HELIX:
High Energy Light Isotope eXperiment

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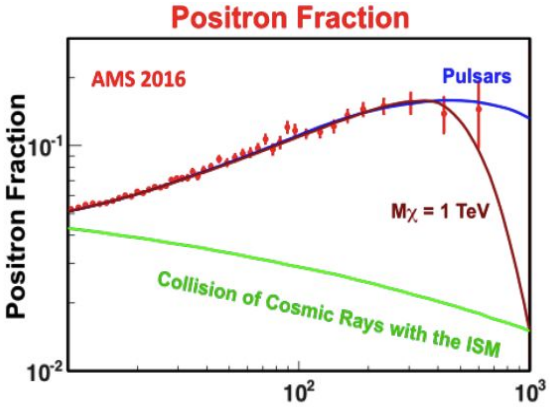
Introduction

- HELIX is a balloon-borne superconducting magnet spectrometer that will perform high mass resolution measurements of various light cosmic ray isotopes.
- Collaboration includes veterans from many previous balloon flights including HEAT and CREST
- Motivated by recent measurements from AMS and PAMELA to explain positron excess.

The Positron Problem

- Increase in positron fraction ($e^+/(e^+ + e^-)$). Hints from HEAT. Seen by PAMELA and AMS. Much higher than what is expected using standard propagation models. Peaks/plateaus around 300 GeV.



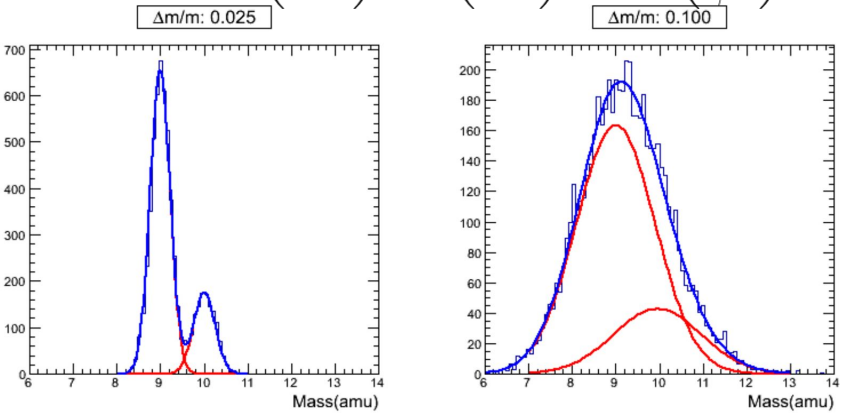
From AMS 2016 press release

- Possible explanations: dark matter annihilation? Pulsar wind nebulae?
- Still possible to explain using secondary production (see M. Kruskal, S. P. Ahlen, and G. Tarle. *Astrophys. J.*, 818(1):70, 2016.)
  - Similarity b/w proton and positron spectral indices suggests secondary origin
- . What is needed?
  - Knowledge of the primary proton spectrum in the ISM
  - Path length between primary proton source and Earth as a function of energy. Can be calculated using antiproton flux.
  - Confinement time of light secondary cosmic rays -> HELIX
- Confinement time from Be
  - Be-10 has half-life of 1.39 Myr. Same time scale as confinement time.
  - Almost exclusively secondary. Produced via spallation in ISM.

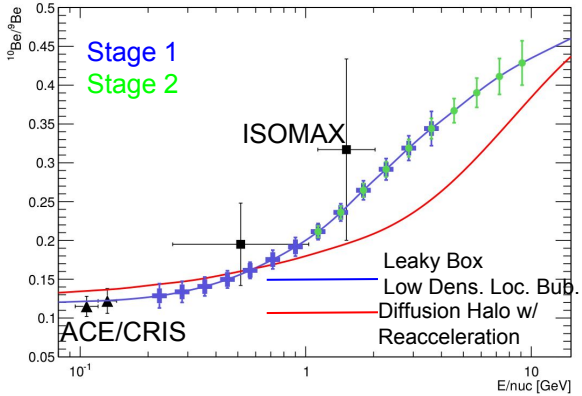
HELIX Goals

- Two stage experiment:
  - Stage 1: Focus on obtaining Be isotope ratio to constrain propagation models. Measure up to energies of ~3 GeV/n.
  - Stage 2: Improve energy range up to ~10 GeV/n. Extend measurements of a variety of light isotope ratios.
- Precision measurement
  - Need mass resolution of < 2.5%
  - Achieved through RICH, DCT and ToF instruments

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



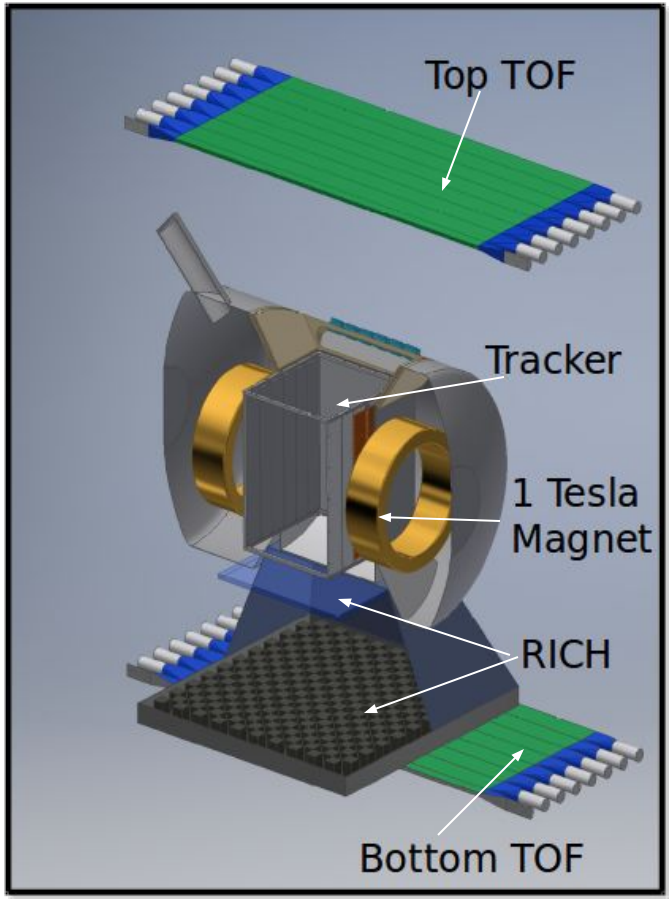
Anticipated Be Isotope Ratio for HELIX



Ratio	Energy (GeV/n)	Purpose
^{10}Be/^{9}Be	0.3 - 10	High Statistics/ 1st Measurement
^{3}He/^{4}He	0.3 - 12	High Statistics
^{22}Ne/^{20}Ne	> 1	1st Measurement
^{7}Li/^{6}Li	>1	1st Measurement
^{10}B/^{11}B	>1	1st Measurement

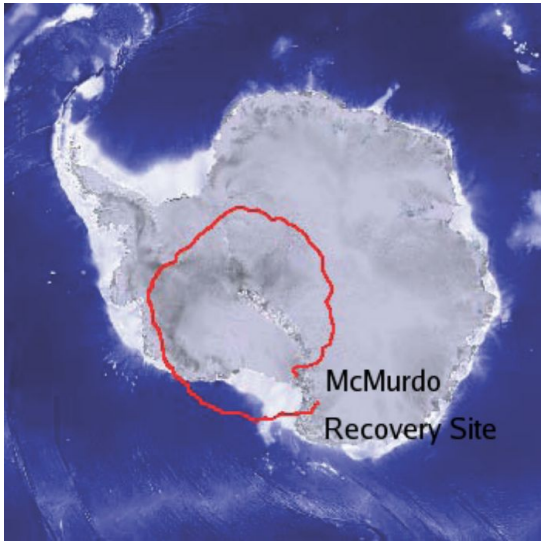
HELIX Instrument

- Design
  - Geometric factor = 0.1 m^2sr
  - Max Detectable Rigidity = 800 GV
- Time of Flight
  - 1.5 cm fast plastic scintillator
  - Goal: < 50 psec for Z > 3
- Drift Chamber Tracker
  - Multi-wire drift chamber w/ CO_2 gas
  - Goal: ~65 um for Z > 3 spatial resolution
- 1 T Superconducting Magnet
  - Reused from HEAT
  - 260 liter cryostat for hold time > 7 days
- Ring Imaging Cherenkov Detector
  - 200 Hamamatsu SiPM array - deciding on model
  - n ~ 1.15 aerogel radiator being manufactured
  - Goal: 0.04% for Z > 3 velocity resolution



Summary

- A difficult measurement
  - Mass resolution requires precise characterization of aerogel
  - Atmospheric effects
  - Payload, power, and magnetic field considerations
- Allow calculations of positron secondary production.
- Two stage experiment
  - Stage 1 in prototyping and design phase. To be deployed end of 2019
  - Stage 2 to include upgrades to RICH, DCT. Would like to increase hold time with secondary dewar.



CREST flight path from McMurdo. HELIX to take similar trajectory.