

## Design of large area MCP-PMT and a novel bowl-shape MCP

The Jiangmen Underground Neutrino Observatory (JUNO) is a multipurpose neutrino experiment designed to determine neutrino mass hierarchy and precisely measure oscillation parameters. The R&D of large area microchannel plate photomultiplier tube (MCP-PMT) for JUNO started in 2011. In the last 3 years, much progress has been achieved. The high performance 8-inch and 20-inch prototypes were developed and 15,000 20-inch MCP-PMTs were ordered by JUNO. In the large area MCP-PMT, the small MCPs replace the bulky dynode chain of the traditional large PMTs. Photoelectrons from the large area photocathode are electrostatically focused to the MCPs. We will present the design of the 20-inch MCP-PMTs.

We will also present the study of photoelectron backscattering on the MCP surface. Finally, A novel bowl-shape MCP with an open area ratio greater than 90% is proposed. The planar area of the electrode is enormously cut down. An additional thin film with a high secondary electron emission yield is deposited on its nickel-chromium electrode. The side surfaces of the input electrode are specially curved to guide secondaries from the electrode into the nearest channel. Results predict that collection efficiency of the bowl-shape MCP is higher than 98% and the delayed pulse is less than 2%. This indicates that good detection efficiency, temporal and spatial resolution can be achieved simultaneously with the novel MCP.

**Author:** Ms CHEN, Ping (Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences)

**Co-authors:** GUO, Lehui (Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences); Mr TIAN, Jinshou (Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences); WEI, Yonglin (Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences); LIU, Hulin (Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences)

**Presenter:** Ms CHEN, Ping (Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences)

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