

Trento Institute for Fundamental Physics and Applications



## Light isotopes in CR: D, p, <sup>3</sup>He and <sup>4</sup>He



### Light Isotope Analysis status

- Analysis substantially complete
  - Fit systematics
  - Data-driven acceptance
  - Unfolding
  - Uncertainties
  - Time dependence
  - D, p, <sup>3</sup>He, <sup>4</sup>He
- 8 (10) yrs analyzed (2011-2019)
- 3 independent analyses:
  - TIFPA (tuned MC Template Fit)
  - HAWAII (tuned MC Template Fit)
  - CIEMAT (2D Unfolding)
- TIFPA and HAWAII in good agreement
- CIEMAT disagrees by a ~20% normalization factor on D flux (probable disagreement on acceptance, on-going investigation)
- Time dependence visible over systematics below ~5 GV



**Deuteron Flux** 

#### The only possible cross check on normalization is from published D/p



### Protons



#### Deuterons



# <sup>4</sup>Helium



Time dep. (∆t=4bartels)



# <sup>3</sup>Helium



Time dep. (∆t=4bartels)



## <sup>3</sup>He/<sup>4</sup>He



- Time var = st. dev
- Break at 4 GV
- Time variability compatible with publication
- Spectral index at high en. compatible with publication



### Flux Time dep.

- Time dep. visible above errors only below ~5 GV
- D behaviour much more similar to <sup>4</sup>He than <sup>3</sup>He





#### D/<sup>4</sup>He time dependence: Analysis

- Variables: φ/<φ> to reduce the dynamics of the plot
- Fit function:
  - $\phi_{D} / \langle \phi_{D} \rangle = C^{*}$  $\phi_{4He} / \langle \phi_{4He} \rangle^{(1+\alpha)}$
- C =1 always
  a = 0 if NO time dep.





![](_page_12_Figure_0.jpeg)

![](_page_13_Figure_0.jpeg)

### Conclusions

- Measured low energy time dependent fluxes for all light isotopes in CR (p,D,<sup>3</sup>He,<sup>4</sup>He)
- From the small differences in flux time dependence, important info about propagation a solar modulation
- Reproduced results of published <sup>3</sup>He/<sup>4</sup>He analysis
- Unexpected: D behaves much more like a primary

### **On-going** (collab. with Hawaii/CIEMAT)

- Investigation on normalization difference between TIFPA/HAWAII and CIEMAT
- Improving the fit in TOF/NaF junction
- Time Regularization of fit to improve time dep. studies