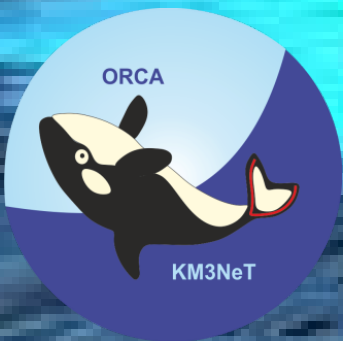


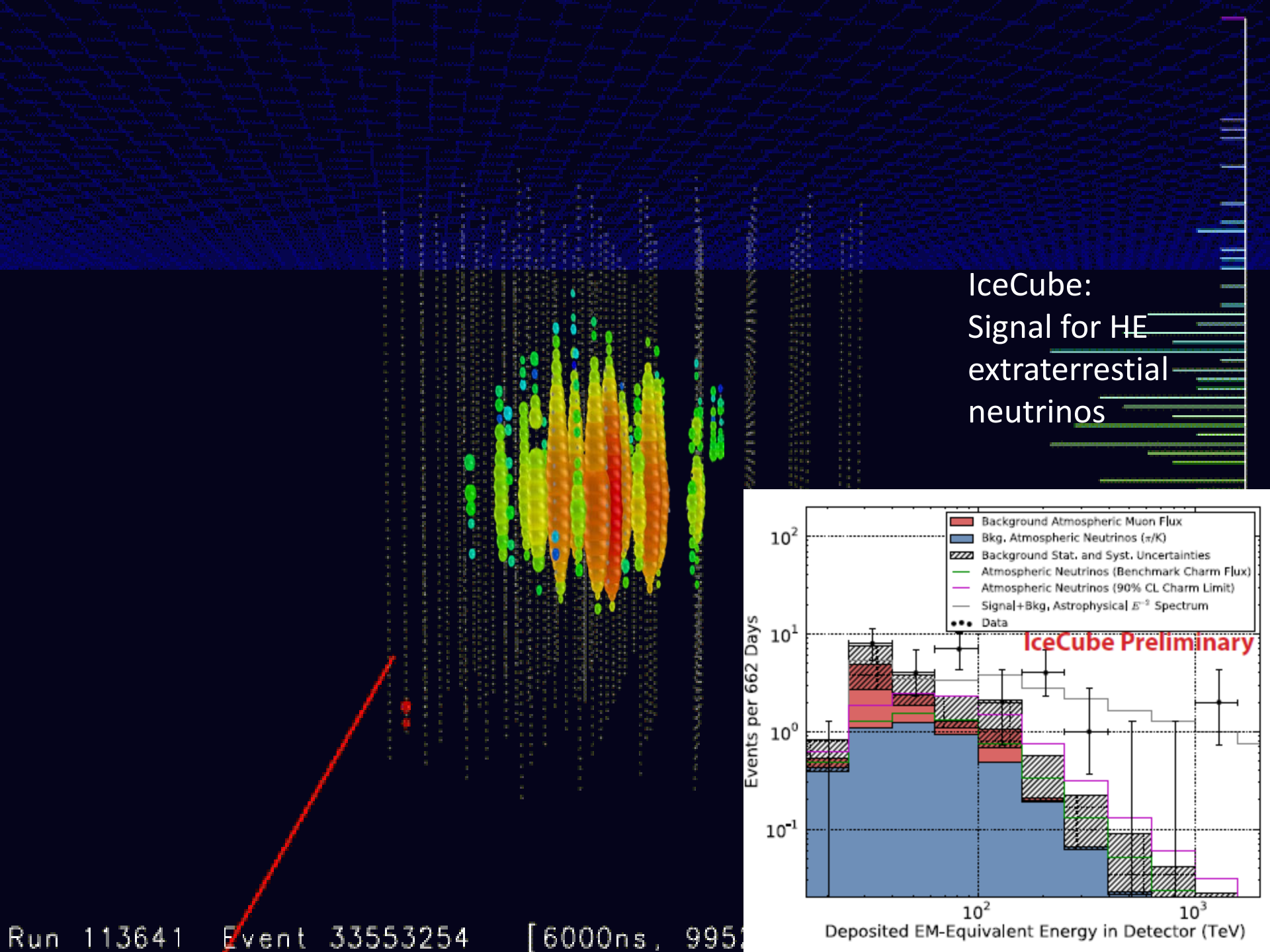
Under H₂O Neutrino Telescopes



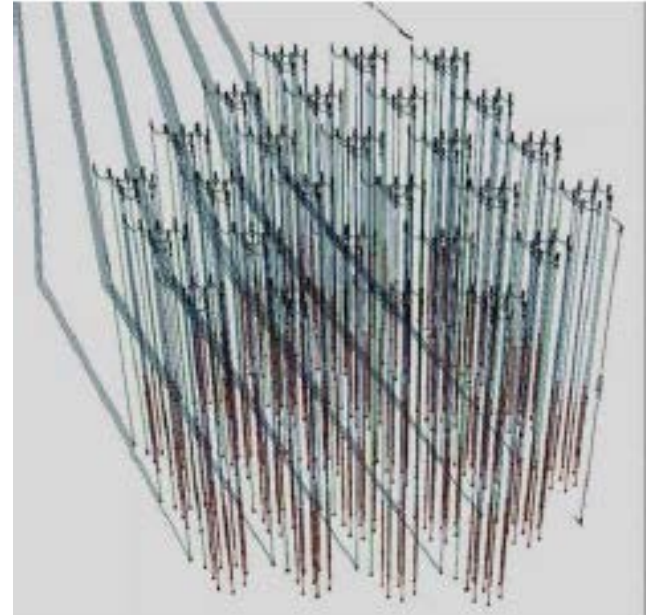
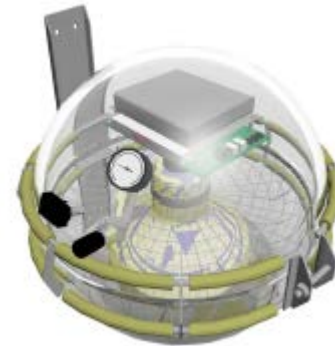
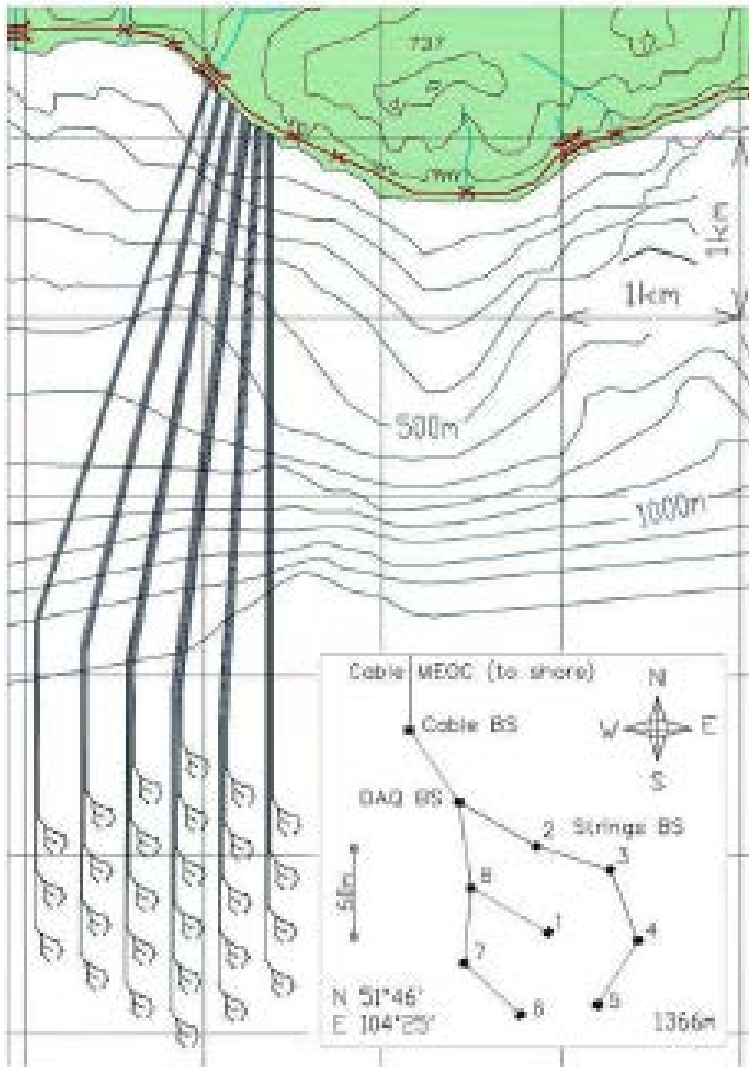
GVD



APPEC H2020 WORKSHOP
Zeuthen, 5 November 2013
Paschal Coyle, CPPM

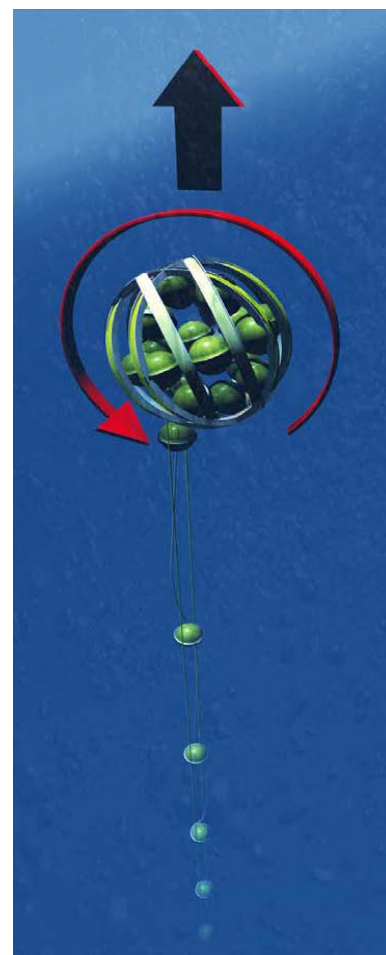
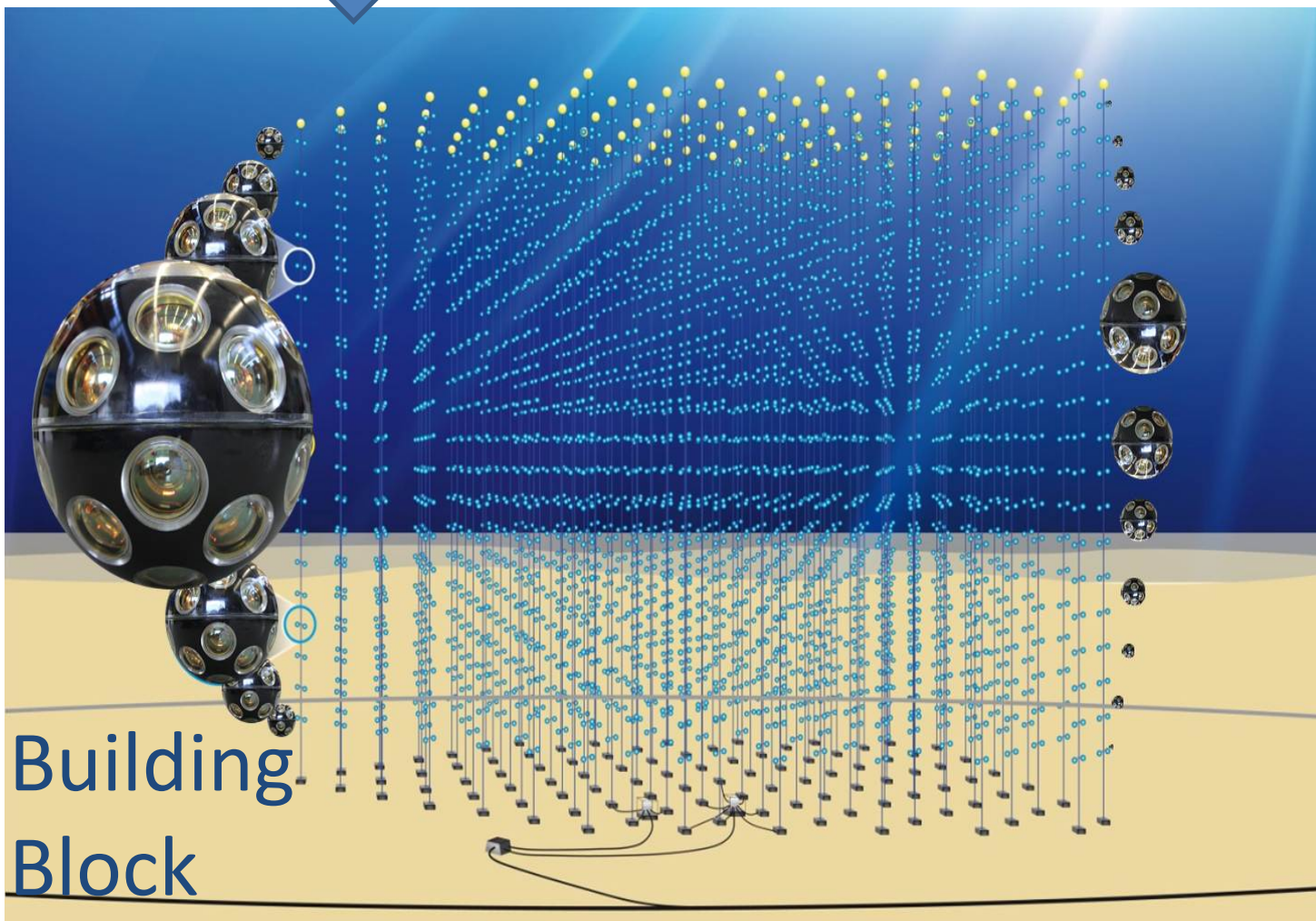
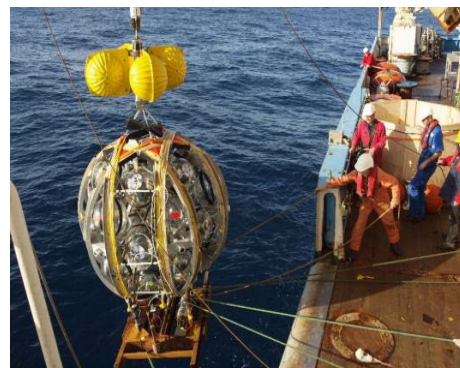


Gigaton Volume Detector (GVD) Lake Baikal-Russia





KM3NeT



KM3NeT Past & Future

| | | |
|---------------------------------|-----------|--------------------------------|
| Design Study (with ESS): | 2006-2009 | 9 M€ |
| Preparatory Phase: | 2008-2012 | 5 M€ |
| Implementation Phase: | | |
| Phase 1 (10-20% IceCube) | 2013-2016 | 33 M€ (ERDF 20 M€, 2 sites) |
| Phase 1.5 (2 blocks ~IceCube) | 2016-2018 | +60-70 M€ |
| Phase 2 (6 blocks ~few IceCube) | 2018-2022 | +100 M€ |

(On ESFRI roadmap since 2006)

Summary of Water Possibilities

- Global Neutrino Network
- KM3NeT Implementation Phase
- KM3NeT technology with industry
 - Cheap wetmateable connectors
 - White Rabbit time synchronisation
 - ebCMOS fast, single photon camera
 - Acoustic positioning system

what is the best instrument?

next INFRADEV

next INFRADEV

ETN (postdoc), EJD(PhD), **EID(PhD)**

- Acoustic detection of UHE neutrinos
- MH using Protvino nu beam to ORCA
(water detectors reconfigurable)

Design study-no, ERC

neutrino WG

- Earth and Sea sciences
 - Acoustic detection of Cetaceans
 - Oceanography (deep water formation, internal waves, precision temp array,...)
 - Seismology
 - Bioluminescence
 - Environmental monitoring/climate change (O_2 , temp, salinity, CO_2)
 - Wally robot explorer

Synergies, societal challenges (2,5)

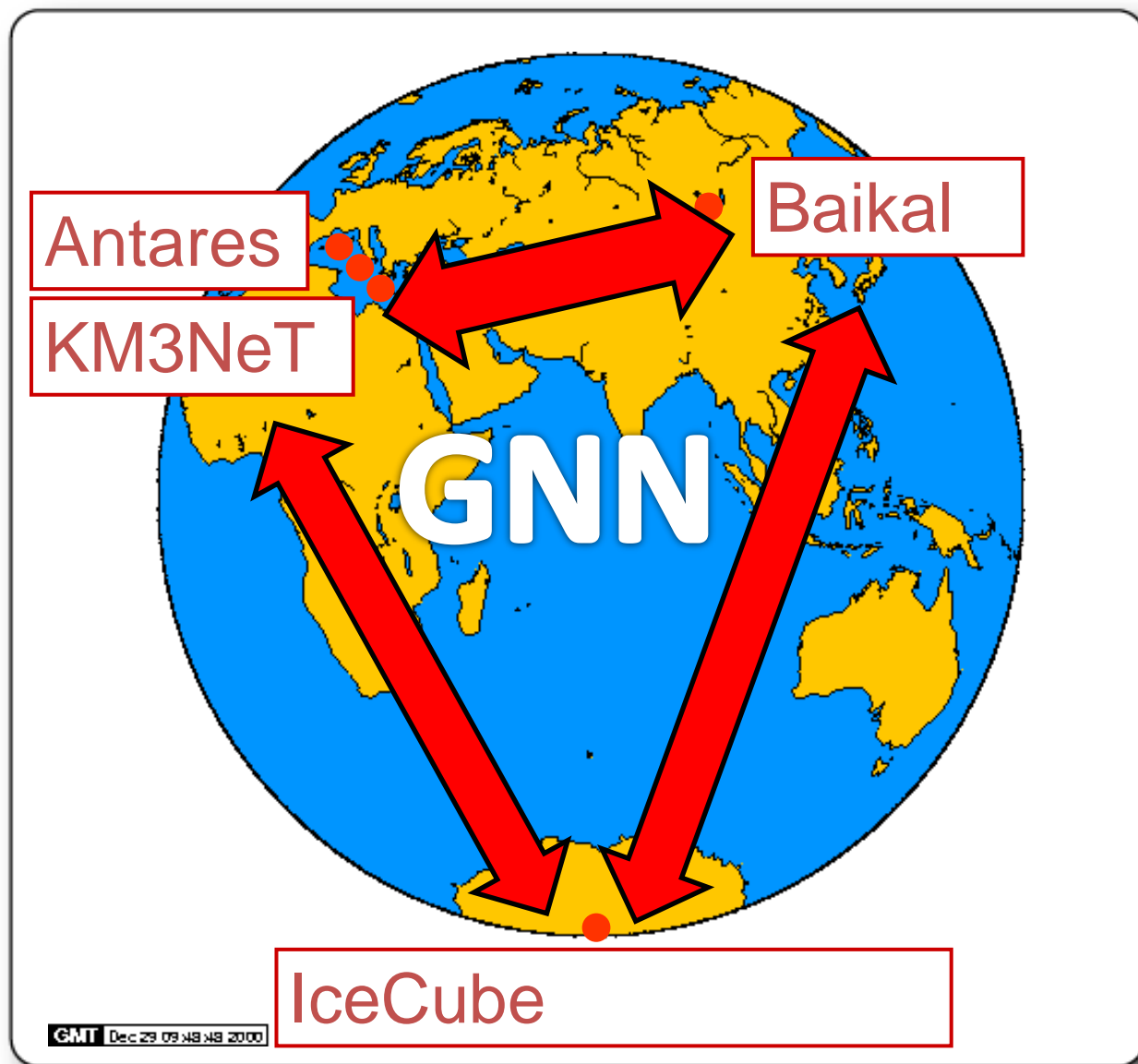
Synergies/cluster with EMSO

Access/database

Member Collaborations of GNN

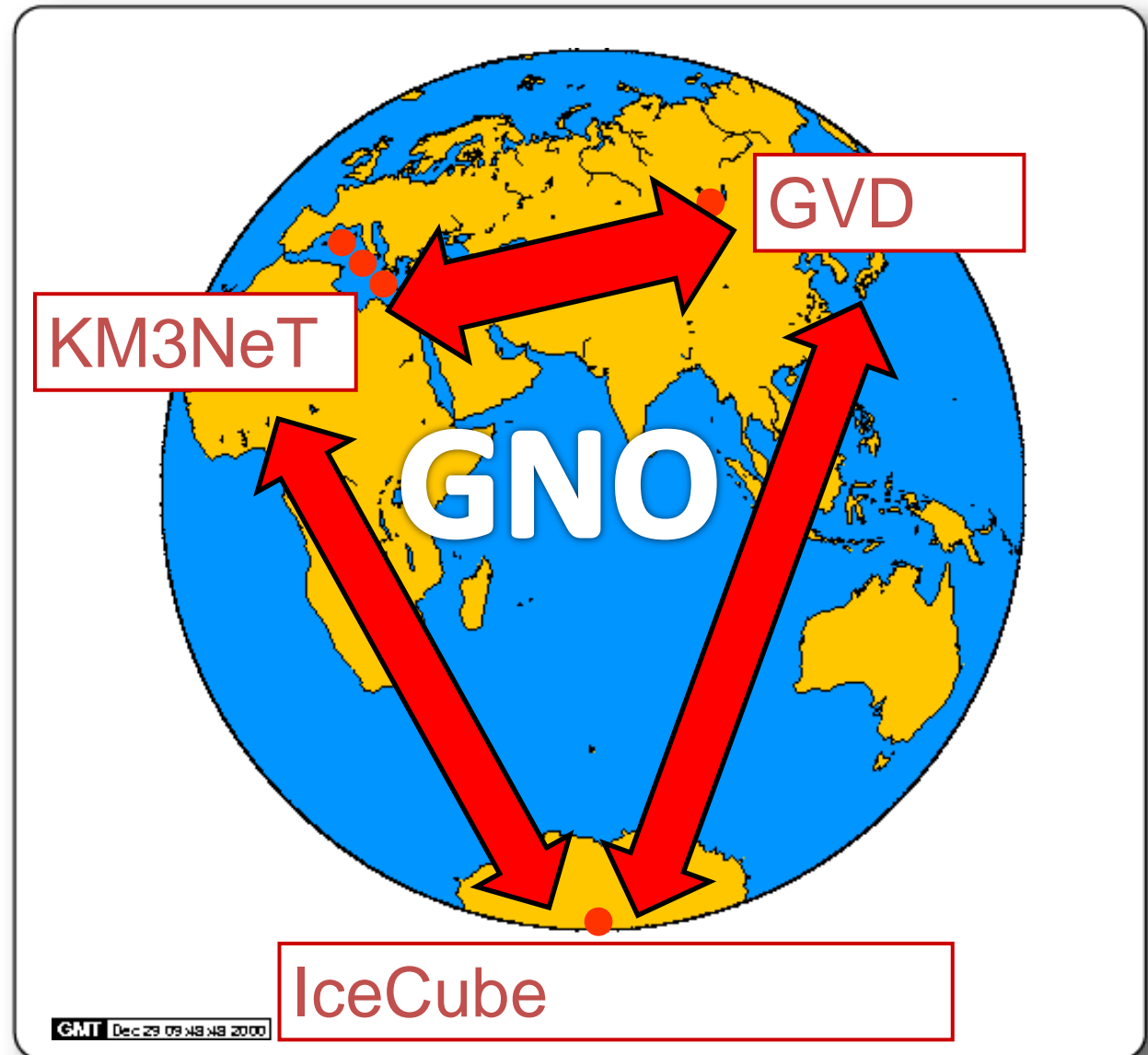
- ANTARES
- Baikal
- IceCube
- KM3NeT

Signed:
October 15, 2013



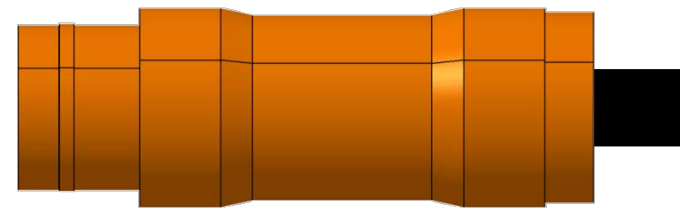
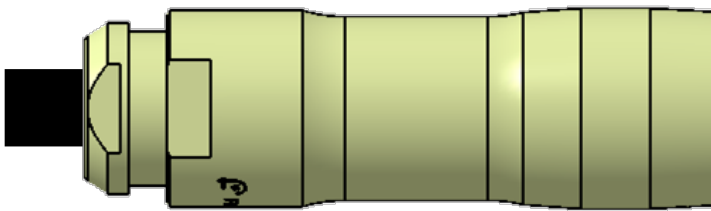
Member Collaborations of a future GNO

- GVD
- IceCube
- KM3NeT
- 3 infrastructures of comparable size



The concept

- Reliable and inexpensive dry connectors exist on the market ...

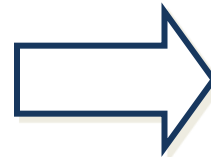


But those are not watertight and wetmate...

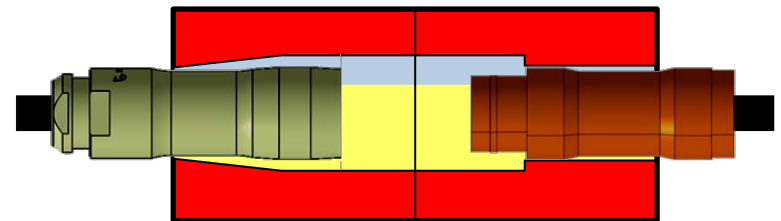
State-of-the-art wetmate connectors:



Complex, expensive and limited voltage

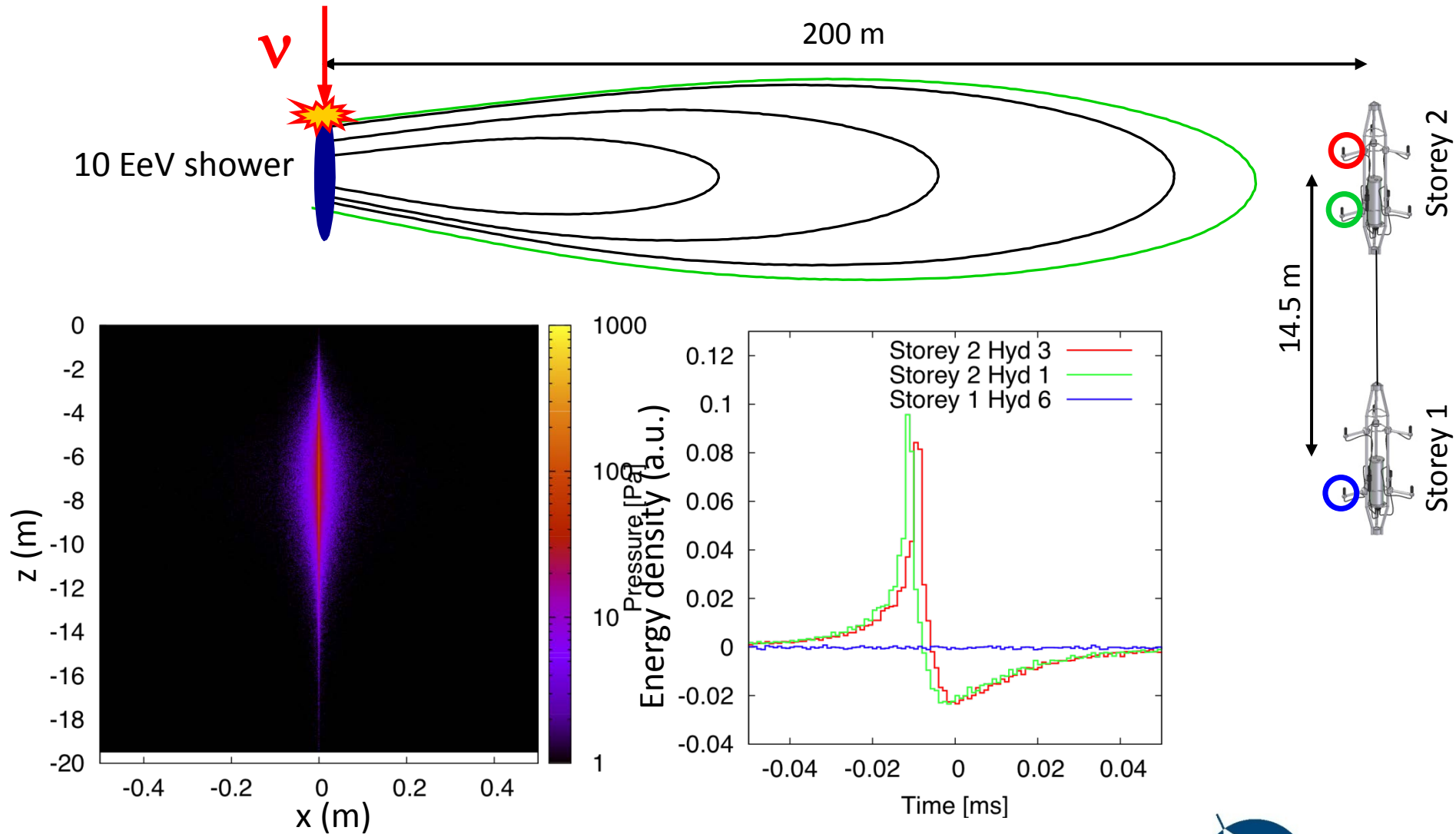


POWERMATE concept:



**Simple marinated dry connector
connected in oil with recoverable tool**

Simulation of Neutrino-Induced Acoustic Pulses



MC according to arxiv/0704.1025v1 (Acorne Coll.)

Synergies between the ESFRI Infrastructures



&

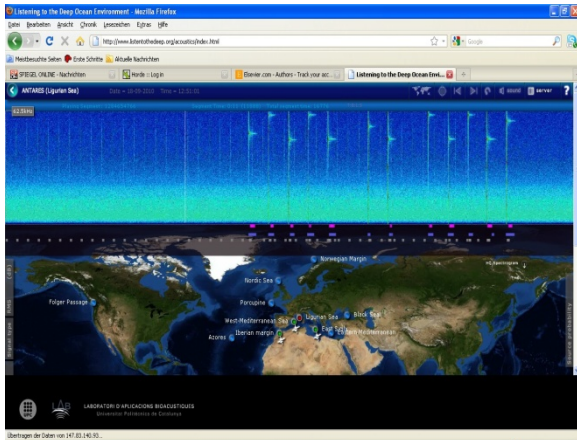


- **Sharing facilities (e.g., cables, junction boxes, handling systems, logistics)**
- **New developments in marine technology and sensors**
- **Approach to newly scientific themes of common interest**
- **Impact on education and job creation opportunities (i.e. new expertises)**

Neutrino Telescopes: Marine Sciences

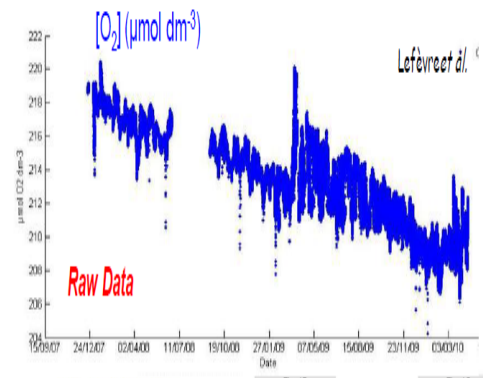
Deep Ocean Cabled Observatories Aspera Workshop, Amsterdam 2011-
<https://indico.cern.ch/conferenceDisplay.py?ovw=True&confId=165389>

Marine Acoustics

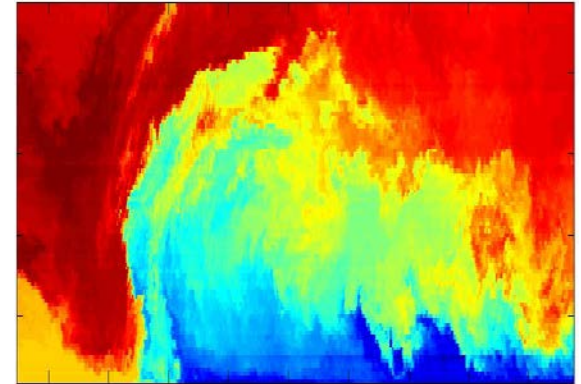


Oceanography

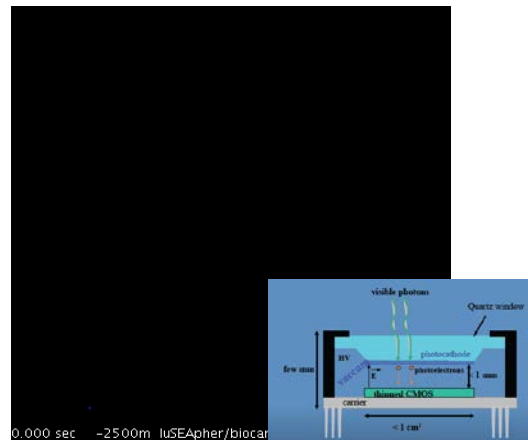
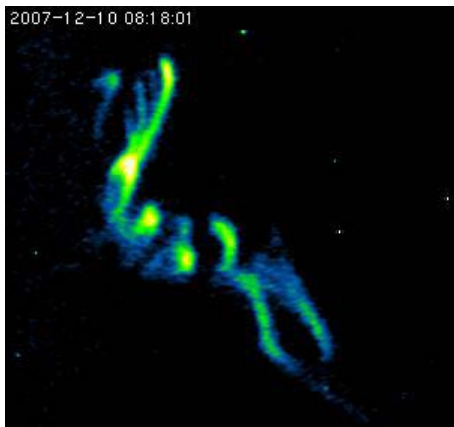
Evolution trend of in situ dissolved oxygen : $-5 \mu\text{mol O}_2 \text{ dm}^{-3} \text{ a}^{-1}$



Deep water formation Internal wave dynamics

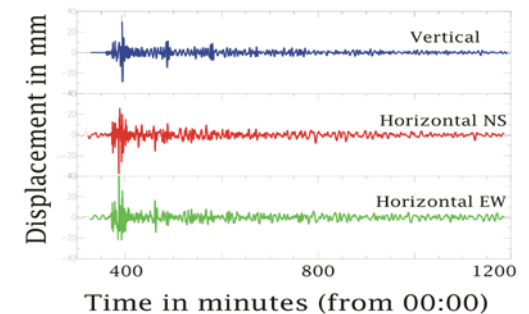


Bioluminescence

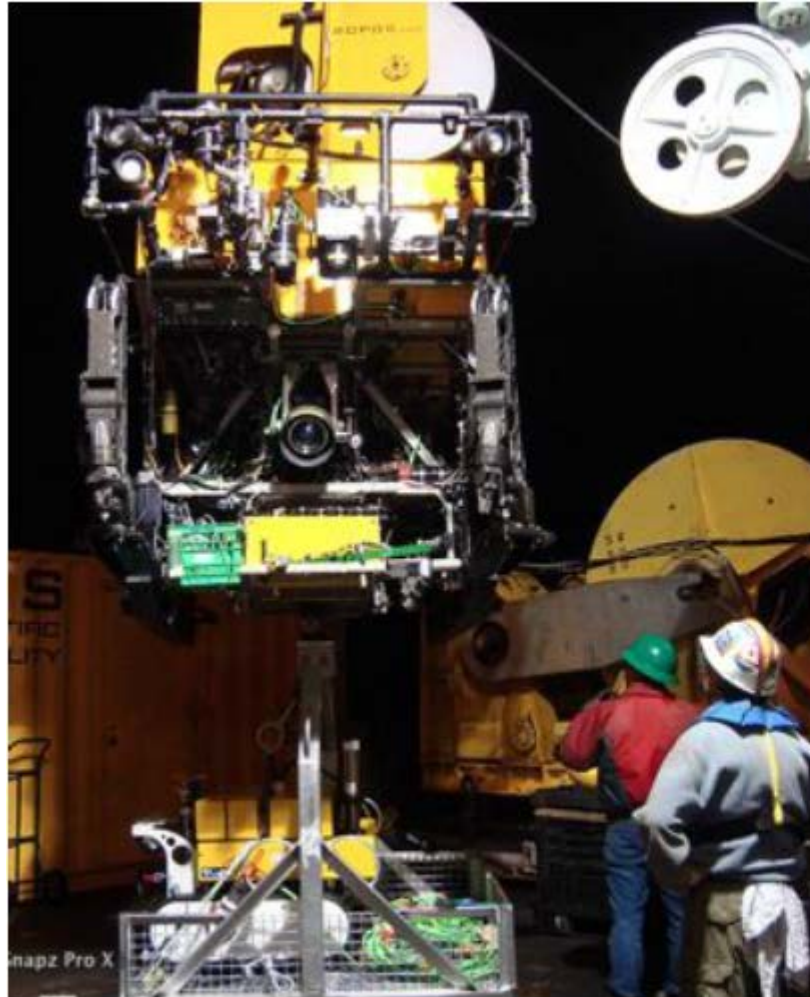


Seismology

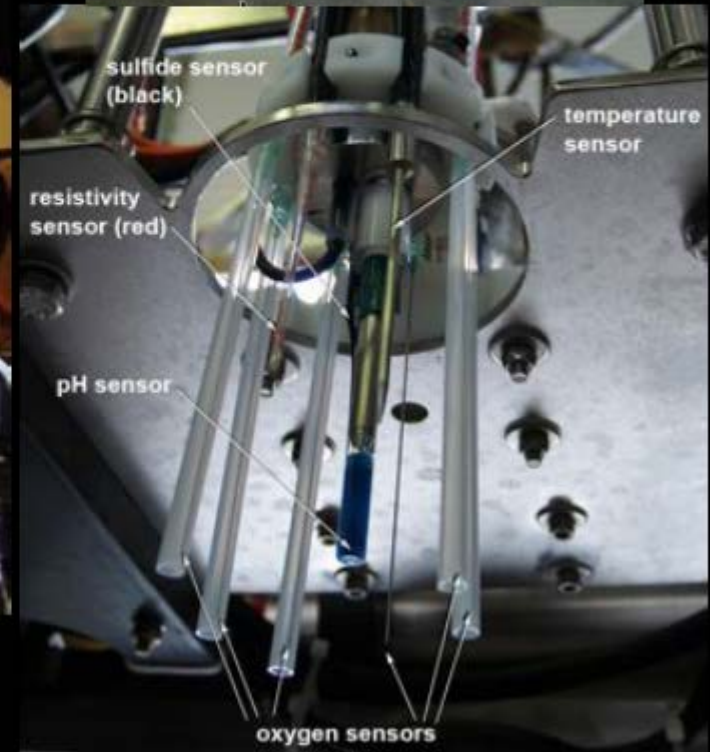
Japan earthquake 2011 March 11
at Antares site



Wally the Robot



Source: Neptune Canada



Ice Possibilities

- MH with atmos neutrinos (PINGU/ORCA) design study-no
- High energy extension design study-no
- Surface veto (Icetop water tanks) design study-no
- Wavelength shifter approach (WOM) ERC
 - very low noise, large area, poor timing
 - Supernova detection of low energy neutrino
 - Distributed array for SN timing
 - Reduced bioluminescence (dense water detector)
 - Veto technology
 - Industry-develop large UV quartz cylinders EJD
- Drilling technology
- Ice cores-> climate library



Low Energy Options Under Study



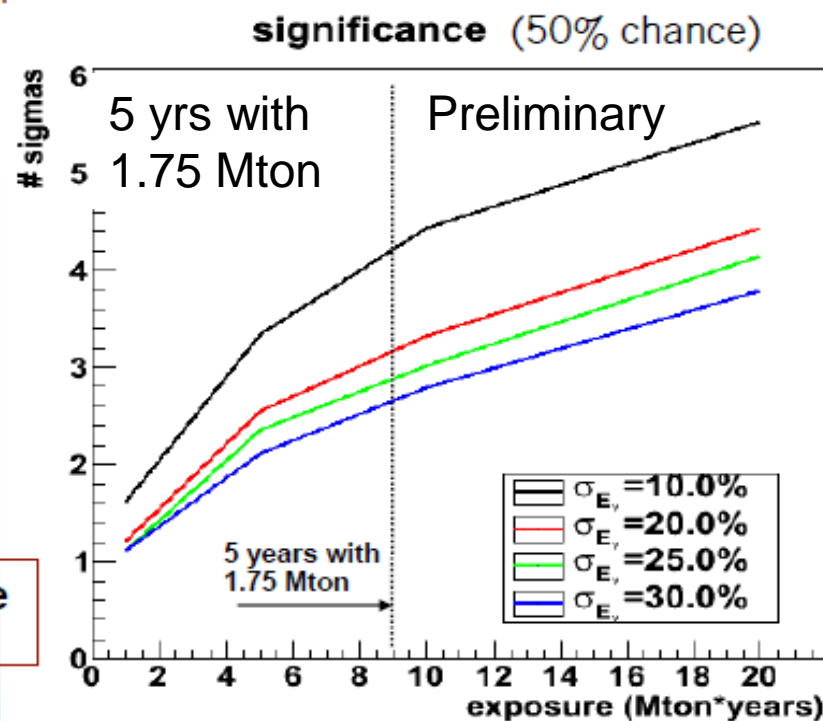
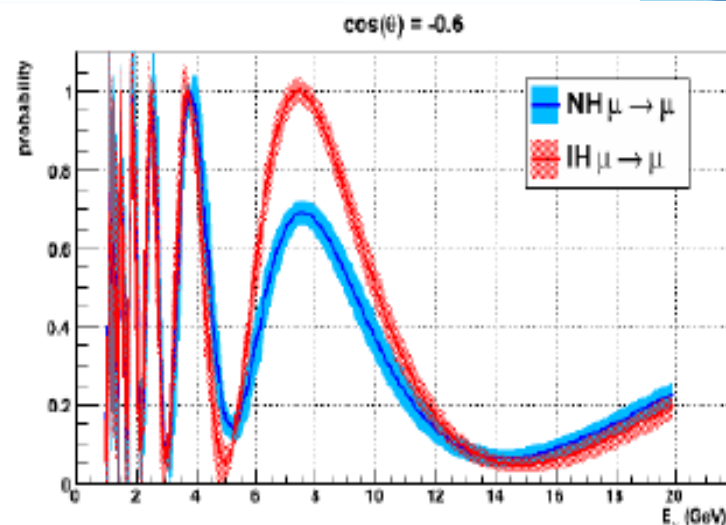
Observable differences in rates of neutrino oscillations in atmospheric neutrinos depending on neutrino mass hierarchy

Akhmedov, Razzaque, Smirnov,
JHEP 02 (2013) 082

Feasibility study ongoing for a dense array optimised for low energies (3-15 GeV):
50 strings, 20m inter-string, 6m inter-DOM

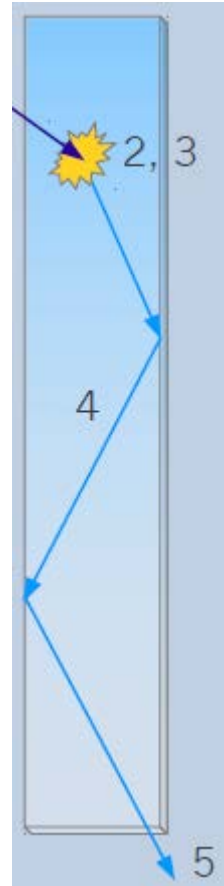
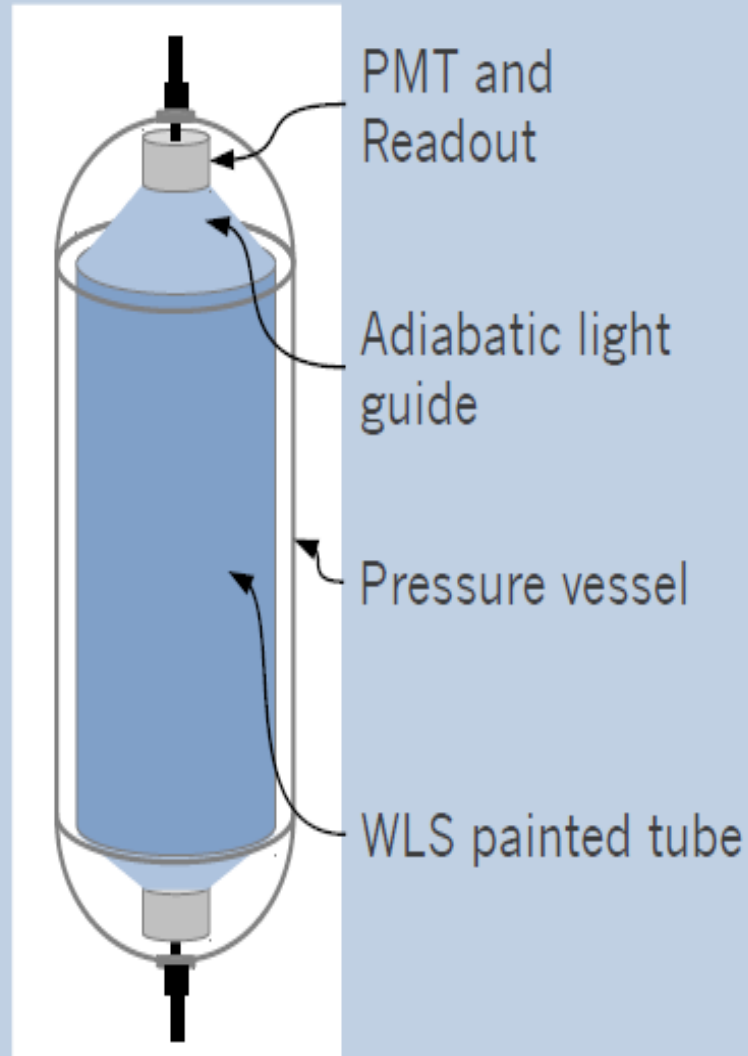
Issues under study-
energy resolution
flavour separation
atmospheric muon rejection
beamline option

Status report ~end of year



WOM concept

- **WOM** – Wavelength-shifting Optical Module
- Wavelength shifter (WLS):
 - (arbitrarily) large collection area
 - low noise (<1 Hz/kg)
 - affordable
- Readout: small, low-noise PMTs
- Housing: fused quartz
 - UV transparent
 - low noise (<0.1 Hz/kg)
- Mostly passive components:
 - Total noise rate $O(10$ Hz)



What Next?

- Mailing list
- Digest information
- Inform HE neutrino community
- Discussion with ESS community
- Video meeting- middle january 2014