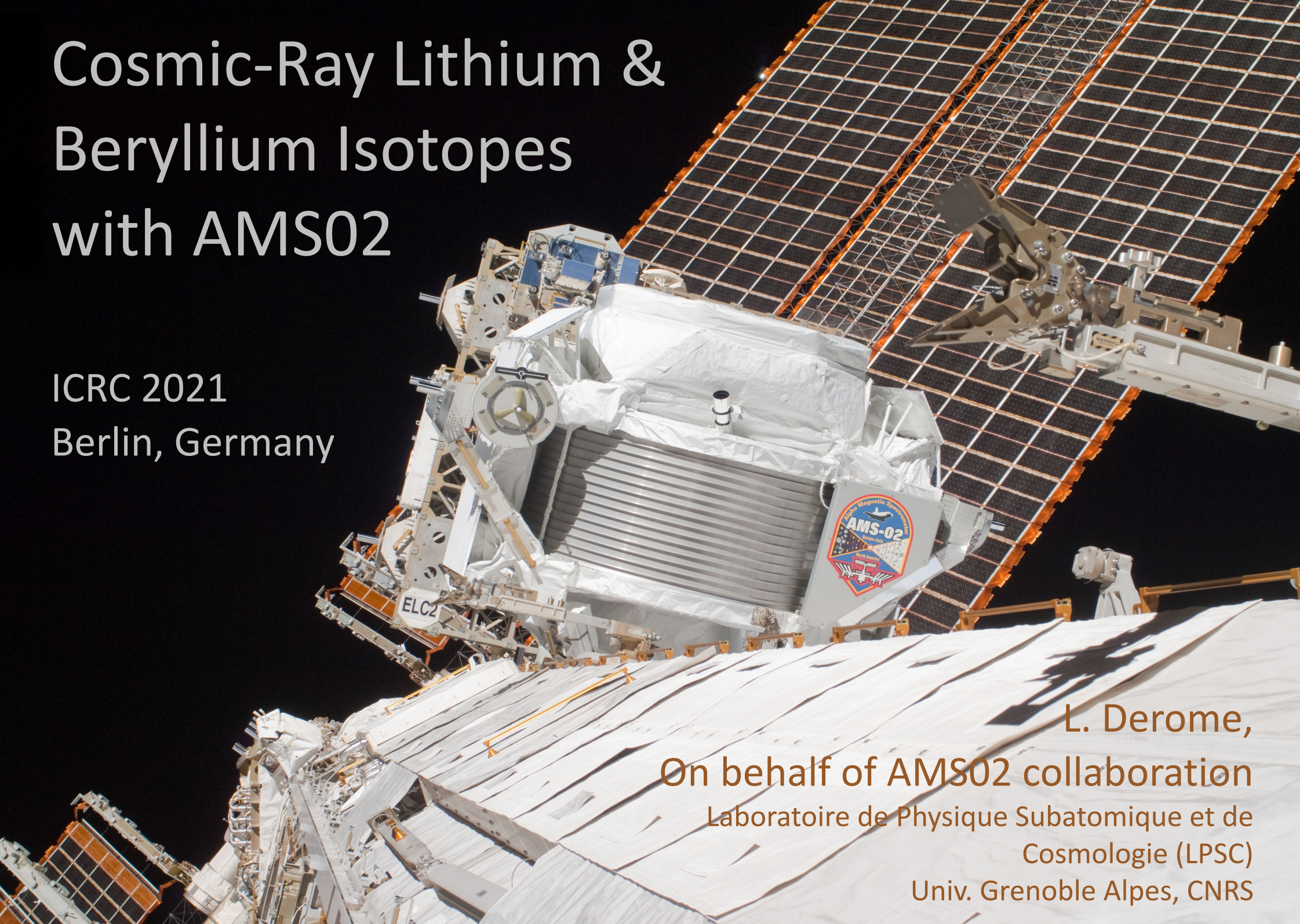
Cosmic-Ray Lithium & Beryllium Isotopes with AMS02

ICRC 2021
Berlin, Germany



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Univ. Grenoble Alpes, CNRS

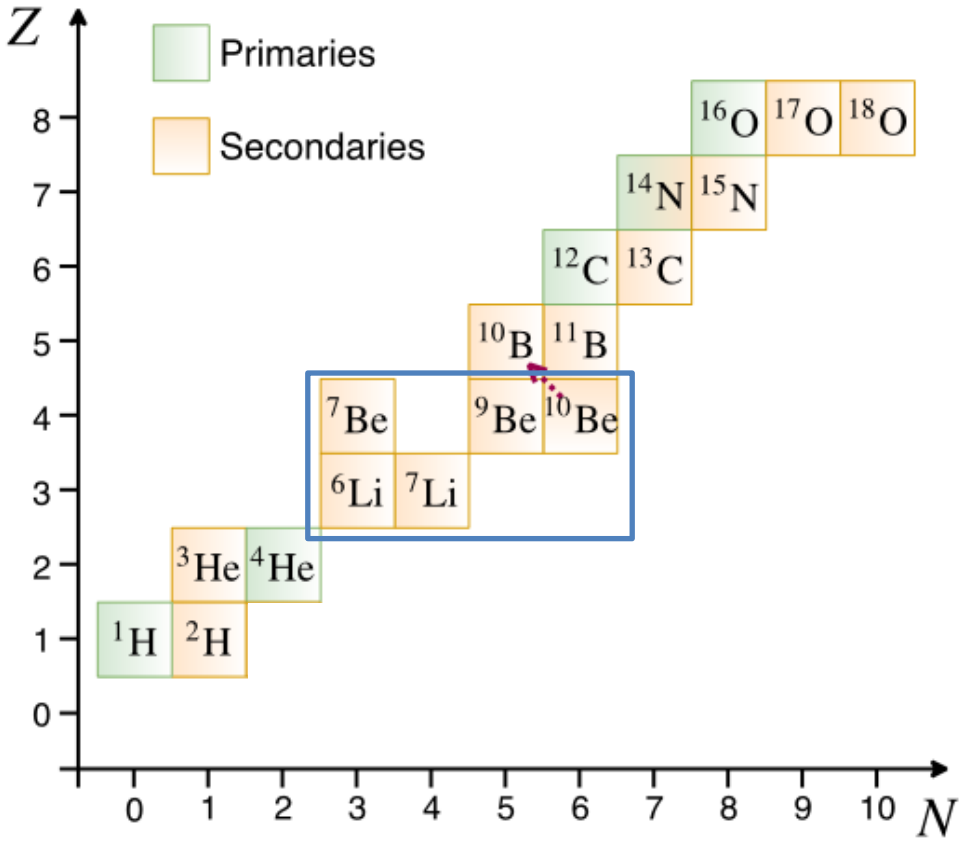
Light Isotopes in Cosmic Rays

- Precise measurement of the light elemental fluxes by AMS *(H. Gast ICRC21#121)*

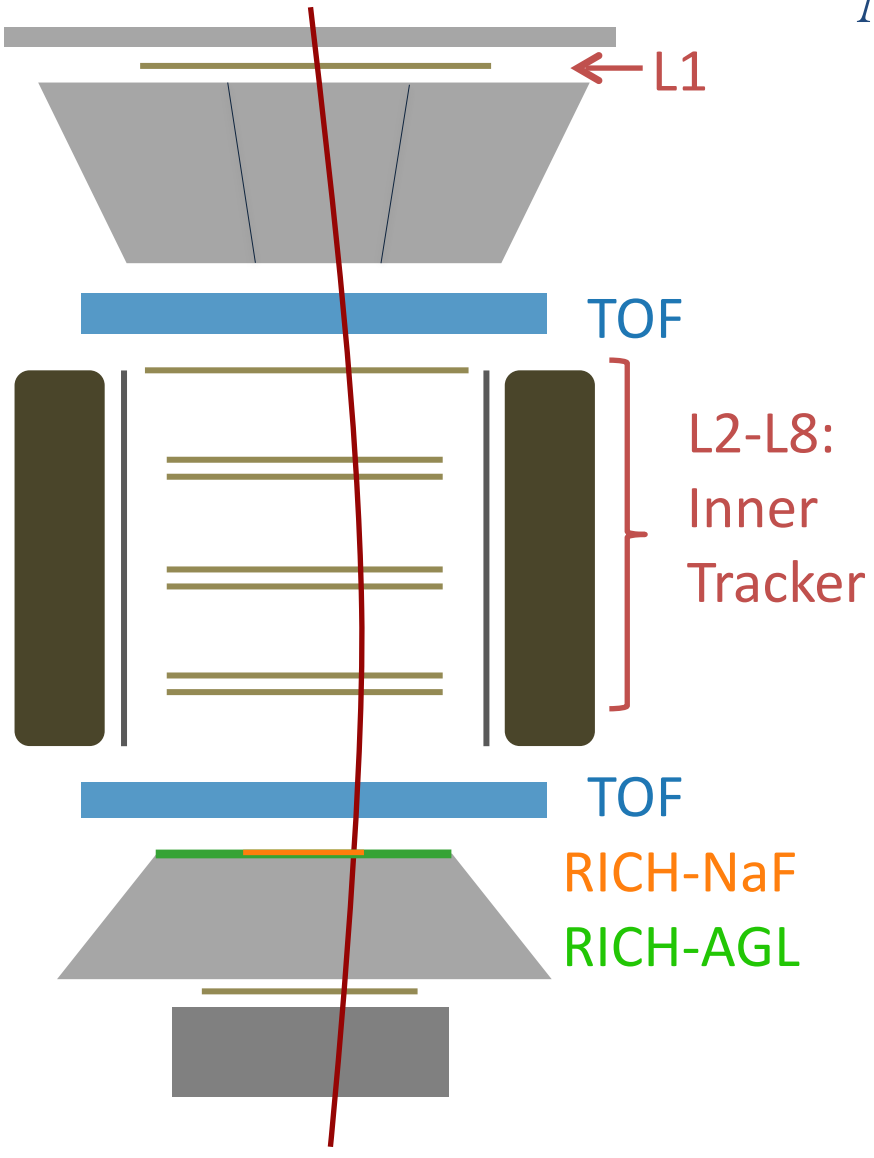
→ Important information to understand the origin and the propagation of Cosmic Rays

- More detailed information from isotopic composition:
  - Different origins (secondary/primary):
    - $^{2}H/^{1}H$ (*E. Ferronato Bueno ICRC21#113*), $^{3}He/^{4}He$ *(F. Giovacchini ICRC21#096)*
    - Primary ^{7}Li component? *(Boschini, 2020, ApJ, 889, 167)*.
  - Different propagation history:
    - ^{10}Be: $t_{1/2}$ = 1.4 My: radioactive clock.
- This presentation: measurement of Isotopic Lithium and Beryllium fluxes with AMS 02

Isotopes in light cosmic rays:



Isotopic identification with AMS02



$$M = \frac{RZ}{\gamma\beta} \rightarrow \frac{\Delta M}{M} = \sqrt{\left(\frac{\Delta R}{R}\right)^2 + \left(\gamma^2 \frac{\Delta\beta}{\beta}\right)^2}$$

- Z measurement:
  - L1 - UTOF - Inner Tracker - LTOF

  → Negligible charge confusion
- R measurement:
  - Tracker (Inner)
- β measurement:
  - TOF:

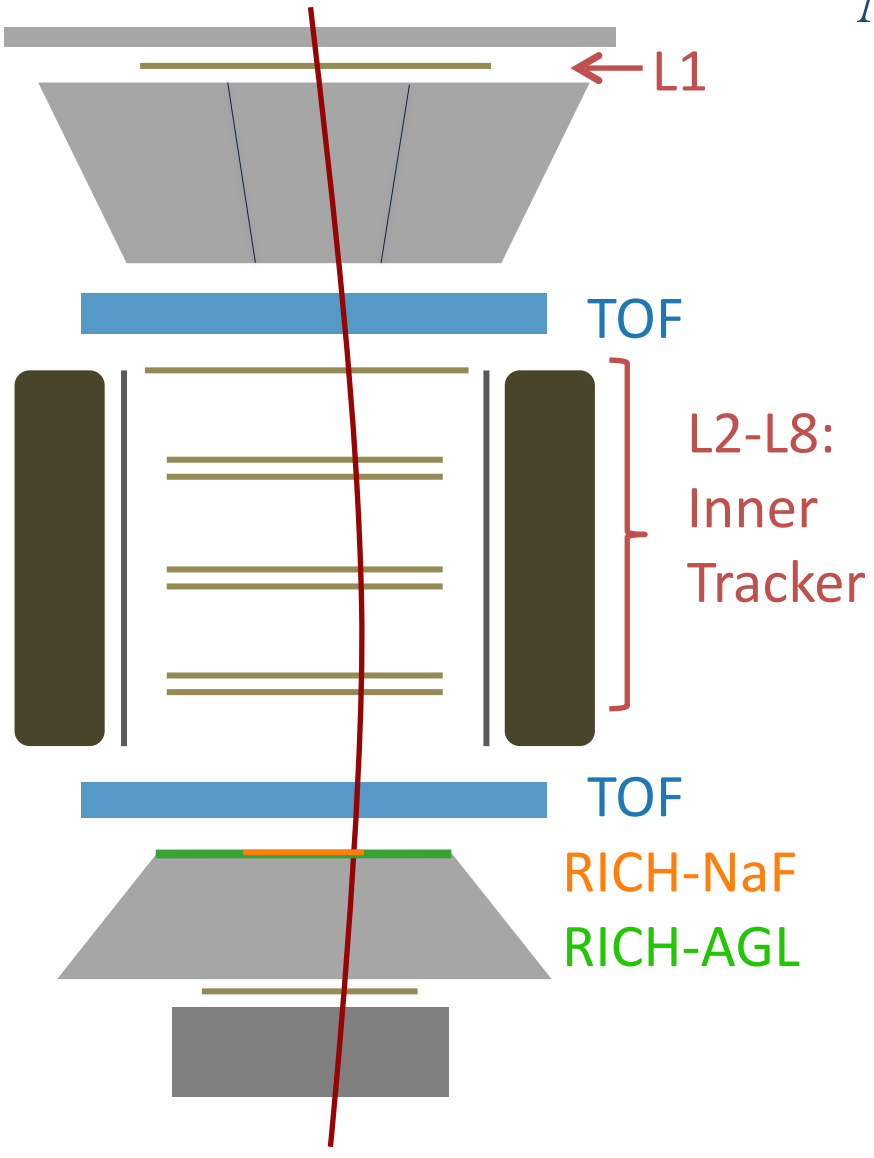
    $\Delta 1/\beta$ (Z=3) ~ 2 10^{-2}
  - RICH - NaF (n_{NaF} = 1.33):

    β > 0.75, $\Delta\beta$ (Z=3) ~ 15 10^{-4}
  - RICH - AGL (n_{AGL} = 1.05):

    β > 0.95, $\Delta\beta$ (Z=3) ~ 5 10^{-4}

→ 3 analyses which cover different E ranges

Isotopic identification with AMS02



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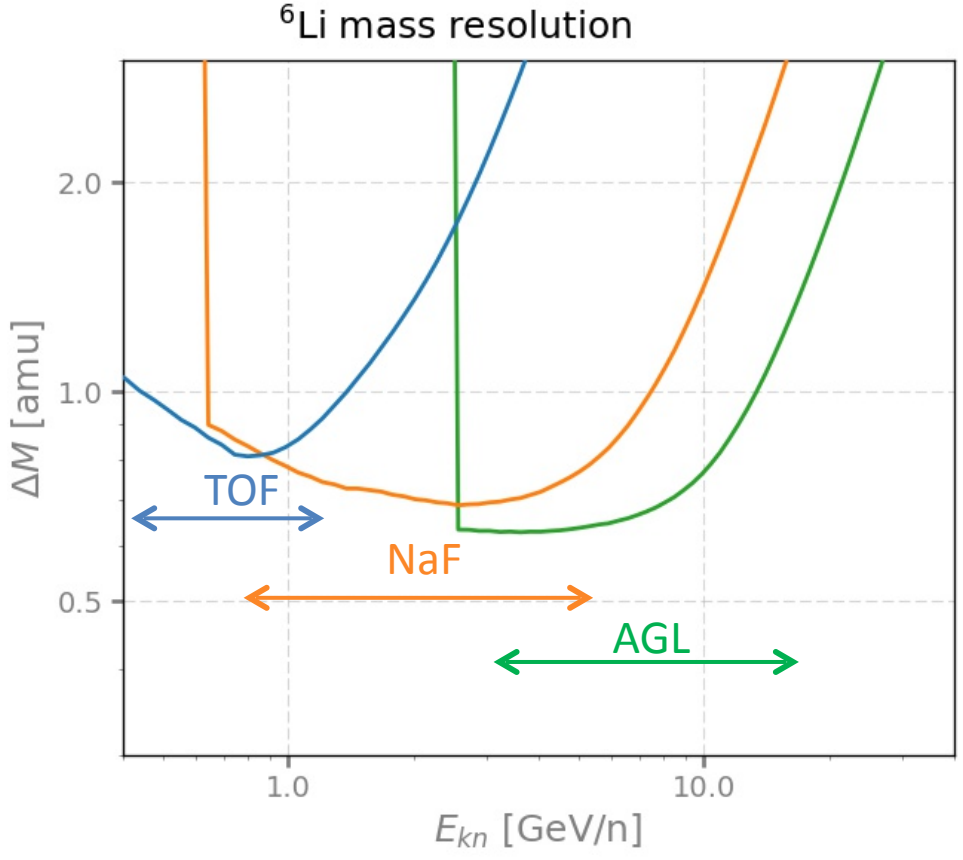


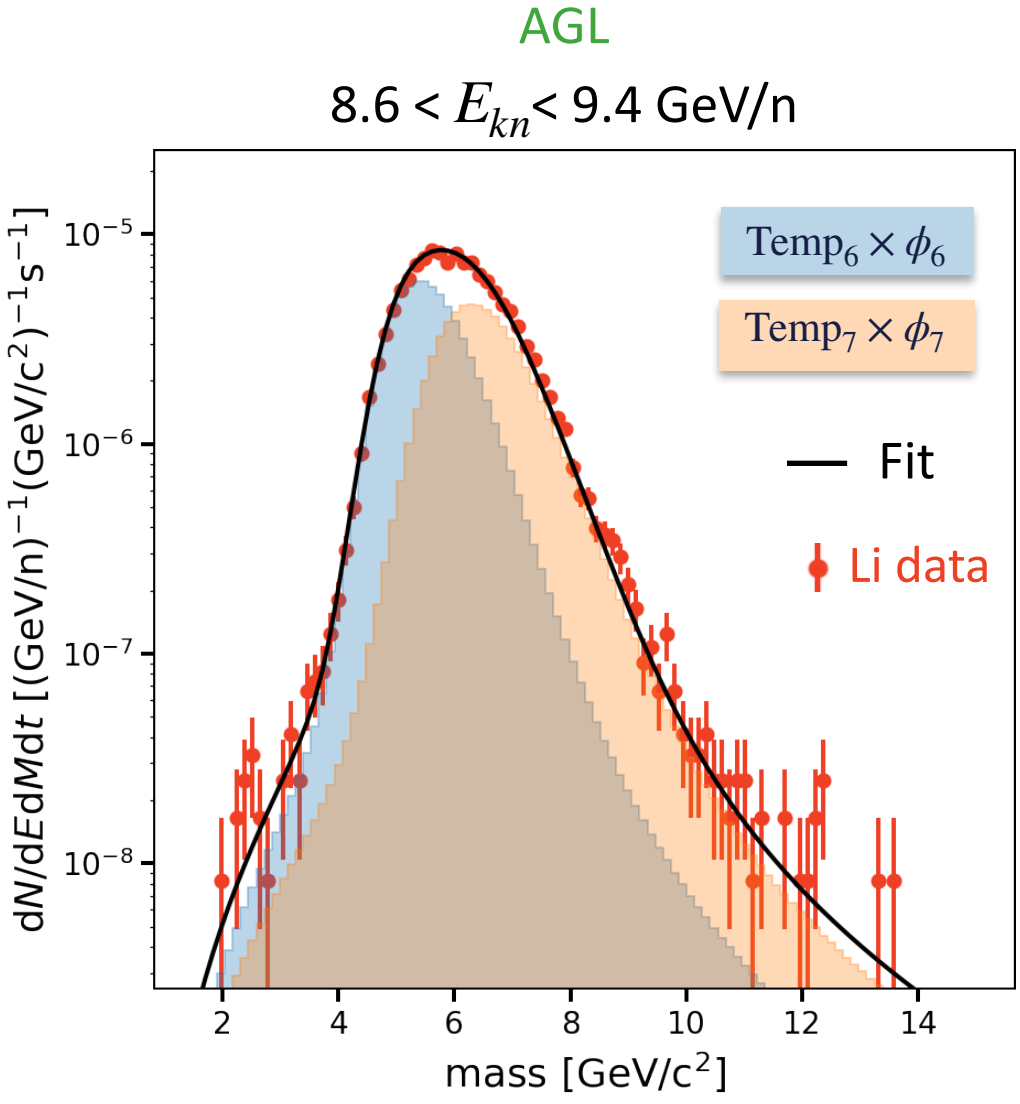
$\Delta M \sim 1$ amu → Event by Event isotopic identification not reachable.

→ Isotopic abundances from the shape of the mass distribution.

Measurement of Isotopic fluxes

- E_{kn} from β measurements with the TOF and NaF/AGL radiators of RICH,
- Isotopic fluxes estimated from the event rates vs. mass for each E_{kn} bins,
- Fitted with the sum of scaled mass templates for each isotopes,
- Mass templates include:
  - Detector acceptance from MC,
  - Data/MC corrections,
  - Energy migration,
  - R and β detector responses with nuisance parameters used to describe the associated systematics.

→ Unfolded fluxes directly obtained from the fitting procedure.



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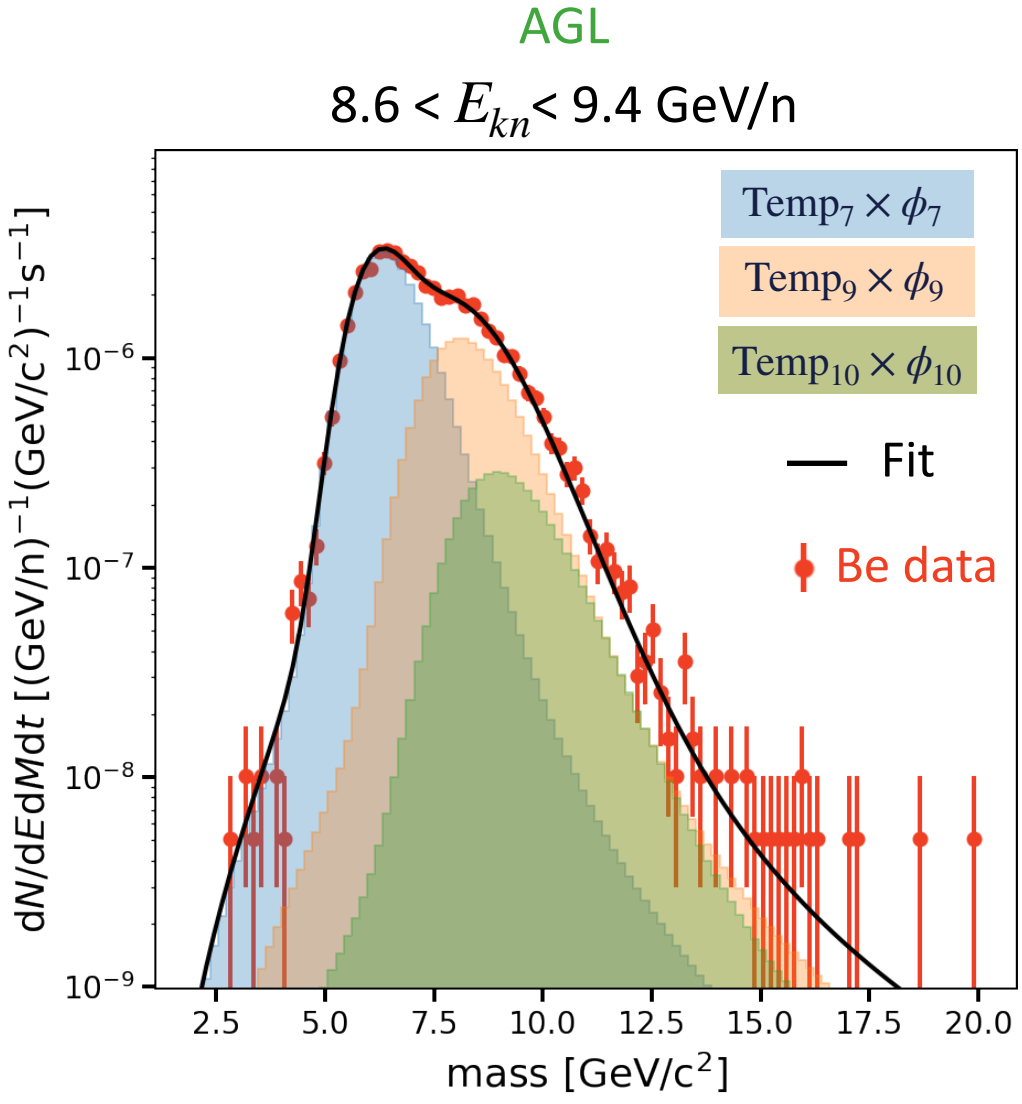


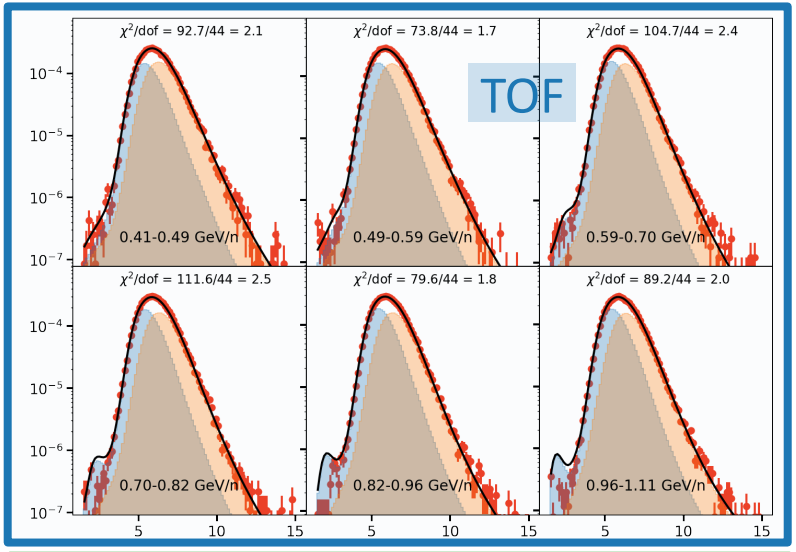
Fitting of Lithium rates

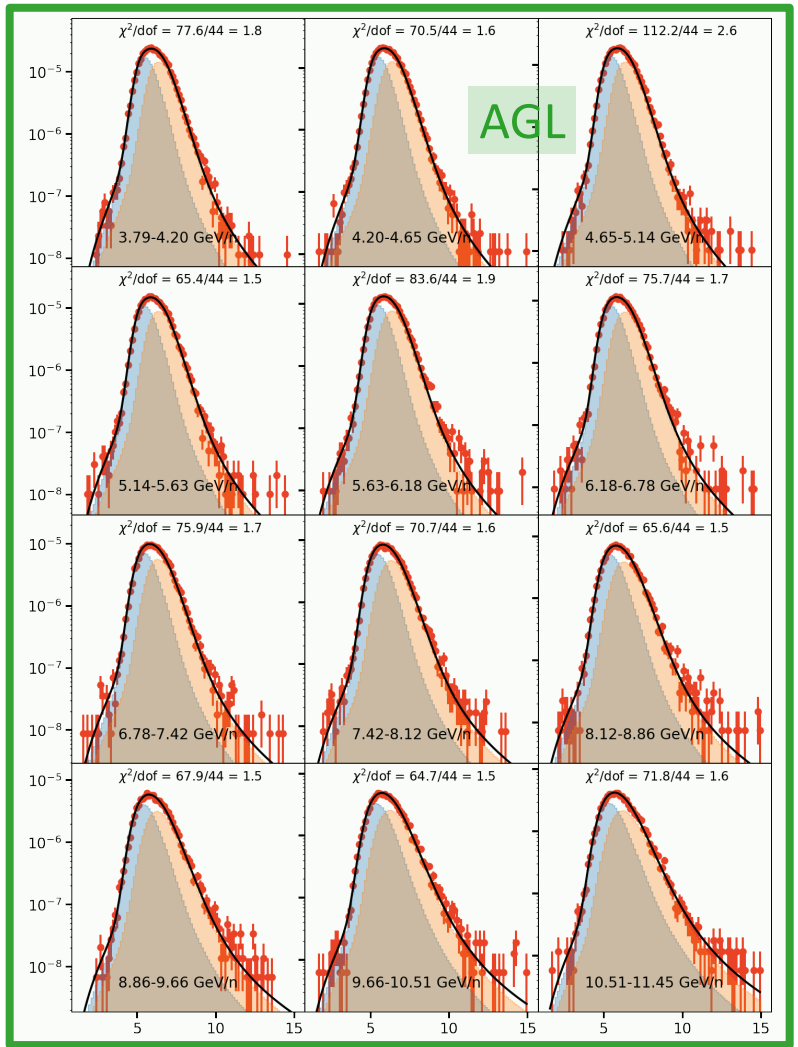
Li data

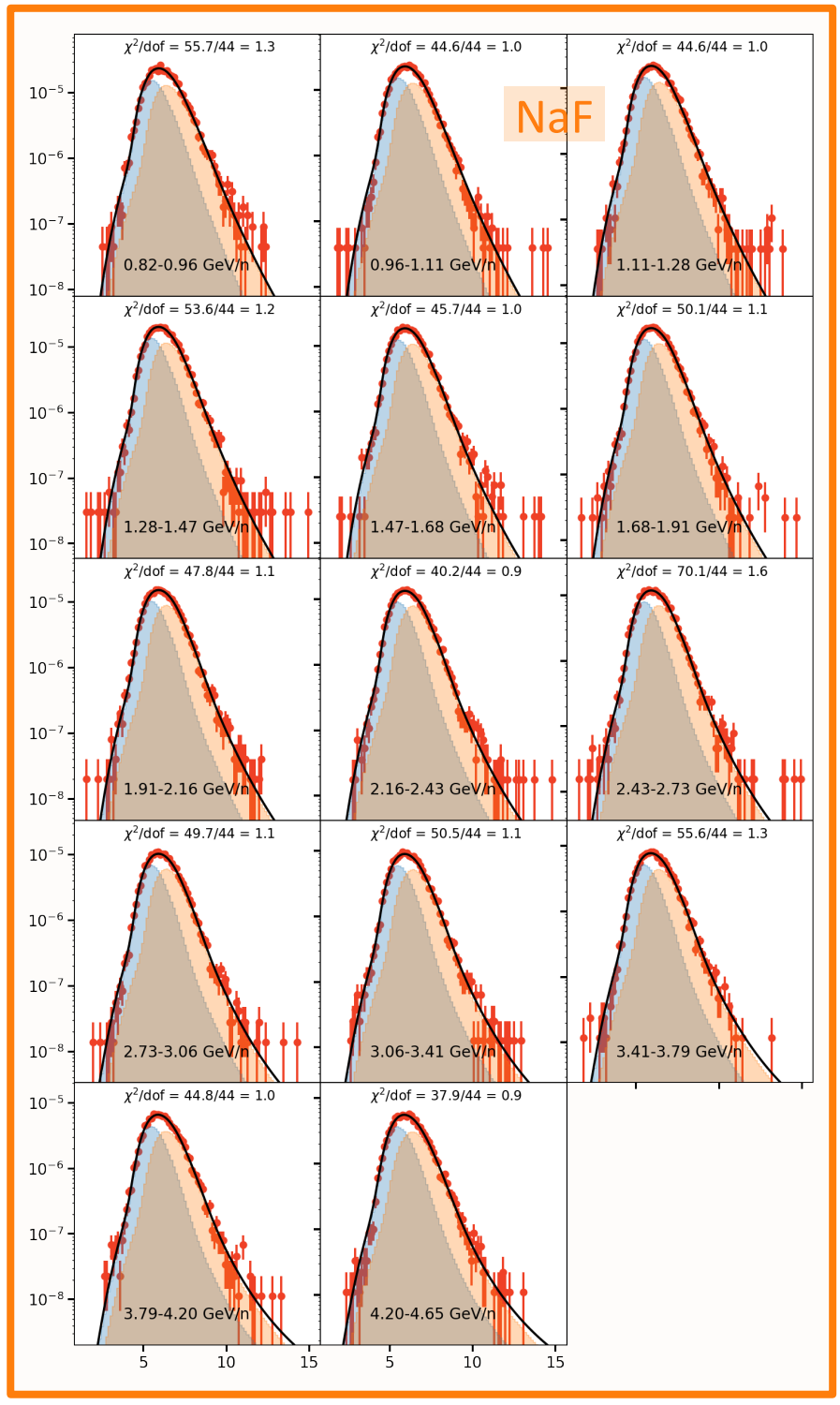
$\mathrm{Temp}_6 \times \phi_6$

$\mathrm{Temp}_7 \times \phi_7$

— Fit

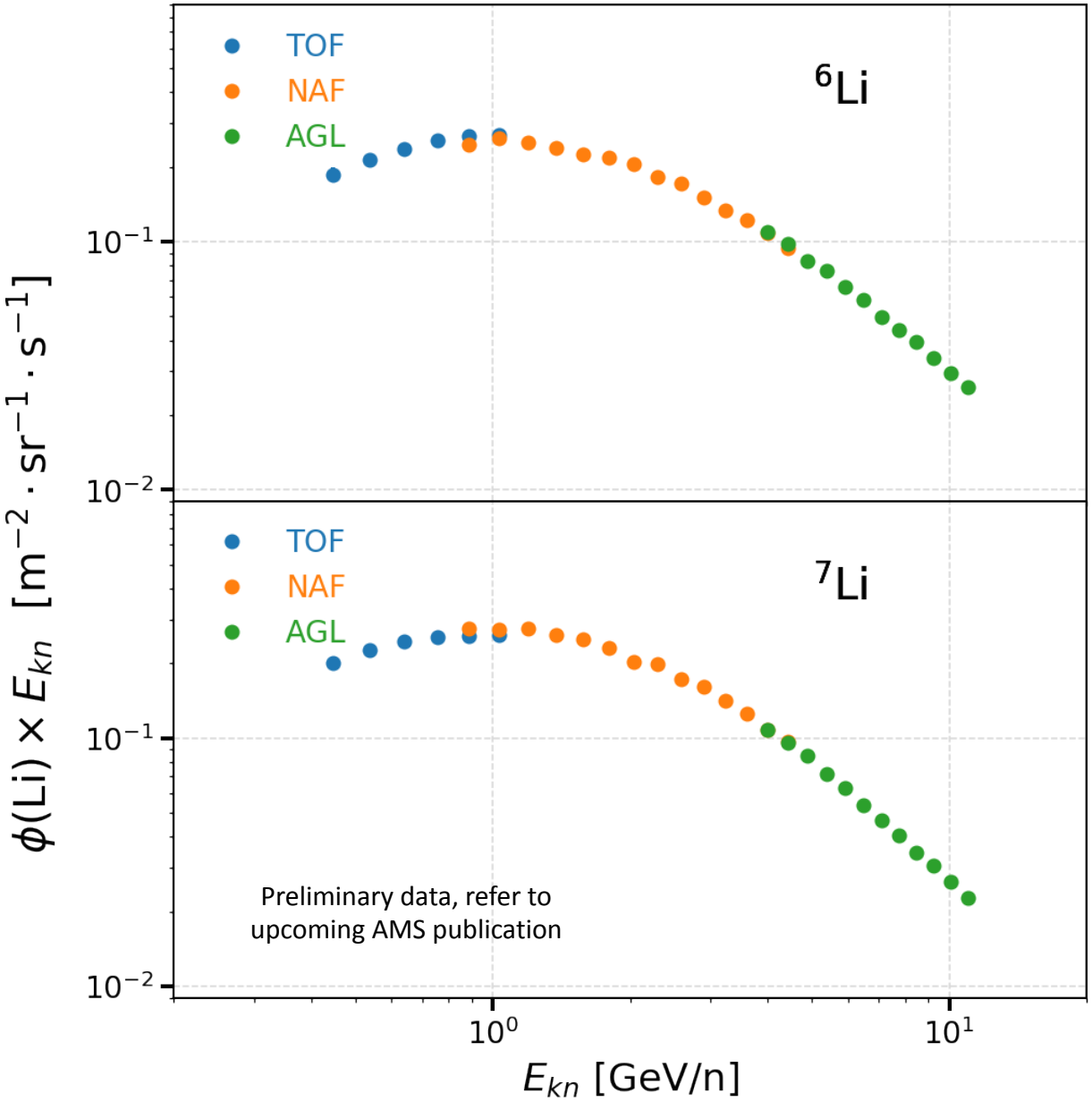






Lithium Isotopic Fluxes

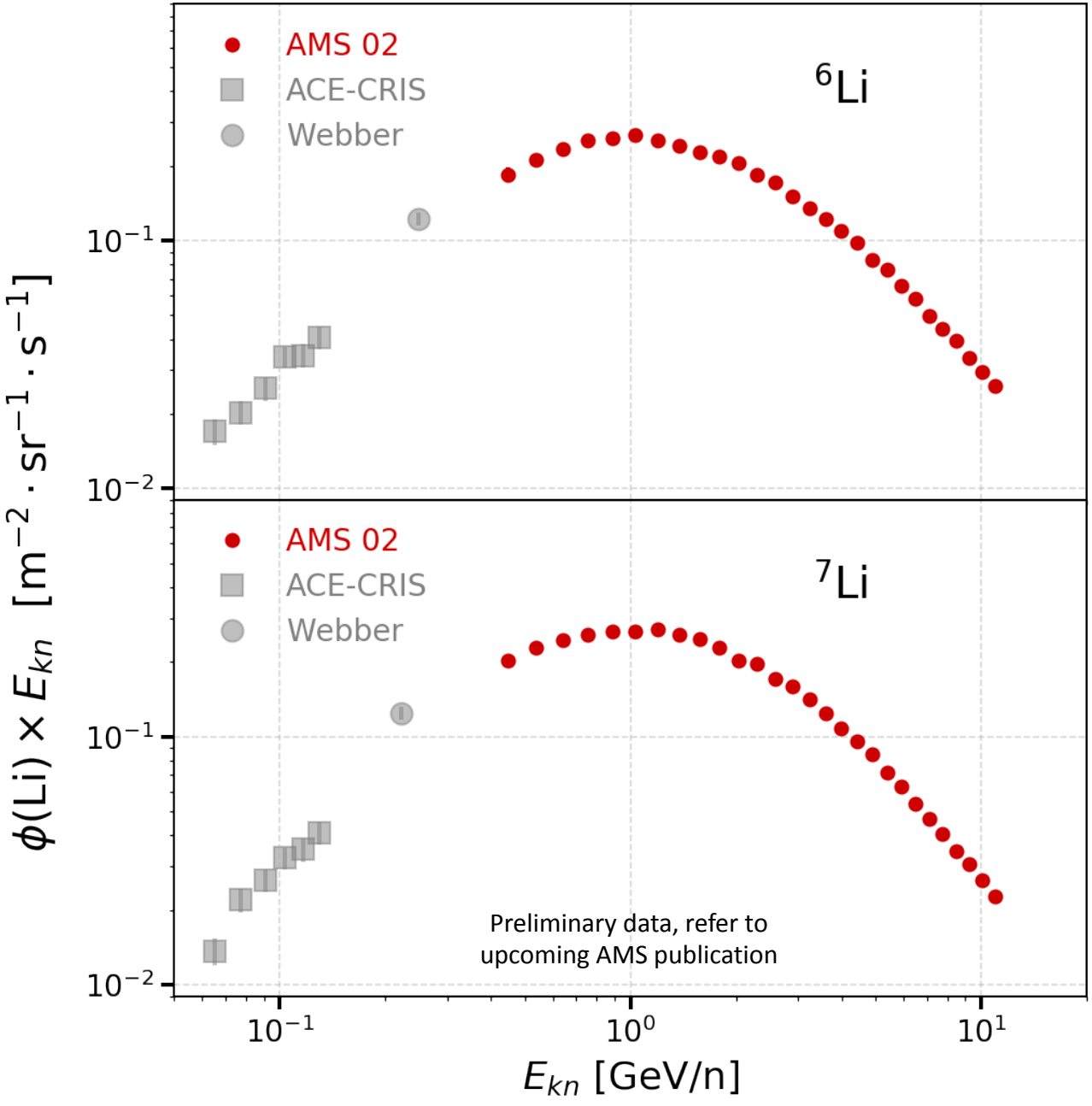
- Isotopic fluxes obtained from the fit.
- Based on 0.8 million lithium events,
- Include Data/MC and unfolding corrections,
- Correction from background coming the interaction of heavier nuclei above L1 applied.



Lithium Isotopic Fluxes

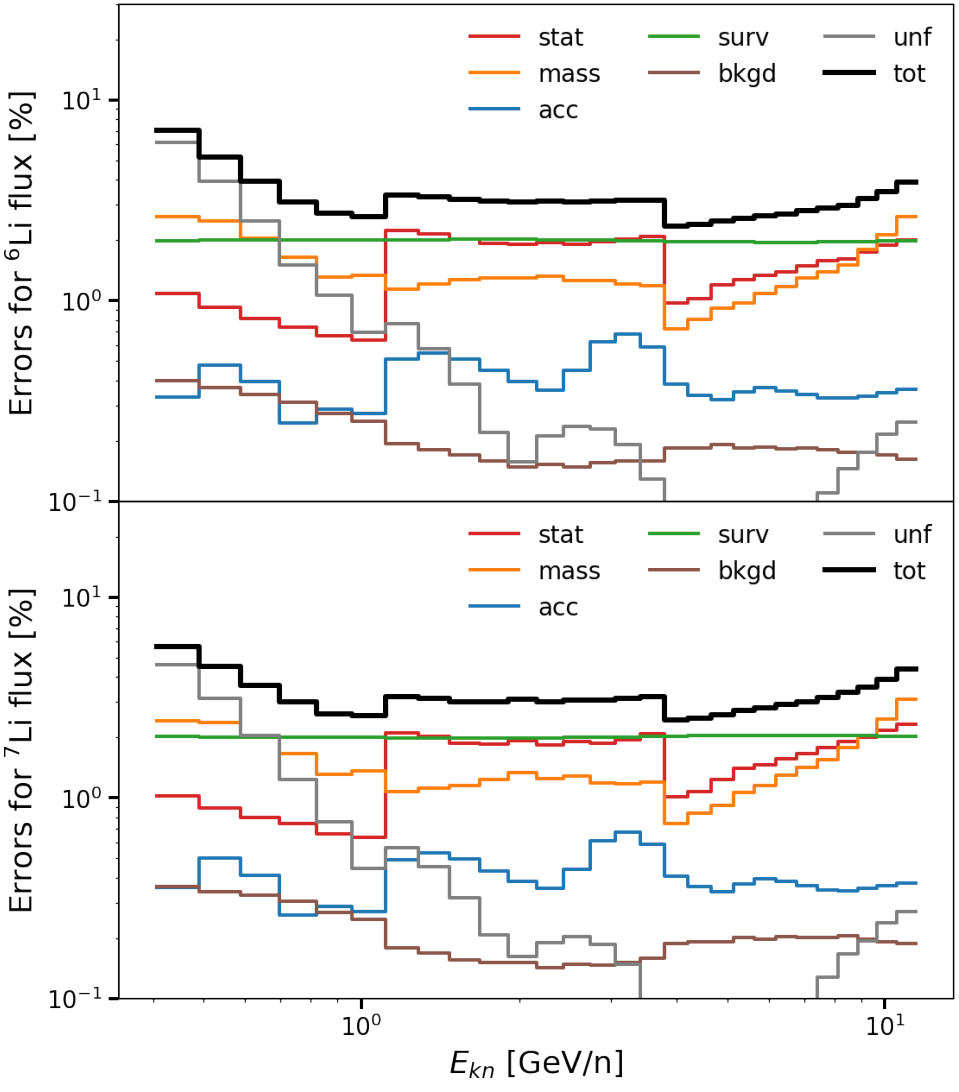
Combined fluxes from AMS 02 compared with previous experiments.

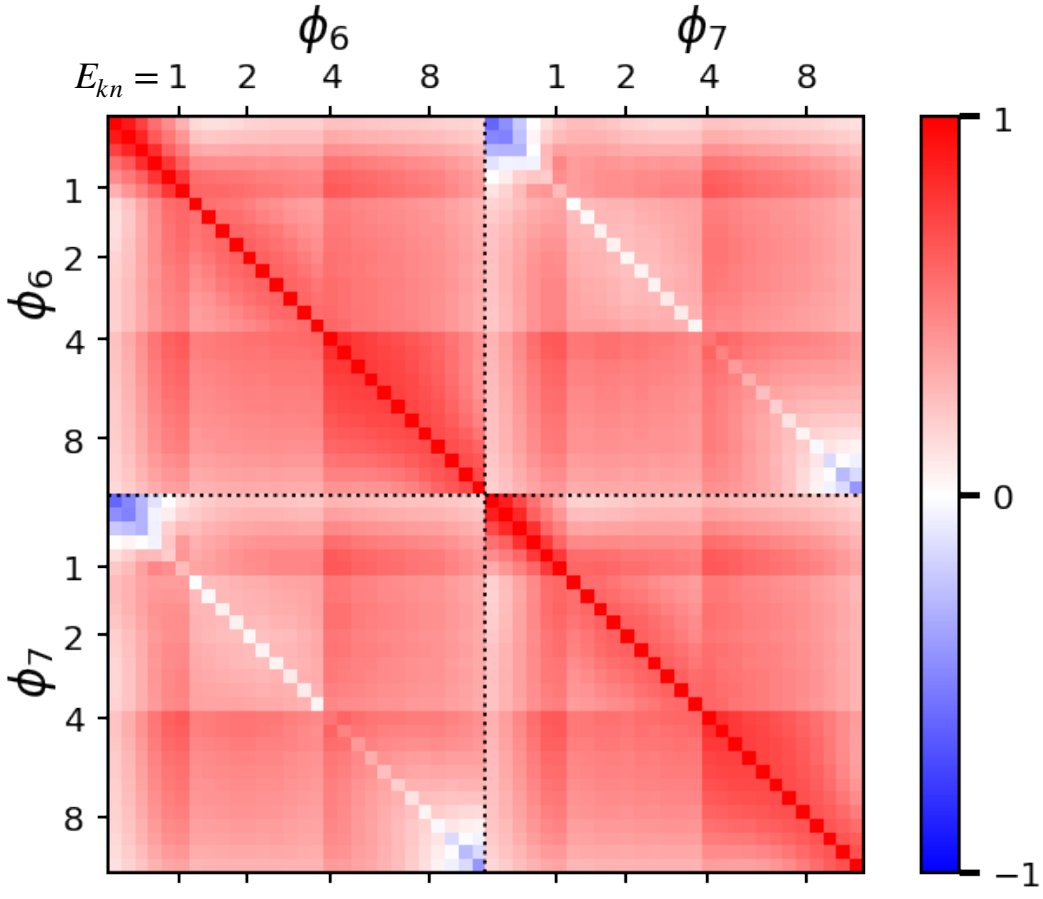
→ First Measurement of ^{6}Li and ^{7}Li fluxes above 0.3 GeV/n and up to 11 GeV/n.



Errors on isotopic lithium fluxes

- Stat. and syst. (mass id.-acceptance-survival prob.-background-unfolding) errors.
- Estimated with the full covariance matrix: important to describe correlation between energy bins and different isotopes.

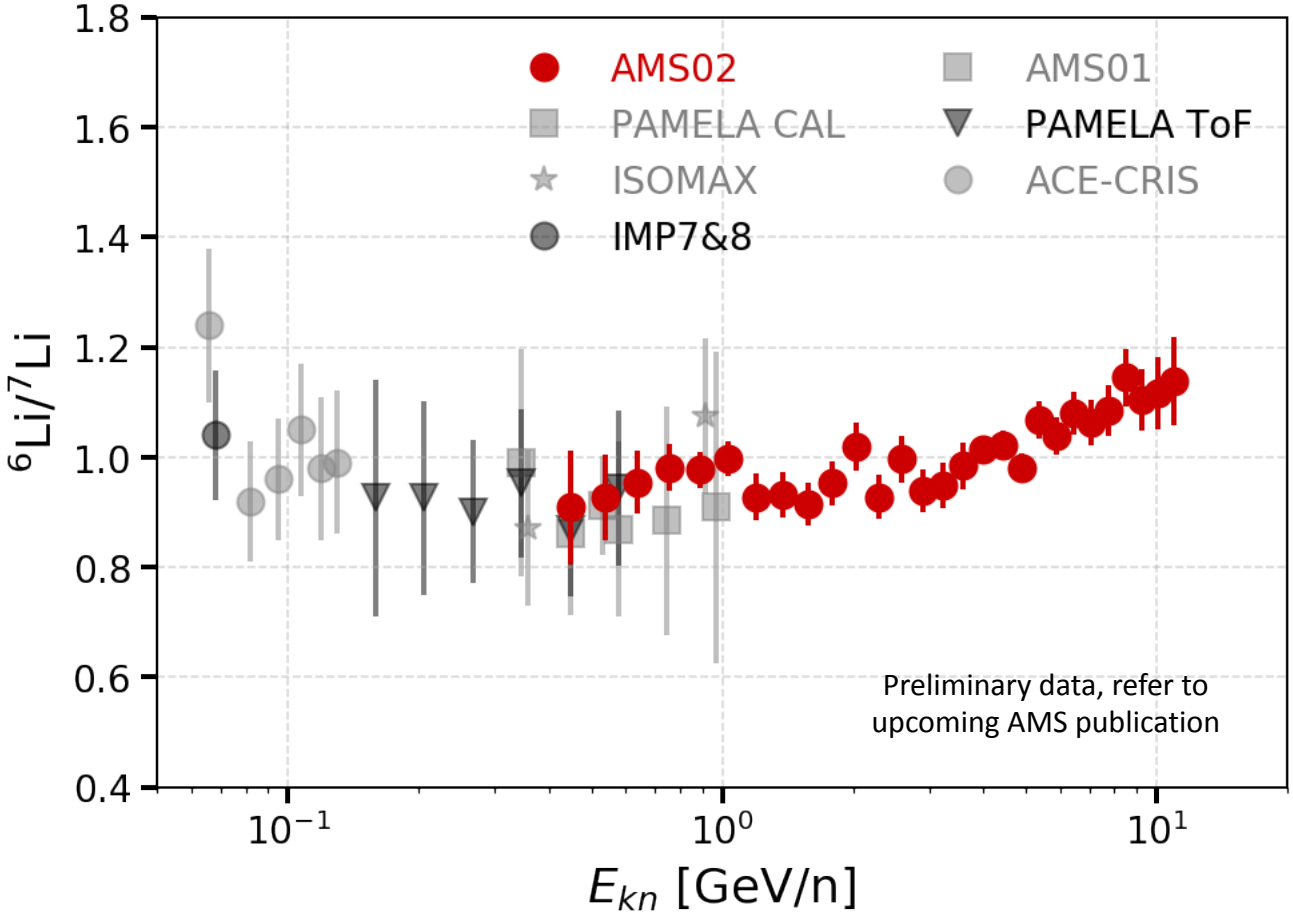


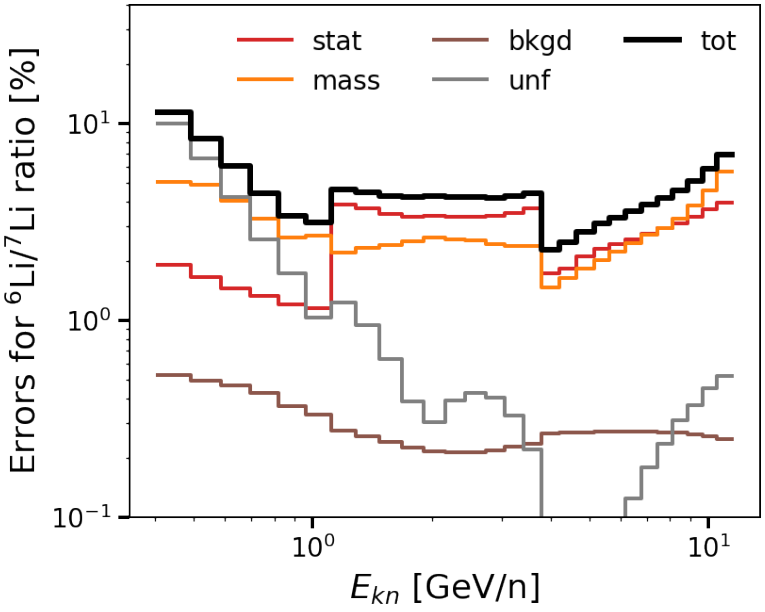


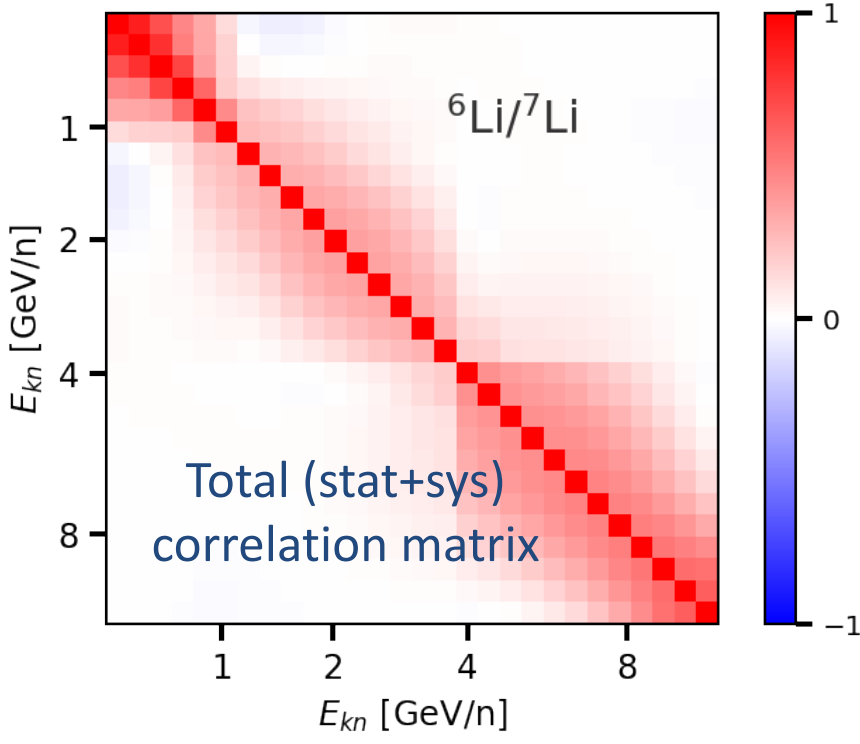
Total (stat+sys) correlation matrix

^{6}Li/^{7}Li ratio

AMS 02 ratio compared with previous experiments:

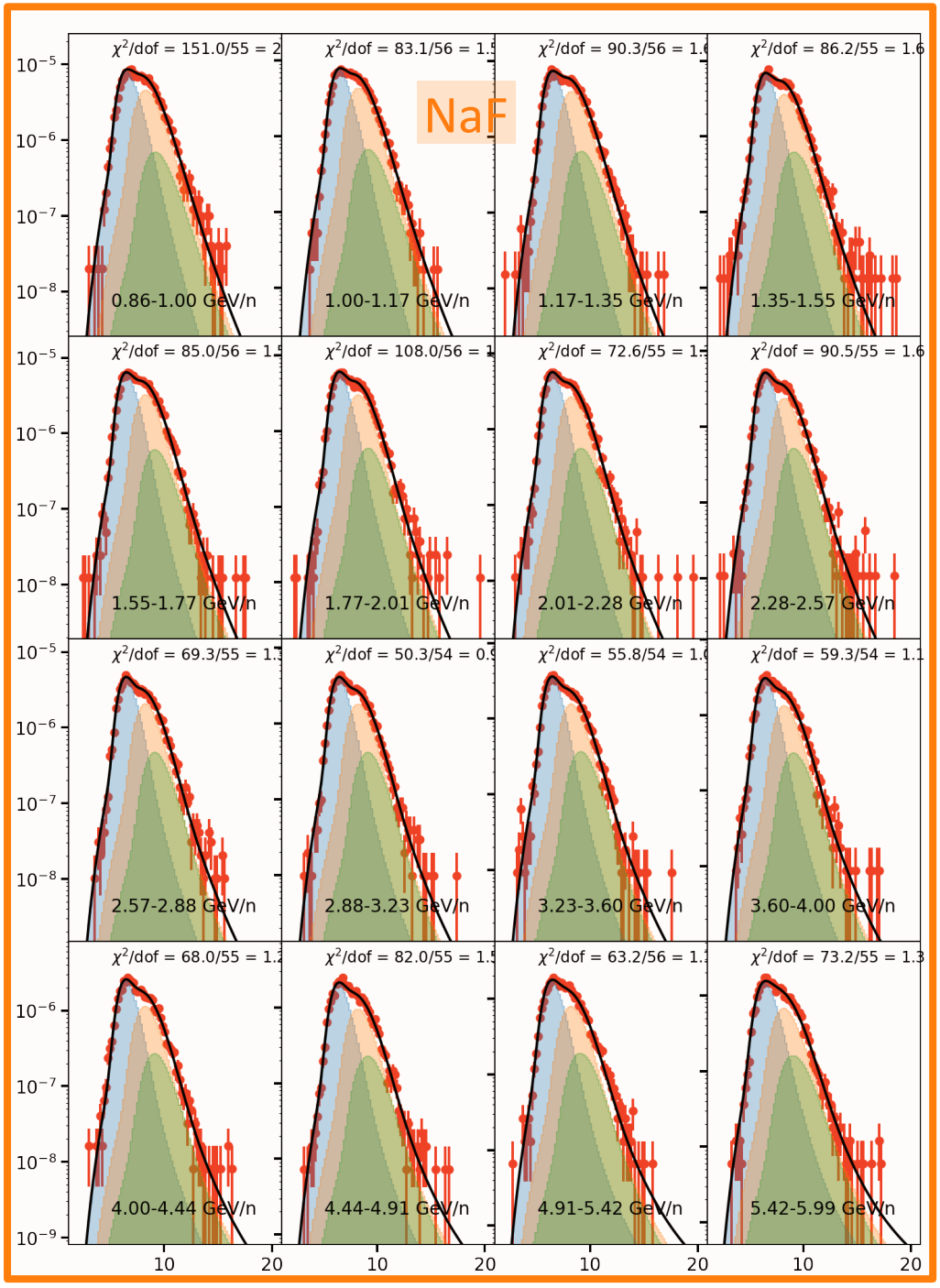


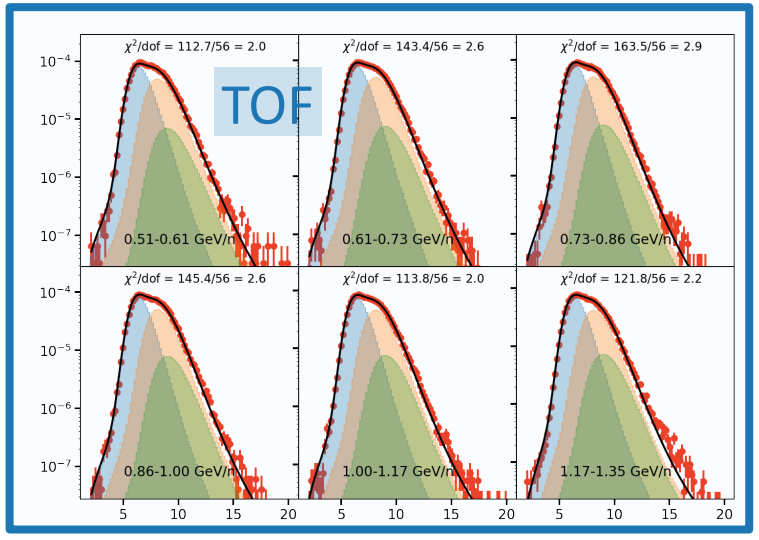


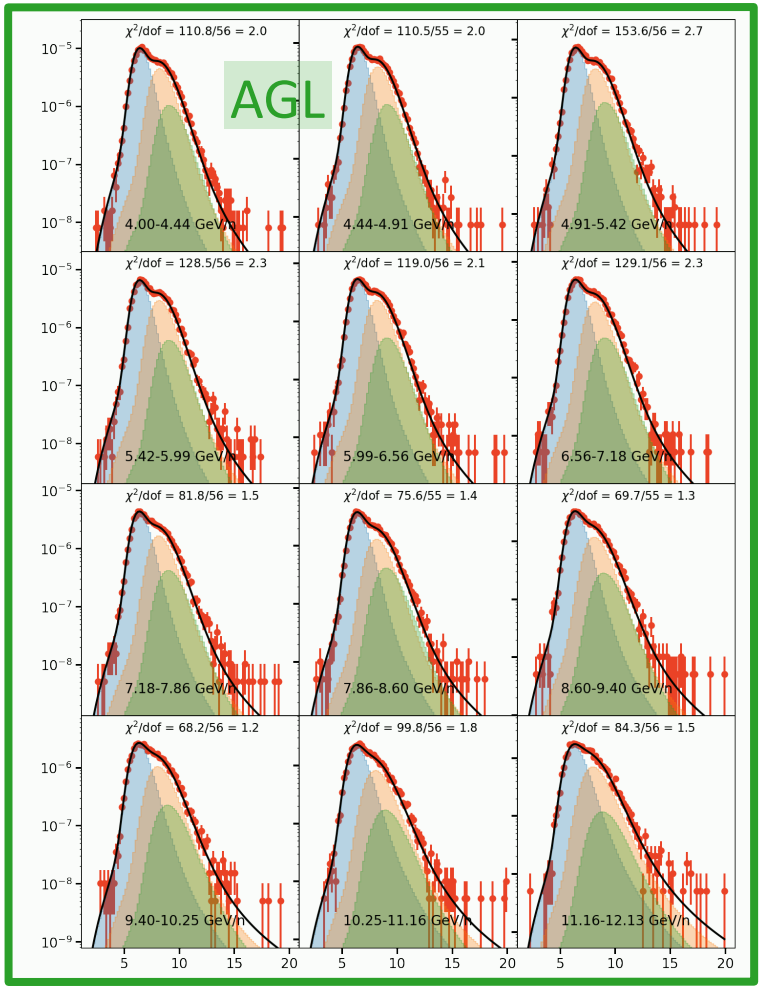


→ Extends ^{6}Li/^{7}Li ratio measurement above 1 GeV/n up to 11 GeV/n

Fitting of Beryllium rates







Be data

$\mathrm{Temp}_7 \times \phi_7$

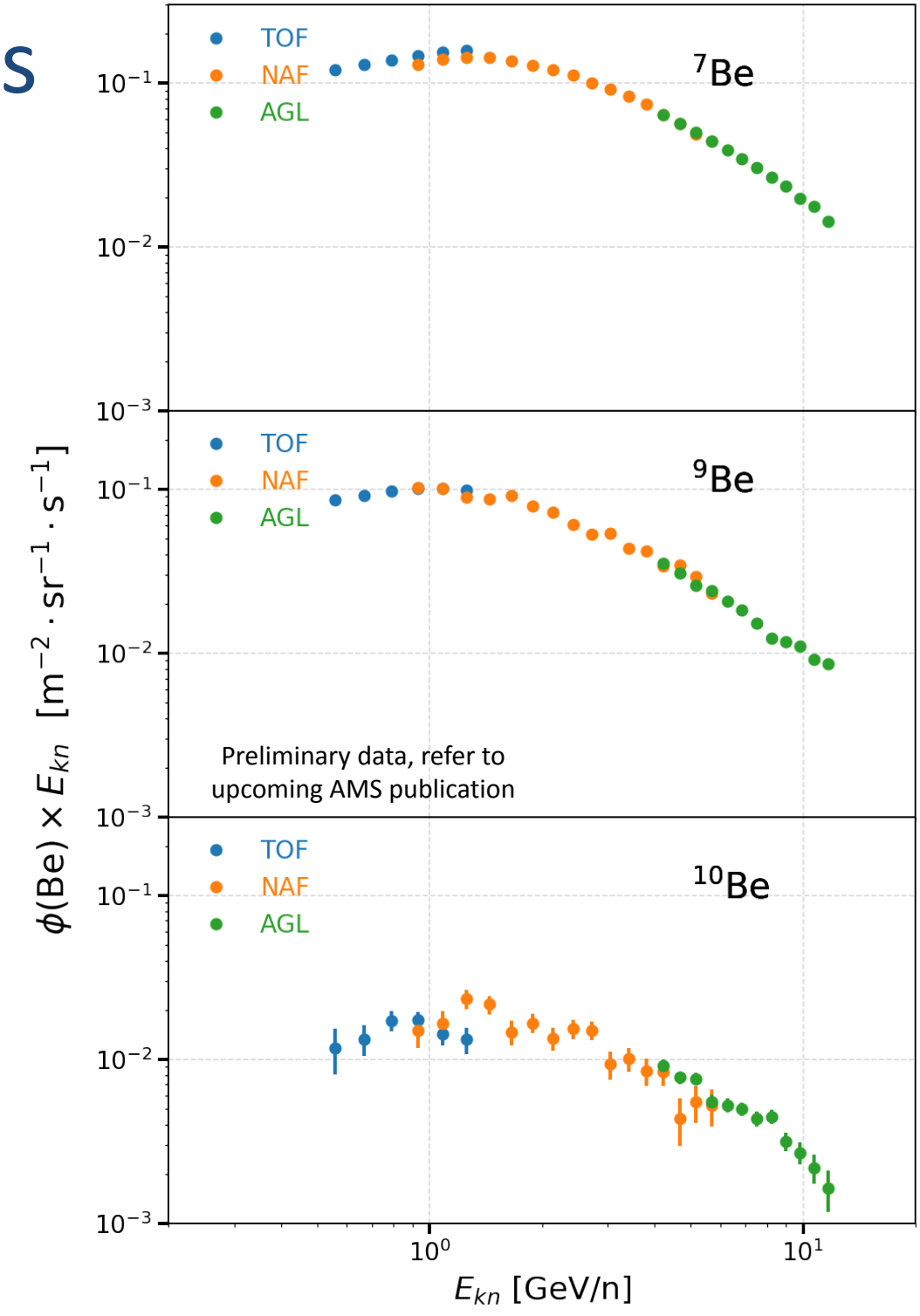
$\mathrm{Temp}_9 \times \phi_9$

$\mathrm{Temp}_{10} \times \phi_{10}$

— Fit

Beryllium Isotopic Fluxes

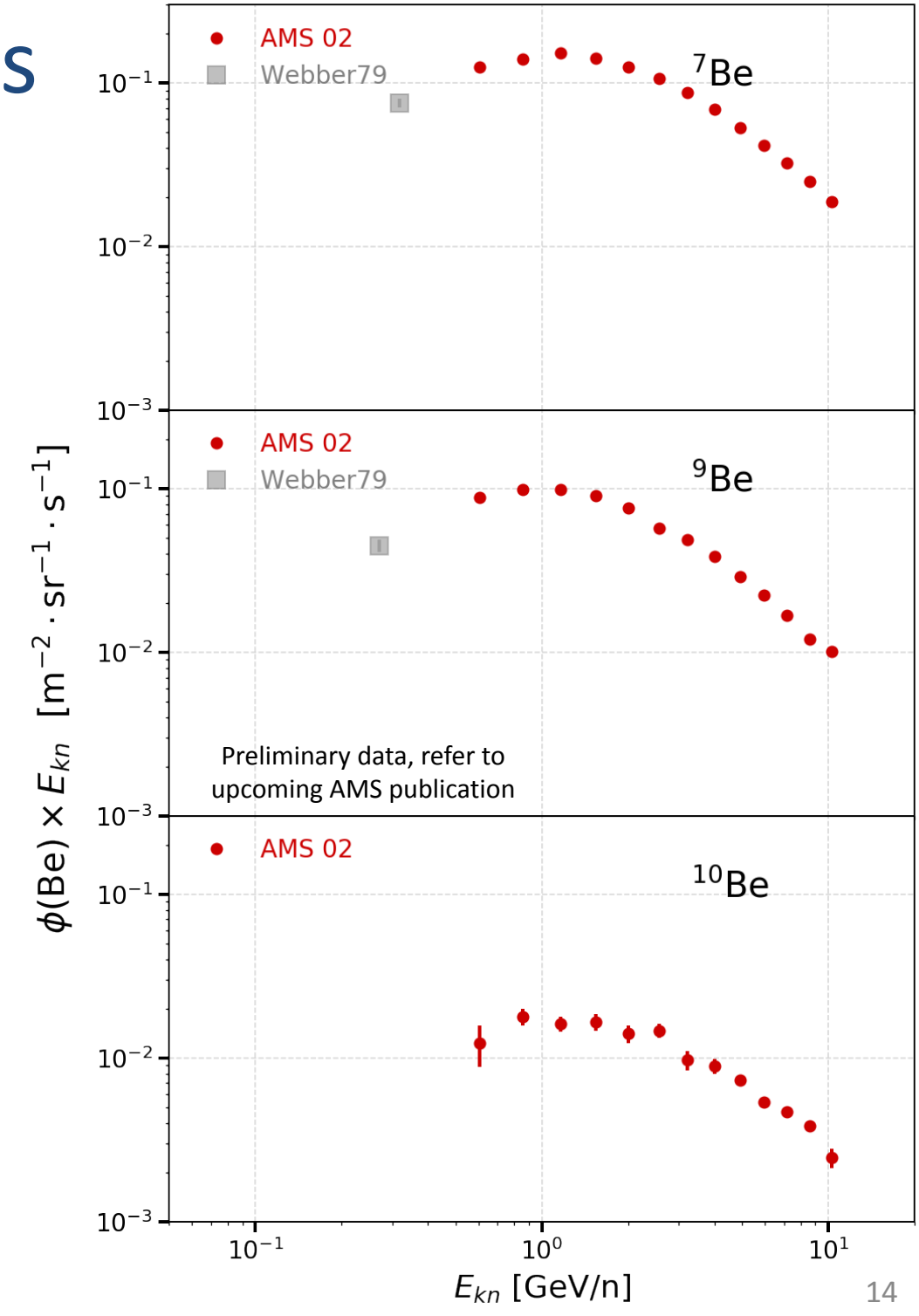
- Isotopic fluxes obtained from the fit.
- Based on 0.4 million beryllium events,
- Include Data/MC and unfolding corrections,
- Correction from background coming from the interaction of heavier nuclei above L1 applied.



Beryllium Isotopic Fluxes

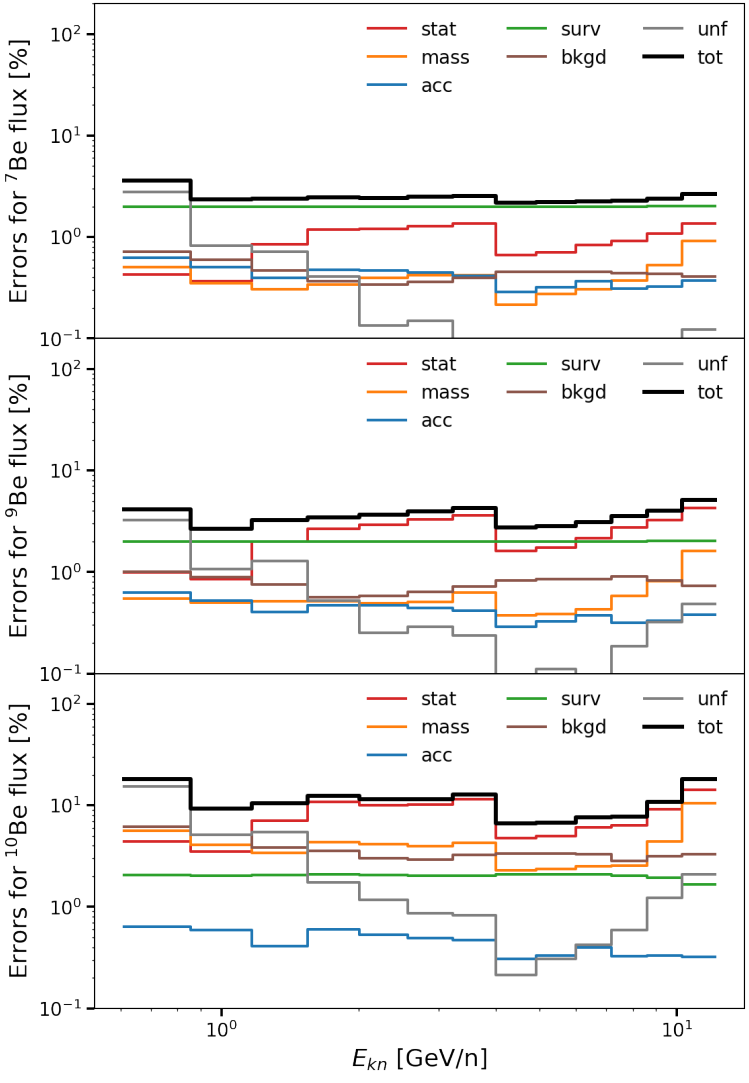
Combined and rebinned fluxes from AMS 02 and comparison with previous experiments.

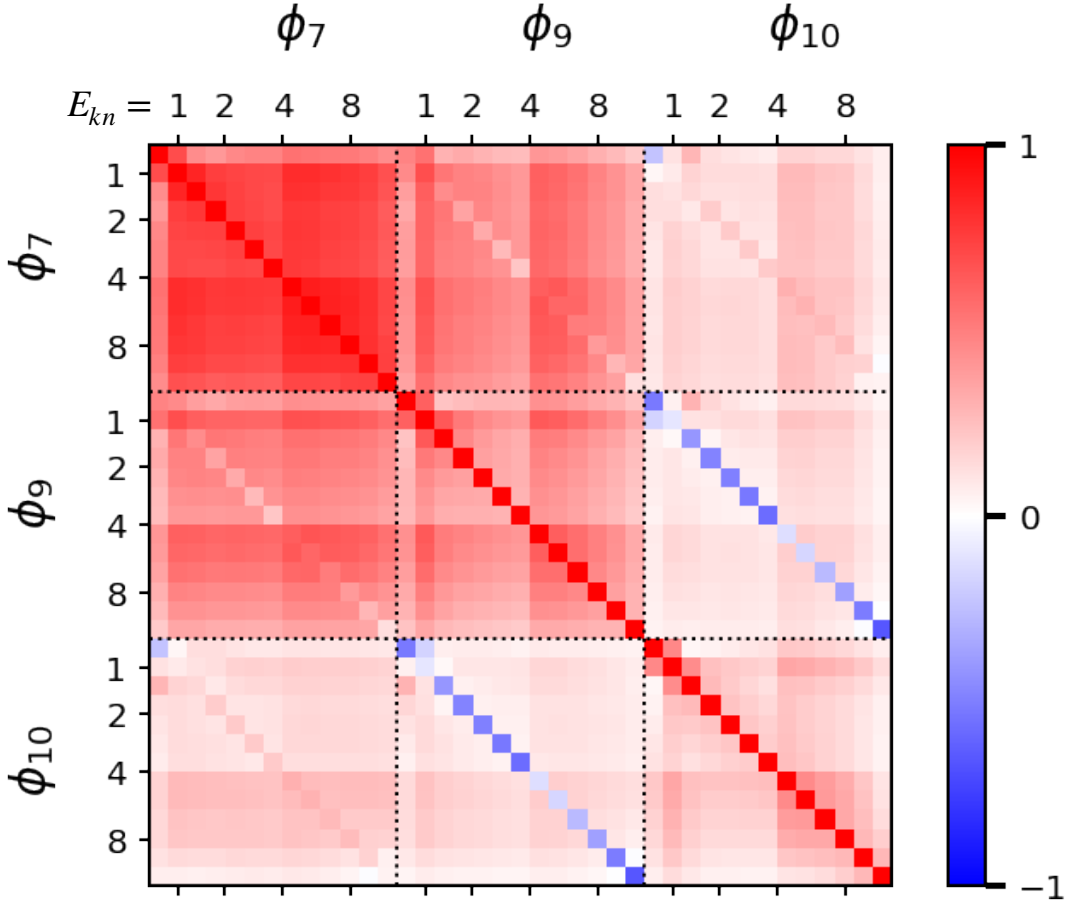
→ First measurement of ^{7}Be, ^{9}Be and ^{10}Be fluxes above 0.4 GeV/n and up to 11 GeV/n.



Errors on isotopic beryllium fluxes

- Stat. and syst. (mass id.-acceptance-survival prob.-backgrougd-unfolding) errors.
- Estimated with the full covariance matrix: important to describe correlation between energy bins and different isotopes.

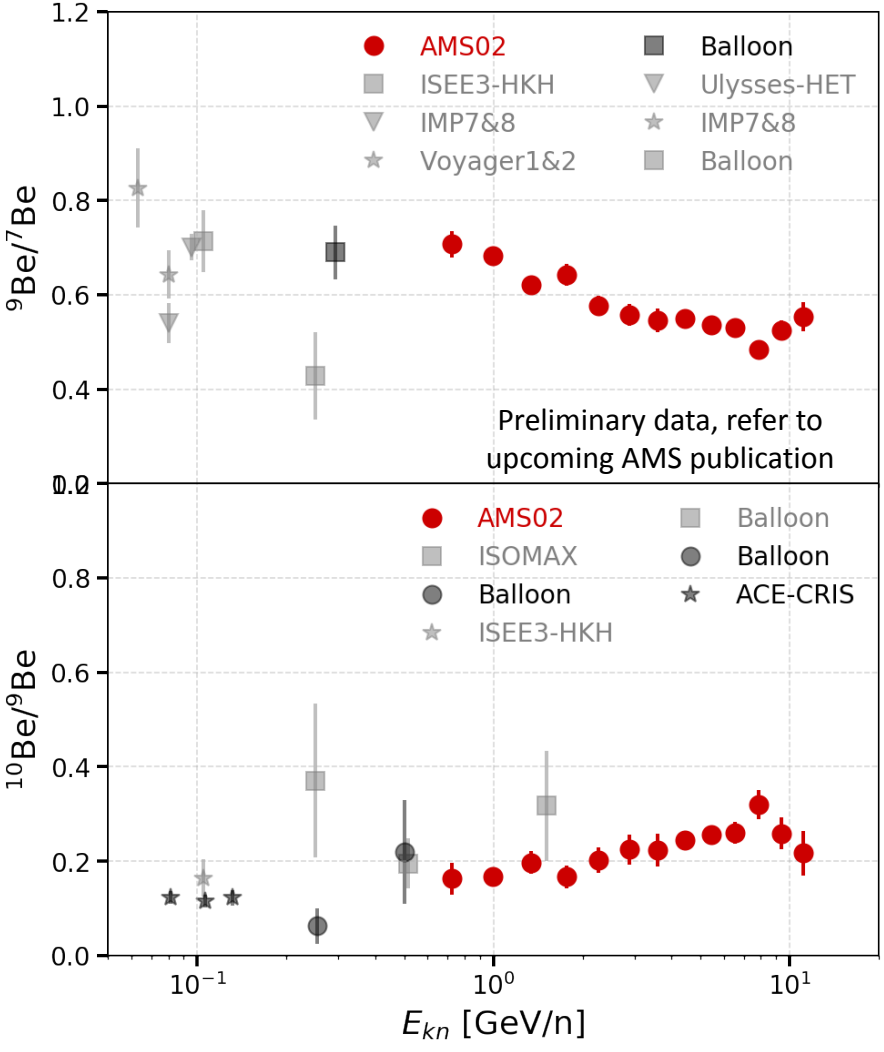




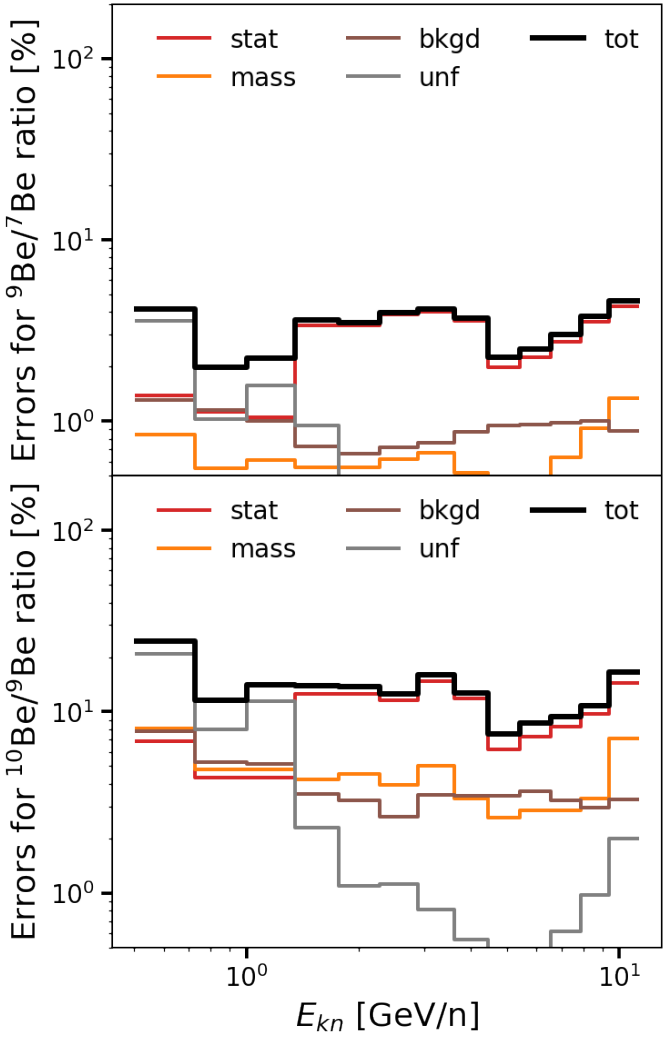
Total (stat+sys) correlation matrix

Beryllium Isotopic Flux ratios vs E_{kn}

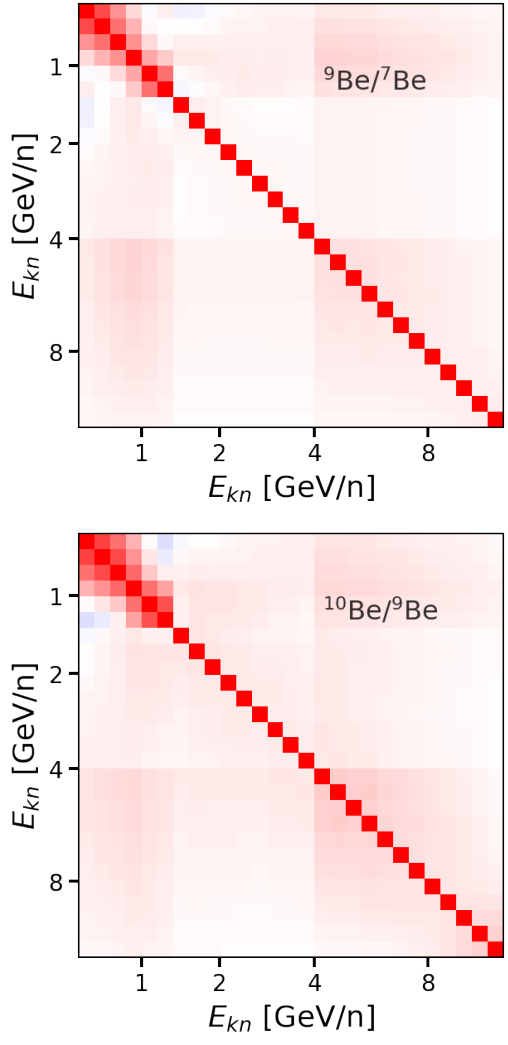
Flux ratios



Errors



Total correlation matrices



Conclusion

- Isotopic composition of light nuclei in cosmic rays is a key measurement to understand cosmic rays origin and propagation.
- Dedicated method based on template used to fit the event rates vs. mass to measure the isotopic fluxes.
- Results presented based on 0.8 million Lithium events and 0.4 million Beryllium events.
- Measurement of Lithium and Beryllium isotopic fluxes and ratios between 0.4 GeV/n and 11 GeV/n with systematic errors and associated covariance matrices assessment have been presented.