Cosmic-ray isotope measurements with HELIX

Presented by Nahee Park
for HELIX Collaboration
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- Breaks in the light elemental spectra
- Rising positron fraction
- Difference in H & He indexes

The importance of propagation studies of the cosmic rays has become more vital.
Elemental 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

![Graph showing Boron-to-Carbon Ratio vs. Kinetic Energy (GeV/n)]

Comparison with measurements from 0.5 GeV/n to 3 TeV/n

Cowsik et al. (2014)
Propagation clock isotope, $^{10}$Be

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

- $^{10}$Be/$^9$Be ratio provides strong constraints for the propagation models
- Challenging measurements
  - Several good measurements at a few hundred MeV/nuc
  - Above this, the ISOMAX balloon payload covers up to ~2 GeV/nuc
- Good model discriminating power around 3 GeV/nuc
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I. Moskalenko - "AMS02 Days"
High Energy Light Isotope eXperiment

University of Chicago
- Scott Wakely, Dietrich Müller, Nahee Park, Ian Wisher

Indiana University
- James Musser, Mark Gebhard, Brandon Kunkler, Mike Lang, Gerard Visser

Pennsylvania State University
- Stéphane Coutu, Isaac Mognet

Northern Kentucky University
- Scott Nutter

University of Michigan
- Michael Schubnell, Gregory Tarlé, Andrew Tomasch, Noah Green

Ohio State University
- Jim Beatty

McGill University
- David Hanna
A new magnet spectrometer payload to measure $^{10}\text{Be}/^{9}\text{Be}$ isotope ratio up to 10 GeV/n

- Two stage approach to cover wider range of energy
- Stage 1: designed to have a flight in Antarctica with a long duration balloon in 2019
HELIX

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

- Two stage approach to cover wider range of energy
- Stage 1: designed to have a flight in Antarctica with a long duration balloon in 2019

- 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
HELIX Configuration

TOF
- 1.5cm thickness scintillator, readout by SiPMs, 2.3m separation
- Timing resolution < 50 psec for Z=4

Magnet
- 1T superconducting magnet, reused from HEAT experiment

Drift Chamber Tracker
- Low material tracker to minimize scattering
- Spatial resolution ~65 um for Z>3

RICH
- 1 m² focal plane covered by SiPM arrays
- $\Delta \beta / \beta \sim 1 \times 10^{-3}$ for Z>3, up to 3 GeV/n (stage 1)
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Detail on I. Wisher’s talk
Expected performance

HELIX stage1 performance goals

- 7-14 day exposure w/ 0.1 m²sr geometry factor
- $^{10}$Be/$^{9}$Be ratio up to ~3 GeV/n with $\Delta m/m \sim 2.5$
  - 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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Future Upgrade for stage 2

- Energies up to 10 GeV/n w/ upgrades to spectrometer & RICH
HELIX – current status

Moving forward to be ready for a flight in 2019!

- Finalize the detector configuration
- Proto-type testing and initial production
- Stage 1 full instrument integration in 2018
Summary

Recent high-precision cosmic-ray measurements have highlighted the importance of well-constrained propagation models

- Precision isotopic measurements, in particular the $^{10}\text{Be}/^{9}\text{Be}$ ratio, provide key inputs for these models

HELIX, the High Energy Light Isotope eXperiment, is a new LDB magnet spectrometer payload designed to make these measurements

HELIX is moving forward to prepare for a flight in 2019