Probing Physics Beyond the Standard Model

also in Finland?

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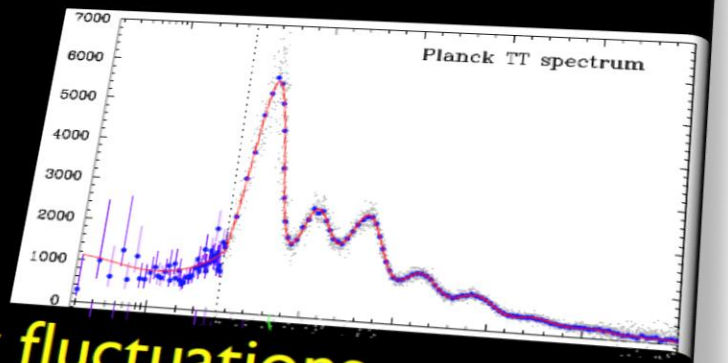
TAUP 2019 TOYAMA

- 540 participants
- 2 Nobel laurates

Plenary talk by
Hitoshi Murayama
at the opening session
of TAUP 2019

Five empirical evidences for physics beyond SM

- at least five missing pieces in the SM:
- dark matter
- neutrino mass
  - 0νββ
  - gravitational wave
- dark energy
  - galaxy surveys
  - DESI, PFS, Euclid, LSST, WFIRST
- apparently acausal density fluctuations
  - Simons Array
  - CMB S4
  - LiteBIRD
- baryon asymmetry
  - HyperK, DUNE
  - LHCb, Belle II



Implicit conclusions

➔ Get more data; especially interesting would be extragalactic neutrinos

- There is a broad consensus that we are at the threshold of a major breakthrough discovery in physics → keep looking!
- We need more data → the first key steps towards the solution are bound to come from experiments!
- Since neutrinos are the only known particles disobeying the predictions of the SM → focus on neutrinos!
- Significance of cosmological aspects → importance of extragalactic messengers

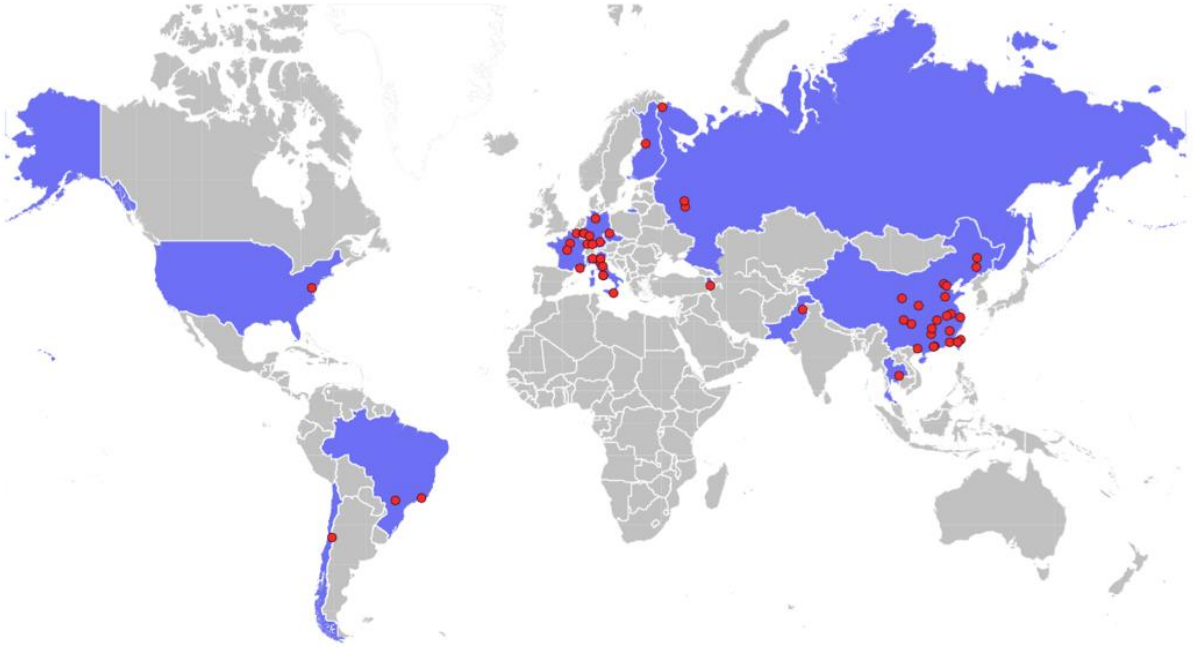
Global response to the BSM challenge

Just a few examples

IceCube

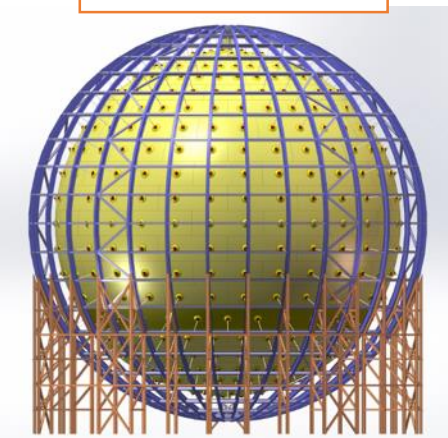
Jiangmen Underground Neutrino Observatory

Multipurpose, medium-baseline reactor neutrino experiment



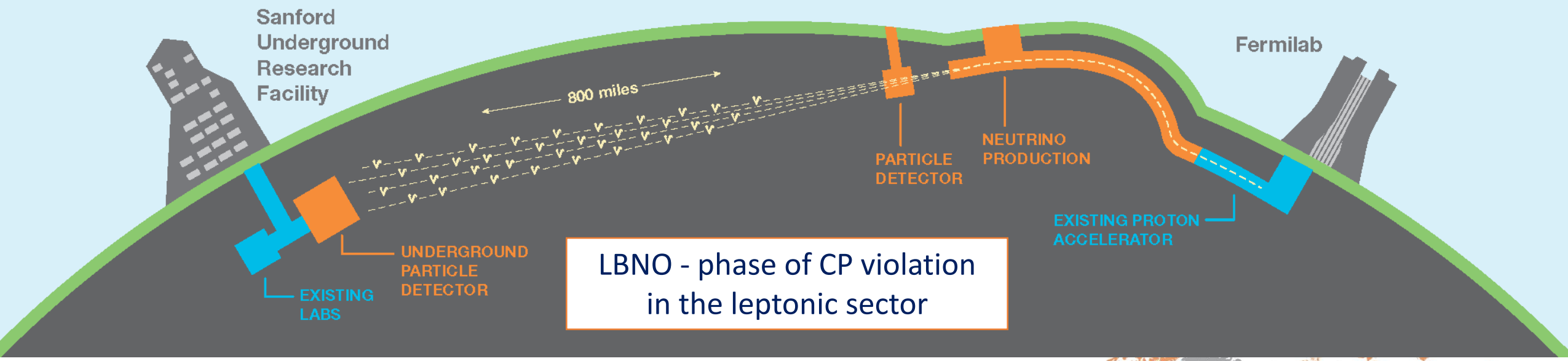
36 GW_{th}

20 kton LS



53 km

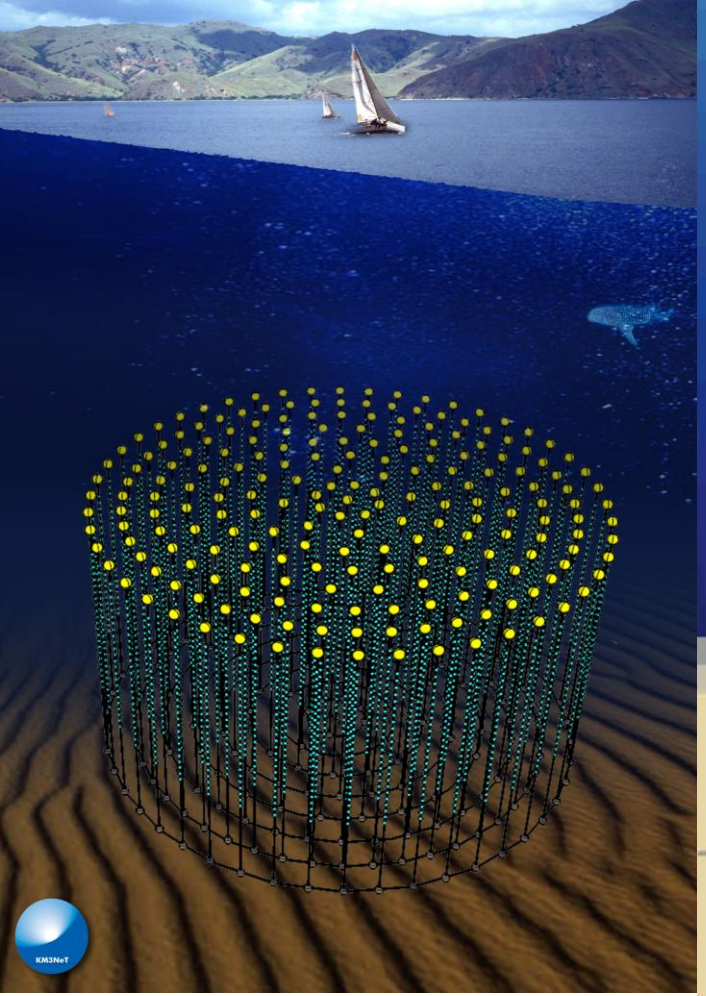
~550 participants from 72 institutions in 17 countries



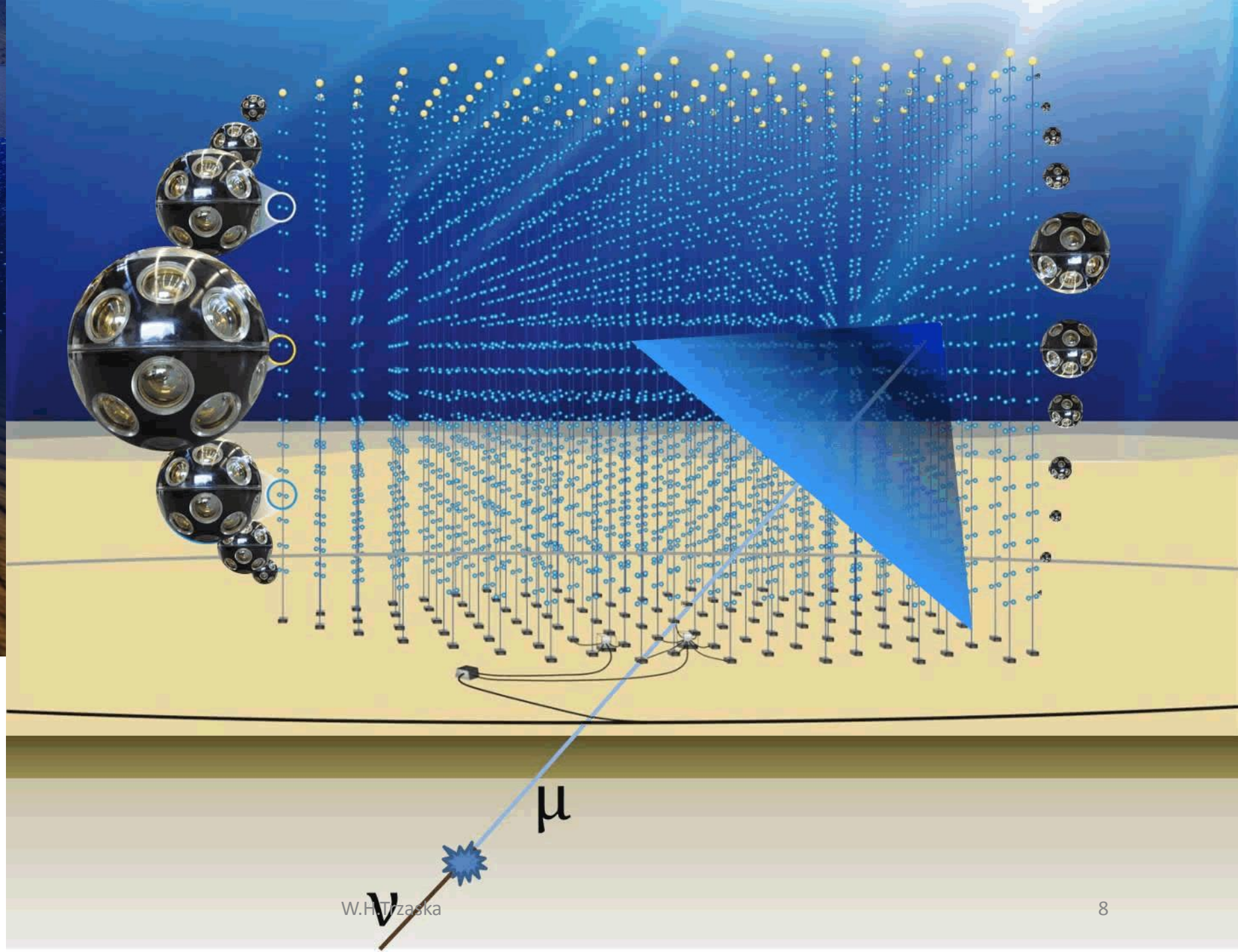
LBNO - phase of CP violation in the leptonic sector

DUNE Collaboration

~1000 members, 184 inst. 32 countries + CERN



KM3NeT



What could be done in Finland now?

1. No financial resources → a novel idea is needed
2. No new constructions → use the available infrastructure
3. No new positions → rely on the network of experts

Background for the idea

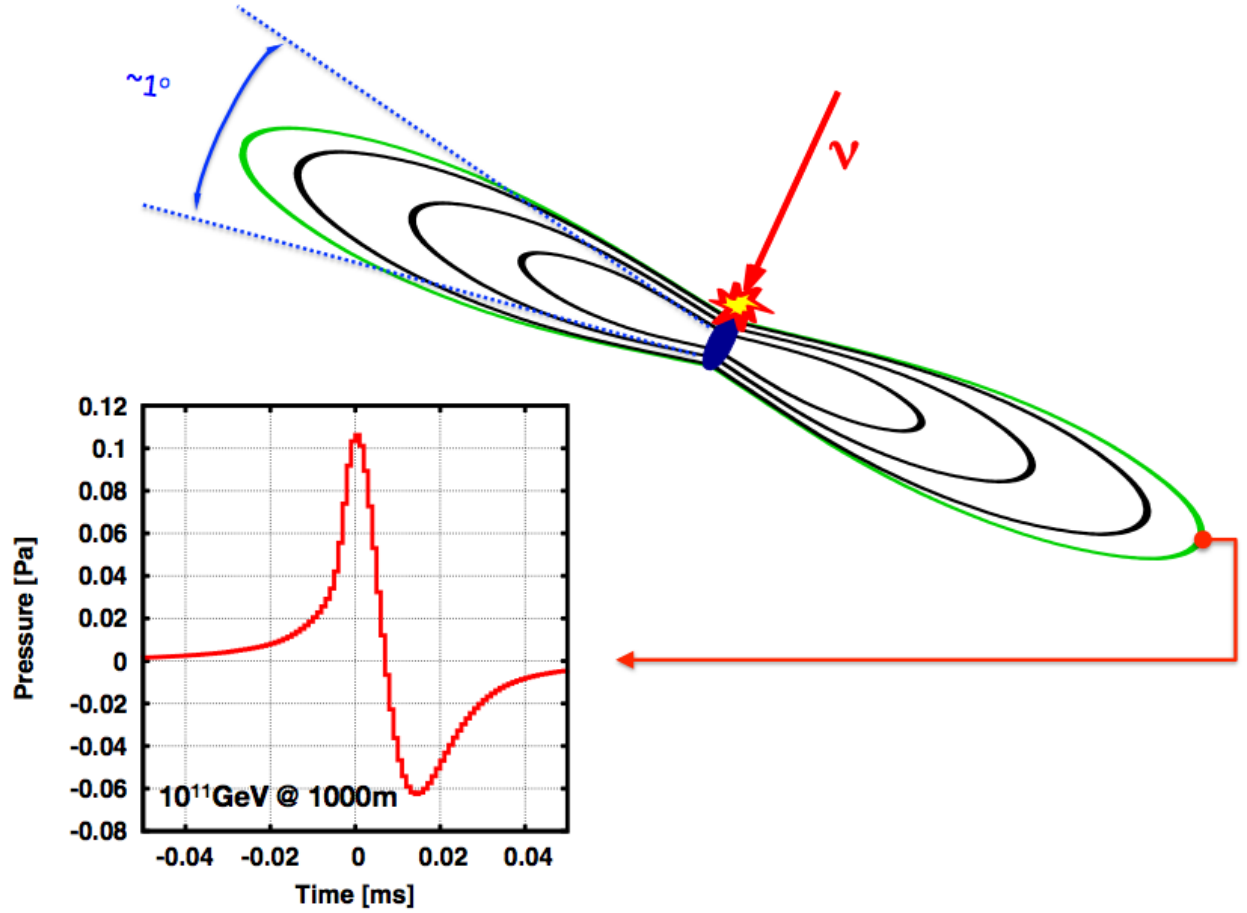
- Ultra high-energy neutrinos are extragalactic & rare
  - giant target mass + long measurements
- Size of water and ice-based experiments is limited ~km^3
- The density of water and ice is only 1 g/cm^3
- IceCube optical sensors are pointing downwards
  - not optimized for top-to-bottom events
- EeV neutrinos are not expected to traverse Earth

1. The idea: Acoustic detection of EeV neutrinos in bedrock

ARENA 2018

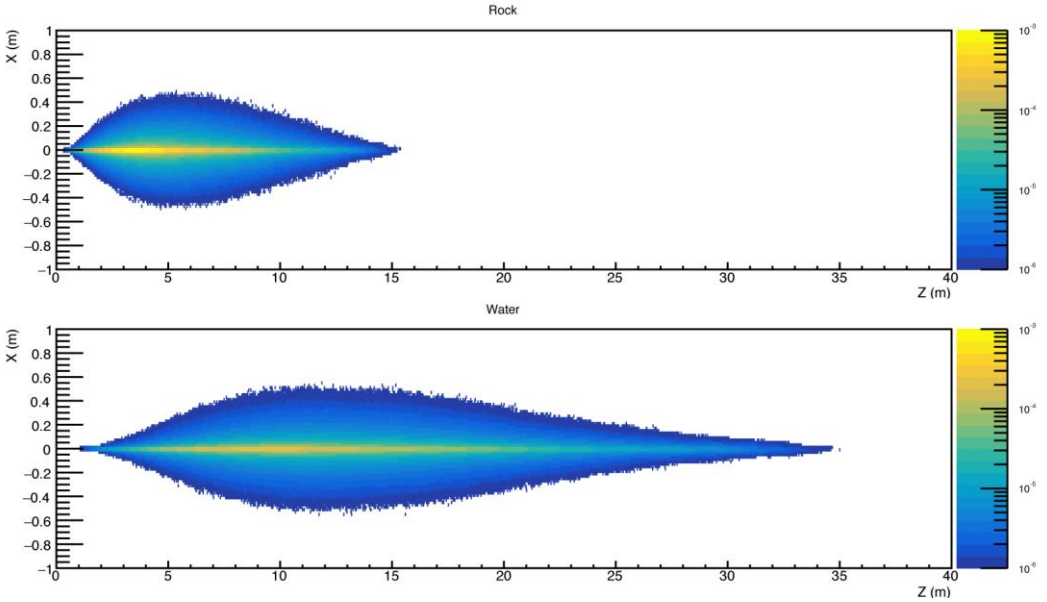
Oral presentation and
peer-reviewed proceedings:
EPJ Web of Conferences 216, 04009 (2019)
https://arxiv.org/abs/1909.00417

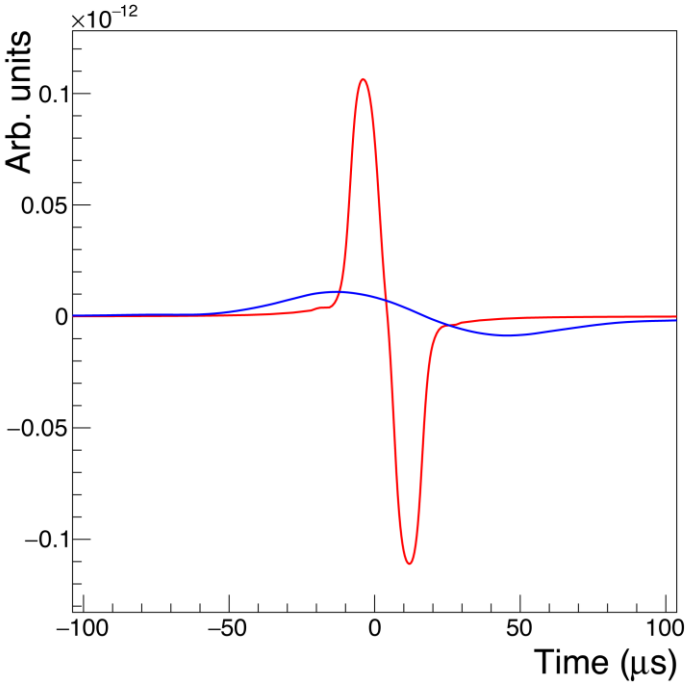
Acoustic and Radio EeV Neutrino detection Activities



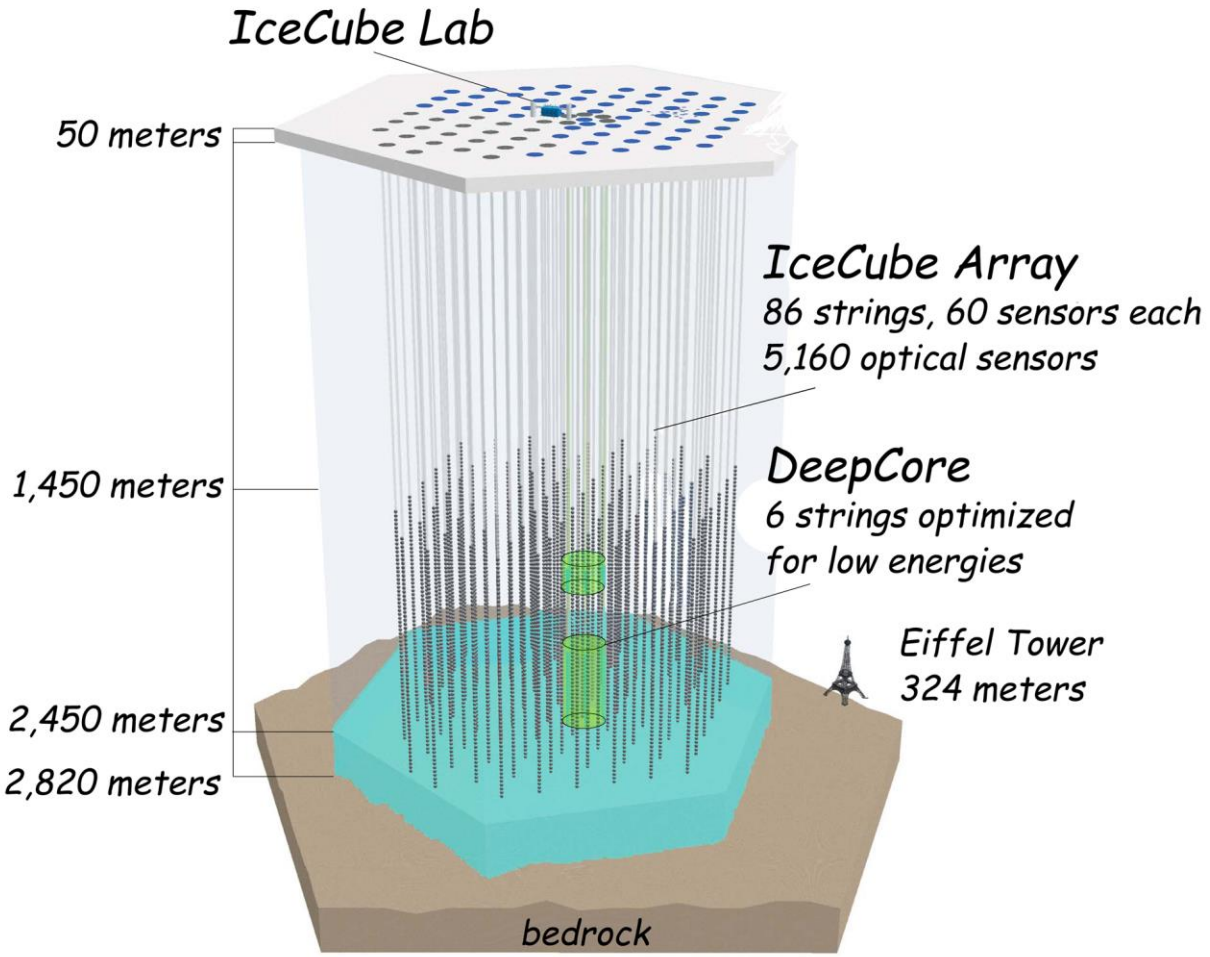
Rock vs. water

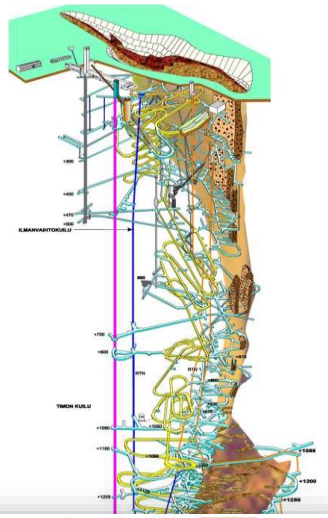
- 3x larger density
- →increased target mass
- → higher event rate for neutrinos
- 4x larger speed of sound
- 10x larger pressure pulse
- Longer attenuation length
- Logistics (mine vs. ocean)



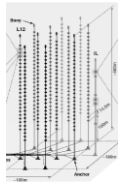


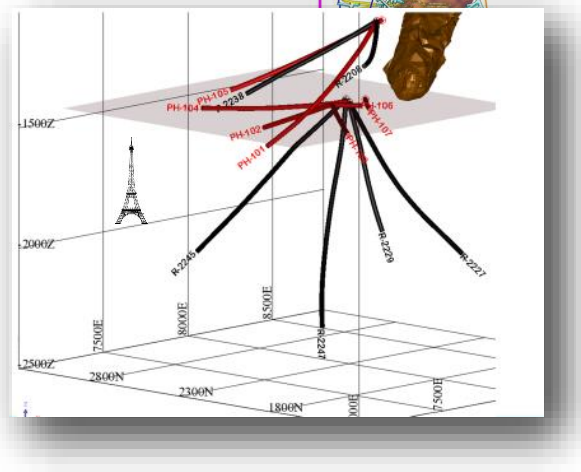
2. Infrastructure



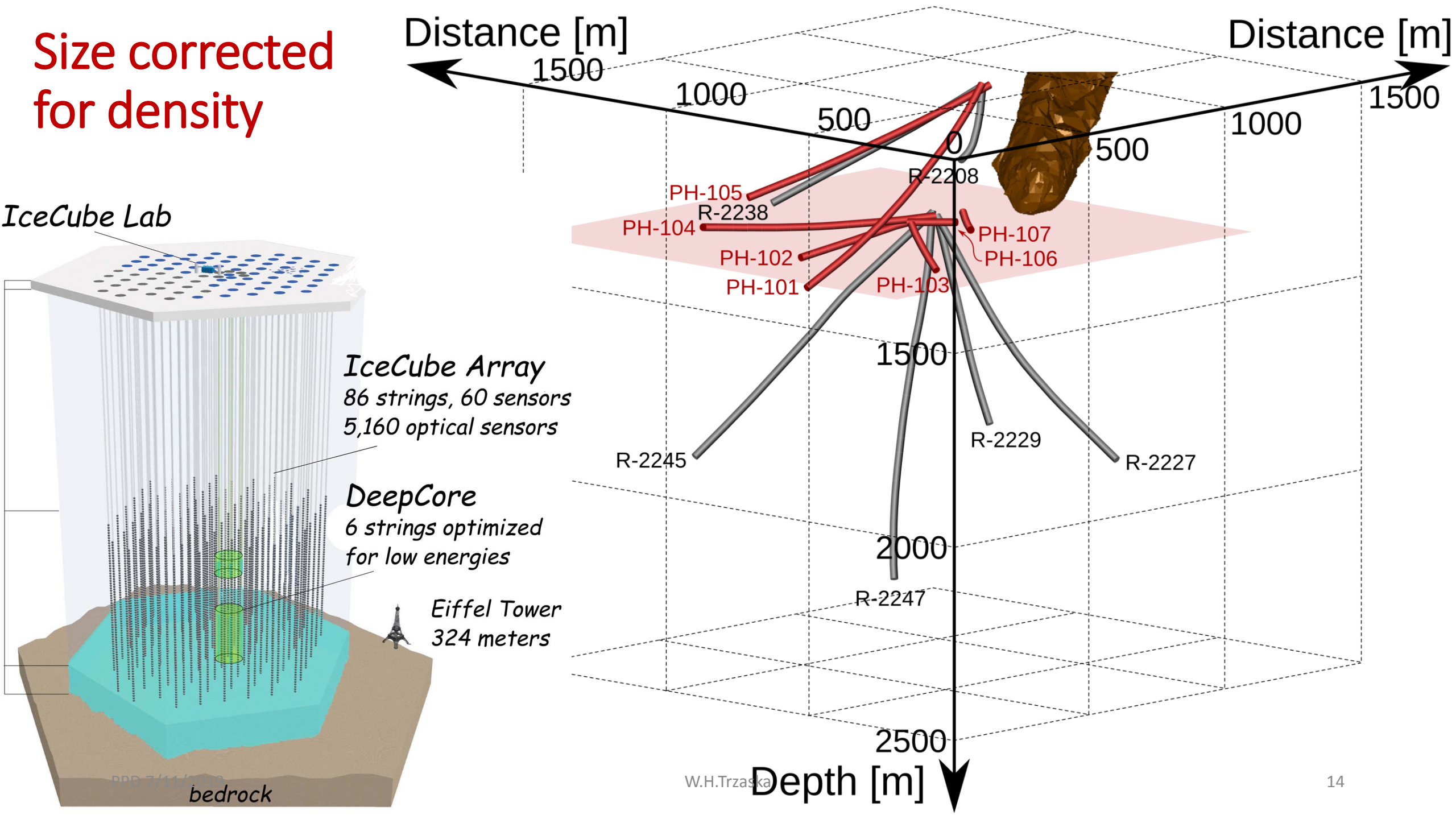


AMADEUS - The Acoustic Neutrino Detection Test System of the ANTARES Deep-Sea Neutrino Telescope

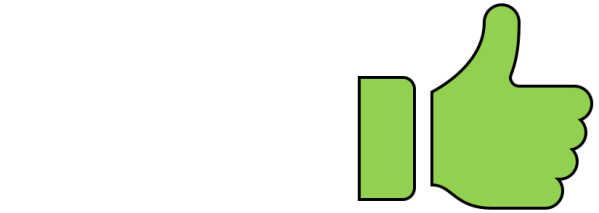


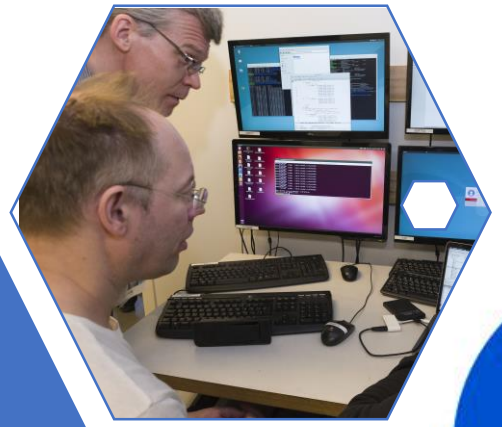


Size corrected for density



3. Know-how network





Geology

HY, OY

Applied Math

LUT

Neutrino community

DUNE

JUNO

CERN

ARENA

Neutrino PLATFORM

CALLIO LAB

Underground Centre for Science and R & D

THEIA

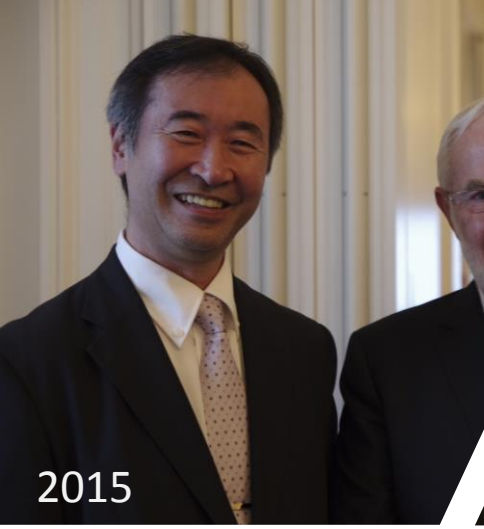
What is the bottleneck?

Funding for the on-site team

To make measurements in the mine, at least two scientist have to be stationed in Pyhäsalmi

A grant from the Academy would solve the problem

SUOMEN AKATEMIA


2015


2002

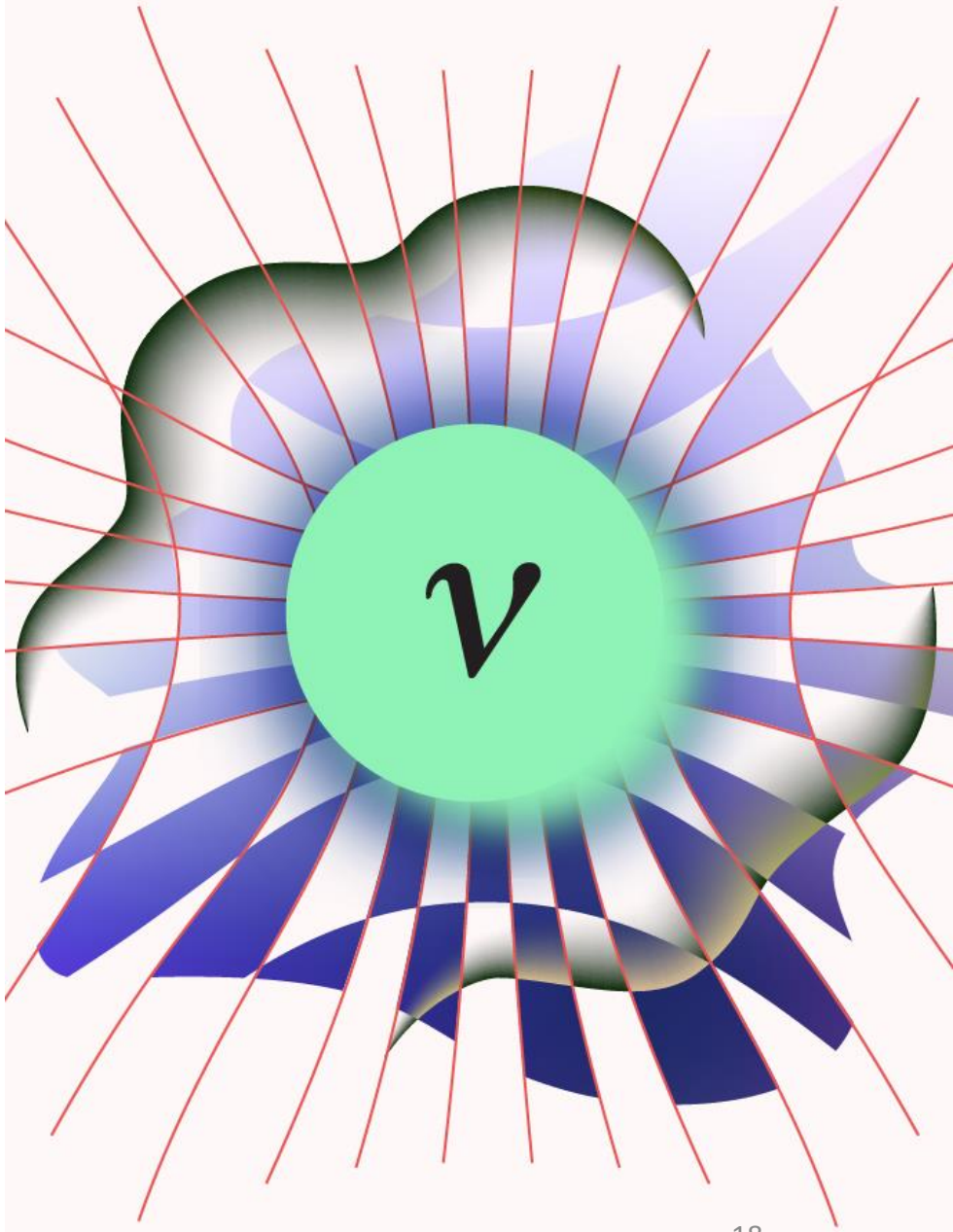

2002


1995

Conclusions:

1. Neutrinos are important & relevant
2. Finland has a realistic chance to make a significant contribution

Thank you for your attention!



Courtesy: Wiki, TAUP, NASA, IceCube, JUNO, DUNE, KM3NeT

Artwork by Sandbox Studio, Chicago with Corinne Mucha