

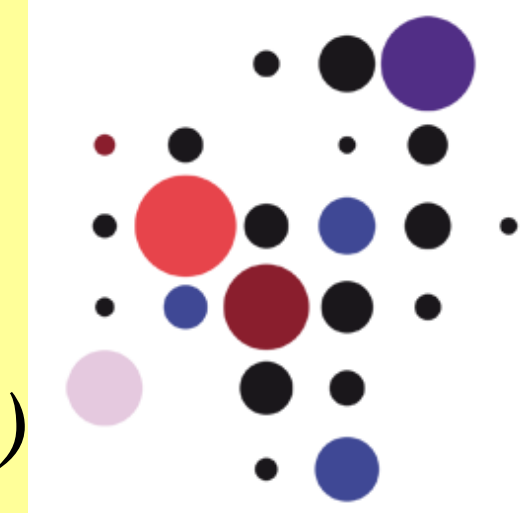
Development of an Automatic Test System for the PMTs used in the BGO ECAL of DAMPE



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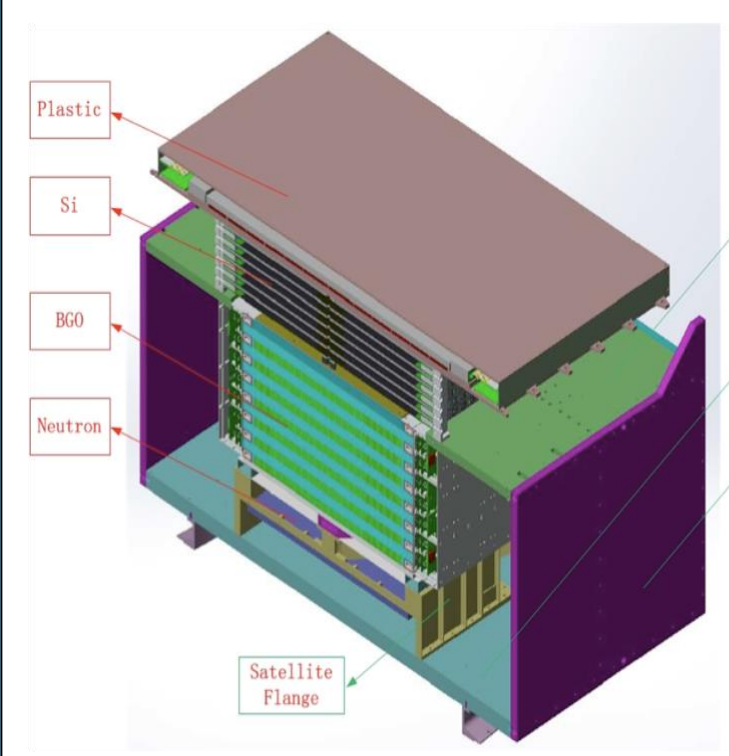


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Abstract: An automatic system has been developed for the batch test of the photomultiplier tubes (PMTs) in the BGO electromagnetic calorimeter (ECAL) of the Dark Matter Particle Explorer (DAMPE). There are 616 PMTs used in the BGO ECAL, which are critical for the realization of high dynamic readout and high precision measurement of the scintillation light from BGO crystals. Considering of the reliability and quality requirements as a space-borne experiment, over 800 PMTs have been tested. Therefore, a light-emitting diode (LED) based system has been designed to test the PMTs automatically. This poster will give a brief description on this automatic test system.

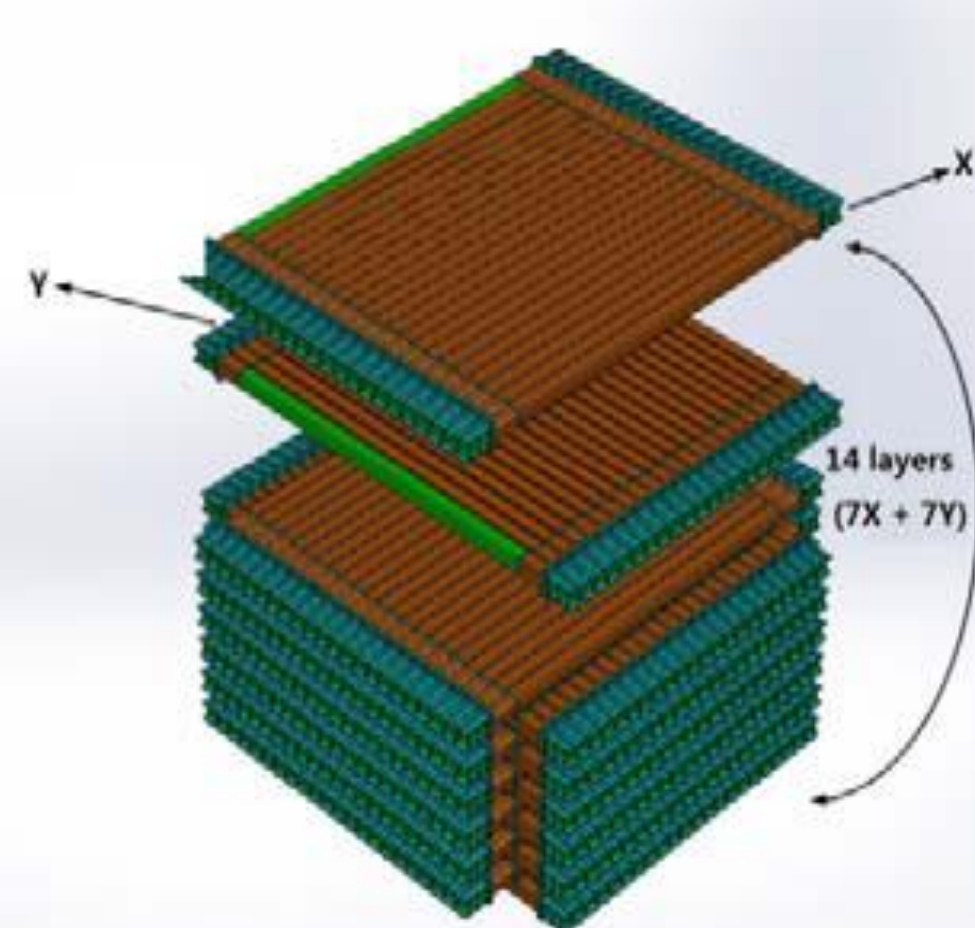
Structure of DAMPE



DAMPE is a detection satellite which aims at measuring the dark matter indirectly. It has the highest dynamic energy range from **5GeV to 10TeV**.

DAMPE is consist of PSD, STK, BGO ECAL and neutron detector, in which **BGO ECAL** is the crucial sub-detector to realize the high dynamic energy range.

Arrangement of 308 BGO crystal bars in BGO ECAL



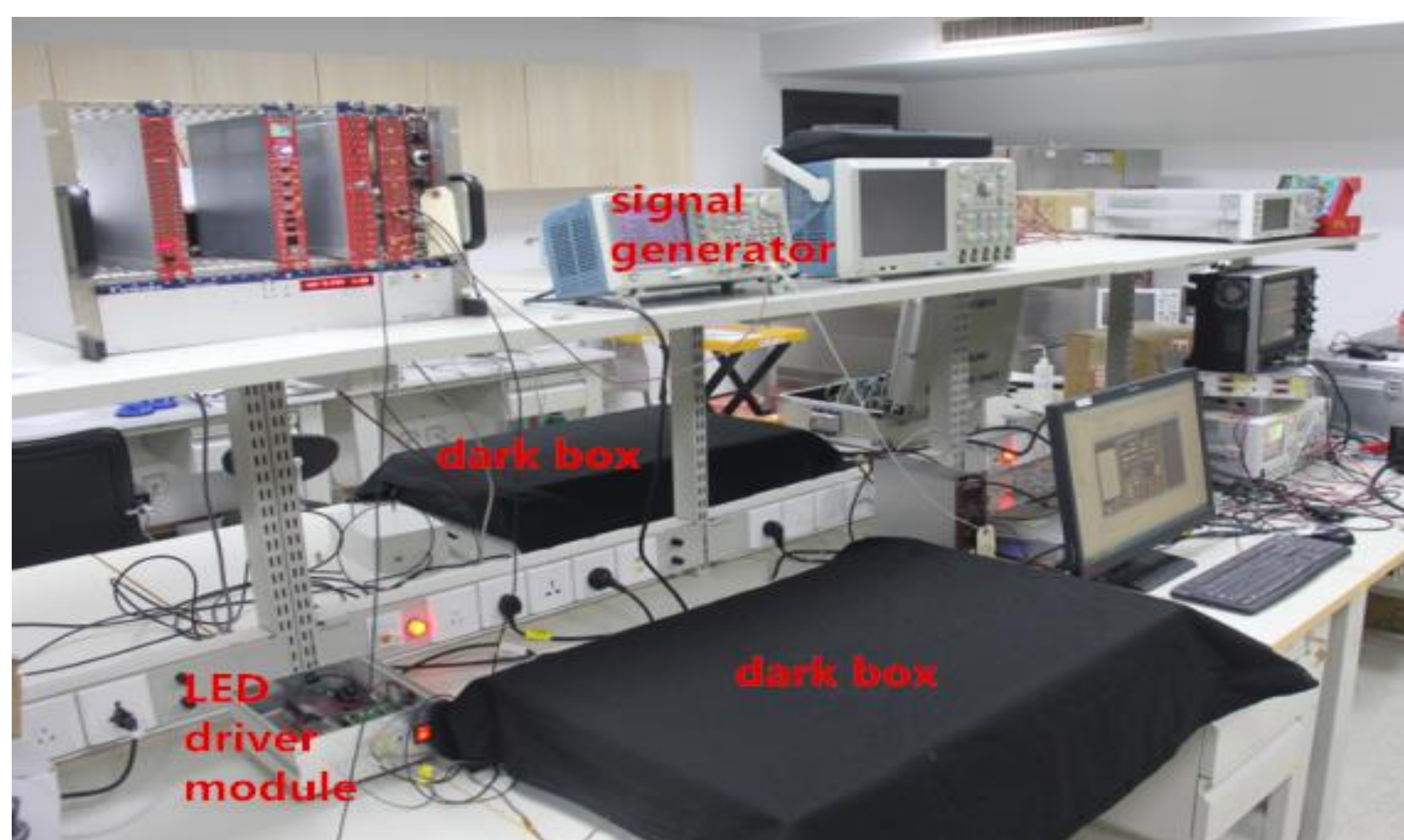
BGO ECAL is composed of 14 layers of BGO crystal and 22 BGO bars are placed in each layer.

Each BGO bar is viewed by two PMTs, from both sides respectively. So **616 PMTs (R5610A-01)** are required in BGO ECAL and 800 PMTs must be tested for the Qualification Model and the Flight Model respectively..

To reach the high dynamic range, the relative gain ratio of the PMT must be greater than 1000.

The Automatic Test System

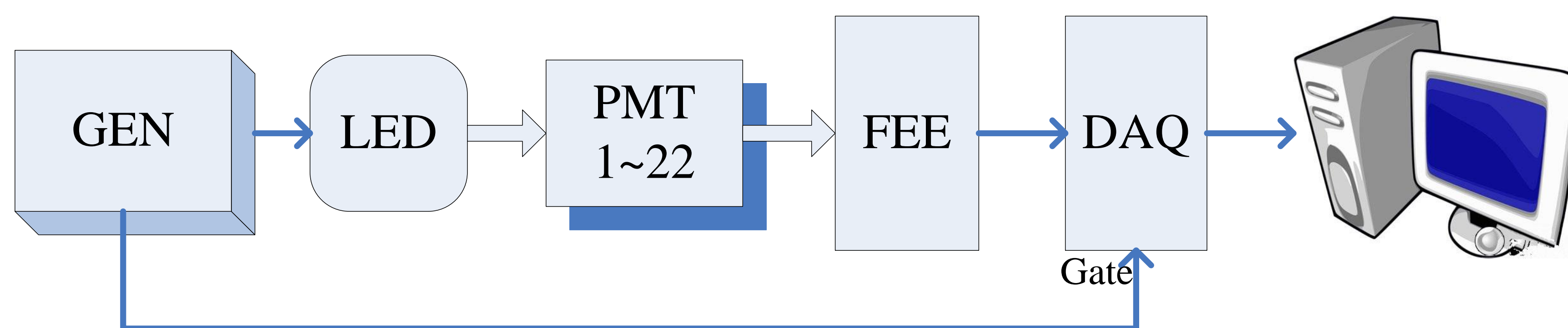
I) Composition of the automatic test system



left> The automatic test system based on LED is made up of a signal generator, a LED driver module, two dark boxes and a readout system.

right> In the dark box, an integrating sphere with a LED in it has two bundles of optical fibers to put out the light uniformly, and 22 of them are connected to 22 grooves in which PMTs can be placed and be illuminated.

II) Block diagram of the LED test system



The GEN drives the LED emit through the LED driver module. 22 PMTs in the grooves can be illuminated by the optical fibers. The light intensity can be adjusted by the GEN with the software based on Labwindows/CVI automatically. Then the ADC counts of Dy8, Dy5, Dy2 of the 22 PMTs can be obtained from the readout system and their relative gain ratios can be analyzed.

It takes ~30 minutes to test 44 PMTs automatically.

Test Results

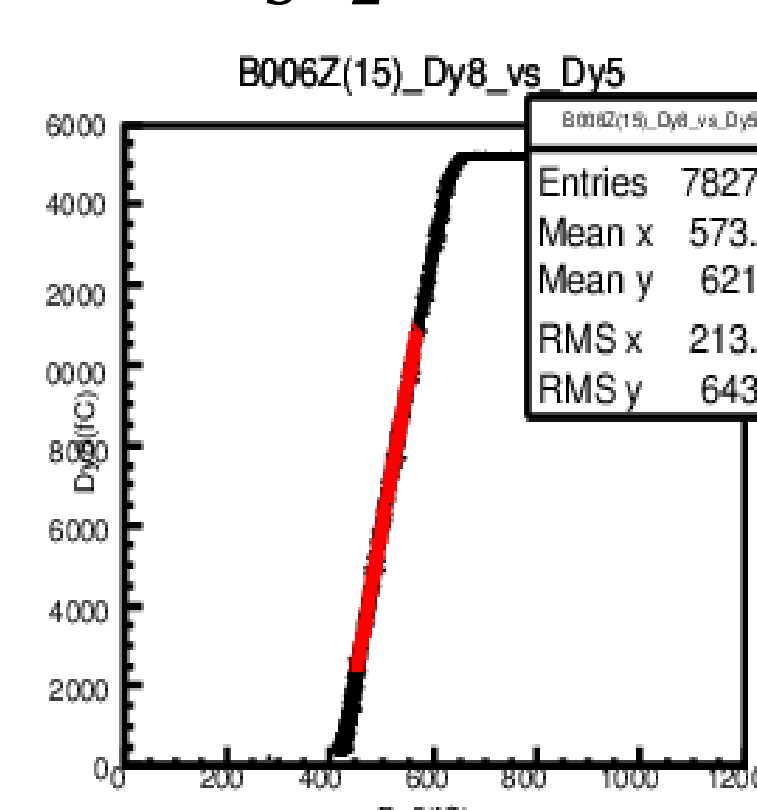
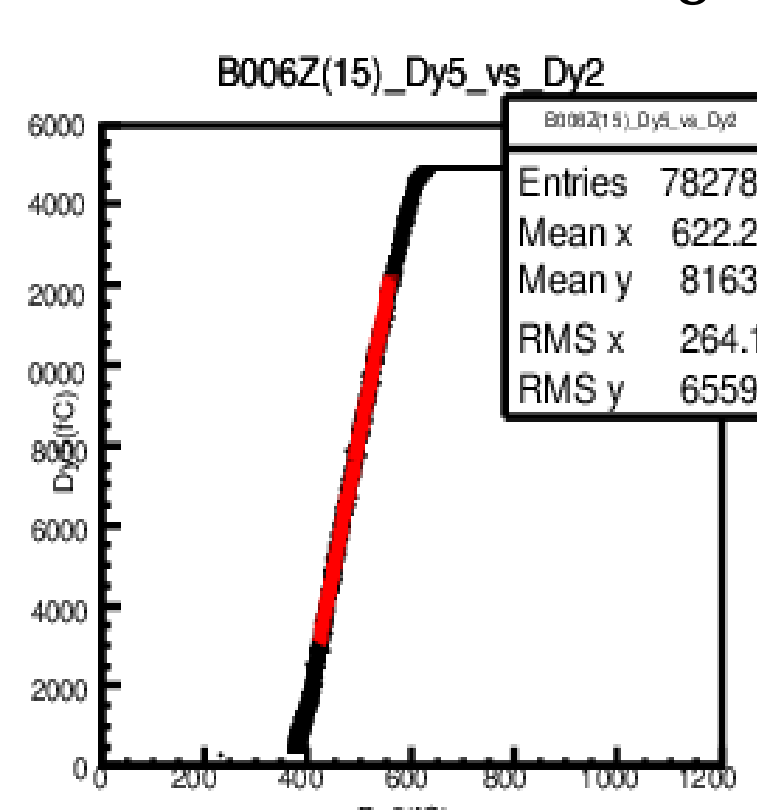
I) Typical PMT's gain ratio

The gain ratio of Dy8 to Dy5 and Dy5 to Dy2 can be calculated as follows and the dynamic range (DR) of the PMT can be reckoned as their product.

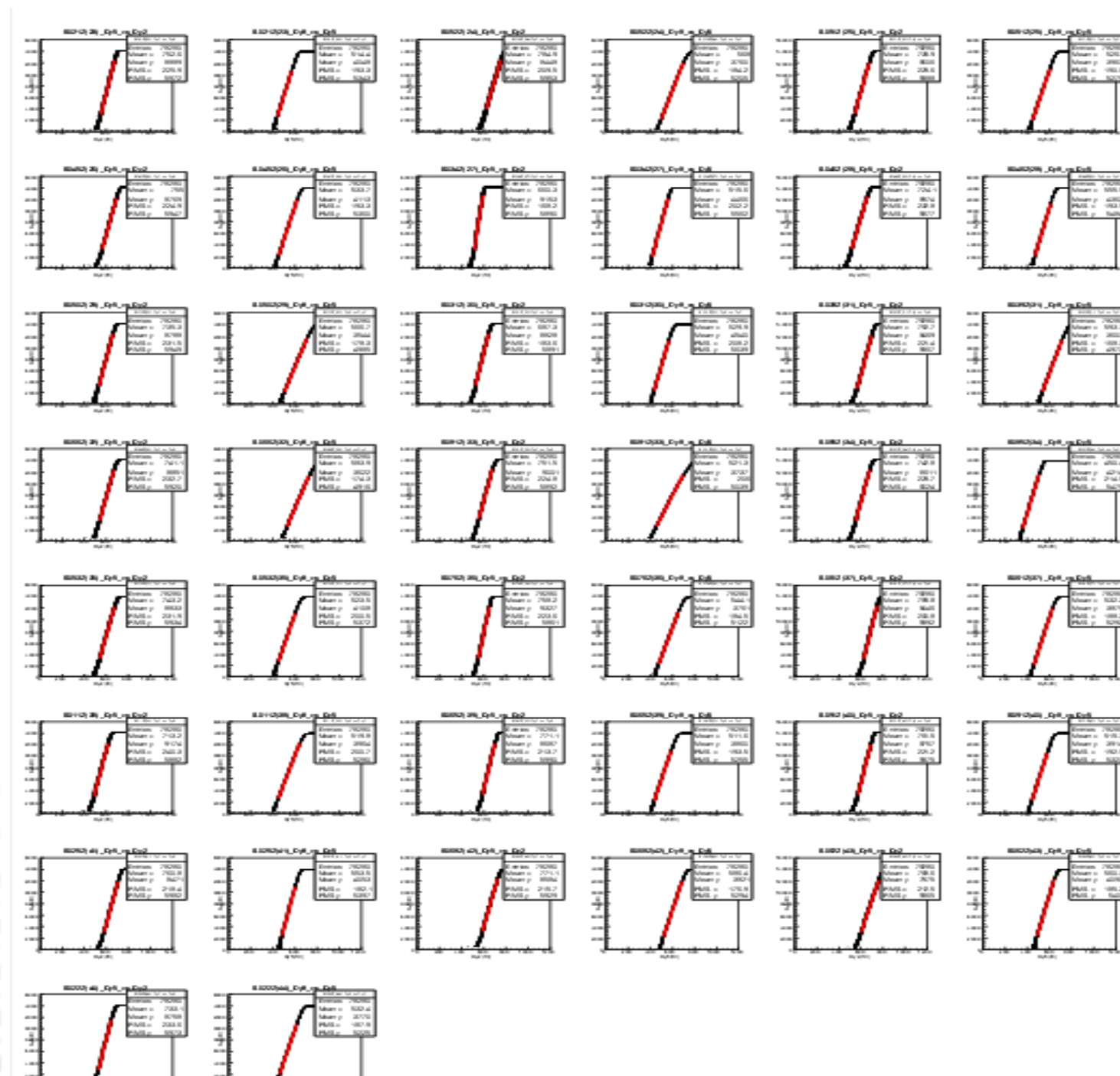
$$Ratio_{8-5} = \frac{ADC_{count8}}{ADC_{count5}}$$

$$Ratio_{5-2} = \frac{ADC_{count5}}{ADC_{count2}}$$

$$DR = Ratio_{8-5} \times Ratio_{5-2}$$



II) Performance of 22 PMTs tested at a time



Under the HV of 670V, 44 PMTs can be tested at a time and the performance of half of them has been showed above.

The dynamic ranges of all the PMTs are over 1000, meeting our need completely.

The typical PMT's gain ratio of Dy8 to Dy5 and Dy5 to Dy2 whose linearity is well. And its dynamic range is over 1000 obviously.

Conclusions

- A LED based test system has been developed to test the relative gain ratio of PMTs automatically.
- 1600 PMTs for the Qualification Model and the Flight Model of DAMPE perform well in the automatic measurement.
- With the automatic test system, 44 PMTs can be tested at a time automatically.
- It takes about 30 minutes to test 44 PMTs and just 38 times are needed to test all the PMTs, which saves a lot of time, reduces the workload greatly and guarantees the project schedule.

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