The Cosmic Ray Electron Spectrum Measured by the FERMI Large Area Telescope

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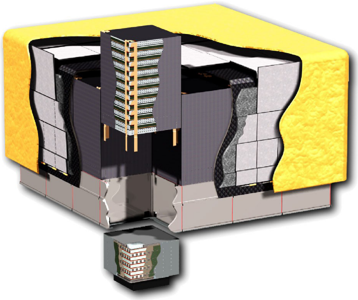
February 25 2010

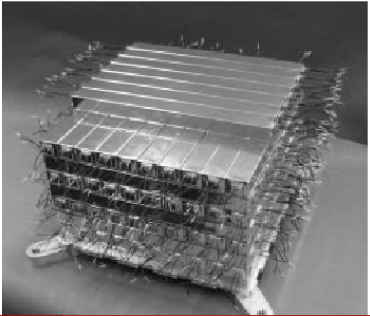
Outline

- What is the Fermi Large Area Telescope (LAT): Essentially a tracker and calorimeter in space
  - Meant to measure γ rays with energy up to 300 GeV
  - Can measure electrons up to an energy of 1 TeV
- What has been measure: Cosmic ray electron spectrum
- What is special about this measurement: Found an excess in electron flux $\longrightarrow$ several different solutions
  - Tweaking current model for cosmic rays
  - Pulsars as local sources for electrons
  - Dark matter annihilation

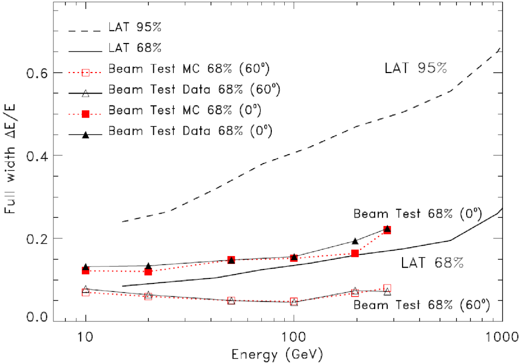
The Detector

- Consists of 4x4 towers with 9500 cm^2 of collecting area
- Each tower contains a silicon strip tracker on top of a CsI calorimeter
- Silicon layers are interleaved with converter plates
- Silicon strips are at a 90 degree angle to each other for better spacial resolution
- CsI calorimeter is set up in a hodoscopic layout (CsI crystals are at 90 degree angle)
- CsI crystals have a asymmetric light yield for position resolution



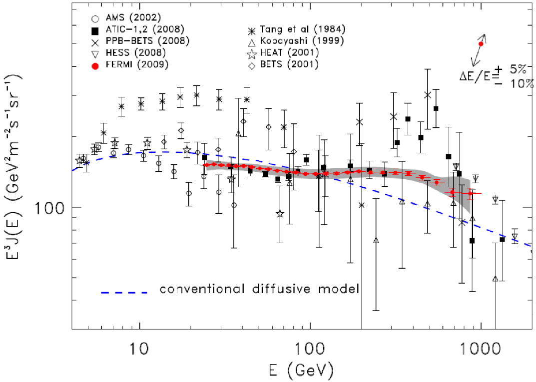


Detector Performance



Angular and Energy Resolution

The total energy resolution is less than 20% up to 1 TeV for electrons while the angular resolution of 0.15 degrees at 10 GeV



There's an Excess

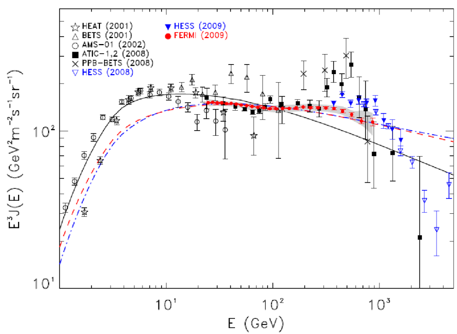
- The Fermi LAT found an excess of electrons with energy above ∼100 GeV. Other experiments also show indications of an excess.
- The measurement was dominated by systematic error (∼5-20%)
- Error was largest at higher energy due to more hadron contamination

Possible Causes of the Excess

Tweaking Conventional Model Parameters

There is a theoretical model that predicts the spectrum of different types of cosmic rays

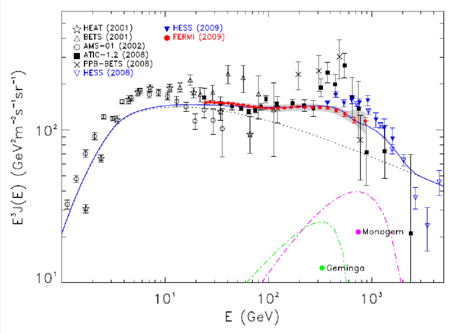
- Worked well for pre Fermi LAT data
- Has two main parameters for the flux: $N_e(E) \propto E^{-(\gamma_0+\delta_0/2+1/2)}$
- Changing γ_0 (the injection spectrum) and δ_0 could yield a better fit LAT data
- New values for the parameters cause problems at low energy and can't explain the PAMELA positron excess



Possible Causes of the Excess (cont.)

Pulsars

- Pulsars are known electron sources
- Electron-positron pairs can be created by the photons emitted from electrons in the pulsar magnetosphere
- These pairs can have very high energies ($\sim 10^3$ TeV) for young pulsars but are lower for older pulsars
- These electrons-positron pairs would be trapped in the pulsar's wind nebula for young pulsars $\rightarrow$ only mature pulsars are considered
- Conventional Model with pulsars fits LAT data very well as well as PAMELA data



Possible Causes of the Excess (cont.)

Dark Matter Annihilation

- Most probable model has dark matter particles with m>100 GeV annihilate to light scalars ($\chi\chi \rightarrow \phi\phi$)
- Light scalar than decays into e^+e^- pair
- Mass of light scalar is constrained by gamma ray and anti-proton measurements
  - Can't have excess due to π_0 decay $\rightarrow m_\phi < m_{\pi_0}$
- Need evidence that only could come from dark matter and not pulsars
  - There should be more radiation near galactic center (recent experimental results show evidence of excess of gamma rays from galactic center)
  - Pulsars are assumed to have a homogeneous distribution throughout the galaxy
- Consitent with PAMELA excess