Daily Proton Flux and SEP Analysis

Francesco Faldi, PhD student in Perugia
Tutors: Nicola Tomassetti, Valerio Vagelli

AMS-Italia, Trento

30-11-2023

LOW-ENERGY MEETING

AMS-lowenergy

Friday 10 Nov 2023, 11:00 → 17:00 Europe/Zurich

Videoconference

zoom AMS-lowenergy — Join

11:30 → 11:35 **Paper Draft** — 5m

11:35 → 11:40 **Aachen** — 5m

Speakers: Fabian Machate (Rheinisch Westfaelische Tech. Hoch. (DE)), Leila Ali Cavasonza (Rheinisch Westfaelische Tech. Hoch. (DE))

11:40 → 12:00 **Bologna** — 20m

Speaker: Alberto Oliva (Universita e INFN, Bologna (IT))

12:00 → 12:20 **Canary Island** — 20m

Speaker: Alejandro Reina Conde (Universita e INFN, Bologna (IT))

12:20 → 12:40 **CIEMAT** — 20m

Speakers: Carmen Maria Gamez Lopez (CIEMAT - Centro de Investigaciones Energéticas Medioambientales y Tec. (ES)), Javier Berdugo Perez (CIEMAT - Centro de Investigaciones Energéticas Medioambientales y Tec. (ES)), Jorge Casaus (CIEMAT - Centro de Investigaciones Energéticas Medioambientales y Tec. (ES)), Miguel Angel Velasco Frutos (CIEMAT - Centro de Investigaciones Energéticas Medioambientales y Tec. (ES))

12:40 → 13:00 **Hawaii** — 20m

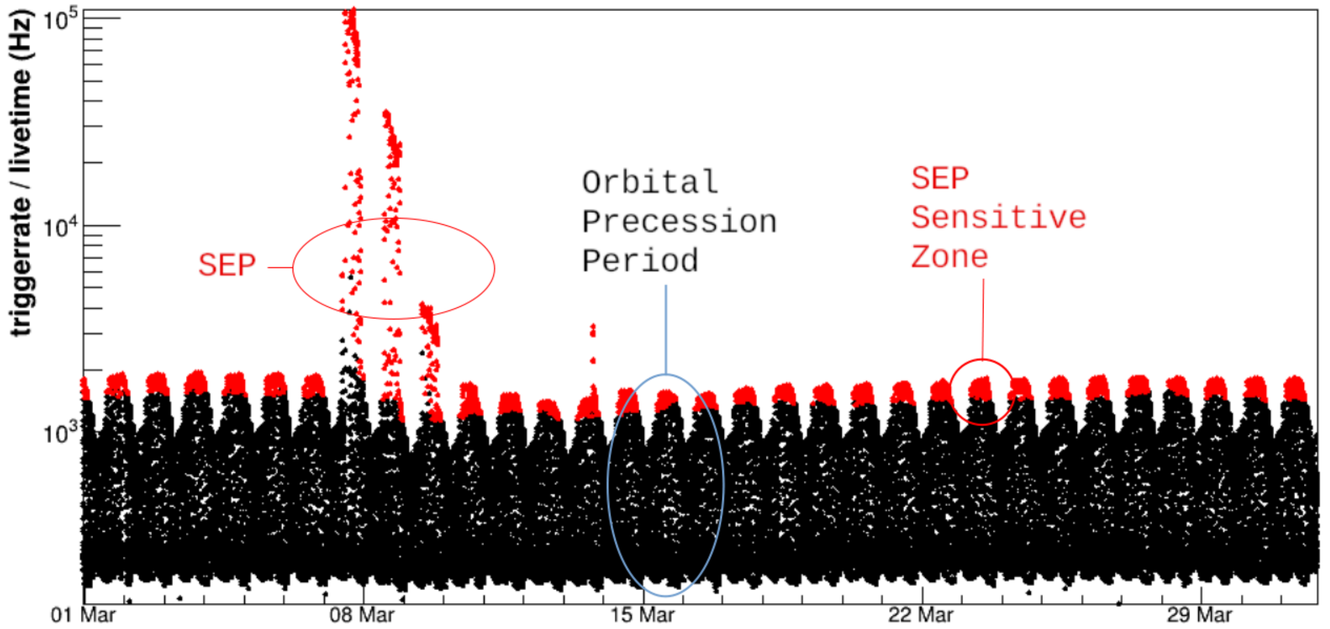
Speakers: Andrew Charles Kuhlman (University of Hawai'i at Manoa (US)), Christopher Li Freeman (University of Hawai'i at Manoa (US)), Christopher Light (University of Hawaii at Manoa), Claudio Corti (University of Hawai'i at Manoa (US)), Cristina Consolandi (University of Hawai'i at Manoa (US)), Matteo Palermo (University of Hawai'i at Manoa (US)), Siqi Wang (University of Hawai'i at Manoa (US))

AMScalendar.pdf Consolandi_SEP_IC...

- Hawaii
- Kiel
- Milano
- Perugia

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



PROTON FLUX VS RIGIDITY

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

$N_{selected}$ → Selected counts corresponding to proton events

T_{exp} → Exposure Time in seconds

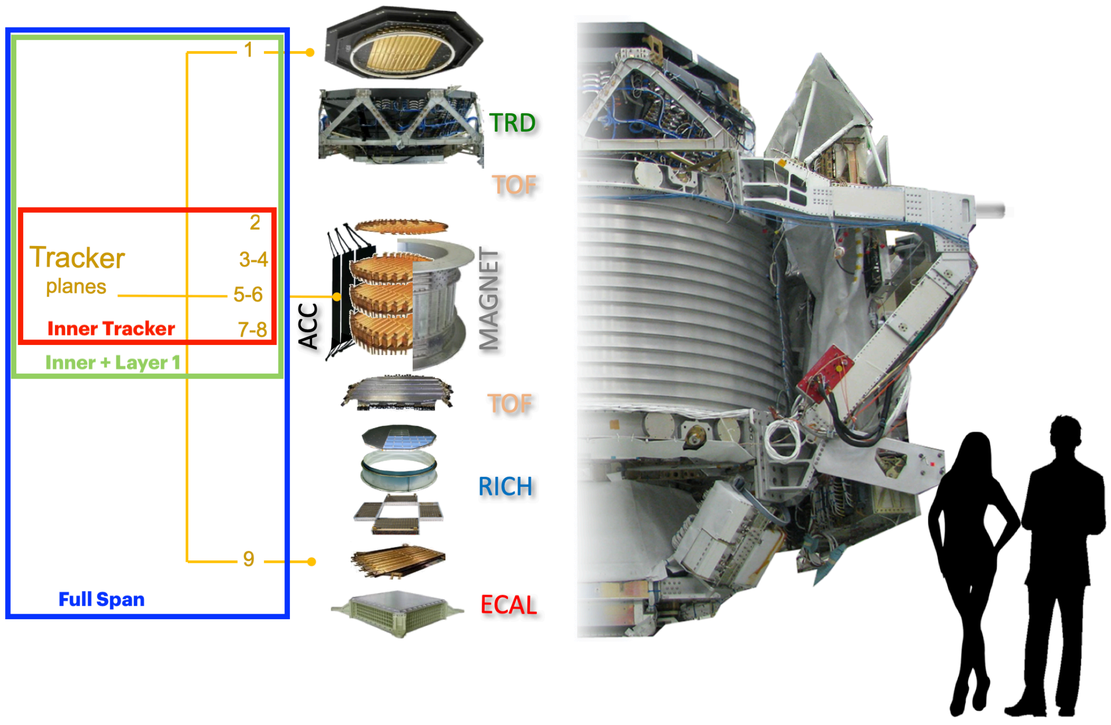
$A_{eff} = A_{MC} \cdot DA/MC\ Corr$ → Effective Acceptance: Montecarlo Acceptance multiplied by corrections

$DA/MC\ Corr$ → Efficiencies on Data / Efficiencies on Montecarlo

EVENT SELECTION CUTS – INNER+L1 ANALYSIS

Charge Reconstruction Type: GBL
Fit Type: Yi Jia

Orange: Only Pass8



RTI Cuts

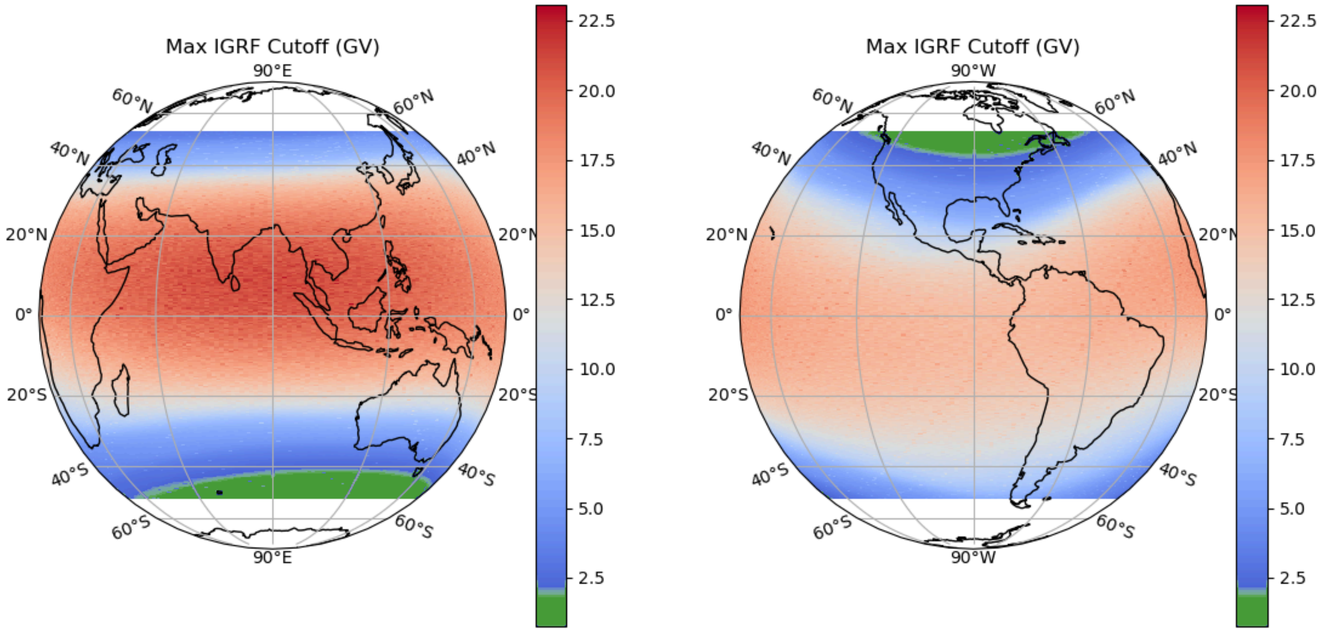
- Livetime Fraction > 0.05
- Zenith Angle < 25
- Not in SAA
- Mean Difference PG-CIEMAT Trk Calibration

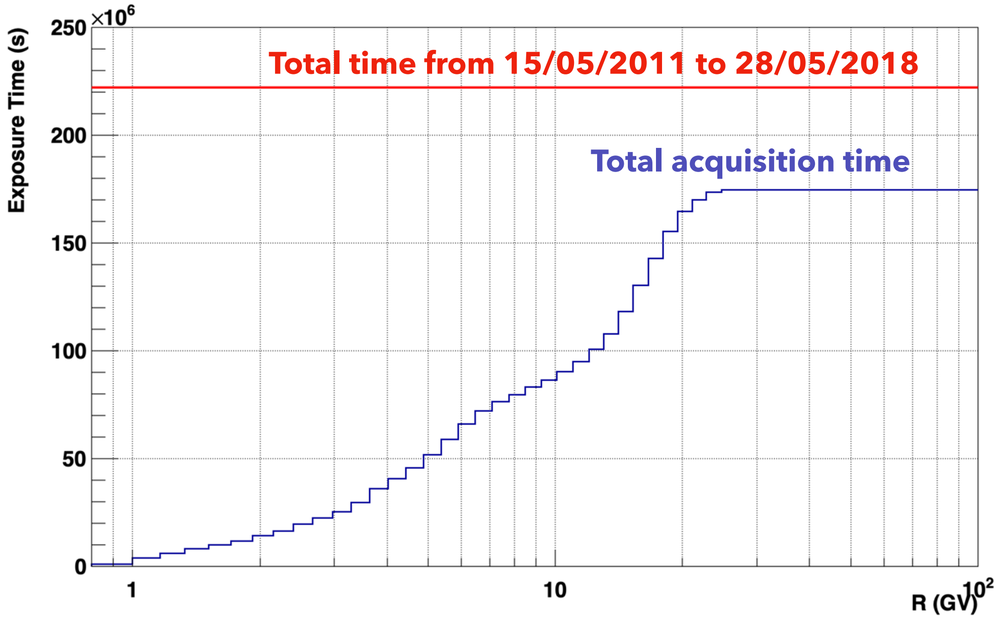
Physical Cuts

- Any Physical trigger
- Chi2Y < 10 (Inner rigidity)
- Hits on: L2 & (L3|L4) & (L5|L6) & (L7|L8)
- At least 5 Hits in Inner Tracker
- Chi2Y < 10 (InnerL1 rigidity)
- 0.7 < Inner Charge < 1.5
- Inner Charge / Inner Charge RMS < 0.4
- 0.6 < L1 Charge < 1.9
- Inside Inner Fiducial (InnerL1 rigidity)
- Inside L1 Fiducial (InnerL1 rigidity)
- L1 Normalized Residual < 10
- Beta > 0.3
- 0.5 < Upper ToF Charge < 2.5
- Mass Cut
- Inner Rigidity > 1 * IGRF Cutoff

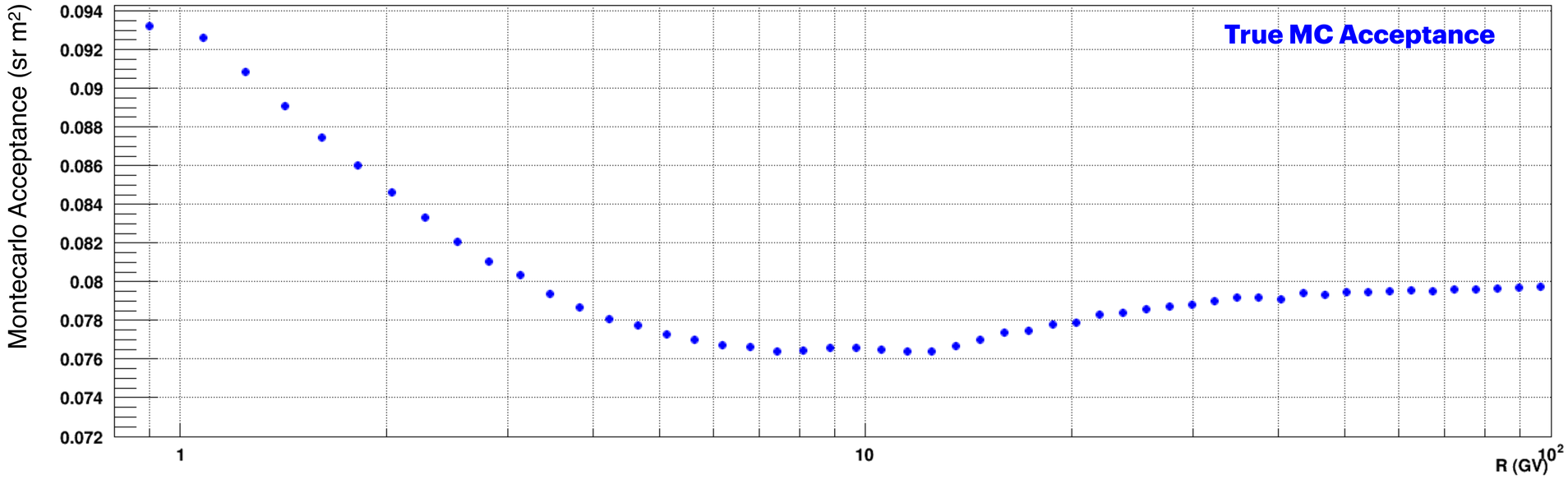
EXPOSURE TIME

- **Exposure Time**: **seconds**, weighted by the detector **livetime**, with rigidity above maximum **IGRF cutoff** in the AMS FoV (for each rigidity bin)
- The **Rigidity Cutoff** is lower near magnetic poles —> A lot of **low energy** particles reach Earth
- The time with **detector not in nominal status** (calibration, ISS technical activities) are excluded from reconstruction





RAW AND CORRECTED ACCEPTANCE



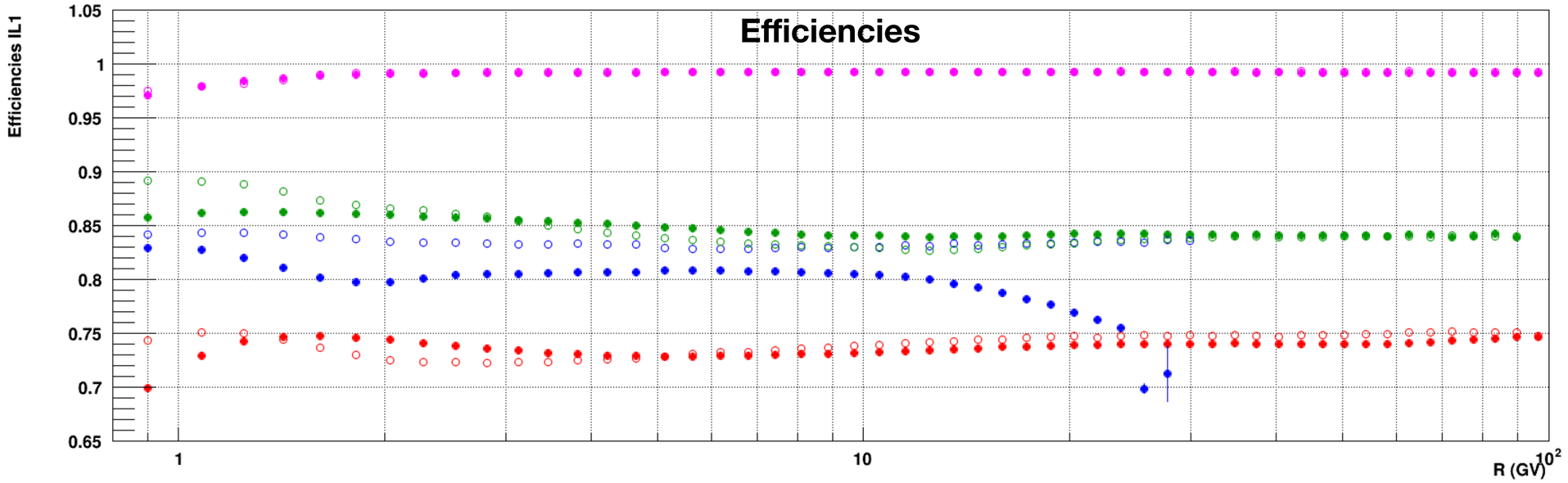
$$A_{MC,i} = \frac{N_i^{selected}}{N_i^{generated}} \cdot S_i^{generated} \cdot \Omega_i^{generated}$$

$$i = i^{th} rigidity\ interval$$

$$S^{gen} = gen\ surface$$

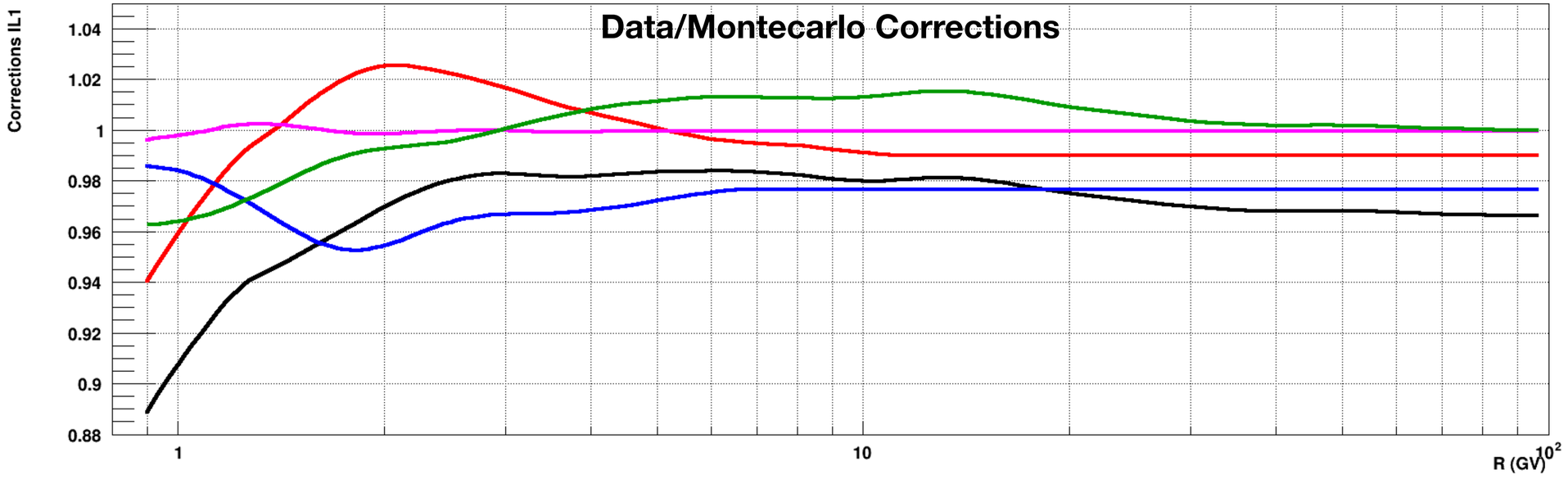
$$\Omega^{gen} = gen\ solid\ angle$$

DATA/MONTECARLO CORRECTIONS



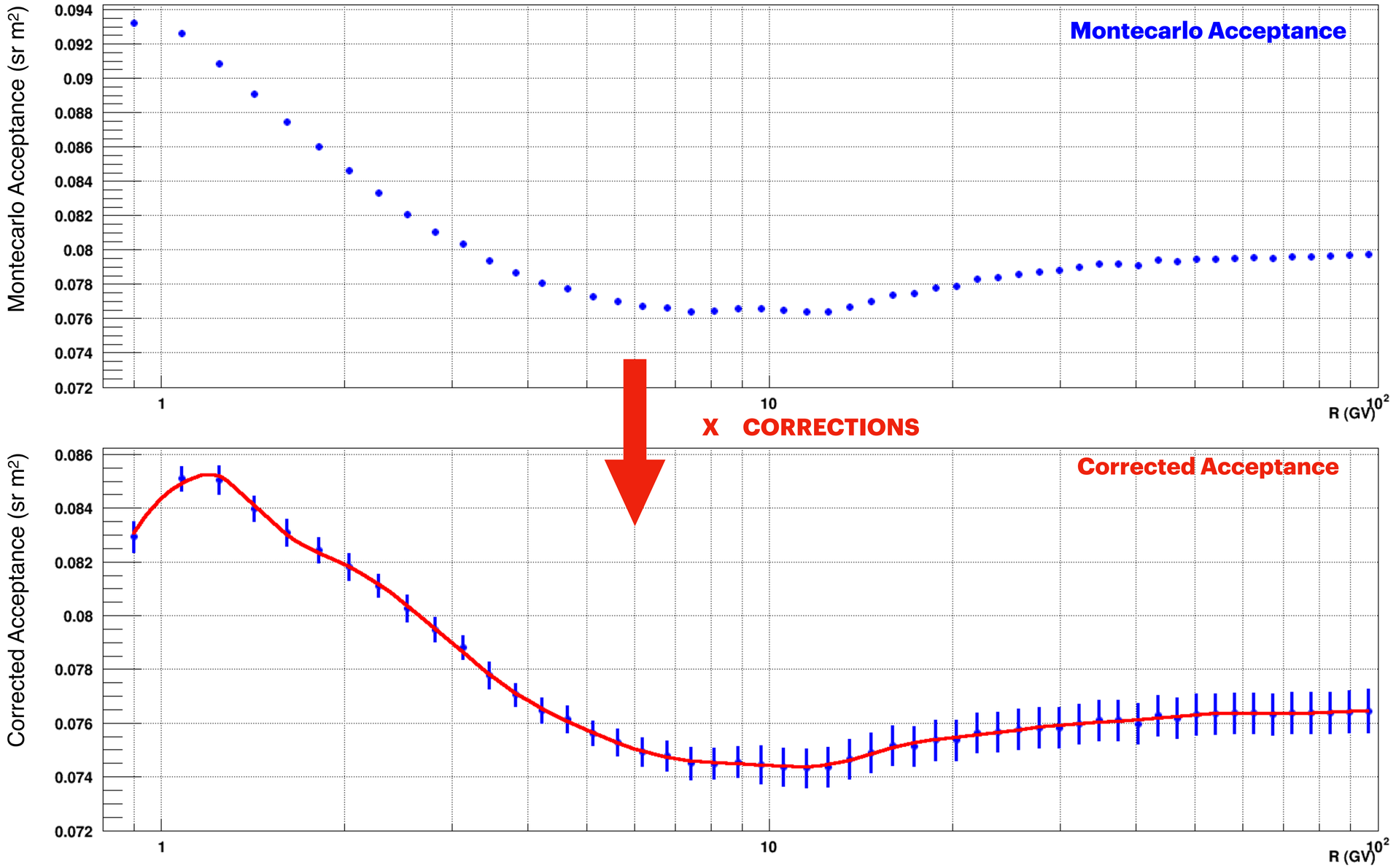
● DATA
○ MC

L1 Pickup Efficiency
Track Efficiency
Tof Efficiency
Trigger Efficiency



L1 Pickup Corr
Track Corr
Tof Corr
Trigger Corr
Total Correction

RAW AND CORRECTED ACCEPTANCE



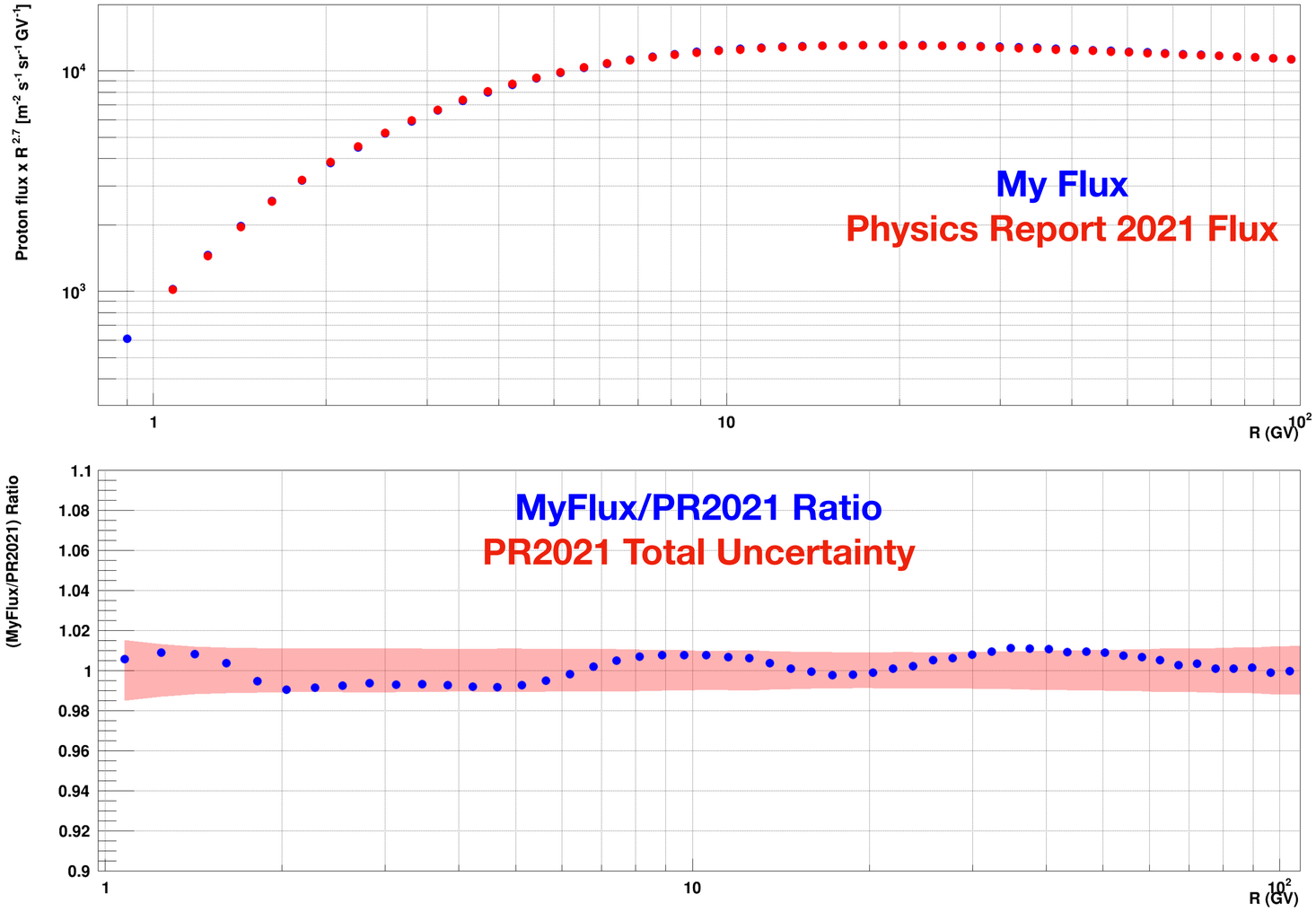
FINAL PROTON INTEGRAL FLUX

- The **flux equation** is finally **integrated in** the time interval **[29-05-2011, 29-05-2018]**, to compare it with the **previous publication** in “Physics Reports 894 (2021) 1–116”

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

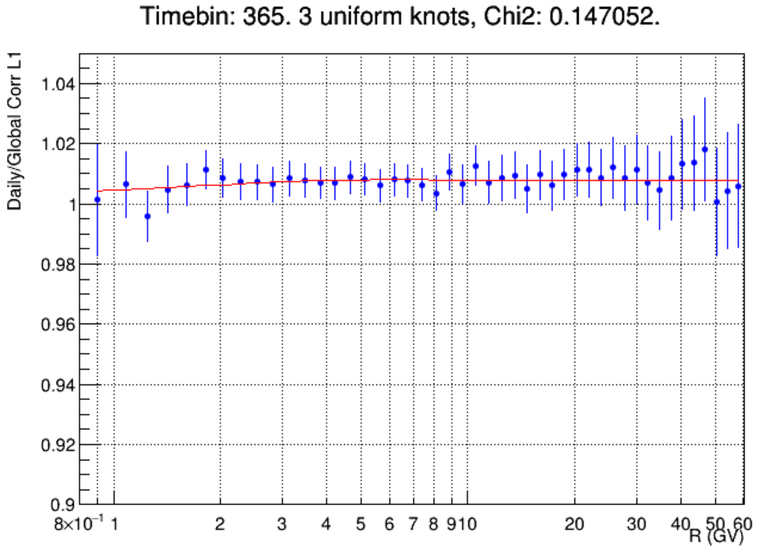
$$i = i^{th} rigidity\ interval$$

- The **flux** is **in agreement** within the total uncertainties of the **published flux.**

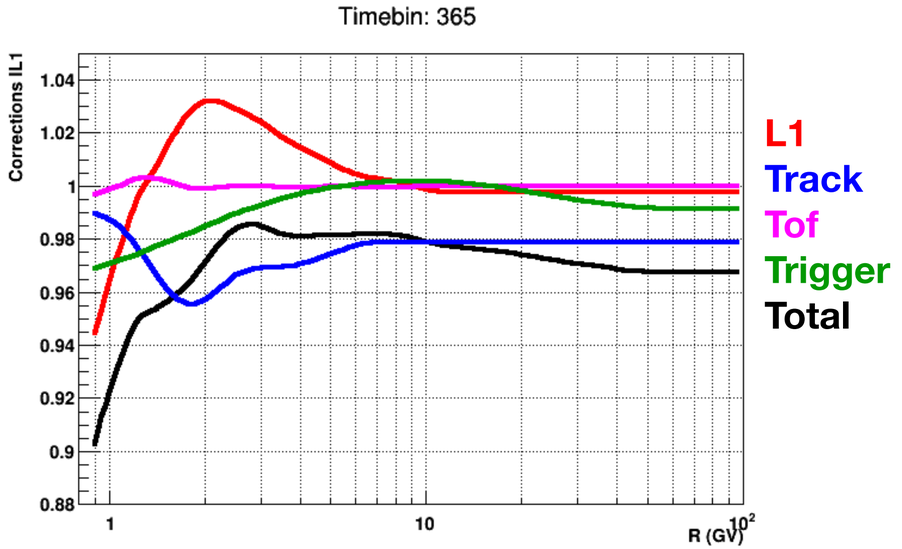


DAILY PROTON FLUX

- The **daily flux** evaluation follows the **same procedure** as the integral flux. Instead of integrating over the whole time period, the flux is calculated for each day.
- The **main difference** is in the **efficiencies**: due to statistical fluctuations, the DATA/MC corrections are not fitted directly with a spline, but the **integral/daily corrections ratio** is evaluated and multiplied to the daily correction to maintain the shape of the integral correction.



Compute Daily/Integral ratio and fit with spline (3 knots) up to 20 GV



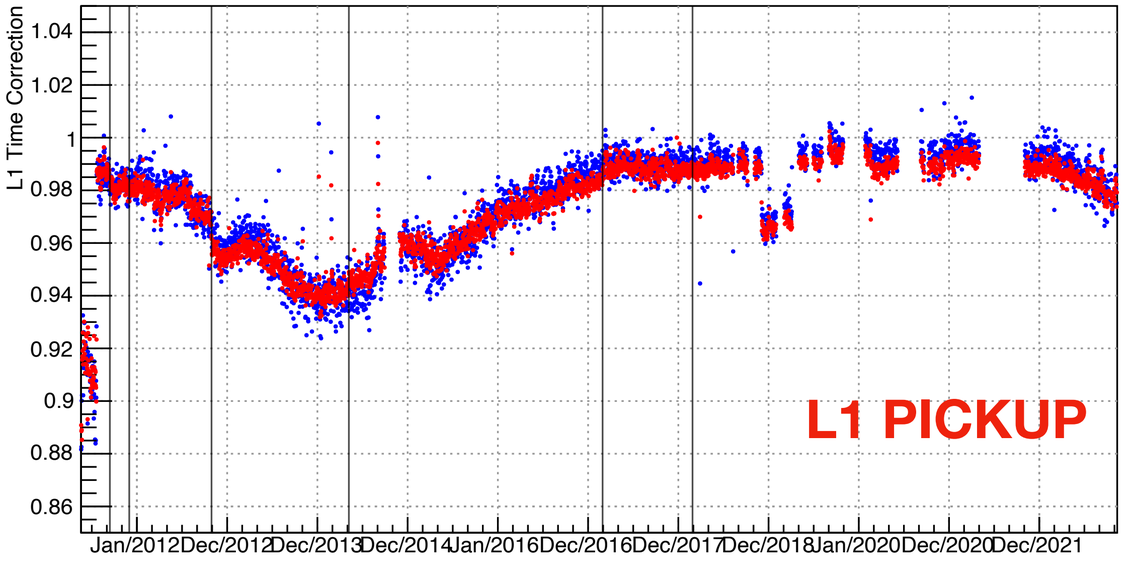
Multiply Integral correction by the spline fit of the ratio

Due to the very low statistics of the daily trigger efficiencies,
a moving average in a 15 day window is considered instead of the daily trigger efficiency.

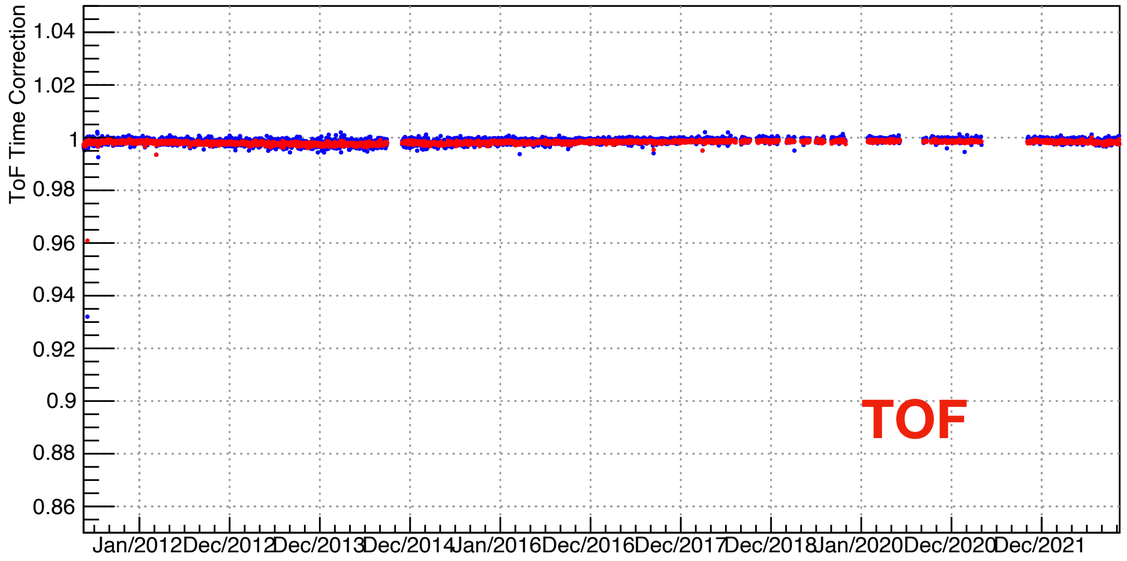
DAILY PROTON FLUX – CORRECTIONS

Data
Spline Fit In Rigidity

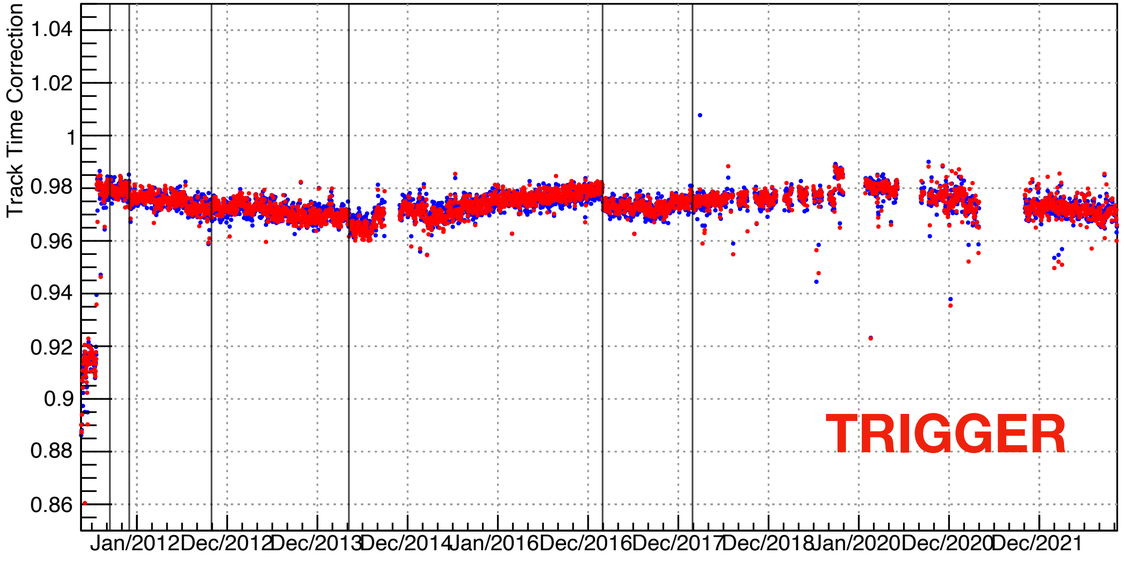
[1.000000, 1.160000] GV



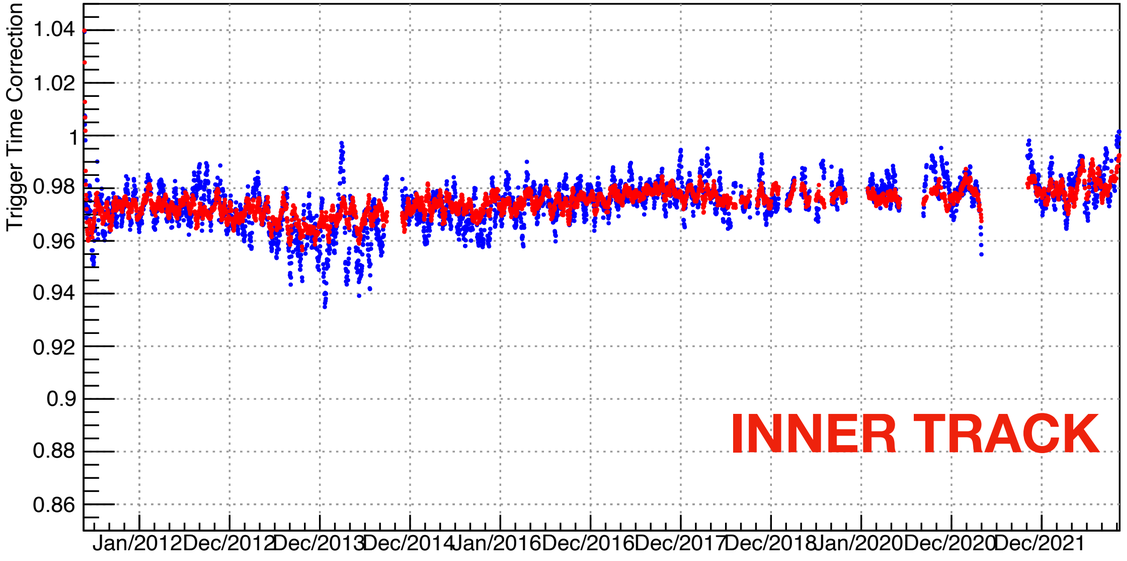
[1.000000, 1.160000] GV



[1.000000, 1.160000] GV

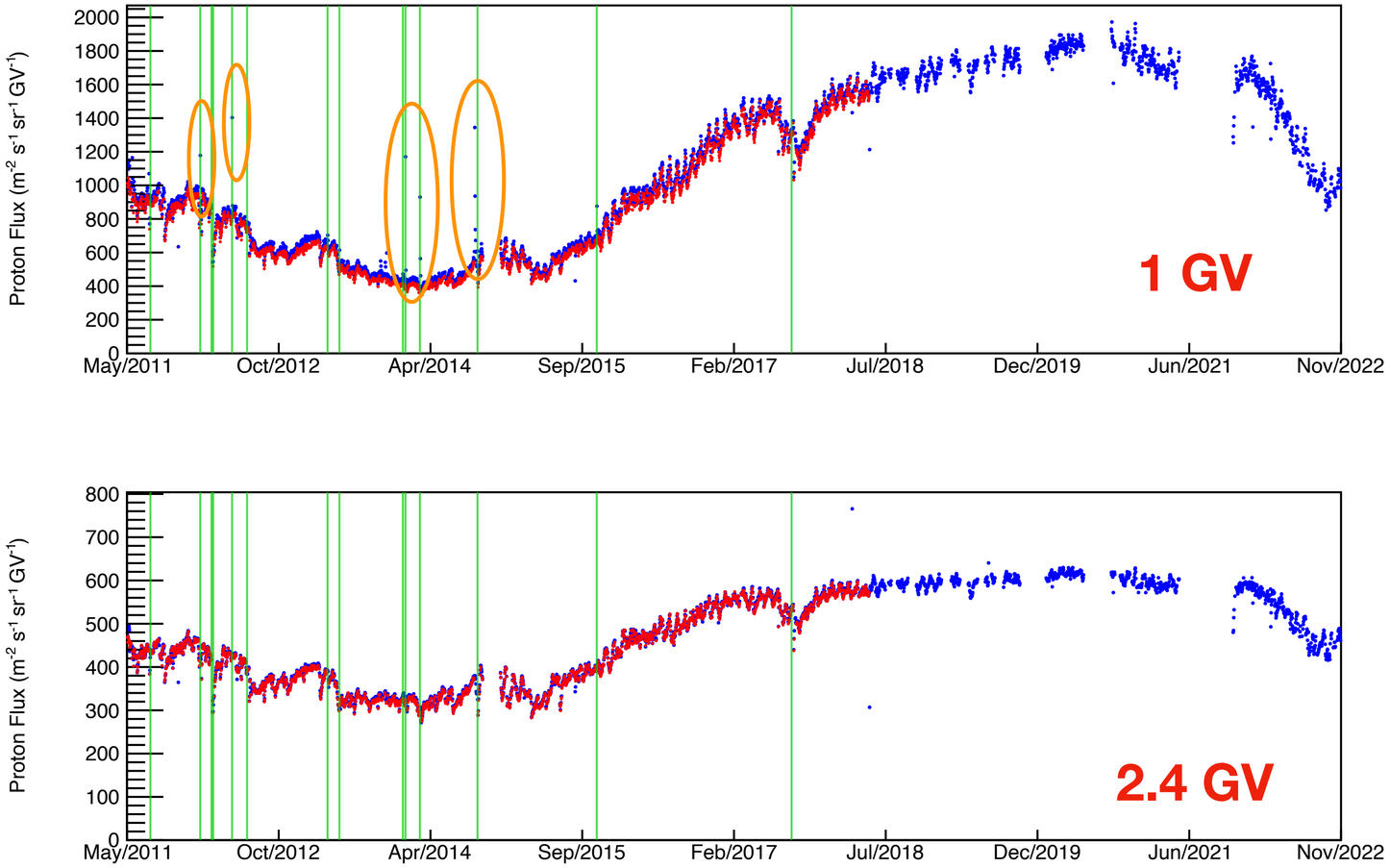


[1.000000, 1.160000] GV

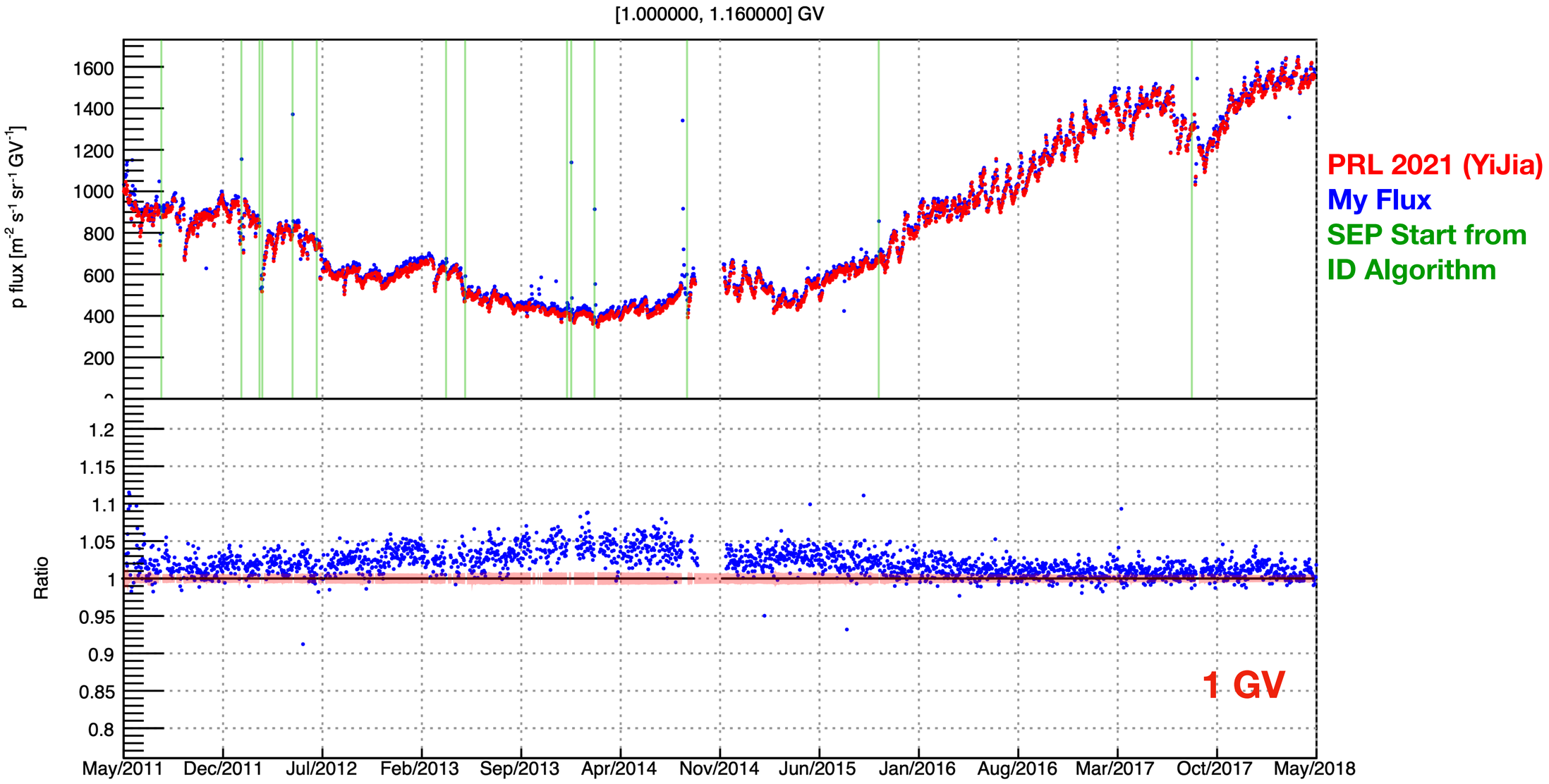


DAILY PROTON FLUX

- The **daily proton flux** (blue) is compared with the **previous publication** (red) in "Phys. Rev. Lett. 127, 271102 (2021)".
- The **new measurements**, in an **extended temporal range**, include **improvements** in the **rigidity reconstruction** algorithm of the AMS tracker and a different **track fitting** method (GBL).
- From 0.8GV up to 2.4GV, **days** with **enhanced flux level** are clearly visible and correspond to **SEP events** found with the SEP ID algorithm (green lines).

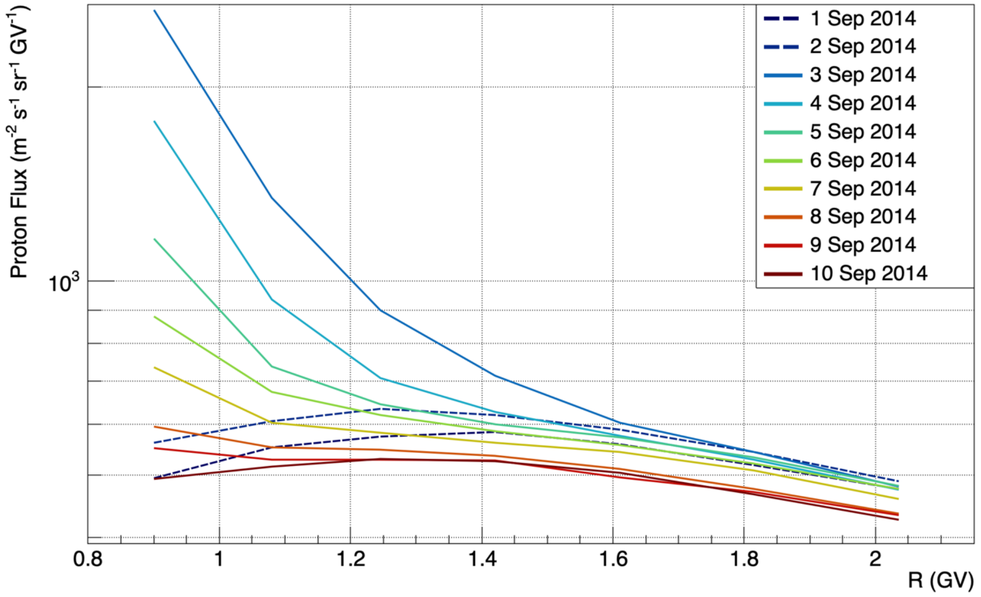


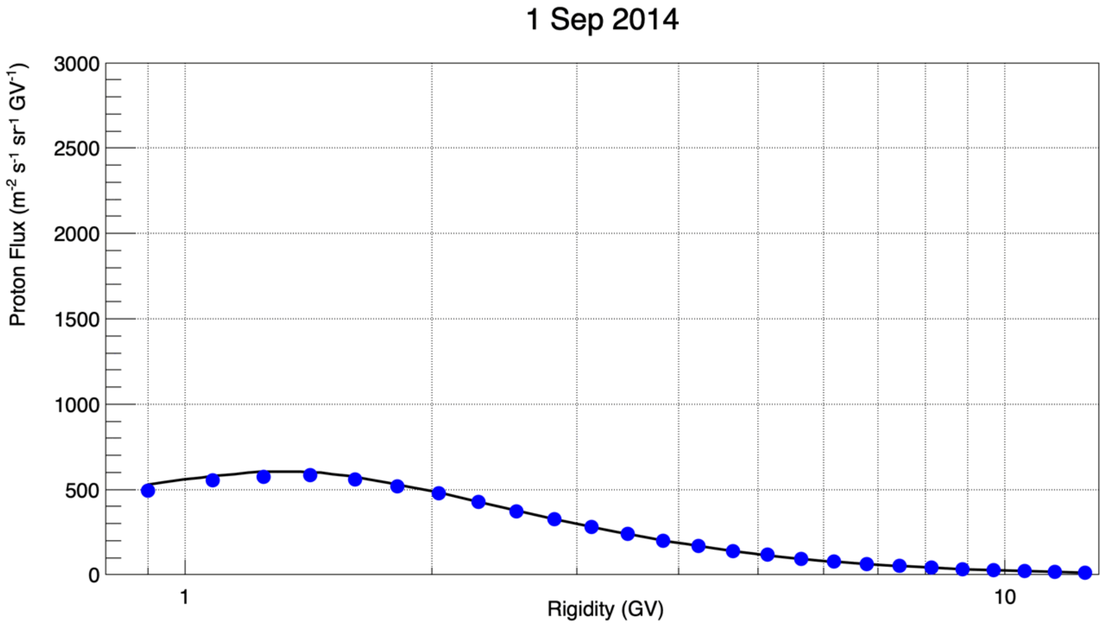
DAILY PROTON FLUX

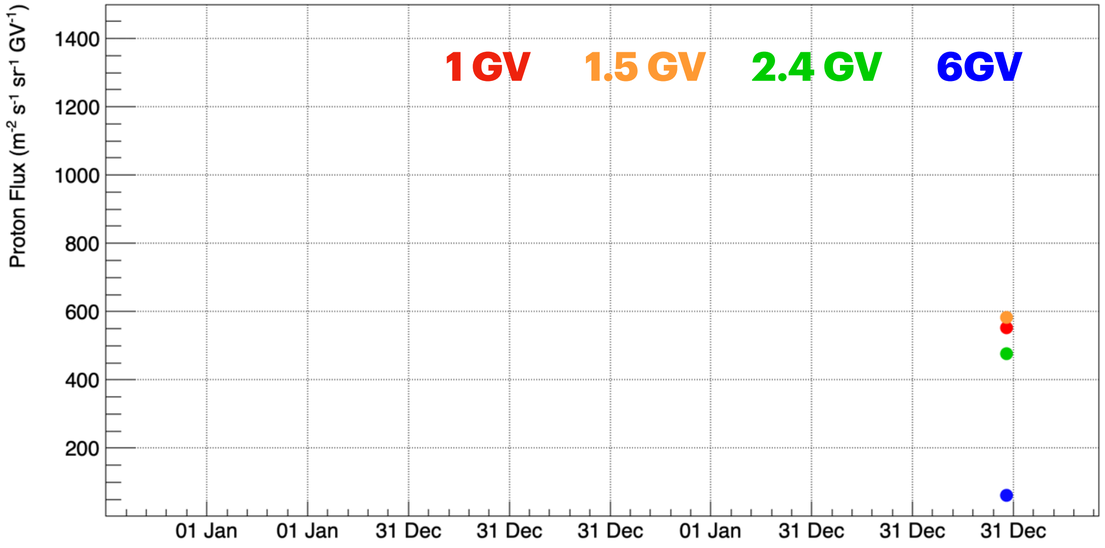


SEP FLUX – 3 SEPTEMBER 2014

- The **AMS proton flux** allows to **study SEP events** with high precision in the charged particles domain.
- The **rigidity spectrum** hints at the possible **acceleration mechanisms** of charged particles.
- The **time evolution** gives important informations on the **evolution** of the ejected plasma from the Sun, within the heliosphere.







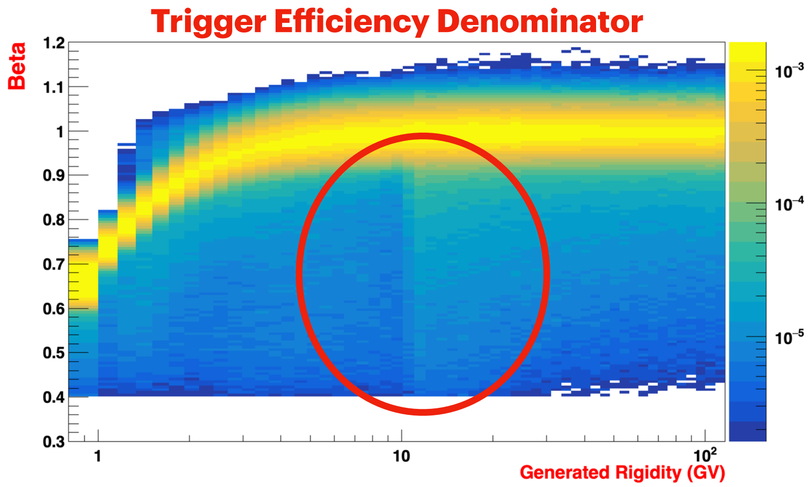
Summary

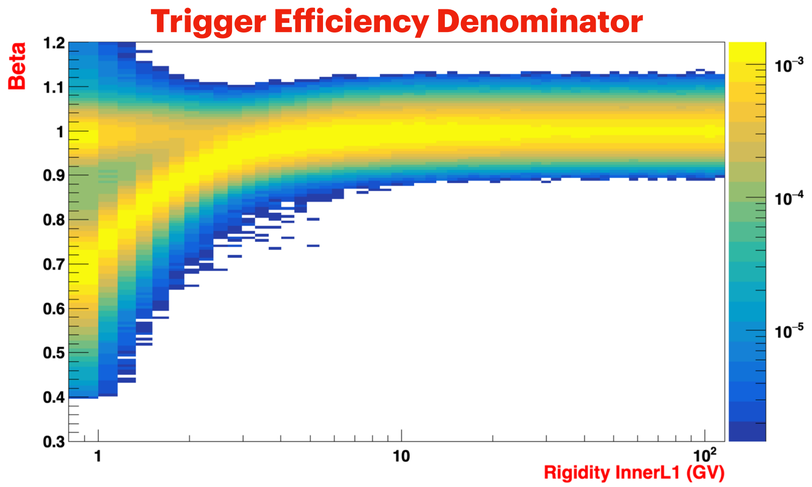
- **Completed Tasks:**
  - **Integral proton spectrum** in agreement with publication.
  - **Daily proton flux** within 8% with publication, temporal variation of corrections under investigation.
  - **SEP Identification Algorithm** completed and operative.
- **To do:**
  - Daily flux **systematics** estimation.
  - **GCR Background** subtraction algorithm under development.
  - Final **SEP-only spectrum and fluxes:** comparison with other solar activity indexes.

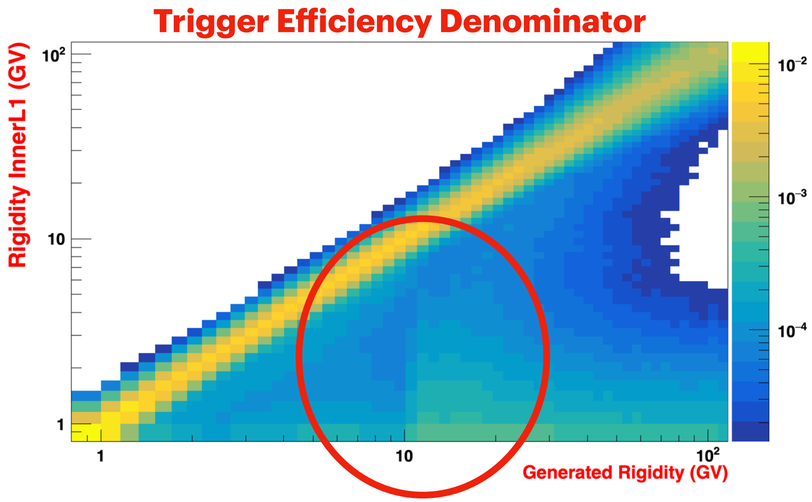
Daily proton flux repository on GitLab by the end of the meeting

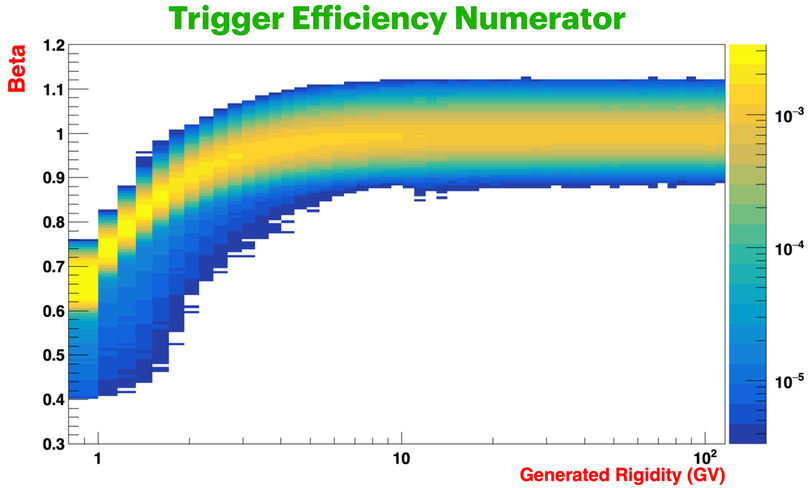
TRIGGER EFFICIENCY STUDIES

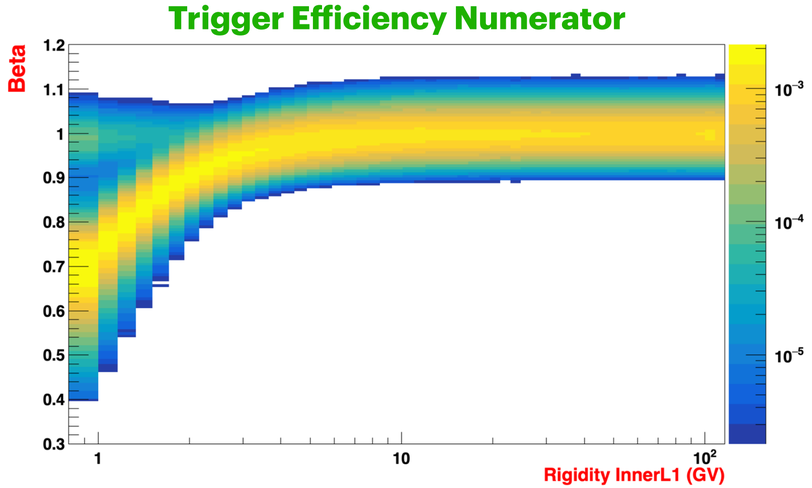
Montecarlo Trigger efficiency susceptible to “**interactions**”? Weird **R_{gen}>10GV** population.

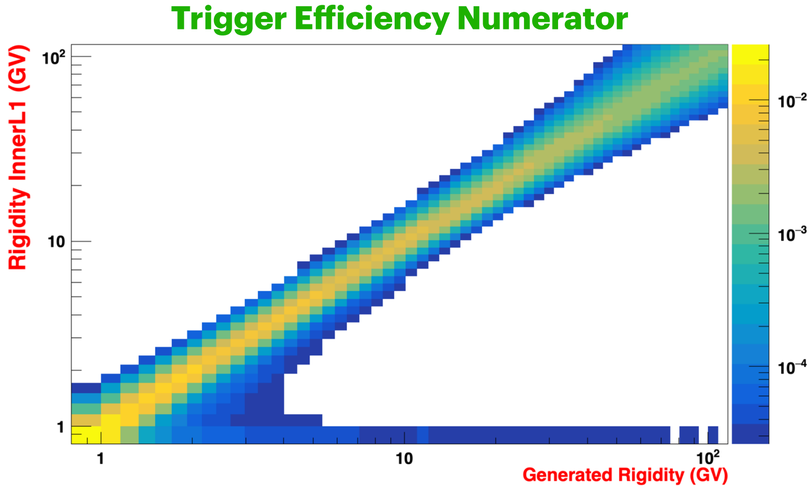












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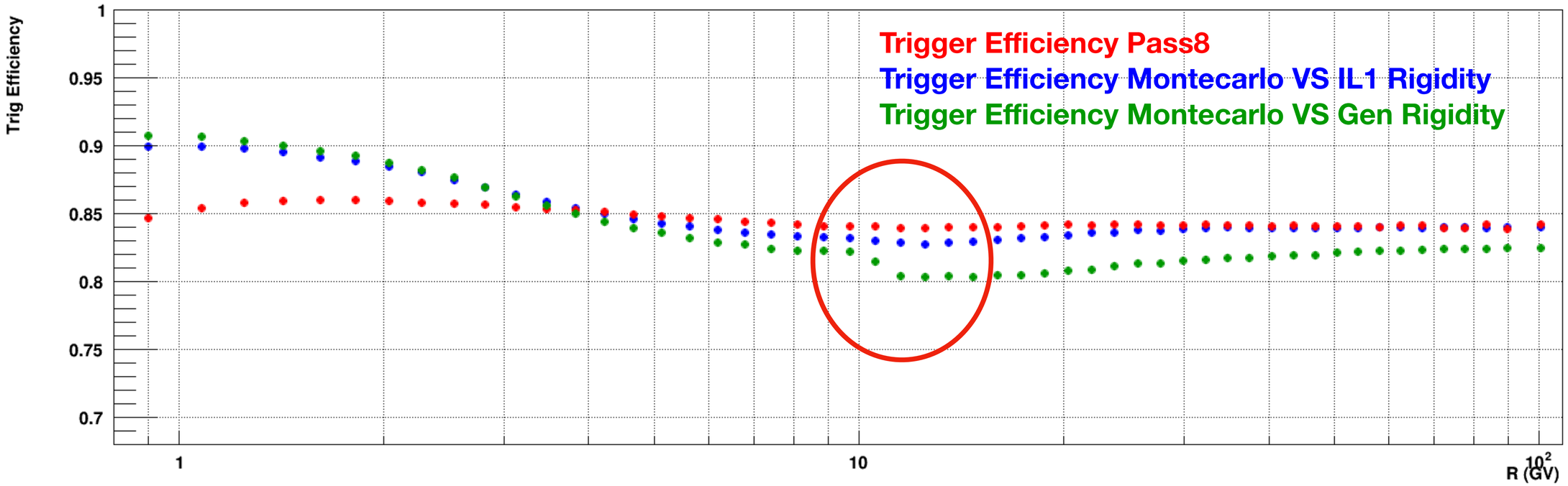

TRIGGER EFFICIENCY STUDIES – NEW MASS CUT