Time dependence of the helium flux measured by PAMELA

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on behalf of PAMELA collaboration
The PAMELA experiment

Payload for Antimatter/Matter Exploration and Light-nuclei Astrophysics

- Search for antimatter
- Search for dark matter
- Study of cosmic-ray propagation
- Study solar physics and solar modulation
- Study of electron spectrum
- Study terrestrial magnetosphere

- Launched on 15th June 2006
The PAMELA experiment

Resurs-DKI - multi-spectral imaging of Earth’s surface

PAMELA - is mounted inside a pressurized container of the Resurs DK-1 spacecraft

- Quasi polar and elliptical orbit
- Inclination ~ 70°
- Altitude ~ 300 - 600 km
- From 2010 circular orbit

Quasi polar orbit allows to perform a survey in each direction of the sky

Orbit period ~ 90 min
The PAMELA experiment

**Spectrometer**

- **microstrip silicon tracking system** + **permanent magnet**
  - It provides:
    - Magnetic rigidity \( R = \frac{p c}{Z e} \)
    - Charge sign
    - Charge value from \( \frac{dE}{dx} \)

**Time-Of-Flight**

- **plastic scintillators + PMT:**
  - Trigger
  - Albedo rejection;
  - Mass identification up to 1 GeV;
  - Charge identification from \( \frac{dE}{dx} \)

**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**

- **36 He\(^3\) counters:**
  - High-energy e/h discrimination

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GF: 21.6 cm\(^2\) sr
Massa: 470 kg
Dimensioni: 130 x 70 x 70 cm\(^3\)
Power Budget: 360 W

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Cosmic rays

Cosmic Ray Spectra of Various Experiments

Solar Modulation

- LEAP - satellite
- Proton - satellite
- Yakutsk - ground array
- Haverah Park - ground array
- Akeno - ground array
- AGASA - ground array
- Fly’s Eye - air fluorescence
- HiRes1 mono - air fluorescence
- HiRes2 mono - air fluorescence
- HiRes Stereo - air fluorescence
- Auger - hybrid

Flux ($m^2 \cdot sr \cdot GeV \cdot sec^{-1}$) vs. Energy (eV)

- Knee (1 particle/m$^2 \cdot$ year)
- Ankle (1 particle/km$^2 \cdot$ century)
- PAMELA

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SOLAR CYCLE
- Solar activity rises and falls over an 11 year cycle
- Can be shorter/longer
- Different events during the cycle
- Activity correlates with Sunspot Number

nasa.gov: solarcycle-primer.html

Oulu Neutron Monitor
Pressure corrected data
Last 24 hours (2017-06-27 14:05 - 2017-06-28 14:05 UT), 5-min averages, Average CR: 6572.88

Last 30 days (2017-05-29 14:05 - 2017-06-29 14:05 UT), Hourly averages, Average CR: 6656.29

Complete data (1964-04-01 - 2017-06-29), Monthly averages, Average CR: 6158.96

https://cosmicrays.oulu.fi/
The solar modulation

Neutron Monitor counts data from http://cosmicrays.oulu.fi/

PAMELA observations covers ~ one solar cycle
PAMELA data

DATASET: From 2006 to 2014

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The charge selection
The charge selection

TOF

S11

S12

S21

Tracker

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The charge selection

TOF

S_{11}

S_{12}

S_{21}

Tracker

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Proton contamination

- Selected proton with ToF+Trk
- Fraction of events which survive the helium cut
- Temporal Period: 1 year
The charge selection

2006

*dEdxTrk X (No Max Value)*

*dEdxTrk Y (No Max Value)*
The charge selection

2014

**dEdxTrk X (No Max Value)**

**dEdxTrk Y (No Max Value)**
**ToF efficiency**

**Temporal Bin = 1 year**

![Graph showing ToF efficiency over time with color-coded data points for different months.](image)

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Charge selection efficiency

Temporal Bin = 1 year

PRELIMINARY

Eff_{Trk} dEdx

PRELIMINARY

Eff_{Trk} dEdx

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Acceptance 0.15
- Black Dots: Science
- Temporal period: 1 year
Evolution of the proton energy spectrum from July 2006 to December 2009

- Acceptance 0.15
- Black Dots: Science
- Temporal period: 1 year
- Extended up to 2014


PRELIMINARY
Conclusions

*PAMELA* took data:

- for a long period of time – [2006 – 2016]
- over a wide range of energies - [800 MeV – 1.2 TV]
- on different particles – [e\(^-\), e\(^+\), p, He ...]

A sample of helium with very low contamination has been selected.

All steps have been computed over precise time period.

Fluxes over different time periods have been computed.