Measurement of nuclei and isotopes of secondary origin in CR with AMS-02



Francesco Dimiccoli on behalf of the AMS-02 collaboration

TIFPA - Trento Institute for Fundamental Physics and Applications

AMS: a unique TeV precision, accelerator-type spectrometer in space



AMS was installed on ISS in May 2011 it will continue through the lifetime of ISS

5m x 4m

7.5 tons

x 3m

To date, it collected more than **127 billions** of charged particles: e⁺, e⁻, p, pbar, nuclei...

F. Dimiccoli -- TIFPA

AMS is MIT led International Collaboration 16 Countries, 60 Institutes and 600 Physicists, 17 years



F. Dimiccoli -- TIFPA



AMS Physics Goals

- Searches for primordial antimatter:
 - Anti-nuclei: AntiHe, ...
- Dark Matter searches:
 - \circ e+ , AntiD , ...
- Measuring CR spectra refining propagation models;
 - Nuclei spectra from p, He -> Fe
- Study effects of solar modulation on CR spectra over 11 year solar cycle





• • •





F. Dimiccoli -- TIFPA

ICCPA - Moscow 2018

Secondary nuclei in Cosmic Rays (CR)

Secondary CR are produced from collisions of primary CR with the interstellar medium (ISM)



The fluxes of the secondary species are very important for the understanding of the origin and propagation of cosmic rays

- They carry information on the history of the travel and **properties of ISM**
- Most abundant species: Li, Be, B and light isotopes (³He and D)

Secondary CR Flux before AMS



AMS: Identification of nuclei and isotopes

• Nuclei: Identified by redundant measurements of particle Z



Event Selection



F. Dimiccoli -- TIFPA

Background from Interactions (1)

Background due to heavier nuclei interactions below L1 are computed with data Estimated background <3% for B, <0.5% for Li and Be in the entire rigidity range.



F. Dimiccoli -- TIFPA



selections on L1 charge.

Background from Interactions (2)

- Background due to **heavier nuclei interactions above tracker L1** is calculated by using MC samples generated according to AMS flux measurements.
- MC interaction channels have been verified with data



systematic error due to this background is < 1.5% in the entire rigidity range

Lithium and Boron Fluxes

Above 7 GV Li and B have identical rigidity dependence



Lithium and Beryllium Fluxes



ICCPA - Moscow 2018

Secondary CR Fluxes



ICCPA - Moscow 2018

Secondary and Primary CR Fluxes

Secondaries and Primaries have distinctively different rigidity dependence



Primary and Secondary Spectral Indices $Flux \phi = CR^{\gamma}$



Above 200 GV both deviate from a single power law

Isotopes: Strategies for the measurement

³He / ⁴He Separation

- Modeling of 1/R and 1/β distributions
- Fit 1/m with analytical functions



D / **P** Separation

- Tuning of MC β resolution
- Fit mass with Tuned MC



16

Isotopes: ³He/⁴He measurement



Preliminary data, please refer to upcoming AMS PRL publication

Isotopes: D/P measurements



Preliminary data, please refer to upcoming AMS PRL publication

Conclusions

- 1. For the first time, AMS was able to precisely measure the spectra of secondary species (Li,Be,B...), fundamental for the refinement of the knowledge of the CR propagation in galaxy.
- 2. Li, Be and B show and identical rigidity dependence above 30 GV, but a distinctively different behaviour with respect to primaries. Be and Li fluxes are different by exactly a factor 2.
- 3. The precision measurement of secondary isotopical components, like D and ³He is on going: AMS can extend of 10 times the energy range currently charted.



AMS in a nutshell

TRD: Identify e⁺, e⁻, Z



Silicon Tracker: Z, P



ECAL: E of e+, e-



Particles and nuclei are defined by their charge (Z) and energy (E) or momentum (P). **Rigidity R = P/Z**

TRD

TOF

3-

5-€

7-8

TOF RICH

29 ECA

Z and P

TOF: Z, E



Magnet: ±Z



RICH: Z, E



Event Selection (1)

 $\begin{array}{c} \textbf{Isotopes:}\\ Good \ measurement \ of \ \beta \end{array}$



Definition of geometry

Definition of nuclei sample





Nuclei: Full span

 Isotopes: L1 + Inner Tracker

F. Dimiccoli -- TIFPA

• Z at different levels

- Quality of Time of Flight
- Multivariate analysis for RICH