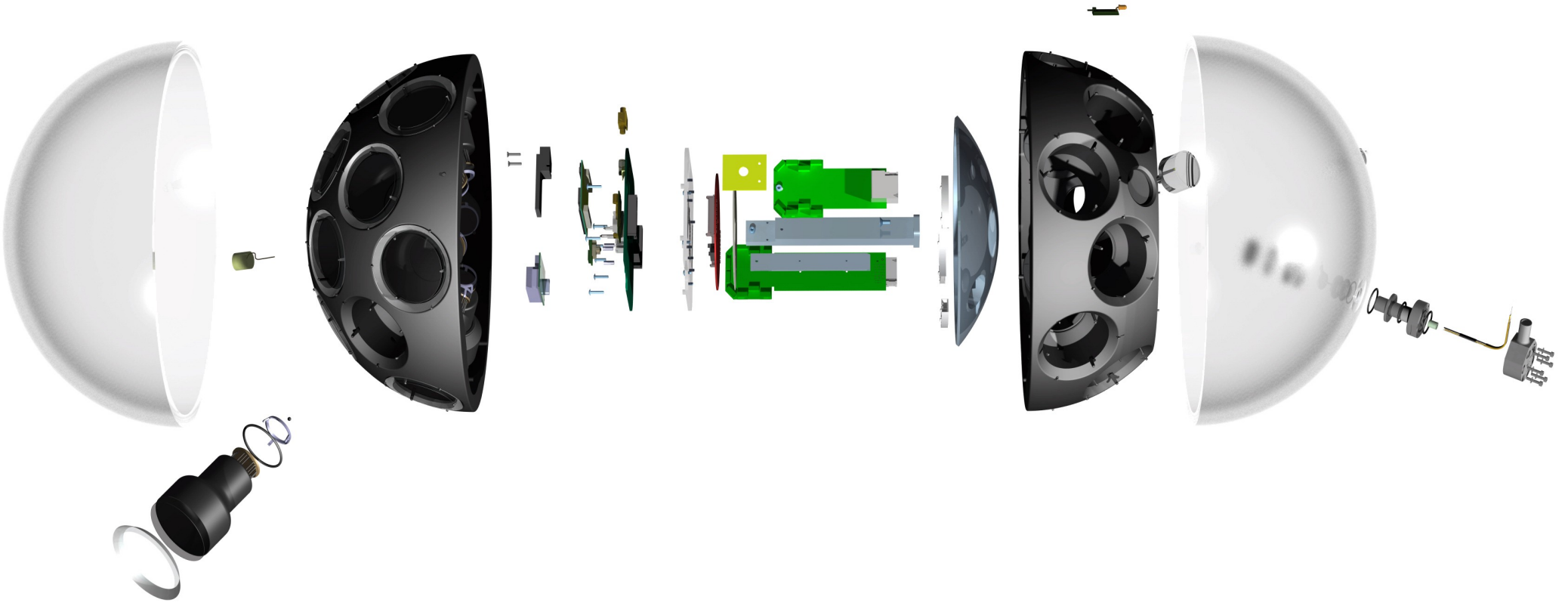
The Multi-PMT DOM

Aart Heijboer, Nikhef

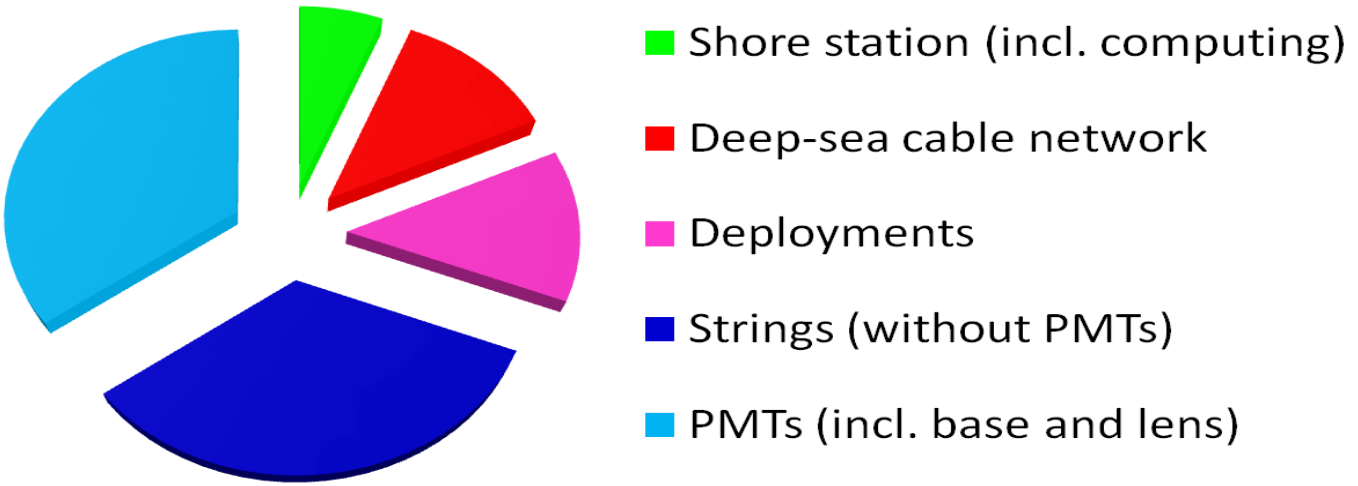


Rationale

- segment the photocathode to allow photon-counting
- minimize overhead by maximizing photocathode in a sphere

•Comparing 31 3 inch PMT to a single 10 inch:
  - 31 x π 1.5^2 / π x 5^2 = **2.8**
  - The price per area of photocathode is (somewhat) lower of 3 inch pmts

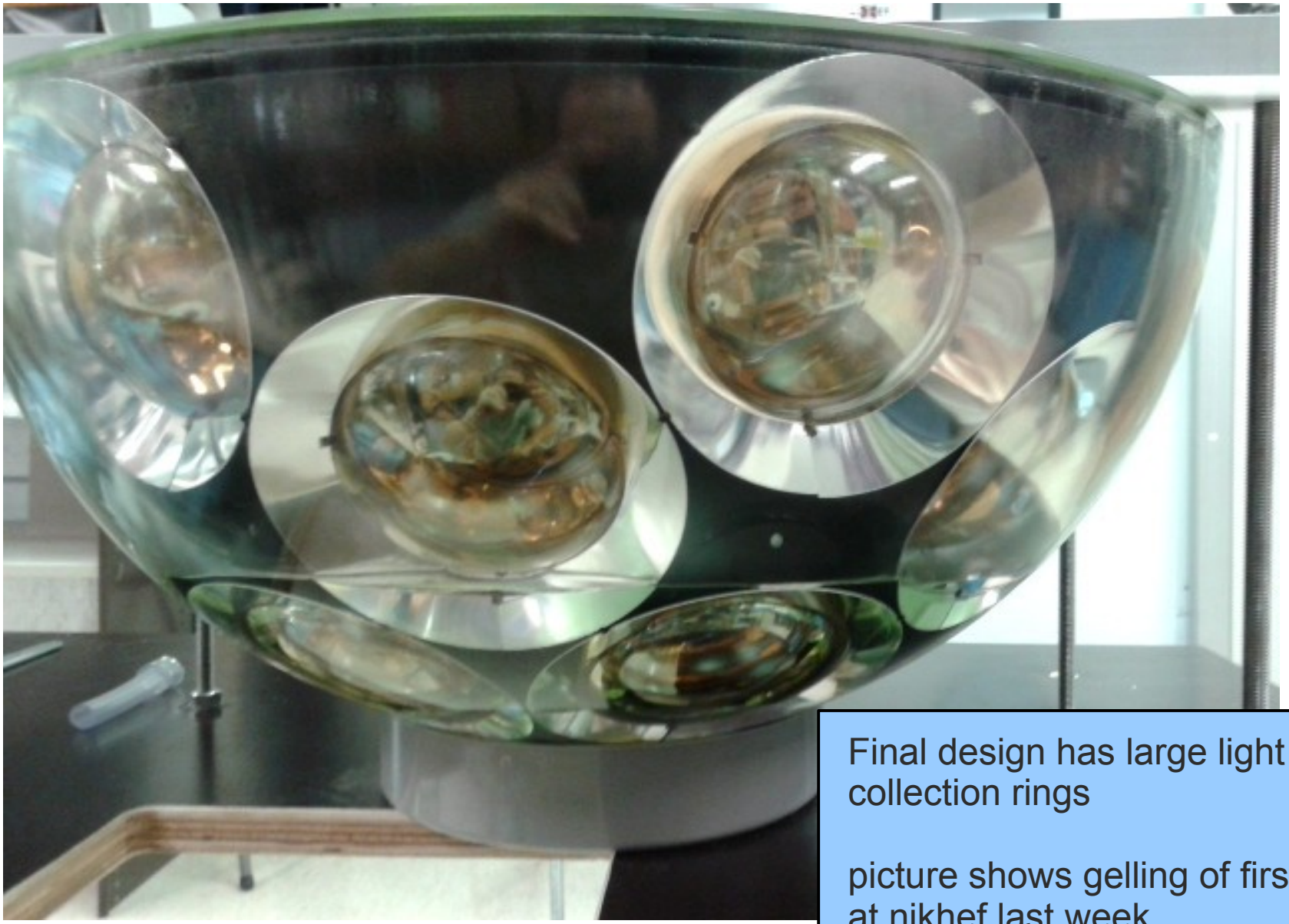
=> need a factor of 2.8 fewer spheres, mechanics, electronics, network



maybe does not look like a factor 2.8


… but it is
NO. 30

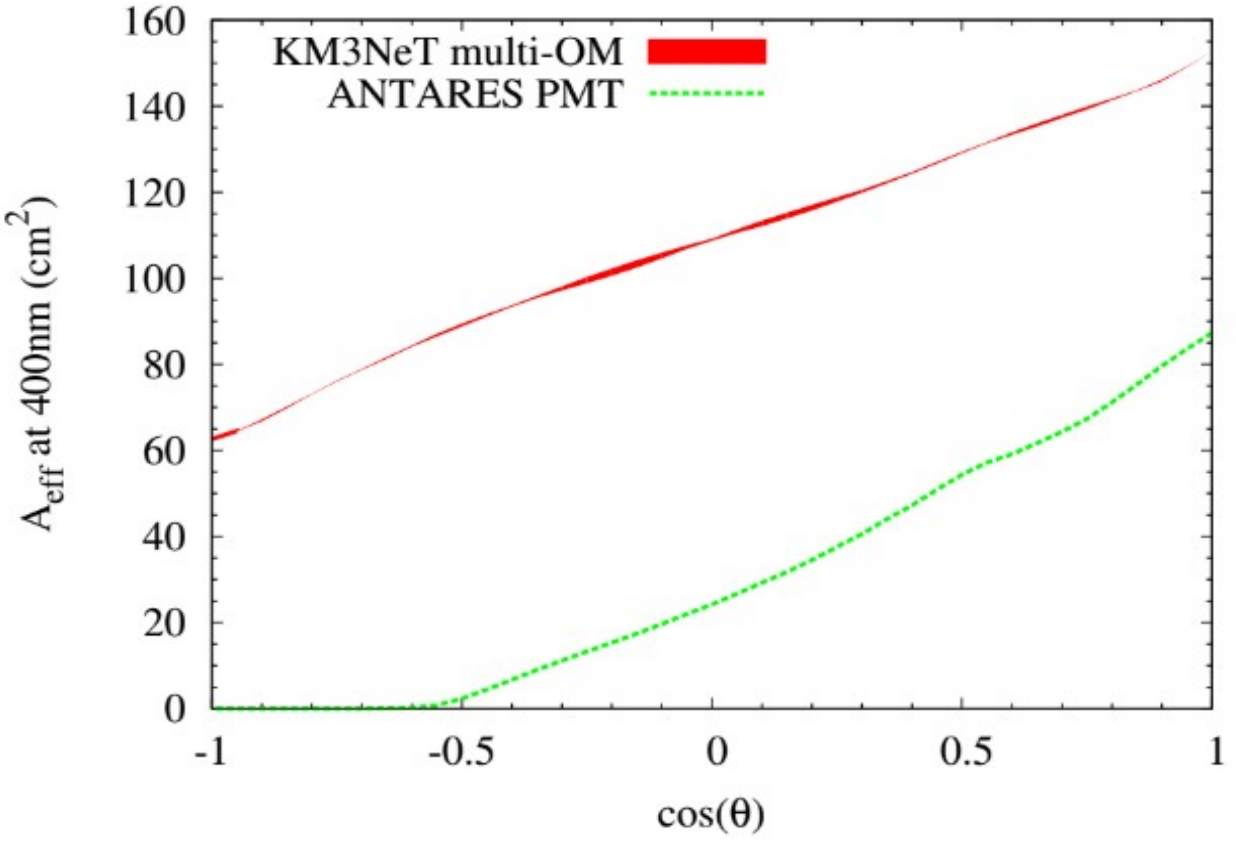
Further increase area: light collection rings



Final design has large light collection rings

picture shows gelling of first DOM at nikhef last week

..one more time



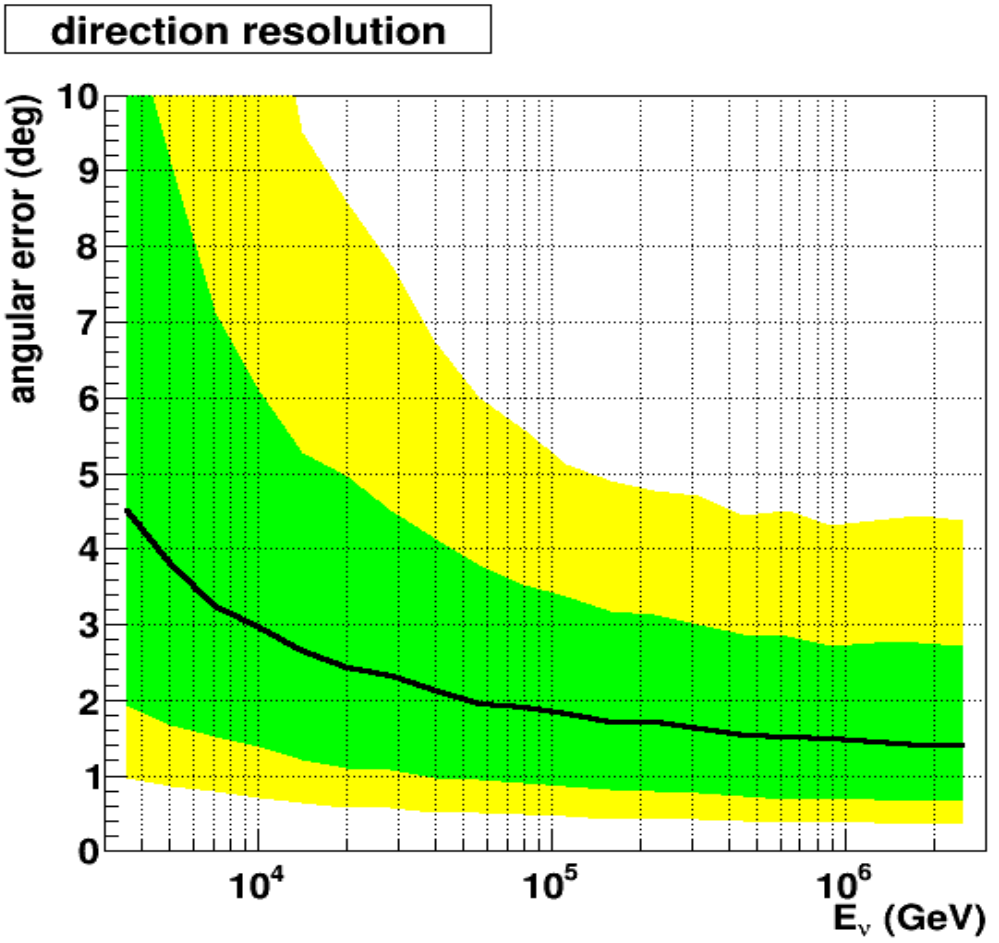
besides having a large area,

segmentation helps analysis.

Allows photon counting: very powerfull

Shower reconstruction using *only* the information about **which PMTs** have fired. (no waveform, charge, ToT etc)

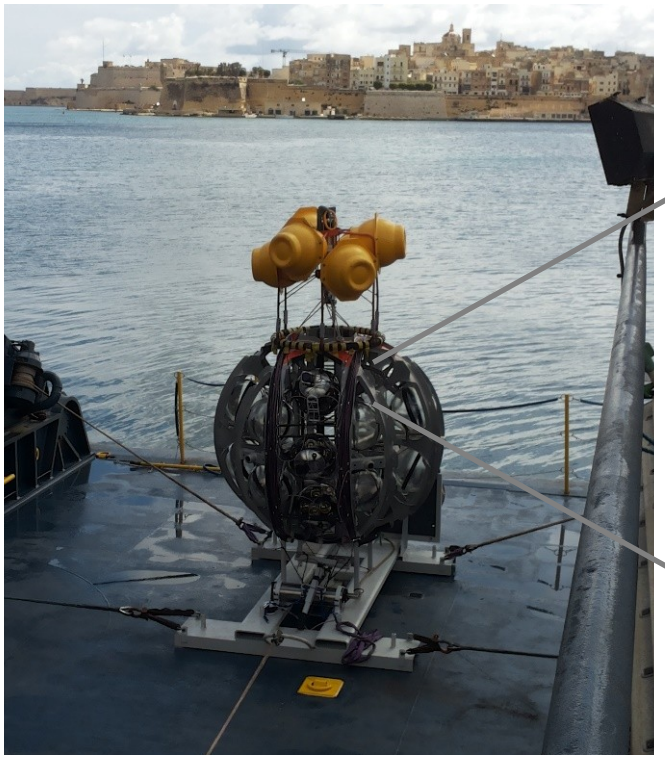
Quite promising results.



(see my talk yesterday)

Design

Launcher vehicle

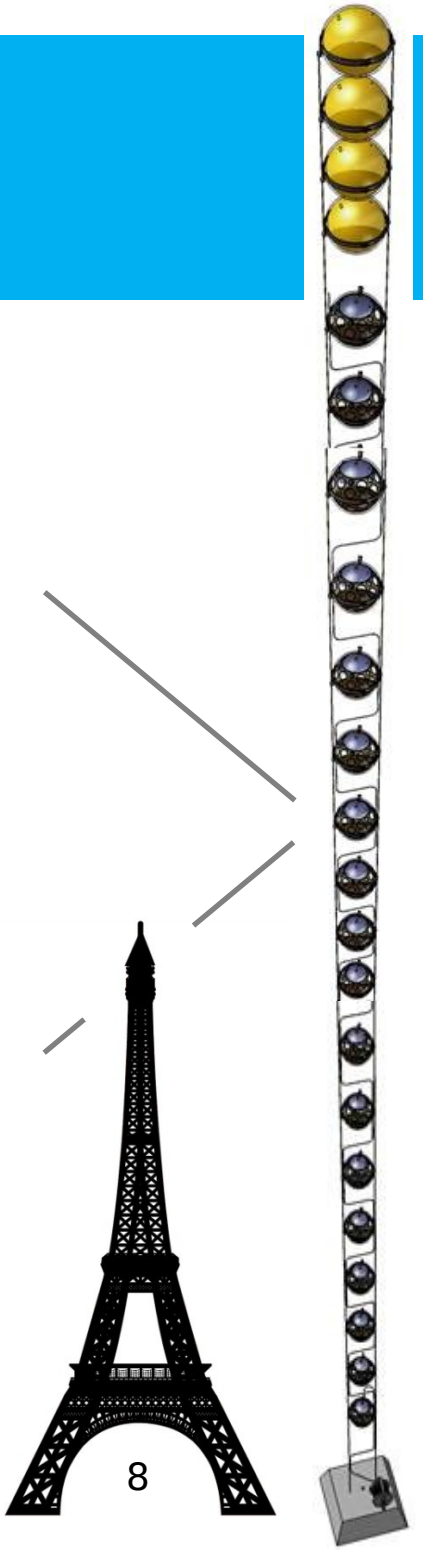


- *rapid deployment*
- *autonomous unfurling*
- *recoverable*

Optical module

17”

- *31 x 3” PMTs*
- *low-power HV*
- *LED & piezo inside*
- *FPGA readout*
- *White Rabbit*
- *DWDM*



Desing

light collecttion cone

piezeo hydrophone

3 inch pmt + custom low-power base

3d printed support structure

compass, tiltmeter

Central logic board
FPGA-based, white rabbit timing,
DWDM optical communication
(80 colors/doms over 1 fibre)

power board

signal collection boards

cooling structure

penetrator (custom design)

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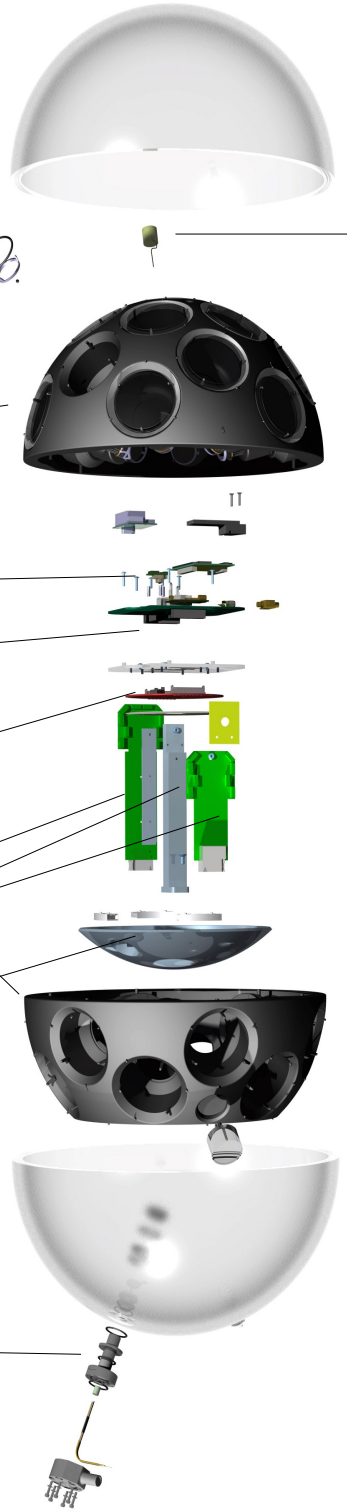


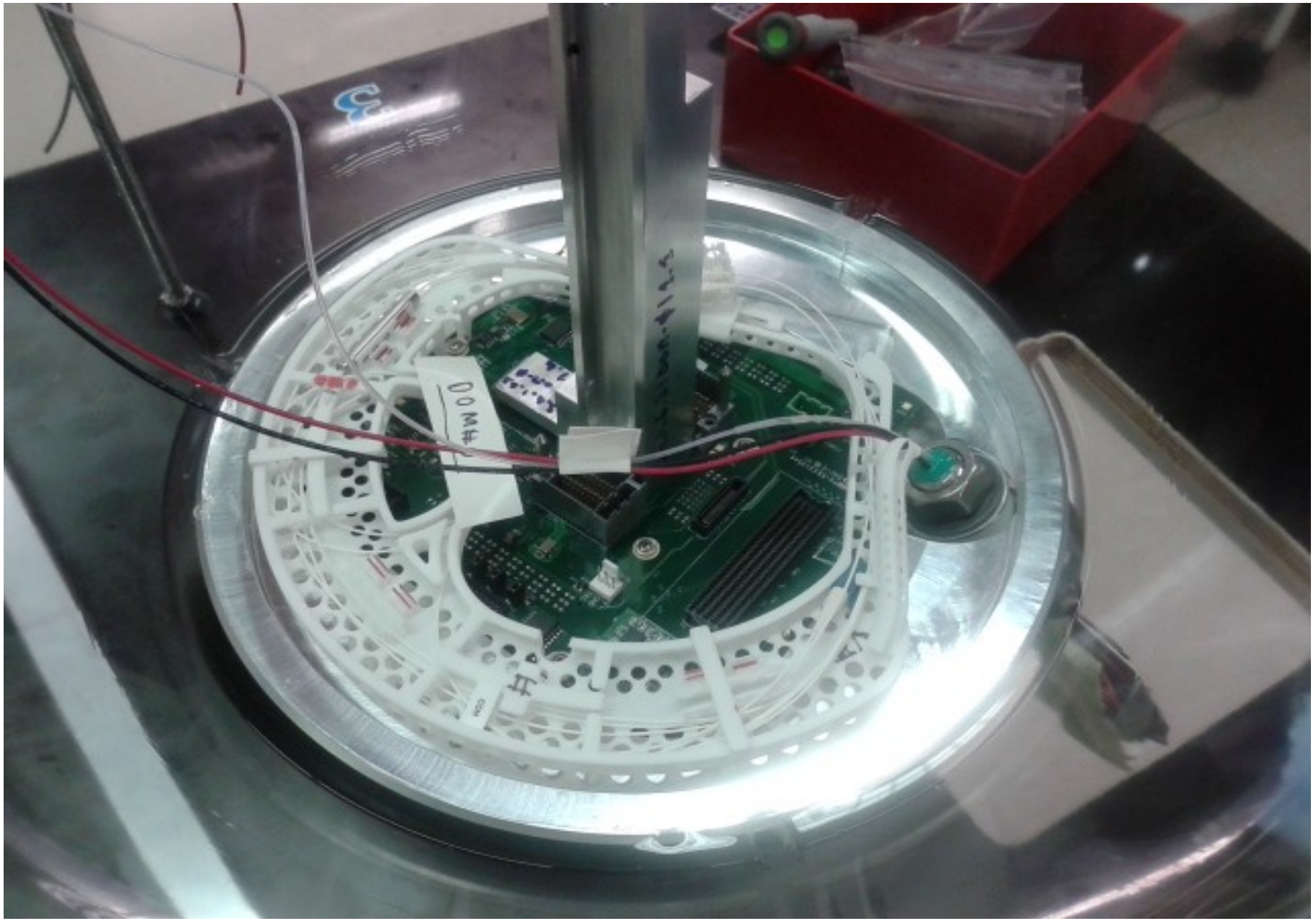
hydrophone

3-inch PMTs

- timing — ≤ 4.5 ns (FWHM)
- QE — “29.6% for many of them” (HAM.)
- collection efficiency — ≥ 90%
- photon counting purity — 100% (by hits, up to 7)
- 3 serious suppliers

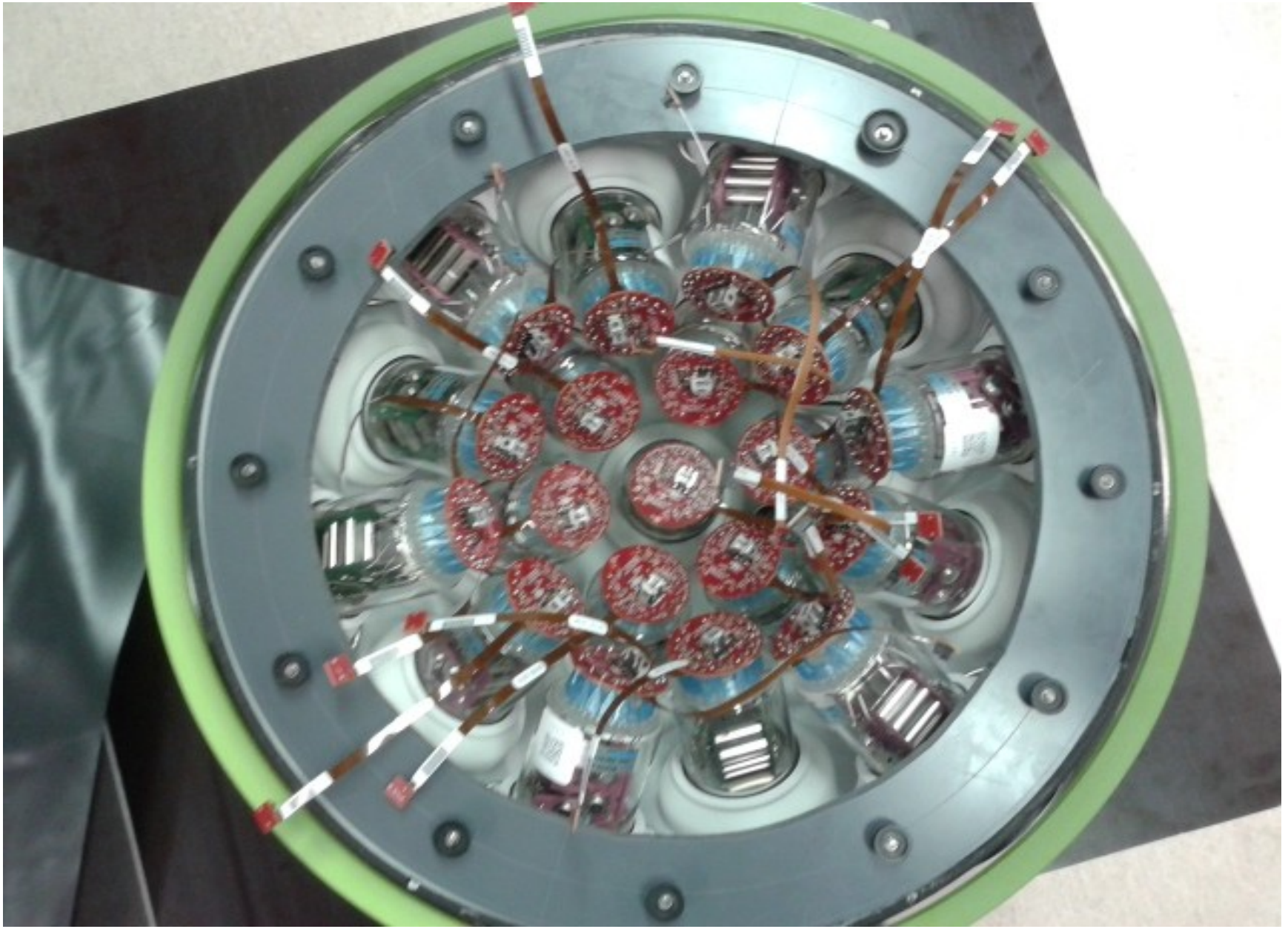
ETEL D792 | Hamamatsu R12199 | HZC XP53B20

cooling mushroom, penetrator, CLB board, fibre tray

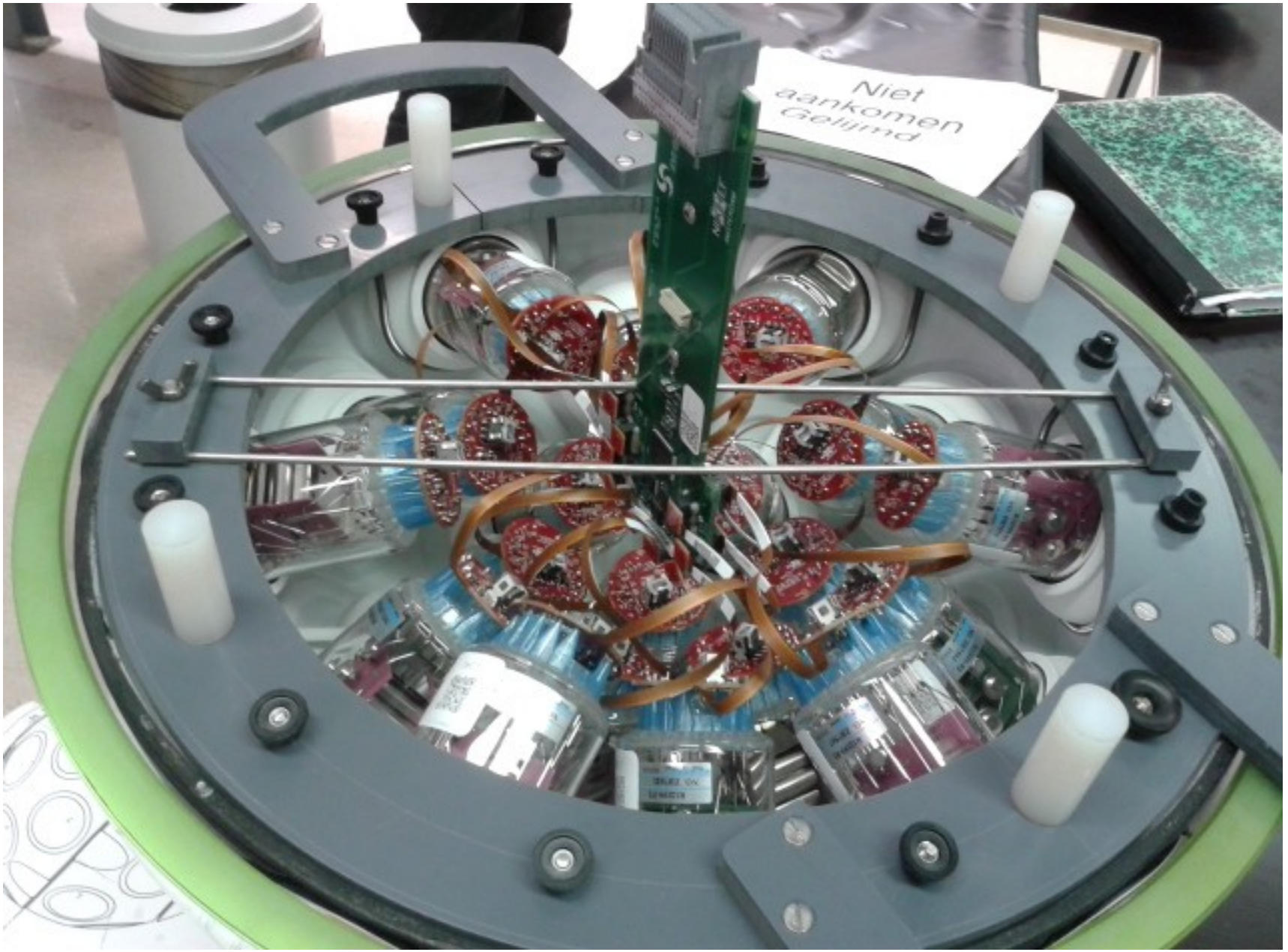


support structure (3d printed)

bottom half, showing bases



bottom half, with octopus board



1st prototype

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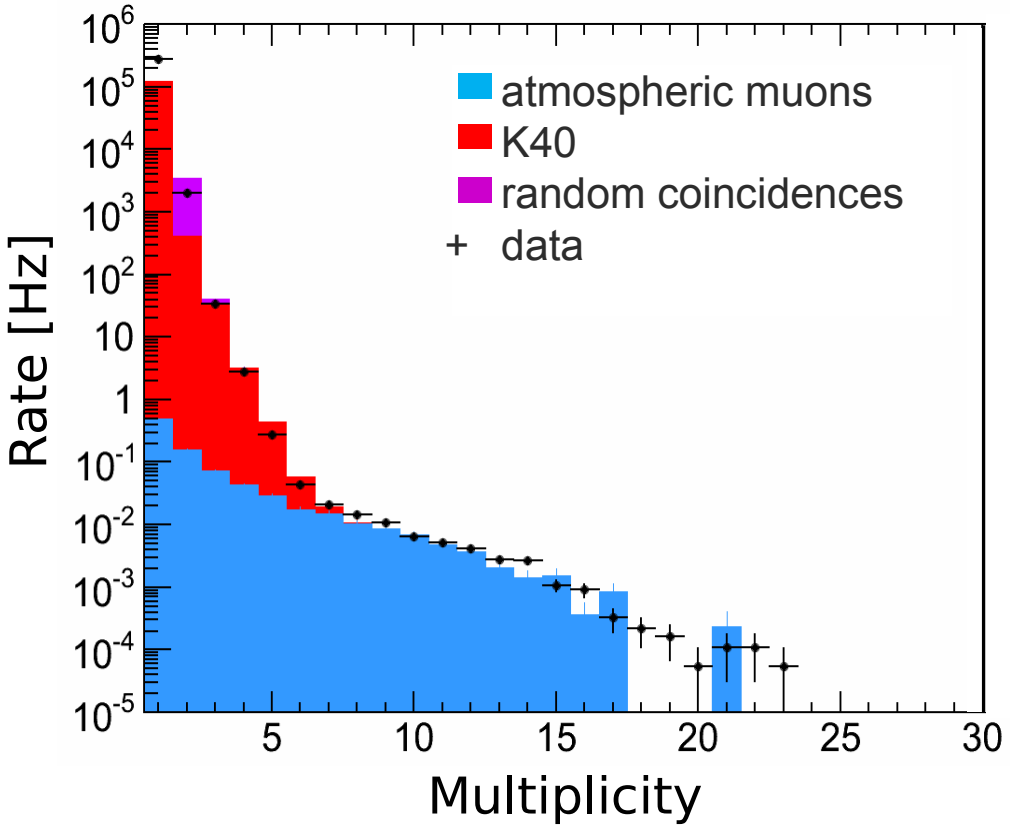
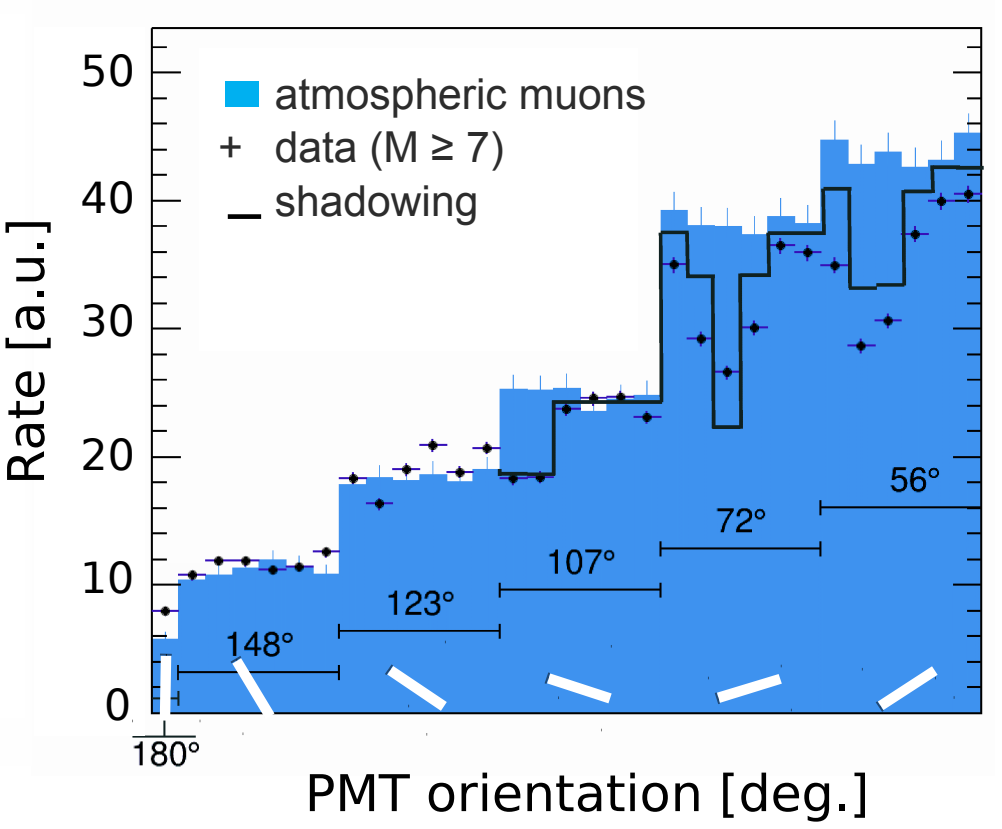
prototype: ppm-dom



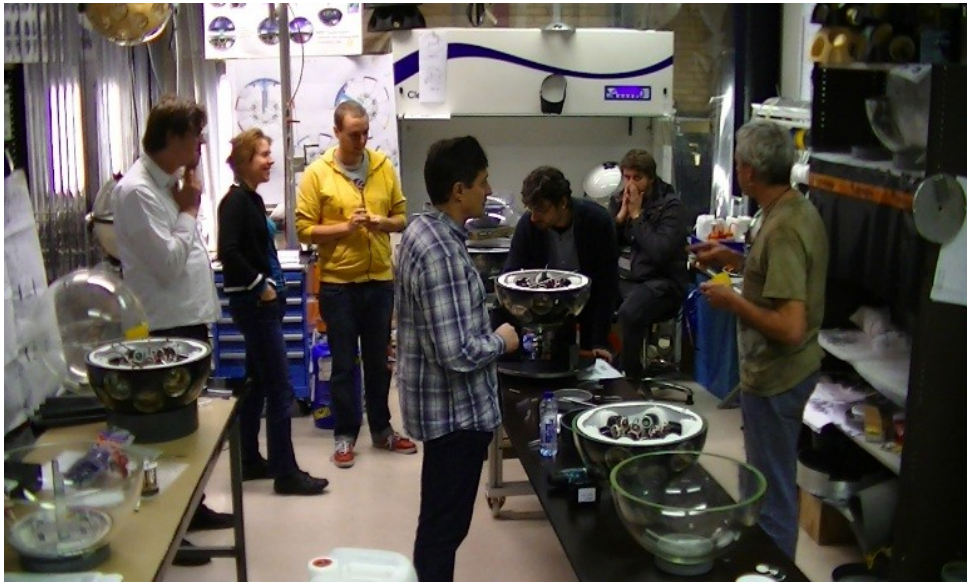


– time calibration in lab, and with ^{40}K decays
– very rich analysis on single DOM

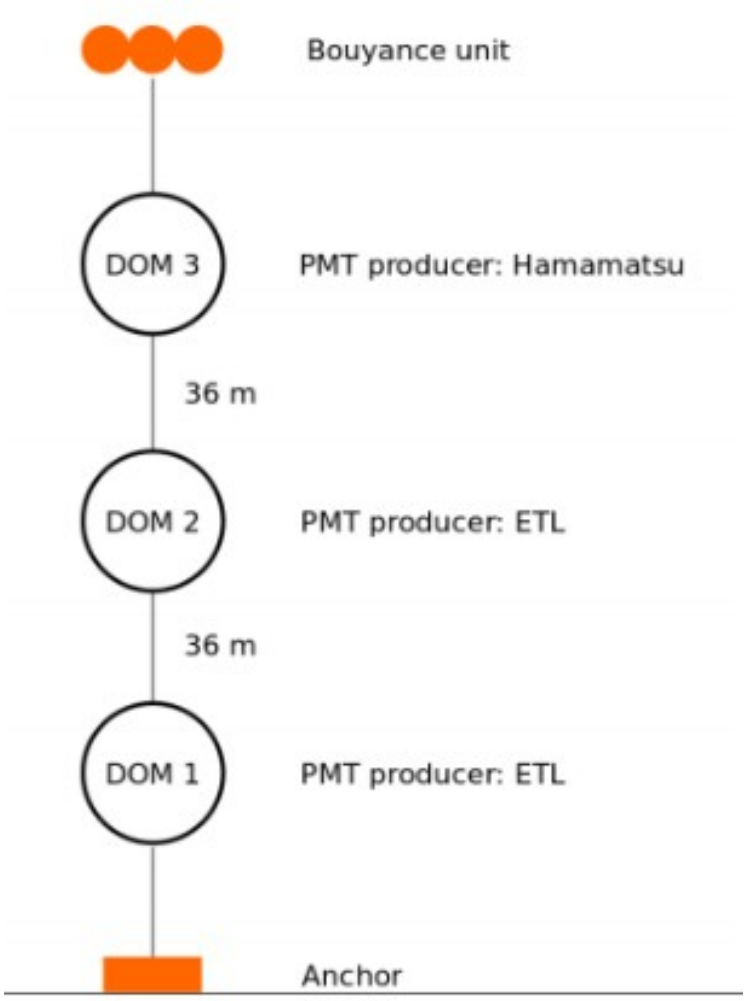
¶ http://arxiv.org/abs/1405.0839

PPM-DU prototype detection line (3 DOMs)

PPM-DU prototype



prototype DU data analysis



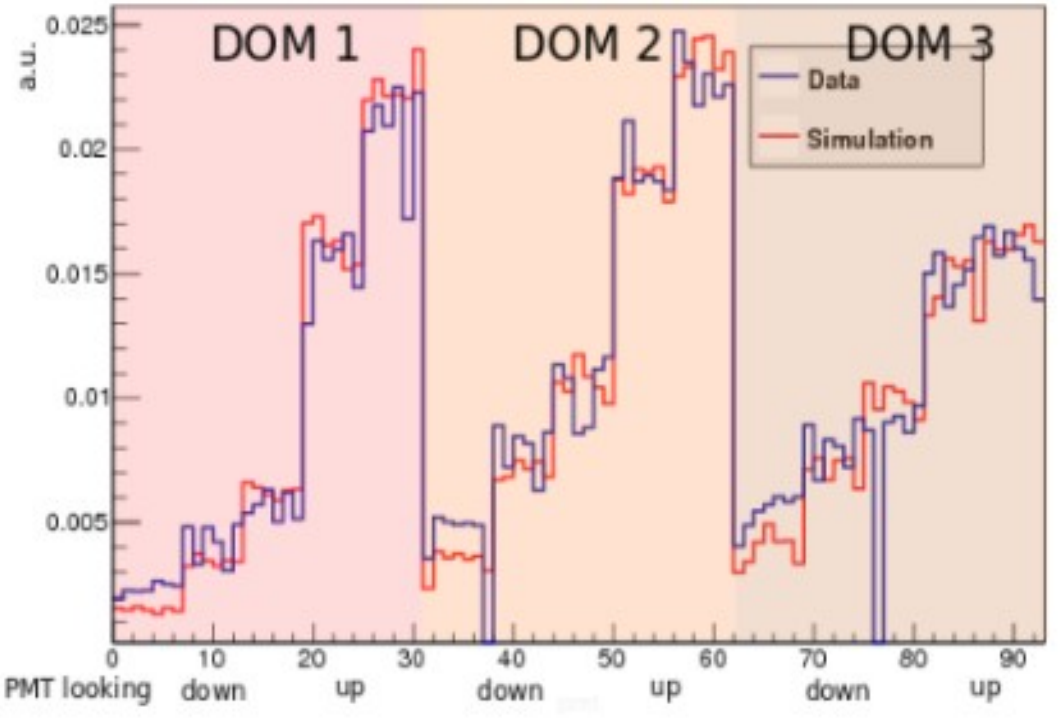
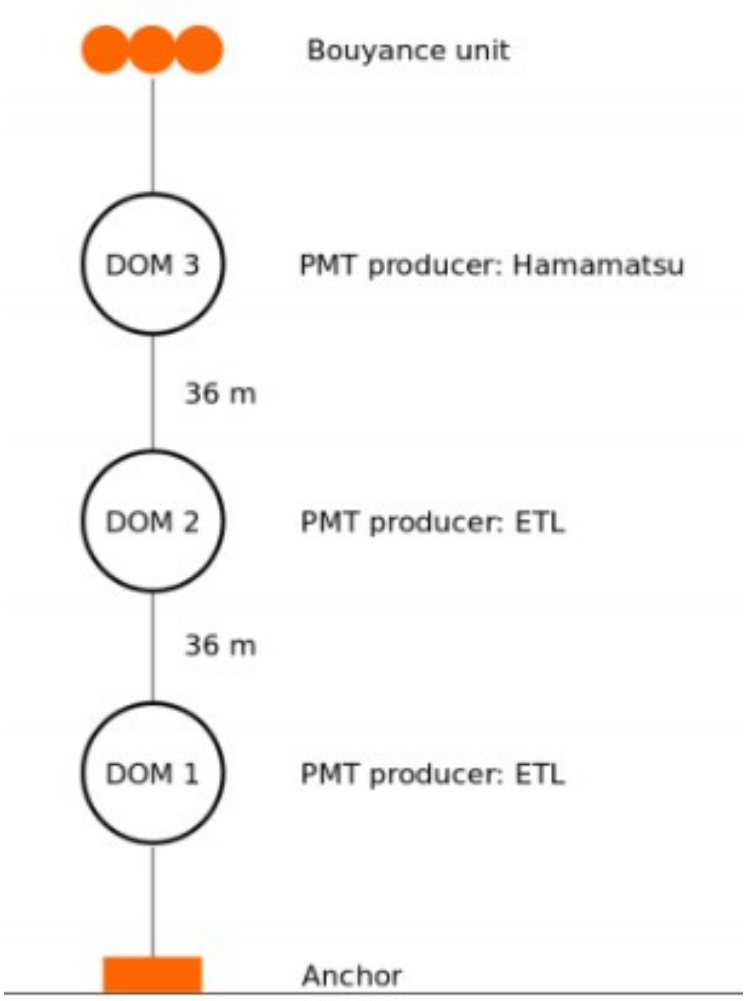
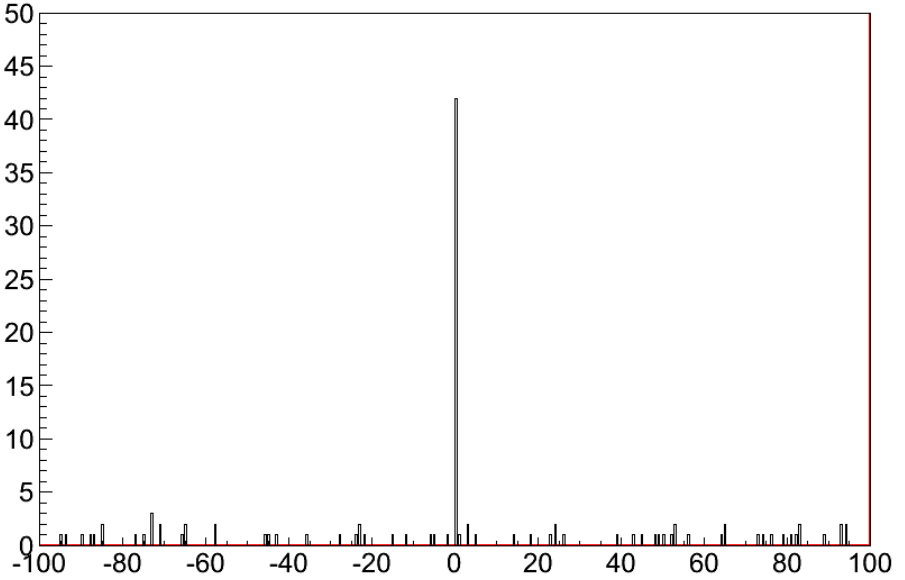


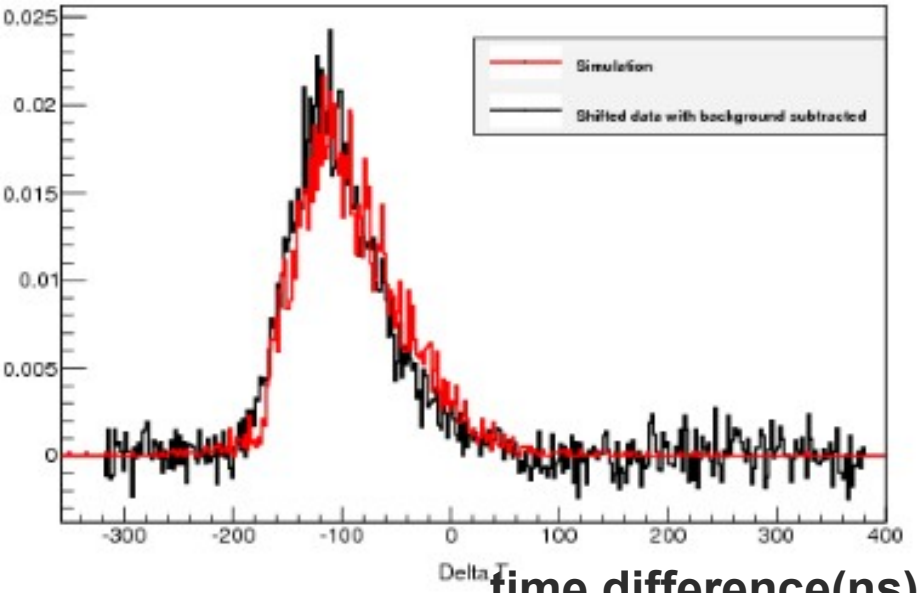
Figure : Data MC comparison for coincidencses ≥ 10

prototype DU data analysis





time difference(μs)



time difference(ns)

Time correlation checked with muons

Concluding remarks

- Small PMTs : great value for money, reduce costs of mechanics per PC area
- DOM construction designed to be light-weight process
- Besides the cost effectiveness, segmentation is really helpfull for physics
- (mass) production of DOMs for phase-1 starting ~now
- Prototypes working
  - ppm-DOM in the water for 17 months now, all channels working from the start
  - 3-DOM line since May : see muons on all 3 DOMS: inter-dom timing checked