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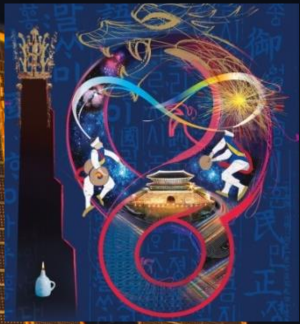

J. Berdugo (CIEMAT)
On behalf of the
AMS-02 Collaboration

Measurements of Light Nuclear Isotopic Composition in Cosmic Rays with AMS

Isotopic abundancies in cosmic rays

AMS is providing new and precise data in cosmic ray physics that requires accurate modelling of the cosmic rays propagation to estimate the secondary production of antiparticles

The study of secondary-to-primary ratios as Li/O, Be/O, B/O or sub-Fe/Fe factors out the source spectrum of the progenitor and provides information to constrain the transport parameters for species $Z \leq 30$.

Most secondary-to-primary ratios have $A/Z \sim 2$. The study of Isotopic abundancies, like (^{3}He,^{4}He), (^{6}Li,^{7}Li) and (^{7}Be,^{9}Be,^{10}Be) probes a different regime and allows to address the question of the "universality" of propagation histories.

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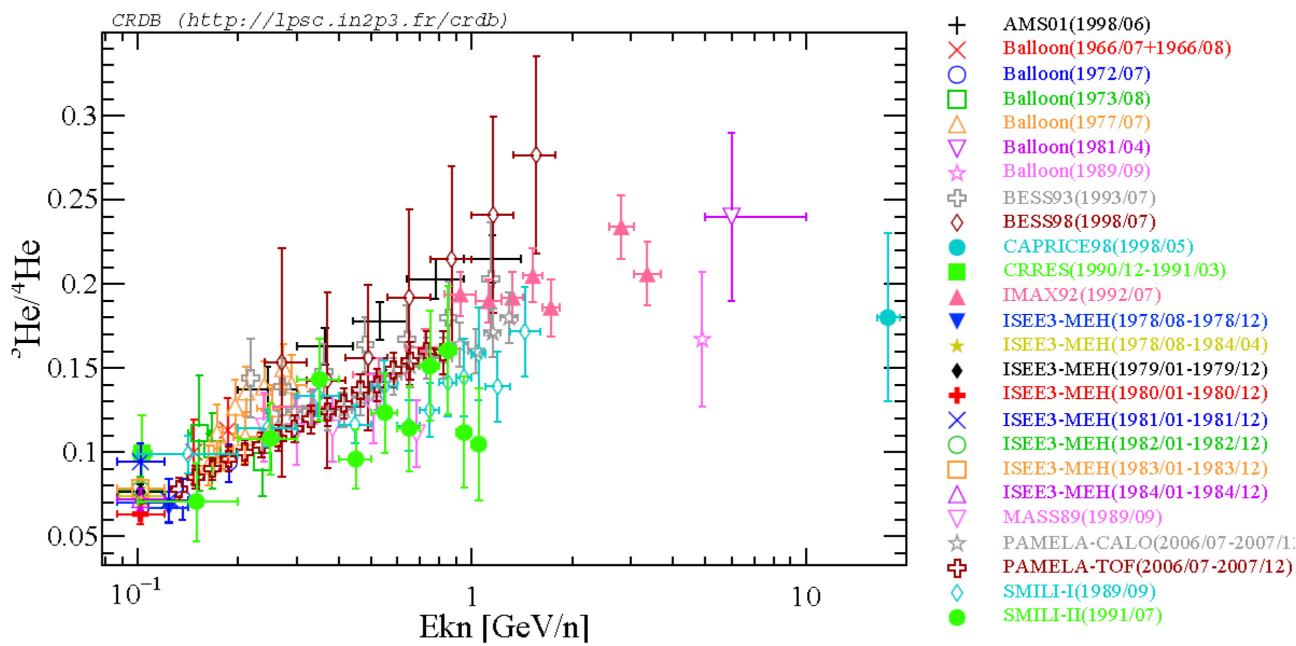
Presentation is focused in the AMS measurements of the He isotopic composition (^{3}He,^{4}He)



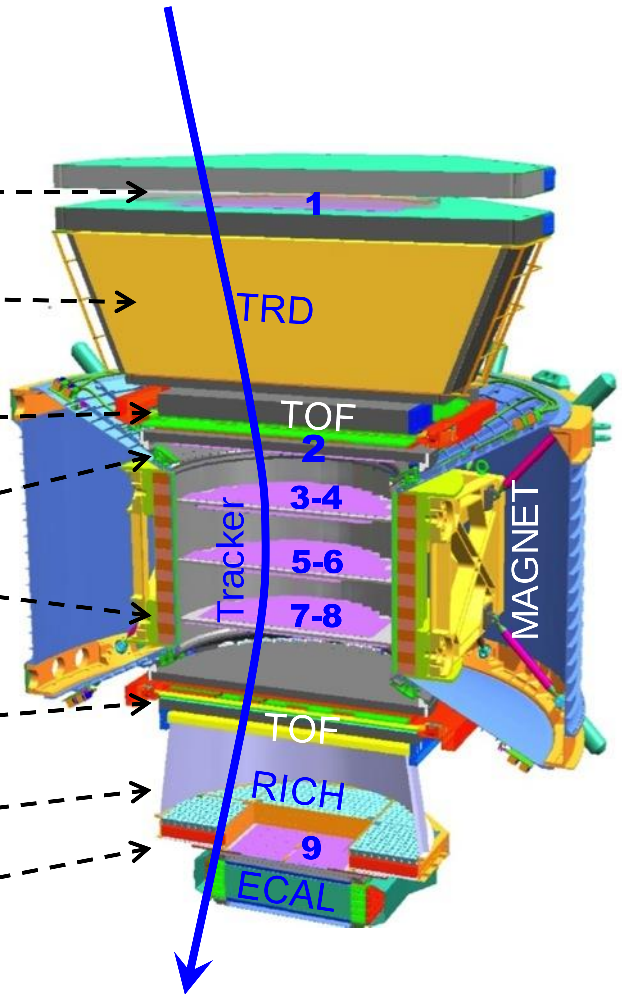
AMS: Helium isotopes identification

Analysis of the first five years of operation of AMS on the ISS

Charge

ΔZ (Z=2)

Tracker L1	0.18
TRD	0.10
Upper TOF	0,08
Tracker L2-L8	0.07
Lower TOF	0.08
RICH	0.31
Tracker L9	0.18



$$Mass = P\frac{\sqrt{1-\beta^2}}{\beta}$$

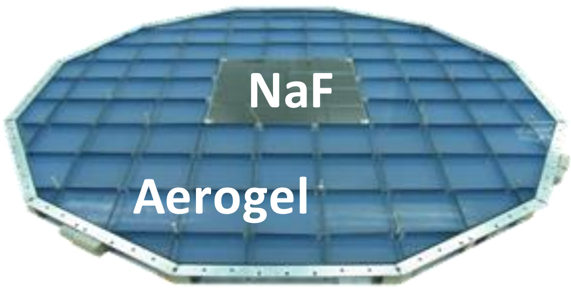
TRACKER: R = p/Z

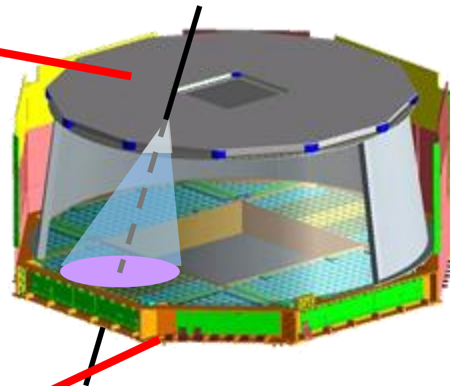
TOF β
Δβ (β=1, Z=2) ≈ 0.02

RICH β
Δβ (β=1, Z=2) ≈ O(10^{-3})

Helium velocity measurement

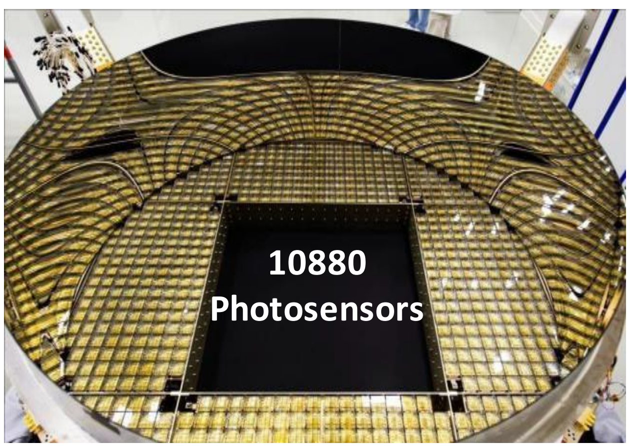
Ring Imaging Cherenkov (RICH)





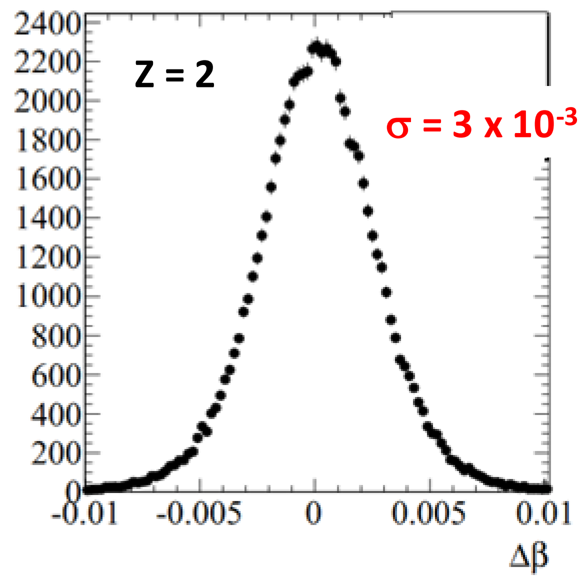
Dual radiator configuration

	NaF	Aerogel
Refractive index	1.33	1.05
Threshold velocity (v/c)	0.75	0.95
Threshold E_{kin}/A (GeV/n)	0.51	2.28

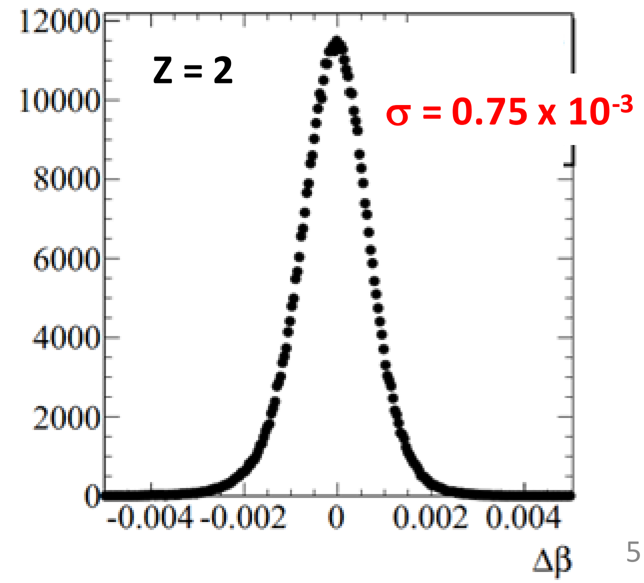


ISS data R > 100 GV

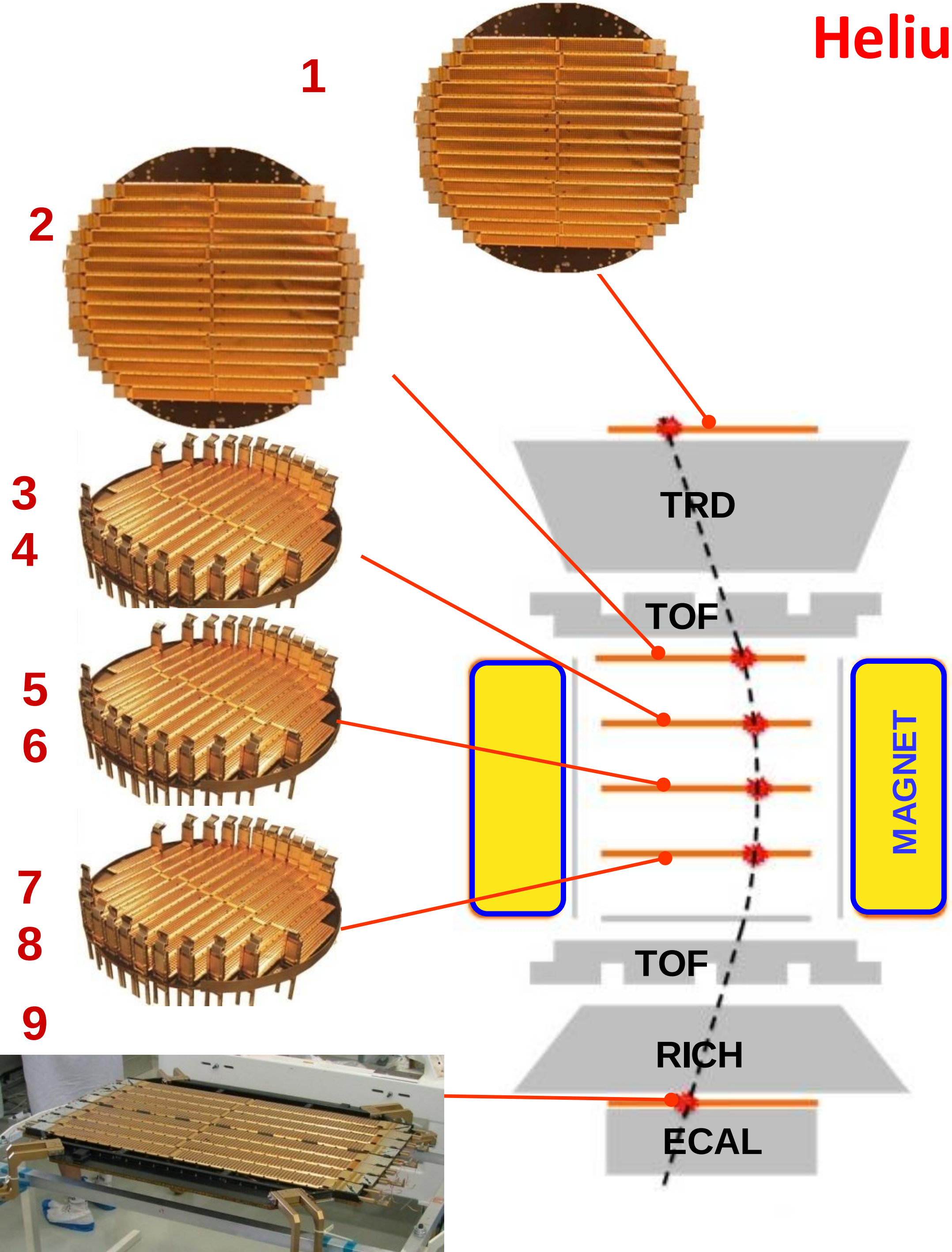
NaF Radiator



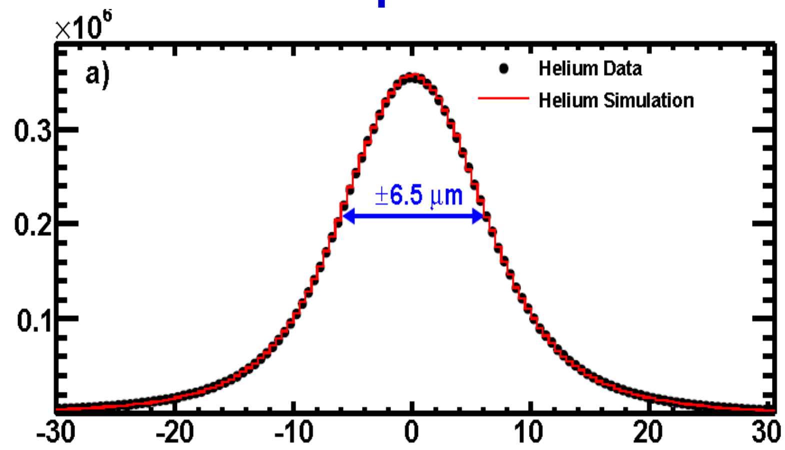
Aerogel Radiator



Helium rigidity measurement



Tracker spatial resolution



MDR = 3.2 TV

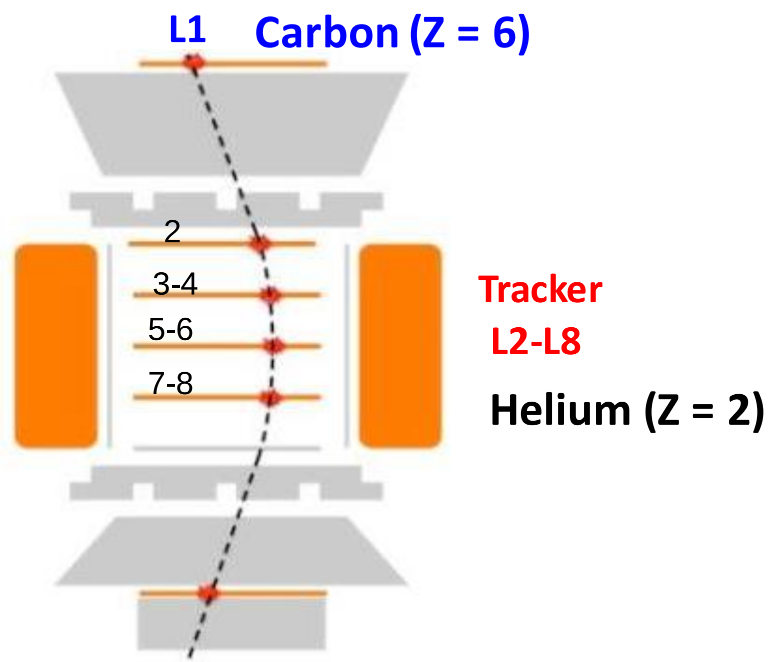
Rigidity resolution (<10% at 20 GV)

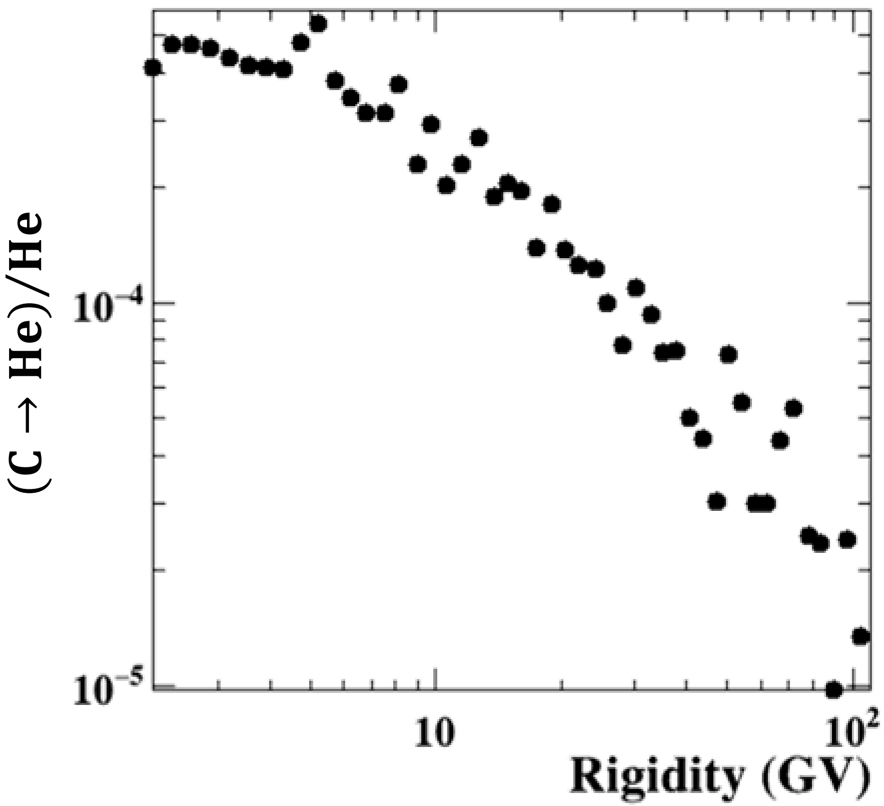
Helium nuclei sample

Z = 2 selection

- Efficiency is > 98%.
- Contamination from neighboring charges < 10^{-4}
- Purity > 99.9%

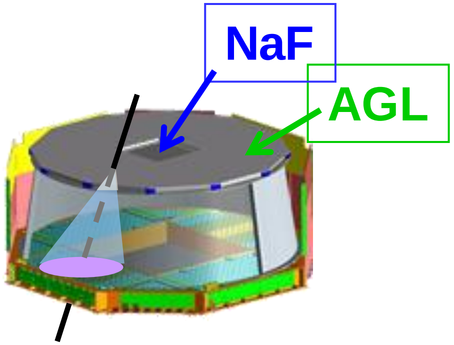
Background due to interactions (CNO → He + X) is <10^{-3}



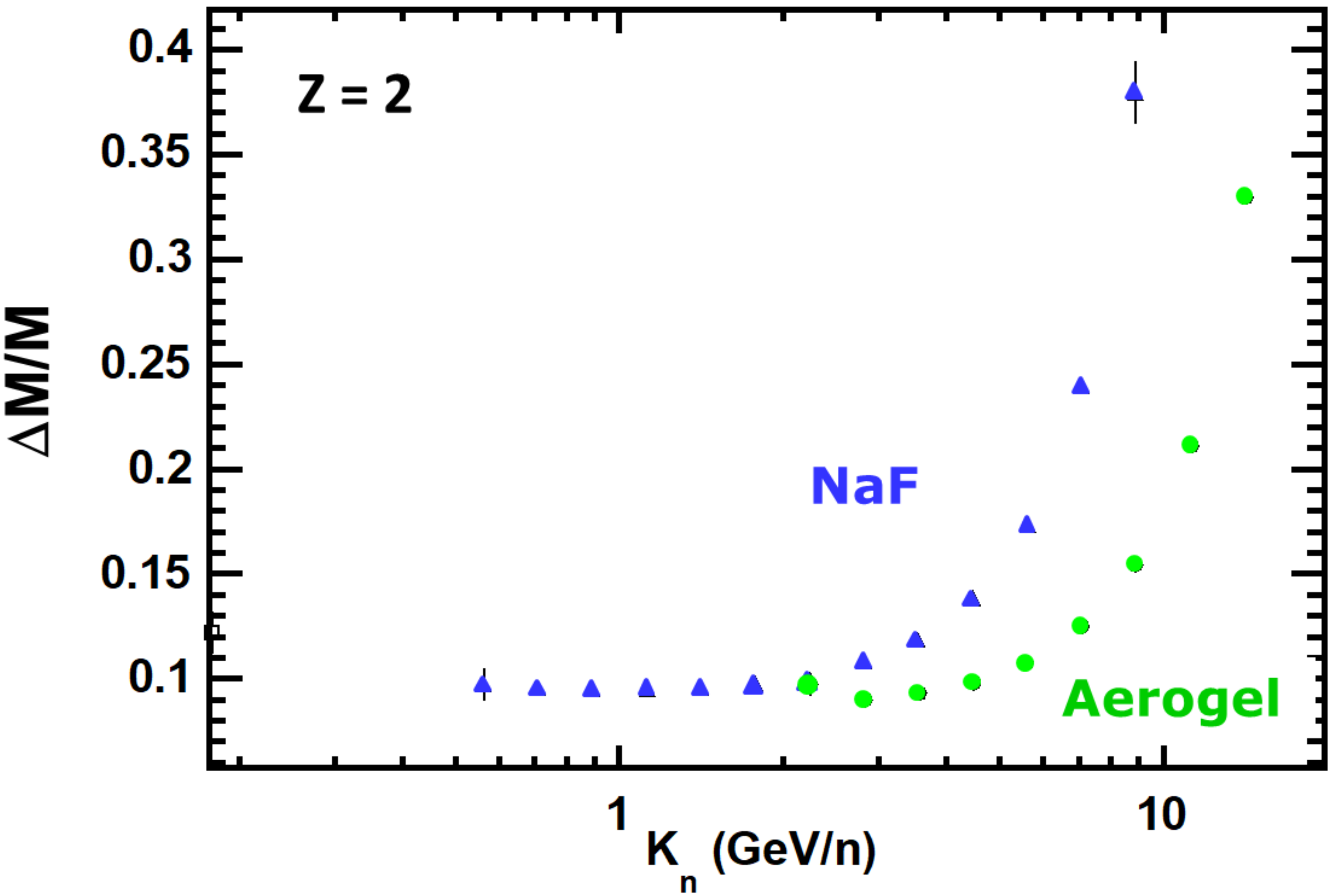


The data sample contains 94 x 10^{6} helium events

Mass Resolution



$$Mass = P \frac{\sqrt{1-\beta^2}}{\beta}$$

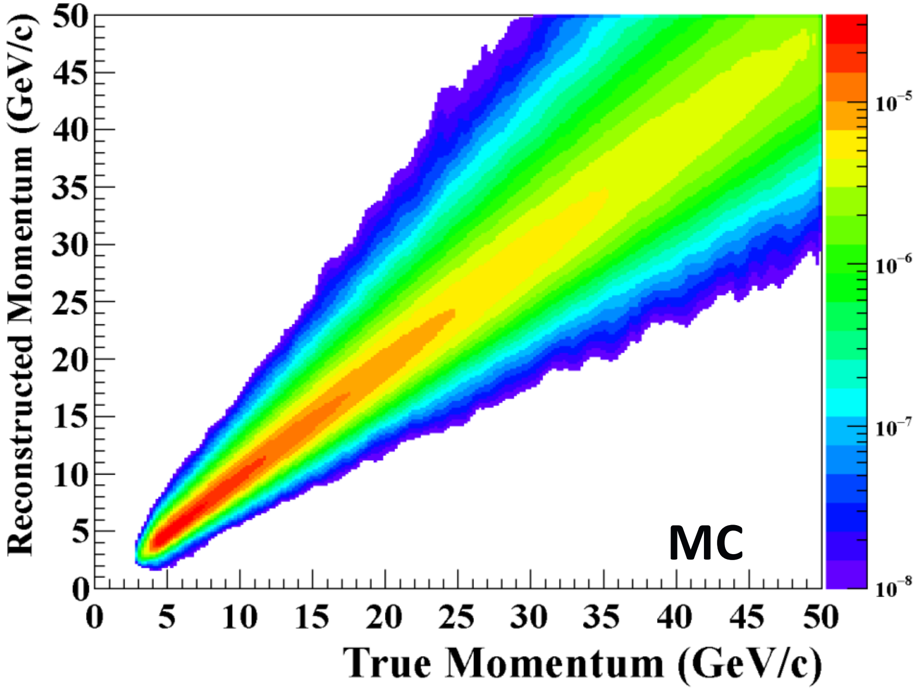


Two data samples: RICH-NaF and RICH-Agl

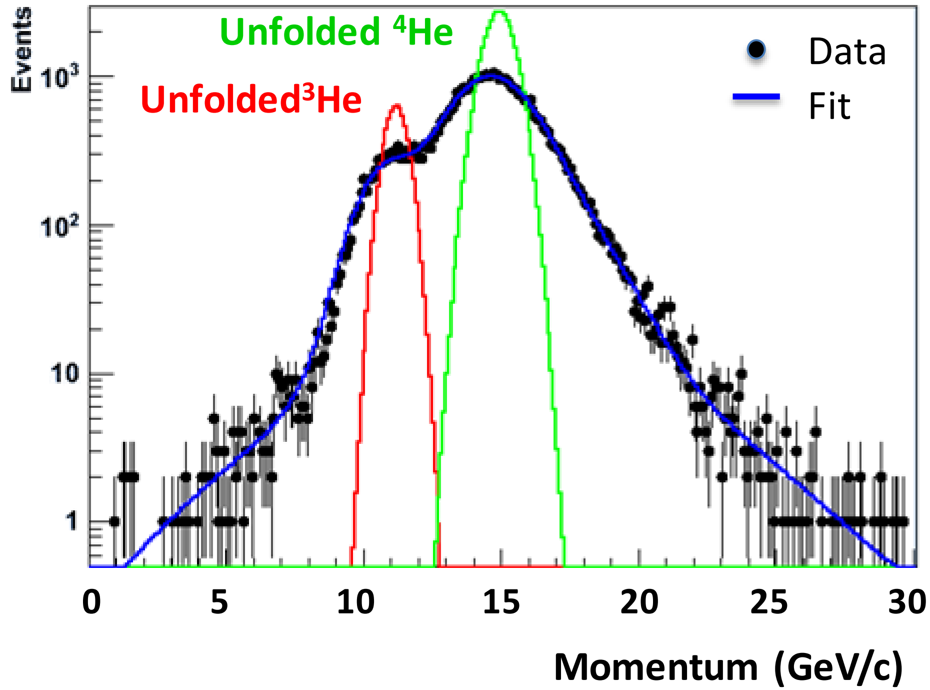
Helium isotopes counting

Select fine β bins and fit the momentum distribution using the tracker resolution matrix to get the unfolded ^{3}He and ^{4}He distributions

He tracker resolution matrix

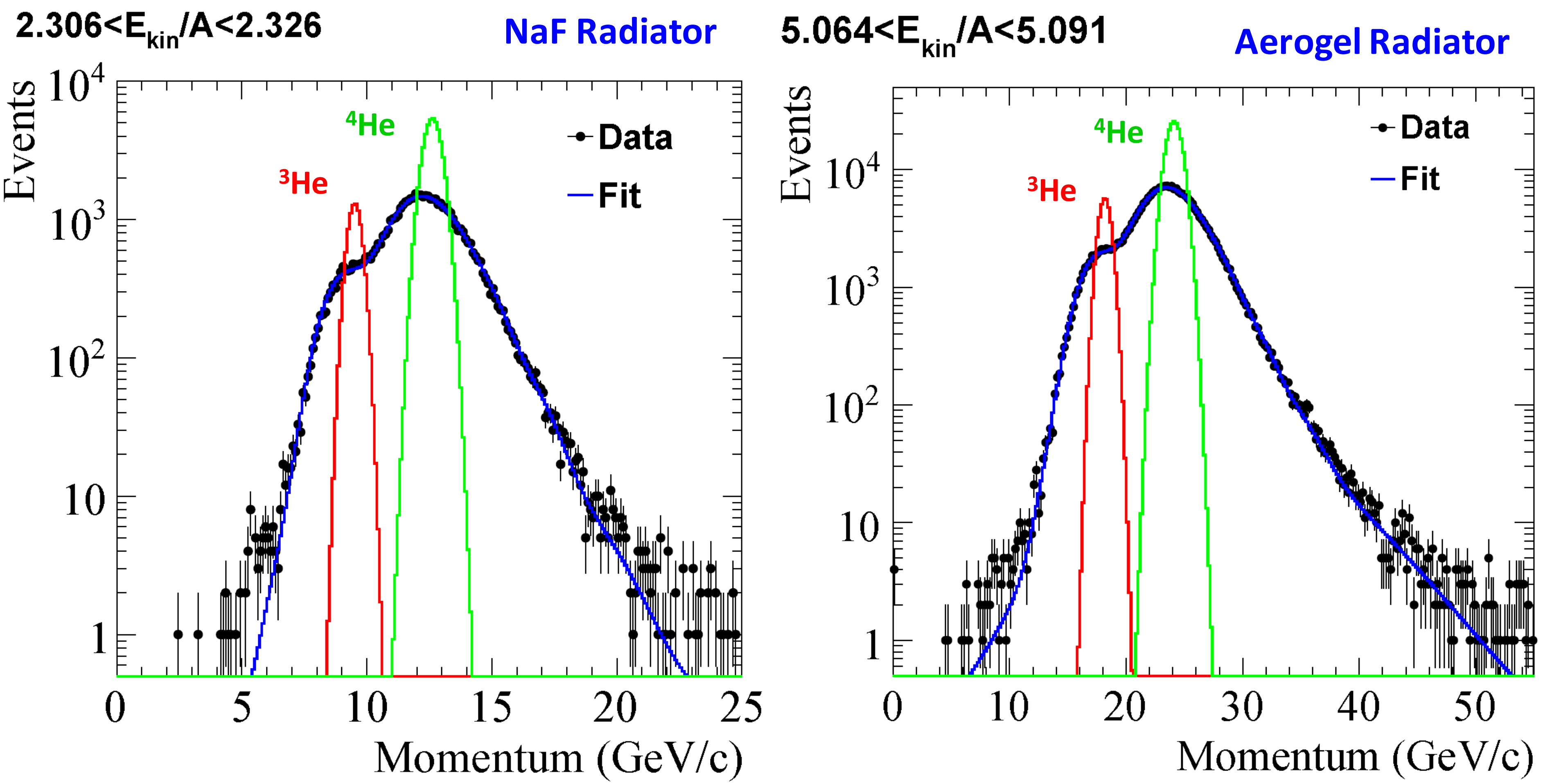


$\beta = 0.97$



Acceptance and energy loss corrections are accounted by the unfolding method

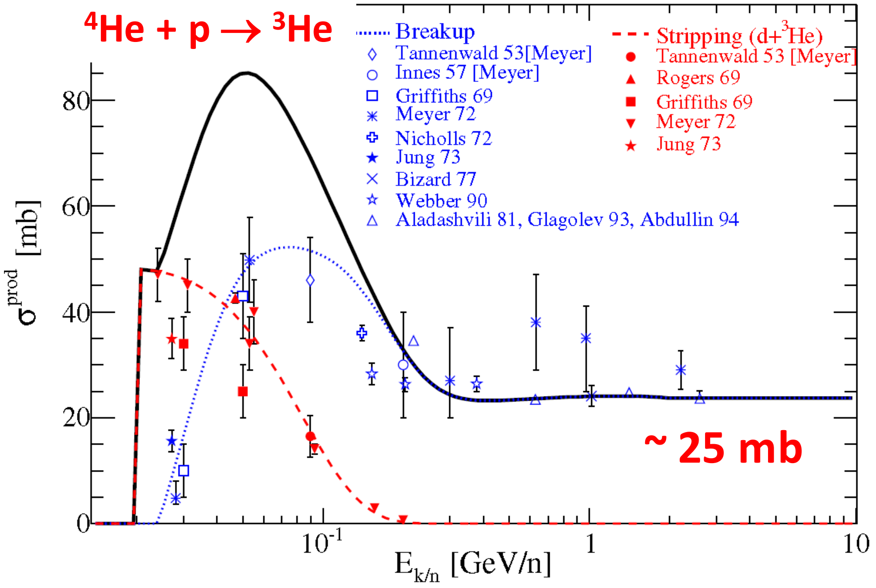
Helium isotopes counting

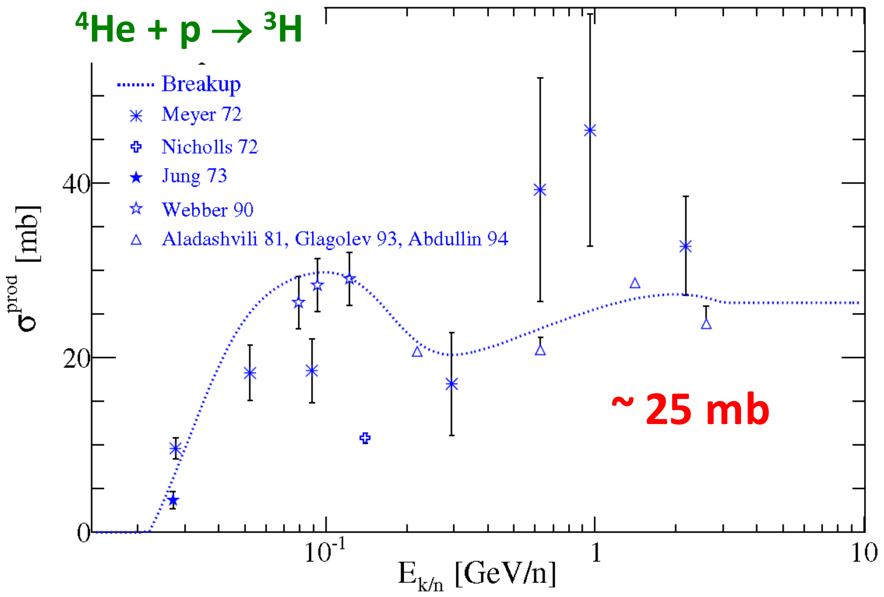


Contamination in the ^{3}He sample due to ^{4}He → ^{3}He fragmentation

^{4}He → ^{3}He and ^{4}He → ^{3}H have similar probabilities at high energy

B. Coste et al. A&A 539, A88 (2012)

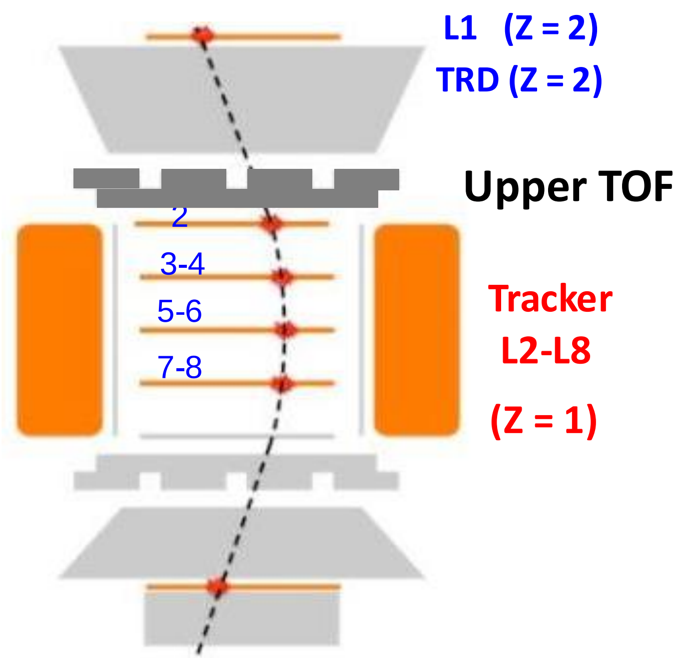


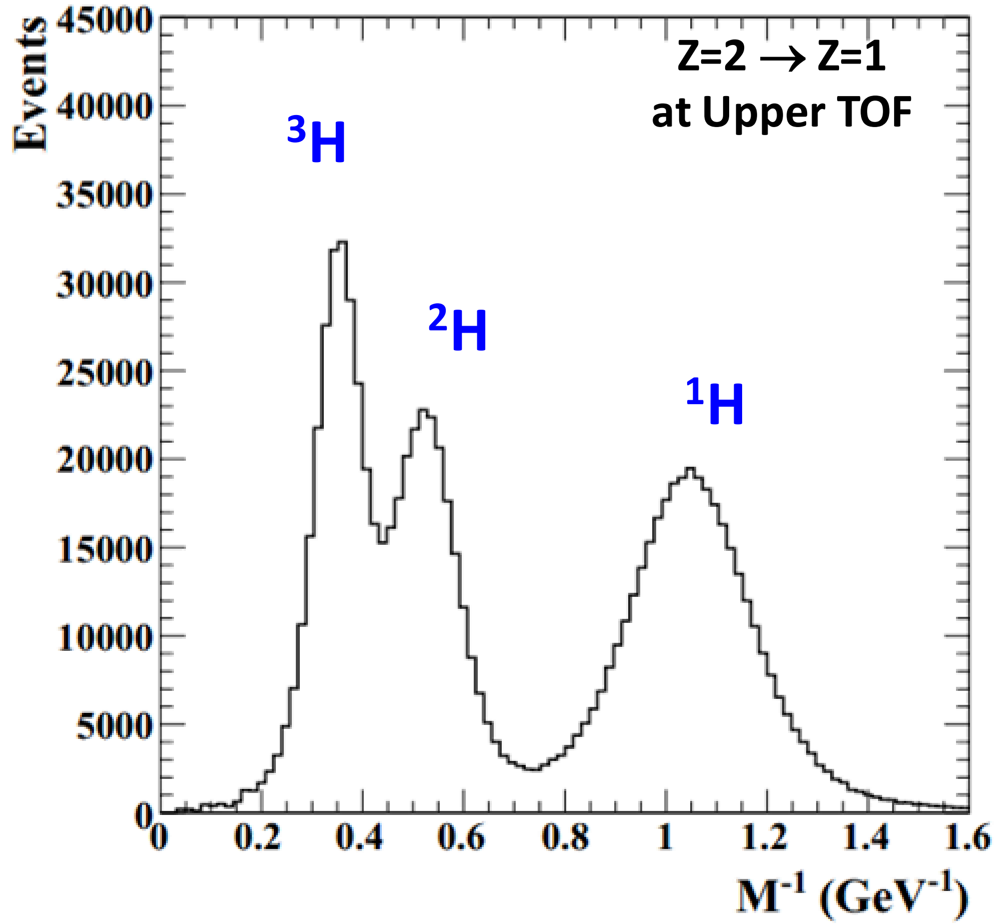


The ^{4}He → ^{3}He fragmentation is determined from the ^{4}He → ^{3}H direct measurement within AMS

$^4He \to {}^3H$ determination

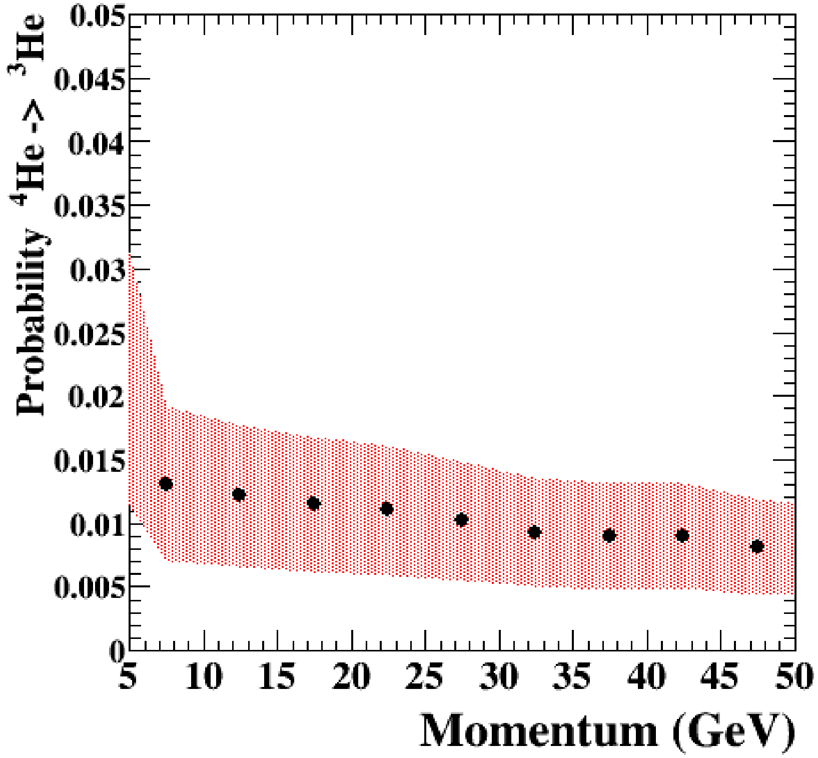
Study of the isotopic composition of charge changing Helium interactions in AMS





$^4He \rightarrow {}^3He$ cross section

$^4He \rightarrow {}^3He$ estimated from $^4He \rightarrow {}^3H$ data and extrapolated to the top of the instrument



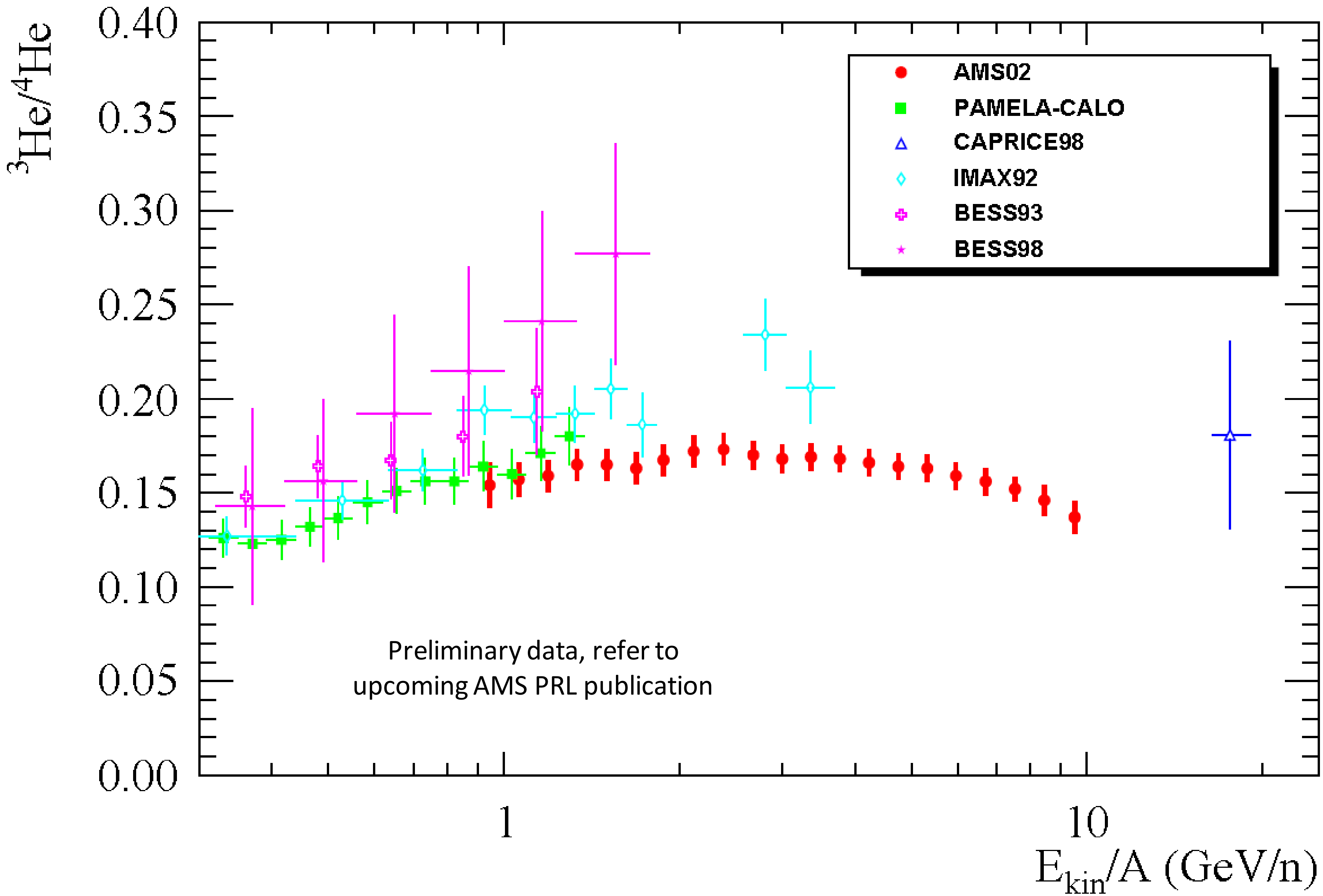
Associated systematic error in the $^3He/^4He$ Ratio is 3.5%

Verification:

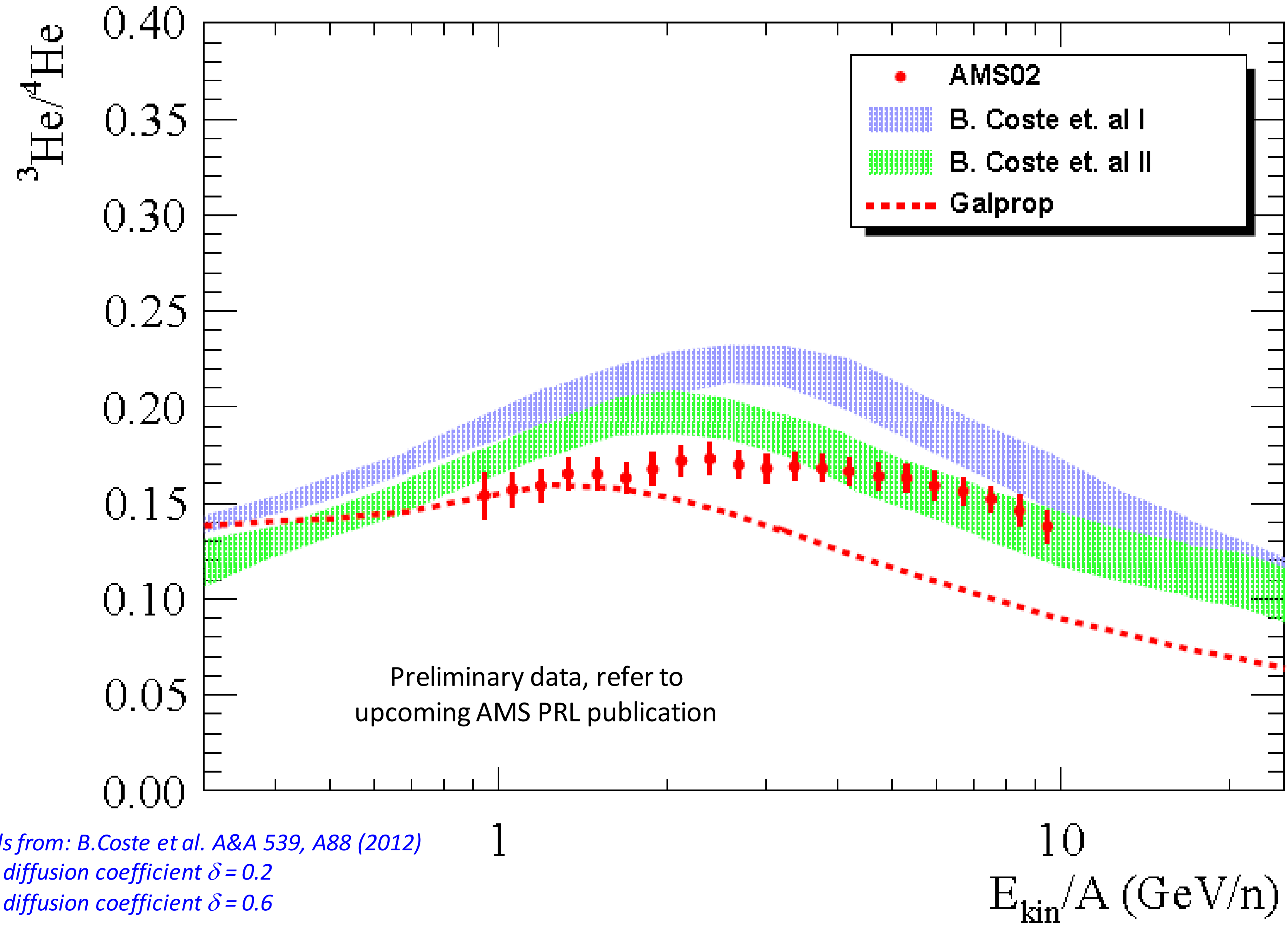
1. Mass distribution of helium tagged interaction at Upper TOF
2. ^3He abundancy as function of the rigidity cutoff

All three methods agree within systematics

$^3He/^4He$ abundancies
compared with earlier measurements



$^3He/^4He$ abundancies
compared with propagation models



Models from: B.Coste et al. A&A 539, A88 (2012)

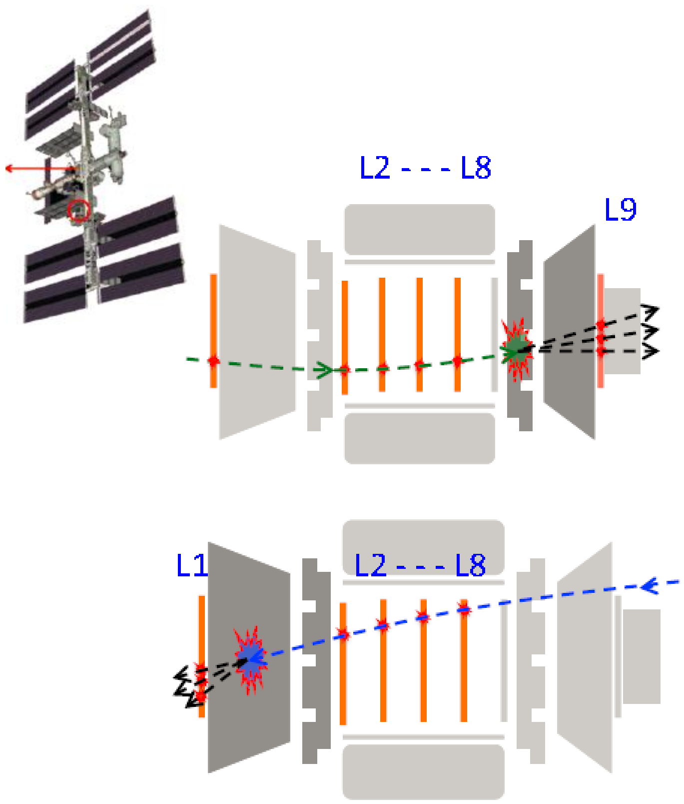
(I) diffusion coefficient $\delta = 0.2$

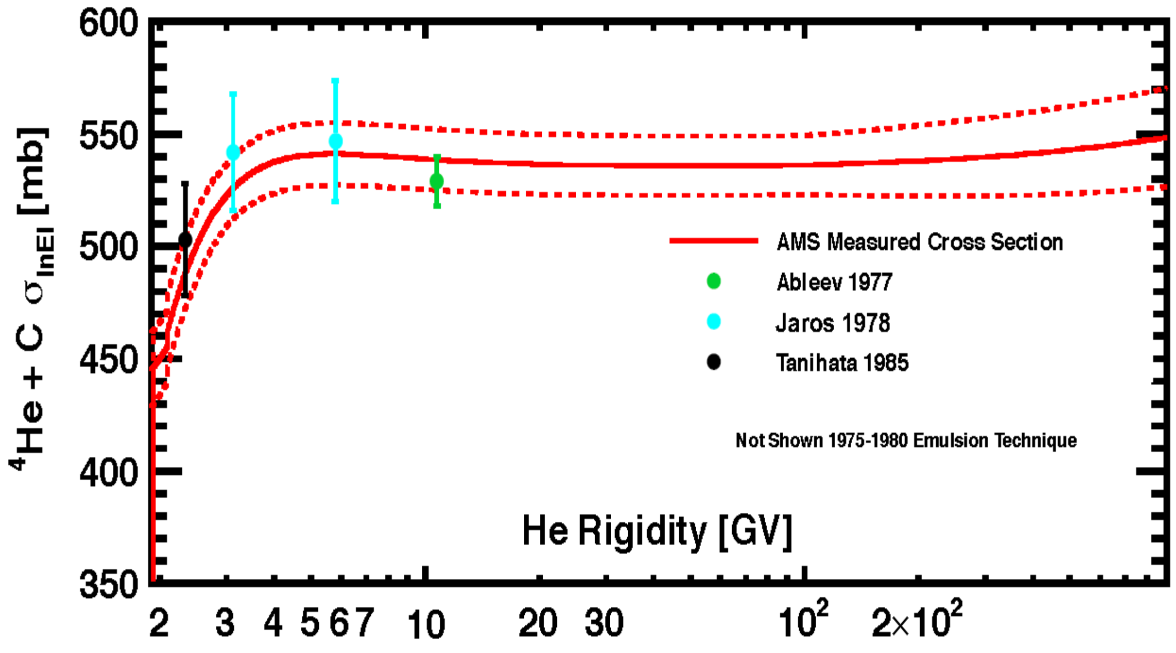
(II) diffusion coefficient $\delta = 0.6$

^3He and ^4He fluxes: Effective acceptance

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

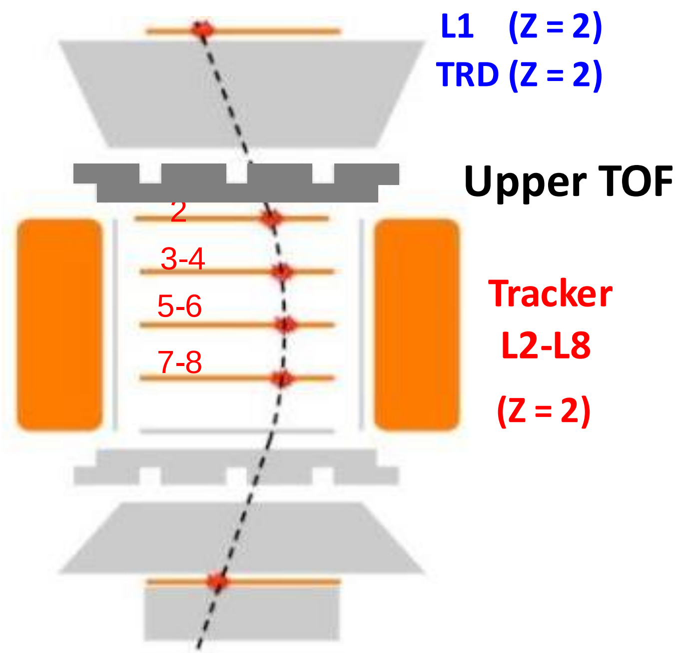
Charge changing inelastic cross sections is measured with AMS data

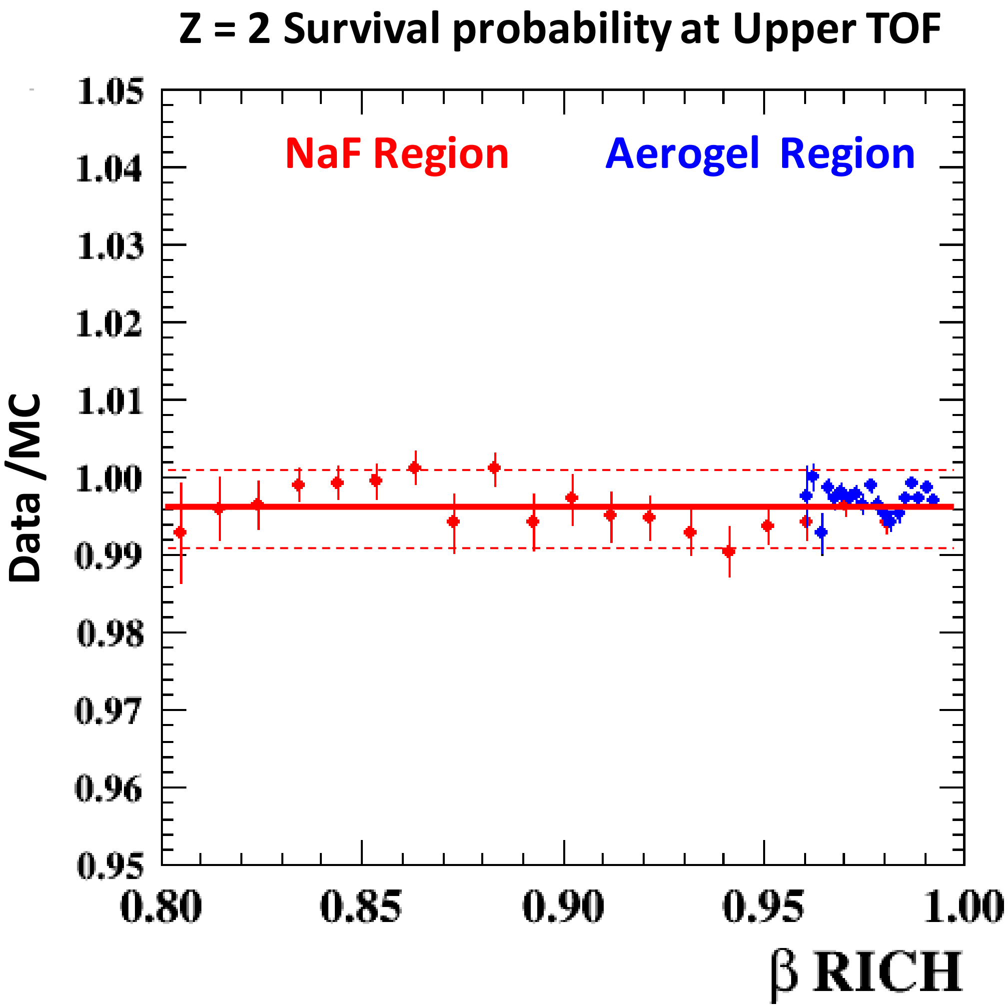




Effective acceptance corrections

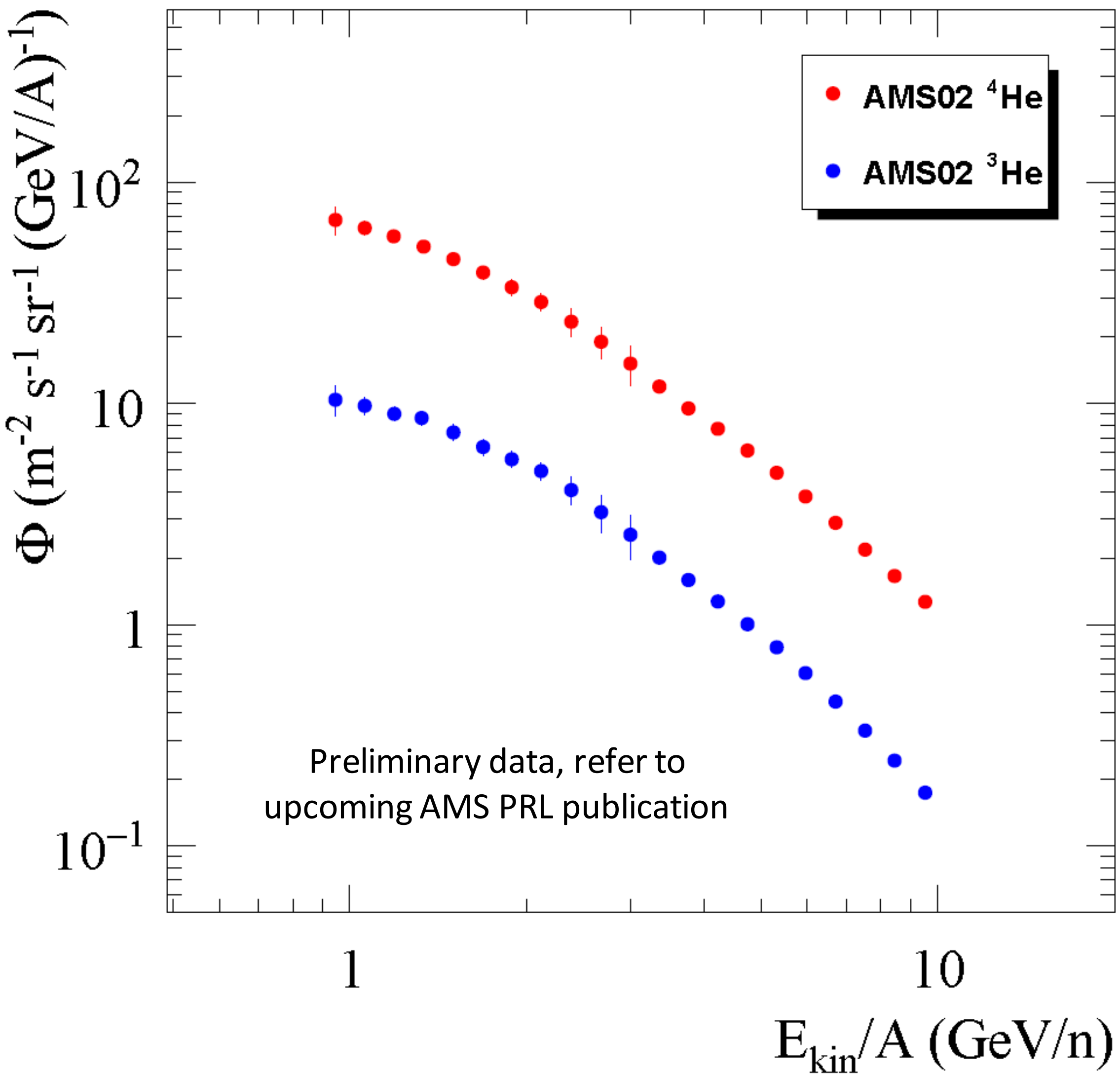
Survival probabilities: Data and MC agree well within 1%





^{3}He and ^{4}He fluxes

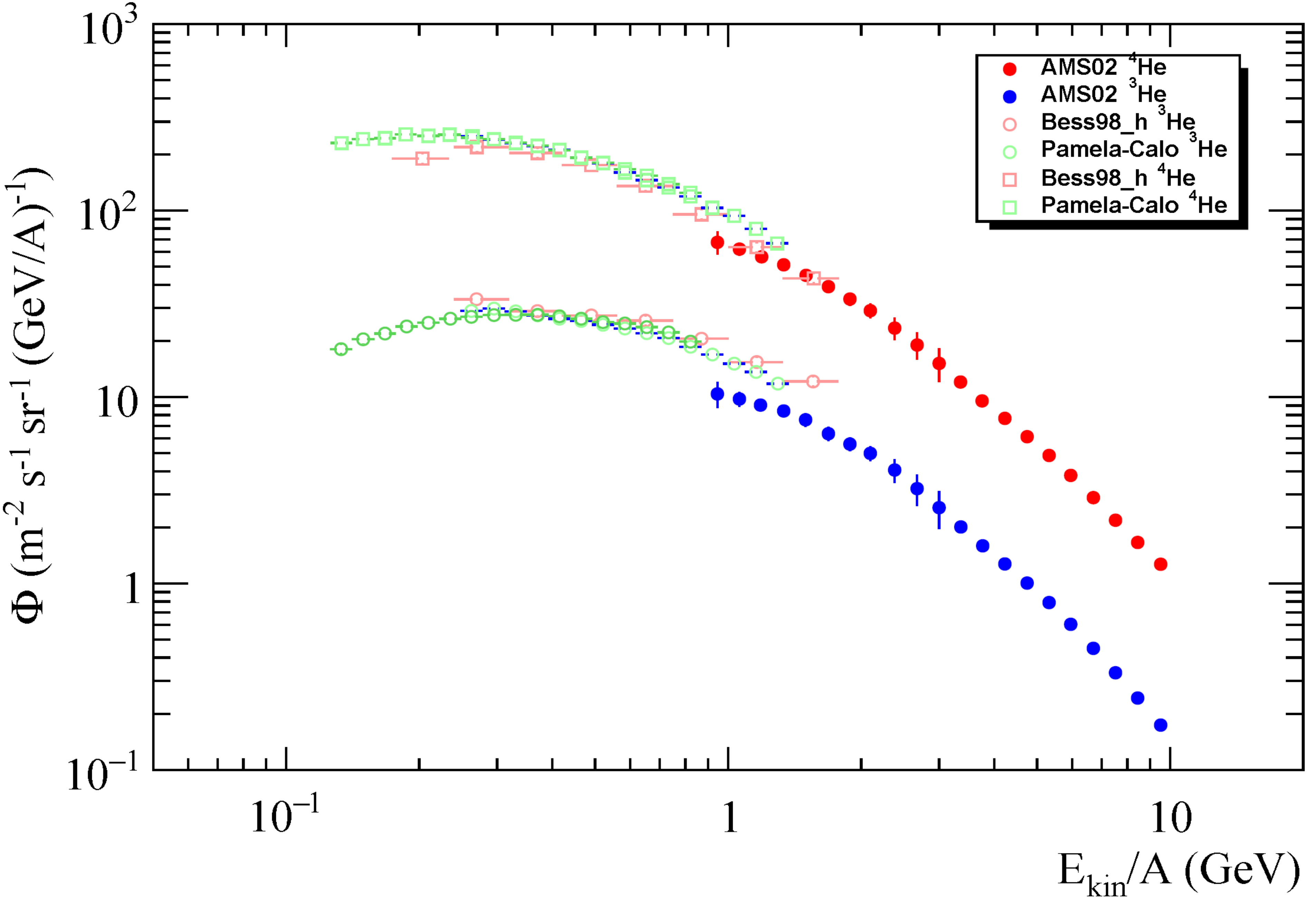
Individual fluxes of isotopes are measured from relative abundances, effective acceptances and exposure time.



Conclusions

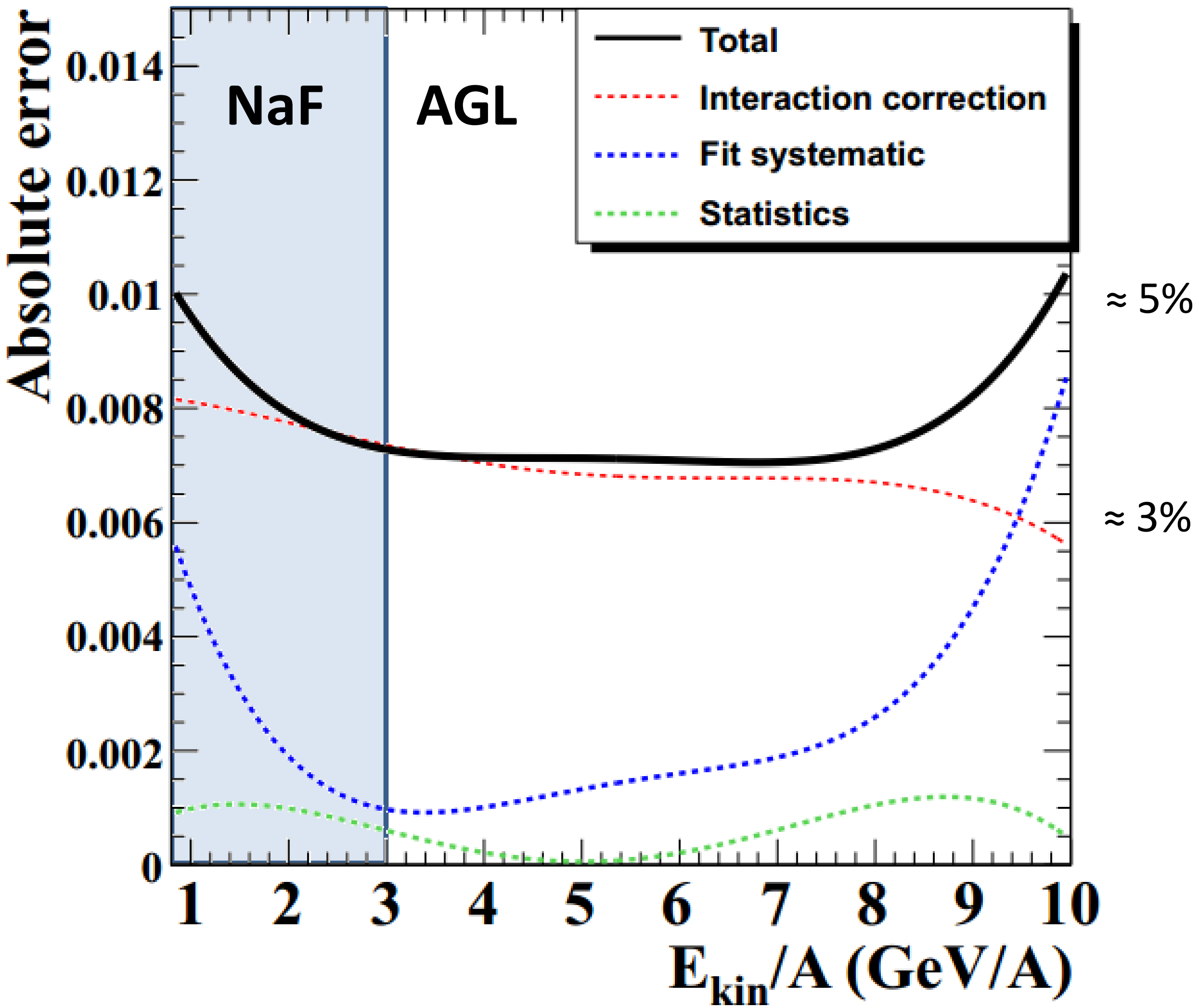
- **Isotopic composition of light nuclei in cosmic rays is a key measurement to understand the origin and propagation of cosmic rays.**
- **A method based on the very high velocity resolution of AMS is used to identify and count the light nuclei isotopes.**
- **A measurement of the helium isotopic abundancies in cosmic rays has been presented. The measurement extends in the energy range from 1 to 10 GeV/n with errors of 4%.**
- **A measurement of the individual ^{3}He and ^{4}He fluxes have been presented in the same energy range**
- **The analysis will be extended to other light nuclei (Li and Be)**

BACKUP

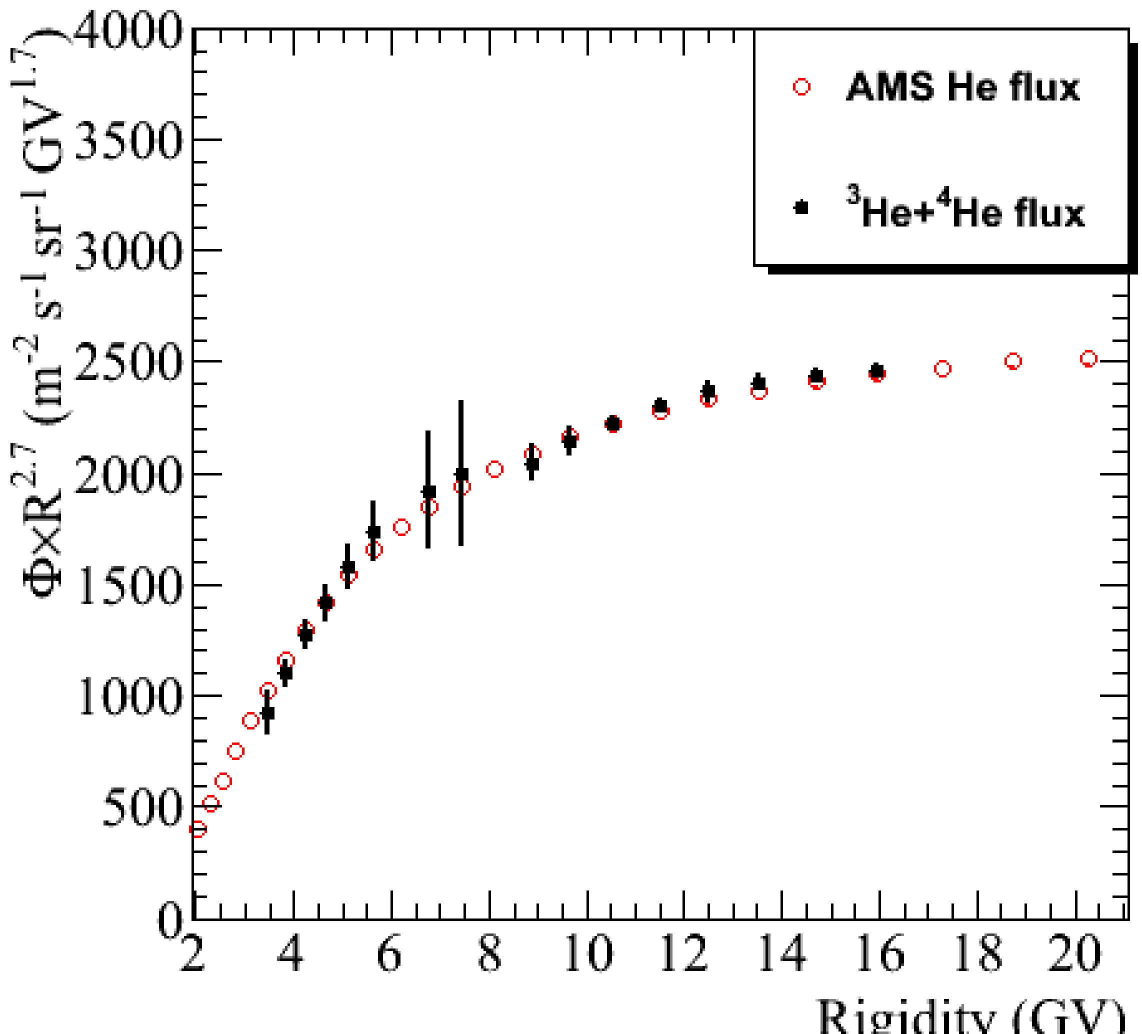


AMS02 4He
AMS02 3He
Bess98_h 3He
Pamela-Calo 3He
Bess98_h 4He
Pamela-Calo 4He
Φ (m-2 s-1 sr-1 (GeV/A)-1)
Ekin/A (GeV)
10-1
1
10
10²
10³

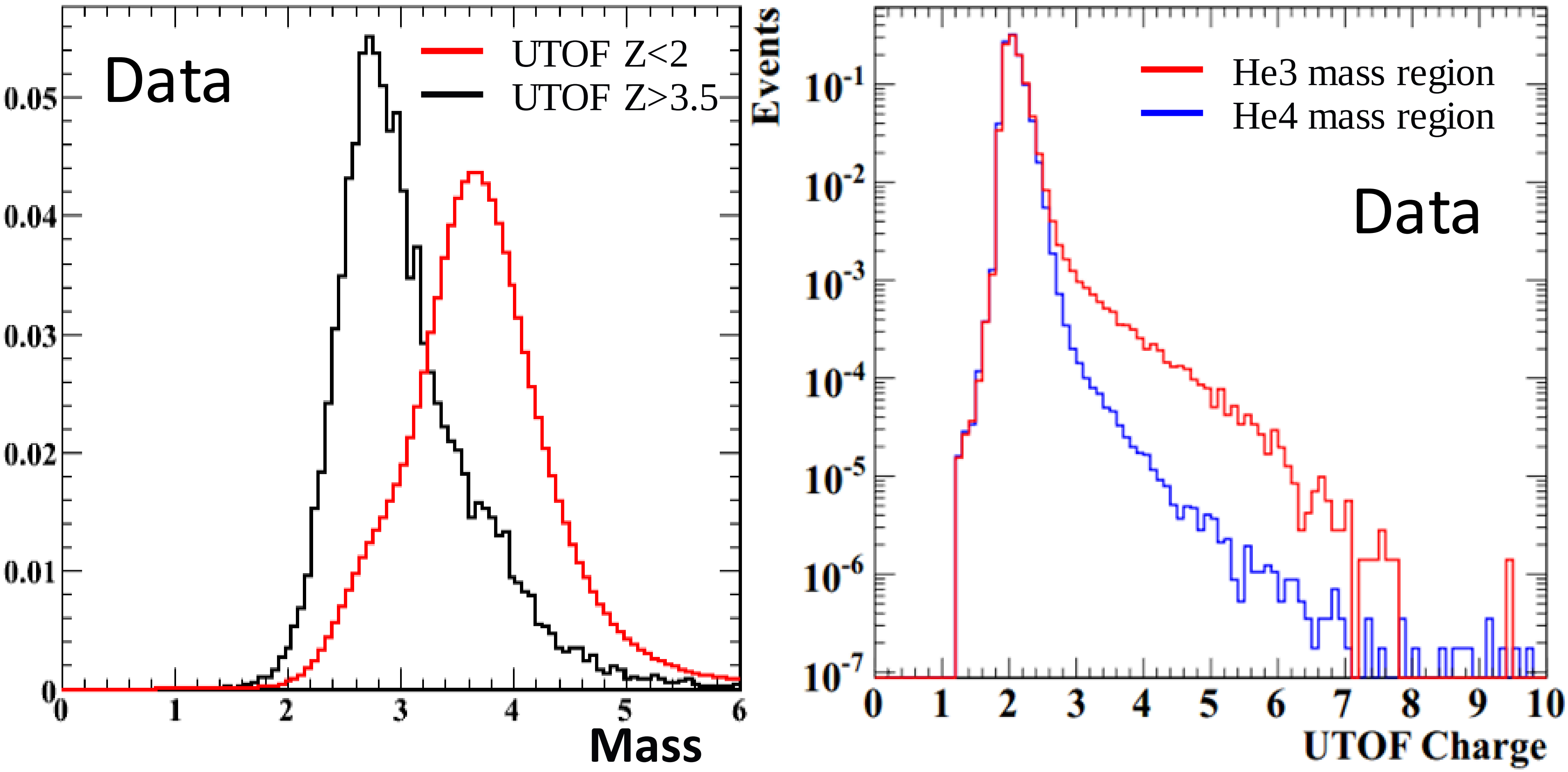
Fraction errors breakdown



$^3He + ^4He$ fluxes vs Rigidity compared with previous AMS measurement



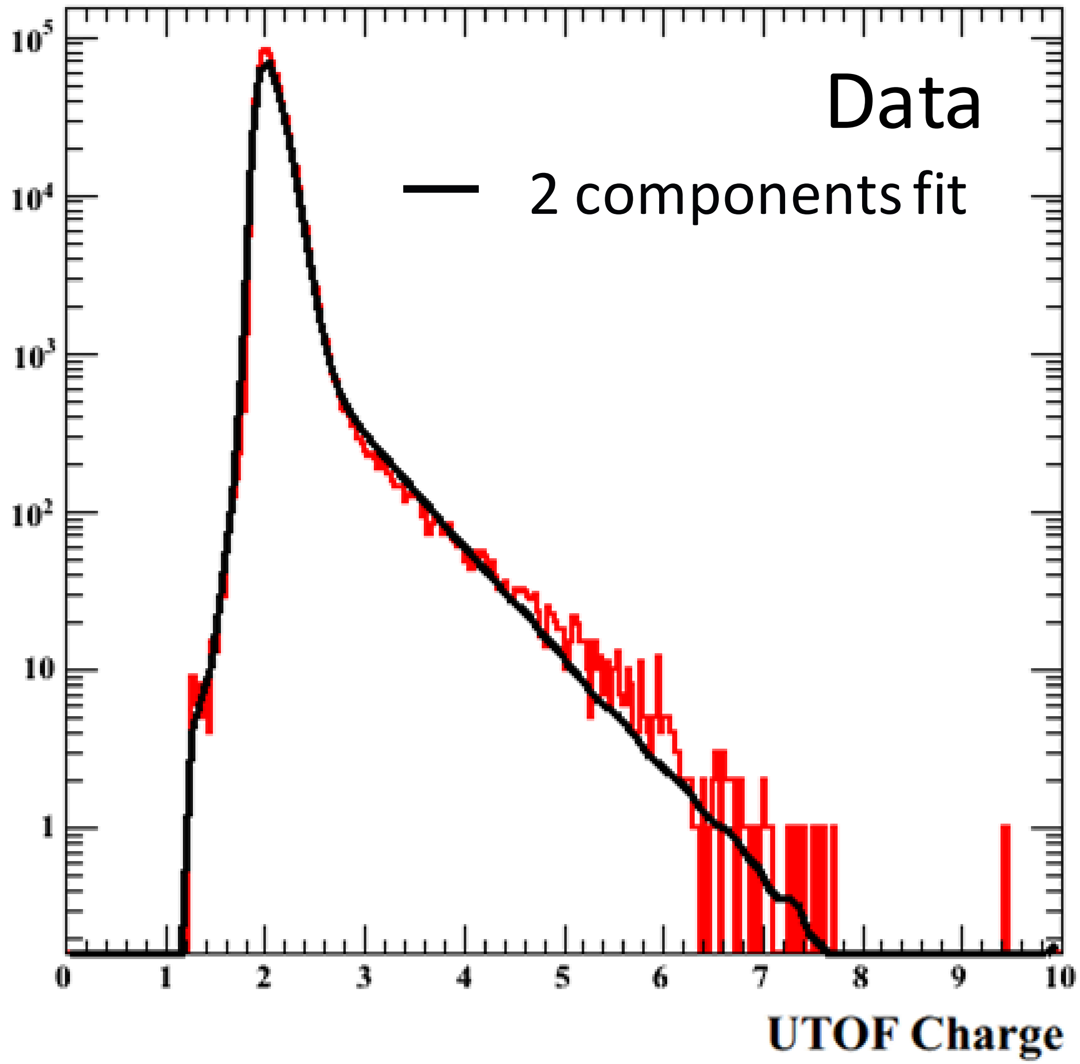
Interactions: He4->He3



Large deposition for inelastic interactions in UTOF or lower TRD.

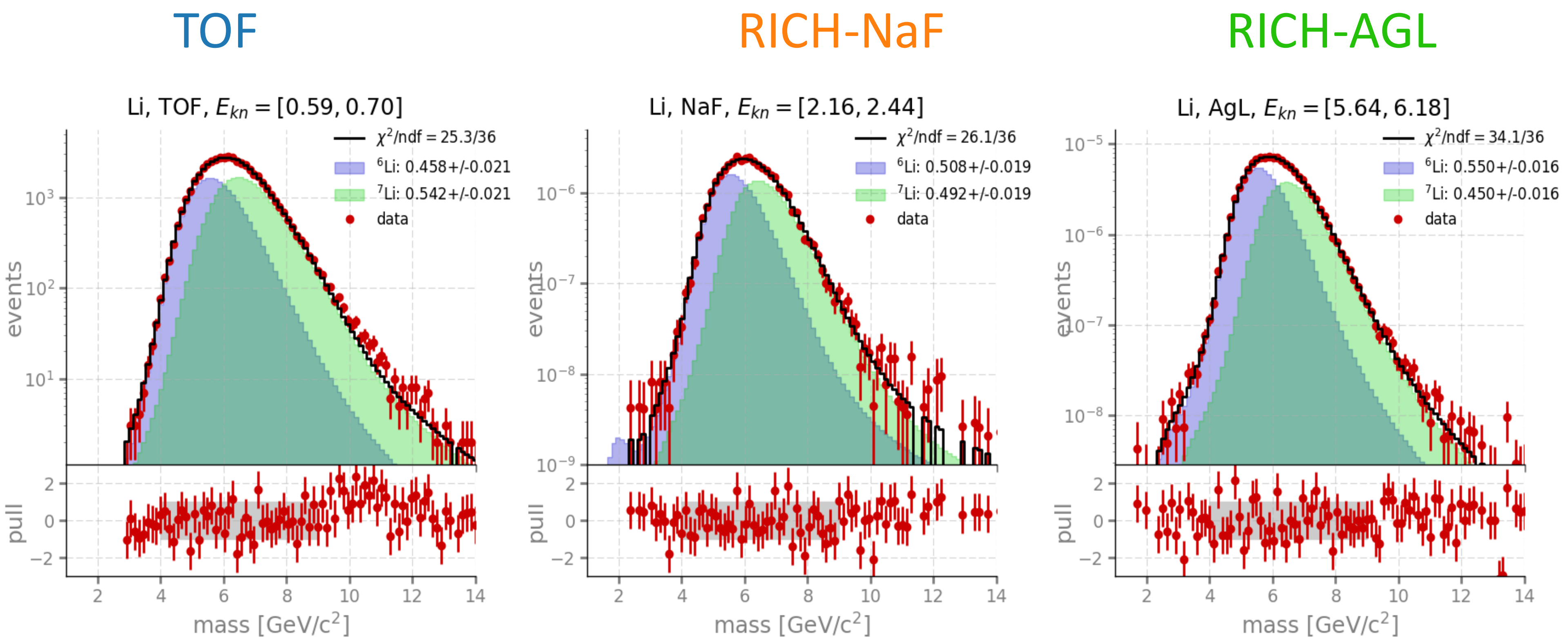
Interactions: He4->He3

- Fit to an He4 template + exponential.
- Get lower limit by counting events in the tails.



^{6}Li/^{7}Li abundances (ISS data)

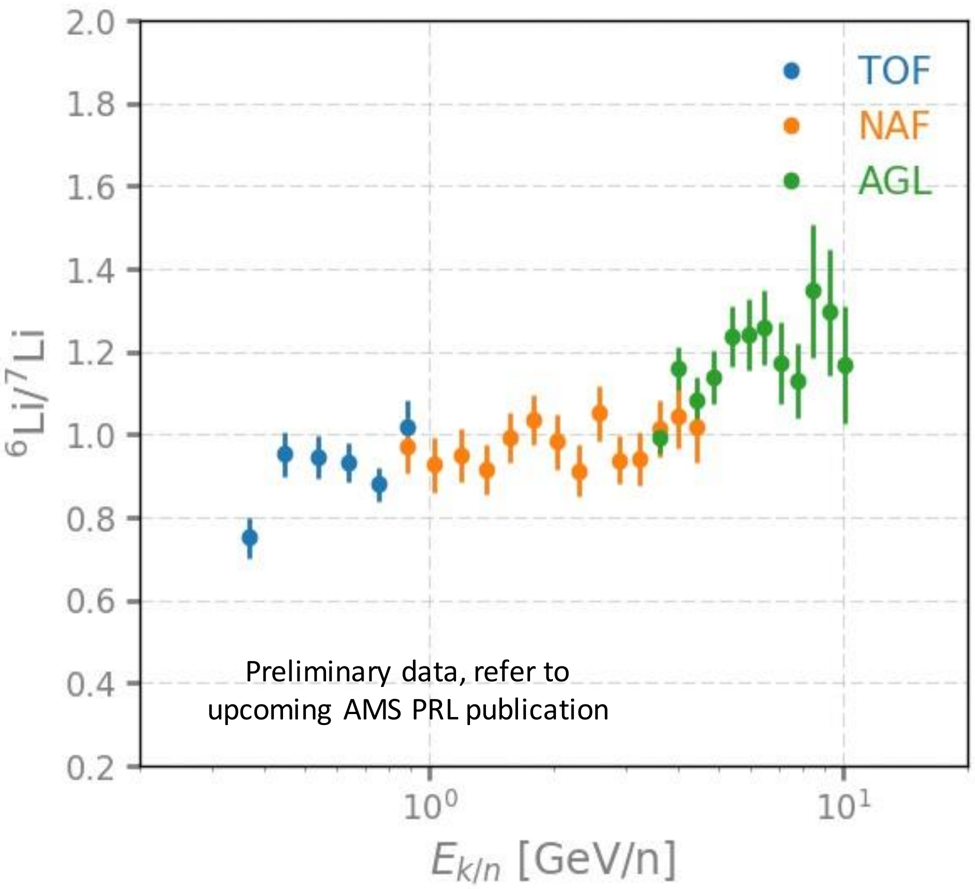
- ^{6}Li and ^{7}Li abundances fitted on the mass distribution for Z=3 ISS data by weighting ^{6}Li and ^{7}Li templates with ^{6}Li and ^{7}Li abundances:



- Errors on the abundances include statistical error and systematic error from the mass template shapes.

$^6Li/^7Li$ abundances (ISS DATA)

- Isotopic abundances from the fit of each mass distribution, corrected with $^6Li/^7Li$ acceptance and exposure time.



Flux reconstruction (ISS data)

- Isotopic fluxes computed from abundances, effective acceptances and exposure time.