INFN BOLOGNA
Istituto Nazionale di Fisica Nucleare
Sezione di Bologna

# NAIA/AMS-02 Italy Meeting:
# **Results for Light Ions Analysis Li, Be, B, C, N & O**

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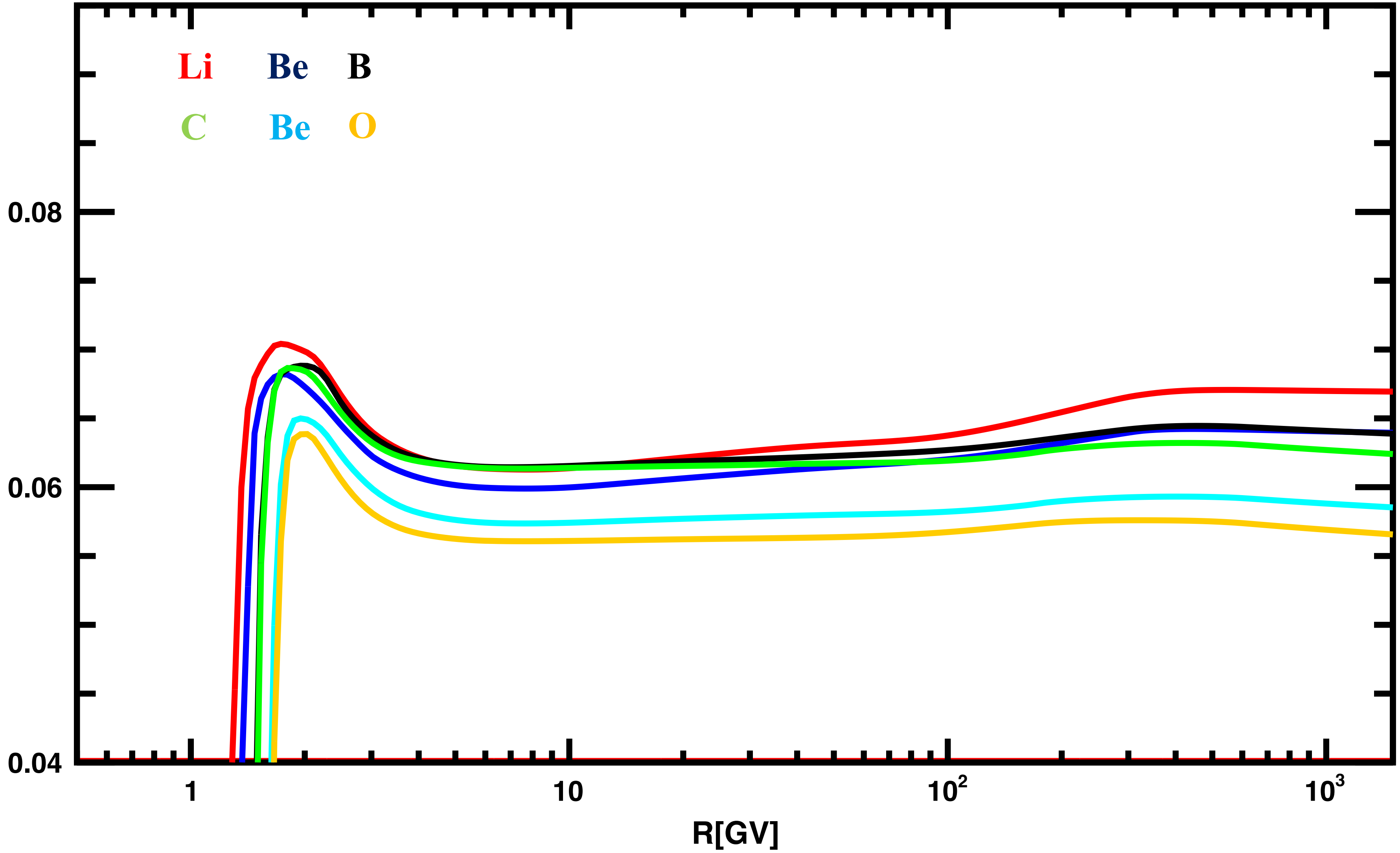
# Some Information

- **NAIA v1.0.2 ntuples**
  - First 11.5 years of AMS-02 pass8 data, from Bartels 2426 to Bartels 2581.
  - MonteCarlo pass8 B1236 for Lithium to Oxygen.
  - RTI v8.
- **What is new from last NAIA/AMS-02 meeting?**
  - Photon Trigger extension (6 more Bartels added from that period).
  - Extension of the analysis to lower rigidities.
    - New parameterization of raw acceptance, response model and unfolding.
  - Interpretations/Results plots.

# Raw Acceptances

Thanks to the new pass8 track reconstruction, the acceptance is higher and an extension of the analysis to lower rigidities is possible.



# Raw Acceptances

For estimating a low R limit for the acceptance, we calculate the ratio between the acceptance value at the lower and upper edges of every bin.

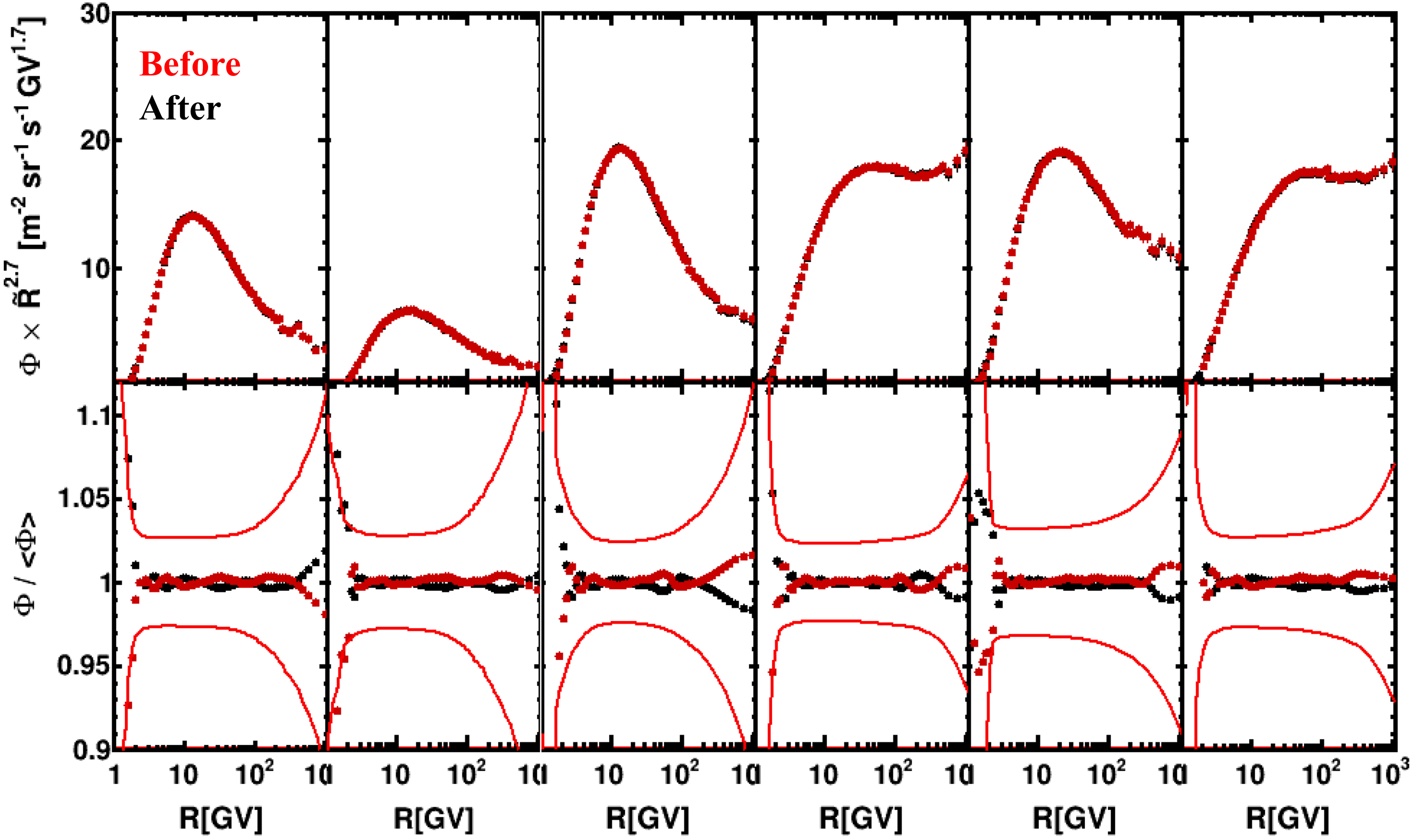
```
Z = 3
 RawAcceptance(1.16)/RawAcceptance(1.00) = inf
 RawAcceptance(1.33)/RawAcceptance(1.16) = 9.57187
 RawAcceptance(1.51)/RawAcceptance(1.33) = 1.28364
 RawAcceptance(1.71)/RawAcceptance(1.51) = 1.02652
 RawAcceptance(1.91)/RawAcceptance(1.71) = 0.995589
 RawAcceptance(2.15)/RawAcceptance(1.91) = 0.987957
Z = 4
 RawAcceptance(1.16)/RawAcceptance(1.00) = inf
 RawAcceptance(1.33)/RawAcceptance(1.16) = 6.56923
 RawAcceptance(1.51)/RawAcceptance(1.33) = 1.86565
 RawAcceptance(1.71)/RawAcceptance(1.51) = 1.0359
 RawAcceptance(1.91)/RawAcceptance(1.71) = 0.993694
 RawAcceptance(2.15)/RawAcceptance(1.91) = 0.981435
Z = 5
 RawAcceptance(1.16)/RawAcceptance(1.00) = inf
 RawAcceptance(1.33)/RawAcceptance(1.16) = 299.274
 RawAcceptance(1.51)/RawAcceptance(1.33) = 240.827
 RawAcceptance(1.71)/RawAcceptance(1.51) = 1.39615
 RawAcceptance(1.91)/RawAcceptance(1.71) = 1.0115
 RawAcceptance(2.15)/RawAcceptance(1.91) = 0.99674
```

```
Z = 6
 RawAcceptance(1.16)/RawAcceptance(1.00) = inf
 RawAcceptance(1.33)/RawAcceptance(1.16) = 11.608
 RawAcceptance(1.51)/RawAcceptance(1.33) = 3063.7
 RawAcceptance(1.71)/RawAcceptance(1.51) = 1.46239
 RawAcceptance(1.91)/RawAcceptance(1.71) = 1.00882
 RawAcceptance(2.15)/RawAcceptance(1.91) = 0.987138
Z = 7
 RawAcceptance(1.16)/RawAcceptance(1.00) = inf
 RawAcceptance(1.33)/RawAcceptance(1.16) = 6.7614
 RawAcceptance(1.51)/RawAcceptance(1.33) = 345.021
 RawAcceptance(1.71)/RawAcceptance(1.51) = 28.9223
 RawAcceptance(1.91)/RawAcceptance(1.71) = 1.11155
 RawAcceptance(2.15)/RawAcceptance(1.91) = 0.992982
Z = 8
 RawAcceptance(1.16)/RawAcceptance(1.00) = inf
 RawAcceptance(1.33)/RawAcceptance(1.16) = 6.23491
 RawAcceptance(1.51)/RawAcceptance(1.33) = 36.9568
 RawAcceptance(1.71)/RawAcceptance(1.51) = 450.775
 RawAcceptance(1.91)/RawAcceptance(1.71) = 1.19026
 RawAcceptance(2.15)/RawAcceptance(1.91) = 0.991899
```

As seen, in first approximation, Li and Be could be estimated down to [1.51-1.71] GV, B and C down to [1.71-1.91] GV and N and O down to [1.91– 2.15] GV.

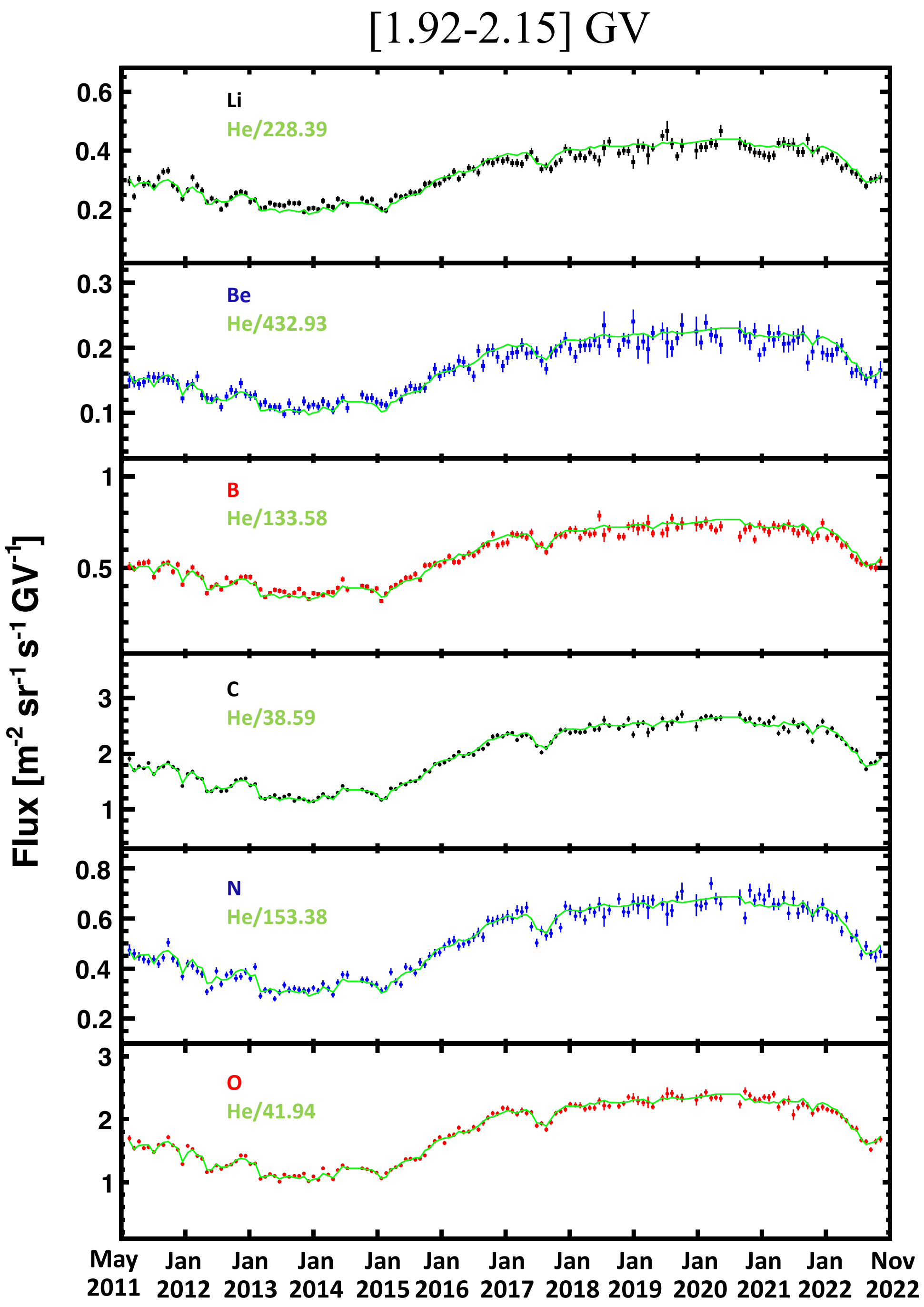
**In this presentation we are going to present every nuclei down to [1.91-2.15] GV.**

- New parameterization of the raw acceptance.
- New parameterization of the response model.
- New parameterization of the unfolding.



# Time Variation of Cosmic Light Nuclei

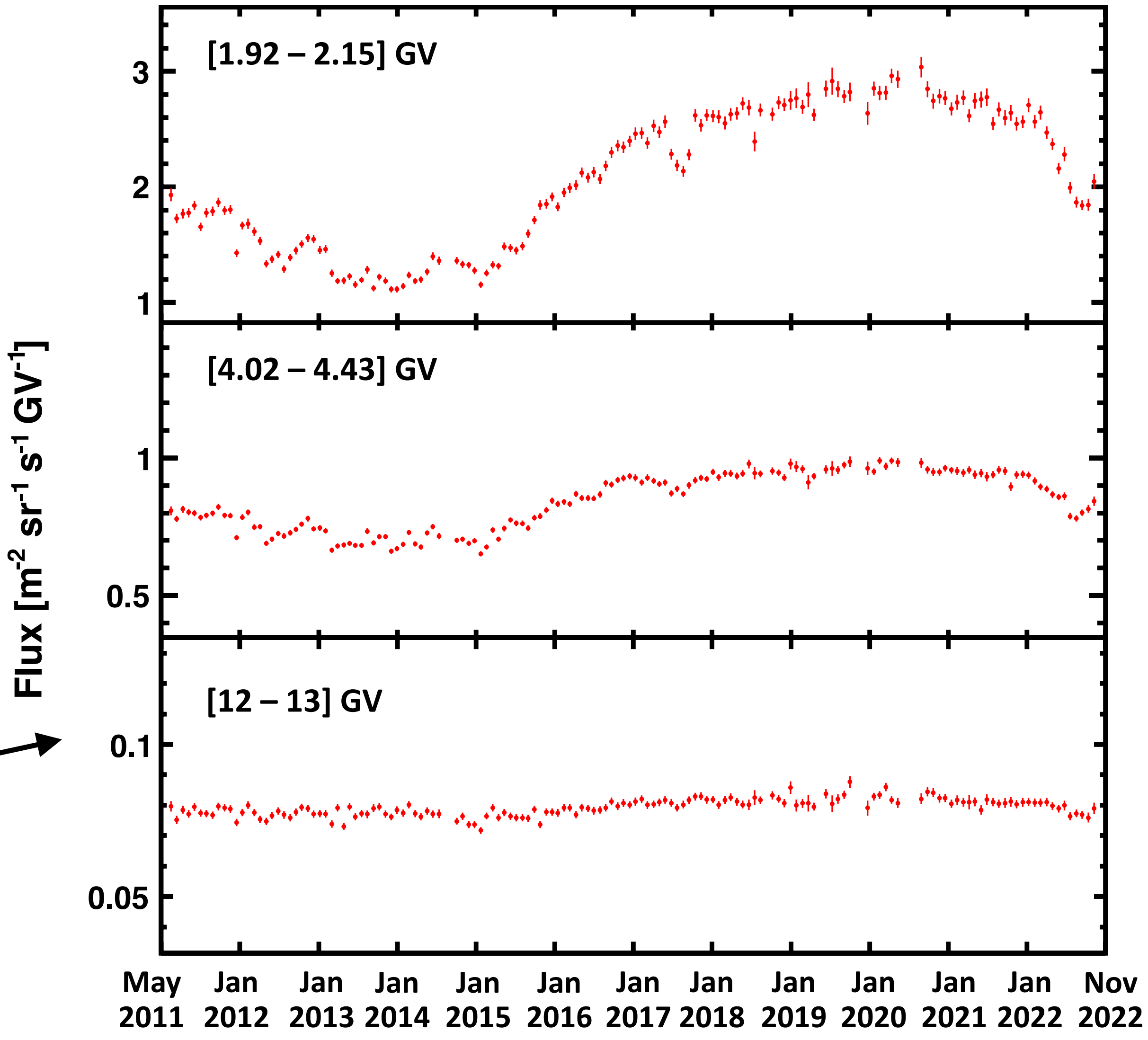
- **Data covers from May 2011 to Nov 2022, from Bartels 2426 to Bartels 2581.**
- **Data covers rigidity from 1.92 to 60 GV.**
- **A total of 5.3M Li, 2.6M Be, 7.8M B, 26.1M C, 6.6M N and 22.1M O.**
- **All fluxes show similar time behavior.**



# Time Variation of Cosmic Light Nuclei

- **Data covers from May 2011 to Nov 2022, from Bartels 2426 to Bartels 2581.**
- **Data covers rigidity from 1.92 (2.15) to 60 GV.**
- **A total of 5.3M Li, 2.6M Be, 7.8M B, 26.1M C, 6.6M N and 22.1M O.**
- **All fluxes show similar time behavior.**
- **The amplitude of the the time structures decrease with increasing rigidity.**

Carbon flux vs time for 3 rigidity bins.



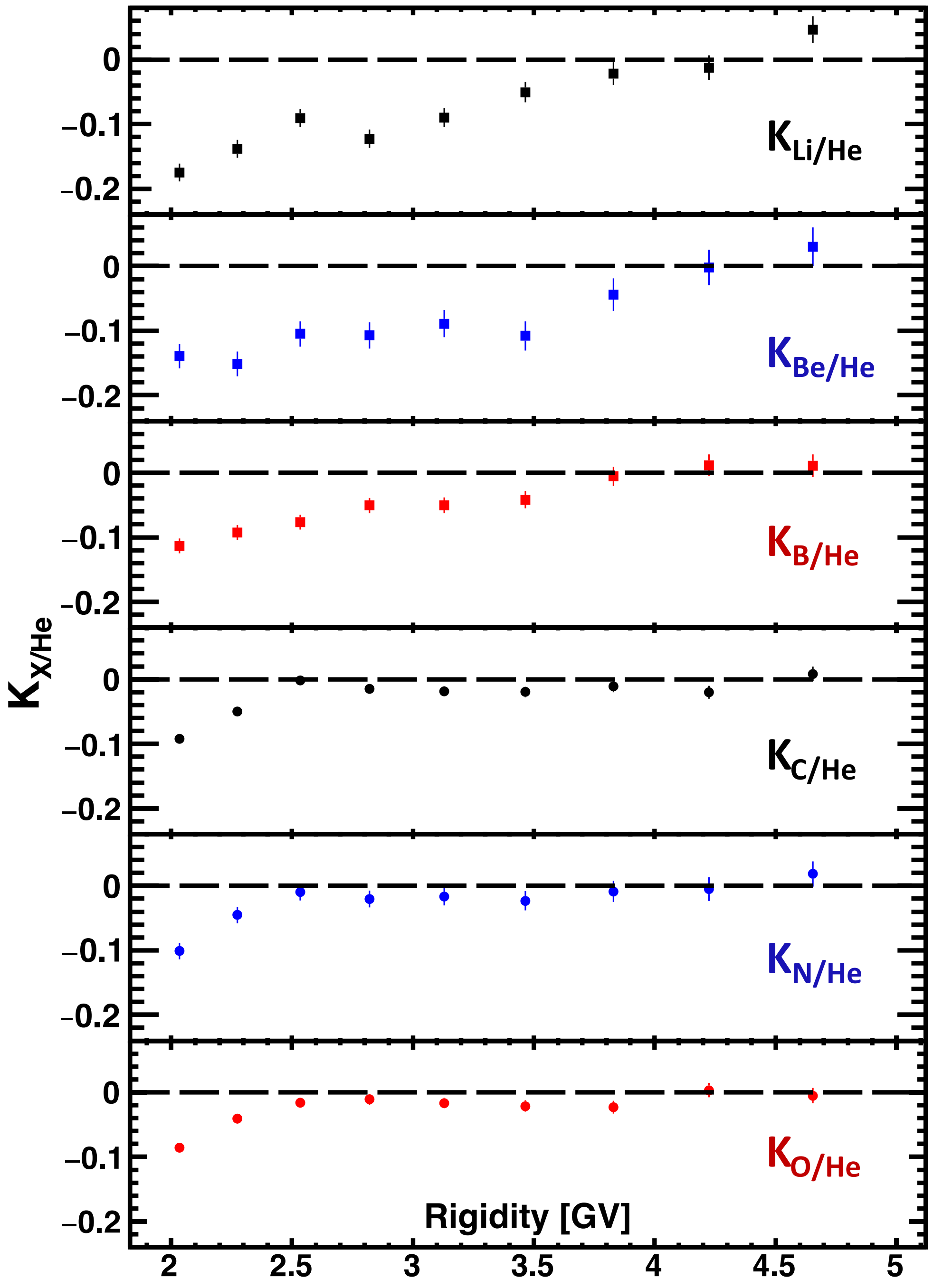
# Differences in solar modulation for light nuclei

We study the dependences of light nuclei using as references He, B and C.

$$\frac{\Phi^i_X/\Phi^i_Y - \langle \Phi^i_X/\Phi^i_Y \rangle}{\langle \Phi^i_X/\Phi^i_Y \rangle} = K^i_{X/Y} \frac{\Phi^i_Y - \langle \Phi^i_Y \rangle}{\langle \Phi^i_Y \rangle}$$

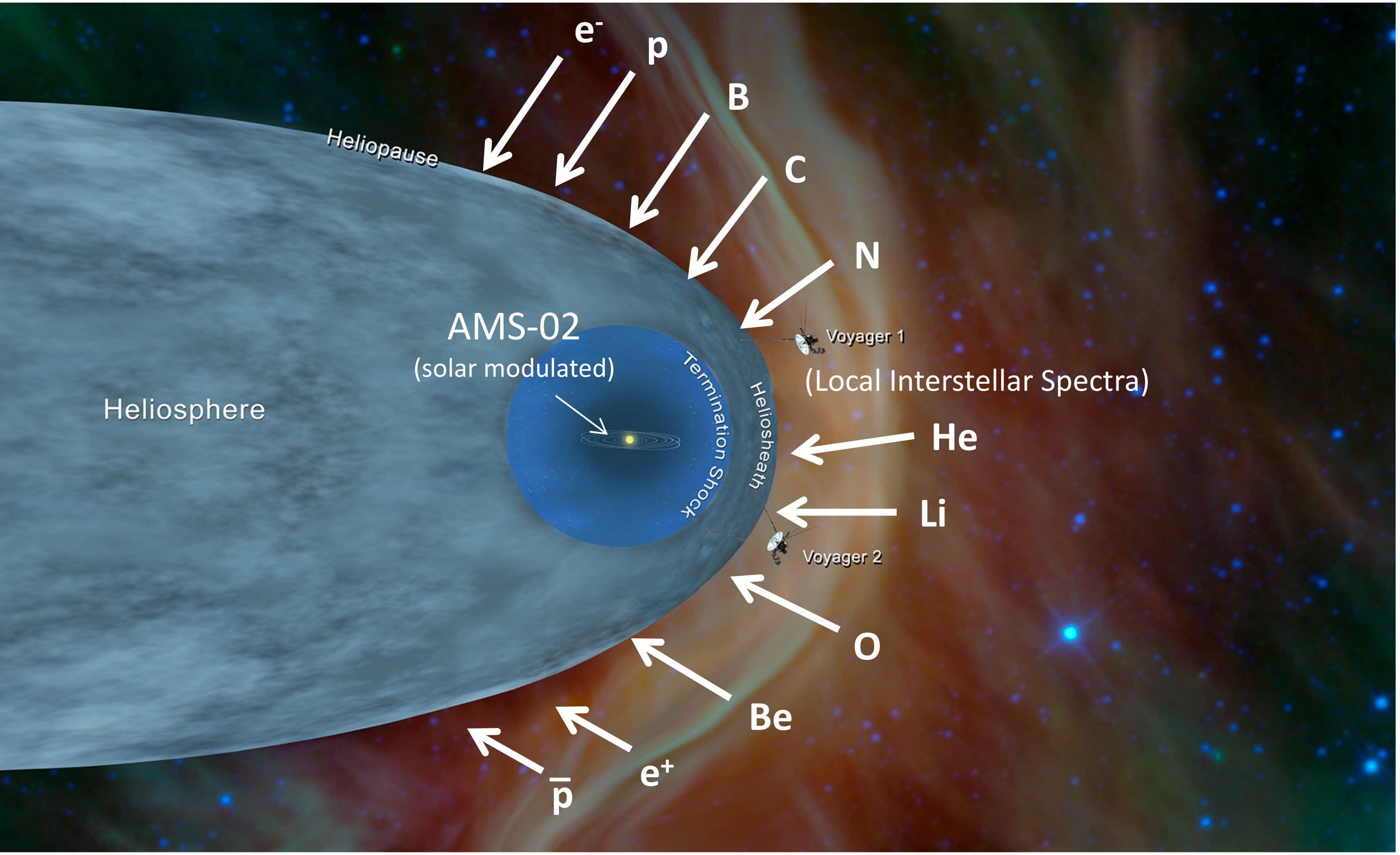
where X is the a selected nuclei from Li to O, and Y is the nuclei used as a reference.

- **Li, Be and B are significantly less modulated than He up to 3.6 GV.**
- **C, N and O are significantly less modulated than He up to 2.4 GV.**



# Galactic Cosmic Rays Propagation in the Heliosphere

GCRs entering the heliosphere are subject to diffusion, convection, adiabatic energy losses and magnetic drift.
This is commonly known as Solar Modulation.

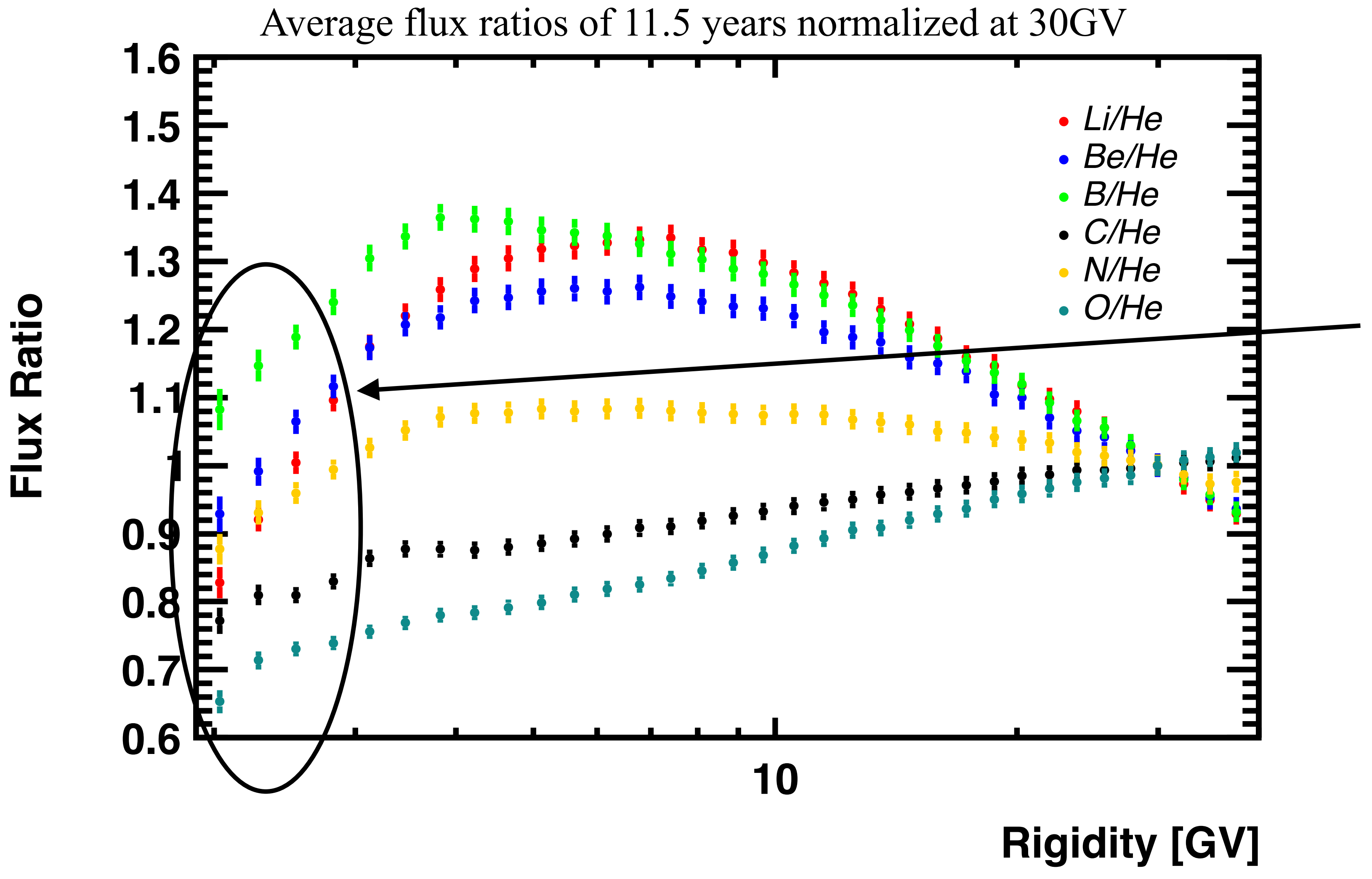



Differences in solar modulation among different nuclei can be attributed to:

- Differences in the spectral (LIS) shape of cosmic rays entering the heliosphere.
- Differences arising from the velocity dependence of the solar modulation (for the same rigidity different species have different velocities depending on the A/Z ratio).

Measuring the rigidity dependences of solar modulation on elements with **different spectral shape** (primary/secondary) and/or **different A/Z** (as ex. 2 for C, 2.167 ± 0.033 for Li) provides information of the propagation of CRs in the heliosphere.

# Galactic Cosmic Rays Propagation in the Heliosphere



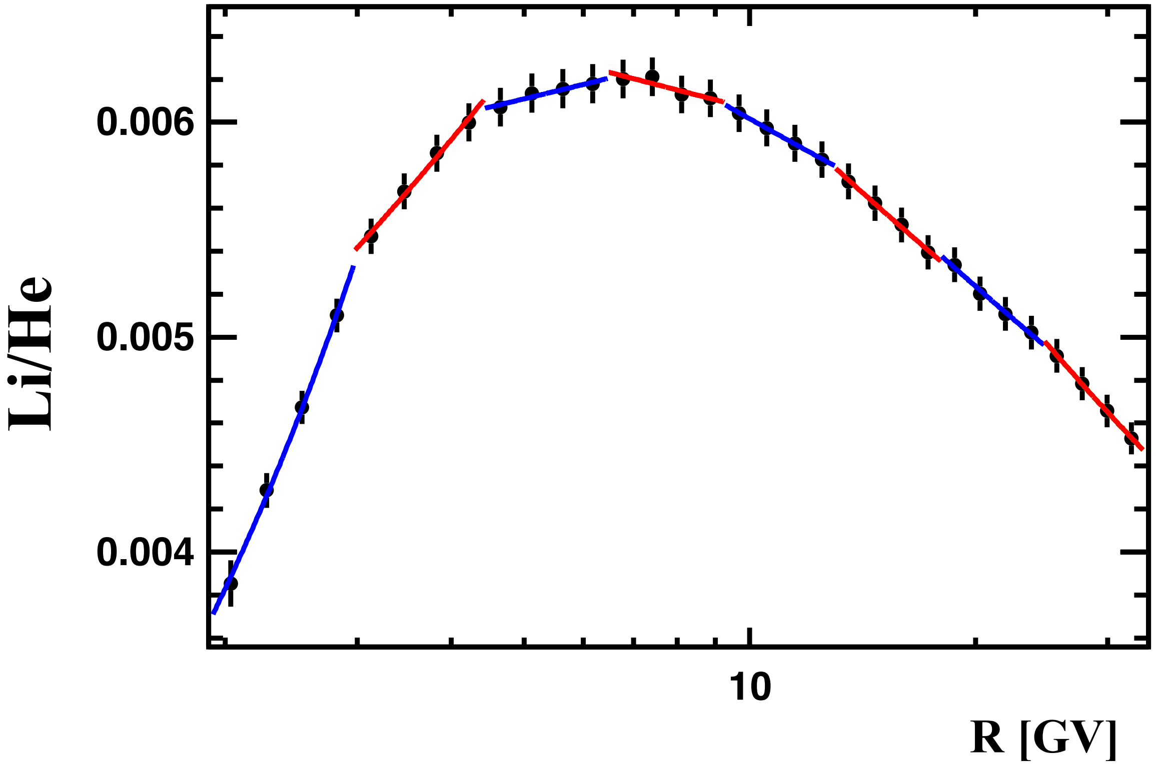

Differences in solar modulation among different nuclei can be attributed to:

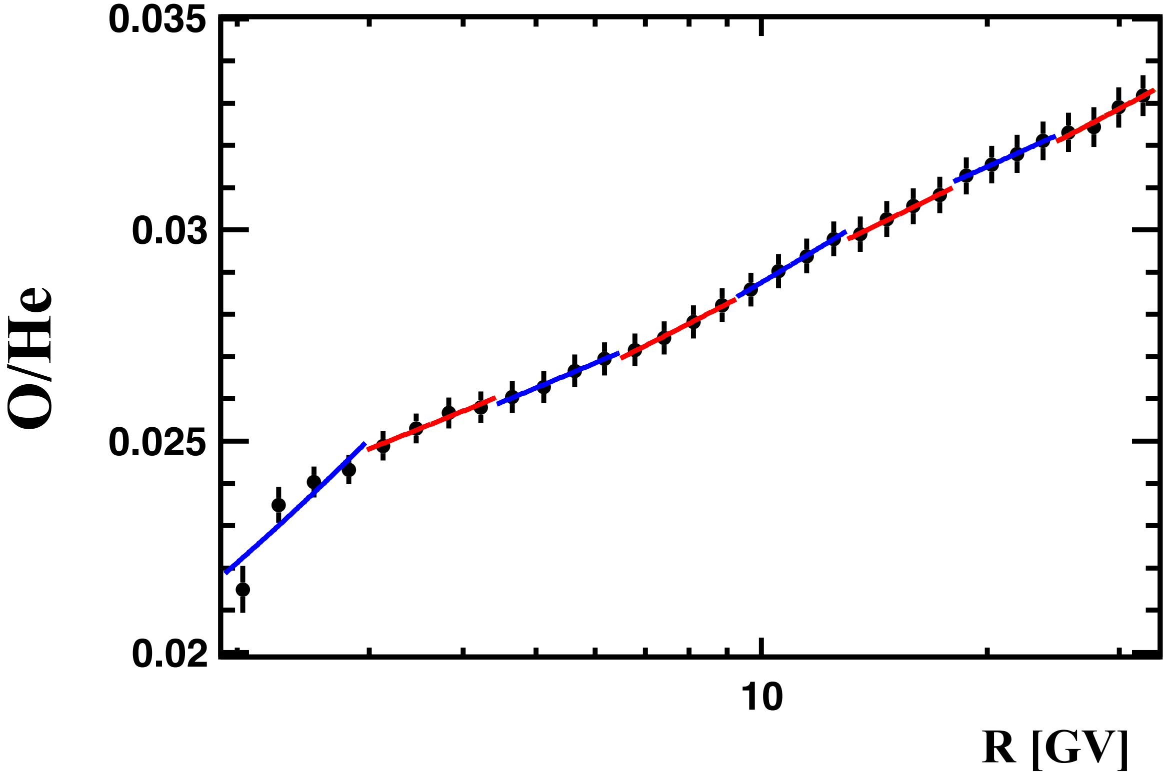
- Differences in the spectral (LIS) dependence of cosmic rays entering the heliosphere.
- Differences arising from the velocity dependence of the solar modulation (for the same rigidity different species have different velocities depending on the A/Z ratio).

The A/Z are 2.17 ± 0.03 for Lithium, **2.00 ± 0.03 for Beryllium**, 2.14 ± 0.02 for Boron, 2 for Carbon, 2.07 ± 0.03 for N, and 2 for O. (From AMS publications)

# AMS X/He ratio fits

The AMS X/He ratios are fitted by a power law in different rigidity ranges.
To have sensitivity we use a 4 bins range for every fit.



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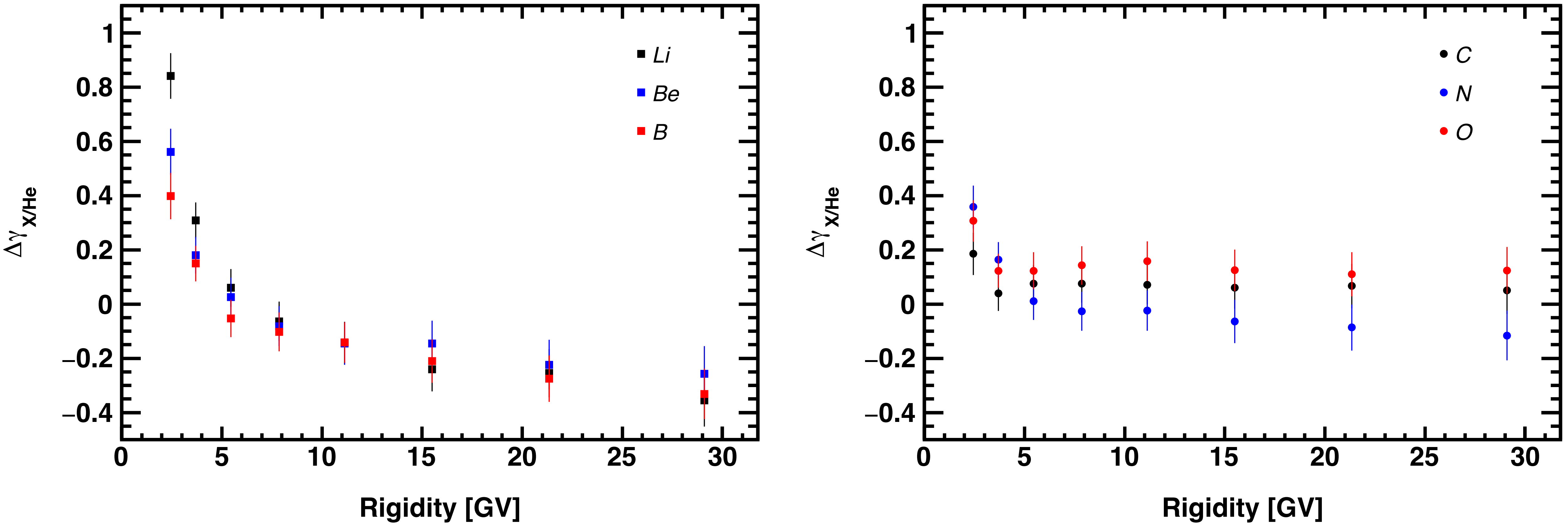




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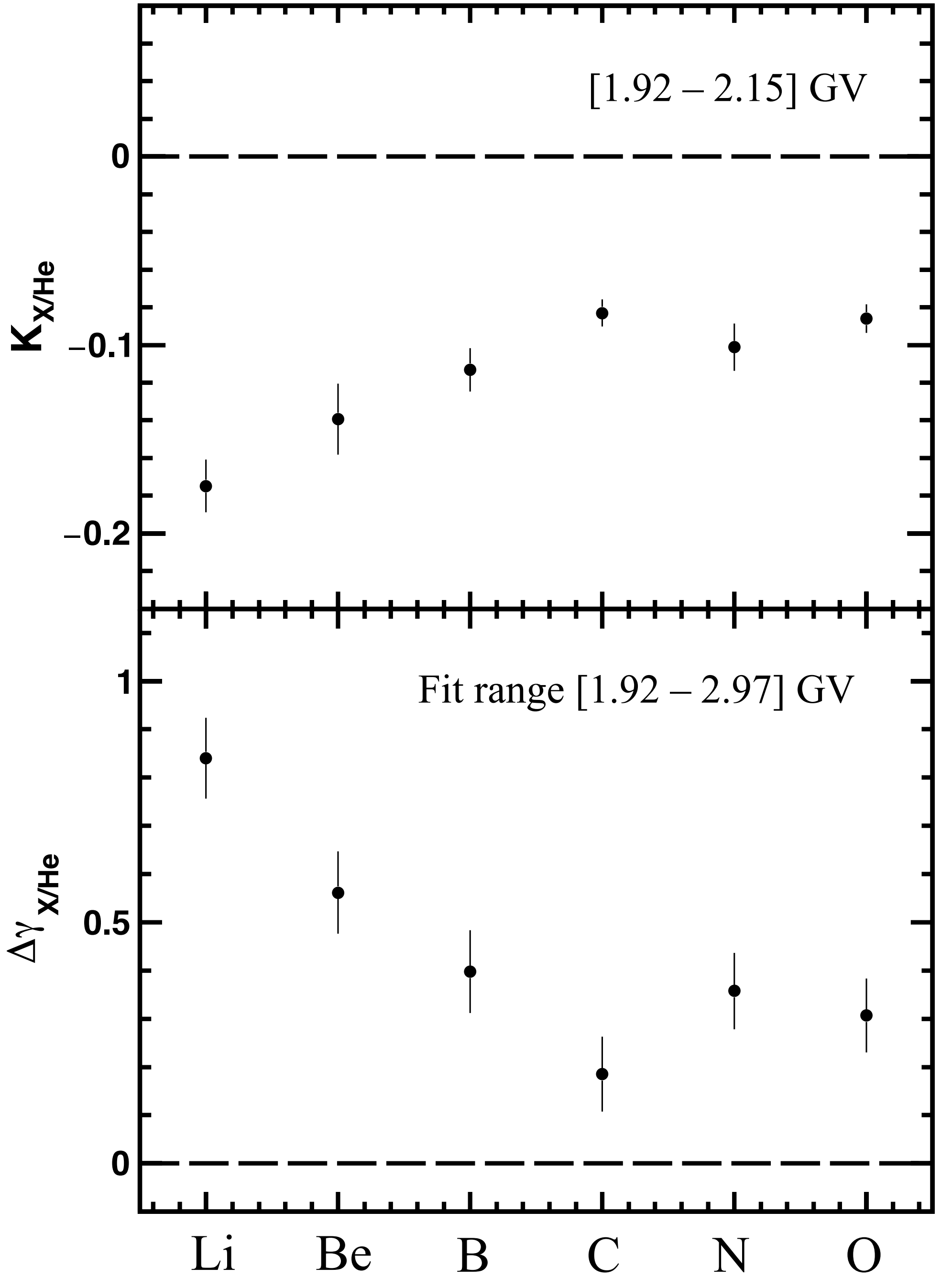
# Spectral Index and K-parameter correlation

- When comparing the $\mathbf{K}_{\mathbf{X/He}}$ for the first rigidity bin vs the $\boldsymbol{\Delta\gamma}_{\mathbf{X/He}}$ ,for the fit over the first 4 rigidity bins, an anti-correlation is observed.
- Nuclei with higher $\boldsymbol{\Delta\gamma}_{\mathbf{X/He}}$ suffer less modulation.
- This is the first time this effect has been measured directly from data, independently of any model.



# Conclusions

- **The Bartels fluxes for Lithium to Oxygen for the first 11.5 years of AMS data taking, from Bartels 2426 to Bartels 2581, have been present.**

- **Thanks to the new reconstruction implemented in pass8, an extension to lower rigidities is possible.**

- **Parameterizations of raw acceptance, response model and unfolding have been extended to those rigidities.**

- **Another point at [1.92-2.15] GV has been added for both nitrogen and oxygen, allowing to a more fair comparison between all the nuclei.**

- **The discussed plots within the collaboration during the paper period have been updated.**

# Back Up