

## Mass Production of MCP-PMT for JUNO and Development of 20-inch MCP-PMT with TTS Improved

*Thursday, 29 November 2018 09:55 (20 minutes)*

In order to meet the requirement of JUNO, 20-inch microchannel plate photomultiplier (MCP-PMT) was researched by the MCP-PMT collaboration, which was established by Institute of High Energy Physics (IHEP) and North Night Vision Technology Co., Ltd (NNVT) in 2012. By the breakthrough of the key technology, such as the electronic optics structure design, the high quantum efficiency photocathode process, and so on, the 20-inch MCP-PMT was developed successfully by the end of 2015. The collection efficiency was about 98% and the detection efficiency (DE) was about 27%. At the same year, NNVT successfully bided for the 15000 PMTs of JUNO. In order to finish the contract of MCP-PMTs, the production line of 20-inch MCP-PMT was built on the 25th Nov of 2016. The production line was the domestic advanced photomultiplier production line with capable of 7500 pieces 20-inch MCP-PMTs a year. By building the batch test system, the charge performance of 32 pieces PMTs could be tested at the same time. Recently, NNVT had delivered JUNO total 7000 pieces 20-inch MCP-PMTs. The average DE was increased to 30% from 27% since June 2018, and the average dark count rate was about 30 kHz. Based on the research finding of 20-inch MCP-PMT for JUNO, the 20-inch MCP-PMT with good time response was researched to meet the requirement of Hyper-K project, and developed successfully. The new 20-inch MCP-PMT had a flower-like focusing electrode. The transit time spread was about 5 ns, namely FWHM, better than the one of the original 20-inch MCP-PMT.

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**Session Classification:** Thursday morning