Electron Spectrum measured by PAMELA

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on behalf of the PAMELA collaboration
Outline

- The PAMELA space experiment
- Electron spectrum measurement
  - Two different approaches
- Conclusions
PAMELA Collaboration

Italy
- Bari
- Florence
- Frascati
- Naples
- Rome
- Trieste
- CNR, Florence

Germany
- Siegen

Sweden
- KTH, Stockholm

Russia
- Moscow
- St. Petersburg

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PAMELA experiment

Payload for Antimatter/Matter Exploration and Light-nuclei Astrophysics

→ Direct detection of CRs in space
→ Main focus on antiparticles component
Orbit characteristics

- Low-earth elliptical orbit
- 350 - 610 km
- Quasi-polar (70° inclination)
- SAA crossed
- 16 Gigabytes transmitted daily to Ground-NTsOMZ Moscow

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PAMELA apparatus

**Time-Of-Flight**
plastic scintillators + PMT:
- Trigger
- Albedo rejection;
- Mass identification up to 1 GeV;
- Charge identification from dE/dX.

**Electromagnetic calorimeter**
W/Si sampling (16.3 $X_0$, 0.6 $\lambda_I$)
- Discrimination $e^+ / p$, anti-$p / e^-$ (shower topology)
- Direct E measurement for $e^-$

**Neutron detector**
$^3$He tubes + polyethylene moderator:
- High-energy $e/h$ discrimination

**Magnetic Spectrometer**
microstrip silicon tracking system + permanent magnet
It provides:
- Magnetic rigidity $\rightarrow R = pc/Ze$
- Charge sign
- Charge value from dE/dx

GF: 21.5 cm$^2$ sr
Mass: 470 kg
Size: 130x70x70 cm$^3$
Power Budget: 360W

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Electron spectrum measurement
Electron identification

Statistics:
• Analyzed data July 2006 - January 2010 (~1130 days)
• Collected triggers >10⁹
• Identified ~ 6 10⁵ electrons between 1 and 200 GeV

Electron identification:
• |Z|=1 (dE/dx=MIP) → SPE & ToF
• β=1 → ToF
• rigidity (R) → SPE
• charge sign separation → SPE
• e-/p-bar separation → CALO

• ~ no background, issues:
  - spillover protons at high energy
  - spectrometer resolution
  - selection efficiencies
Electron spectrum, methods

**Two independent energy measurements:**

- **Rigidity from Tracker**
- **Energy from Calorimeter**

 possibility to cross-check the energy measurement
Electron spectrum, methods

Two different approaches:

1) Tracker-based selection
   - strong track quality requirements
     - loose calorimeter selection
     - energy measured by the tracker

2) Calorimeter-based selection
   - loose track quality requirements
     - negative charged particle
     - strong calorimeter selection
     - energy measured by the tracker
Electron spectrum - tracker-based

Negatives tracks with $E > 20 \text{GeV}$

Number of events

Data

Electrons

$p$ simulation

Spillover Protons

Deflection [GV$^{-1}$]

20 GeV  50 GeV  100 GeV

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Electron spectrum - tracker-based

• Event selection: topology of the shower

Longitudinal profile topological variable

Transversal profile topological variable

100 - 200 GeV, simulations

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Electron spectrum - tracker-based

Negatives tracks with $E > 20\text{GeV} +$ electron selection

- Data
- Electrons
- Proton simulation

Residual spillover proton contamination

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Energy measurement by the tracker

Rigidity from Tracker
- bremsstrahlung above tracker
- decreasing energy resolution

\[ \text{e}^{-} \quad 1.8 \text{ GV} \]

\[ \gamma \quad \text{e}^{-} \]

\[ \sim 1.2 \text{ GV} \quad \sim 0.6 \text{ GV} \]

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Unfolding (or deconvolution)

Real energy particle spectrum

Instrumental effect (energy loss, energy resolution, ...)

Measured energy particle spectrum

Bayesian Unfolding Procedure


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Energy measurement

Energy from Calorimeter

- sampling calorimeter + dead areas
- increasing energy resolution
Electron flux - calorimeter-based

Transversal and dead areas leakage:
strong containment conditions

Longitudinal leakage:
Integrate a longitudinal fit of the shower

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Electron spectrum

Flux $\mathrm{GeV}^{3.0}$ $(\mathrm{s} \, \mathrm{sr} \, \mathrm{m}^2 \, \mathrm{GeV})^{-1}$

- Tracker-based
- Calorimeter-based

Preliminary

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Negative Electron spectrum

PAMELA Electron Flux

$E^3 \times \text{Flux GeV}^{-2} (m^2 \text{sr s GeV}^{-1})$

$10^3$

$10^2$

$10$

Energy (GeV)$10^3$

Preliminary
Conclusions

PAMELA has been in orbit and studying cosmic rays for \(~1500\) days. \(>10^9\) triggers registered, and \(>20\) TB of data has been down-linked.

We present the electron spectrum measured by Pamela in the energy range 0.5 - 500 GeV.

Electron spectrum analyses based on different approaches with different systematics are in agreement.

Analysis ongoing to finalize the electron spectrum.

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Thank you

http://pamela.roma2.infn.it/index.php

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