Photomultipliers for the KM3NeT optical modules

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Neutrino telescope with an instrumented volume of > 5 km³ at the bottom of the Mediterranean Sea at a depth of 2.5 – 5 km.

Detection of high-energy neutrinos from distant astrophysical sources or from annihilation of dark matter particles: a new window on the Universe.

Detection principle: Cherenkov light emitted by charged particles resulting from neutrino interactions in the matter surrounding the telescope.

KM3NeT: a future European research infrastructure

Innovative detection units:
- multi-PMT digital optical modules (OM) containing 31 3-inch phototubes; the segmentation aids in distinguishing single-photon from multi-photon hits; two-photon hit separation with 85% probability; small transit time spread, no magnetic shielding required
- KM3NeT technical design [1]

Detection unit of the telescope – flexible tower with horizontal bars, each holding two multi-PMT OMs

Three pieces were delivered in January 2011 and tested. Preliminary results of measurements of quantum efficiency (QE), single photoelectron (Spe) jitter, centre-to-edge difference (CED) in transit time of photoelectrons from the photocathode to the first dynode, total transit time spread (TTS), dark rate, gain and peak-to-valley ratio are presented.

KM3NeT specification for 3-inch PMTs

<table>
<thead>
<tr>
<th>Serial no</th>
<th>QE at 350nm (%)</th>
<th>Spe jitter ns</th>
<th>TTS PWHM ns</th>
<th>Gain</th>
<th>Dark rate kHz</th>
<th>Peak-to-valley</th>
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<tbody>
<tr>
<td>ZB3501</td>
<td>27.3</td>
<td>1.4</td>
<td>6.8</td>
<td>1.5-10⁻⁶ @ 1200V</td>
<td>1.2</td>
<td>1.2</td>
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<td>1.8</td>
<td>5.8</td>
<td>2.0-10⁻⁶ @ 1200V</td>
<td>2.5</td>
<td>3.5</td>
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<td>1.3</td>
<td>6.4</td>
<td>2.1-10⁻⁶ @ 1200V</td>
<td>2.8</td>
<td>3.1</td>
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KM3NeT: a future European research infrastructure

New detection units:
- New Hamamatsu PMTs R6233mod
- New MELZ PMT
- New ETEL PMTs D783KFLA

Quantum efficiency of new Hamamatsu PMTs R6233mod

<table>
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<tr>
<th>Serial no</th>
<th>390nm (%)</th>
<th>470nm (%)</th>
<th>500nm (%)</th>
<th>550nm (%)</th>
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Increased photon collection efficiency through use of expansion cone – aluminium reflector.

Manufacturing:
- ET Enterprises Ltd (ETEL), Hamamatsu, and MELZ develop new types of 3-inch PMTs; first PMT samples have been delivered and tested
- New Hamamatsu R6233mod PMTs: increased effective photocathode area → increased sensitivity
- New MELZ PMT: MELZ (Moscow, Russia) is developing a new 83mm diameter PMT. An effective photocathode diameter of 76mm is expected, corresponds to a ~20% increase of the effective photocathode area in comparison with a standard 3-inch PMT. The new PMT is under internal tests at the company. Expected delivery of first samples – September 2011.

New ETEL PMTs D783KFLA

Two new ETEL PMTs are available for tests since May 2011. Test results will be presented elsewhere. 45 dummy PMTs from ETEL are used for mechanical prototyping of optical modules.