# KM3NeT: scientific prospects and current status

Particle Astrophysics in Poland 2019
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NATIONAL CENTRE
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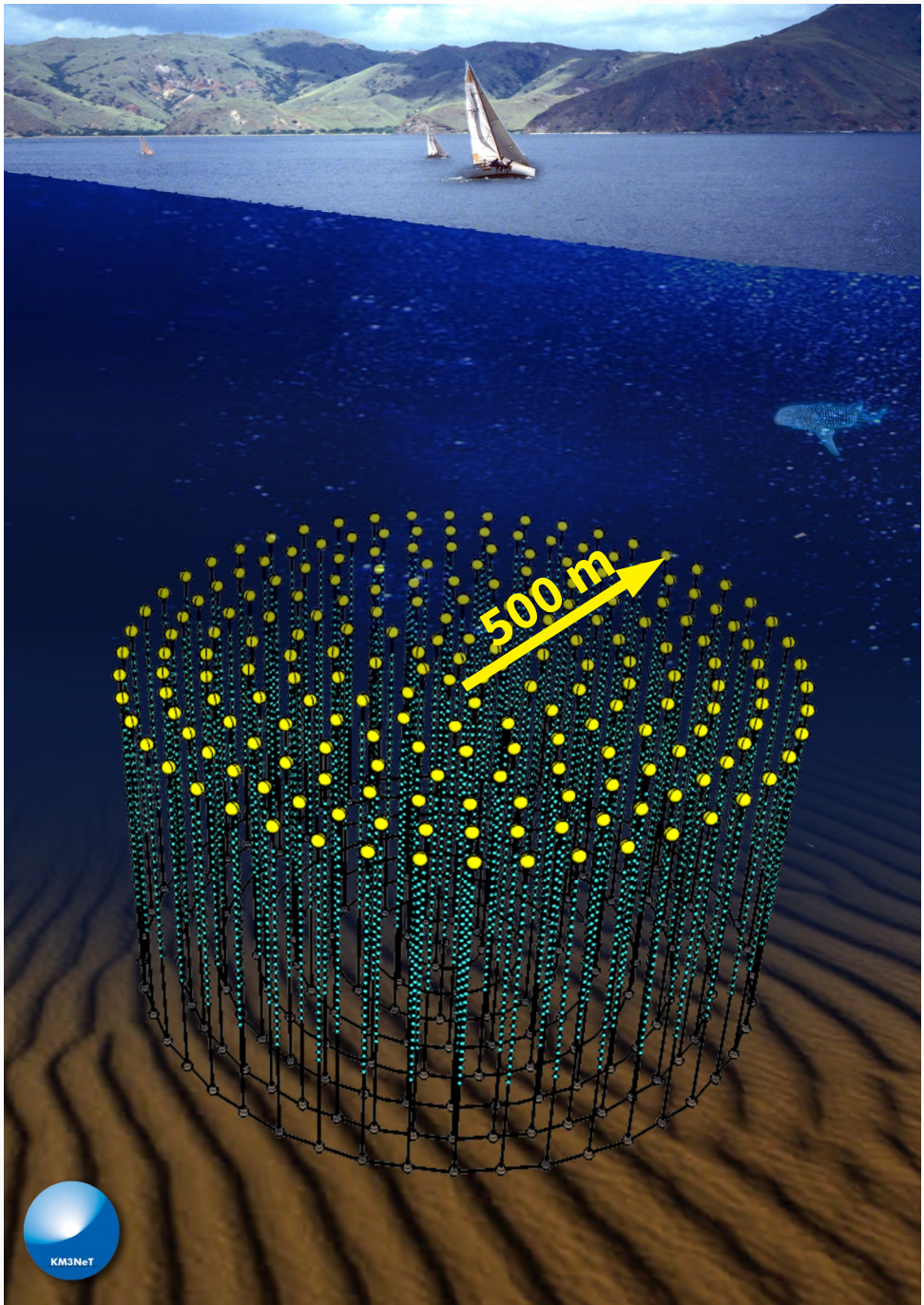
KM3NeT

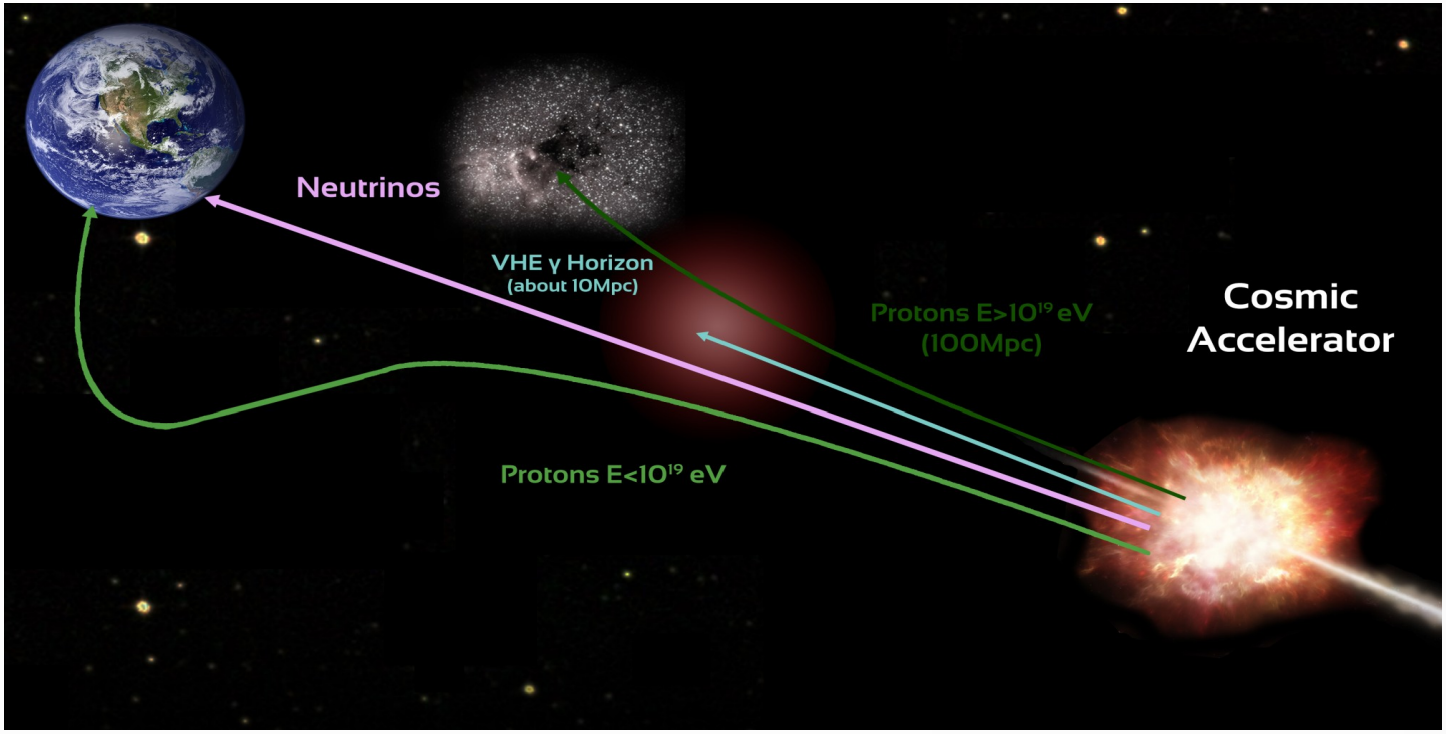
# Outline

1. Neutrinos at large water Cherenkov telescopes
2. KM3NeT
   ARCA & ORCA detectors
   scientific objectives
3. KM3NeT activities in Poland



# Neutrinos: messengers from Universe

4 messengers in the Universe:
- photons,
- GWs,
- CRs
- neutrinos




Neutrinos:
- Perfect messengers from the Universe
- Cannot be deflected (like CR) nor absorbed (like CR with CMB)
- Can escape from dense environments
- Cross section is extremely low : very large detection volume needed

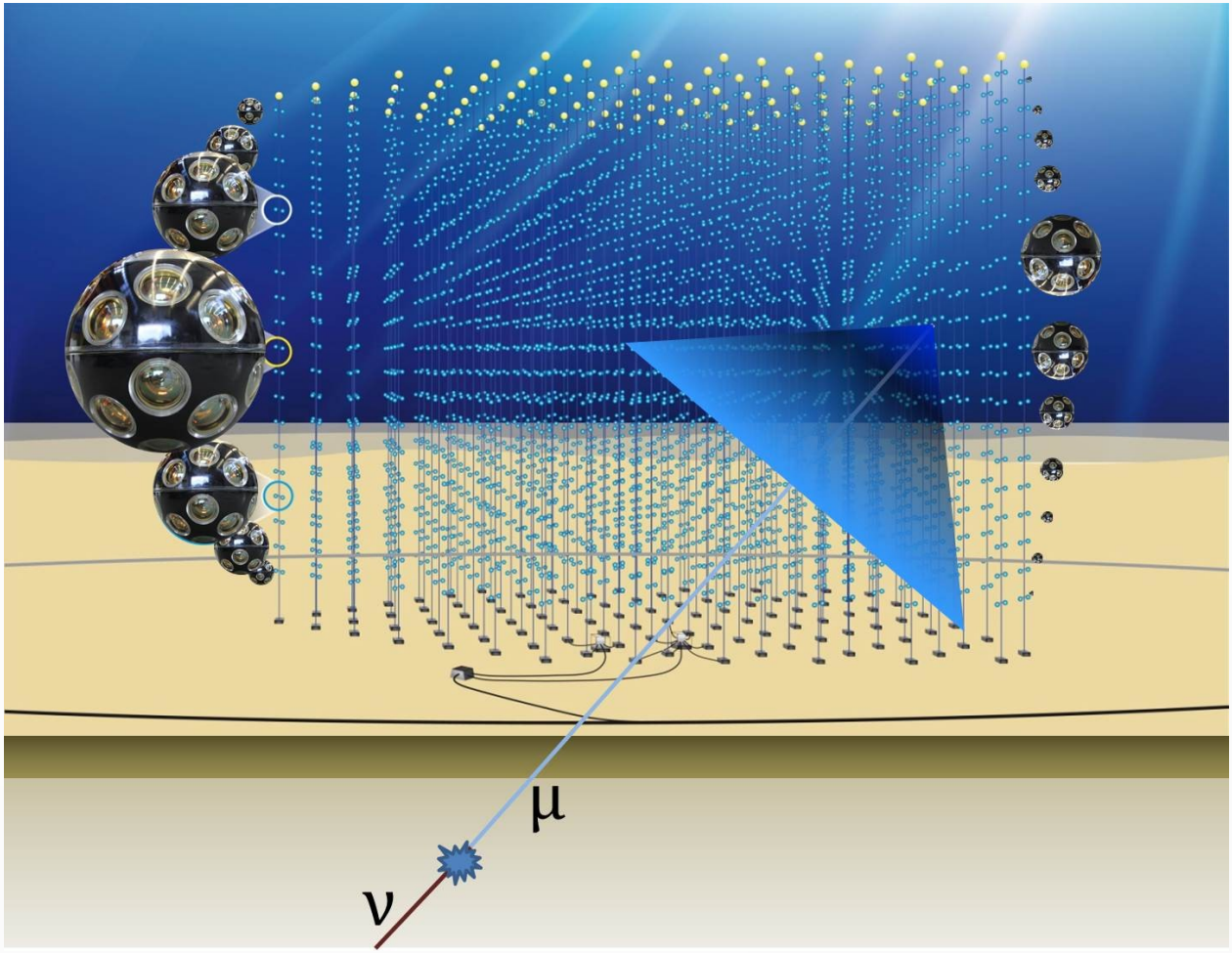
# Neutrino telescopes detection principle

Neutrinos interact in water

Charged particles produce Cherenkov light (in water at 43° with respect to ν direction)

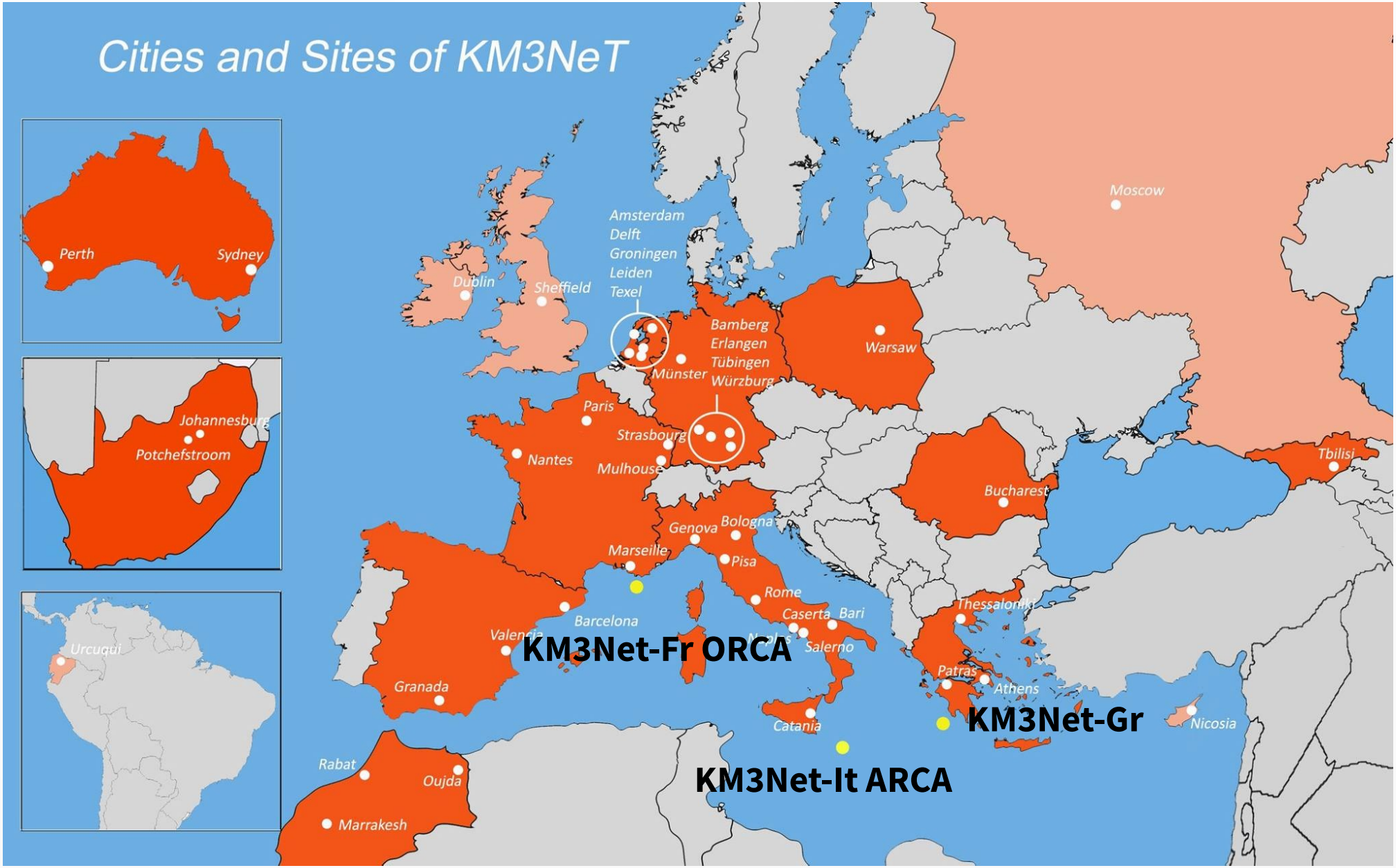
Array of photomultipliers (PMT) detects Cherenkov light

Reconstruction of ν interactions products (mainly e, μ, τ) direction with PMT positions and photon arrival times




Background: $K^{40}$ decays and possible bioluminescence from life forms in deep underwater

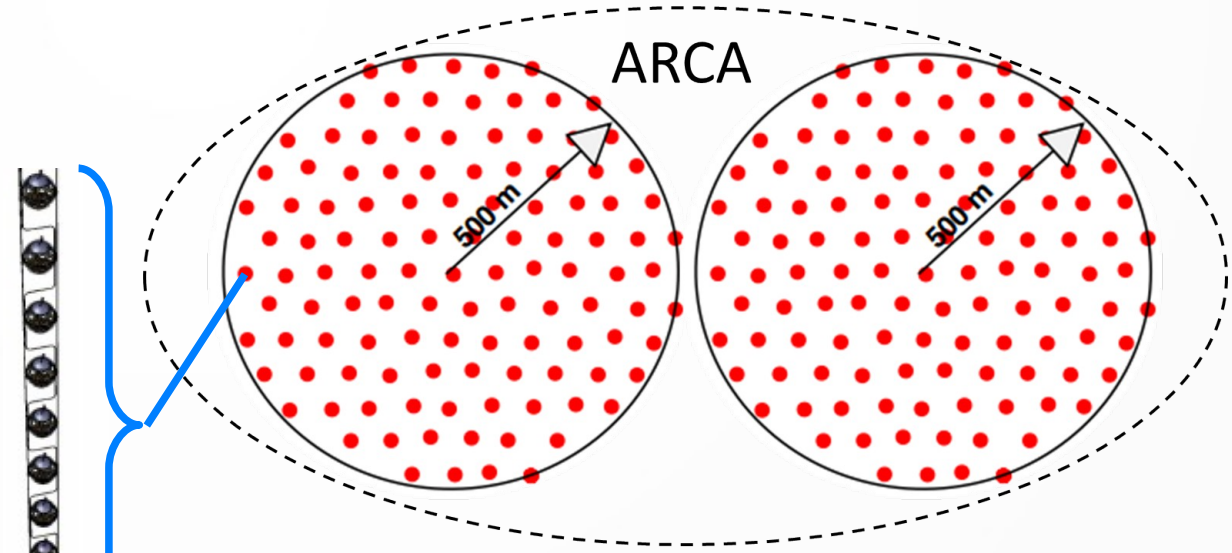
# KM3NeT Collaboration



# KM3NeT neutrino telescopes

- **ARCA - Astroparticle Research with Cosmics in the Abyss**
  - energy: TeV- PeV
  - volume: 1 km$^3$
  - high-energy astrophysical ν and their sources
  - prompt processes (charm/ bottom hadrons) at end of μ/ν spectrum
  - identyfying tau neutrinos

- **ORCA - Oscillation Research with Cosmics in the Abyss**
  - energy range: 3-20 GeV
  - volume: 0.0036 km$^3$
  - atmospheric neutrino oscillations
  - determination of mass hierarchy






**DU – detection unit (string) holds 18 DOM**

ORCA

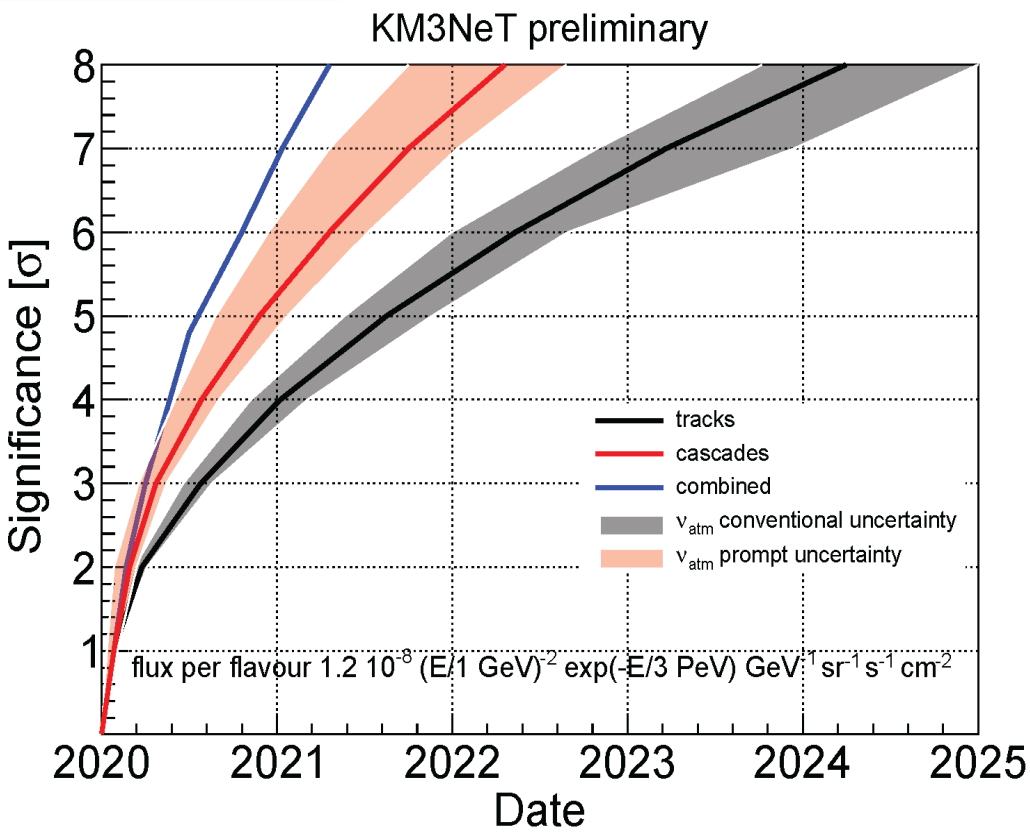
100 m

**DOM – digital optical module holds 31 PMT each**

| | ARCA | ORCA |
|---|---|---|
| Diameter [m] | 500 | 106 |
| Height [m] | 612 | 102 |
| Depth [m] | 3450 | 2450 |
| Number of strings (DU) | 115 x2 | 115 |
| Number of DOM/ string | 18 | 18 |
| Vertical DOM spacing [m] | 36 | 6 |
| DU spacing [m] | 90 | 20 |

# Scientific goals

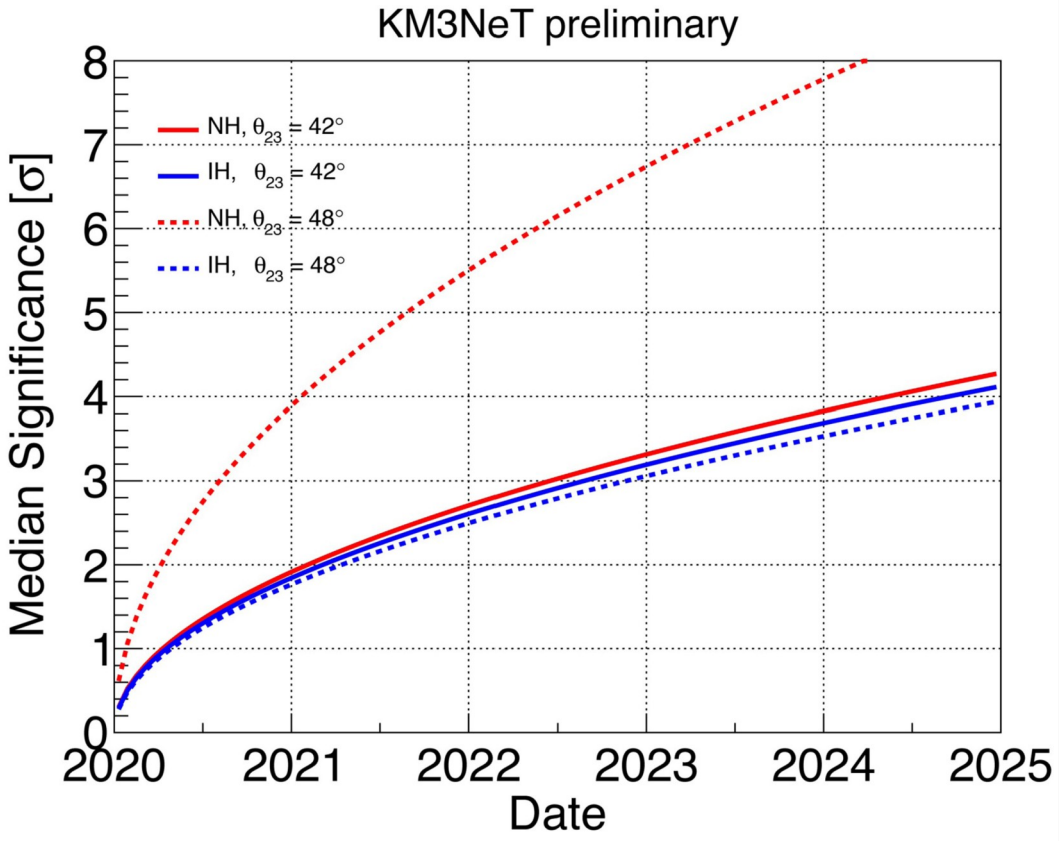
## ARCA




**Relative time from start of operation**

Significance as function of time for detection of diffuse flux of neutrinos corresponding to IceCube signal. **5 σ in 1 year.**

## ORCA



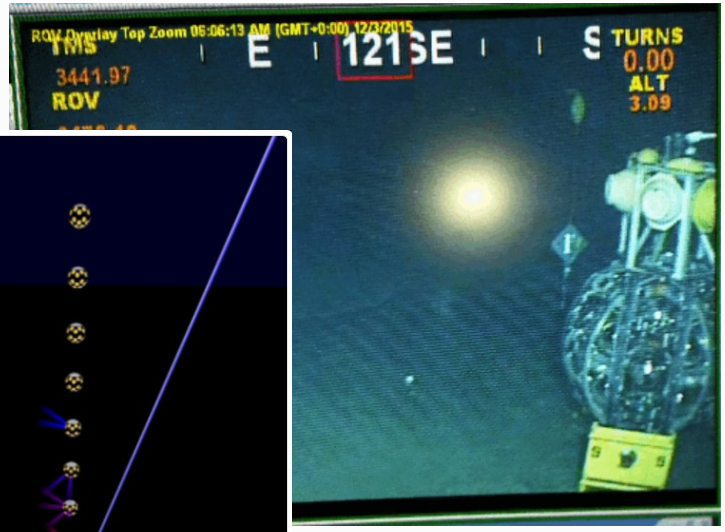

Significance as function of time for determination of neutrino mass hierarchy. **3 σ in 3 years.**

**Adrian-Martinez et al 2016, LOI 2.0 (left & right)**

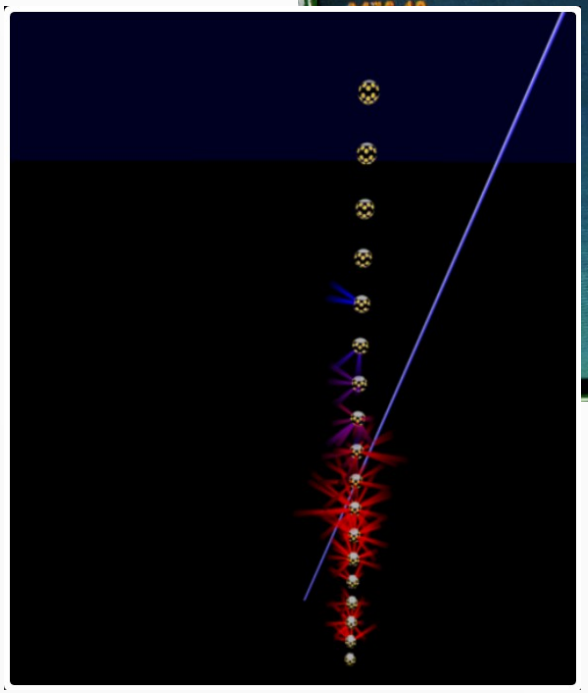
# Current status

## ARCA

- 2015 –2017: deployment of 3 string and some data taking
- 2017 – 2019:  fault in seafloor cable
- 2019: data taking resumed on 1 string




ARCA DOM on seabed



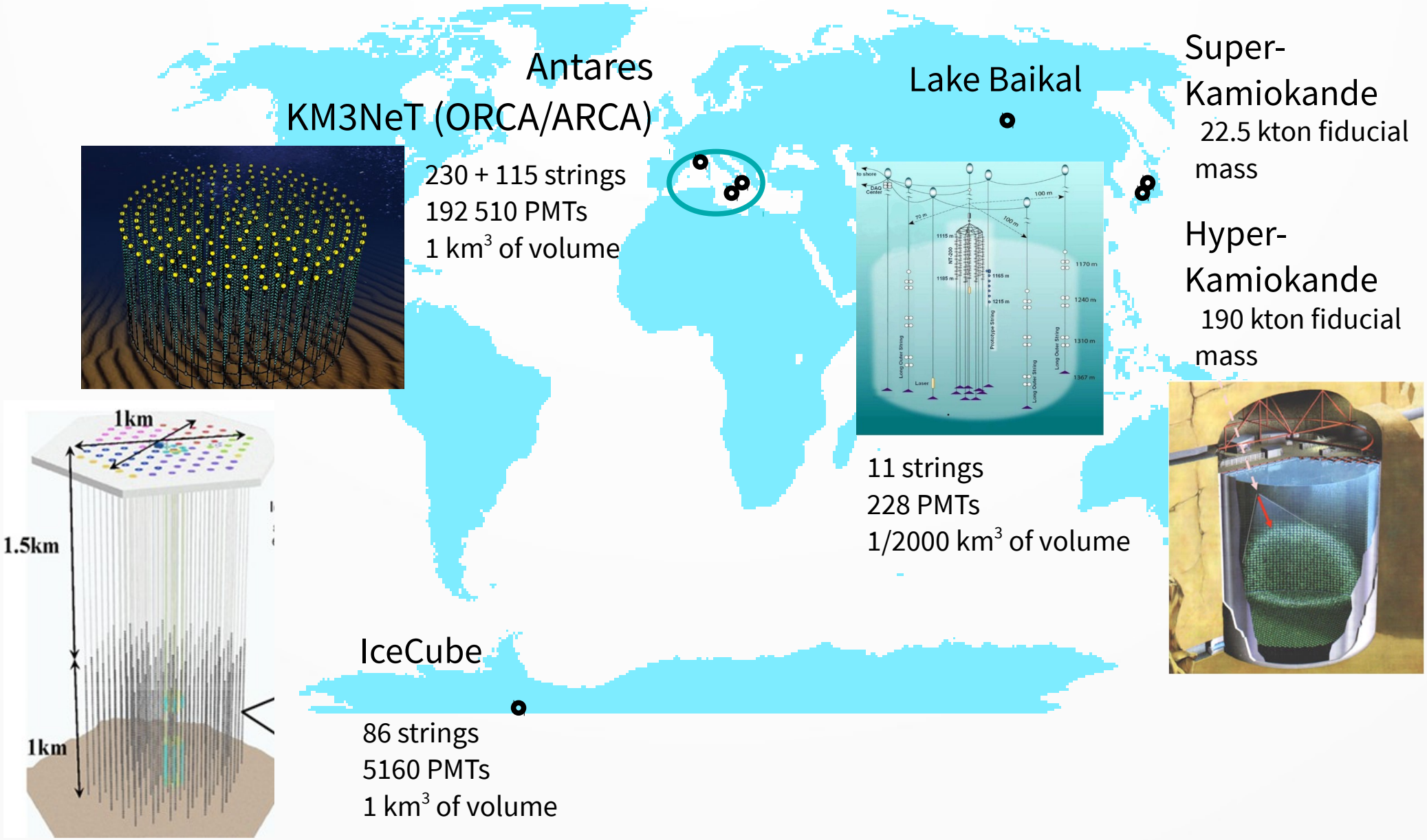
First ARCA event recorded

## ORCA

- 2017: first string deployed and deep sea cable problem
- 2019 : re-installation of 1 string

Deployment of 4 ORCA DOMs

# Neutrino observatories around the world



# KM3NeT activities in Poland

**Team**:

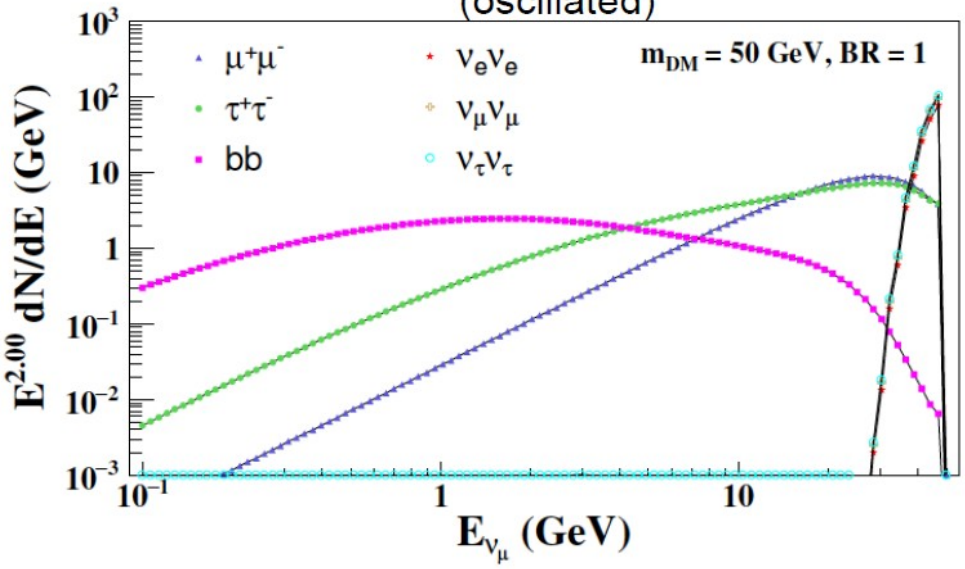
Piotr Mijakowski (coordinator), Piotr Kalaczyński (PhD), Meghna K.K., Rafał Wojaczyński (post-doc)

**Topics**:

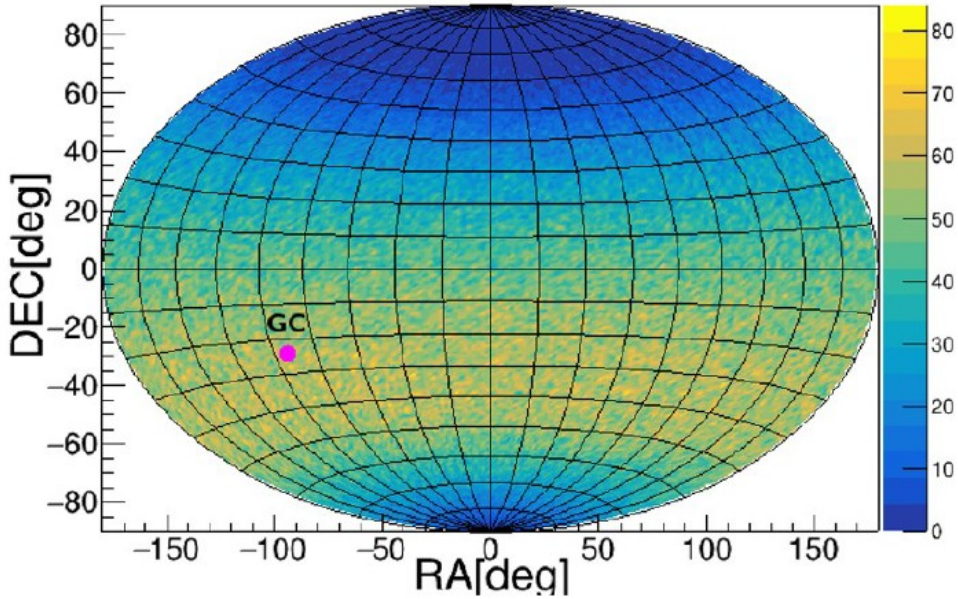
- Providing grid and computing infrastructure for KM3NeT - CIŚ computing centre (Centrum Informatyczne Świerk)
- Cosmic ray shower simulations & MC in general (Piotr K.) → next presentation
- Self-veto effect (Rafał)
- Indirect dark matter search (Meghna).

Sensitivity search for DM-induced ν's from Galactic Center and halo using ORCA detector

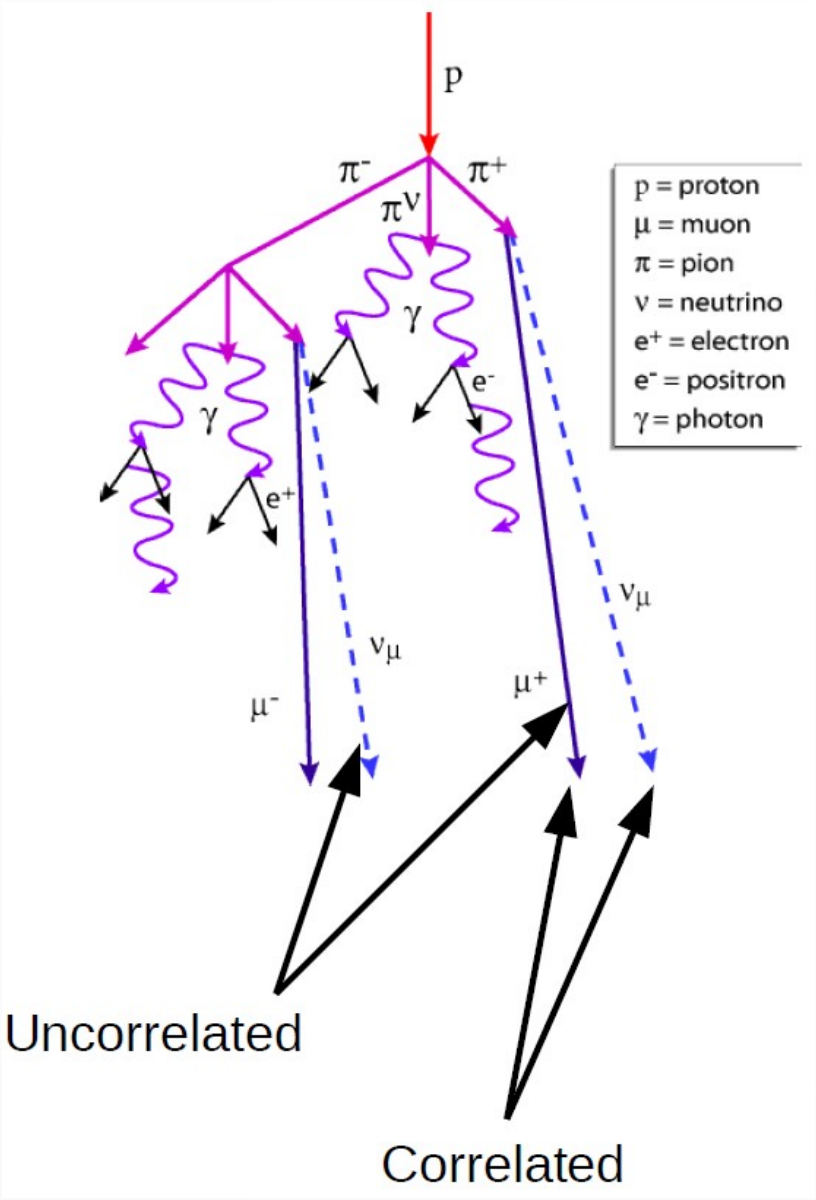
example: simulated signal spectra from Galactic center (oscillated)



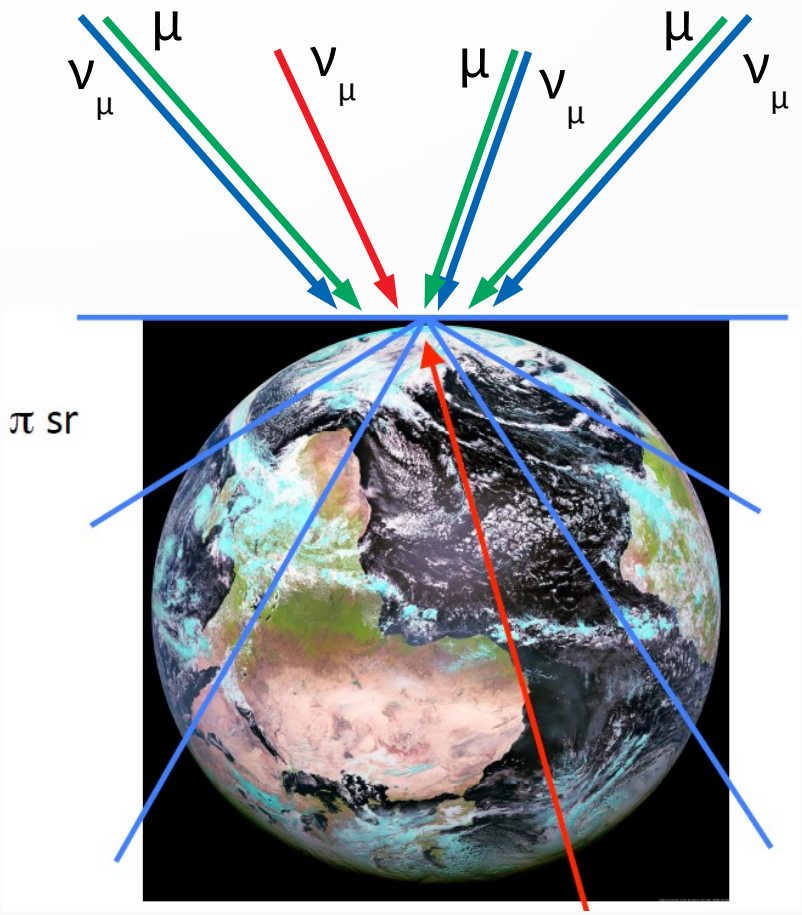

atmospheric ν's background seen in ORCA in RA/DEC (MC)



# Self-veto effect studies




- downgoing atmospheric neutrino events can be vetoed by accompanying μ's from the same shower
- cosmic ν's does not have muon companions



# Atmospheric neutrino passing fraction

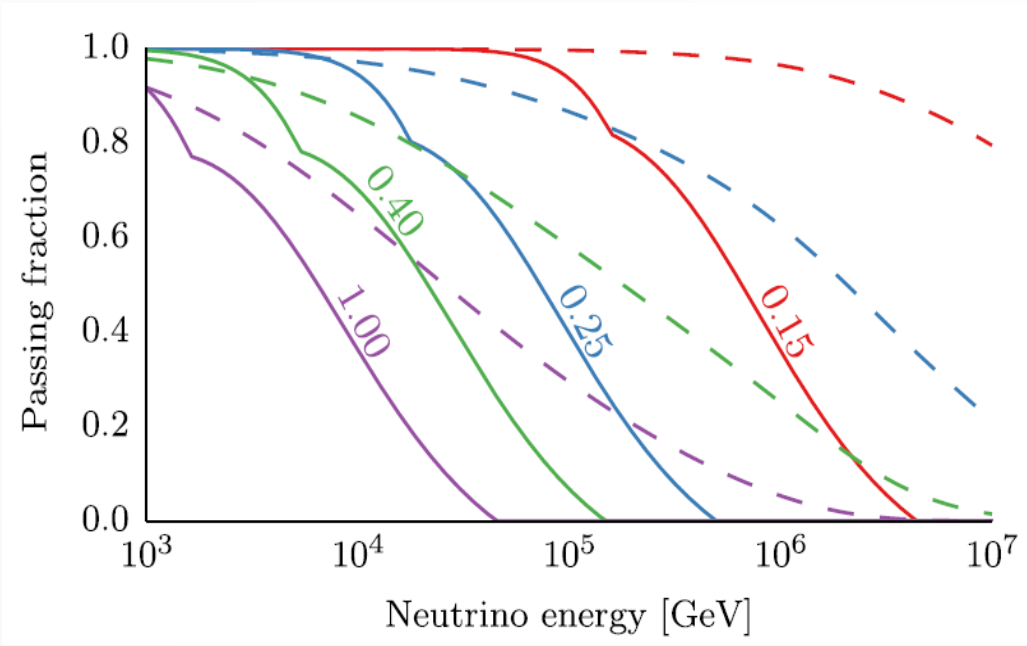
**Passing fraction - fraction of atmospheric ν's not accompanied by muon from same shower**

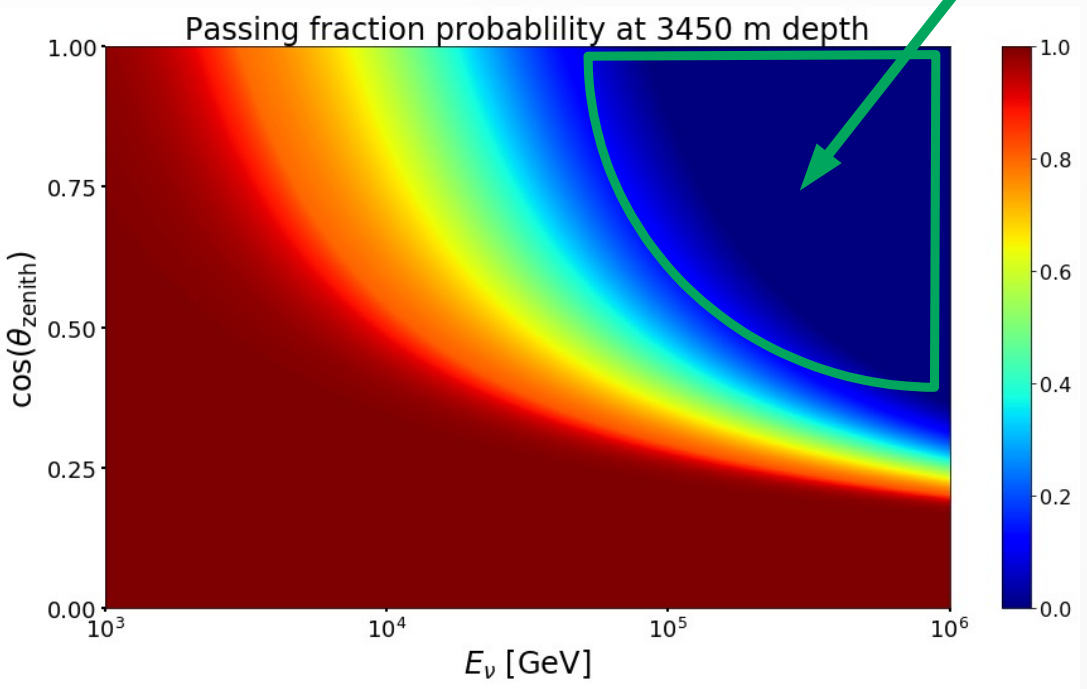
Atmospheric neutrino differential flux

Flux of atmospheric neutrino accompanied by a muon

$$P_{frac} = \frac{\phi_\nu(E_\nu) - \phi^*_\nu(E_\nu, E_{\mu,\min})}{\phi_\nu(E_\nu)}$$

**Every neutrino has companion:**




Gaisser et al 2014

# Summary

- KM3NeT: 2 large detectors ARCA & ORCA in total over 1 cubic km$^3$
- Project in progress: 1 Detection Unit for ARCA and ORCA operating
- Plans:
  Replacement of failed ARCA DU-2 with new one by end of year
  1/3 of the full ORCA detector operative in two years
- Polish funding: NCN SONATA-BIS grant DEC-2015/18/E/ST2/00758
- KM3NeT is looking for new candidates to collaborate (PhD, post-docs),
  Let us know !

**In fall 2019 we organize a KM3NeT Collaboration meeting in Warsaw**

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NATIONAL SCIENCE CENTRE
POLAND
(grant 2015/18/E/ST200758)

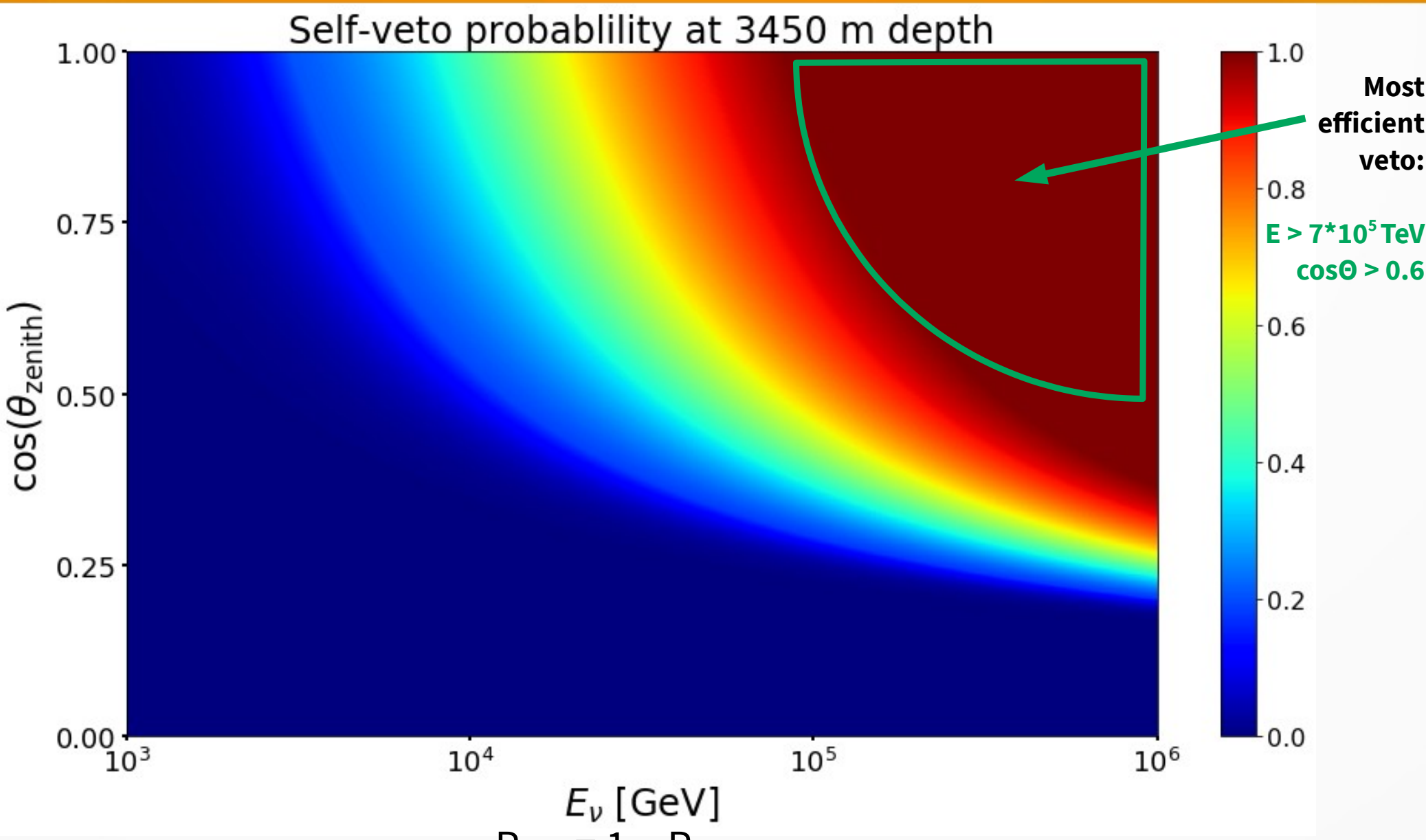
# The end

Thank you for attention

**Are there any questions ?**

# Backup

# Self-veto heat map




$P_{veto} = 1 - P_{frac}$

**Atmospheric neutrino self-veto**