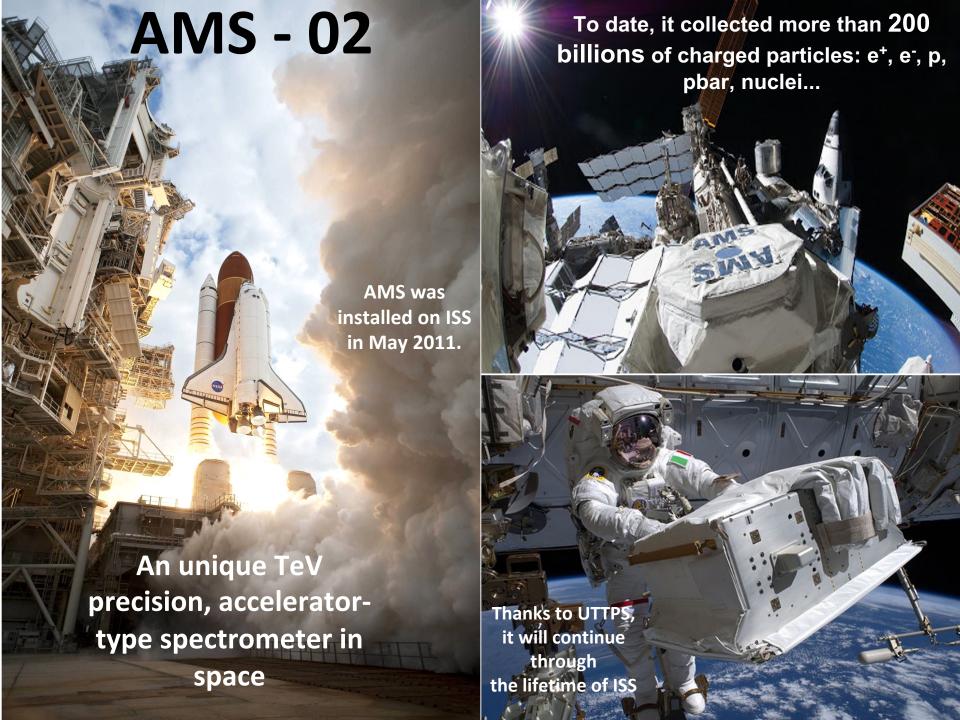
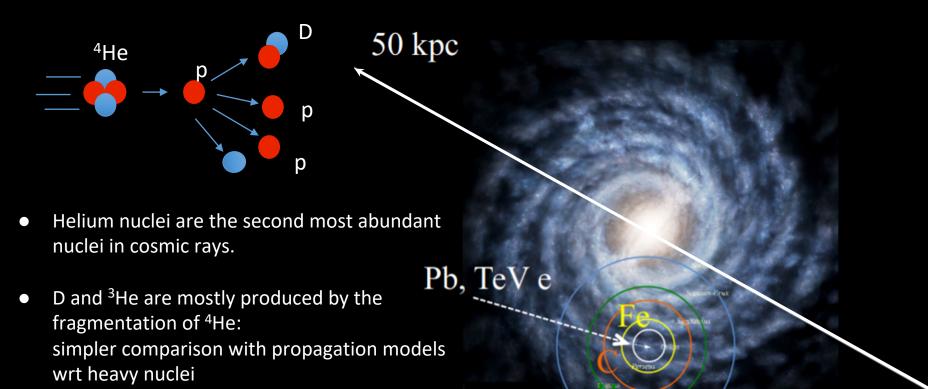


Properties of cosmic Deuterons and ³He

P. Zuccon (Trento University and INFN) on behalf of the AMS-02 Collaboration



Why Z=1&2 isotopes?



Smaller cross section of He:
 D/⁴He and ³He/⁴He probe the properties of diffusion at larger distances

 Different A/Z ratios of D and ³He allow to disentangle kinetic energy and rigidity dependence of propagation.

p, 10 GeV e



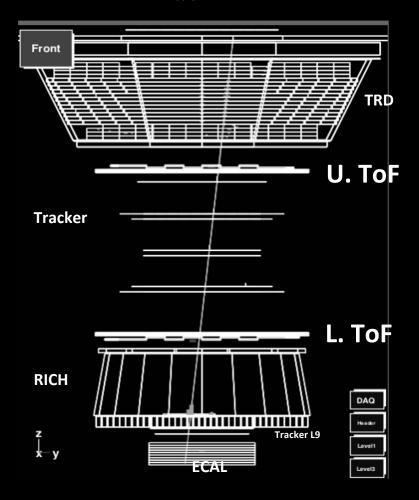
AMS is composed by different sub-detectors for the redundant ID of the elements in CR

- The Mass is identified from the concurrent measurement of Rigidity, Velocity and Charge
- Mass resolution not good enough for event-by-event isotope ID -> Fit of distribution

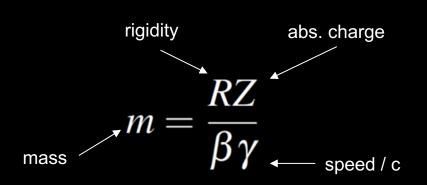
< 3.7 GeV/n
E _k < 8.9
ieV/n

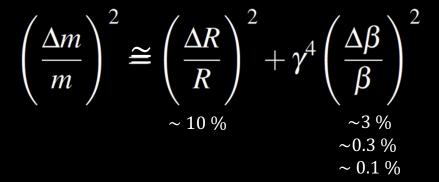
Light isotope measurements with AMS02

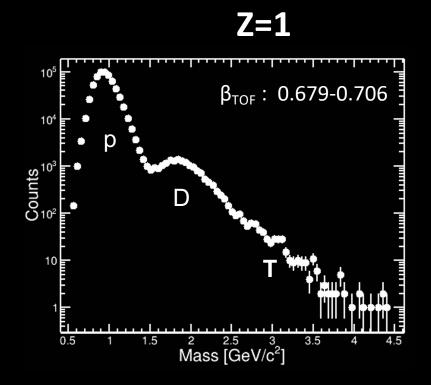
Tracker L1

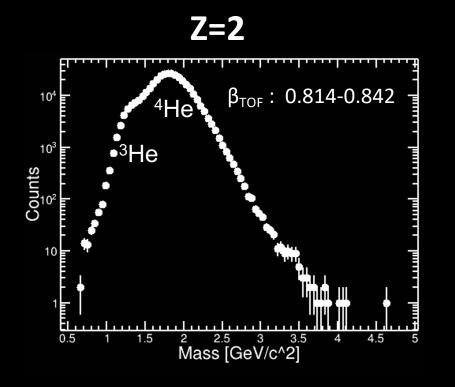


Isotope separation:



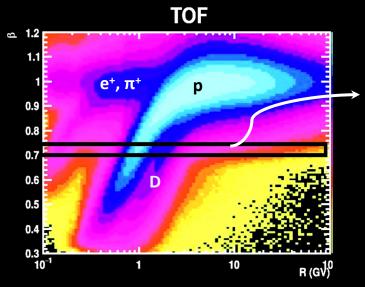






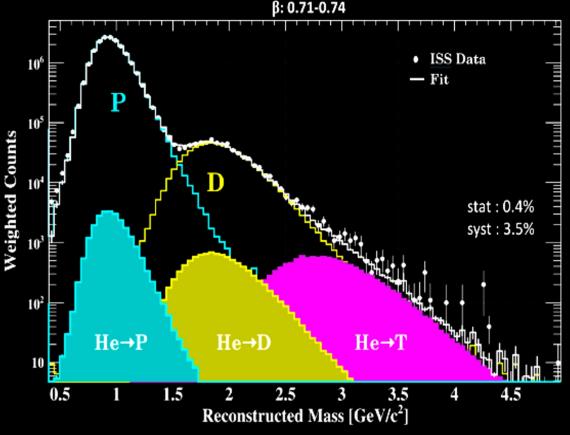
Method2: Isotope template fitting

The separation power depends on rigidity and velocity (β) resolutions



Fit of the mass with templates from MC

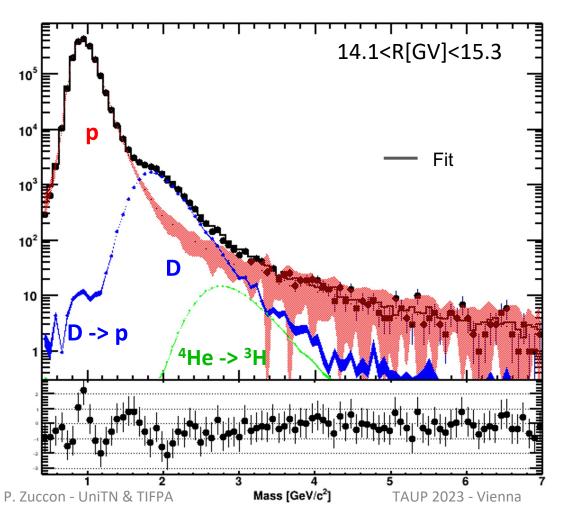
- MC templates tuned using data
- data driven estim. fragmentation from Z>1
- D'Agostini iterative method for bin-to-bin migration

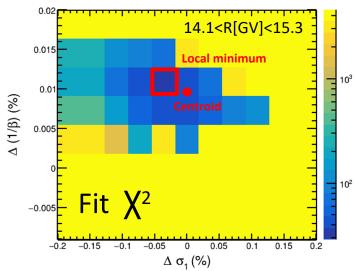


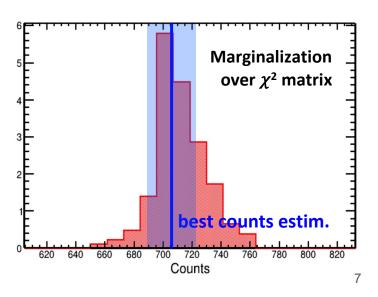
Fit to data (on Mass distributions)

The two remaining free parameters (σ_1 and μ_1) are fixed bin-by-bin directly fitting the mass distributions

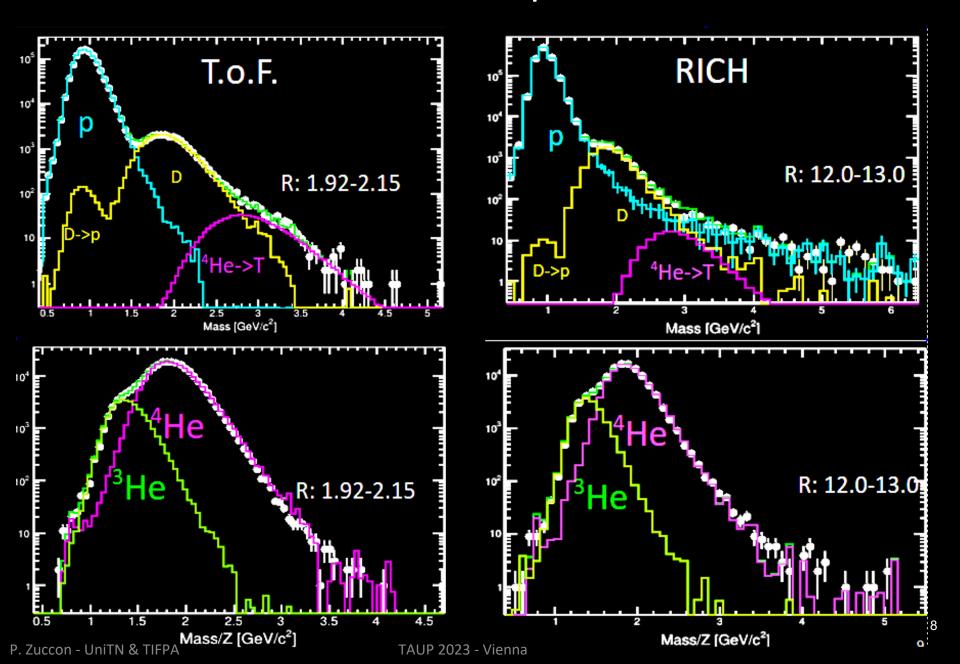
- NxN mass templates obtained changing σ_1 and μ_1 in a $\pm 20\%$ range
- Independent fit for every template
- Marginalization: To every template a weight is assigned: $w = \exp(-\chi^2/2)$



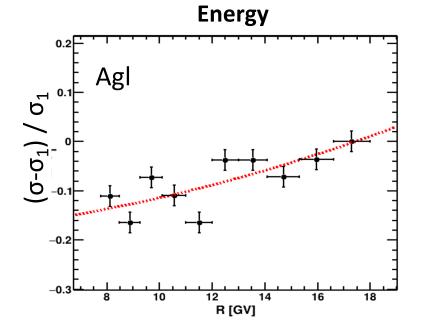


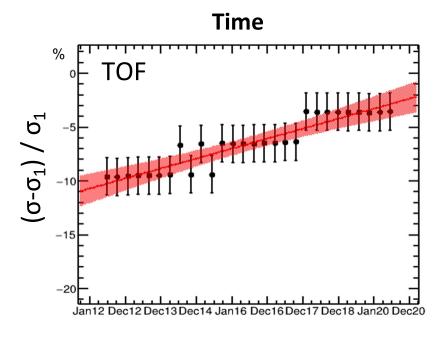


Z=1 and Z=2 Template fits

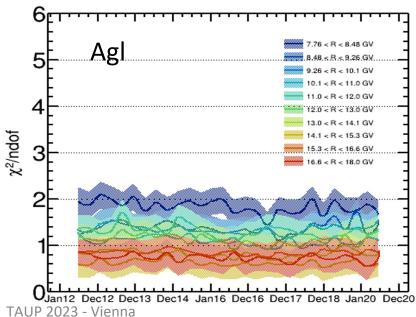


Trends for the free parameter were extracted as a function of:



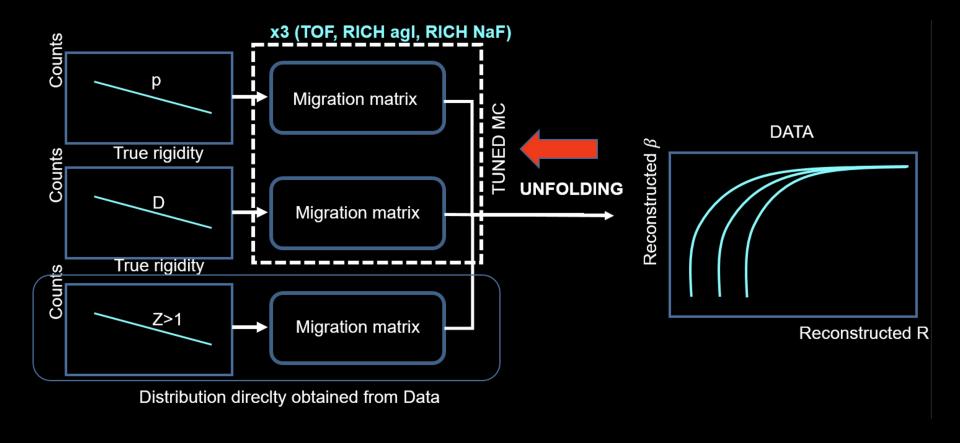


The stability of fit results were also checked to be stable against time



Method2: Global bi-dimensional unfolding on R vs β distributions

- Migration matrices for R and β from MC (iteratively adapted to data)
- Fit on the total Z=1(2) data distribution for TOF, NaF and Agl (assumption: unique continuous flux)

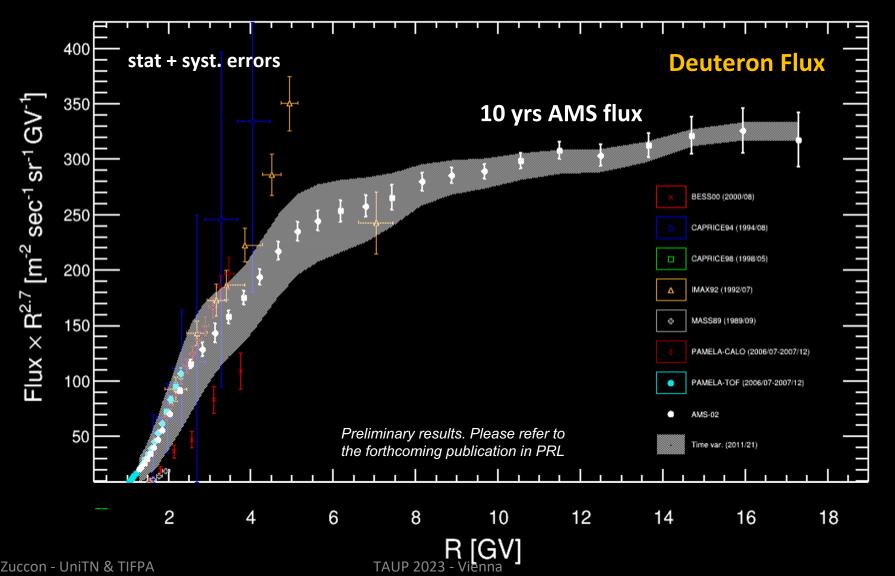


Deuteron Fluxes

MC templates carry informations about:

- **Detector Efficiency**
- Bin-to-bin migration

It is possible to directly use them to calculate Acceptance and Unfolding factor to normalize the counts and obtain fluxes

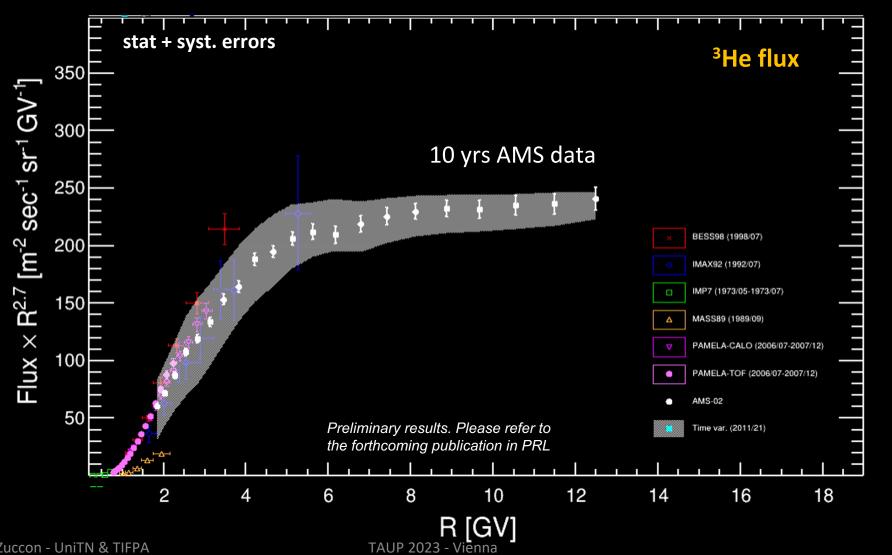


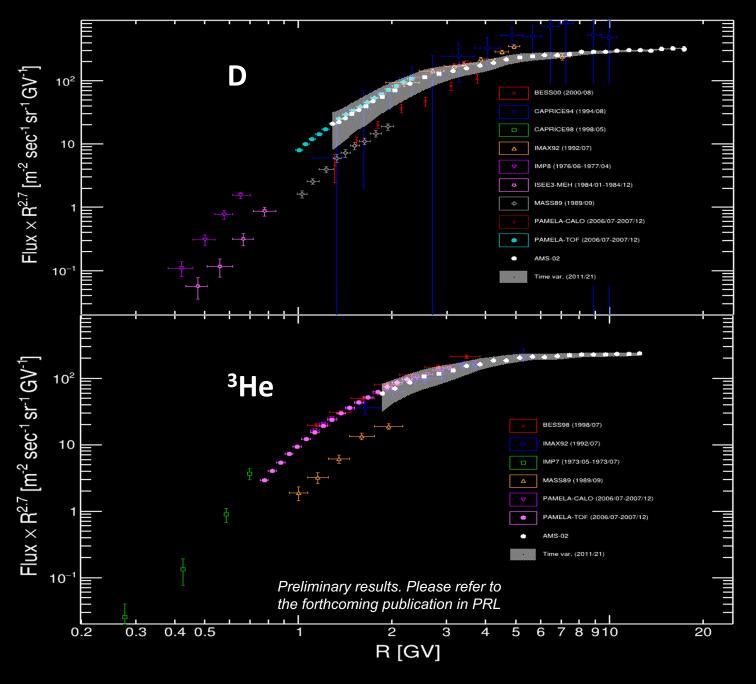
Helium-3 Flux

MC templates carry informations about:

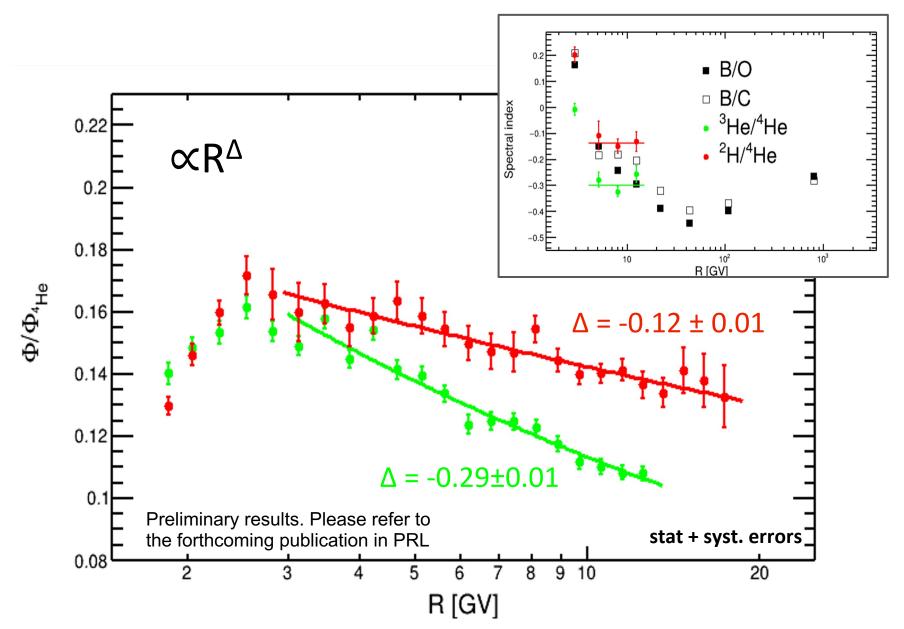
- **Detector Efficiency**
- Bin-to-bin migration

It is possible to directly use them to calculate Acceptance and Unfolding factor to normalize the counts and obtain fluxes



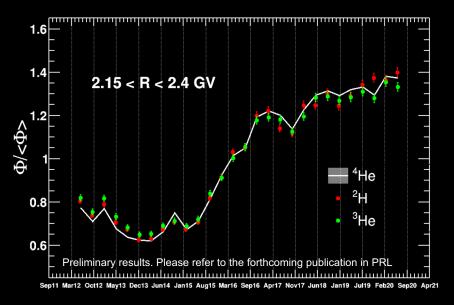


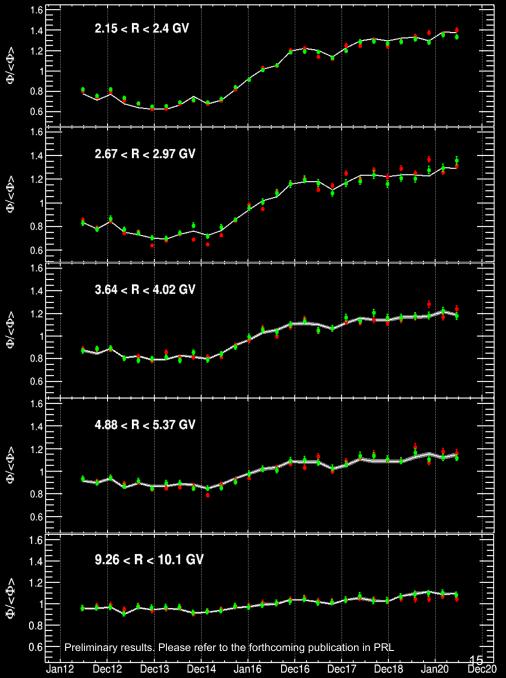
D/4He vs 3He/4He Spectral index



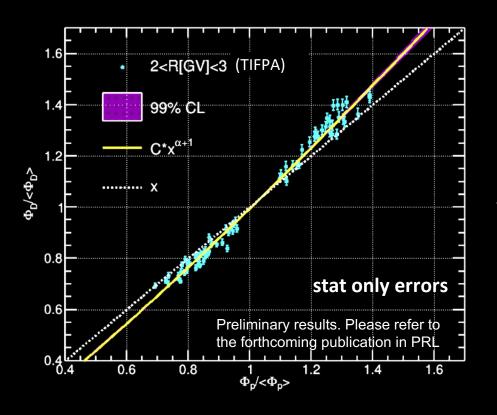
Fluxes time dependence

- Time variation are visible above systematics only below ~ 5 GV
- ²H and ³He qualitatively follow the same time evolution of ⁴He
- More sophisticated analysis is needed





Time evolution of D vs ⁴He



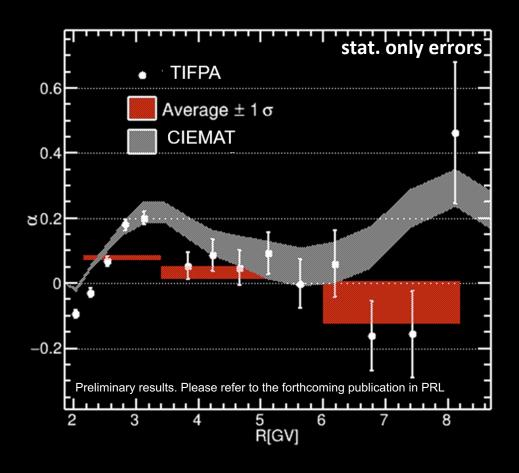
Comparison of the relative time evolution of the flux of ²H and ⁴He

For each R bin, fitted to

$$\frac{\Phi(^2H)}{\Phi(^4He)} \sim \frac{\langle \Phi(^2H) \rangle}{\langle \Phi(^4He) \rangle} \times \left(\frac{\Phi(^4He)}{\langle \Phi(^4He) \rangle}\right)^{\alpha}$$

a = 0 if the evolution of the two species is the same

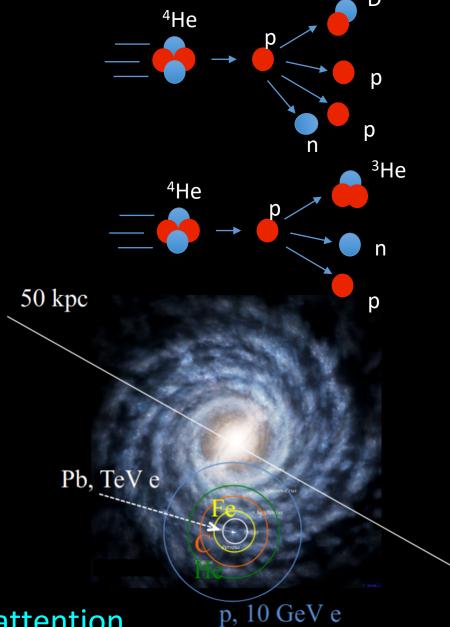
Time evolution of D vs ⁴He



- Only fit statistical errors are shown
- For R<3.5 GV, both groups see hints of significative time dependence of the ratio
- For R>3.5 GV, the two species show evolution compatible within the errors

Summary

- AMS-02 measured the ³He and D fluxes using 10 years of data in the rigidity range from 2GV to 20 GV.
- Below ~4GV: solar modulation induces a time evolution of the the measured fluxes larger than the systematics of the measurement.
- Above ~4GV: the ratio of ³He and D to ⁴He are compatible with a power law function.
 The spectral indexe seem to be different for the two species.
- The fluxes time evolution are qualitatively similar to those of ⁴He. We observe hints of significantly different behaviour of the two species below ~3GV

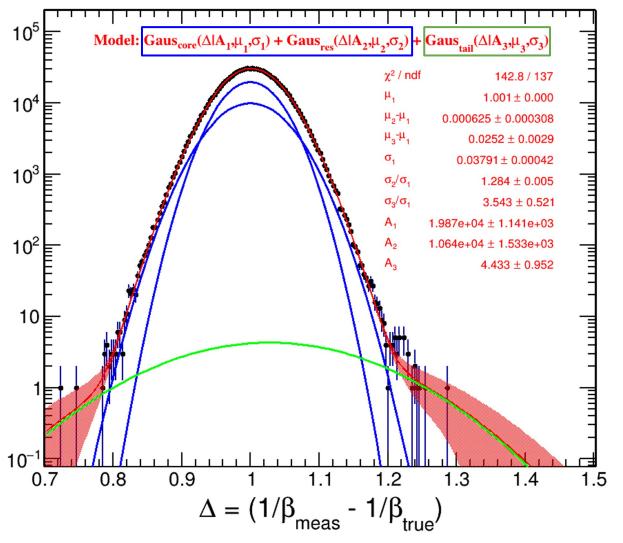


Thanks for your attention

Backup Slides

General Parametrization of the velocity resolution (Z=1 - TOF)

double gaussian core + tail of bad reconstructed events (not in MC)



 σ_1 is the only free parameter of the model

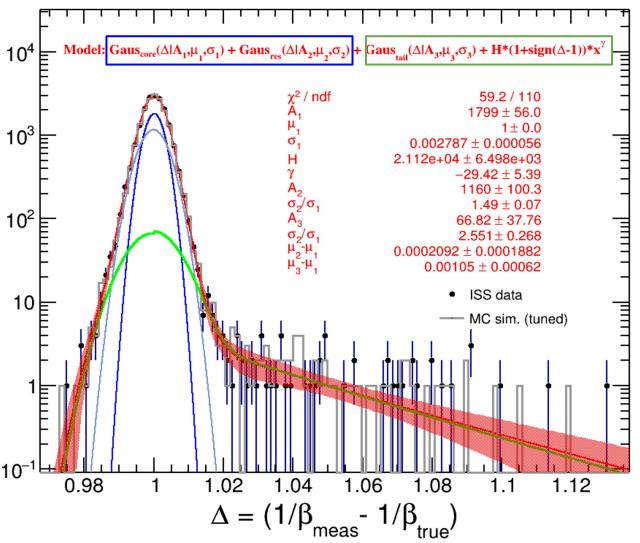
other parameters are fixed by the high velocity behaviour

TOF:

bad rec. events modeled as third gaussian

General Parametrization of the velocity resolution (Z=1 - NaF)

double gaussian core + tail of bad reconstructed events (not in MC)



 σ_1 is the only free parameter of the model

other parameters are fixed by the high velocity behaviour

RICH (NaF):

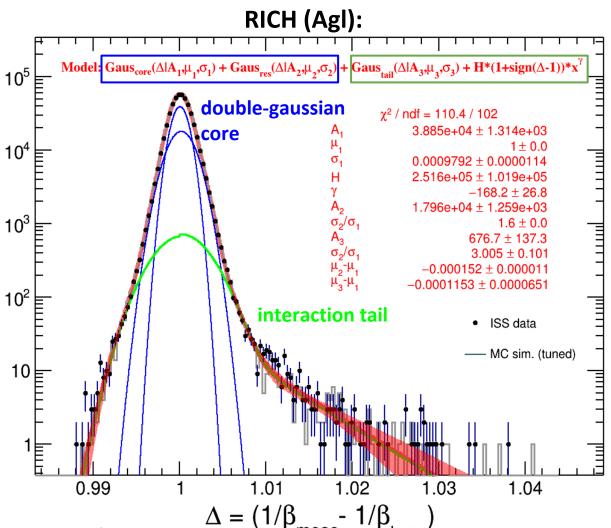
bad rec. events modeled as gaussian + power law tail

21

General Parametrization of the velocity resolution (Z=1 - Agl)

The velocity response was modeled from high energy flight data: (R>50 GV)

 $\beta_{true} \approx 1$: distribution not influenced by isotopic composition



 σ_1 and μ_1 are the only free parameter of the model

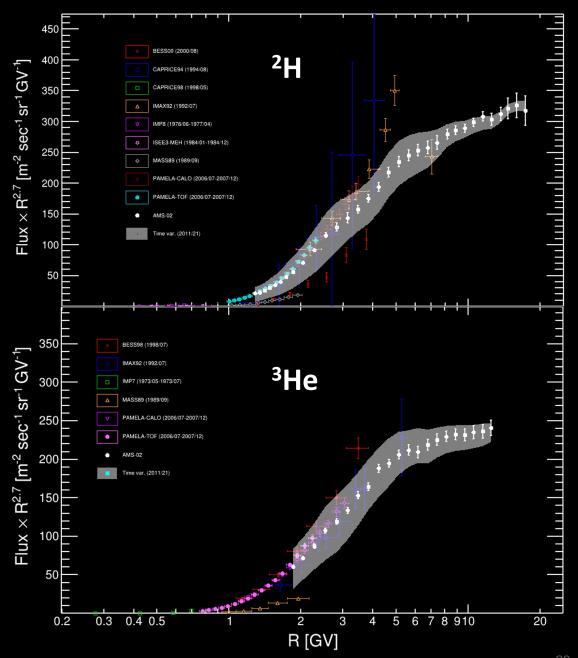
other parameters are kept rigidly related to them at all velocities

Isotope Fluxes

MC templates carry informations about:

- Selection Efficiency
- Bin-to-bin migration

It is possible to directly use them to calculate **Acceptance** and **Unfolding factor** to normalize the counts and obtain **fluxes**



Average Deuteron Ratios Fit

Ratios against rigidity factor out the solar modulation -> $^{\sim}$ Time independent

Fit: A·
$$\begin{cases} R^{\delta 1} R < R_0 \\ R^{\delta 2} R > R_0 \end{cases}$$

