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## The R&D of 20 inch MCP-PMTs in China (12' + 3')

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The JUNO (Jiangmen Underground Neutrino Observatory) to be built in JiangMen, Guangdong province in south China is a generic underground national lab for neutrino physics and other research fields. Its neutrino program requires a high performance large detector, which needs approximately 16,000 Photomultiplier Tubes (PMTs), that have large sensitive area, high quantum efficiency, high gain and large peak-to-valley ratio (P/V) for good single photoelectron detection.

Researchers at IHEP, Beijing have conceived a new concept of MCP-PMT several years ago. The small MCP (Microchannel Plate) units replace the bulky Dynode chain in the traditional large PMTs. In addition transmission photocathode on the front hemisphere and reflection photocathode on the rear hemisphere are fabricated in the same glass bulb to form nearly  $4\pi$  effective photocathode in order to enhance the efficiency of photoelectron conversion.

A number of experienced researchers and engineers in research institutes and companies related to PMT fabrication in China jointly worked on the large area MCP-PMT project. After three years R&D, a number of 8 inch prototypes were produced and their performance was carefully tested at IHEP in 2013 by using the MCP-PMT evaluation system built at IHEP. The 20 inch prototypes were followed in 2014, and its performance were improving a lot in 2015.

The characteristics of the transmission photocathode (Trans. PC) was carefully studied by measuring the I-V curves, the quantum efficiency (QE) vs. wavelength, and by mapping the QE for both the 8 and 20 inch photocathodes. Charge spectra of single photoelectrons, timing properties of anode signals and anode linearity were measured. Noise characteristics and after pulse properties were studied at gain  $\sim 1.0 \times 10^7$ .

We are continuing simulation and experimental work to further improve our 8 and 20 inch MCP-PMT prototypes, in particular to improve the QE of the transmission photocathode and the photoelectron collection efficiency (CE) of the MCP unit. We believe for 20 inch prototypes, QE greater than 30% and CE better than 90% CE is possible.

**Primary author:** QIAN, Sen (Institute of High Energy Physics, CAS)

**Presenter:** LIU, shulin

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