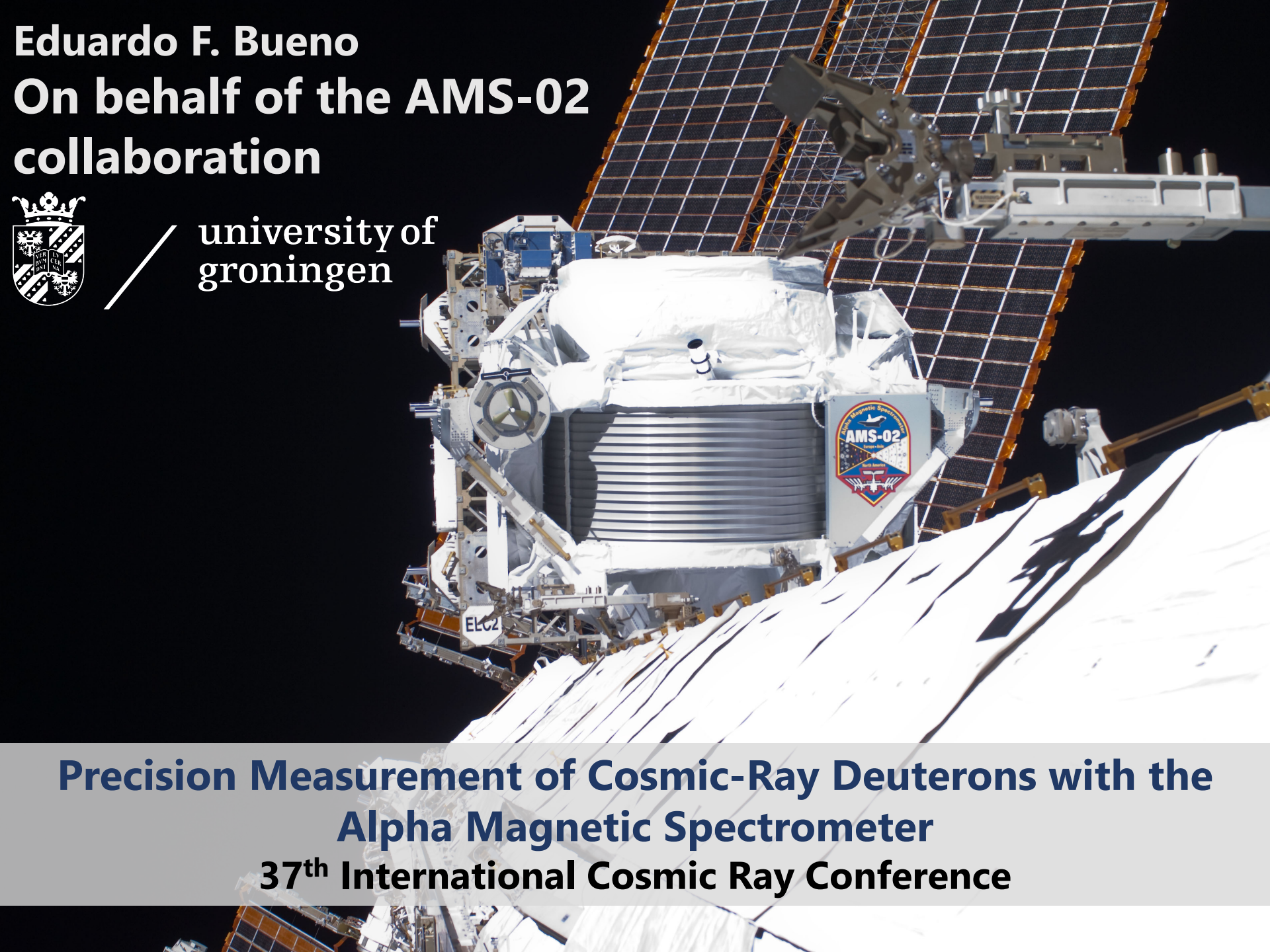
Eduardo F. Bueno
On behalf of the AMS-02 collaboration

university of groningen

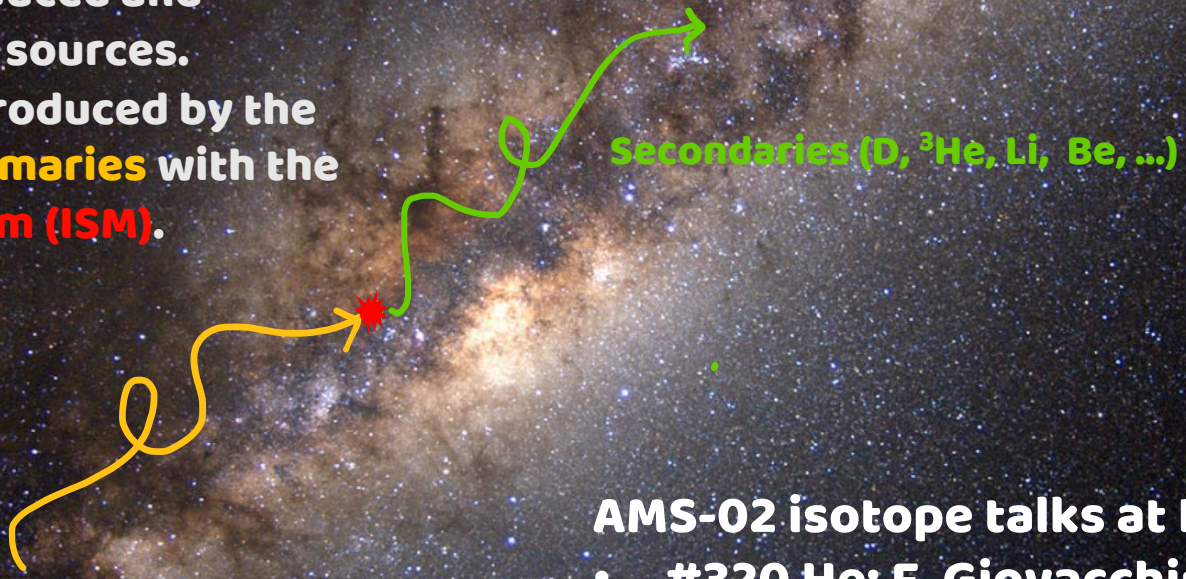


Precision Measurement of Cosmic-Ray Deuterons with the Alpha Magnetic Spectrometer

37th International Cosmic Ray Conference

Nuclei in cosmic rays

Primaries are produced and accelerated at the sources.
Secondaries are produced by the interactions of **primaries** with the **interstellar medium (ISM)**.



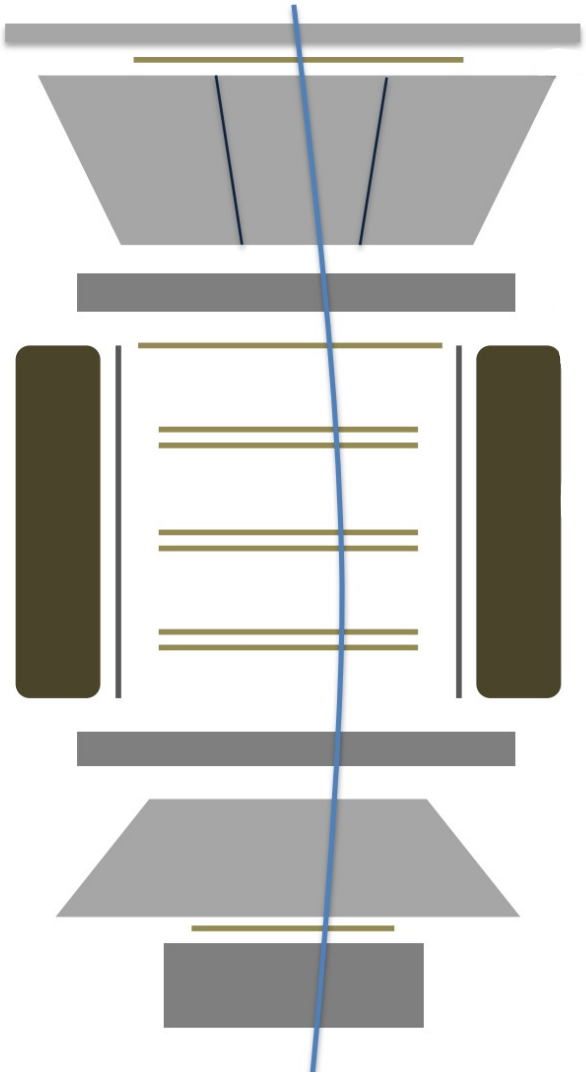
AMS-02 isotope talks at ICRC 2021:

- **#320 He: F. Giovacchini**
- **#992 Li, Be: L. Derome**

Secondaries carry important information about the propagation processes and properties of the ISM.

Deuterons are the most abundant secondary species.

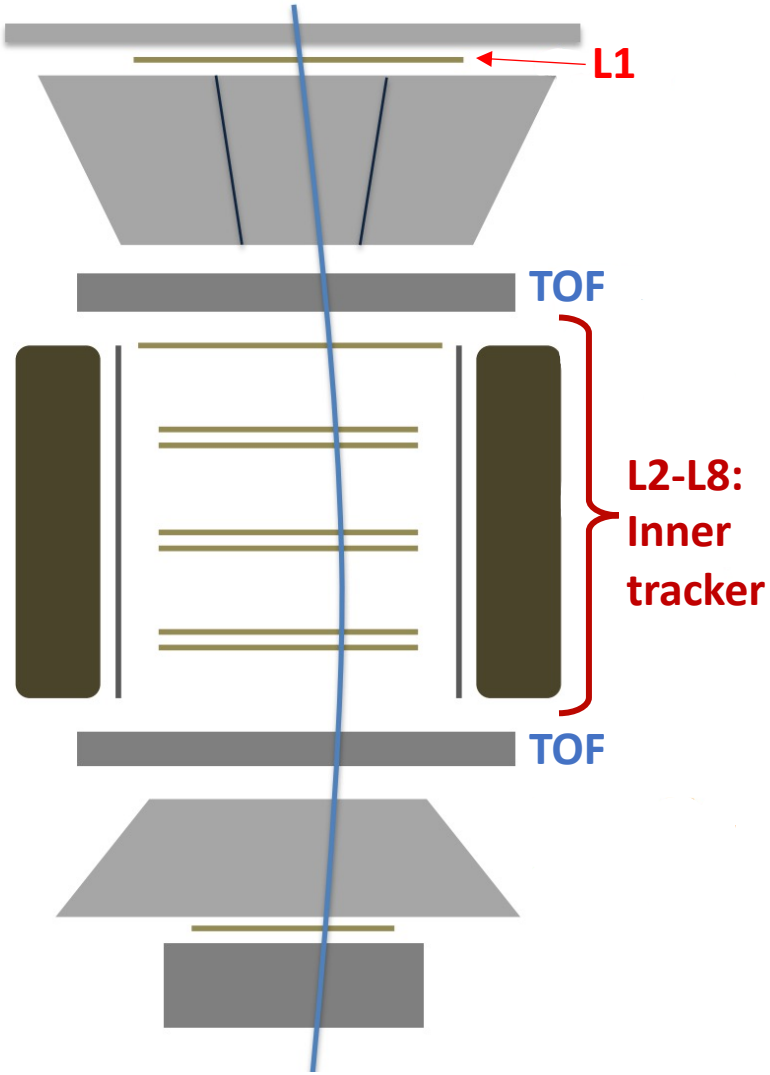
Isotope identification in AMS



The mass is defined by:

$$M = \frac{RZ}{\beta\gamma}$$

Isotope identification in AMS



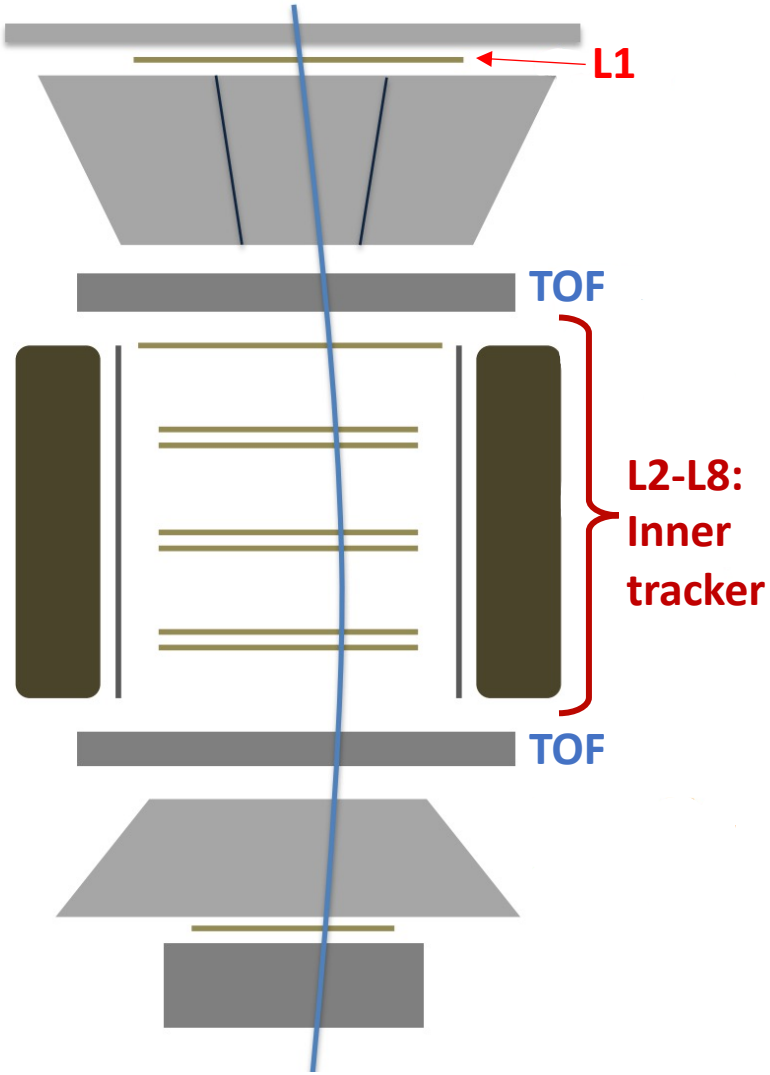
The mass is defined by:

$$M = \frac{RZ}{\beta\gamma}$$

Charge (Z):

- **L1, TOF, Inner tracker**

Isotope identification in AMS



The mass is defined by:

$$M = \frac{RZ}{\beta\gamma}$$

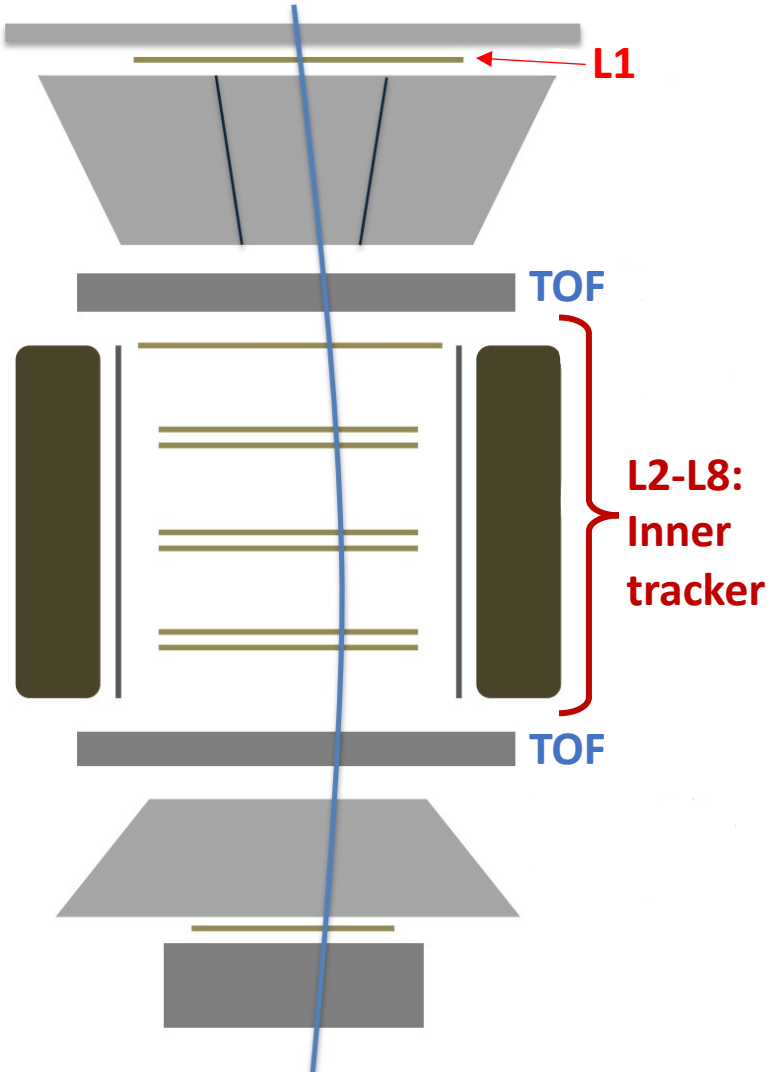
Charge (Z):

- **L1, TOF, Inner tracker**

Rigidity (R):

- **Inner tracker**

Isotope identification in AMS



The mass is defined by:

$$M = \frac{RZ}{\beta\gamma}$$

Charge (Z):

- **L1**, **TOF**, **Inner tracker**

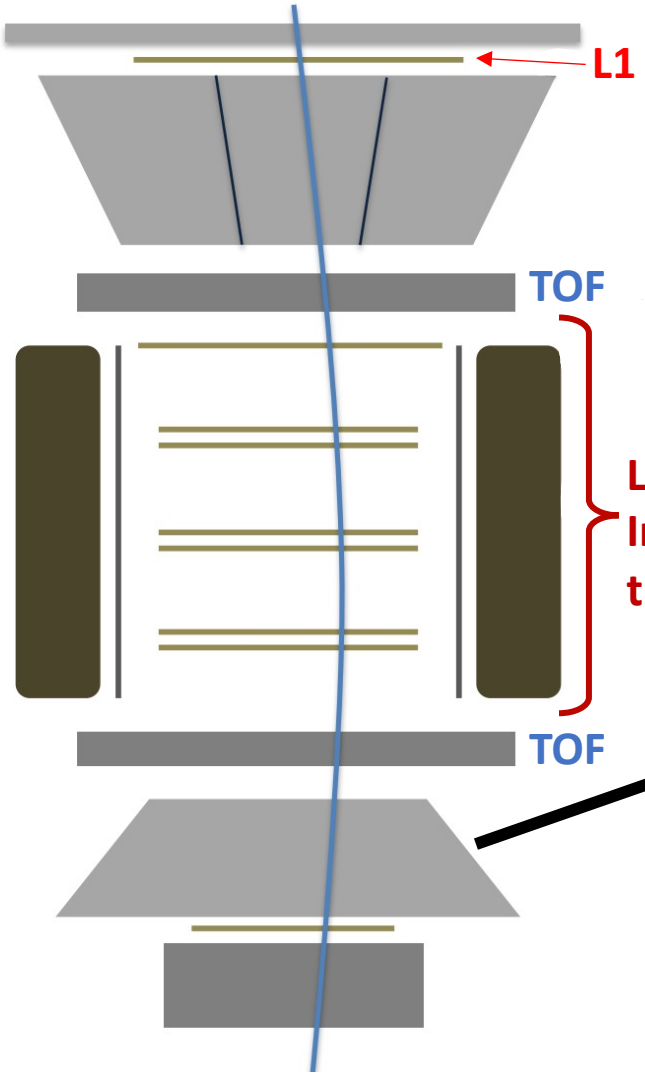
Rigidity (R):

- **Inner tracker**

Velocity (β):

- **TOF**: $\Delta\beta/\beta^2 \approx 4\%$ (Z =1; β = 1)

Isotope identification in AMS



RICH-NaF

n = 1.33;

$\beta > 0.75$;

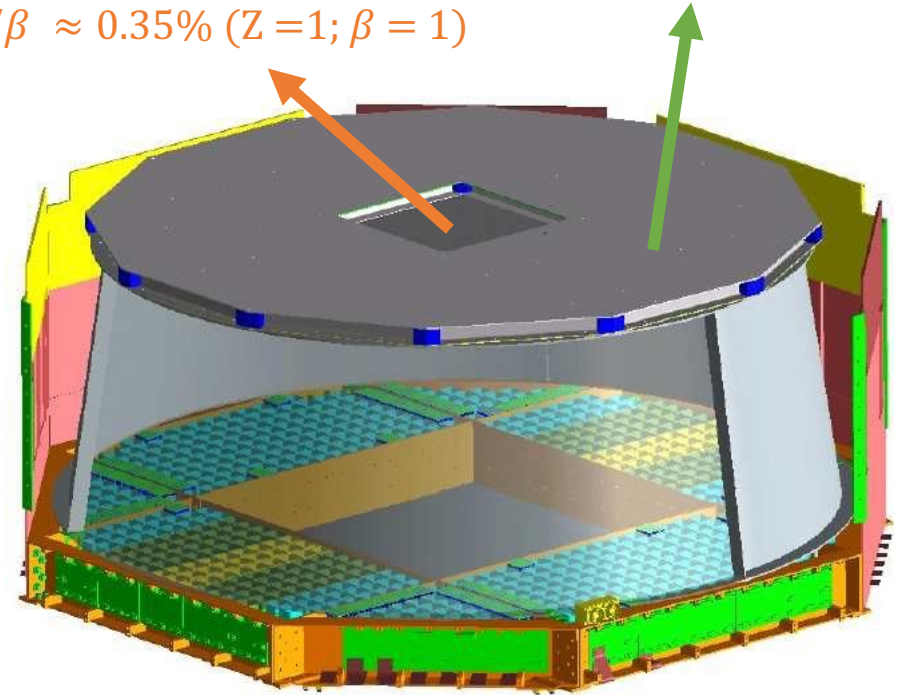
$\Delta\beta/\beta \approx 0.35\%$ (Z =1; $\beta = 1$)

RICH-AGL

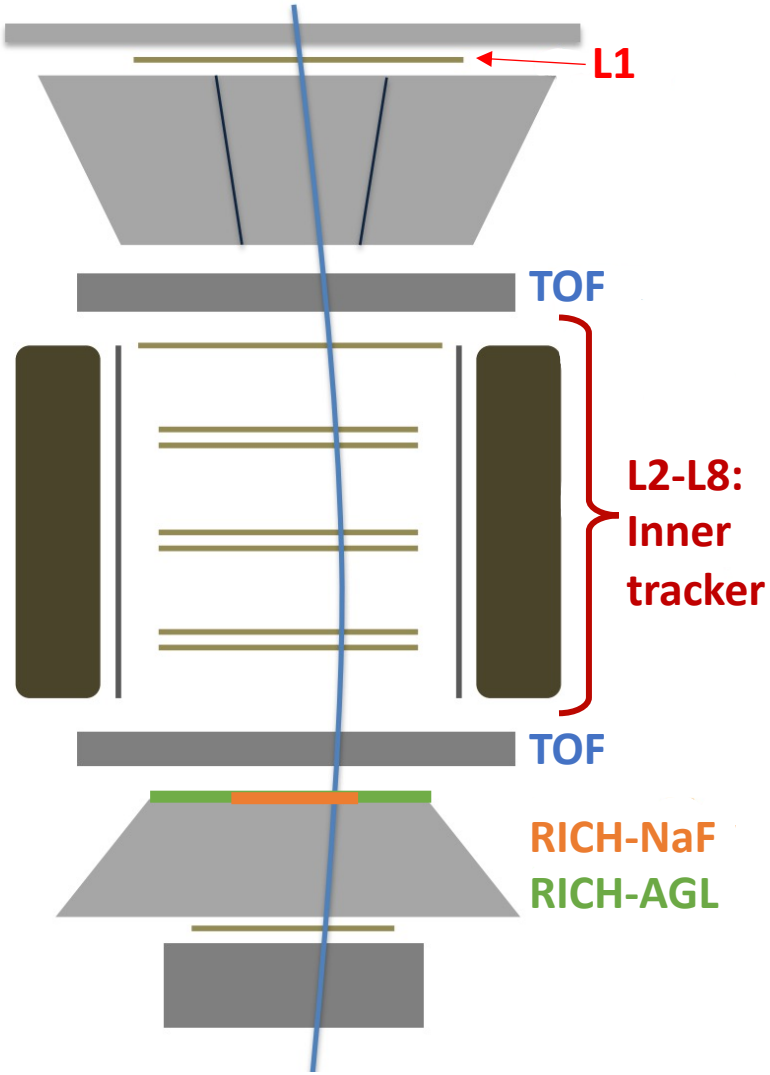
n = 1.05;

$\beta > 0.96$;

$\Delta\beta/\beta \approx 0.12\%$; (Z =1; $\beta = 1$)



Isotope identification in AMS



The mass is defined by:

$$M = \frac{RZ}{\beta\gamma}$$

Charge (Z):

- **L1, TOF, Inner tracker**

Rigidity (R):

- **Inner tracker**

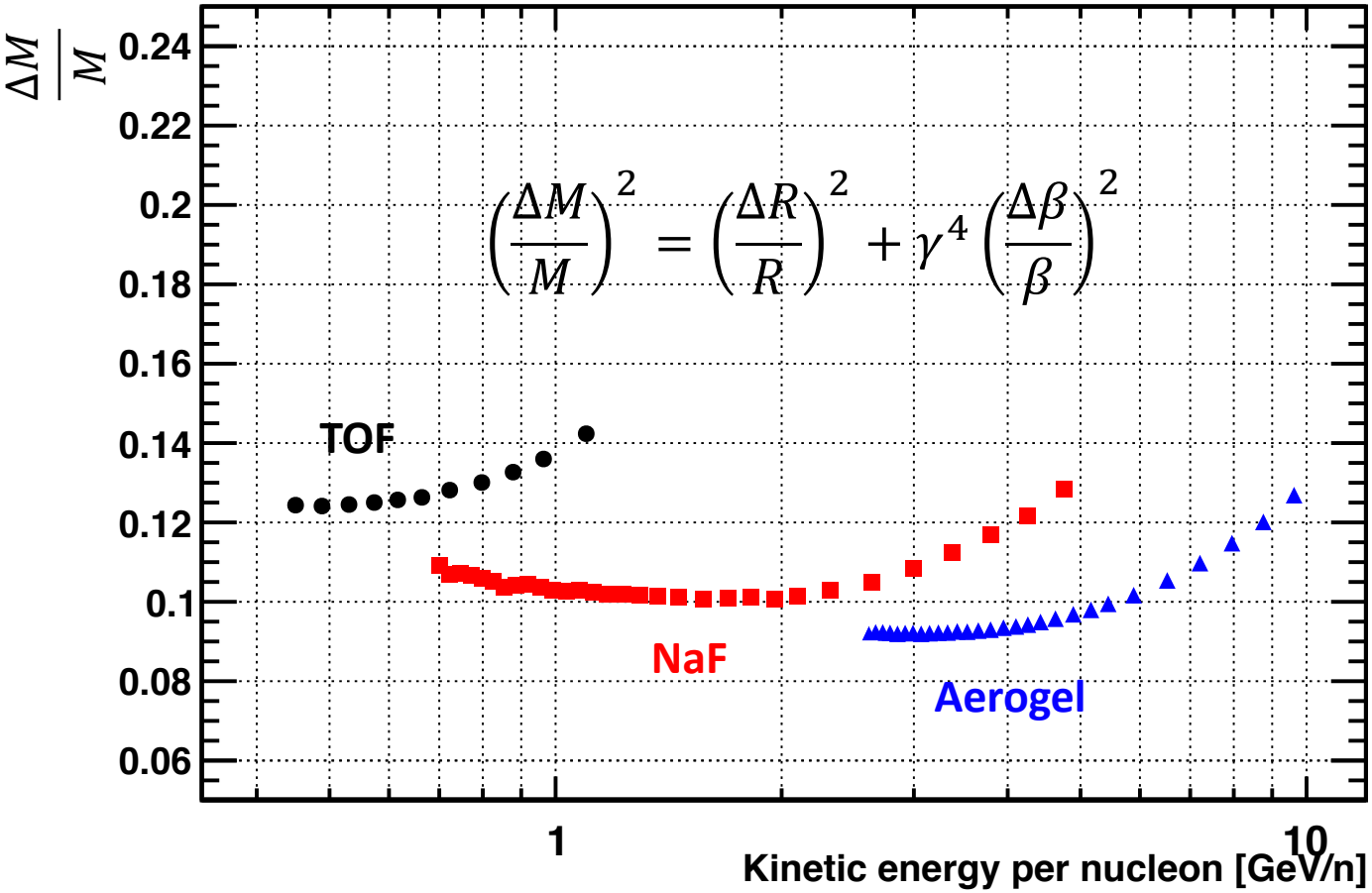
Velocity (β):

- **TOF**: $\Delta\beta/\beta^2 \approx 4\%$ (Z =1; β = 1)
- **RICH-NaF**:
  - $\beta > 0.75$; $\Delta\beta/\beta \approx 0.35\%$ (Z =1; β = 1)
- **RICH-AGL**:
  - $\beta > 0.96$; $\Delta\beta/\beta \approx 0.12\%$ (Z =1; β = 1)

- Three different analyses covering the different velocity ranges.

Performance of mass reconstruction in AMS-02

The three complementary ranges allow for the separation of isotopes up to 10 GeV/n.



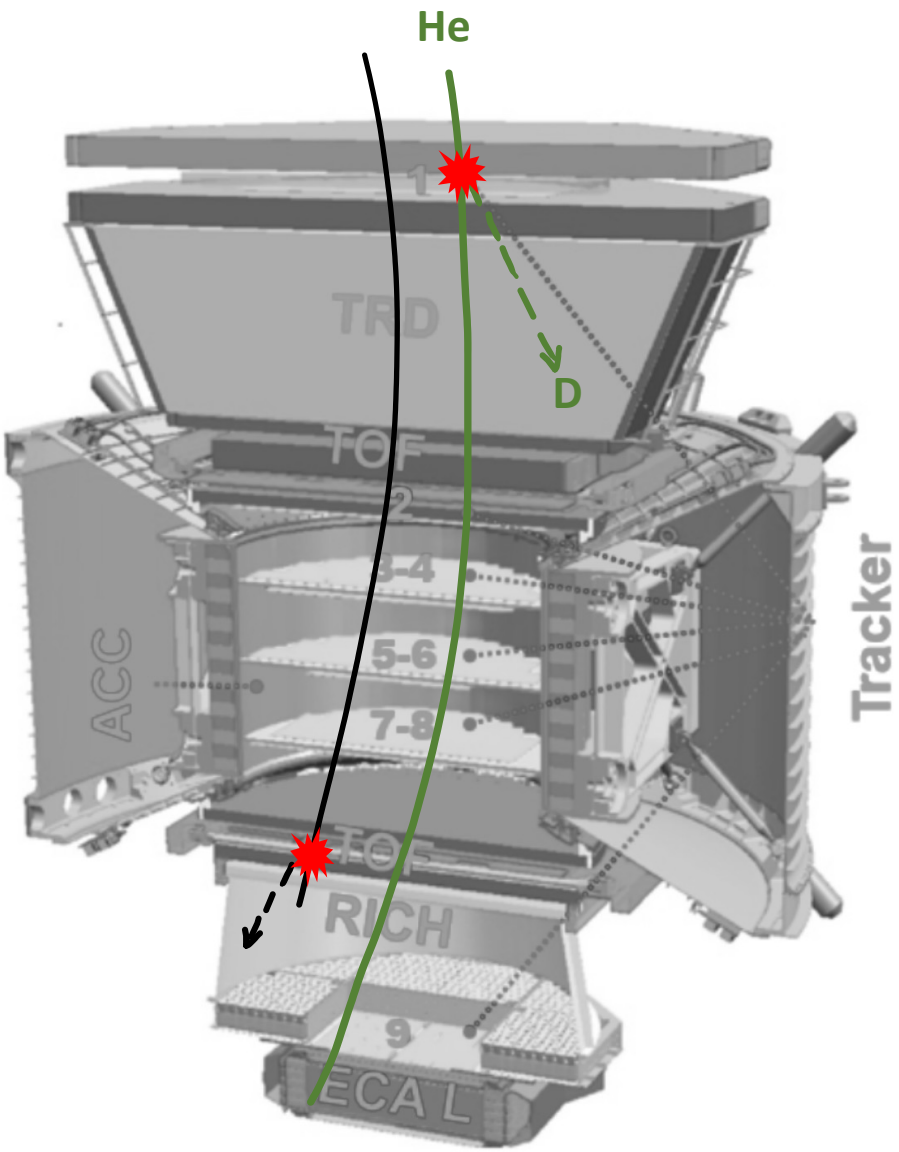
Analysis

1. **Event selection**
   a) Z = 1 selection;
   b) Good rigidity reconstruction;
   c) Good velocity reconstruction in each range.
2. **Event counting:**
   a) Slice data in velocity bins;
   b) Template fits on mass distributions.
3. **Unfolding of the counts**
4. **Flux calculation:**

$$\Phi(E_{kn}) = \frac{N(E_{kn})}{A\epsilon\Delta T\Delta E_{kn}}$$

N: counts
ΔE_{kn}: bin width
ΔT: exposure time
A: effective acceptance
ϵ: trigger efficiency

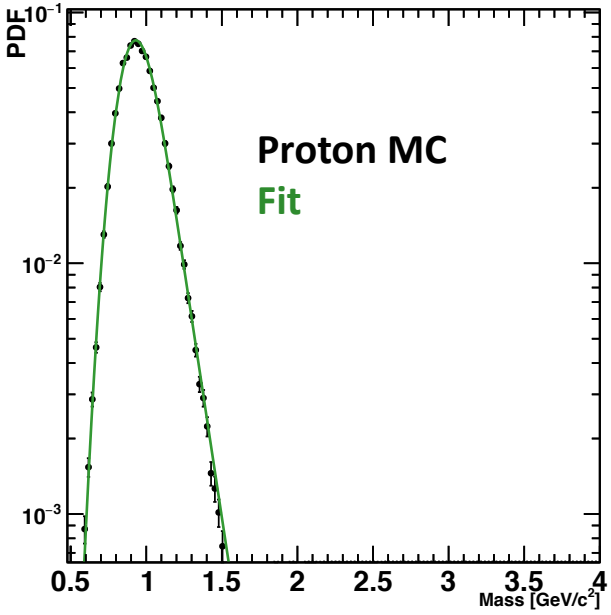
Sources of background



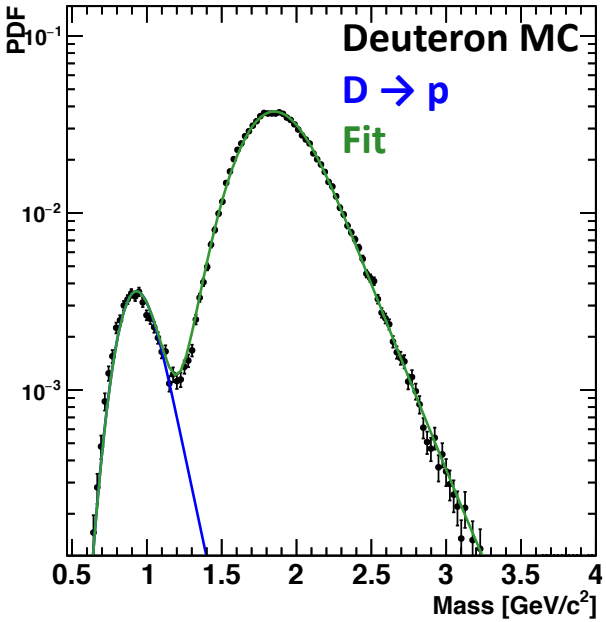
1. **Interactions inside AMS:**
   - Interactions can affect the reconstruction of velocity and rigidity.
2. **Fragmentation of heavier nuclei above L1:**
   - Helium may fragment above the first tracker layer, producing Z = 1 particles (protons, deuterons and tritons)

Signal extraction: simulations

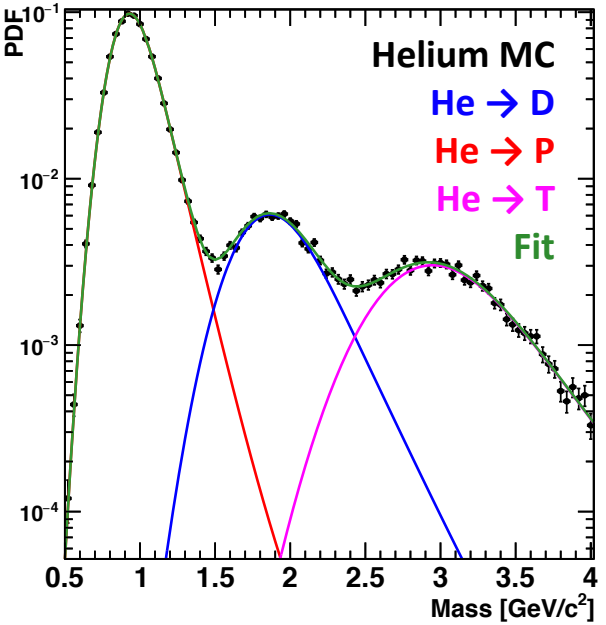
- Parametric mass templates built from MC simulations of each species.
  - Same model for the 3 velocity ranges (TOF, NaF and AGL)



Protons (TOF)
0.48 < E_k/n < 0.52 GeV/n



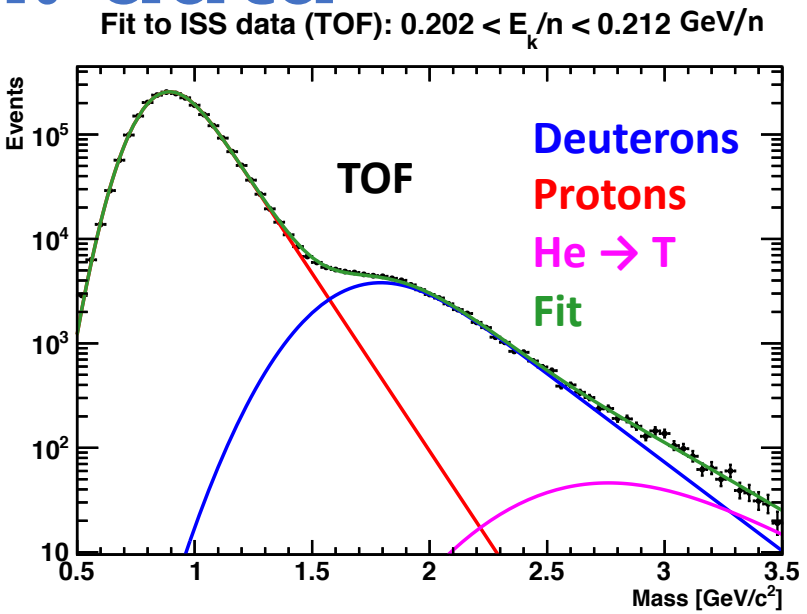
Deuterons (TOF)
0.48 < E_k/n < 0.52 GeV/n

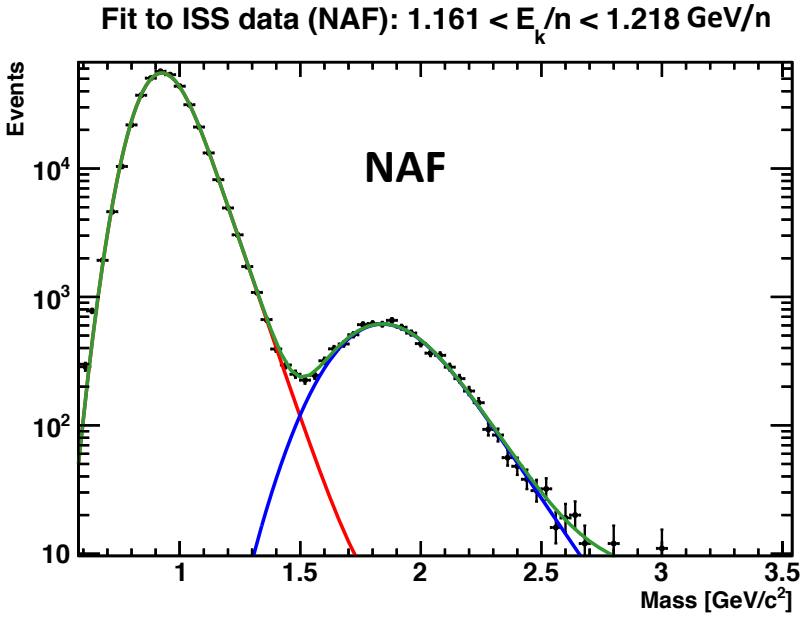


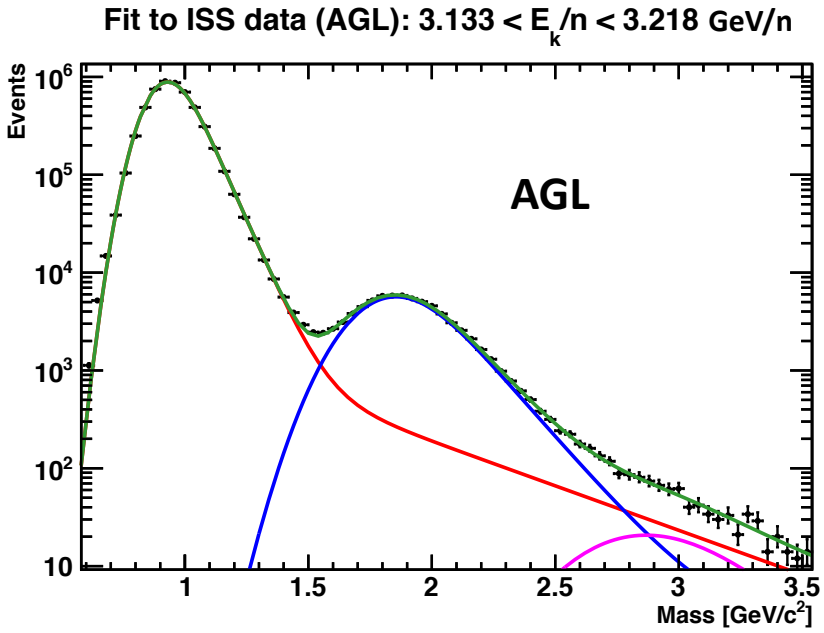
Helium frag. (TOF)
0.48 < E_k/n < 0.52 GeV/n

Signal extraction: data

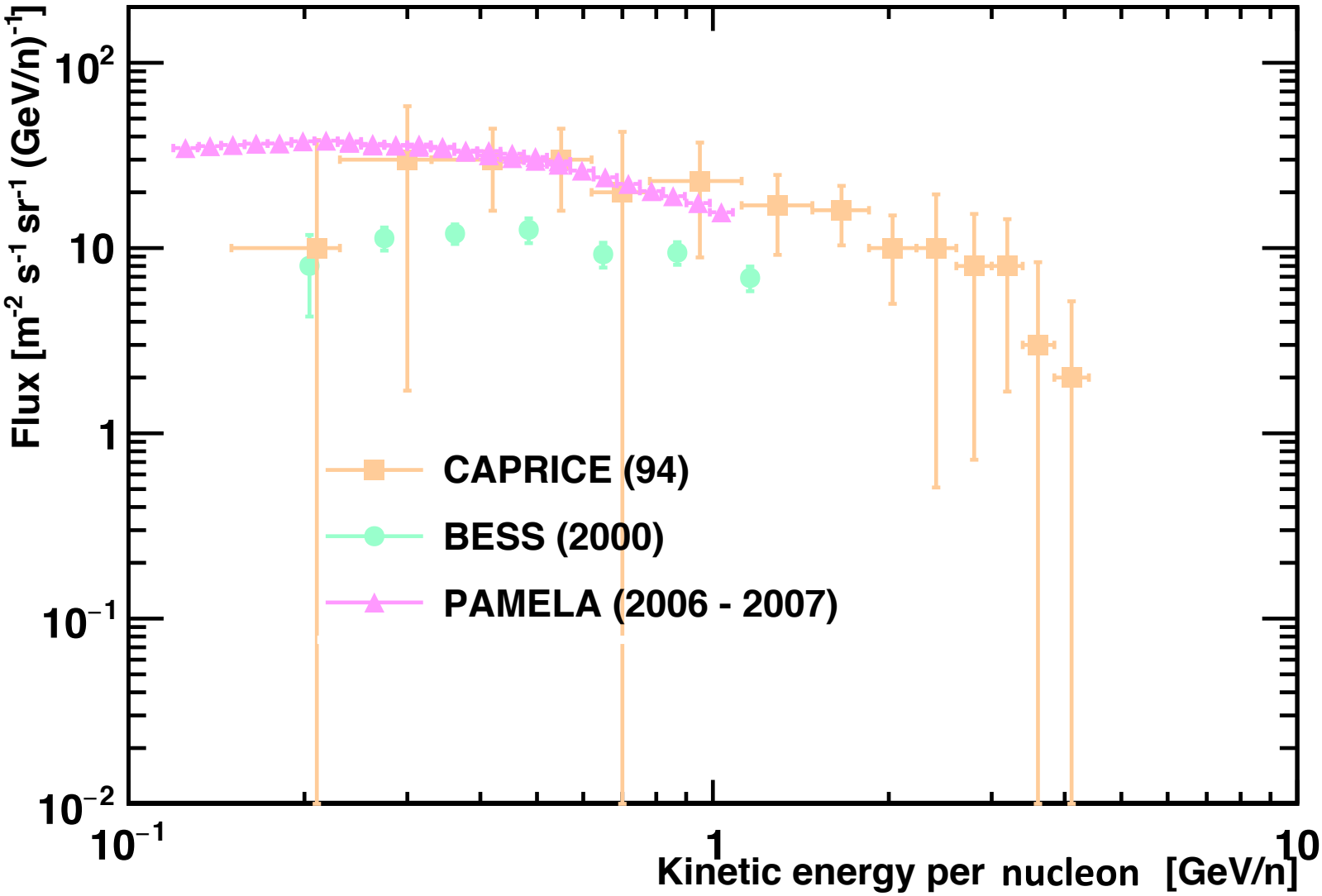
- Number of protons, deuterons and tritons extracted by fitting the mass distributions obtained in MC to data.



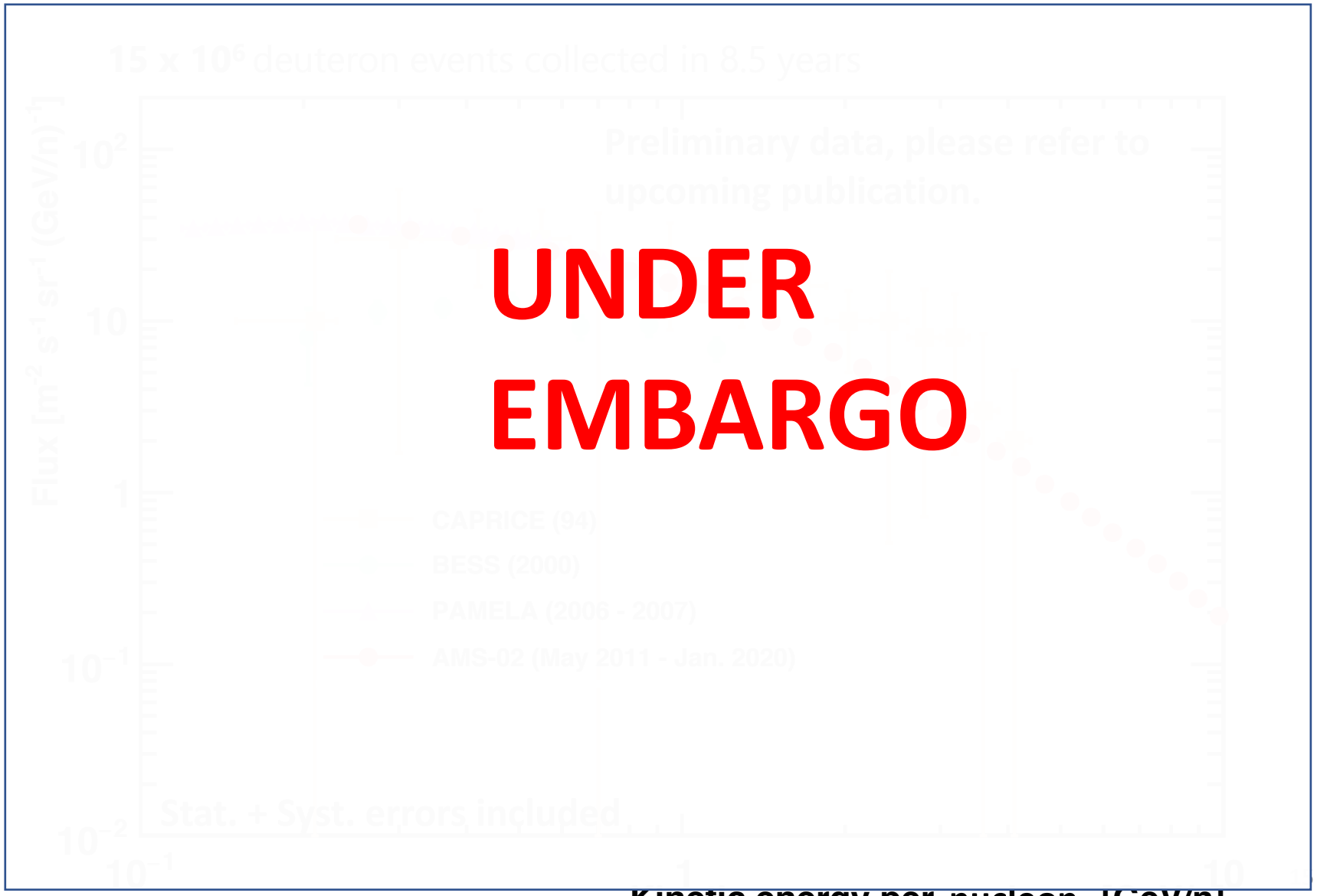




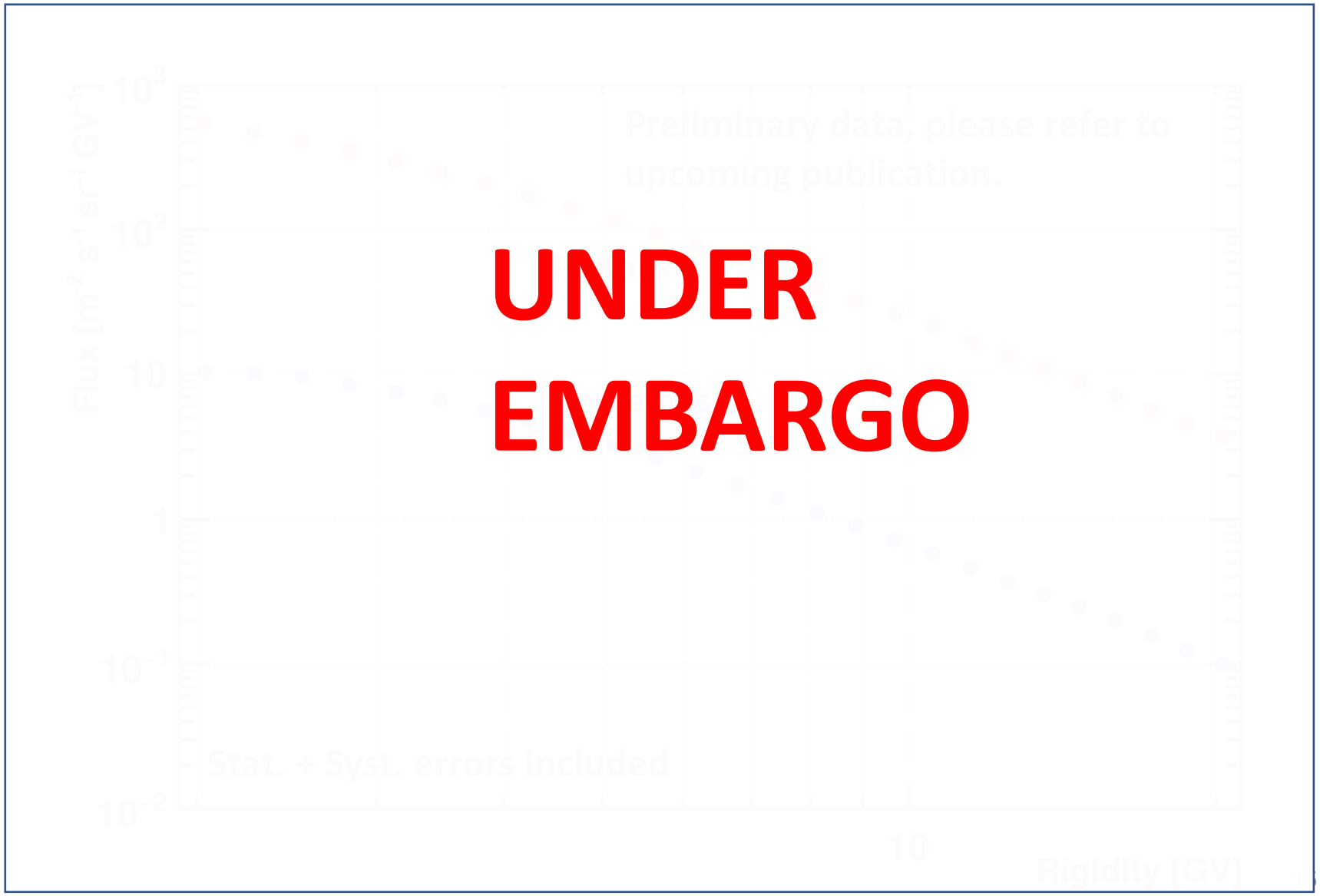
Deuterons before AMS



AMS deuteron flux

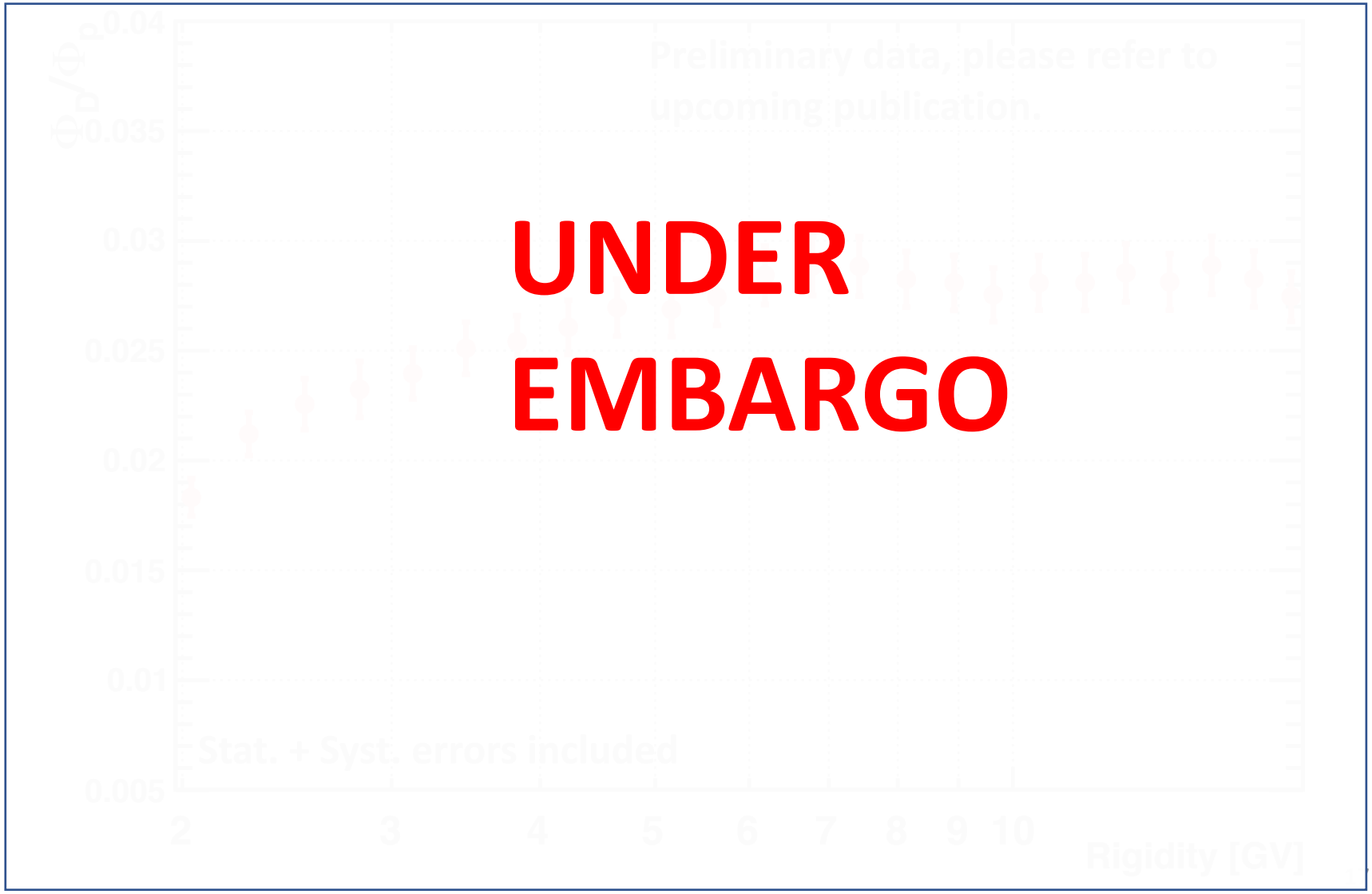


Fluxes versus rigidity



UNDER EMBARGO

D/p flux ratio



D/^{4}He flux ratio

Conclusion

- Deuteron flux measurement was performed between 0.2 and 10 GeV/n, based on **15 million** deuteron events detected by AMS between May 2011 and January 2020
- AMS is also able to perform the measurement as a function of rigidity, providing measurements of the deuteron flux , the D/p flux ratio and D/^{4}He flux ratio from 2 to 20 GV