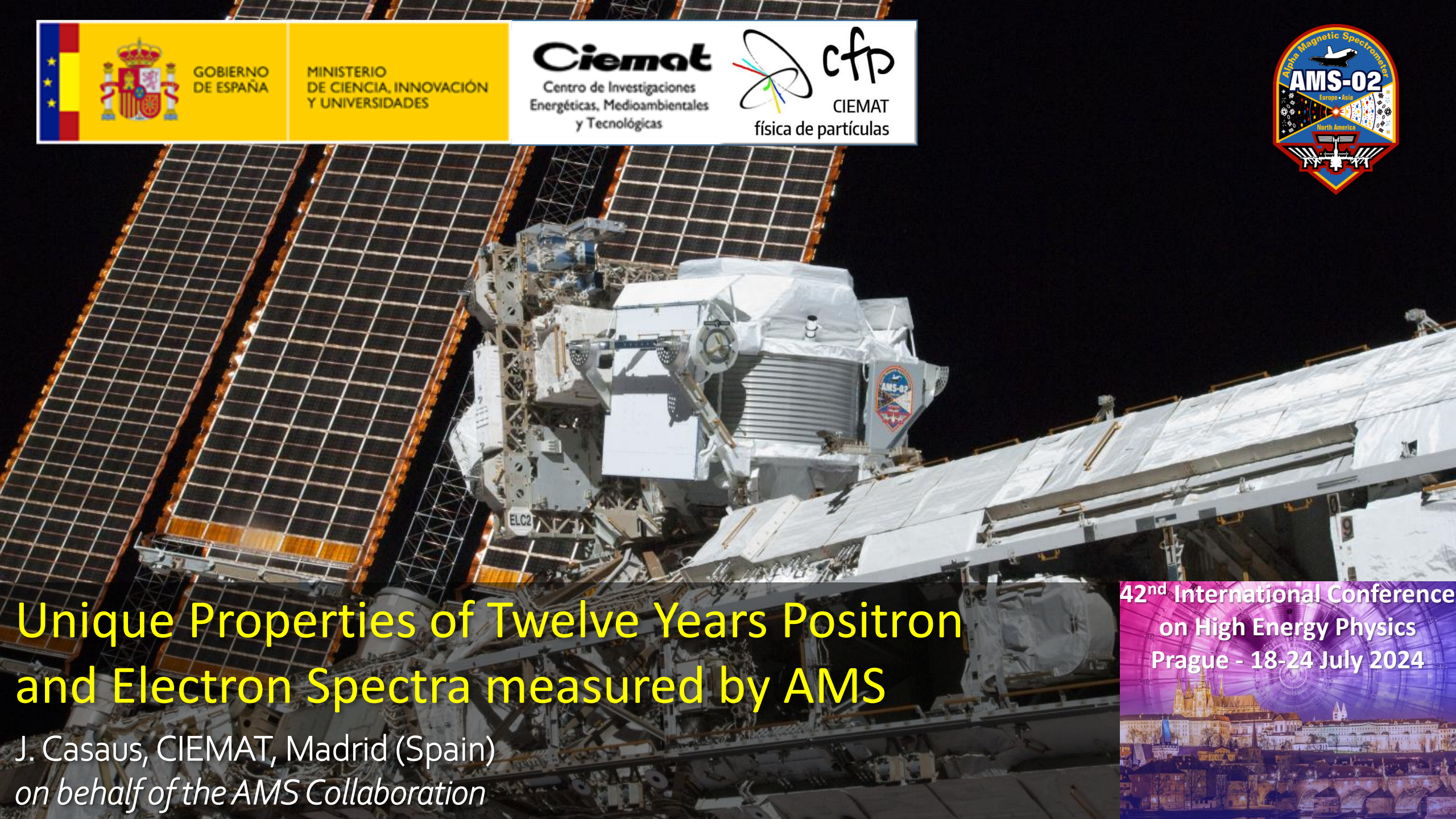
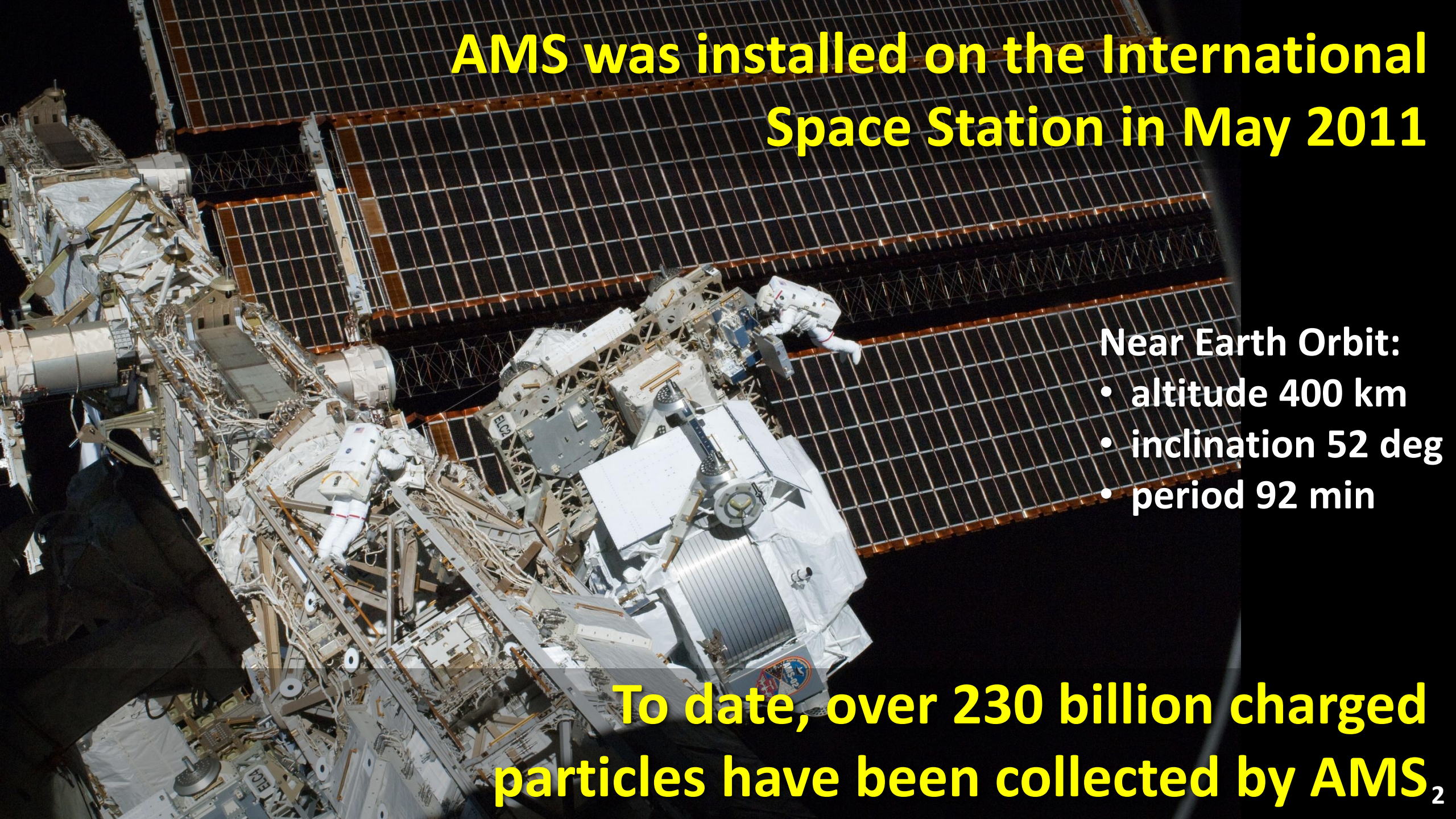


Unique Properties of Twelve Years Positron and Electron Spectra measured by AMS

J. Casaus, CIEMAT, Madrid (Spain)
on behalf of the AMS Collaboration

42nd International Conference on High Energy Physics
Prague - 18-24 July 2024



AMS was installed on the International Space Station in May 2011

Near Earth Orbit:

- altitude 400 km
- inclination 52 deg
- period 92 min

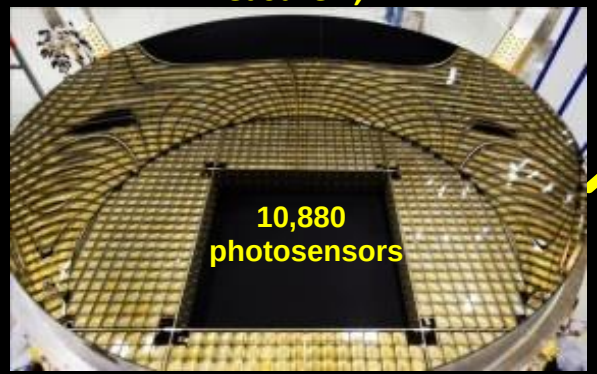
To date, over 230 billion charged particles have been collected by AMS_2

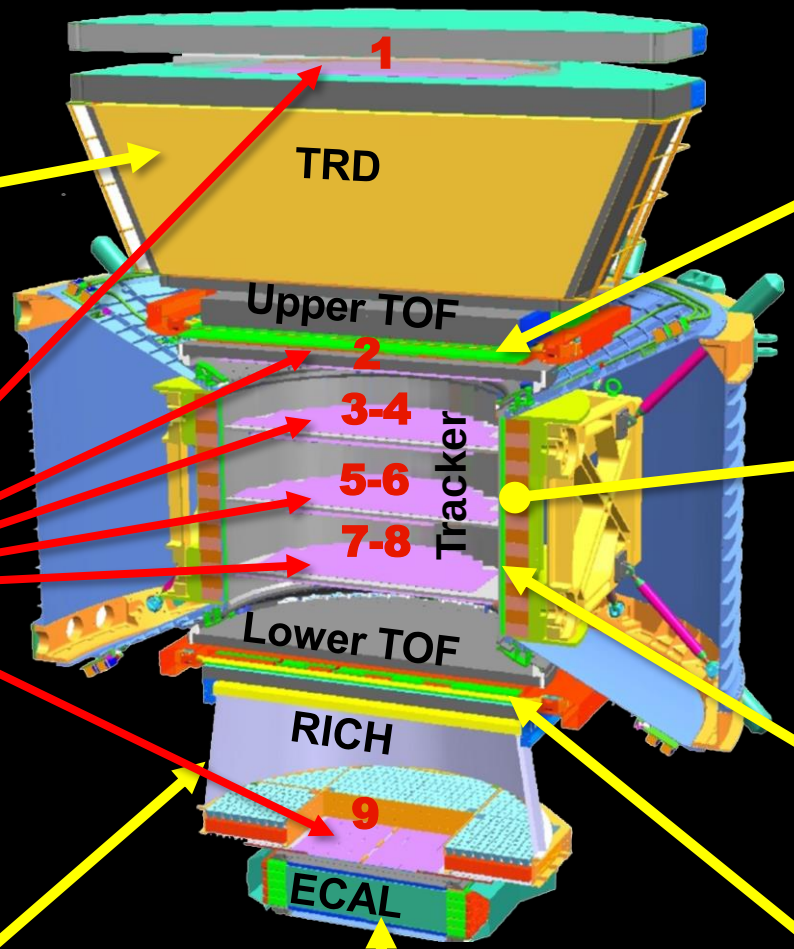
AMS is a TeV precision magnetic spectrometer in space

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

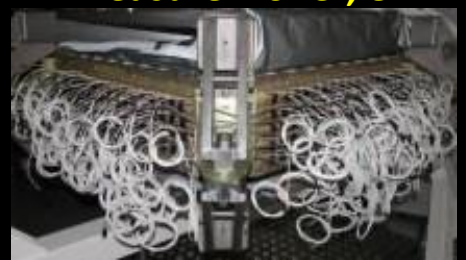
Silicon Tracker
measure Z, P

Ring Imaging Cerenkov (RICH)
measure Z, E



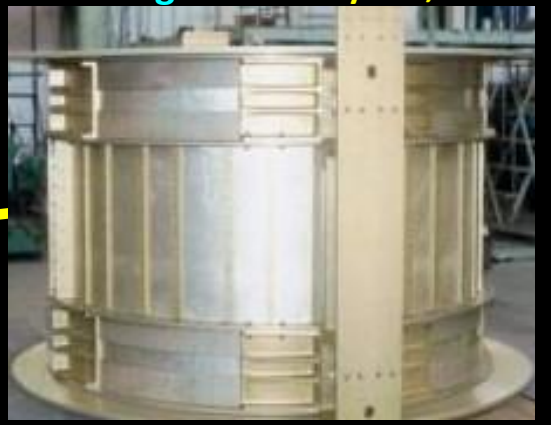


Electromagnetic Calorimeter (ECAL)
measure E of e^+, e^-



Upper TOF measure Z, E

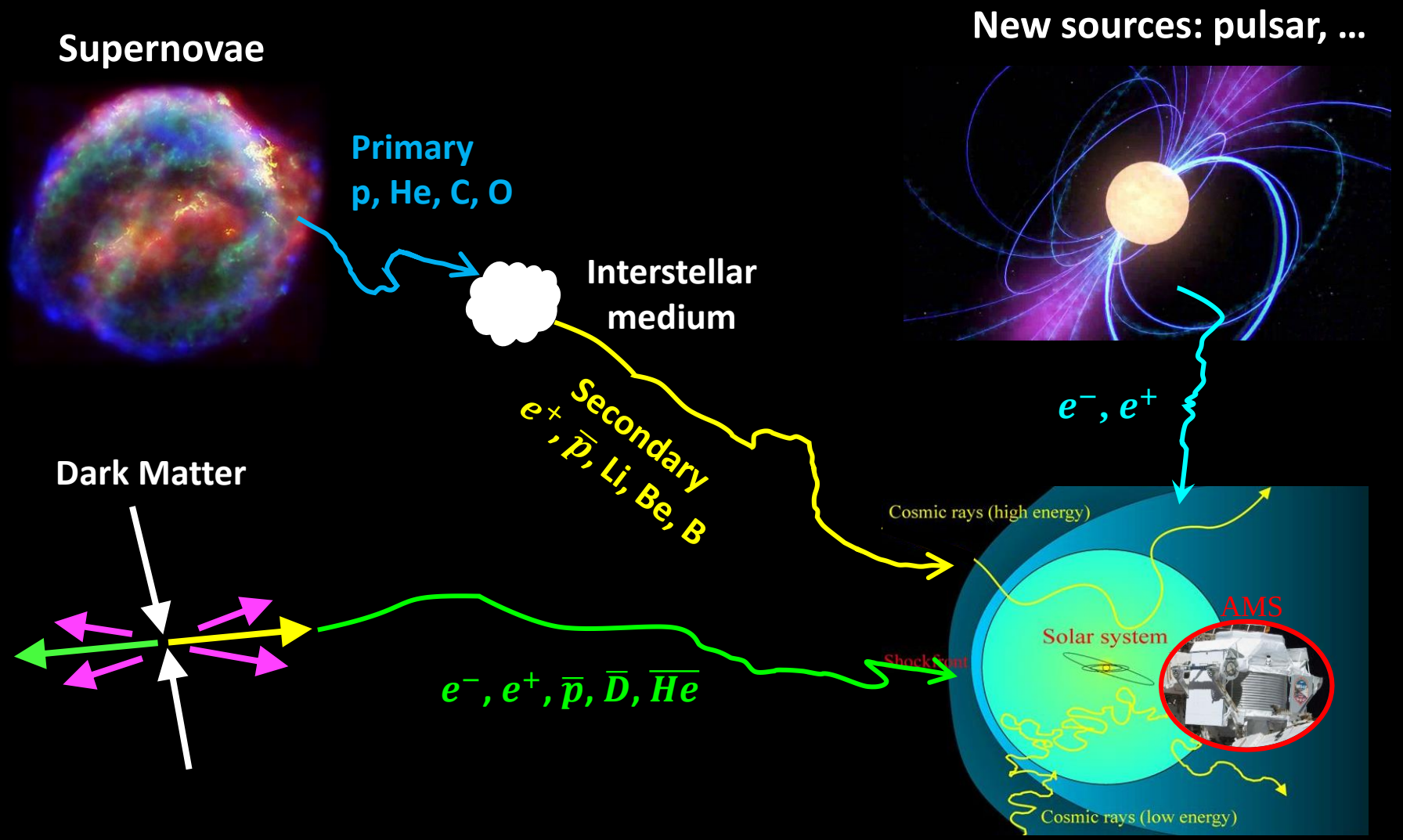
Magnet identify $\pm$Z, P



Anticoincidence Counters (ACC)
reject particles from the side

Lower TOF measure Z, E

Origin and Propagation of Cosmic Rays

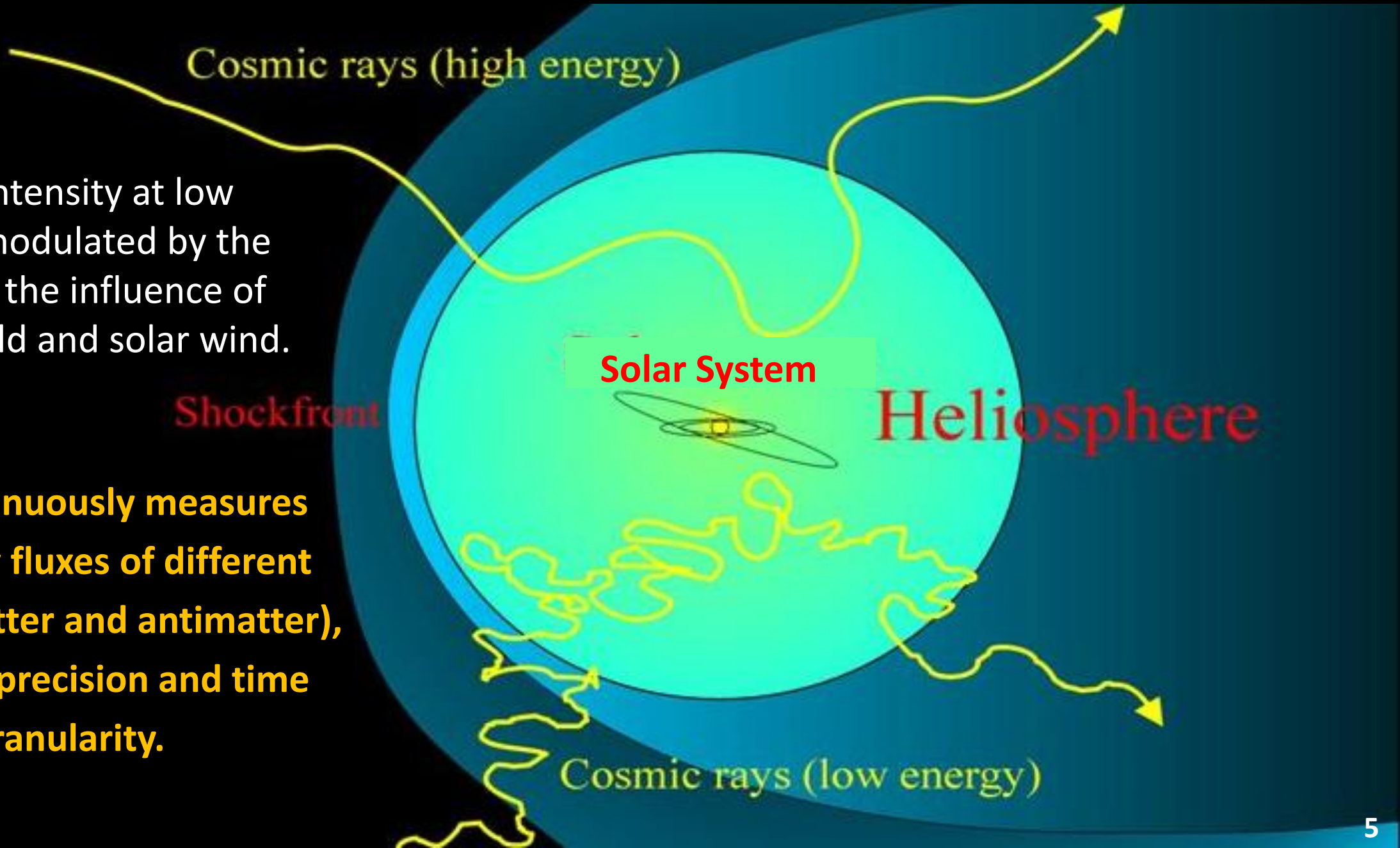


Before being detected by AMS,
All the galactic cosmic rays propagate in the solar system (heliosphere)

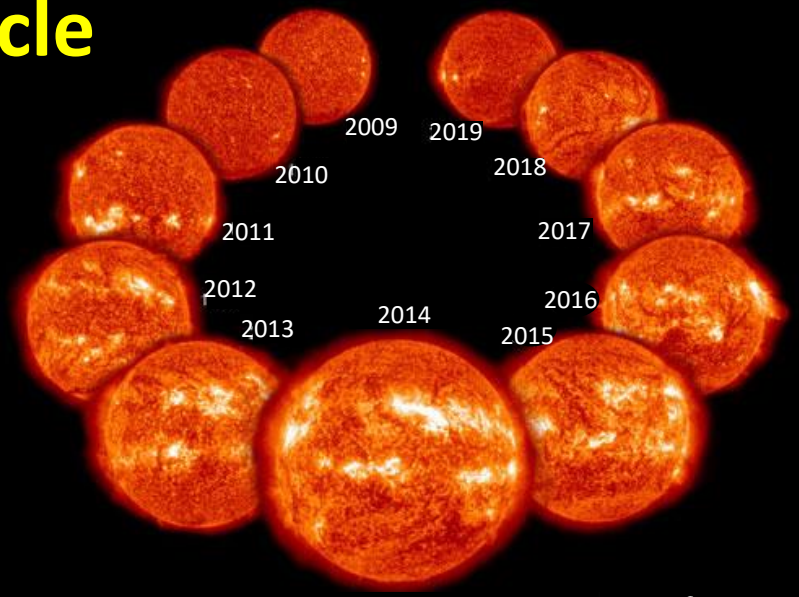
Solar Modulation of Cosmic Rays

Cosmic ray intensity at low energies is modulated by the Sun through the influence of magnetic field and solar wind.

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

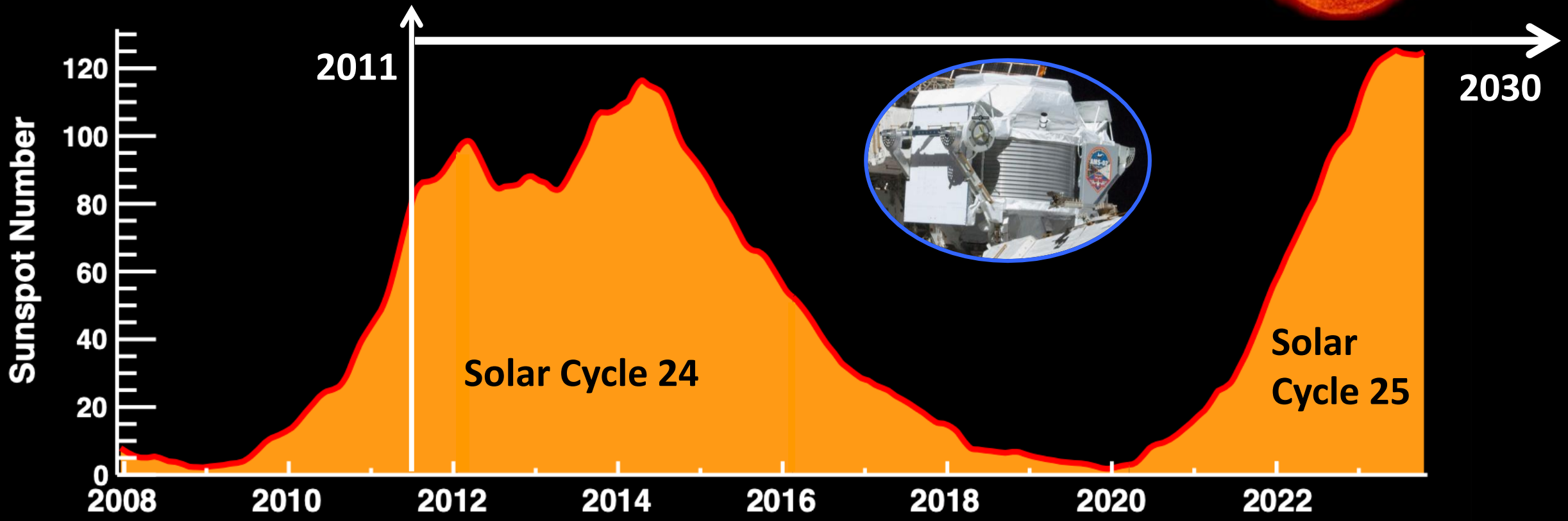


Long Term Variation: Solar Cycle



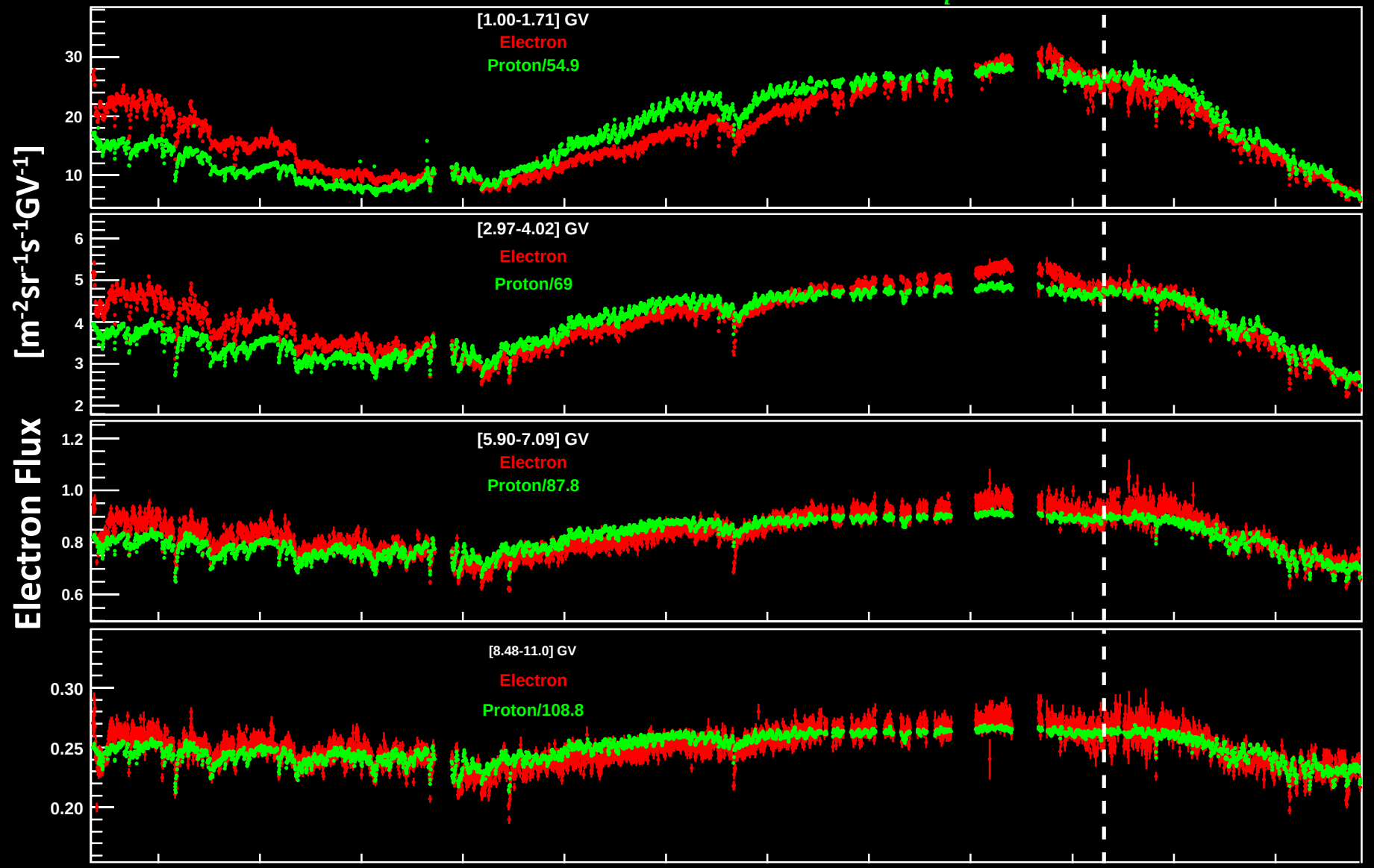
The most significant long-term scale variation of cosmic rays is related to the 11-year solar cycle.

Sunspot activity is extensively recorded since 1755

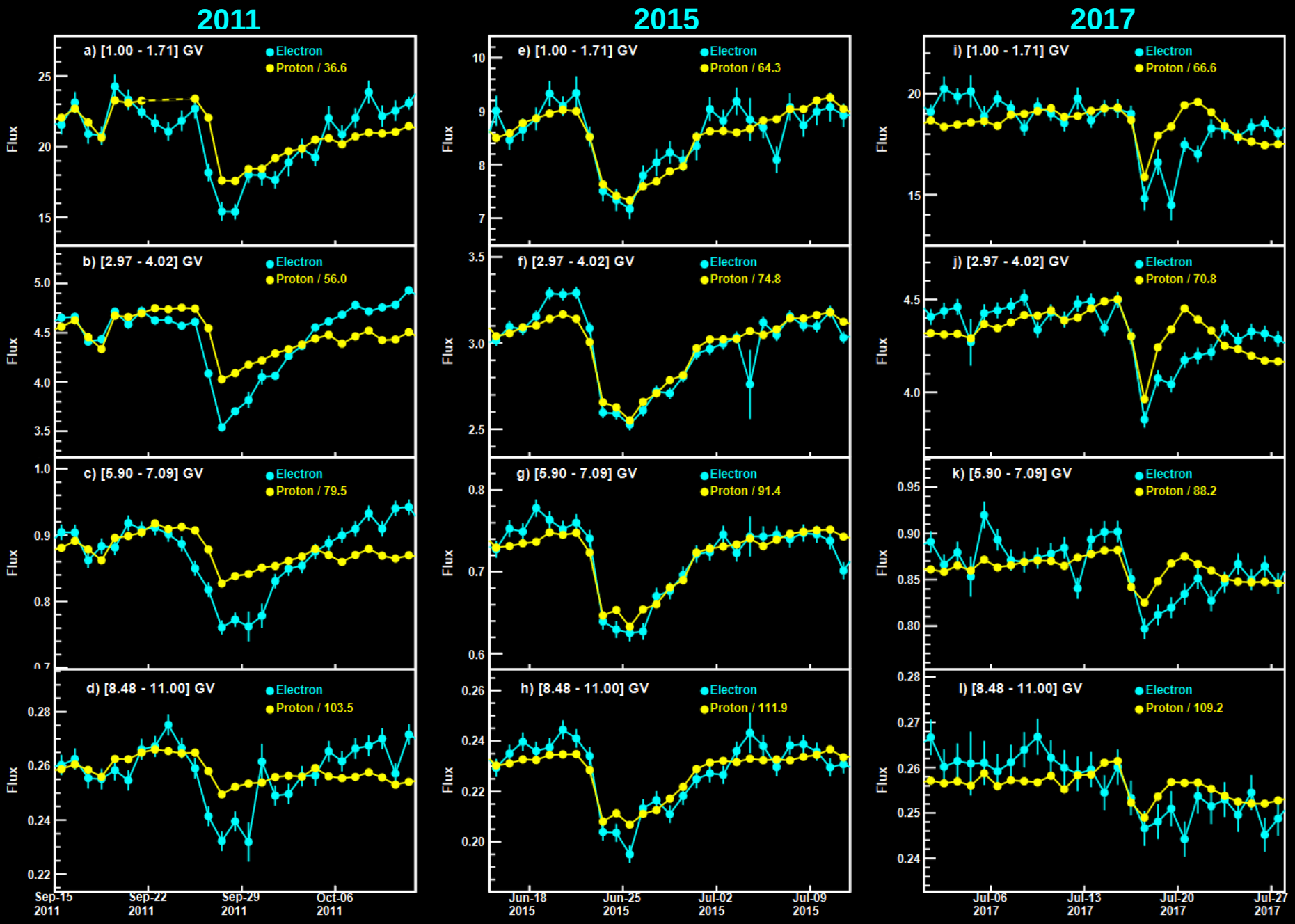


Daily electron and daily proton over 12.5 years

The time-dependent behavior of the Φ_{e^-} and Φ_p is distinctly different



Non recurrent variations of Electron and Proton Fluxes

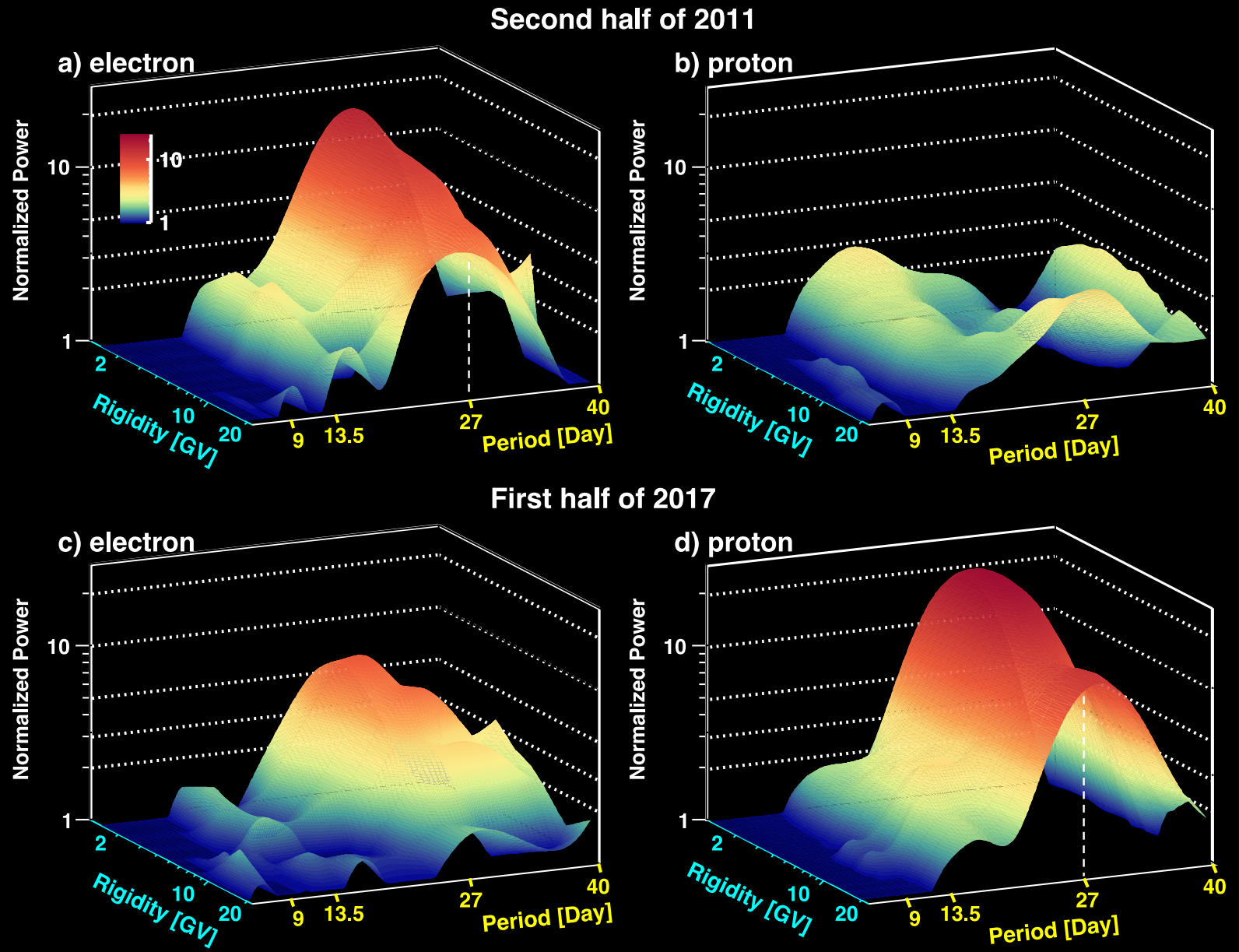


During **lower solar activity** in 2011 and 2017, a **difference between the short-term evolution of electrons and protons** is observed, while during the **solar maximum** in 2015 the **difference vanishes**.

These observations indicate a charge-sign dependence in nonrecurrent solar modulation.

Recurrent variations of Electron and Proton Fluxes: Periodicities

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

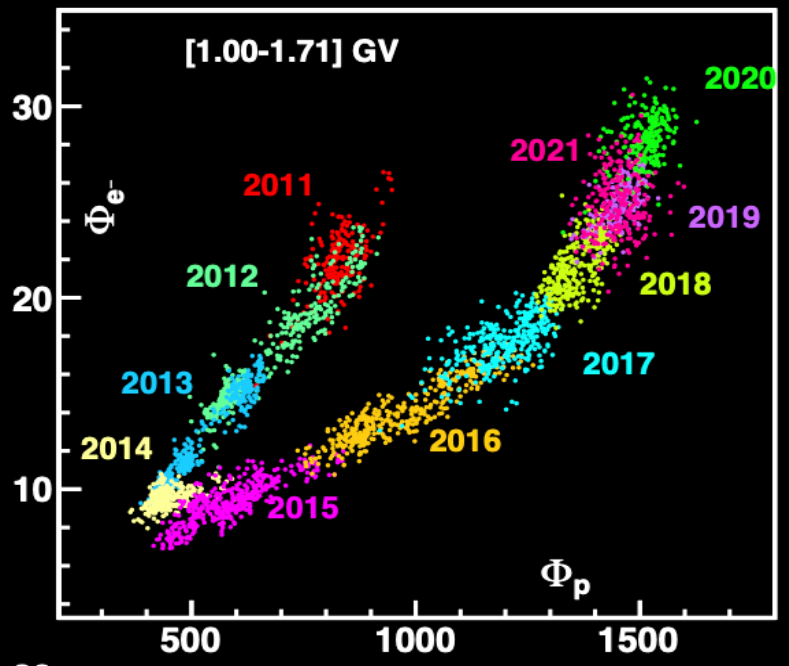


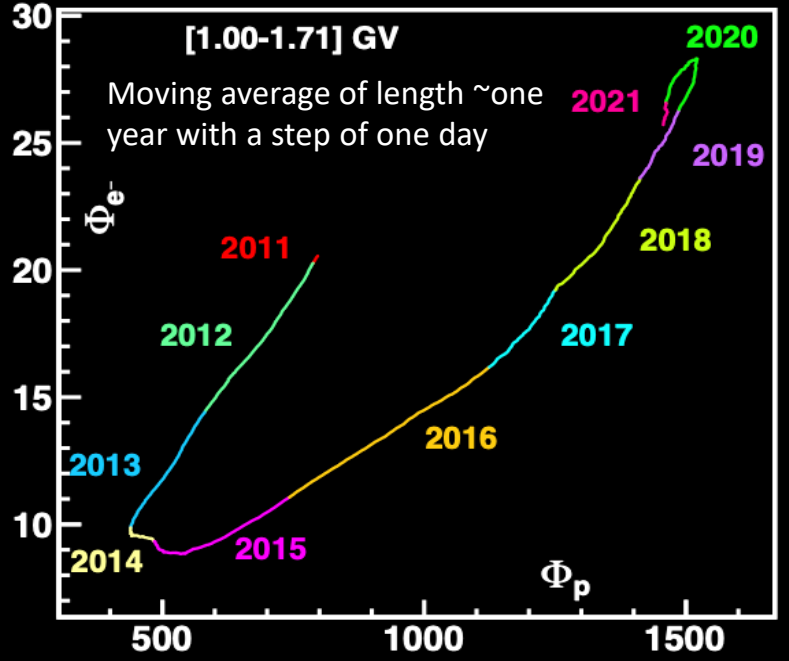
In the second half of 2011 the strength of the 27-day period of electrons is **greater** than that of protons.

In the first half of 2017 the strength of the 27-day period of electrons is **less** than that of protons.

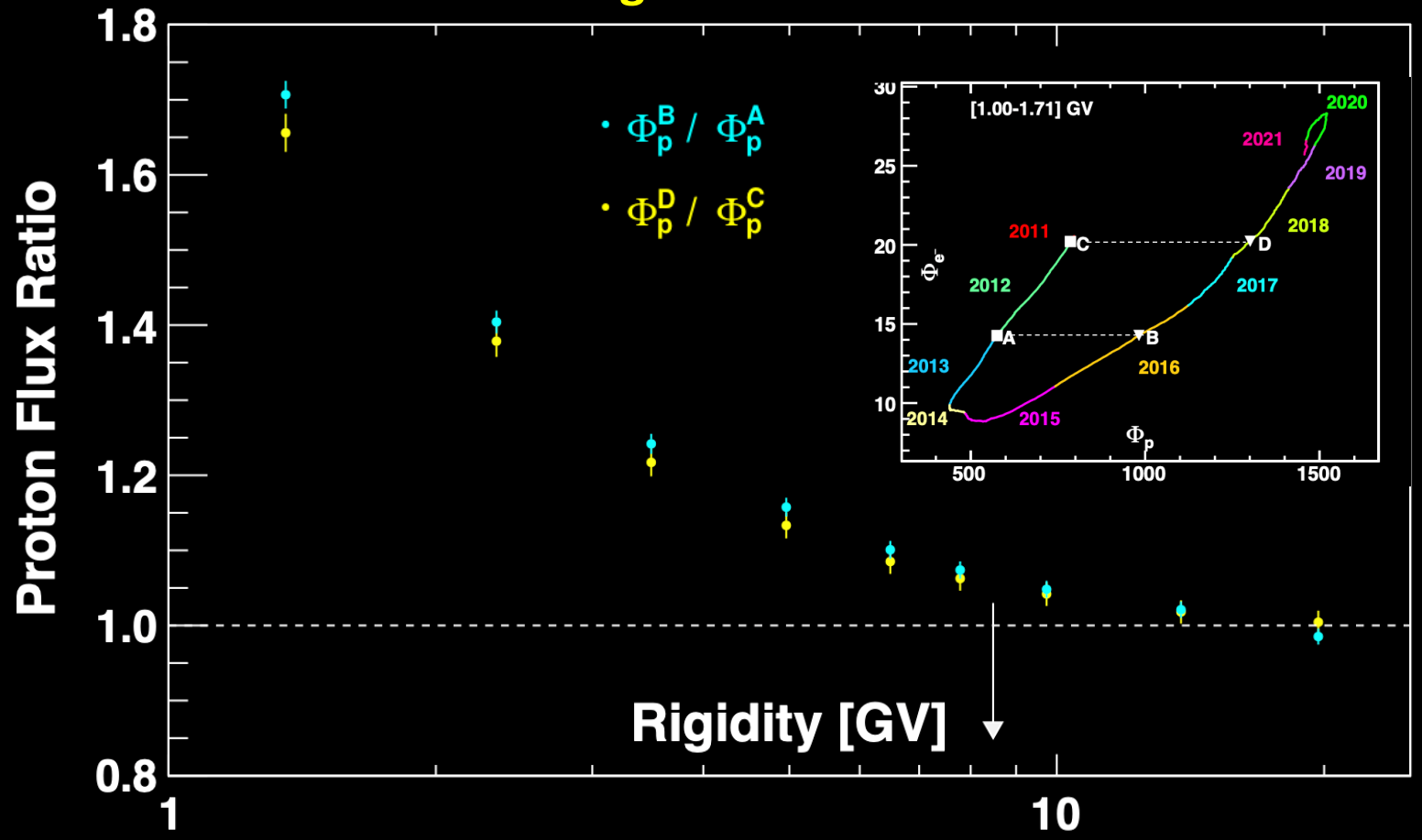
A Hysteresis between Φ_{e^-} and Φ_p

To assess the significance of the hysteresis we study, at different solar conditions, the values of Φ_p at the same Φ_{e^-}

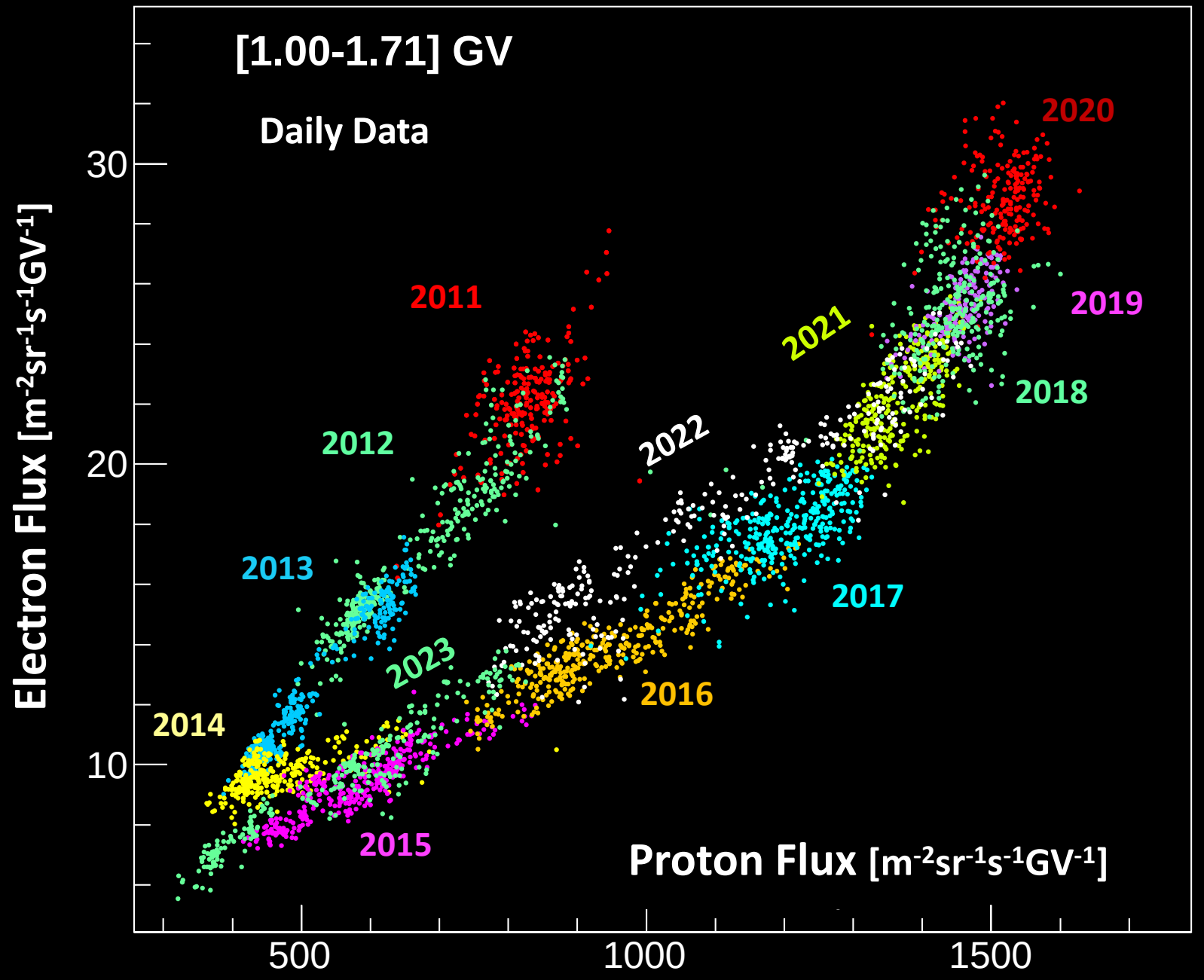




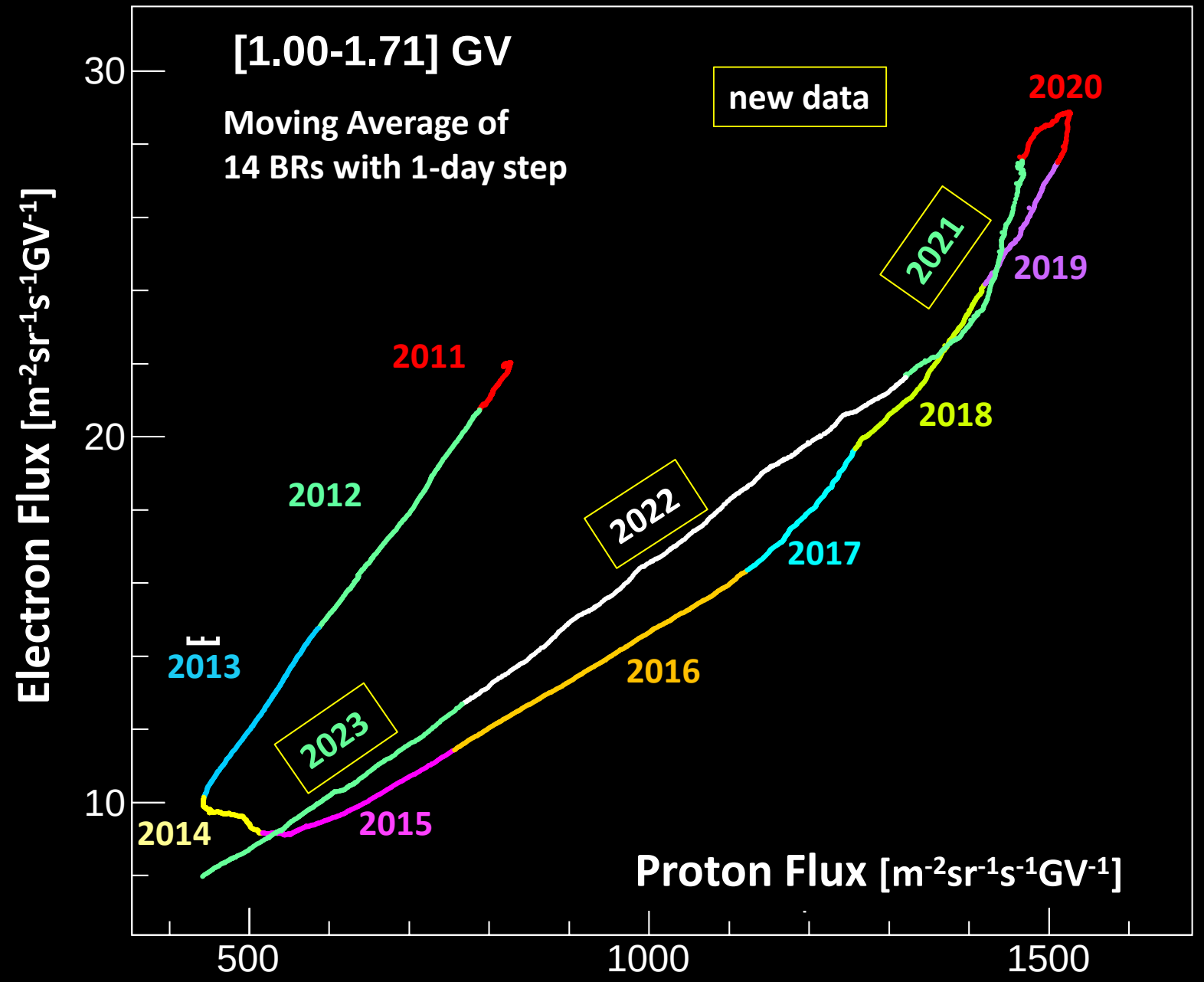
The hysteresis is observed with a significance > 6σ at rigidities below 8.5 GV



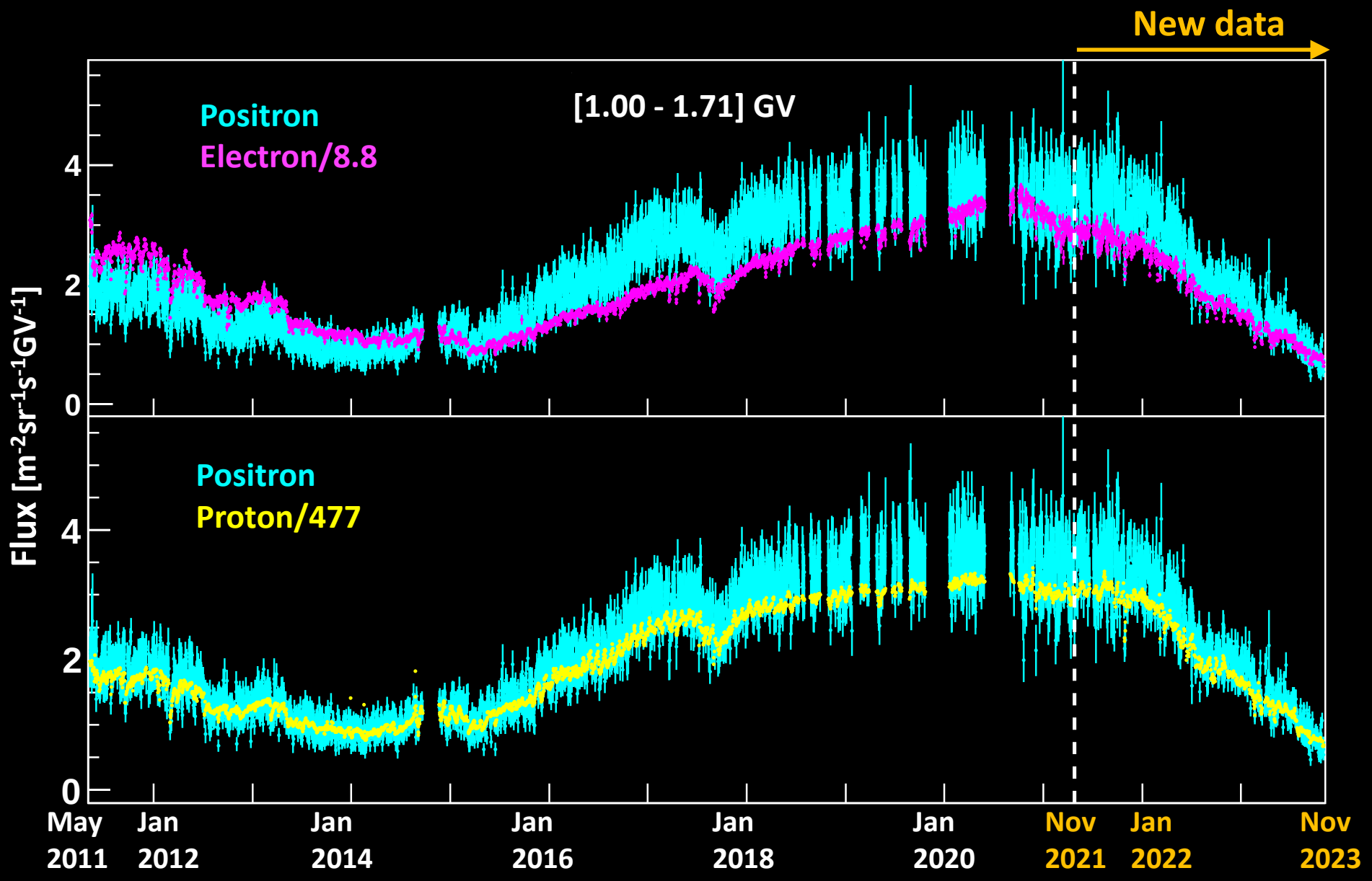
New hysteresis between electron and proton



New Hysteresis between electron and proton

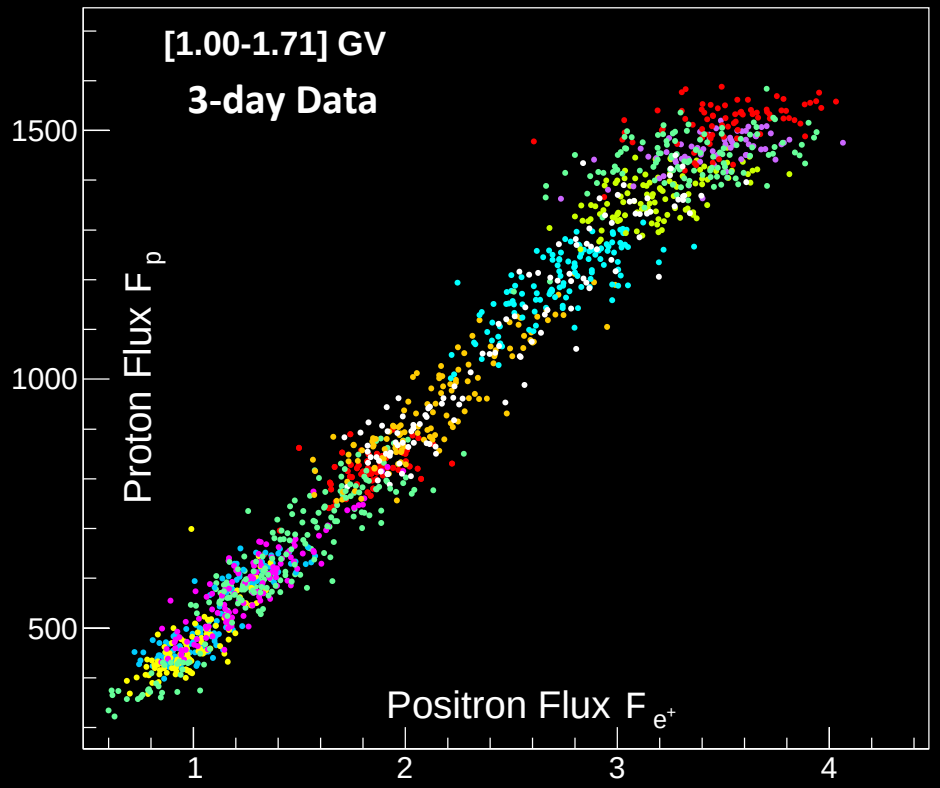


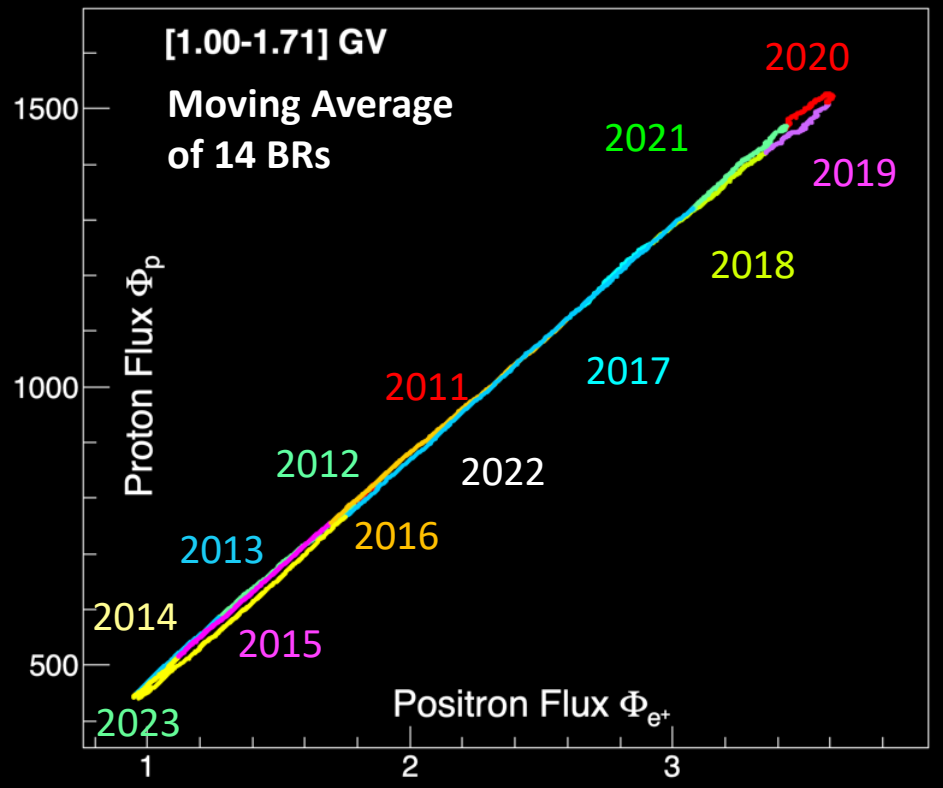
Daily positron extending to November 2023



Linear relationship between positron and proton fluxes

Different mass, same charge



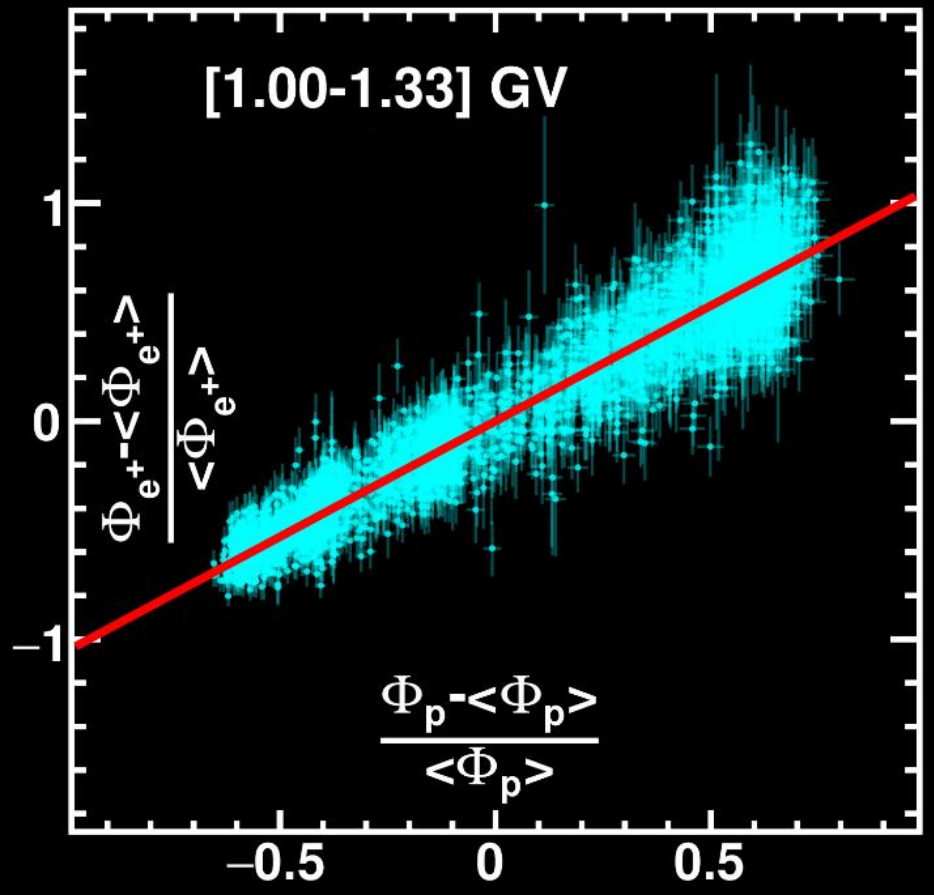


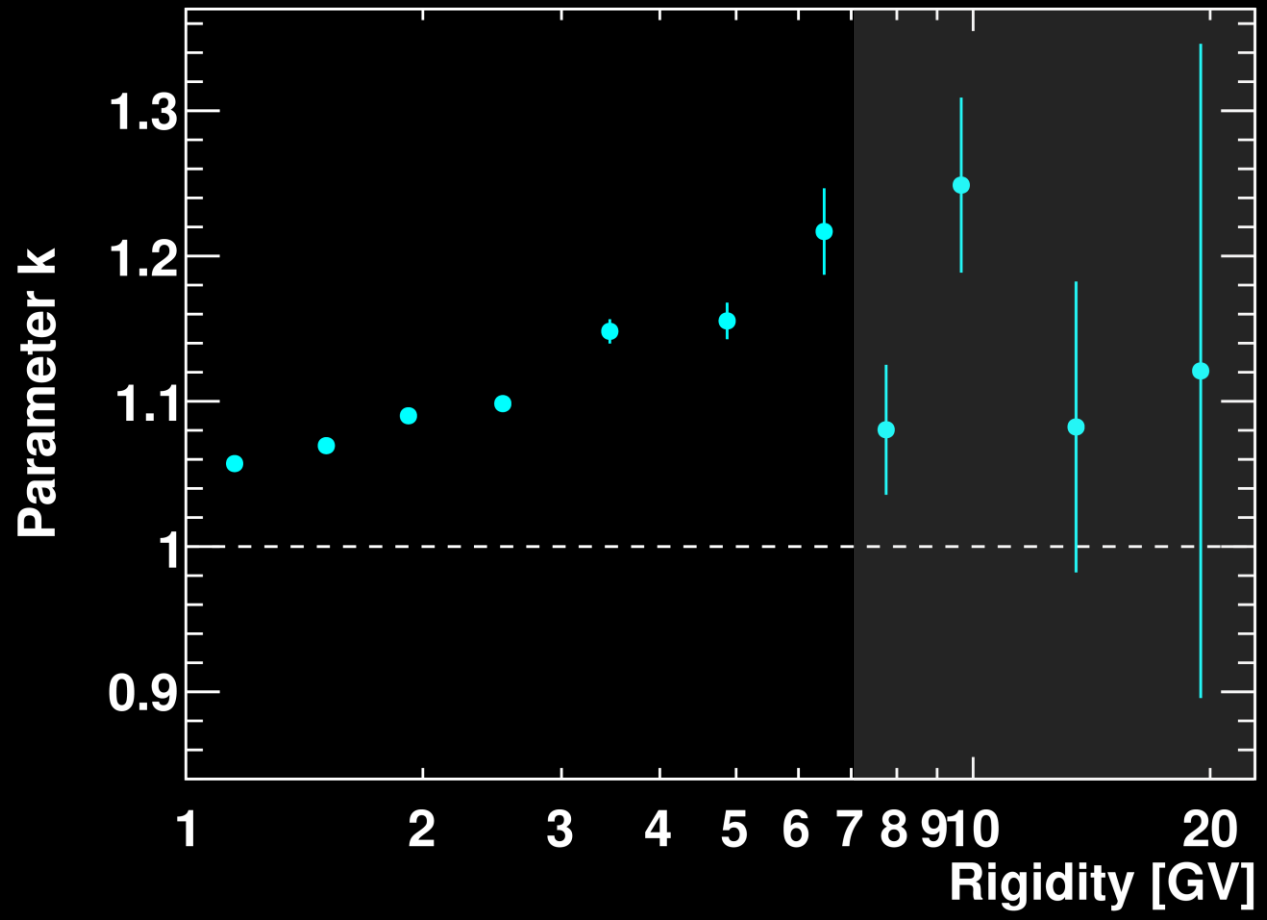
Fluxes in unit of $[m^{-2}sr^{-1}s^{-1}GV^{-1}]$

Linear relation between Φ_{e^+} and Φ_p

To compare the long-term variations of the **proton** and **positron** fluxes a linear relation between the relative variations of the fluxes is studied: $\frac{\Phi_{e^+}-\langle\Phi_{e^+}\rangle}{\langle\Phi_{e^+}\rangle} = k\,\frac{\Phi_p-\langle\Phi_p\rangle}{\langle\Phi_p\rangle}$

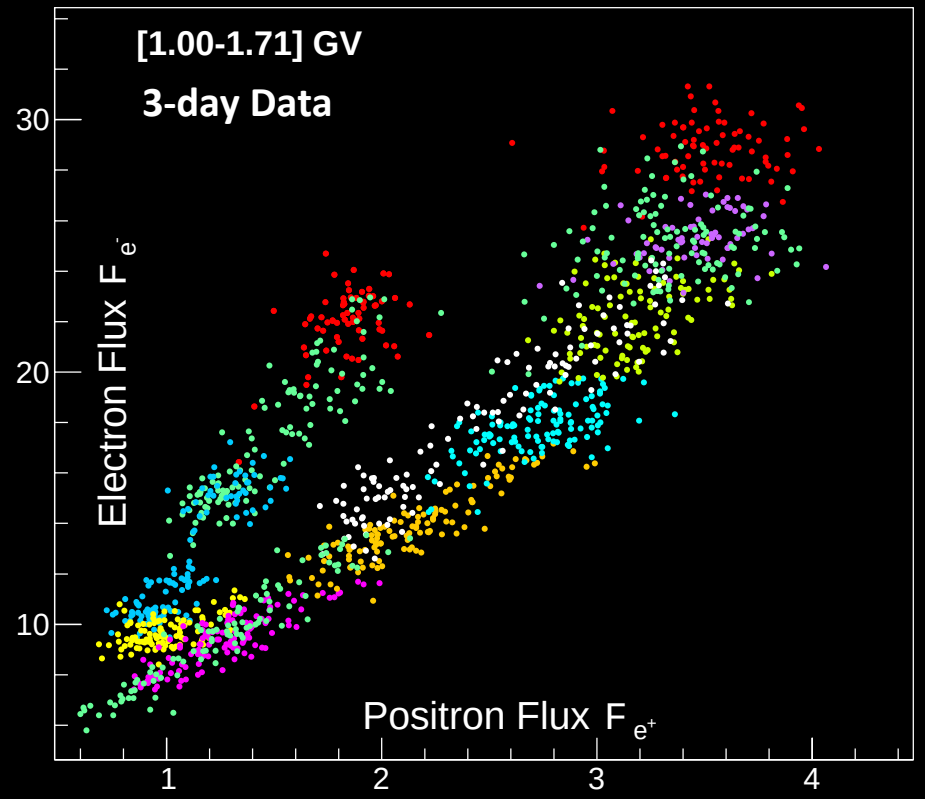
Below 7 GV, the positron flux is more modulated than the proton flux

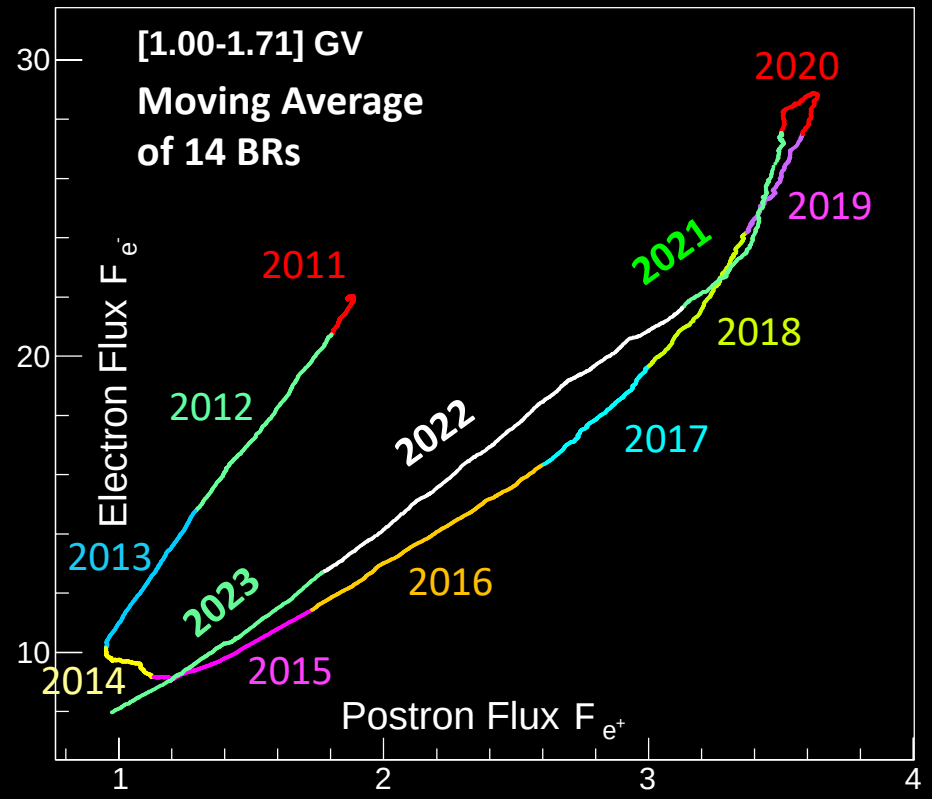




Hysteresis between positron and electron fluxes

Same mass, opposite charge

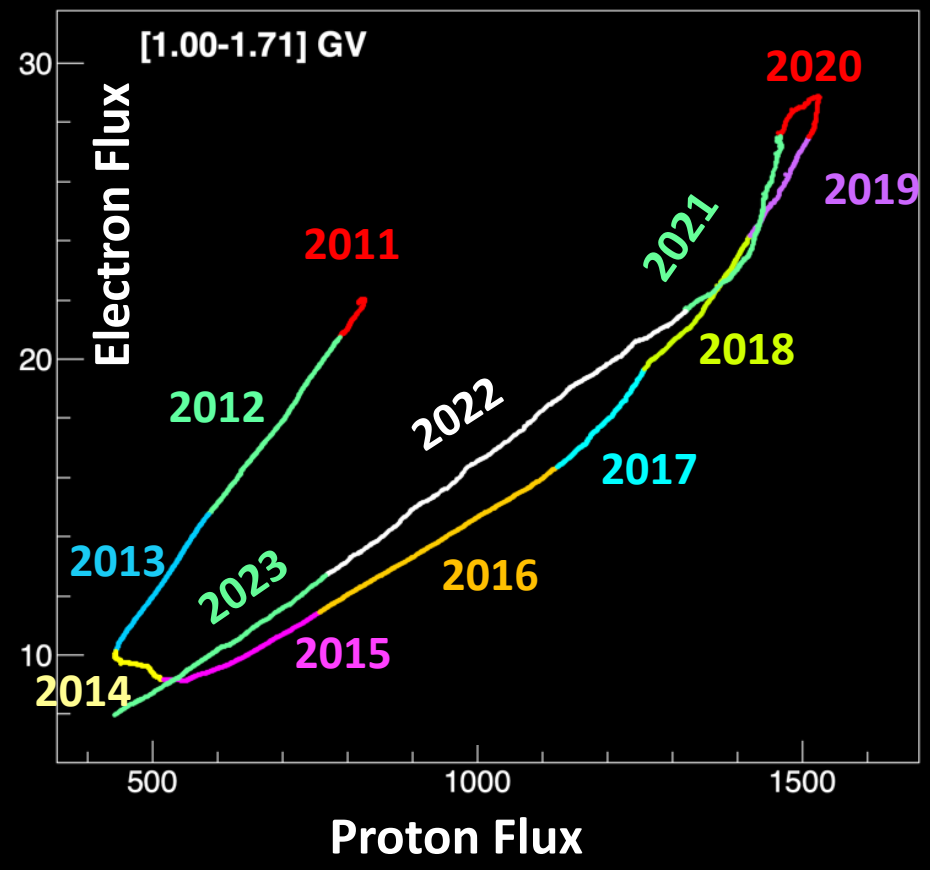




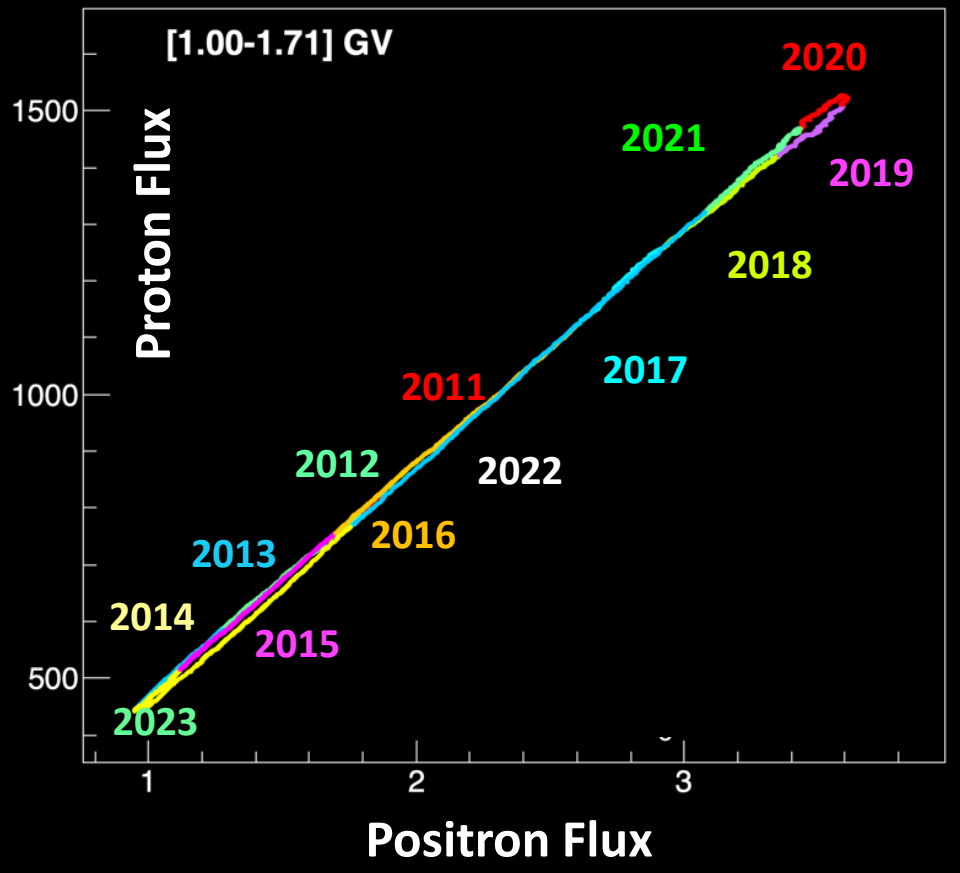
Fluxes in unit of [$m^{-2}sr^{-1}s^{-1}GV^{-1}$]

Summary of daily electron and positron fluxes

Electron vs Proton
Opposite charge
Complex Hysteresis



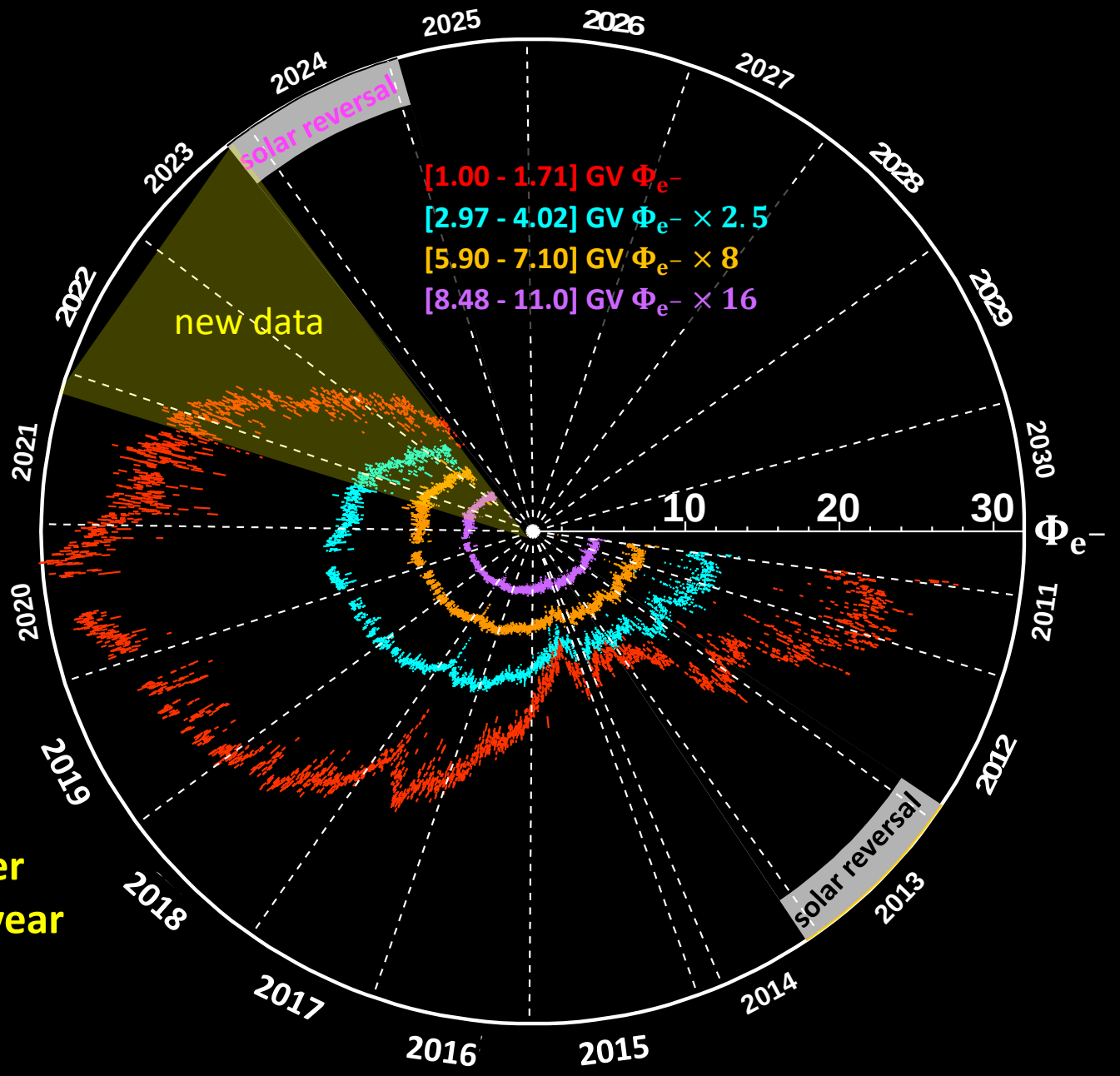
Positron vs Proton
Same charge
"Repeated" linearity



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



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

AMS is a unique experiment to carry out precise studies on the time variability of the individual species in cosmic rays

By 2030, AMS will cover a complete 22-year solar cycles, and more unexpected results are yet to come