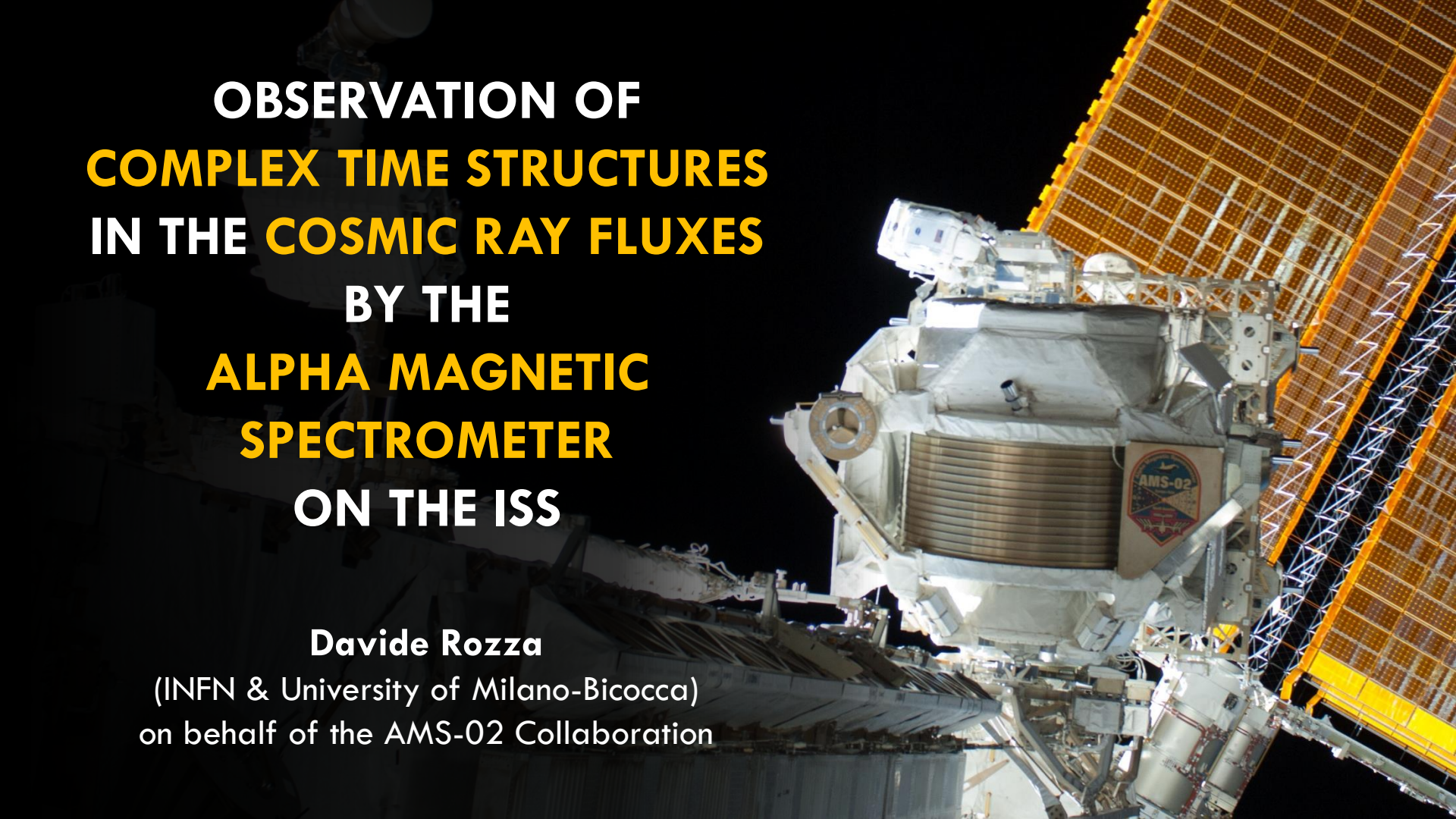
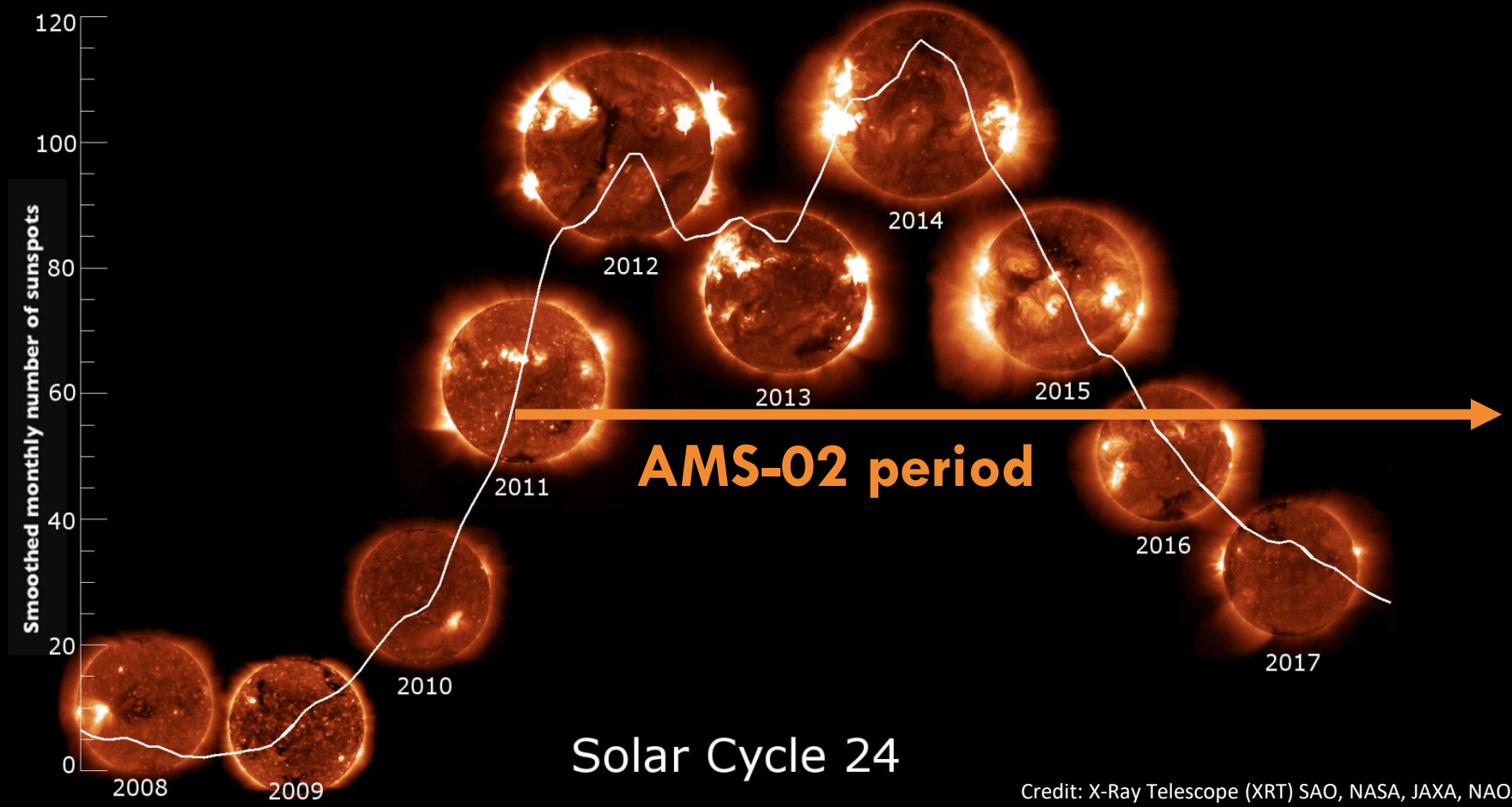
OBSERVATION OF COMPLEX TIME STRUCTURES IN THE COSMIC RAY FLUXES BY THE ALPHA MAGNETIC SPECTROMETER ON THE ISS

Davide Rozza
(INFN & University of Milano-Bicocca)
on behalf of the AMS-02 Collaboration



How does SOLAR ACTIVITY influence COSMIC RAYS?



Credit: X-Ray Telescope (XRT) SAO, NASA, JAXA, NAOJ

AMS was installed on the ISS in May 2011
It will continue through the lifetime of ISS

>140 billion charged cosmic rays have been measured in 8 years

AMS-02 objectives

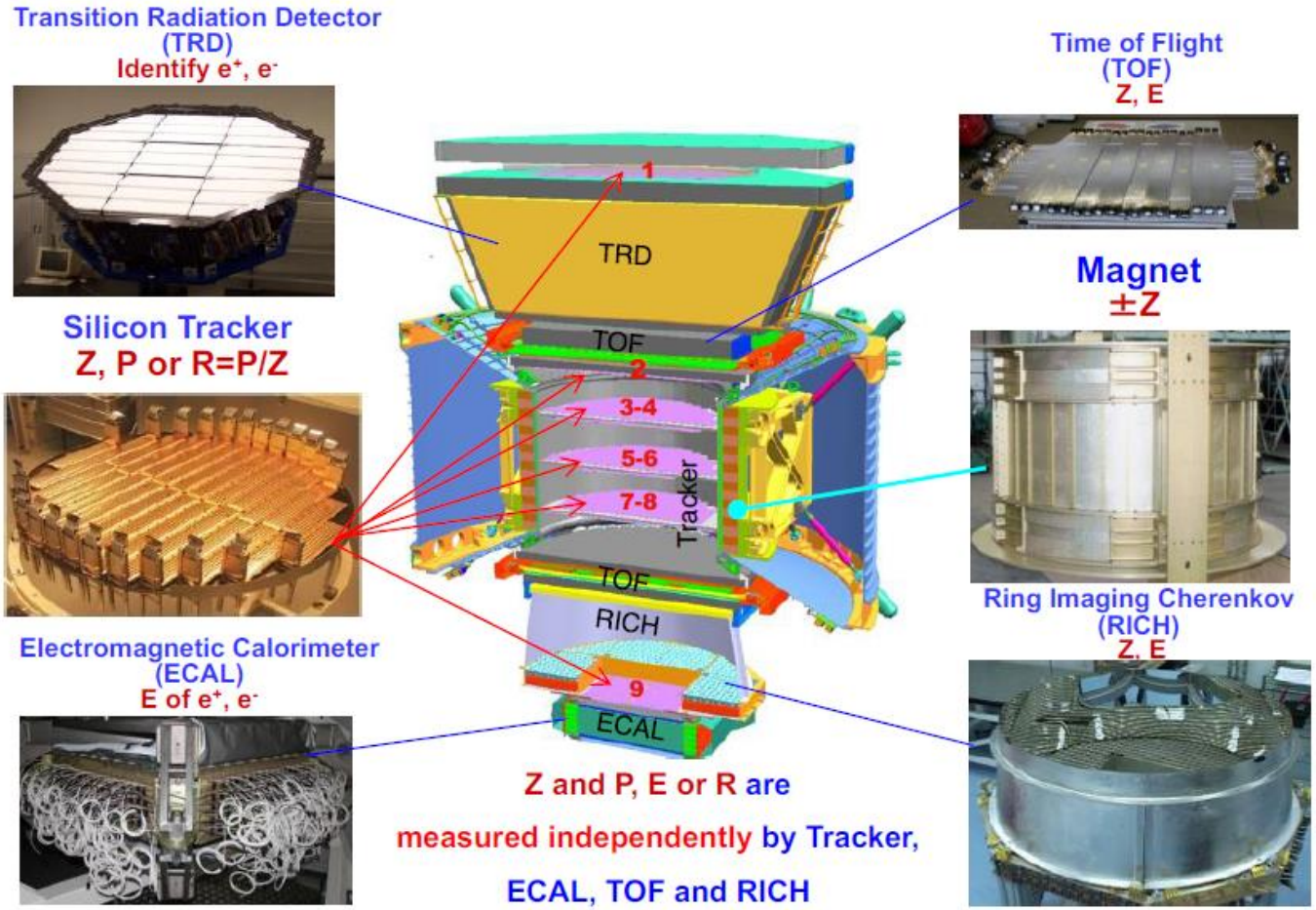
measurement of charged particles for:

Primordial **antimatter** search with sensitivity of 10^{-9}

Dark matter search in antimatter channels (e.g. antiprotons…)

Cosmic ray composition and spectra analysis

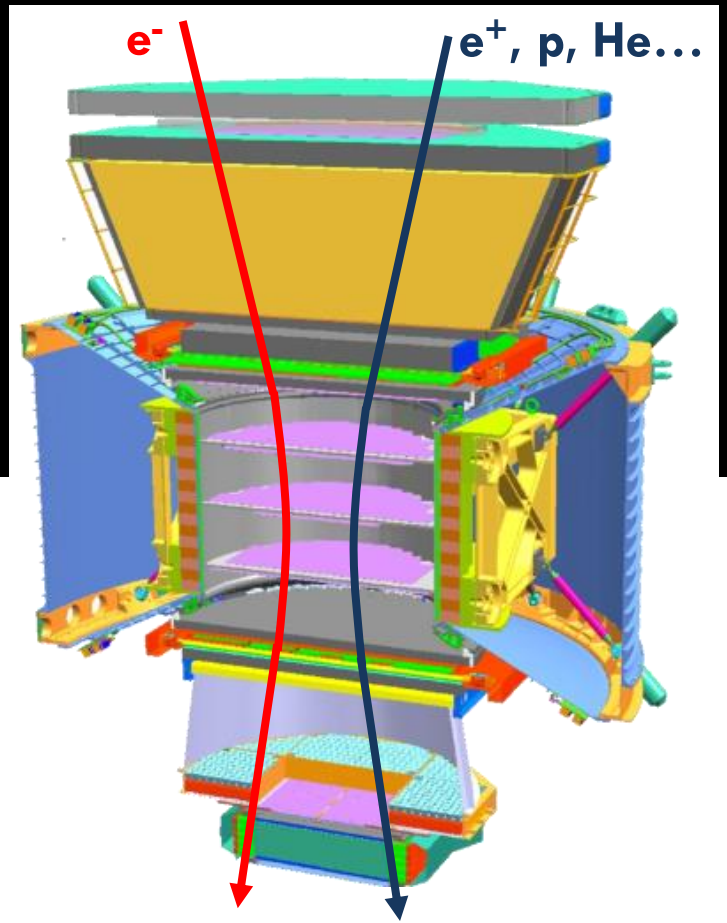
AMS-02 apparatus



AMS-02 particle identification

CHARGE SIGN

matter to anti-matter separation



HIGH ENERGY

identification up to TeV energy region

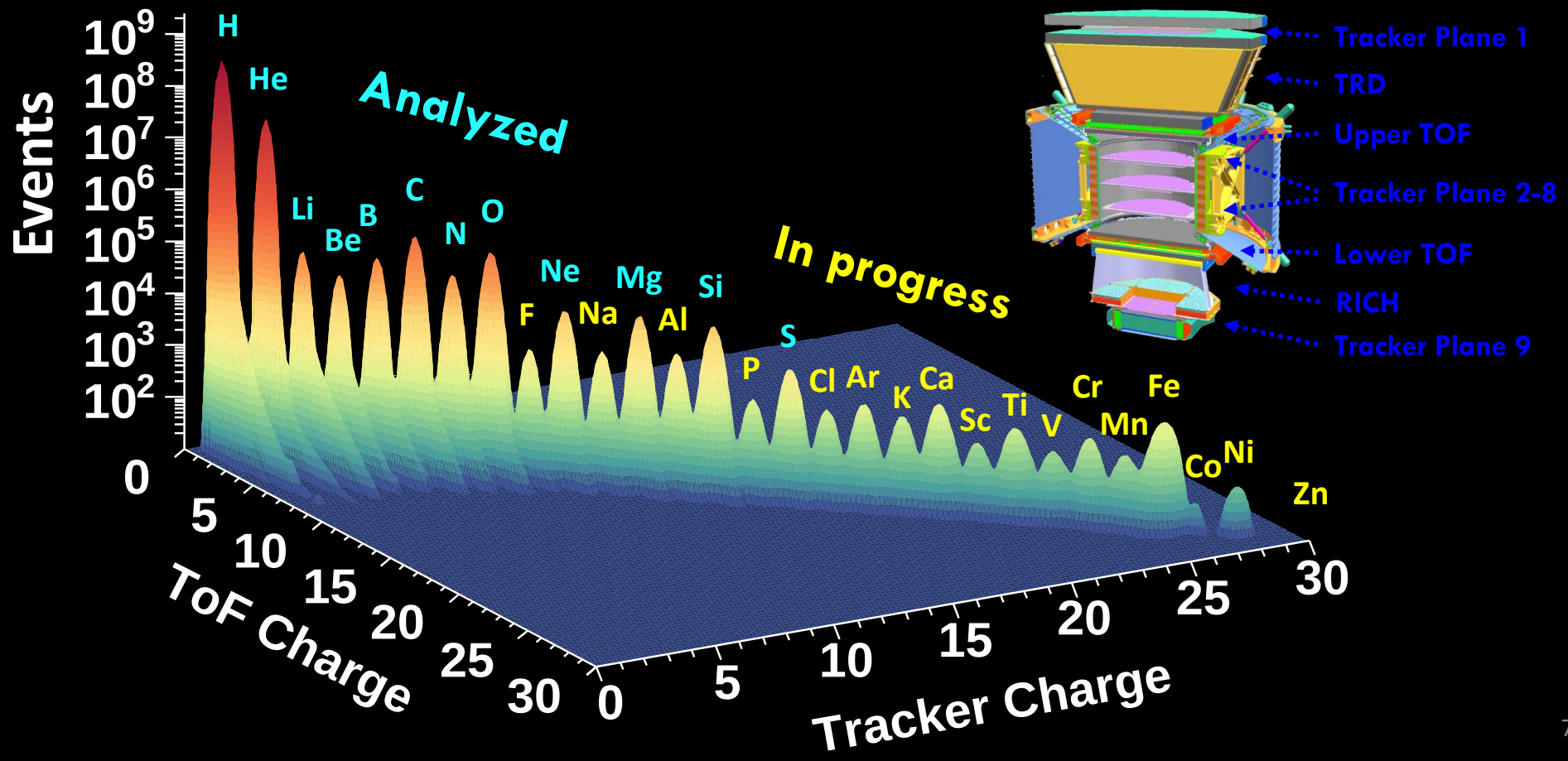
e/p SEPARATION AT THE 10^6 LEVEL

combining TRD, TRACKER and ECAL measurements

NUCLEI MEASUREMENTS

Z redundant measurements to evaluate fragmentation along the detector

AMS has seven instruments which independently measure charge



AMS-02

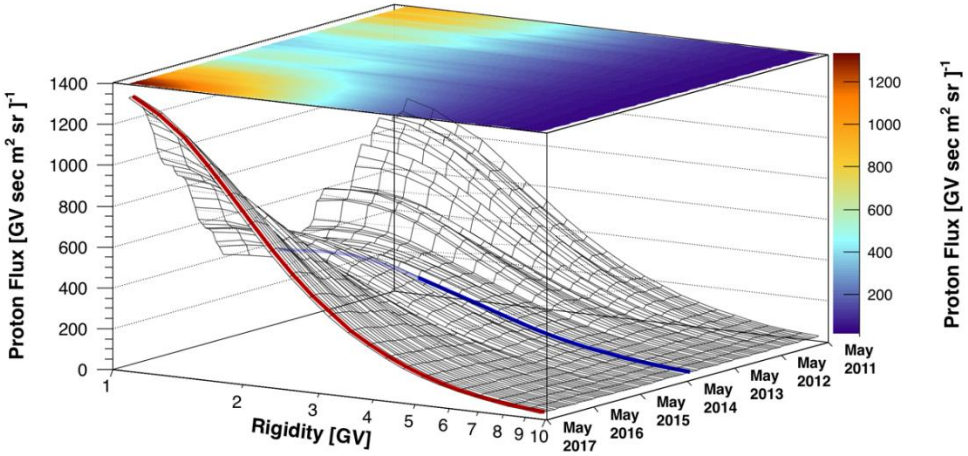
an high statistics precision, multipurpose spectrometer

WIDE ENERGY RANGE

LARGE ACCEPTANCE

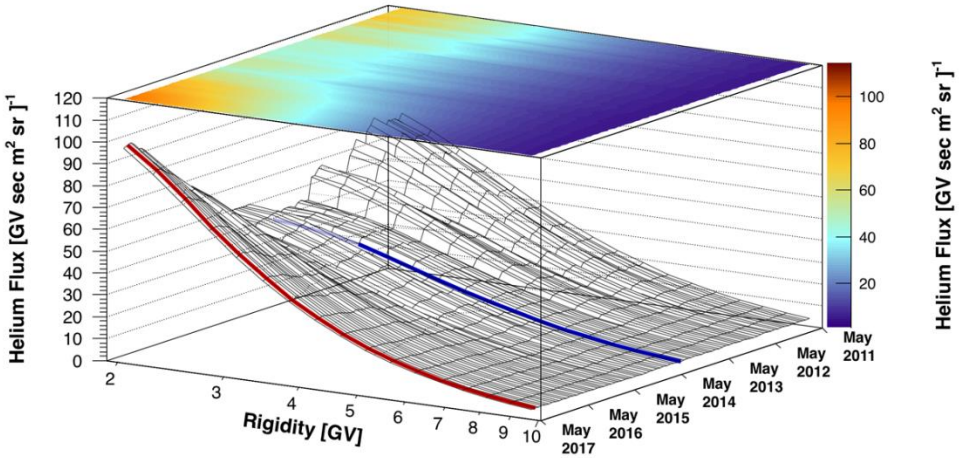
LONG EXPOSURE TIME

Proton



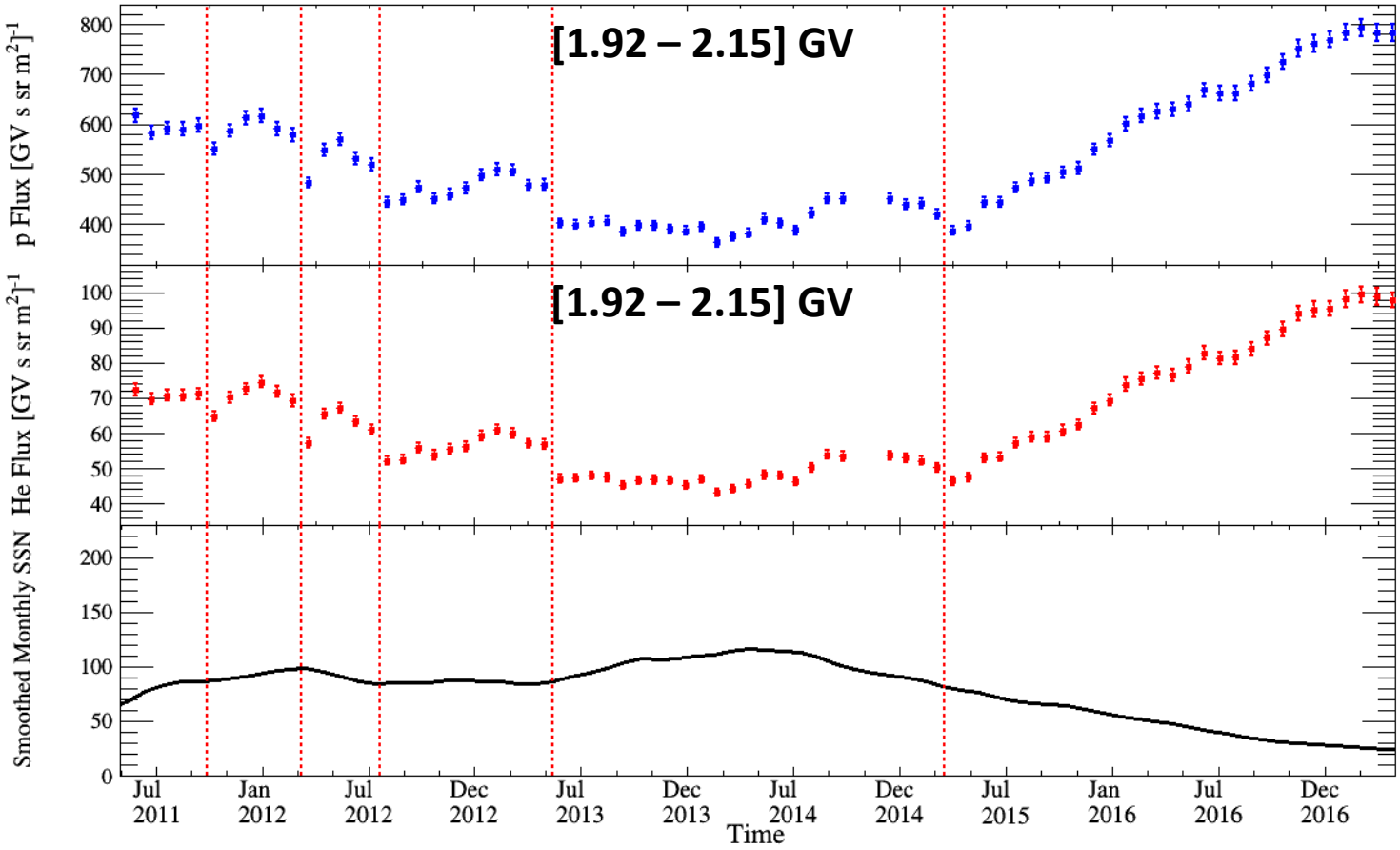
based on $8.46 \cdot 10^8$ events

Helium



based on $1.12 \cdot 10^8$ events

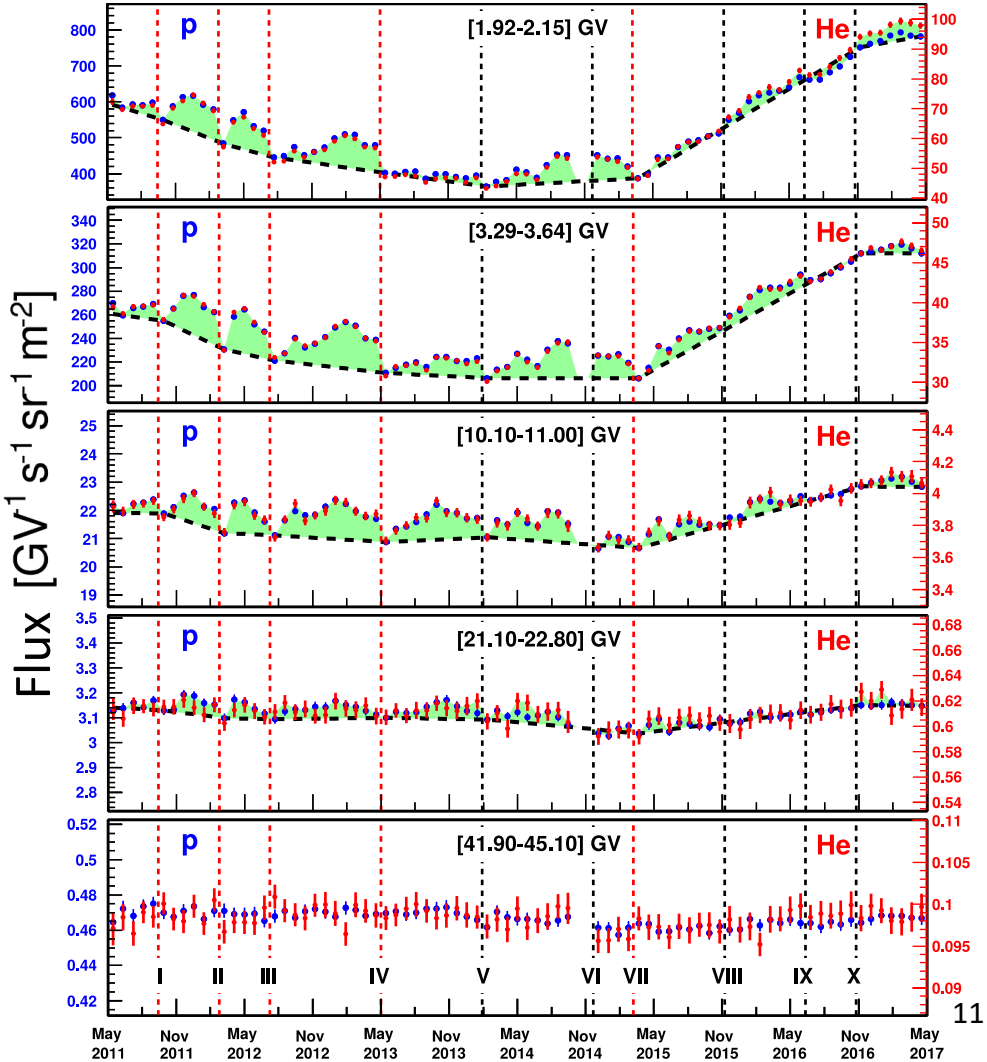
AMS-02 during Solar Cycle 24



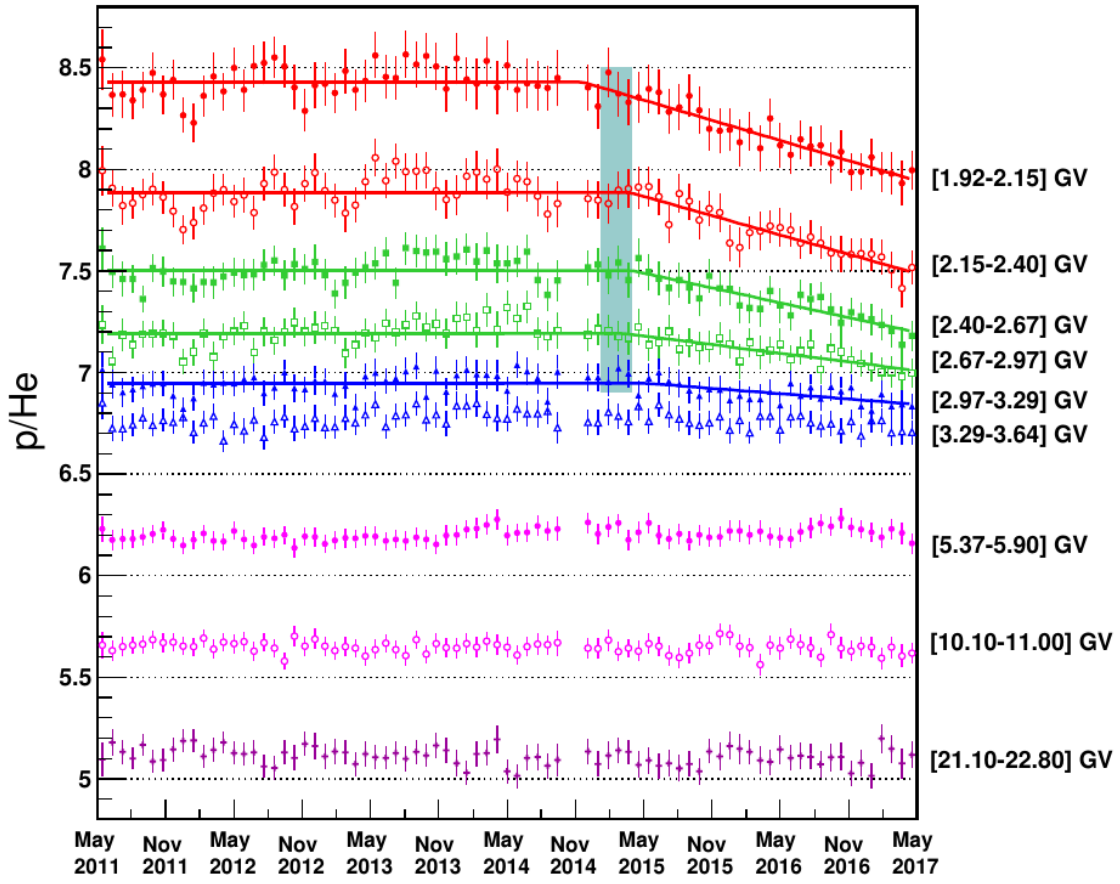
STRUCTURES BELOW 40 GV
(green shading and dashed lines to guide the eye)

THE AMPLITUDE OF THE STRUCTURES DECREASES WITH INCREASING RIGIDITY

SIMILAR STRUCTURES OBSERVED ALSO IN e^+ & e^- MEASUREMENTS
(indicated here by red dashed lines)



AMS-02 p/He ratio

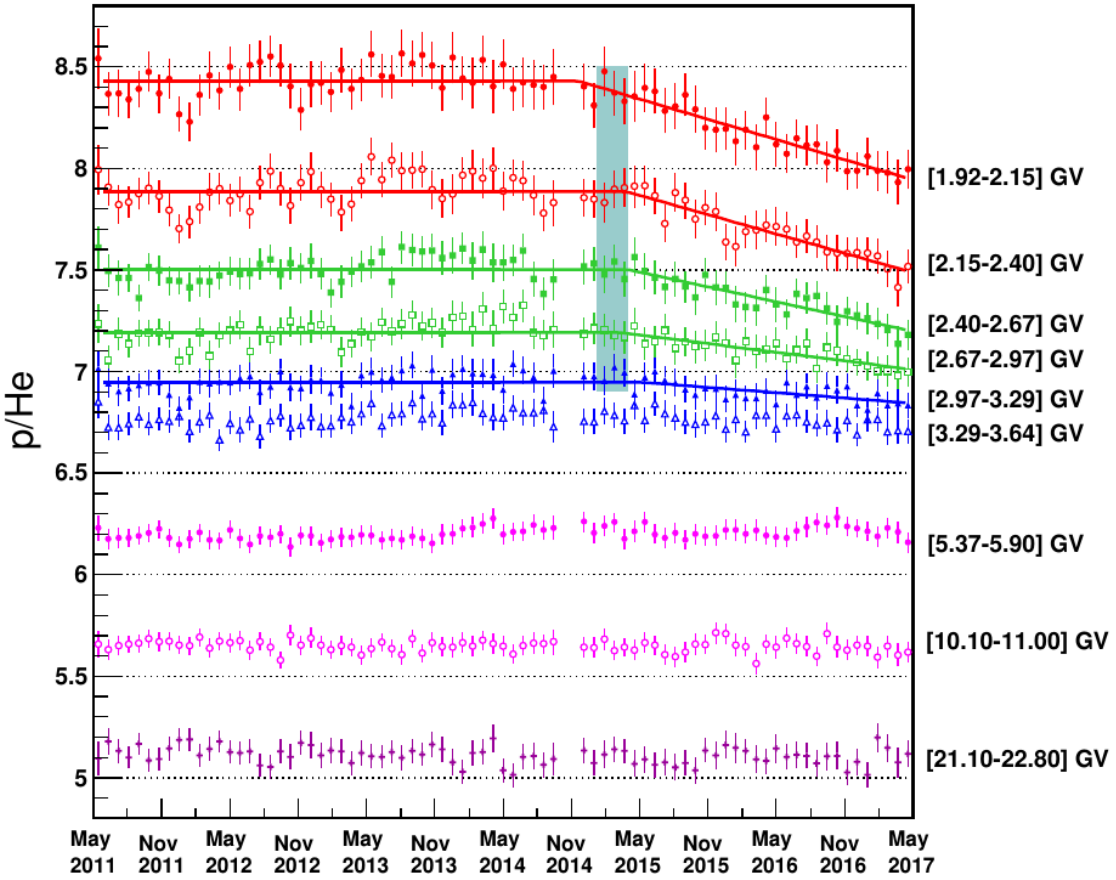


BELOW 3 GV

the p/He flux ratio has a long-term decrease

- ? Differences in p and He diffusion coefficients
- ? Differences in the local interstellar spectra of p and He
- ? ^{3}He and ^{4}He isotopic composition

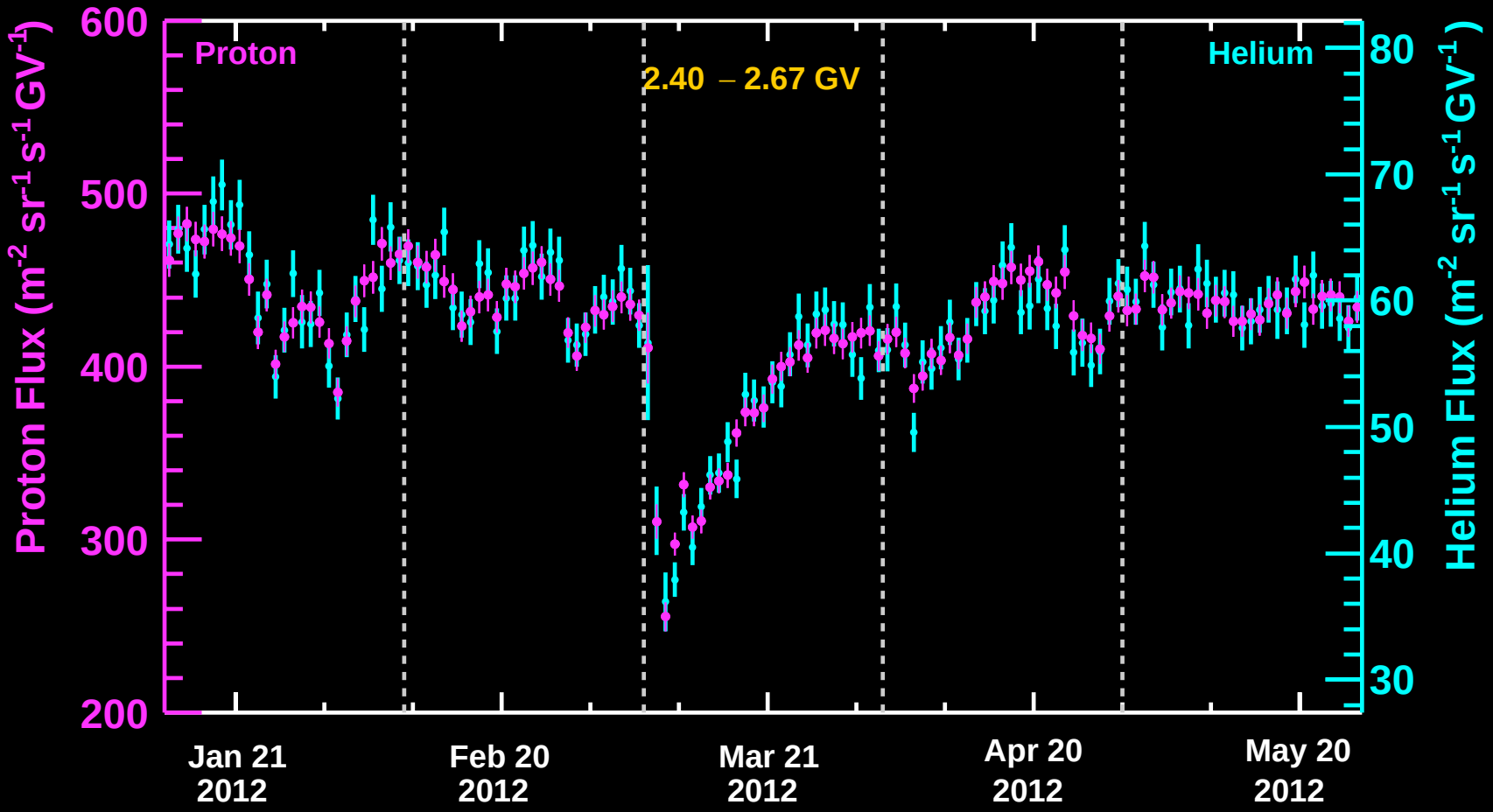
AMS-02 p/He ratio



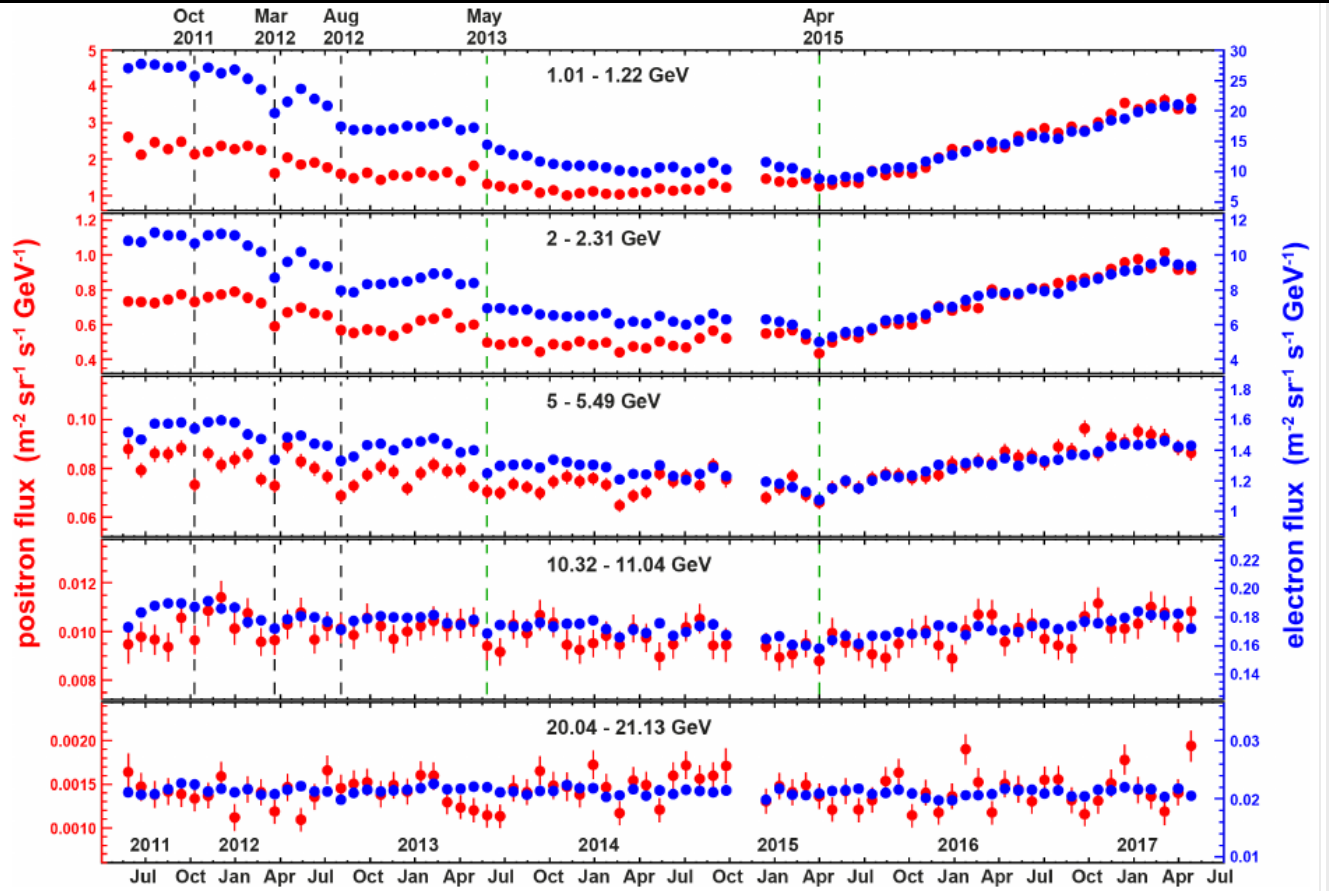
ABOVE 3 GV

the p/He flux ratio is time-independent

IDENTICALLY DAILY time variation of the p, He fluxes



AMS-02 electron and positron fluxes

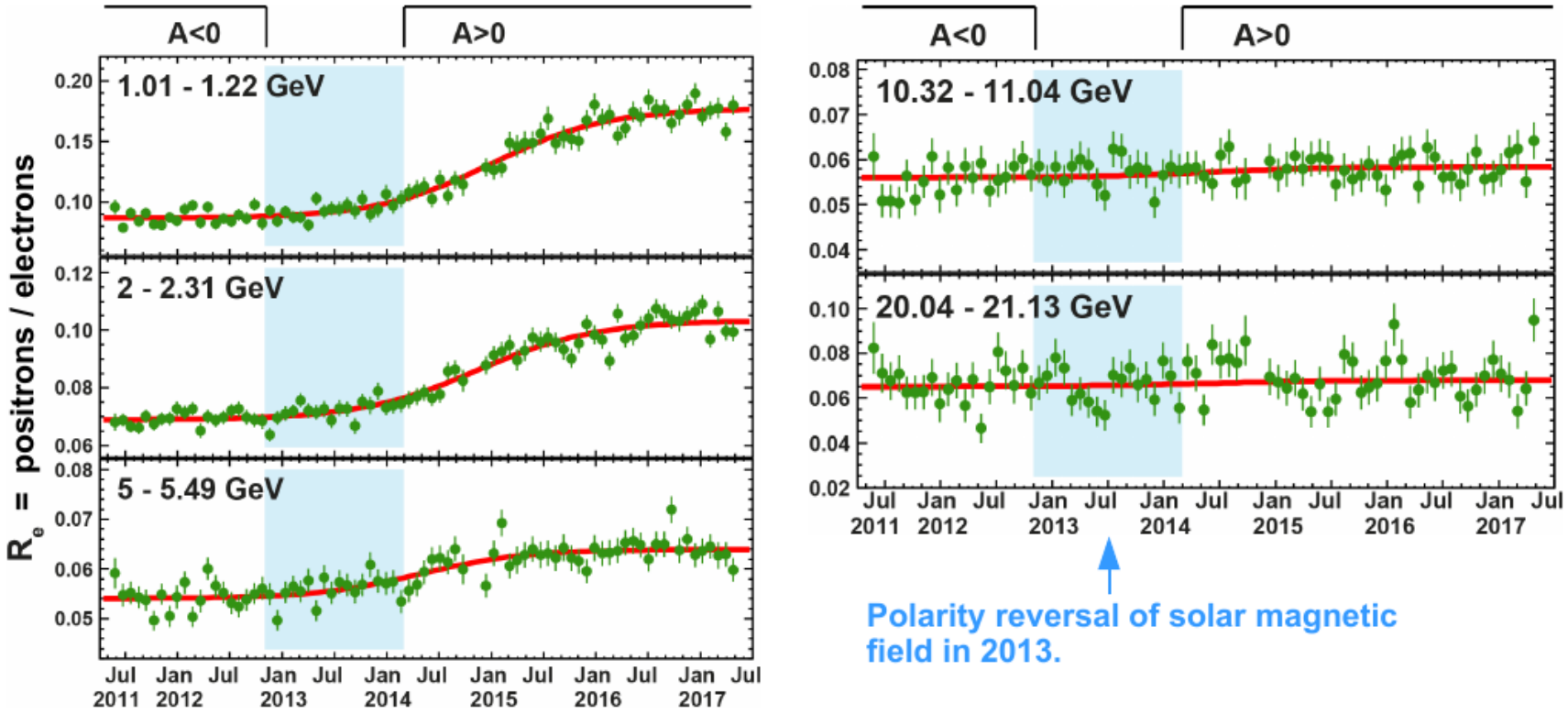


Prominent and distinct TIME STRUCTURES visible in both e^+ and e^- spectrum and at different energies

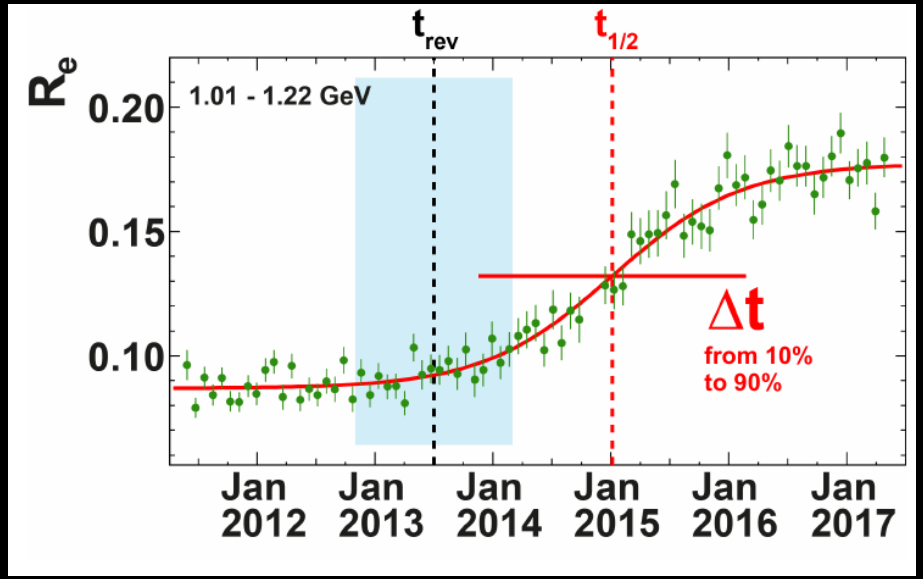
(marked by dashed vertical lines)

Based on $23.5 \cdot 10^6$ events

AMS-02 e^+/e^- ratio



AMS-02 e^+/e^- ratio

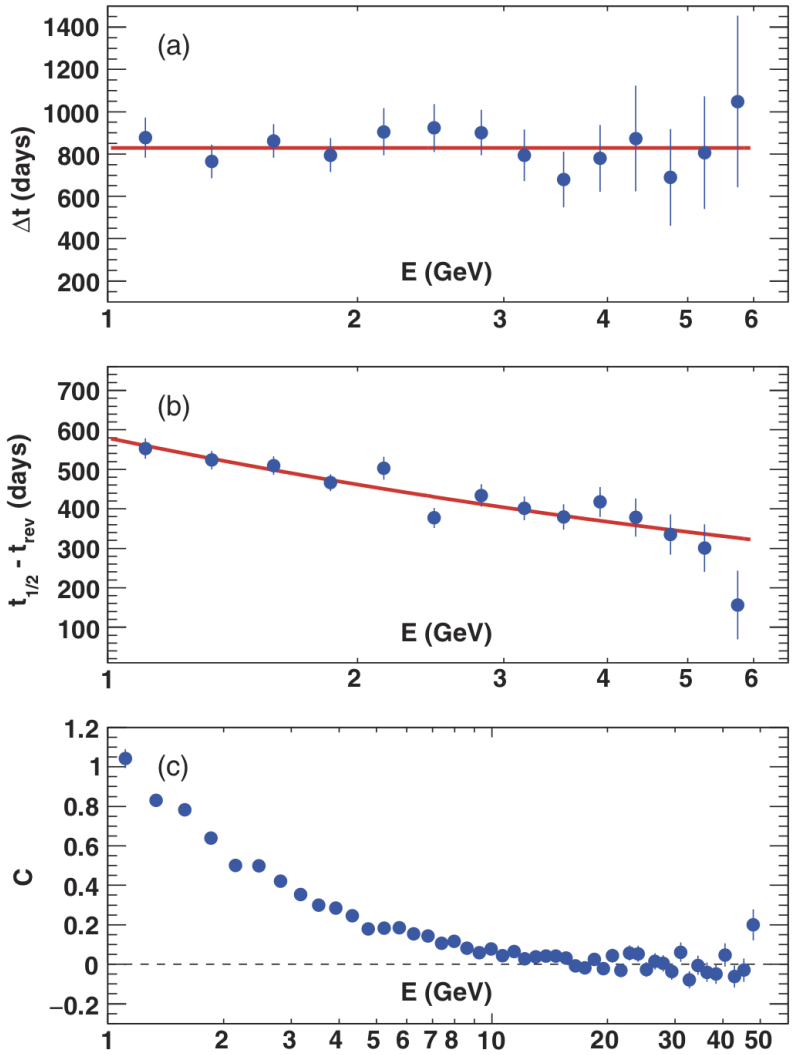


Midpoint of the transition

Amplitude of the transition

$$R_e(t,E) = R_0(E)\left[1 + \frac{C(E)}{\exp\left(-\frac{t-t_{1/2}(E)}{\Delta t(E)/\Delta_{80}}\right)+1}\right]$$

Duration of the transition



DURATION of transition is energy independent

The ratio exhibits a **SMOOTH TRANSITION** over **830±30 DAYS** from one value to another

MIDPOINT ($t_{1/2}$) and **AMPLITUDE** (**C**) of the transition are energy dependent

Midpoint shift of **260±30 days**

t_{rev} = **01/July/2013**, time of the solar magnetic field reversal

C consistent with 0 for E > 20 GeV

AMS-02 measured p, He, e^+, e^- monthly fluxes during Solar Cycle 24

(ascending phase, its maximum and toward its minimum)

PhysRevLett.121.051101

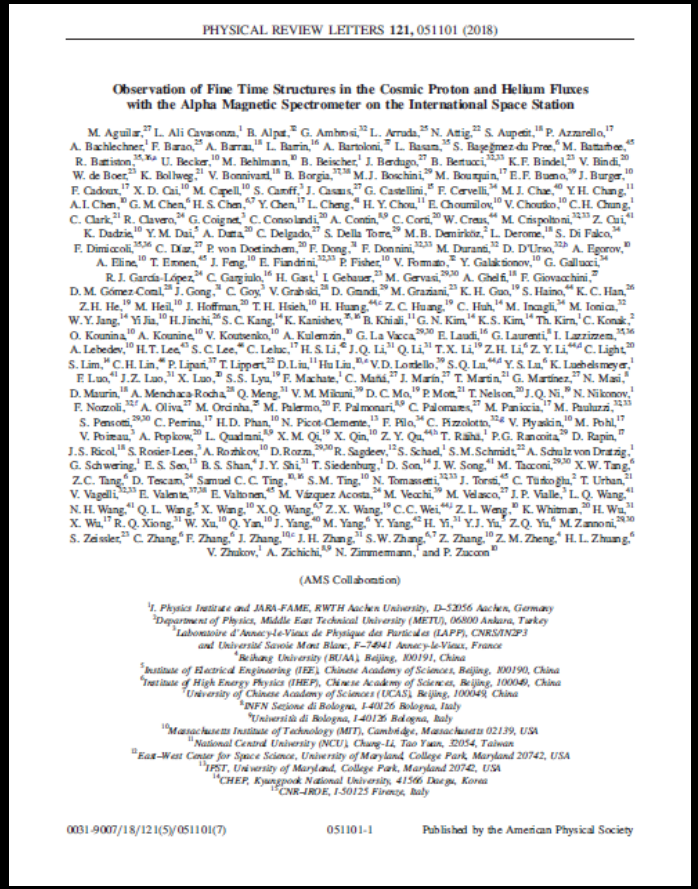
(p and He)

PhysRevLett.121.051102

(e^- and e^+)

Editors' suggestion

PhysRevLett.121.051101 (p and He)



PHYSICAL REVIEW LETTERS **121,** 051101 (2018)

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(AMS Collaboration)

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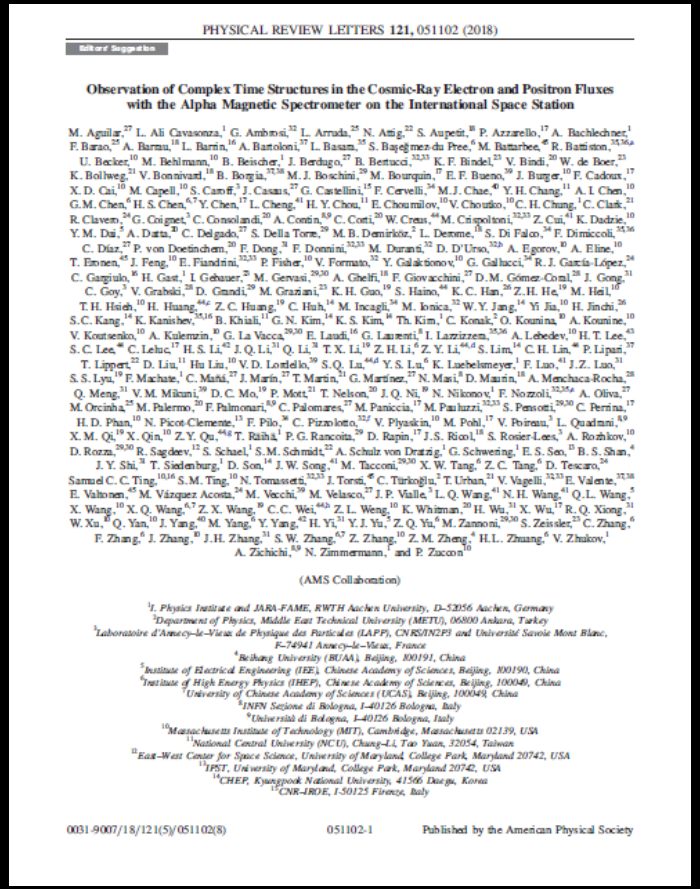
0031-9007/18/121(5)/051101(7) 051101-1 Published by the American Physical Society

FLUX RATIO (p/He)

above 3 GV is time independent

below 3 GV has long-term decrease

PhysRevLett.121.051102 (e^- and e^+)



PHYSICAL REVIEW LETTERS 121, 051102 (2018)

Editors' Suggestion

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0031-9007/18/121(5)/051102(8) 051102-1 Published by the American Physical Society

FIRST accurate measurement of both e^- and e^+ fluxes over time

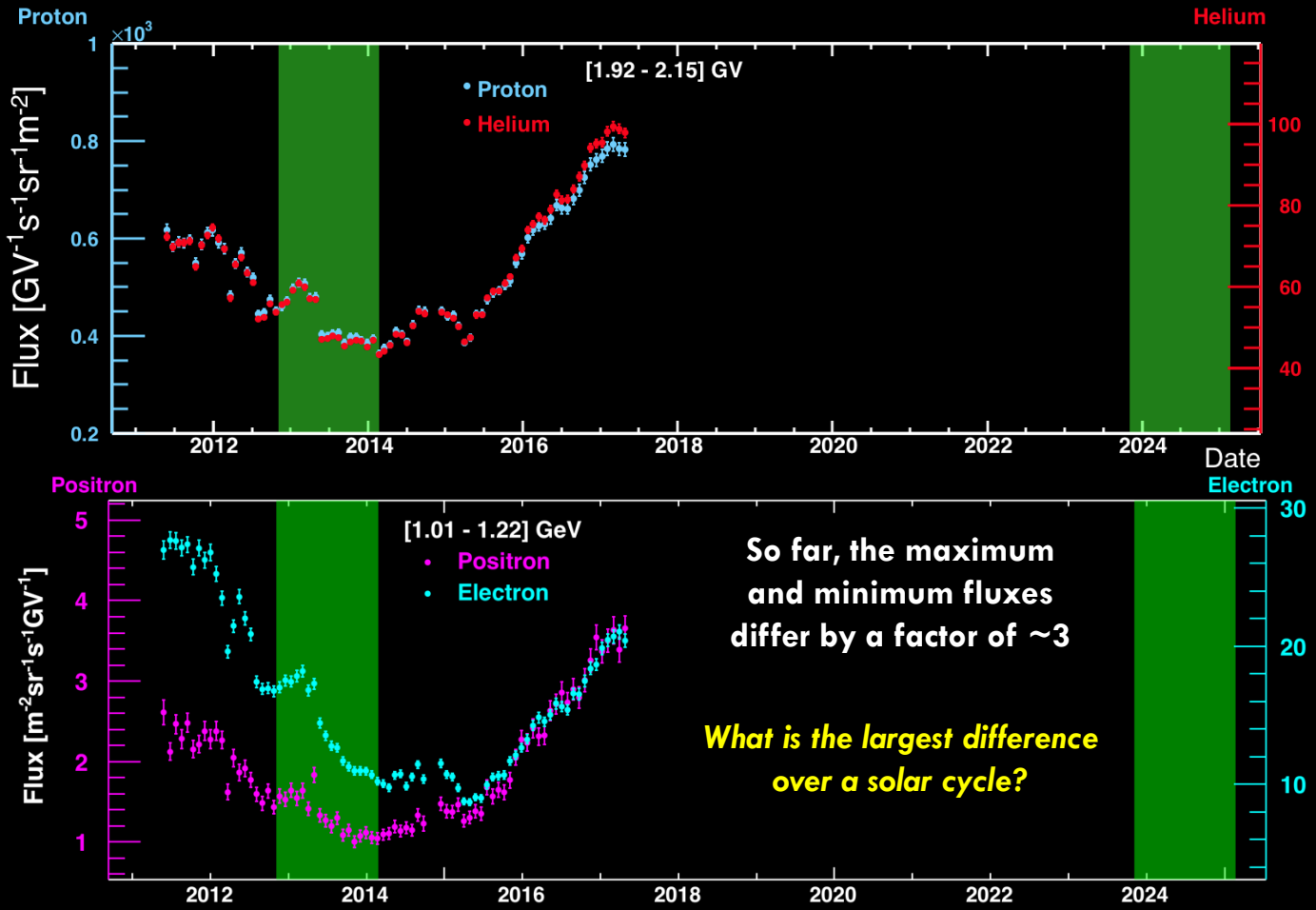
SHORT-TERM STRUCTURES coincident in both fluxes and are not visible in the e^+/e^- flux ratio

FLUX RATIO (e^+/e^-)

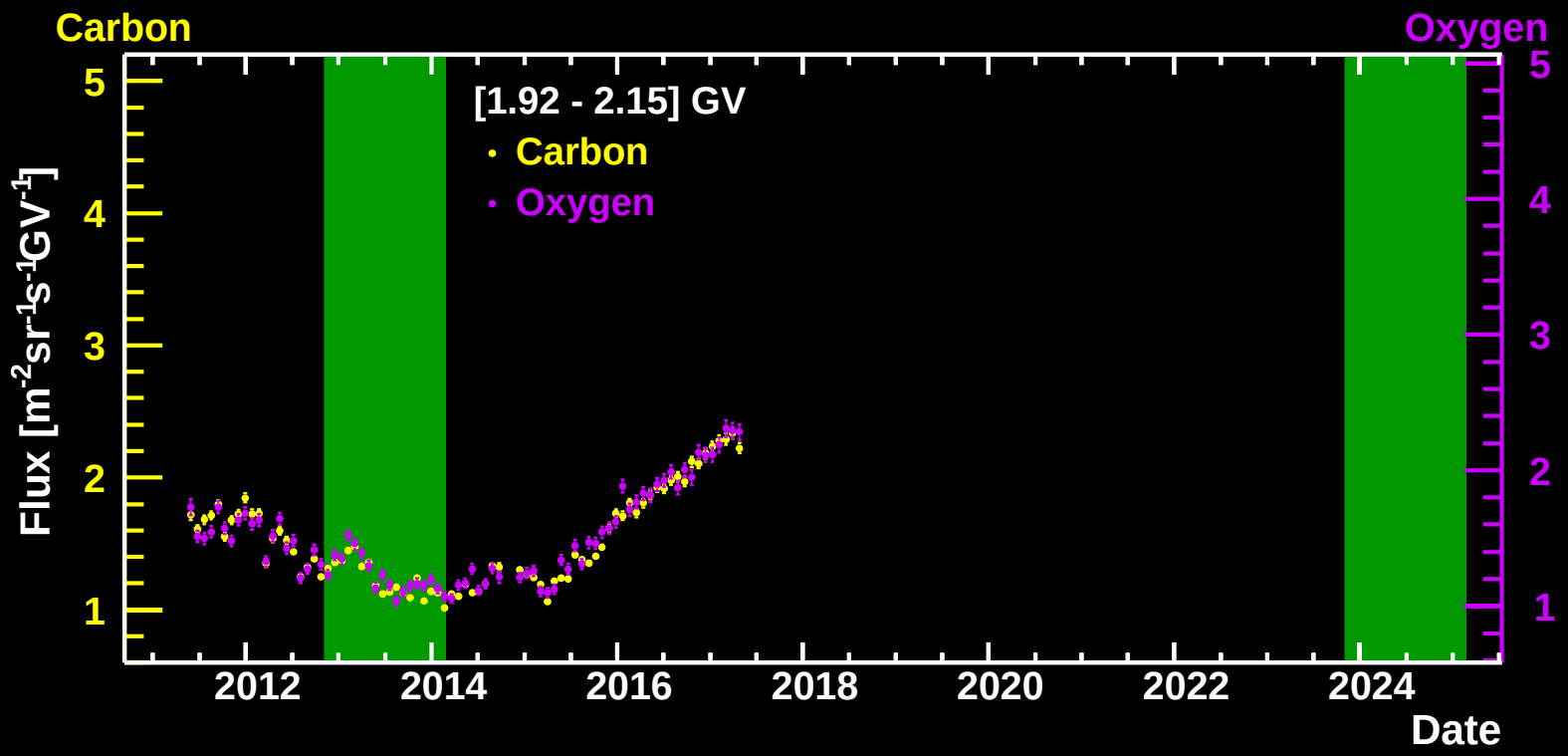
smooth transition over 830±30 days

midpoint of the transition shows an energy dependent delay relative to the reversal and changes by 260±30 days from 1 to 6 GeV.

Solar physics over a complete 11-year solar cycle



Solar physics over a complete 11-year solar cycle



The maximum and minimum fluxes differ by a factor of ~3

What is the largest difference over a solar cycle?

AMS is measuring solar effects for all nuclei, particle and anti-particle fluxes in the present and next solar cycle

Refer to the AMS forthcoming publication in PRL