KM3NeT
Opens a new window on our universe

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Photomultipliers for the KM3NeT optical modules

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NIKHEF

KM3NeT: a future European research infrastructure

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.

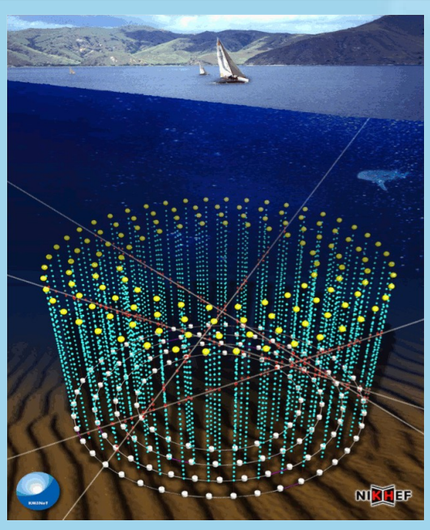
Innovative detection units:
multi-PMT digital optical modules (OM) containing 31 3-inch phototubes;
the segmentation aids in distinguishing single-photon from multi-photon hits;
two-photon hit separation with 85% probability;
small transit time spread, no magnetic shielding required

Manufacturing:
ET Enterprises Ltd (ETEL), Hamamatsu, and MELZ develop new types of 3-inch PMTs; first PMT samples have been delivered and tested

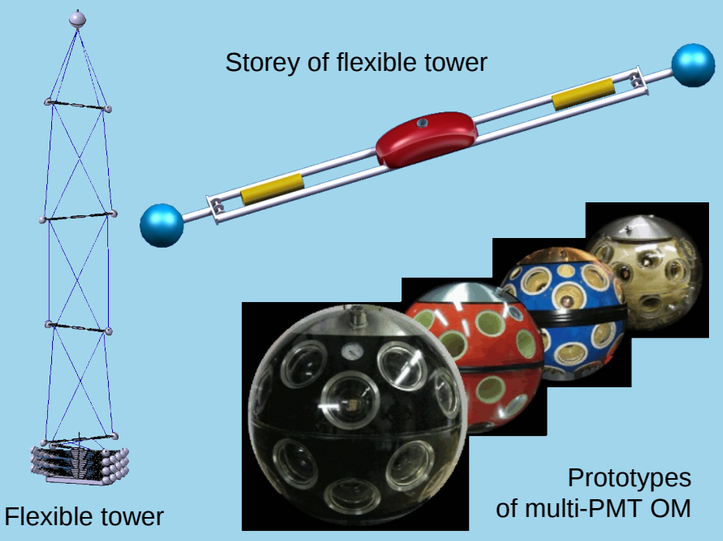
Reflector cone:
Each 3-inch PMT surrounded by reflective cone
additional photons onto the photocathode → increased effective photocathode area → increased sensitivity.

KM3NeT technical design [1]

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



Artist view of the KM3NeT telescope



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.

New 3-inch ETEL D783KFLA PMTs

Electromechanical prototype of the multi-PMT OM. Dummy PMT from ETEL is shown in the insert

KM3NeT specification for 3-inch PMTs

Quantum efficiency (QE) at 470 nm	>20%	Transit time spread (TTS)	<2ns (sigma)
Inhomogenity of cathode response	<10%	Peak to valley ratio	>3
Supply voltage	<1400V	Length	<12cm
Gain	>2x10⁶	Convex input window	198mm radius
Dark count rate at 15°C	<3 kHz		

New MELZ PMT

MELZ (Moscow, Russia) is developing a new 82mm 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.

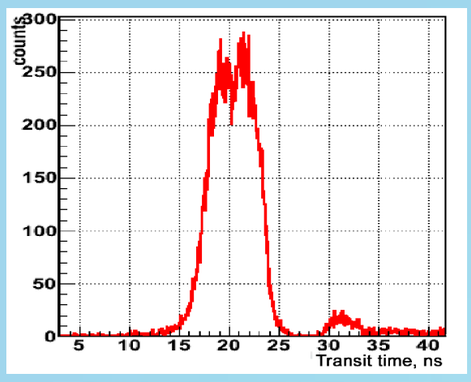
New Hamamatsu PMTs R6233mod

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.

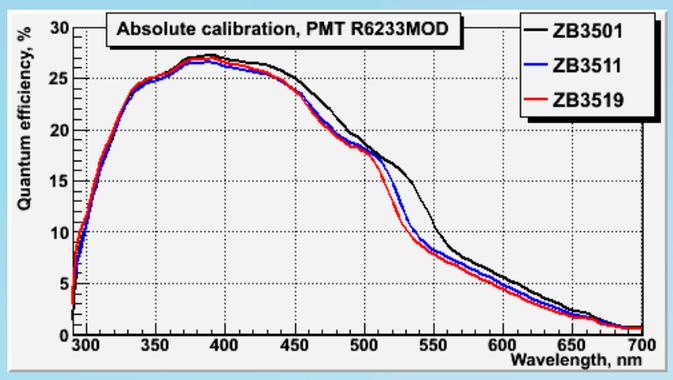
Serial no	QE at 390nm %	Spe jitter ns	TTS FWHM, ns	Gain	Dark rate kHz	Peak-to-valley
ZB3501	27.3	1.4	6.8	1.5·10⁶ @ 1200V	1.2	1.8
ZB3511	26.6	1.3	5.8	2.0·10⁶ @ 1100V	2.5	3.5
ZB3519	26.9	1.3	6.4	2.1·10⁶ @ 1200V	2.8	3.1

New 3-inch Hamamatsu R6233mod PMT

New MELZ PMT

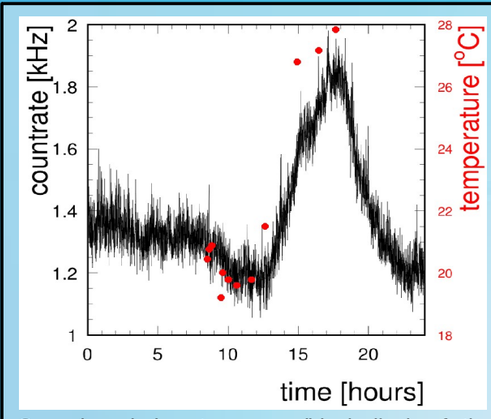


TTS of R6233mod PMT

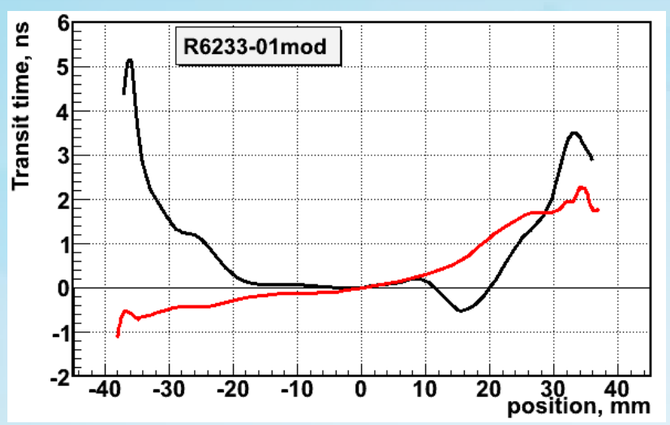


Quantum efficiency of new Hamamatsu PMTs R6233mod

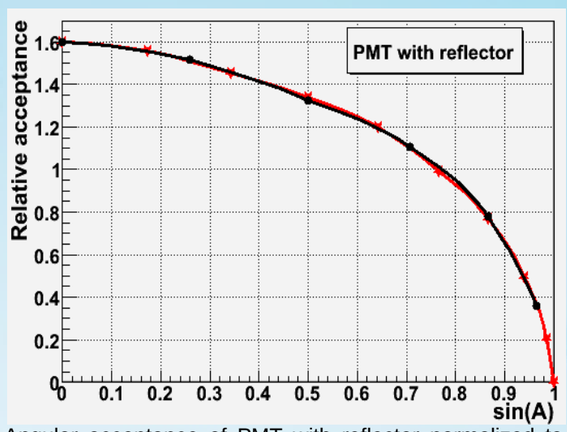
Increased photon collection efficiency through use of expansion cone – aluminium reflector
Photonis XP53B20 PMT – with expansion cone designed, manufactured and assembled in KVI, University of Groningen (see "Multi-PMT optical module for the KM3NeT neutrino telescope" poster for more details) – is being tested. Angular acceptance is measured by illumination of the whole assembly with a pulsed LED from a distance of 3m, covering a PMT polar range of ±90°. A mask of 76mm diameter is used to estimate the PMT's sensitivity without the expansion cone, to normalize the angular acceptance to this value.



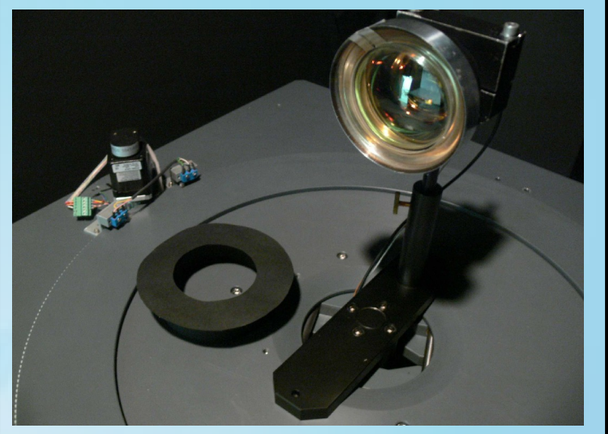
One day dark rate curve (black line) of the R6233mod PMT correlating to ambient temperature (red circles)



Transit time across the photocathode (CED). Red curve - scan in a dynode's system symmetry plane, black curve - perpendicular



Angular acceptance of PMT with reflector normalized to the front-illuminated PMT without reflector. Colours correspond to different illumination levels per pulse. Red – single photoelectron, black – a few tens photoelectrons.



PMT with expansion cone of 52mm radius in the setup for an angular acceptance test. The mask nearby is used to shadow the reflective ring.

Acknowledgement and references.
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[1] KM3NeT Consortium, P. Bagley et al., KM3NeT Technical Design Report for a Deep-Sea Research Infrastructure Incorporating a Very Large Volume Neutrino, 2010, (ISBN 978-90-6488-033-9), http://km3net.org/TDR/KM3NeT-TDR