Measurement of electron spectrum to high energies with the BESS-1999 experiment

T. Hams[1,a], K. Abe[4], K. Anraku[3,b], H. Fuke[3], M. Imori[3], K. Izumi[3], T. Maeno[4,c], Y. Makida[2], N. Matsui[3], H. Matsumoto[3], J.W. Mitchell[1], A. Moiseev[1], J. Nishimura[3], M. Nozaki[4], S. Orito[3,*], J.F. Ormes[1], T. Sanuki[3], M. Sasaki[1,a], E.S. Seo[6], Y. Shikaze[4], A.S. Stephens[1,a], R.E. Streitmatter[1], J. Suzuki[2], K. Tanaka[2], T. Yamagami[5], A. Yamamoto[2], Y. Yamamoto[3], K. Yamato[4], T. Yoshida[2], and K. Yoshimura[2]

(1) NASA/Goddard Space Flight Center, Code 661.0, Greenbelt, Maryland, 20771, USA

(2) High Energy Accelerator Research Organization (KEK), Tsukuba, Ibaraki, 305-0801, Japan

(3) The University of Tokyo, Tokyo, 113-0033, Japan

(4) Kobe University, Kobe, Hyogo, 657-8501, Japan

(5) The Institute of Space and Astronautical Science (ISAS), Sagamihara, Kanagawa, 229-8510, Japan

(6) University of Maryland, College Park, Maryland, 20742, USA

Abstract

We present our preliminary electron spectra (e^-). The data were obtained with the BESS instrument during a balloon flight from Canada in 1999.

1. Introduction

Electrons constitute less than 1% of the total cosmic radiation. However, due to their small mass they suffer severe energy loss through Bremsstrahlung radiation with the interstellar gas and, synchrotron and inverse Compton processes in galactic magnetic and radiation fields, respectively. As a result, their spectral shape is modified differently than that of nuclei during propagation. Thus, by studying the electron component one can gain additional information on the cosmic ray transport in the Galaxy.

2. Instrument & Balloon Flight

The Balloon-borne Experiment with Superconducting Spectrometer (BESS) is designed as a high-resolution spectrometer with a large geometry factor to provide accurate measurements of the galactic cosmic radiation ($|Z| < 3$) [1, 9, 4].

The detector systems, as shown in Figure 1, are cylindrically arranged

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around a thin superconducting solenoid with a uniform magnetic field of 1 Tesla. A jet-type drift chamber (JET) and two drift chambers inside the magnet's warm bore measure the curvature, and thus the magnetic rigidity, $R \equiv pc/Ze$, and charge sign of incoming particles [1]. A time-of-flight hodoscope (TOF) measures the particle velocity, β, and energy loss, dE/dx [10]. An aerogel Cherenkov counter is employed as a threshold detector [3].

In addition, BESS-1999 is equipped with an electromagnetic shower counter, called the double decker detector (DDD), located above the lower TOF layer [8]. The DDD system consists of a plastic scintillator and an acrylic Cherenkov counter. Both counters of the DDD extend over the full field-of-view of TOF system. A lead radiator with a thickness of two radiation lengths (11.2 mm) partially interleaves the two counters of the DDD. This lead section covers the DDD system in its full width in the azimuthal direction, but due to weight restriction as well as to minimize influence on the low energy antiproton measurement covers only one fifth (200 mm) of the length along the magnet axis. Each detector in the DDD is contained in a light-diffusion box, viewed by an array of photomultipliers (PMTs) whose signals are pulse-height analyzed. The DDD system has been effectively used for e^-/μ^- separation in the cosmic radiation [11].

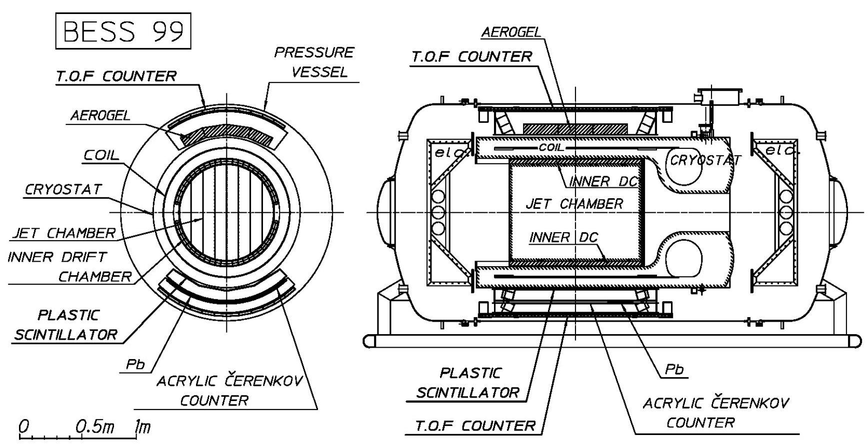

Fig. 1. Cross-sections of BESS-1999 Instrument.

BESS was launched in the summer of 1999 from Lynn Lake, Manitoba, Canada. During the 34 hours flight we obtained 31 hours of data at a residual atmospheric depth of less than $5\,\mathrm{g\,cm^{-2}}$. The typical geomagnetic rigidity cut-off for the flight data is 0.4 GV.

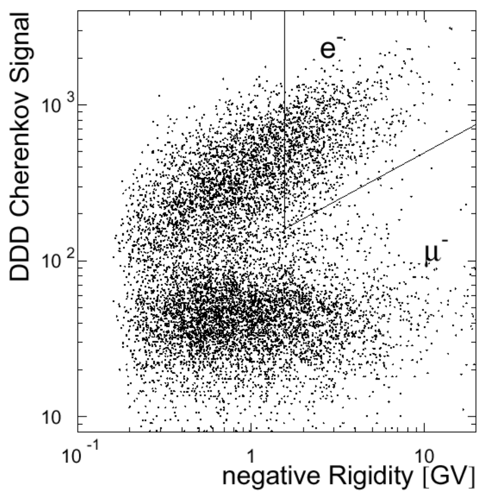

Fig. 2. Separation and selection of e$^-$ with DDD Cherenkov counter.

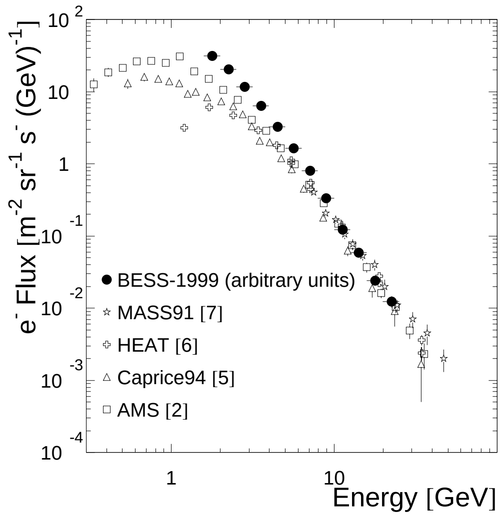

Fig. 3. Preliminary BESS-1999 electrons spectra in arbitrary units compared with other magnet spectrometers.

3. Data Analysis & preliminary Results

In order to identify the electron component (e$^-$) of the cosmic radiation, we first used the TOF to select, from the BESS-1999 float data, single-charged particles that penetrated the detector in the downward direction. Negatively charged particles are then selected with the magnetic spectrometer by requiring a negative rigidity. For the present investigation we only considered events with $|R| \leq 20\,\mathrm{GV}$. With these cuts applied, the data sample contains mostly electrons and muons, and a small number of anti-protons. For the preliminary results discussed in this paper we neglected the antiproton contribution, which is less than one percent of the electron component. Of this sample of events, only those passing through the lead covered section of the DDD are selected for further analysis. With the latter requirement the geometric factor for this analysis is approximately $400\,\mathrm{cm}^2\,\mathrm{sr}$. We have rejected events that interacted above the DDD system by requiring the plastic scintillator above the lead to detect only one single-charged minimum-ionizing particle. Muons do not interact in the lead and the DDD Cherenkov counter below the lead detects only the yield of one particle, whereas most electrons produce an electro-magnetic shower in the lead. The outgoing charged particles in that shower result in a high light yield in the DDD Cherenkov counter. We also have found a good correlation of DDD Cherenkov response to the combined energy loss in the lower TOF scintillator. In Fig. 2 we show the DDD Cherenkov signal (channels) vs. rigidity. The separation between muons and electrons can easily be seen. The cuts shown in the figure were used to select events for further analysis. The non-interacting muons have on average a DDD Cherenkov signal of 40 channels. At present, we required for electrons at least two particles in the DDD Cherenkov counter (yield $\propto Z^2$) after penetrating the lead. The selected electrons in Fig. 2 are distributed into different energy bins and the number in each bin is divided by the width of the bin and the total collecting power to give a differential energy spectrum. This electron spectrum as a preliminary result is plotted in Fig. 3 along with the recently measured data of MASS91 [7], AMS [2], Caprice94 [5], and HEAT [6]. Since the selection efficiencies and the muon contaminations are currently under investigation, we have normalized our measured spectra around 10 GeV with the data of Caprice94. The apparent excess of electrons in our data below about 2 GeV may be due to muon contamination at lower rigidities (see Fig. 2) and solar modulation.

4. Discussion

Currently the efficiencies and contamination of the different cuts are under investigation. At the conference we will present our absolute spectra.

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[a] Resident Research Associate of the National Academy of Sceince
[b] Present address: Kanagawa Univ. Yokohama, 221-8582, Japan
[c] Present address: CERN CH-1211 Geneva 23, Switzerland
[*] deceased

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