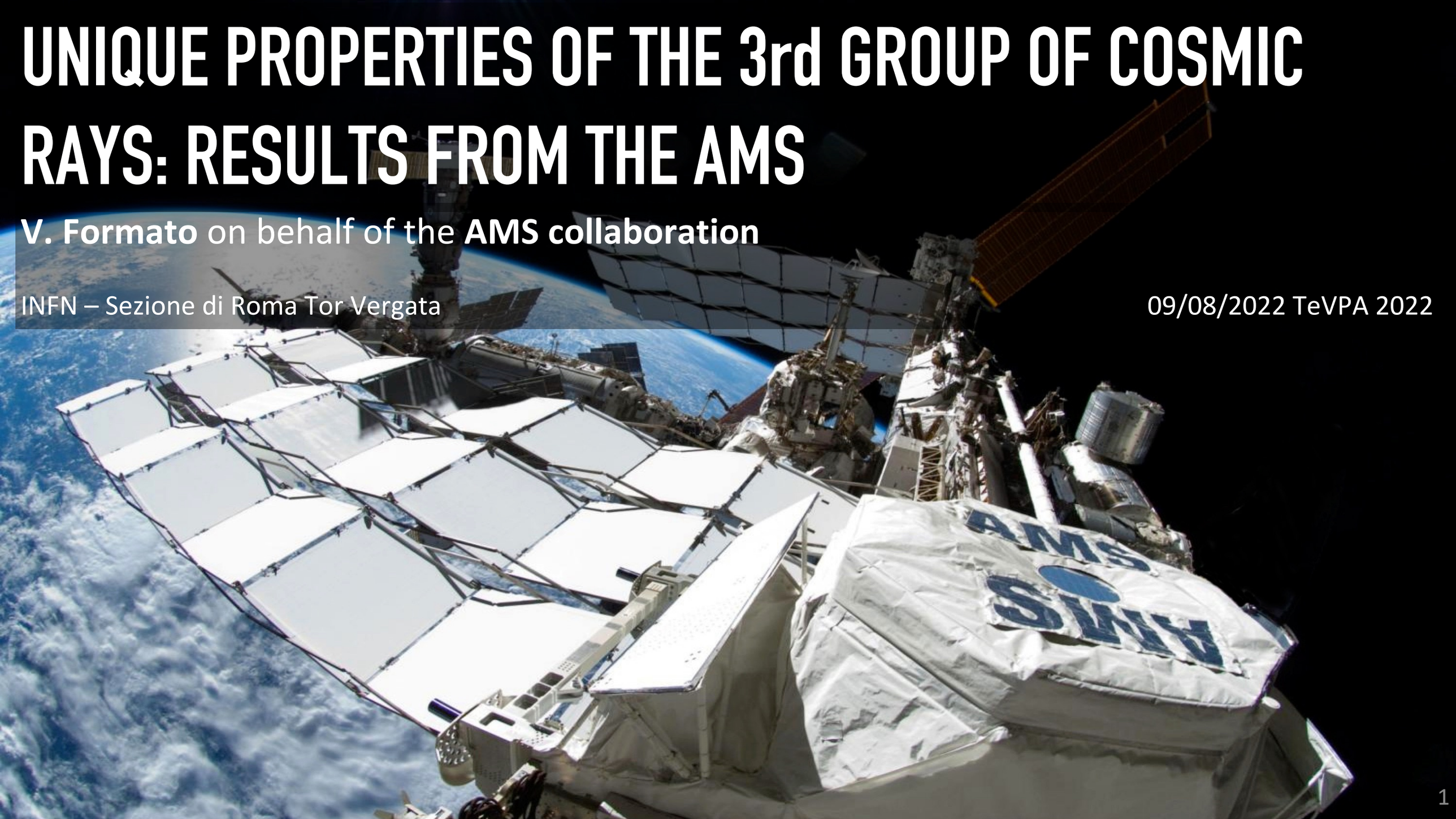
UNIQUE PROPERTIES OF THE 3rd GROUP OF COSMIC RAYS: RESULTS FROM THE AMS

V. Formato on behalf of the **AMS collaboration**

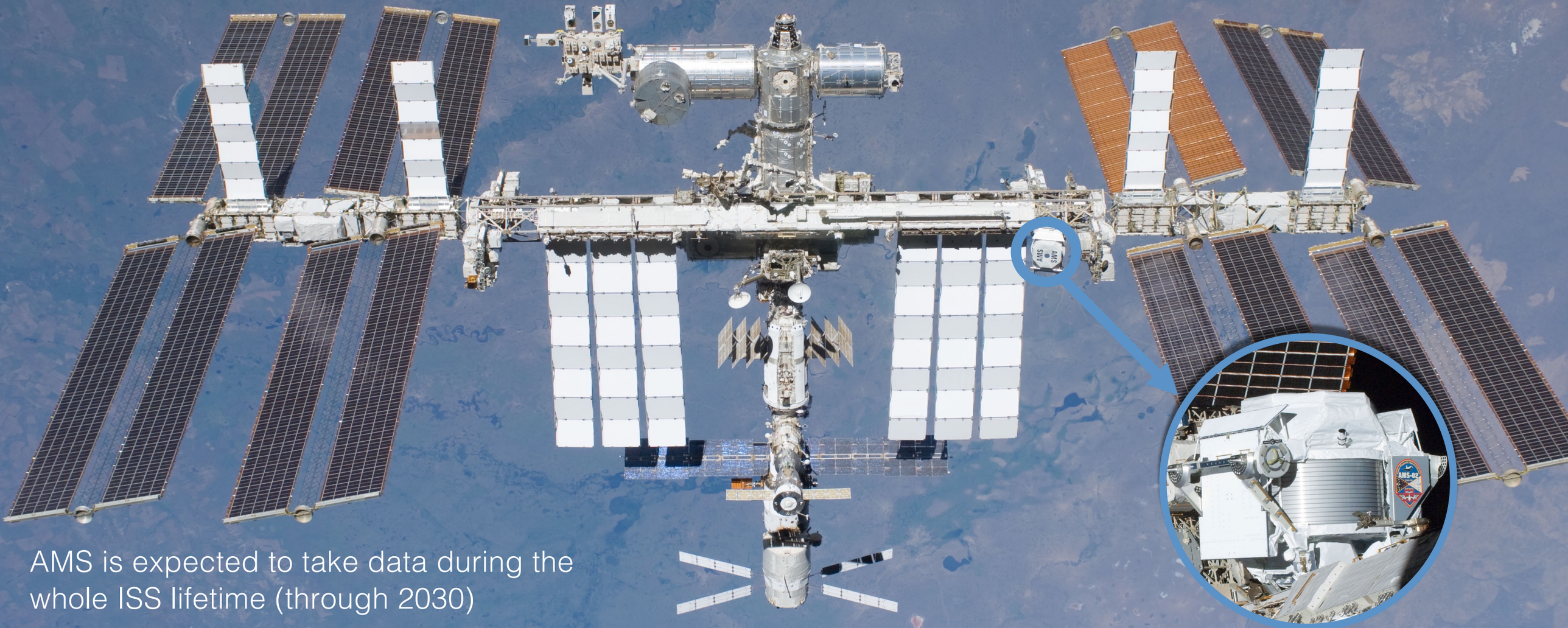
INFN – Sezione di Roma Tor Vergata

09/08/2022 TeVPA 2022



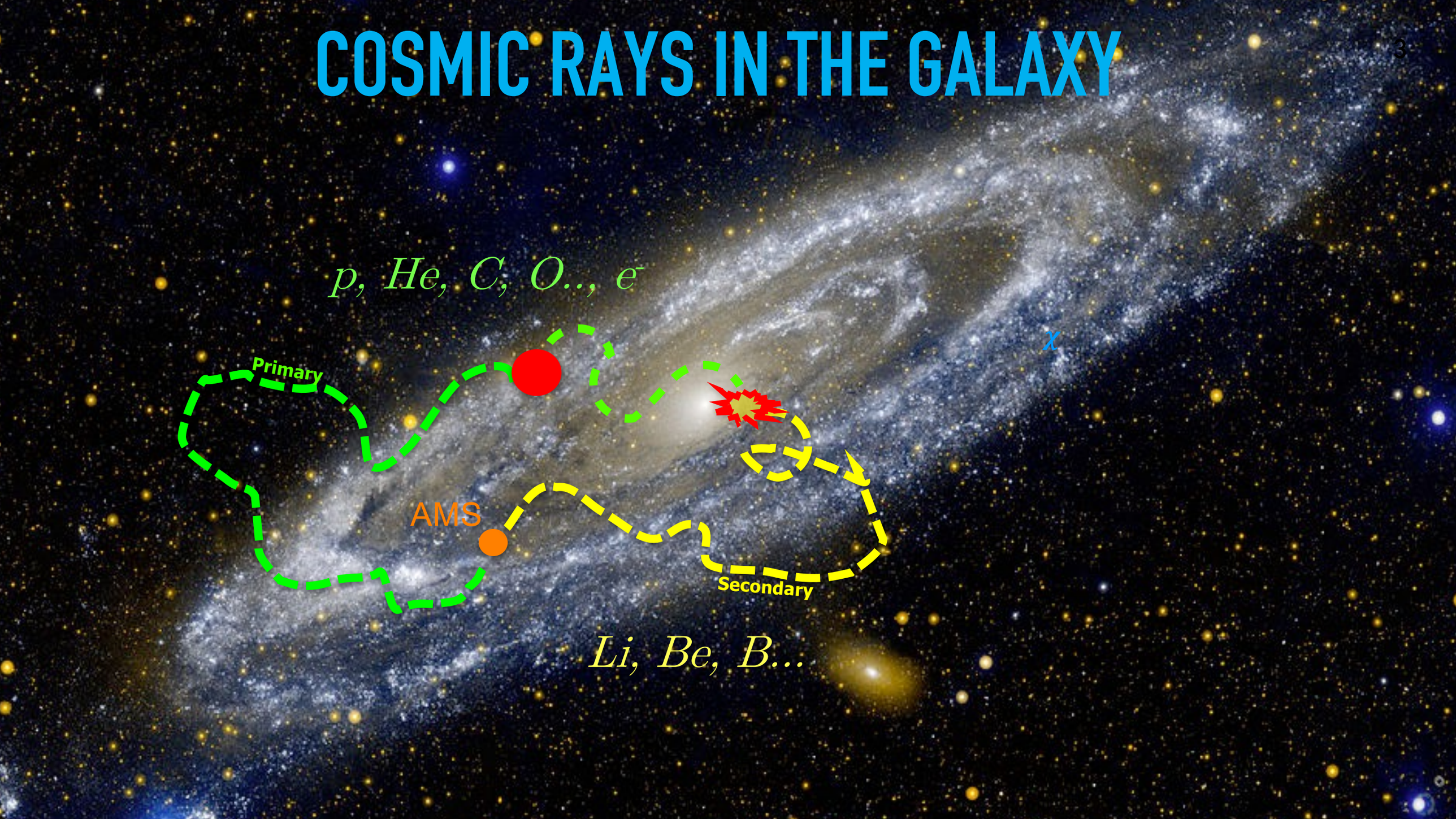
AMS-02 IN ORBIT

AMS-02 is a large-acceptance high-energy **magnetic spectrometer** capable of measure accurately particles in the **GeV-TeV** energy range.Since **2011** May 19th AMS-02 has been operating on the International Space Station (ISS). AMS recorded **>200 billion CR triggers** in ~11 years of operation.

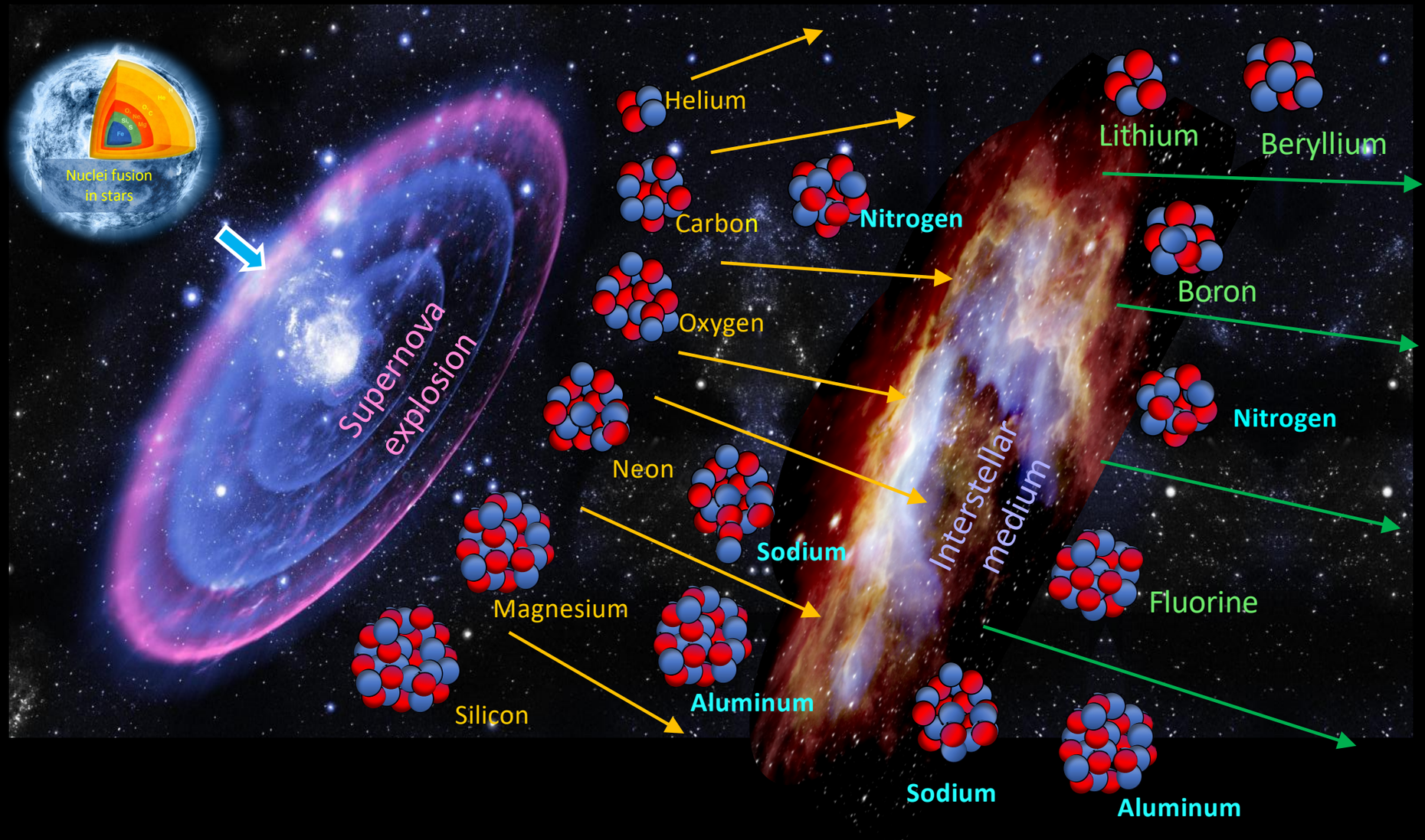


AMS is expected to take data during the whole ISS lifetime (through 2030)

COSMIC RAYS IN THE GALAXY



The third Group of Cosmic Rays: Nitrogen, Sodium and Aluminum nuclei

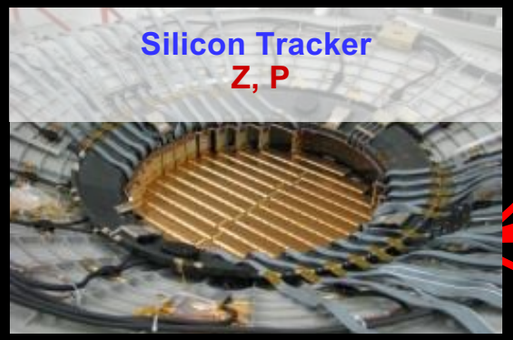


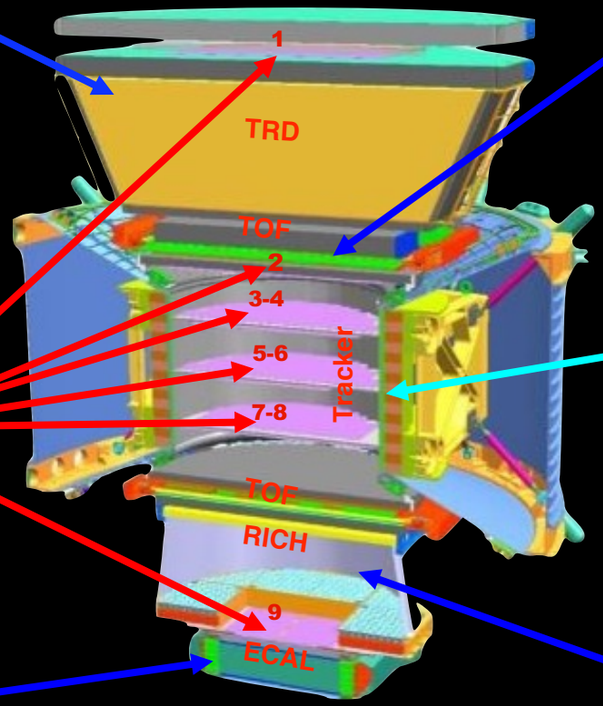
Nitrogen, Sodium and Aluminum nuclei are produced both in stars and by collisions of primary cosmic rays with the interstellar medium.

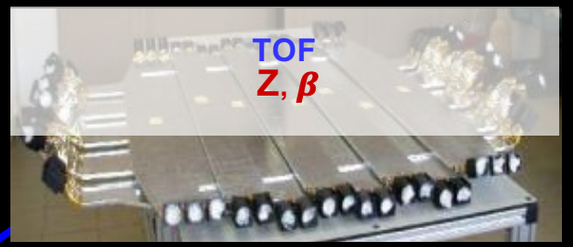
AMS-02

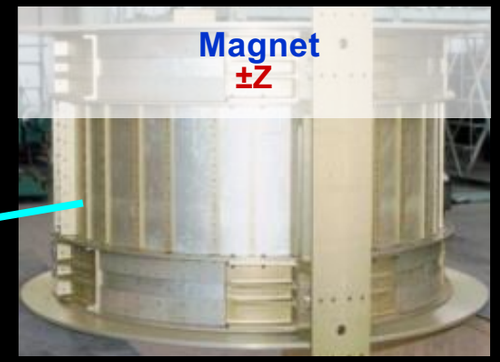
Particles and nuclei are defined by their charge (**Z**) and energy (**E ~ P**)

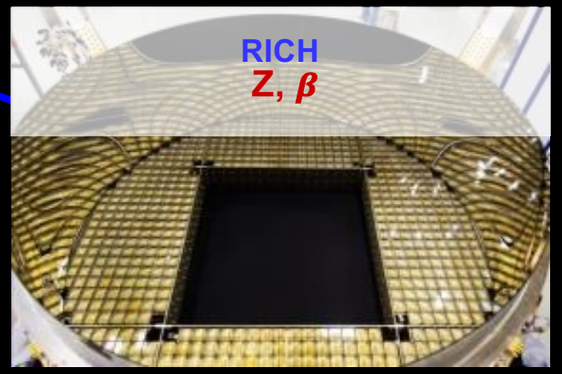
Both quantities are measured redundantly and independently by the *Tracker, TOF, RICH* and/or *ECAL*



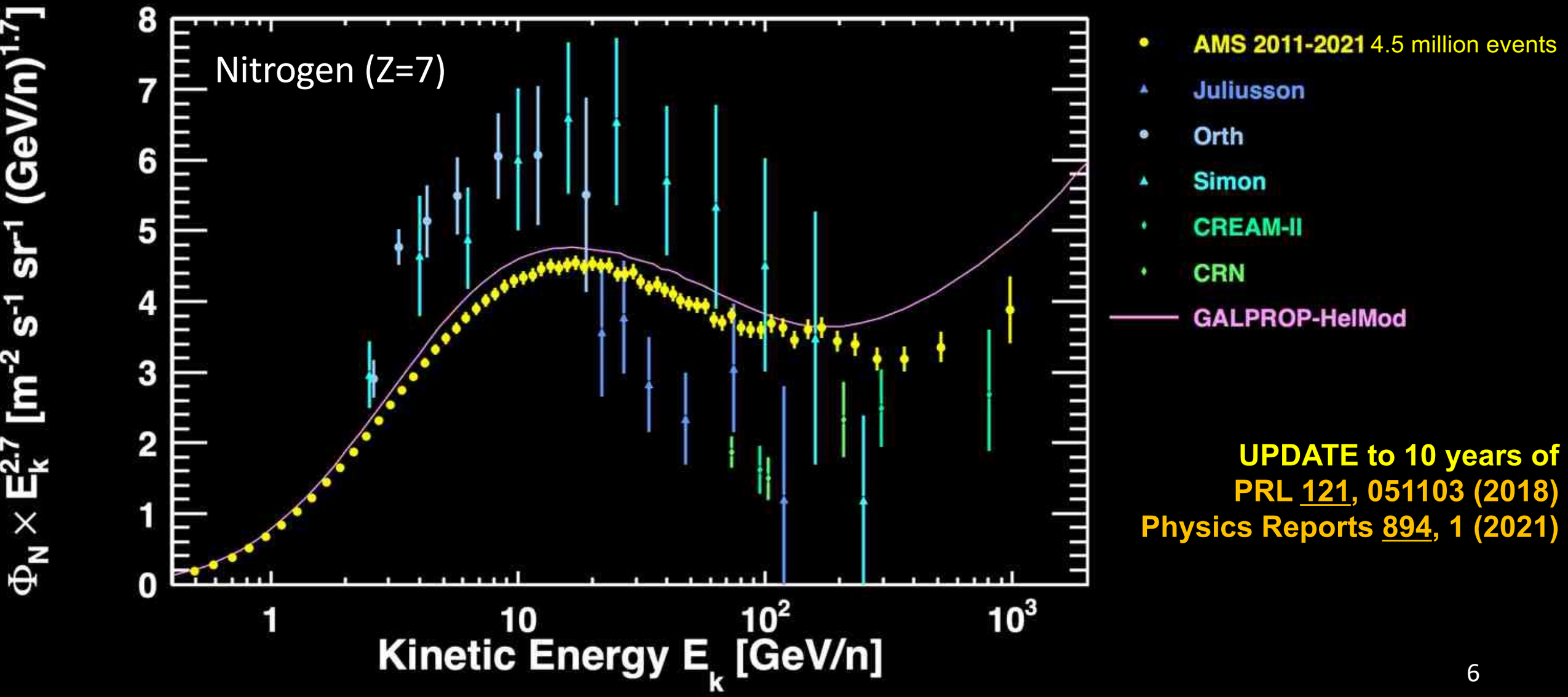








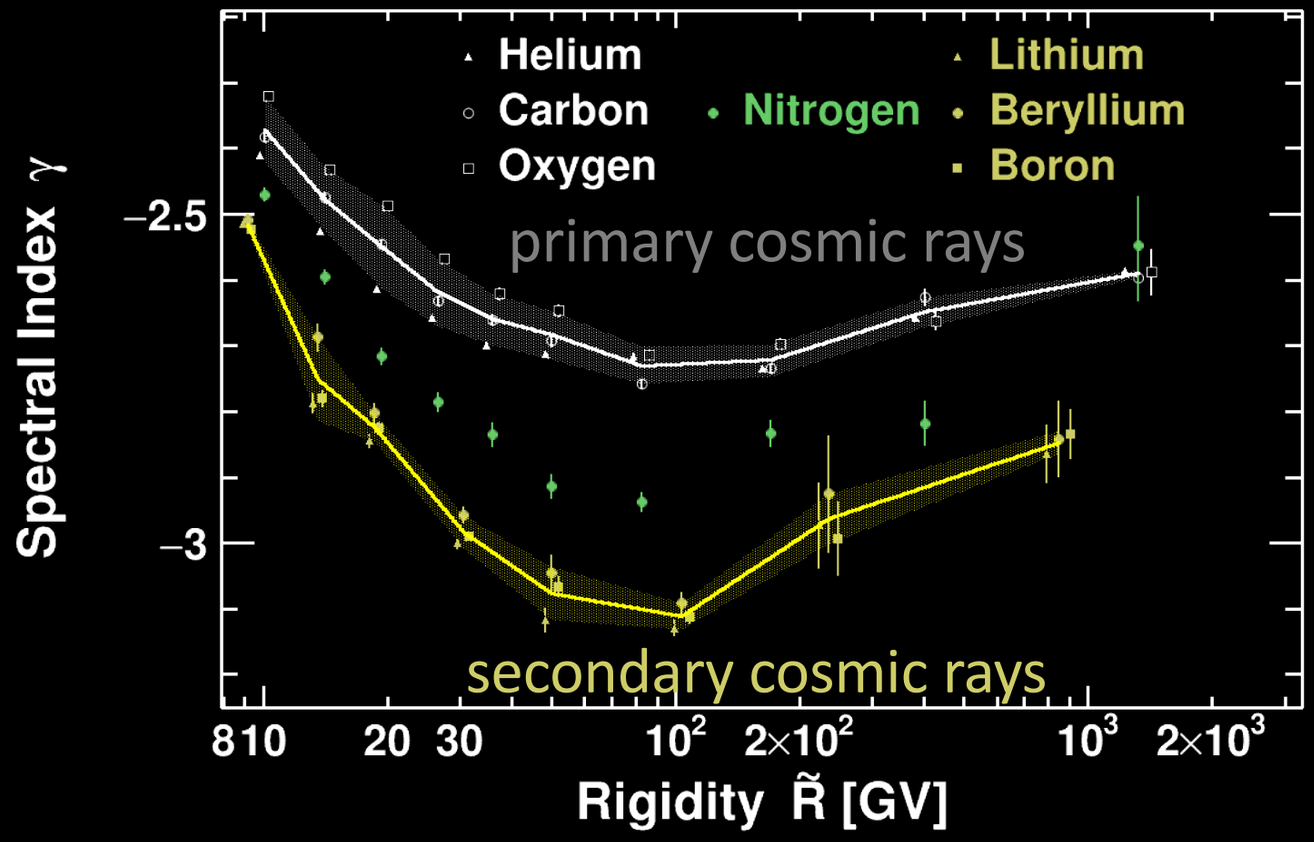
AMS Nitrogen Spectrum



UPDATE to 10 years of
PRL 121, 051103 (2018)
Physics Reports 894, 1 (2021)

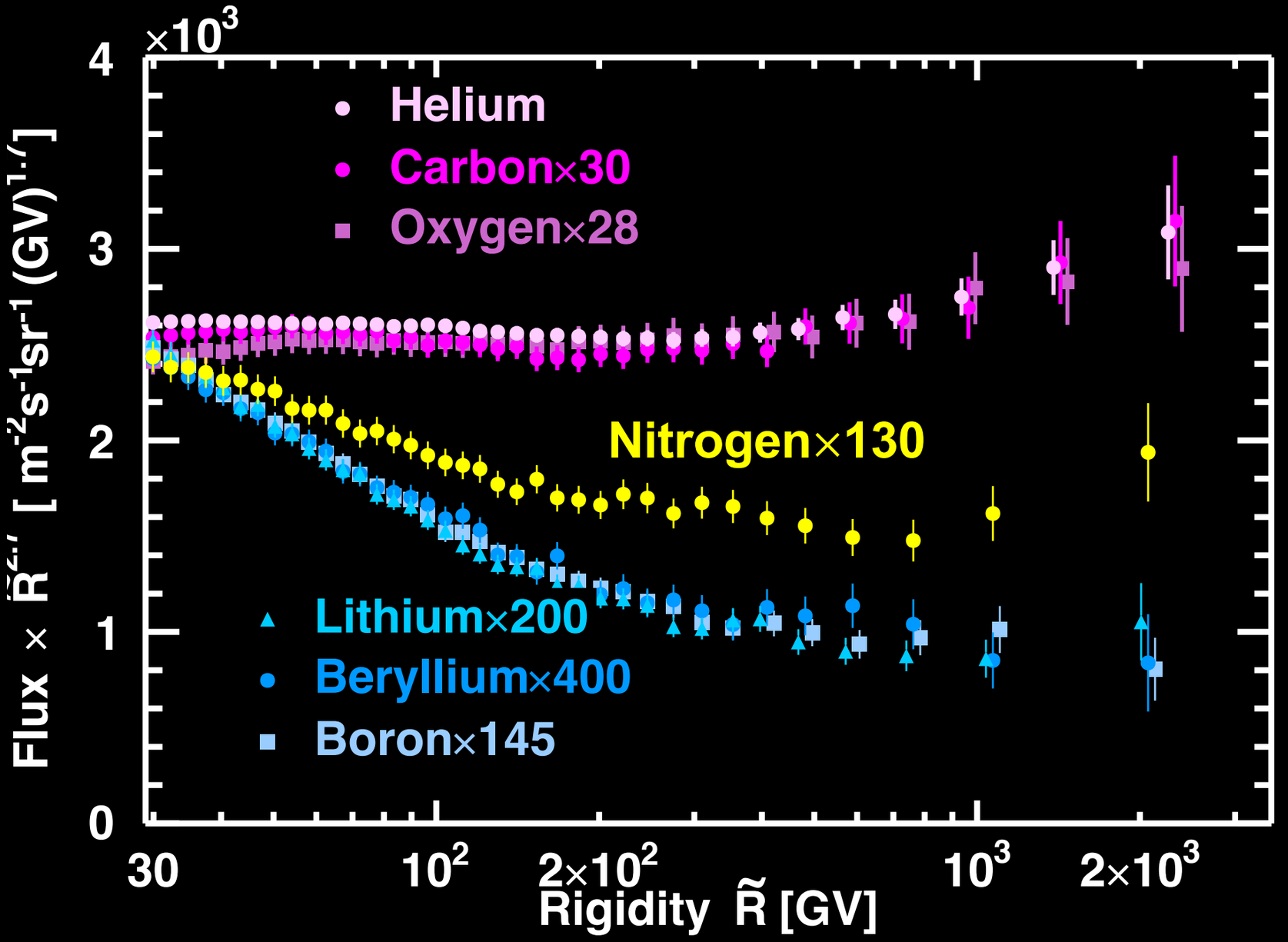
Detailed characterization of the Nitrogen energy spectrum with AMS

Nitrogen spectrum: $\Phi_N(R) \propto R^{\gamma}$ with spectral index $\gamma(R)$ which depends on rigidity R



The Nitrogen spectral index is situated between the spectral indices of primary and secondary cosmic rays.

The third group of cosmic rays: Nitrogen

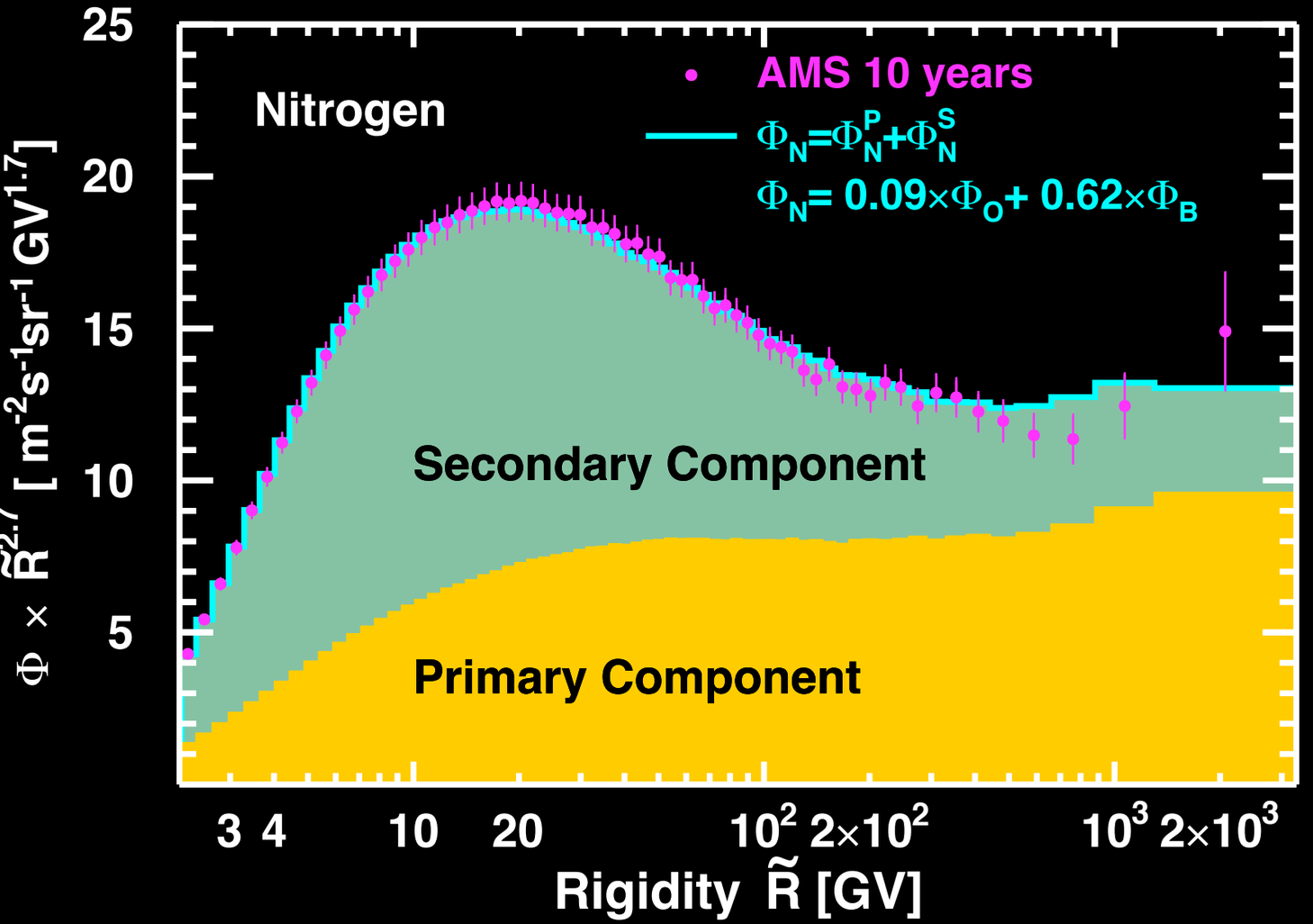


The class of light primary cosmic rays

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

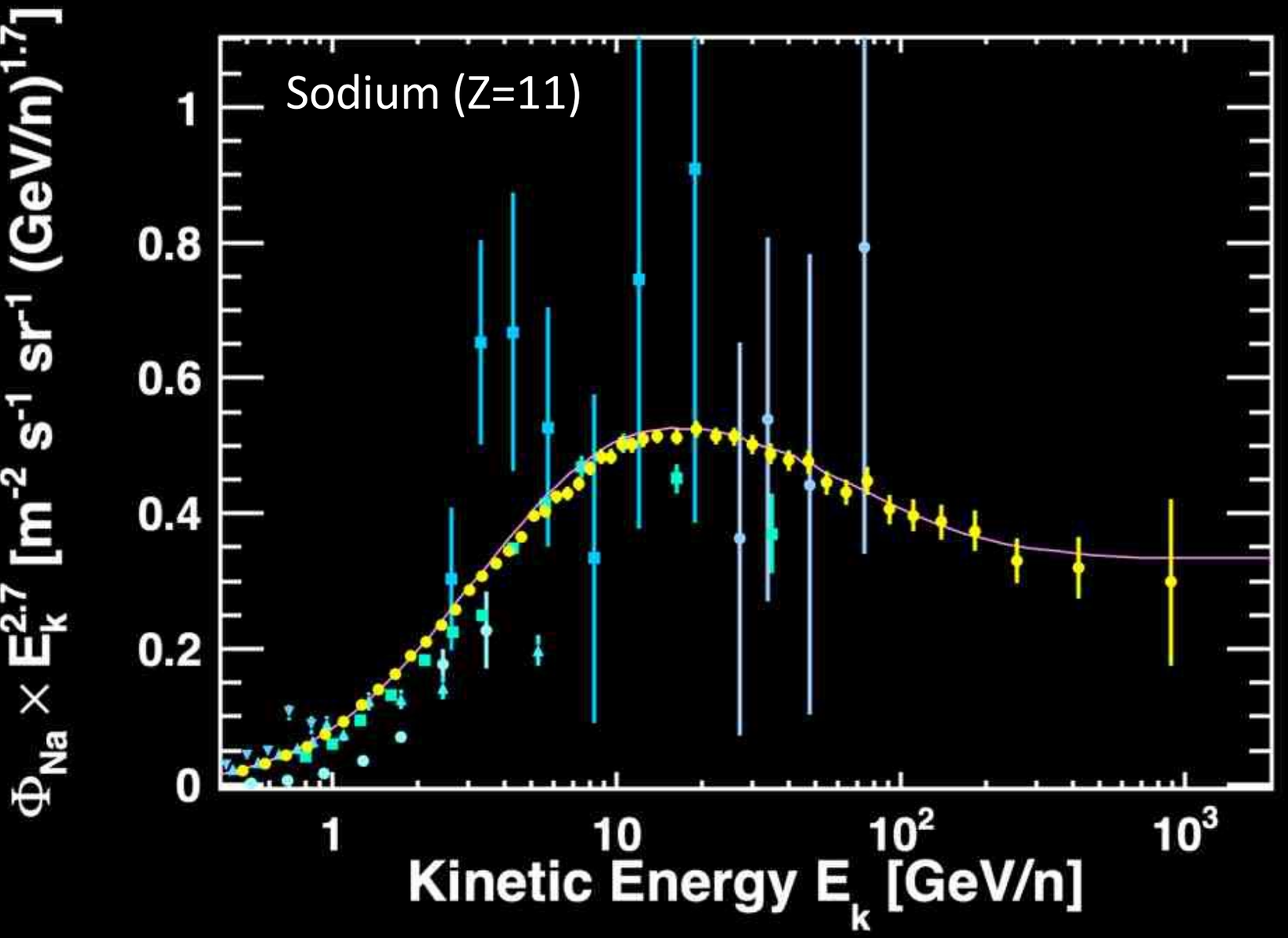
The class of light secondary cosmic rays

AMS has accurately determined the secondary and primary fraction of the Nitrogen energy spectrum as function of energy



The Nitrogen spectrum Φ_N is well described by the weighted sum of a primary component $\boldsymbol{\Phi_N^P \propto \Phi_O}$ and a secondary component $\boldsymbol{\Phi_N^S \propto \Phi_B}$

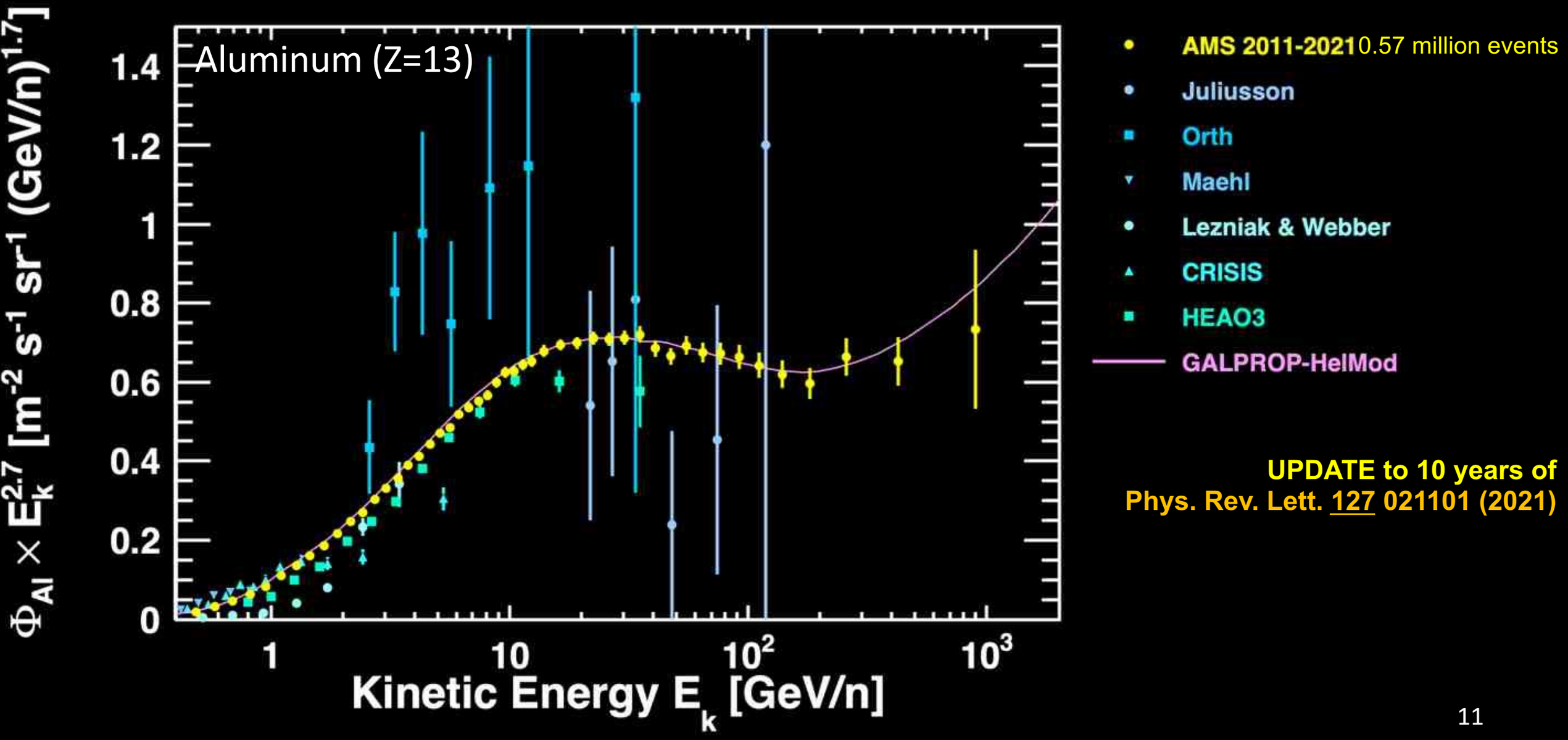
AMS Sodium Spectrum



- AMS 2011-2021 0.52 million events
- Juliusson
- Orth
- Maehl
- Lezniak & Webber
- CRISIS
- HEAO3
- GALPROP-HelMod

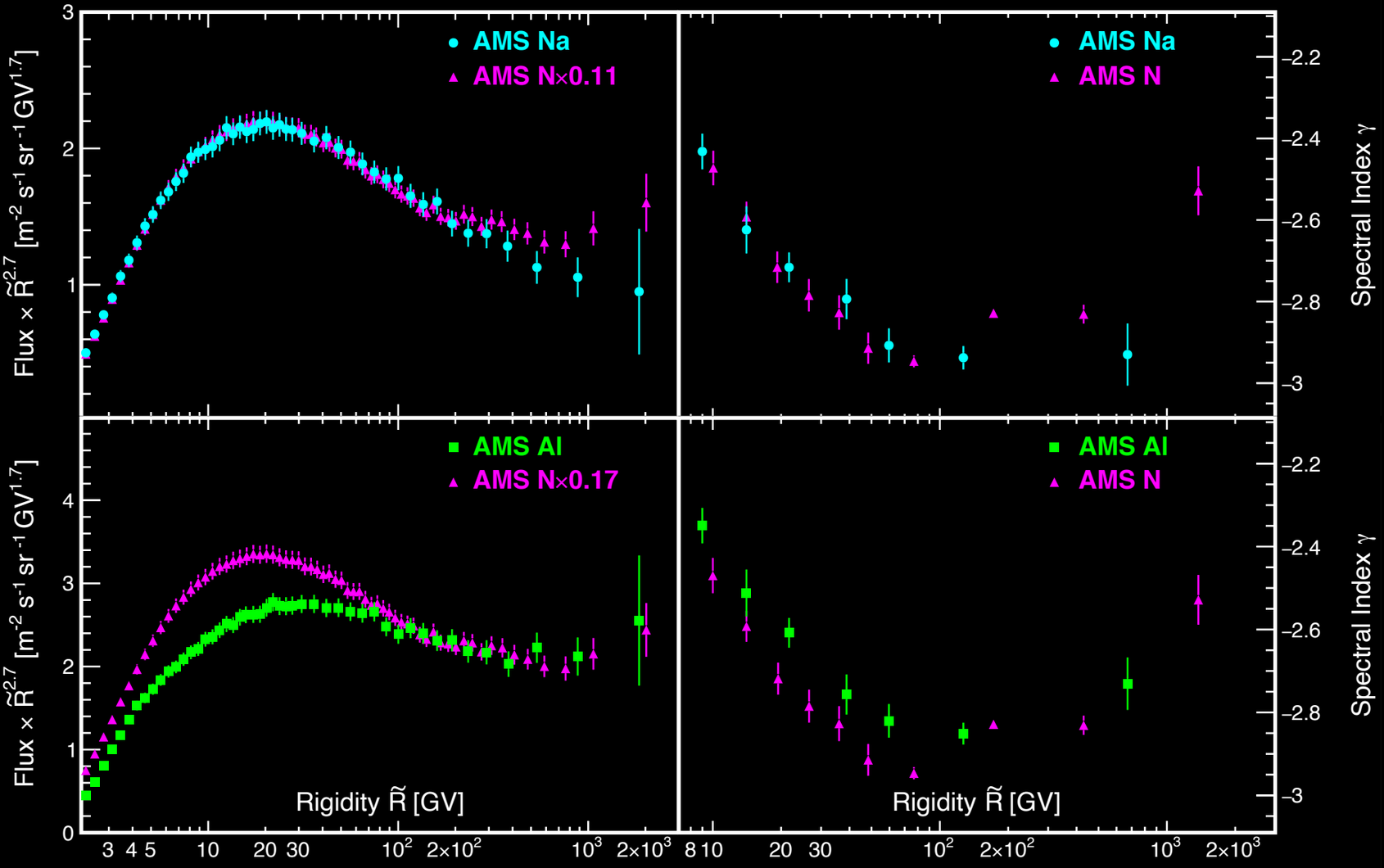
UPDATE to 10 years of Phys. Rev. Lett. 127 021101 (2021)

AMS Aluminum Spectrum



UPDATE to 10 years of
Phys. Rev. Lett. 127 021101 (2021)

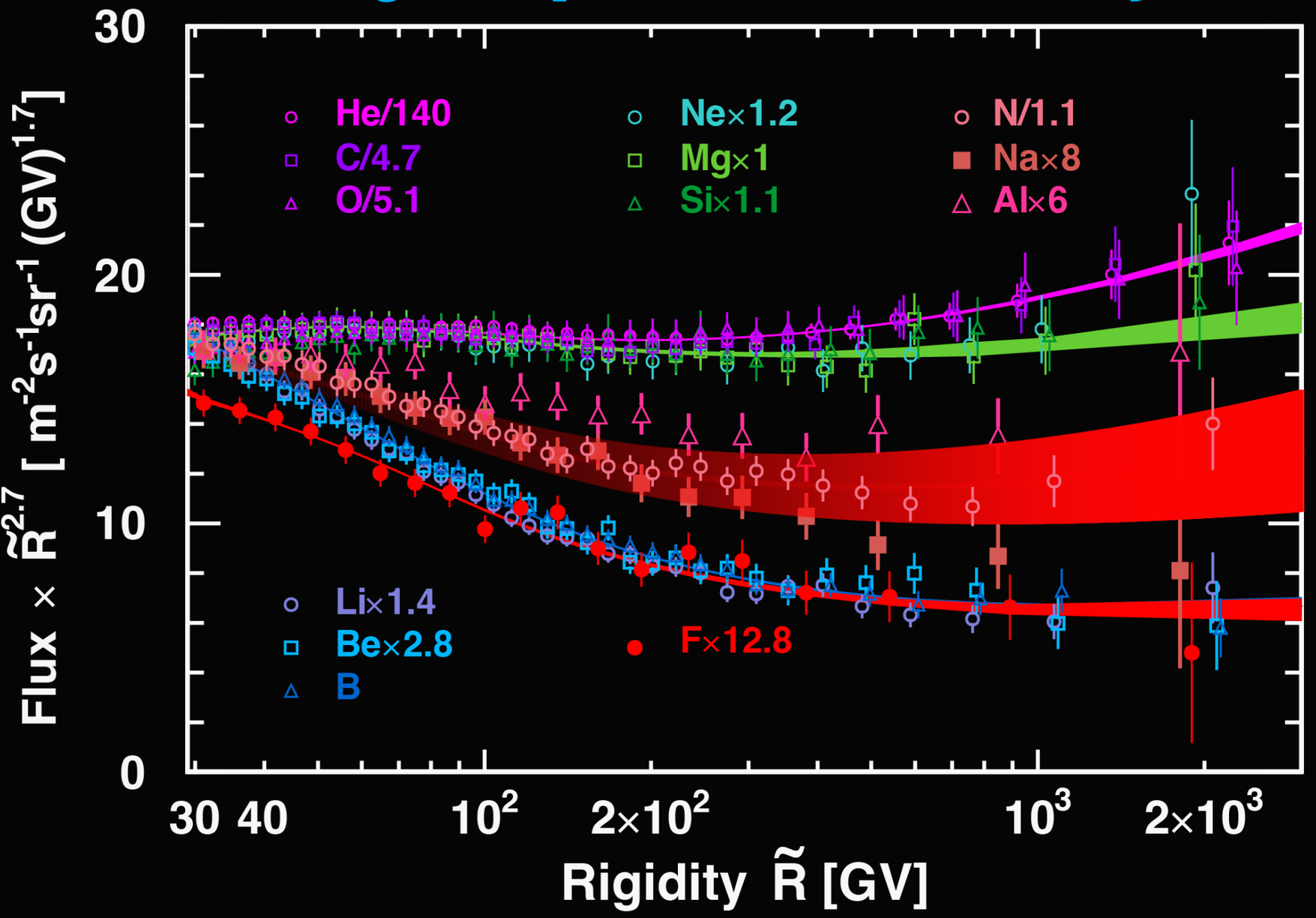
Detailed characterization of the Na and Al energy spectra with AMS



Below 100 GV, the Sodium flux and spectral index follow the Nitrogen flux and spectral index

Above 100 GV, the Aluminum flux and spectral index follow the Nitrogen flux and spectral index

The third group of cosmic rays

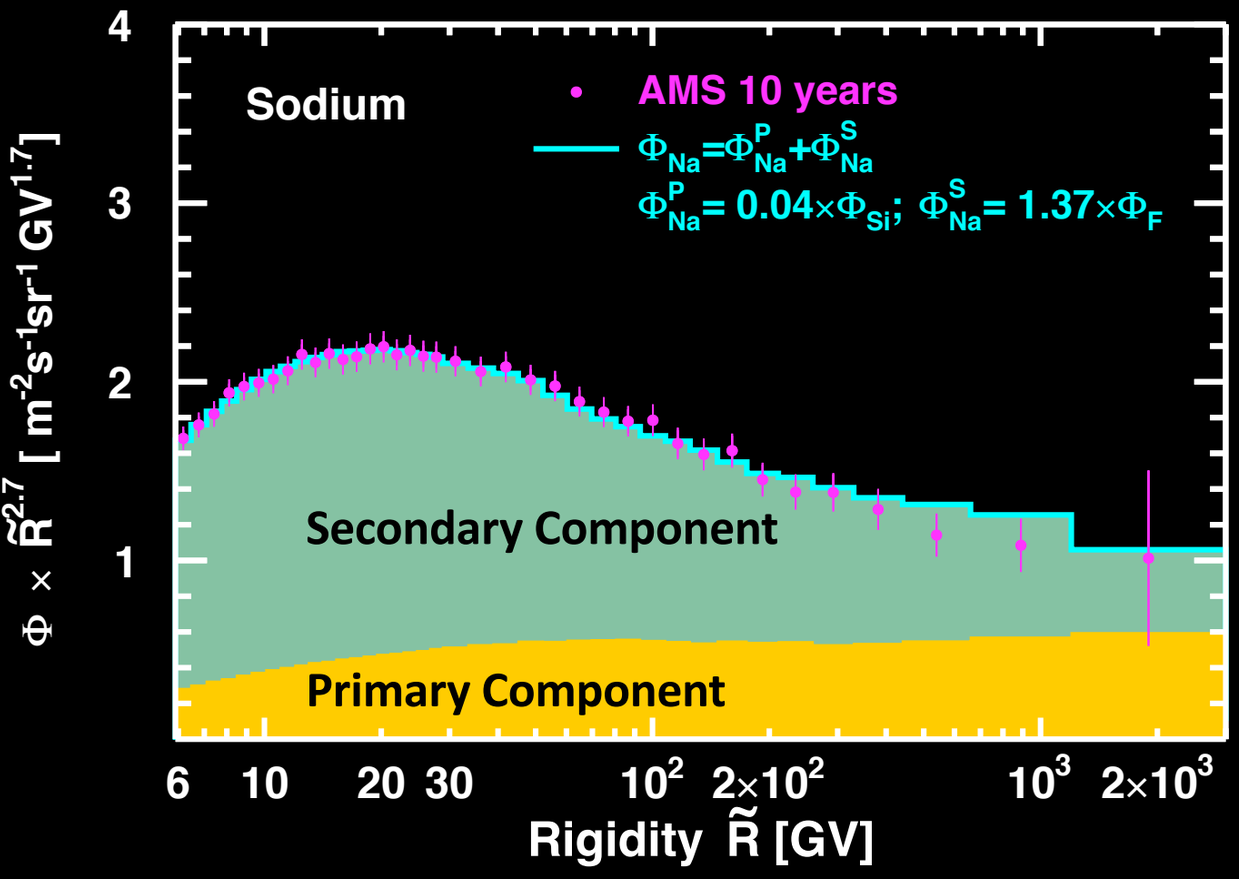


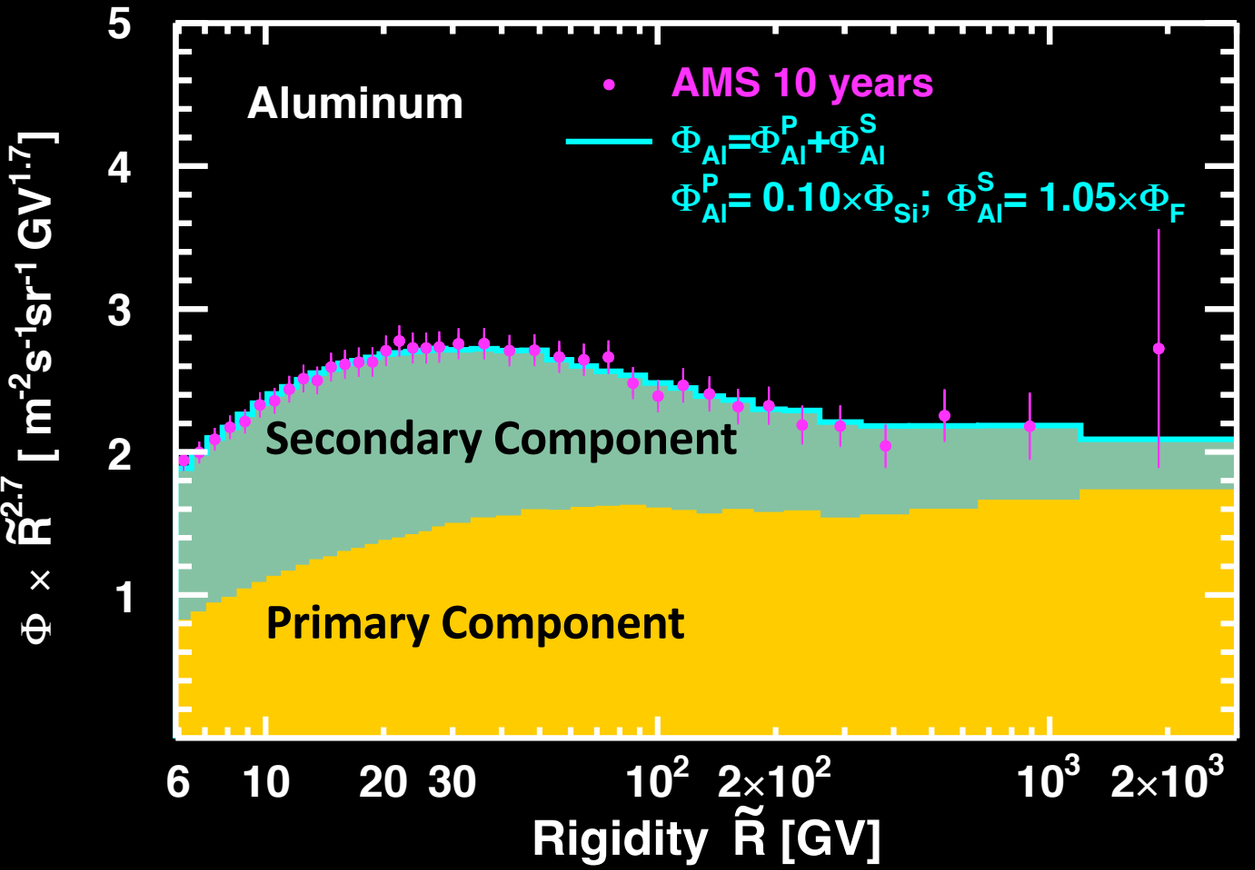
The group of primary cosmic rays has two classes: He-C-O and Ne-Mg-Si

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

The group of secondary cosmic rays has also two classes: Li-Be-B and Fluorine

AMS has accurately determined the secondary and primary fraction of the Sodium and Aluminum energy spectra as function of energy



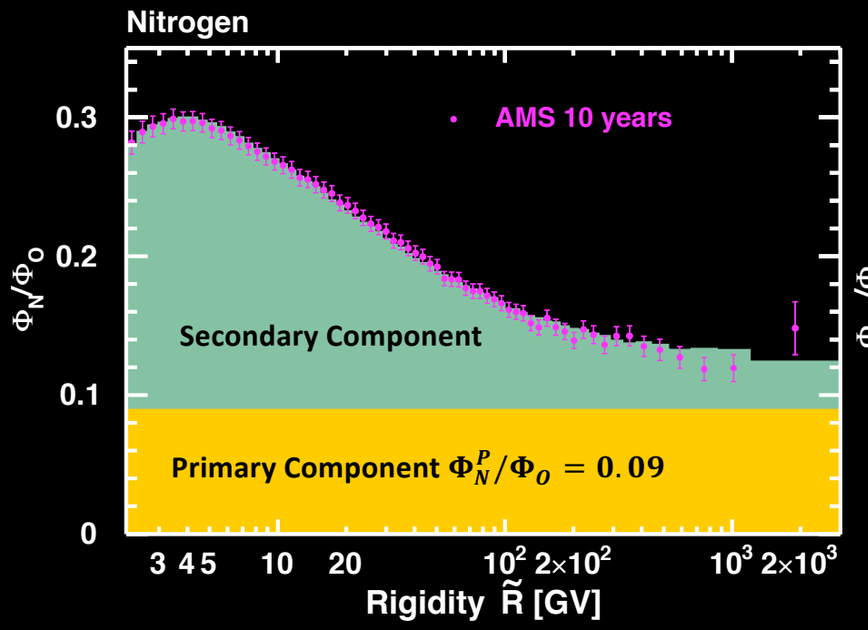


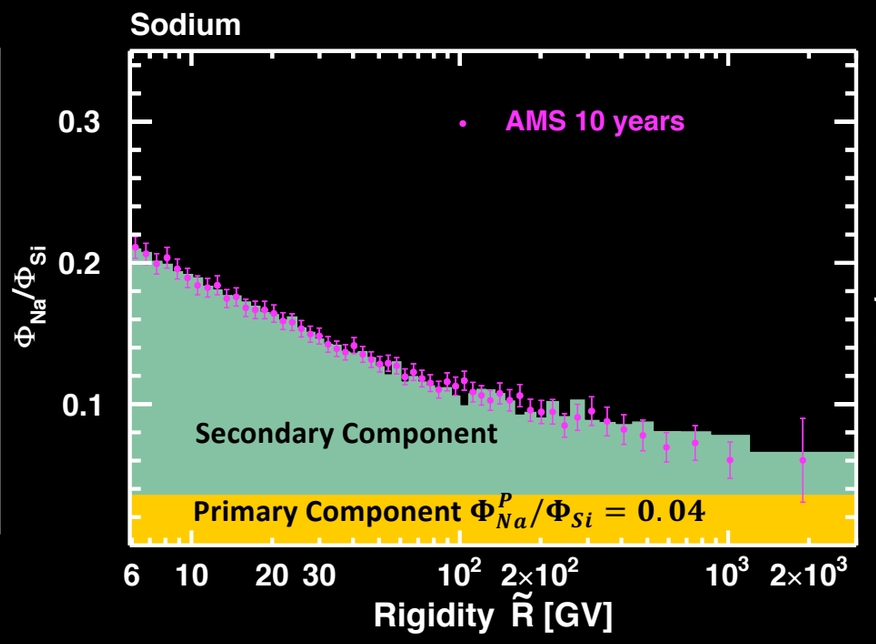
The Sodium spectrum Φ_{Na} and the Aluminum spectrum Φ_{Al} are well described by the weighted sum of a primary component $\boldsymbol{\Phi^{P}_{X} \propto \Phi_{Si}}$ and a secondary component $\boldsymbol{\Phi^{S}_{X} \propto \Phi_{F}}$

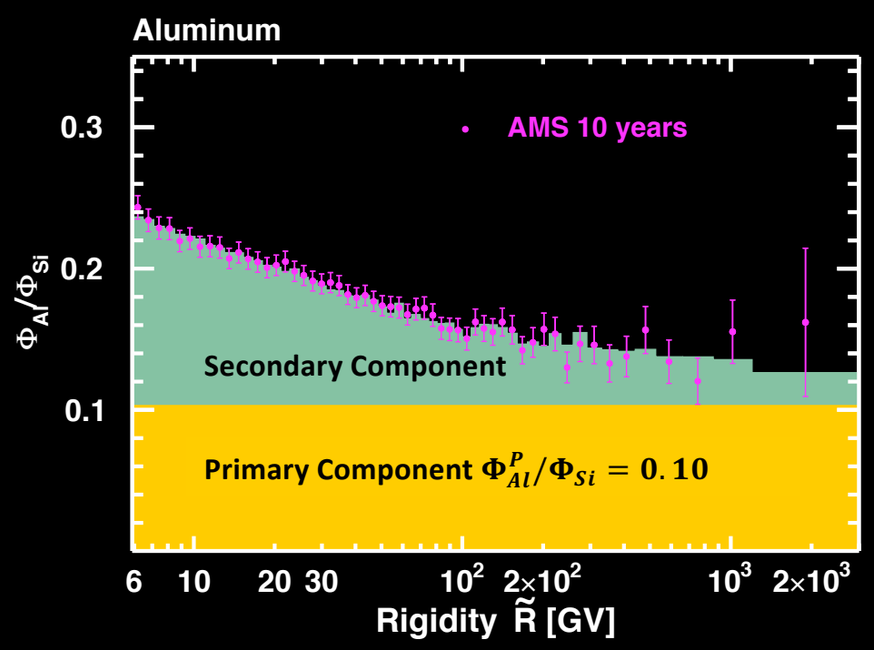
Determination of relative abundance ratios at the source

The observation that N , Na, and Al spectra can be fit over wide a rigidity range as simple linear combinations of primary and secondary spectra over a wide energy range is an unexpected result.

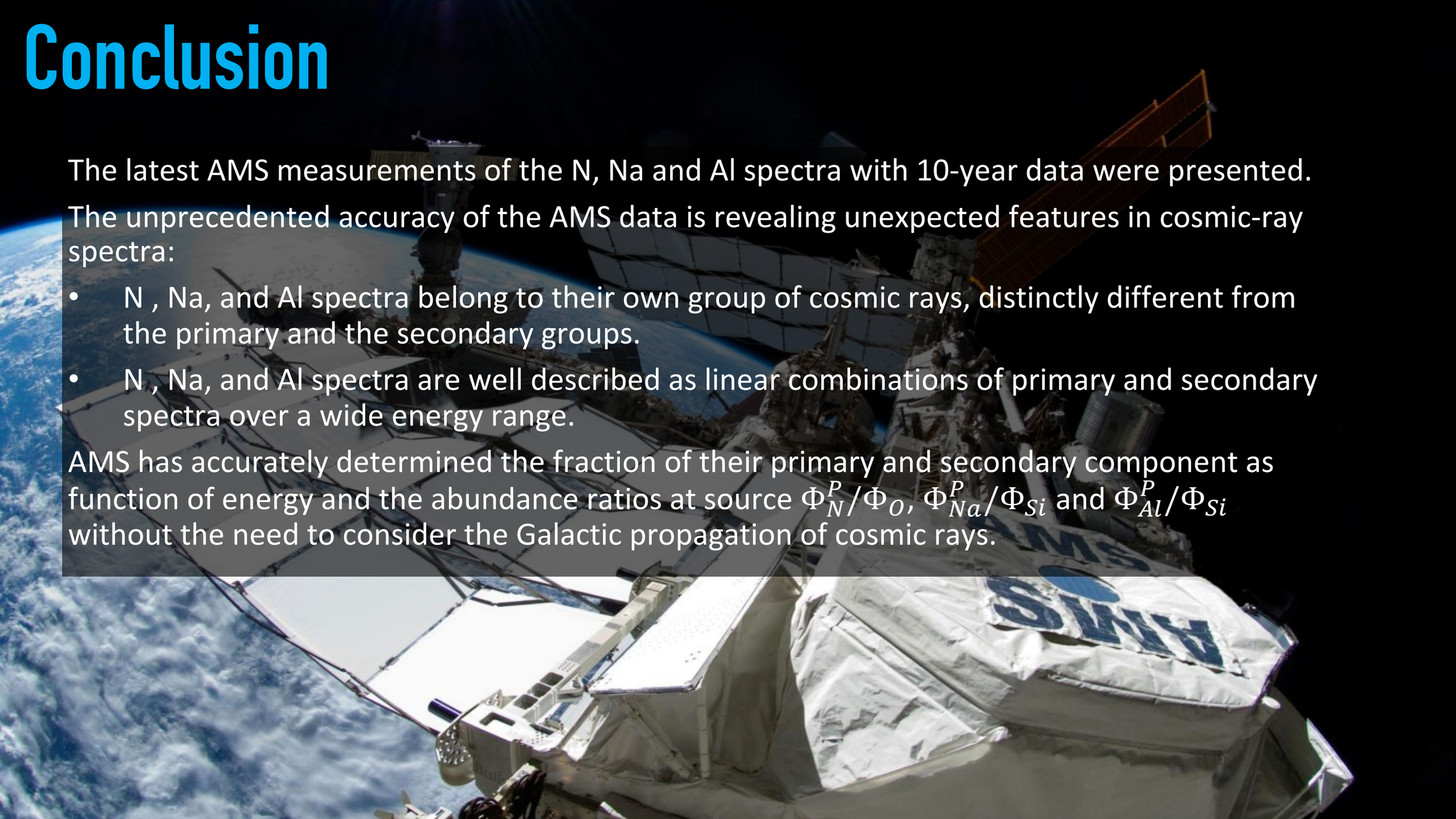
This permits the determination of the Φ_N^P/Φ_O, Φ_{Na}^P/Φ_{Si} and Φ_{Al}^P/Φ_{Si} abundance ratios at the source without the need to consider the Galactic propagation of cosmic rays.







Conclusion



The latest AMS measurements of the N, Na and Al spectra with 10-year data were presented.

The unprecedented accuracy of the AMS data is revealing unexpected 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 groups.
- 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 their primary and secondary component as function of energy and the abundance ratios at source Φ_N^P/Φ_O, Φ_{Na}^P/Φ_{Si} and Φ_{Al}^P/Φ_{Si} without the need to consider the Galactic propagation of cosmic rays.