Precision Measurement of the monthly cosmic Ray fluxes (e⁻, e⁺, p, He) with the Alpha Magnetic Spectrometer on the ISS

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Measurement of charge cosmic rays up to TeV

Fundamental physics & antimatter :

- Primordial antimatter search with sensitivity of 10⁻⁹
- ▷ Dark Matter search (e⁺, p, D,...)

Cosmic Ray composition and energy spectrum

- Sources & Acceleration (p, He, C, O)
- Propagation in the ISM : Relative abundances of nuclei and isotopes in primary cosmic rays

*see Matteo Duranti's talk: "The AMS-02 detector on the International Space Station – Status and highlights, after 7 years on orbit"

AMS-02: A TeV precision, multipurpose spectrometer



→ Particle identification:

- e/p separation at the 10⁶ level combining TRD, TRACKER and ECAL measurements.
- nuclei measurements: Z redundant measurements to evaluate fragmentation along the detector
- Charge sign: matter to anti-matter separation

TRD

→ High Statistics

- Large Acceptance
- Long Exposure time



Proton and Helium Fluxes vs. Time



Proton and Helium Fluxes vs. Time

- Clear presence of structures (green shading and dashed lines to guide the eye) below 40 GV
- The amplitude of the structures decreases with increasing rigidity
- Similar structures observed also in e⁺ & e⁻ measurements (indicated here by red dashed lines)



Proton/Helium ratio vs. Time



solar maximum

the p/He flux ratio has a long-term decrease:

- Differences in p and He diffusion coefficients
 - Differences in the local interstellar spectra of p and He
 - 3He and 4He isotopic composition

Above 3 GV: the p/He flux ratio is time-independent

Electron and **Positron** fluxes vs Time



Prominent and distinct time structures visible in both the **positron spectrum** and the **electron spectrum** and at different energies are marked by dashed vertical lines

Positron/Electrons ratio (R_e) vs Time



- short-term variations in the fluxes largely cancel
- charge-sign dependent effects clearly visible



Positron/Electrons ratio vs Time

The midpoint $(t_{1/2})$ and the amplitude (C) of transition are energy dependent:



The duration of transition is energy independent:



The ratio exhibits a smooth transition over **830±30** days from one value to another

Conclusion

► AMS p, He,e⁺,e⁻ monthly fluxes were measured during the ascending phase of solar cycle 24 through its maximum and toward its minimum. PhysRevLett.121.051101 (He and p) PhysRevLett.121.051102 (e⁻ and e⁺) → selected as Editors' suggestion

- Above 3 GV the p/He flux ratio is time independent while below 3 GV the p/He flux ratio has a long-term decrease

 new information!
- The unique performance of AMS provides the first accurate measurement of both electrons and positrons fluxes as a function of time:
 - Based on 23.5×10⁶ events, we report the observation of short-term structures on the timescale of months coincident in both the electron flux and the positron flux. These structures are not visible in the e⁺/e⁻ flux ratio.
 - The precision measurements across the solar polarity reversal show that the ratio exhibits a smooth transition over 830±30 days from one value to another. The midpoint of the transition shows an energy dependent delay relative to the reversal and changes by 260±30 days from 1 to 6 GeV.

AMS is measuring solar effects for all nuclei, particle and anti-particle fluxes in the present and next solar cycle.

Back up slides

Solar modulation of Cosmic Rays



Solar modulation of CRs



Measurement of Electron and Positron fluxes

-TRD:

identify the particle as e⁺/e⁻
 rejecting the hadronic hypothesis

-TOF:

- main trigger
- down going relativistic particle
- Z=1

-TRACKER:

- identify sign of the charge (e⁻)
- Z=1

-ECAL:

- identify the particle as e⁺/e⁻/γ rejecting the hadronic hypothesis
- measurement of energy



TRACKER \rightarrow key instrument for the charge sign **ECAL**, **TRD** \rightarrow keys instrument for e/p separation

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Positron/Electrons ratio vs Time – Parametrization



During March 2012 a huge Solar events occurs.

AMS-02 detects:

- an increments of primary particles (SEP) on 7th
- a reduction of flux (FB) that last for ~1 month



