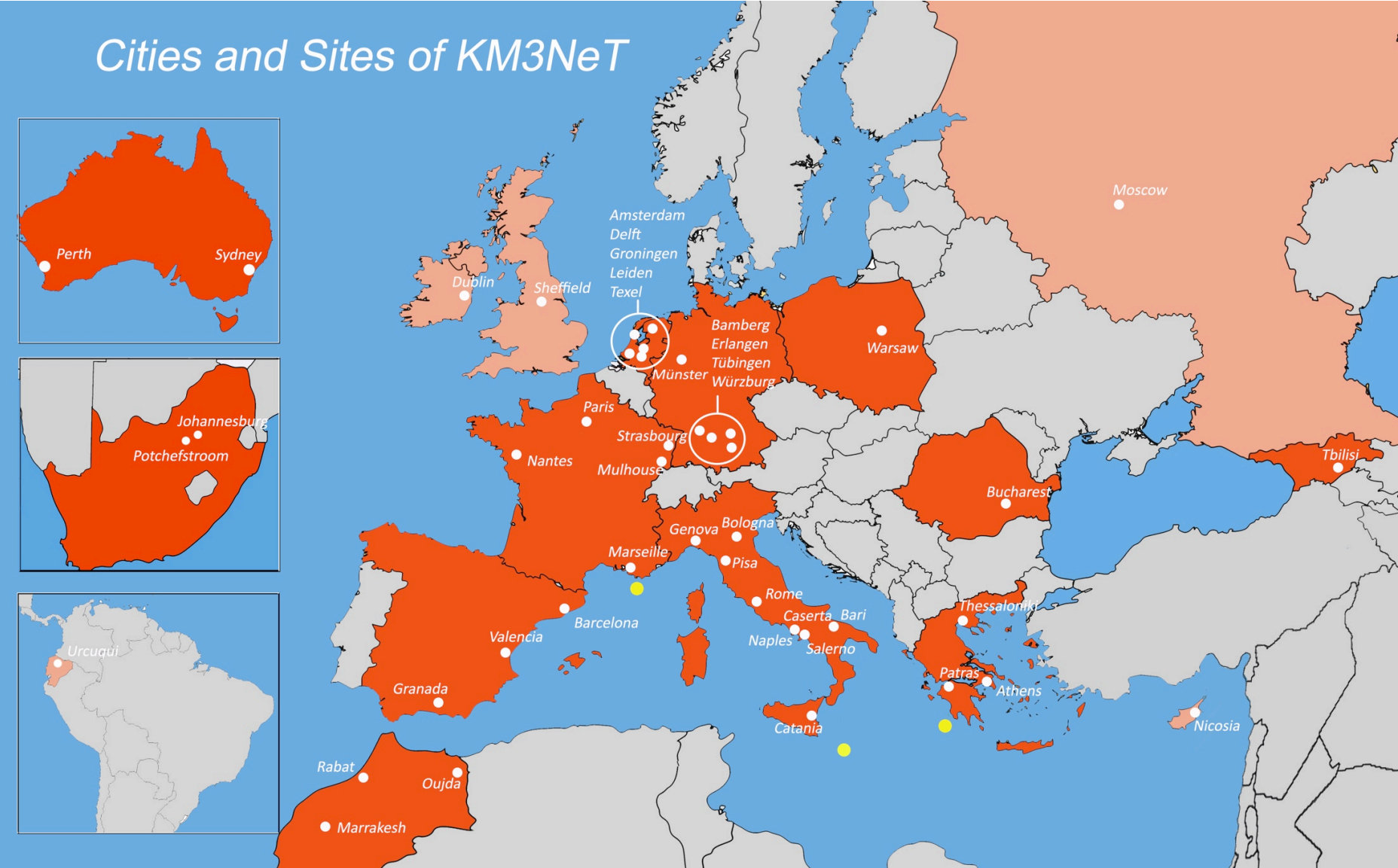
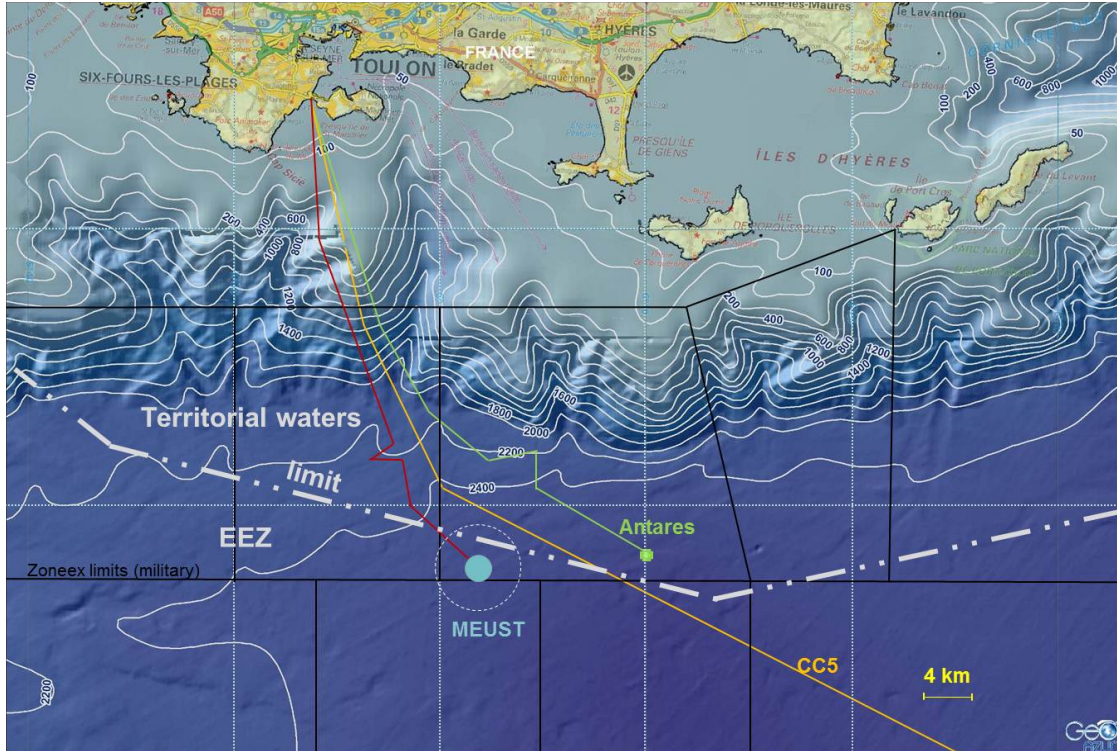


KM3NeT plans for the Hidden Universe



+ observer
Sun Yat-Sen univ.
Guangzhou
China

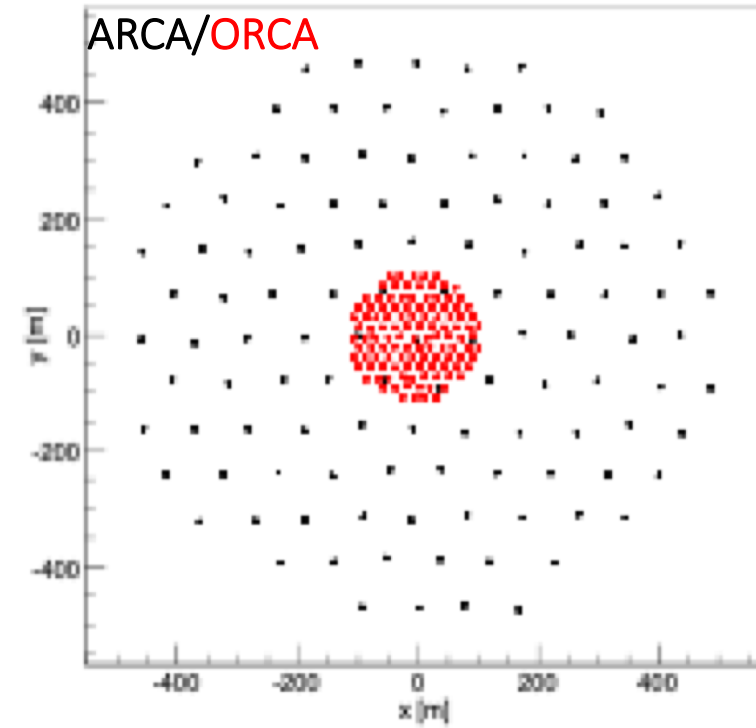
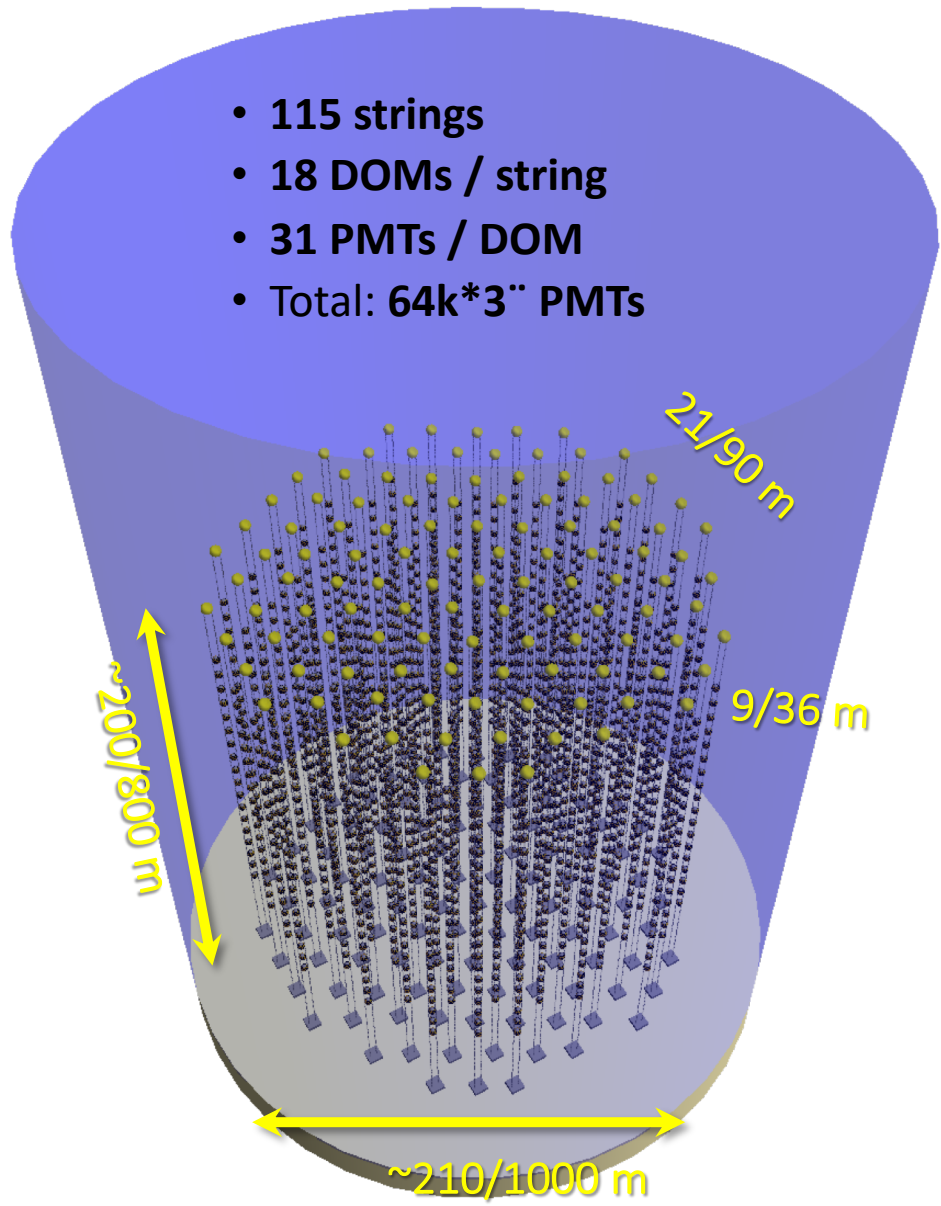
KM3NeT sites: ORCA and ARCA



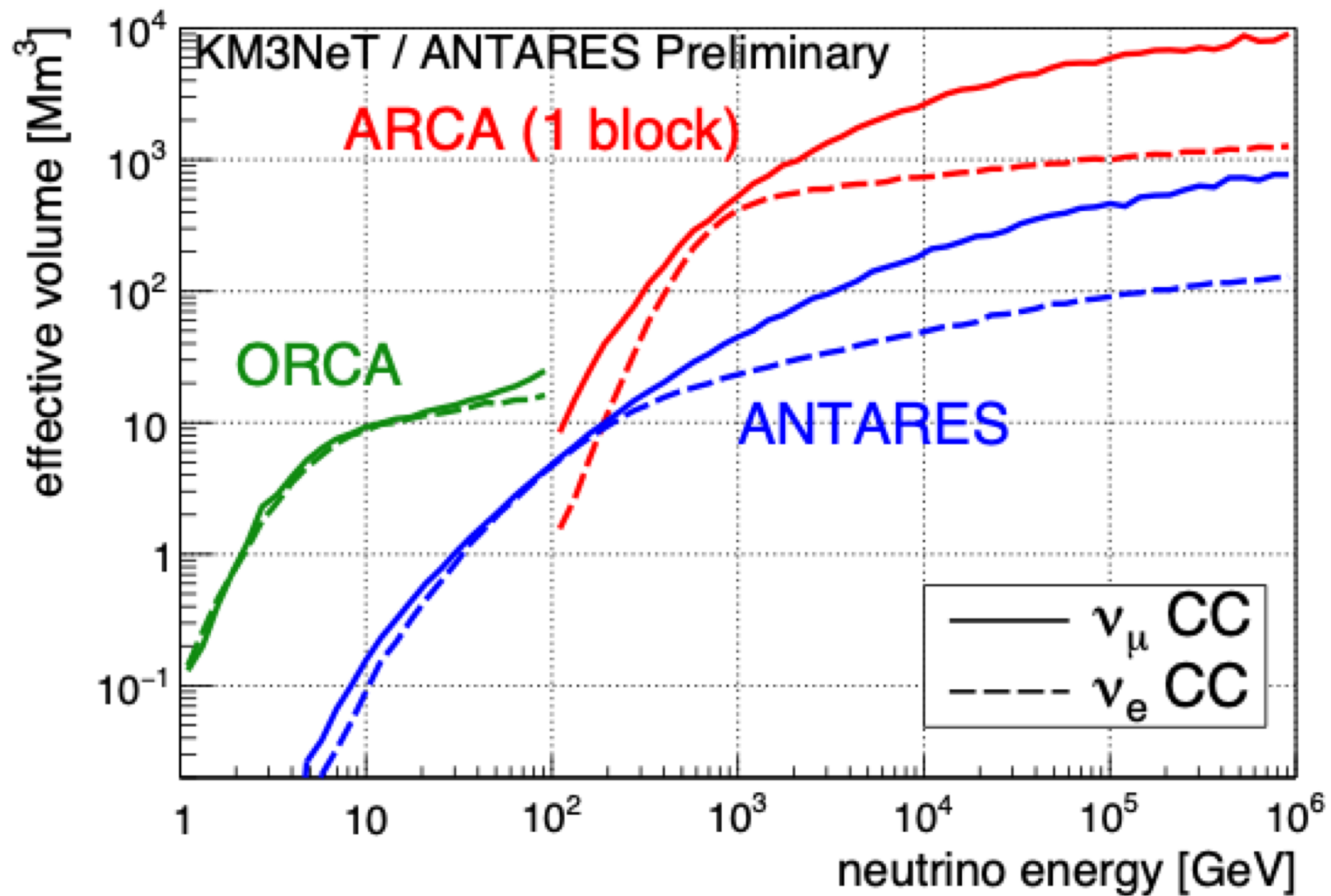
Oscillation Research with Cosmics In the Abyss



Astroparticle Research with Cosmics In the Abyss



	ORCA	ARCA
String spacing	21 m	90 m
OM spacing	9 m	36 m
Depth	2470 m	3400 m
Instrumented mass	8 Mton	500*2 Mton



Physics: Oscillations of atmospheric neutrinos

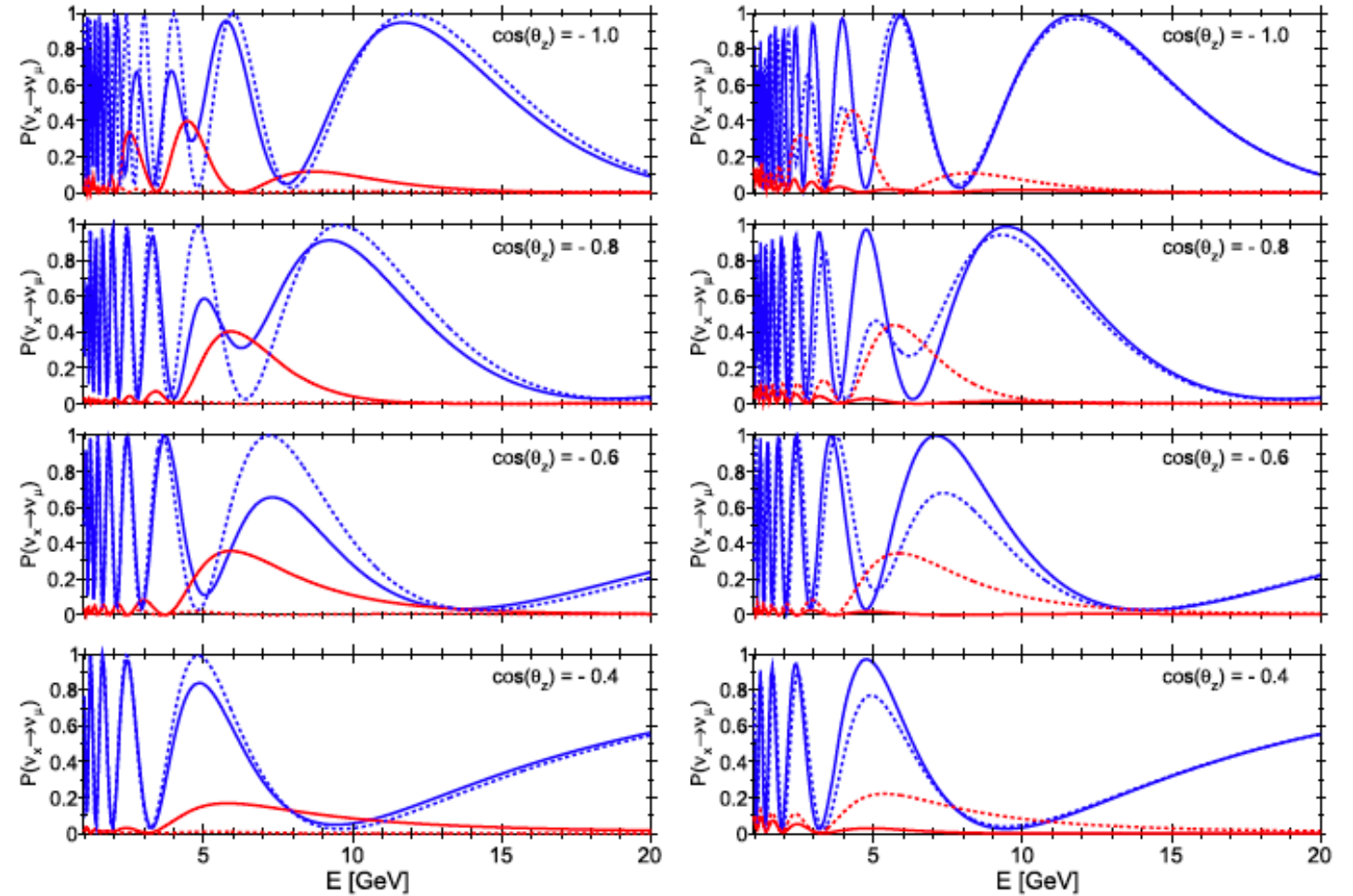
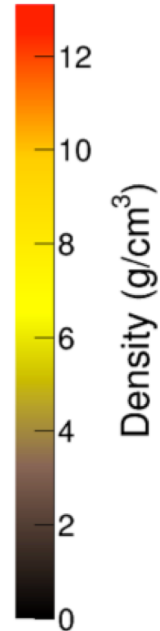
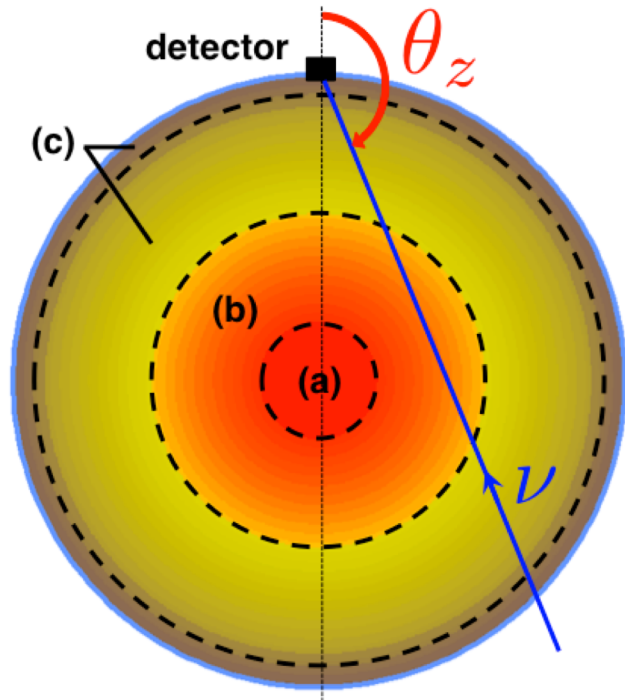
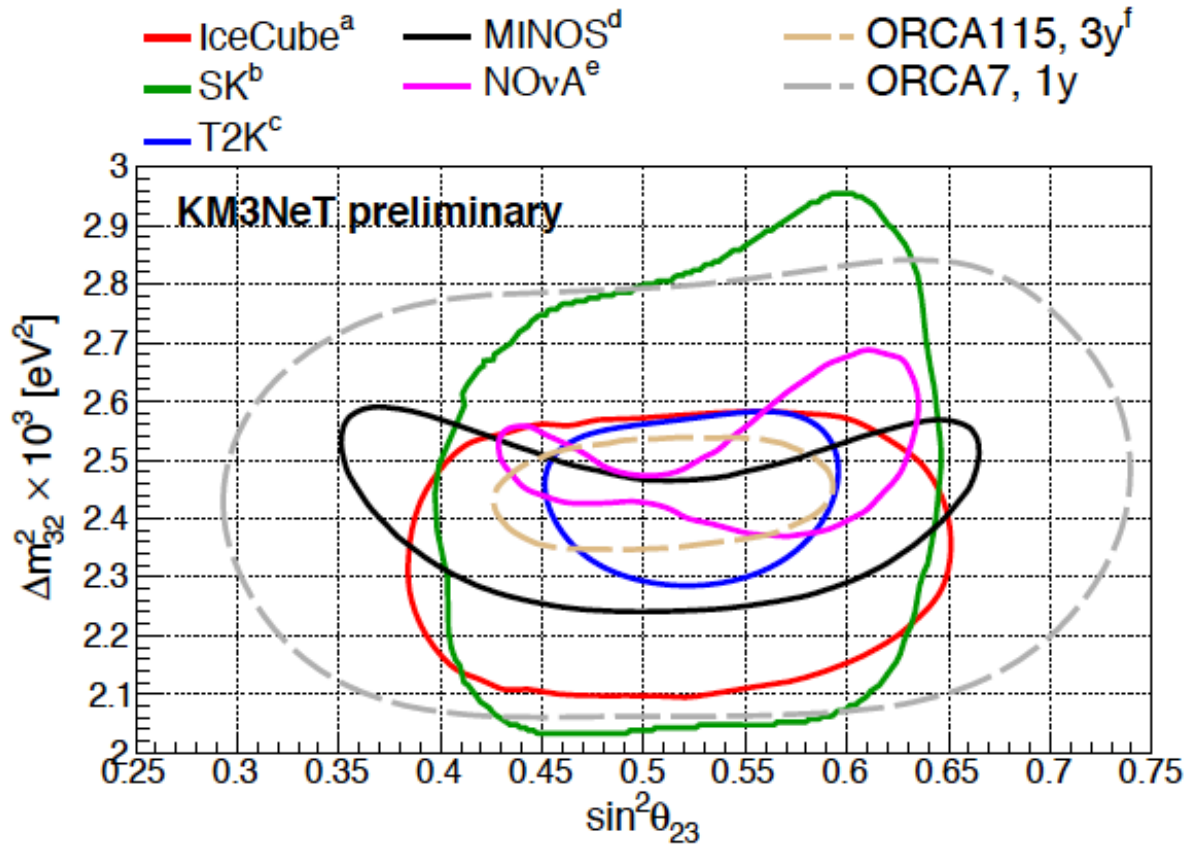


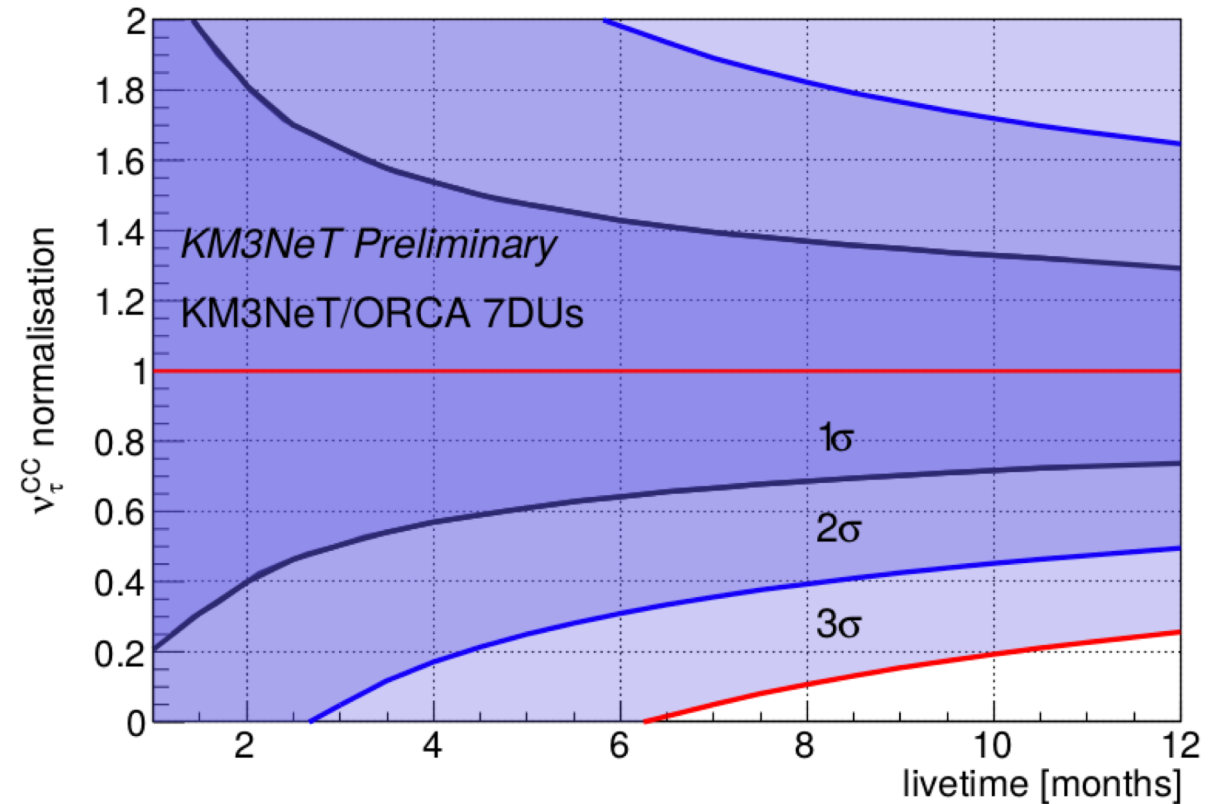
Figure 47. Oscillation probabilities $\nu_\mu \rightarrow \nu_\mu$ (blue lines) and $\nu_e \rightarrow \nu_\mu$ (red lines) as a function of the neutrino energy for several values of the zenith angle (corresponding to different baselines). The solid (dashed) lines are for NH (IH). For neutrinos (left) and for antineutrinos (right).

Oscillation fit



(former Nikhef postdoc Bruno Strandberg)

Tau neutrino appearance



For true $\theta_{23} = 48^\circ$ the correct octant can be determined at 1σ after 1 year, 2σ after 5 years

Neutrino mass ordering

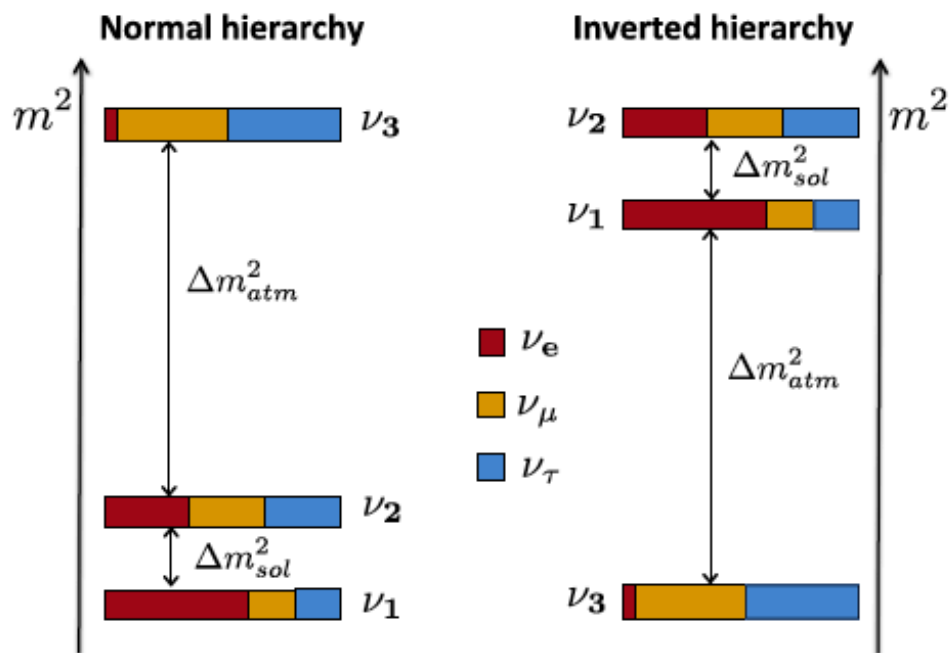
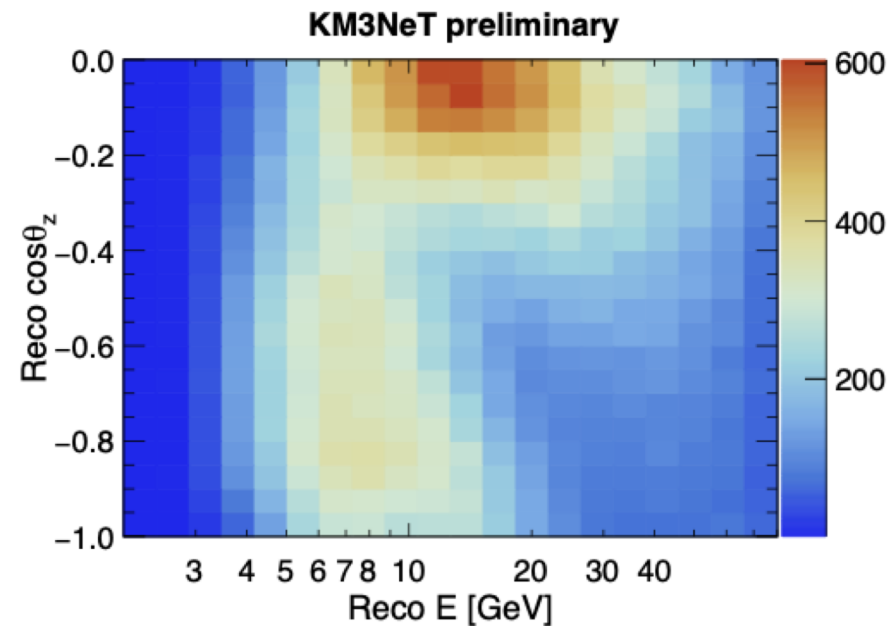


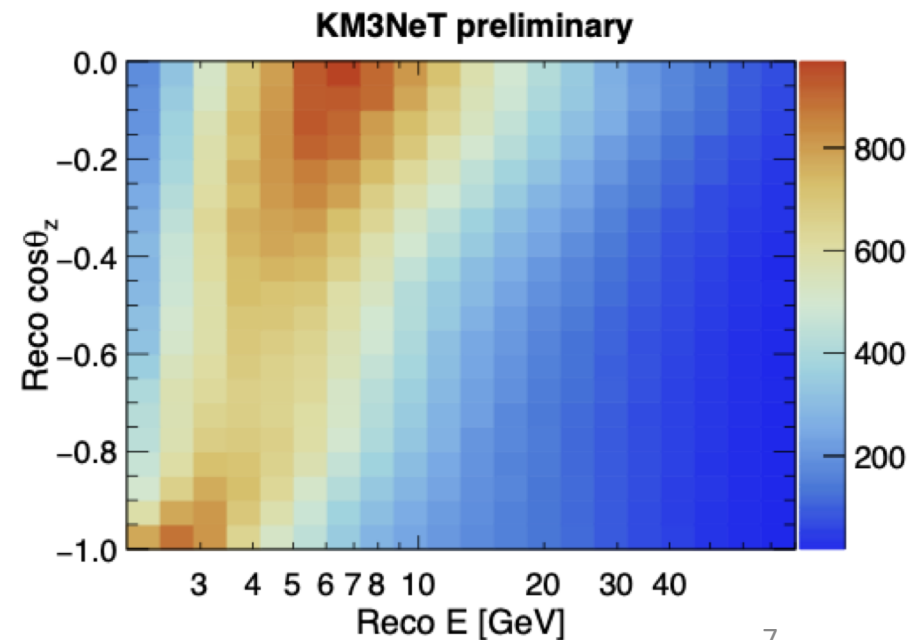
Figure 46. Scheme of the two distinct neutrino mass hierarchies. The colour code indicates the fraction of each flavour (e , μ , τ) present in each of the mass eigenstates (ν_1 , ν_2 , ν_3).

Event rates for
3 year ORCA

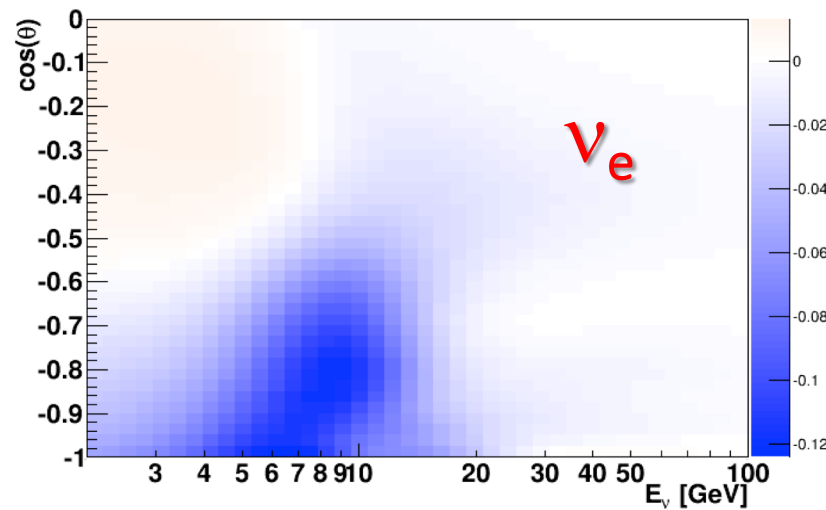
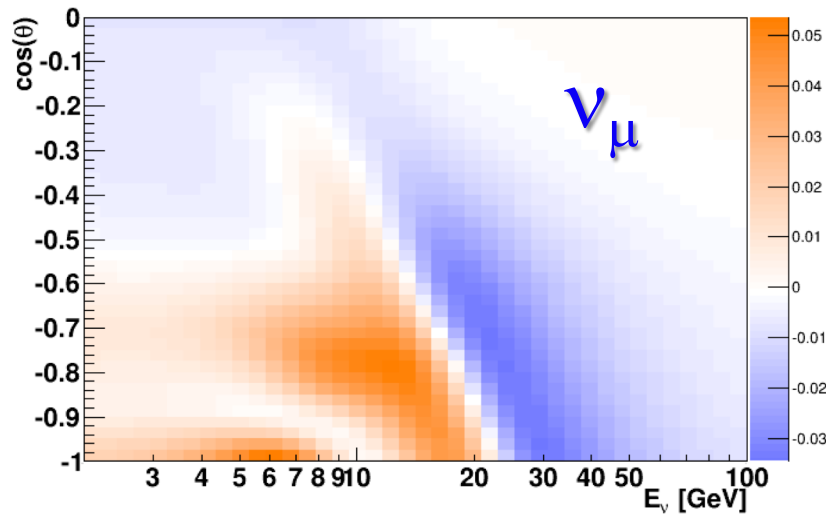
tracks



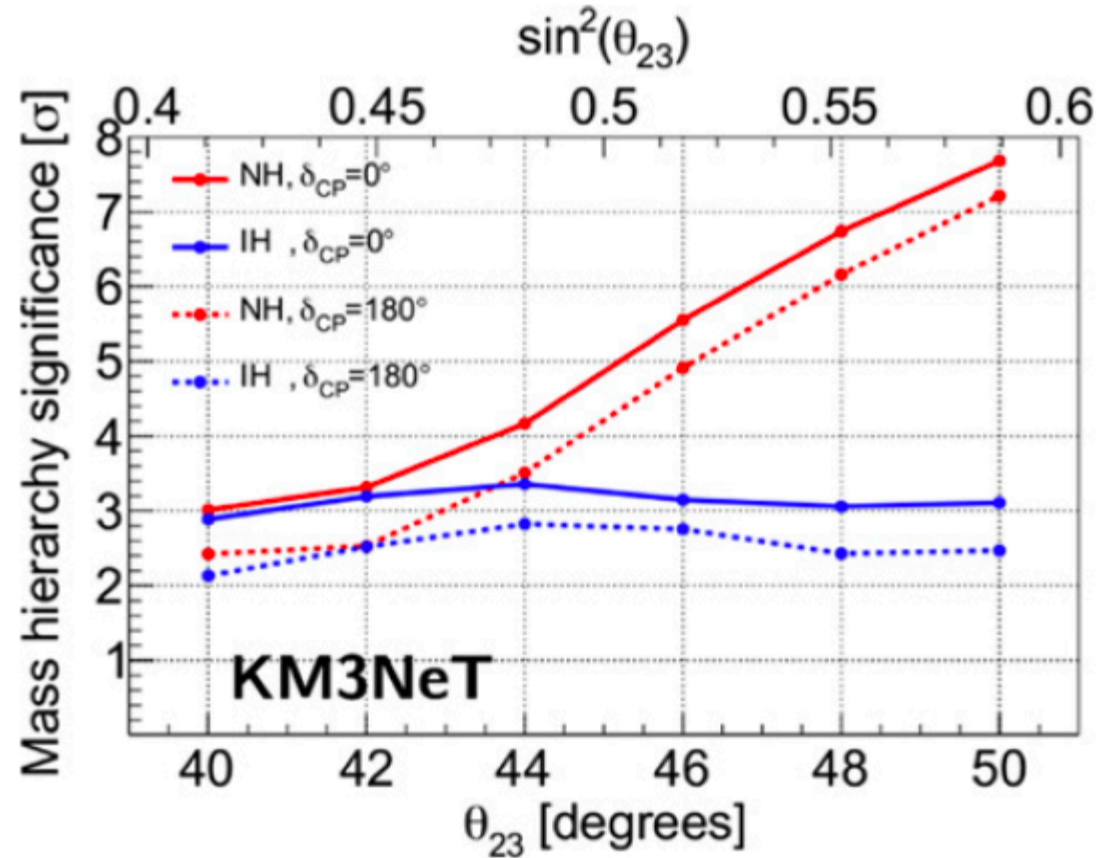
showers



Asymmetry: $(N_{IO} - N_{NO}) / N_{NO}$

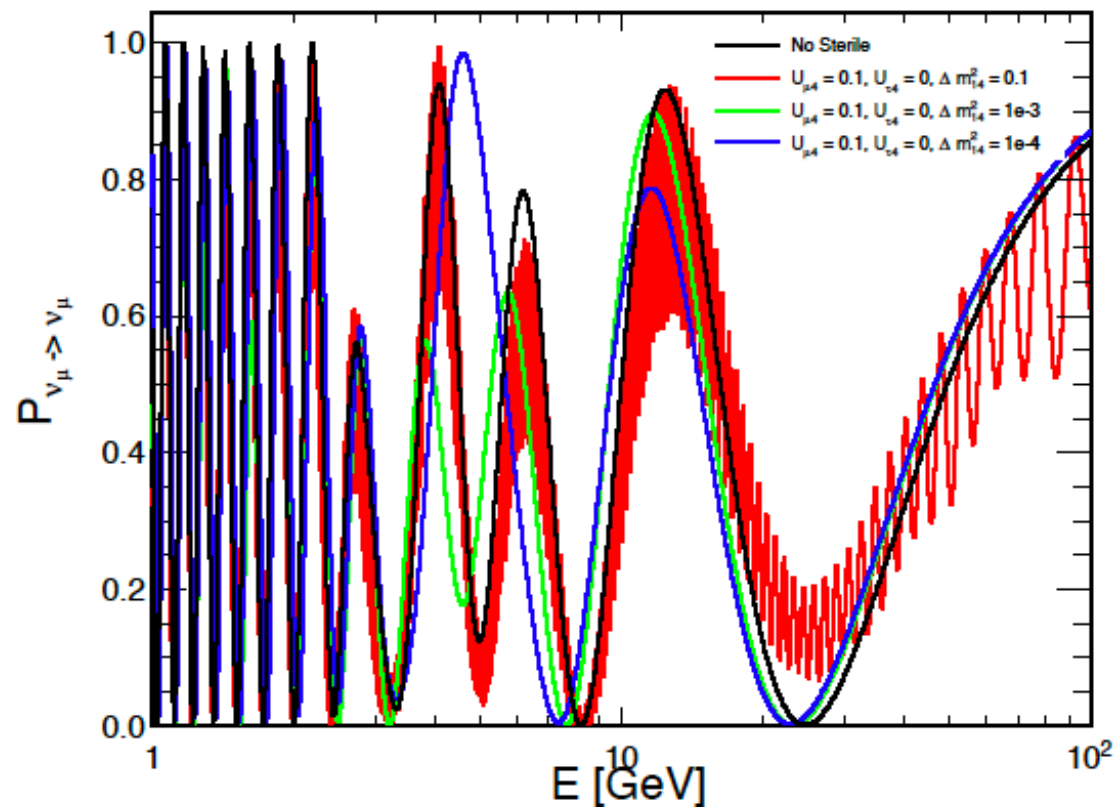


Sensitivity ORCA after 3 years

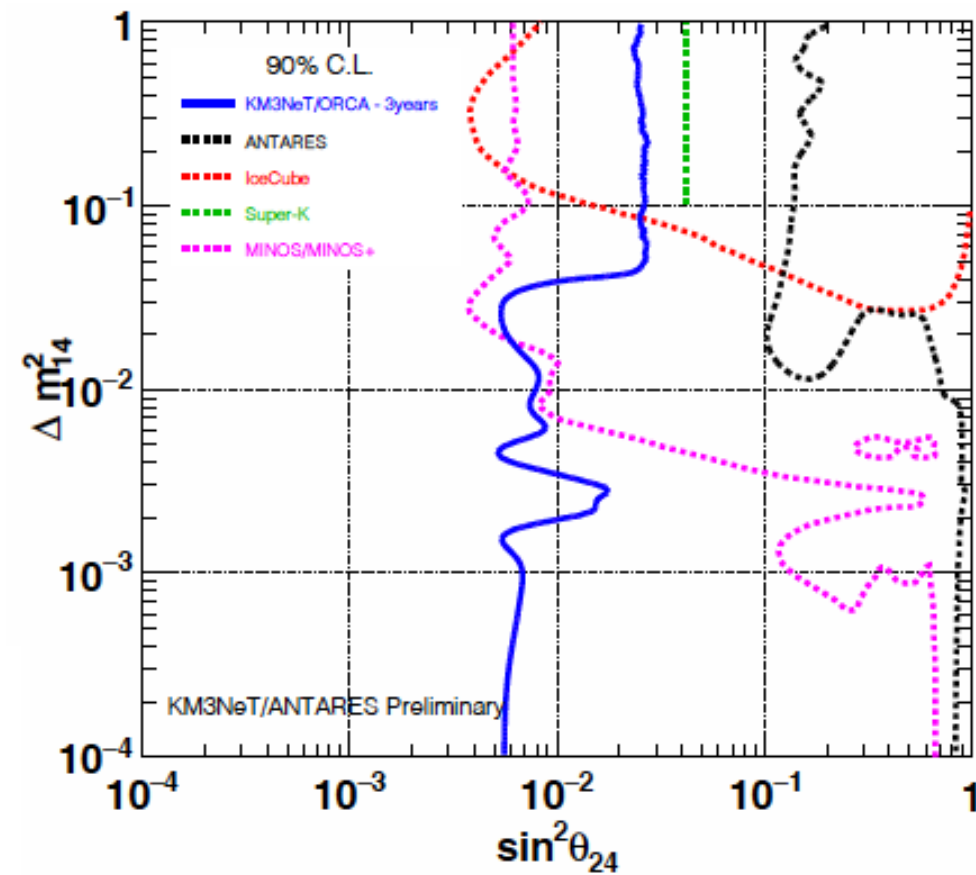


Sterile neutrinos: affect oscillation fit

Example: effects in ORCA for low Δm^2_{41}



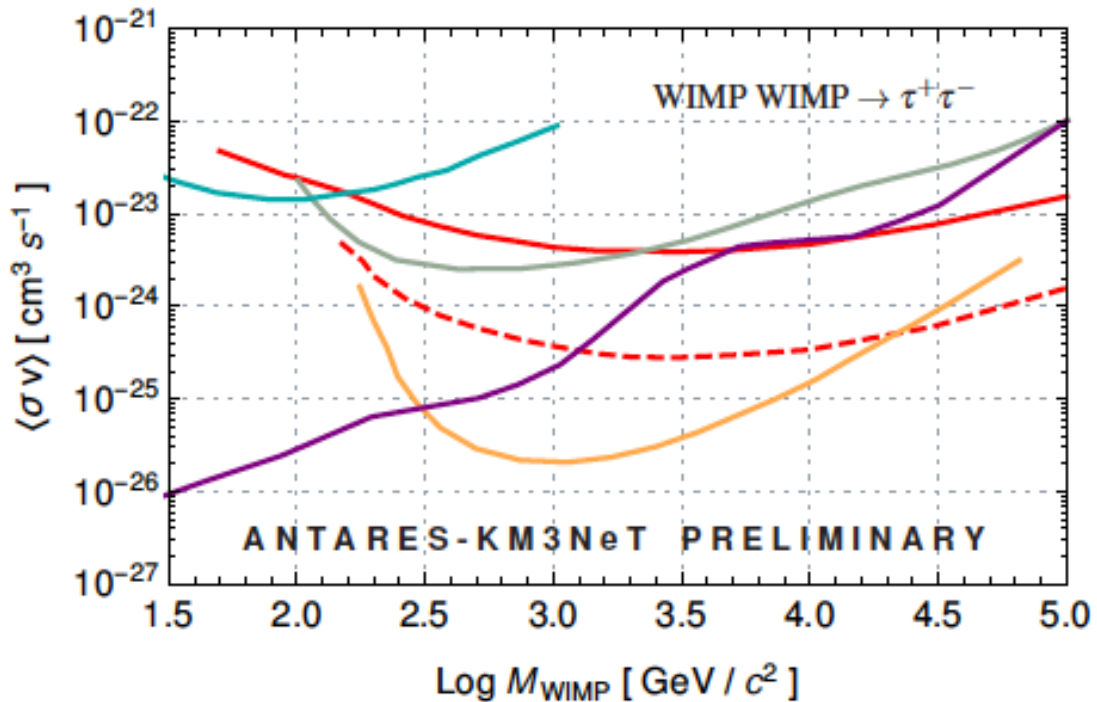
(To be explored more systematically)



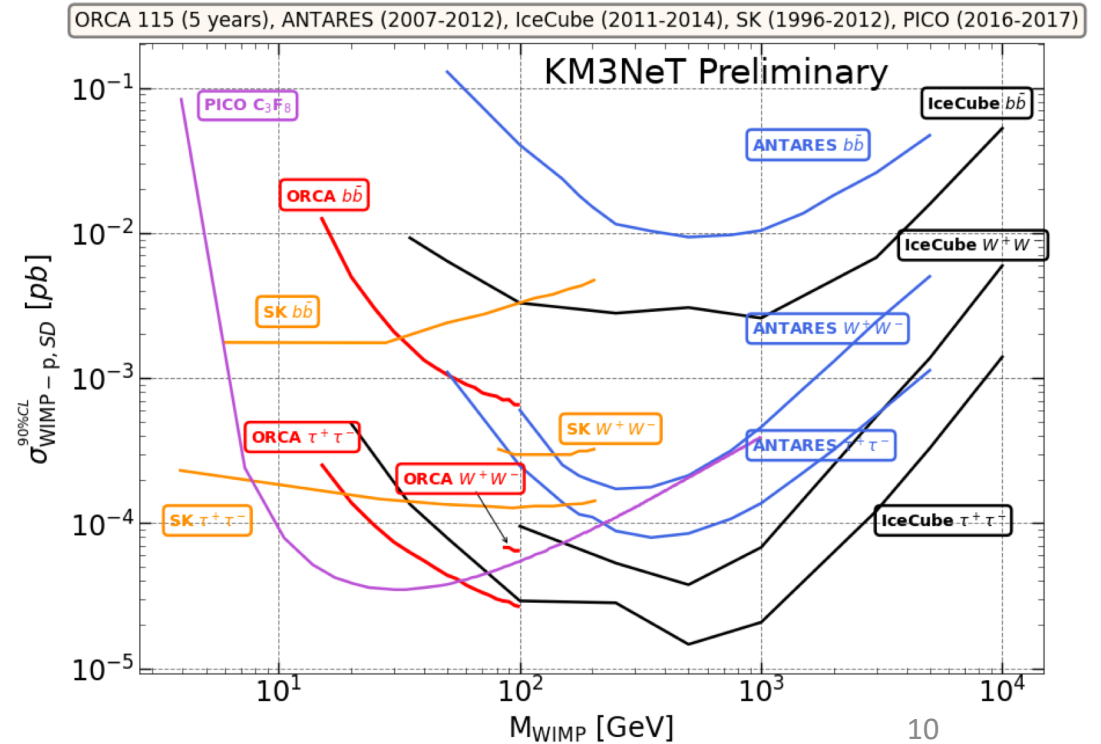
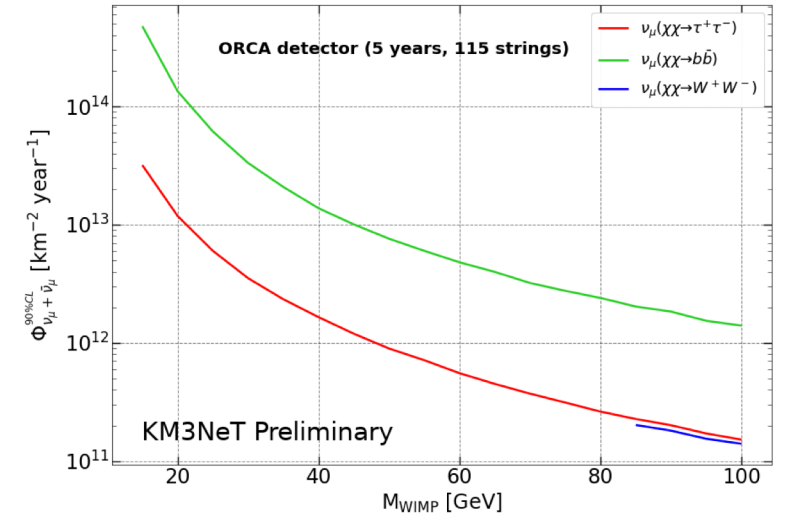
Dark matter

ARCA, galactic center
(One year ARCA-24 \cong ANTARES)

- ANTARES 11 years NFW - - - KM3NeT ARCA 230 lines 1 year NFW
- HESS 10 years GC survey Einasto — VERITAS Dwarf Spheroidals NFW
- Fermi+MAGIC Dwarf Spheroidals NFW — IceCube IC86 WIMP GC NFW

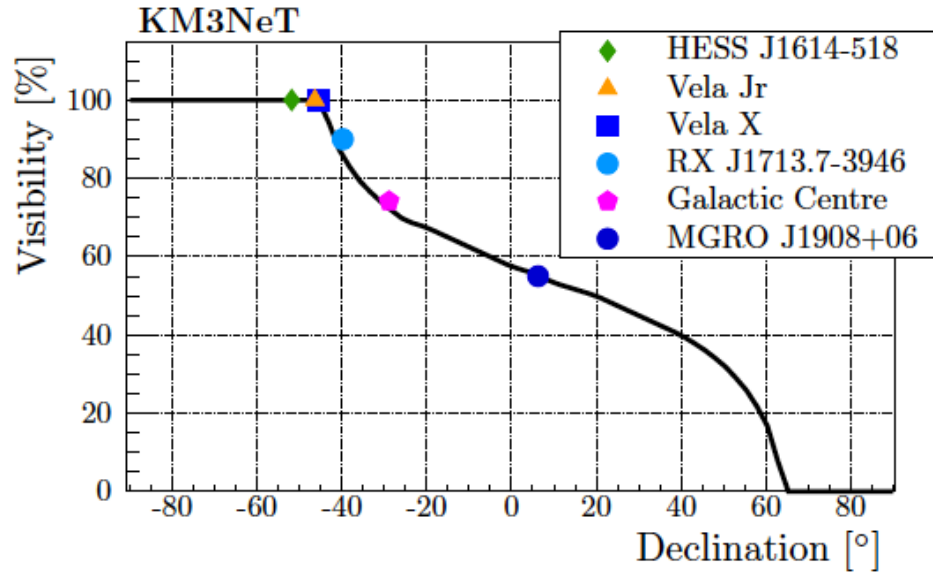
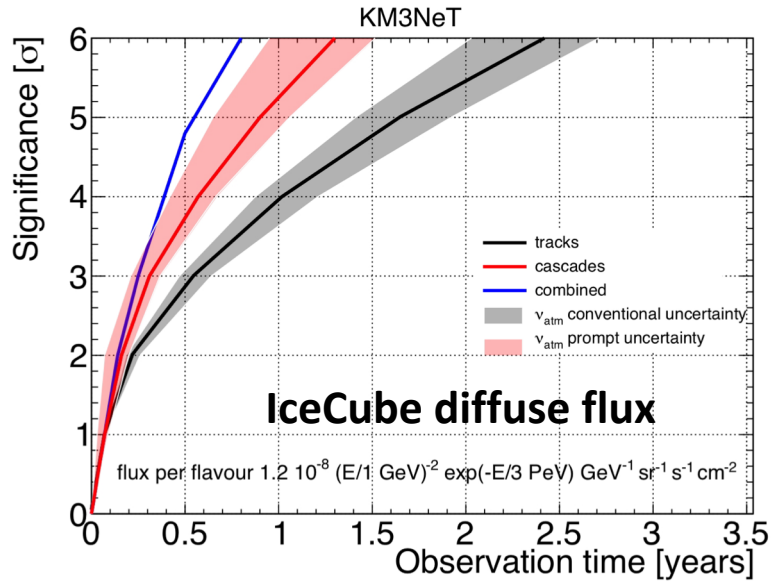


ORCA, sun

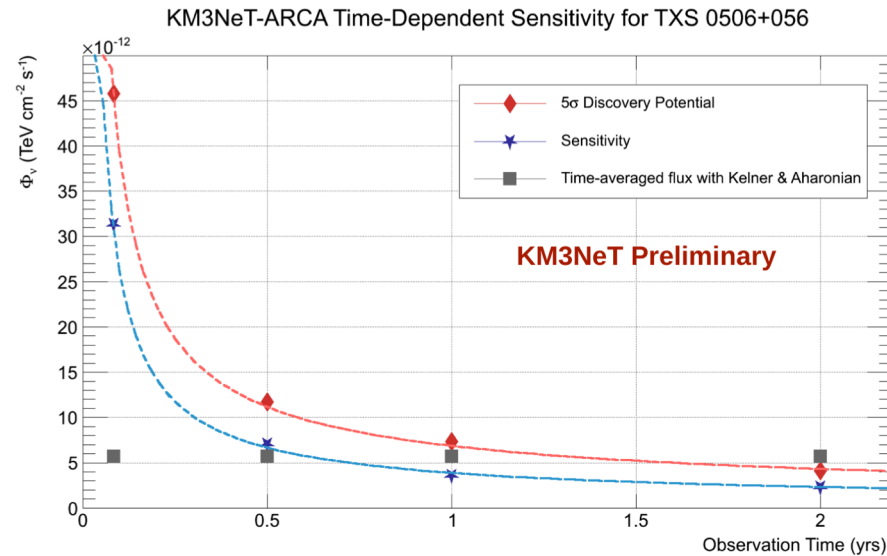
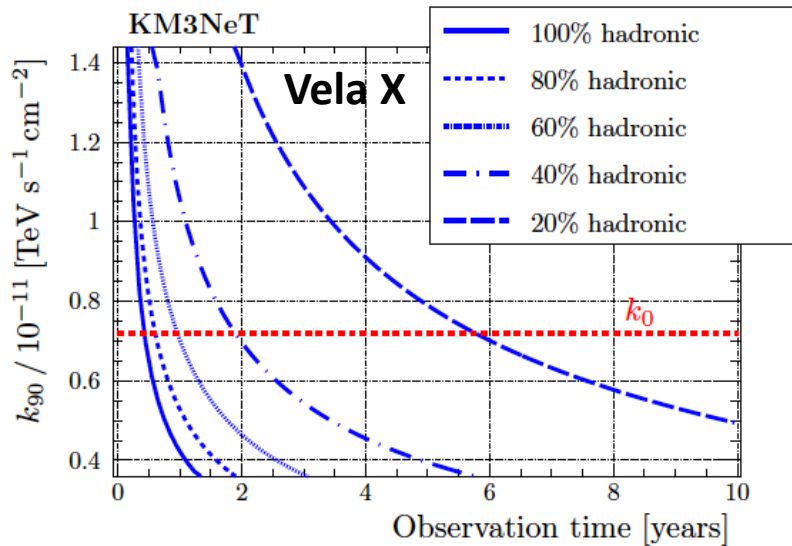


Rich Astrophysics Program (mostly ARCA)

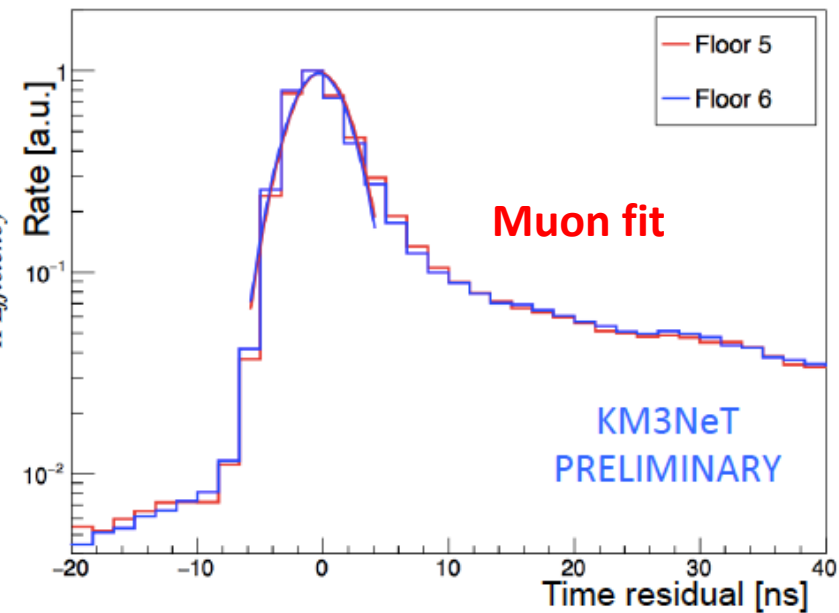
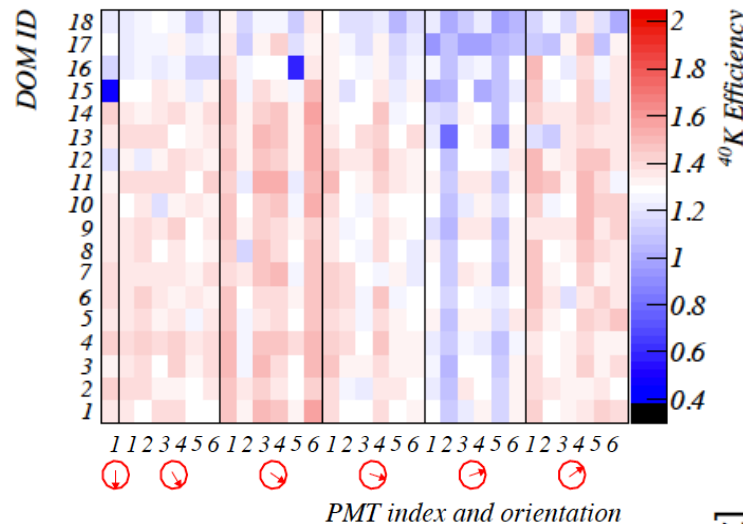
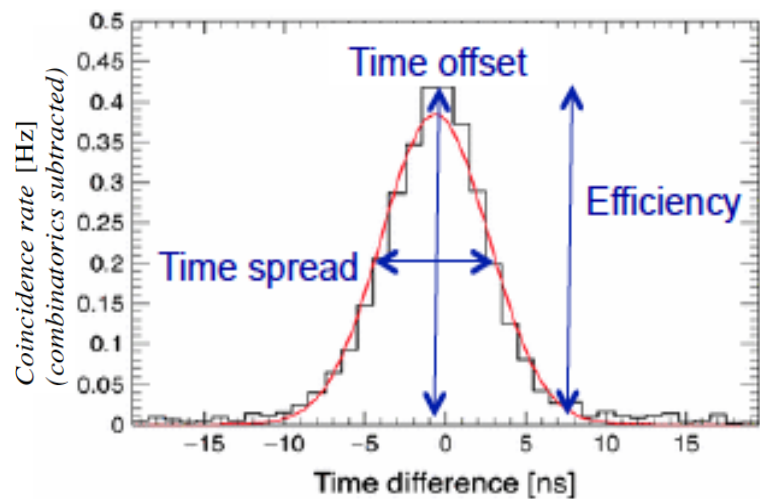
Excellent view of galactic centre



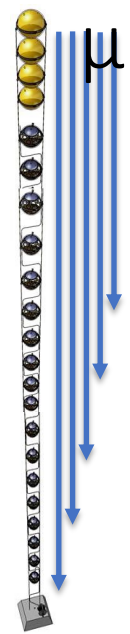
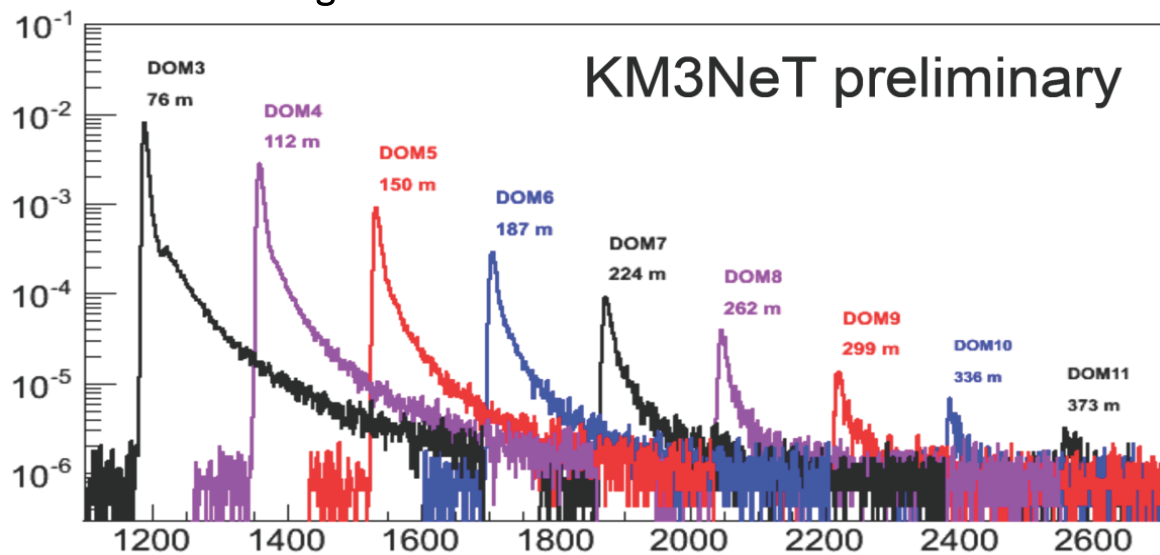
Also: cosmic rays



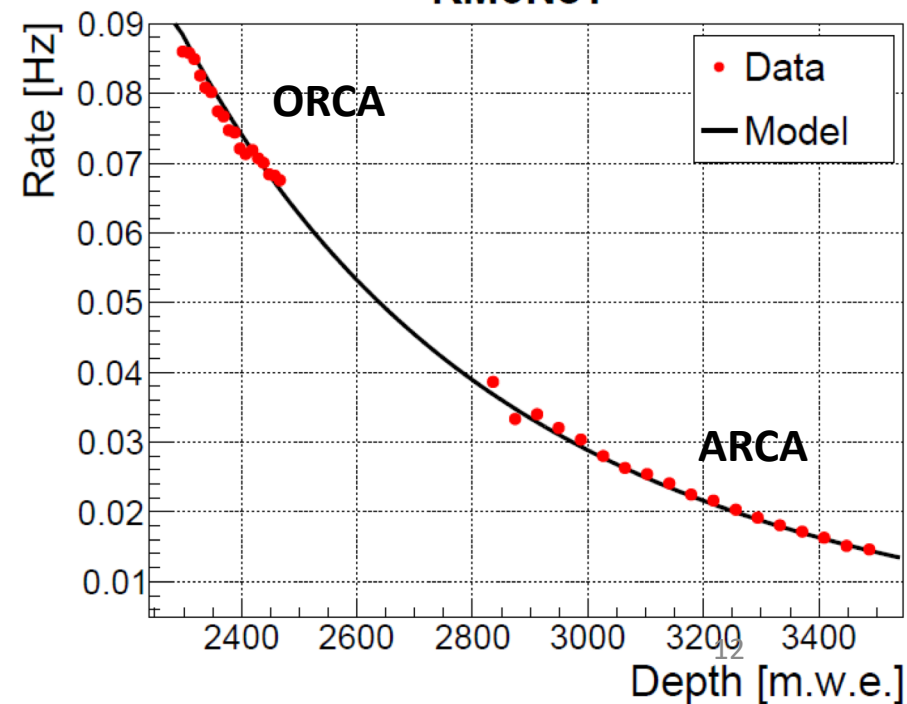
Work to do: Calibration (^{40}K , led/laser, acoustics, muon fit)



Timing check with LED flashers

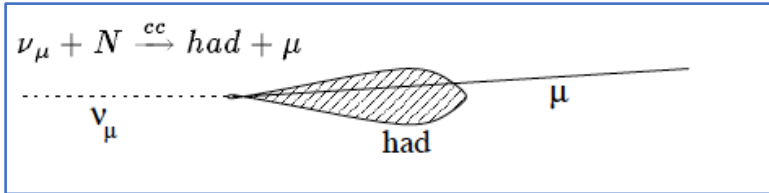


KM3NeT

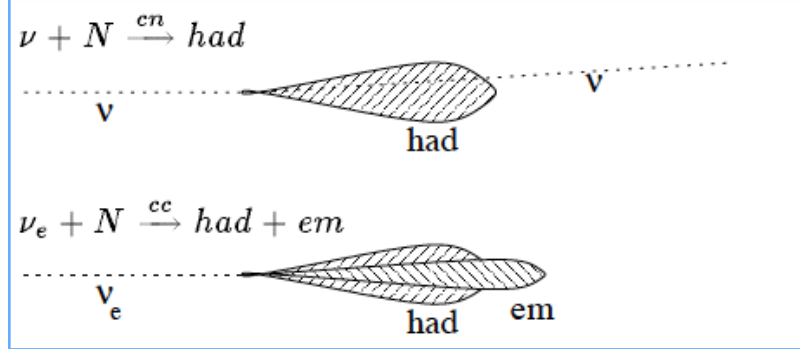


Tracks and showers

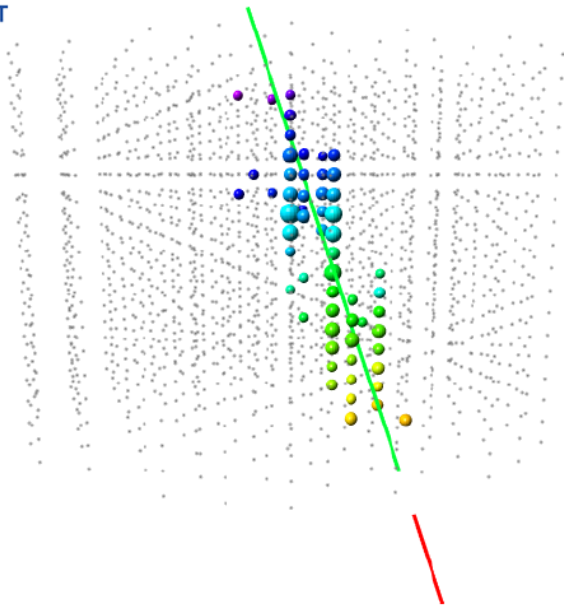
Track-like (ν_μ^{CC})



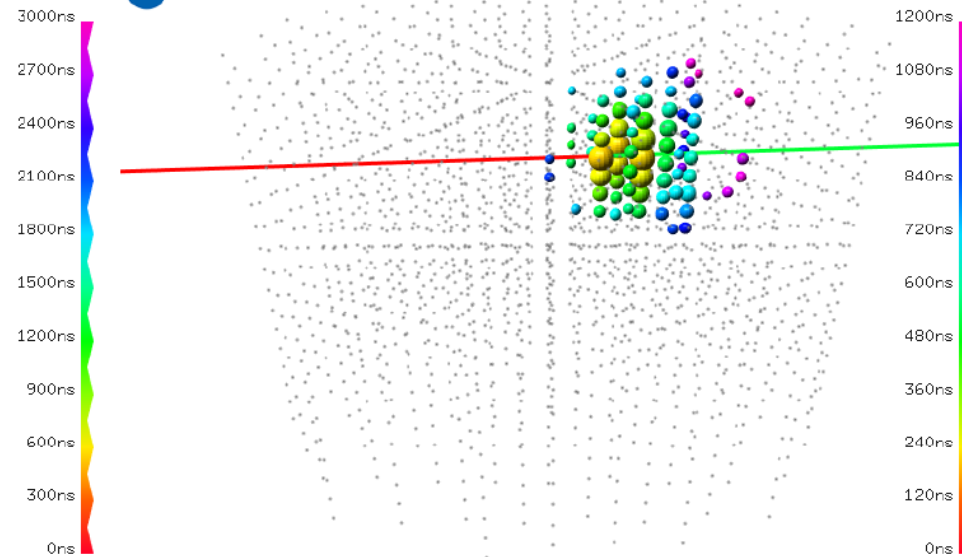
Shower-like (ν^{NC}, ν_e^{CC})



KM3NeT



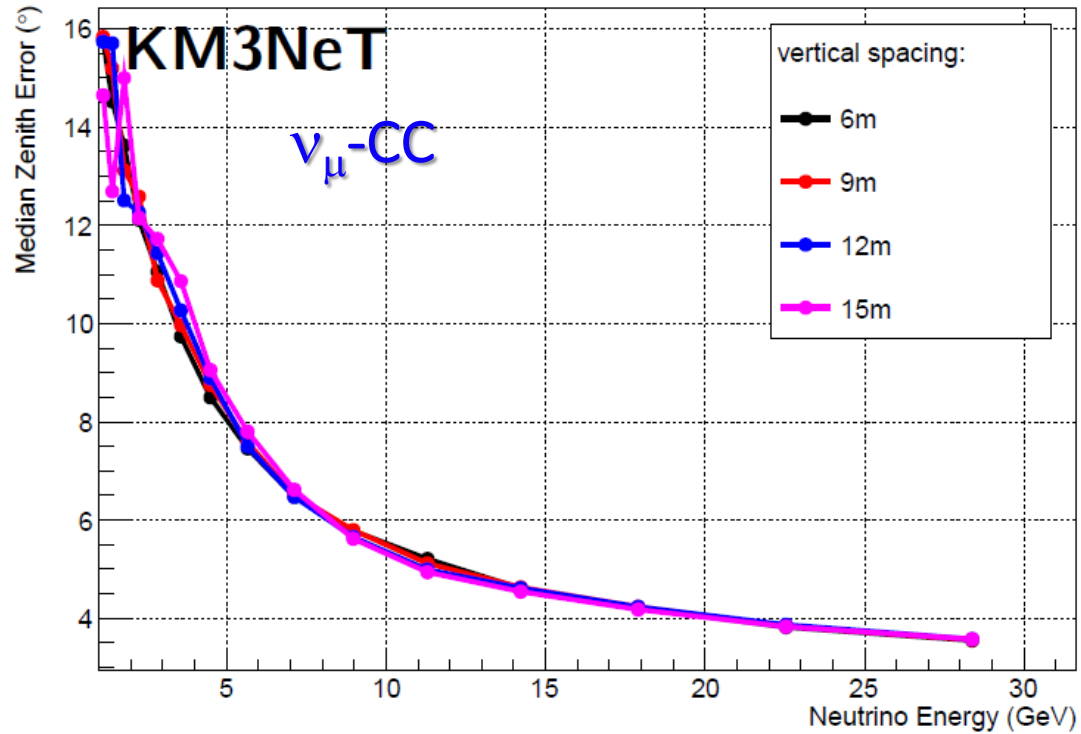
KM3NeT



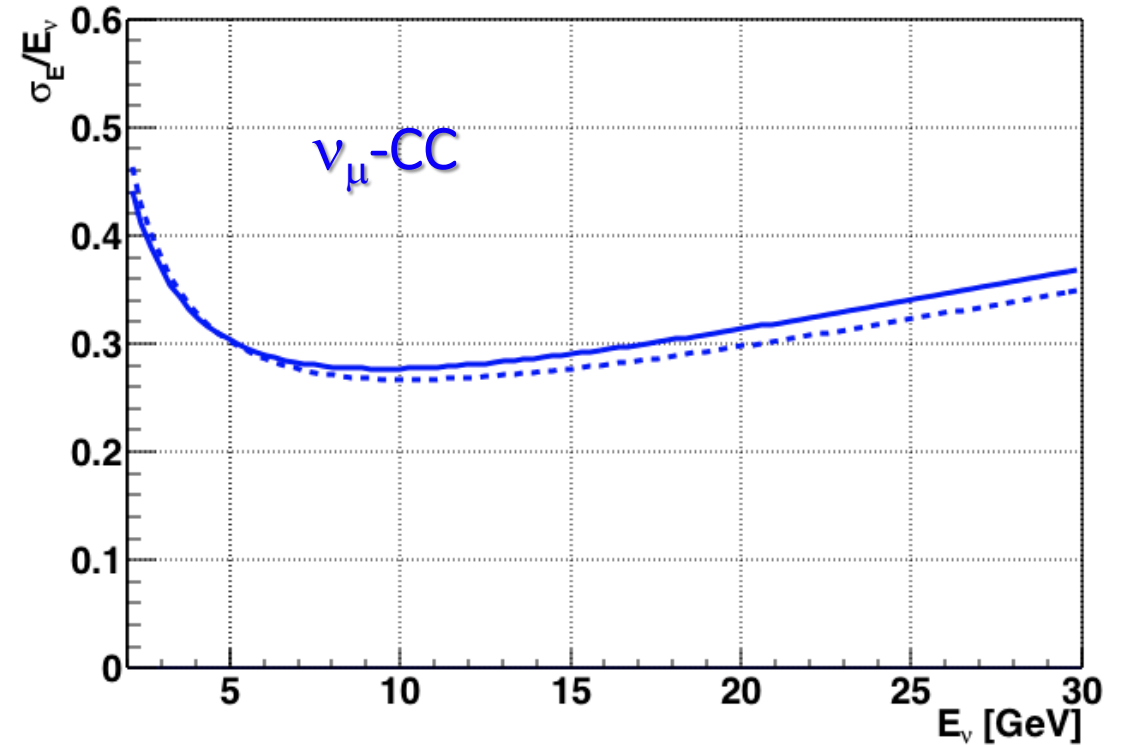
But at ORCA energies,
tracks are short...

ARCA simulation, TeV neutrino energies

Work to do: Track reconstruction

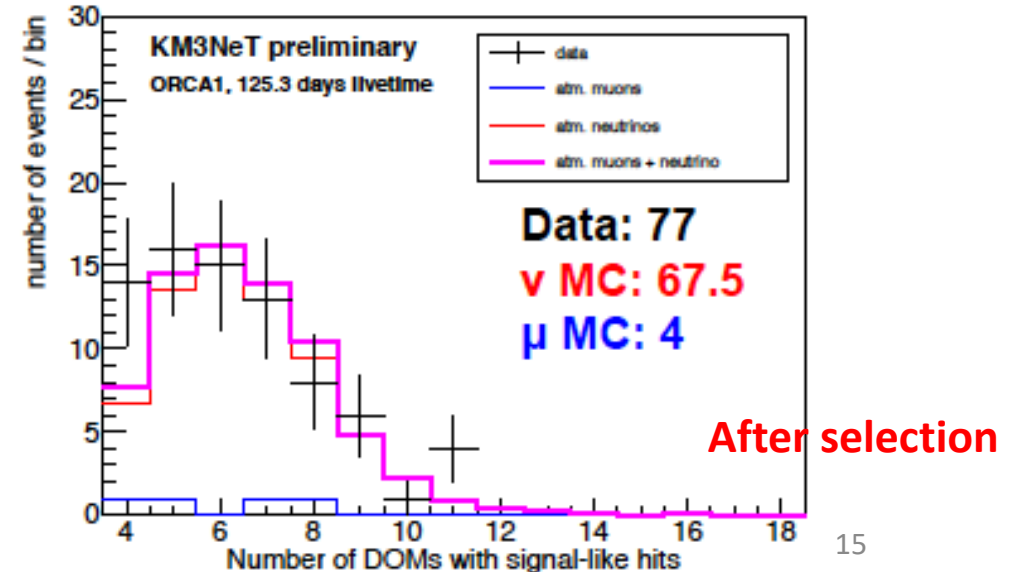
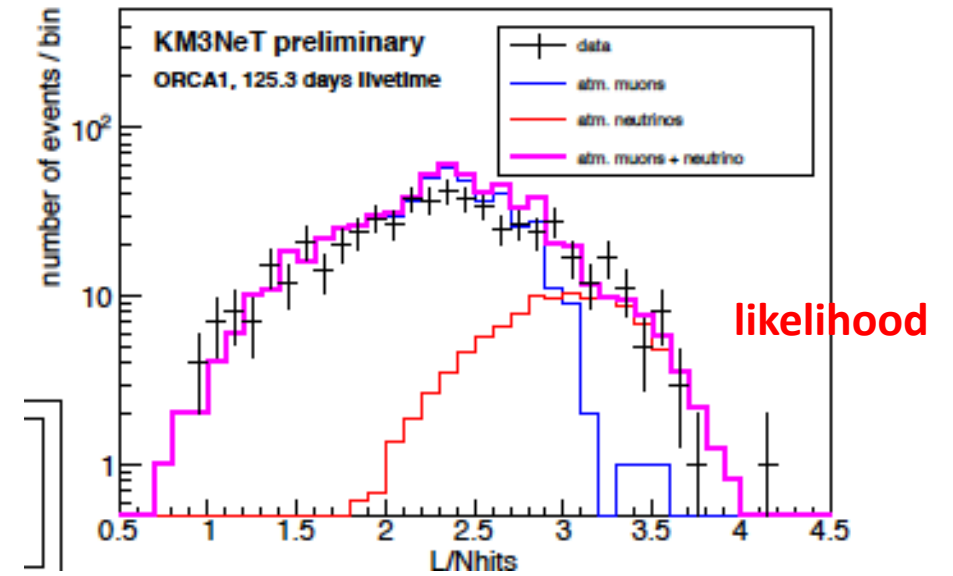
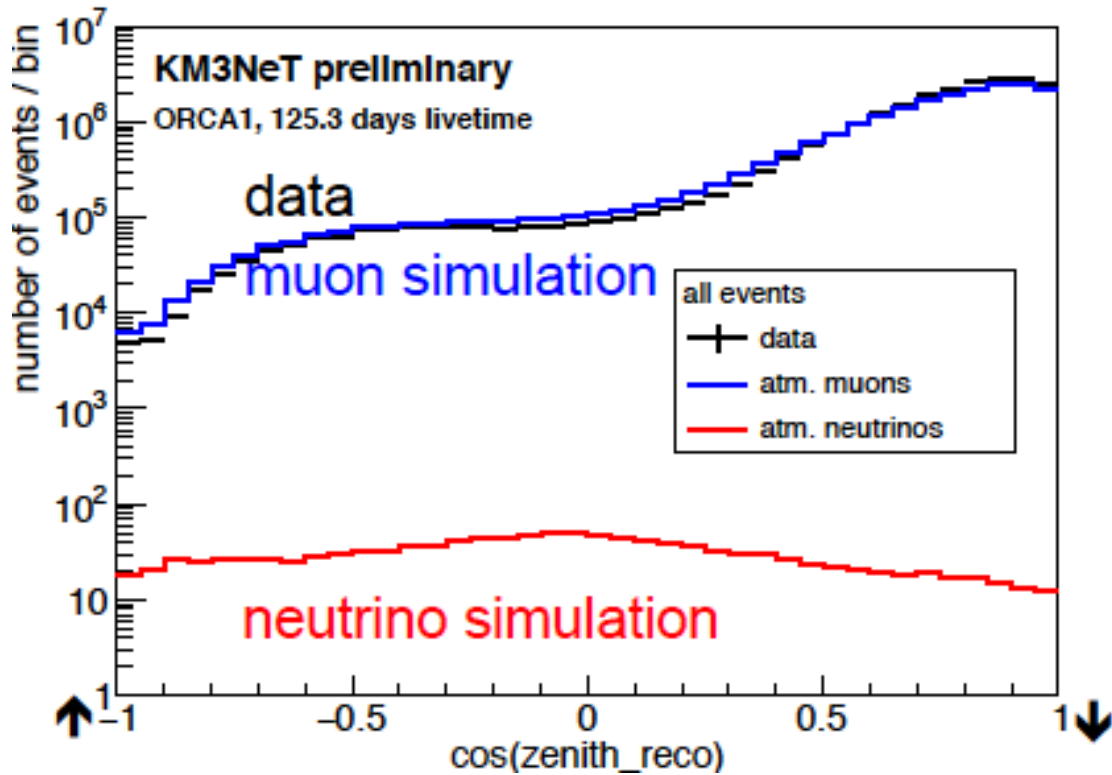


Angular resolution

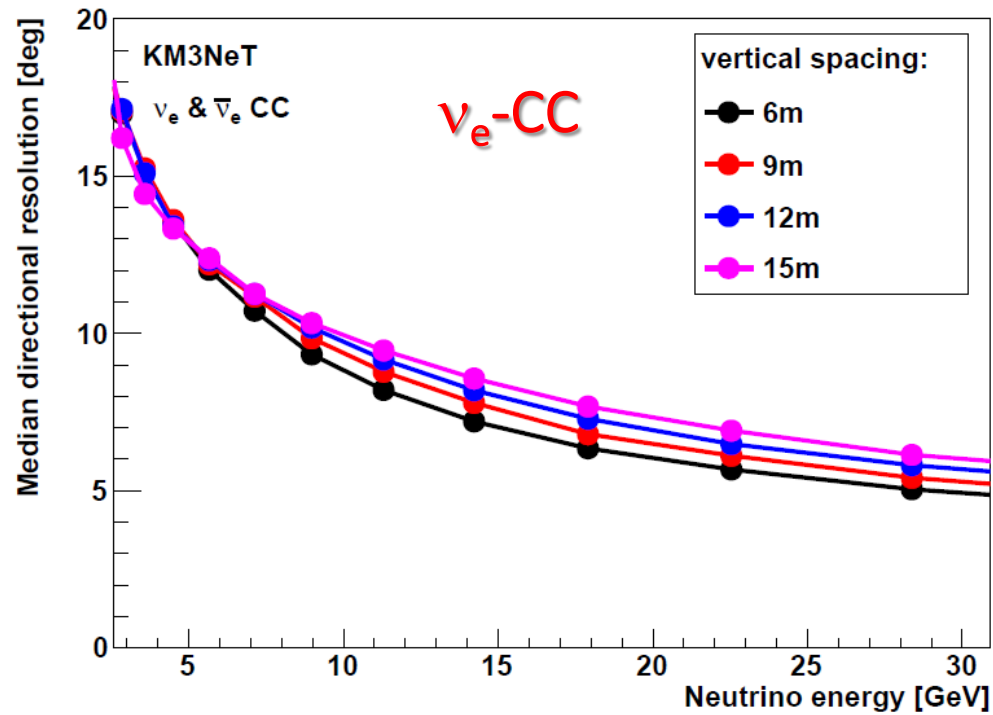


Energy resolution

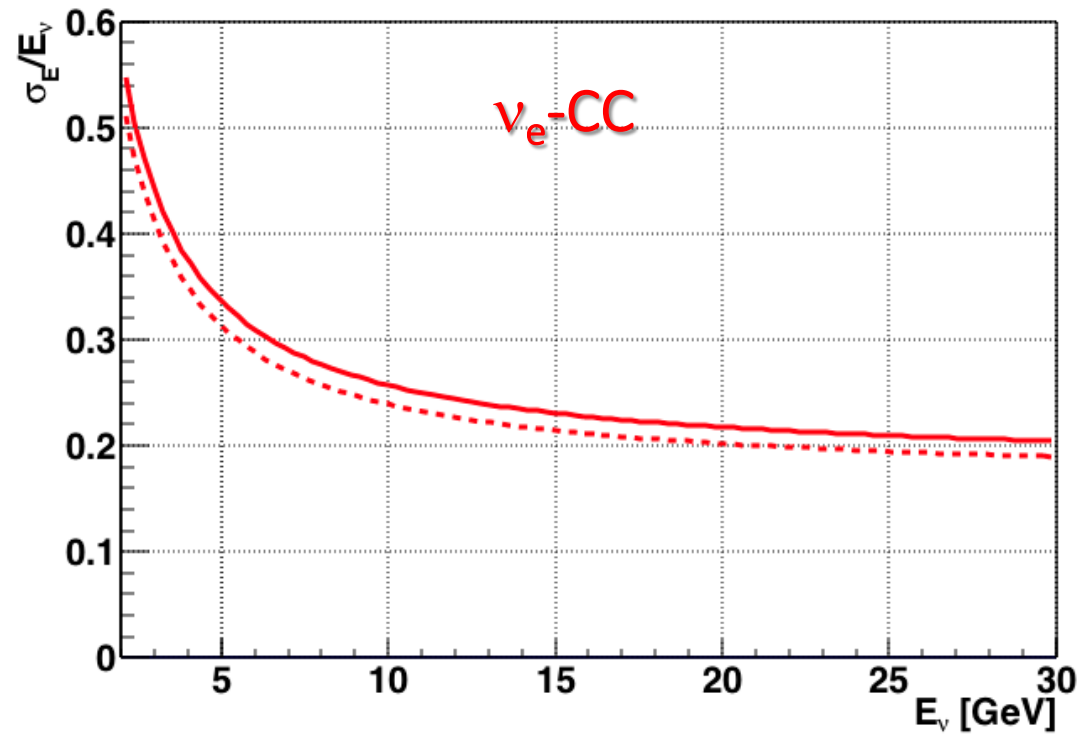
Work to do: data/simulation comparisons, neutrino selection



Work to do: Shower reconstruction



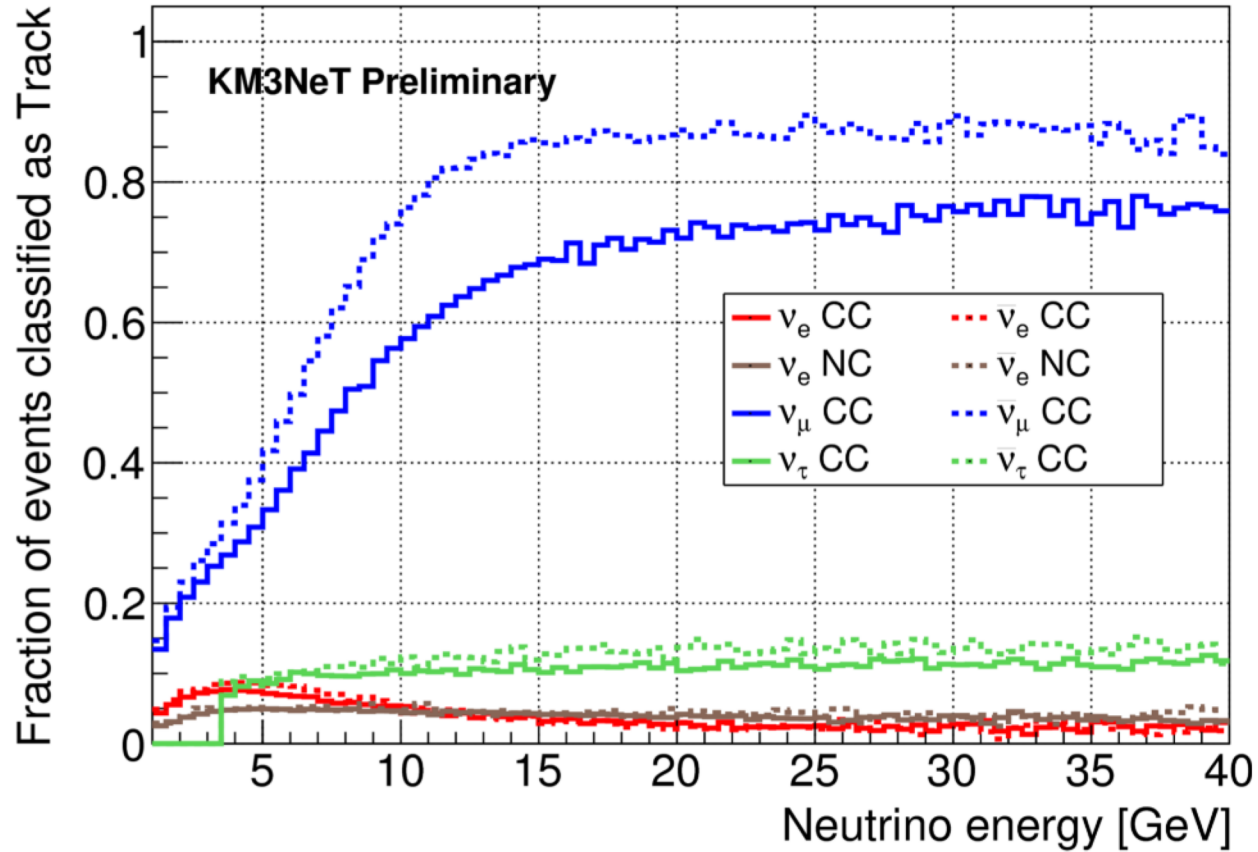
Angular resolution



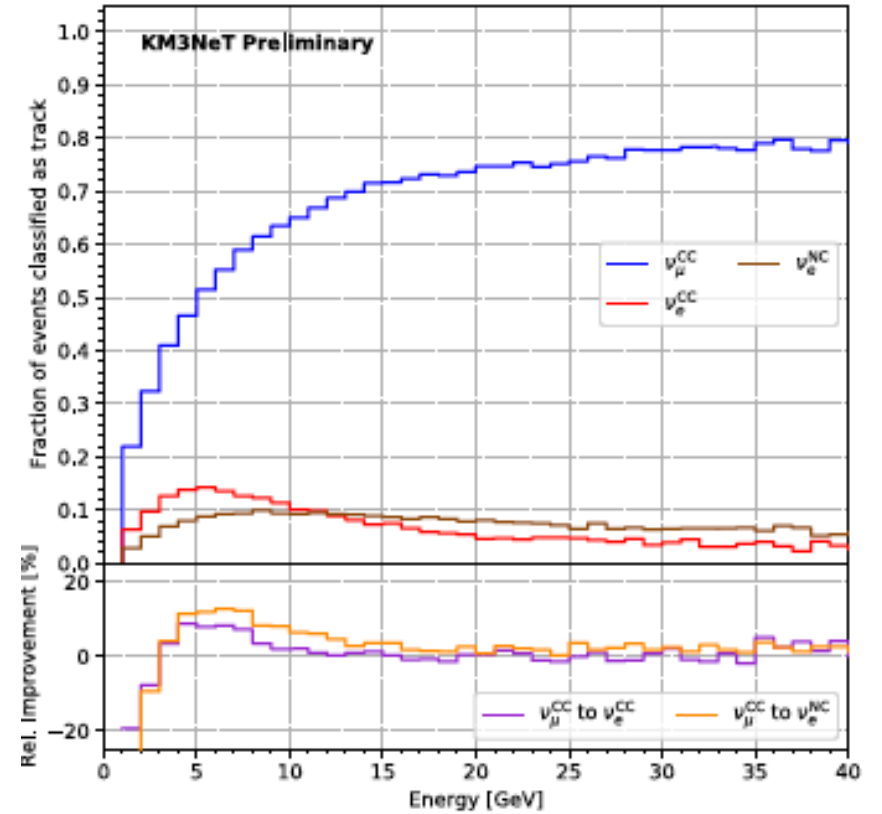
Energy resolution

Work to do: Event classification

Classified as Track (conventional)



Convolutional Neural Network



More work to do:

Improve triggering and reconstruction at low neutrino energy

Improve oscillation fit, incorporate inelasticity

Systematics

...

Room for collaboration: machine learning?

WP	Project	2019	2020	2021	2022	2023	2024	
1	KM3NeT	Muon neutrino flux [PhD]						
				Electron neutrino reconstr. [PD]				
				Oscillation fit [PhD]				
2	XENONnT	WIMP SI and SD analysis [PhD]						
		Axions, ALPs and sterile neutrinos [PhD]						
				Annual modulation [PD]				
	KM3NeT		Neutrinos from DM annihilation [PhD]					
3	SHiP		Sterile neutrino search optimization [PhD]					
	GAMBIT		Sterile neutrino BSM fit [PD]					
	SUSY-DM		DM fit and interpretation [PhD]					

Table 1: Timeline of the proposed projects. One PhD position in KM3NeT and one in XENON are not requested from NWO, but are matched by Nikhef.