The Application of 20 inch MCP-PMT In LHAASO-WCDA

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Abstract

In the Large High Altitude Air Shower Observatory (LHAASO), the main physics objective of the Water Cherenkov detector array (WCDA) is to survey the gamma-ray sky continuously in the energy range from 100 GeV to PeV. The Water Cherenkov detector array, covering an area of about 78,000 m^2 area, is constituted by 3120 detector units divided into 3 separate arrays.In the second and third pond are installed 2220 20" PMTs instead of the 8" PMT used in the first $150 \times 150 m^2$ array[1]. The newly developed 20 inch PMT uses micro-channel-plate (MCP) instead of the traditional dynodes enables better energy resolution and good detector response. In this work, we will report on the application of 20 inch MCP-PMT at LHAASO-WCDA.

The 20 inch MCP-PMT

The 20 inch MCP-PMT is manufactured by North Night Vision Technology Co., Ltd(NNVT) at Nanjing, China. It consists of bialkali photocathode, a focusing electrode, a MCP, and an anode. The distance between the photocathode and MCP is nearly 300 mm. Time resolution of the 20-inch MCP-PMT predominantly depends on the electrical field distribution between the photocathode and the MCP, therefore, a lotus-like focusing electrode was designed to reduse transit time spread(TTS) to 5.8 ns(FWHM)[2].

1.Dimension of 20 inch MCP-PMT

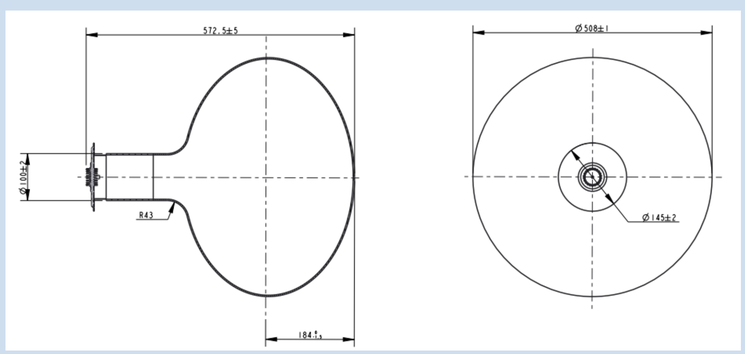

Figure 1. Dimension of 20 inch MCP-PMT.

2. PMT waterproof potting

The 20 inch MCP-PMTs in LHAASO-WCDA had been anchored at 4.5m water depth and will operate at least for 10 years, waterproof potting of PMT is one of the keys for system reliability. Based JUNO's design, waterproof potting was designed to optimize in signal quality and stability under water pressure. The potted detector is consist of PMT, HV divider and 30 meters cable.

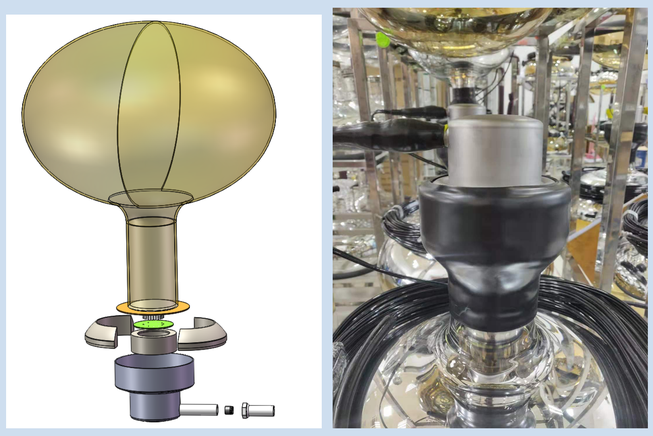

Figure 2. Design of waterproof potting and potted PMT.

Test Result

All parameters meet LHAASO-WCDA's requirements. Part of test result are shown at Fig 3, where the mean working voltage 1777V(Gain@5×10^6). The transit time Spread below 7 ns and the Peak-to-Valley ratio greater than 2.

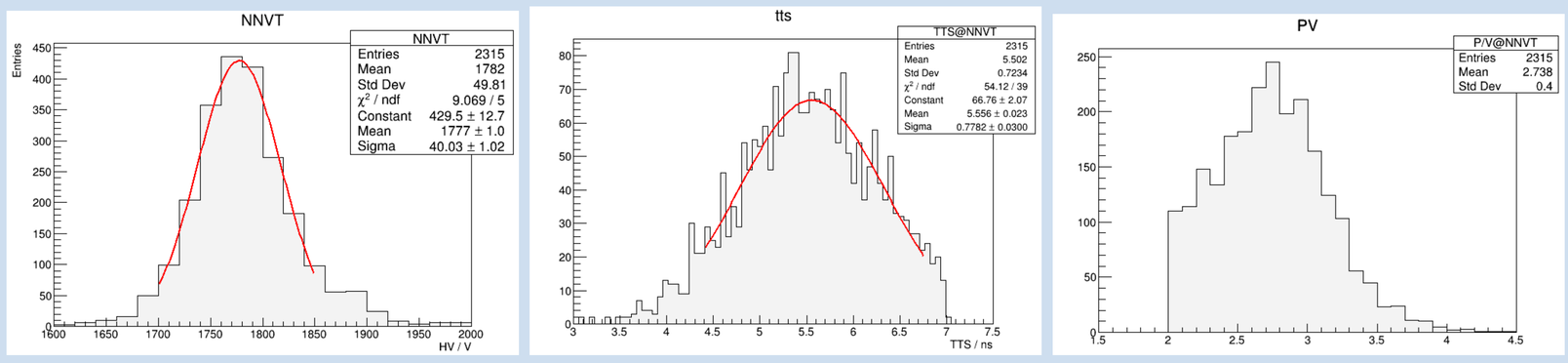

Figure 3. Part of test result at NNVT. Left: the distribution of working voltage, Right: transit time spread.

The Permalloy Geomagnetic Shield

Due to the large size of 20 inch MCP-PMT, the geomagnetic field have big influence on the performance of PMT. A Permalloy shielding is a nickel-iron magnetic alloy, with about 80% nickel and 20% iron content. Permalloy can change the direction of the magnetic field because of its higher permeability compared to ordinary steel. Since the magnetic field is guided through a low magnetic resistance path, it ensured that the PMT is not affected by the geomagnetic field.

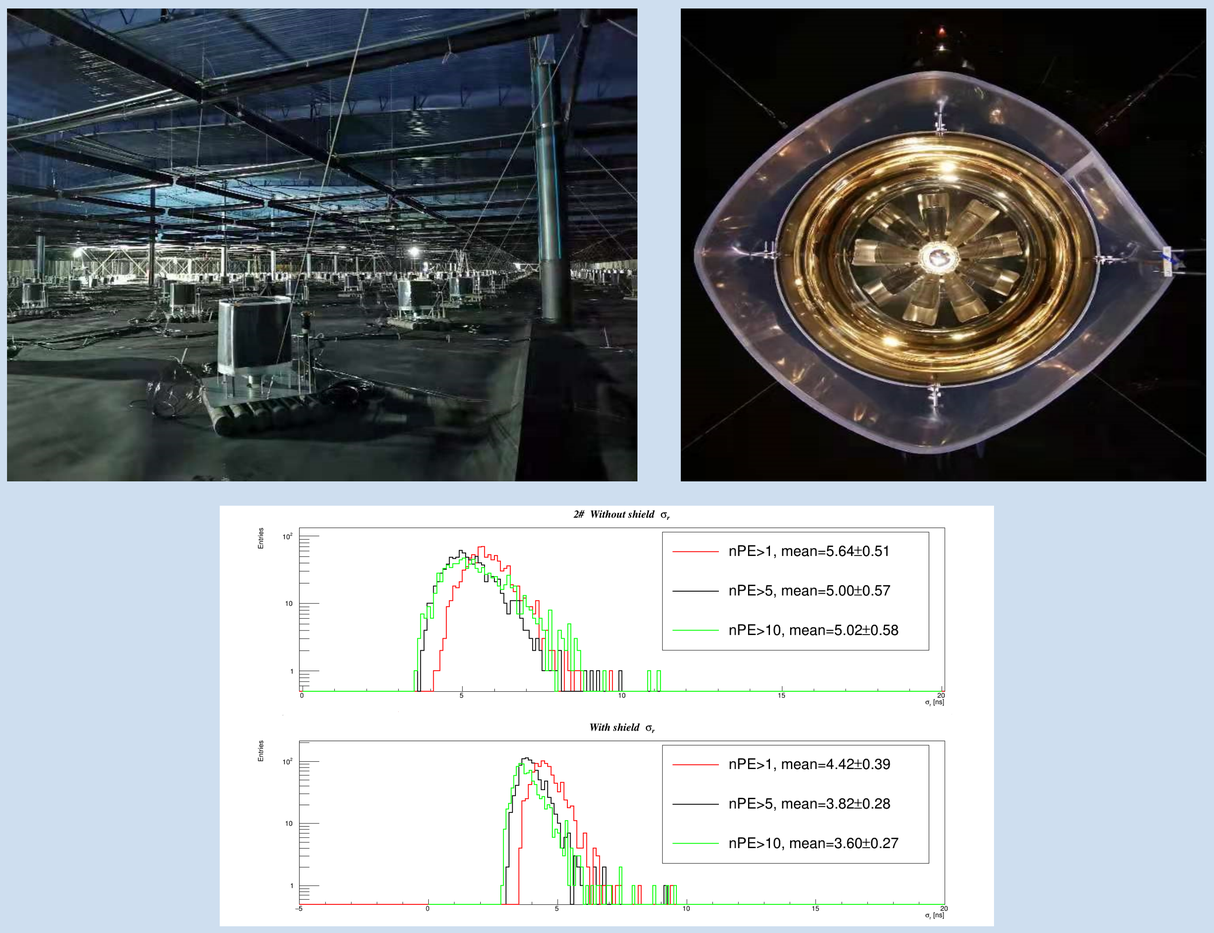

Figure 4. Up Left: full view of magnetic shield-Permalloy installed on 20 inch MCP-PMT. Up right: top view of PMT. Bottom: comparison of σ_r of time residual in 900 MCP-PMTs with/without magnetic shield. The red line represents the distribution of σ_r at nPE>1 ($E(\sigma_{without-shield})$=5.64ns, $E(\sigma_{with-shield})$=4.42ns), the black line represents the distribution of σ_t at nPE>5 ($E(\sigma_{without-shield})$=5.00 ns, $E(\sigma_{with-shield})$=3.82ns), the green line represents the distribution of σ_r at nPE>10 ($E(\sigma_{without-shield})$=5.02ns, $E(\sigma_{with-shield})$=3.60ns).

Conclusion

The time resolution performance of PMT with magnetic shield is significantly better than that of PMT without shield as shown in Fig.4 and the potting failure rate is less than 1% as of June 31,2021. LHASSO-WCDA is taking data and the total array results will publish at October 2021 on current schedule.

Acknowledgements

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References

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