

Detection Units 1&2 : *The making of*

R. Bruijn

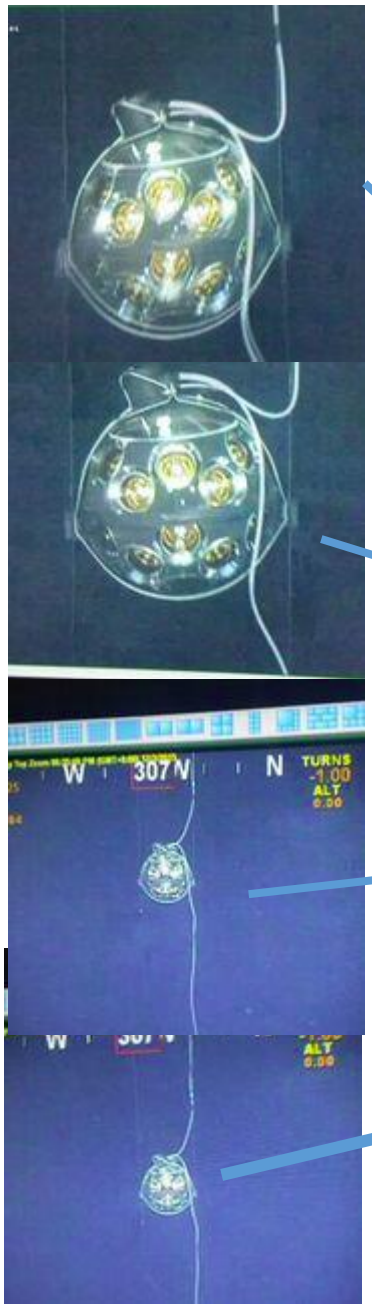
Jamboree 2015

Nikhef



Take home message of this talk:

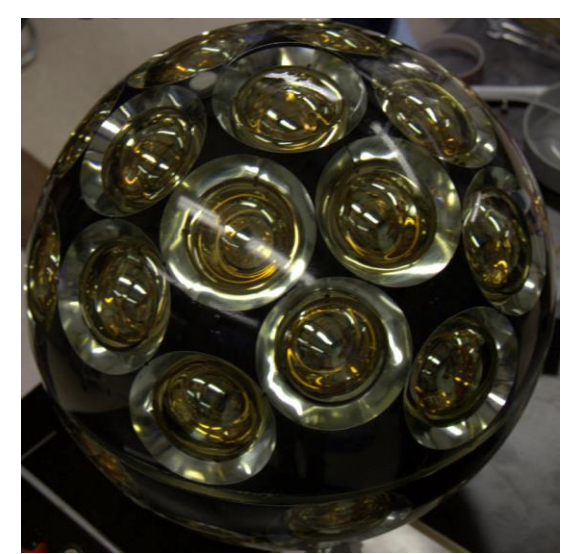
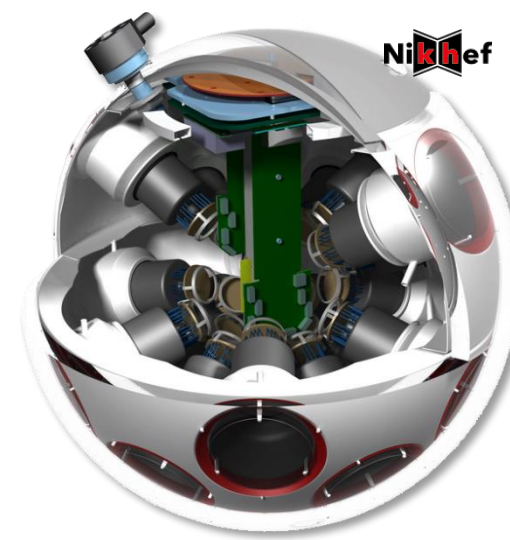
Those were made here. (And I'll tell you a bit how.)



3500 m
below
sea-level

~1 m below sea-level

DOM (Digital Optical Module)



PMT Features:

- Timing $\leq 2\text{ns (RMS)}$
- QE $\geq 25\text{-}30\%$
- Collection efficiency $\geq 90\%$
- Photon counting purity 100% (by hits, ≤ 7)
- Price/cm² $\leq 10''$ PMT

ETEL D792

Hamamatsu R12199

HZC XP53B20



Segmented cathode area: 31 x 3" PMTs

- Directional Sensitivity
- Photon Counting

Light concentrator ring

Cathode area: $\sim 3 \times 10\text{-inch}$ PMT

- Less overhead

Custom low-power HV bases

LED, piezo, compass and tiltmeter inside
PMT Time-over-Threshold measurements

FPGA readout



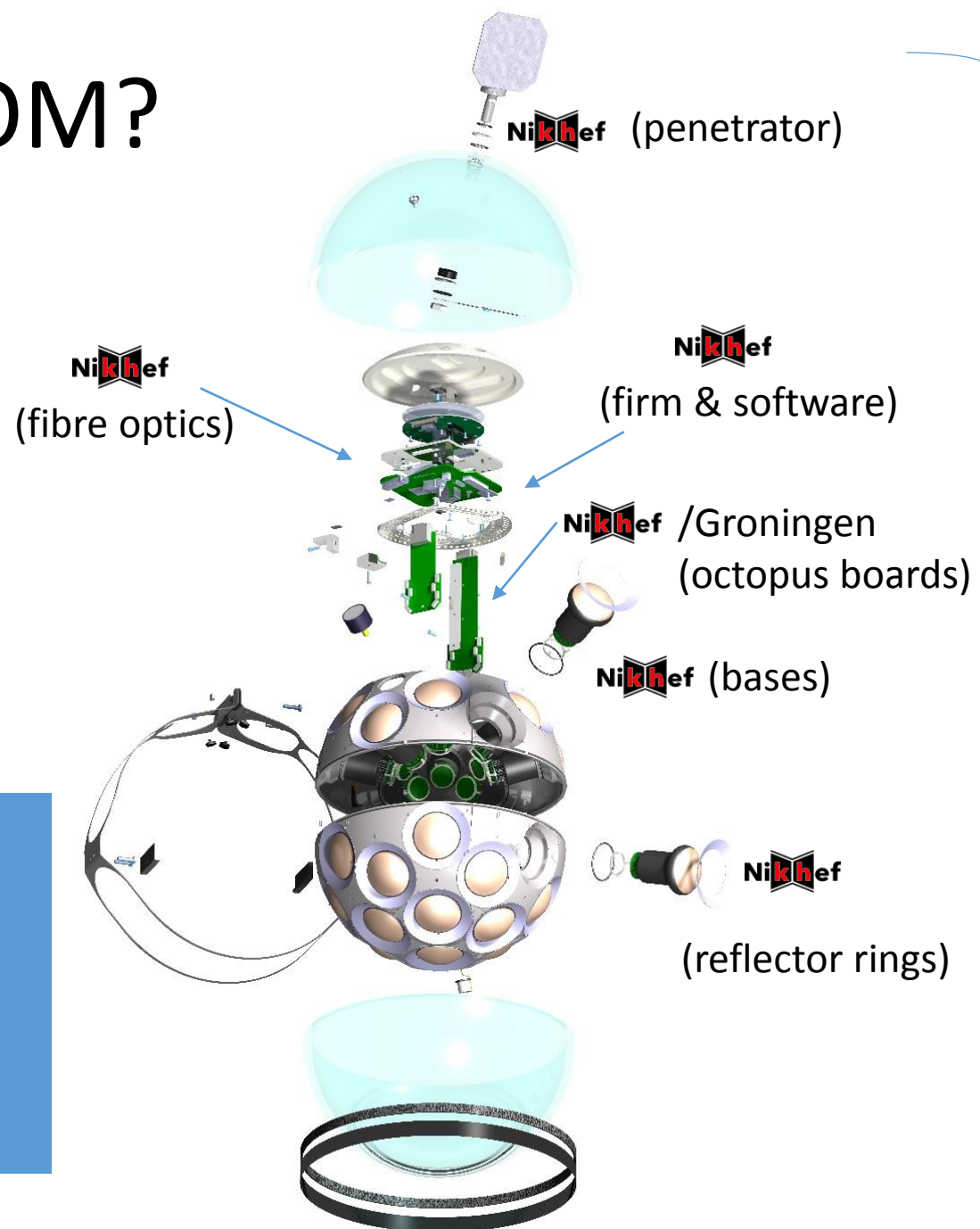
So, how to build a DOM?

272 components
(76 unique components)
need to be integrated

Nikhef has a leading role in the design of many of the components and systems

Components arrive from collaboration institutes or directly from industry. Nikhef supplies components too.

Ready to be integrated
(Currently, some components need final checks/adjustments)



The steps ...

Simplified Top half

Clean and glue cooling shell

Prepare core (support structure) (insert PMTs, rings, ...)

Glue hardening (wait)

Internal mechanics and electronics (mushroom, CLB, penetrator, ...) and insert core in hemisphere

Splice fibre to penetrator & test

(Wait in darkness)

Functional test

Glue core to cooling shell, make connections

Glue hardening (wait ...)

Gel pouring

Gel setting (wait)

Close DOM (add external mechanics)

The glass sphere consists of two halves

Simplified Bottom half

Clean hemisphere and glue piezo

Prepare core (insert PMTs, rings,)

Piezo (hydrophone) glue hardening (wait)

Insert core (support structure) in hemisphere

(Wait in darkness)

Functional test

Gel Pouring

Gel setting (wait ...)

Close DOM (add external mechanics)

Per DOM there is a lot of waiting (glue, gel, PMTs)....

One DOM takes 3 days

Parallel : 4 take a week! (1.5 FTE)

First integration procedure (document) developed⁵ at Nikhef

The cores (support structures)

Nikhef design

3D printed (SLS)@Shapeways

After some iterations, all is now going very well. Just placed another big order.

Many functions:

- Define positions of PMTs in DOM
 - Essential in integration procedure
- Barrier for gel (optical coupling)
- Holds pressure gauge
- Holds reflector rings (increase light yield)
- Holds hydrophone



Penetrators

The penetrators allow the passing through of two power wires and an optical fibre into the DOM

Essential component : failed penetrator means a lost DOM!!

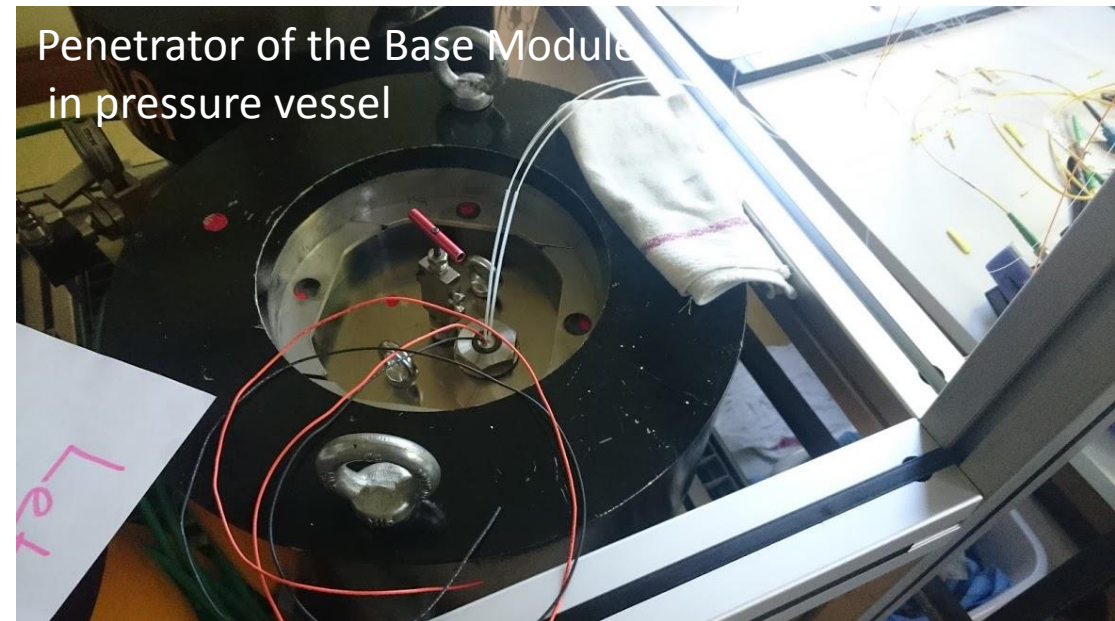
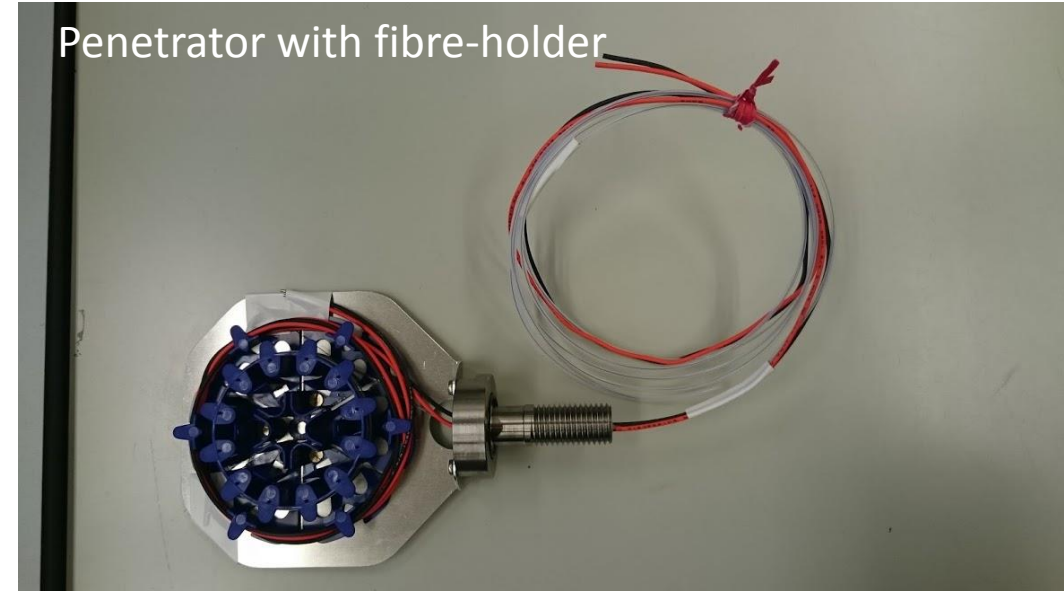
Nikhef design

DU-1 : produced at Nikhef

DU-2 : Include penetrators acquired in industry

Currently 100% of the penetrators are tested at Nikhef

- Nikhef penetrators : 650 bar
- Industry (Pave) : 380 bar
 - 64 delivered, 100 more ordered, 3 base penetrators

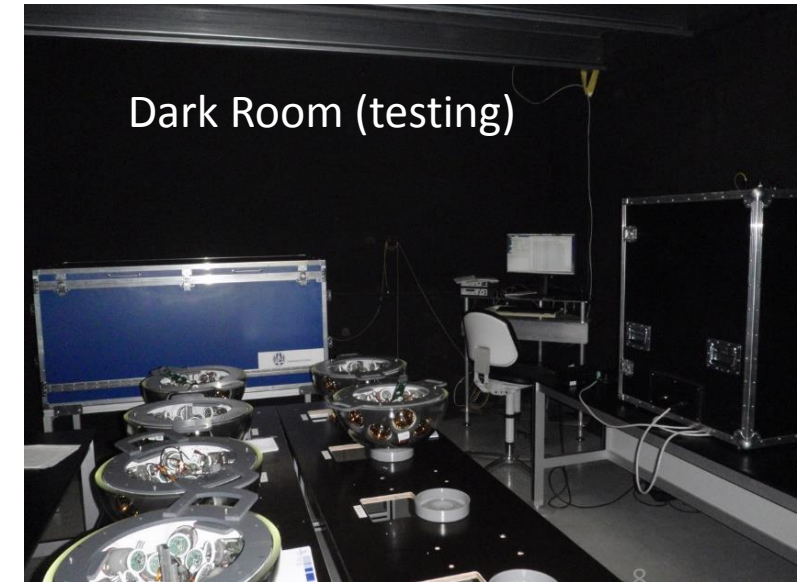


Integration lab

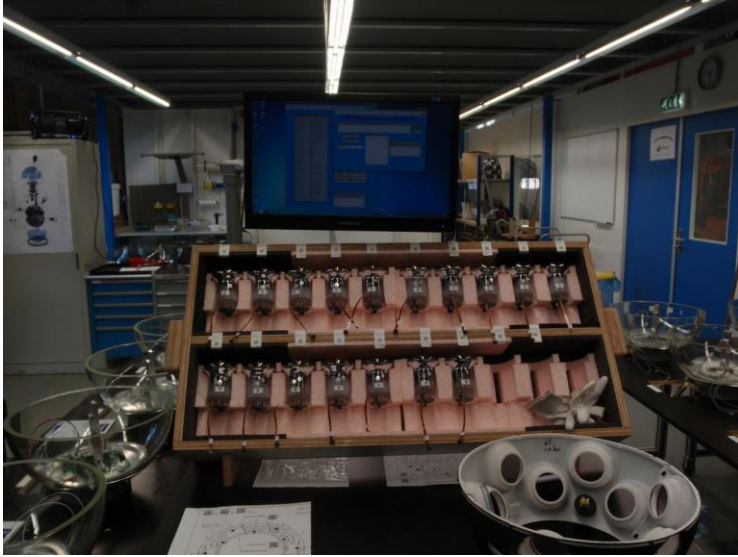


Before DU-2, production was moved to a newly built integration lab in the beginning of the year. This is to sustain required production rate and integrate testing facilities.

Capacity: 12 simultaneous in production
Production storage buffer : 40 locations



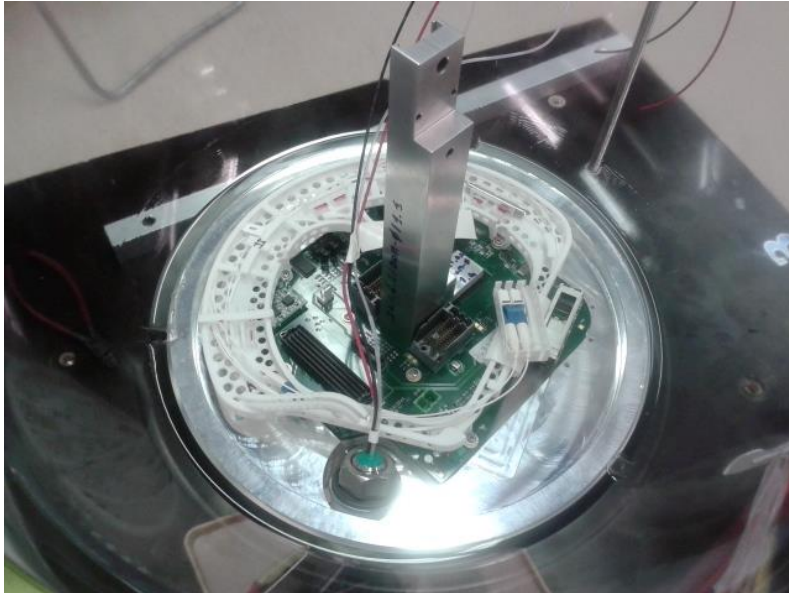
Putting PMTs in cores



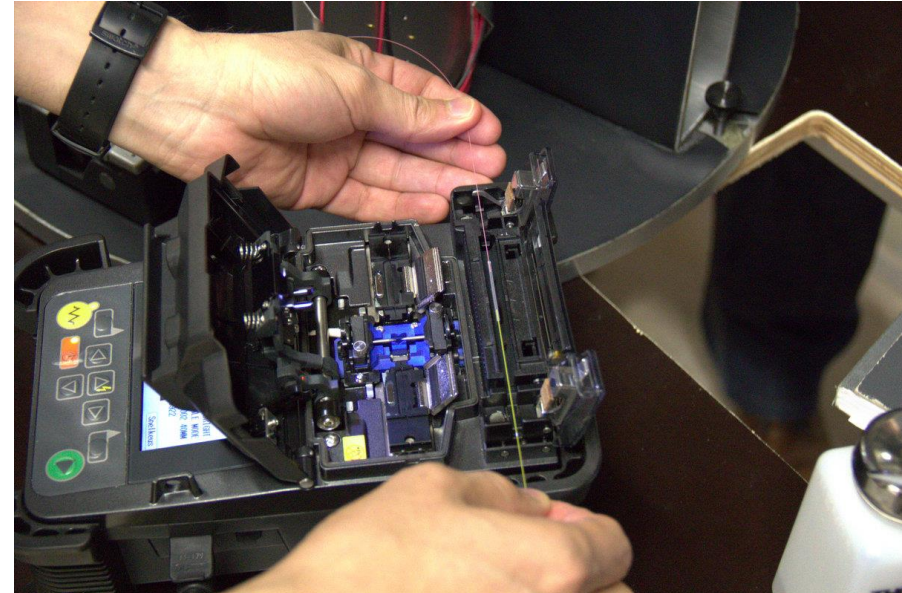
Helium leak testing

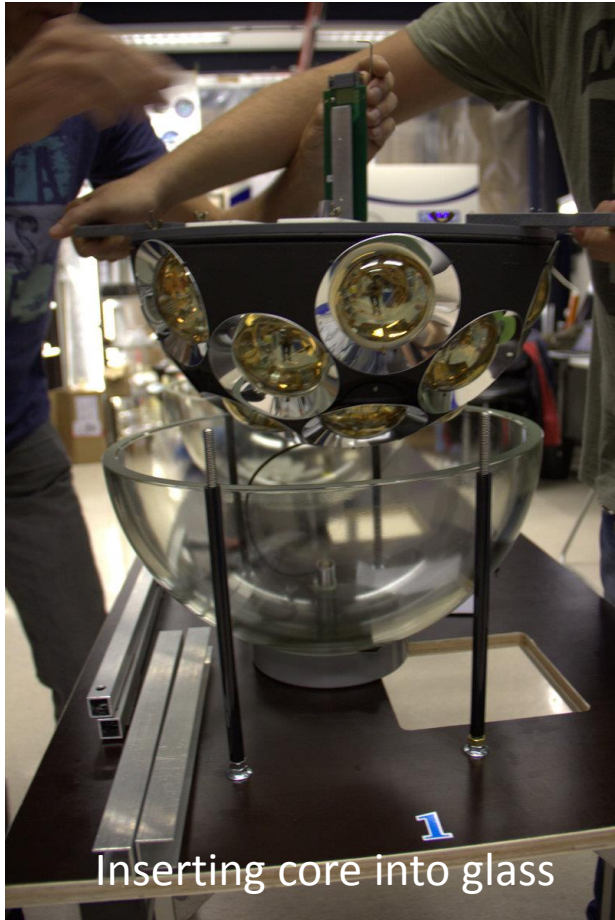


Internal mechanics



Splicing

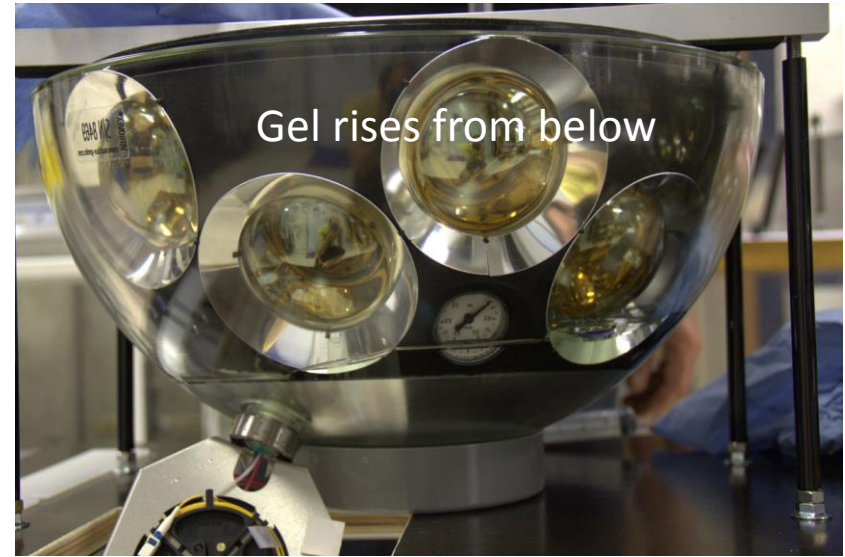




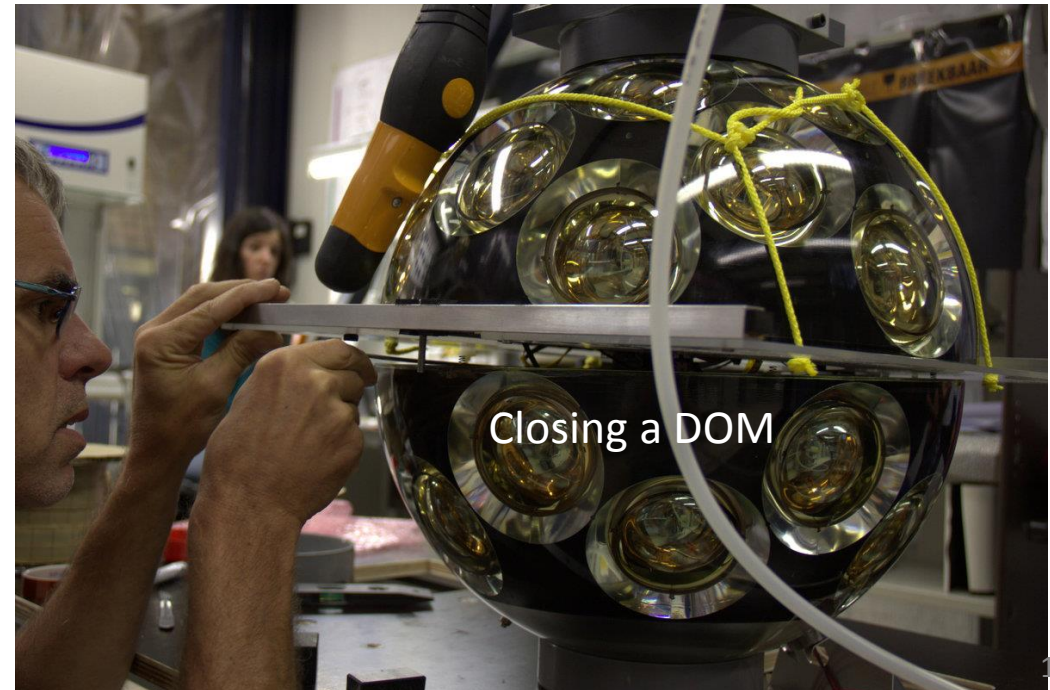
1
Inserting core into glass



Gel pouring



Gel rises from below



Closing a DOM

Testing (before doing something irreversible)

Splice fibre



Helium leak test:

Check whether the penetrator is mounted correctly

Assemble
DOM halves



Test of fibre optic splice

(connection between inside and outside)

Functional test:

Check if all electronics is functional and operates within parameters. Two way communication. Power use. Compass/tiltmeter, Correct firm/software, PMTs can be addressed, nanobeacon, piezo,

Pour gel
in DOM



Acceptance test

Does the DOM operate within specifications
Includes data-taking runs
Calibration of compass

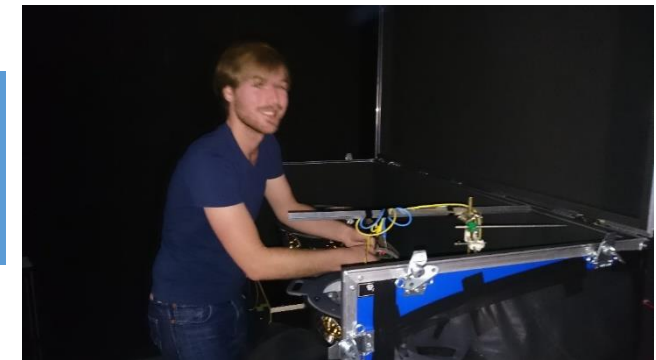


Finished ! Pass DOM on to DU integration.

Dark/test boxes
developed by
Leiden University
(D. Samtleben)



Guided by collaboration wide
criteria (developed mostly
at Nikhef)

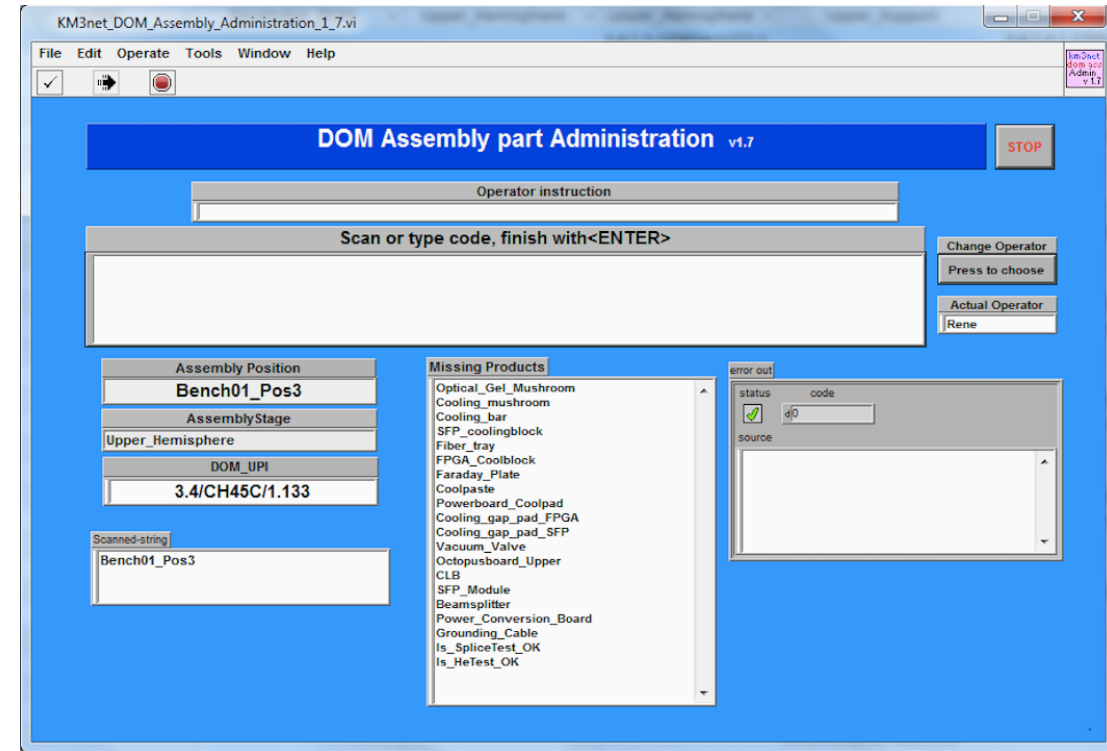


Testing is a potential bottleneck when production
is at full speed.....

Quality Assurance & Control

All components are registered, labelled and tracked within the collaboration

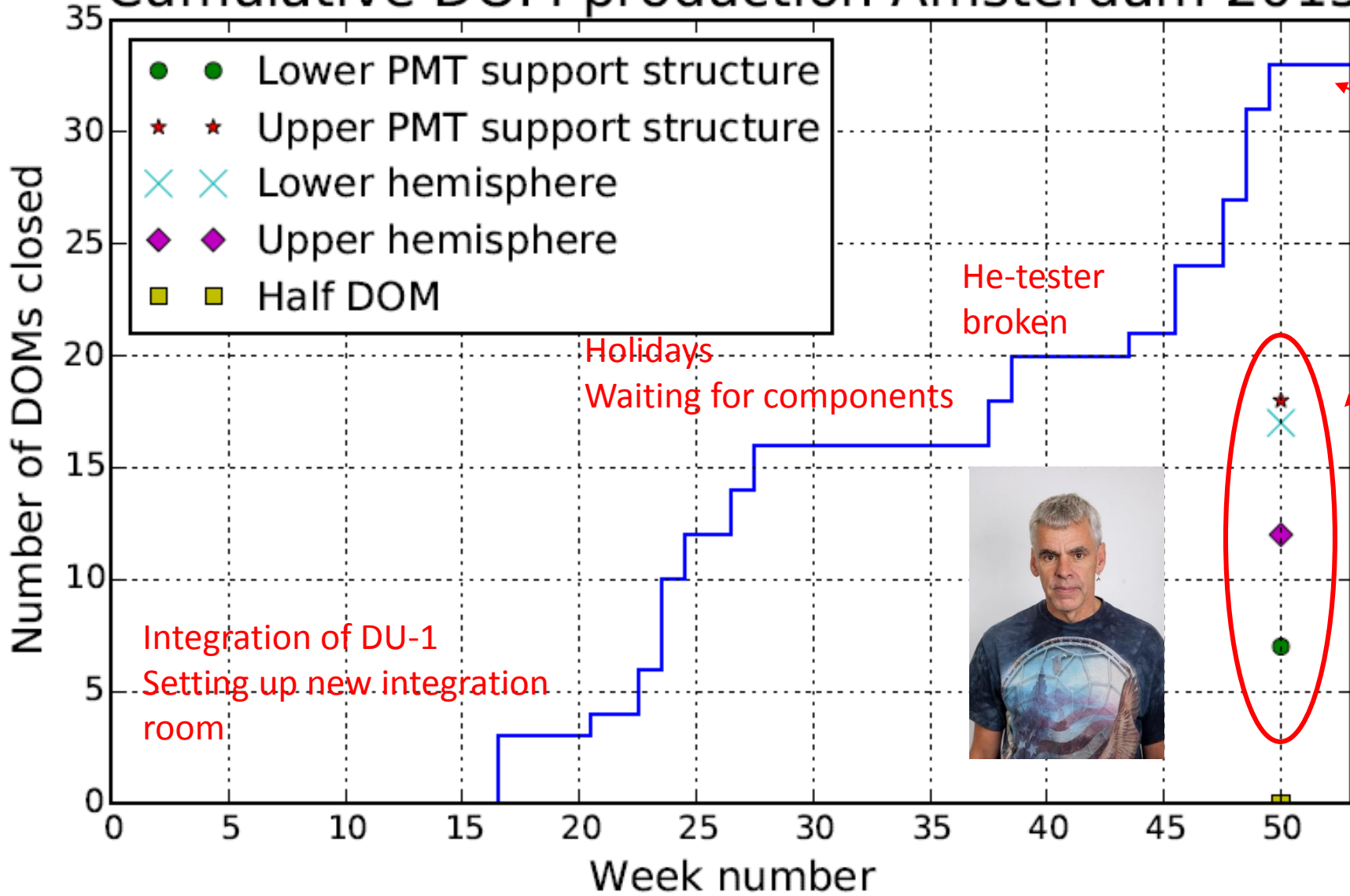
All characteristics (e.g. PMT HV) are in a central database



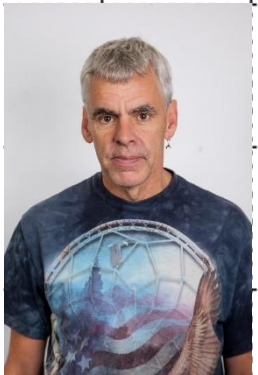
We need to know what components are in which DOM.

Software developed at Nikhef is essential in bookkeeping and tracking.

Cumulative DOM production Amsterdam 2015



On hold, pending collaboration decision on compass/tiltmeter issue. (if not, we could have finished a third line + some!!!!)



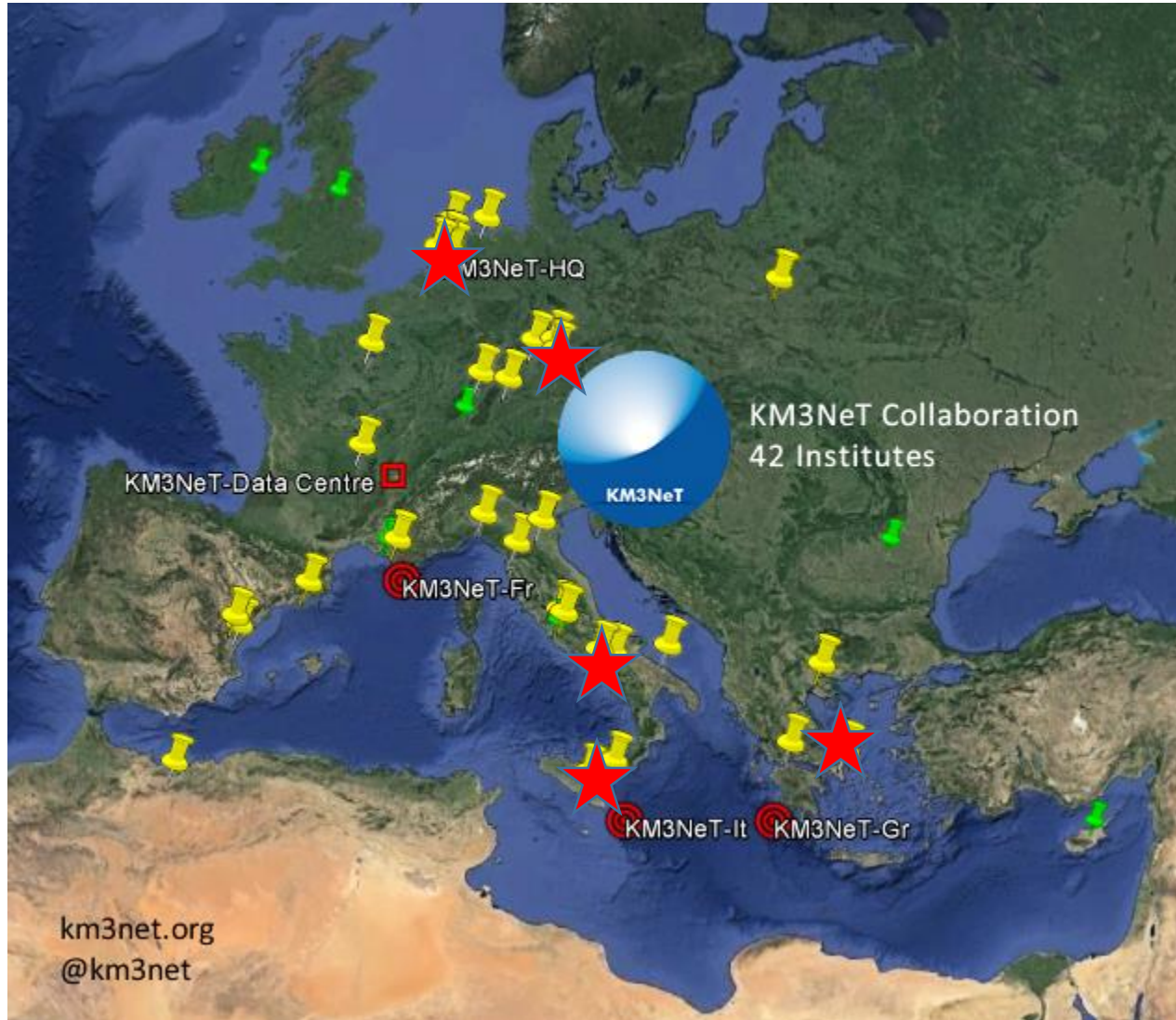
2014: 19 (DU-1 + 1)

2015: 33(+18)

Total : 70 (52)



Collaboration production overview



Other sites have started production or are preparing production
(Coordination: D. van Eijk)

Site	DOMs
Nikhef	52 (70)
Catania	4
Naples	4
Erlangen	0
Athens	0

Nikhef : In full production swing!



Naples



Catania



Erlangen

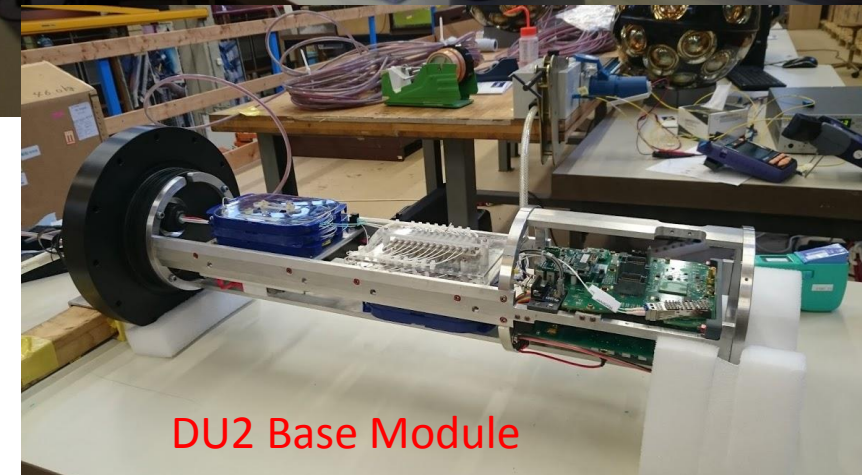
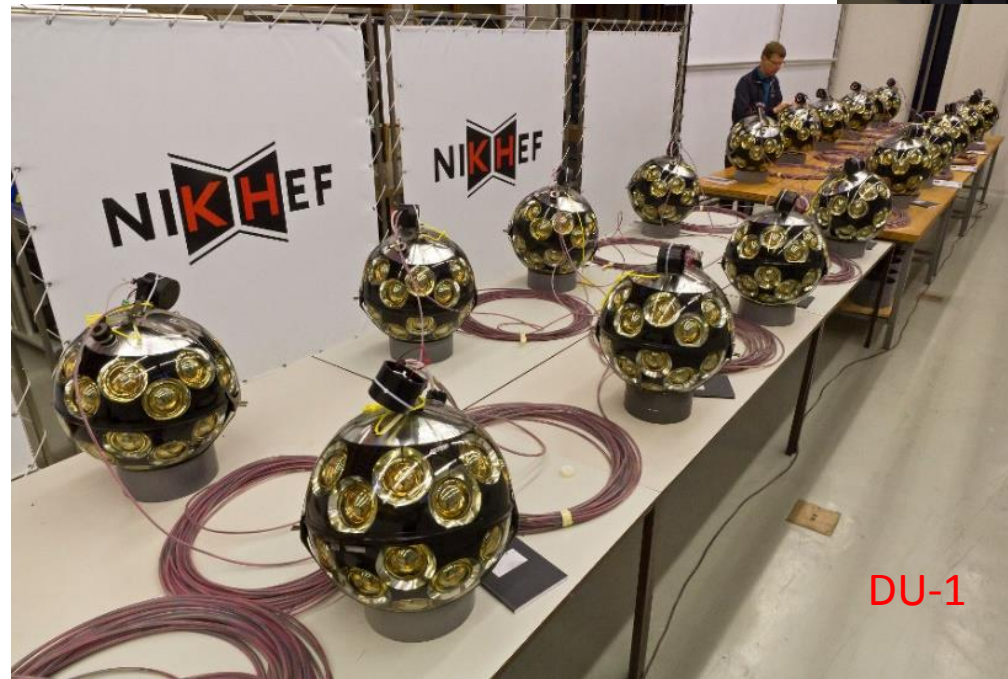
Other sites are ramping up

Detection Unit integration

Integration of DU2 was done one top of the integration lab

DU1 and DU2 have been integrated at Nikhef :

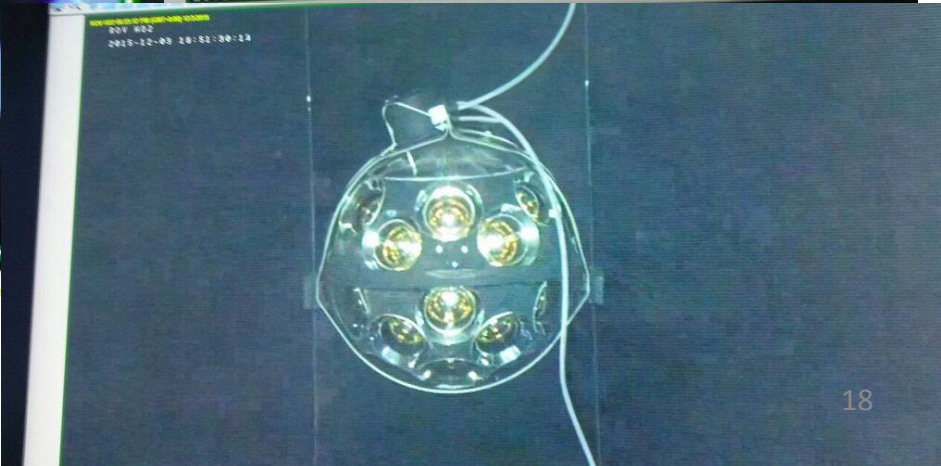
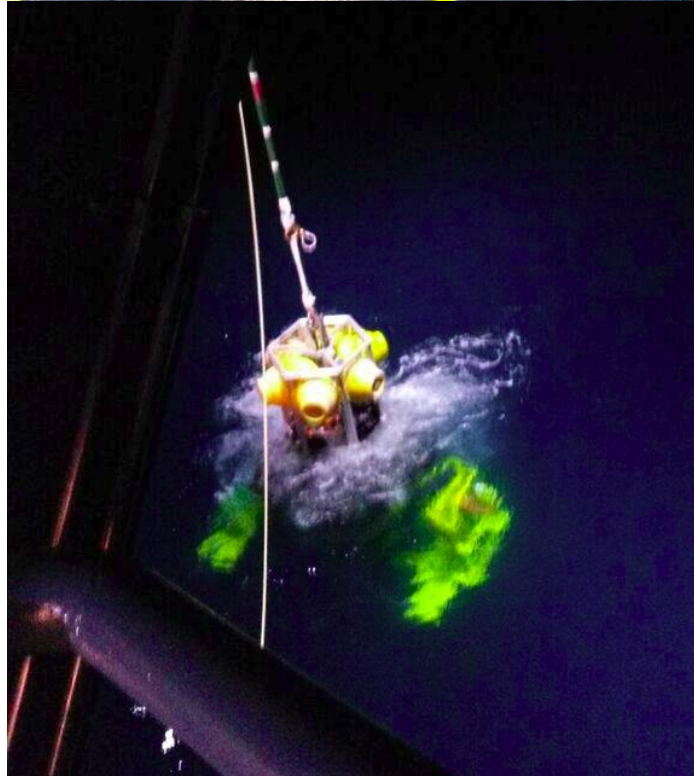
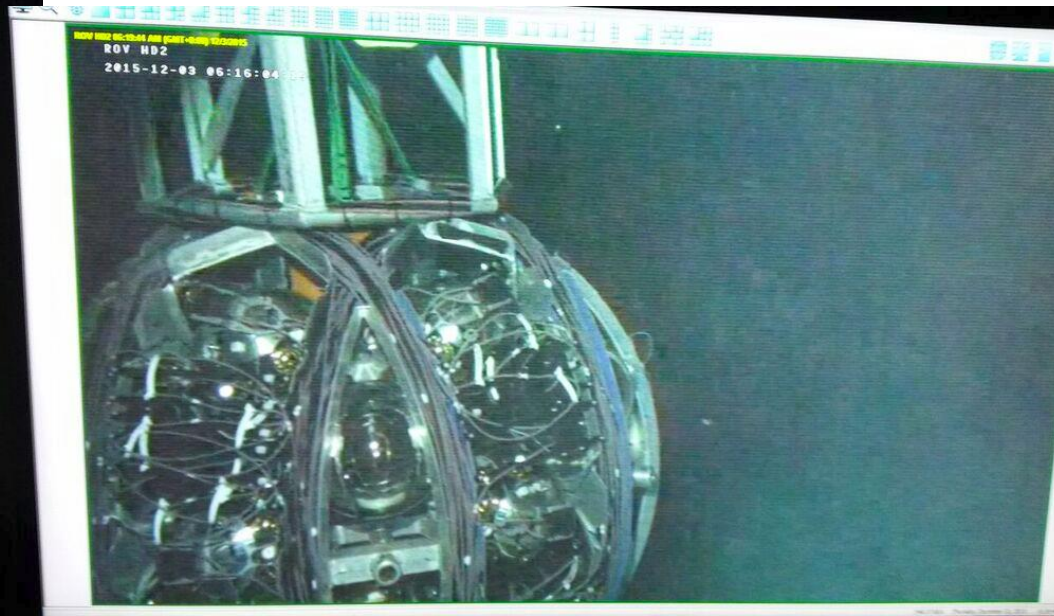
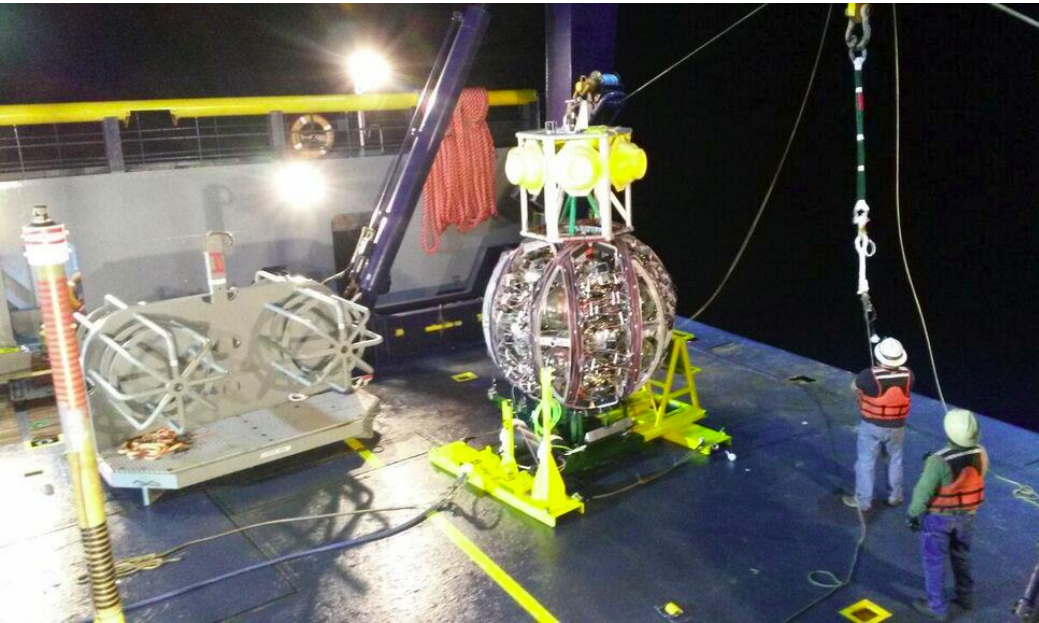
- Prepare VEOC
- Splice DOMs to VEOC, connect DC/DC converter
- Plastic welding : BEOC, close break-out-box,
- Fill with oil
- Test for leaks
- Prepare bottom of VEOC : patch box or base container



Line mechanics & mounting on LOM



Mounting of DU on LOM at Naples, with Nikhef instruction and participation.



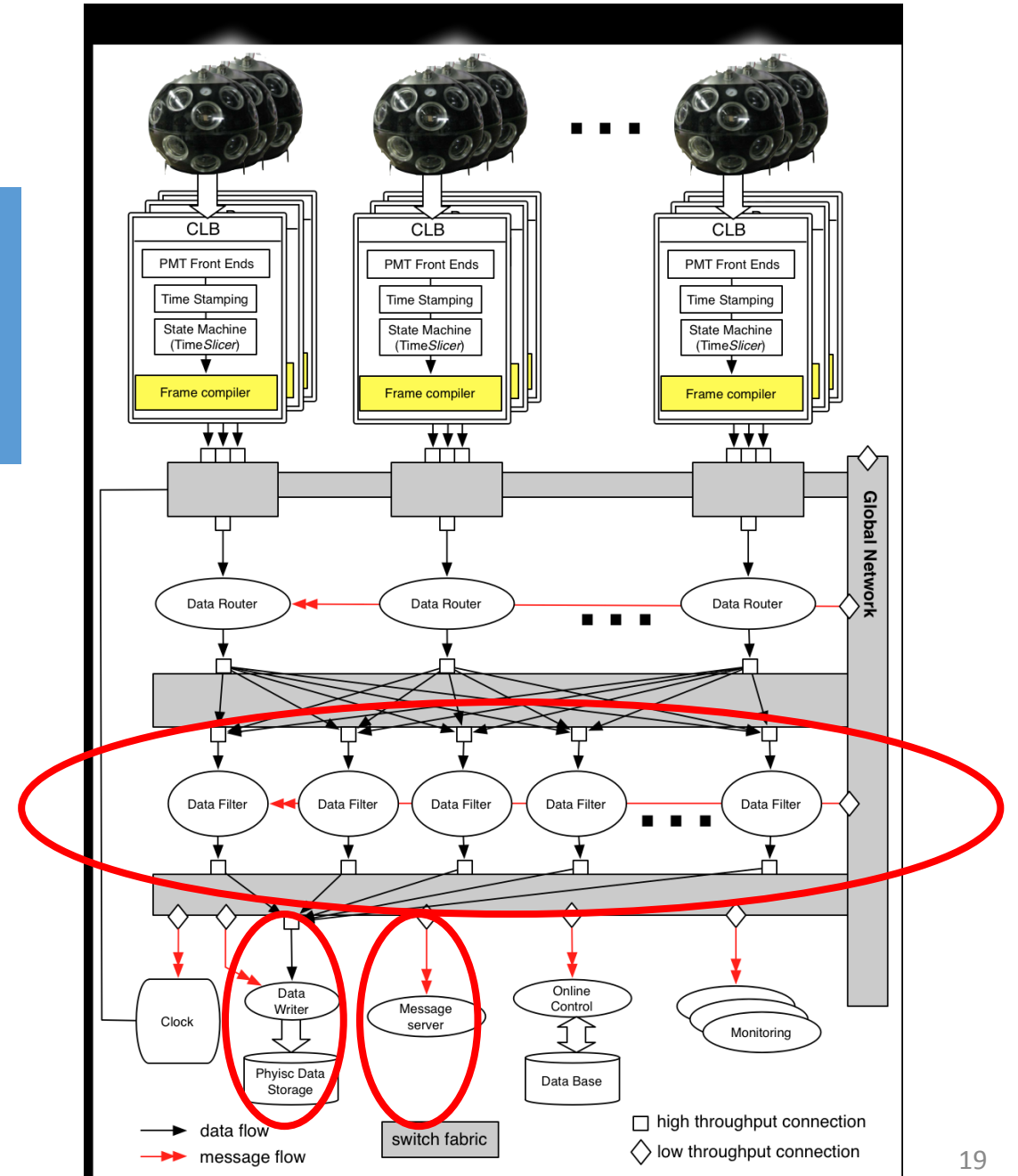
Other

Other major responsibilities/activities for DU2 :

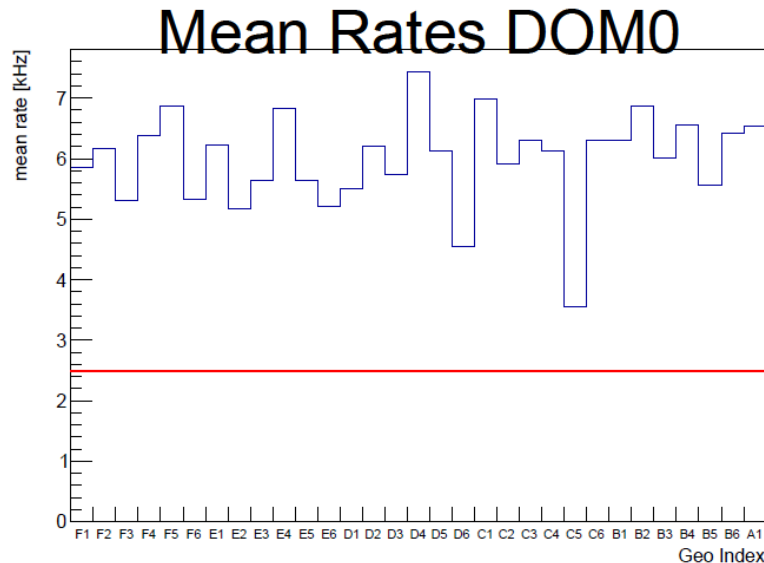
- DAQ: On shore data-filtering/Trigger (R. Bruijn)
- DAQ: 'Software Framework' (M. de Jong)
- Timing calibration (M. Bouwhuis)
- Fibre optic shore station (Nikhef Optics Team)



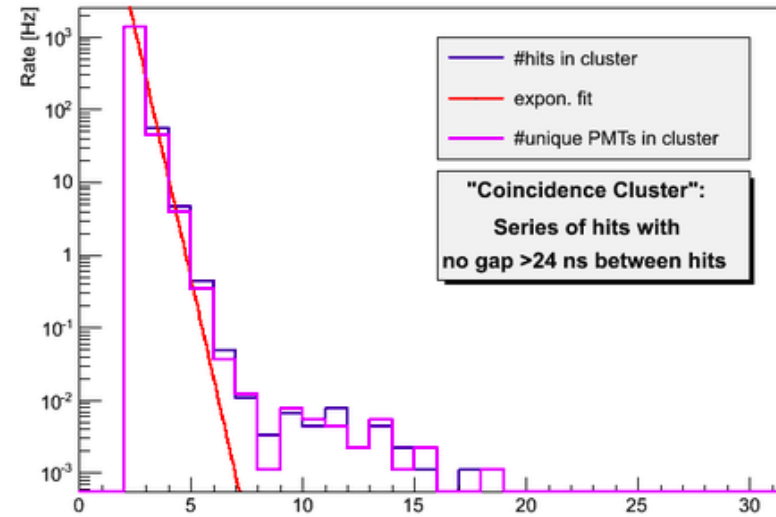
Timing calibration in transport box!



DU2 taking data!



Coincidence clusters DOM1



```

km3net@naptridas:~
File Edit View Search Terminal Help
CLBSK - port: 56017, mon channel - DOMs number: 1 - 'q' to quit, 'h' for help

Press ESC to return back.
DOMID  MAC ADDRESS      Name      Run #  Hit rate (min, max, avg)  Last viewed  S Delta time
808982574  08:00:30:38:18:2E      0          3.02,  9.88,  6.26 kHz      0 sec ago  * 100 ms

Sec: 1449228370, Tic: 31250000 - 2015 Dec 4 11:26:10 +500000000ns GMT

CH00:  691  CH01:  588  CH02:  665  CH03:  698  CH04:  531  CH05:  698  CH06:  484  CH07:  587
CH08:  610  CH09:  598  CH10:  697  CH11:  548  CH12:  582  CH13:  751  CH14:  663  CH15:  641
CH16:  473  CH17:  656  CH18:  605  CH19:  693  CH20:  364  CH21:  585  CH22:  685  CH23:  570
CH24:  619  CH25:  688  CH26:  602  CH27:  622  CH28:  641  CH29:  656  CH30:  784

Validity: 0x0
Yaw: 0.0000 Pitch: 0.0000 Roll: 0.0000
Accel: 0.0000, 0.0000, 0.0000
Gravity: 0.0000, 0.0000, 0.0000
Compass: 0.0000, 0.0000, 0.0000
Temperature: 2039
Humidity: 3857
    
```

So, what's in this data? Stay tuned for next talk !

Je moet er even handigheid in krijgen



You must get in there as dexterity



Je moet er even handigheid in krijgen



KM3NeT

You must get in there as dexterity



The End

Meanwhile in the Shore Station: Coffeeand Champagne!!

