REAL TIME MONITORING OF THE RADIATION ENVIRONMENT ON THE ISS WITH AMS-02

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REAL TIME MONITORING OF THE RADIATION ENVIRONMENT ON THE ISS WITH THE AMS-02 DETECTOR

Introduction to Space Weather

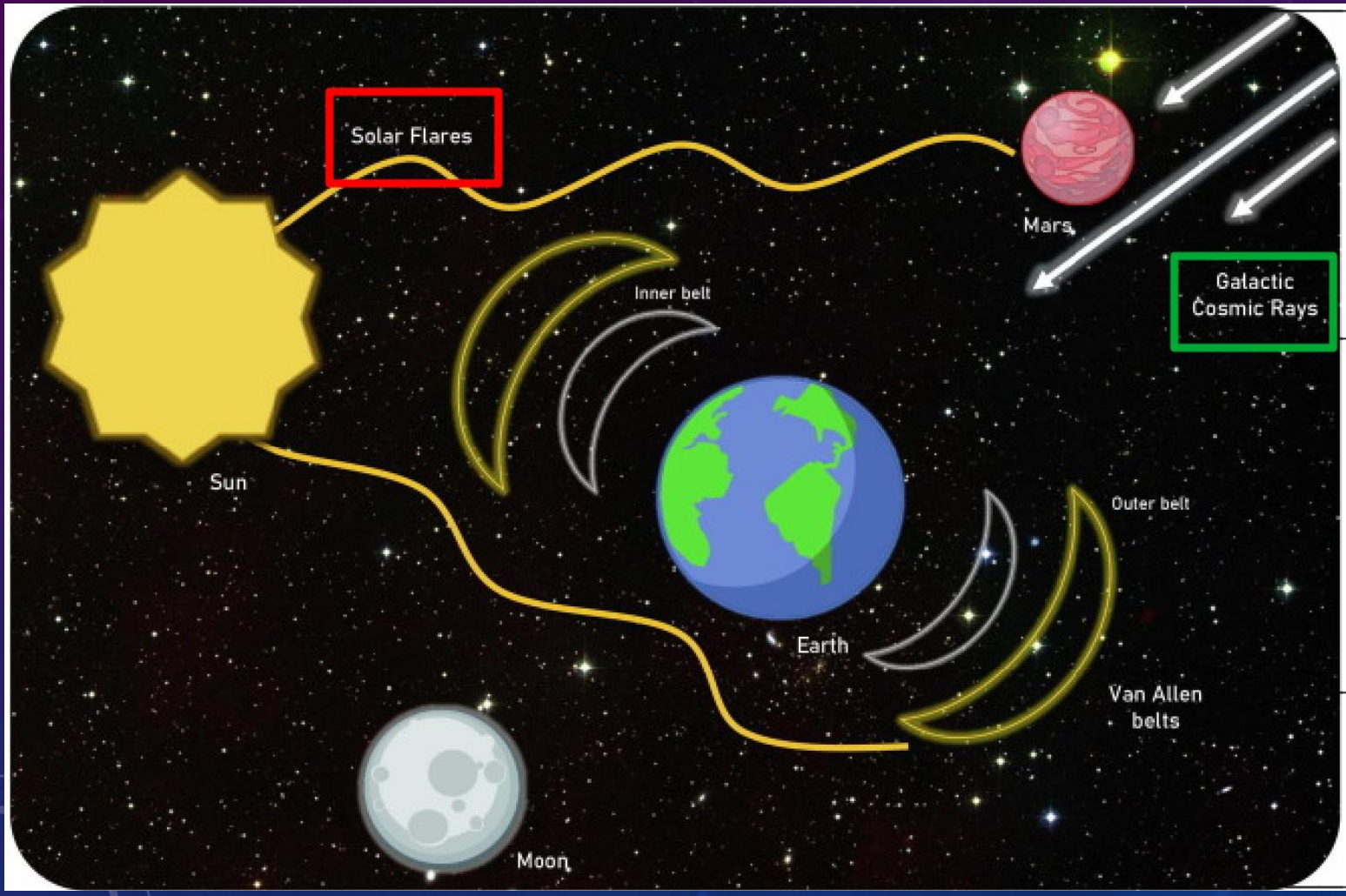
Dosimetry on the International Space Station (ISS) and AMS-02

Space Weather with AMS-02

Solar Energetic Particles (SEP) Identification Algorithm

Results and correlation with other experiments

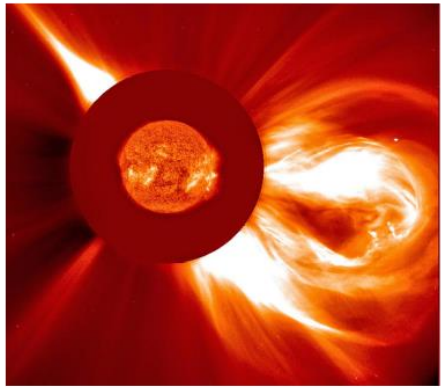
CHARGED RADIATION IN THE SOLAR SYSTEM



Solar Wind:

constant flux of charged particles emitted from the solar corona

E < 10-100 KeV



Solar Energetic Particles (SEP)

Intense flux of charged particles emitted in short lifespan events

E < 1-10 GeV

Galactic Cosmic Rays (GCR)

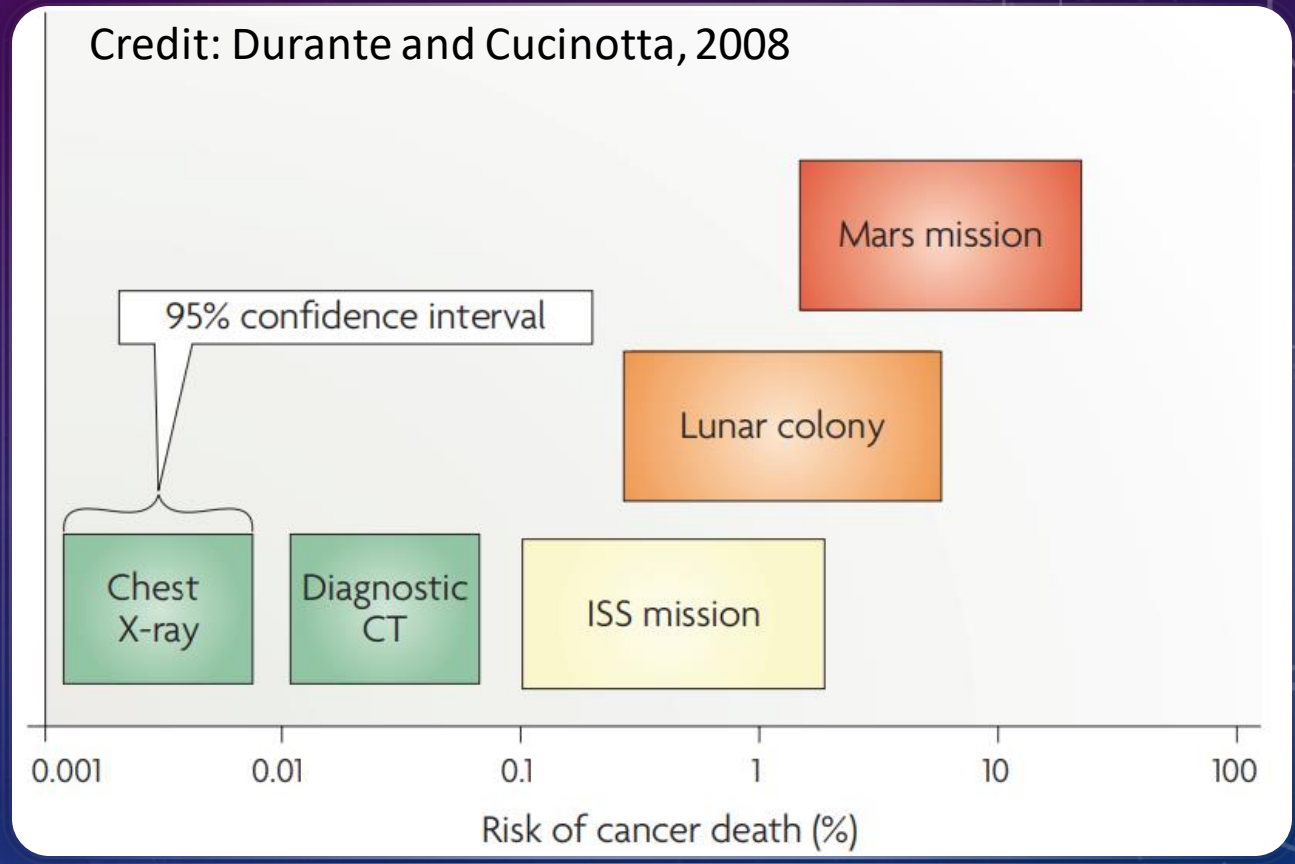
Low intensity flux of high energy particles emitted from galactic sources

E < 1 PeV

DOSIMETRY AND RADIATION DAMAGE

- Lethal Dose: 6 Sv
- US Citizen: 6.2 mSv/year
- Astronaut: 1 mSv/day

  -> Up to 100x during SEP event!



DOSIMETRY ON THE ISS

Area Monitoring
(DOSIS-3D, ISS-RAD, ALTEA, LIDAL, …)

Phantoms
(Matroshka, …)

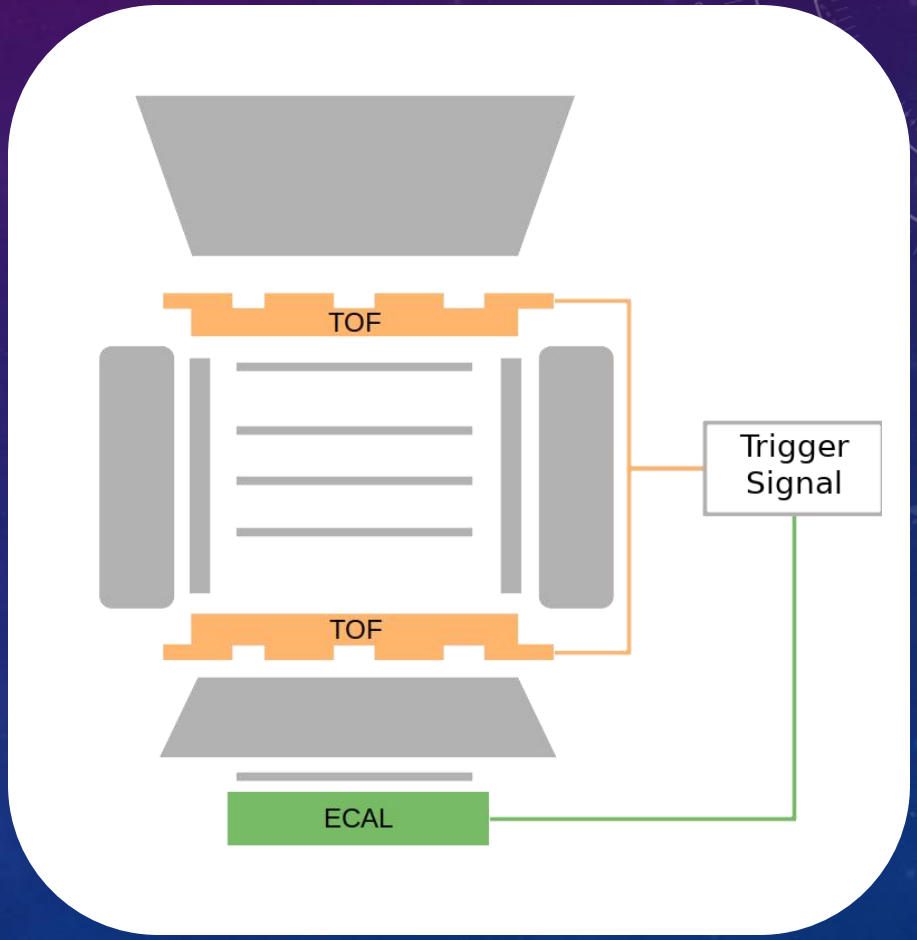
Personal dosimetry
(EuCPAD, …)

Cosmic ray detector
(AMS-02, CALET)

ISS internal environment

ISS external environment

TRIGGER LOGIC IN AMS-02



SPACE WEATHER WITH AMS

OBJECTIVE

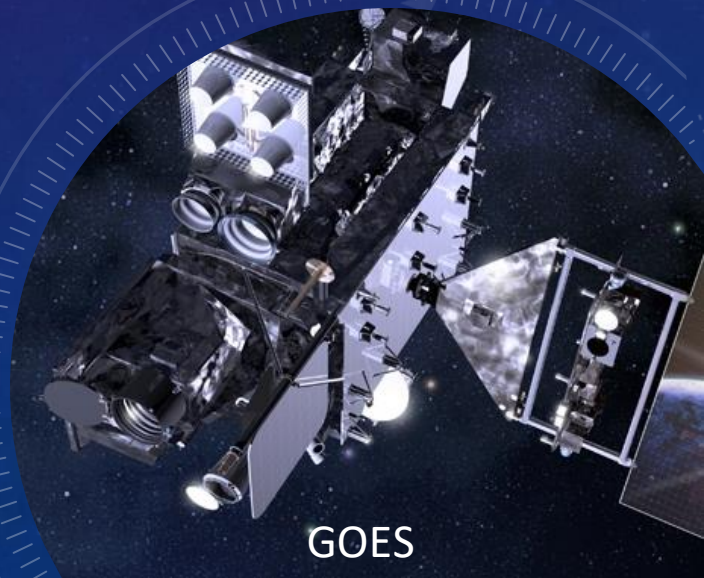
- Real time SEP monitoring system based on AMS trigger rate

METHOD

- SEP identification algorithm development and testing on offline data

PROOF

- Reliability test of the algorithm on GOES data



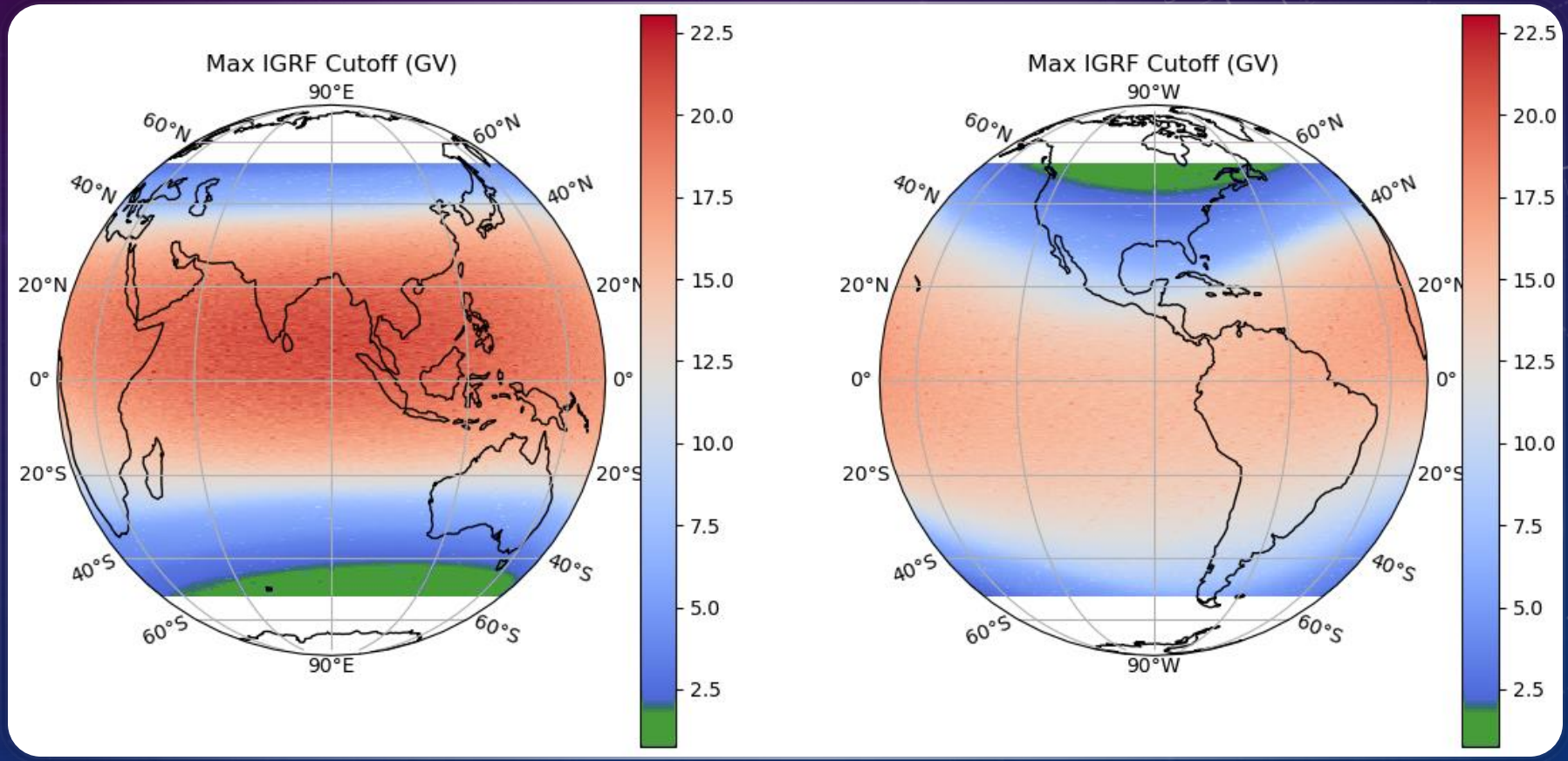
GOES

RIGIDITY CUTOFF AND SENSITIVITY ZONE

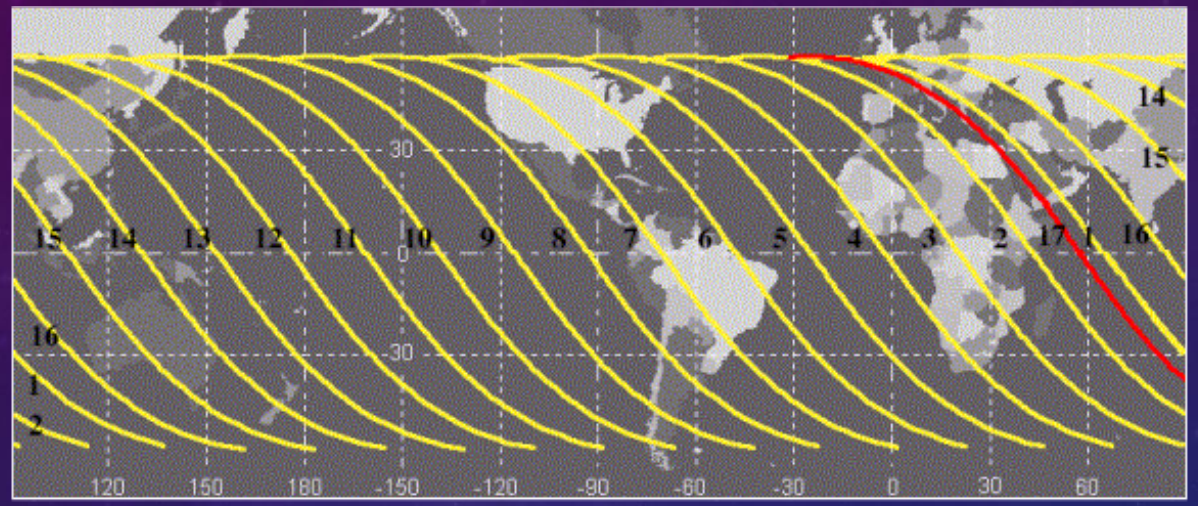
- Particles with magnetic rigidity below cutoff (Rc) at ISS altitude don't reach the station

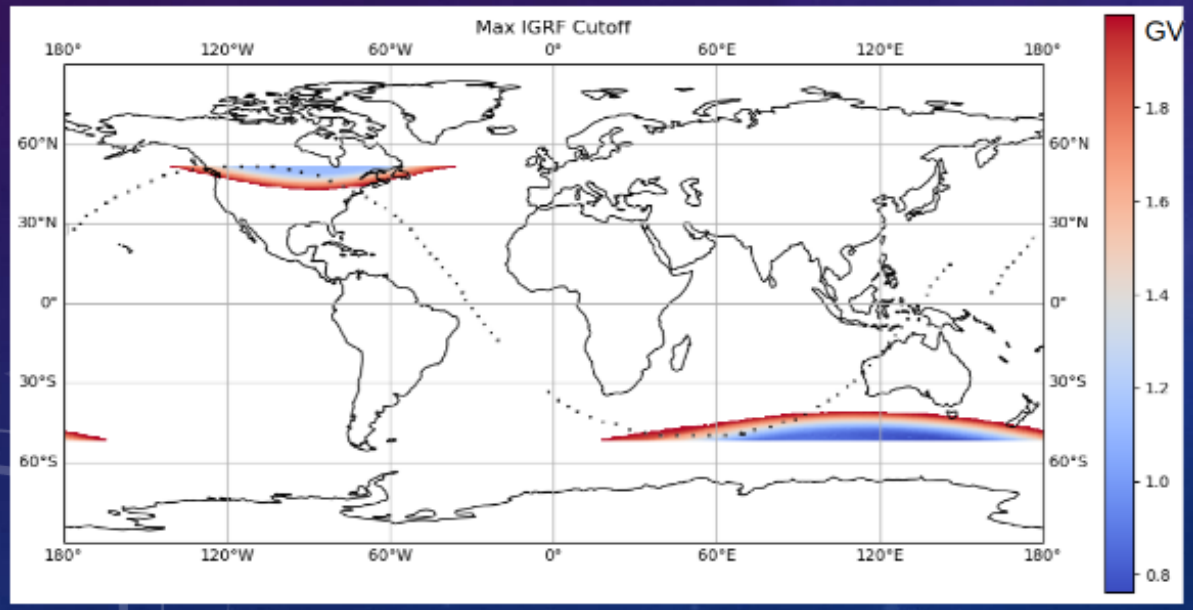
$$R = p/Z \text{ [GV]} < Rc$$

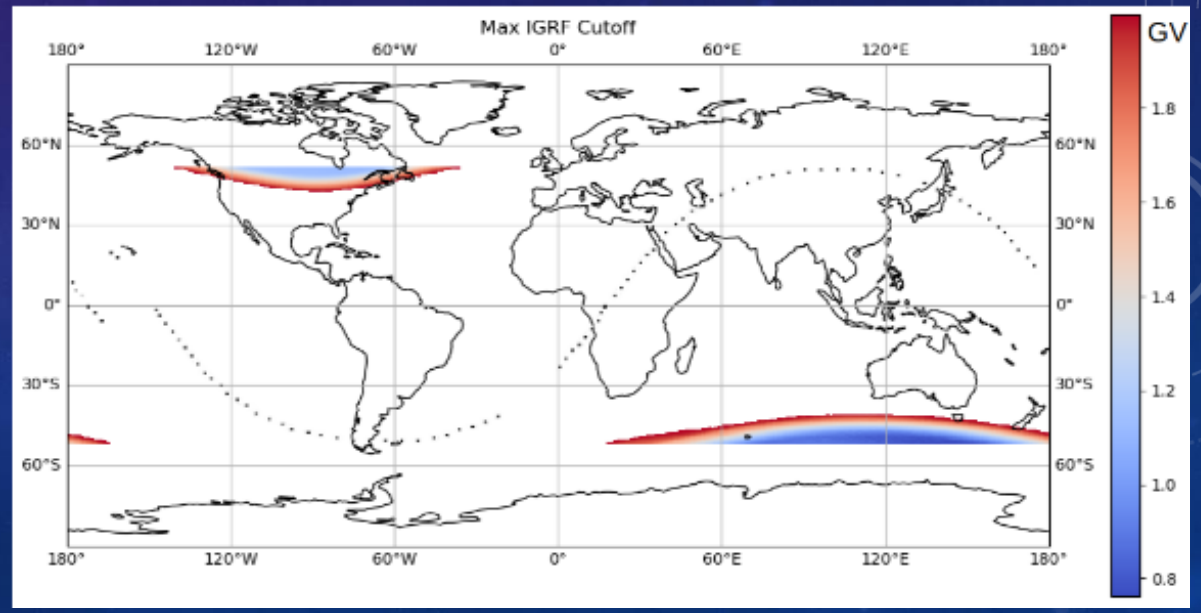
- Cutoff < 2GV defines the *sensitivity zone* in which AMS can detect SEPs



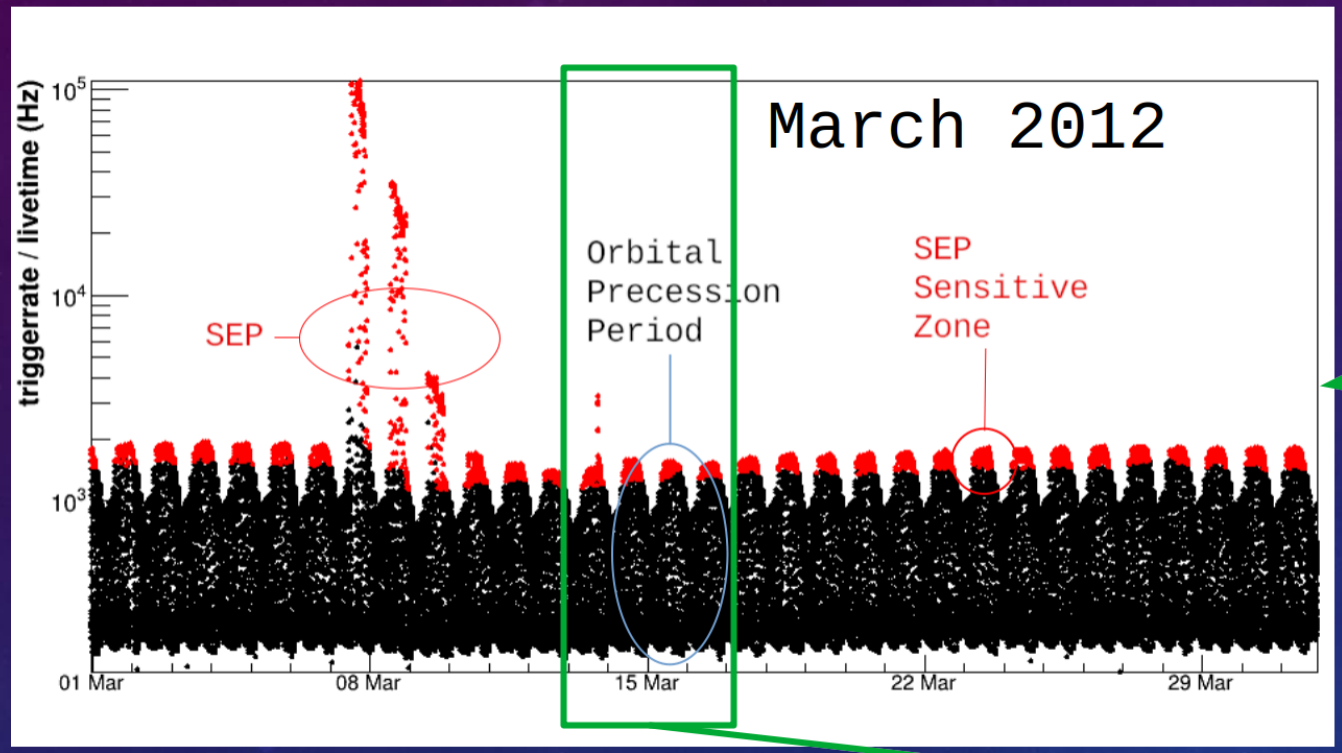
ISS ORBITS IN THE SENSITIVITY ZONE

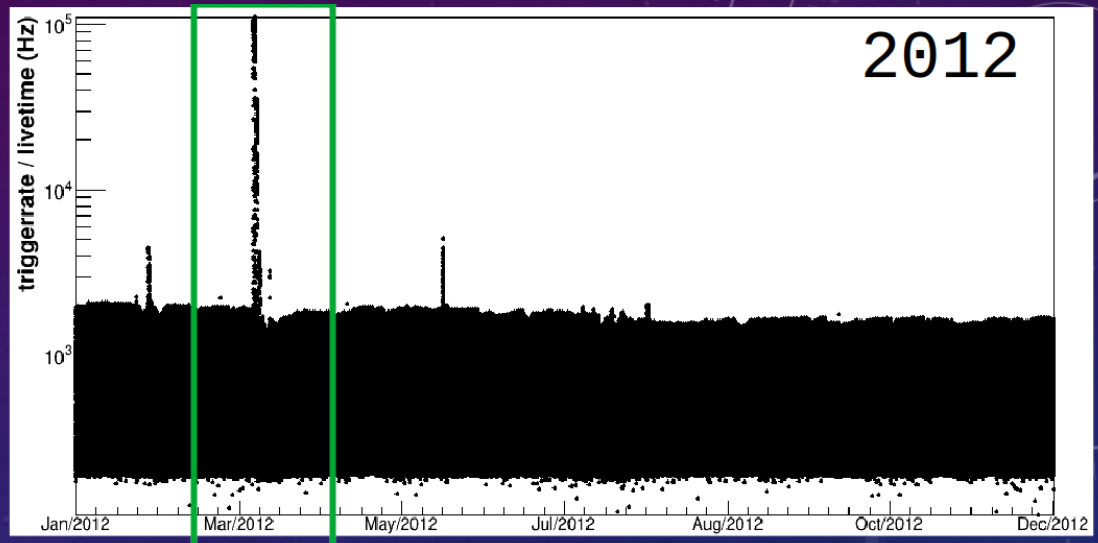


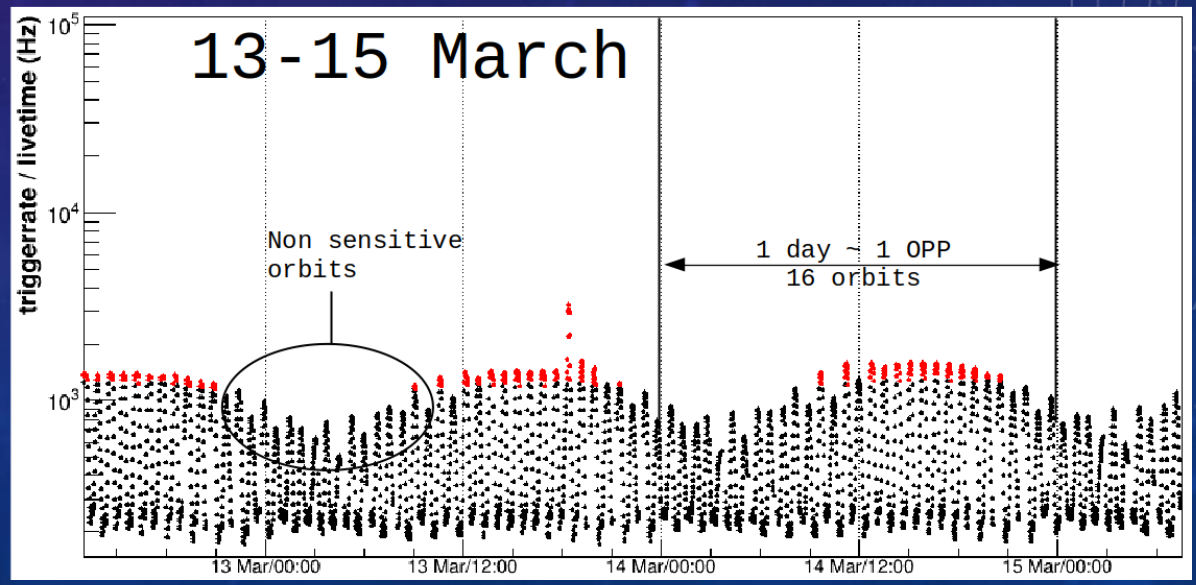




TRIGGER RATE _VS_ TIME

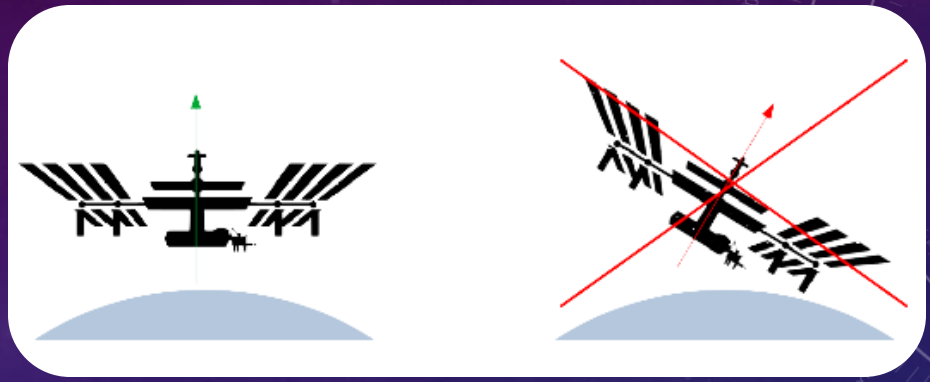




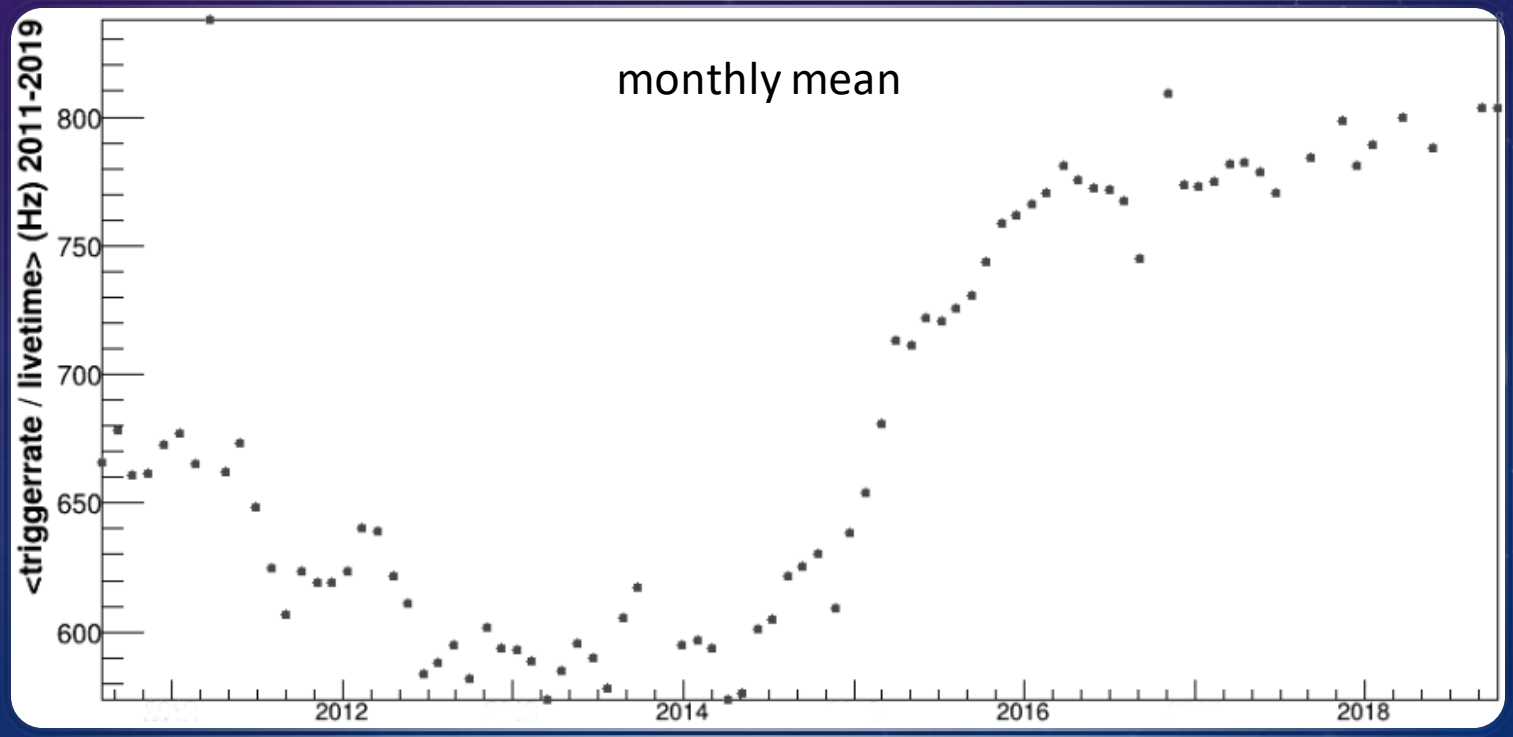


DATA PRESELECTION

- Intervals with corrupted data
- Intervals in the South Atlantic Anomaly (SAA)
- Intervals in which ISS attitude is not nominal



- Solar Activity Cycle
- High trigger rate variability, even on quiet periods
- Dynamic threshold required



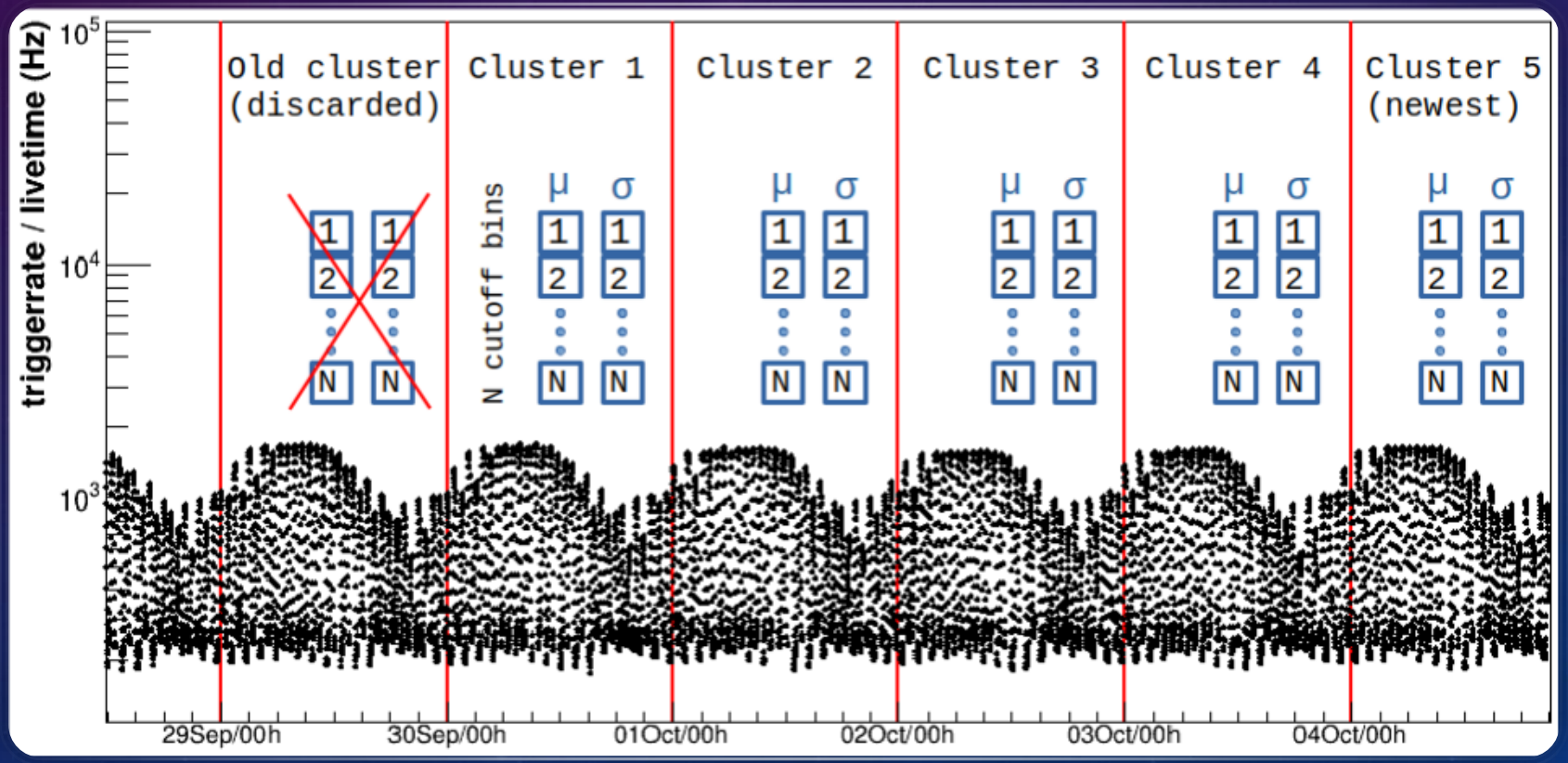
SEP IDENTIFICATION ALGORITHM

Trigger rate quiet level (μ, σ)

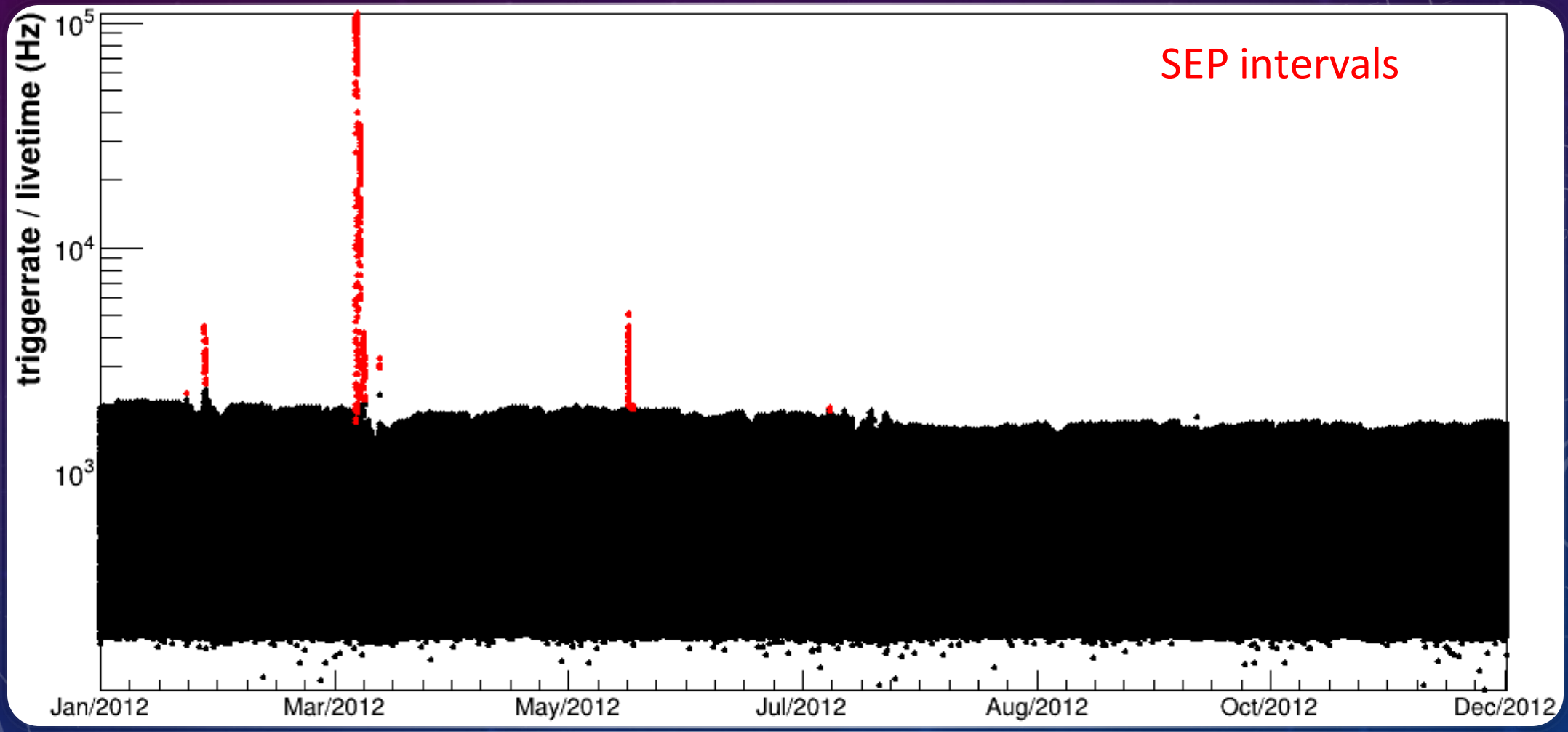
Significance: S=(triggerrate-μ)/σ

If S above significance threshold (S>7)

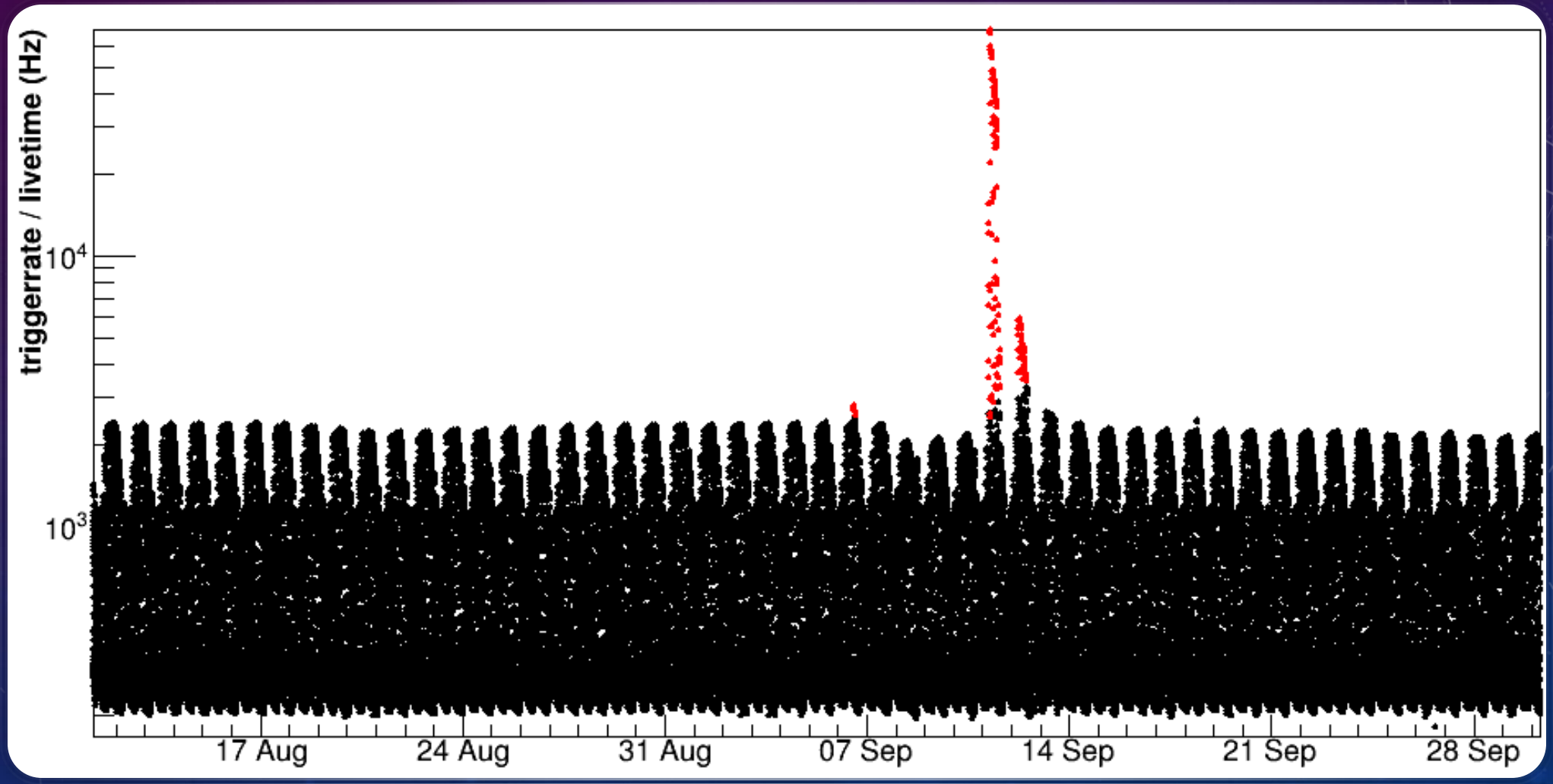
SEP interval



SEP EVENTS ON AMS-02 2012 DATA

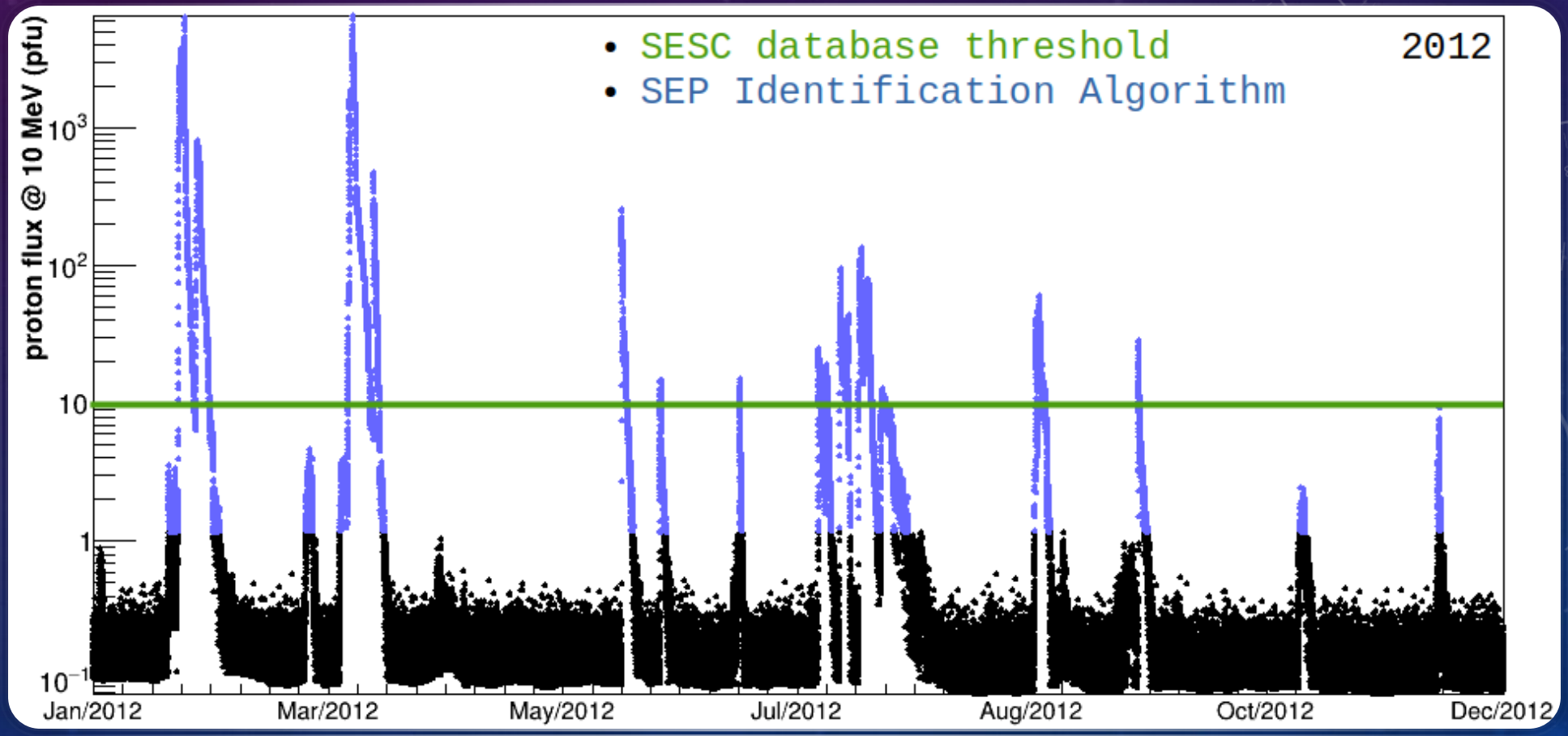


SEP EVENTS ON AMS-02 SEPTEMBER 2017 DATA



SEP EVENTS ON GOES 2012 DATA

- Same algorithm on GOES
- NOAA already has a SEP event database
- Correlation with AMS-02 to verify algorithm's reliability



SEP EVENT COMPARISON AMS-GOES

- SEP events found by the algorithm on GOES and AMS data are compared with the NOAA database
- Similar resoults on other years (2011-2019)

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

CONCLUSION

An algorithm has been developed to identify SEP events on AMS data

low latency AMS data is sufficient to build a real-time SEP monitoring system

An application of the algorithm on live data is already in progress

The algorithm can be used to study temporal evolution of SEP events in detail