

Abstract

A Large High-Altitude Air Shower Observatory (LHAASO) is building at Haizi mountain, Sichuan, China at an elevation of 4410 m. One of its main goals is to survey the northern sky for very-high- energy (above 100 GeV) gamma ray sources via its ground-based Water Cherenkov Detector Array (WCDA). WCDA is 78000 m² in dimension and consists of 3120 water detector cells divided into 3 water ponds. A hemispherical 8-inch photomultiplier tube (PMT) CR365 from Beijing Hamamatsu Photon Techniques INC. (BHP) is installed at the bottom-center of each cell of the first water pond to collect the Cherenkov light produced by air shower particles crossing water. In this presentation, technical design of WCDA is introduced. The design of a high dynamic range base for CR365 is presented. The batch test system for PMTs and test results of 997 PMTs are included.

LHAASO project and WCDA

Primary scientific goals of LHAASO:

- The origin of cosmic ray
- Search for very high energy gamma ray sources
- New physics: Lorentz invariance, dark matter, quantum gravity, et. al.

Detector arrays:

- Water Cherenkov Detector Array (3000)
- KM2A
 - Scintillation detectors (5195)
 - Muon detectors (1171)
- Wide FoV Cherenkov Telescopes (18)

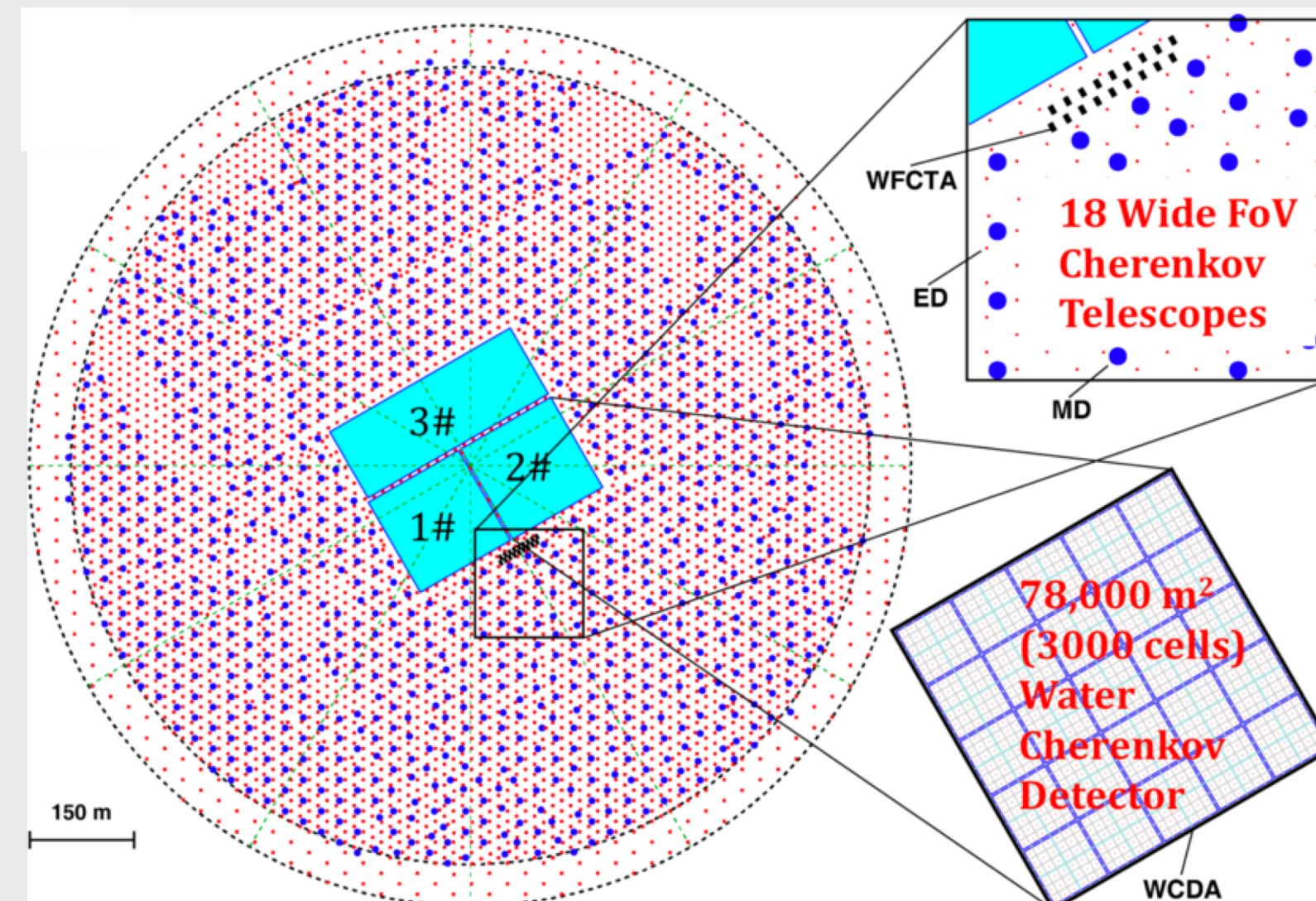


FIG. 1. LHAASO detector layout

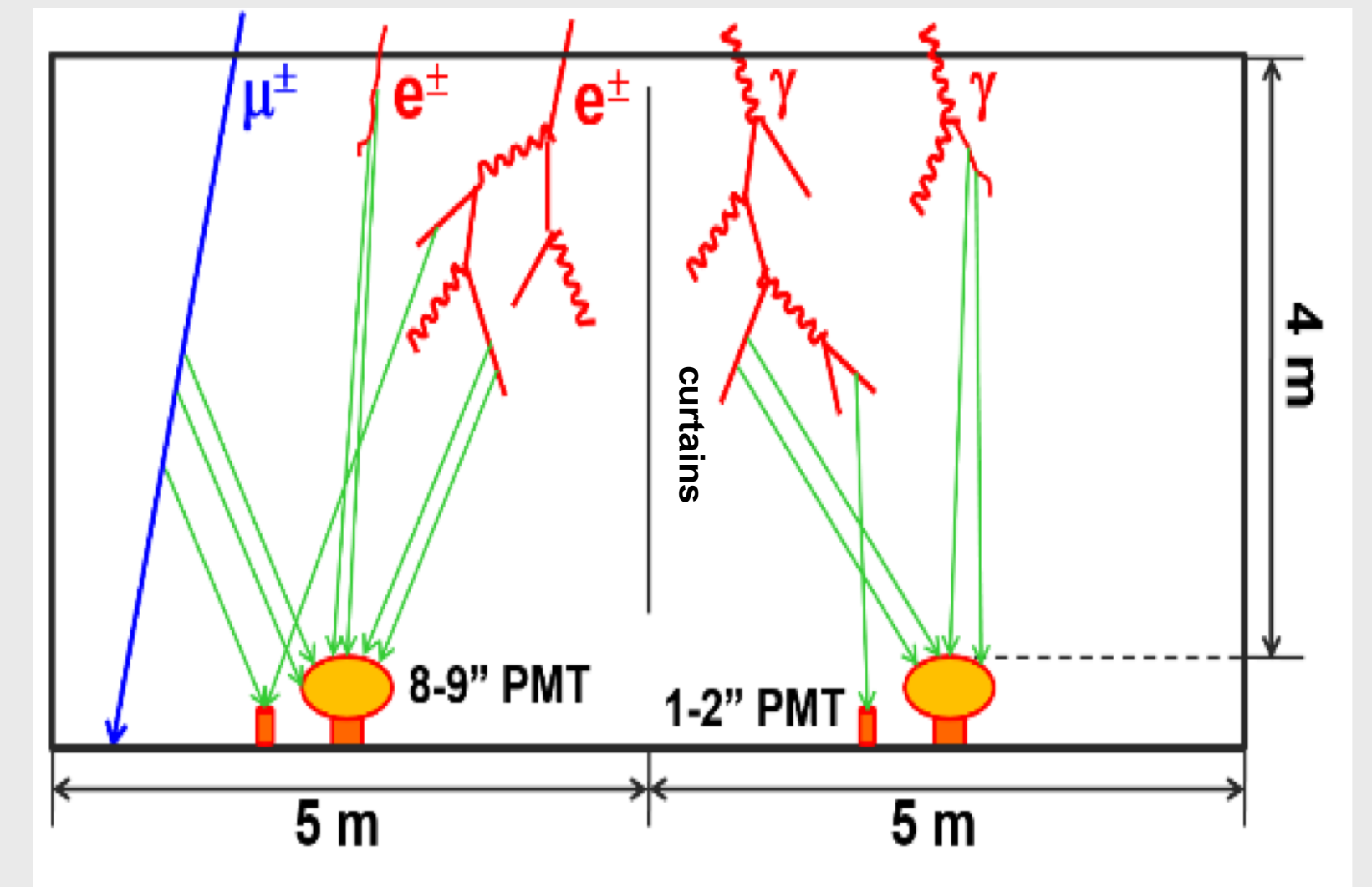
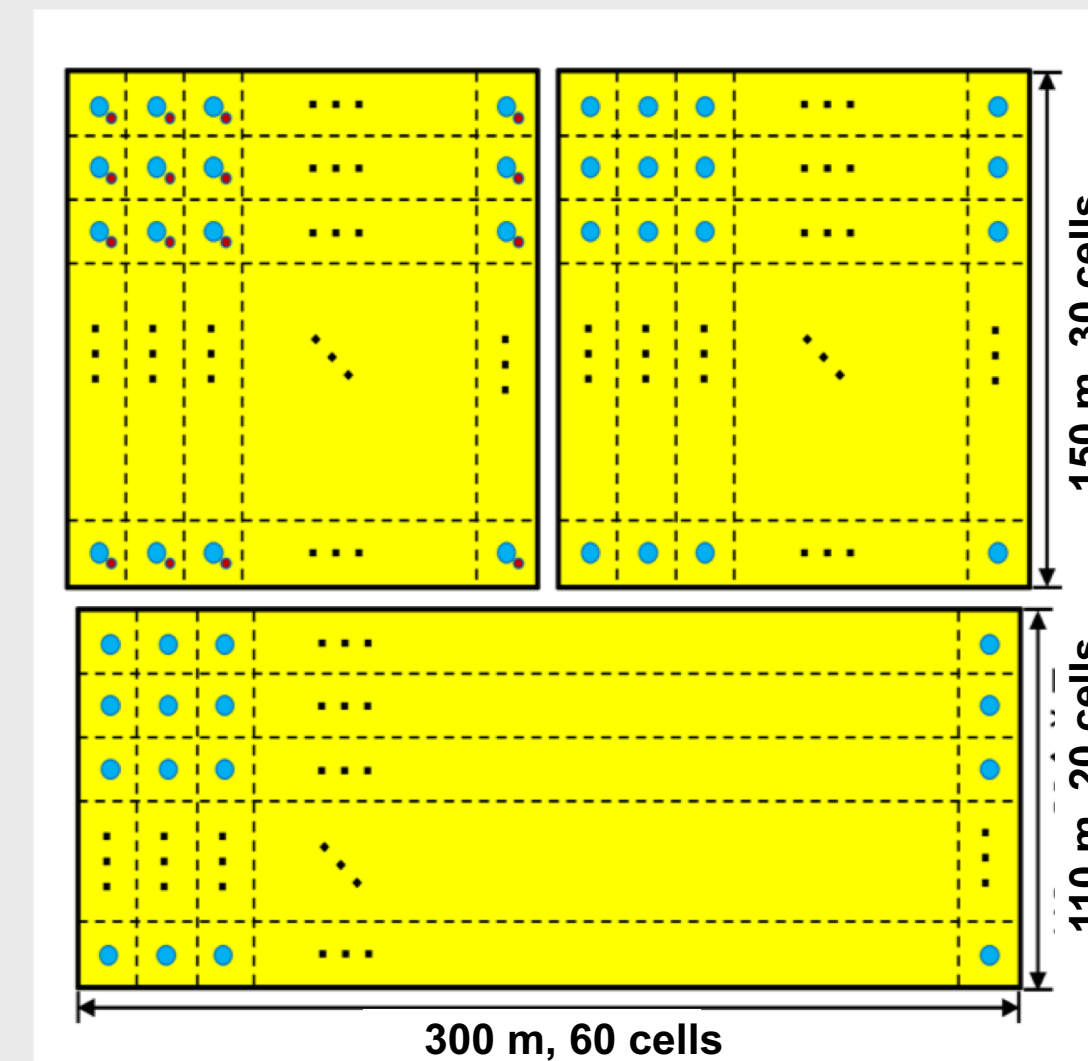


FIG. 2. Water Cherenkov Detector Array (WCDA)

PMT CR365-02-1 and PMT batch test system



FIG. 3. 8 inch PMT CR365-02-1 from BHP

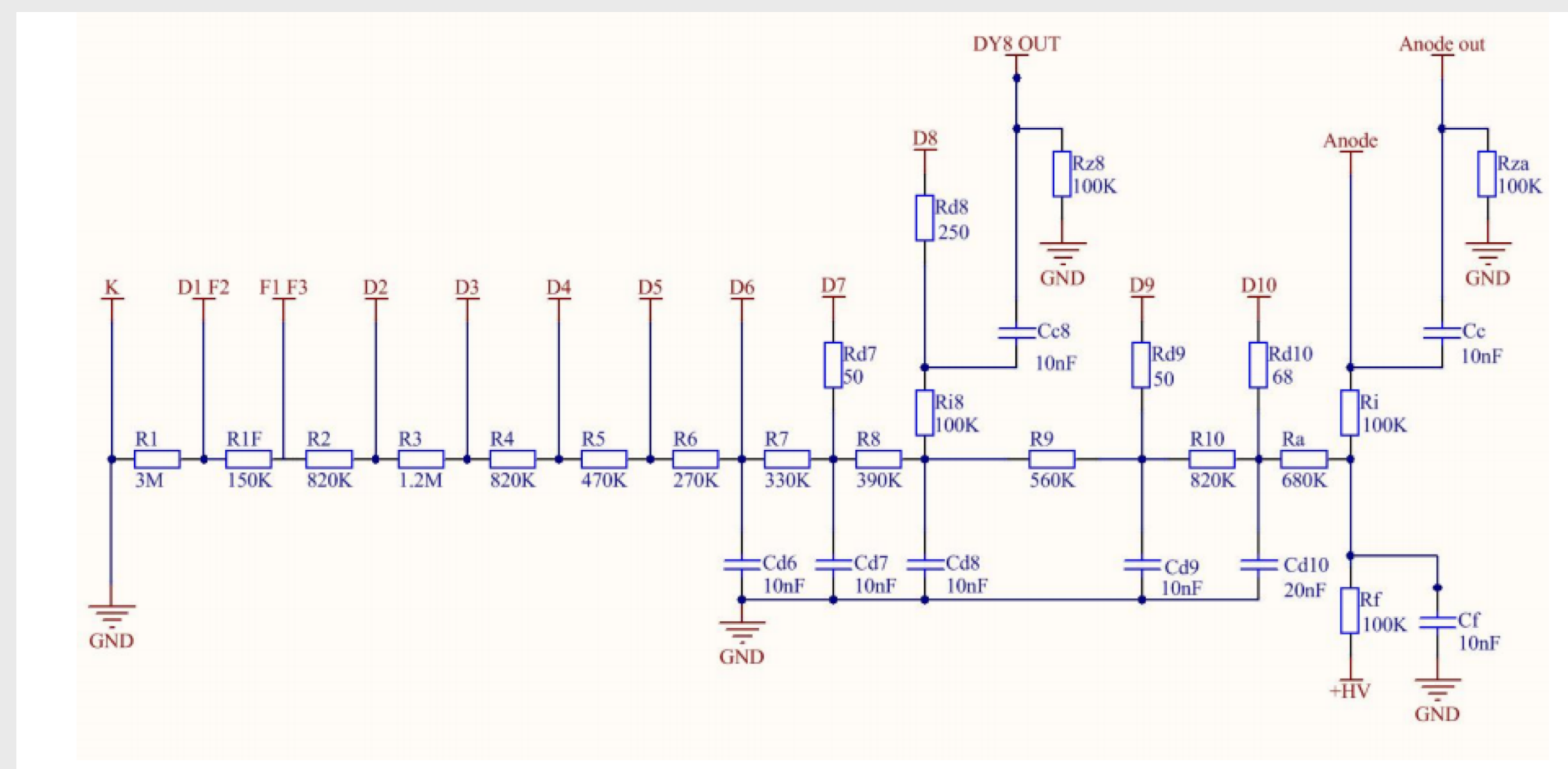


FIG. 4. PMT base circuit



FIG. 5. PMT batch test system

Parameters	Specifications
Distribution of working voltage	Mean ± 100 V, < 2000 V
Distribution of HV-gain coefficient (α)	Mean ± 0.5
Peak-to-valley ratio	> 2.0
Quantum efficiency	> 22%
Transit time spread (FWHM)	< 4 ns
Dark count rate (> 1/3 PE)	< 5 kHz
After-pulse rate (100 – 10000 ns)	< 5%
Anode linearity (5%)	> 1000 PEs
Dynode linearity (5%)	> 4000 PEs
Distribution of anode-to-dynode charge ratio	Mean $\pm 15\%$

- Taped voltage divider circuit to reduce space-charge effect
- Outputs: anode + dynode
- High dynamic range: 1– 4000 PEs

- Automatic control, DAQ and analysis
- Measurement: high voltage response, SPE, dark count rate, after-pulse rate, non-linearity, anode/dynode

PMT test results

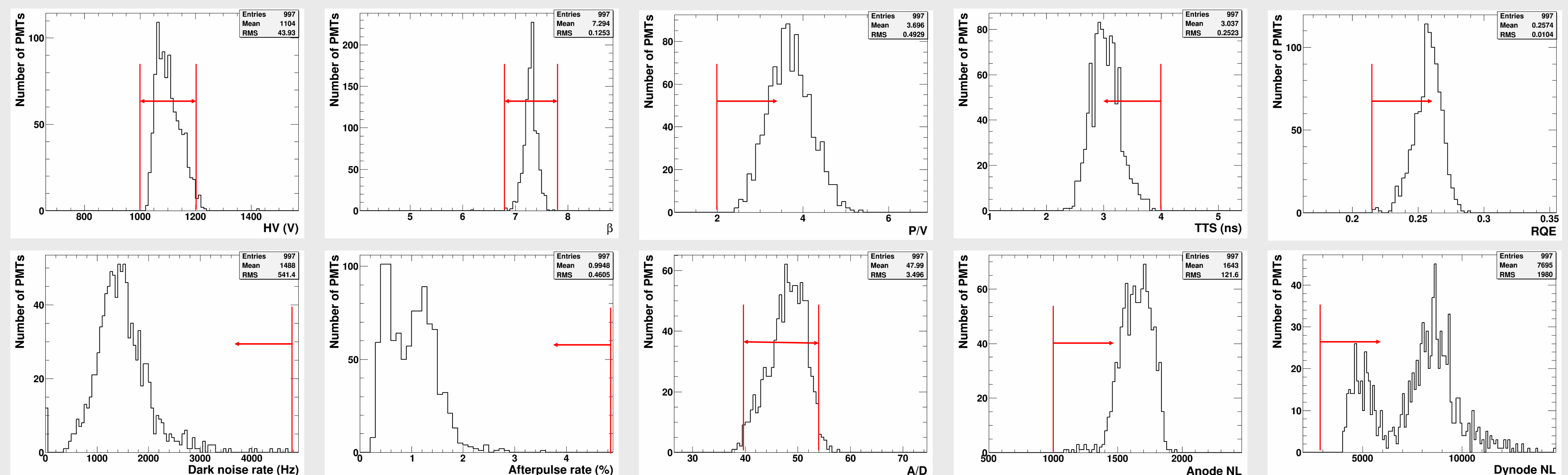


FIG. 6. Distributions of PMT parameters

6. Summary

- LHAASO is under construction at Haizi Mountain, Sichuan, China.
- A PMT voltage divider circuit with high dynamic range readout for LHAASO-WCDA has been designed.
- A PMT batch test system for LHAASO project is designed and constructed.
- Totally 997 8-inch PMTs CR365-02-1 are tested to meet the requirements of LHAASO-WCDA, with 46 (4.6%) unqualified. Among them, one PMT failed in conforming the specification for β , 17 PMTs (1.7%) failed in HV, 32 PMTs (3.2%) failed in A/D. Over 900 PMTs have been transported to Haizi Mountain and have been installed.