HELIX

(High Energy Light Isotope eXperiment)

Presented by Nahee Park

For CRIS-MAC 2024

HELIX Collaboration

University of Chicago

- Hyebin Jeon, Rostom Mbarek, Keith McBride, Dietrich Muller, Kenichi Sakai, Scott P. Wakely

Indiana University

- Brandon Kunkler, Michael Lang, James Musser, Gerard Visser

McGill University

- David Hanna, Ste O'Brien

Northern Kentucky University

- Scott Nutter

Ohio State University

- Patrick Allison, James J. Beatty, Lucas Beaufore, Dennis Calderon

Pennsylvania State University

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

Queen's University

- Melissa Baiocchi, Avani Bhardwaj, Connor McGrath, Nahee Park

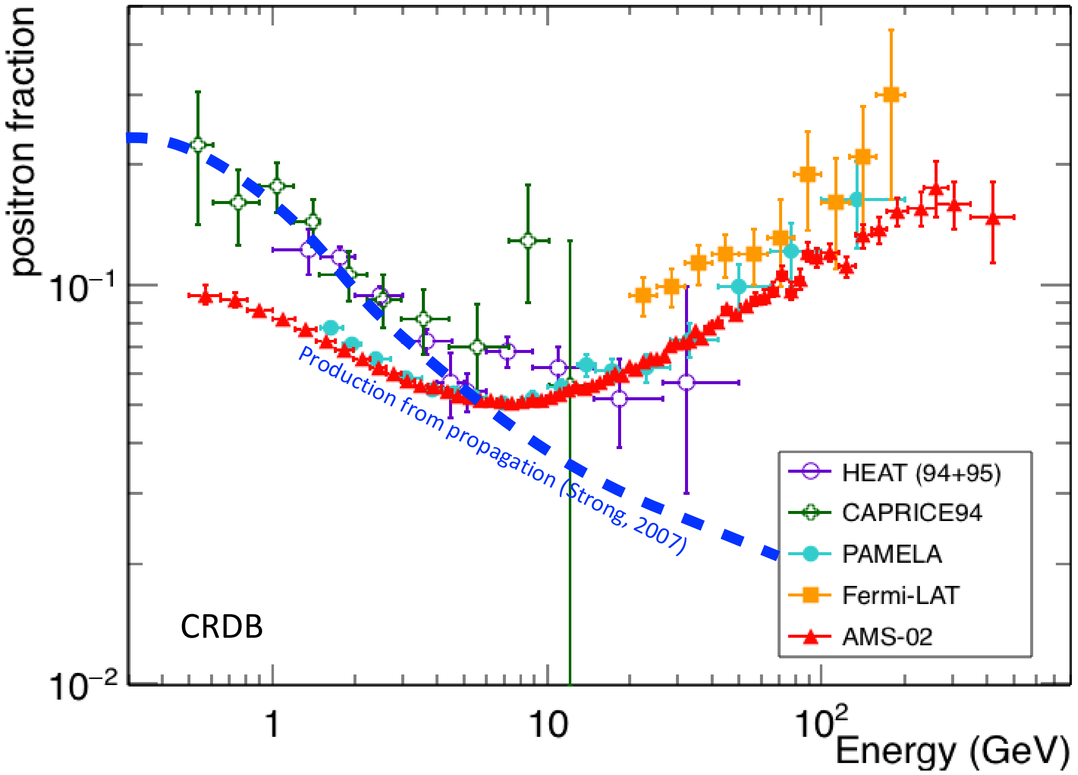
University of Michigan

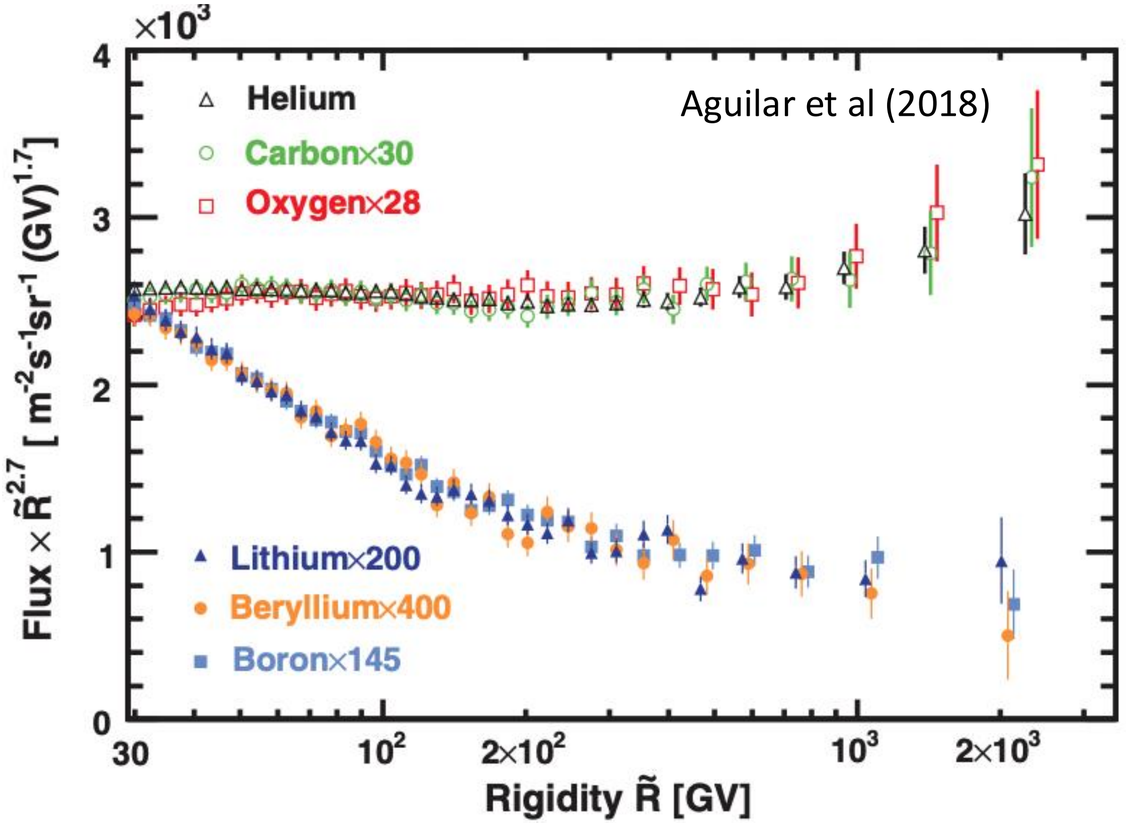
- Noah Green, Gergory Tarle, Andrew Tomasch

New discoveries challenge classical paradigm of cosmic rays

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

- Rising positron fraction
- Spectral index changes before the knee energy



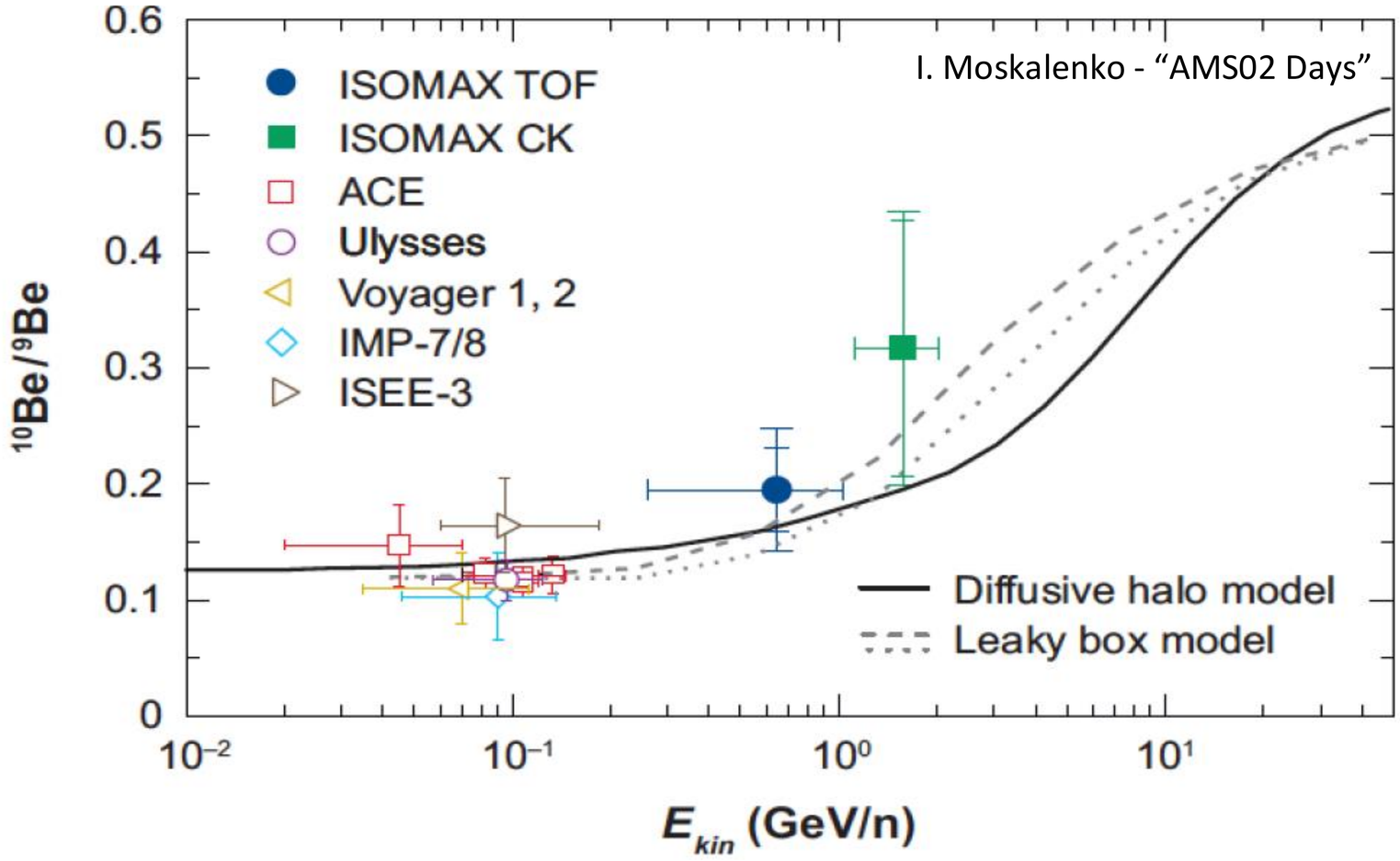


→ It is critical to understand the propagation!

$^{10}Be/^{9}Be$ measurements

^{10}Be : Unstable isotope with known half life of 1.4×10^6 yr

- $^{10}Be/^{9}Be$ ratio provides strong constraints for the propagation models
- Challenging measurements

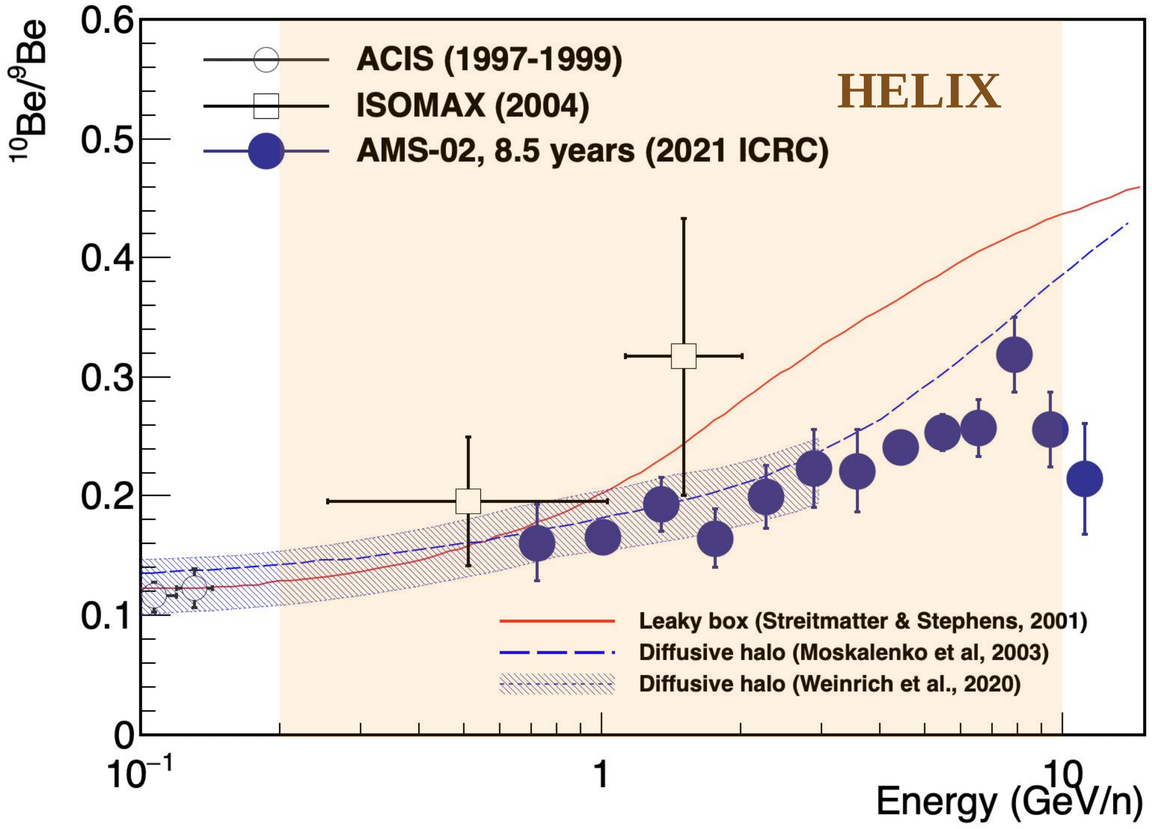


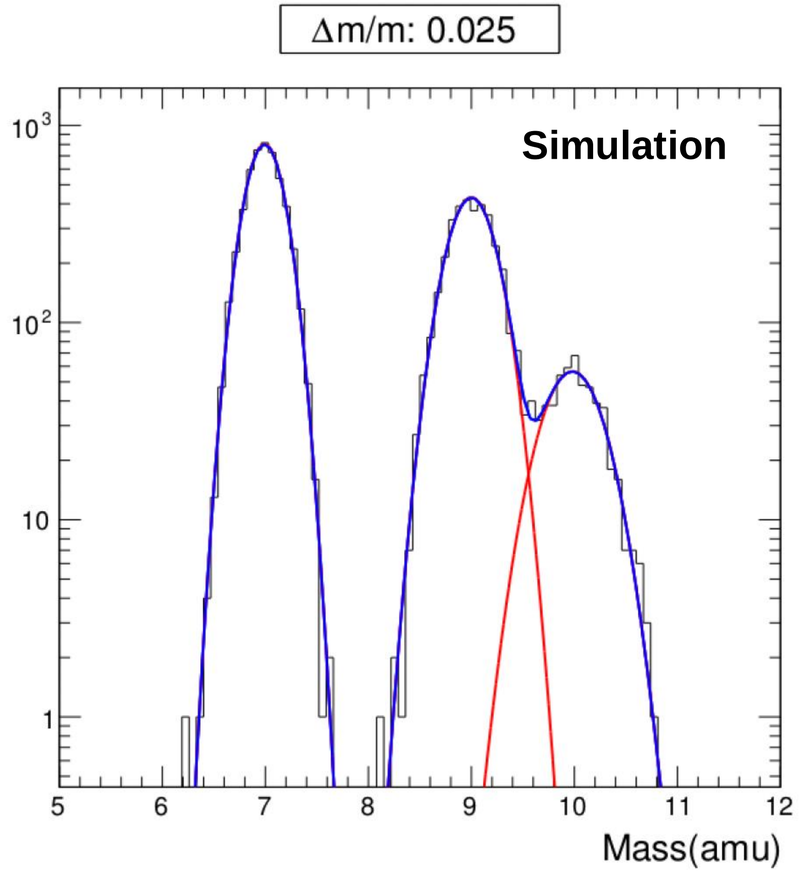
$^{10}Be/^{9}Be$ measurements

^{10}Be : Unstable isotope with known half life of 1.4×10^6 yr

- $^{10}Be/^{9}Be$ ratio provides strong constraints for the propagation models
- Challenging measurements

HELIX is designed to provide a precision measurement of ^{10}Be!

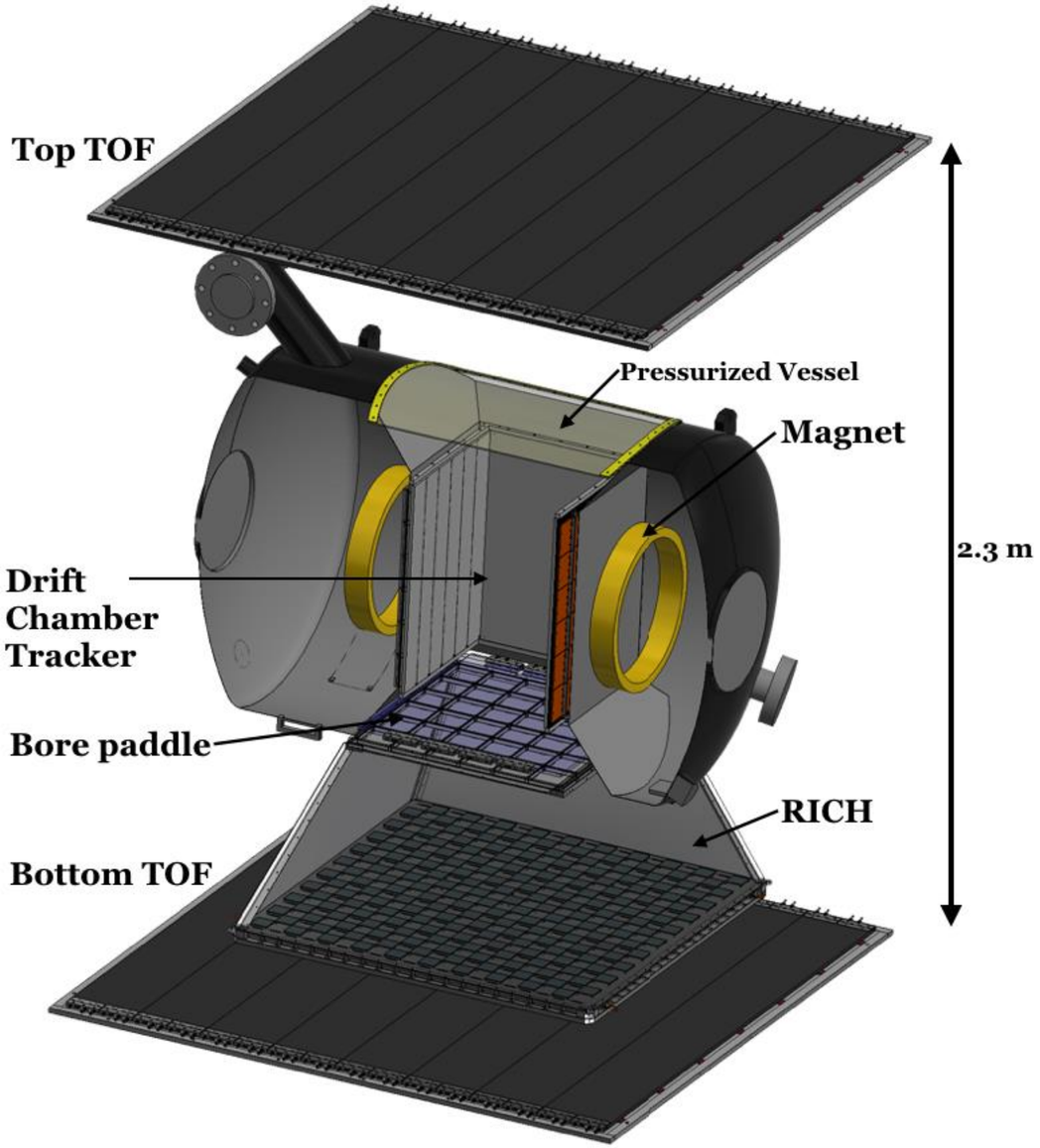




High Energy Light Isotope eXperiment

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

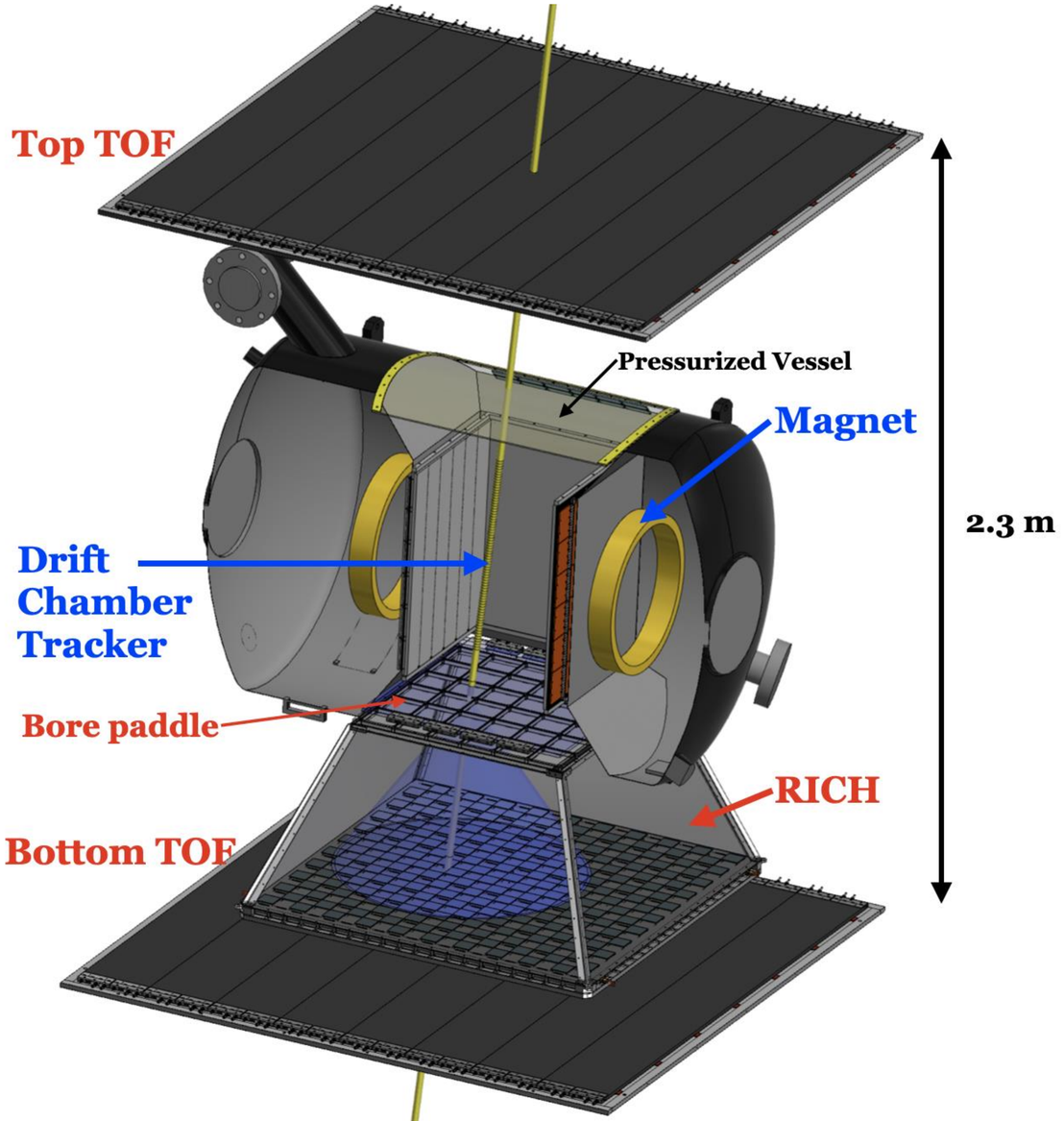
- Design considerations
  - -A mass resolution of few % up to 10 GeV/n
  - -Readout within a very strong magnetic field (Superconducting magnet used for HEAT balloon payloads, B field at the center ~ 1 T)
  - -All SiPM readout needs good thermal design



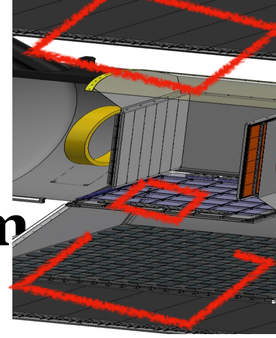
High Energy Light Isotope eXperiment

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

- Design considerations
  - -A mass resolution of few % up to 10 GeV/n
  - -Readout within a very strong magnetic field (Superconducting magnet used for HEAT balloon payloads, B field at the center ~ 1 T)
  - -All SiPM readout needs good thermal design
- Two stage approach to cover wider range of energy
  - -Stage 1 : covers up to ~ 3 GeV/n



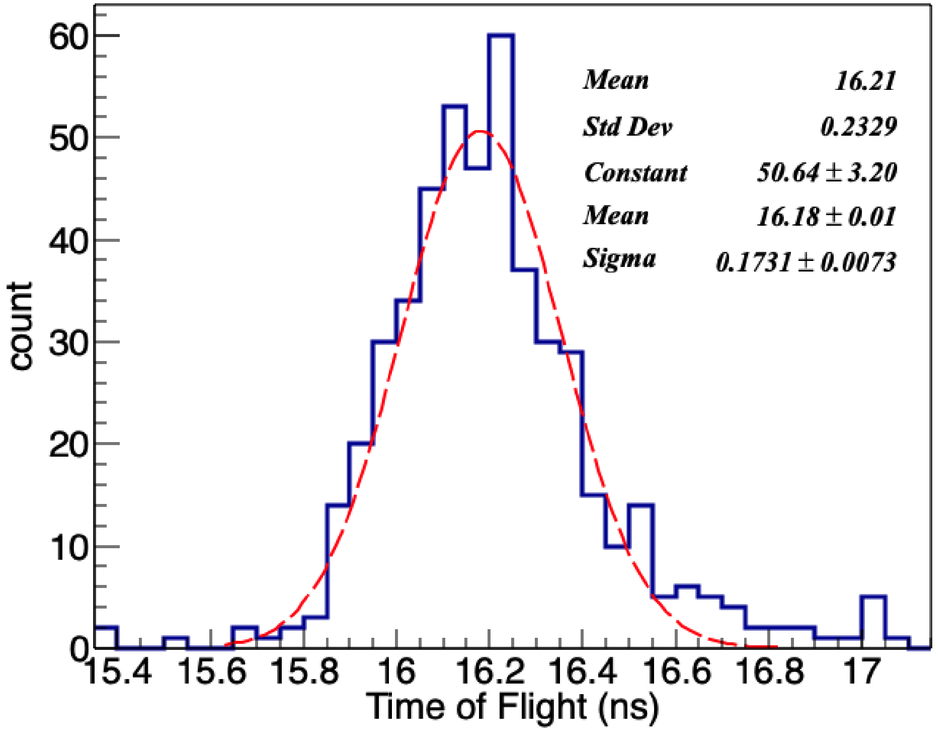
Time-Of-Flight



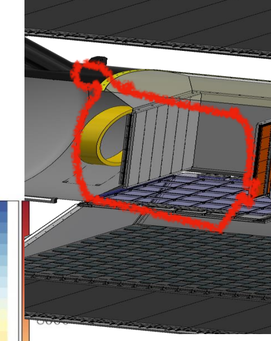
Three layers of 1 cm thickness fast plastic scintillator, 2.3m top to bottom

- Timing resolution of <50 ps for Z>3
  - -Each 20cm EJ200 scintillator paddle with each end read by 8 SiPMs
  - -TDC timing resolution better than 25 ps
- Preliminary analysis on the muon test shows a timing resolution better than 200 ps

Δt between Top TOF and bottom TOF w/ muon (w/ restricted geome

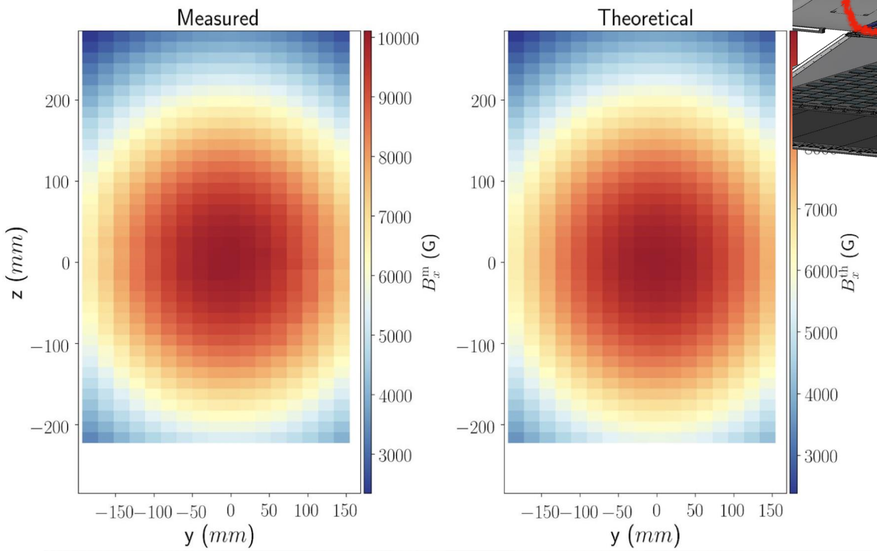


Magnet



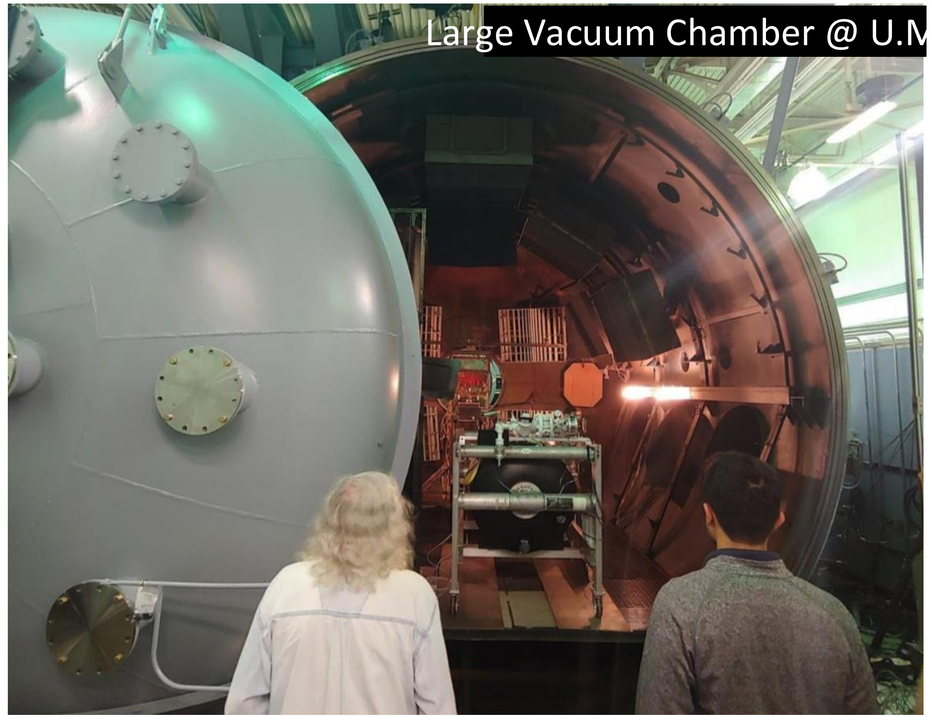
1T Superconducting magnet

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

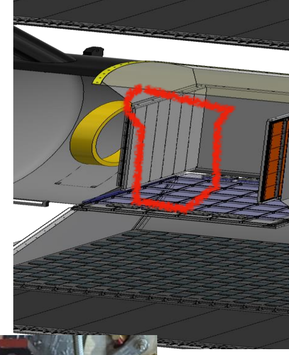


Many successful cool down tests

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



Drift Chamber Tracker

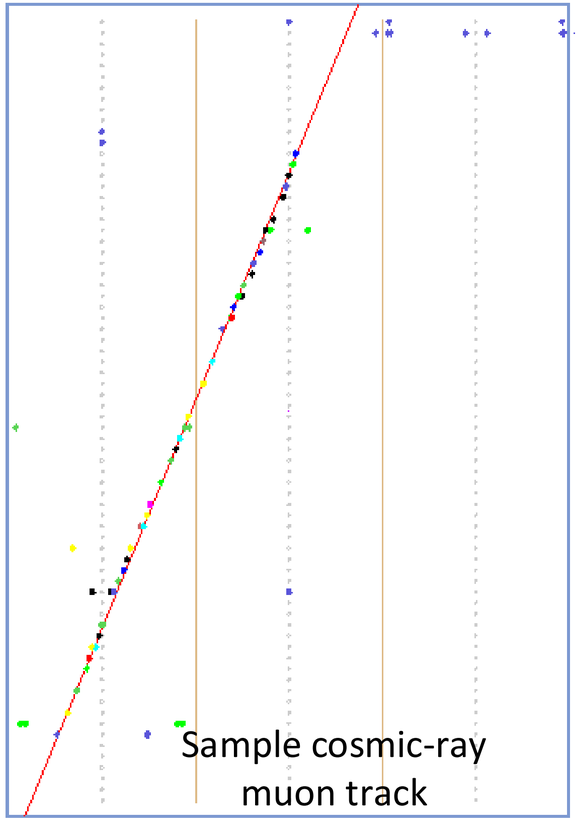


Multi-wire drift chamber with drift gas CO_2 + Ar

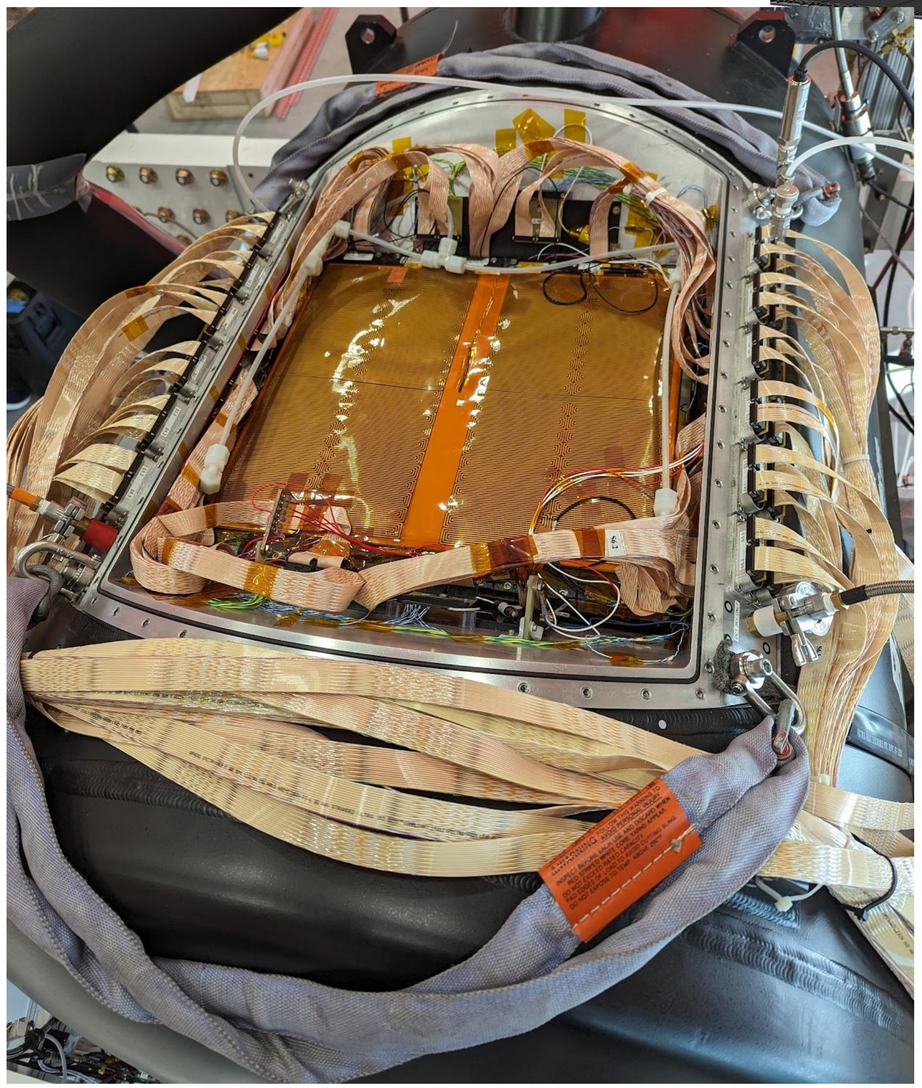
- Spatial resolution of 65 μm for Z>3

  -72 sense layers, read out with 80 MHz sampling

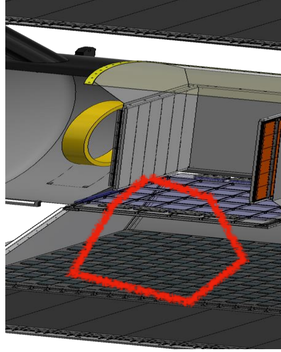
- Tracking resolutions for muons are consistent with reaching the design goal



Sample cosmic-ray muon track



Ring Imaging Cherenkov Counter

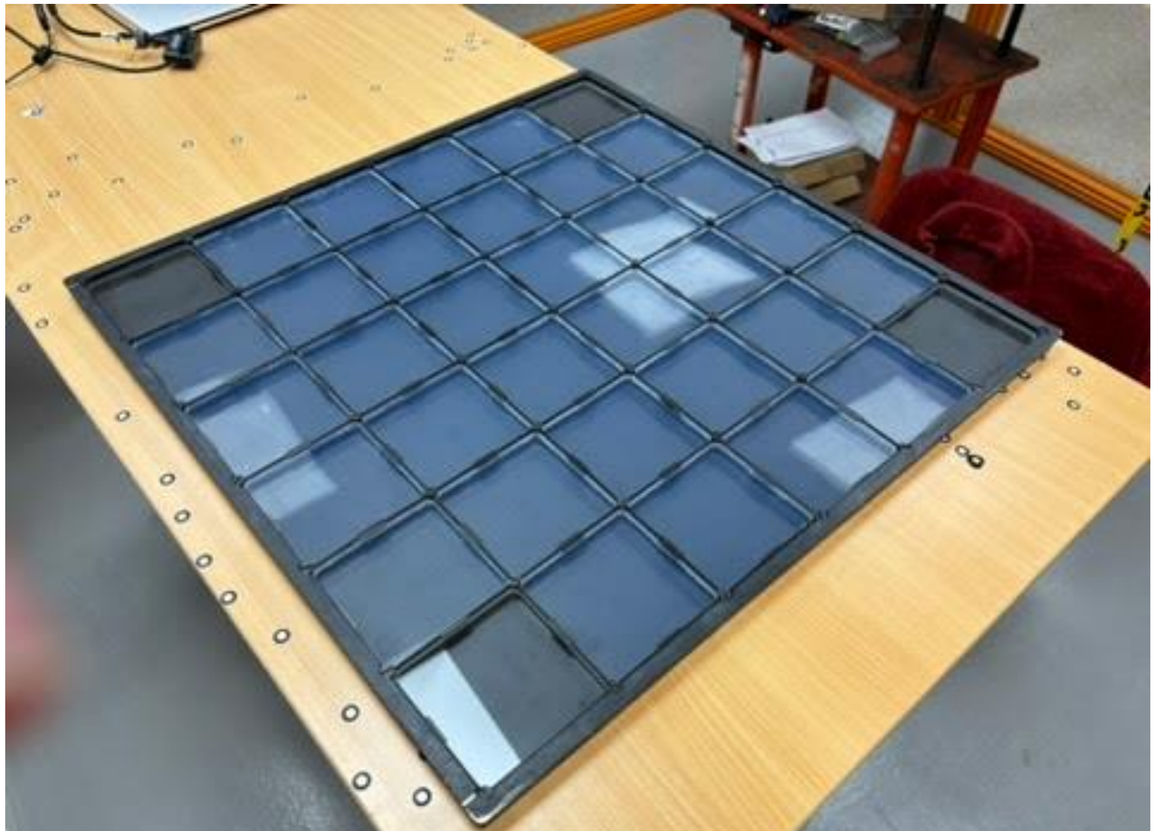


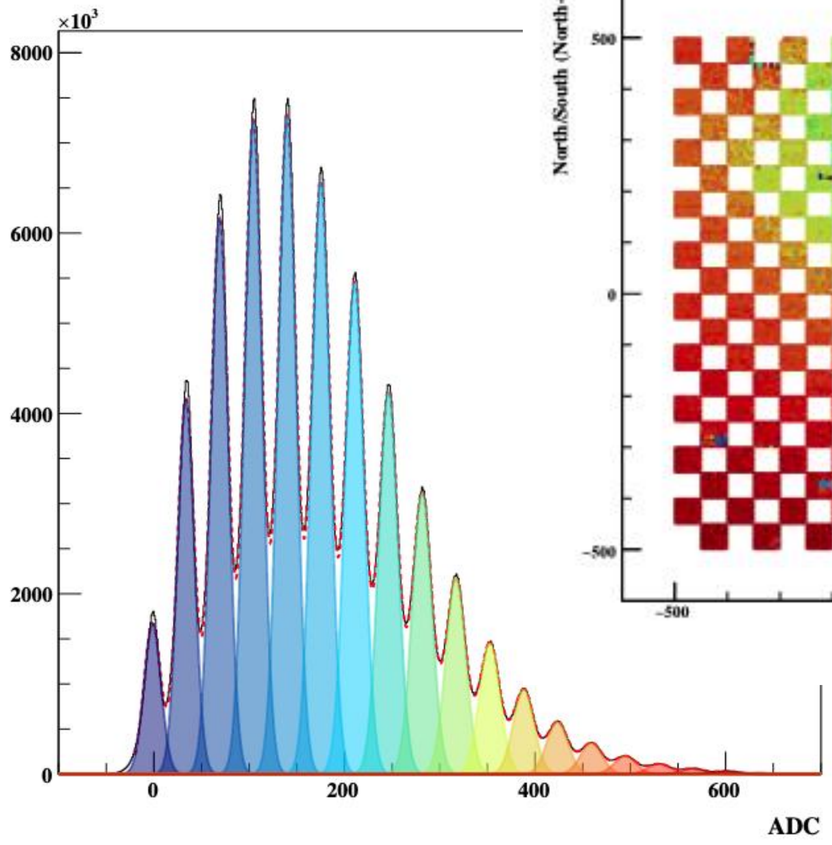
Proximity-focused RICH with SiPM readout

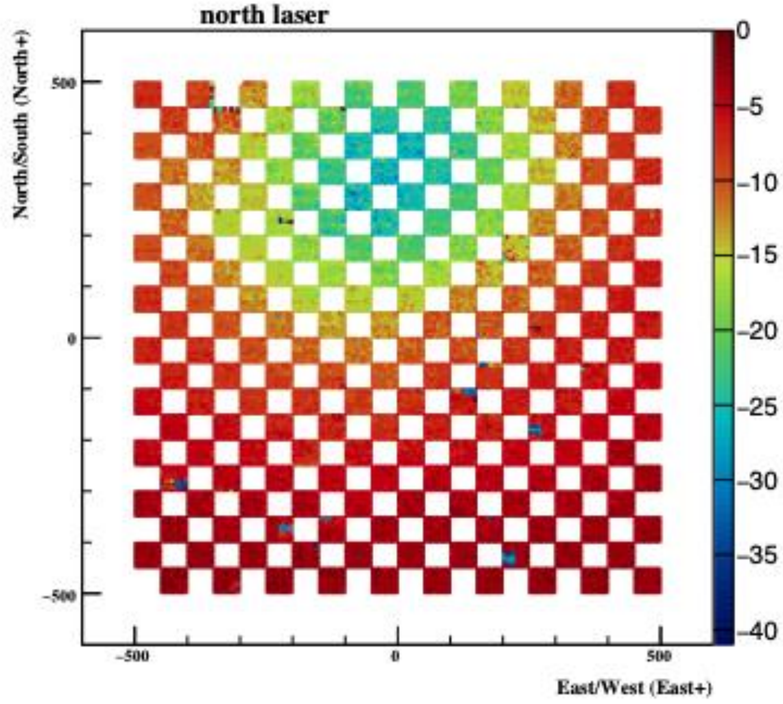
- Velocity resolution of $\Delta\beta/\beta \sim 1\times10^{-3}$ for Z>3 for E>1 GeV/n

  -Main radiator : highly transparent & hydrophobic aerogel (n~1.15)

  -Focal plane (1 m × 1 m) covered by 6 mm × 6mm SiPM array in checker board configuration: 12.8k channels!



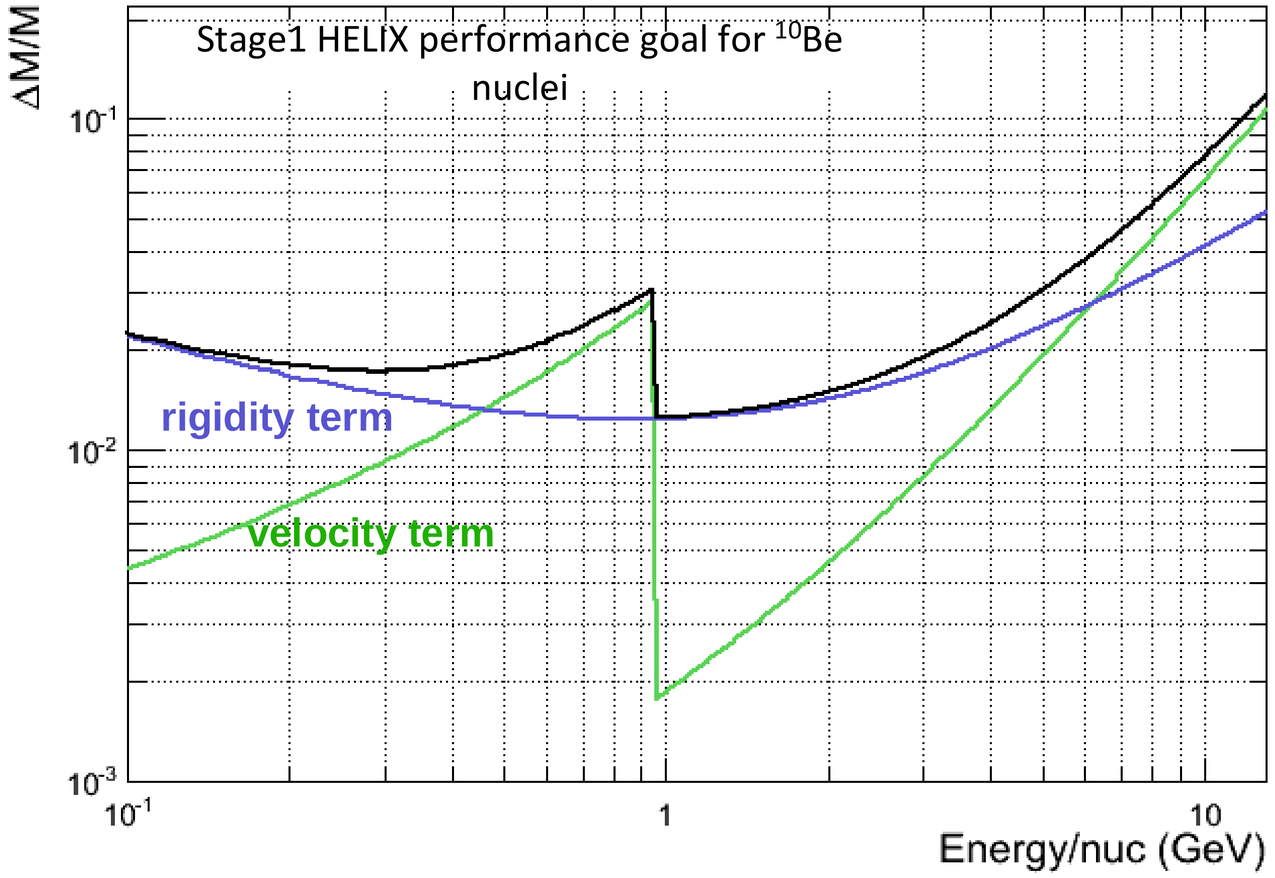




HELIX Stage1 Performance Goals

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

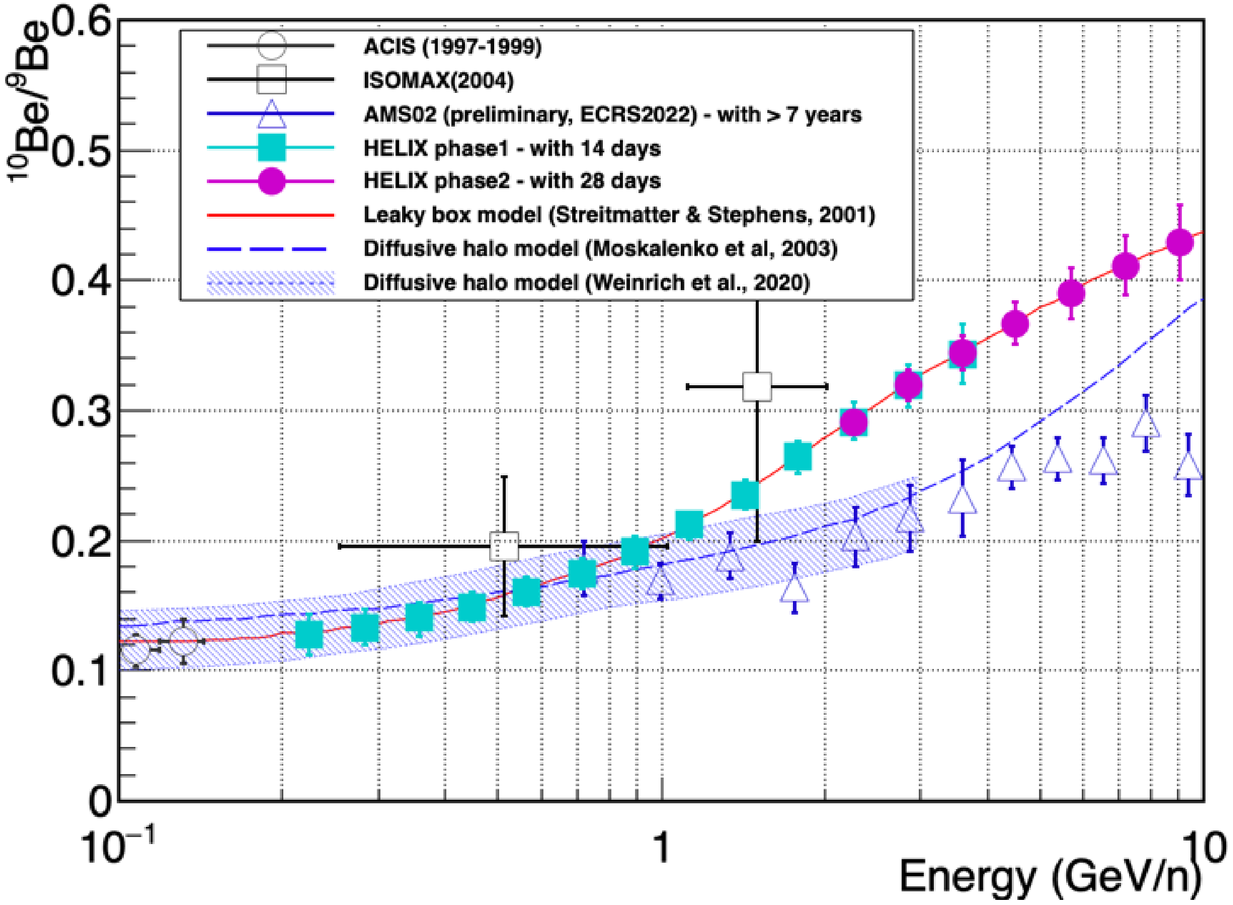
- 7-14 day exposure with 0.1 m²sr geometry factor
- Measure the charge of CR up to neon (Z=10)
- Mass resolution of few percentage for light isotopes up to 3 GeV/n



HELIX Stage1 Performance Goals

^{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



HELIX Flight 2024

HELIX was successfully launched from Kiruna, Sweden on May 28th, 2024.

https://www.youtube.com/watch?v=Po0fJ8a14S4

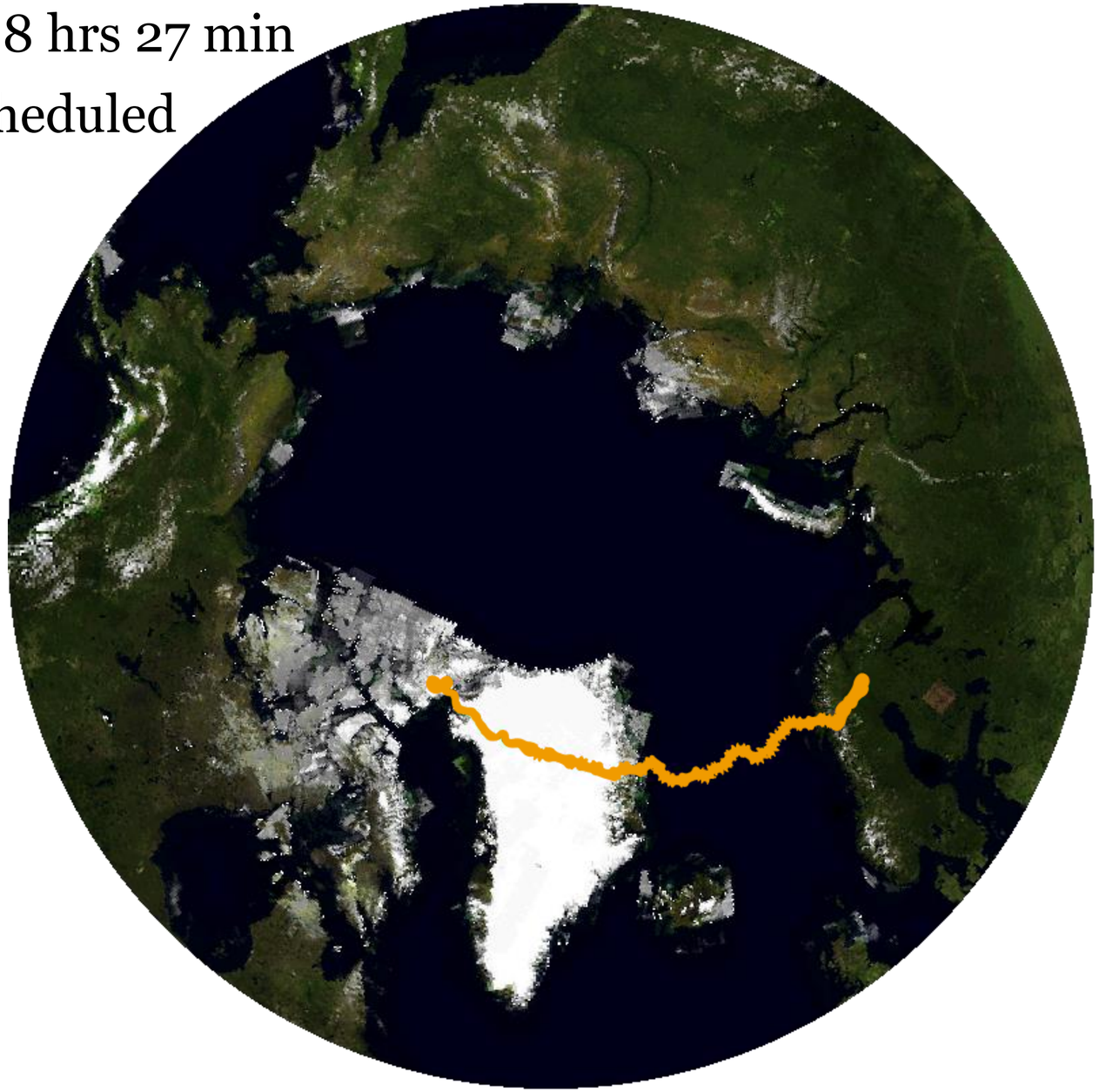
HELIX Flight 2024

HELIX was successfully launched from Kiruna, Sweden on May 28th, 2024.

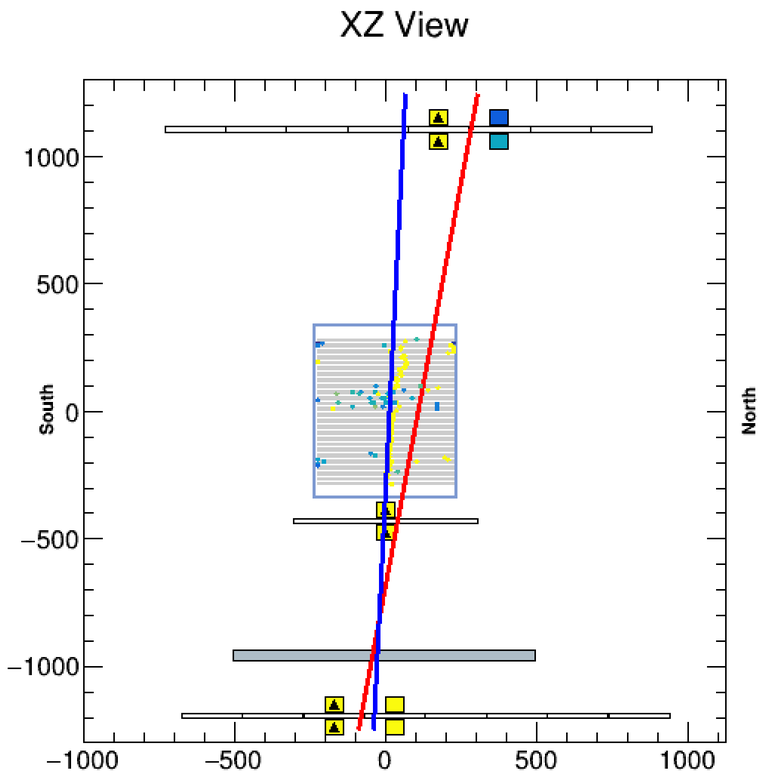
HELIX Flight 2024

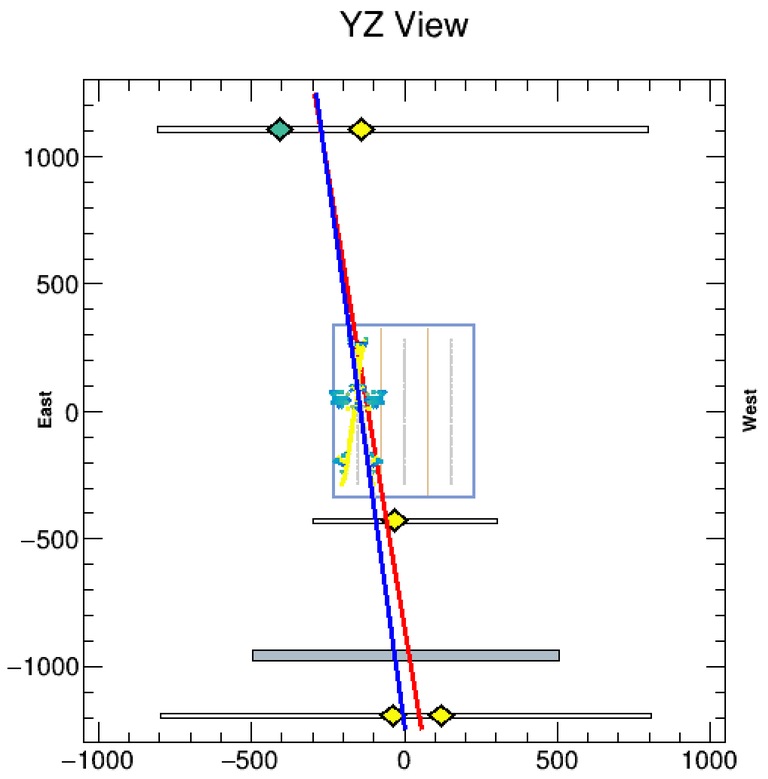
Total flight time: 6 days 8 hrs 27 min

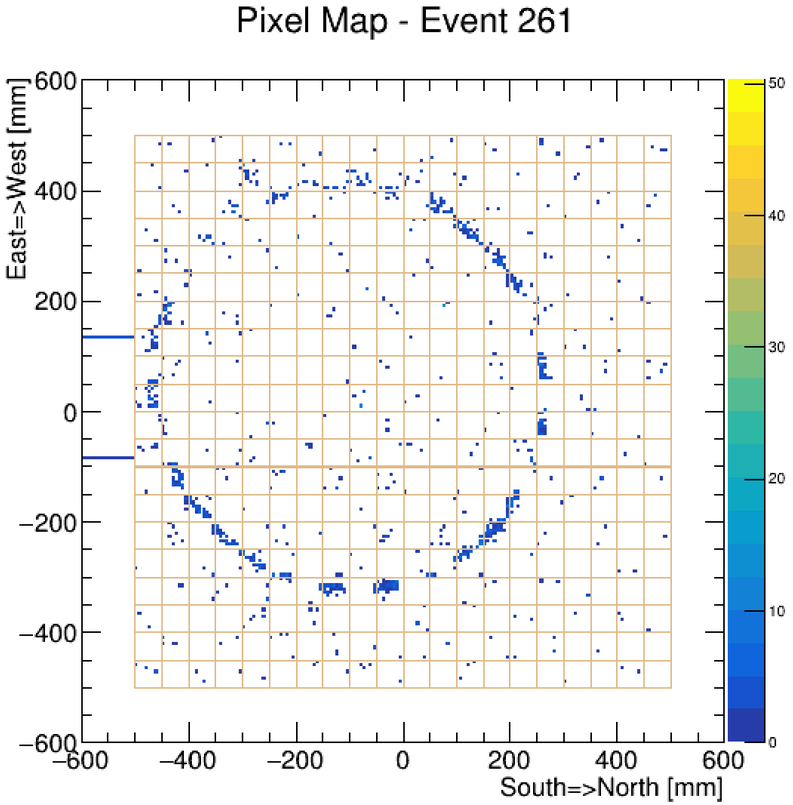
- Recovery campaign scheduled in late June



Raw data example (downlink)



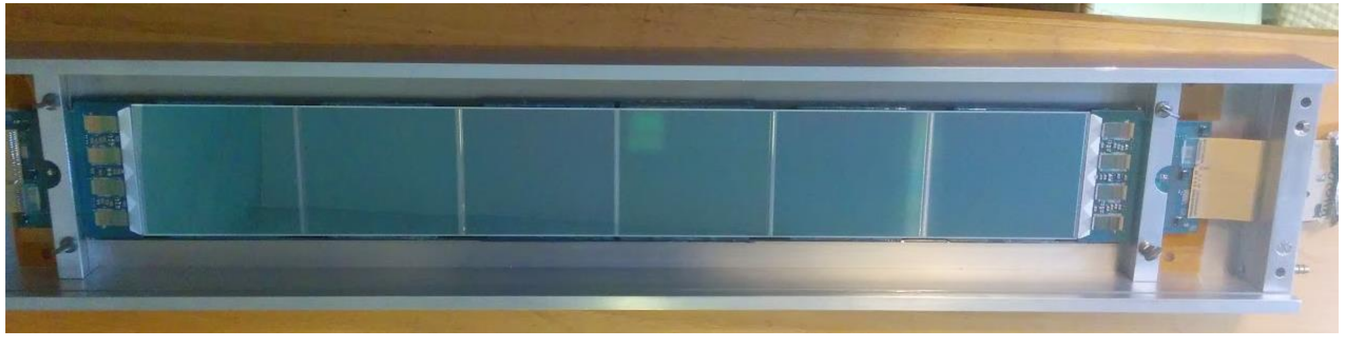


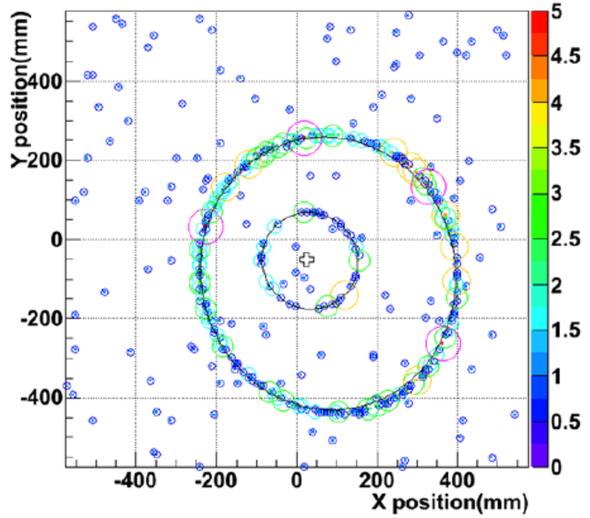


HELIX Stage2

Needs extend to the measurements to 10 GeV/n with several new detector developments

- Magnet upgrade: longer exposure time (7 days → 28 days)
- Tracker upgrade: better resolution (65 μm→ 5 μm)
  → moving to 4-6 layers of silicon strip trackers
- RICH upgrade
  - -Upgrade to a full focal plane
  - -Potential upgrade to a dual refractive radiator





Summary

HELIX has launched & successfully finished the flight!

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 magnet spectrometer designed to measure the light isotopes from proton up to neon (Z=10). The instrument is optimized to measure ^{10}Be from 0.2 GeV/n to beyond 3 GeV/n with a mass resolution $\lesssim$ 3%.

Recovery campaign is currently on-going

- Stay tuned for the updates!