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Abstract: Photodetection in water Čerenkov detectors requires large area photon counting detectors with timing capability at nanosecond level to suppress background, as well as high efficiency and low cost per channel. Significant increase in sensitivity can be achieved by the employment of novel optical sensors, and the most promising new design is based on the multi-PMT (mPMT) concept, an array of small size PMTs, inside a transparent pressure vessel, firstly used in the KM3NeT experiment. Other experimental projects are considering the mPMT photon-detection system, as the Hyper-Kamiokande project. In this contribution, the development of a mPMT optical module prototype, housing an array of 3 inch PMTs, front-end electronics and digitization inside an acrylic pressure vessel will be described.

The mPMT concept

A new design for optical sensors developed by the Km3NeT collaboration: array of photodetectors and their electronics arranged inside a pressure resistant vessel.



- Superior photon counting
- Improved angular acceptance
- Extension of dynamic range
- Intrinsic directional sensitivity
- Local coincidences

Reconstruction capability improved by exploiting directionality of photodetectors

Requirements for low background water Čerenkov experiments

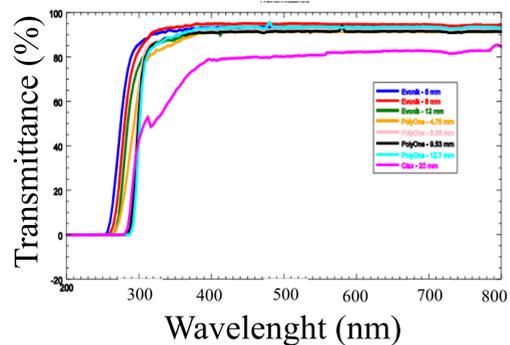
- Vessel: radio purity of material.
- Electronics: good timing resolution better than PMT TTS:
 - ~300-500 ps timing resolution from electronics for 1 PE
 - Good charge resolution ~0.05 PE up to 25 PE

Several future projects are considering the mPMT option:

Hyper-Kamiokande (HK) baseline option is 40000 20 inch PMTs, but the Collaboration is considering to add mPMTs.

Acrylic vessel

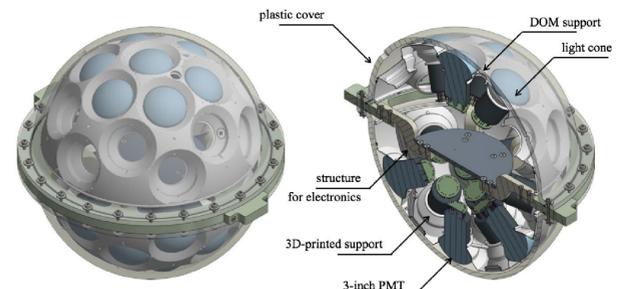
Several acrylics tested: PLEXIGLAS® GS UV Transmitting by Evonik chosen for the construction of mPMT for HK



Pressure test
15mm-thick vessel resisted to 1.8MPa (Constrain: up to 1.26 MPa)

Radioactivity measurements: contamination lower than requirements

mPMT Prototype @ INFN Napoli



- Demonstrate the effectiveness of a vessel system based on acrylic
- Define a solution for electronics
- Same geometry as in Km3Net but different closure and cooling system



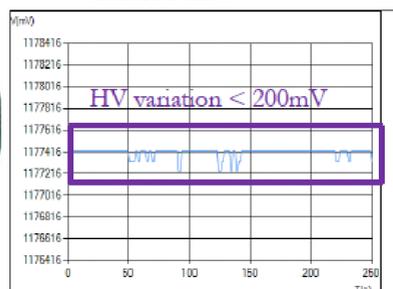
mPMT electronics

High voltage:

Basic Cockcroft-Walton voltage multiplier circuit



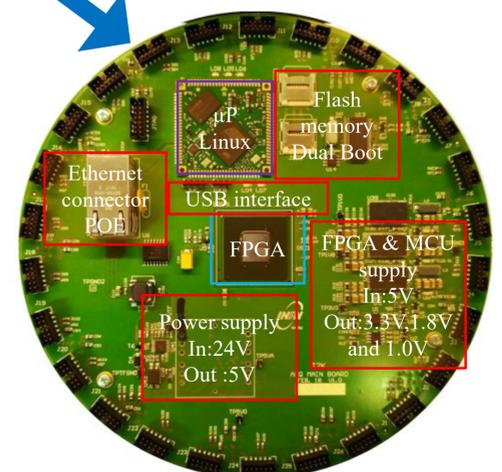
Stable HV



Power consumption: 237.5 mW for 19 channel

Front-end board and main board

Energy resolution: FWHM/ch 0.1%
Time resolution: 300ps



Total Power consumption: ~4.1 W for 19 channel