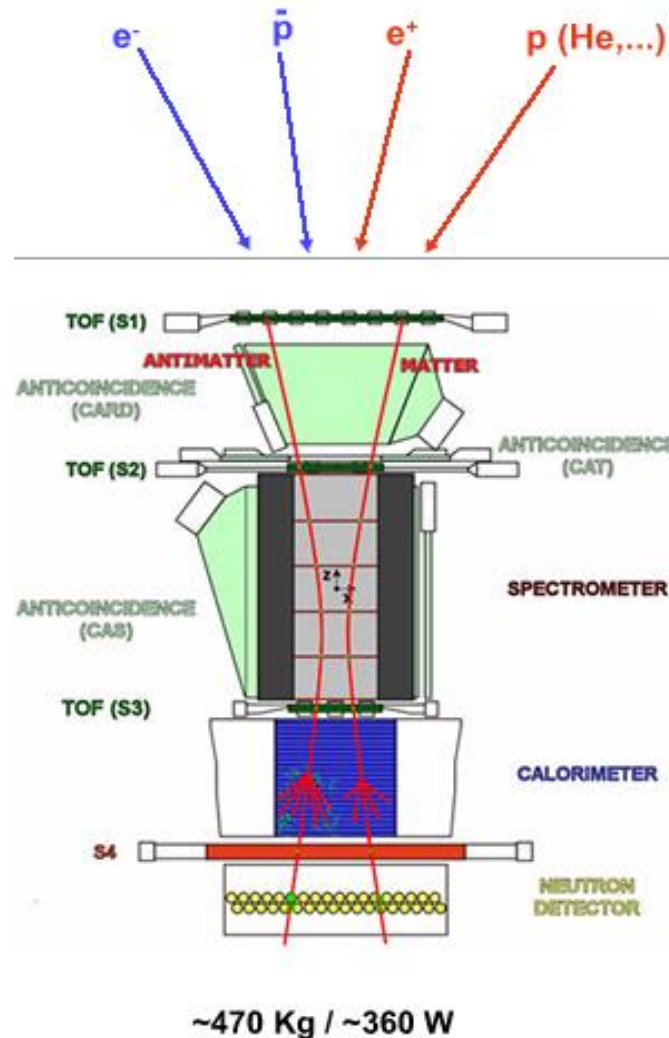
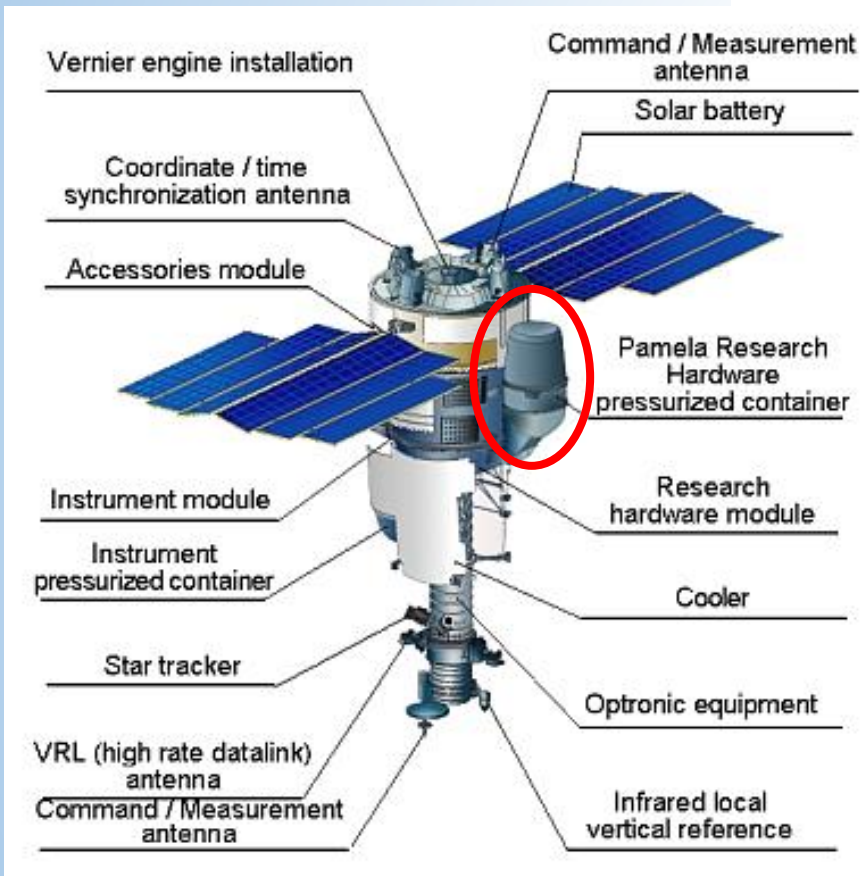


# Time dependence of the proton and helium fluxes measured by PAMELA during solar minimum (2006 - 2009)

ICRC 2019 – 25/07/19

Speaker: *Nadir Marcelli*

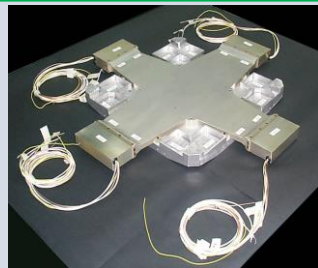
# PAMELA detector



## Time-Of-Flight

Plastic scintillators:

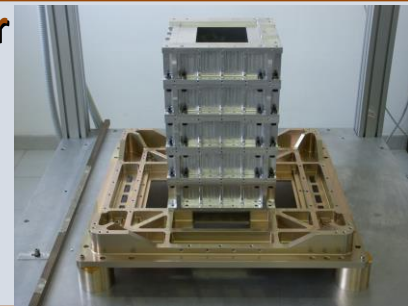
- Trigger
- Charge identification  $dE/dx$



## Magnetic spectrometer

Silicon strip + permanent magnet:

- Trajectory track
- Sing and absolute value of the charge



## Calorimeter

Silicon Strip and tungsten:

- Electromagnetic shower energy
- Incident  $e^-/+$  energy



## Neutron Detector

$^3\text{He}$  gas cylinders:

- Adrons and leptons discrimination



## Trigger configuration:

- Registered hit on S1 & S2 & S3

## Track selection:

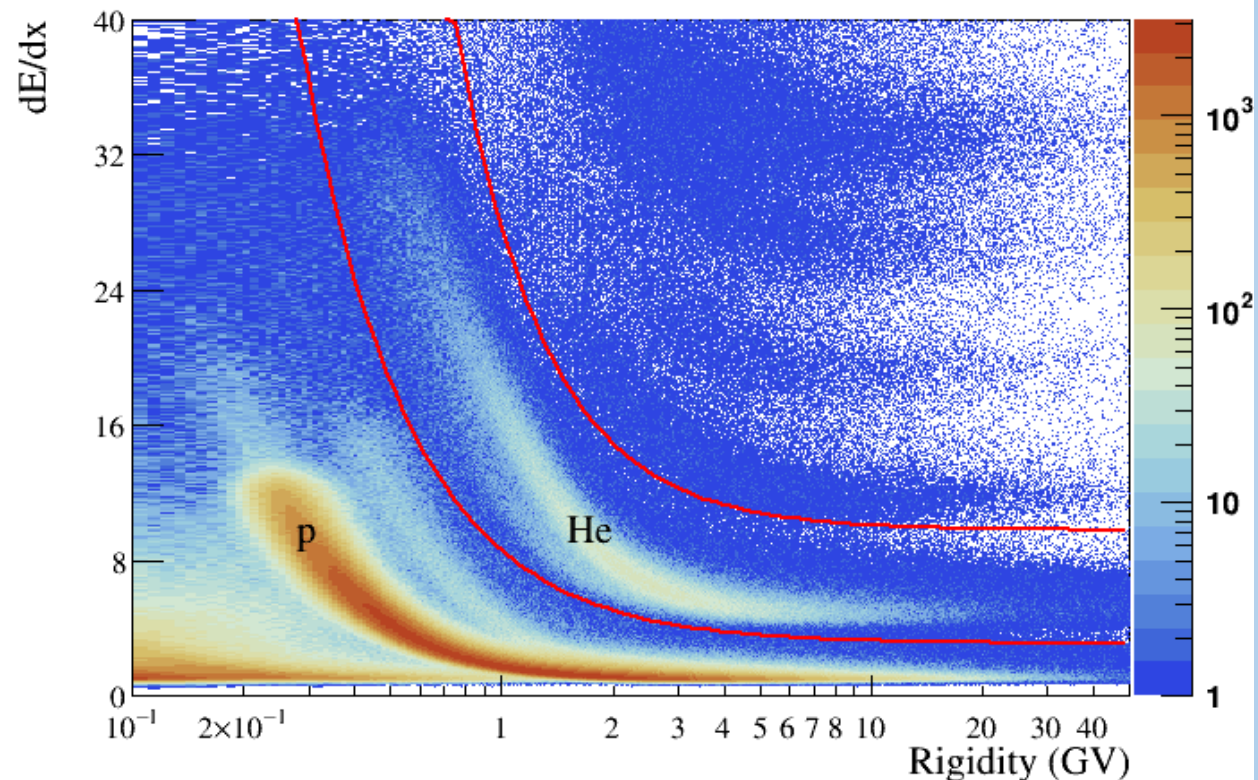
- Lever-arm of at least 4 silicon planes with at least 3 hits on both *x-view* and *y-view*
- Single track fitted in the spectrometer
- Fully contained within 1.5 *mm* away from the magnet walls

## ToF selection:

- Albedo particle rejection requiring  $\beta = \frac{v}{c} > 0$

## Charge selection:

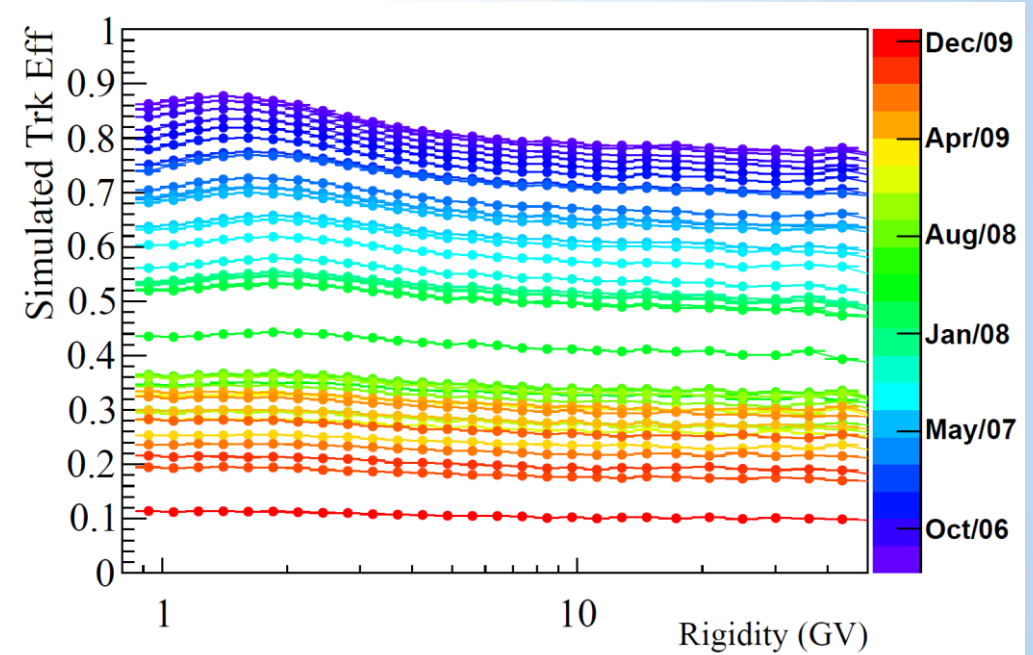
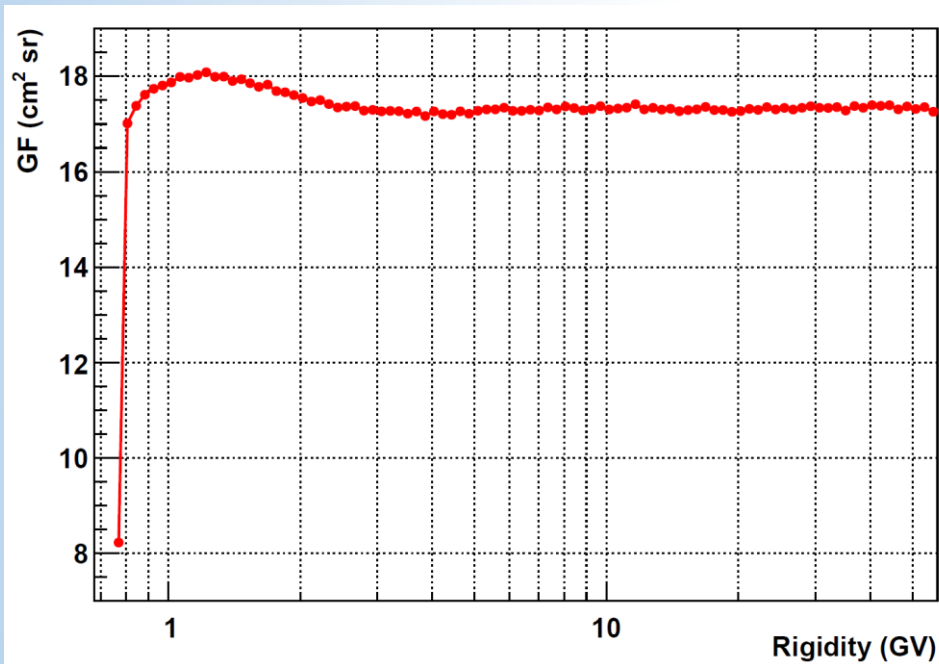
- Mean ionization energy release over tracker silicon planes contained inside the region defined by the two red curves





# Flux computation

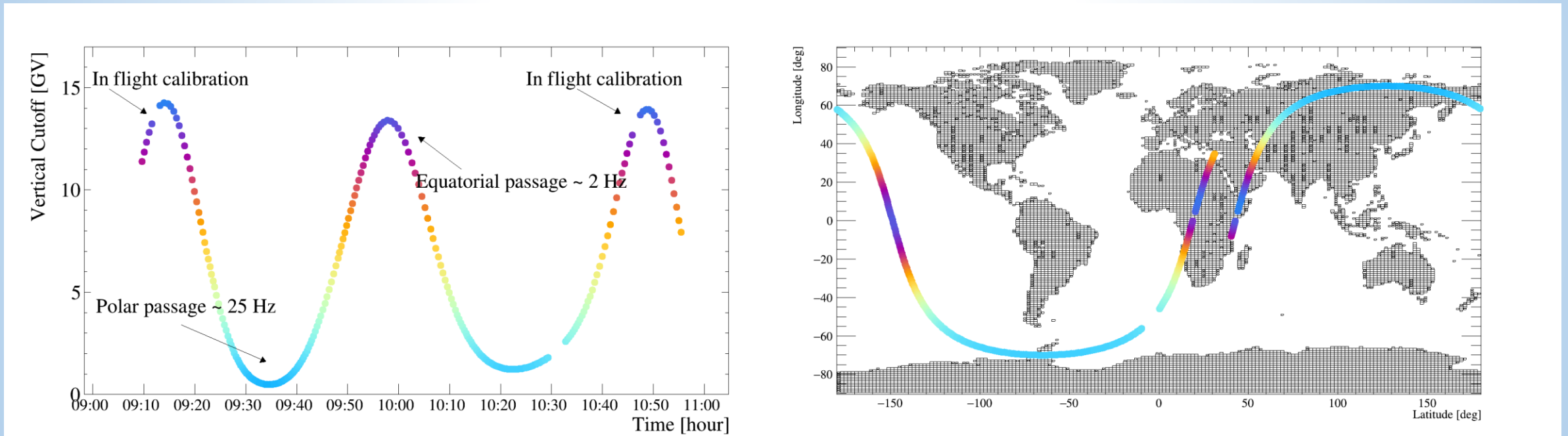
$$\phi(R_i) = \frac{N_{sel}(R_i)}{\Delta R_i} \cdot \frac{1}{GF(R_i) \cdot \varepsilon_{total}(R_i) \cdot T_{live}(R_i)}$$



Helium fluxes computed in time intervals of 1 Carrington Rotation between  $0.86 \text{ GV}$  and  $\sim 50 \text{ GV}$

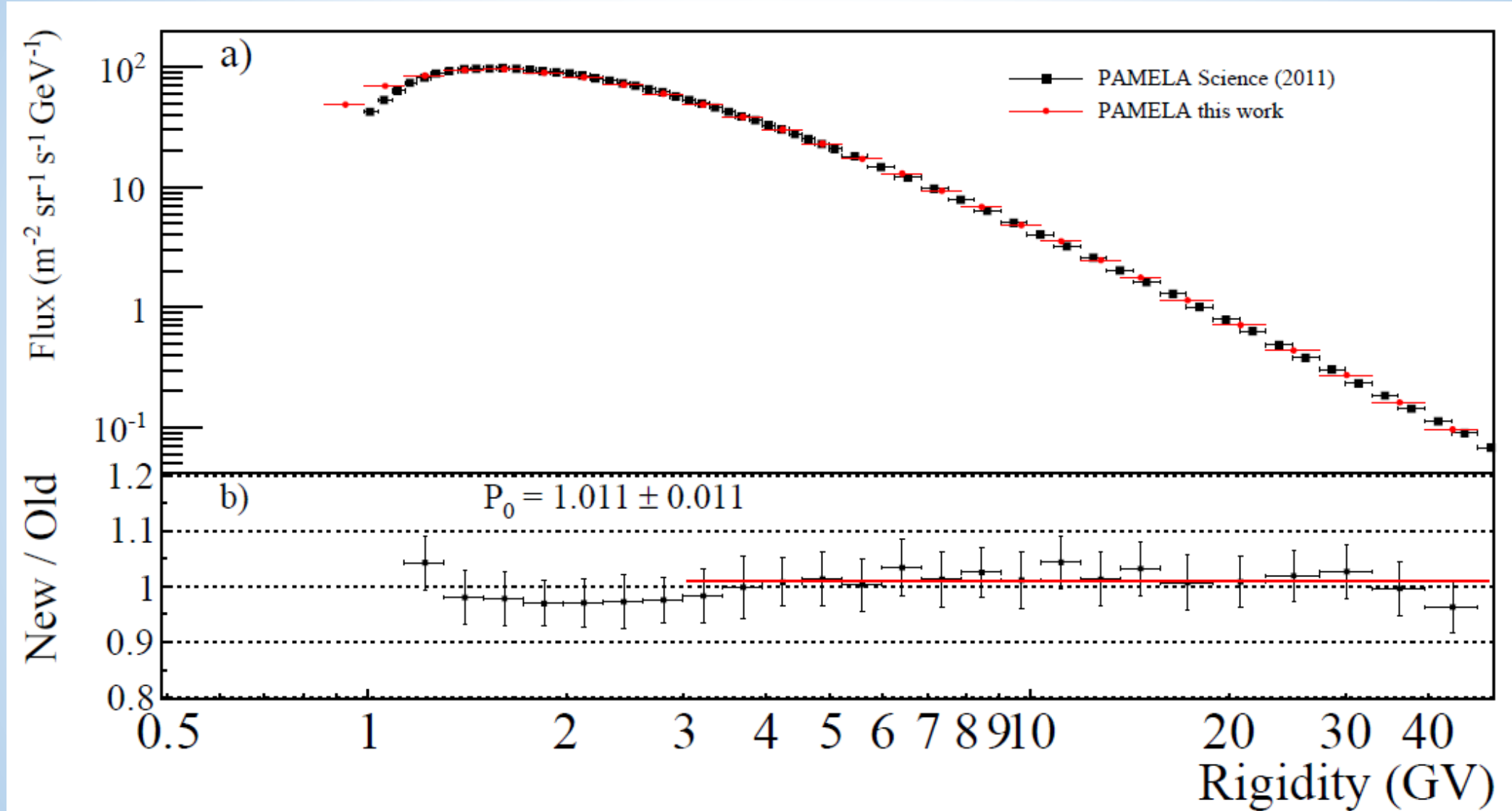
# Flux computation

$$\phi(R_i) = \frac{N_{sel}(R_i)}{\Delta R_i} \cdot \frac{1}{GF(R_i) \cdot \varepsilon_{total}(R_i) \cdot T_{live}(R_i)}$$

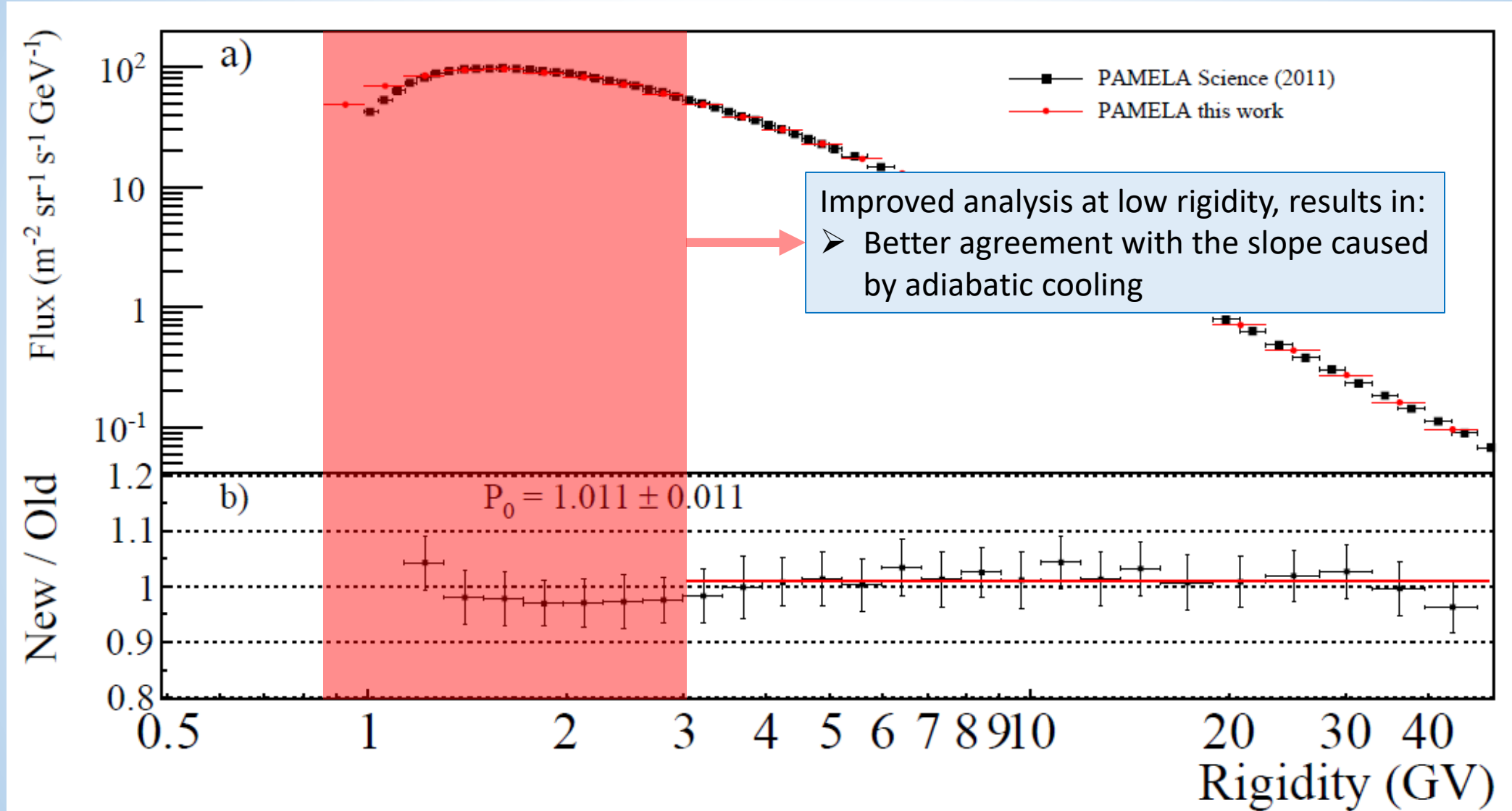


Helium fluxes computed in time intervals of 1 Carrington Rotation between  $0.86 \text{ GV}$  and  $\sim 50 \text{ GV}$

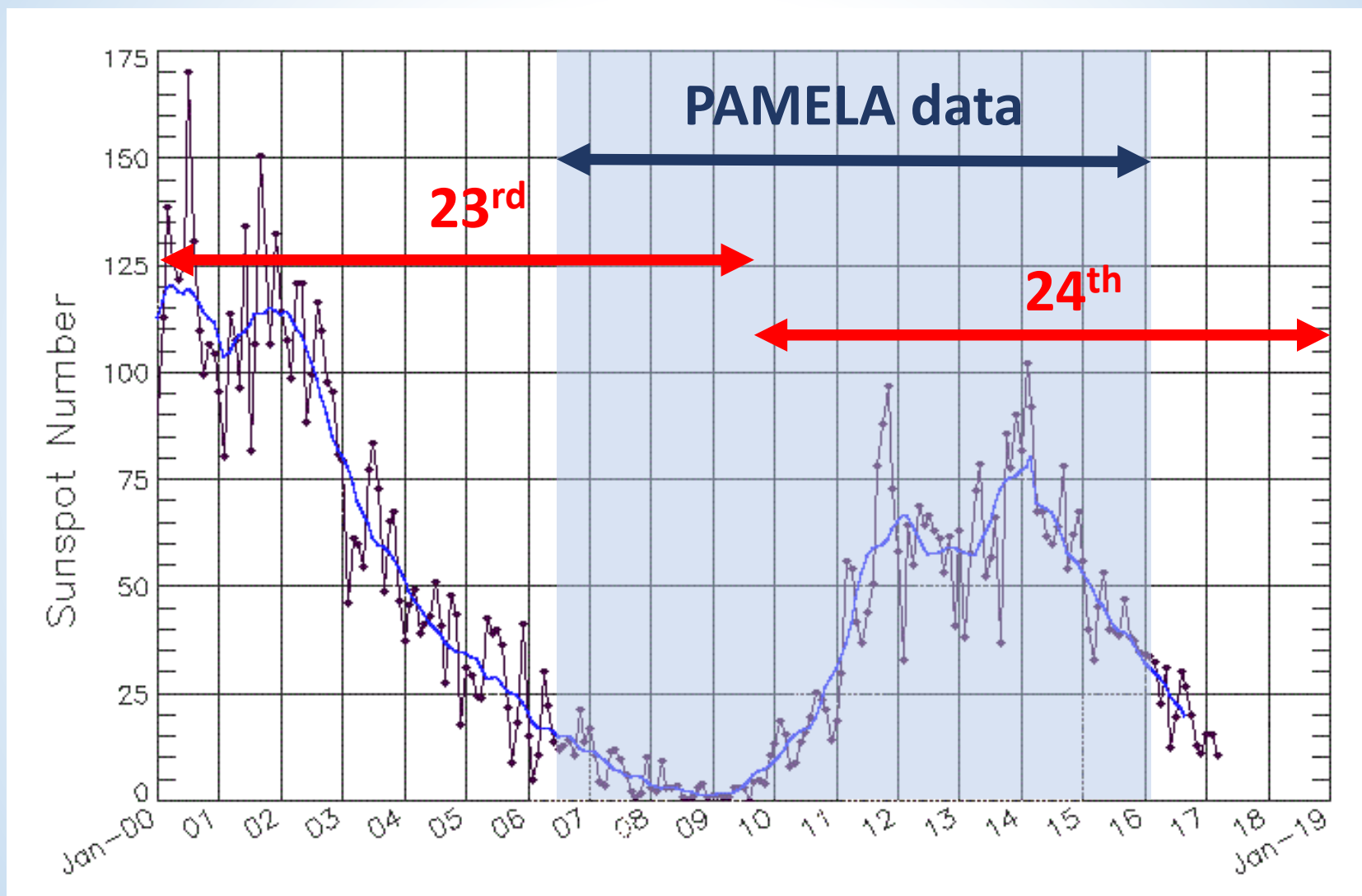
# Check with previous analysis



# Check with previous analysis

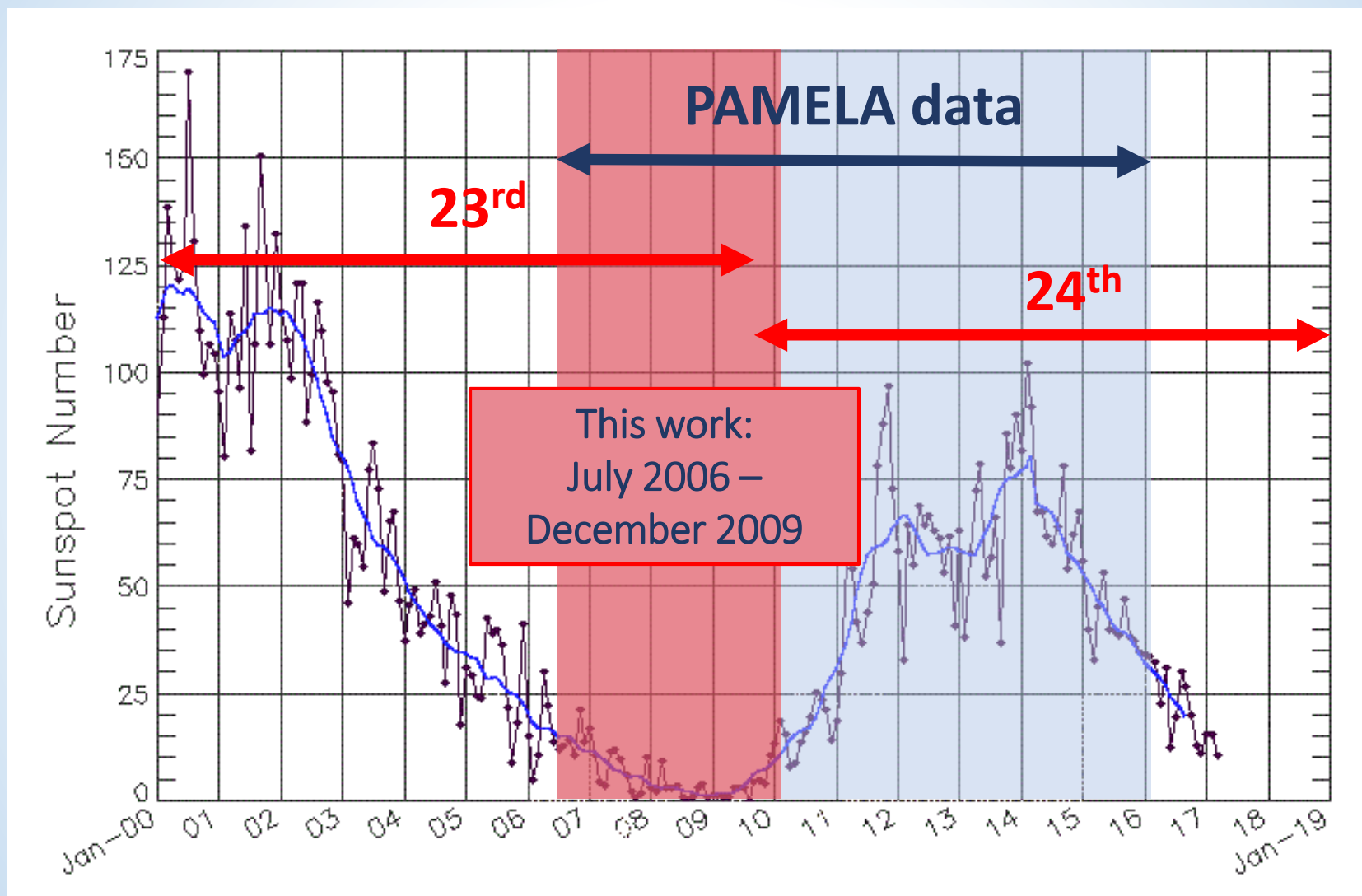


# Solar activity

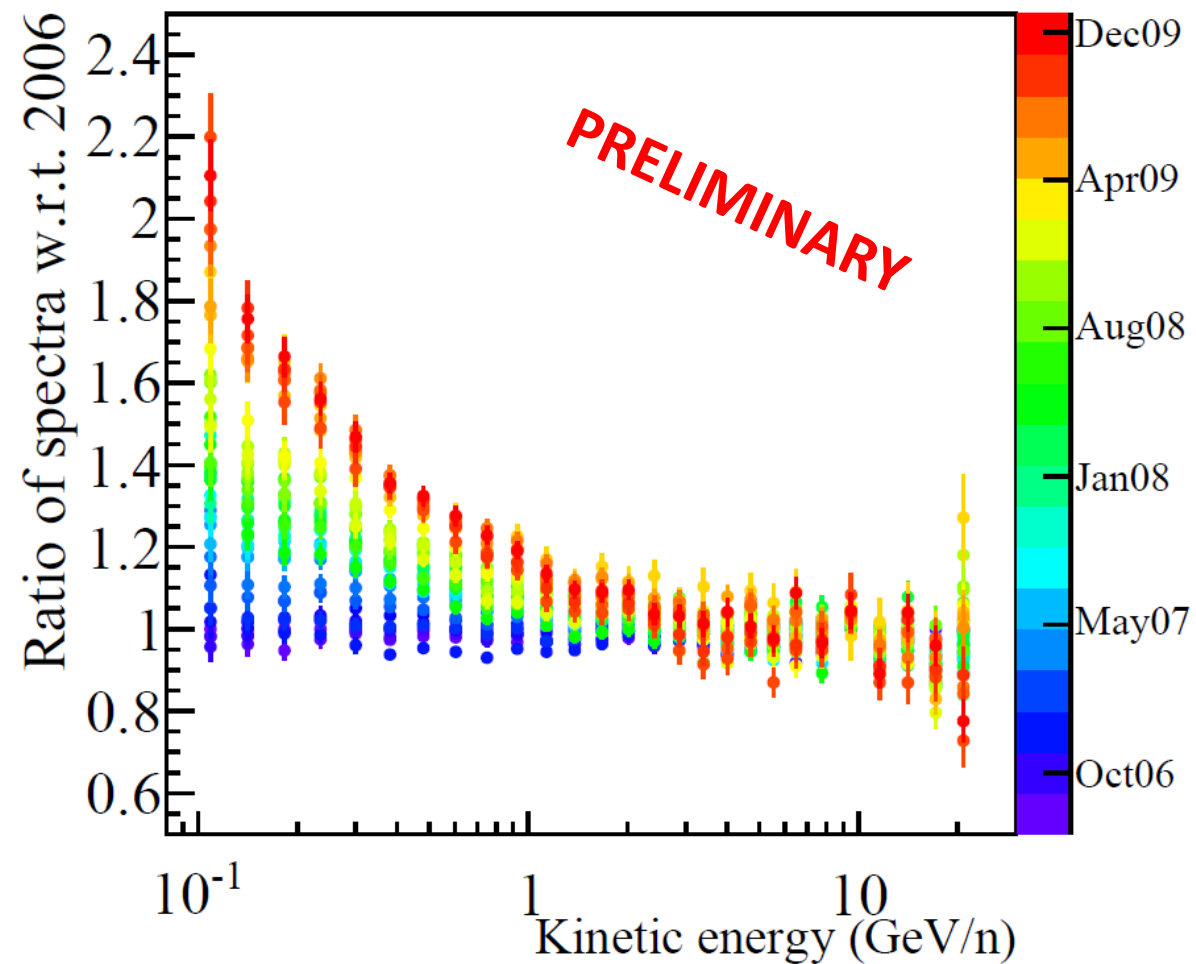
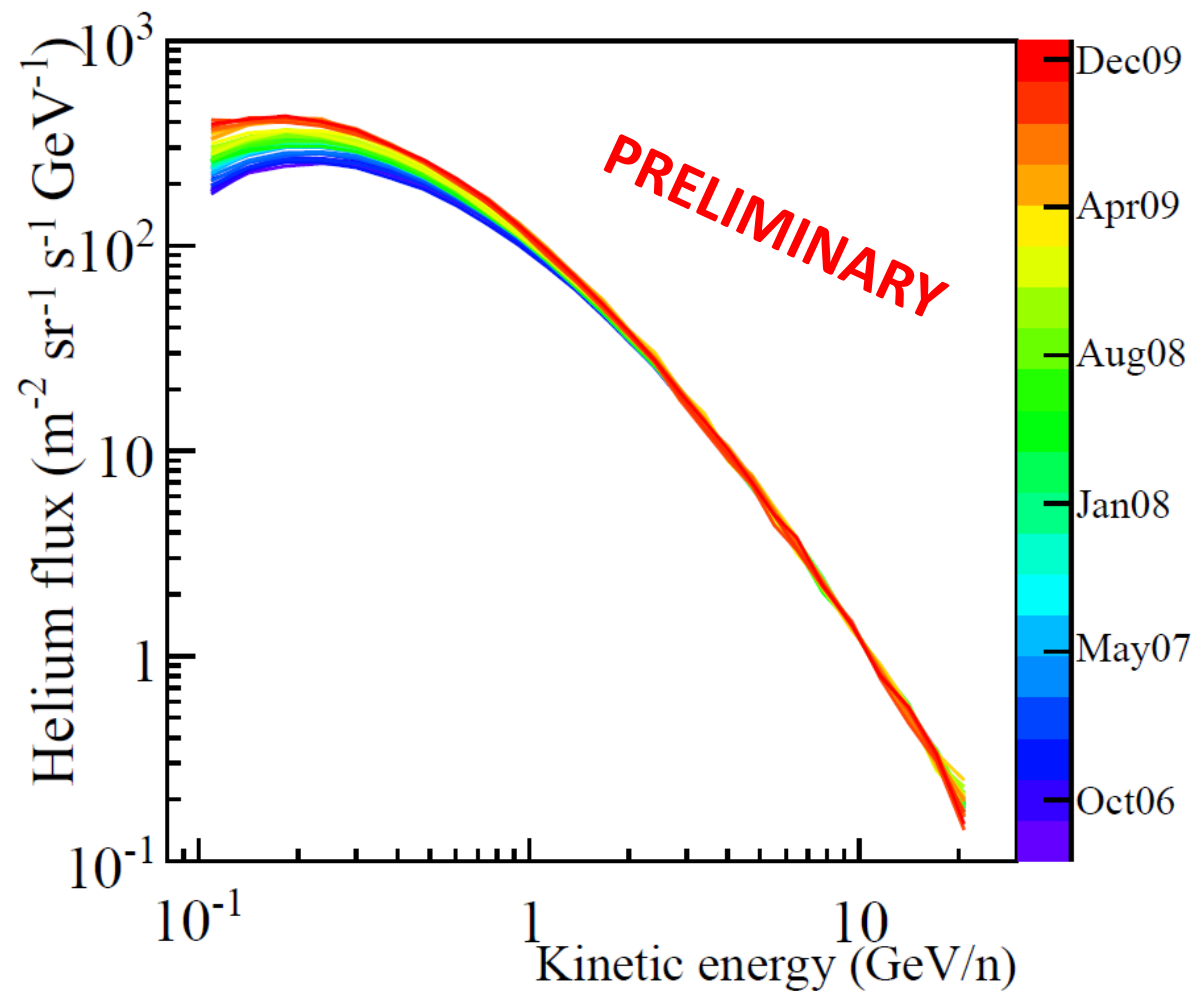




# Solar activity



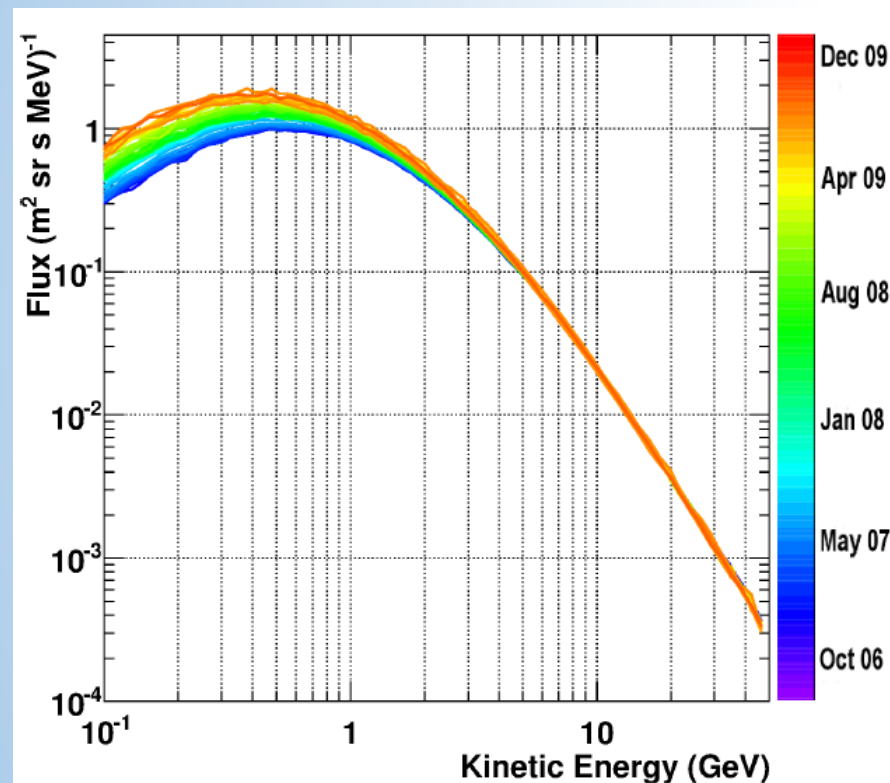
# Helium fluxes



# Proton fluxes

## Solar minimum

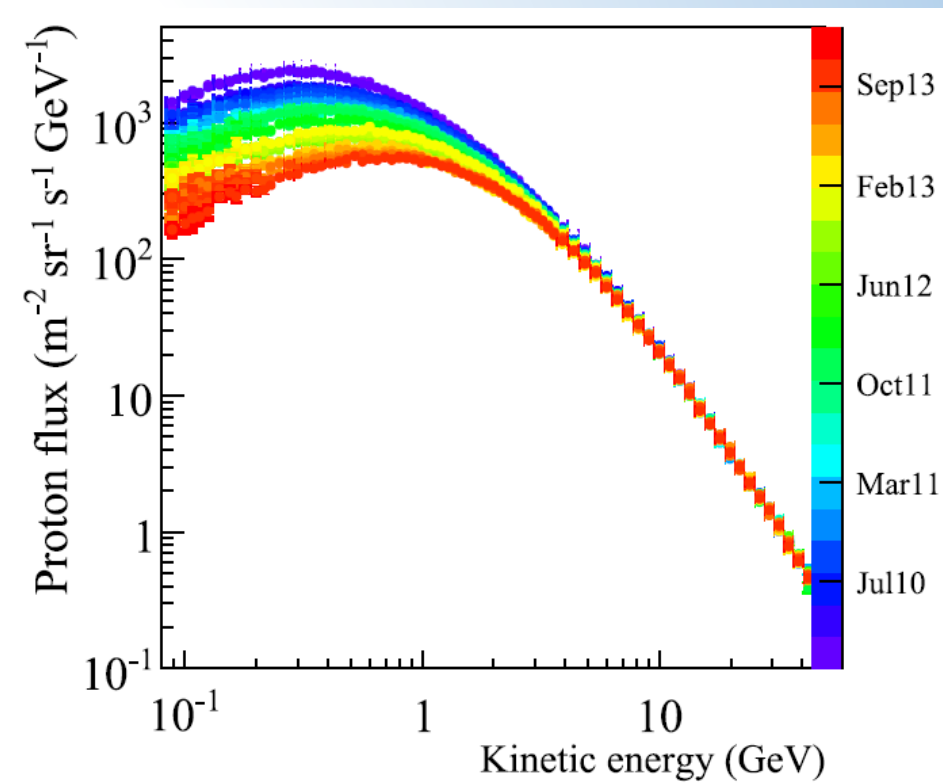
From July 2006 to December 2009



*Adriani et al., 2013 - ApJ*

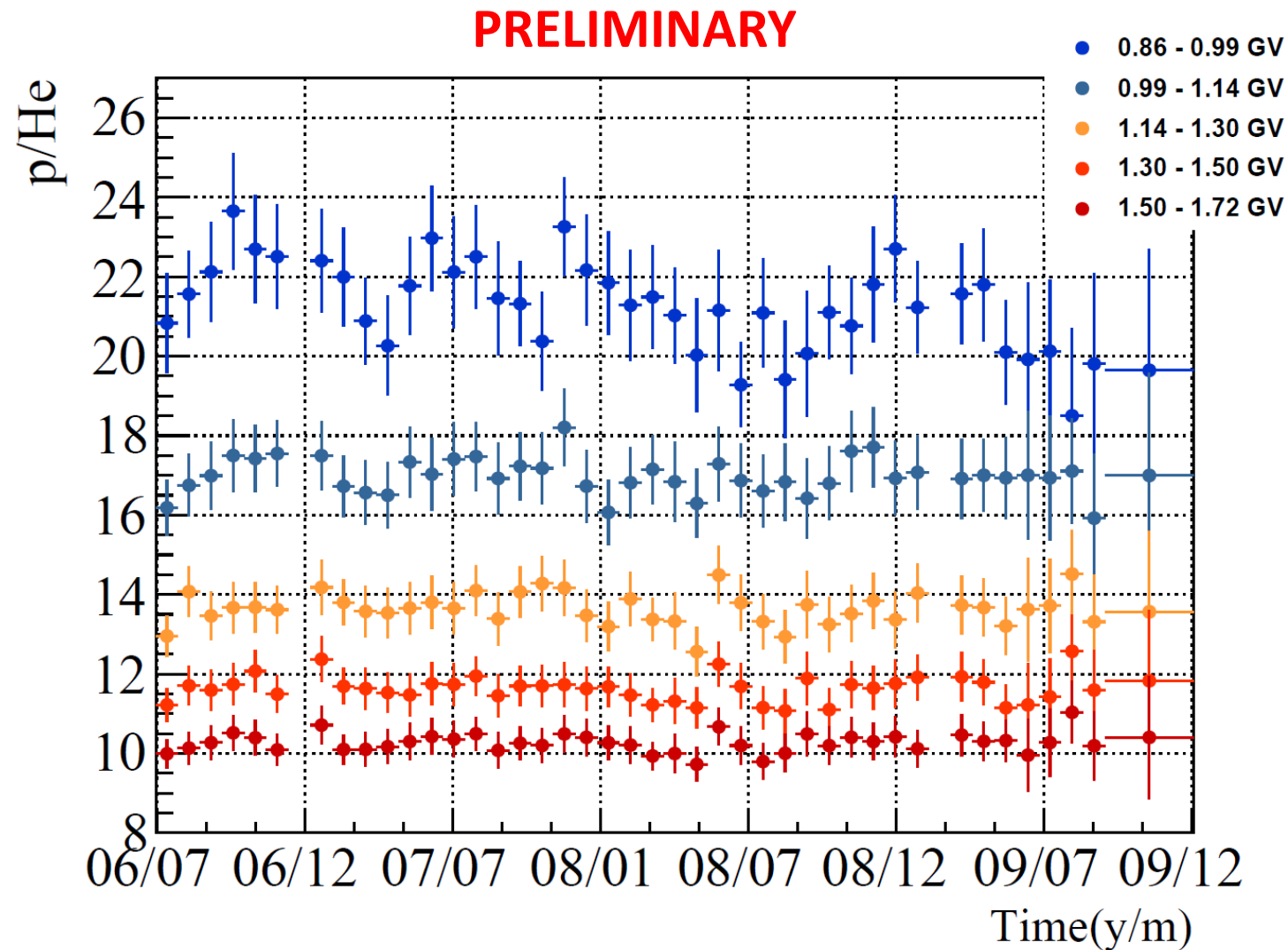
## Solar maximum

From January 2010 to February 2014



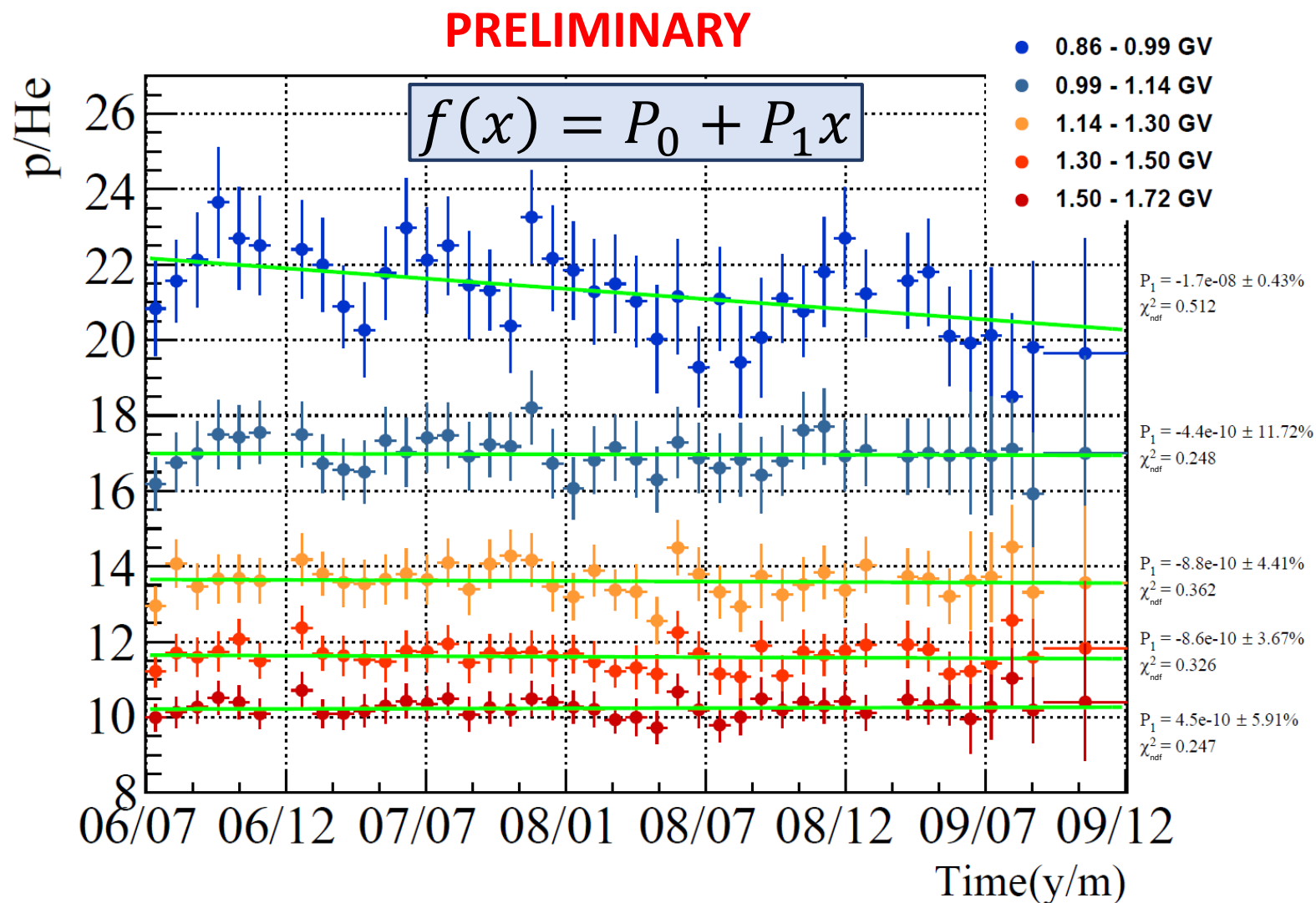
*Martucci et al., 2018 - ApJ*

# Proton over helium ratio





# Proton over helium ratio



# Conclusion

- At around 90 MeV the helium flux increased by  $\sim 90\%$  from June 2006 to middle 2009, when the solar activity reached the absolute minimum
- The helium modulation analysis is nearly finished and will be published soon
- An indication of a time dependence in the p/He ratio is observed, suggesting either a difference in the processes involved in solar modulation effects and/or a difference in the LIS for the two species
- Developing accurate models to predict He spectra at 1AU from Sun during solar minimum
- The analysis of the following solar maximum period (January 2010 – January 2016) is in progress