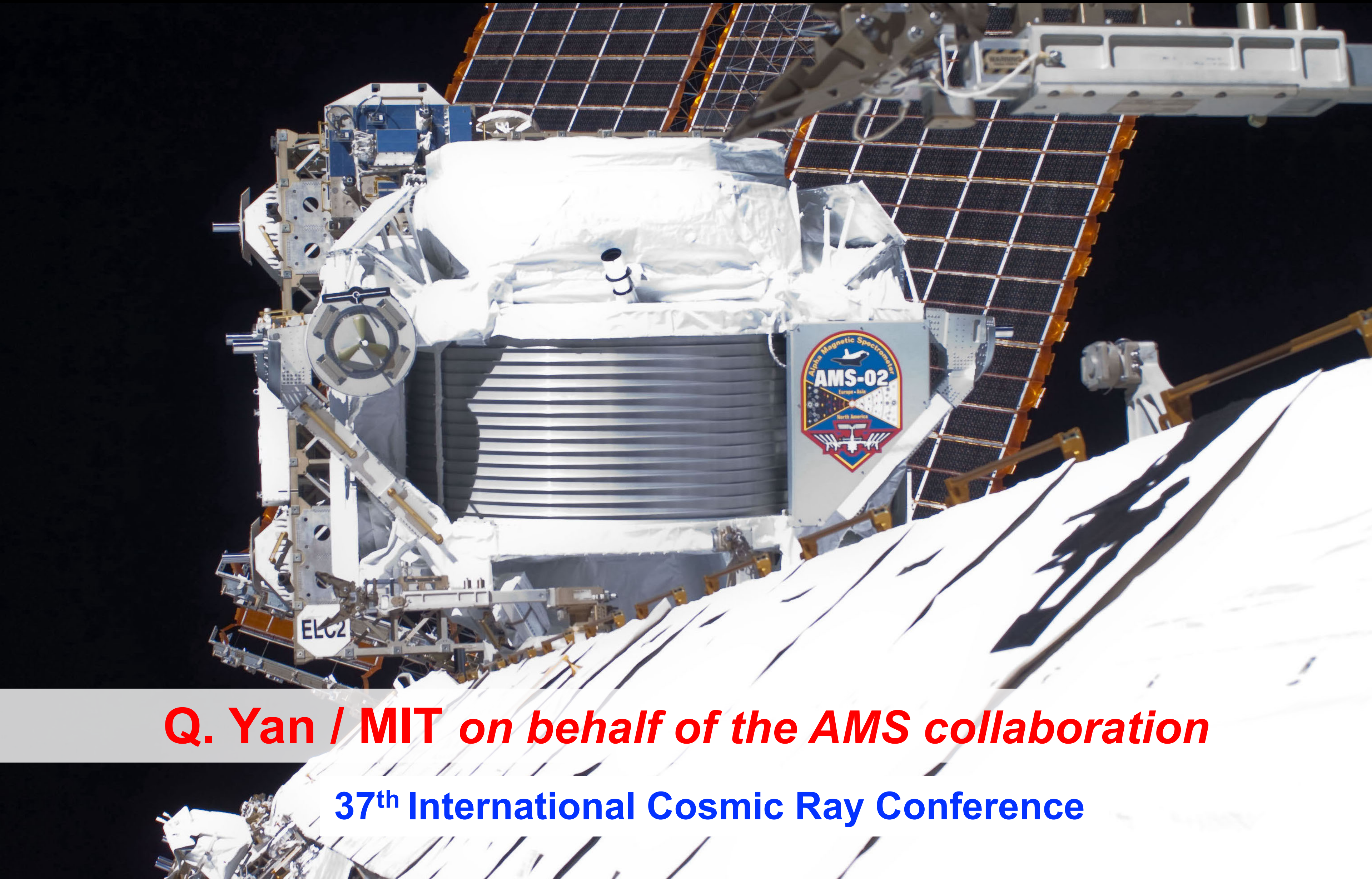
Properties of Heavy Secondary Fluorine Cosmic Rays Results from AMS

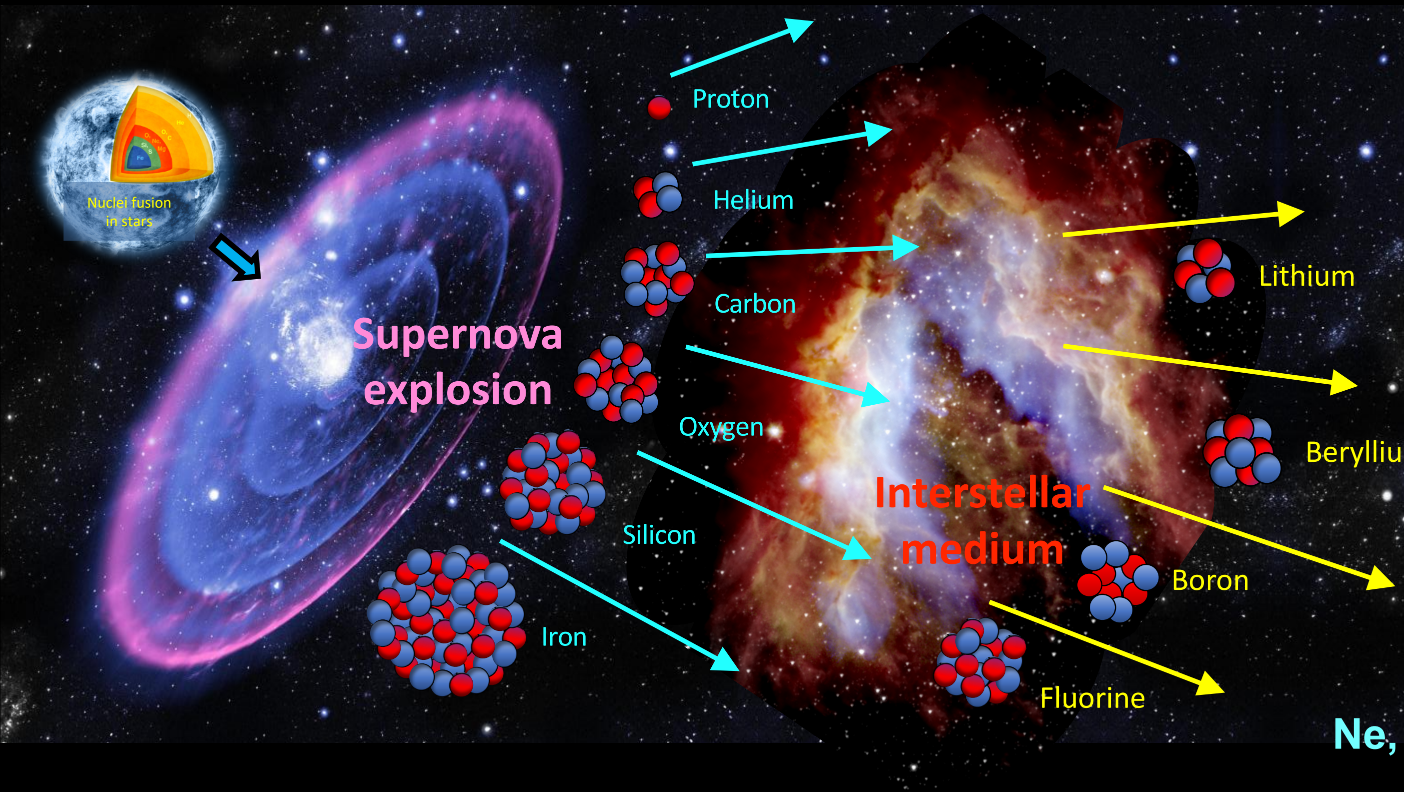


Q. Yan / MIT ***on behalf of the AMS collaboration***

37th International Cosmic Ray Conference

Secondary Cosmic Ray Nuclei

Secondary Li, Be, B, and F nuclei in cosmic rays are produced by the collision of primary cosmic rays C, O, Ne, Mg, Si, …, Fe with the interstellar medium.



C, O, … + ISM → Li

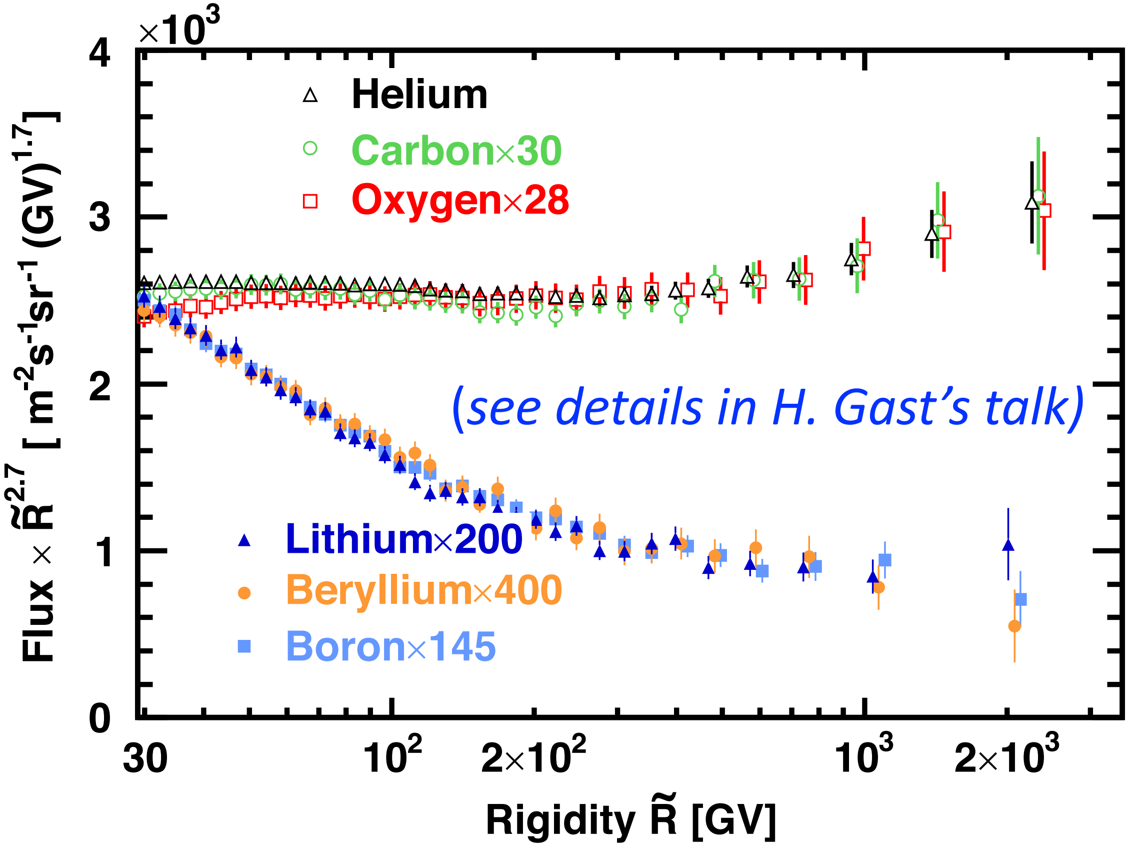
C, O, … + ISM → Be

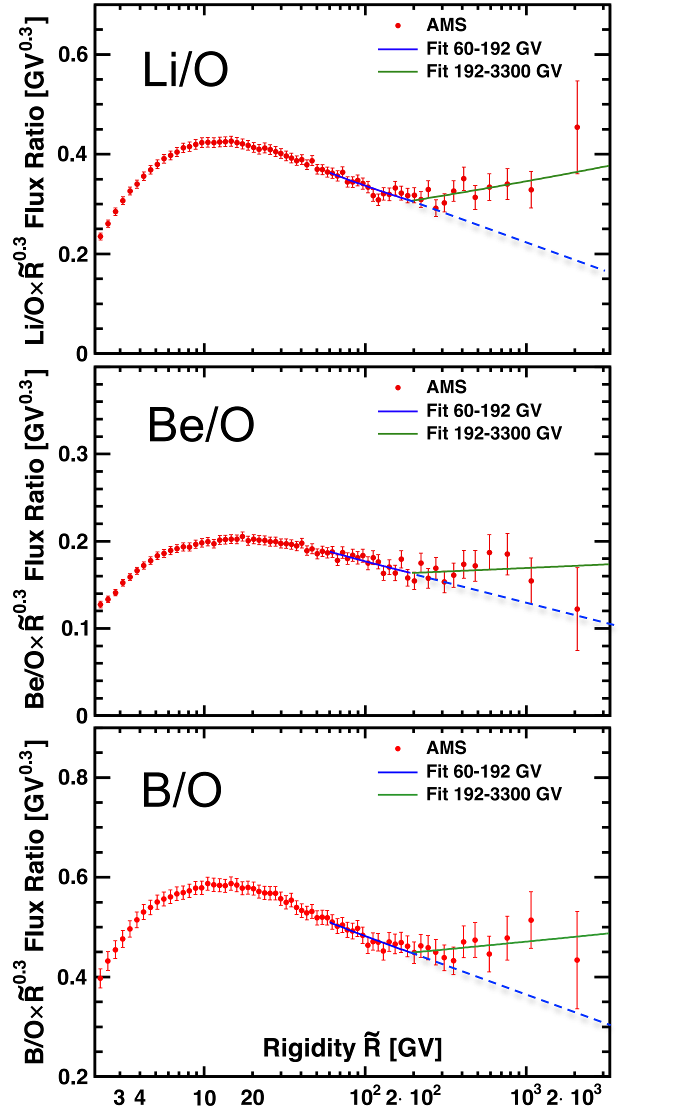
C, O, … + ISM → B

Ne, Mg, Si, … + ISM → F

Measurements of the secondary cosmic ray nuclei fluxes and the secondary-to-primary flux ratios are important in understanding the propagation of cosmic rays in the Galaxy.

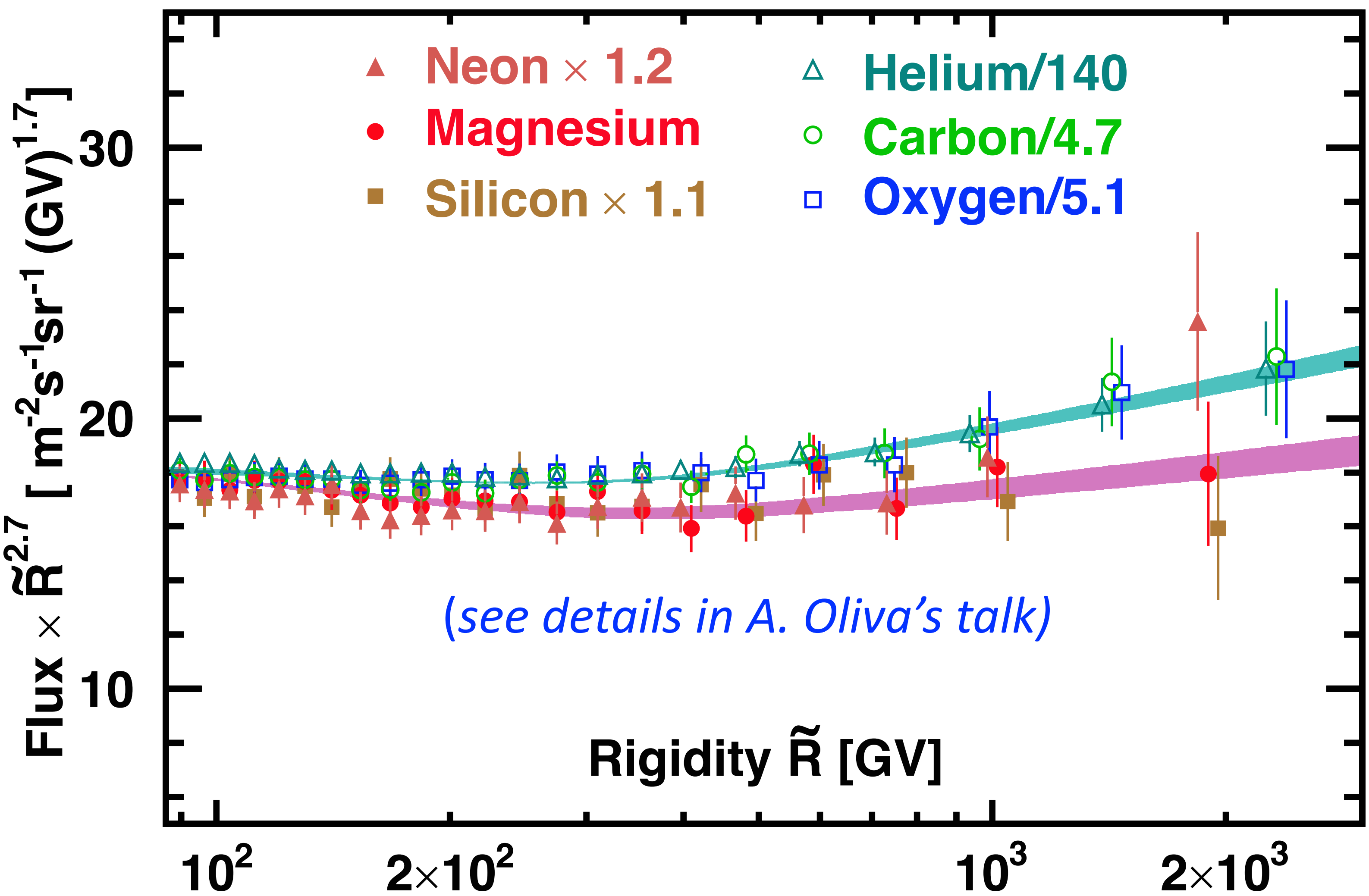
AMS Results on Light Primary and Secondary Nuclei Fluxes





The spectral hardening presents both in primary and secondary cosmic ray nuclei fluxes. Surprisingly, the secondary hardens more than the primary.

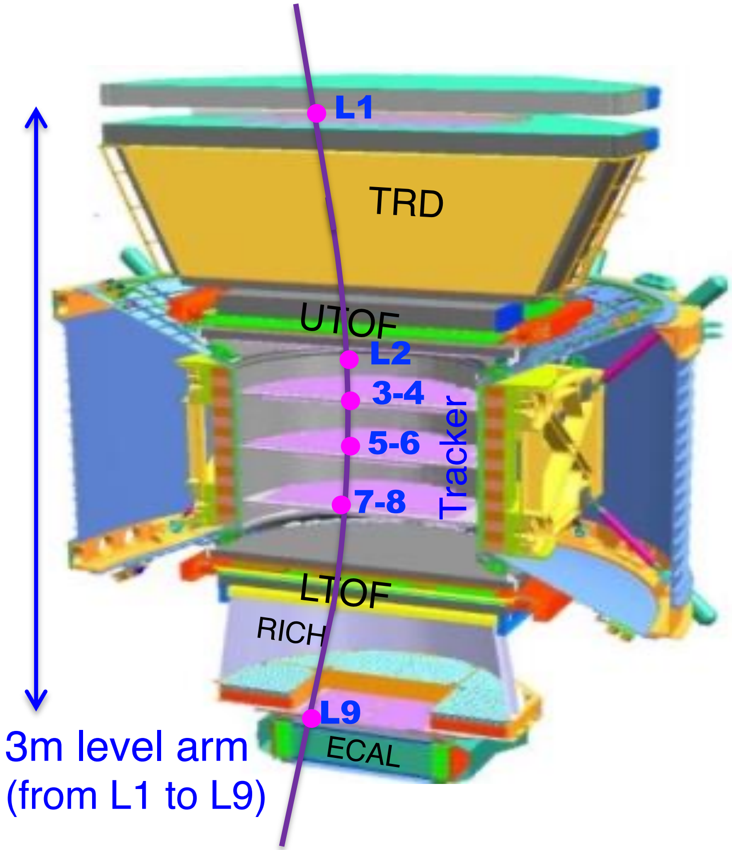
AMS Results on Heavy Primary Nuclei Fluxes (Ne, Mg, Si)



Two different classes of primary cosmic rays: He, C, O and Ne, Mg, Si.

What's the nature of the heavy secondary cosmic rays?

AMS Measurements of Heavy Secondary Fluorine Nuclei



Tracker (9 Layers) + Magnet: Rigidity (Momentum/Charge)

	Coordinate Resolution	MDR
Z =1	10 μm	2 TV
2≤Z≤8	5-7 μm	3.2-3.7 TV
Z=9	8 μm	3 TV

TOF (4 Layers): Velocity and Direction

$\Delta\beta/\beta^2 \approx 4\%$ (Z=1)

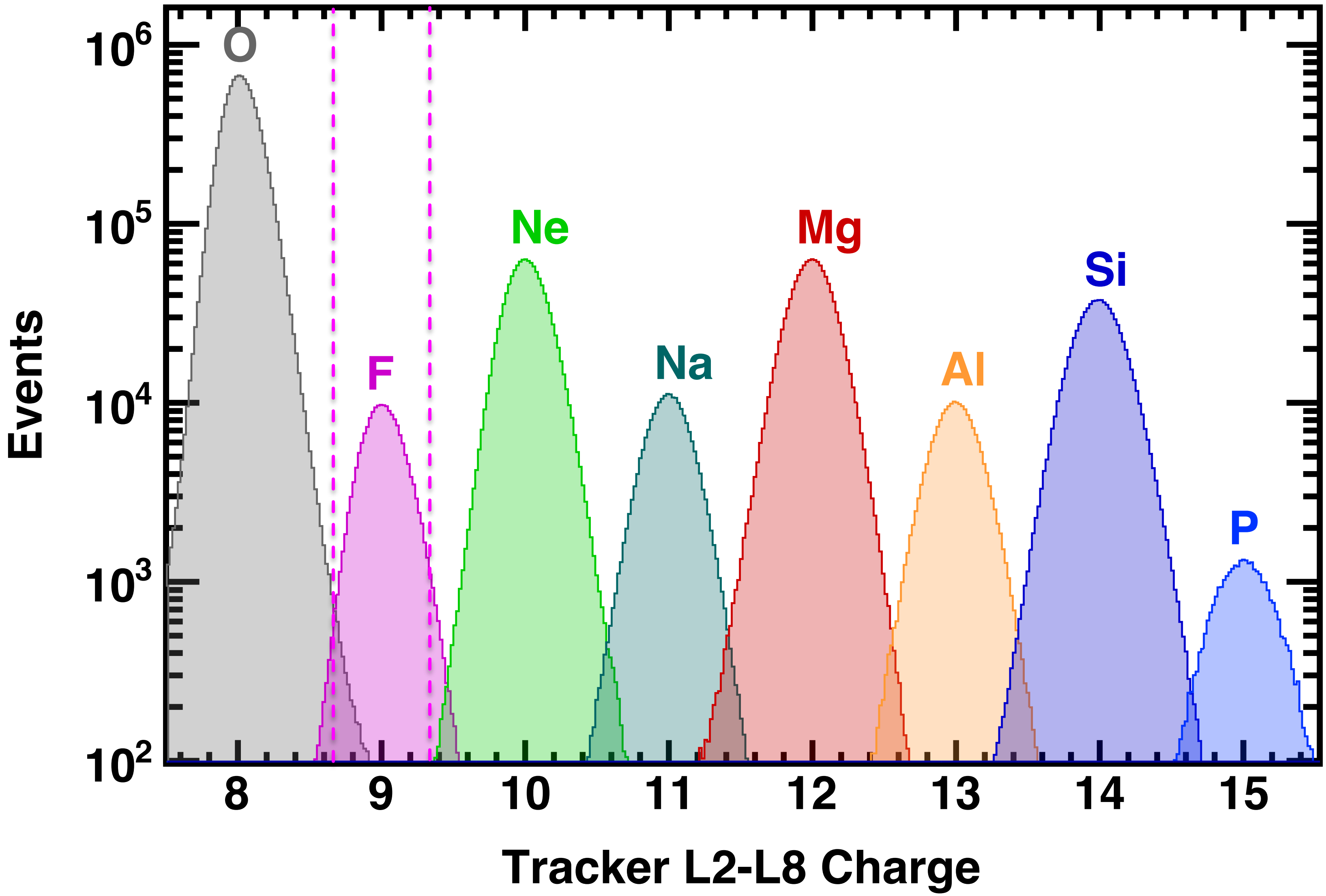
$\Delta\beta/\beta^2 \approx 1\text{-}2\%$ (Z≥2)

L1, UTOF, Inner Tracker (L2-L8), LTOF* and L9*

Consistent Charge Along Particle Trajectory

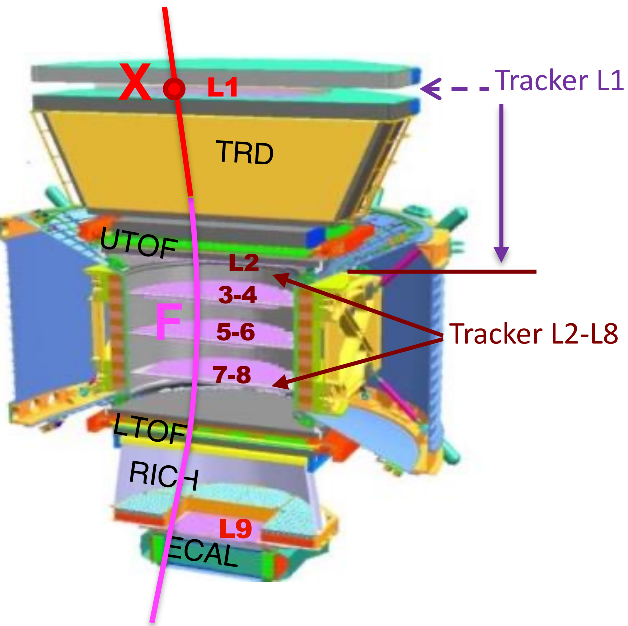
	Tracker L2-L8 Charge Resolution (c.u.)
1≤Z≤8	ΔZ ≈ 0.05-0.12
Z=9	ΔZ ≈ 0.13

Fluorine Event Selection

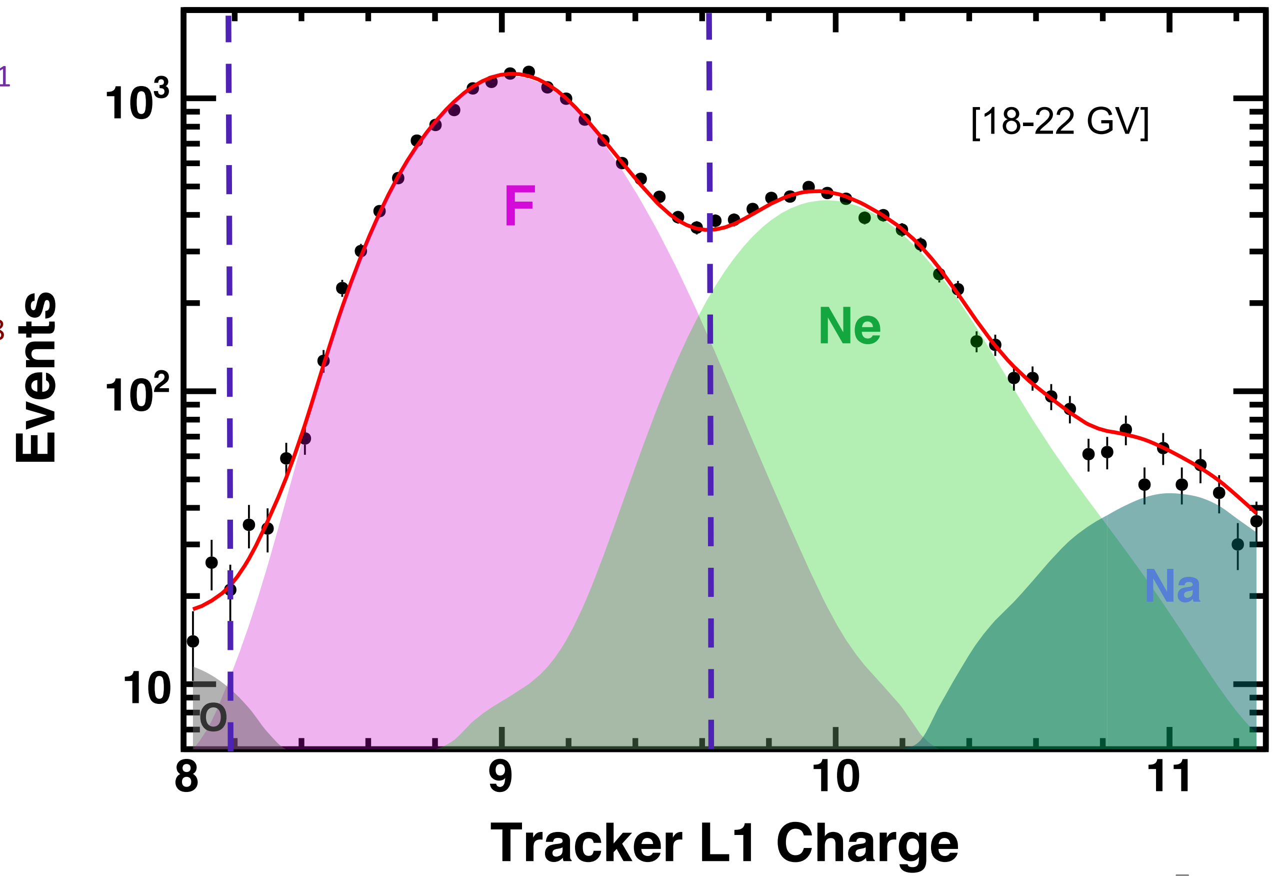


Fluorine Background (1)

The Fluorine nuclei were selected by using charge measurements on the inner tracker (L2-L8) and upper TOF (UTOF). The residual background below Tracker L1 (resulting from heavier nuclei interactions in the materials of TRD and UTOF) can be precisely subtracted by the L1 measured charge.



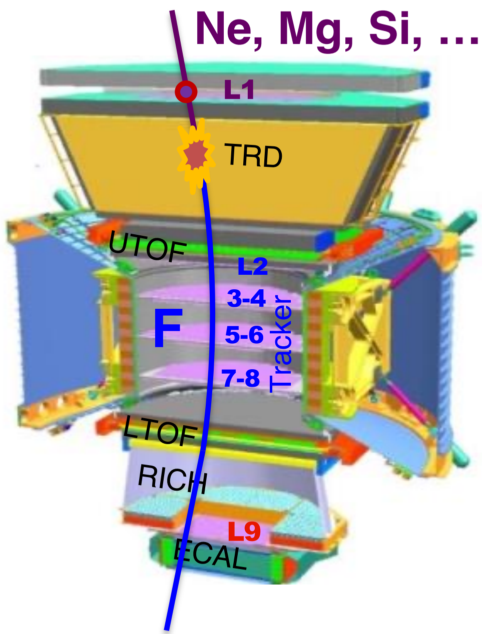
Tracker L1 charge cut

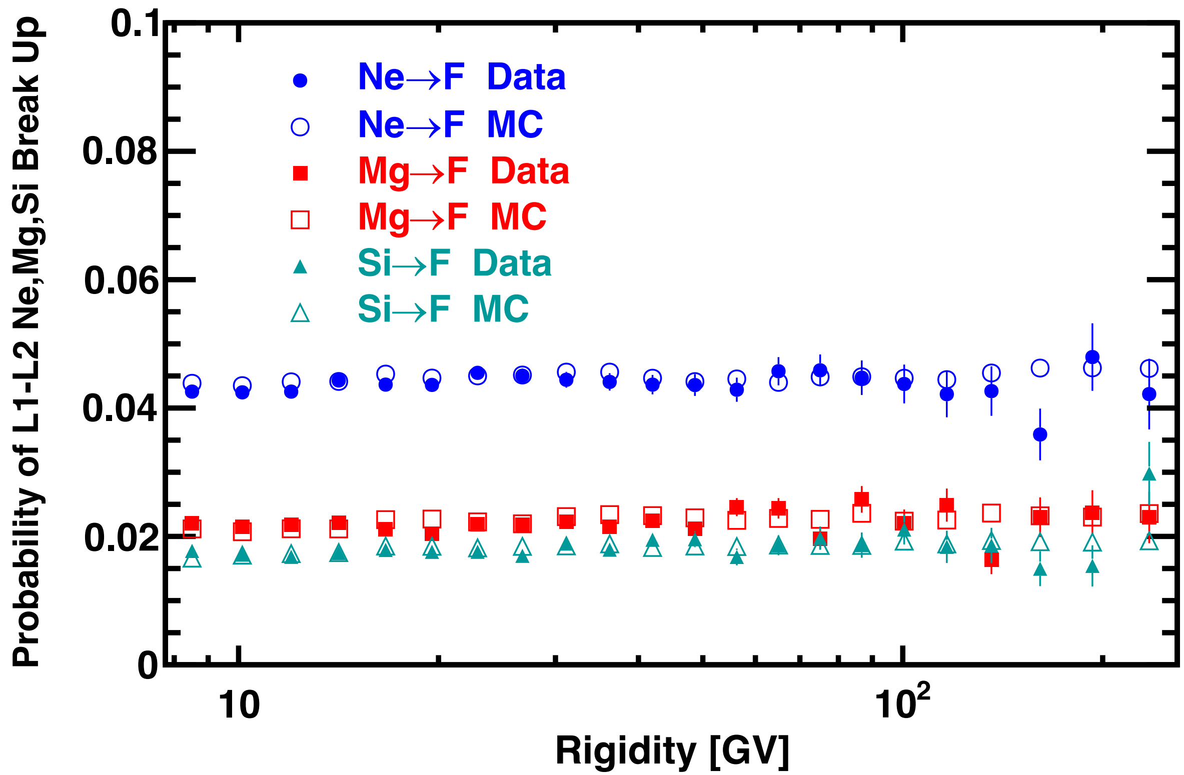


Fluorine Background (2)

The F background from interactions in materials above Tracker L1 (thin support structures made by C fiber and Al honeycomb) has been estimated from simulation using Monte Carlo samples generated according to AMS flux measurements. The simulation of nuclear interactions has been validated with AMS measured data:

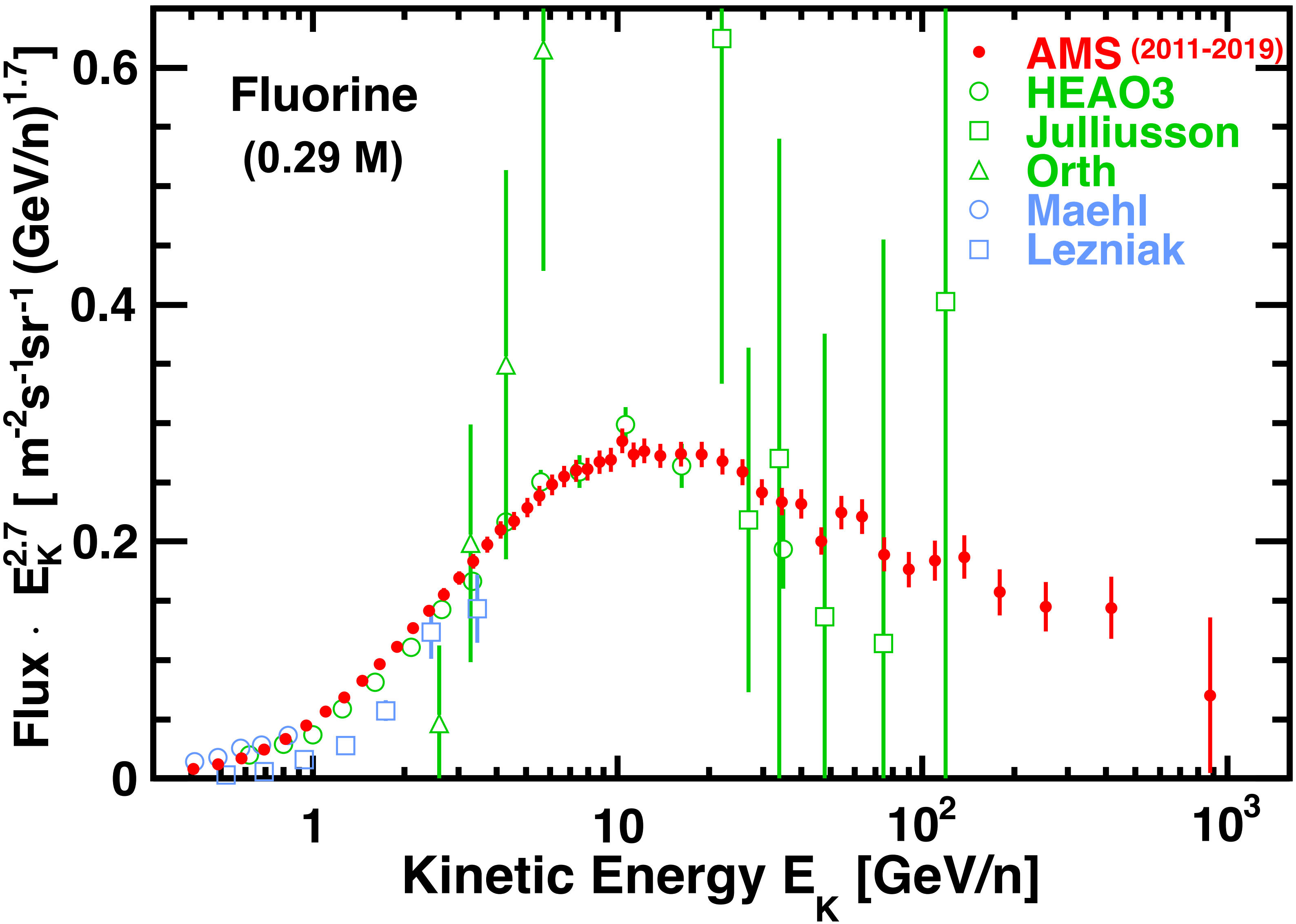
- Select primary nuclei (Ne, Mg, Si, …) by L1 charge
- Measure nuclei breaking-up probability using Tracker L2-L8 for channels: Ne, Mg, Si, …→F



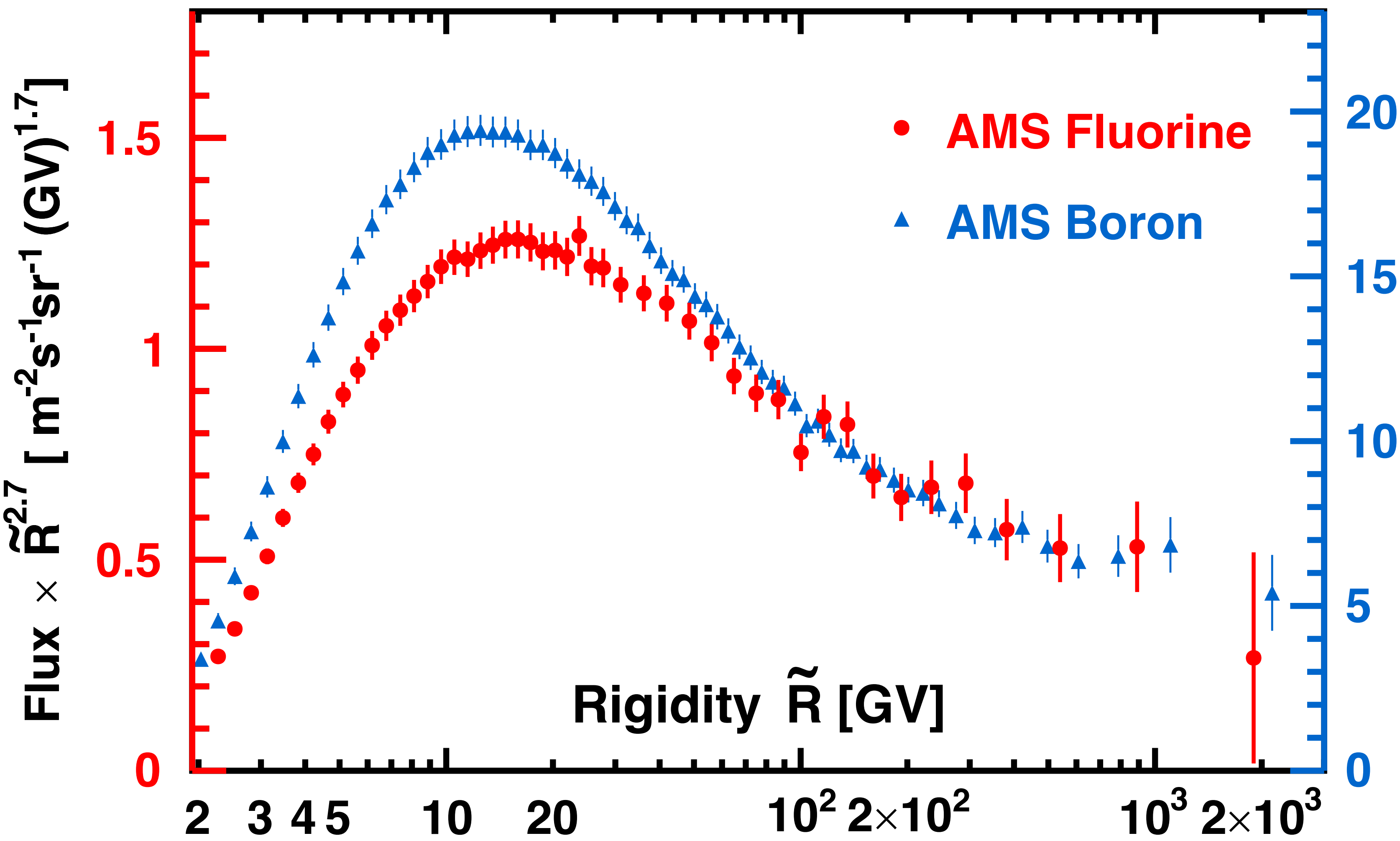


See details in "Q. Yan *et al*., Nuclear Physics A 996, 121712 (2020)".

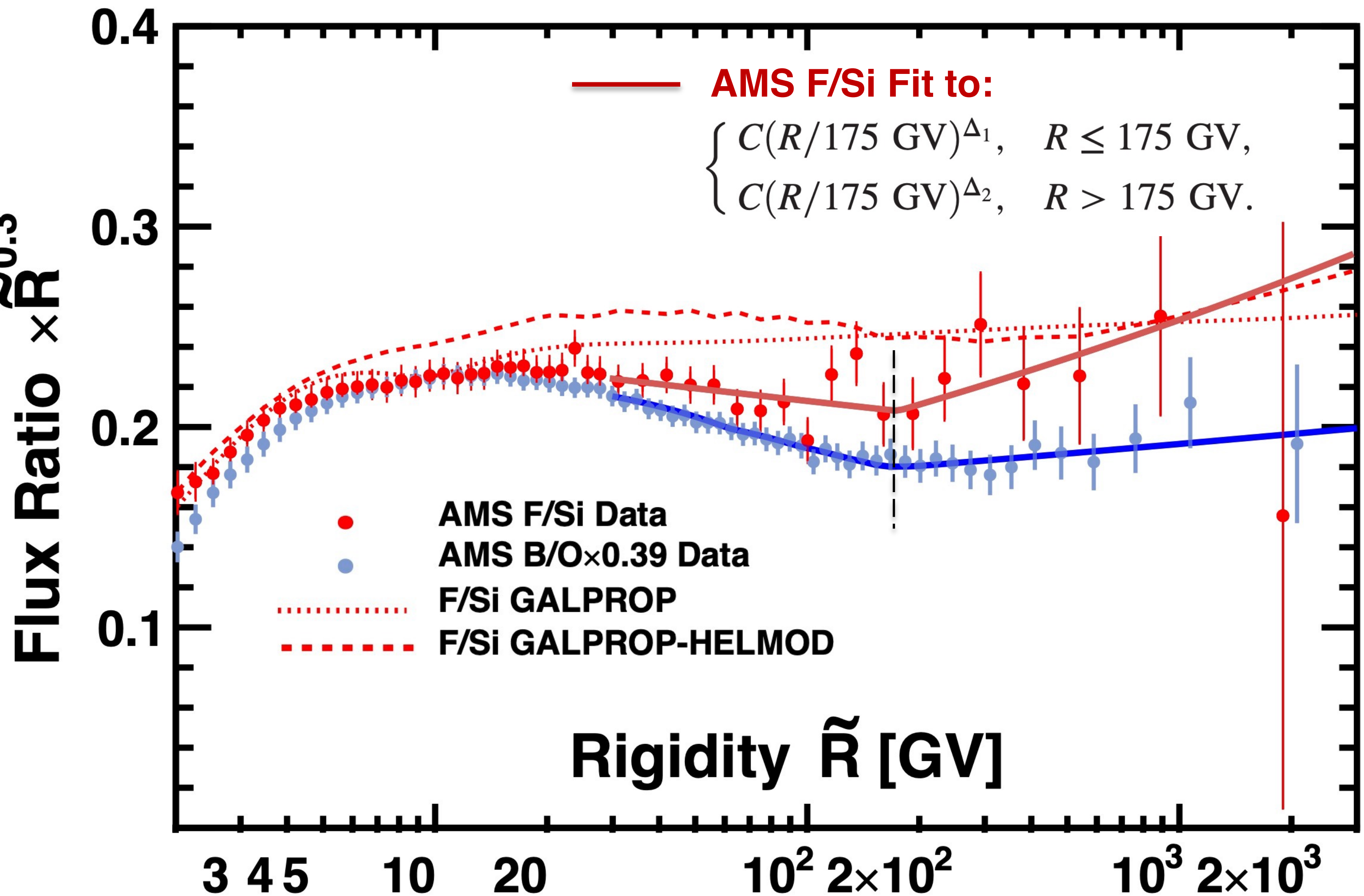
AMS Fluorine Flux Compared with Other Experiments



Heavy Fluorine Flux Compared with Boron Flux

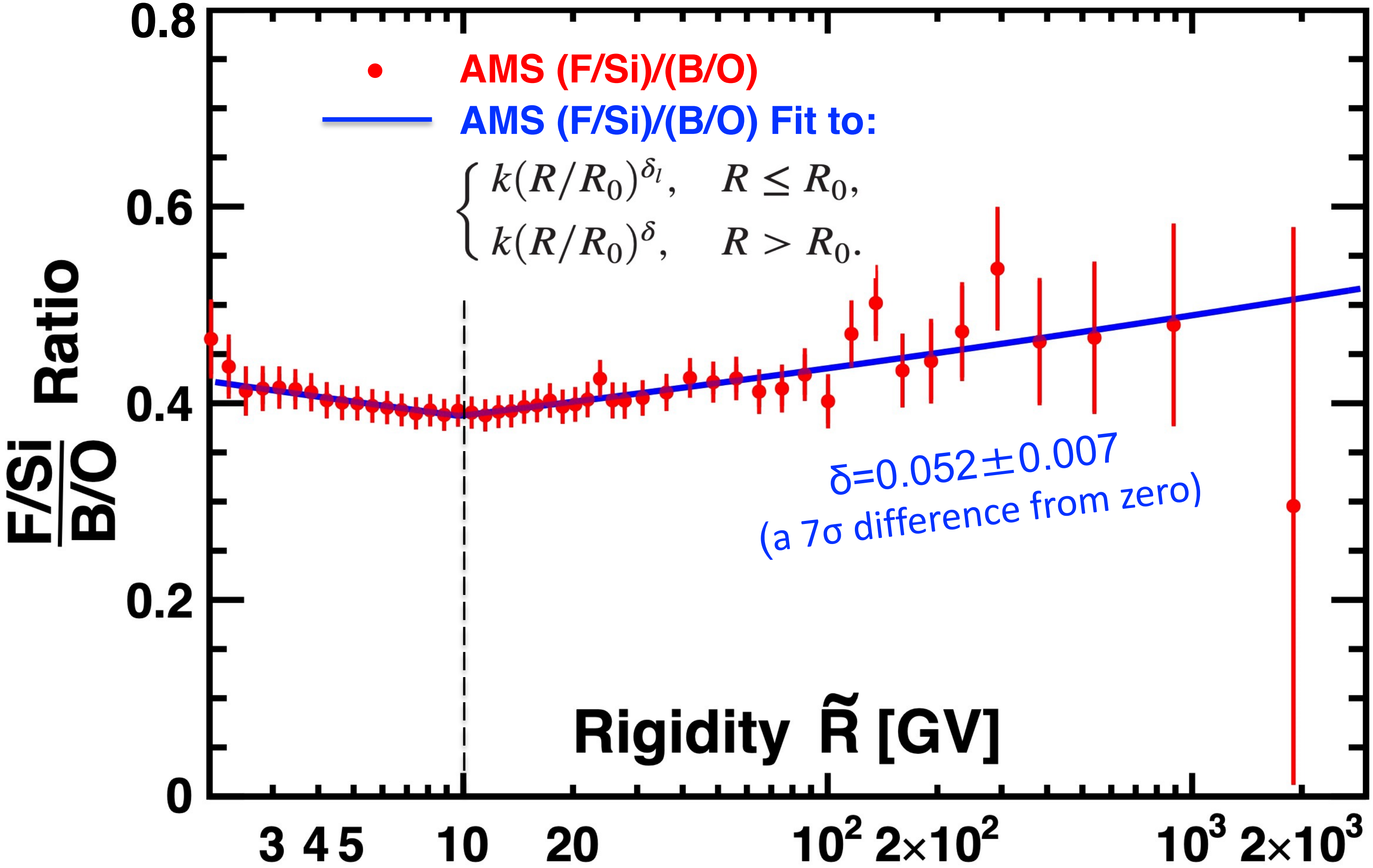


Heavier F/Si Flux Ratio compared with lighter B/O Flux Ratio



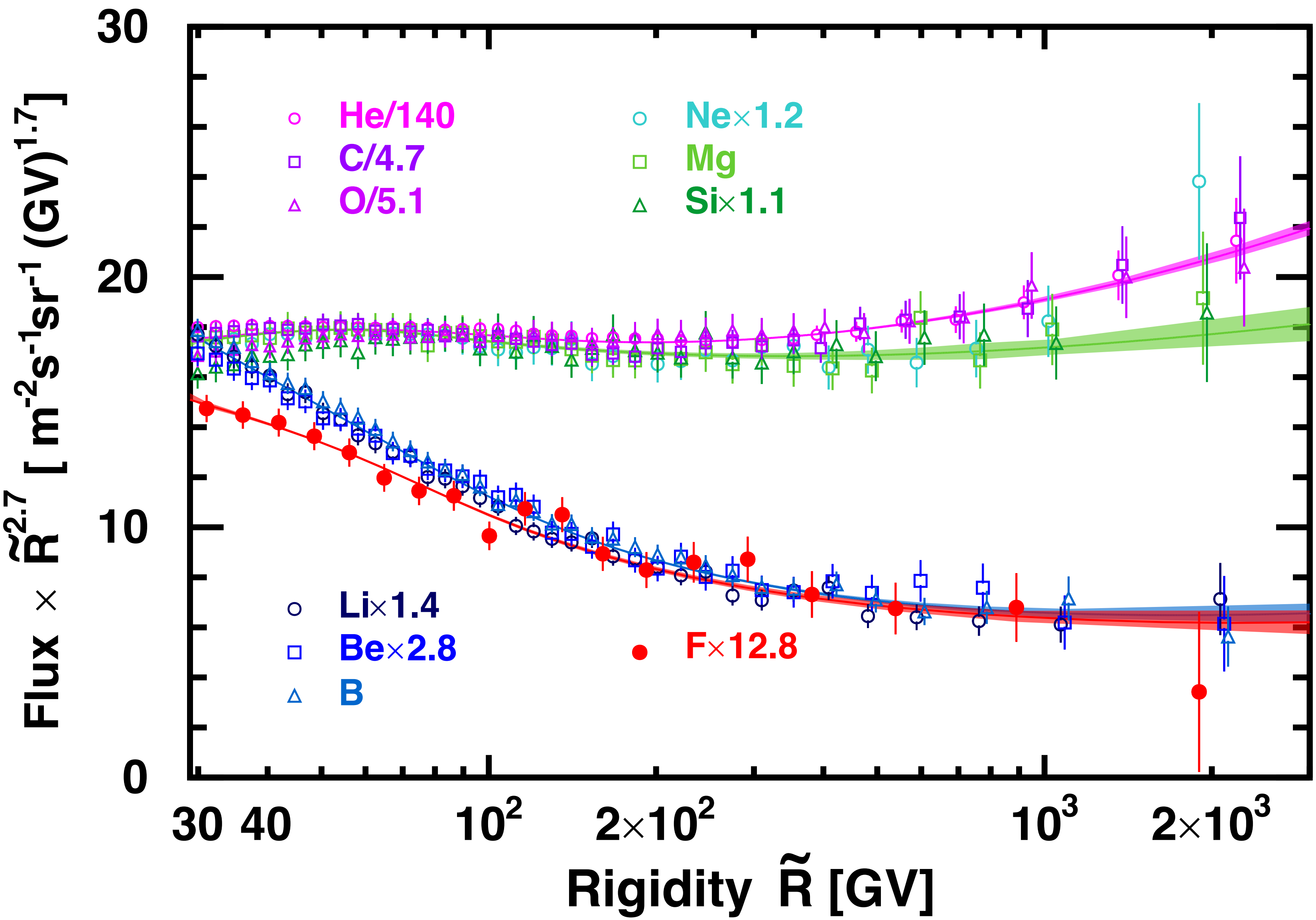
Above 175 GV, the F/Si ratio exhibits a hardening ($\Delta_2^{F/Si} - \Delta_1^{F/Si}$) of 0.15±0.07 compatible with the AMS result on the hardening of the Li/O, Be/O, and B/O flux ratios.

AMS (F/Si)/(B/O) Ratio



Above 10 GV, the (F/Si)/(B/O) ratio can be described by a single power law with δ=0.052±0.007, revealing that the propagation properties of heavy cosmic rays, from F to Si, are different from those of light cosmic rays, from He to O.

Primary and Secondary Cosmic Ray Fluxes (AMS He-Si)



Summary

- Precision measurement of the heavy secondary Fluorine (Z=9) cosmic ray flux from 2.15 GV to 2.9 TV based on 8.5 years AMS data (2011-2019) has been presented.

- The heavier secondary-to-primary F/Si flux ratio rigidity dependence is distinctly different from the lighter B/O (or B/C) rigidity dependence. In particular, above 10 GV, the (F/Si)/(B/O) ratio can be described by a power law R^{δ} with $\delta=0.052\pm0.007$, revealing that the propagation properties of heavy cosmic rays, from F to Si, are different from those of light cosmic rays, from He to O.

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