Measuring the B/C ratio with TRACER



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B/C with TRACER

Motivation

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- Source Spectrum: $Q_i = n_i \cdot E^{-\alpha}$
- ► Escape: $\Lambda_{\rm esc} = \lambda \cdot E^{-0.6} + \Lambda_0$
- Spallation: $\Lambda_i \propto A^{-2/3}$

- Data from first flight suggest soft source spectrum (α) and non-zero residual pathlength (Λ₀).
- B/C must be measured at high energy to determine propagation and source properties.

Schematic Overview of TRACER

Electro-magnetic processes are used to determine Z and E: Scintillator, Cerenkov, ionization in gas, and transition radiation.

- Large area for low weight: 5 m² sr
- Individual elements resolved.
- Energy range: 10⁹ - 10¹³ eV/amu



1600 proportional tubes (2 m long, 2 cm Ø)

The Detector

Response Curves of Subdetectors



- ► Δ*E*/*E* < 10% (CER, TRD); 40-70% (DEDX).</p>
- Spans 4 orders of magnitude in energy!
- Can be calibrated with singly charged particles.

The LDB Flight



- 2006 from Sweden to Canada
- ► 5 days duration
- Residual atmosphere 3.8 g/cm²
- Boron to Iron (Z = 5 to 26)

CRAD 2006 Oct 12 05:45:00 TRACER

Charge

Charge Analysis



- Charge determined at top and bottom. ►
- Charge resolution about 0.23 c.u. ►

Energy Analysis

- Cerenkov detector identifies high ► energy events
- DEDX and TRD signal determine energy



Oxygen Spectrum 2006



Carbon Spectrum 2006



- Agreement with previous measurements
- ▶ 10 events in integral TR data point with *E* > 1500 GeV/amu

Boron above 3 GeV/amu



- ► 40,000 Boron events.
- 200 Carbon events remaining in sample.
- One unambiguous Boron TR event.

Absolute Spectra of Boron and Carbon



The Boron to Carbon Ratio



- Highest Energy point: 10 carbon, 1 boron
- Data above 10 GeV/amu consistently above E^{-0.6}

Summary

- TRACER is currently the largest balloon-borne CR detector. It utilizes only electro-magnetic interactions.
- Measurements of the first LDB flight suggest a soft source spectrum and a non-zero residual pathlength
- After TRACER was upgraded it had a second LDB flight. The measurement includes Boron and Carbon.
- Results of 2006 agree with previous measurements and provide the B/C measurement with the best statistics yet.
- ► Boron to Carbon ratio hints towards non-zero residual pathlength.

Outlook

Still, more exposure is needed

- ► Repeated LBD flights of large detectors.
- ► i. e. TRACER with an aerogel Cerenkov detector.
 - Improves overall efficiency.
 - ► Includes Be, B and sub-Fe elements in the measurement.

