Cosmic-ray isotope measurements with HELIX

Presented by Nahee Park

for HELIX Collaboration

HELIX Collaboration

University of Chicago

- Lucas Beaufore, Rostom Mbarek, Dietrich Muller, Ethan Schreyer, Scott P. Wakely, Tyler Werner, Ian Wisher

Chiba University

- Makoto Tabata

Indiana University

- Mark Gebhard, Brandon Kunkler, James Musser, Kelli Michaels, Gerard Visser

McGill University

- Emma Ellingwood, David Hanna, Stephane O'Brien, Thomas Rosin

Northern Kentucky University

- Scott Nutter

Ohio State University

- Patrick Allison, James J. Beatty, Keith McBride

Pennsylvania State University

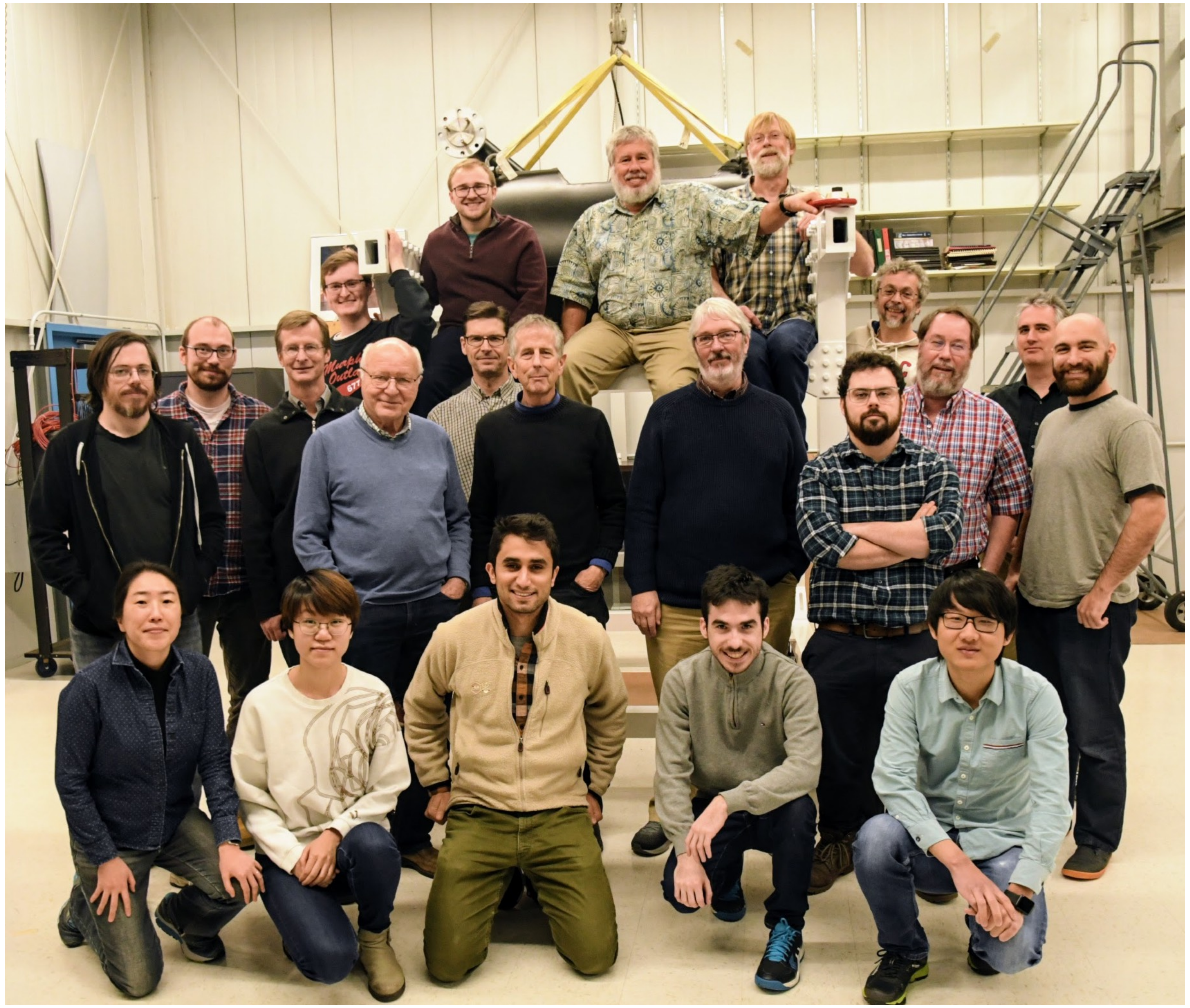
- Yu Chen, Stephane Coutu, Issac Mognet, Monong Yu

University of Michigan

- Noah Green, Gergory Tarle, Andrew Tomasch

University of Wisconsin-Madison

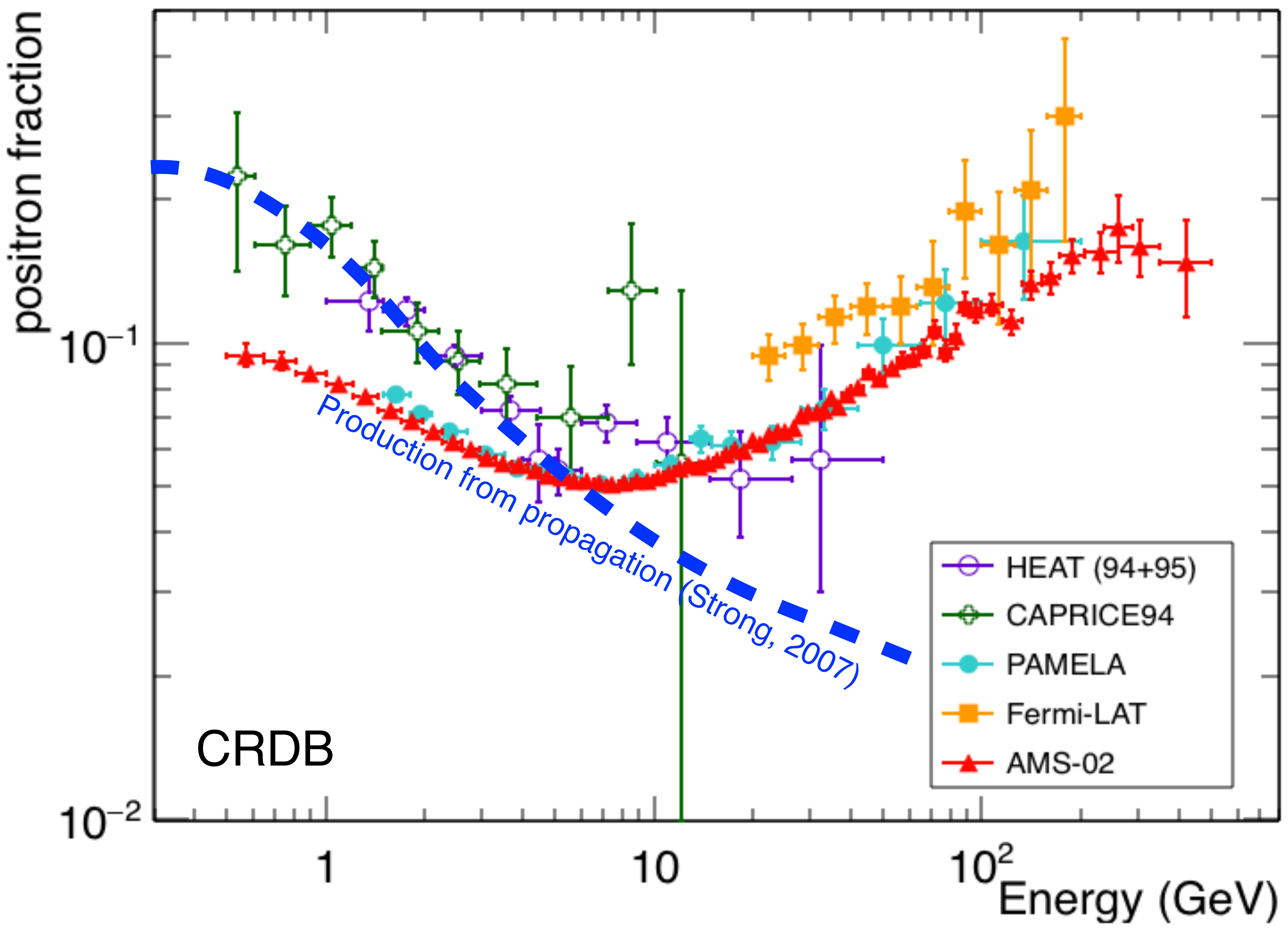
- Nahee Park

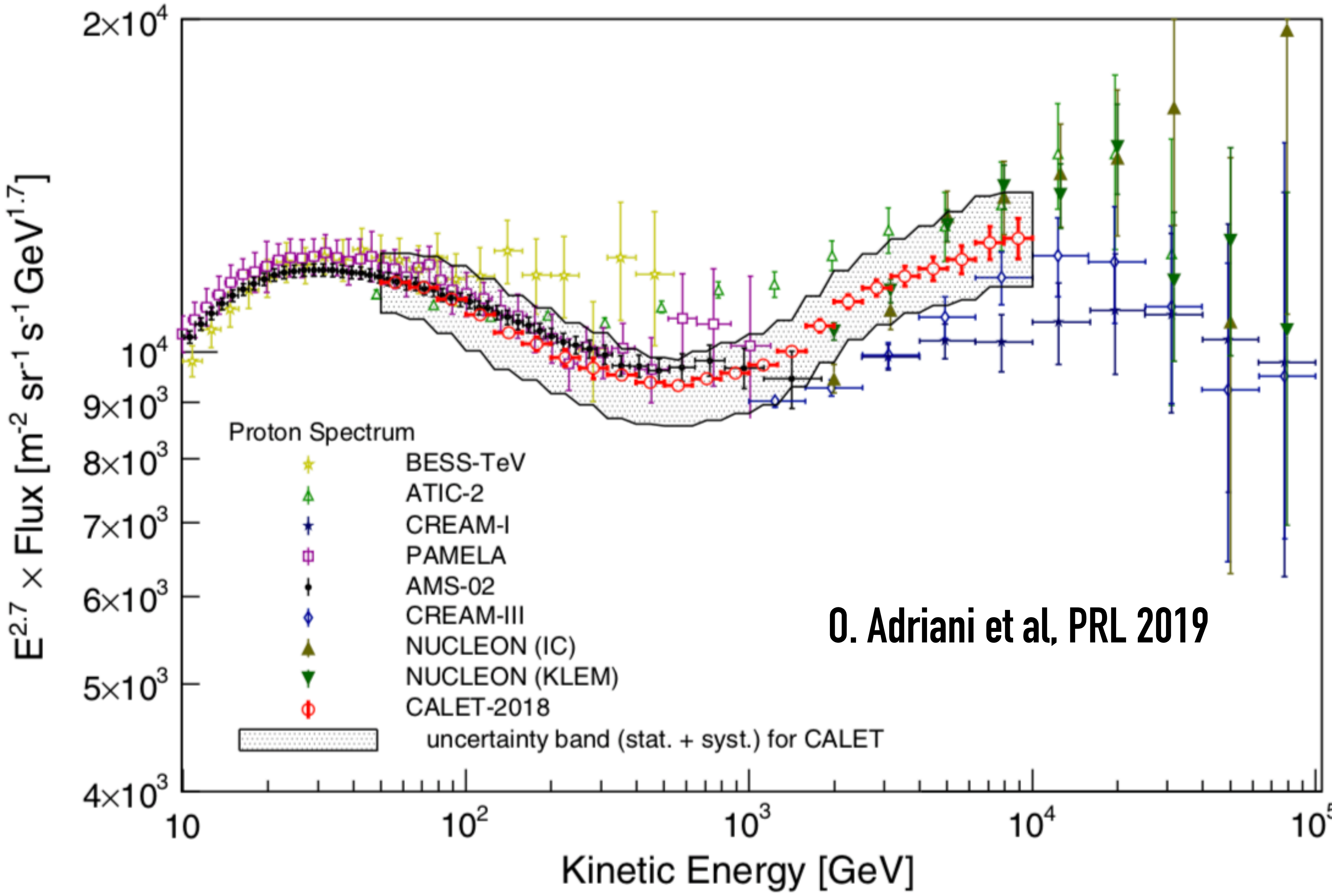


Recent Updates from Direct Measurement

A new era of precision space-based measurements has brought some real surprises

- Rising positron fraction
- Potentially rising anti-proton fraction
- Hardening at ~ 300 GV in the spectra of H, He, Li, C, O, …
- Different spectral index between proton and helium





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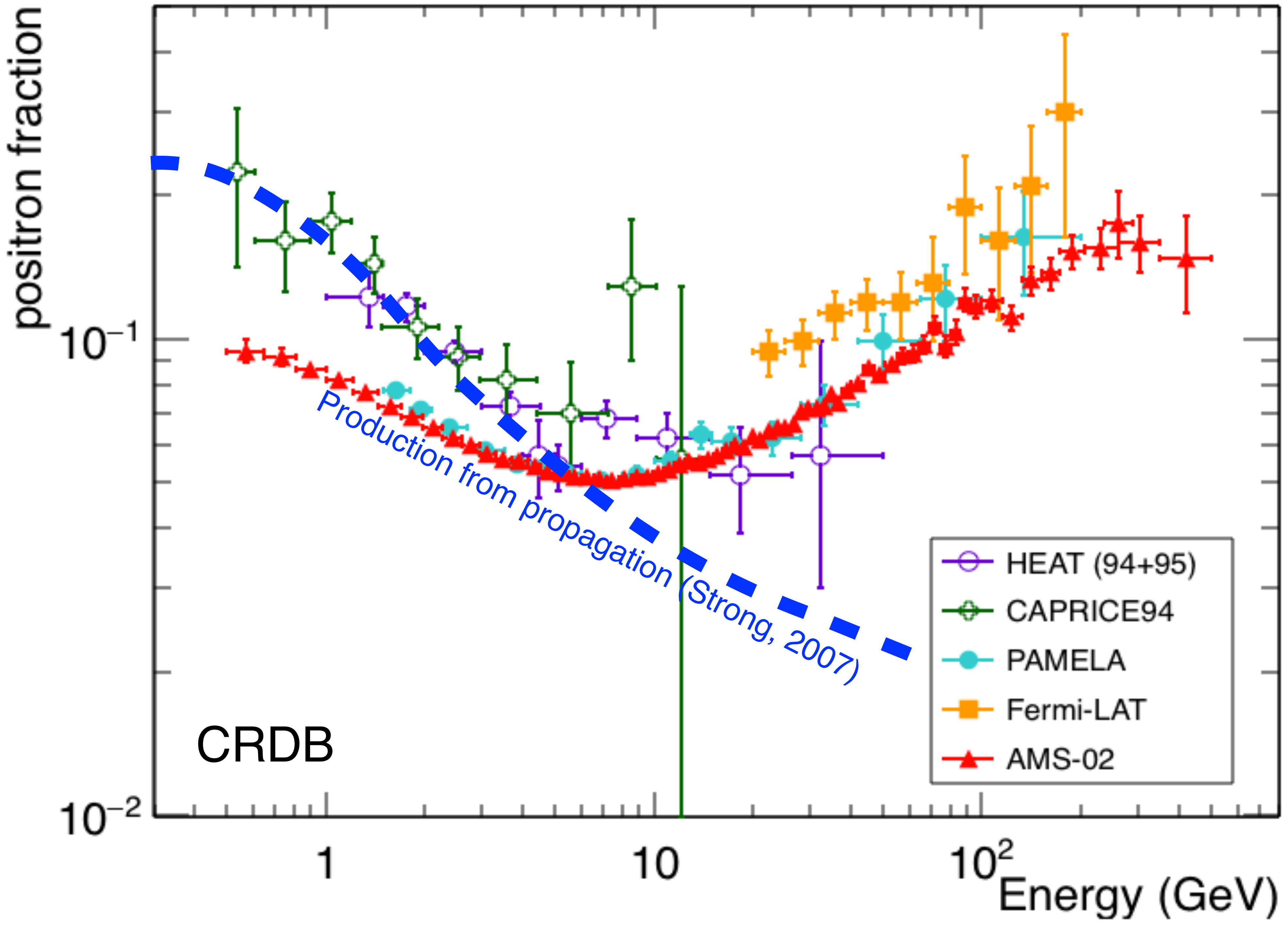
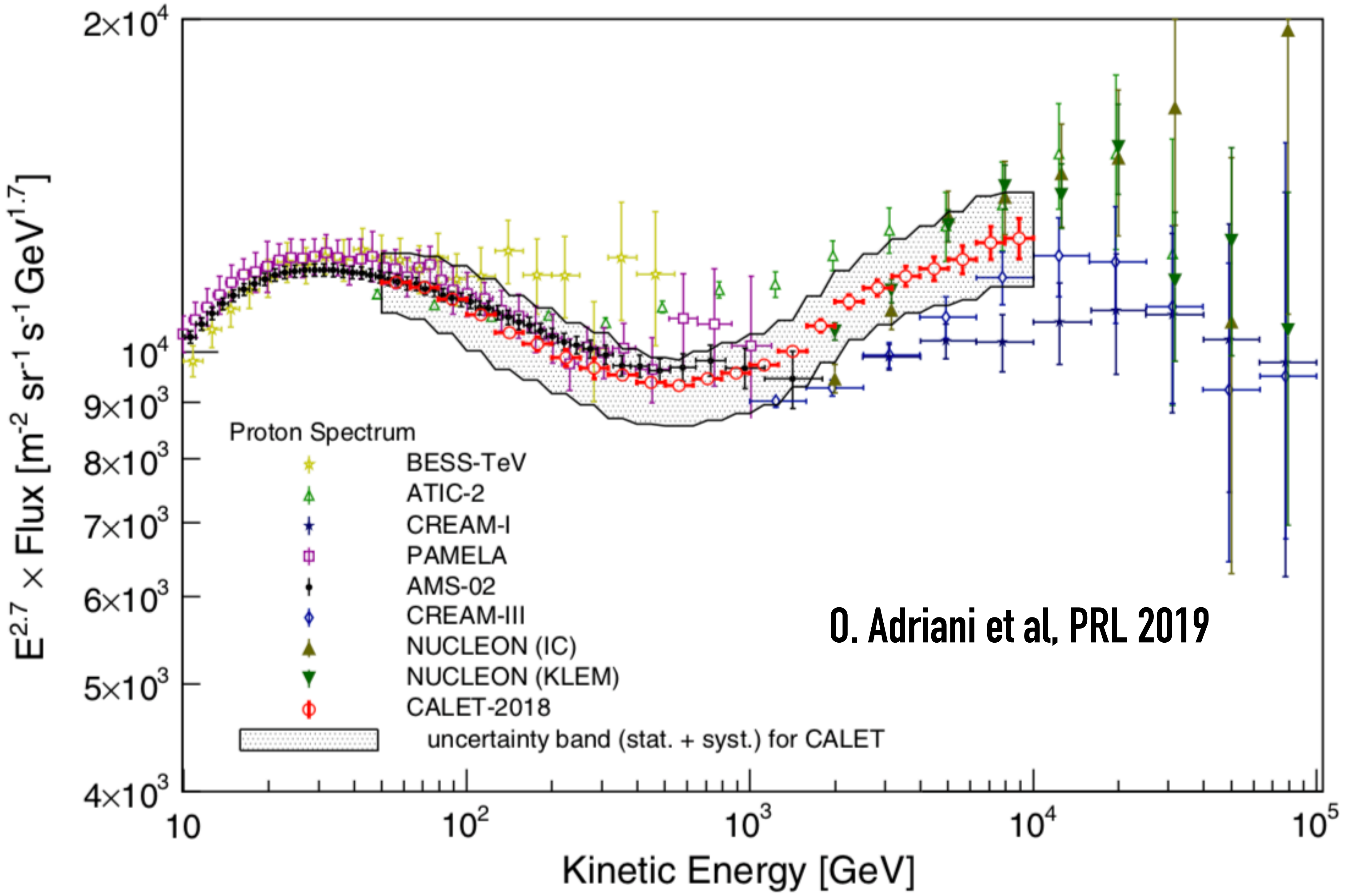


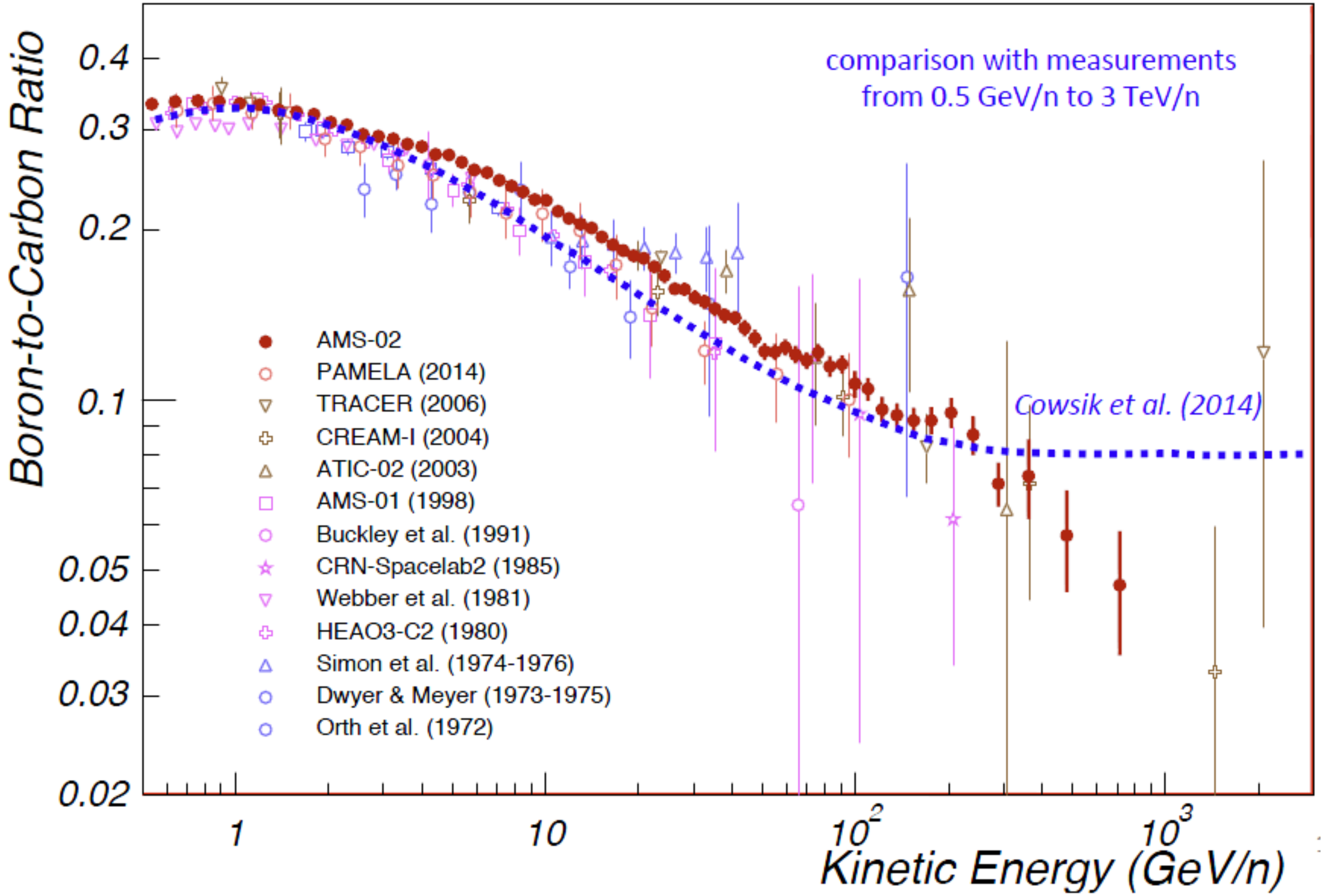


→ It is critical to understand the propagation!

Secondary-to-Primary ratio

Best measured observable to study the propagation:Secondary-to-primary ratio (e.g. B/C)

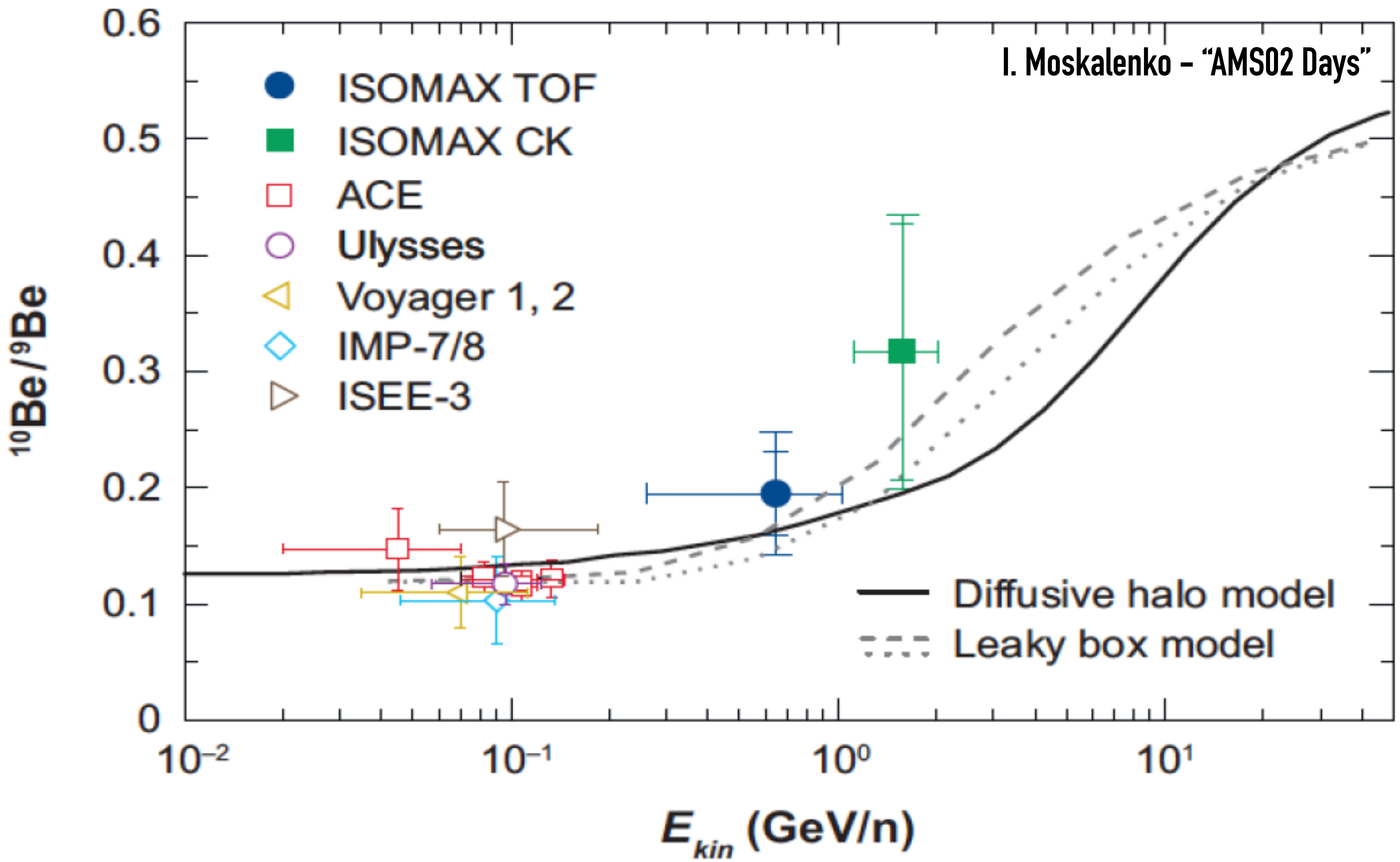
- Sensitive to the amount of matter traversed by the CRs
  → Degeneracy between average amount of matter traversed and average life time



Propagation Clock Isotope, ^{10}Be

^{10}Be : Unstable isotope w/ known half life of 1.5×10^6 yr

- ^{10}Be/^{9}Be ratio provides strong constraints for the propagation models
- Good model discriminating power around 3 GeV/nuc
- Challenging measurements
  - ☆ Several good measurements at a few hundred MeV/nuc. Above this, the ISOMAX balloon payload covers up to ~2 GeV/nuc



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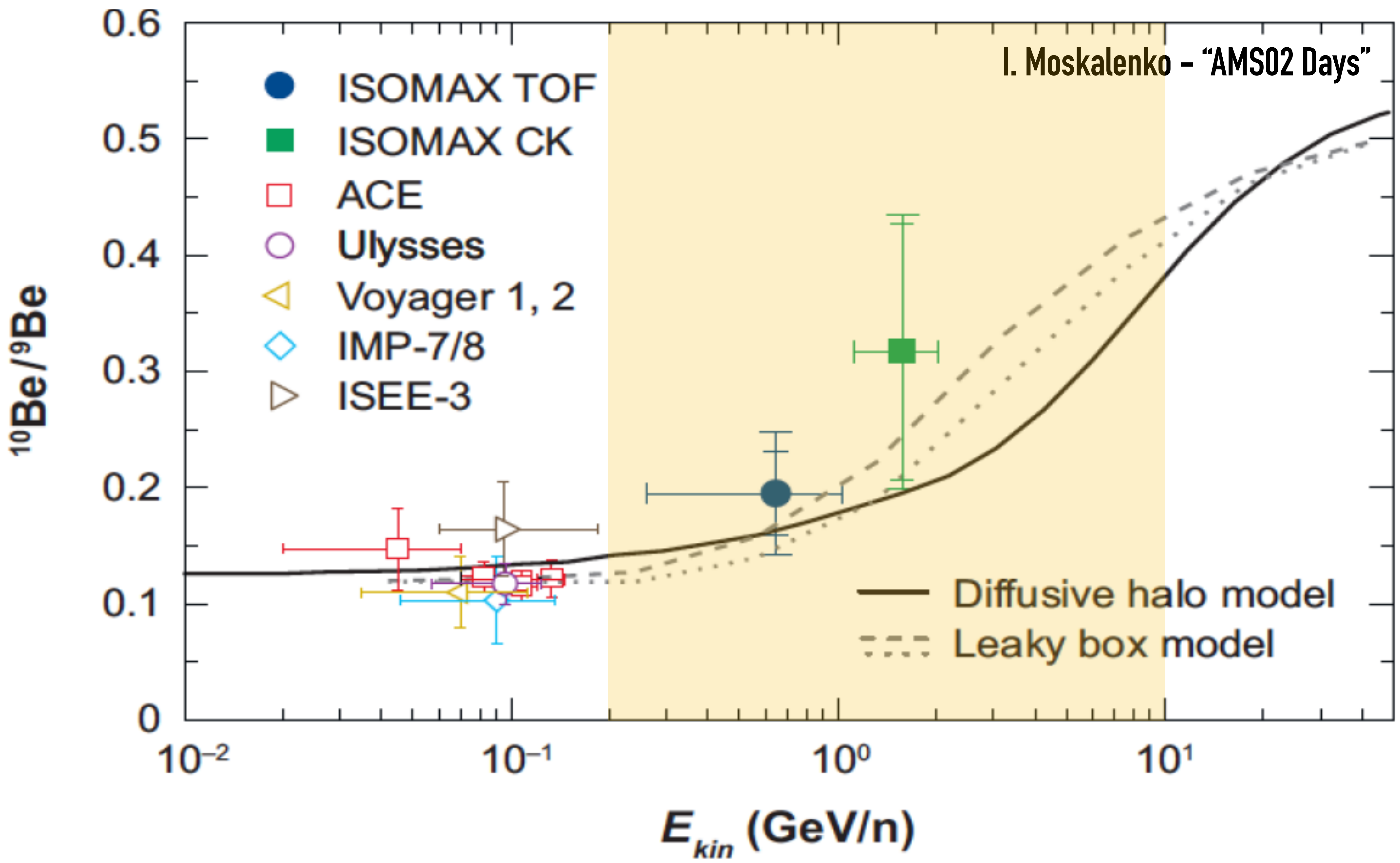
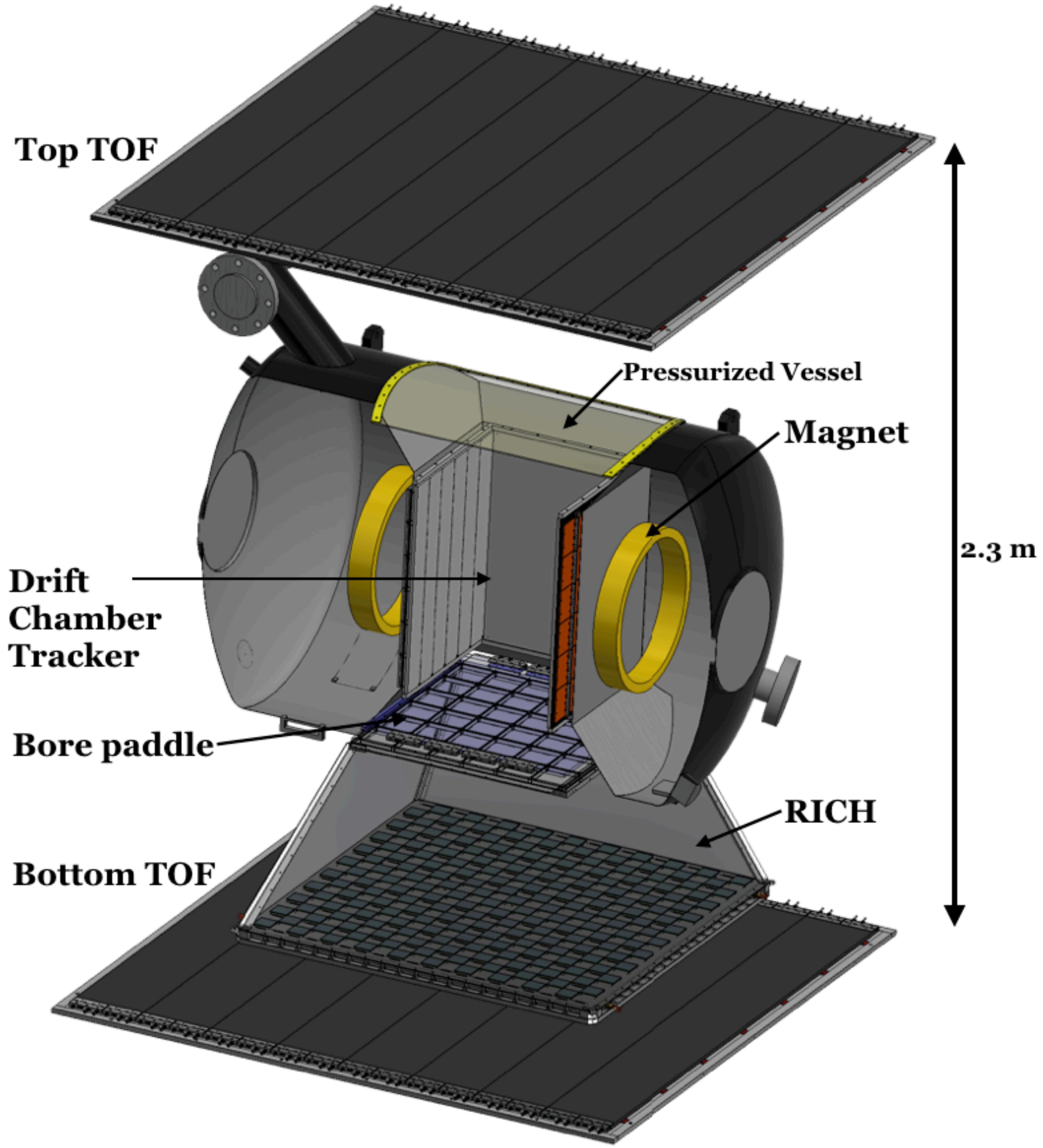


High Energy Light Isotope eXperiment

A new magnet spectrometer payload to measure $^{10}Be/^{9}Be$ isotope ratio up to 10 GeV/n

$$m = Ze\ R\ \frac{\sqrt{1-\beta^2}}{\beta}$$

- Two stage approach to cover wider range of energy
- Stage 1 : covers up to ~ 3 GeV/nuc, designed to have a flight in Antarctica with a long duration balloon in 2020



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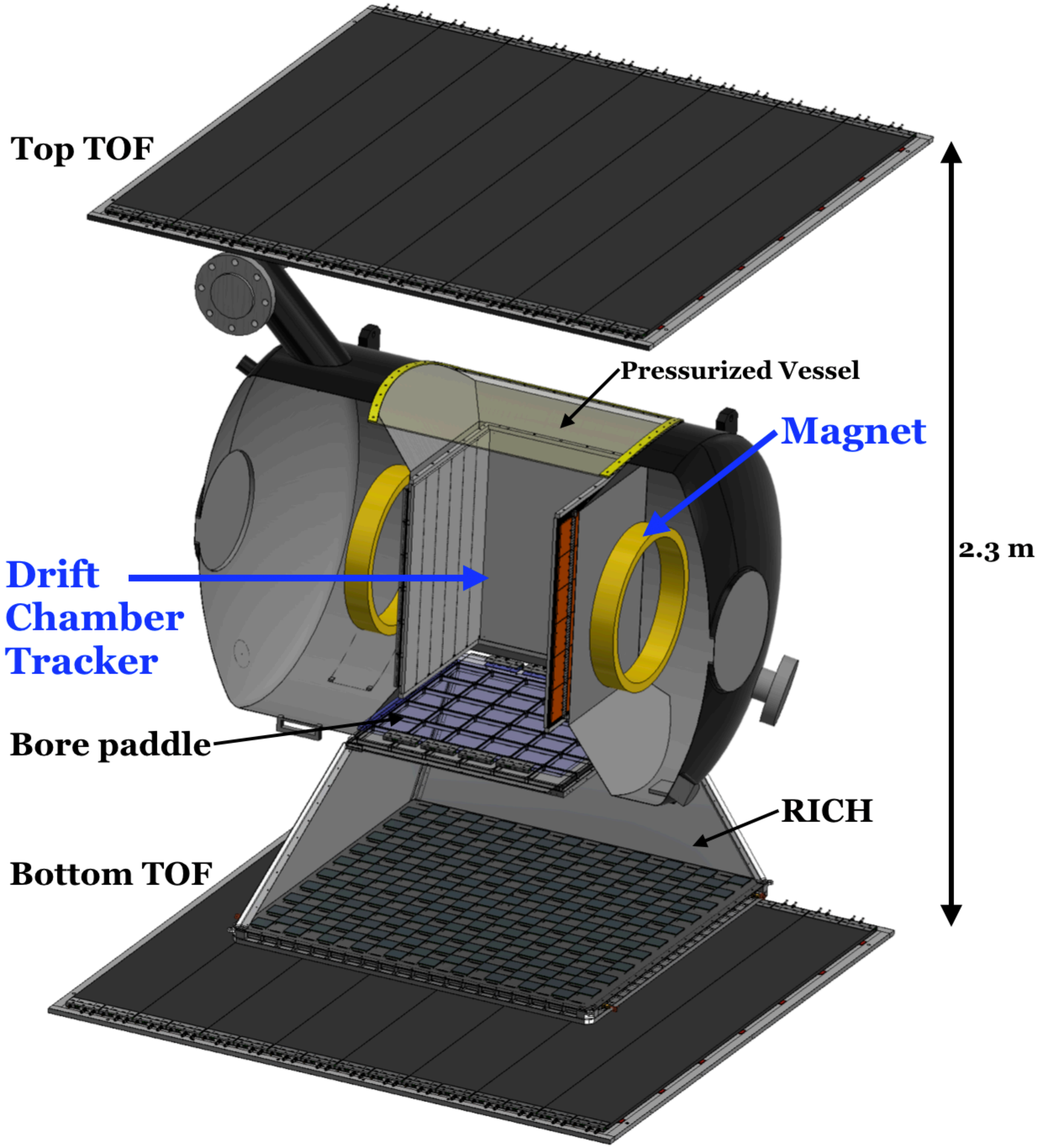

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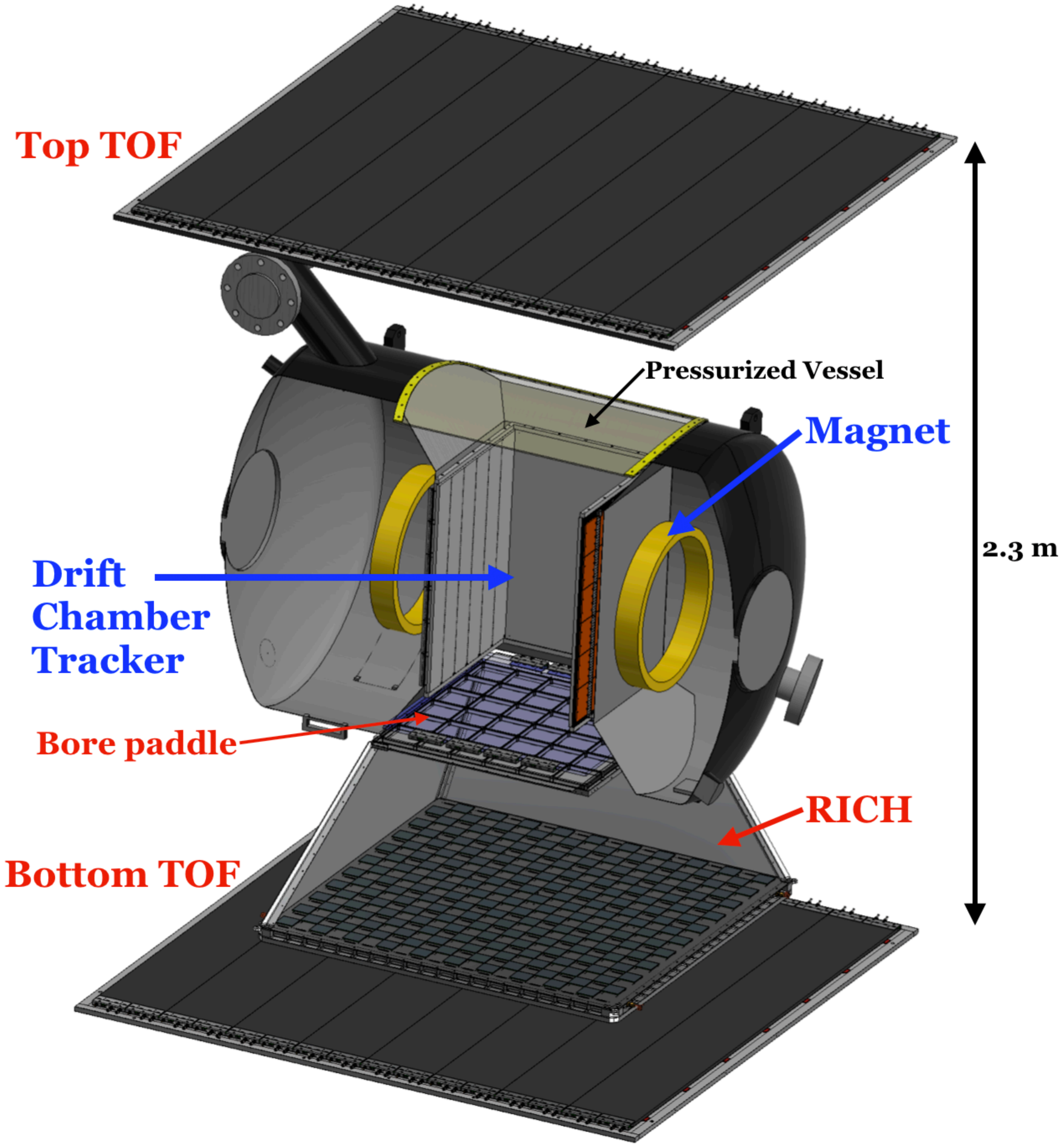

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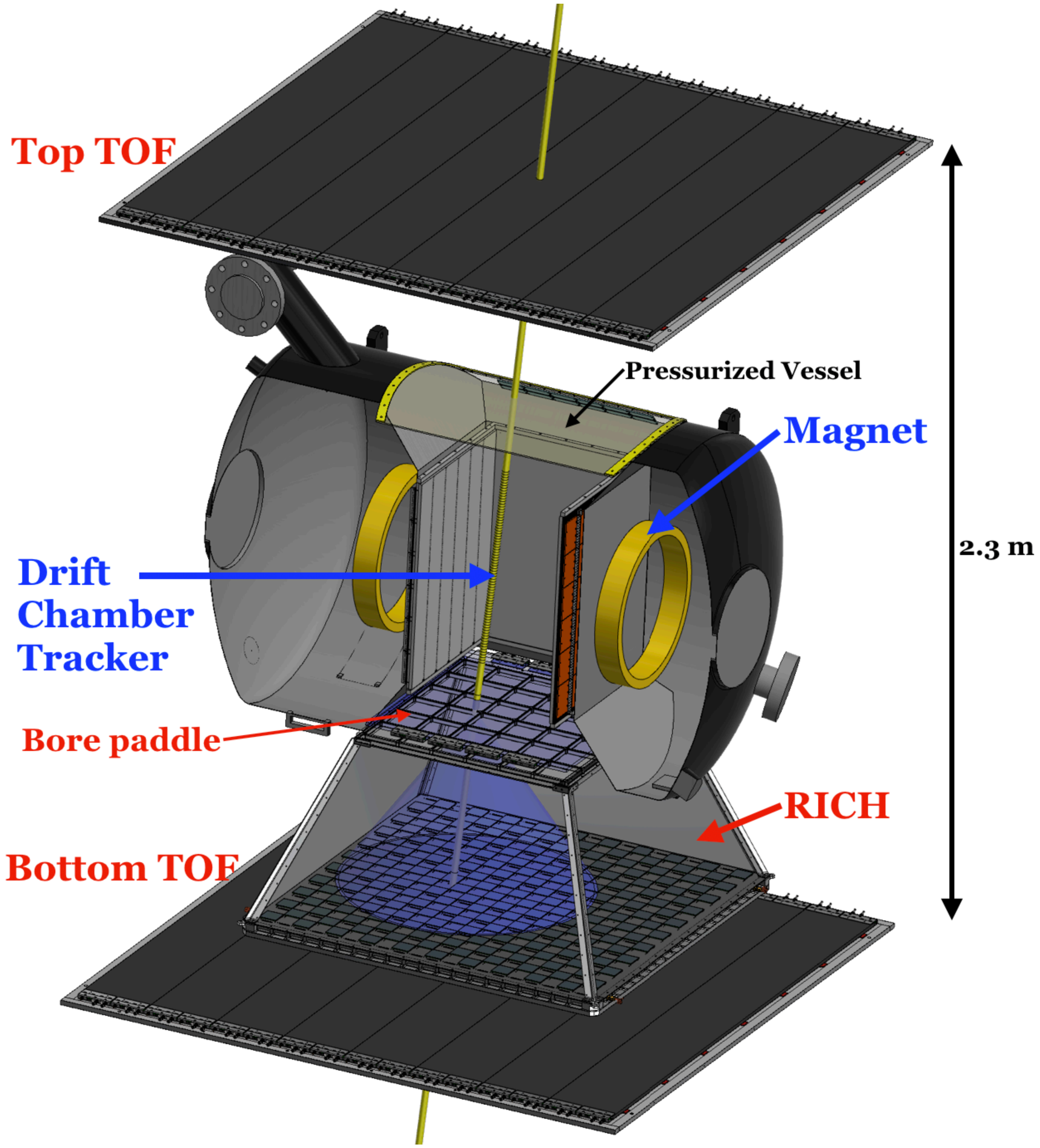
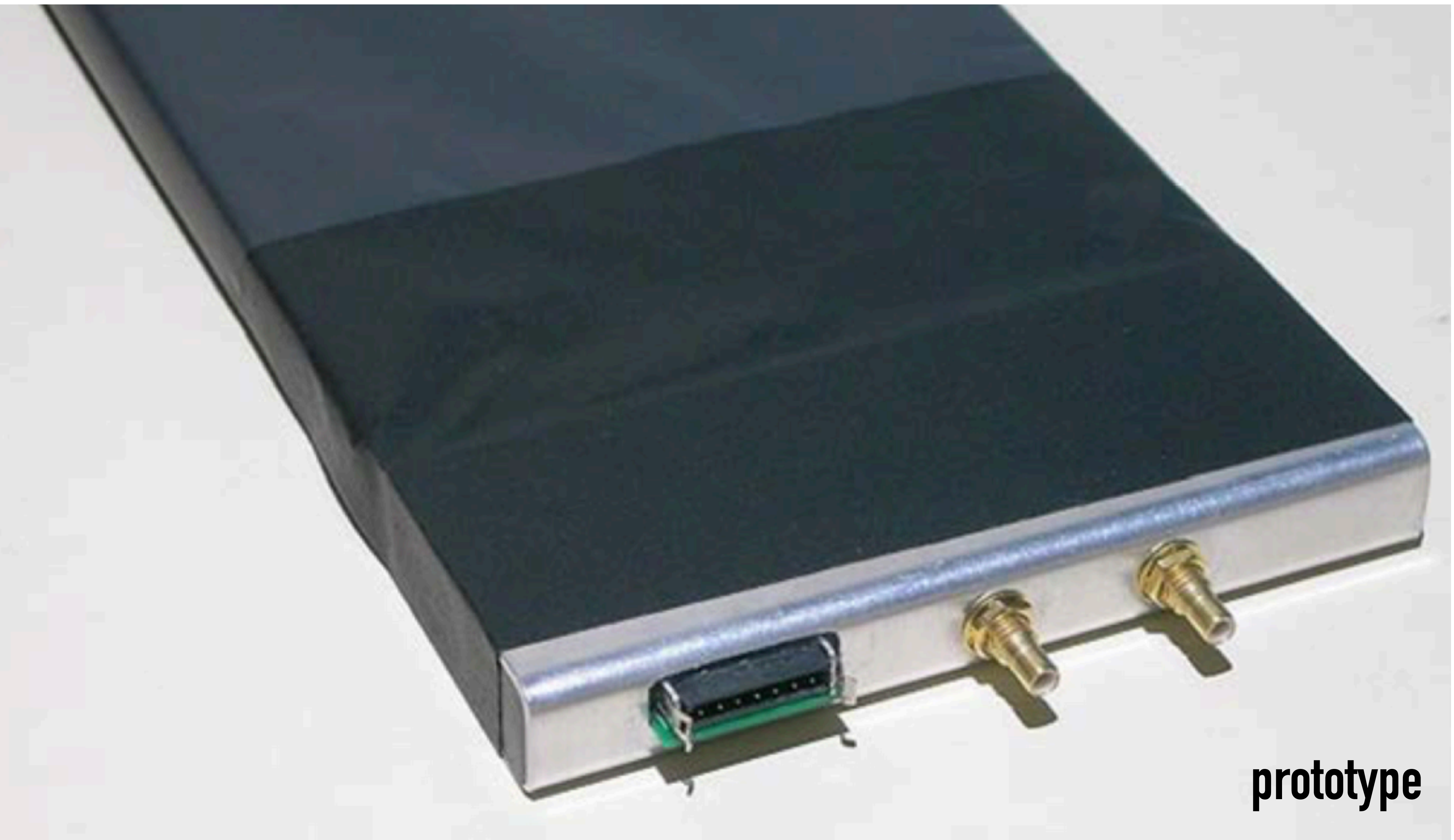
- Very challenging measurements
  - ☆ Mass resolution of few % up to 10 GeV/n
  - ☆ Readout within a very strong magnetic field (HEAT superconducting magnet, B field at the center ~ 1 T)
  - ☆ All SiPM readout needs good thermal design
  - ☆ Total ~ 26k channels for full configuration

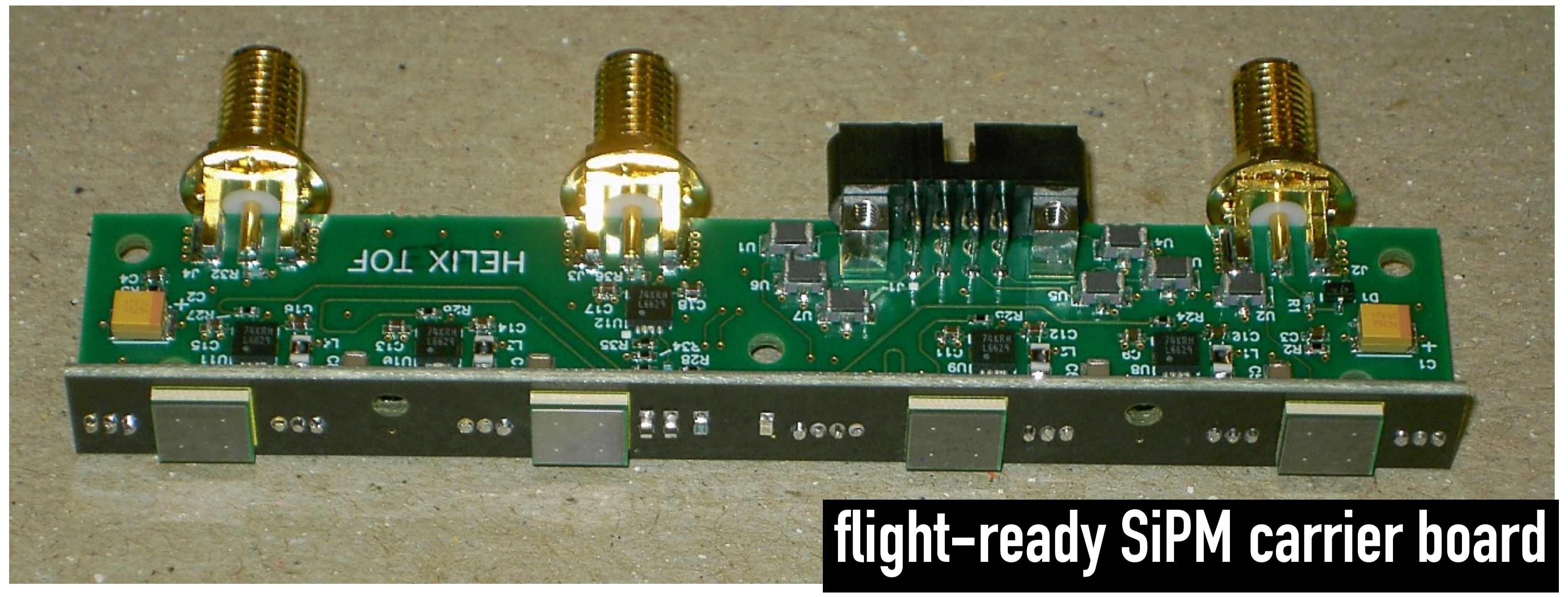


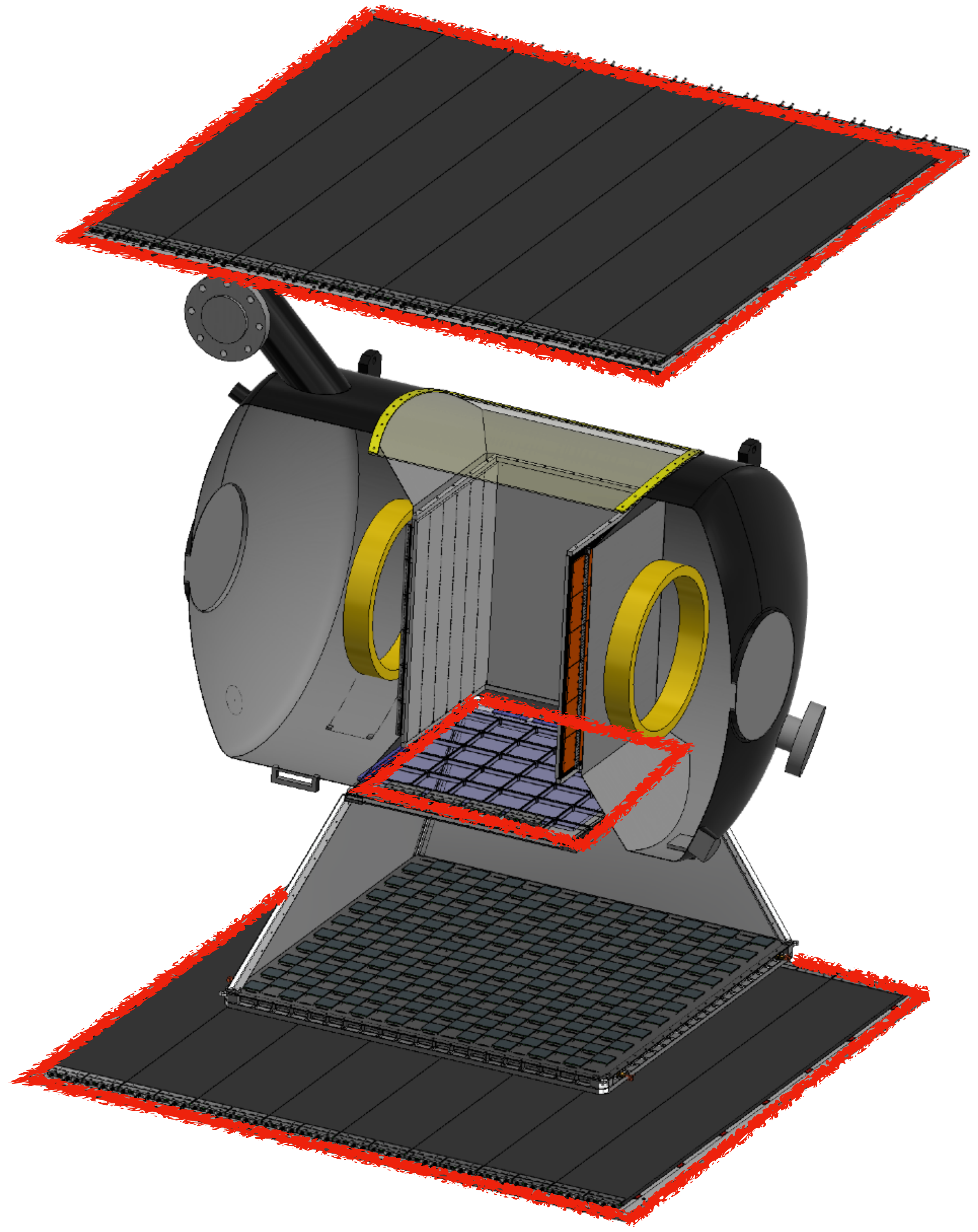
Time-Of-Flight

Three layers of 1 cm thickness fast plastic scintillator, L=2.3 m

- Timing resolution of <50 ps timing resolution for Z>3
- Combination of three layers of TOF provide system-wide trigger





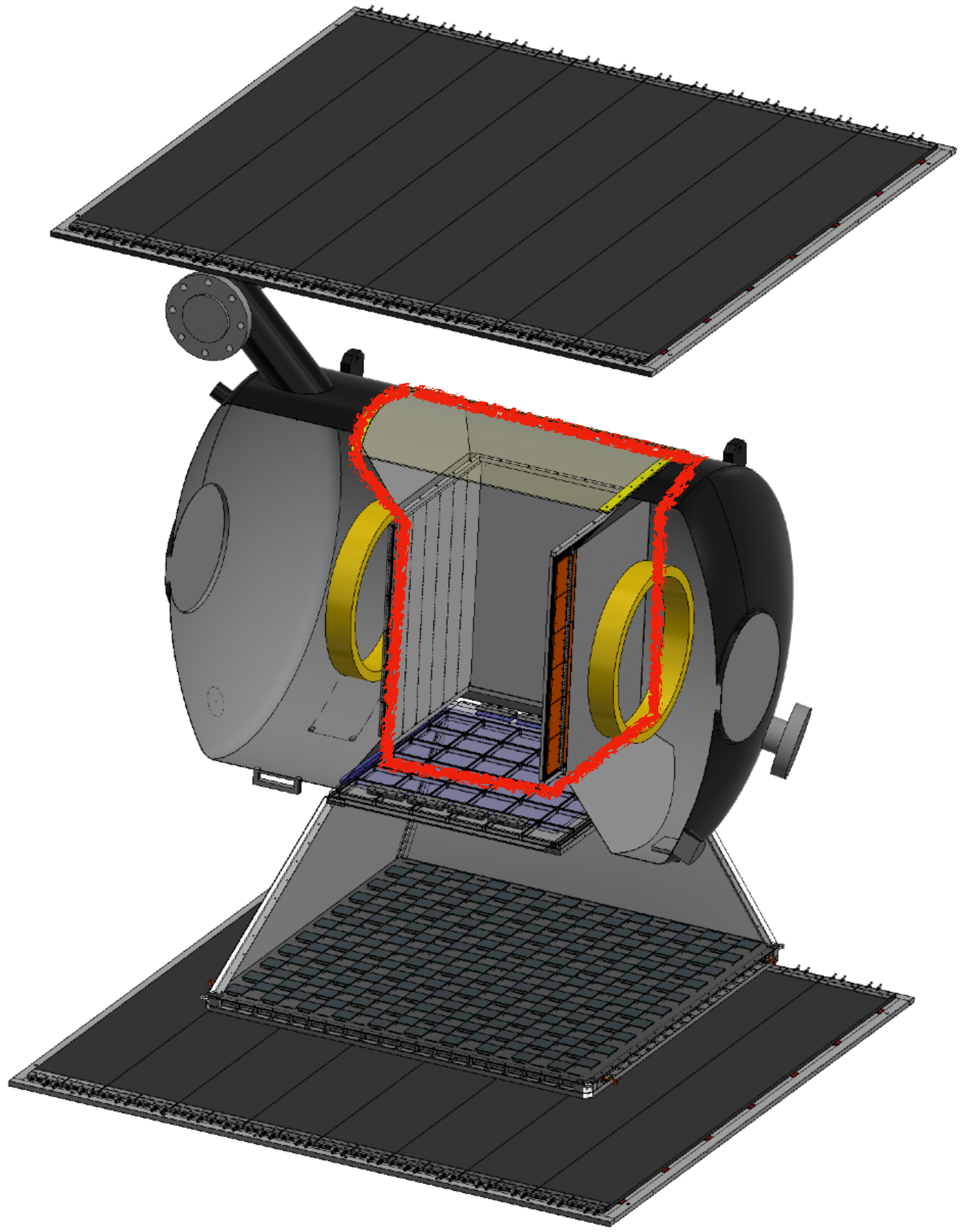


Muon test with SiPMs

- Timing resolution of SiPM output was matching with expected performance from the simulation

Ready for the paddle assembly

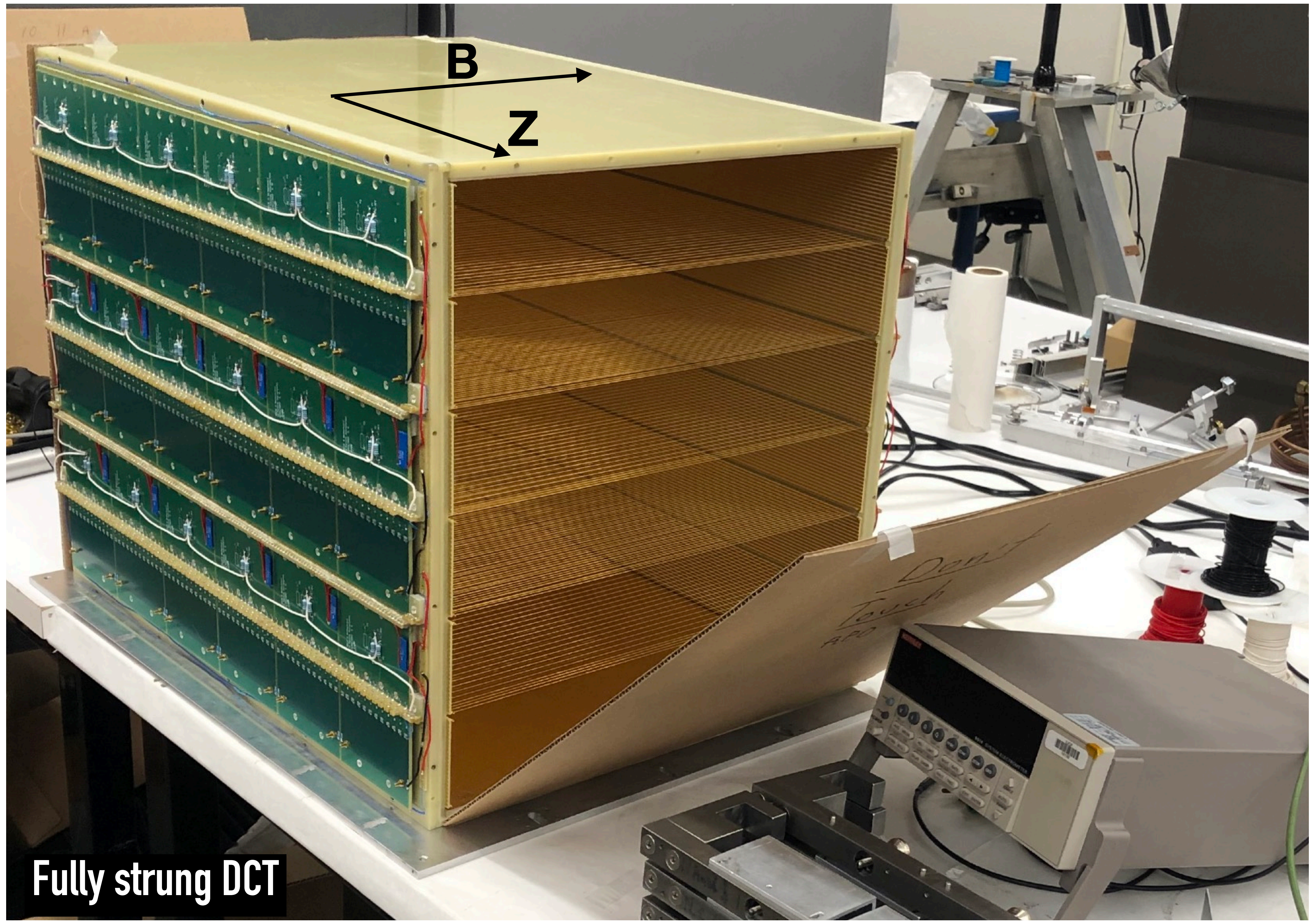
Drift Chamber Tracker



Multi-wire drift chamber with drift gas CO2

- Spatial resolution of 65 μm for Z>3
- 72 sense layers, readout with high-speed sampling electronics
- Installed in the bore of magnet within a thin pressure vessel

Wire fully strung & final test is underway



Fully strung DCT

Pressure vessel for DCT

Magnet

1T Superconducting magnet

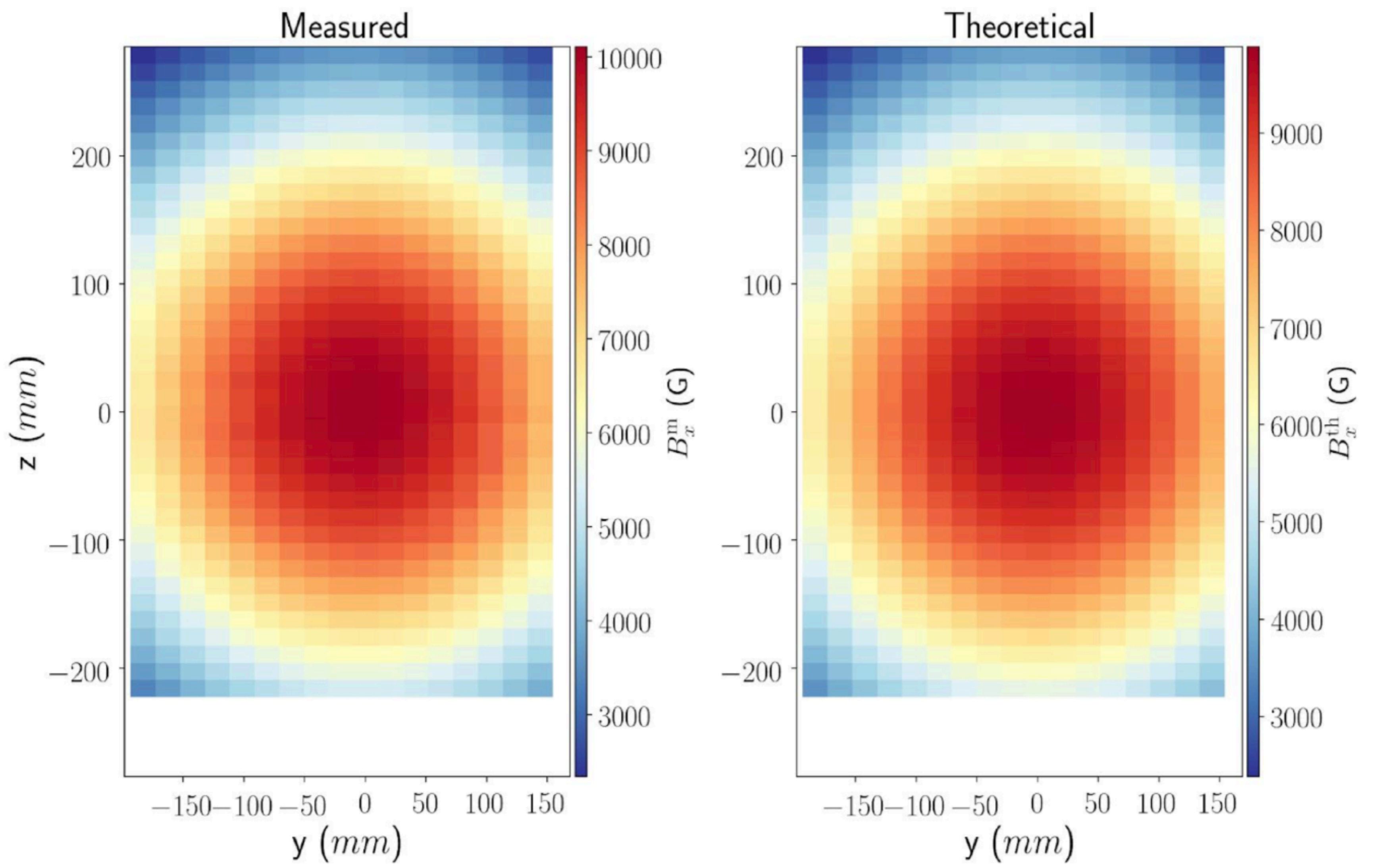
- Hold time : ~7 days
- Reused from the HEAT instrument
  - Refurbished to operate the magnet without pressure vessel
- NbTi coils cooled to ~ 4.2 K

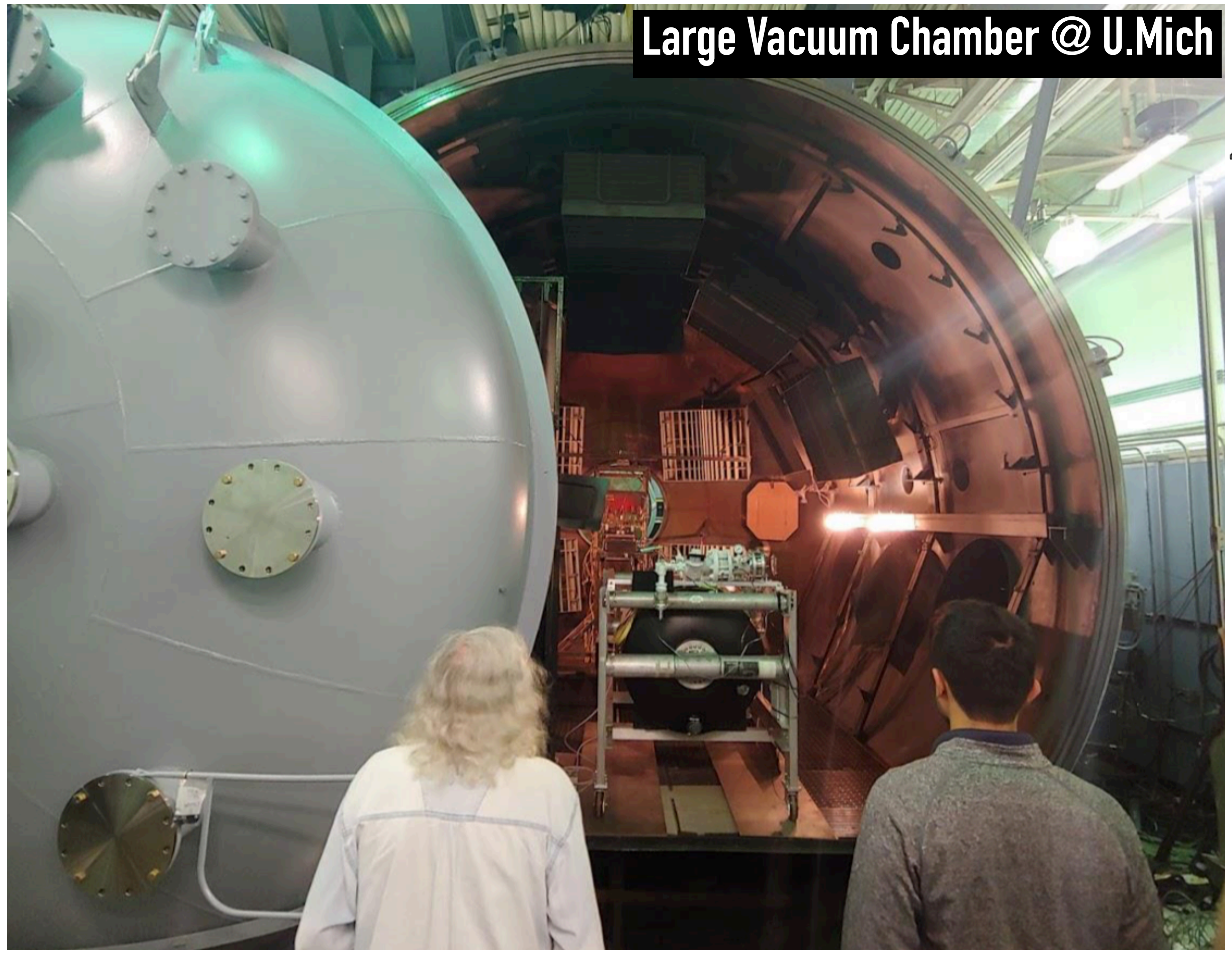
2 Successful cool down tests

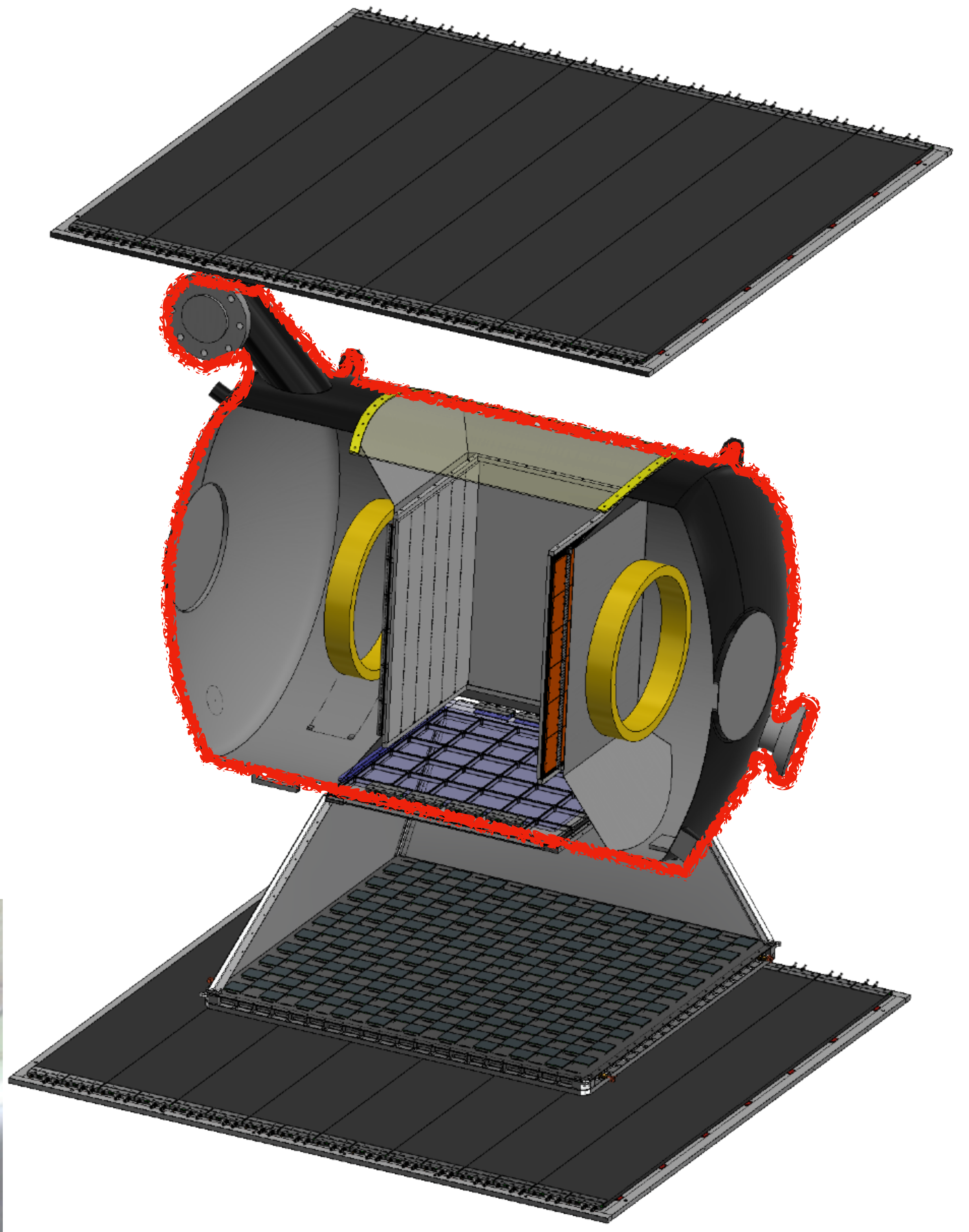
- Measured detailed 3D magnetic field map
  - Matching well with the theoretical model

Successful vacuum test at Large Vacuum Chamber

- Successful operation at the flight vacuum condition (5 torr)



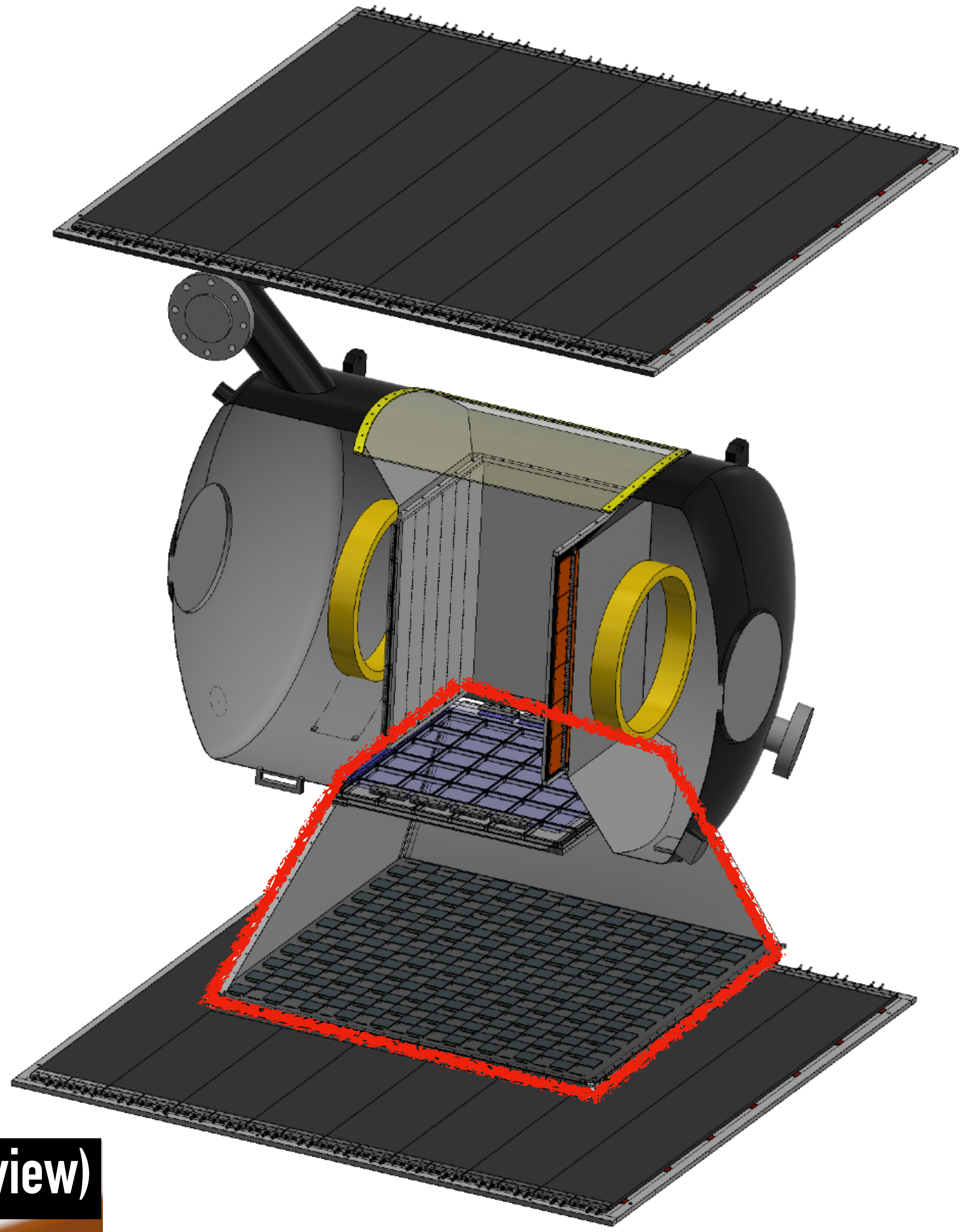


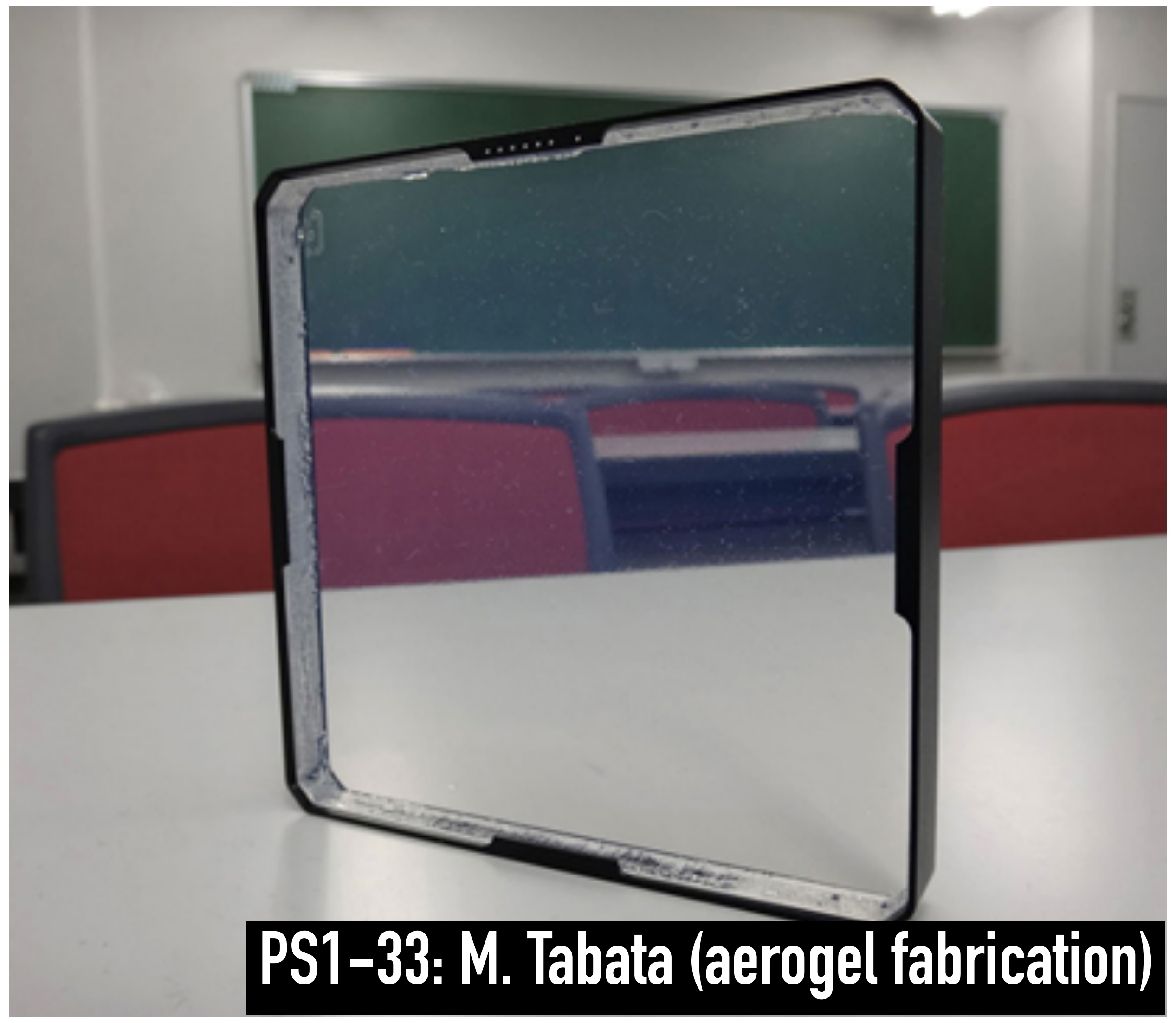


Ring Imaging Cherenkov Counter

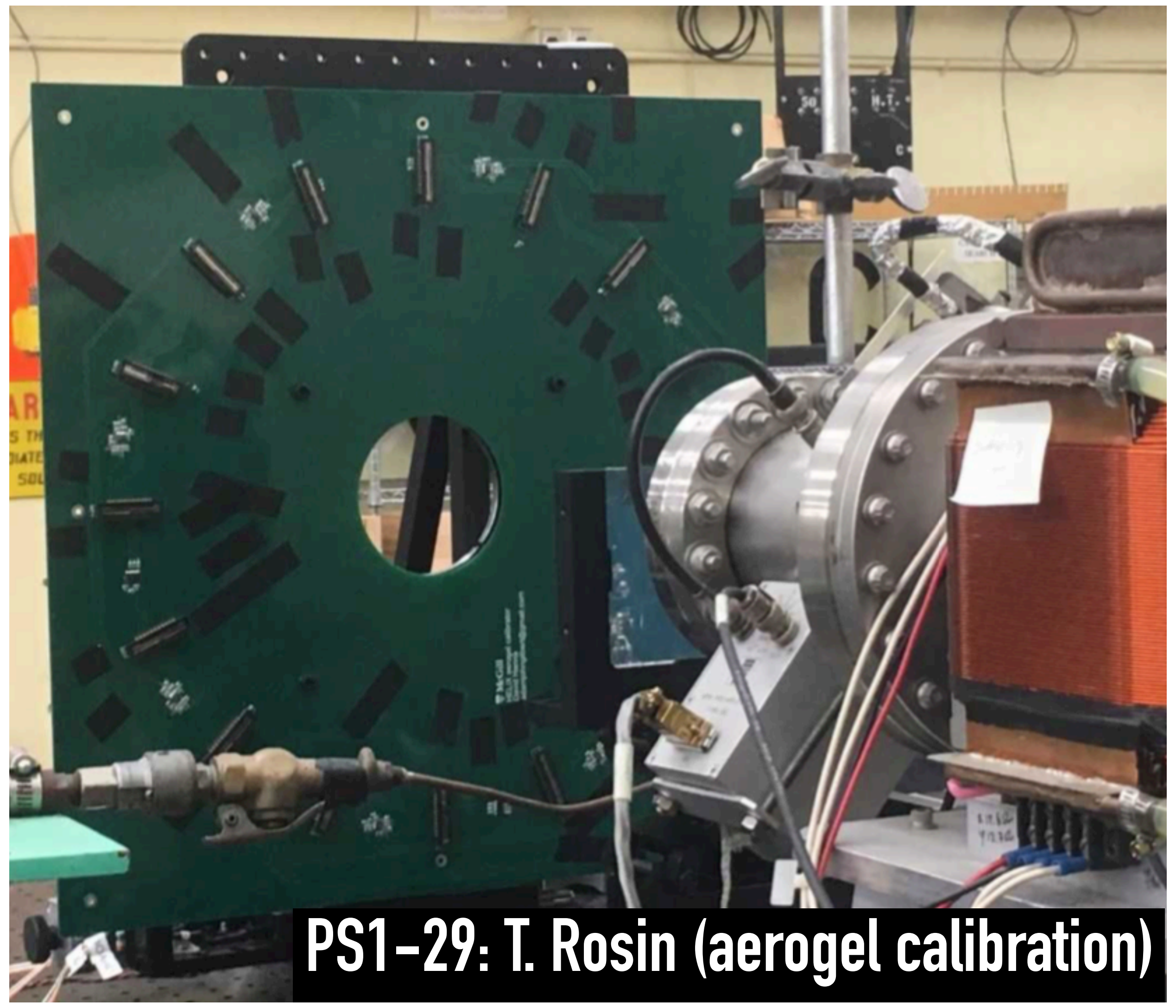
Proximity-focused RICH with SiPM readout (→PS1-39: I. G. Wisher)

- Velocity resolution of $\Delta\beta/\beta \sim 1\times10^{-3}$ for Z>3 for E>1 GeV/n
- Radiator : high refractive index aerogel (n~1.15)
  - ☆ Highly transparent & hydrophobic (→PS1-33: M. Tabata)
  - ☆ Refractive index calibration w/ systematic error of 10^{-4} level (→PS1-29: T. Rosin)
- Focal plane
  - ☆ 1 m × 1 m focal plane covered by Hamamatsu SiPM array (half-filled)
    - Single p.e. detectability
    - Thermal plate underneath to provide cool temperature



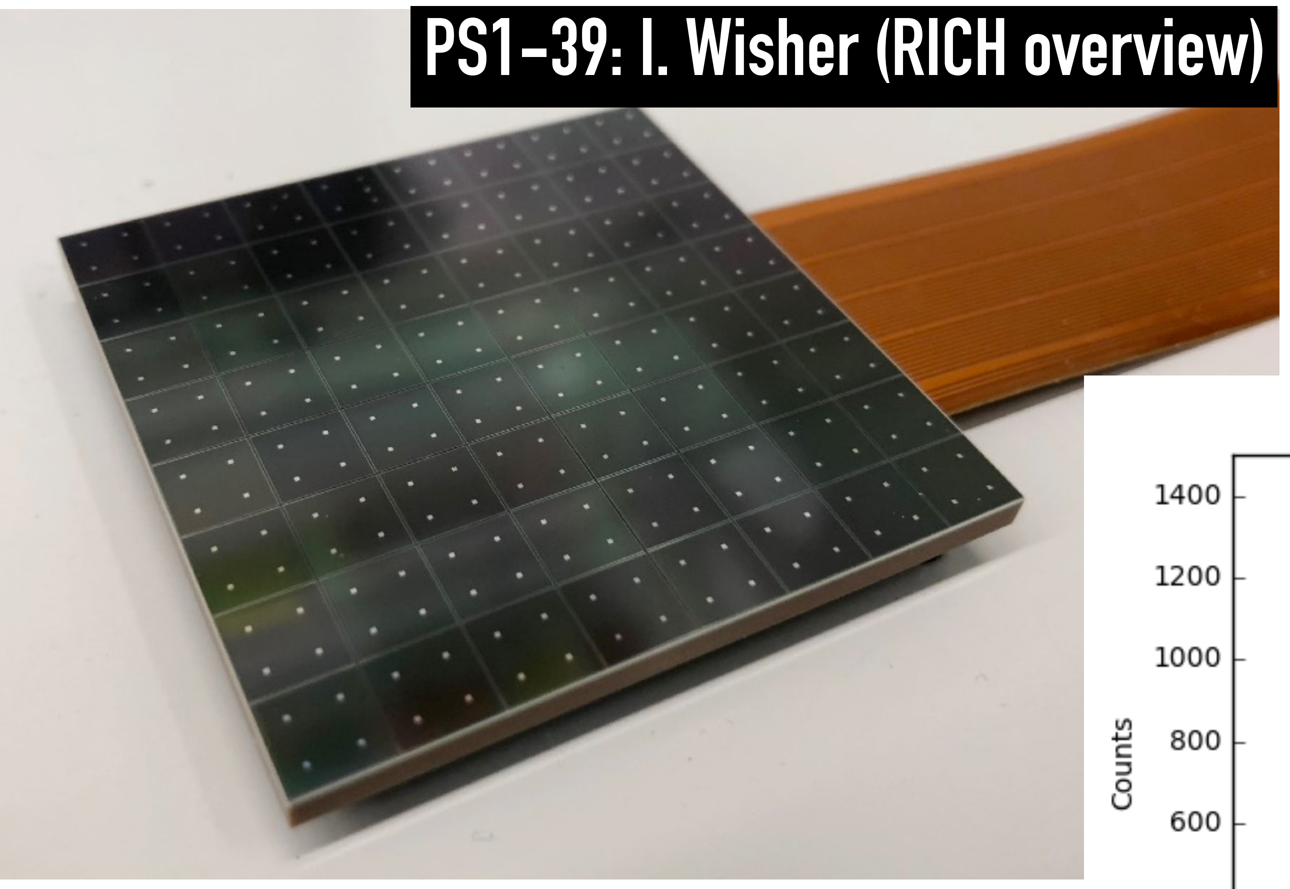


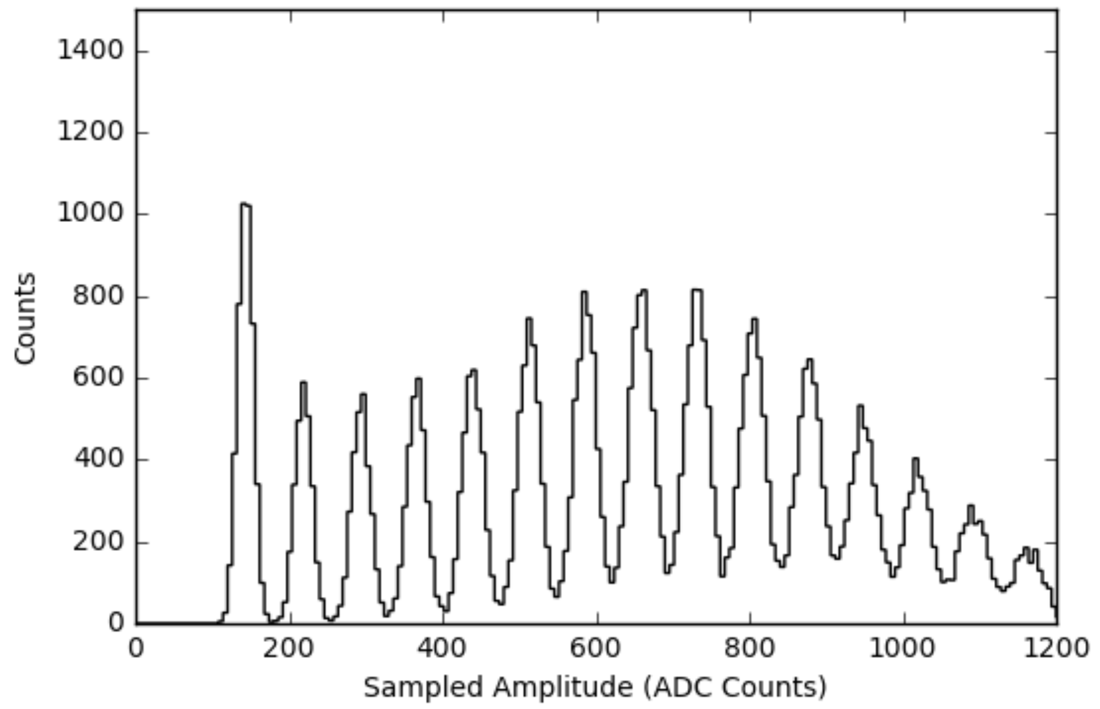
PS1-33: M. Tabata (aerogel fabrication)



PS1-29: T. Rosin (aerogel calibration)

PS1-39: I. Wisher (RICH overview)

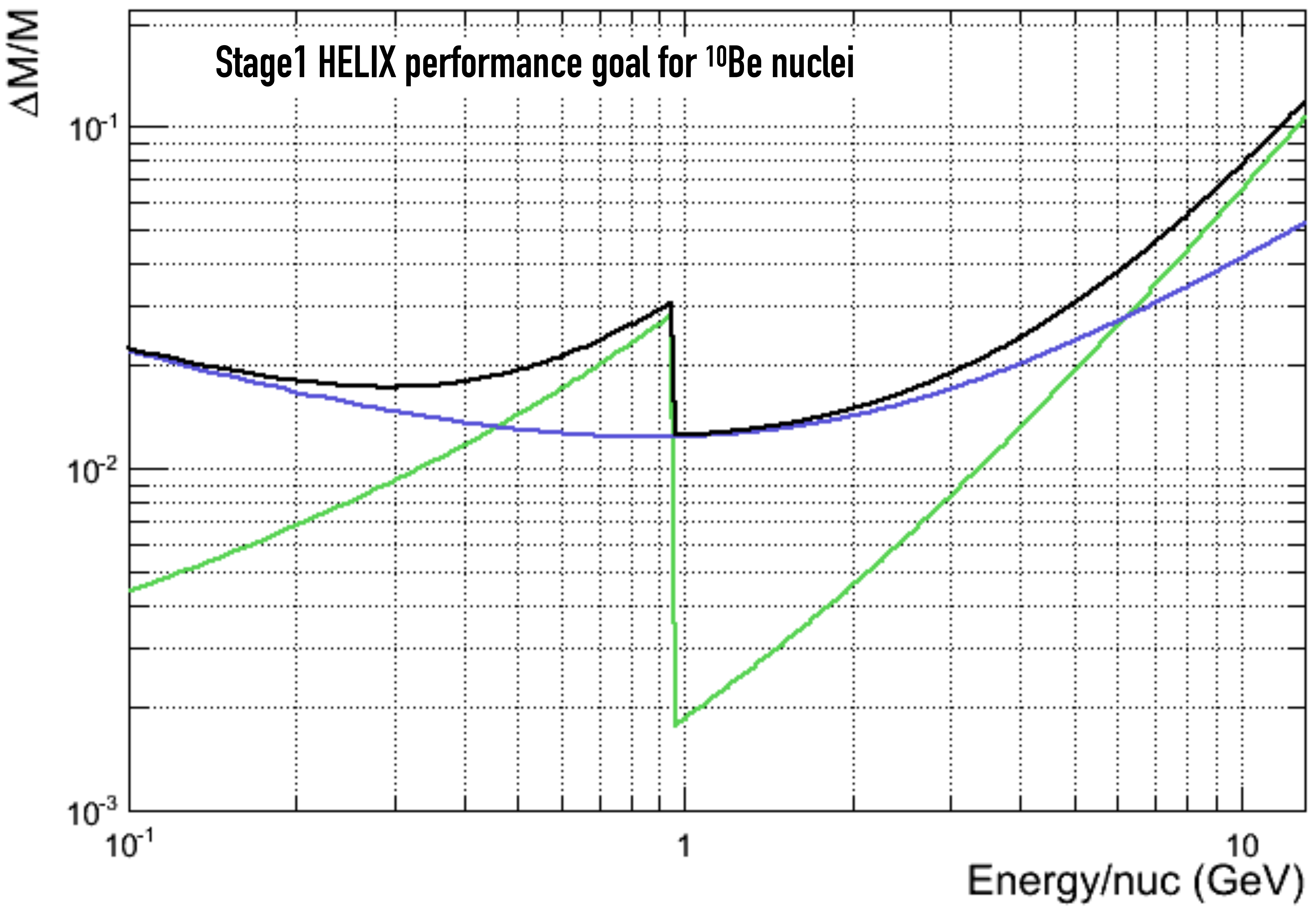


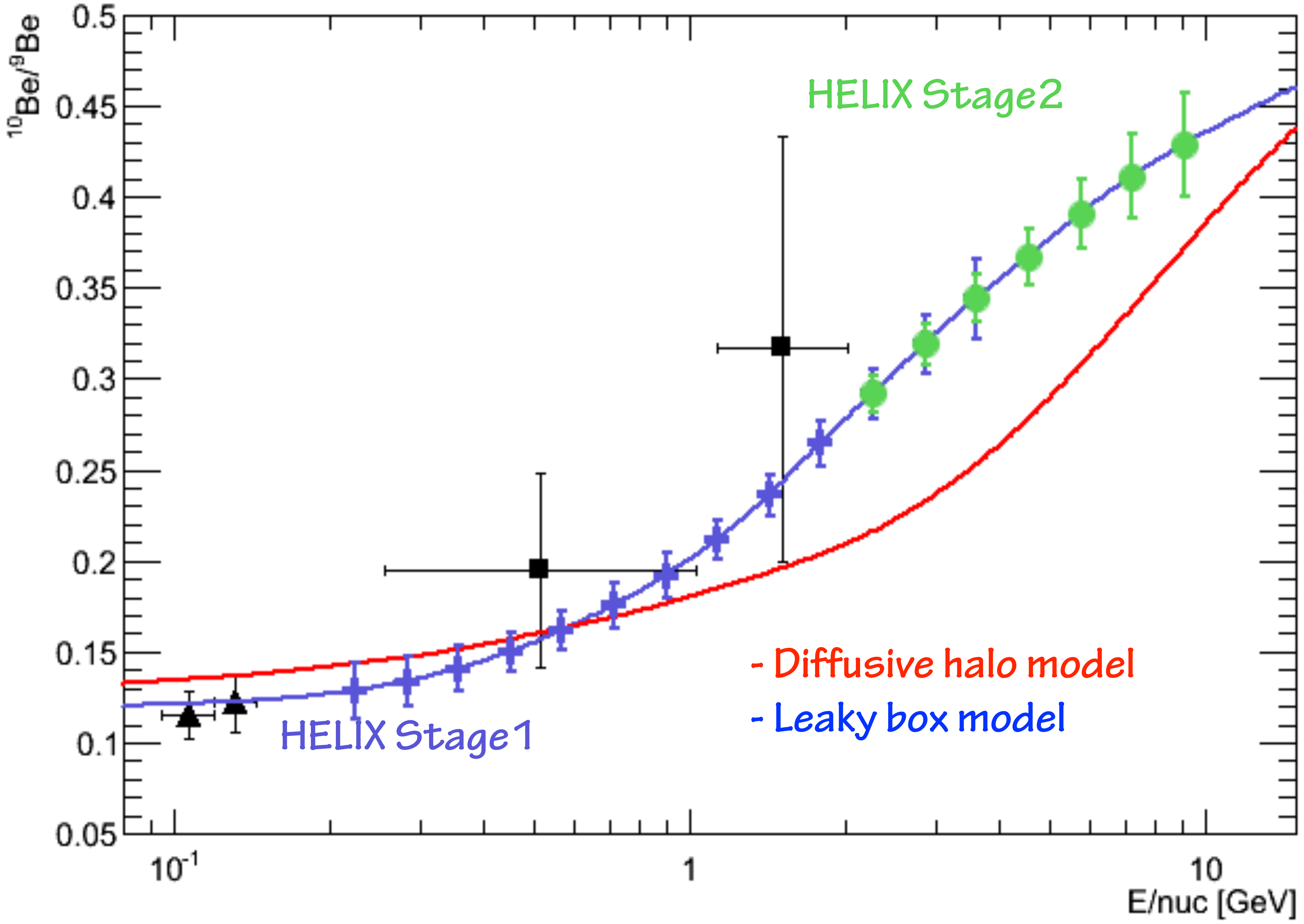


HELIX Stage1 Performance

^{10}Be/^{9}Be ratio up to ~3 GeV/n with Δm/m ~2.5%

- 7-14 day exposure with 0.1 m²sr geometry factor
- Measure the charge of CR up to neon (Z=10)
- Mass resolution of few percentage for light isotopes up to 3 GeV/n





Summary

HELIX is moving forward to be ready for integration test in 2019, and an Antarctica flight in 2020!

Recent discoveries of new features of CRs require better understanding of CR propagation.

Measurement of propagation clock isotope, such as ^{10}Be can provide essential data.

HELIX is a balloon-borne experiment designed to measure ^{10}Be from 0.2 GeV to beyond 3 GeV/n.

All of the sub detectors are under construction.