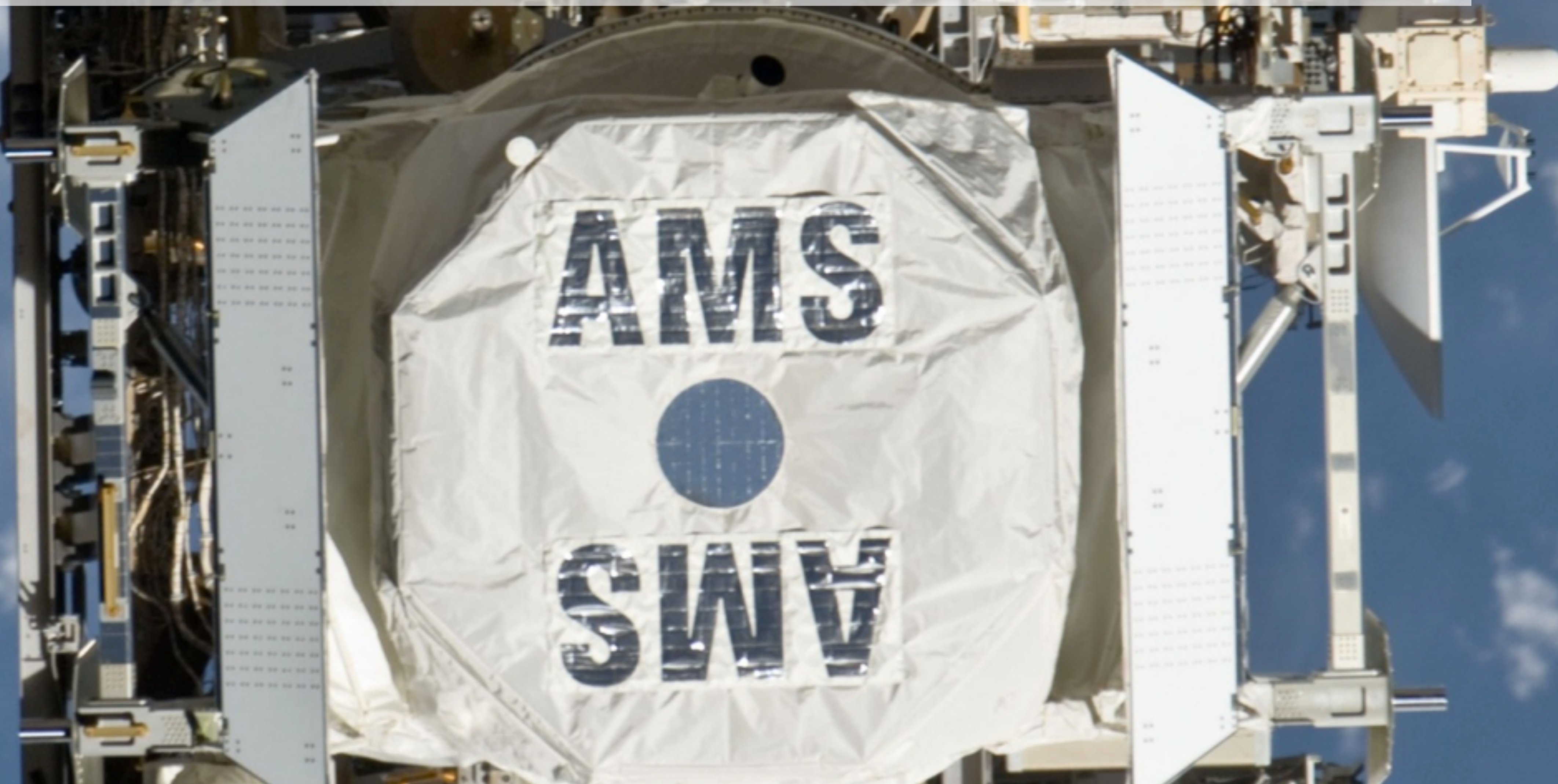
Observation of the Energy Dependence of Primary and Secondary Cosmic Rays with the AMS Detector on the International Space Station

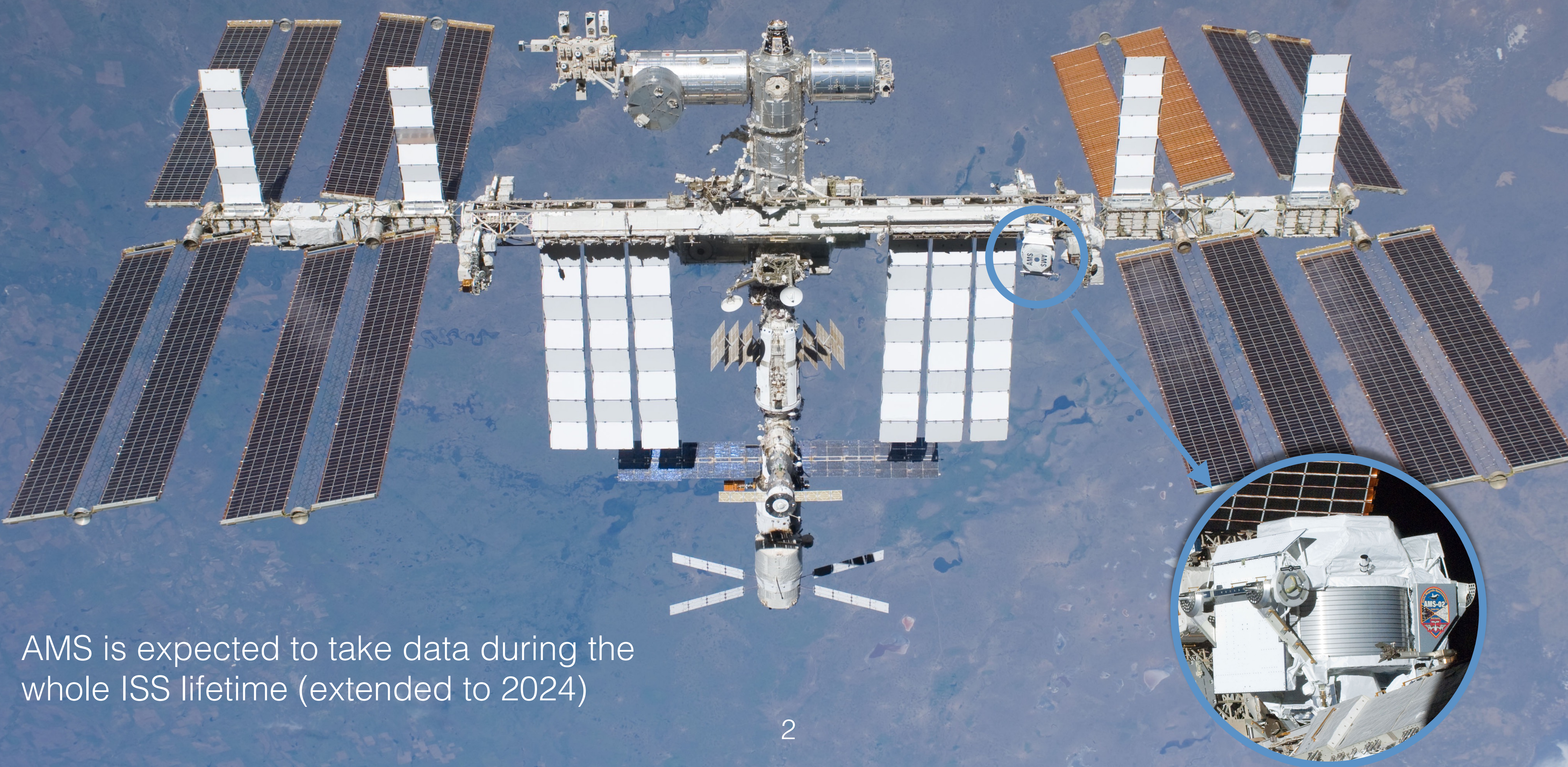
V. Formato on behalf of the AMS collaboration
INFN - Sezione di Perugia

05/09/2018 - RICAP - Roma



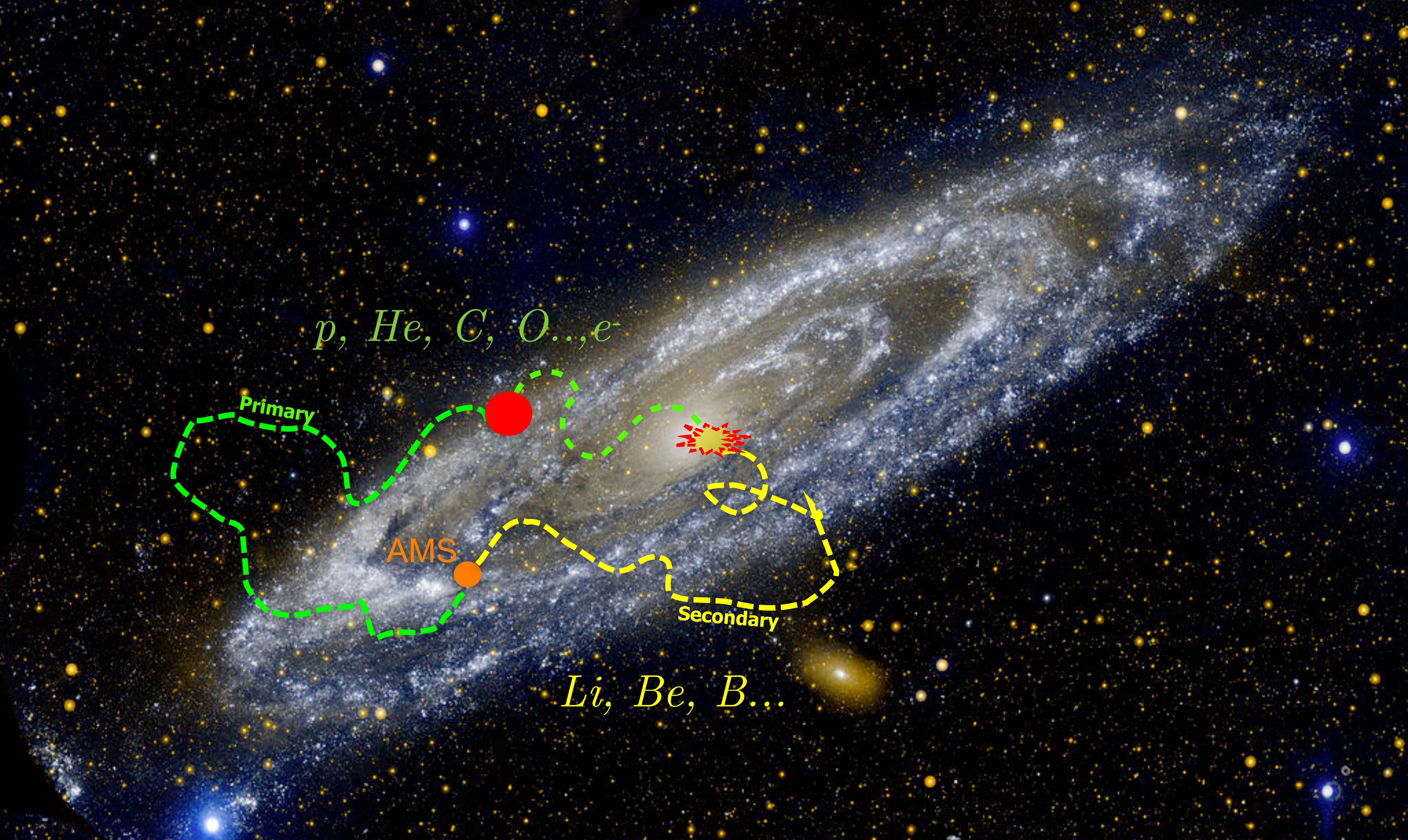
AMS-02 in orbit

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 **>120 billion CR triggers** in ~7 years of operation.

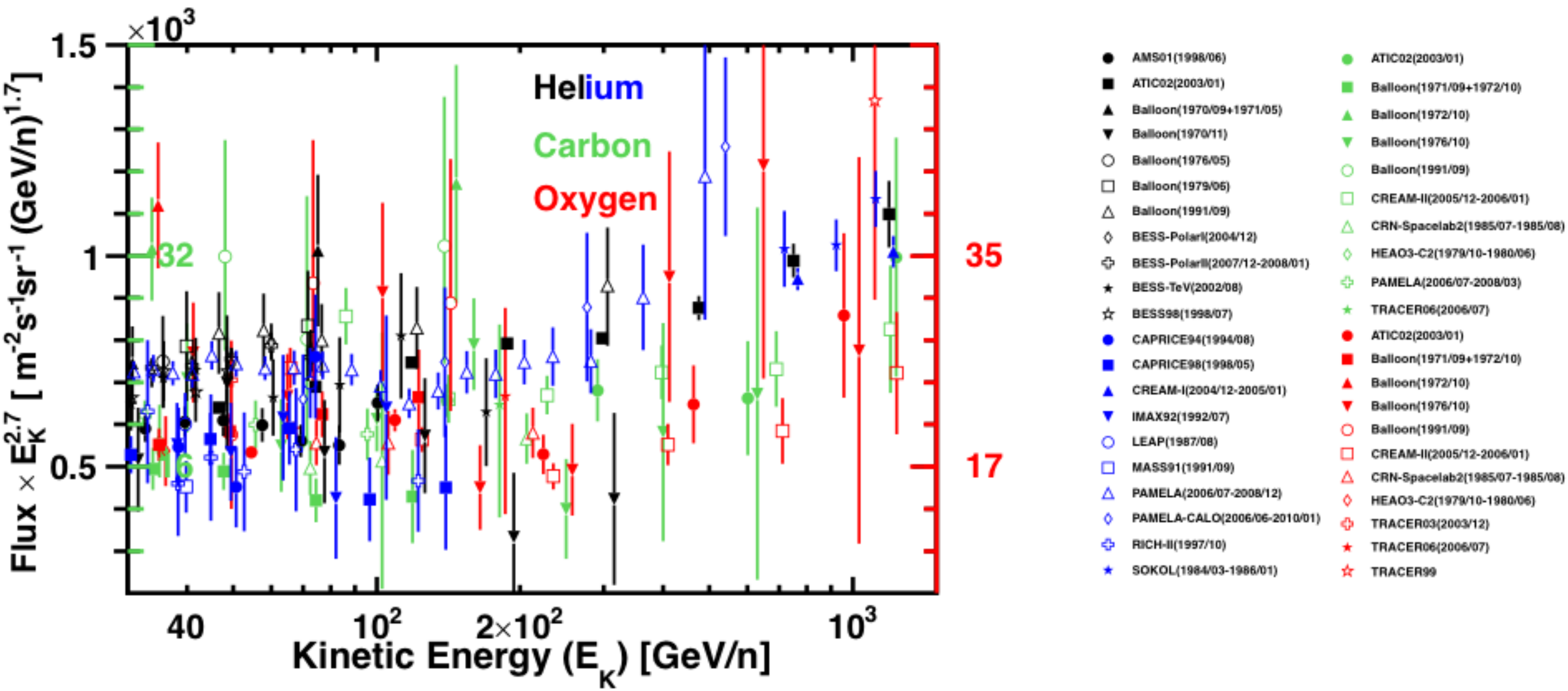


AMS is expected to take data during the whole ISS lifetime (extended to 2024)

Cosmic rays in the Galaxy

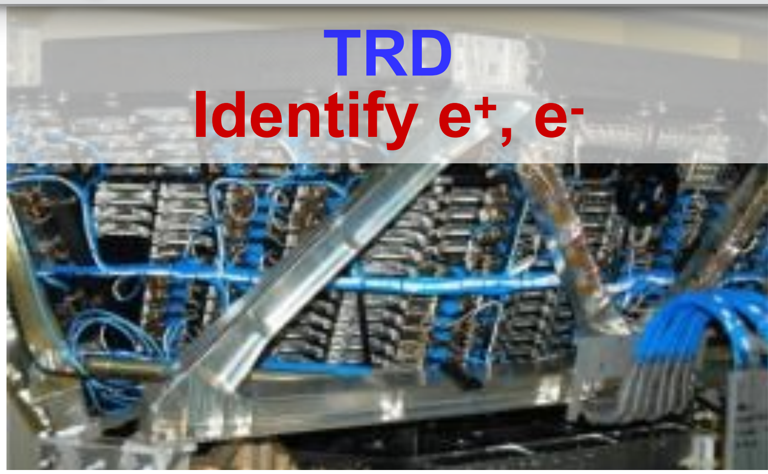


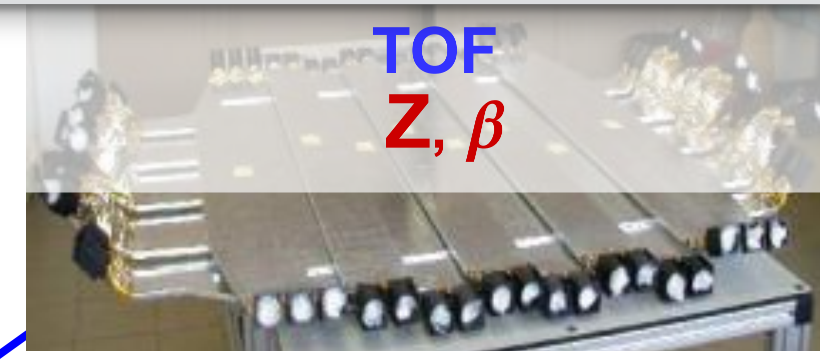
CR primaries before AMS

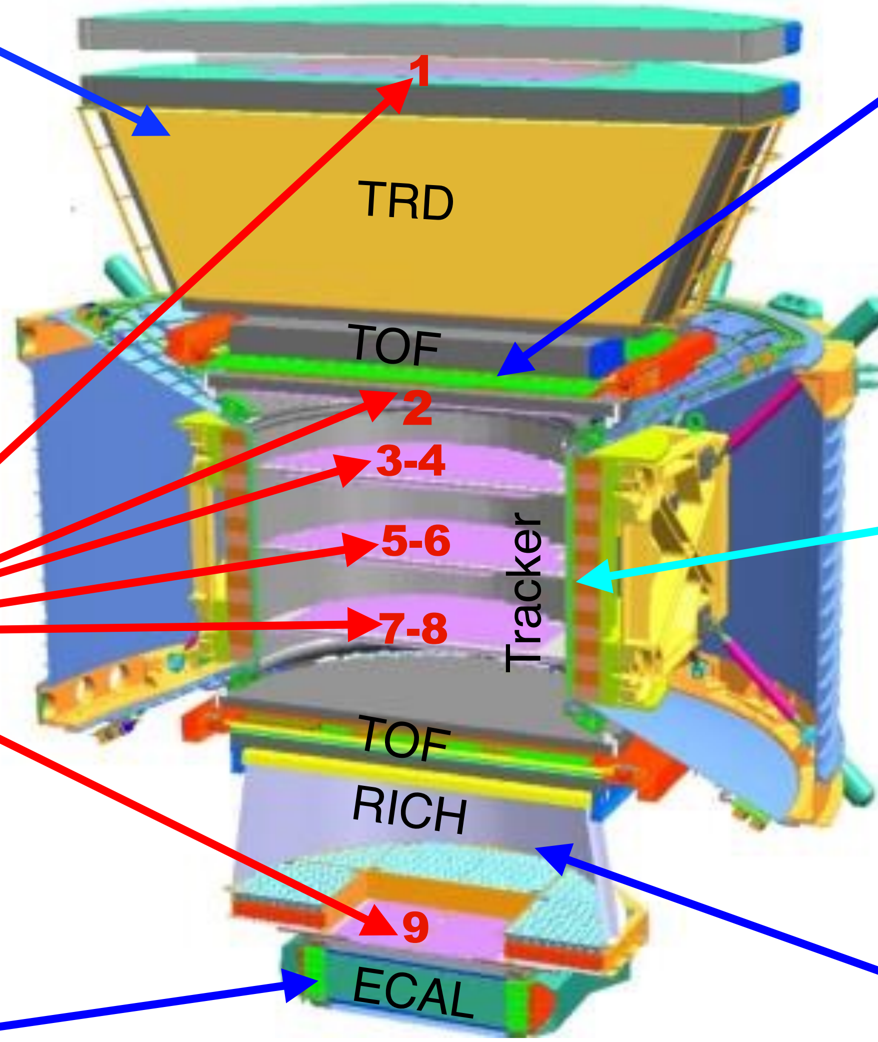


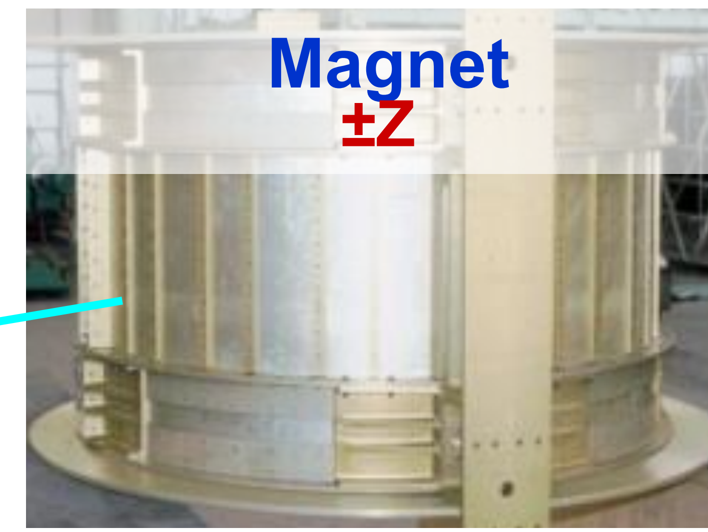
AMS-02

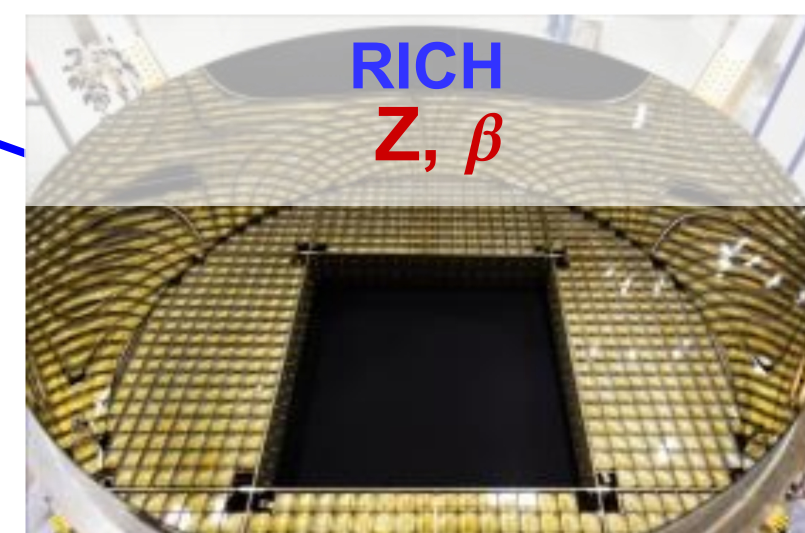
Particles and nuclei are defined by their charge (**Z**) and energy (**E ~ P**)











***Z, P** are measured independently by the Tracker, RICH, TOF and ECAL*

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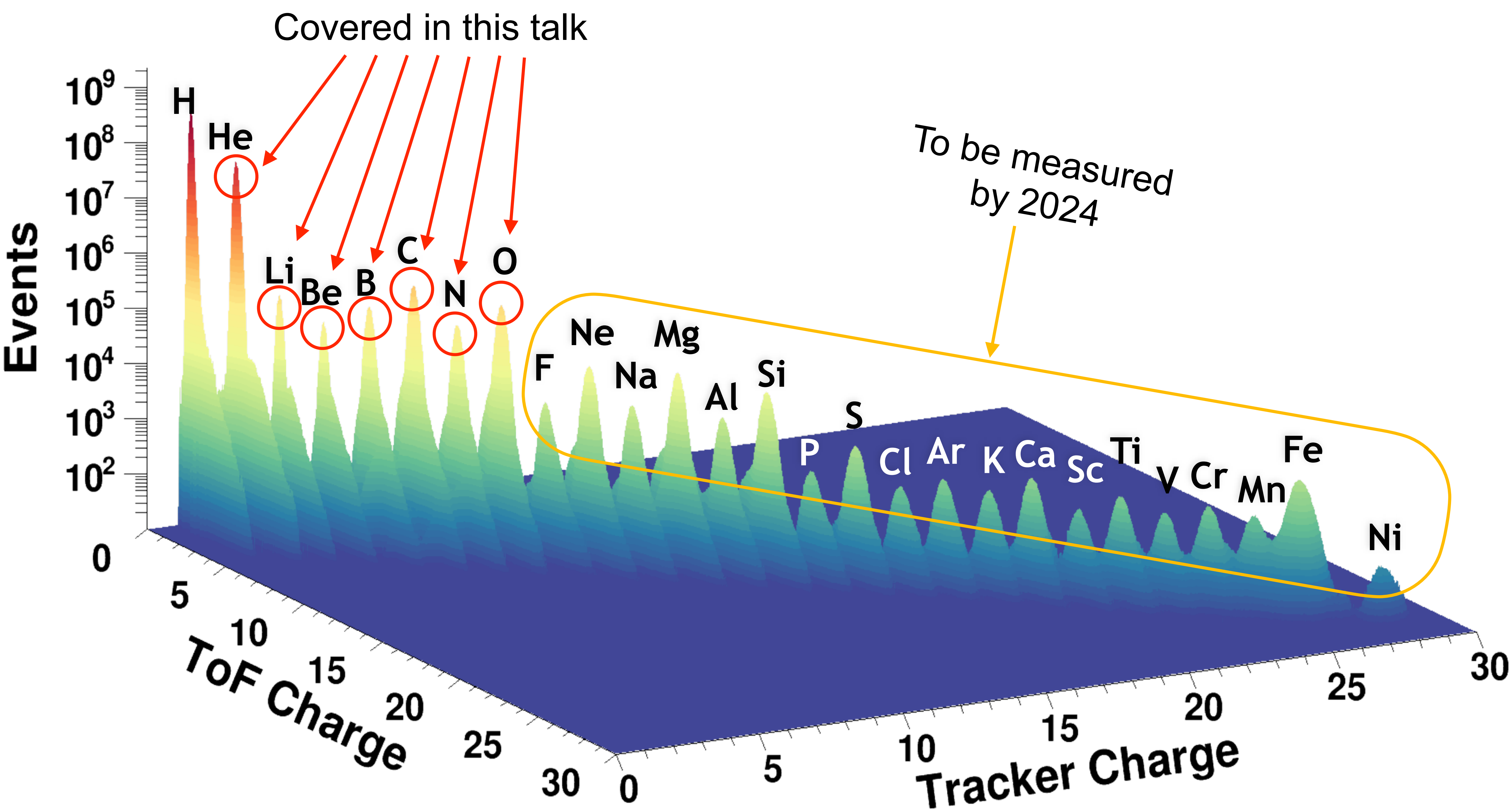
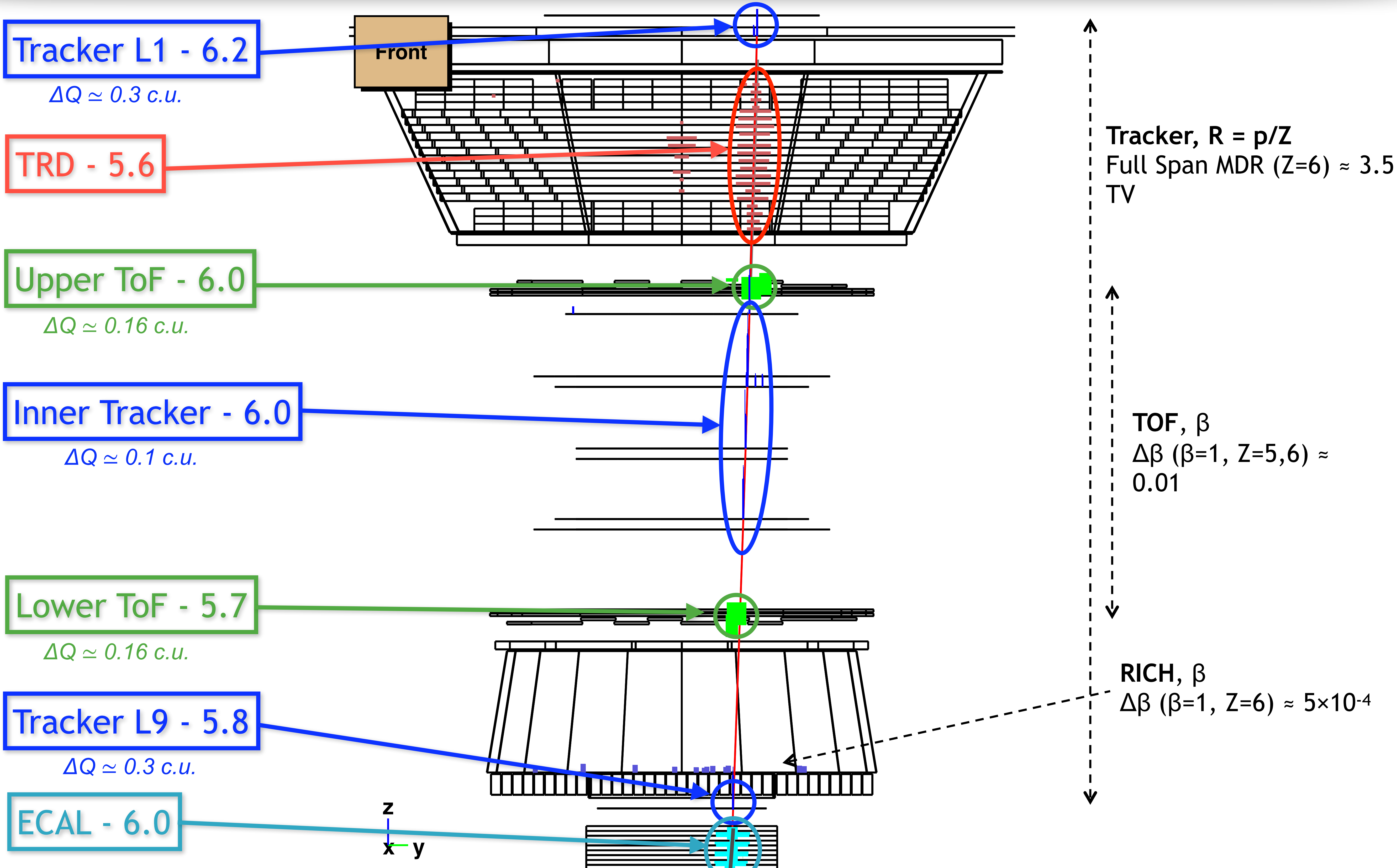
The AMS periodic table



Charge measurements in AMS

(e.g. Carbon nucleus: Z=6)



Data purity

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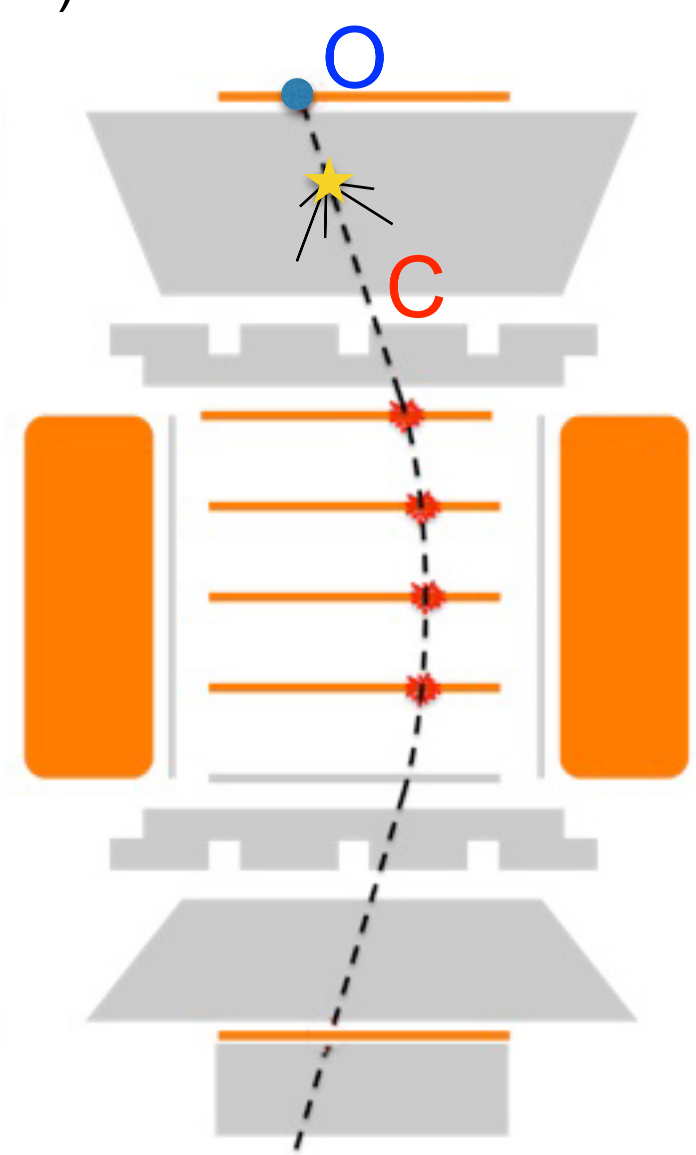
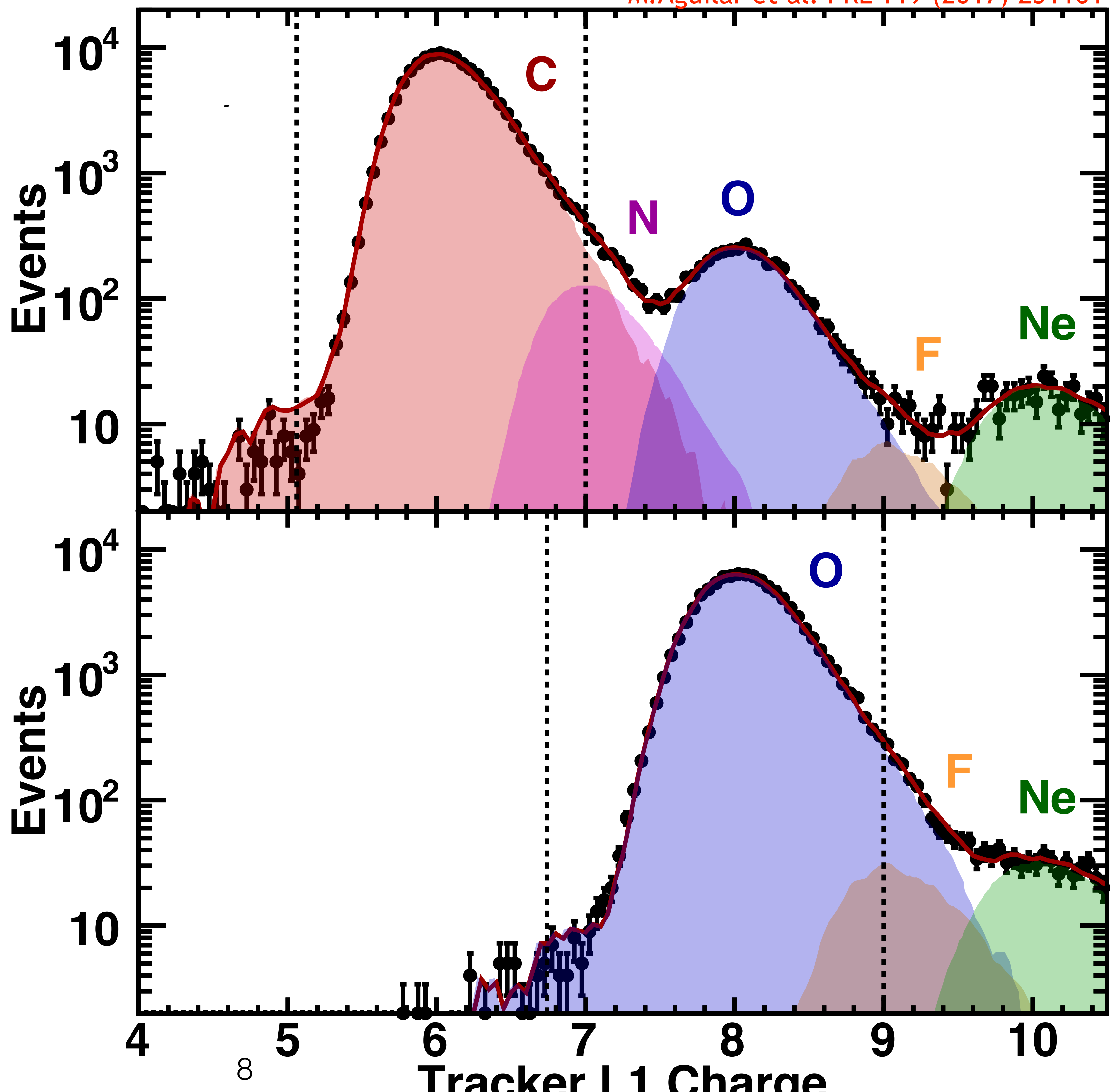
With the track defined by the inner tracker (L2-L8), examine the charge distribution on the tracker L1.

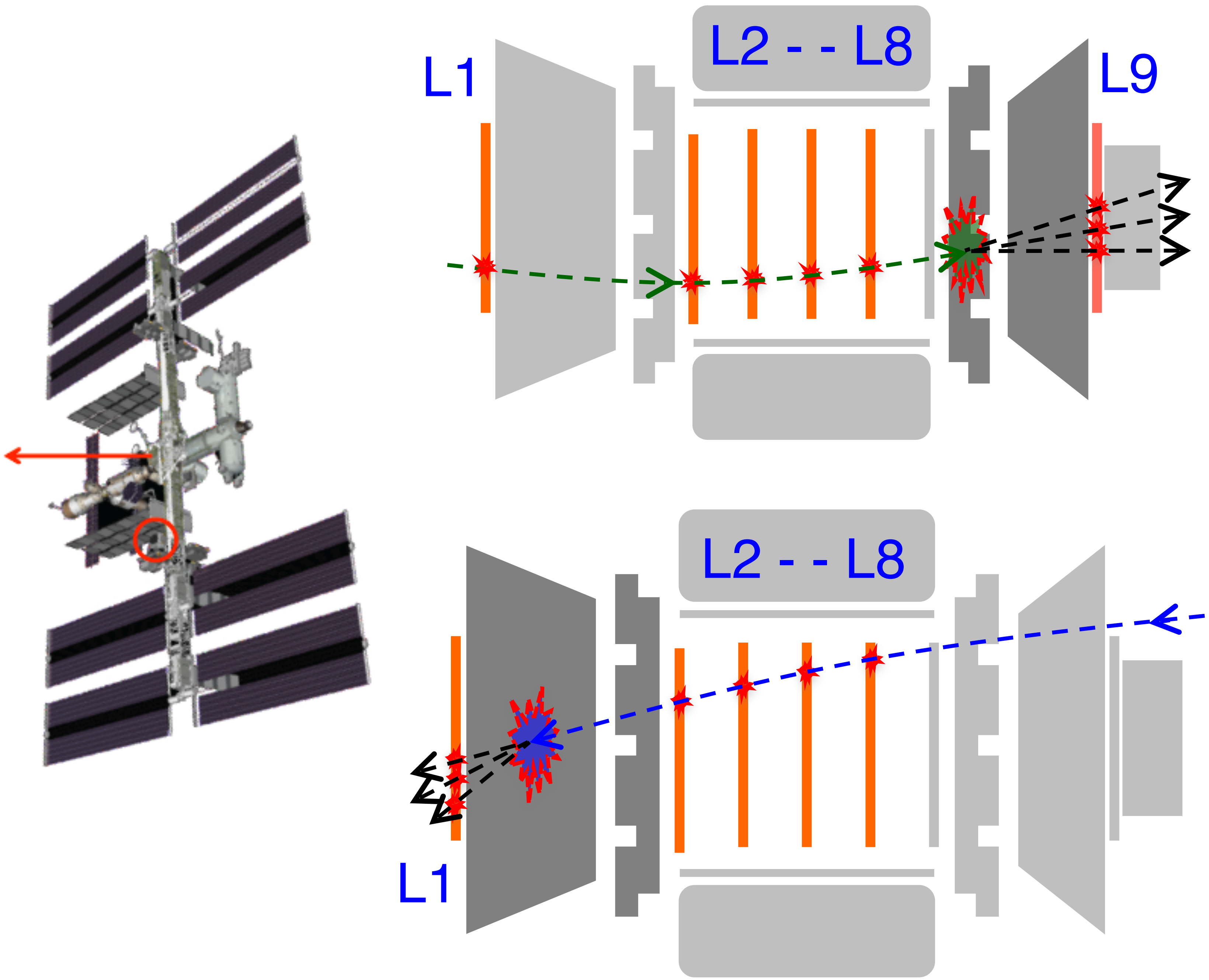
The high redundancy of charge measurements allows to keep under control interactions in the upper part of the detector (between Tracker L1 and L2)





Cross-sections and materials

Measurement of nuclear cross sections / accurate check of the materials when AMS is flying in horizontal attitude



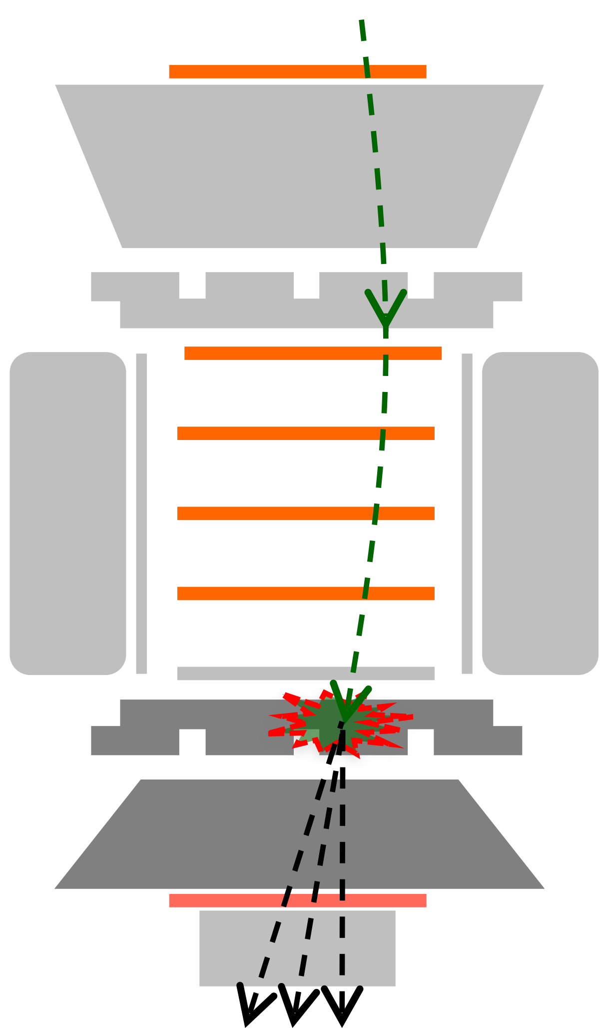
First, we use the seven inner tracker layers, L2-L8, to define beams of nuclei: He, Li, Be, B, …

Second, we use left-to-right particles to measure the nuclear interactions in the lower part of the detector.

Third, we use right-to-left particles to measure the nuclear interactions in the upper part of detector.

Cross-sections and materials

The measured "Survival probabilities" are then compared with the corresponding predictions from the MC simulation. The relevant cross-sections are then estimated from this procedure and corrected in the MC simulation.



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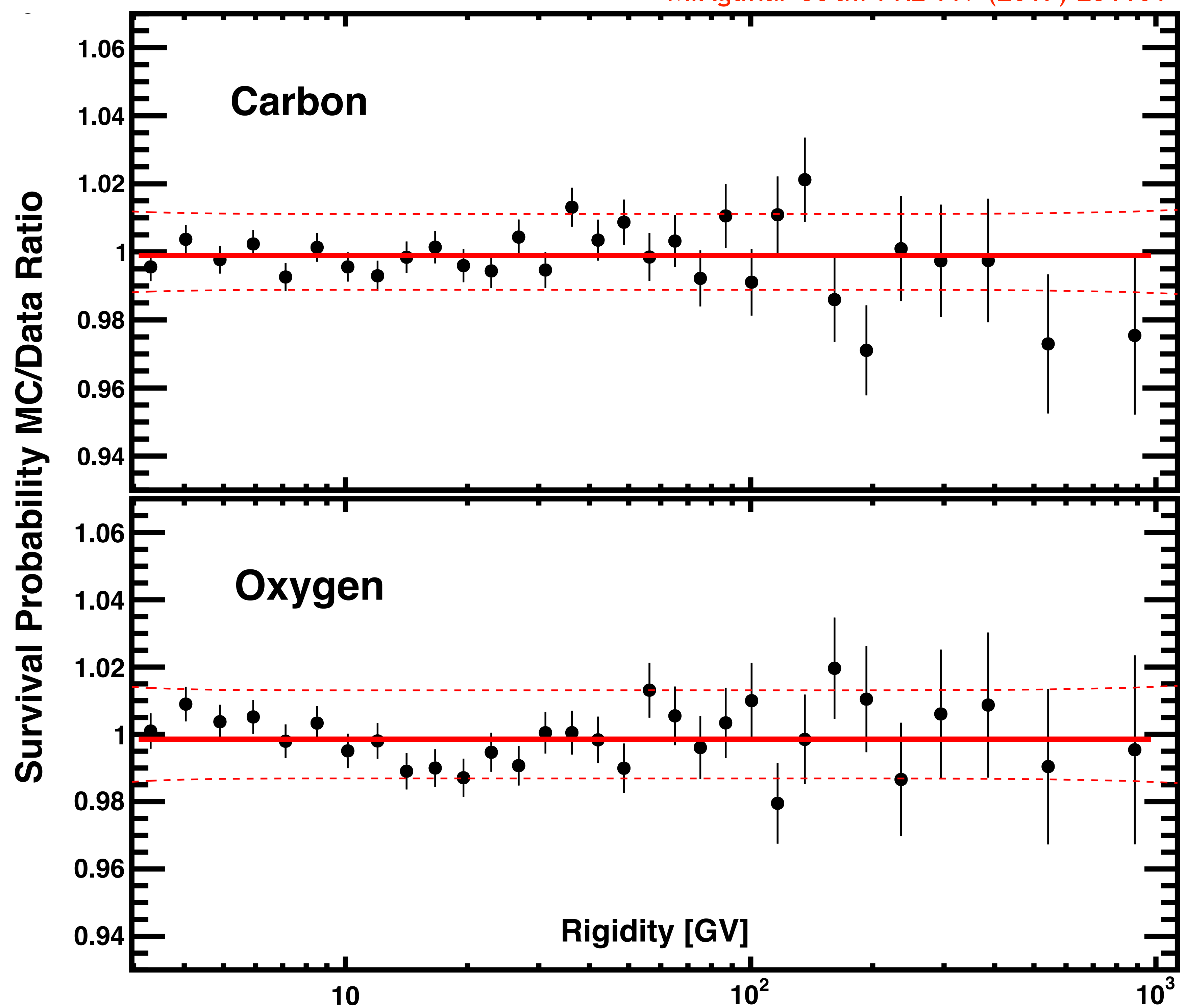

Cross-sections and materials

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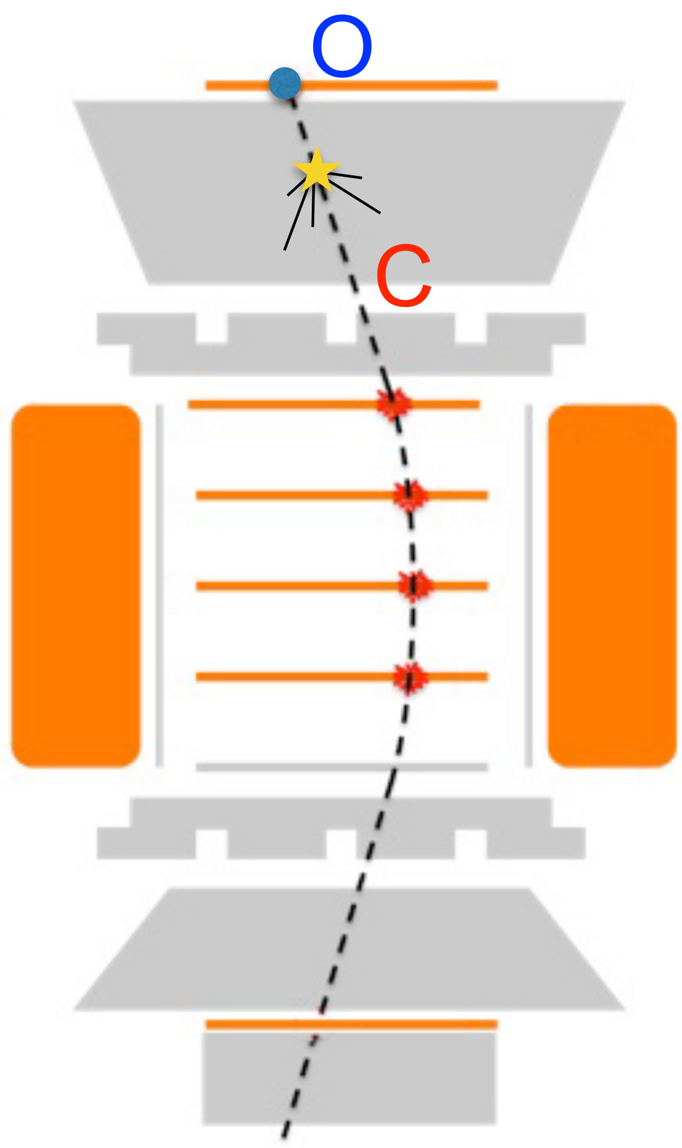
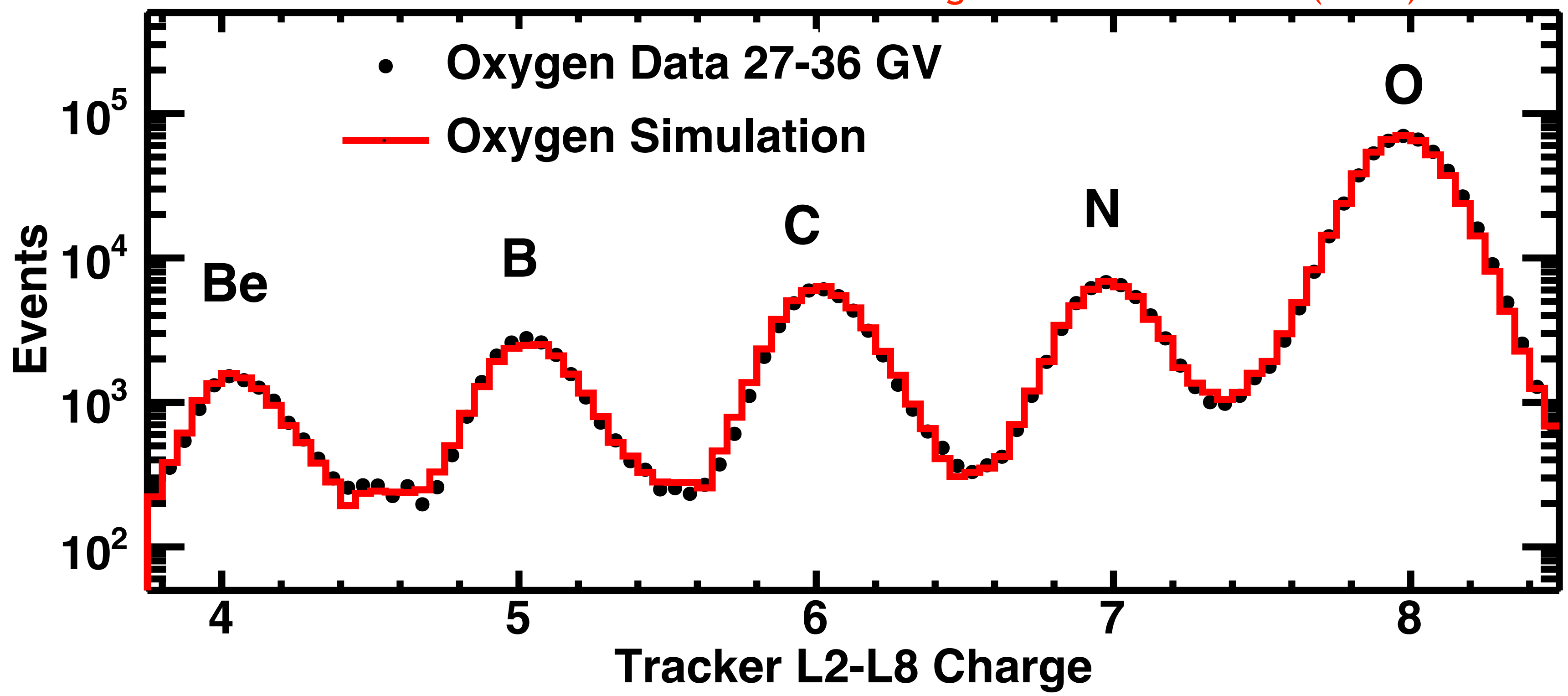
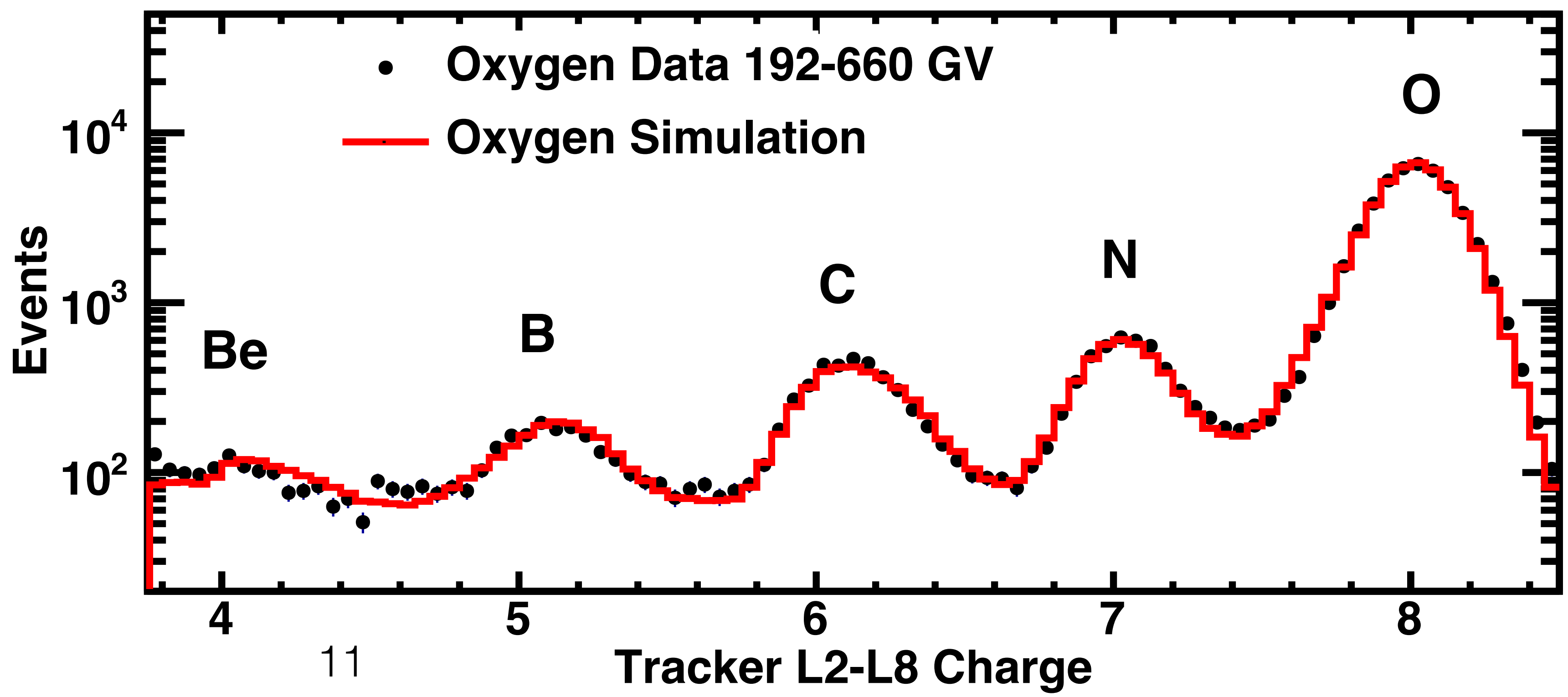
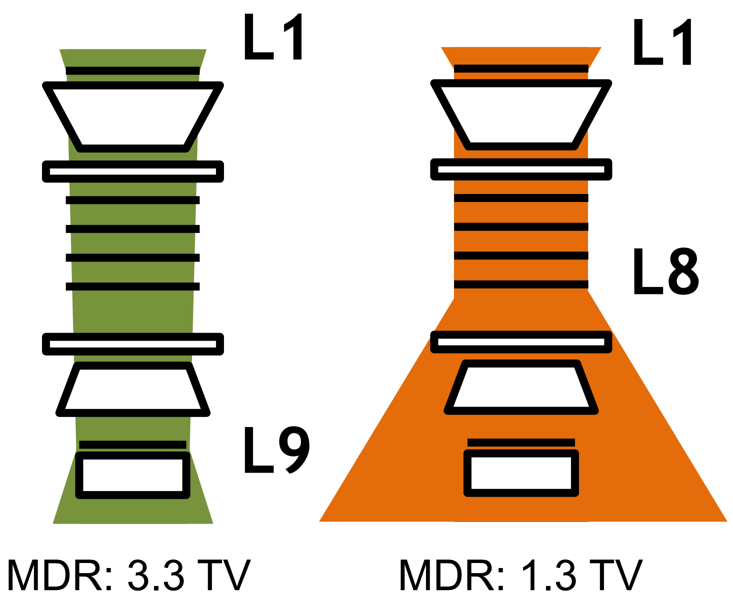
The cross-sections are studied at the level of the single nuclear branching-factor thanks, again, to the high redundancy in the charge measurements in AMS.







Measurement verification



Fluxes measured using events passing through L1-L9 divided by the ones measured using events passing through L1-L8 (or L2-L8).

The observed agreement verifies:

(i) **acceptance**: the amount of material traversed is different

(ii) **unfolding**: bin-to-bin migration is different due to different resolution

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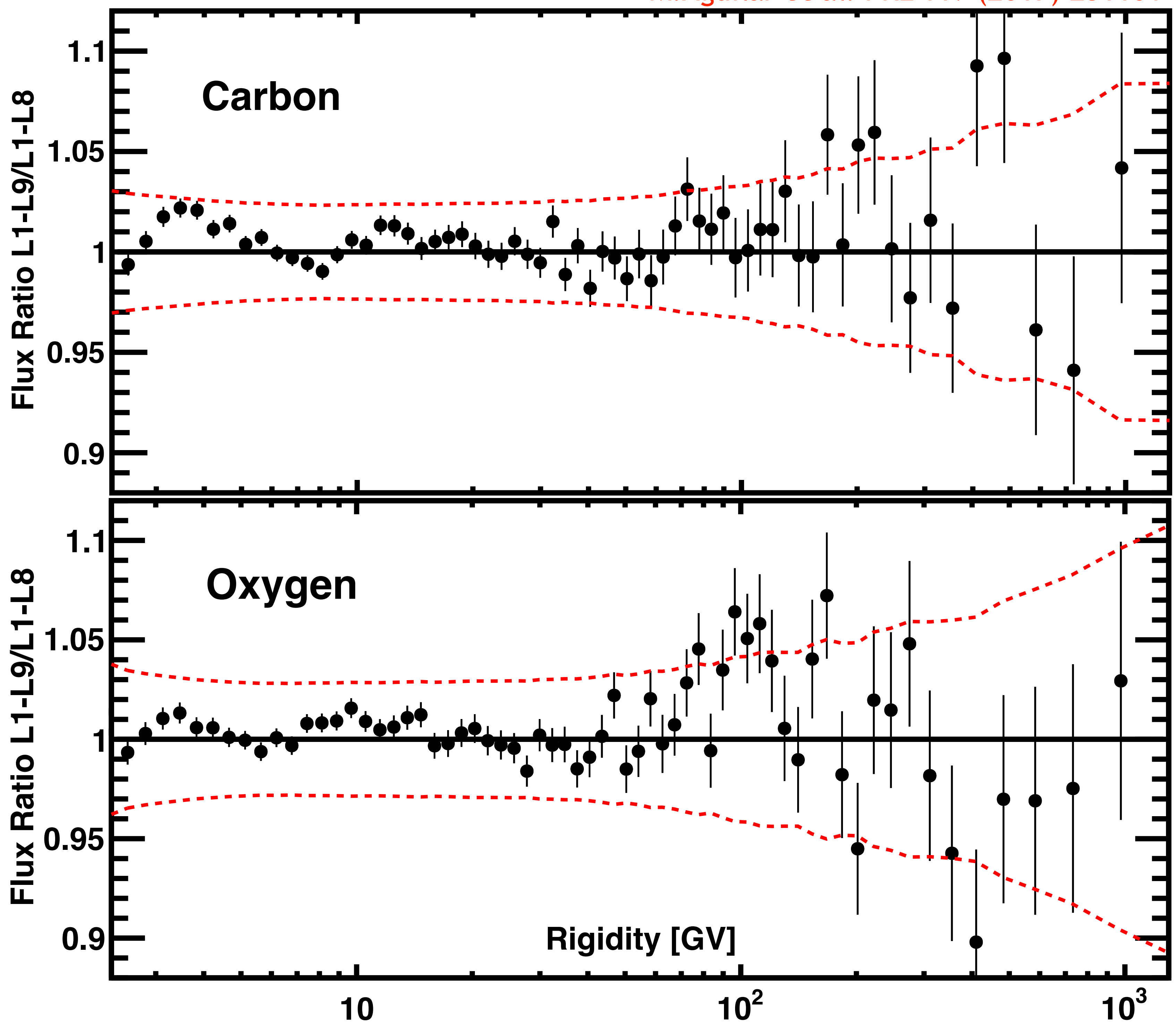

Primary fluxes in Rigidity

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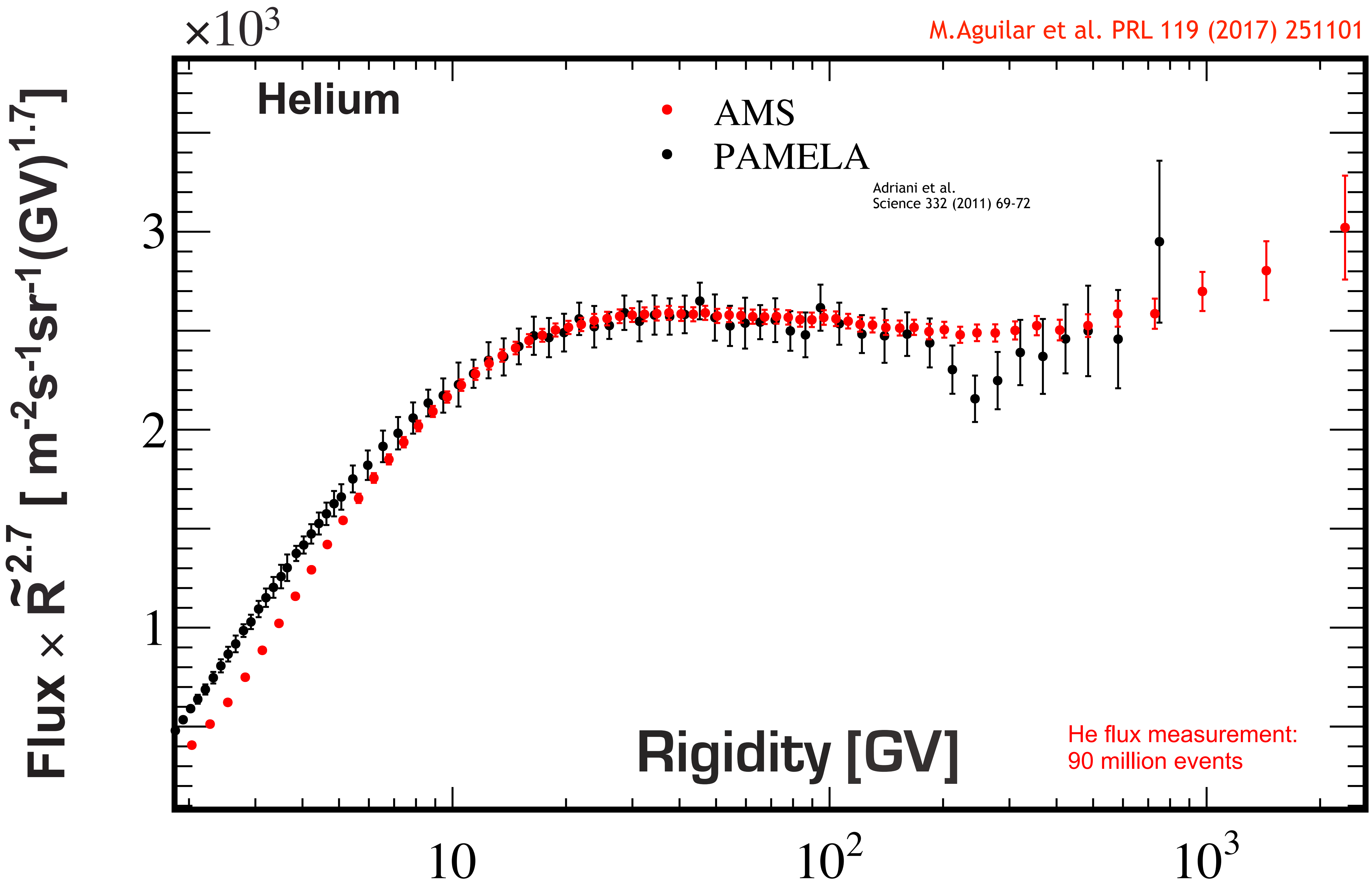

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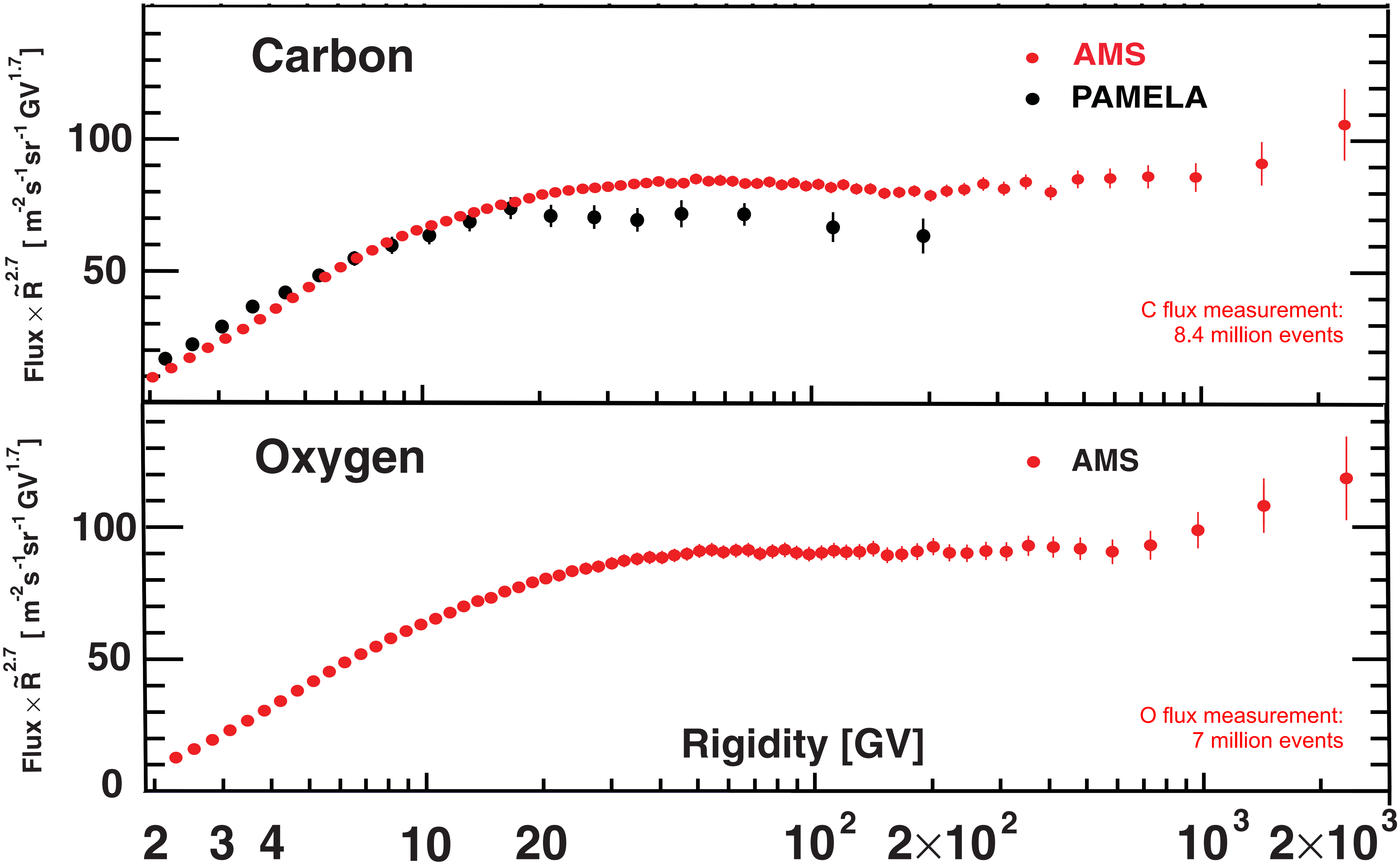
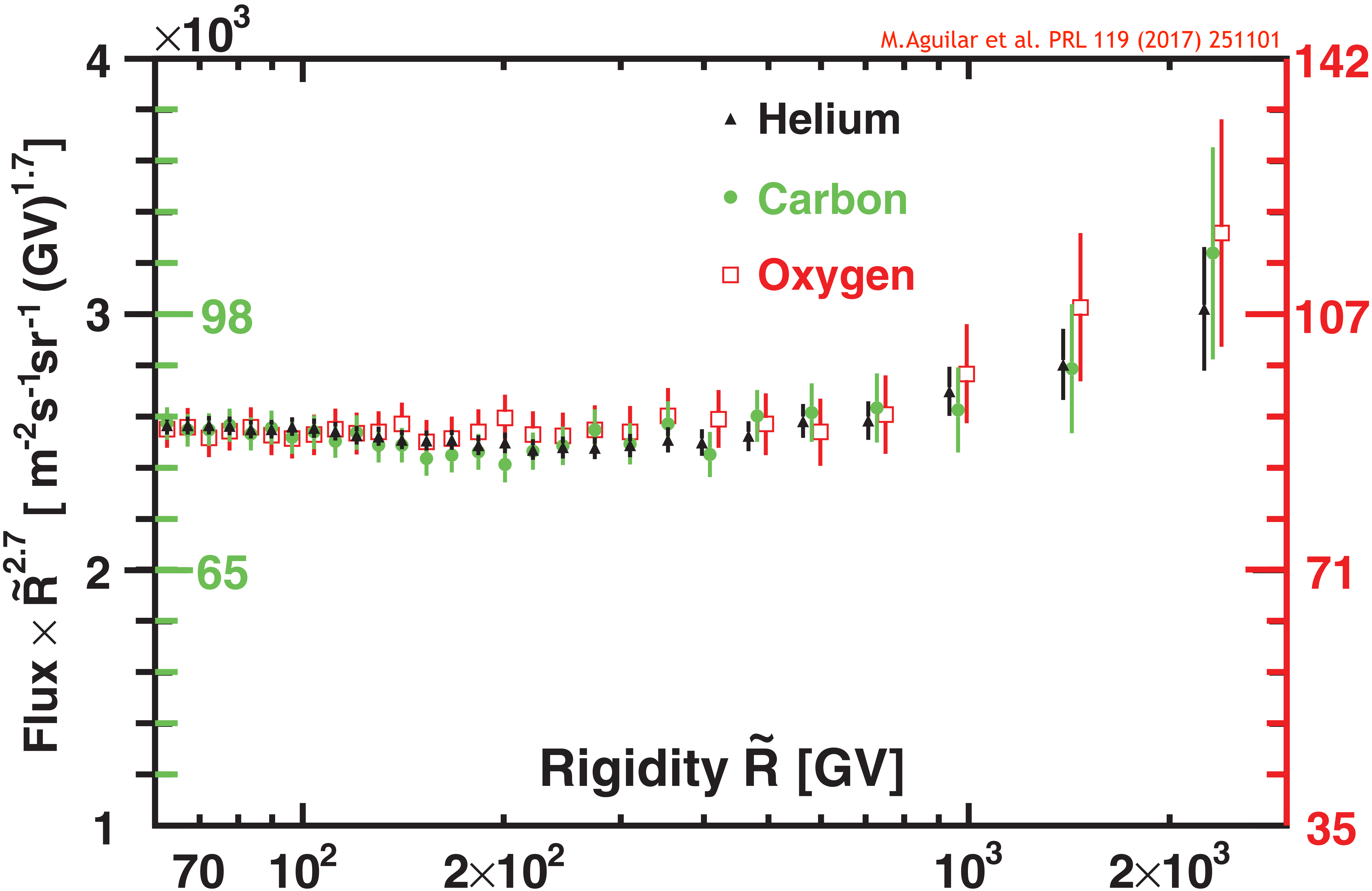
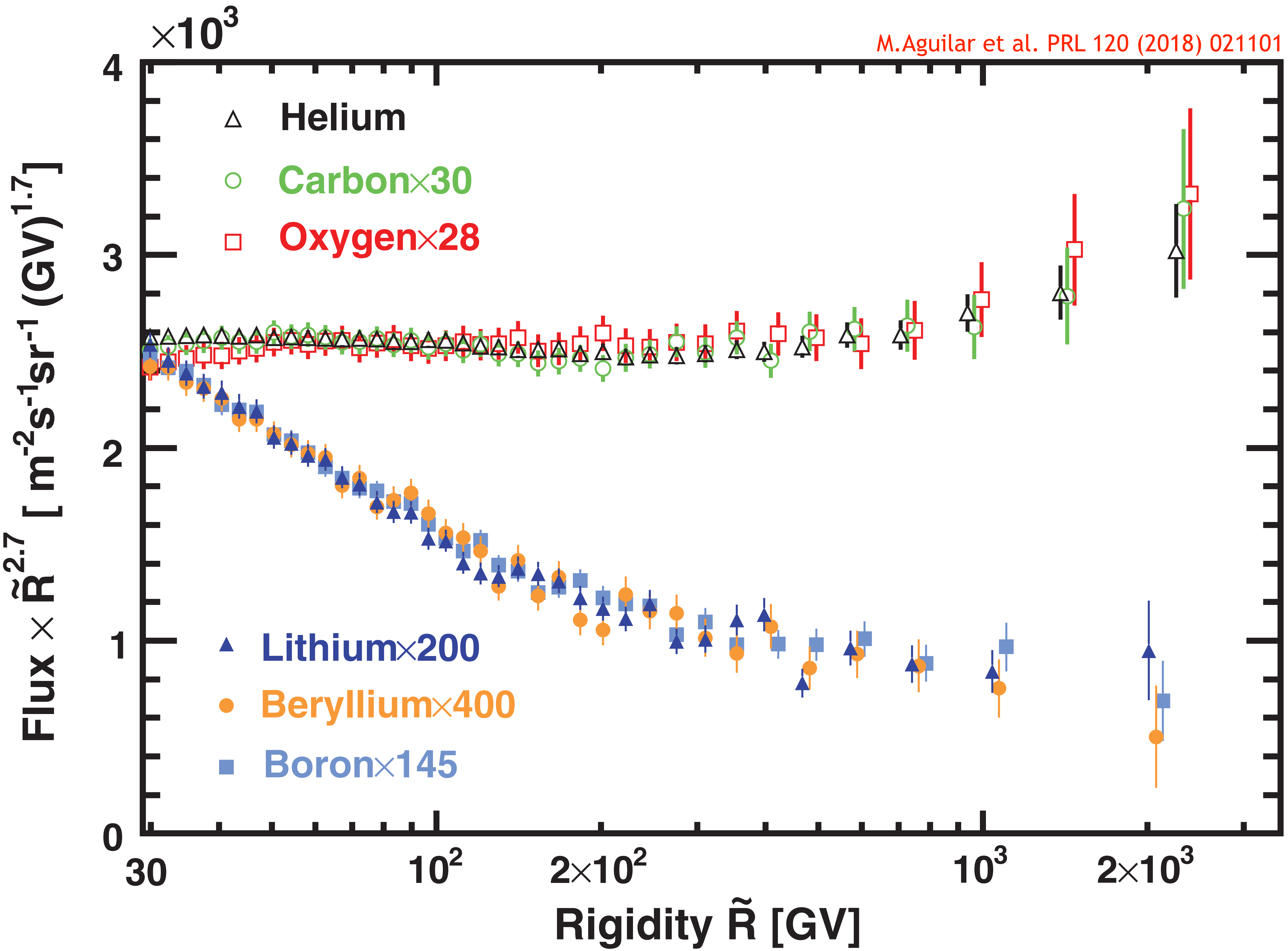


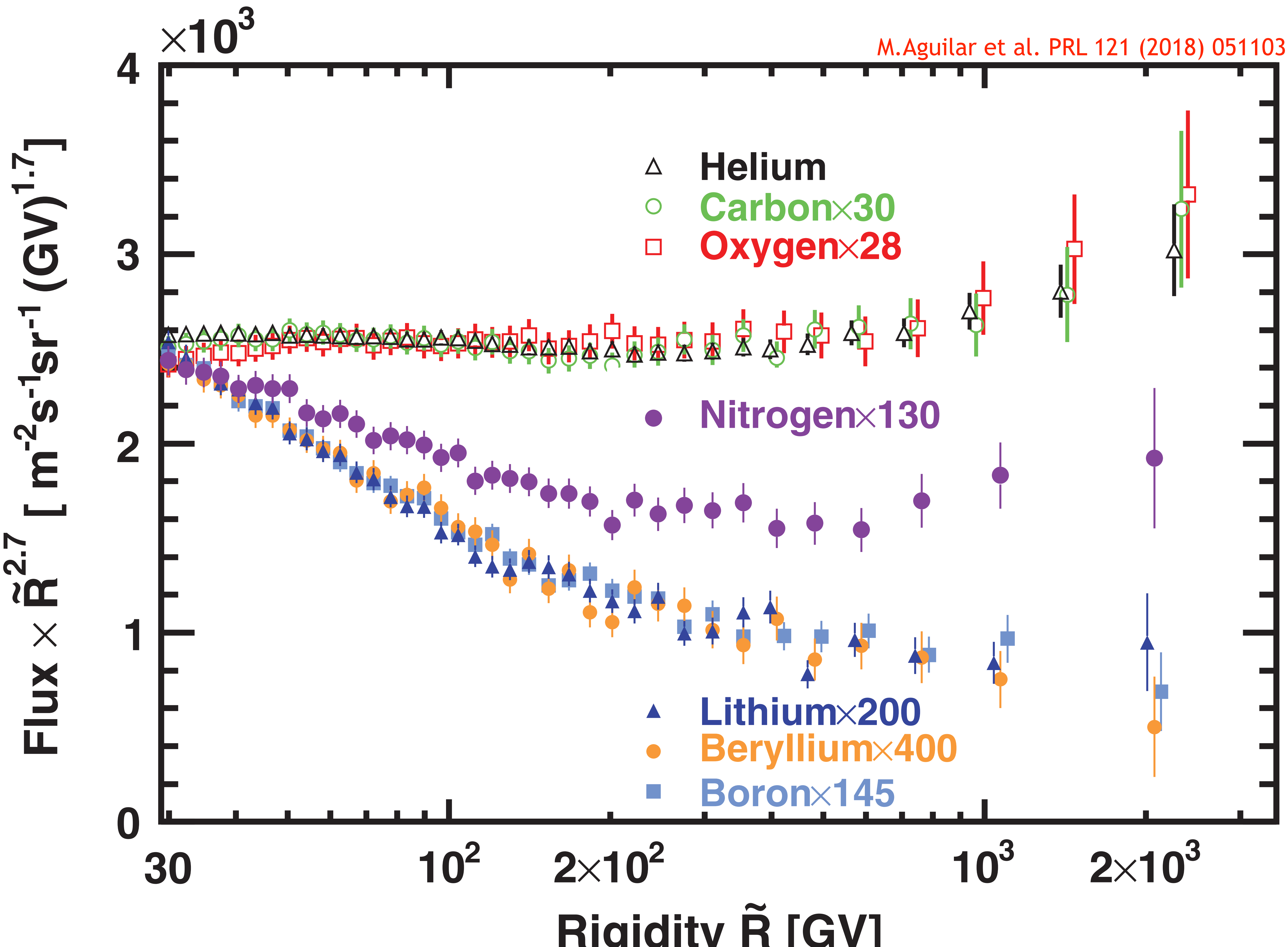
Same spectral shape



Same spectral shape



Same spectral shape (2)



Spectral index

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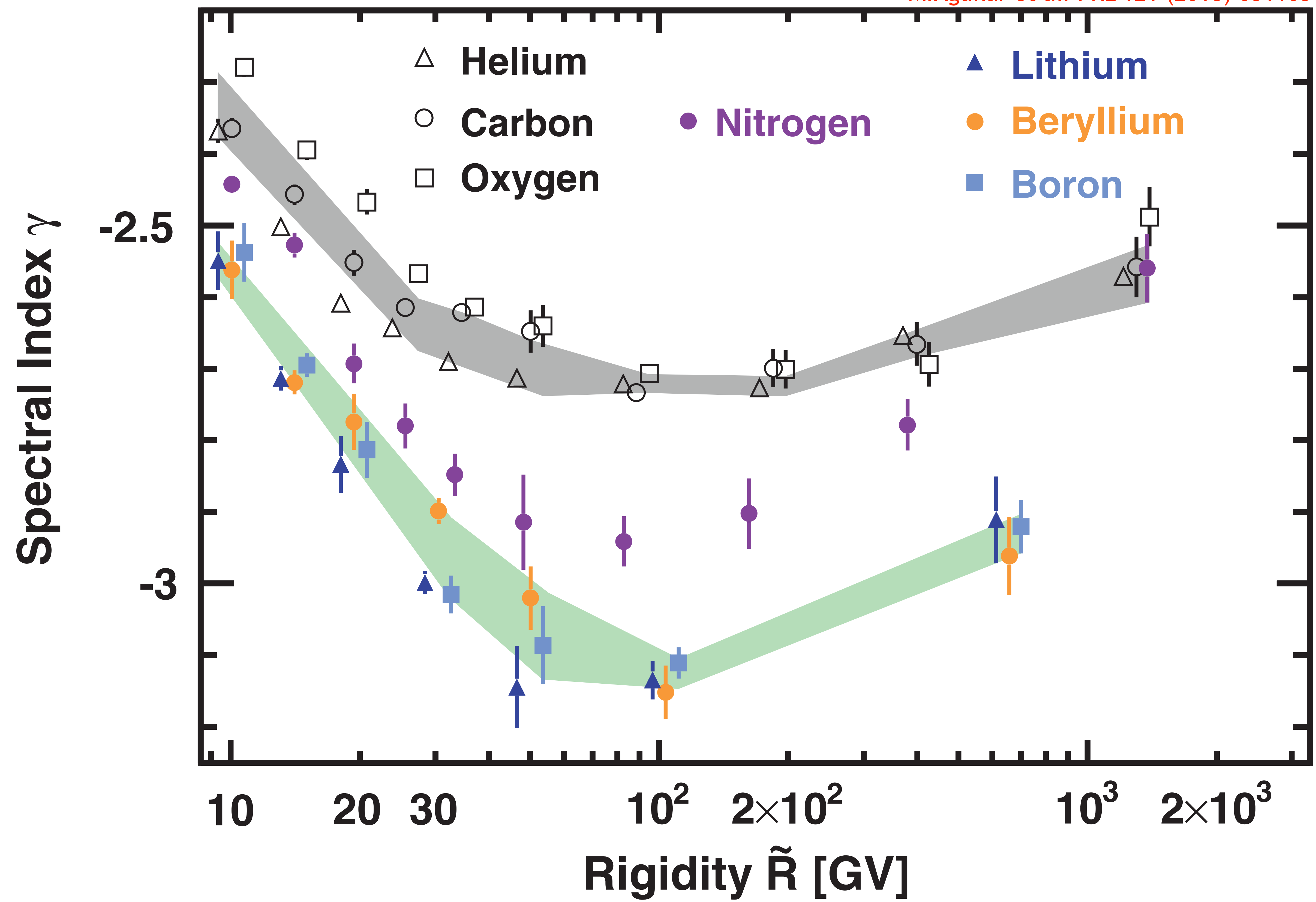

Nitrogen ‘composition’

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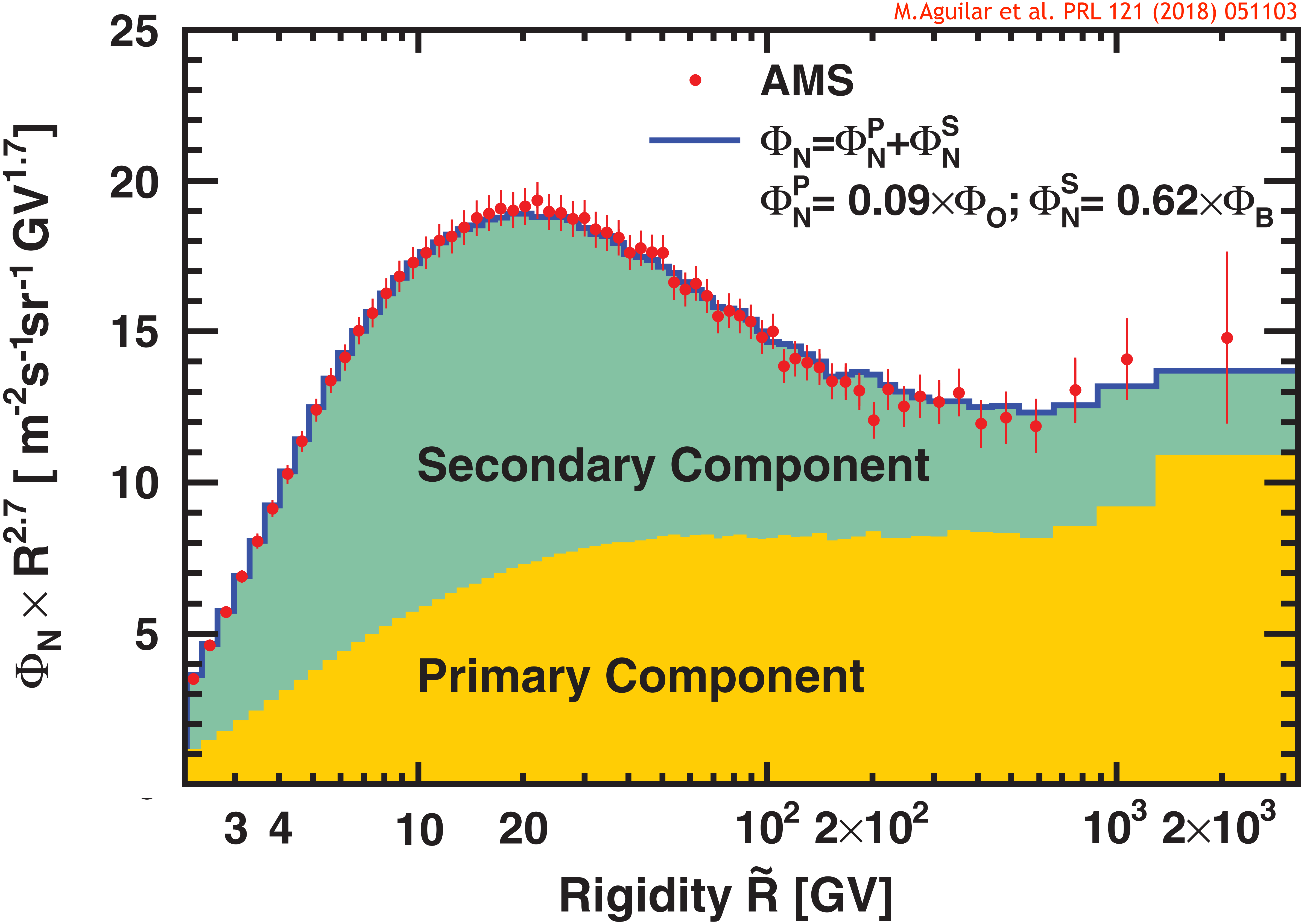
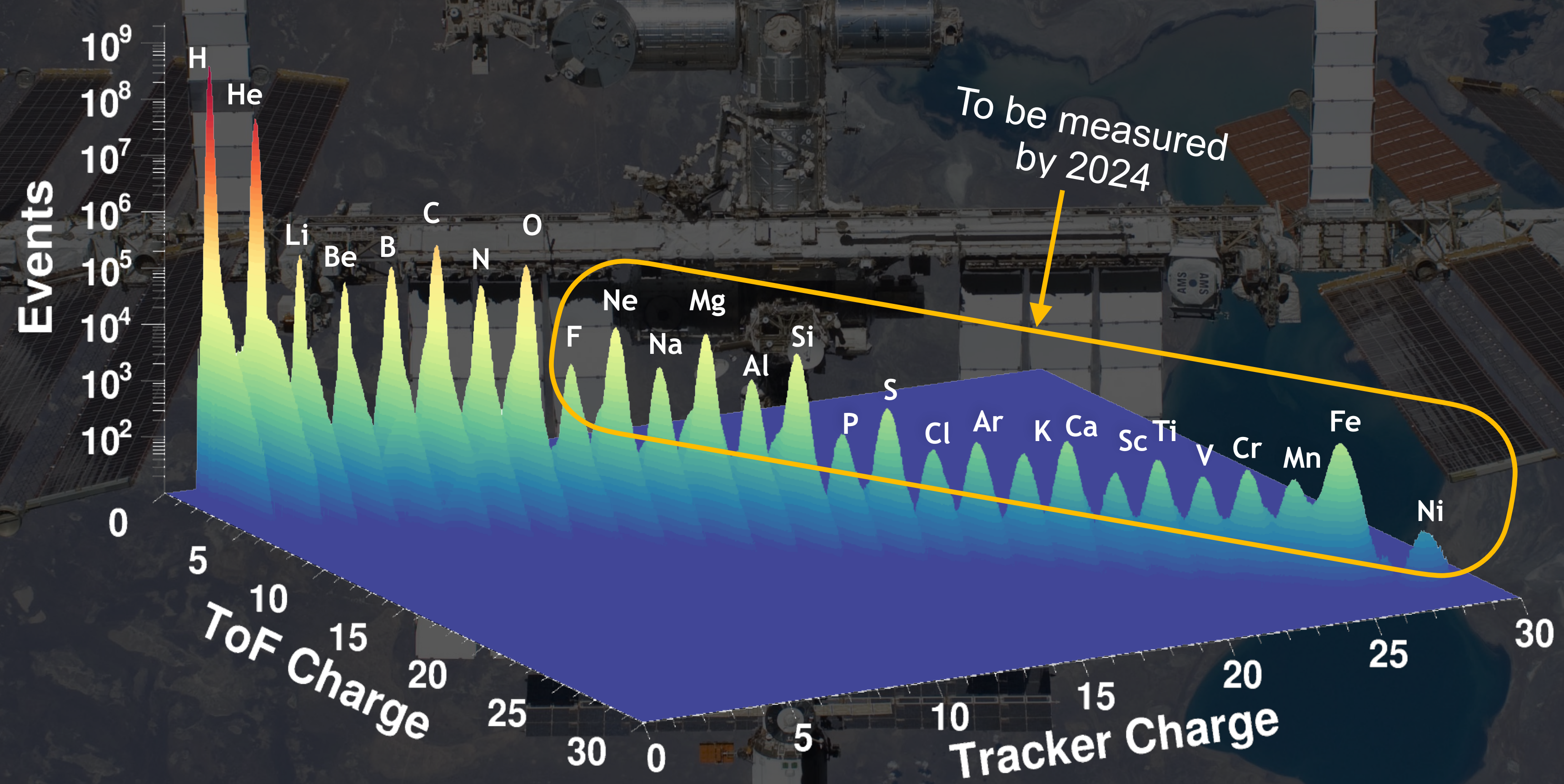


Conclusions

- AMS is providing precision measurements of CRs primary elements (**protons, helium** and **heavier nuclei** fluxes) with a **few percent** precision.
- **Simultaneous** measurement of many CR species is a key instrument for acquiring knowledge of **cosmic ray physics** and for the discovery of **new phenomena**.
- AMS will continue gathering data for the entire duration of the **ISS**, continuing the search for **dark matter**, **primordial antimatter** and, in particular, a more detailed description of **cosmic rays fluxes**.



- Unexpected **patterns** are emerging from the **hadronic** component of cosmic rays. He, C, and O, and Li, Be and B fluxes, respectively, share the same energy dependence, showing a change of spectral index at around 300 GV. The N flux shows a behaviour compatible with a mixture of a *"primary-like"* and *"secondary-like"* component
Spectral features are emerging on almost every species and are **challenging** our current view of CR production, acceleration, and propagation.

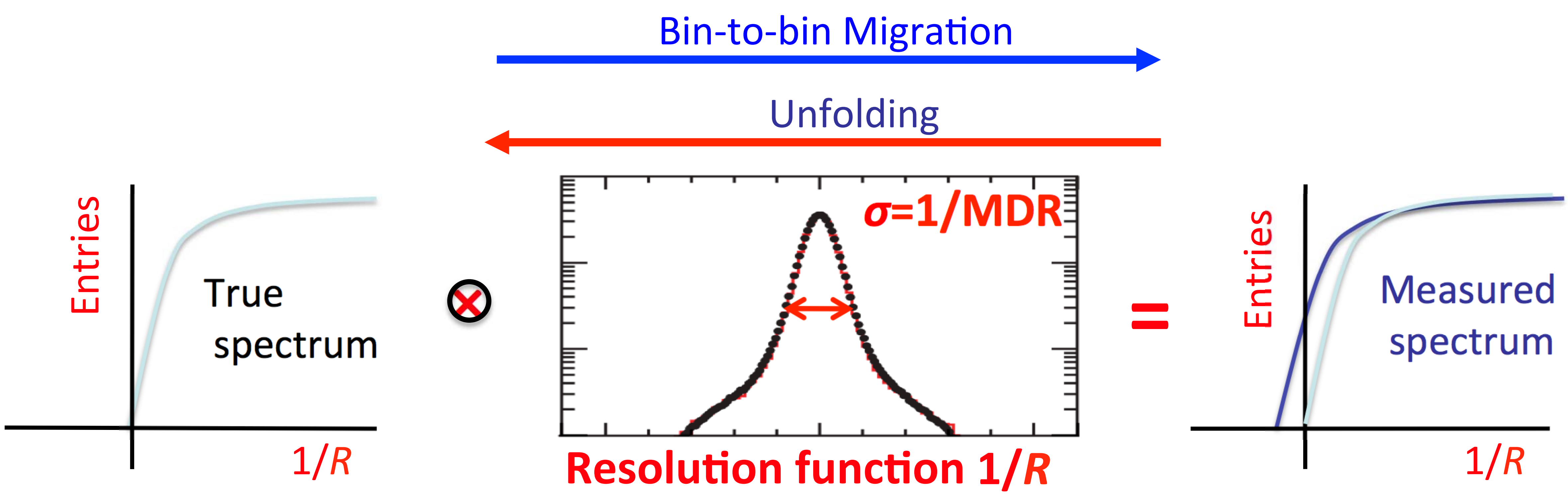
Backup

KEEP
CALM
AND
CHECK
BACKUP SLIDES

Unfolding

Due to the finite resolution of the Tracker events can be measured in a rigidity bin they don’t belong to. This, combined with the steep power-law nature of the CR spectrum leads to a distortion in the measured flux. Many different procedures to correct for this effect, all relying on a precise knowledge of the resolution function.

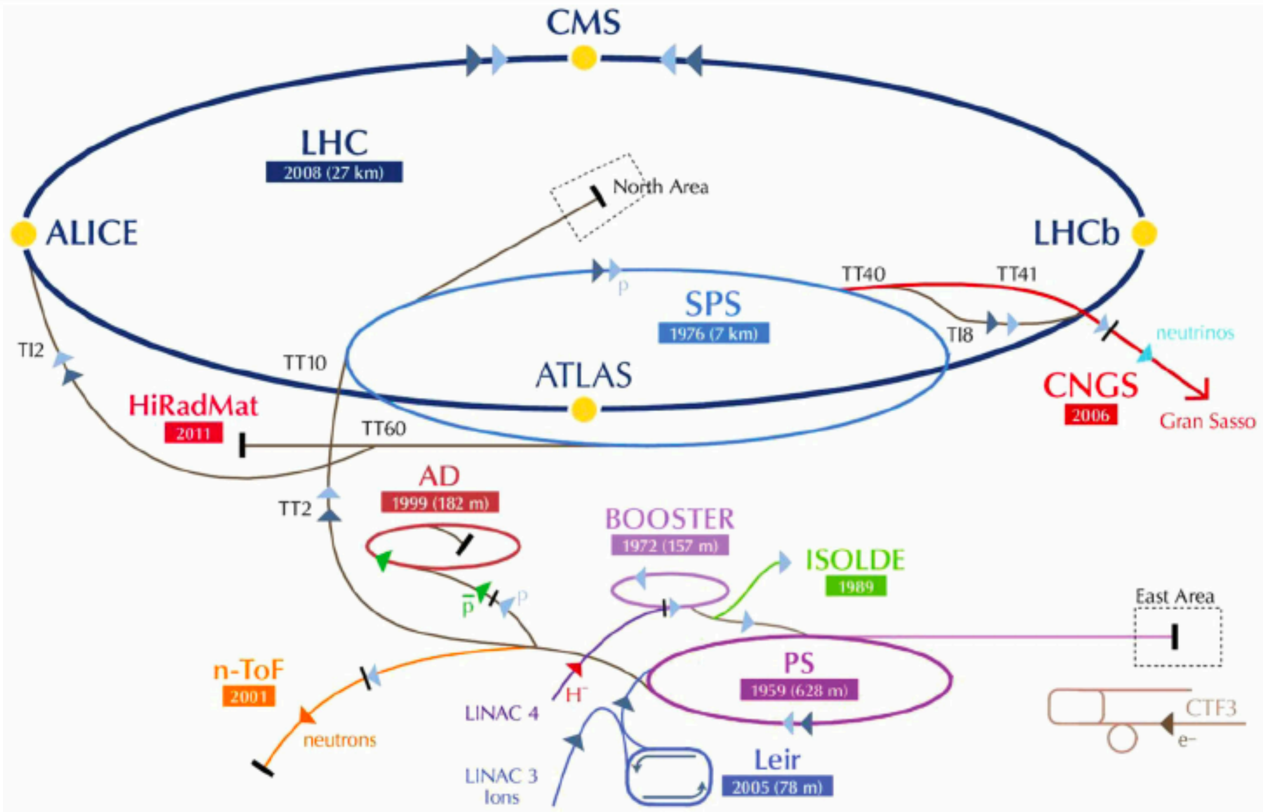
$$\Phi_j = \frac{N_j}{A_j\, \varepsilon_j\, T_j\, \Delta R_j}$$

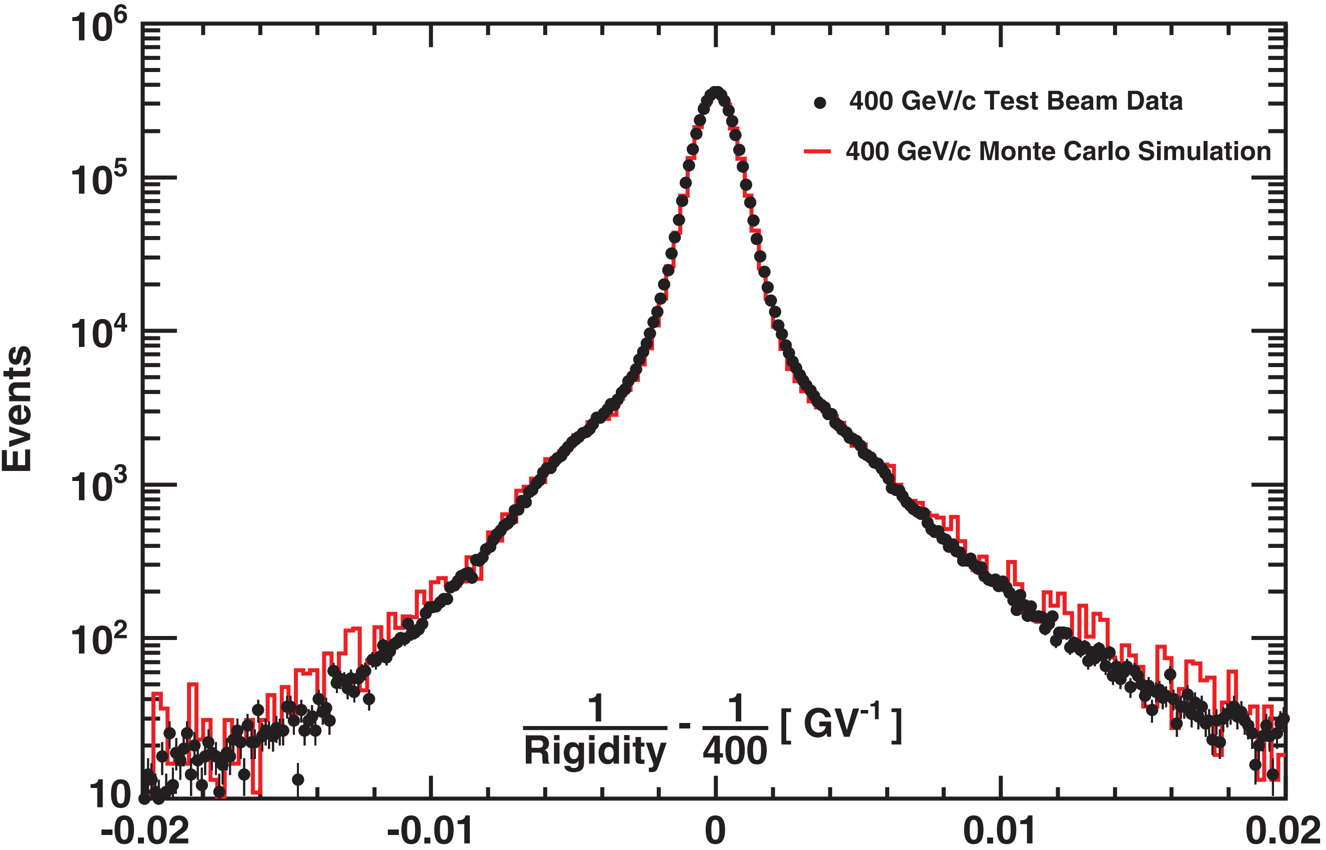


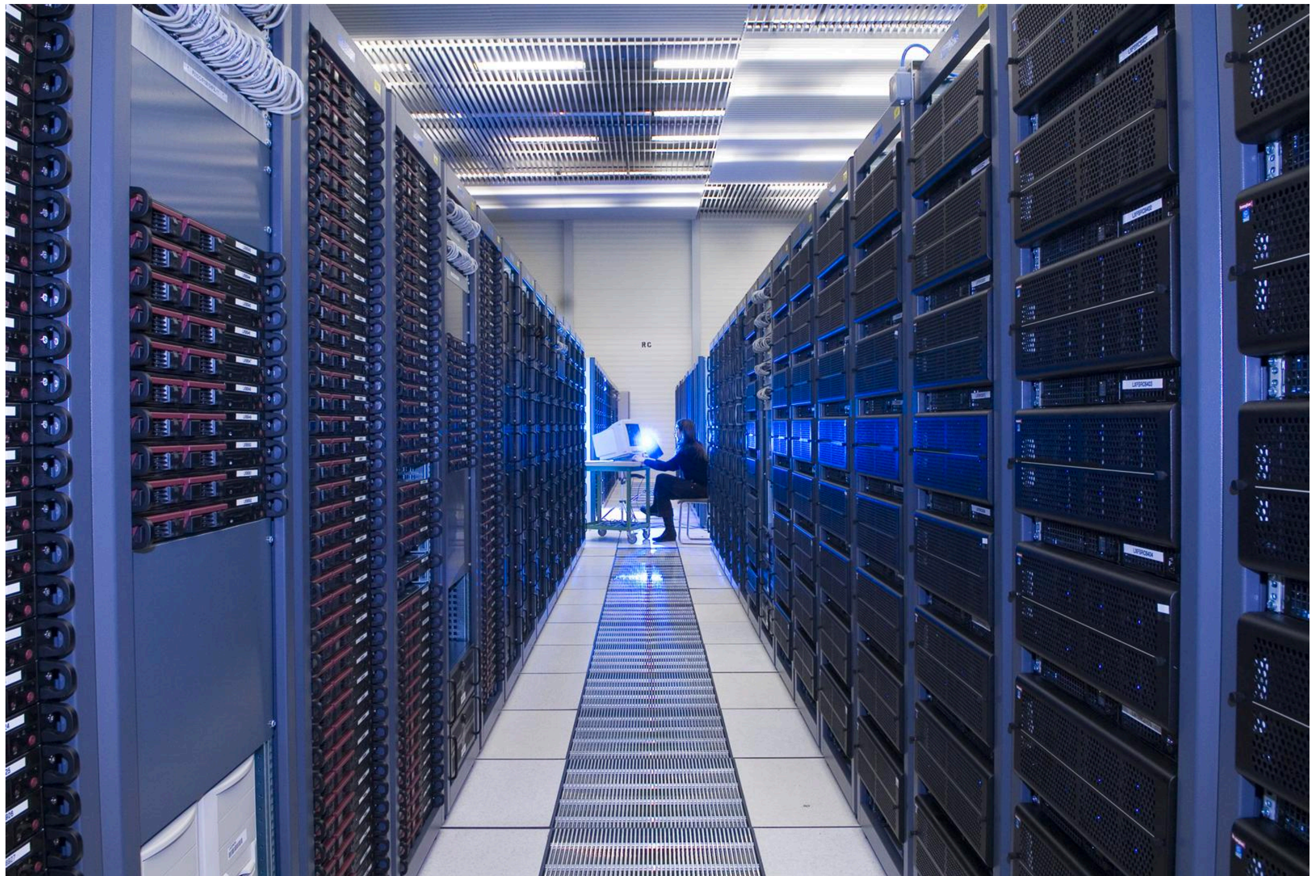
Difference between different unfolding algorithms gives a systematic error ~0.5%

Rigidity measurement

Another important source of systematic uncertainties is the knowledge of the rigidity measurement.
This affects both the energy scale of the AMS spectrometer and the bin-to-bin migrations due to the spectrometer resolution.
On protons the resolution function has been measured on the 400GV SPS beam. For heavier nuclei it can be validated with the MC simulation by examining the spatial resolution of the silicon sensors.







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