

KM3NeT

*Astro-particle and Oscillations Research
with Cosmics in the Abyss
(ARCA & ORCA)*



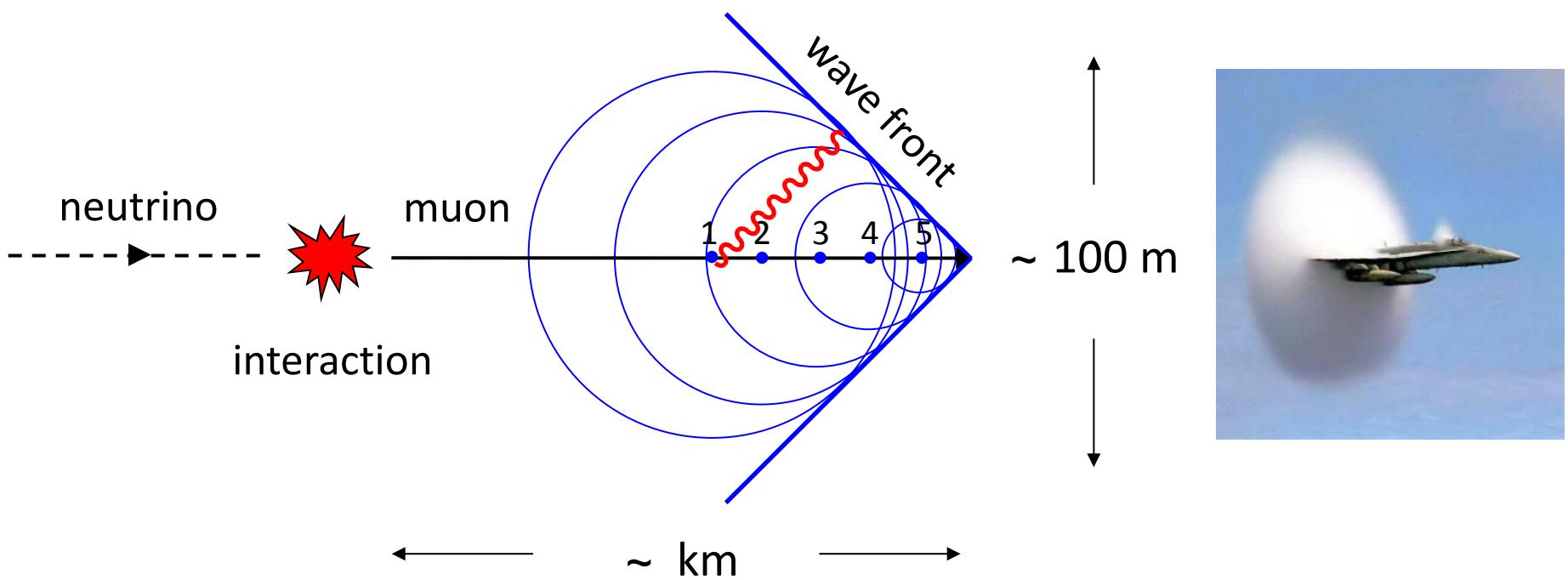
International Solvay Institutes
27–29 May 2015, Brussels, Belgium.
Maarten de Jong



Introduction

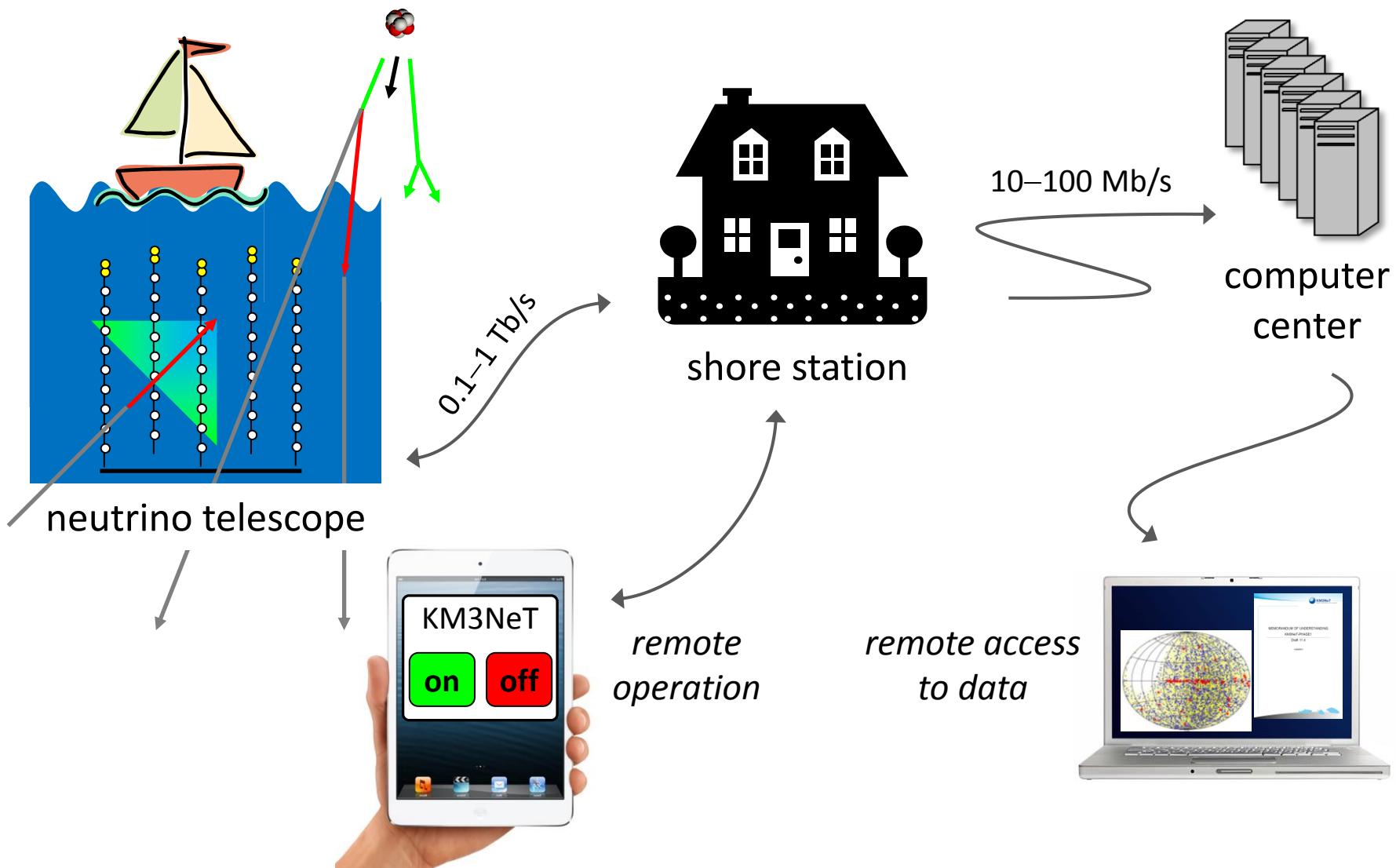
- KM3NeT is a new Research Infrastructure
 - network of cabled observatories
 - located in deep waters of Mediterranean Sea
 - hosting multi-km³ Neutrino Telescope
1. Discovery and subsequent observation of high-energy neutrino sources in Universe
 2. Measurement of neutrino mass hierarchy
 3. Synergy with Earth & Sea sciences

Detection principle



time resolution 1 ns
position resolution 10 cm angular resolution 0.1 deg

Architecture



Design

Launcher vehicle

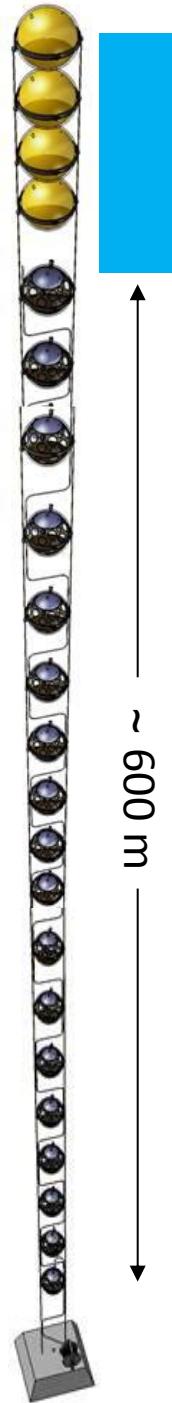


- *rapid deployment*
- *autonomous unfurling*
- *recoverable*

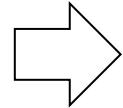
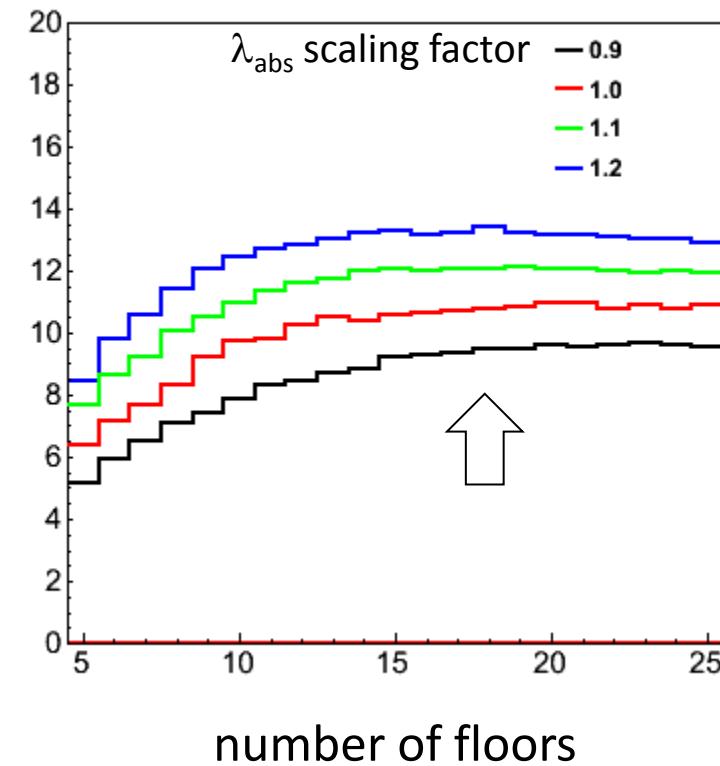
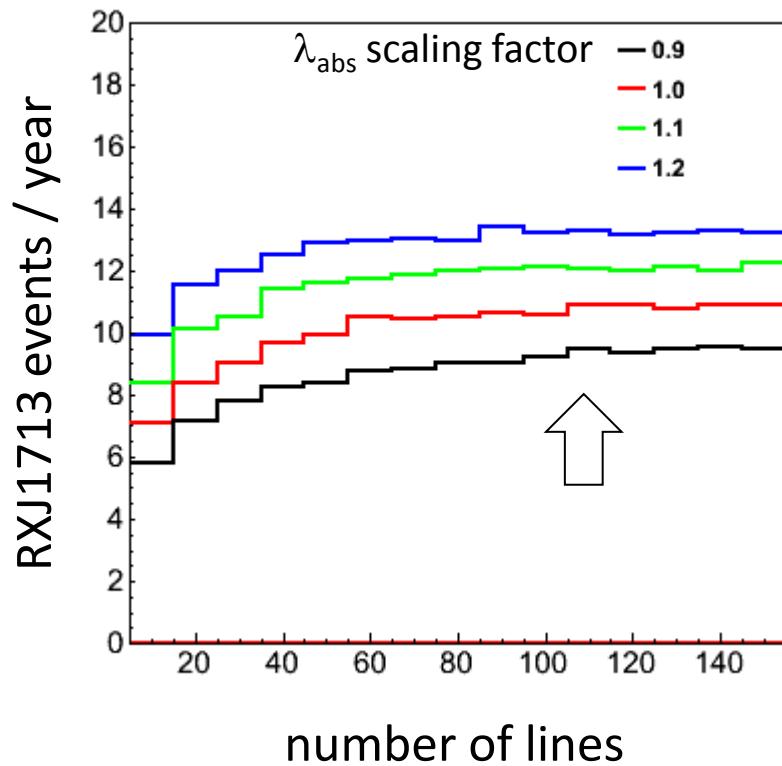
Optical module



- *31 x 3" PMTs*
- *low-power HV*
- *LED & piezo inside*
- *FPGA readout*
- *White Rabbit*
- *DWDM*



Building block



Smallest detector with optimal efficiency $\sim 1/6$ total size

3-inch PMTs

Key features:

- timing $\leq 2 \text{ ns (RMS)}$
- QE $\geq 25\text{-}30\%$
- collection efficiency $\geq 90\%$
- photon counting purity ~~100% (by hits, up to 7)~~
- price/cm² $\leq 10'' \text{ PMT}$

ETEL D792



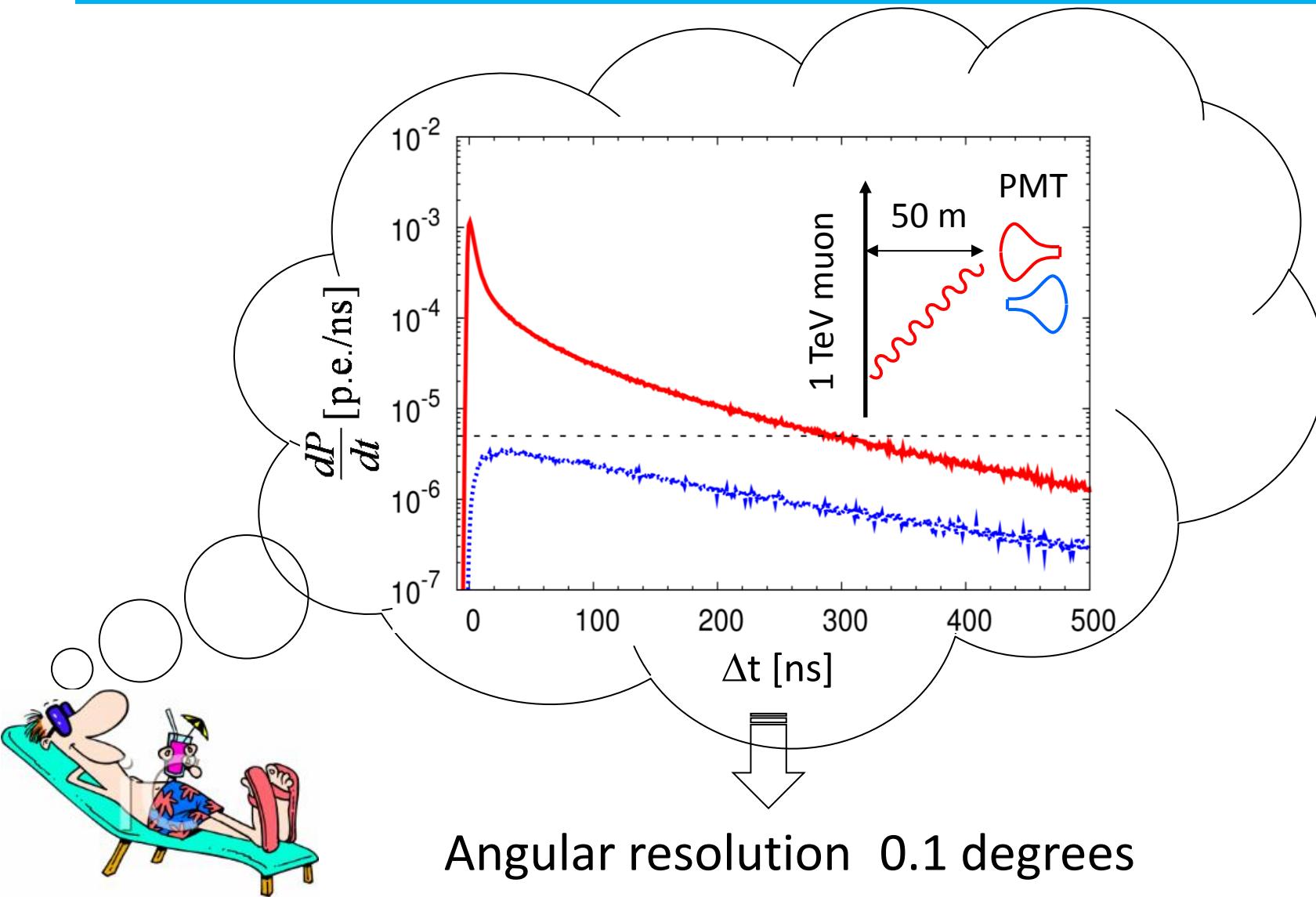
Hamamatsu R12199



HZC XP53B20



PDF of muon light

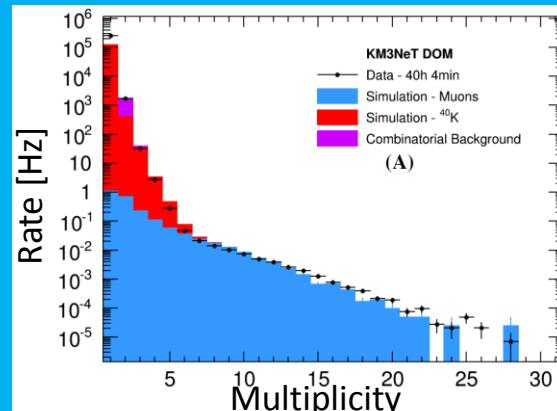


Phased implementation

Phase	Blocks	Primary deliverables
1	0.2	Proof of feasibility and first science results;
2.0	2 <i>ARCA</i>	Measurement of neutrino signal reported by IceCube; All flavor neutrino astronomy;
	1 <i>ORCA</i>	Neutrino mass hierarchy;
3	6 (+1)	Neutrino astronomy including Galactic sources;

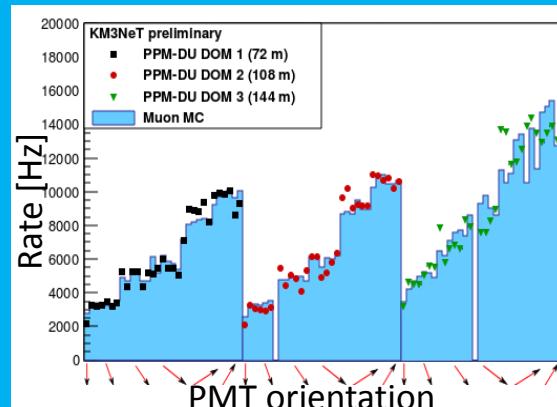
Prototyping

1) Optical module deployed at Antares April 2013 (2500 m)



Eur. Phys. J. C (2014)
74:3056

2) Mini string deployed at Capo Passero May 2014 (3500 m)



To be submitted
Eur. Phys. J. C

Phase-1

- ✓ First string assembled end of last year



→ to be deployed at KM3NeT-France following weeks

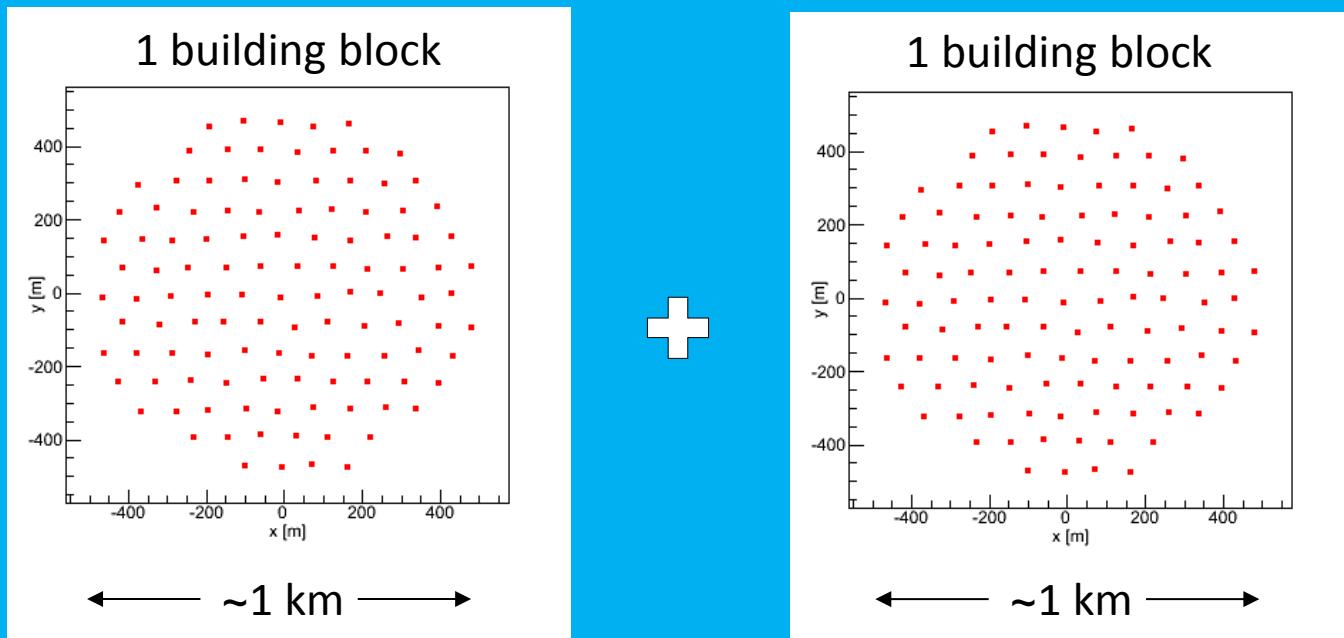
- Completion Phase-1 by end 2016
 - 24 strings in KM3NeT-Italy
 - 6 more strings à la *ORCA* in KM3NeT-France

Phase-1

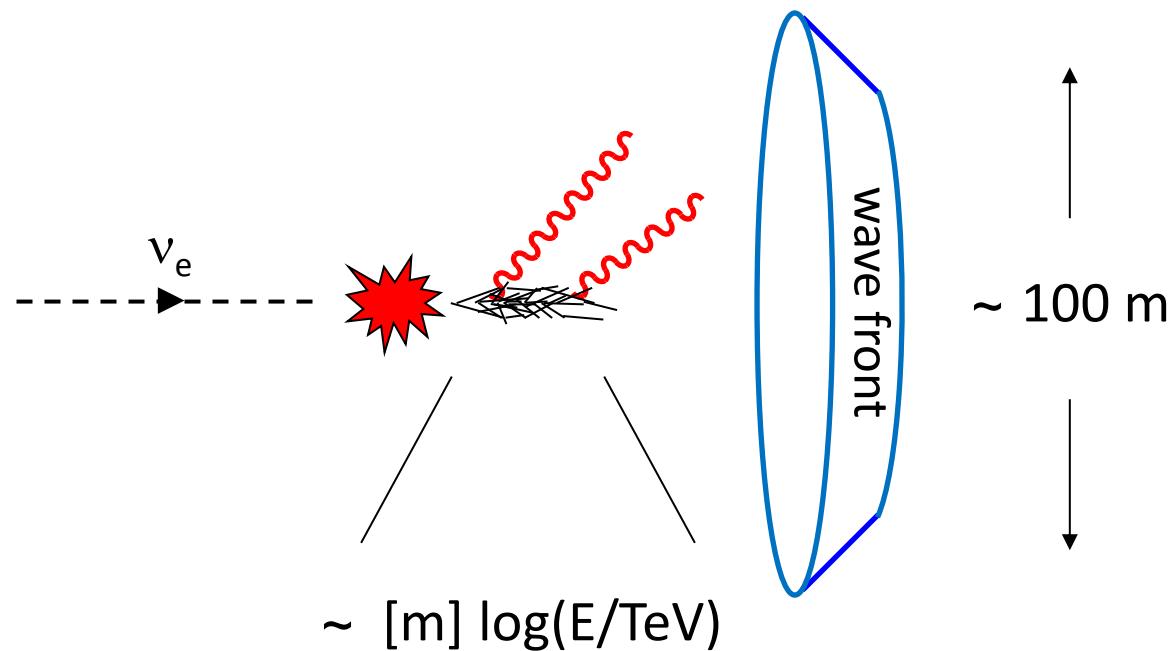


ARCA

Measurement of neutrino signal reported by IceCube



PDF of shower light (I)



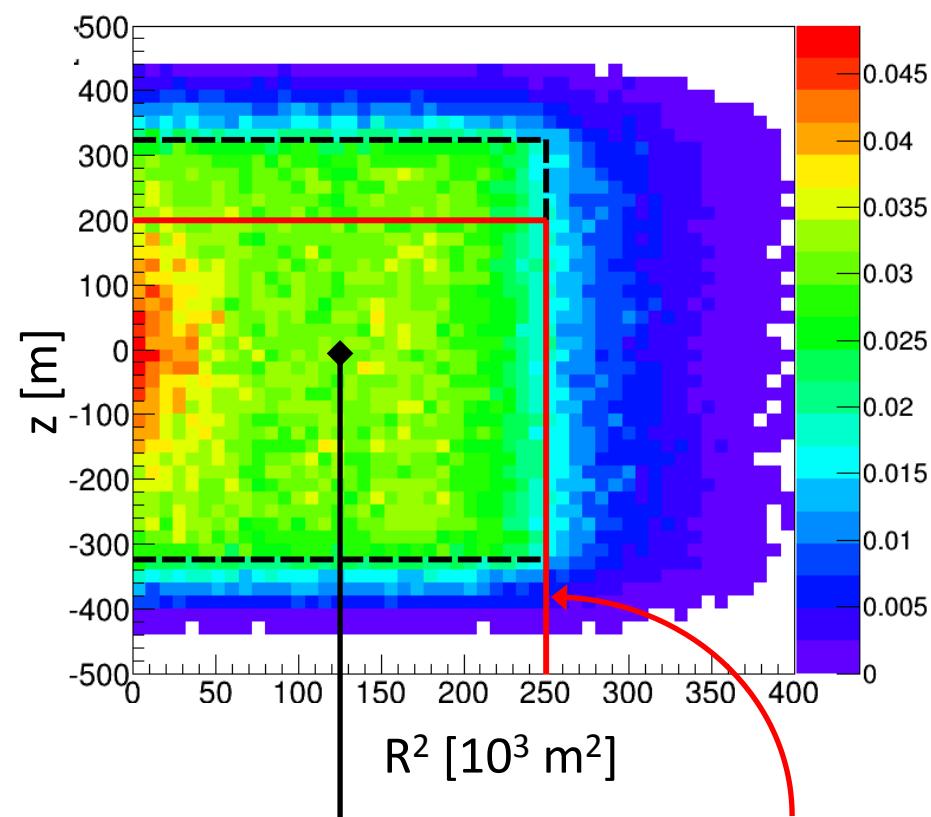
time resolution 1 ns angular resolution ?
position resolution 10 cm

Cascade analysis 1.0 – cut & count

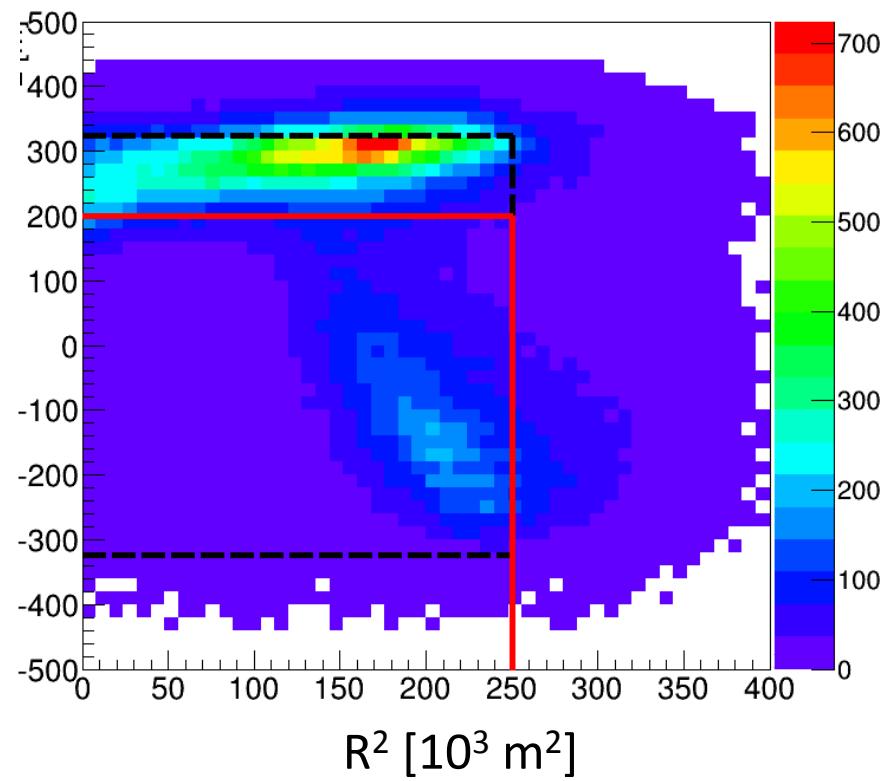
1. Online data filter
 - 5 (or more) coincidences between PMTs in same optical module ($\Delta T = 10$ ns)
2. Event filter
 - number of hits ≥ 2000
3. Vertex cut
 - veto atmospheric muons
4. Energy cut
 - total time-over-threshold $\geq 12 \mu\text{s}$
5. MRF/MDP cut
 - 2D cut based on Boosted Decision Tree & energy estimate

3.) Atmospheric muon veto

cosmic neutrinos

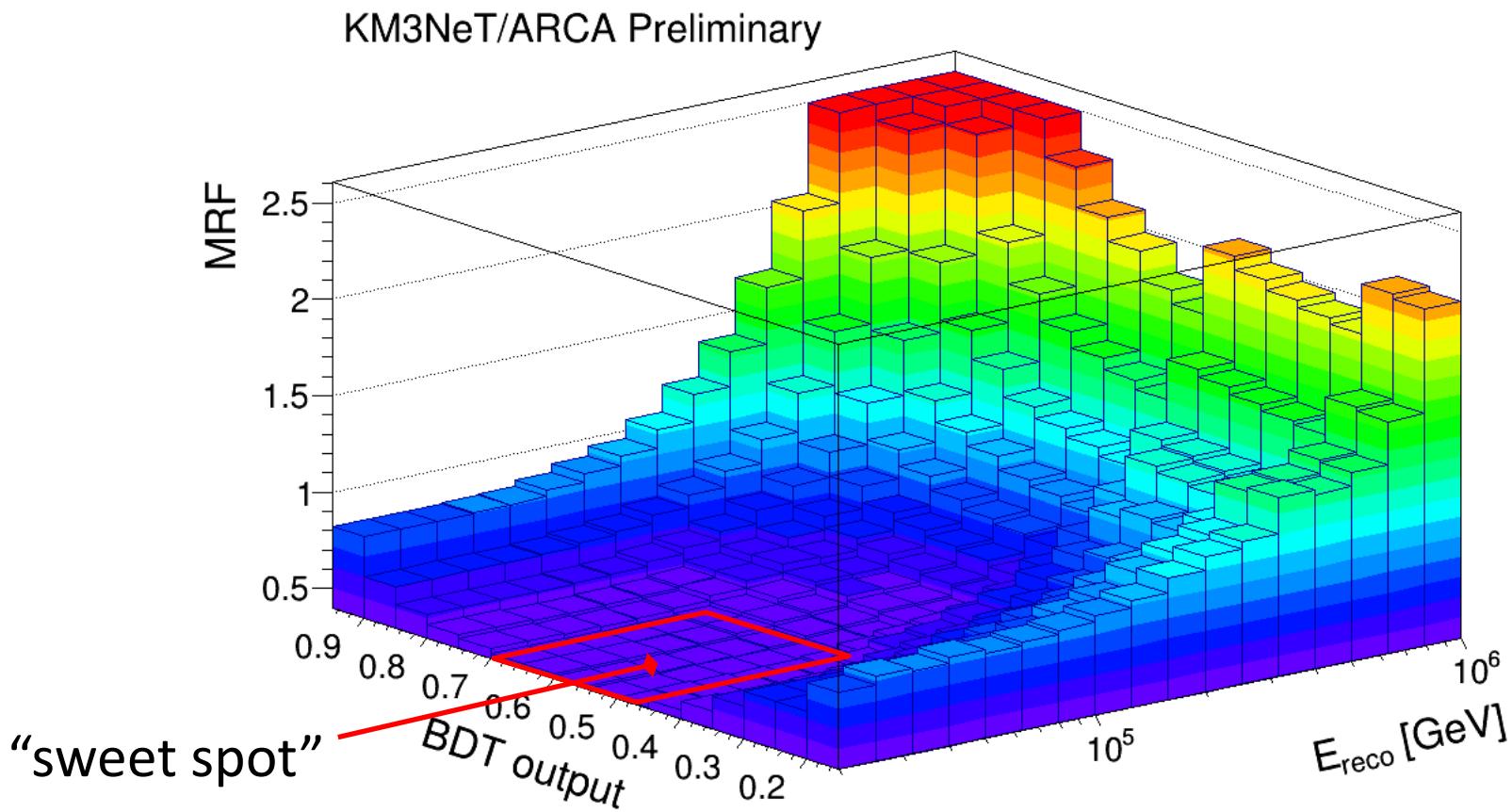


atmospheric muons

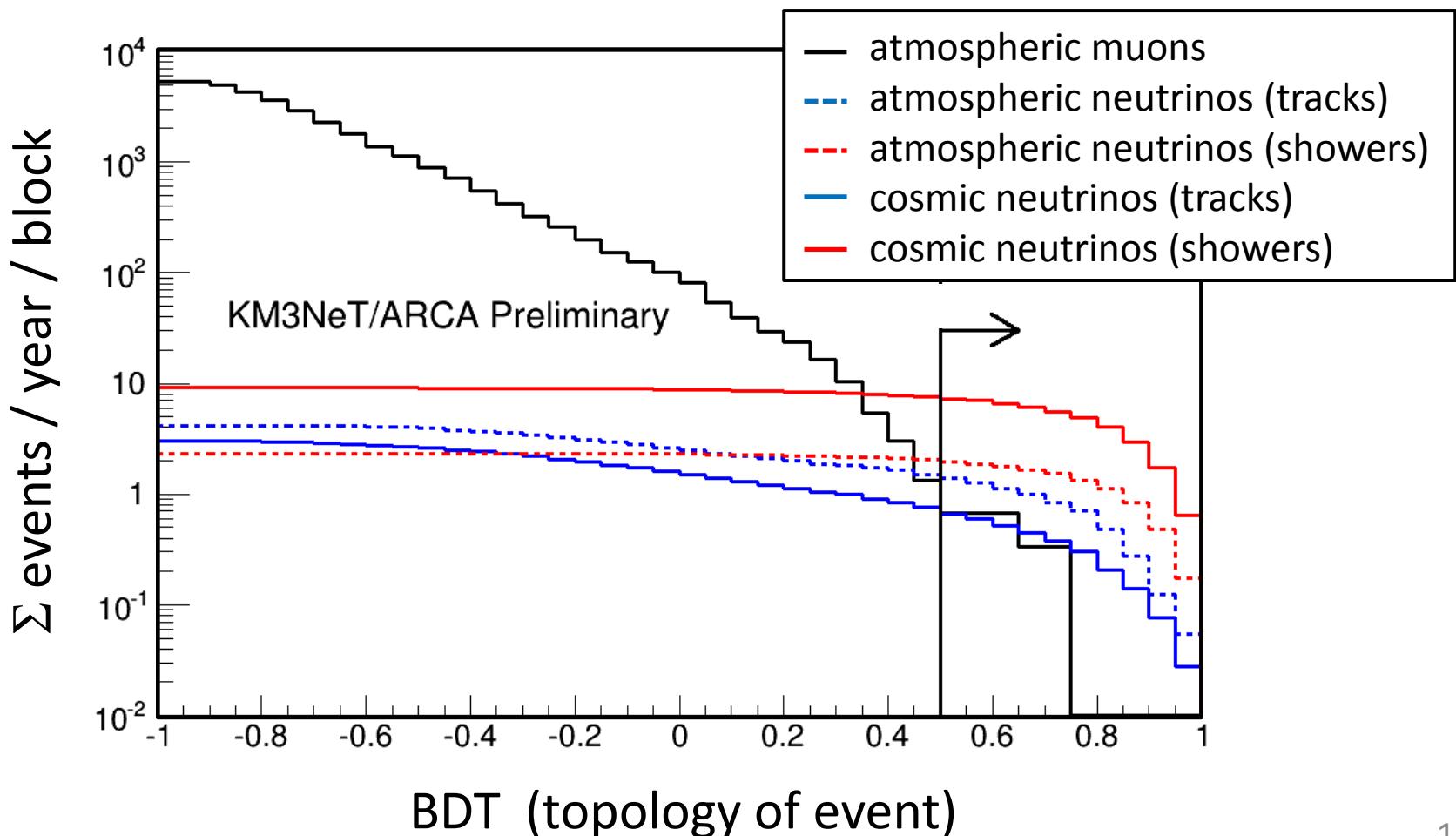


detector volume \otimes vertex cut $\equiv 80\%$

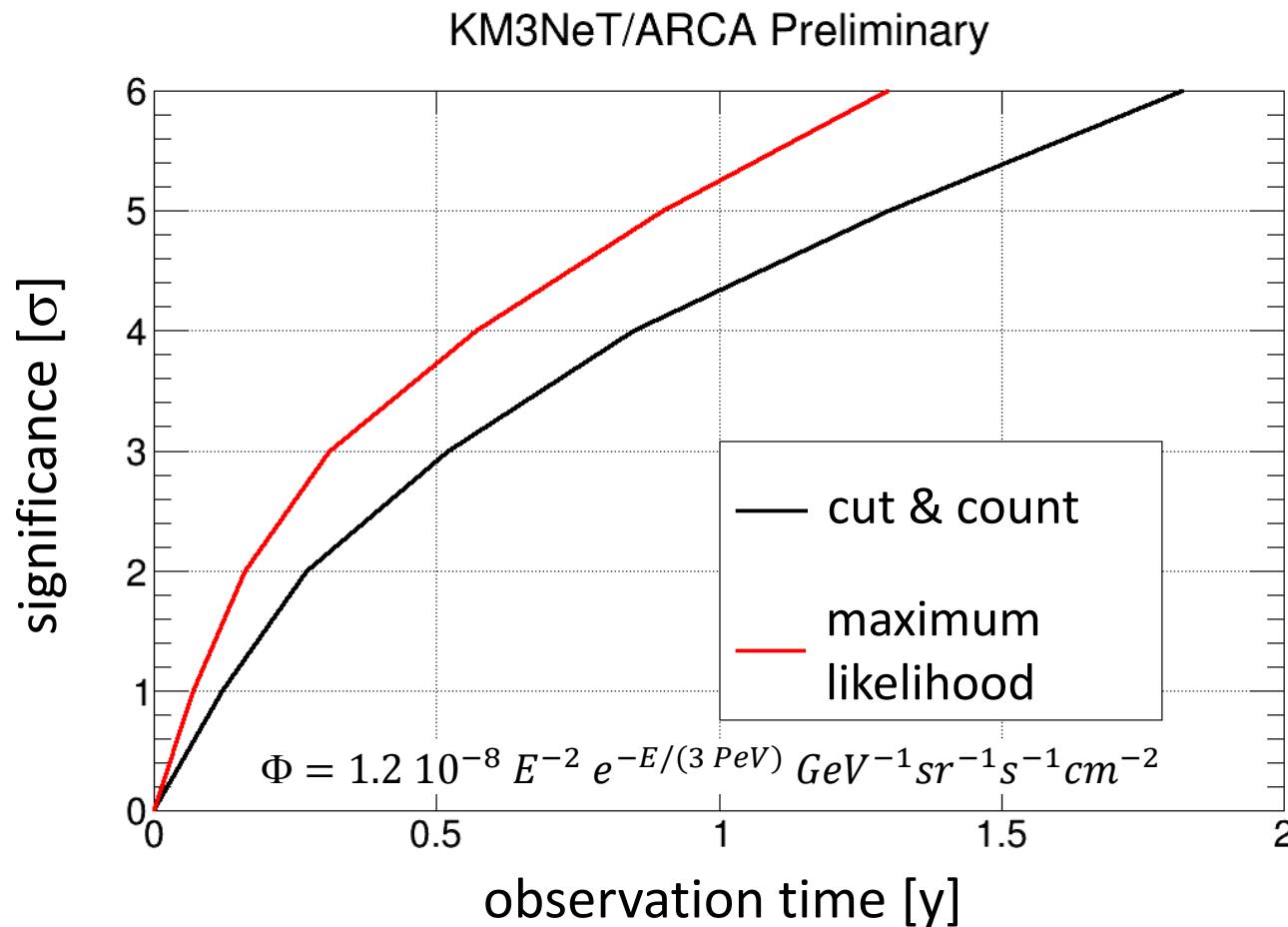
5.) Signal to Noise



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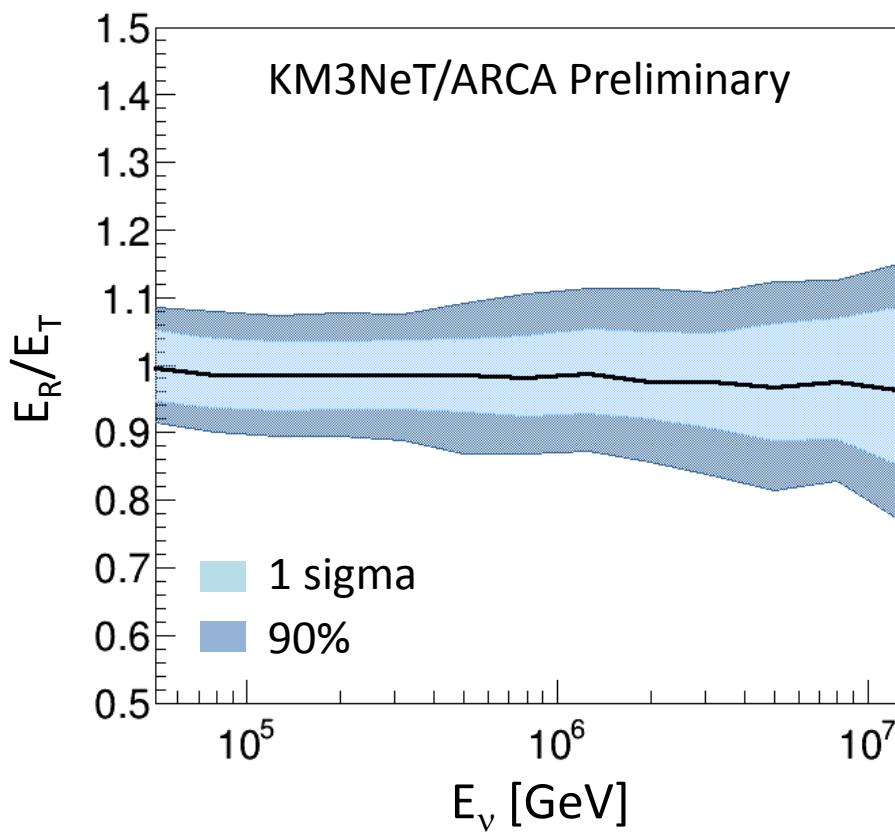
Sensitivity[¶]



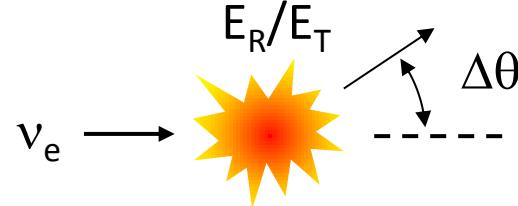
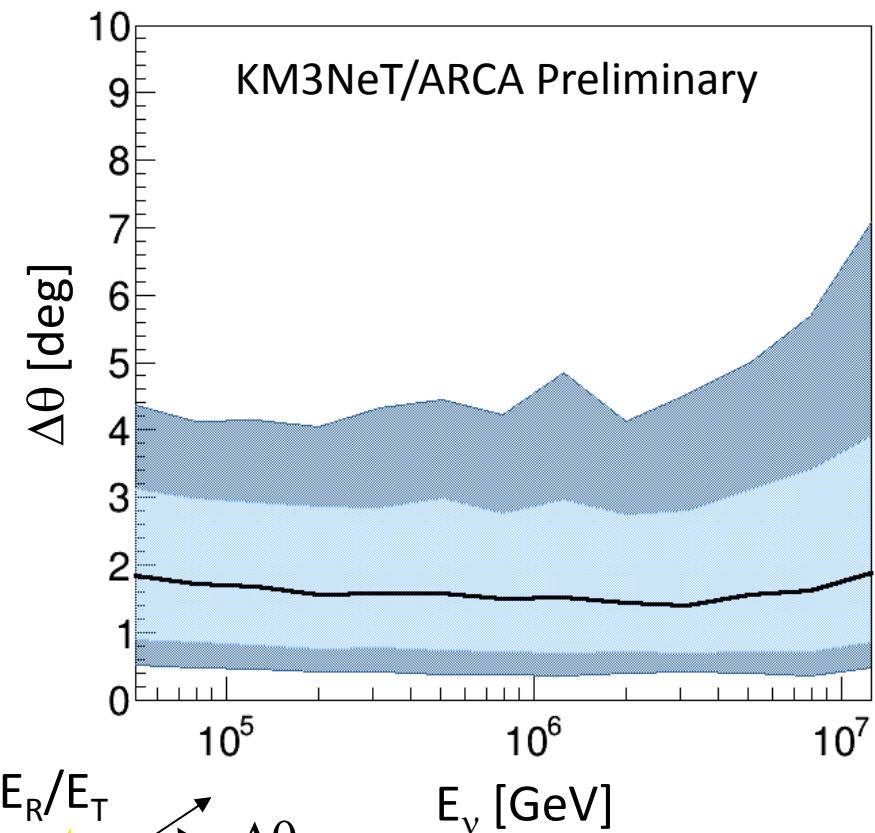
[¶] Vetoing of atmospheric neutrinos not included.

Resolution

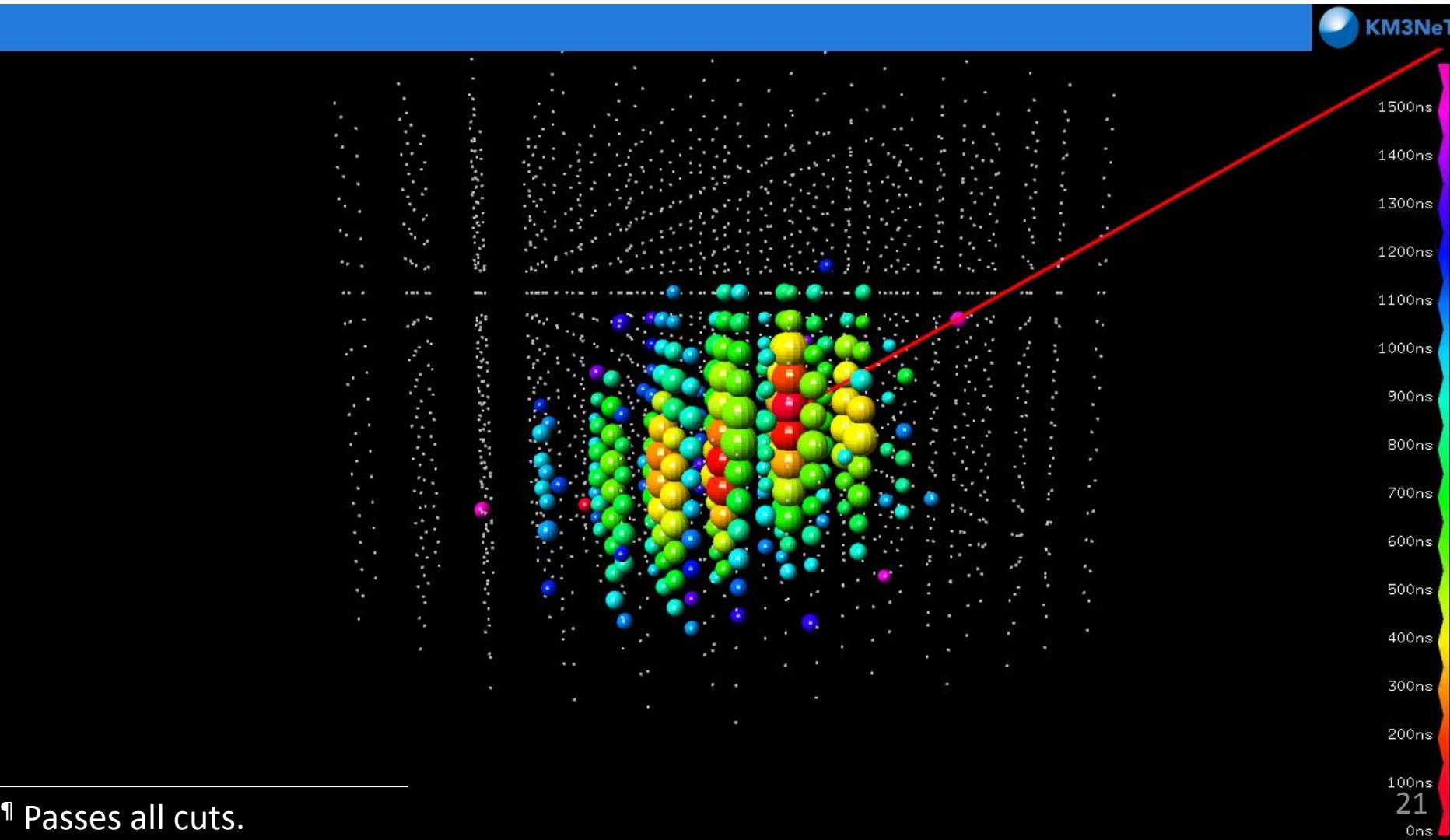
Energy



Direction

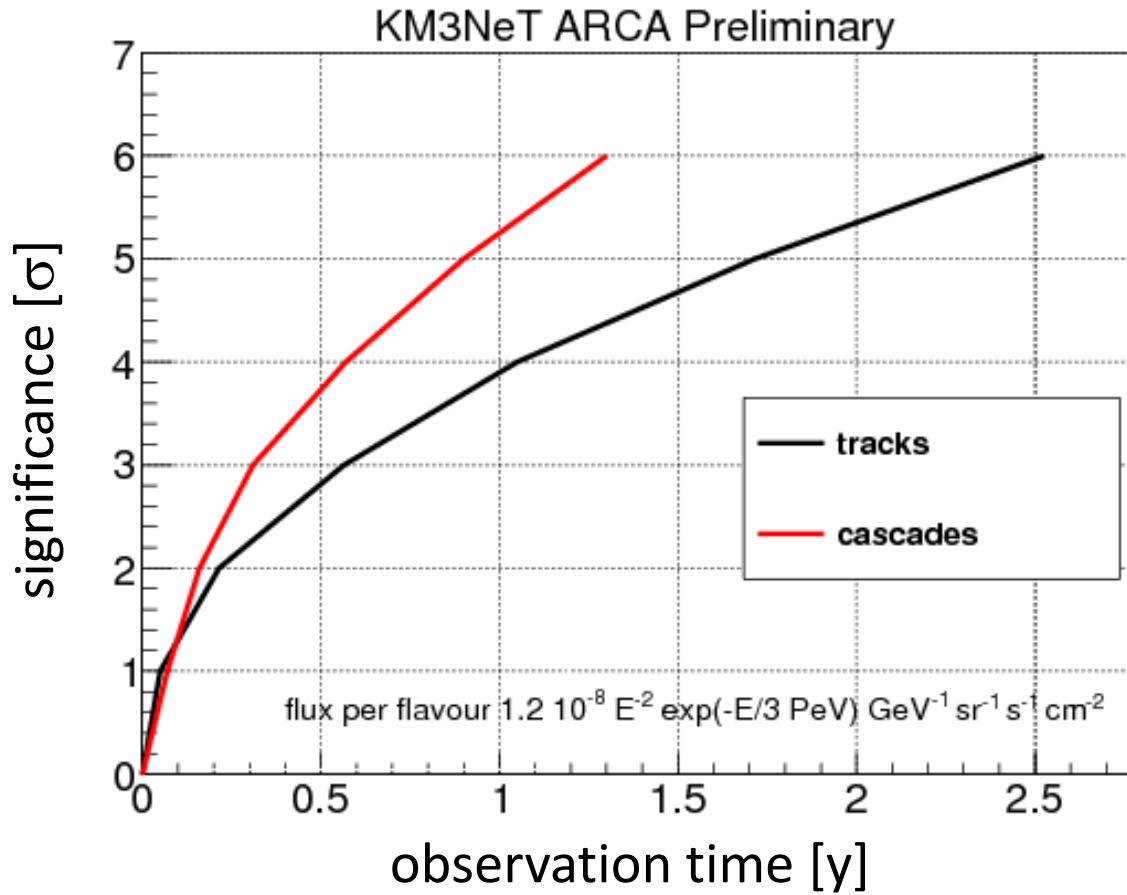


Simulation of 1.5 PeV ν_τ event[¶]



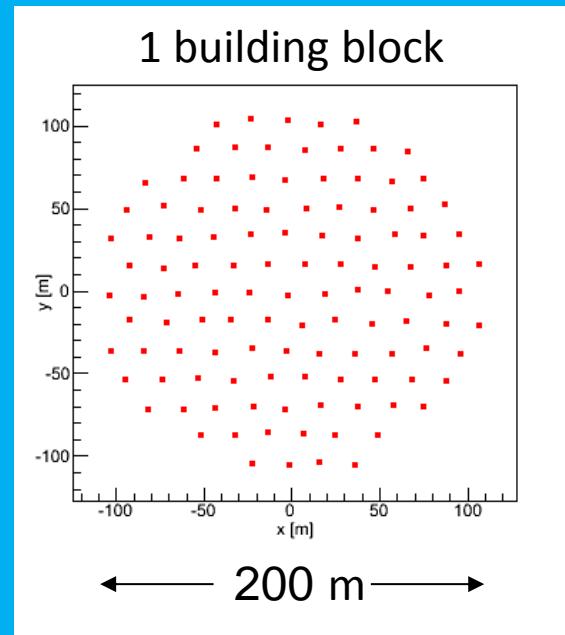
[¶] Passes all cuts.

Diffuse muon analysis

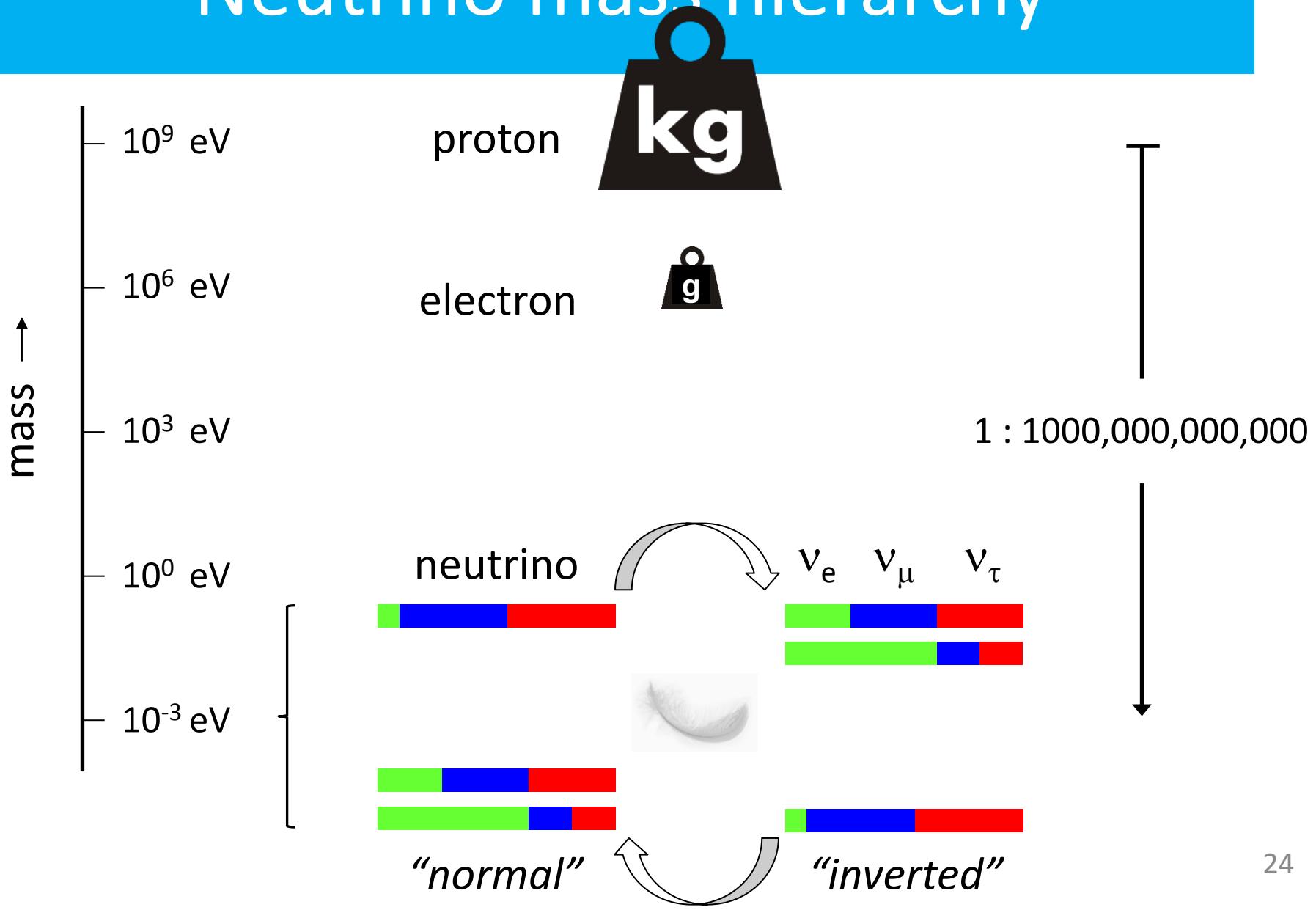


ORCA

Measurement of neutrino mass hierarchy

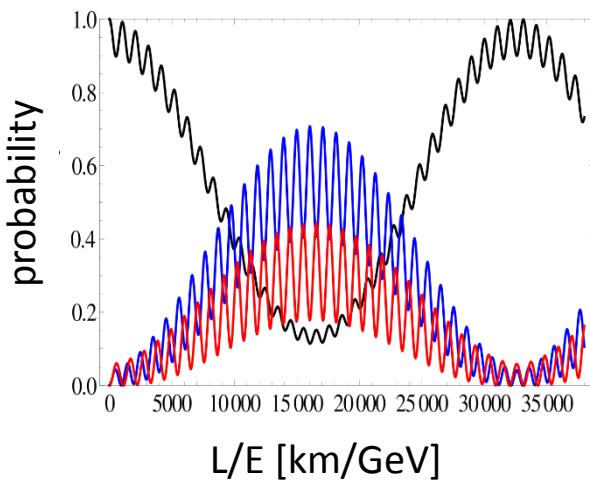


Neutrino mass hierarchy

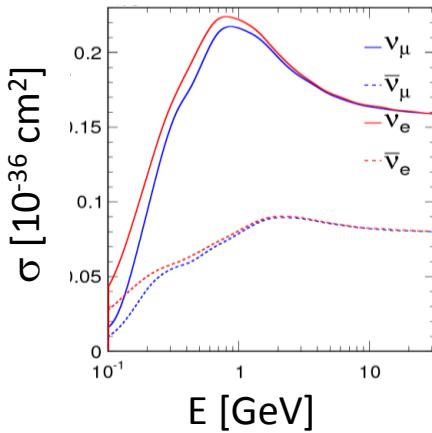


Neutrino mass hierarchy

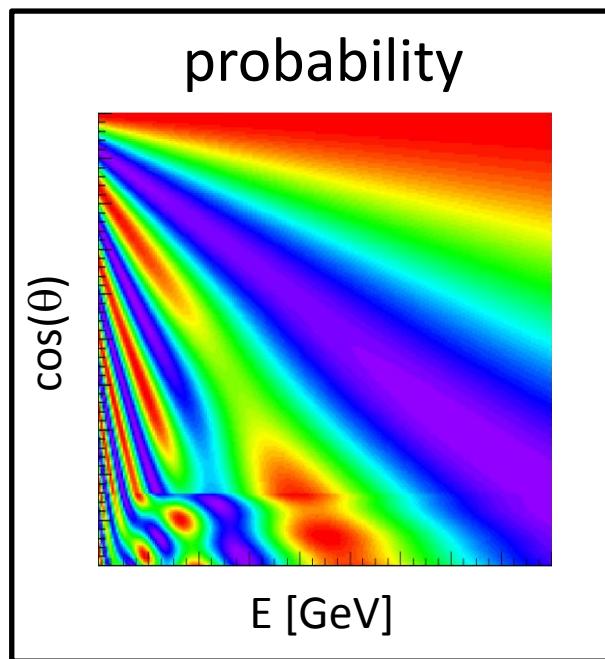
oscillations



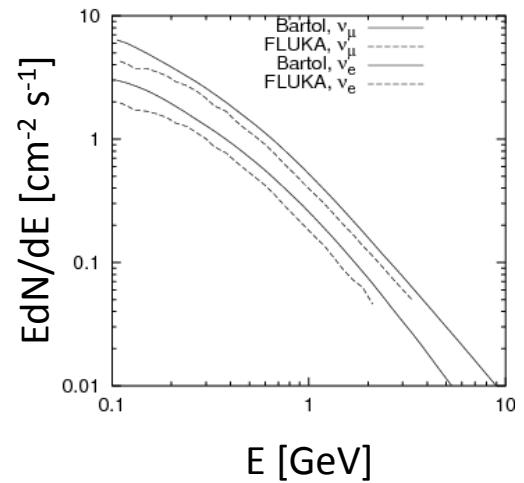
cross sections



probability



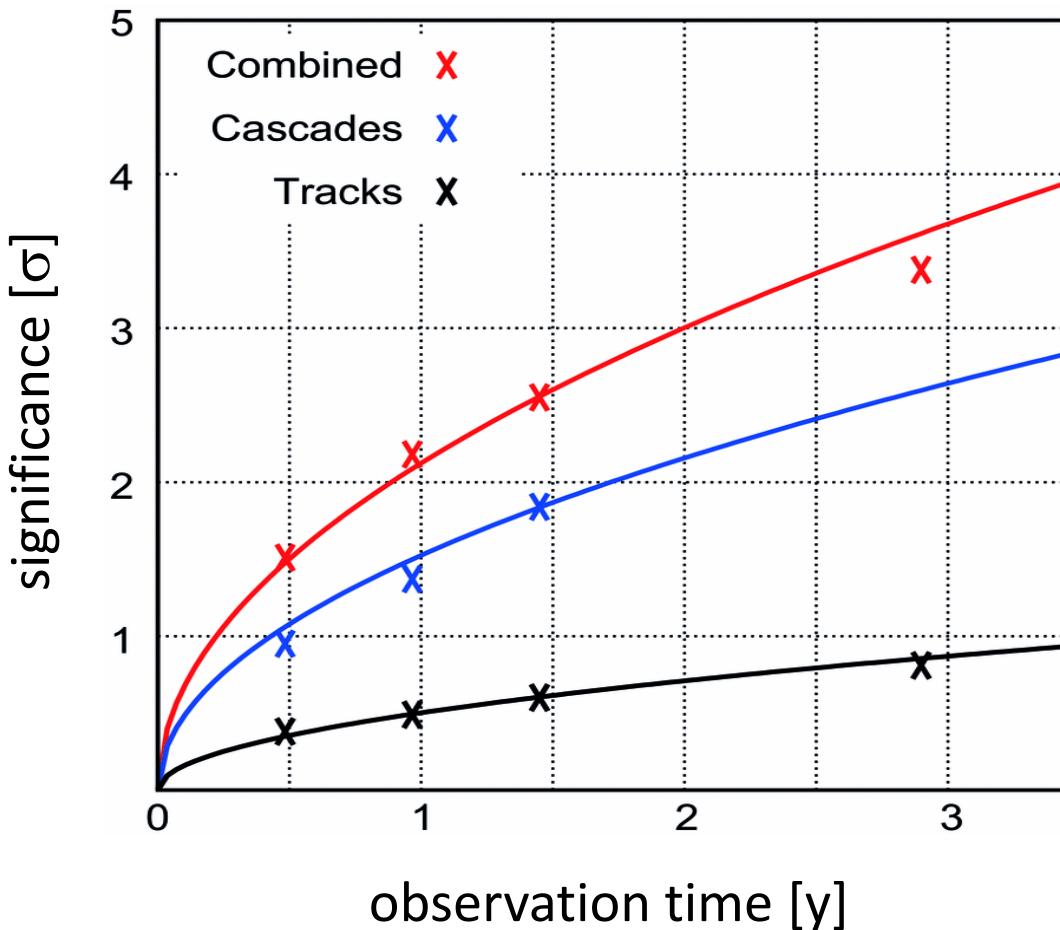
fluxes



matter

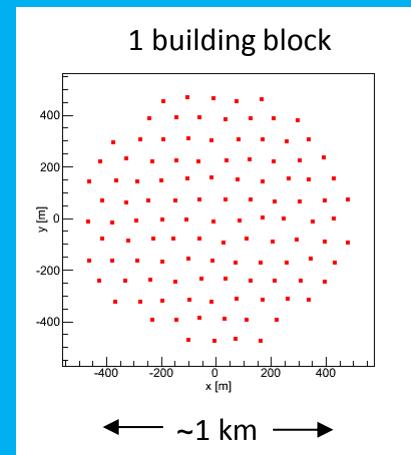
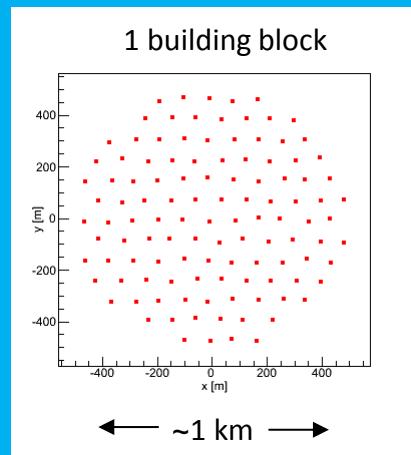
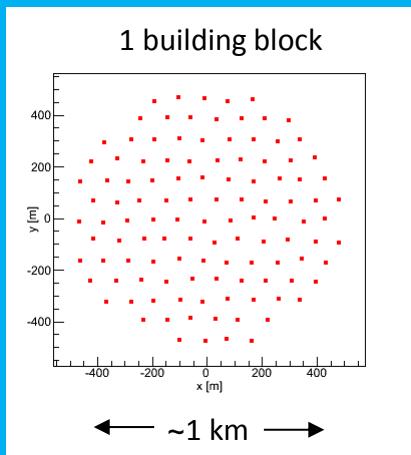
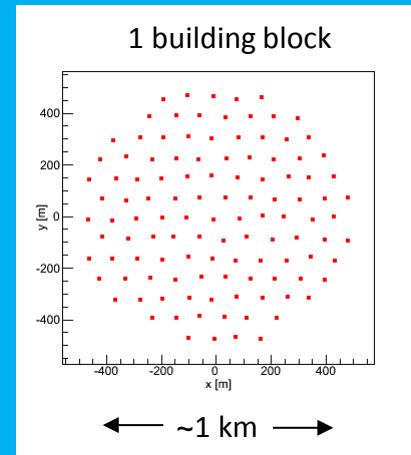
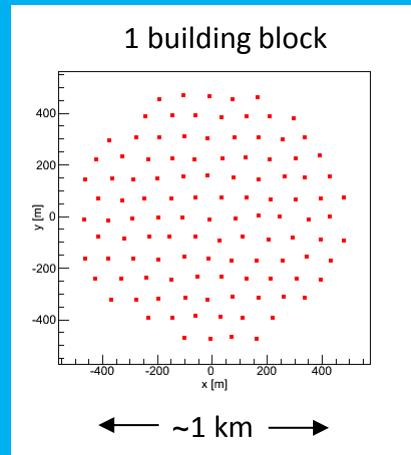
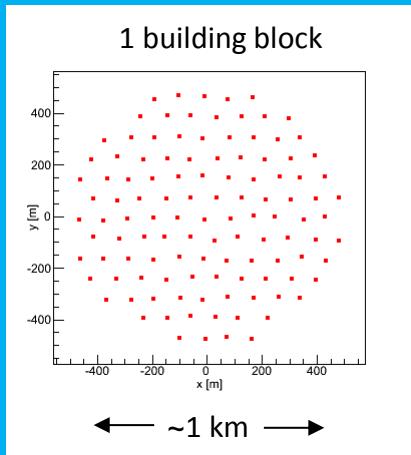


ORCA



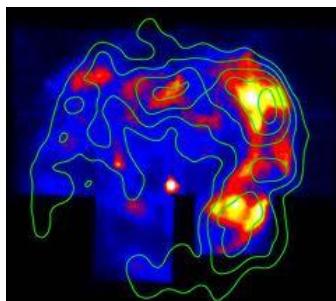
¶ Using prior for θ_{23} octant and δ_{CP} angle.

Future prospects (I)

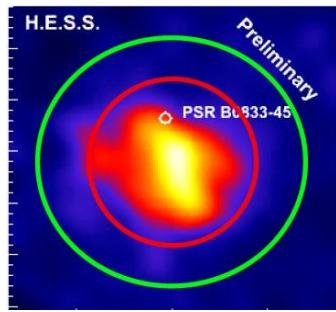


Future prospects (II)

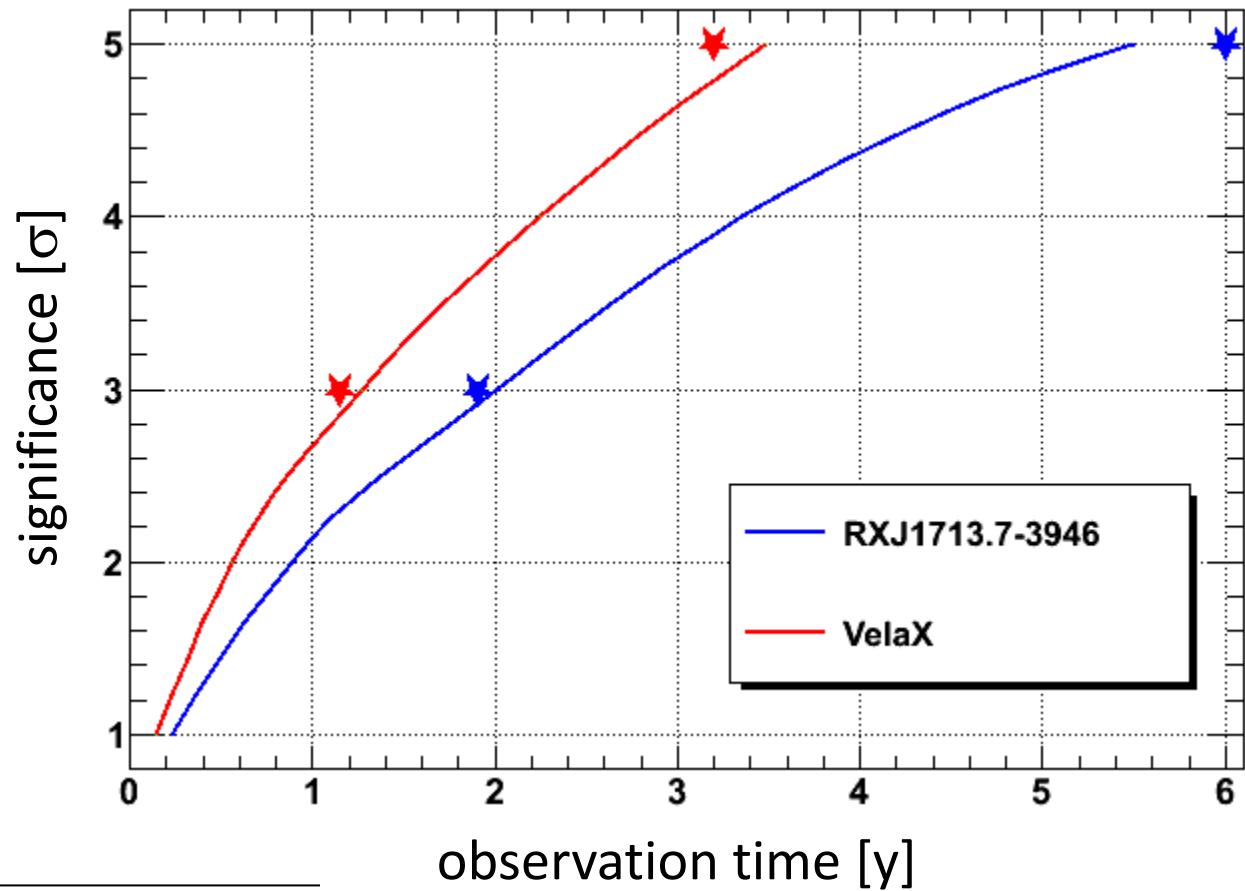
RXJ1713[¶]



Vela X[§]



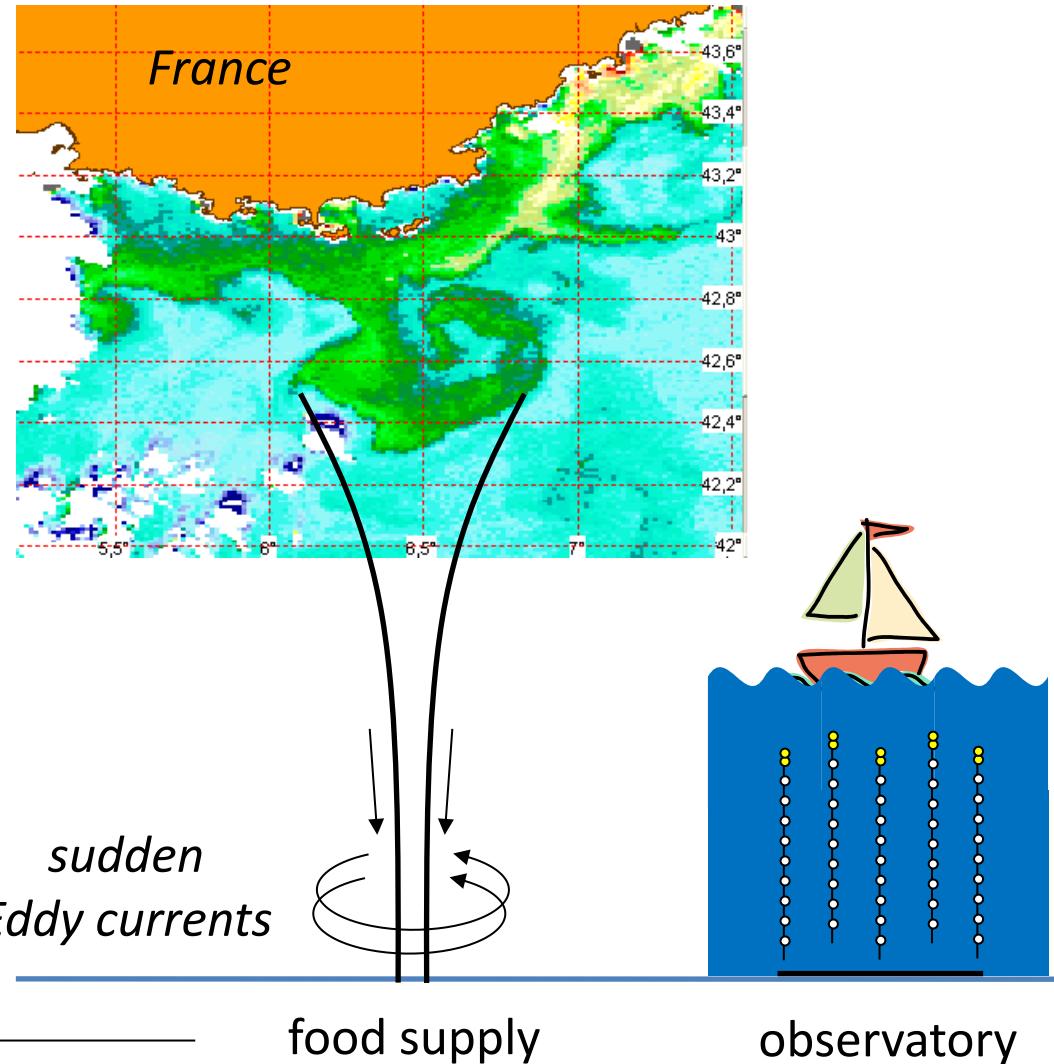
Galactic sources



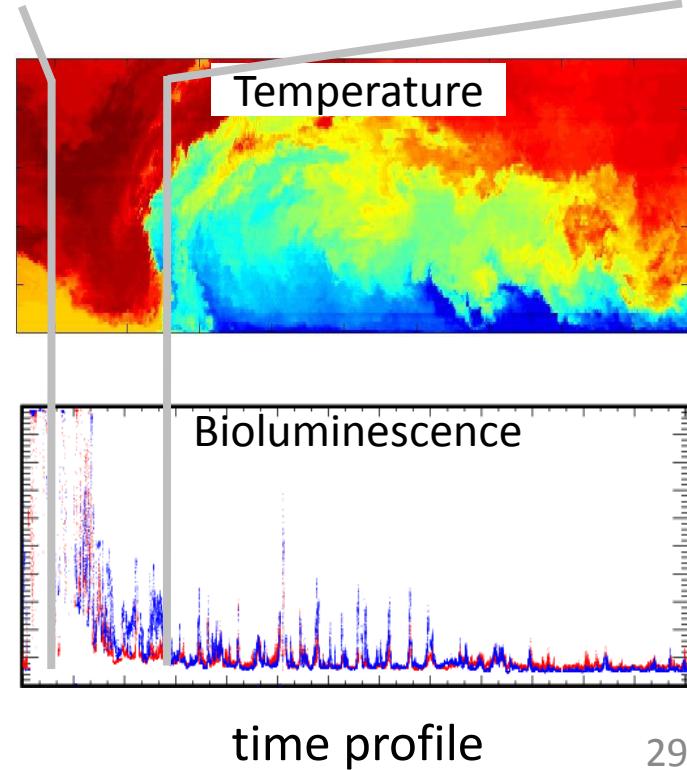
[¶] S.R. Kelner, et al., Phys. Rev. D 74 (2006) 034018.

[§] F.L. Villante and F. Vissani, Phys. Rev. D 78 (2008) 103007.

Earth & Sea sciences[¶]



short lived (rare) events
dominate life in deep-sea
↓
permanent observatory



KM3NeT status & outlook

- R&D
 - developed cost-effective technology
 - feedback from prototypes confirm key specifications
- Phase-1
 - going ahead as planned
- Phase-2
 - *ARCA*
 - measurement of IceCube flux with different methodology, complementary field of view and improved resolution
 - all flavour neutrino astronomy
 - *ORCA*
 - measurement of neutrino mass hierarchy
- Future prospects
 - exploration of our Galaxy