The ATIC Science Flight in 2002-03: Description and Preliminary Results

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Abstract

The Advanced Thin Ionization Calorimeter (ATIC) balloon experiment completed a 19.7 day science flight, 29 Dec. 02 to 18 Jan. 03, from McMurdo, Antarctica, yielding 67 Gbytes of science data. The instrument was fully recovered just over the trans-Antarctic mountain range. ATIC is designed to make new measurements of the composition and energy spectra of cosmic rays in the region up to 100 TeV total energy. The flight and the instrument performance are described and compared to the ATIC-1 flight from 2000-01, and some preliminary results are discussed.

1. Introduction

The ATIC experiment, shown cut-away in Fig. 1 (left) and pictured being prepared for launch in the right half of Fig. 1, was designed for multiple Long Duration Balloon (LDB) flights from remote locations. The rationale is to use a single apparatus to accumulate sufficient exposure to measure the energy spectra of the cosmic ray elements up to 10^{14} eV. ATIC is composed of a Bismuth Germanate (BGO) calorimeter of 18 r.l. depth to measure the cascade developed from primary particles interacting in the carbon target. Interspersed within the target are strip scintillator hodoscopes to provide triggering, geometry definition, trajectory tracing and auxillary charge measurements. At the top of the instrument is a pixelated silicon-detector array which provides the principal measurement of the charge of the primary cosmic ray. Details of the design, operation and calibration

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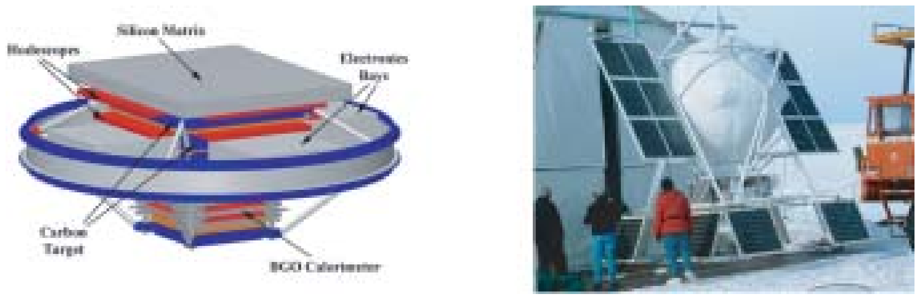

Fig. 1. The ATIC Instrument

of ATIC have been described previously [1-3].

ATIC had its initial test flight (ATIC-1) in 2000-01 from McMurdo, Antarctica [4-6], and demonstrated sucessful system operation and defined instrument performance. Subsequently, the flight systems were refurbished for the science flight. The analyses of ATIC-1 data, including preliminary energy spectra, are presented in accompanying papers at this conference.

2. The ATIC-2 Flight

Once the ATIC team arrived in Antarctica, preparing the experiment for launch went rapidly, and ATIC was flight ready weeks before the polar vortex had established itself. We had an excellent launch on 29 Dec. 2002 at 4:59 UTC (just one day later than the test flight launch two years earlier) and remained in line of sight telemetry range for about 24 hours, until 5:40 UTC on 12/30/02, providing ample time for adjusting thresholds and taking calibration data.

Fig. 2 (left) shows the trajectory around Antarctica for the science flight (ATIC-2) compared to the test flight, labeled ATIC-1. Note the larger, more elliptical shape of the ATIC-2 flight path compared to the previous flight. This was due, in part, to the polar vortex which never stabilized. Rather, the center of the vortex itself followed an elliptical trajectory around the pole, carrying

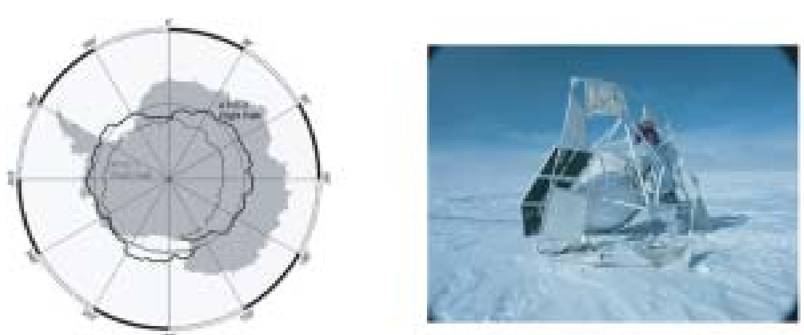

Fig. 2. Flight Tragectories and ATIC-2 Landing

the upper altitude winds with it. The extended trajectory contributed to the longer flight, which was good for the science return. The balloon turned inland in the final days, and the flight was terminated 1/18/03 at 2:01 UTC and landed on the mid-level plateau (5500 feet altitude) in similar terrain to the previous flight. Fig. 2 (right) shows the condition of ATIC-2 after landing and parachute release. The equipment within the gondola suffered little damage, and ATIC-2 was disassembled on the plateau and recovered with two Twin Otter airplane flights, the second of which was completed on 29 Jan. 03.

3. Performance and Results

Fig. 3 displays the balloon and payload performance in terms of altitude, internal pressure and temperature during the flight. The altitude performance was excellent, with a mean of about 36.5 km, equivalent to the test flight. The temperature remained 5 C lower than the previous flight, and showed about the same daily excursions. The pressure declined somewhat during the first part of the flight and then stabilized. This was not unexpected, since prior to launch we discovered a pin-point leak believed to be in the pressure bladder in the lower hemisphere of the gondola. The leak rate was tiny, but, to be on the safe side, we flew two gas make-up cylinders, and used about 1/4 of one bottle.

During the flight we recorded 67 Gbytes of data on the Data Archive Unit's 70 GB disk, consisting of 16.9 million cosmic ray events, 26,000 rate records and about 184,000 housekeeping records of various types. Among these are 436 full instrument calibrations to track any changes in performance. The right portion of Fig. 3 shows the gated master trigger (MT) rate for the ATIC-2 flight. We took data in a mode equivalent to the previous flight for the first few days and then shifted to a higher energy threshold. This threshold was increased once, on 1/9/03, to preserve disk archive space, anticipating a long flight. Note also the drop-out on 1/15-16/03. Here the Detector Control Unit processor hung, and it required almost a day (23 hours) of commanding to bring it back on-line. In

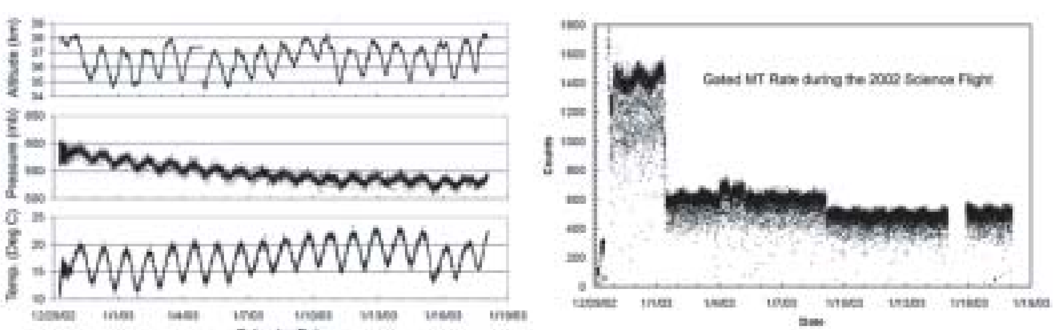

Fig. 3. Preformance During Flight

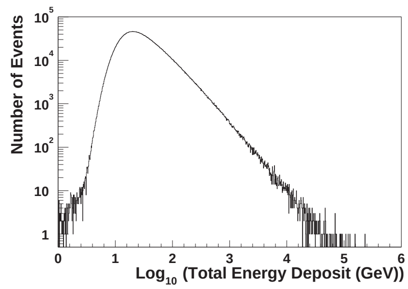

Fig. 4. All-particle energy deposit distribution for ATIC-2.

addition, we had one high voltage converter (affecting one of the two redundant layers of S1 and S3) refused to hold at the prescribed voltage, but appeared stable at a lower voltage. This affected the trigger efficiency by a small amount. Overall, we anticipate about 17 days of good, analyzable data from this ATIC science flight. Fig. 4 shows the all-particle energy deposit spectrum for 1/3 of the ATIC-2 flight data, derived by applying the pre-flight muon calibration. Above 100 GeV deposited energy, the all-particle spectrum follows the anticipated power law. At lower energies, the trigger efficiency must be unfolded from the data.

4. Summary

The ATIC science flight was quite successful, returning over 17 days of useful data. The instrument performed well and the quality of the data is as good or better than the data from the ATIC-1 test flight.

5. Acknowledgements:

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