Measurement of the Cosmic-ray Proton Spectrum with the *Fermi* Large Area Telescope

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On Behalf of the *Fermi*-LAT Collaboration

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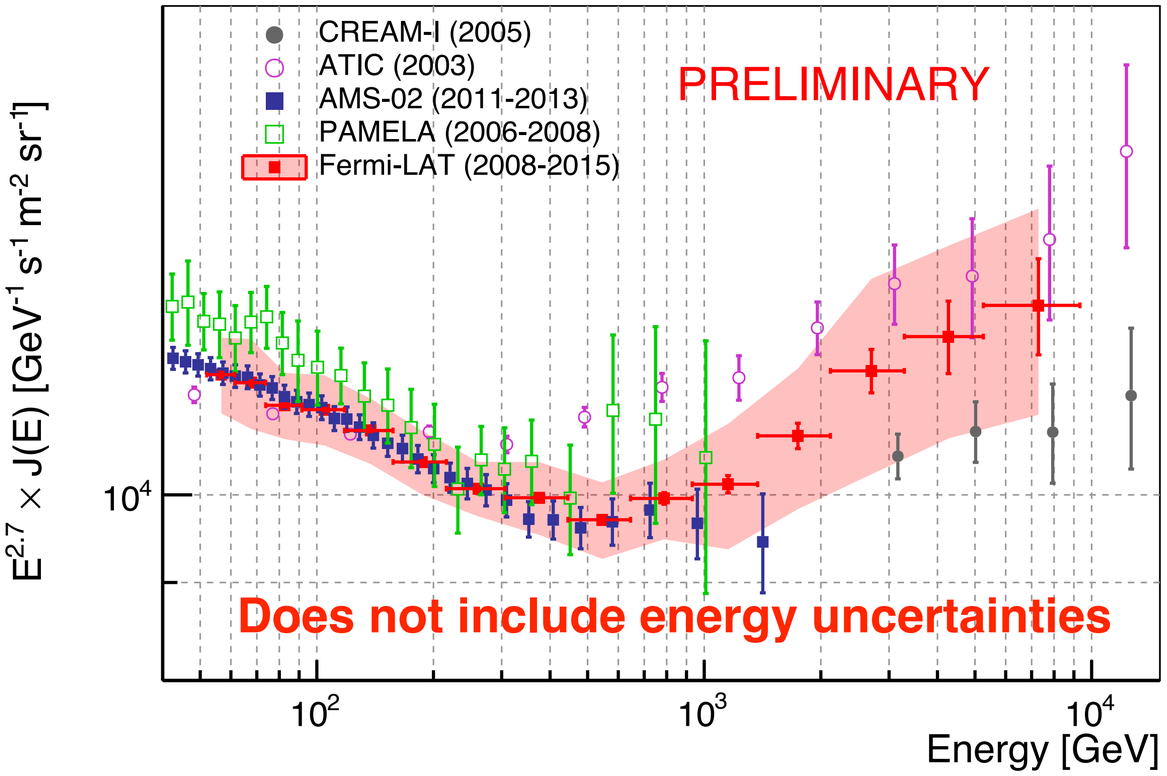


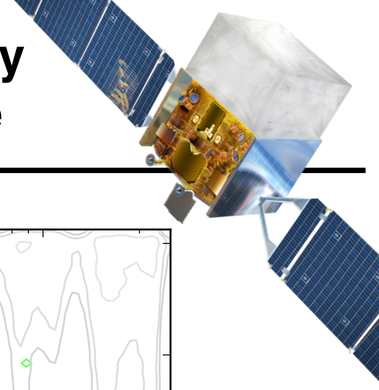
We report the measurement of the cosmic-ray proton spectrum between 54 GeV and 9.5 TeV using 7 years of Pass 8 flight data from the *Fermi* Large Area Telescope (LAT).

Our analysis yields a dataset with statistical uncertainty under 1% up to 1 TeV and residual contamination less than 5% from all other cosmic-ray species.

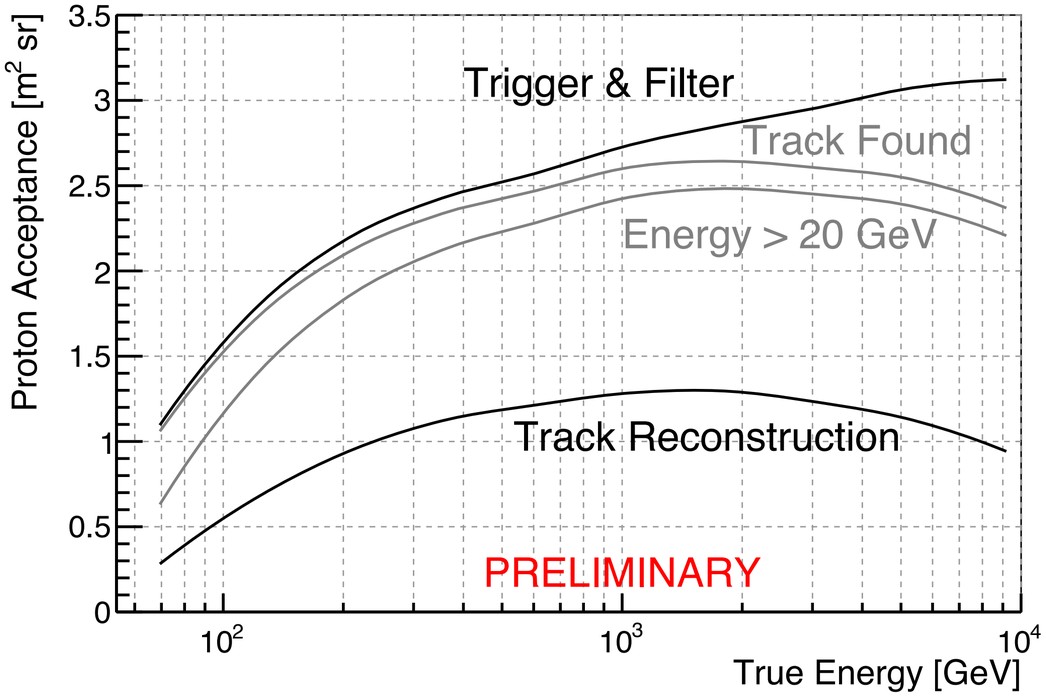
We estimate the systematic uncertainties by testing different event selections and different hadronic interaction models for the GEANT4 Monte-Carlo simulations, and we found that they are an order of magnitude larger than the statistical uncertainty.

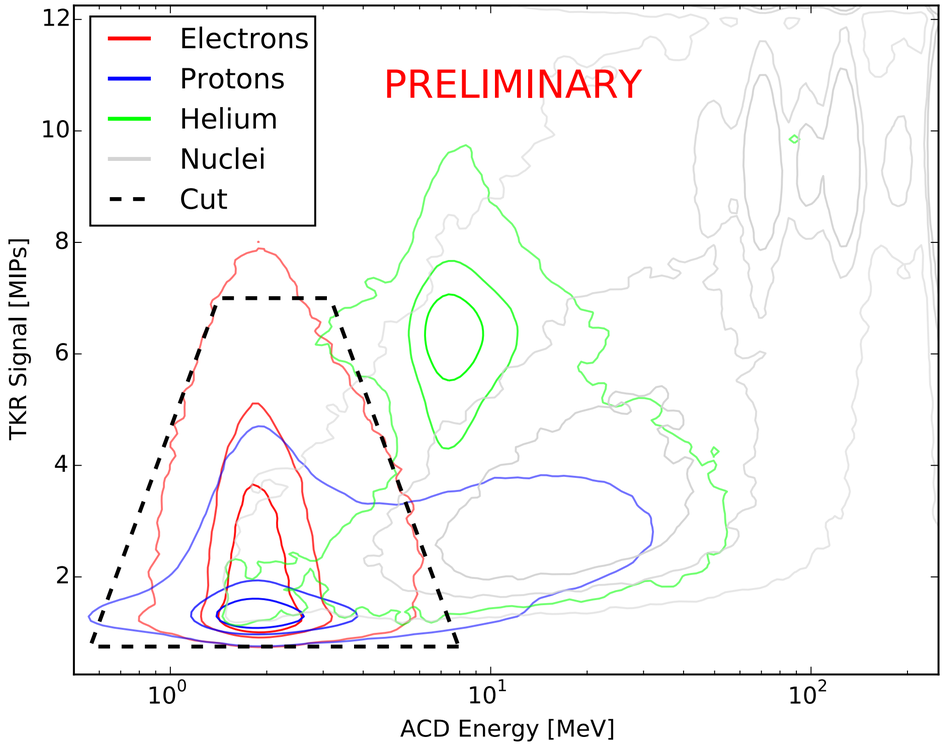
Event Selection

Fermi Gamma-ray Space Telescope



- The proton event selection is defined as:
  - Event has to trigger and pass onboard filters
  - Require event to have reconstructed track
  - Deposited energy >20 GeV in CAL
  - Require a well reconstructed track using Pass 8 direction classifier

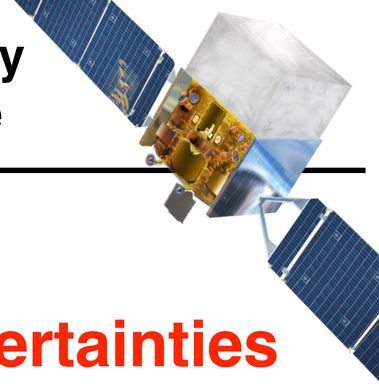




- Use the TKR and the ACD to independently measure the charge of incoming cosmic rays (CR)
- Find a residual contamination from CR helium and nuclei less than 1%
- After final event selection electron contamination is 4% at 50 GeV and decreasing with increasing energy

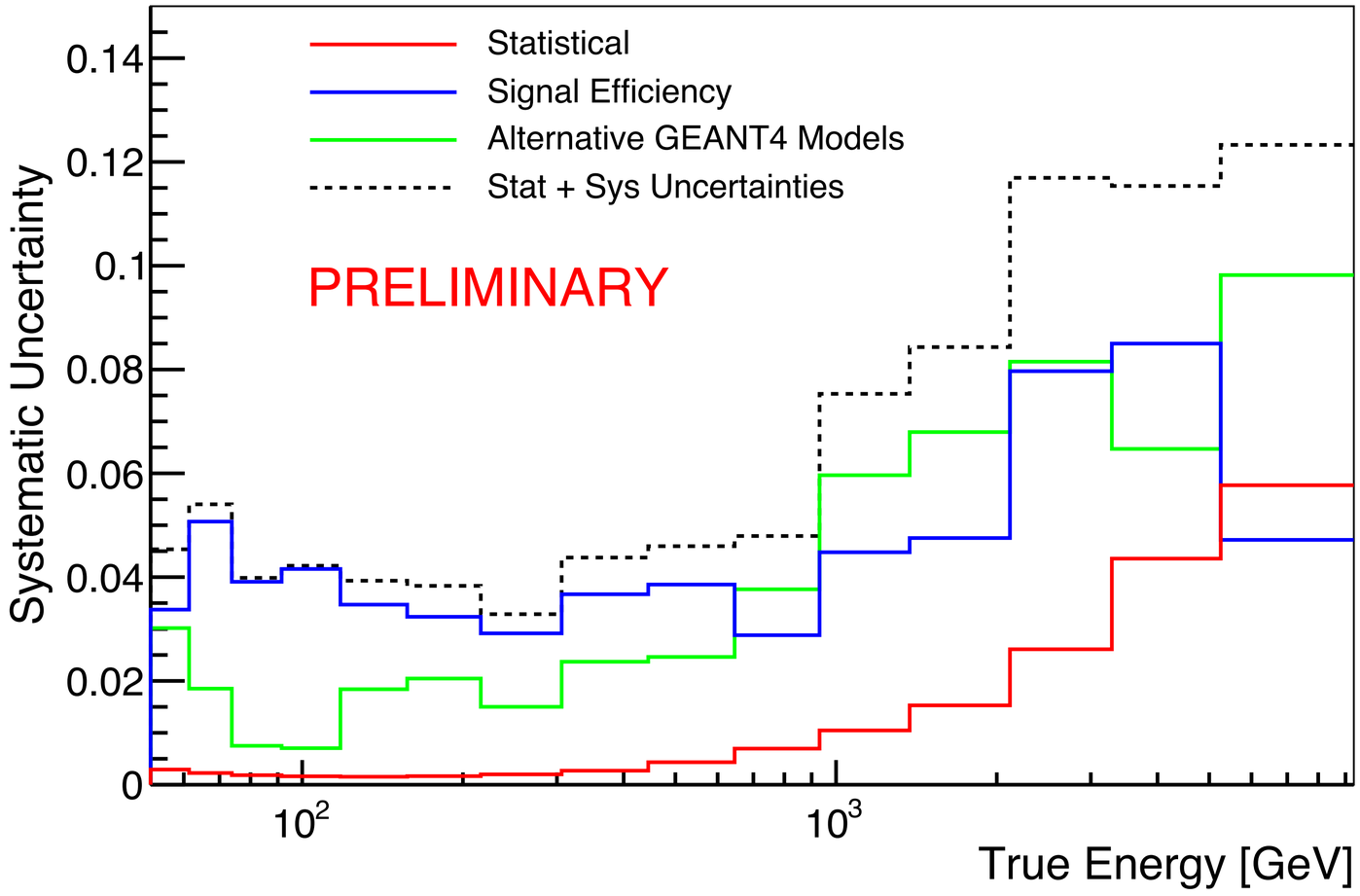
Systematic Uncertainties

Fermi Gamma-ray Space Telescope



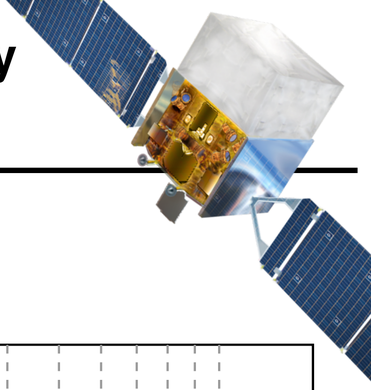
- This study is dominated by systematic uncertainties
- We use two methods to estimate our systematic uncertainties:
- Signal Efficiency
  - Selecting events with different path-lengths
- Alternative GEANT4 models
  - Response uncertainties via alternate hadronic models
- Uncertainty in the energy measurement is still being finalized

Does not include energy uncertainties



Cosmic-ray Proton Spectrum

Fermi Gamma-ray Space Telescope



- Using 7 years of LAT flight data, August 4, 2008 to July 30, 2015
- Extends energy of space-based measurement to 9.5 TeV
- Red markers represent statistical uncertainty
- Red shaded region includes systematic uncertainties
- Good agreement with other cosmic-ray measurements
- Allows for additional cosmic-ray proton studies with the LAT