Understanding the Origin of Cosmic-Ray Electrons

TEVPA 2023
Napoli

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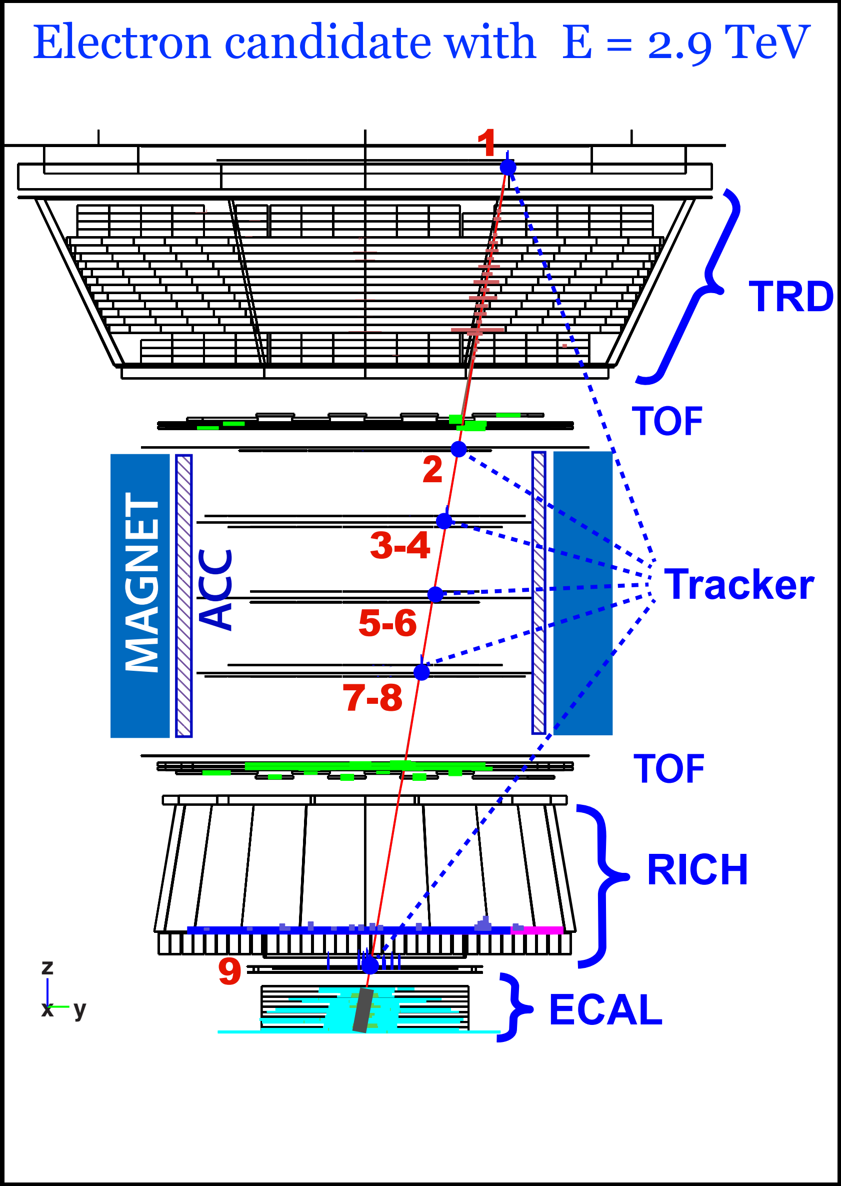
on behalf of the AMS Collaboration

Electron identification with AMS



- Tracker planes 1 to 9 measure the particle charge and momentum.
- The TRD identifies the particle as an electron.
- The TOF measures the charge and ensures that the particle is downward-going.
- The RICH independently measures the charge and velocity.
- The ECAL measures the 3D shower profile, independently identifies the particle as an electron and measures its energy.

AMS on ISS

AMS 2011-2025

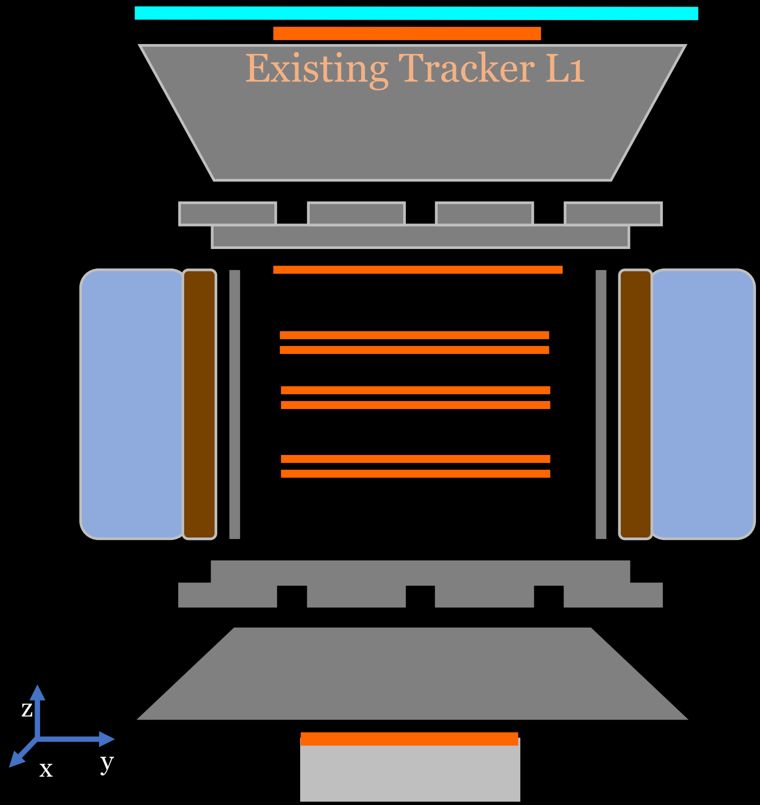
Continuous data-taking

Latest Results: 2011-2022

AMS 2025-2030

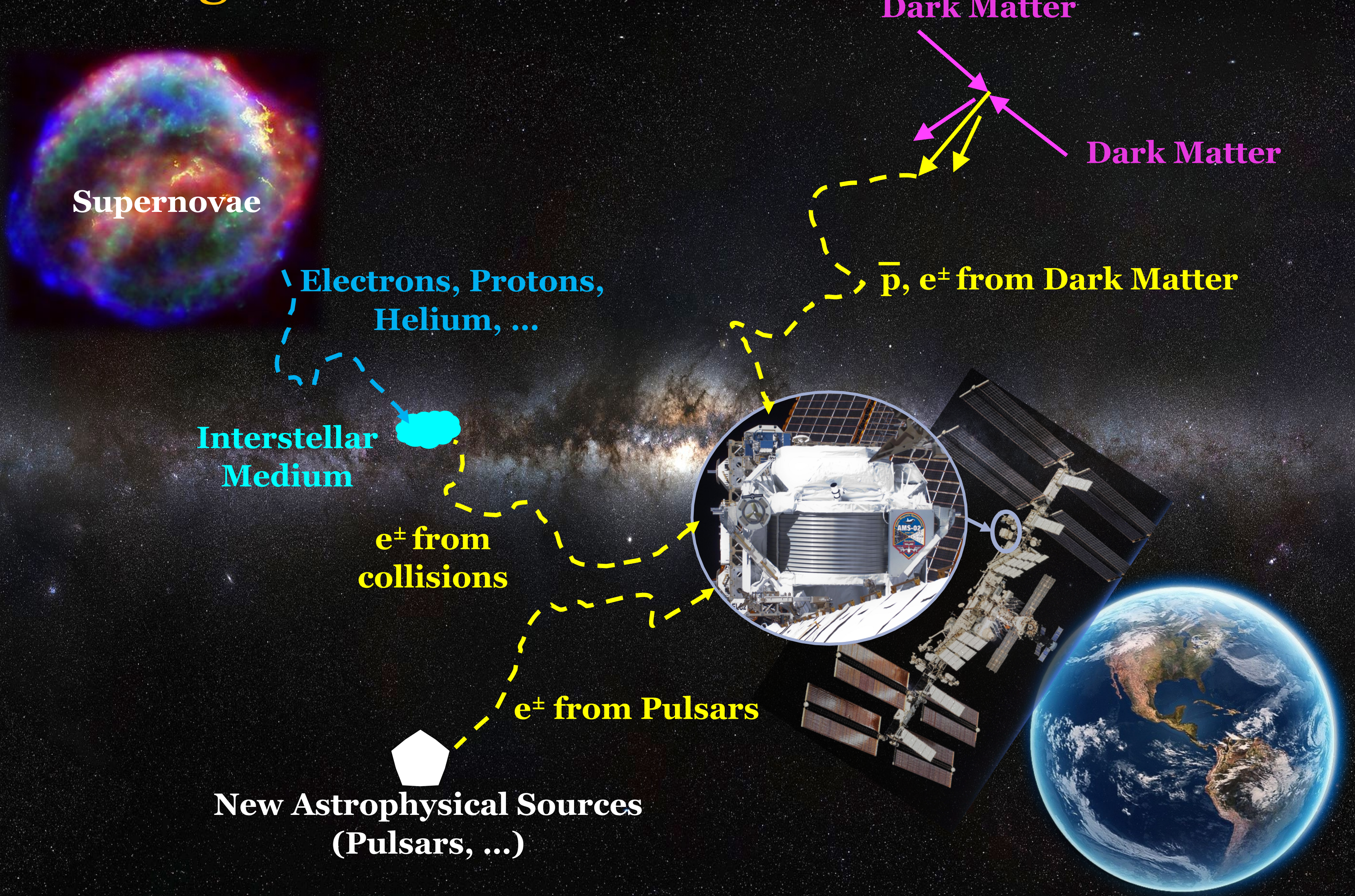
New 8m² Silicon Tracker Layer

Acceptance increased to 300%

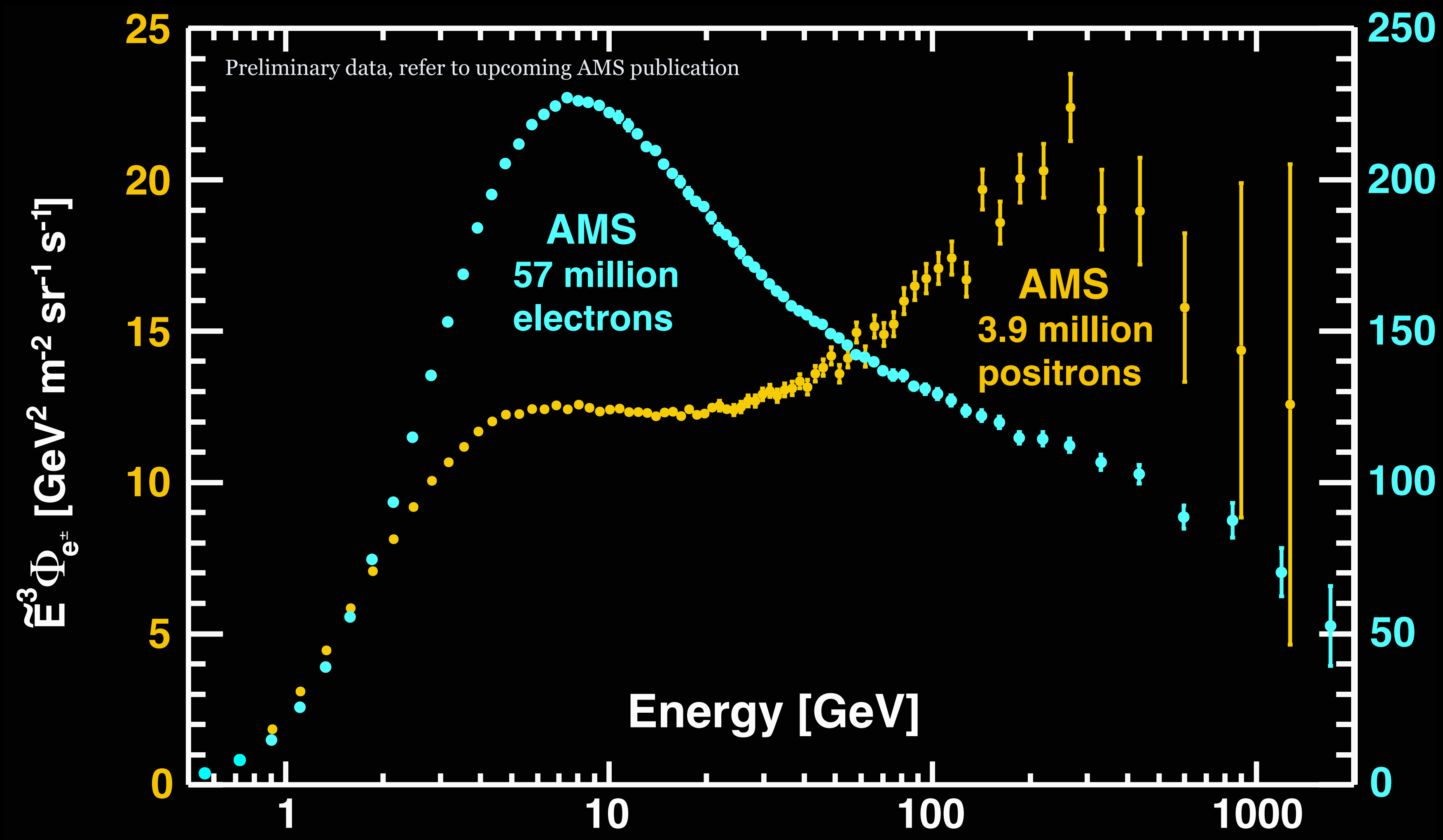


Projections to 2030

The origins of cosmic electrons

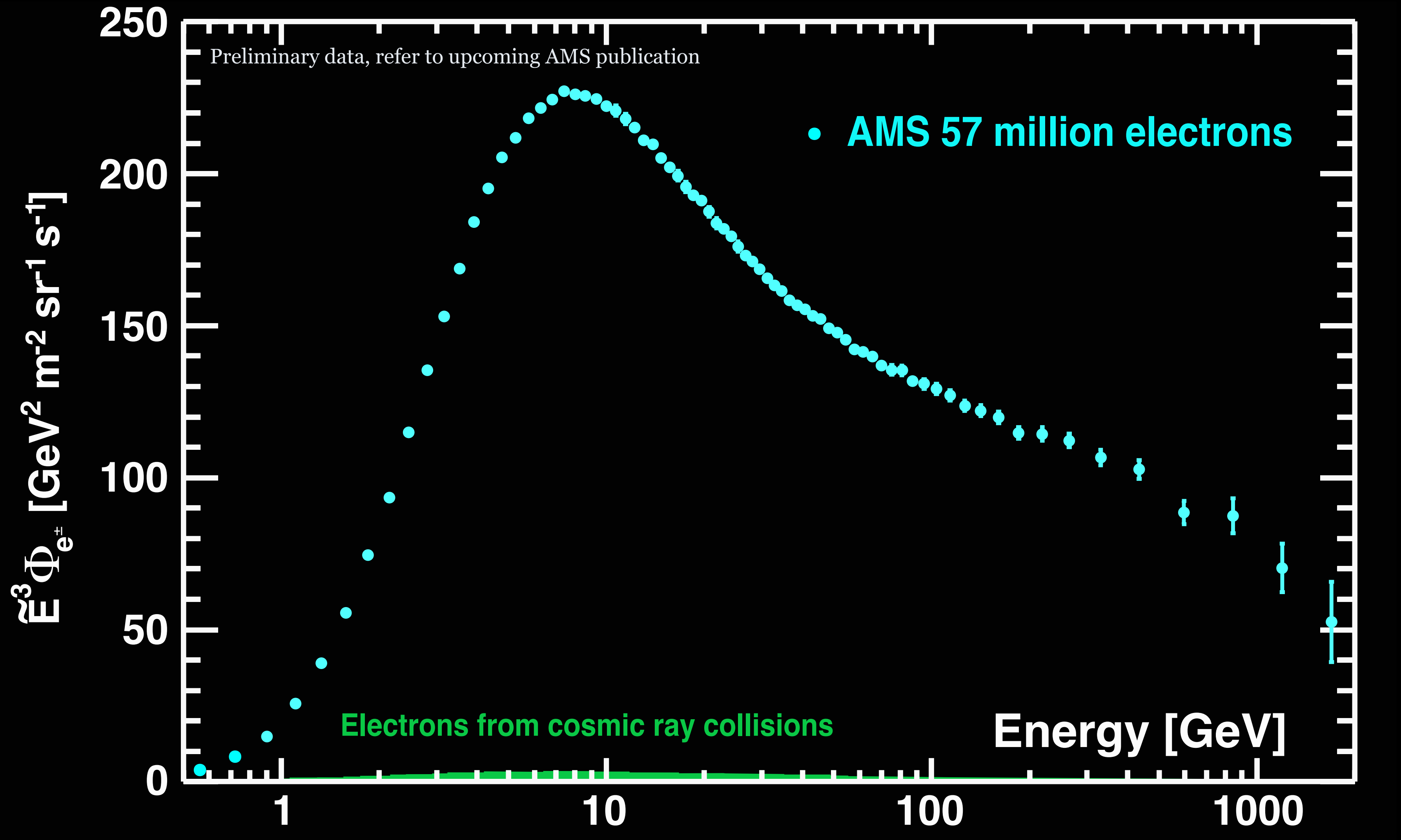


Latest Physics Results from AMS: Study of Positrons & Electrons



The Origin of Electrons

The contribution from cosmic ray collisions is negligible



The Origin of Electrons

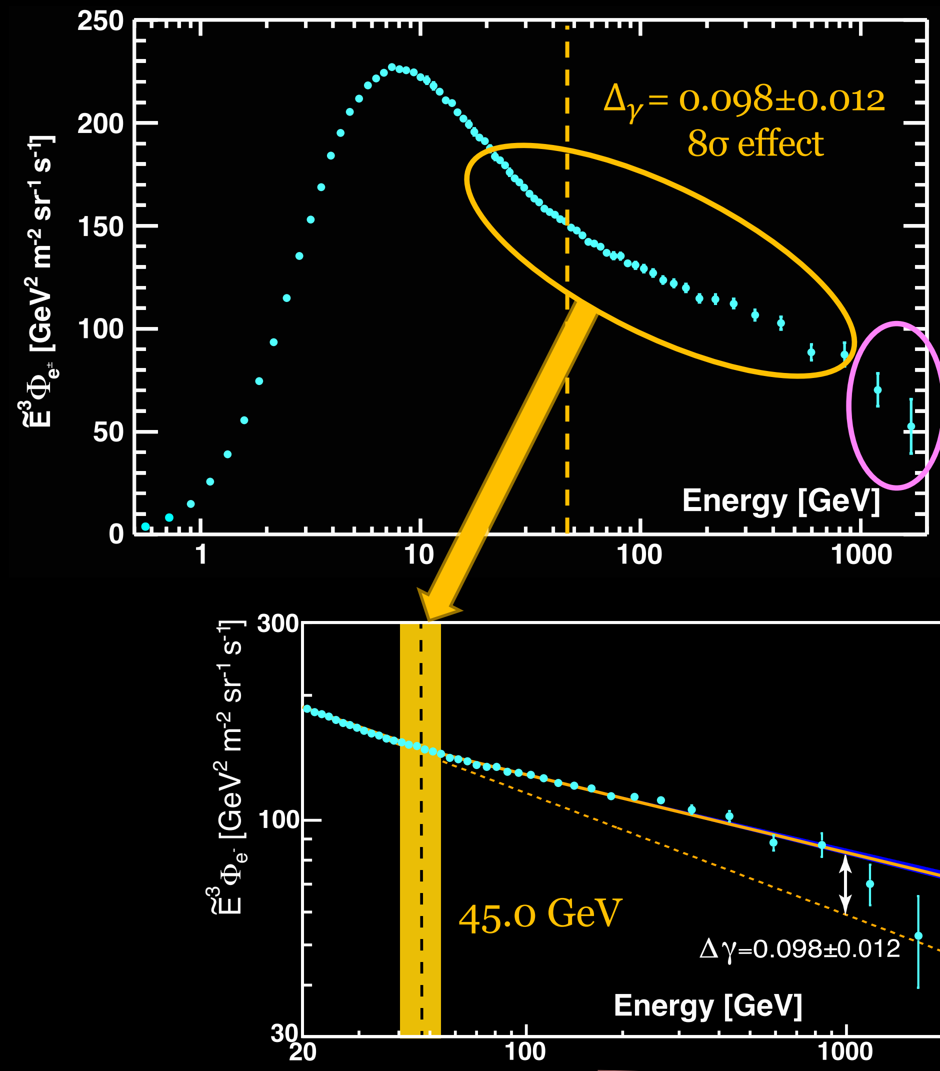
Traditionally, cosmic ray spectrum is described by a power law function

Fit to data

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

A significant excess at
E_o = 45.0±3.1 GeV

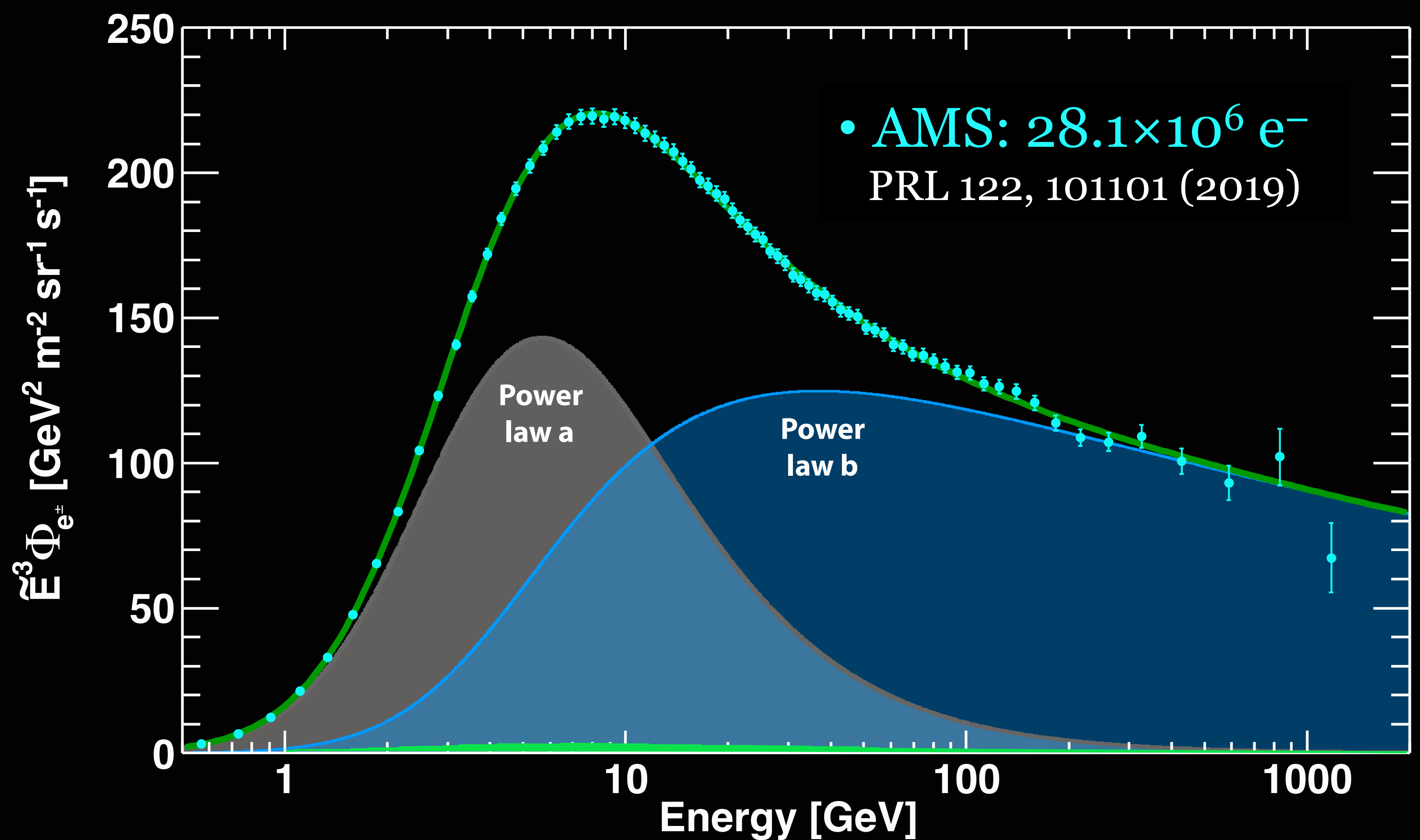
Change of the behavior at ~1 TeV



The electron flux description

$$\Phi_{e^-}(E) = S(E)\left[C_a(\hat{E}/E_a)^{\gamma_a} + C_b(\hat{E}/E_b)^{\gamma_b}\right]$$

Solar & low-energy — Power law a — Power law b



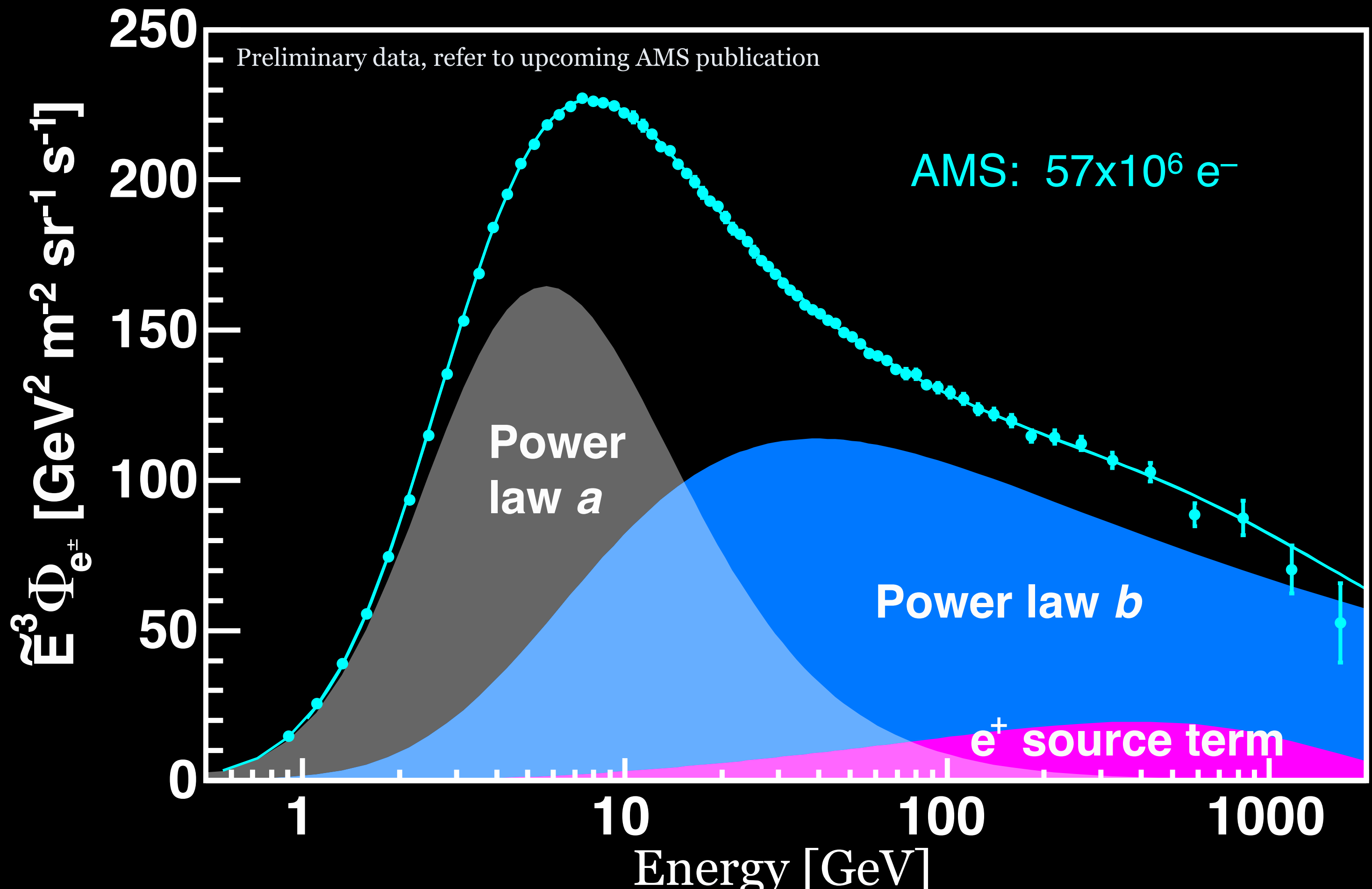
With new portion of data this description is no longer favorable

AMS Result on the electron spectrum

The spectrum fits well with two power laws (a, b) and a source term like positrons

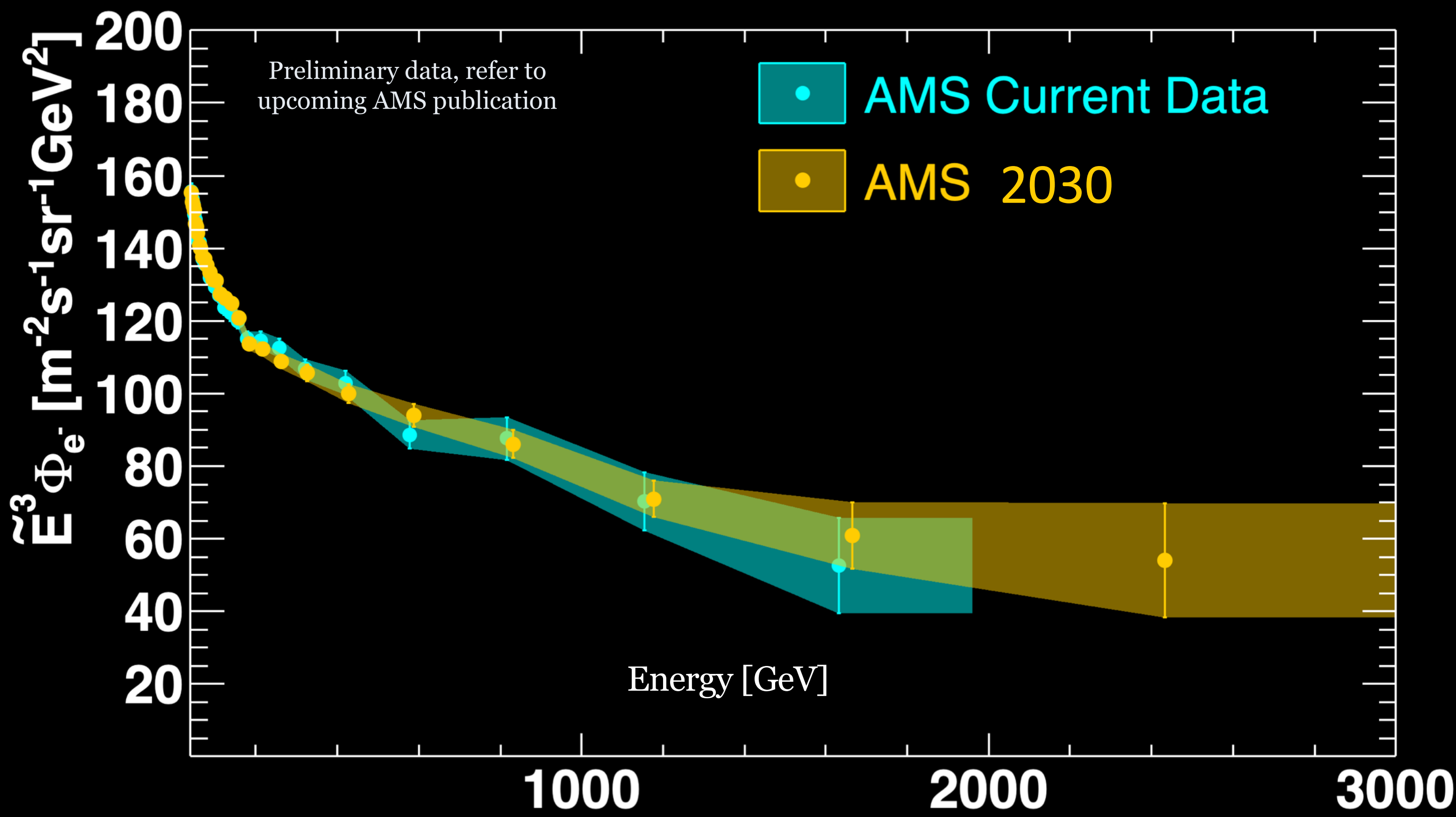
$$\Phi_{e^-}(E) = \frac{E^2}{\hat{E}^2}\left(C_a \hat{E}^{\gamma_a} + C_b \hat{E}^{\gamma_b} + \textbf{Positron Source Term}\right)$$

Solar   Power law a Power law b 2.6σ effect

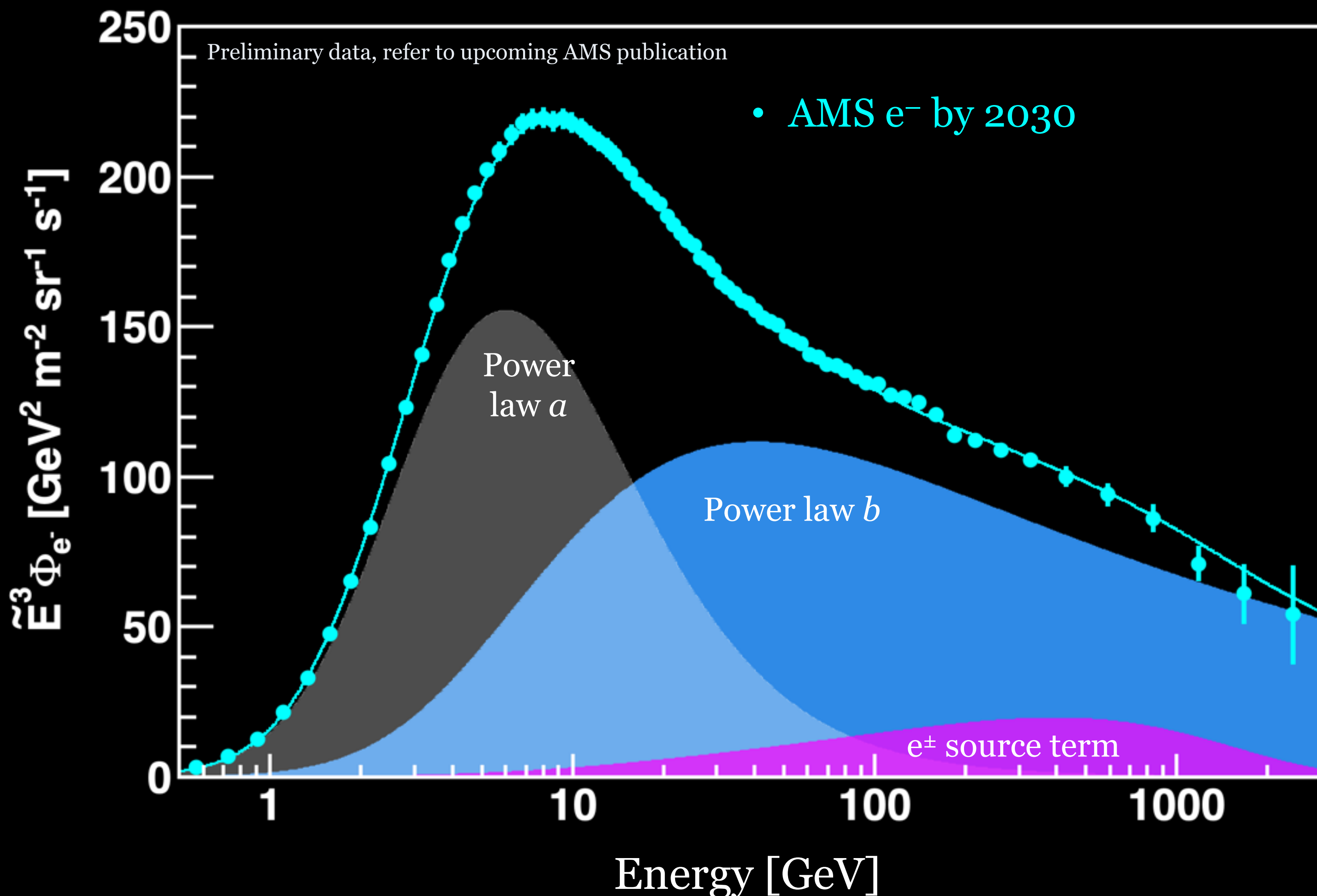


New sources, like Dark Matter or Pulsars, produce equal amounts of e+ and e–

By 2030, AMS will extend the energy range of the electron flux measurement from 2 to 3 TeV and reduce the error by a factor of two compared to current data

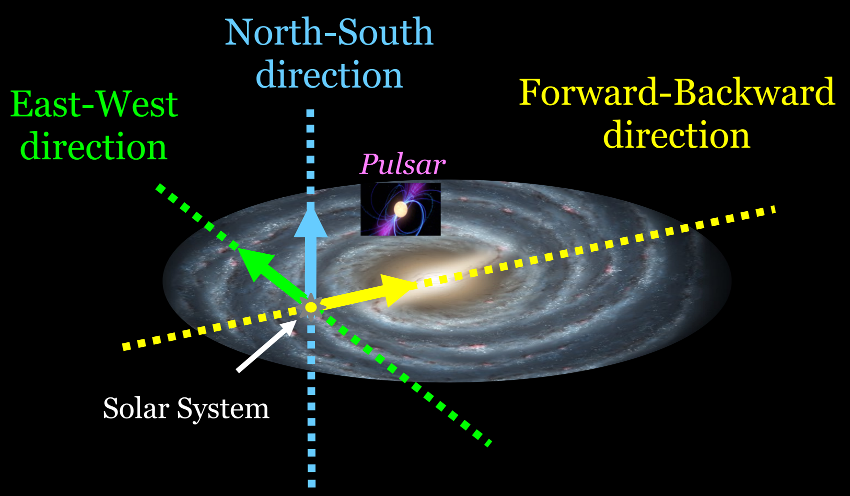


By 2030, the charge-symmetric nature of the high energy source will be established at the 4σ level



Electron Anisotropy

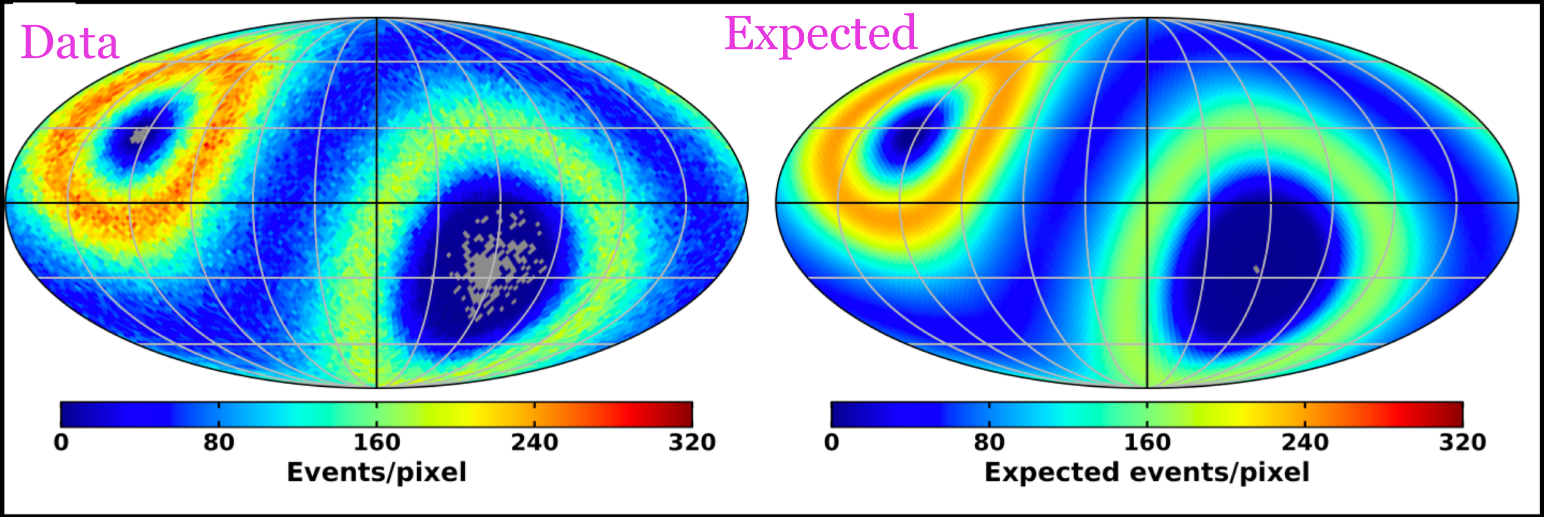
The electron flux is found to be consistent with isotropic distribution.



Dipole anisotropy:

$$\delta = 3\sqrt{C_1/4\pi}$$

C_1 is the dipole moment



Summary

- The behavior of the electron and positron spectra is distinctly different.
- Electron spectrum shows complex behavior that can be best described by the sum of two power law functions and the contribution of the positron-like source term.
- Significance of this observation is 2.6σ at present. More data is needed to establish the existence of charge-symmetric positron-like source term at highest electron energies.
- By 2030, the charge-symmetric nature of the high energy source will be established at the 4σ level.