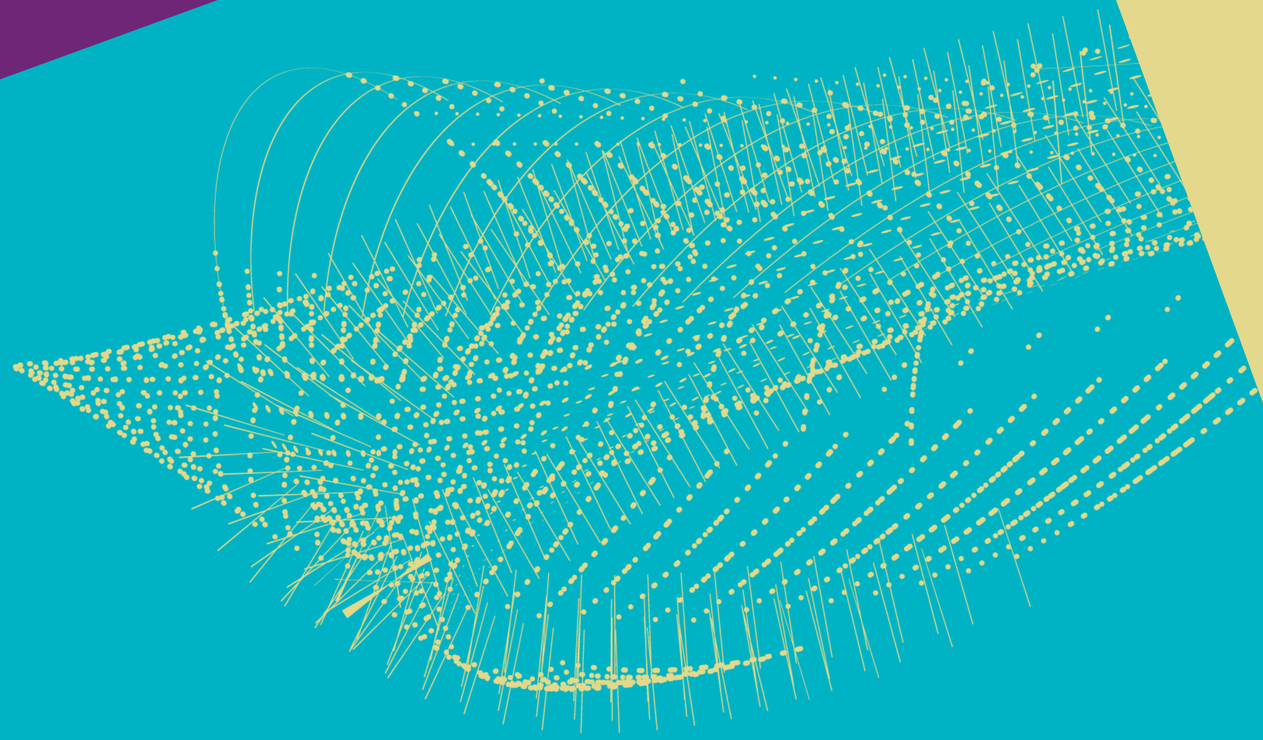
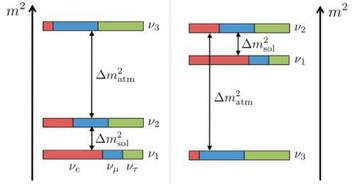
Nikhef

KM3NeT/DUNE

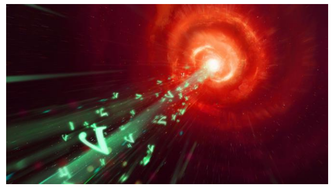


NEUTRINO PROGRAMME

Dorothea Samtleben
Paul de Jong
SAC visit 2025



Neutrino group - Science



Determine fundamental neutrino properties

- neutrino oscillations -> mass ordering, mixing angles, δ_{CP}

=> crucial to complete Standard Model

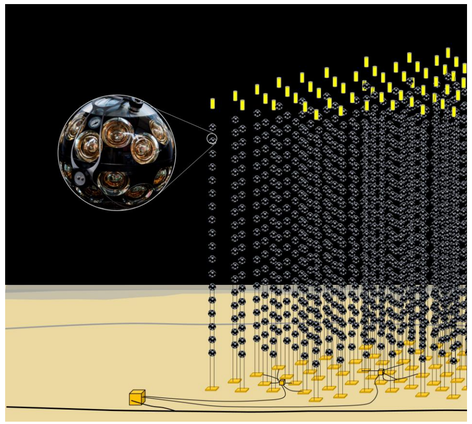
=> promising route to find new physics, link to dark matter

Discover and investigate high energy cosmic neutrino sources

=> trace the unknown origin of high energy cosmic rays

=> understand particle acceleration in cosmic sources

=> explore uncharted territory of the Universe



KM3NeT: Water Cherenkov detector on the bottom of the Mediterranean Sea

under construction, to be finalized end of this decade;

Formal status as **AISBL** targeted, to be finalized this year

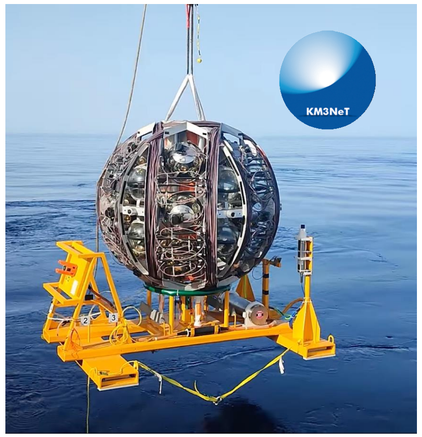
@Nikhef: major production site and software development

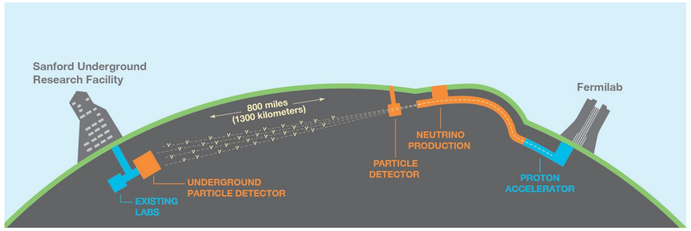
KM3NeT/ORCA: detector 40km from the French coast

Focus on atmospheric neutrinos, neutrino properties

KM3NeT/ARCA: ~1km^3 detector 100km from Sicily

Focus on cosmic neutrinos





DUNE: Neutrino beam from Fermilab to detectors at 600m and 1300km distance

Under construction, prototype detector at CERN

Focus on neutrino properties, CP violation

Group Composition

KM3NeT group with alumni

Celebration of ‘Cosmic Catch’
12 February 2025

KM3NeT neutrino telescopes

6 staff, 2 PDs, 3 PhD candidates (2 finishing, 2 starting)
1 FTE support from e-science center (ending this year)
0.4FTE from TNO (to end September 2025)
=> Decreasing group size makes for risk in exploitation

DUNE accelerator neutrino experiment

4 staff (only small fraction of FTE), 1 PD, 2 PhD candidates

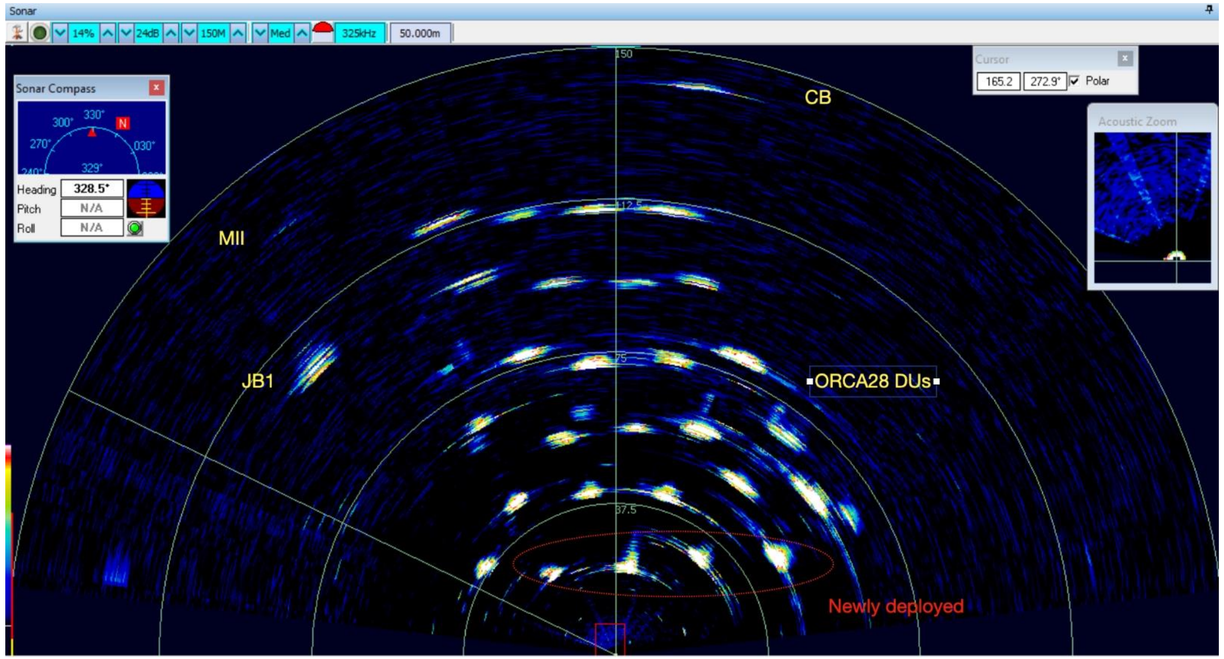
+ several bachelor/master students
+ PhD student visitors from other institutes

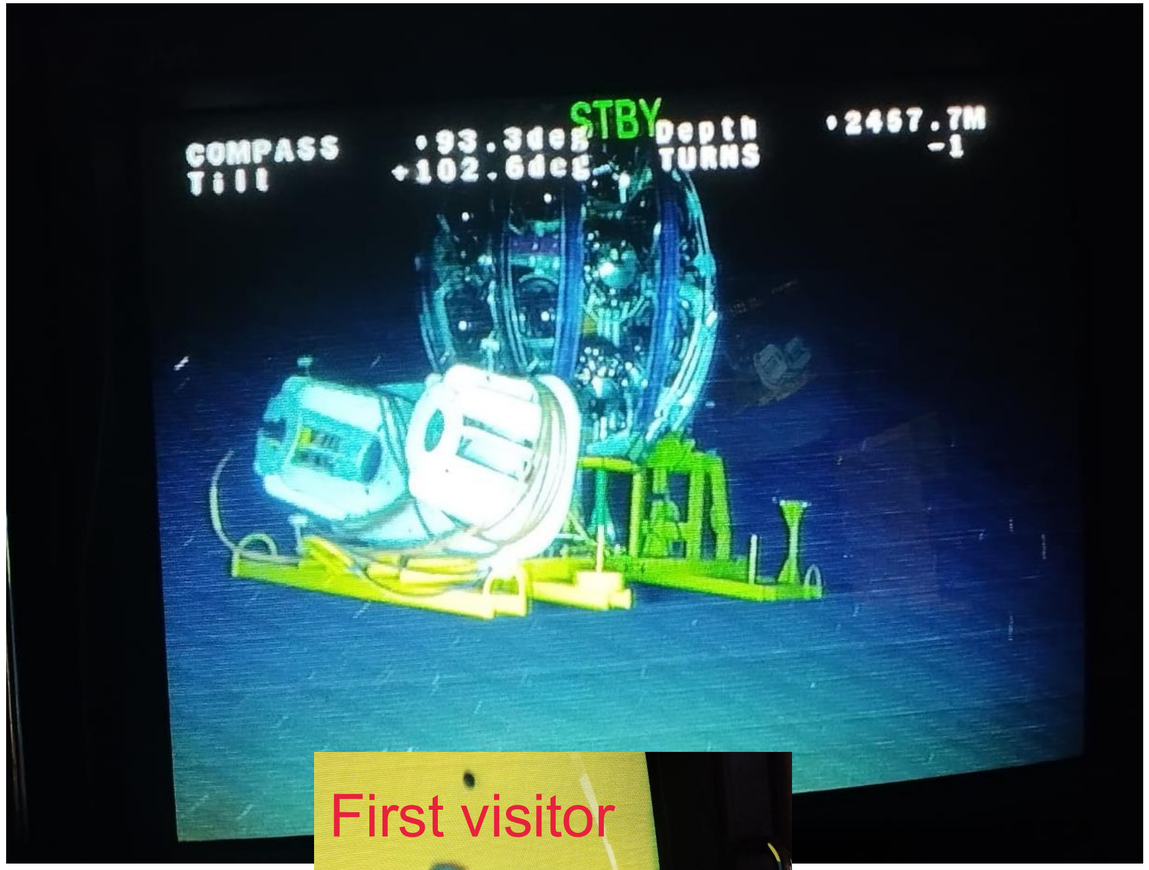
Important roles in KM3NeT

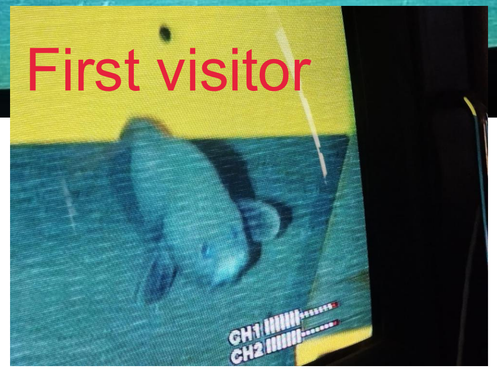
Spokesperson: Paul de Jong (elected Oct 2024)
Technical Project Manager: Antonio d’Amico (elected Oct 2024)
Physics and Software Coordinator Aart Heijboer (til Oct 2024)
Cosmic ray physics group convener: Ronald Bruijn
Oscillation working group convener: Victor Carretero Cuenca
Computing group convener: Mieke Bouwhuis (til November 2024)
Detection Unit integration coordinator: Daan van Eijk (til March 2025)
Optical system coordinator: Jan Willem Schmelling
Mechanical system coordinator: Edward Berbee
System Engineer: Ernst-Jan Buis (TNO)
(New!) Acoustic group convener: Ernst-Jan Buis (TNO)

Also PhD students contributing to Sea Operations, run coordination, data processing, calibrations, DOM production

ORCA status







May 2025: 4 more strings deployed

=> **28 strings in the water**

Funding for 48 (of 115) strings available

further funding sought in

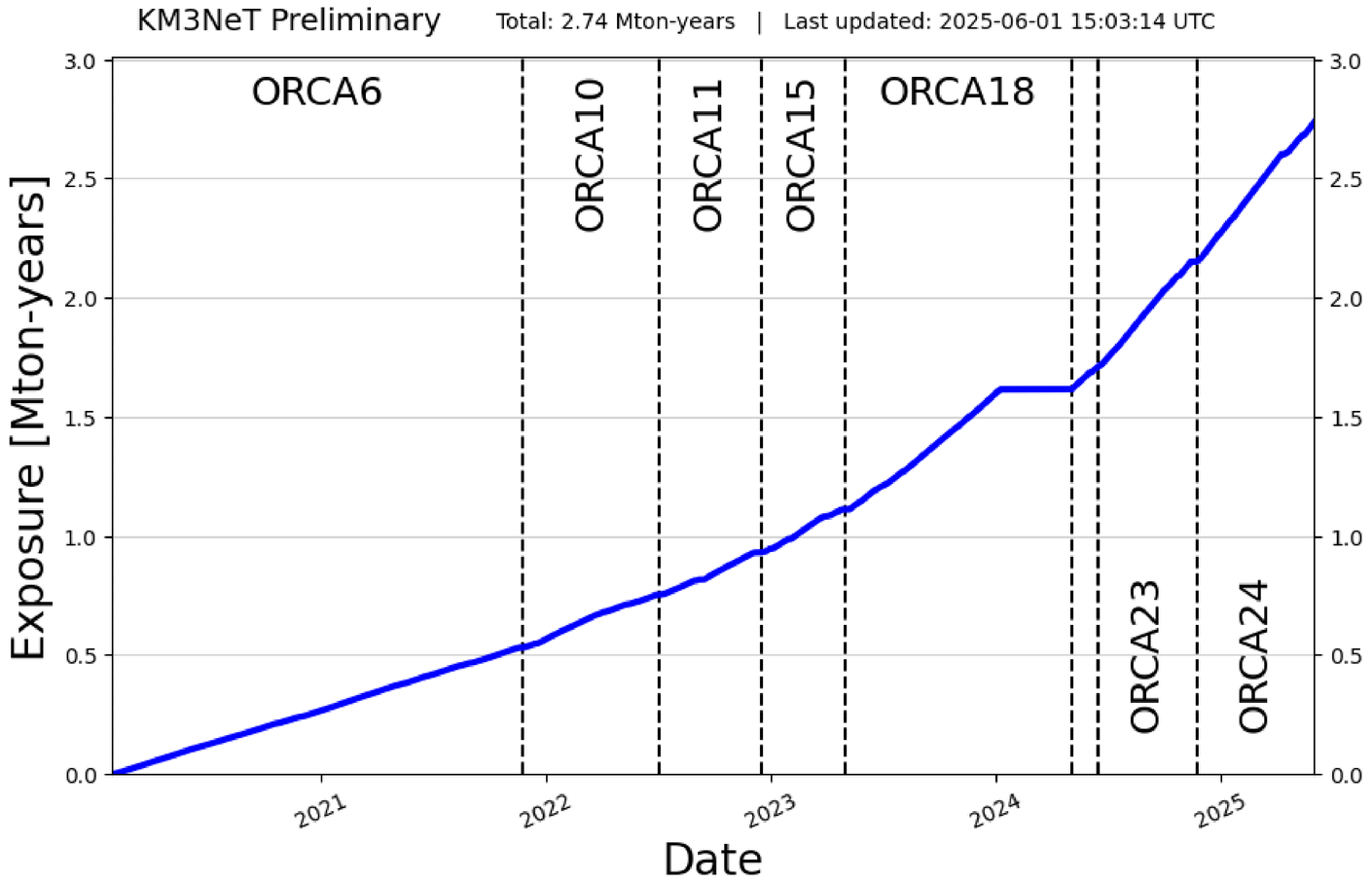
Netherlands, France

ORCA data

Neutrino oscillation analysis published

In addition BSM physics (neutrino decay, non-standard interactions)

⇒ Upper limits comparable to other experiments.



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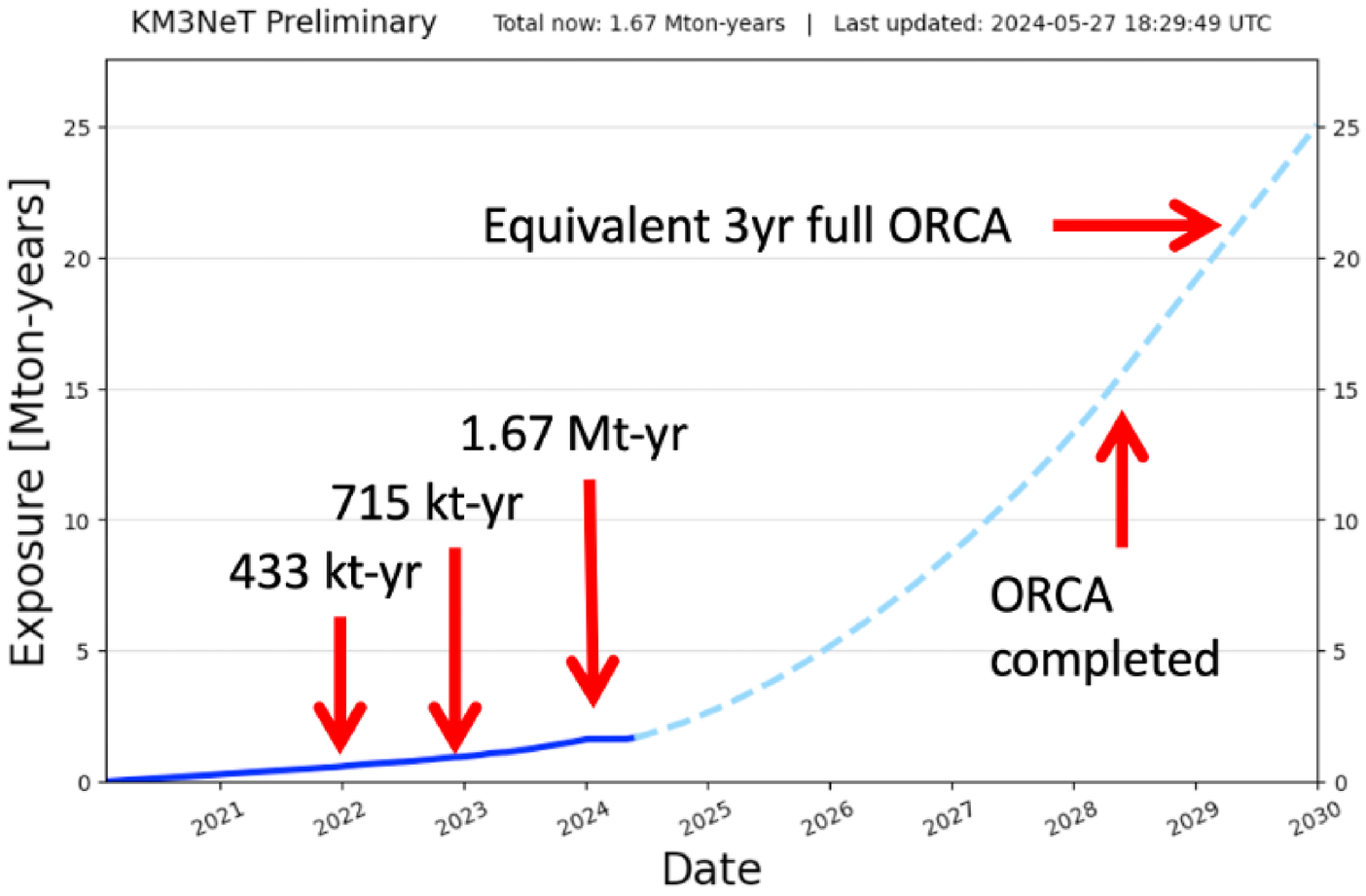
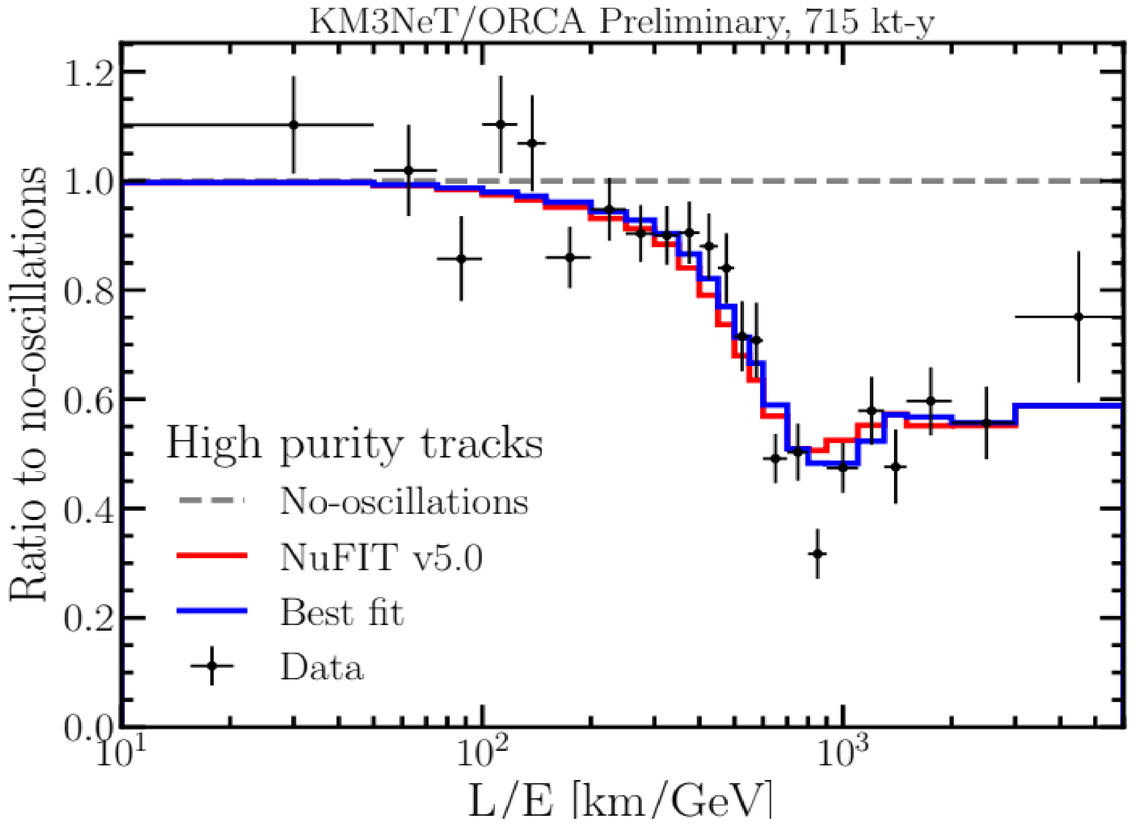
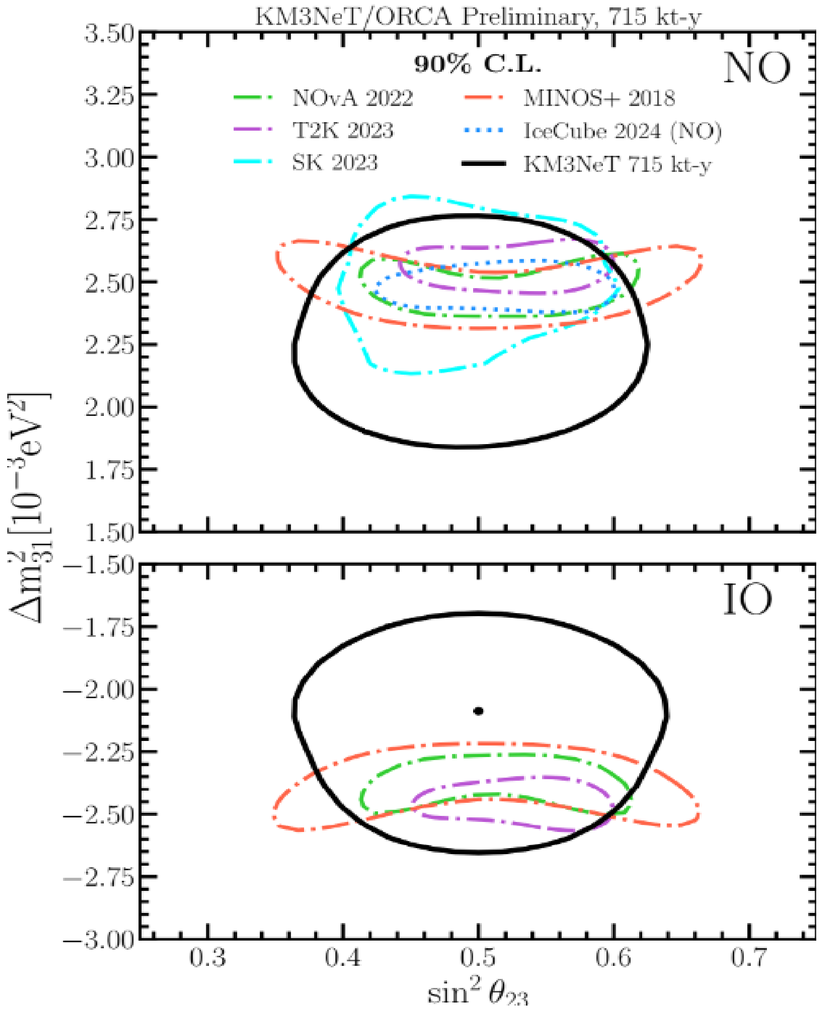


Neutrino oscillations

ORCA 715kt years





Clear evidence for Oscillations

Analysis by **Victor Carretero Cuenca**

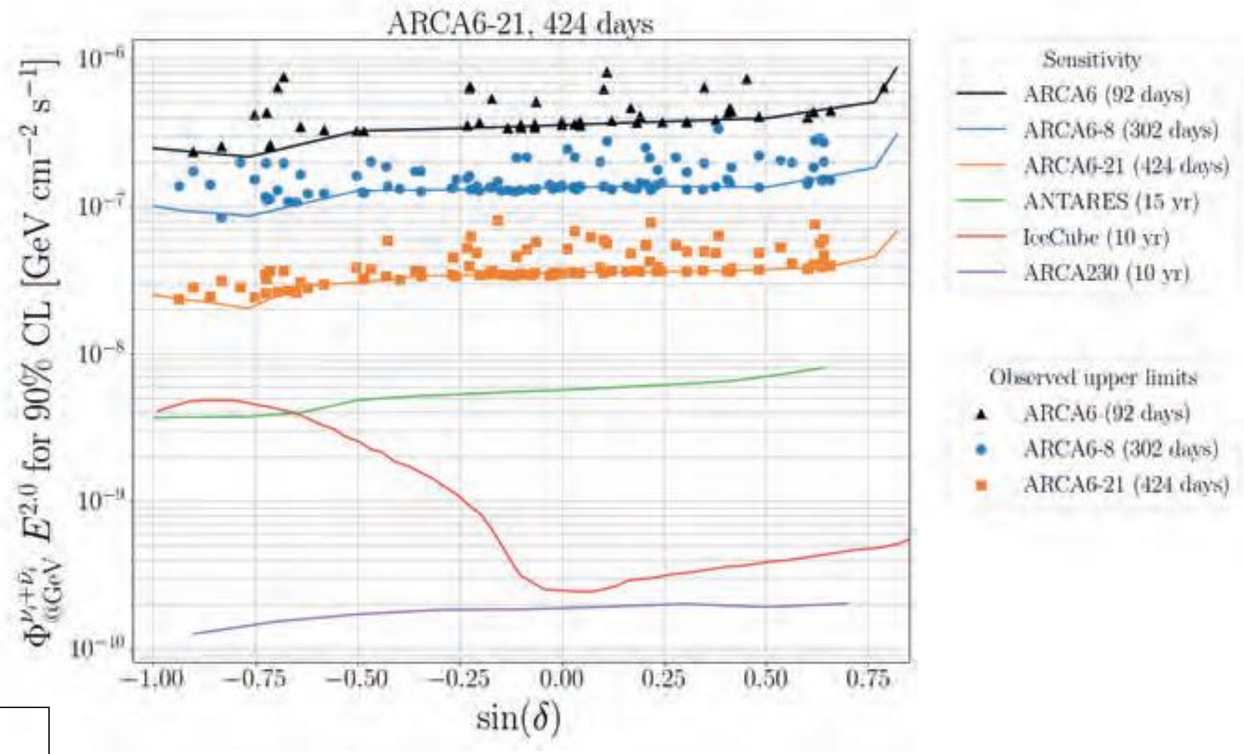
ARCA status

33 strings in the water
for 30 strings power problem
=> to be investigated in next Sea Operation

Funding for 128 (of 2x115) strings available,
further funding sought in Italy

Various cosmic neutrino point source analyses and astronomy prospects published,
analysis framework: **Aart Heijboer**

Neutrino flux limits as function of declination



PhD thesis **Thijs van Juan Eeden**

Cosmic Catch

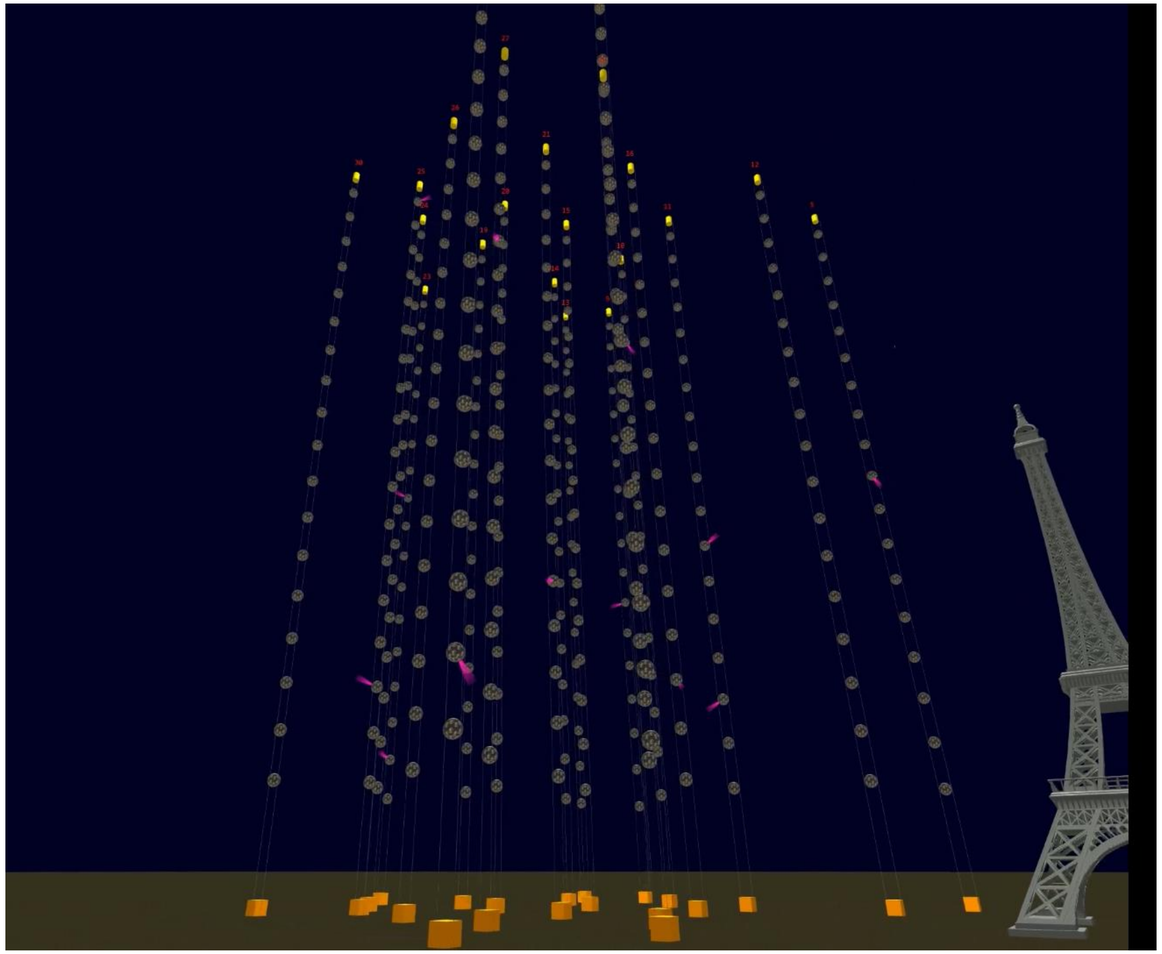
Highest energy neutrino ever observed

$$E_\mu = 120^{+110}_{-60} PeV$$

90% CL: $35PeV - 380PeV$

$$E_\nu = 220^{+570}_{-100} PeV$$

90% CL: $72PeV - 1.5EeV$



- Excellent demonstration of detector performance
- Angular resolution dominated by uncertainty of the detector rotation

=> new acoustic system to be deployed next Sea Operation

=> Detailed moon/sun shadow studies for pointing improvements

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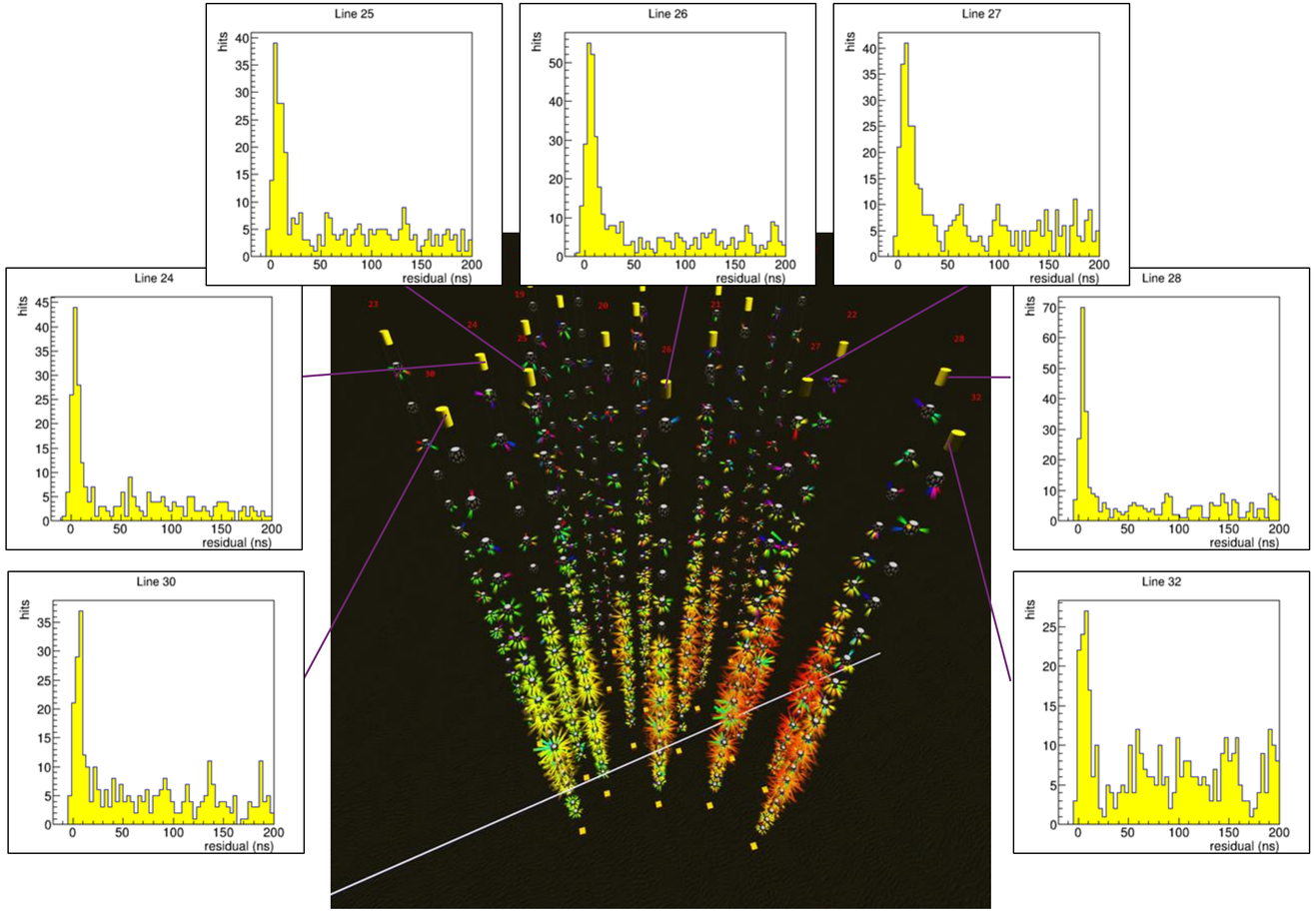

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Technical Contributions

Hardware involvement

- DOM and DU design
- Mechanics
- Optics
- Construction and tests
- PMT base electronics
- Vertical-Electrical-Optical Cable
  VEOC (with MCAP)
- DU deployment procedure
- Commissioning

Software

- All calibration software
  (PMT response, timing,
  positioning, orientation)
- All trigger and reconstruction software
- Neutrino oscillation and point source search
  analysis frameworks

Activities for KM3NeT

- **Completion of KM3NeT ARCA/ORCA detectors**

  => National Roadmap proposal
  8.8MioEuro for 20 strings + 1.9MioEuro acoustics with NIOZ
  + 650kEuro computing, interview 2nd of June, decision September

- **First single-experiment measurement the neutrino mass ordering**
- **Discovery and study of cosmic high energy neutrino sources**

  => NWO-XL (3MioEuro), NWO-M (0.8MioEuro) proposals underway/planned

- **Cosmic ray physics**

  => NWO-M (0.8MioEuro), NWO-XS(60kEuro), NWO-GO (1 PhD) underway

- **Explore acoustic detection technique** => access to higher energies

  => National Roadmap proposal (above), NWO-M-Weave(1PhD)

Senior personpower decreasing
Group needs more personpower for optimal exploitation
and harvesting from investments

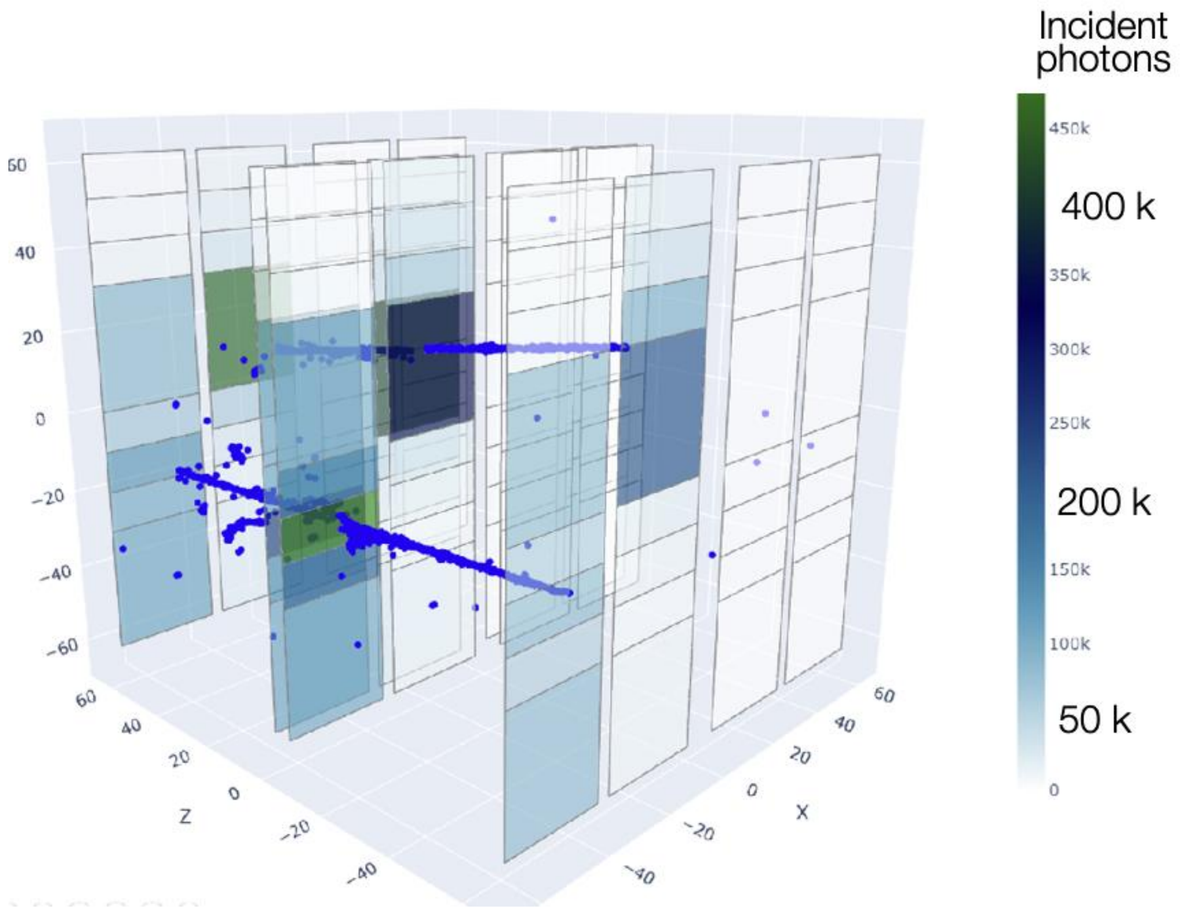
Activities in DUNE

Analysis of prototype data

- **ProtoDUNE** (**DUNE Far Detector prototype** at CERN)
  - Cross section analysis
- 2x2 (**DUNE Near Detector prototype** at FermiLab)
  - Event display, pulse finding
  - Calibration/performance of the light detection system
  - Particle identification

Hardware development

- DUNE Near Detector light detection system
  - R&D to improve photon collection plates
    (existing plates do not meet requirements)
  - Full chain of read-out electronics for light detection system:
    pre-amplifiers for SiPMs inside the liquid argon, cabling,
    feedthrough from the liquid argon cryostat to air,
    frontend electronics, digitizers, bias voltage supply



Recent funding requests not successful

Research Infrastructure proposal planned for next year; NWO-M (0.8MioEuro) planned