Geomagnetic effects on cosmic ray propagation under different conditions for Malargüe city, Argentina

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Roadmap

- Anisotropy in CRs
- Bgeo Models
- Rigidity cutoff

- Geomagnetic effects in calm periods
- Geomagnetic effects in storm periods

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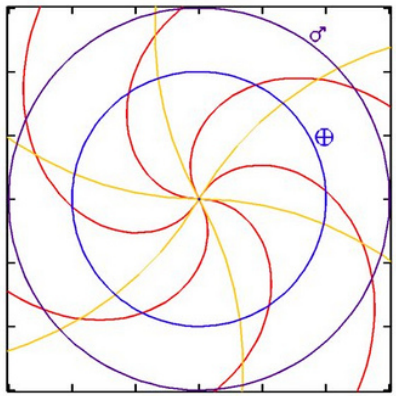
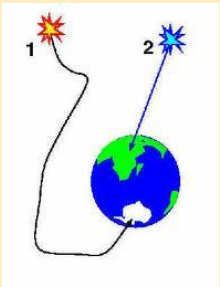
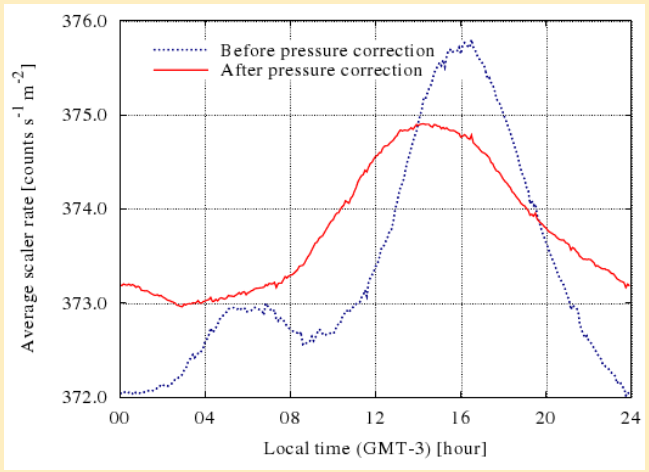
Anisotropy in cosmic ray (CR) flux direction:

Interplanetary field lines

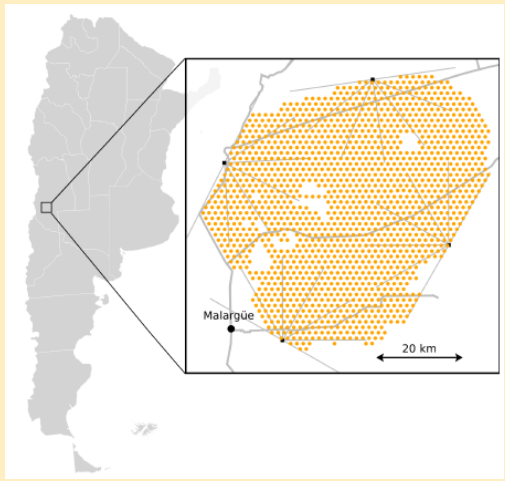




Diurnal modulation in average scaler data (Mar2005-Sep2005)



[Pierre Auger Colaboration (2011), JINST 6, No P01003]



[Pierre Auger Observatory]

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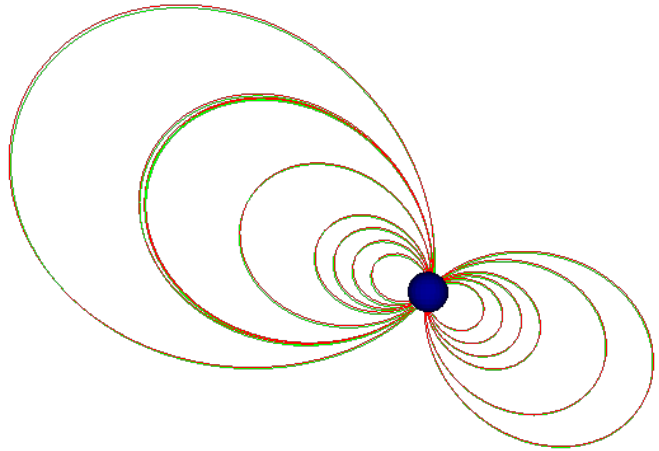
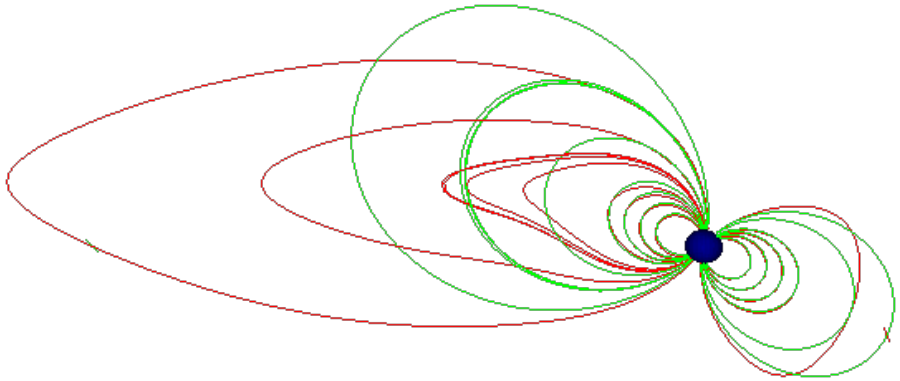
B_{geo} Models



Centered Dipole (green) and IGRF Model (red).



Centered Dipole (green) and Tsyganenko Model "TSY01"(red).

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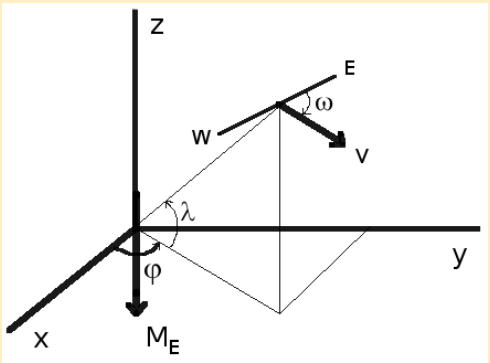
Definitions and equations

Rigidity : $R = mvc/q \rightarrow$[GV]

Equation of motion:

$$m\frac{d\mathbf{v}}{dt} = \frac{q}{c}\mathbf{v}x\mathbf{B} \qquad (1)$$

Obs: Energy is conserved.

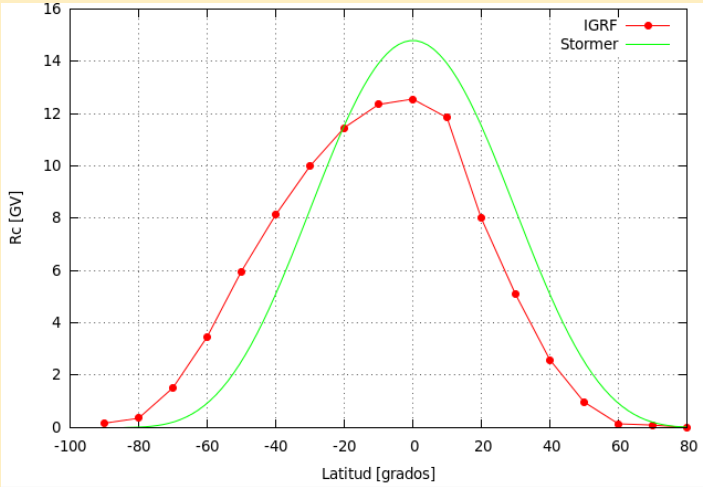


Rigidity cutoff

Rigidity cutoff for a dipole:

$$R_c(\lambda,\omega) = \frac{59{,}2cos^4\lambda}{(1+\sqrt{1-cos\omega cos^3\lambda})^2}\,GV$$

Latitud dependence of Rc in a dipole and an empirical model (IGRF 2010):



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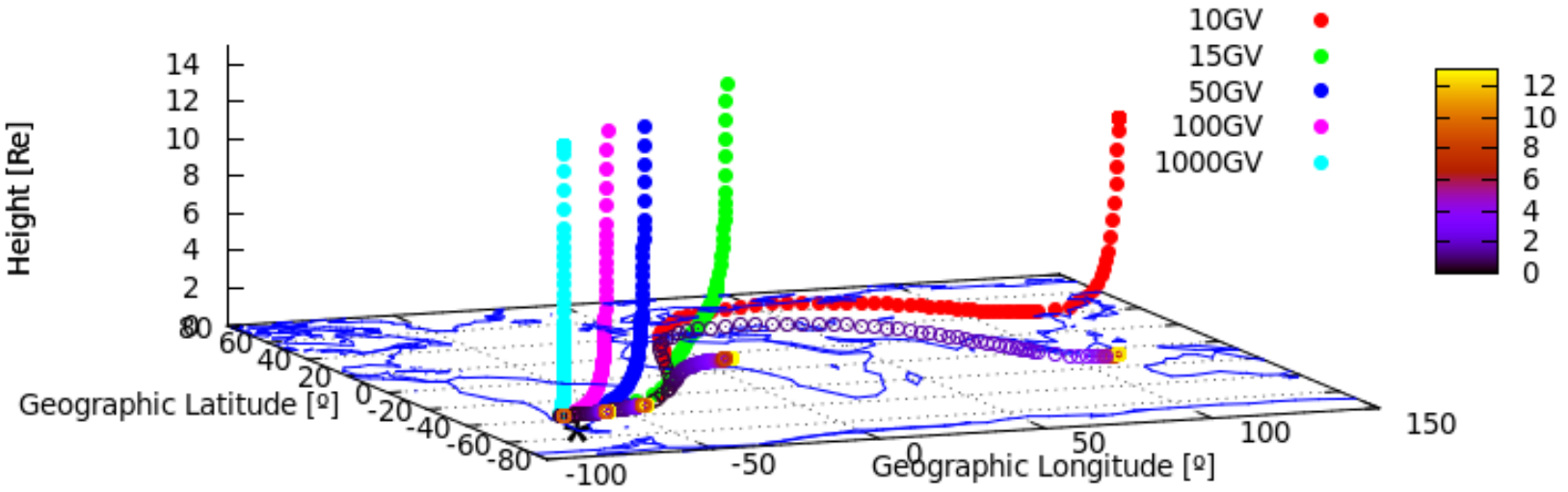
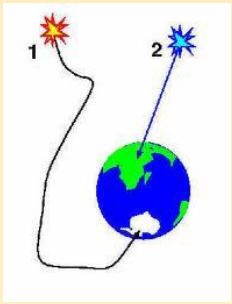
Proton trajectories inside the magnetosphere:

- Color bar represents the height in Earth radius units (Re).
- zenith = 0^o.

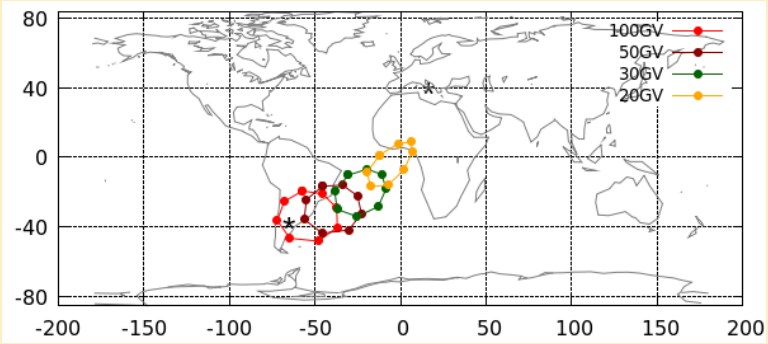


Asymptotic Directions for zenith=15° (projected on Earth surface):
Obs: These directions do not change along the day.

Asymptotic trajectory direction

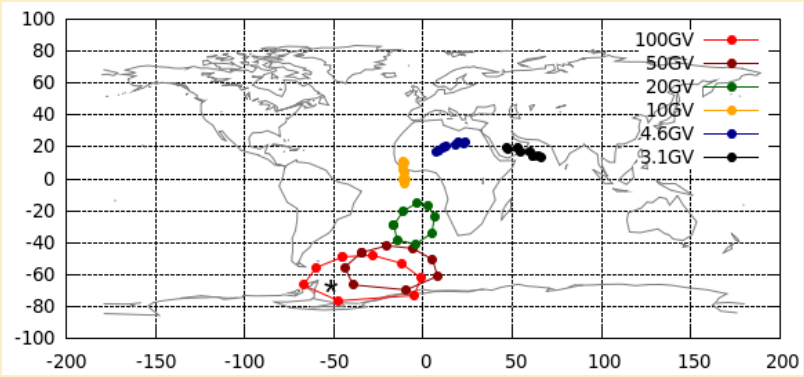


Malargue (Rc=9.6 GV)

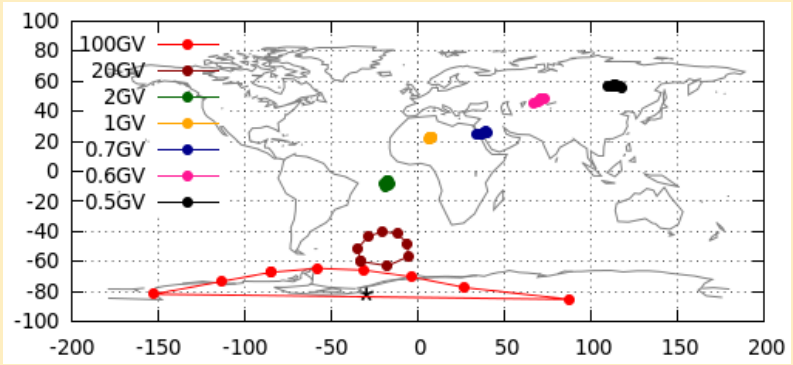


Masias-Meza et al. (IAU Proceedings, 2012)

Marambio (Rc=2.22 GV)



Belgrano II (Rc=0.33 GV)



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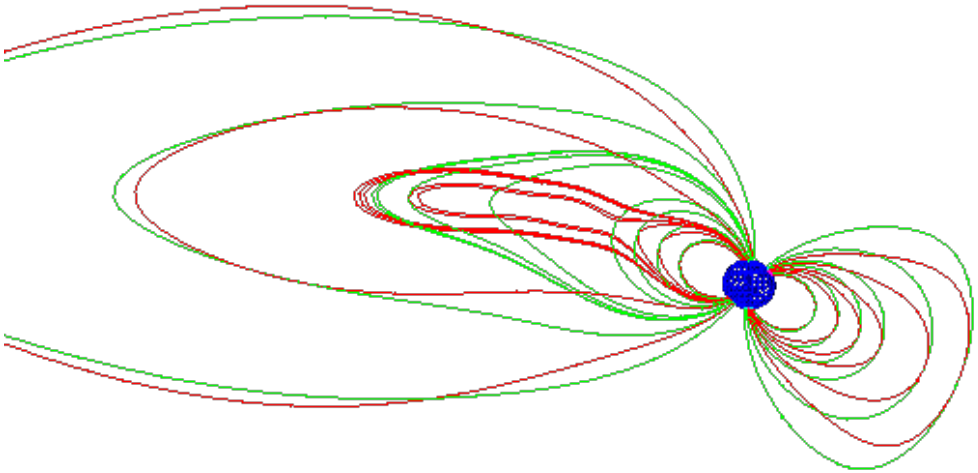
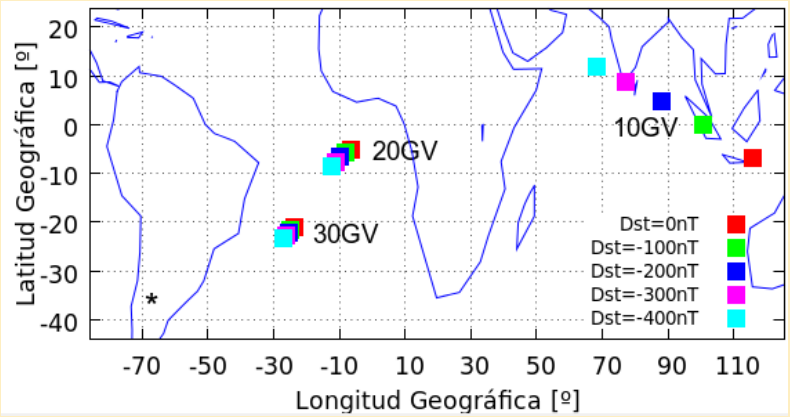


Bgeo geometry using IGRF+TSY01 with Dst=0nT (green) and Dst=-250nT (red).
From Masias-Meza et al. (IAU Proceedings, 2012)

Asymptotic directions for different storm conditions:

Malargue (zenith=0°)

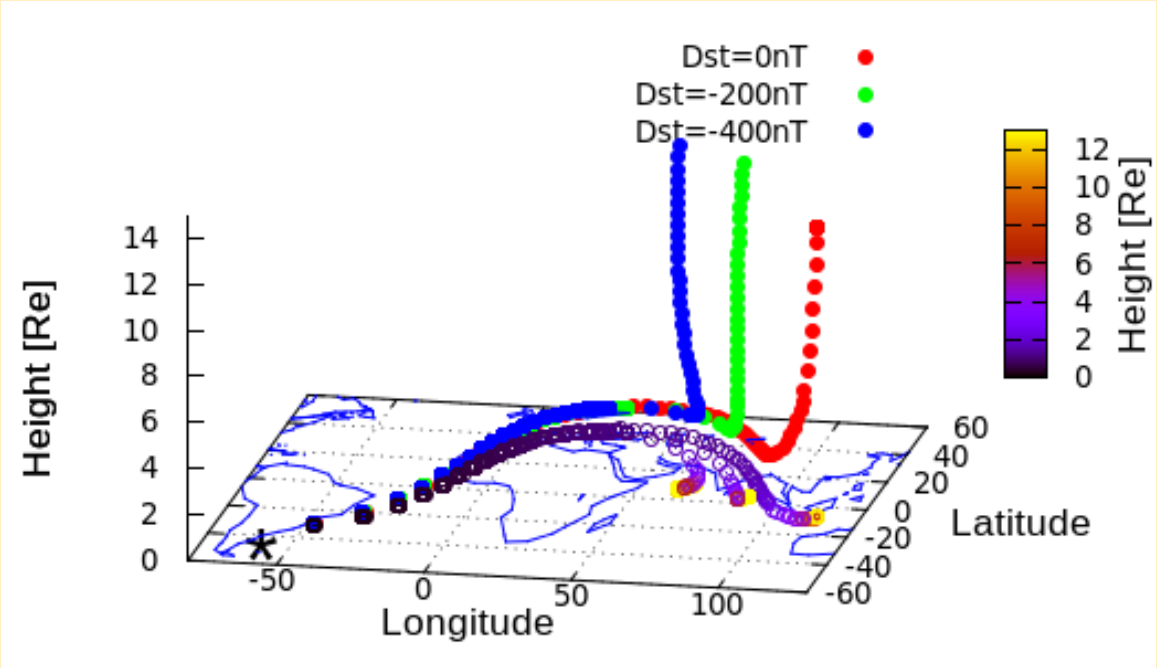


Azimutal shift in hours from detector position:

$\delta\phi^{Mlg}[hrs]$	0nT	−100nT	−200nT	−300nT	−400nT
10 GV	12.33	11.32	10.48	9.77	9.16
15 GV	5.39	5.18	4.99	4.81	4.64
20 GV	4.19	4.08	3.98	3.88	3.79
30 GV	3.03	2.97	2.92	2.86	2.81

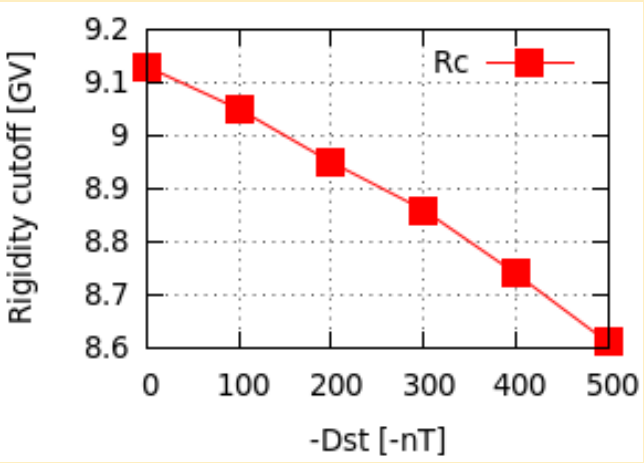
Trajectories under different storm conditions for Malargue:

10GV



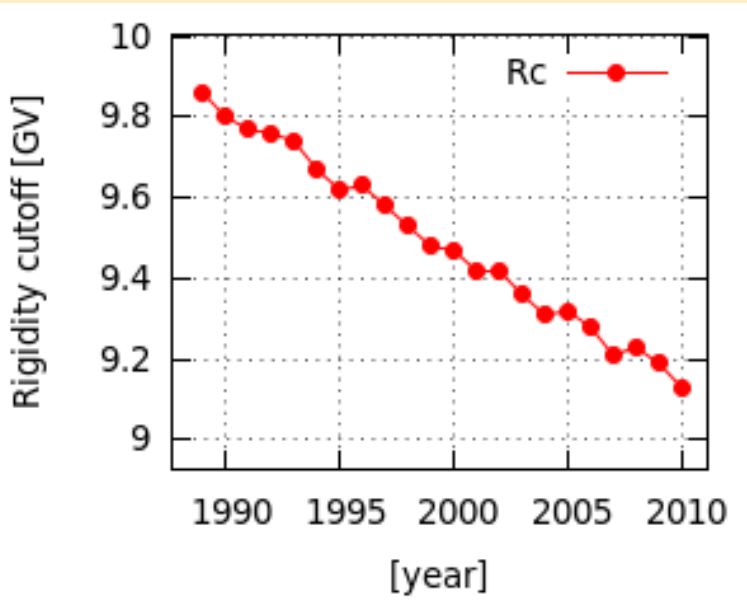
Rc trends using IGRF + TSY01 (at Malargue):

Rc vs Dst



Simulations considering different values of Dst show a -0.001GV/nT decrease.

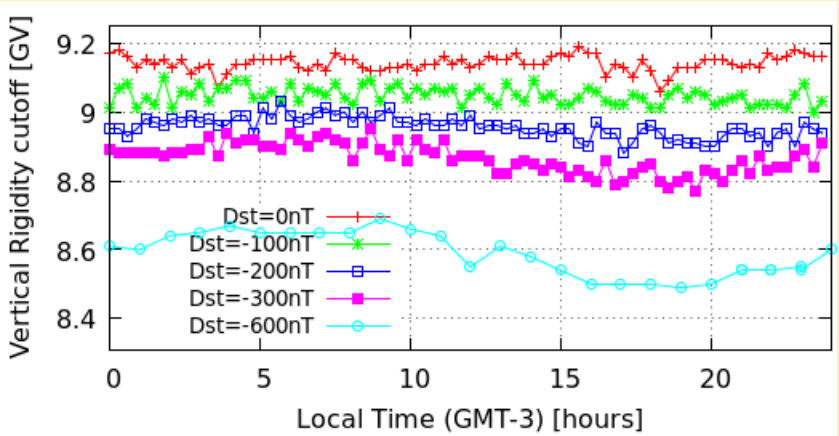
Rc vs years



The effective rigidity cutoff decreases linearly with $-0{,}03 GV/year$.

Vertical rigidity cutoff (Rc with zenith=0°) along the day in storm conditions:

Malargue (Rc=9.6GV with Dst=0)



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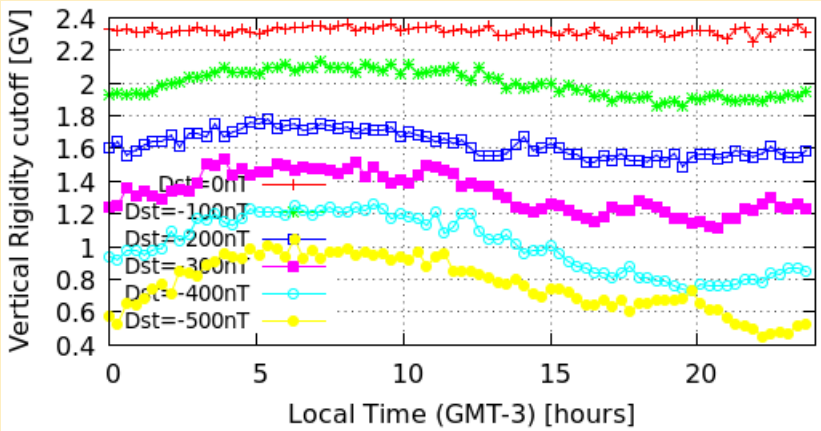
Marambio (Rc=2.22GV with Dst=0)



SUMMARY:

• We determined the cut-off rigidity (Rc) for different incidence directions, using trajectories at the site of the Pierre Auger Observatory.
• We determined the variation of R_c along a day for different geomagnetic storm conditions.
• The secular variation rate of R_c^{Mlg} was found to be $-0{,}03 GV/year$.
• The variation rate of R_c^{Mlg} with Dst was found to be -0.001GV/nT.
• All these results can be used to interpret cosmic ray modulation using Auger data for calm and storm periods.

Thanks!