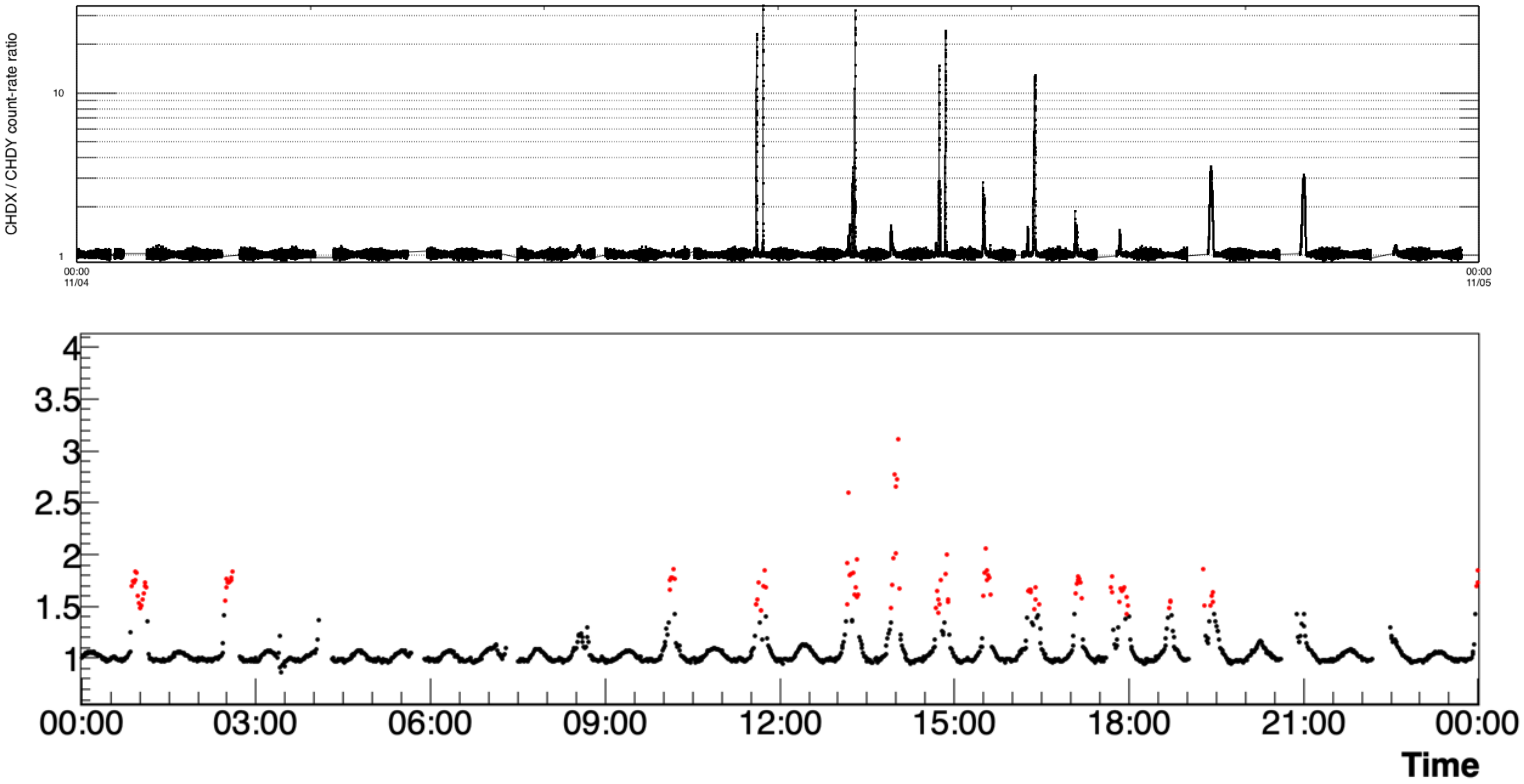


REP IDENTIFICATION WITH CALET

- The ratio between **layer 1 and layer 10** is **higher** for REP, but we see the orbital precession effects

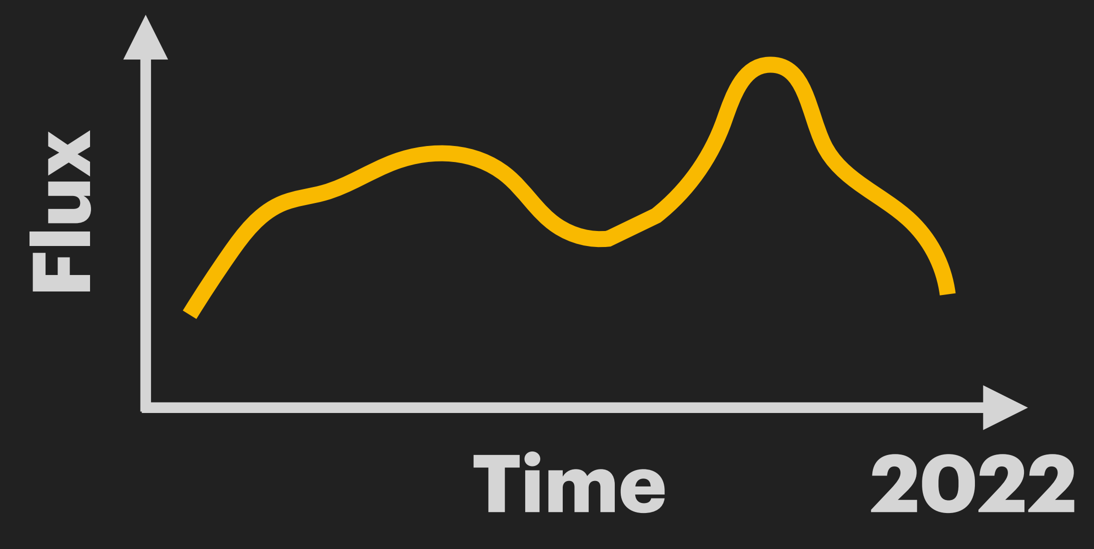


CALET-AMS COMPARISON

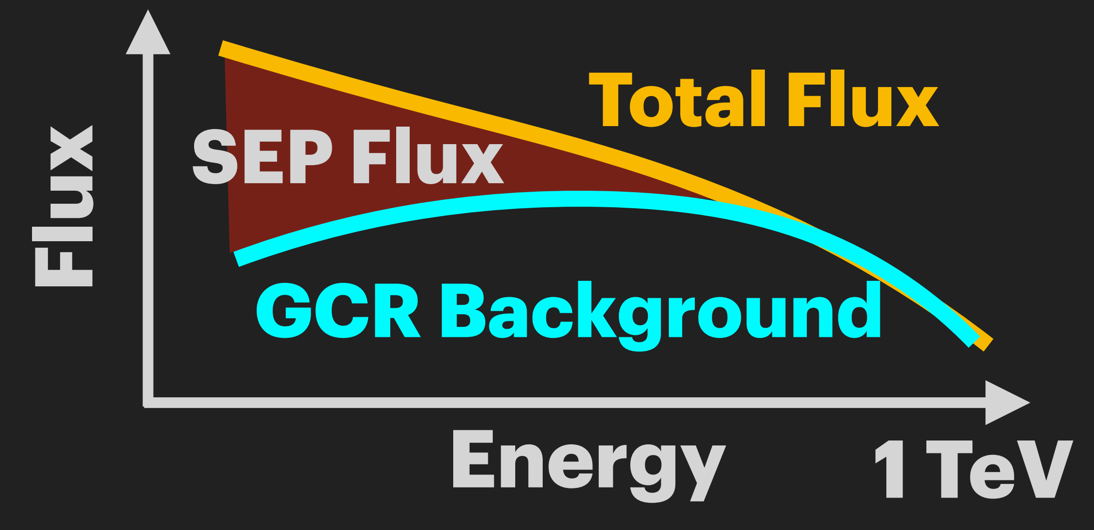


MY PHD PROJECT

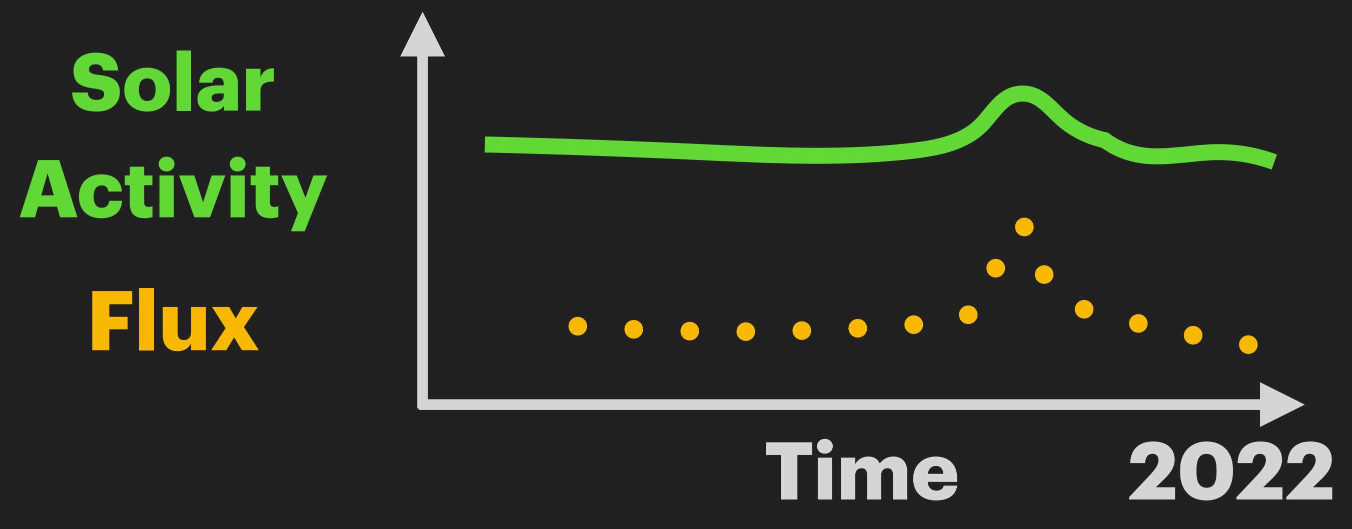
- Characterization of **temporal evolution** of the cosmic ray flux in **quiet periods**, during **solar storms** and **follow-up**



- **Energetic spectra** reconstruction of **"Solar Energetic Particles" events**, which lead to intense emissions of high energy particles in short periods of time



- Study of **correlation** between **charged particle fluxes** and **solar activity** or **geomagnetic indexes**, during solar storms (solar wind velocity, IMF strength and polarity, ecc...)



Summary

- AMS **low latency data** provide **enough information** to build a real time monitoring system.

- The **algorithm** has been **tested** even on one-minute root files, without access to RTI data.

- **SEP-ID algorithm** can also be applied to **TRD layers ratio analysis**, in order to identify **REP** events.

PROTON FLUX COMPARISON – PASS7, GBATCH