IceCube Astrophysical Neutrinos

MARSDEN FUND
TE PŪTEA RANGAHAU A MARSDEN

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Ice Sculpture: Sebastian Böser and Matthias Leuthold

The IceCube Collaboration

Funding Agencies

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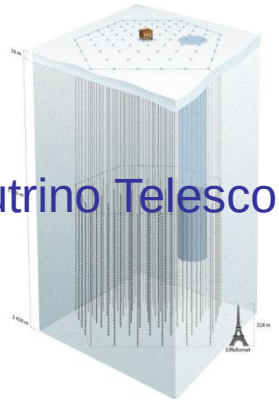
University of Wisconsin Alumni Research Foundation (WARF)
US National Science Foundation (NSF)

Neutrino Telescope Physics Inventory

Cosmic-ray physics

Dark matter

Extragalactic/galactic cosmic ray accelerators

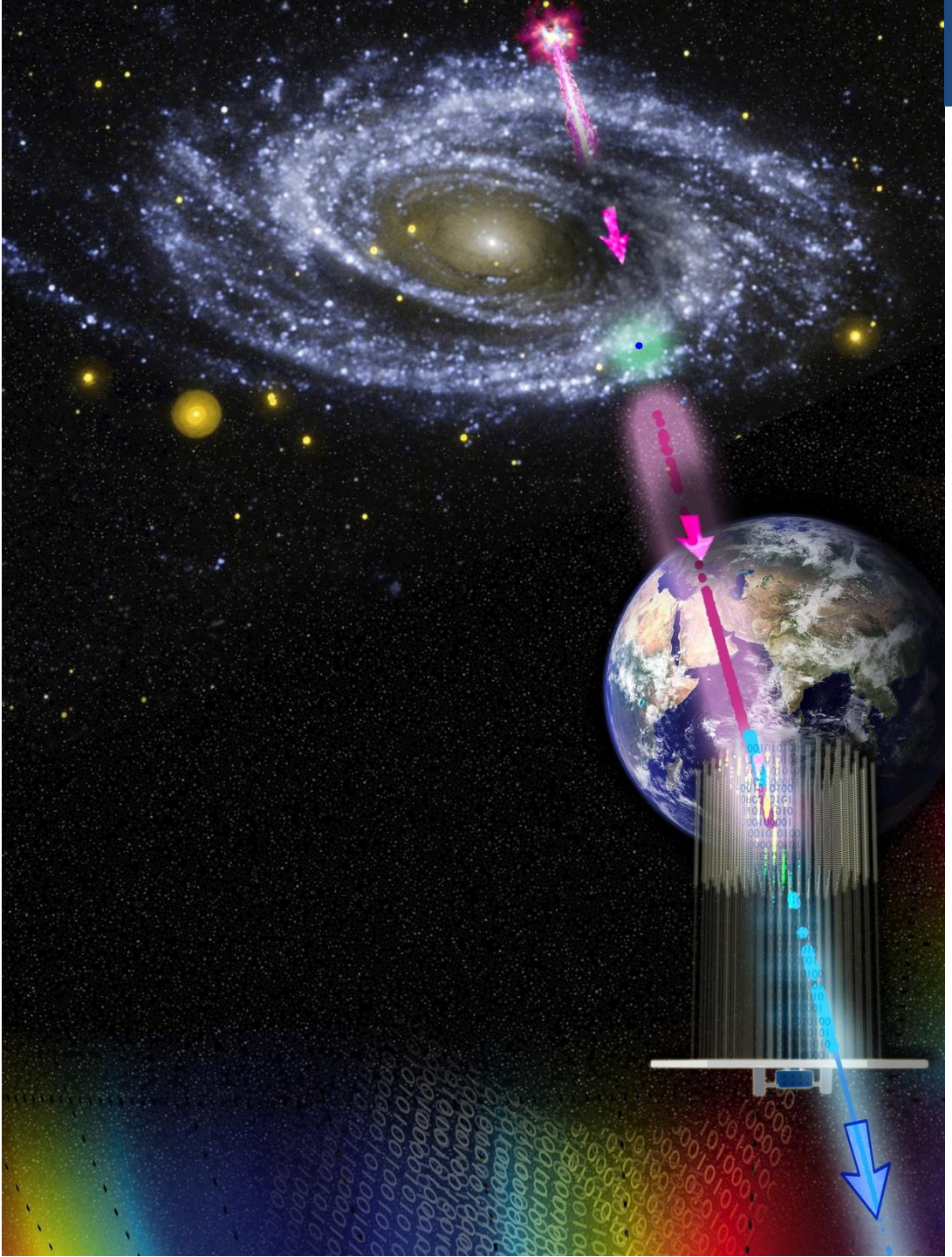


Neutrino Telescopes

Supernovae

High energy astrophysics – gamma-ray bursts, active galactic nuclei, gamma-ray sources

Beyond the standard model physics

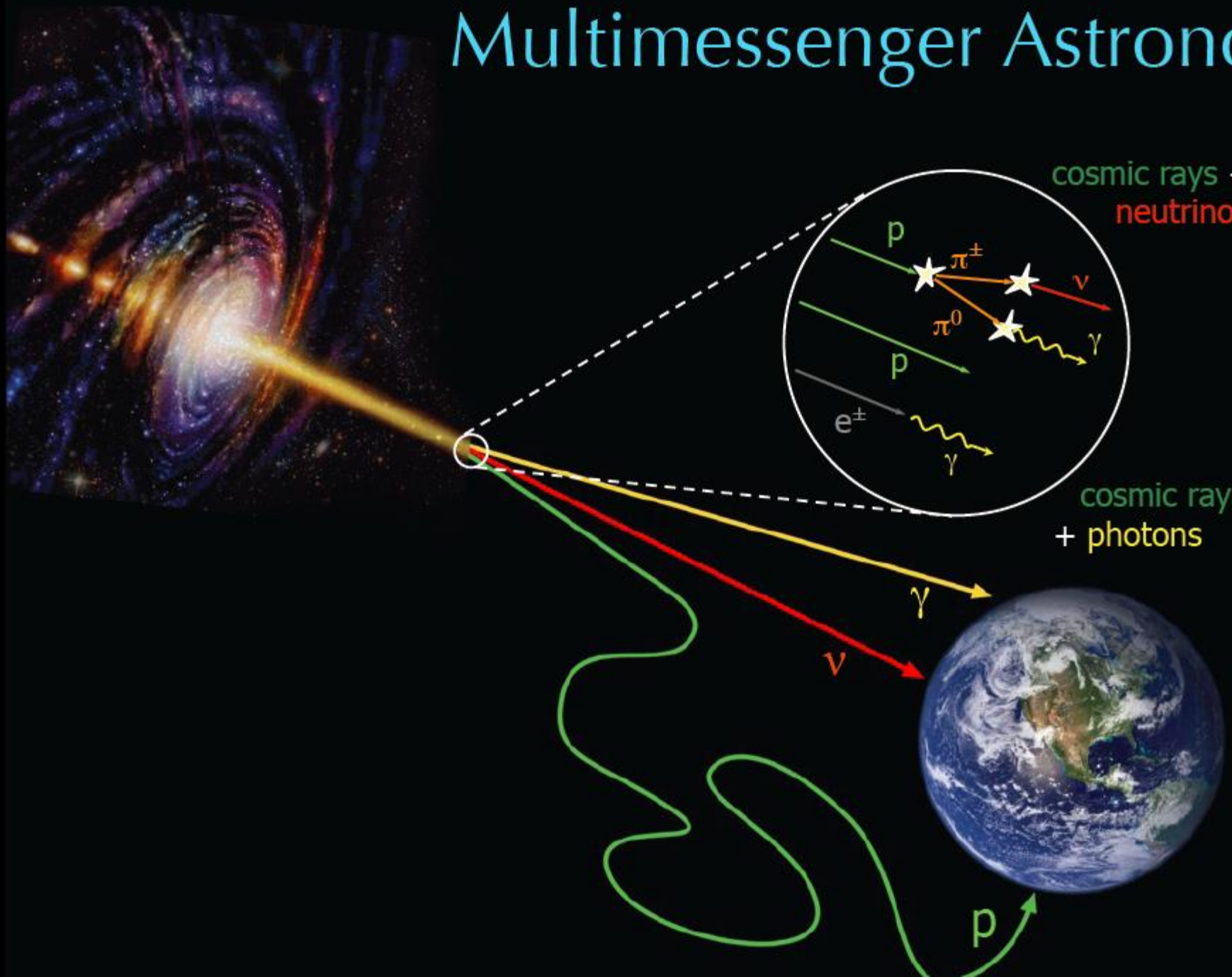


IceCube:

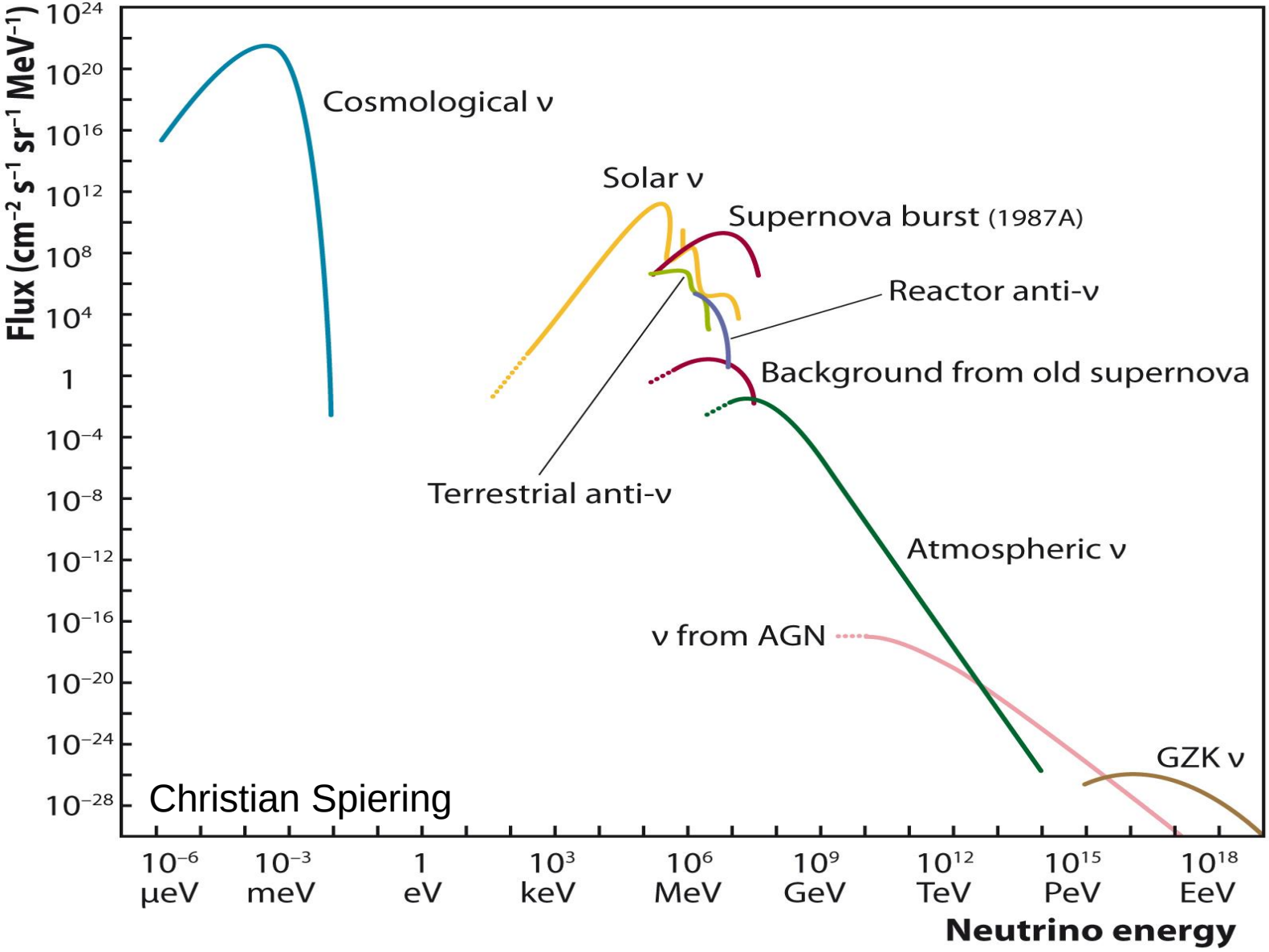
Detects astrophysical neutrinos

Using an array of optical sensors in the ice below the South Pole

Multimessenger Astronomy

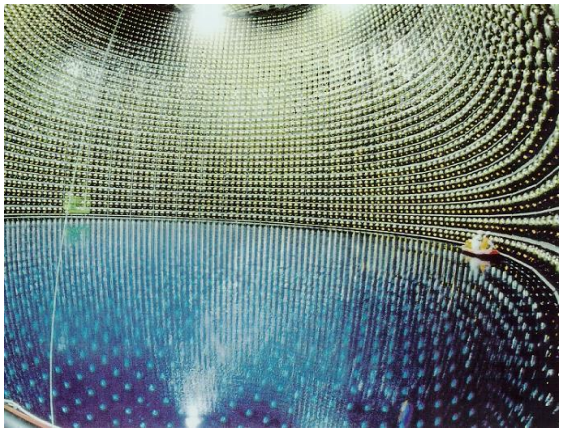


Neutrino source fluxes



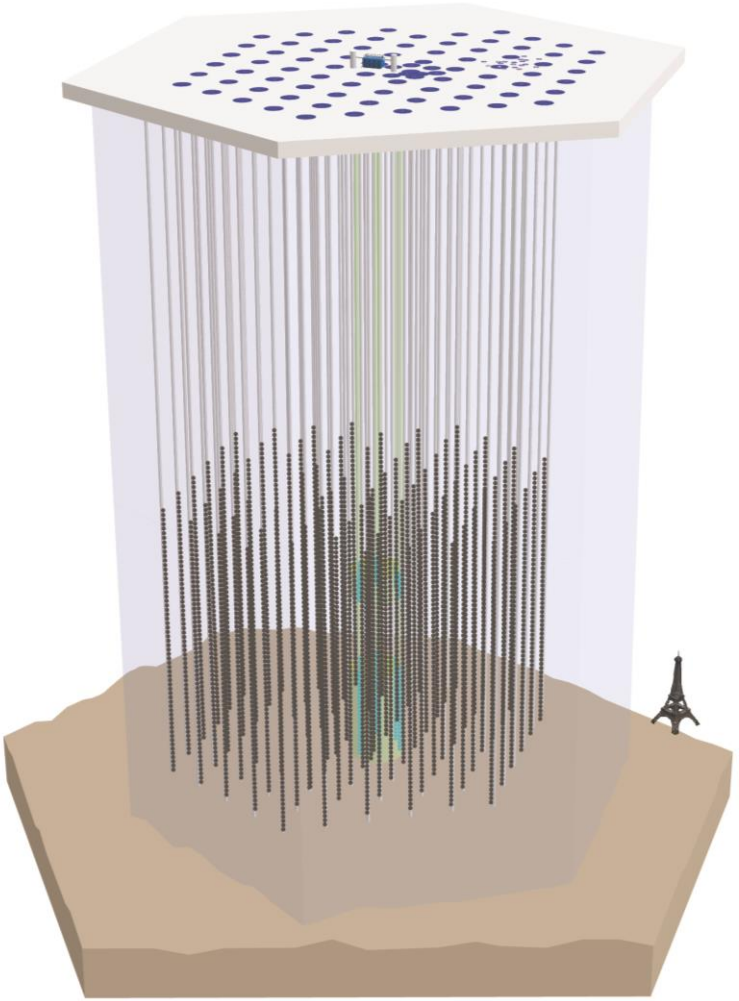
IceCube is a LARGE neutrino detector...

Comparison with other neutrino detectors



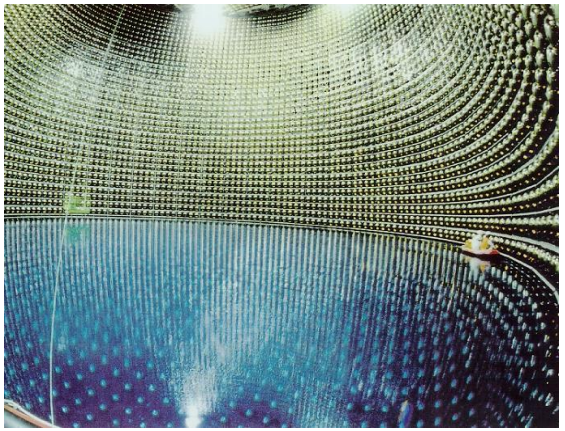
Super Kamiokande

SNO



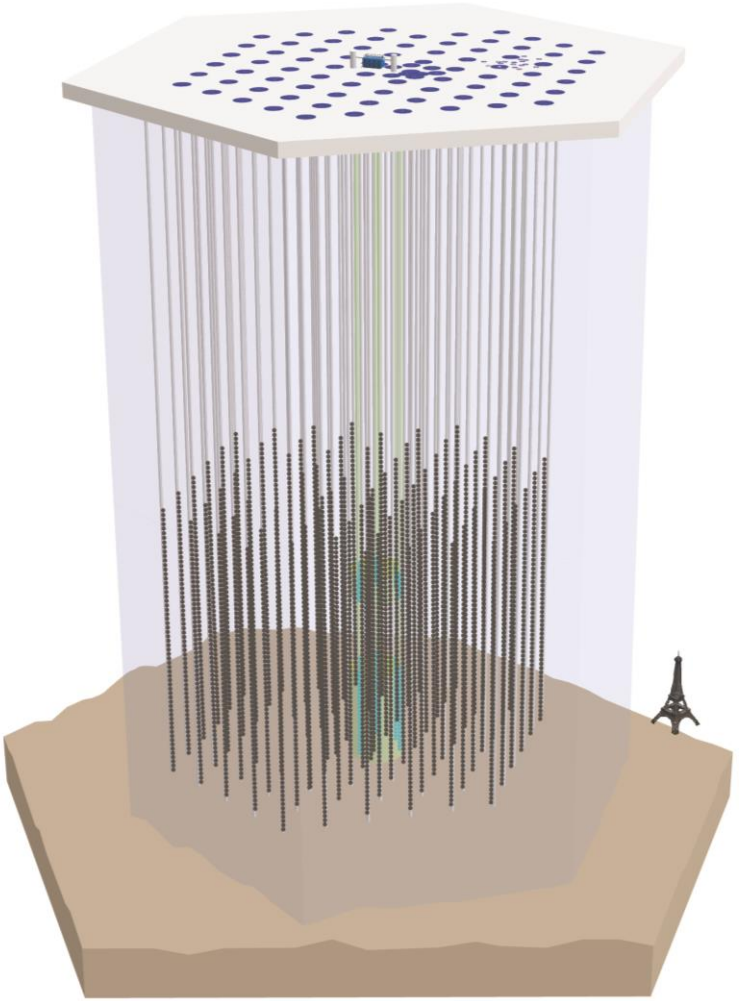
IceCube is a large and sparsely instrumented neutrino detector...

Comparison with other neutrino detectors



Super Kamiokande

SNO



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Comparison with other neutrino detectors

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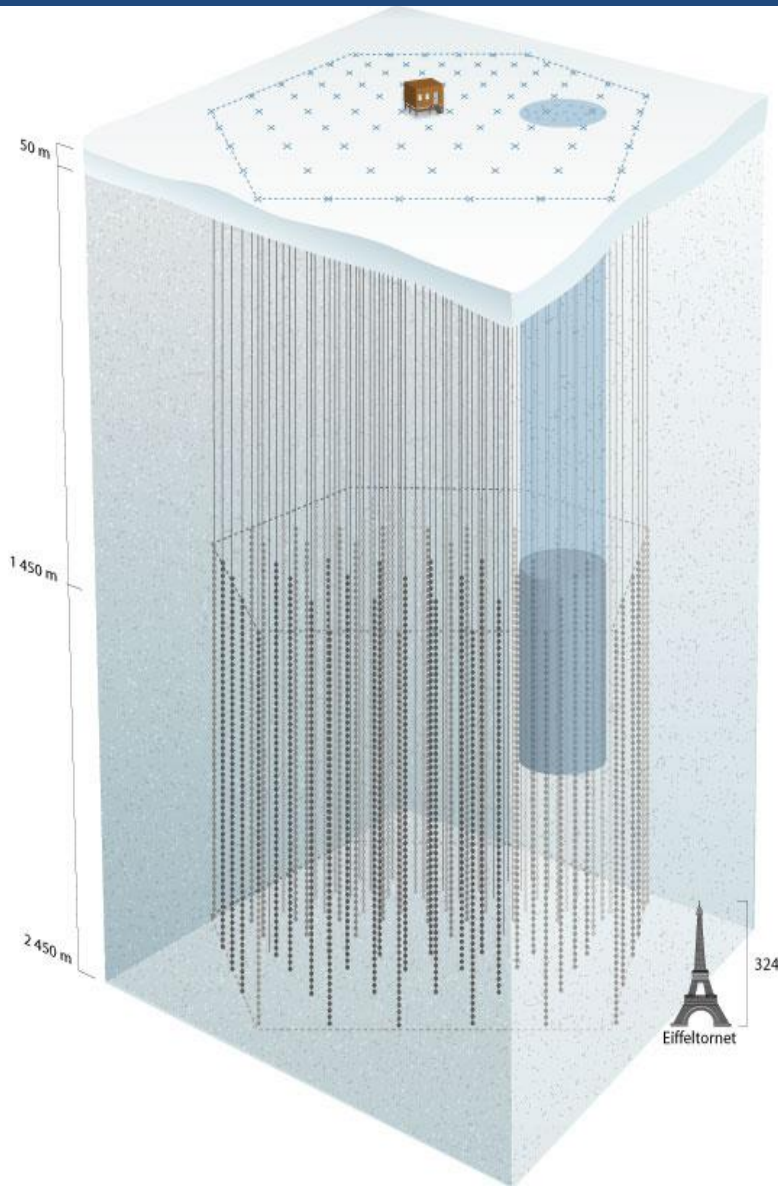
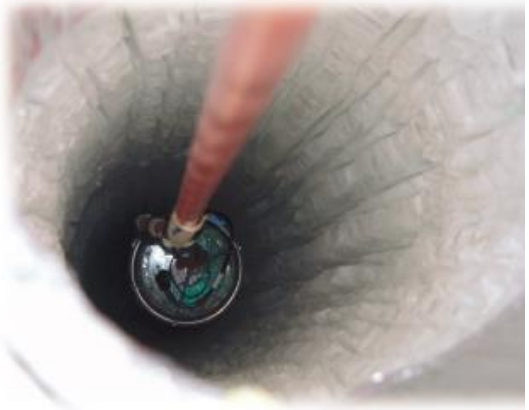
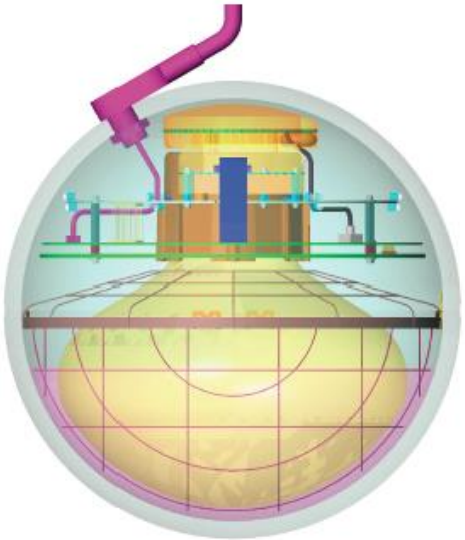
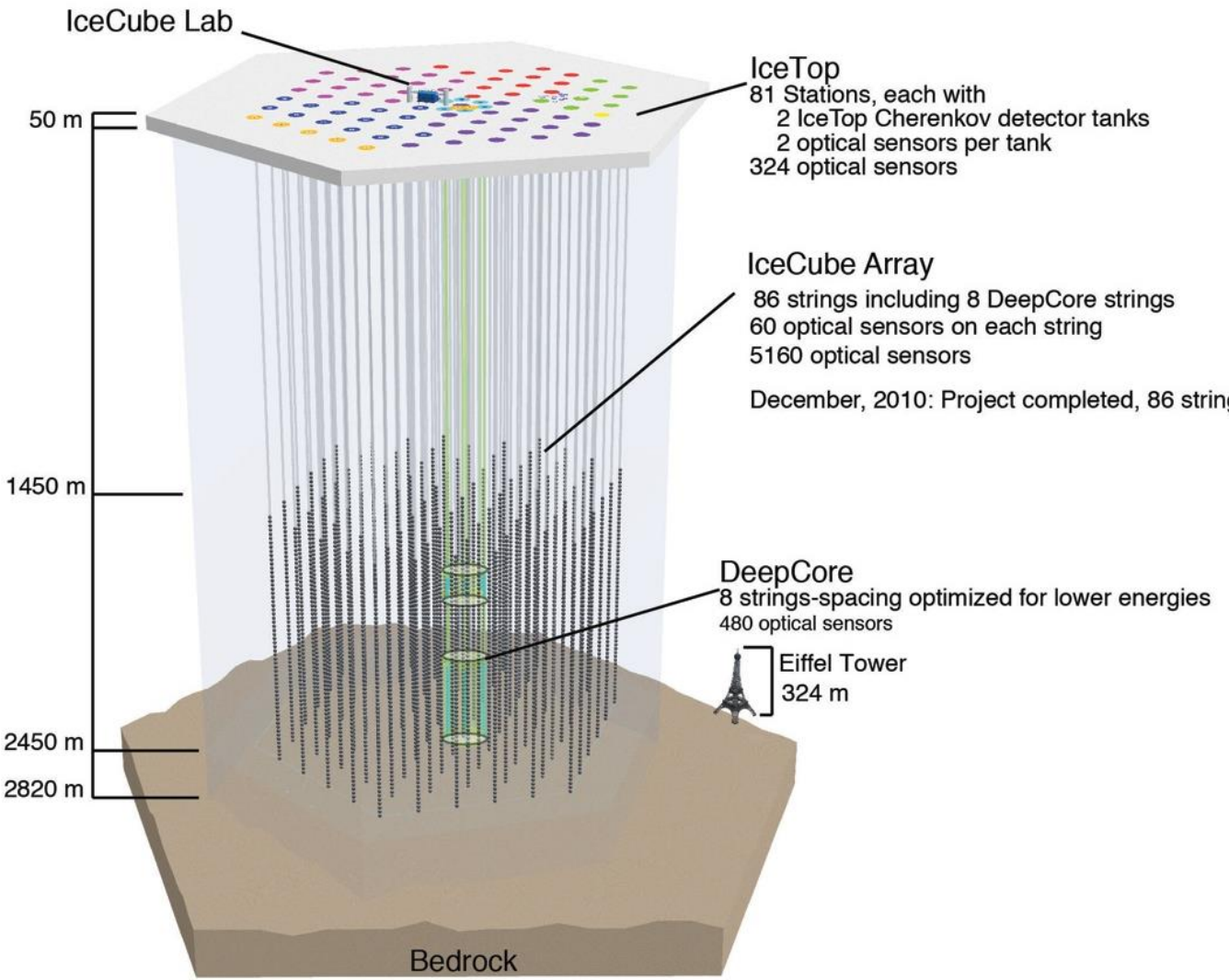


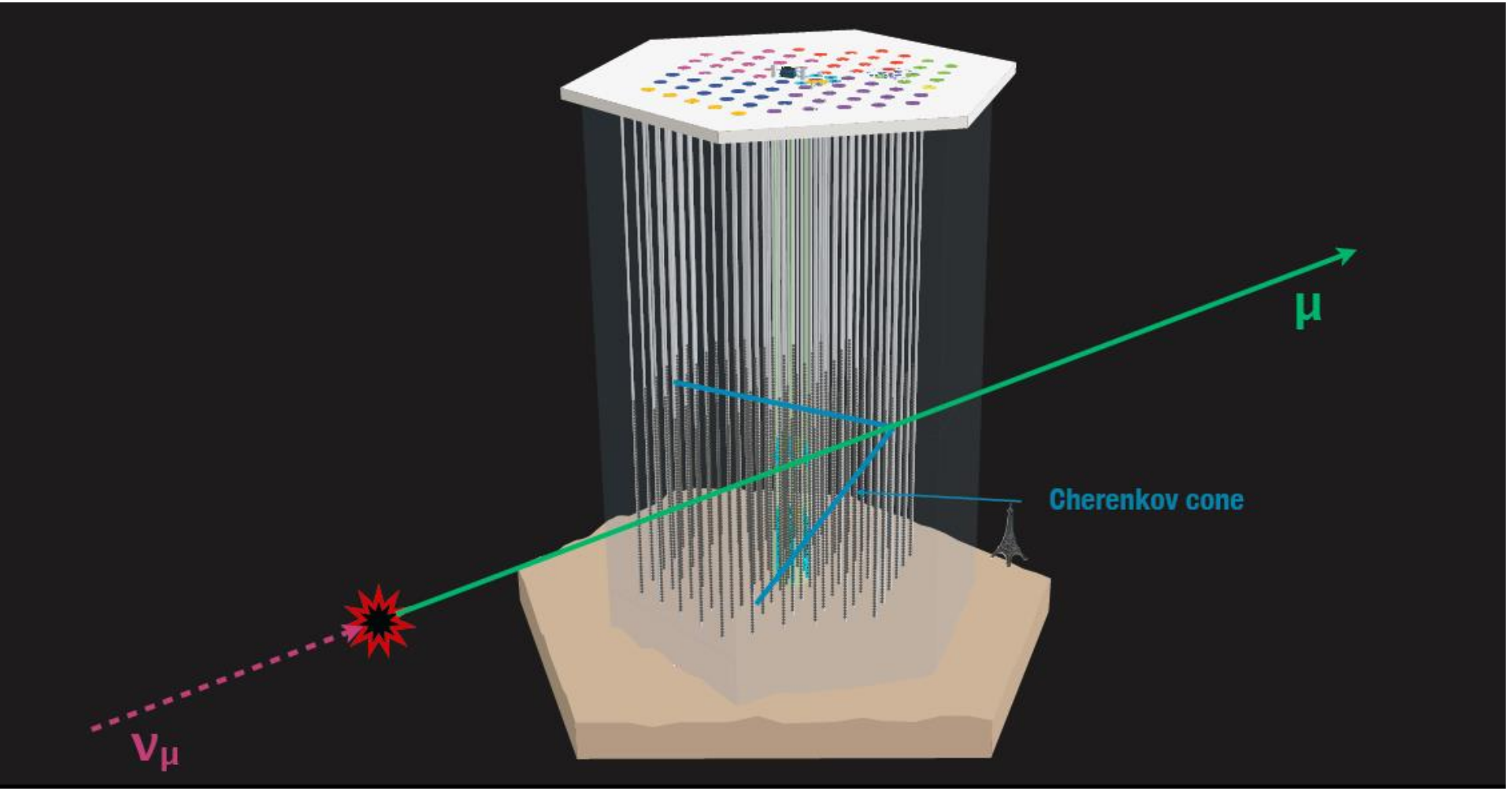
IceCube Detector

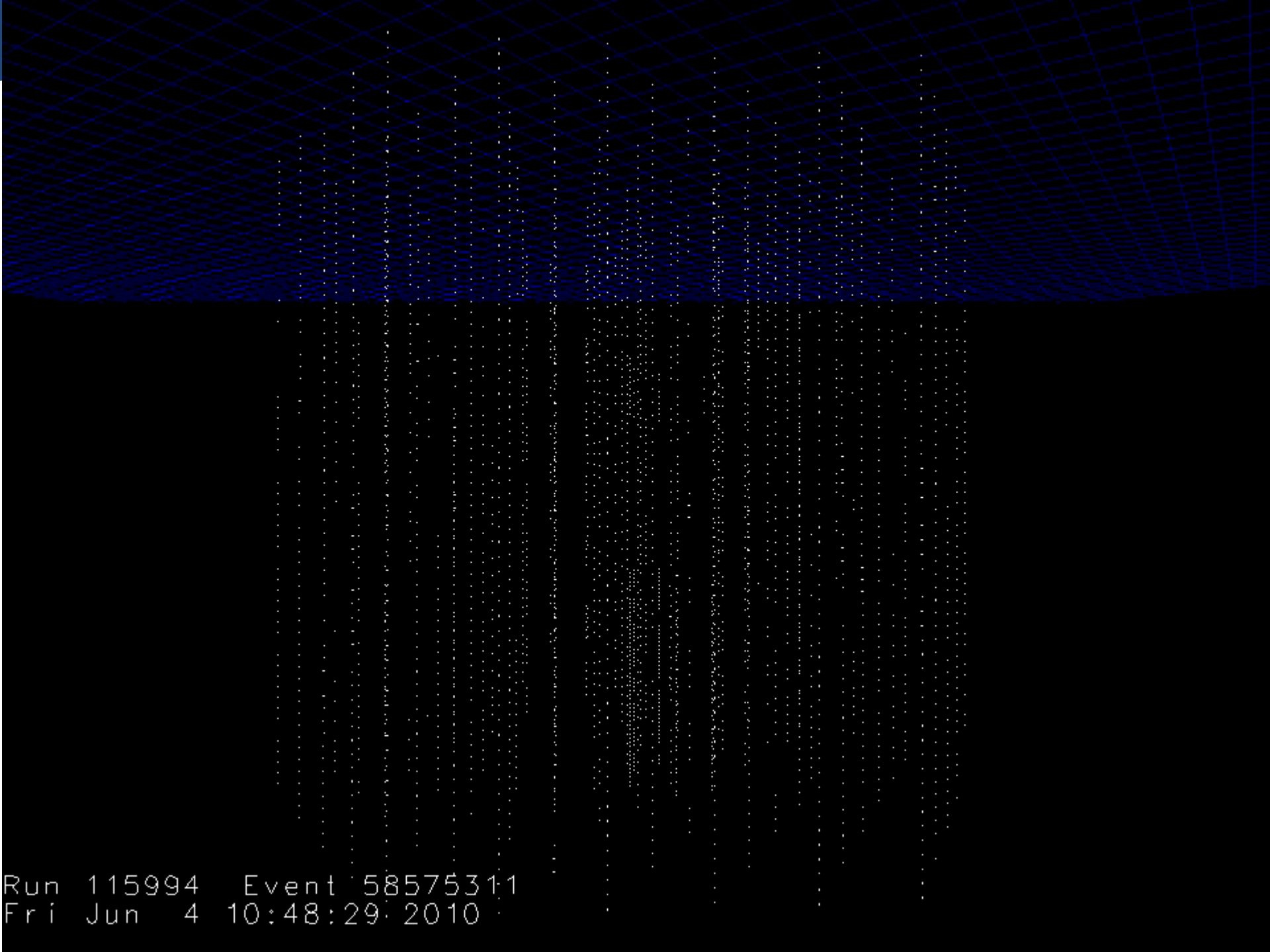






Detection principle

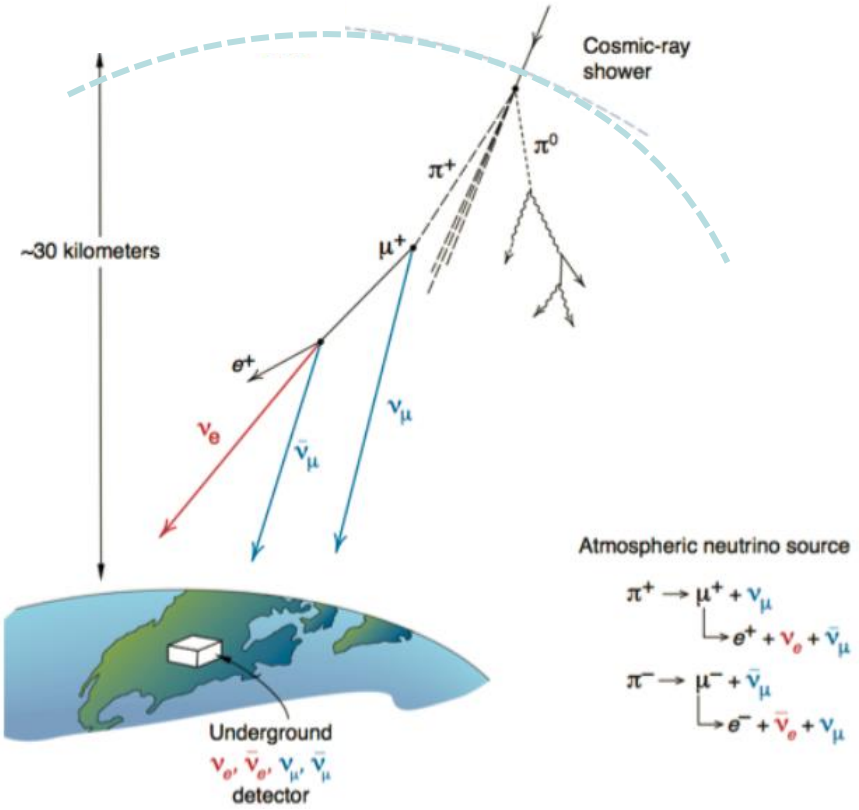



Run 115994 Event 58575311
Fri Jun 4 10:48:29 2010

Backgrounds…

Backgrounds…

Cosmic rays – interacting in the Earth's atmosphere
– source of atmospheric neutrinos and muon background



Muon rate:
In ice: **~3000 Hz**

Atmospheric neutrinos:
~1 neutrino/10 minutes

Neutrino Detection:
Requires 10^6 background rejection

Detection strategy…

Reduce background by:

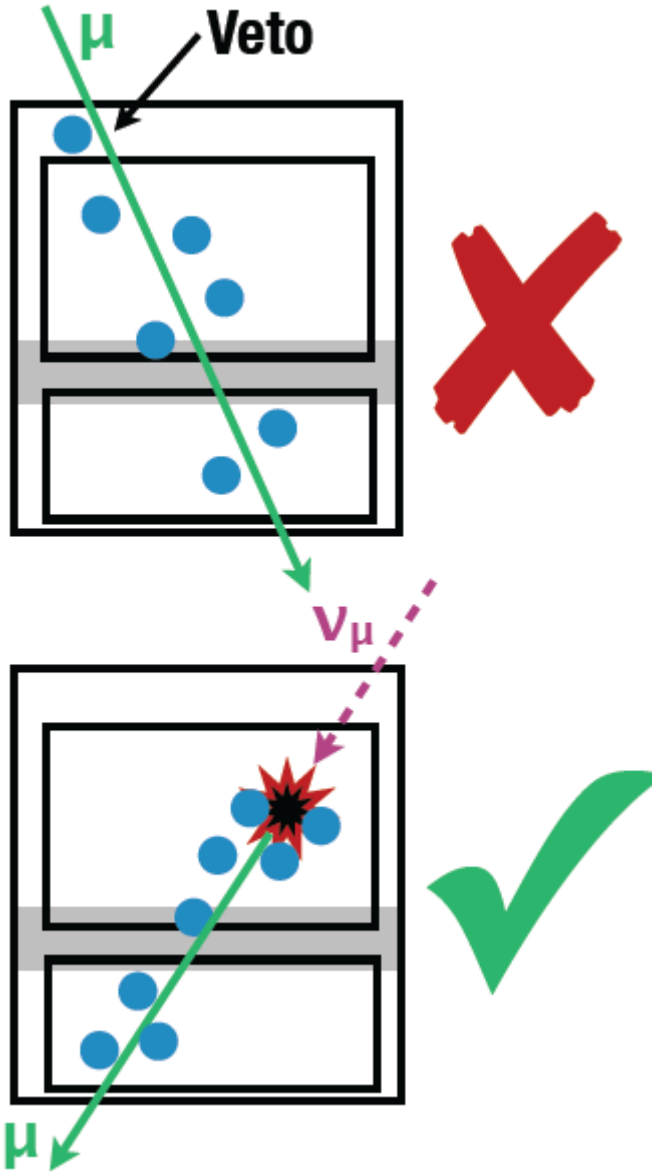
Astrophysical and Atmospheric neutrinos

- Looking for upward going tracks
- Looking for events that "start" in the detector

Astrophysical neutrinos

- Looking for point sources
  - Look for hot spots
  - Look for correlations with astrophysical objects (including in time for transient objects)

High Energy Starting Event search



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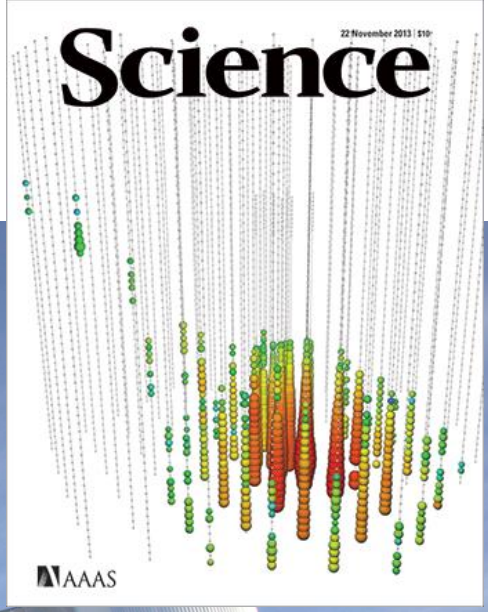
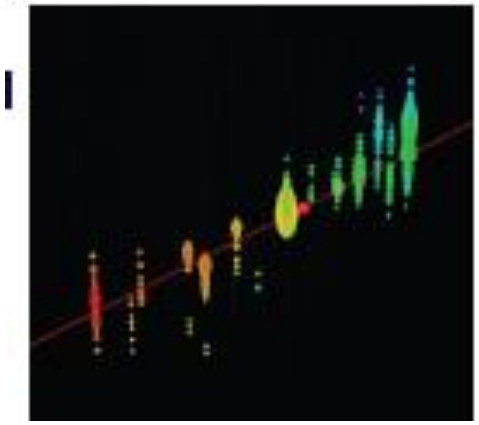
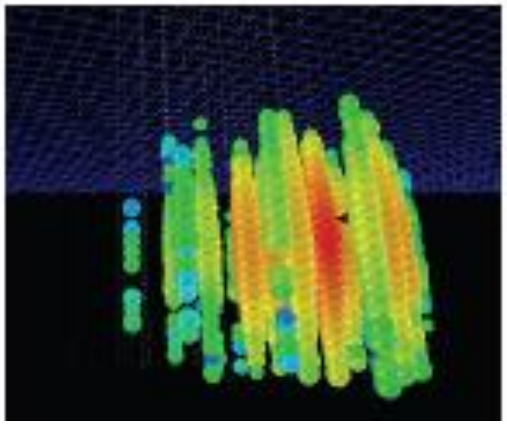


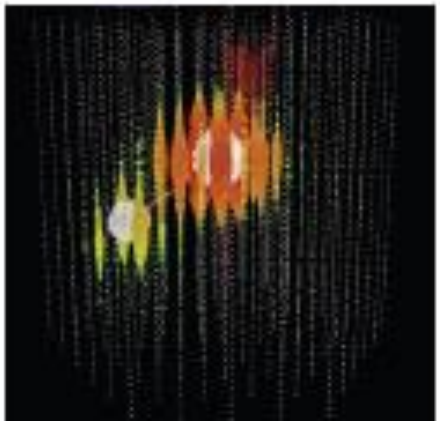
Event light pattern dependent on neutrino flavour and interaction



Muon neutrino



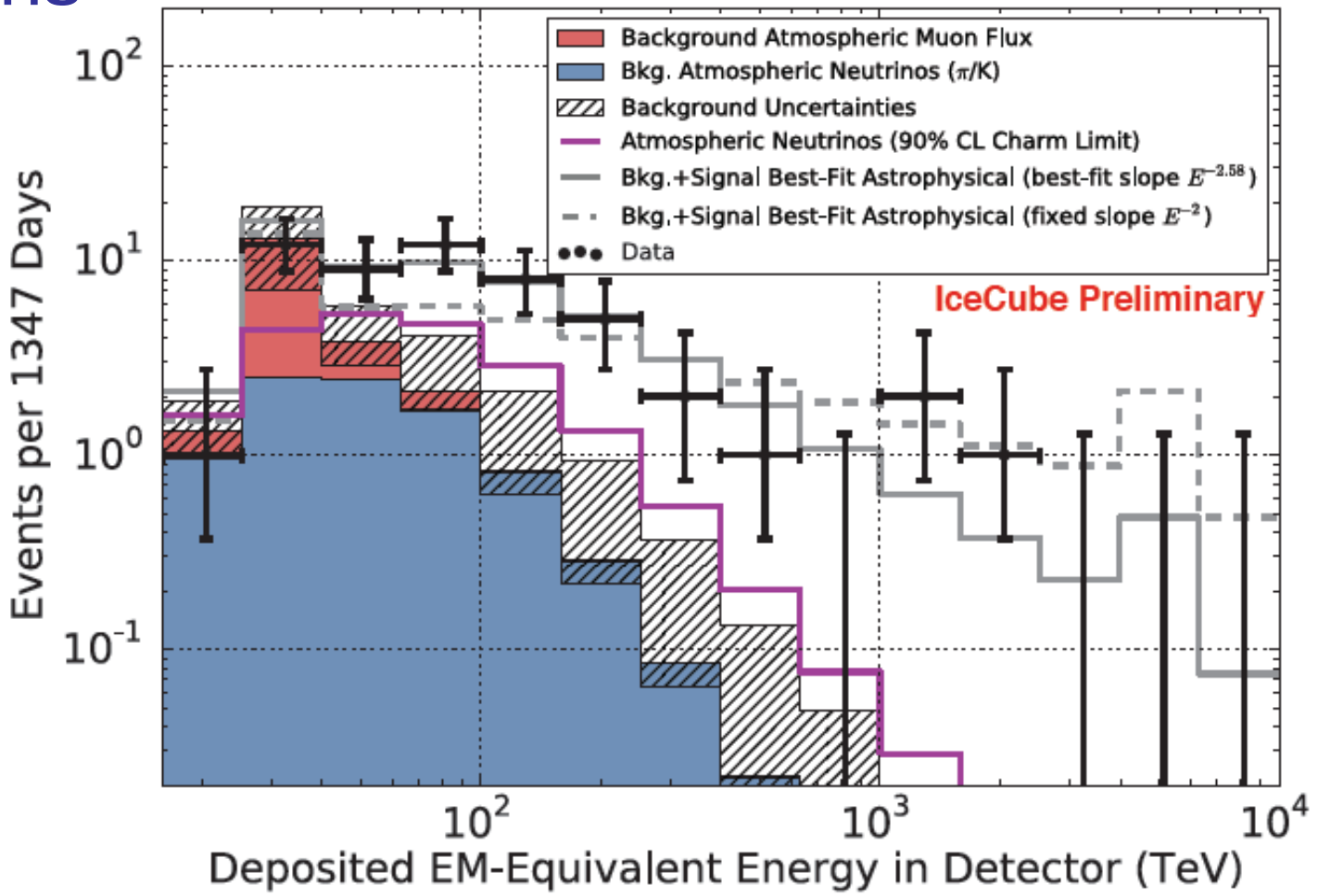
Electron neutrino



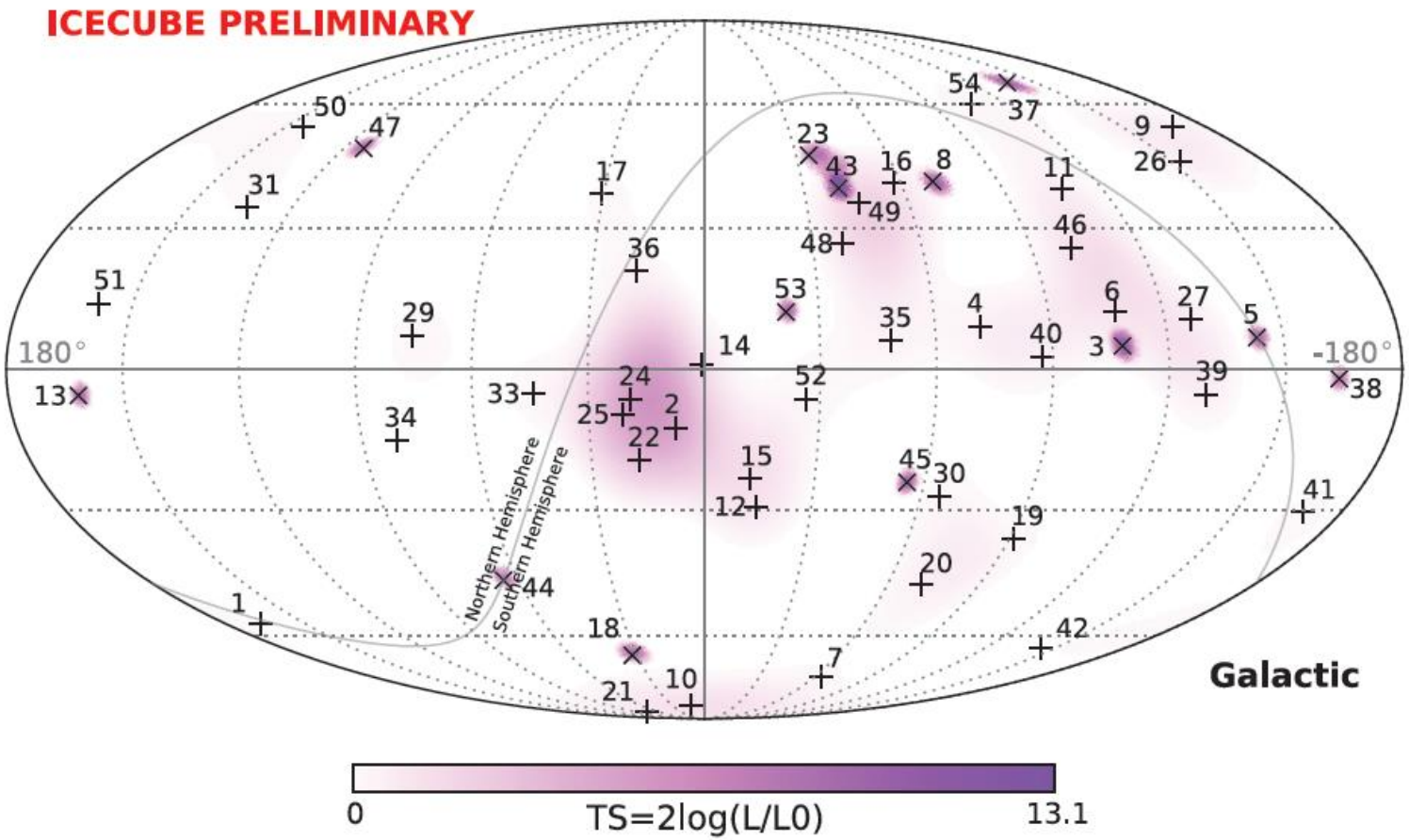
Tau neutrino

HESE 4 year

- 54 neutrino candidate events
- 14 tracks events, 39 cascade, 1 coincident muons



Skymap

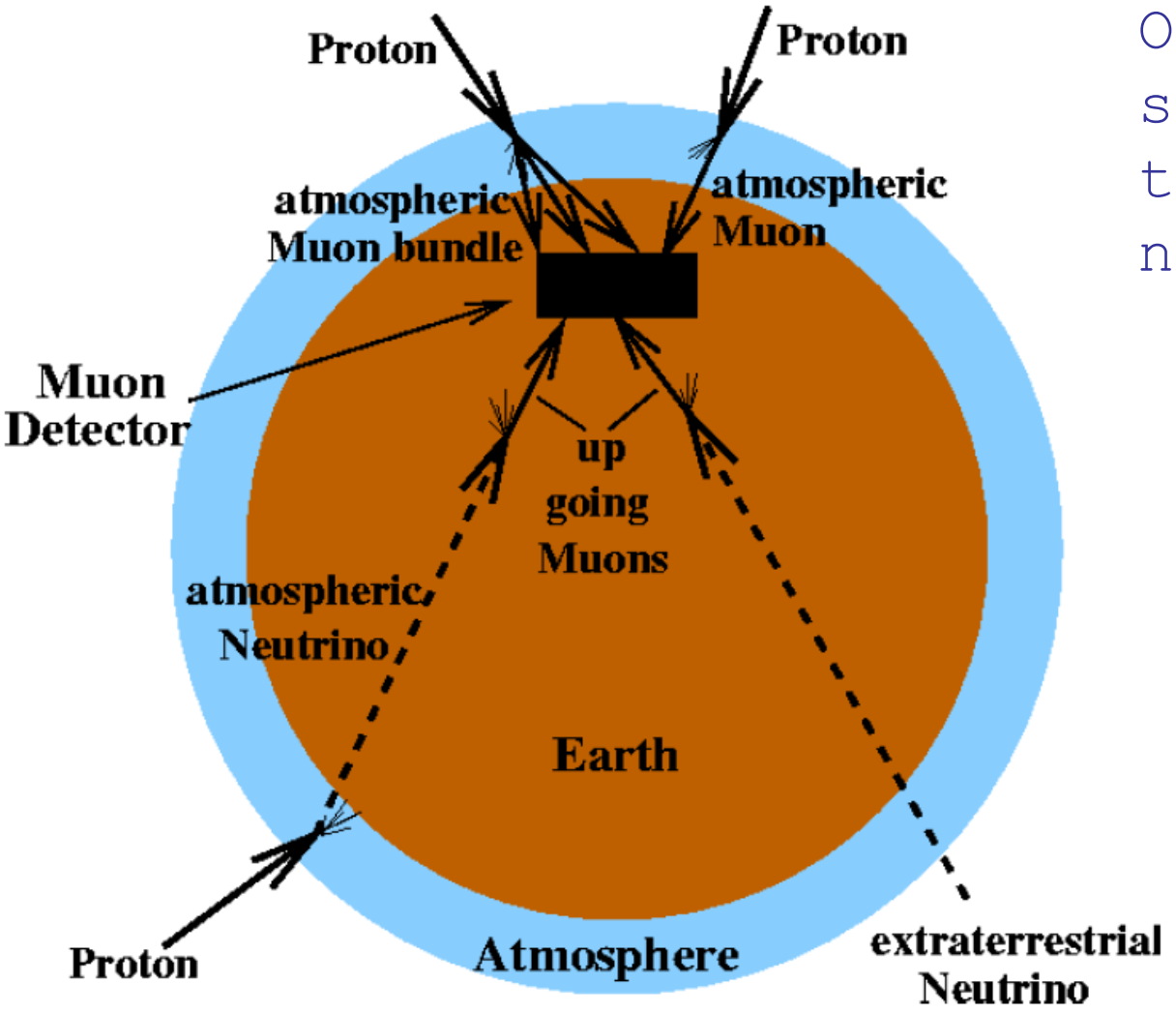


Scrambled datasets produced locations with equal or greater TS 58% of the time for all events and and 44% for shower-like events

What can we say so far…?

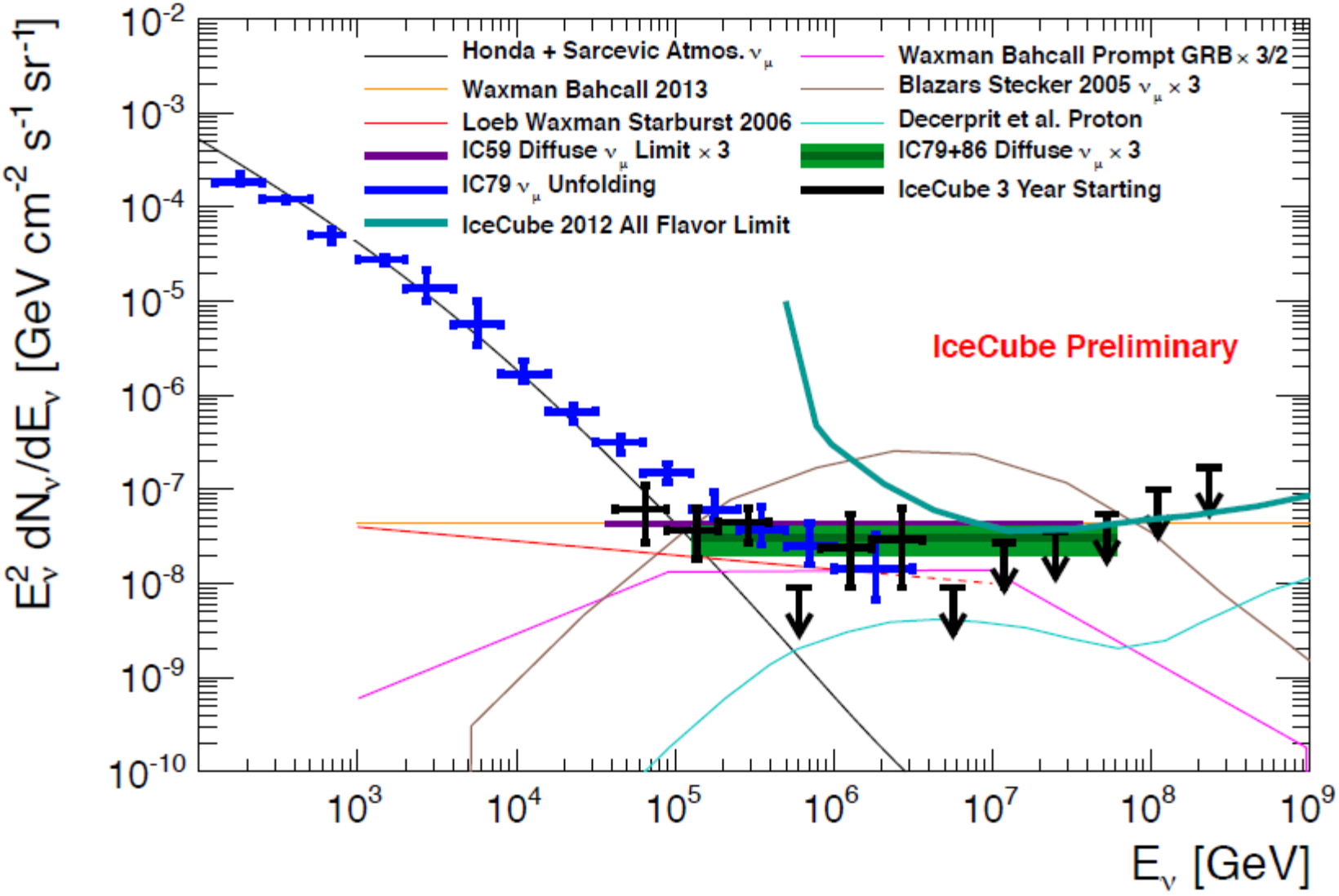
- Galactic or extra-galactic?
  - Probably a mixture... Likely extra-galactic component
- Popular extragalactic candidates: GRBs, AGNs, Starburst galaxies...
  - GRB neutrinos make up at most 10-20% of the flux (caveats..)
  - Anisotropy searches favour common, weaker sources

Upward track strategy

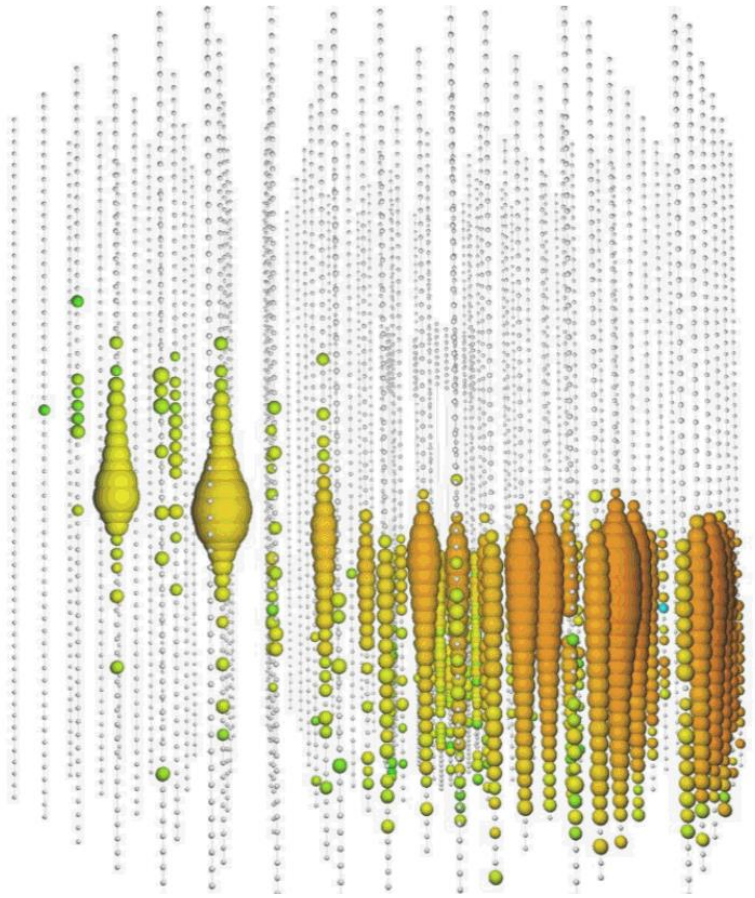


Only sensitive to muon neutrinos

Upward track strategy - results

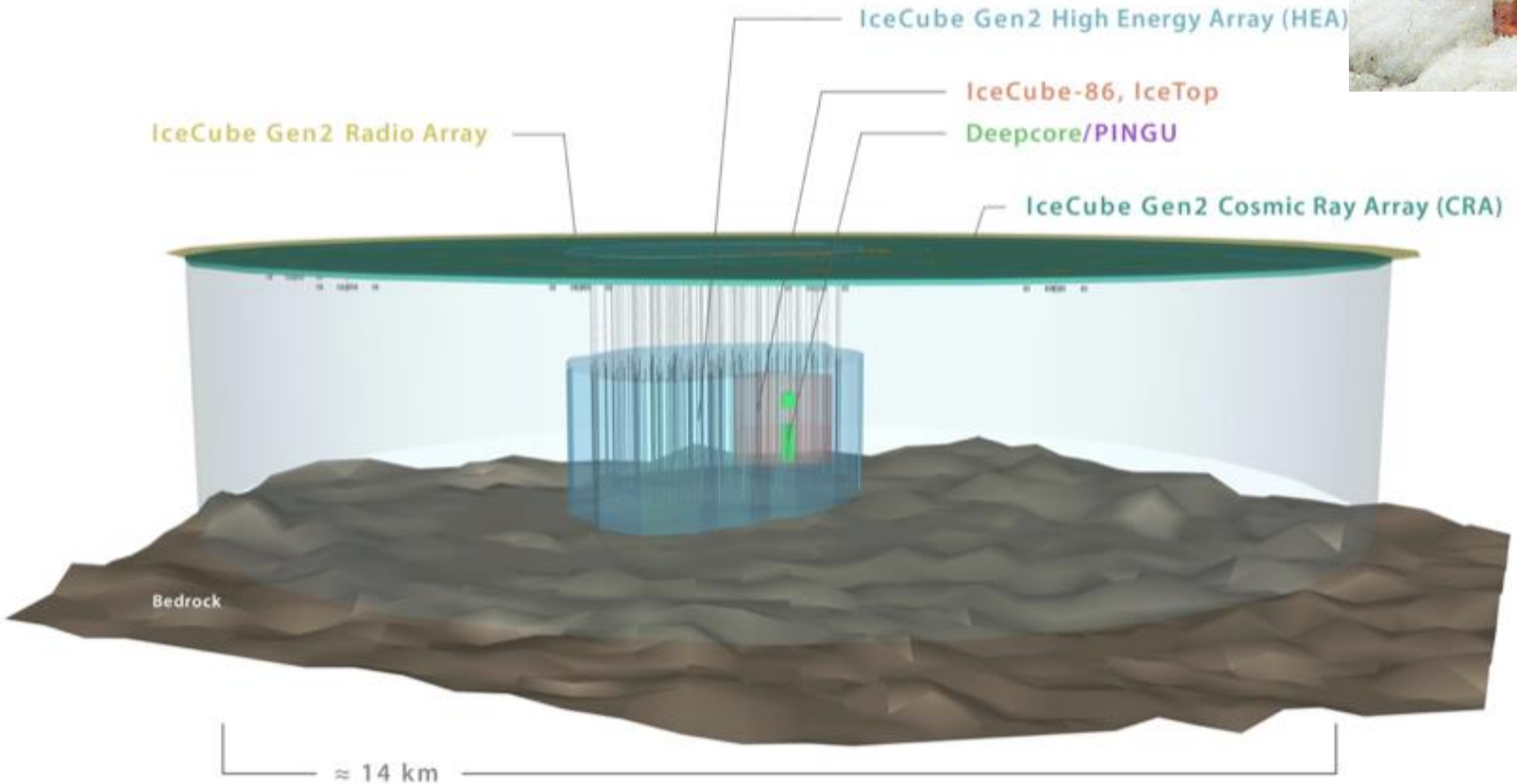


New highest energy event 2.6 PeV track



- June 11th 2014

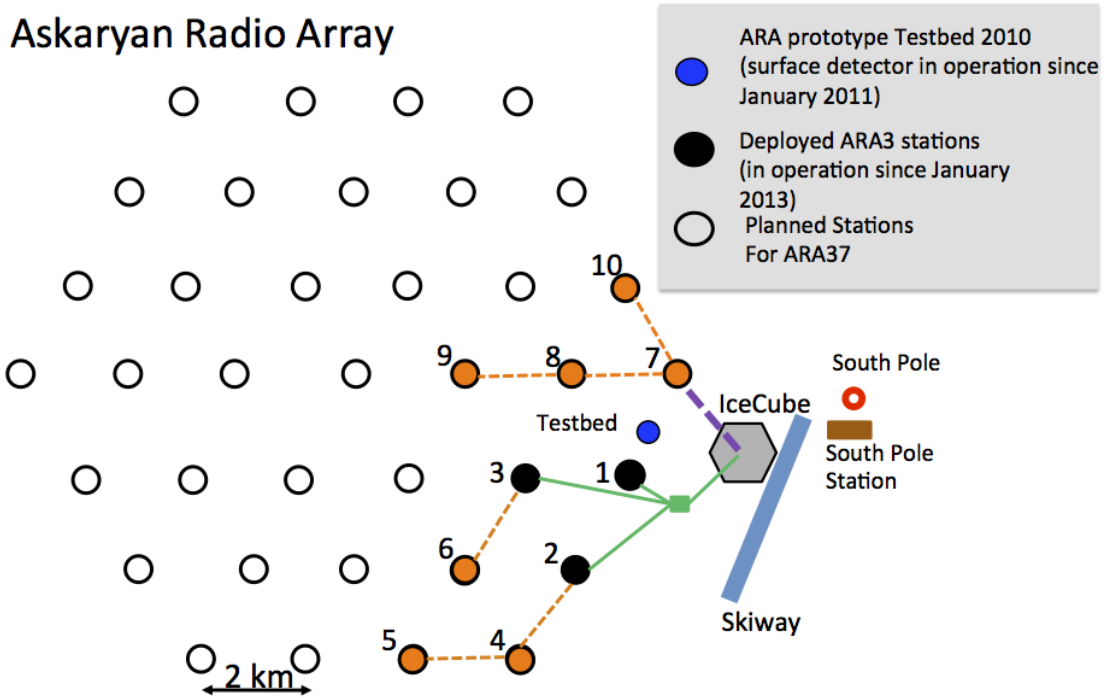
IceCube Gen2



ARA - Towards 100 km^2

- Currently installed: 3 design stations + 1 shallow prototype Testbed:
  - Testbed @ 30m depth
  - ARA1 @ 100 m depth; ARA2/3 installed @ 200 m depth
- Each station is an autonomous neutrino detector
  - 2 km spacing to maximize total sensitivity

Slide: Aongus Ó Murchadha, ICRC 2015



ARIANNA

Antarctic **R**oss **I**ce Shelf **An**tenna **N**eutrino **A**rray

Moore's Bay
Ross Ice Shelf