Measurement of $^{3}\overline{\mathrm{He}}$ absorption cross-section with ALICE

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Introduction and motivation

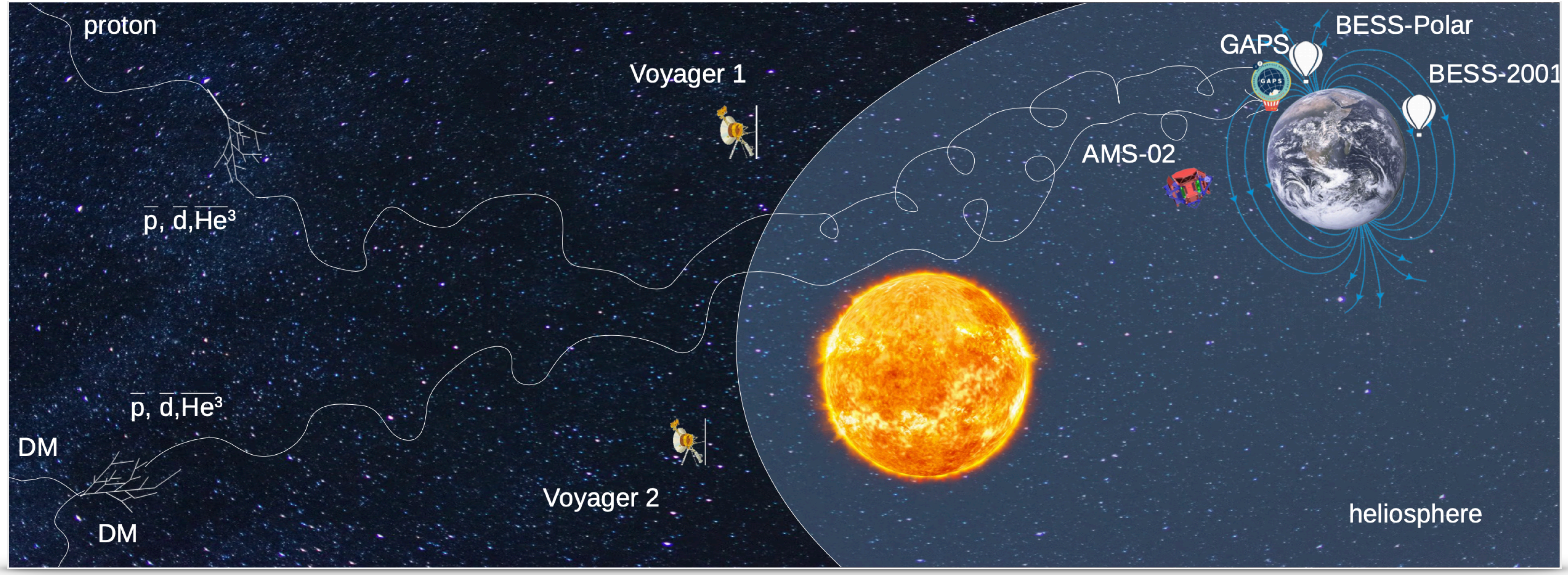
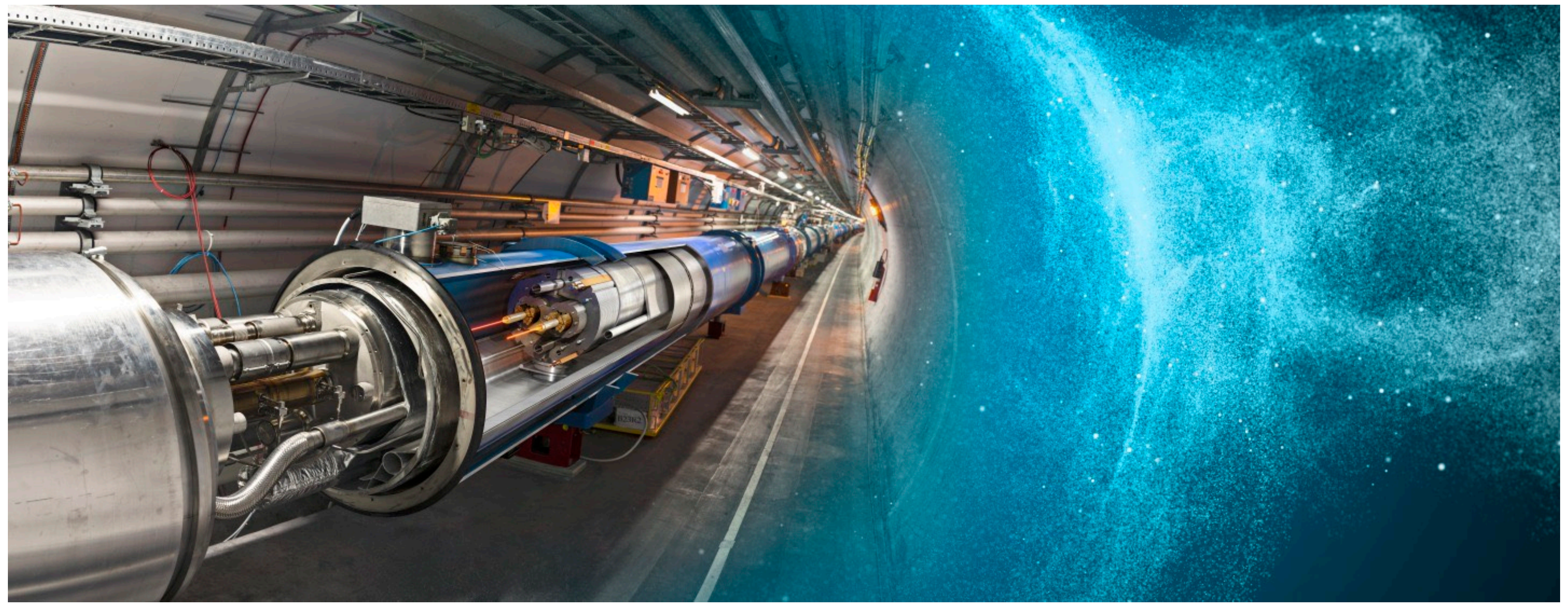
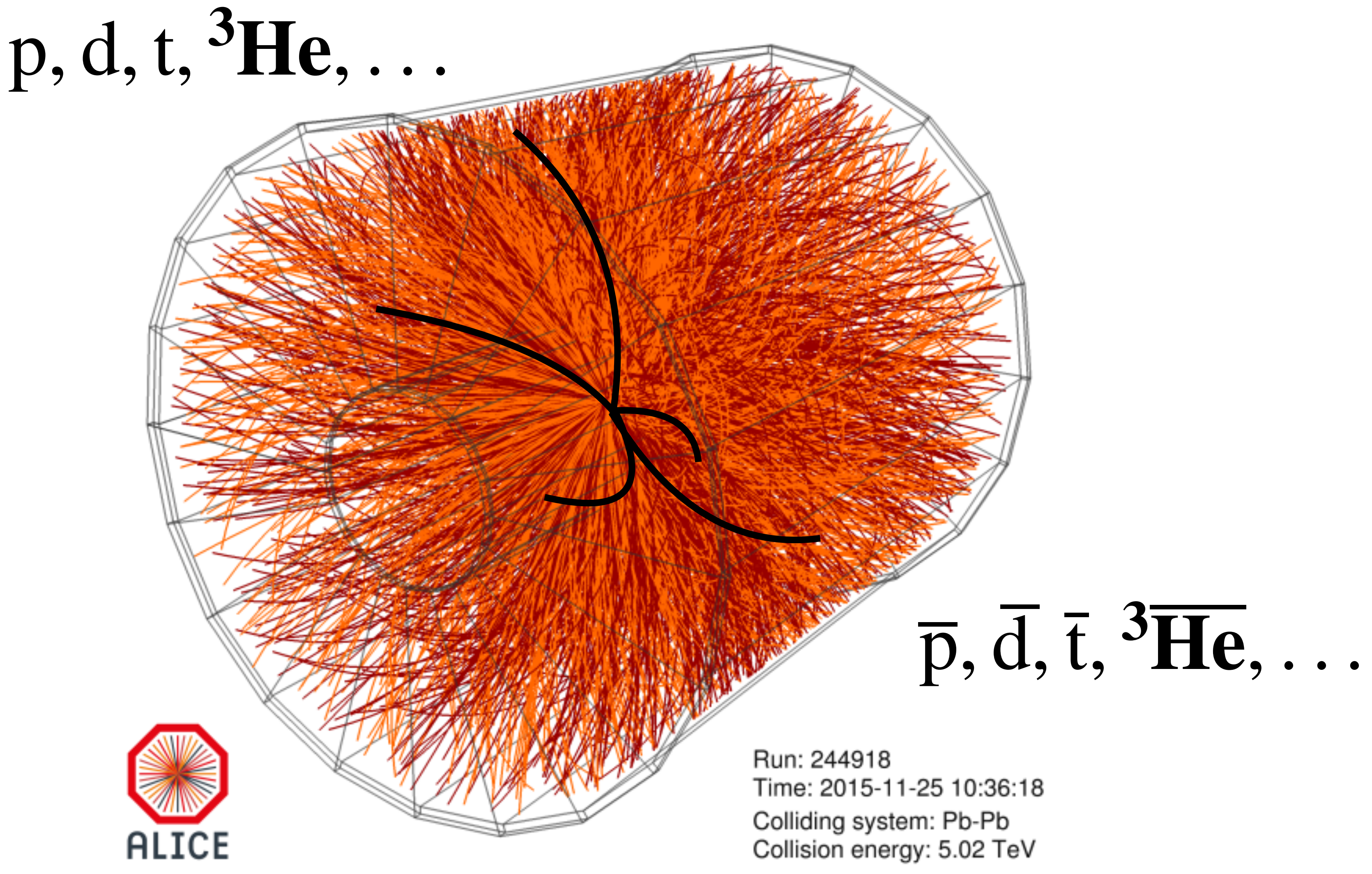


Figure by L. Šerkšnytė

- Cosmic ray antinuclei - unique Dark Matter probe
- Antinuclei flux currently being measured by satellite and balloon-borne experiments
- Inelastic processes during propagation of antinuclei in space → crucial to determine signal and background correctly
- **No data for $^{3}\overline{\mathrm{He}}$ inelastic cross section. It has never been measured!**

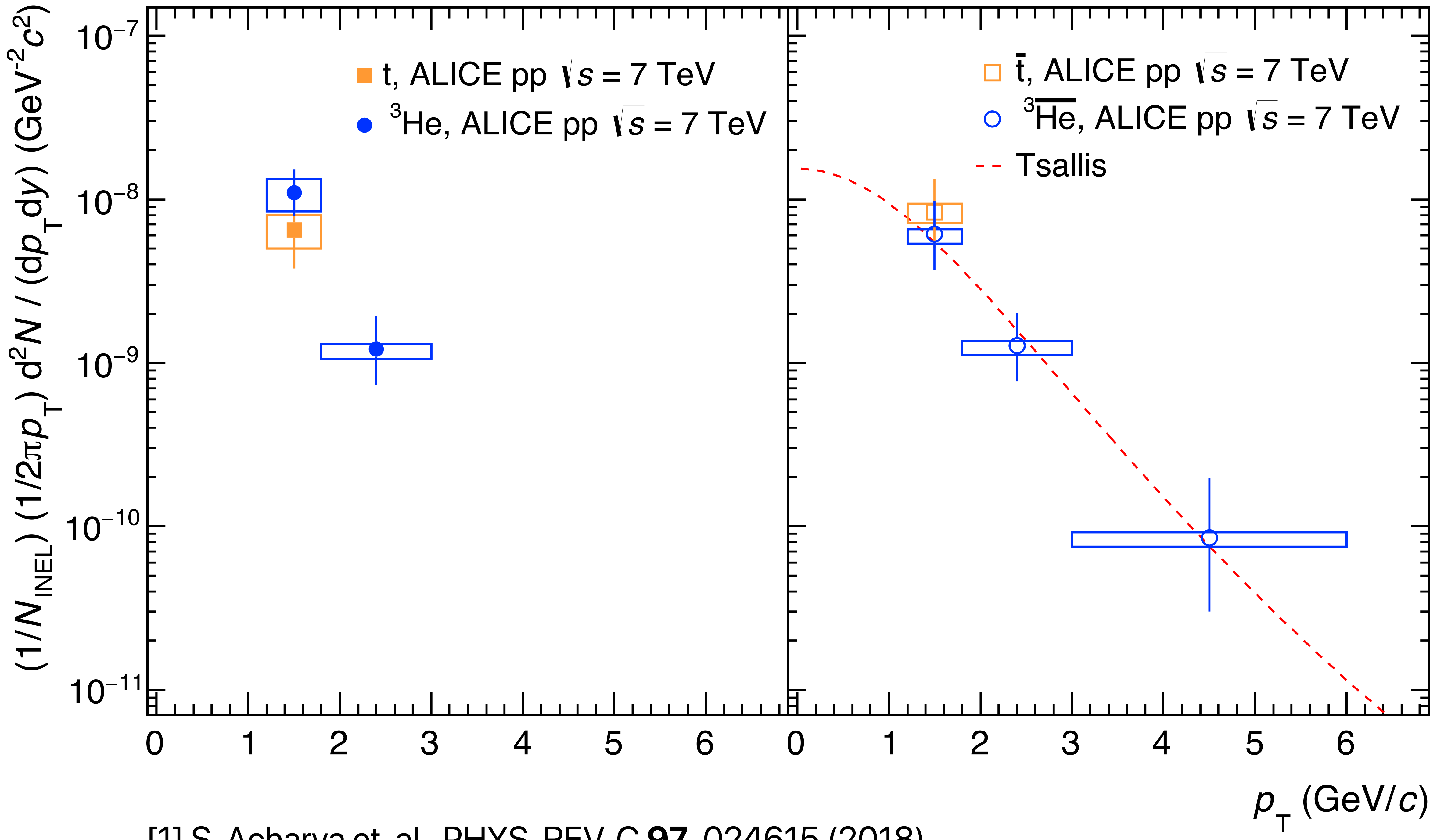
Antimatter production at the LHC





- High energy collisions at LHC = the most suitable environment to produce and study light (anti)nuclei
- At LHC energies matter and antimatter are produced in almost equal amounts → both $^{3}\mathrm{He}$ and $^{3}\overline{\mathrm{He}}$ are produced and propagate through detector material
- The (anti)nuclei get absorbed inside the detector → in ALICE we are in a unique position to quantify it!

Antimatter production at the LHC



[1] S. Acharya et. al., PHYS. REV. C **97**, 024615 (2018)

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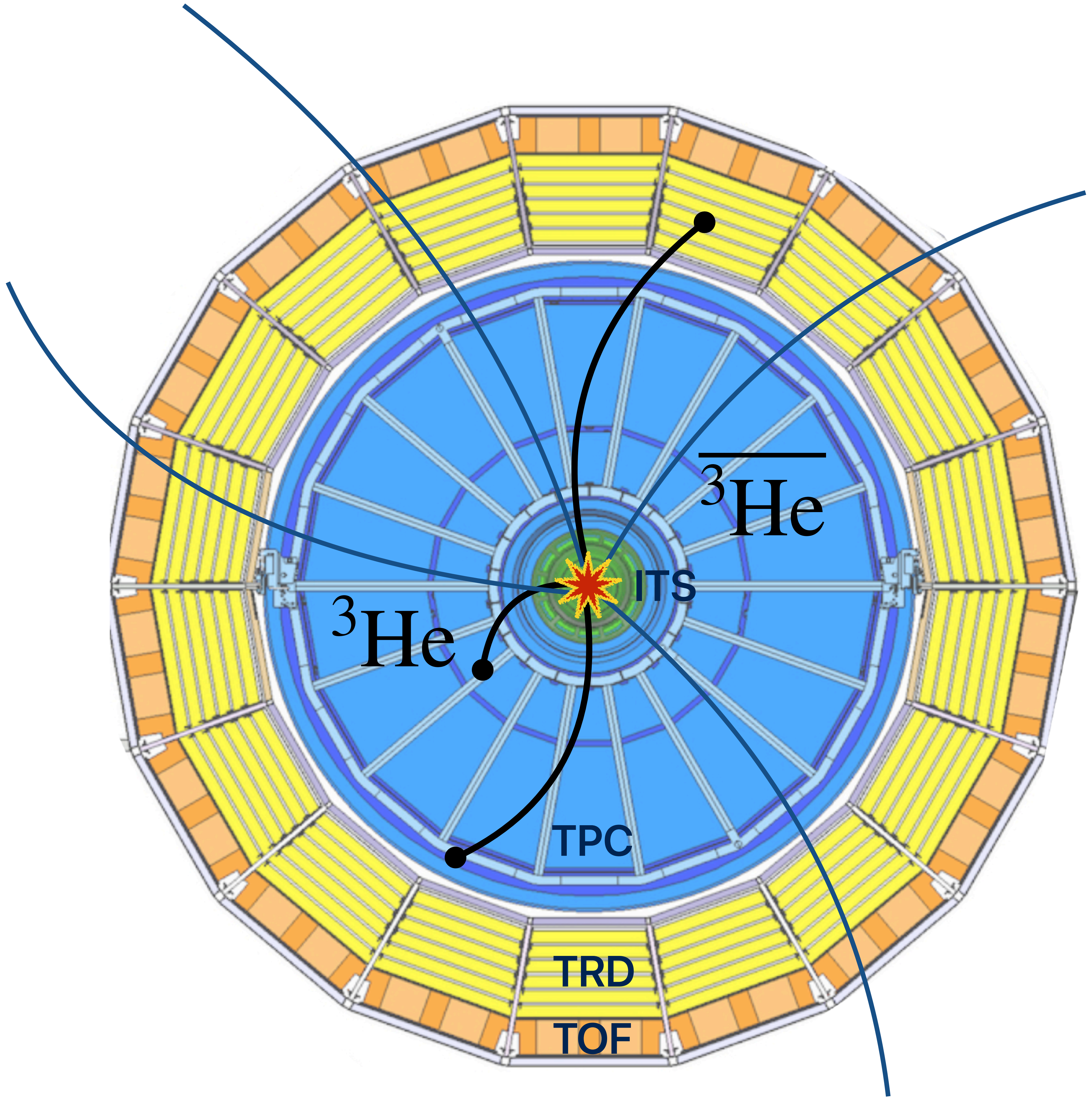
ALICE detector as a target



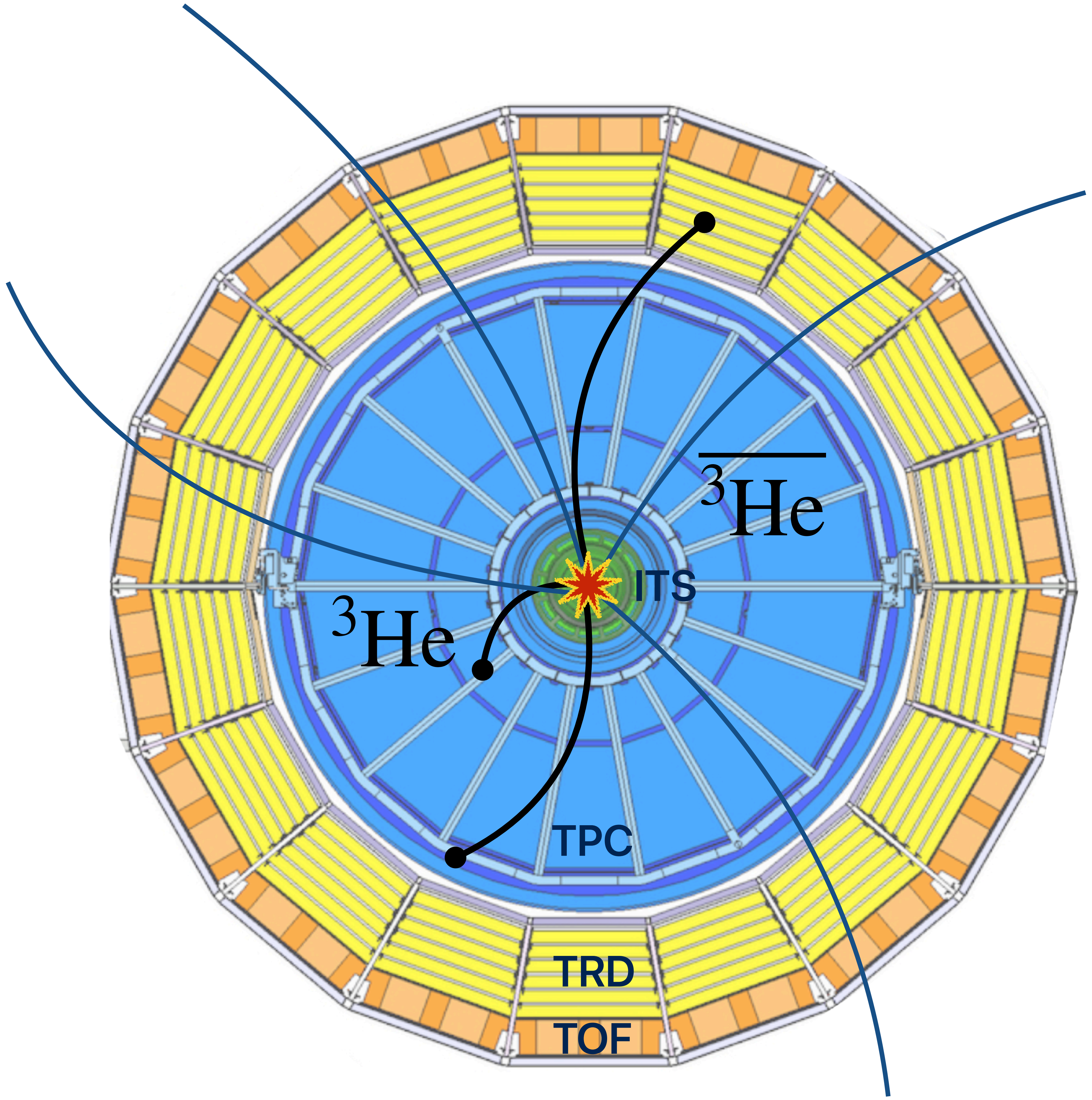
Absorption of produced (anti)matter inside the detector material:

- Beam pipe (~ 0.3% X_0)
- ITS (~ 8% X_0)
- TPC (~ 4% X_0)
- TRD (~ 25% X_0)
- Space frame (~ 20% X_0) between TPC and TOF detectors

Idea: use raw reconstructed antiparticle to particle ratios:

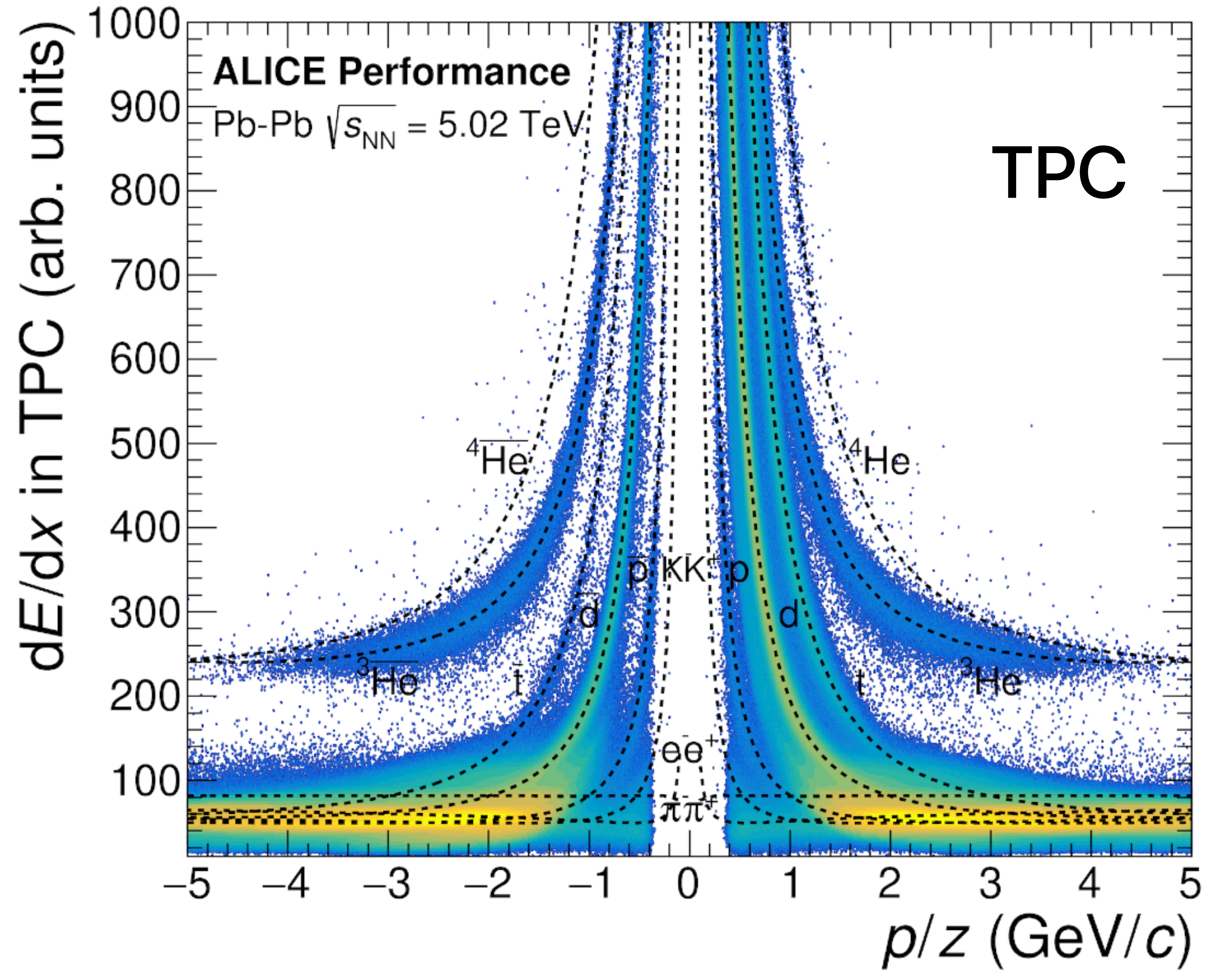
- No correction due to detection efficiency or absorption
- Correction for secondary (anti-)particles from weak decays or spallation processes
- Raw reconstructed $^{3}\overline{\mathrm{He}}/^{3}\mathrm{He}$ ratio is sensitive to $\sigma_{\mathrm{INEL}}(^{3}\overline{\mathrm{He}})$
- Constrain $\sigma_{\mathrm{INEL}}(^{3}\overline{\mathrm{He}})$ via comparison with dedicated MC simulation (Geant4)

ALICE detector as a target



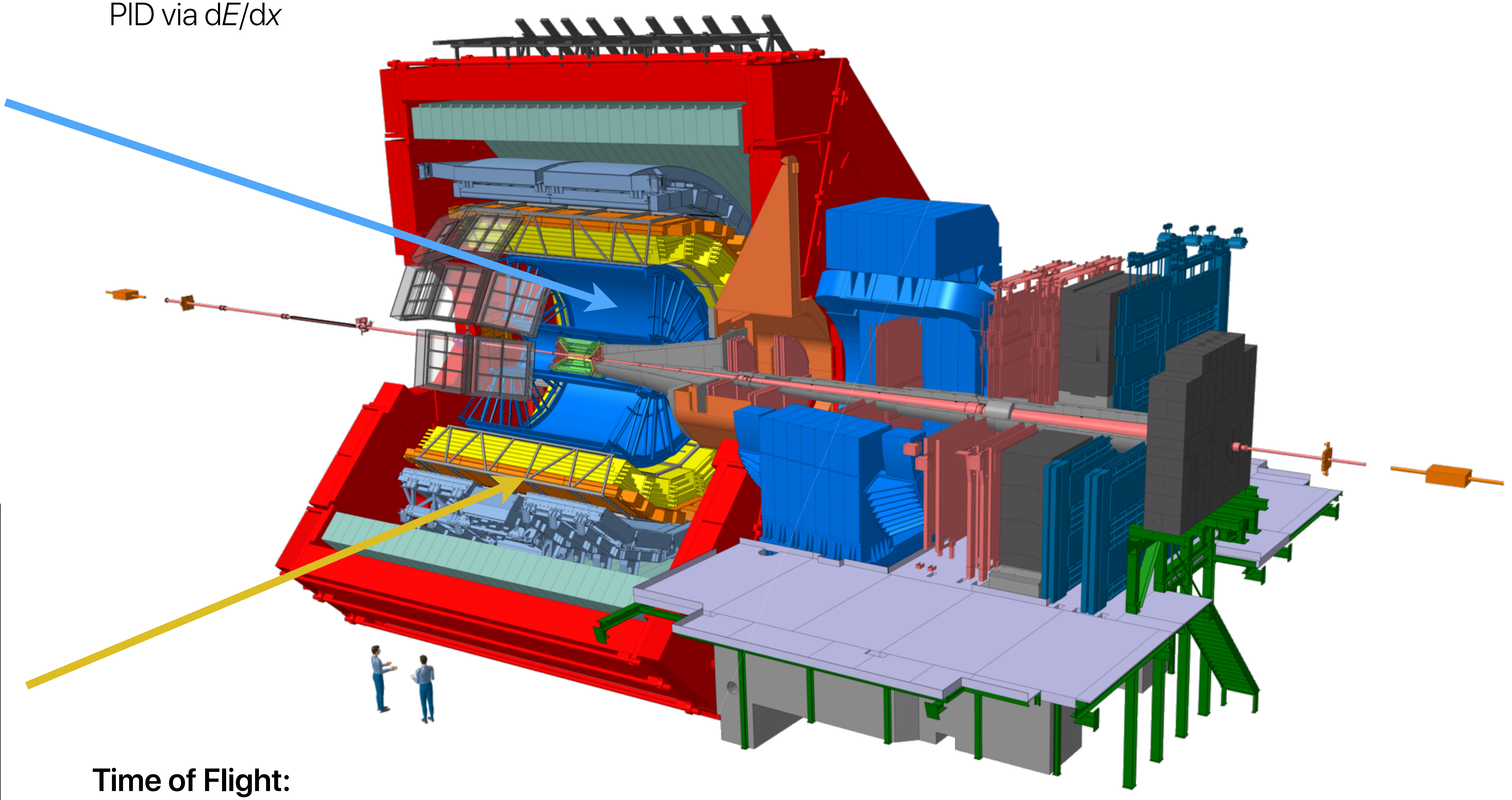
- ALICE has successfully measured low-energy $\sigma_{\mathrm{INEL}}(\bar{\mathrm{d}})$: arXiv:2005.11122
- This talk → measurement of $\sigma_{\mathrm{INEL}}(^{3}\overline{\mathrm{He}})$ in high multiplicity pp collisions at 13 TeV with ALICE

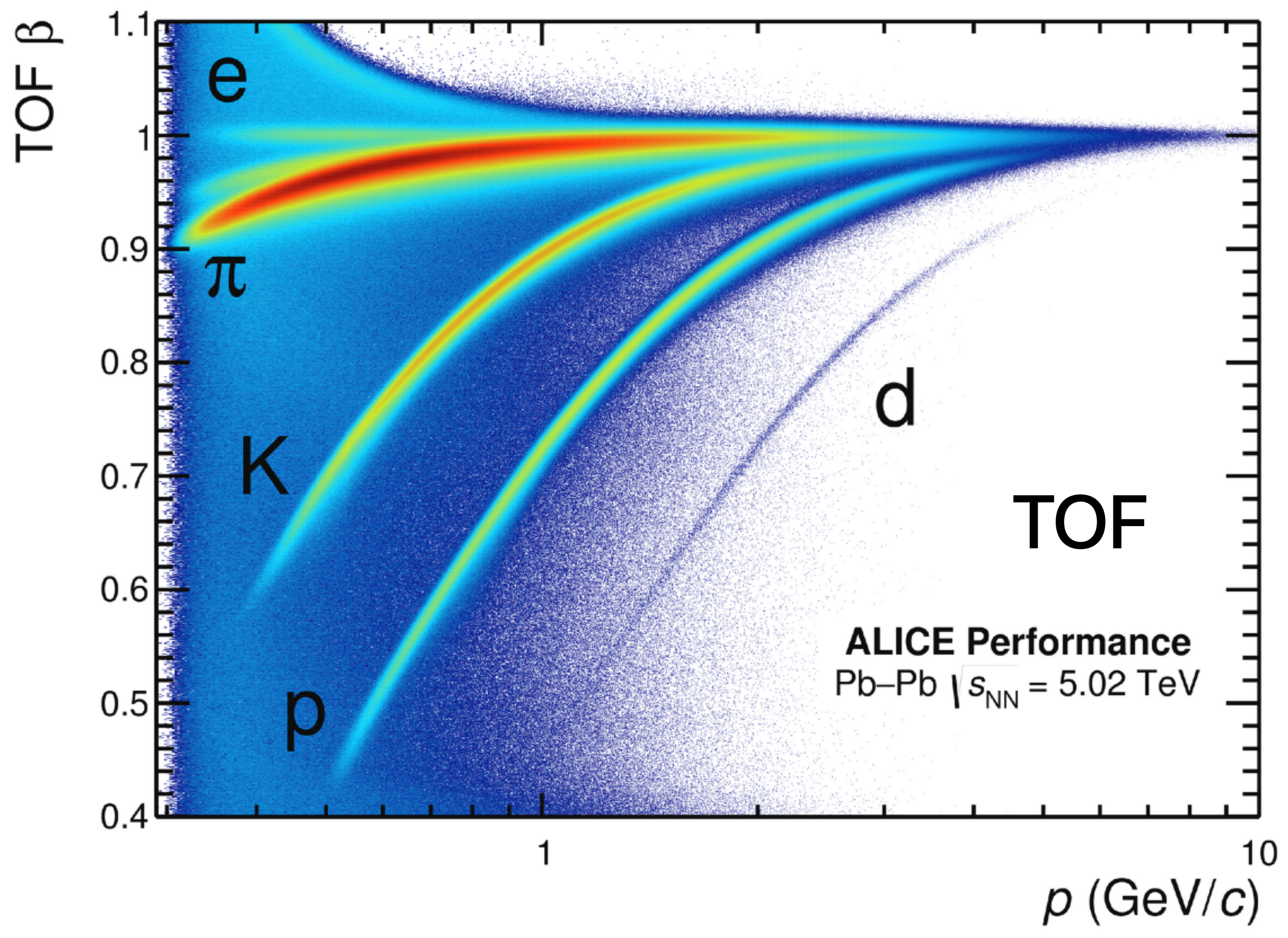
Detectors used in the analysis



ALI-PERF-341664

Time Projection Chamber:
PID via dE/dx

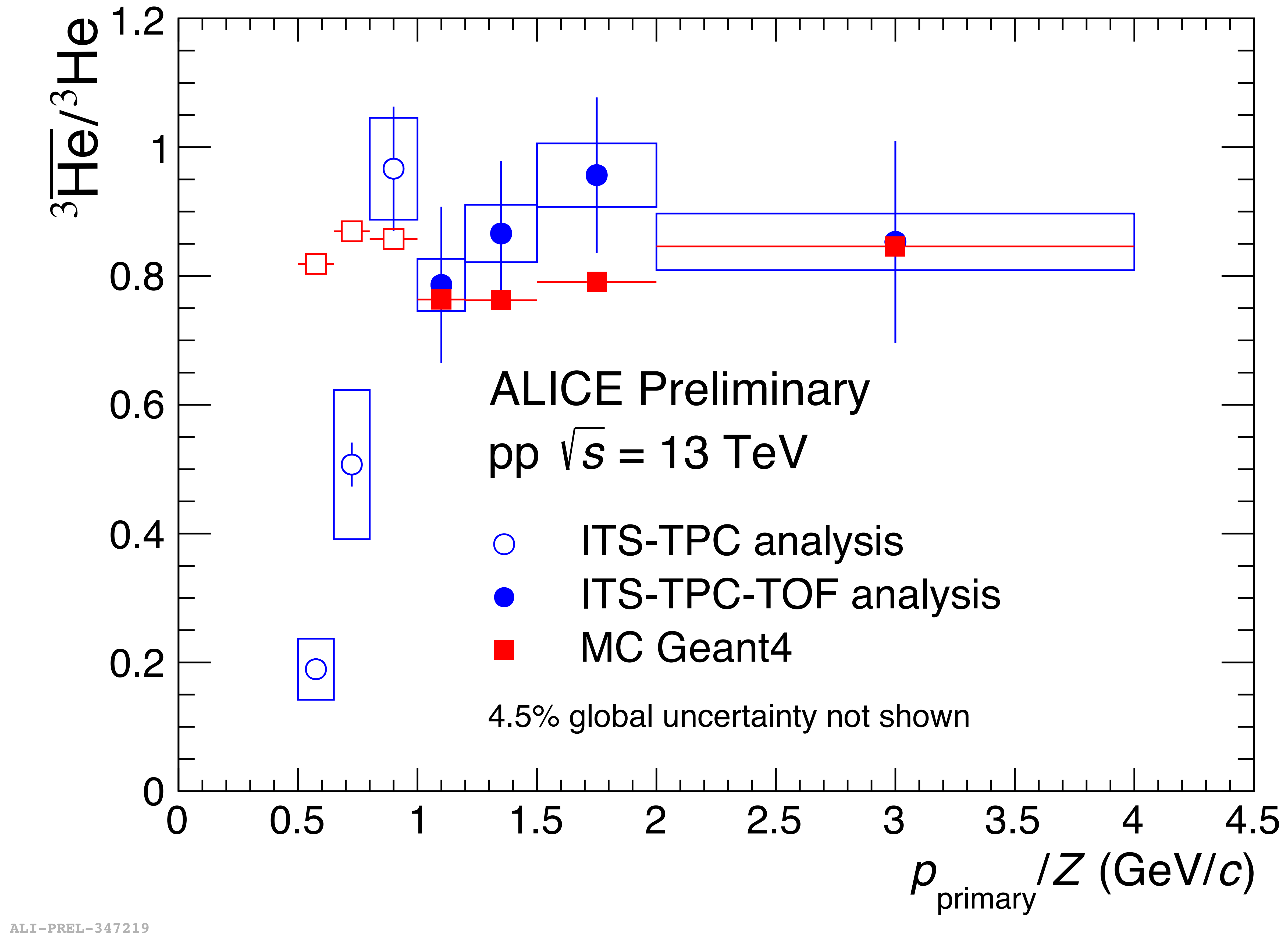




ALI-PERF-106336

Time of Flight:
PID via time-of-flight measurement

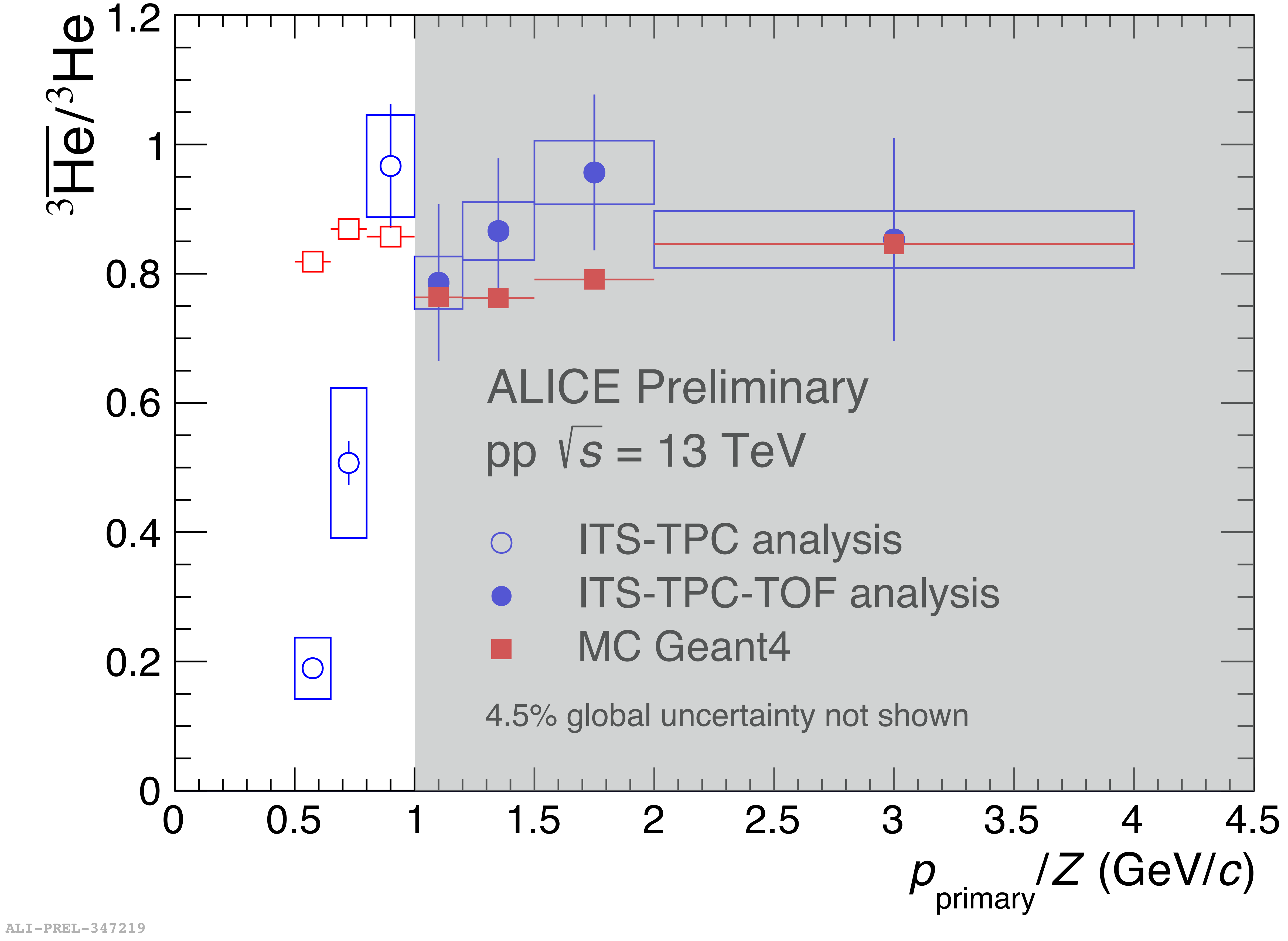
Raw primordial $^{3}\overline{\mathrm{He}}/^{3}\mathrm{He}$ ratio



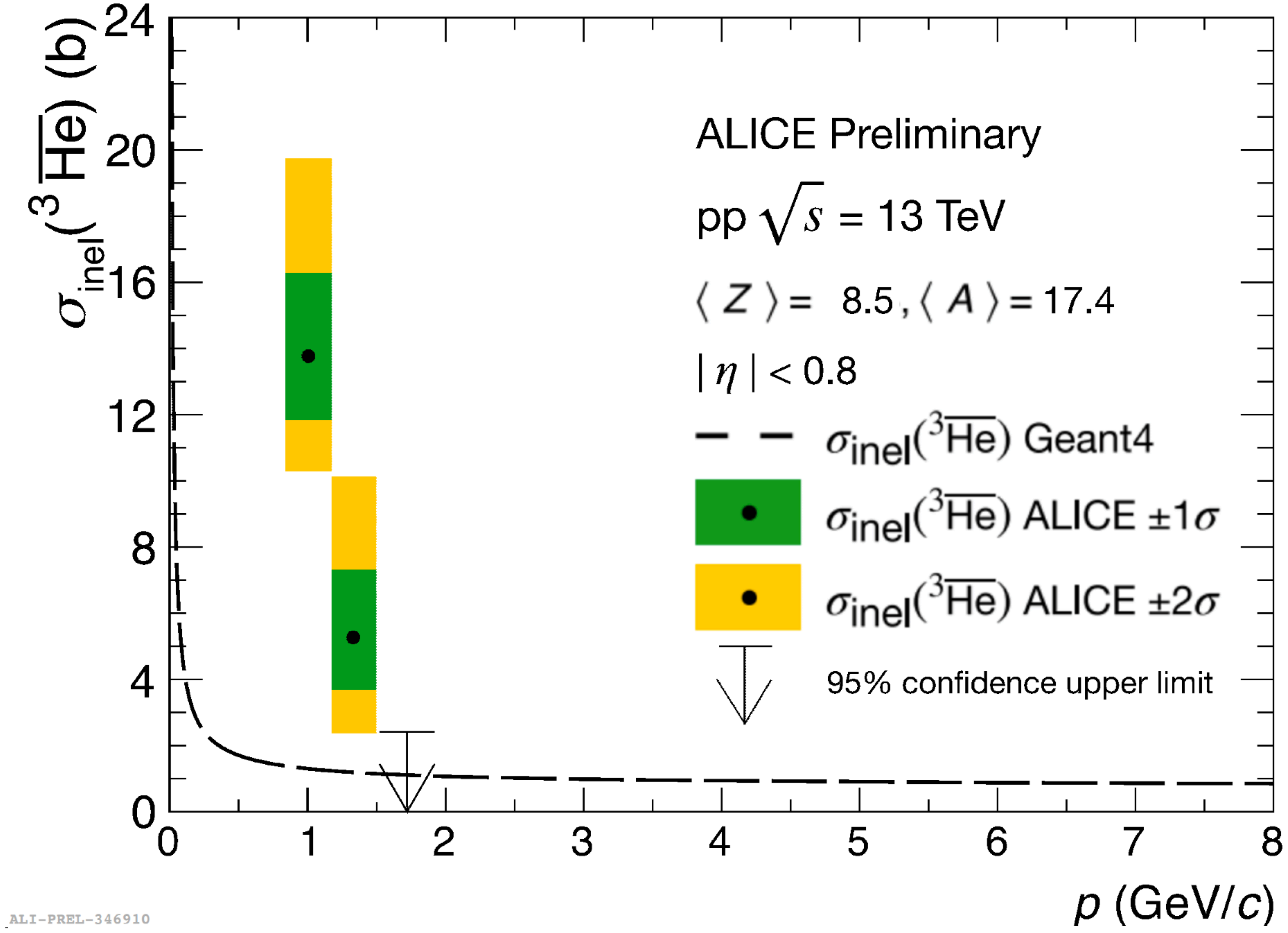
- Raw primordial $^{3}\overline{\mathrm{He}}/^{3}\mathrm{He}$ ratio: larger absorption of antiparticles, especially at low momentum
- Dedicated Monte Carlo simulation with varied hadronic inelastic cross-section of $^{3}\overline{\mathrm{He}}$: ± 50% w.r.t. the default in Geant4
- Vary the $\sigma_{\mathrm{INEL}}(^{3}\overline{\mathrm{He}})$ in Monte Carlo to reach the $\pm 1\sigma^{*}$ and $\pm 2\sigma$ experimental limits in data
- The variation corresponds to $\pm 1\sigma$ and $\pm 2\sigma$ constraints on the $^{3}\overline{\mathrm{He}}$ inelastic cross section

*σ includes statistical, systematic and global uncertainties

Results: $^{3}\overline{\text{He}}$ inelastic cross-section

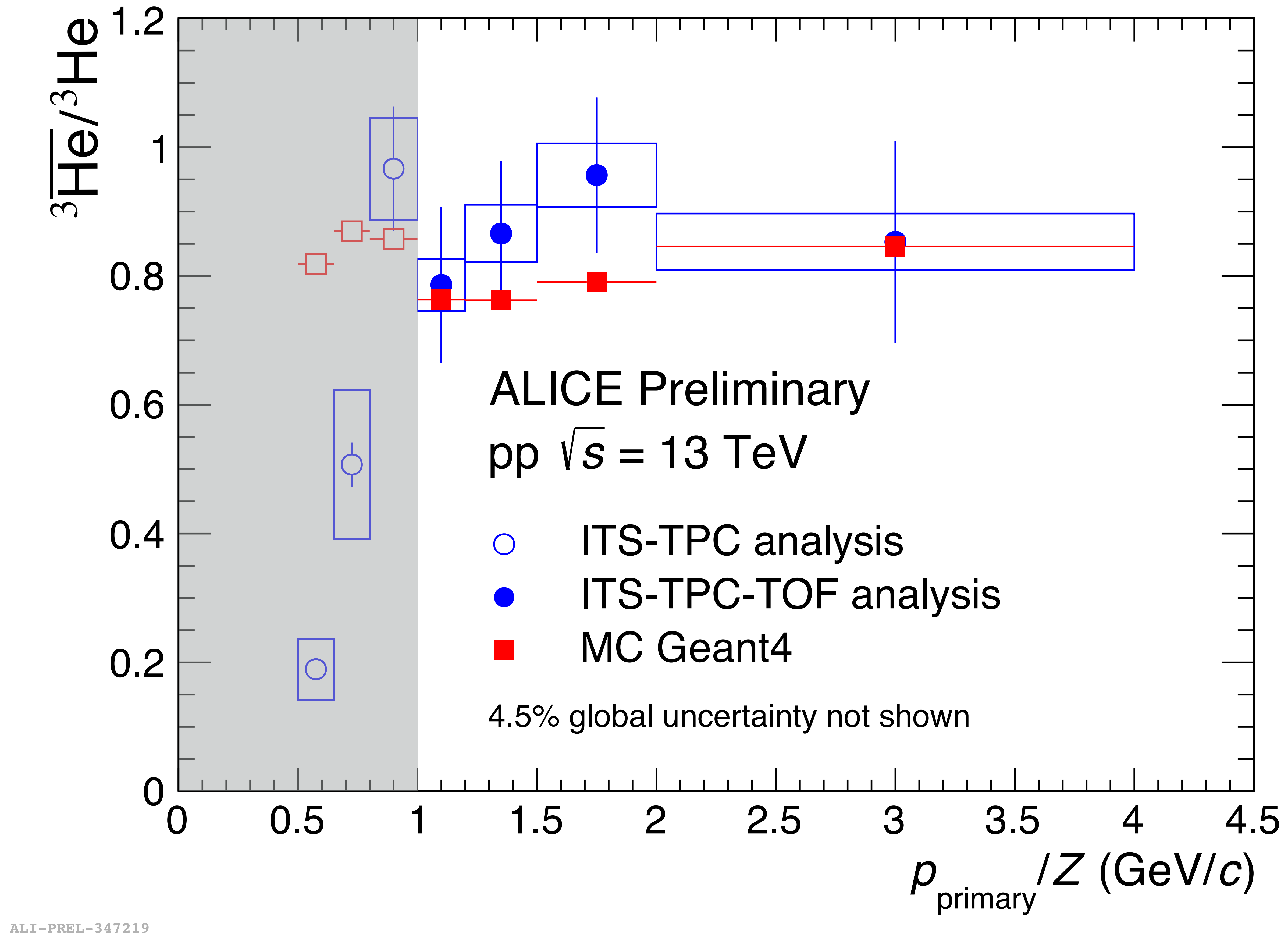


ITS-TPC

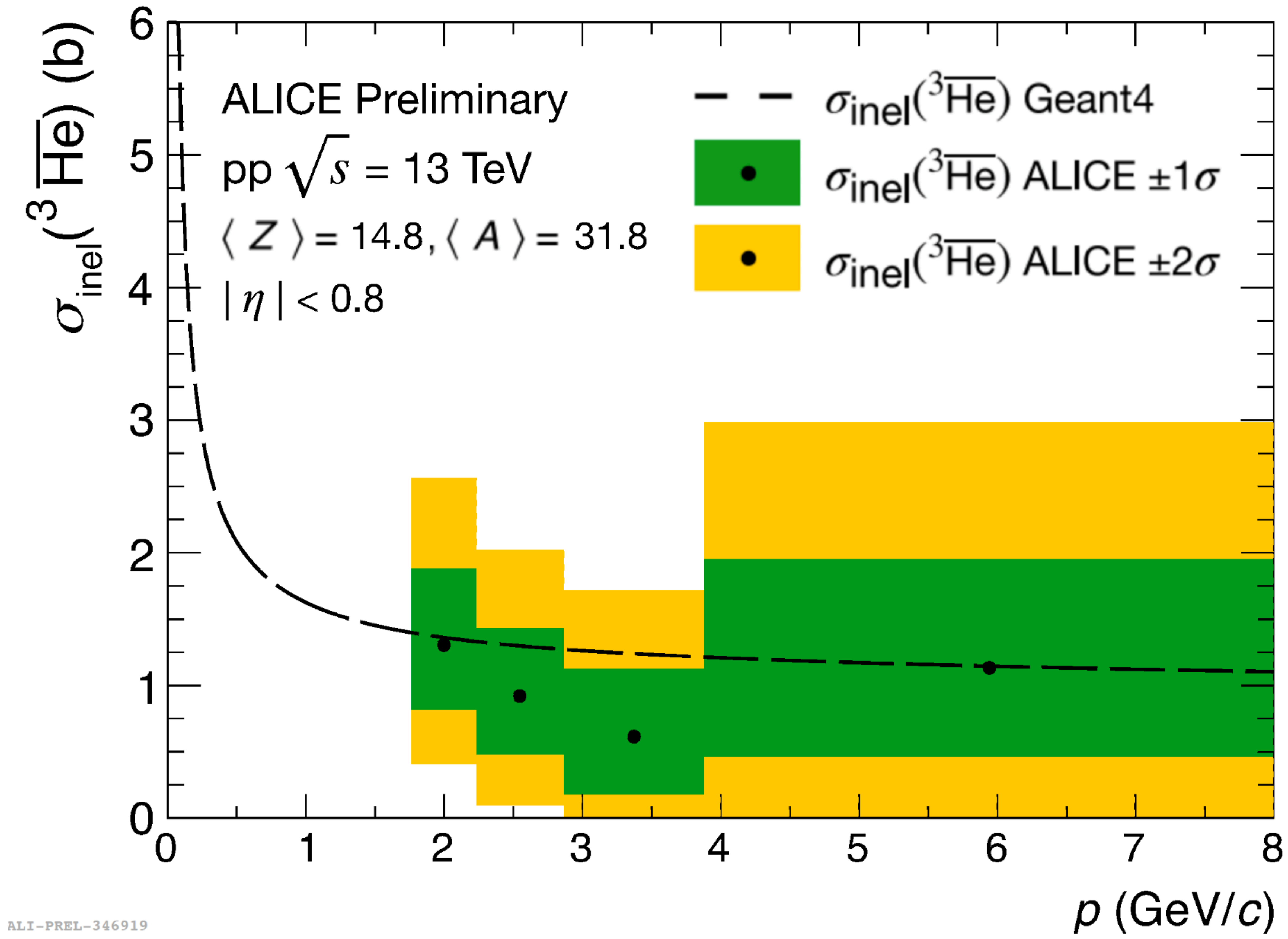


$\sigma_{\text{INEL}}(^{3}\overline{\text{He}})$ at low momentum: steeper rise with respect to Geant4

Results: $^{3}\overline{\mathrm{He}}$ inelastic cross-section



ITS-TPC-TOF



$\sigma_{\mathrm{INEL}}(^{3}\overline{\mathrm{He}})$ at high momentum: good agreement with Geant4

Summary and outlook

- **First measurement of $^{3}\overline{\mathrm{He}}$ inelastic cross-section** using raw primordial antiparticle to particle ratio
- Dedicated Monte Carlo simulations to extract the constrains on $\sigma_{\mathrm{INEL}}(^{3}\overline{\mathrm{He}})$
- $\sigma_{\mathrm{INEL}}(^{3}\overline{\mathrm{He}})$ shows steeper rise towards lower momentum w.r.t Geant4 and good agreement at momenta > 1.5 GeV/*c*
- Crucial input for the propagation of antinuclei in space and eventual determination of mean free path of $^{3}\overline{\mathrm{He}}$ - how far can we observe the antinuclei candidates in the Universe?

Thank you for your attention!