Towards Understanding the Origin of Cosmic-Ray Electrons

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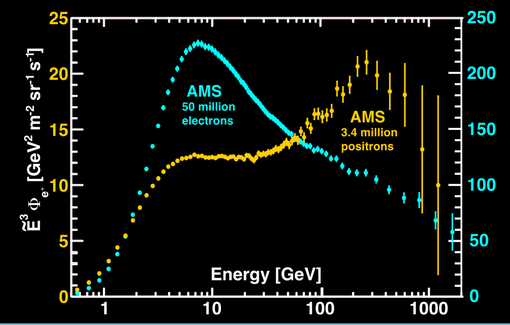
Abstract

Precision results on cosmic-ray electrons are presented in the energy range from 0.5 GeV to 2.0 TeV based on 50 million electrons collected by the Alpha Magnetic Spectrometer on the International Space Station. In the entire energy range the electron and positron spectra have distinctly different magnitudes and energy dependences. At medium energies, the electron flux exhibits a significant excess starting from 49.5 GeV compared to the lower energy trends, but the nature of this excess is different from the positron flux excess above 24.2 GeV. At high energies, our data show that the electron spectrum can be best described by the sum of two power law components and a positron source term. This is the first indication of the existence of identical charge symmetric source term both in the positron and in the electron spectra and, as a consequence, the existence of new physics.

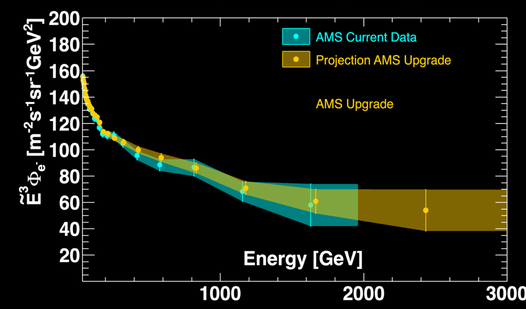
Latest Positrons and Electrons Results

In the entire energy range the electron and positron spectra have distinctly different magnitudes and energy dependences.



About AMS Upgrade

Electron Spectrum at High Energy



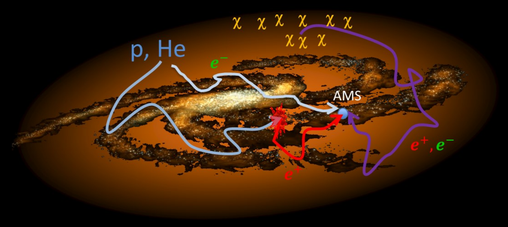
The upgrade will extend the energy range of the electron flux measurement from 2 TeV to 3 TeV and reduce the error by a factor of two.

Electrons and Positrons in the Cosmos

Electrons are produced and accelerated in SNR together with proton, Helium. They are primary cosmic rays that travel through the galaxy and detected by AMS.

These particle interact with the interstellar matter and produce secondary source of anti-particle: positron, anti-protons etc. They are much less abundant in astrophysics process.

New physics sources like Dark Matter produce both particles and antiparticles in equal amount.



Result

Origins of Cosmic Electrons

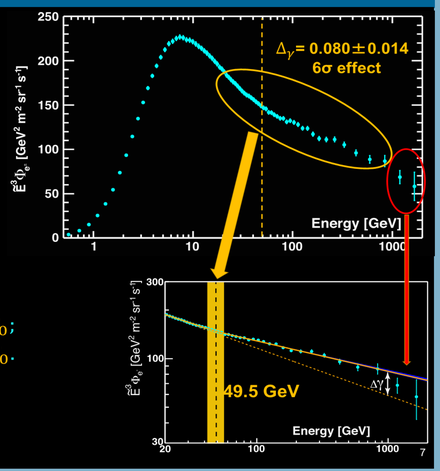
Traditionally, Cosmic Ray spectrum is described by a power law function

Change of the behavior at ~50 GeV and at ~1 TeV

Fit to data

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

A significant excess at $E_0 = 49.5 \pm 5.6$ GeV



About AMS Upgrade

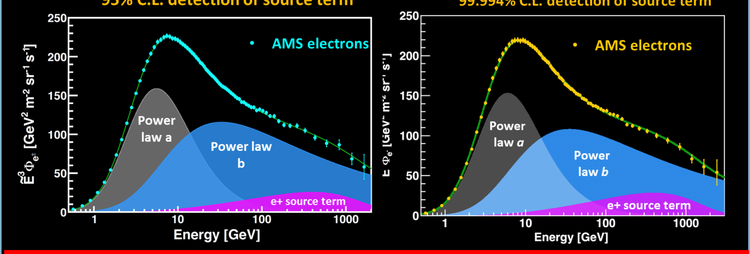
Origin of high energy electrons

New sources like Dark Matter will produce equal amounts of positrons and electrons

$$\Phi_{e^-}(E) = \underset{\text{Power law } a}{C_a E^{\gamma_a}} + \underset{\text{Power law } b}{C_b E^{\gamma_b}} + \underset{\text{Positron source term}}{C_s E^{\gamma_s} \exp(-E/E_s)}$$

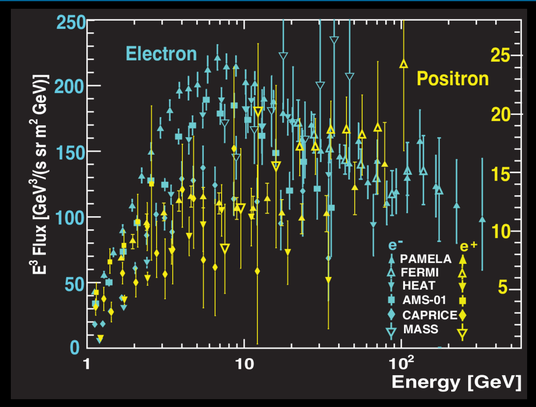
Current Data
95% C.L. detection of source term

With Upgrade
99.994% C.L. detection of source term



The upgrade will establish the charge-symmetric nature of the high energy positron source term at the 99.994% C.L.

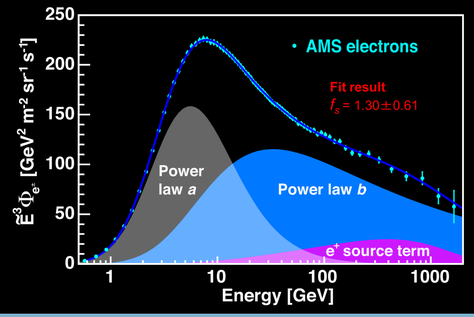
Measurements of positrons and electrons before AMS



Result

Electron spectrum favors the contribution of the positron-like source term

$$\Phi_{e^-}(E) = S(E)\left[C_a(\hat{E}/E_a)^{\gamma_a} + C_b(\hat{E}/E_b)^{\gamma_b} + f_s C_s^{e^+}(\hat{E}/E_2)^{\gamma_s^{e^+}} \exp(-E/E_s^{e^+})\right]$$



Conclusion

we have presented the high statistics precision measurements of the electron flux from 0.5 GeV to 2.0 TeV based on a data sample of 50 million electrons. The electron flux exhibits a significant excess starting from 49.5GeV compared to the lower energy trends, and changes the behavior at ~1TeV. The electron flux is well described by the sum of two power law components and a positron source term. With the AMS upgrade, the energy range of electron flux will be extended from 2TeV to 3TeV with reducing the error by a factor of two, and the existence of positron source term will be established at the 99.994% C.L.