Temporal Variation of The Charged Cosmic Ray Fluxes

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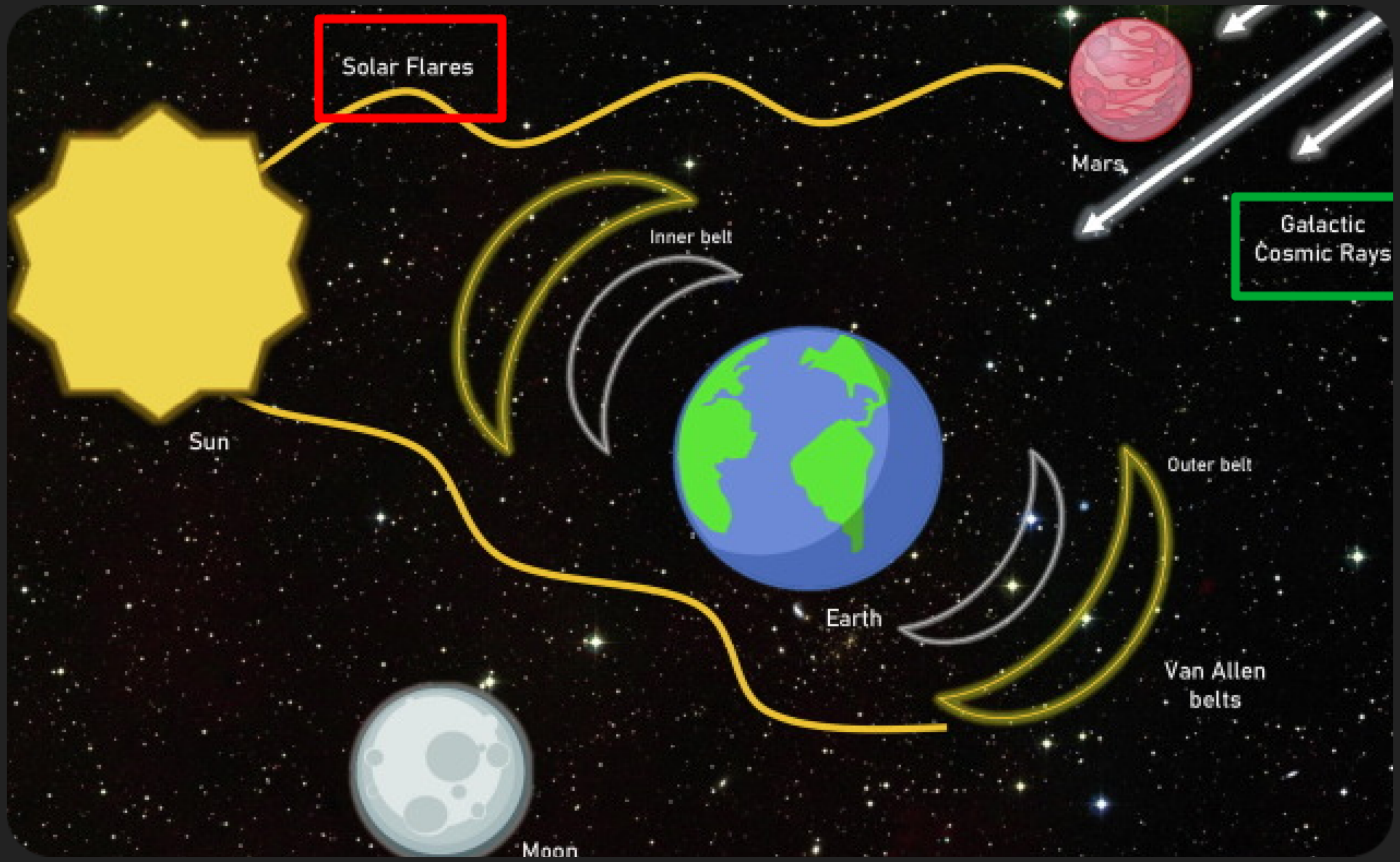
Tutors: Nicola Tomassetti, Valerio Vagelli

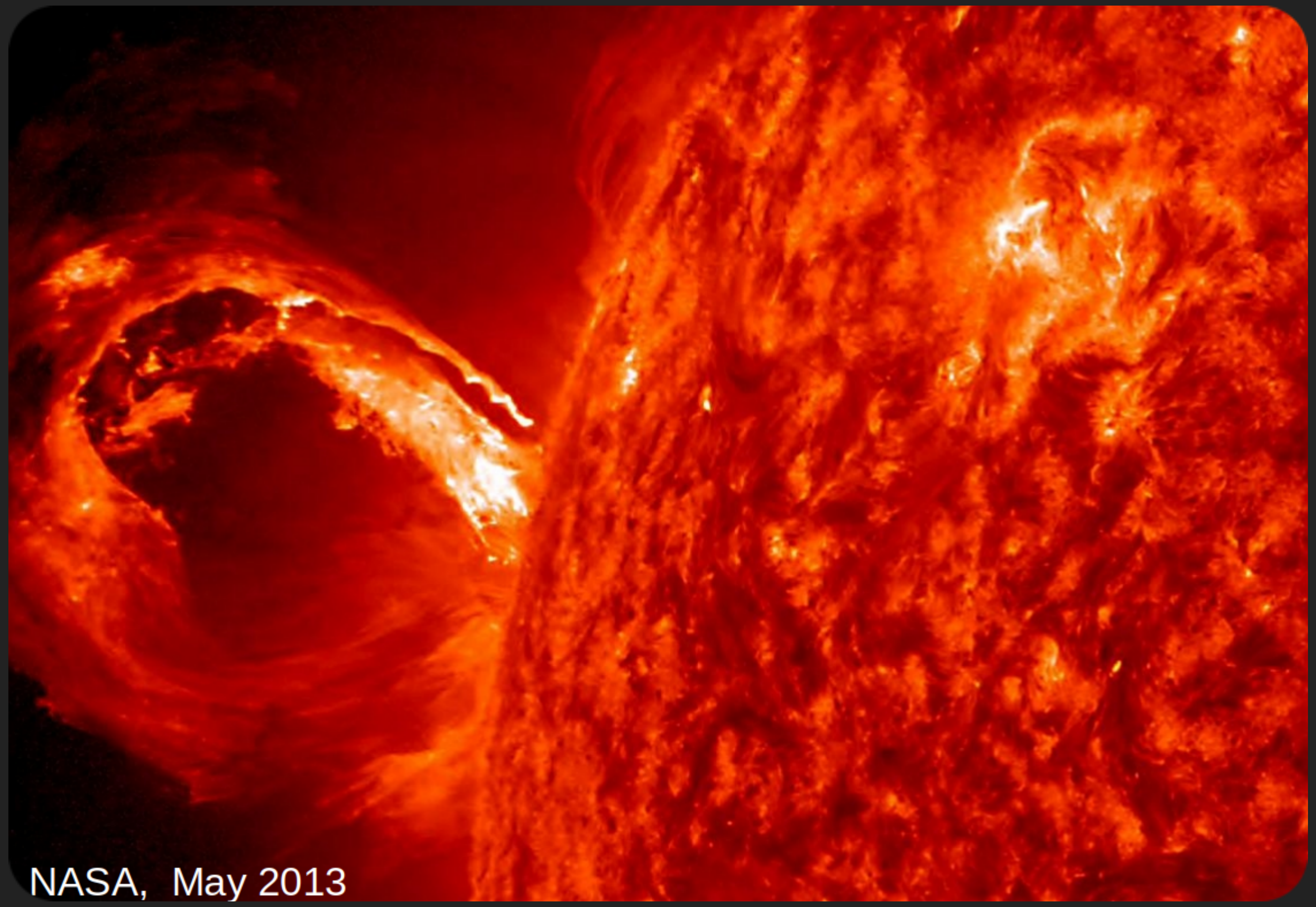
First Year PhD Report, XXXVII Cycle

28-10-2022

SOLAR ACTIVITY AND SPACE WEATHER

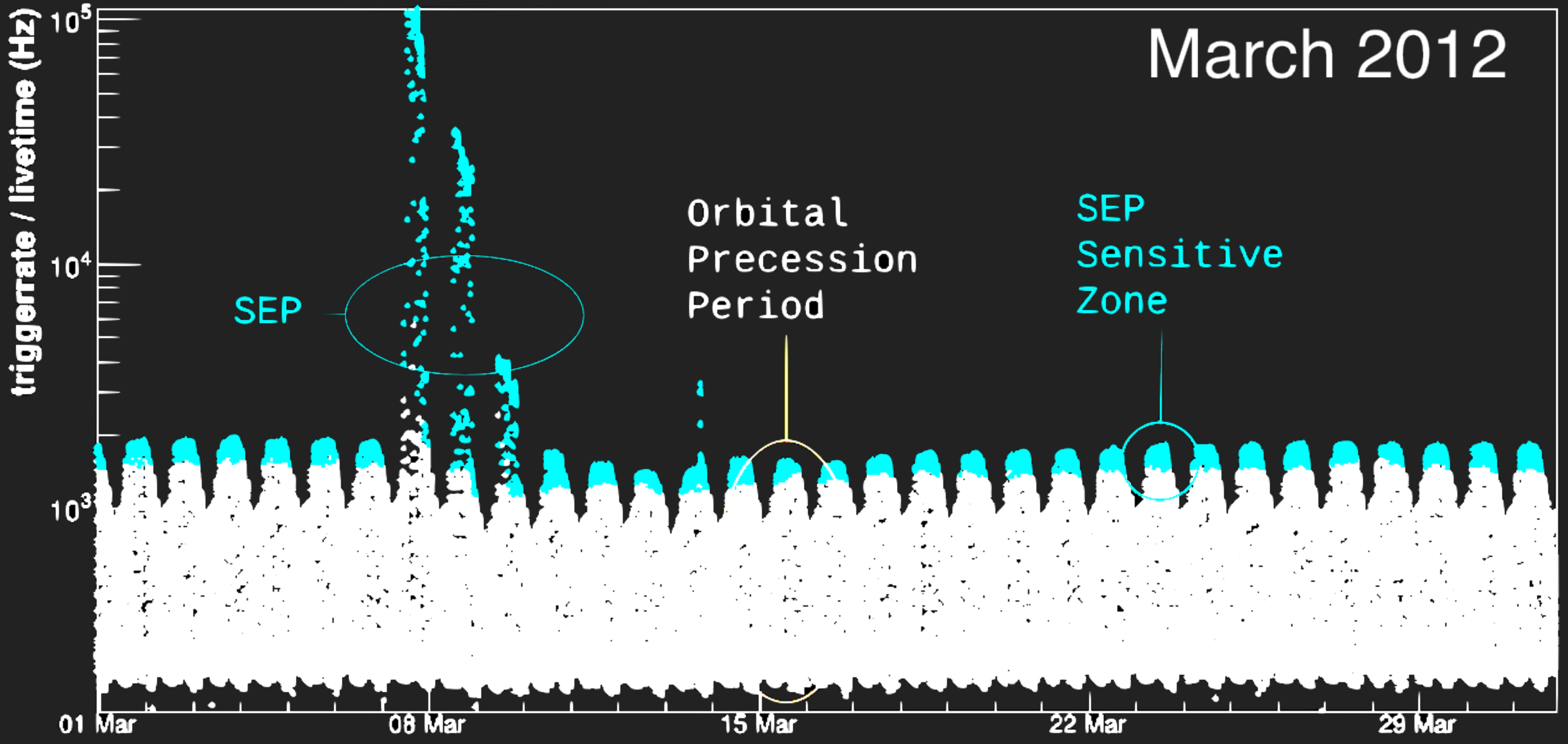
- The solar **activity cycle** has a period of 11 years, alternating between solar **minimum** and **maximum**
- On the Sun's surface **occasional** and **short duration** phenomena take place: **solar flares** and **CMEs**
- **Solar Energetic Particles (SEPs)** are emitted in these events
- **Space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





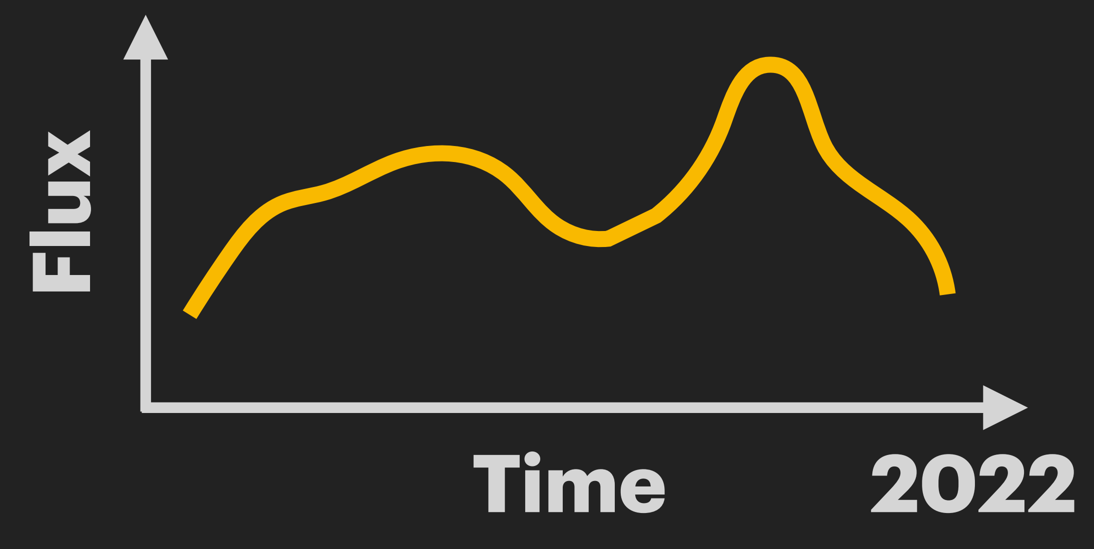
SPACE WEATHER WITH AMS

- **SEP Identification Algorithm** development based on AMS low latency **real-time data**, using the AMS analysis software, starting from the preliminary test on offline data ✔
- Algorithm reliability **test** and **implementation** at POCC, CERN — From November

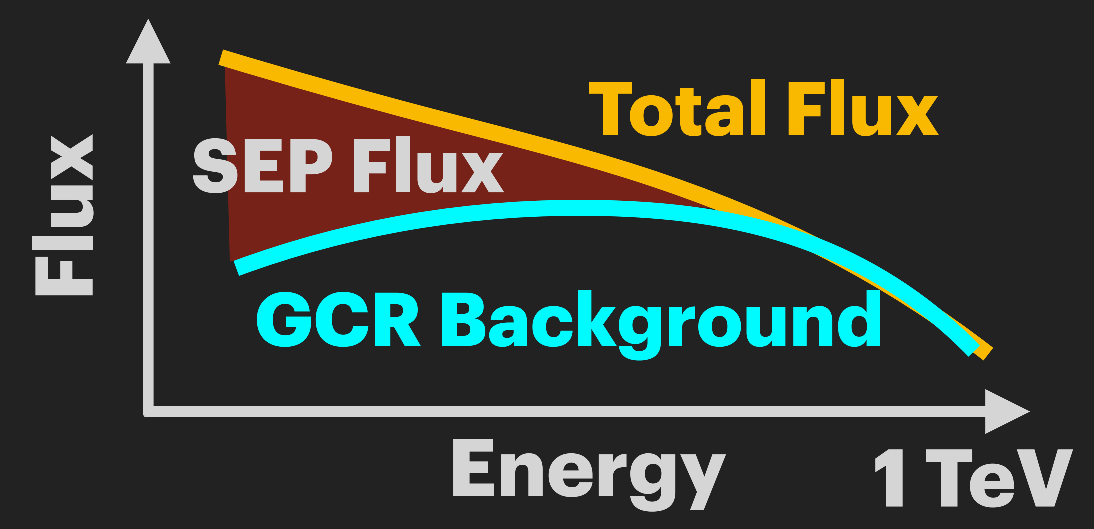


SCIENTIFIC OBJECTIVES

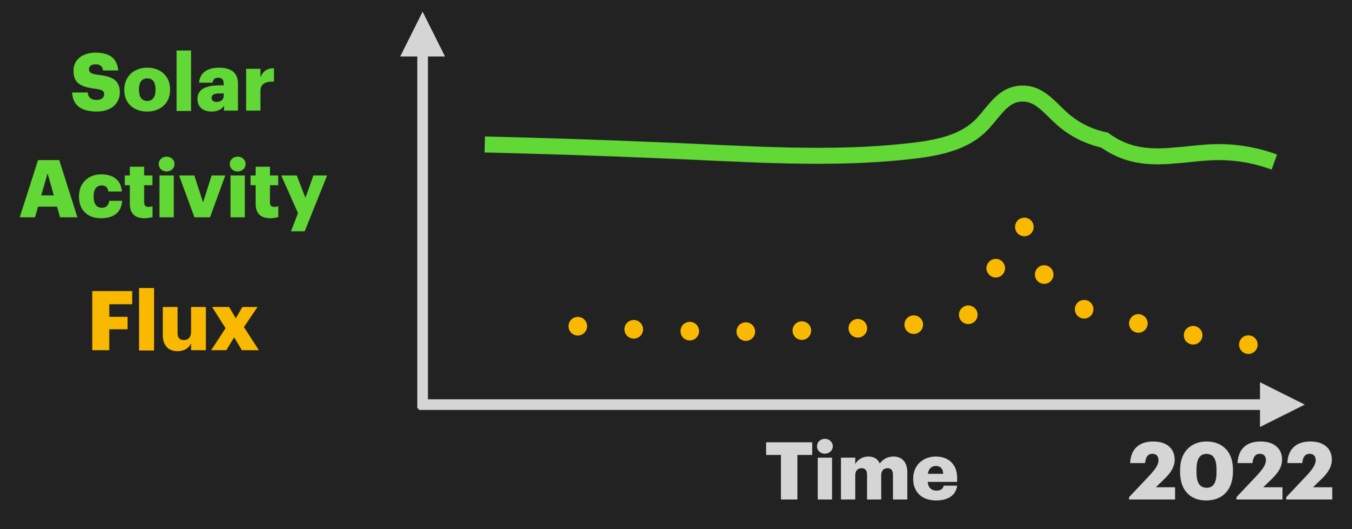
- Characterization of **temporal evolution** of the cosmic ray flux (on AMS data) in **quiet periods**, during **solar storms** and **follow-up**



- **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)



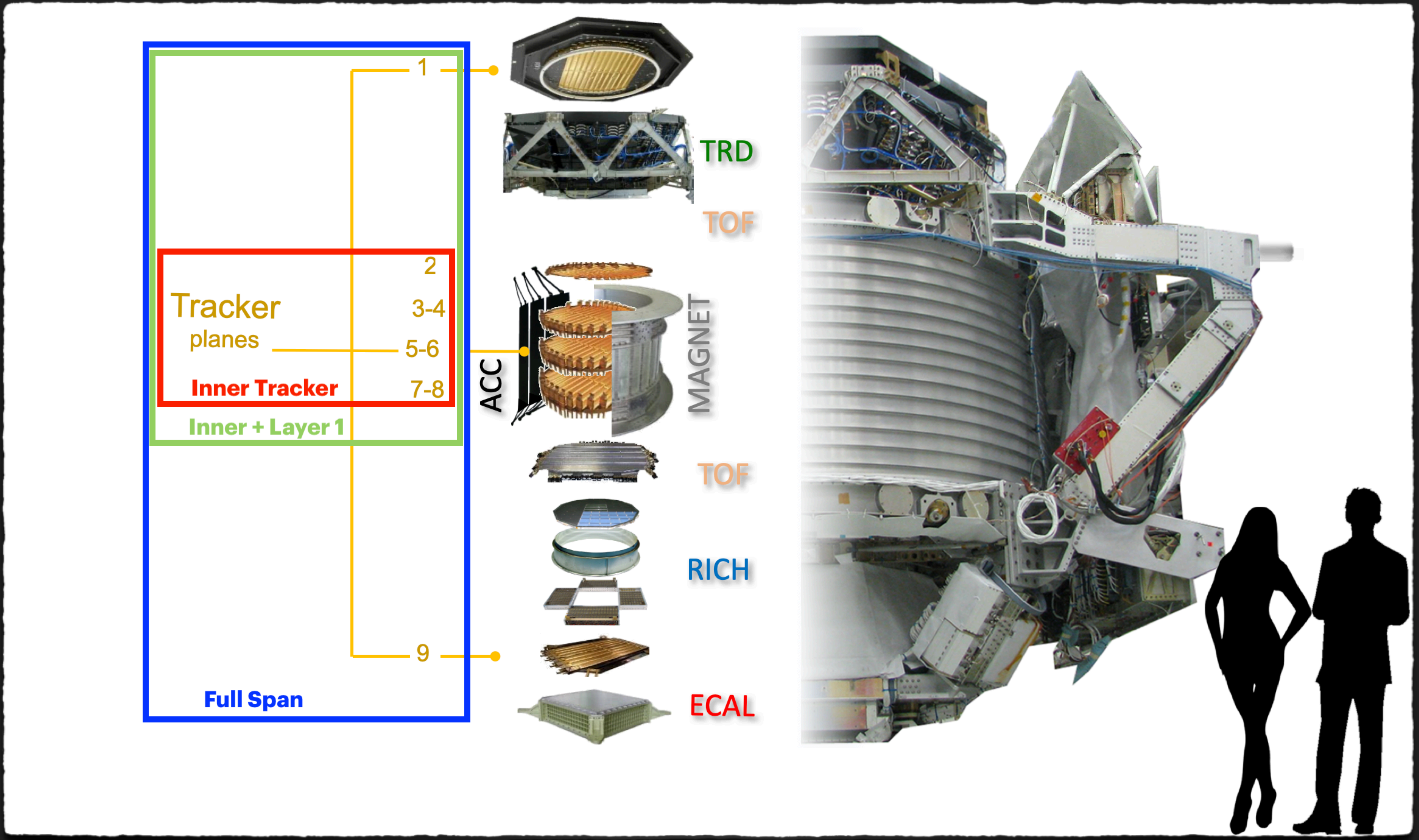
PROTON FLUX VS RIGIDITY

$$\Phi_i = \frac{N_{selected,i}}{\Delta R_i \cdot T_{exp,i} \cdot A_{eff,i} \cdot \epsilon_{trigg,i}} \qquad i = i^{th} rigidity\ interval$$

- $N_{selected}$ → Selected Counts relative to Proton events
- T_{exp} → Exposure Time in seconds
- A_{eff} → Effective Acceptance
- ϵ_{trig} → Trigger Efficiency

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

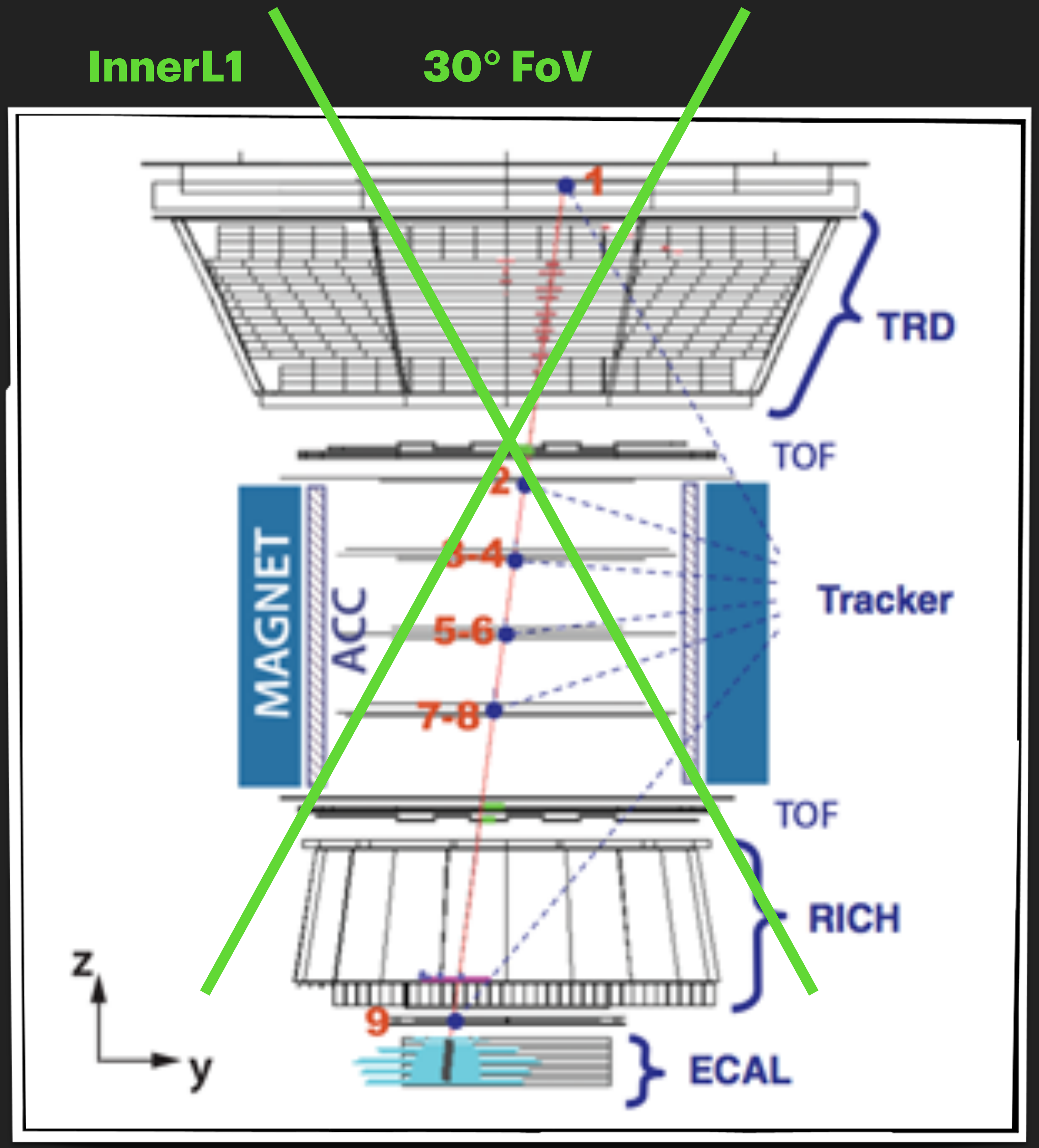
THE AMS-02 EXPERIMENT



EVENT SELECTION CUTS – COMMON ANALYSIS

Trigger: Any Physical Trigger	
Inner Tracker: Unitary charge - Hit on each layer - Track $\chi^2 < 10$	
Time of Flight: Unitary charge on Upper ToF - $\beta > 0.3$	
InnerLayer 1: Unitary charge - Hit on Layer 1 - Track $\chi^2 < 10$ - Fiducial Volume	

–> InnerL1 Counts



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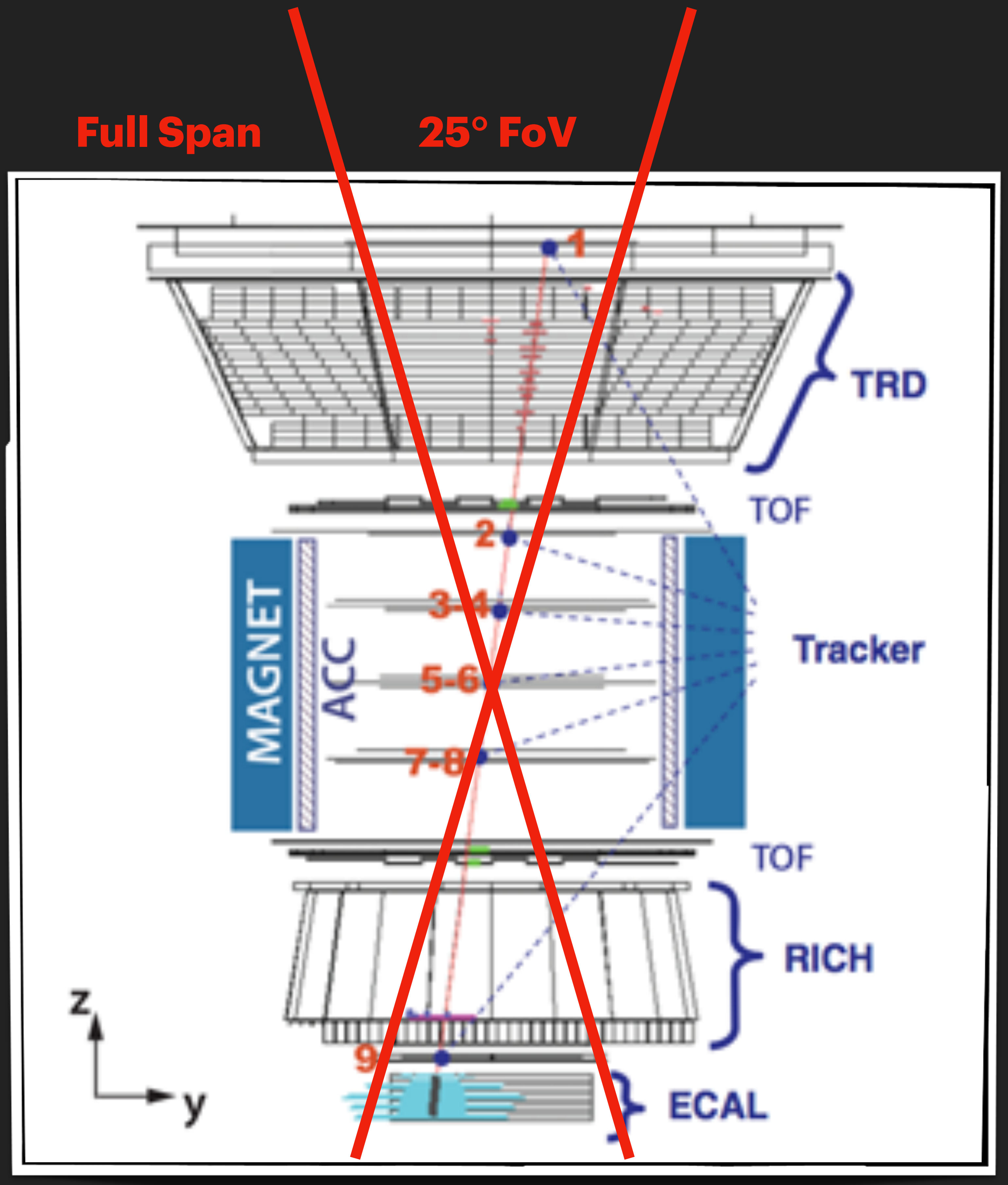
–> InnerL1 Counts

Full Span: Unitary charge - Hit on Layer 9 - Track $\chi^2 < 10$ - Fiducial Volume
Lower ToF: Unitary charge on Lower ToF

–> Full Span Counts



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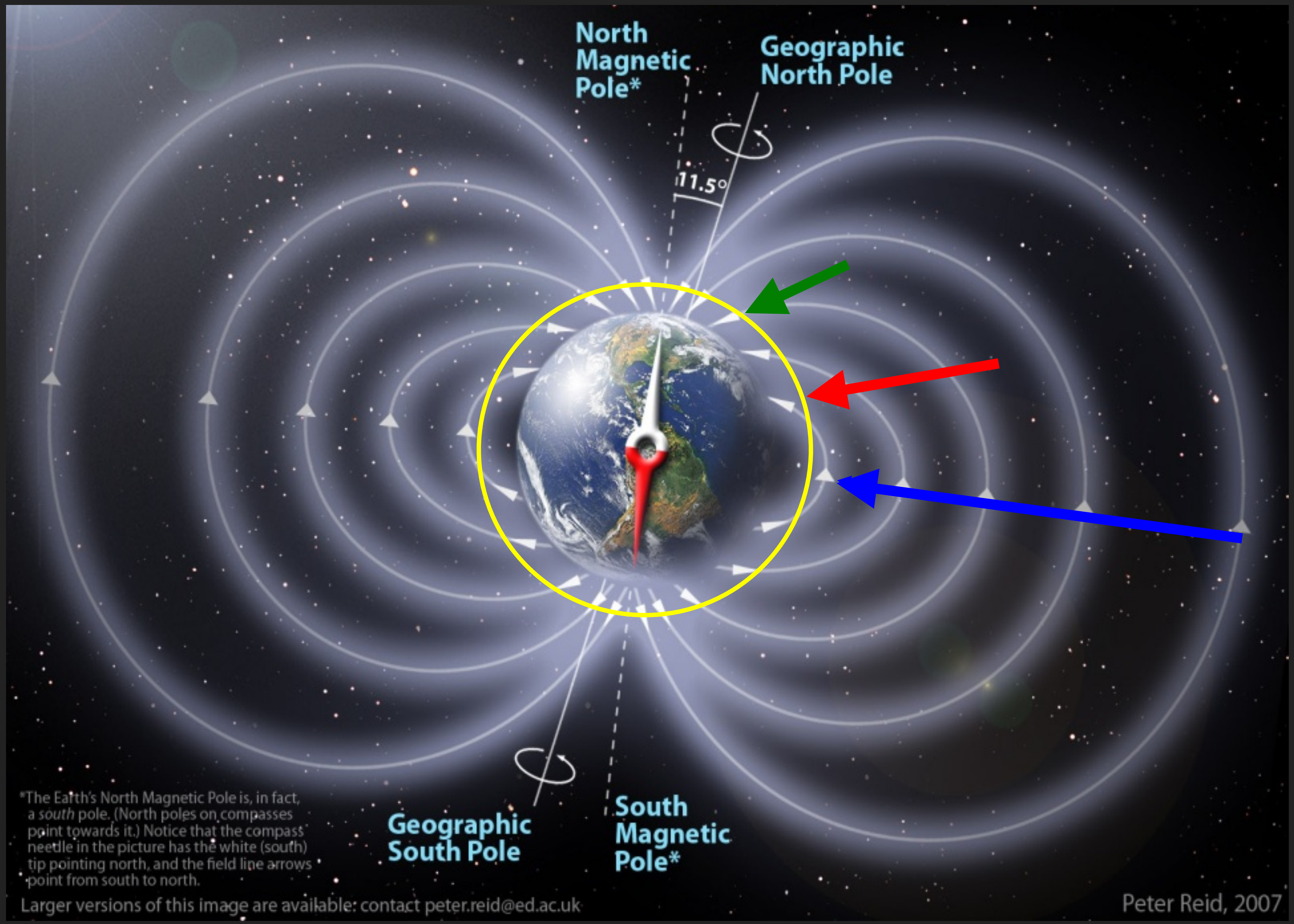
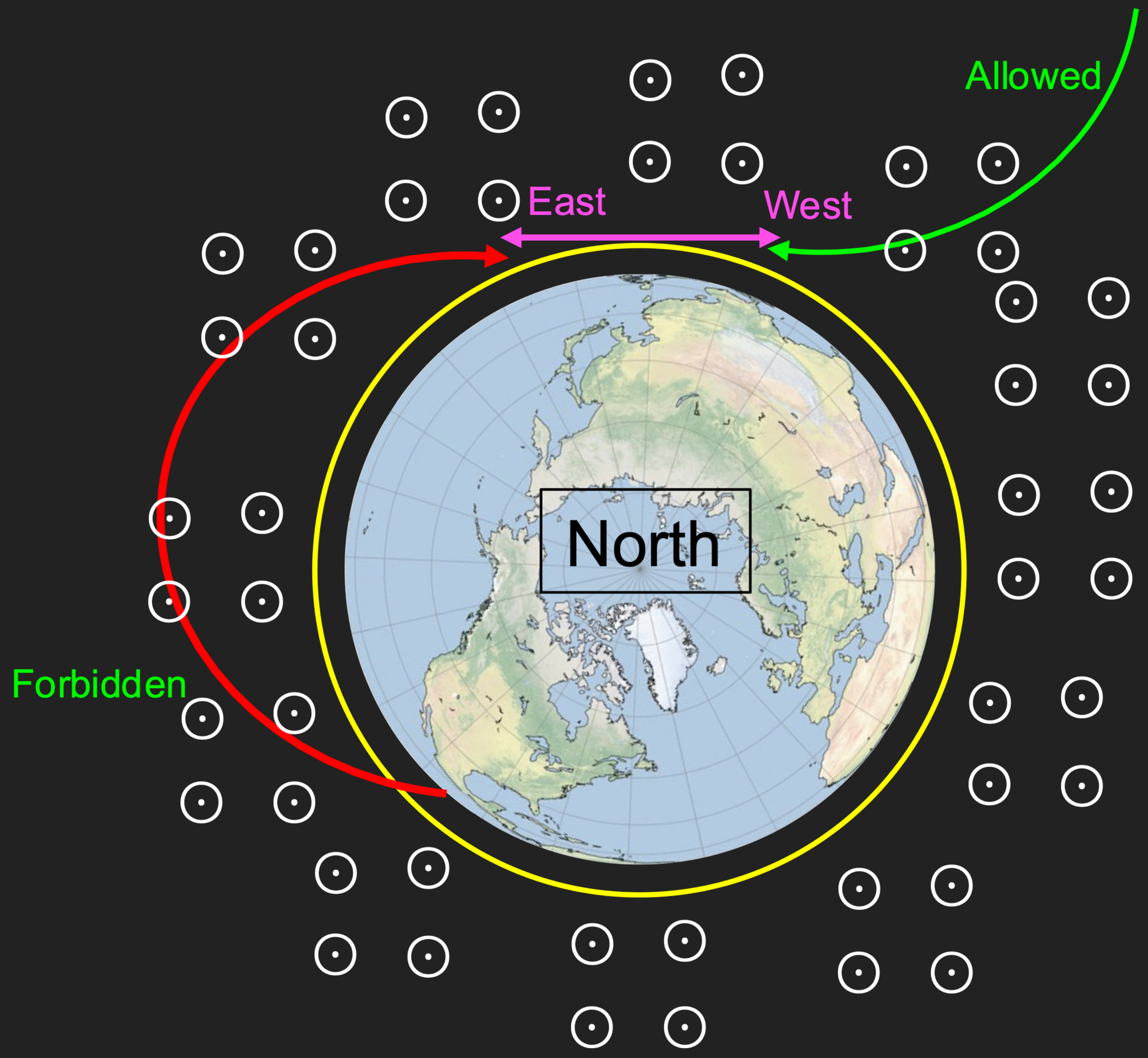
THE GEOMAGNETIC RIGIDITY CUTOFF

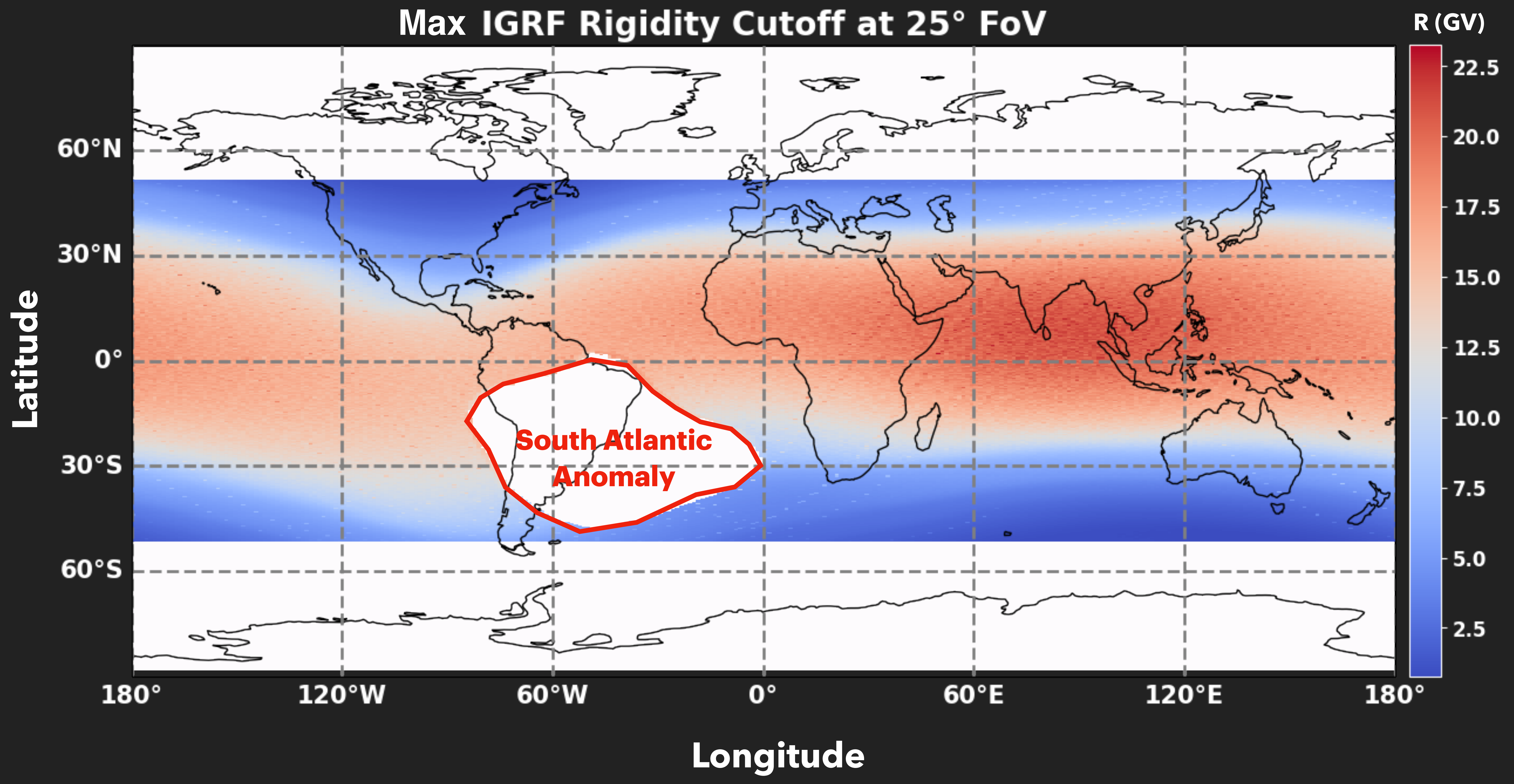
- Charged CRs are **deflected** by the geomagnetic field -> **minimum rigidity** required to reach Earth
- Geom. **Cutoff** depends on **position** and, at a given location, on **direction/charge** of incoming particle





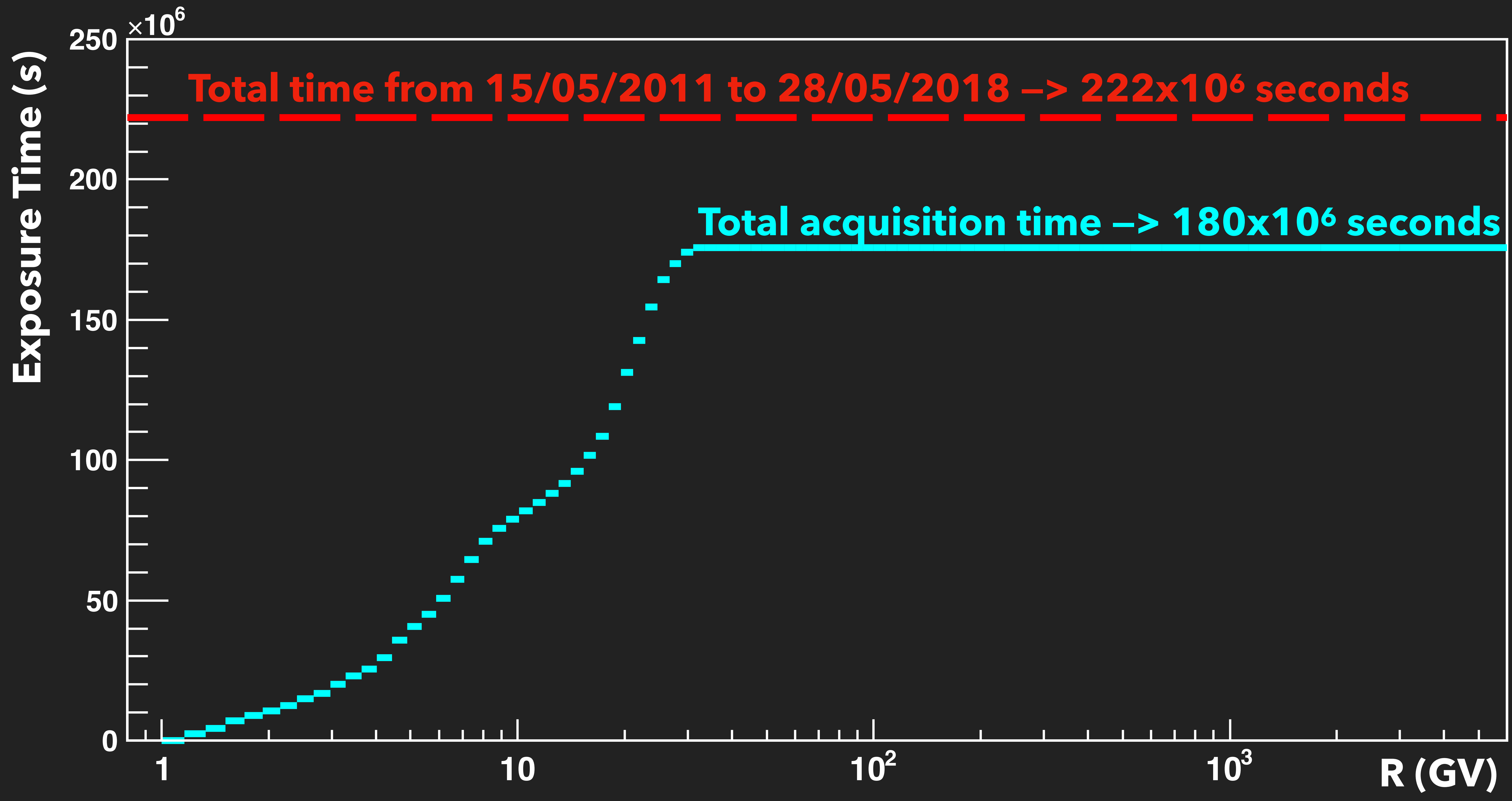
THE GEOMAGNETIC RIGIDITY CUTOFF

- The **Rigidity Cutoff** is lower near magnetic poles —> A lot of **low energy** particles reach Earth
- In the **South Atlantic Anomaly (SAA)** the **livetime** is almost **null** due to the intense flux



EXPOSURE TIME

- **Exposure Time: seconds**, weighted by the detector **livetime**, with rigidity above maximum **IGRF cutoff** in the AMS FoV (for each rigidity bin)
- The time with **detector not in nominal status** (calibration, ISS technical activities) or in the **SAA** are excluded from reconstruction



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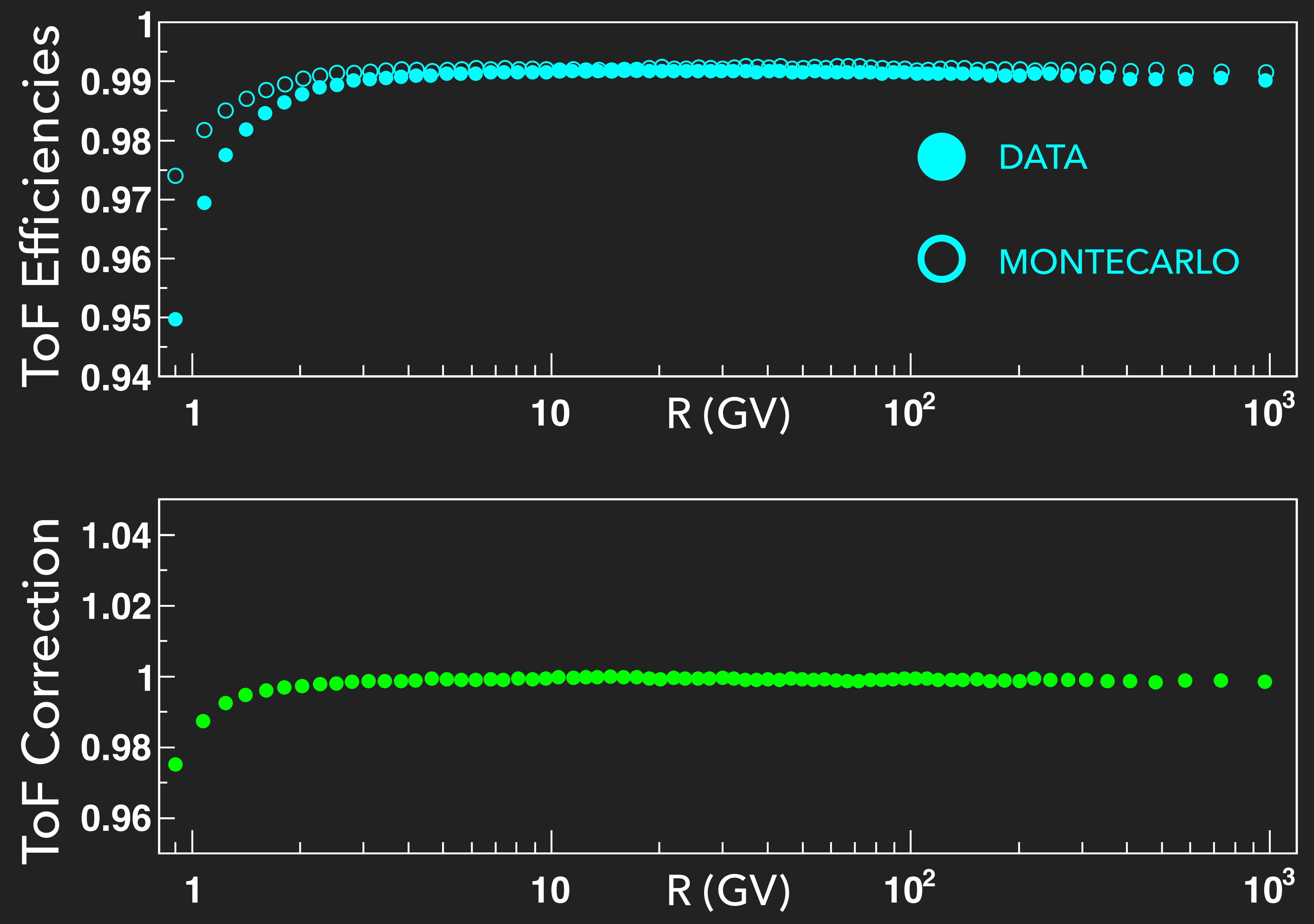
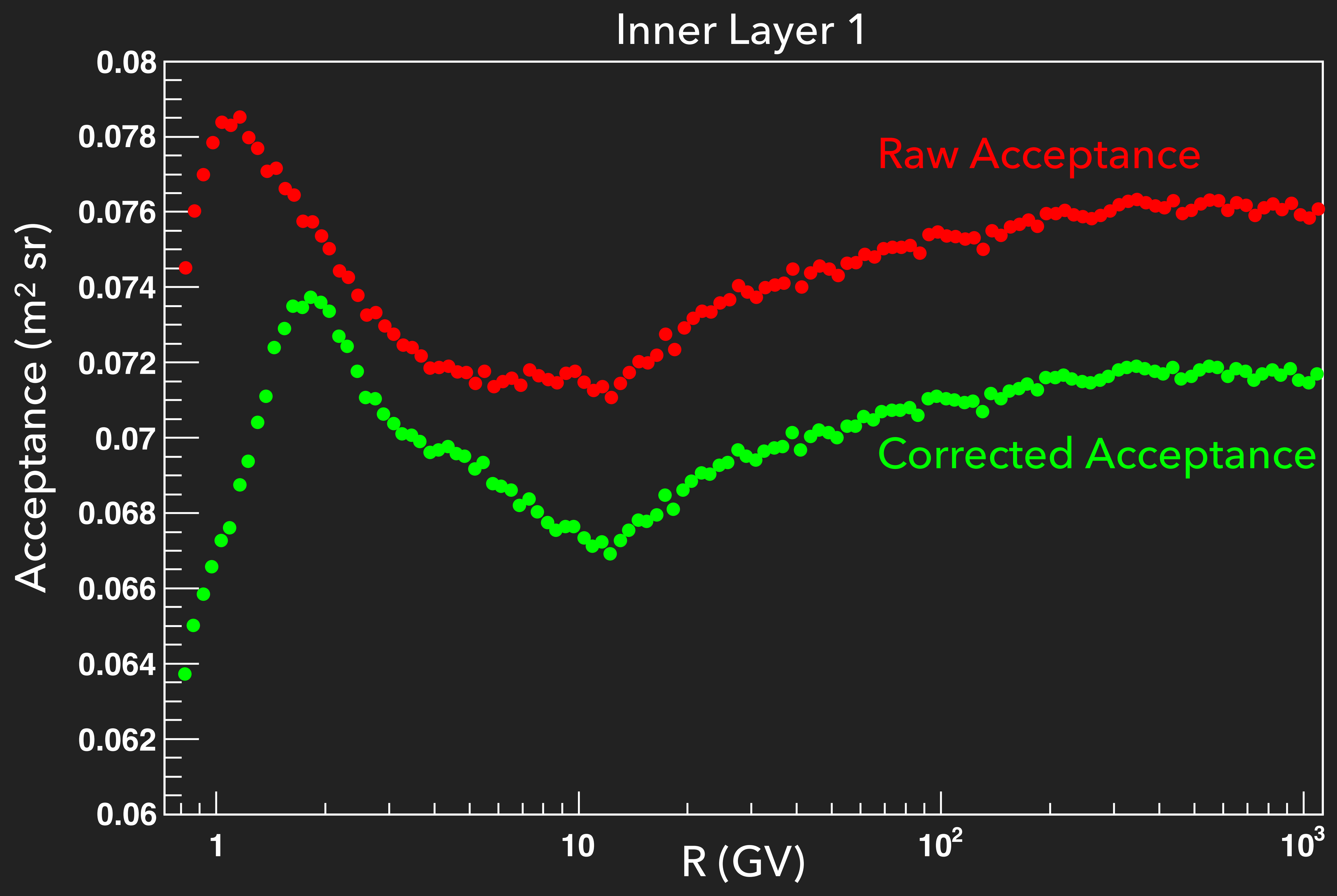
ACCEPTANCE CORRECTION

L1 Pickup Correction	L9 Pickup Correction	ToF Correction	Track Correction

Correction: efficiency on **DATA** / efficiency on **MONTECARLO**





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TRIGGER EFFICIENCY FOR PROTONS

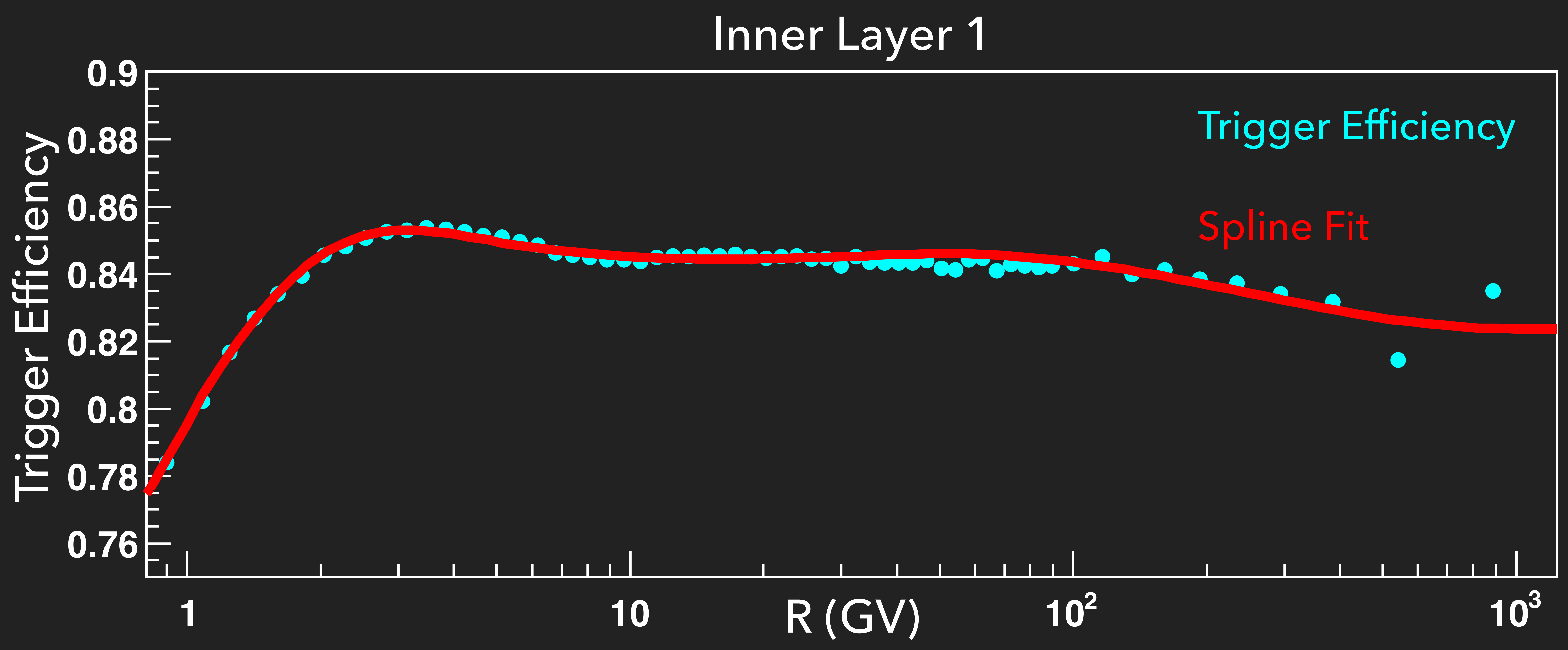
$$\text{Trigger Efficiency (After Proton Selection)} = \frac{\text{Any Physical Trigger}}{100^*(\text{Unbiased Charged} + \text{Unbiased EM}) + \text{Any Physical Trigger}}$$

There are seven types of trigger in AMS-02:

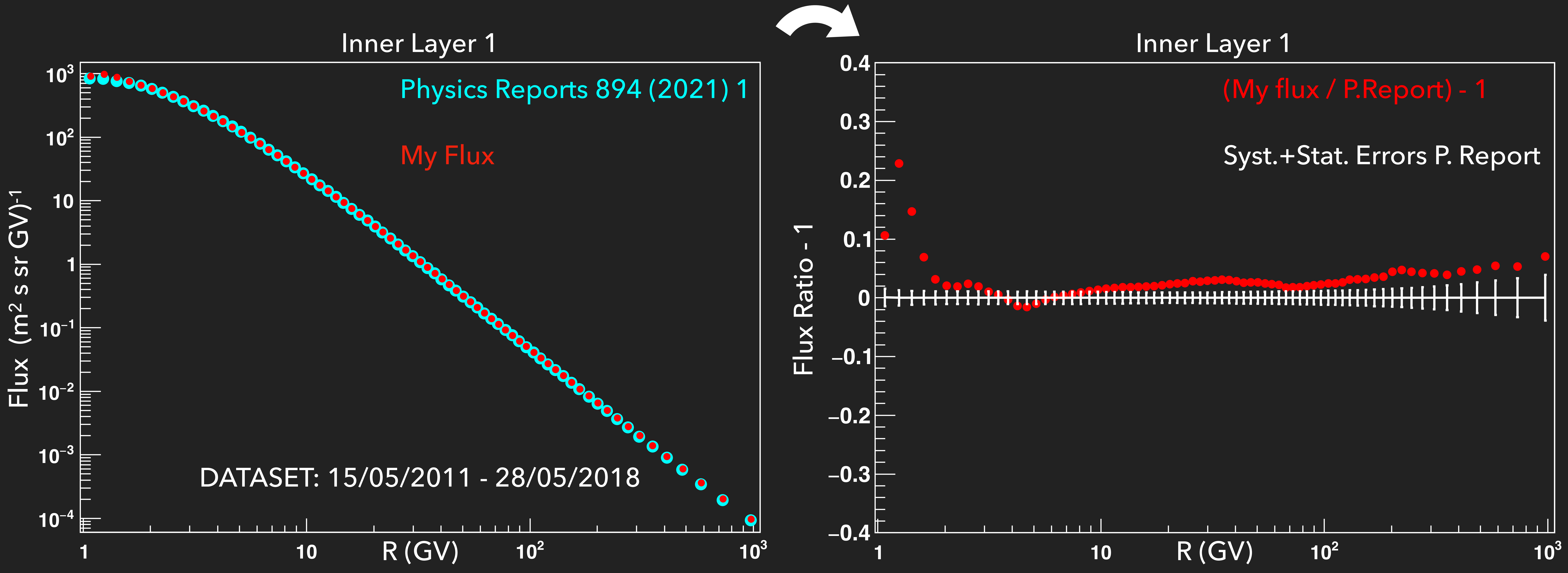
- LV1-0 "Unbiased Charged"
- LV1-1 "Single Charged"
- LV1-2 "Normal Ions Z>1"
- LV1-3 "Slow Ions Z>1"
- LV1-4 "Electrons"
- LV1-5 "Photons"
- LV1-6 "Unbiased EM"

Physics Triggers (LV1-1 to LV1-5)

Unbiased: only 1/100 is registered



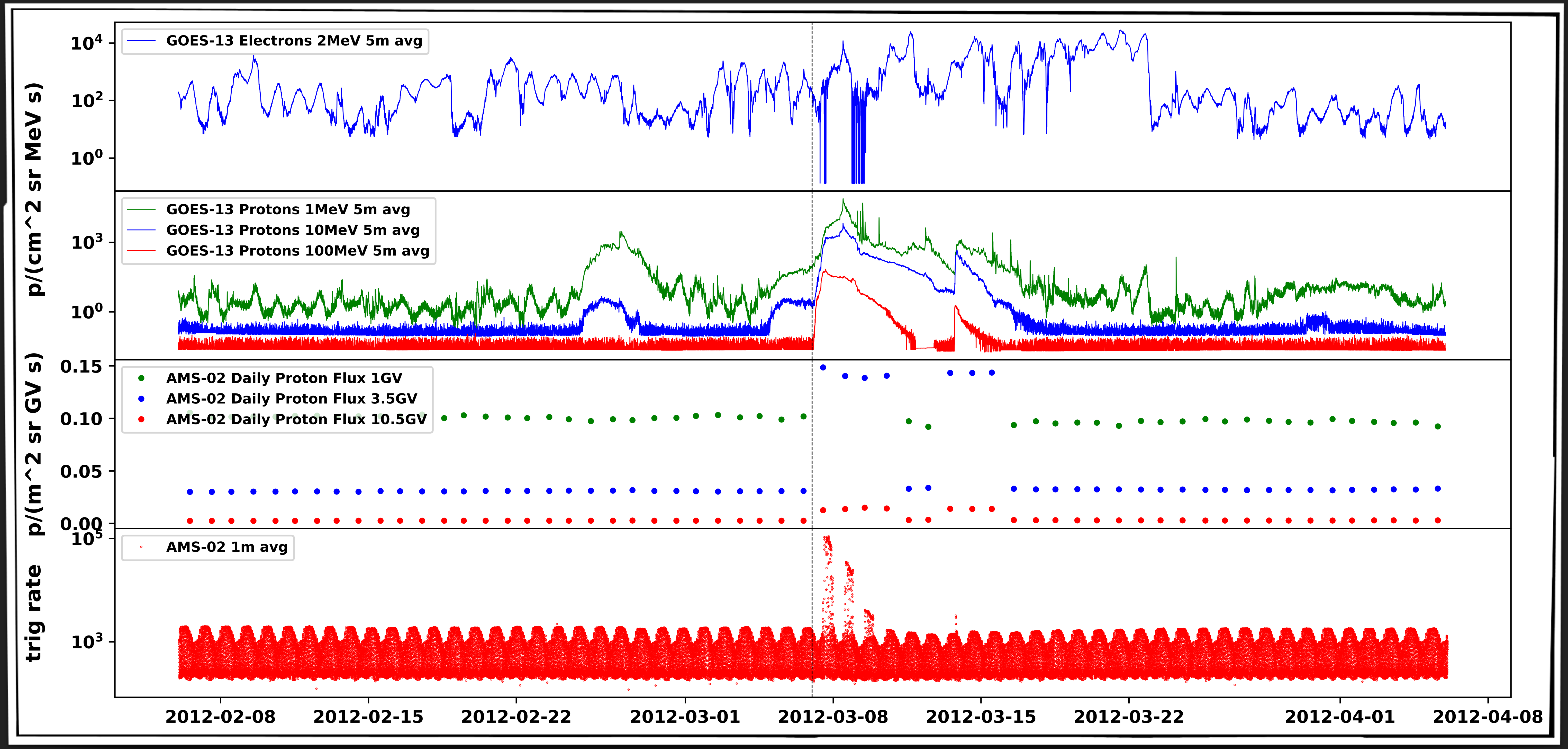
PROTON FLUX COMPARISON



- Different flux shape probably due to Unfolding (under investigation, wrong rigidity reconstruction in some Montecarlo events)

CAESAR PROJECT CONTRIBUTION

- Caesar has the objective of realizing the prototype of the scientific data centre for Space Weather of the the Italian Space Agency (ASI), called ASPIS (ASI SPace Weather InfraStructure)
- WP1210: multi-instrument real-time investigation of SEP events



AMS-02 MONITORING SHIFT ROLE

- The shift role is dedicated to the monitoring of crucial subsystems of the detector; every shifter covers 8 hours per day for 6 consecutive days
- I've been trained to the TEE shifter role (Tracker, TRD and ACC) and contributed for a total of 21 shifts

SCHOOLS, CONFERENCES, PHD COURSES

PhD Courses

- "Nanosystems 2", F. Ripanti
- "Introduction to Space Physics", N. Tomassetti
- "Teaching and Learning Physics", G. Organtini

Schools

- "INFN School of Statistics 2022", 15 - 20 May 2022, Paestum

Conferences

- "SIF 2021, 107° Congresso Nazionale", 13 - 17 September 2021, Online
- "Secondo Congresso Nazionale SWICo", 9 - 11 February 2022, ASI Roma
- "SIF 2022, 108° Congresso Nazionale", 12 - 16 September 2022, Milano

PUBLICATIONS

Comunicazione tra le menzioni speciali del 107°congresso SIF, che ha permesso la pubblicazione su “Il Nuovo Cimento C”

IL NUOVO CIMENTO **45 C** (2022) 79
DOI 10.1393/ncc/i2022-22079-6

COMMUNICATIONS: SIF Congress 2021

Real time monitoring of the radiation environment on the ISS with AMS-02

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Dipartimento di Fisica e Geologia, Università degli Studi di Perugia - Perugia, Italy

received 30 January 2022

Proceeding contributo SWICo 2022, in fase di reviewing su “Rendiconti Lincei - Springer Nature”

Real time monitoring of Solar Energetic Particles outside the ISS with the AMS-02 instrument

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Summary

- **Main analysis**: the proton flux with respect to rigidity, for the whole time period considered in the analysis, is under construction

- **Future work**: once the rigidity flux is fixed, it will constitute the basis for the temporal flux and the SEP-only rigidity flux construction

- **Other**: Caesar Project contributions, shift role for AMS-02, three contributions at conferences, one summer school attended