Precision Measurement of the Monthly Cosmic Ray Fluxes with the Alpha Magnetic Spectrometer on the ISS

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On behalf of AMS Collaboration

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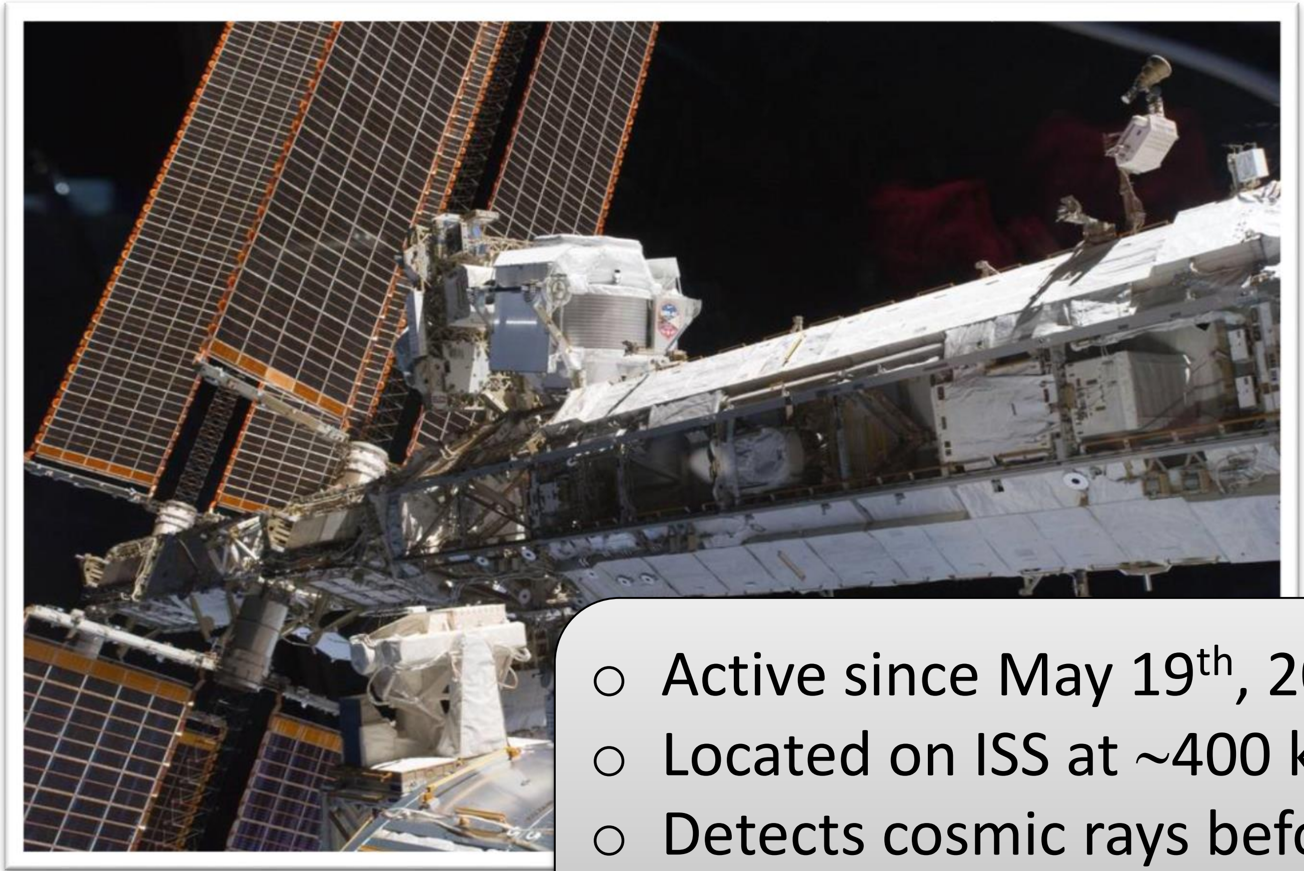
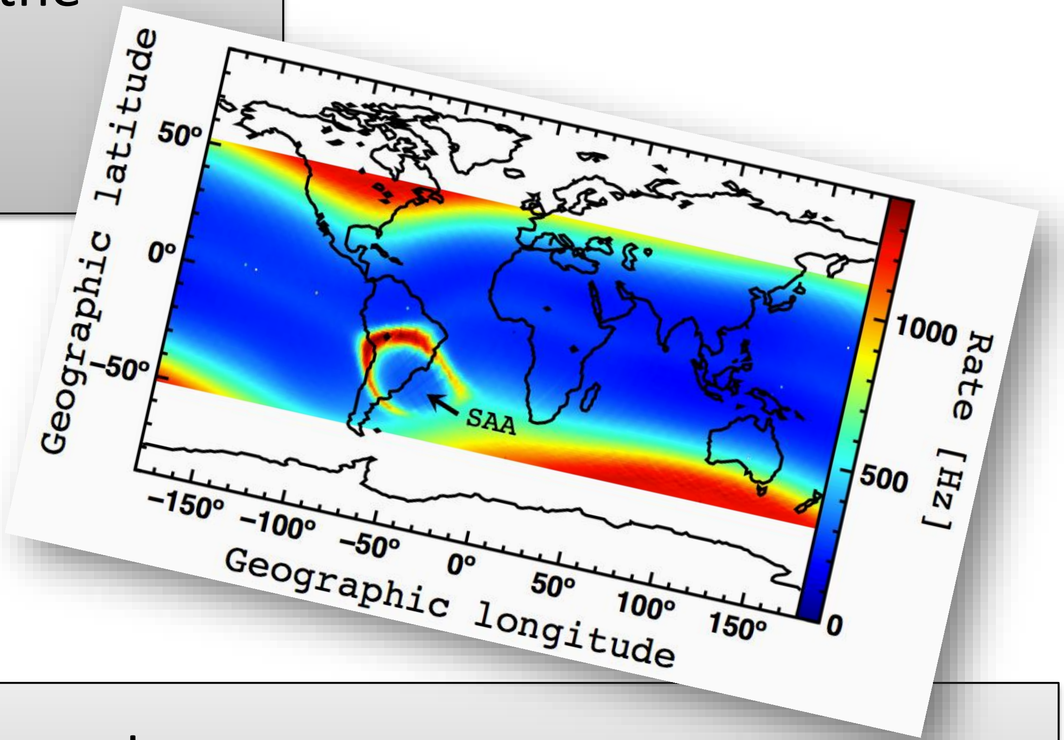
AMS is the magnetic spectrometer in space



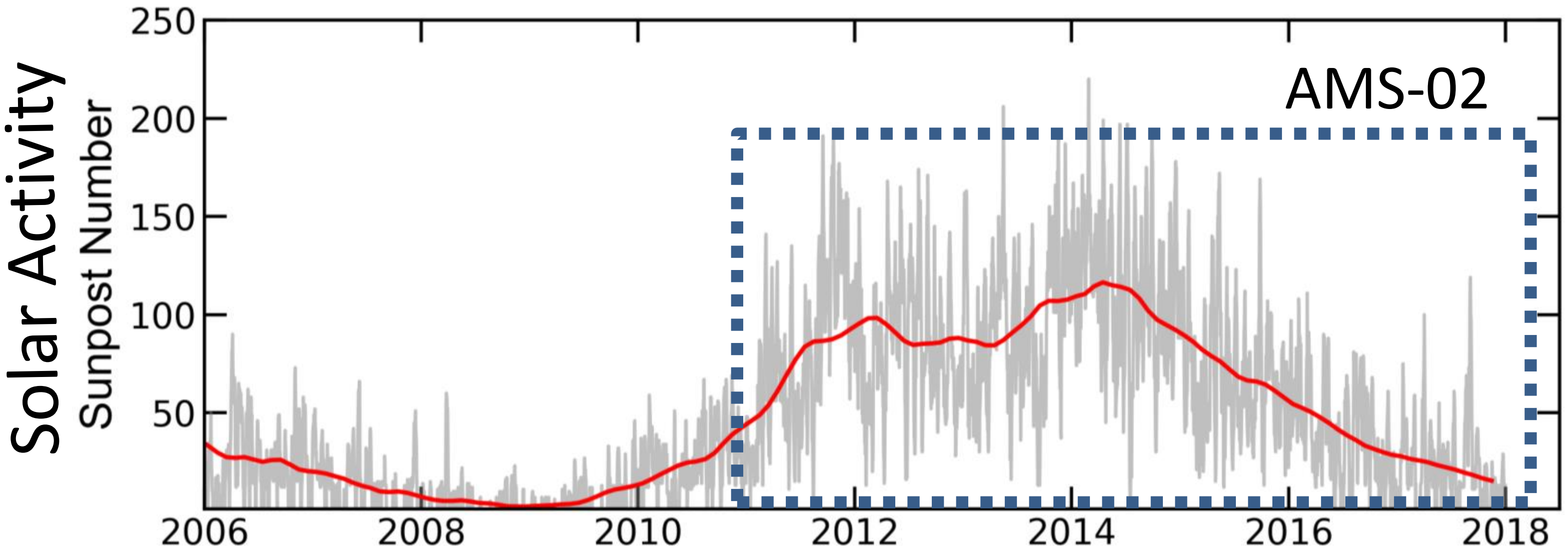
- Active since May 19th, 2011
- Located on ISS at ~400 km altitude
- Detects cosmic rays before they interact with the atmosphere

- Continuous operation 7d/7 - 24h/24
- 54 million particles/day
- Detector operation through the lifetime of ISS (~2024)
- Average rate ~ 700 Hz



- High acceptance.
- Fine rigidity resolution.
- Total uncertainty at the percentage level

In 7 year of operation, AMS has collected more than 120 billion events

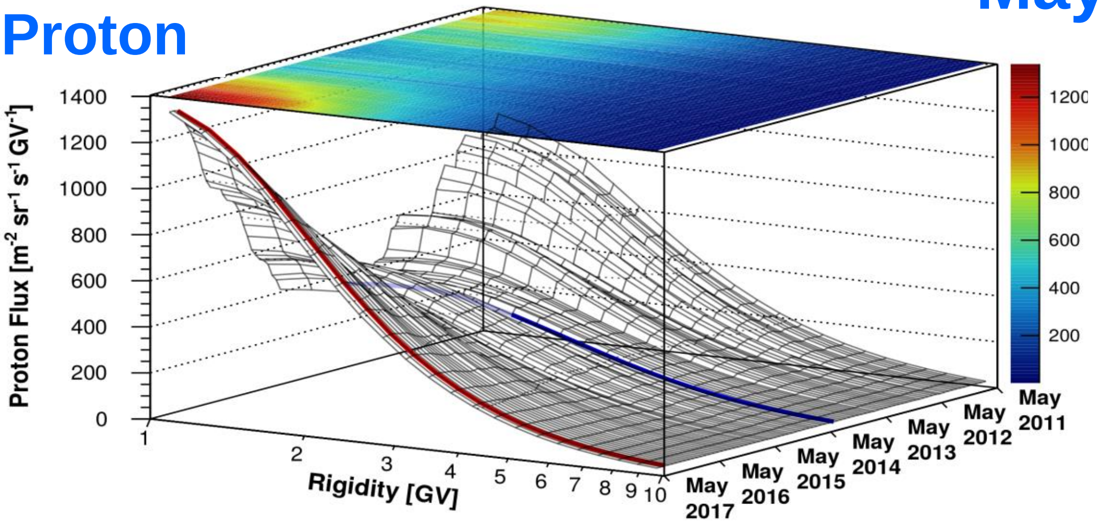


- Detailed time evolution of Galactic Cosmic Ray during both periods of maximum and minimum of solar activity.
- **AMS measurements will help to understand the propagation of charged particles in heliosphere**.

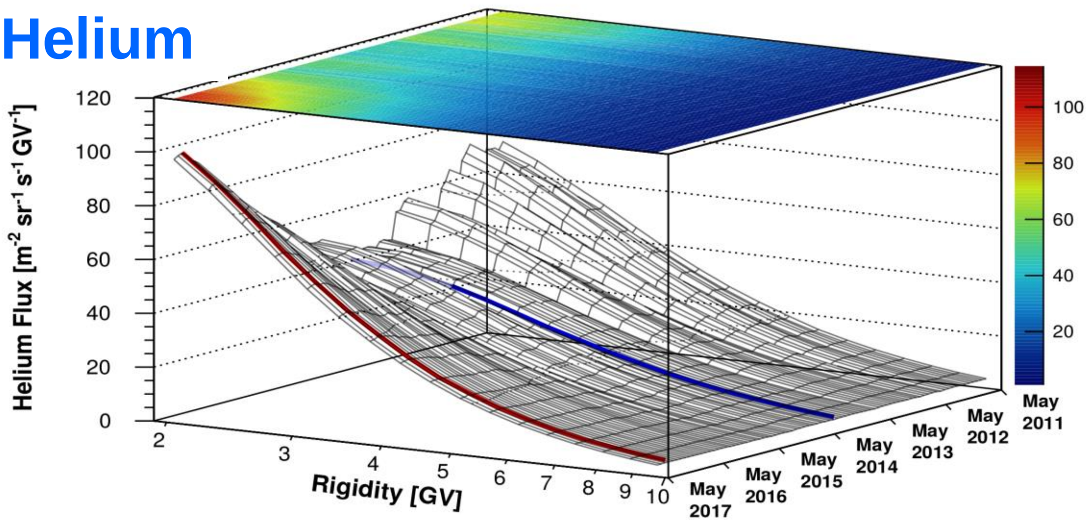
Detailed Analysis of Time evolution for p, He, e^+,e^-

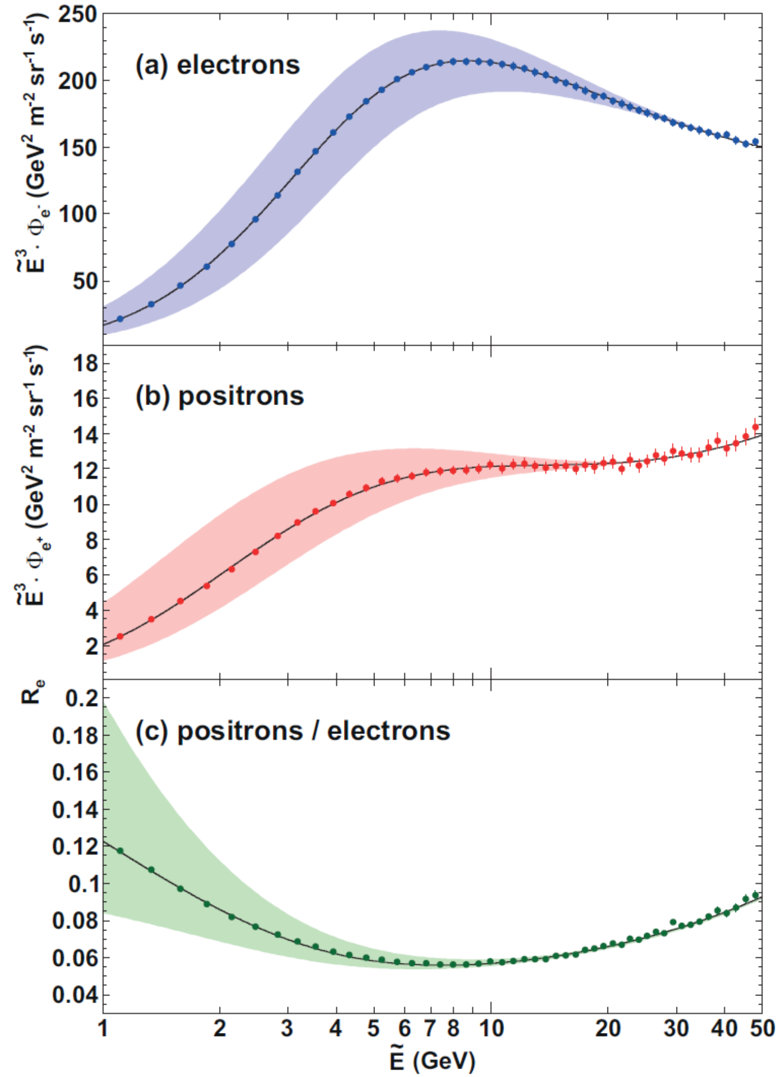
May 2011- May 2017

Proton

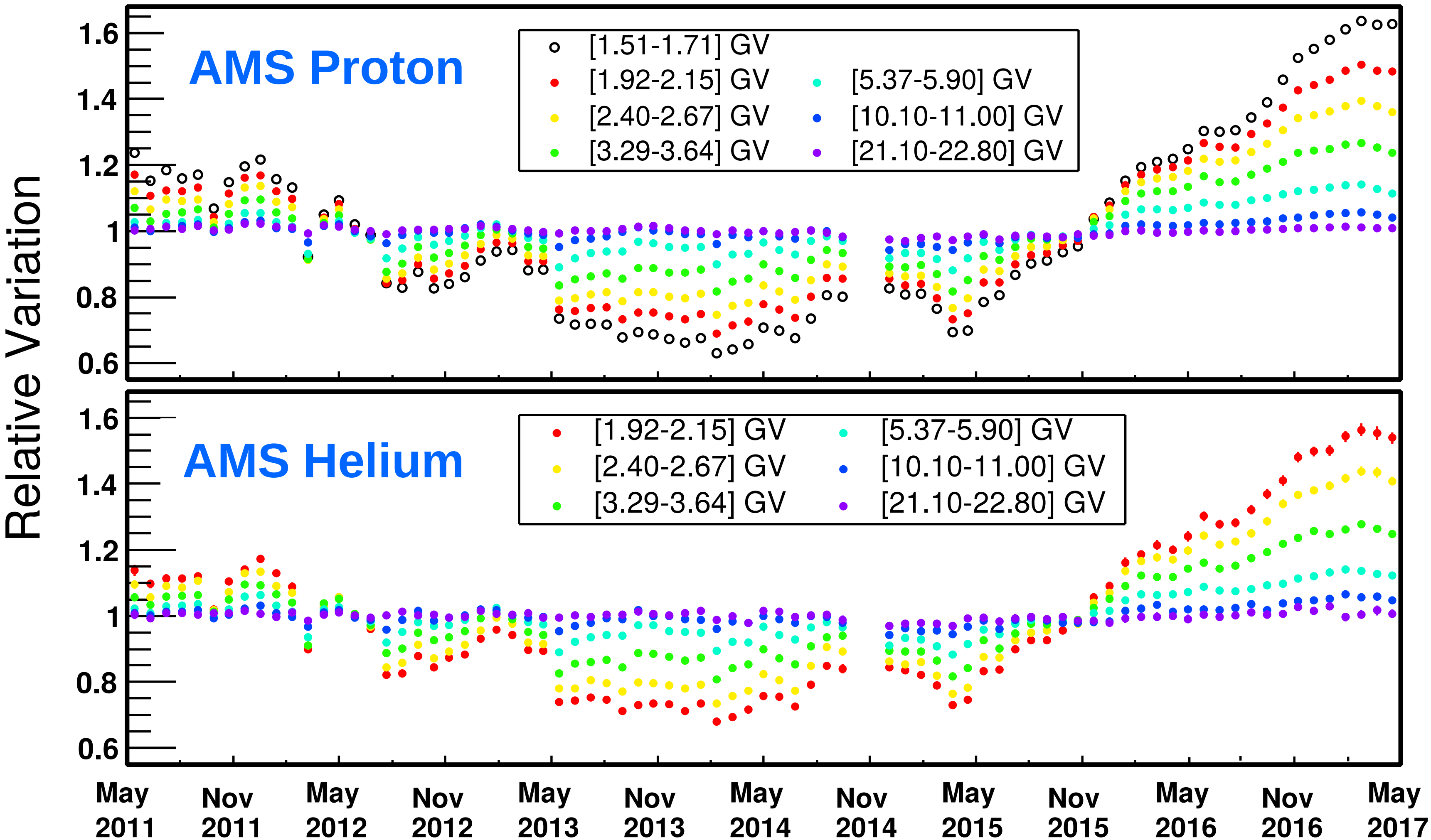


Helium



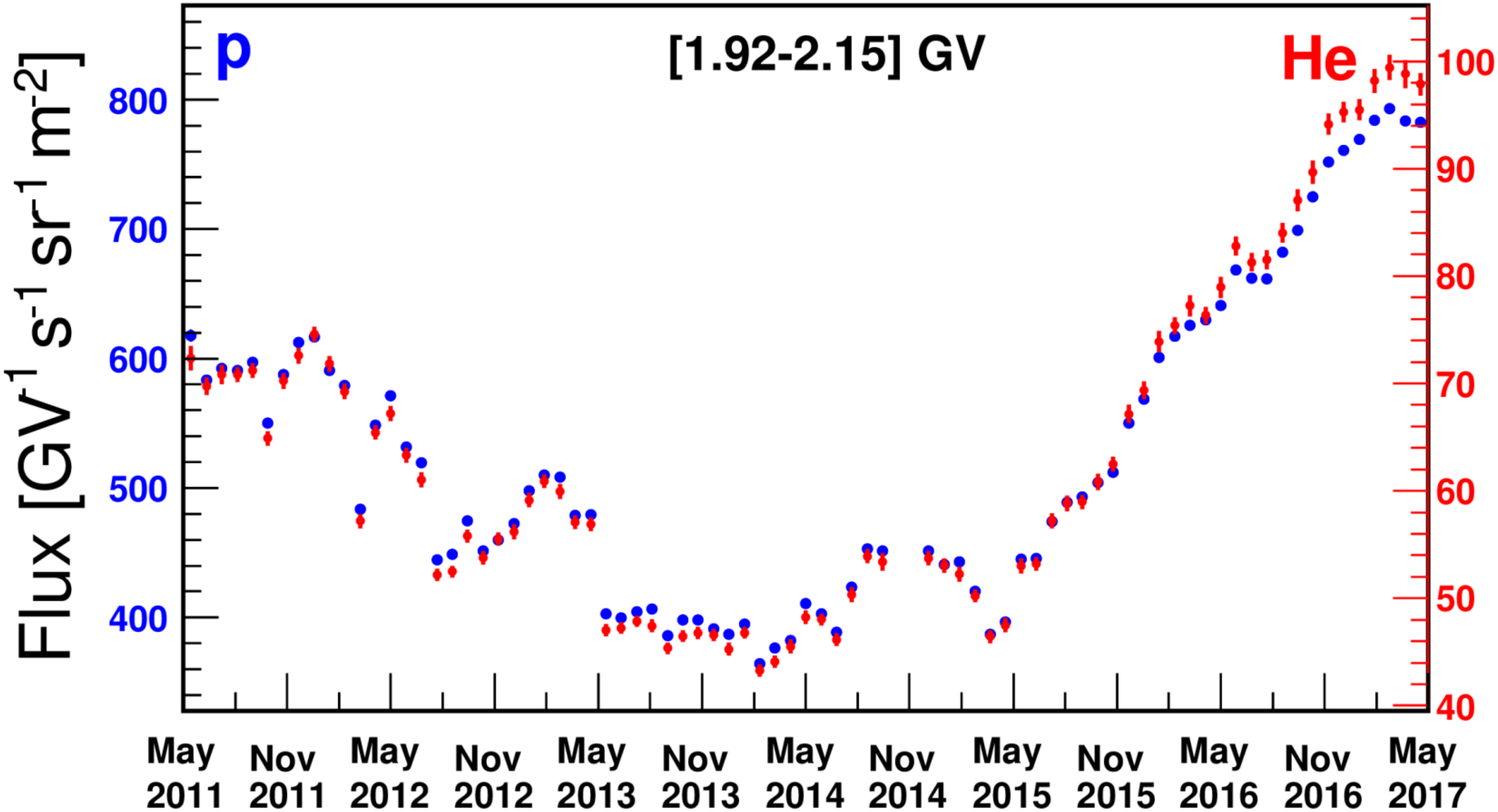


AMS Monthly Proton and Helium Fluxes (27 days, Bartels Rotation) Relative Variation



Both flux have a Minimum in February 2014

Proton and Helium flux have a fine time structure nearly identical in both time and relative amplitude



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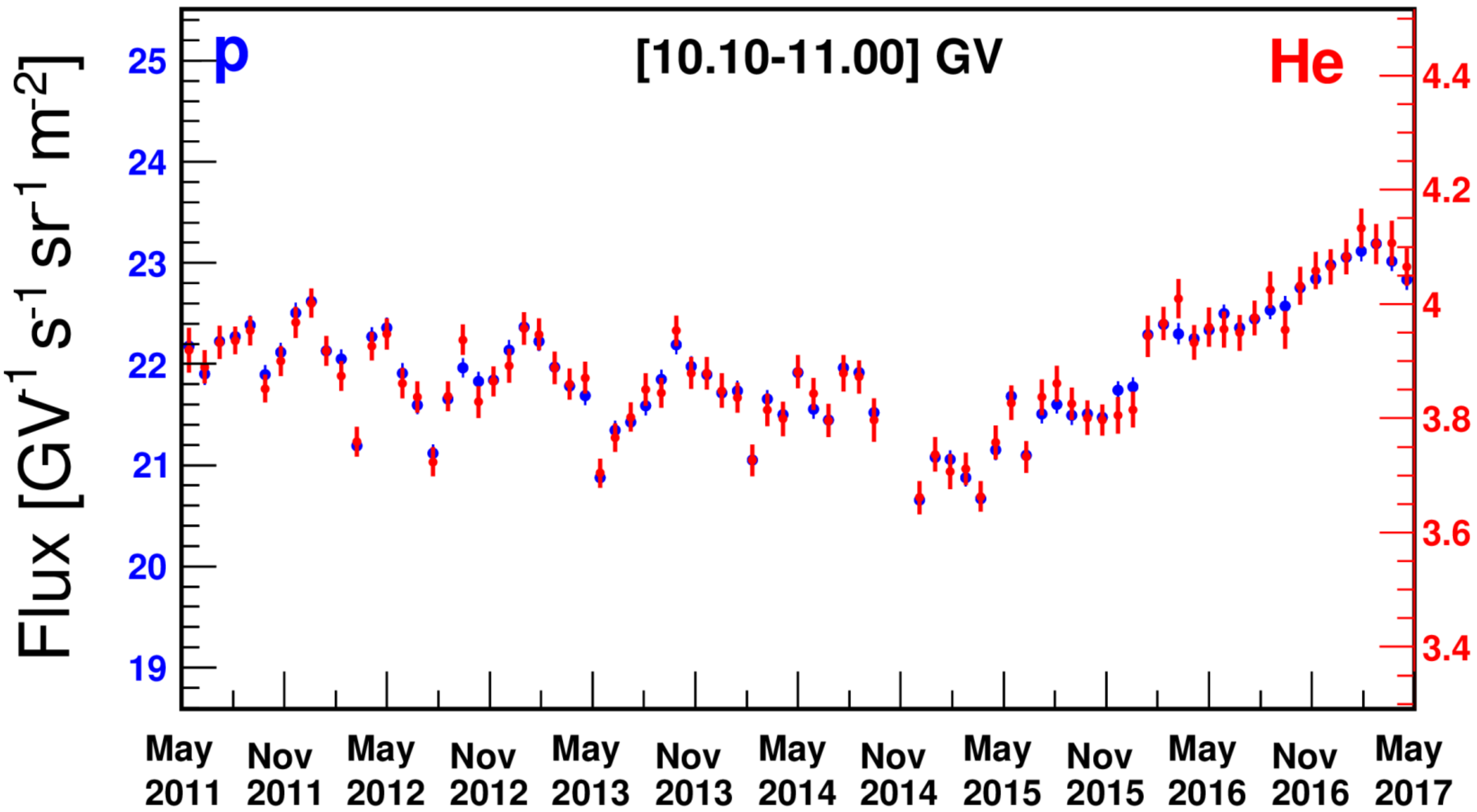
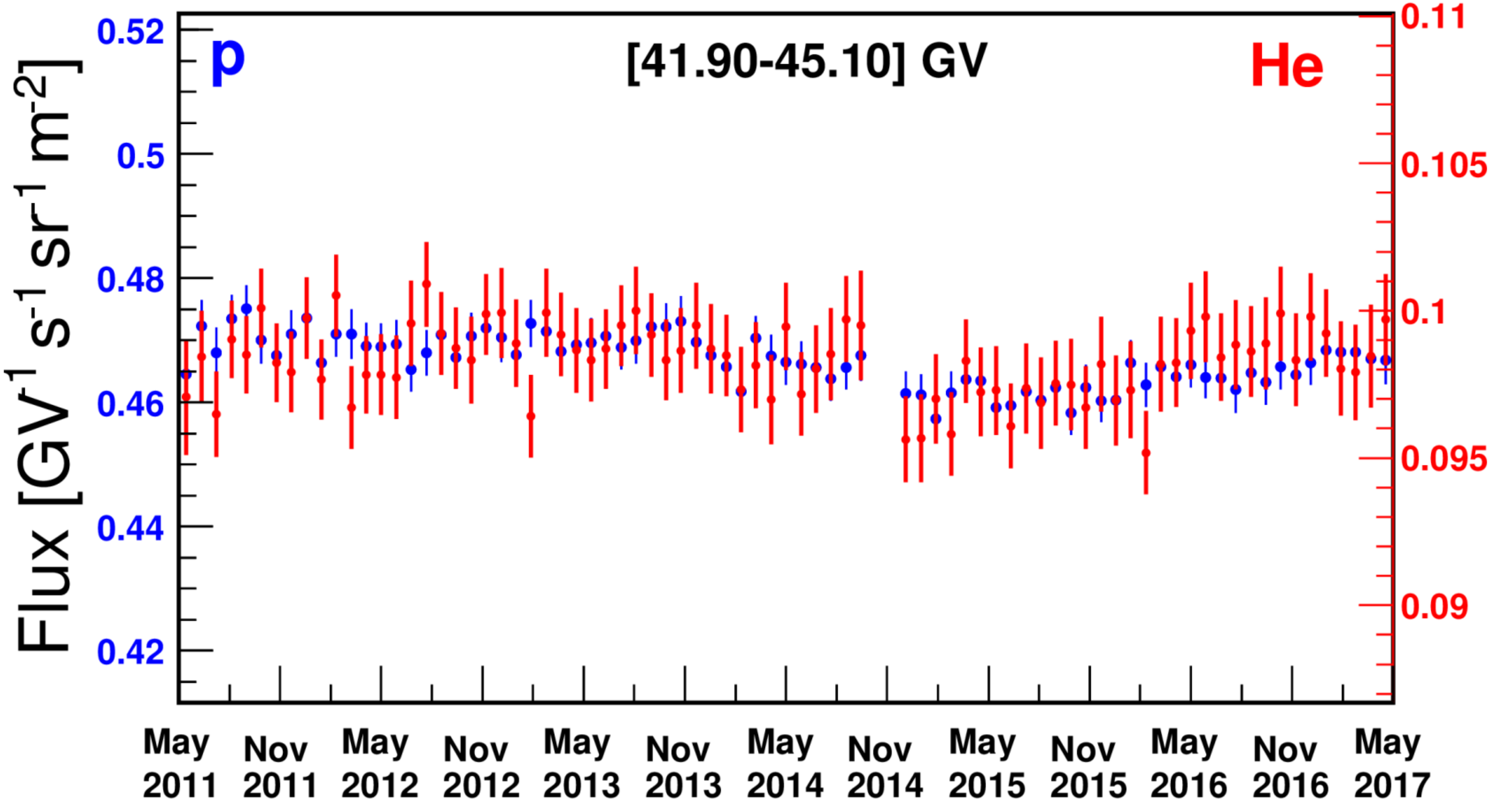
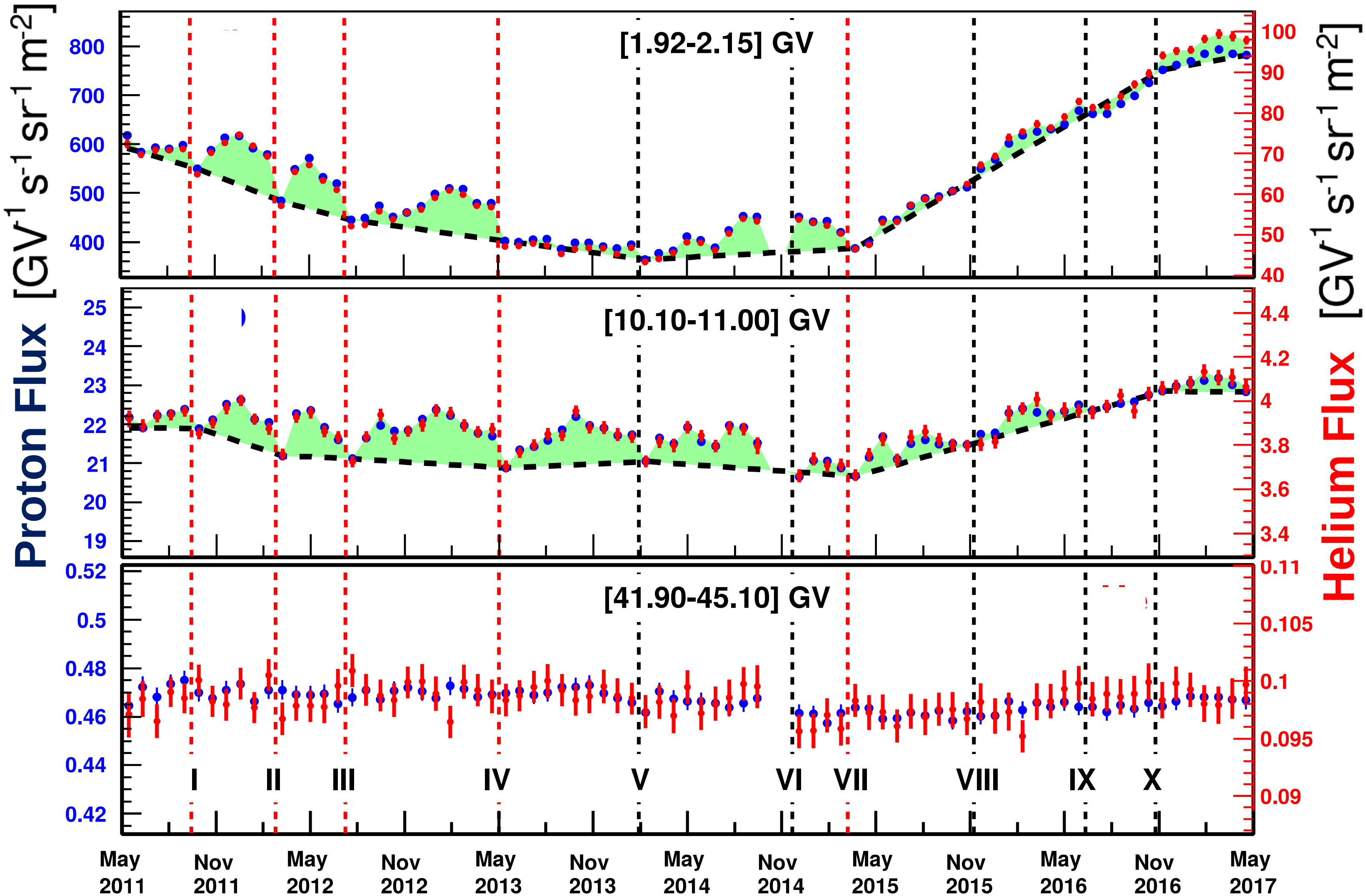


The amplitude of the structures decreases with increasing rigidity up to ~40 GV

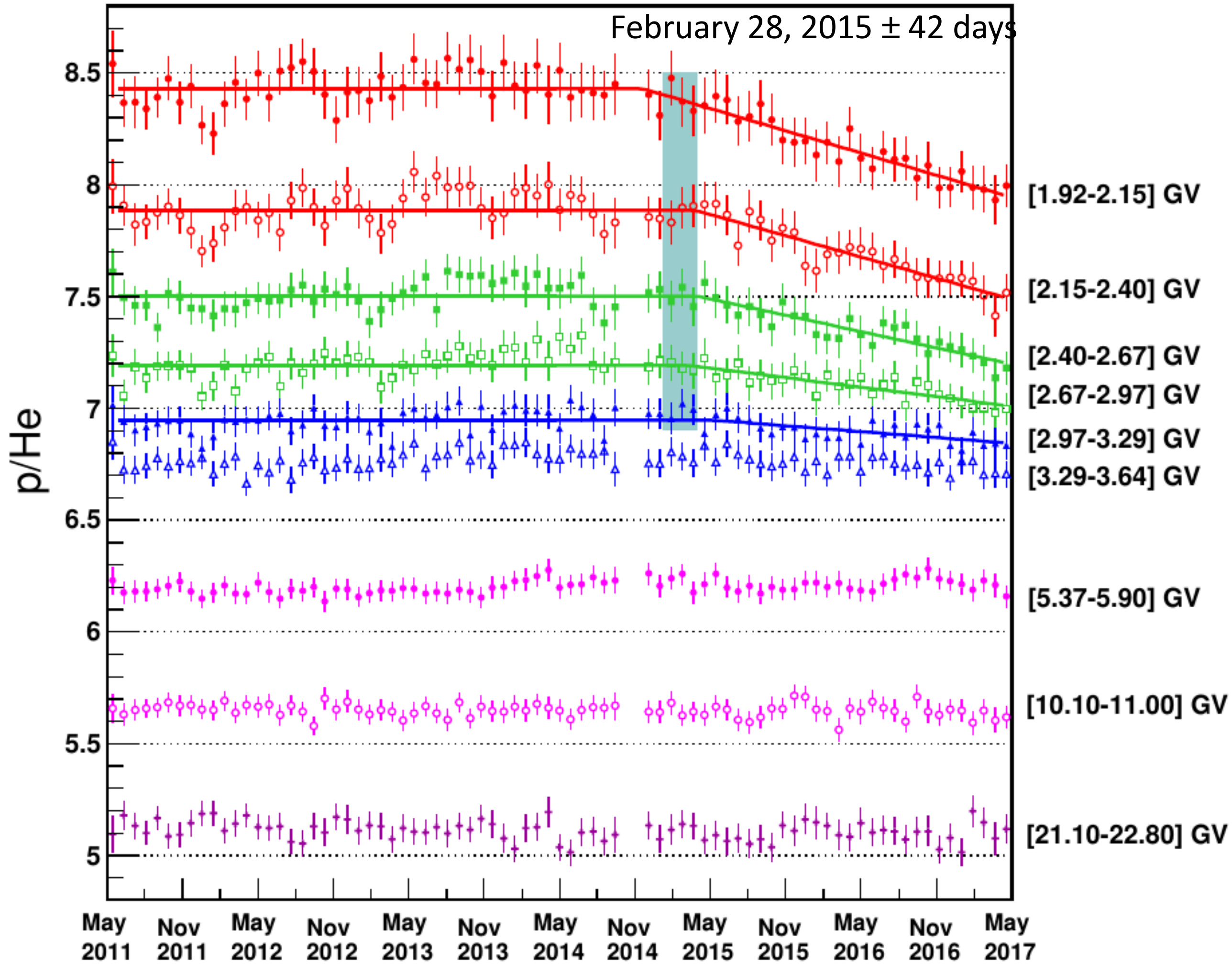




The **red vertical** dashed lines denote structures that have also been observed by AMS in the electron and positron fluxes.

Above 3 GV the p/He ratio is consistent with a constant value:

This shows the universality of the solar modulation of cosmic rays nuclei at relativistic energies

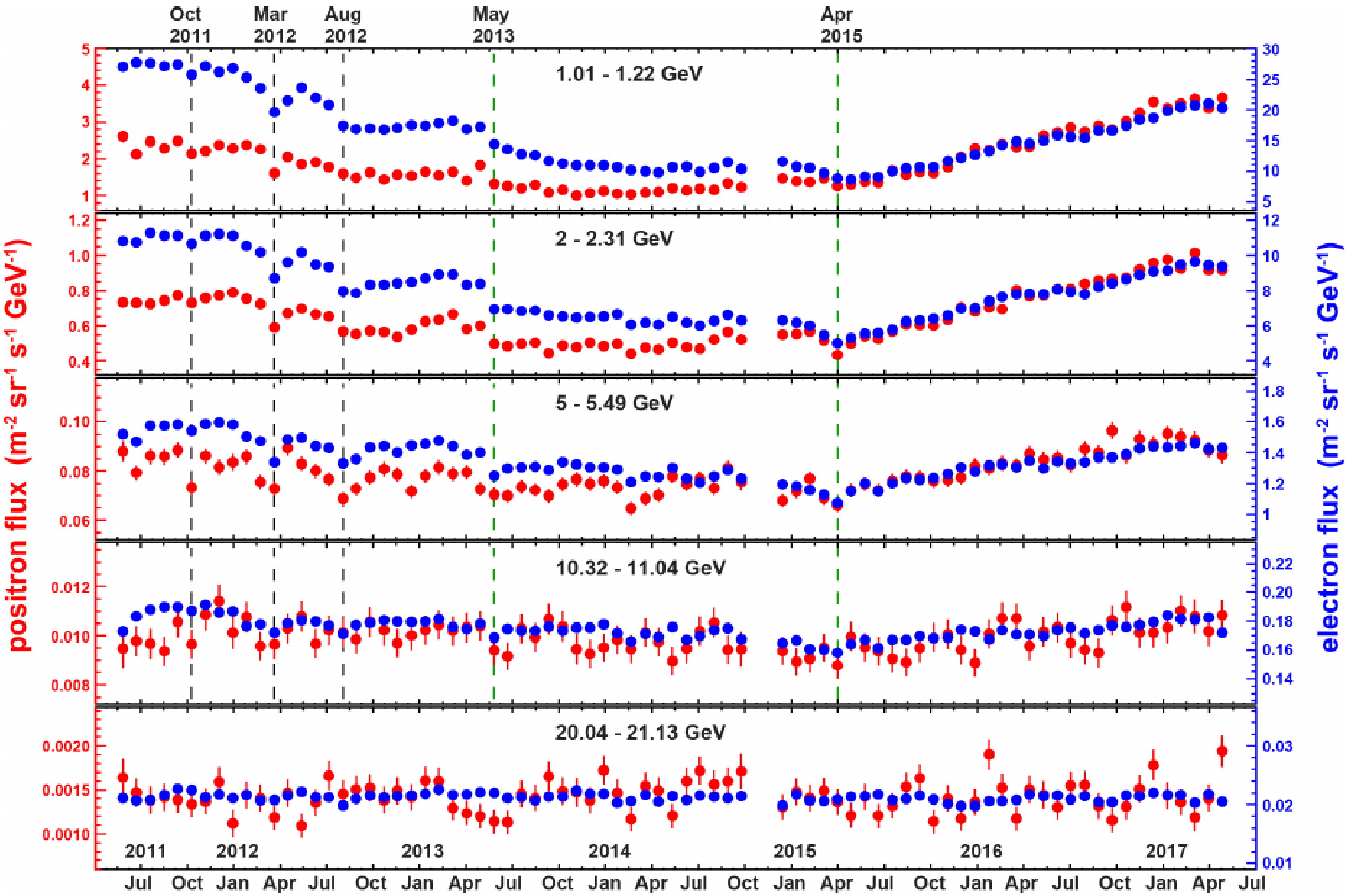


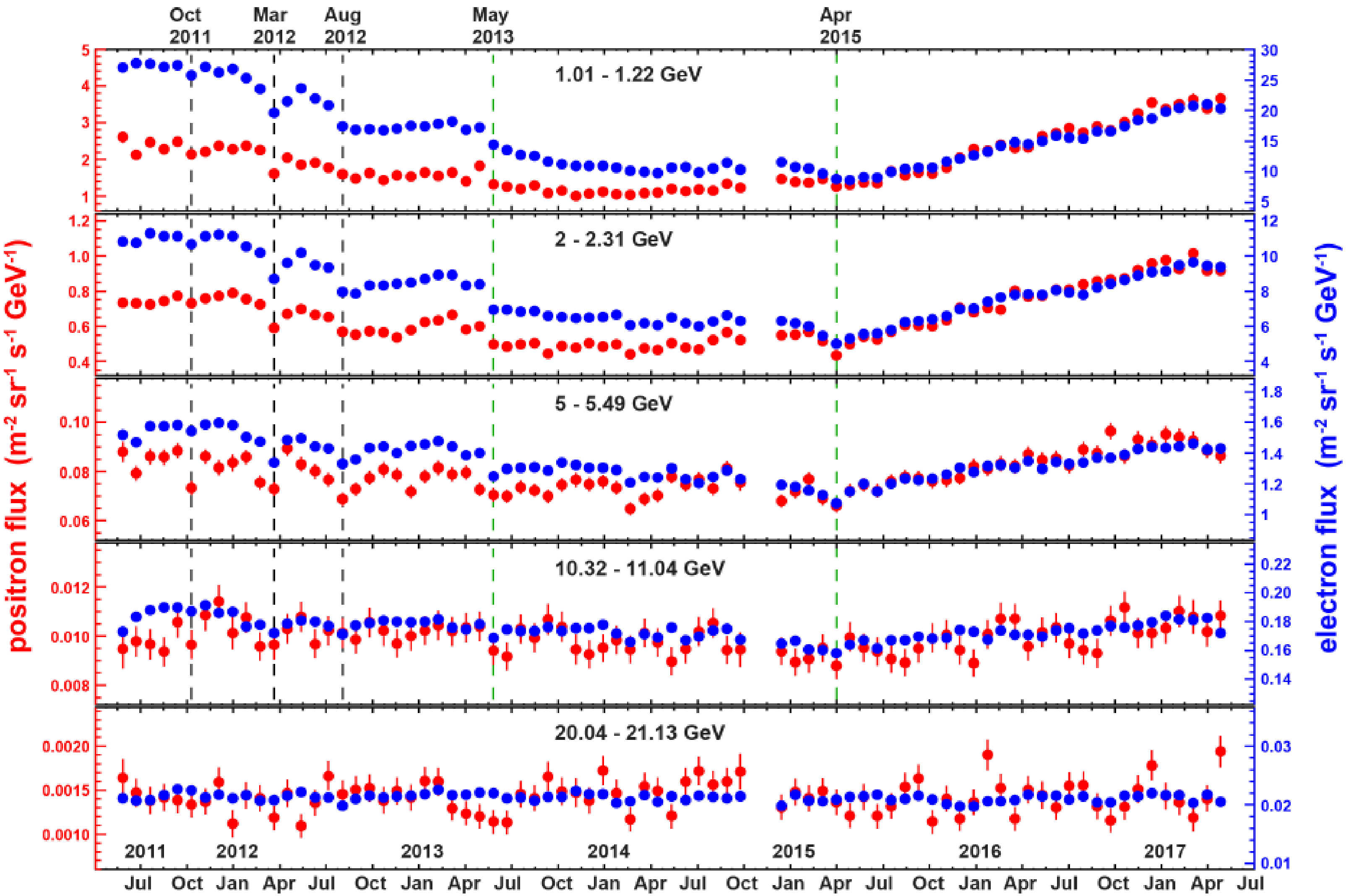
Below 3 GV the p/He flux ratio has a long-term decrease

- *Velocity dependence of the diffusion tensor;*
- *Differences in the local interstellar spectra of p and He.*
- *3He and 4He isotopic composition.*

AMS Electron and Positron Monthly Fluxes

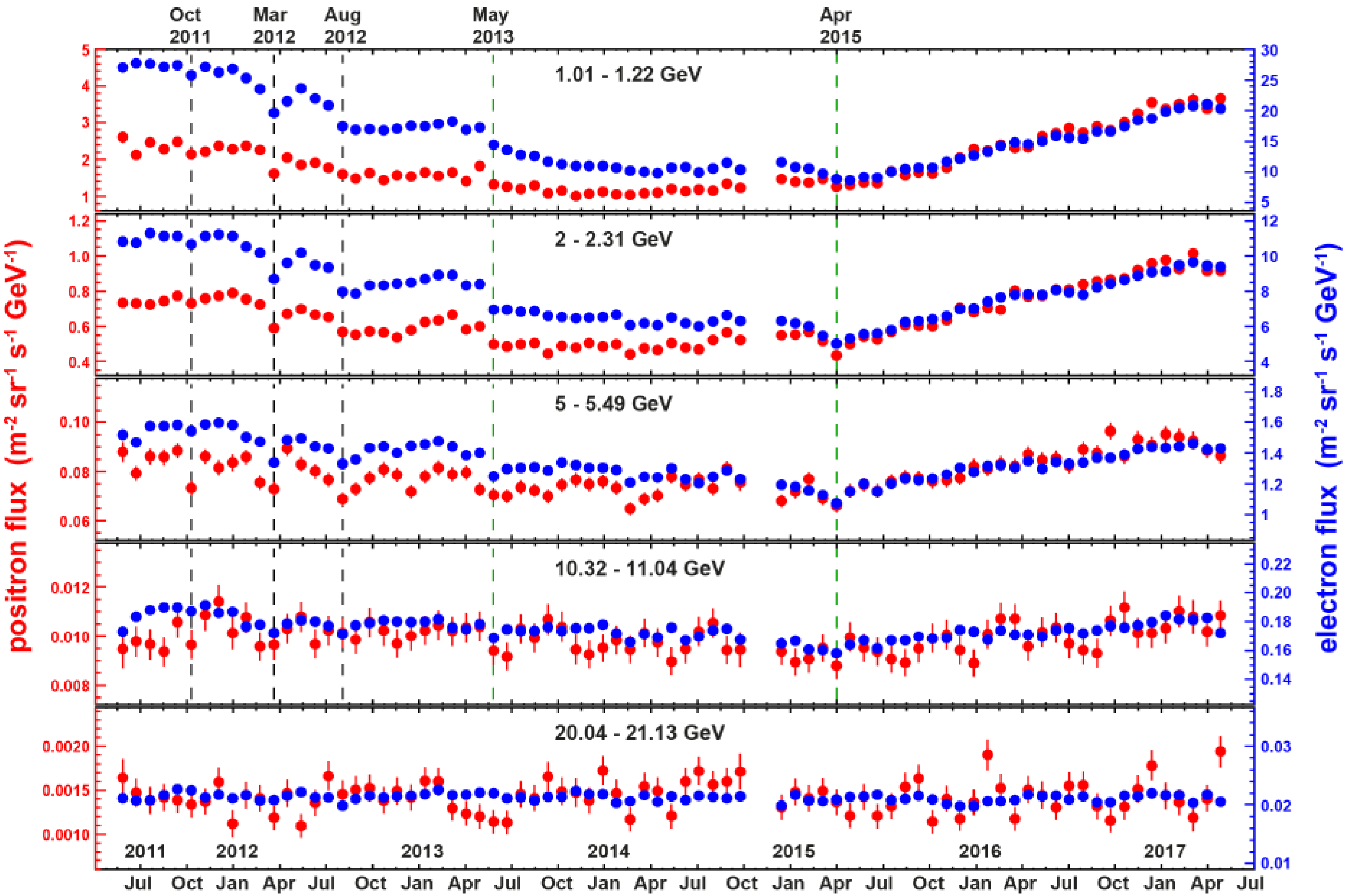
The charge-sign dependent modulation during solar maximum has been investigated with e+ and e-





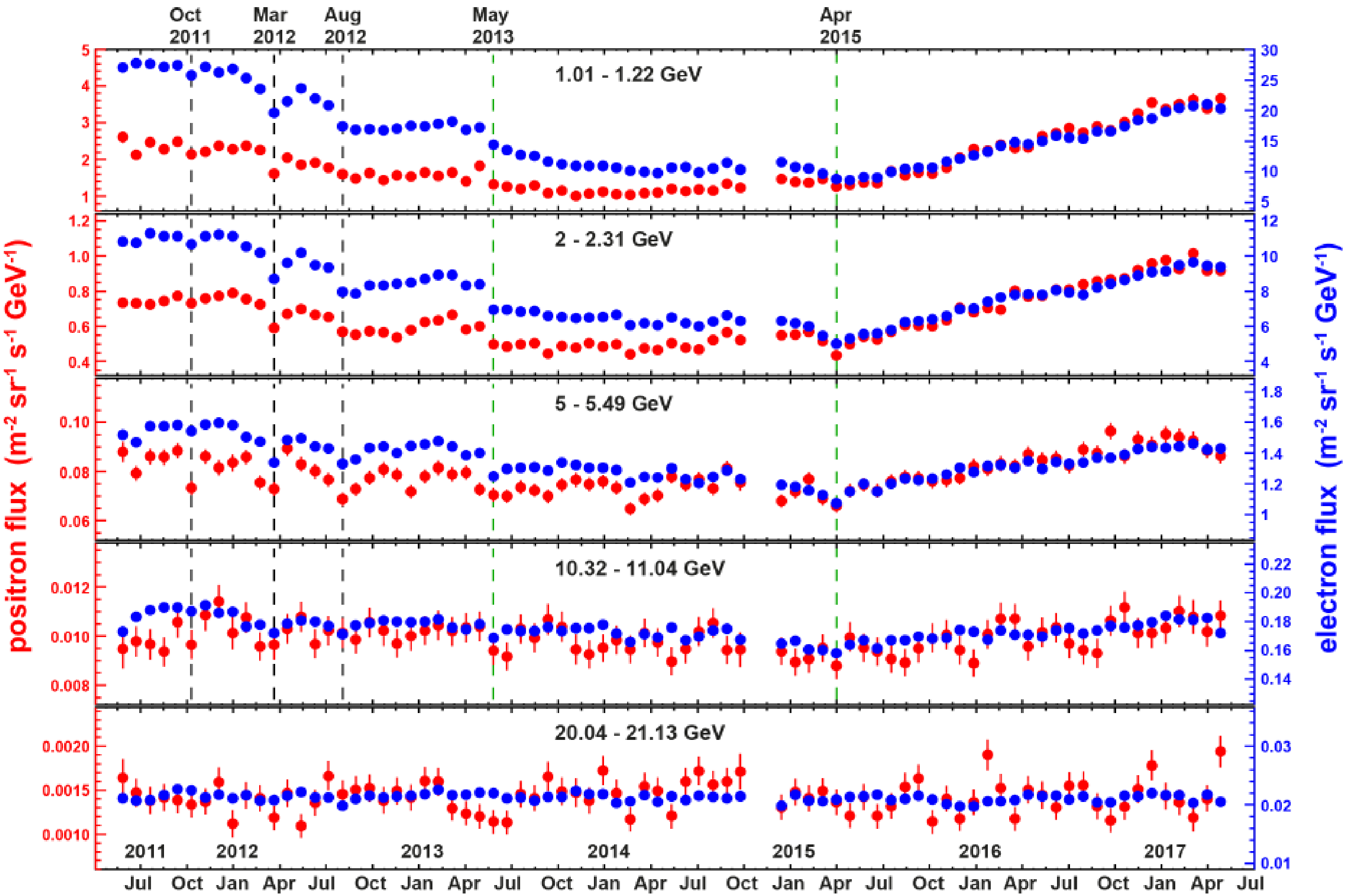
(I) At low energy: clear evolution of the fluxes with time, that gradually diminishes toward high energy.

At lowest energies the amplitude of e+, e- flux change by a factor 3.



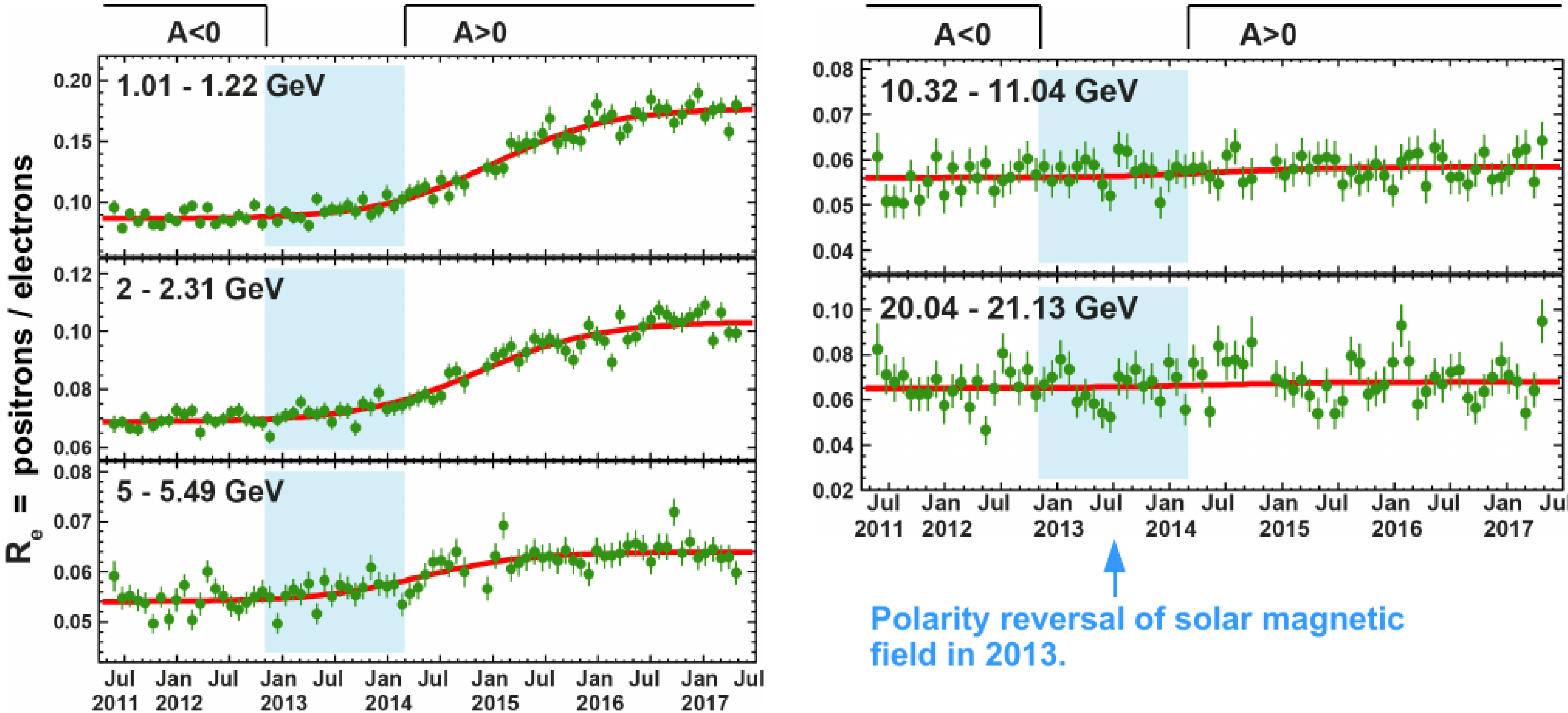
(II) Short term variation occurs simultaneously in both fluxes with approximatively the same relative variation.

Prominent and distinct time structures visible in both the positron spectrum and the electron spectrum and at different energies are marked by dashed vertical lines

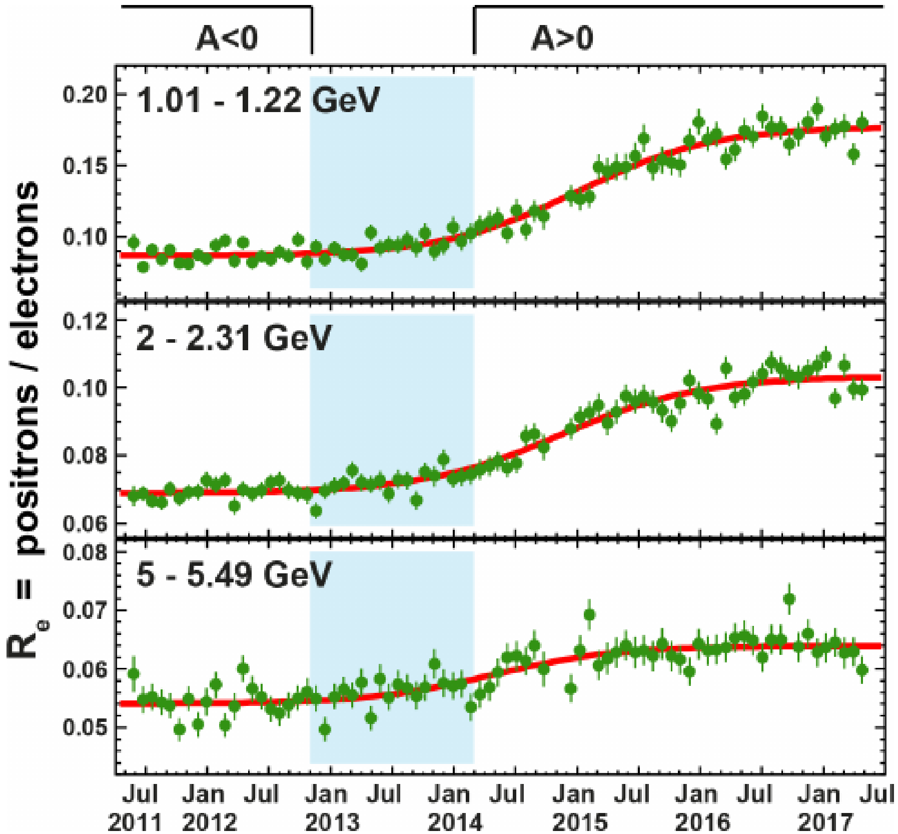


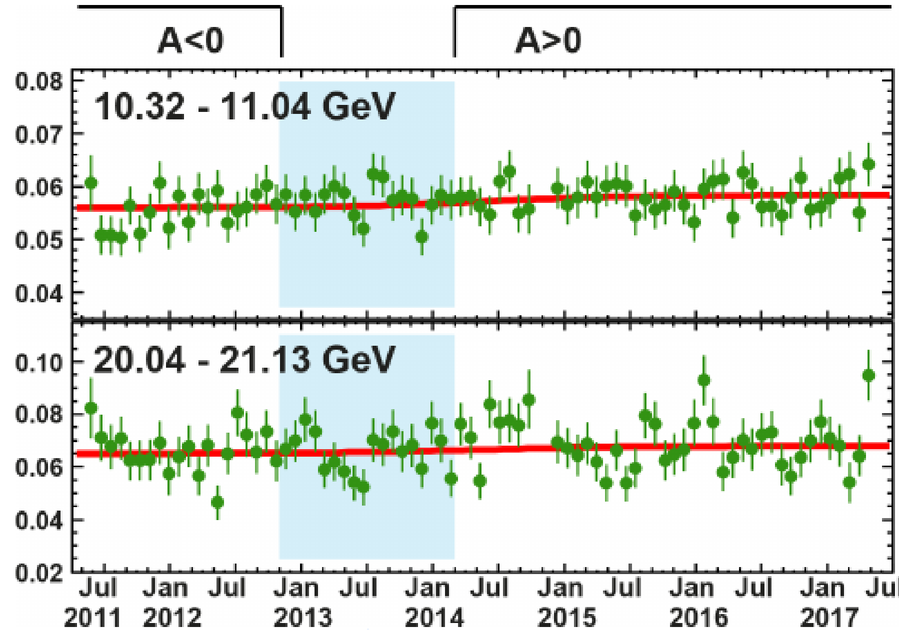
(III) The long-term time structure shown that the changes in relative amplitude are different for electrons and positrons.

In the e+/e-, the short-term prominent and distinct structures in the flux largely cancel and a clear long-term trend appears.



The Time variation of e+/e- is a clear evidence of charge-sign dependent solar modulation.



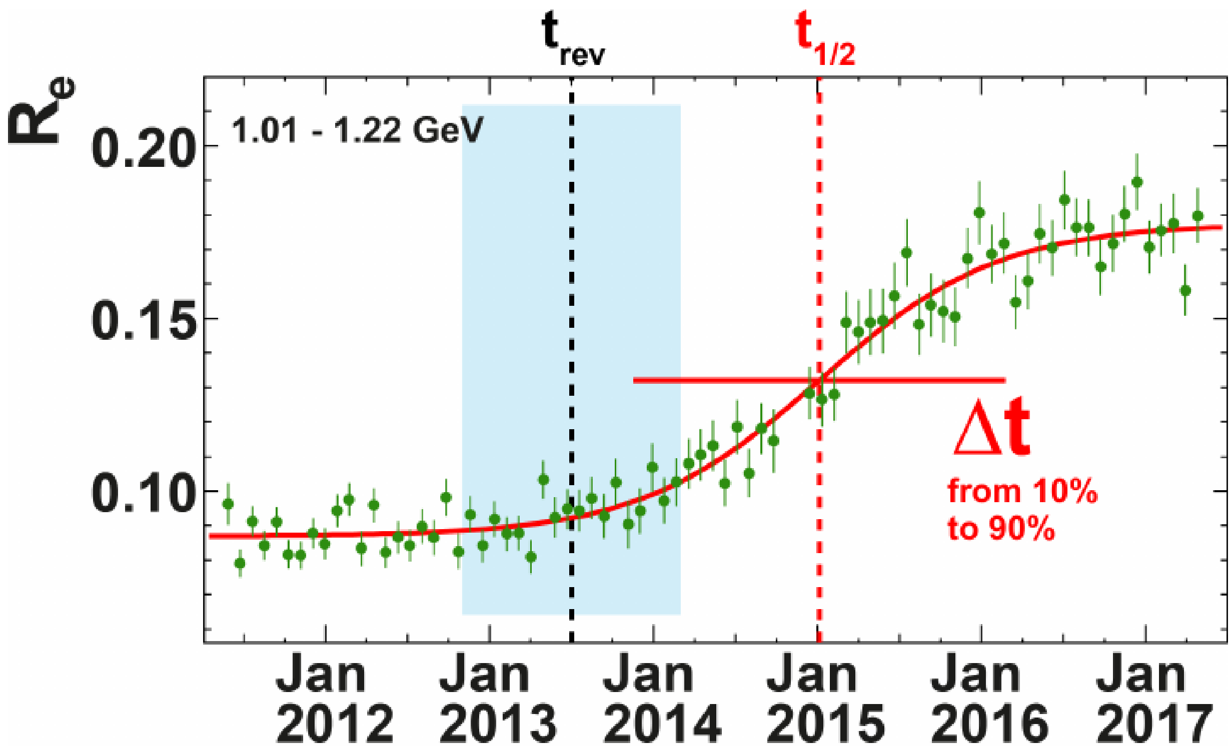


Polarity reversal of solar magnetic field in 2013.

The ratio exhibits a smooth transition over 830 ± 30 days from one value to another.

This is in qualitative agreement with the expectation from solar modulation models including drift effects

We adopted a model independent approach to study the transition in $R_e = e^+/e^-$



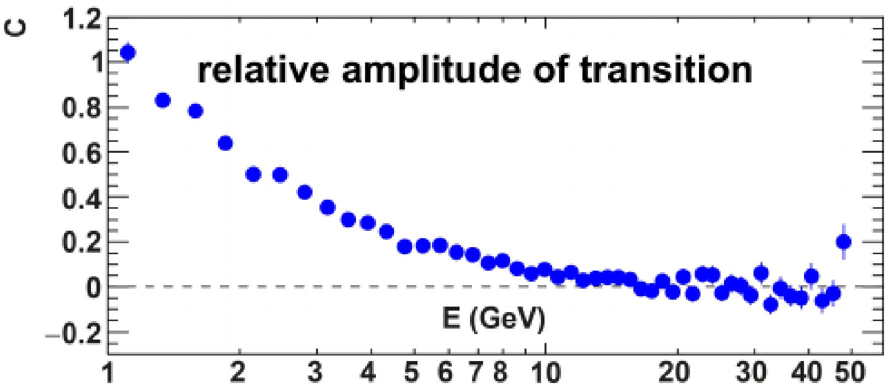
$$R_e(t, E) = R_0(E)\left[1 + \frac{C(E)}{\exp\left(-\frac{t - t_{1/2}(E)}{\Delta t(E)/\Delta_{80}}\right) + 1}\right]$$

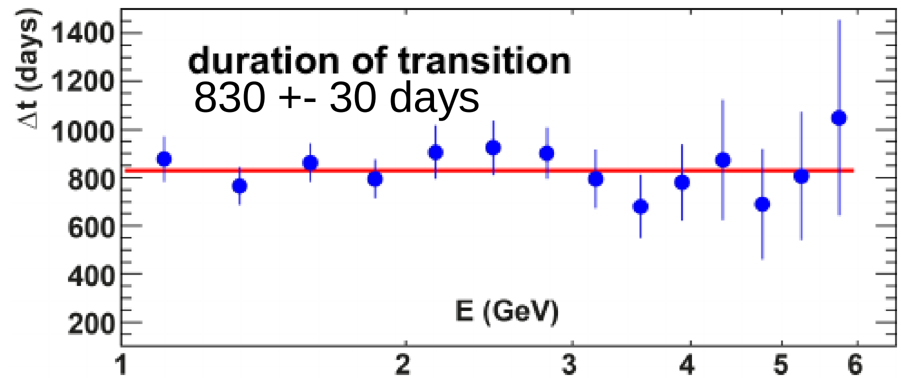
relative amplitude of transition

duration of transition

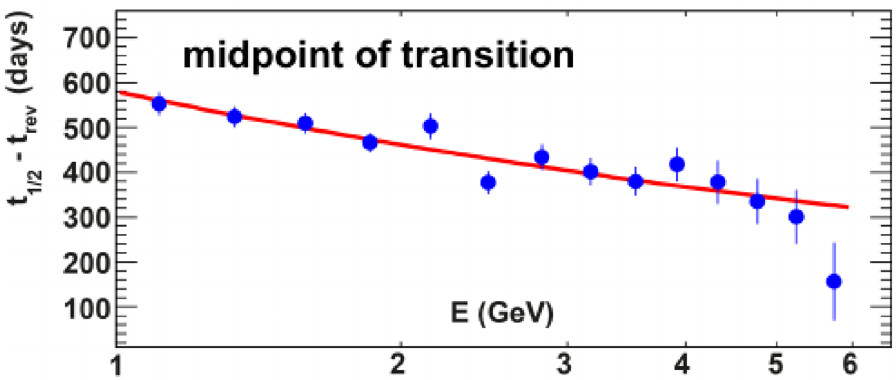
midpoint of transition

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





Midpoint of transition changes by (260 ± 30) days from 1 to 6 GeV.



We found an unexpected energy dependence of midpoint of transition that reflects the different response of cosmic-rays to changing modulation conditions

Conclusions

- AMS p, He, e+,e- monthly fluxes were measured during the ascending phase of solar cycle 24 through its maximum and toward its minimum. These high-statistics, precision data provide accurate input to the understanding of solar modulation.
- The High AMS precision, enable us to observe fine time structures in the p, He, e+ and e- fluxes for both long and short time scale phenomena.
- Prominent and distinct time structures are visible in p, He, e+ and e- spectra and at different energies.
- In the e+/e- and p/He, the short-term prominent and distinct structures in the flux largely cancel and a clear long-term trend appears.
- Above 3 GV the p/He flux ratio is time independent. This shows the universality of the solar modulation of cosmic rays nuclei at relativistic energies. Below 3 GV the p/He flux ratio has a long-term decrease.
- The Time variation of e+/e- is a clear evidence of charge-sign dependent solar modulation.

Thanks for your attention