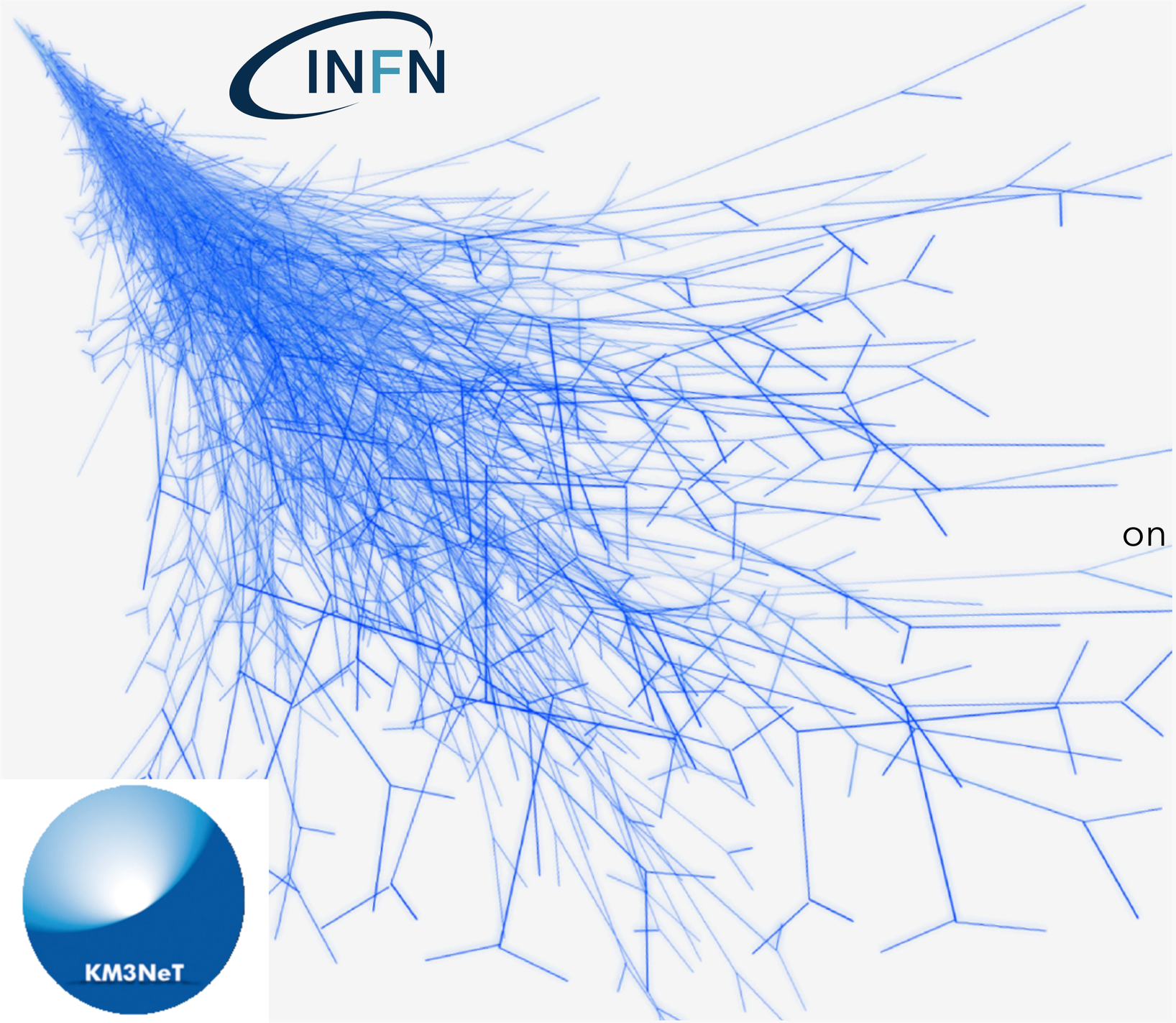


A MULTI-PEV NEUTRINO IN KM3NET/ARCA

Antonio Condorelli
on behalf of the KM3NeT collaboration

Universita' Federico II & INFN Napoli
antonio.condorelli@unina.it

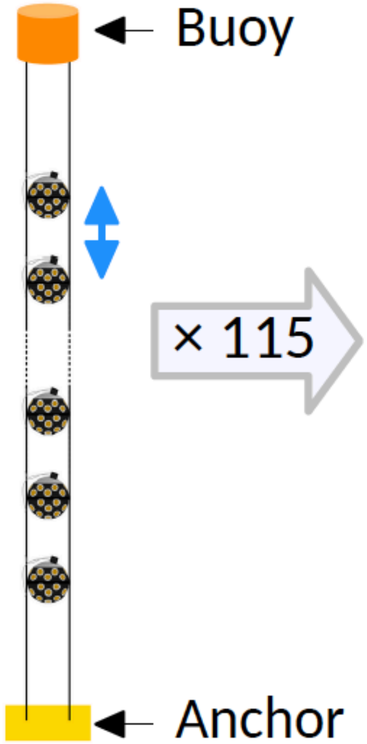
KM3NeT: ARCA, ORCA

Digital Optical Module (DOM)

31 × 3” PMT, ⊘ =43 cm

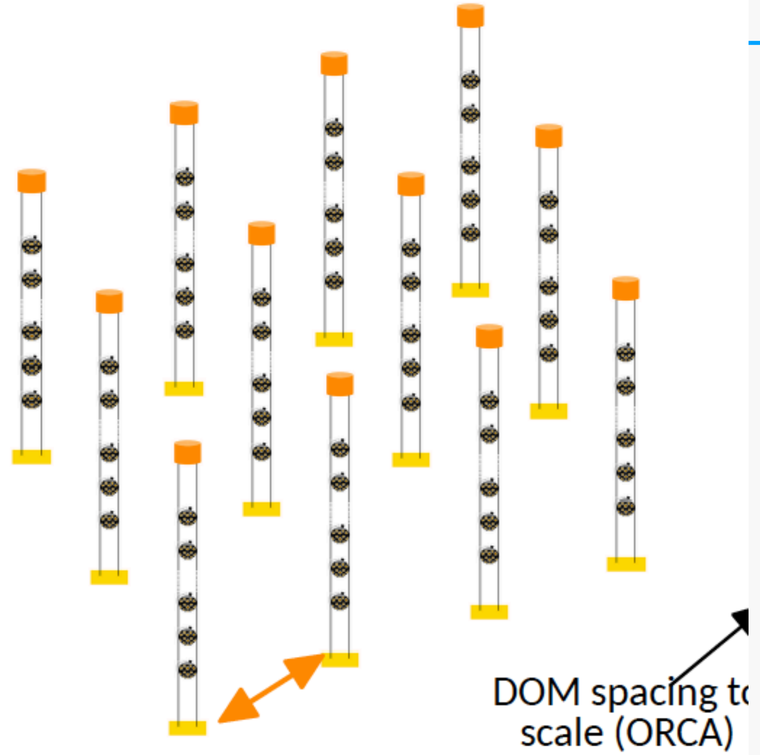
× 18

Detection Unit (DU)



× 115

Building Block (BB)



ARCA (1TeV – 10 PeV)
Max. depth = 3500 m
1 Gt (2 BB)
H = 700 m
⊘ = 1000 m
Vertical spacing: 36 m
Horizontal spacing: 90 m

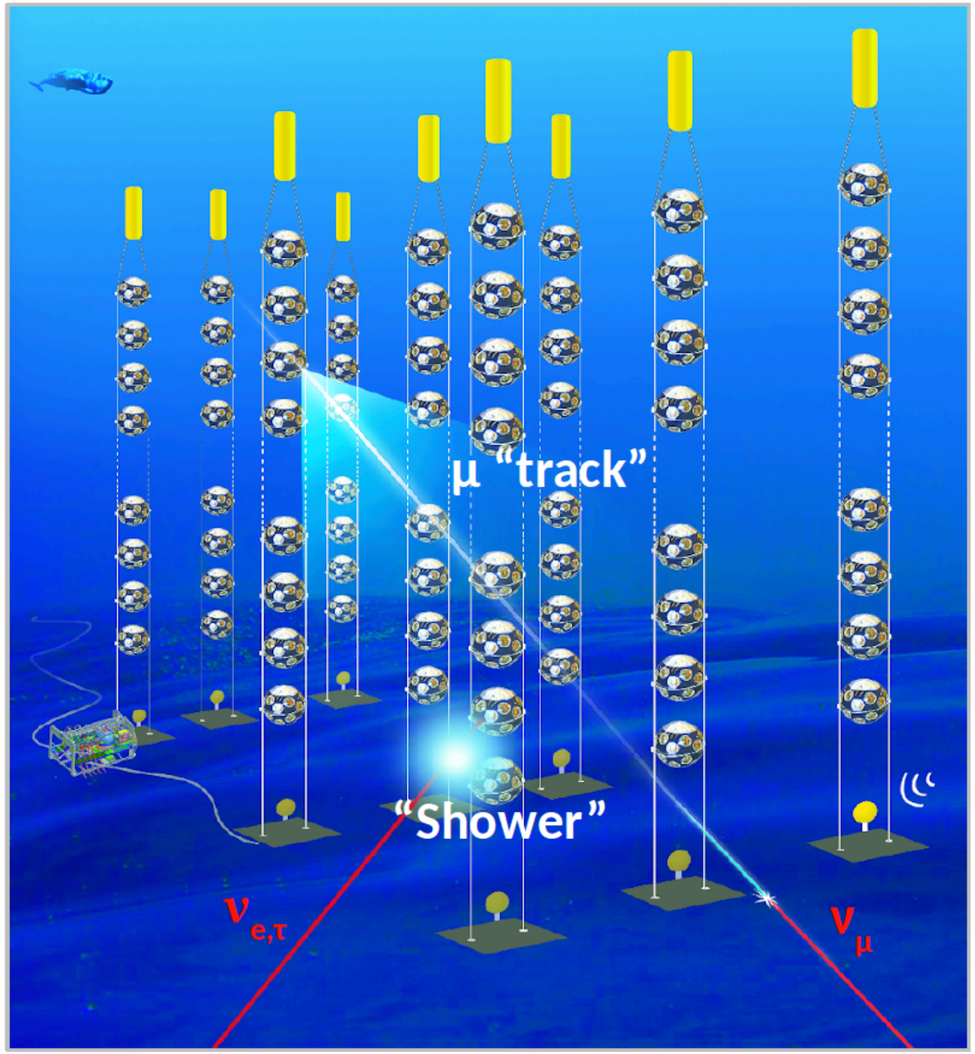
ORCA (1 – 100 GeV)
Max. depth = 2450 m
7 Mt
H = 200 m
⊘ = 200 m
Vertical spacing: 9 m
Horizontal spacing: 20 m

KM3NeT goals

Detect atmospheric and astrophysical neutrinos through Cherenkov effect of the produced
leptons propagating in sea-water.

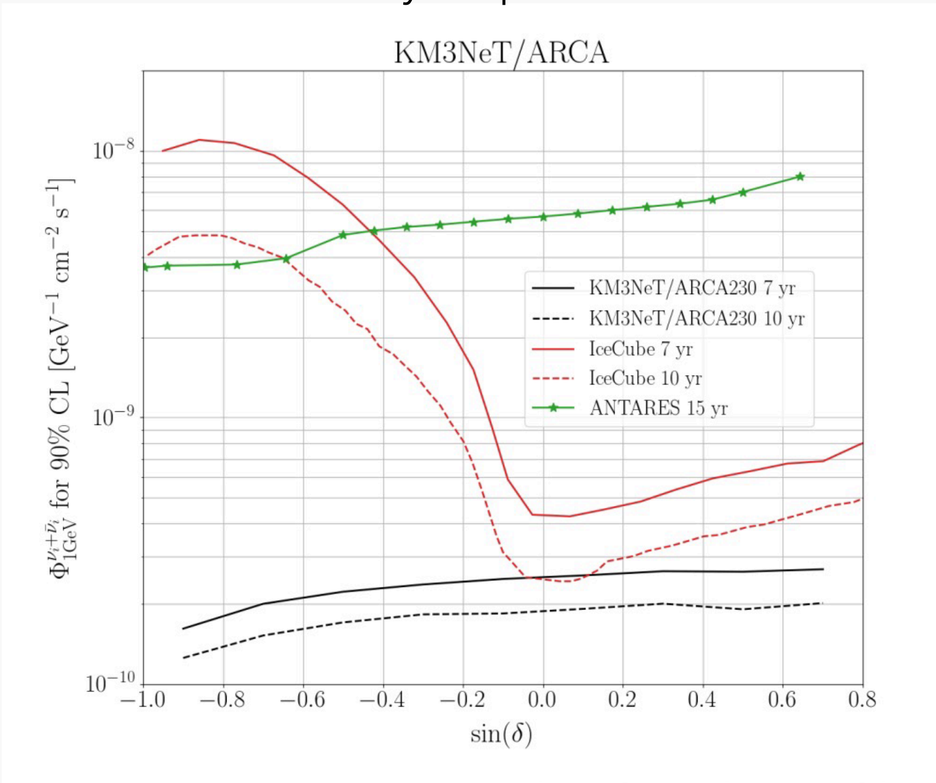
Two main physics goals:

- Oscillations: Neutrino Mass Ordering;
- Astronomy: Astrophysical ν sources;



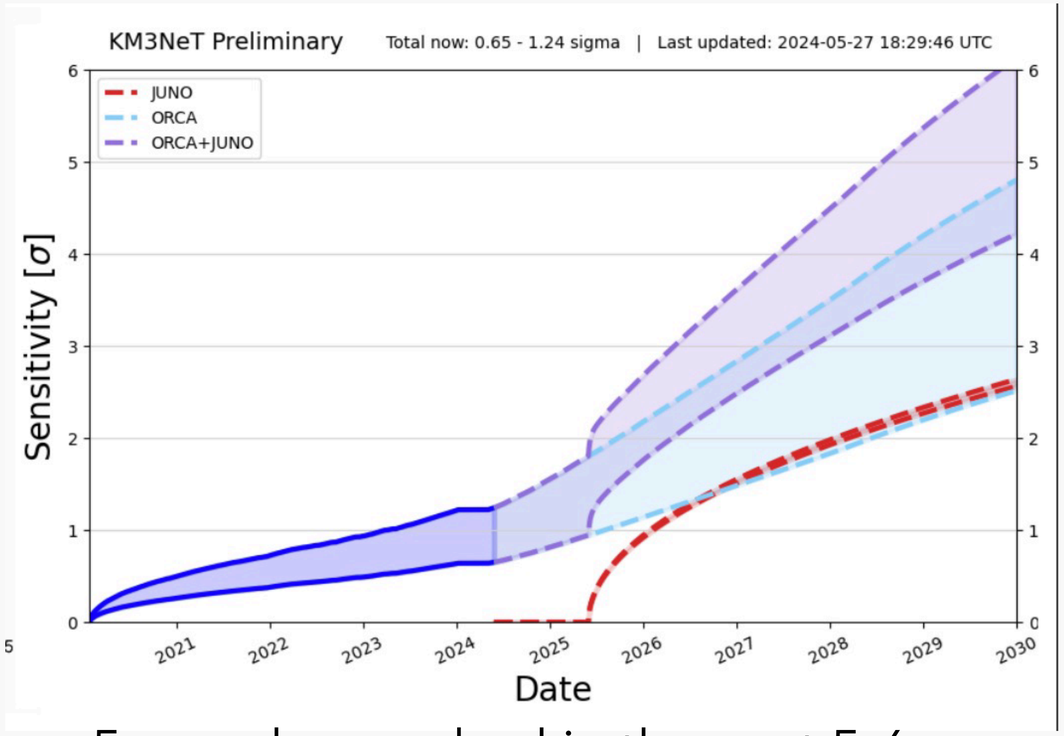
KM3NeT perspectives

ARCA - Sensitivity for point-like searches

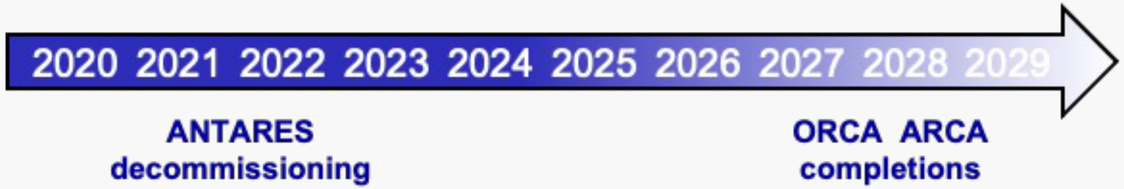


Best sensitivity in the Southern Sky

ORCA - Neutrino mass ordering

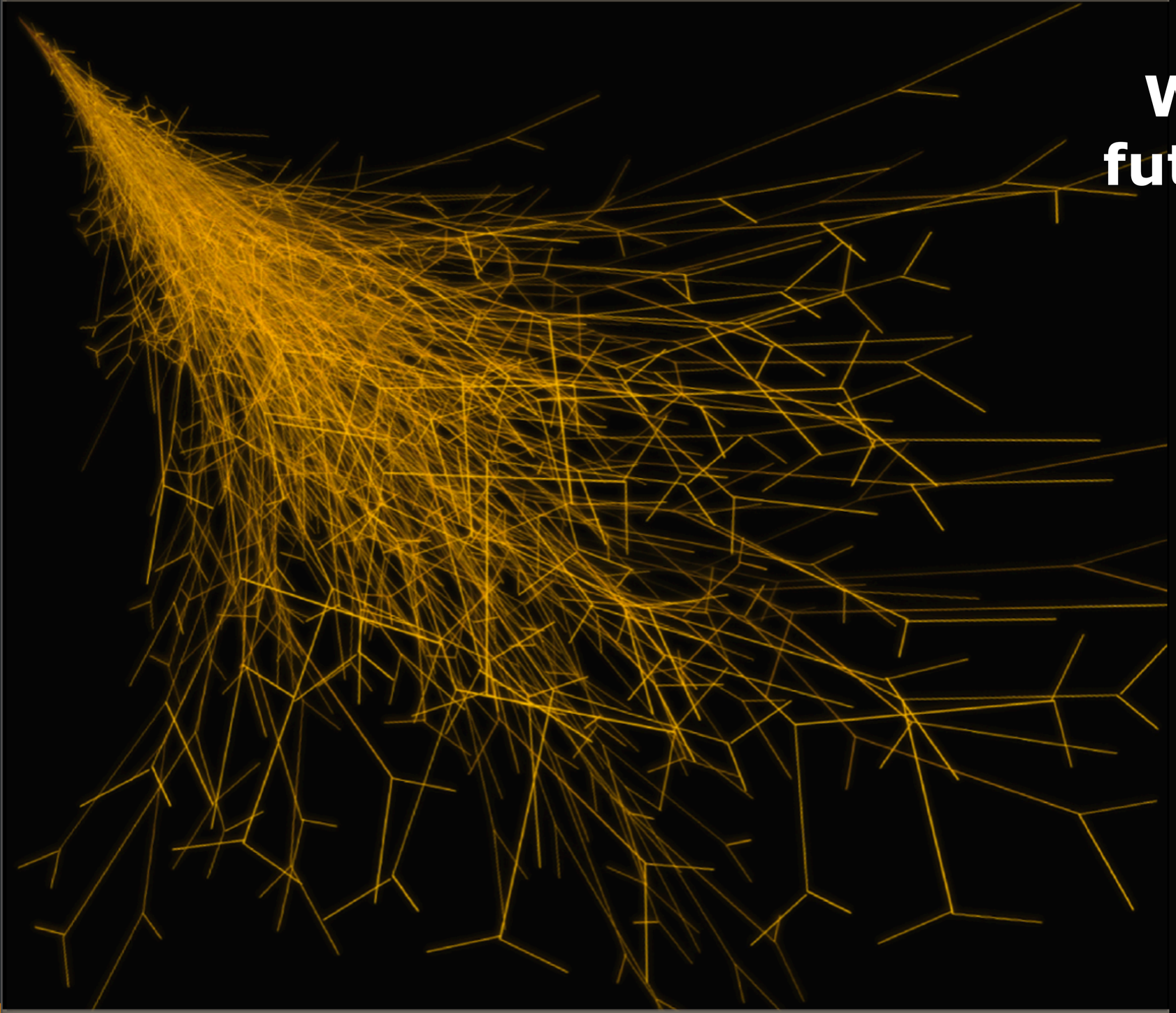


5σ can be reached in the next 5-6 years if combined with Juno



The KM3NeT collaboration, https://arxiv.org/abs/2402.08363

J. Brunner @ Neutrino2024

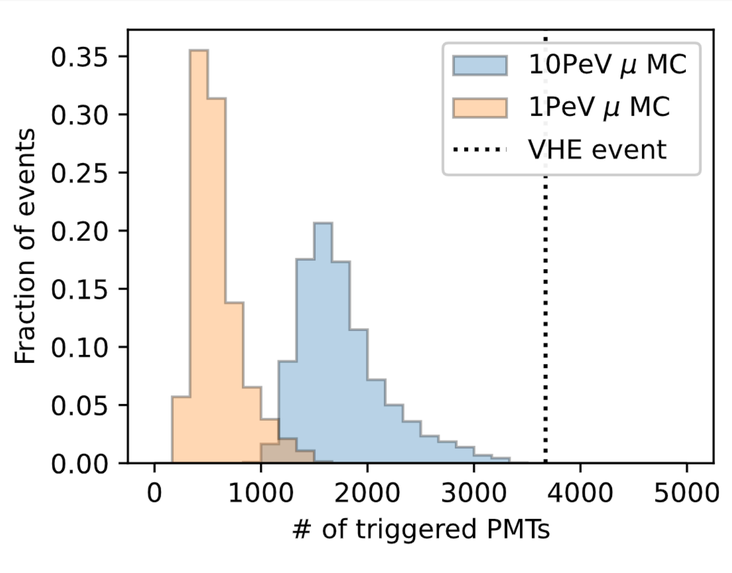


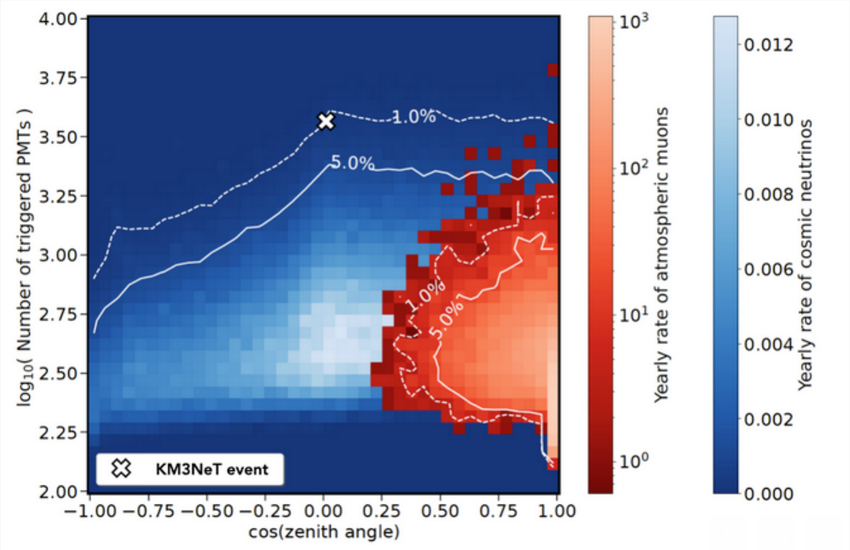
We have a bright future ahead of us…

but the present is not too bad either!

A Multi-PeV event

- Significant event observed with huge amount of light
- Horizontal event (1° above horizon) as expected since earth opaque to neutrinos at PeV scale
- 3672 PMTs (35%) were triggered in the detector
- Muons simulated at 10 PeV almost never generate this much light
- Likely multiple 10's of PeV

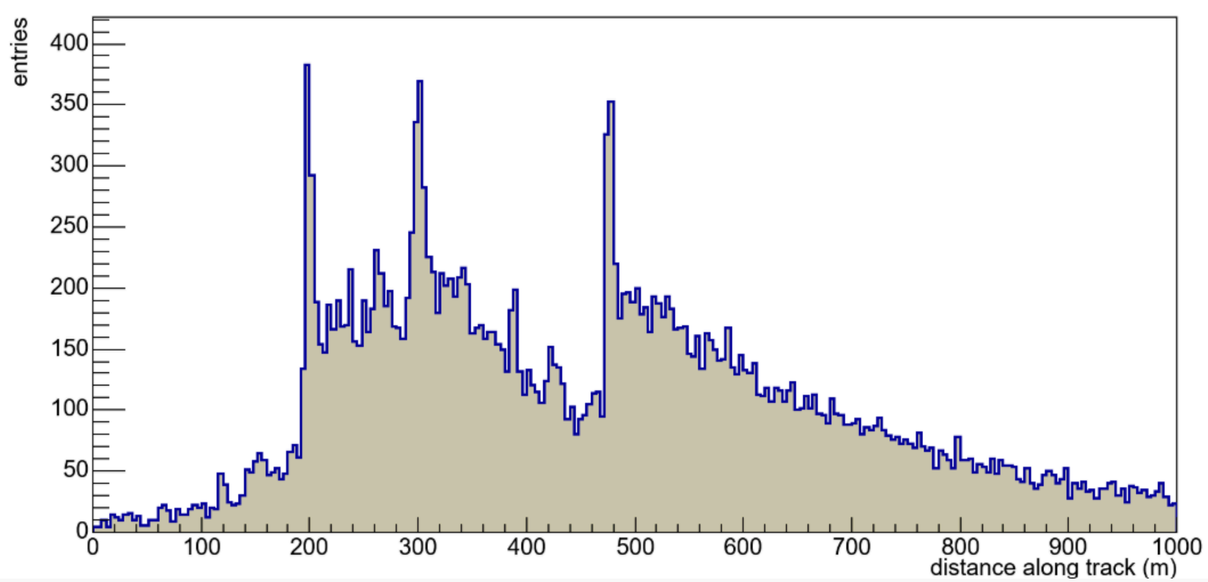




A Multi-PeV event

Light profile consistent with at least 3 large energy depositions along the muon track:

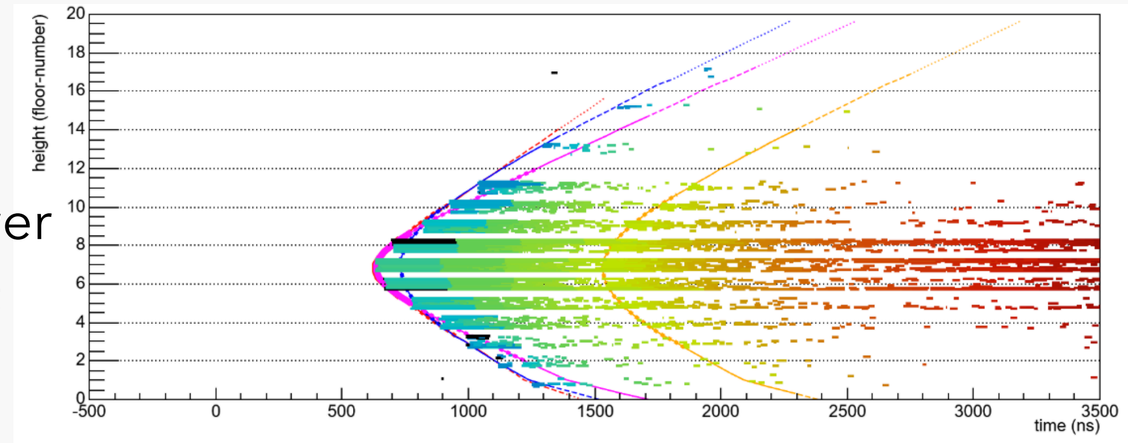
- Characteristic of stochastic losses from very high energy muons;

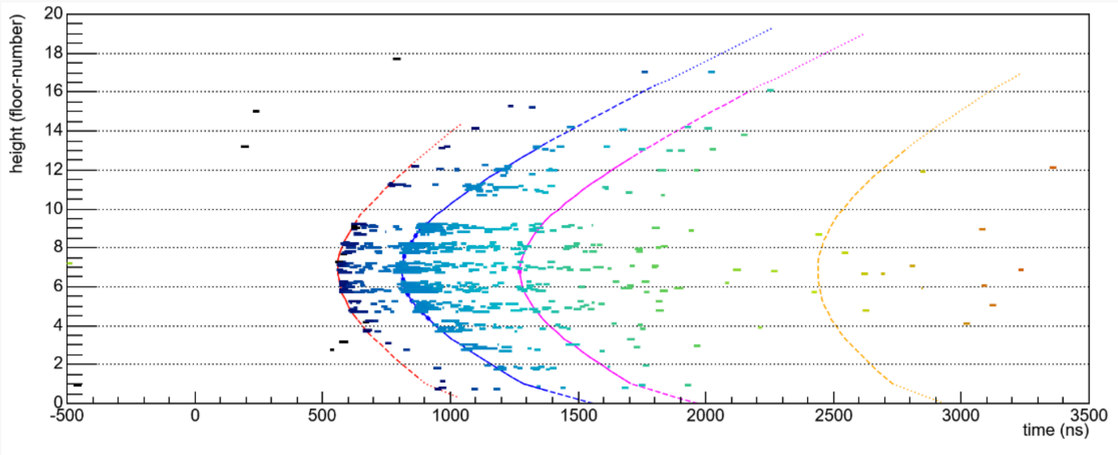


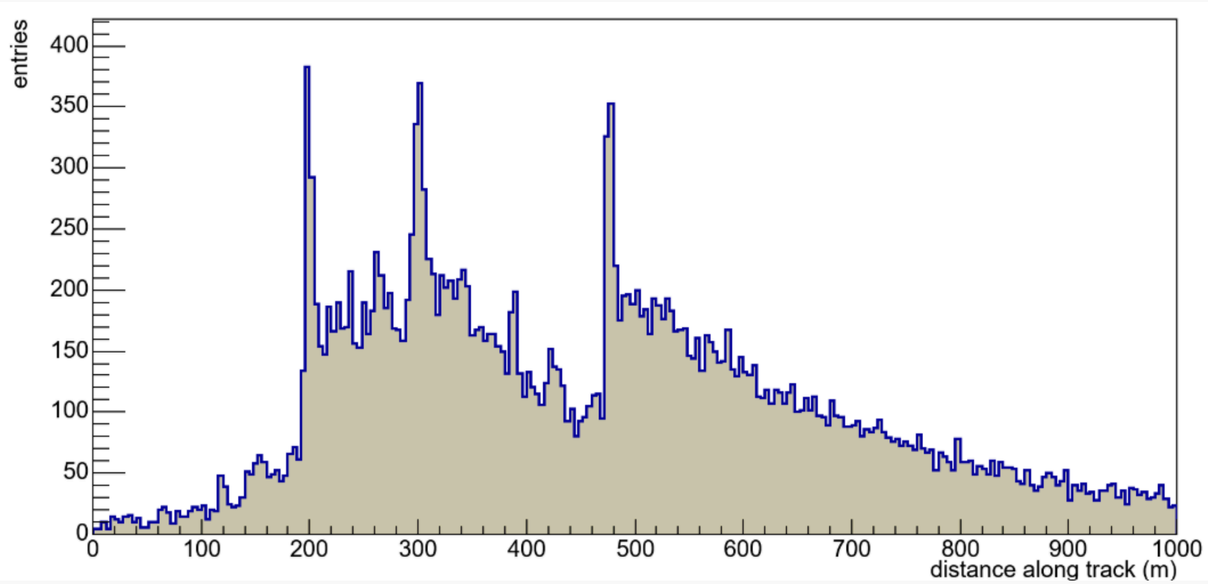
A Multi-PeV event

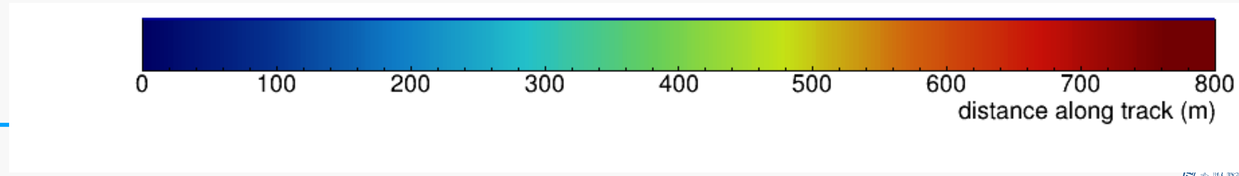
Light profile consistent with at least 3 large energy depositions along the muon track:

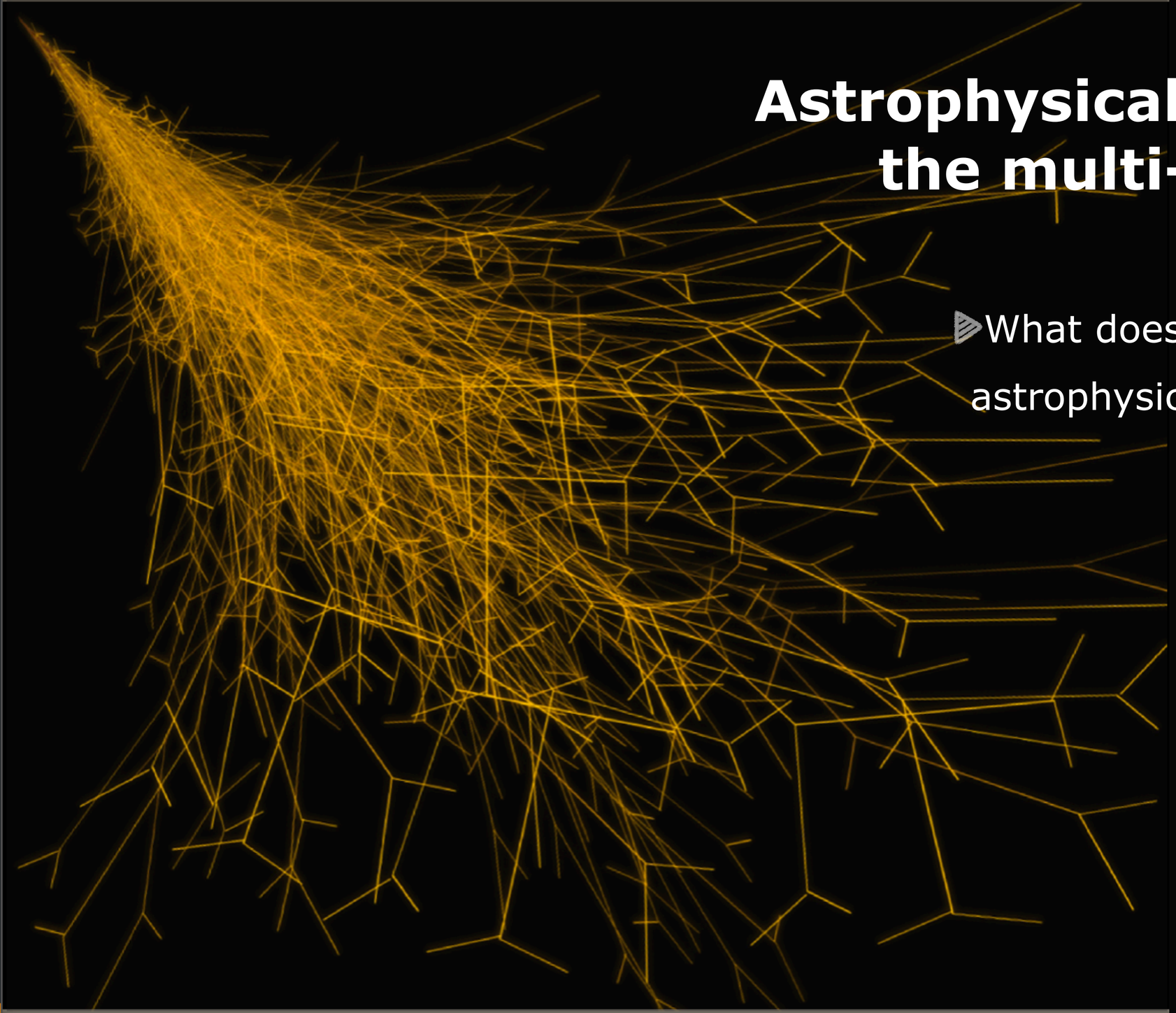
- Characteristic of stochastic losses from very high energy muons;
- Space-time distribution of light consistent with shower hypothesis associated with these energy depositions;
- Low scattering is key to observing this richness of detail.











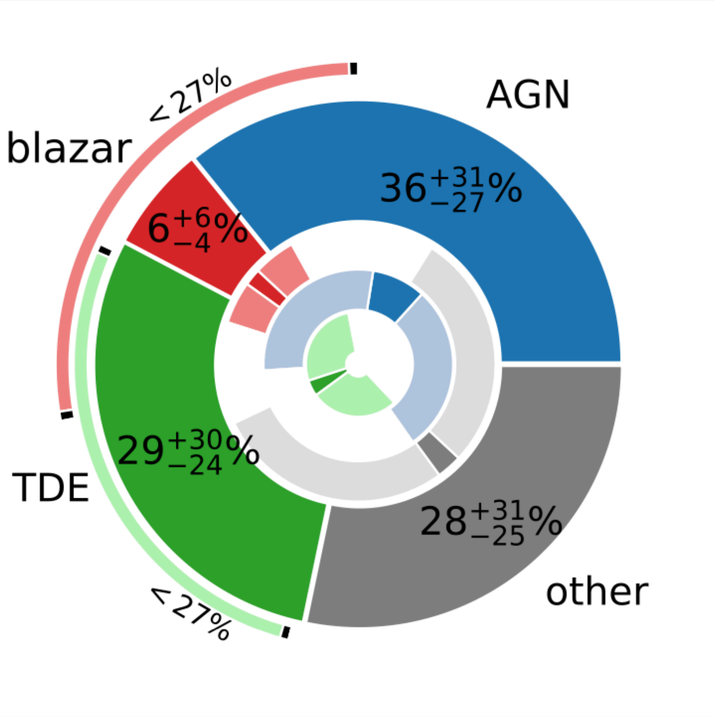
Astrophysical interpretation of the multi-PeV neutrino

- What does it mean in terms of plausible astrophysical sources?

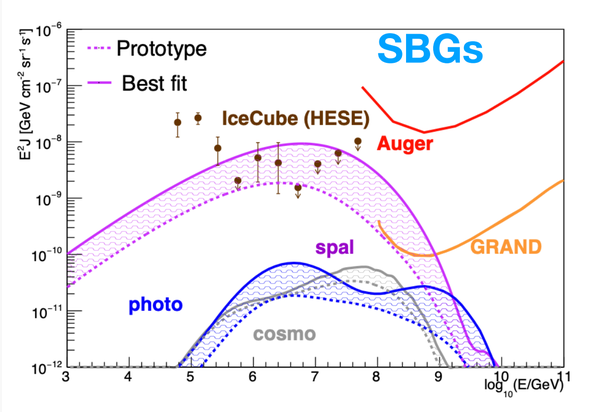
Neutrino from source environment

Evidence for multiple individual neutrino source populations emerging

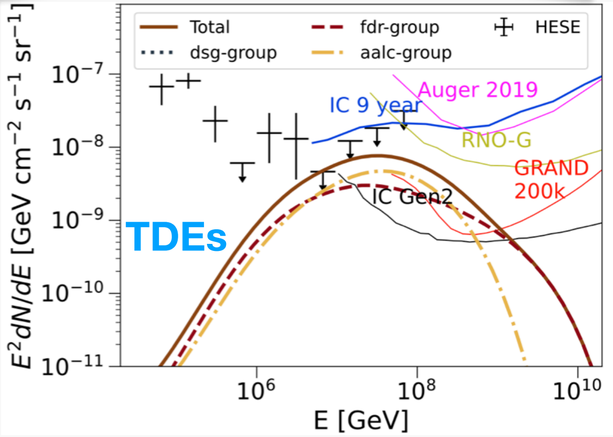
- AGN blazars
- AGN cores
- Galactic
- TDE?



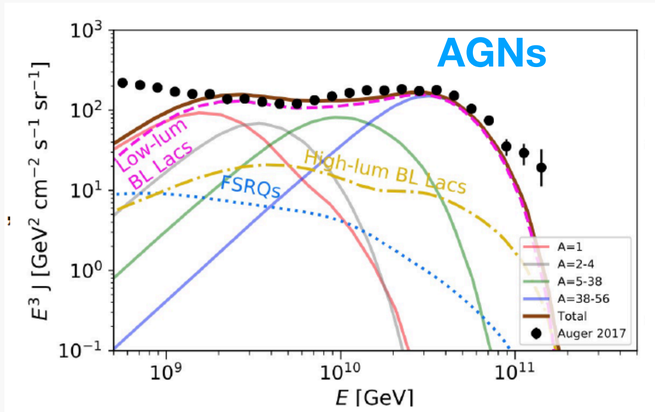
Bartos et al, arXiv:2105.03792

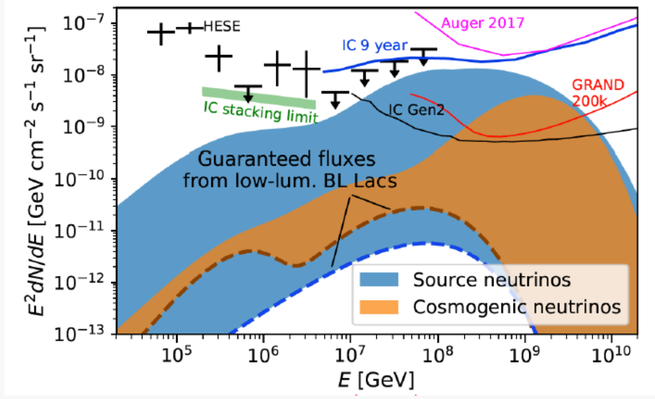


Condorelli et al., , Phys. Rev. D 107 (8), p. 083009



Plotko et al, in preparation



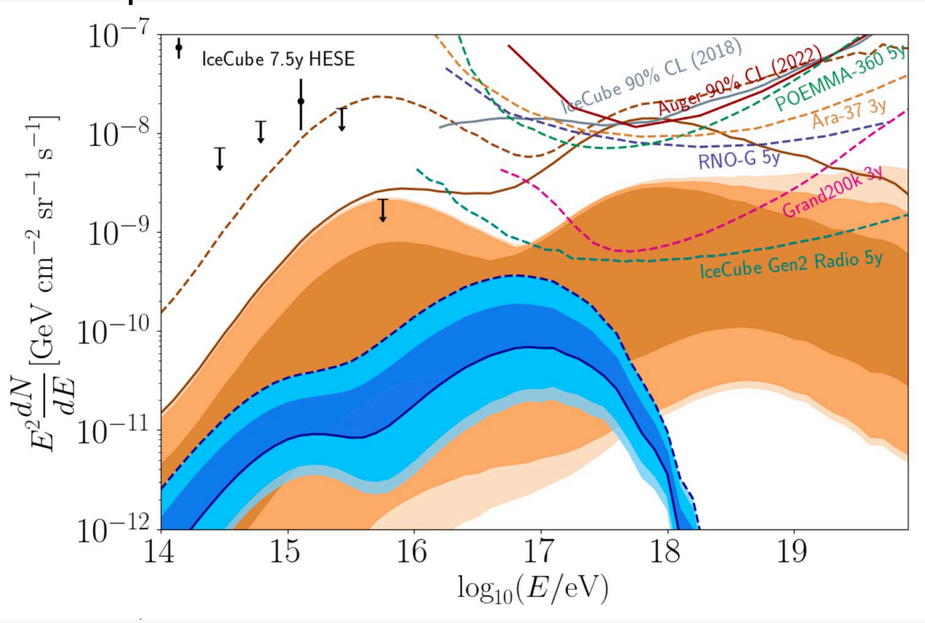


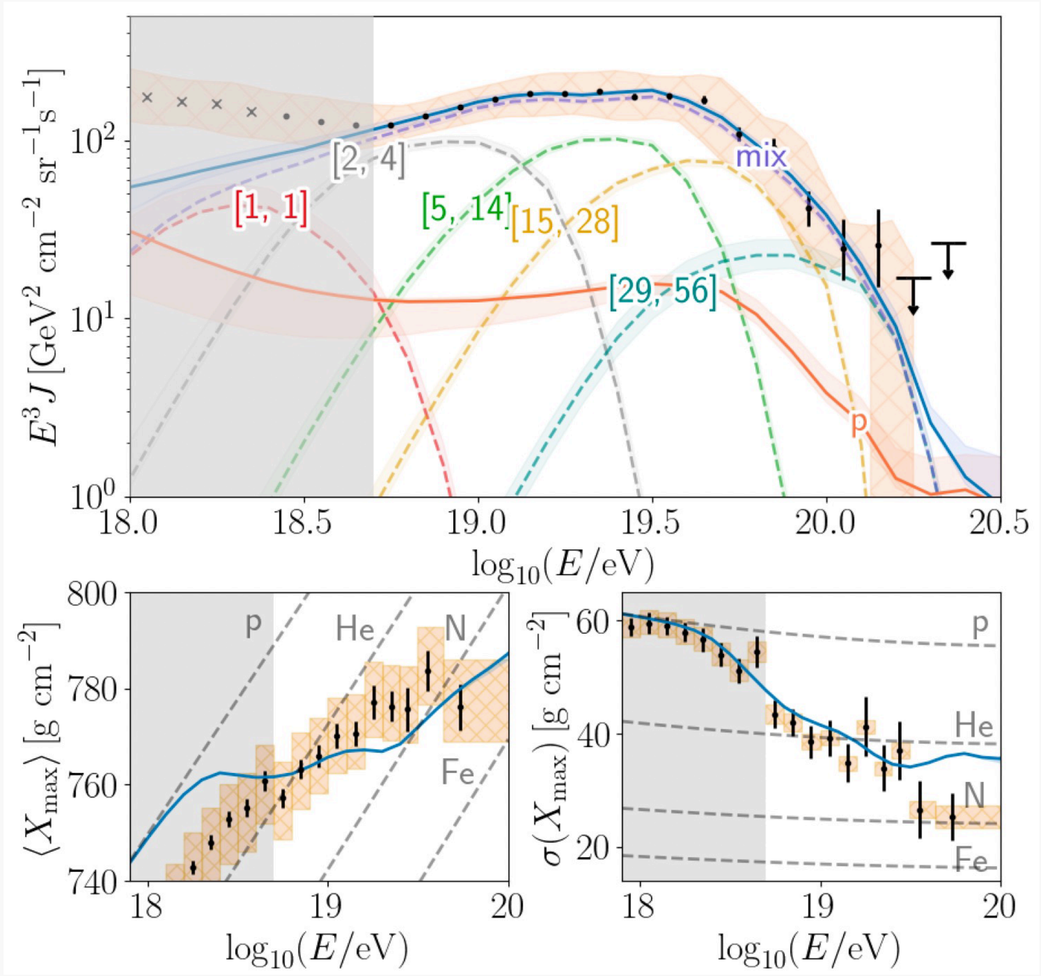
Rodrigues, et al., PRL 126 (2021) 191101

Cosmogenic neutrinos

Cosmogenic neutrino prediction from fit to UHECR flux

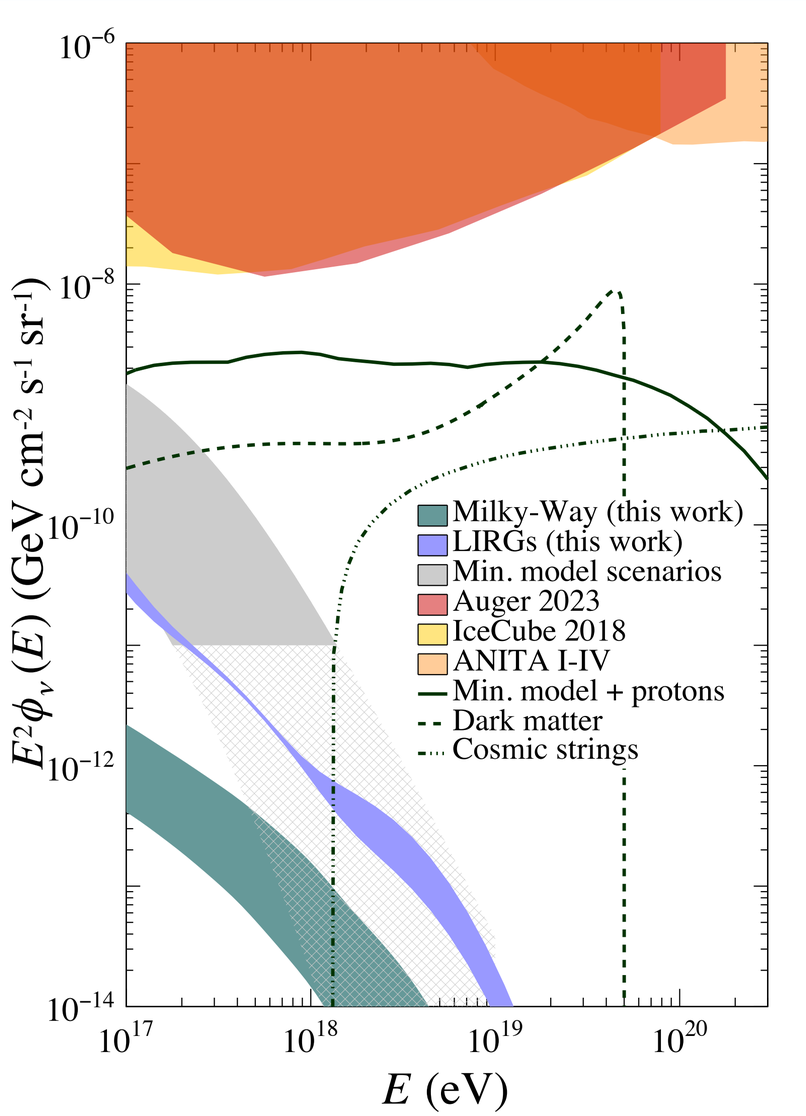
- Depends on extrapolation for z>1 (UHECRs not sensitive there!)
- No cosmogenic neutrinos in minimal scenario;
- Strong evolution and proton component –> boost in neutrino production!





Ehlert, van Vliet, Oikonomou, Winter, JCAP 02 (2024) 022;

BSM neutrinos



- The neutrino flux associated to the minimal scenario is very low, –>room for detecting rare events:
- Super Heavy Dark Matter Decay: searching for byproduct of decay in VHE neutrinos.
- Cosmic strings: hypothetical 1-dimensional topological defects which may have formed during a symmetry-breaking phase transition in the early universe (top-down scenario).

Berat, Condorelli et al., 2024 *ApJ* **966** 186

Conclusions

- KM3NeT under construction –> present status: ARCA 28 DUs (12% of full detector) and ORCA 23 DUs (20% of the full detector);
- Detectors in data taking from the first strings deployed;
- KM3NeT has been taking high quality data during construction phase;
- Promising results in southern sky astronomy & neutrino mass hierarchy.

An exceptional high energy track event detected –> a horizontal event with energy above 10 PeV . More information will follow soon ;)

Conclusions

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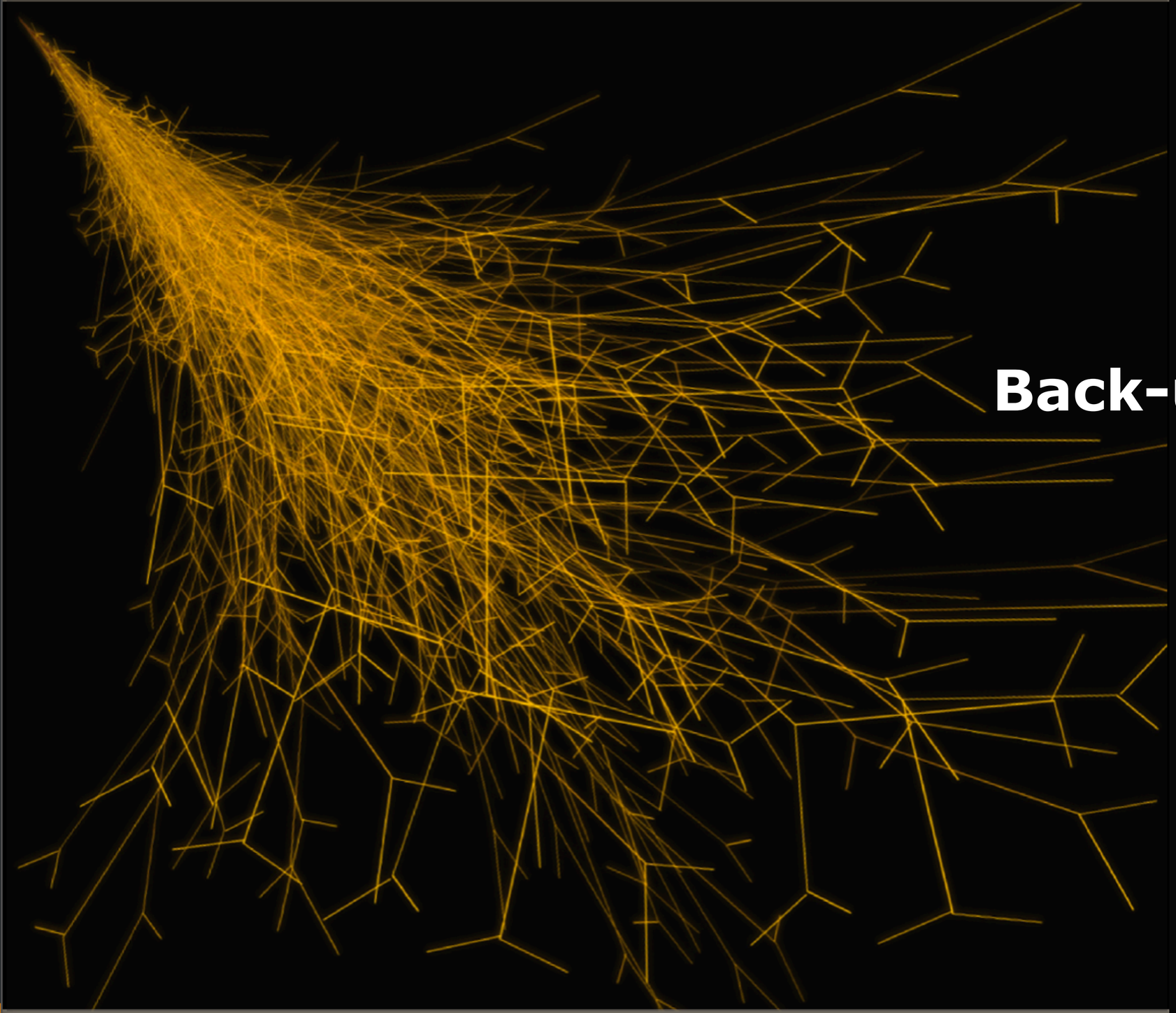
Thanks for your attention



Back-up slides

Muon shielding

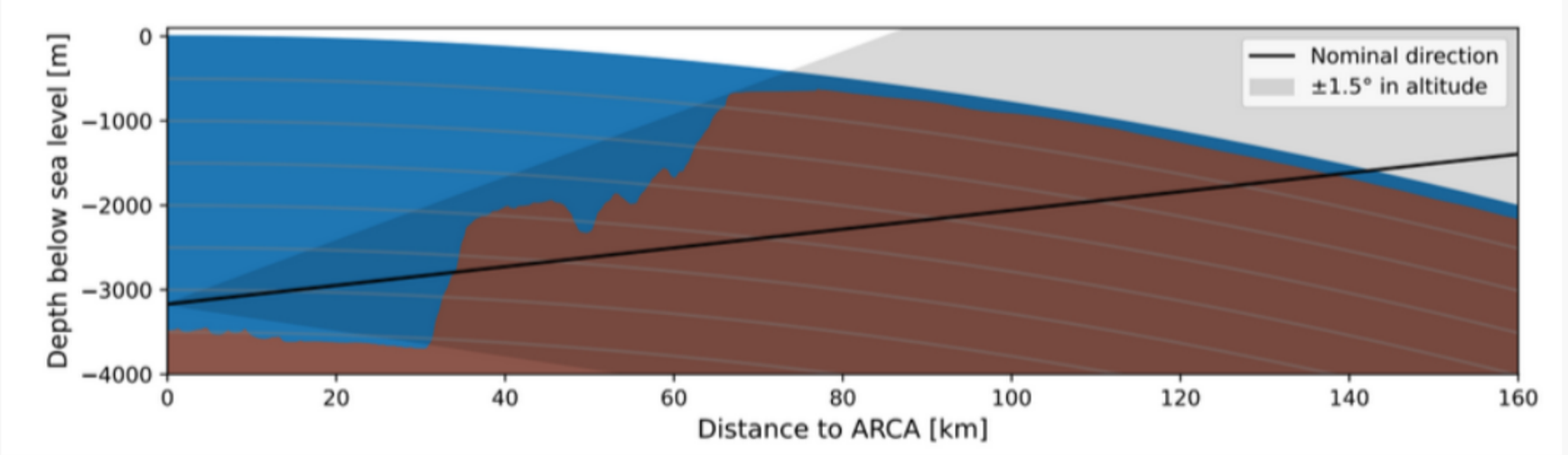
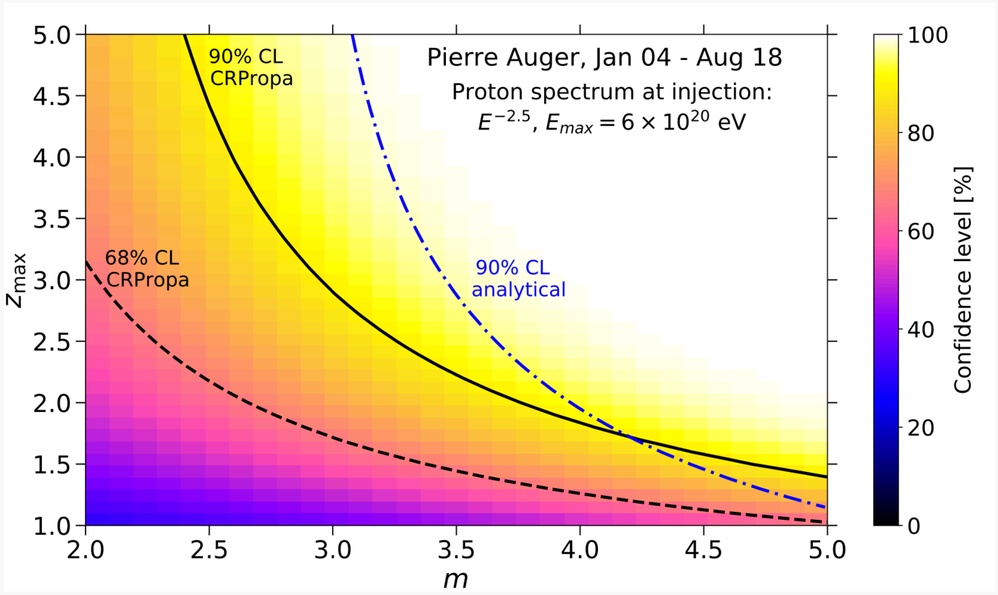


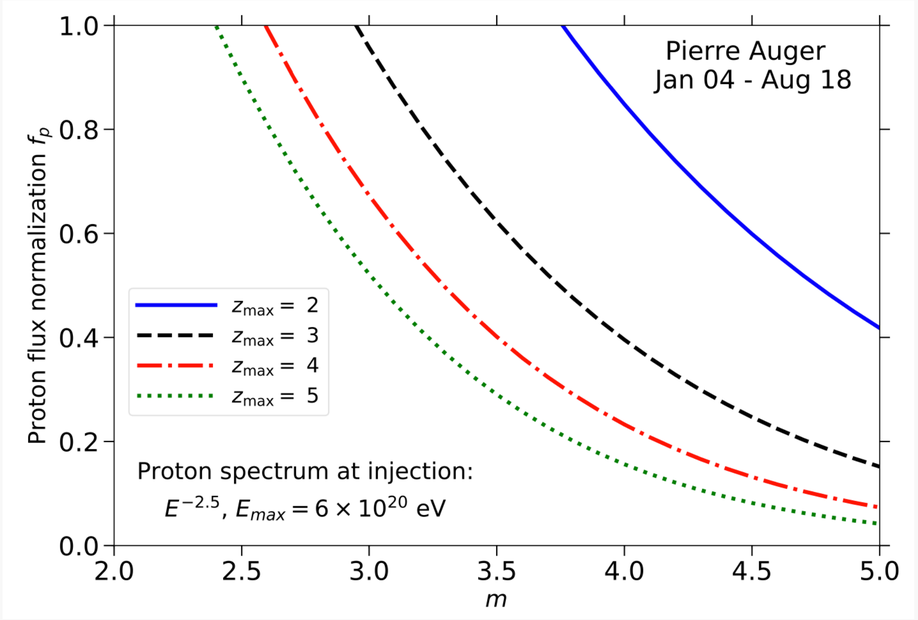
Figure 7: Illustration of the topography in the direction of KM3-230213A using bathymetric data from EMODnet [79]. A sectional view along the incoming direction and position of the event is provided, with the sea shown in blue and the seabed and the rock beneath in brown. The x-axis indicates the total distance from the ARCA site, while the y-axis and the grey lines represent the depth with respect to the sea level. The shaded area shows the effect of a variation of ±1.5°

It is important here to stress: the 1.5 degree is shown here as an arbitrary example. Our error on the absolute alignment for this angle is smaller.

Multi-messenger constraints

Energy spectrum, mass composition and neutrinos can constrain **source evolution** and **proton fraction**!





The Pierre Auger Collaboration, JCAP 10 (2019) 022