Charge measurement of cosmic rays by Plastic Scintillantor Detector of DAMPE

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Introduction

Plastic Scintillantor Detector (PSD) is part of DArk Matter Particle Explorer (DAMPE), which plays a crucial role of charge measurement for charged cosmic rays and acts as a veto for gamma rays. In this work, we give some updated correction methods to enhance the quality of charge measurement, especially for heavy nuclei. DAMPE has collected nearly 10 billions events by middle of 2021, it has substantial potential to measure the spectra of cosmic ray nuclei up to hundreds of TeV energies, which could be benefited from these corrections for charge measurement.

PSD is composed of two orthogonal PSD planes, there are 41 PSD units in each plane. Left panel of Fig.1 shows the structure of PSD.

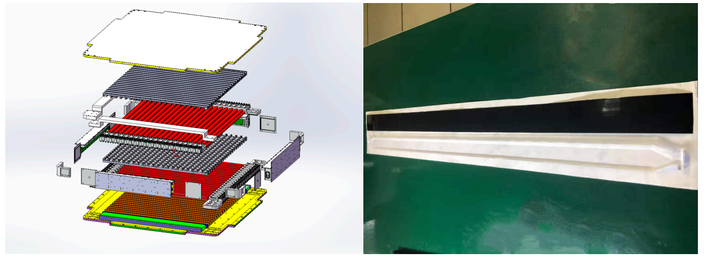

Figure.1 PSD detector. Left side shows the structure of PSD,;
Right picture contains one PSD detector unit with Tyvek 1056D (white) and heat-shrinkable tube (black)

Method

One of DAMPE's major scientific goals is precise measurement of cosmic-rays from proton up to iron even more heavy nickel, which means good charge recognition ability is needed. Based on a series of previous work, we found that heavy nuclei shows different pattern with hit position on different PSD detector units, seen in Fig. 2. these phenomena of charge value variation as a function of hit position were found to be existed on each PSD units, furthermore, pattern of each unit is unique.

Based on a series of former works on PSD[1,2,3,4], we develop a new method to eliminate the phenomenon in Fig. 2 by using interpolation with the template as shown in right panel of Fig. 2. After elimination of charge variation within one bar, we re-uniform all bars with nominal charge, seen in Fig.3 and 4.

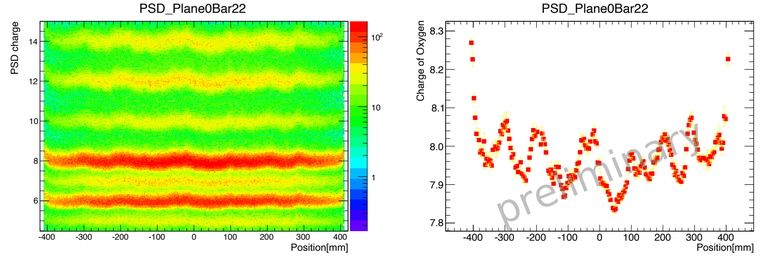

Figure.2 Charge values as function of hit position. Left plot shows the pattern of PSD unit located in first plane and 23rd. Right side is carbon charge value fitted with Landau convoluted with Gassian function for each hit position

Results

Based on a series of previous works, we developed a new method to eliminate charge variation with hit position, meanwhile, after applying this new correction, we also finished a charge uniformity for all PSD units in order to obtain better charge resolution and precise cosmic-rays spectra. The uniformity is based on energy threshold for different spectra measurement.

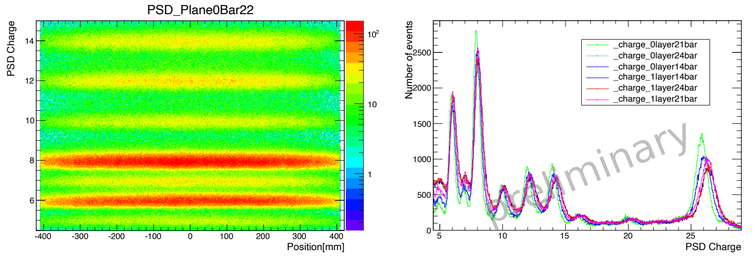

Figure.3 Charge values as function of hit position after position correction. Left panel shows the non-relation between charge measurement and hit position of the PSD unit in first plane and 23rd one. Right sides presents differences among different PSD units

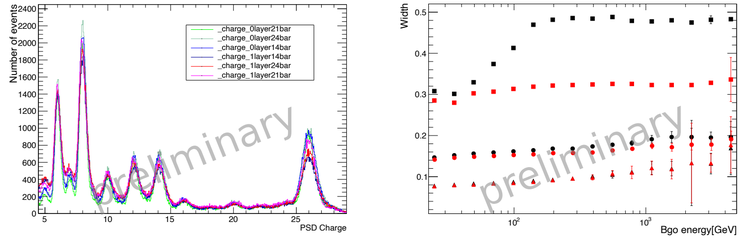

Figure.4Charge measurement from boron to nickel for several PSD units, the uniformities between units are significantly improved as shown in left panel, right plot shows the charge resolution comparisons of helium, carbon and iron with (red) and without (black) from lower to upper positions along Y-axis, respectively.

Summary

We developed a method to significantly eliminate charge variation at different hit positions within PSD unit, which is proved to be necessary and helpful to cosmic-rays spectra measurement, especially for heavy ions.

References

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