Rope & Cable management

A vertical electro-optical backbone cable for KM3NeT

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On behalf of the km3net collaboration
Nikhef Mechanical department
Nikhef Electronic department

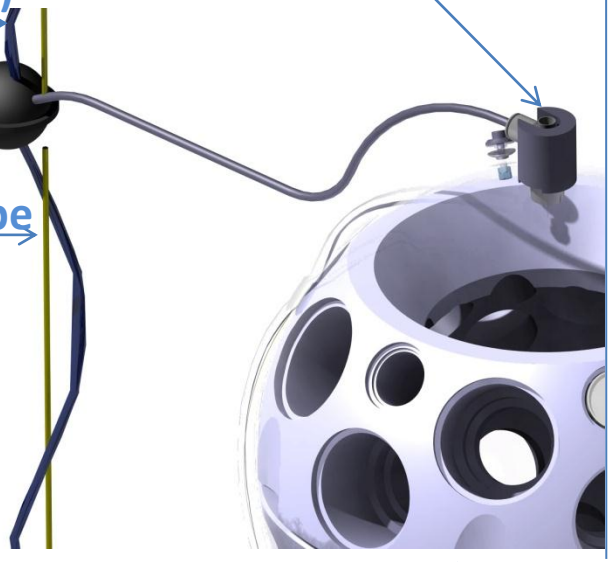
Introduction

3) Penetrator

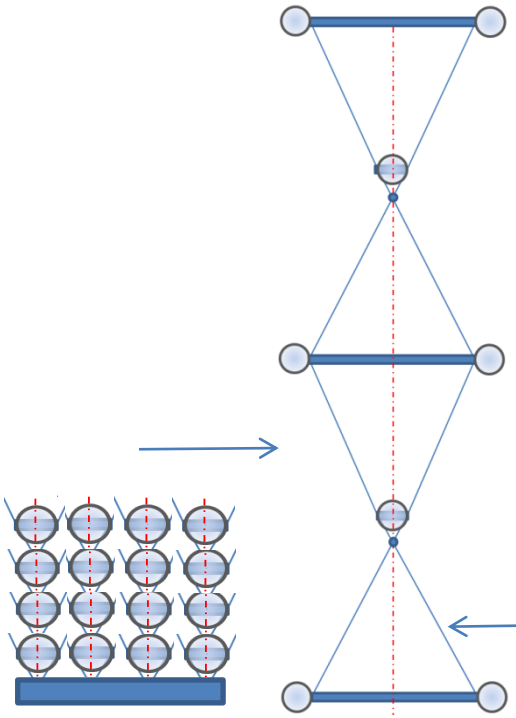
2) Backbone (VEOC)

Break out box

1) Mechanical Rope
(rope layout)



Optical module



Detector unit

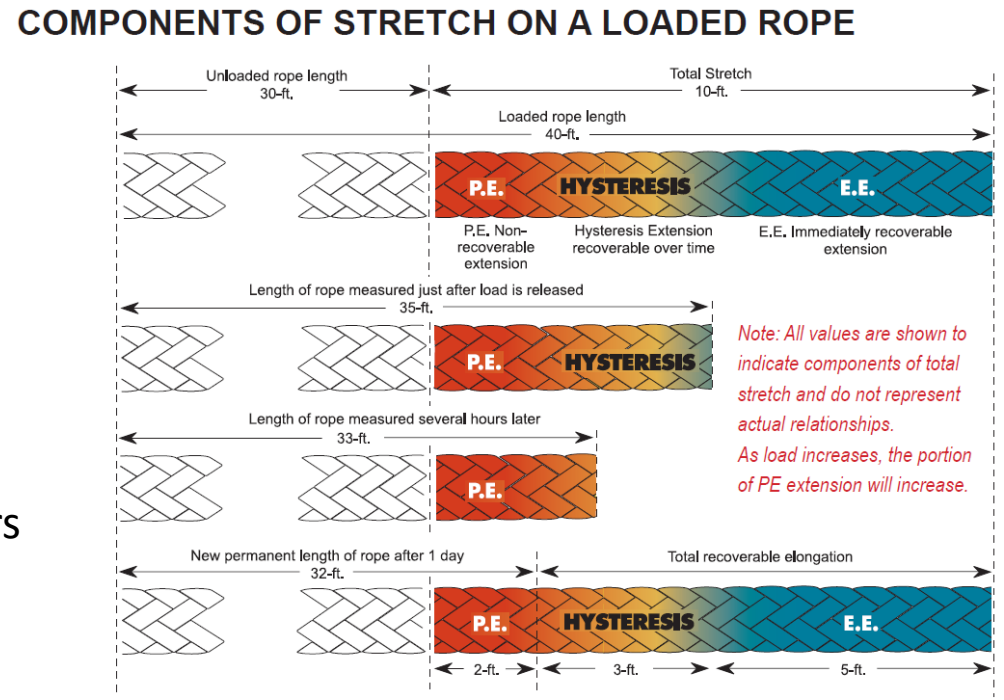
Detector unit pallet

Mechanical Rope specifications

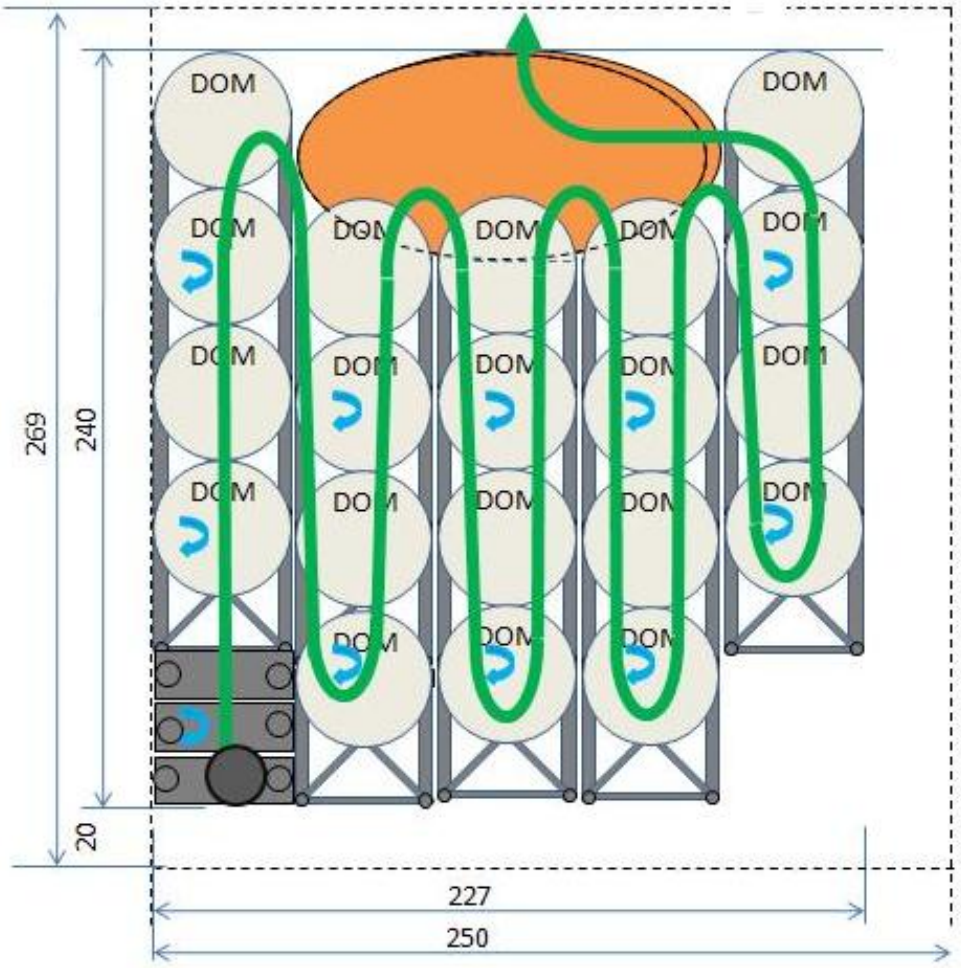
Load /part 250 kg

Mechanical Rope
-Dyneema(R) SK78
-4 mm diameter
-breaking load of 1250kg.
-1% stretch

Creep of Dyneema(R) at 15 deg
And 20% static load is 0.9% / 10 yrs



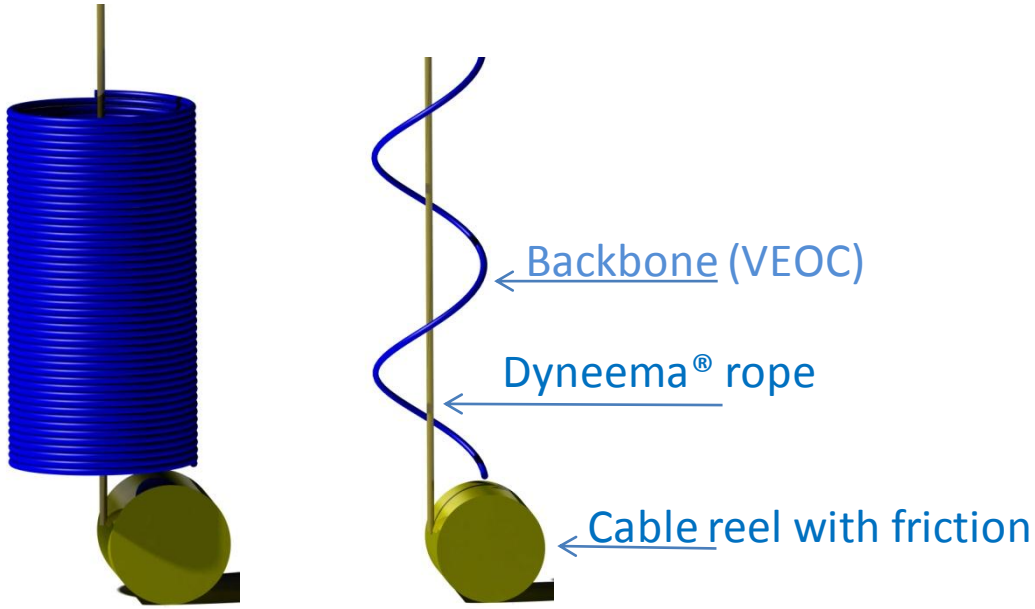
Rope layout Detector Unit (DU)



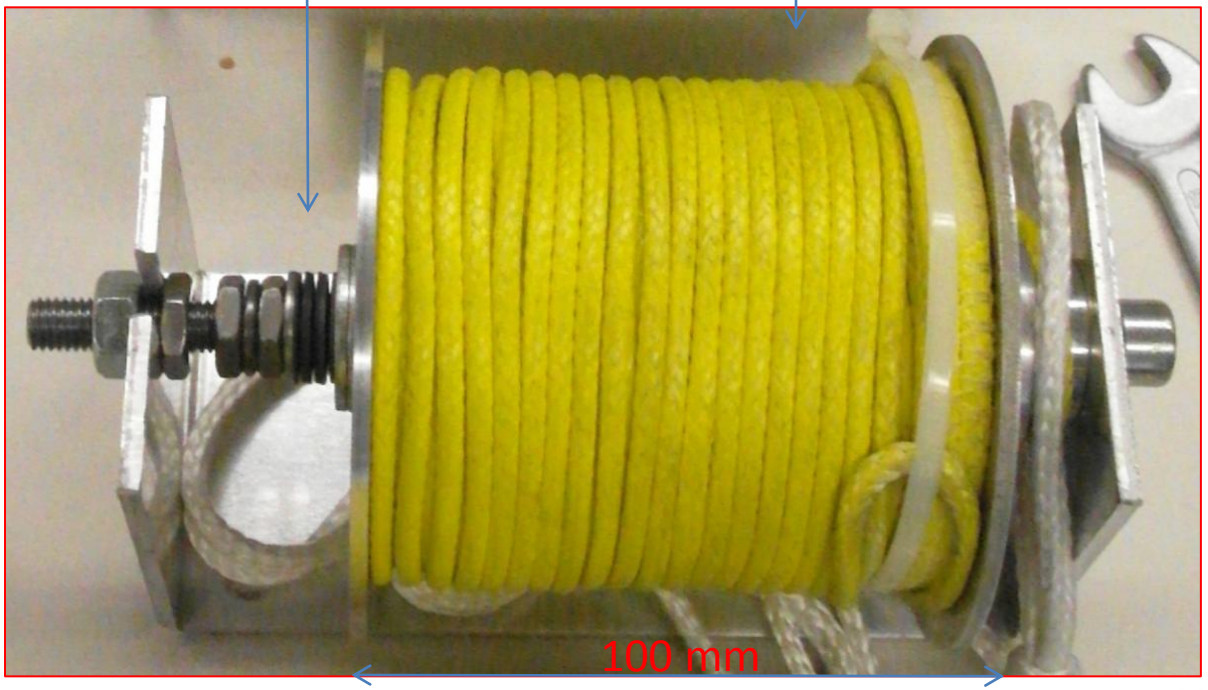
Rope layout Detector Unit (DU)

Before unfurling the VEOC and Dyneema® must be stored.

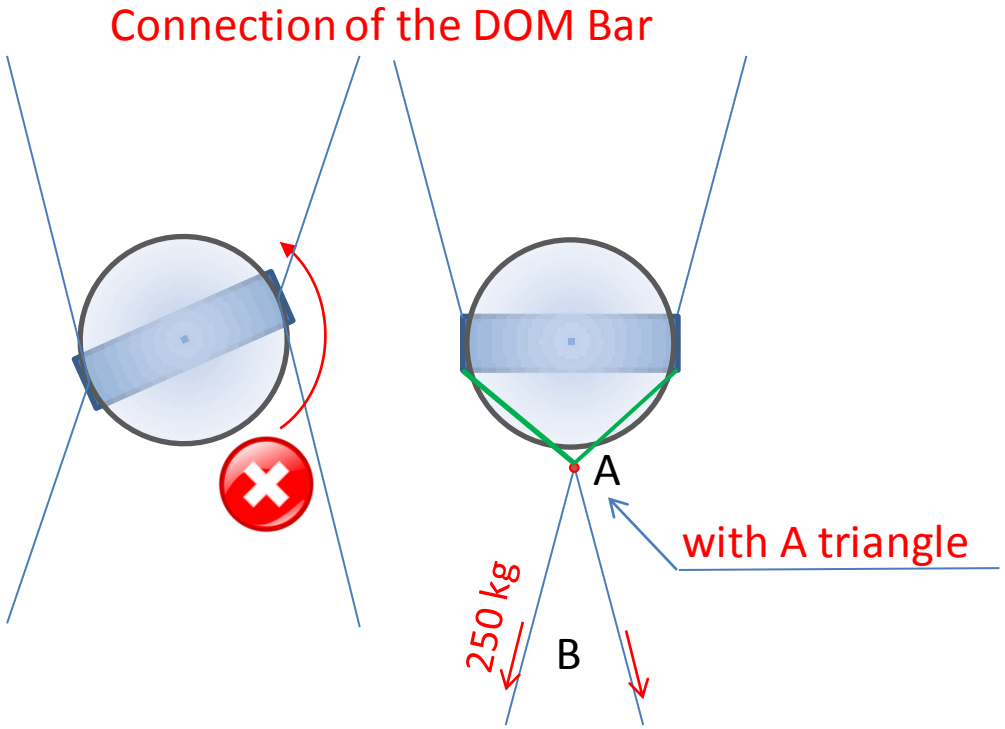
During unfurling and mission time of the DU the VEOC must be supported to the mechanical cable.



Rope layout Detector Unit (DU)

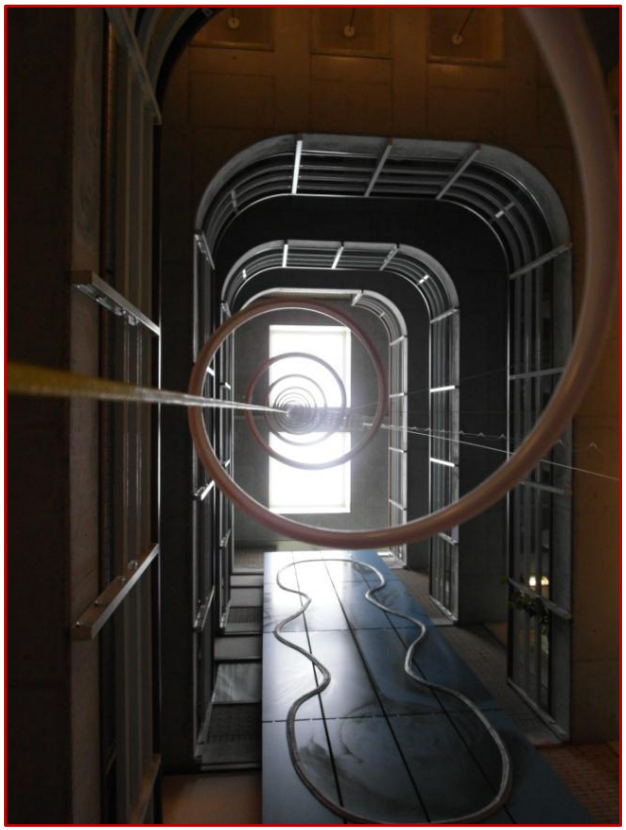


Increasing Stability



Constraining a degree of free dom

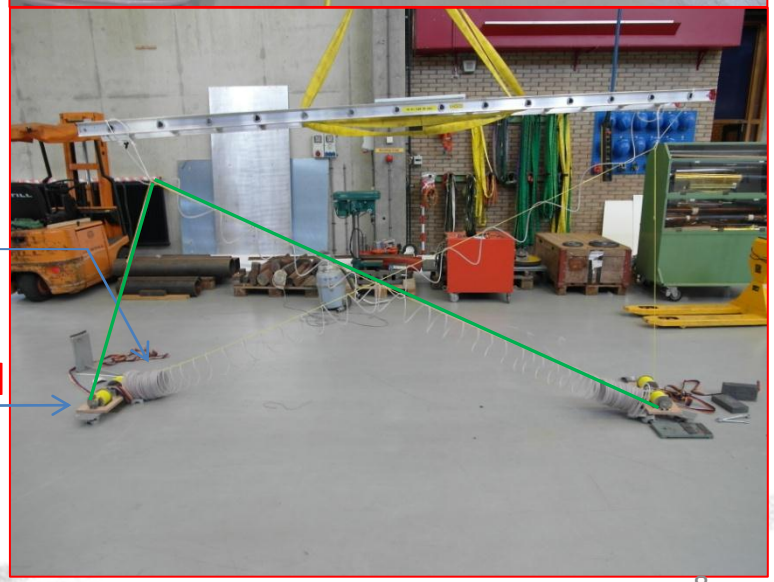
Test Rope management July 2011



Roll Stabilility

VEOC

Dyneema® Reel



4 m

Rope Summary

- No floating ropes which can tangle during deployment. (Cable reel with a friction system)

- Compact storage for deployment.

- Avoid tension on the VEOC . (spiral around the rope)

- Stability and smooth unfolding by A triangle

KM3NeT VEOC (Vertical Electrical Cable)

-Layout

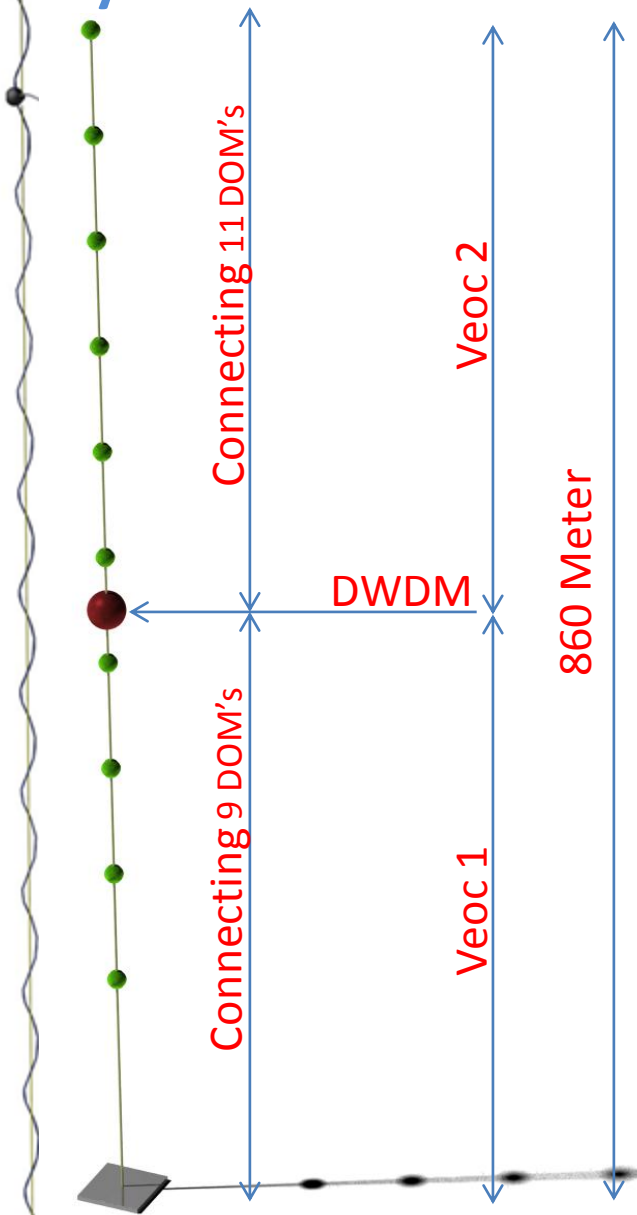
-Goal

-Design

-History

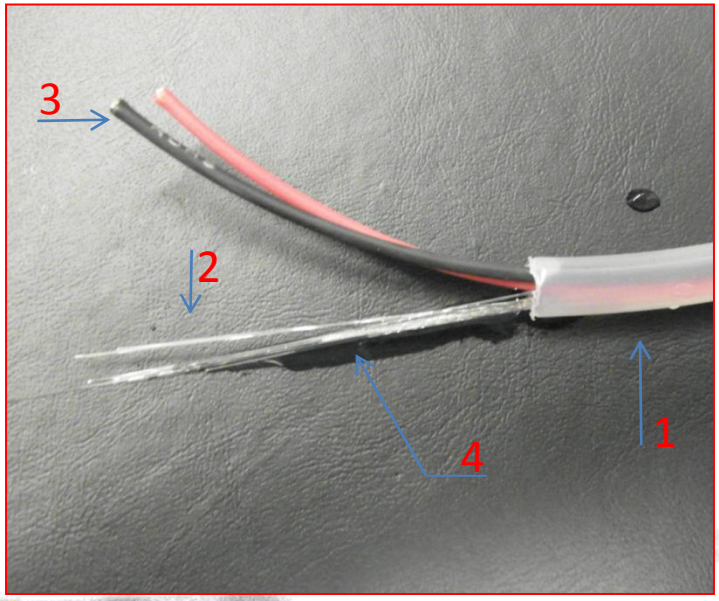
-Production of Prototype Nikhef

Layout



Cross section of the pressure balanced cable

1) Outer shell ¼ LDPE Tube
2) 11 optical fibers
3) 2 Electrical wire
4) Oil Filling



Goals

-Cable with a low drag For DU Mechanical stable

-A Flexible Cable for deployment and logistics

-An Easy cable to manufacture for the lowest Cost

For this Nikhef looked at an oil filled cable design.
Pressure Balanced Oil Filled (PBOF)

History

100 meter Cable by Nikhef and Seacon.
22 fibers 1” tube 4 electrical wires
Test at NIOZ under pressure 600 bar
Performance; **OK**

History

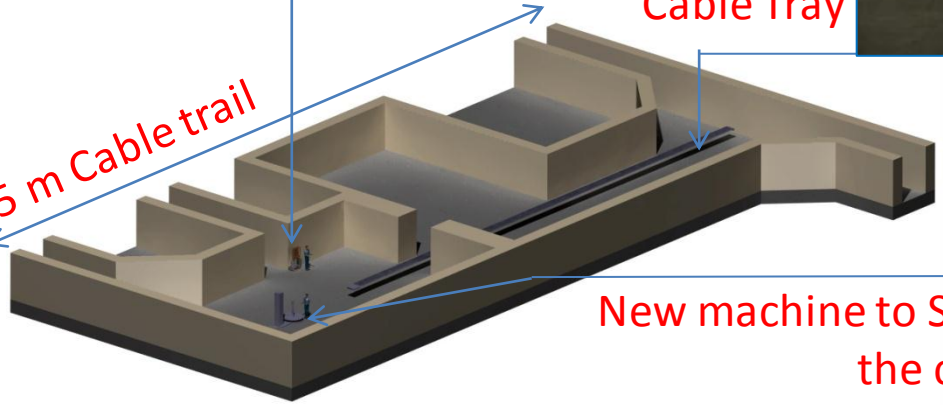
210 meter Cable by Nikhef, Baas and Seacon.
13 fibers in a bundle 2 electrical wires.
(fibers are gradient-index bend bright 10 mm bend radius)
Test at NIOZ and Southampton under pressure 600 bar.
¼ " LDPE tube
Performance; **OK**

Production of Prototype Nikhef

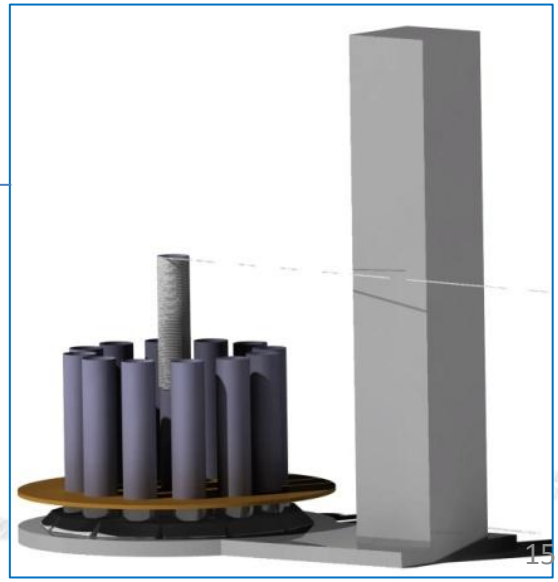
Oil Filler

Cable Tray

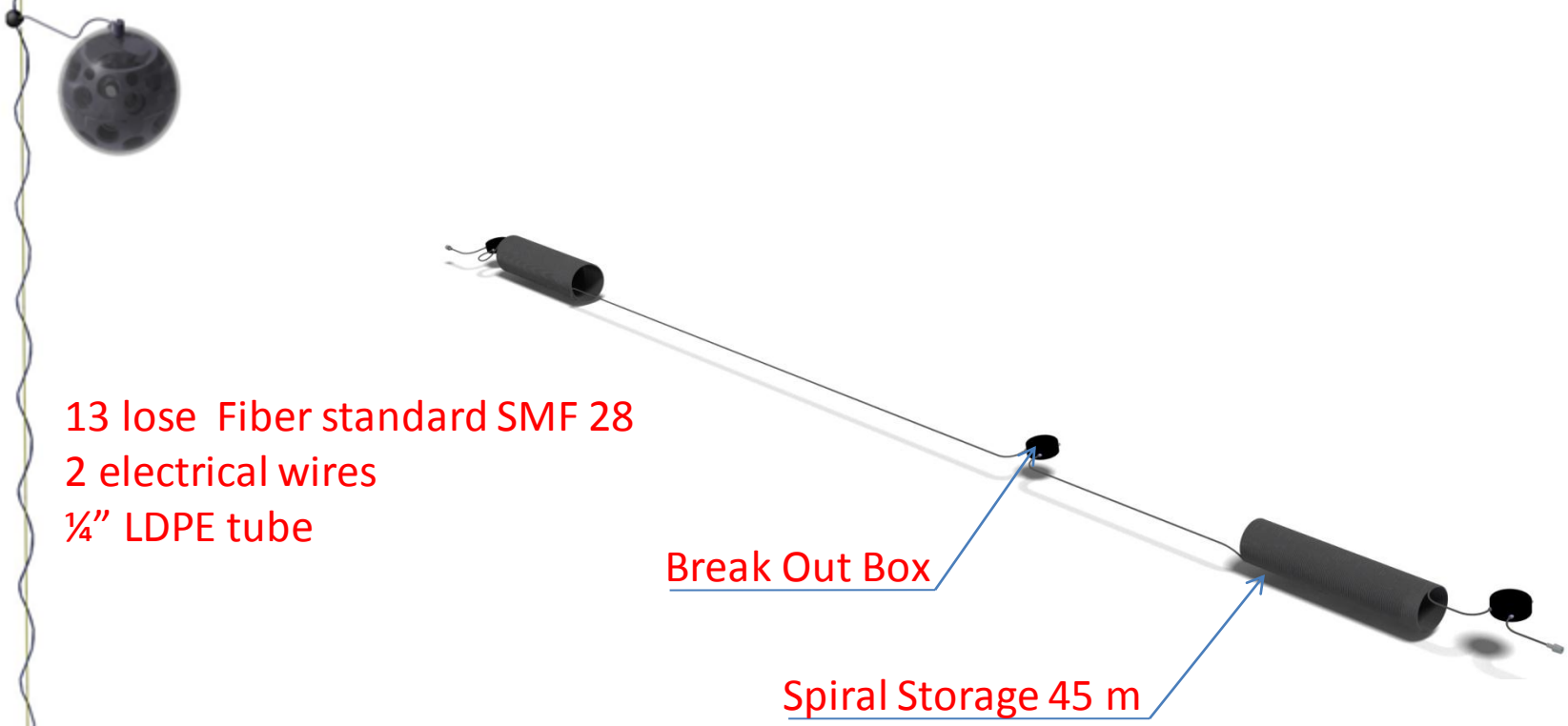
45 m Cable trail



New machine to Spiral the cable

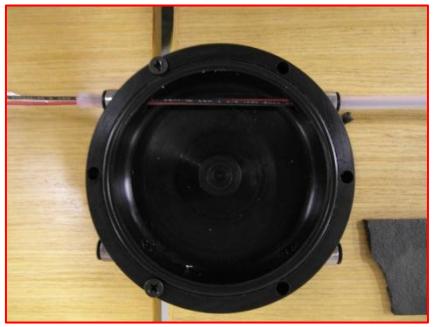


Production of Prototype Nikhef

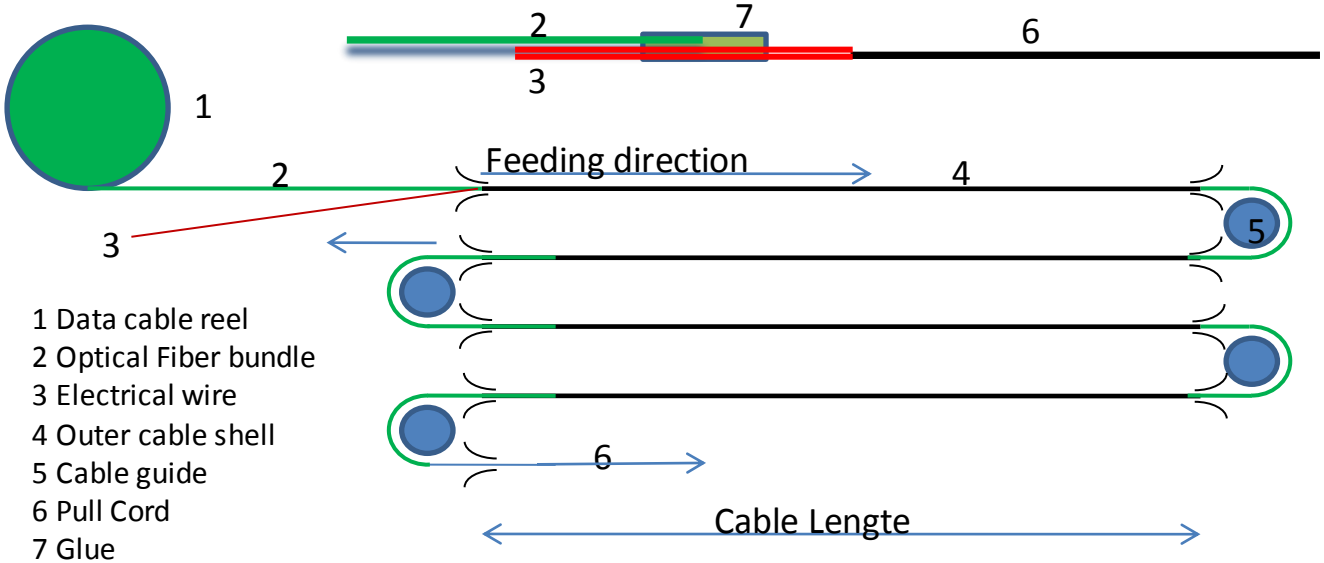


Production of Prototype Nikhef

Production Scheme

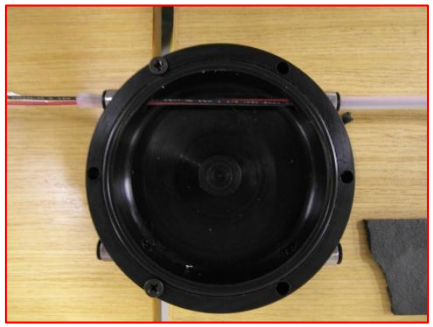


Cable guide



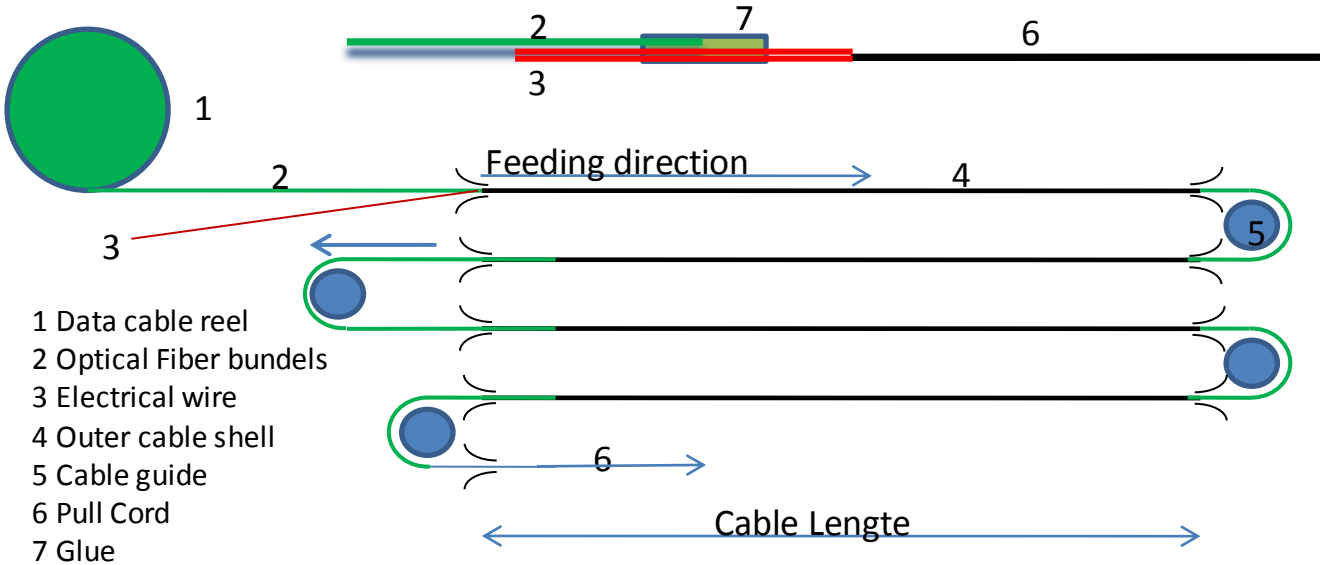
1 Data cable reel
2 Optical Fiber bundle
3 Electrical wire
4 Outer cable shell
5 Cable guide
6 Pull Cord
7 Glue

Production of Prototype Nikhef



Cable guide

Production Scheme



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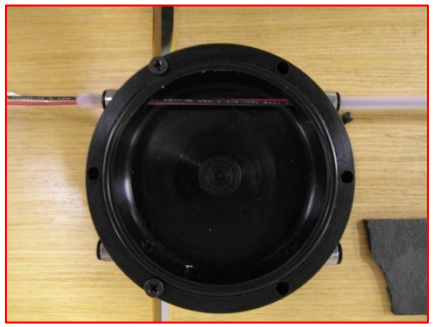
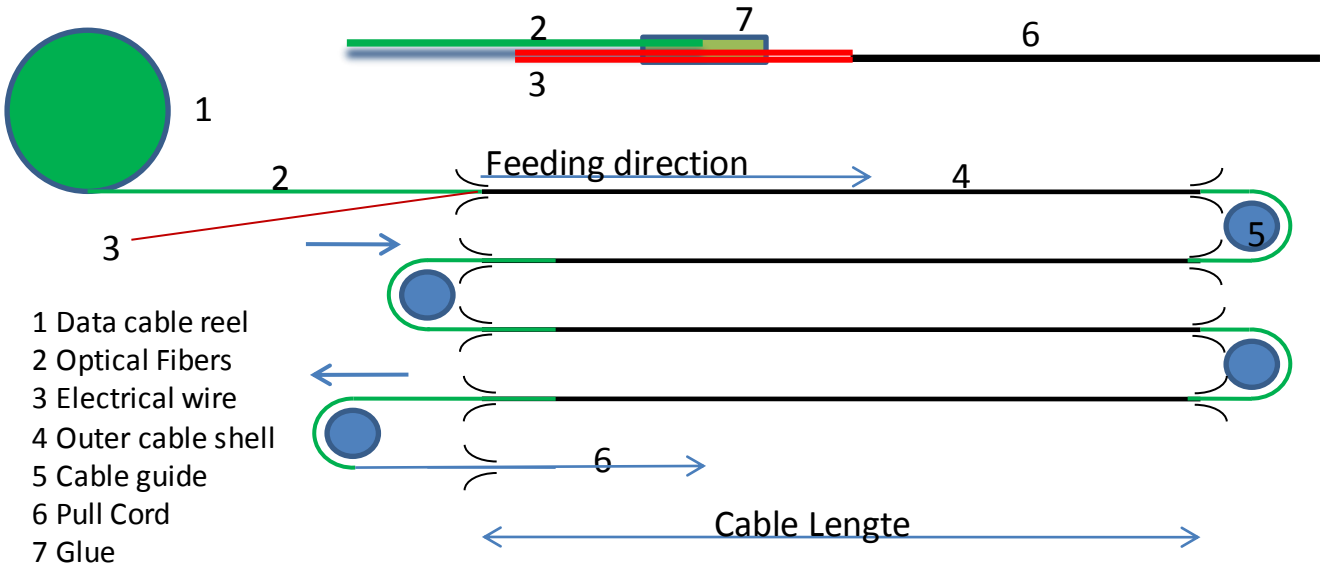


Cable guide

Production Scheme



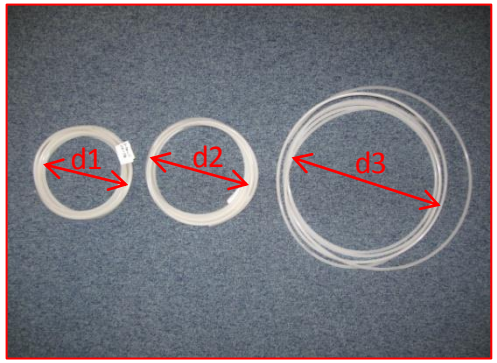
1 Data cable reel
2 Optical Fibers
3 Electrical wire
4 Outer cable shell
5 Cable guide
6 Pull Cord
7 Glue

Production of Prototype Nikhef

Coiling

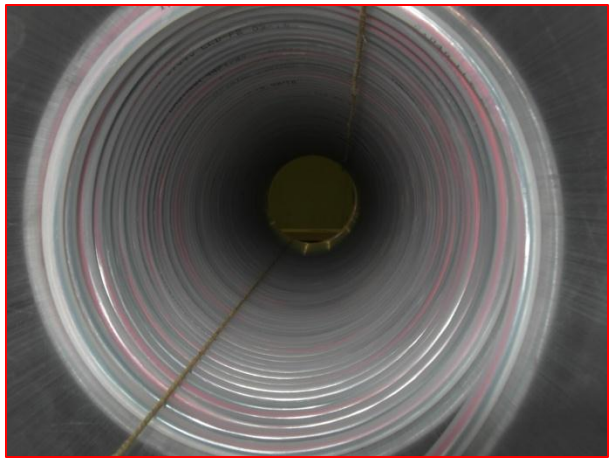
Tempering

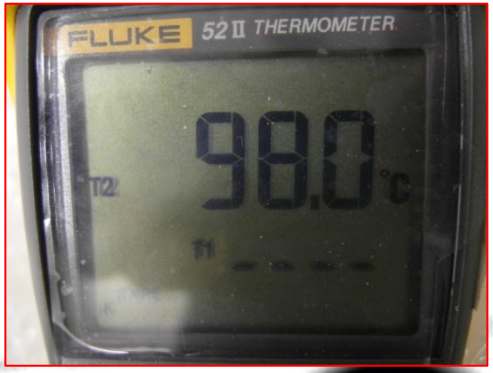
Steam Boiler
-100 °C
-5 min
-.1 MPa



D1 =167 mm 110 °C during 1 hour
D2 =190 mm 90 °C during 1 hour
D3 =320 mm no heat treatment

Production of Prototype Nikhef





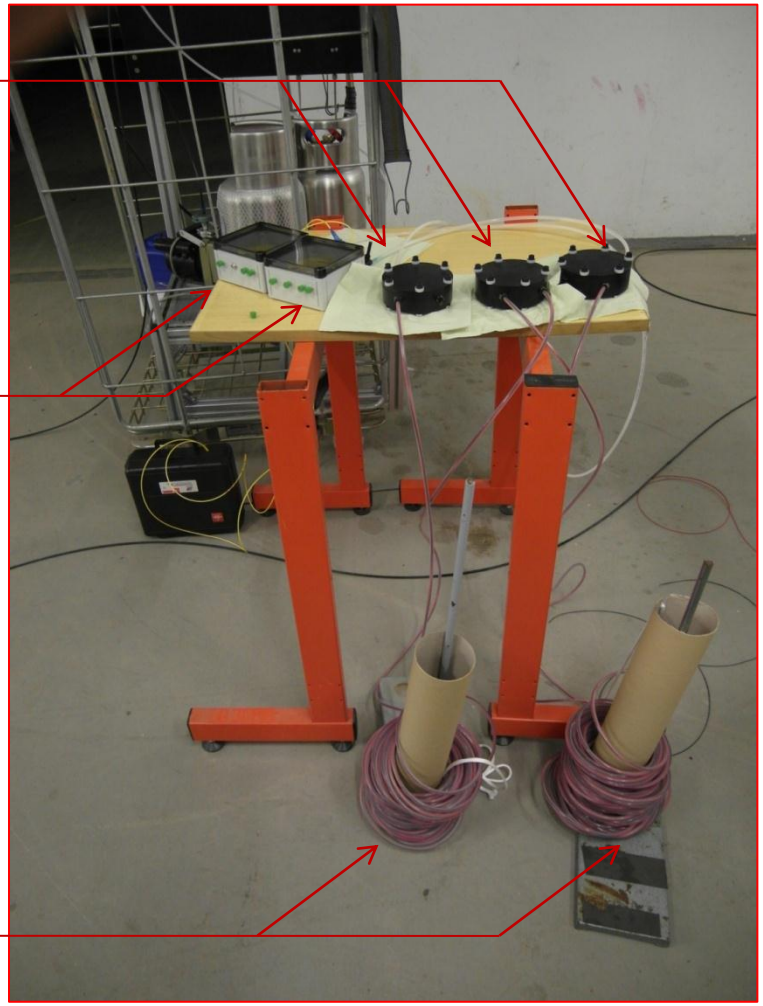
Production of the proto type

Test of the proto type

Break Out Box

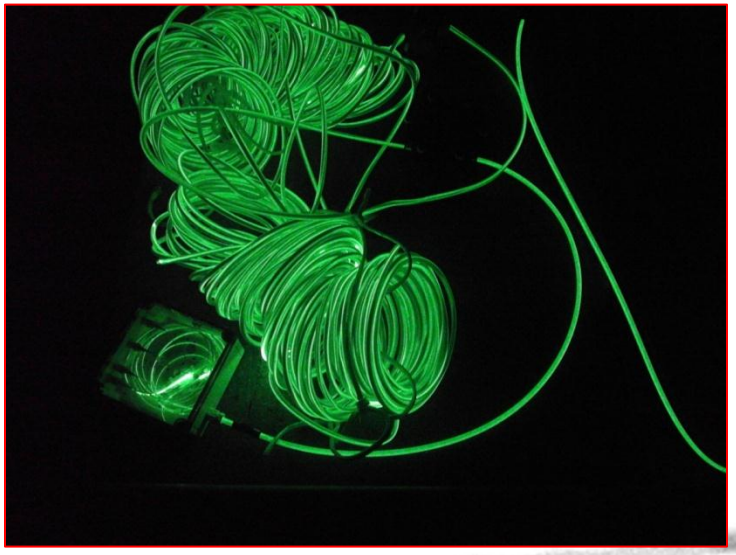
Connector Box

VEOC Spiral



Production of Prototype Nikhef

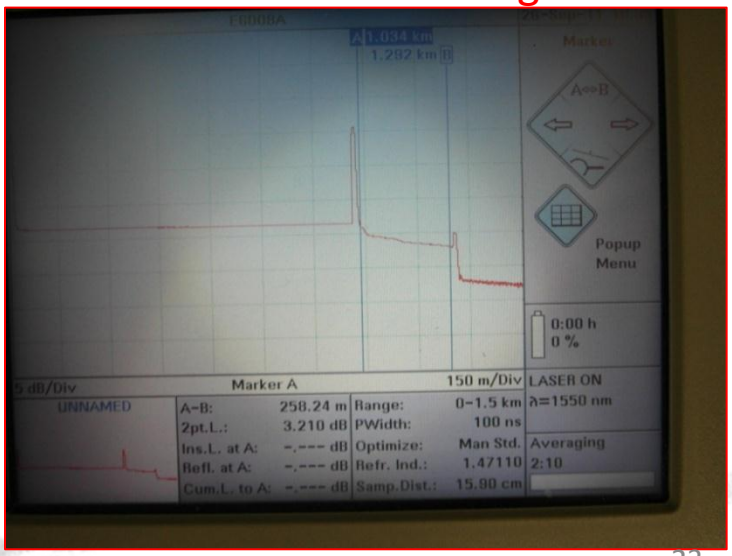
Attenuation 2.731 dB Not stretched



Green laser 125 mW

Test of the proto type

Stretched over a length



Attenuation 3.21 dB Stretched

Production of Prototype Nikhef

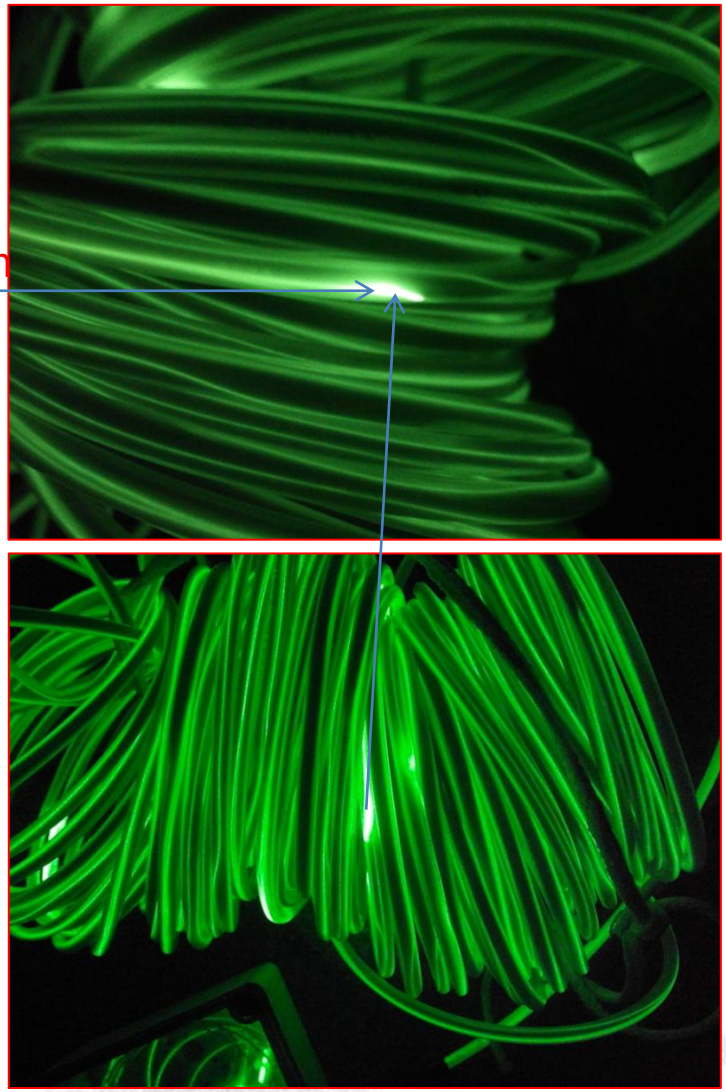
Problems loose fibers

-Because of length differences in tube
optical fiber twist at some points in the tube
resulting in a small bend < 30

-Standard fibers have a min. bend radius of 30 mm

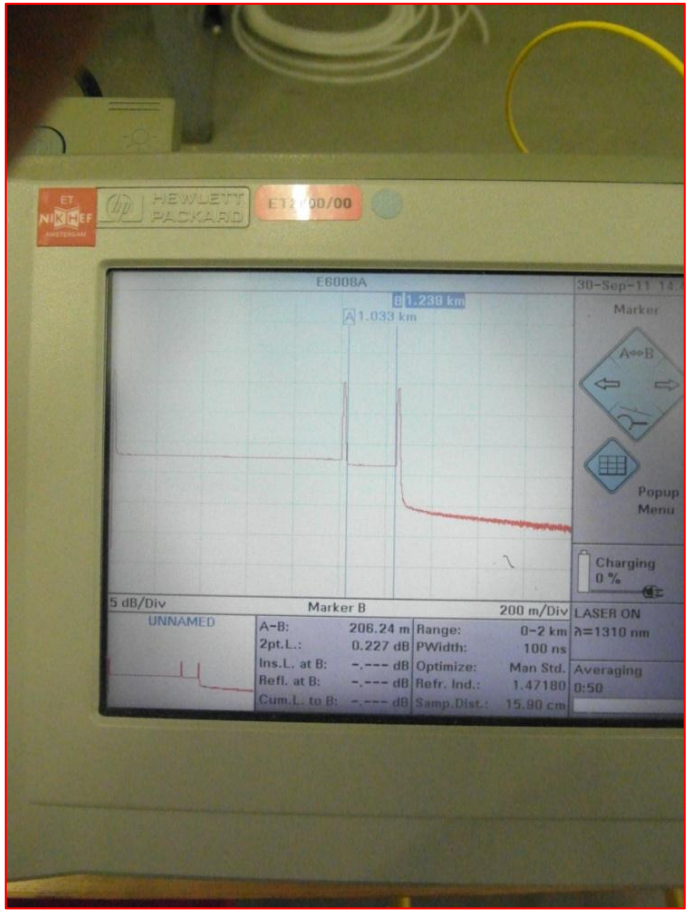
Test of the proto type

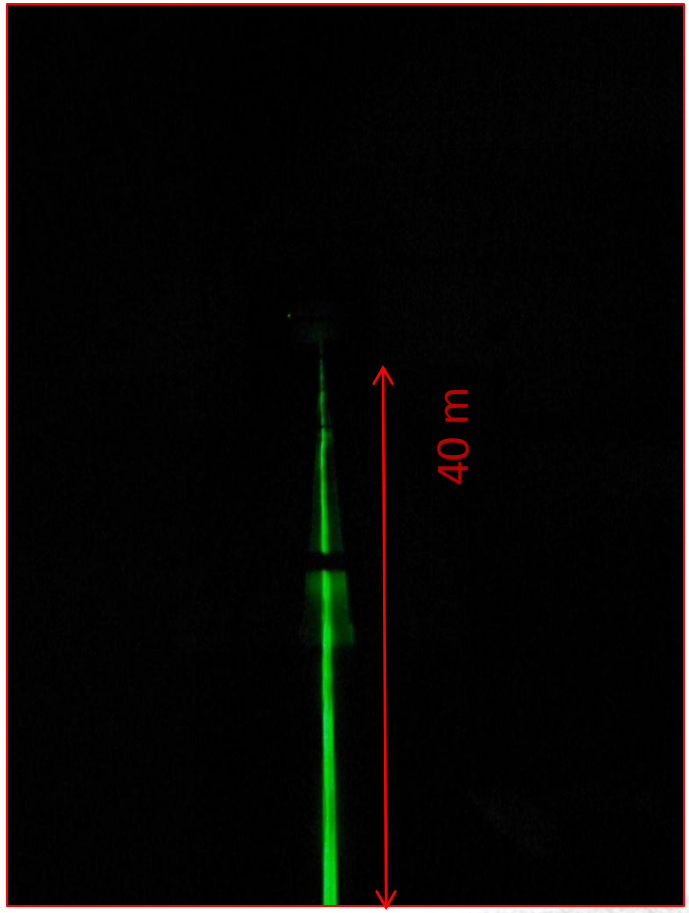
Sharp bend < 30 mm
Attenuation



Production of Prototype Nikhef

Test of the proto type





New 40 meter Cable, Optical 0,227 dB 5 fibers standard smf28

Production of Prototype Nikhef

Summarized

2 pressure balanced cables tested proof the system works.

1 spiral cable with the 13 smf28 standard fibers.
-Due to length differences many twists with small bending radius occured.

2 new spiraling test tubes to build. To test if losses can be reduced by improving the production method.
-Instead of loose fibers a bundle is used for pulling into the tube.
-Use of bend bright fiber.

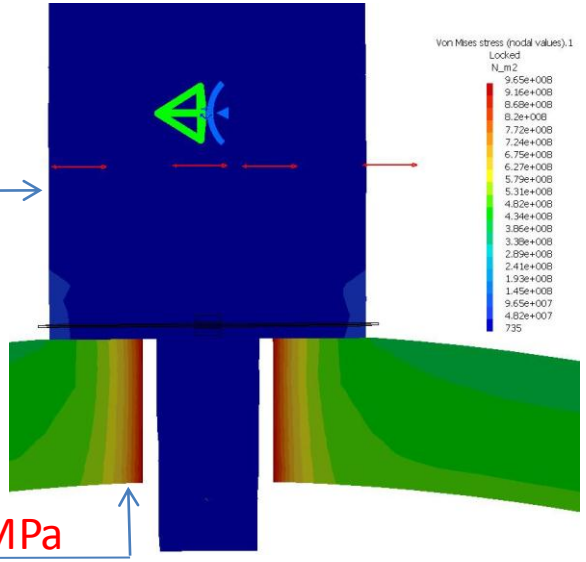
Penetrator

A reliable high pressure penetrator.
By reducing the **stress** in the glass

Design principle

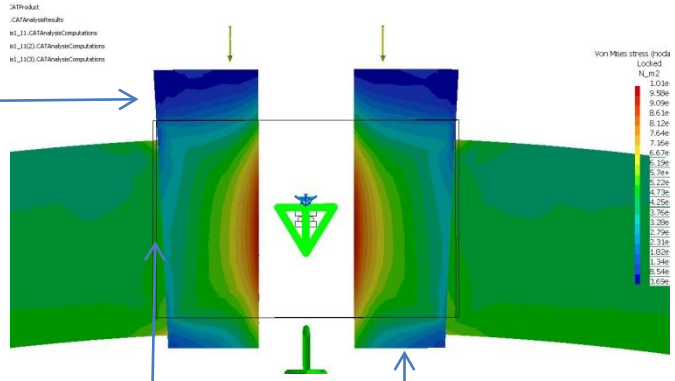
Load
60 MPa pressure

Penetrator



Stress in glass near hole 1000 MPa

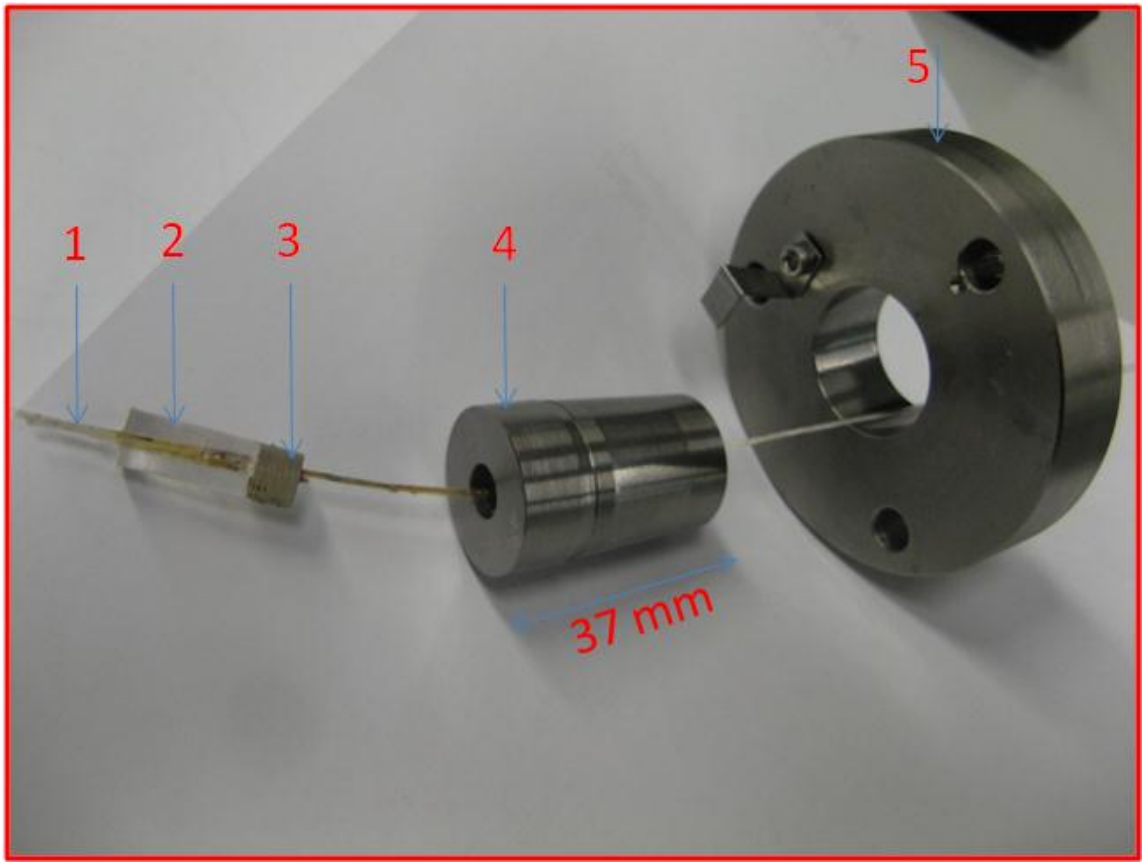
Penetrator



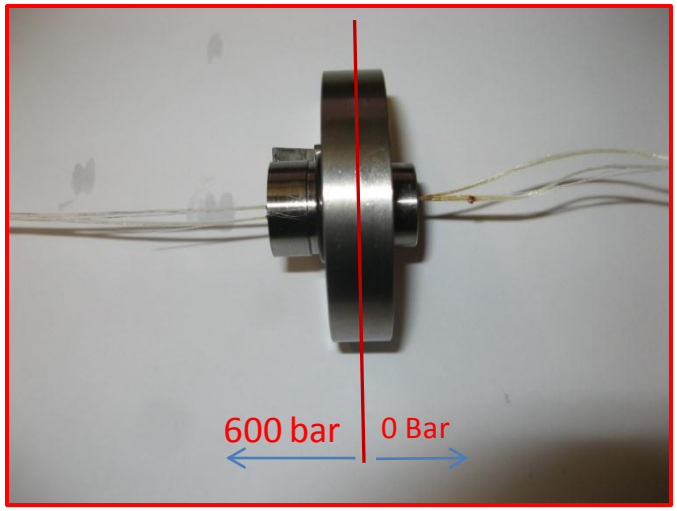
Stress in glass near hole 500 MPa

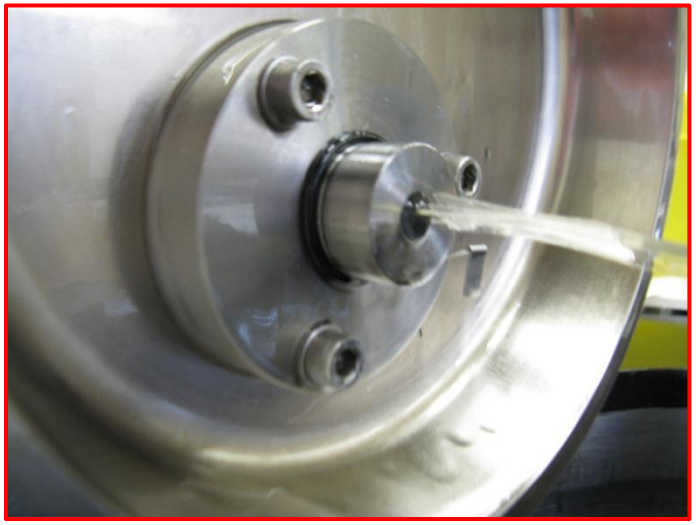
Ti grade 39

Penetrator Feedthrough Test

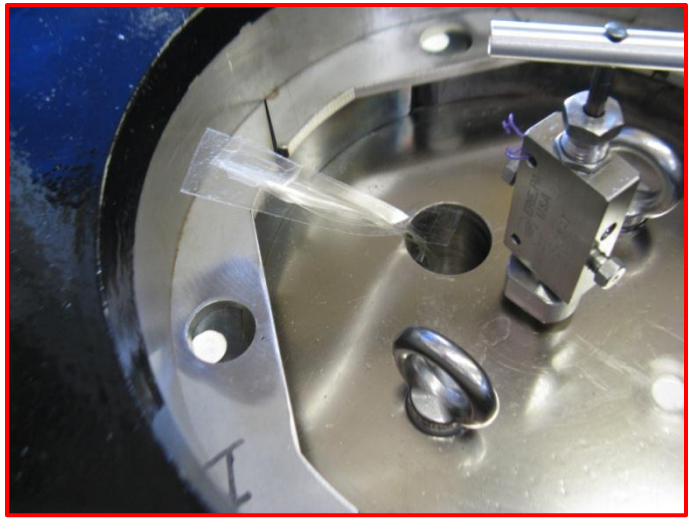


1) 16 Optical Fibers
2) Silicon Seal
3) Glass Epoxy Plate
4) Conical Plug
5) Test flange for Hera Pressure Vessel





Pressure difference 600 Bar for 3 weeks



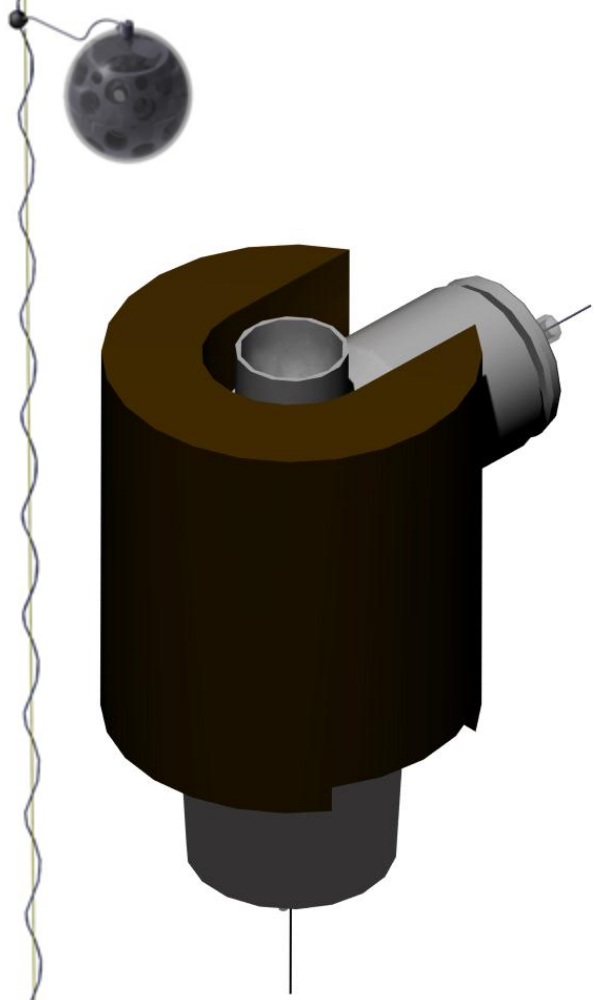
Penetrator Test

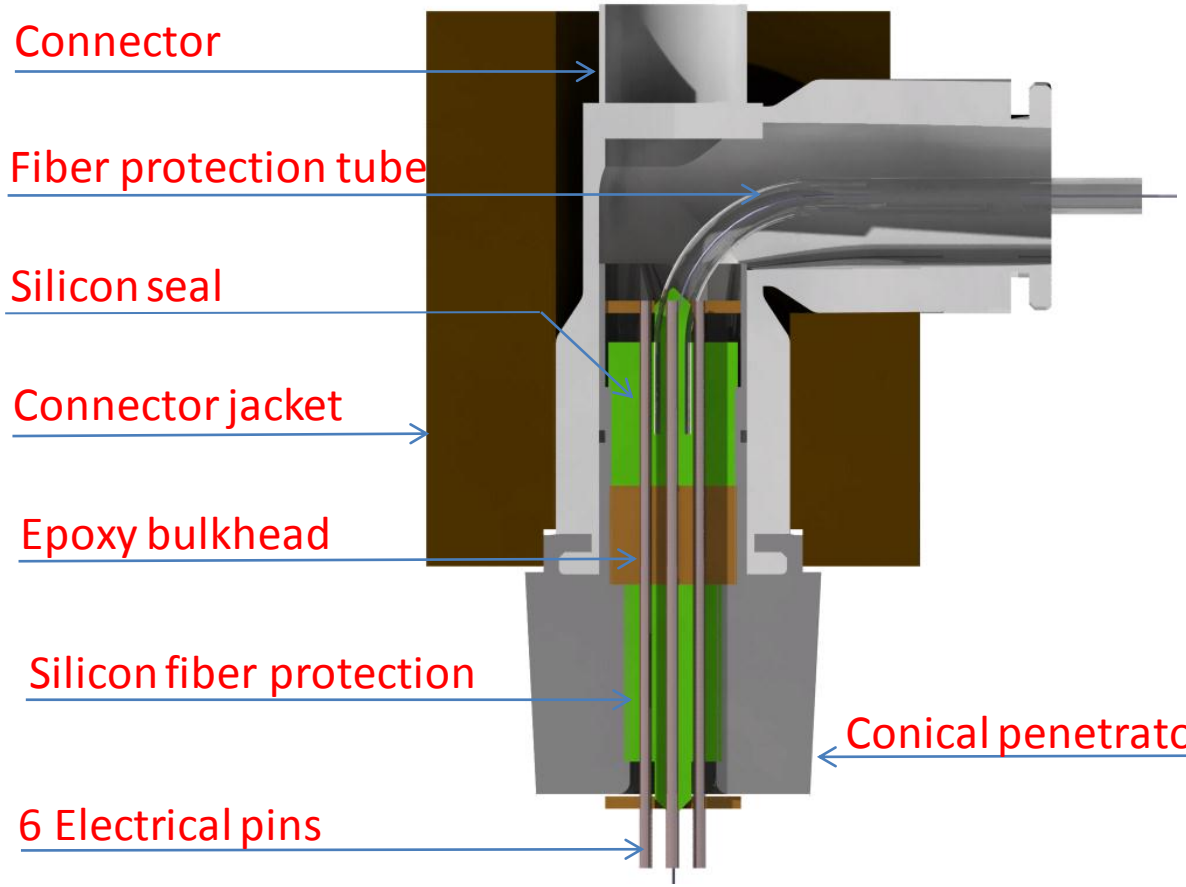
Mechanical Test
-5 conical plugs distributed over 1 hemisphere
80% of the sphere is filled with water for safety

The sphere is submerged in the NIOZ pressure tank.
Test Pressure 600 Bar for 1 hour.

After removing the sphere from the tank
the conical plugs and holes were inspected: **OK**

Proto design





Summarized

The design reduced stress at the hole edge.

Test of the penetrators at 600 bar show no problems.

Test of the penetrators feedthrough at 600 bar shows no problems.

Optimized design will be implemented in the BEOC.

Rope & Cable management

To summarize

-Keep the ropes under tension with a cable reel and break system.
-Locking the VEOC around the Dyneema ® rope in a spiral.
-Connection of the DOM bar with an A triangle.

-VEOC performs well with gradient-index fiber (bend bright).
-The spiraled VEOC must be optimized with gradient-index fiber.

-Conical plug reduces stress on the edge of the hole.
-Optimization for production.