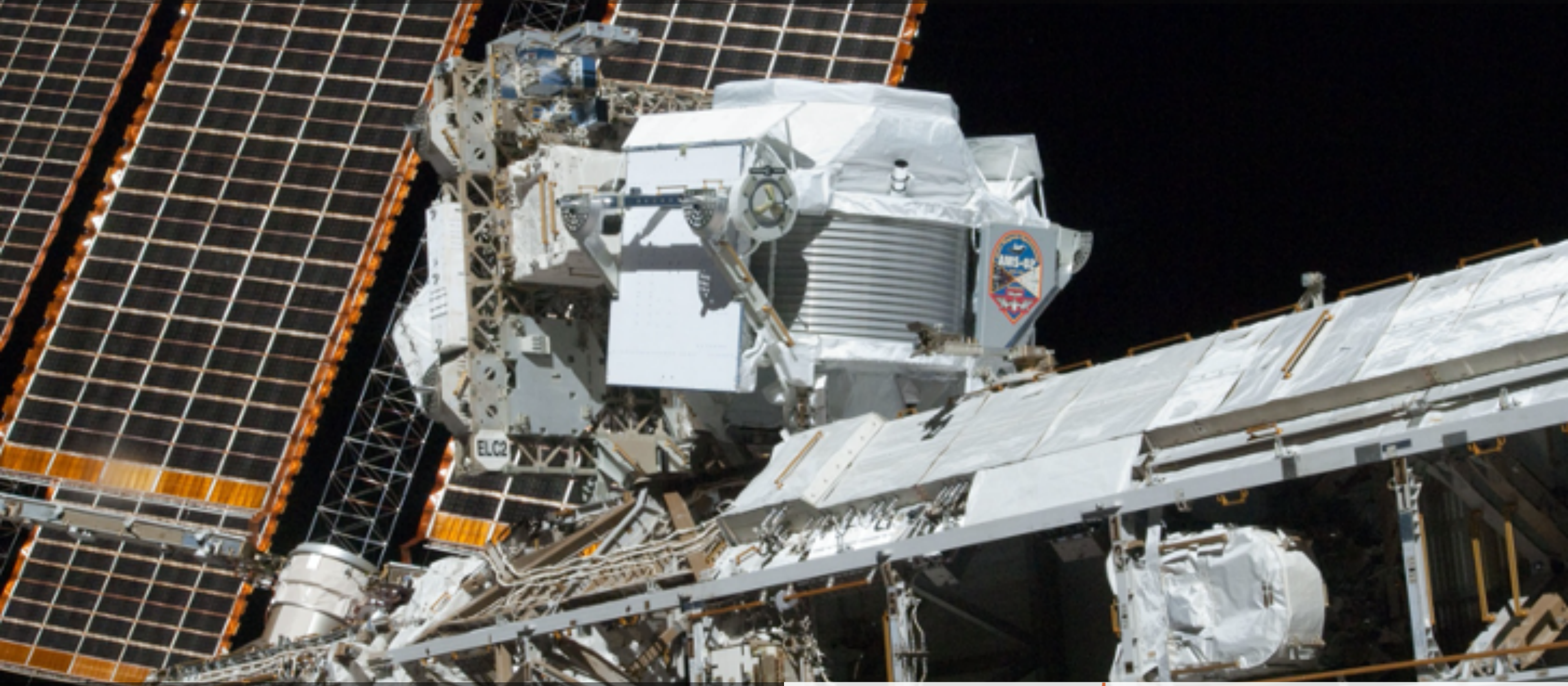
Properties of Cosmic Helium Isotopes measured by the Alpha Magnetic Spectrometer



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on behalf of the AMS-02 collaboration

ONLINE ICRC 2021
THE ASTROPARTICLE PHYSICS CONFERENCE
Berlin | Germany

37th International Cosmic Ray Conference
12–23 July 2021

Helium Isotopes on Cosmic Rays

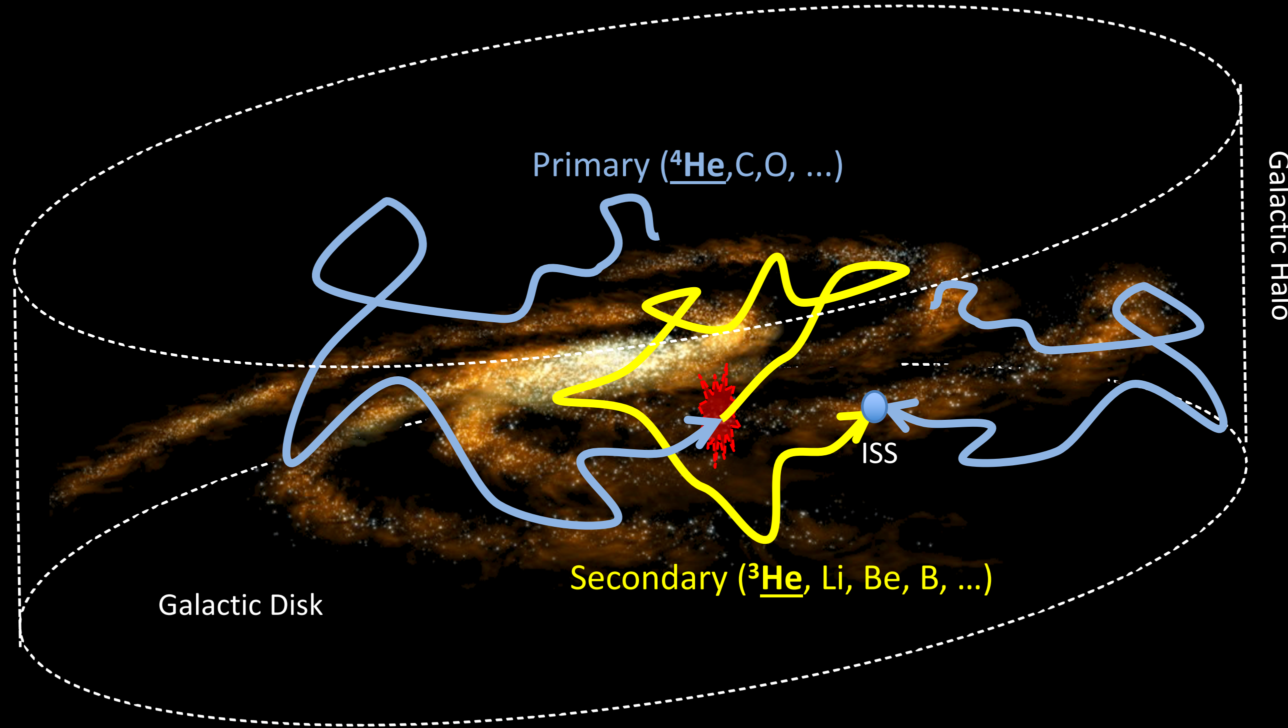
AMS nuclei @ ICRC 2021:
H.Gast, #1008: He,C,O,Li,Be,B
Q.Yan, #707: F
A.Oliva, #763: Ne, Mg, Si
C. Zhang, #743: Na
Z. Liu, #893: Al
Y.Chen : Fe

Precise measurements of primaries and secondary elemental fluxes by AMS
→ important information to understand the origin and the propagation of Cosmic Rays

More detailed insight from isotopic composition *(see L.Derome #992: Li, Be isotopes; E.Bueno #887: D)*

- **Helium** are the second most abundant nuclei in CRs, consisting of the two isotopes:

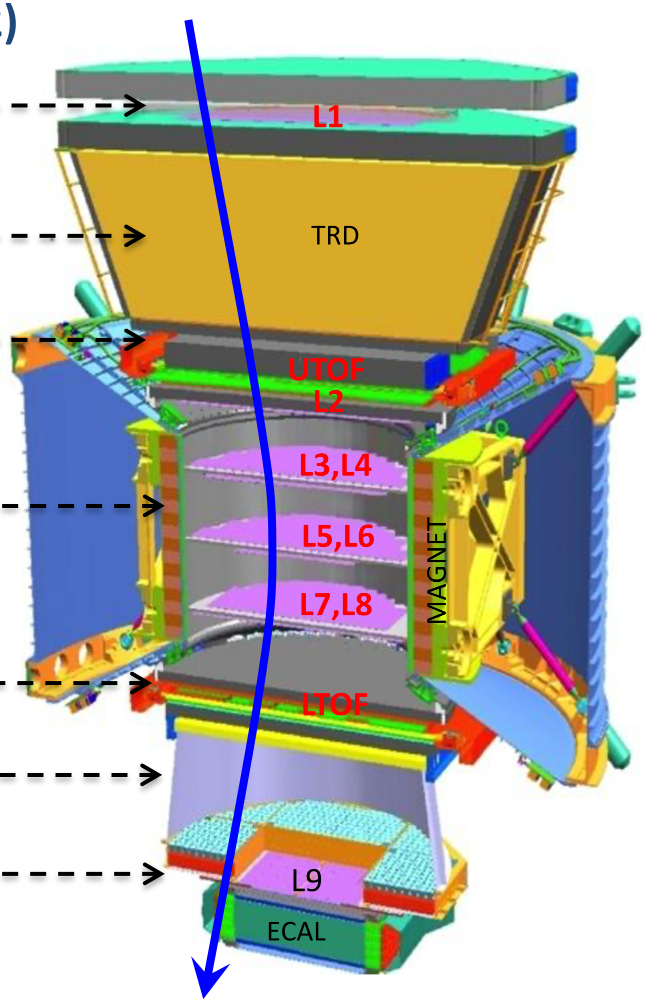
^{4}He (primary cosmic rays) are mostly produced and accelerated in astrophysical sources;
^{3}He (secondary cosmic rays) mostly produced by fragmentation of primary ^{4}He with ISM



- The small cross section of He with respect to heavier nuclei, allows ^{3}He/^{4}He to probe the properties of diffusion at larger distances than any other sec. to prim. ratio (like B/C, B/O).

He identification with AMS

	Charge ΔZ (Z= 2)
Tracker L1	0.18
TRD	0.10
Upper TOF	0.08
Tracker L1-L8	0.07
Lower TOF	0.08
RICH	0.31
Tracker L9	0.18



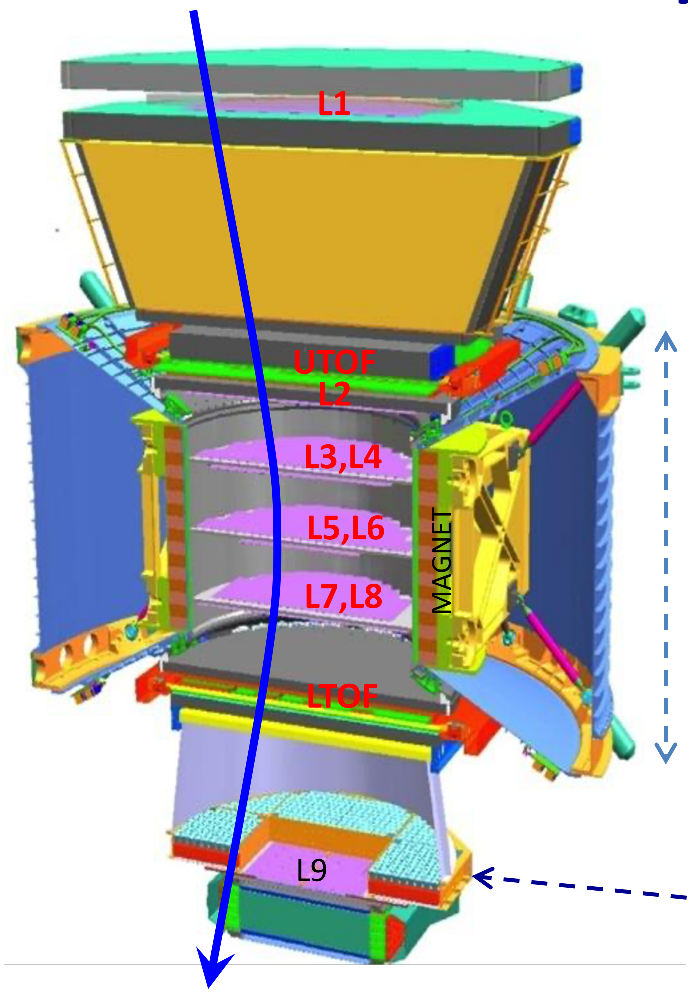
Z measurement:
L1 - UTOF - Inner Tracker – LTOF

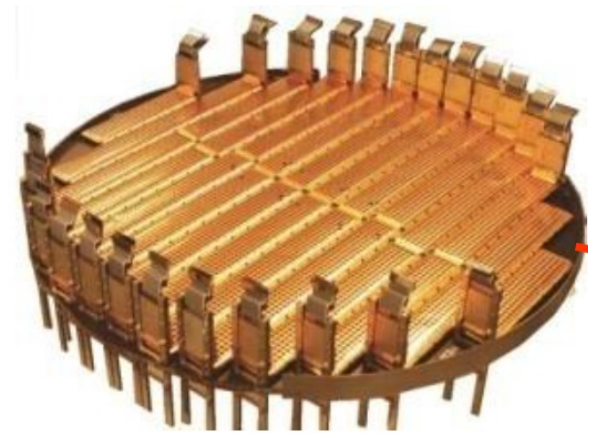
→ Negligible misidentification
Efficiency is >98%
Purity >99.9%

→ L1 charge selection:
Background due to Z>2 fragmenting into He is $<10^{-3}$

He isotopes identification with AMS

$$m = ZR / \beta\gamma$$

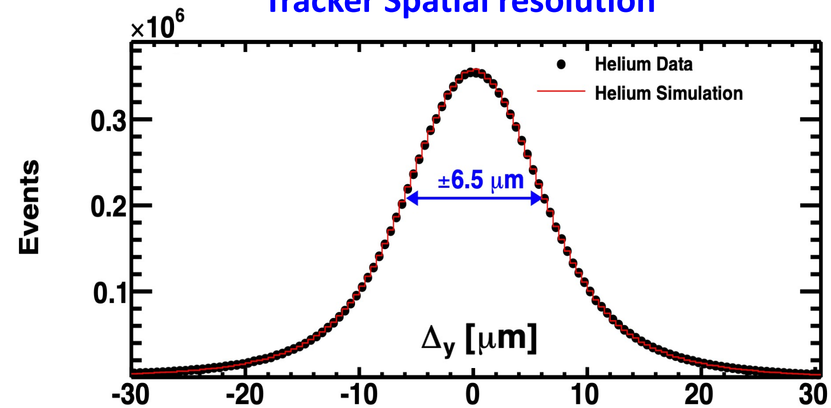




Tracker, R(=p/Z) measurement, ΔR/R <10% @20GV

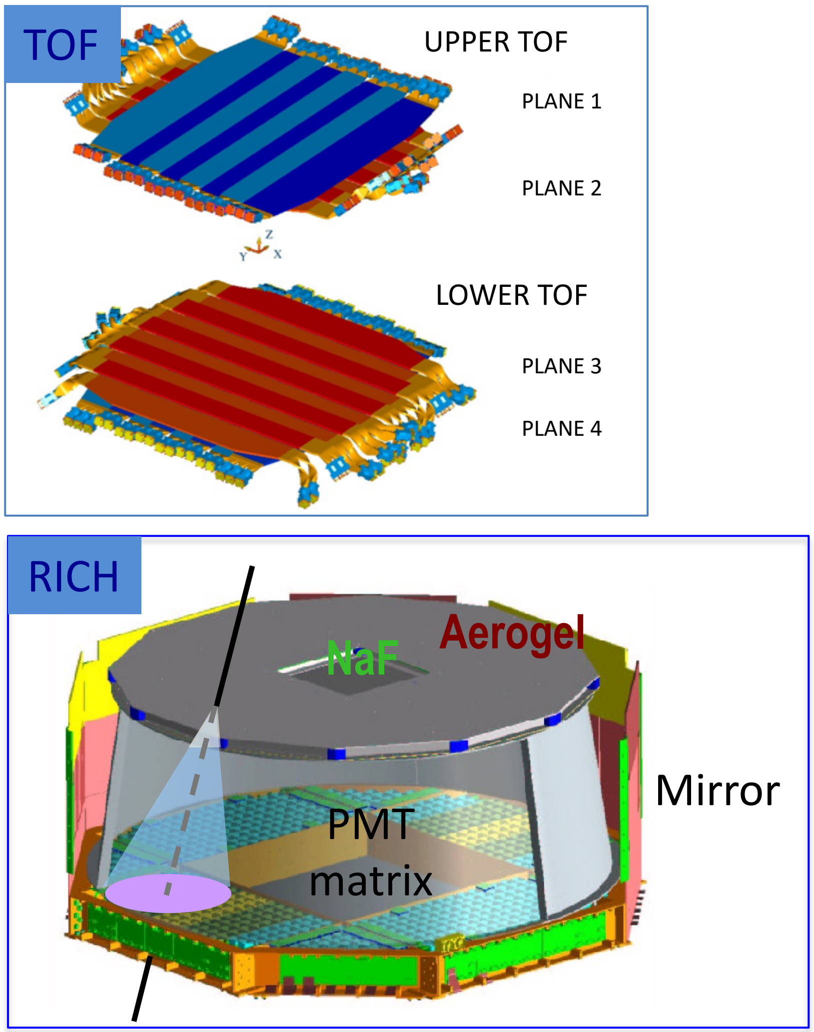
TOF, β

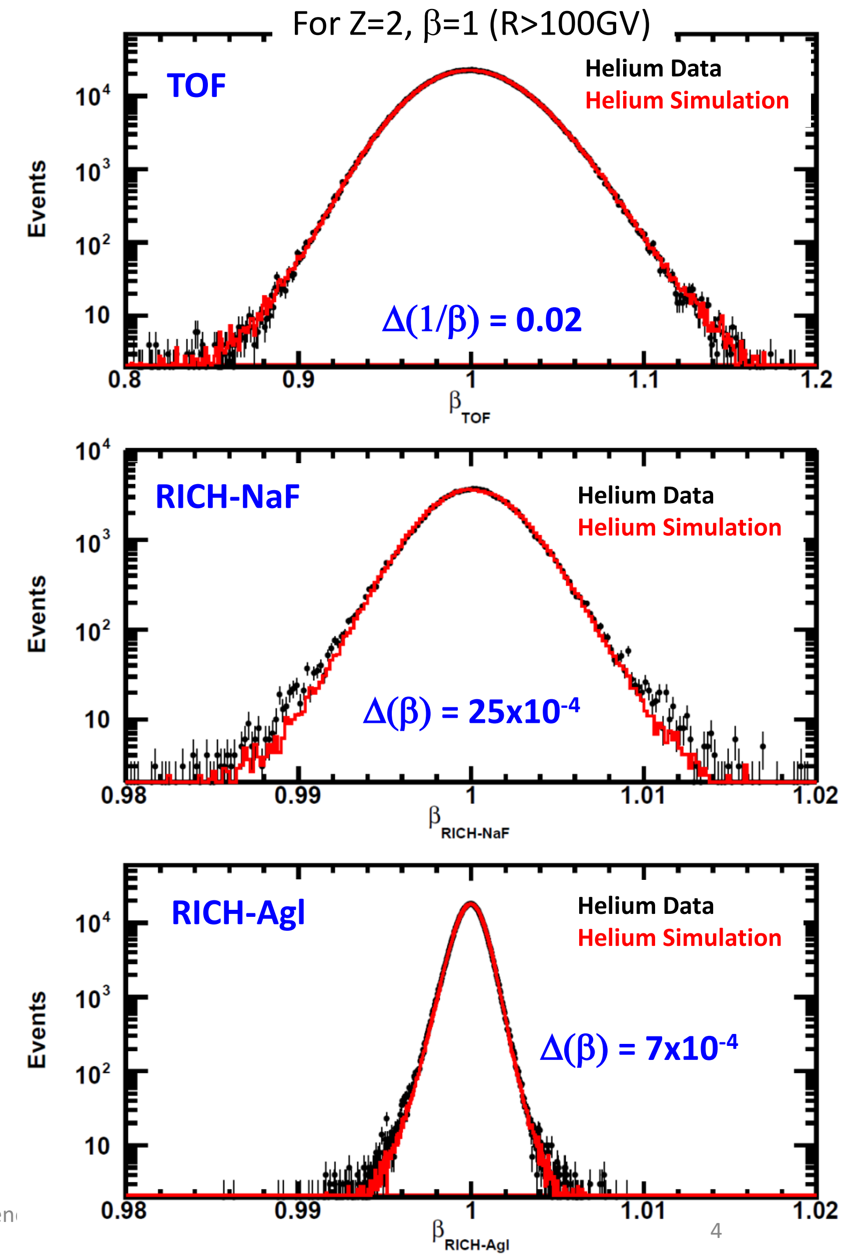
RICH, β



He isotopes identification with AMS

β Measurement: TOF, RICH





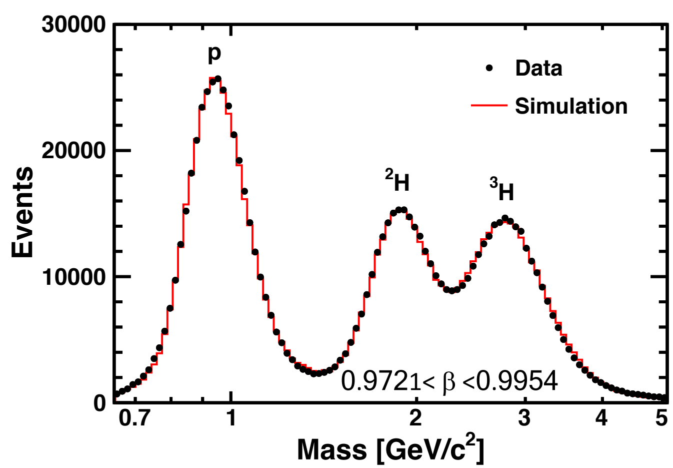
Top-of the-Instrument correction

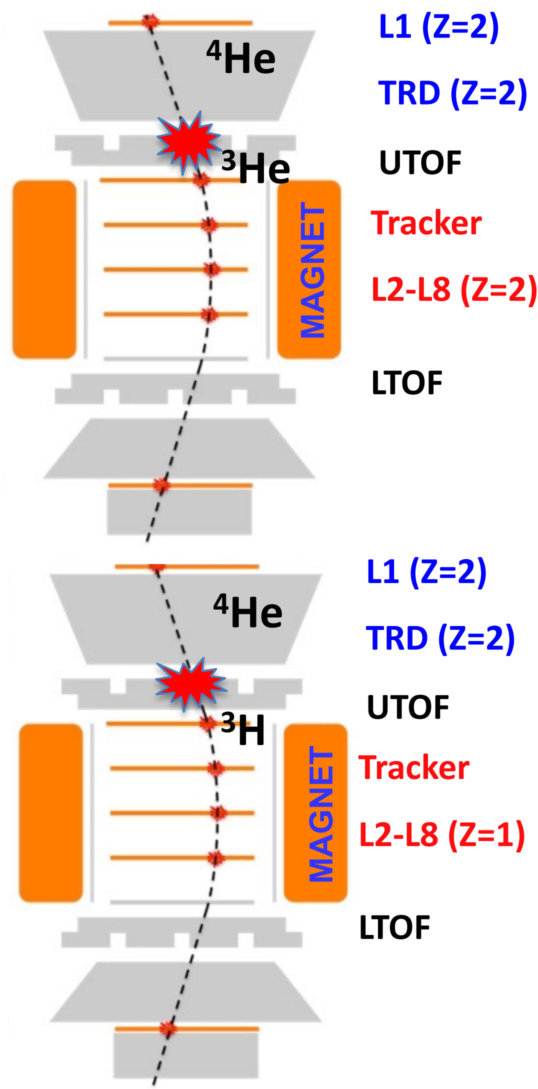
Contamination in ^{3}He from ^{4}He → ^{3}He

Since ^{3}He and ^{3}H production cross sections in ^{4}He interactions are expected to be similar and constant above ~0.2 GeV/n:

the contamination due to ^{4}He → ^{3}He fragmentation is estimated from the ^{4}He → ^{3}H

Validate simulation with direct measurement: He → p, ^{2}H, ^{3}H





Contamination < 10% of the ^{3}He sample with associated systematic error smaller than 1% for ^{3}He flux.

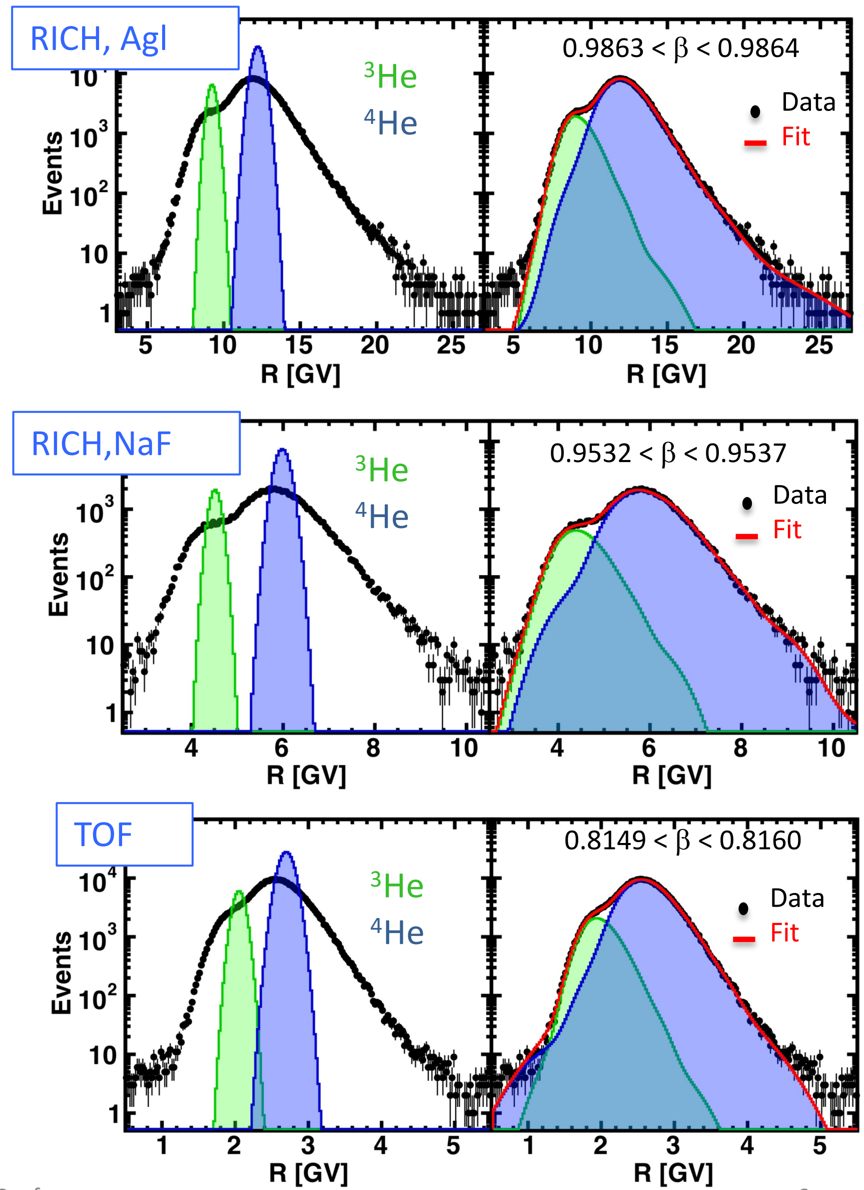
He isotopes identification with AMS

To identify the helium isotopes:

-Select narrow velocity bins compared with beta resolution (0.2 $\Delta\beta$);

- Unfold the momentum distribution, within the beta bin, using the tracker resolution function to get ^{3}He and ^{4}He peaks and count events on TOP of AMS;

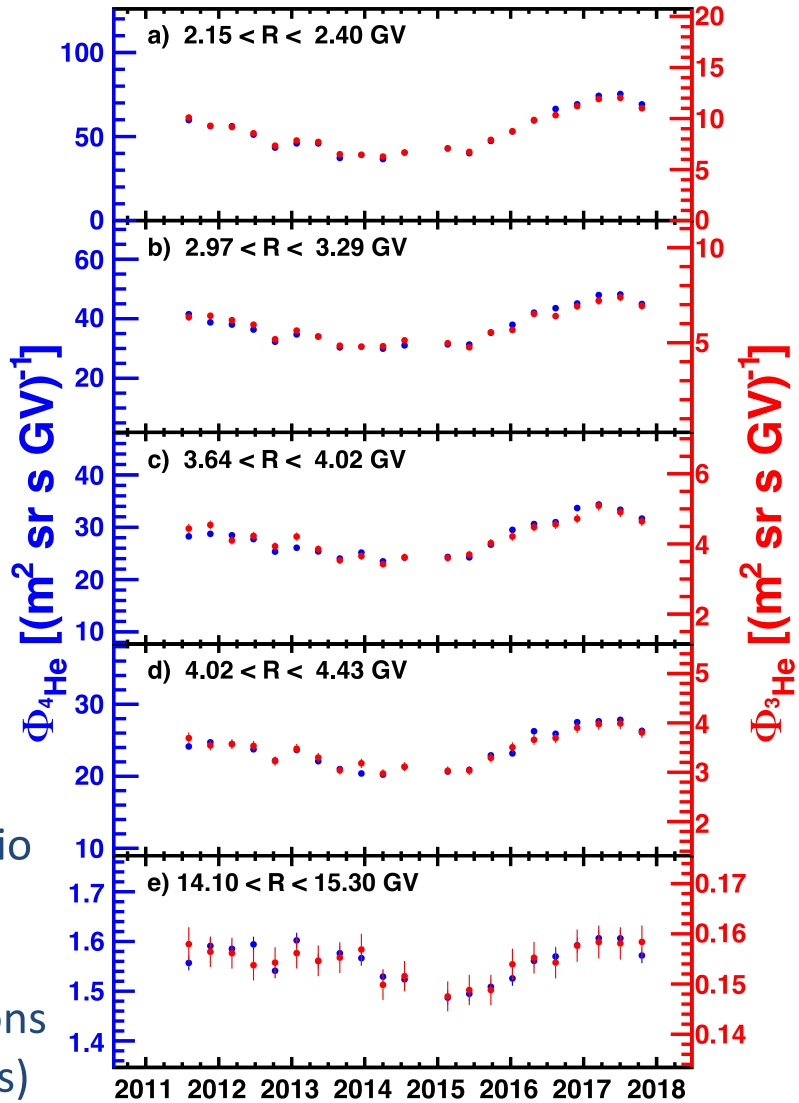
- Fold back the results and Fit to the data.

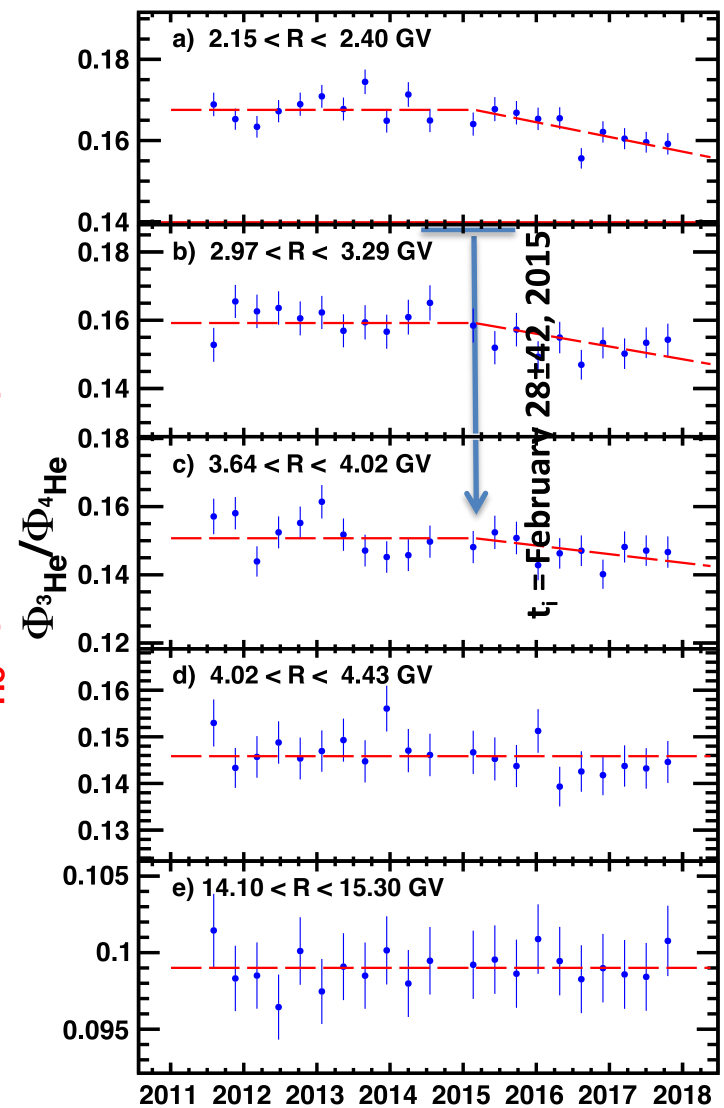


^{3}He and ^{4}He and ratio time variation

[PLR 123,181102(2019)]

Data: 6.5 yr (05/2011 to 11/2017)



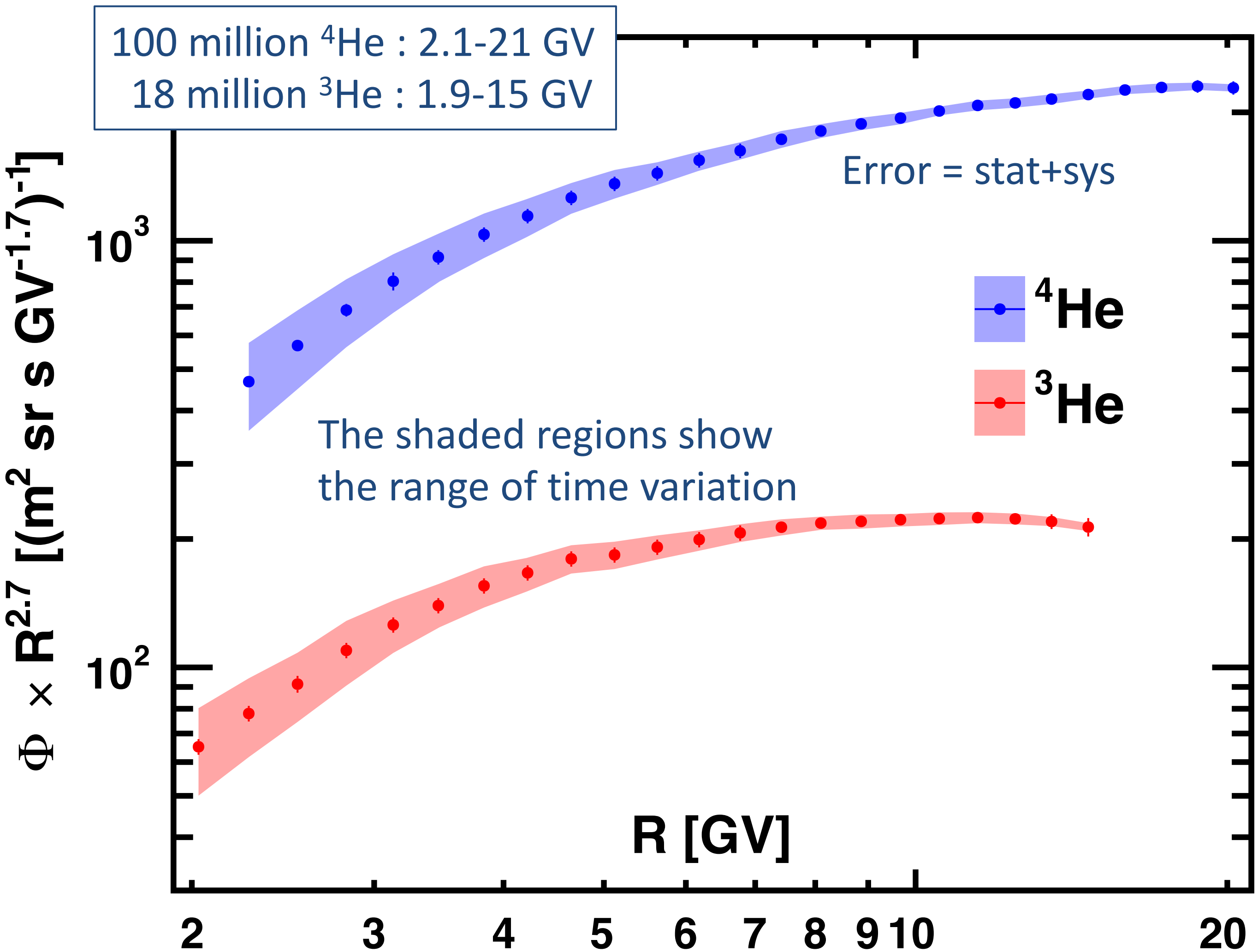


Above 4GV the ratio is time independent

^{4}He and ^{3}He Fluxes and ratio vs time in 21 periods of 4 Bartels rotations each (108 days)

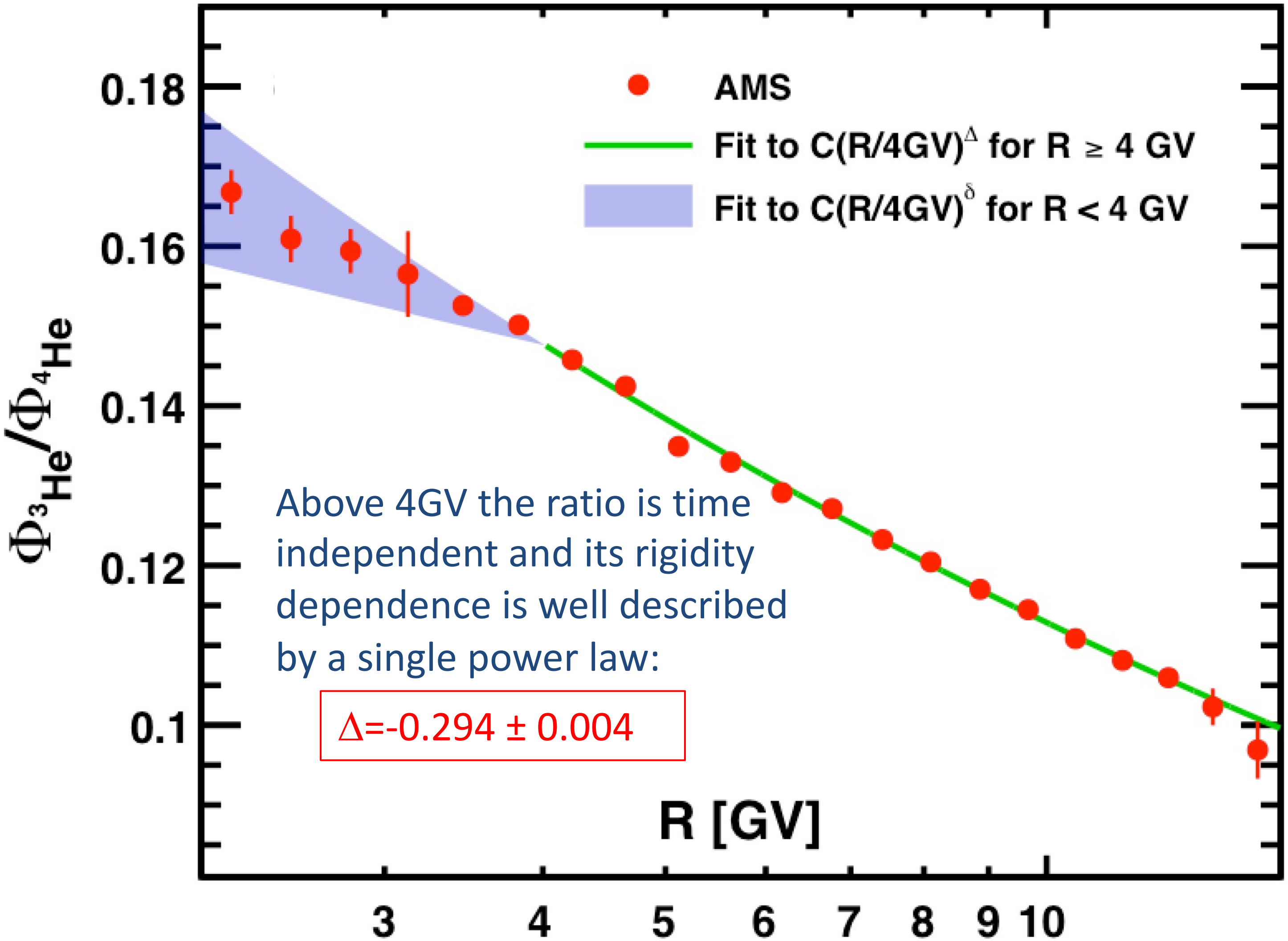
Helium Isotopes Flux vs R

The ^{3}He and ^{4}He fluxes averaged in time as function of rigidity



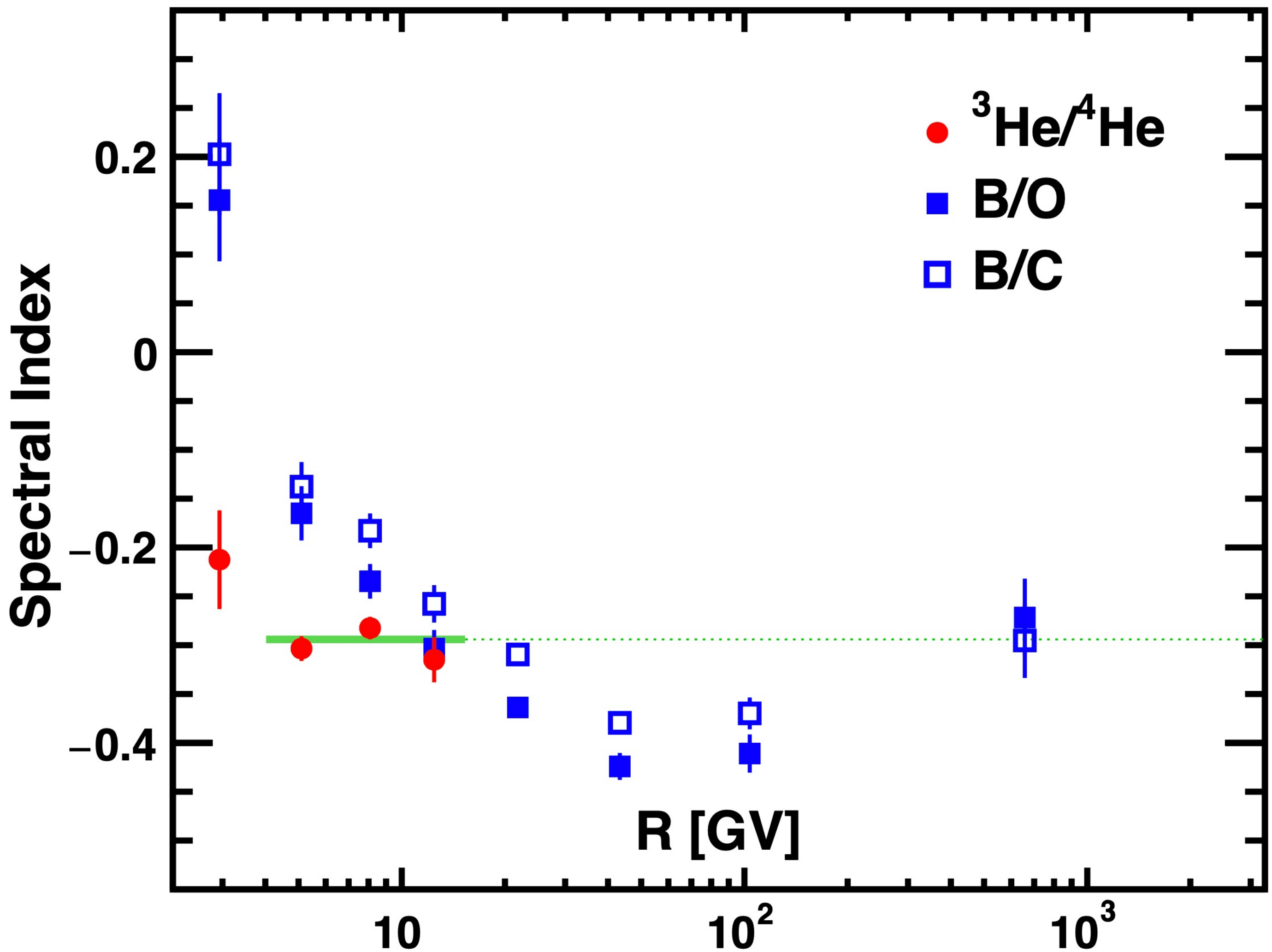
Helium Isotopes ratio vs R

The time-averaged $^3He/^4He$ flux ratio as function of rigidity [2.1-15GV]



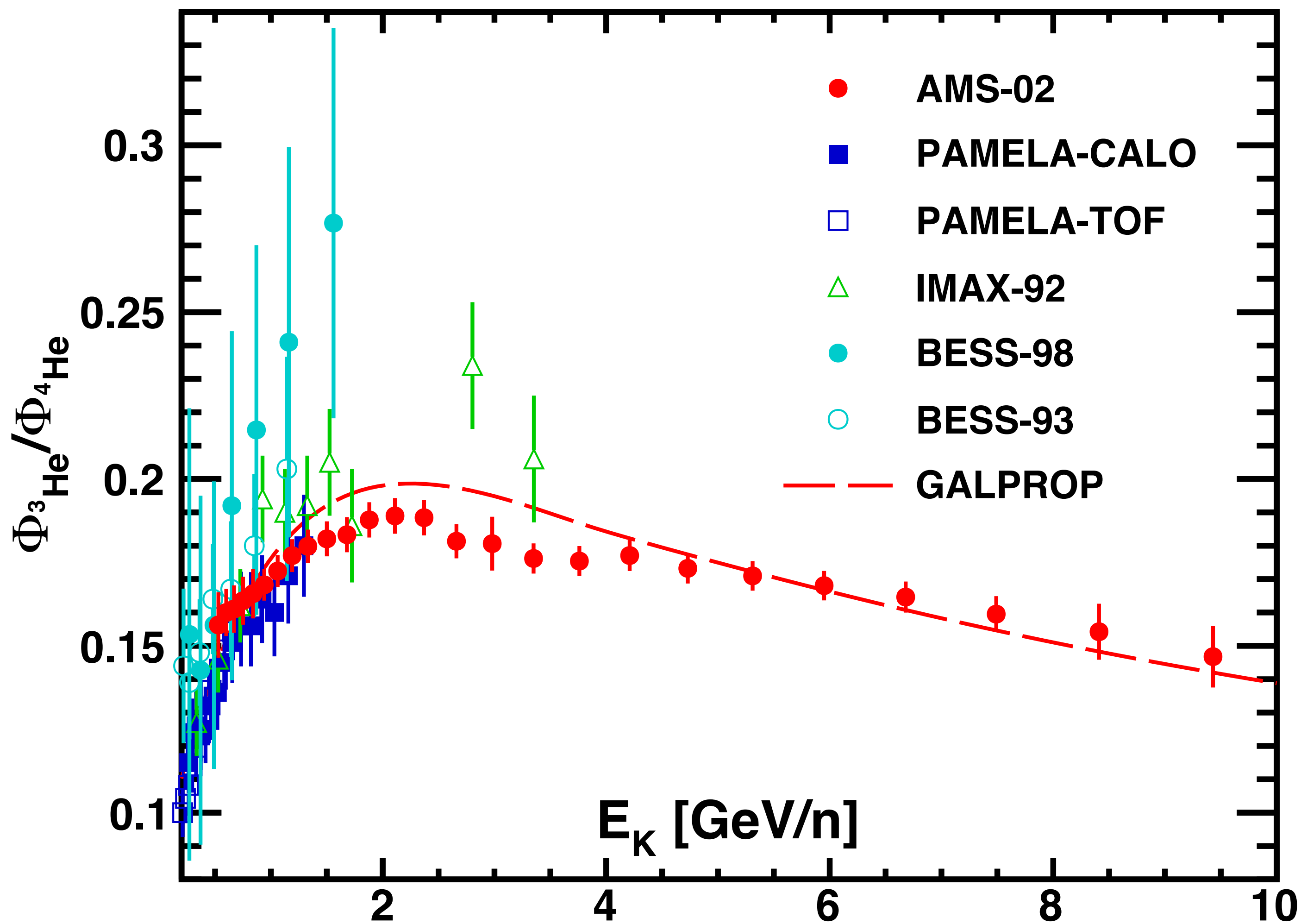
Spectral Index of Helium Isotopes ratio

The $^3He/^4He$ flux ratio spectral index vs R



Helium Isotopes vs Ekin

The analysis has been also performed vs E_k
AMS measurement togheter with previous experiments



Summary

- AMS has performed a precision measurements of the cosmic-ray ^{3}He and ^{4}He fluxes and their ratio with rigidity from 1.9 GV to 15 GV for ^{3}He, from 2.1 GV to 21 GV for ^{4}He and from 2.1 GV to 15 GV for ^{3}He/^{4}He, based on 100 million ^{4}He and 18 million ^{3}He nuclei.

- Below 4 GV the ^{3}He/^{4}He flux ratio shows a long-term time dependence.

- Above 4 GV the ^{3}He/^{4}He flux ratio was found to be time independent and its rigidity dependence is well described by a single power law ($C R^{\Delta}$) with $\Delta = -0.294 \pm 0.004$.

- The measured ^{3}He/^{4}He flux ratio power law spectral index is in agreement with the one measured at high rigidity for the B/O and B/C ratio.