KM3NeT

Opens a new window on our universe

Neutrino 2010 -
Athens, Greece, June 16, 2010

Status of the KM3NeT Project

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- The Challenge
- Technical options
- Physics sensitivity
- Resources/timeline …

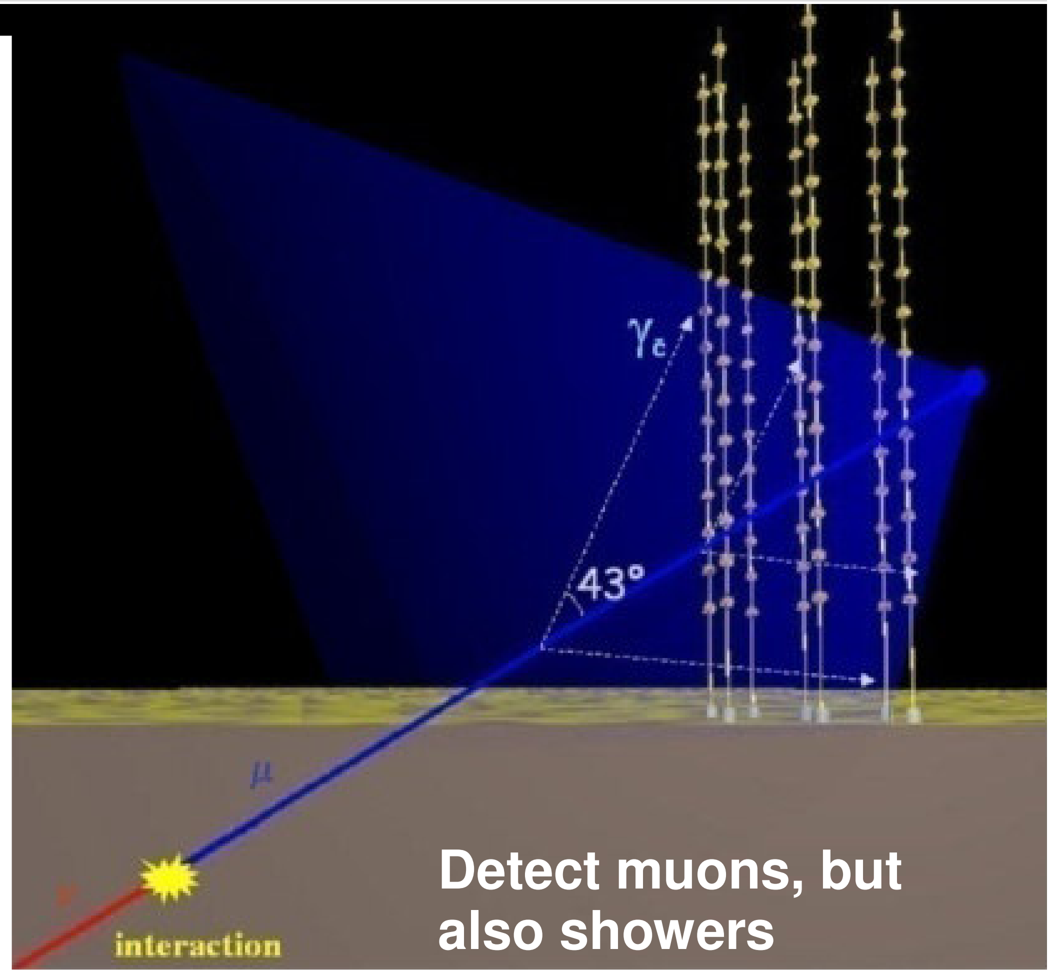
What is KM3NeT ? – Why KM3NeT

What:

- Future cubic-kilometre **km^3** scale **ne**utrino **t**elescope in the Mediterranean Sea

Why ? - The previous two speakers made the case !

- Exceeds Northern-Hemisphere telescopes by factor ~50 in sensitivity
- Exceeds IceCube sensitivity by substantial factor
- Focus : Neutrino astronomy in the energy range from 1 TeV to the 100 TeV, and HE neutrinos (~ PeV)
- Provides node for earth and marine sciences

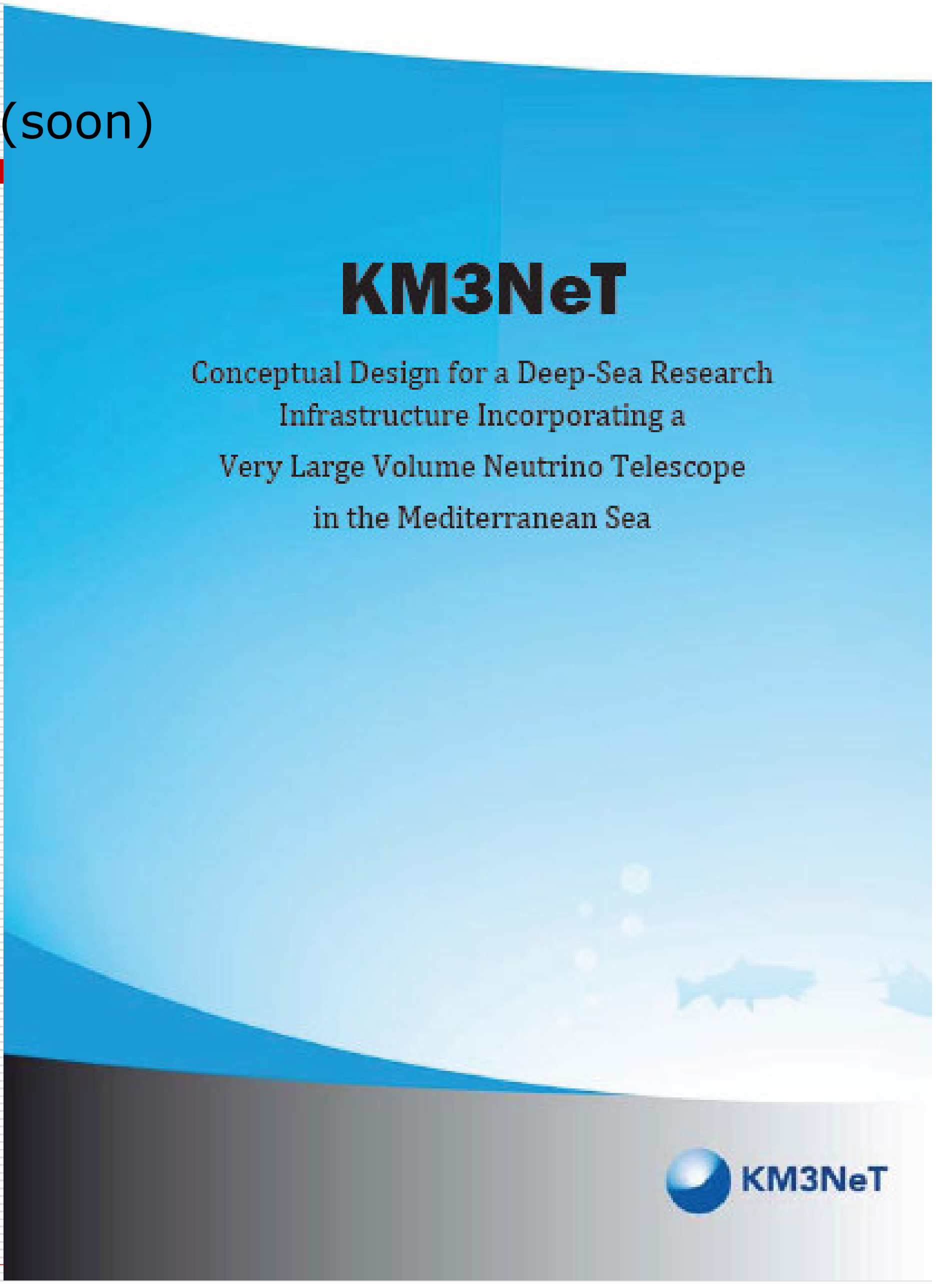


The Objectives

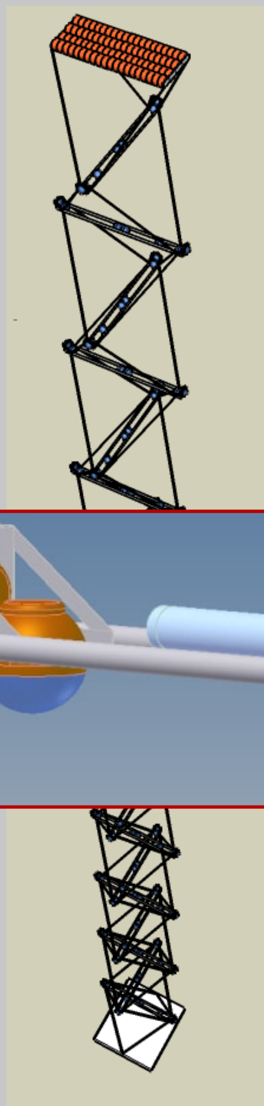
- Central physics goals:
  - Investigate neutrino “point sources” in energy regime 1-100 TeV
  - Look for very high energy neutrinos (PeV’s)
  - Complement IceCube field of view
  - Exceed IceCube sensitivity
- Operational aspects:
  - Construction time ≈4 years
  - Operation over at least 10 years without “major maintenance”

The CDR and the **TDR** (soon)

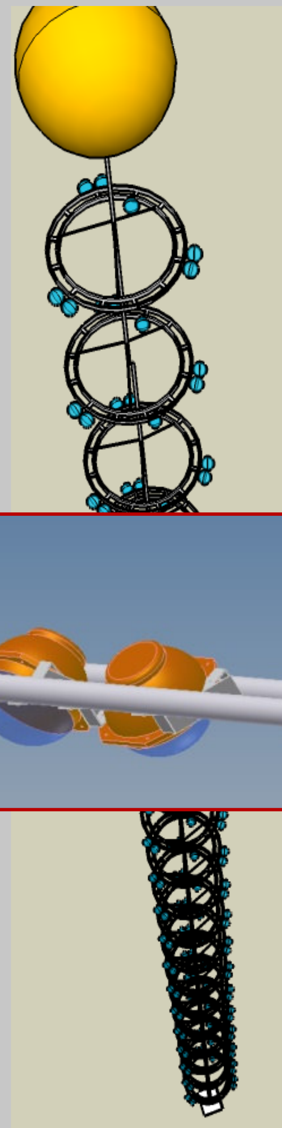
- Three different complete design options worked out to verify functionality and allow for optimisation (a path to convergence)
- Simulation studies to quantify sensitivities
- Decision on common technology platforms



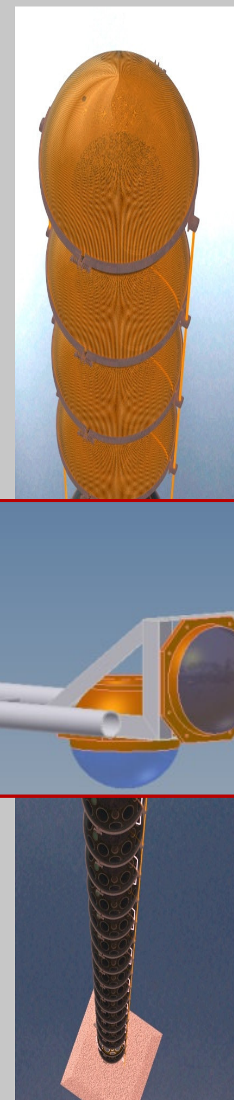
The three options for the basic detector unit being considered :



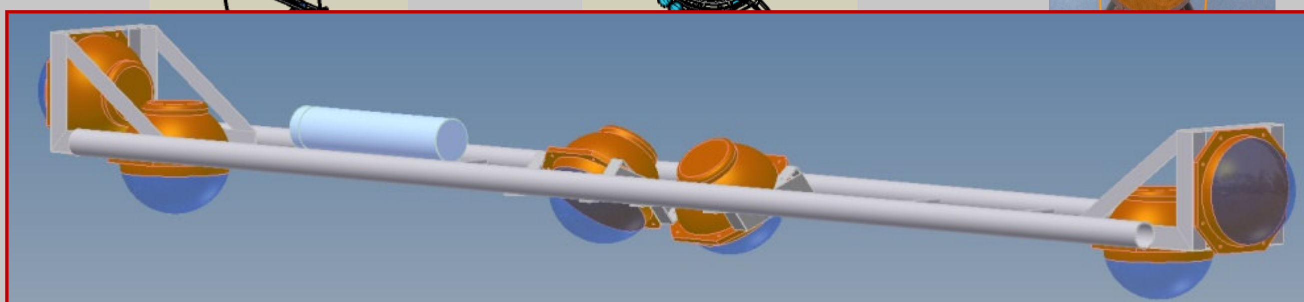
Bar design



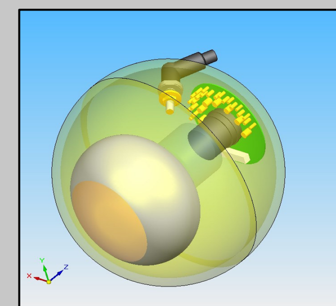
Triangular cluster



Multi-pmt strings



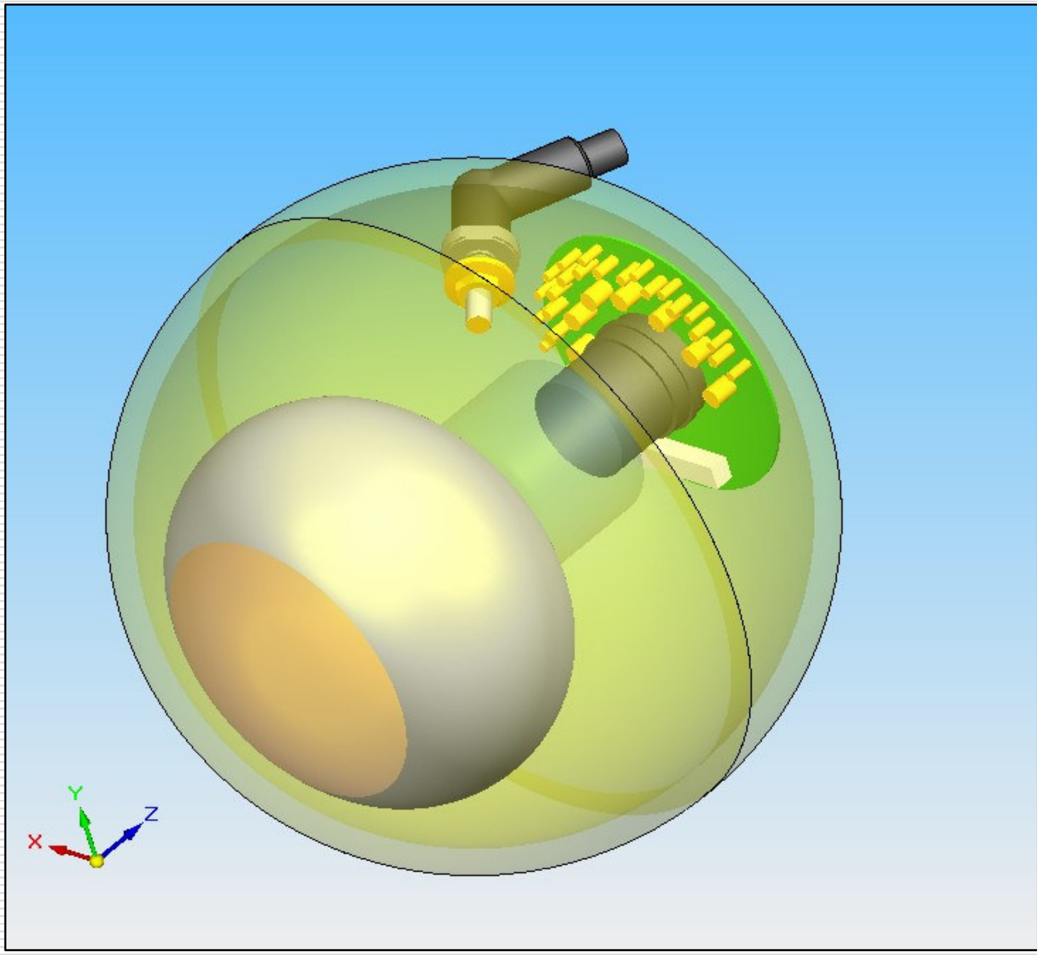
Basic component is the Optical Module :



The "classical" Optical Module: One PMT, no Electronics

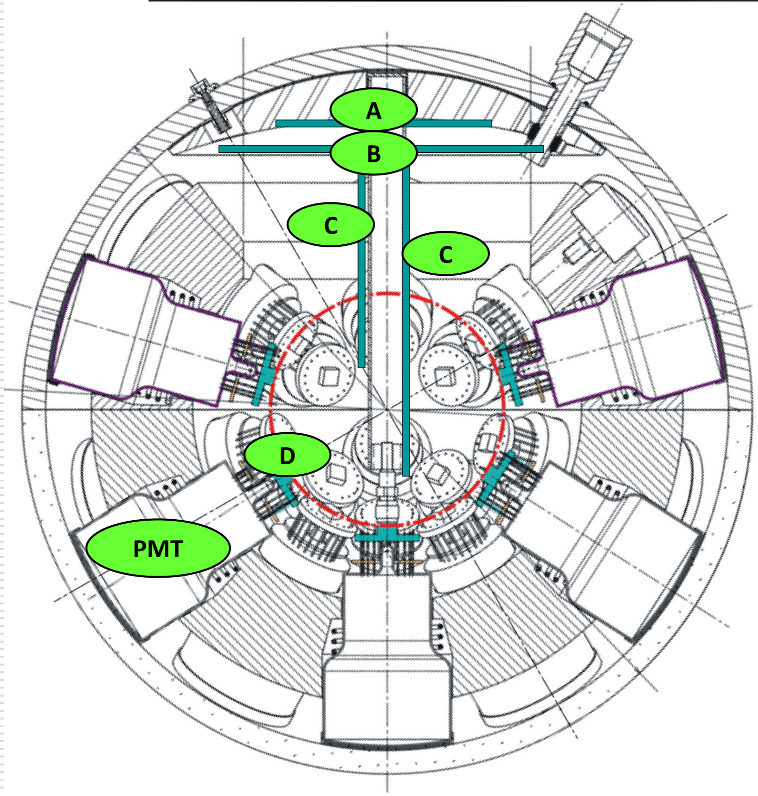
<u>Evolution from pilot projects</u>:

- 8-inch PMT, increased quantum efficiency
  (instead of 10 inch)
- 13-inch glass sphere
  (instead of 17 inch)
- no valve
  (requires "vacuum" assembly)
- no mu-metal shielding



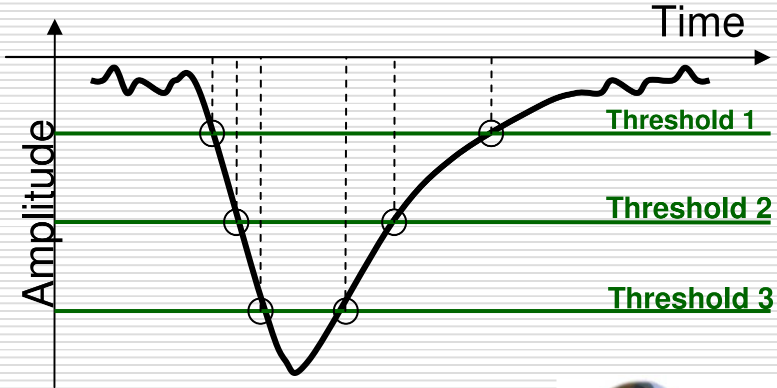
OM with many small PMTs

- 31 3-inch PMTs in 17-inch glass sphere (cathode area~ 3x10” PMTs)
  - 19 in lower, 12 in upper hemisphere
  - Suspended by compressible foam core
- 31 PMT bases (total ~140 mW) **(D)**
- Front-end electronics **(B,C)**
- Al cooling shield and stem **(A)**
- Single penetrator
- 2mm optical gel



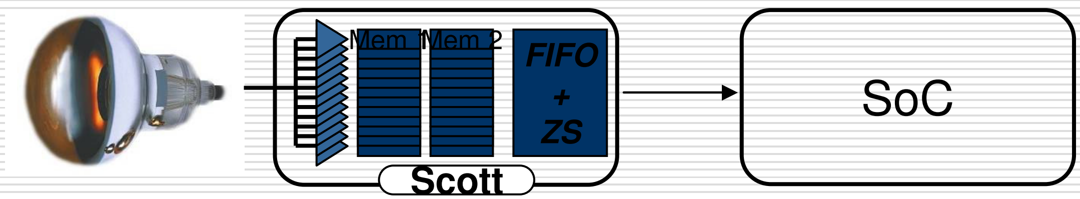
Front-end Electronics: Time-over-threshold

From the analogue signal to time stamped digital data:

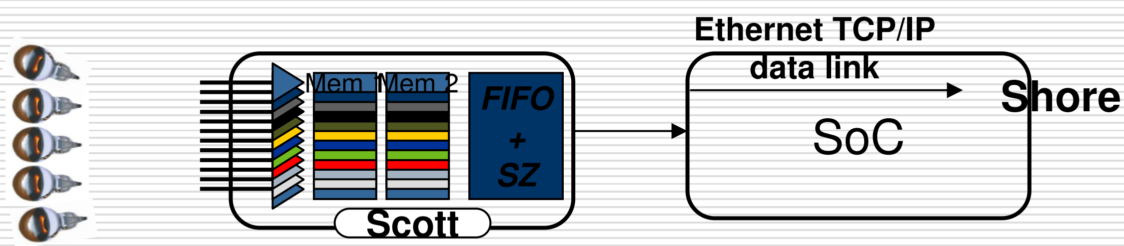


…

- N thresholds for 1 PMT



- N/k thresholds for k PMTs



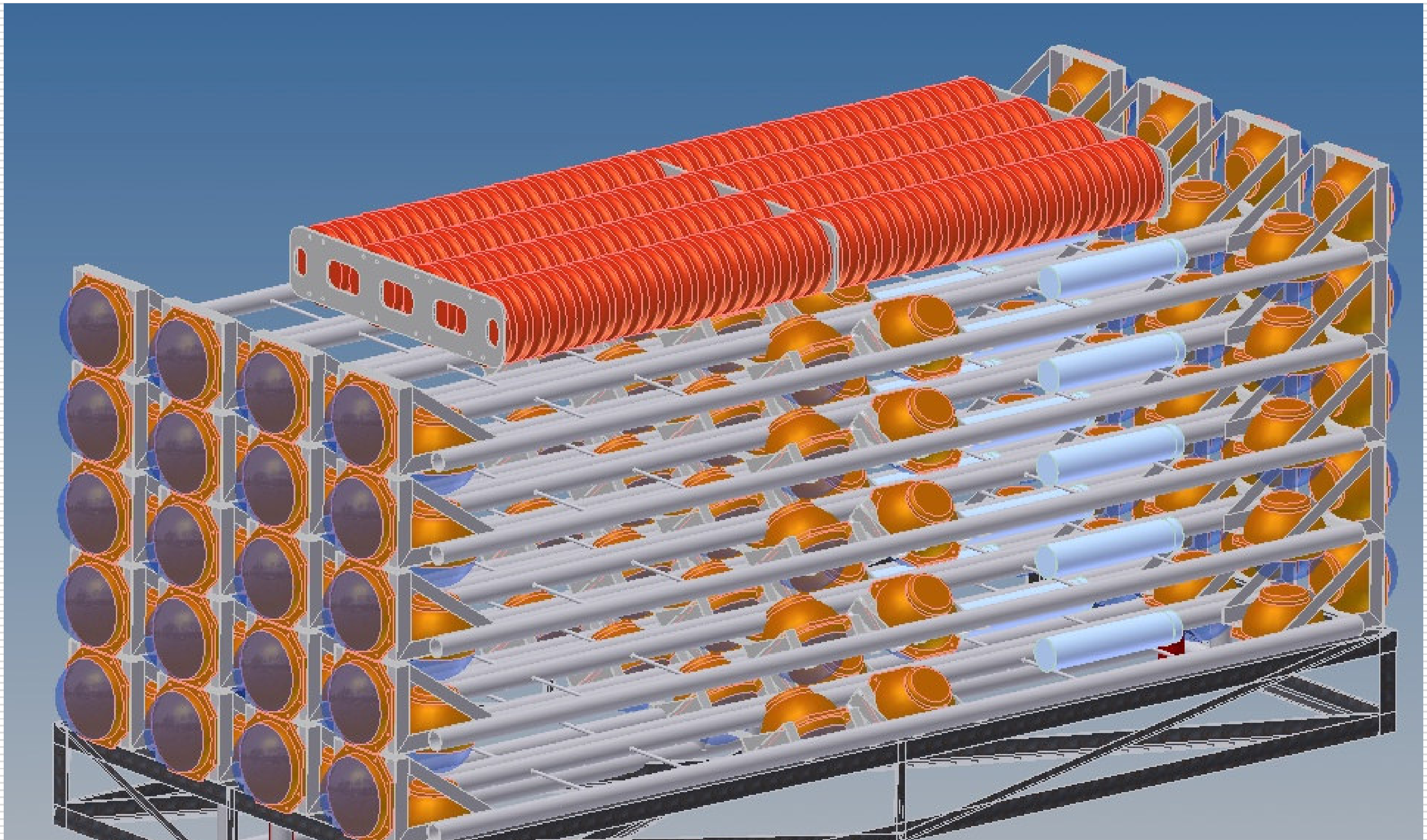
Data Network

- All data to shore:
  Full information on each hit satisfying local condition (threshold) sent to shore
- Overall data rate ~ 100-300 Gbit/s
- Data transport:
  Optical point-to-point connection shore-OM
  Optical network using DWDM and multiplexing
  Served by lasers on shore
  Allows also for time calibration of transmission delays
- Deep-sea components:
  Fibres, modulators, mux/demux, optical amplifiers
  (all standard and passive)

Deployment Strategy

- All three mechanical solutions:
  Compact package – deployment – self-unfurling
  - Eases logistics
  - Speeds up and eases deployment;
    several DUs can be deployed in one operation
  - Self-unfurling concept for all three mechanical structures;
    needs to be thoroughly tested and verified
- Connection to seabed network by ROV

A Flexible Tower Packed for Deployment

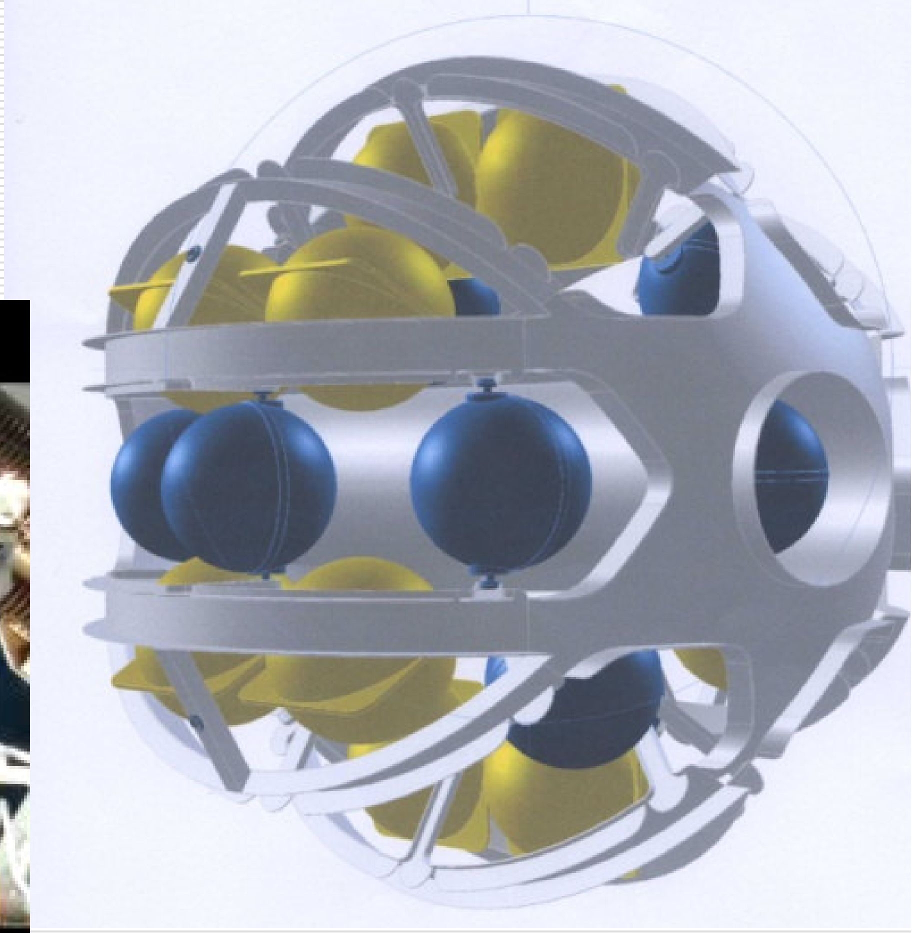


Tested in February 2010

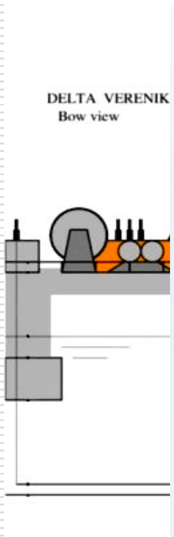
(3 minute video not included)

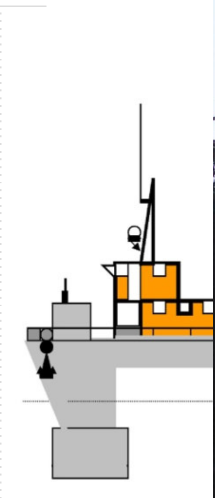
Compactifying Strings

Slender string rolled up
for self-unfurling
(tested in Dec. 2009):



A Work Platform: Delta Berenike





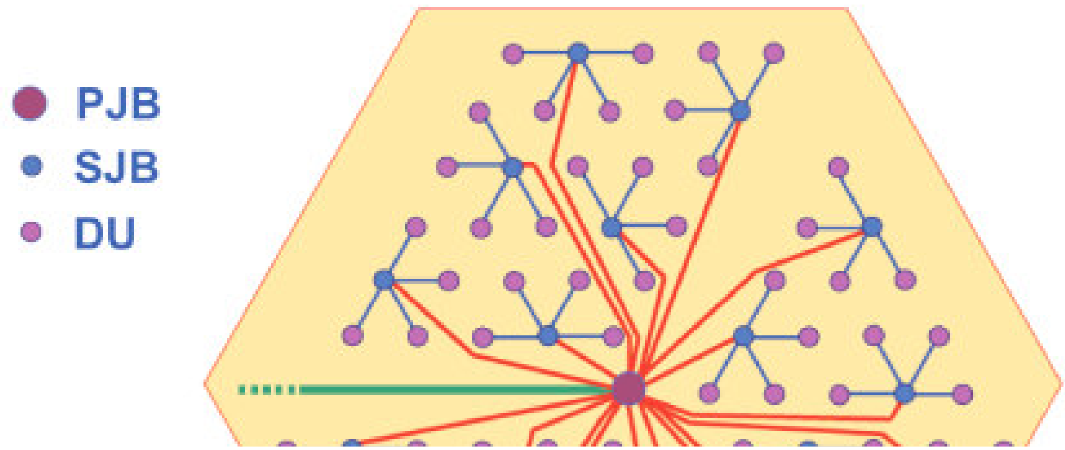
nd

surface

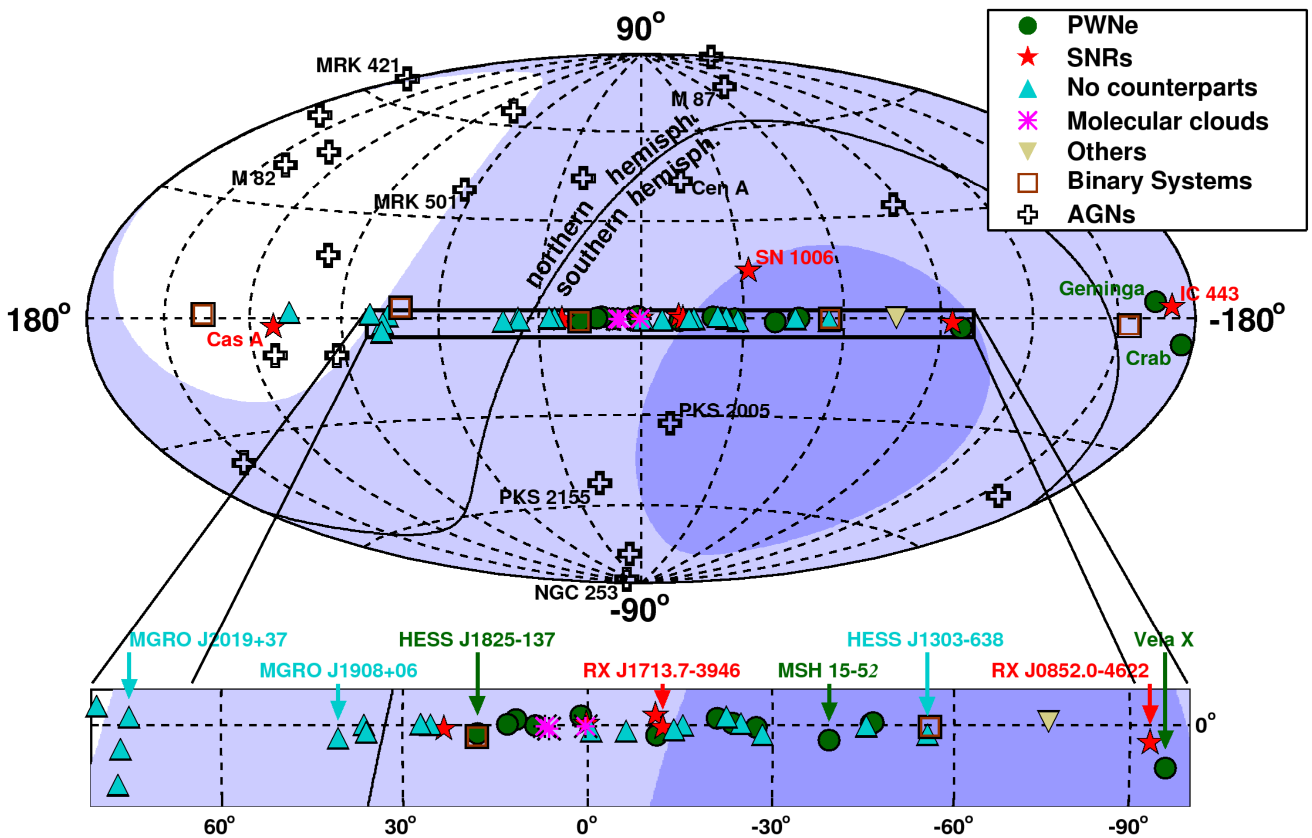
Sea-Floor Plant

- Requirements:
  - Distribute power
  - Support data network
  - Slow control communication
- Structure:
  - Hierarchical topology
  - Primary & secondary junction boxes
  - Commercial cables and connectors
  - Installation requires ROVs

Example configuration:



- Layout and topology:
  - Depends on DU design, deployment procedure and “detector footprint”
  - Important for risk minimisation and maintainability
  - Other topologies are considered

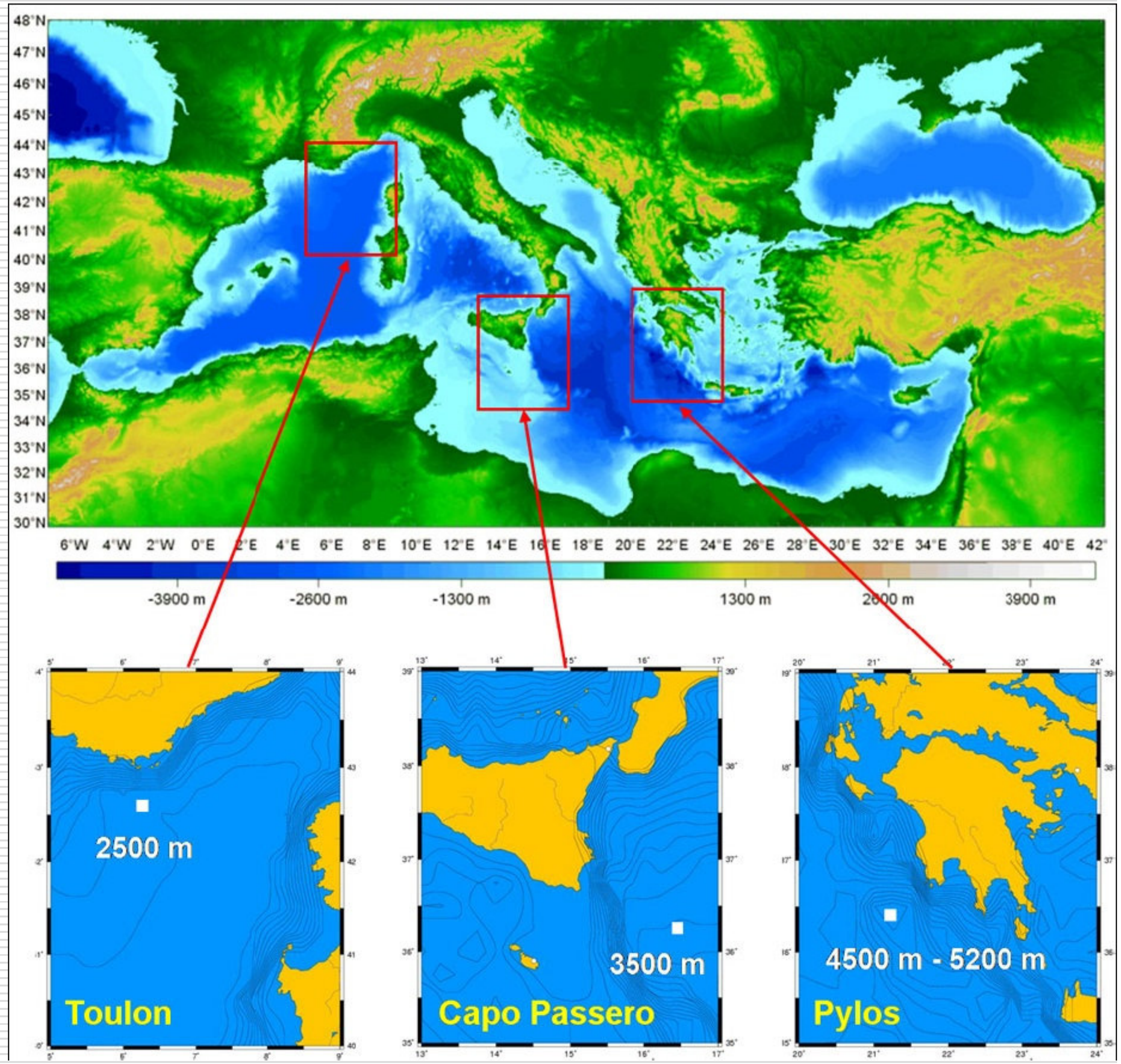


Sky coverage for detectors located in the Mediterranean Sea

Visibility for a detector in the Mediterranean with 2π downward coverage; dark (light) blue areas are visible at least 75% (25%) of the time.

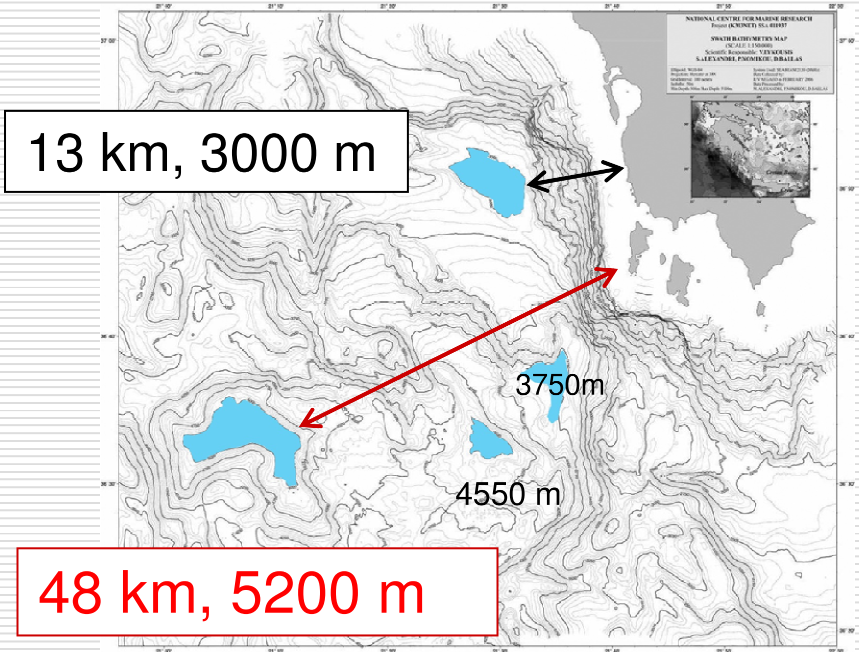
Candidate Sites

- Locations of the three pilot projects:
  - ANTARES: Toulon
  - NEMO: Capo Passero
  - NESTOR: Pylos *
- Long-term site characterisation measurements performed
- Site decision requires scientific, technological and political input



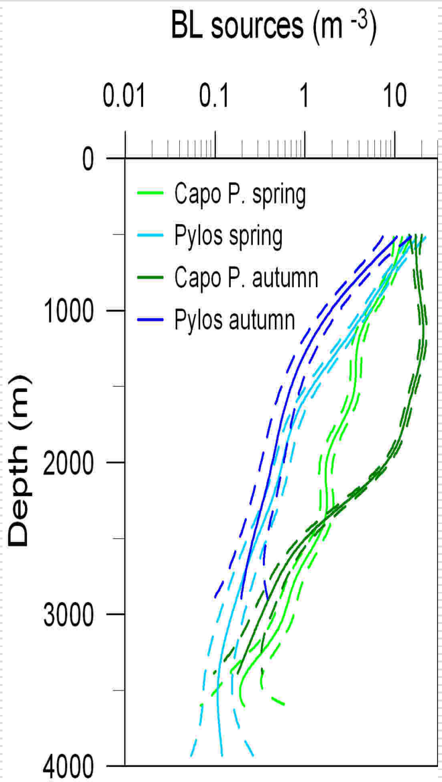
* Visitors welcome ! A lovely tourist spot as well !

A flavor of site studies …



Similar maps for Toulon and Capo Passero

Bioluminescence



The ‘other’ sciences … not to be ignored

- **Earth and marine science node**
  Objective: Design interface to instrumentation for marine biology, geology/geophysics, oceanography, environmental studies, alerts, …

  Examples:

  - Lines of autonomous sensors such as seismographs
  - Moorings containing suites of instruments to monitor surface water, water column, sea bed and subsea-floor in a co-ordinated manner
  - Fixed structures with removable modules containing instruments such as cameras and flash lights, acoustic sensors and suites of oceanographic sensors such as the proposed ESONET standard instrumentation module
  - Futuristic docking stations for gliders or autonomous underwater vehicles

Simulation Studies

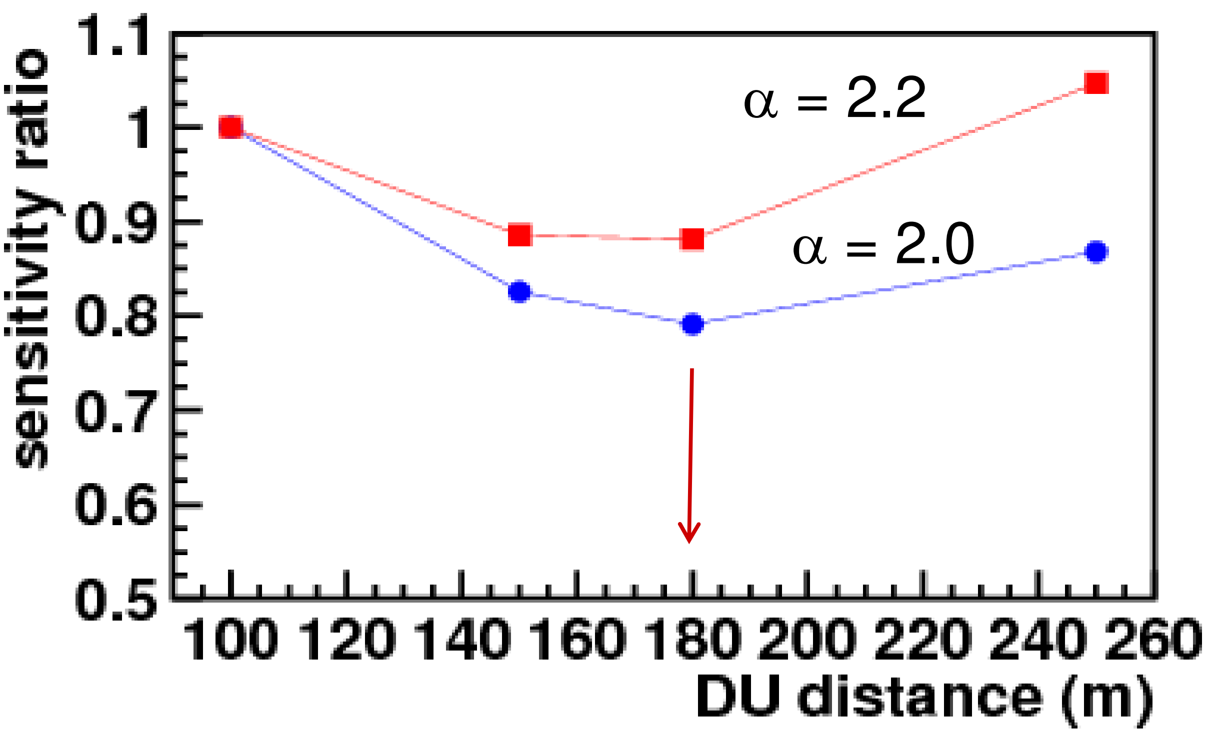
- **Simulation**
  Objective: Determine detector sensitivity, optimise detector parameters;
  Input: OM positions/orientations and functionality, readout strategy, environmental parameters
  - Simulation (using existing software)
    fruitful cooperation with IceCube on software tools (software framework, auxiliaries, …: Thank you!)
  - Reconstruction (building on existing approaches)
  - Focus on point sources

Reminder :

- Flexible towers with horizontal bars
- Slender strings with multi-PMT OMs
- Strings with triangular arrangements of PMTs

Optimisation Studies

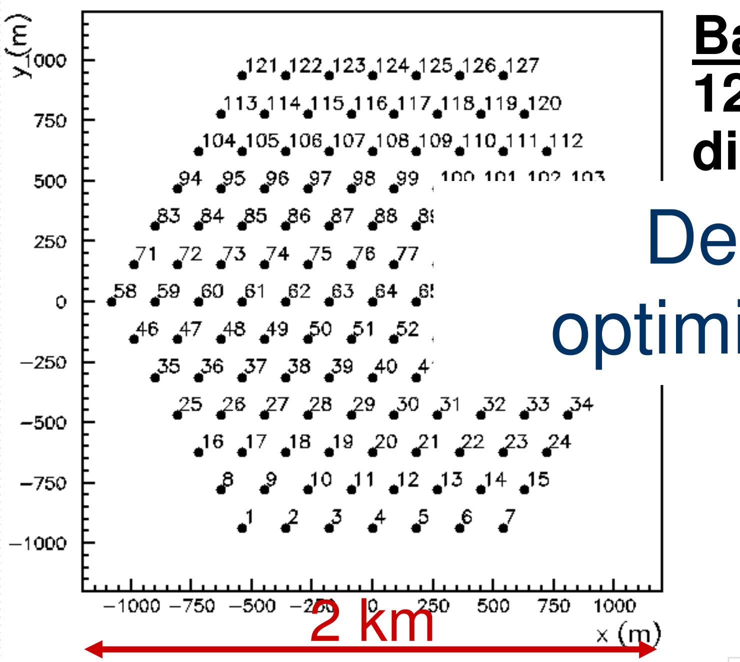
<u>Example</u>: Sensitivity dependence on DU distance for flexible towers (for neutrino fluxes ~$E^{-\alpha}$, no cut-off)



Detector Configurations

- Different DU designs
  - require different DU distance
  - differ in photocathode area/DU
  - are different in cost

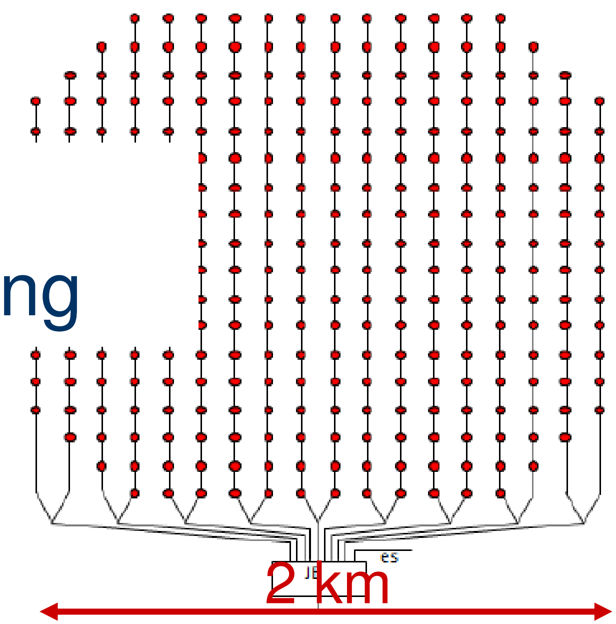
} different „detector footprints“



Bars, triangle:
127 DUs,
distance 180/150 m

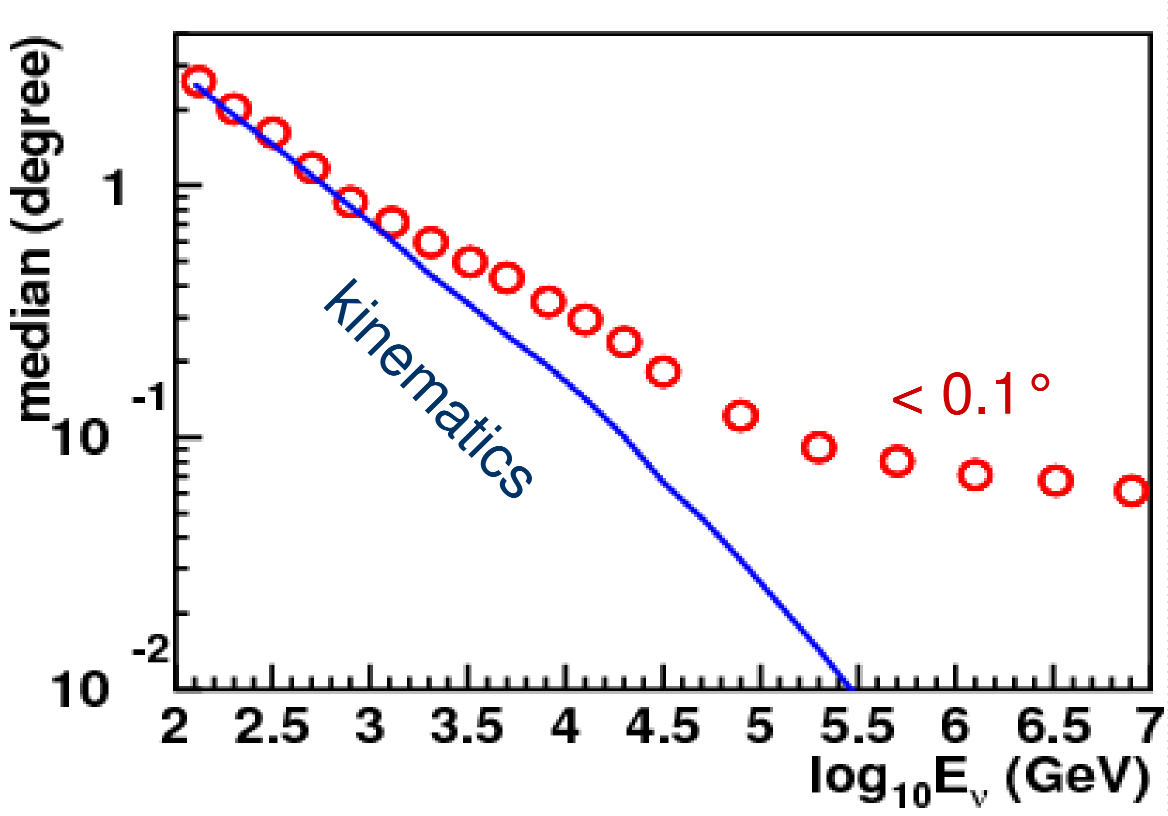
Detector footprint optimisation is ongoing

Slender string:
310 DUs,
distance 130 m

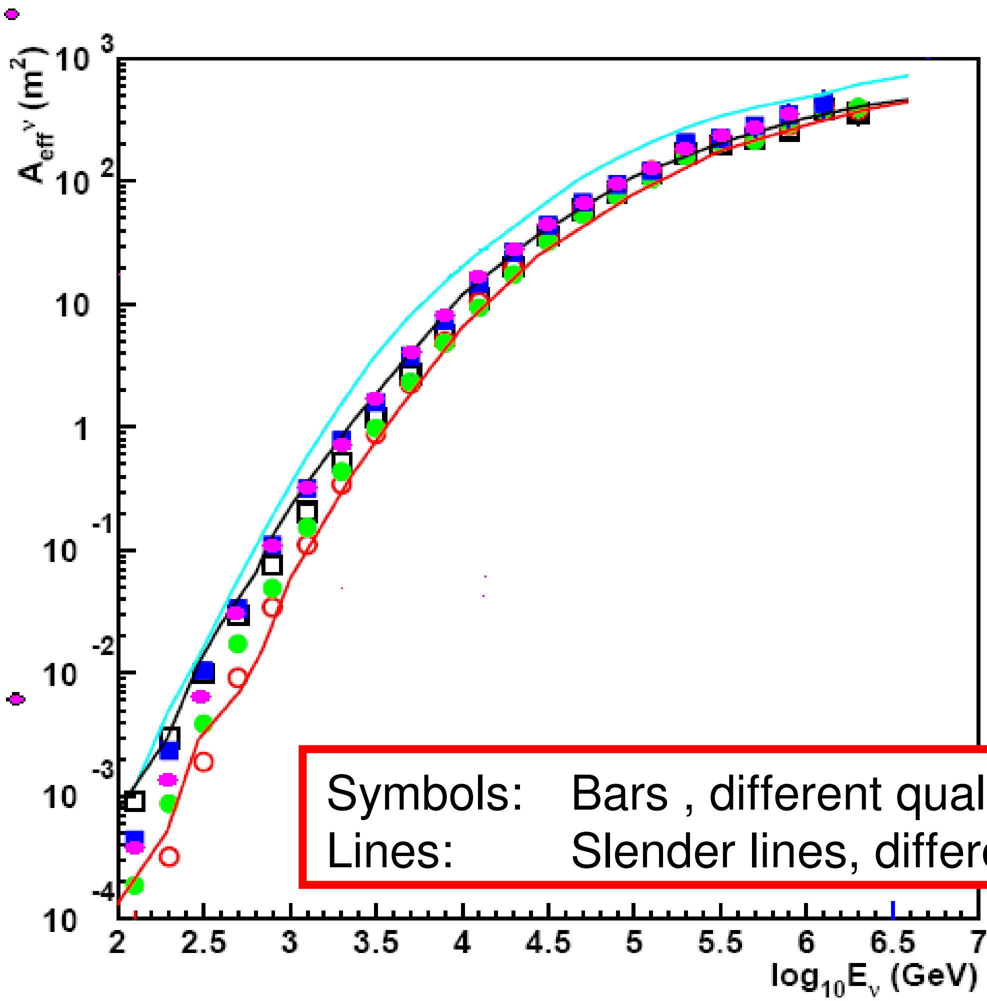


Angular Resolution

- Median angle between incoming neutrino and reconstructed muon
- dominated by kinematics up to ~1TeV

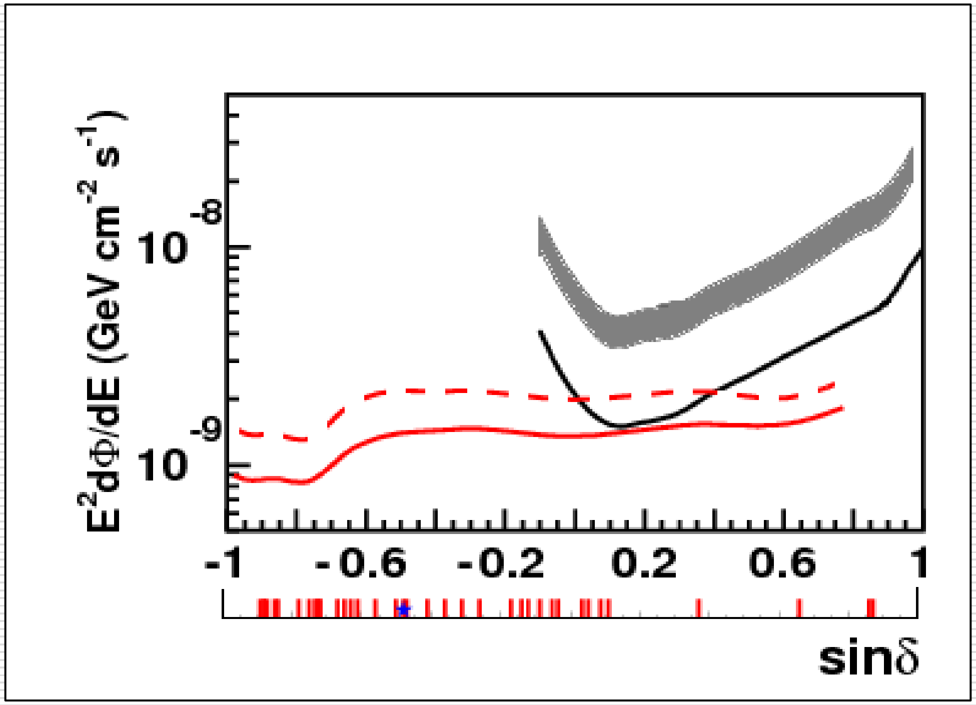


Effective Areas



Symbols: Bars , different quality cuts
Lines: Slender lines, different quality cuts

- Significant dependence on choice of quality cuts
- Flexible towers with bars and slender strings “in same ballpark”
- Driven by overall photocathode area



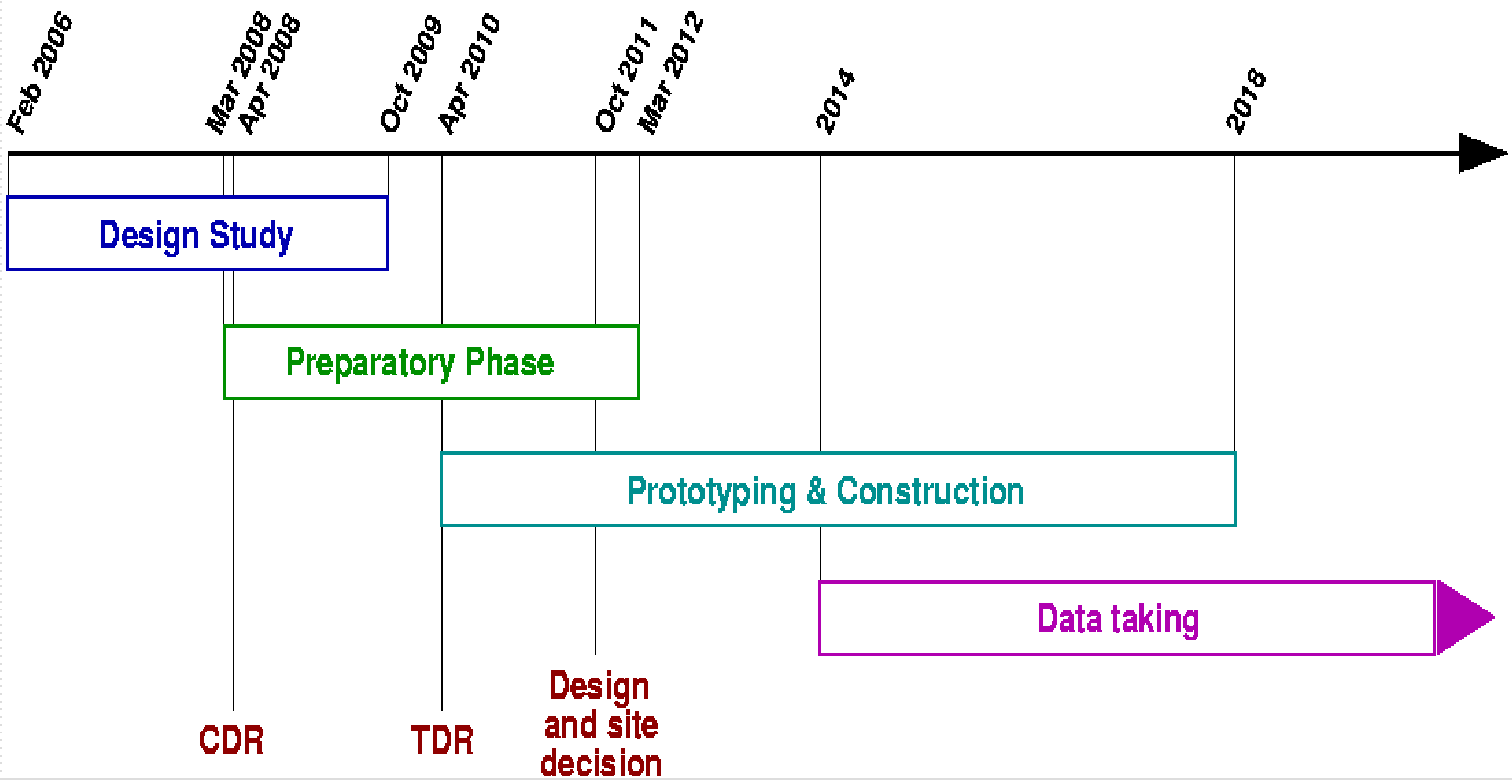
Red KM3NeT exclusion (solid) and discovery (dashed) reach for one year

(neutrino point sources with an E^{-2} spectrum Both are estimated with the binned analysis method)

Black are the IceCube exclusion sensitivities for one year, estimated with the unbinned method (full line).

Shaded band - IceCube discovery a factor 2.5 to 3.5 above the exclusion line.

Time line



Feb 2006
Mar 2008
Apr 2008
Oct 2009
Apr 2010
Oct 2011
Mar 2012
2014
2018
Design Study
Preparatory Phase
Prototyping & Construction
Data taking
CDR
TDR
Design
and site
decision

Conclusions

- A design for the KM3NeT neutrino telescope for ~250 M€ would *substantially* increase the physics potential of existing experiments
- Within at most 2 years, remaining design decisions have to be taken and the site question clarified
- Construction could start in ~ 2013 and data taking in 2-3 years time after that
- A brave new world in neutrino (astro)physics and neutrino astronomy will soon be arriving!

For more details ….

We have three posters on display … highly recommended !

- Katerina Tzamariudaki (no 185)

  KM3NET: A Large-Scale Underwater Neutrino Telescope
- Oleg Kalekin (no. 187)

  Optical Modules and Readout Scheme for the KM3NeT Neutrino Telescope
- Tommaso Chiarusi (no 186)

  Towards a Design for a Large Scale Underwater Neutrino Telescope, Test Deployments, and the Site Studies

Also a related poster is :

- Apostolos Tsirigotis (no 196)

  Tools and Methods for Underwater, High Energy Neutrino Telescopy

The end

backup and other picture slides follow