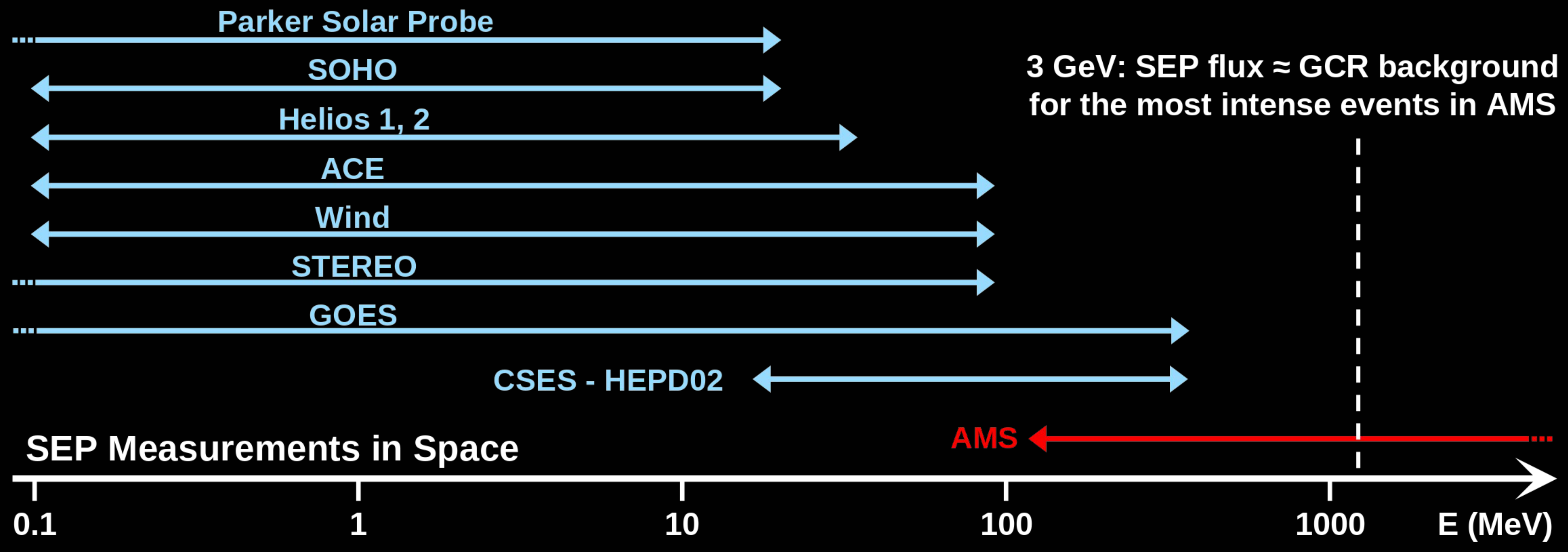
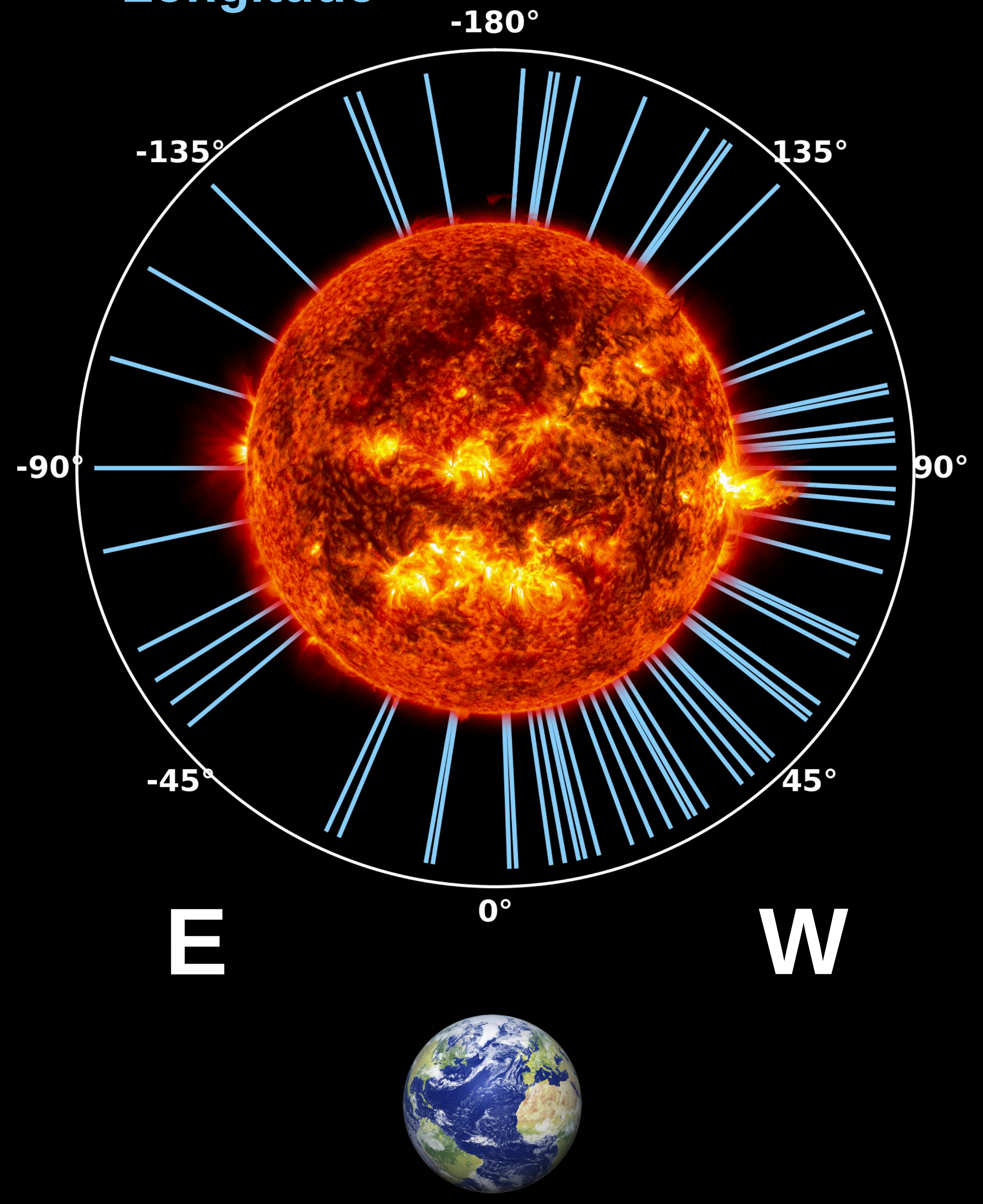
# Solar Energetic Particles measured by AMS-02

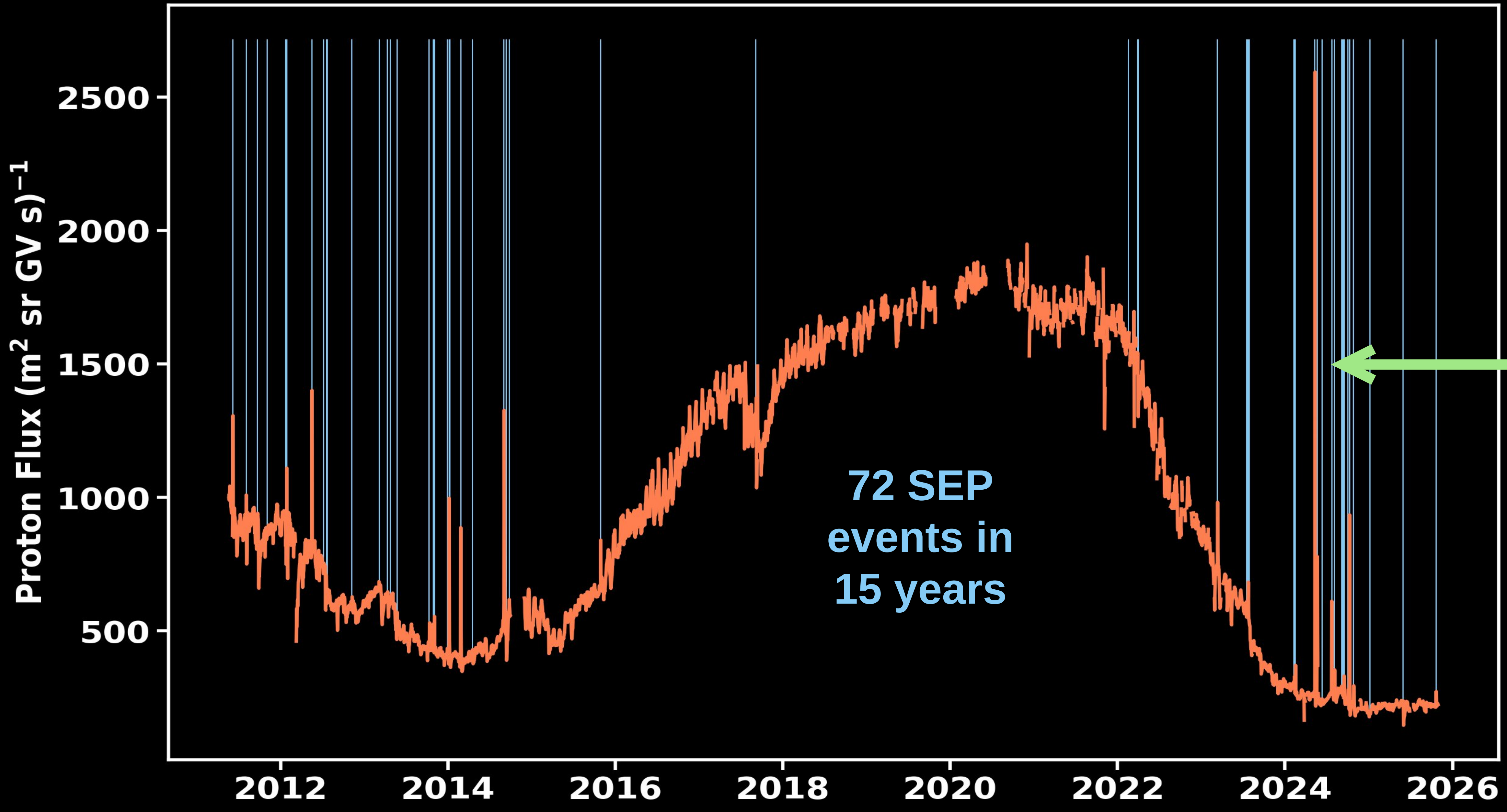
## AMS-02 on the ISS since 2011



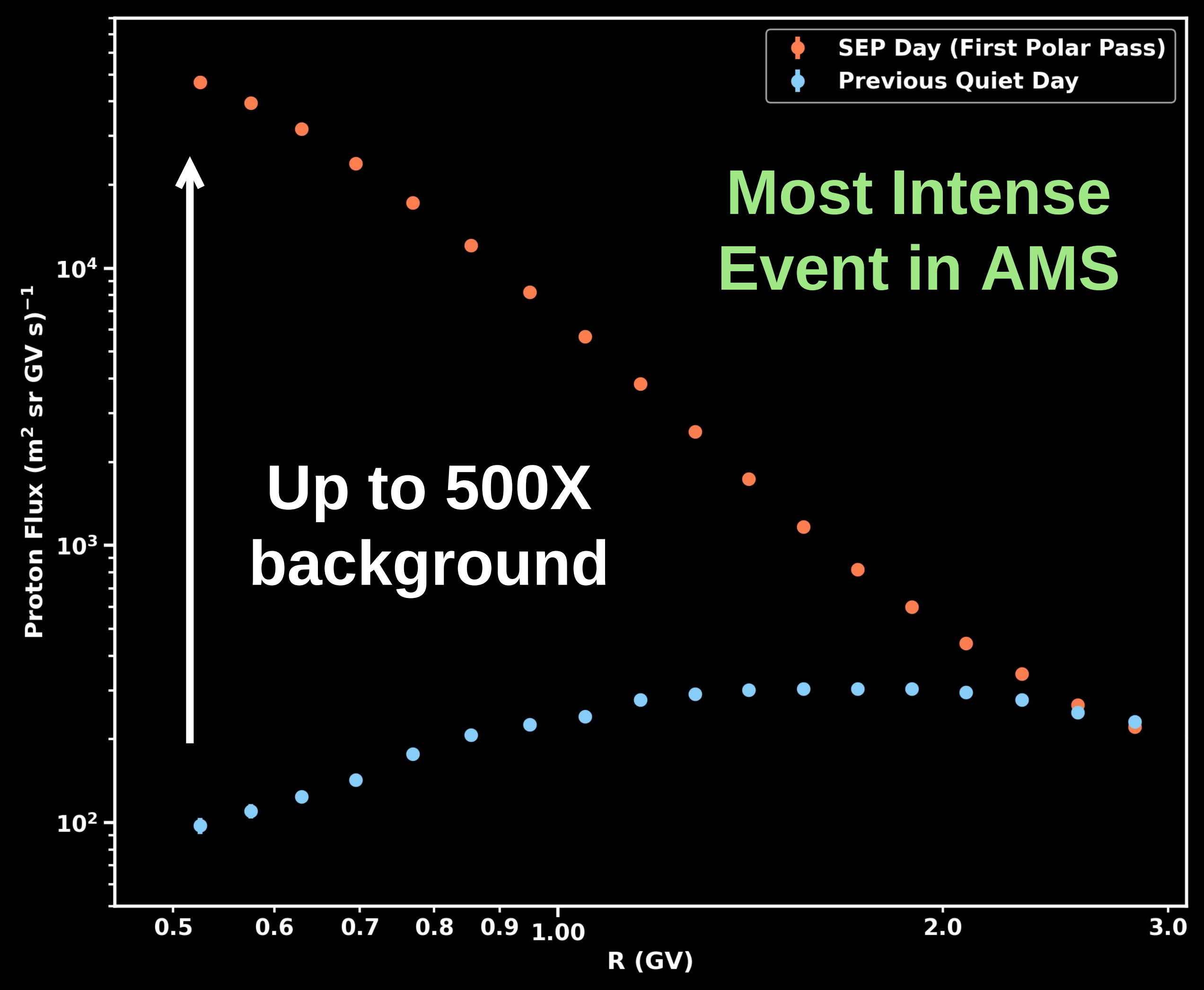

CME Direction
Longitude




Daily Proton Flux at 1 GV




11 May 2024 Proton Flux



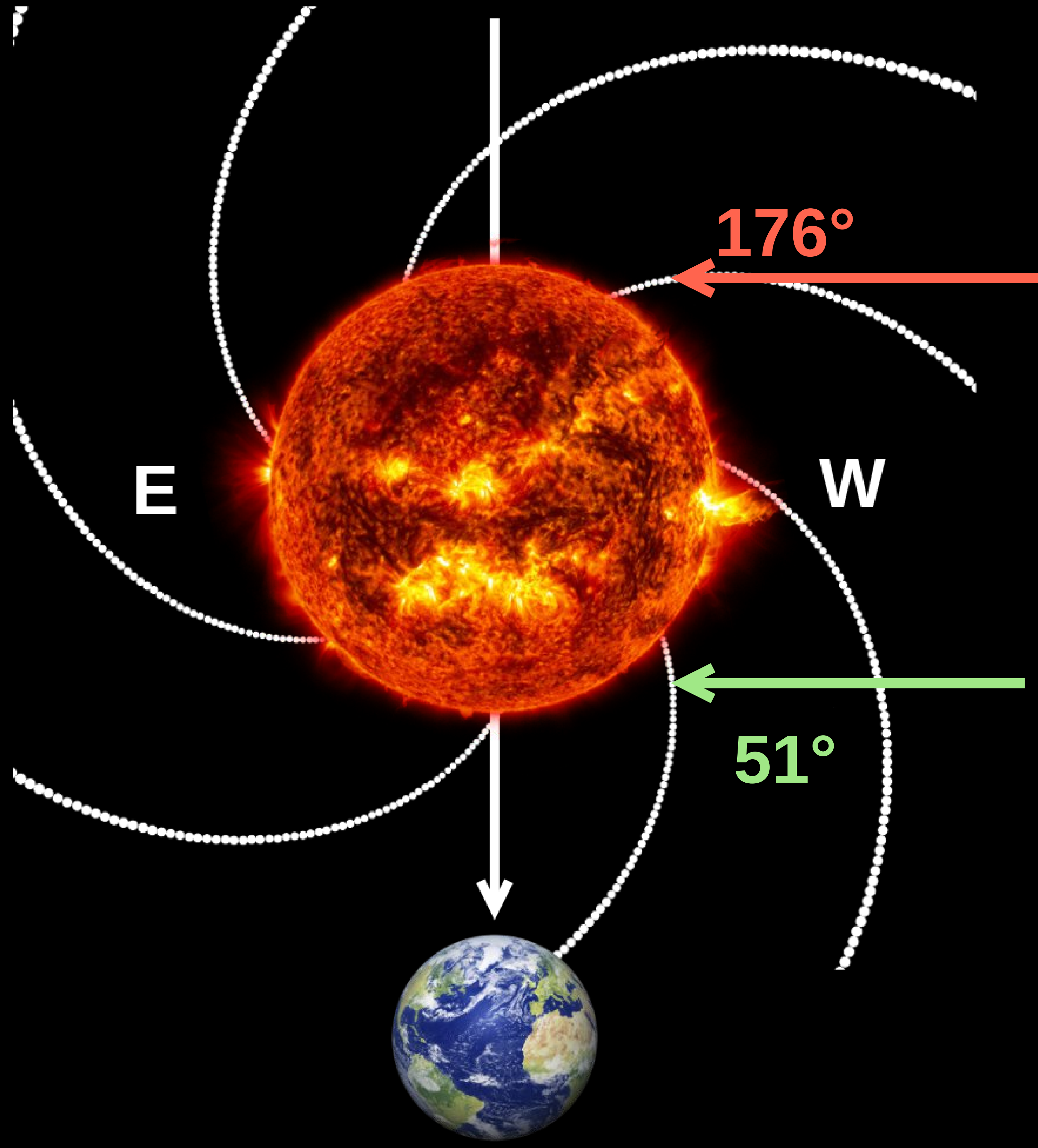

Francesco Faldi (SDIAT, Jinan)

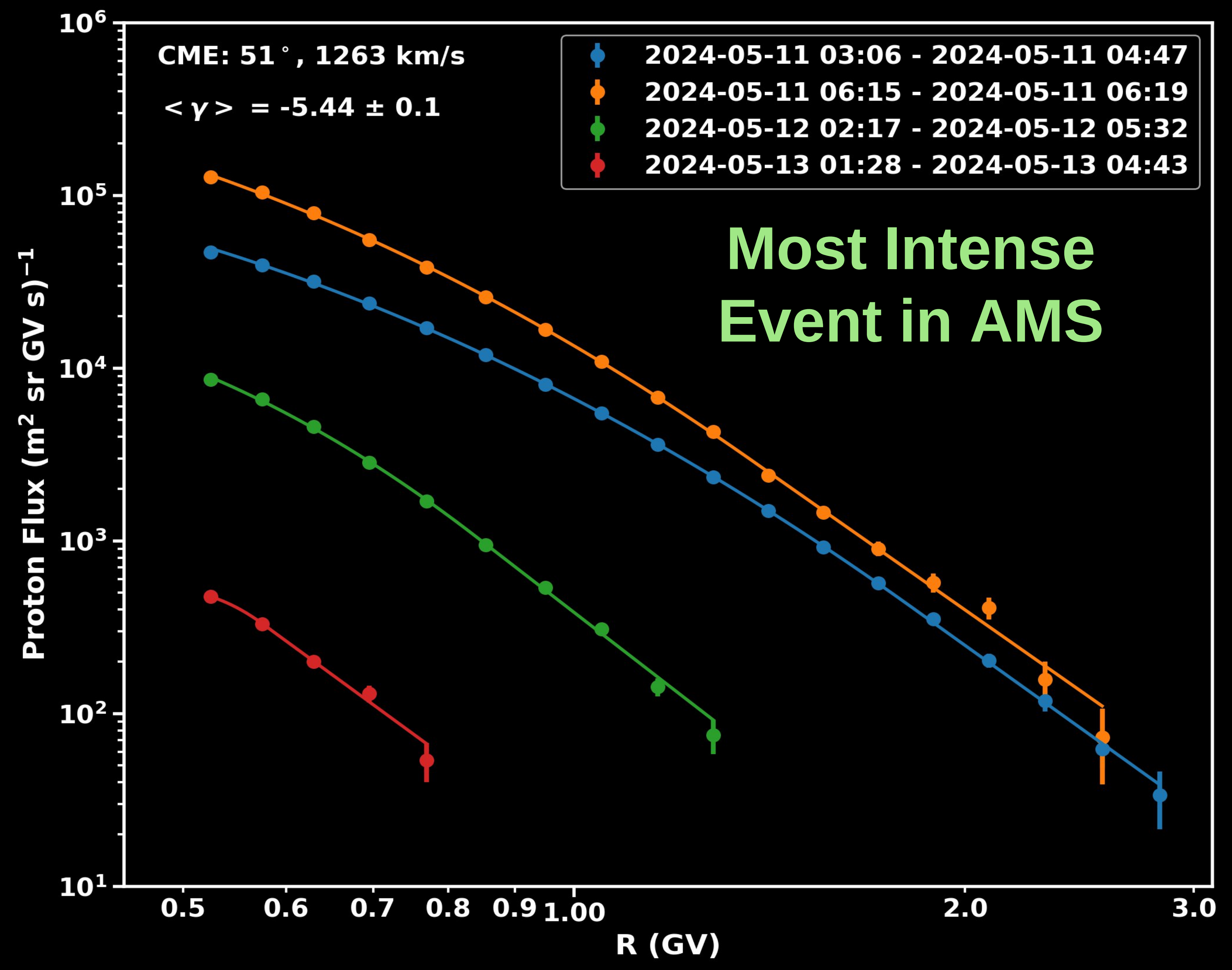
中国物理学会高能物理分会第十二届全国会员代表大会暨学术年会, 广州, 17-07-2026

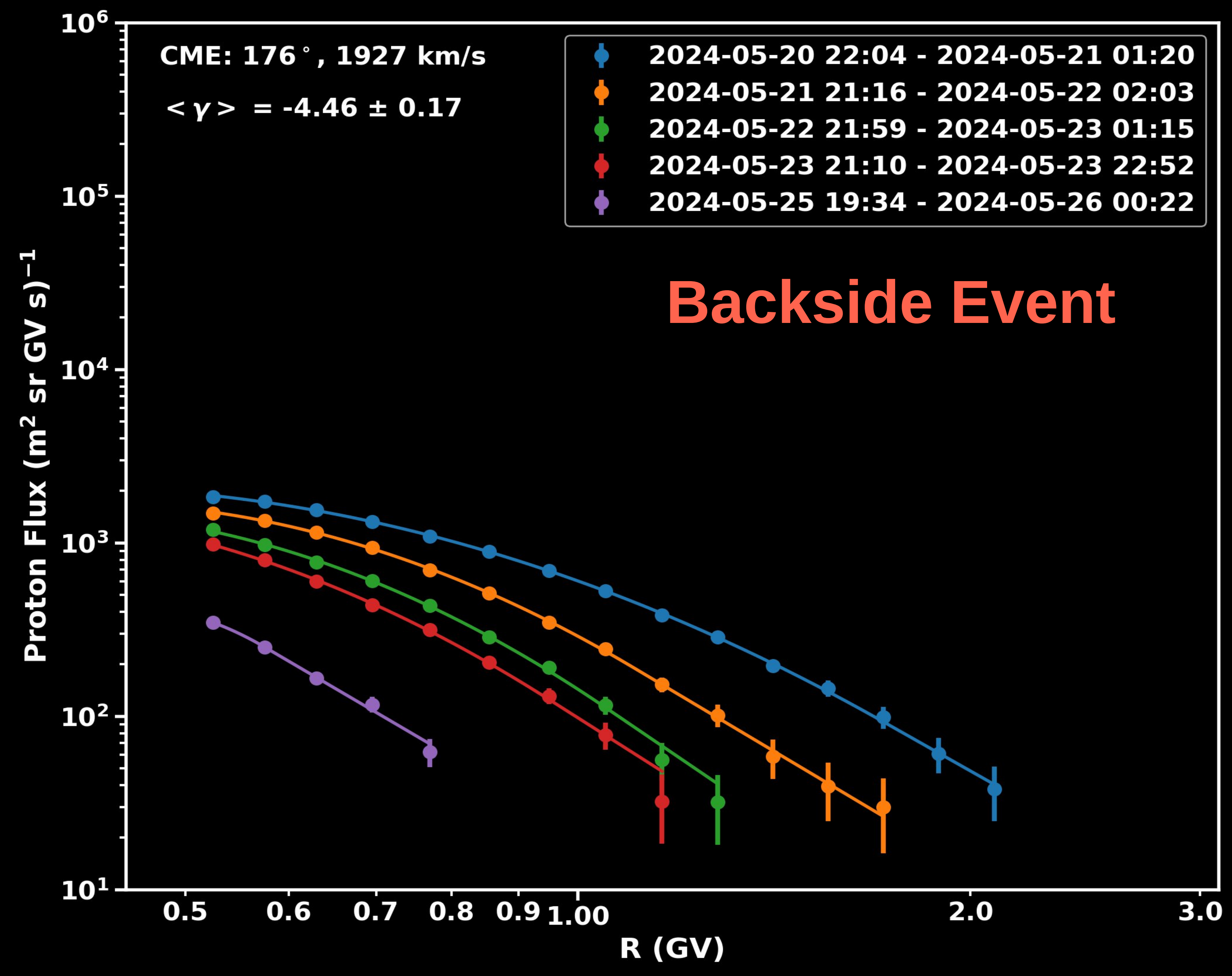
# Rigidity and Time Evolution of SEP Spectra

Most of the events show a **single power law** spectrum with some **“rollover”** at low rigidity.

Events in the **backside** last **longer** and with more **rollover**. A **time evolution is visible.**



# BACKUP

# Cosmic Ray Flux Definition



i = $i^{th}$ rig. interval

$$\Phi_i(t) = \frac{N_{selected,i(t)}}{\Delta R_i \cdot T_{exp,i(t)} \cdot A_{eff,i(t)}}$$

Rigidity = $\frac{\text{Momentum}}{\text{Charge}}$

$N_{selected}$ ⟶ Selected counts identifying proton events

$T_{exp}$ ⟶ Effective Exposure Time in seconds

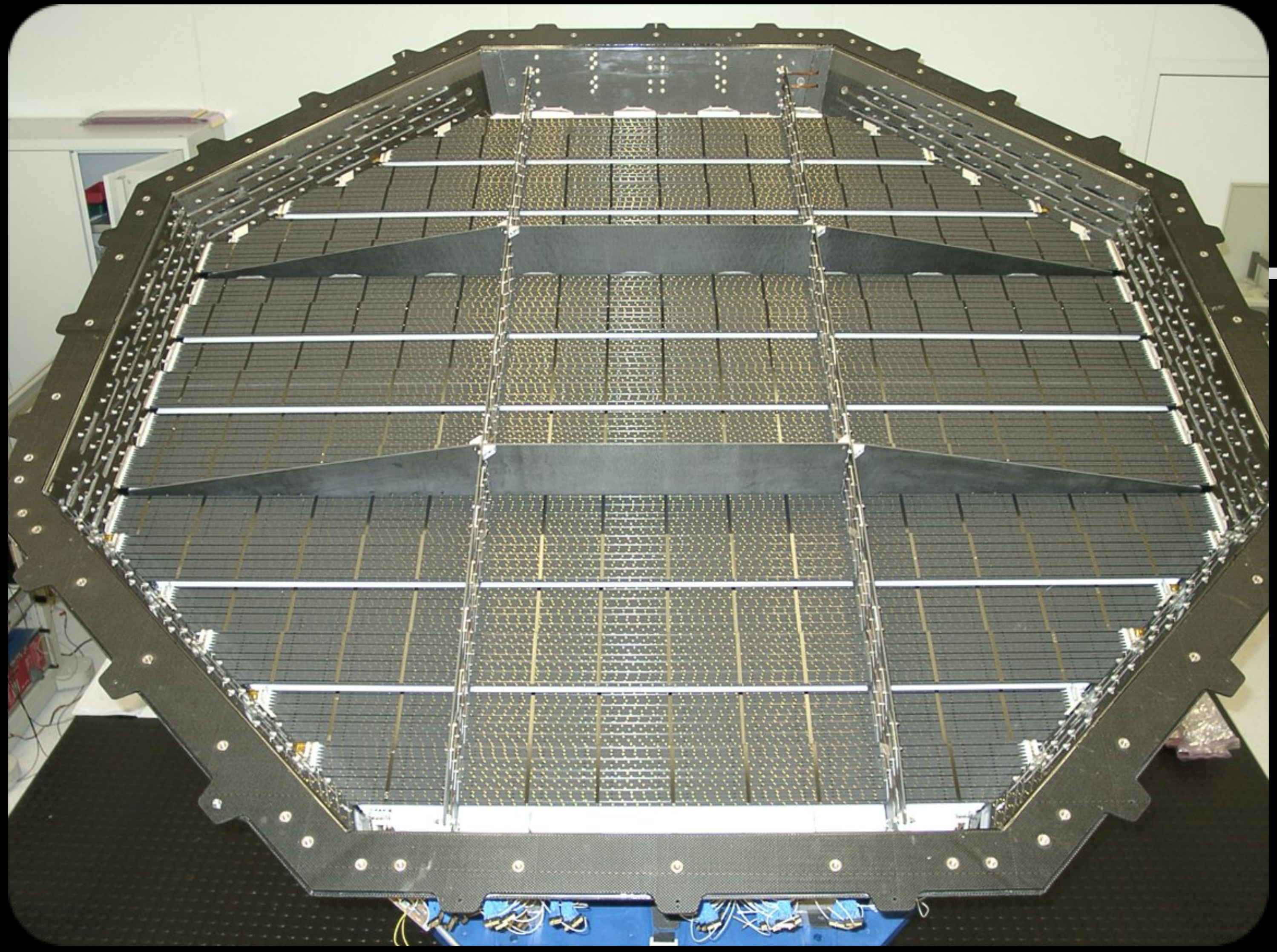
$A_{eff} = A_{MC} \cdot C_{tot}$ ⟶ Effective acceptance: Monte Carlo acceptance multiplied by the total correction

$C_{tot}$ ⟶ Total correction: product of all the DATA/MC corrections

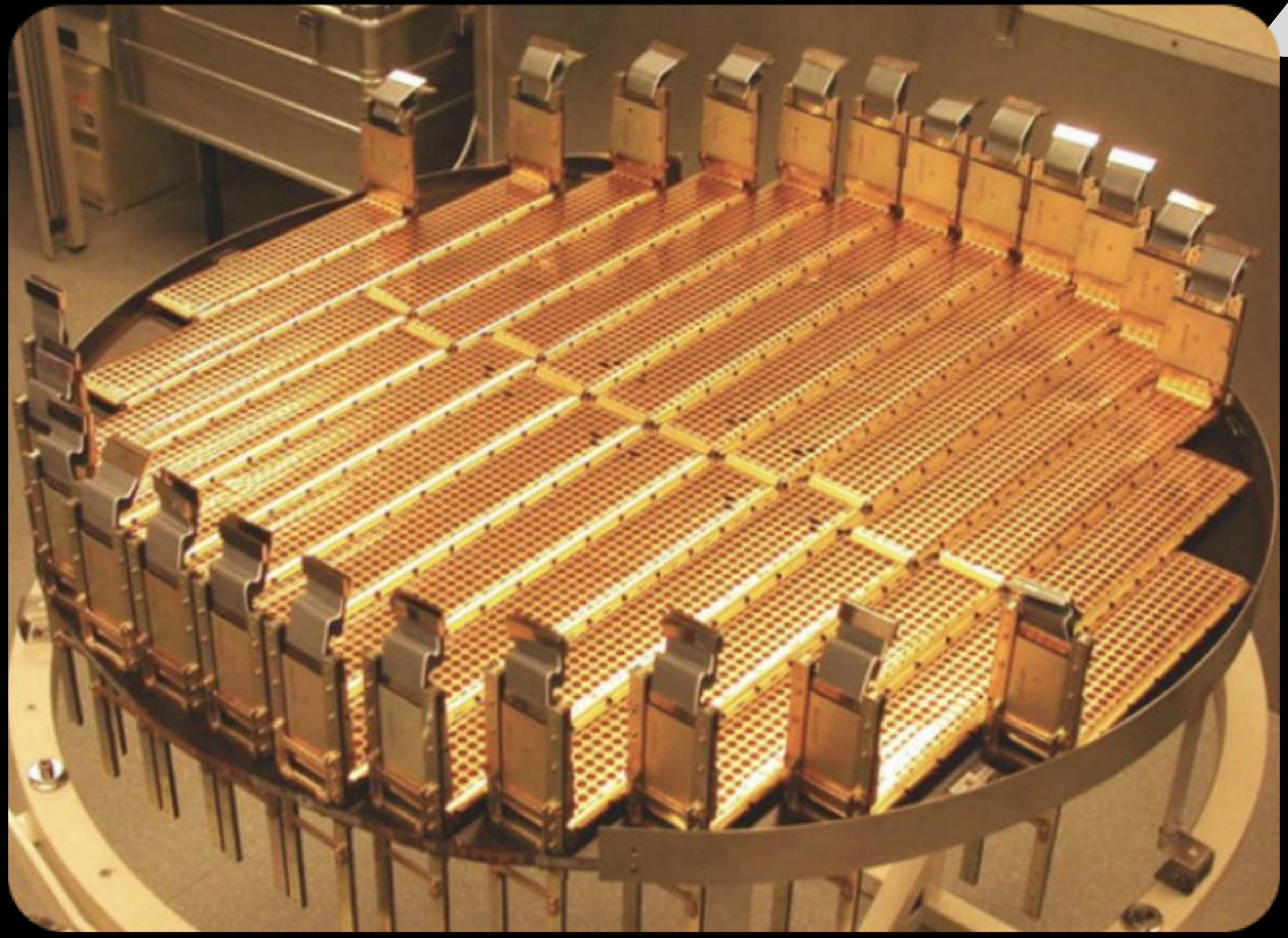
**DATA/MC corrections** are defined as the **ratio** between **efficiencies** over **on-flight data** and **Monte Carlo**.

# The AMS-02 Detector

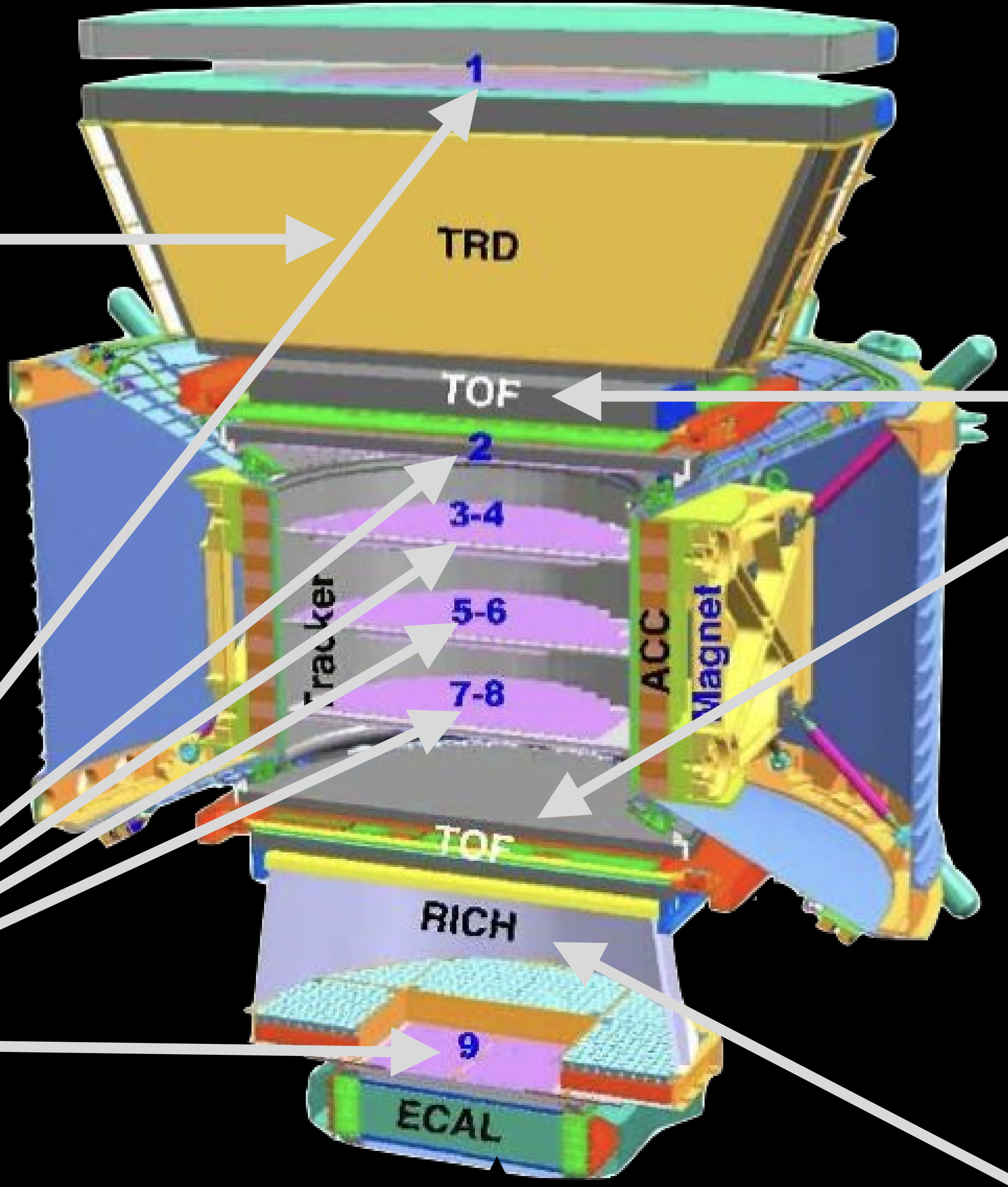
**Transition Radiation Detector** $e^+/e^-$ **id.**



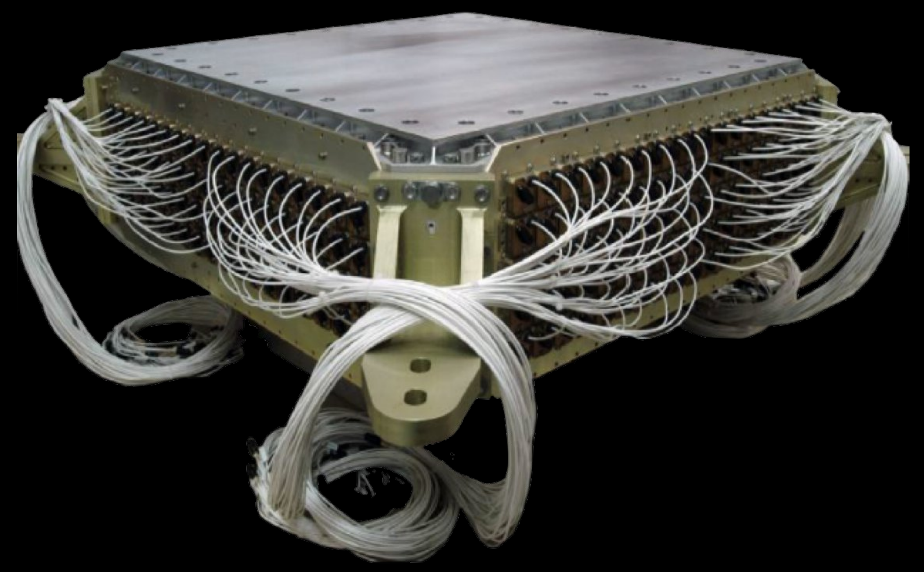
**Silicon Tracker Layer** **signed Z, R**



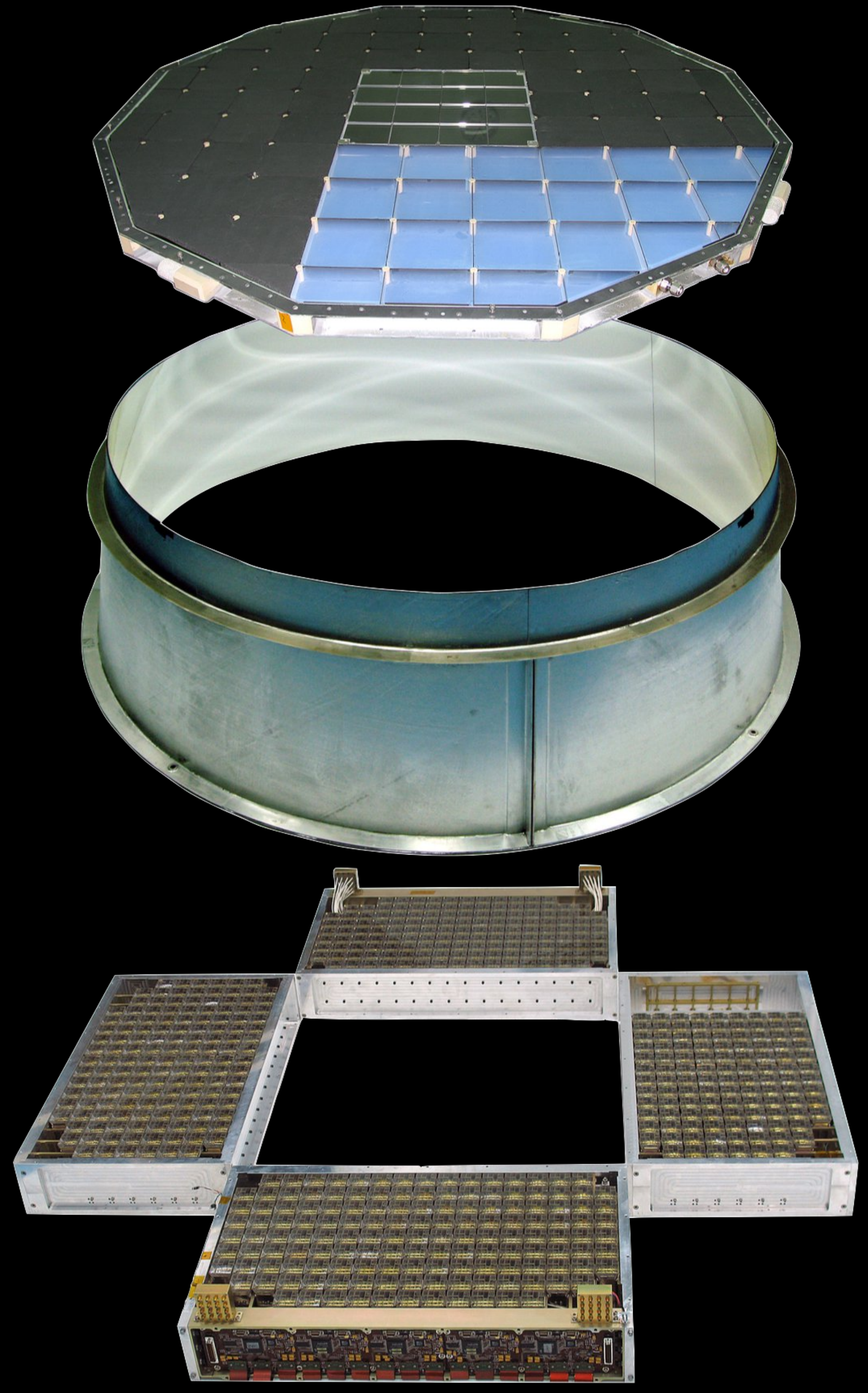
**Tracker Layer 0 in 2027**




**EM Calorimeter** **E of** $e^+/e^-$



**Time Of Flight System** **Z, β**

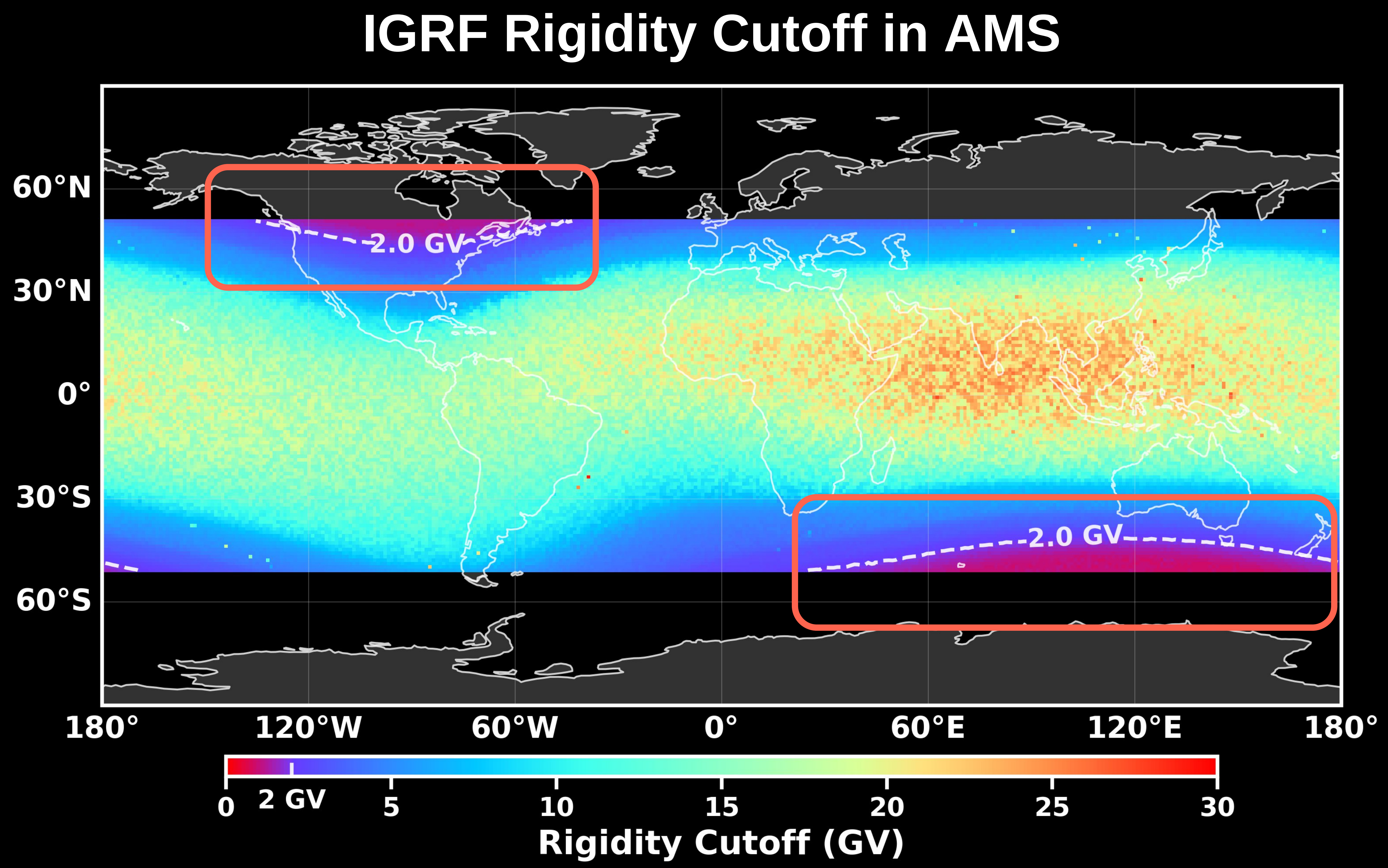


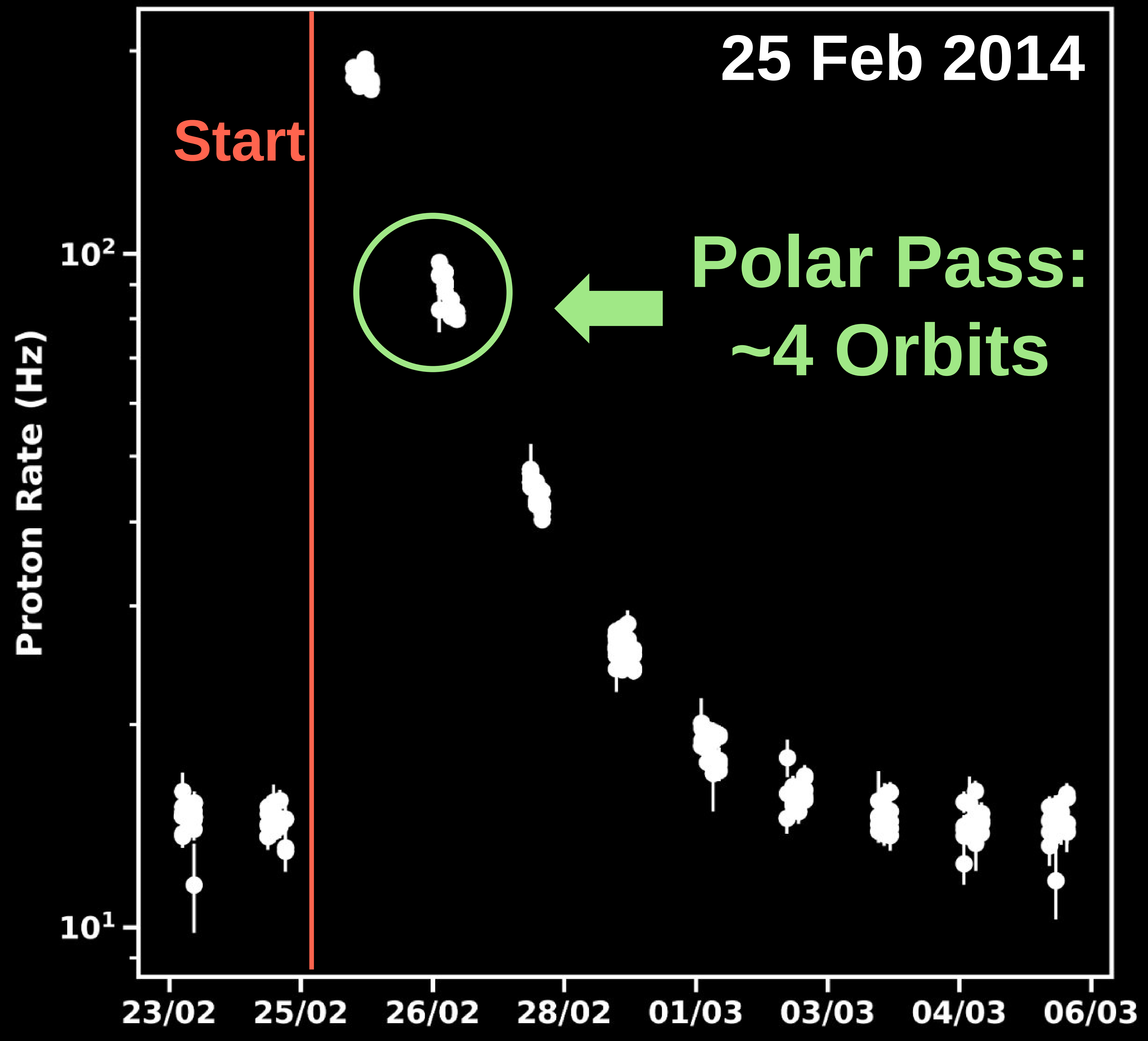
**Ring Imaging Cherenkov Detector**

**Z, β**

# AMS Exposure to SEP Events

AMS is **exposed to SEP** only for a **small fraction** of time, near **magnetic poles**, where the cutoff is low ($R_C$ < 2 GV).



# SEP Events Measured by AMS

CME: https://ccmc.gsfc.nasa.gov/tools/DONKI/

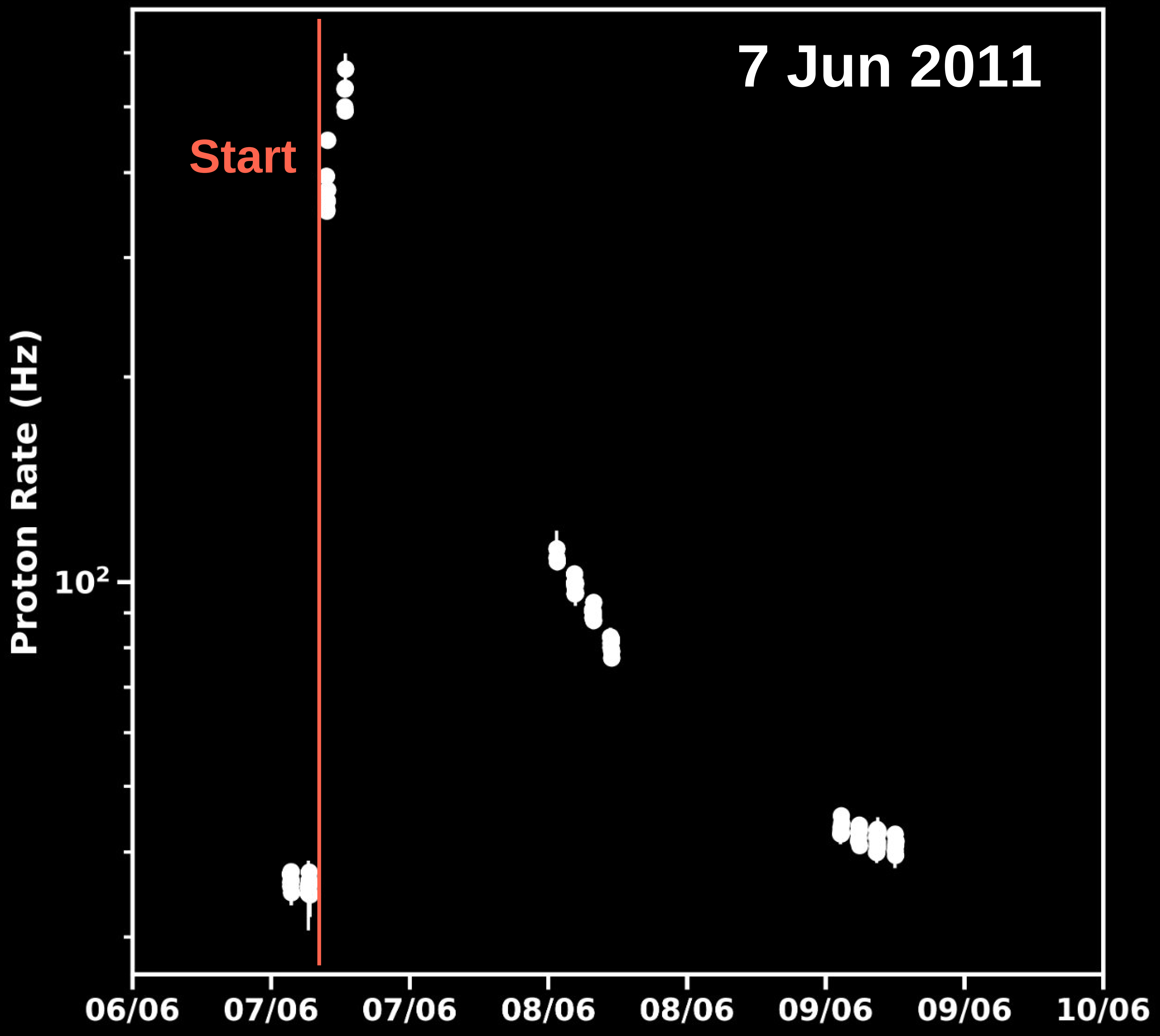


| # | Date | CME Lon Dir (°) | CME Vel (km/s) |
|---|---|---|---|
| 1 | 2011-06-07 | 52 | 1400 |
| 2 | 2011-08-04 | 40 | 1950 |
| 3 | 2011-08-09 | 62 | 1175 |
| 4 | 2011-09-06 | 15 | 300 |
| 5 | 2011-09-07 | 20 | 650 |
| 6 | 2011-09-23 | -90 | 1000 |
| 7 | 2011-11-04 | -160 | 1100 |
| 8 | 2012-01-23 | 26 | 2211 |
| 9 | 2012-01-28 | 75 | 2200 |
| 10 | 2012-03-07 | -23 | 1800 |
| 11 | 2012-03-14 | 43 | 2250 |
| 12 | 2012-05-17 | 75 | 1500 |
| 13 | 2012-07-07 | 65 | 1200 |
| 14 | 2012-07-08 | 90 | 1000 |
| 15 | 2012-07-19 | 94 | 1550 |
| 16 | 2012-07-23 | 144 | 3435 |
| 17 | 2012-09-28 | 30 | 1160 |
| 18 | 2012-11-08 | 176 | 1285 |
| 19 | 2013-03-06 | -135 | 1900 |
| 20 | 2013-04-11 | -25 | 675 |
| 21 | 2013-04-24 | 80 | 400 |
| 22 | 2013-05-23 | 80 | 1200 |
| 23 | 2013-09-30 | 38 | 1100 |
| 24 | 2013-10-11 | -106 | 780 |
| 25 | 2013-10-25 | -63 | 980 |
| 26 | 2013-10-28 | -10 | 900 |
| 27 | 2013-11-02 | 145 | 1078 |
| 28 | 2013-12-28 | 101 | 769 |
| 29 | 2014-01-06 | 102 | 1275 |
| 30 | 2014-01-08 | 30 | 2061 |
| 31 | 2014-02-25 | -78 | 1670 |
| 32 | 2014-04-18 | 10 | 1400 |
| 33 | 2014-09-02 | -120 | 1400 |
| 34 | 2014-09-11 | 10 | 1400 |
| 35 | 2014-09-25 | -170 | 1400 |
| 36 | 2015-10-29 | 95 | 390 |

| # | Date | CME Lon Dir (°) | CME Vel (km/s) |
|---|---|---|---|
| 37 | 2017-09-06 | 23 | 1238 |
| 38 | 2017-09-11 | 85 | 2650 |
| 39 | 2022-02-16 | -158 | 2554 |
| 40 | 2022-03-28 | 12 | 662 |
| 41 | 2022-03-30 | 40 | 808 |
| 42 | 2022-04-02 | 54 | 1370 |
| 43 | 2023-03-13 | -160 | 2127 |
| 44 | 2023-07-18 | 32 | 1388 |
| 45 | 2023-07-24 | 158 | 1411 |
| 46 | 2023-07-28 | 110 | 2000 |
| 47 | 2023-09-01 | 54 | 1142 |
| 48 | 2024-01-29 | 64 | 1277 |
| 49 | 2024-02-09 | 110 | 1754 |
| 50 | 2024-02-11 | 13 | 912 |
| 51 | 2024-02-12 | 148 | 3180 |
| 52 | 2024-02-14 | 168 | 2012 |
| 53 | 2024-02-16 | 87 | 681 |
| 54 | 2024-03-23 | 2 | 1613 |
| 55 | 2024-05-11 | 51 | 1263 |
| 56 | 2024-05-20 | 176 | 1927 |
| 57 | 2024-06-09 | 44 | 1106 |
| 58 | 2024-06-12 | 113 | 1312 |
| 59 | 2024-07-23 | 172 | 1299 |
| 60 | 2024-08-05 | 97 | 1095 |
| 61 | 2024-09-04 | 144 | 1247 |
| 62 | 2024-09-06 | 171 | 1329 |
| 63 | 2024-09-11 | 75 | 1452 |
| 64 | 2024-09-15 | -50 | 1070 |
| 65 | 2024-10-03 | 3 | 822 |
| 66 | 2024-10-09 | 8 | 1509 |
| 67 | 2024-10-27 | -54 | 1523 |
| 68 | 2025-01-05 | -58 | 1590 |
| 69 | 2025-02-24 | 29 | 1421 |
| 70 | 2025-05-31 | -9 | 1302 |
| 71 | 2025-10-22 | 135 | 1320 |

# Event Start Uncertainty






**Polar Pass:**
**4 Consecutive Orbits in the SEP Sensitive Region**

- **In some cases** AMS detects the **rising phase** of the SEP event, i.e. when the event begins within the “polar pass”.
- Even when the events begins inside the sensitive region, the **uncertainty on the event start** corresponds to $T_{ORBIT} / \sqrt{12}$ ($T_{ORBIT} \sim 90$ min).