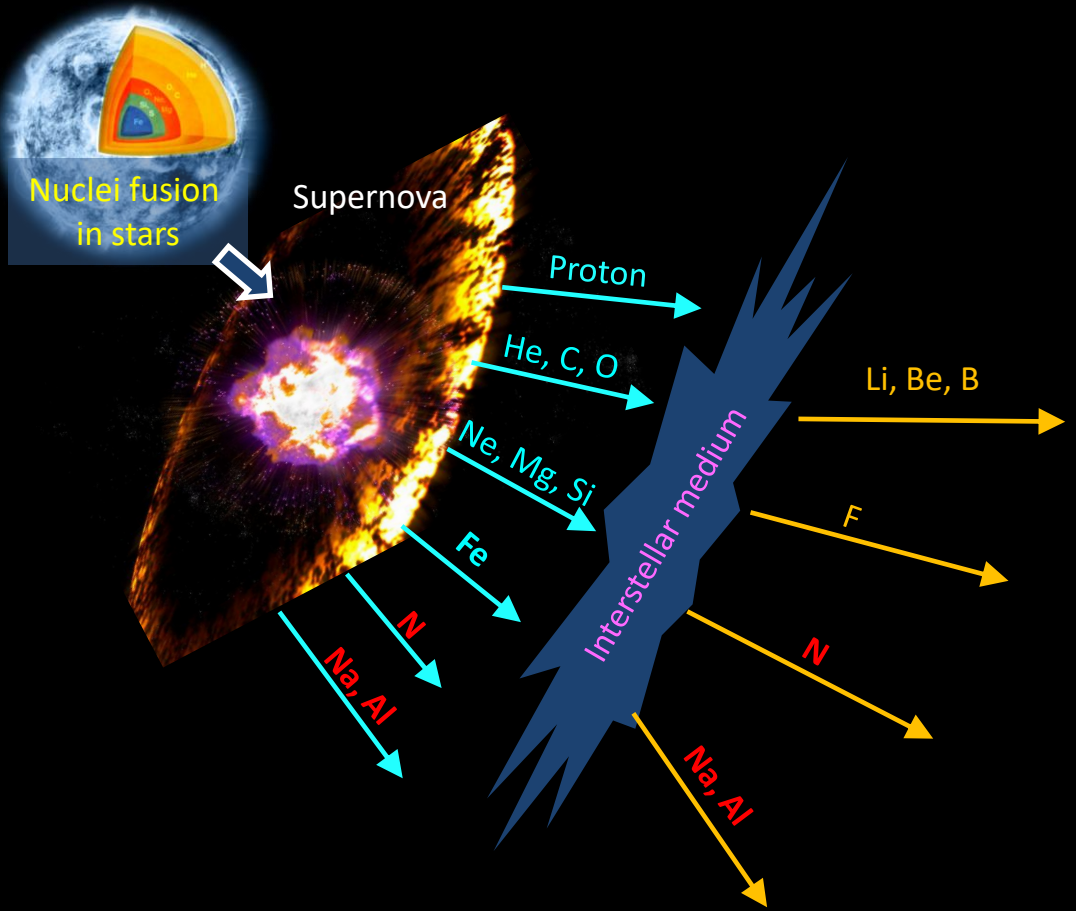
Unique Properties of the 3rd Group of Cosmic Rays Results from the Alpha Magnetic Spectrometer

Yao Chen, Shandong Institute of Advanced Technology (SDIAT)
on behalf of the AMS Collaboration
ICHEP 2022, Bologna, 07/07/2022

Three kinds of Charged Cosmic Rays

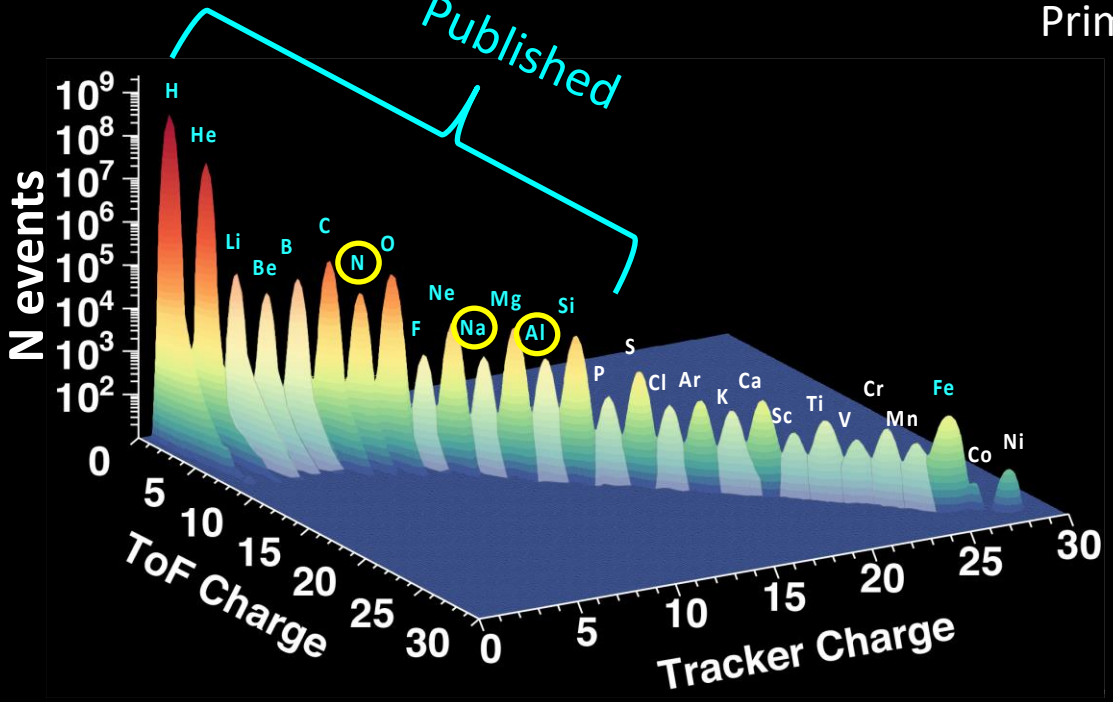


Primary cosmic rays (**Proton**, **He, C, O, Ne, Mg, Si**, ..., **Fe**) are produced during the lifetime of stars. They are accelerated in supernovae explosions

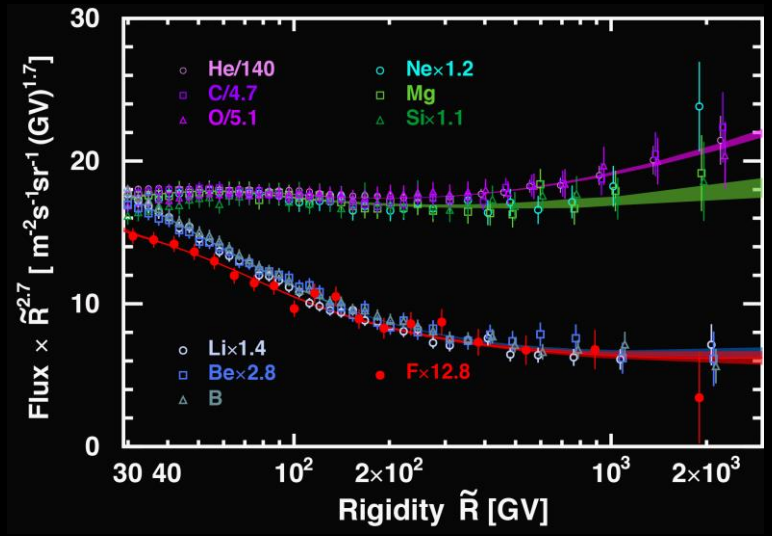
Secondary cosmic rays (Li, Be, B, F, ...) are produced by the collision of primary cosmic rays and interstellar medium

Cosmic nuclei with both primary and secondary components (N, Na, Al, ...)

Cosmic-ray nuclei measurements with AMS



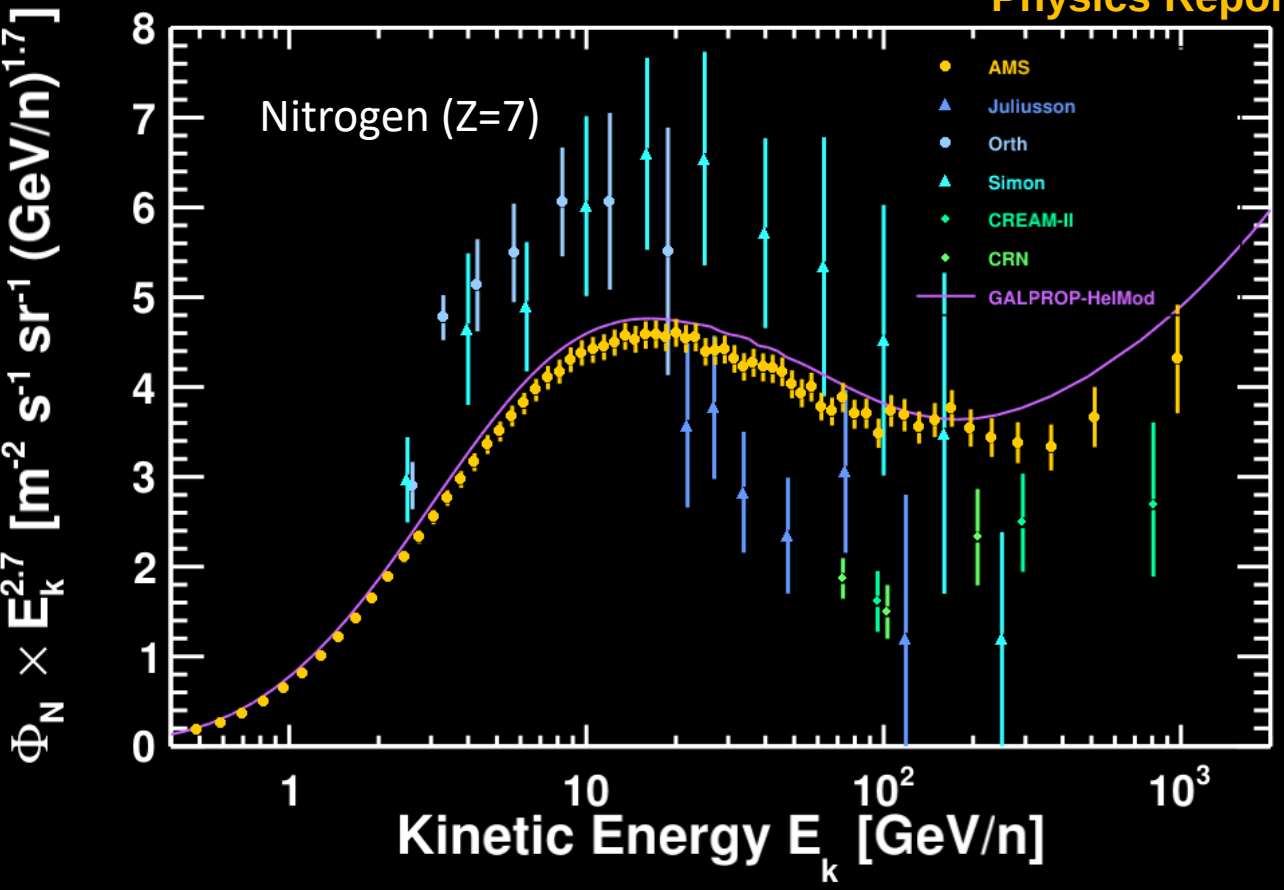
Primary and secondary cosmic-ray spectra



In this talk: Nitrogen, Sodium and Aluminum

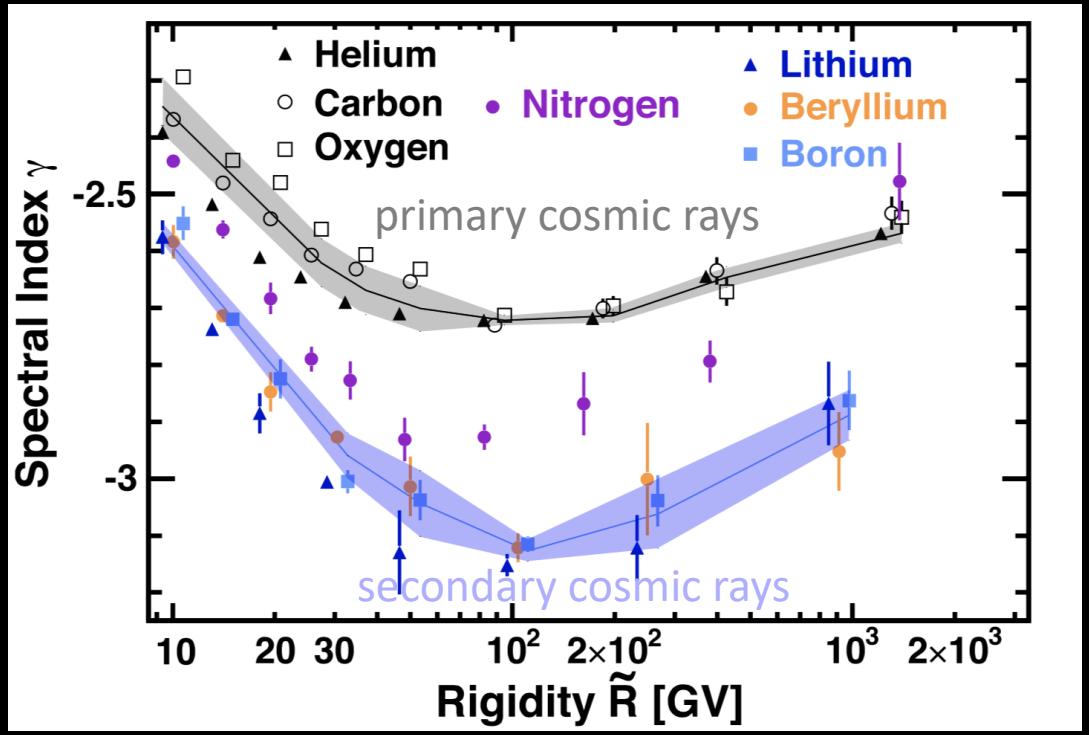
AMS Nitrogen energy spectrum together with earlier measurements and theory predictions

Phys. Rev. Lett. 121, 051103 (2018)
Physics Reports 894, 1 (2021)

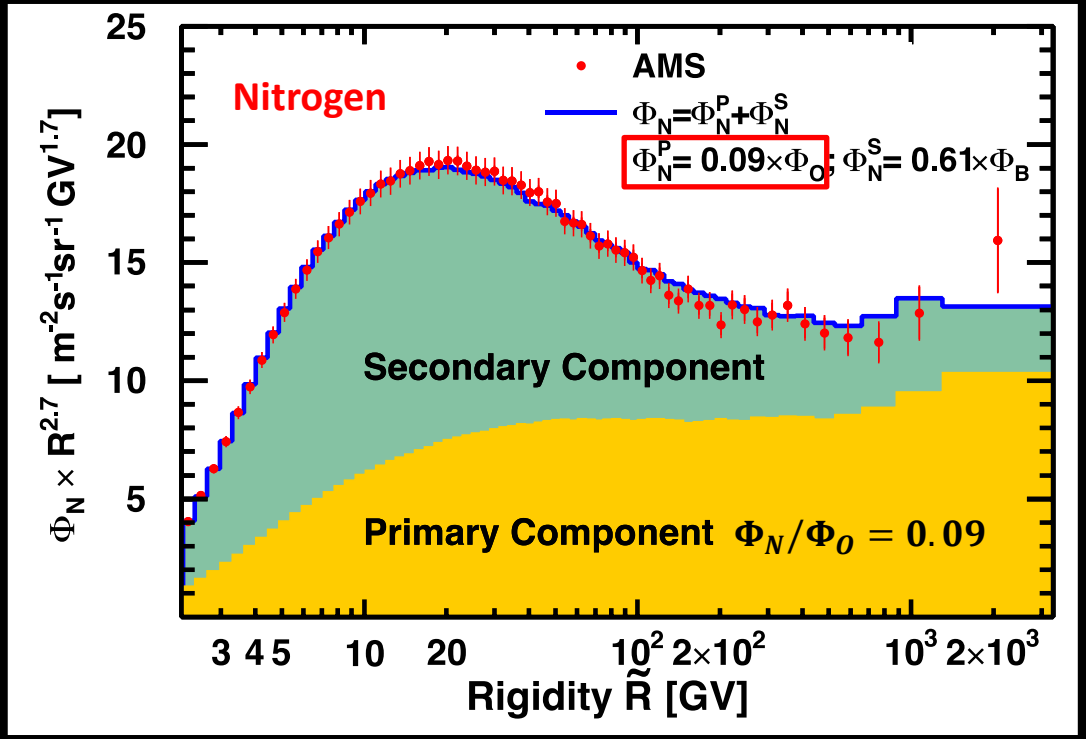


Detailed understanding of the Nitrogen energy spectrum with AMS

The Nitrogen spectral index is situated between the primary and secondary cosmic ray spectral indices

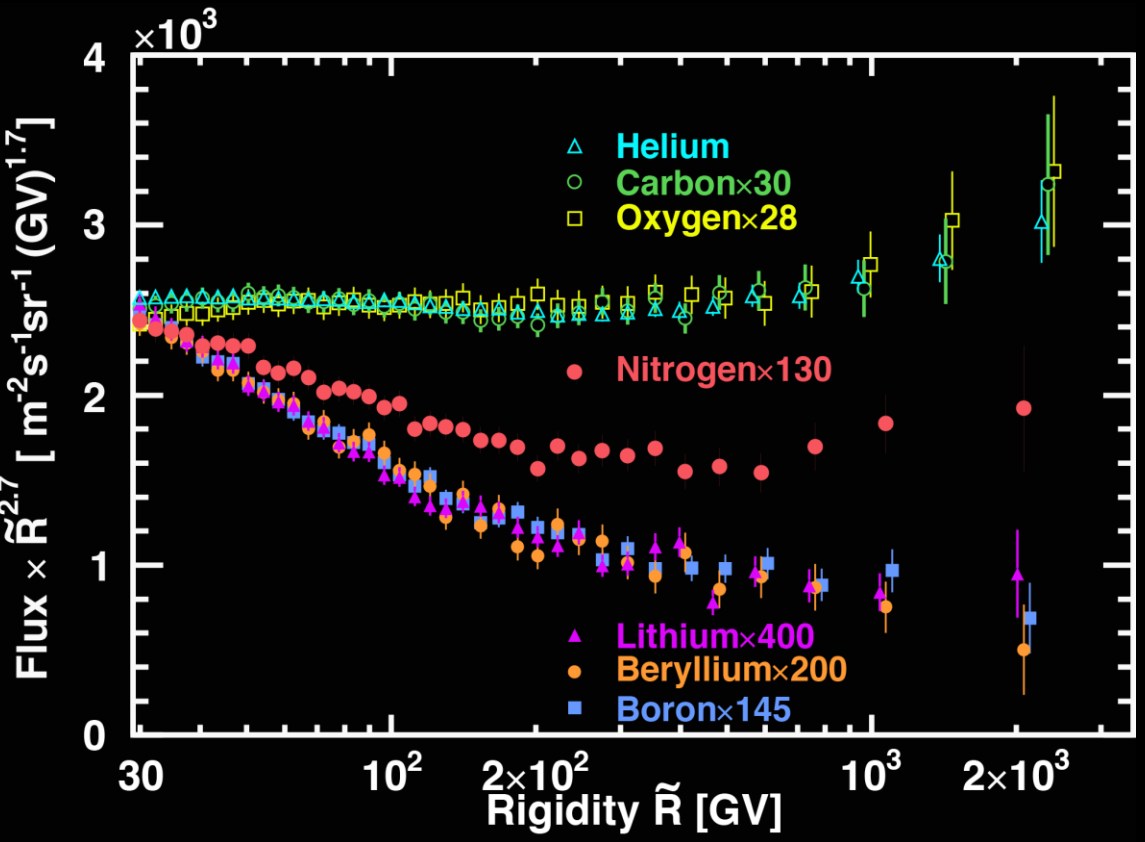


Determination of the secondary and primary fraction of the Nitrogen energy spectrum



The Nitrogen spectrum Φ_N is well described by the weighted sum of a primary component Φ_O and a secondary component Φ_B.

The third group of cosmic rays: Nitrogen



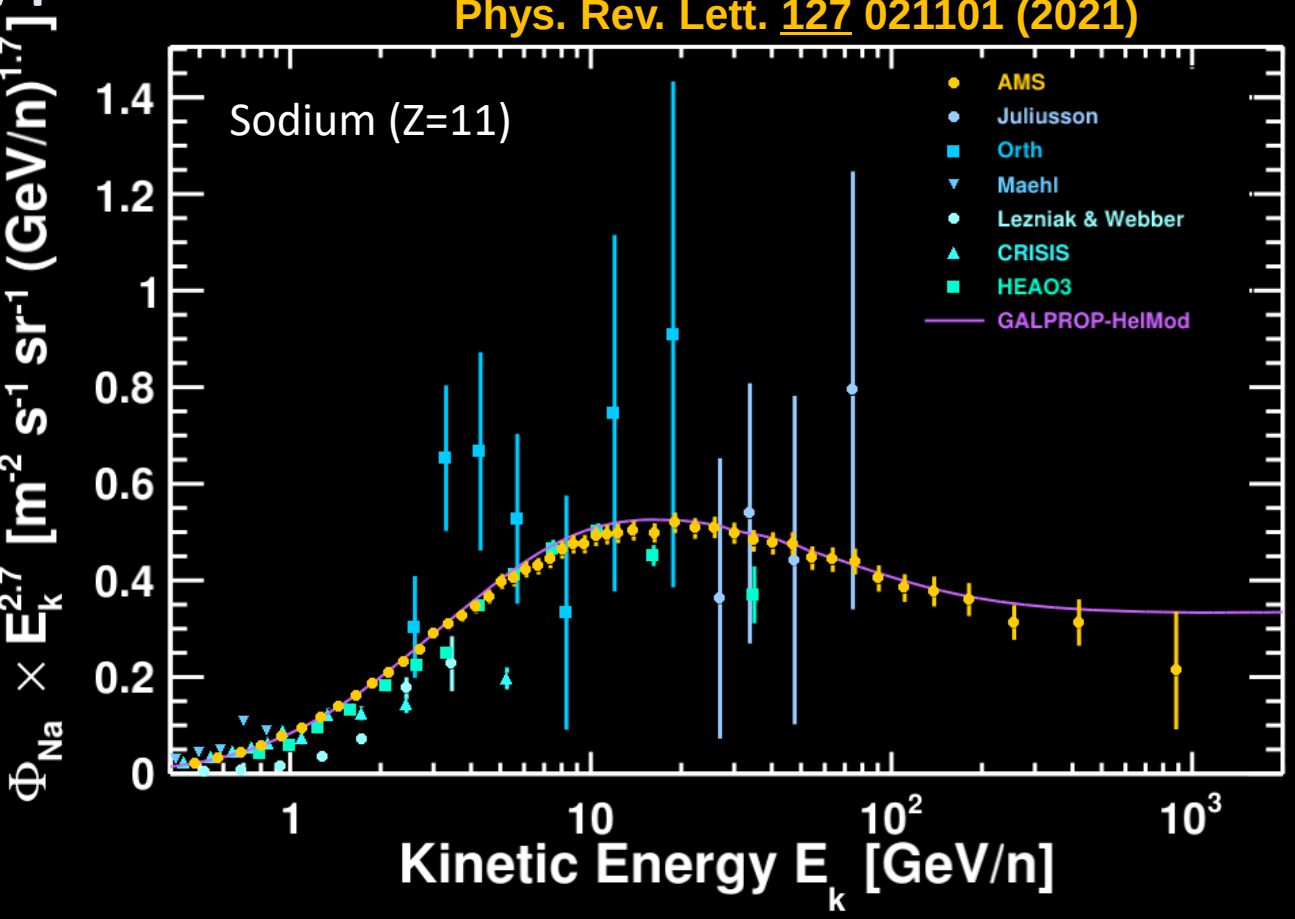
Light primary cosmic rays

Nitrogen belong to a third group of cosmic rays which is a combination of primary and secondary cosmic rays

Light secondary cosmic rays

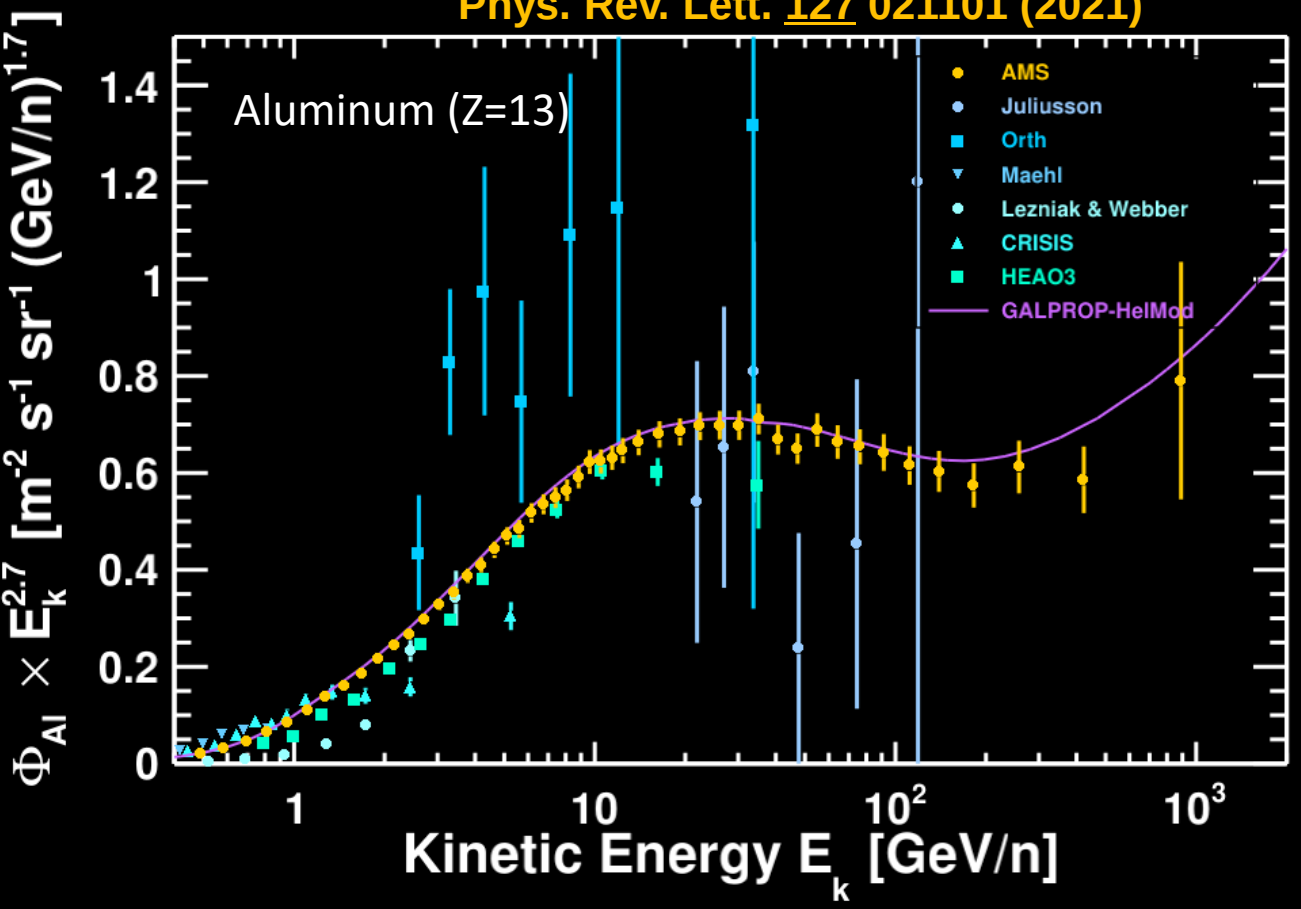
AMS Sodium energy spectrum together with earlier measurements and theory predictions

Phys. Rev. Lett. 127 021101 (2021)

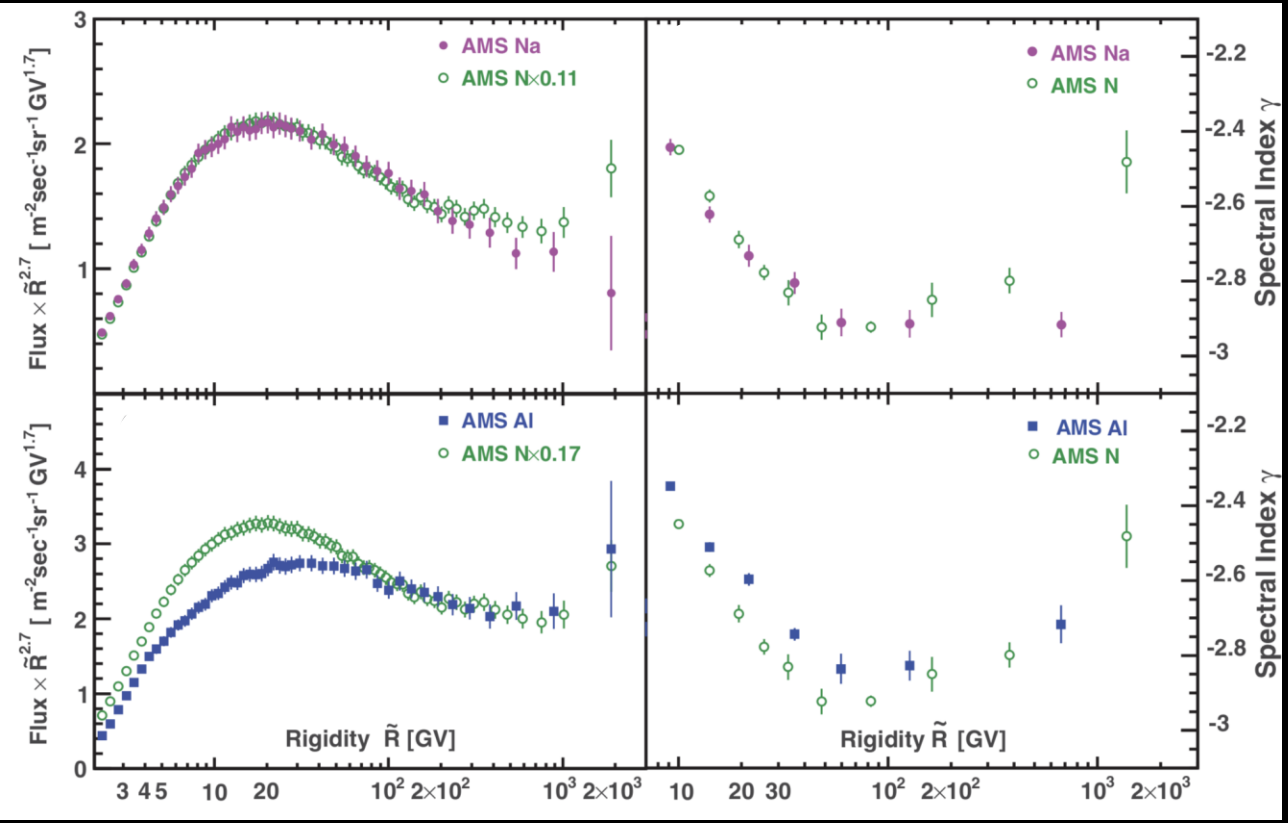


AMS Aluminum energy spectrum together with earlier measurements and theory predictions

Phys. Rev. Lett. 127 021101 (2021)



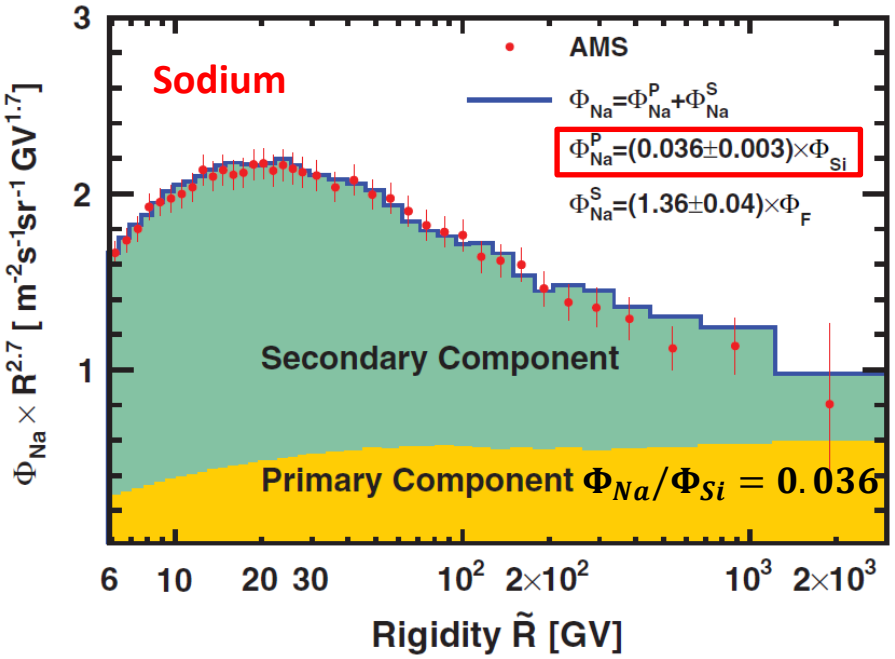
Detailed understanding of the Na and Al energy spectra with AMS

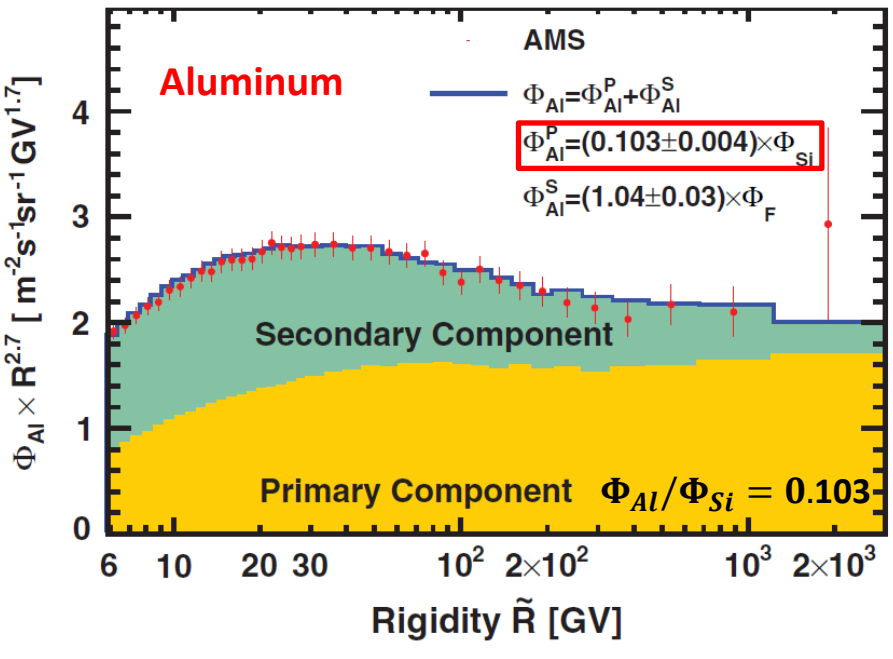


Below 100 GV, the Sodium flux and spectral index are similar to the Nitrogen flux and spectral index

Above 100 GV, the Aluminium flux and spectral index are similar to the Nitrogen flux and spectral index

Determination of the secondary and primary fraction of the Sodium and Aluminum energy spectra



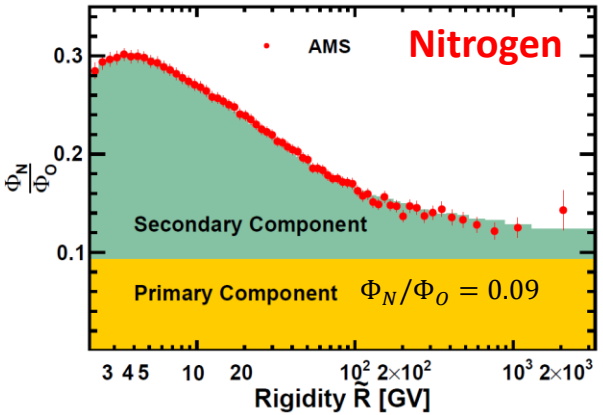


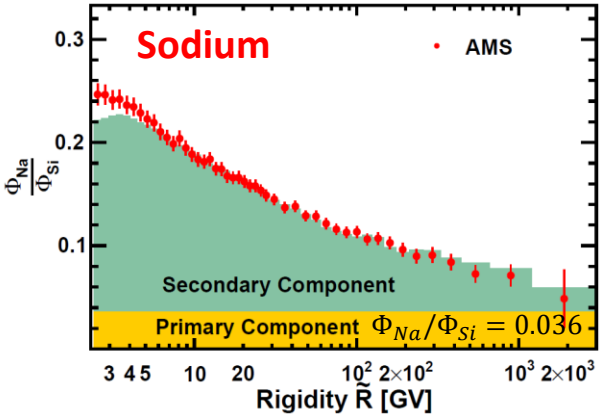
The Sodium spectrum Φ_{Na} and the Aluminum spectrum Φ_{Al} are well described by the weighted sum of a primary component Φ_{Si} and a secondary component Φ_{F}

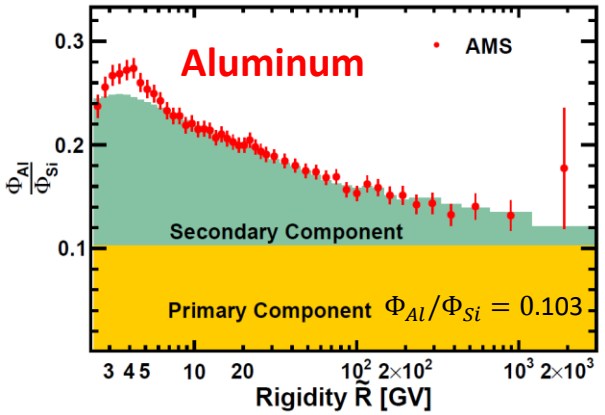
Determination of relative abundance ratios at the source

AMS observed that N , Na, and Al spectra can be fitted as simple linear combinations of primary and secondary spectra over a wide energy range.

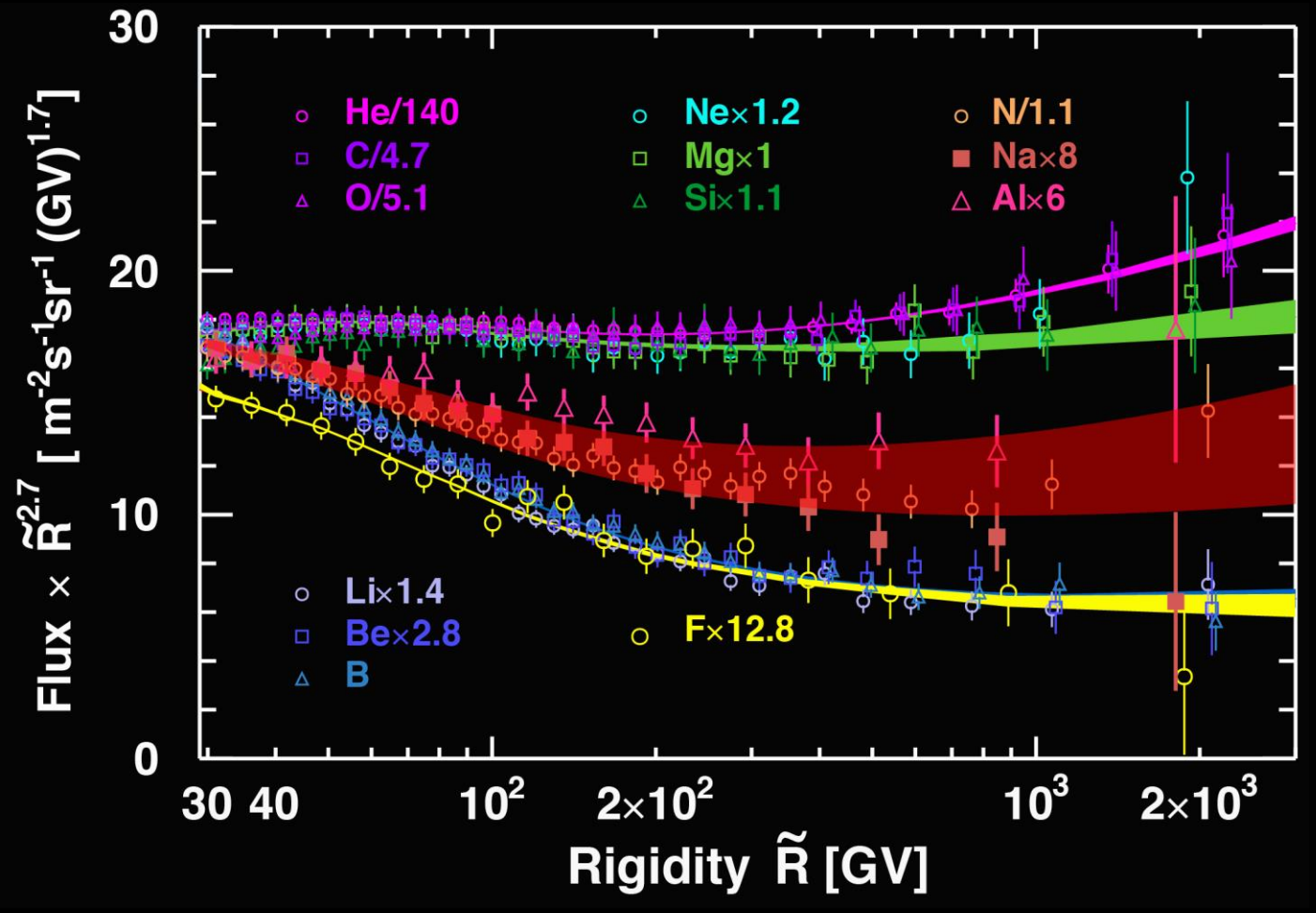
This permits the determination of the Φ_N/Φ_O, Φ_{Na}/Φ_{si} and Φ_{Al}/Φ_{Si} abundance ratios at the source without the need to consider the Galactic propagation of cosmic rays.







The Third Group of Cosmic Rays: Nitrogen, Sodium and Aluminum



The primary cosmic rays has two classes:
He-C-O and Ne-Mg-Si

N, Na and Al, belong to a distinct group, and are combinations of primary and secondary cosmic rays.

The secondary cosmic rays has also two classes:
Li-Be-B and F

Summary

The unprecedented accuracy of the AMS data is revealing unique features in cosmic-ray spectra:
N, Na and Al spectra belong to their own group of cosmic rays, distinctly different from the primary and the secondary cosmic rays.
N, Na and Al spectra are well described as linear combinations of primary and secondary spectra over a wide energy range.

AMS has accurately determined the fraction of the primary and secondary components of N, Na and Al. The abundance ratios at the source, Φ_N/Φ_O=0.092$\pm$0.002 , Φ_{Na}/Φ_{Si} =0.036$\pm$0.003 and Φ_{Al}/Φ_{Si} = 0.103$\pm$0.004 are determined without the need to consider the Galactic propagation of cosmic rays.