



Technical Activities for KM3NeT at Nikhef (+ Status & Plans)

R. Bruijn

Nikhef Jaarvergadering 'Jamboree' 2017

Pakhuis de Zwijger

Take away message:

Nikhef has an essential contribution to the conceptual and technical design of the KM3NeT detector and its implementation.

Some highlights ...

**Detection Unit mechanics
Incl. VEOC**

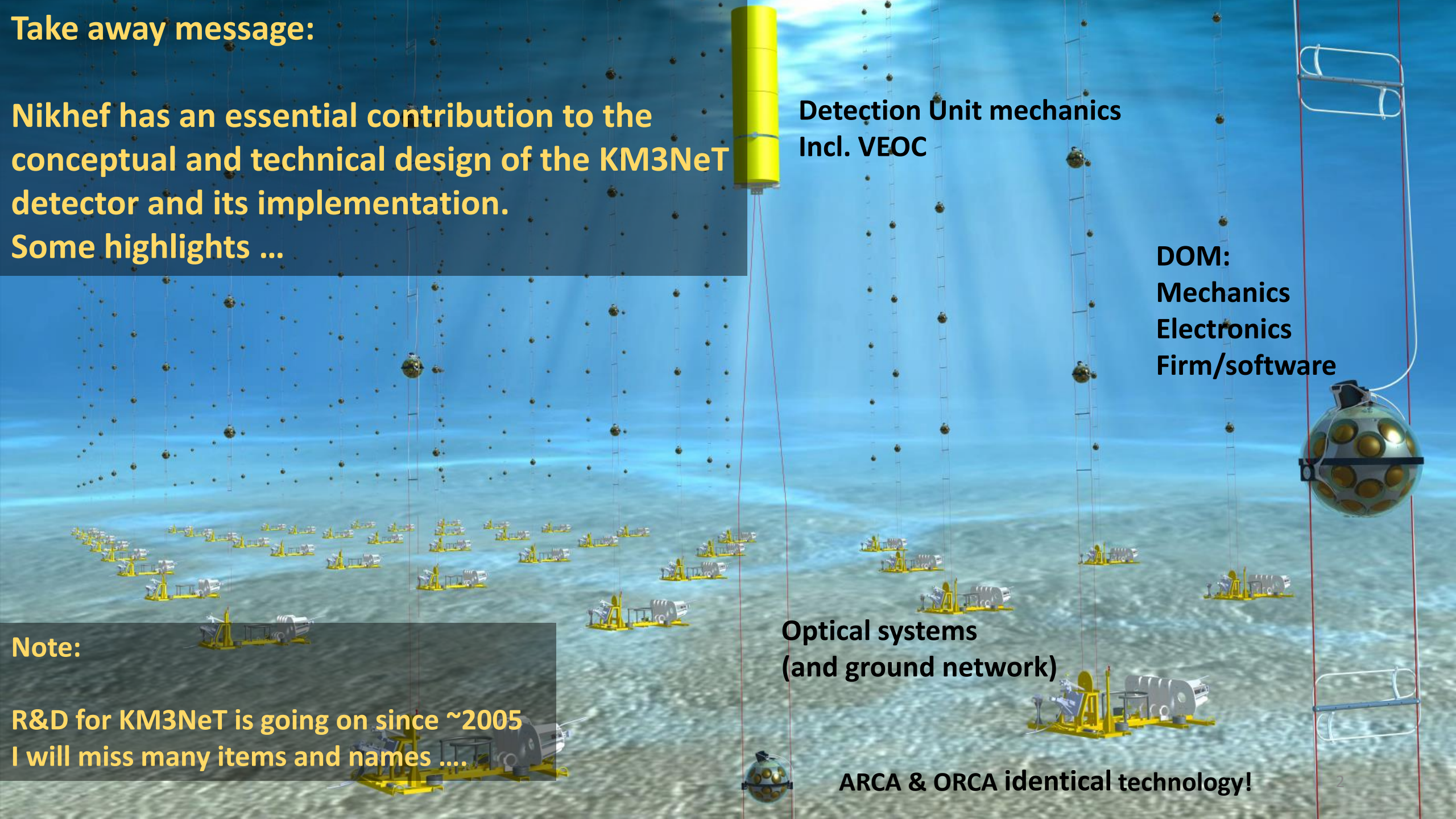
**DOM:
Mechanics
Electronics
Firm/software**

**Optical systems
(and ground network)**

ARCA & ORCA identical technology!

Note:

**R&D for KM3NeT is going on since ~2005
I will miss many items and names**



Digital Optical Module

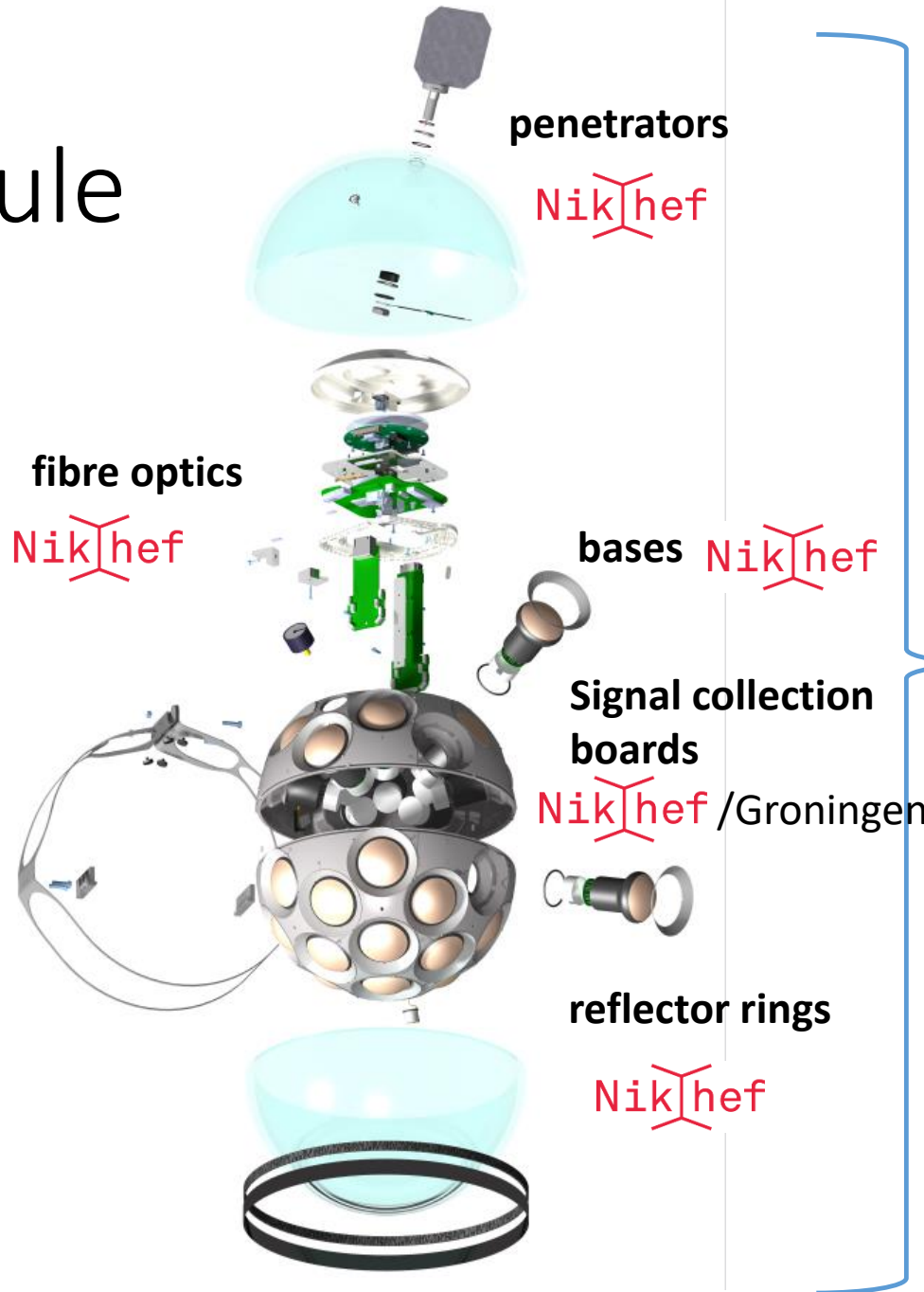
DOM :

Core detection element of KM3NeT
31 3" PMTs in 17 inch glass sphere
Nanosecond timing of photo arrival times
Fibre optical communication

various mechanical
components

Nikhef

fibre optics
Nikhef



Multi-PMT
concept and
mechanical design

Nikhef

Mechanics Highlight: 3D printing

Support structures are currently 3D printed in industry with an selective laser sintering (SLS) technique



Exploring new 3D printing techniques to lower costs and increase speed

Includes redesigning structures for efficient packing in specific machines

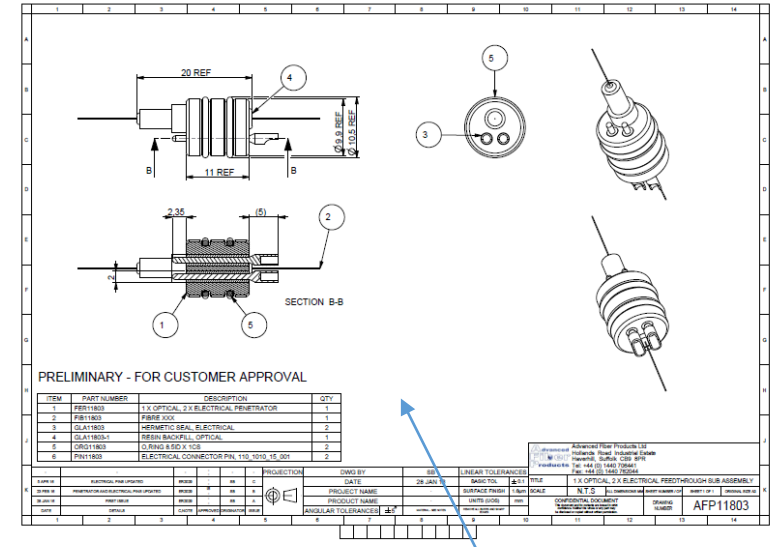
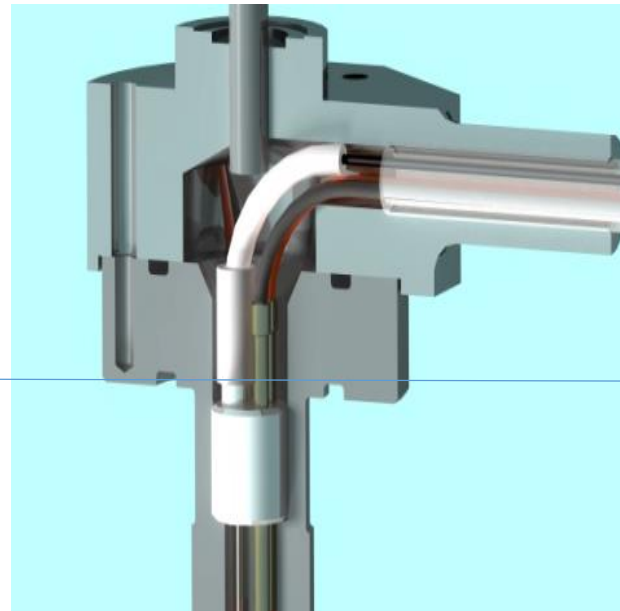


Mechanics Highlight: Penetrator

Penetrator: feedthrough of optical fibre and copper in pressure gradient (into DOM, into DU base-module)

First design and implementation at Nikhef based on ceramic feedthrough

Transferred to industry due to required volume ... based on epoxy or glass seal



Insert with fibre sealed in glass (industry)

High pressure

Low pressure

High Pressure

Besides by the salt-water, the deep-sea is characterized by high-pressures !

All relevant components must be qualified for these pressures

Full (100%) pressure testing of some critical components

Penetrators, DOM and Anchor

Characterization of the behaviour of components under pressure

PE-tubes (water absorption)

Optical fibres (attenuation)

DC/DC converters

Involved: Jean-Paul, Paul T., Auke, Berend,
Jan-David, Mathijs (MT student)

Pressure testing Facilities at Nikhef:

3 vessels of 12 liters volume

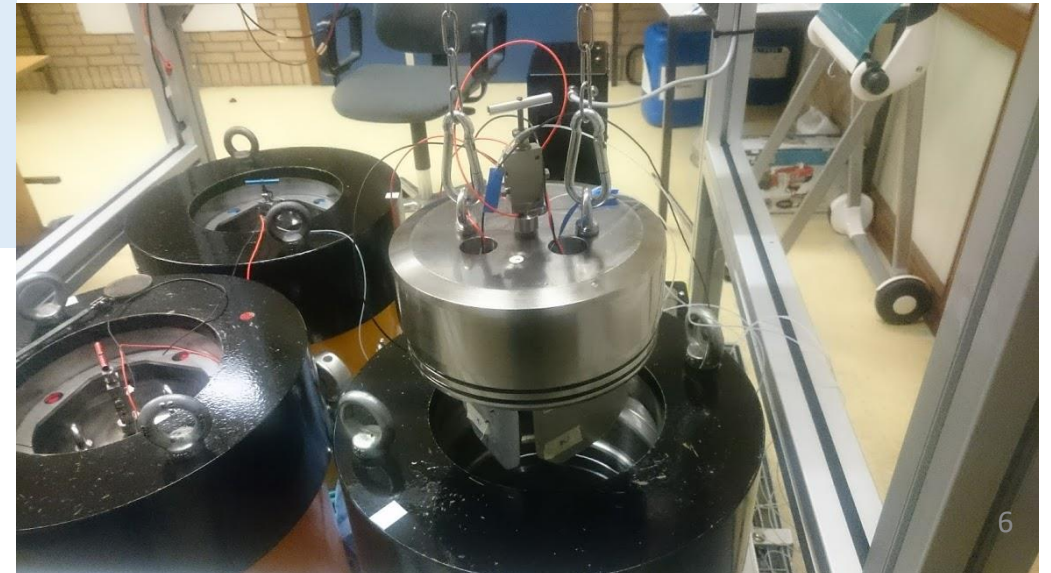
Oil pressure up to 470 bar

(limited by CE tanks qualified for 800 bar!)

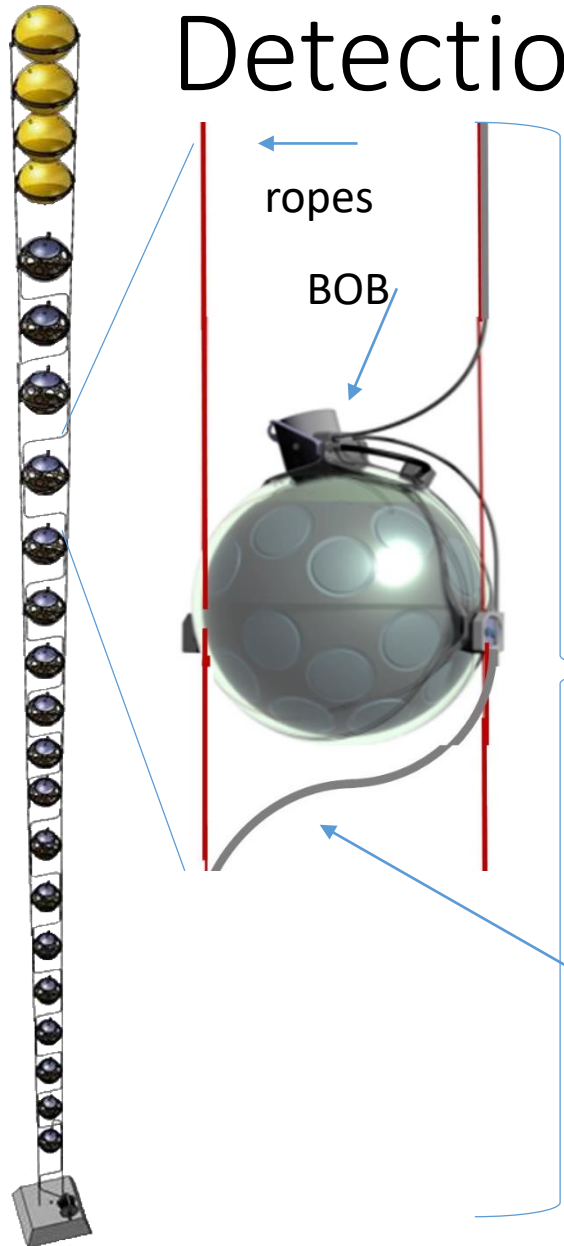
Ongoing work in automatization

Ongoing work in alternative pressure testing

Methods for high-volume throughput



Detection Unit (DU)

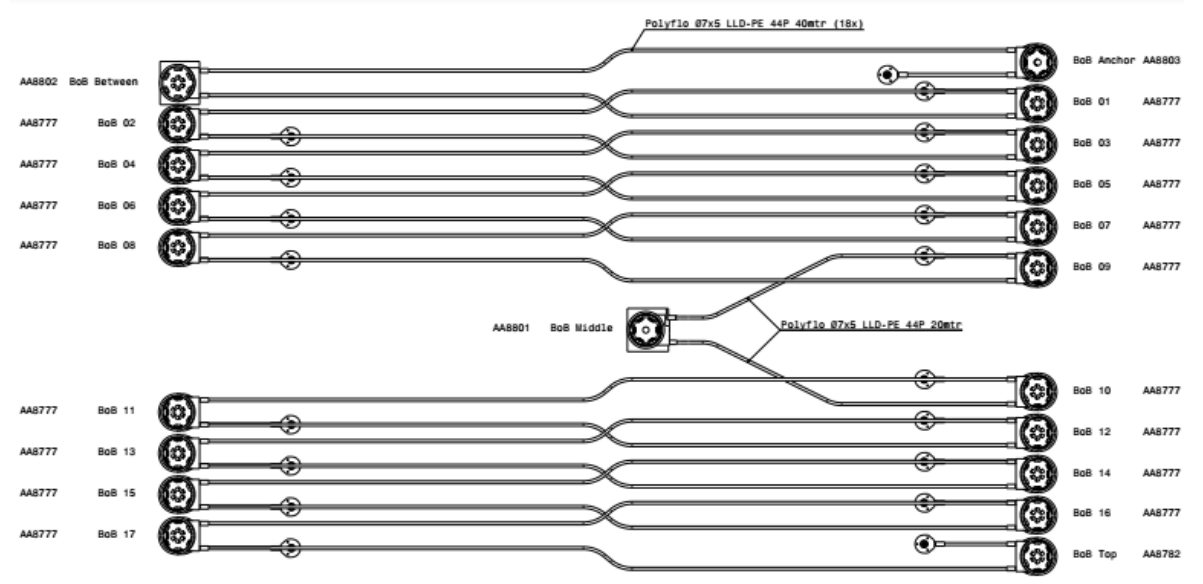


DU
Mechanical Design



Vertical Electro-Optical cable
Oil-filled/pressure balanced cable
Nikhef design
Produced in industry (NL)

Involved: Edward, Hans, Els, Frank



Detail of VEOC assembly drawing

Ground-floor Network (Optical+Power)

Optical Systems & Ground floor network:

Design of optical network infrastructure

Phase-1 and Phase-2

Full optical system, from DOMs, via ground-floor network to switches on shore

Simulations

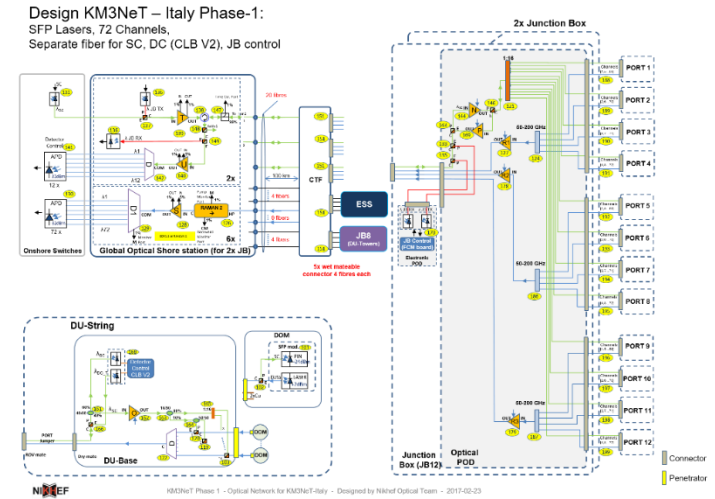
Full-scale test-bench

Mechanical/optical systems interface

Development of assembly procedures for DU and DOM

Component qualification & testing (e.g. base penetrator)

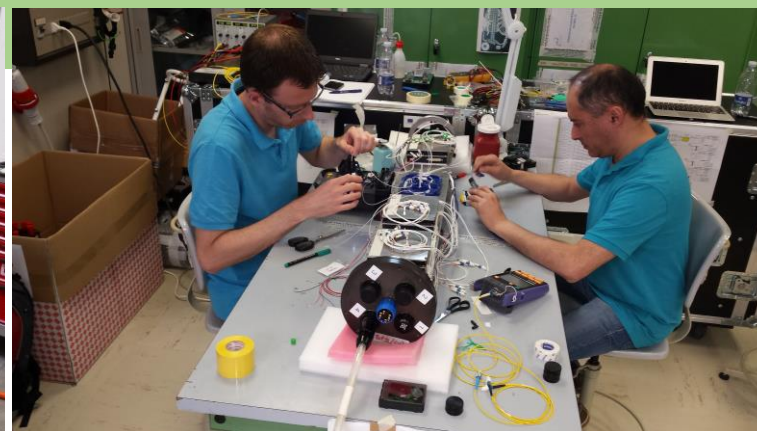
Involved in re-design of phase-1 Junction Box



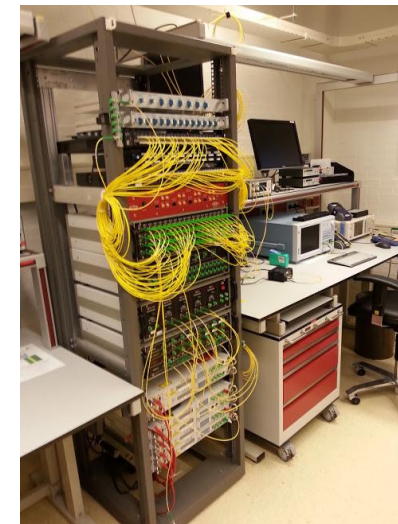
Phase-1 ARCA network overview



Phase-1 Junction box



Making optical connections in base-module



Test-bed @ Nikhef

Involved :
Gerard, Jan-Willem,
Antonio,
Jan

CLB/White-Rabbit

CLB : Central Logic Board:
 DAQ pipeline, timing, communication, slow control
 Mostly implemented in FPGA

Nikhef activities (phase-1 & phase-2) :

FPGA firmware development/maintenance
 White-Rabbit (see P. Jansweijers talk tomorrow!)

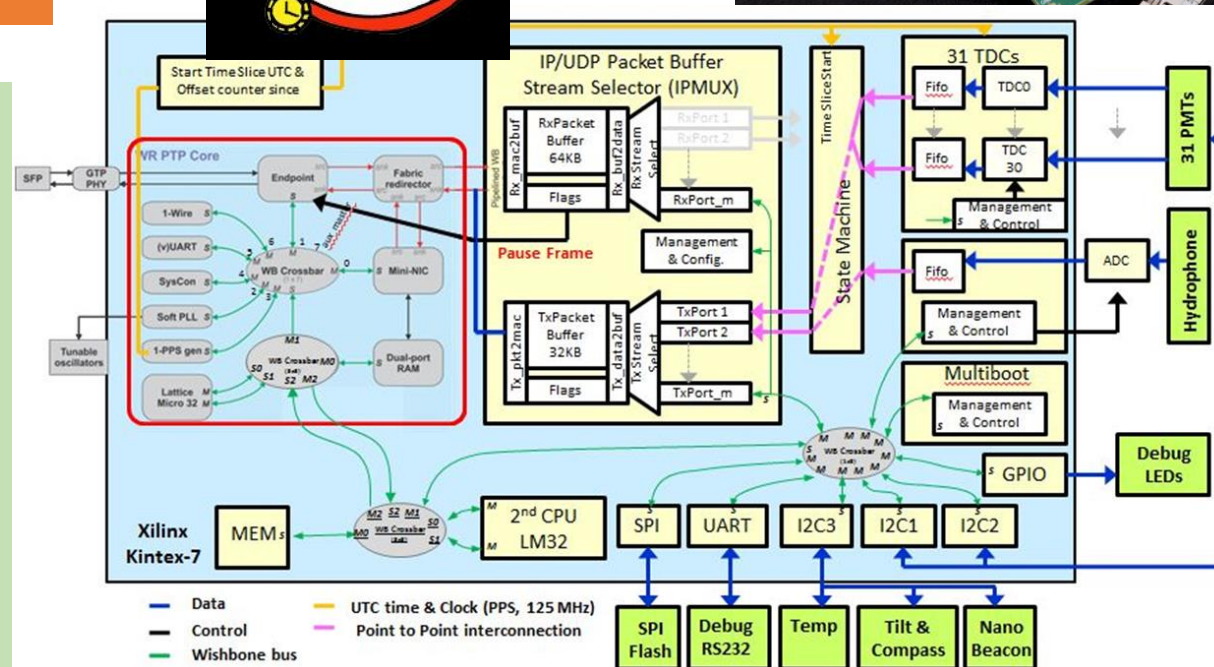
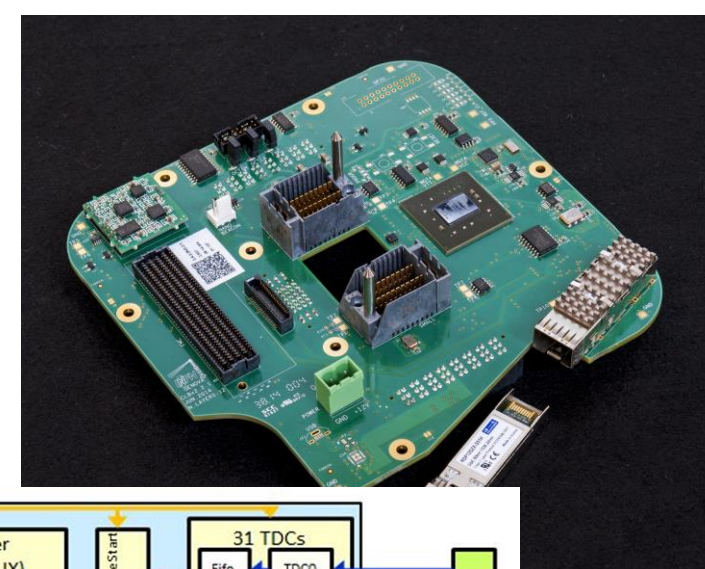
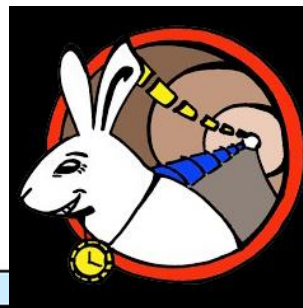
FPGA software development/maintenance

Timing calibration procedure

Firm/software release qualification

New compass/accelerometer

Involved: Peter, Vincent

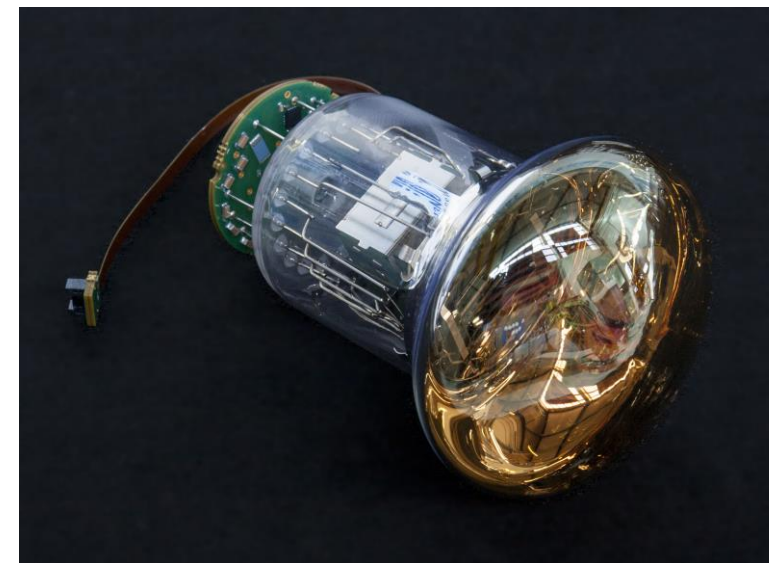
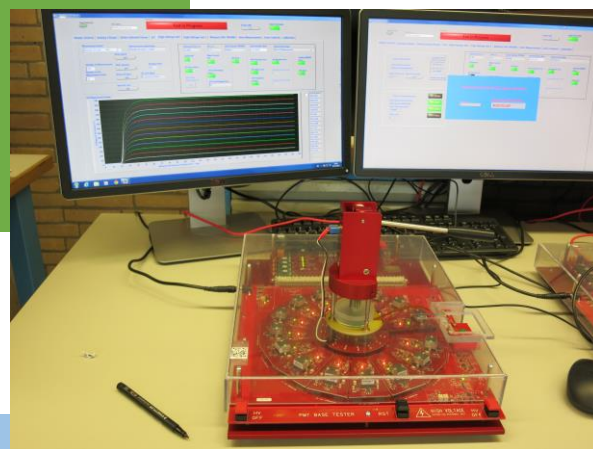


compass/accelerometer board (Paul T., Charles)

PMT Bases & DC/DC converters

Nikhef design :

Low-Power Bases for PMTs
2 Custom (Nikhef) ASICs for HV and digitization
Modified for different PMTs
Automated test setup
(for industry)



Nikhef design :

DC/DC converters
400V to 12V, external to DOM works under (500 bar) pressure!
Also pressure/stress testing at Nikhef



Involved:
Paul T, Ad, Deepak,...

**DU Integration:
Attach DOMs to VEOC**



DOM integration:

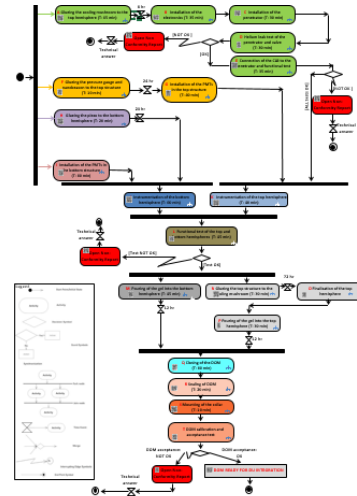
Assemble DOMs from components

Test room

DOM integration



**71 unique components
(in solid or liquid phase)**



A procedure



Tools

People!

1.5 FTE mechanics
0.4 FTE electronics
0.4 FTE Testing (staff/students)
0.3 FTE administration/coordination

Time!

~4 Days/DOM
> 5 DOMs/week



A DOM !

Involved: Rene, Robin (MT), Jan, Jean-Paul (ET), Bruno, Lodewijk, Karel, Martijn ... (PhD students)

NO.	DESCRIPTION	QUANTITY	UNIT	DATE	BY
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Taking stock ...



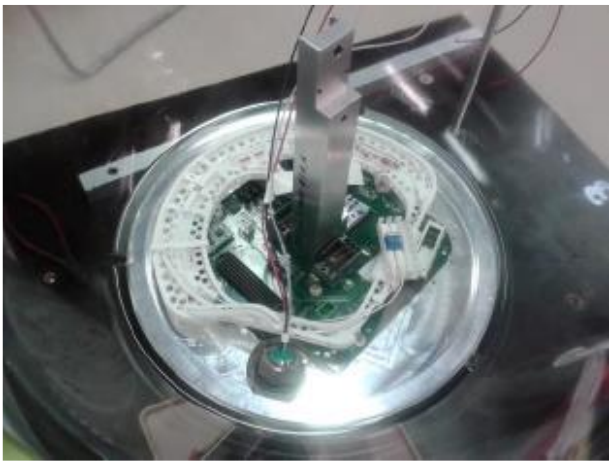
DOMs are assembled in halves and move around on tables



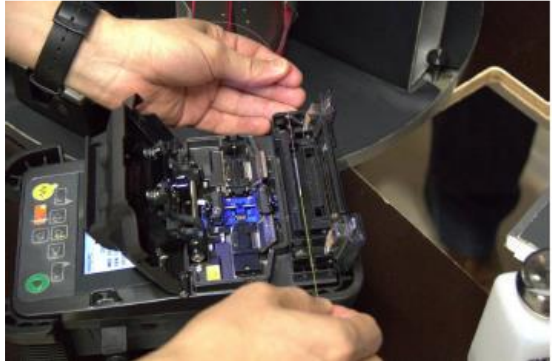
Communication



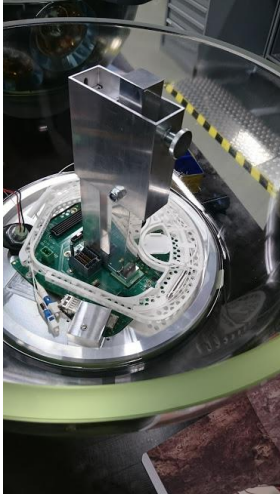
Inserting PMTs in structures



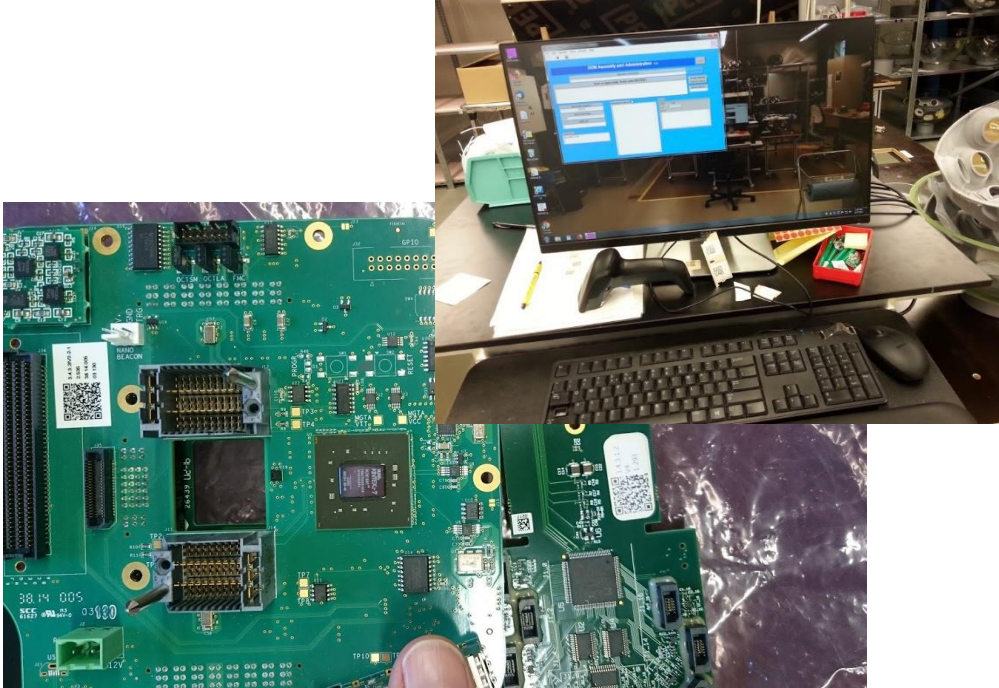
Assemble



Splicing fibres



Testing tools ...



Administrating components/Tracking



Various tests



Moving around

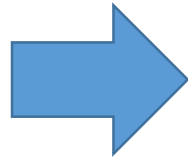


Last 4 DOMs of this year ready!

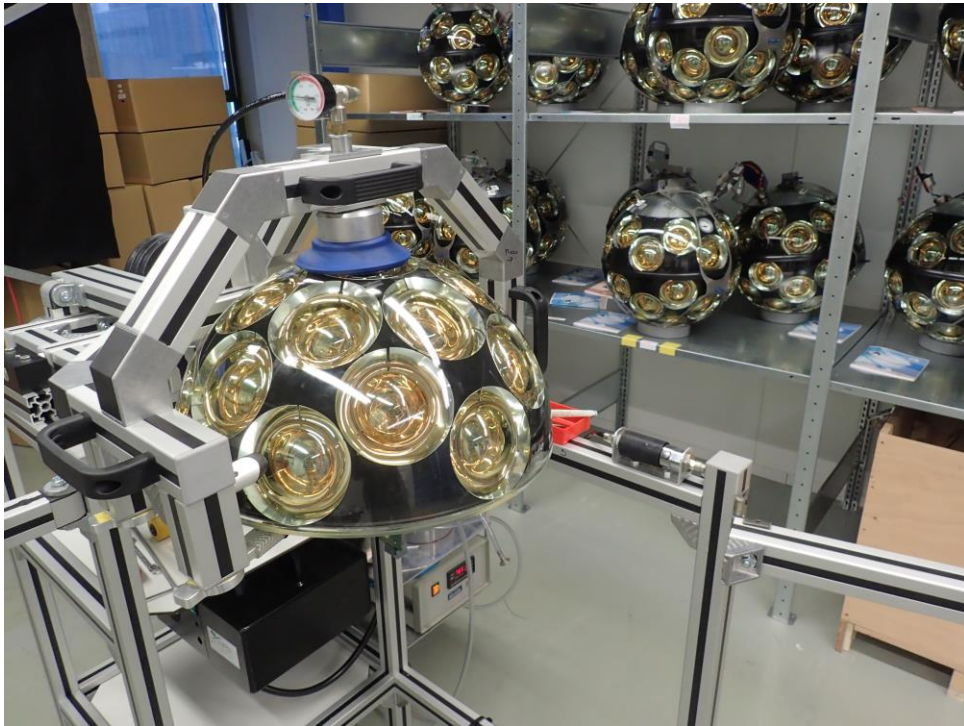
DOM integration - Tooling

Nikhef first site to :

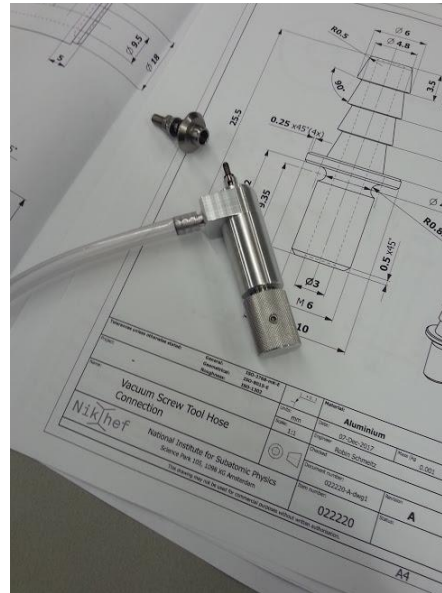
Start DOM production
Sustain target production rate



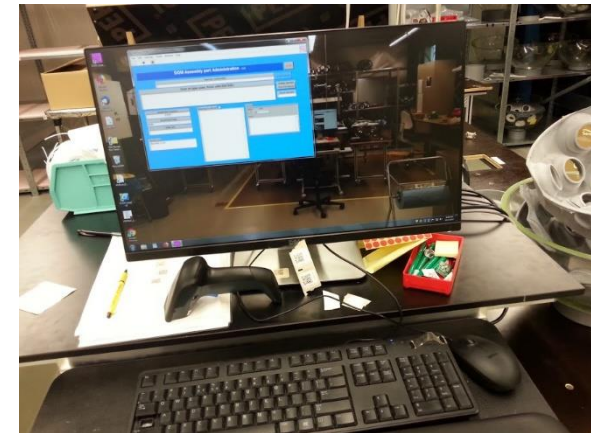
Procedure for DOM integration and most tool designs originate from Nikhef



e.g. Tool to rotate, close, open DOM



e.g. DOM pressure tool



Software tools for component tracking and quality control

Involved: Rene, Robin, Edward, Fred (Jan-David taking over)

DOM integration - Status

2017:
Two production runs of 36 DOMs
+ remnants of 2016

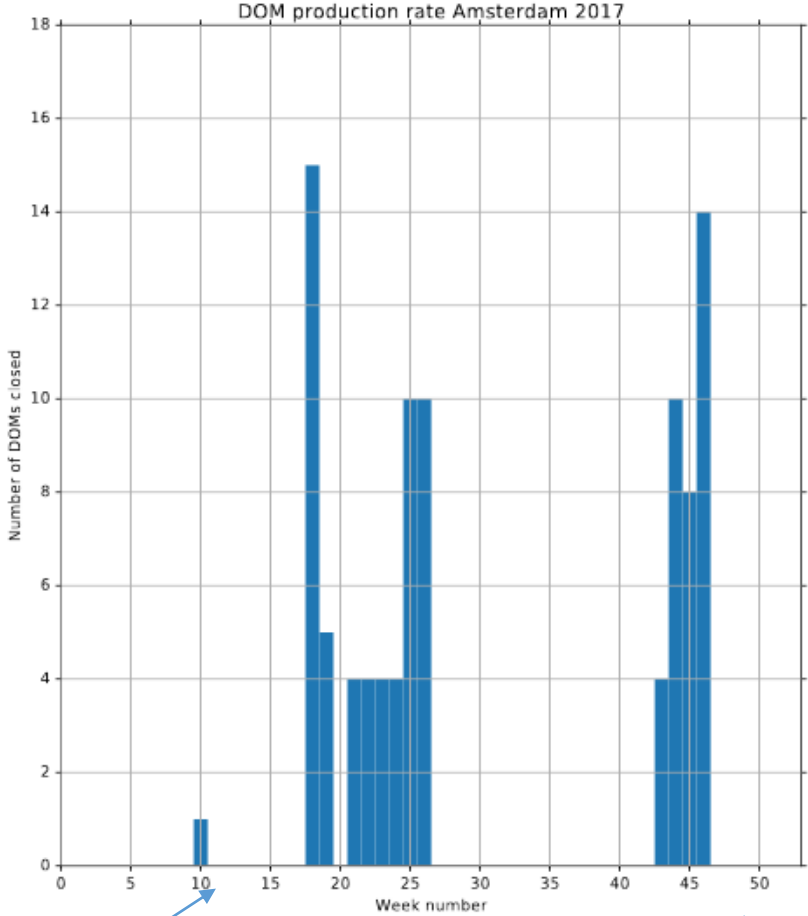
Production speed exceeds collaboration goal : first and only to do this!

Cumulative numbers:

Nikhef : 200 DOMs built !
(excluding prototypes)

KM3NeT (end 2017) : 344 DOMs

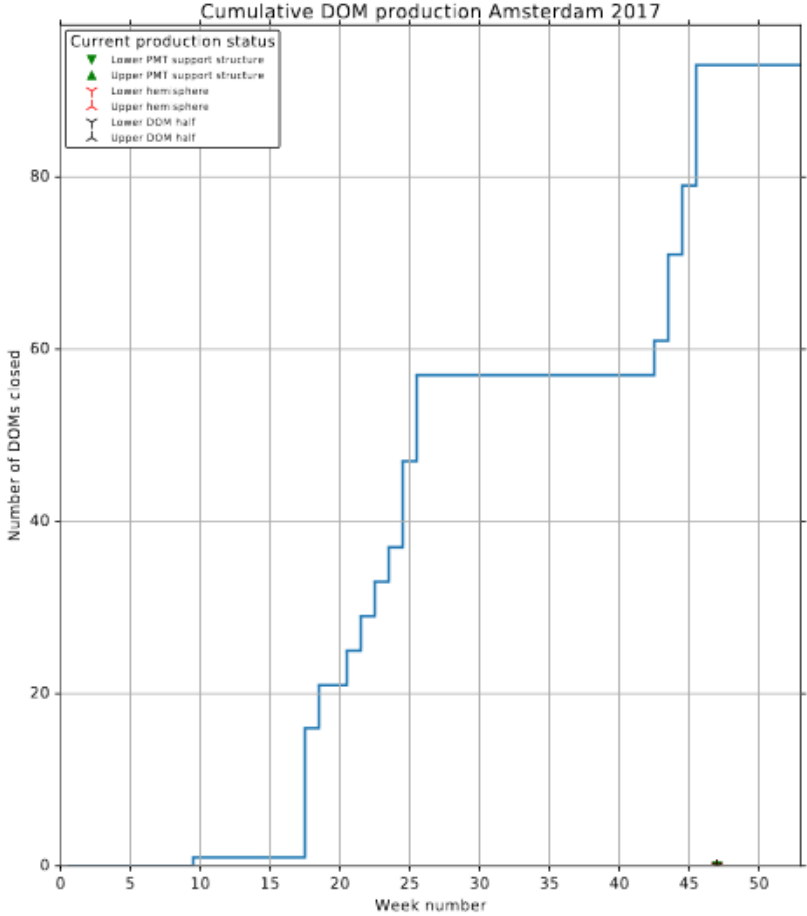
~ 60 % of all DOMs produced at Nikhef



2016 remnant

Summer production

Fall production



DU integration

Assembly of DOMs on to VEOC

Electrical and optical connection of DOMs

Filling the BOBs with oil and closure

Leak tests

Optical and electrical tests

~2 weeks work (if no issues)

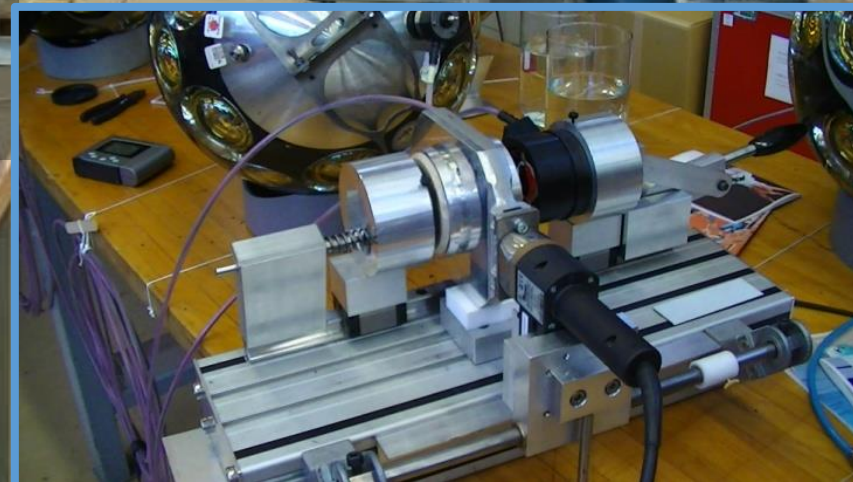
Involved: Jan, Jean-Paul, Edward, Hans, Oscar

2017:

1 Integrated

1 on the bench right now
(some repairs ongoing)

1 remaining (Dec/Jan)



Plastic welding tool (also used in VEOC production)

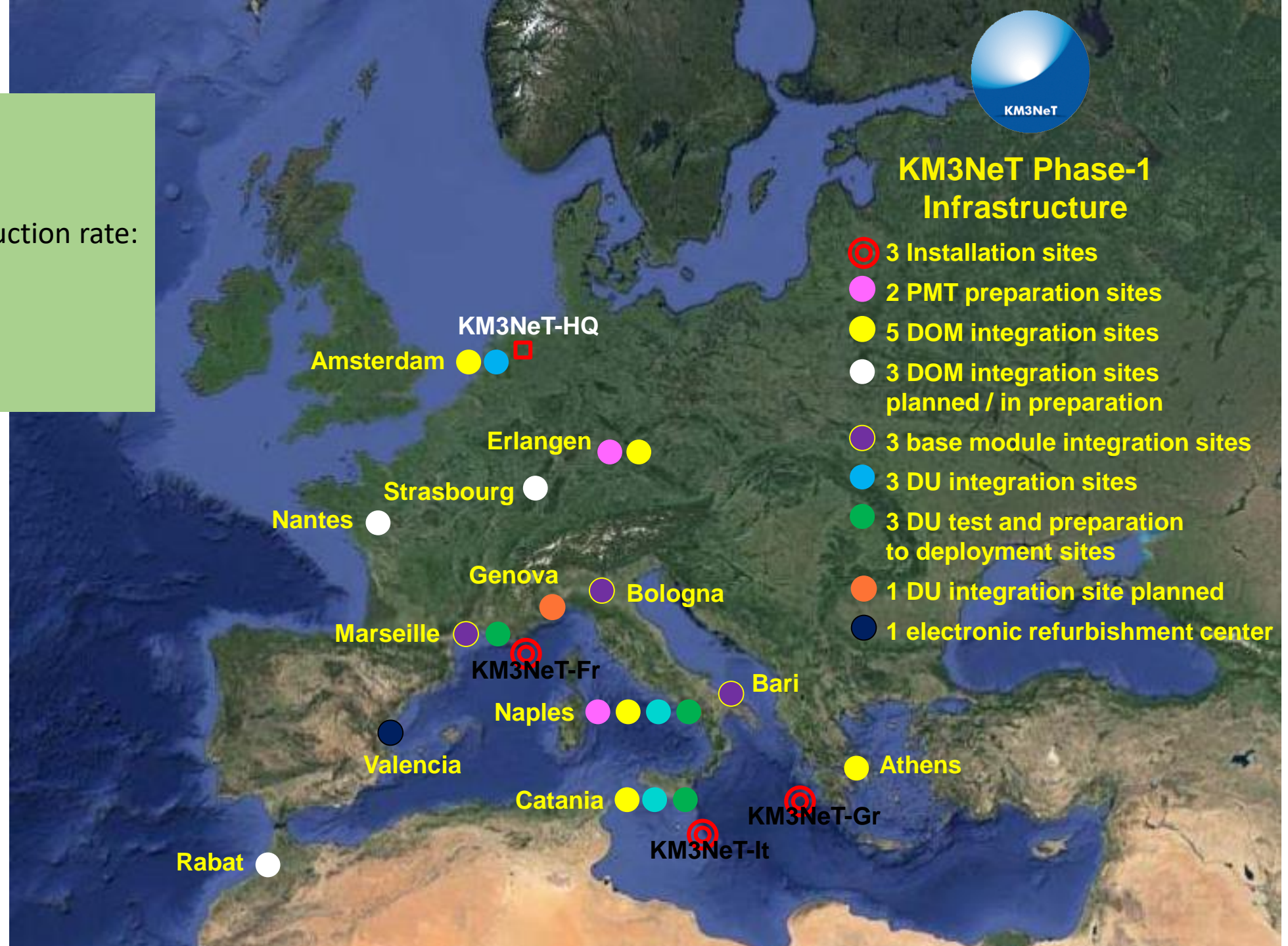


KM3NeT Phase-1 Infrastructure

- 3 Installation sites
- 2 PMT preparation sites
- 5 DOM integration sites
- 3 DOM integration sites planned / in preparation
- 3 base module integration sites
- 3 DU integration sites
- 3 DU test and preparation to deployment sites
- 1 DU integration site planned
- 1 electronic refurbishment center

Ramping up for mass-production

Nominal DOM production rate: 5/week/site (proven @ Nikhef)



Amsterdam ●●■ KM3NeT-HQ

Erlangen ●●

Strasbourg ●

Nantes ●

Genova ●●

Bologna ●

Marseille ●●

KM3NeT-Fr ●●

Naples ●●●●

Valencia ●

Bari ●

Athens ●

Catania ●●●

Rabat ●

KM3NeT-Gr ●●

KM3NeT-It ●●

KM3NeT DU integration planning&realisation

2018 @ Nikhef :
90 phase-1 DOMs (beyond original commitment)
126 phase-2 DOMs
6-8 DU integrations

(all current best estimate)

Status

ORCA site (France)

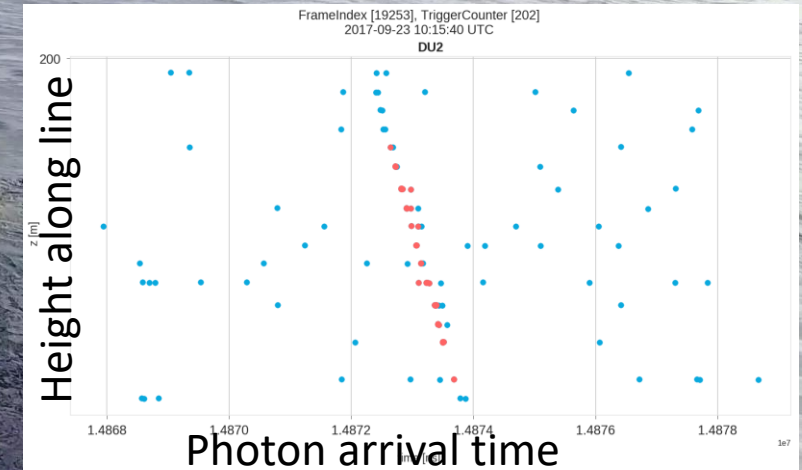
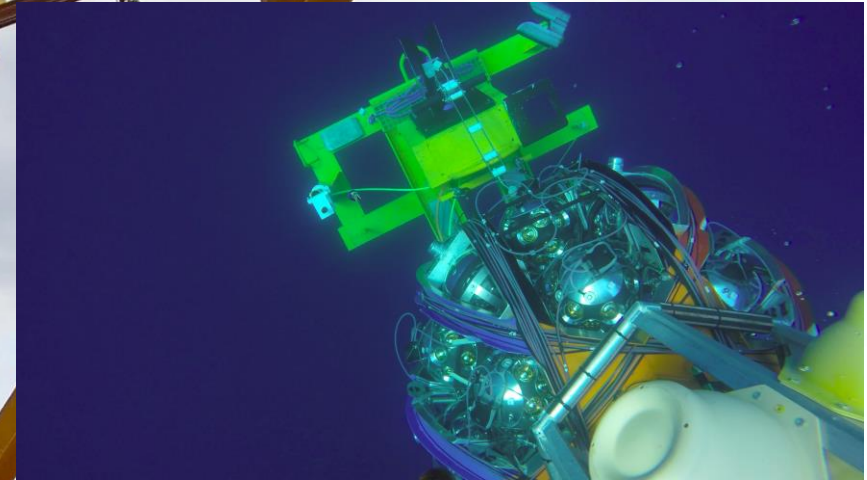
1 DU operational

1 DU ready to be deployed (Mid-January)

ARCA site (Italy)

2 DUs deployed

Off, due to issues in sea-floor network



(Technical) Persons

Strong technical presence in the KM3NeT collaboration :

Els Koffeman : Technical coordinator KM3NeT

Edward Berbee : Mechanics working group leader

Gerard Kieft : Optical Systems Working group leader

At Nikhef:

R. Bruijn: DOM & DU project leader

F. Kayzel: Quality supervisor, contact industry for VEOC, integration assistance

E. Koffeman: chair KM3NeT 'werkoverleg' at Nikhef

D. Samtleben: DOM testing coordination & PMTs

Summary

- Nikhef has a crucial technical contribution to the KM3NeT experiment
 - A lot of activity across the technical departments at Nikhef
- Nikhef is currently leading the the integration of detector elements
 - DOMs
 - DUs (DOMs to VEOC)
- Construction of KM3NeT is ramping up!