20-inch PMT testing at the scanning station for the JUNO experiment

Ilya Butorov
on behalf of JUNO collaboration
Joint Institute for Nuclear Research

e-mail: butorov.ilya@gmail.com

Introduction

JUNO's primary goal is to determine the neutrino mass ordering. Detector must provide unprecedented energy resolution of $3\%/\sqrt{E[\text{MeV}]}$. It places high demands on the PMTs characteristics:

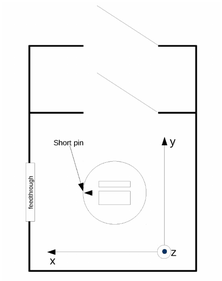
- Photon detection efficiency>24%
- High photocathode uniformity (better than 15%)

Scanning station

- Dark room
- Helmholtz coils on the walls
- Base
- Support
- Rotating frame
- Self-stabilized LEDs

Testing method

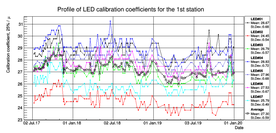
The PMT is put into the SS and illuminated by LEDs installed on the arc. The arc is being rotated by a step motor. 7 LEDs allow to test the PMT at 7 zenith angles.



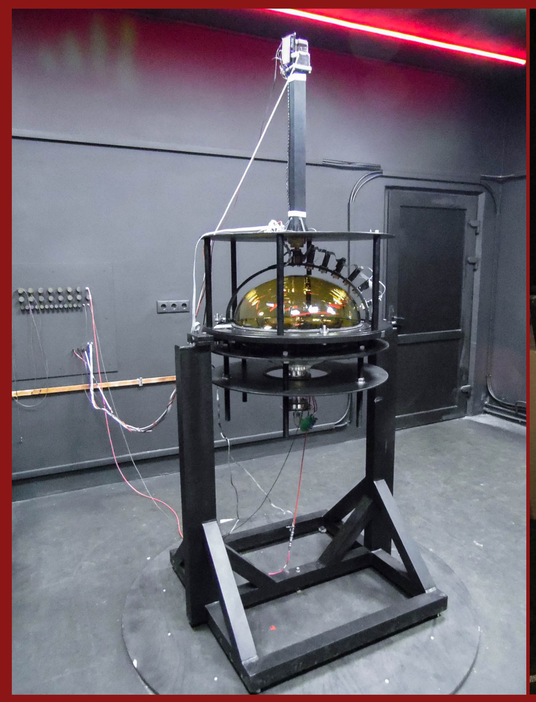
The PMT is located in the center of the room where the Earth magnetic field is cancelled out. It's possible to alter the magnetic field to examine how the PMT performance is affected.

Calibration

Weekly LEDs calibration provides us with the test results reliability. 4 small PMTs are used for cross-check.



JUNO PMTs **photocathode uniformity** and **magnetic field sensitivity** are verified.



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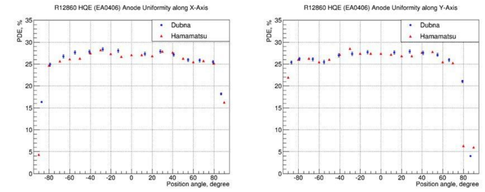
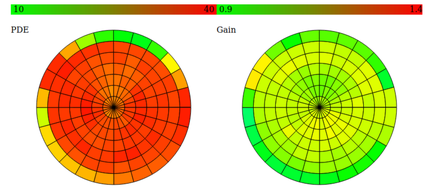
Results

Comparison of the measured PDE with those provided by the vendor (HAMAMATSU)

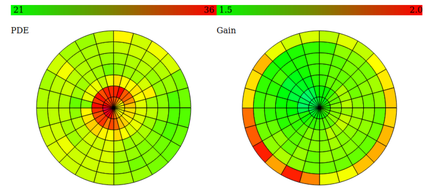


PDE and gain maps examples

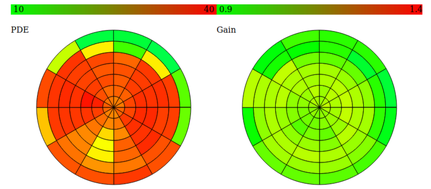
- HAMAMATSU PMT w/o magnetic field



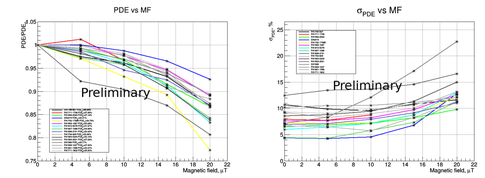
- MCP PMT w/o magnetic field



- HAMAMATSU PMT in magnetic field



EMF sensitivity along the worst direction



Conclusion

Considered PMTs provide us with good performance. Those can meet all the requirements even in the presence of the Earth magnetic field. PDE values obtained from the SS are consistent with those provided by the vendor.