The Fermi-LAT measurement of the primary cosmic ray electron spectrum between 7 GeV and 1 TeV

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on behalf of the Fermi-LAT Collaboration

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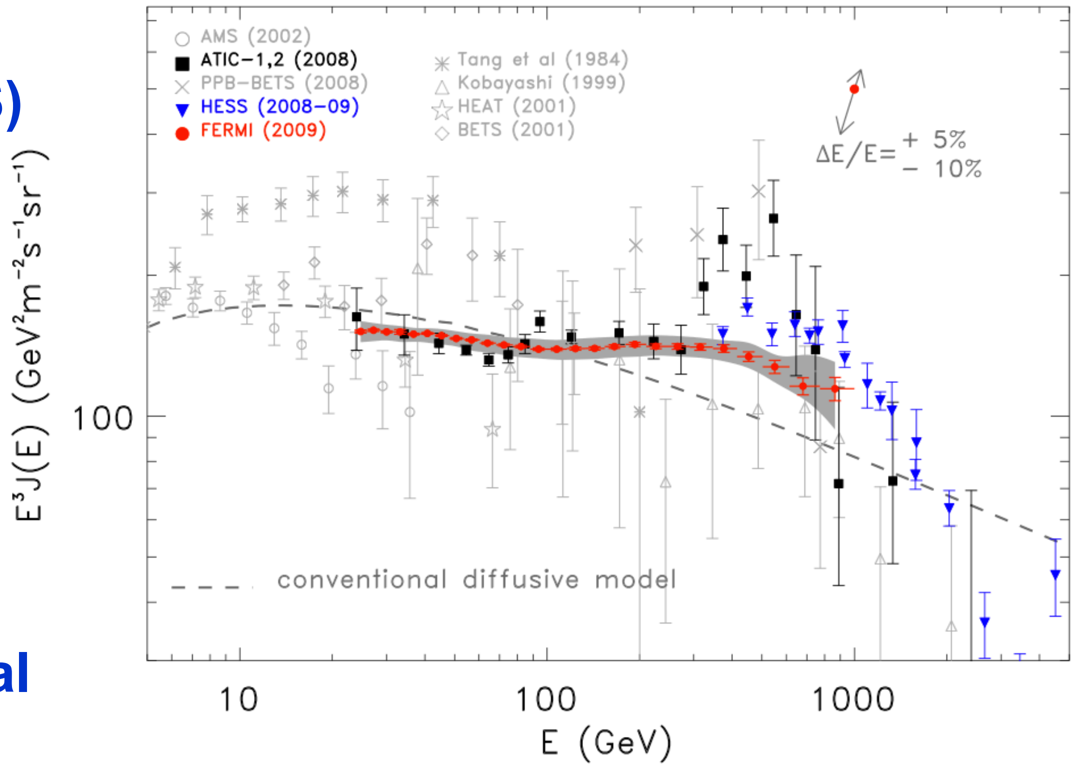
The Fermi CRE Spectrum in May 2009

- **Measurement 20 GeV – 1 TeV**
  - **hard (~ E^{-3})**
  - **flat (no spectral features)**
  - **cutoff above ~1 TeV (HESS)**
- **Observational consequences**
  - **Pure diffusive models**
    - **pre-Fermi too soft**
    - **proper choice of model params fit data**
    - **source stochasticity can explain hardness**
  - **Models with additional local electron source**
    - **Many fit data well**
    - **Local component nature is astrophysical or Dark Matter**

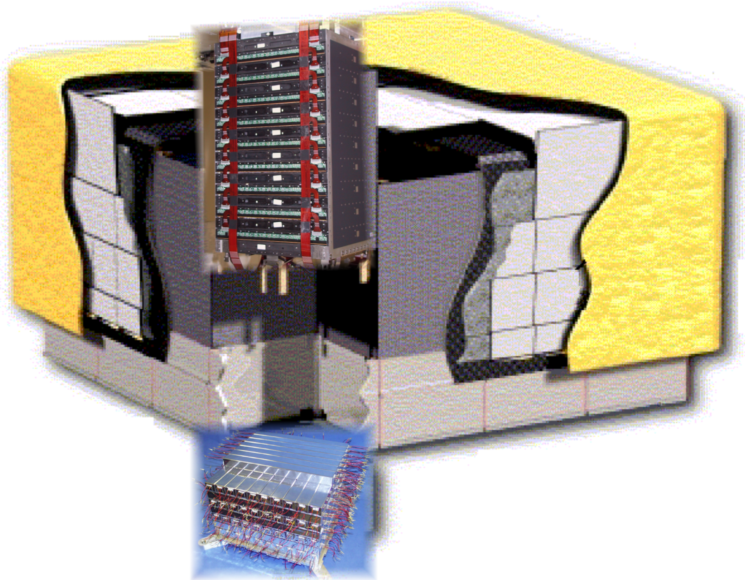


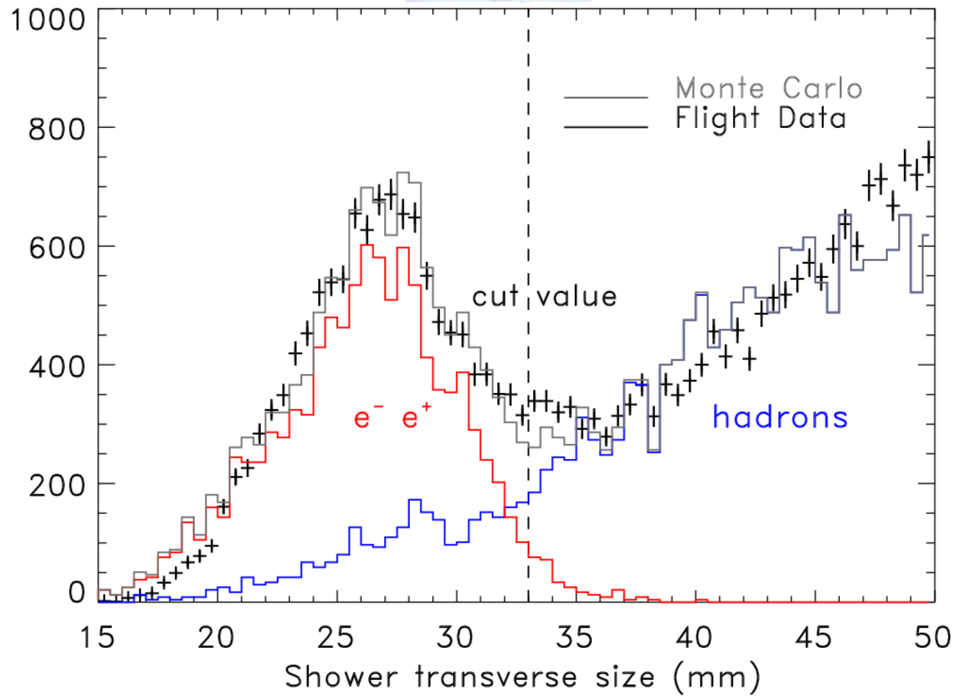
Abdo, A. A. et al, PRL 102 181101 (2009)

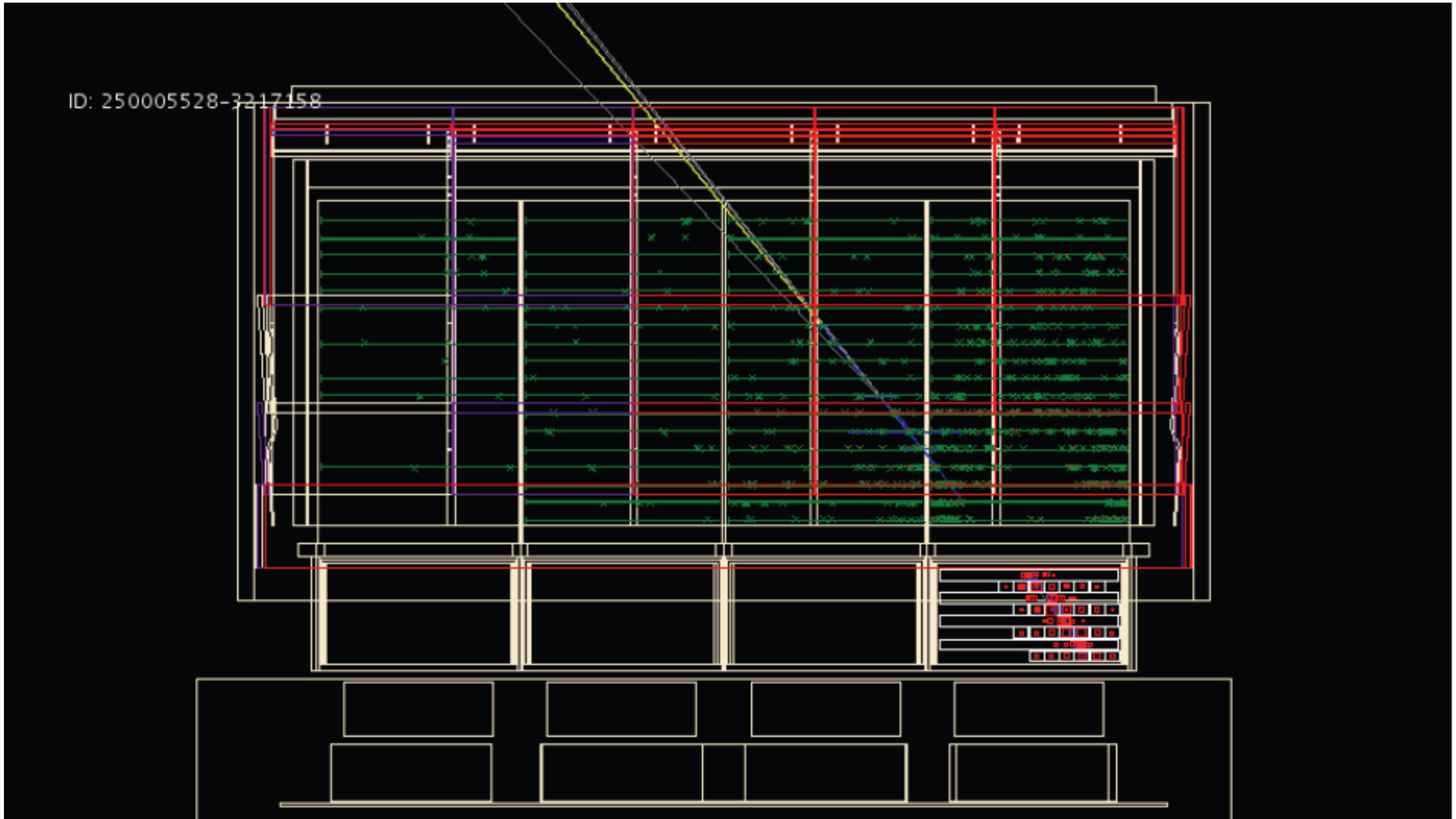
→ > 1 ref/day (>60% related to DM scenarios)

LAT electron detection capabilities

- ❑ **Huge electron statistics (~8M/yr)**
  - **Large area, high duty cycle**
- ❑ **3 powerful detectors (ACD, TKR, CAL)**
  - **All contribute to electron ID by sampling EM vs hadron shower development**
- ❑ **Very accurate MonteCarlo instrument simulation**
  - **Performance metrics, event selection, residual contamination**
- ❑ **Validations with flight and ground data**
  - **Energy reconstruction**
  - **MC simulation**







A candidate hadron event – raw energy > 800 GeV

CalEnergyRaw
8.228e+05

CTBBestEnergy
1.026e+06

CTBBestEnergyProb
0.146

TkrNumTracks
5

CalCsIRLn
10.9

CTBBestZDir
-0.387

CTBTKRHEEProb
N/A

CTBCALHEEProb
N/A

CalLRmsAsym
0.00419

CalTrSizeTkrT95
1022.6

CalTransRms
34.4

Tkr1CoreHC
1

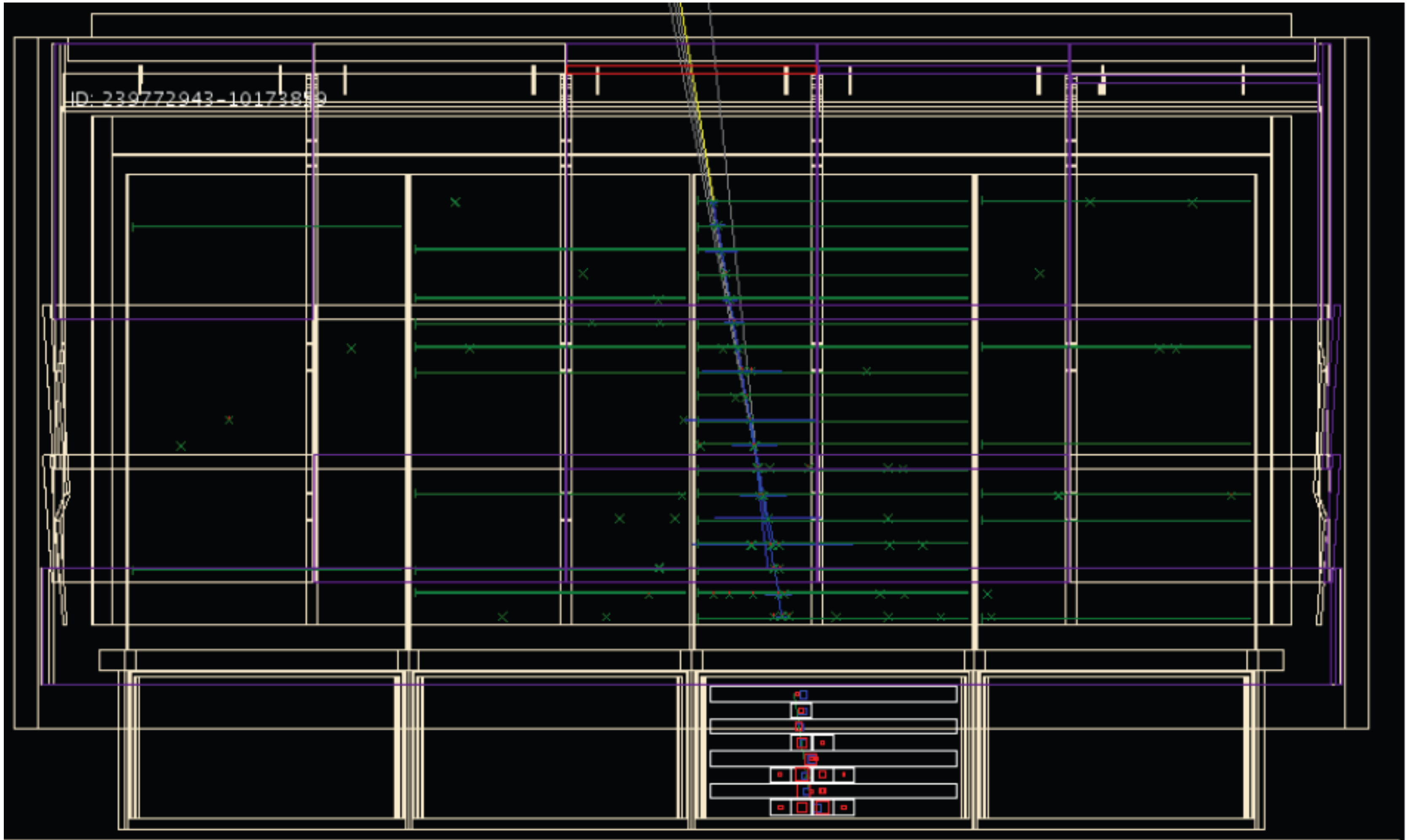
Tkr1Hits
6

Tkr1ToTTrAve
0

AcdTotalEnergy
660.7

AcdTileCount
65

- **ACD: large energy deposit per tile**
- **TKR: small number of extra clusters around main track, large number of clusters away from the track**
- **CAL: large shower size, low probability of good energy reconstruction**



A candidate electron – 844 GeV

CalEnergyRaw
2.501e+05

CTBBestEnergy
8.443e+05

CTBBestEnergyProb
0.531

TkrNumTracks
5

CalCsIRLn
8.49

CTBBestZDir
-0.986

CTBTKRHEEProb
0.924

CTBCALHEEProb
0.733

CalLRmsAsym
0.0656

CalTrSizeTkrT95
9.73

CalTransRms
23.8

Tkr1CoreHC
29

Tkr1Hits
35

Tkr1ToTTrAve
5.40

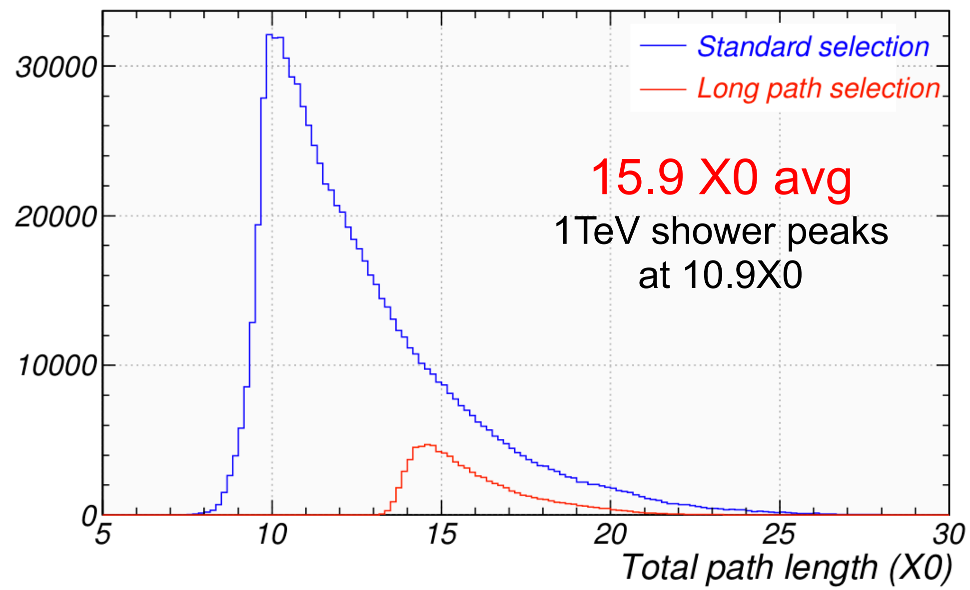
AcdTotalEnergy
8.99

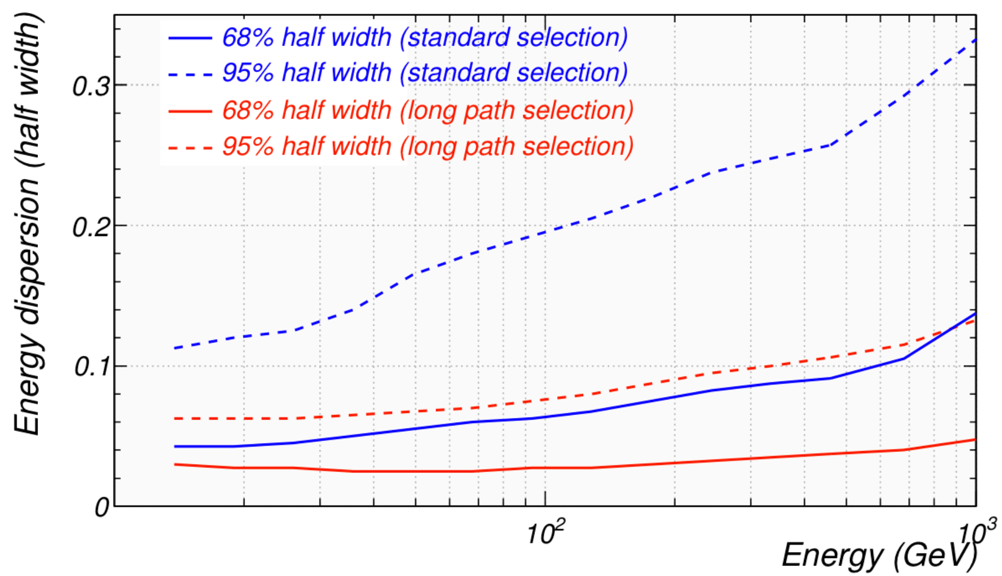
AcdTileCount
20

- **ACD: few hits in conjunction with track**
- **TKR: single clean track, extra clusters around main track clusters (preshower)**
- **CAL: clean EM shower not fully contained in CAL**

Energy resolution checks – High X0 events

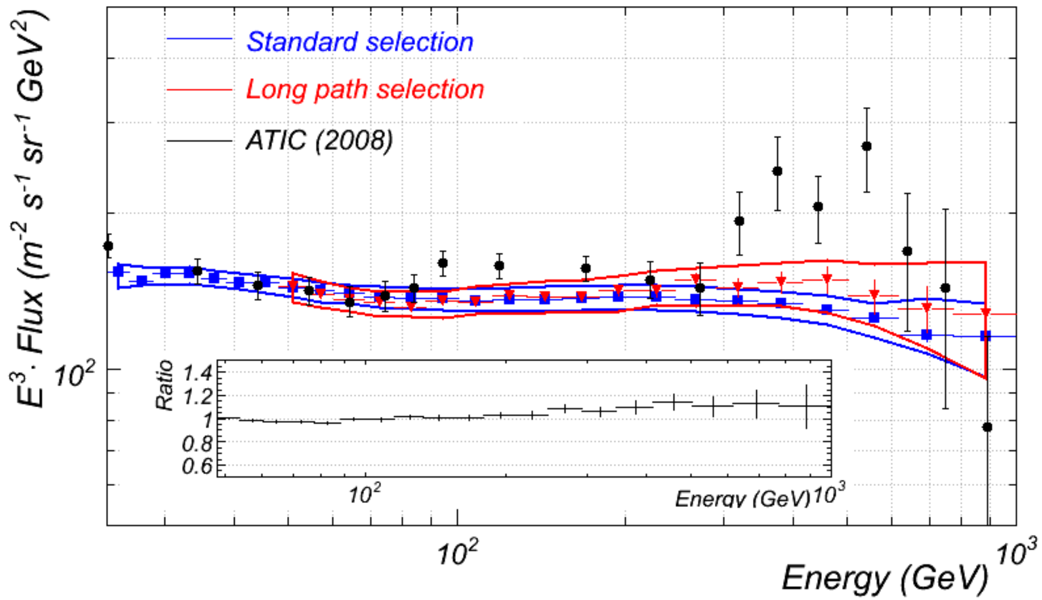
- Critical for high energies
  - Shower leakage from CAL
- Select subsample of events with long path-length (HI-X0)
  - X0>13
    - 12 in CAL + minimum track length in TKR + events contained in a single CAL module
- ↑ Energy resolution X ~ 2 – 4
  - Down to 5% at 1 TeV (68% containment half-width)
- ↓ Instrument acceptance to ~ 5% of standard and limited to a specific portion of instrument phase space
  - Much higher systematics



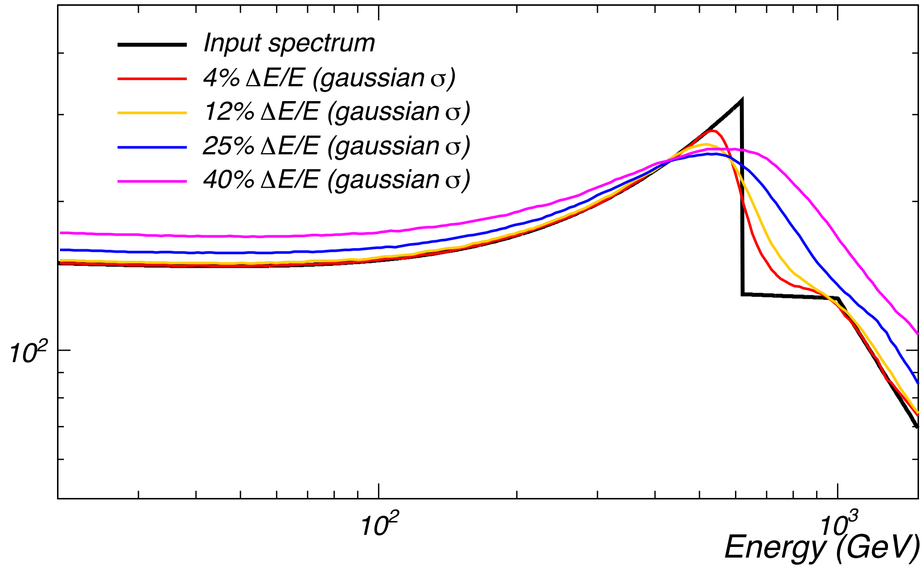


Comparison of standard and High-X0 spectra

- Consistent within their own systematics



- already demonstrated by simulation of LAT response to spectral features with artificially worsened resolution

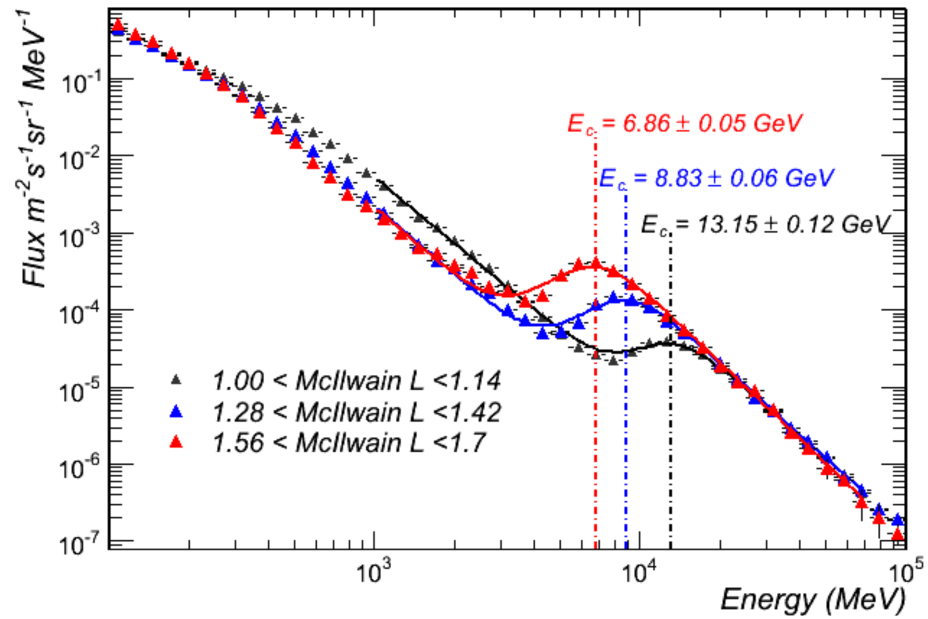


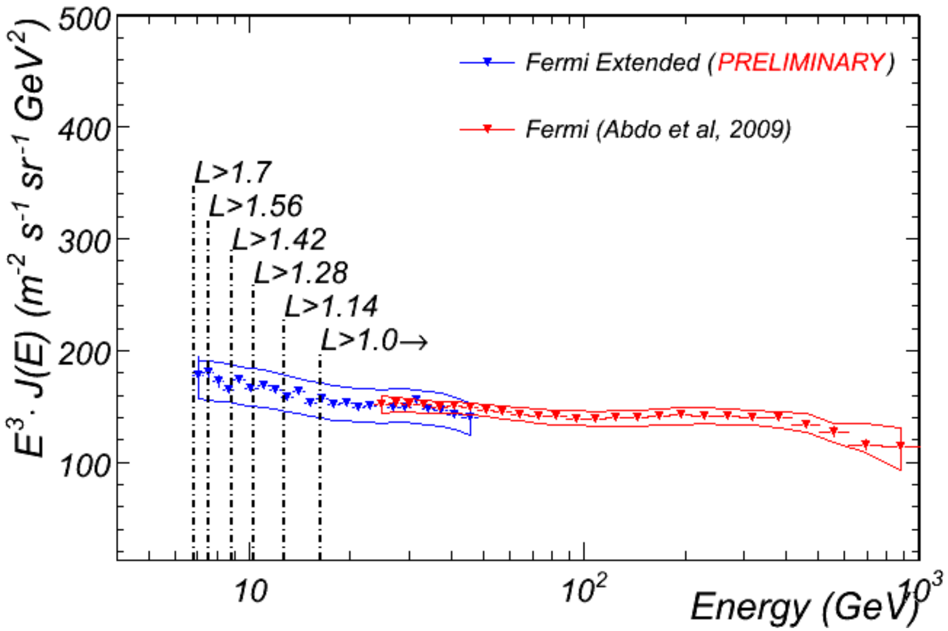
➔ the LAT energy resolution is adequate to detect prominent spectral features

➔ the Fermi spectrum is NOT dependent on the energy resolution of the bulk of the events

Extension to low energy measurements

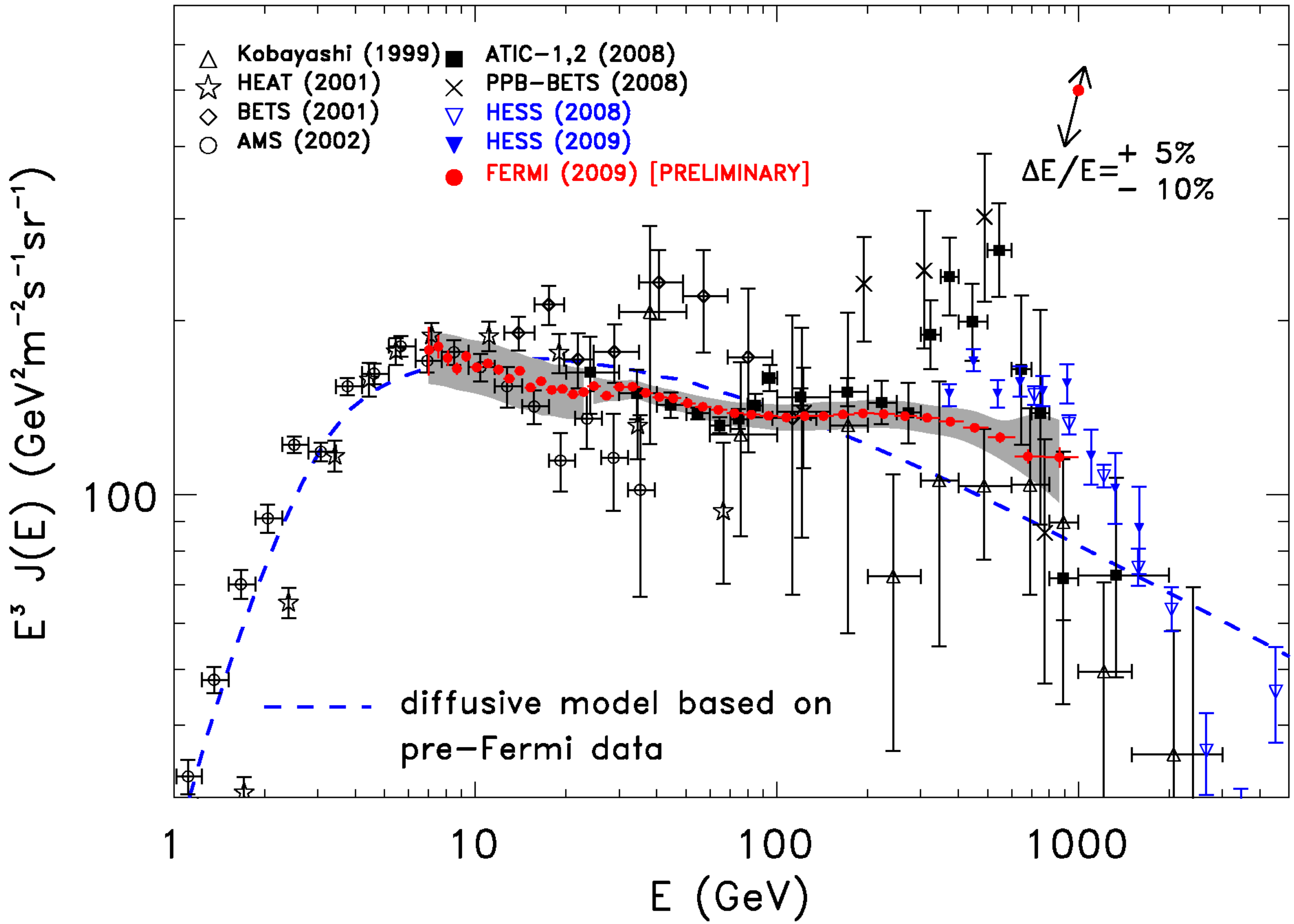
- Determine geomagnetic cutoff energy as a function of geomagnetic orbital coordinates
  - Higher McIlwainL, lower cutoff energy
- Measure spectrum for primary component above cutoff
- Recombine spectra into global spectrum





see M. Pesce-Rollins poster P4 – 124

The Fermi CRE spectrum in october 2009

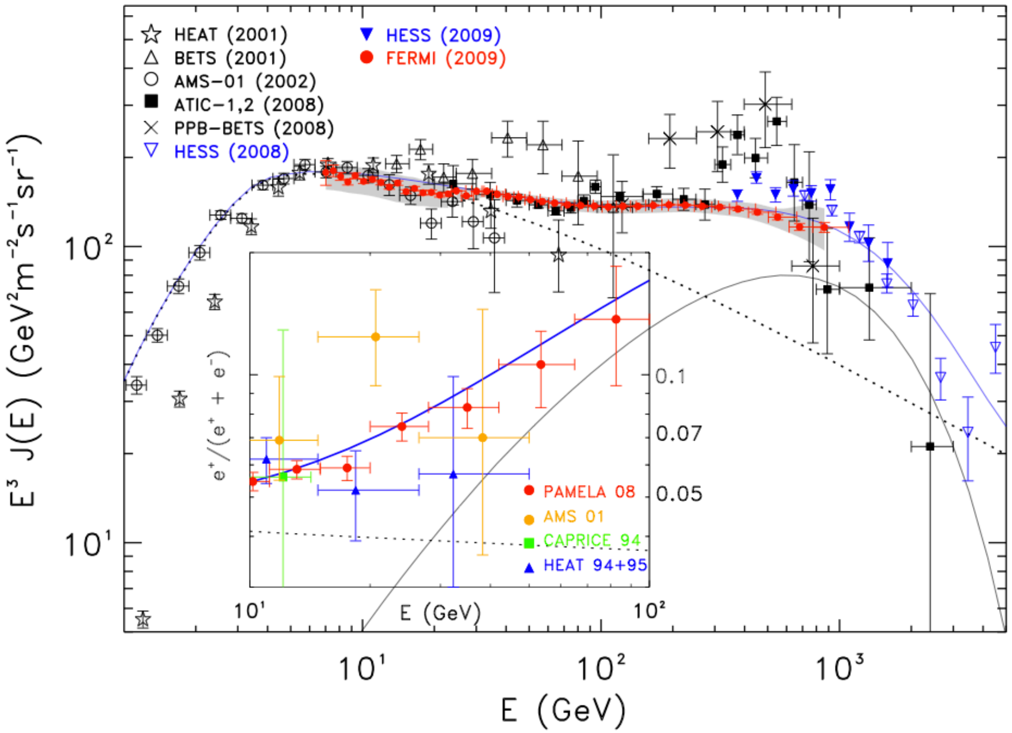


Extended Energy Range (7 GeV – 1 TeV) – One year statistics (8M evts)

Possible interpretations

- **Two-component scenario**
  - **Modified background (primary electron index at source $\gamma0$ = -2.70)**
  - **Additional local component (index = -1.5; E_{cut} = 1.0 TeV)**
  - **Fits Pamela data too**

- **Revised diffusion model**
  - **compliant with gamma-ray data (Fermi) and other CR measurements**
  - **Modifications to standard diffusion and propagation processes**
  - **Modifications to solar modulation effects**



see D. Grasso poster P4 - 237

Conclusions and prospects

- Fermi CRE measurement extended down to 7 GeV and to 1 year statistics
- Event selection checks with long path-length requests indicate no dependence of the measured spectrum on energy resolution
- Spectrum adds valuable information below 10 GeV where strong constraints to propagation models can be imposed
- Several possible interpretations
  - Revised diffusion model
  - Extra component, astrophysical or Dark Matter
- Further work
  - extend energy above 1 TeV to find TeV spectral cut-off
  - Reduce systematics to constrain different components in the overall spectrum
  - Search for anisotropies *(see poster P4 – 121 Vasileiou & Mazziotta)*