29th International Cosmic Ray Conference Pune (2005) **3**, 397–400

BGO Temperature Dependence and Energy measurements in the ATIC Calorimeter

J. Isbert[a], J.H. Adams[b], H.S. Ahn[c], G.L. Bashindzhagyan[g], K. E. Batkov[g], J. Chang[d,e], M. Christl[b], A.R. Fazely[f], O. Ganel[c], R.M. Gunasingha[f], T.G. Guzik[a], K.C. Kim[c], E.N. Kouznetsov[g], M.I. Panasyuk[g], A.D. Panov[g], J.P. Wefel[a], W.K.H. Schmidt[d], E.S. Seo[c], N.V. Sokolskaya[g], J. Wu[c] and V.I. Zatsepin[g]

(a) Louisiana State University, Baton Rouge, LA, USA
(b) Marshall Space Flight Center, Huntsville, AL, USA
(c) University of Maryland, College Park, MD, USA
(d) Max Plank Institute for Solar System Research, Lindau,Germany
(e) Purple Mountain Observatory, Chinese Academy of Sciences (CAS), China
(f) Southern University, Baton Rouge, LA, USA
(g) Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow, Russia
Presenter: J. Isbert (isbert@phunds.phys.lsu.edu), usa-isbert-J-abs1-og15-poster

The Advanced Thin Ionization Calorimeter (ATIC) Balloon Experiment had a successful test flight and a science flight in 2000-01 and 2002-03 respectively from McMurdo, Antarctica, returning 16 and 19 days of flight data. ATIC is designed to measure the spectra of cosmic rays (protons to iron). The instrument is composed of a Silicon matrix detector followed by a carbon target interleaved with scintillator tracking layers and a segmented BGO calorimeter composed of 320 individual crystals totalling 18 radiation lengths to determine the particle energy. BGO (Bimuth Germanate) is an inorganic scintillation crystal and its light output depends not only on the energy deposited by particles but also on the temperature of the crystal. The temperature of balloon instruments during flight is not constant due to sun angle variations as well as differences in albedo from the ground. For this purpose the response to temperature variations of the ATIC calorimeter was determined in a thermal chamber.

1. The ATIC Calorimeter

The ATIC Calorimeter is composed of 320 individual BGO crystals totalling 18 radiation lengths arranged in 8 trays each holding 40 crystals. The individual BGO crystals, each 2.5 cm by 2.5 cm by 25 cm in size are wrapped in 25 micron thick teflon, and 25 micron aluminized mylar foil for light tightness (6 of which can be seen in Figure 1) and viewed by a single photomultiplier tube, a Hamamatsu R5611-01. To protect the crystals against shock and provide some thermal resistance the top and bottom of a tray are lined with 0.5mm thick latex. Once a tray is closed the BGO crystals are practically surrounded by aluminum, giving good thermal conductivity across the calorimeter. The 8 BGO trays cover an active area of 51cm x 51cm. Alternating layers are rotated 90 degrees relative to each other forming 4 X and 4 Y layers. Above the top and below the bottom the calorimeter is thermally insulated with 12.5 mm of gaterfoam.

This design minimizes the thermal gradients so that the temperature variations during flight effect all BGO crystals uniformly.

2. The Temperature Calibration

In order to determine the Temperature sensitivity of the ATIC calorimeter the ATIC instrument was taken to the NSBF in Palestine, TX and set up in their thermal vacuum chamber. Since the chamber was too small to

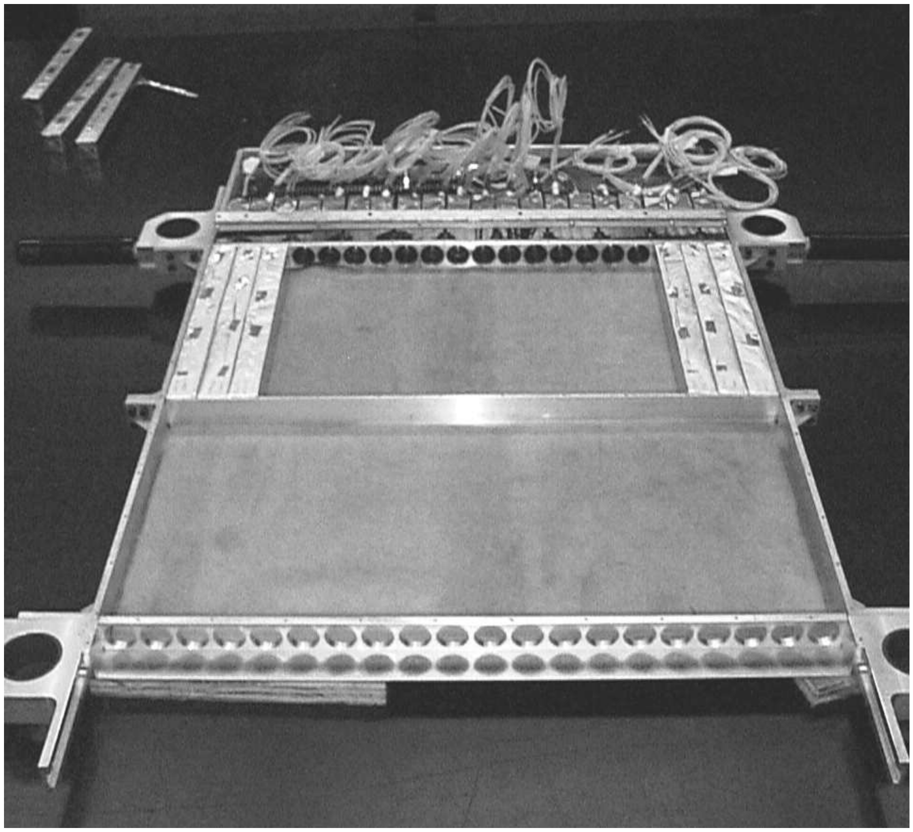

Figure 1. BGO tray top view

fit the entire instrument only the BGO calorimeter, 2 scintillator panels and the readout electronics including the entire flight electronics was set up on a cart and moved into the chamber. Figure 2 shows the setup of the instrument and its tight fit in the Thermal vacuum chamber.

In order to determine the Temperature sensitivity of the ATIC calorimeter the ATIC instrument was taken to the NSBF in Palestine, TX and set up in their thermal vacuum chamber. Since the chamber was too small to fit the entire instrument only the BGO calorimeter, 2 scintillator panels and the readout electronics including the entire flight electronics was set up on a cart and moved into the chamber.

3. Results

The Calorimeter was held at various temperatures and cosmic ray muon data were taken. The Calorimeter was held at various temperatures (35°, 25°, 15°, 1° C) and cosmic ray muon data were taken. Figure 3 shows the histograms of the muon data for 4 individual BGO crystal channels at these temperatures. The position of the muon peaks was determined by fitting at Landau distribution combined with an exponential distribution, shown separately and as sum with the histogram of the data.

The temperature sensitivity for each individual crystal was determined by plotting the peak position as a func-

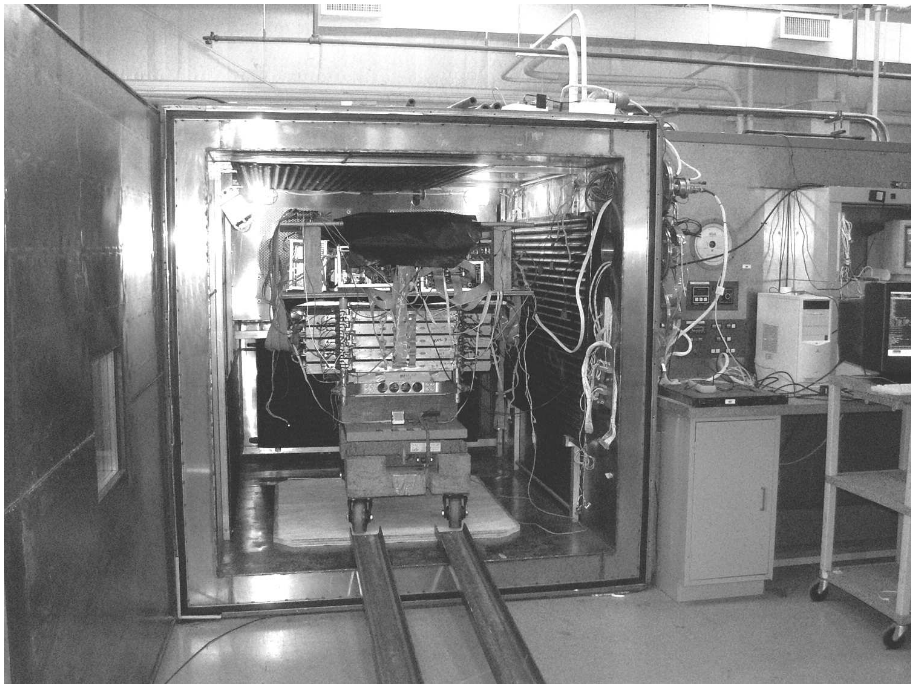

Figure 2. The BGO calorimeter and its readout electronics in the Thermal-Vacuum chamber at NSBF

tion of temperature and a line fitted to these data. The left plot of Figure 4 shows this dependance for one BGO crystal. As an illustration of the variation from crystal to crystal the slopes of 320 BGO crystals normalized to 0° C are shown in the right plot of Figure 4.

These values describe the sensitivity of the BGO as well as that of the electronics. For the data analysis a correction is applied to each individual crystal to compensate for temperature variations during the flight as well as to correct the difference between muon calibration and flight.

4. Acknowledgements

The work was supported by Russian Foundation for Basic Research grants Nos 02-02-16545 and 05-02-16222 in Russia, NASA grants Nos. NAG5-5064, NAG5-5306, NAG5-5155, NAG5-5308 and the NASA SR&T program in the USA, and the Chinese Academy of Science and Max Plank Institute for Solar System Research.

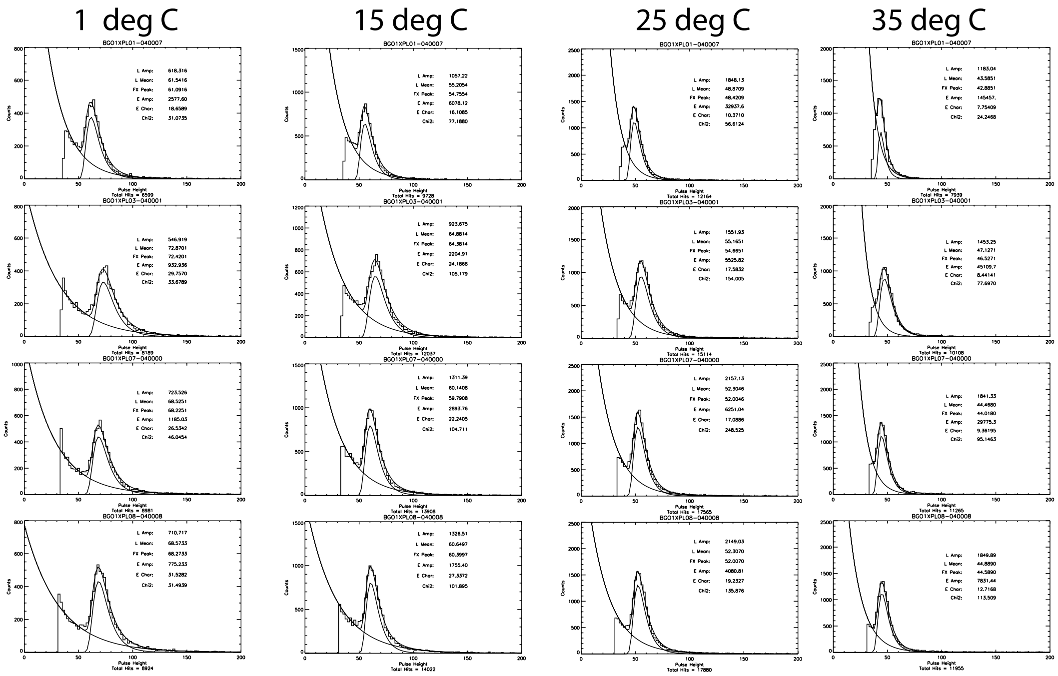

Figure 3. Muon peak histograms for 4 individual BGO crystals

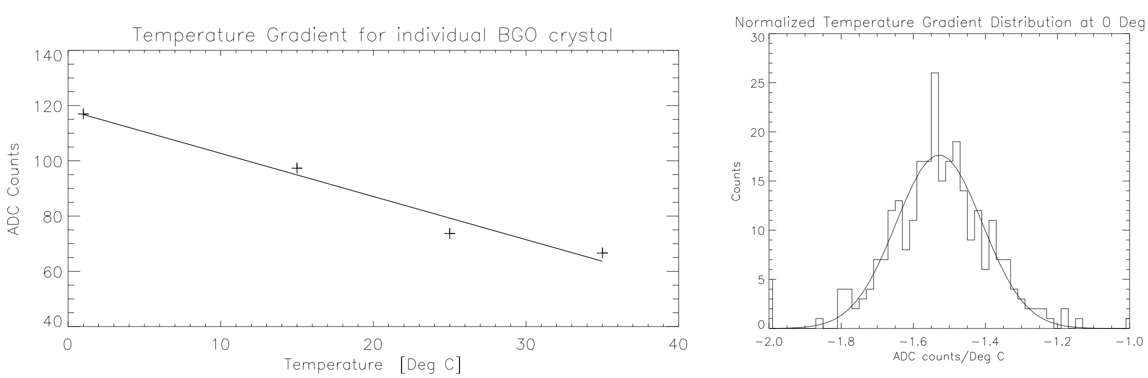

Figure 4. Temperature sensitivity of one BGO crystal (left), Normalized Sensitivities for 320 BGO crystals (right)