Towards Understanding the Origin of Cosmic-Ray Electrons

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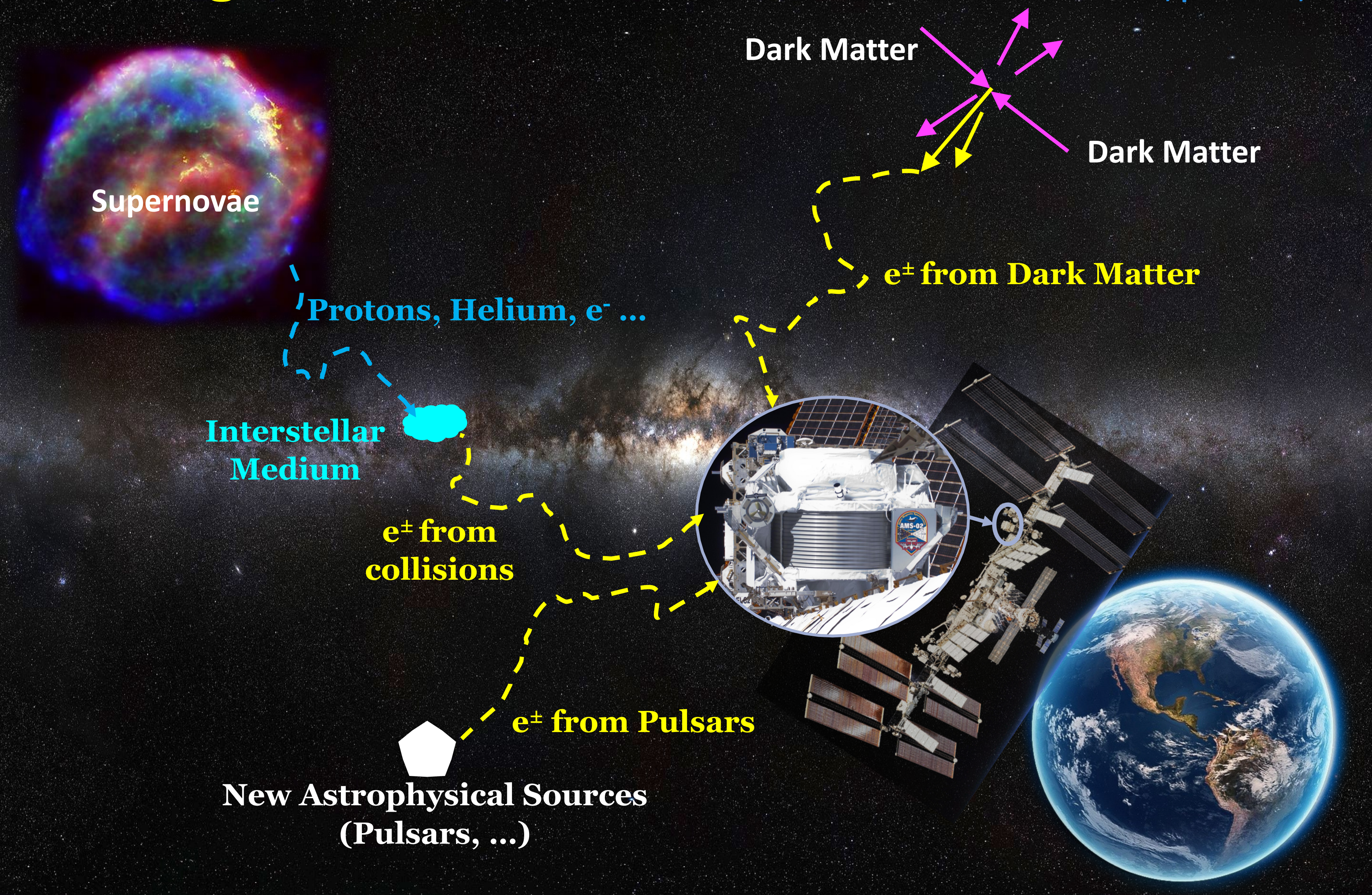
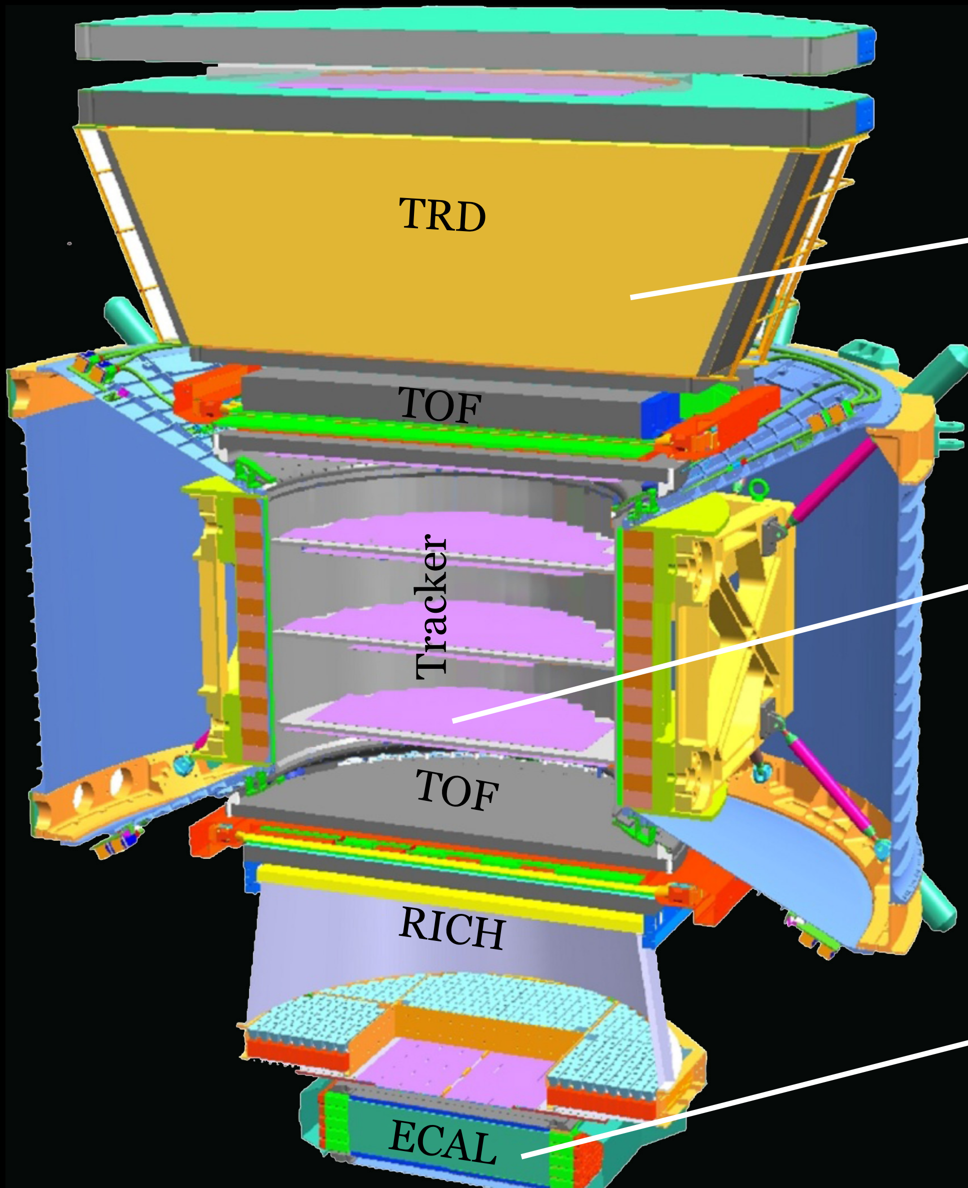
on behalf of the AMS Collaboration

The origins of cosmic electrons



Electron measurements with AMS detector

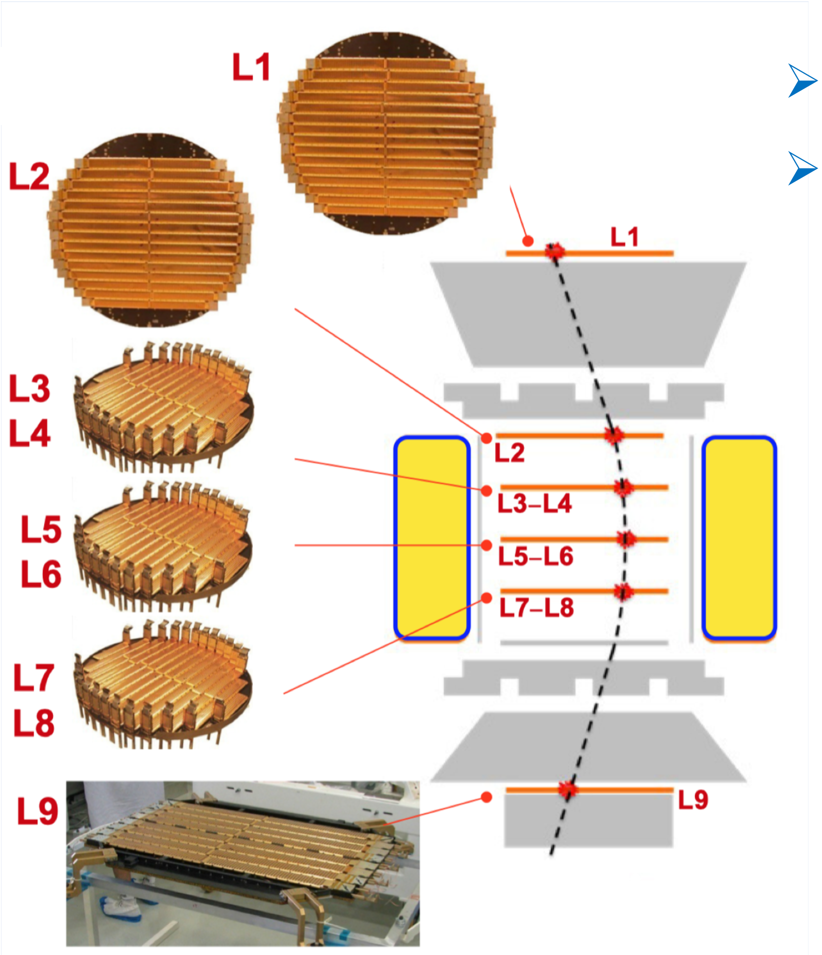


Transition Radiation Detector (TRD) identifies $e^{\pm}$ from protons using transition radiation. TRD is composed of 20 layers of proportional tubes.

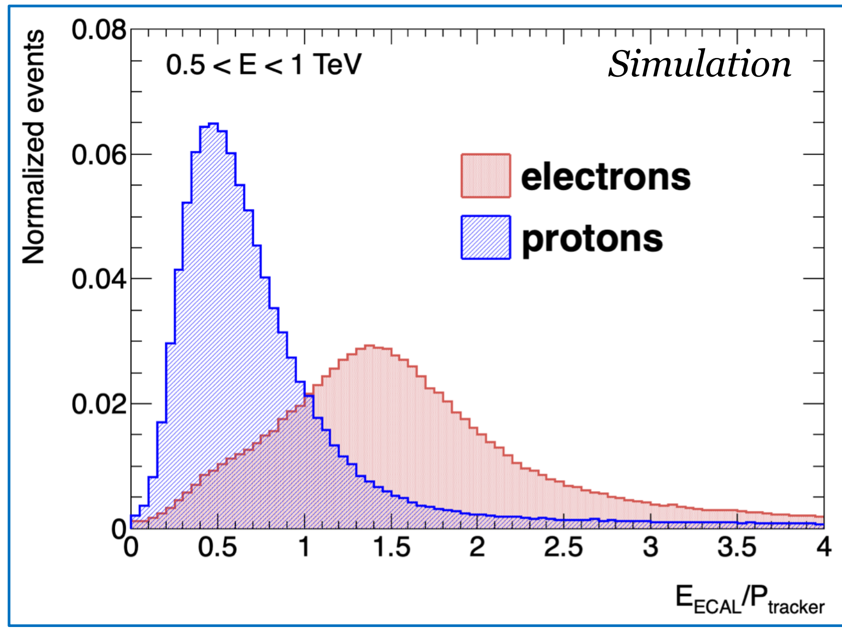
Silicon tracker and magnet distinguish between e^- and e^+ up to a few TeV.

Electromagnetic Calorimeter (ECAL) provides a precision 3D measurement of energy and shower development. ECAL has $17X_0$

Energy and momentum measurements



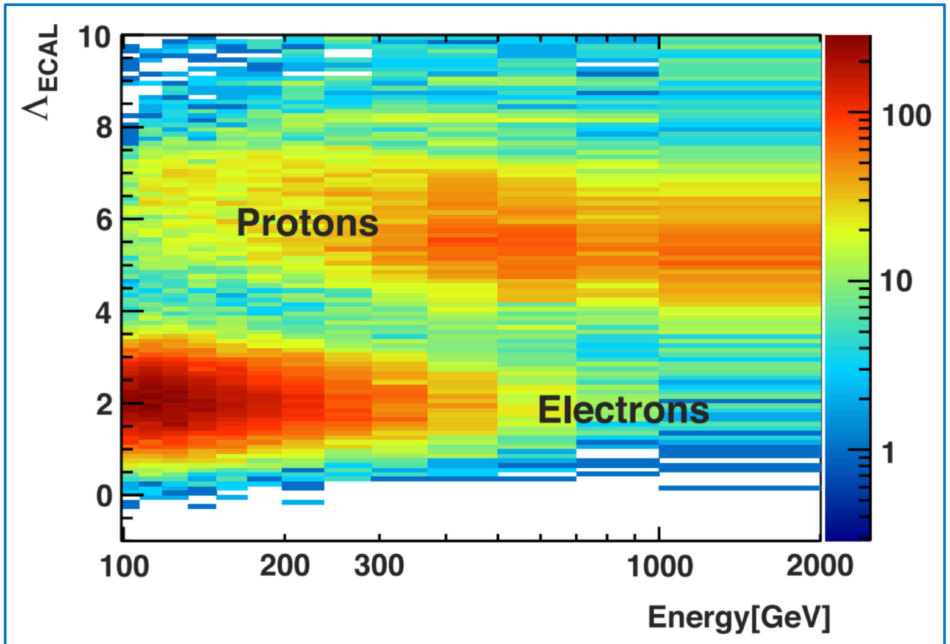
- Nine layers in AMS tracker forms 3 m lever arm
- For particle with Z=1:
  - Single point resolution is **10 μm**
  - The maximum detectable rigidity is **2 TeV**

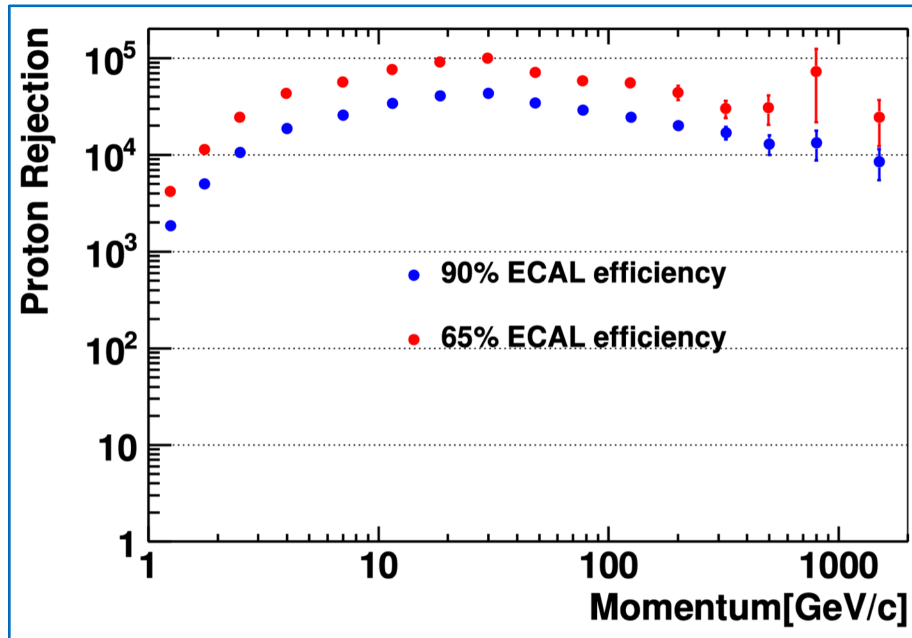


Independent momentum (by tracker) and energy (by calorimeter) measurements allows to distinguish $e^{\pm}$ from protons

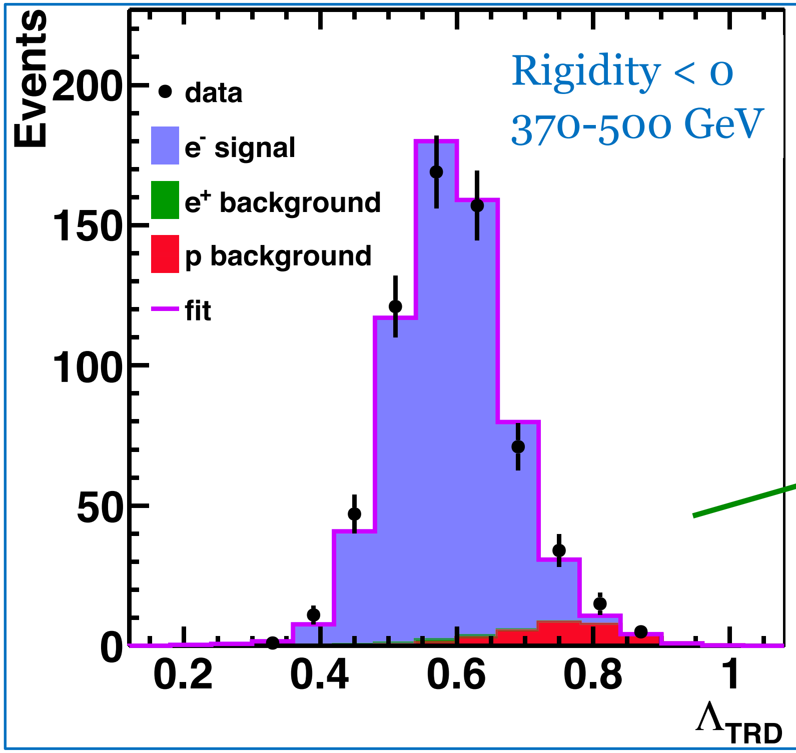
Proton rejection: ECAL

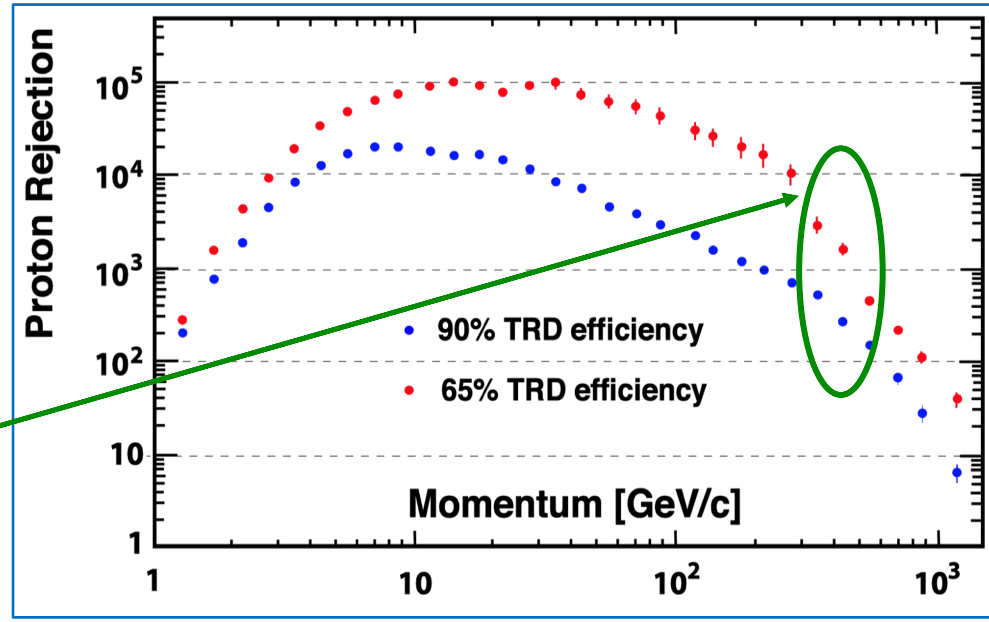
- Multivariable estimator Λ_{ECAL} is built based on measurements from ECAL
- Above 2 GV proton rejection power at 90% signal efficiency is above **1 in 10^4**





Proton rejection: TRD



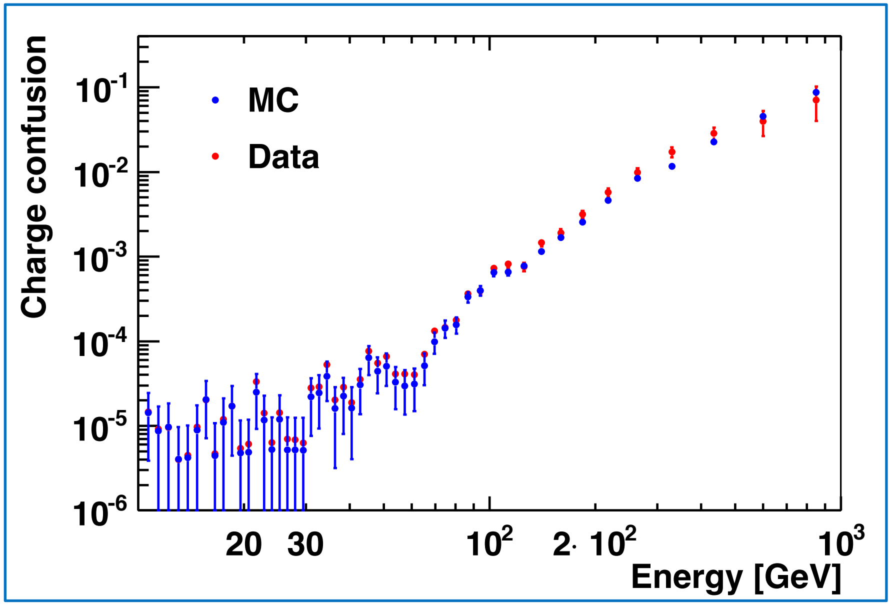


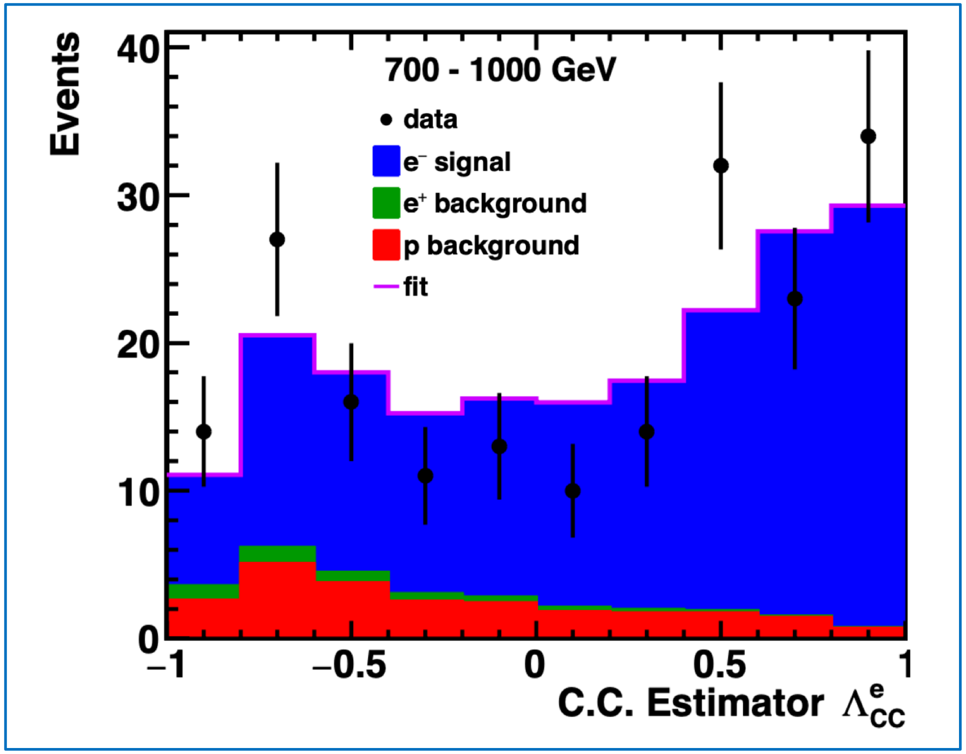
- TRD and ECAL provides independent proton rejection
- Combined (from TRD and ECAL) proton rejection power at 90% signal efficiency is above **1 in 10^6**

Charge sign confusion

Charge sign confusion events are identified using Charge confusion estimator.

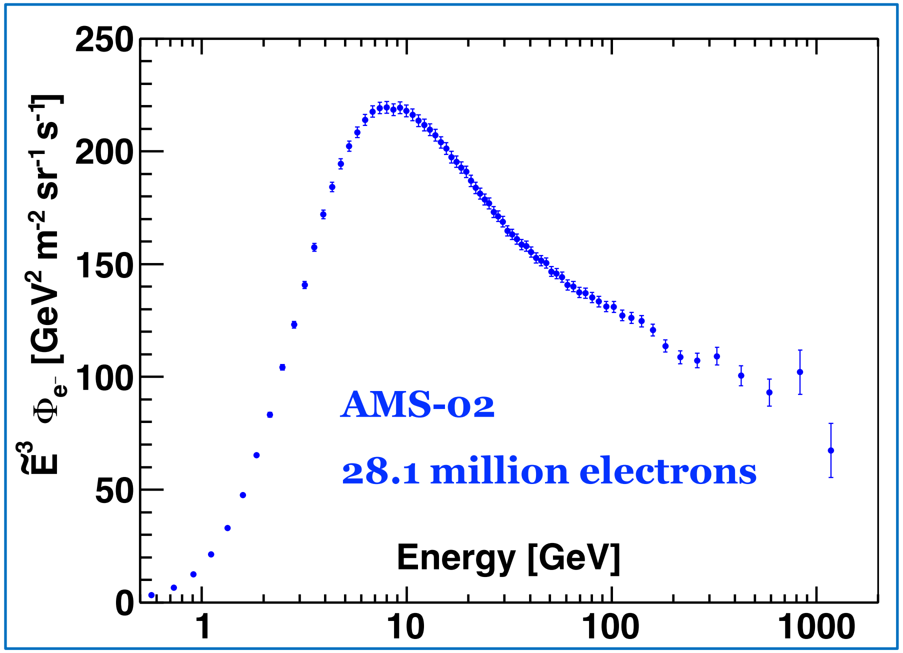
This estimator uses information from various detectors (tracker, ECAL, TOF) and is efficient up to with the highest measured energy.

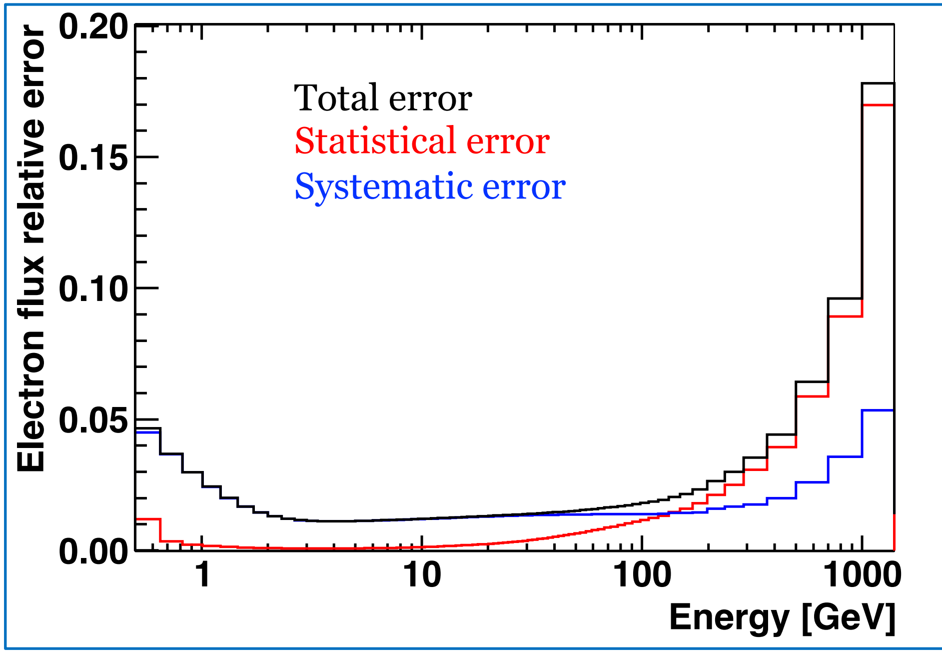




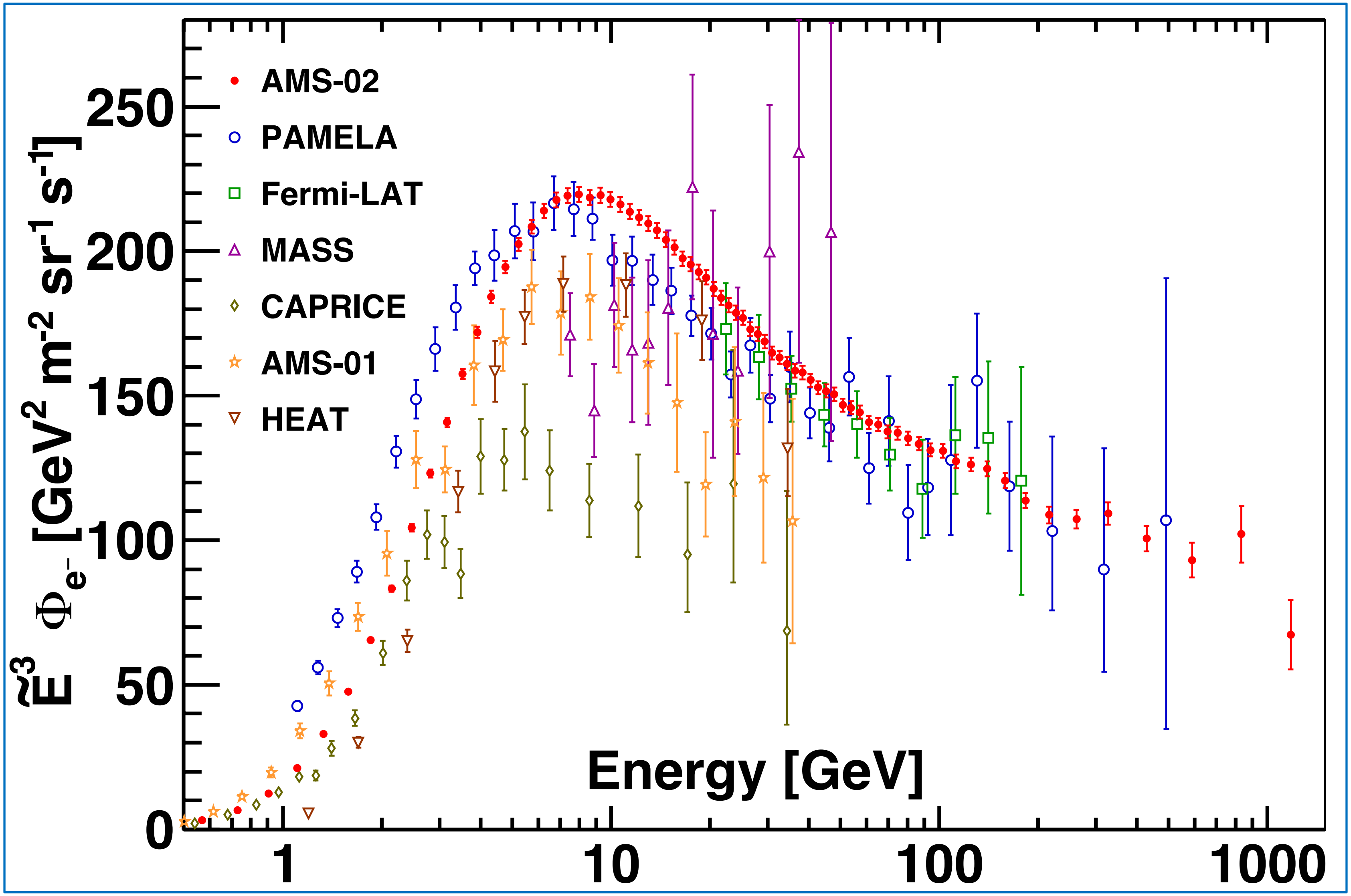
AMS electron energy spectrum

- ✓ In total, **28.1 million electrons** are identified with energy from 0.5 GeV to 1.4 TeV using fit in Λ_{TRD} - Λ_{CC} plane.
- ✓ Statistical uncertainty dominates above 200 GeV.





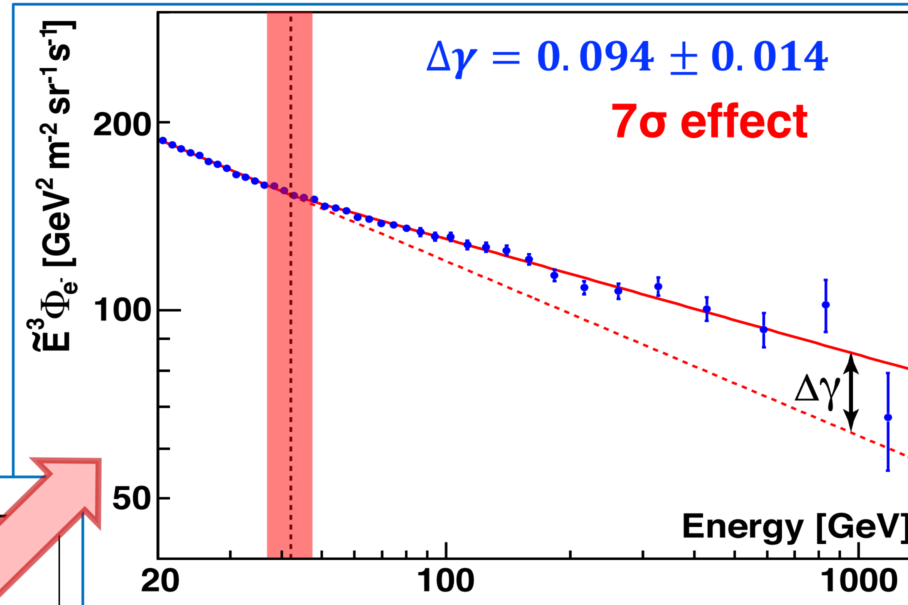
Comparison with earlier experiments

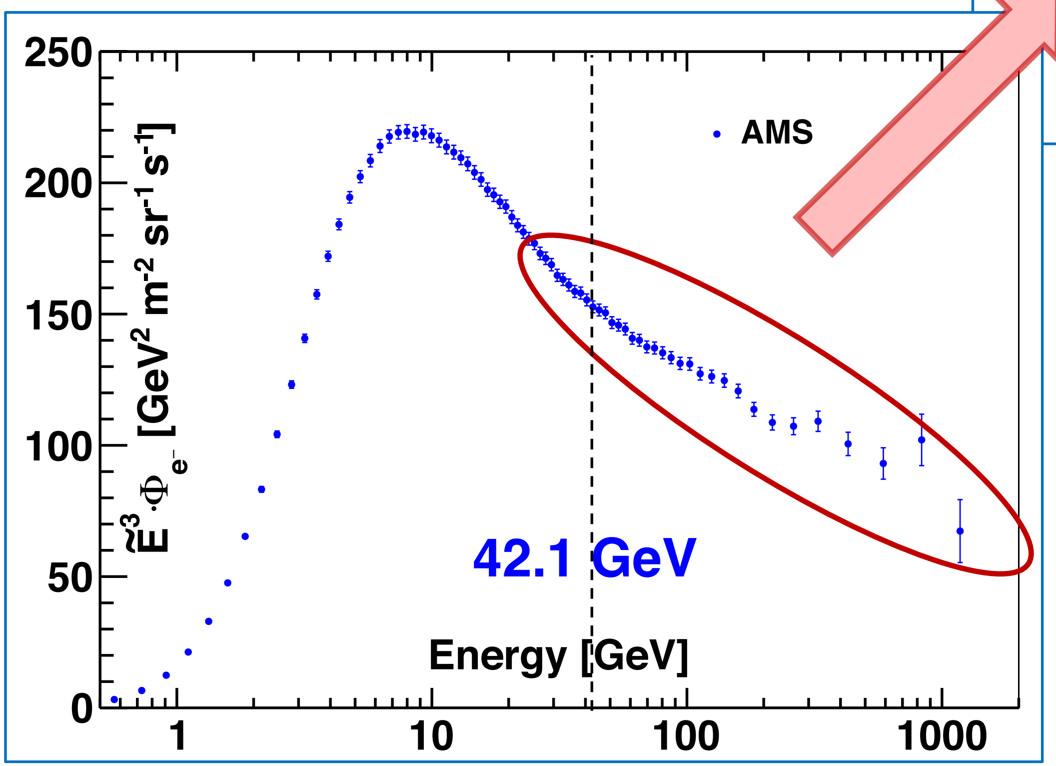


Energy Dependence of Electron Spectrum

Fits of the data to:

$$\Phi_{e^-}(E) = \begin{cases} CE^{\gamma}, & E \le E_0; \\ CE^{\gamma}(E/E_0)^{\Delta\gamma}, & E > E_0. \end{cases}$$



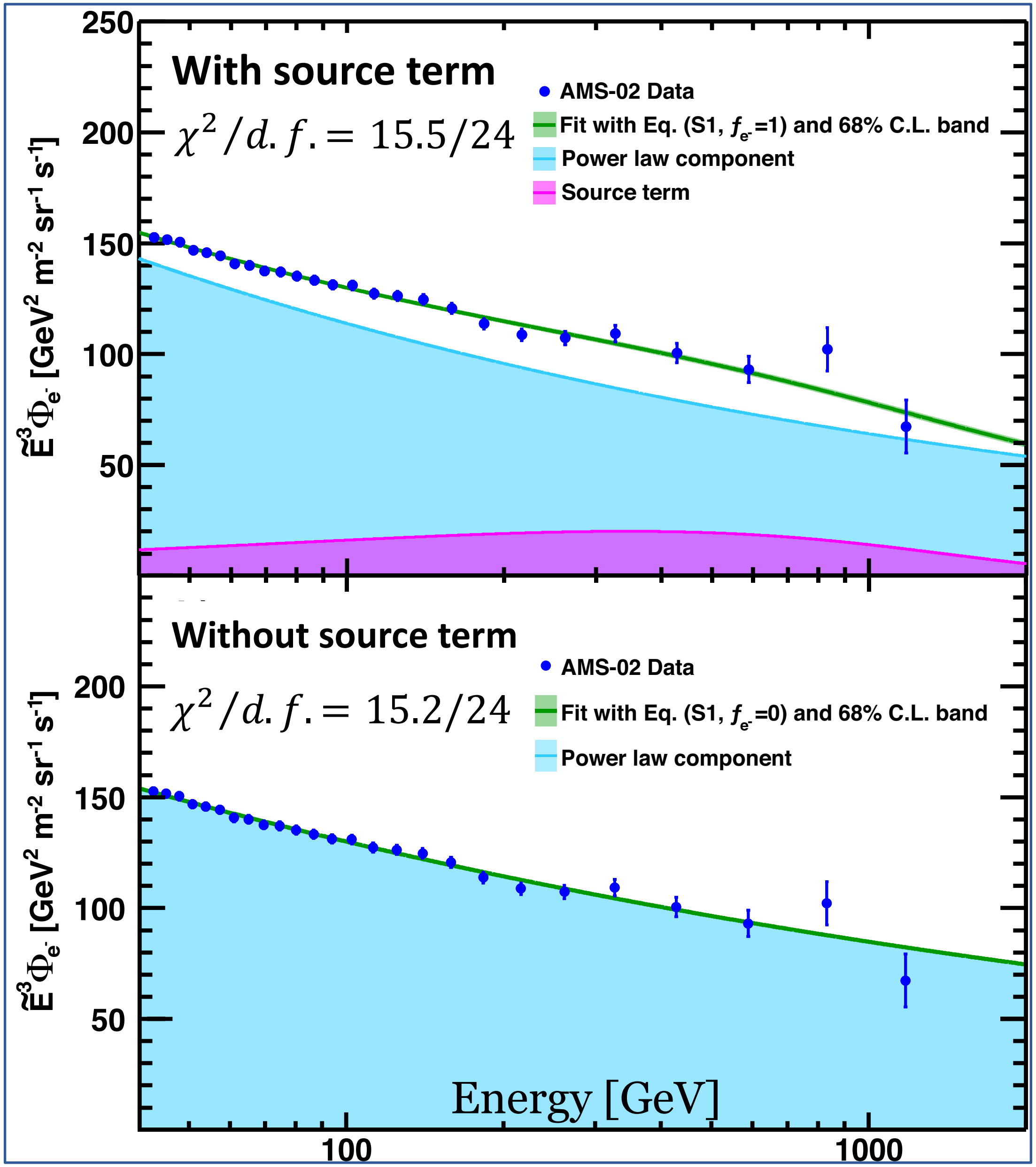


A significant excess above $42.1^{+5.4}_{-5.2}$ GeV

Charge symmetric source term

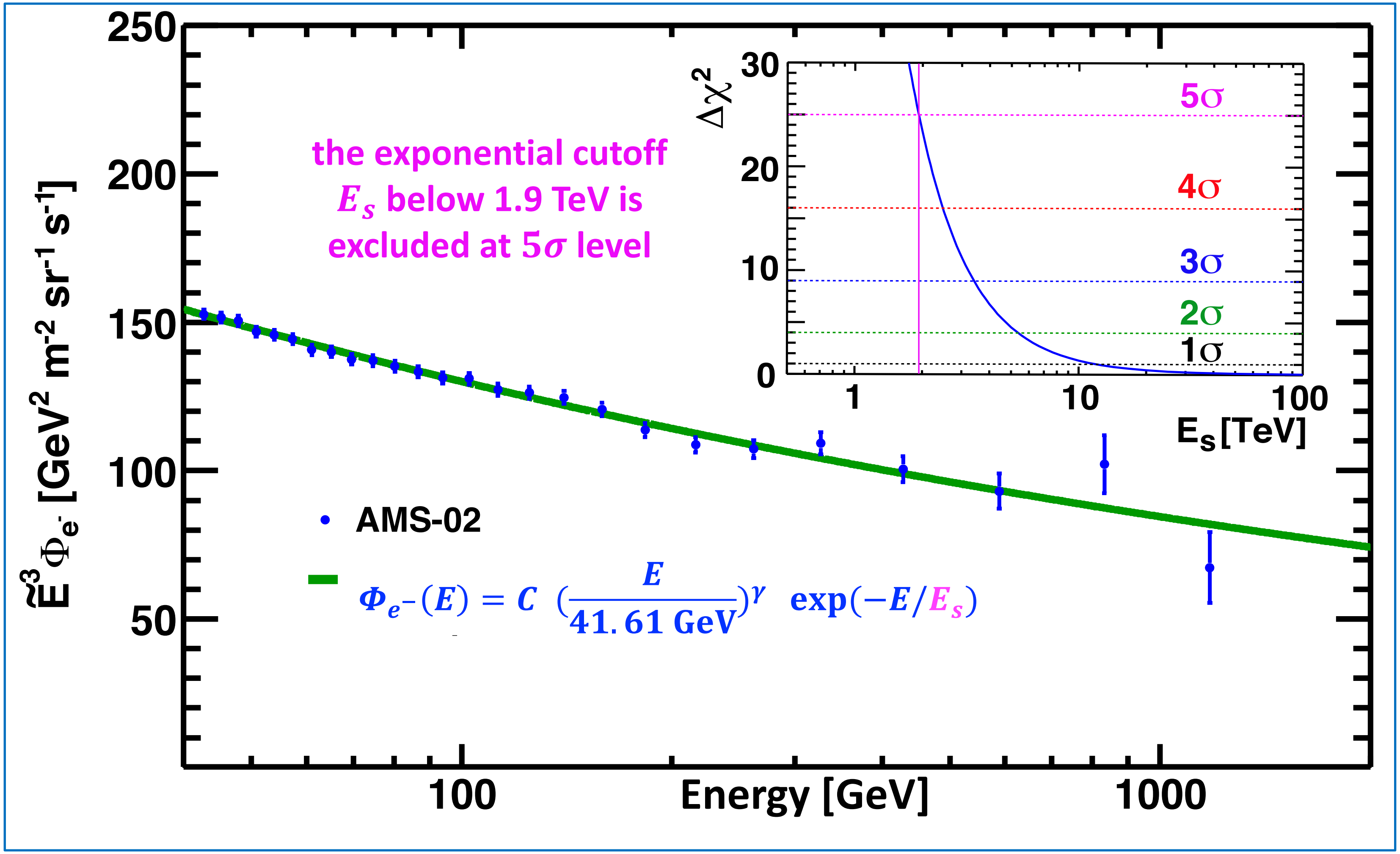
$$\Phi_{e^-}(E) = C_{e^-}(E/E_1)^{\gamma_{e^-}} + f_{e^-}\, C_s^{e^+}(E/E_2)^{\gamma_s^{e^+}} \exp(-E/E_s^{e^+})$$

- AMS Electron flux is consistent both with or w/o a charge symmetrical source
- Future AMS measurements with improved accuracy and energy reach will reveal detail features in the electron spectrum.

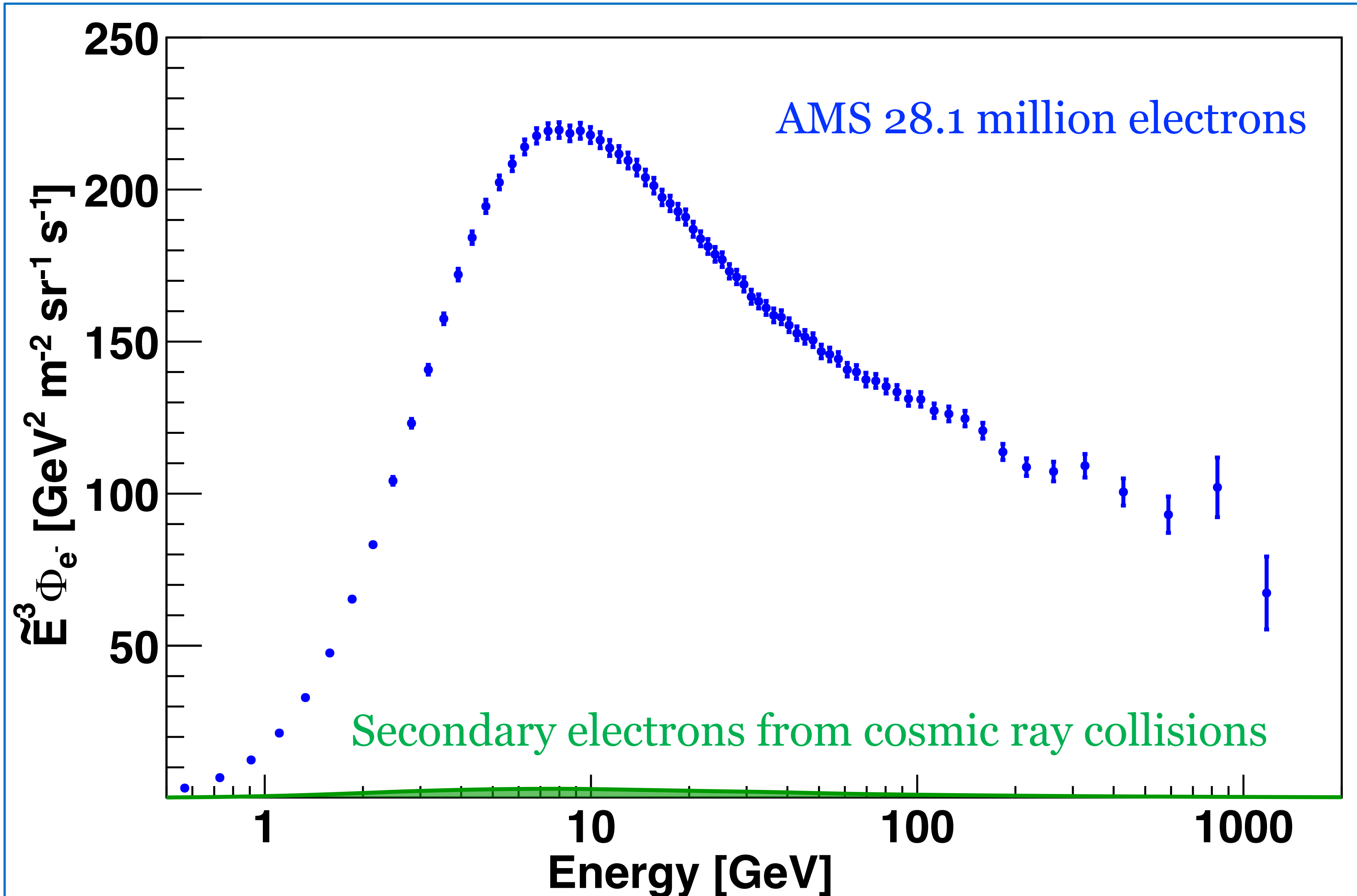


High energy cutoff in the electron flux

The electron flux does not show a cutoff below 1.9 TeV, contrary to 4σ exponential cutoff at 810^{+310}_{-180} GeV in the positron flux (talk #1024 by Zhili Weng)



Origin of Cosmic electrons



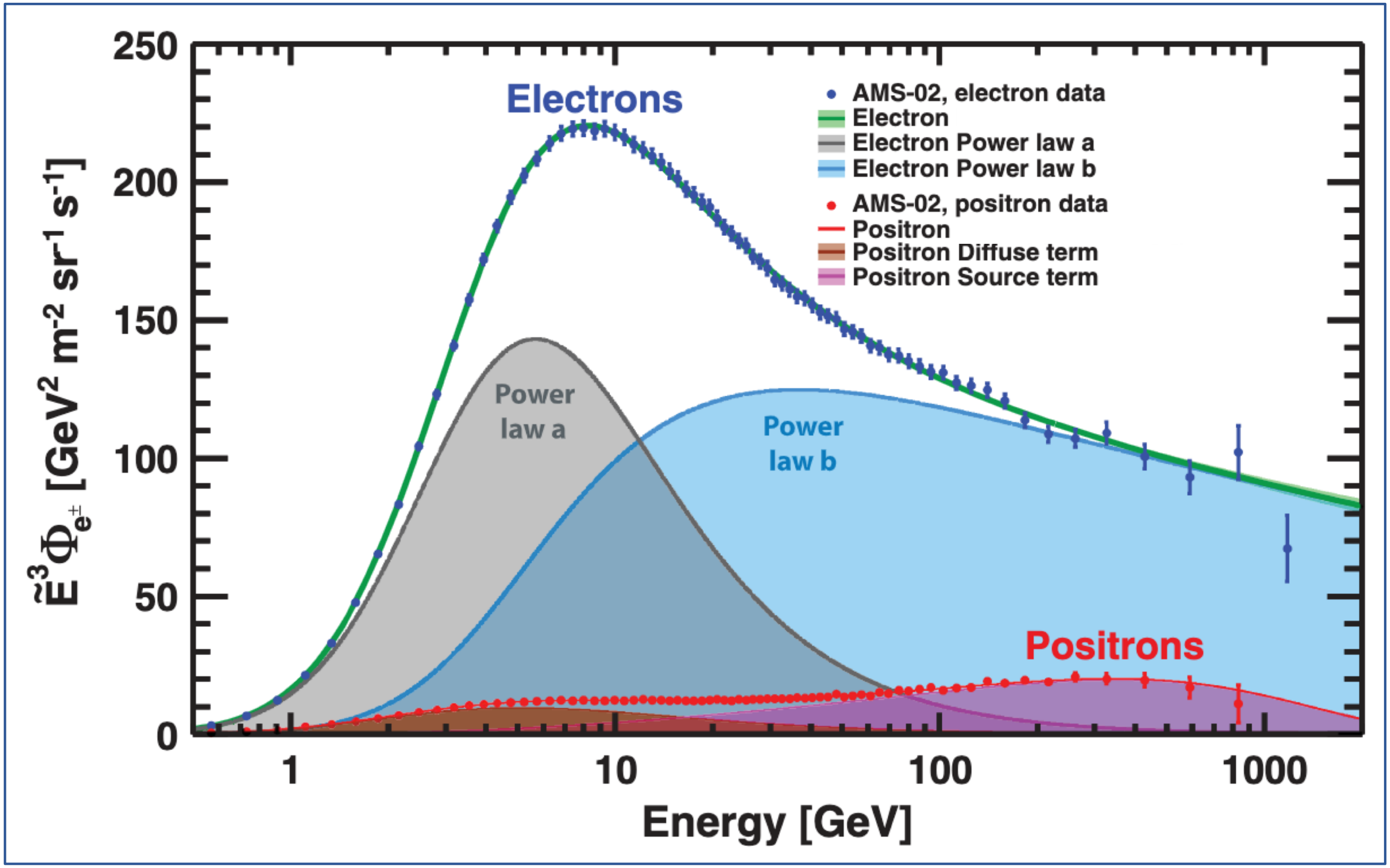
The contribution from cosmic ray collisions is negligible.

Origin of Cosmic electrons

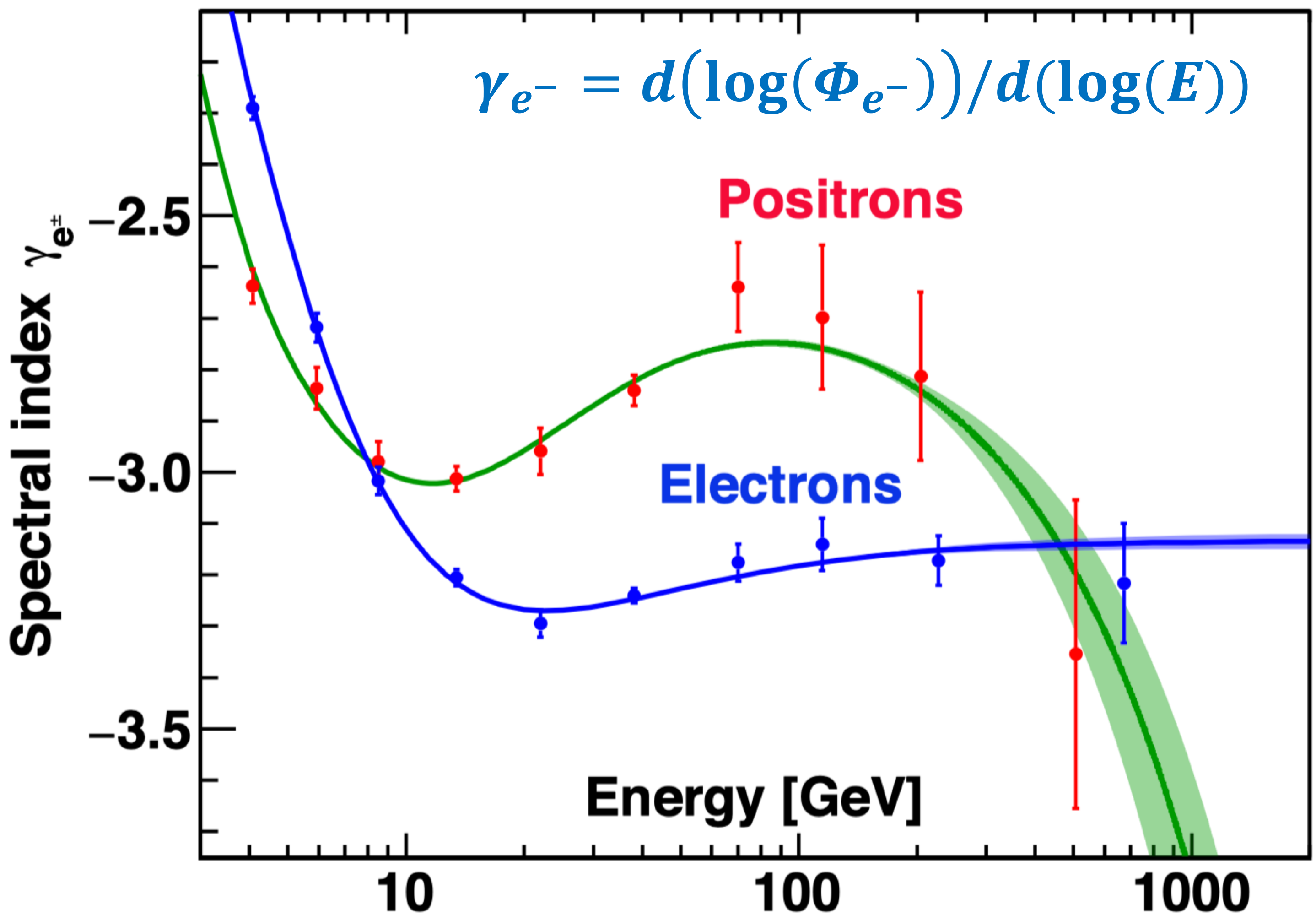
- The electron flux can be described by two power law functions *a* and *b*.

$$\Phi_{e^-}(E) = \frac{E^2}{\hat{E}^2}[1 + (\hat{E}/E_t)^{\Delta\gamma_t}]^{-1}[C_a(\hat{E}/E_a)^{\gamma_a} + C_b(\hat{E}/E_b)^{\gamma_b}]$$

- At high energy most of electrons originate from different sources than positrons.

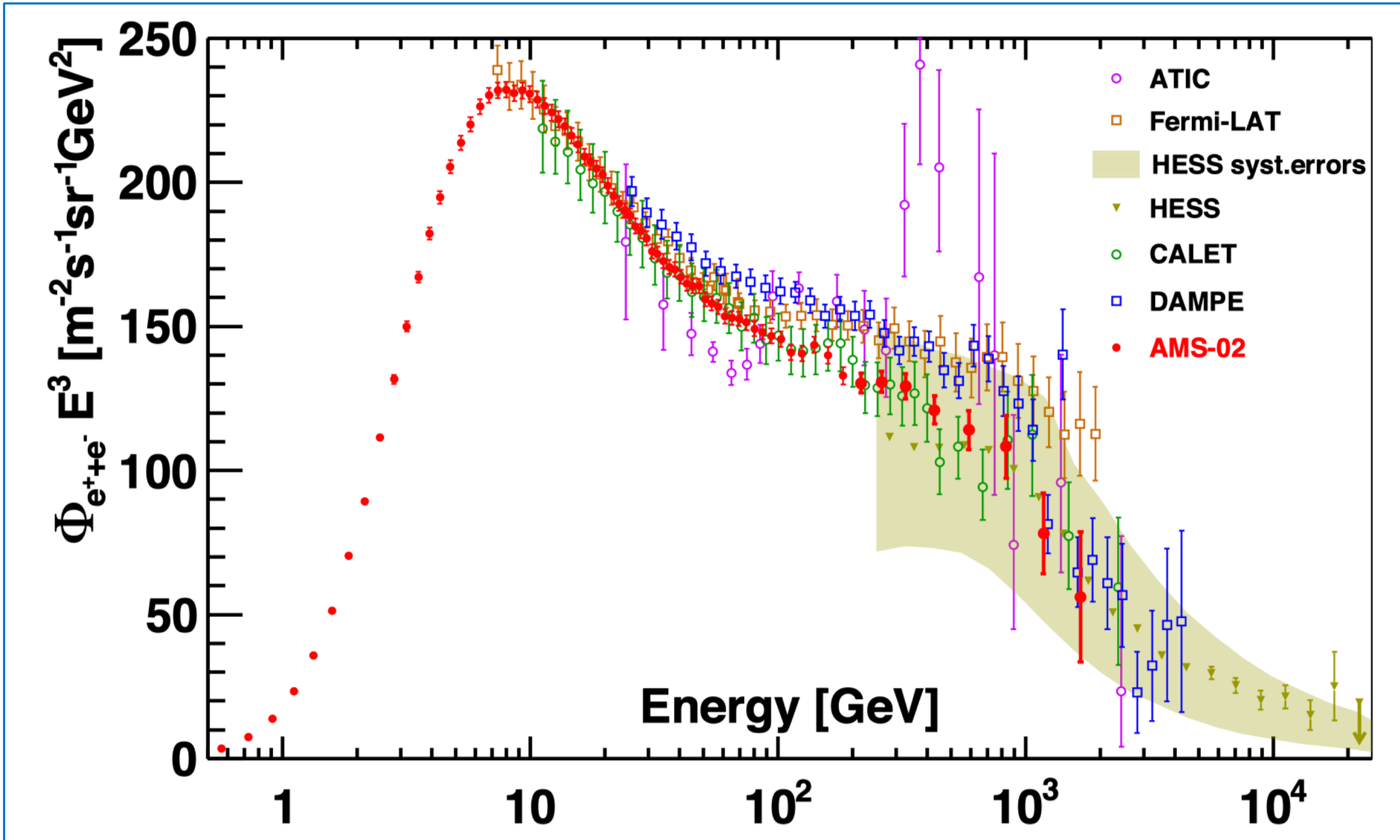


The spectral index



Electron spectral index hardens starting from ~20 GeV and is energy independent towards high energy.

Comparison with earlier experiments



CALET and HESS results are in agreement with the AMS measurements

Summary

- Precision measurements of the electron flux up to 1.4 TeV were presented using 28.1 M electrons collected by AMS
- The electron flux exhibits a significant excess starting from 42 GeV and does not show an exponential energy cutoff.
- In the entire energy range the electron flux is well described by the sum of two power law components.
- The electron spectra have distinctly different magnitudes and energy dependences from positron spectra. At high energy most of electrons originate from different sources than positrons.
- AMS will continue the measurements through the life time of the Space Station and more results are yet to come.