KM3NeT

P.Kooijman
Universities of Amsterdam & Utrecht
for the consortium

KM3NeT Goals

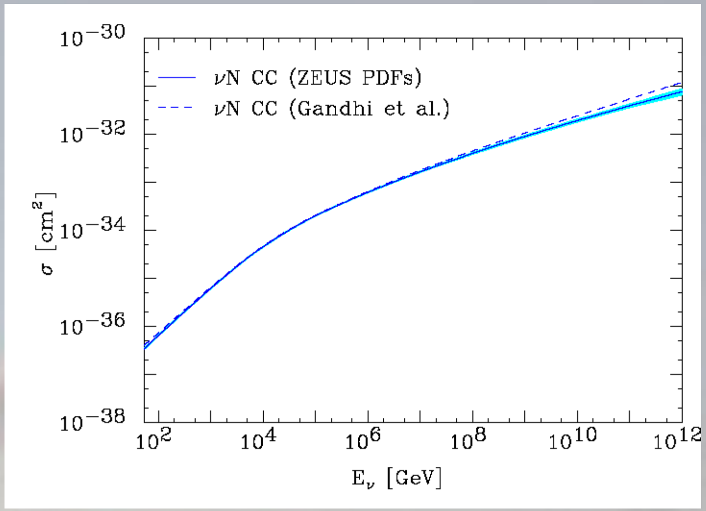
Neutrino telescope for detecting cosmic neutrinos

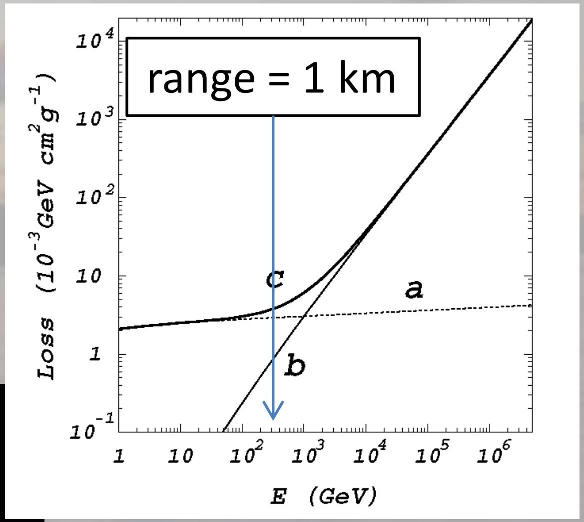
- Dark Matter Annihilation (100-500 GeV)
- Galactic sources (E^{-2} up to ~100 TeV)
- Extragalactic sources (E^{-2})
- Gamma Ray Bursts (E^{-1} to E^{-2})
- GZK neutrinos ($p\gamma \rightarrow \Delta \rightarrow n\pi$) (≥ 10 PeV)

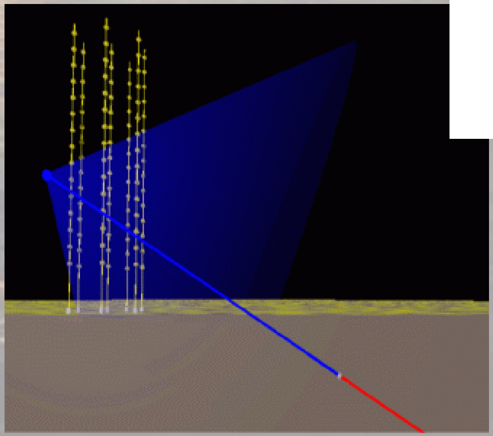
Design study FP6 last 4 years --- TDR just published
Preparatory Phase FP7 ongoing
On ESFRI Roadmap

Detection Method

- Interaction of neutrino with water or earth
  - charged current for ν_μ produces high energy muon
  - neutral current and ν_e and ν_τ produce showers
- Cross section rises with energy
- Muon range increases with energy
- Charged particles produce Cherenkov light





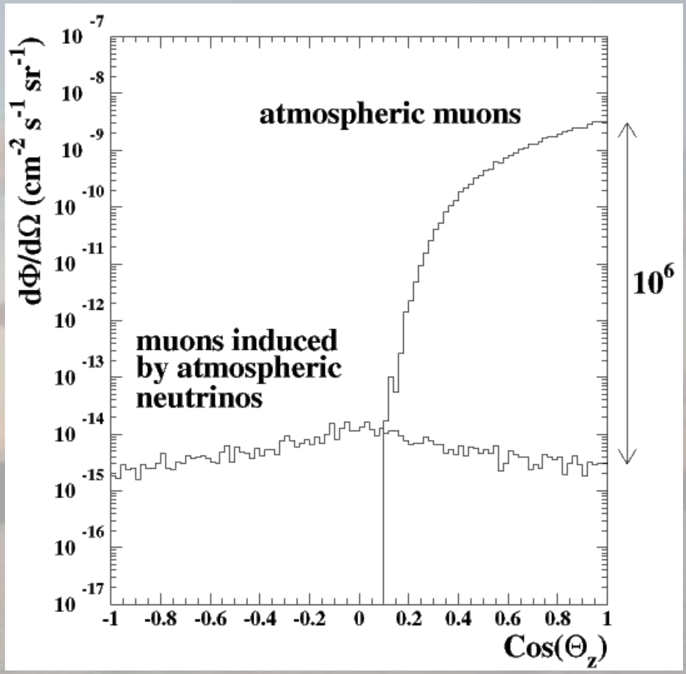


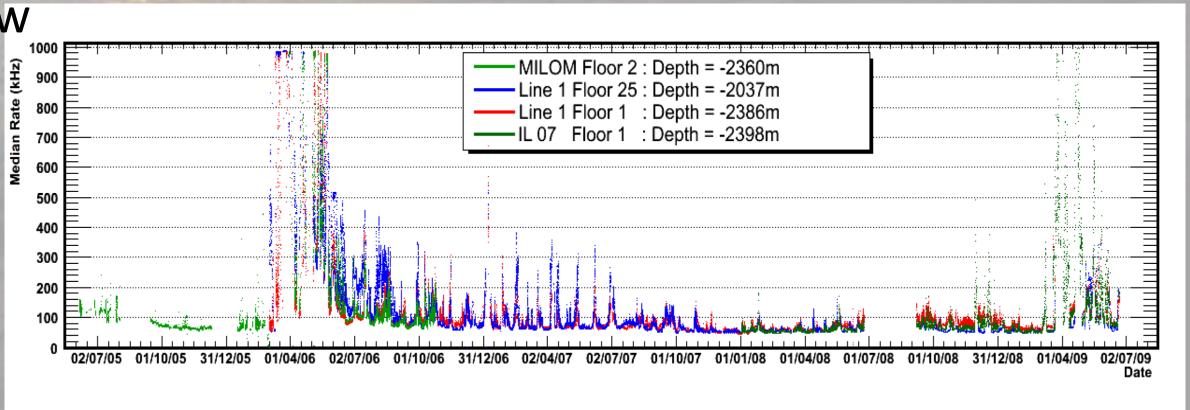
KM3Net Design Study

- Detector in Northern Hemisphere
  - neutrinos from galaxy travel upward -> low background
- More sensitive than any other neutrino telescope
  - IceCube is ~1 km^3 in southern hemisphere
- Build on experiences of pilot projects
  - ANTARES (Toulon), NEMO (Sicily), NESTOR (W. Peleponesis)

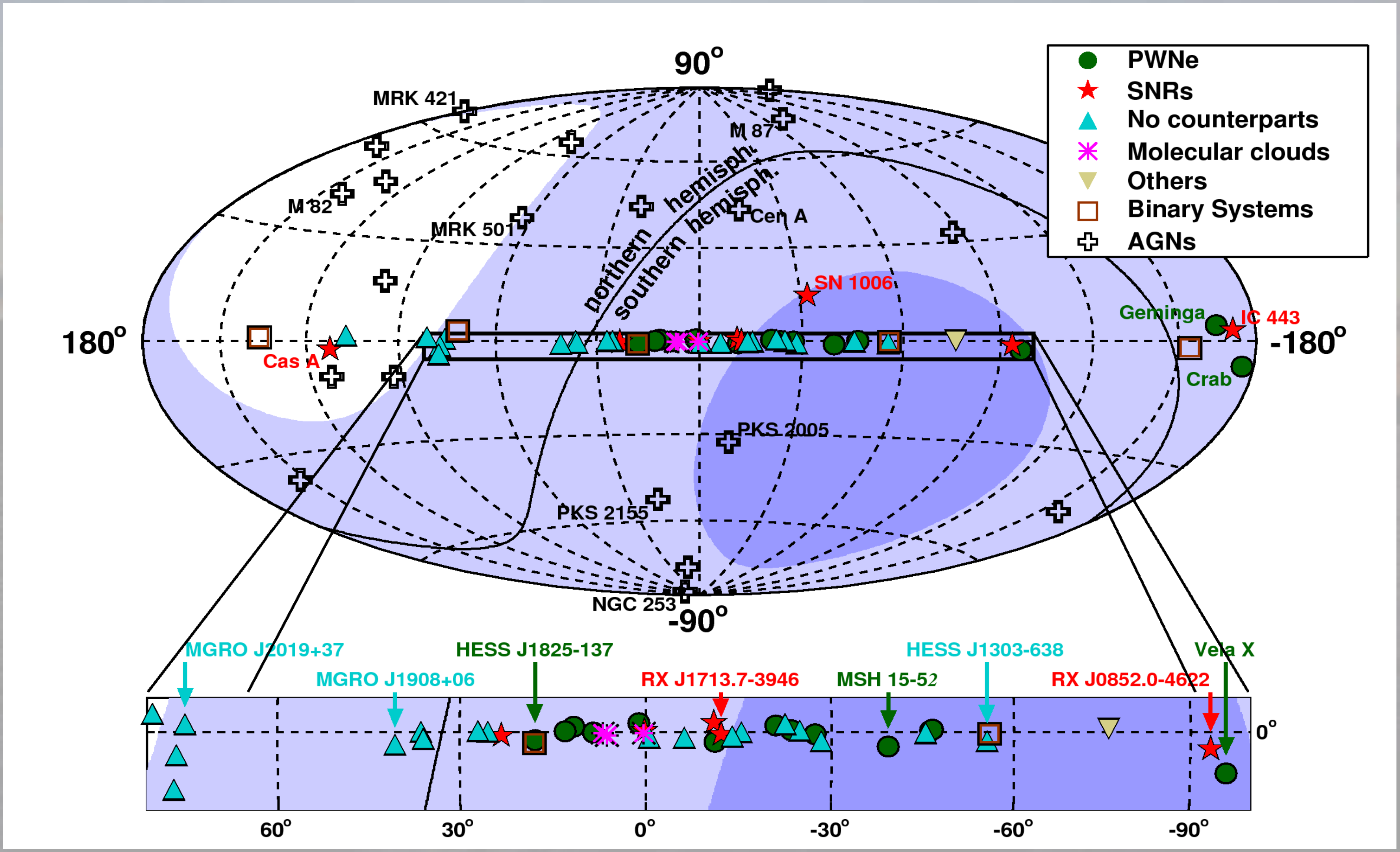
Detection method

- Need enormous volume
- Light sensors for single photons
- Backgrounds from 40K
- Backgrounds from bioluminescence
- Backgrounds from cosmic rays
  - muons from extensive airshowers from above
  - neutrinos from extensive airshowers from below



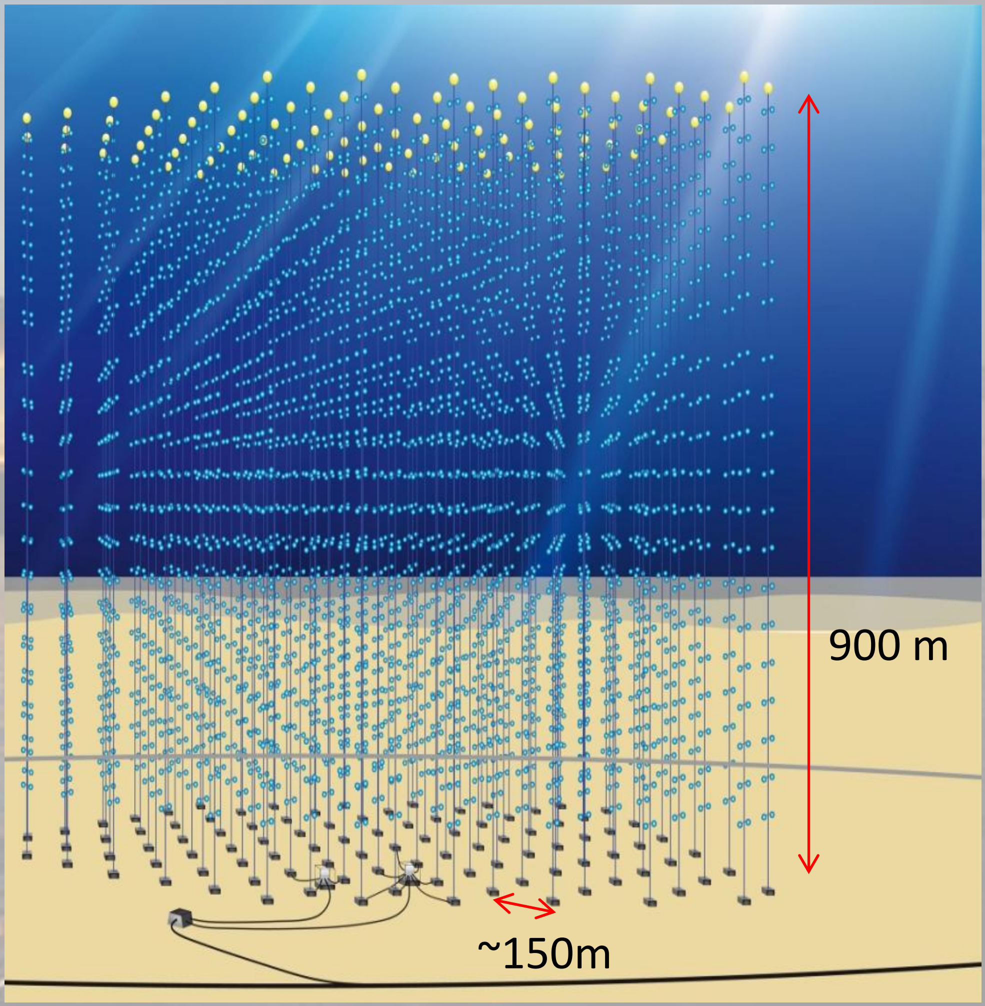


Sky Coverage for Mediterranean



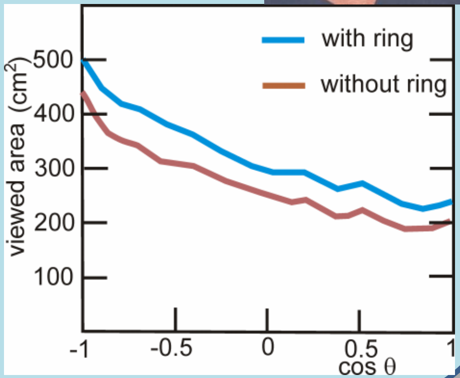
Detector Array

- Distribute photo-sensors over large volume - sustaining up to 500 bar
  - area on sea bottom 6-8 km^2
  - height about 1 km
- Transport the signals to shore
  - collect via seafloor network fibre optic network (several kilometres)
  - via fibre optic cable to shore (up to 100 km)
- Power via copper in opposite direction
  - premium on low power consumption (< 100 kW)
- Reconstruct tracks from time and position information
  - relative time calibration to better than 1 ns (over pathlength differences of km)
  - relative position calibration to better than 20 cm (deep sea water current)

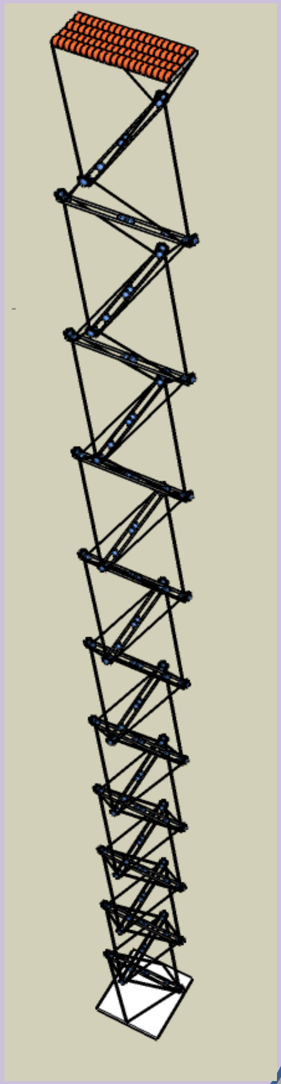


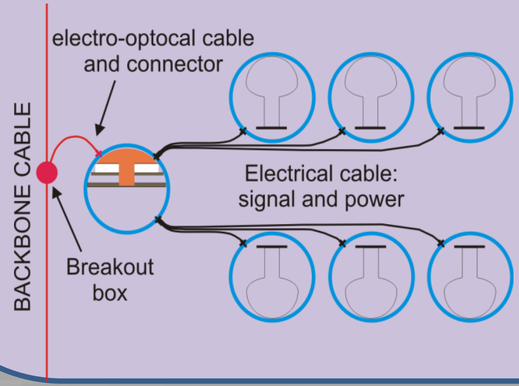
Cherenkov single photon detection modules being considered

- Multi-PMT DOM
- Connected by strings
- Equivalent of 3 10” PMT in single sphere
  - r/o electronics in sphere
  - 1 high pressure feedthrough



- 6 OM with 8 or 10 inch PMT
- 1 electronics container
- Concentrated on horizontal structure
- Tower structure

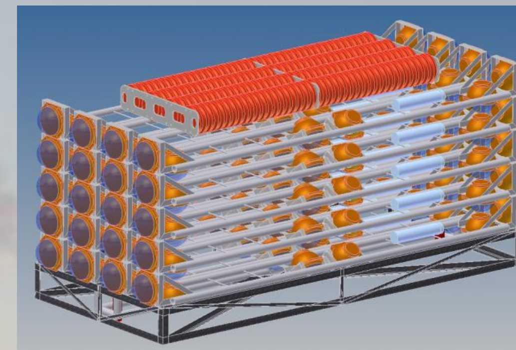


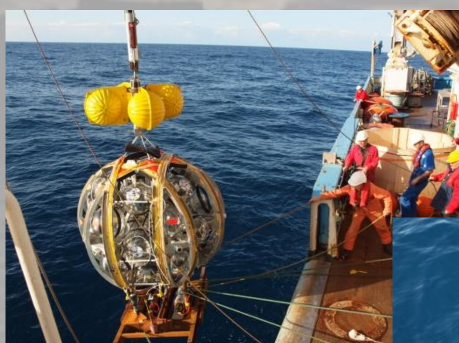


To speed up deployment units are brought to the bottom and unfurled

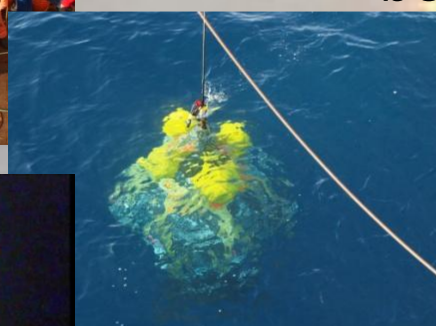
String

Tower



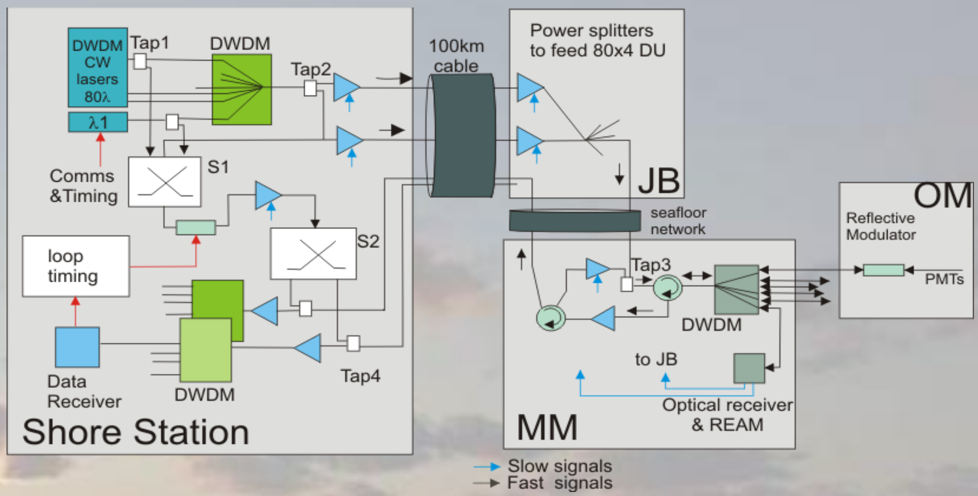


Real life deployment tests both work



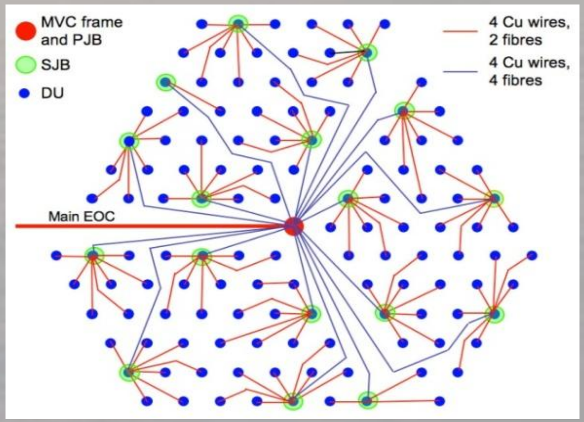
Investigating solution with tower with two MultiPMT DOMs on each floor

- Readout via reflective modulation – transfer up to 10 Gb/s.
- Timing accuracy 10-100 ps
- DWDM technique
- One colour to one floor
- Communication laser on shore
- Tested for 100 km



Seafloor architecture
Tree structure
Isolation possible at each branching

10 kV from shore to primary junction
400 V from primary junction to each floor
Conversion at each floor to needed voltage



Physics Performance

Foot print of detector to be optimized

Possibly not all energy regimes optimal with unique layout

- dense core for low energies
- sparse array for ultra high energies

Simulations done with hexagonal shape.

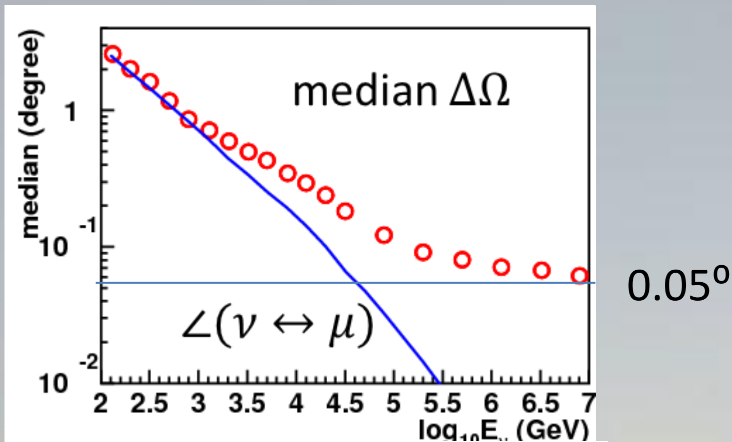
Both designs simulated

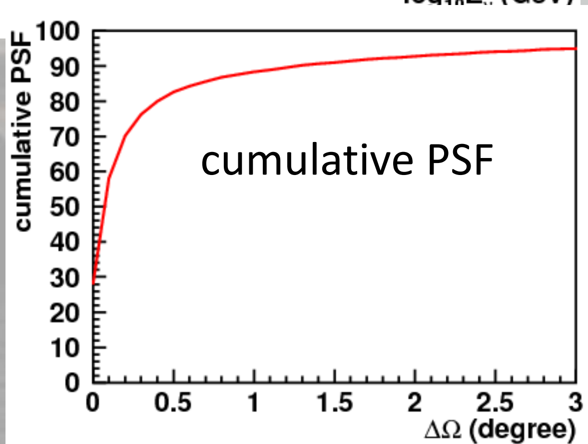
Both give same results for the same estimated price

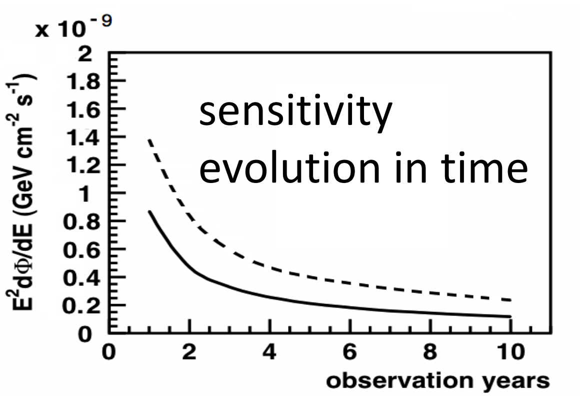
Both give roughly the same building time of 250 FTE years

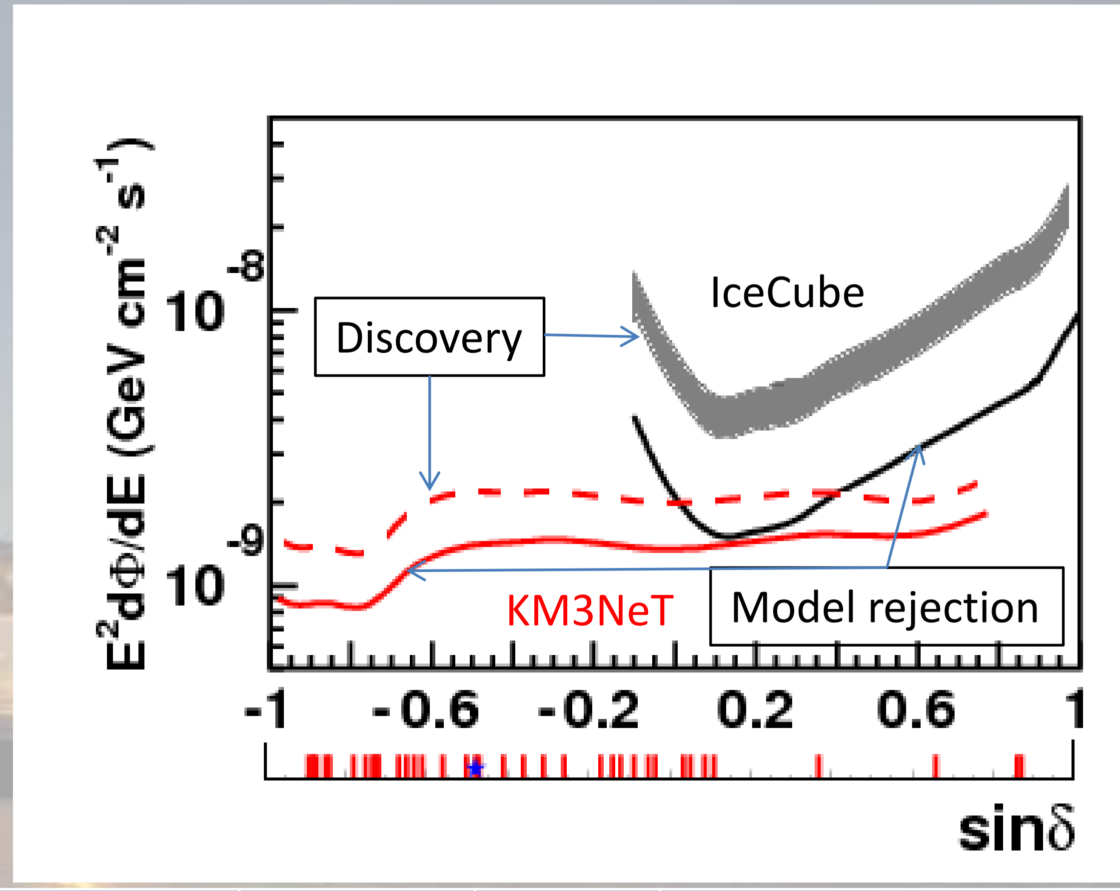
The final sensitivity is for a 250 M€ detector

Point source sensitivity







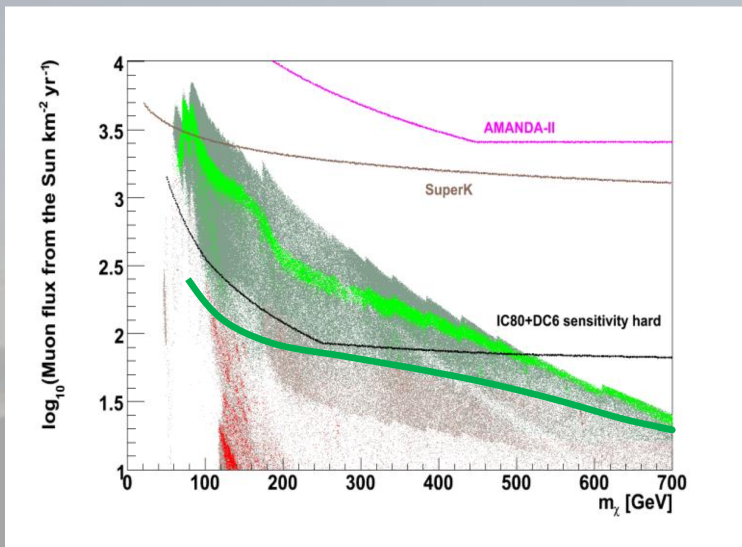


Source Name	Source radius (°)	Visibility	Number of events per year For E_ν> 5 TeV	
			Signal ν	Atm ν
RX J1713.7−3946	0.7	0.74	4 – 11	6.4
RX J0852.0−4622	1.0	0.84	2 – 6	17
HESS J1745−303	0.2	0.66	0 – 22	1.4
HESS J1626−490	< 0.1	0.91	4 – 9	1.6
Vela X	0.4	0.81	4 – 15	3.5
Crab Nebula	< 0.1	0.39	1 – 3	0.8

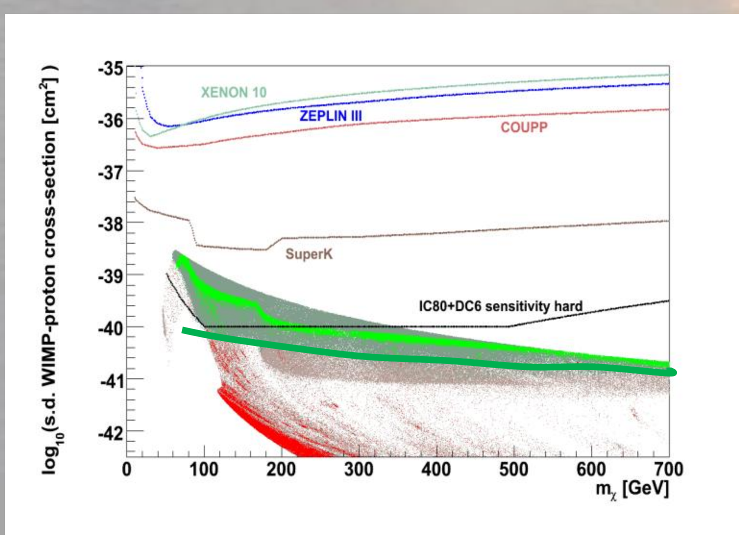
Dark Matter Annihilation in the Sun

Sensitivity for GRB

Muon flux from the Sun



Spin dependent WIMP-p X-section



GRB signal calculated using
Waxman-Bahcall flux
For GRBs of 2008

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

Sensitivity for GZK

For shower detection 0.6 events per year for E>1 PeV contained.
For muon events a further 2-3 events.

Conclusions

- Possible to build a detector of > 5 km^3
- Sensitivity better than any other detector
  - For Galactic sources two orders of magnitude. Can still be further optimized
  - For W-B GRB flux a few events per year with a few neutrinos detected.
  - Dark matter: spin dependent interactions best sensitivity
- Future plans