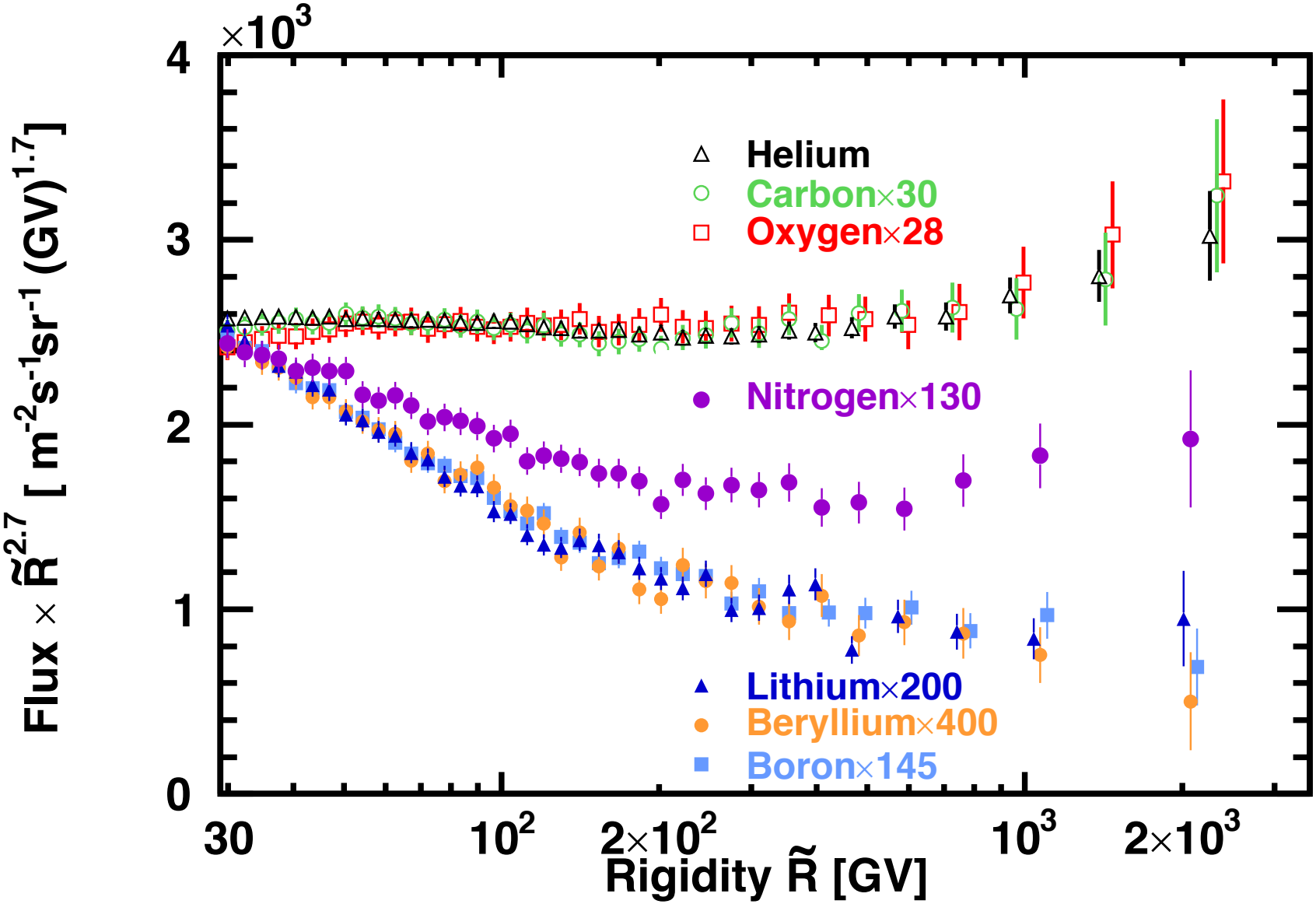
Measurements of Neon, Magnesium, Silicon and Sulfur Fluxes in Cosmic Rays with AMS

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

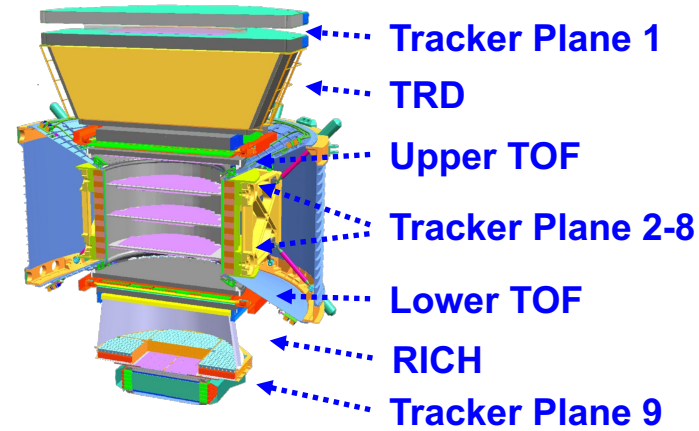
36th International Cosmic Ray Conference, Madison, USA

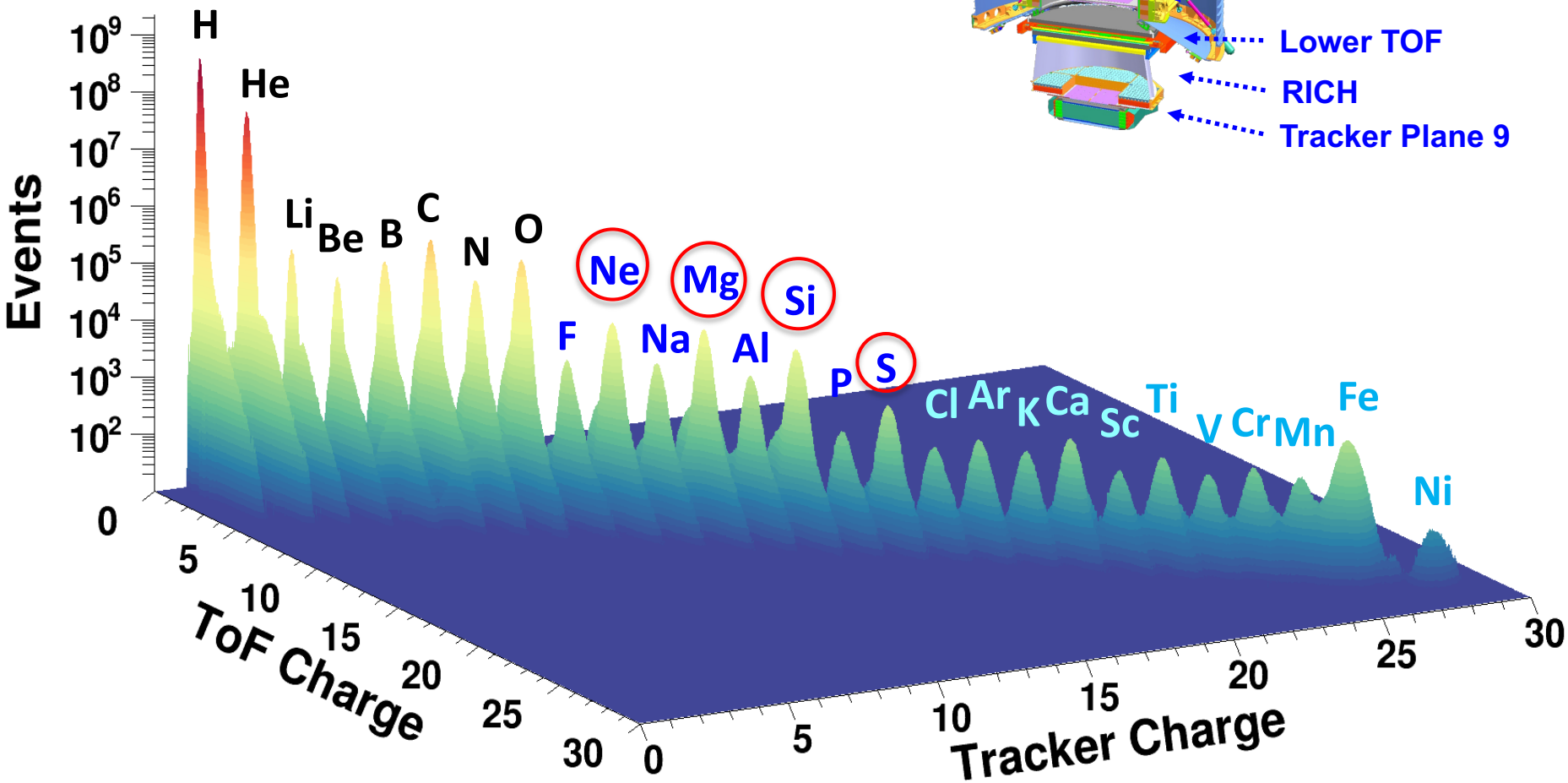


[1] M. Aguilar *et al.*, Phys. Rev. Lett. **119,** 251101 (2017).
[2] M. Aguilar *et al.*, Phys. Rev. Lett. **120,** 021101 (2018).
[3] M. Aguilar *et al.*, Phys. Rev. Lett. **121**, 051103 (2018).

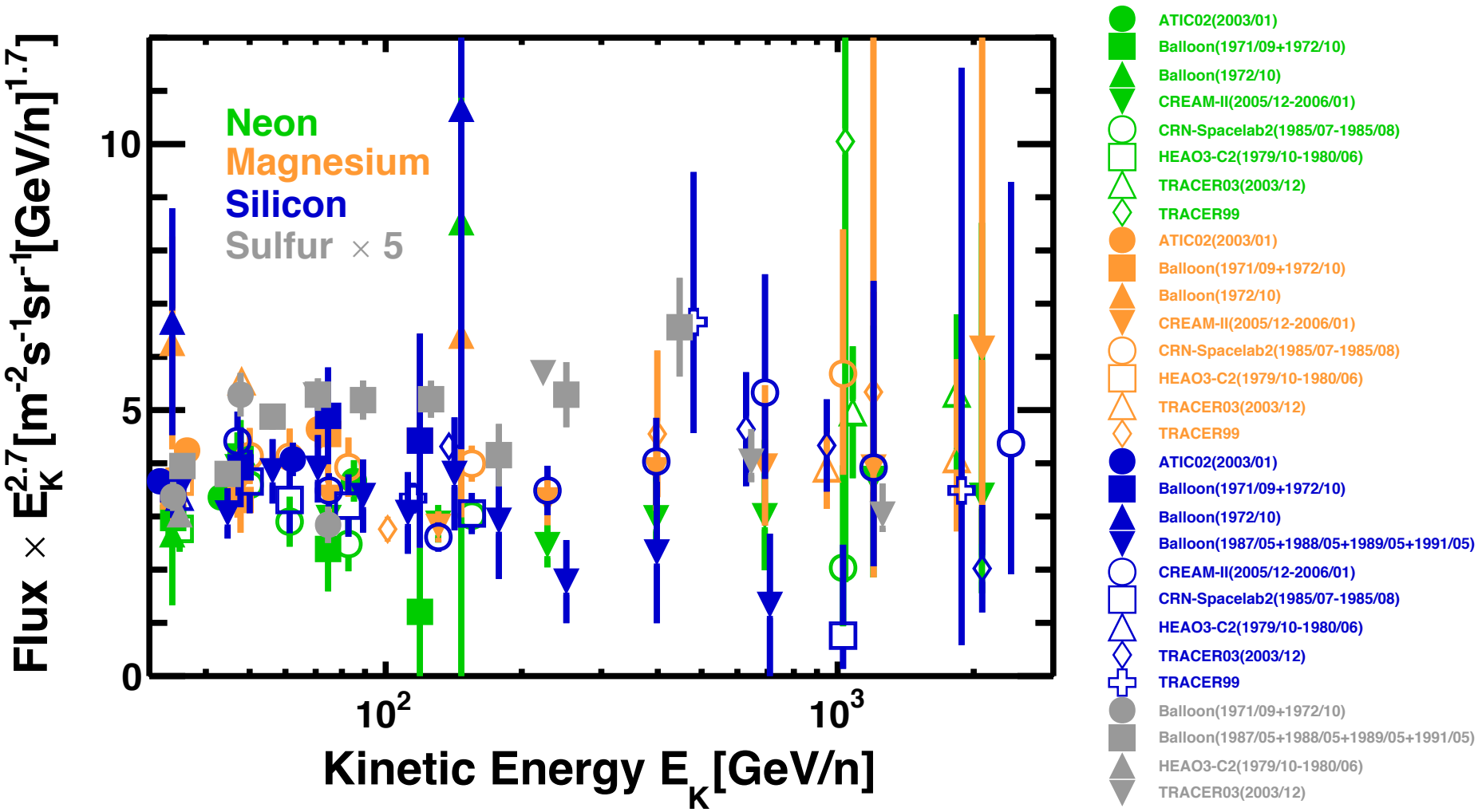
Primary Cosmic Rays Ne (Z=10), Mg (Z=12), Si (Z=14) and S (Z=16)

AMS has seven instruments which independently measure Cosmic Nuclei charge

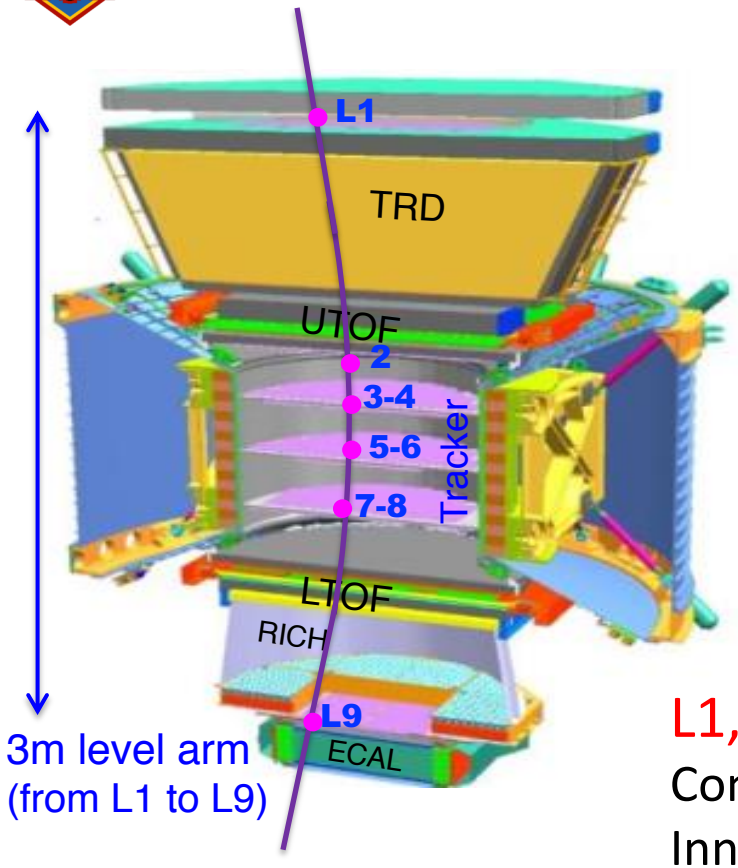




Measurements of Primary Cosmic Rays Ne, Mg, Si and S Before AMS



AMS Nuclei Measurements (Ne-S)



Tracker + Magnet

Rigidity (Momentum/Charge)

Bending Coordinate Resolution ≈ 6-8 μm

MDR ≈ 3 TV

TOF (4 Layers)

Velocity and Direction

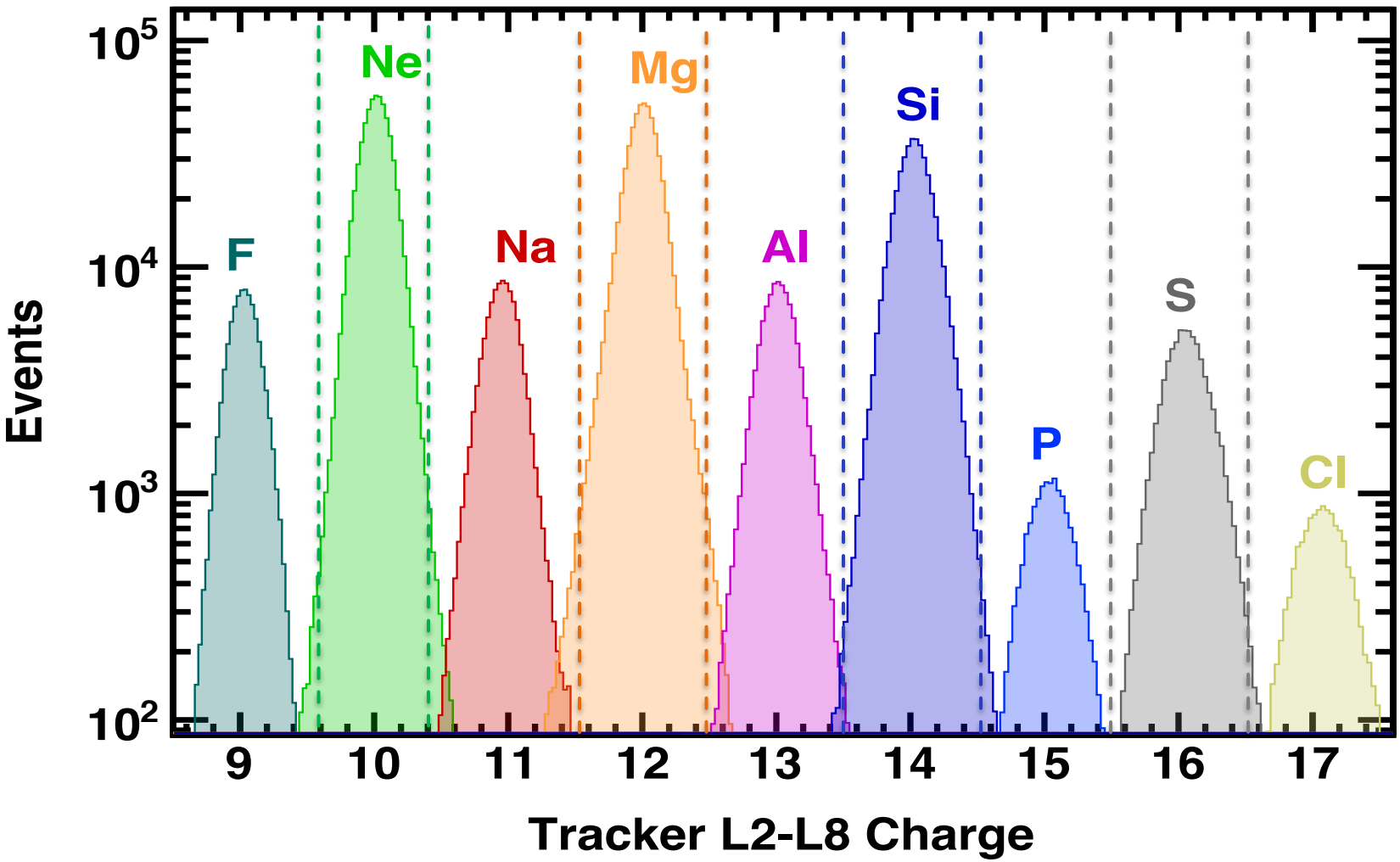
$\Delta\beta/\beta^2 \approx 1\%$

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

Consistent Charge Along Particle Trajectory

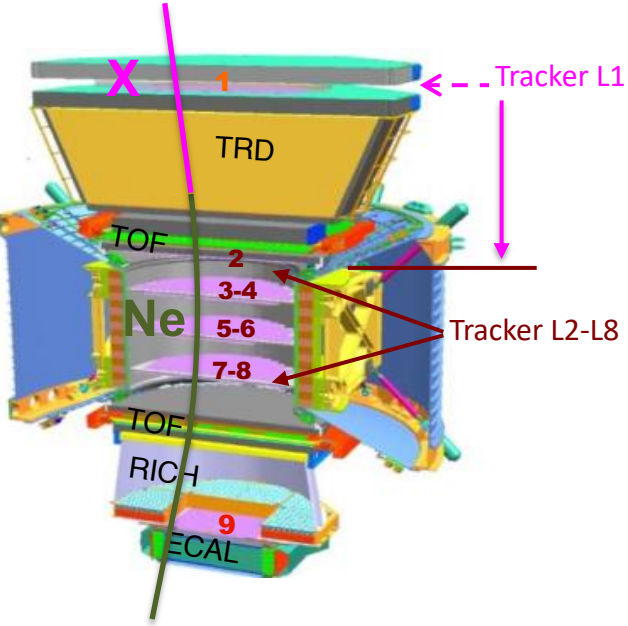
Inner Tracker only Resolution $\Delta Z \approx 0.13\text{-}0.19$

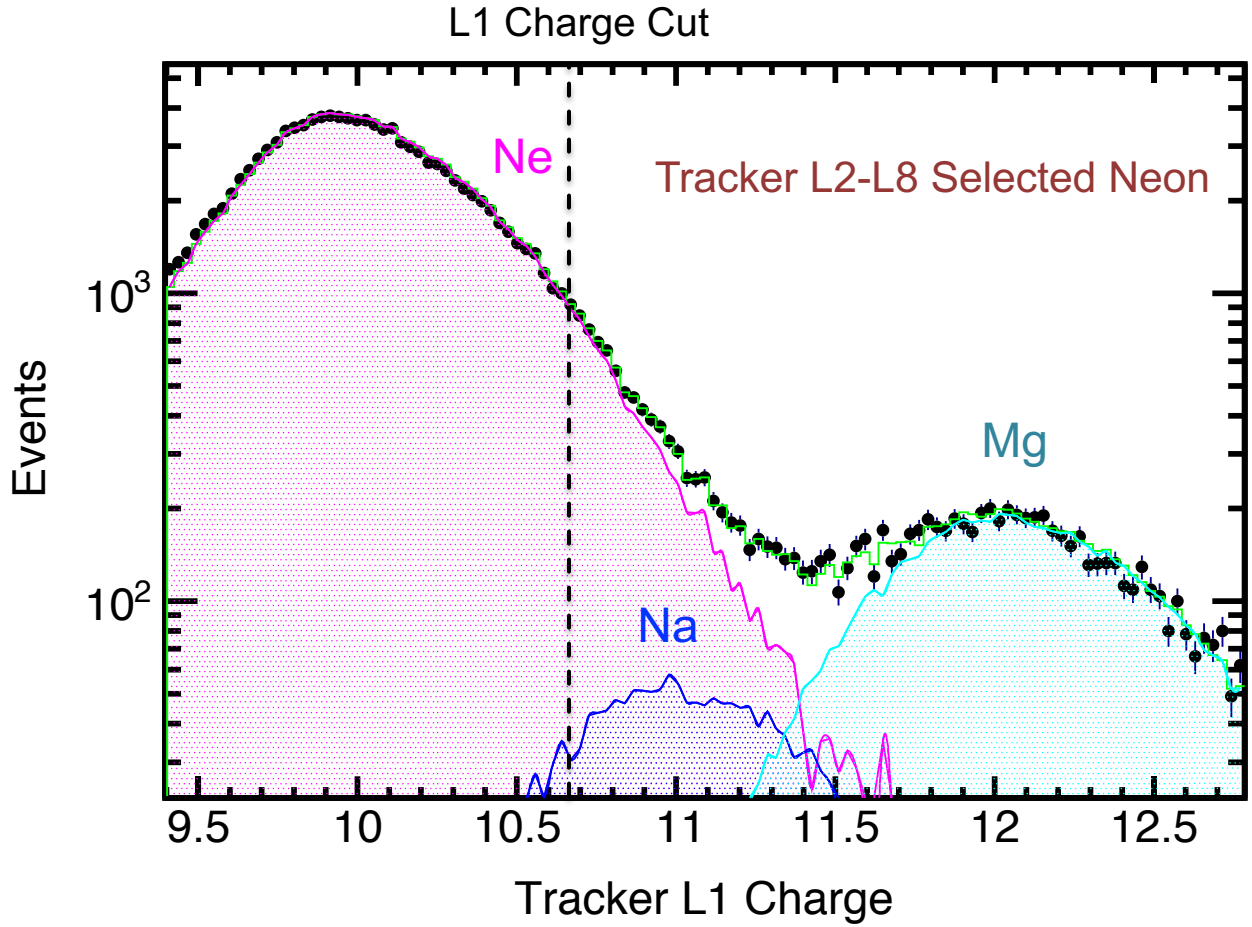
Ne, Mg, Si and S Events Selection



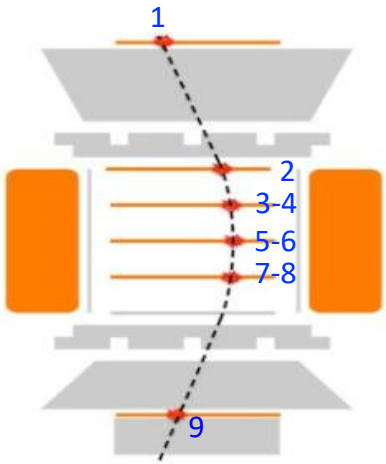
Background

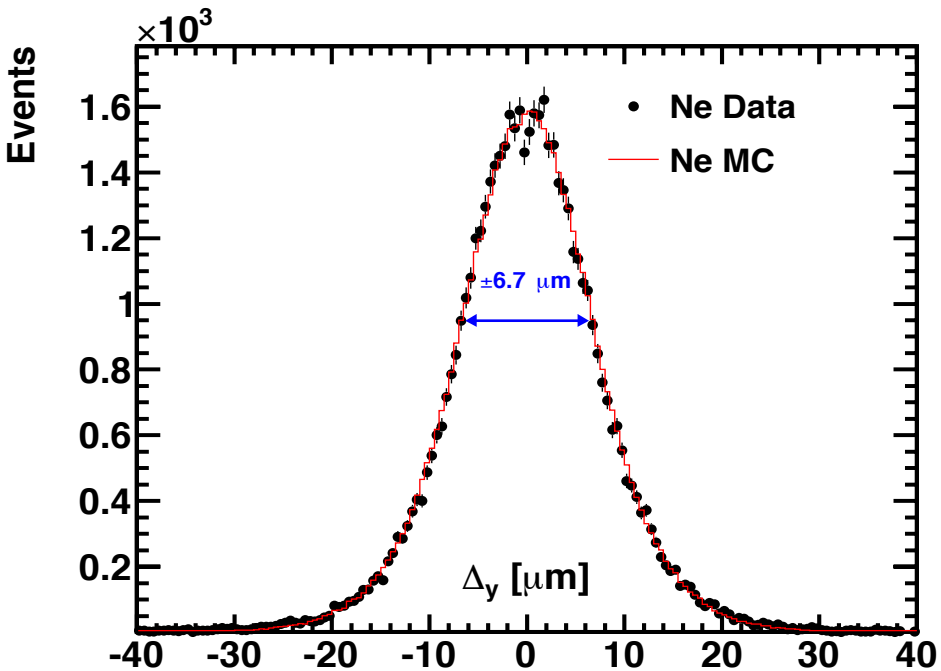
The background resulting from heavier nuclei which interact between tracker L1 and L2 (for example: Mg,Na …->Ne) can be subtracted by L1 charge measurement. After the selection, the background is <0.2% in the entire rigidity range for Ne, Mg, Si and S.

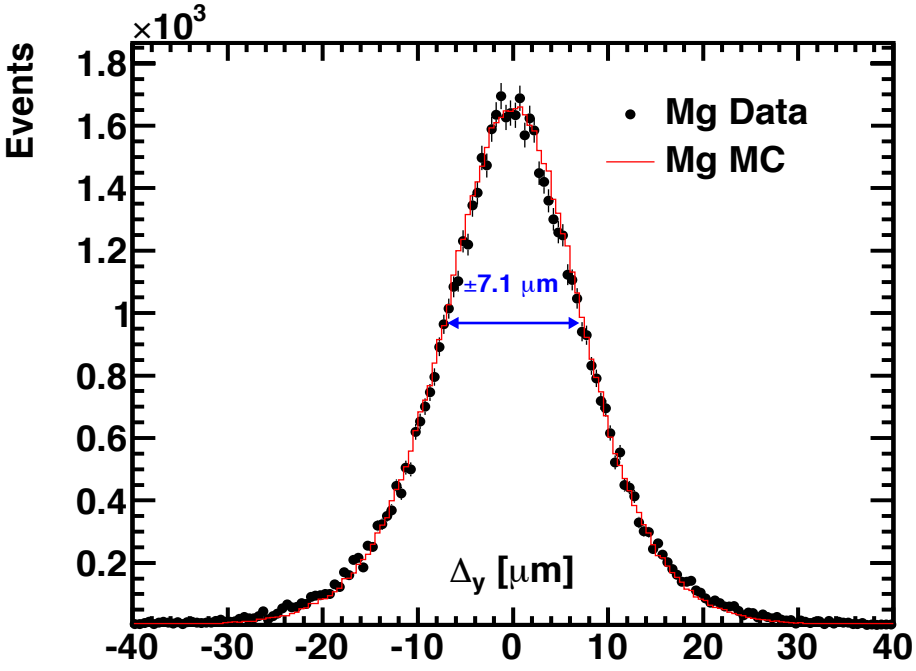




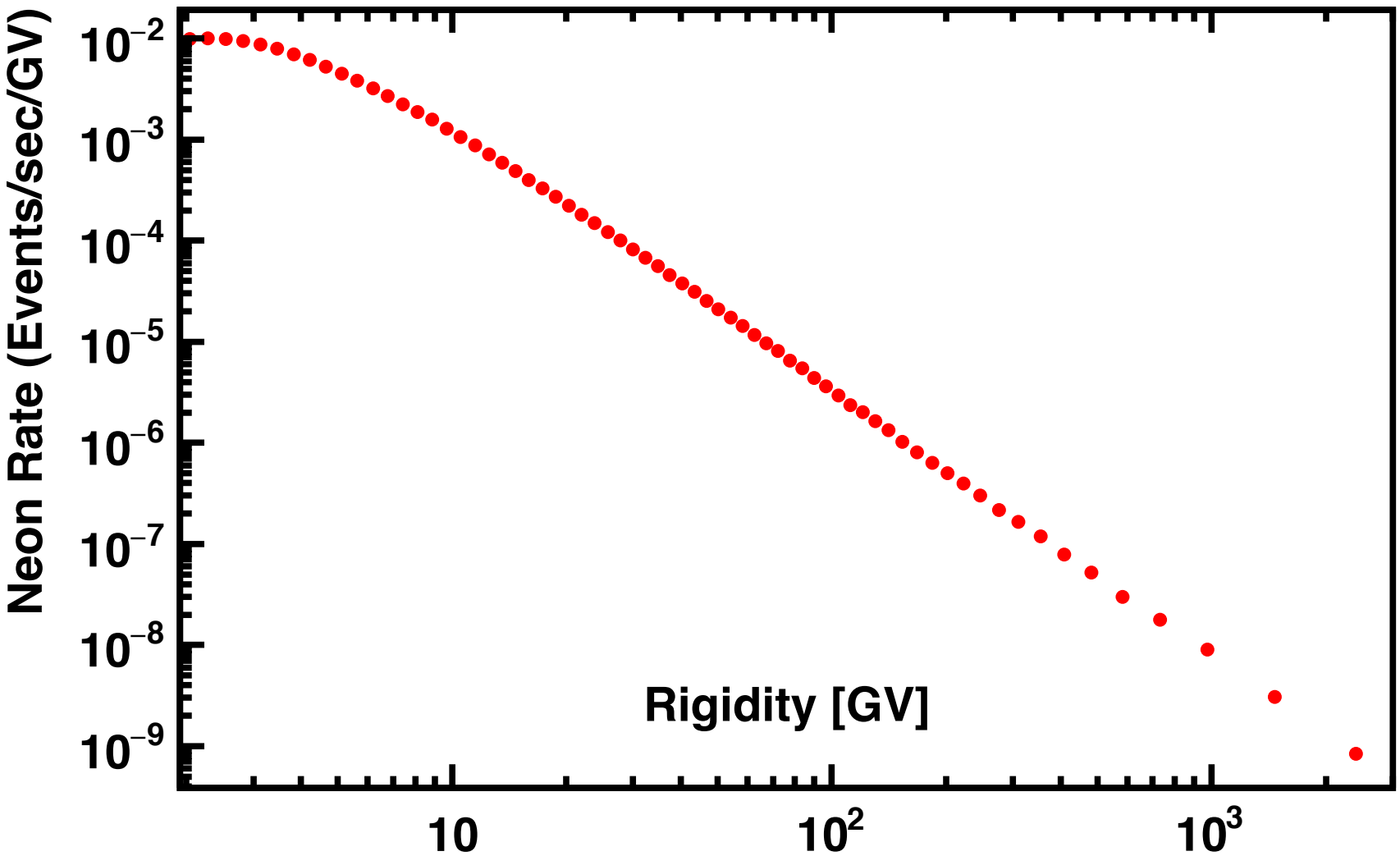
Tracker Coordinate Resolution Data and MC







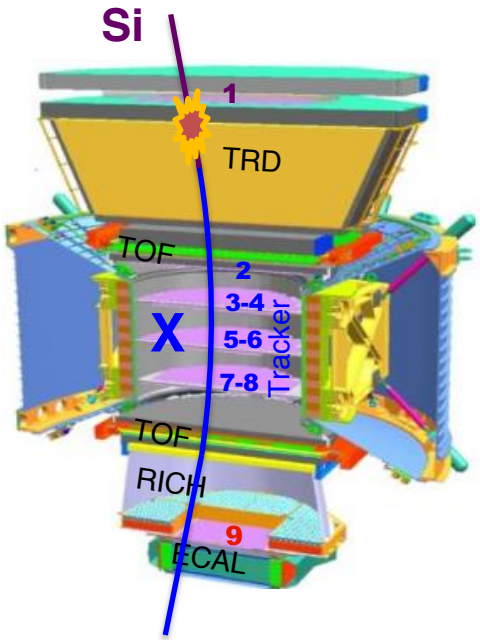
Neon Rate (Events/T/ΔR)

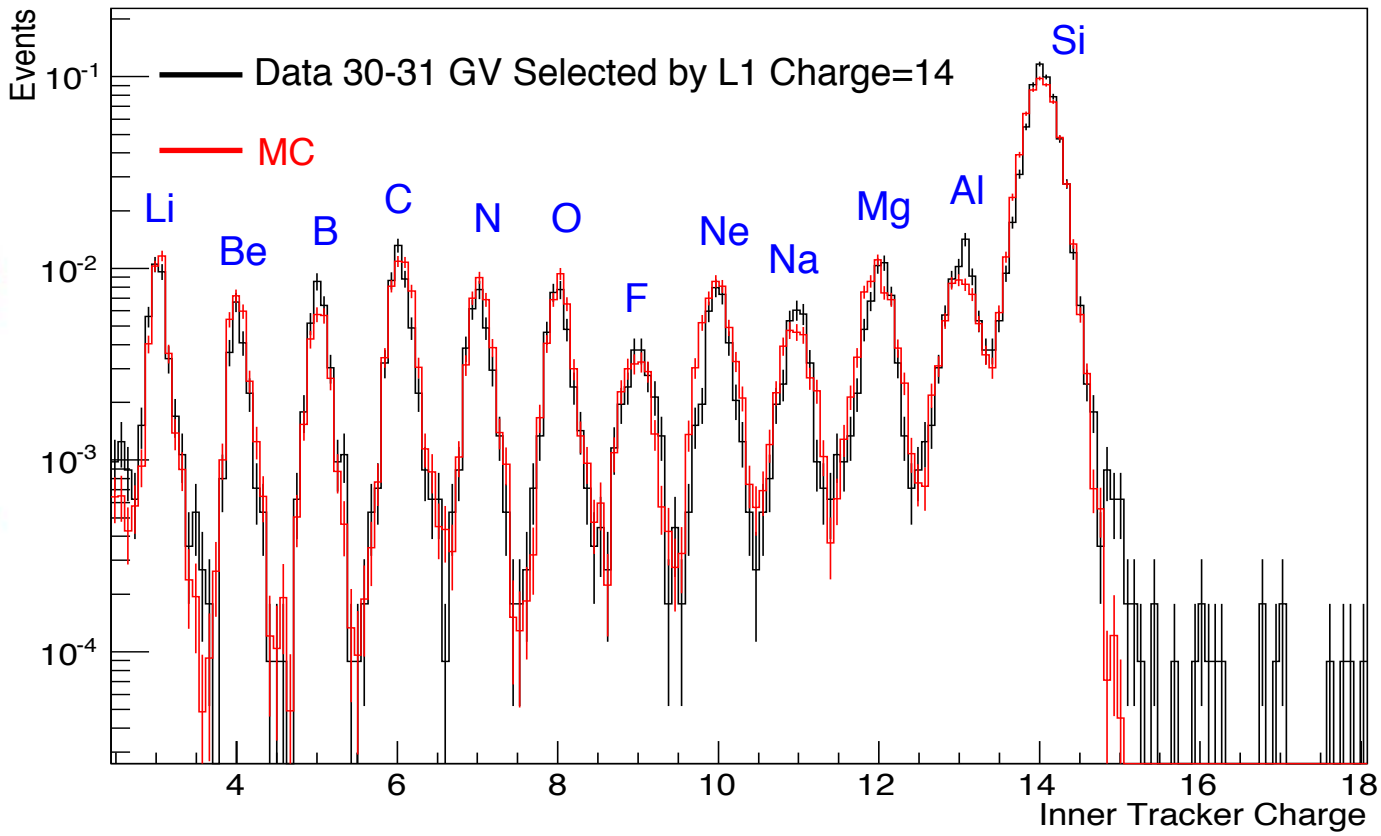


Nucleus Inelastic Interaction and Breaking-Up Channels Distribution (Silicon)

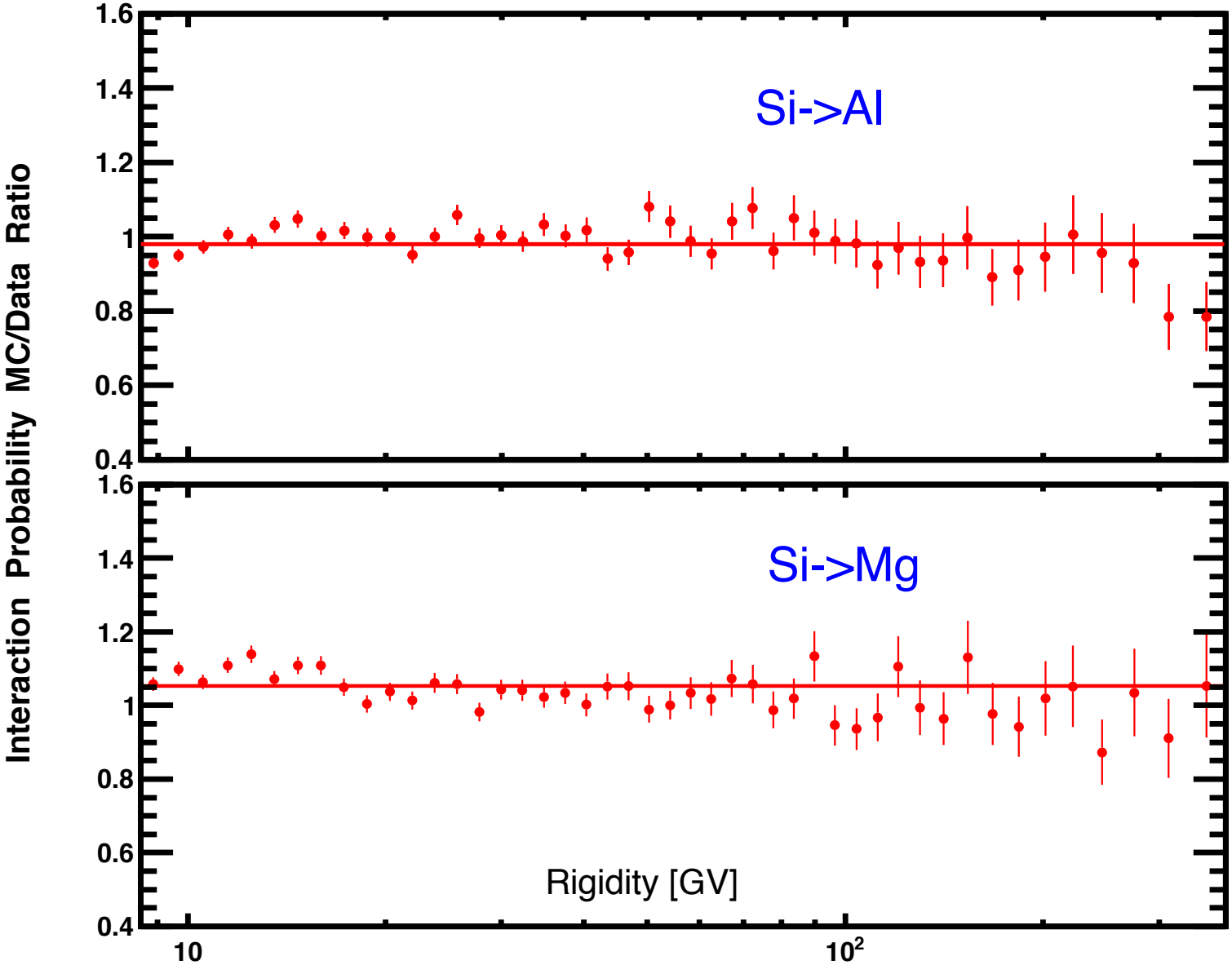
Statistics in “horizontal” runs are not sufficient for high Z survival probability evaluation, so different method was used

- Select primary nuclei by L1 charge
- Obtain survival probability by comparing charge measured with inner tracker

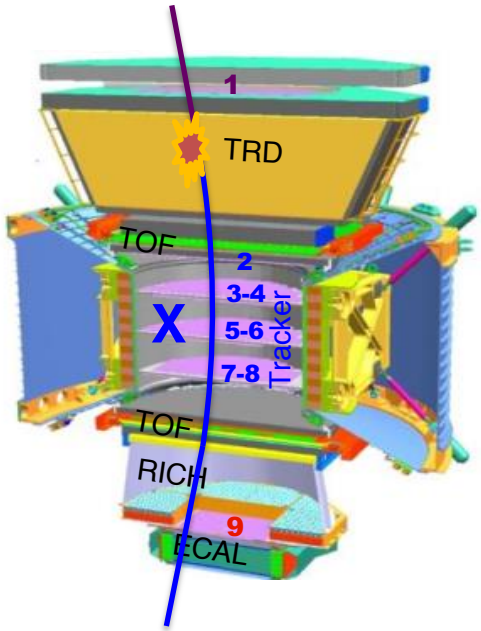


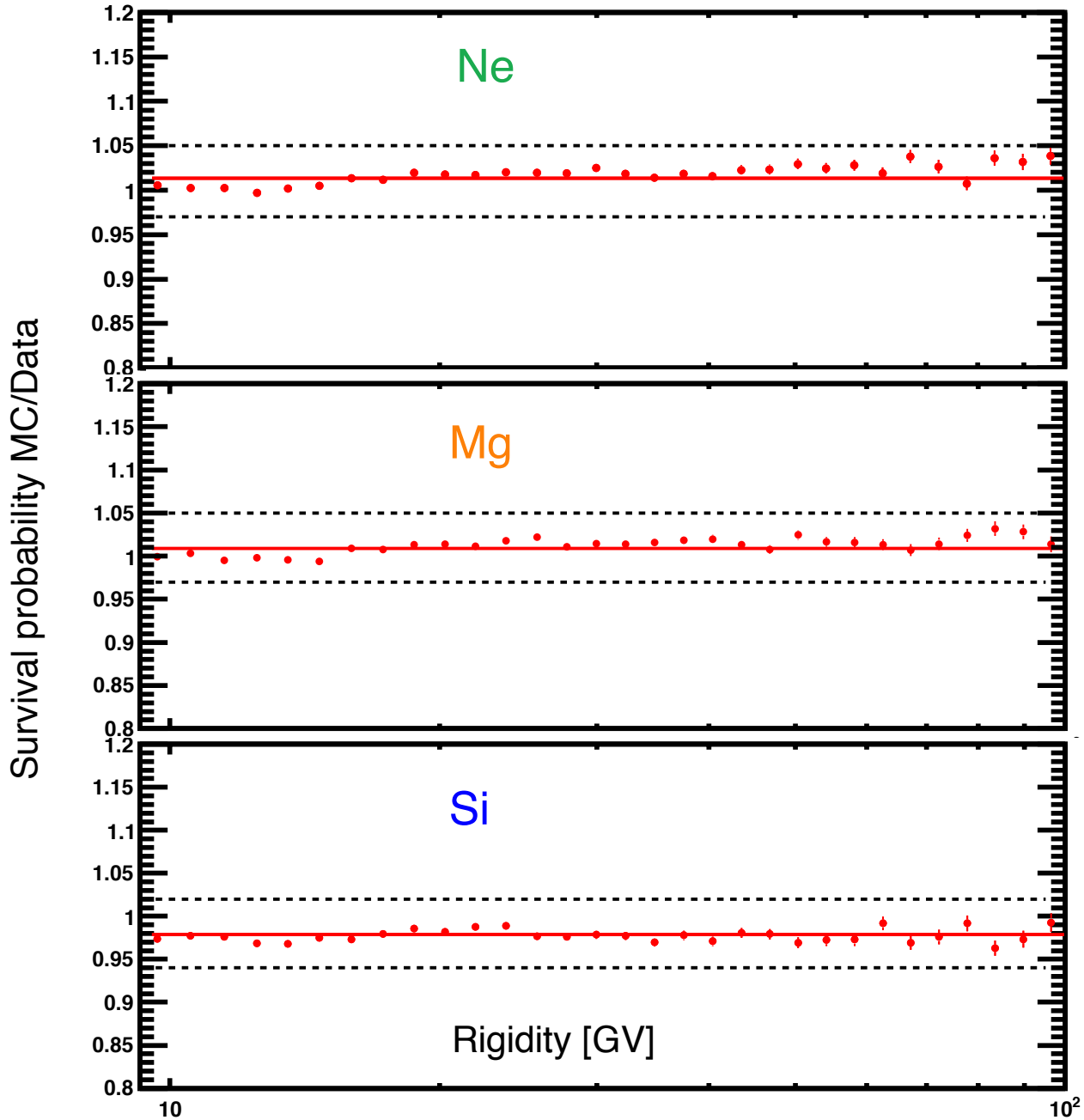


Nucleus Interaction Breaking-Up Channels
MC to Data Ratio (Silicon)

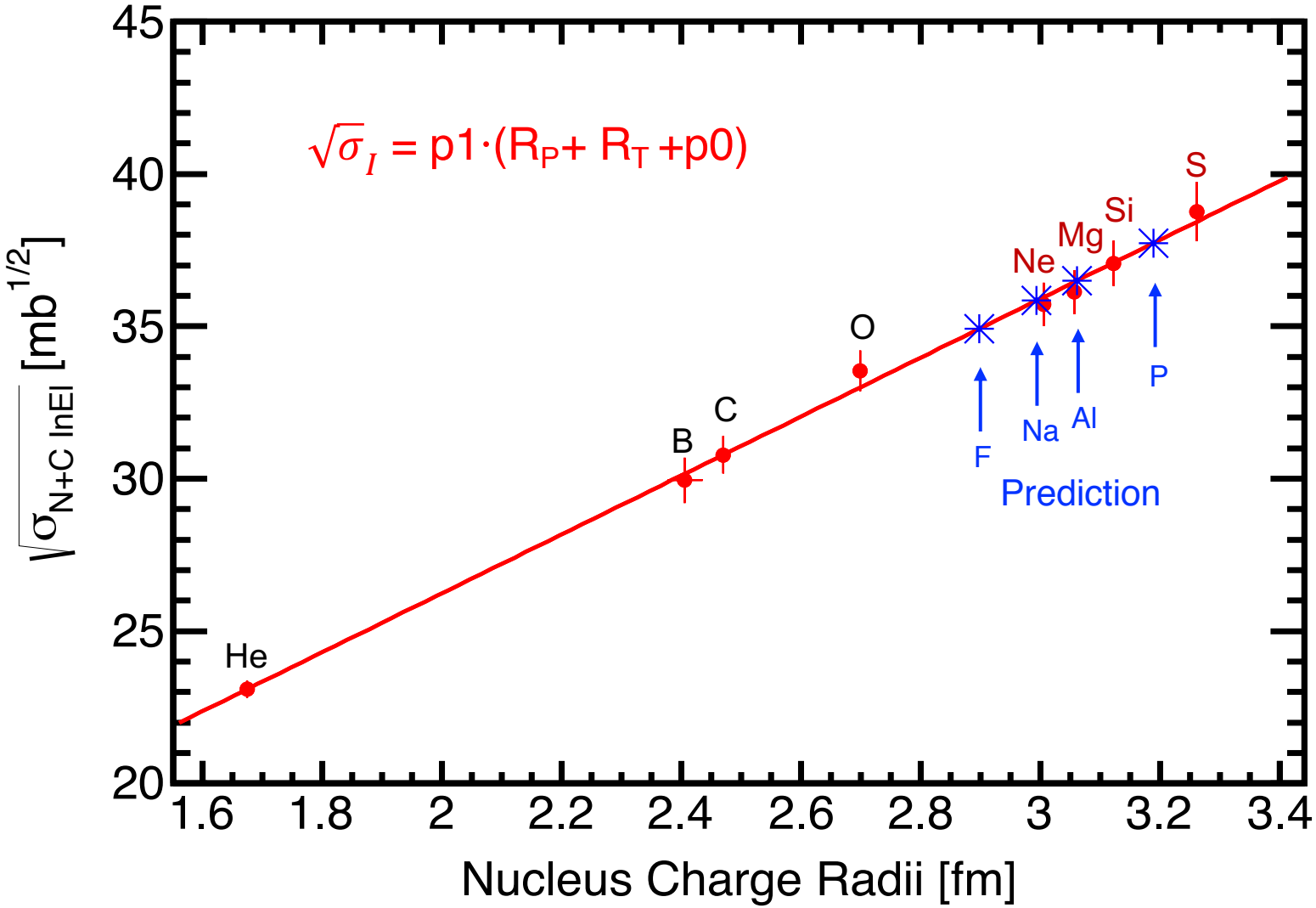


Nuclear Inelastic Interaction Survival Probability MC/Data



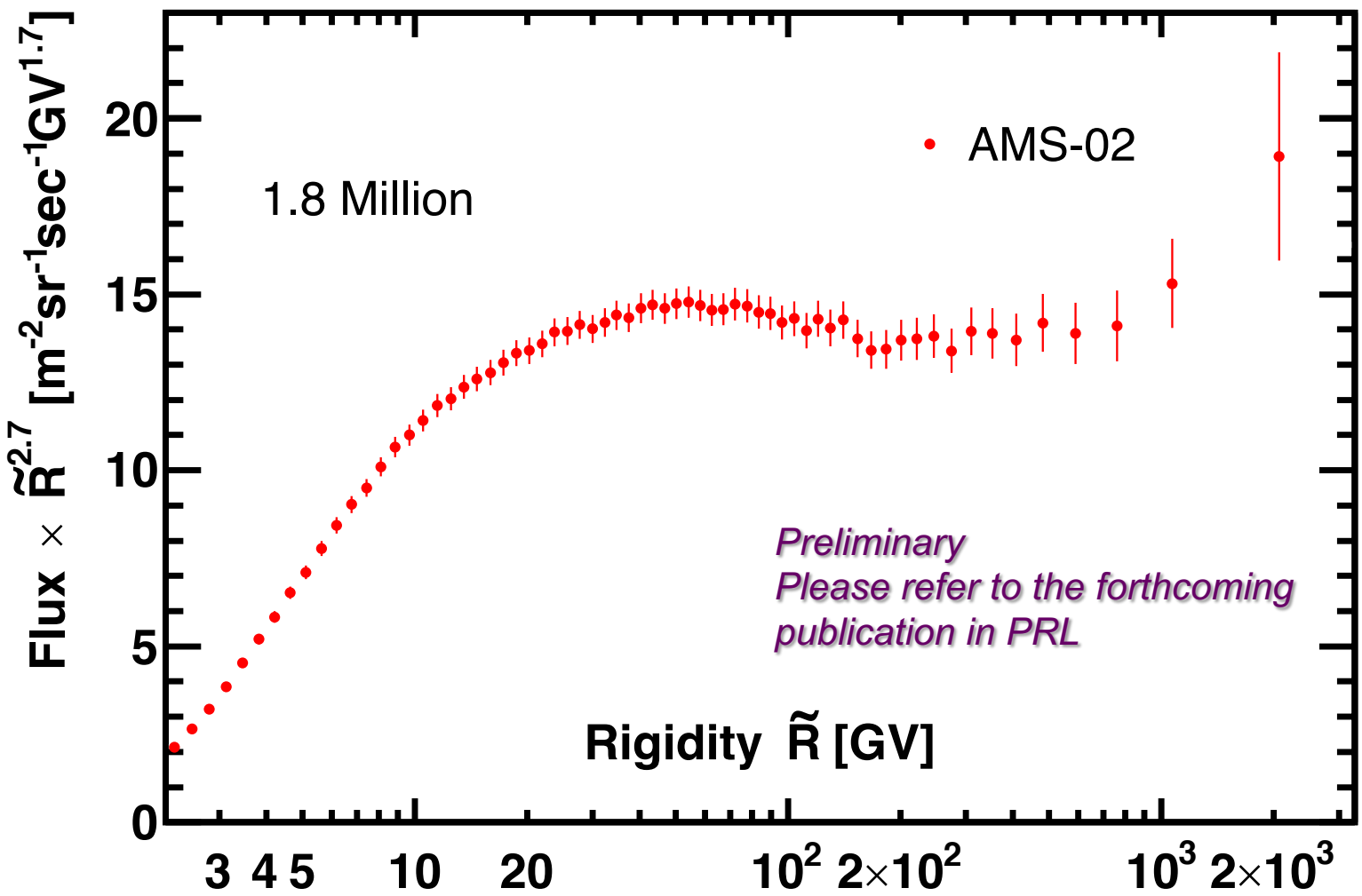


AMS Nucleus + C Inelastic Cross Section Measurements (5-100 GV Rigidity)

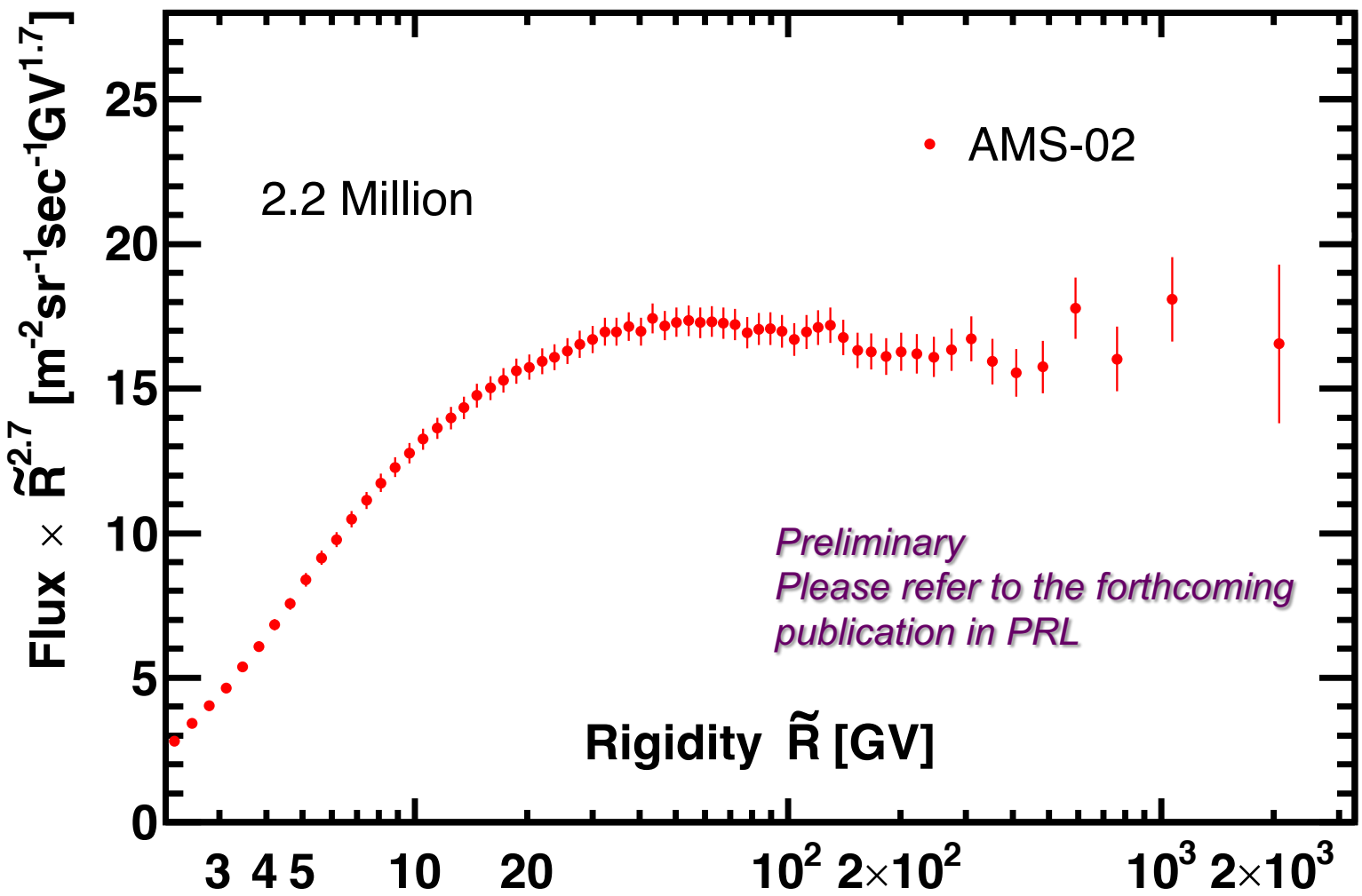


I. Angeli and K. P. Marinova. "Table of experimental nuclear ground state charge radii: An update." *Atomic Data and Nuclear Data Tables* 99.1 (2013): 69-95

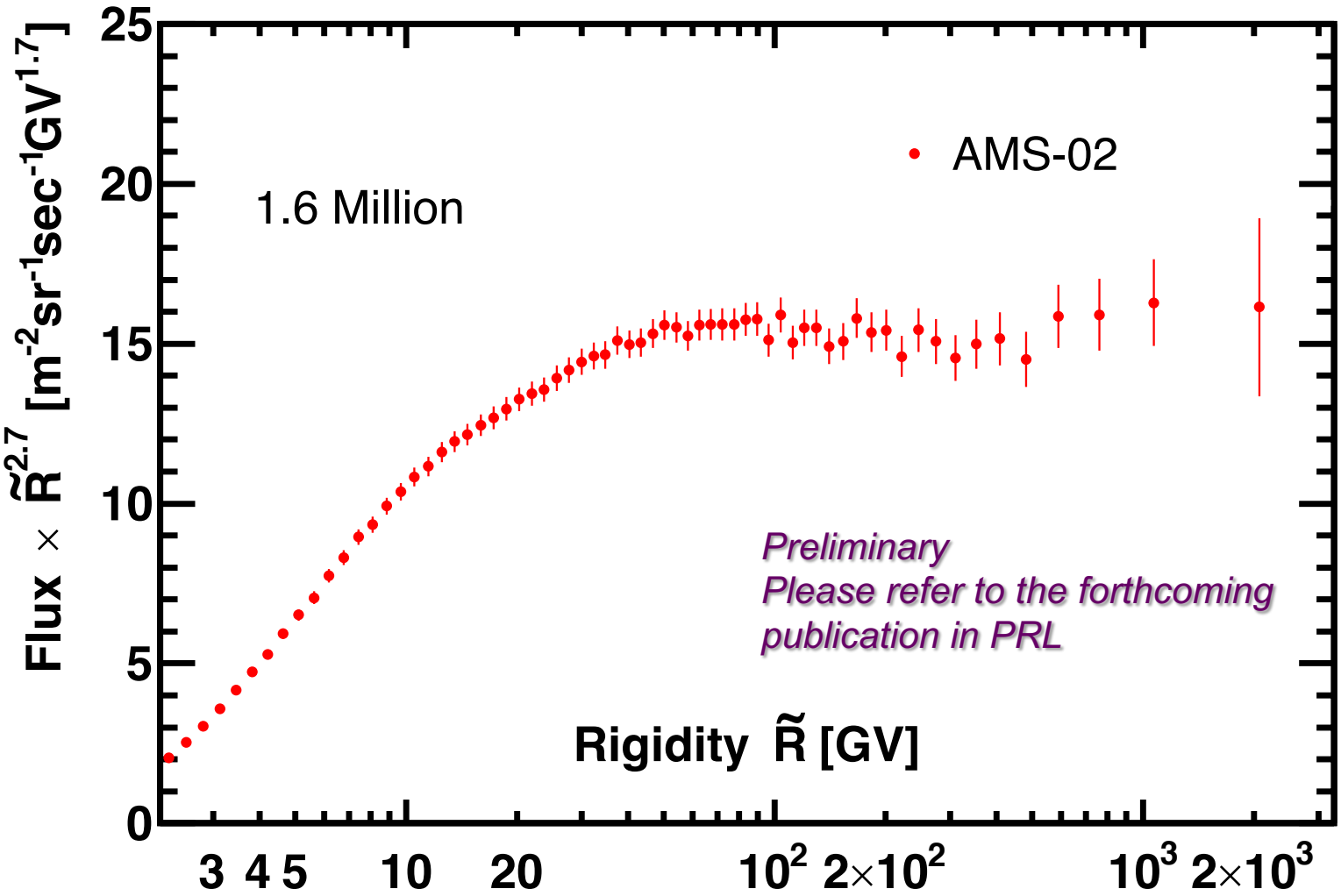
Neon Flux


Flux × $\tilde{R}^{2.7}$ [$m^{-2}sr^{-1}sec^{-1}GV^{1.7}$]
20
15
10
5
0
1.8 Million
AMS-02
Preliminary
Please refer to the forthcoming publication in PRL
Rigidity $\tilde{R}$ [GV]
3 4 5 10 20 10^2 2×10^2 10^3 2×10^3

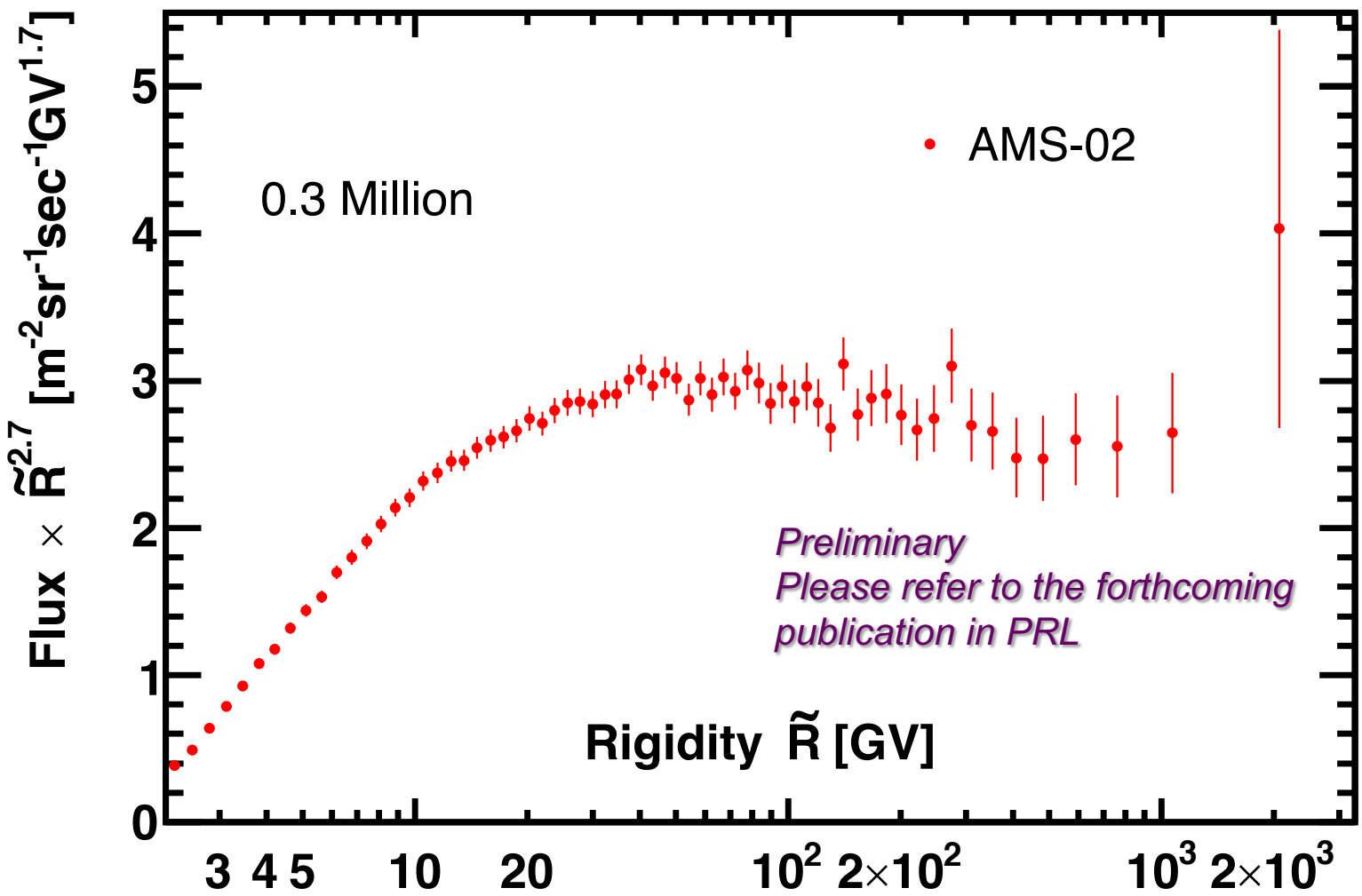
Magnesium Flux



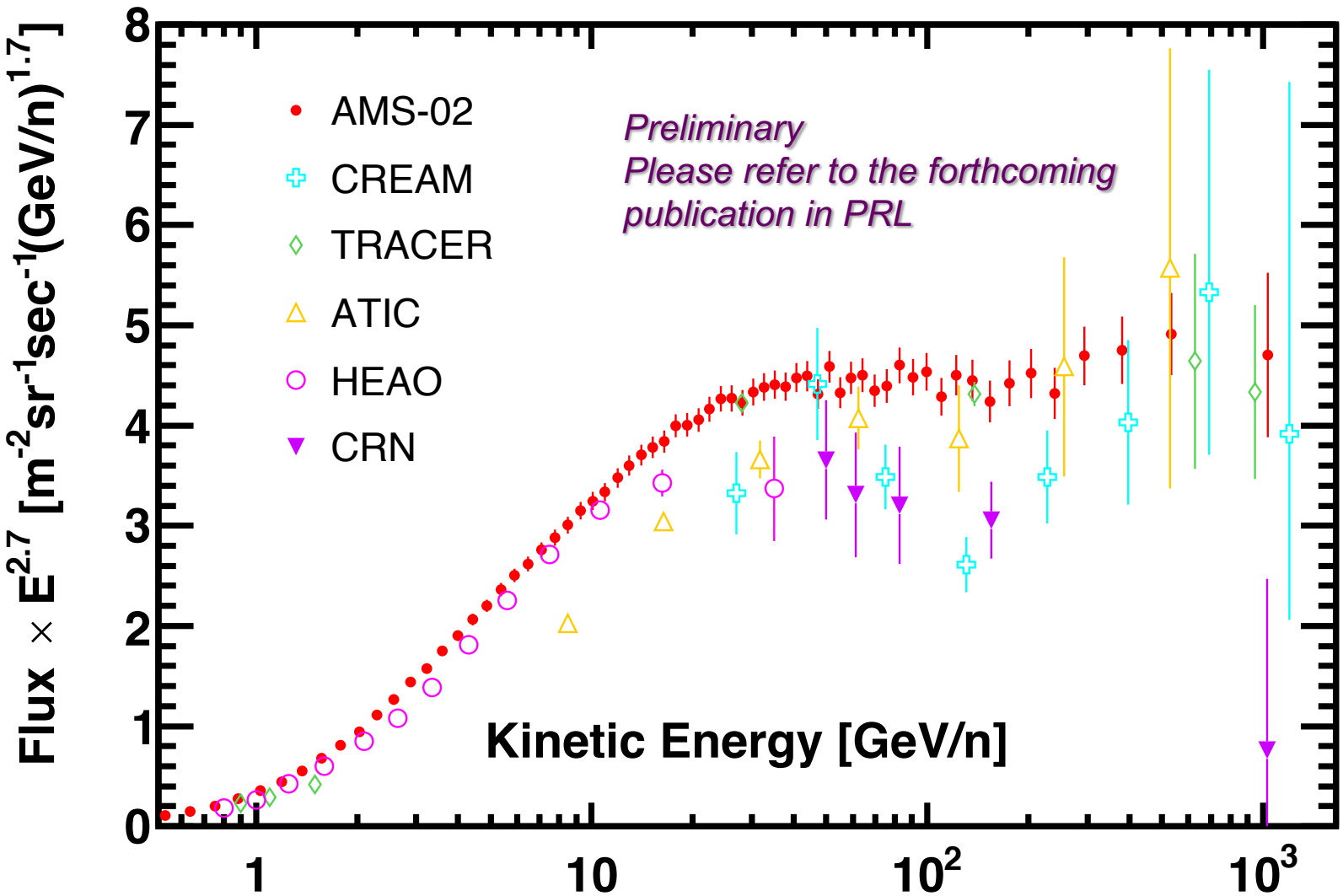
Silicon Flux



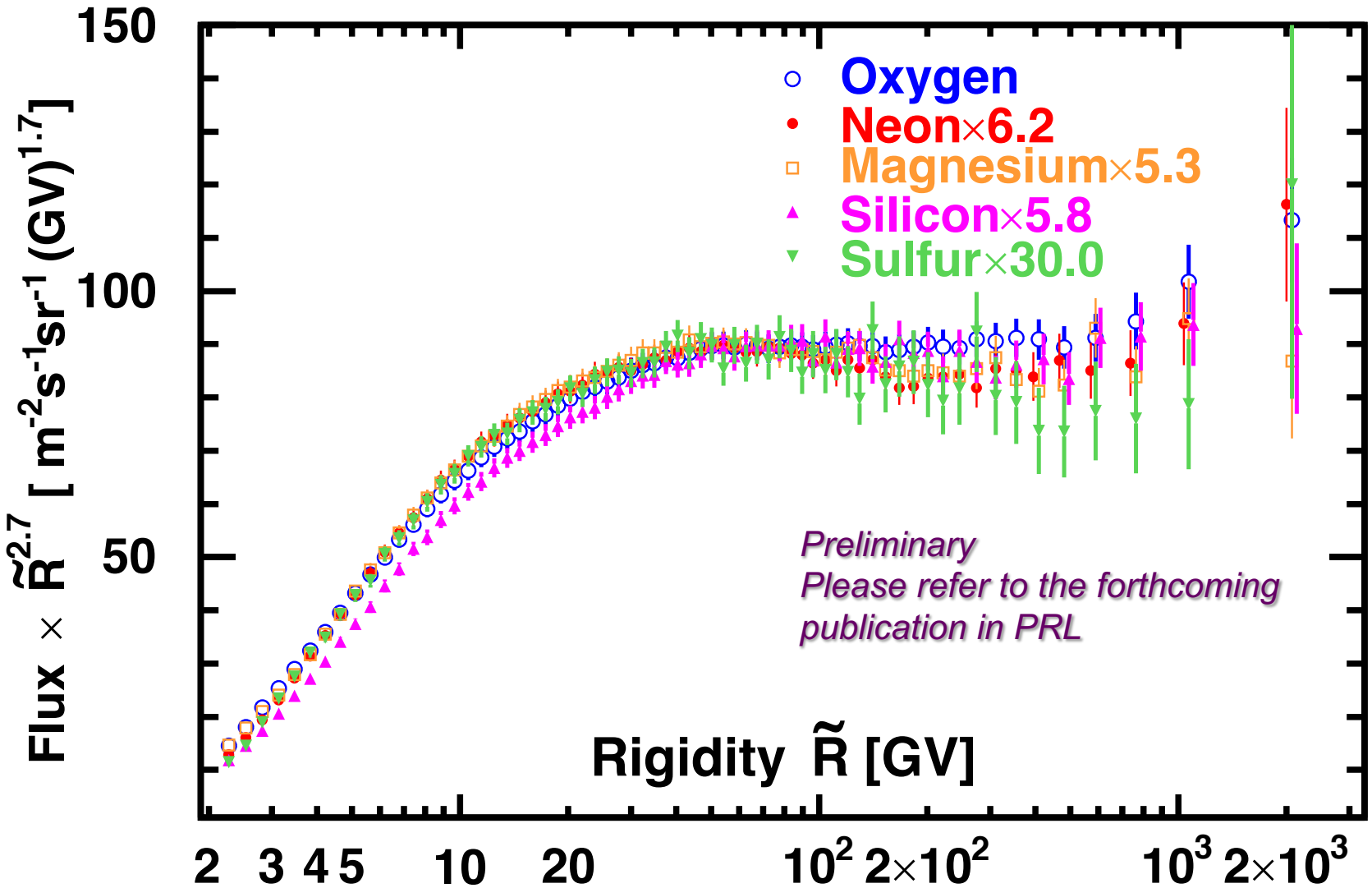
Sulfur Flux


Flux × $\tilde{R}^{2.7}$ [$m^{-2}sr^{-1}sec^{-1}GV^{1.7}$]
0
1
2
3
4
5
0.3 Million
AMS-02
Preliminary
Please refer to the forthcoming publication in PRL
Rigidity $\tilde{R}$ [GV]
3
4
5
10
20
10^2
2×10^2
10^3
2×10^3

Compared with Other Experiments (Silicon Flux)

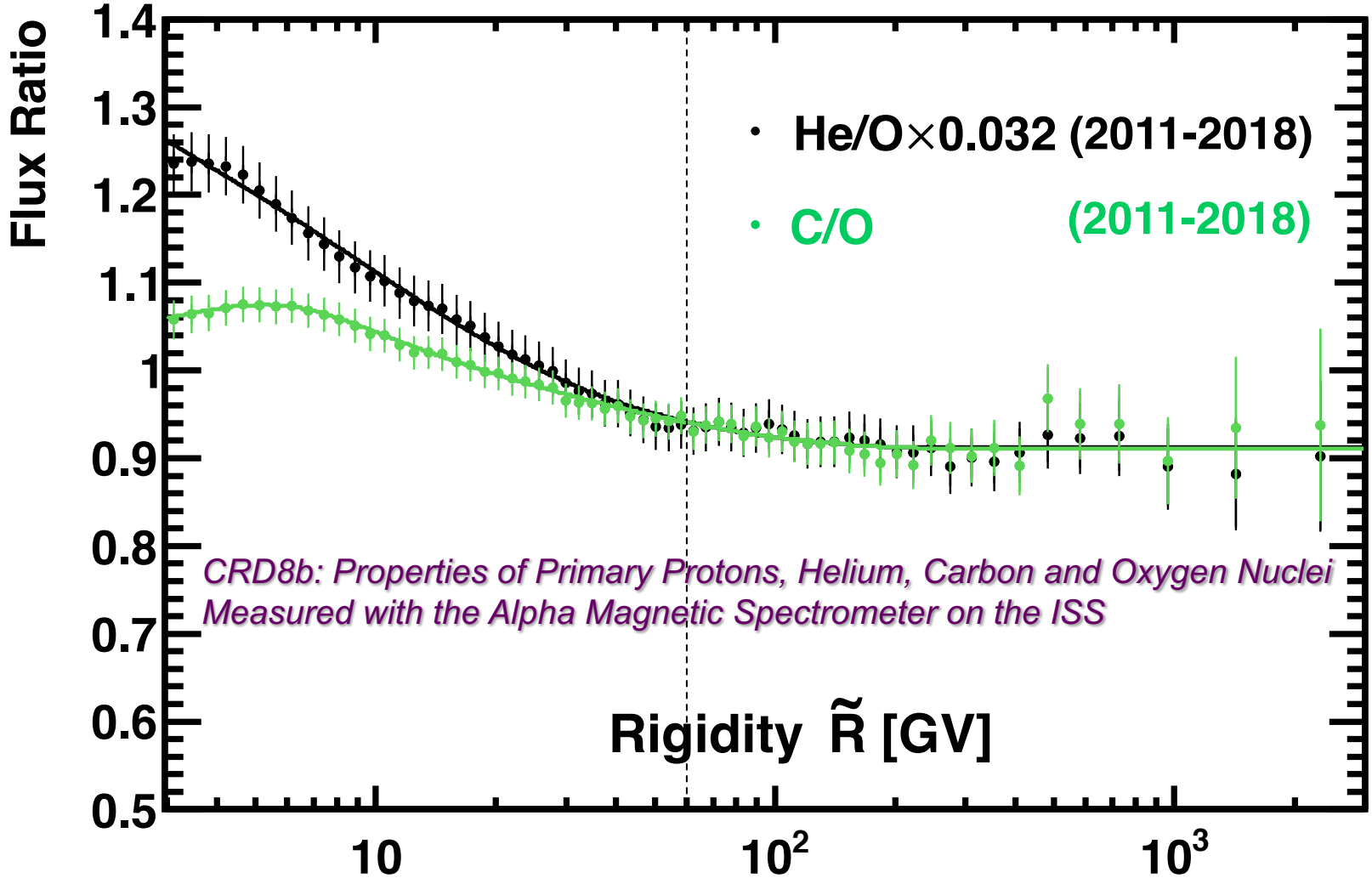


O, Ne, Mg, Si and S Fluxes



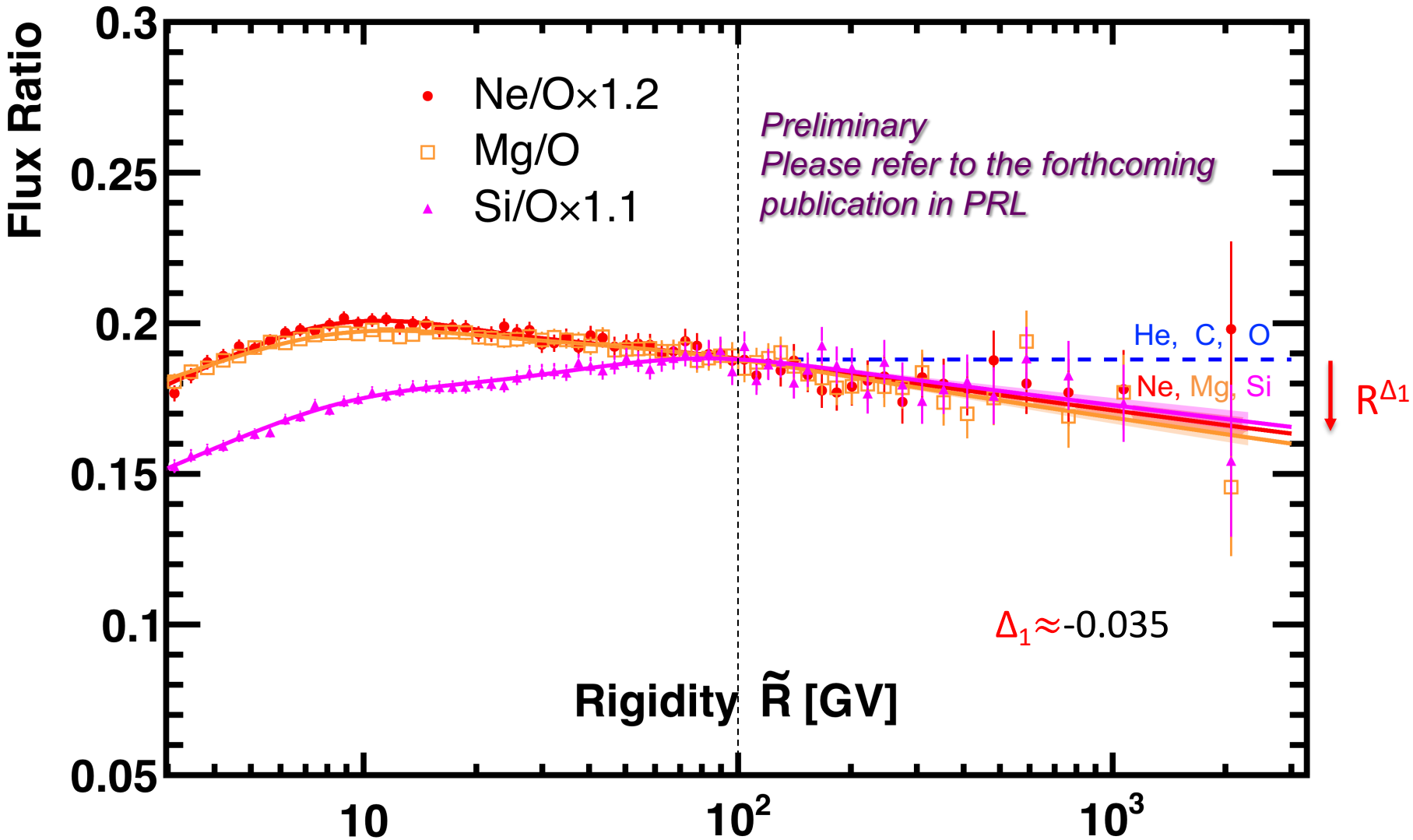
Light Elements Flux Ratio to Oxygen (He/O, C/O)

Above ~60 GV, the He, C and O spectra have identical rigidity dependence



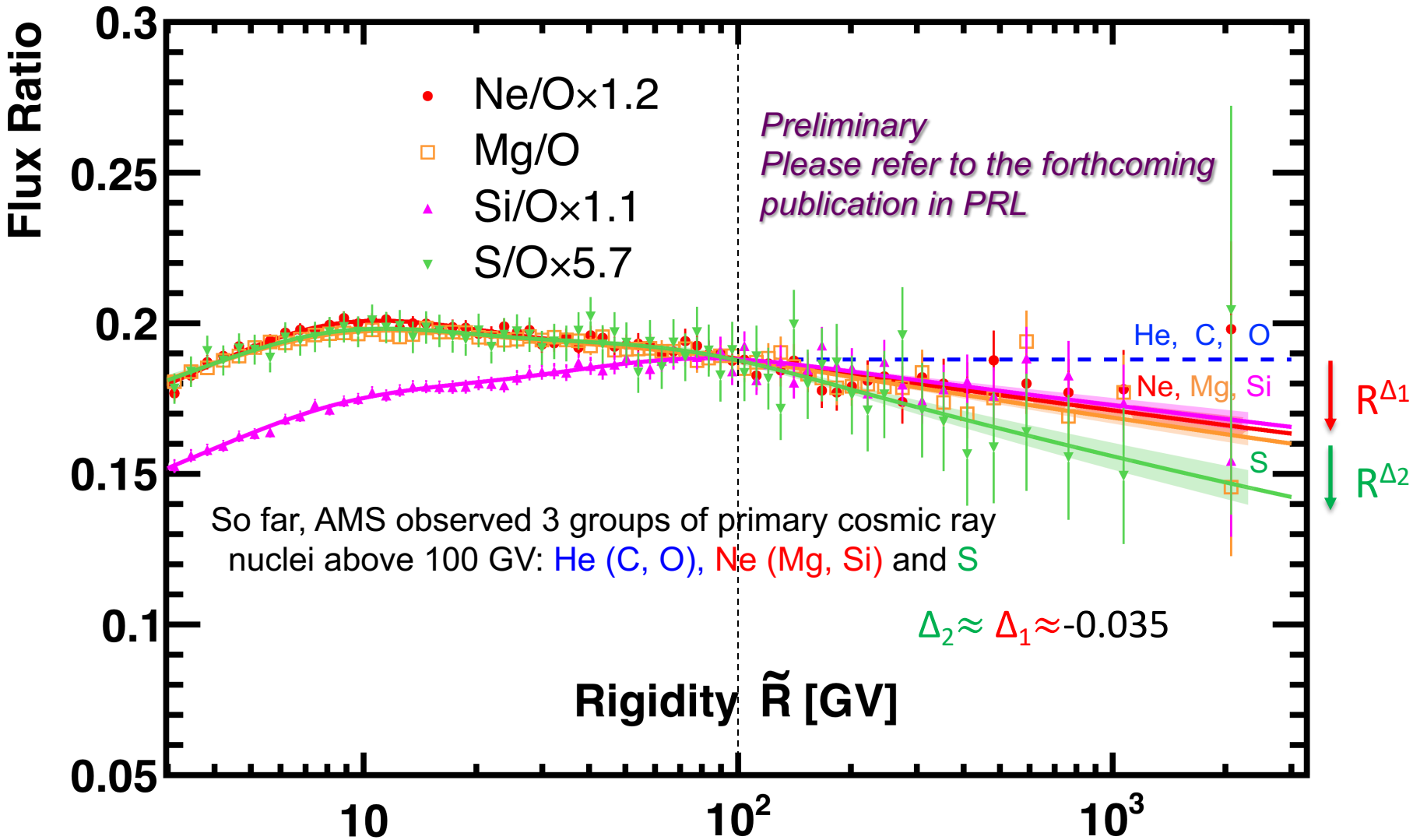
The new AMS result (2011-2018) is consistent with earlier AMS PRL result (2011-2016) "M. Aguilar *et al.*, Phys. Rev. Lett., **119**, 251101 (2017)" but with improved accuracy

Heavy Elements Flux Ratio to Oxygen (Ne/O, Mg/O, Si/O)



Above 100 GV, the spectra rigidity behavior of Ne, Mg, and Si is identical, but it differ from O (He, C) by a single power law (R^{Δ_1}) with spectral index $\Delta_1 \approx -0.035$

Flux Ratio to Oxygen (Ne/O, Mg/O, Si/O and S/O)



Above 100 GV, the spectrum rigidity behavior of S is different from Ne (Mg, Si) by another single power law (R^{Δ_2}) with spectral index $\Delta_2 \approx \Delta_1 \approx -0.035$

Summary

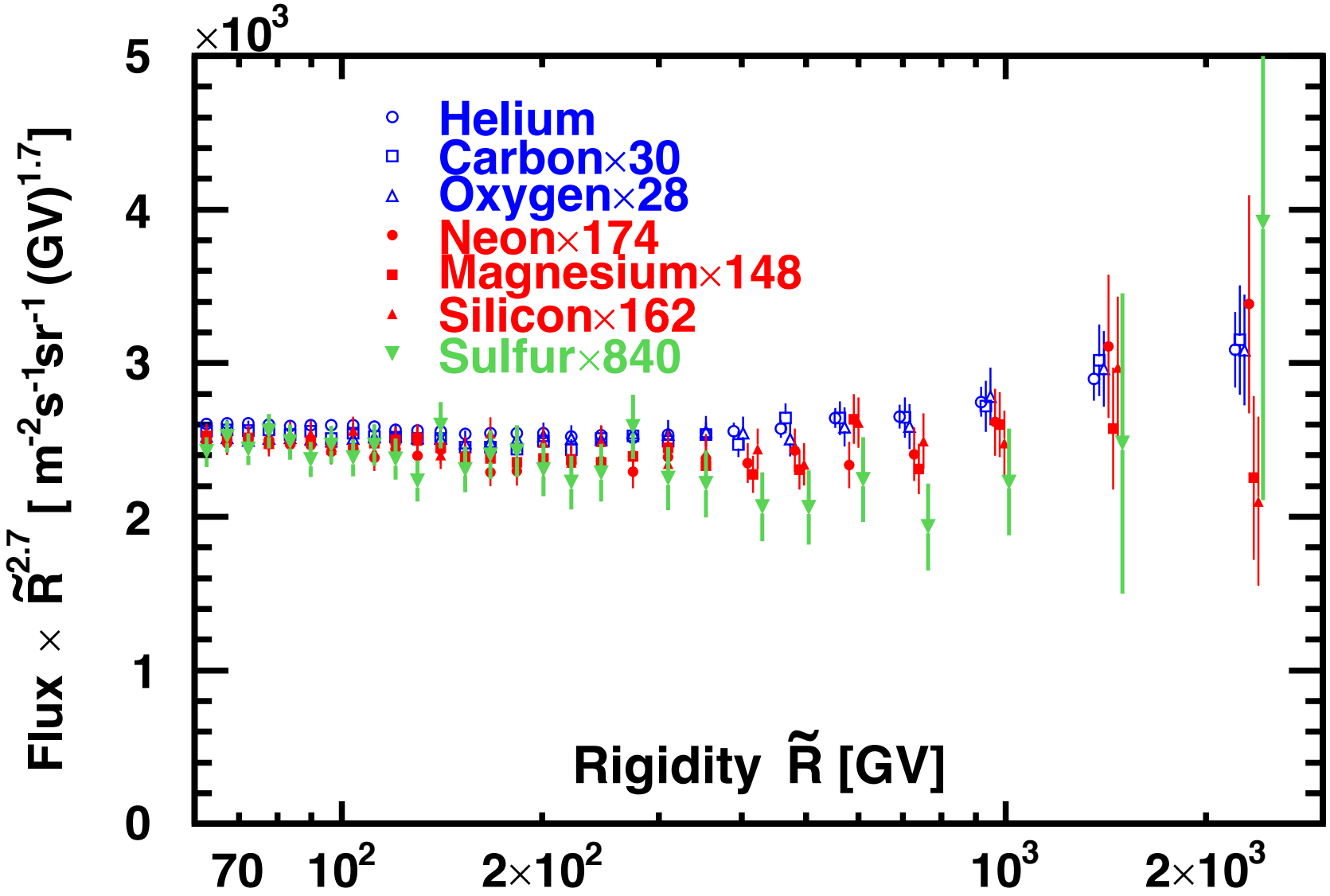
- Precision measurements of Primary Cosmic Rays Neon, Magnesium, Silicon and Sulfur (Z=10,12,14,16) fluxes from 2 GV to 3 TV based on 7 years (2011-2018) AMS data have been presented.

- From Oxygen (Z=8) to Neon (Z=10), the flux drops by a factor of ~5. The abundance of the elements Neon, Magnesium, and Silicon (Z=10,12,14) is in the same order of magnitude (<20% difference). Above 100 GV, the flux Rigidity behaviors of Neon, Magnesium, and Silicon are identical, while they are all soften than Oxygen by a single power law (R^{Δ_1}) with a spectral index $\Delta_1 \approx -0.035$.

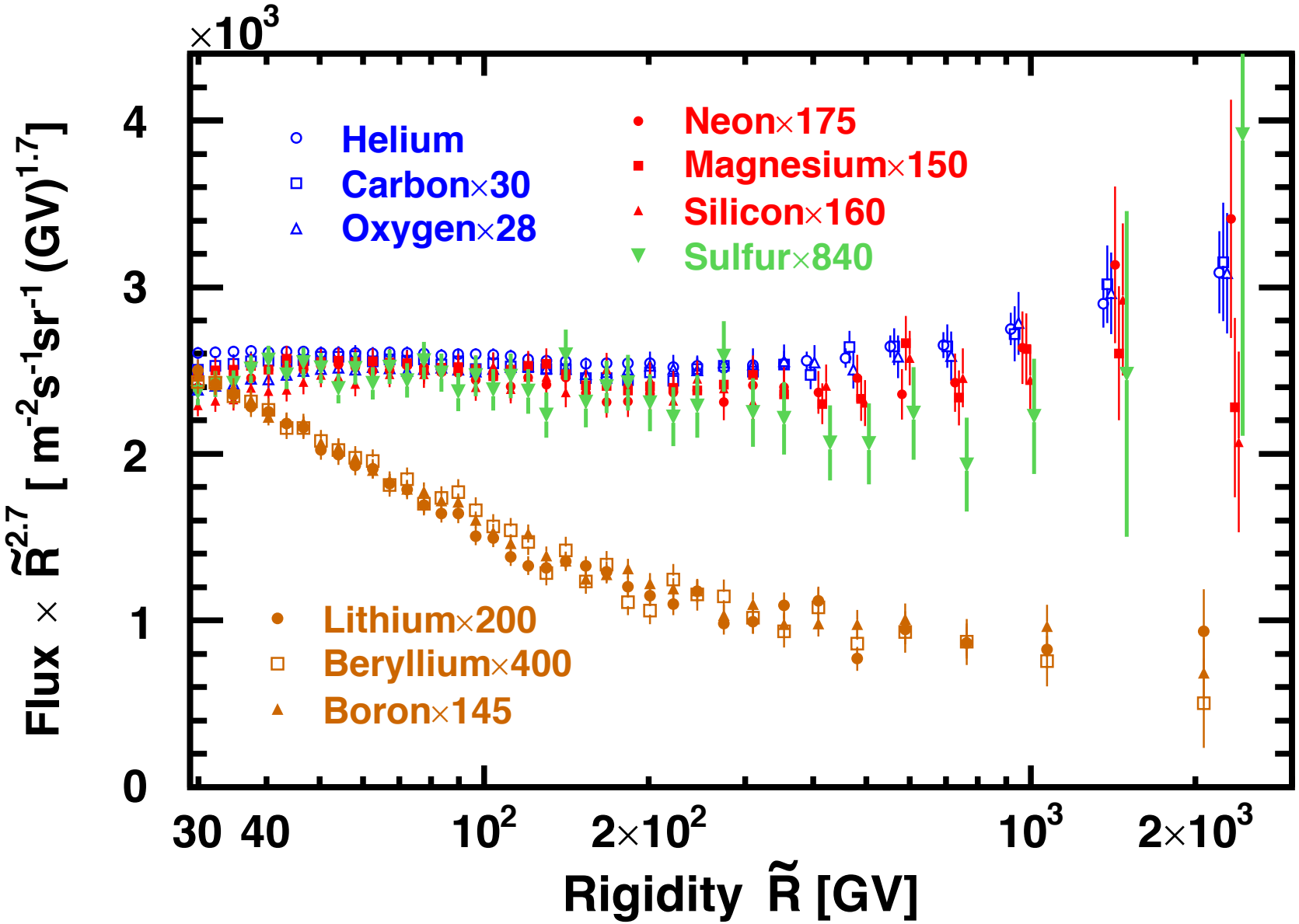
- From Silicon (Z=14) to Sulfur (Z=16), the flux decreases by another factor of ~5. And the flux of Sulfur is soften than Silicon by another single power law (R^{Δ_2}) with spectral index $\Delta_2 \approx \Delta_1$ above 100GV.

- The flux of Iron (Z=26) ?

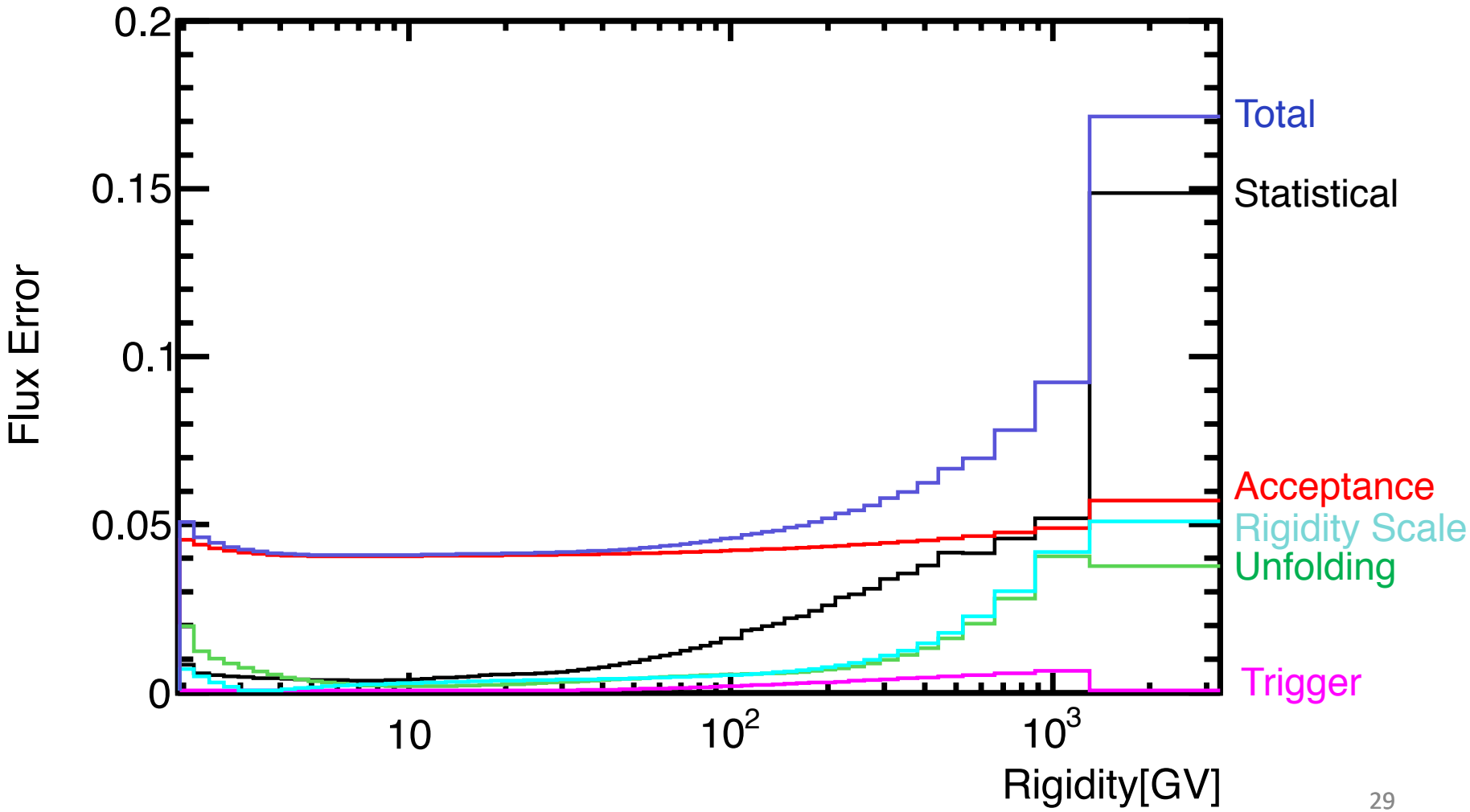
He, C, O, Ne, Mg, Si and S Fluxes



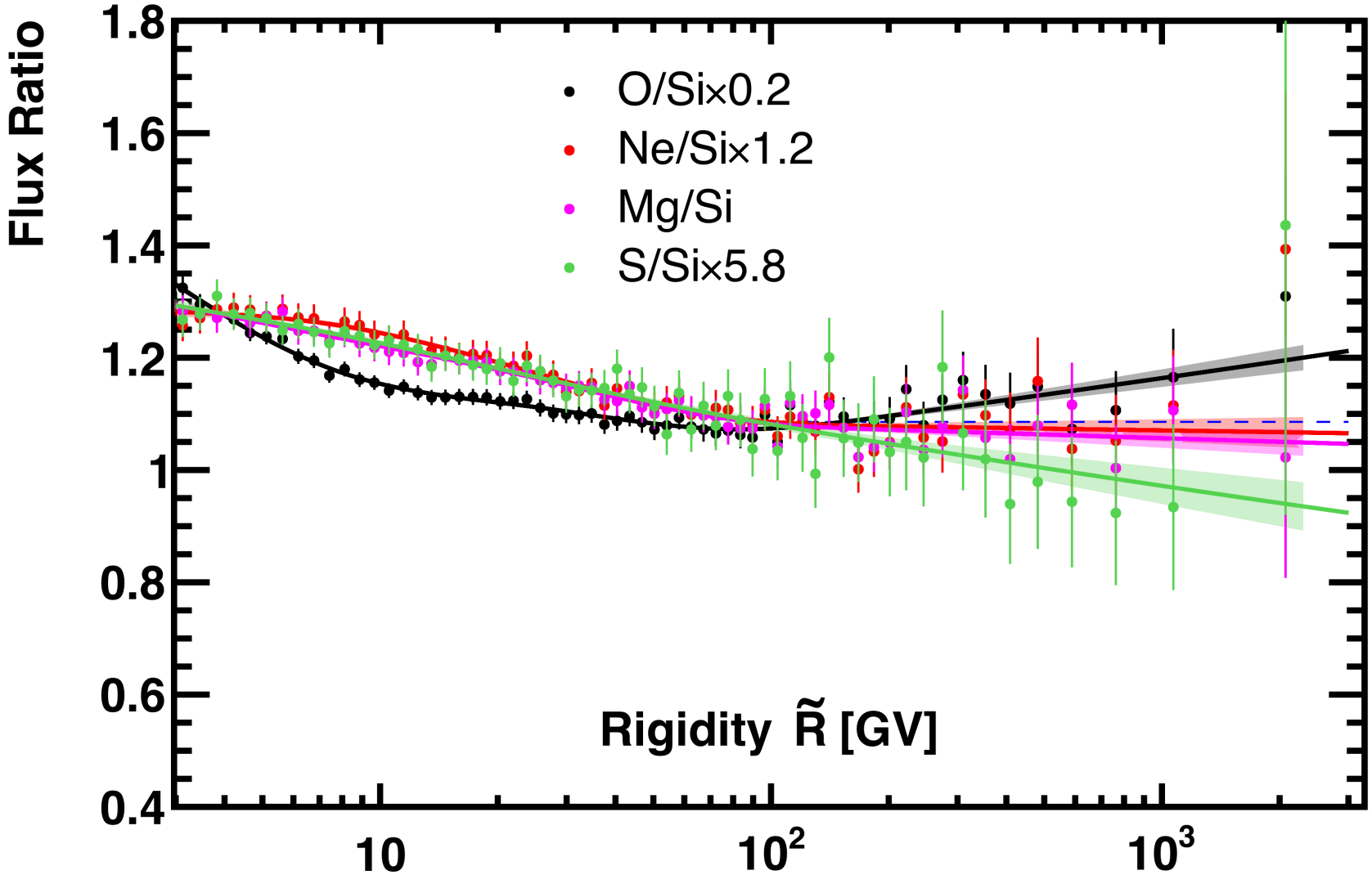
He-S Fluxes


×10^3
Helium
Carbon×30
Oxygen×28
Neon×175
Magnesium×150
Silicon×160
Sulfur×840
Lithium×200
Beryllium×400
Boron×145
Flux × R̃^2.7 [m^-2s^-1sr^-1 (GV)^1.7]
Rigidity R̃ [GV]
0
1
2
3
4
30
40
10^2
2×10^2
10^3
2×10^3

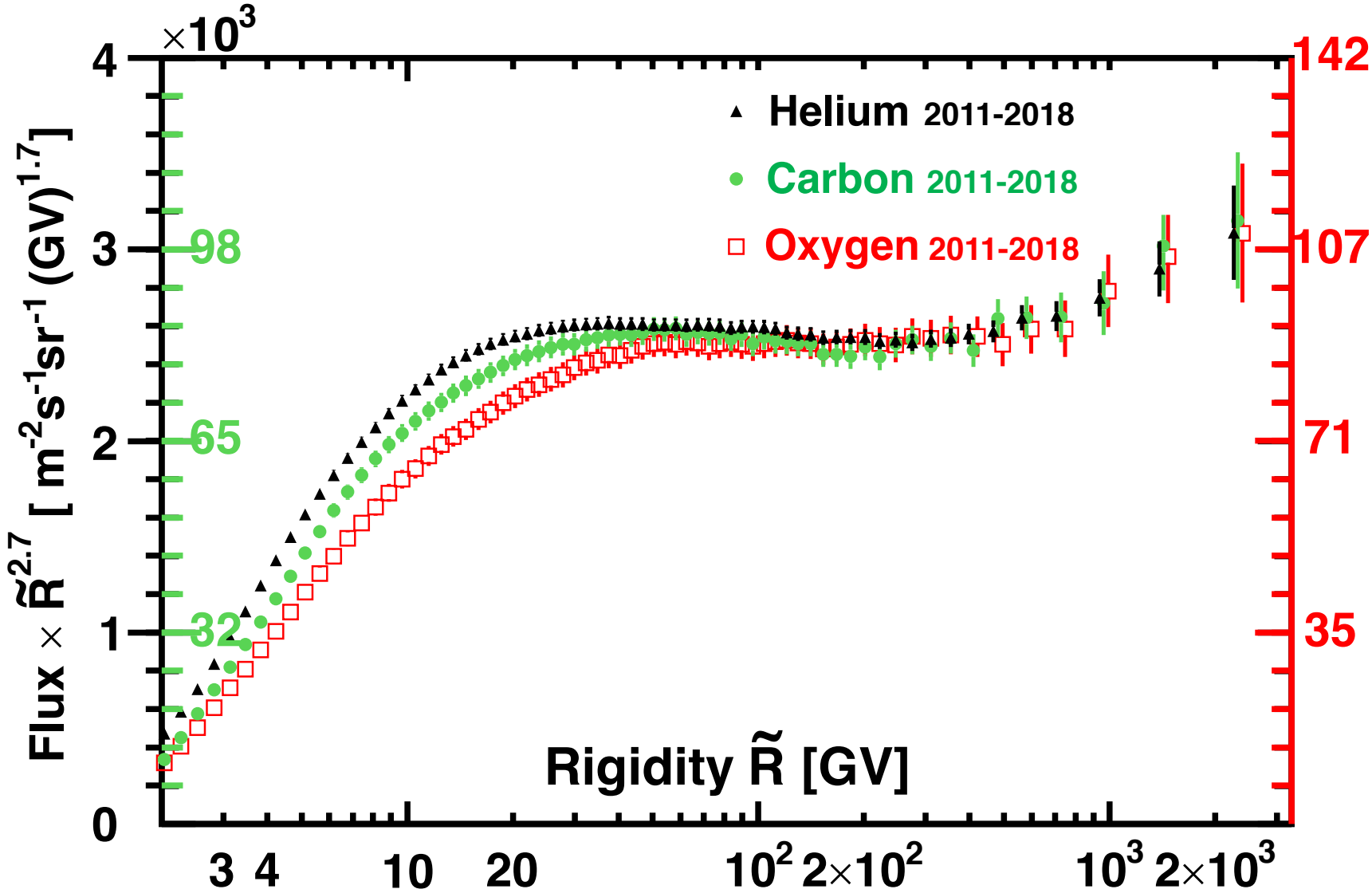
Error Break Down (Silicon Flux)



Flux Ratio to Silicon



Latest AMS Measurements of He, C and O spectra



The new AMS result (2011-2018) is consistent with earlier AMS PRL result (2011-2016) "M. Aguilar *et al.*, Phys. Rev. Lett., **119**, 251101 (2017)" but with improved accuracy

The Primary and Secondary Components of Carbon Flux