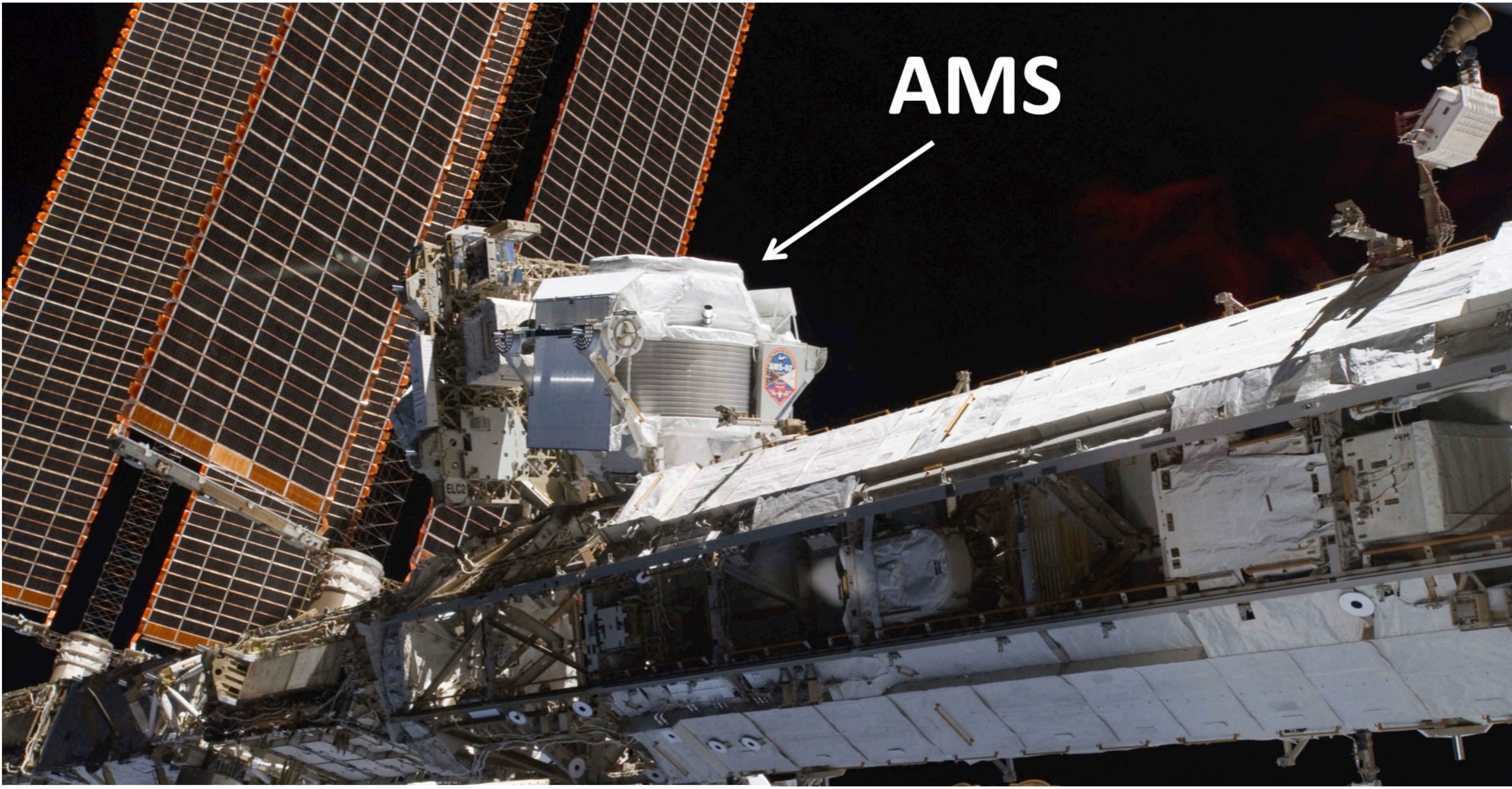
OBSERVATION OF COMPLEX TIME STRUCTURES IN THE COSMIC-RAY ELECTRON AND POSITRON FLUXES WITH AMS



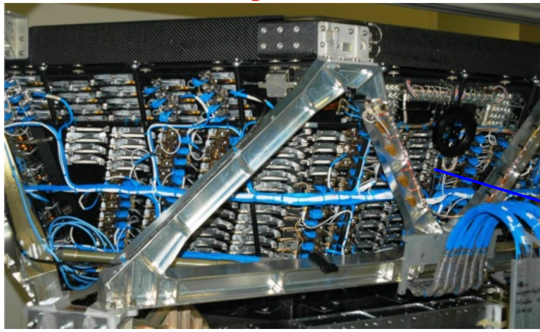
S. Schael, RWTH Aachen University
on behalf of the AMS Collaboration

AMS: A TeV precision, multipurpose spectrometer

Particles and nuclei are defined by their charge (Z) and energy (E ~ P)

TRD

Identify e^+, e^-

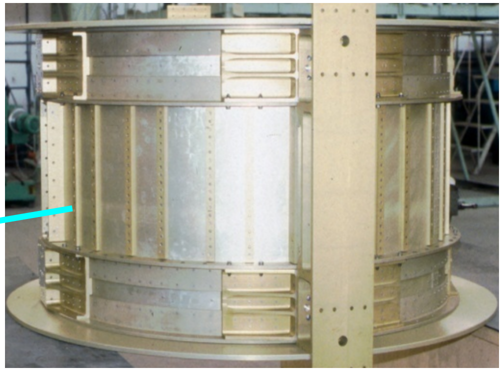


TOF

Z, E

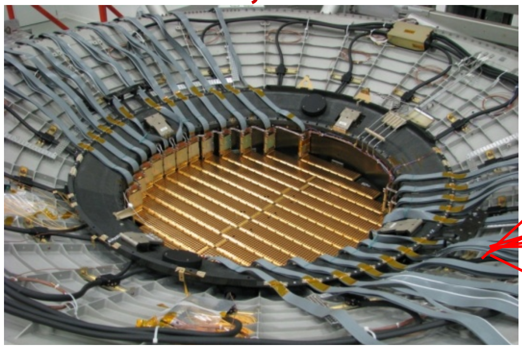
Magnet

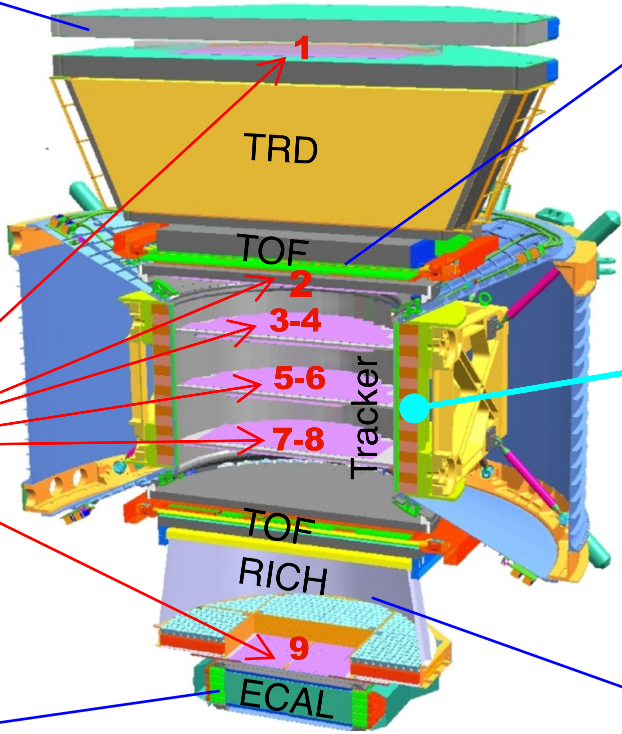
±Z



Silicon Tracker

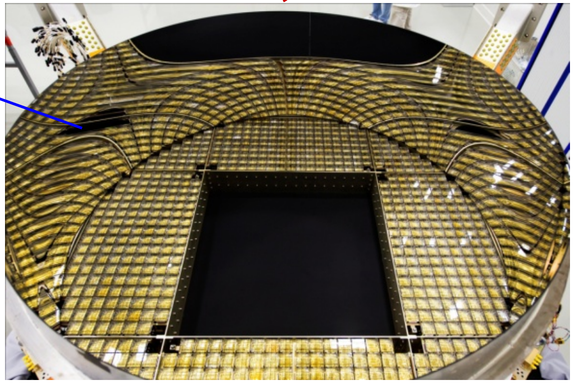
Z, P





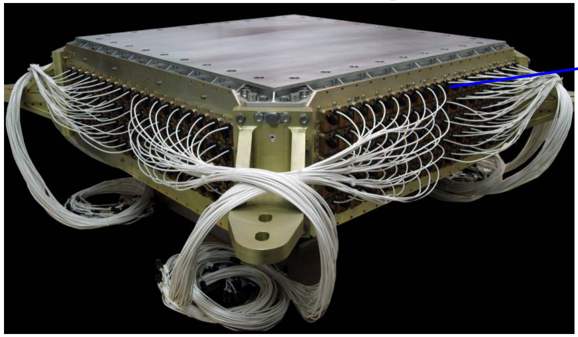
RICH

Z, E



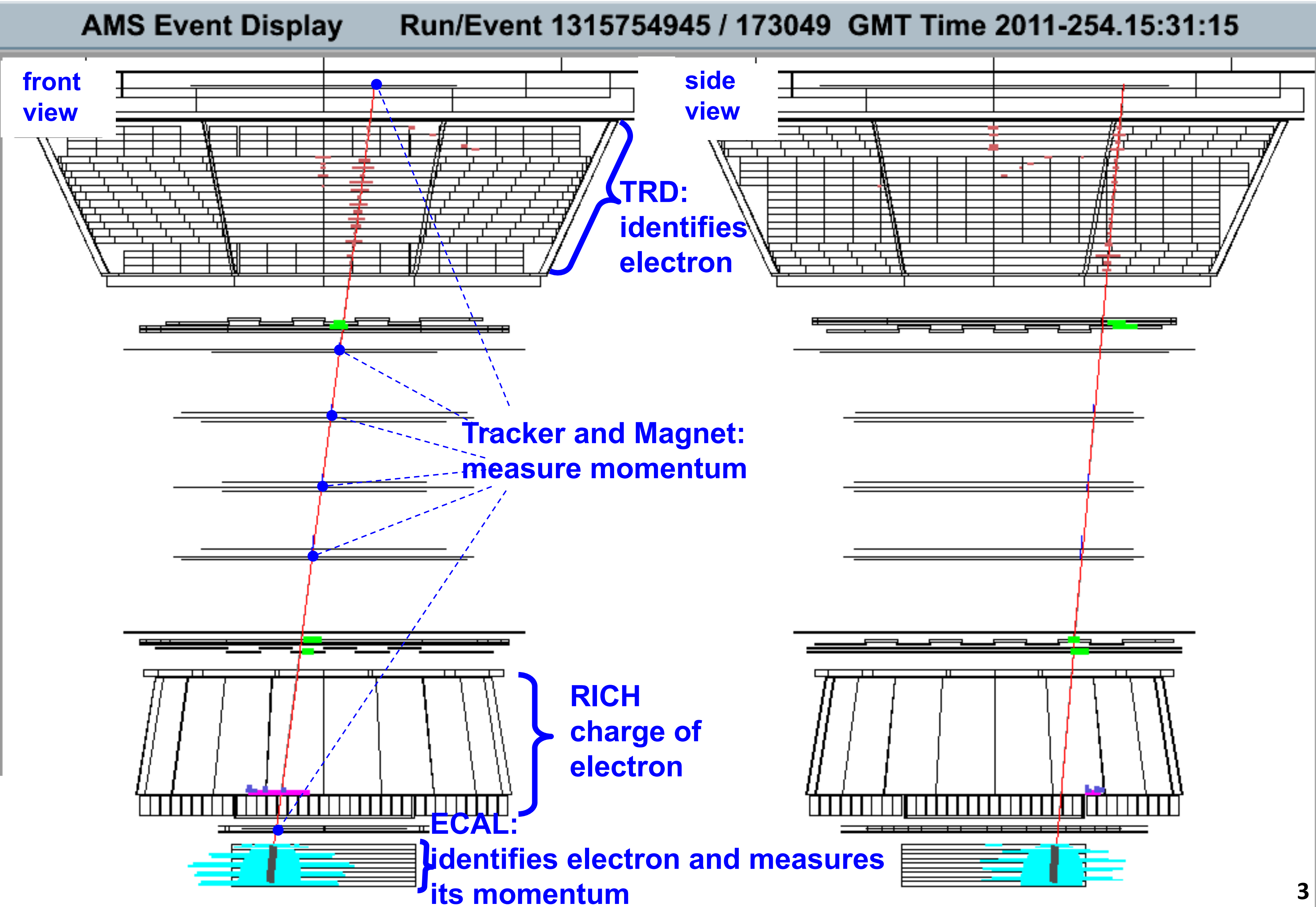
ECAL

E of e^+, e^-, γ



Z, P are measured independently by the Tracker, RICH, TOF and ECAL

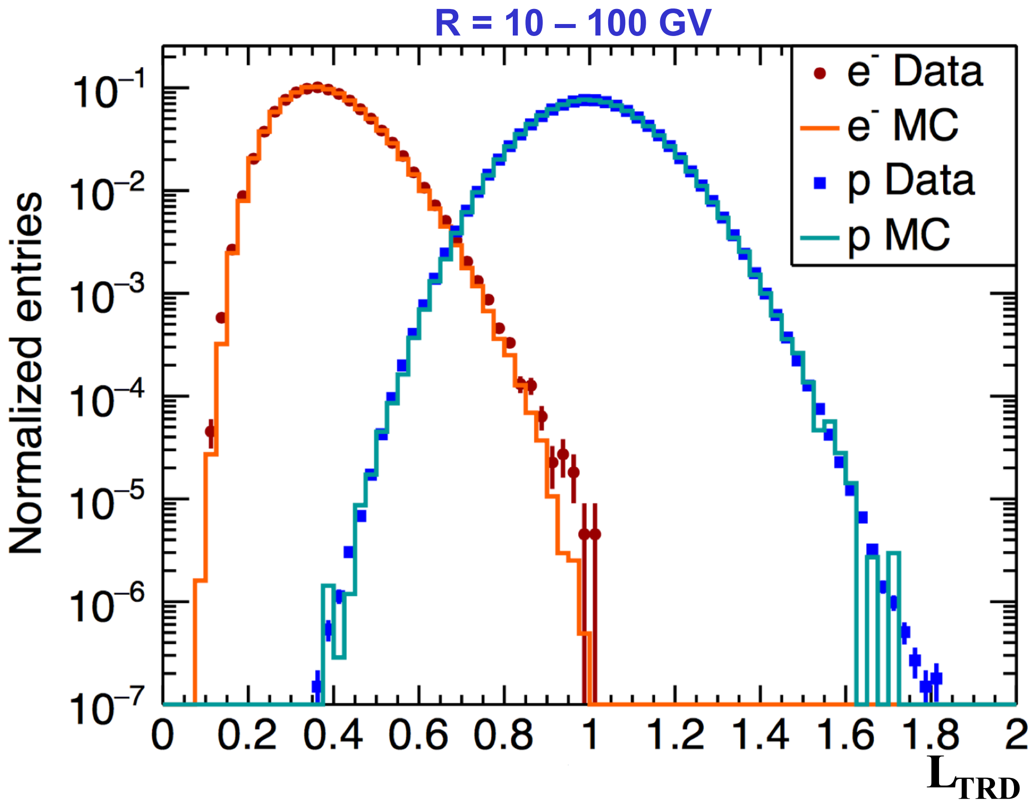
1.03 TeV electron

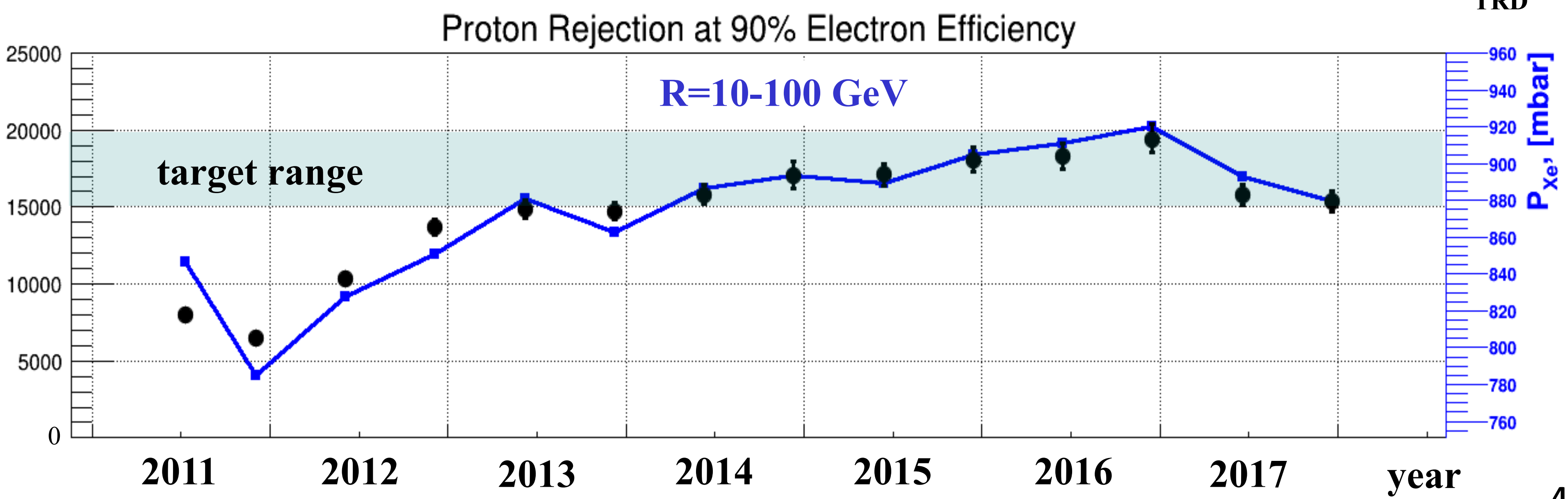


Time Stability of the TRD Particle Identification

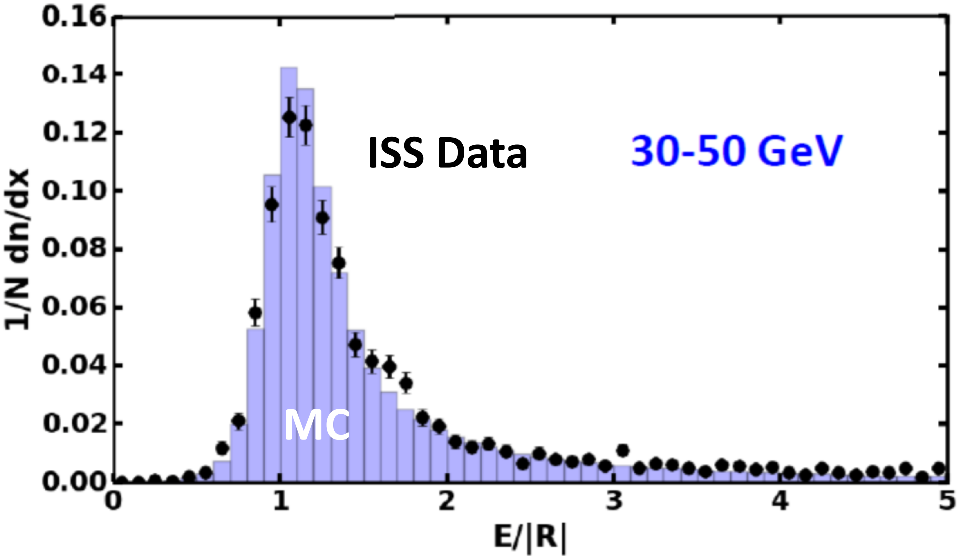
$$L_{e,p} = \sqrt[n]{\prod_i^n p_{e,p}(dE_i/dx_i)}$$

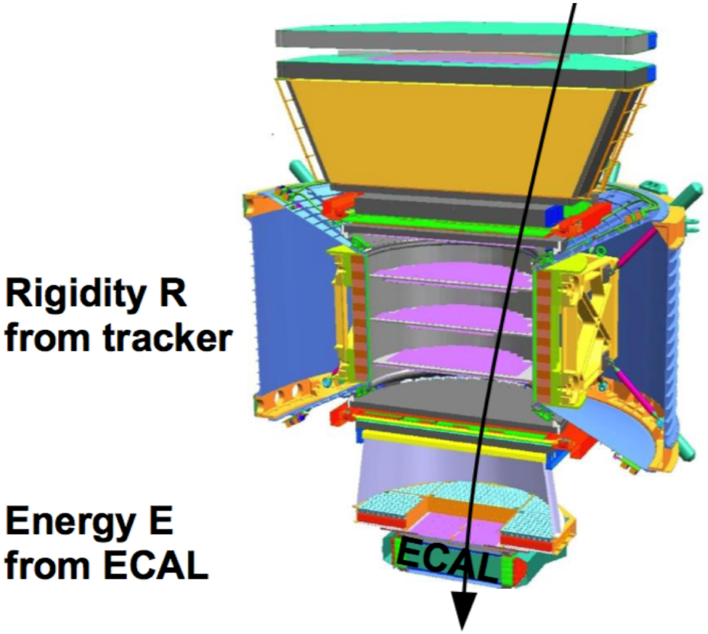
$$L_{\mathrm{TRD}} = -\log \frac{L_e}{L_e + L_p}$$

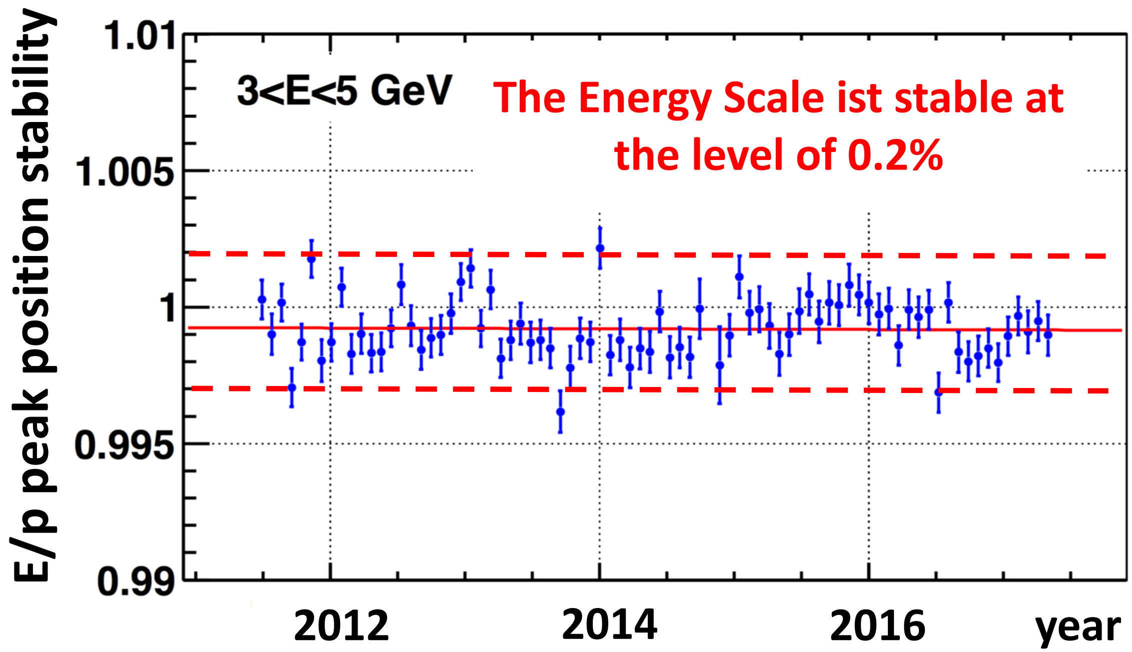




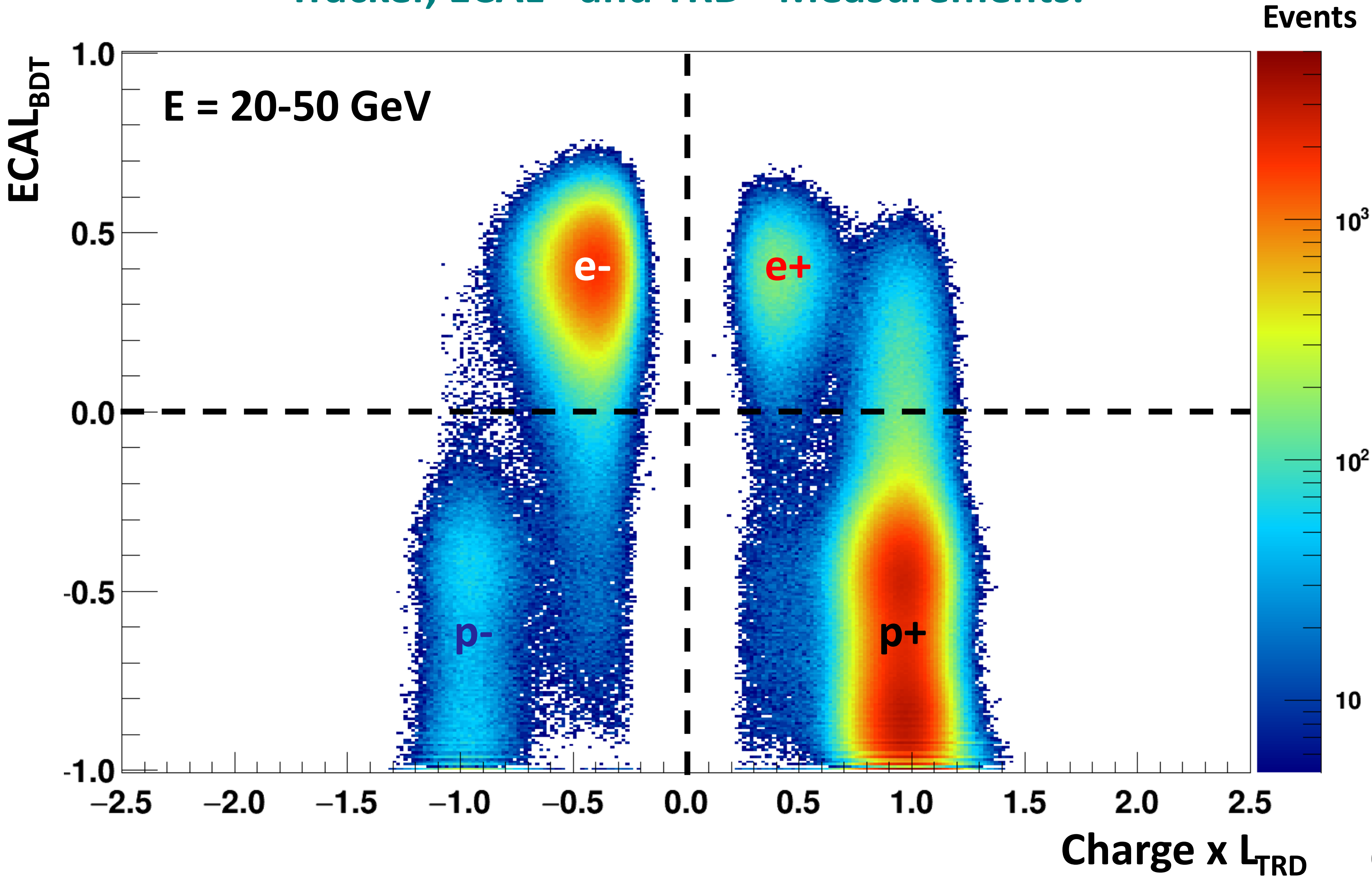
Time Stability of the AMS Energy Scale



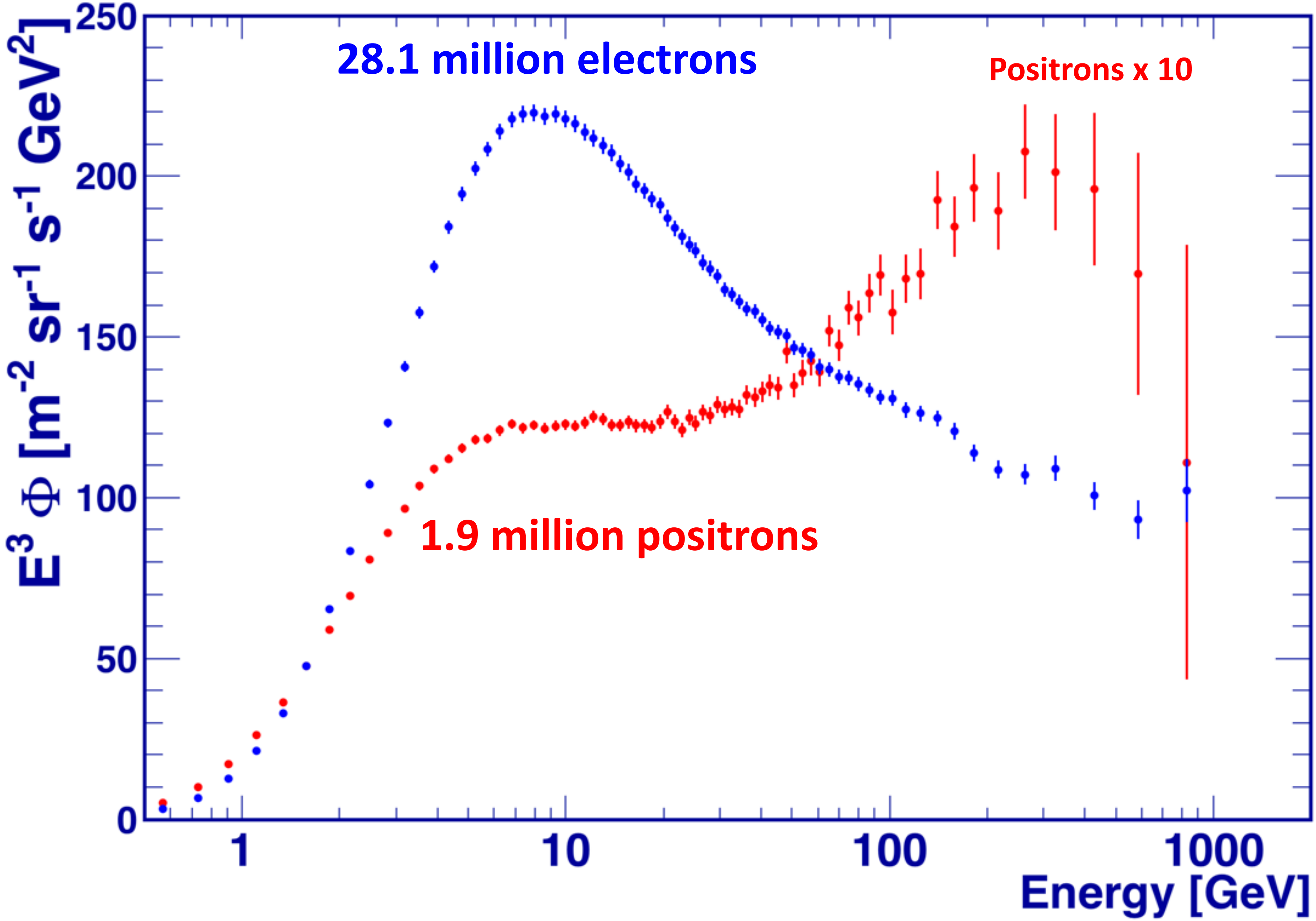




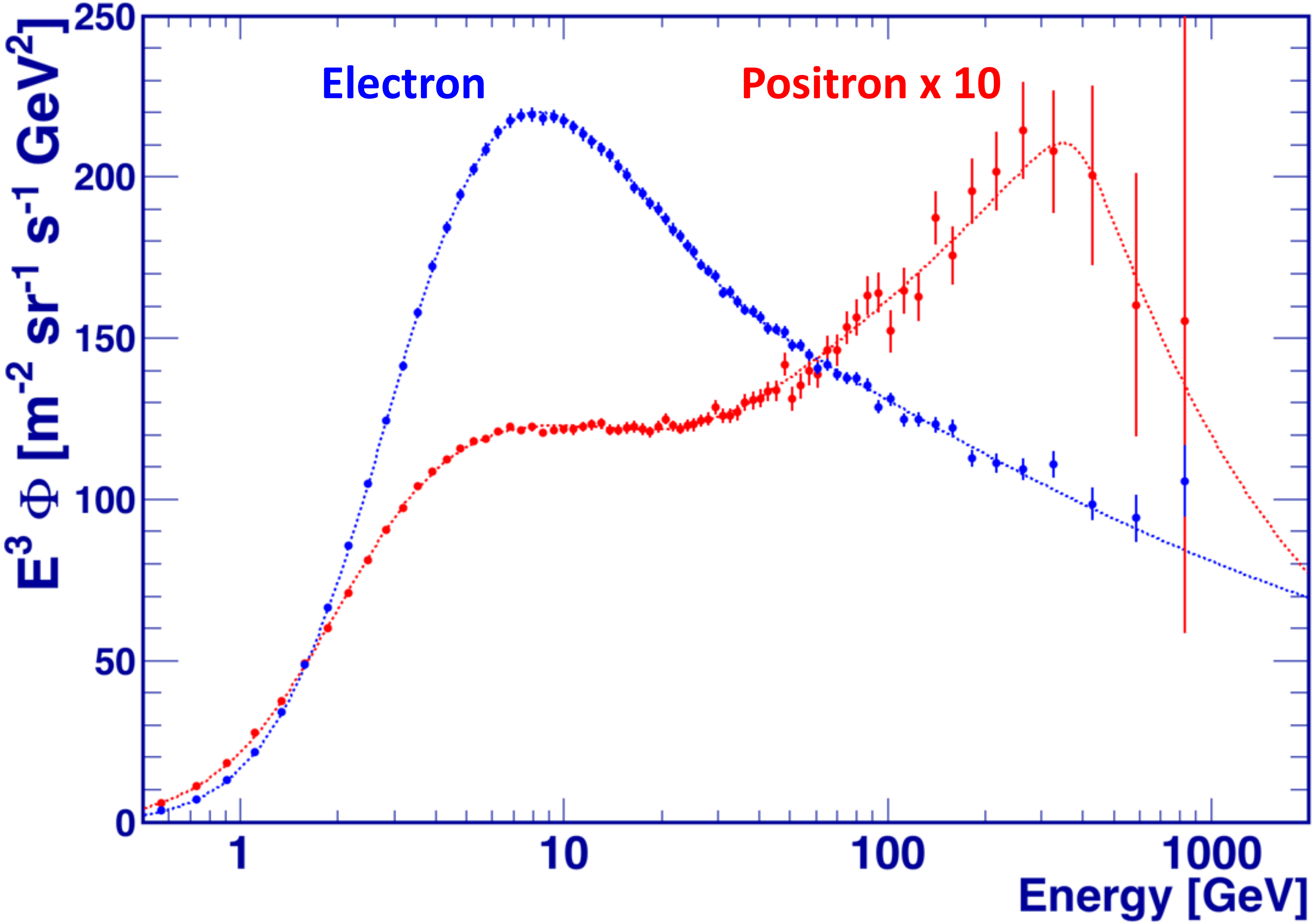
Due to its magnetic spectrometer AMS can accurately identify four components combining the Tracker, ECAL - and TRD - Measurements.



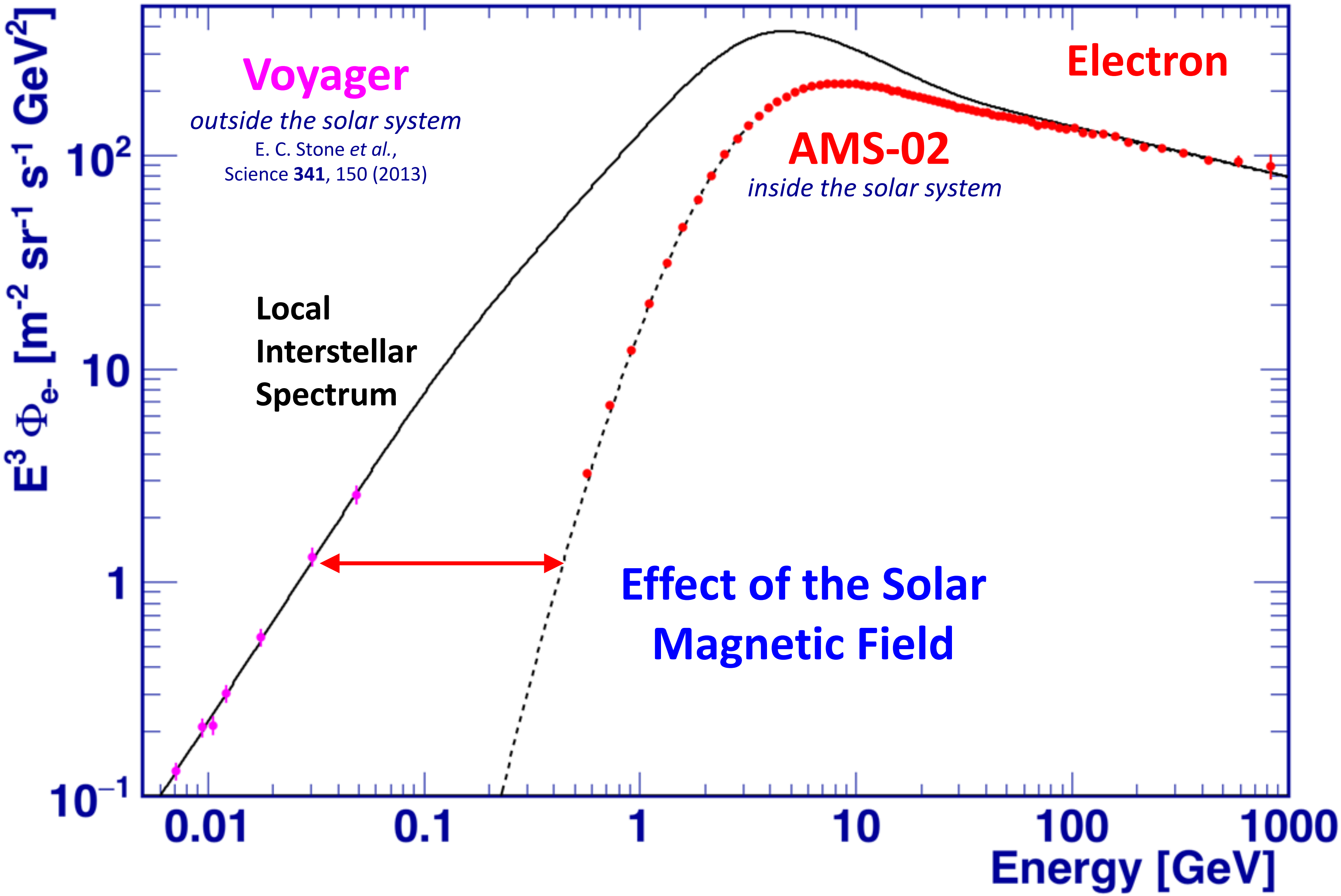
Latest AMS results on positron and electron fluxes



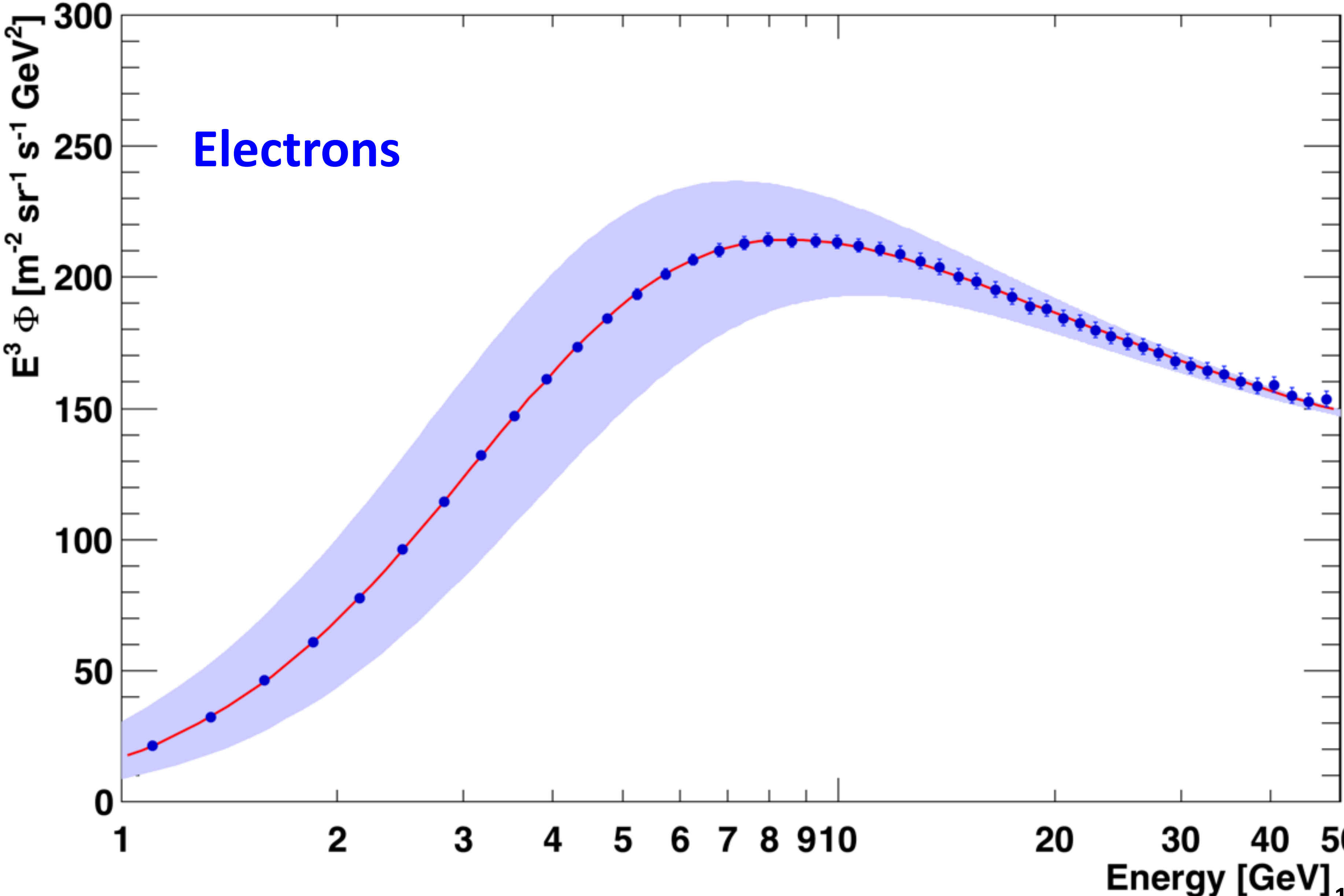
Both the electron and the positron flux can be described by power laws $\phi(E) = C \cdot E^{\gamma(E)}$ with energy dependent spectral index $\gamma(E)$.



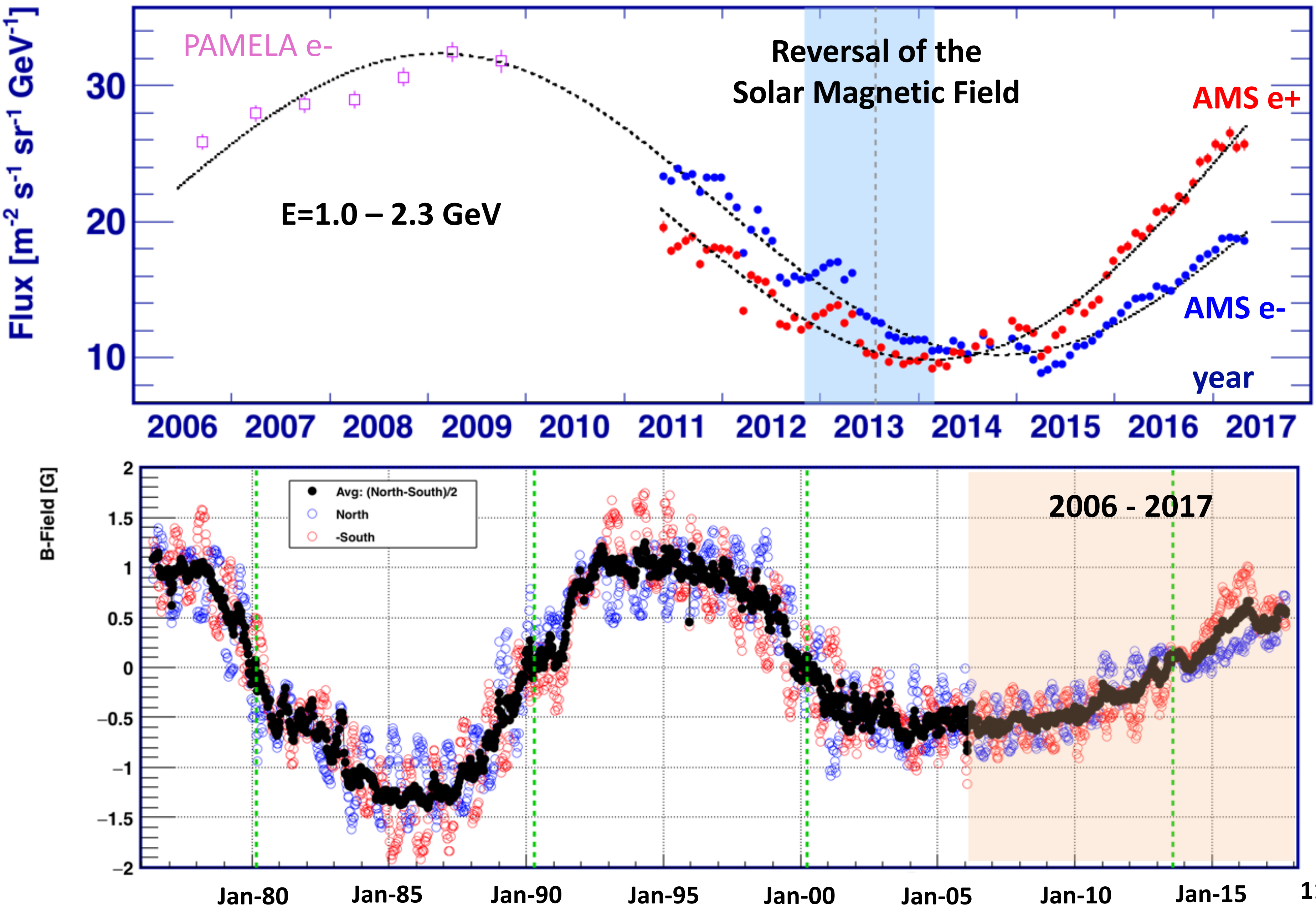
The Force Field Approximation is used to describe the Solar Modulation.



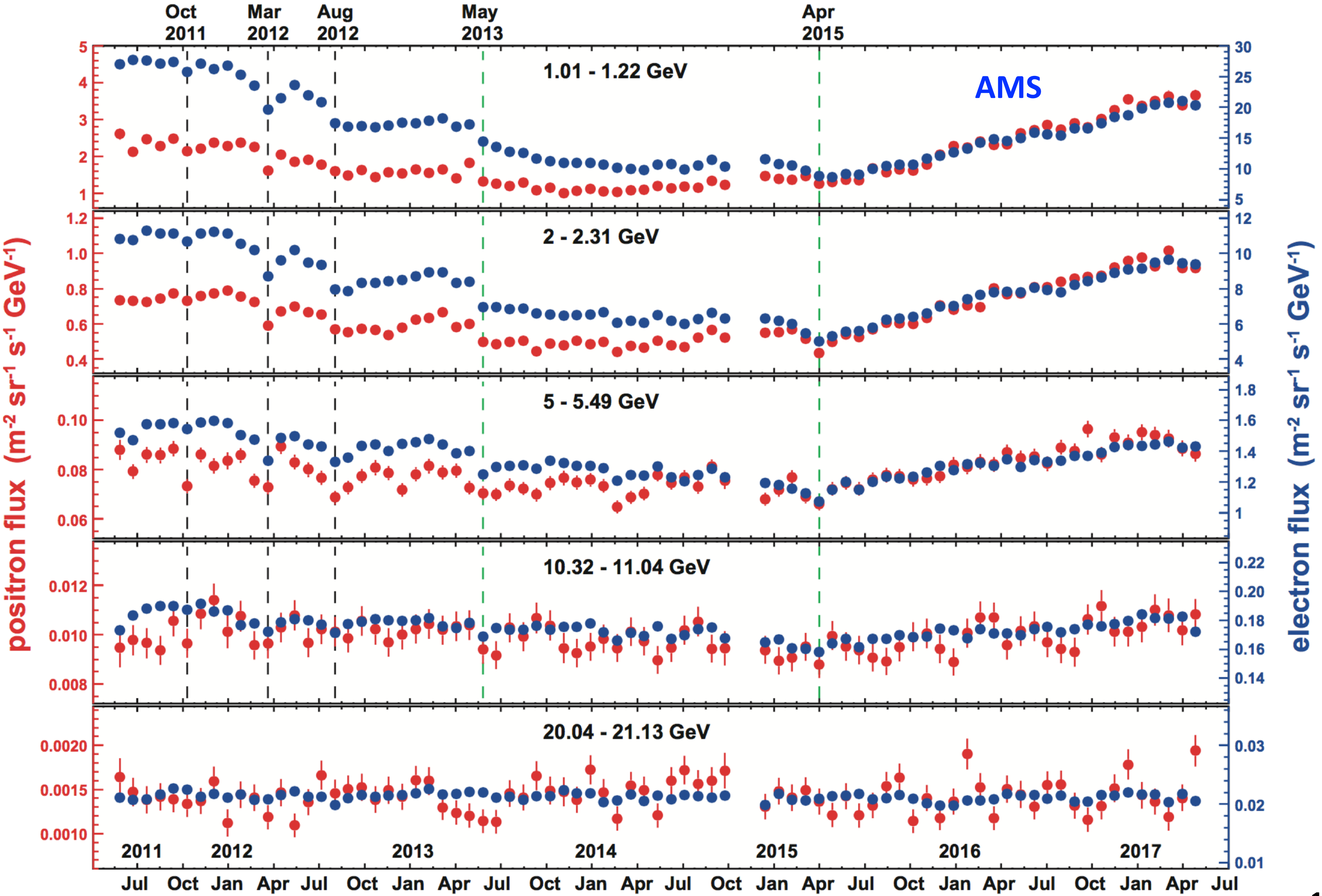
For the time interval May 2011 – May 2017 we observe significant time variations of the cosmic ray electron flux for low energies.



e+ and e- fluxes are time dependent due to the variability of the magnetic field of the sun.

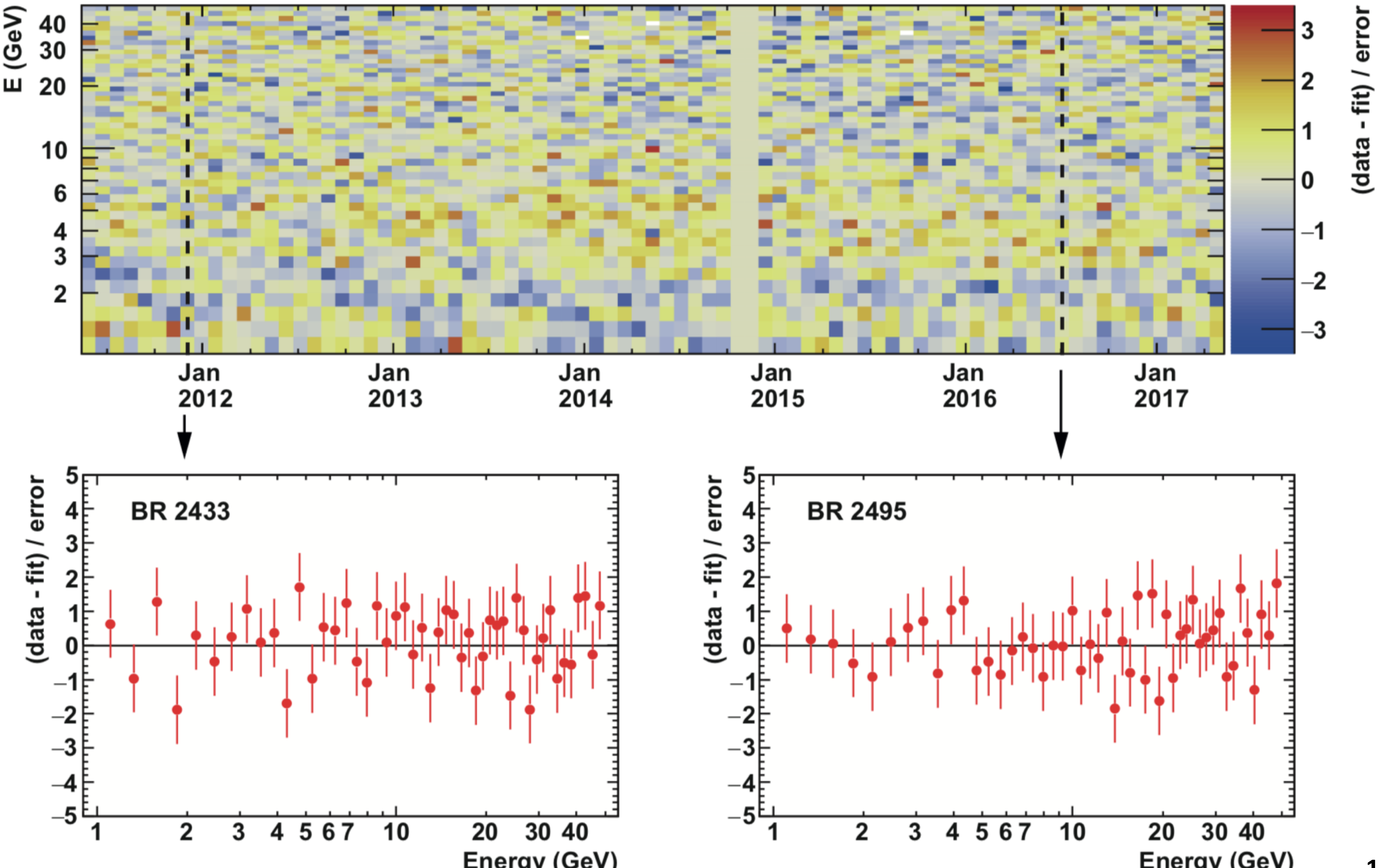


Examples of the continous measurement of the e+ and e- flux in the energy range 1 -50 GeV over 6 years with a time resolution of 27 days.



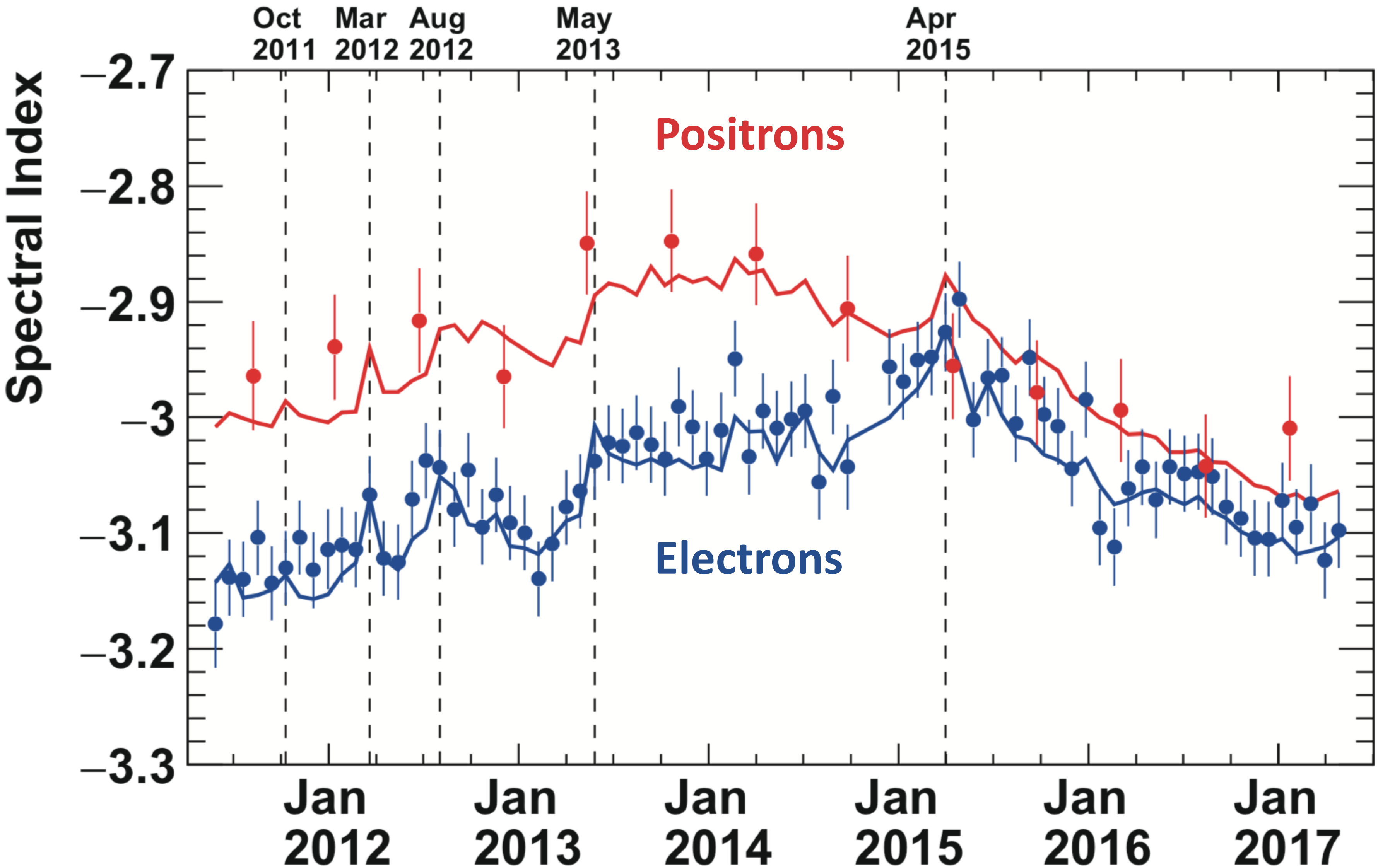
Positrons

The smoothly broken power law fits yield an average χ^2/d.o.f.≈1 for all Bartels Rotations and no fine-structures in the e- or e+ energy spectra were found.



Spectral Index for E = 7 – 13 GeV

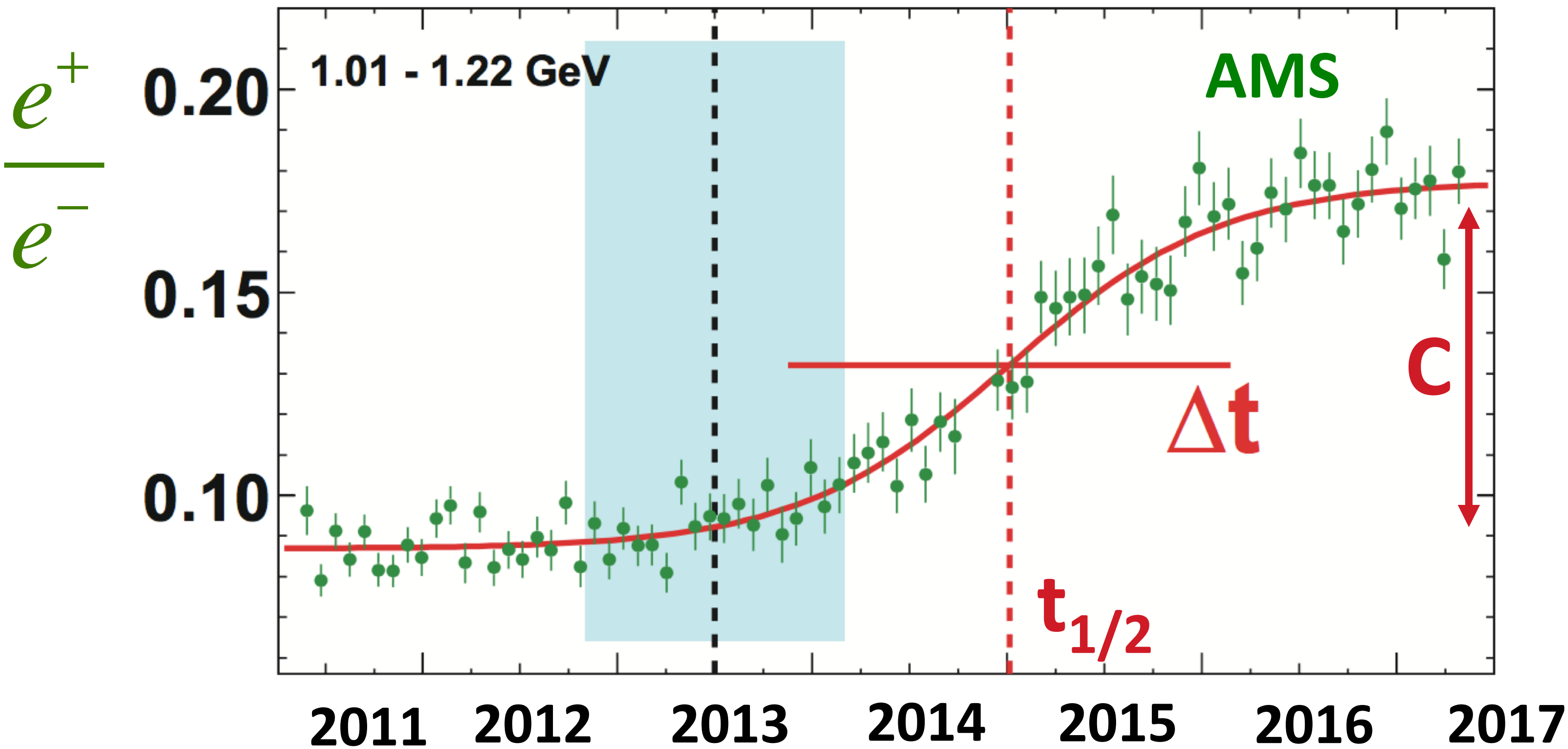
The spectral indices for both the electrons and the positrons harden continuously with different slopes until April 2015 and then continue to soften with an identical slope. The prominent and distinct short-term structures are visible as a hardening in the spectral indices.



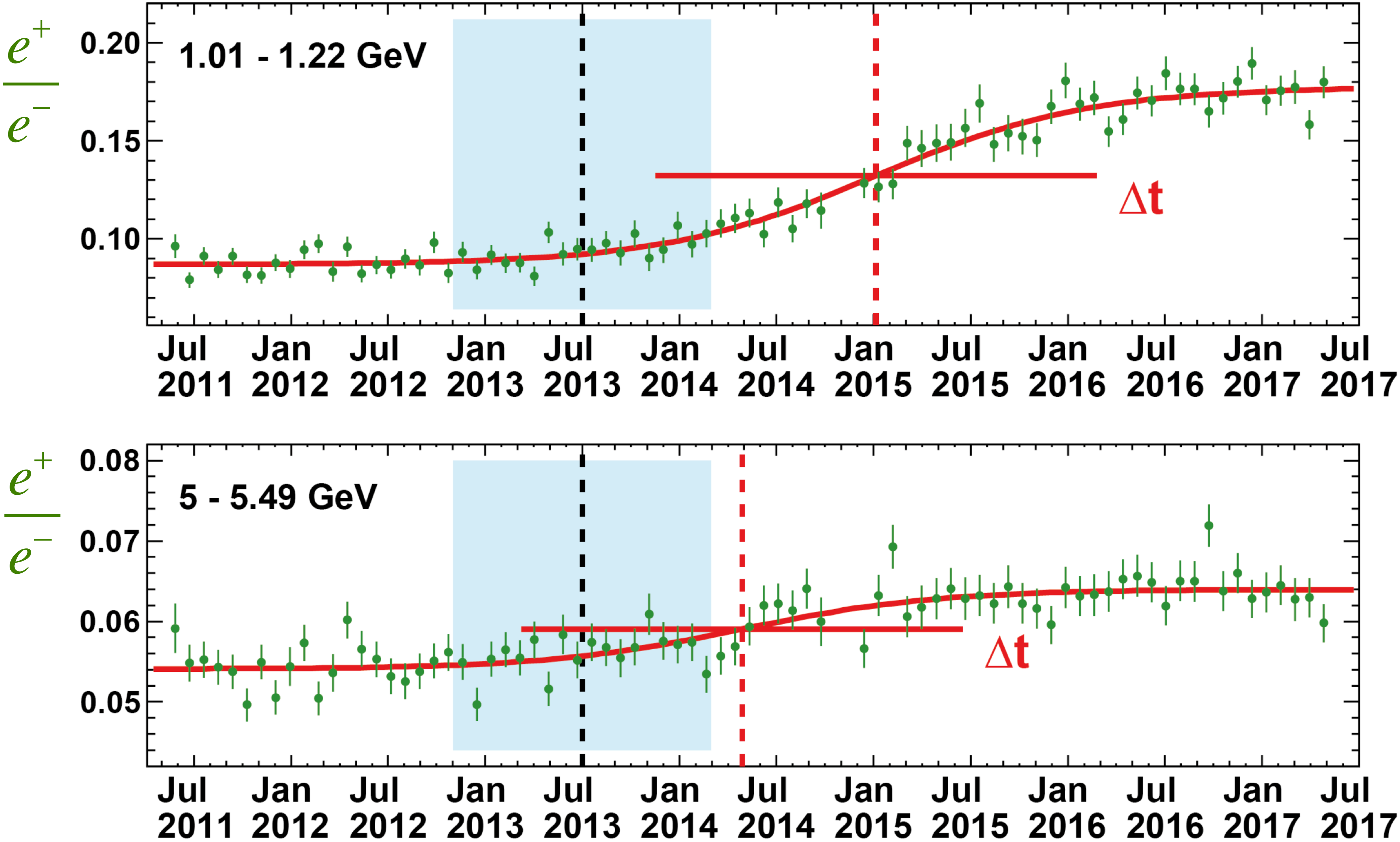
Electron/Positron Ratio R_e

- The short term structures cancel in the e^+/e^- flux ratio.
- The existence of a smooth transition in the e^+/e^- flux ratio from one value to another, after the polarity reversal of the solar magnetic field, is observed.
- This transition can be well described by a logistic function with 4 energy dependent parameters:

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



- The amplitude **C** of the transition decreases as a function of energy.
- The midpoint of the transition $t_{1/2}$ is energy dependent.
- The duration of the transition period Δt is independent of energy.



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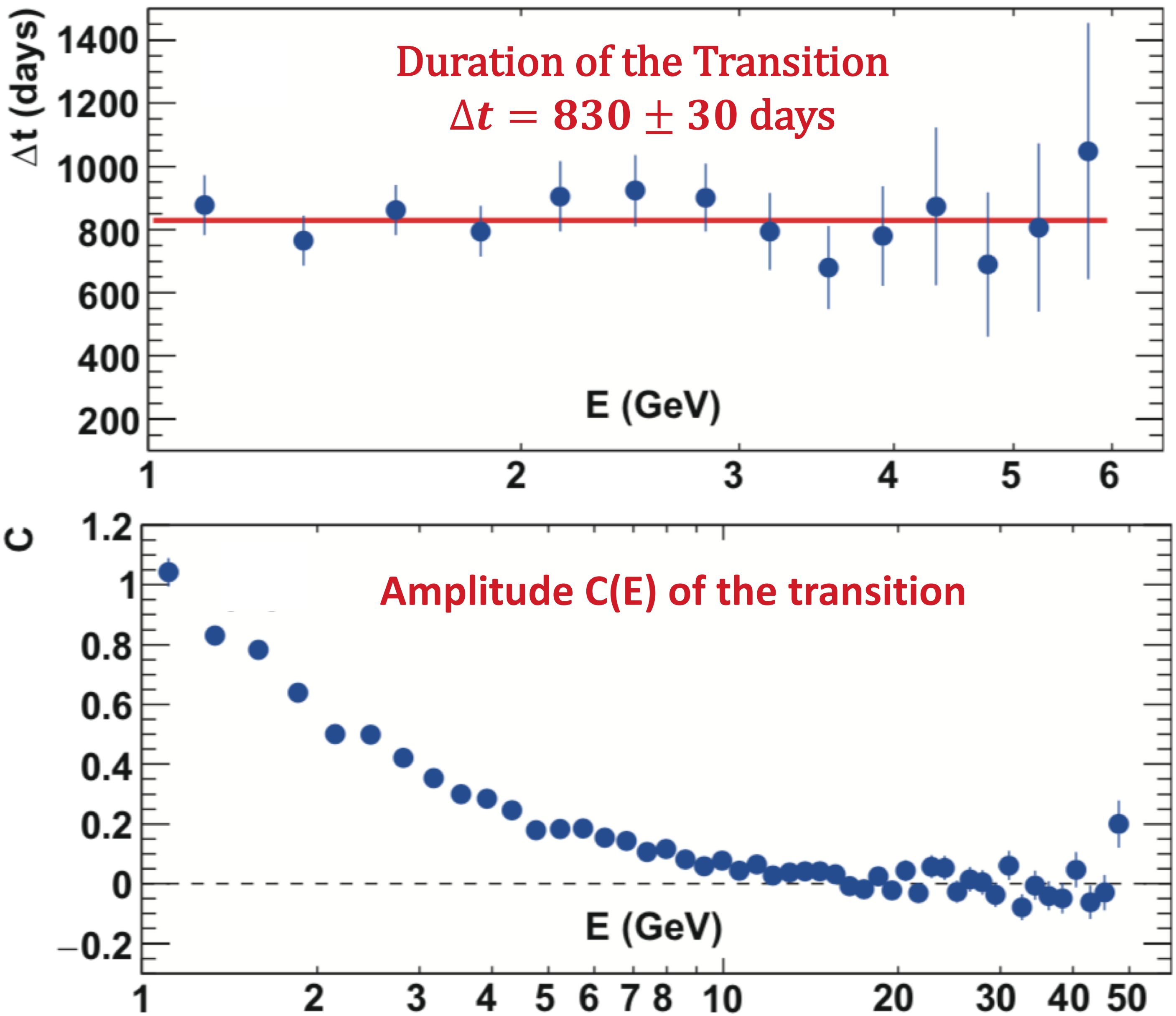
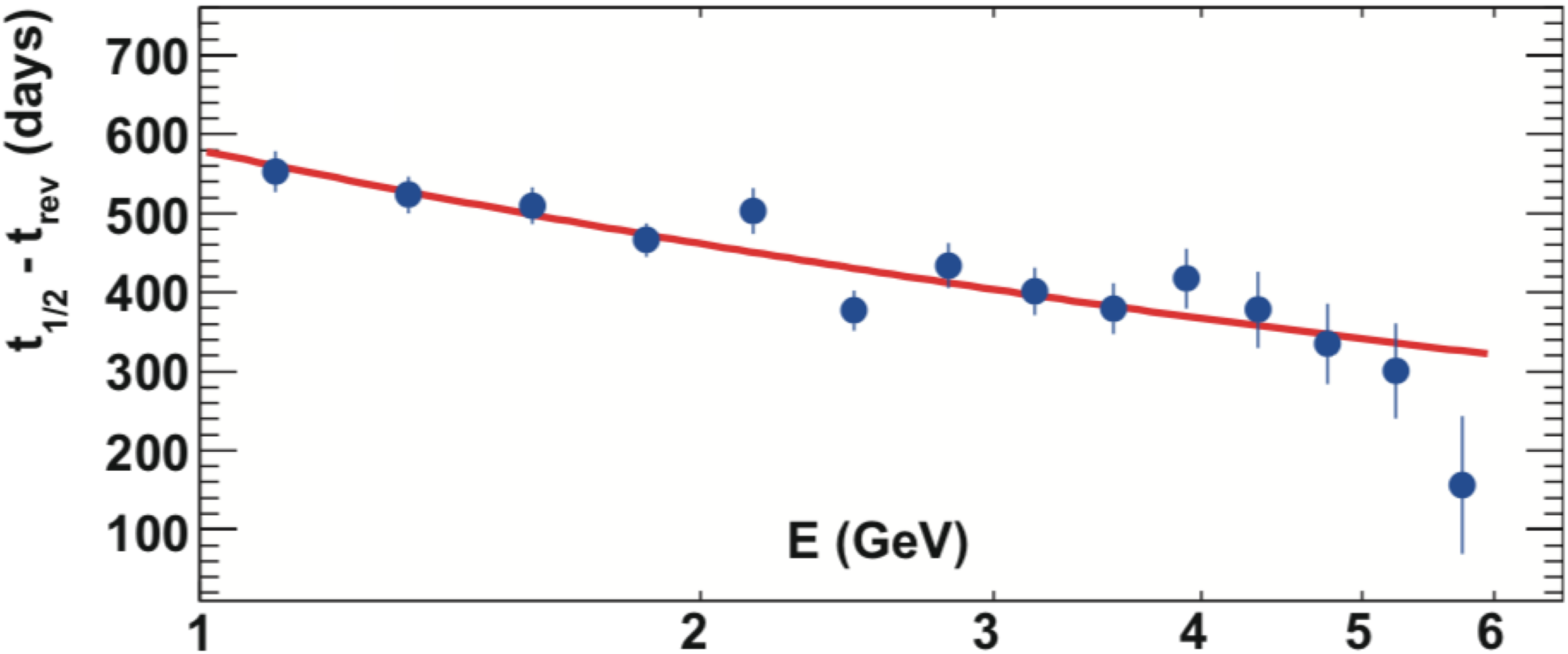


The midpoint of the transition follows a power law in Energy:

$$t_{1/2} - t_{rev} = \tau \cdot E^{\rho}$$

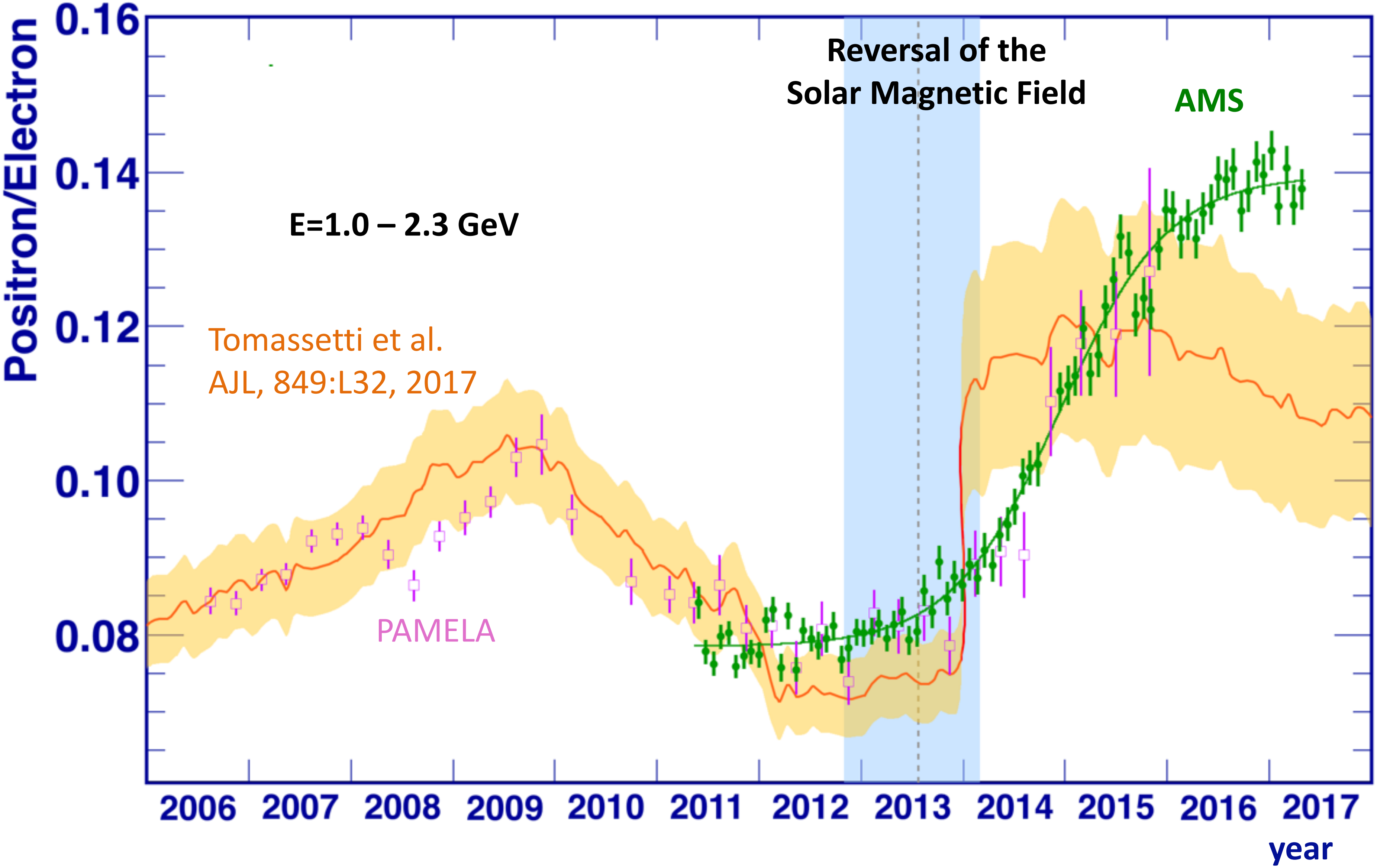
$$\rho = -0.33 \pm 0.04(stat) \pm^{0.08}_{0.15} (syst)$$

$$\tau = 580 \pm 19(stat) \pm 136(syst) \text{ days}$$



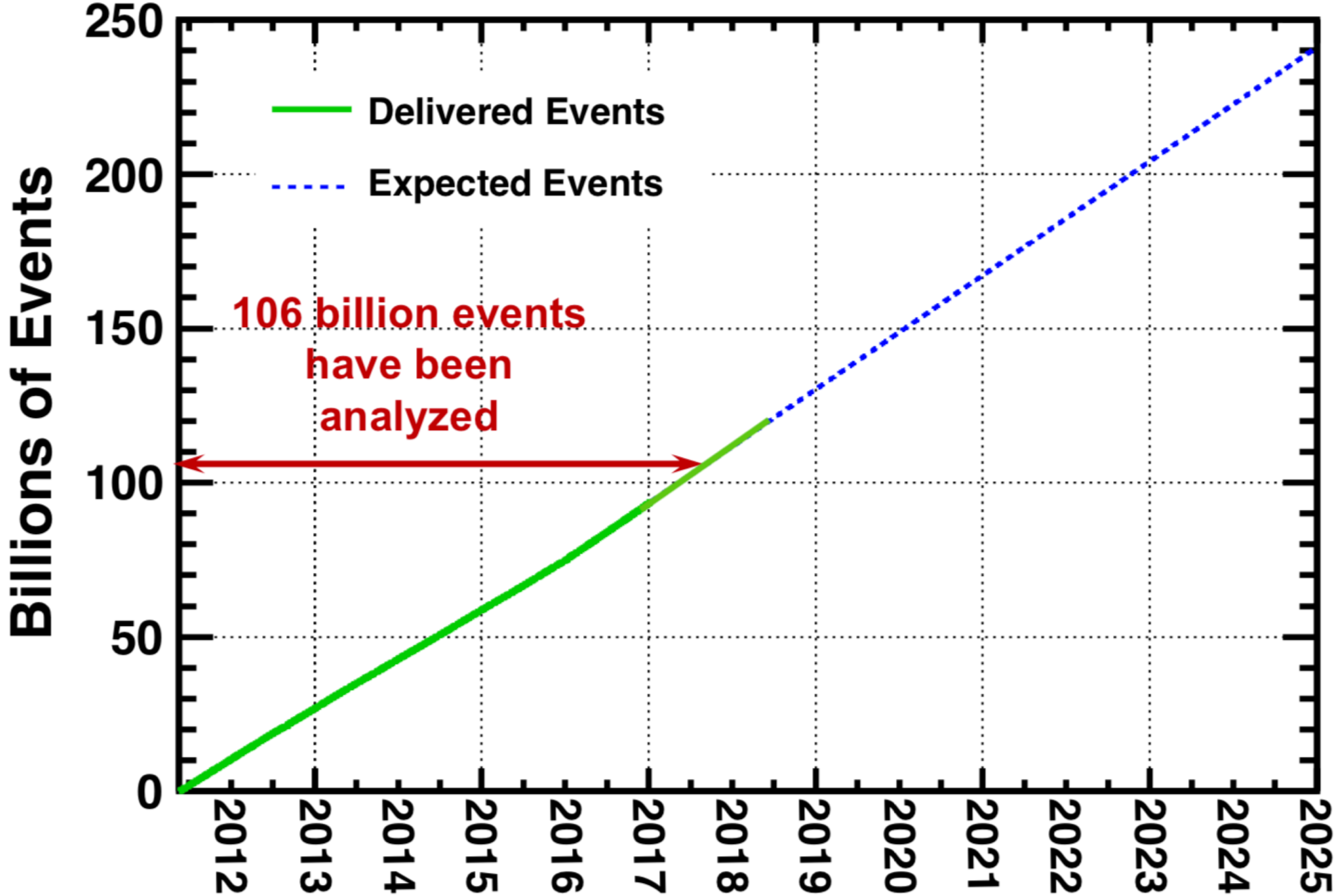
$$R_e(t,E) = R_0(E)\left[1 + \frac{C(E)}{\exp\left(-\frac{t - t_{1/2}(E)}{\Delta t(E)/\Delta_{80}}\right) + 1}\right]$$

In one energy bin we can compare our results with PAMELA and model predictions.



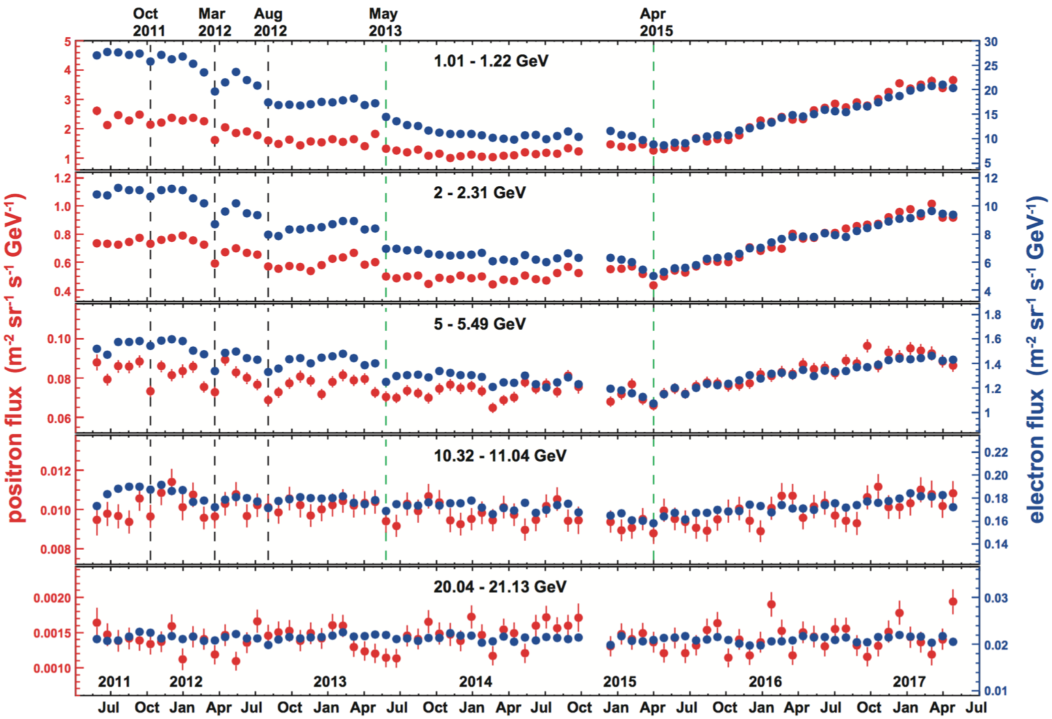
AMS on ISS to date: 121 Billion Events

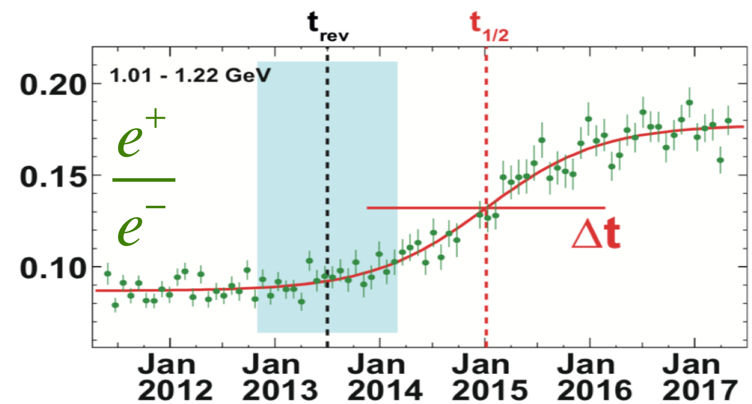
AMS on ISS in 2024: 240 Billion Events

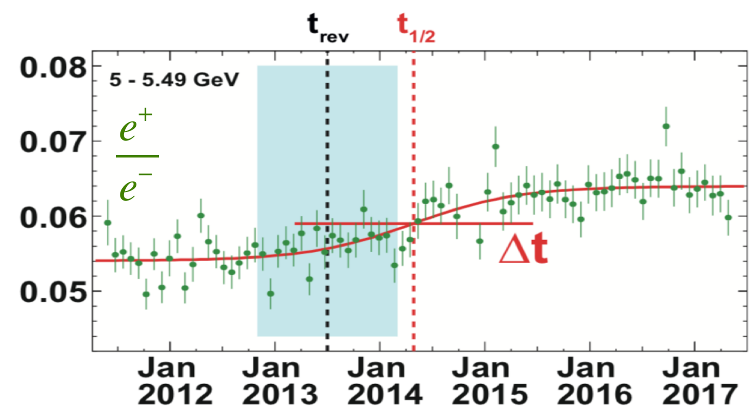


The next polarity change of the solar magnetic field is expected in 2024.

Summary





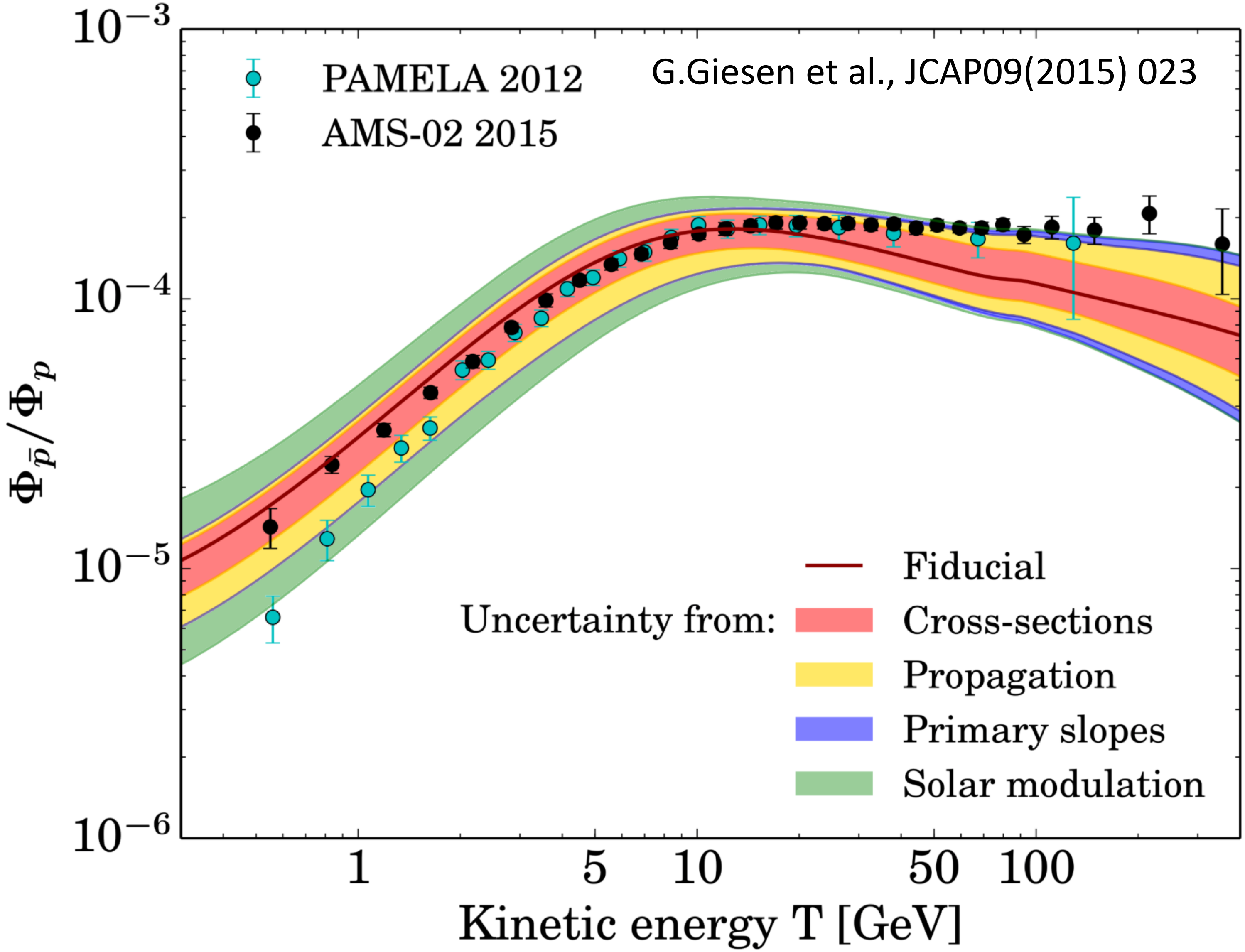


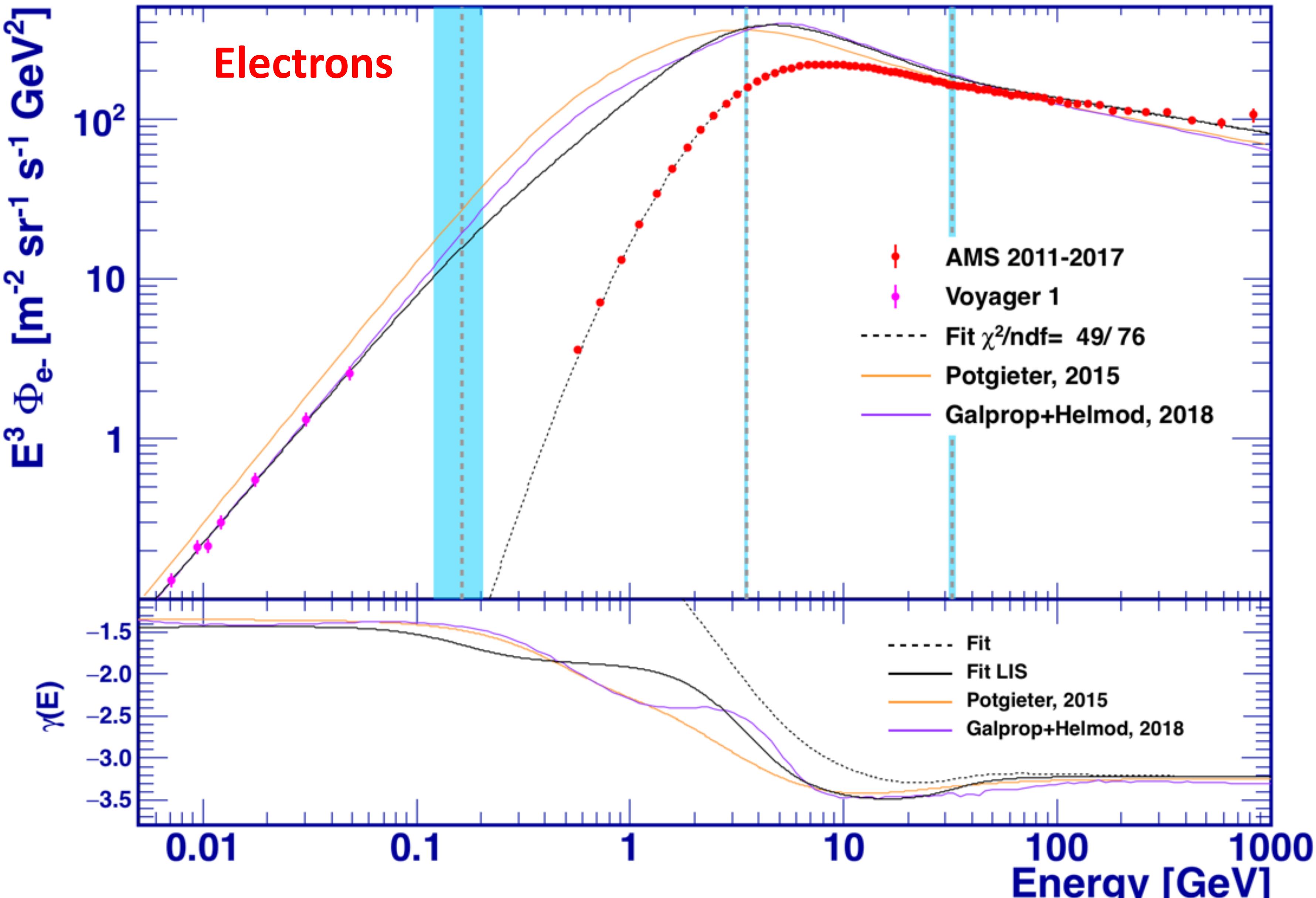
- These precise measurements require a new and comprehensive explanation of cosmic ray propagation in the Heliosphere.
- This will allow us to extract the local interstellar spectra of cosmic rays outside the solar system and hence to understand the underlying physical processes in our galaxy that drive the production, acceleration and propagation of cosmic rays.
- With its magnetic spectrometer AMS is the only experiment in space to perform the required long term measurements.

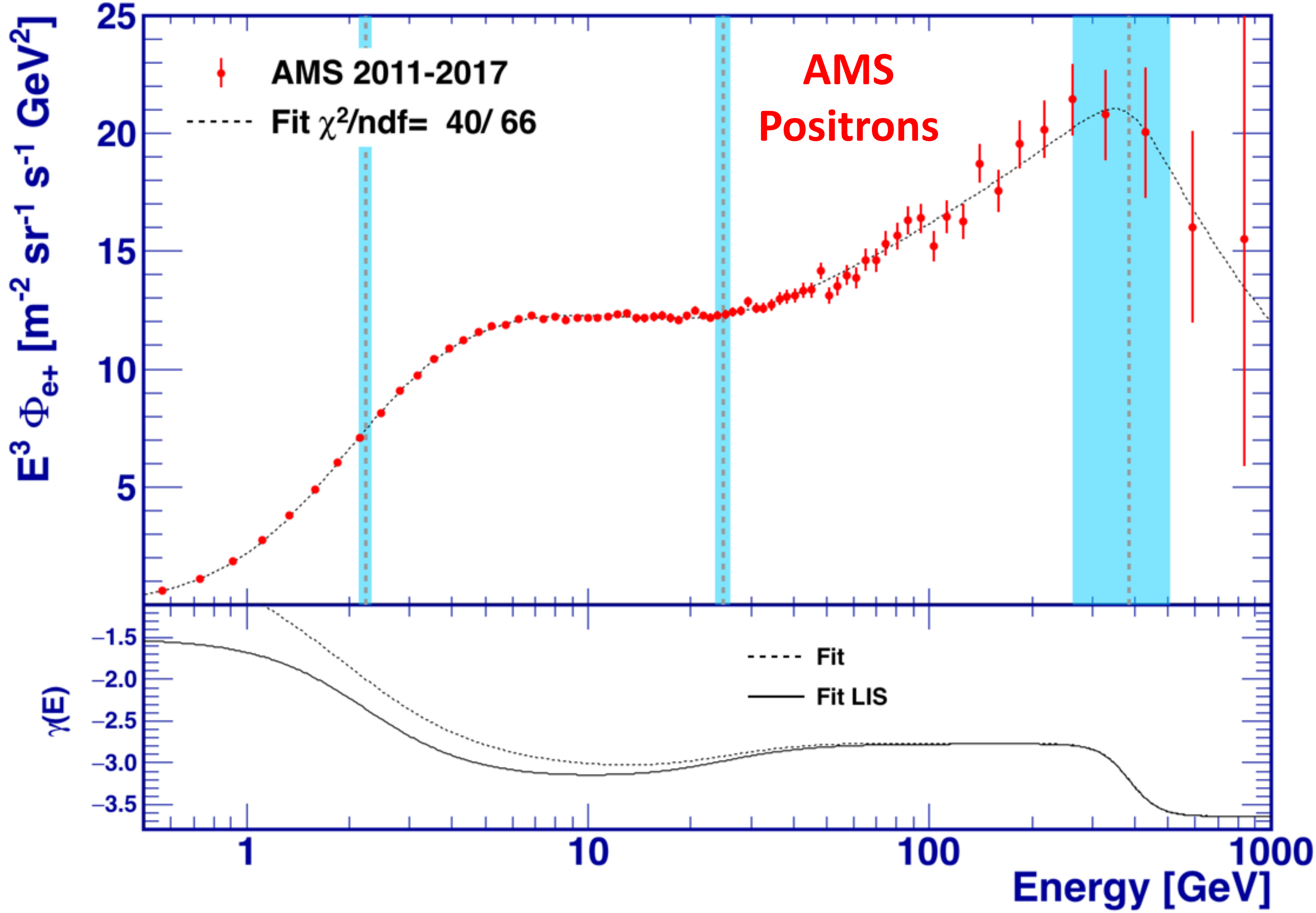
Backup

Dark Matter ?

Solar Modulation is an important systematic uncertainty for the interpretation of the AMS Data.




Electrons
$E^3\ \Phi_{e-}$ [m^{-2} sr^{-1} s^{-1} GeV^2]
AMS 2011-2017
Voyager 1
Fit χ^2/ndf= 49/ 76
Potgieter, 2015
Galprop+Helmod, 2018
γ(E)
Fit
Fit LIS
Potgieter, 2015
Galprop+Helmod, 2018
Energy [GeV]



AMS 2011-2017
Fit χ^2/ndf= 40/ 66
AMS
Positrons
$E^3\ \Phi_{e+}$ [m^{-2} sr^{-1} s^{-1} GeV^2]
25
20
15
10
5
γ(E)
−1.5
−2.0
−2.5
−3.0
−3.5
Fit
Fit LIS
1
10
100
1000
Energy [GeV]

For the time interval May 2011 – May 2017 we observe significant time variations of the cosmic ray positron to electron flux ratio for low energies.