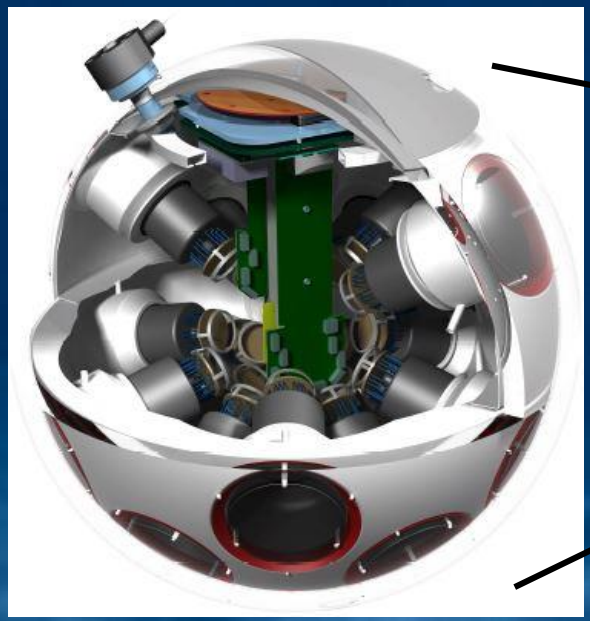
Status of KM3NeT
ARCA & ORCA

Astroparticle and Oscillation Research with Cosmics in the Abyss

(Same technology for different goals)

KM3NeT DOMs and DUs

- 31 PMTs installed in 17” Digital Optical Modules (DOMs)
- 18 DOMs (Digital Optical Modules) on each Detection Unit (DU), spaced by ~36 m or ~9 m (in ARCA or ORCA layout, resp.)
- DUs placed at distances of ~90 m and ~20 m, resp. for ARCA and ORCA
- Same DOMs but different DUs (as to mechanical layout and adaptation to different infrastructures) used in ARCA and ORCA



More on Digital Optical Modules

- 31 PMTs of 3” photocathode in a 17” glass sphere
- Optical gel coupling between PMTs and glass
- Reflection rings around the PMTs to increase detection surface
- Electronics, optics for long-range communications and calibration devices (including: ‘nanobeacon’ LED pulser, compass/tiltmeter, and piezo-sensor for acoustic measurements) installed inside the sphere – each DOM acting as an individual, autonomous detection node
- Connection to the rest of the apparatus requires two conductors (+12 V power) and one optical fibre through a single penetrator

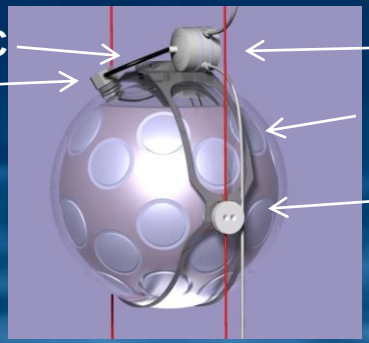
DU mechanics

- Mechanical structure of the string is based on two dyneema ropes, anchored on the sea floor and kept taut by a top buoy (plus DOM buoyancy)
  - Slender and strong arrangement
  - DOMs keep the correct attitude
  - String dynamics under control

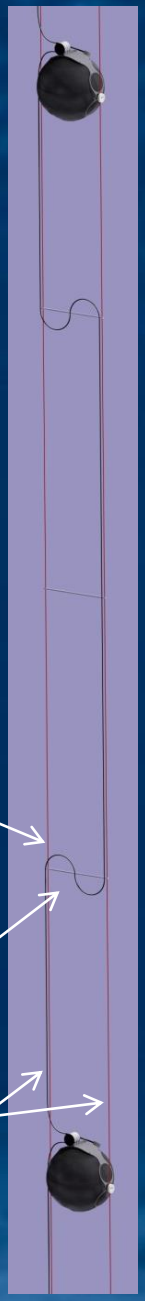
- A backbone (VEOC - Vertical Electrical-Optical Cable) connects all DOMs to the DU base module – the VEOC is built on an oil-filled pressure-balanced hose

- DOM collars allow the DOMs to be fixed to the ropes

- Break-out-boxes (BOBs) allow connections of consecutive segments of VEOC and a DOM (or base module)
  - A BOB hosts all needed fibre splices and a DC/DC converter
  - A short cable (BEOC – BOB Electrical-Optical Cable) connects the BOB to the DOM penetrator (2 conductors and 1 fiber needed)



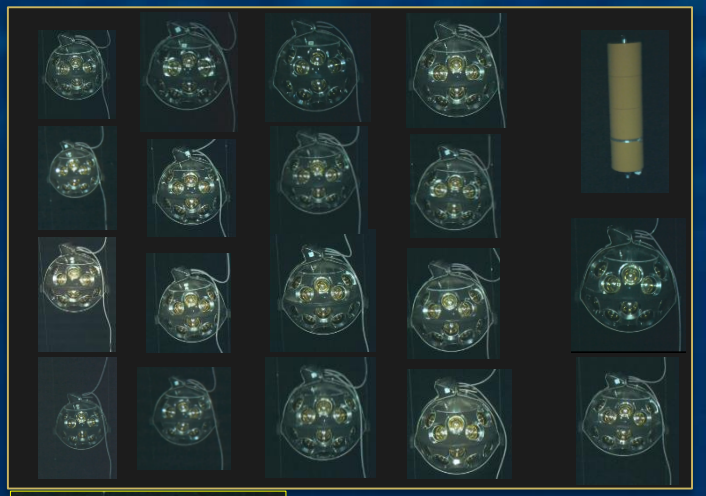
DOM and ropes



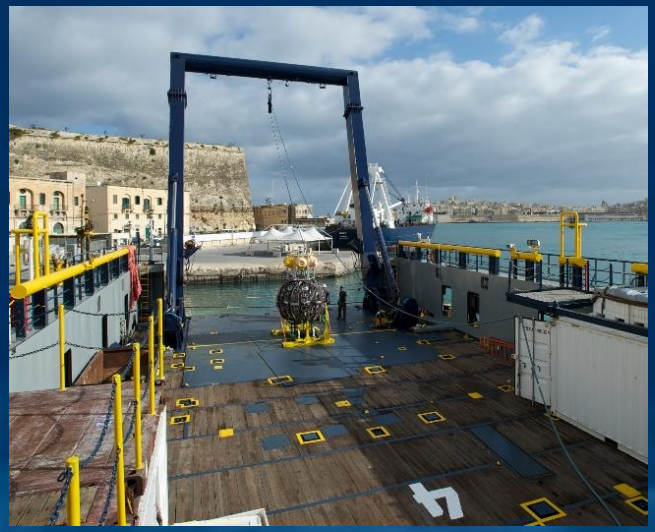
(ARCA) DU

DU installation

- DU is packed on a launcher vehicle (LOM) and installed on the anchor
- After deployment on sea bed and connection to the infrastructure, unfurling is done by operating a release mechanism (either acoustic or ROV-operable)
- LOM (and acoustic release as well, if applicable) is recovered after unfurling



ROV inspection of an unfurled DU



Deployment campaign of Dec. 2015 (ARCA-DU1)

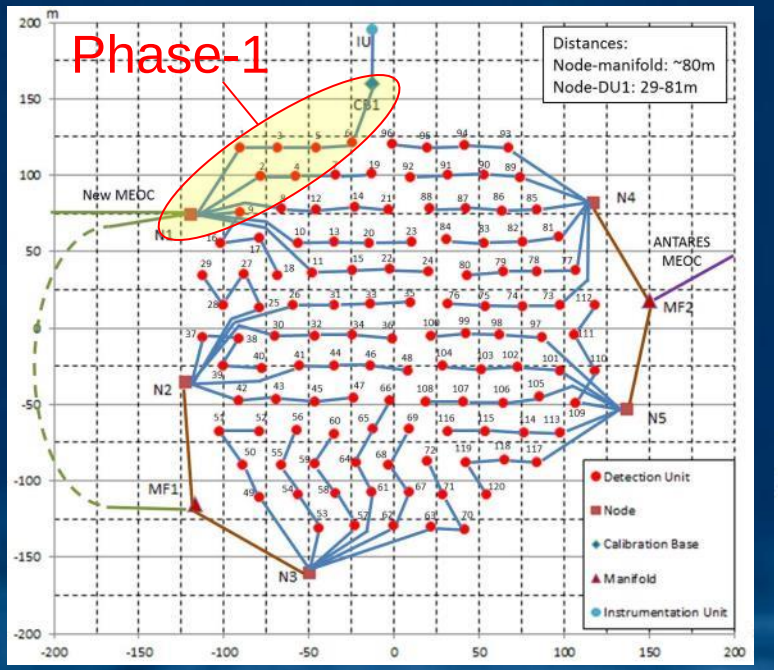
DU deployment

Phase-1 vs. Phase-2

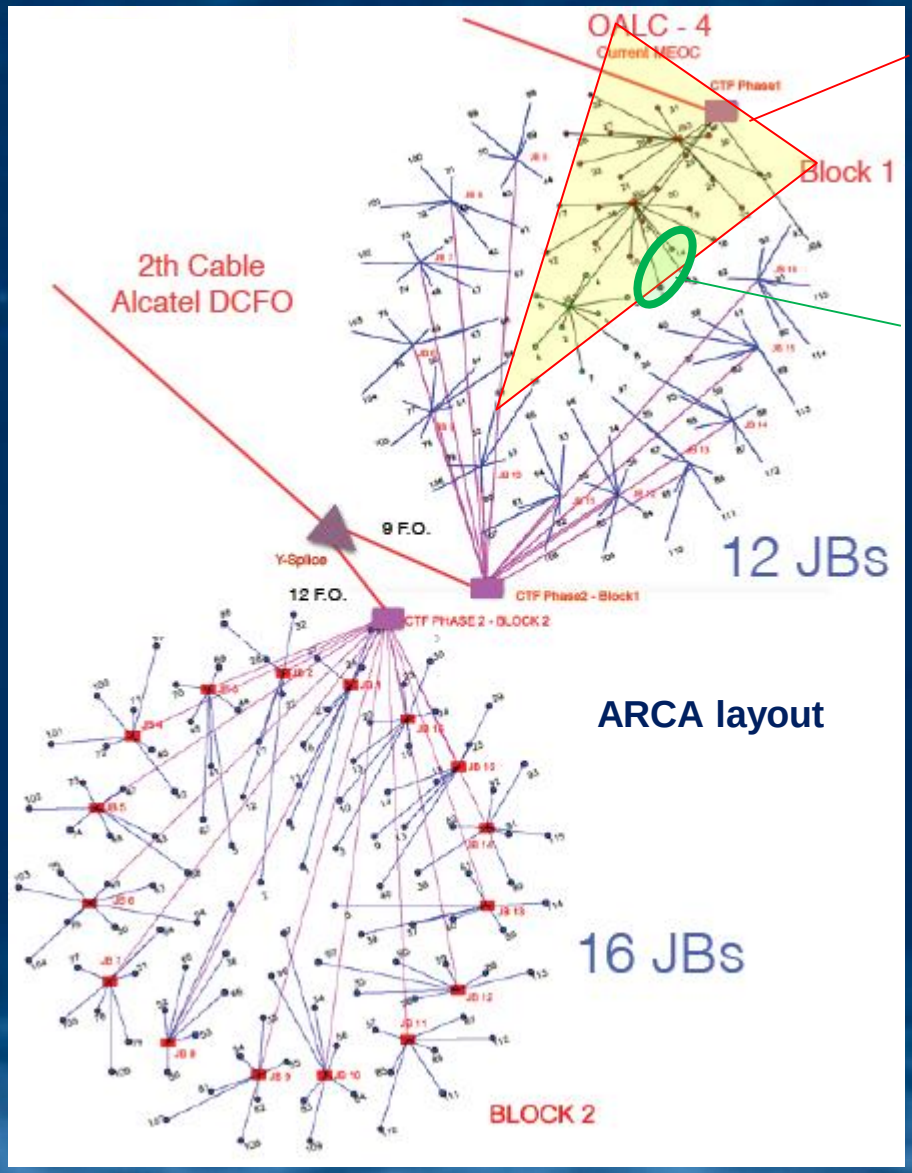
Phase-1 (ongoing):
- **24 ARCA DUs at KM3NeT-It**
- **6 ORCA DUs at KM3NeT-Fr**

Phase-2 (coming up possibly soon!):
- **2 ARCA blocks at KM3NeT-It**
- **1 ORCA block at KM3NeT-Fr**

(1 block = 115 DUs)



ORCA layout



Phase-1

2 DUs deployed

Infrastructure at KM3NeT-Fr

- **Shore station set up**
- **Long distance cable and Phase-1 node reinstalled (NEW!)**

- **Status: ready to connection of first DU!**

Power hut(s)
at La Seyne sur mer

The node ready to board the deployment ship

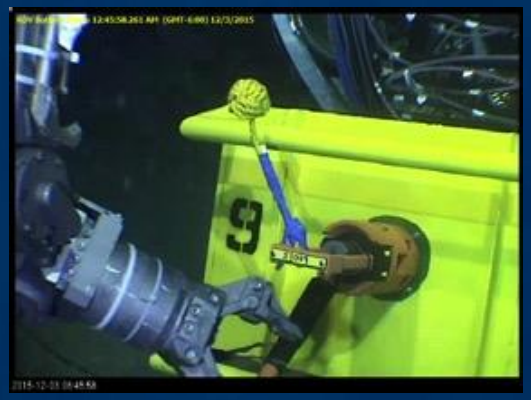
Overboarding!

Infrastructure at KM3NeT-It

- Shore station set up
- One of the 2 Junction Boxes needed for Phase-1 installed

- Status: 2 DUs in operation

ARCA-DU1 on sea bed
(Dec. 2015)



Underwater connection
of ARCA-DU1

The shore station
at Portopalo di Capo Passero

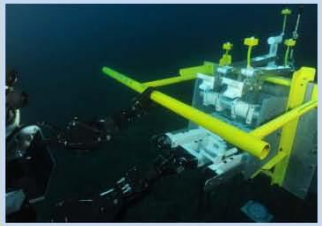
Preparing to deploy ARCA-DU2
and ARCA-DU3 (May 2016)

Junction Box (July 2016)

Development plan

Validation of the LOM unfurling concept

Sea qualification of connection tool



PPM DU

ARCA-DU1

ORCA Sea qualification

Dec09 — Feb.11 — Apr.13 — Feb.14 — May14 — Jun.14 — Dec.14 — Dec.15 — Mar.16

Deployment PPM DOM

Mechanical tests I

Mechanical tests II

DOM « 0 »

BUT:

May2016
ARCA-DU2
ARCA-DU3

ARCA-DU3

DU installed in May together with ARCA-DU2

Problem on one DOM noticed at the underwater test prior to unfurling – rest of the DU was operational

BUT… power short detected after unfurling

Symptoms not conclusive for understanding the problems; hence the DU was recovered

Remark: recovery was not a planned option – check the TDR:

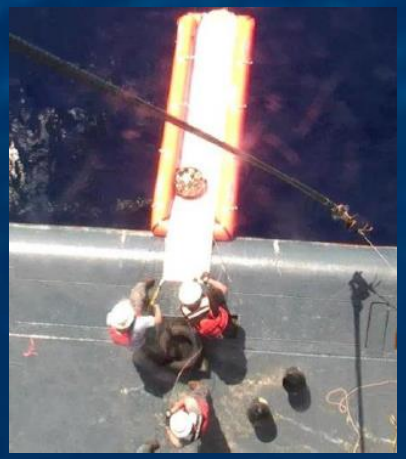
Maintenance

Following unfurling no maintenance of detection units is planned. When predicting the global performance of the detector, account must be taken of the probability that parts - storeys or optical modules - will become blind. The power and data network must be designed in such a way that in no case can the failure of a detection unit propagate to another part of the detector.

Hence an extra-effort was needed for a detailed preparation

ARCA-DU3: the story of a summer

- **ARCA-DU3 was recovered at end of July (2.5 months after deployment)**
- **Recovery is performed by pulling up the anchor – orientation of the DU monitored during recovery (transponder on HLL on anchor + beacon installed on top buoy)**
- **First round of tests in Malta, then autopsy at Nikhef**
- **All problems understood (see next slide)**



Recovery of a DOM

Start of recovery (anchor pulled up)

Beacon installed on top buoy

Top of DU at sea
(hint: there are 3 DOMs in the picture!)

Anchor onboard

Outcome of ARCA-DU3 investigations

Failure of ARCA-DU3 was due to a letal combination of factors (each of which possibly not fatal if taken individually) – a detailed report is under finalization (to be submitted to the STAC and RRB next week)

Strong points (confirmed):

- Layout and mechanics of the DU
- DU integration (including fiber treatment at all levels)
- Installation (including transportation, unfurling)
- Base module
- DOMs (minor corrections needed)

Weak points (to be improved):

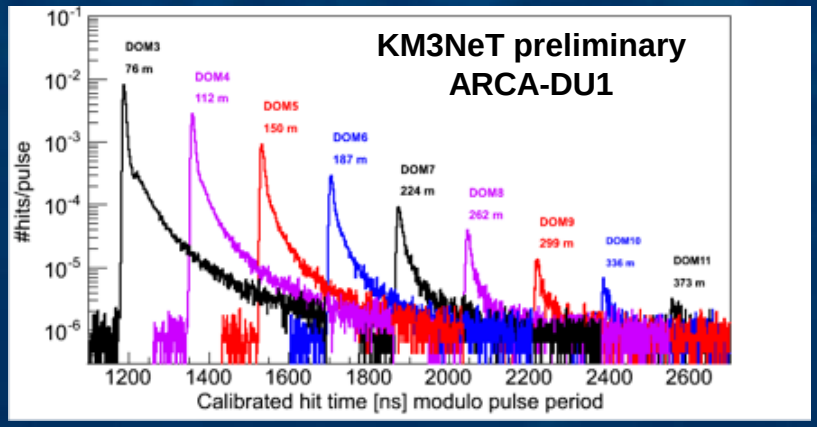
- Design of some parts (mechanical and electronic) of VEOC
- Integration and test of VEOC
- Minor changes to DOM integration and test

Next:

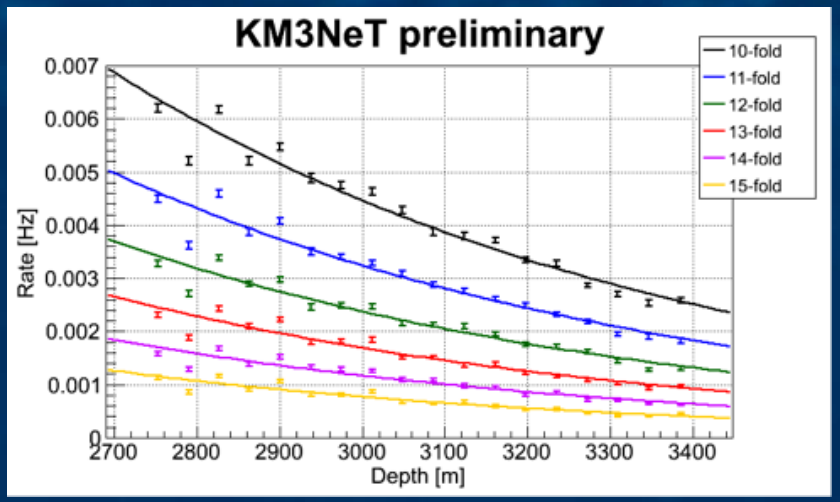
- **Define all needed corrective/preventive actions (as part of all other actions already planned, such as reviews – see next)**
- **Assess status of already available components (vital input for production of new DUs on a short term, such as ORCA-DU1, and for deciding about the good, old "DU1")**
- **Assess status of DUs already deployed**

Quoted from our action plan: "*The approach is that the schedule of next deployment of detection units should not compromise the quality of the detection units*"

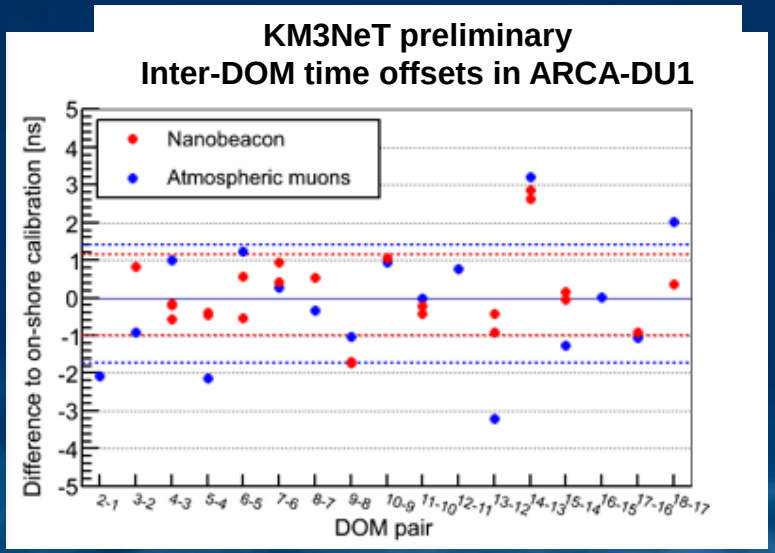
Selected results from ARCA-DU1&2



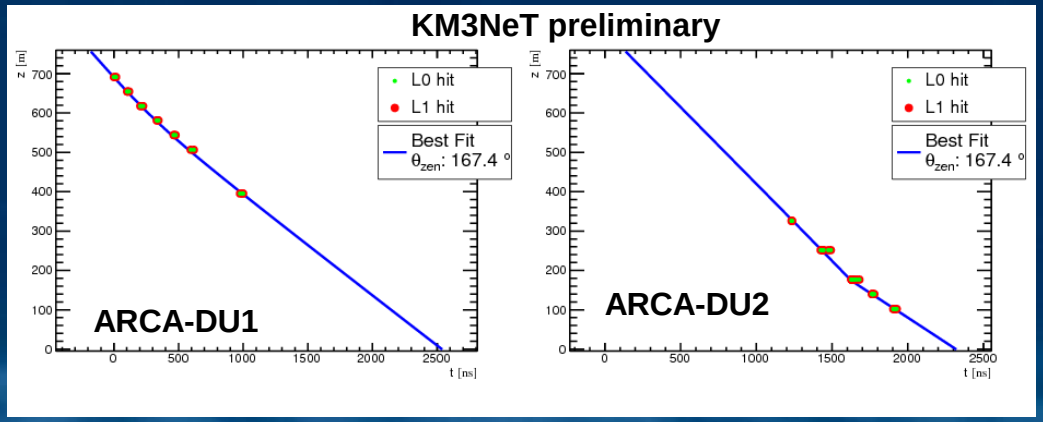
Nanobeacon-induced hits in DOMs
(light emitted from DOM1 upwards)



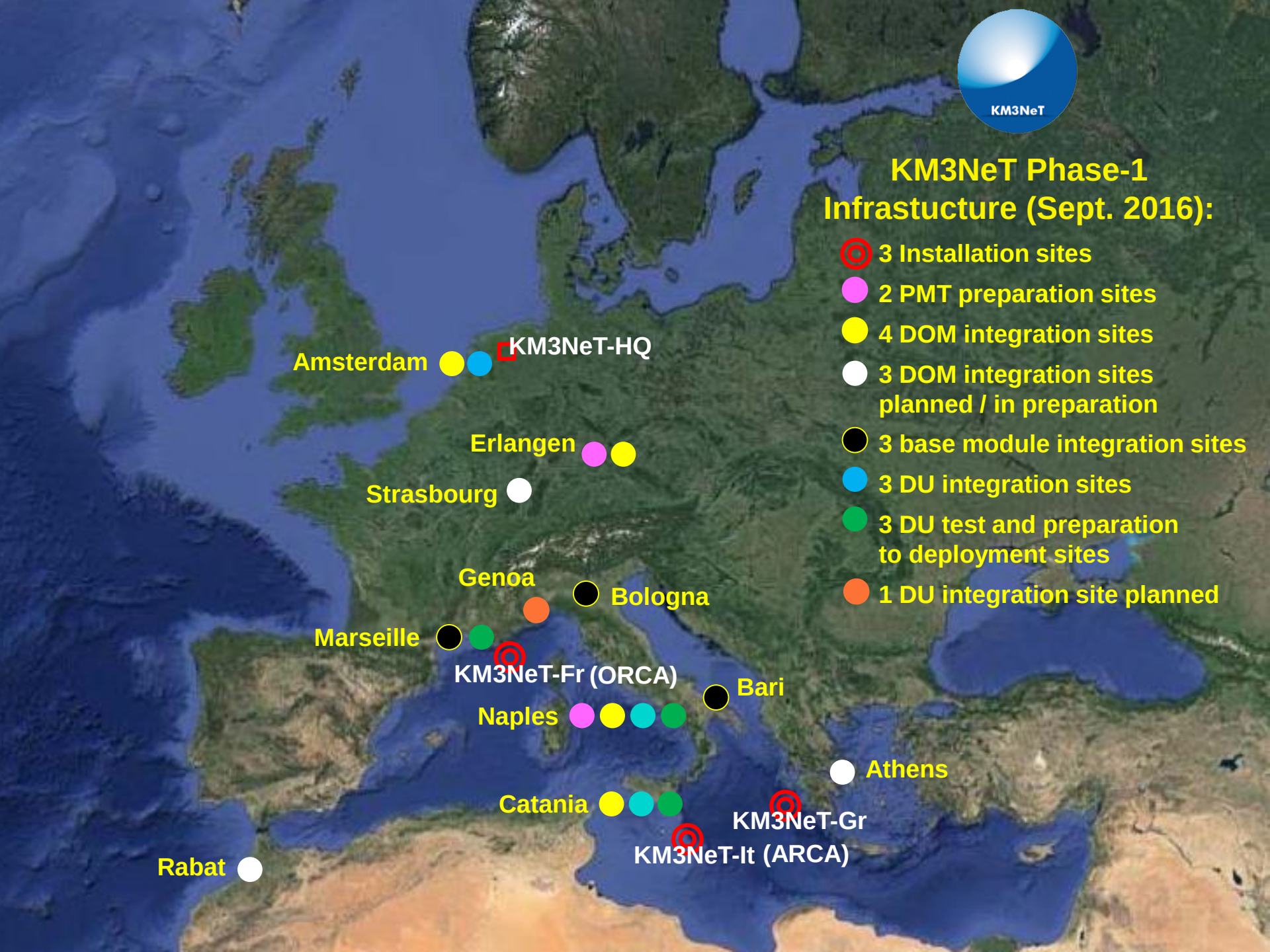
Depth dependence
of multiple-hit coincidence rates



Comparison of time offsets
determined with different methods



A muon track detected by the two DUs


KM3NeT
KM3NeT Phase-1
Infrastucture (Sept. 2016):
3 Installation sites
2 PMT preparation sites
4 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
Amsterdam
KM3NeT-HQ
Erlangen
Strasbourg
Genoa
Bologna
Marseille
KM3NeT-Fr (ORCA)
Bari
Naples
Athens
Catania
KM3NeT-Gr
KM3NeT-It (ARCA)
Rabat

Status & conclusions

- **Letter of Intent for ARCA and ORCA published Jan. 2016**
- **KM3NeT back in the ESFRI roadmap!**
- **Possibility that funding becomes available soon to extend Phase-1 into Phase-2!**
- **Finalization of return of experience of ARCA-DU3 and of review of the project needed before launching massive construction of DUs**
- **Setting up structures which can build DUs at a speed ~2-3 DUs/month (adequate for Phase-1, to be further increased for Phase-2)**
- **Data taking started (2 DUs) for ARCA at KM3NeT-It!**
- **Considering when to deploy first ORCA DU at KM3NeT-Fr**