KM3NeT

a multi-km^3 neutrino detector

on behalf of the KM3NeT consortium
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ECRS 2010, Turku, Finland

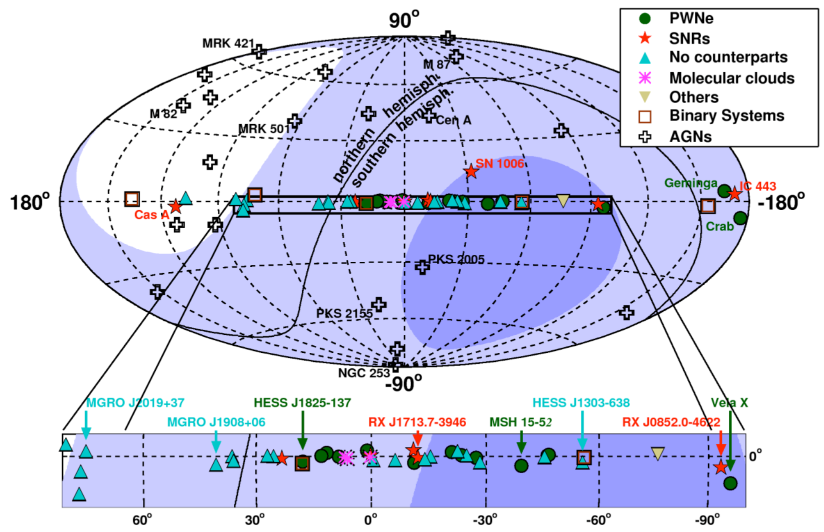
Research objectives

- Detection of neutrinos from
  - High energy gamma ray sources
    - Galactic (SNR, Micro-Quasars, ….)
    - Extra galactic (AGN)
  - Gamma ray bursters
- GZK neutrinos: $p\gamma \rightarrow \Delta \rightarrow n\pi^{+}$
- Indirect search for Dark Matter
- Earth and Marine Science measurements *(not in this talk)*

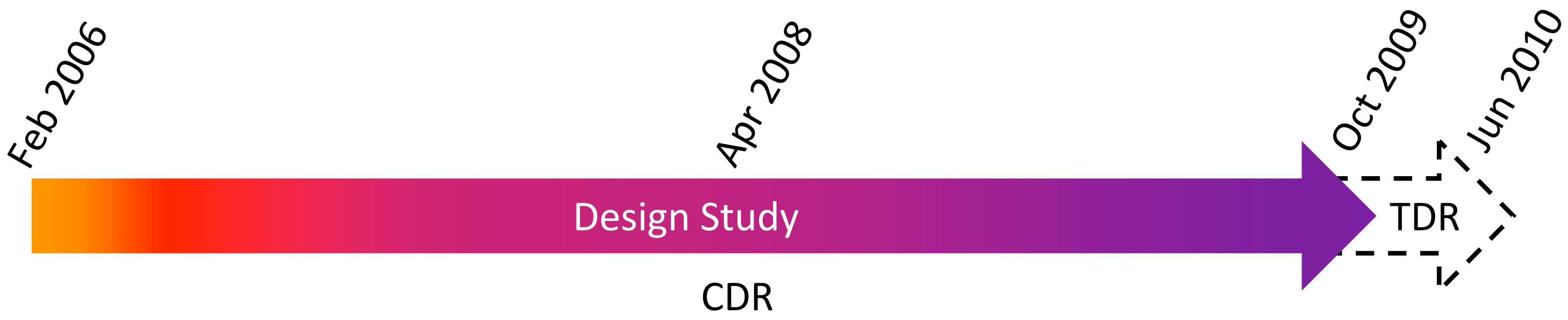
Plenary talk of A. Kouchner

Design study

- Detector for cosmic neutrinos of at least 5 km^3
- Situated in the Mediterranean Sea
- Optimal sensitivity for Galactic sources
- Targeted budget 200-250 M€



Sky view from Mediterranean Sea



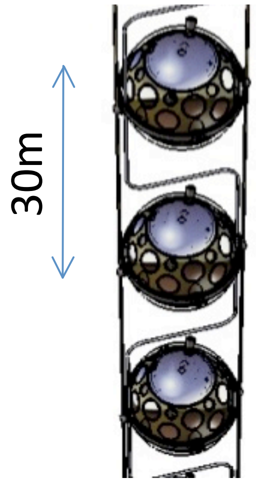
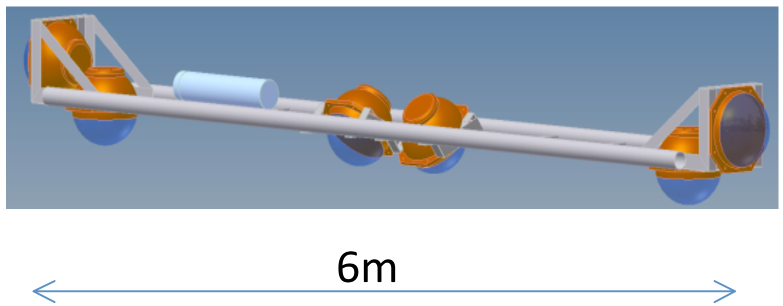
Environmental constraints

Technical constraints due to detector environment:

- Deep sea at 3-5 km depth → tests at 600 bar
- 40-100 km off shore → long distance data transmission
- Sea water
  - sea currents → flexible mechanical structures
  - chemically aggressive → choice of materials
  - ^{40}K decay → local coincidences required
- Weather at sea → compact sensor deployment

Details of design in TDR at www.km3net.org

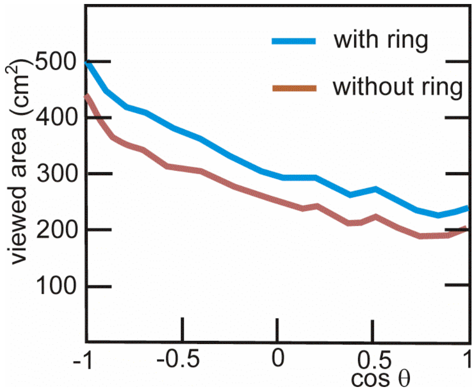
Sensor distribution strategies

Distribute sensors as uniform as possible	**Concentrate sensors as much as possible on a single unit**
• "Easy" deployment – many units at a time • Lightweight units  	• Extended "tower" structure • Less wet-mateable connections 

Light detection modules

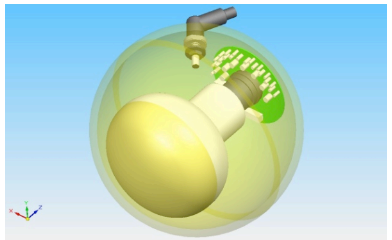
Multi-PMT Digital Optical Module

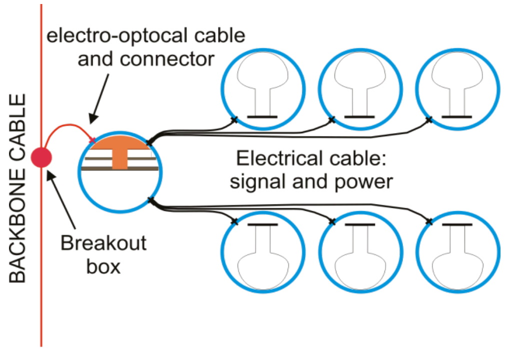
- Stand-alone module with 3 inch PMTs +reflector rings
- Equivalent of 3 10" PMT in single sphere
- r/o electronics inside



"Standard" Single-PMT Optical Modules

- 6 modules with 8 inch PMT
- 1 electronics container





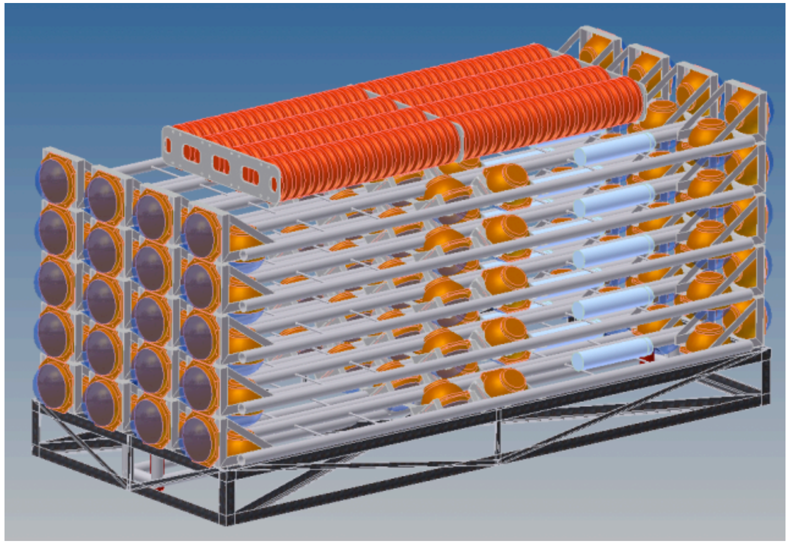
Compact deployment

Re-usable frame

Unfurling “bottom to top”

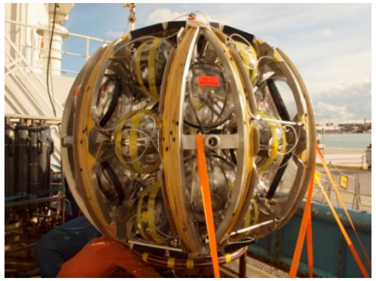
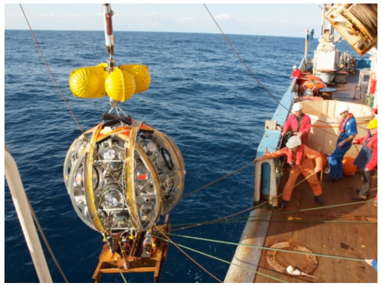
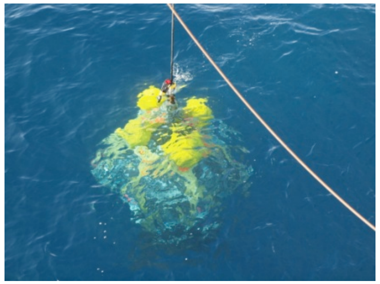
Packaged bars

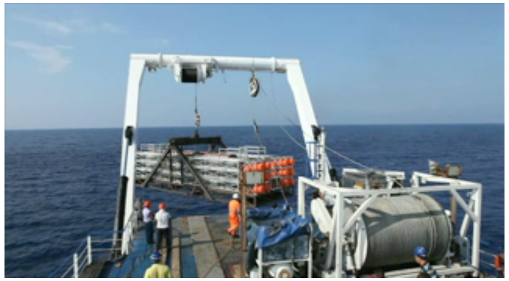
Unfurling “top to bottom”



Deployment tests

December 2009 **Un-furling "from bottom to top"**	**February 2010** **Un-furling "from top to bottom"**

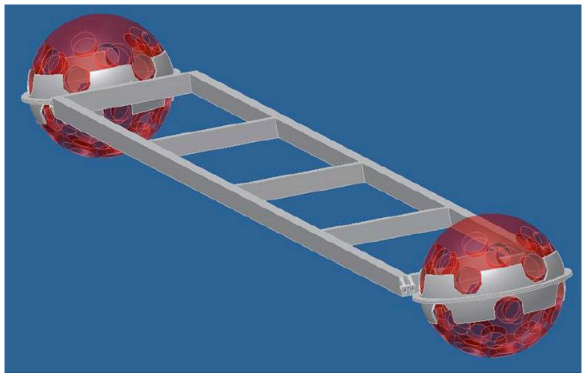





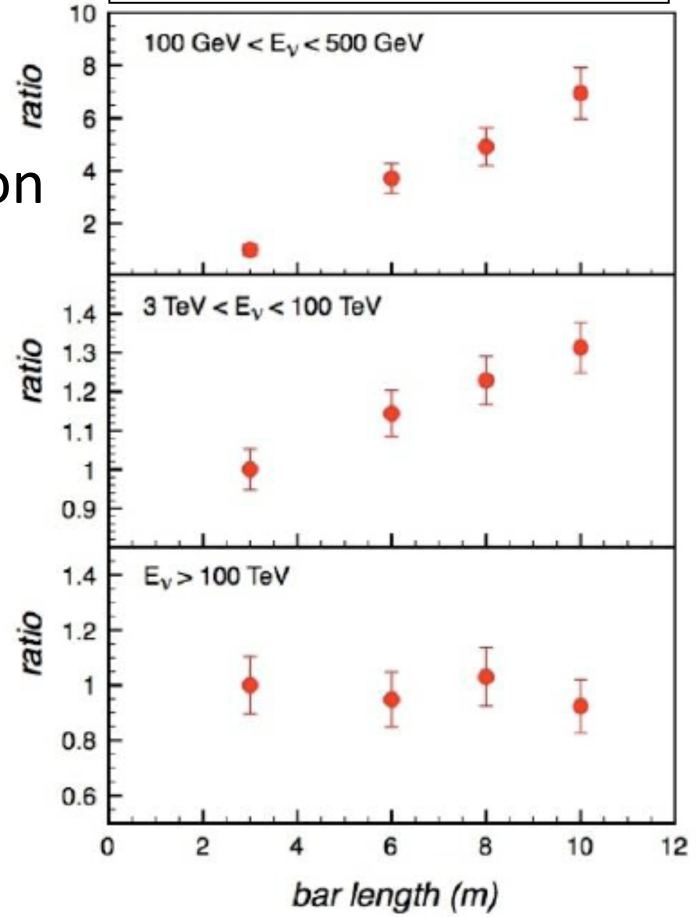

Optimisation

- Advantage of tower with bars
  - At low energy higher neutrino effective area
- Advantage of multi-PMT DOM
  - Excellent separation one/two photon hits
  - Looking upwards

→ Two multi-PMT DOMs at either end of a bar (field tests)

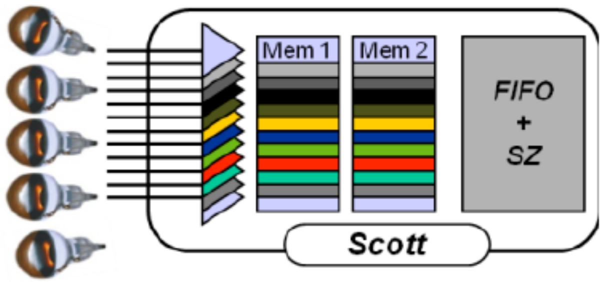


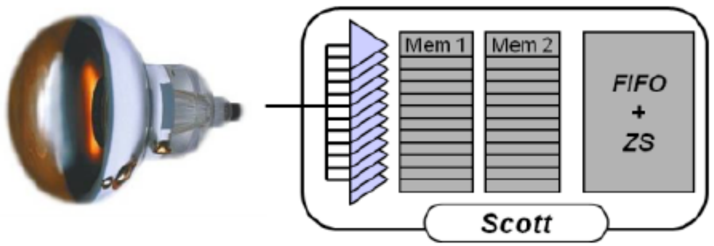
Ratio compared
to bar length of 3m



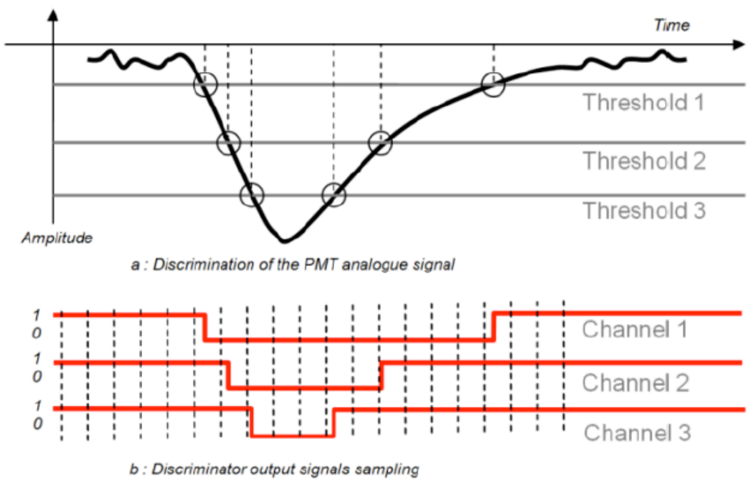
FE electronics

- Dedicated ASIC





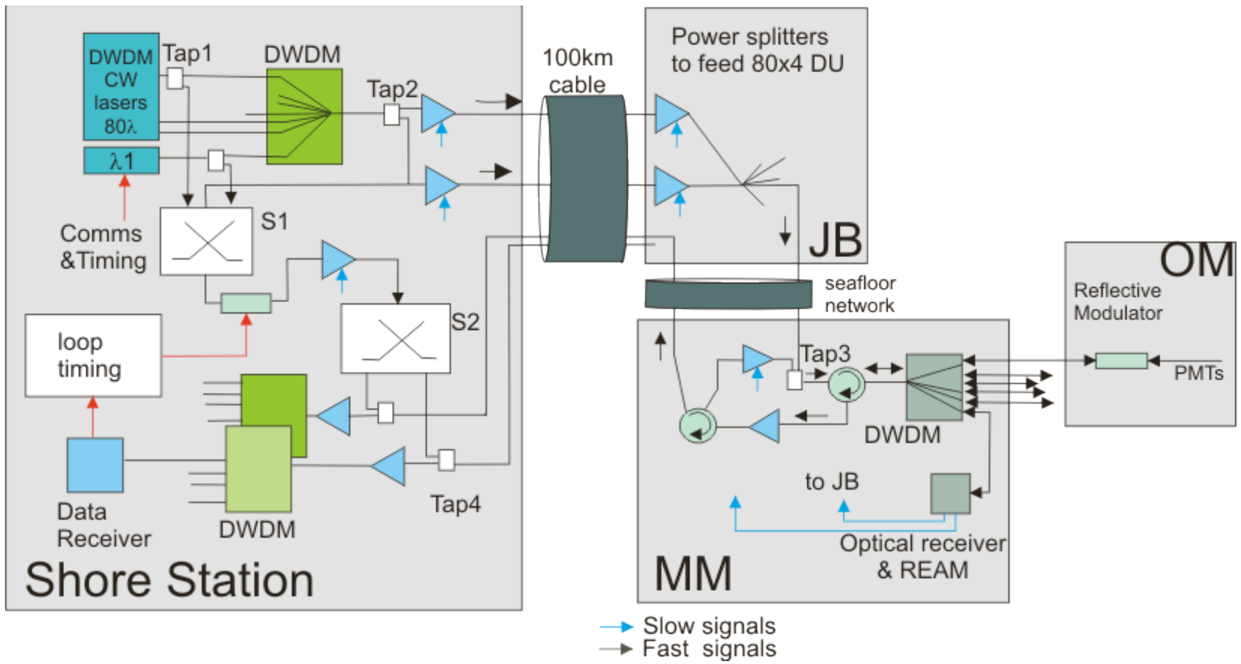
- ToT processing
  - 1 threshold for multi-PMTs
  - Multi thresholds for single PMT



Readout/DAQ network

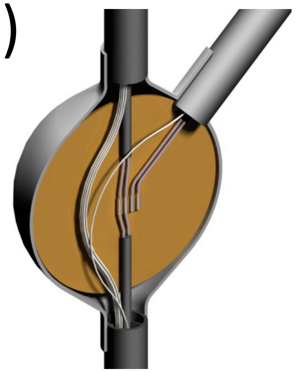
Readout via optical reflective modulation

- transfer up to 10 Gb/s
- timing accuracy 10-100 ps over 100 km



Vertical e/o backbone cable

- Every bar/every DOM has a single optical channel to shore
- Need vertical cable with breakout at each bar
- Two solutions:
  - "standard" armoured cable with breakout in pressure vessel
  - Pressure Balanced Oil Filled system – fibres run in oil-filled hose at ambient pressure (field tests)



Facilities for sea operations

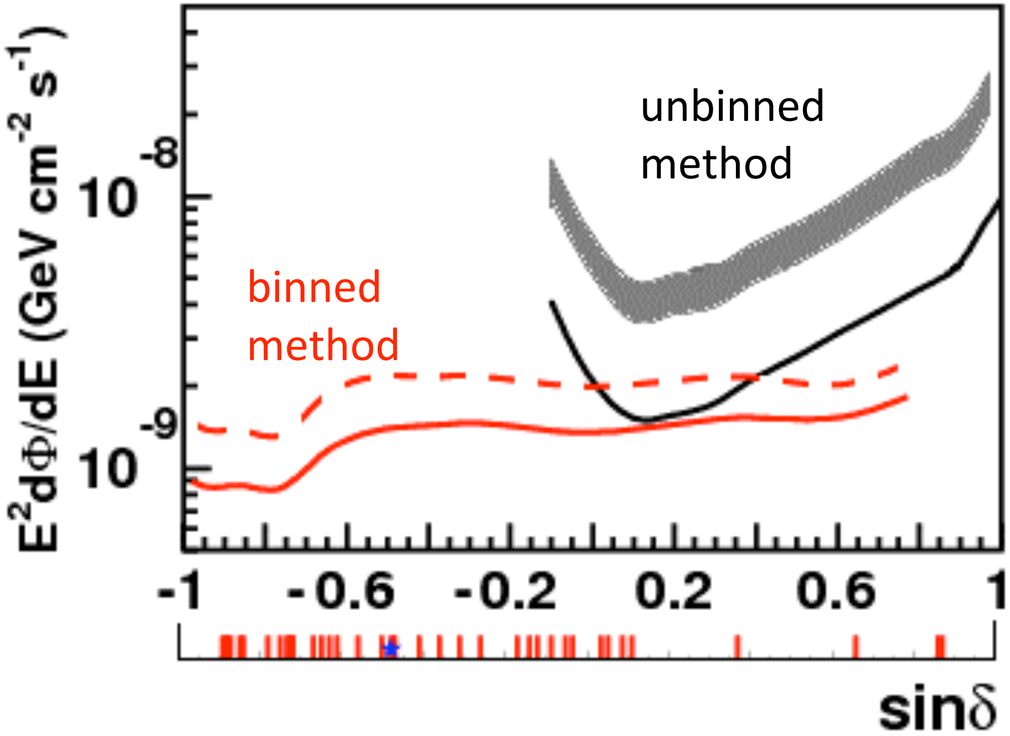
Deployment platform
Delta Berenike

Cougar in its garage

ROVs for deep sea

Performance

Sensitivity to neutrino point sources with E^{-2} spectrum (one year of observation time)



| Observed Galactic TeV-γ sources

F. Aharonian et al. Rep. Prog. Phys. (2008)

Abdo et al., MILAGRO, Astrophys. J. 658 L33-L36 (2007)

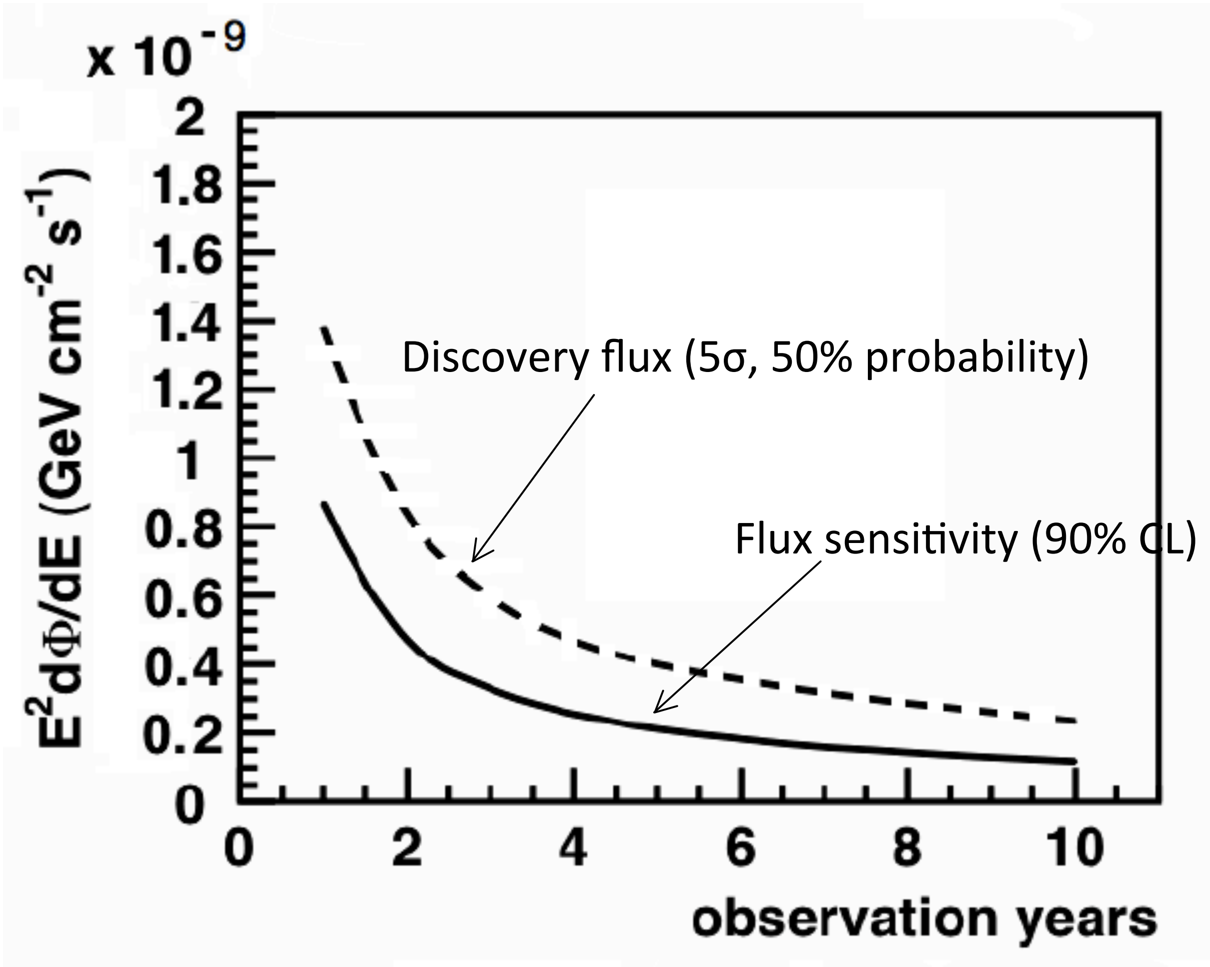
★ Galactic Centre

For Galactic sources, sensitivity of Antares/Baikal surpassed by ~ two orders of magnitude

Performance

Sensitivity as function of observation time

Declination 60º and α=-2



Performance

expected events in 5 year observation time for possible Galactic neutrino sources

Source Name	Source radius (°)	Visibility	Number of events For $E_\nu > 5$ TeV	
			Signal ν	Atm ν
RX J1713.7– 3 946	0.7	0.74	4 – 11	6.4
RX J0852.0– 4 622	1.0	0.84	2 – 6	17
HESS J1745– 3 03	0.2	0.66	0 – 22	1.4
HESS J1626– 4 90	< 0.1	0.91	4 – 9	1.6
Vela X	0.4	0.81	4 – 15	3.5
Crab Nebula	< 0.1	0.39	1 – 3	0.8

Performance

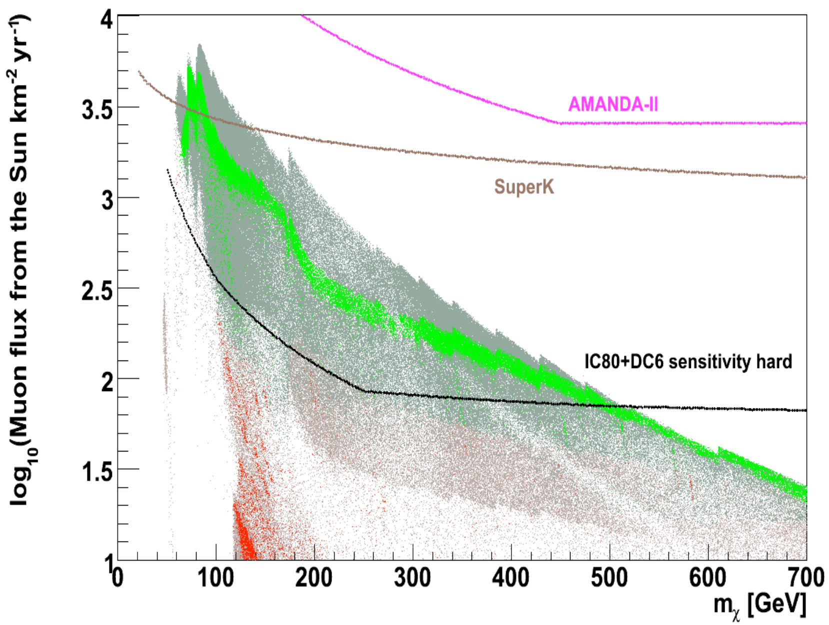
expected events (large uncertainty) for the two most energetic GRBs detected in 2008

GRB	Signal	Background
GRB080319B	2.6	5×10^{-4}
GRB080916C	2.7	5×10^{-4}
100 typical GRB	12	6×10^{-2}

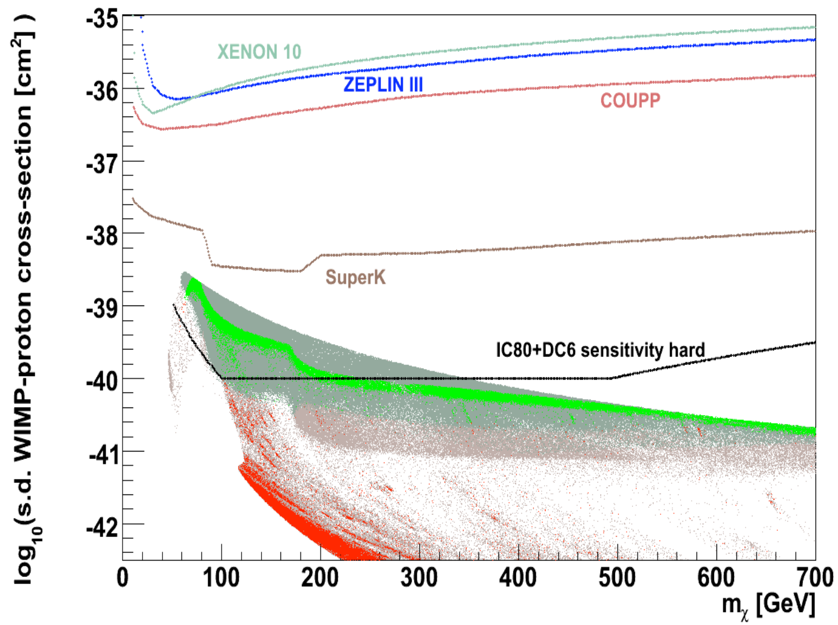
expected events for 100 GRBs according to Waxman-Bahcall reference spectrum

Performance

mSUGRA Dark matter annihilation in the Sun



Spin-dependent WIMP-proton cross section



Green: models within KM3NeT detection reach

Red: outside this reach

Preparatory Phase

- Production preparation → description of production-models (PM)
  - Field tests of pre-production-models (PPM)
  - Tender rules for production-models
  - Assembly/Integration lines inclusive test equipment, HR+location requirements
- Site/footprint decision
- Governance/Legal Identity/Funding profile

Summary

- Possible to build a detector of > 5 km^3
- Technology optimisation is on going
- Sensitivity better than any other detector
- For Galactic sources two orders of magnitude better than Antares/Baikal - Can still be further optimised
- For W-B GRB flux a few events per year with a few neutrinos can be detected
- Dark matter: sensitivity to spin dependent interactions better than that of direct experiments
- Need to start building (taking data) → 2013 (2014)

KM3NeT
Opens a new window on our universe