

# Temporal Structures in Electron and Positron Spectra and Charge Sign Effects in Galactic Cosmic Rays

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AMS



# AMS is a Space Version of a Precision Detector Used in Accelerators

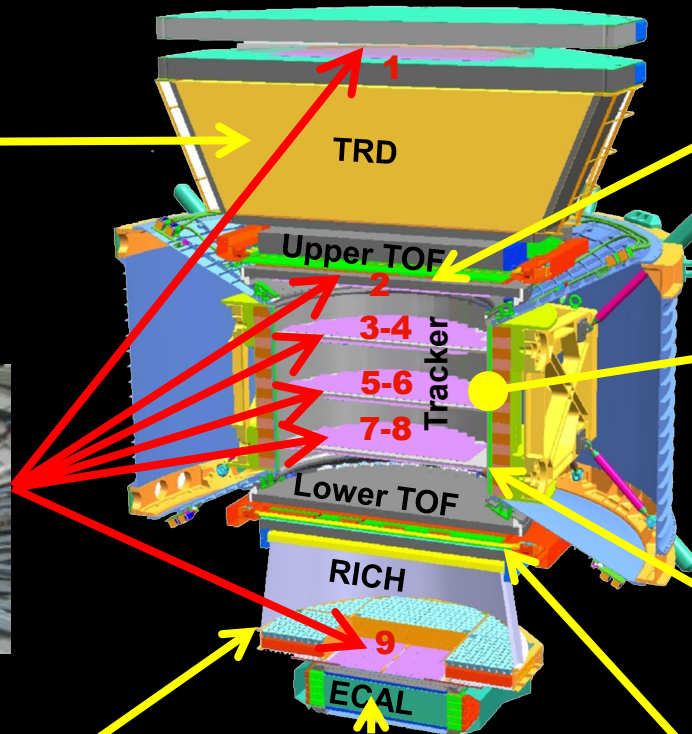
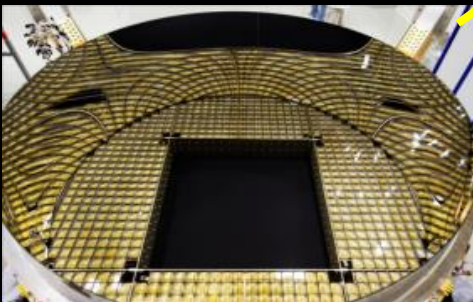
**Transition Radiation Detector (TRD)**  
identify  $e^+$ ,  $e^-$



**Silicon Tracker**  
measure  $Z$ ,  $P$



**Ring Imaging Cerenkov (RICH)**  
measure  $Z$ ,  $E$



**Electromagnetic Calorimeter (ECAL)**  
measure  $E$  of  $e^+$ ,  $e^-$



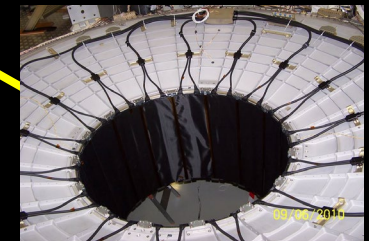
**Upper TOF** measure  $Z$ ,  $E$



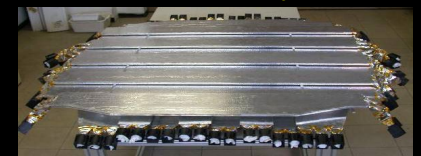
**Magnet** identify  $\pm Z$ ,  $P$



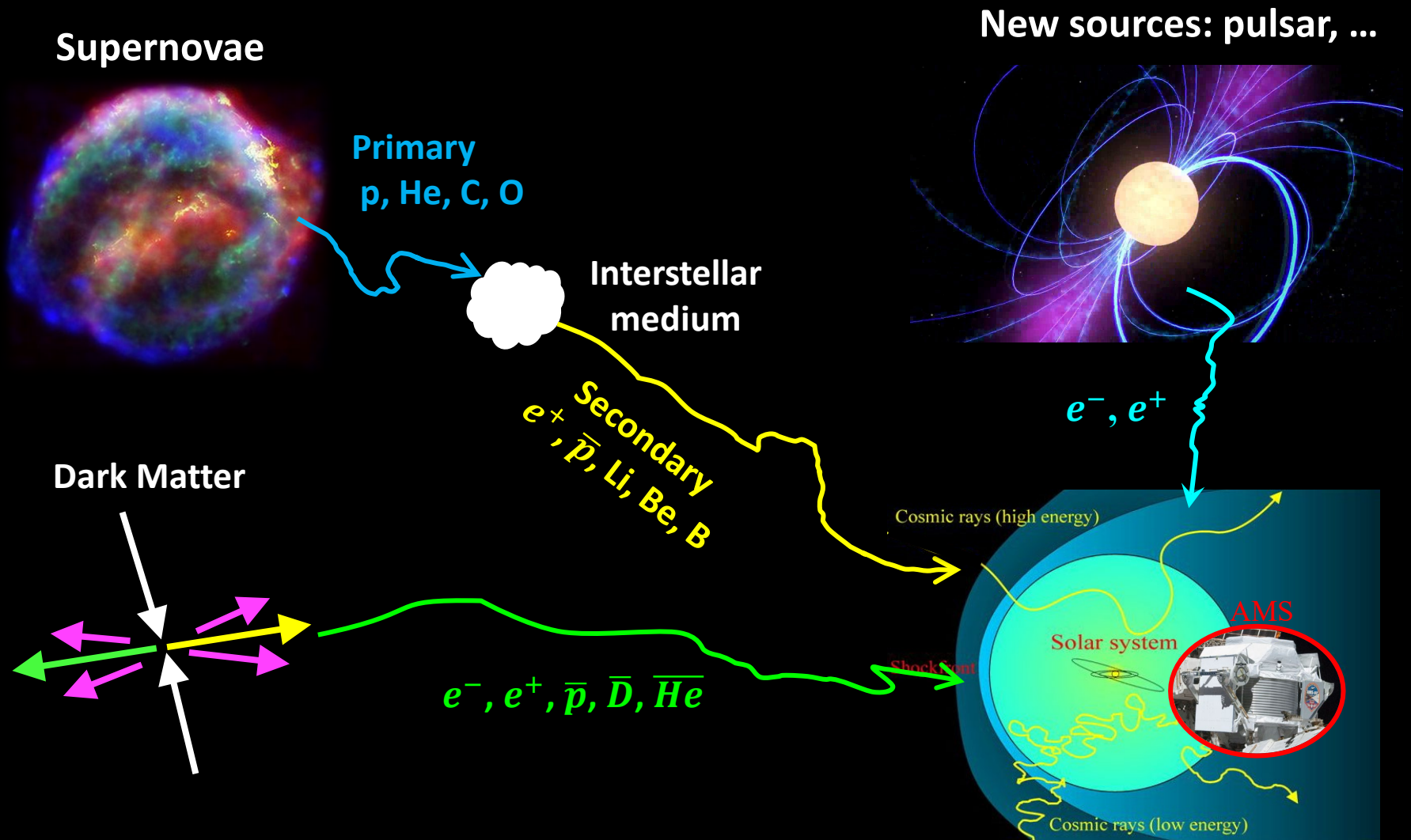
**Anticoincidence Counters (ACC)**  
reject particles from the side



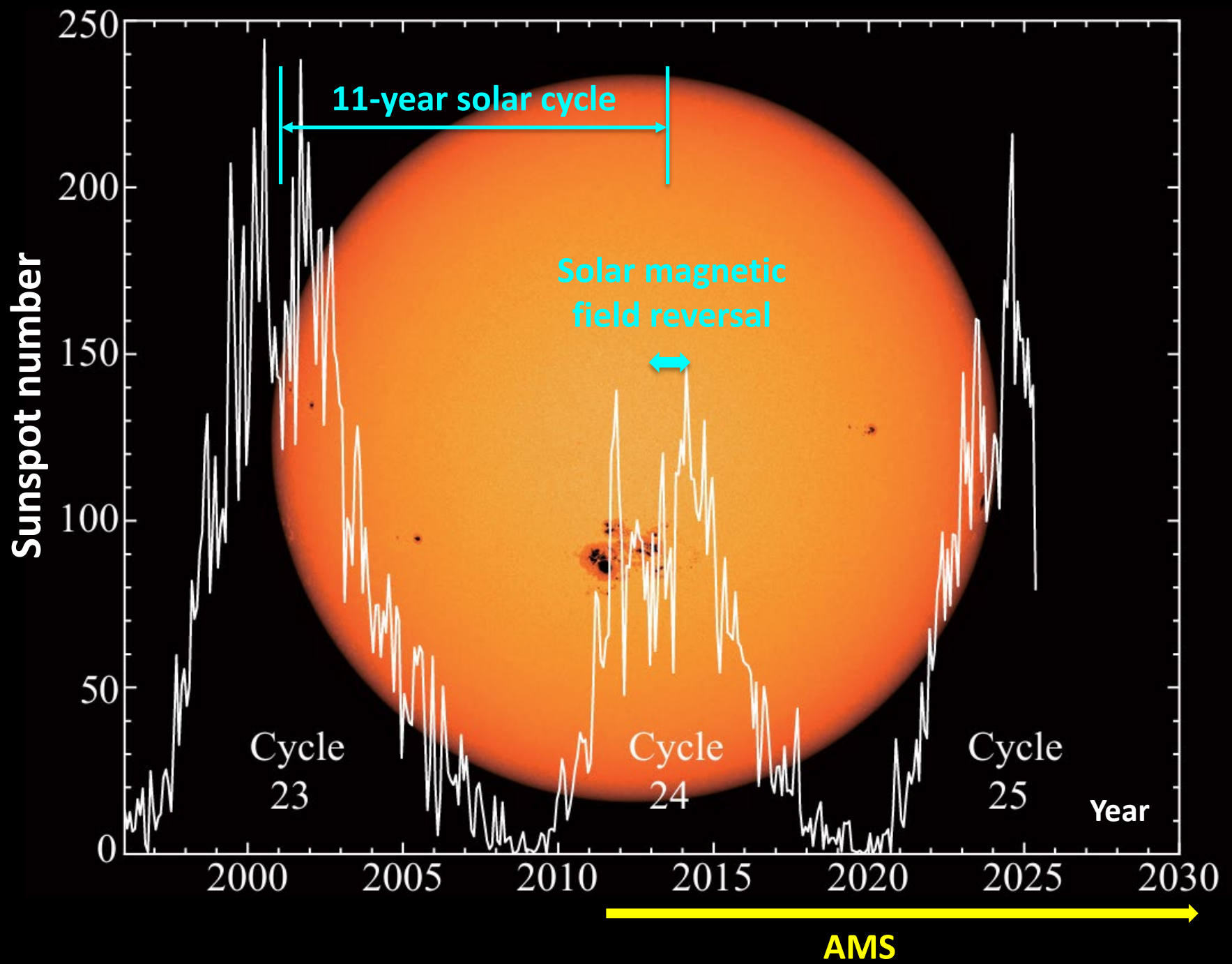
**Lower TOF**  
measure  $Z$ ,  $E$



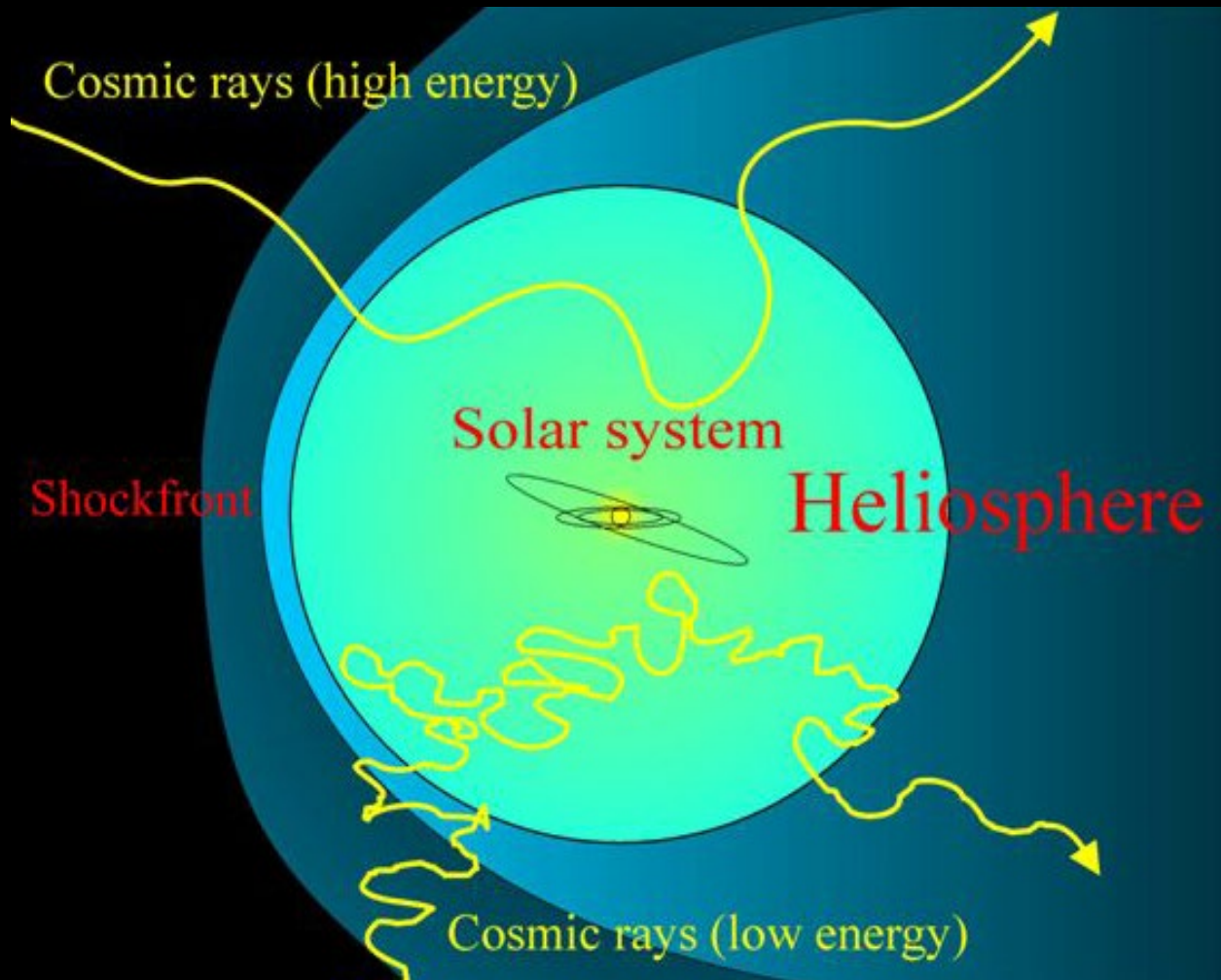
# Origin and Propagation of Cosmic Rays



Before being detected by AMS,  
all the galactic cosmic rays propagate in the solar system (heliosphere)

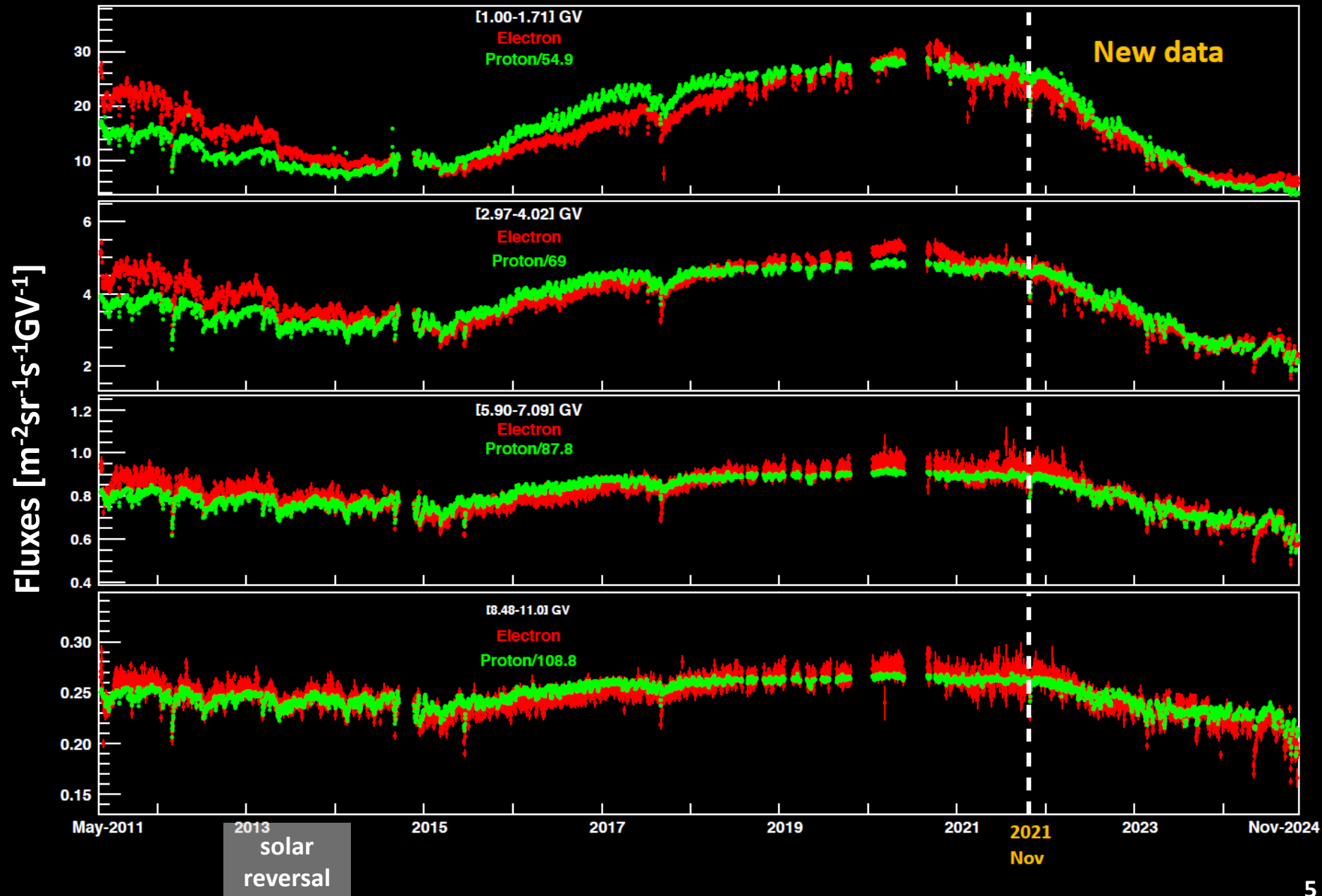


# AMS studies of the cosmic ray propagation in solar system



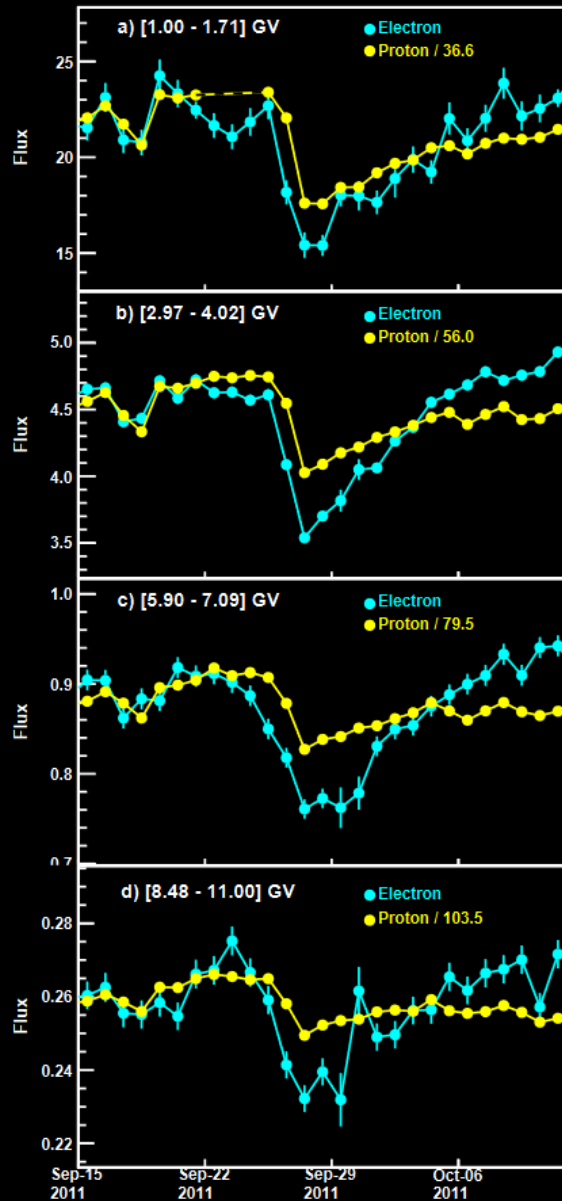
**AMS continuously measures cosmic ray fluxes of different species (matter and antimatter), with high precision and time granularity.**

# Daily electron and daily proton over 13.5 years

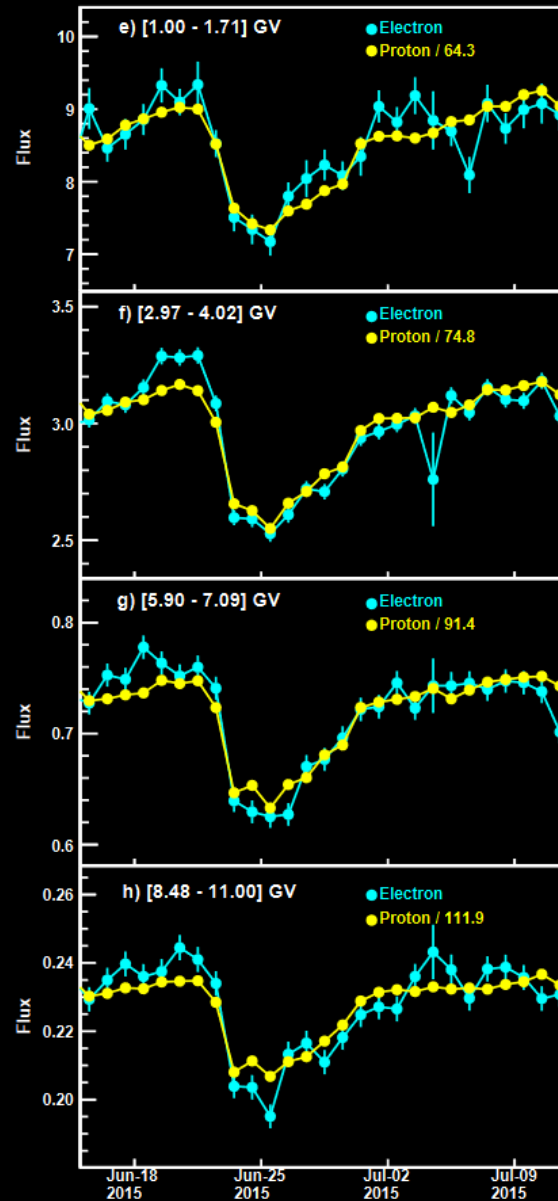


# Comparison of nonrecurrent variation between Electron and Proton

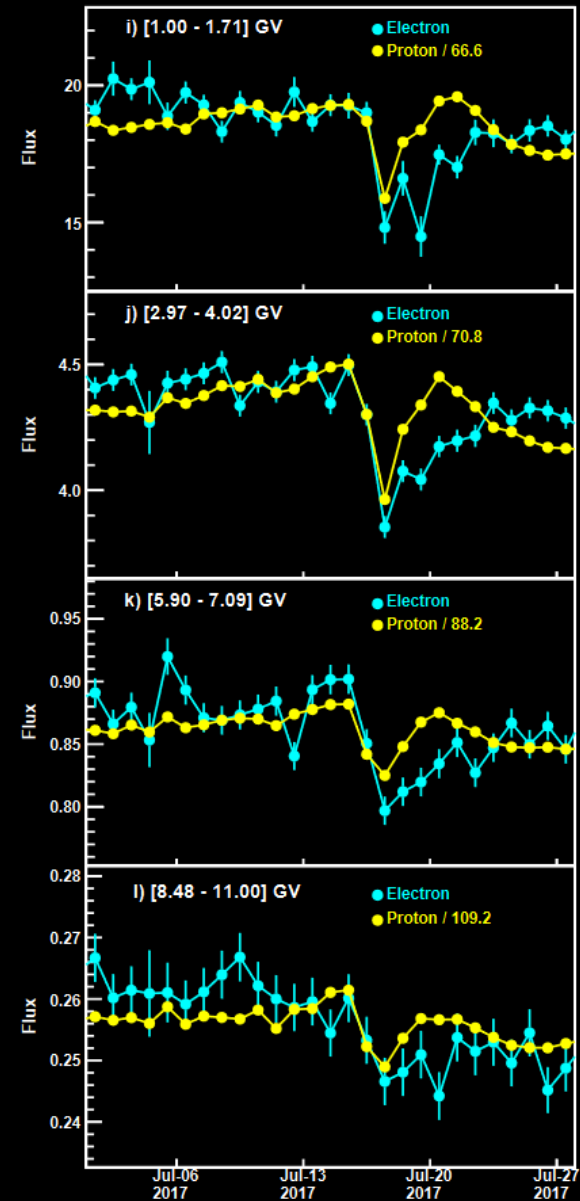
2011 A<0



2015 A>0

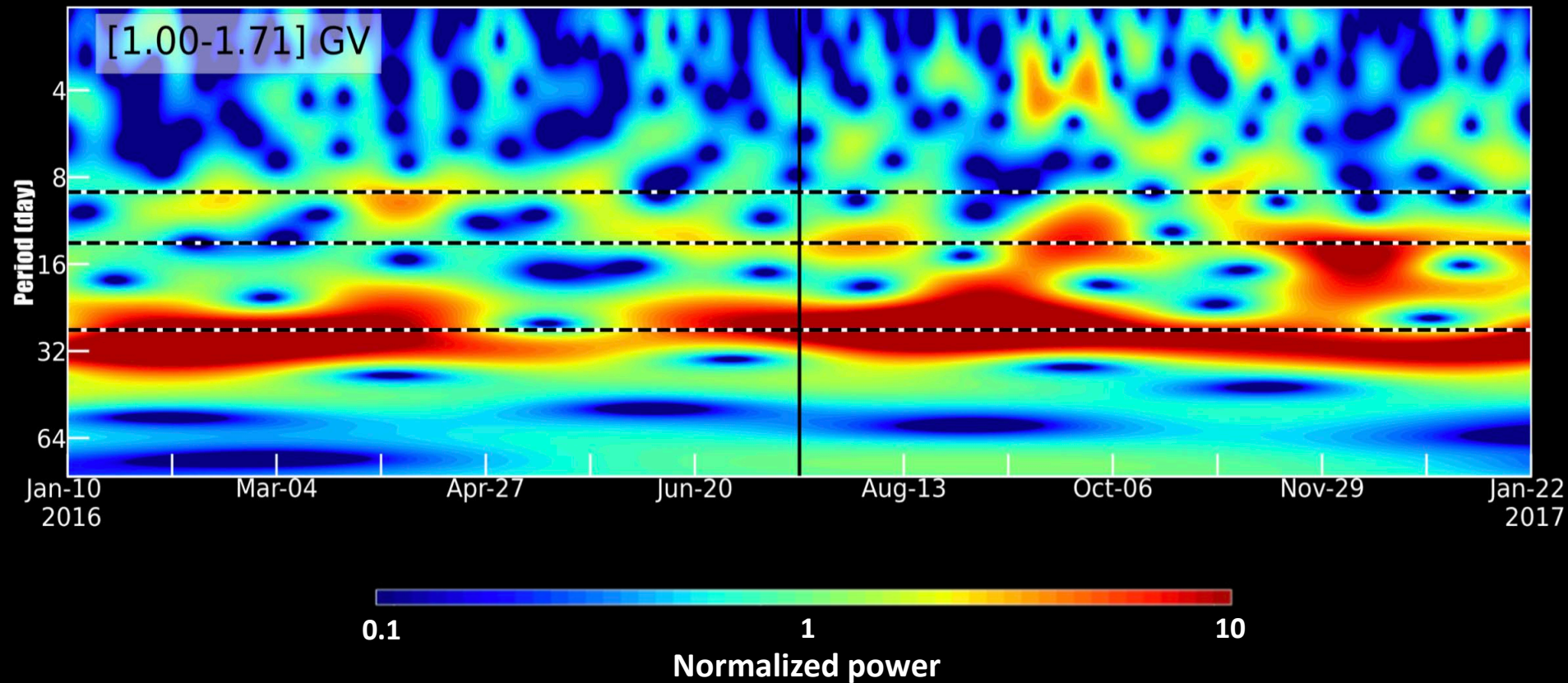


2017 A>0



# The recurrent variation in electron flux: Periodicity

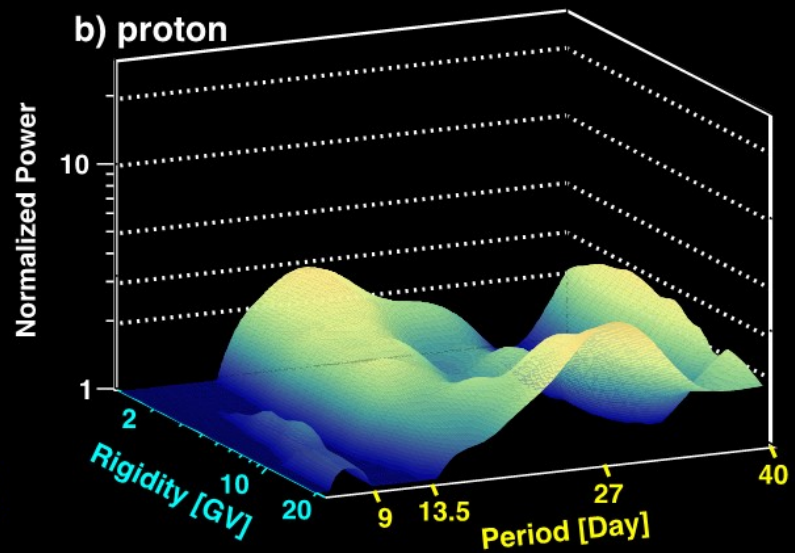
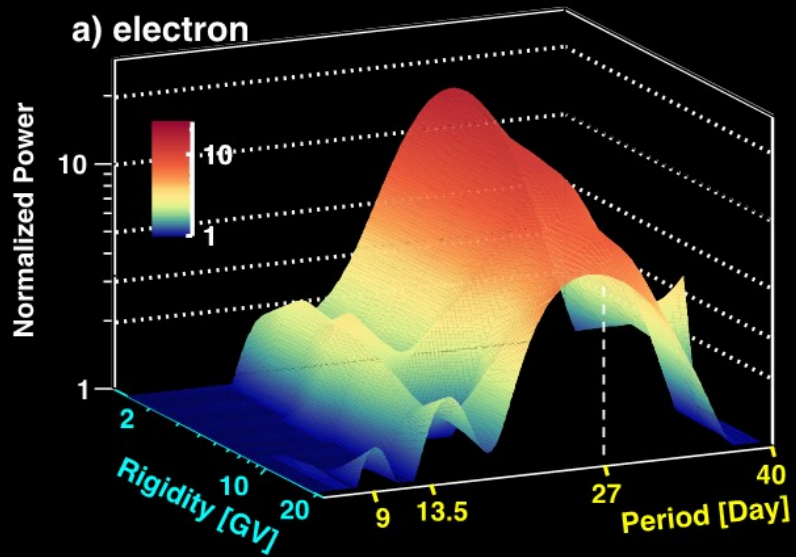
- The wavelet analysis is used to study the periodicity in electron fluxes.
- Red-noise model is used to estimate the significance of the periods.



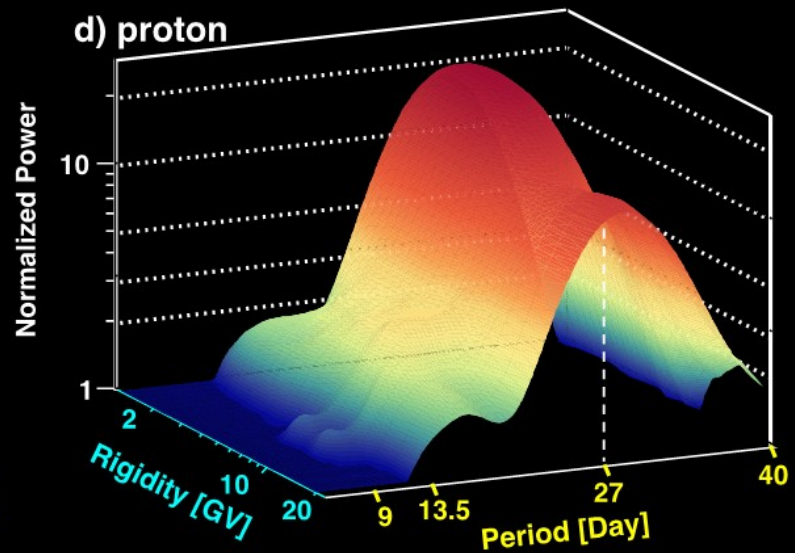
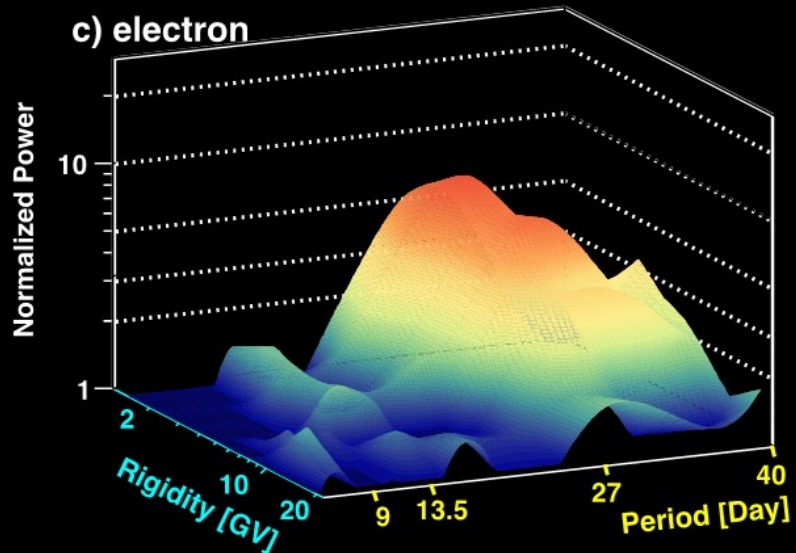
# Periodicities of daily electron fluxes

The rigidity dependence of the electron periodicities is different from that of protons.

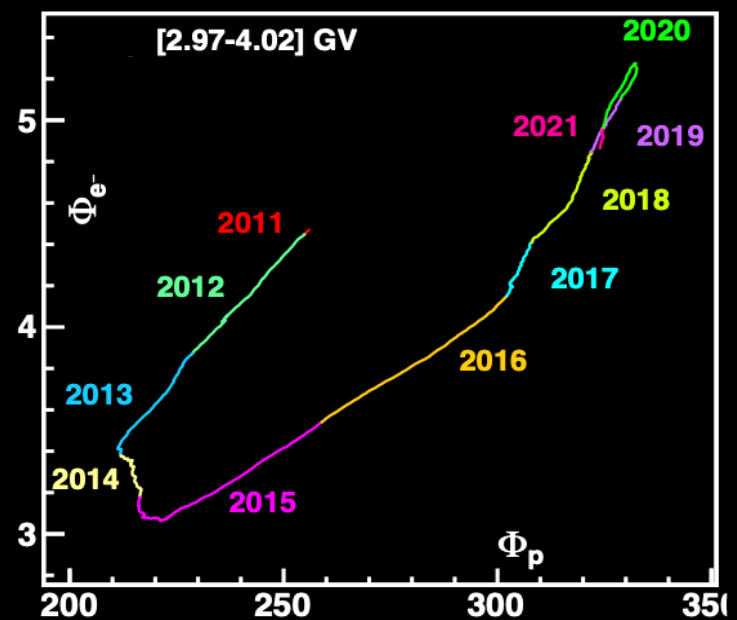
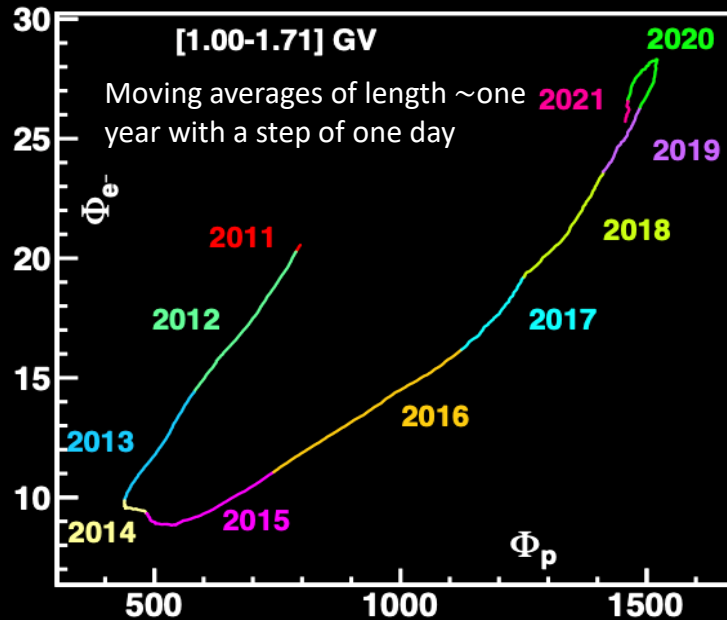
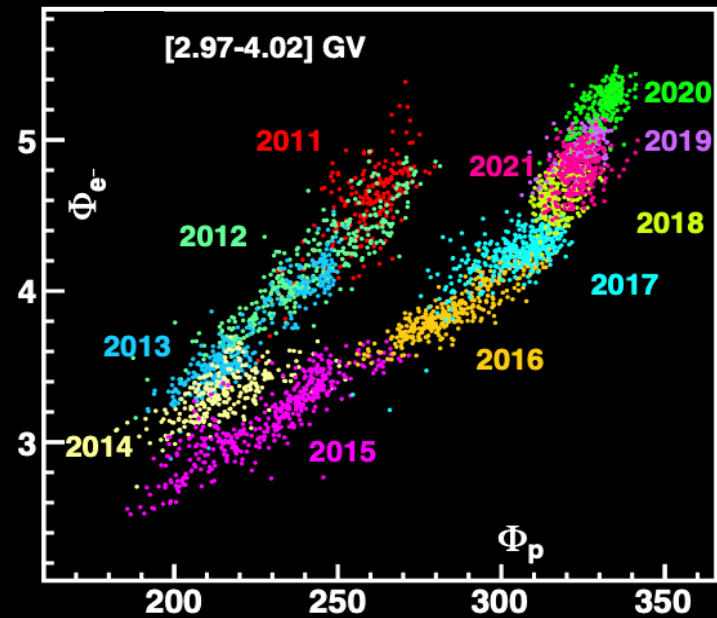
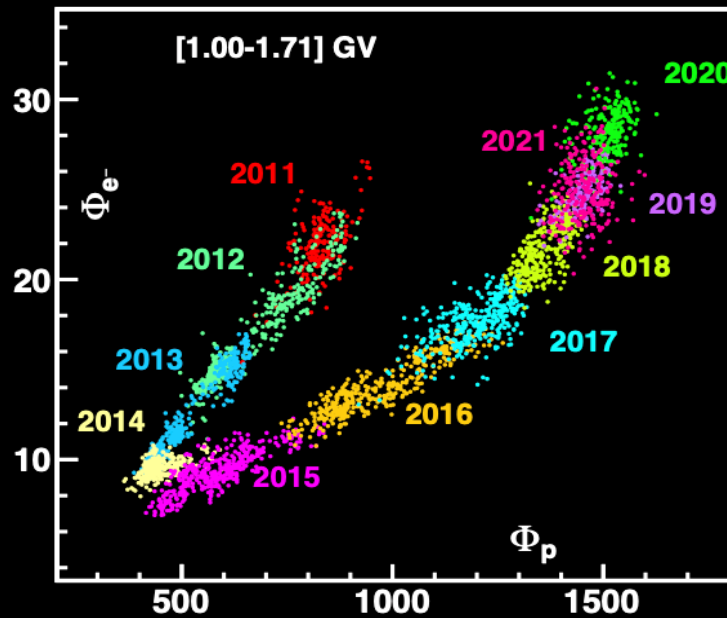
Second half of 2011



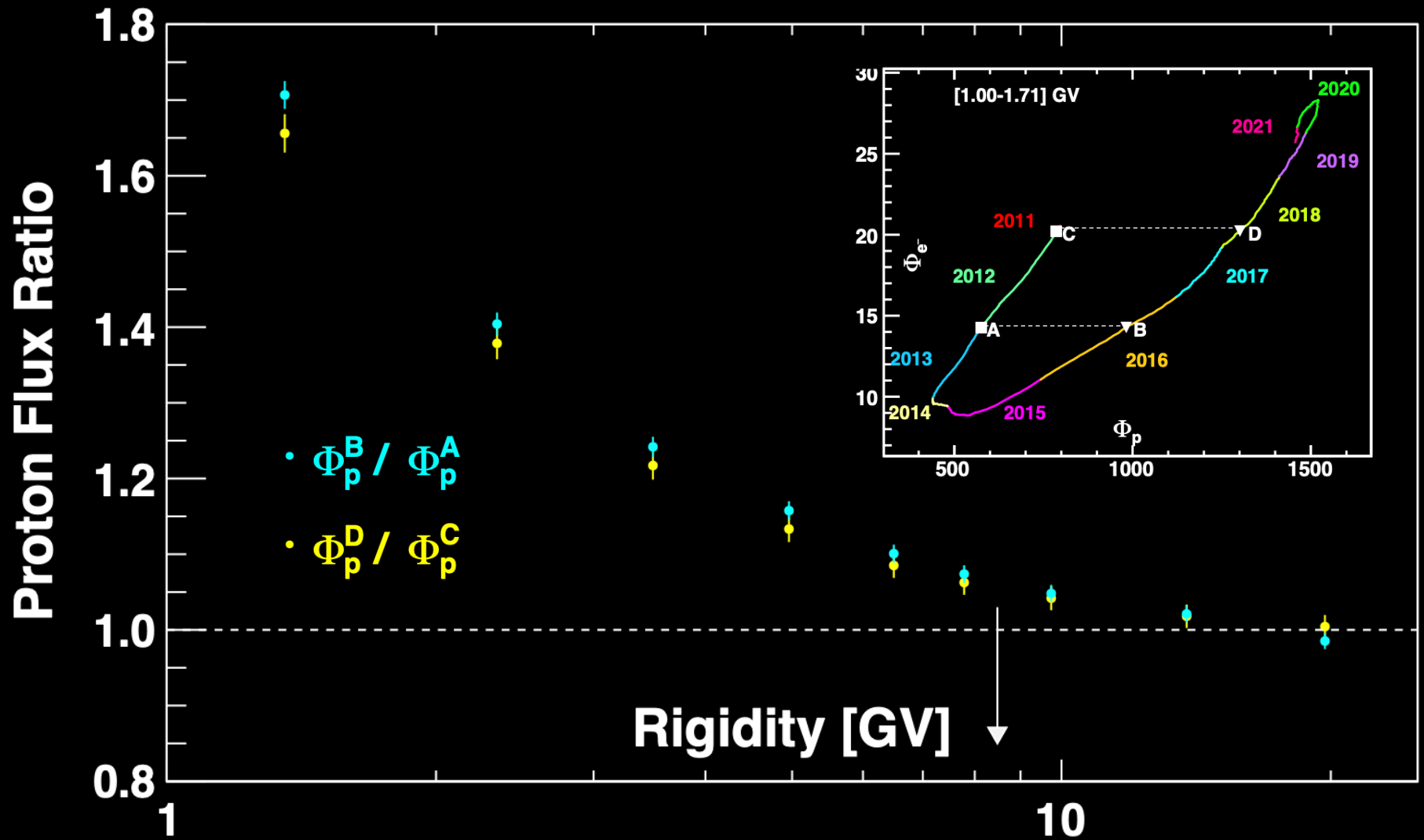
First half of 2017



# Hysteresis between $\Phi_e$ - and $\Phi_p$ (data before 2021)

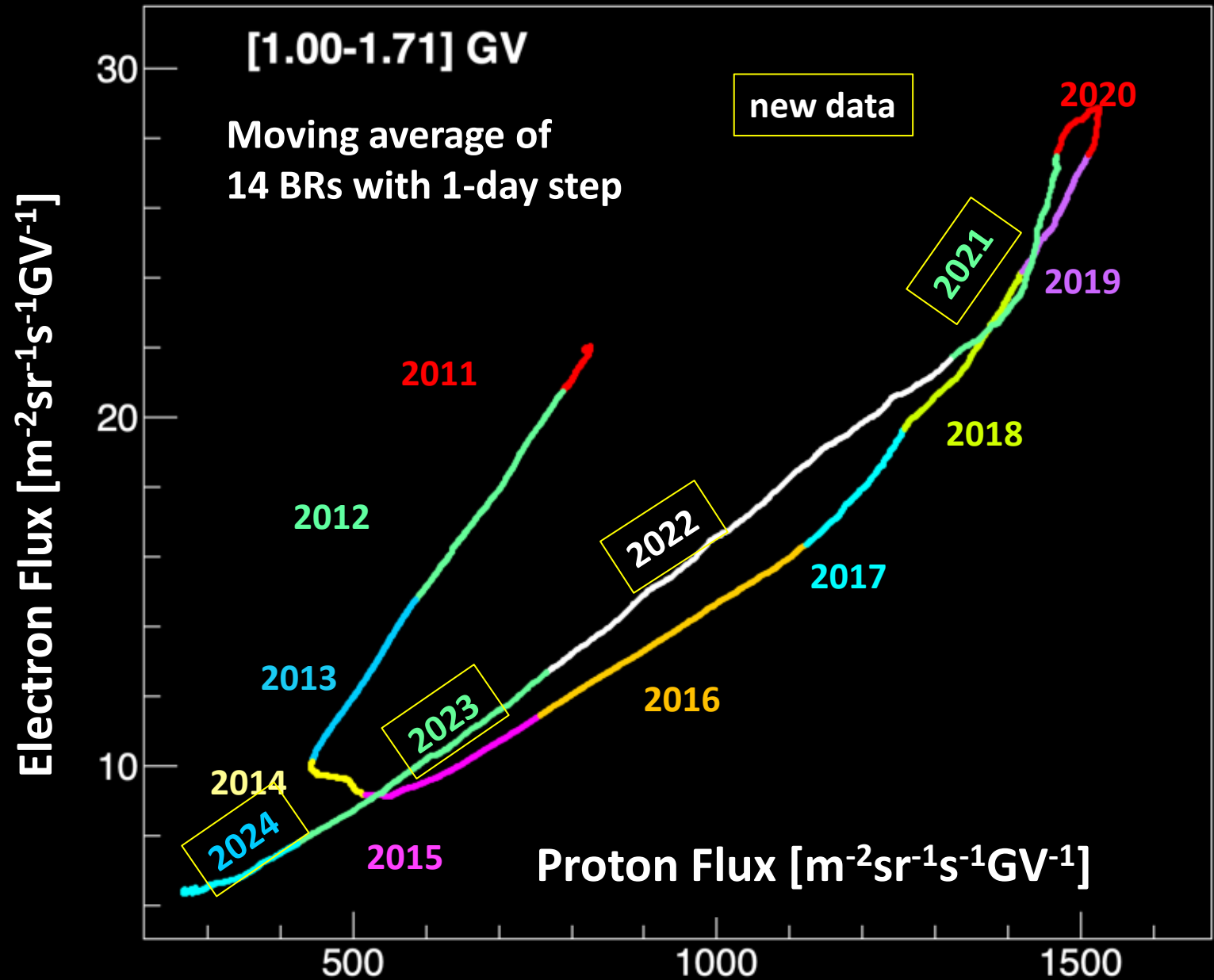


# Hysteresis between $\Phi_{e^-}$ and $\Phi_p$

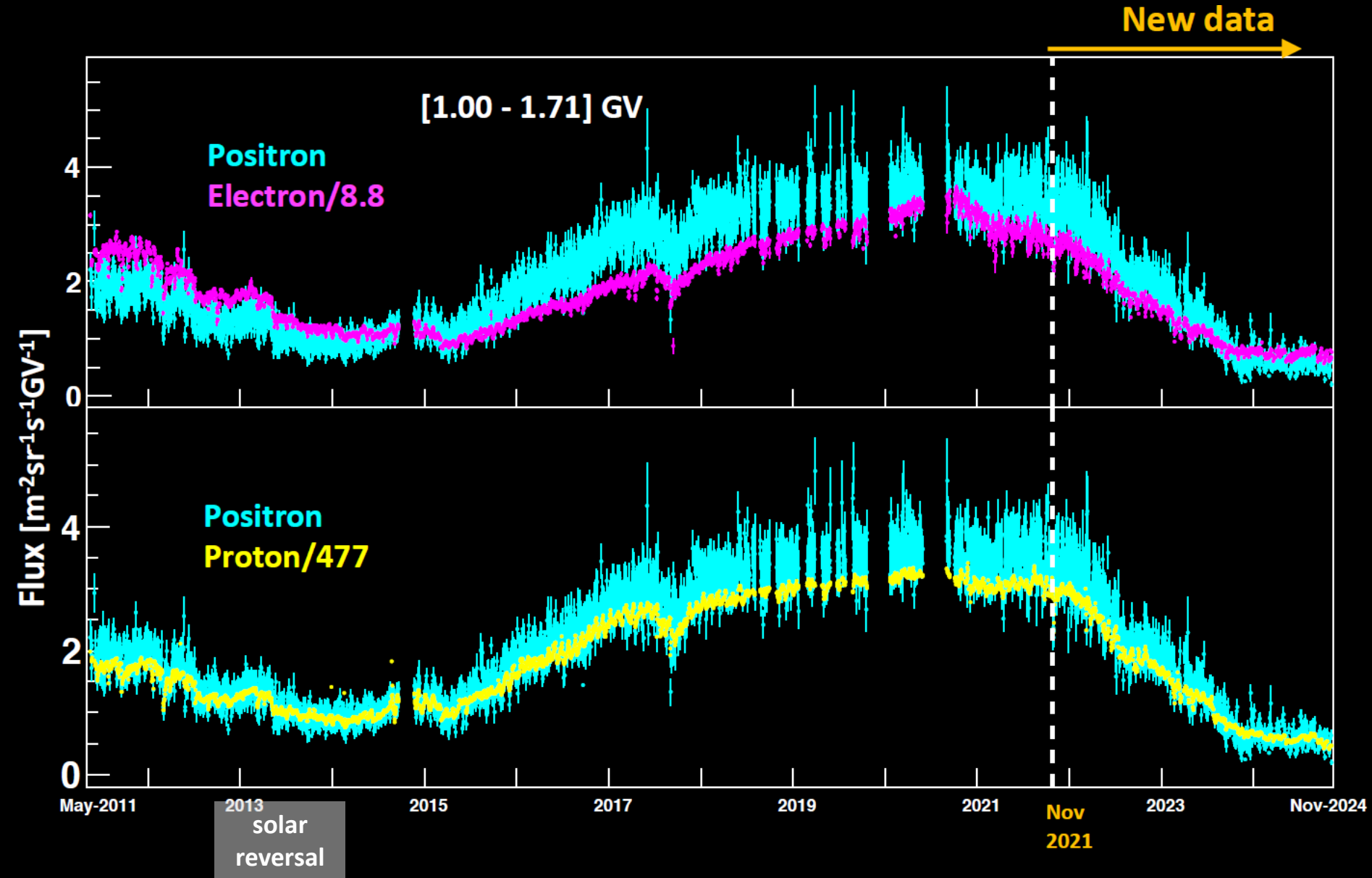


The hysteresis is observed with a significance greater than  $6\sigma$  at rigidities below 8.5 GV

# Updated hysteresis between electron and proton

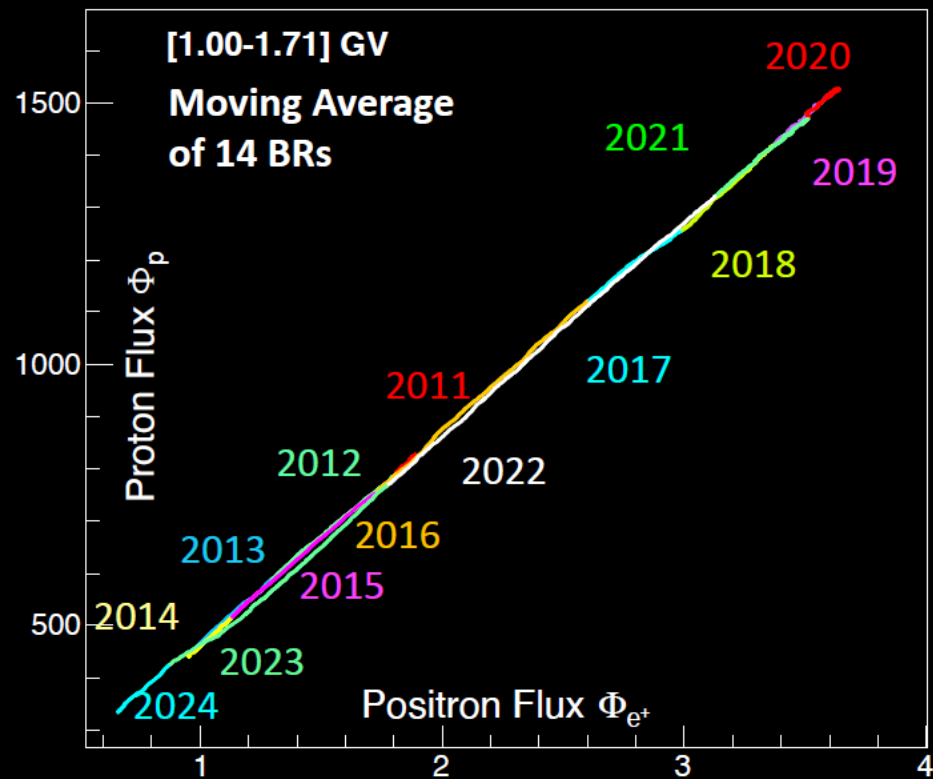
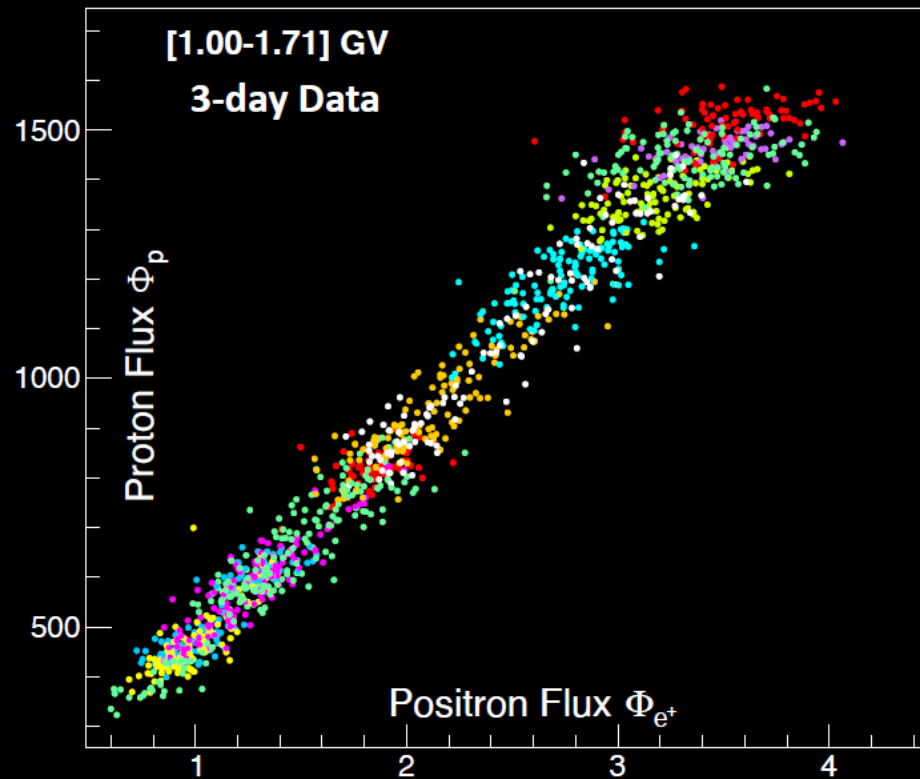


# Daily positron fluxes extending to November 2024



# Linear relationship between positron and proton fluxes

Different mass, same charge



Fluxes in unit of  $[m^{-2}sr^{-1}s^{-1}GV^{-1}]$

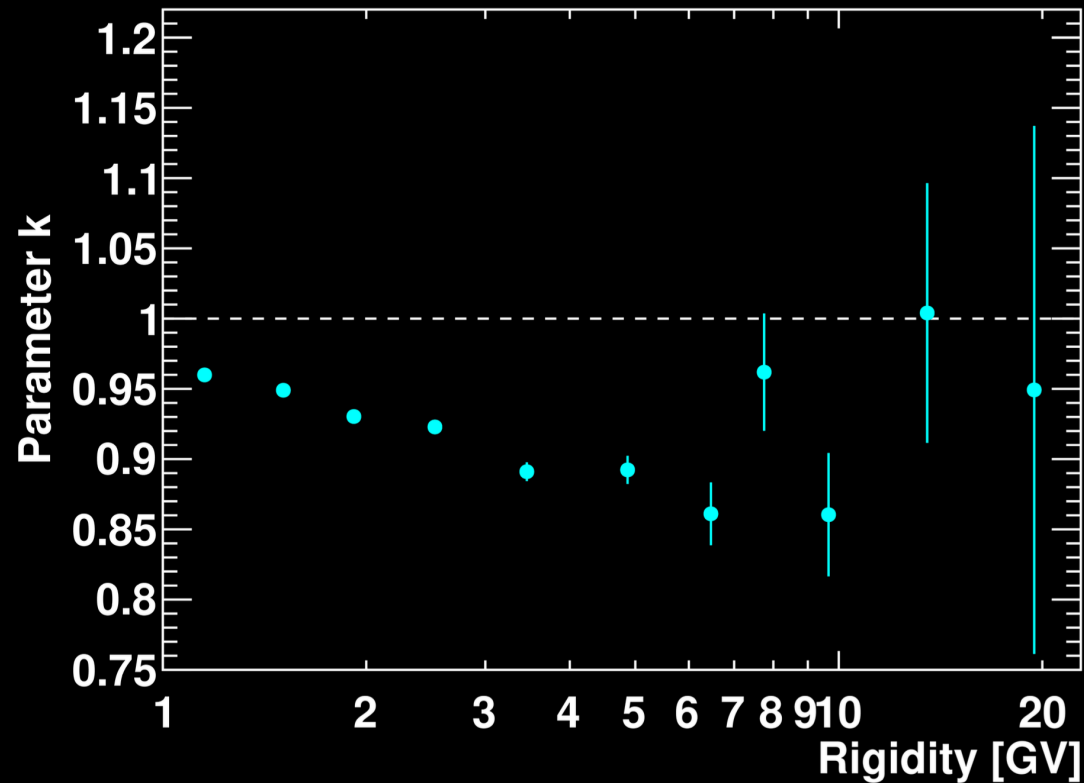
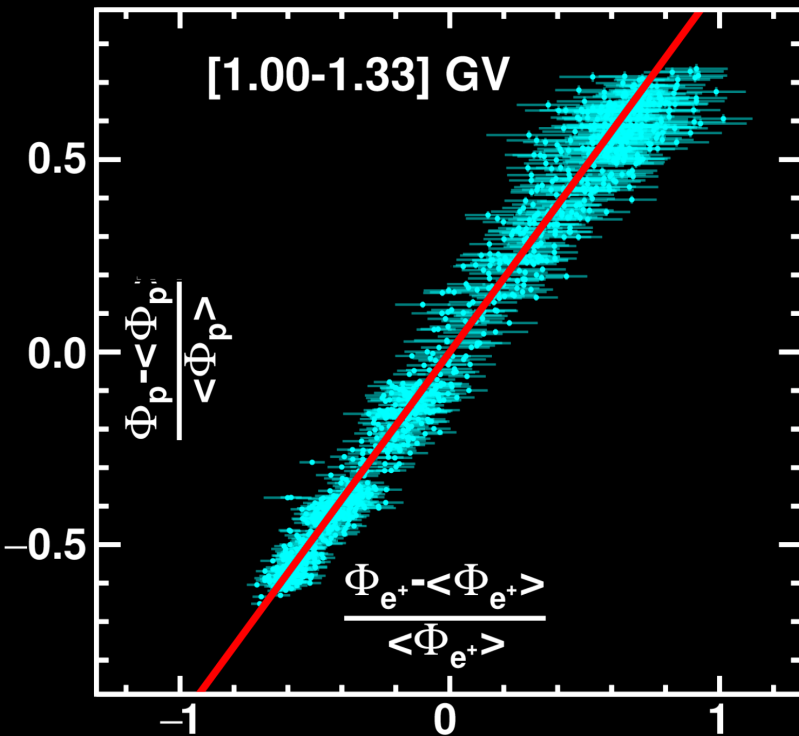
# Linear relationship between positron and proton fluxes

$$\frac{\Phi_p^i - \langle \Phi_p^i \rangle}{\langle \Phi_p^i \rangle} = K \frac{\Phi_{e^+}^i - \langle \Phi_{e^+}^i \rangle}{\langle \Phi_{e^+}^i \rangle}$$

**K=1:** Positron variation = Proton variation

**K<1:** Positron variation > Proton variation

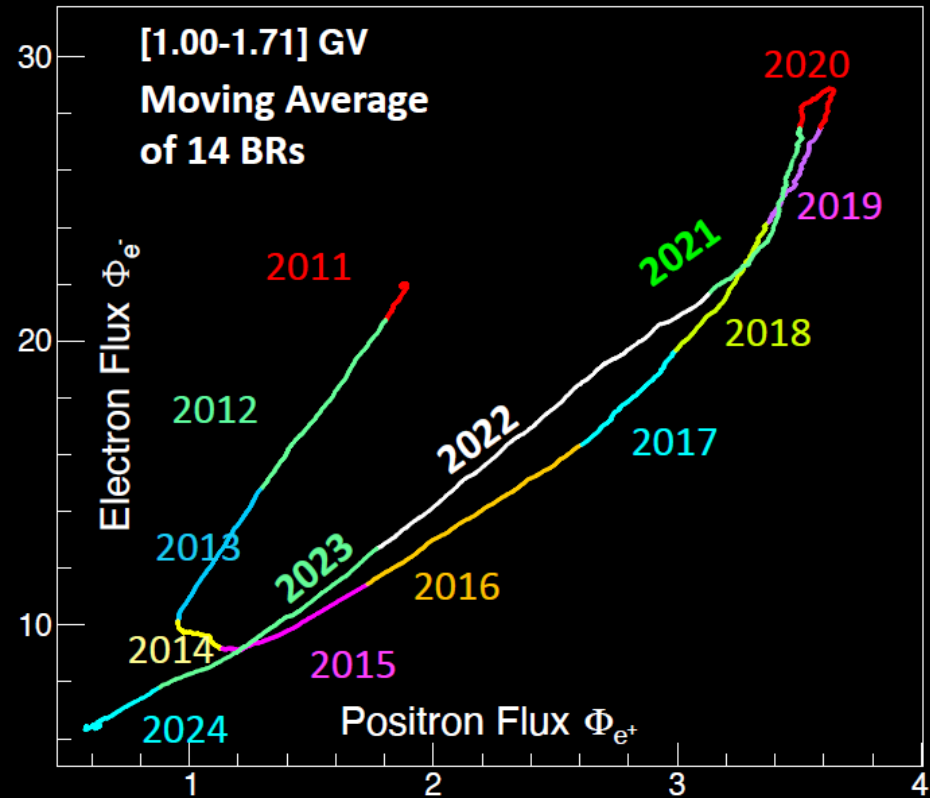
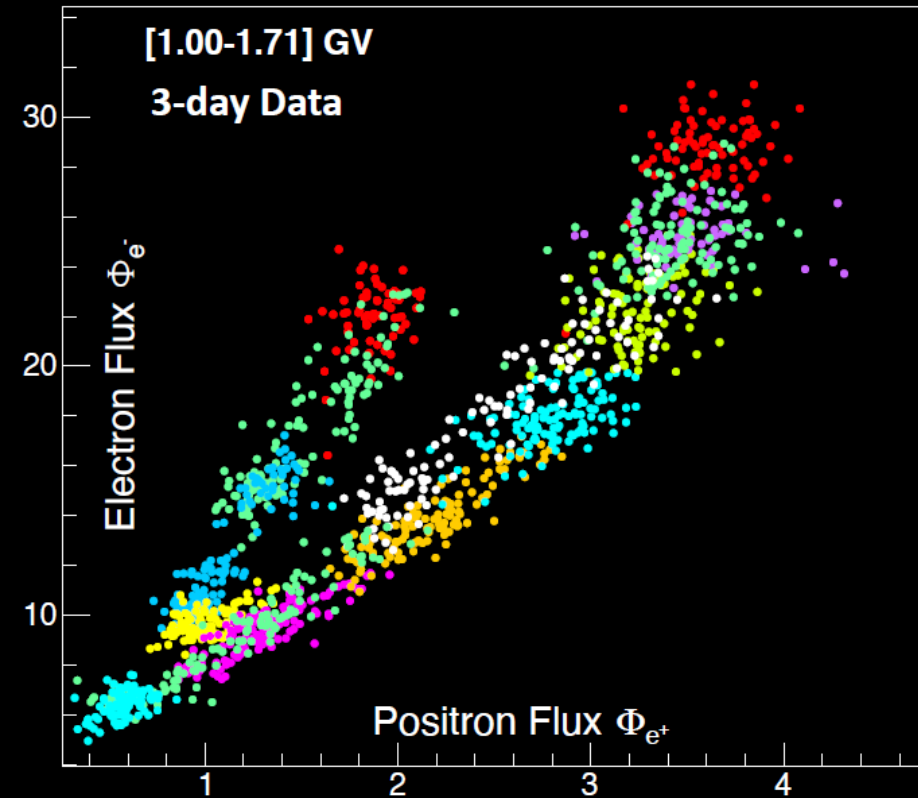
**K>1:** Positron variation < Proton variation



**For rigidities below 7 GV, Positron variation > Proton variation ( $> 5\sigma$ )**

# Hysteresis between positron and electron fluxes

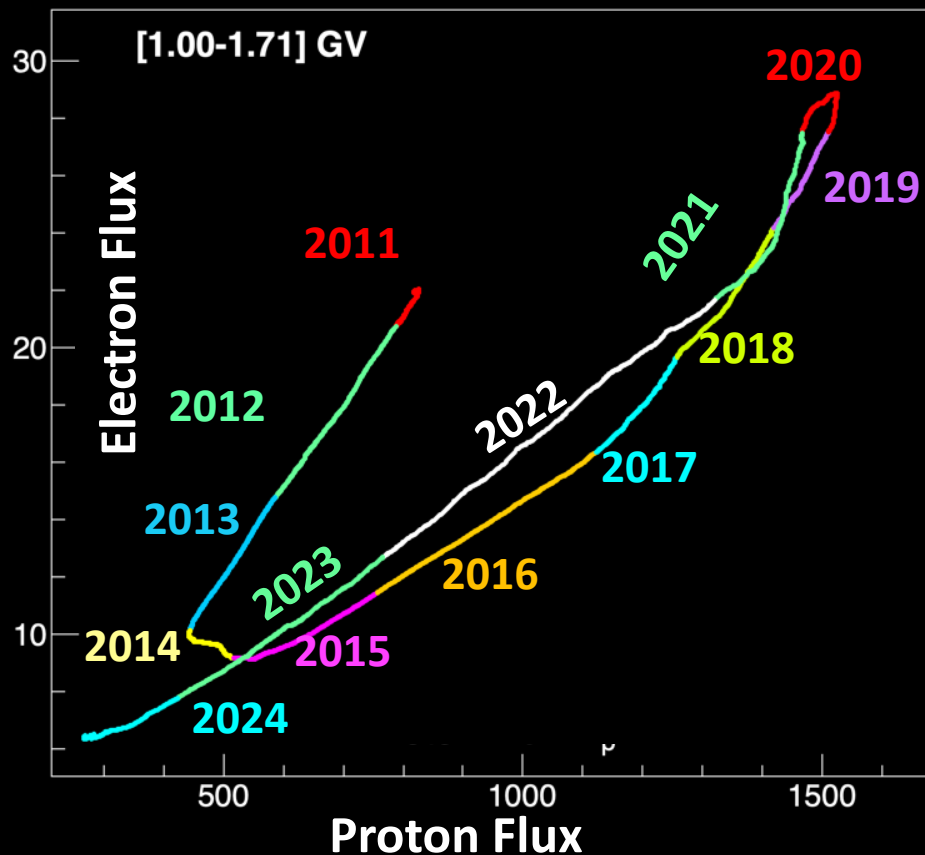
Same mass, opposite charge



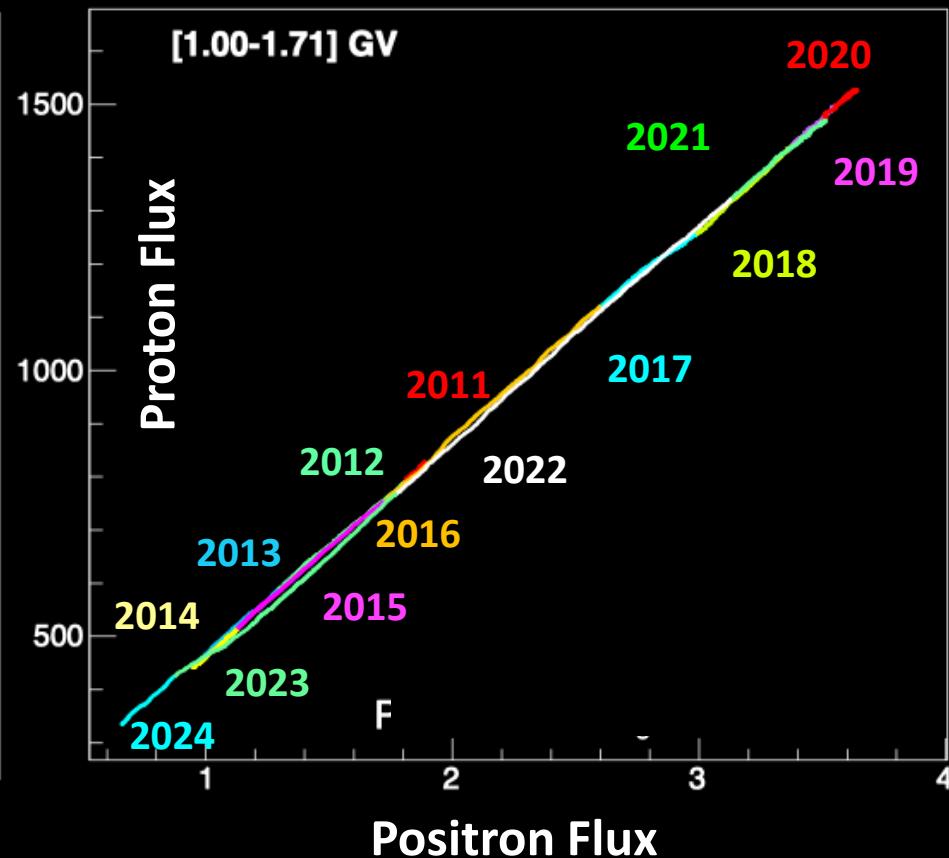
Fluxes in unit of [ $\text{m}^{-2}\text{sr}^{-1}\text{s}^{-1}\text{GV}^{-1}$ ]

# Summary of daily electron and positron fluxes

Electron vs Proton  
Opposite charge  
Complex Hysteresis



Positron vs Proton  
Same charge  
“Repeated” linearity

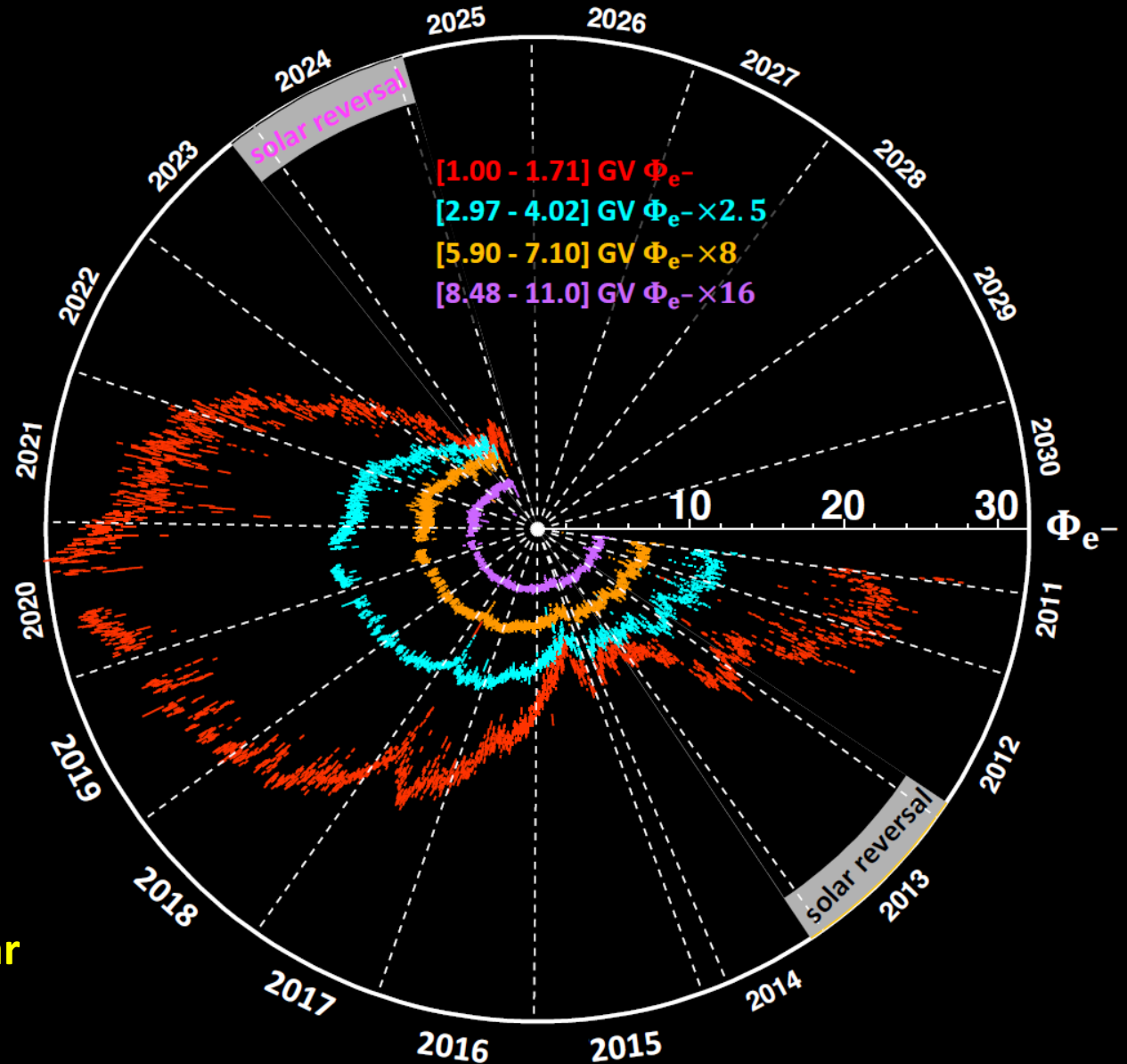


Fluxes in unit of  $[m^{-2}sr^{-1}s^{-1}GV^{-1}]$

# Daily fluxes over a 22-year solar cycle

We are approaching  
the next solar  
magnetic field reversal

June - November 2024,  
*ApJL* 962 (2024) L15



By 2030, AMS will cover  
nearly a complete 22-year  
solar cycle