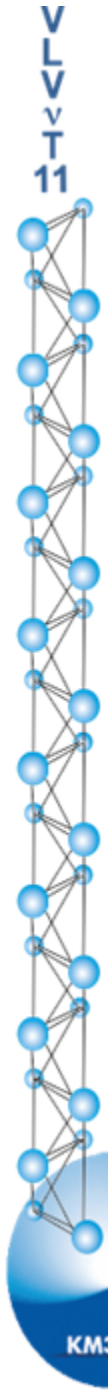
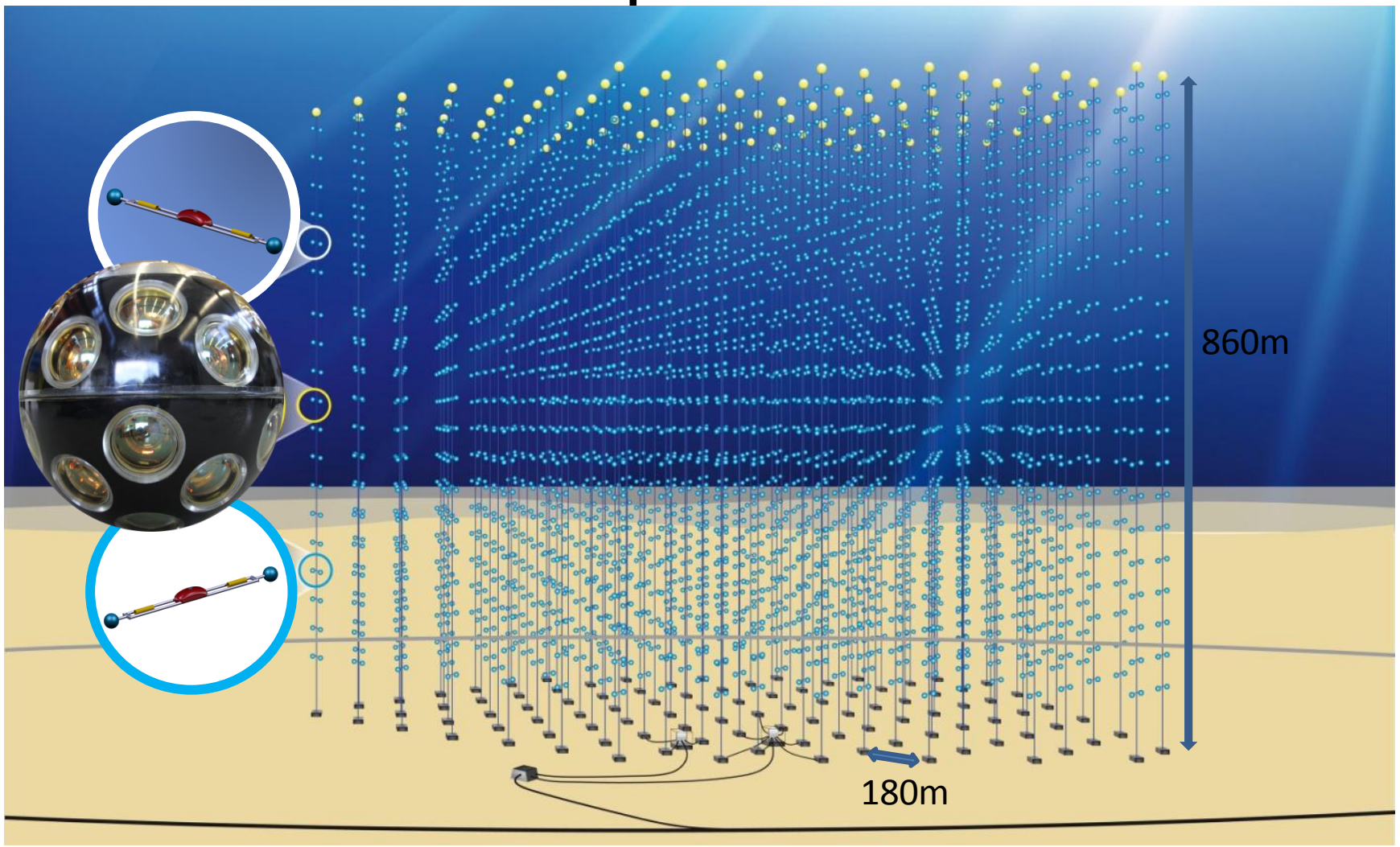


KM3NeT: Where are we and where do we go

P.Kooijman, For the KM3NeT Consortium

Artists Impression (~1/3)



Intro

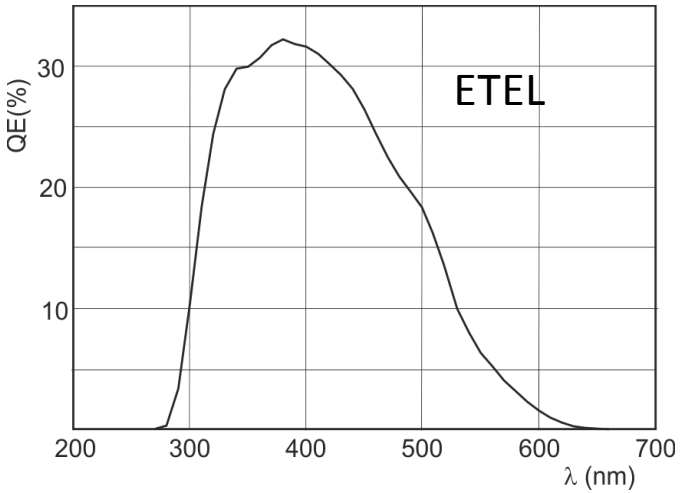
- Technical status
- Technical decisions
- Prototyping
- Science priority
- Prospects for the near future

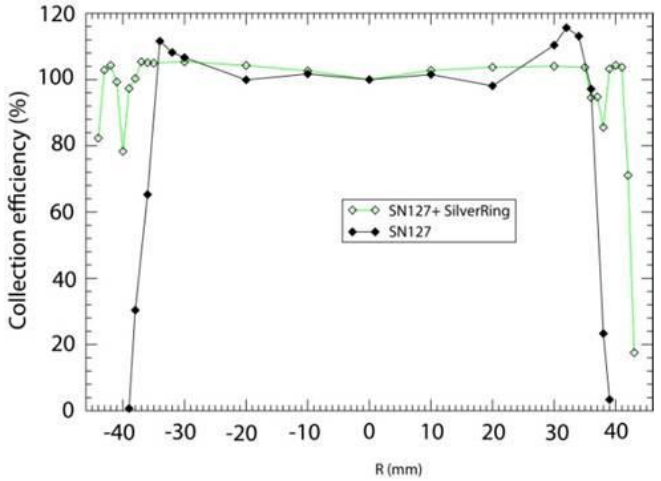
Technical Solution: Digital Optical Module

- Multi-PMT DOM
- Many small PMTs
- Almost uniform coverage
- Photon counting
- Minimize pressure transitions
- All electronics inside
- Concentrator ring→ “free” larger tube
- All identical units

DOM: PMT

- 75 mm PMT
- 4 manufacturers
  - ETEL (25 delivered)
  - Hamamatsu (10 delivered)
  - MELZ (first prototype expected)
  - Zhan Chuang Photonics
- High QE (>32%@380nm;>22%@470nm)
- Extension to ~90 mm diameter with concentrator ring

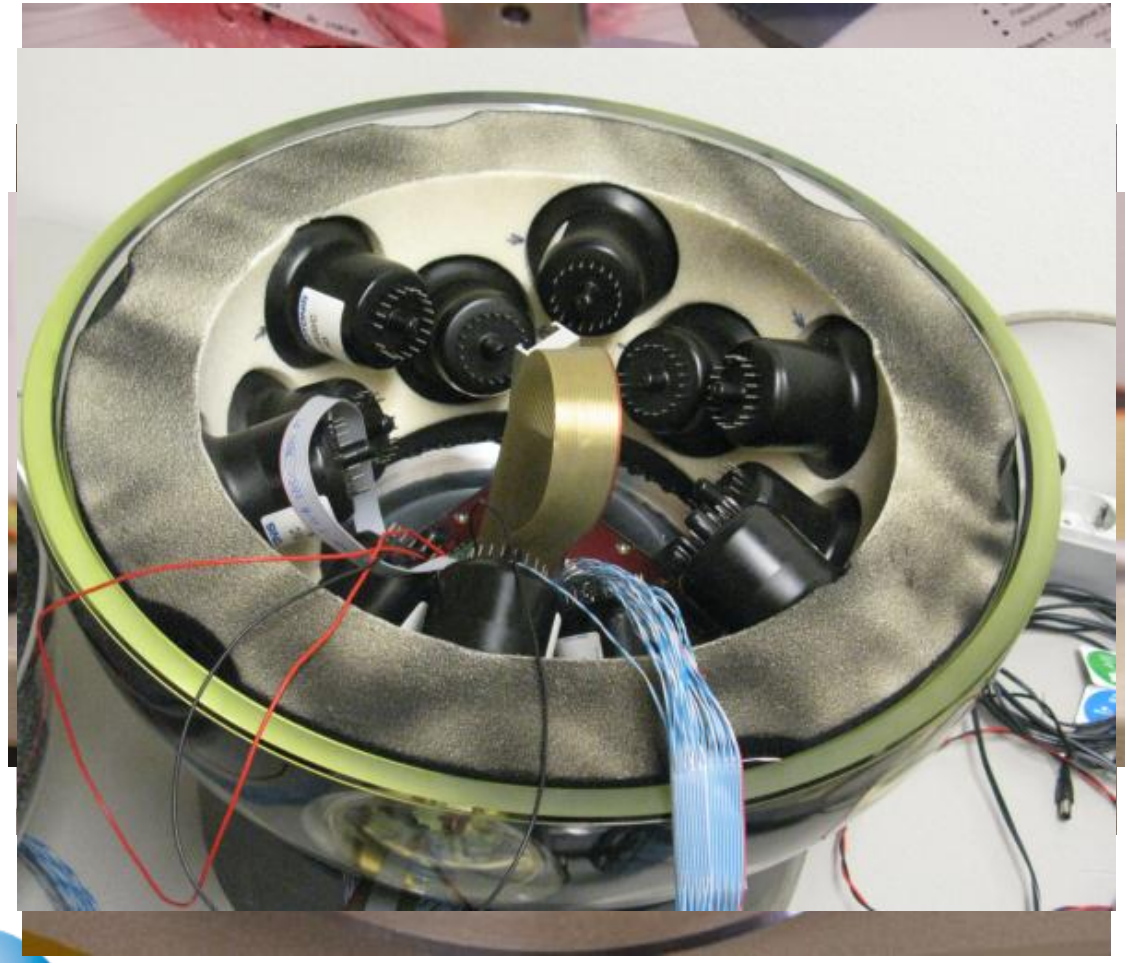




DOM: PMT placement

- New design HV with <35 mW power consumption
- 12 PMTs in top
- 19 PMTs in bottom
- Front matched to sphere
- Supported by foam cores via concentrator ring
- Optically coupled with optical gel

DOM: Construction



Cooling Mushroom

Heat conducting foil

Power board

Logic board (dummy)

On shield

On Mushroom

Foam core with PMTs (temperature sensor cabling)

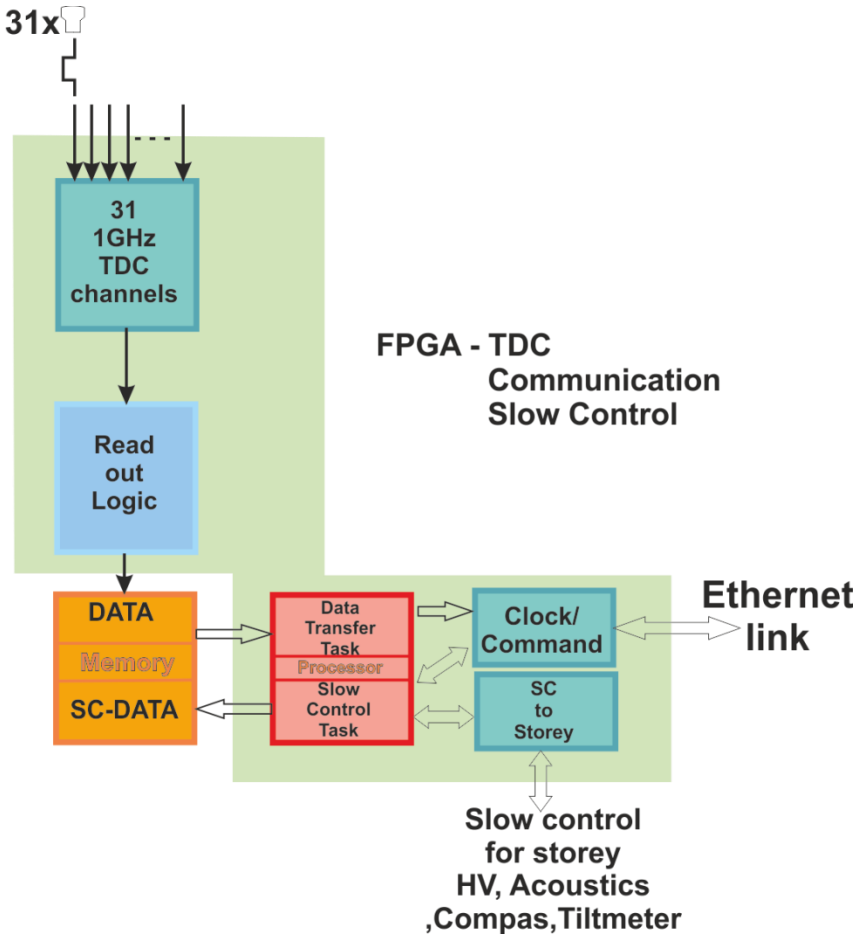
Poor optical gel

DOM: Construction

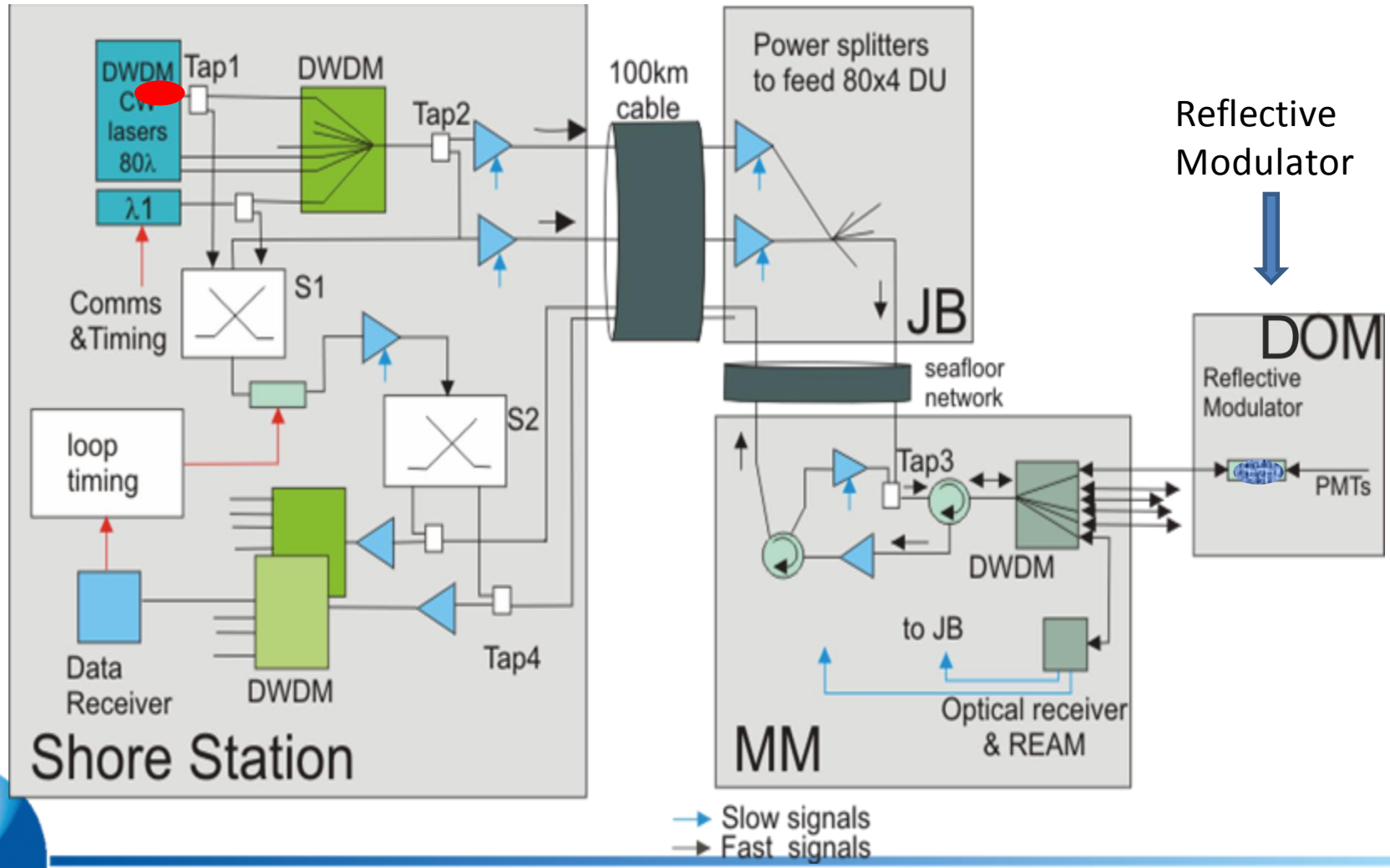
12800

DOM: read-out electronics

- Local time-stamping
- FPGA based
- Slow Control incorporated, I^2C/SPI
- TDC
- 1 Gb/s Ethernet to shore



DWDM Fibre-Optic Connection

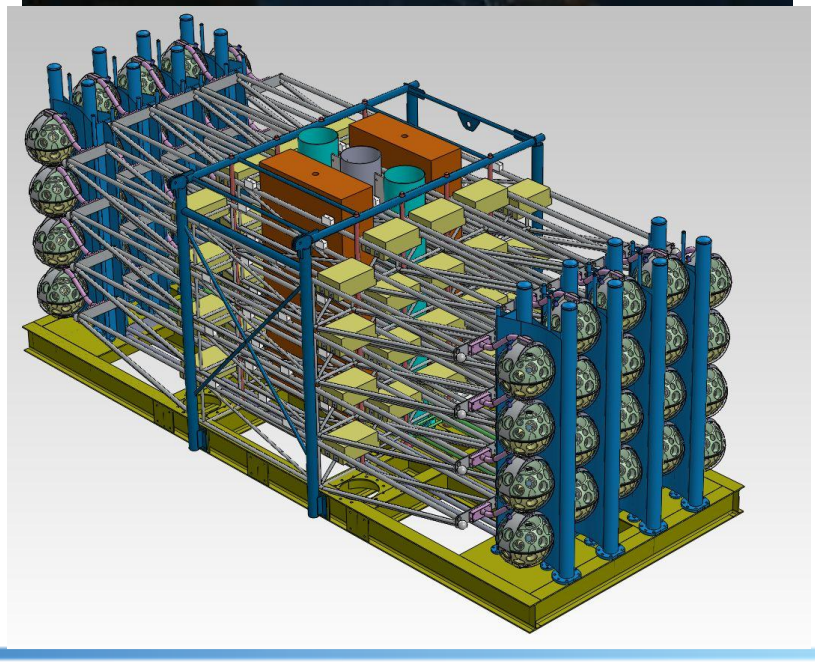


Network Components

- Verification of system in lab.
- Most components for the network off the shelf
- Exception
  - REAM bendiness
  - PBOF vertical cable: Necessary for ~~flexibility~~
  - Some connectors problematic, expensive or both

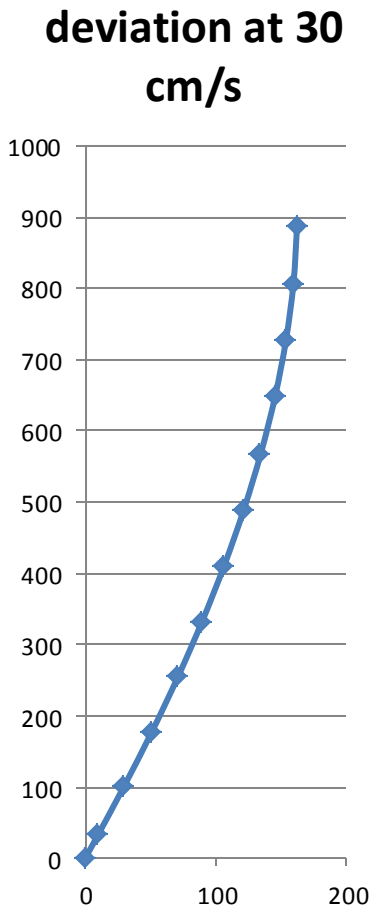
Vertical Structure

- 6 m bar length
- DOM on either end
- Consecutive storeys perpendicular
- Two vertical electro-optical cables
- 40 m inter-storey distance
- 320 towers
- Compact deployment



Hydro-dynamic behaviour

- When unfurled – 900 m high
- Sea currents up to 30 cm/s (rare – survival intact)
- Deviation at top of tower – ~150 m
- Can be made smaller with bigger buoy and larger anchor



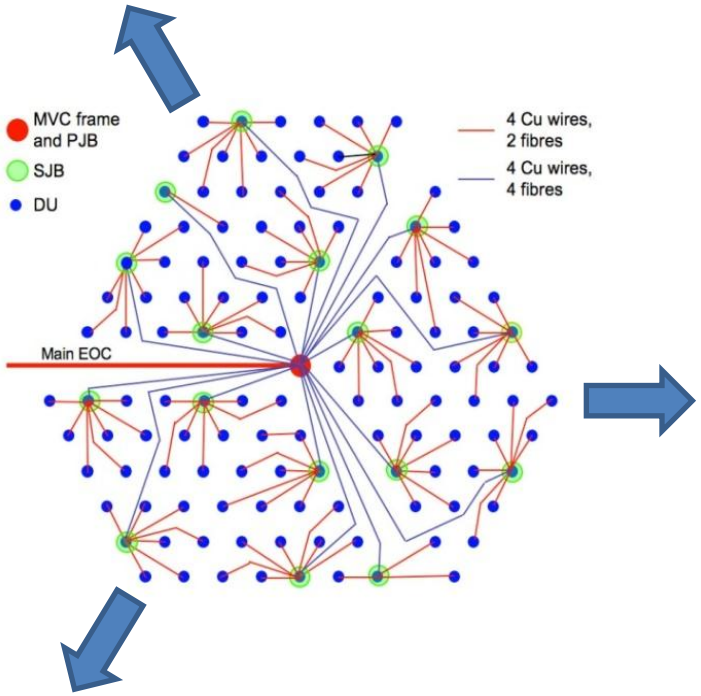
Prototype schedule

- Reflective readout
  - ➢ Performed in lab 50ps over 100km
- OM including readout electronics
  - ➢ First four Dec.-Feb.
- Tower mechanical structure
  - ➢ First 6 in Dec.-Jan.
  - ➢ Full structure Q2-3 2012
- Vertical cable
  - ➢ Q1-2 2012

Sea-floor power network

- DC 10 kV Shore to primary junction box
- Limit power losses
- 10 kV to 400 V DC/DC 10 kW converter á la Neptune
- Distribution via secondary JBs to 320 towers
- Complications
  - Need access
  - Deployment during data taking
  - Risk of single cable/JB
  - Distances → Power loss
  - Wet mateable connections
- Easier if Detector built from smaller blocks with each primary JB ??(Physics?? Cost??)

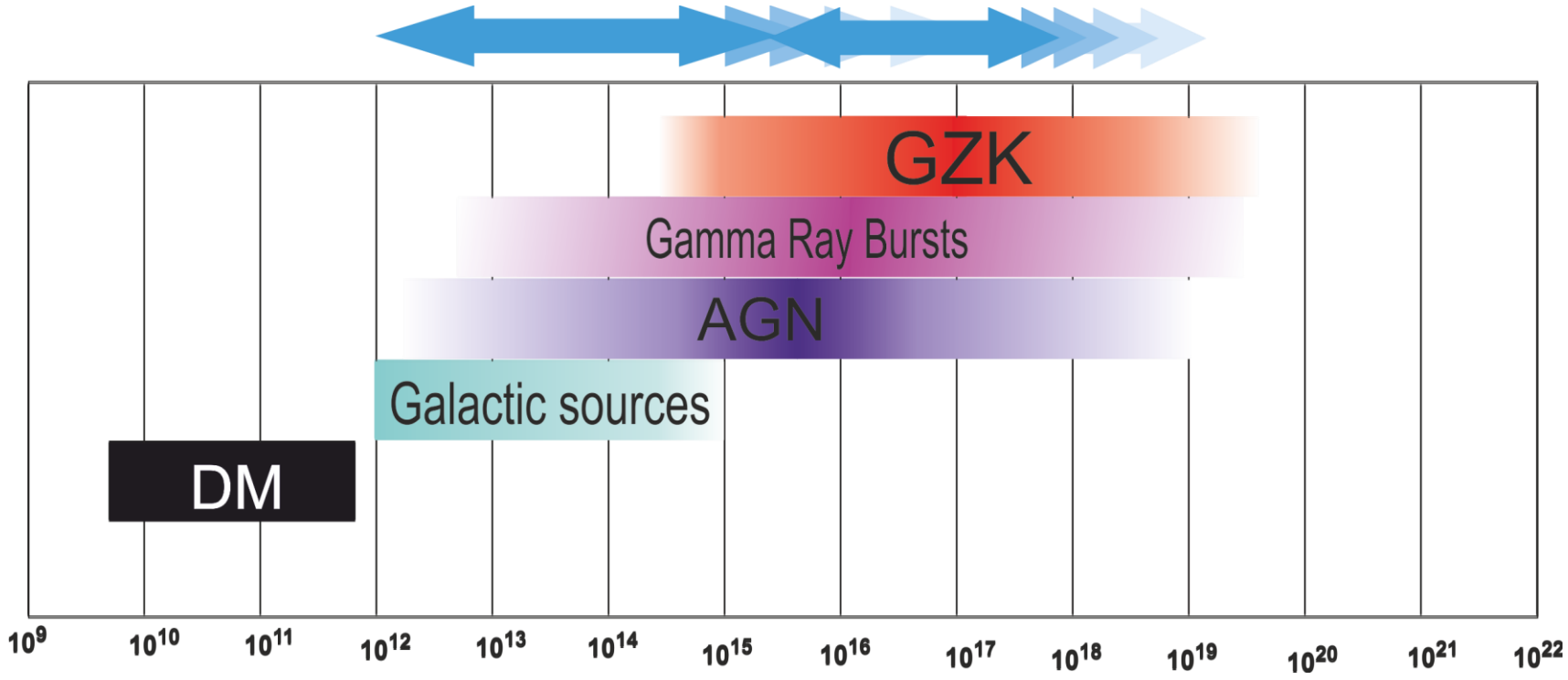
This is only **half** a detector



Cosmic Neutrino Sources

- Galactic sources
  - SuperNova Remnants
  - Pulsar Wind Nebulae
  - Micro Quasars
- Extra Galactic Sources
  - Active Galactic Nuclei
  - Gamma Ray Bursts
- Cosmogenic (GZK) neutrinos
- Dark Matter annihillation

Sensitivity

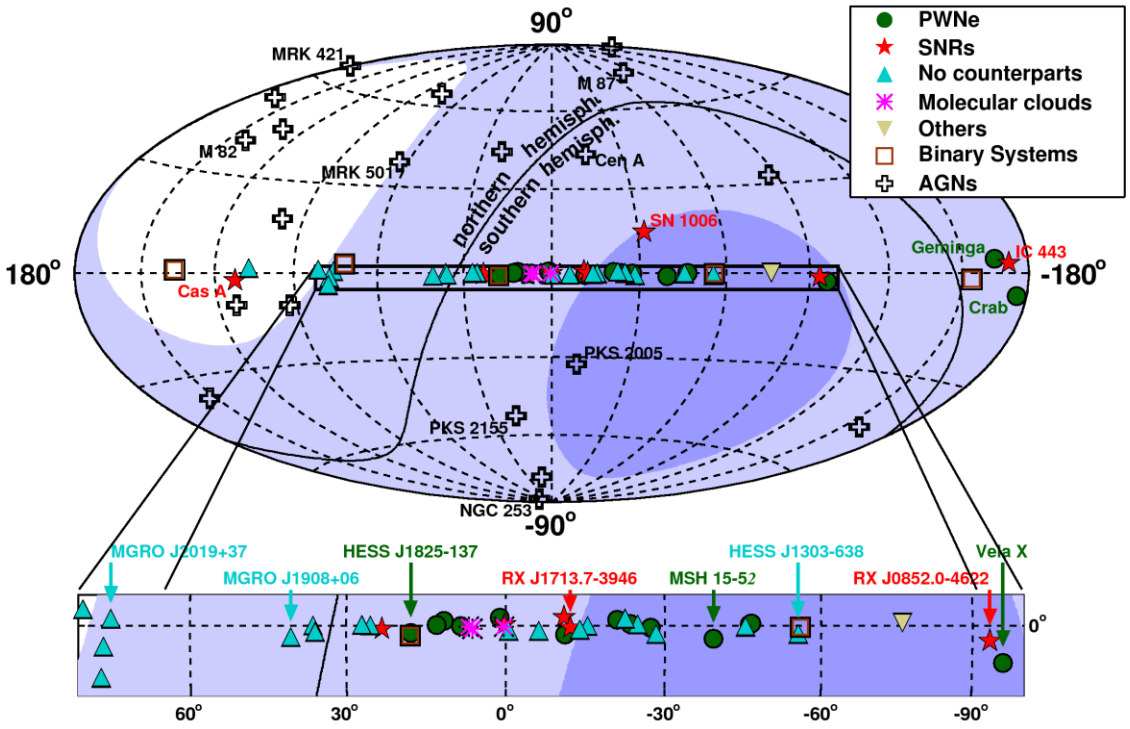


For fixed number of € can optimize sensitivity for different sources
This depends on photocathode density (m^{-1})

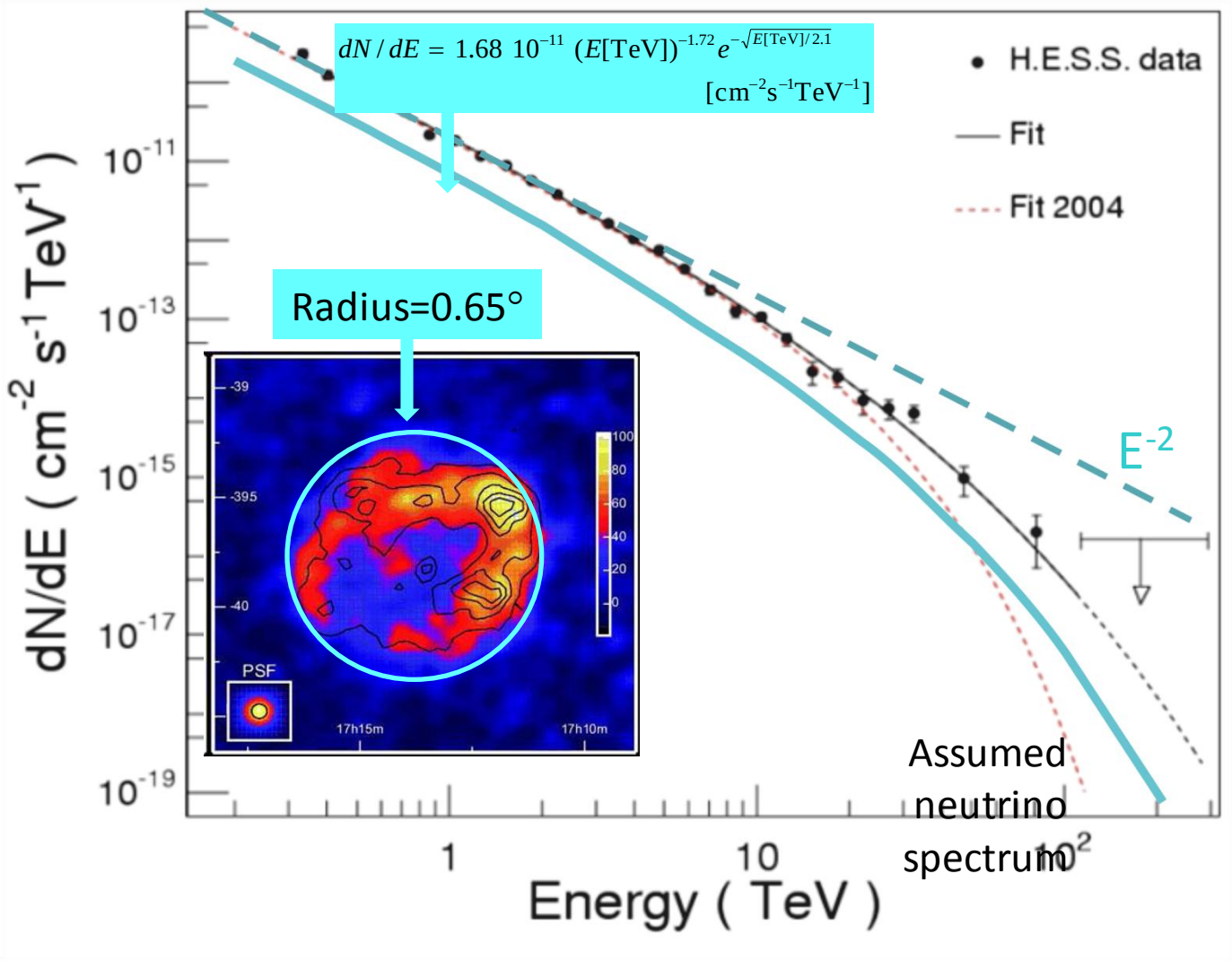
Mediterranean Sea →Galactic Sources

→Optimize sensitivity to "cut off" spectra

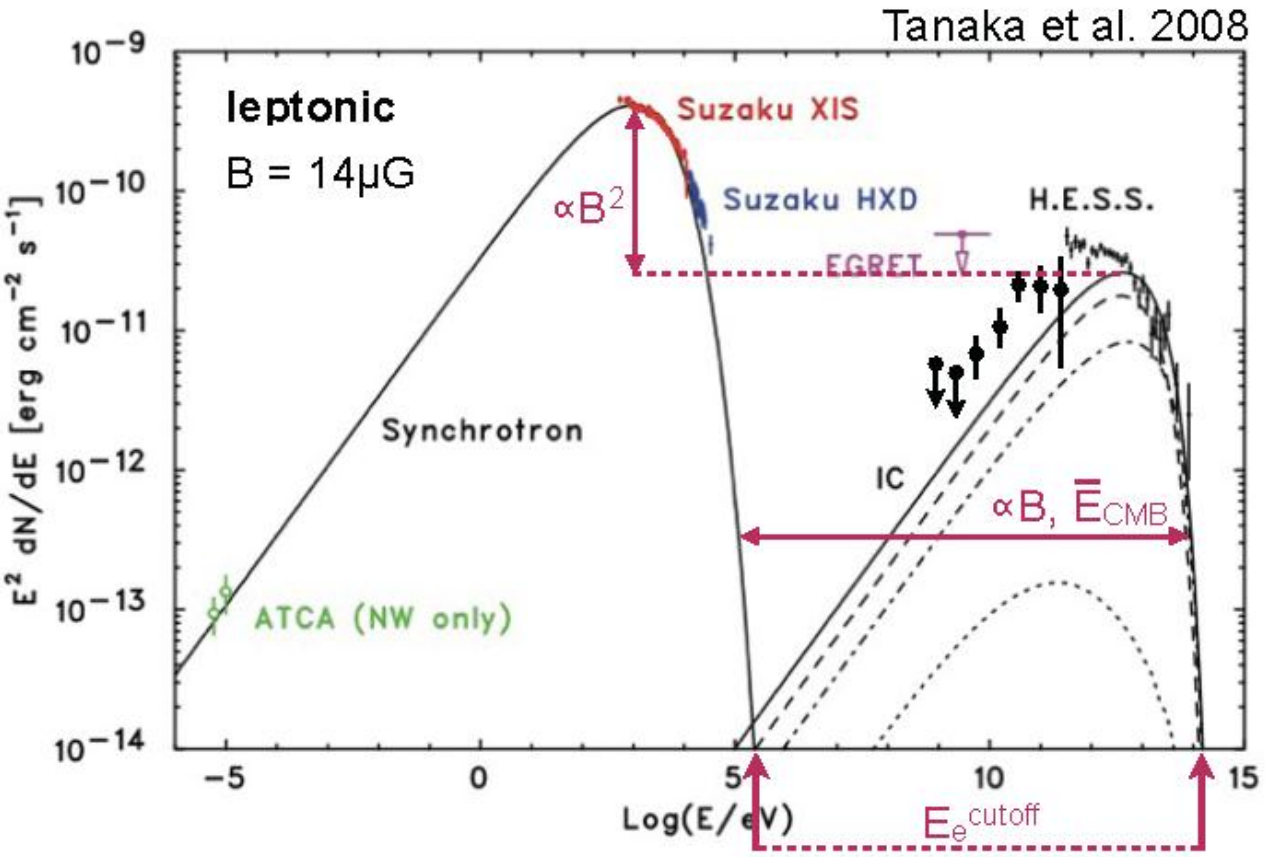
→Smaller spacing than in TDR



Example source RXJ1713

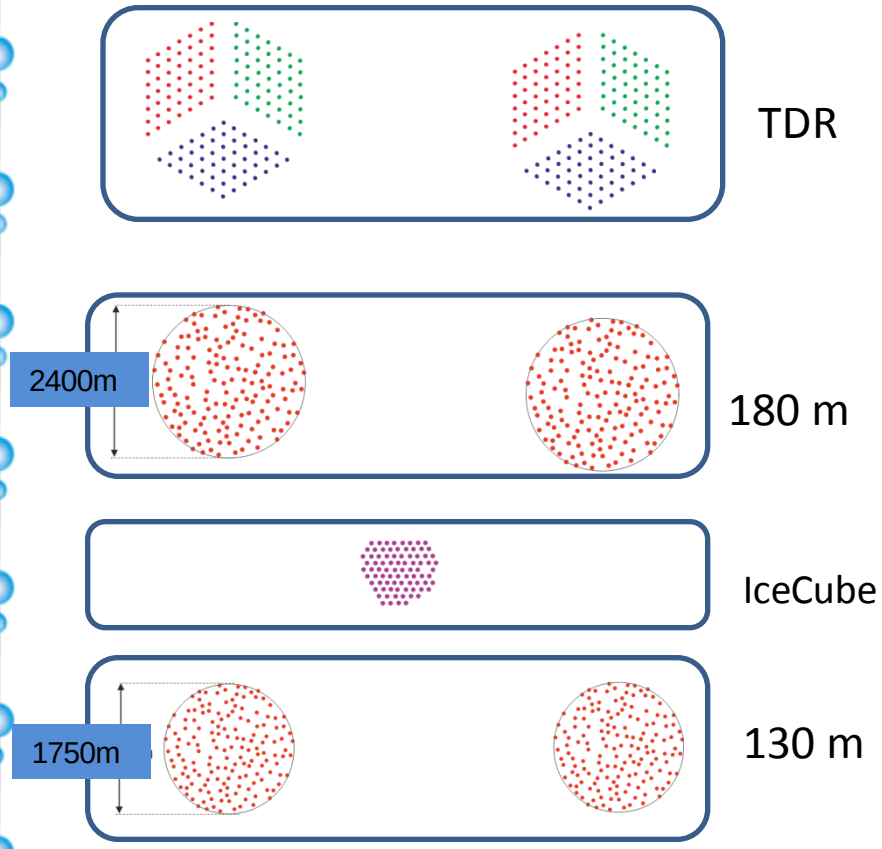


Fermi-LAT



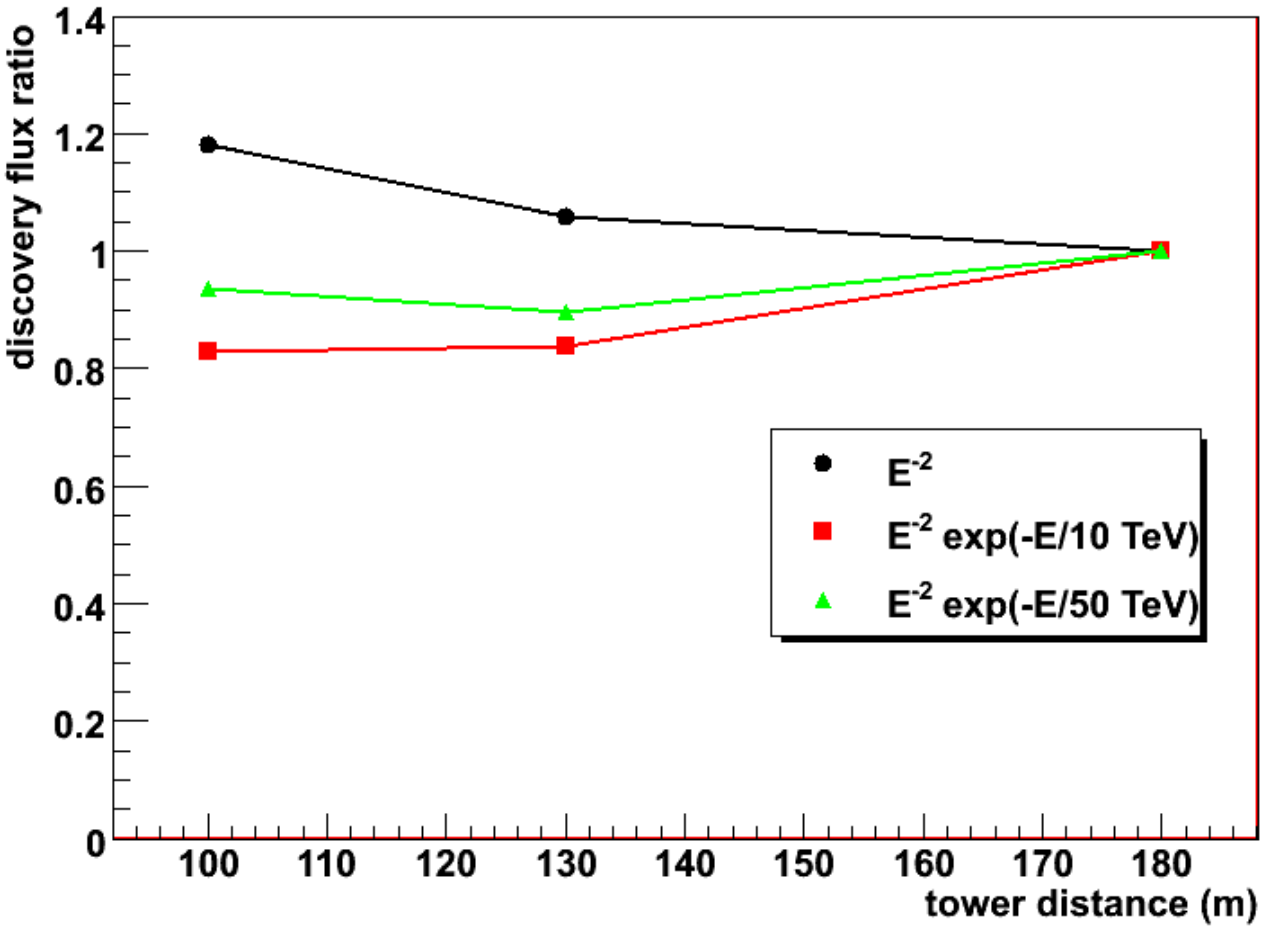
Mixed spectrum need neutrinos??

Layout for physics

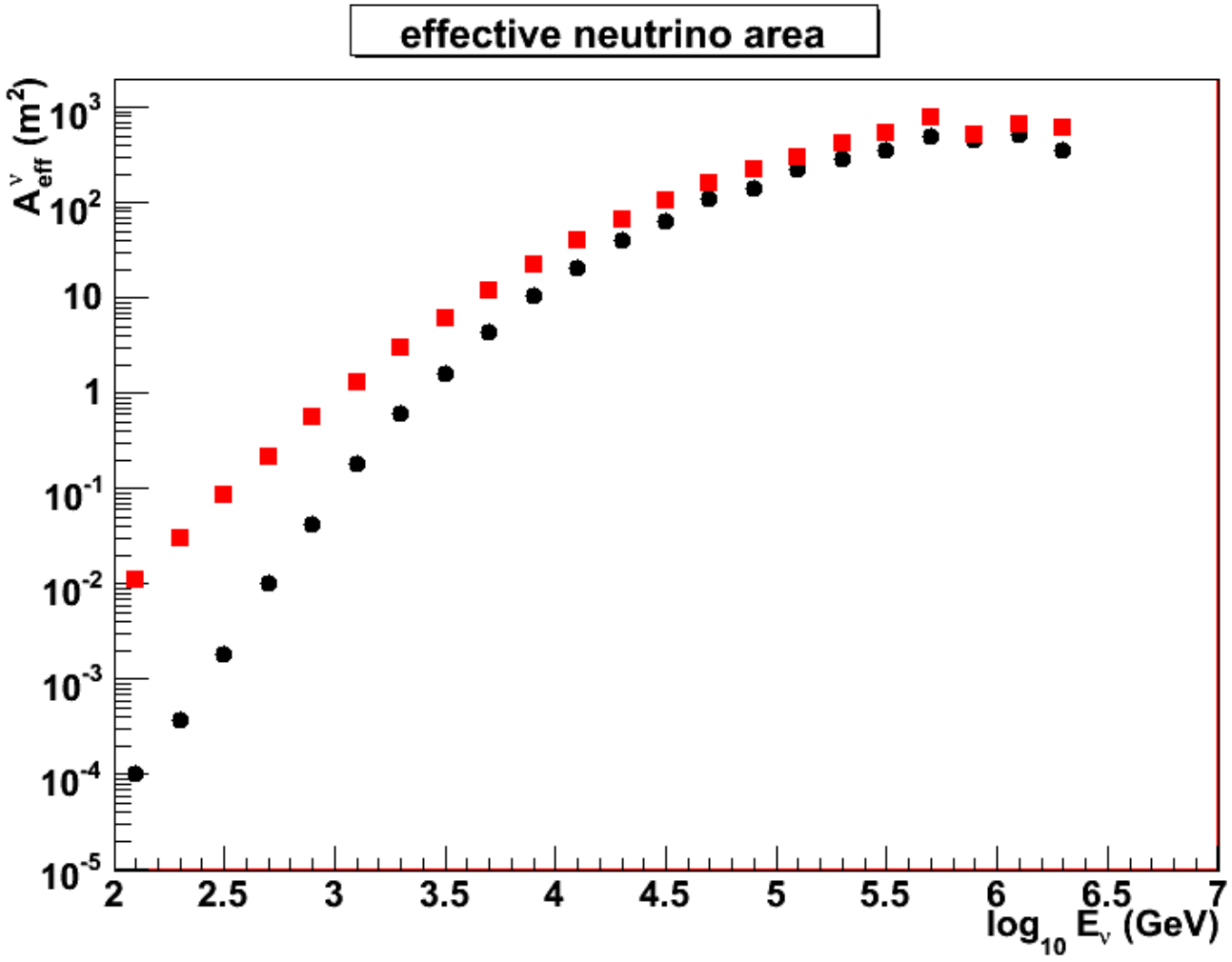


- TDR 180 m distances
  - Regular patern
- Average 180 m distances
  - Irregular pattern
- Average 130 m distances
  - Irregular pattern
  - Energy threshold lower
  - More optimised for Galactic sources

Dependence of distance

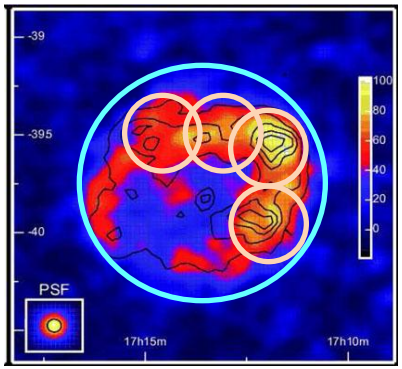


Effective area



Time needed for signal

	years	Signal	bkg
180m 5σ (0.6°)	12.1	41.1	50.8
130m 5σ (0.6°)	8.0	21.8	12.9
130m 3σ (0.6°)	2.9	7.9	4.8

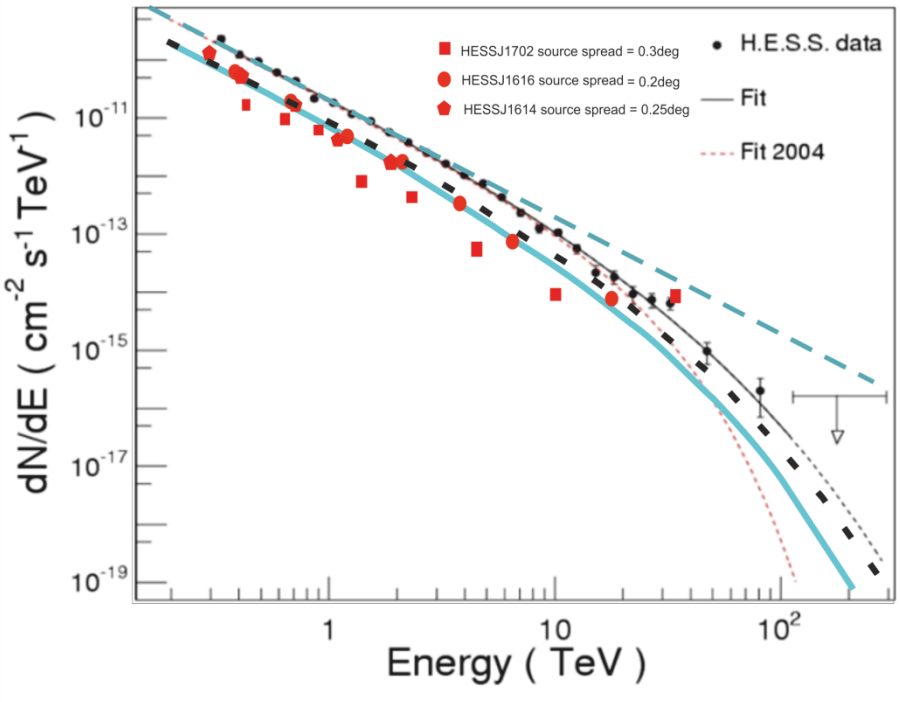


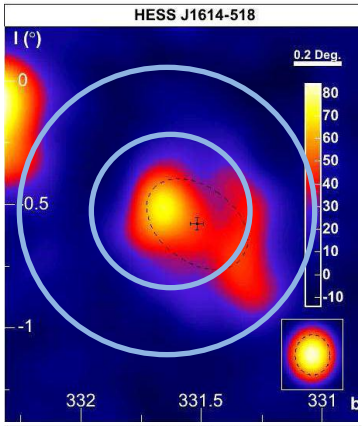
- Acceptance toward lower energy increases
- Use of energy estimator and directionality of DOM gives 20-30% improvement (verified for 180m distance).
- The source morphology will allow a smaller number of years
- Reanalysis with unbinned method will also improve results

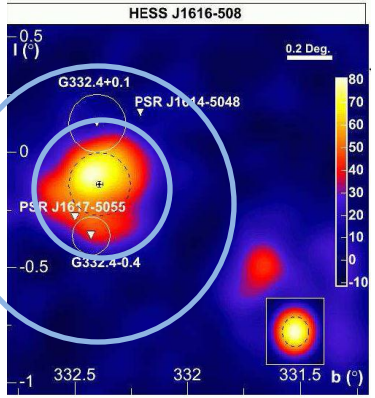
Around 5.0 years for 5σ is achievable
Sensitive to tracking, trigger and cuts
Can be further improved

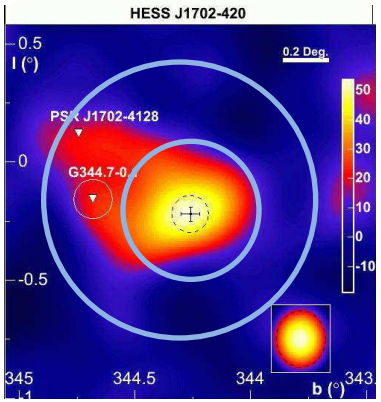
Other Source examples

Quite a number within factor of 2
But with factor 2 smaller spread
→Same 5σ time
Quite a few within factor 5 and small
→3σ in about the same time

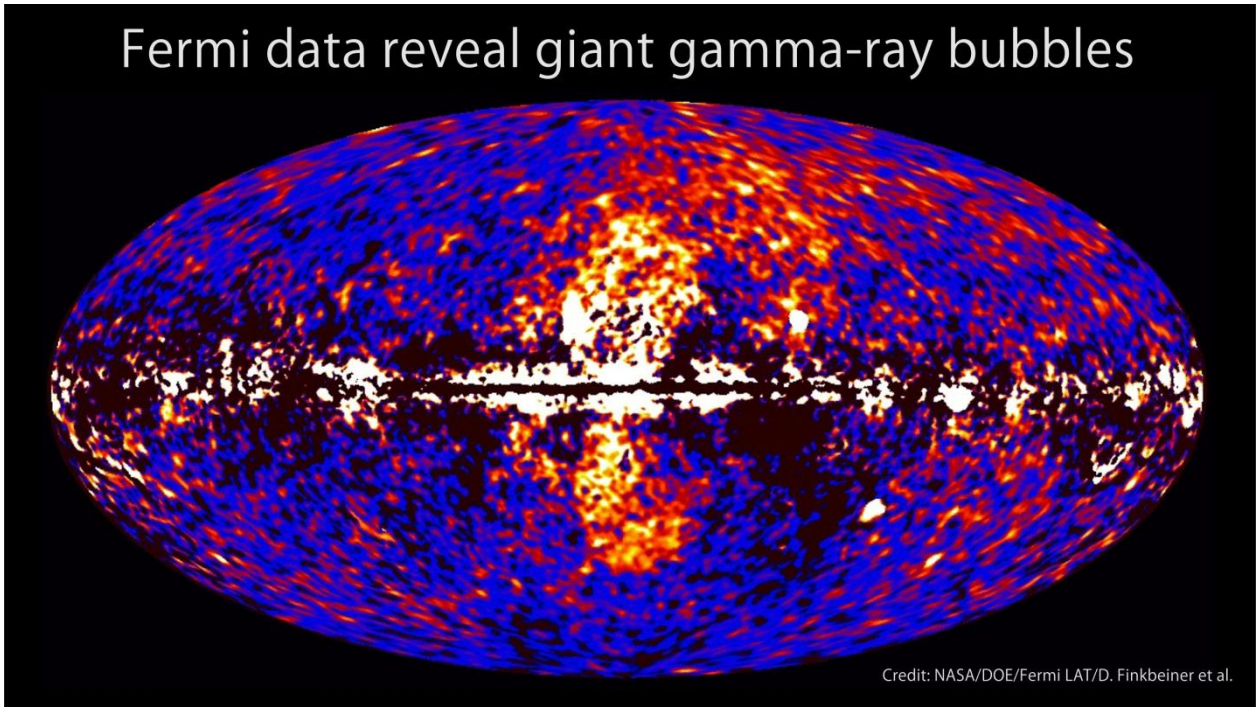








Fermi Bubbles?

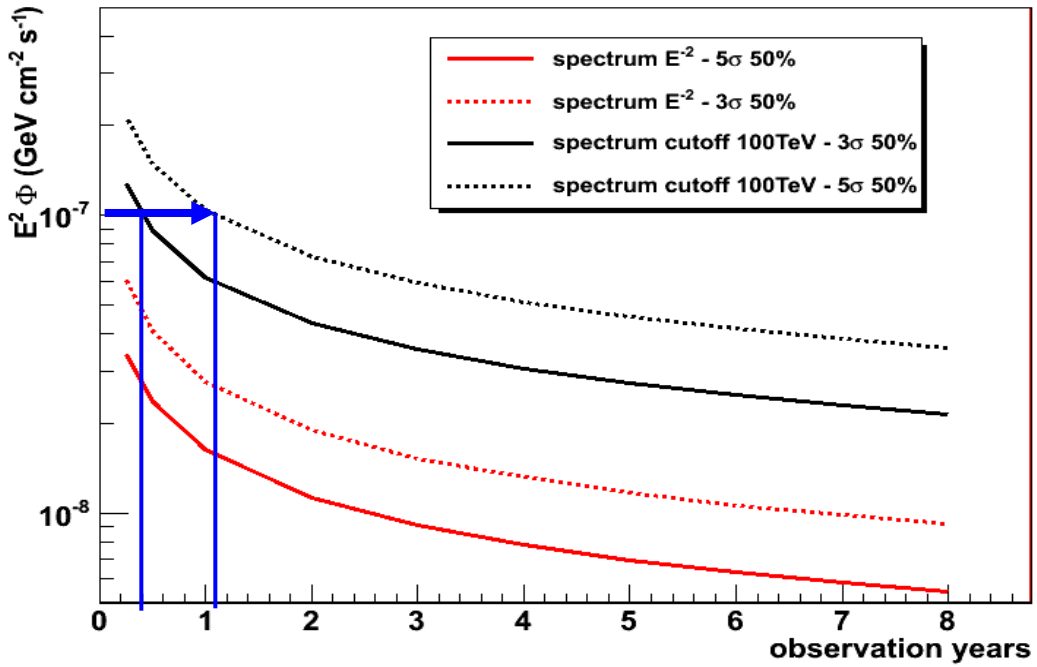


What are they?

Models:

- Electronic
- Hadronic
  - If hadronic then: from gamma ray flux

$$E^{-2}\,F_{\nu}(\mathrm{TeV}) \sim 1 \div 2\ 10^{-7}\ \ [\mathrm{GeV\ cm^{-1}\ s^{-1}}]$$



Higher Energies

Going from 180 to 130 m impacts on high energies

Total Volume is reduced from 5.8 to 3.6 km^3

GZK neutrinos for 5.8 km^3 0.01-1 km^{-3} $year^{-1}$

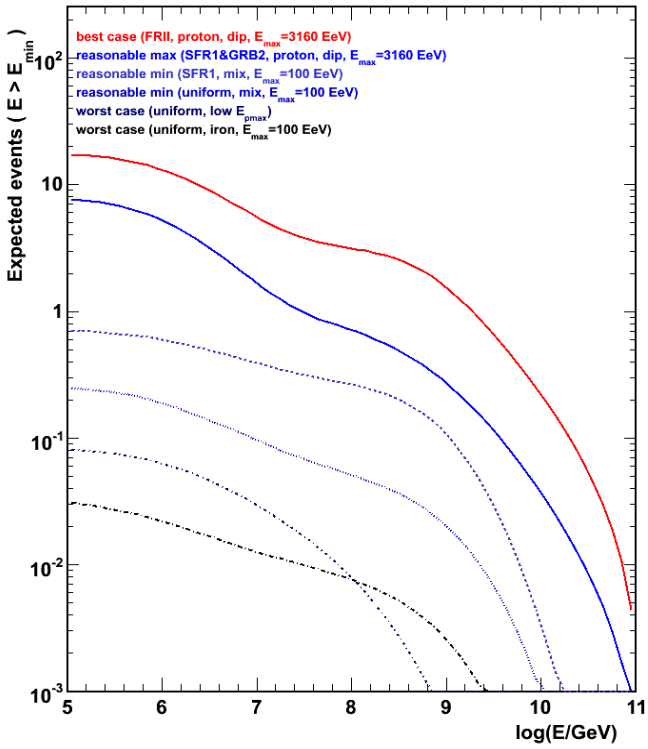
so 0.5-60 → 0.3-30 in 10 years (> 10 PeV)

Assuming showers

- Depends on footprint
- Timing very good so maybe 2x for >10 PeV

Area of the detector for high energies reduces by 30%

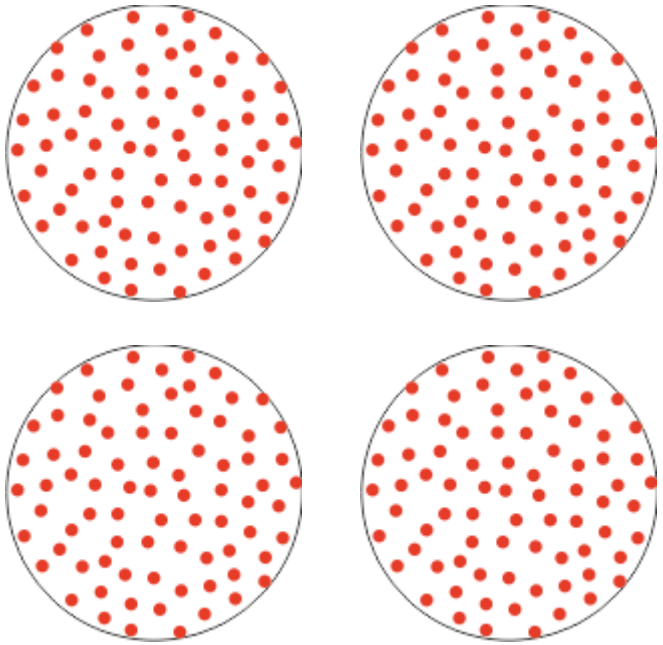
- Depends on footprint

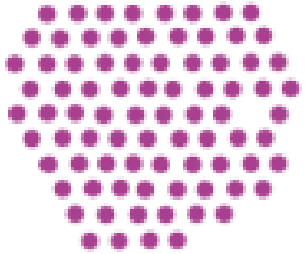


Still being investigated

Splitting detector into even smaller pieces
Helps for deployment
Four times 80 towers for instance – each similar to IceCube
(IceCube = 4800 DOMs; KM3NeT = 3200 DOMs 3 times PC area; ^{40}K)
First impressions very similar to two large detectors

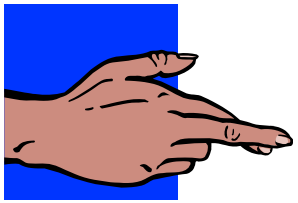
1250m





Where do we go from here

- Financing → Requests for roughly half the budget
- Requested from European Structural Funds
- Expect decisions in the coming six months



- If it comes, then need to start construction before 2015
- Need to coordinate orders
- Need legal structure → ERIC (no VAT)

Where do we go from here

- Networked detector
- Remotely operated – all together
- Identical building blocks
- Software for all the same
- Central data centre
- Central data analysis

Conclusions

- Galactic sources are within reach
- Technical convergence
- Most technical solutions are (near to being) verified
- Networked remotely operated detector
- On the legal structure is being worked
- We welcome new collaborators
- Future looks exciting

You have to follow something
Your gut, life karma or whatever

My GUT feeling is good!