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Precise Measurement of the Cosmic-Ray Electron and Positron Spectrum with CALET on the International Space Station

Shoji Torii and Yosui Akaike, on behalf of the CALET Collaboration
Waseda University, Tokyo, Japan

Precise measurements of the cosmic-ray electron and positron (all-electron) spectrum are being carried out with the CALorimetric Electron Telescope (CALET) onboard the International Space Station since December 2015. The instrument, consisting of a charge detector, an imaging calorimeter and a total absorption calorimeter, is optimized to measure the all-electron spectrum well into the TeV region with a thick calorimeter of 30 radiation lengths with fine shower-imaging capability. Due to the excellent energy resolution (~2 % above 20 GeV) and the outstanding e/p separation (~10^5), CALET achieves optimal performance for a precise measurement in range of 10 GeV up to the TeV region.

CALET has been accumulating scientific data for more than five years with very stable and continuous observations, and the statistics of observed electron events has increased more than double since the second publication of Ref. [PRL 120, 261102 (2018)]. Figure 1 presents a preliminary result of the all-electron spectrum in 11 GeV to 4.8 TeV with CALET, which are obtained by observations over 5 years. The error bars along horizontal and vertical axes indicate bin width and statistical errors, respectively. The gray band is representative of the quadratic sum of statistical and systematic errors. For comparison, the spectra with the other recent experiments in space, AMS-02, DAMPE and Fermi-LAT, are shown.

In Fig.2, we fit our spectrum with a smoothly broken power-law model in the energy range from 55 GeV to 4.8 TeV, while fixing the break energy at 914 GeV (blue line) as adopted in DAMPE. A broken power law steepening from -3.151±0.012 by -0.873±0.178 fits our data well, with χ^2 /NDF = 11.64/29. This result is consistent with DAMPE regarding the spectral index change of 0.7±0.3. A single power-law fit over the same energy range (black line) gives an index -3.197±0.011 with χ^2/NDF=54.50/30, which means that the broken power law is favored with 6.55 σ significance over the single power law. An exponentially cut-off power law (green line) is also presented for comparison, which has the power index of -3.054 $\pm$ 0.026 below a cutoff energy of 2170 GeV $\pm$ 340 GeV with a significance of σ =6.58 over the single power law. In paper, we are discussing also a fitting by astrophysical sources.

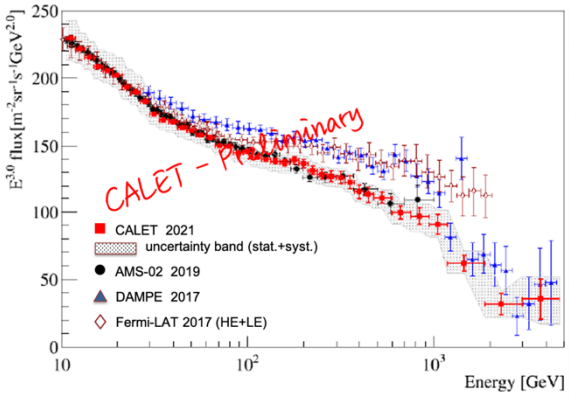

Fig.1: Preliminary result of All-electron spectrum measured with CALET, where the gray band indicates the quadratic sum of statistical and systematic errors, compared with other direct measurements in space.

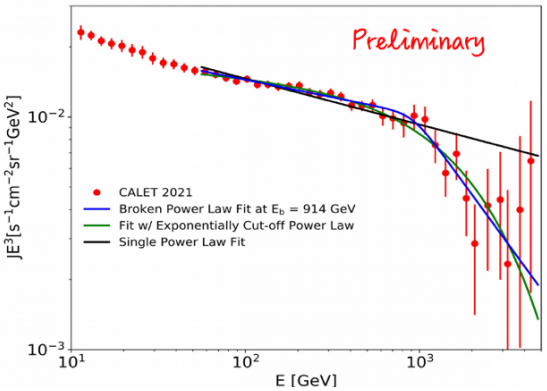

Fig.2: All-electron spectrum measured with CALET, using the same energy binning as DAMPE's result [Nature, 2017]. See text for function fittings of the spectrum.