Rigidity Cut-Off Imrpovements: IGRF Safety Factor

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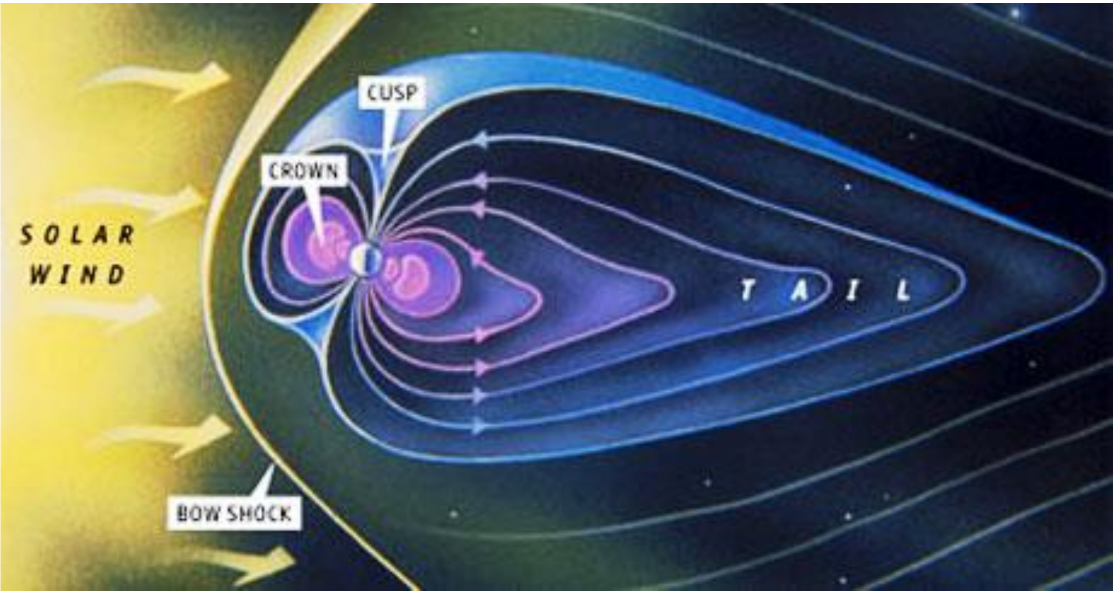
Back-tracing in the geomagnetic field

Our GOAL: find IGRF cut-off corrections based on OUR particle back-tracing.

- We performed the back-tracing using **GeoMagSphere** model (*http://www.geomagsphere.org/*) developed within the AMS-02 INFN – Milano Bicocca group

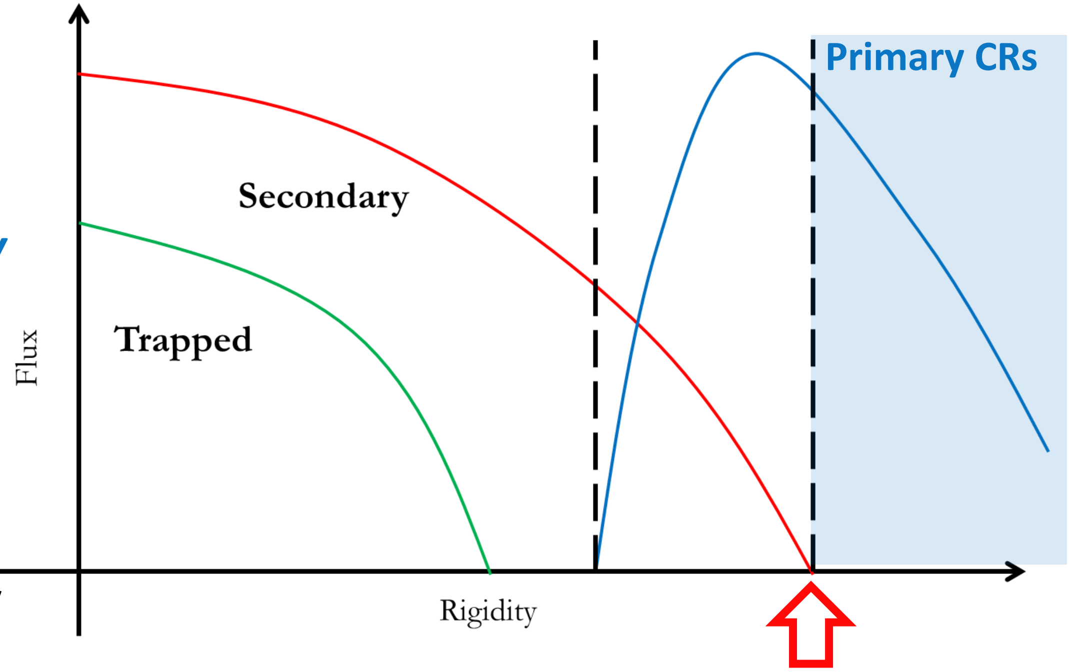
- **GeoMagSphere** is a back-tracing numerical code running IGRF internal field with external **Tsyganenko models** (in particular *Tsyganenko 1996* for quiet periods and *Tsyganenko 2005,* specifically developed to reproduce the magnetosphere during magnetic storms)
  - Tsyganenko models showed to **reproduce with good accuracy the geomagnetic field observations during quiet and disturbed periods.**



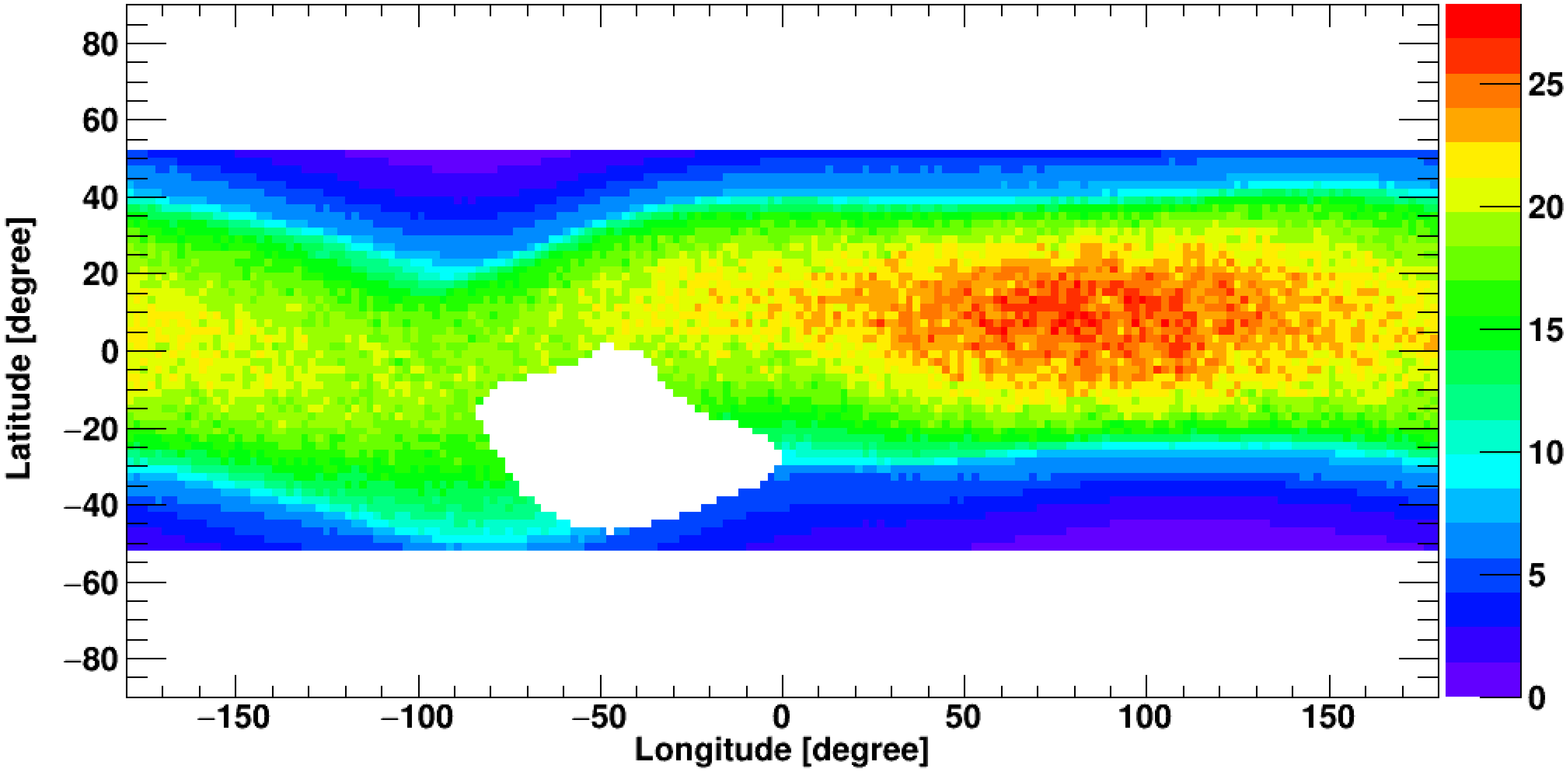
The Tsyganenko cut-off

In order to determine the cut-off, we used real selected events (in place of generated MC events) in the detector field of view.

- We selected AMS-02 protons between 0.8 GV < R < 100 GV, during **quiet** and **disturbed** periods of the solar activity.
- Using **GeoMagSphere** we back-traced all the selected particles, determining the rigidity distribution of:
  - particles coming from the outer magnetosphere → **PRIMARY**
  - particles created in the atmosphere → **SECONDARY**
  - particles trapped in the magnetic field lines → **TRAPPED**
- **The Tsyganenko rigidity cut-off** is the upper rigidity cut-off, defined as the highest rigidity for particles identified as secondary
- **SO NO PENUMBRA!**

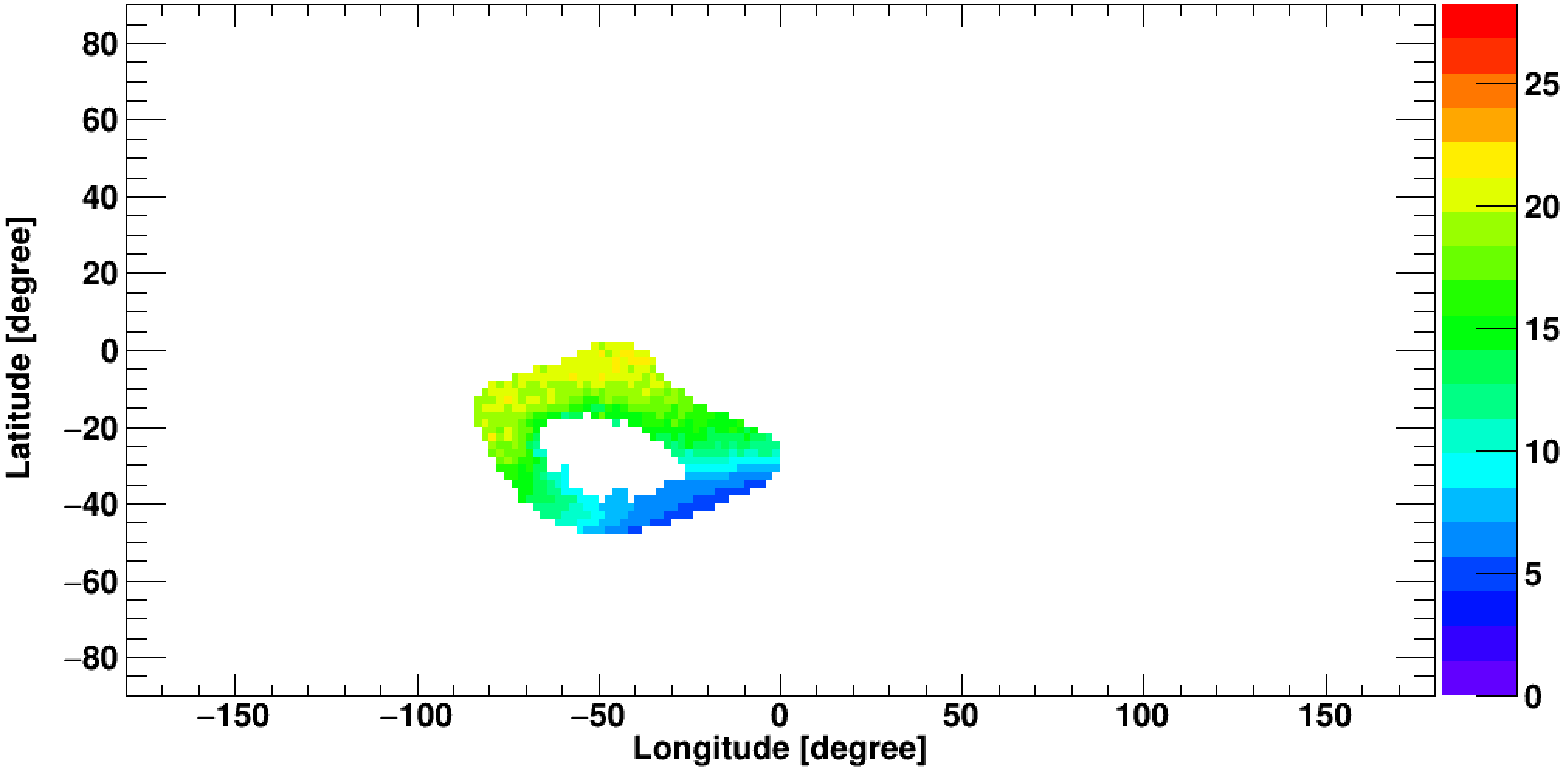


Tipical Cutoff Map using Tsyganenko Models



Primary CR: **Upper cutoff map outside SAA – inner – lt>0.1**

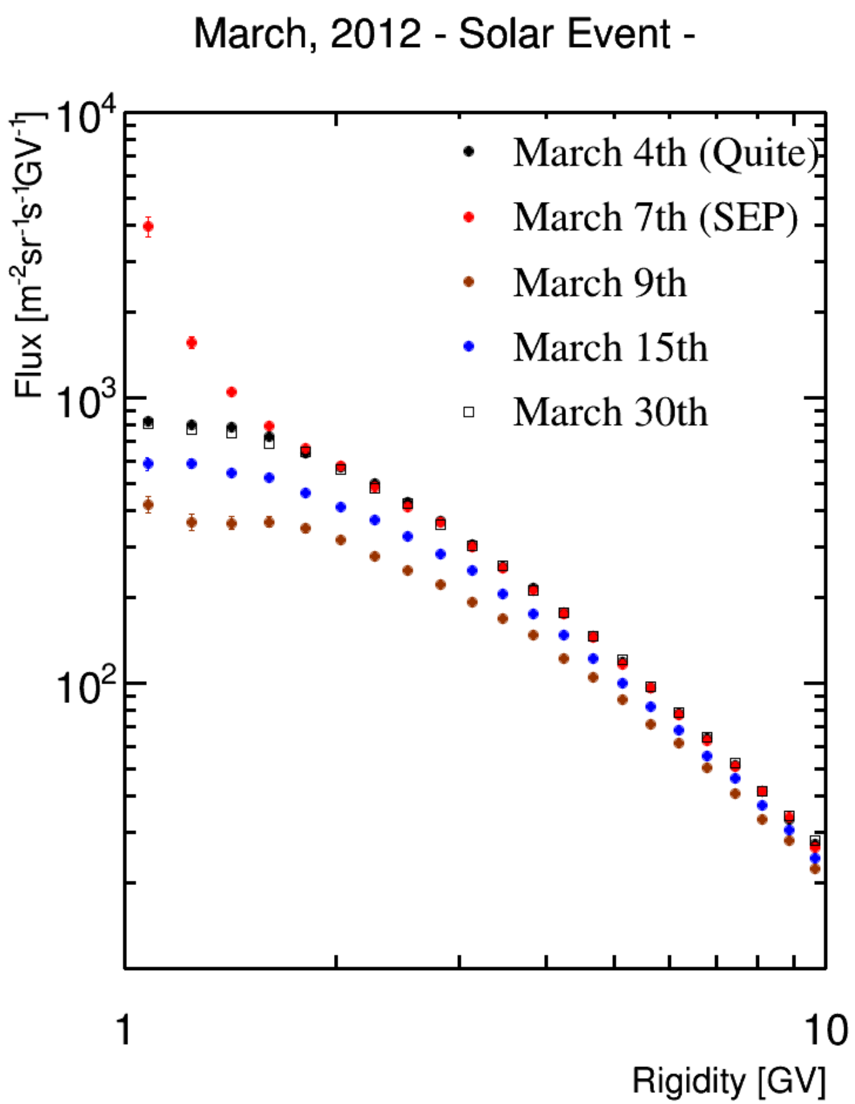
Tipical Cutoff Map using Tsyganenko Models



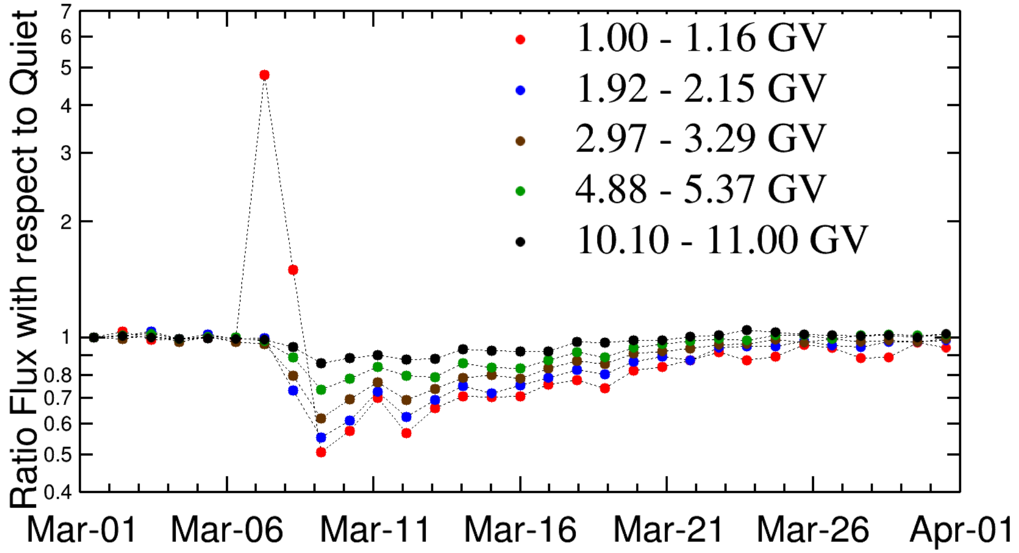
Primary CR: Upper cutoff map inside SAA – inner – lt>0.1

AMS -02 Analysis

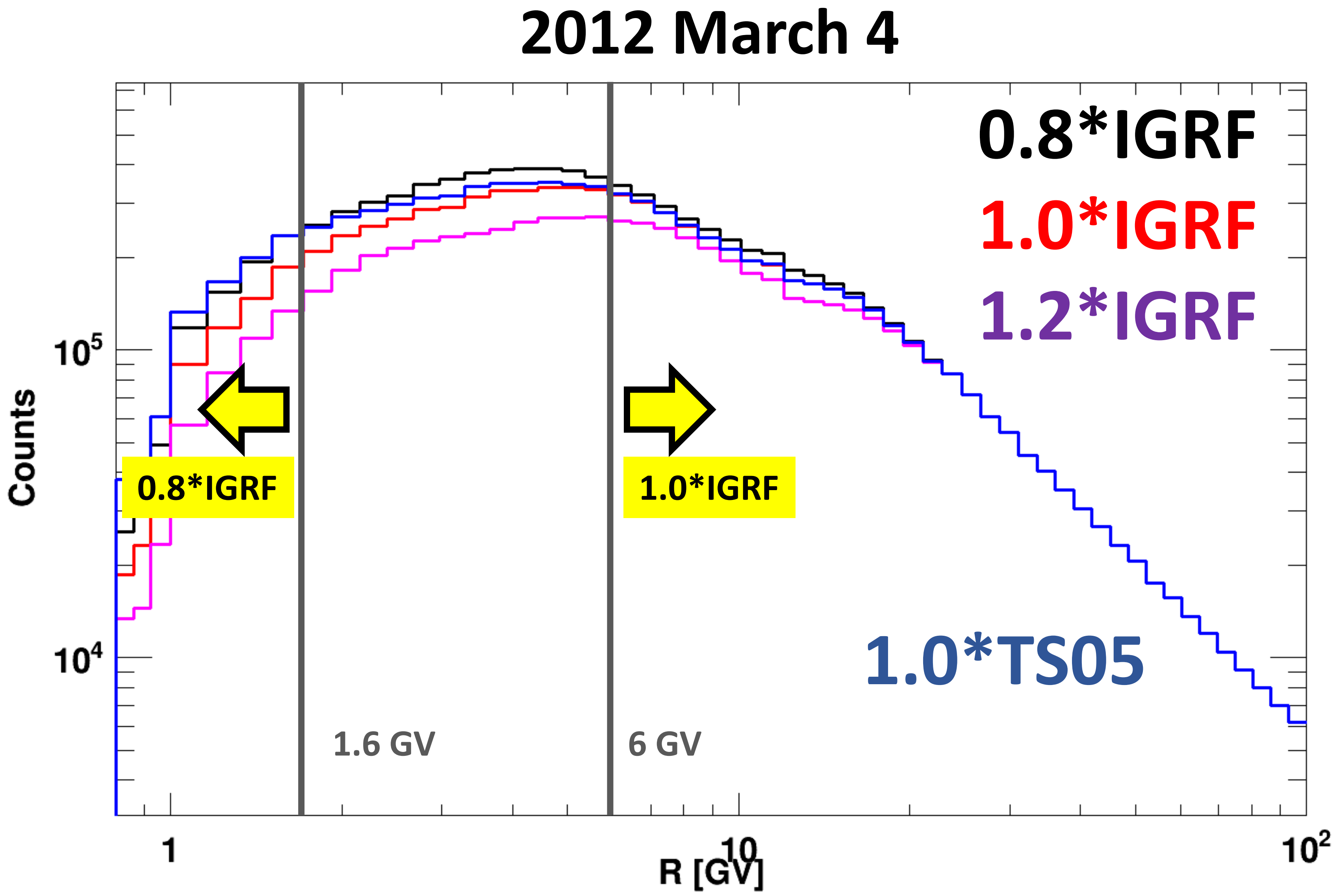
SEZIONE DI MILANO-Bicocca



During March 2012 a huge Solar events occurs. AMS-02 detect a increments of primary particles on 7th then a reduction of flux that last for ~1 month



Tsyganenko vs IGRF – SF?



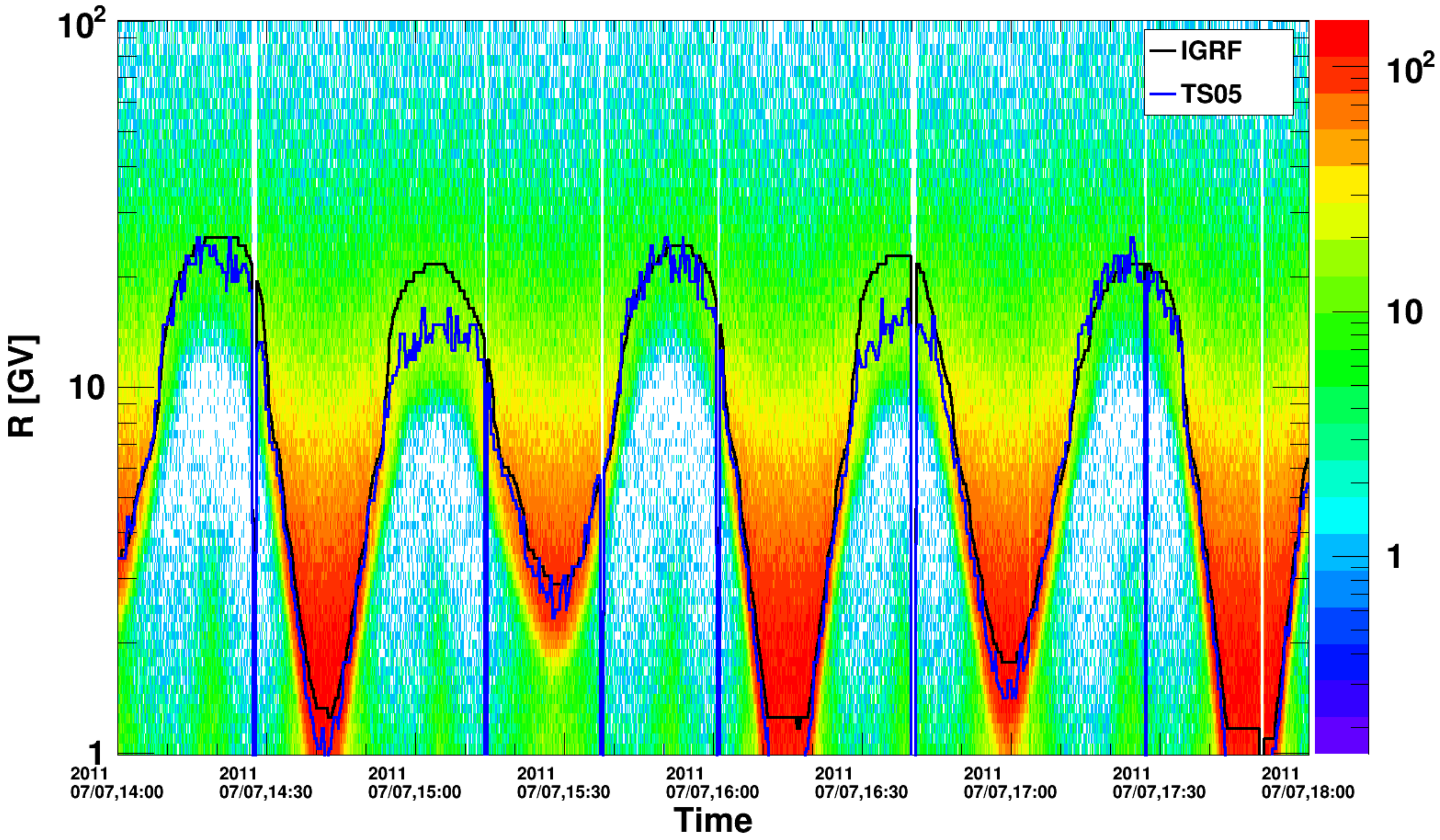
Data Selection and strategy -1

- We selected AMS-02 protons in 2 Bartel Rotations a **quiet one** June/July 2016 and **disturbed one** March/April 2012.

- Using **GeoMagSphere** we back-traced all the selected particles, with different models:
  - Tsyganenko 2005 and Tsyganeno 96
  - IGRF

- **The Tsyganenko rigidity cut-off** is taken as REFERENCE
- **IGRF counts are compared with TS05 ones**
- **Exposure and Rate are then obtained**

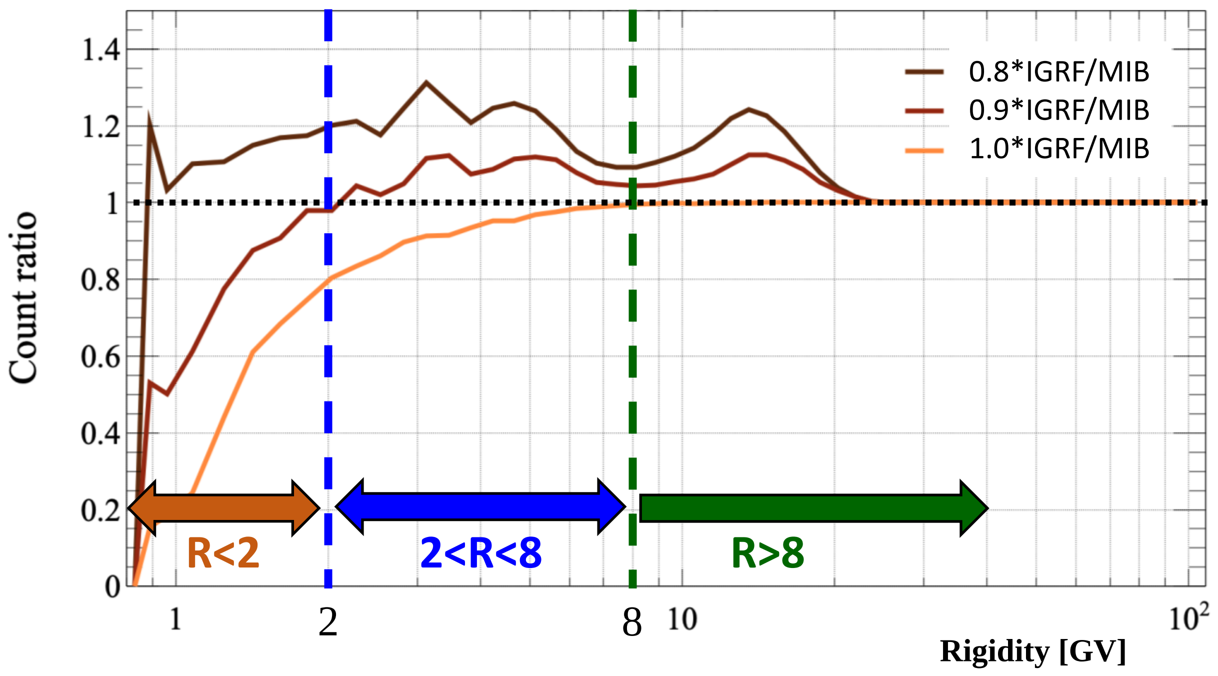
Data Selection and strategy – 2



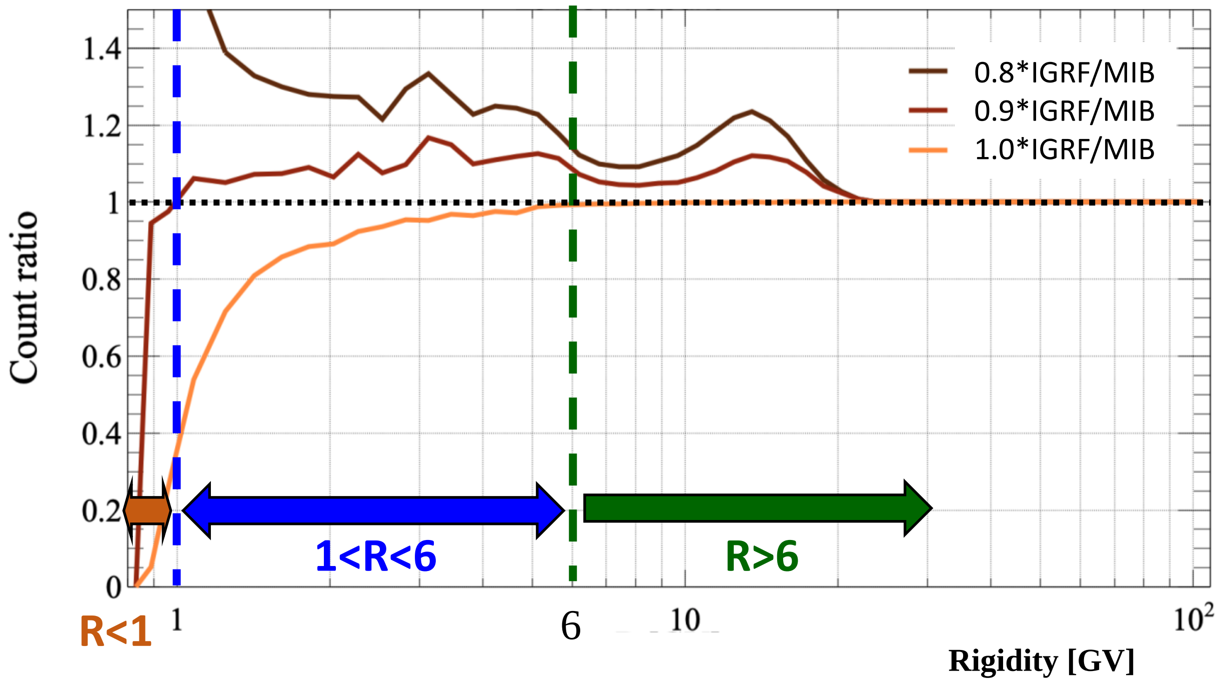
Cut-off optimization: IGRF vs. Tsyganenko cut-off

For each rigidity bin, the **correction factor** is the factor to be applied to the IGRF cut-off in order to **match (within 1%) the event count obtained using the Tsyganenko cut-off**.

Inner Tracker + L1 geometry



A disturbed period – March 2012

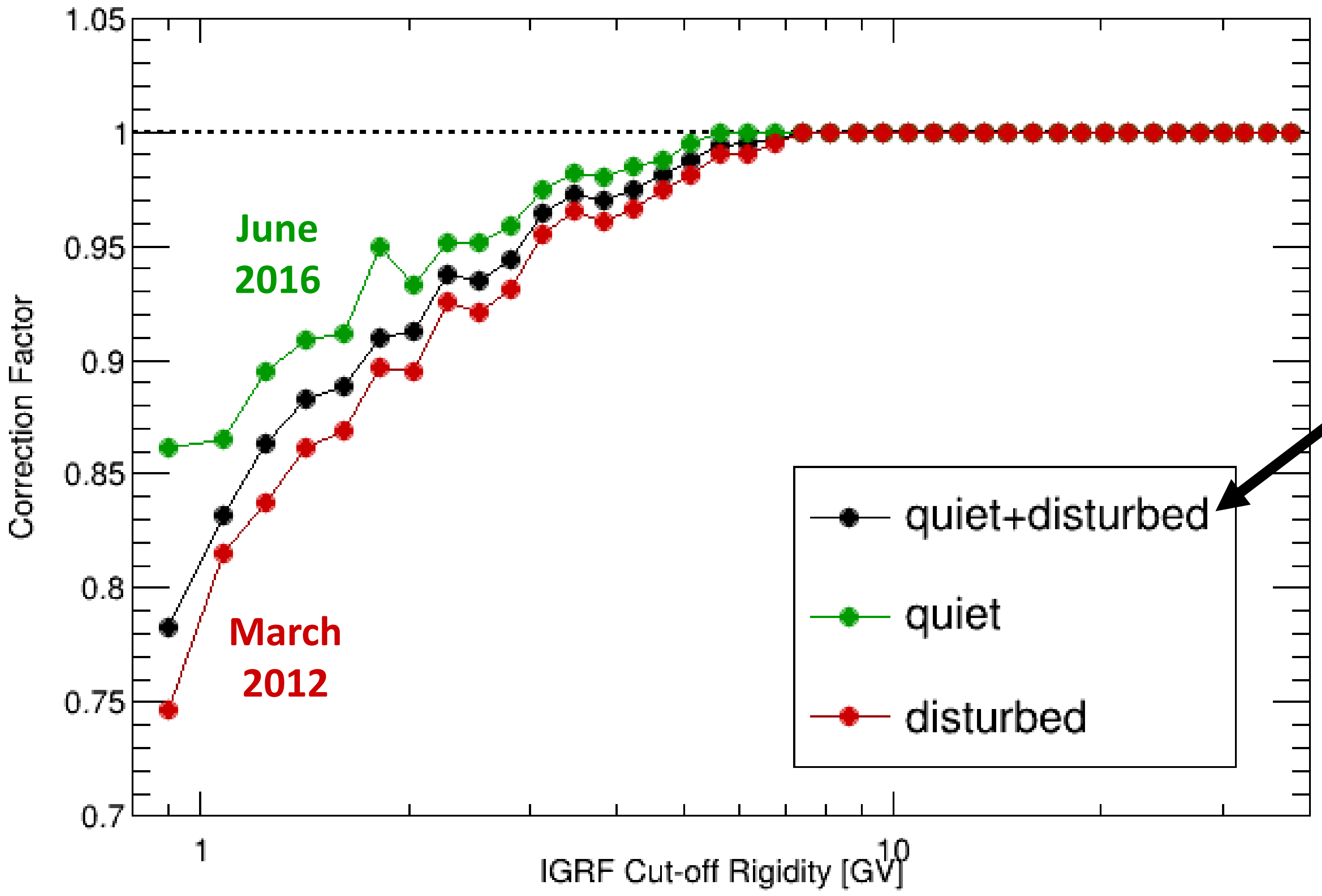


A quiet period – June 2016

The correction factor is rigidity dependent.
Moreover it varies according to geomagnetic disturbances.

Geomagnetic cut-off correction factor

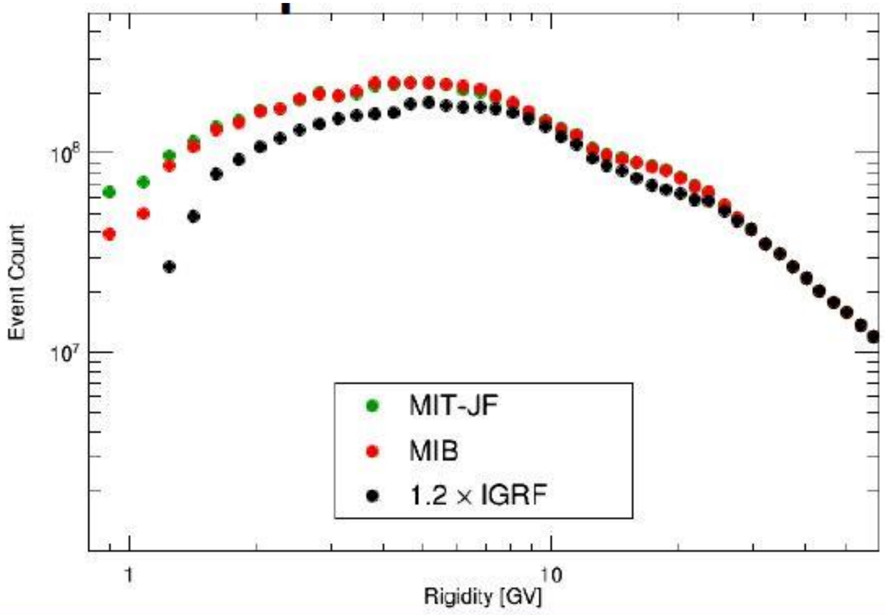
Inner Tracker + L1 geometry



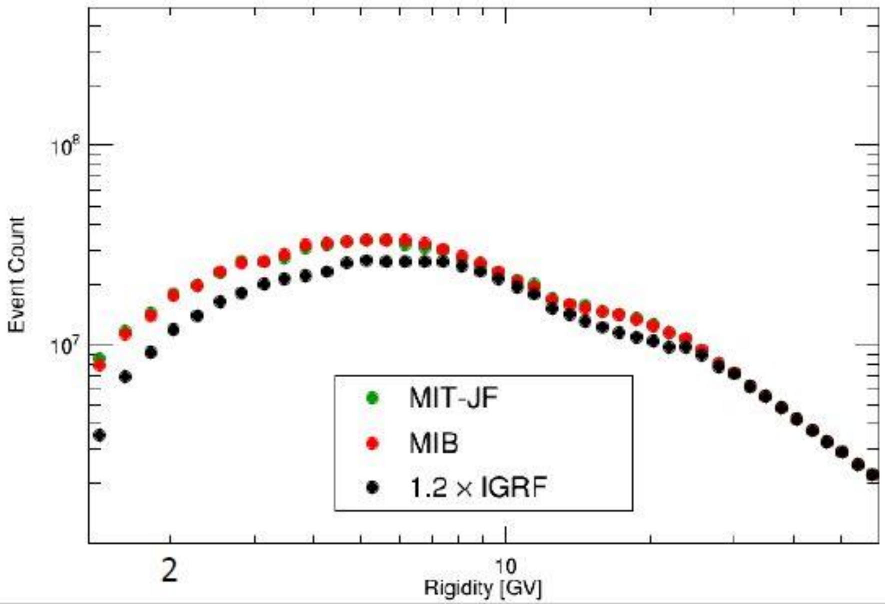
For the present study the “averaged” correction factor has been used

Event Counts: direct comparison

Proton

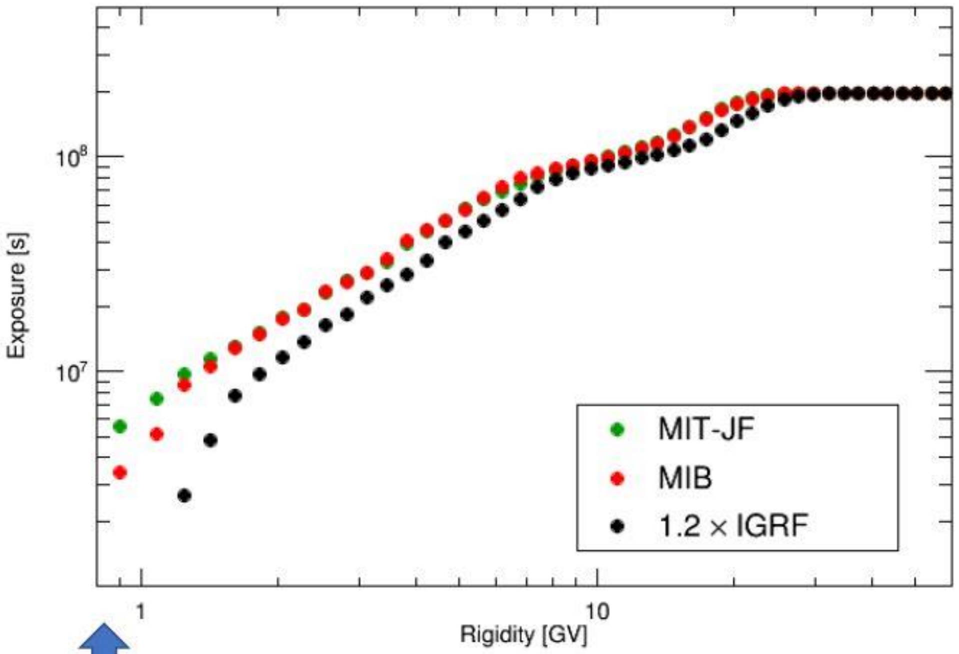


Helium



Protons

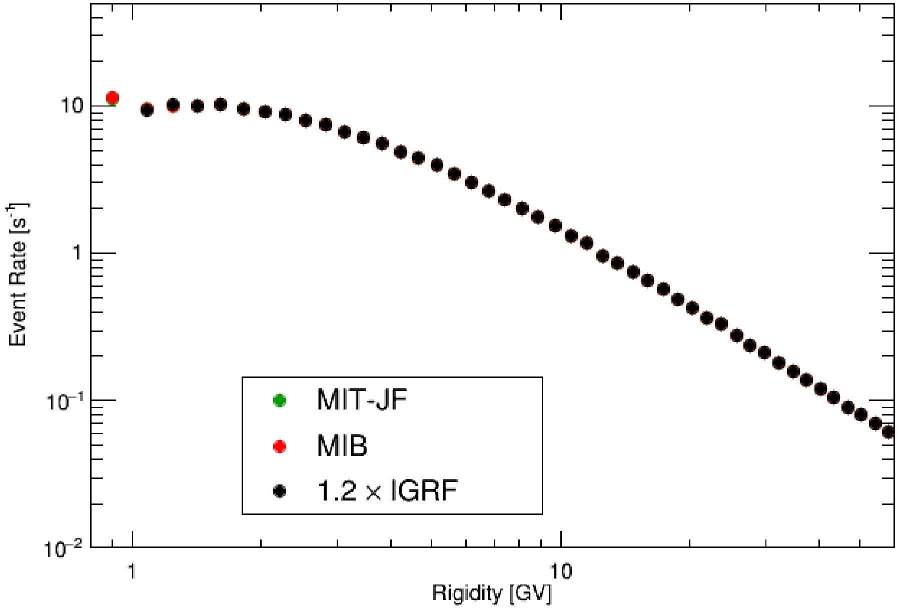
Exposure



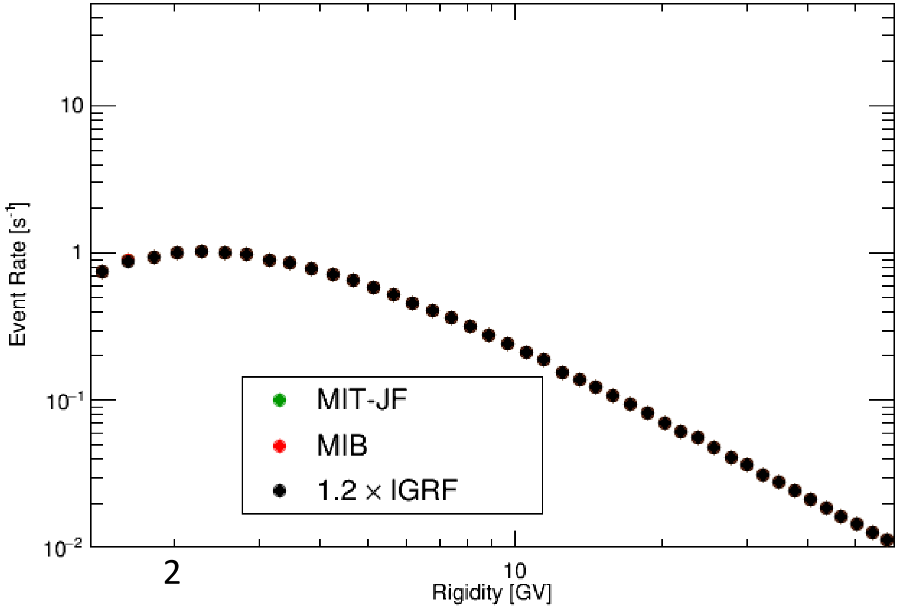
[0.8,1.0]GV
Bin not allowed
using IGRF cut-off

Event Rate: comparison with 1.2×IGRF cut-off

Proton



Helium



Summary

- We back-traced real events by means of the **GeoMagSphere** code, in order to estimate the cut-off in the AMS field of view, using realistic models of the geomagnetic field, such as the Tsyganenko models;
- We determined the **correction factor** to be applied to the IGRF cut-off in order to **match (at 1% level) the event count obtained using the Tsyganenko cut-off**. The present study as been performed considering two Bartel rotations, during a quiet (June 2016) and a disturbed (March 2012) period;

- **The increment in p & He statistics** using the corrected cut-off can reach **a factor larger than 10 at low rigidities**, with respect to the 1.2×IGRF cut-off**;**
- **The agreement between MIB and MIT-JF rate is <0.5% above 1.0GV;**

- In addition, peculiar periods with **solar energetic particles (SEPs),** need a suitable treatment, *i.e.* **back-tracing the full sample** with Tsyganenko magnetospheric field model.

Work in progress…

The correction factor is rigidity dependent.
Moreover it varies according to geomagnetic disturbances.

On going analysis:

- considering shorter (daily) periods;
- correlate the IGRF cut-off correction factor to the parameters describing the magnetospheric disturbance level (e.g. *solar wind dynamic pressure* P_{dyn} , *disturbance storm time index* Dst)