PRECISION MEASUREMENT OF THE MONTHLY COSMIC RAY FLUXES WITH THE ALPHA MAGNETIC SPECTROMETER ON THE ISS

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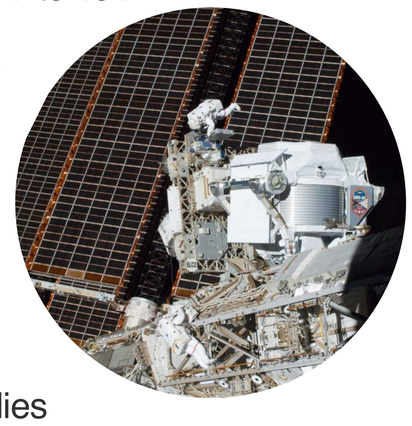
LABORATÓRIO DE INSTRUMENTAÇÃO E FÍSICA EXPERIMENTAL DE PARTÍCULAS - LIP

1 The AMS detector

Alpha Magnetic Spectrometer (AMS) is a state-of-the-art particle physics detector installed on the **International Space Station (ISS)** that allows for high precision cosmic rays measurements in the GeV to TeV energy scale.
Installed in May 2011, thanks to its high acceptance (~0.5 m^2sr) and its long exposure time, it has collected over **115,000,000,000** cosmic rays.



Physical Goals

- ✓ Search for primordial antimatter
- ✓ Search for dark matter signals
- ✓ Search for strange quark matter particles
- ✓ Astrophysics of Galactic cosmic rays & γ-rays
- ✓ Magnetospheric physics & space radiation studies
- ✓ **Solar Physics (long-term cosmic ray modulation & solar events)**

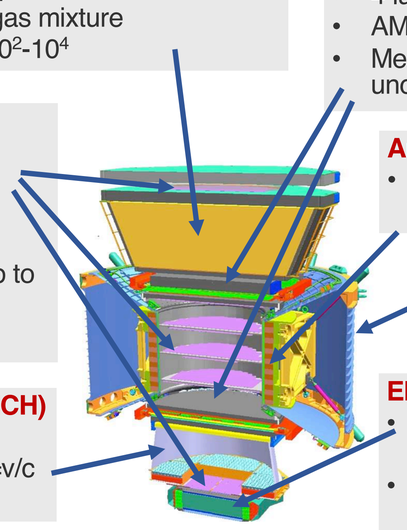
Transition Radiation Detector (TRD)
- 20 layers of proportional chambers filled with a Xe/CO_2 gas mixture
- p/e rejection ~10^2-10^4

Time-of-Flight (ToF)
- 4 layers of scintillation counters
- AMS main trigger
- Measurement of β=v/c with ~1% uncertainty

Sillicon Tracker
- 9 layers of double-sided silicon sensors
- Spatial accuracy in bending direction: ~10μm
- Measurement of rigidity (p/q) up to ~2 TV for protons
- Measurement of charge-sign

Anti-Coincidence Counters (ACC)
- Veto for particles traversing from the side

Permanent Magnet
- 6000 Ne-Fe-B magnets
- Magnitude: 0.15 T



Ring Imaging Cherenkov (RICH)
- Aerogel and NaF radiators
- Precise measurement of β=v/c with ~0.1% uncertainty

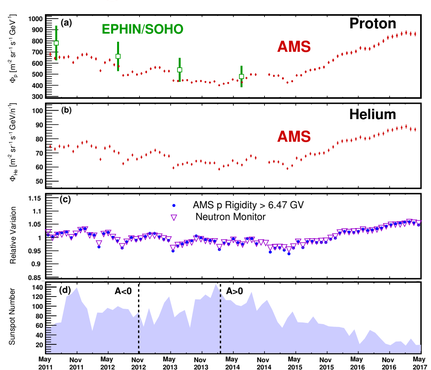
Electromagnetic Calorimeter
- 9 super-layers of lead and scintillating fiber (17 X_0)
- Measurements of e± and γ energy ($\Delta E/E$~2% - 100GeV)
- p/e rejection >10^4

2 Solar modulation of cosmic rays

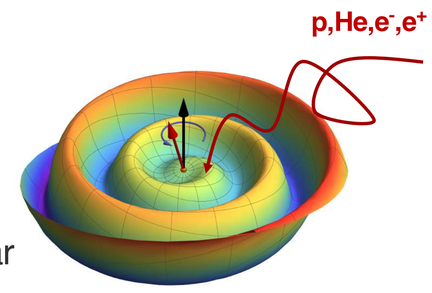
The Sun emits a continuous stream of highly conductive plasma that permeates the entire **Solar system**, transporting **Solar magnetic field lines** with it. This stream of particles is known as **Solar wind**. This magnetic field changes the **direction** and **energy** of particles inside the Solar system, creating an effect known as **Solar modulation**.

The cosmic ray flux is modulated by solar activity.
Solar activity enhances this effects by changing the shape, density and velocity of the Solar wind, thus introducing a **time dependent** element to this effect. Since this interaction is electromagnetic in nature, it also presents a **charge dependence**.

Long-term modulation

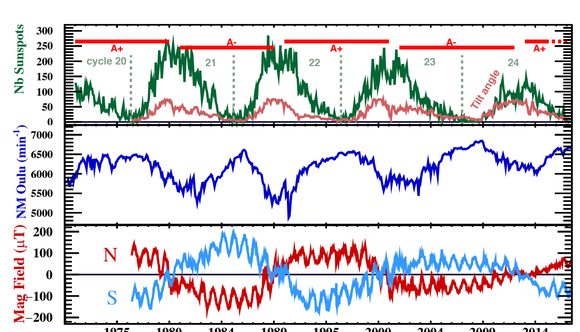


The **Solar activity cycle** is characterized by a periodic change in solar parameters as it evolves. Solar activity is at a maximum during the **solar magnetic reversal**.
Solar modulation introduces variations of several time scales which are directly correlated with Solar activity.



Time Variability

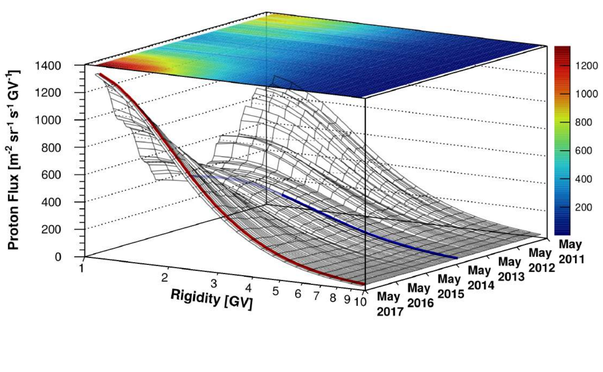
- ❑ **Long time scale (~11 years)**
  - Change of cosmic ray intensity
  - Charge-sign effects (magnetic reversal)
- ❑ **Short time scale (~days)**
  - Forbush decrease and Solar energetic particles (SEP)



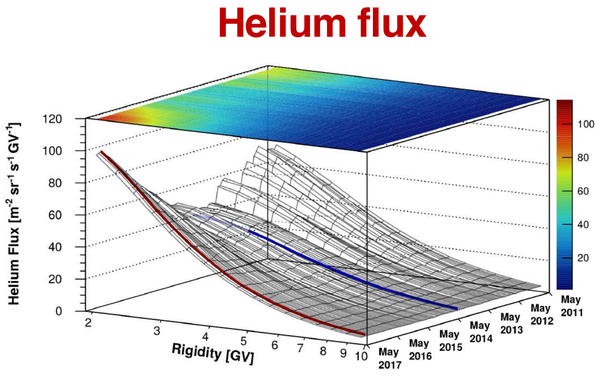
3 AMS Monthly Proton and Helium fluxes

Based on **846 million** proton events and on **112 million** helium events, the proton and helium fluxes were precisely measured for 79 Bartels Rotations (27 days) from May 2011 to May 2017, on a monthly time scale.

Proton flux



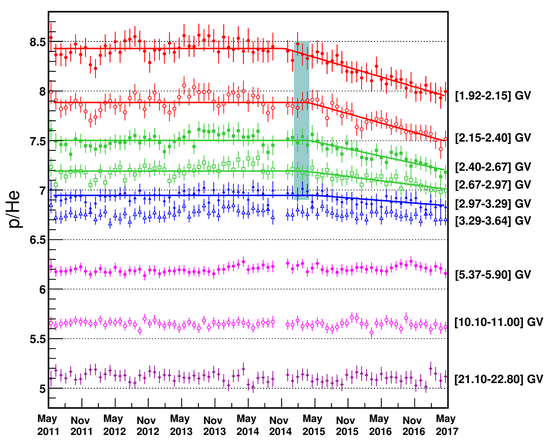
Helium flux



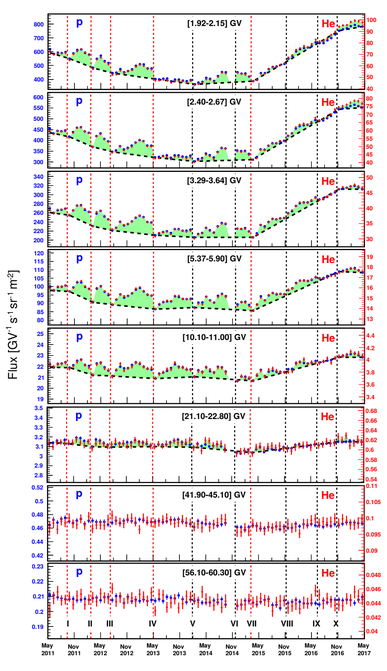
Both proton and helium spectra exhibit **large variations with time, at low rigidities**, which decrease at higher rigidities. During the period of observation, both fluxes have a minimum in February 2014 and a maximum in February 2017.

Proton and helium show similar structures both in time and amplitude. The structures I, II, III, IV and VII are also visible on the electron/positron fluxes.

Long-term behaviour of the p/He ratio



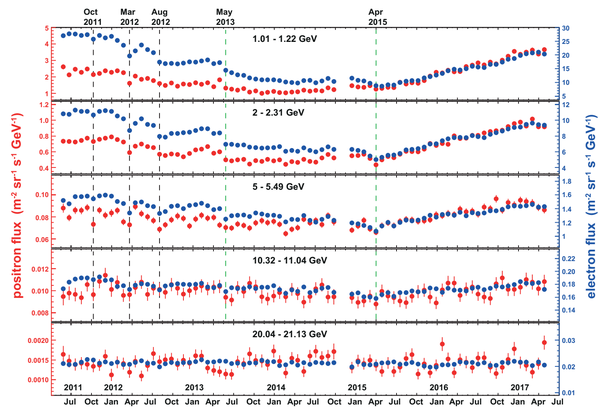
Fine-time structures



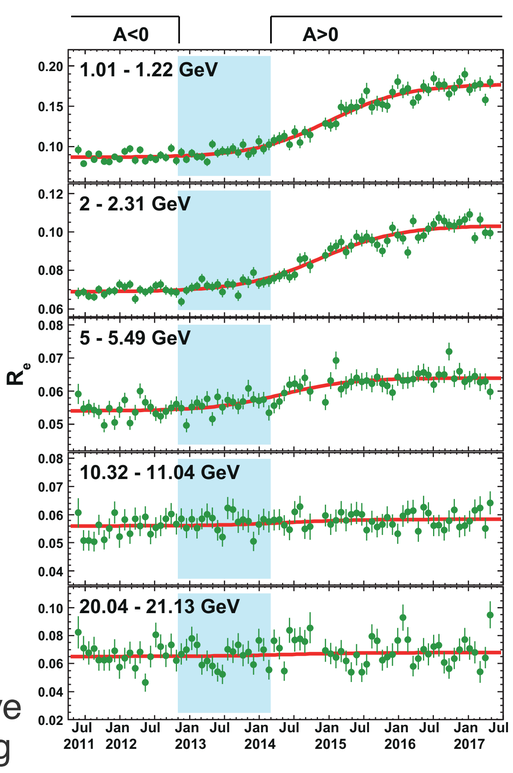
4 AMS Monthly Electron and Positron fluxes

Based on **23.5 million events**, from May 2011 to May 2017, AMS made precise measurements of the electron and positron fluxes for 79 Bartels Rotations on a monthly time scale.
Electron and positron fluxes show common **short-term time structures** to each other and share some with the proton and helium fluxes.

Electron and Positron fluxes



Charge-sign dependency



The **long-term variations** of the positron/electron ratio show evidence of **charge-sign dependency**. This effect is associated with particle drift motion along the regular spiral structure of the heliospheric magnetic field.
Due to drift, positrons and electrons behave differently during the solar cycle and during the magnetic reversals their roles interchange.

These AMS results are under publication in PRL.

Acknowledgements

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