

HELIX

(High Energy Light Isotope eXperiment)

Presented by Nahee Park



Queen's
UNIVERSITY

HELIX Collaboration

University of Chicago

- Hyebin Jeon, Keith McBride, Kenichi Sakai, Scott P. Wakely

Indiana University

- 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

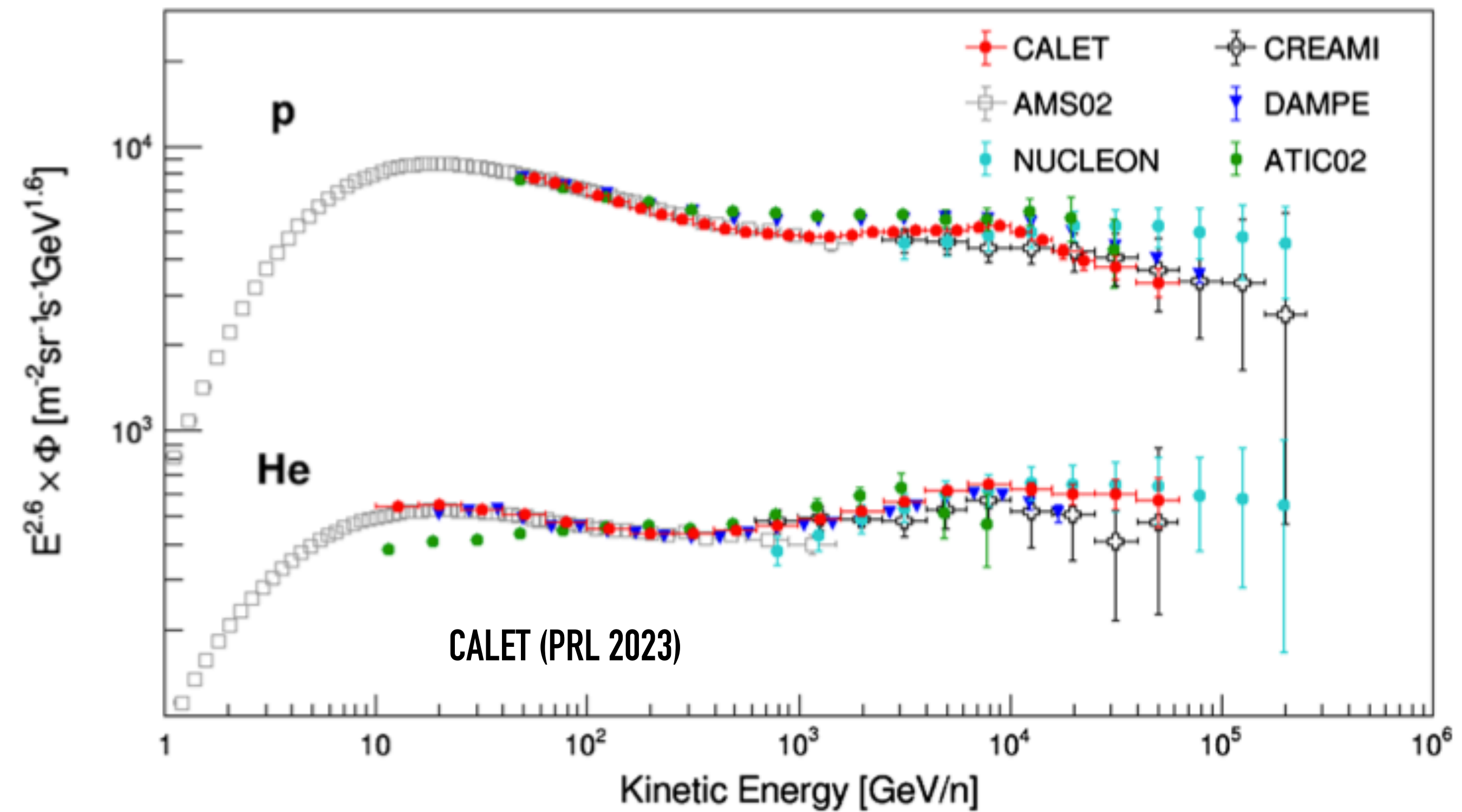
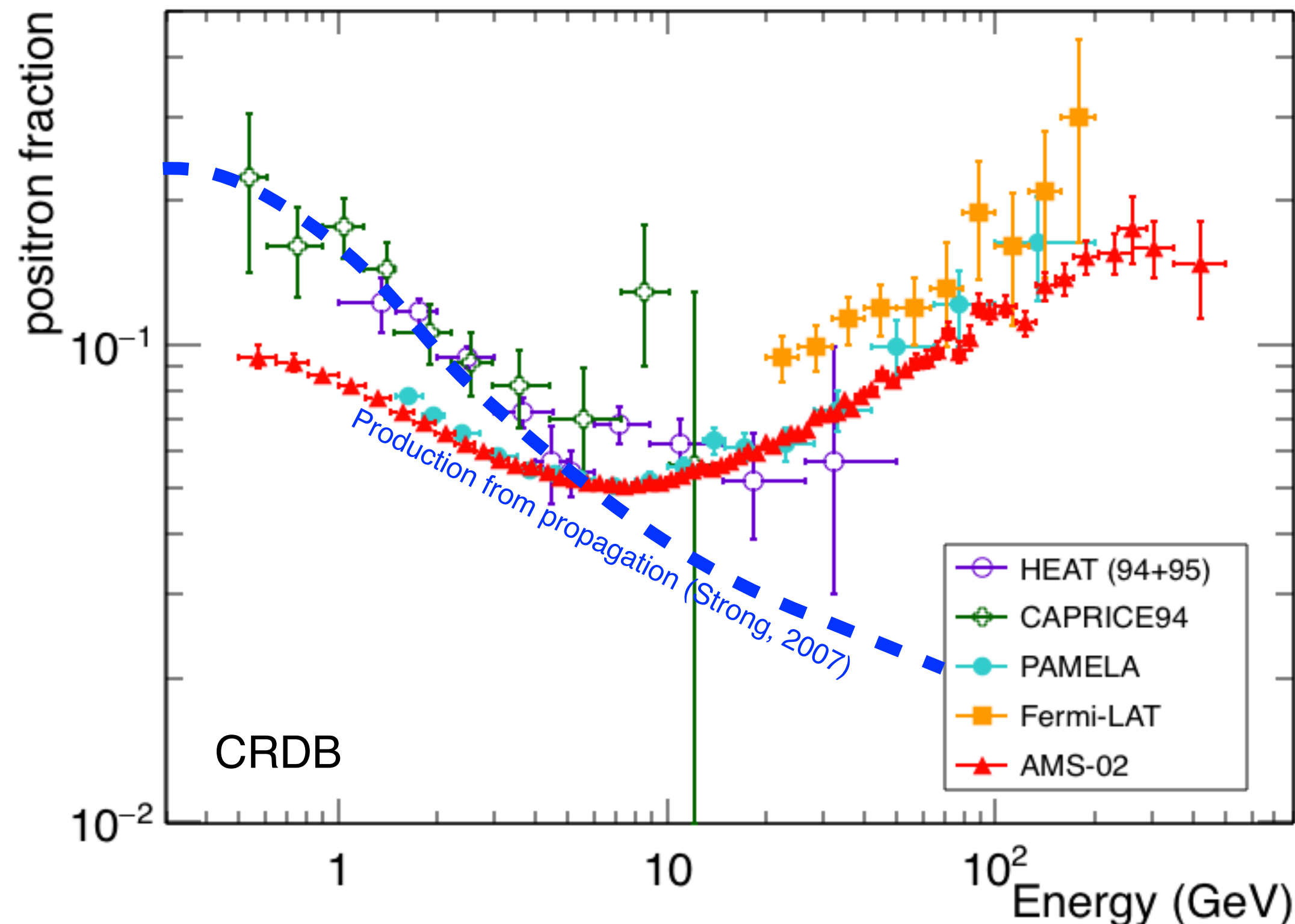
- Noah Green, Gergory Tarle



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

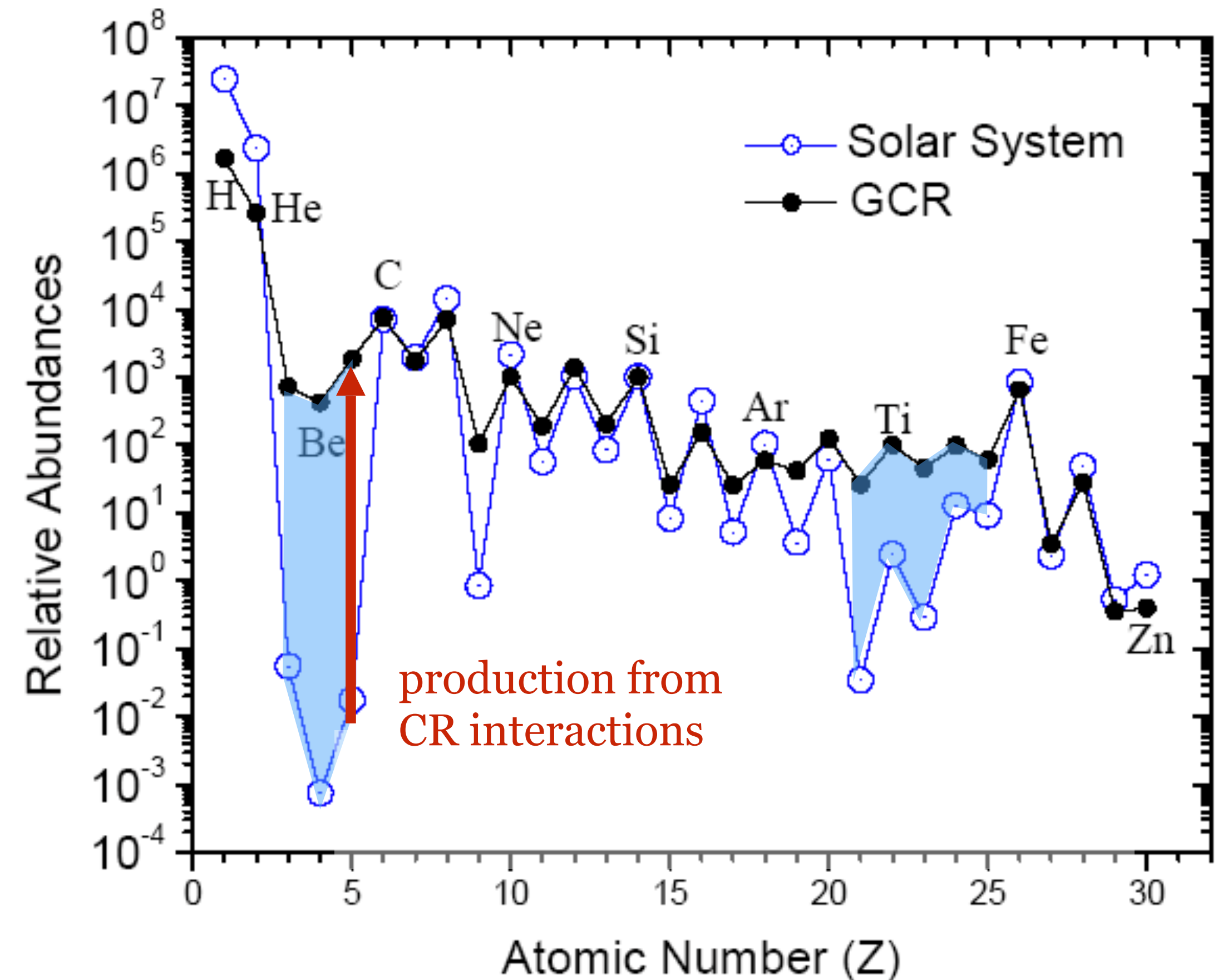
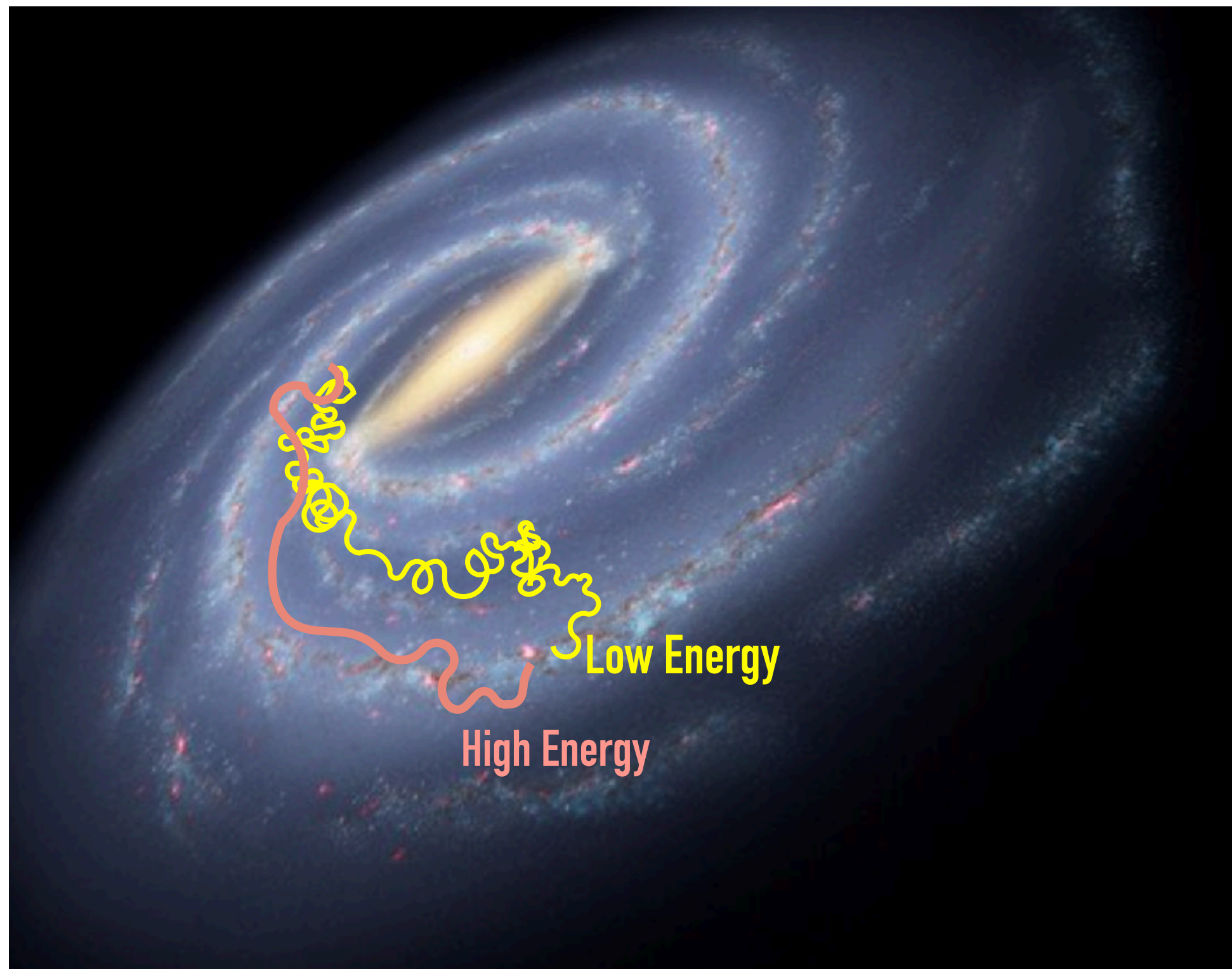


→ *It is critical to understand the propagation!*

Primary/Secondary Ratio for Propagation Studies

Amount of material traversed by CRs in our Galaxy can be estimated by primary-to-secondary ratio

- Boron-to-Carbon (B/C) ratio is best measured

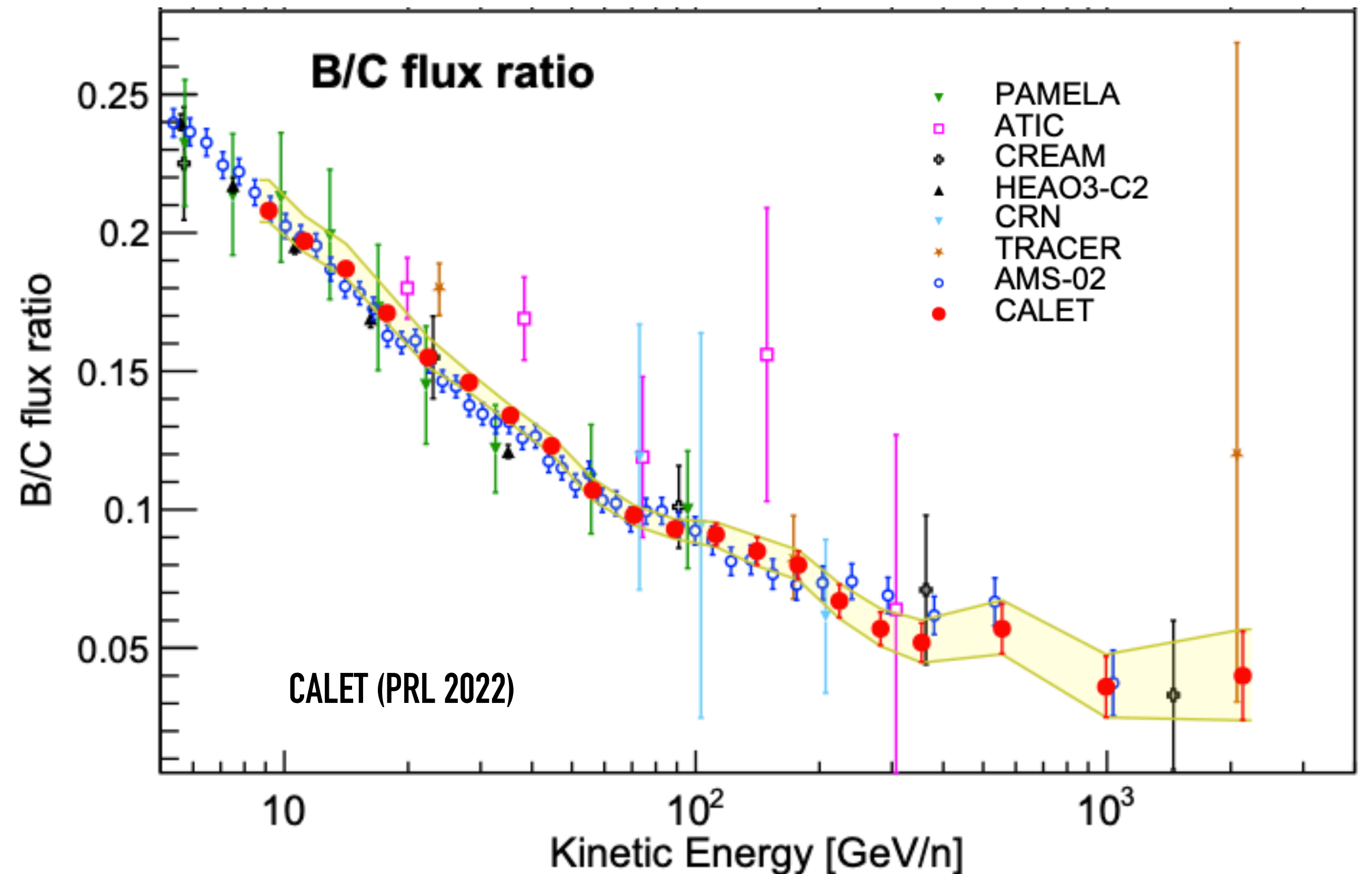
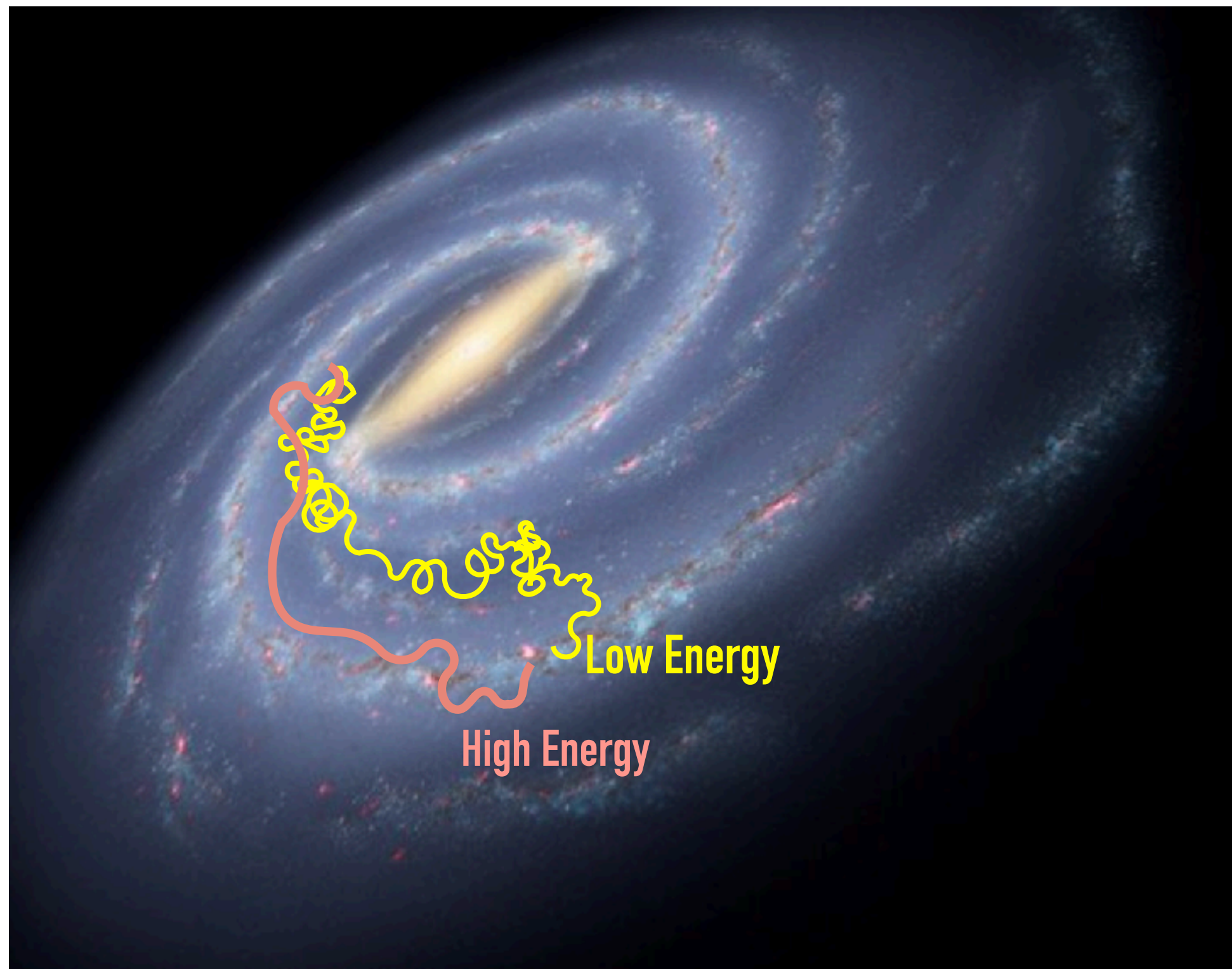


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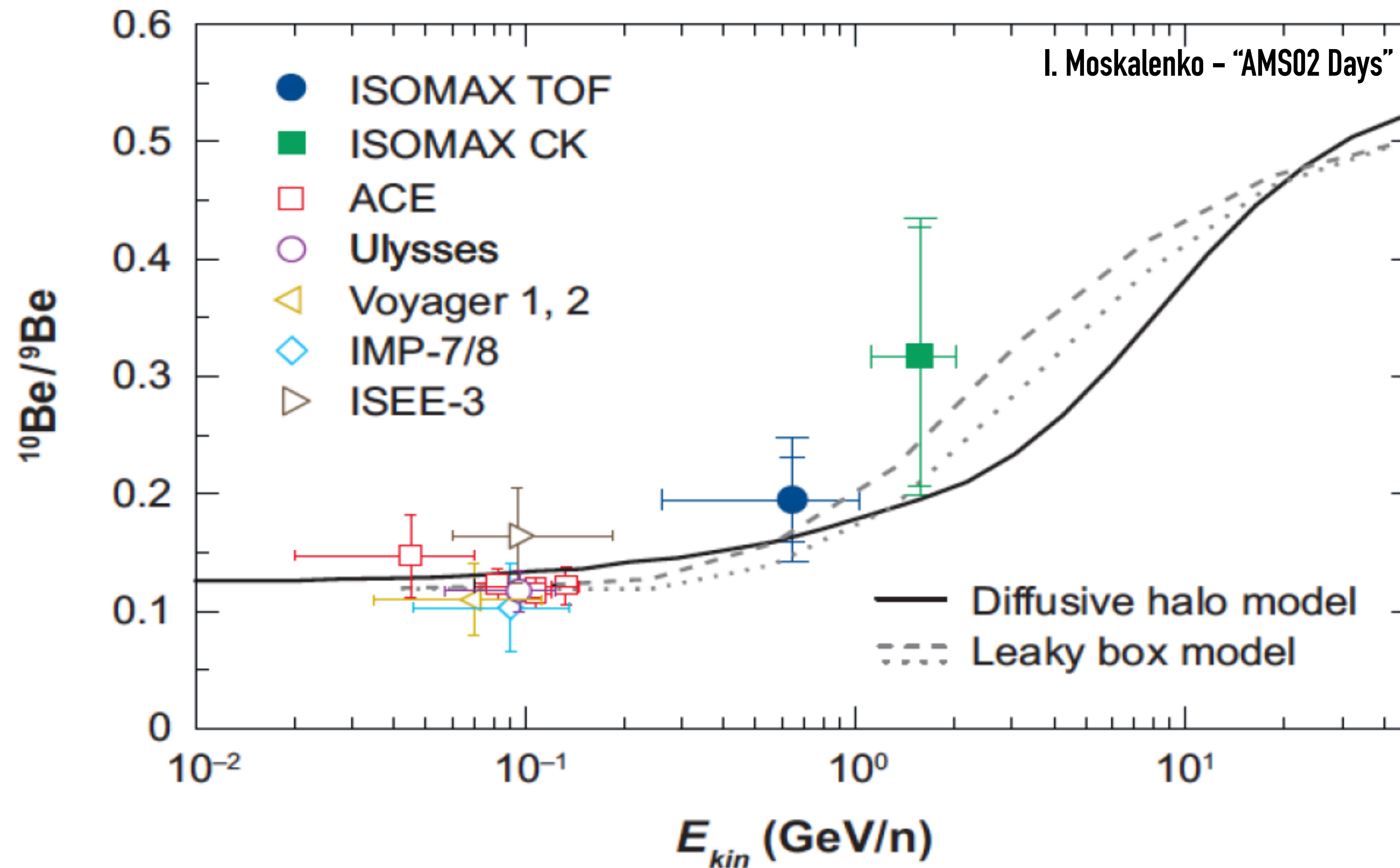
→ *Sensitive to the average amount of matter traversed by CRs during their average lifetime in our Galaxy*



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

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

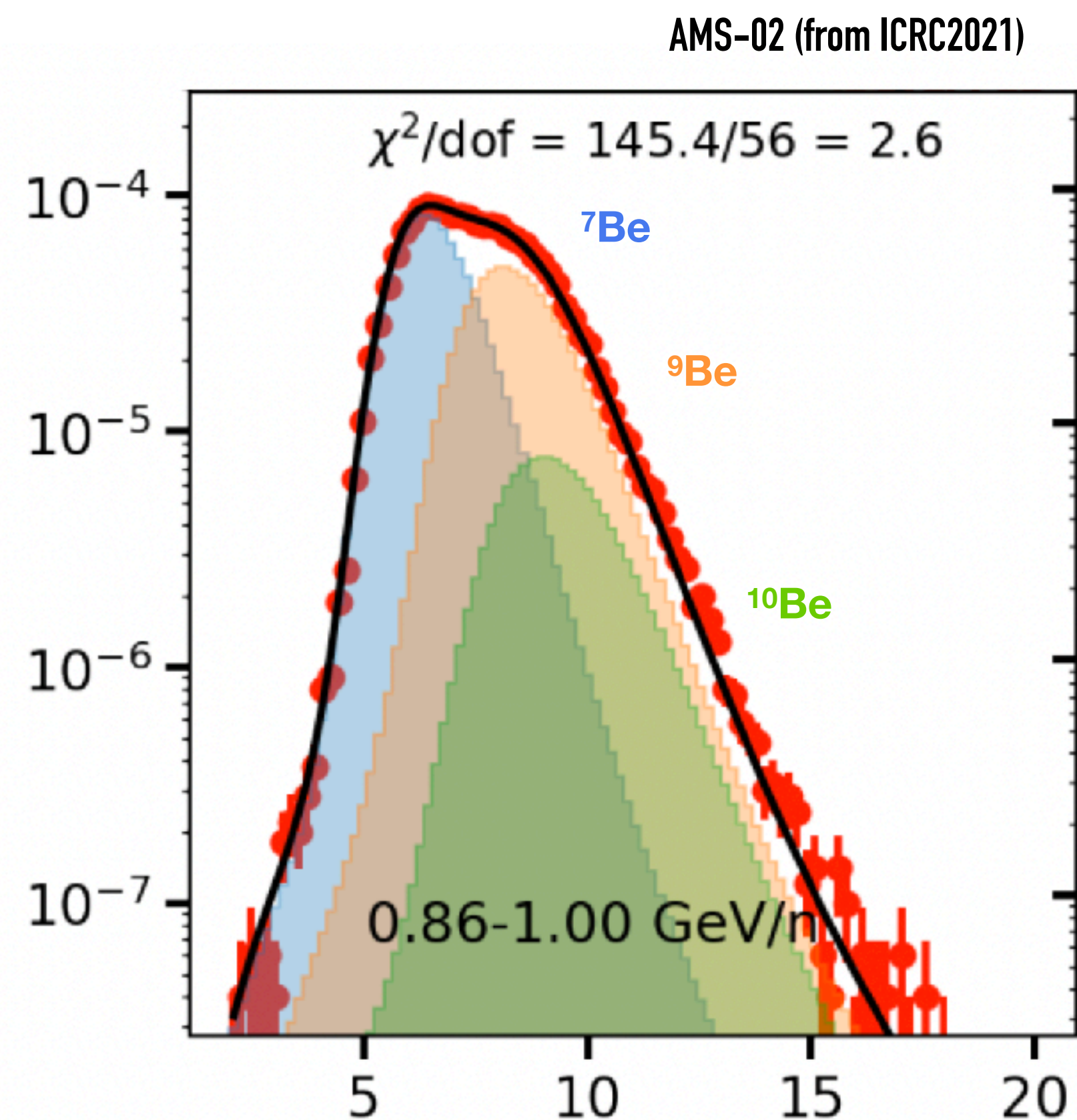
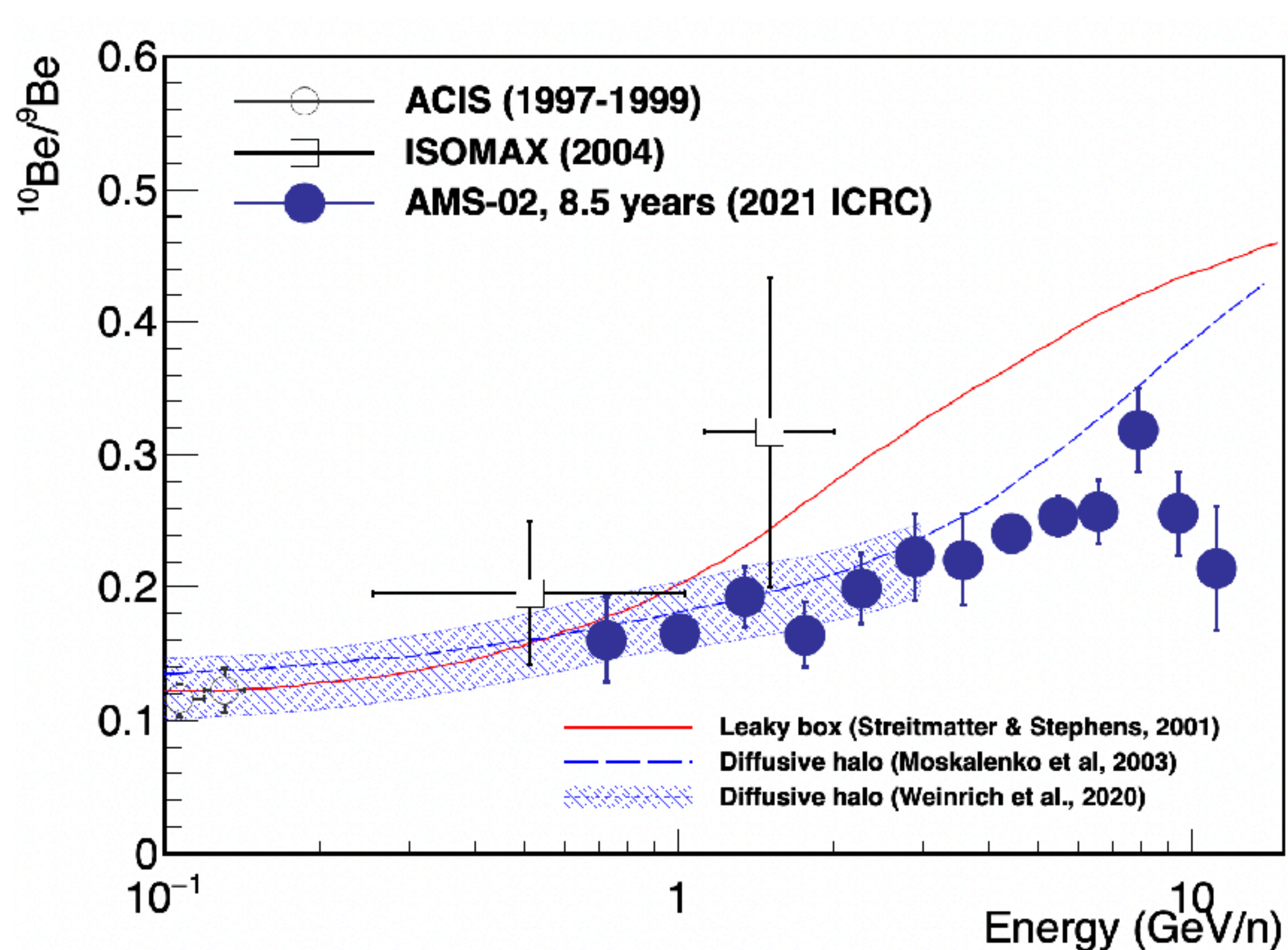
- $^{10}\text{Be}/^9\text{Be}$ ratio provides strong constraints for the propagation models
- Challenging measurements



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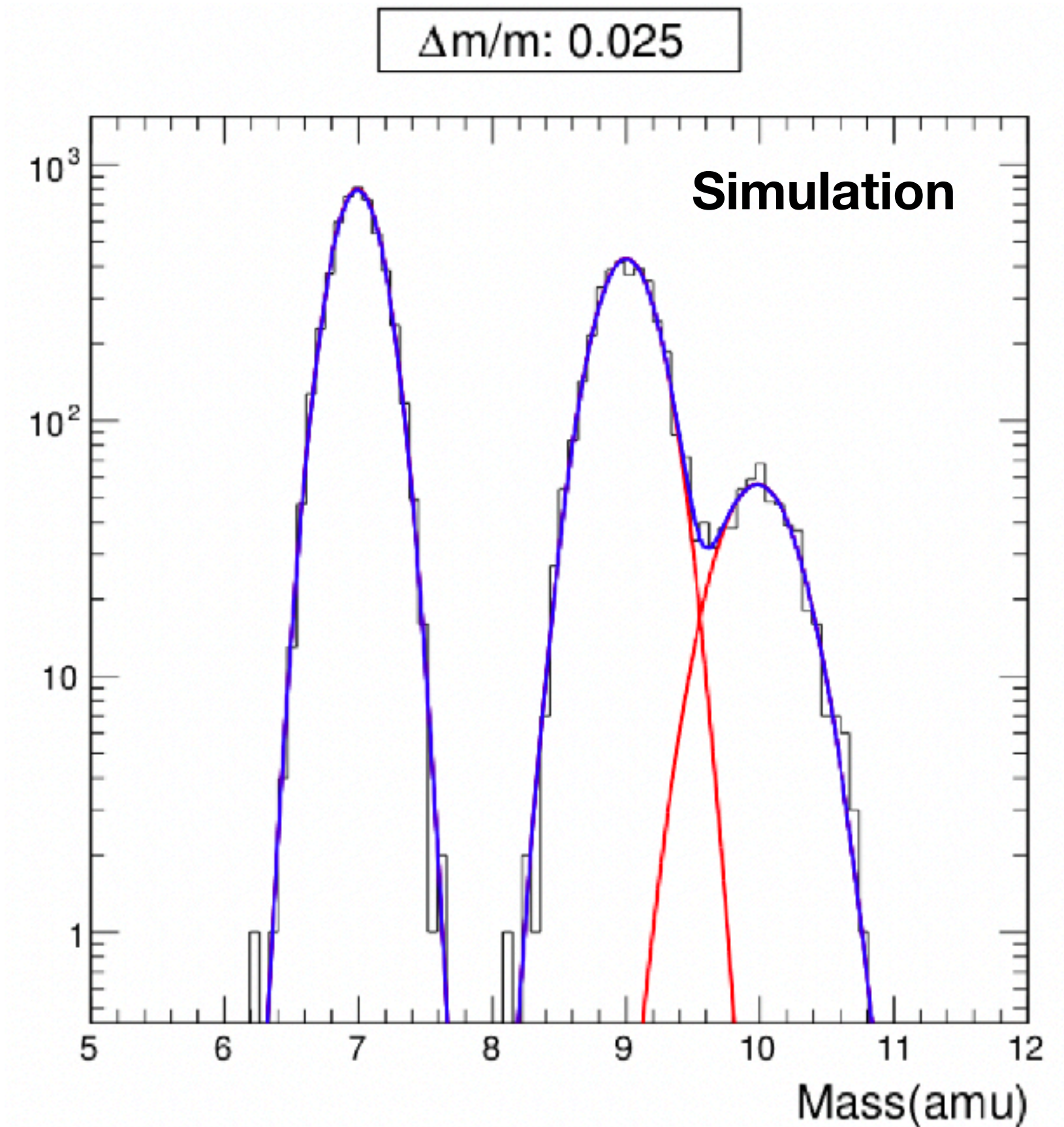
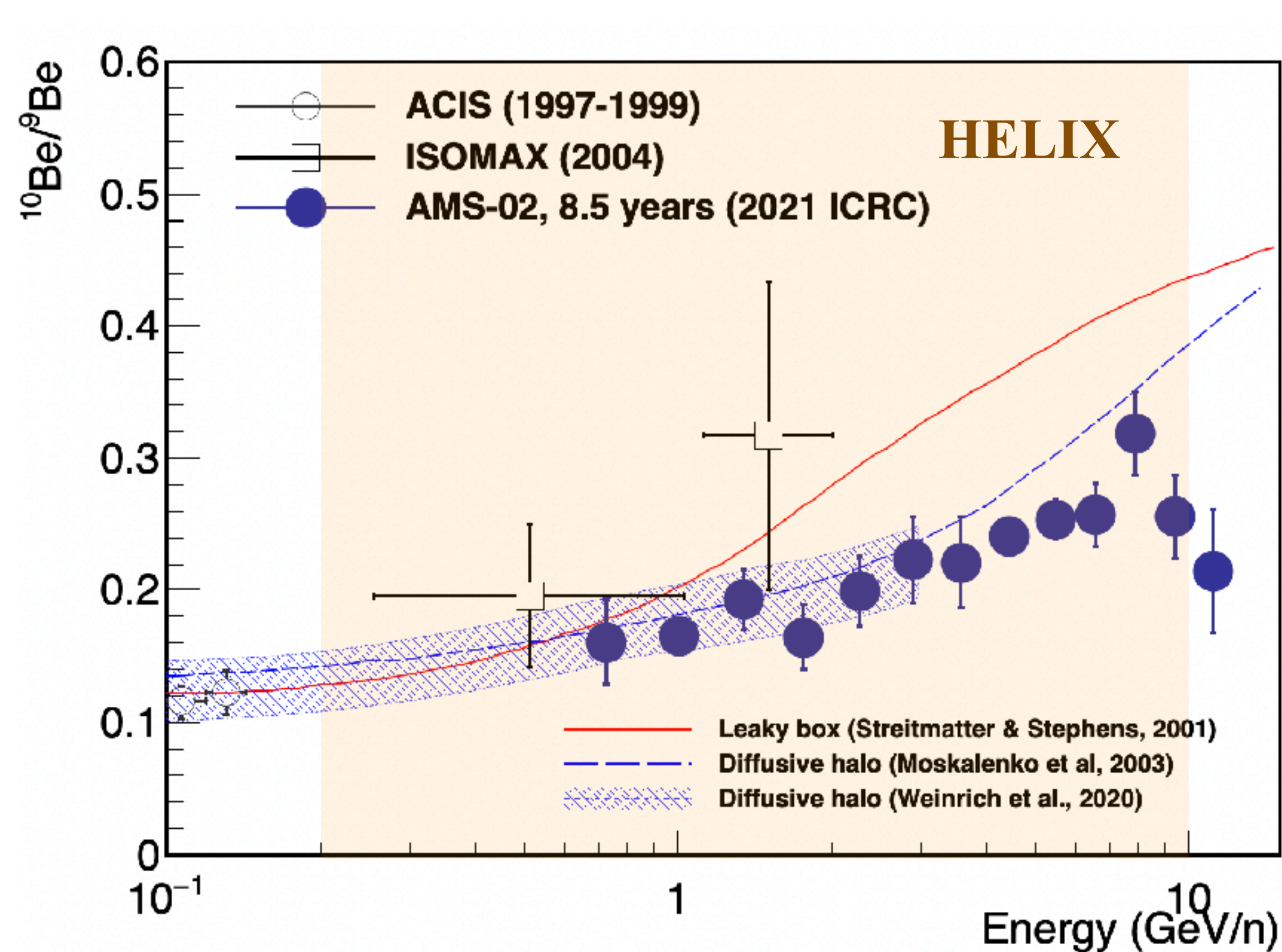


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HELIX is designed to provide a precision measurement of ^{10}Be !

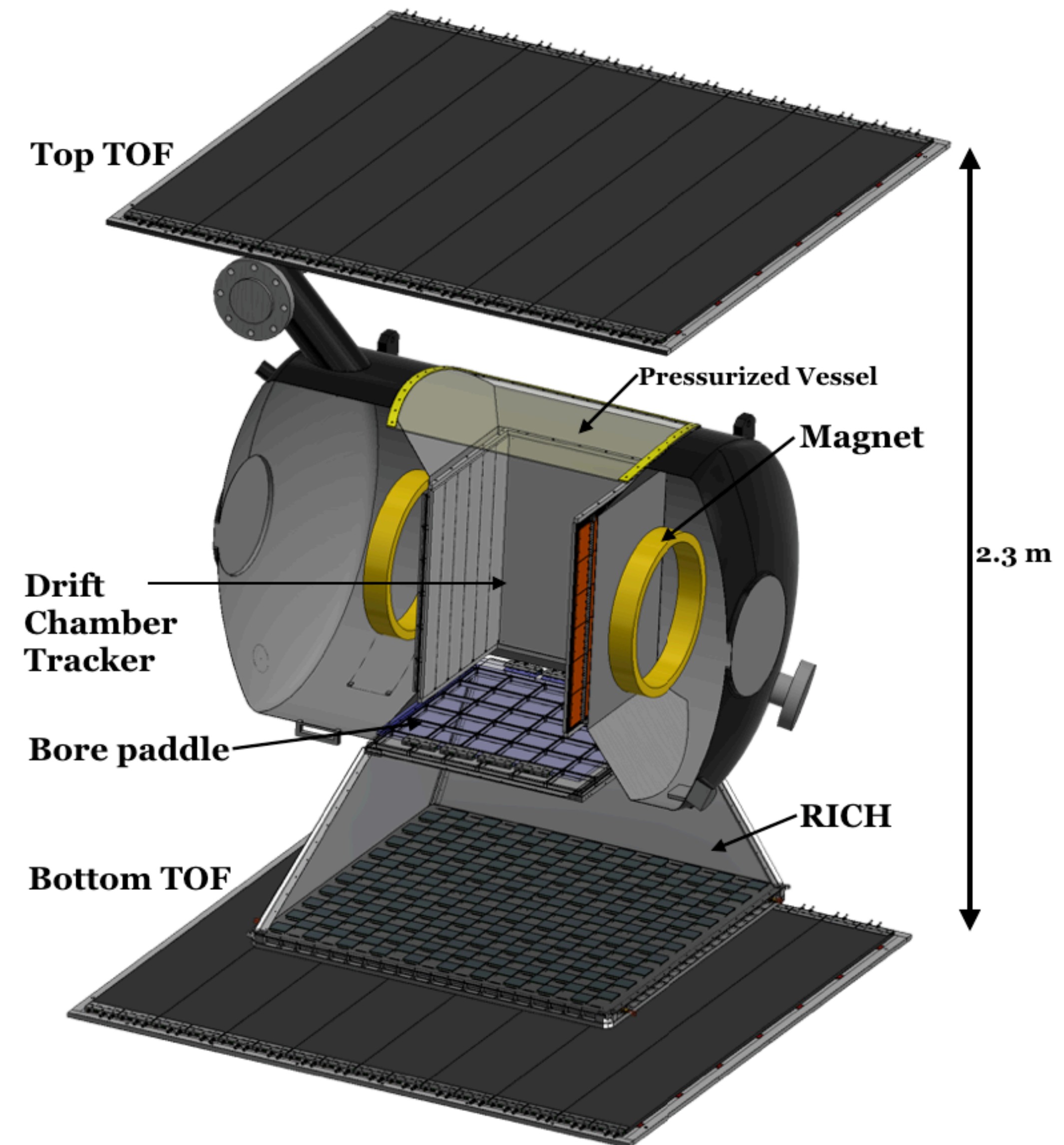


High Energy Light Isotope eXperiment

A new balloon-borne magnet spectrometer payload to measure $^{10}\text{Be}/^9\text{Be}$ 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

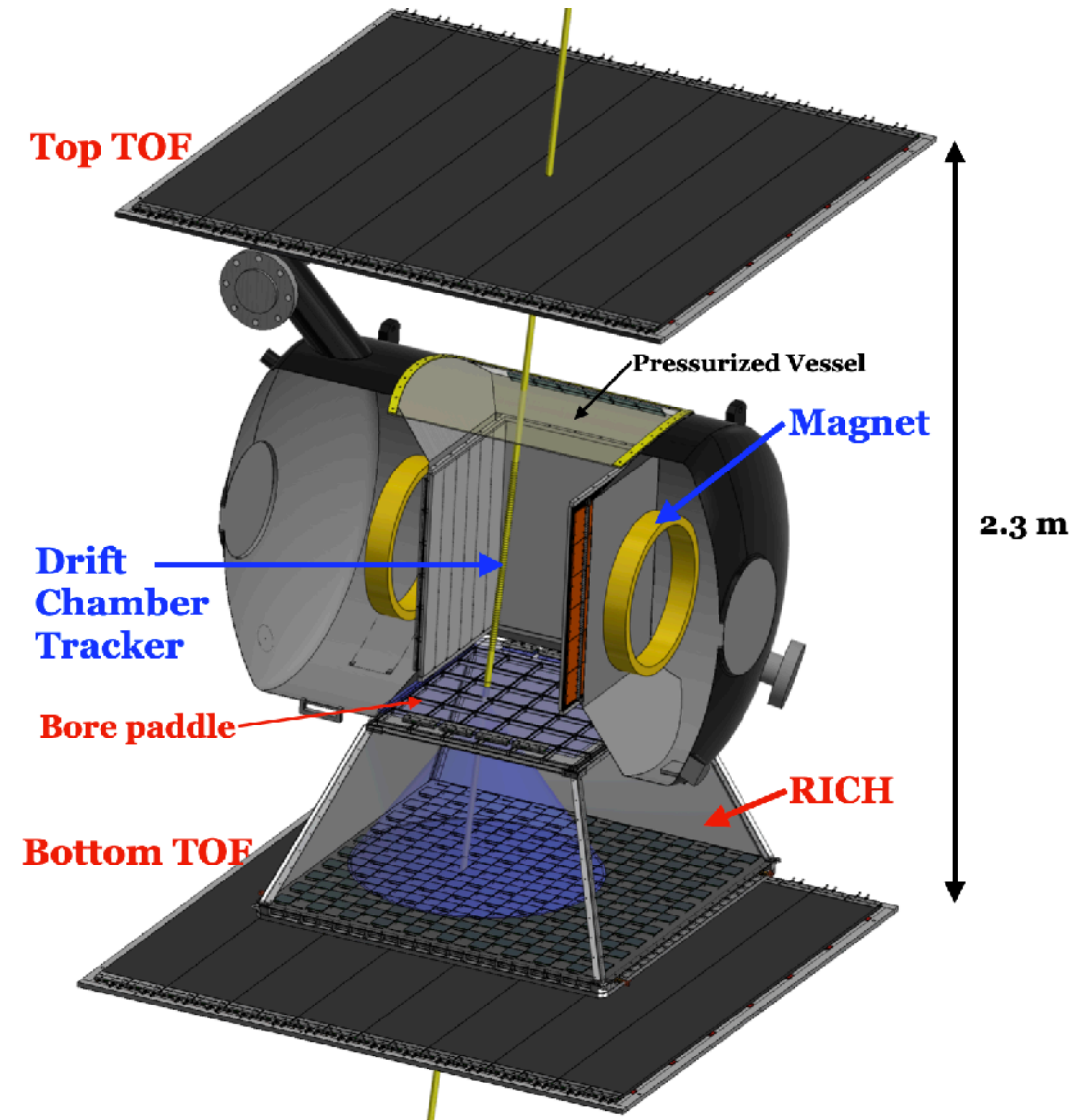
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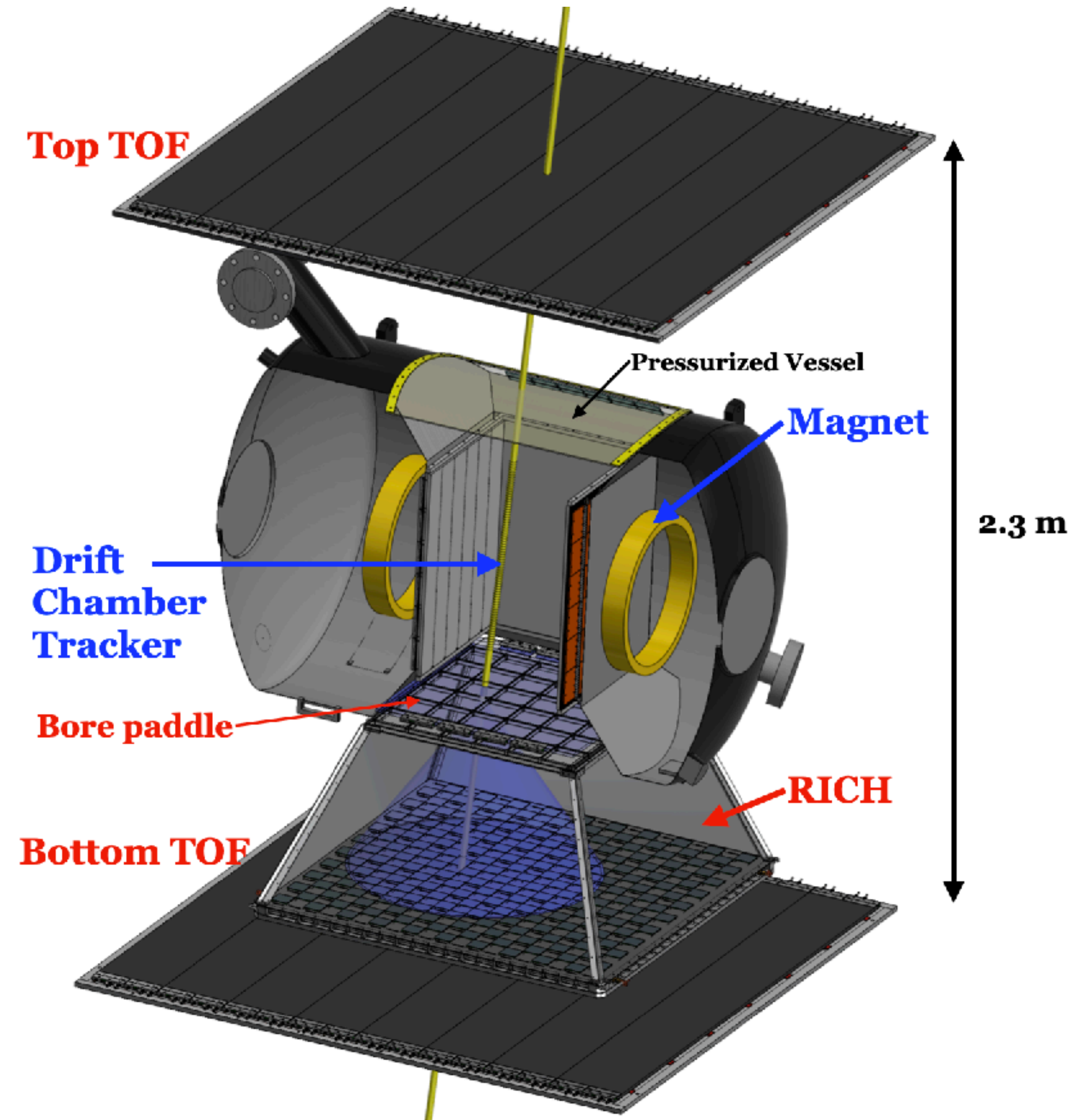
- Two stage approach to cover wider range of energy

- Stage 1 : covers up to ~ 3 GeV/n



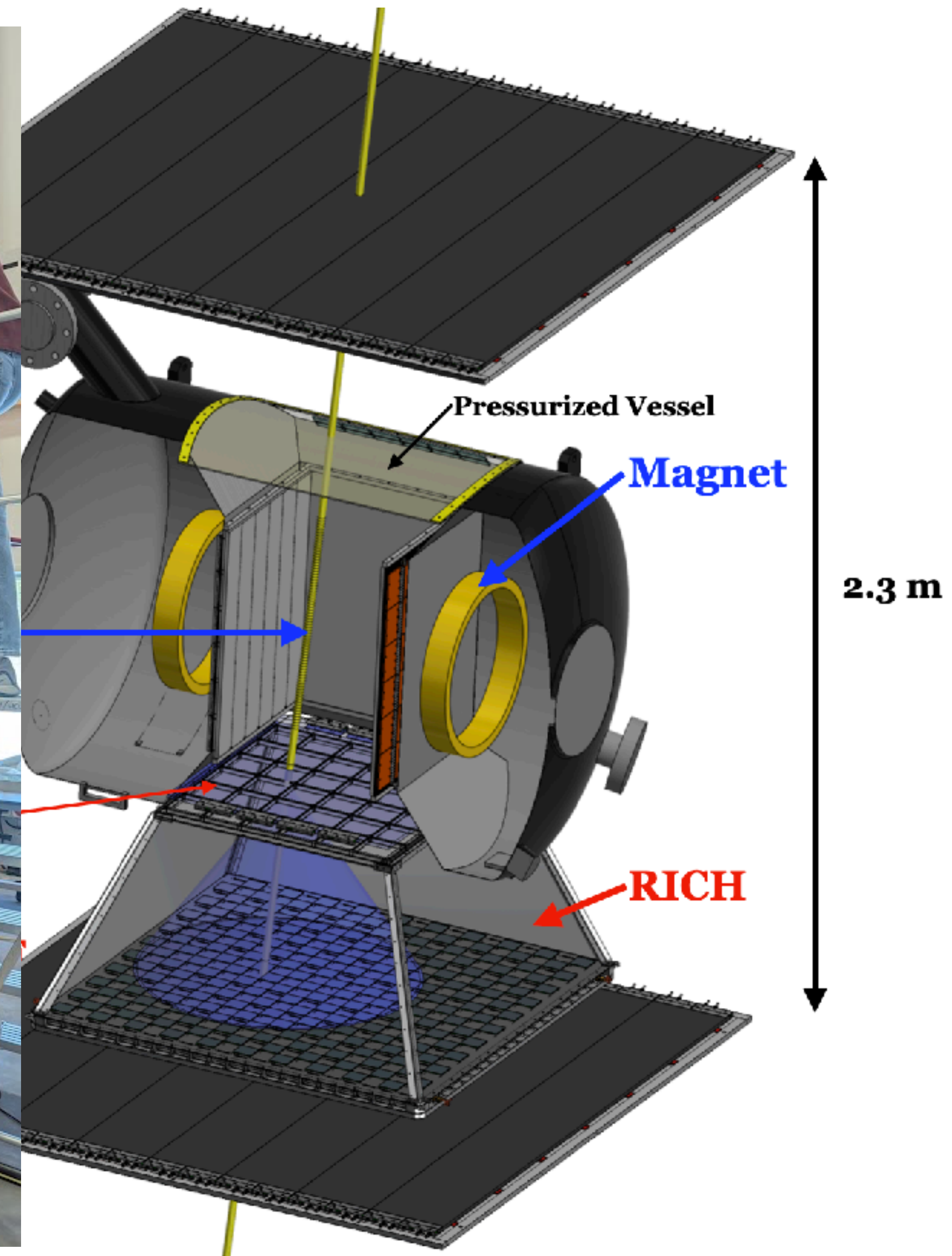
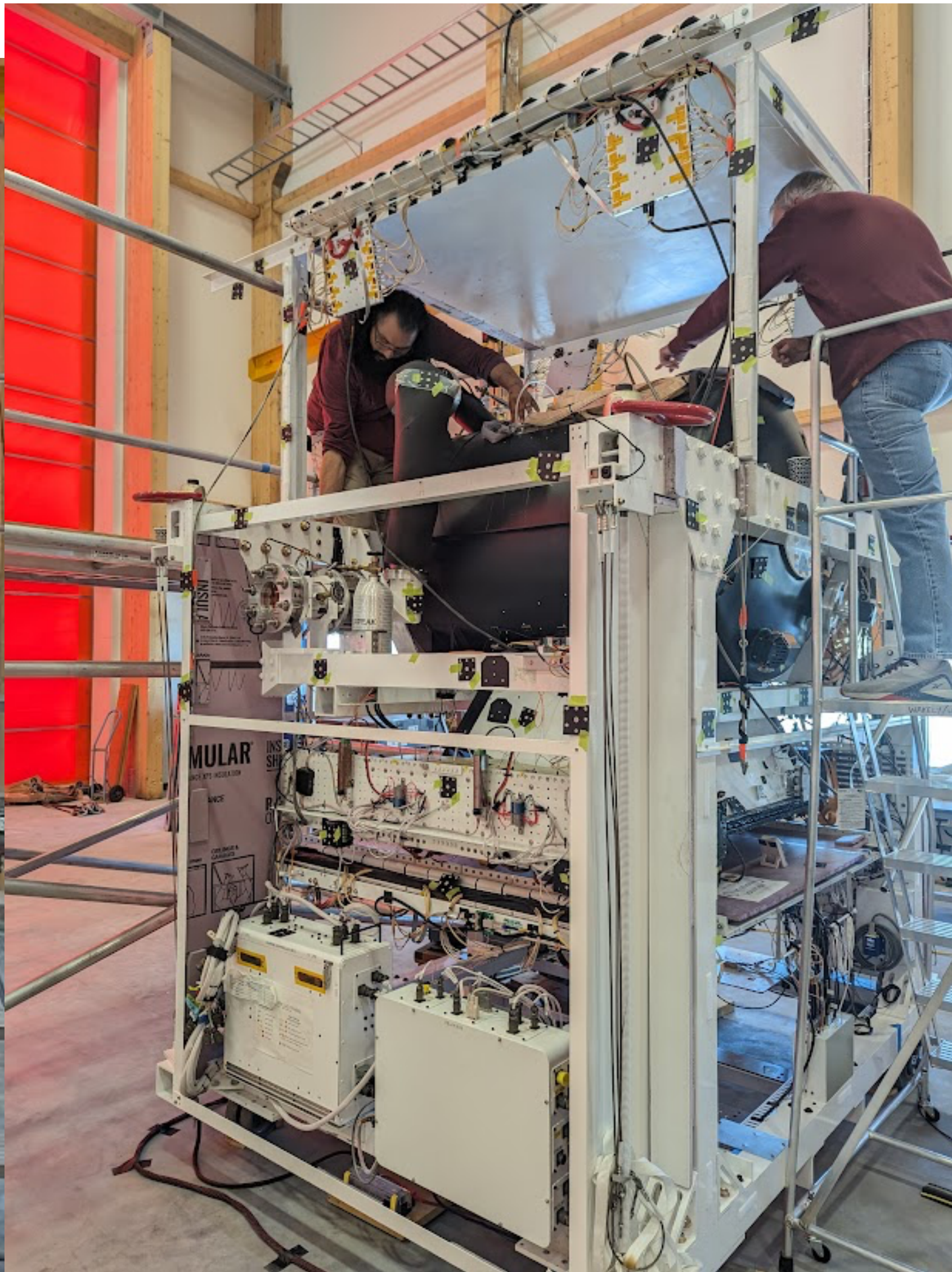
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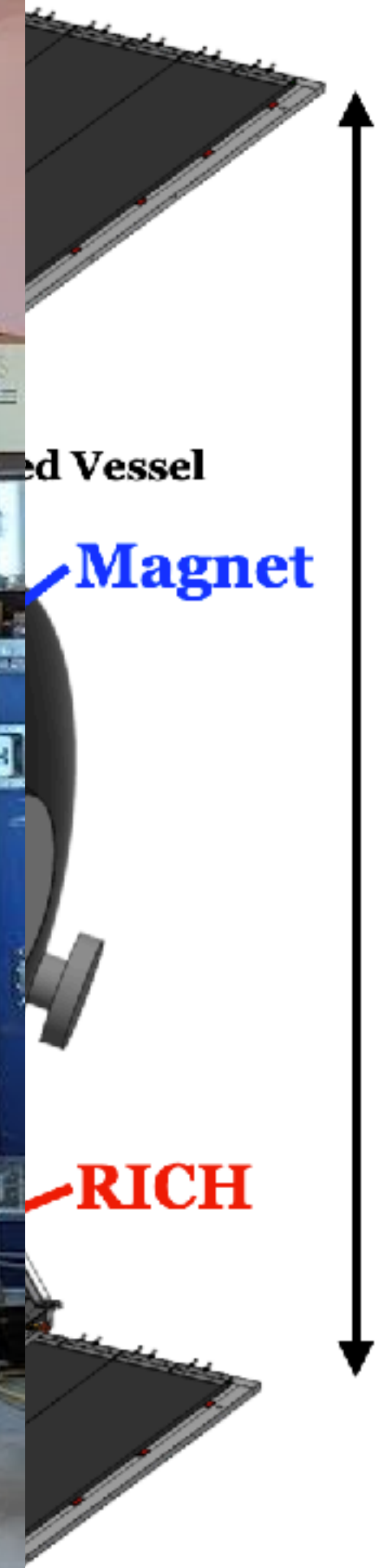
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A new n
10 GeV/



ment
up to

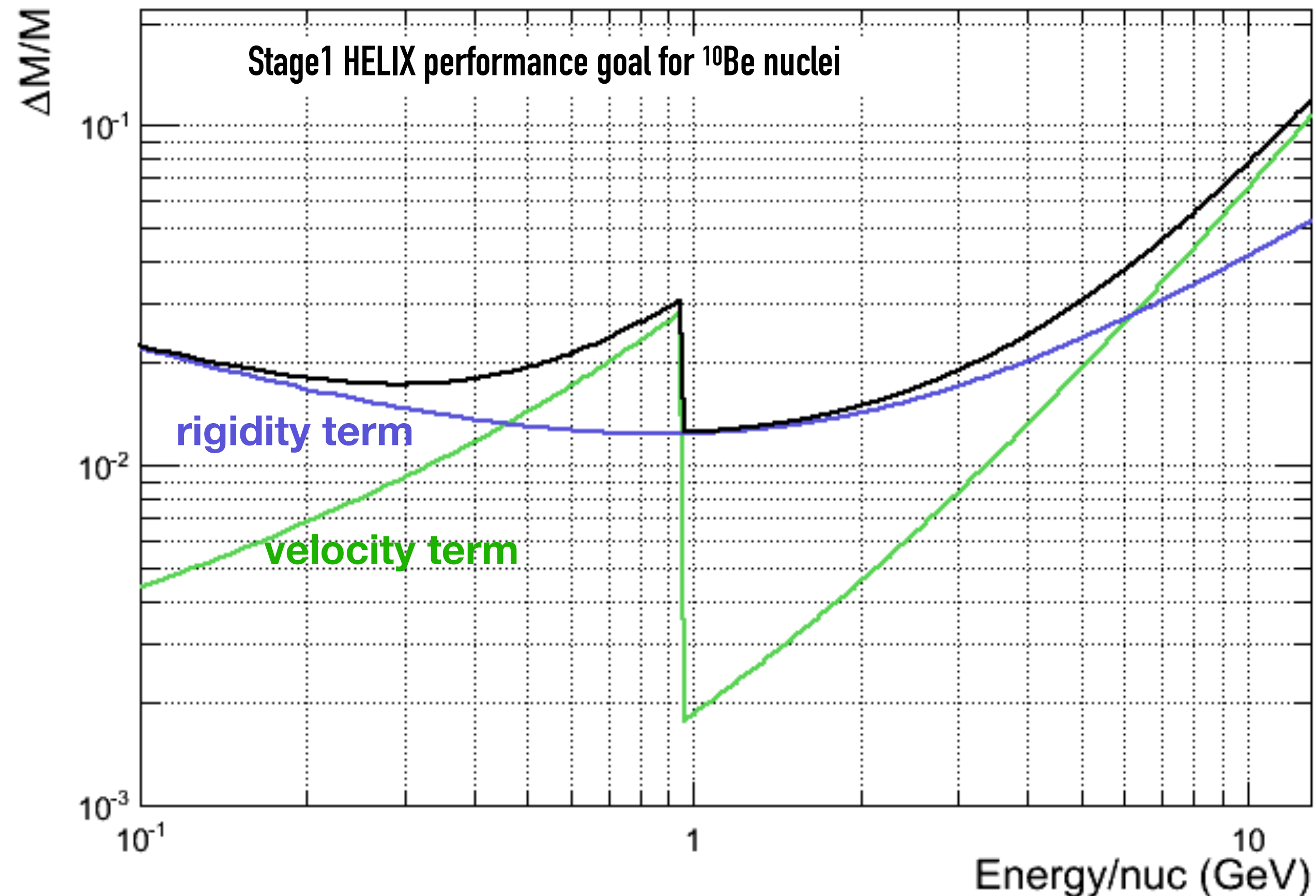


2.3 m

HELIX Stage1 Performance Goals

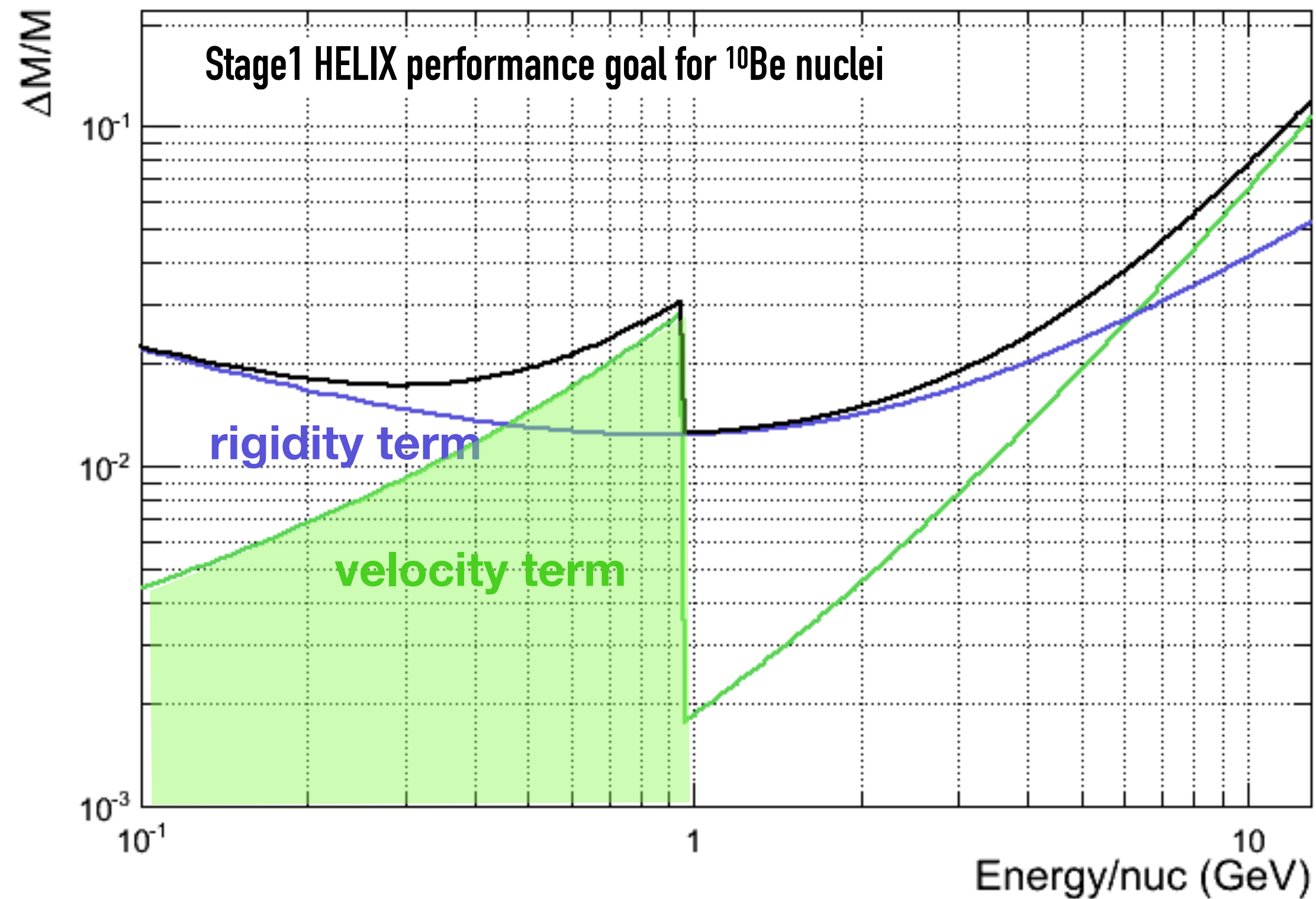
$^{10}\text{Be}/^9\text{Be}$ ratio up to ~ 3 GeV/n with $\Delta m/m \sim 2.5\%$

- 7-14 day exposure with $0.1 \text{ m}^2\text{sr}$ 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



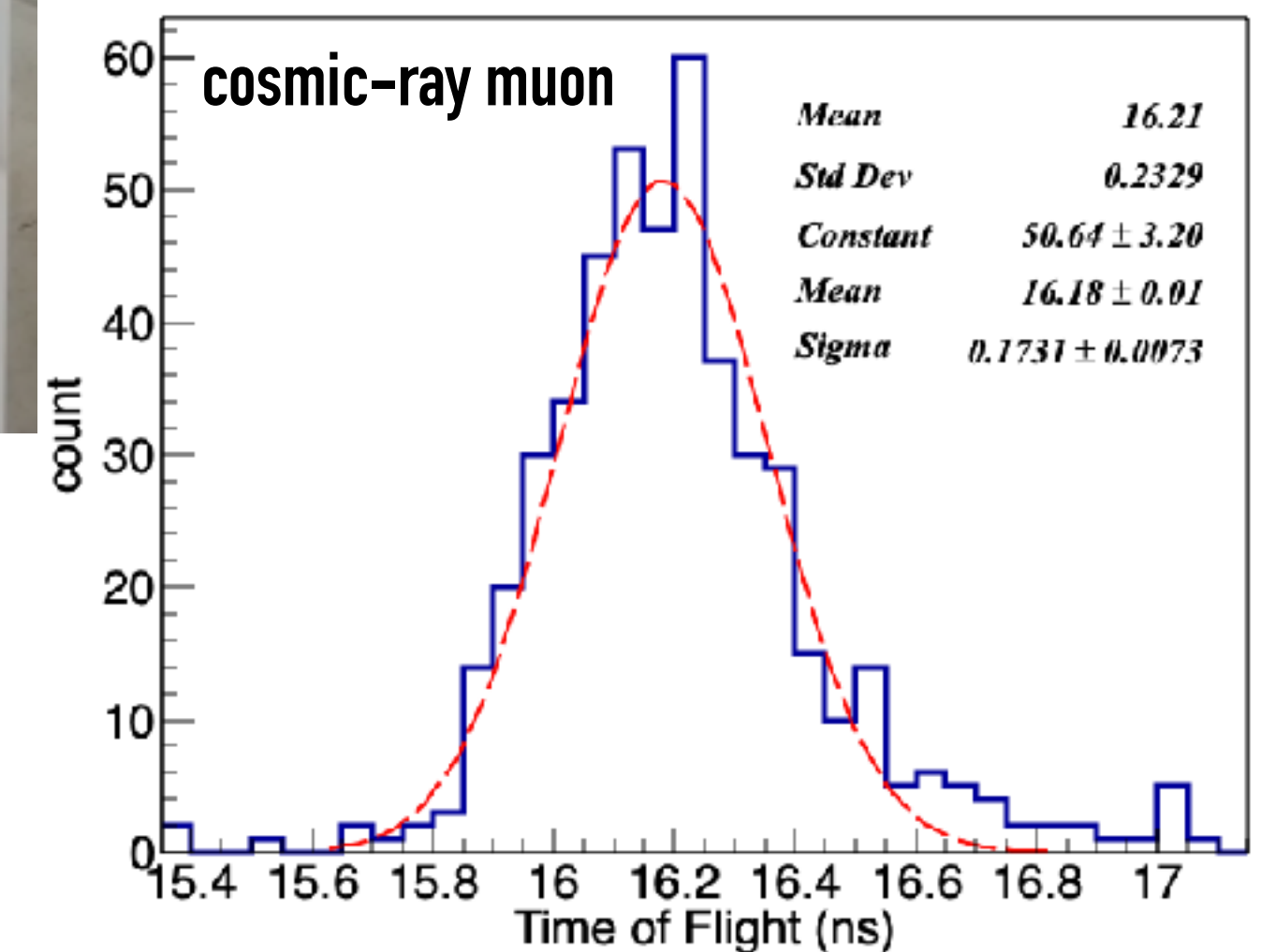
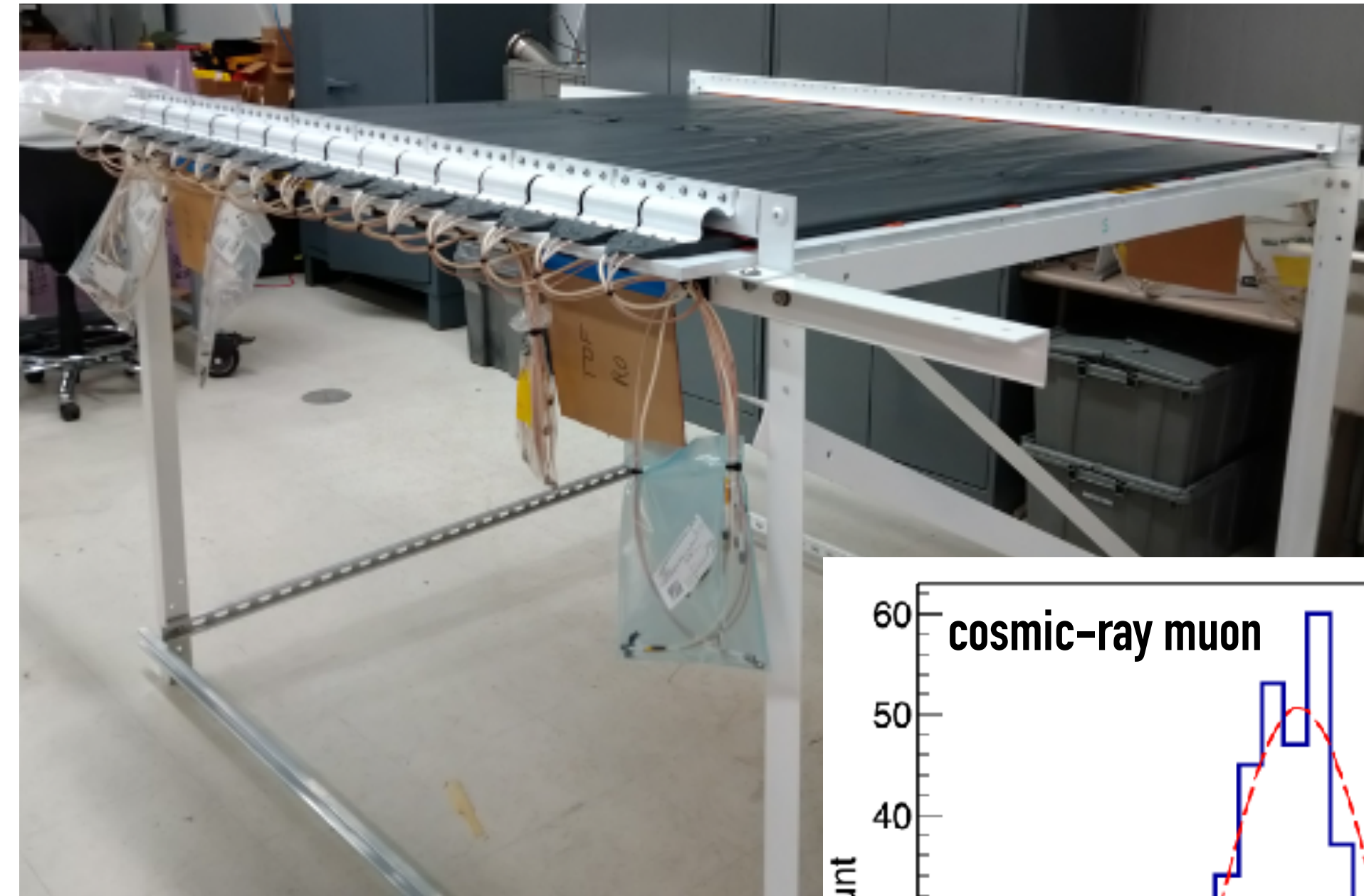
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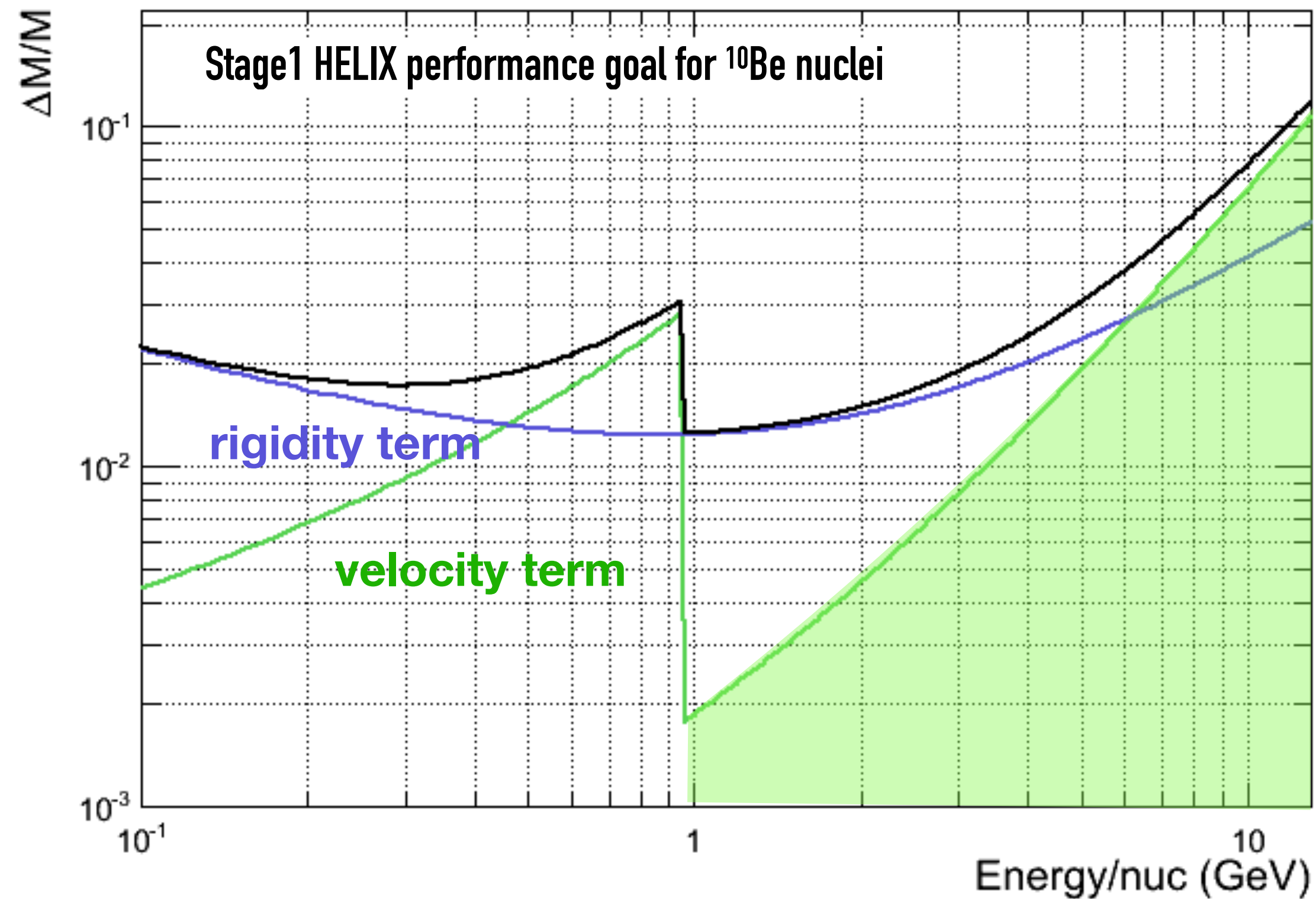
Time of Flight (TOF)

- 3 layers of scintillating paddle, read by SiPMs
- Separation between top & bottom: 2.3 m
- TDC timing resolution better than 25 ps



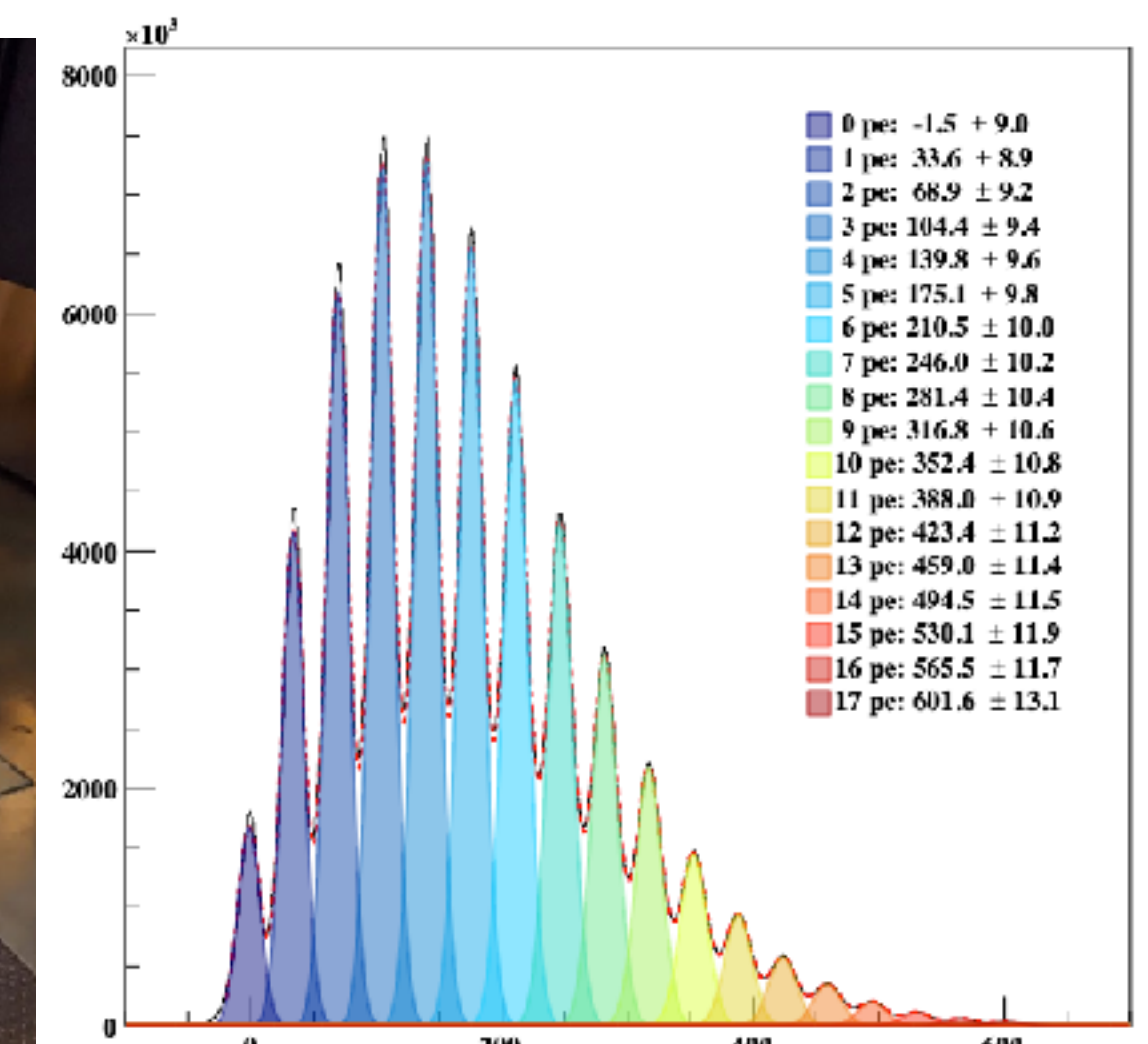
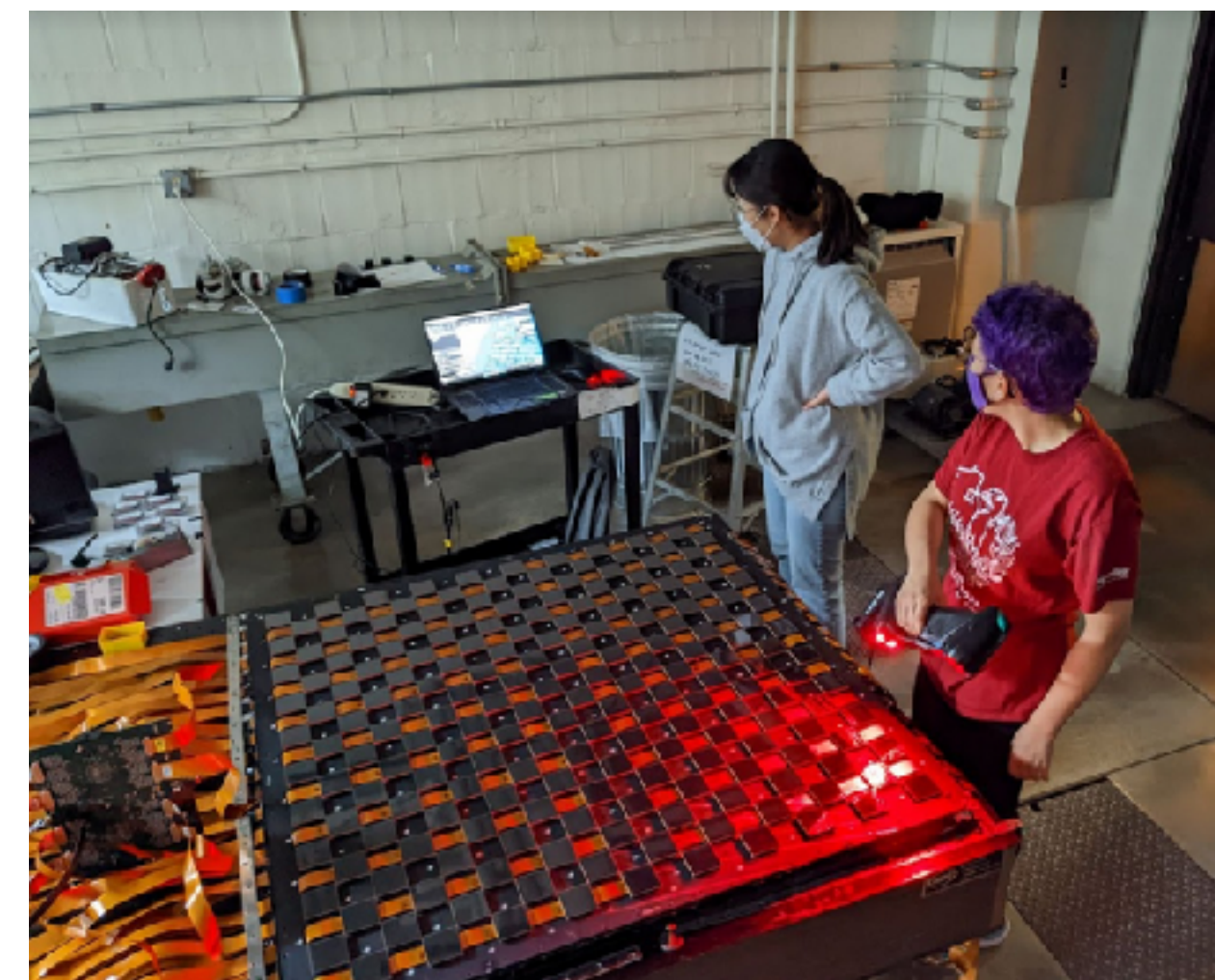
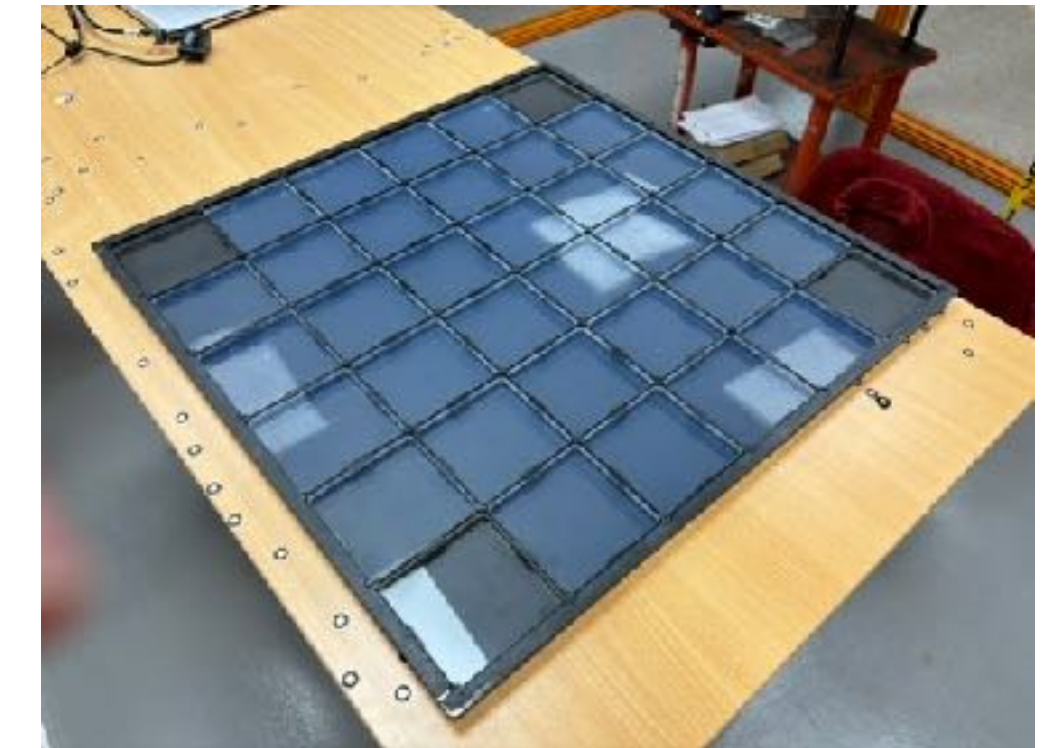
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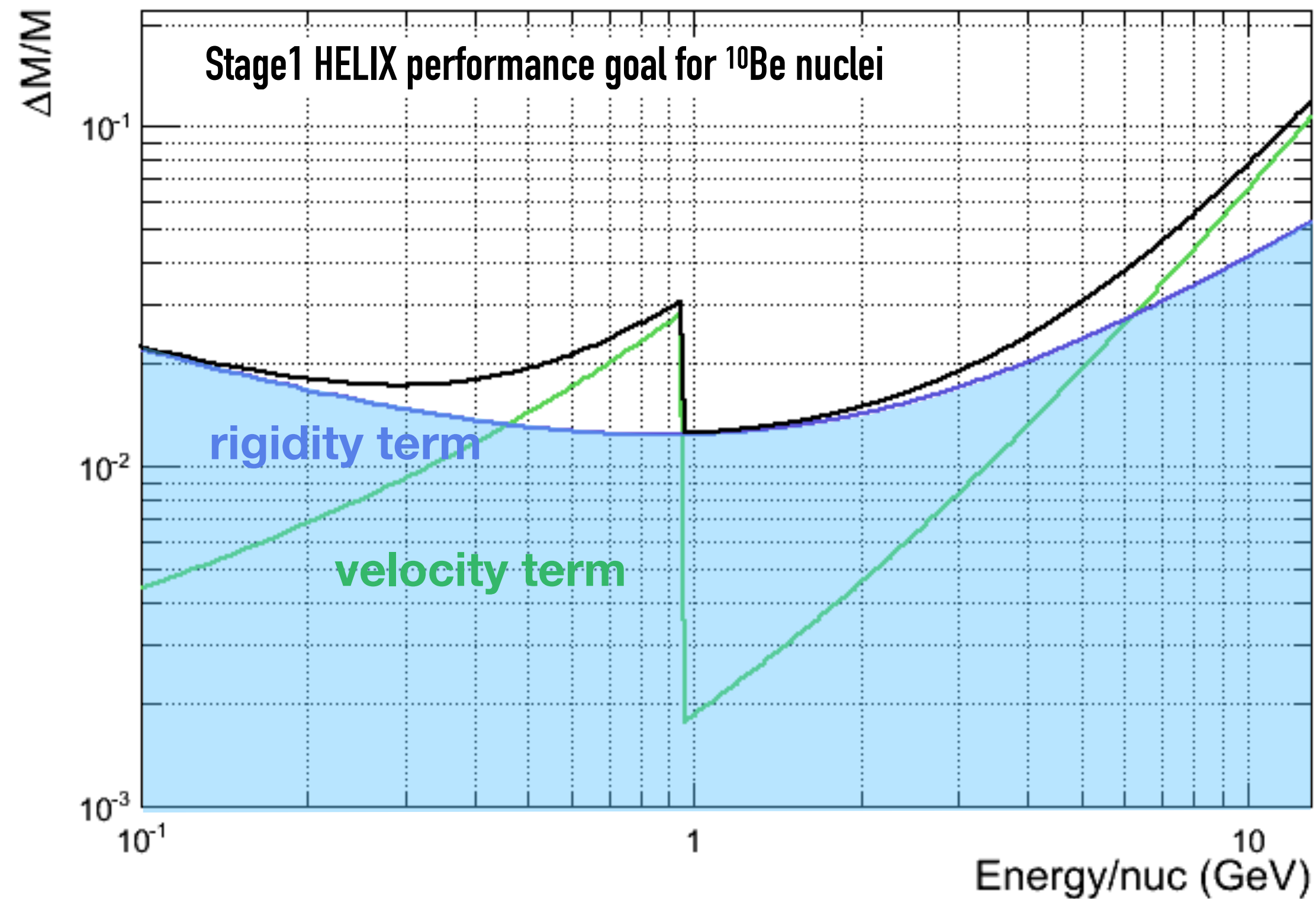
Ring Imaging Cherenkov Counter (RICH)

- Highly transparent, hydrophobic aerogel ($n=1.15$)
- Focal plane ($1\text{ m} \times 1\text{ m}$) covered by $6\text{ mm} \times 6\text{ mm}$ SiPM array



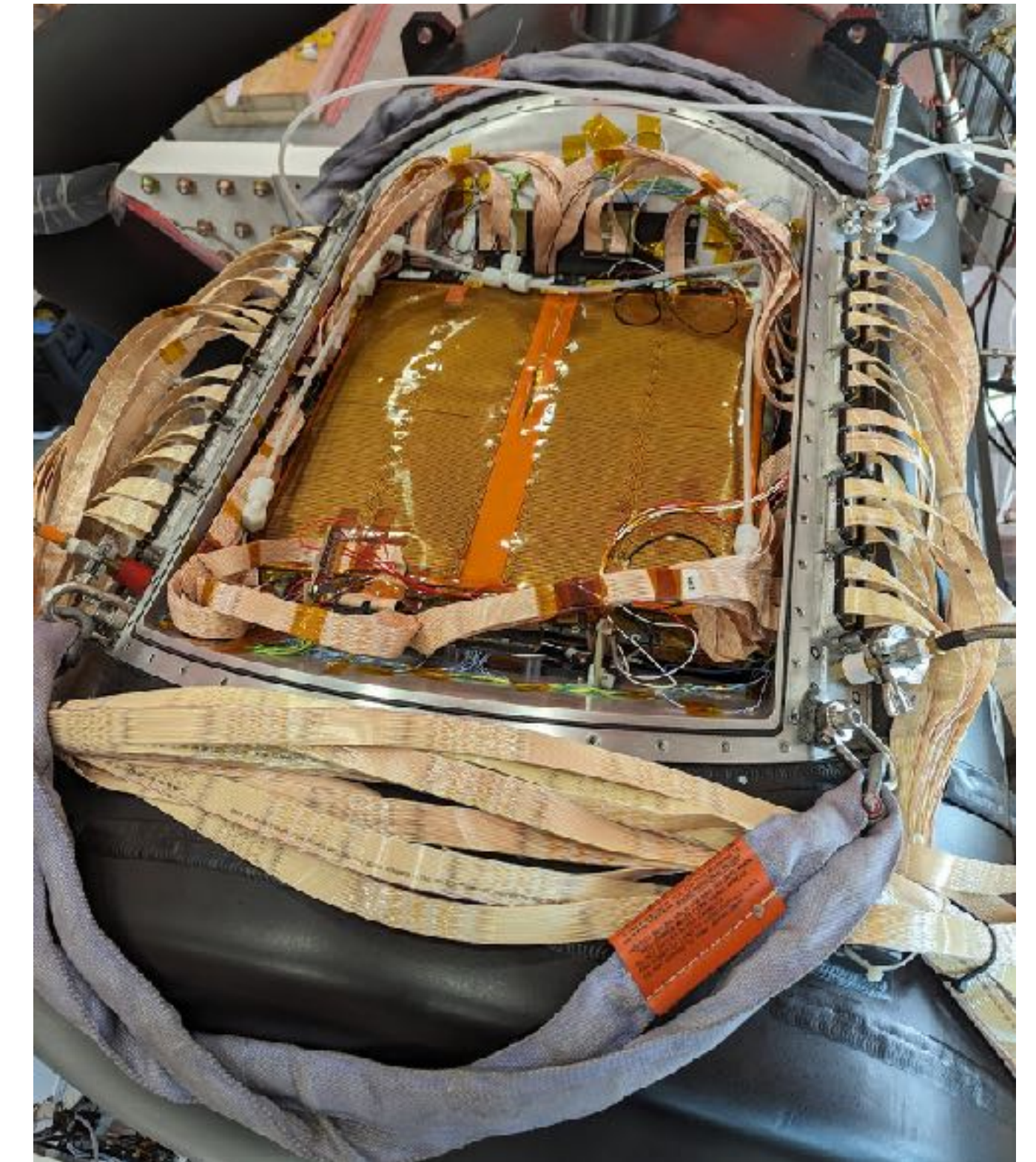
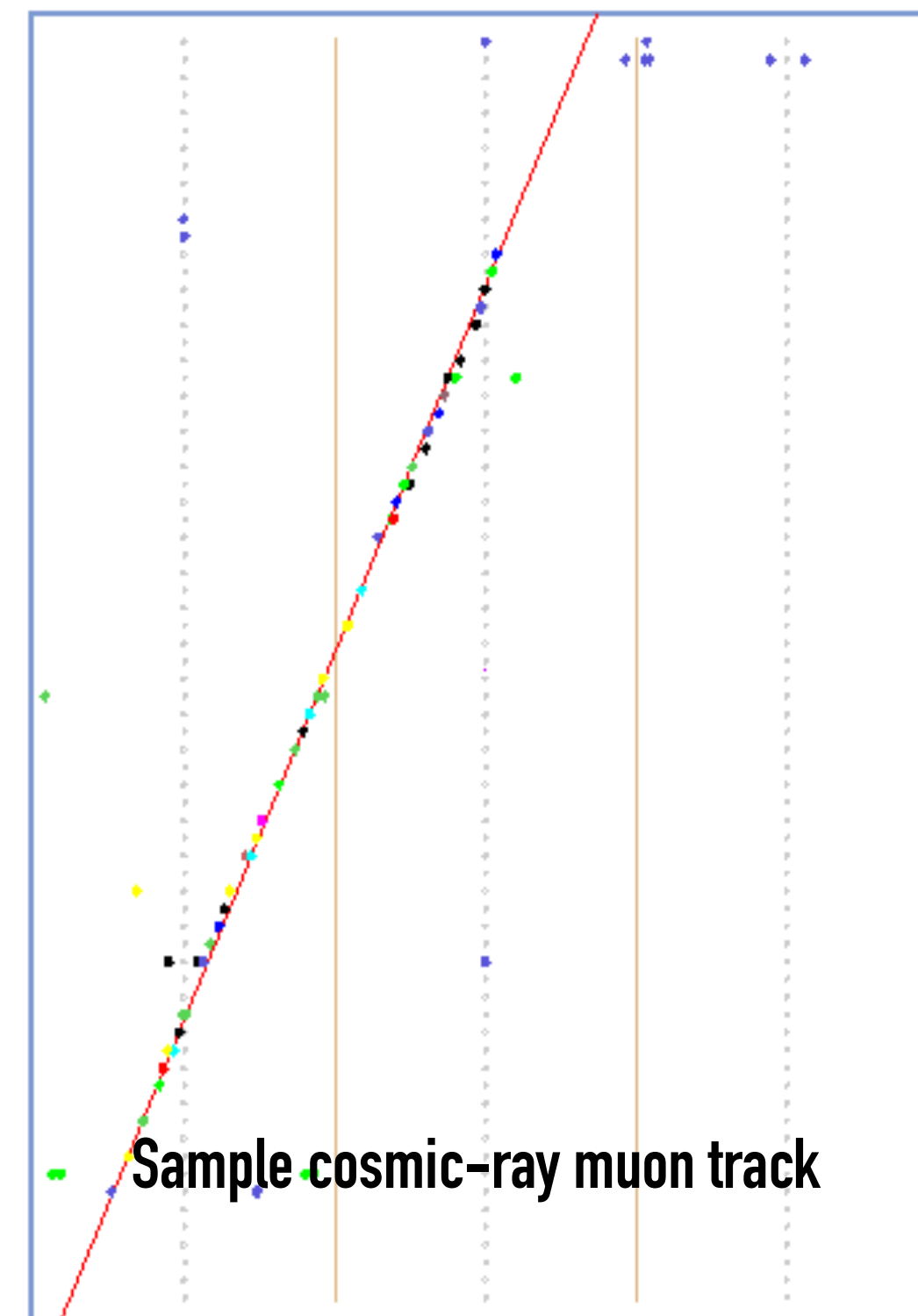
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1T Superconducting magnet & Drift Chamber Tracker

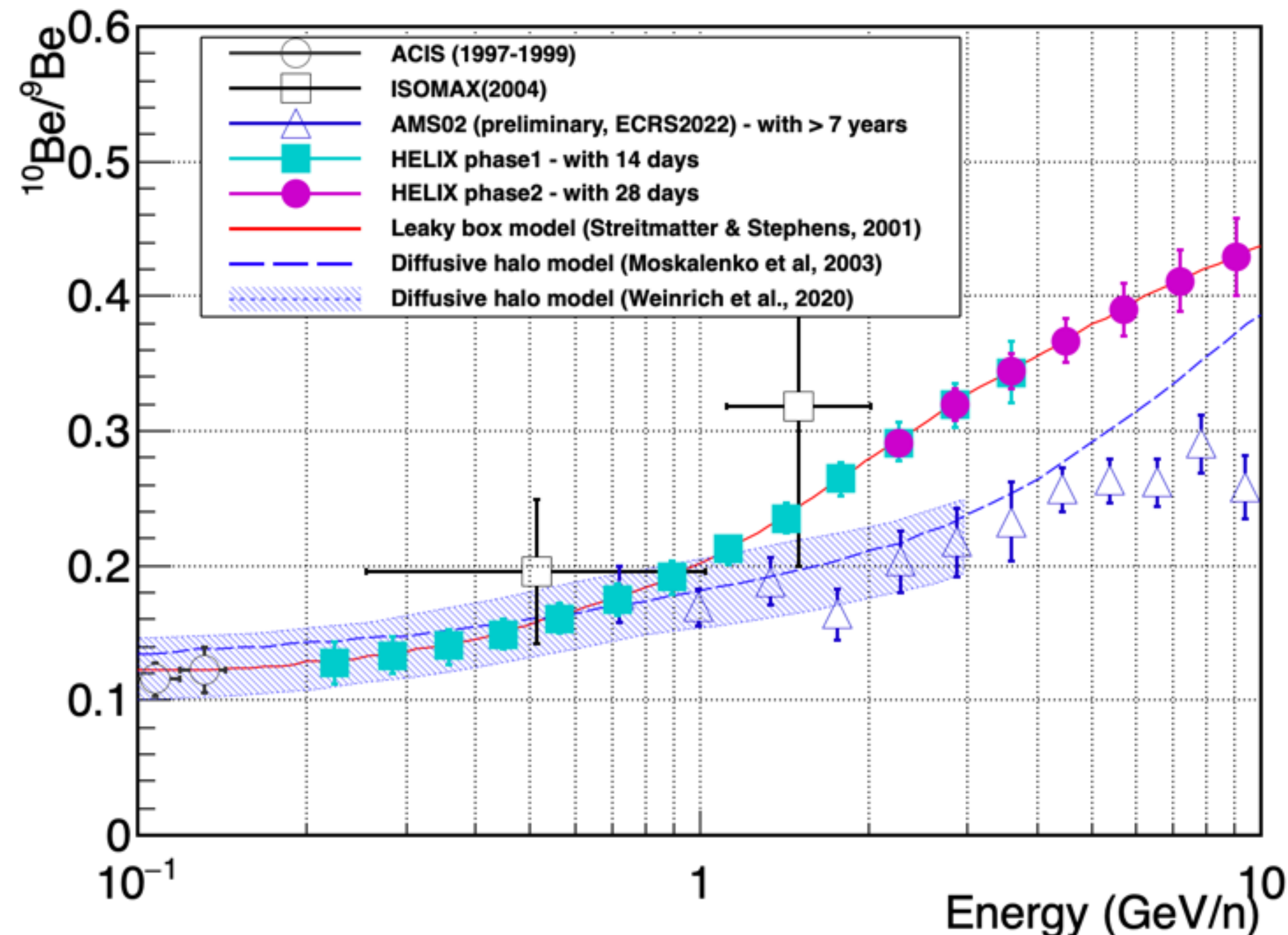
- Multi-wire drift chamber with drift gas $\text{CO}_2 + \text{Ar}$
- Spatial resolution of $65 \mu\text{m}$ for $Z > 3$
- 72 sense layers, read out with 80 MHz sampling



HELIX Stage1 Performance Goals

$^{10}\text{Be}/^9\text{Be}$ ratio up to $\sim 3 \text{ GeV/n}$ with $\Delta m/m \sim 2.5\%$

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HELIX Flight 2024

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

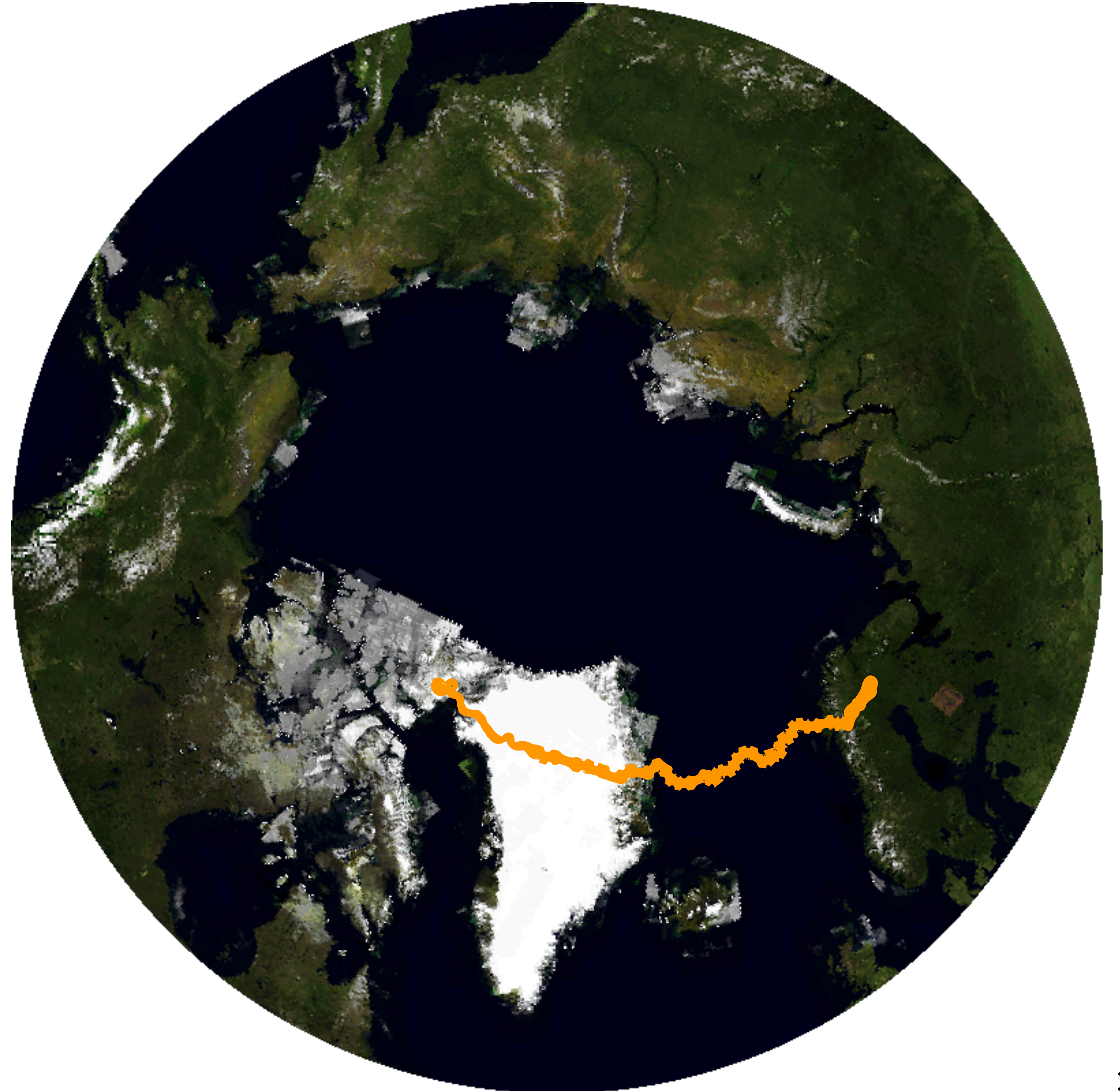


<https://www.youtube.com/watch?v=PoofJ8al4S4>

HELIX Flight 2024

Total flight time: 6 days 8 hrs 27 min

● 125M triggers

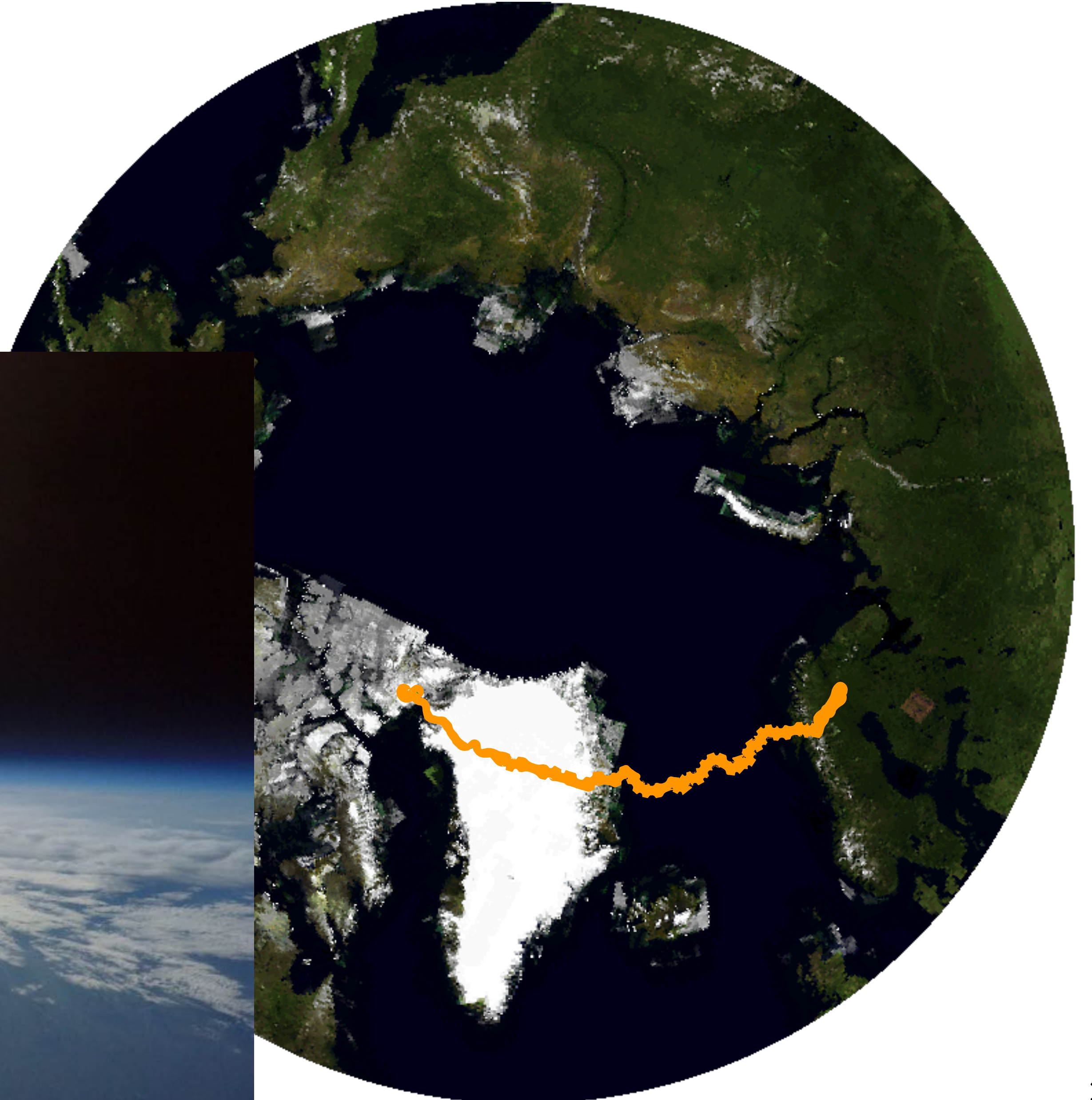




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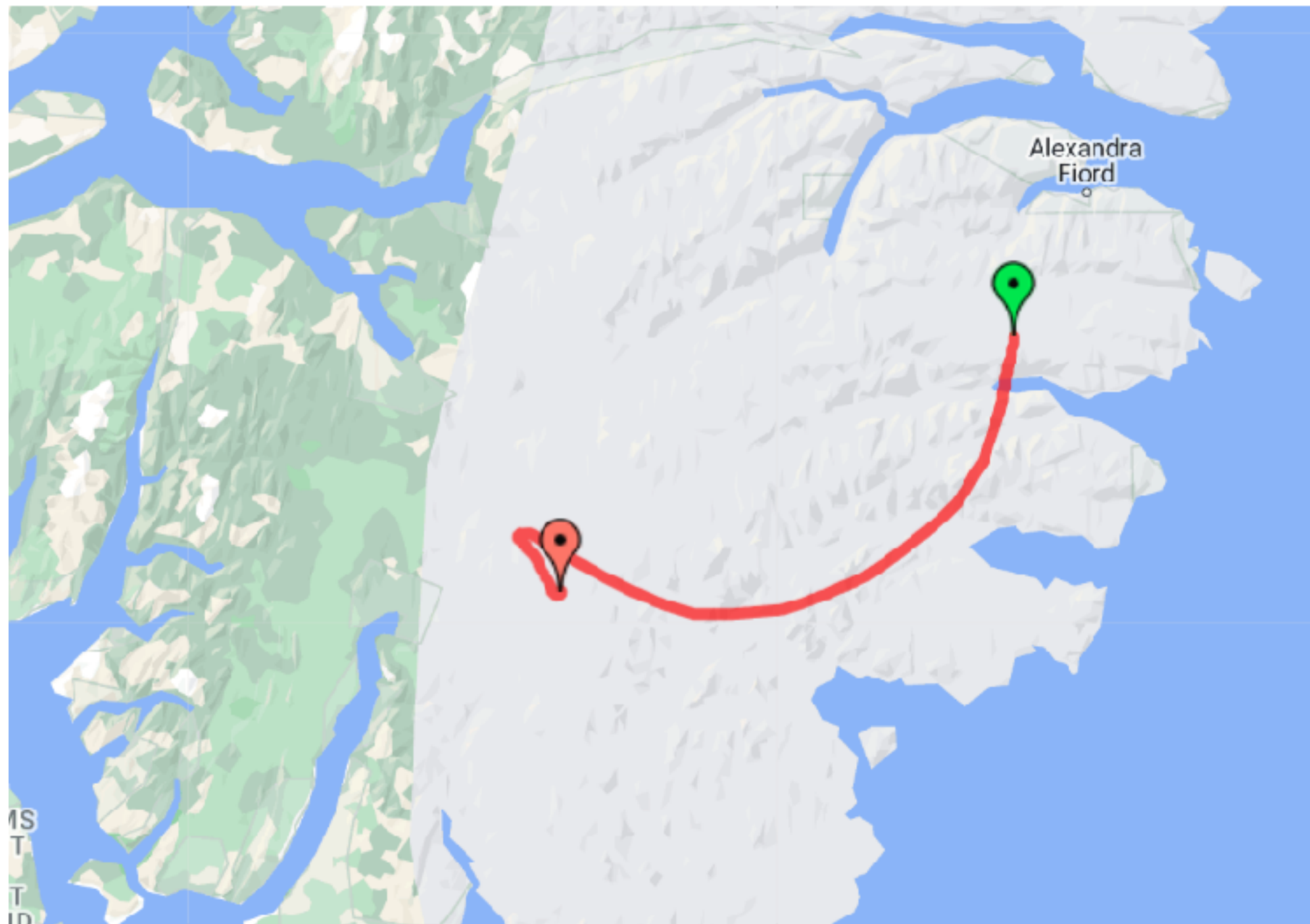
HELIX Flight 2024

Total flight time: 6 days 8 hrs 27 min

© 125M triggers

June 3rd: landed at Ellesmere Island, Nunavut

HELIX Position



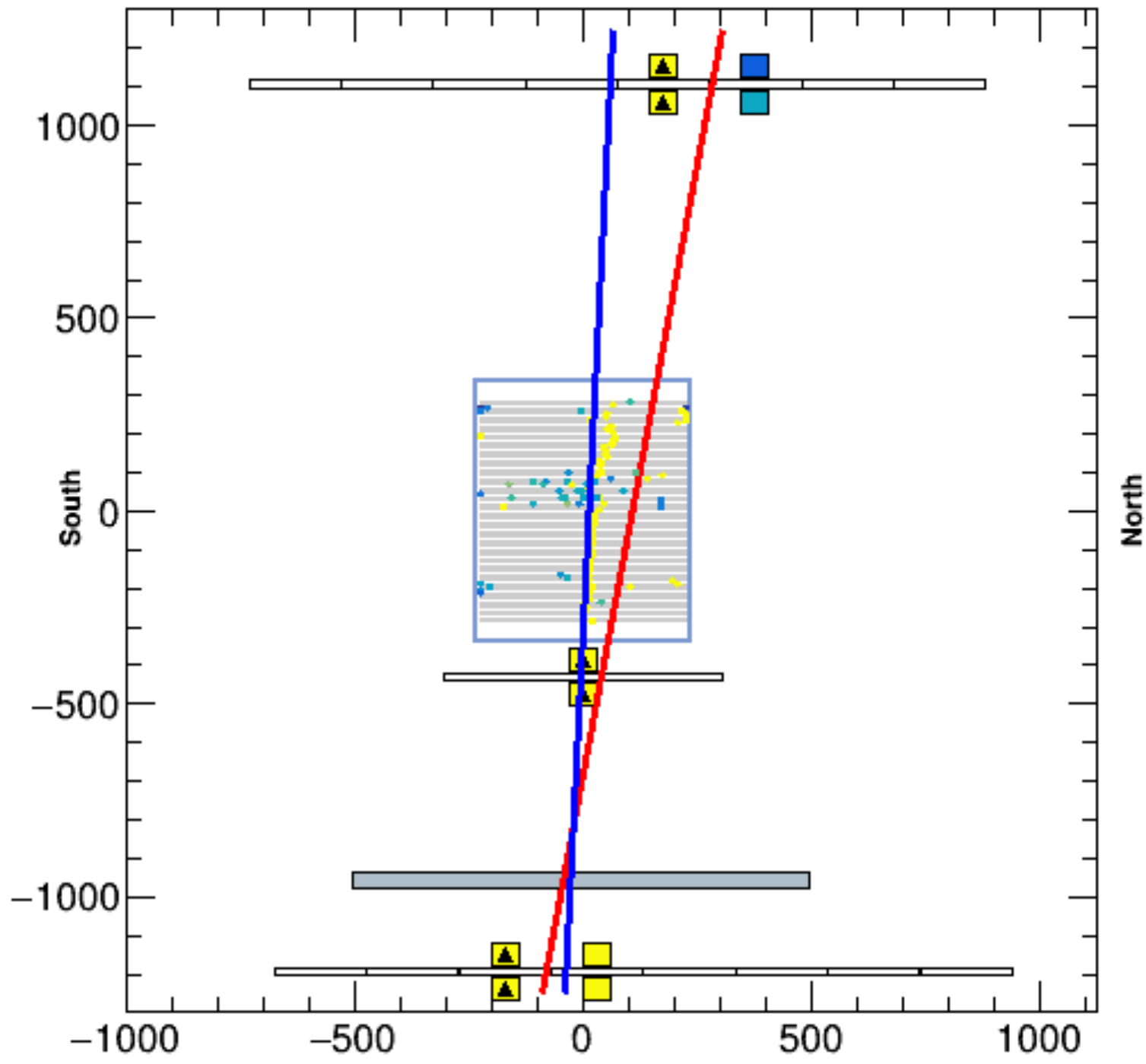
[600 Positions | Last: 78.1252N, -80.8220E | alt:1381.28m]



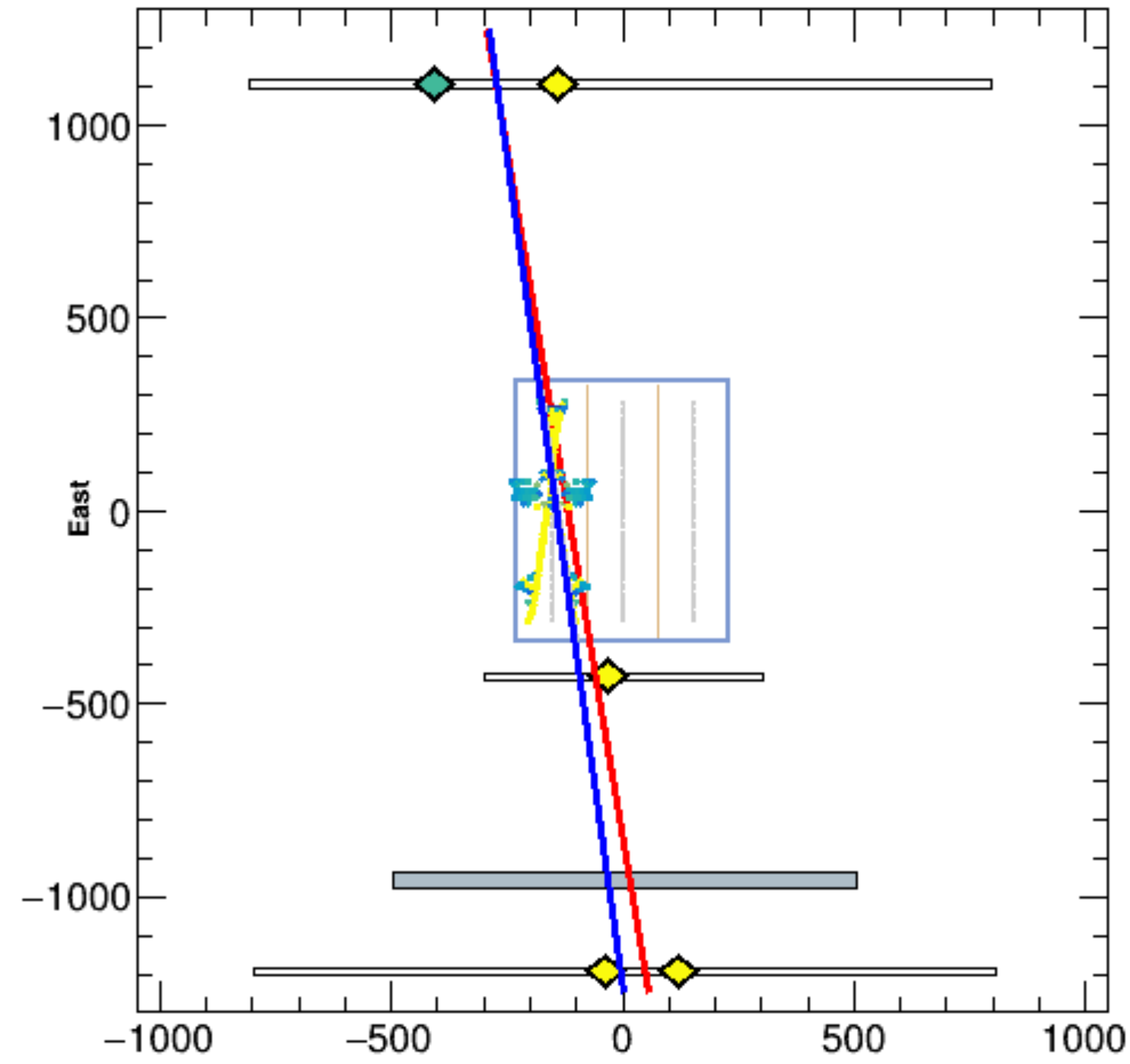
July 3rd: A graduate student-initiated land acknowledgement discussion led by Alex Pedersen

Raw data example (downlink)

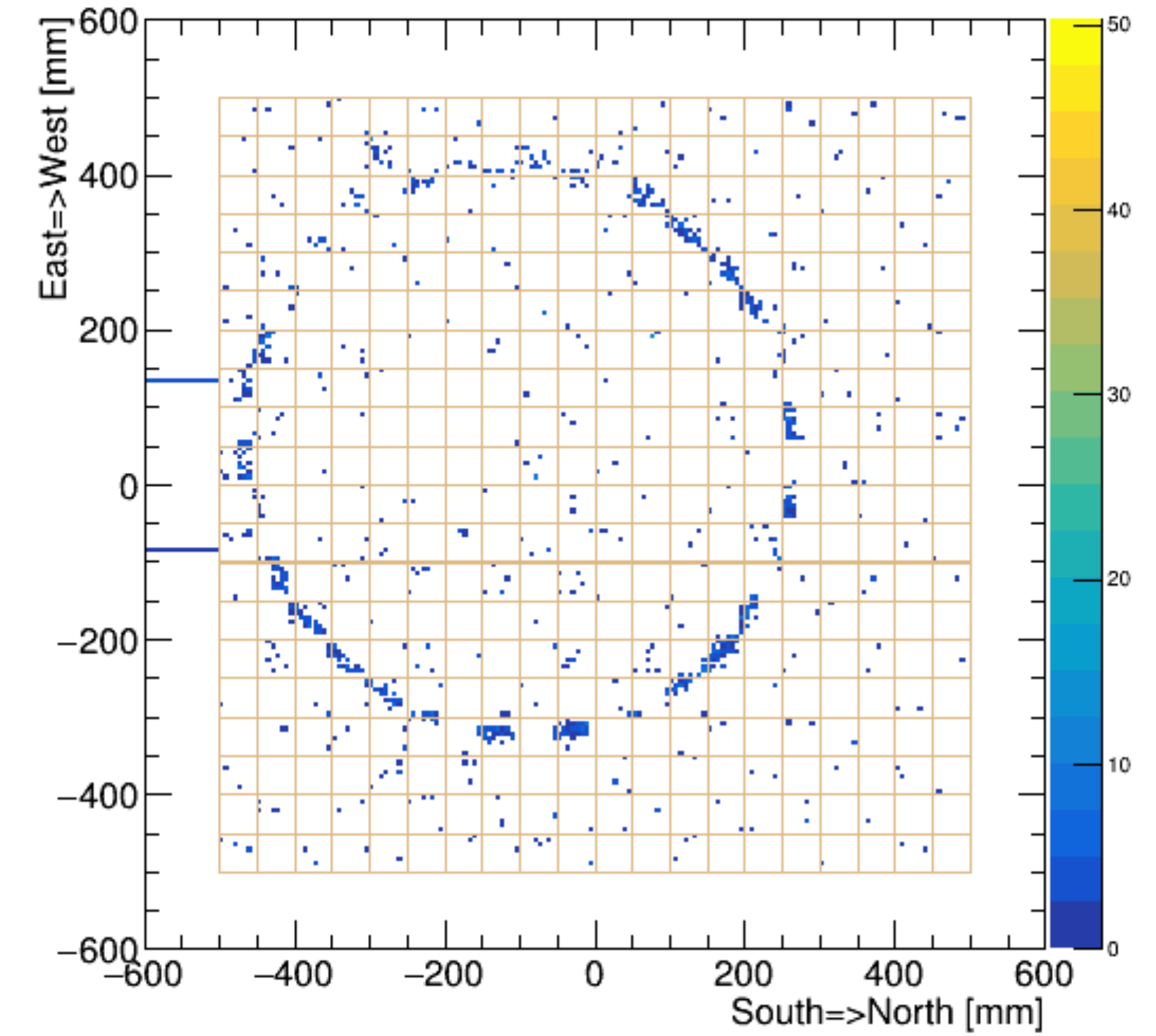
XZ View



YZ View



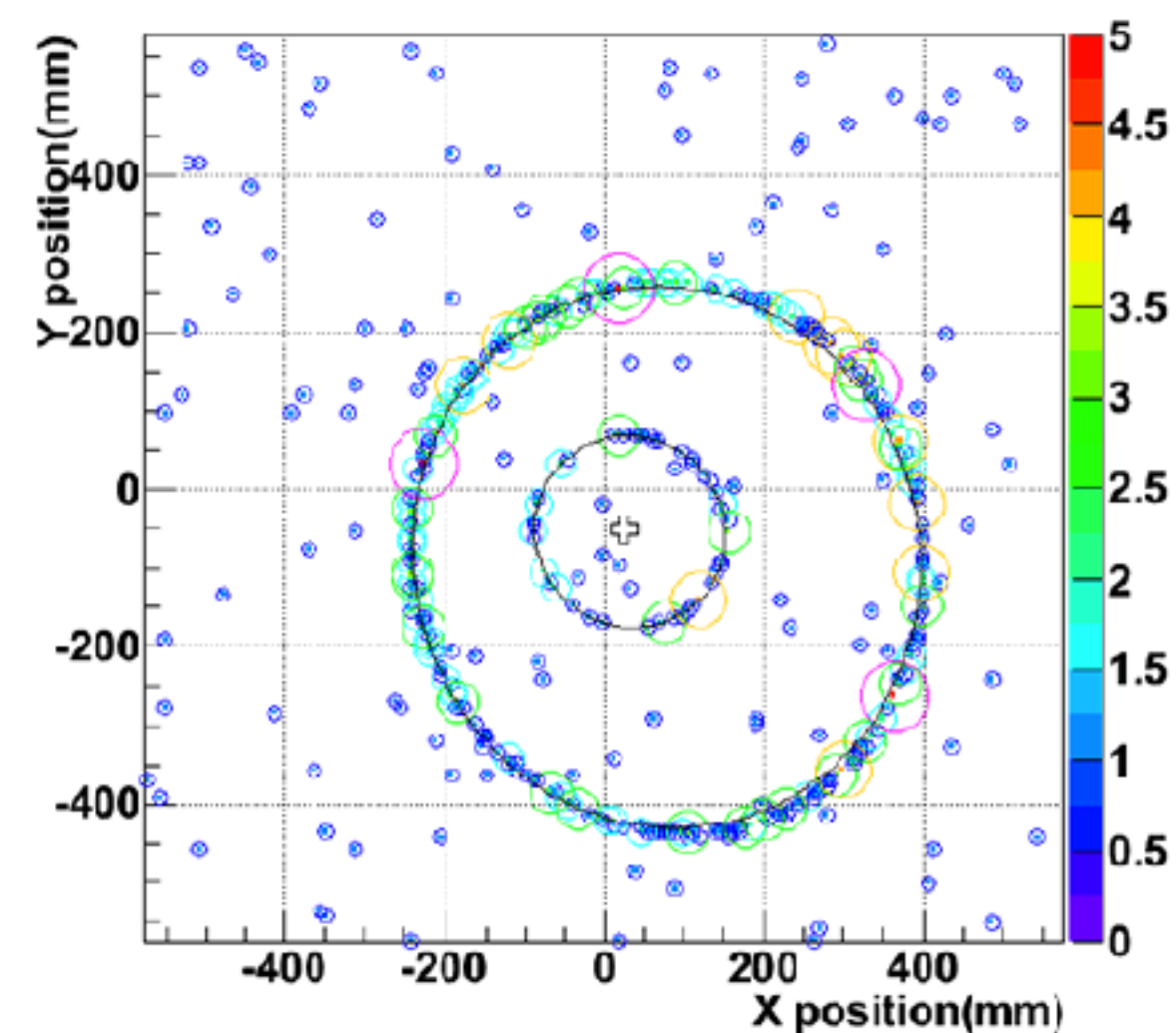
Pixel Map - Event 261



HELIX Future Upgrades

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

- Magnet upgrade: longer exposure time (7 days \rightarrow 28 days)
- Tracker upgrade: better resolution ($65\ \mu\text{m} \rightarrow 5\ \mu\text{m}$)
 - \rightarrow moving to 4-6 layers of silicon strip trackers
- RICH upgrade
 - Upgrade to a full focal plane
 - Potential upgrade to a dual refractive radiator



First of all...

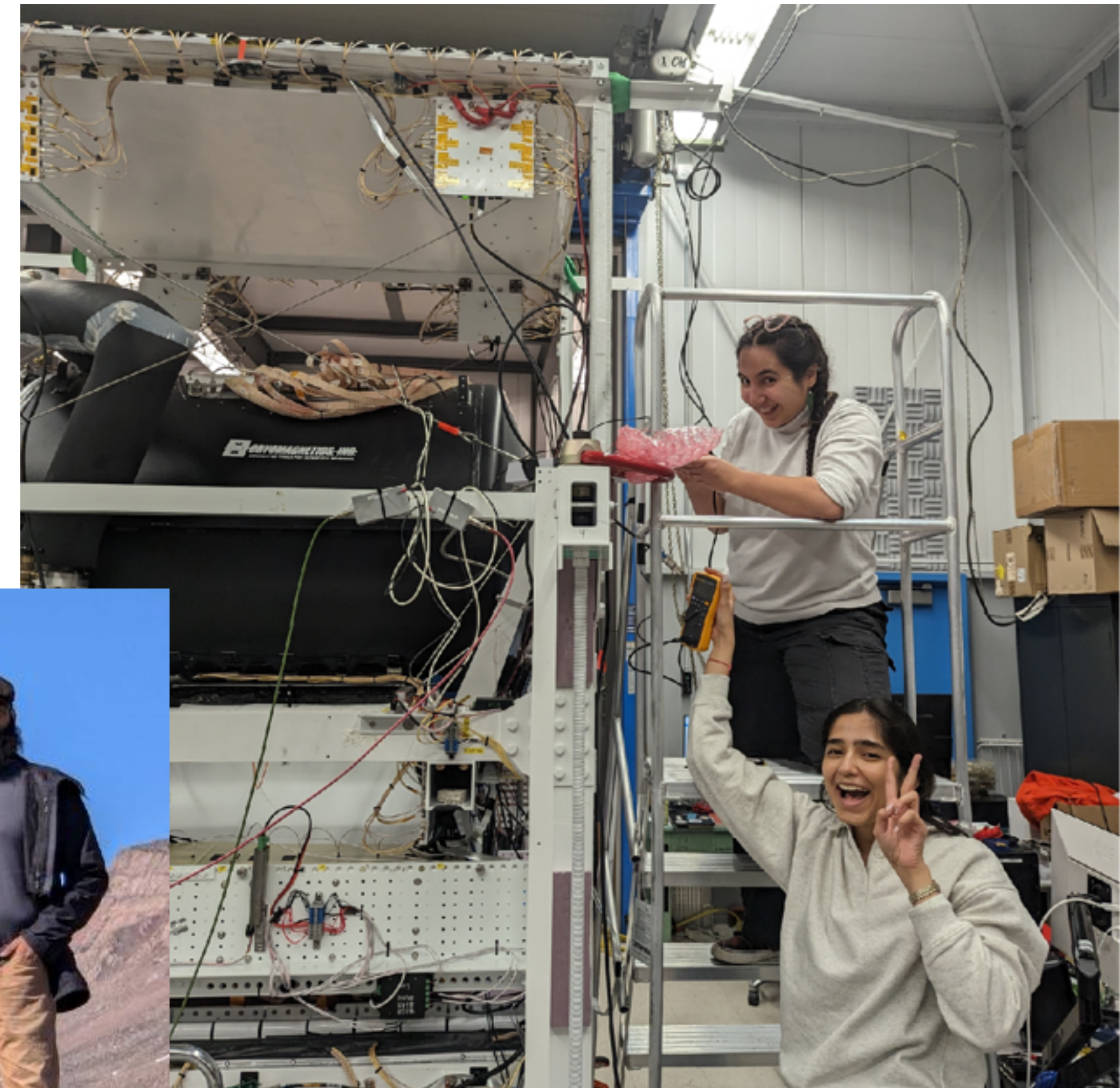
We need to assess how much fraction of the detector can be reused

Recovery site on July 6th



Canadian Effort

- Aerogel calibration
- Payload thermal simulation
- Payload metrology & Geant4 model developing
- Flight data analysis - in-flight detector calibration (using DRAC cluster)
- Flight & recovery support
- On-going R&D for future detector developments



Summary

**HELIX has launched & successfully finished the flight!
The payload is successfully recovered
and just delivered to Chicago this Monday**

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 $\approx 3\%$.

Stay tuned for the results!

