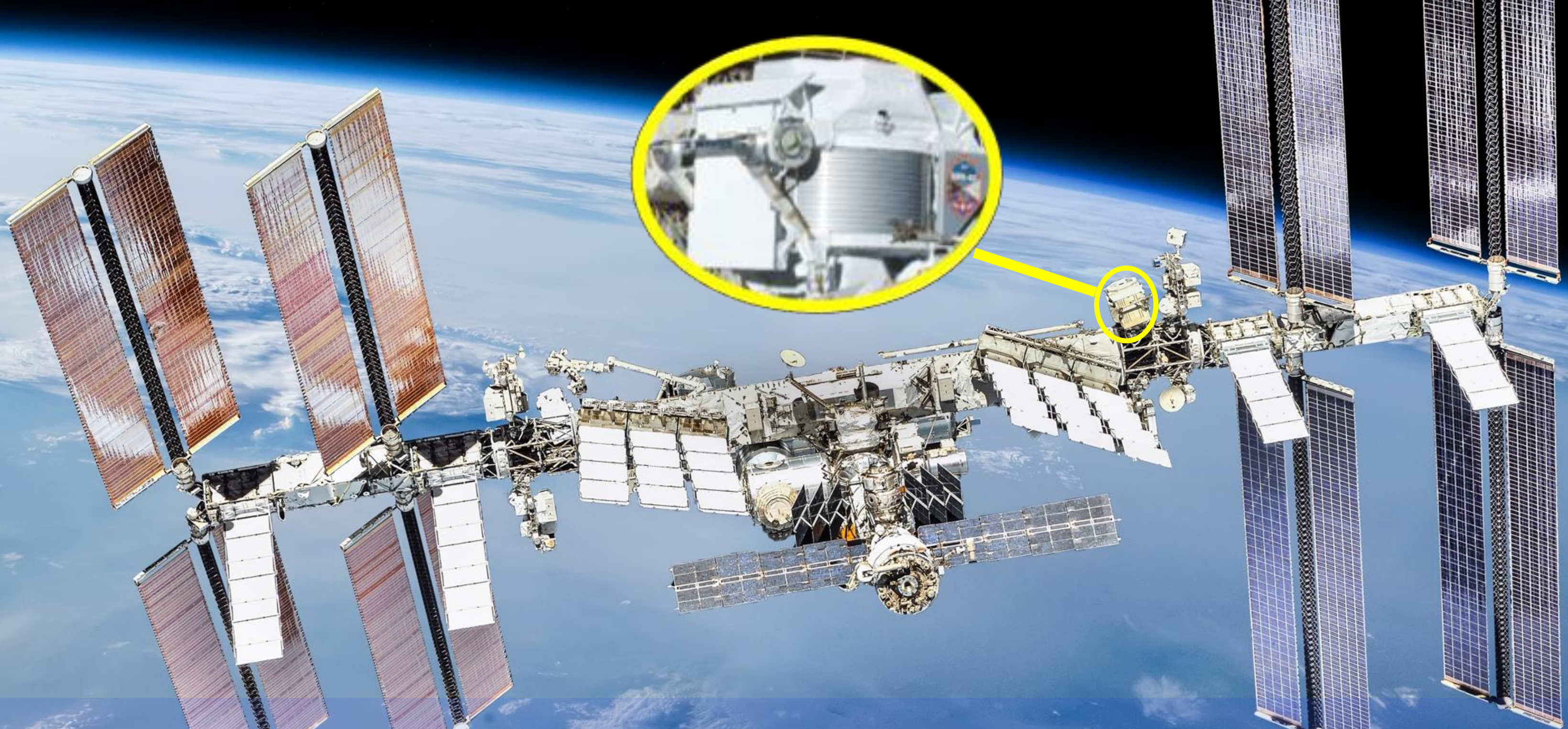
Unique Properties of Secondary Cosmic Rays Results from the Alpha Magneti Spectrometer



Zhaomin Wang

On Behalf of the AMS Collaboration

Shandong Institute of Advanced Technology(SDIAT)

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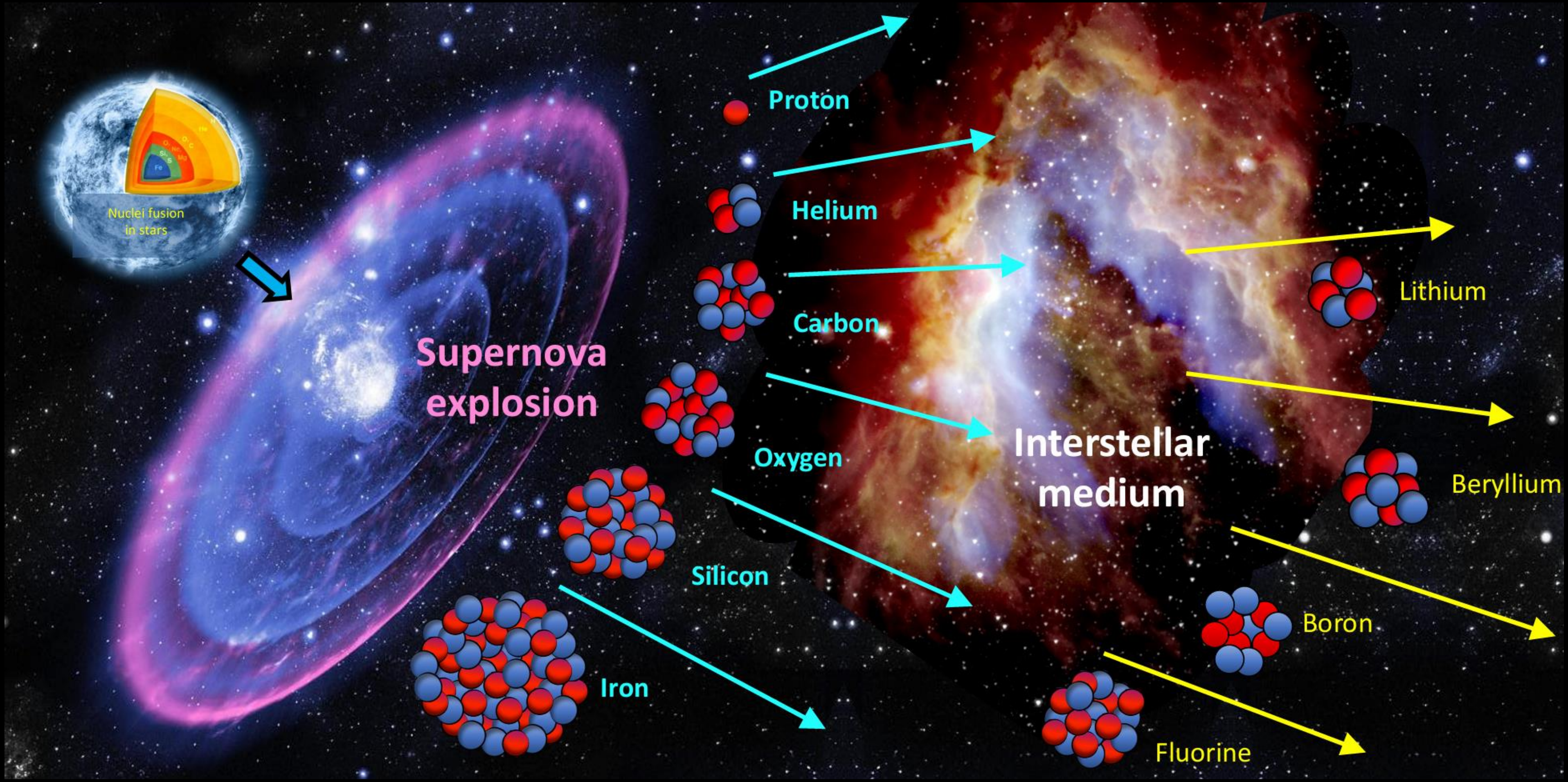
Introduction

The Nuclei in cosmic rays can be separated into two classes according to their origins: the primary cosmic rays are produced during the lifetime of stars and accelerated in supernovae shocks; The secondary cosmic rays are produced by the collisions of primary nuclei with the interstellar medium.

Measurements of secondary cosmic ray nuclei fluxes are fundamental to understanding the and propagation processes of cosmic rays in the Galaxy.



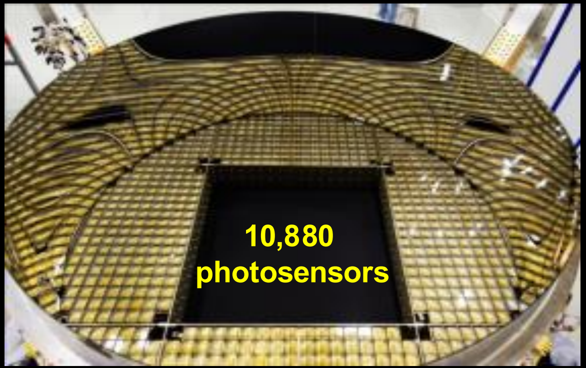
Alpha Magnetic Spectrometer (AMS)

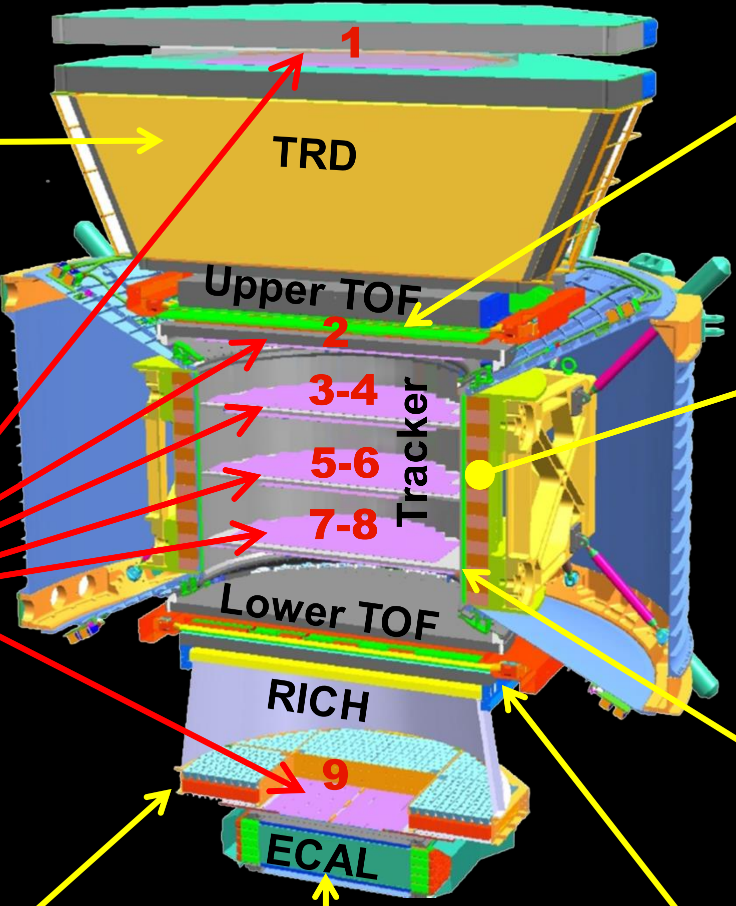
Particle Physics Experiment in Space

Transition Radiation Detector (TRD)
identify e^+, e^-

Silicon Tracker
measure Z, P

Ring Imaging Cerenkov (RICH)
measure Z, E





Electromagnetic Calorimeter (ECAL)
measure E of e^+, e^-

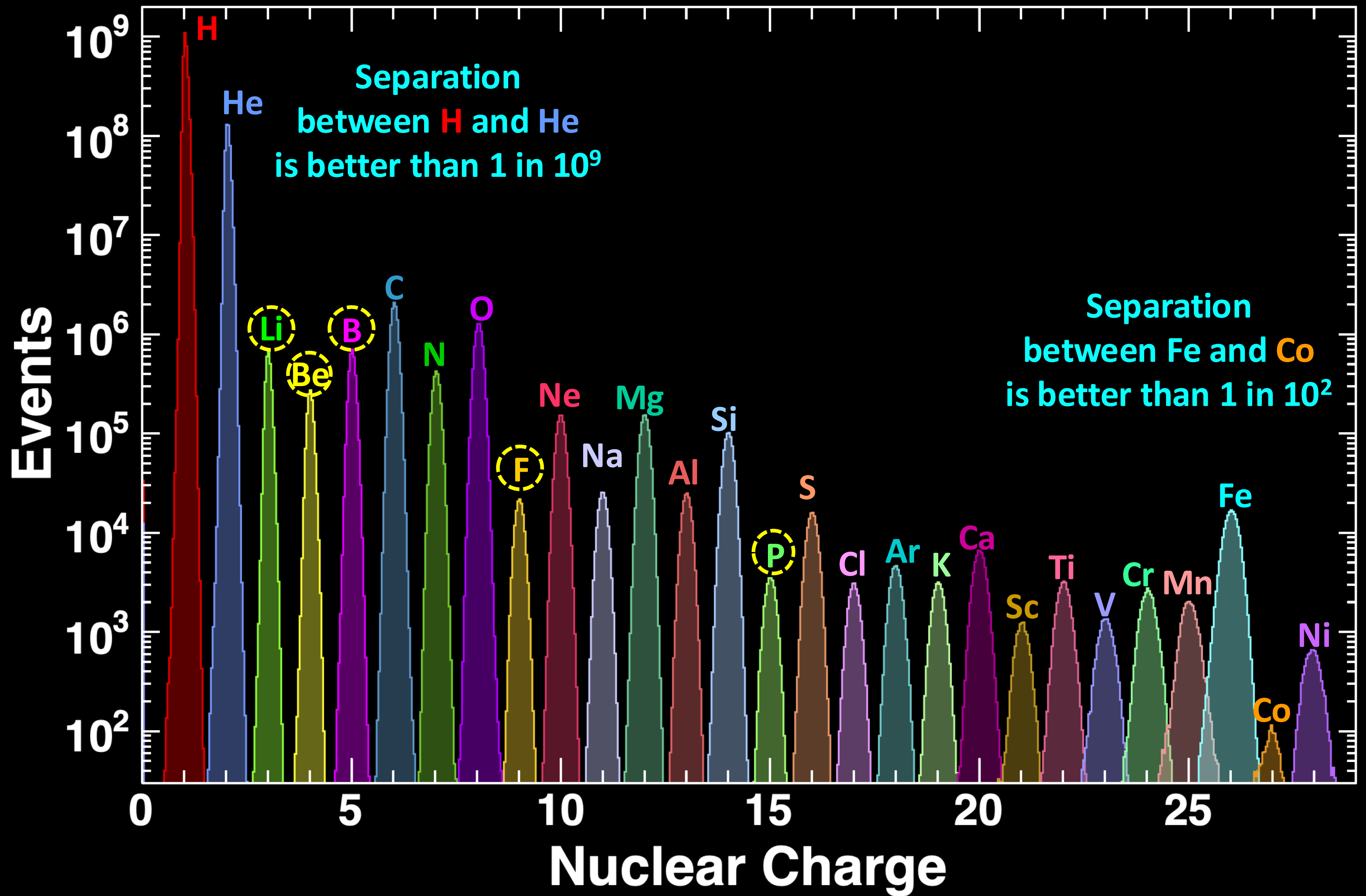
Upper TOF measure Z, E

Magnet identify ±Z, P

Anticoincidence Counters (ACC)
reject particles from the side

Lower TOF measure Z, E

AMS Measurement on Cosmic Ray Nuclei Charge



AMS Nuclei Flux Measurements

$$\Phi_i = \frac{N_i}{T_i A_i \varepsilon_i \Delta R_i}$$

Rigidity p,…Fe 1…3500 GV

Selected Events
-- Background removed
-- Corrected for Bin to Bin Migration

Time 220,000,000 sec R> 30 GV

Bin width

Effective Acceptance

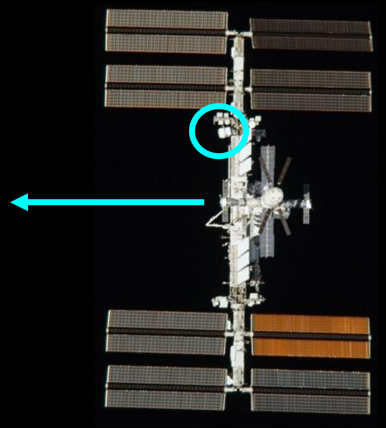
Trigger Efficiency

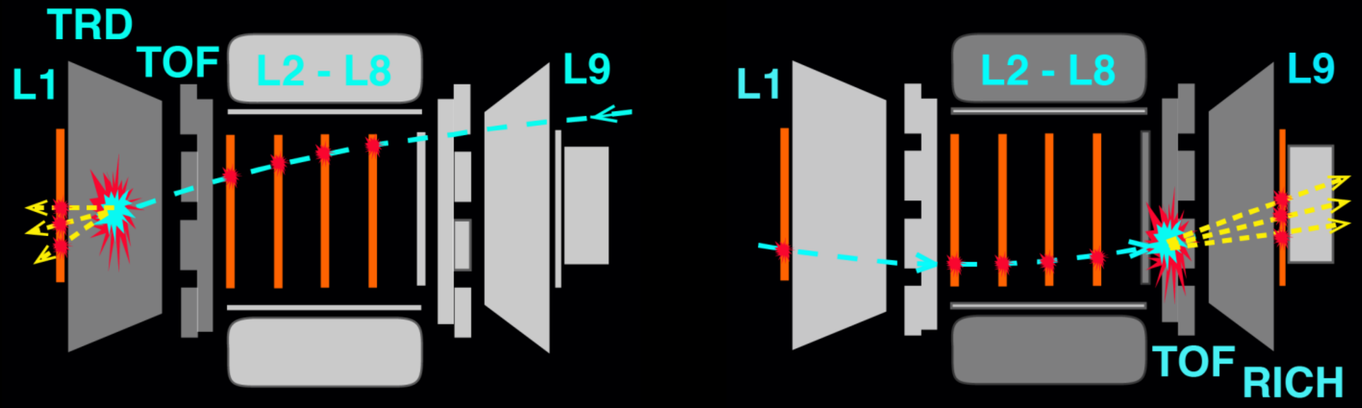
Measurements require knowledge of detector performance details, the resolution functions, acceptance … obtained by AMS Monte Carlo Simulations

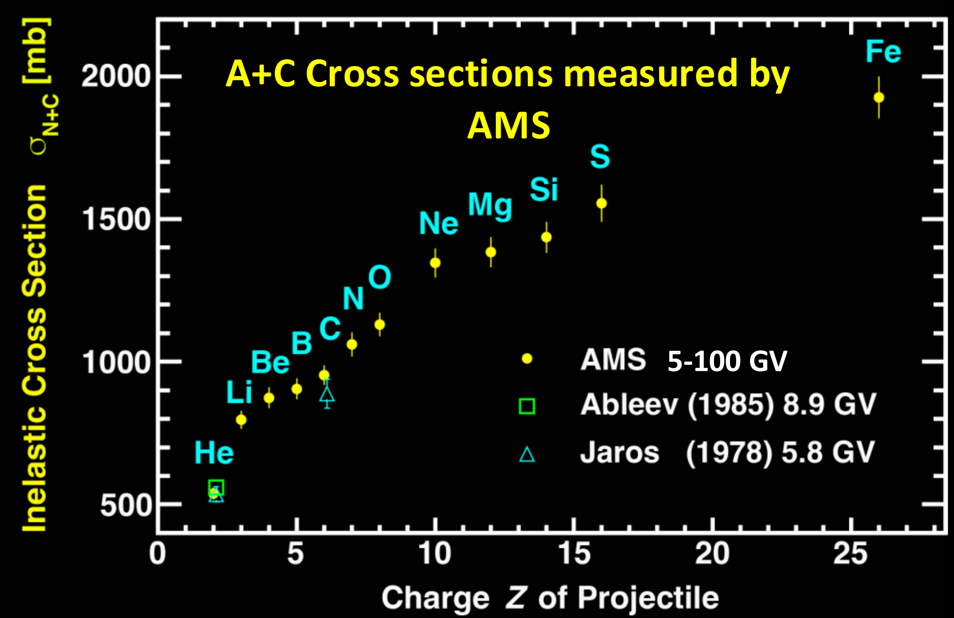
In AMS 2 to 4 independent analysis are done to compute N_i, A_i, ε_i, T_i for each flux

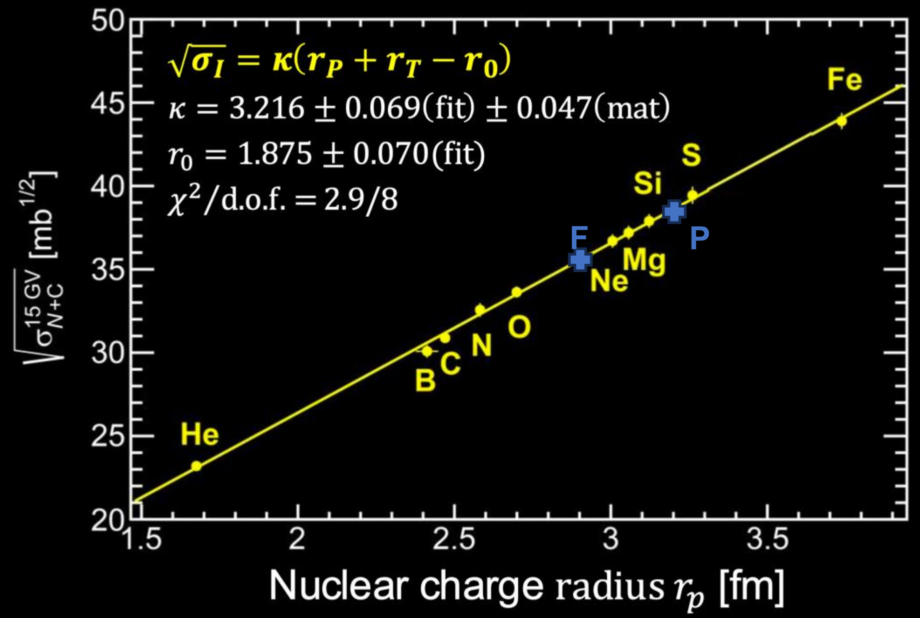
Unique of AMS: Measure Nuclear Reaction Cross Section with Cosmic Rays

AMS can collect cosmic particles entering the detector from both the right and the left directions when the detector is flying horizontally. This allows the measurement of reaction cross-sections of various nuclei colliding on the AMS material within the GV to TV rigidity ranges.



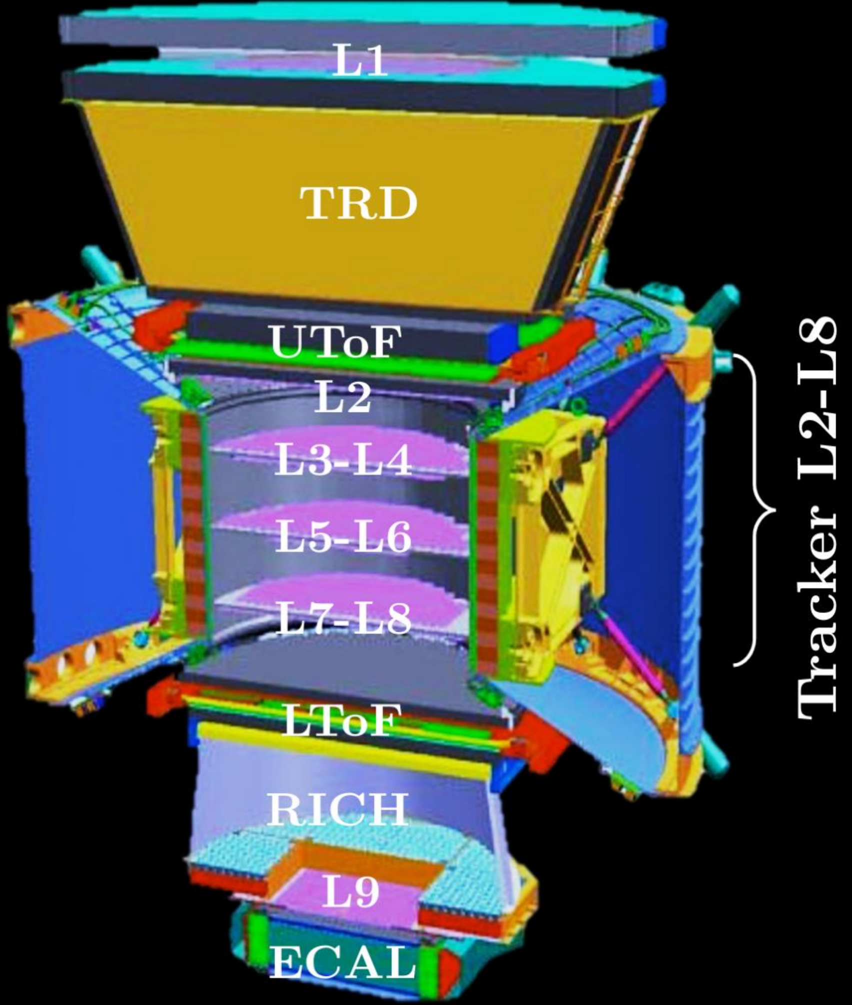




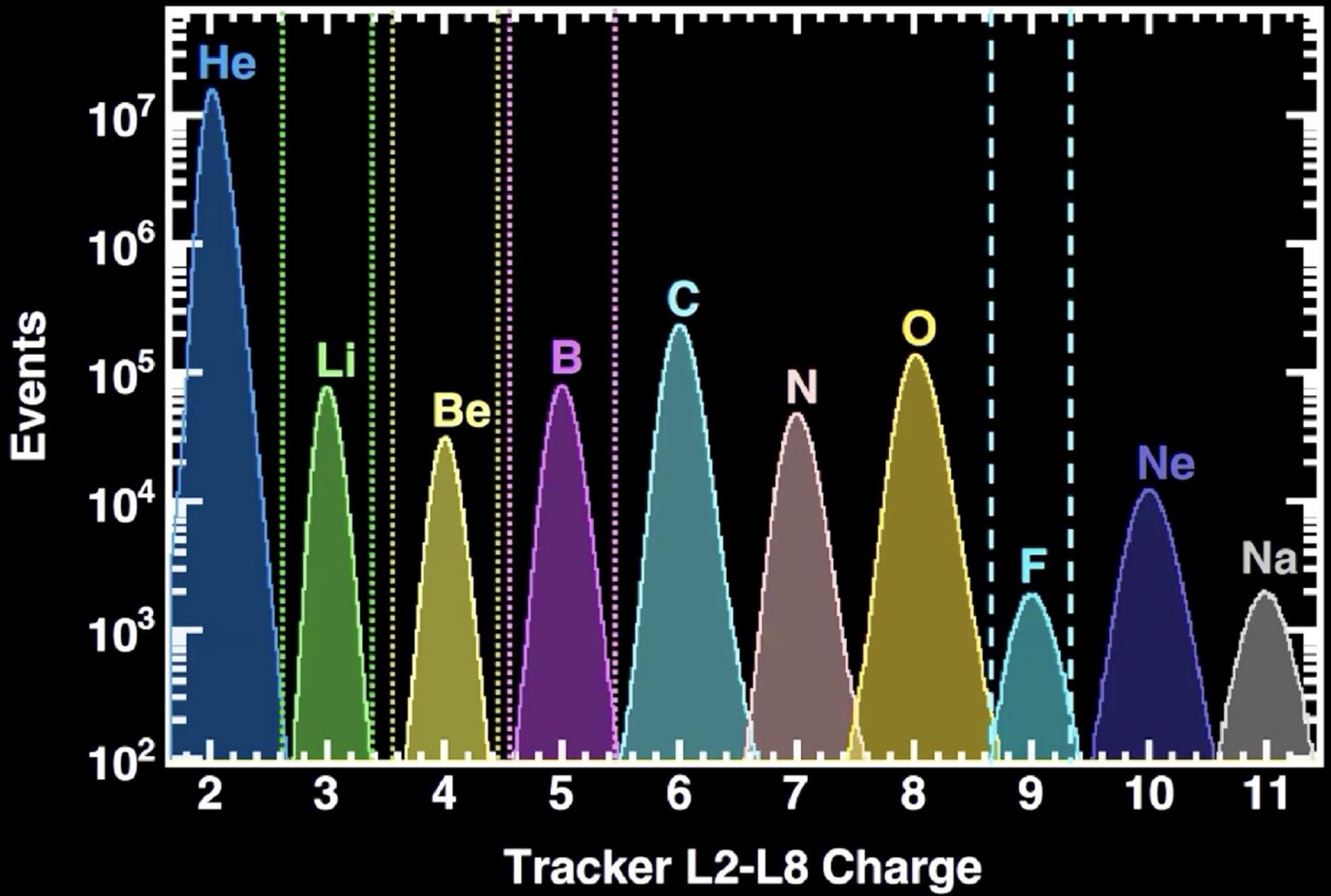


Based on the measurements, AMS adjusted the relevant parameters of nuclear interaction models in the simulation data to guarantee a better precision for the spectra measurements.

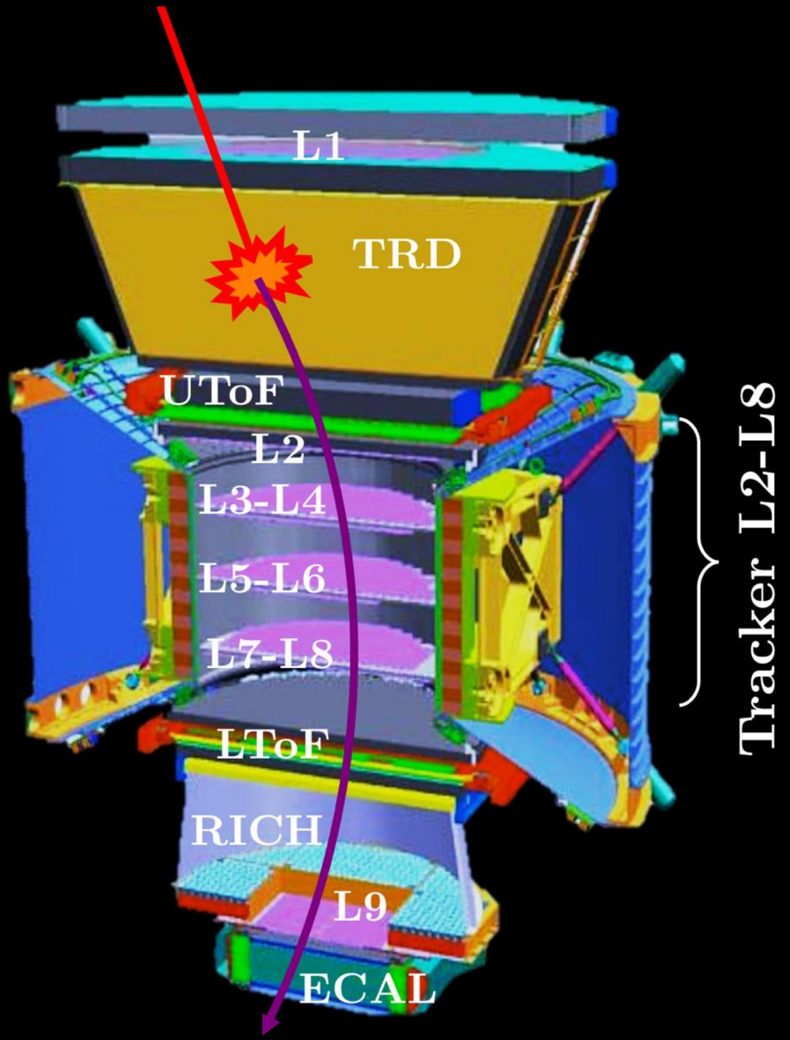
Secondary Cosmic Rays Selections



Thanks to redundant charge measurements and good charge resolution, AMS is able to identify Li, Be, B and F nuclei with a negligible background (<0.5%) arising from charge misidentification over the whole rigidity range.

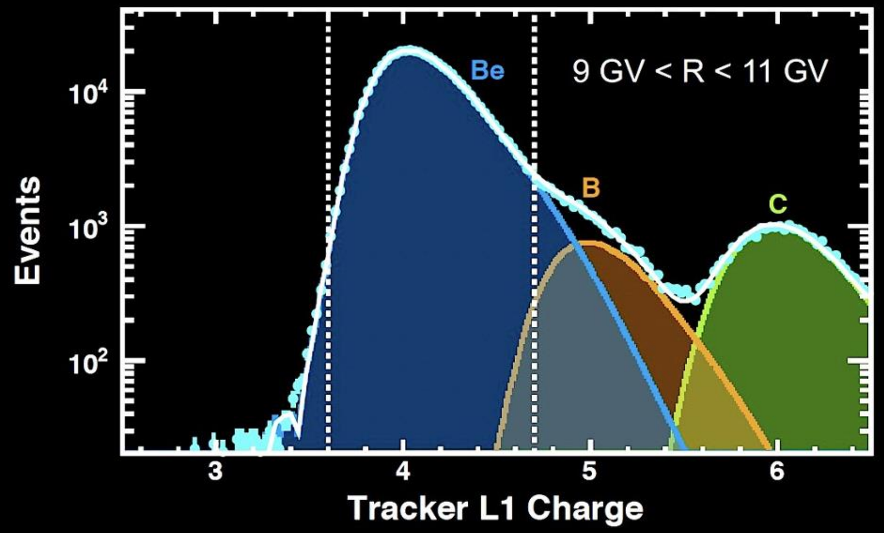


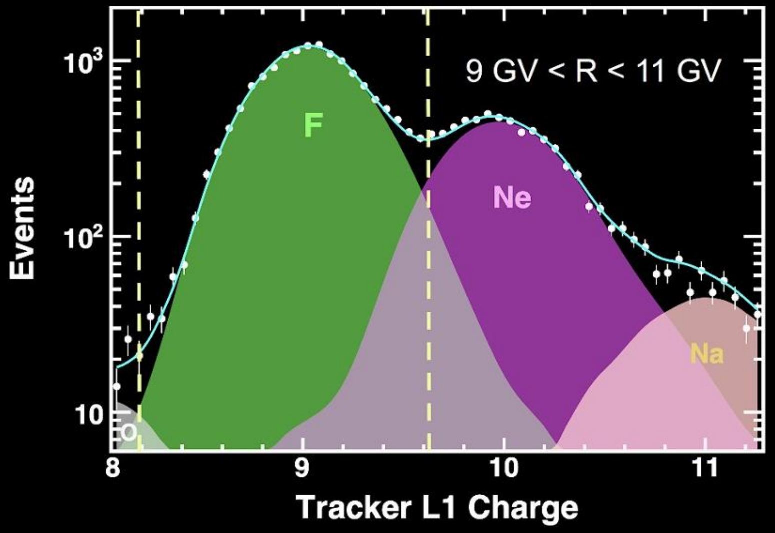
Background from Nuclei Interaction in AMS Materials



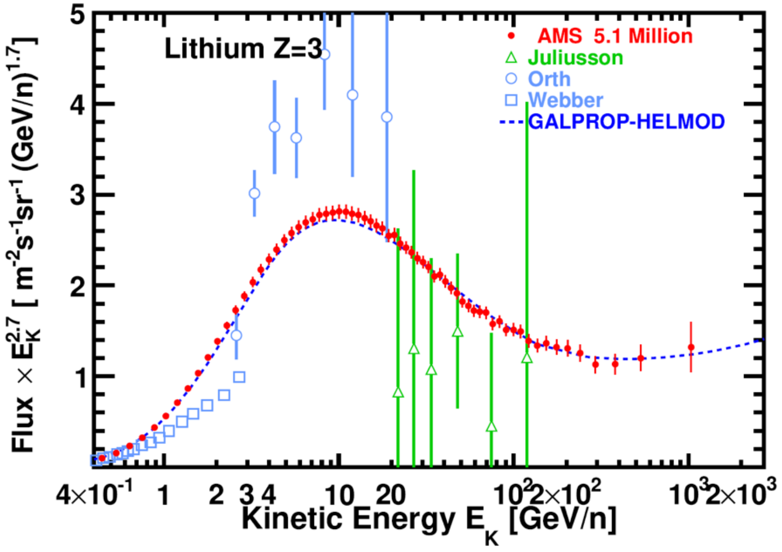
The background mainly coms from heavier nuclei interaction with AMS material, they are accurately measured (with typical error of few percents). A clean sample is obtained by subtracting the background from measured event numbers.

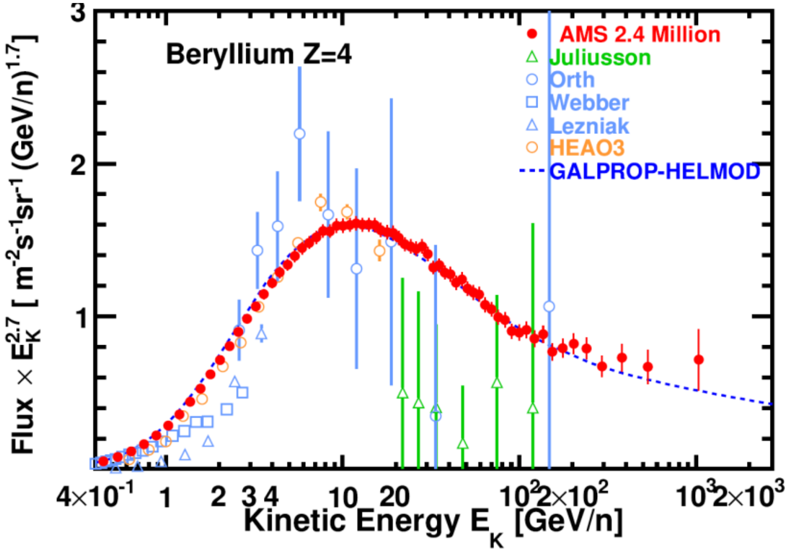
Example of the measurements of the background arising from the interaction with TRD and UToF material:

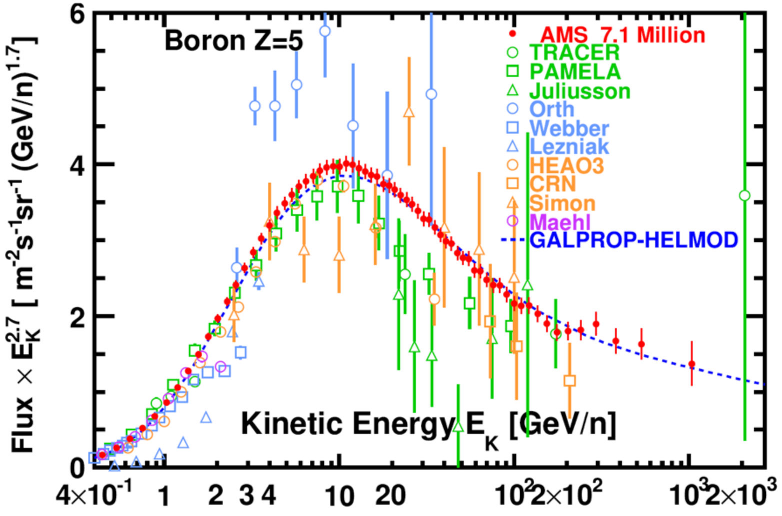




Cosmic Rays Lithium Beryllium and Boron Fluxes

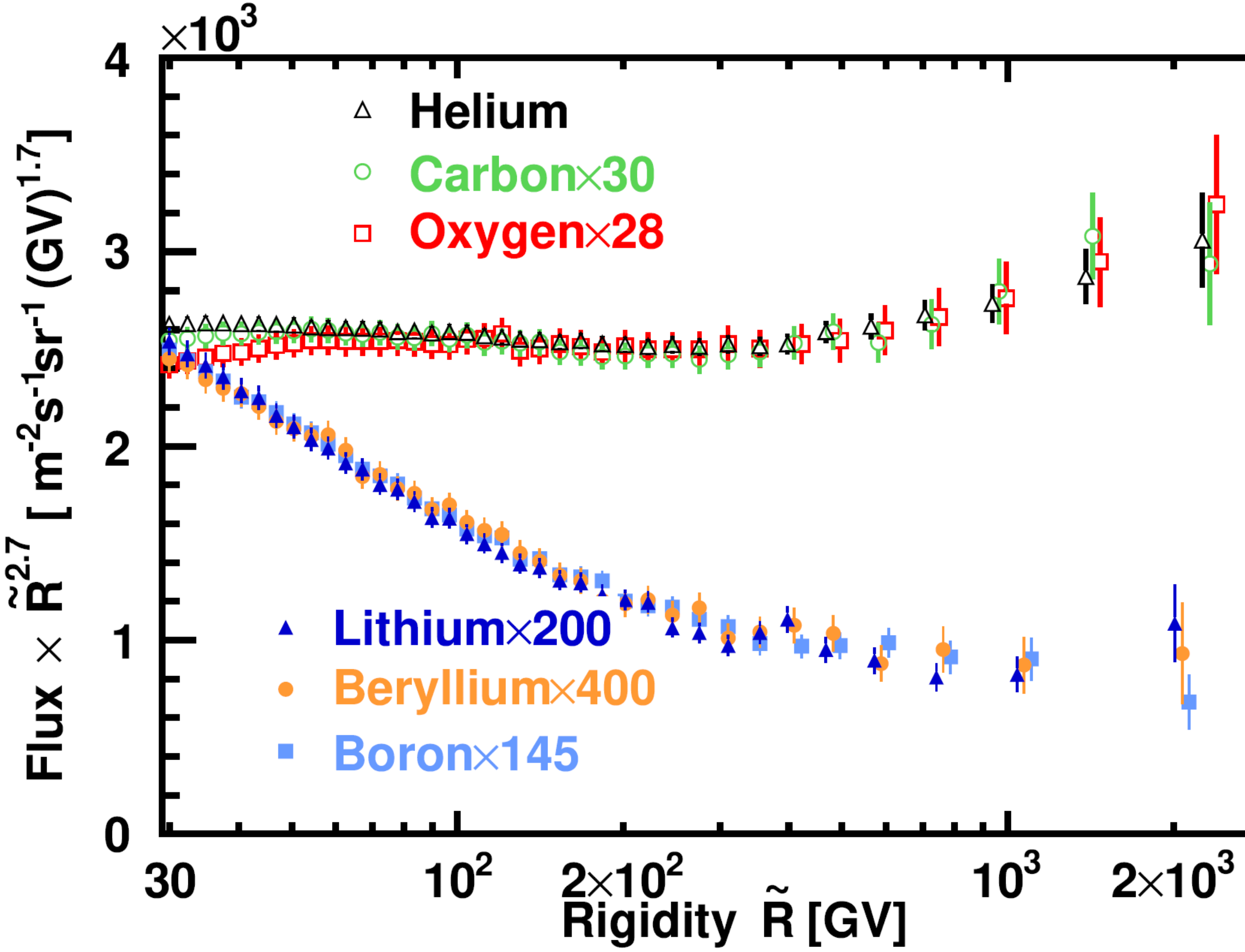






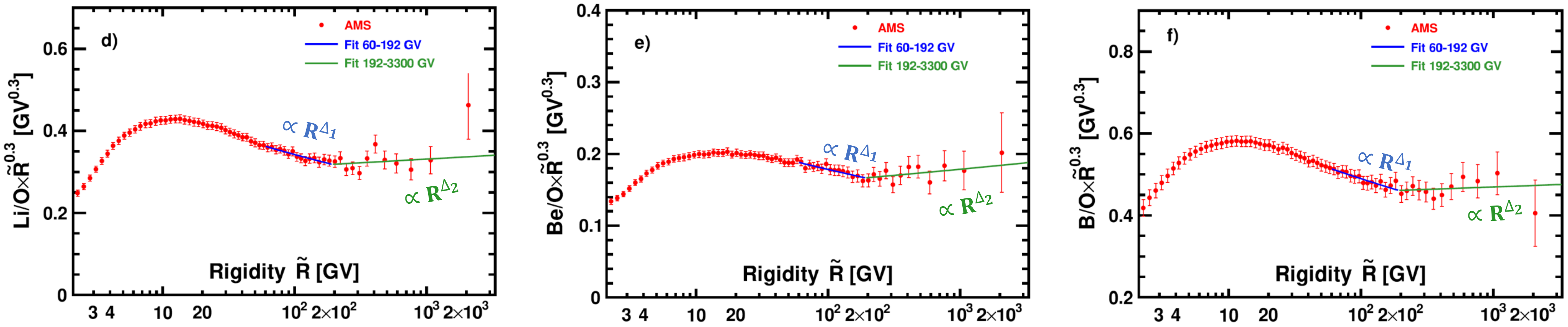
AMS measured the Lithium (Li), Beryllium (Be) and Boron (B) fluxes with unprecedented precision.

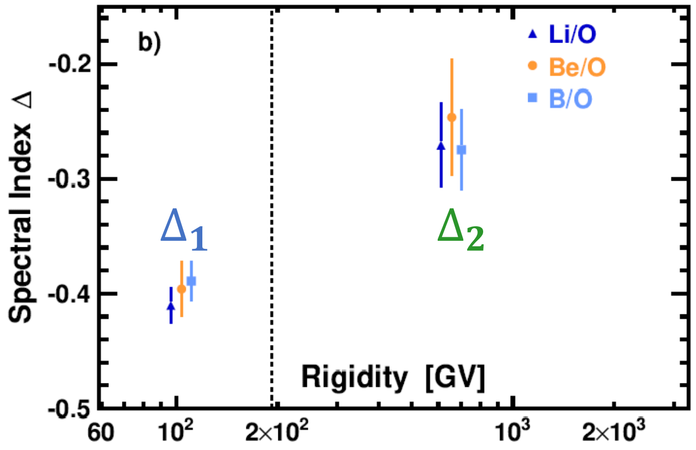
Secondary Primary Fluxes Comparison



The secondary Li-Be-B fluxes have the same rigidity dependence above 30 GV, and it is distinctly different with primary cosmic rays(see the incoming talk from Prof. Yan).

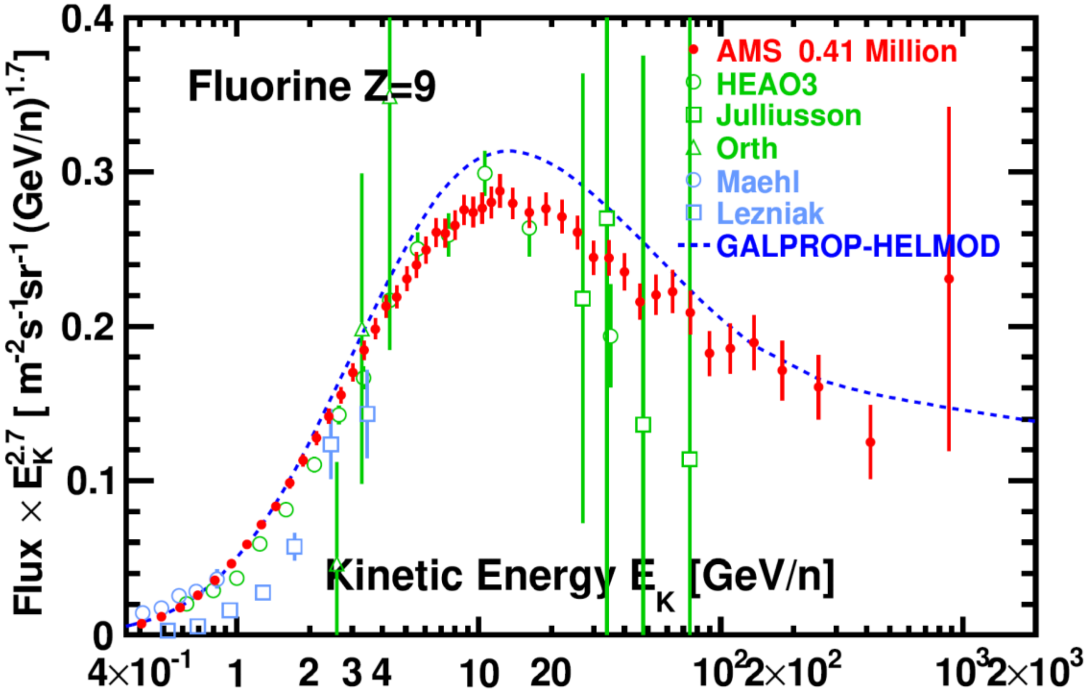
Secondary to Primary Fluxes Ratios

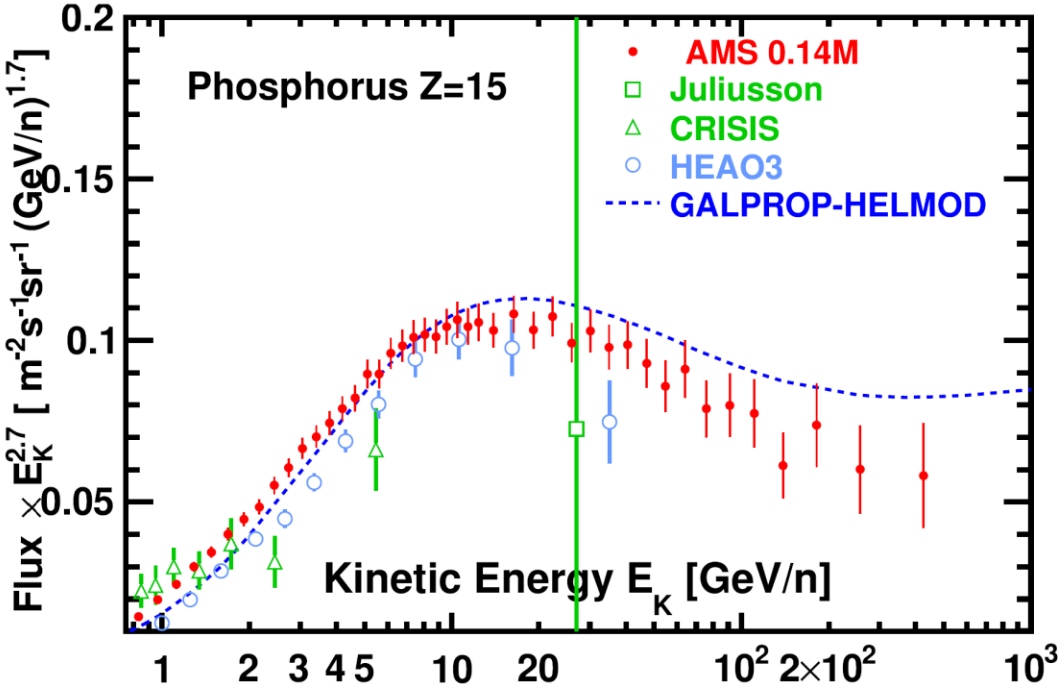




- Above ~200 GV, all three secondary-to-primary flux ratios harden with Δ_2- $\Delta_1 = \mathbf{0.13 \pm 0.025}$
- The Δ_2 is not compatible with Δ_1 with C.L more than 5σ show that the spectral hardening at ~200GV is due to propagation effect.

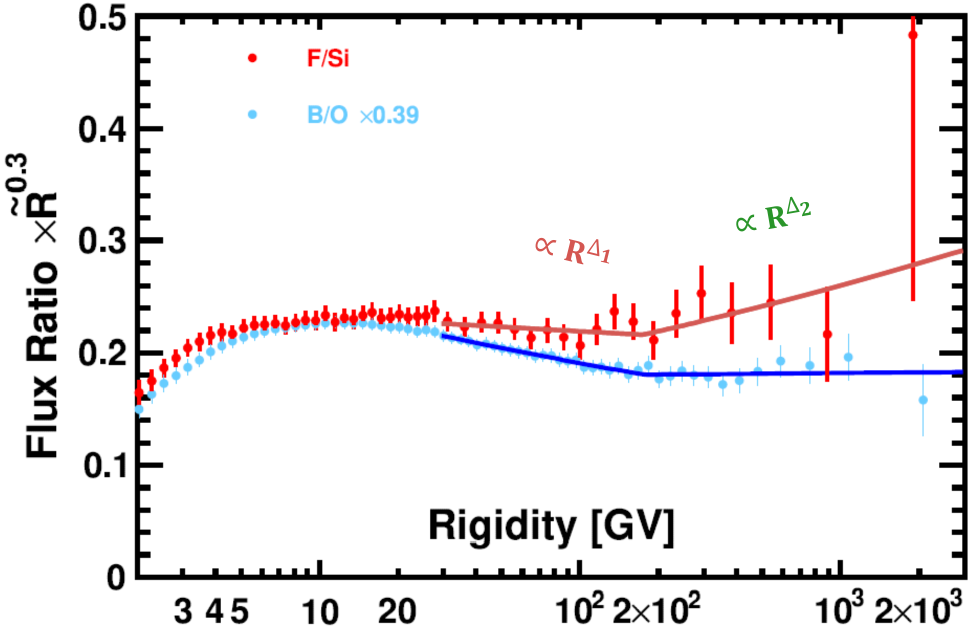
Cosmic Rays Fluorine and Phosphorus Fluxes



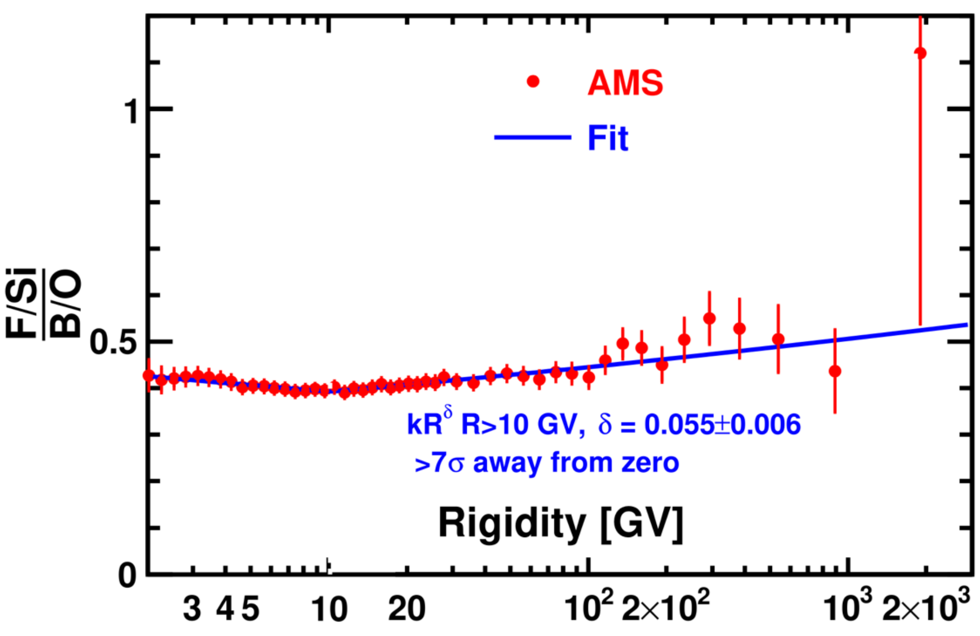


AMS measured the Fluorine (F) and Phosphorus (P) fluxes with unprecedented precision and extended the measured rigidity to a much higher range.

Fluorine Spectral Structures

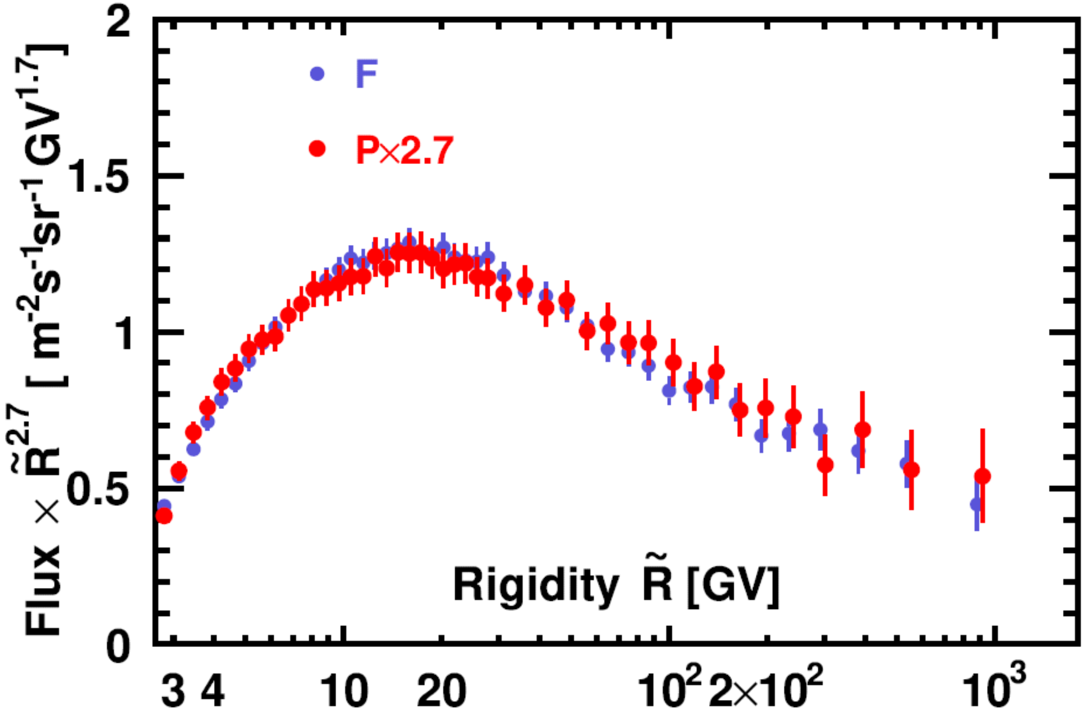


The F/Si flux ratio also show a spectral hardening with Δ_2- $\Delta_1 = 0.14 \pm 0.06$ which is compatible with that of B/O flux ratio hardening with 0.13 ± 0.025 .

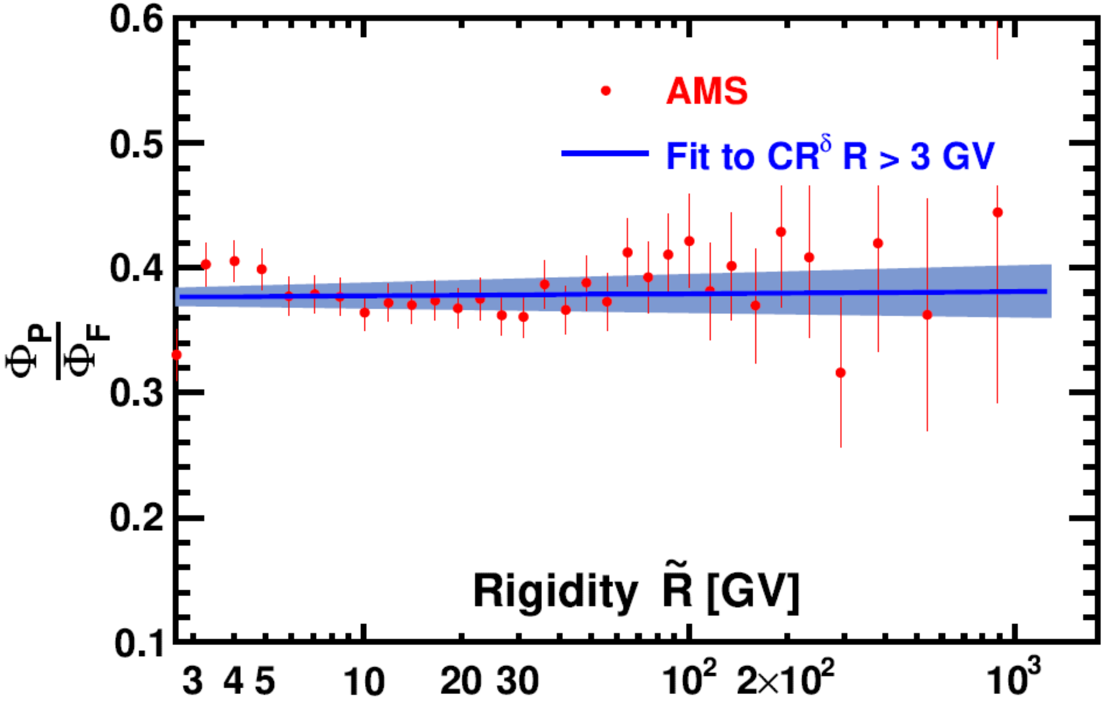


Above 10 GV, the ratio of $\frac{\mathrm{F/Si}}{\mathrm{B/O}}$ can be described by a single power law with $\delta = 0.055 \pm 0.006$ (>7σ difference from 0) show that the heavier secondary-to-primary F/Si flux ratio is distinctly different from the light B/O, which indicates that secondary cosmic rays also have two classes.

Fluorine and Phosphorus Fluxes Comparison

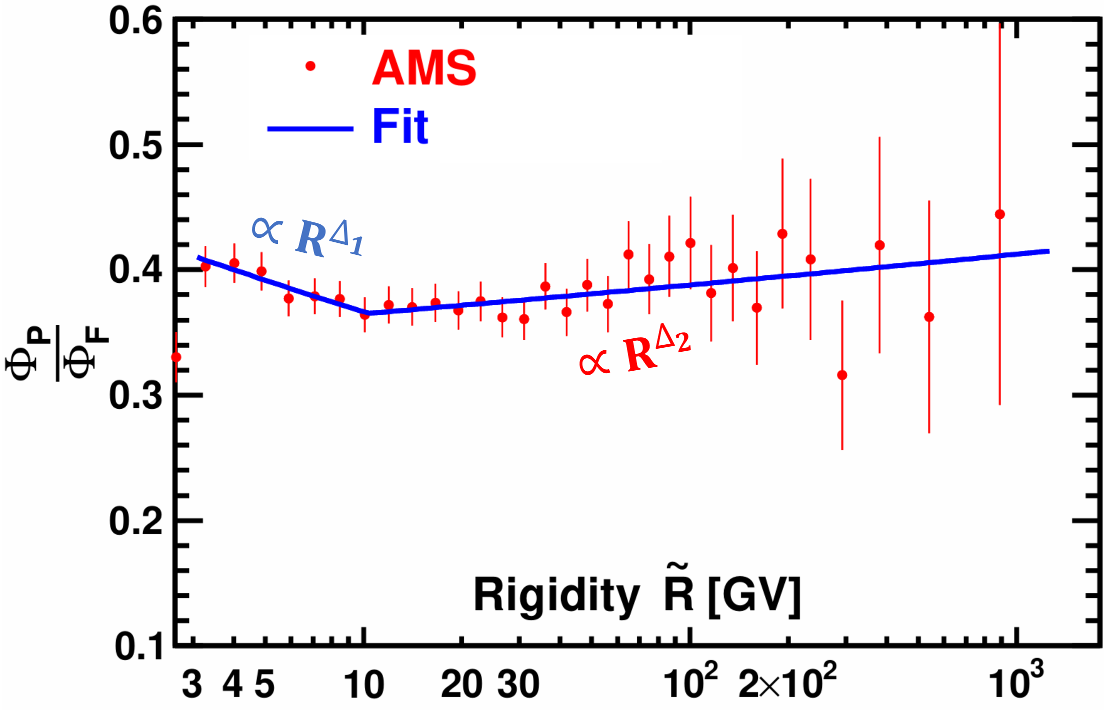


The rigidity dependence of P and F fluxes are very similar over the entire rigidity range

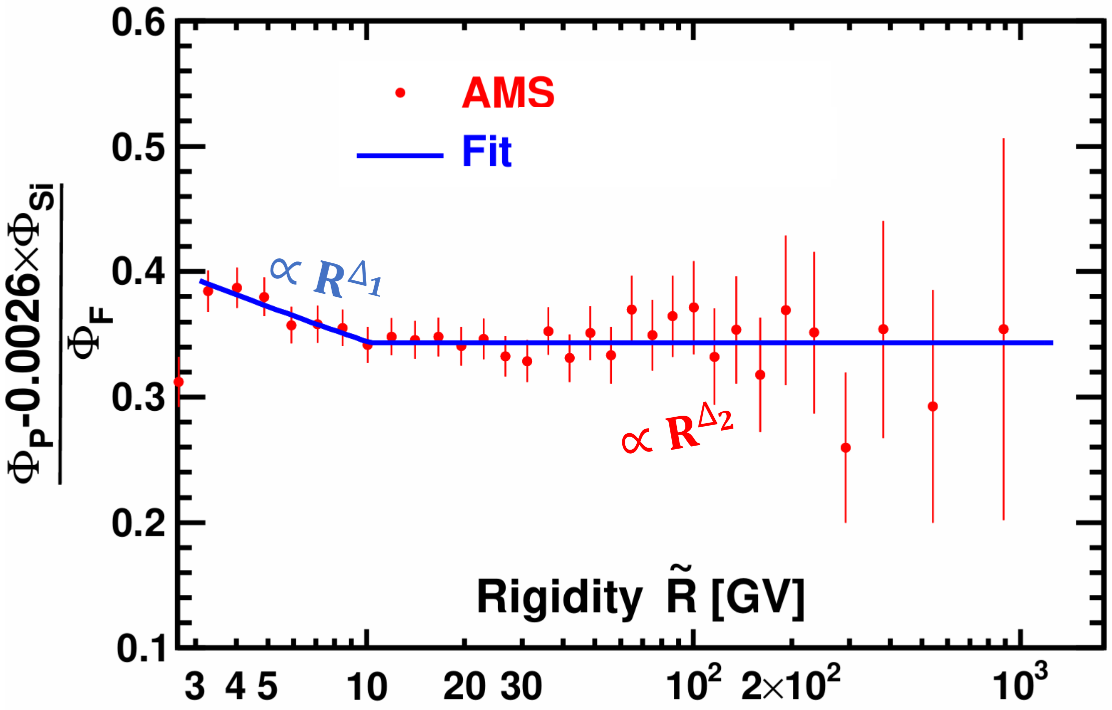


The flux ratio of P and F can be fitted with single power law, which yields $\boldsymbol{\delta} = 0.002 \pm 0.009$.

Potential Primary Contribution to P Flux



The P/F flux ratio also show a spectral hardening with Δ_2- $\Delta_1 = 0.127 \pm 0.034$.



After subtracting the scaled Si flux, the P/F flux ratio above 10 GV can be well described by a constant($\Delta_2 = 0$), this indicates potential primary contribution to P flux.

Summary

- The latest AMS measurements of secondary cosmic ray Li, Be, B, F, and P fluxes are presented
- All fluxes exhibit a hardening above 200 GV, however, the secondary fluxes harden more than the primary fluxes, which favors a propagation origin of the observed hardening
- The $\frac{F/Si}{B/O}$ ratio deviates from a constant by more than 7σ demonstrating that F belongs to different class of secondary cosmic ray with Li-Be-B
- The P flux shows similar rigidity dependence with F flux, however, the slight difference in their rigidity dependence indicates that P contains primary component