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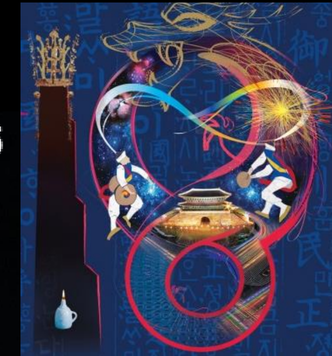


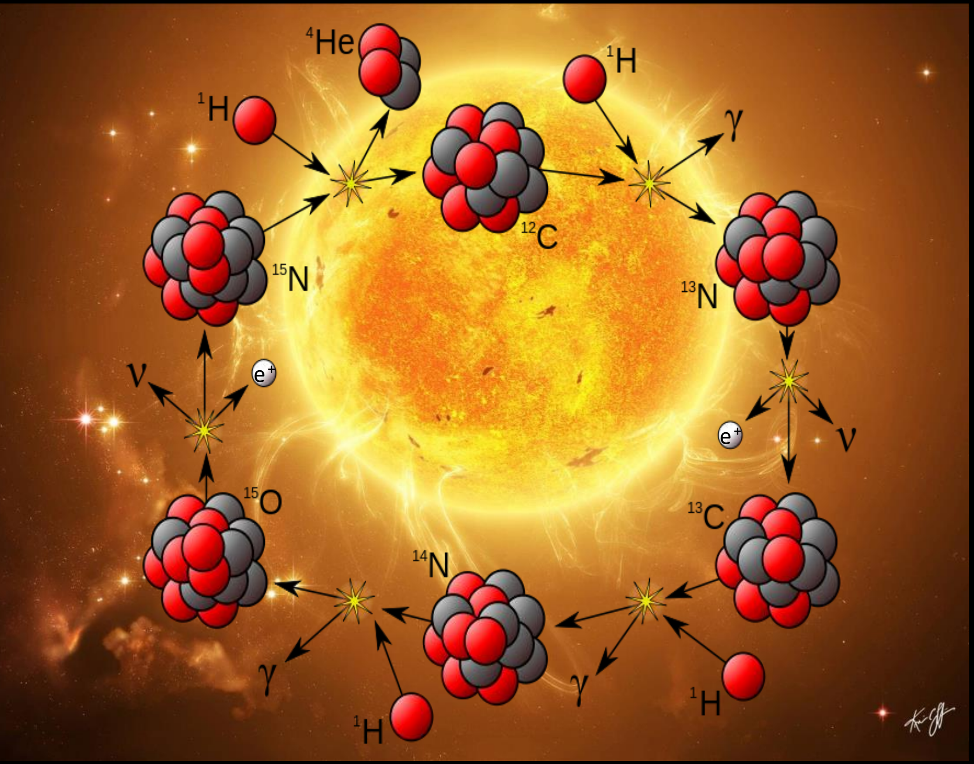
J. Berdugo
On behalf of the
AMS-02 Collaboration
CIEMAT (Madrid)

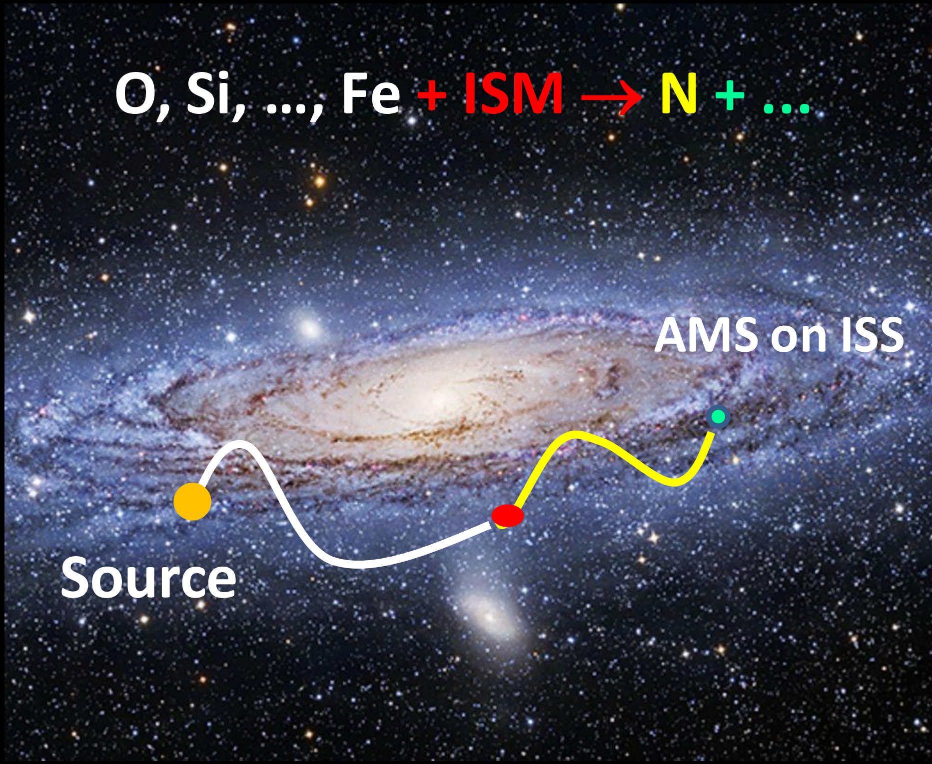
Precision Measurement of Nitrogen flux by AMS

Nitrogen nuclei in cosmic rays

Astrophysical sources, mostly via the CNO cycle

Collisions of heavier nuclei with the interstellar medium





The nitrogen flux is expected to contain both primary Φ_N^P and secondary Φ_N^S components.

In the Solar System: N/O ≈ 0.14

Synthesis of Elements in Stars , Lodders, K. , Springer-Verlag Berlin Heidelberg p. 379-417 (2010)

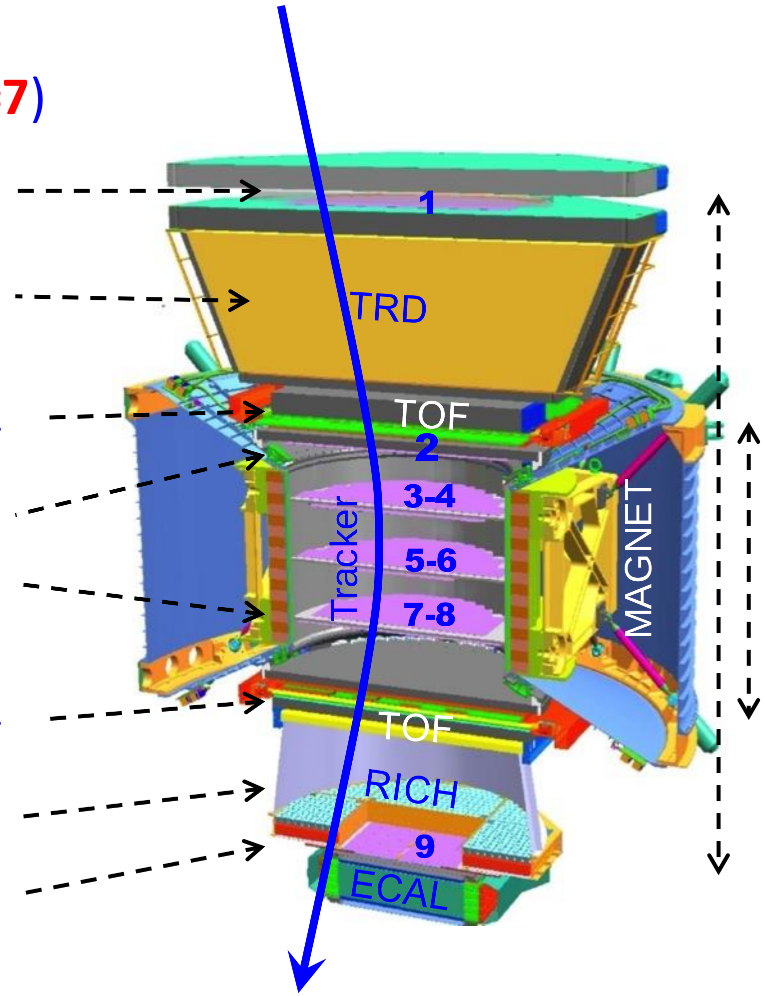
AMS: Nitrogen nuclei flux measurement

In the first five years AMS collected 85 x 10^9 cosmic ray events

Charge

ΔZ (**Z=7**)

Tracker L1	0.32
TRD	0.33
Upper TOF	0,14
Tracker L2-L8	0.12
Lower TOF	0.14
RICH	0.35
Tracker L9	0.32



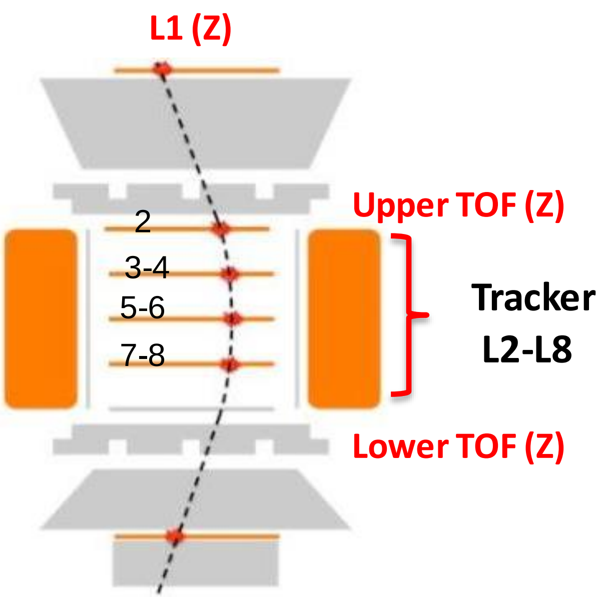
Momentum

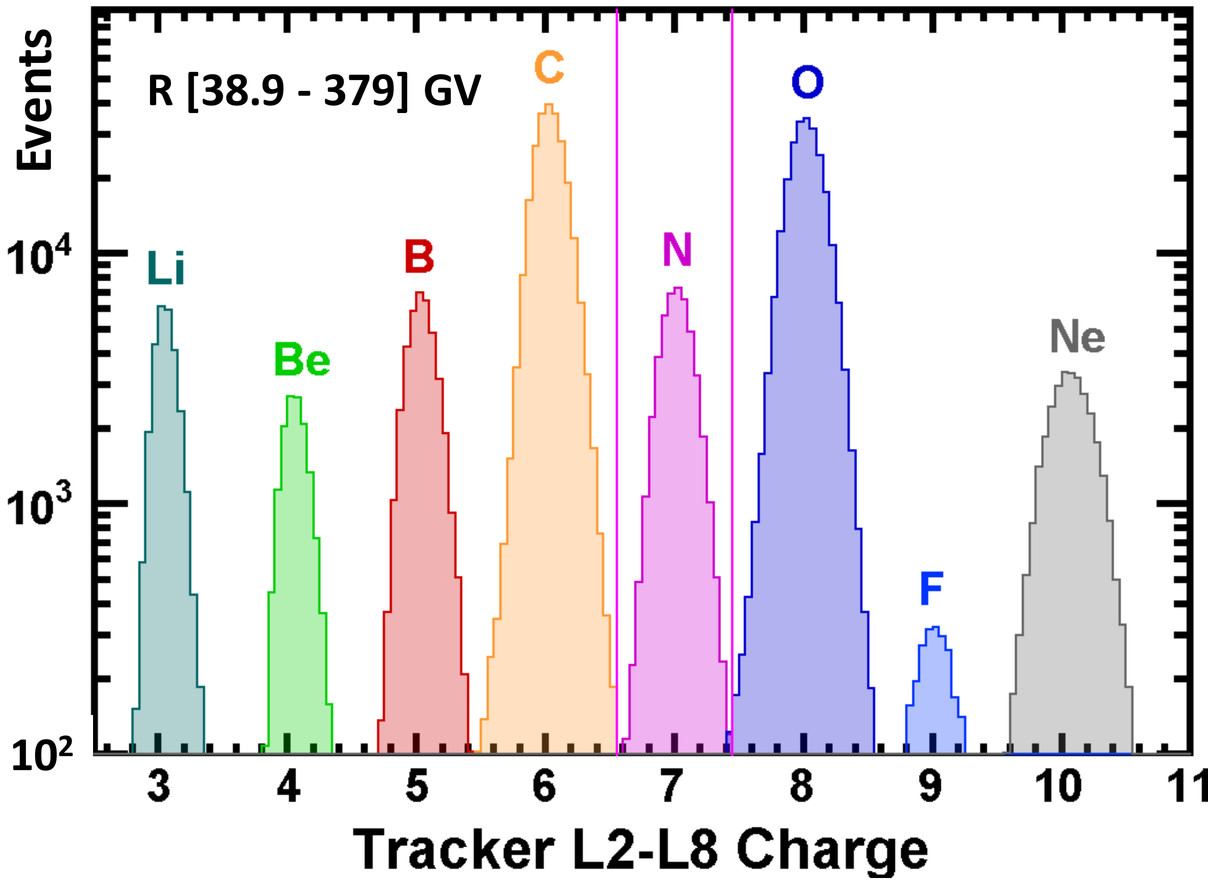
Tracker, R = p/Z
Full Span MDR (**Z=7**) ≈ 3.5 TV

TOF, β
Δβ (β=1, **Z=7**) ≈ 0.01

Nitrogen nuclei selection

Measurement of the charge of the particles in the inner Tracker

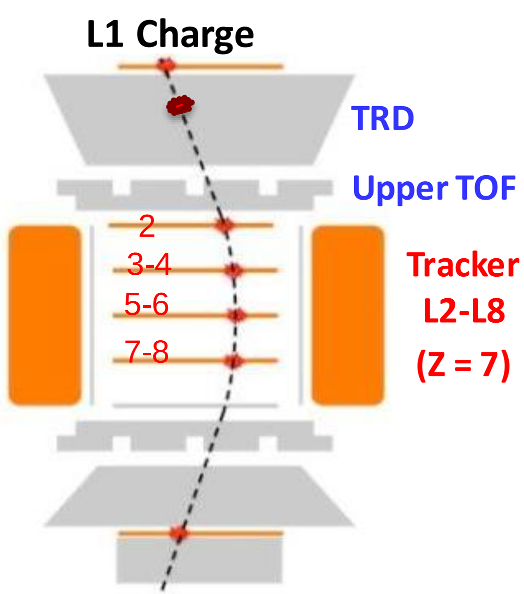


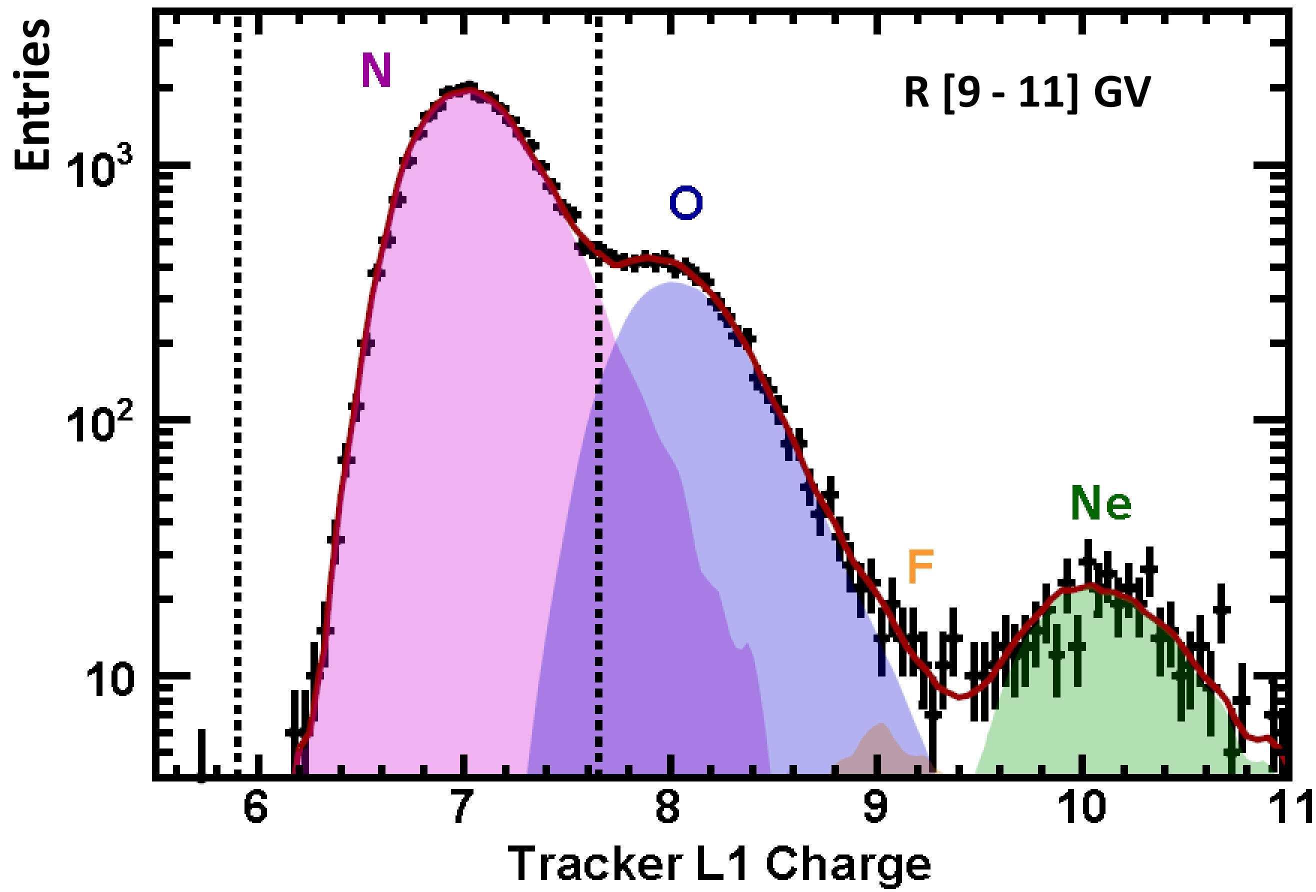


The charge misidentification is <0.1% over the whole rigidity range

Nitrogen nuclei background subtraction

a) interactions of heavier nuclei in the TRD and upper TOF material



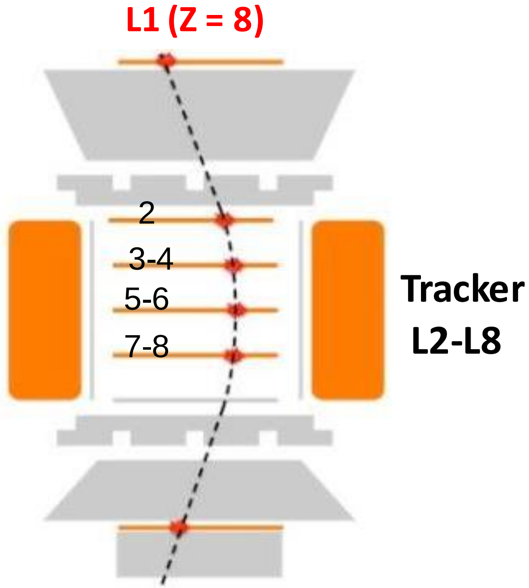


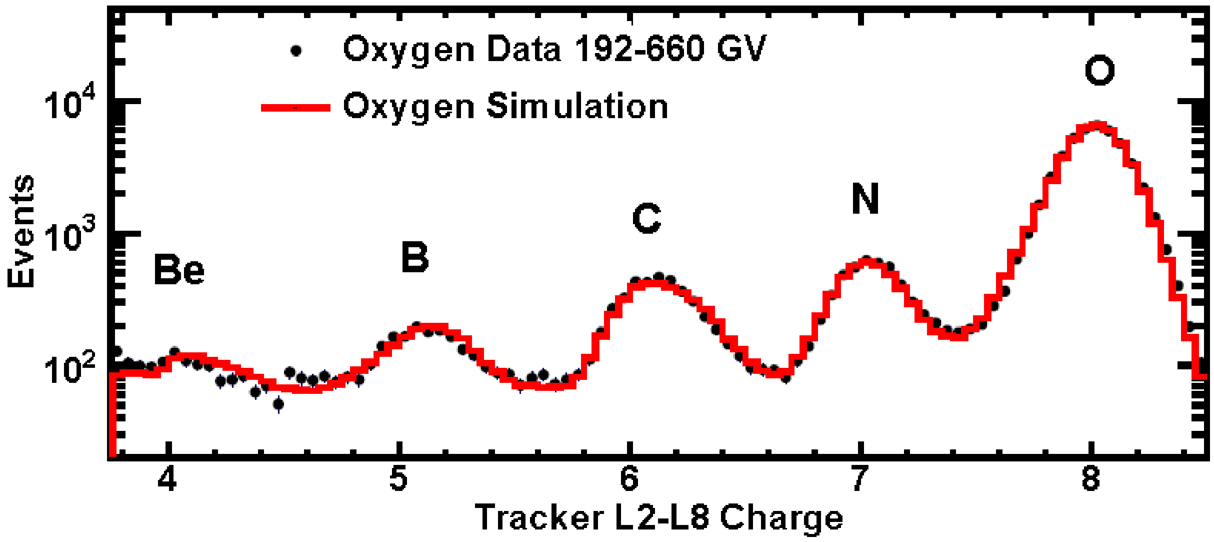
After Tracker L1 charge cut, the background due to interactions of heavier nuclei inside AMS is <5% over the whole rigidity range

Nitrogen nuclei background subtraction

b) interactions of heavier nuclei above L1 is estimated using MC
→ Background <3% below 200 GV and 6% at 3.3 TV

MC Verification with Data





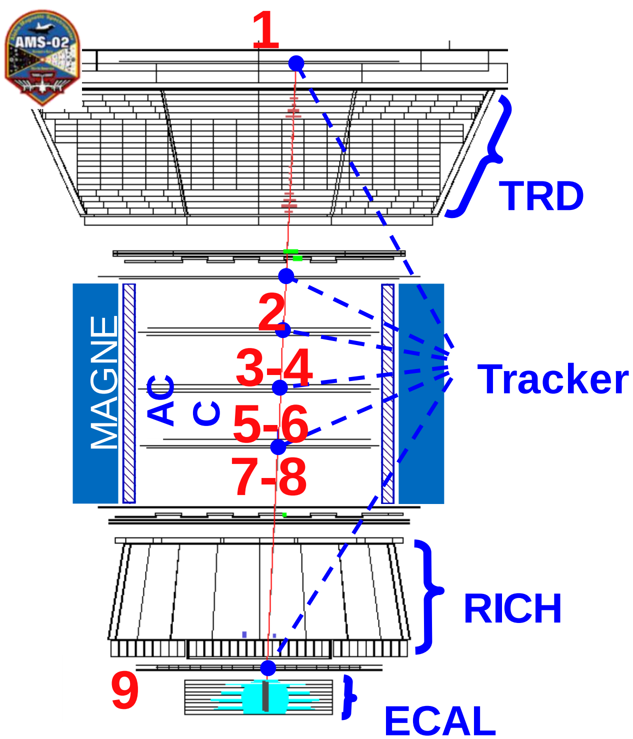
The systematic error on the flux due to uncertainties due to the total background subtraction is <1.5% over the entire rigidity range.

The data sample contains 2.2 x 10^6 nitrogen nuclei events

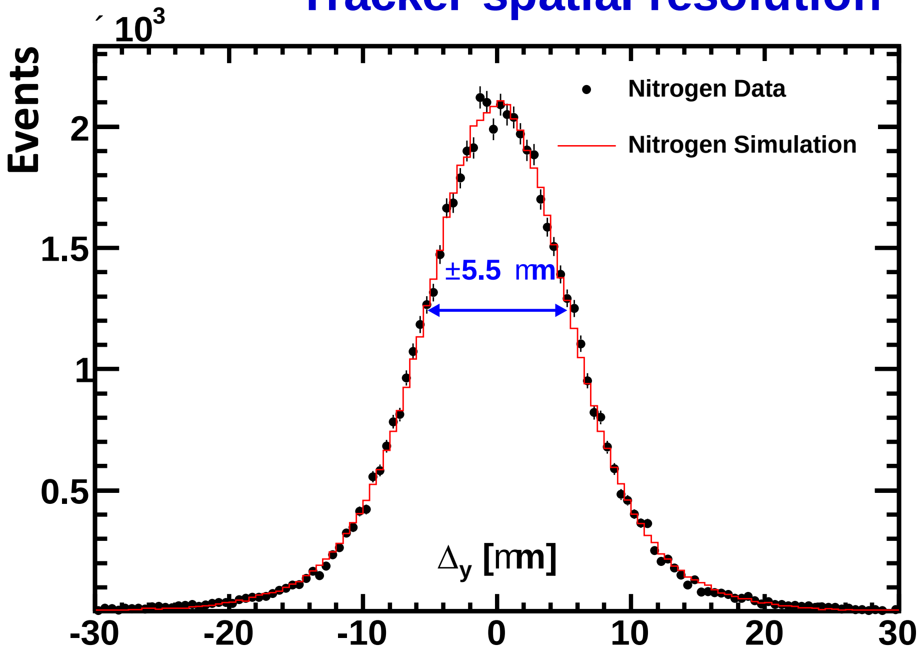
Nitrogen nuclei rigidity resolution

The bin-to-bin migration of events was corrected with unfolding procedures using the rigidity resolution function

Resolution function verification



Tracker spatial resolution



L1 – L9: MDR ≈ 3.5 TV

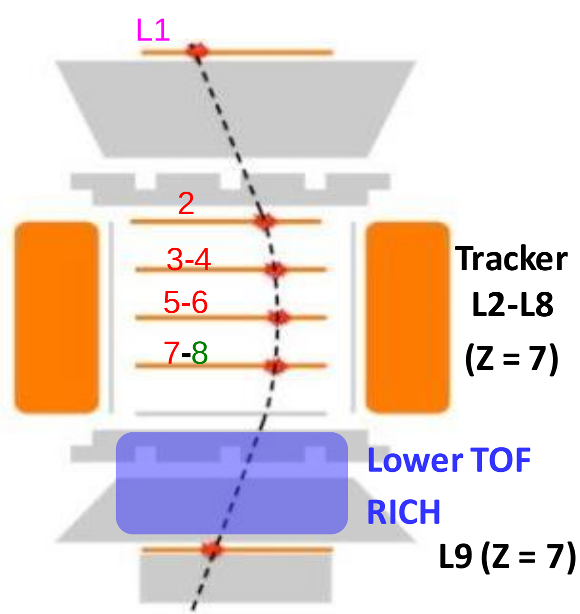
The systematic error on the flux due to uncertainties

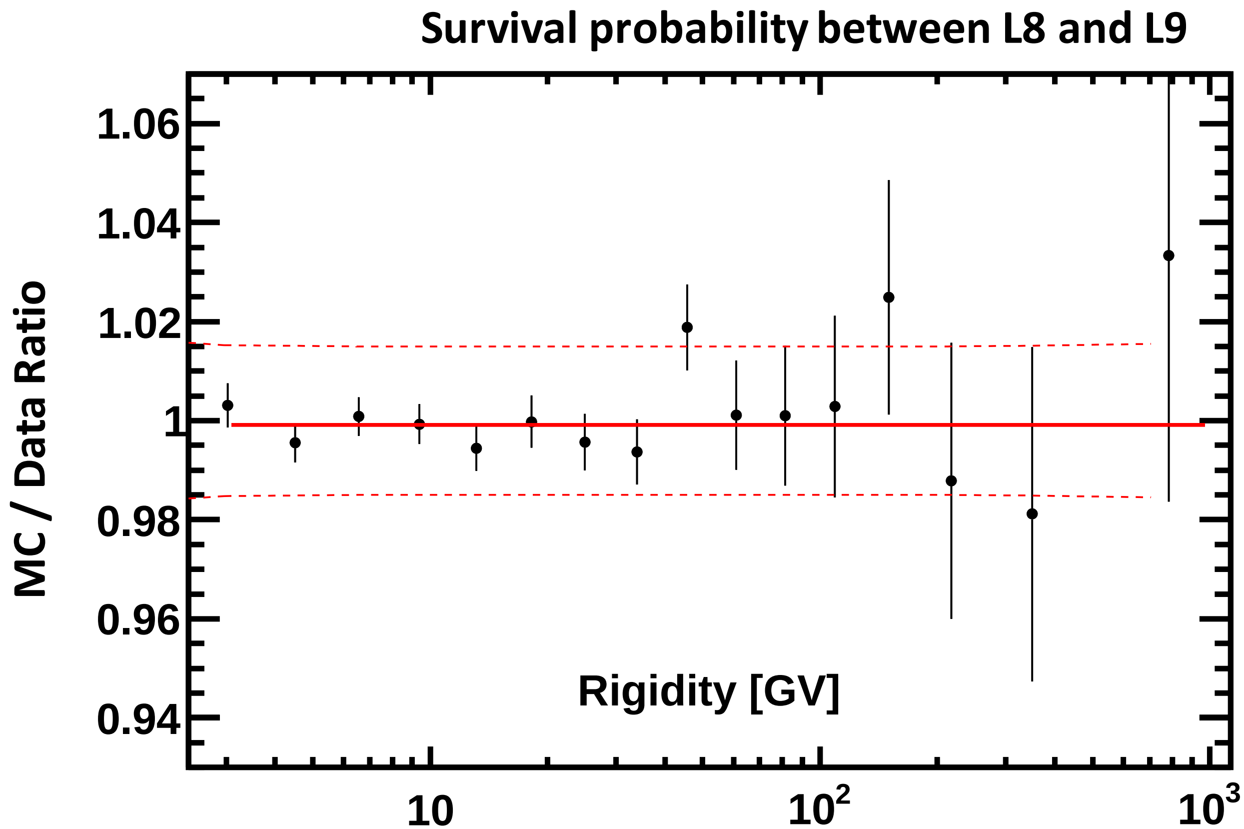
- **in the rigidity resolution function is <1% below 150 GV and 3% at 3.3 TV**
- **in the energy scale is <0.6% below 100 GV and 5% at 3.3 TV**

AMS Nitrogen effective acceptance

Calculated using MC and corrected for small differences between the data and simulated events

MC verification with Data
Inelastic cross section

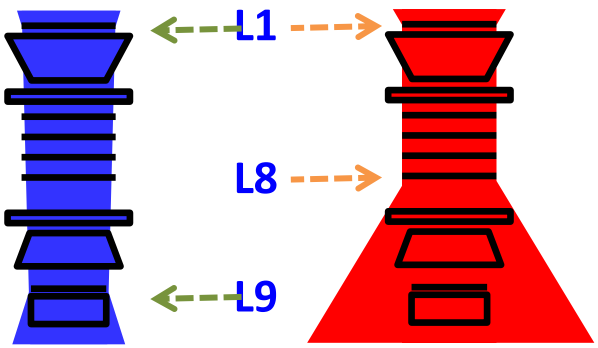


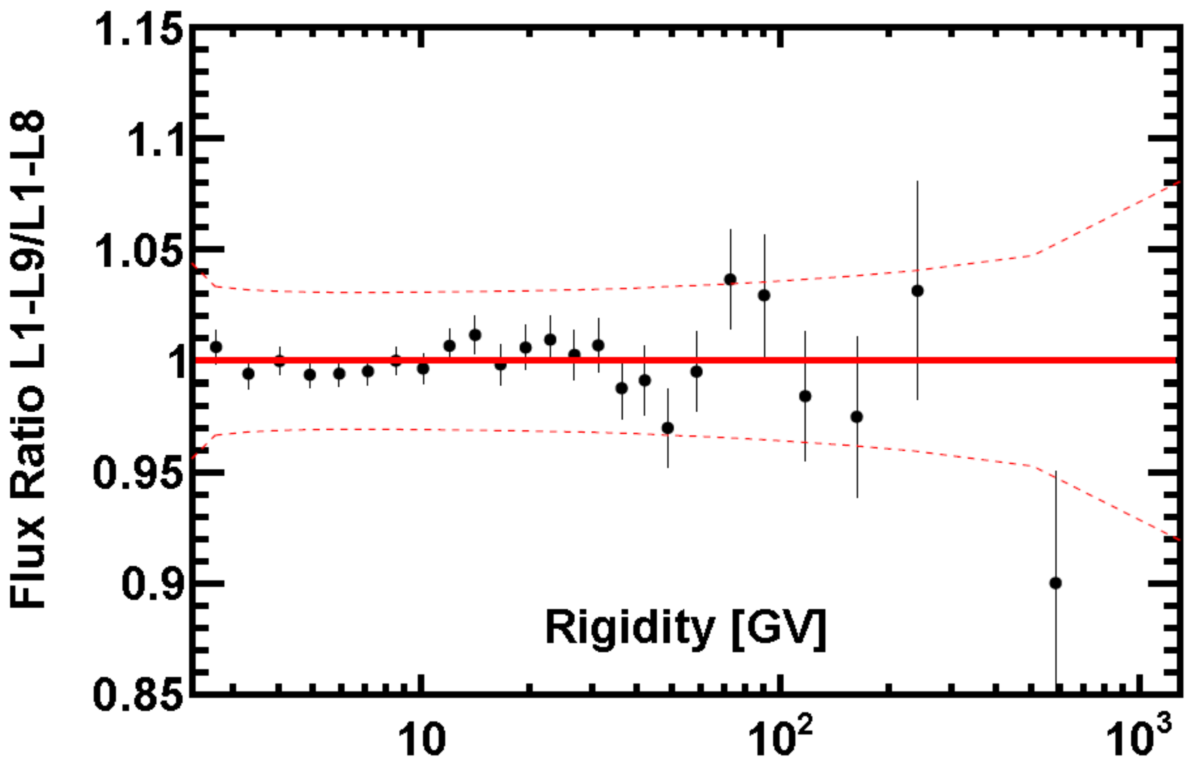


Systematic error due to uncertainties on the effective acceptance
<3 % below 100 GV and 4 % at 3.3 TV

Verification of the systematic errors

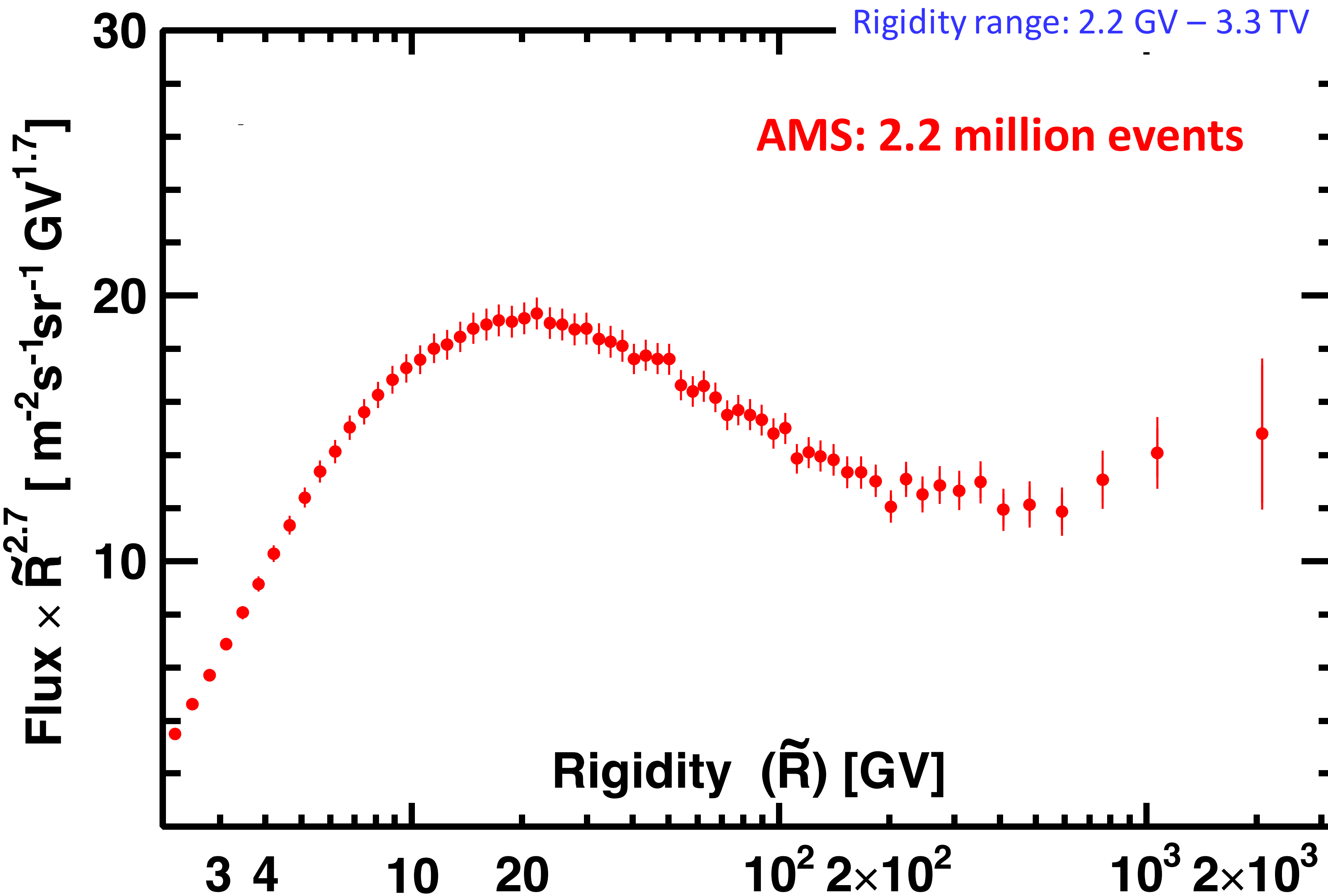
Ratio of flux measured using events passing through L1-L9 over the flux measured using events passing through L1-L8





The observed agreement verifies the estimation of the systematic errors on the acceptances and on the resolution functions

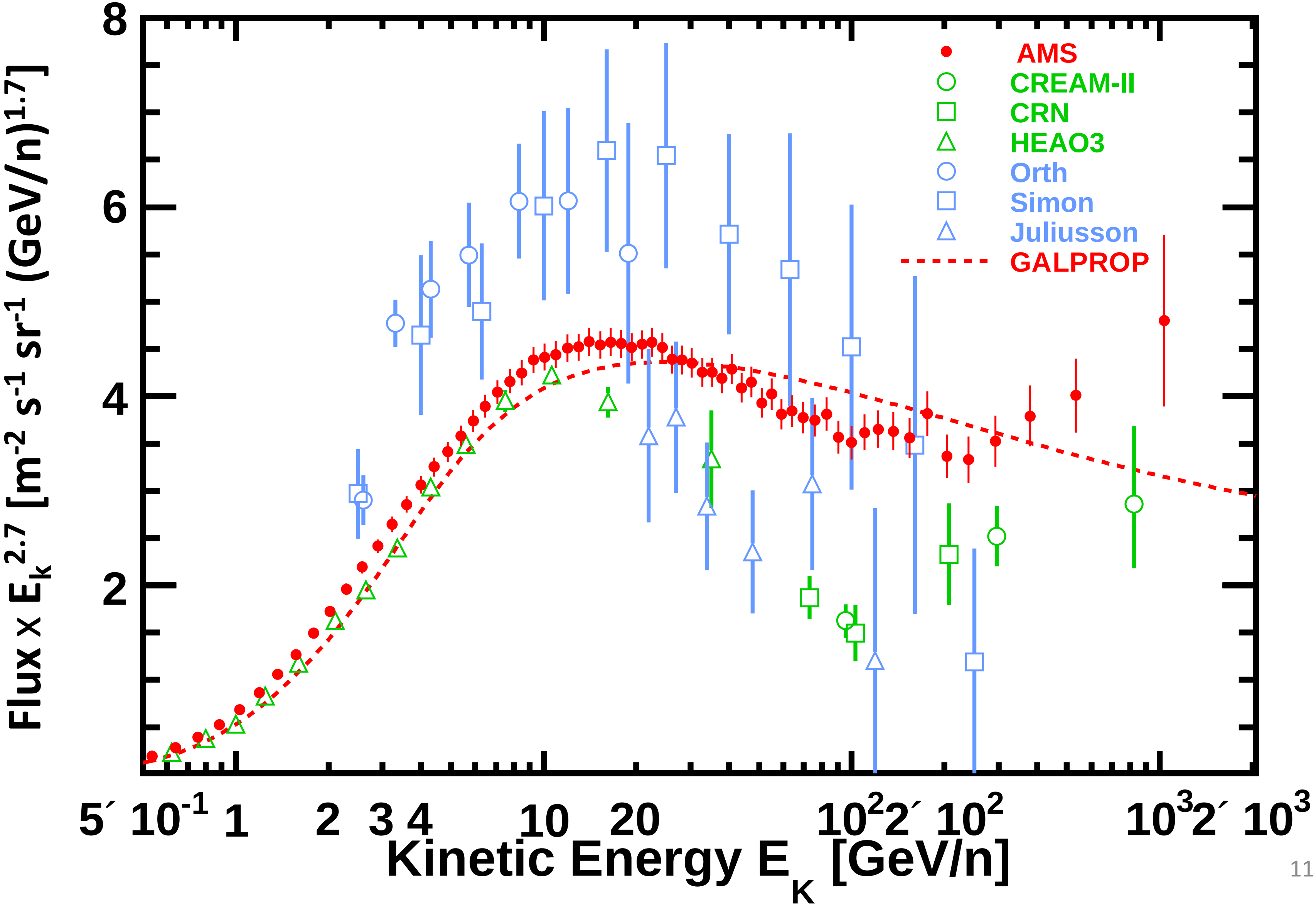
The AMS Result on the Nitrogen Flux



Total systematic error: 3% 3.5% 7%

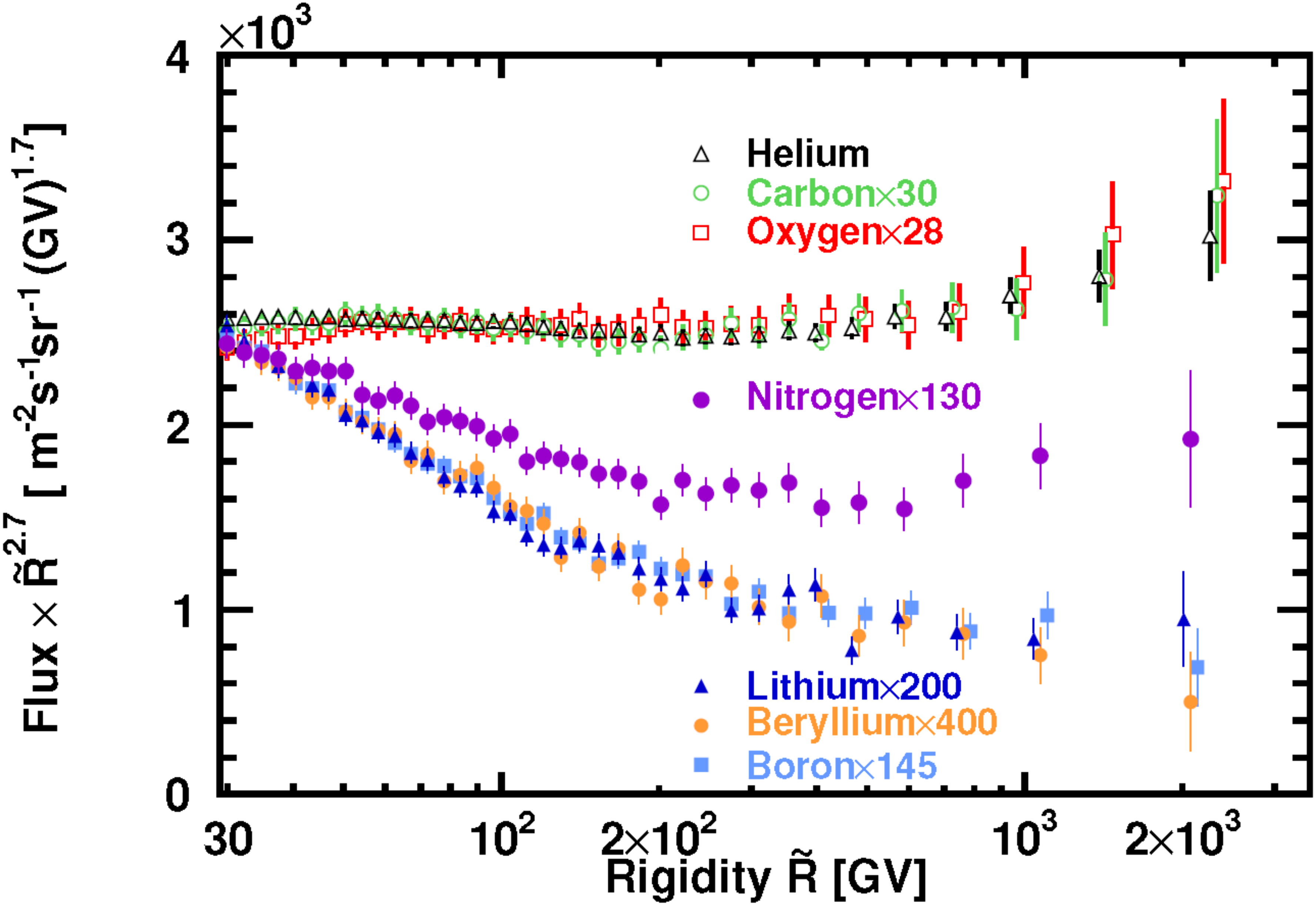
The AMS Result on the Nitrogen Flux

compared with earlier measurements

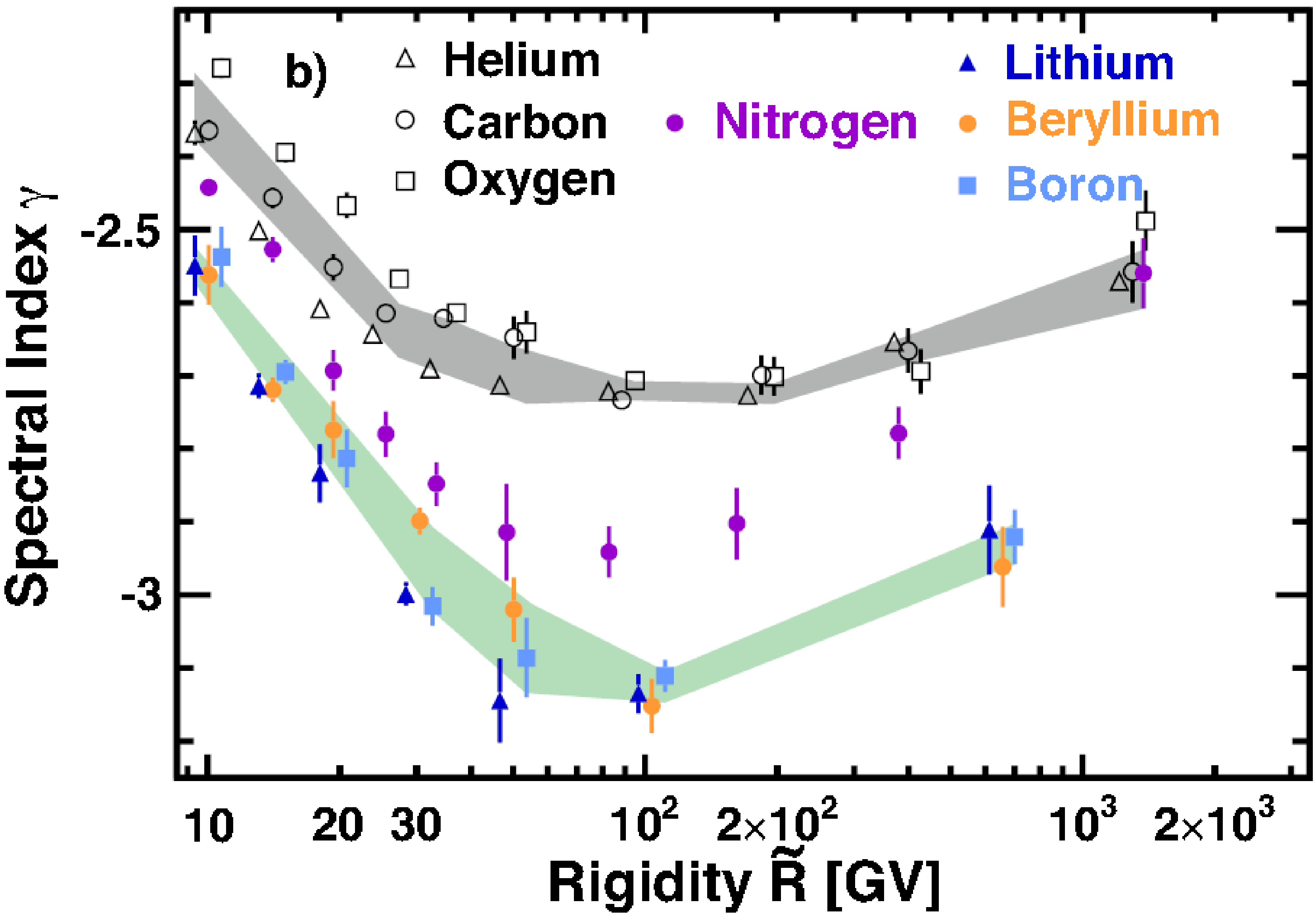


The AMS Result on the Nitrogen Flux

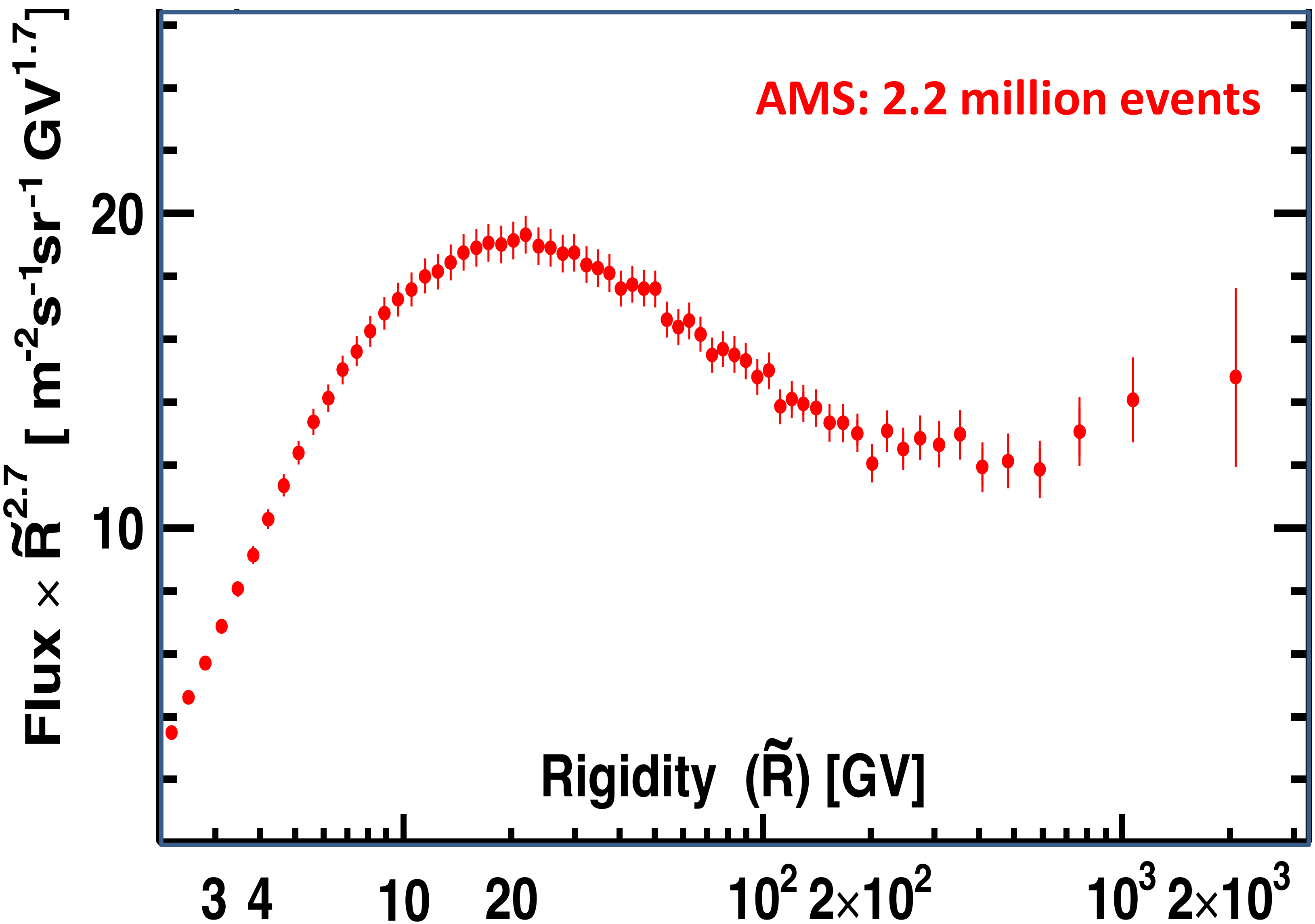
compared with primary and secondary cosmic ray fluxes



Spectral index of the Nitrogen cosmic ray flux

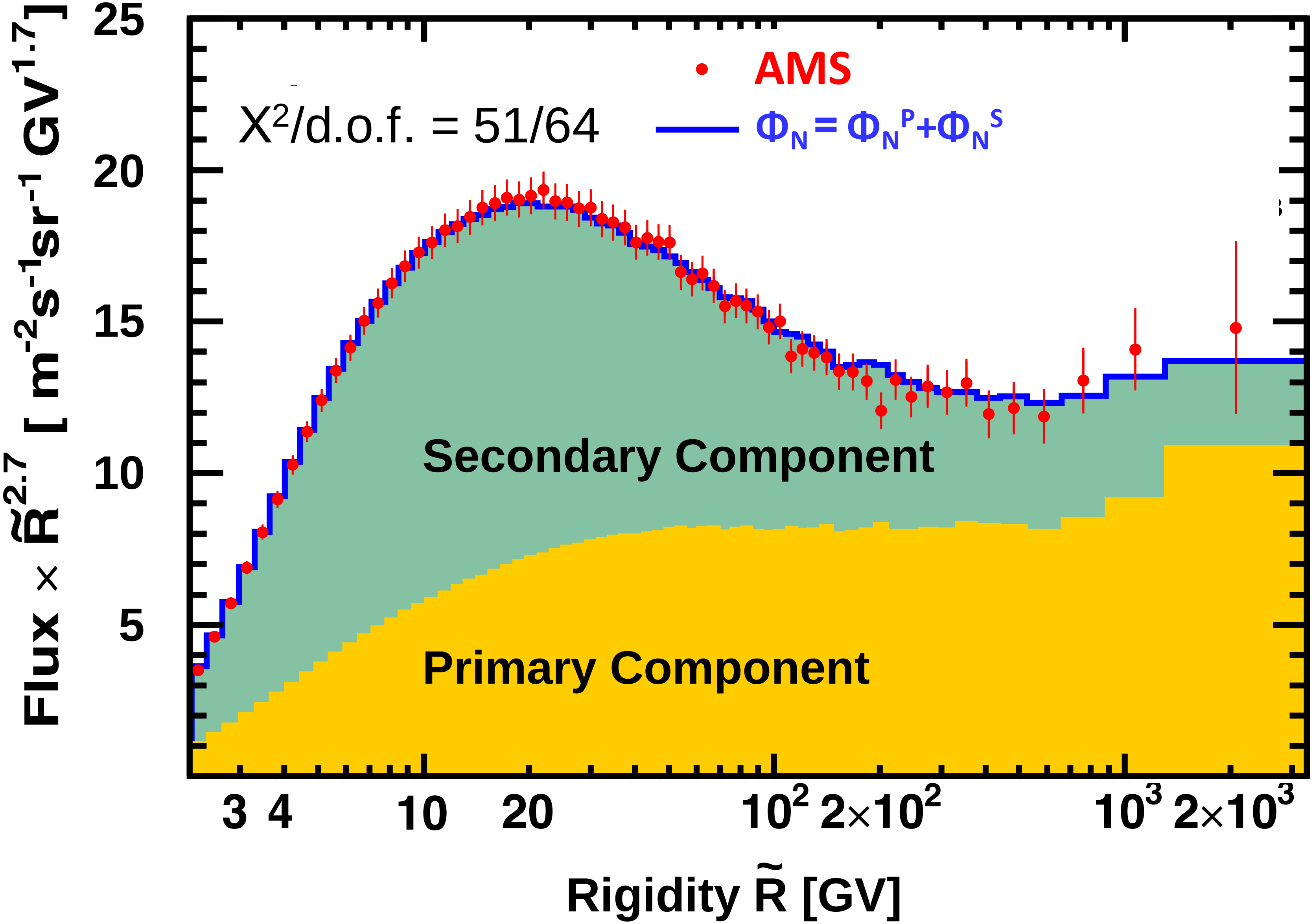


The Nitrogen flux Φ_N is composed of a Primary flux Φ_N^P and a Secondary flux Φ_N^S



Nitrogen Flux

$$\Phi_N = \Phi_N^P + \Phi_N^S = (0.090 \pm 0.002) \times \Phi_O + (0.62 \pm 0.02) \times \Phi_B$$



Nitrogen to Boron Flux Ratio

$(\Phi_N / \Phi_B) = 0.62 \pm 0.02$

- (C,N,O) + p → B + X ~ 94 mb

Fragmentation cross-sections and model uncertainties in Cosmic Ray propagation physics

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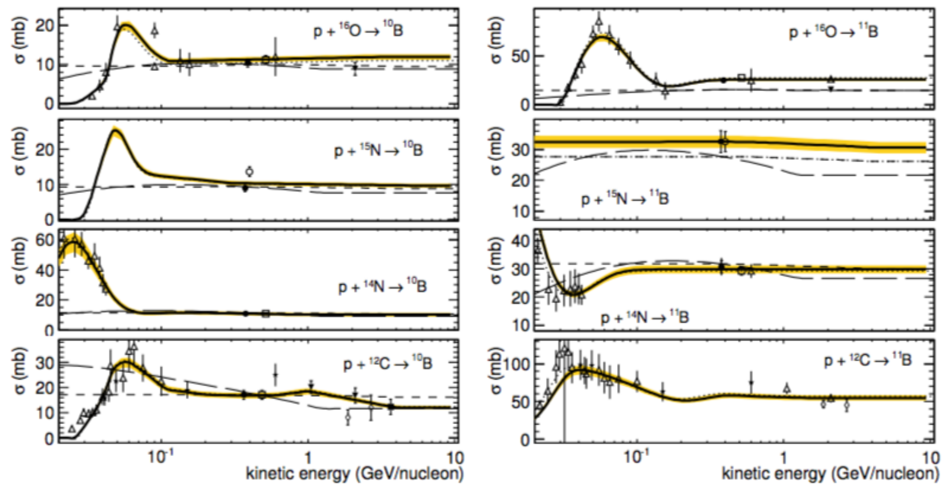

- O+p → N + X ~ 55 mb

NUCLEAR FRAGMENTATION CROSS SECTIONS AT RELATIVISTIC ENERGIES

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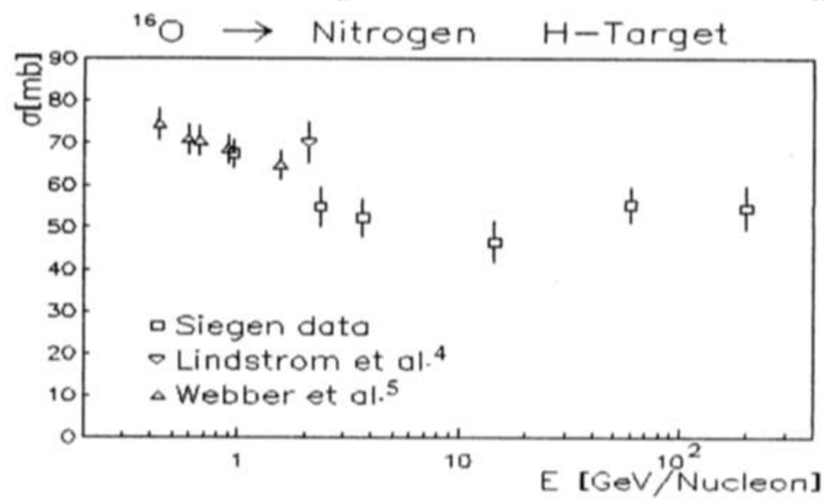
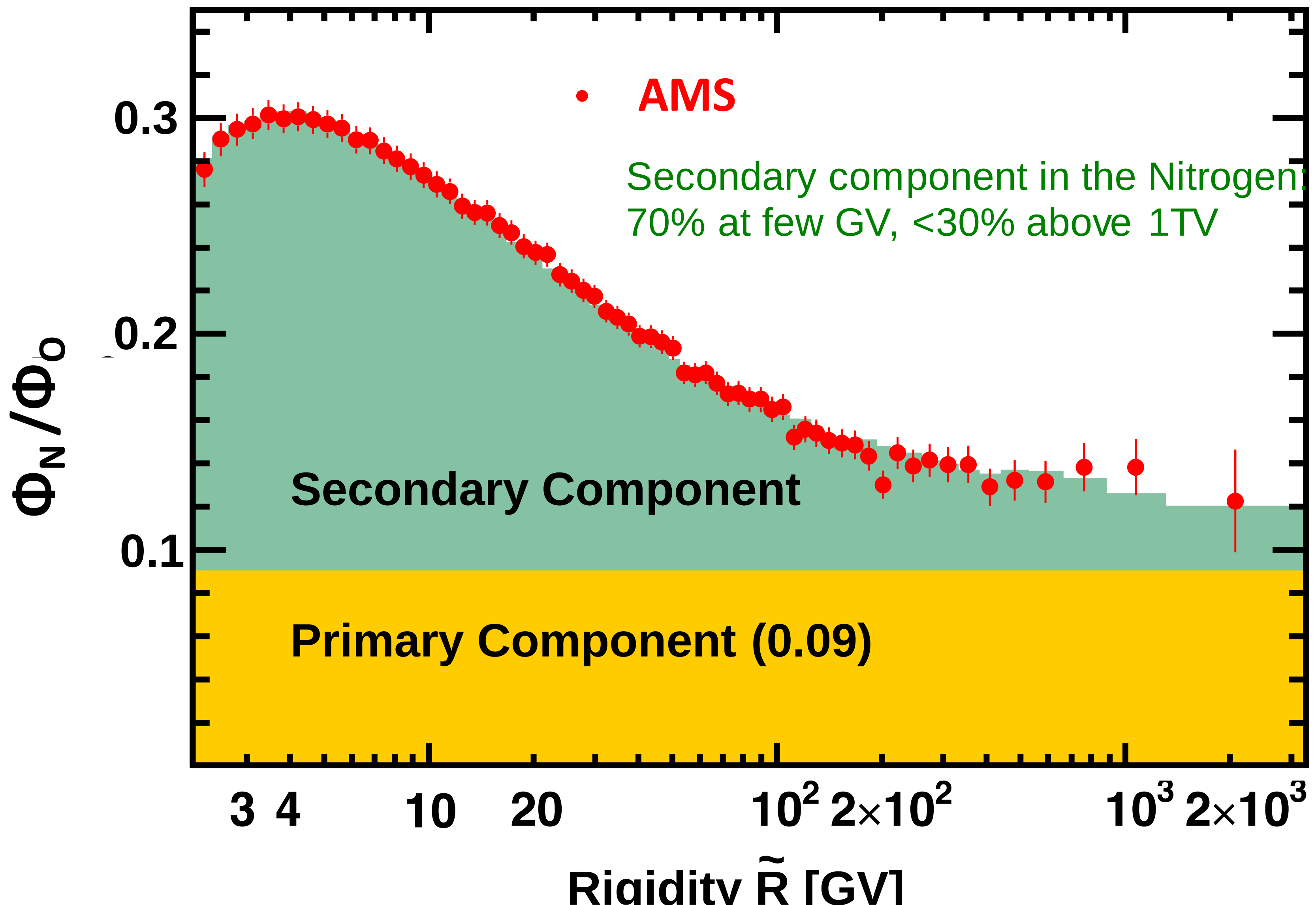


➢ **Secondary N/B ~ 55/94 ~ 0.6±0.1**

Nitrogen to Oxygen Flux Ratio (Φ_N / Φ_O):



Conclusions

- Precise measurement of the Nitrogen flux with Rigidity from 2.2 GV to 3.3 TV based on 5 Years AMS Data was presented. The total flux error is 4% at 100 GV.

- The spectral index rapidly hardens at high rigidities and becomes identical to the spectral indices of primary He, C, and O cosmic rays above ~700 GV

- The Nitrogen flux Φ_N can be presented as sum of its primary component Φ_N^P and secondary component Φ_N^S

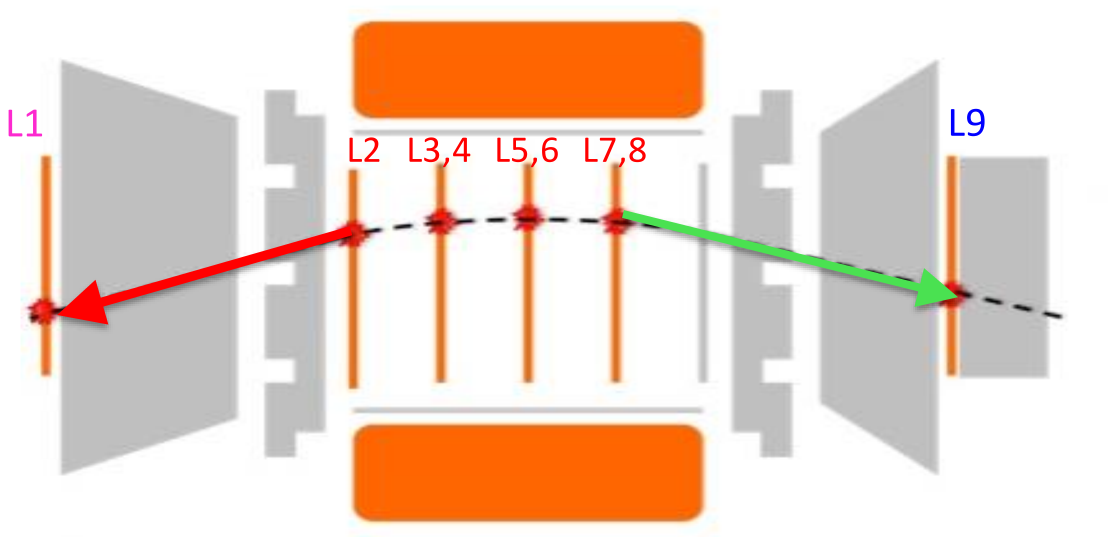
$$\Phi_N = \Phi_N^P + \Phi_N^S = (0.090 \pm 0.002) \times \Phi_O + (0.62 \pm 0.02) \times \Phi_B$$

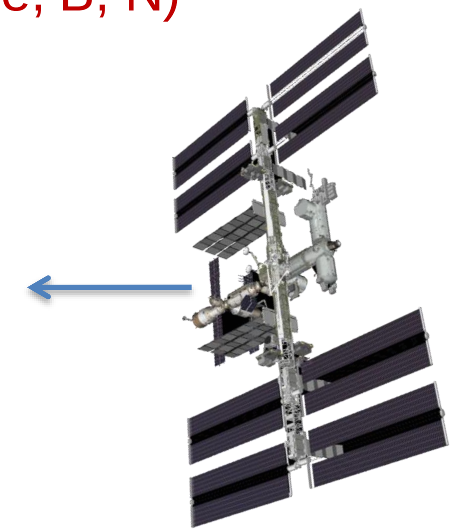
In the Solar System: N/O $\approx$ 0.14

- The observation that the nitrogen flux can be fit as the linear combination of primary and secondary fluxes permits the determination of the N/O abundance ratio at the source without considering the Galactic propagation of cosmic rays.

Measurement of nuclei cross sections by AMS

The detector components are mostly made of Carbon (C) and Aluminum (Al). The inelastic cross sections of X+ C, X+ Al are only measured below few GV (He, C, O) or not measured (Li, Be, B, N)

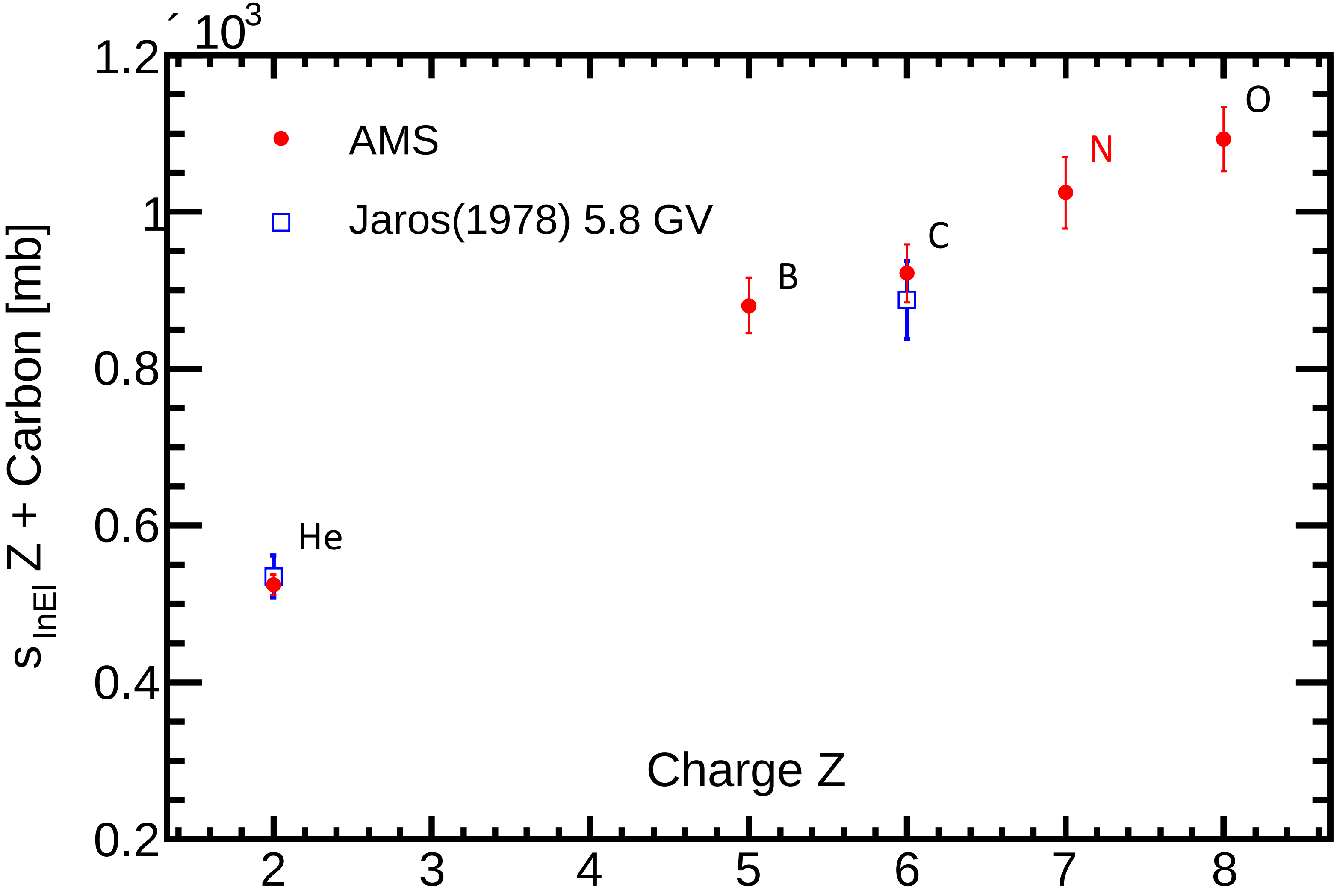




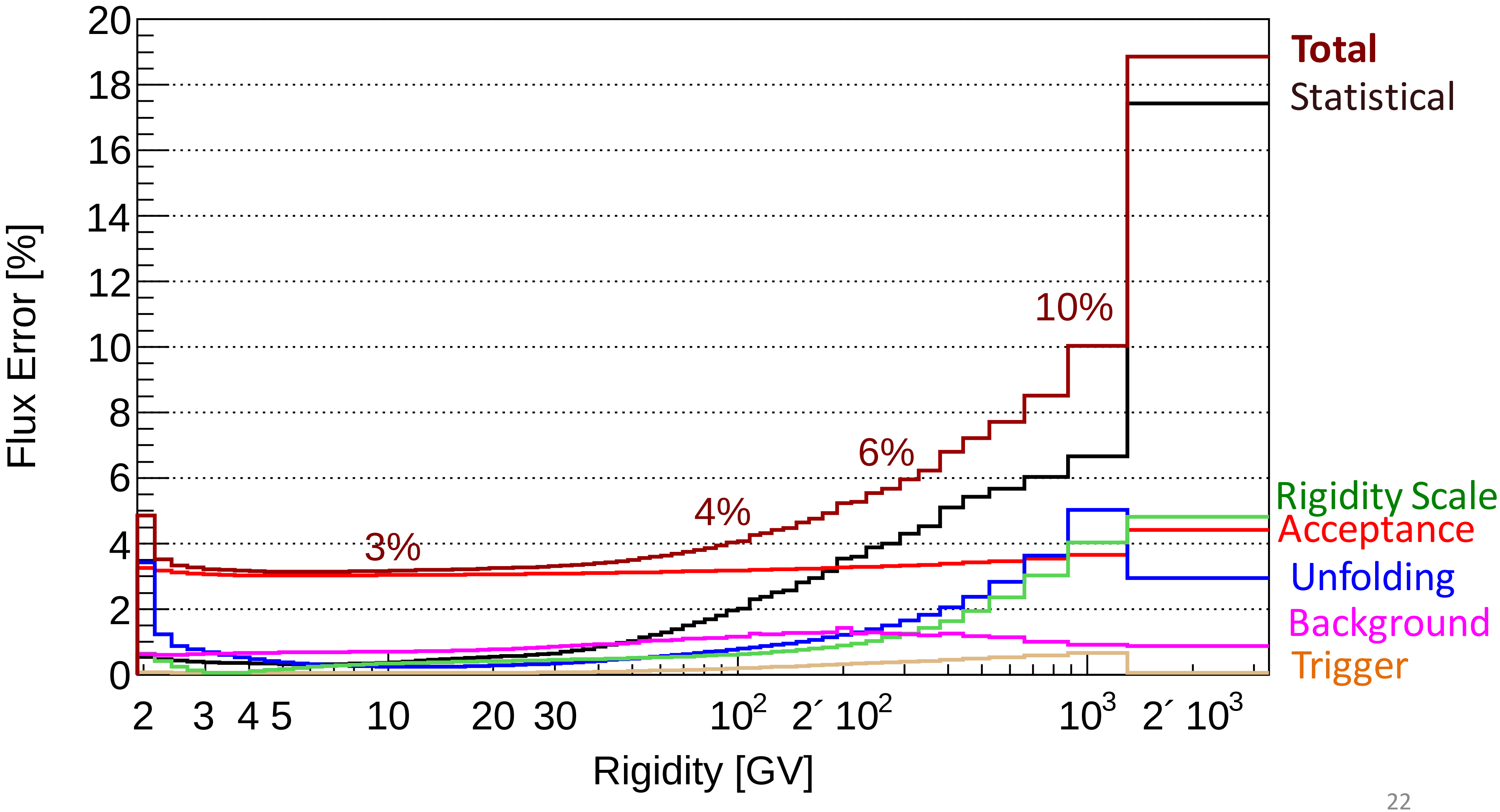
AMS measured the Survival Probabilities during “Horizontal” runs [~10^5 sec exporsure] in which CRs can enter AMS both right to the left and left to the right.

Most importantly, by flying horizontally, AMS was able to make Interaction cross sections measurements which were not available from accelerators.

AMS Nuclei + C Inelastic Cross Section measurements average in 5-100 GV



Nitrogen Flux Errors breakdown



Flux Measurement

Isotropic differential flux
[$(m^2$ sr s GV$)^{-1}$]

Number of particles
(subtracted for backgrounds
and corrected for rigidity migrations)

$$\Phi_i^Z = \frac{N_i^Z}{A_i^Z \, \epsilon_i^Z \, T_i \, \Delta R_i}$$

Effective acceptance [m^2 sr]
(from MC, verified with data)

Trigger Efficiency
(ε>98% over entire R range)

Exposure Time [s]
(1.23×10^8 s, for R > 30 GV)

Bin width [GV]
(66 bins between
2.2 GV and 3.5 TV)