# FINE STRUCTURE IN THE COSMIC RAY ELECTRON SPECTRUM MEASURED BY ATIC

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*Abstract.* New analysis to separate electrons from protons in the ATIC experiment has been performed. Five new discriminants were studied by different Monte Carlo programs. New electron spectrum, when compared with the published results [1], show good agreement in the most interesting region of energy (from 90 GeV to 600 GeV). It is argued that there is no disagreement between ATIC's results and Fermi-LAT ones. Finally, high-resolution electron spectrum is obtained and possible fine structure is found out in it.

The ATIC (Advanced Thin Ionization Calorimeter) balloon-borne spectrometer was designed to measure the energy spectra of elements from H to Fe with individual resolution of charges in primary cosmic rays for energy region from 50 GeV to 100 TeV. ATIC has had three successful flights around the South Pole in 2000–2001 (ATIC-1), 2002-2003 (ATIC-2) and 2007-2008 (ATIC-4). ATIC is comprised of a fully active bismuth germanate (BGO) calorimeter, a carbon target with embedded scintillator hodoscopes, and a silicon matrix that is used as the main charge detector. The calorimeter is comprised of 8 layers with 40 BGO crystalls in each for ATIC-1 and ATIC-2 and of 10 layers for ATIC-4. The details of the construction of the apparatus are described in the papers [2–4]. It was shown that it is possible also to measure the spectrum of cosmic ray electrons plus positrons [5] with ATIC (hereinafter we use 'electrons' for brevity). To separate electrons from the higher background of protons and other nuclei some differences in shower development for incident electrons and for nuclei are used. The spectrum of electrons measured with the ATIC spectrometer by this method was published in the paper [1]. The most notable detail of the electron spectrum reported was an 'excess' of electrons between energies of 300–800 GeV. The main purpose of this work is to investigate possible alternate techniques to separate electrons from hadrons and was curried

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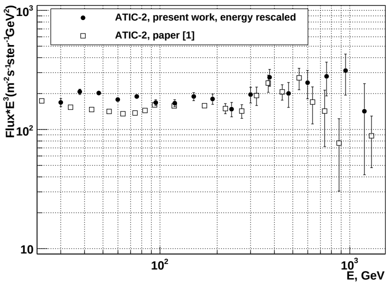


Figure 1: Comparison of the electron spectrum of ATIC-2 of present paper with the spectrum of the paper [1]. The proton background is not subtracted in both spectra.

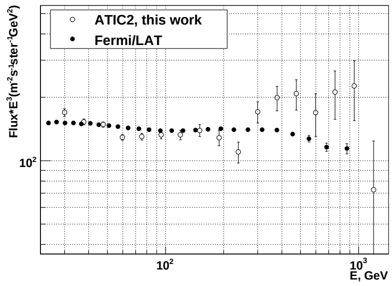


Figure 2: Comparison of the electron spectra of ATIC-2 (present paper) with the electron spectrum measured by Fermi-LAT [6].

out completely independent of the previous analysis with new discriminants to look at the resulting electron spectrum.

For better cross-checking of the results we constructed and worked with five new discriminants that permit to separate electron showers (by its shape) from proton showers. The first conclusion obtained during analysis was that the procedure of the proton background subtraction from the spectrum of the selected electron-like events may be a source of significant systematics. Therefore we did not rely on the proton background subtraction as was done in the paper [1], but, instead, we tried to reduce the proton contamination as much as possible. The things that may be studied are various sharp features in the behavior of the electron spectrum (like 'ATIC's excess').

We compare the obtained spectrum of electrons with the spectrum of [1] in Fig. 1. A problem was that the spectrum of [1] was corrected for the scattering of the electrons in the atmosphere by simple rescaling of the spectrum measured at the top of the apparatus, but we present the spectrum at the top of the apparatus as the main result. Therefore to compare the spectra we artificially normalize the energy of each event of our spectrum in Fig. 1 by factor 1.15 that corresponds to the mean loss of energy by the electrons in the atmosphere. The result of the comparison is shown in Fig. 1. It is seen that there exists very good agreement of both spectra in the region from 90 GeV to 600 GeV. We completely confirm 'ATIC's excess' measured in ATIC-2 in this region.

In Fig. 2 we compare our data for the ATIC-2 flight with recent results for the electron spectrum in the region from 20 GeV to 1 TeV measured by Fermi/LAT telescope [6]. The comparison of ATIC's results and the spectrum of Fermi/LAT shows no sign of disagreement between the experiments. Actually, the ATIC spectrum are shown without subtraction of proton back-

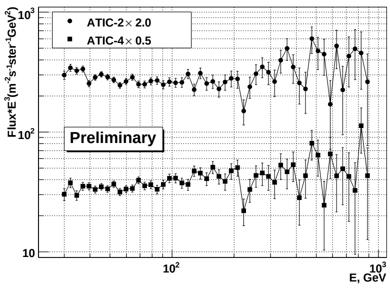


Figure 3: Fine structure in the spectra of electrons of ATIC-2 and ATIC-4.

ground. It is most probable that at the energies 30–100 GeV this background is not high, but above some hundreds of GeV the intensity of background is higher. Actually, the ATIC data agree with Fermi/LAT at the energies less than 200 GeV well and the deviation above 300 GeV may be related to unaccounted background. The only significant difference of the ATIC's spectrum from the Fermi/LAT's one is a sharp dip near 250 GeV but it may be explaind by lower energy resolution of Fermi/LAT relative to ATIC.

The energy resolution of the ATIC apparatus for electrons actually is very high and one could measure the electron spectrum with narrower energy bins than in the previous paper [1]. The electron spectra for ATIC-2 and ATIC-4 flight measured with bin width of 0.03 for decimal logarithm of energy are compared in Fig. 3. It is seen that between 200 GeV and 600 GeV some structure (three dips and three peaks) exists in ATIC-2 spectrum. One may think that it is only a play of statistics, but the preliminary spectrum measured by the ATIC-4 experiment in the same region completely confirms the structure. This is a sign that this fine structure may be real.

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