Unique Properties of Primary Cosmic Rays: Results from the Alpha Magnetic Spectrometer

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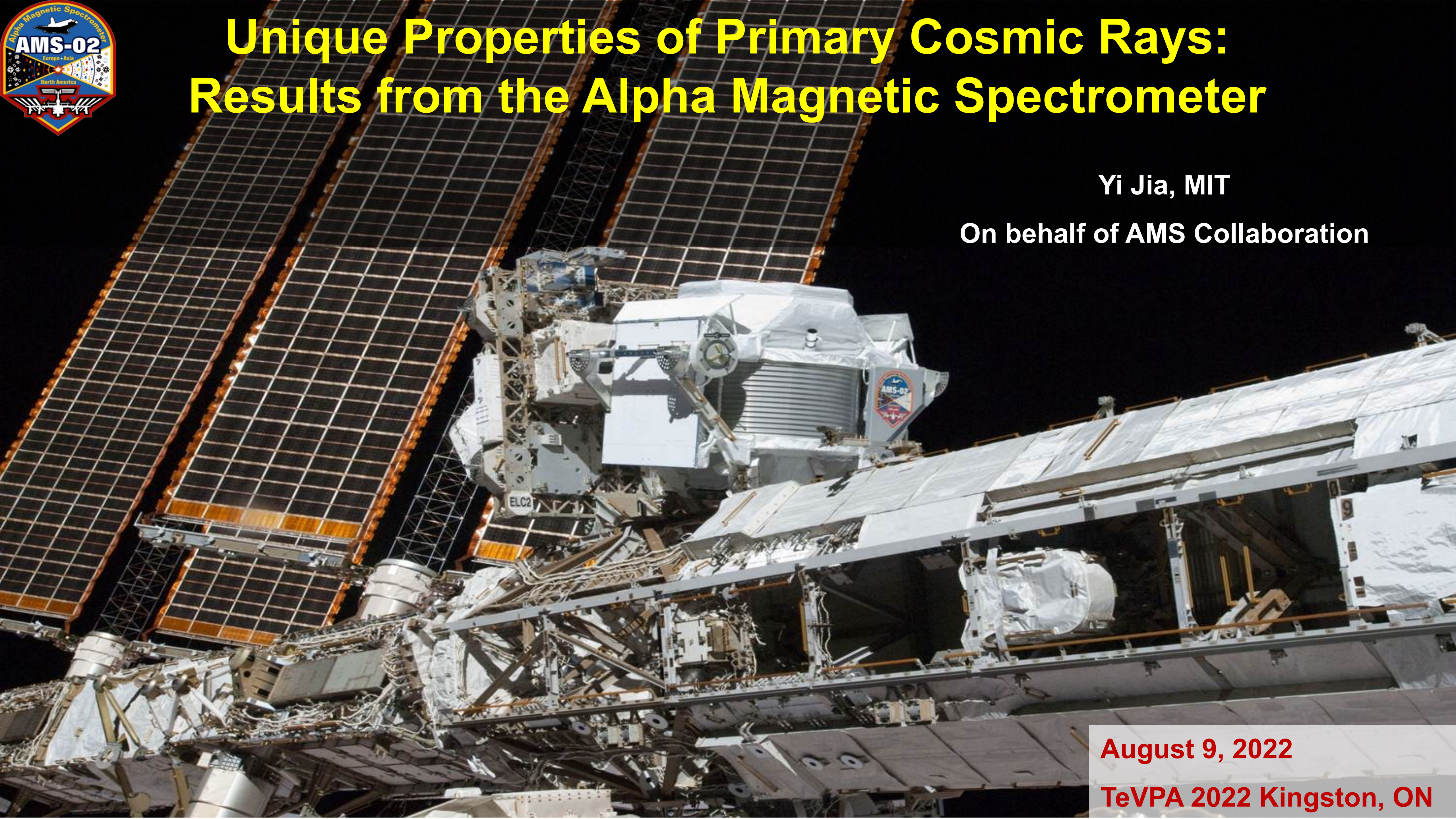
On behalf of AMS Collaboration



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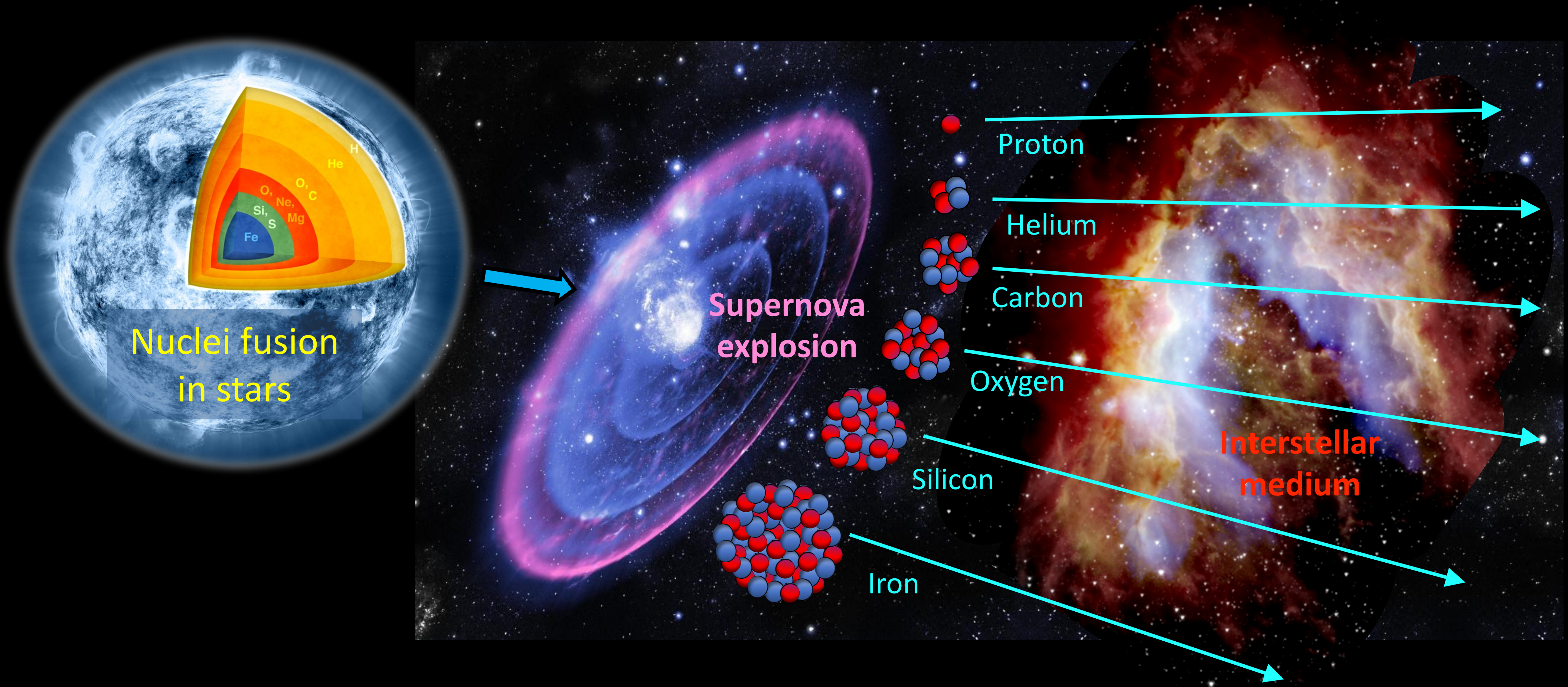
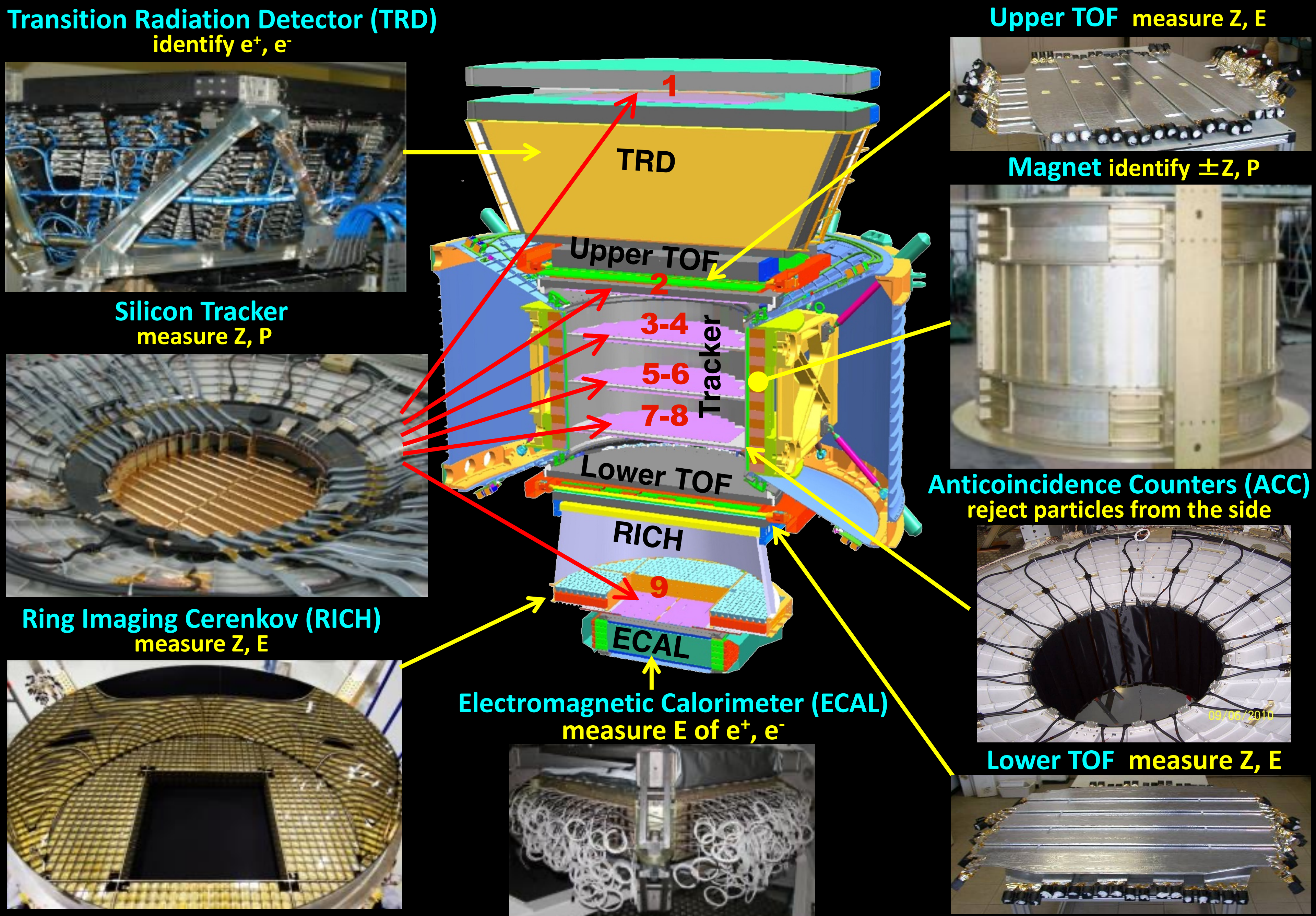
Primary Cosmic Rays

Primary cosmic rays p, He, C, O, ..., Si, ..., Fe are produced during the lifetime of stars and accelerated by supernovae. They propagate through interstellar medium before they reach Earth.



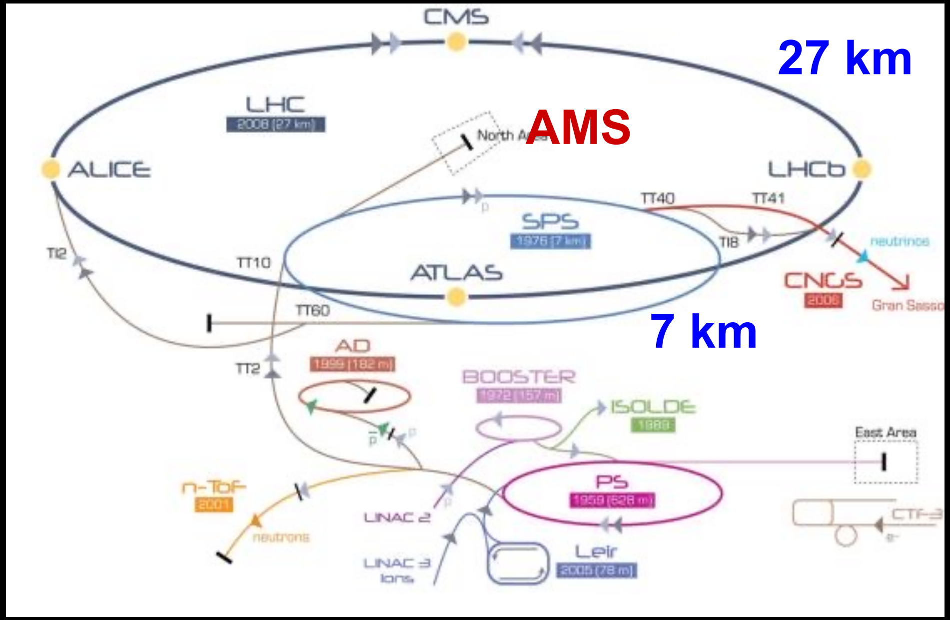
Measurements of primary cosmic ray fluxes are fundamental to understanding the origin, acceleration, and propagation processes of cosmic rays in the Galaxy.

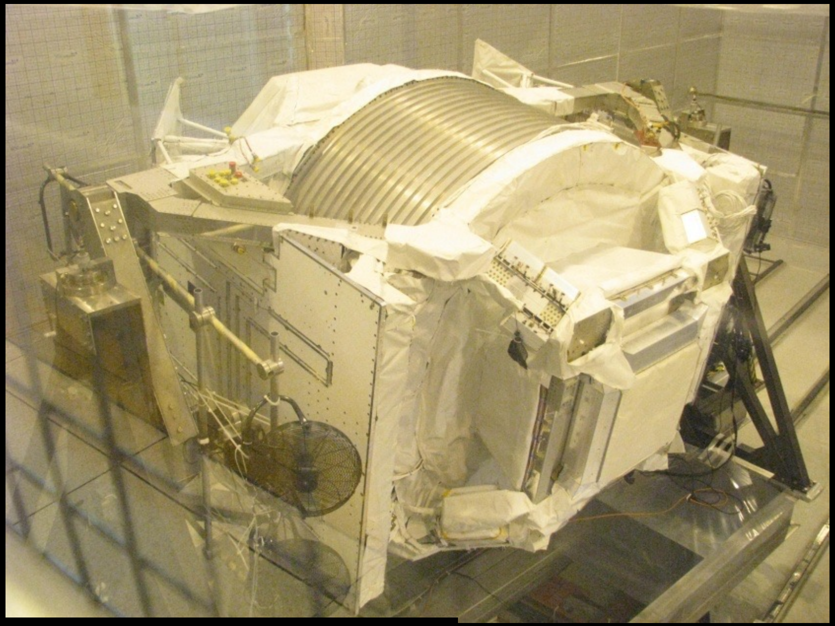
AMS is a space version of a precision detector used in accelerators

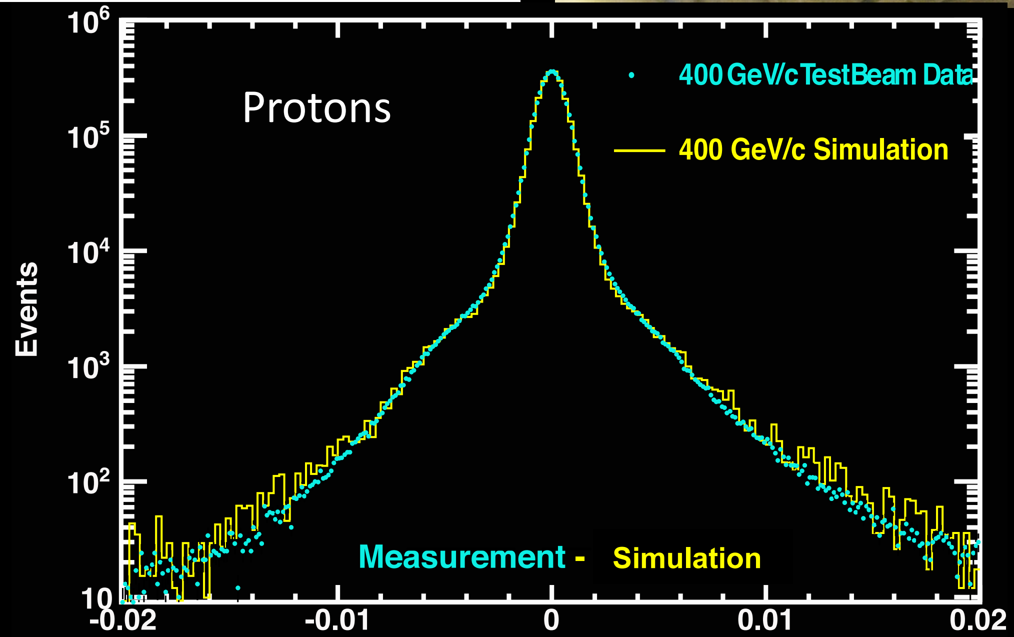


Calibration at CERN

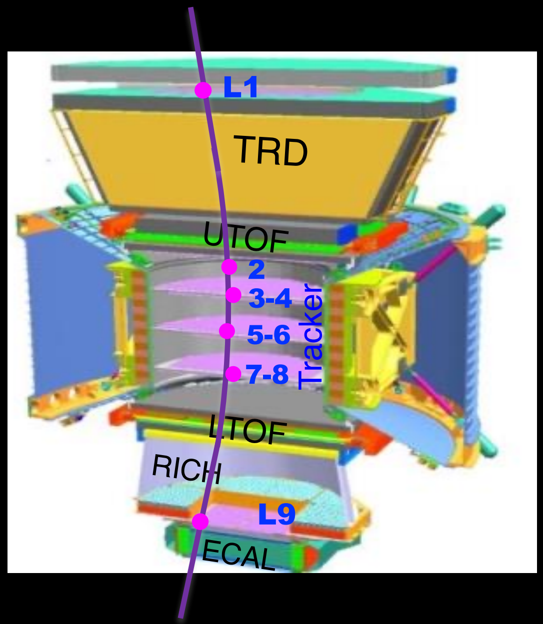
with different particles at different energies

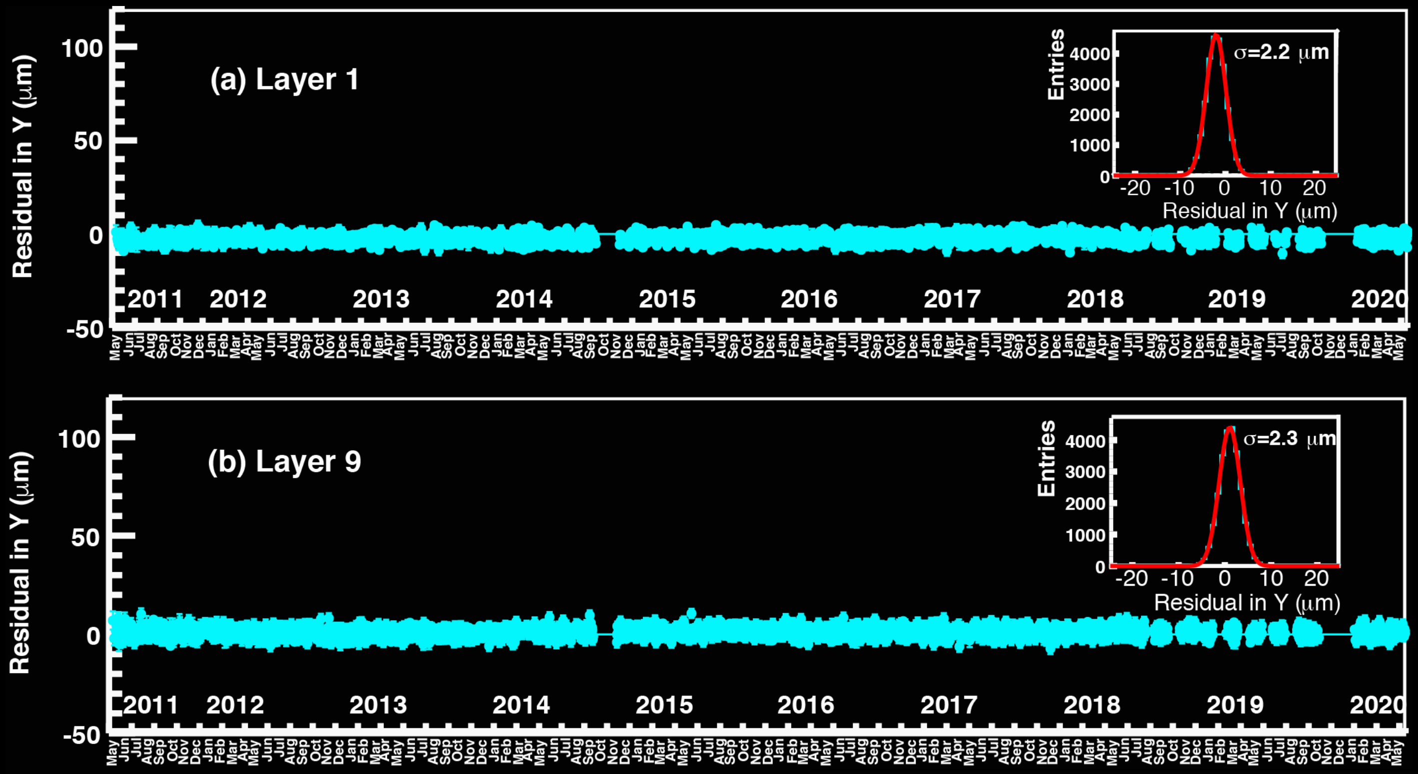






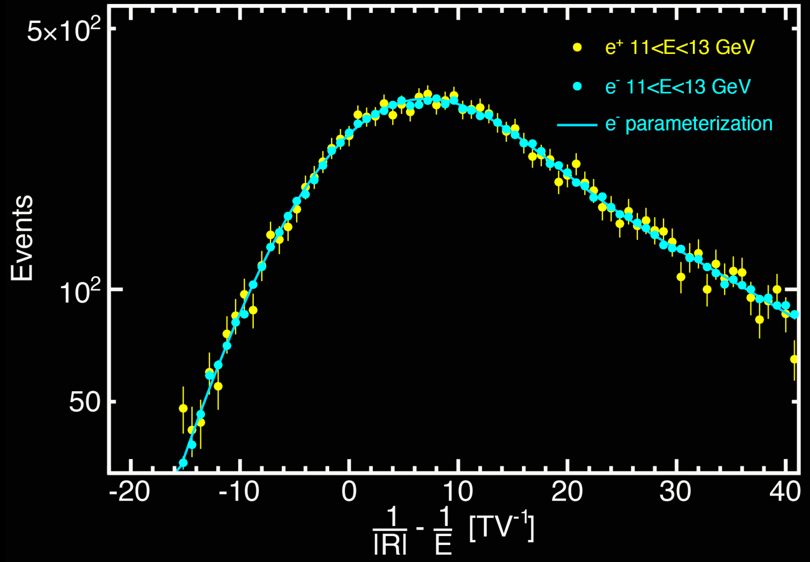
AMS Accurate Rigidity Scale Determination





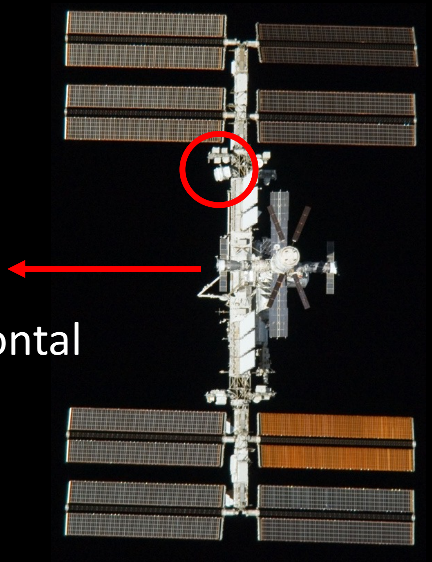
The position of the outer planes L1 and L9 are precisely aligned by using cosmic ray events to a stability of ~ 2 microns.

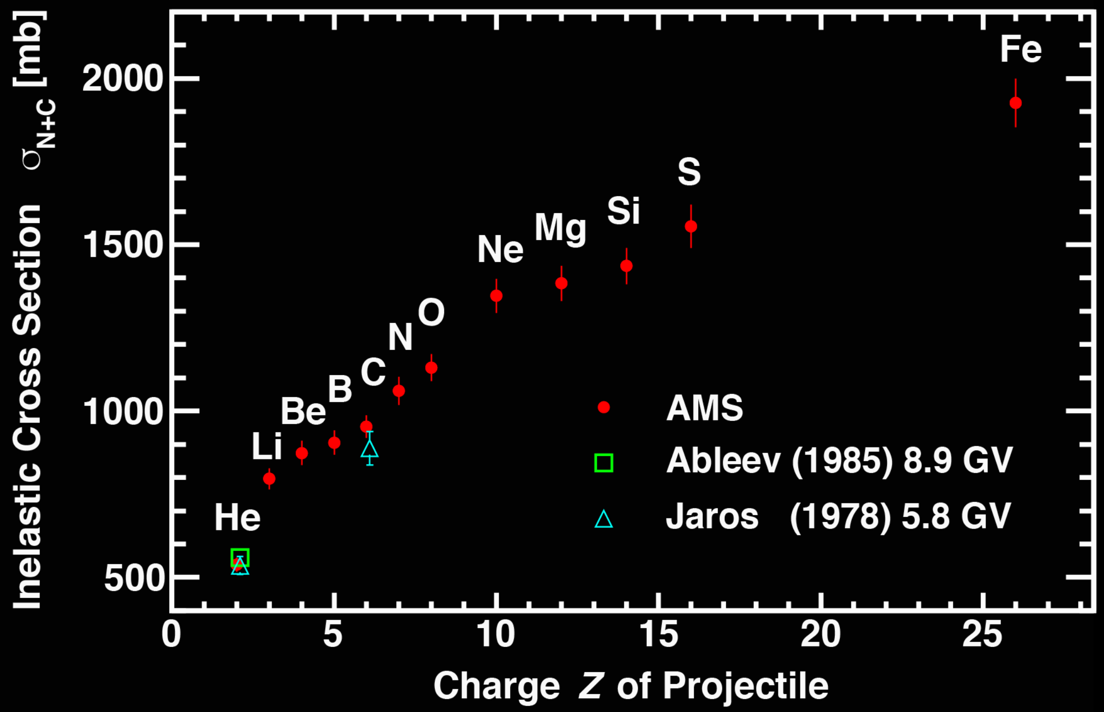
The stability of inner tracker layers (L2-L8) is a tenth of micron.



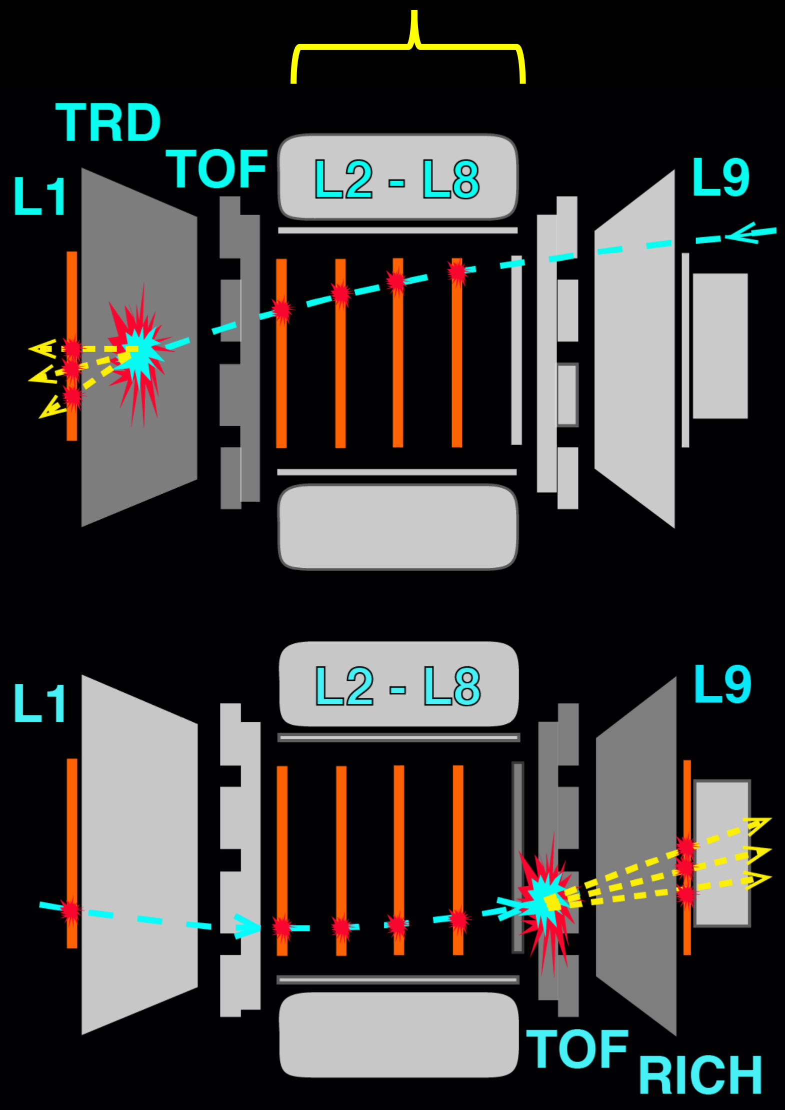
The vibrations and accelerations during the AMS launch into space could change the tracker ladder positions at the micron level. Such misalignment was corrected in space by analyzing trajectories of opposite charged particles in tracker, namely by comparing of the tracker measured rigidity (R) with electromagnetic calorimeter measured energy (E), for positron and electron events. This allows to measure the coherent displacement of the L2-L8 layers with accuracy better than 0.2 μm, corresponding to the accuracy of the tracker rigidity scale of better than 1/30 TV^{-1}.

Precision Measurements of Inelastic Cross Sections for Accurate Flux Determination

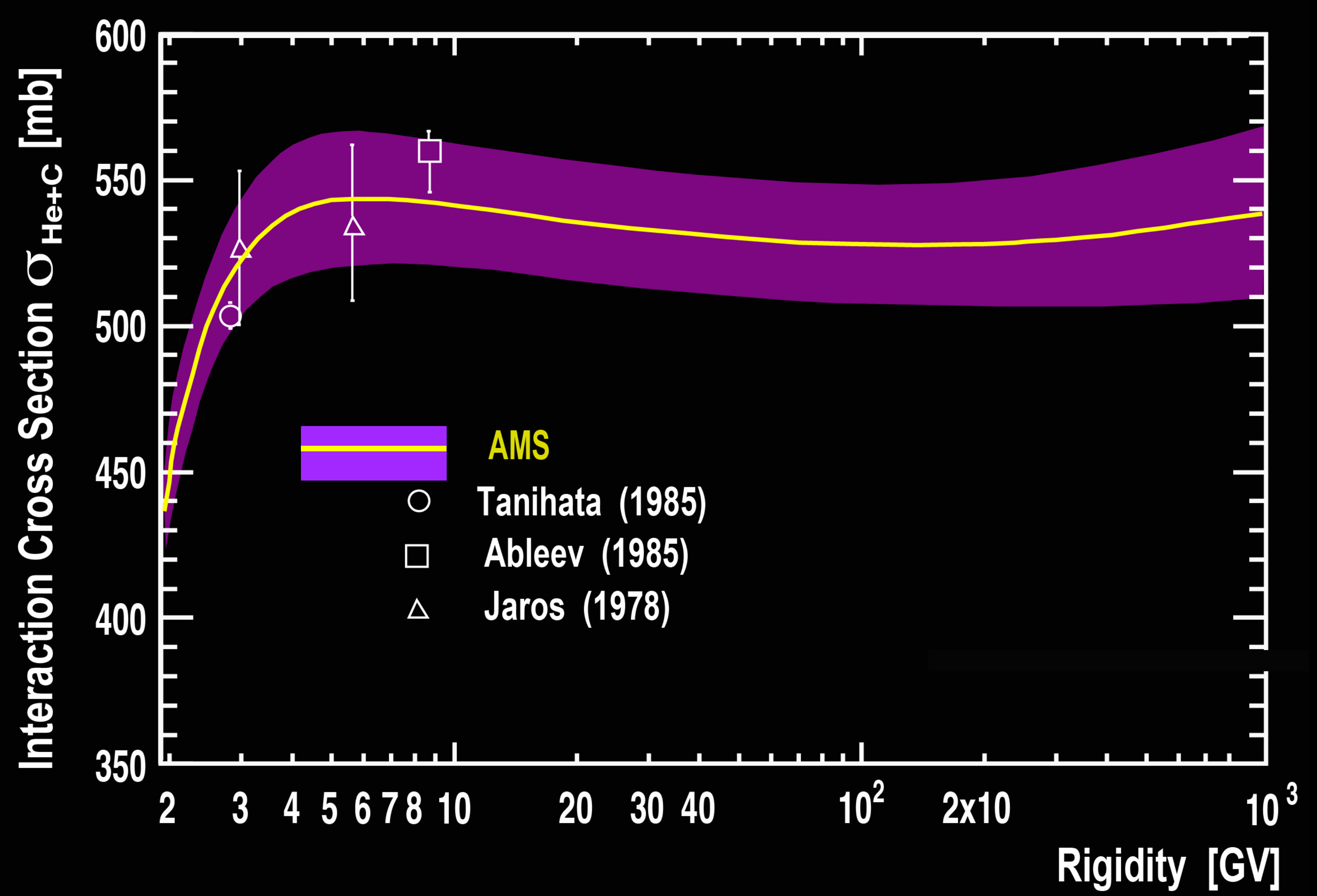




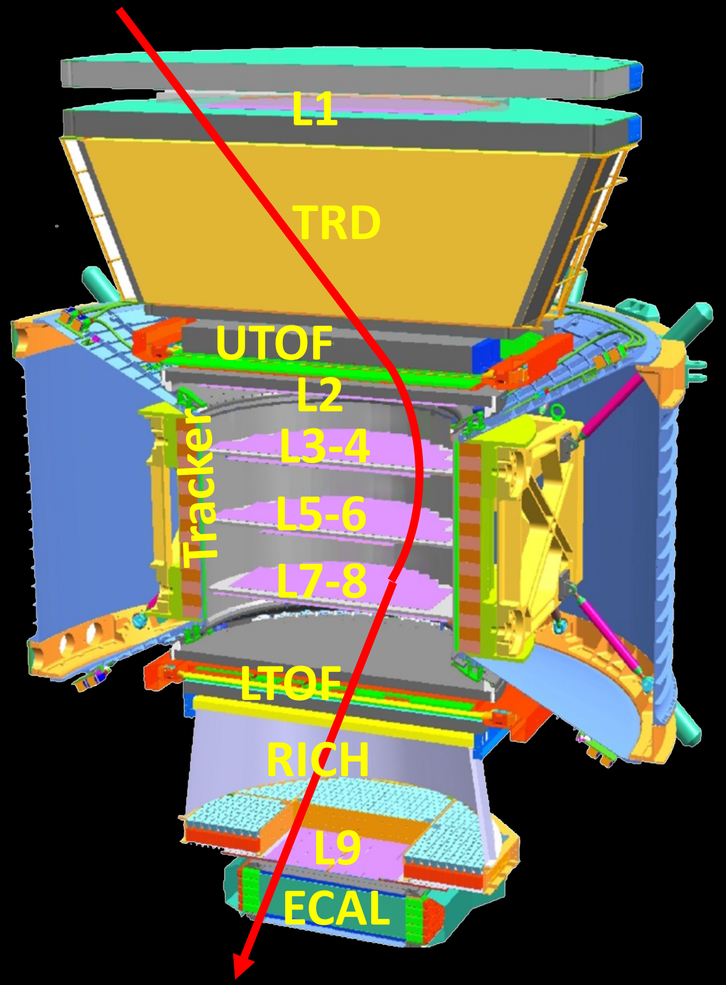
Define (P, Z) of the nuclei with the central spectrometer



AMS measured He + C Interaction Cross Section



Precision Measurements of Cosmic Ray Nuclei



Tracker (9 Layers) + Magnet: Rigidity (Momentum/Charge) with multi-TV maximal detectable rigidity (MDR)

	Coordinate Resolution	MDR
Z=1	10 μm	2 TV
Z≥2	5 - 8 μm	3.0 - 3.7 TV

TOF (4 Layers): Velocity and Direction

$\Delta\beta/\beta^2 \approx 1{-}2\%$ ($Z \geq 2$), 4% (Z=1)

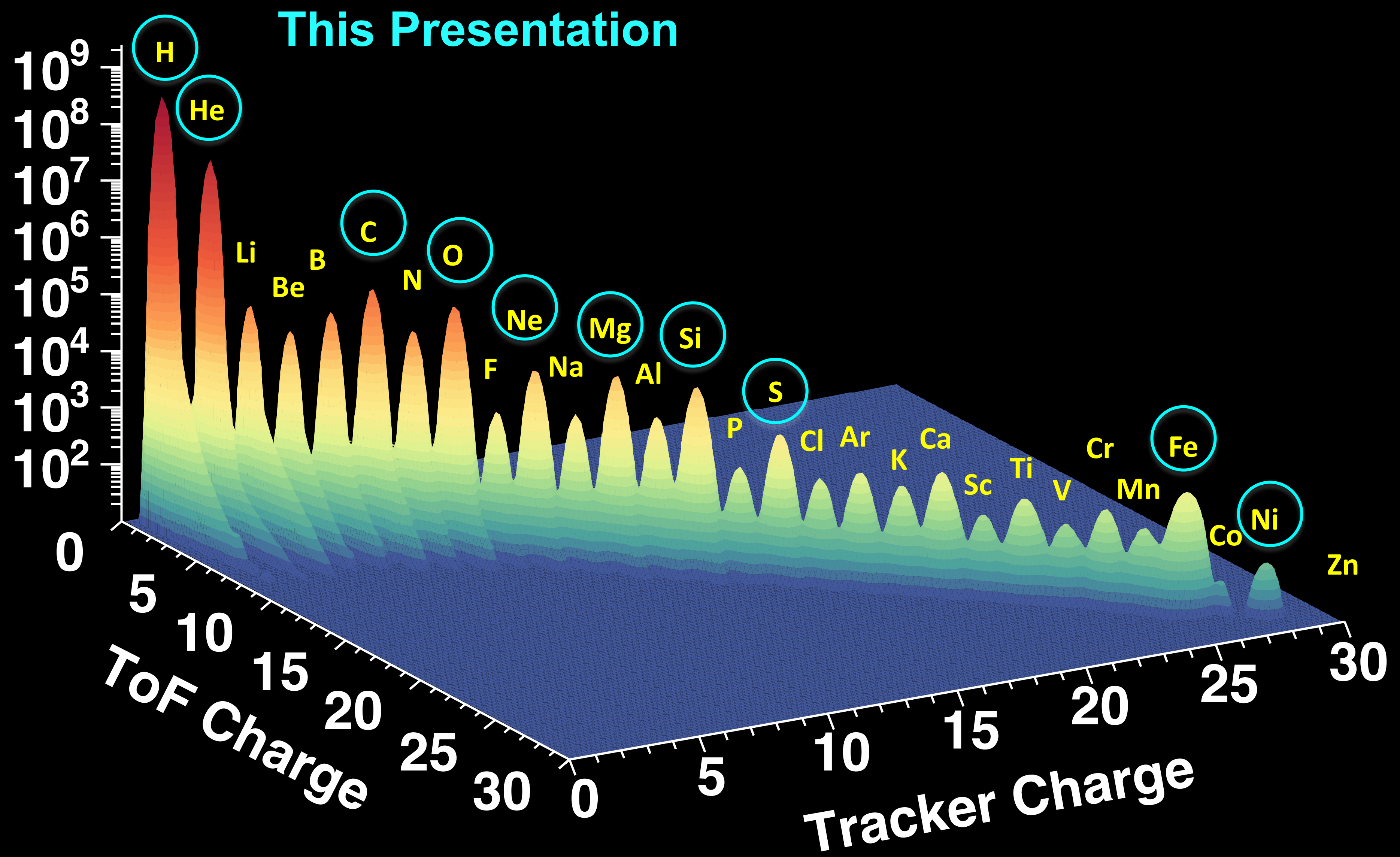
L1, UTOF, Inner Tracker (L2-L8), LTOF and L9

Consistent Charge Along Particle Trajectory

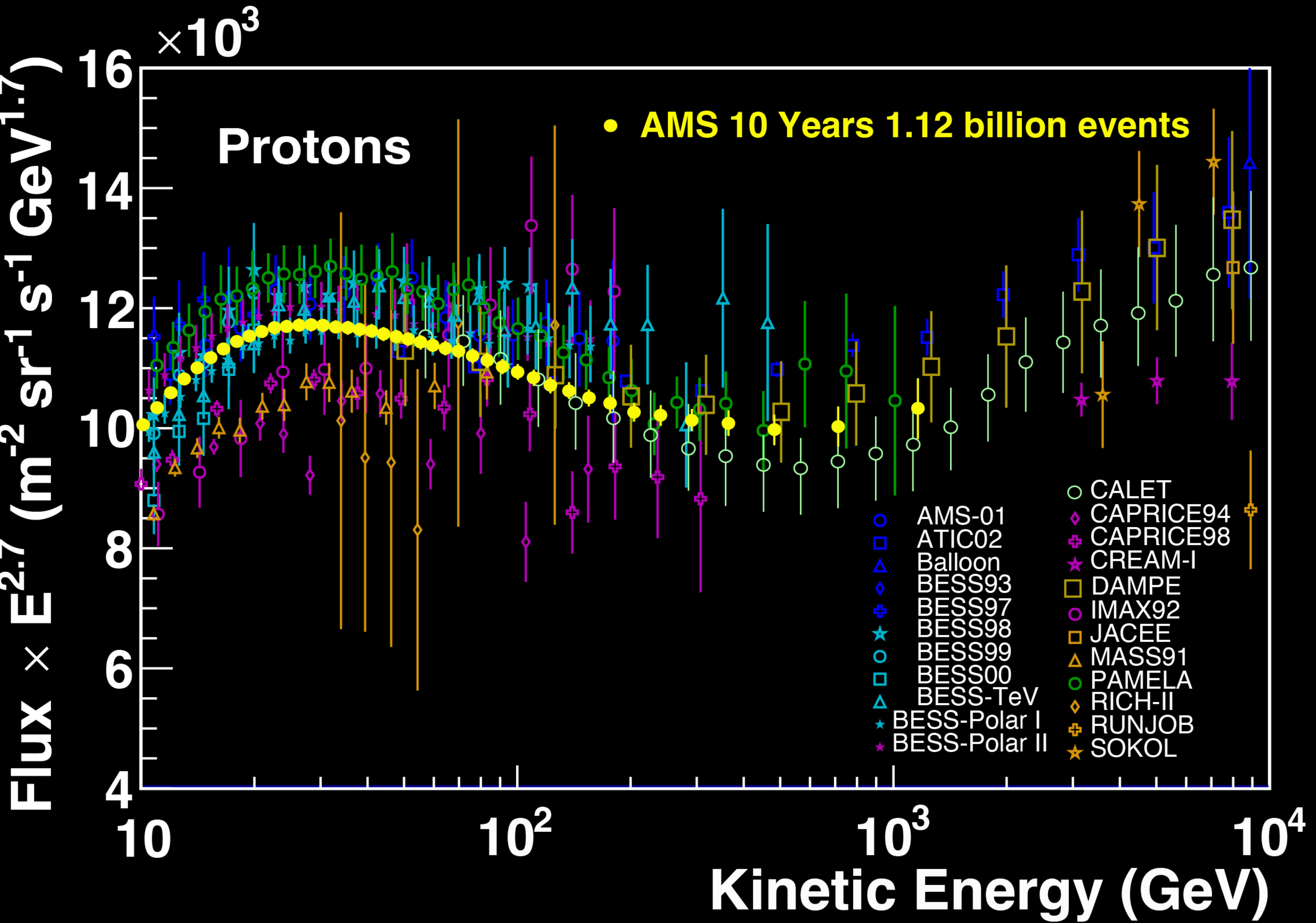
Inner Tracker Charge Resolution:

$\Delta Z = 0.05\text{-}0.35$ ($1 \leq Z \leq 28$)

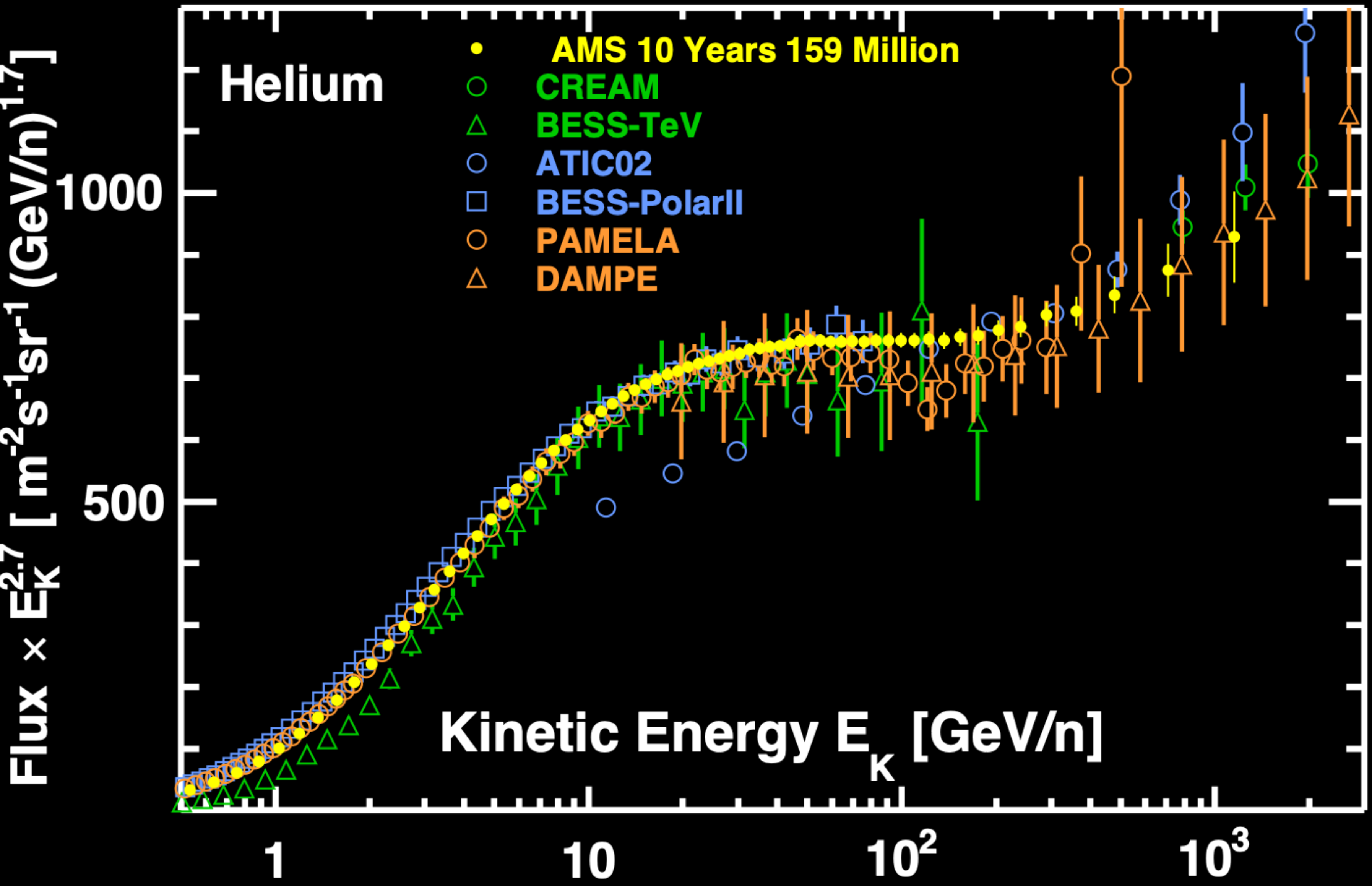
Precision Study of Cosmic Nuclei through the lifetime of ISS



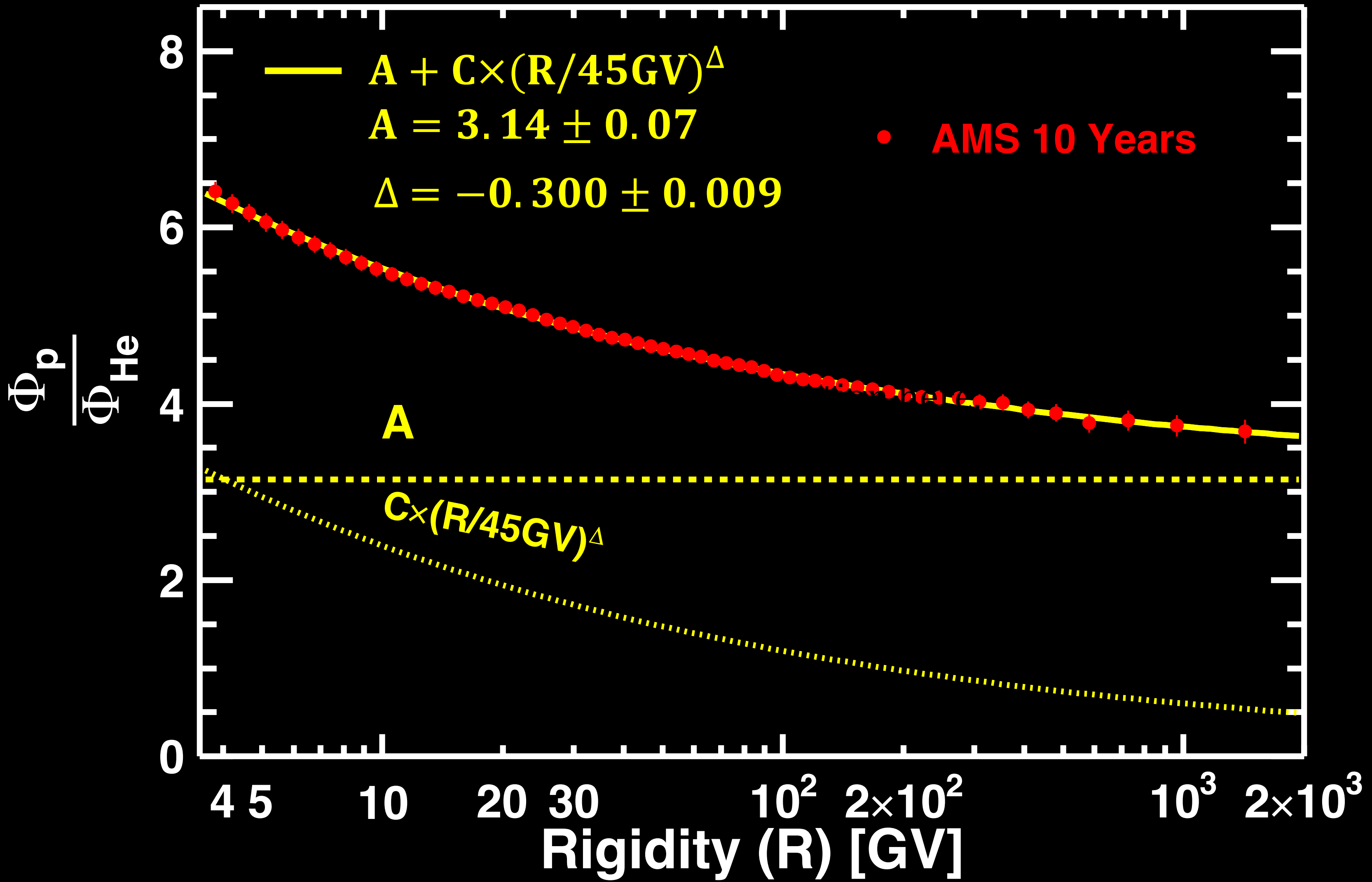
Latest AMS proton flux measurement



Latest AMS Helium flux measurement



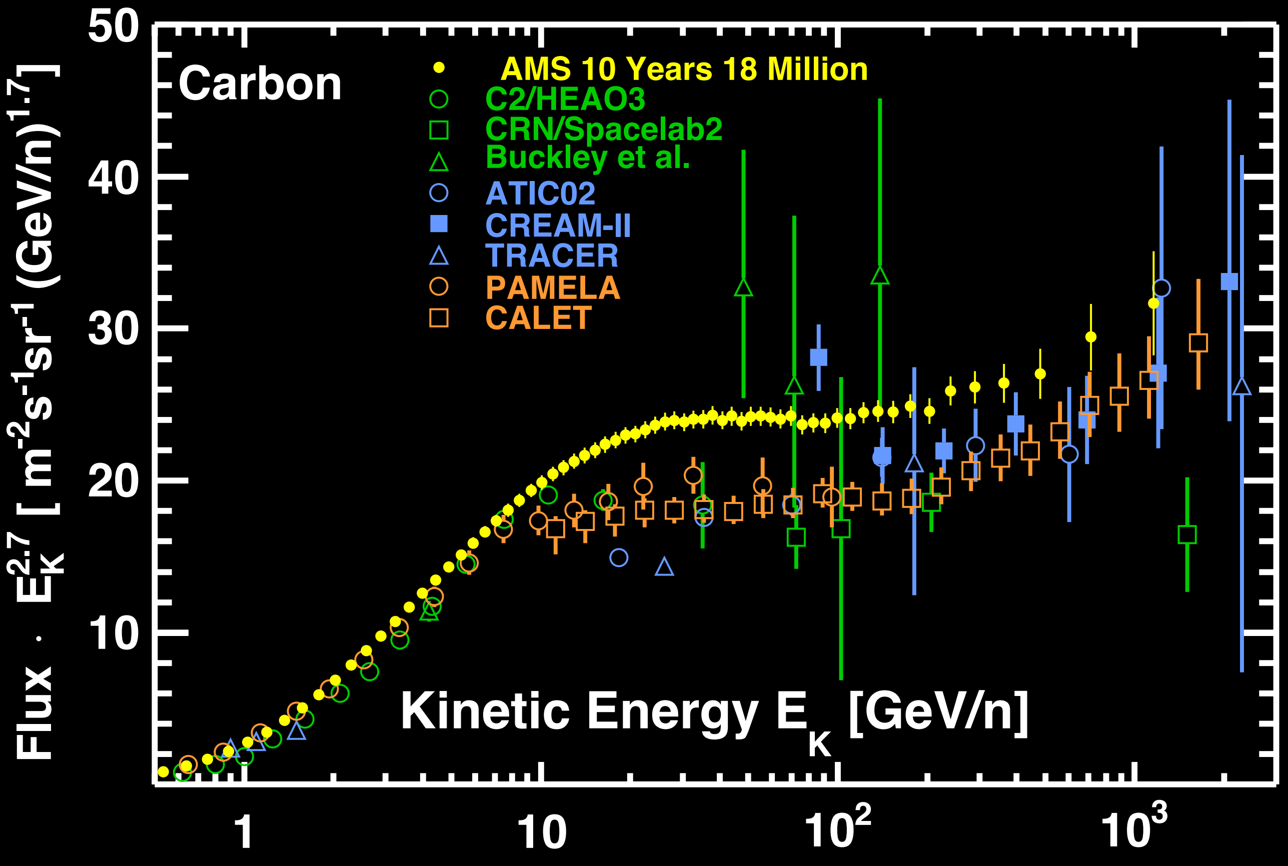
AMS Proton/Helium Flux Ratio

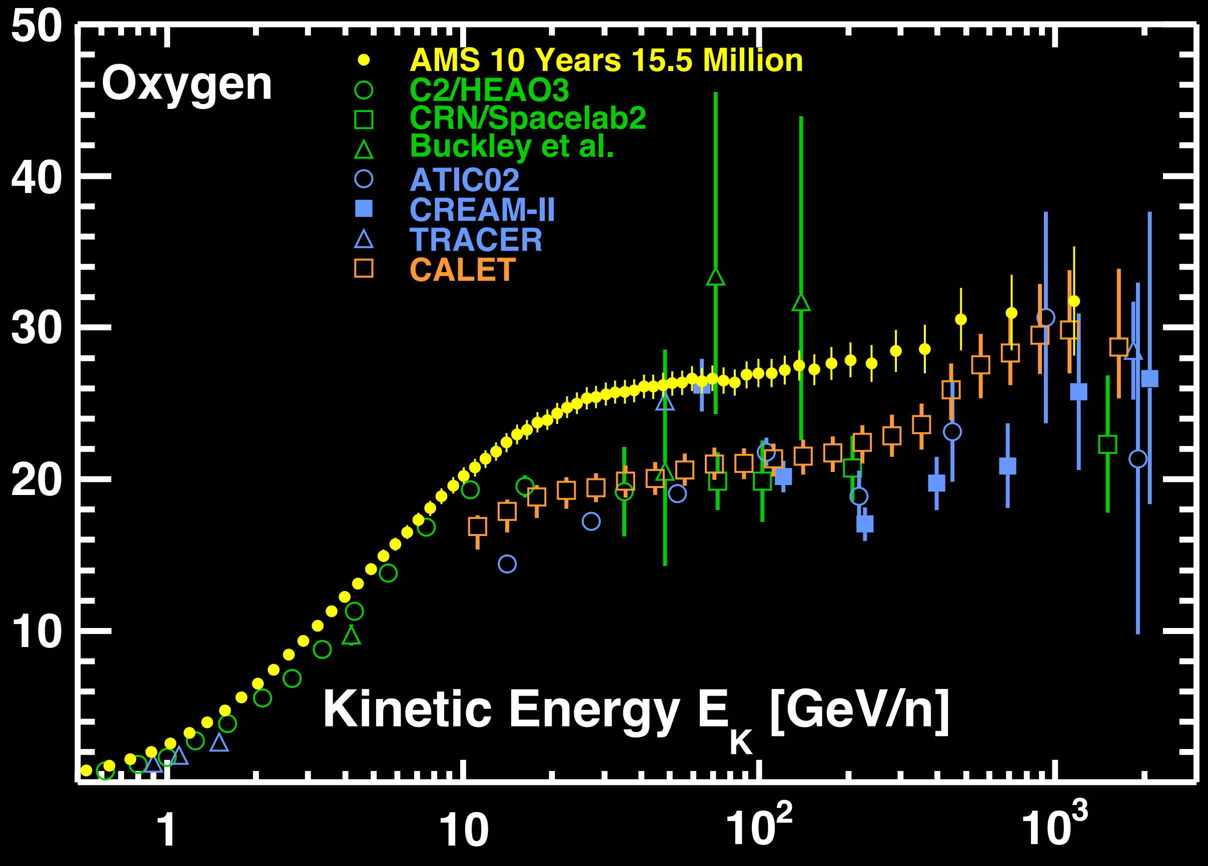


AMS found that proton flux have two components, one is like Helium and the other is unique to proton flux.

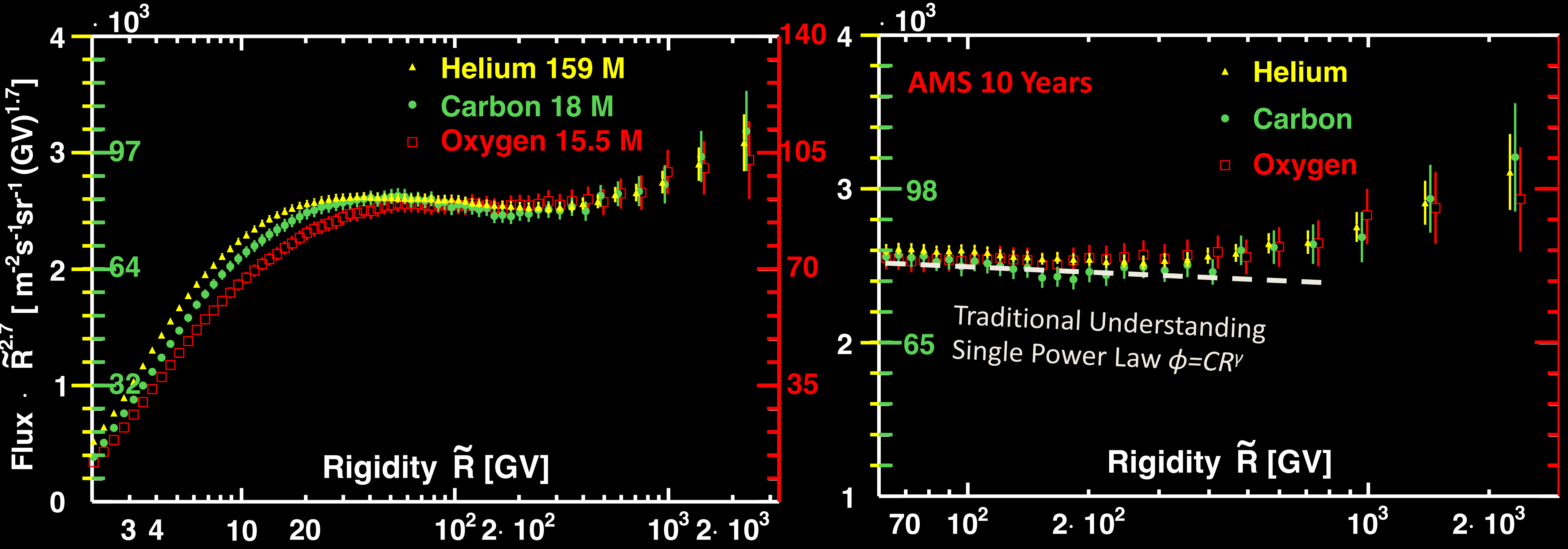
AMS C and O Nuclei Flux Measurement

AMS results are different from other measurement both in magnitude and the energy dependence.





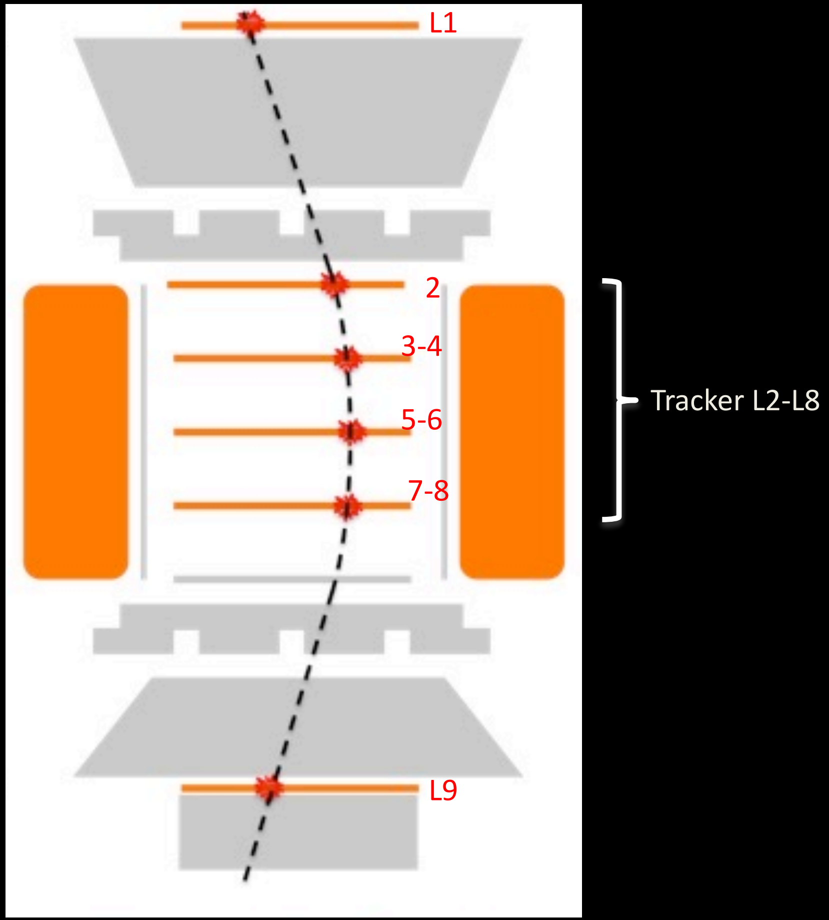
Latest AMS Measurements of He, C, and O Fluxes

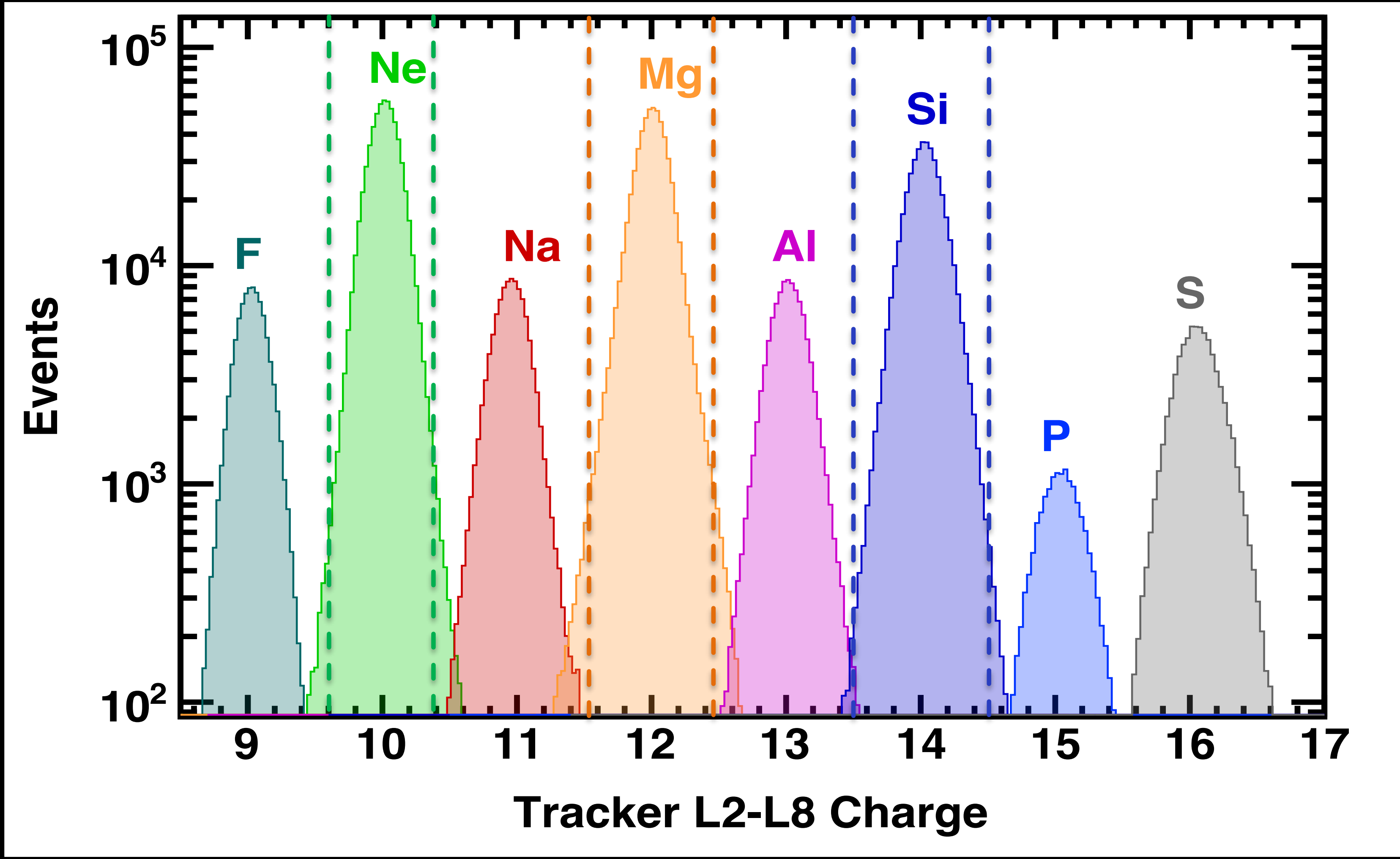


He, C and, O fluxes have an identical rigidity dependence above 60 GV.
Above 200 GV, they all deviate from a single power law in an identical way.

Ne, Mg, and Si Identification

Charge misidentification from non-interacting nuclei is negligible <0.1%

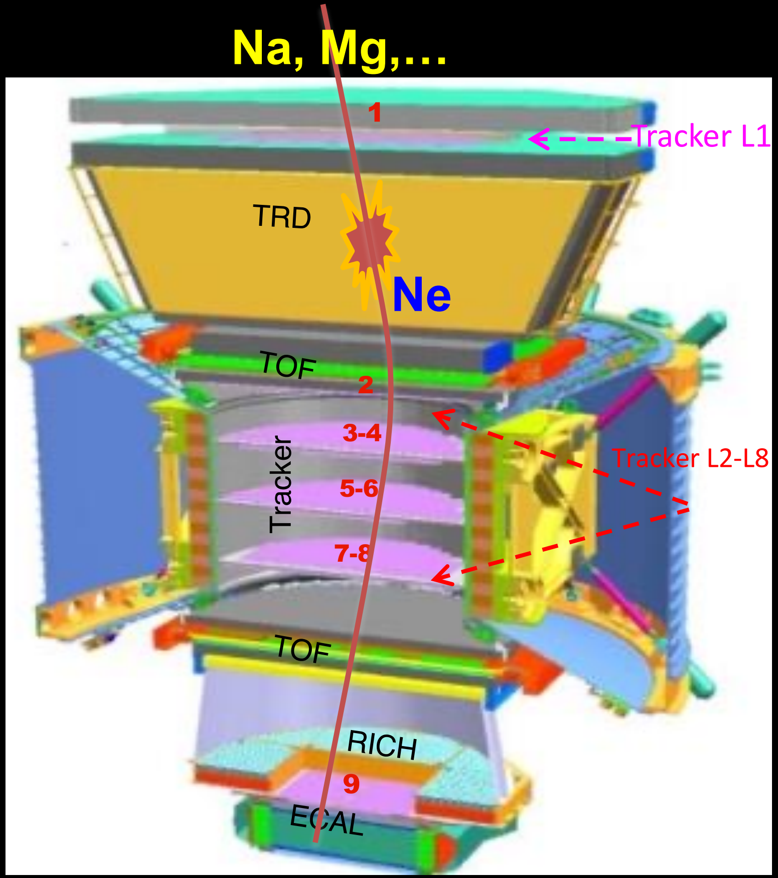


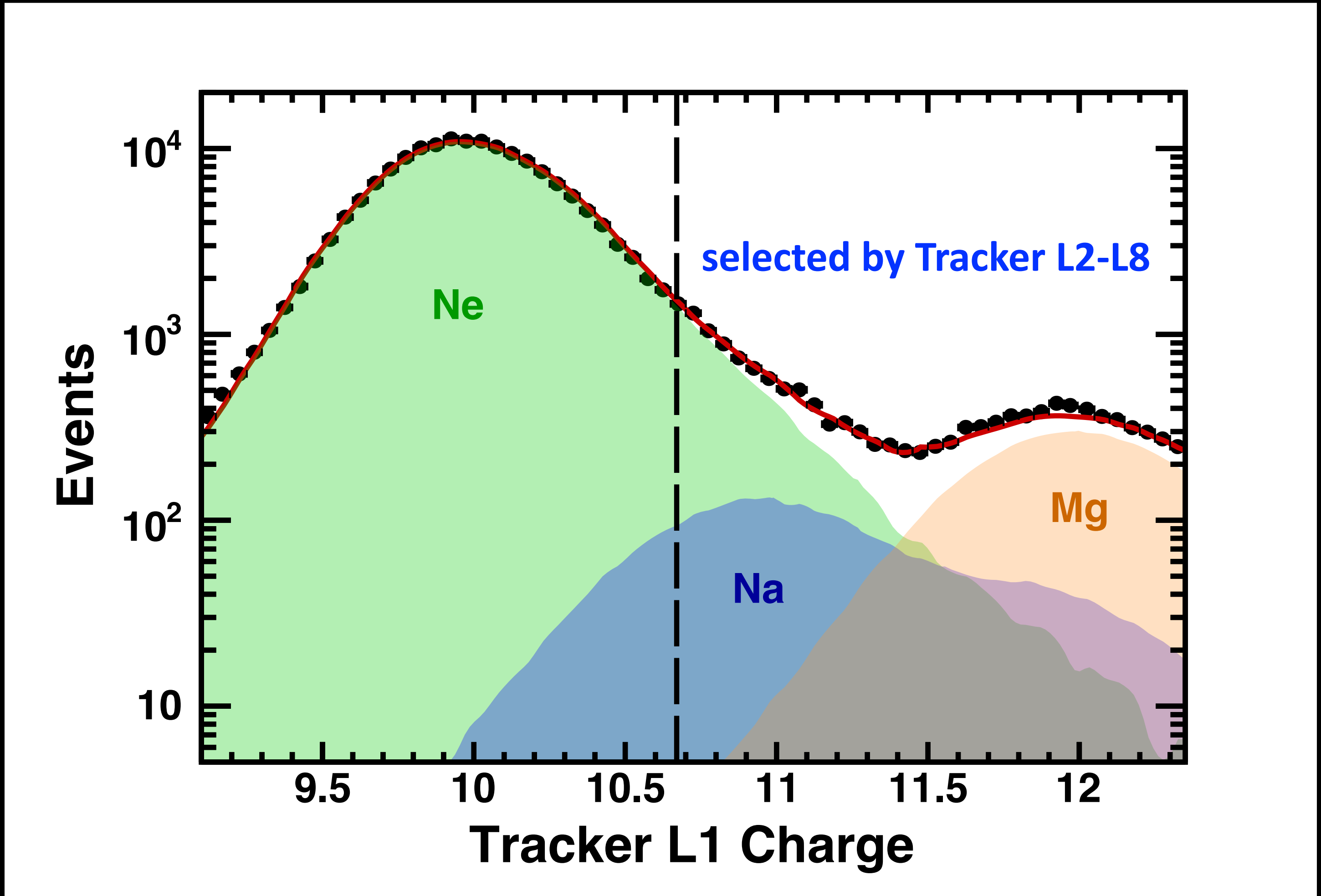


For the events R > 4 GV selected by Tracker L1, UpperTOF and LowerTOF.

Background from Nuclei Interactions

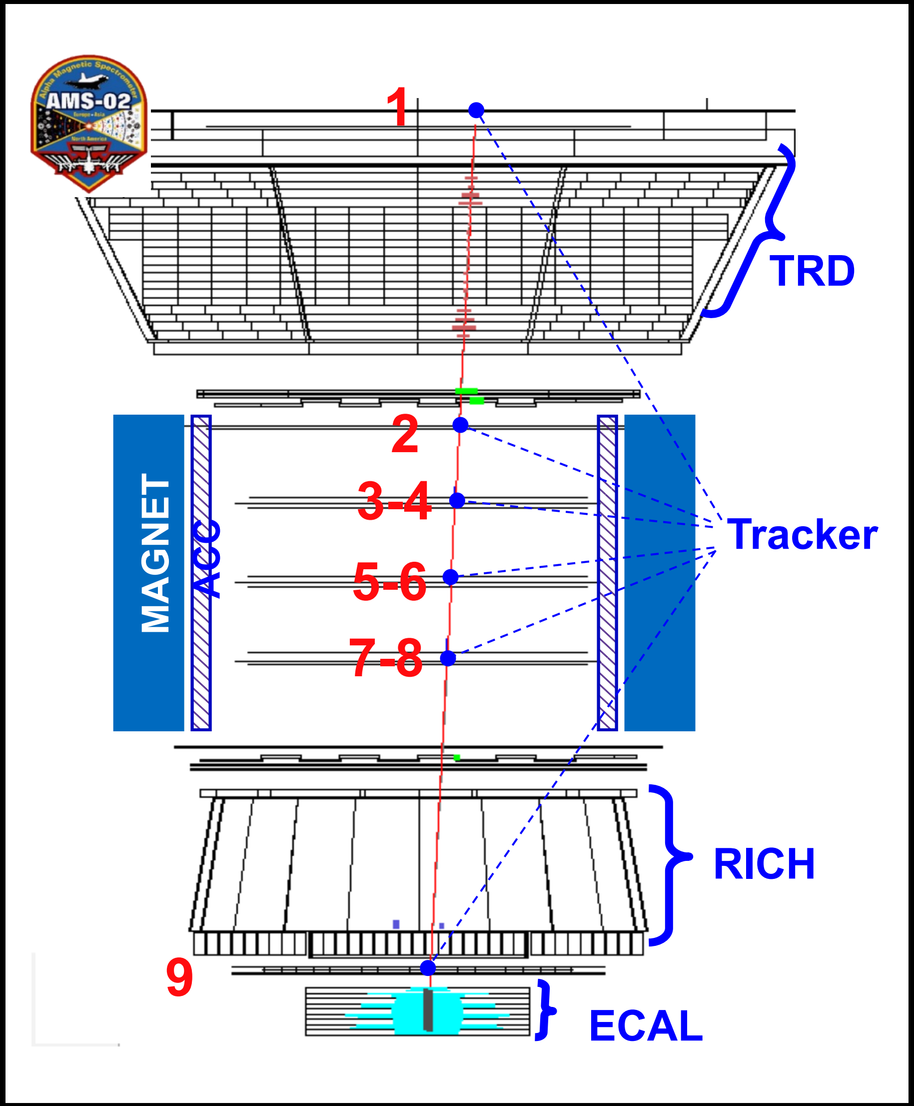
Residual background from heavy nuclei , interacting in AMS materials between L1 and L2 , was found to be 1-2% depending on rigidity, with systematic error on flux measurements <0.5%.



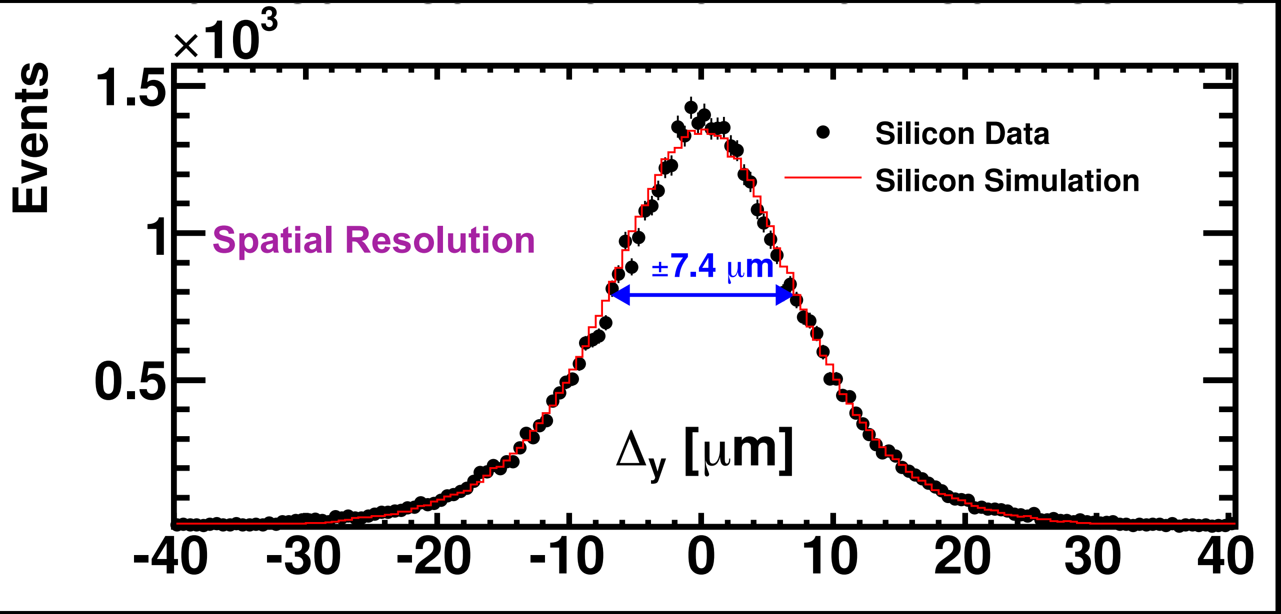


Tracker Rigidity Resolution

The tracker spatial resolution is **6.7 μm** for Ne, **7.1 μm** for Mg, and **7.4 μm** for Si.

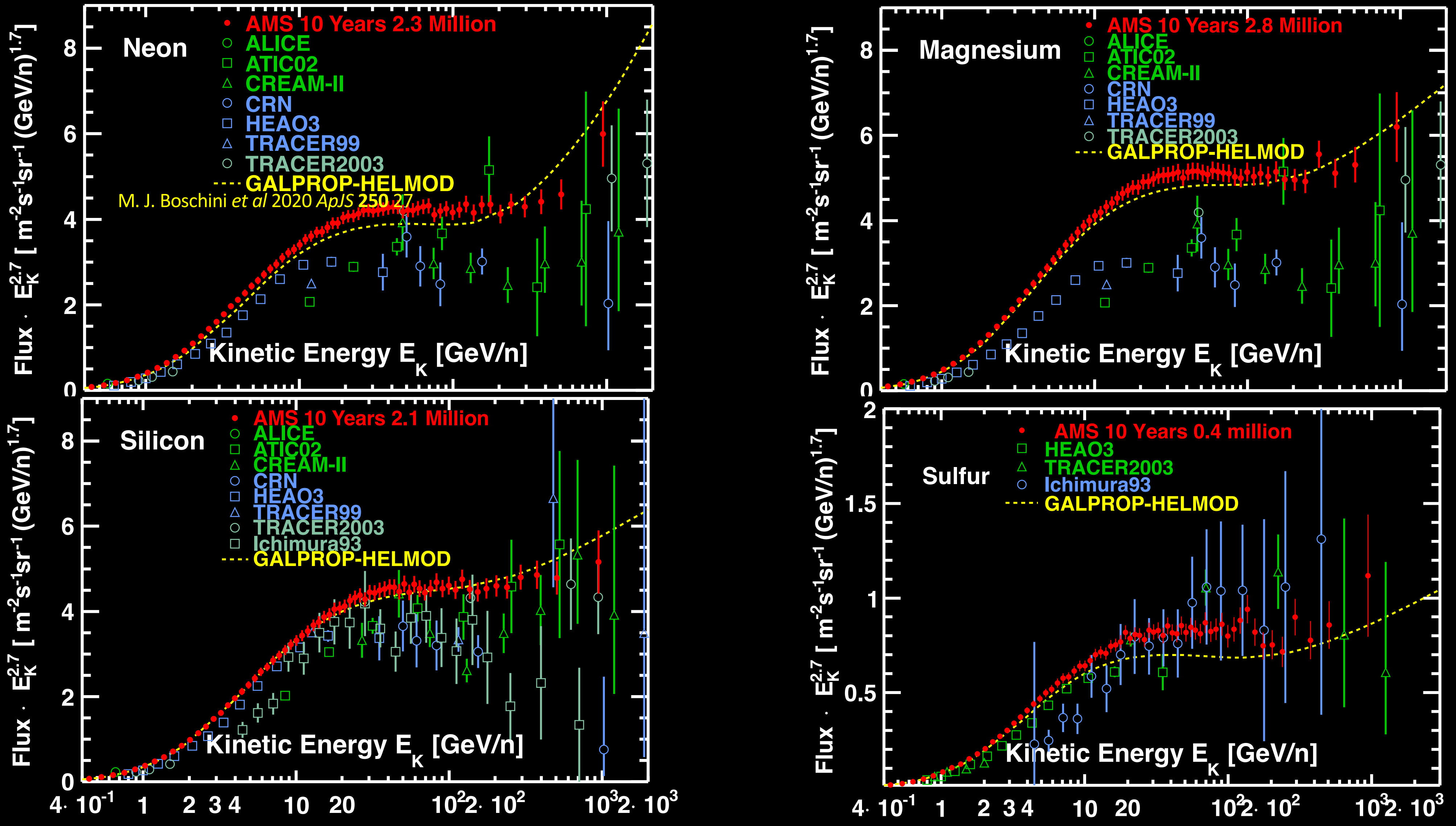


Maximum detectable rigidity ≈ 3 TV

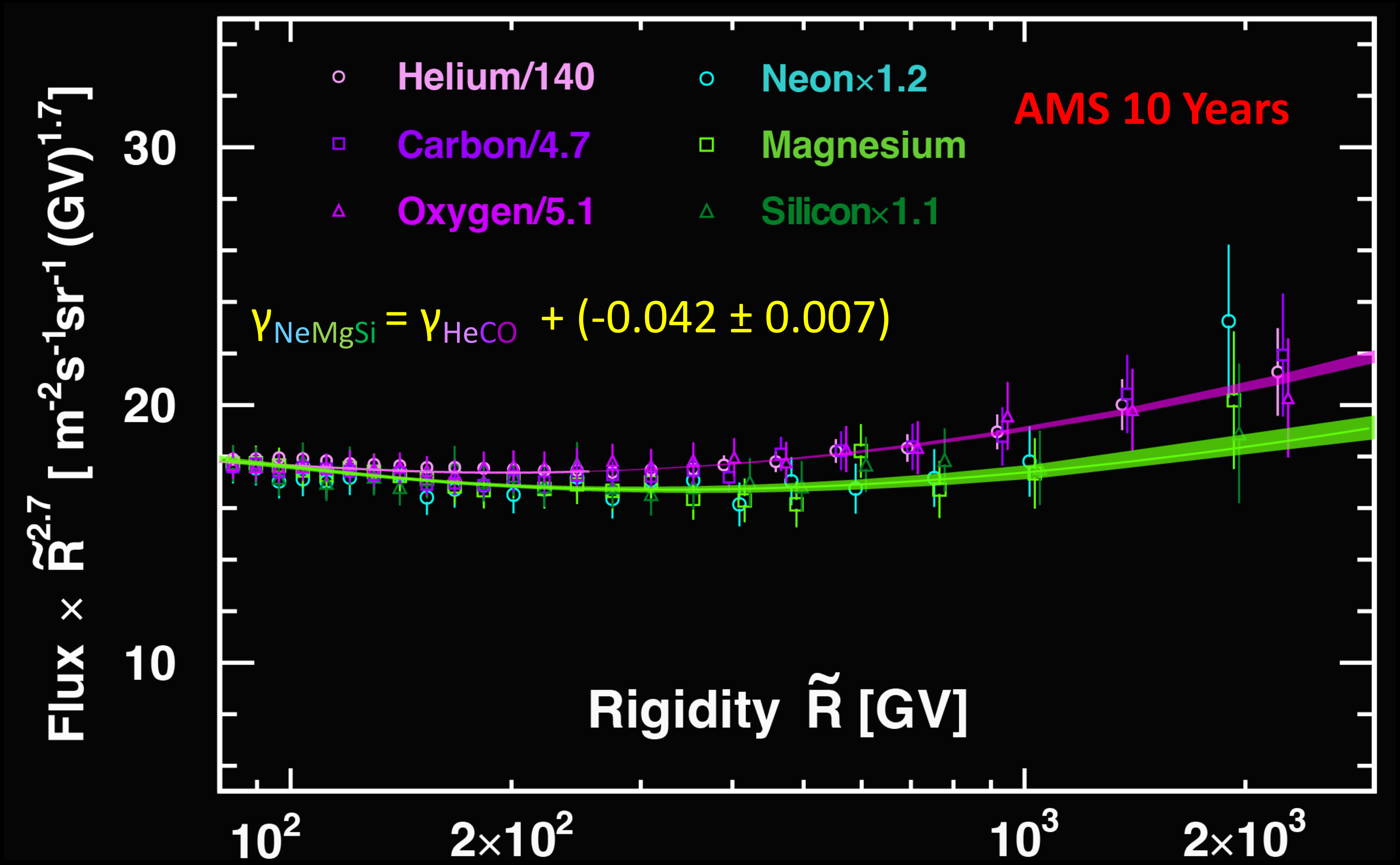


Latest AMS Measurements of Ne, Mg, Si, and S Fluxes

AMS results are different from previous measurement both in magnitude and the energy dependence. They are also different from the cosmic ray theory predictions.



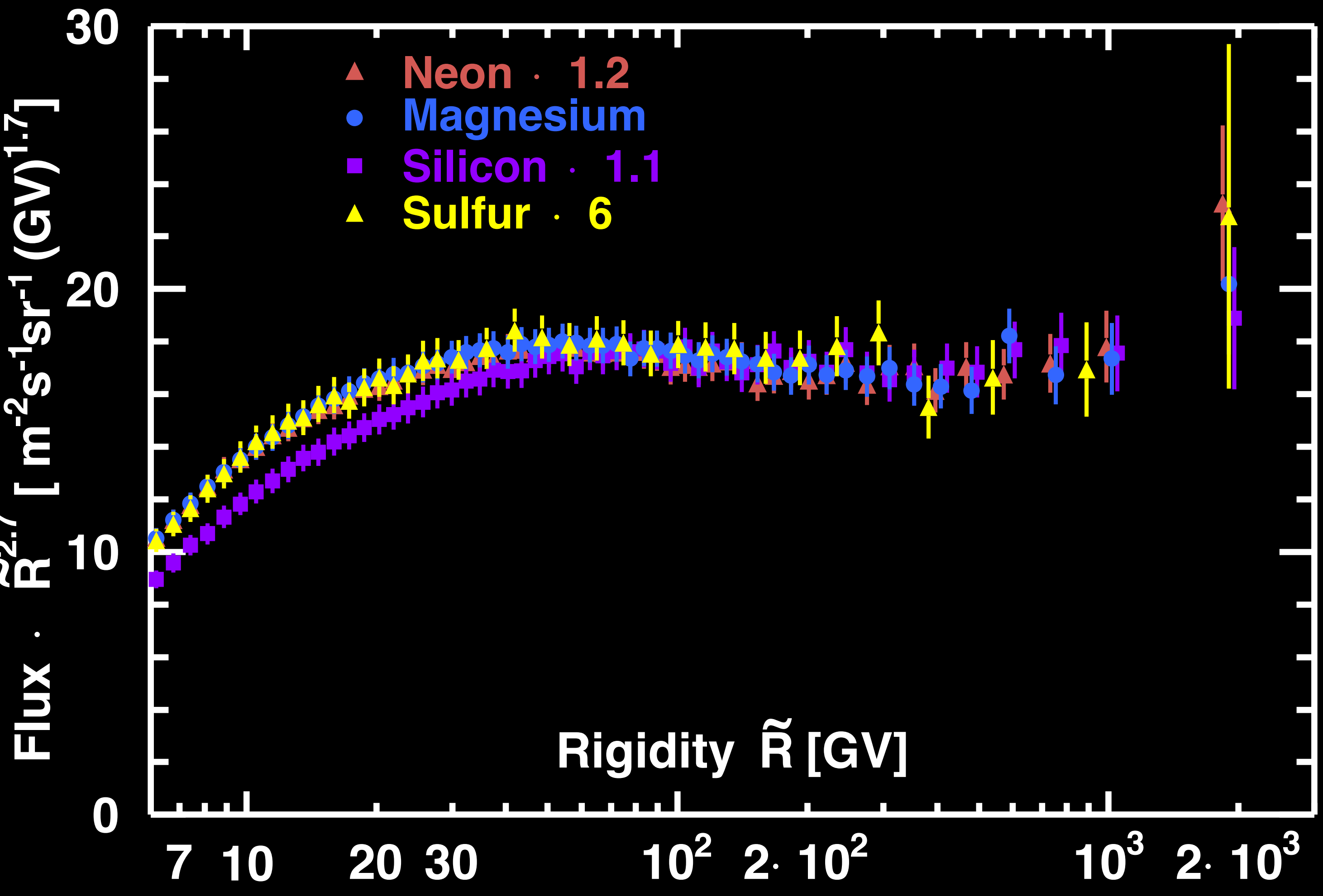
Properties of Heavy Primary Cosmic-Ray Ne, Mg, Si



Suprisingly, heavy primary cosmic rays Ne, Mg, and Si also have identical rigidity dependence above 86 GV, but it is distinctly different from light primary cosmic rays He, C, and O.

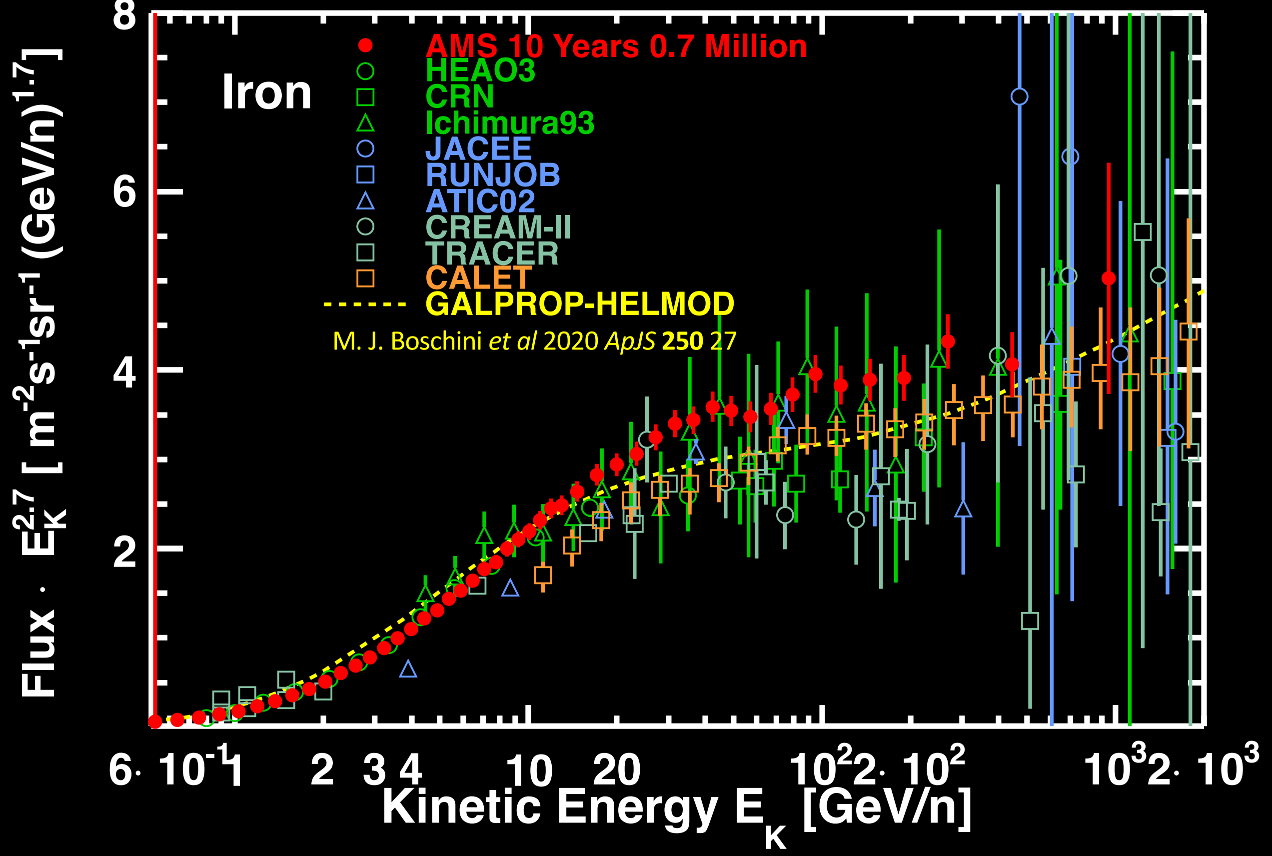
This shows that primary cosmic rays have at least two distinct classes.

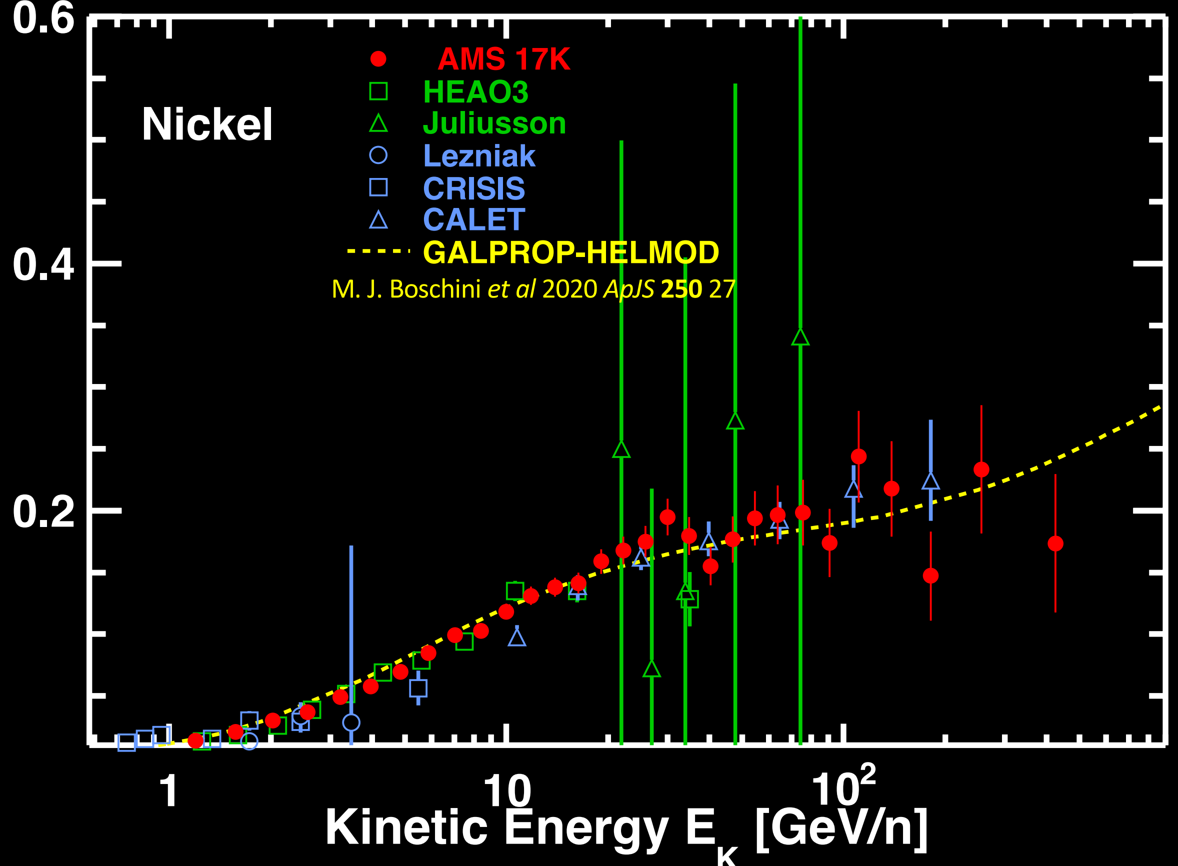
Latest AMS Results: Sulfur Rigidity Dependence



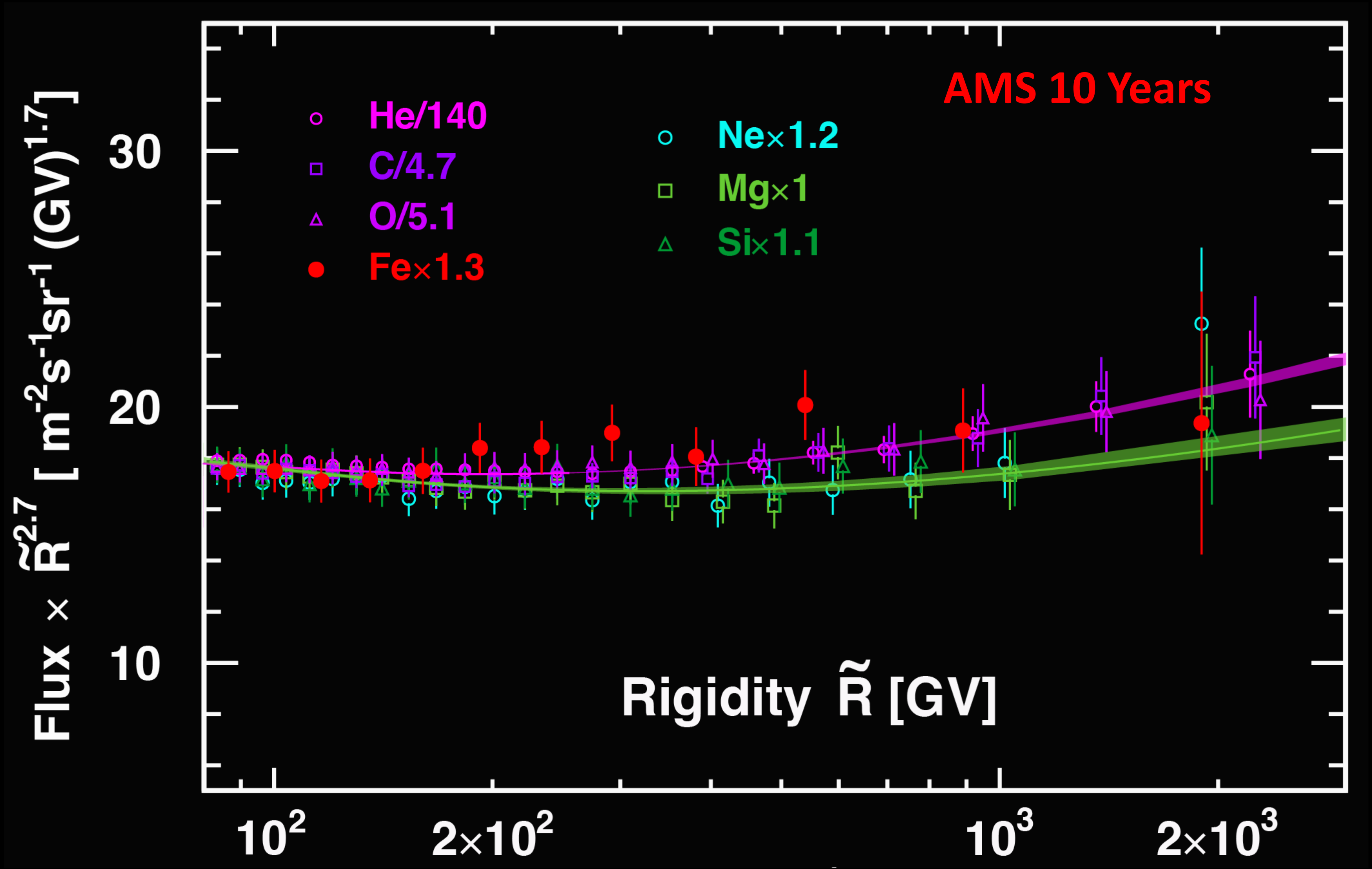
Sulfur belongs to the same class as Ne, Mg, and Si.

Heavy Primary Cosmic Rays: Iron and Nickel Fluxes

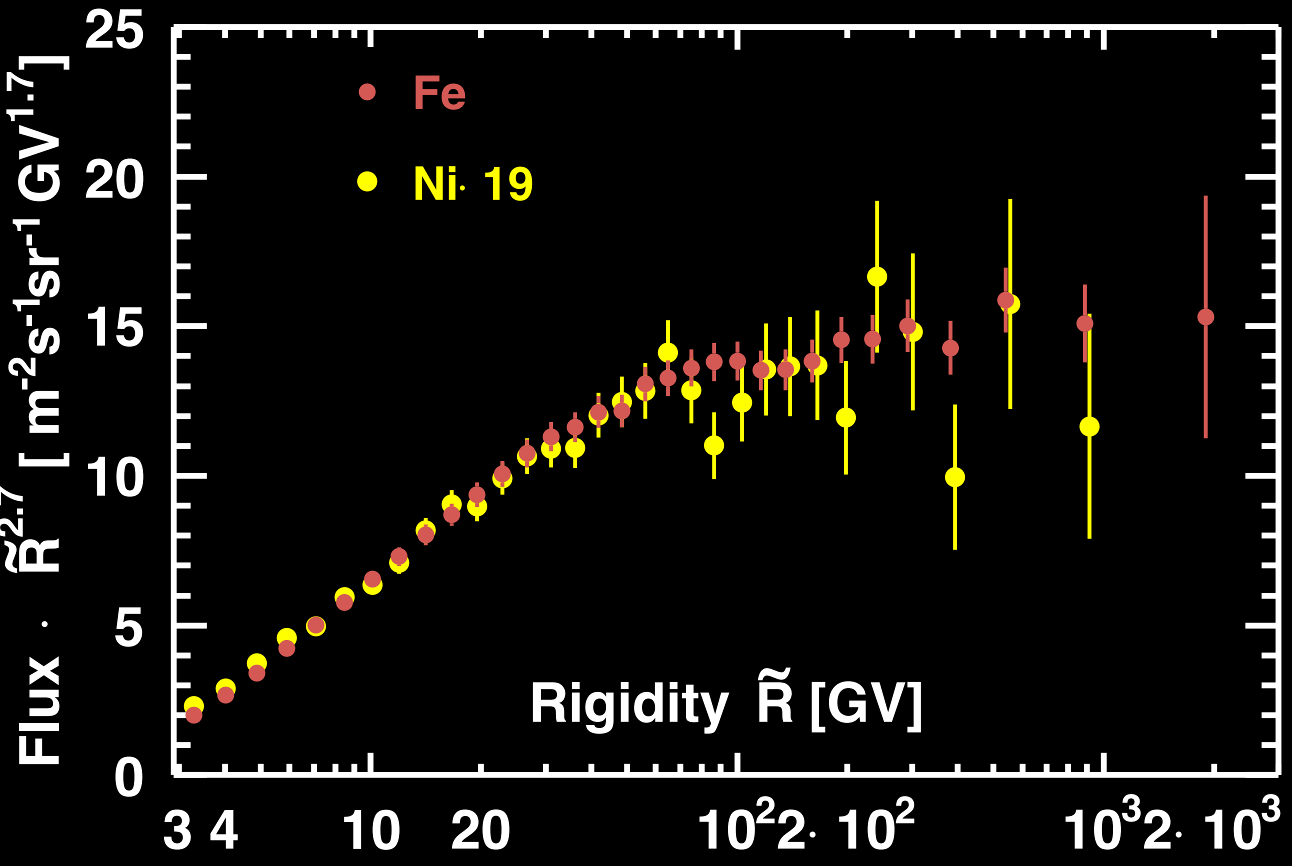


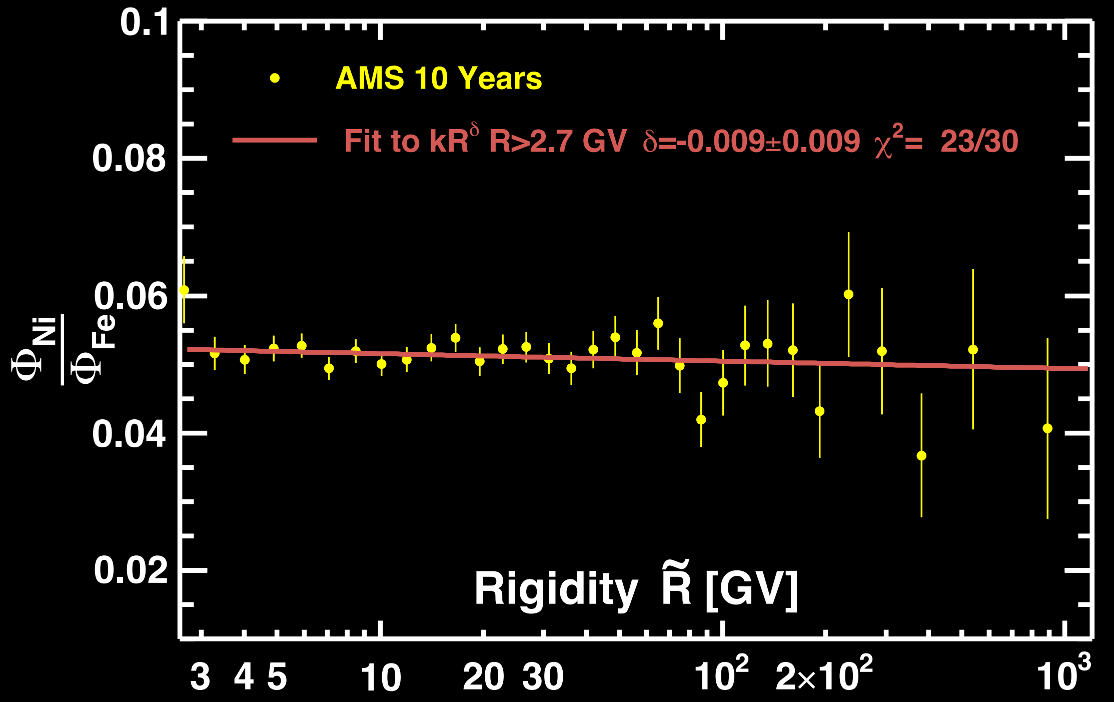


Unexpected Results: Iron is the Same Class as He, C, O instead of the heavier Ne, Mg, Si



AMS Nickel Flux: rigidity dependence is similar to Fe





Summary

- The latest ten-year results on primary cosmic rays p, He, C, O, Ne, Mg, Si, S, Fe, and Ni from 2 GV to 3 TV were presented. These new measurements are challenging our understanding of cosmic ray physics.

- AMS will continue taking data for the ISS life time and explore properties of cosmic ray nuclei up to Zn and beyond.