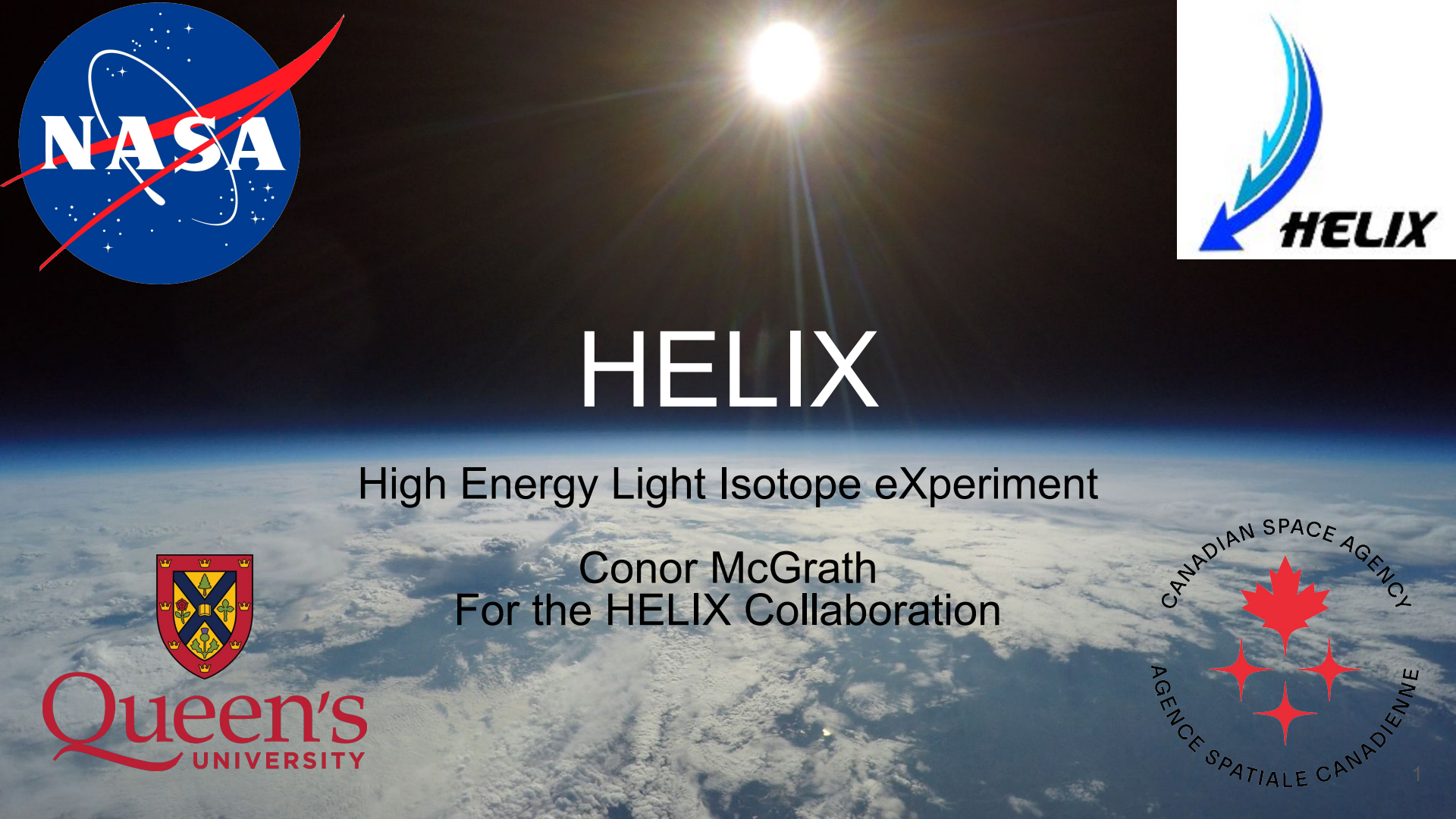


HELIX

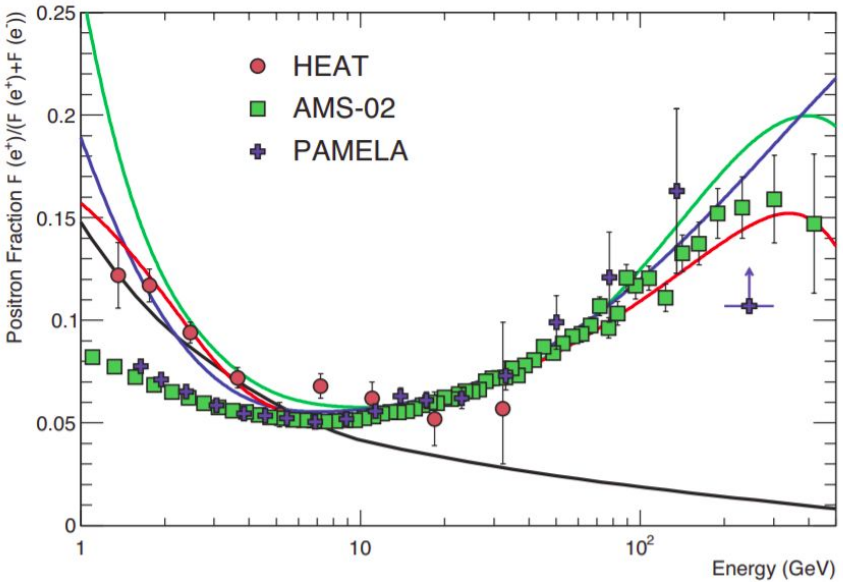
High Energy Light Isotope eXperiment

Conor McGrath
For the HELIX Collaboration

Scientific Motivation - Investigating CR Propagation

Unexpected results from recent measurements of cosmic-ray fluxes

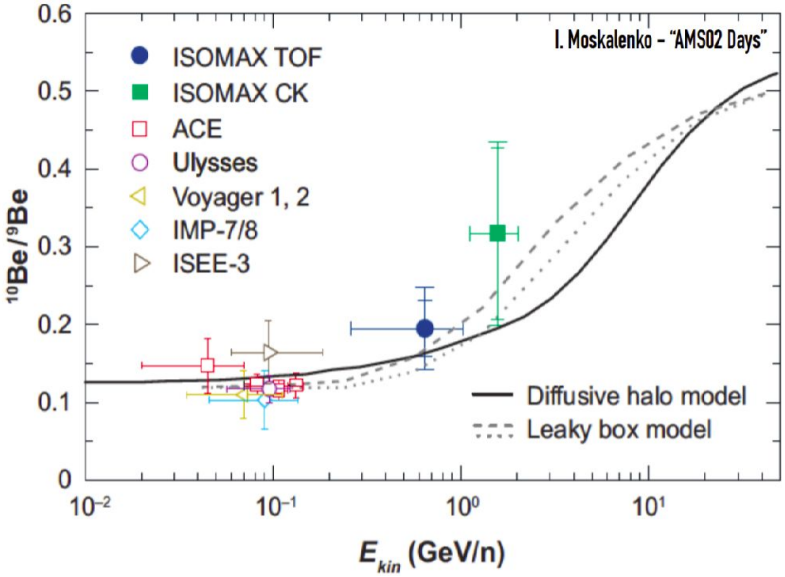
- Excess positron fraction above 25 GeV
  - Possible explanations : CR Propagation Models, Dark Matter (Or other exotics), Particle Production



Particle Data Group.

^{10}Be/^{9}Be Measurements

- ^{10}Be/^{9}Be ratio
  - Can be used to measure CR propagation times
  - “Clock isotopes” break time vs density degeneracy that other approaches encounter



B/C ratio only gives measure of the grammage cosmic rays have traversed. Degeneracy comes from unknown travel times

^{10}Be is unstable, ^{9}Be is stable - observed flux at Earth gives estimate of travel time since production

HELIX Science Goals

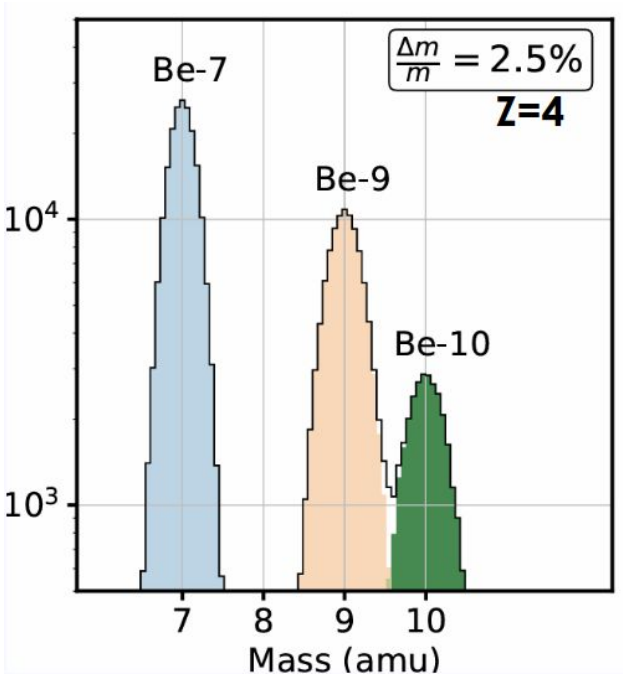
Measure ^{10}Be/^{9}Be ratio to provide strong constraints on propagation models

- ^{10}Be is unstable “clock isotope”
  - Known half life of 1.4x10^{6} yr
  - Can estimate travel time since production
- Challenging measurement
  - Peaks of ^{10}Be and ^{9}Be are close for E > 1 GeV/n
  - Mass resolution of ~2.5% required for 4σ separation

$$\left(\frac{\delta m}{m}\right)^2 = \left(\frac{\delta R}{R}\right)^2 + \gamma^4 \left(\frac{\delta \beta}{\beta}\right)^2$$

$$m = R\frac{Ze}{\gamma\beta c^2} \qquad R = \frac{pc}{Ze}$$

Simulated mass resolution



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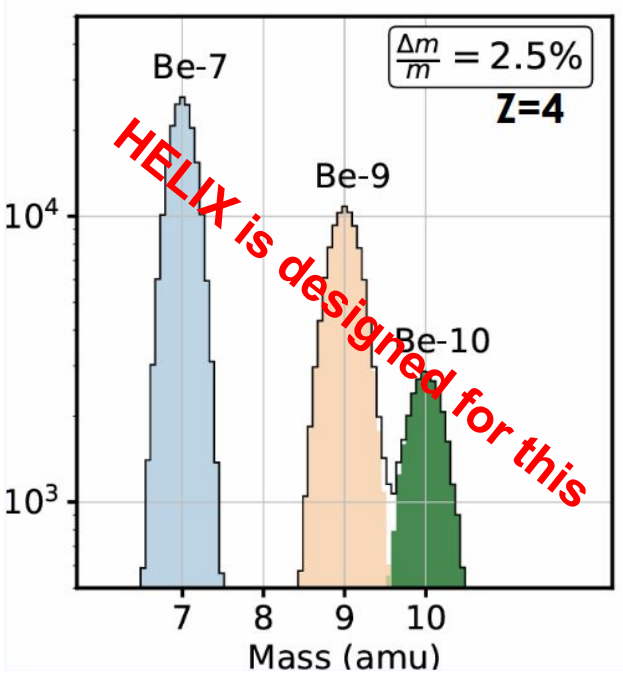
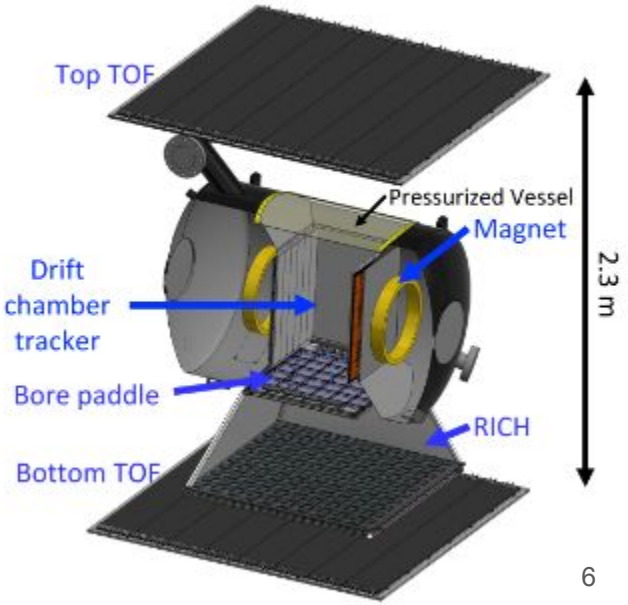


What is HELIX

- High Energy Light Isotope eXperiment
- E ≤ 3 GeV/n - HELIX stage 1
  - E ≤ 10 GeV/n in future flights
- Balloon-borne cosmic-ray detector
  - Magnetic Spectrometer
  - Multiple flights planned
  - One flight complete : ~6 days
- 1T superconducting magnet
  - Previously flown on HEAT experiment
- Drift chamber tracker (DCT)
- Ring imaging Cherenkov detector (RICH)
- Time-of-flight system (TOF)



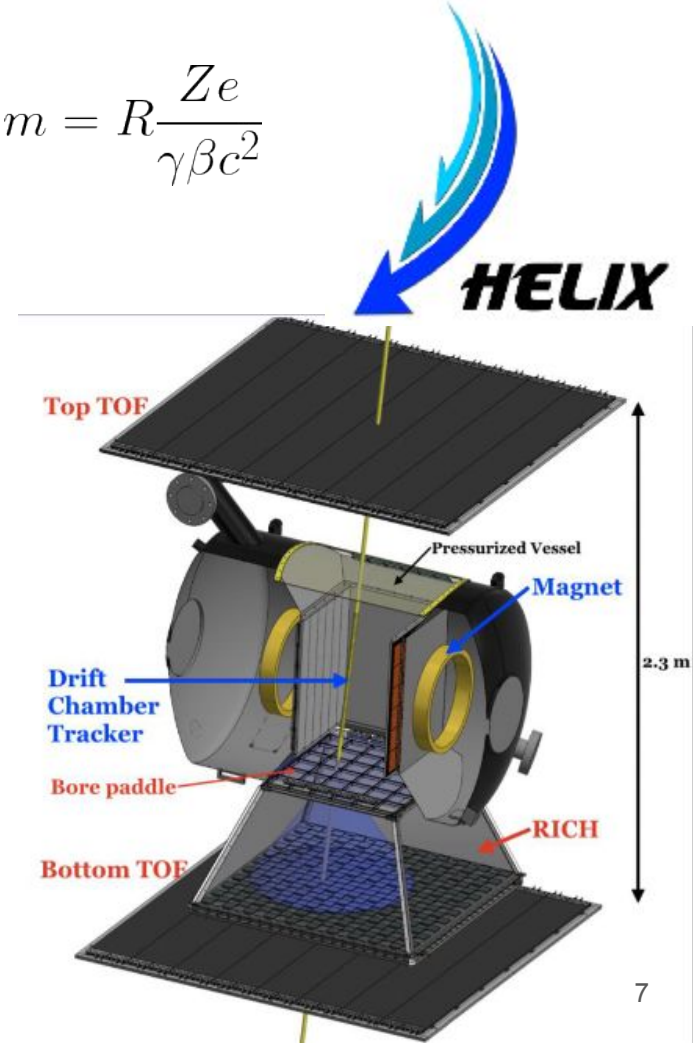
How Does HELIX Measure Mass?

$$m = R\frac{Ze}{\gamma\beta c^2}$$

- **TOF (Time Of Flight)*** can measure β up to E ~1 GeV/n from Δt and Ze of up to 10

- Higher energy β measurements performed by **RICH (Ring Imaging Cherenkov Detector)***

- Measuring bending of particle in **DCT (Drift Chamber Tracker)** gives R
  - Utilising 1T superconducting magnet



*SiPMs used for readout due to high magnetic field

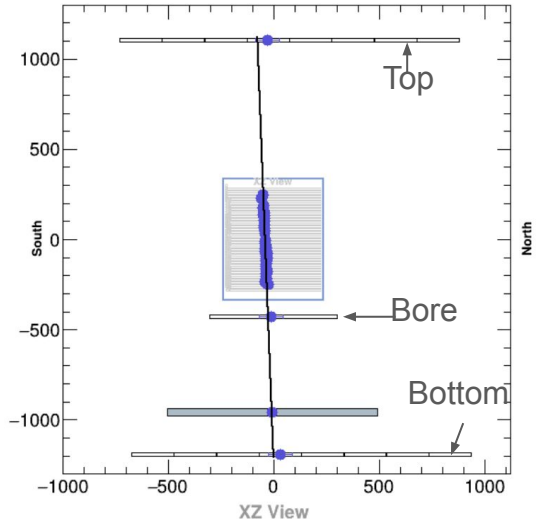
Time Of Flight

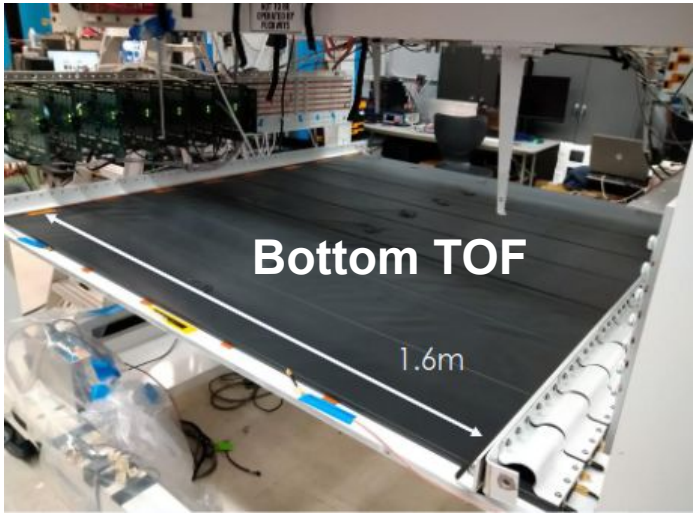
Measures velocity and charge

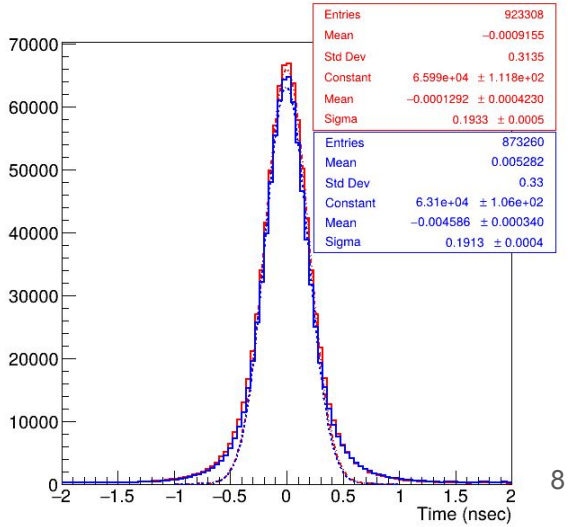
3 sections (top, bottom,~middle) of 1 cm thick plastic scintillators

- 2.3 m separation between top and bottom
- 8 single-pixels per scintillator end

Time resolution per event:
Top (red)/bottom (blue)







Magnet

- 1T Superconducting magnet
- Formerly flown on HEAT experiment
  - Proven flight capable
- Hold time : ~7 days
  - Standard Arctic flight time
- Cryogen operations @ 4 K

Drift Chamber Tracker

Measures rigidity

Multi-wire gas (90% CO_2 + 10% Ar) drift chamber tracker

- Custom designed to fit in magnet bore

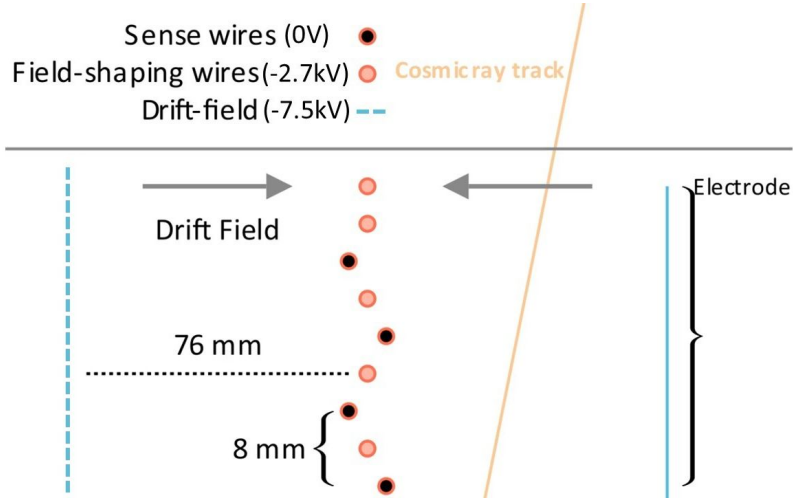
Detects ionisation tracks left by charged nuclei in two 2D planes

- Goal spatial resolution ~65 μm for Z>3
- 72 sense layers
- 80 MHz sampling

$$m = R\frac{Ze}{\gamma\beta c^2} \qquad R = \frac{pc}{Ze}$$

DCT Position Reconstruction

- Strong electric drift field of 0.8 kV/cm to towards sense wires
  - 3 detector planes of 72 sense wires each
- Drift distances measured from timing of drifting ionisation
  - Bending plane
  - 80 MHz readout
- Non-bending plane position measured with charge division along sense wire



Staggered sense wires are used to solve L/R ambiguity

Ring Imaging Cherenkov Detector

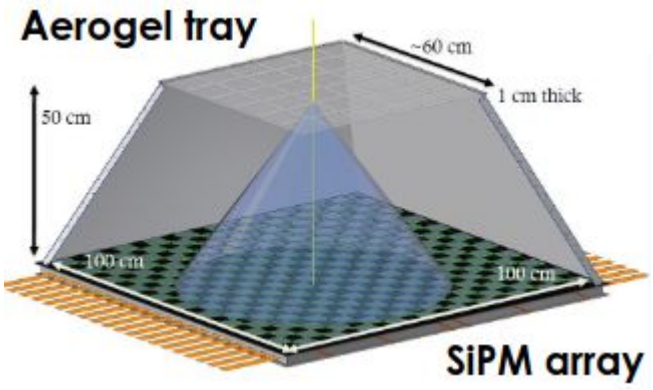
Measures velocity

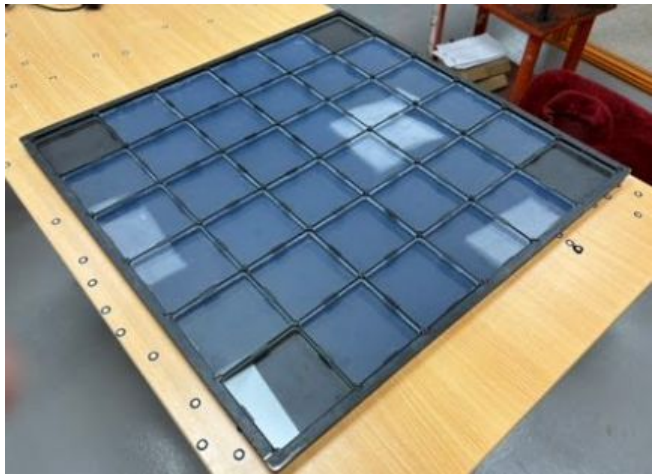
Use aerogel radiator to induce Cherenkov radiation

- Transparent with refractive index n ~1.15

Focal plane made of 200 SiPM arrays (12800 pixels)

- 1 m^2 area half-filled with SiPMs
- Goal β resolution of 0.1% for Z>3

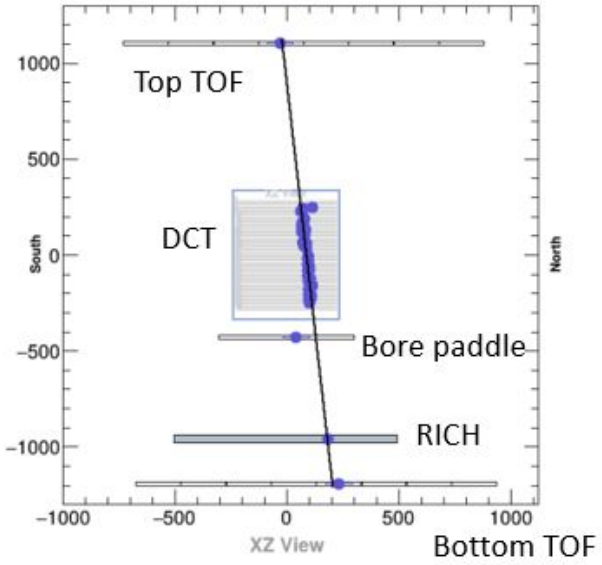




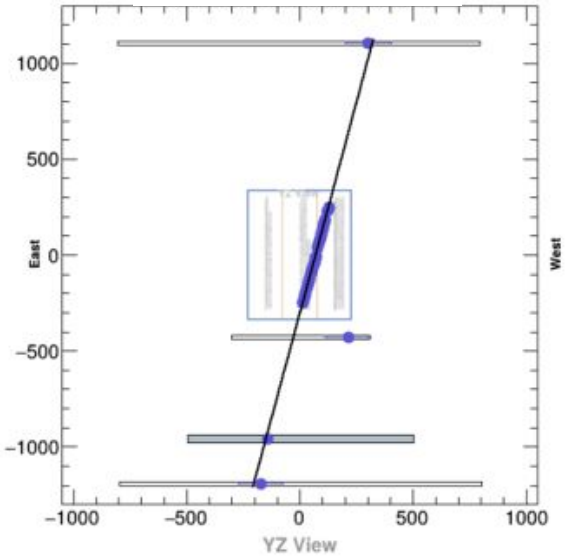
Engineering Flight

- Successfully launched on first attempt
- Flight time : 6.3 days
- > 120 million triggers
- Challenging recover location - Second most northern landing!

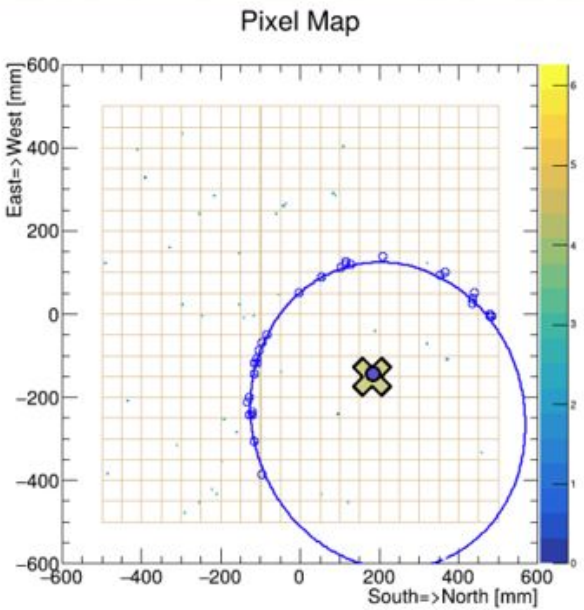
Candidate Be Event (Preliminary)



Non-bending plane



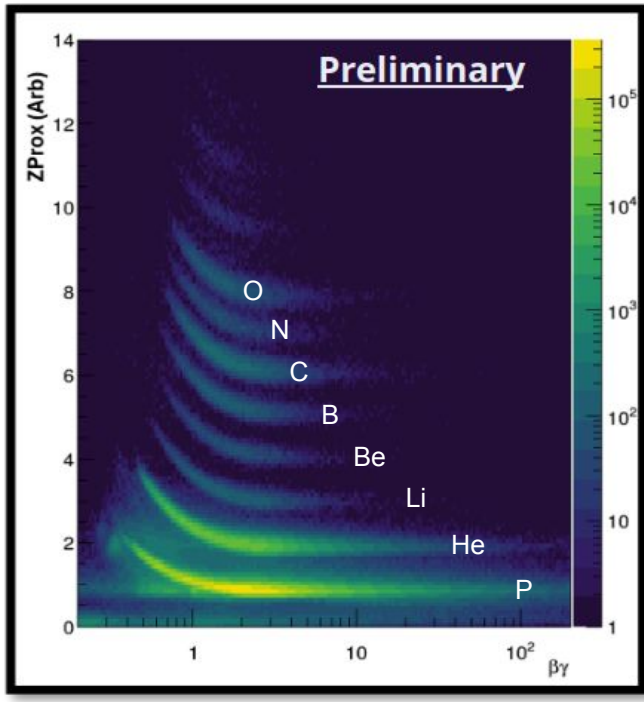
Bending plane



Cherenkov ring image on the RICH

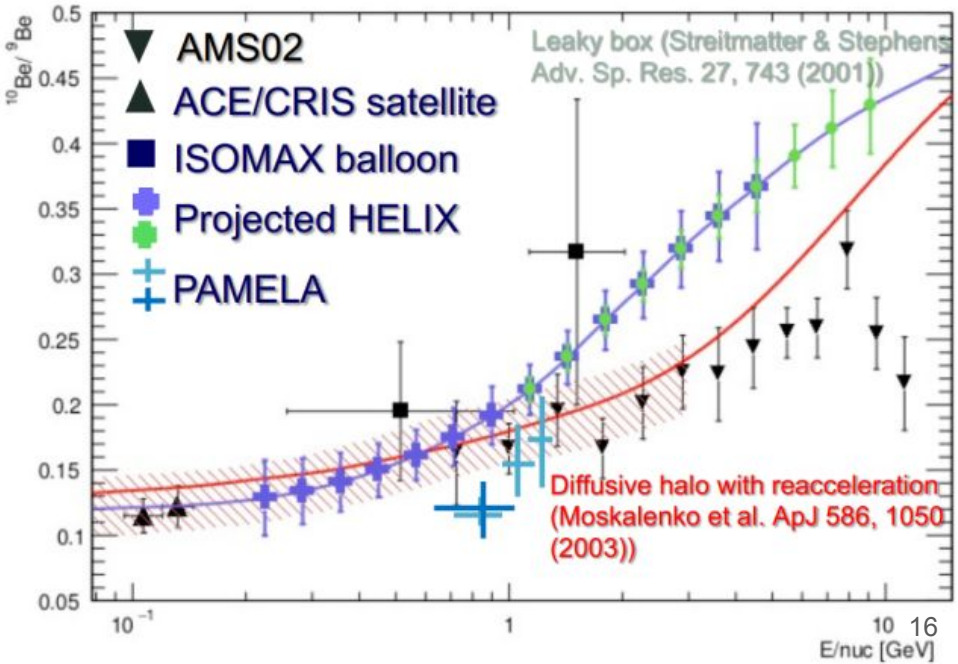
Ongoing Analysis Status

- DCT tracking and charge calibrations are ongoing
- Preliminary results from early analyses
- βγ estimation from TOF top and bottom timing difference
- Rigidity measurements ongoing
- Detector performance is promising



Going Forward

- Greater magnet hold time
  - 7 days -> 28 days
- Greater tracking spatial resolution
- Improved velocity measurements
  - Full RICH detector plane
- Thermal system improvements
- Antarctic flight?



Conclusion

- HELIX is designed to measure $^{10}Be/^{9}Be$ ratio
  - Stage 1 : Up to 3 GeV/n
  - Further : Up to 10 GeV/n
- Successful first flight and recovery
- Calibrations, analysis and refurbishment ongoing

Thank you for your attention

Questions Welcome