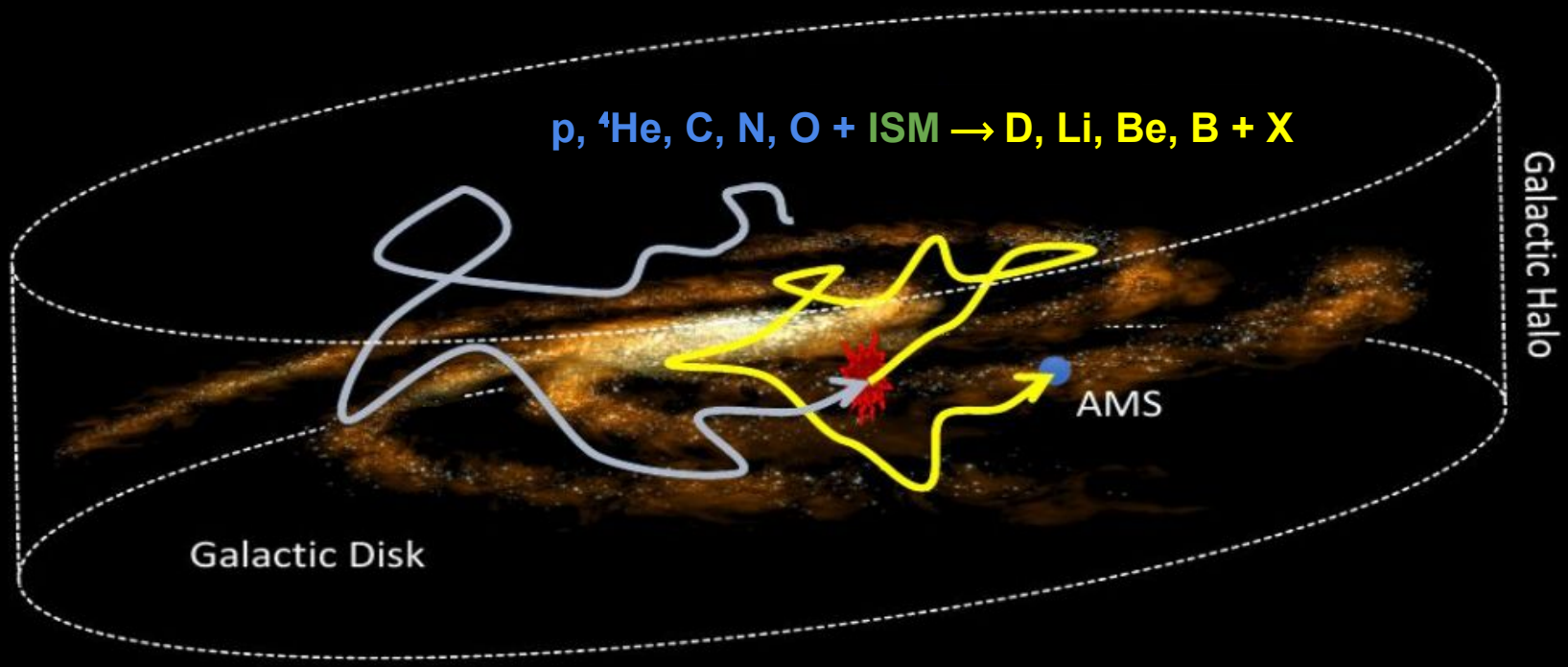
Measurement of the deuteron flux in cosmic rays with the AMS-02 RICH detector

Eduardo F. Bueno

university of groningen

Secondary nuclei in Cosmic Rays (CR)

Secondary CR are produced from collisions of **primary CR** with the **interstellar medium (ISM)**



The fluxes of the secondary species are very important for the understanding of the origin and propagation of cosmic rays

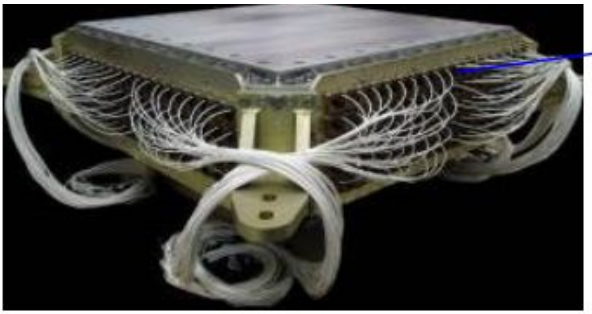
- They carry information on the history of the travel and **properties of ISM**
- Most abundant species: **Li, Be, B and light isotopes (^{3}He and D)**

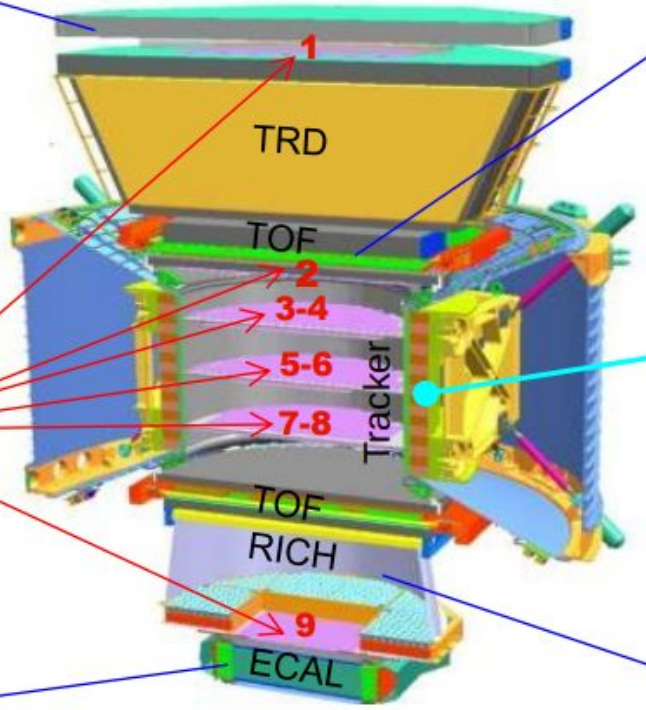
The Alpha Magnetic Spectrometer

TRD
Lepton-hadron separation

Silicon Tracker
Momentum, Z

ECAL
E, lepton-hadron separation

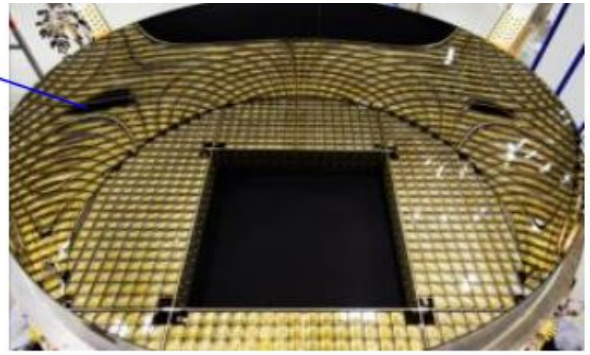




TOF
Z, β

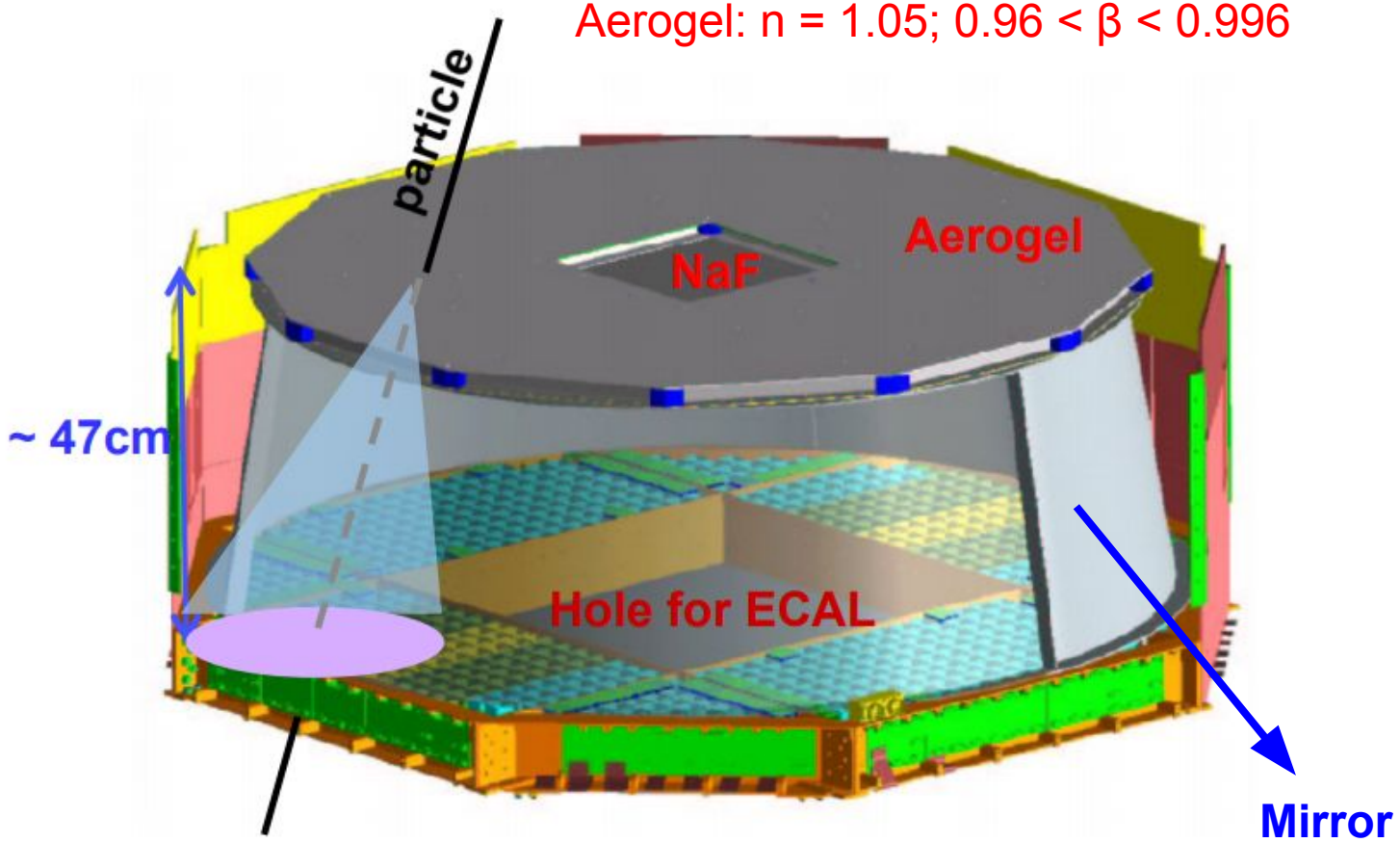
Magnet
Sign of Z

RICH
Z, β



The Ring Imaging Cherenkov (RICH) detector (I)

RICH radiators:
NaF: n = 1.33; 0.75 < β < 0.97
Aerogel: n = 1.05; 0.96 < β < 0.996

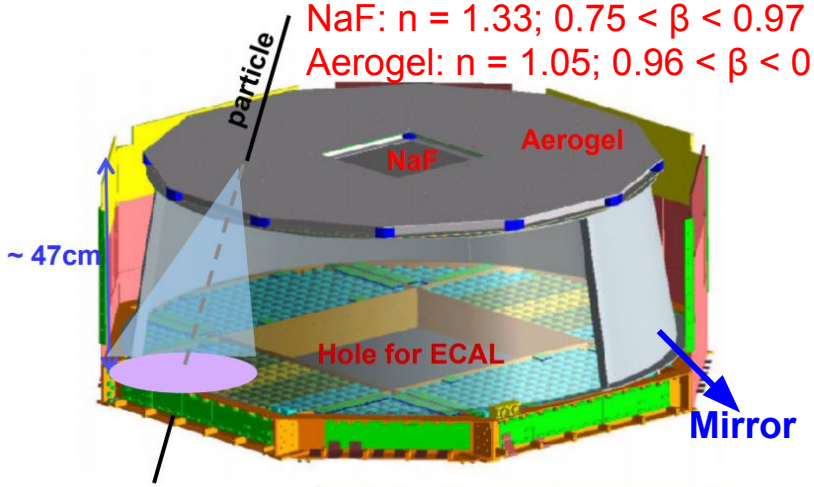


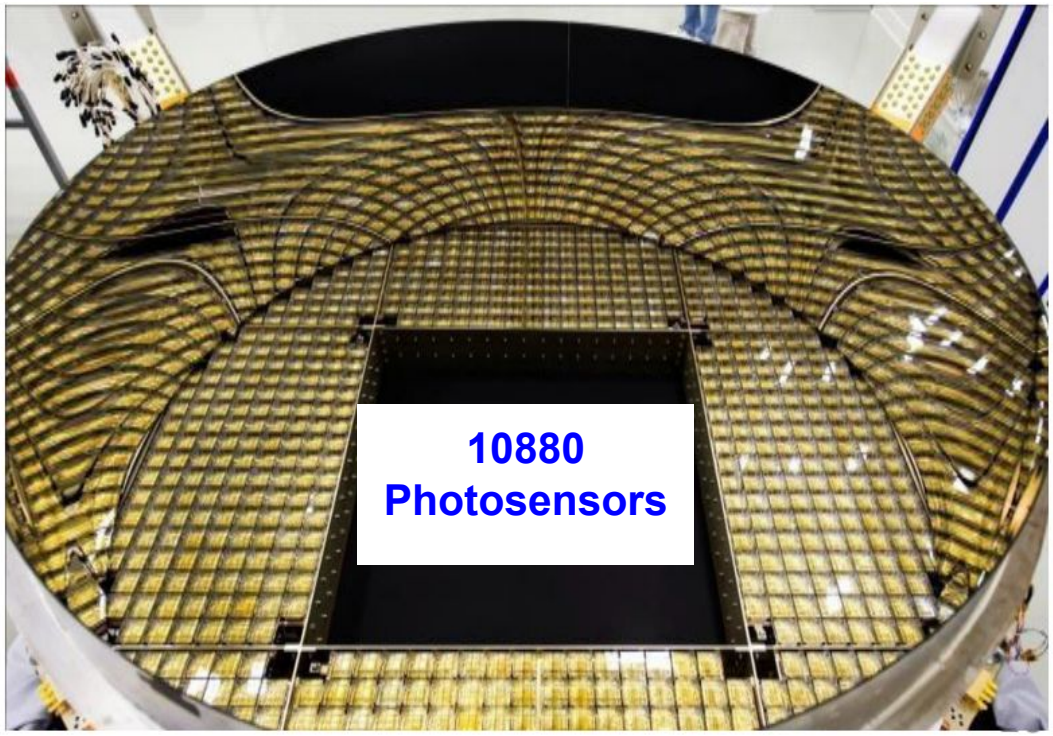
The Ring Imaging Cherenkov (RICH) detector (II)

RICH radiators:

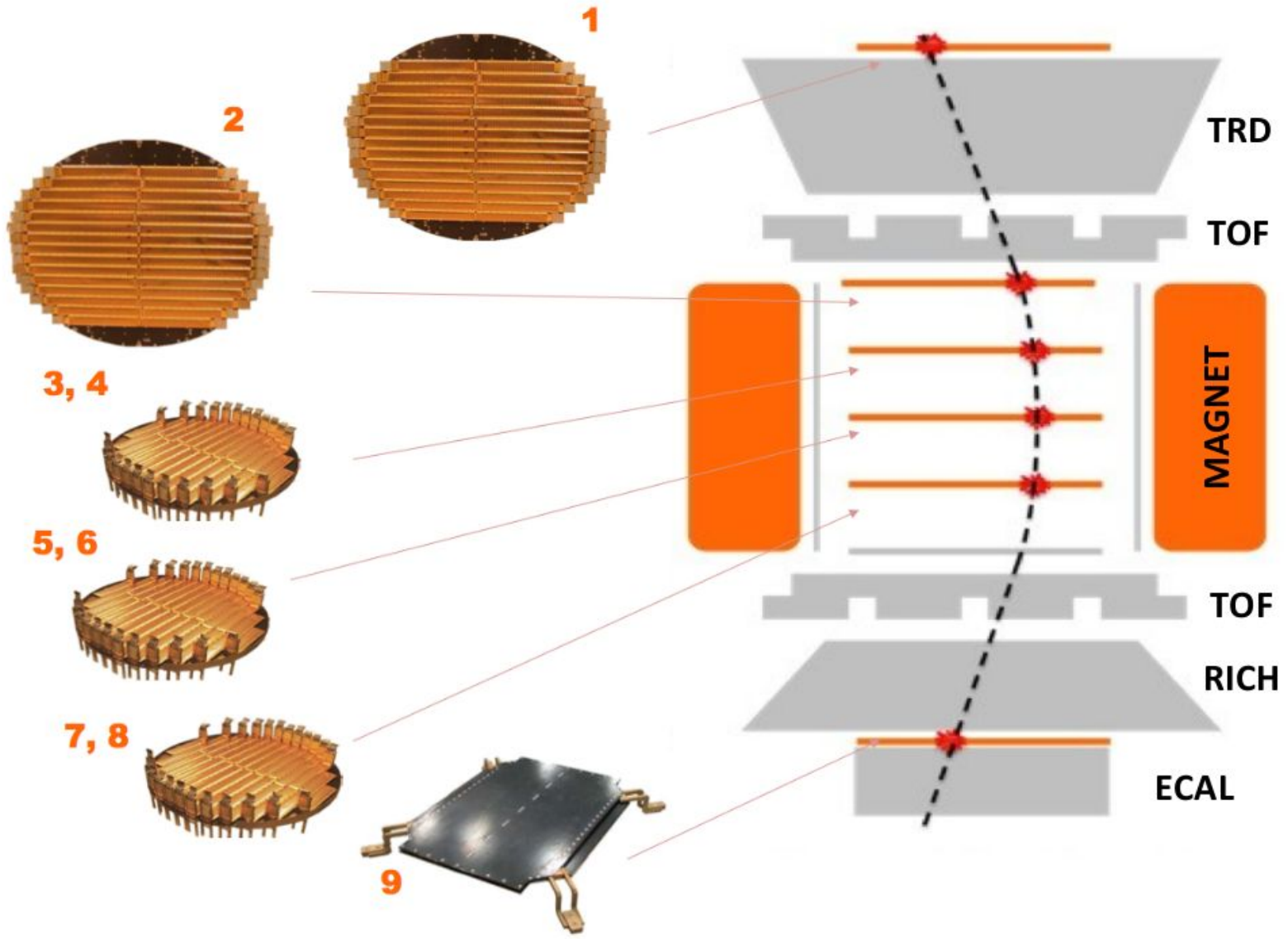
NaF: n = 1.33; 0.75 < β < 0.97

Aerogel: n = 1.05; 0.96 < β < 0.996

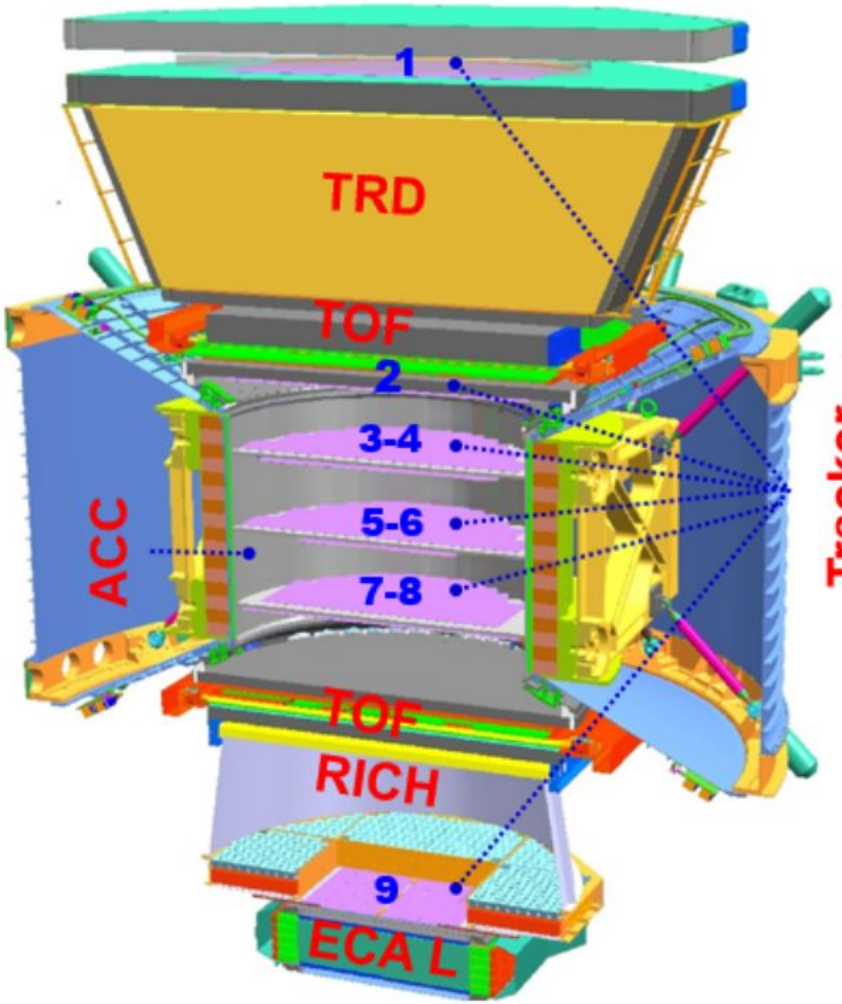




Silicon tracker



Isotope identification with RICH in AMS-02



- Mass measurement:

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

Rigidity: Inner tracker: $\Delta R \approx 10\%$ up to 20 GeV for Z = 1

Velocity:

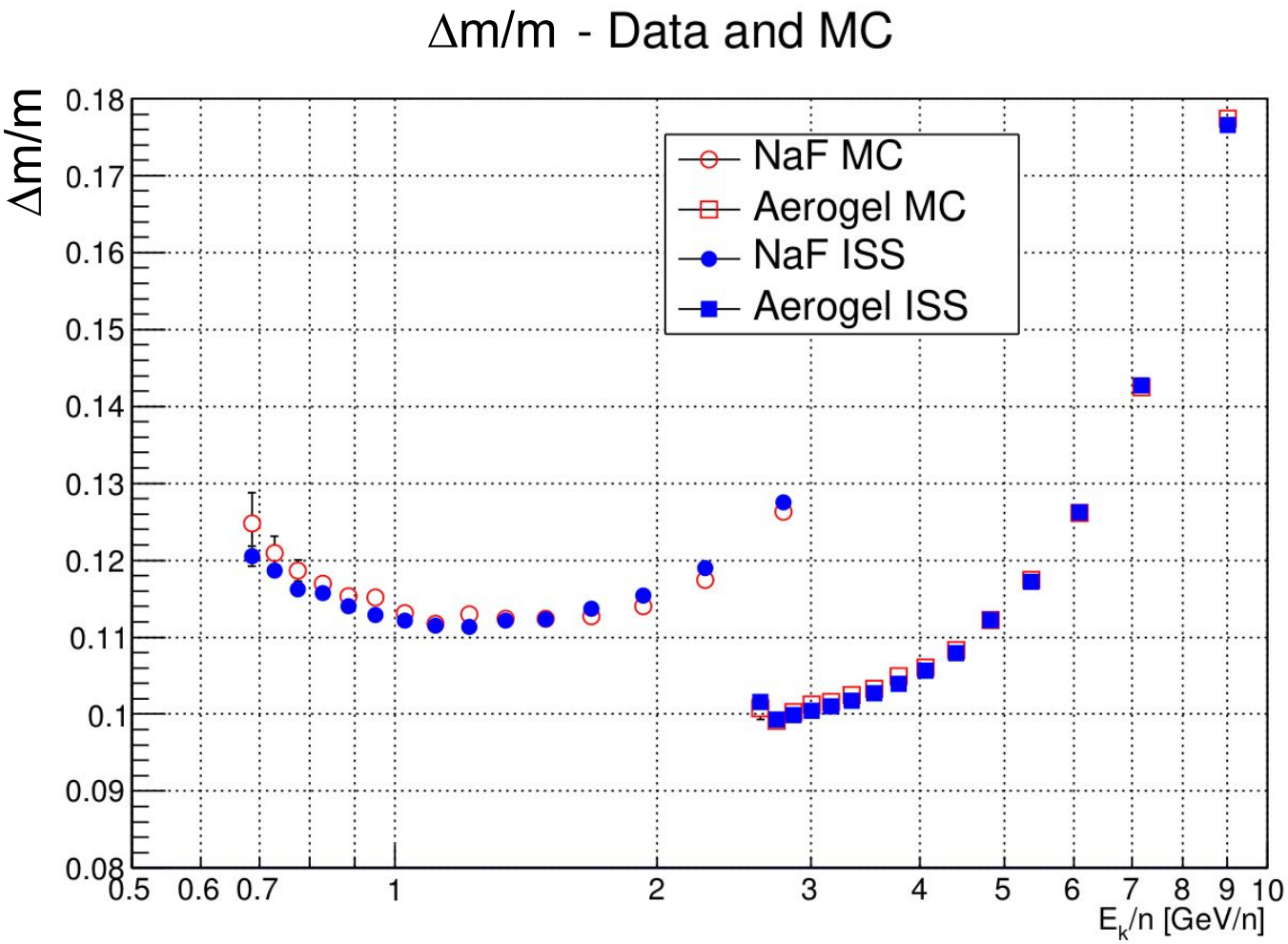
- RICH-NaF: $\Delta\beta \approx 0.4\%$ at Z =1 and $\beta = 1$.
- RICH-Aerogel: $\Delta\beta \approx 0.1\%$ at Z =1 and $\beta = 1$.

Mass resolution (Z = 1)

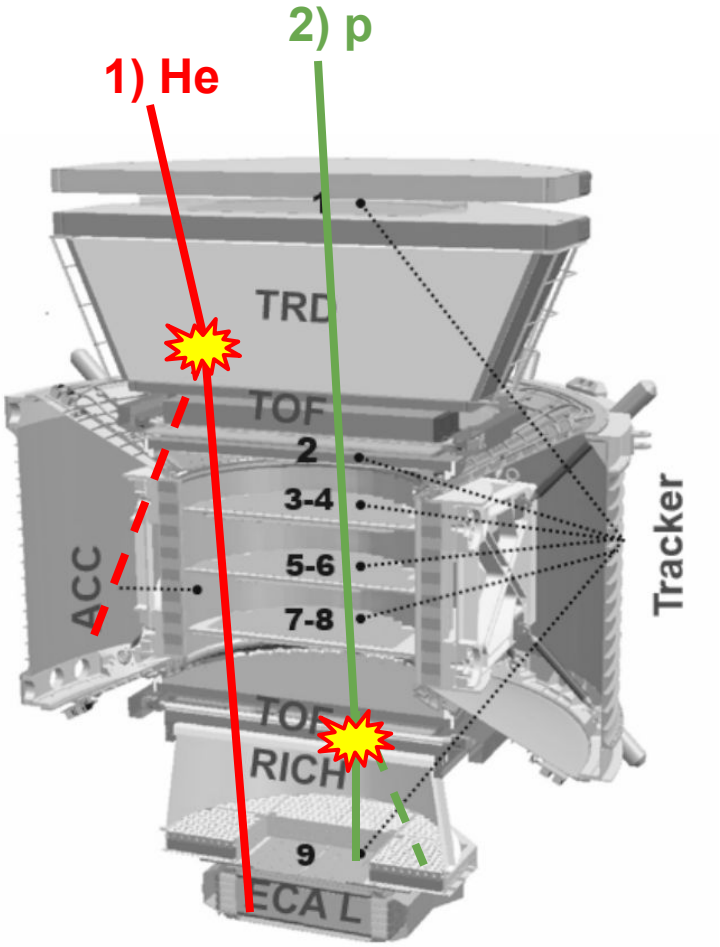
MC: Monte Carlo simulations
ISS: data

$$\left(\frac{\Delta m}{m}\right)^2 = \left(\frac{\Delta R}{R}\right)^2 + \gamma^4 \left(\frac{\Delta \beta}{\beta}\right)^2$$

→ Dominated by the rigidity resolution at low energies



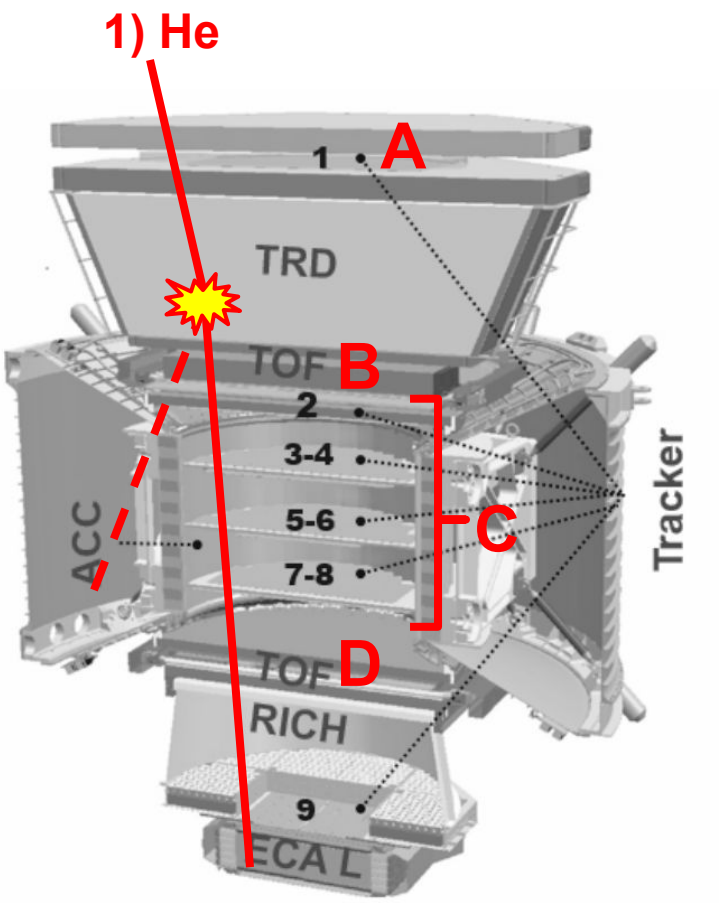
Sources of background



1. Fragmentation of heavier nuclei causes spurious Z = 1 signals.

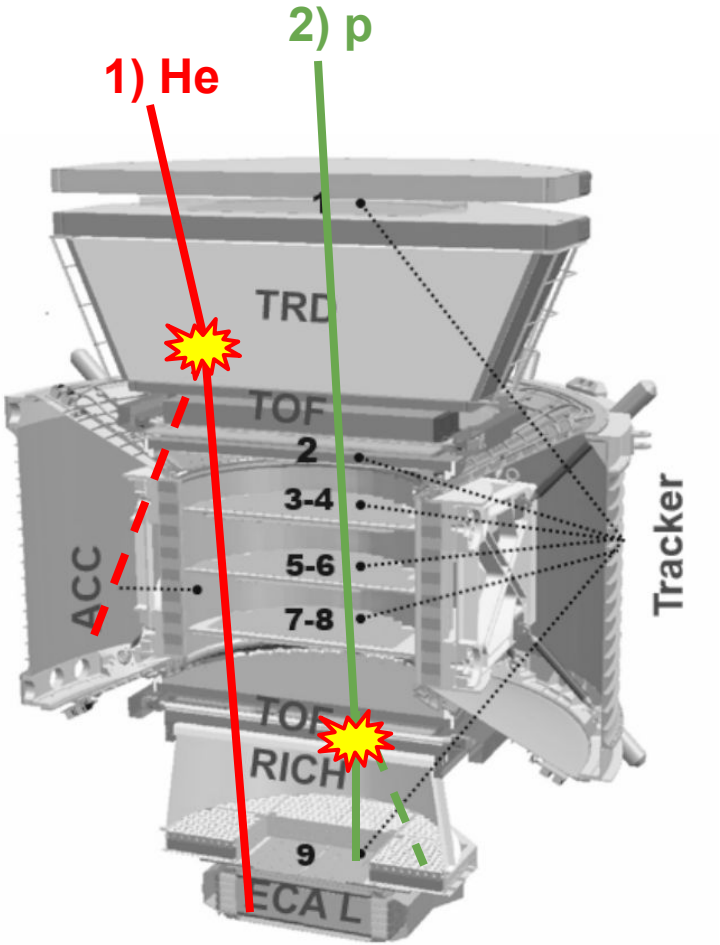
2. Protons interacting inside AMS-02 producing secondary particles which affect the mass measurement.

Event selection (I): charge



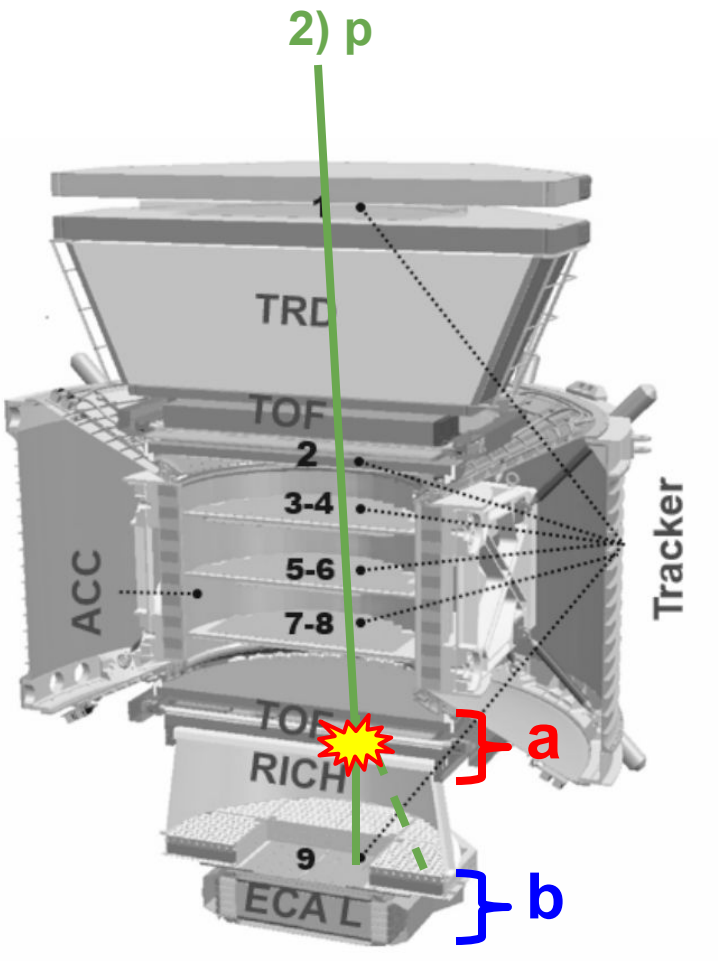
1. Spurious events from fragmentation can be removed by requiring Z = 1 in different layers of the detector:
   - A. **<u>Tracker L1</u>**
   - B. Upper TOF
   - C. Inner Tracker
   - D. Lower TOF

Event selection (II): quality of rigidity



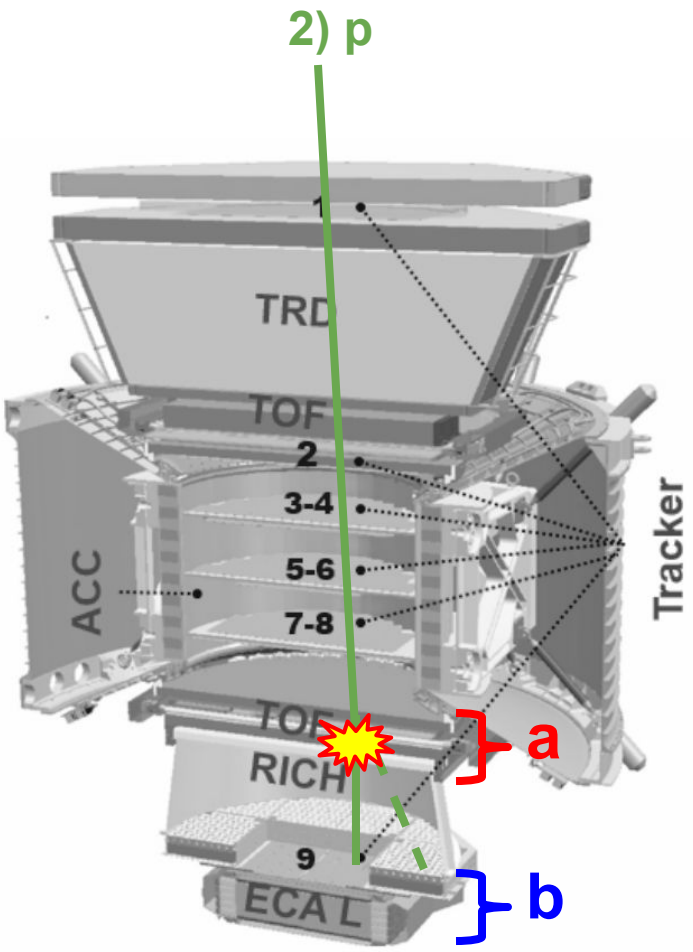
- 1 and 2 can be reduced by requiring events to be well reconstructed in the tracker:
  - Single track
  - Good track fitting

Event selection (III): quality of velocity



2. There are two main types of interaction that affect the velocity measurement:
   a. Secondary particles produced above in the lower TOF and the RICH radiator plane.
   b. Backsplash coming from the ECAL.

Event selection (III): quality of velocity



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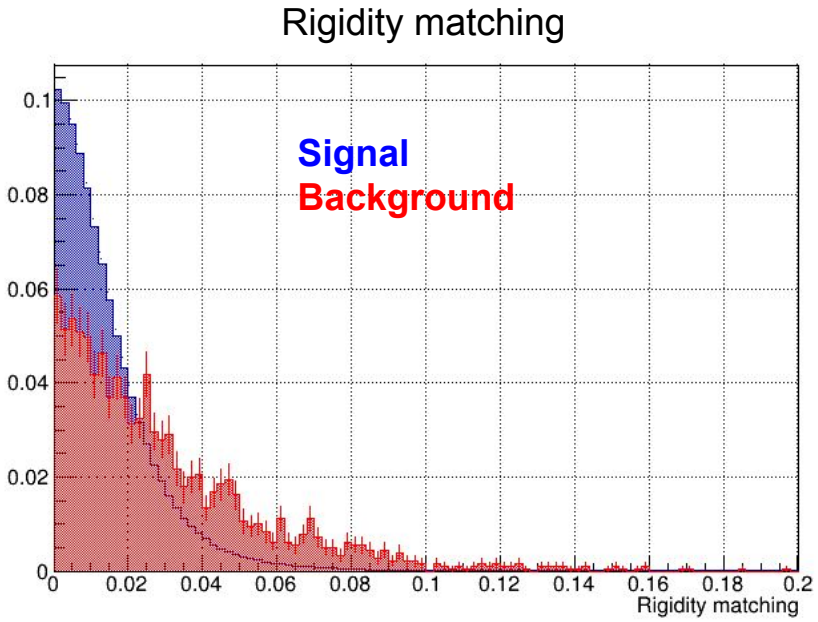
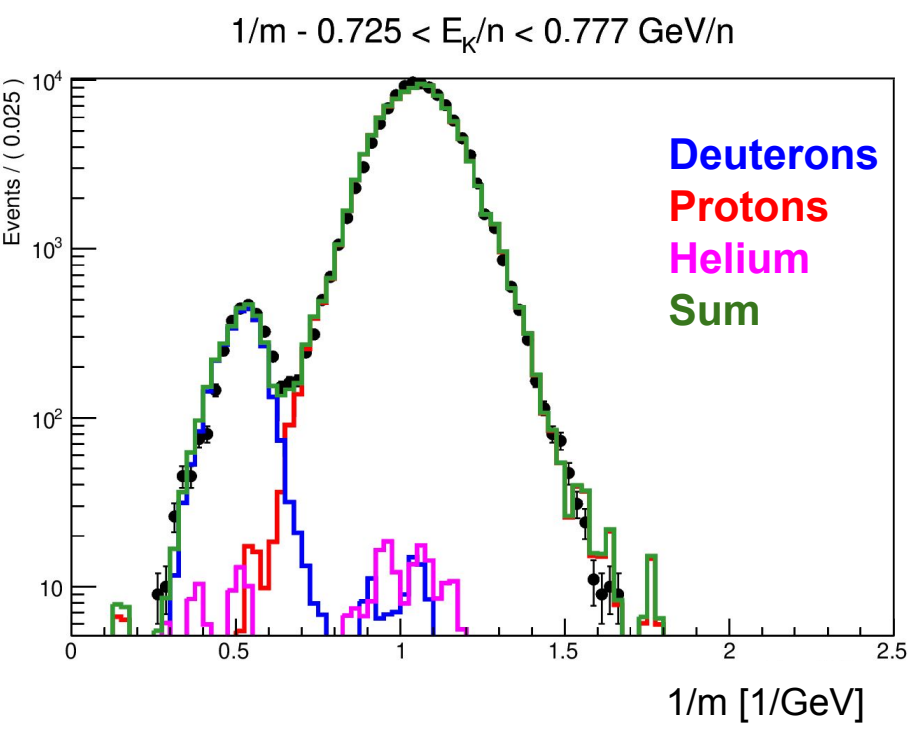
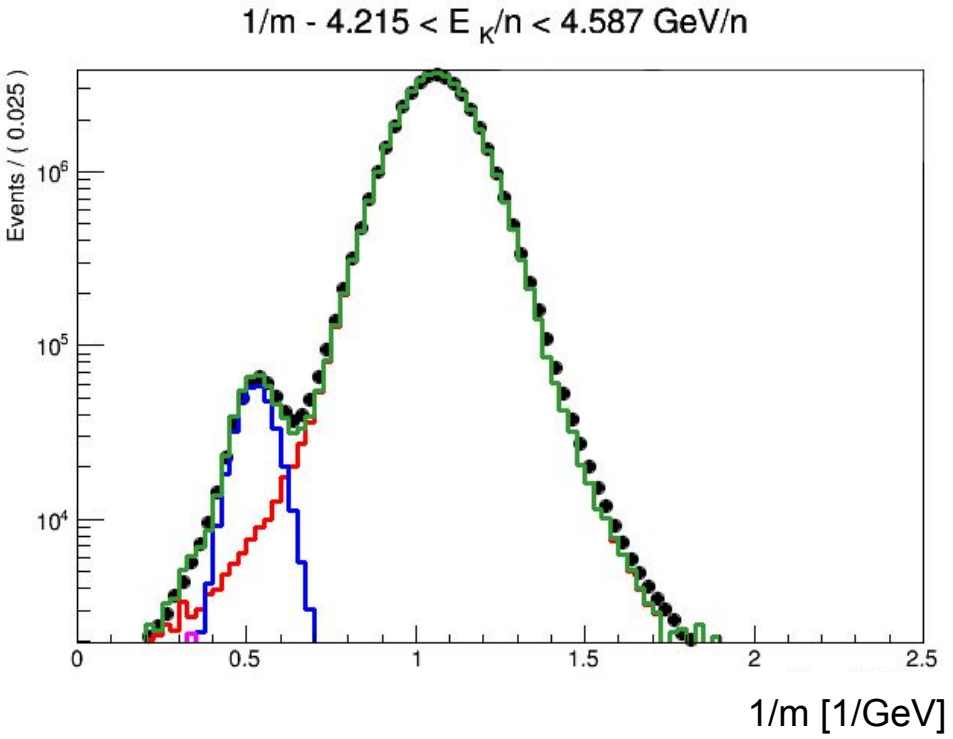


Signal extraction

- **Template fit:** templates obtained from MC simulations of helium, deuterons and protons

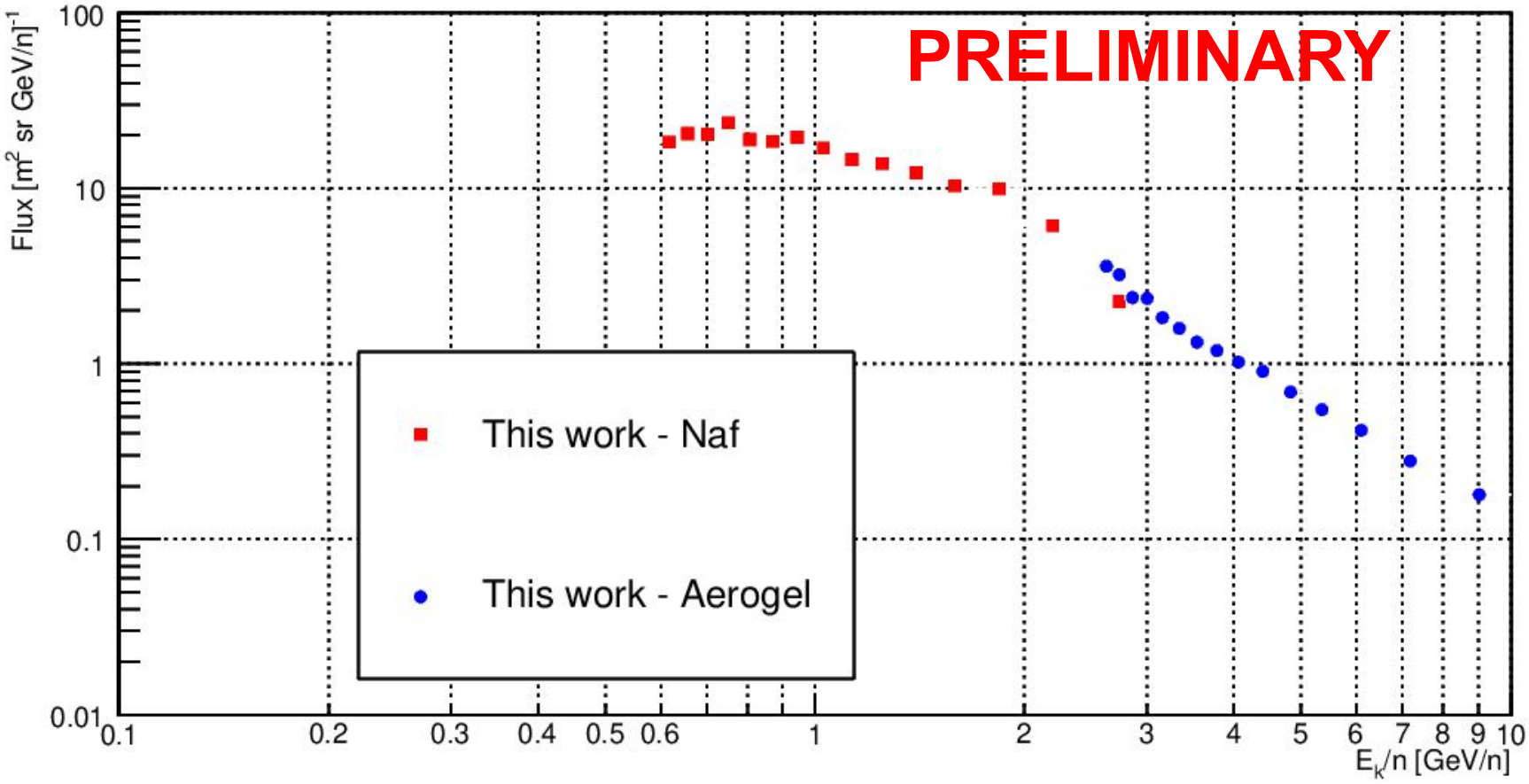


NaF



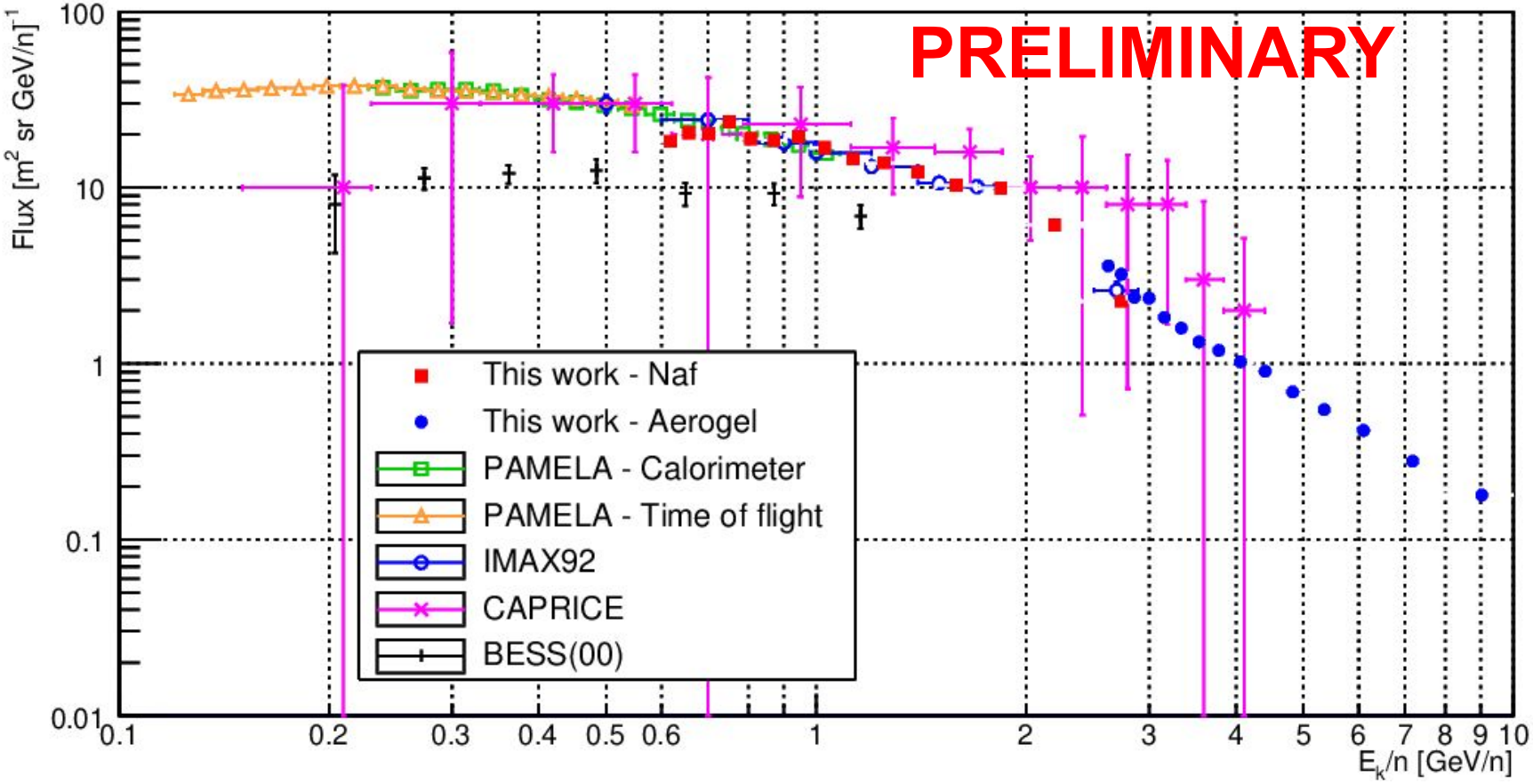
Aerogel

Deuteron flux



This work: statistical error only!

Deuteron flux



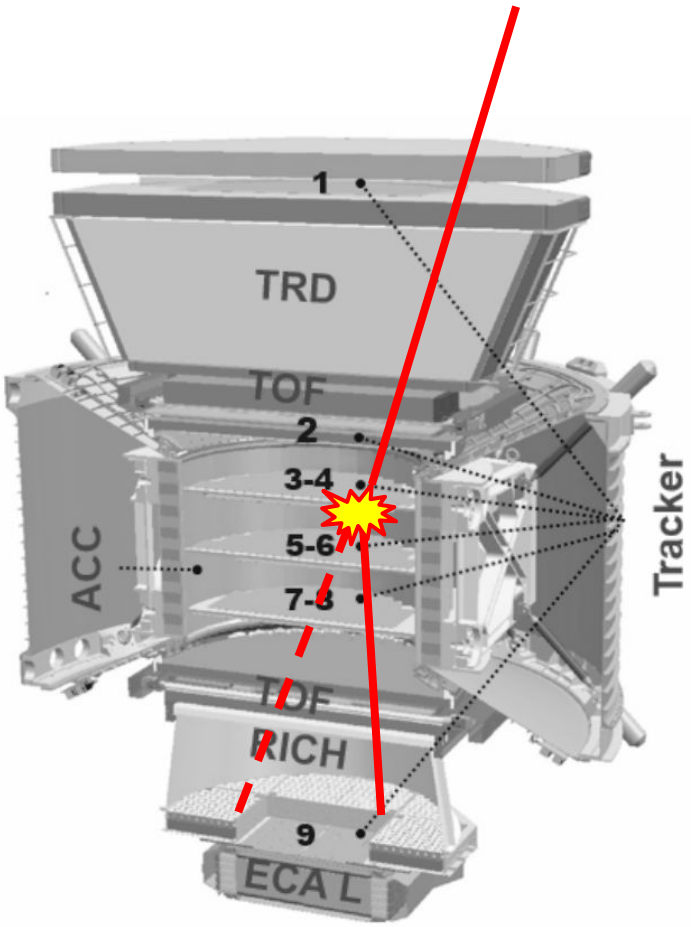
This work: statistical error only!

Conclusion

- The measurement of secondary cosmic rays (including deuterons) is important to study the propagation of cosmic ray.
- AMS-02 complementary measurements of the charge allow an efficient removal of the background caused by fragmentation inside the detector.

Backup slides

Main sources of systematics



- **Fragmentation:** protons and deuterons interact differently inside AMS. The number of protons and deuterons has to be corrected by using MC simulations.
- **Template fit:** shape affected by several factors, such as:
  - Event selection
  - Corrections from data/MC comparison

Acceptance corrections

- MC simulations do not reproduce data perfectly.
- Corrections must be applied to the acceptance before calculating the flux:

$$A_{eff}(E_K) = A_{MC}(1 + \delta(E_K))$$

- The efficiency of every cut is obtained in data and MC and compared:

$$C_i(E_K) = \frac{\epsilon_{i,data}(E_K)}{\epsilon_{i,MC}(E_K)}$$

- The overall correction is then:

$$1 + \delta(E_K) = \prod_{i=1} C_i(E_K)$$