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Elemental Spectra from the First ATIC Flight

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The Advanced Thin Ionization Calorimeter (ATIC) instrument is a balloon-borne experiment designed to measure the composition and energy spectra of Z = 1 to 26 cosmic rays over the energy range from $\sim 10^{11}$ to $\sim 10^{14}$ eV. The instrument consists of a silicon matrix charge detector, plastic scintillator strip hodoscopes interleaved with graphite interaction targets, and a fully active Bismuth Germanate (BGO) calorimeter. ATIC had two successful Long Duration Balloon flights launched from McMurdo Station, Antarctica in 2000 and 2002. In this paper, preliminary energy spectra of C and O measured during the first 16-day flight are presented.

1. Introduction

The ATIC balloon-borne experiment is designed to measure the charge and energy of cosmic ray nuclei from hydrogen to iron by combining: (1) a silicon matrix for charge measurements, (2) a 0.75 interaction length graphite target to induce nuclear interactions, (3) scintillator strip hodoscopes for triggering and enhancing trajectory reconstruction, and (4) a 17.9 radiation length BGO calorimeter to measure the energy of incident particles. Details of the experiment can be found in reference [1].

In this paper, preliminary energy spectra of C and O, from the analysis of the first ATIC flight data, are presented and compared with the results from other experiments at lower energies. Those of H and He can be found in reference [2].

2. Charge Identification

To determine the incident particle charge, the particle trajectory was reconstructed using χ^2 fitting of a straight line through the selected hits of the sub-detectors including silicon matrix as shown in Figure 1. The silicon pixel that participated in the trajectory reconstruction and its neighbors were compared to get a maximum signal or an average of two consistent signals in the overlapped region, for charge assignments [3]. Figure 2 shows the measured charge distribution from the first ATIC flight, for C and O with a non-negligible contribution from neighboring elements (B, N, F). Multiple Gaussian functions were applied to parameterize each of the heavy elements, as shown in Figure 2. The number of events was counted for each element within a lower and upper boundaries (e.g. 5.3 and 6.5 for C in Figure 2), within each energy deposit bin(N^{dep}), where samples are too small to be fitted at higher energies, before can be unfolded to get incident energy spectra. The contributions

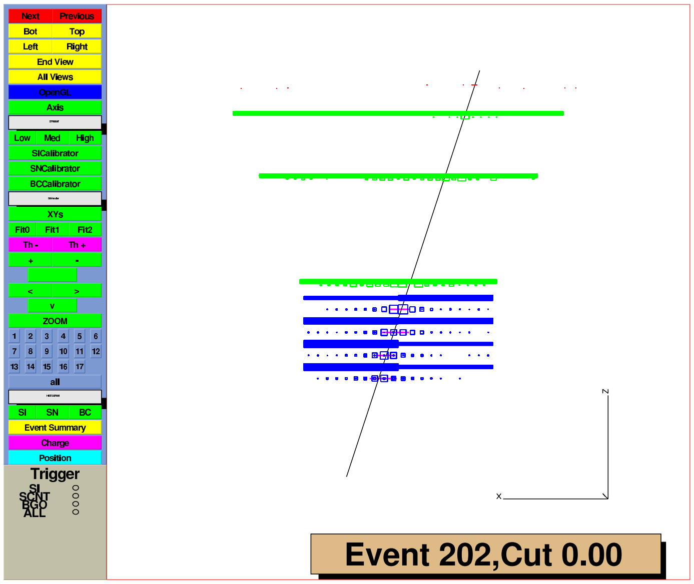

Figure 1. ATIC event display shows each sub-detector's responses (from top to bottom, hits in a silicon matrix, 3 scintillator hodoscopes and 8 layers of BGO calorimeter) to a high energy cosmic ray particle, along which a trajectory is reconstructed. Box size is proportional to the corresponding signal size.

from neighboring elements within boundaries and the missing number of events that went out of the boundaries were estimated using the fitting parameters to improve counting accuracy.

3. Energy Spectra

The number of events in each bin of incident energy of size ΔE, N^{inc}, is estimated by unfolding the deposited energy spectra, N^{dep}, by the matrix method:

$$N_i^{inc} = \frac{1}{C_i} \cdot \sum_j P_{ij} \cdot N_j^{dep}, \tag{1}$$

where the matrix element P_{ij} is a probability that the events in the deposited energy bin j come from the incident energy bin i, and the compensation factor C_i is the fraction of N_i^{inc} that escape the selected range of energy deposit. P_{ij} and C_i parameterize the energy dependent calorimeter response.

To obtain the differential fluxes (F) at the top of the atmosphere, N^{inc} is normalized by

$$F = \frac{N^{inc}}{\Delta E} \times \frac{\beta}{\mathrm{GF} \cdot \varepsilon \cdot T \cdot \eta}, \tag{2}$$

where β is the correction for the finite energy bin size, GF is the geometry factor, ε is a correction for various inefficiencies, T is live time, and η is the correction for atmosphere attenuation loss.

The energy spectra of C and O from the first ATIC flight are shown as filled squares in Figure 3, in comparison with other measurements. Stars, circles, diamonds, triangles and crosses represent the measurement of HEAO3

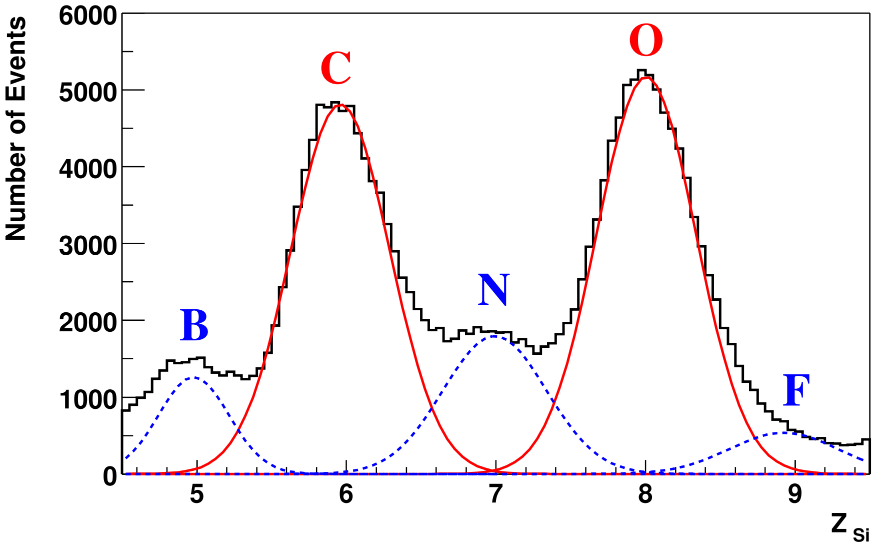

Figure 2. Charge distribution for C and O, from the ATIC 2000 flight, as measured by the silicon matrix. Fitting results used to improve event counting superimposed on the distributions.

[4], GAHECRT [5], Buckley et al. [6], HEN [7] and CRN [8], respectively. Despite the fact that the spectra of C and O are based on preliminary estimate of normalization parameters, the results are in overall agreement with other observations.

4. Summary

Preliminary energy spectra of C and O from the first ATIC flight data were presented in this paper. The results are in general agreement with earlier observations. The analysis of other heavy elements such as Ne, Mg, Si and Fe is still in progress.

5. Acknowledgements

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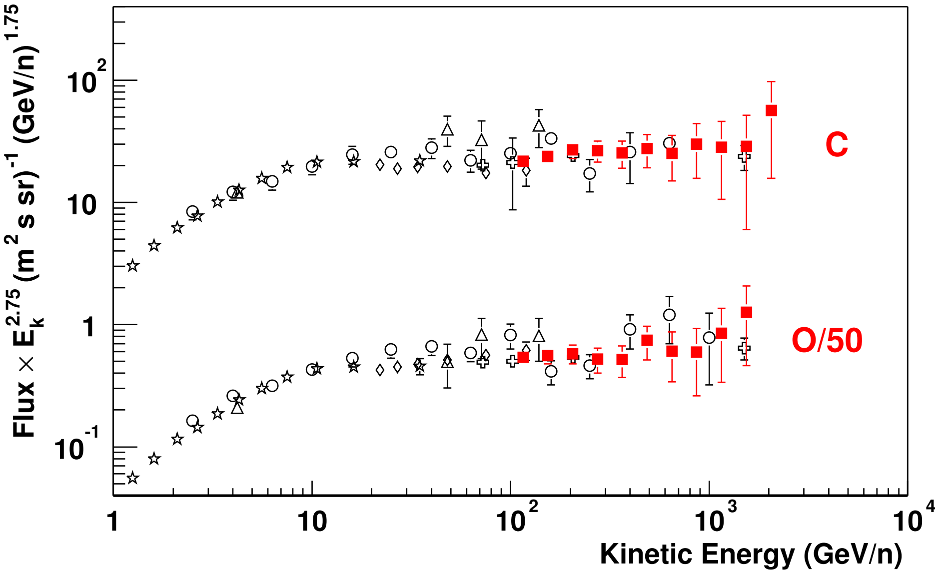

Figure 3. Preliminary energy spectra of C and O from the first ATIC flight (filled squares) are compared with other measurements. Stars, circles, diamonds, triangles and crosses represent the measurement of HEAO3, GAHECRT, Buckley et al., HEN and CRN, respectively.

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