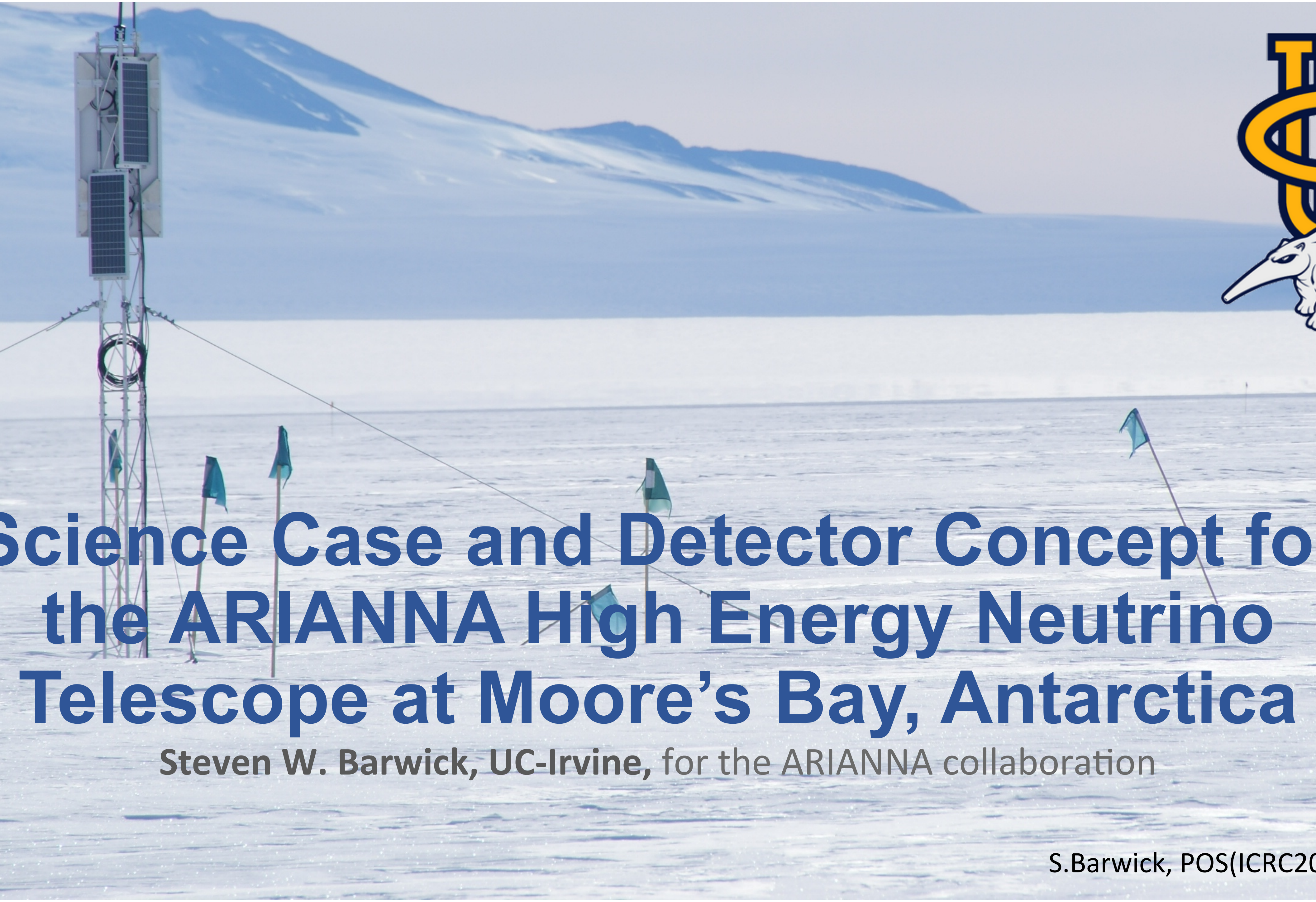
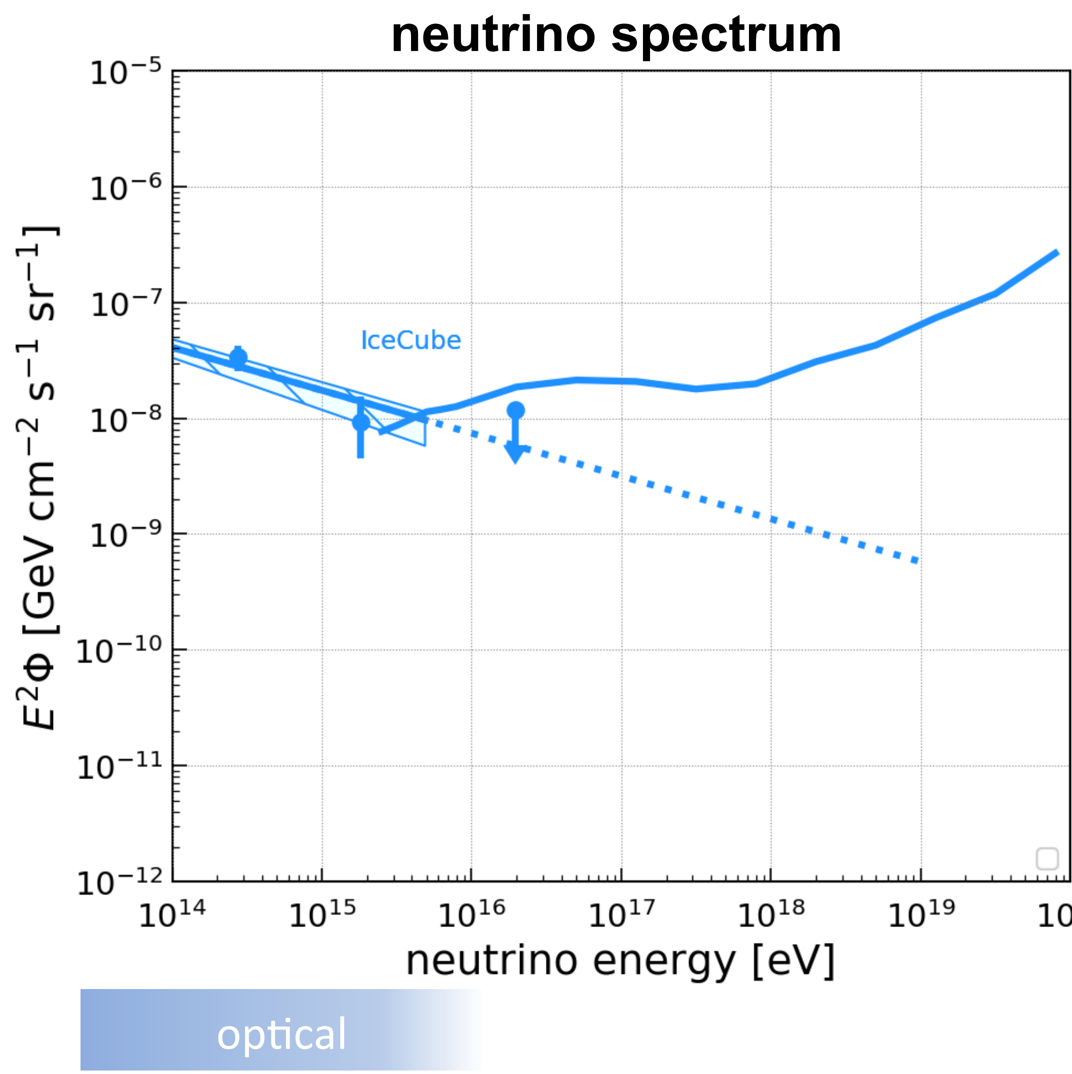


Science Case and Detector Concept for the ARIANNA High Energy Neutrino Telescope at Moore's Bay, Antarctica

Steven W. Barwick, UC-Irvine, for the ARIANNA collaboration

Going to ultra-high energies

- Low interaction cross section of neutrinos
- Very low neutrino flux
- Very large volumes needed for reasonable rates



Going to ultra-high energies

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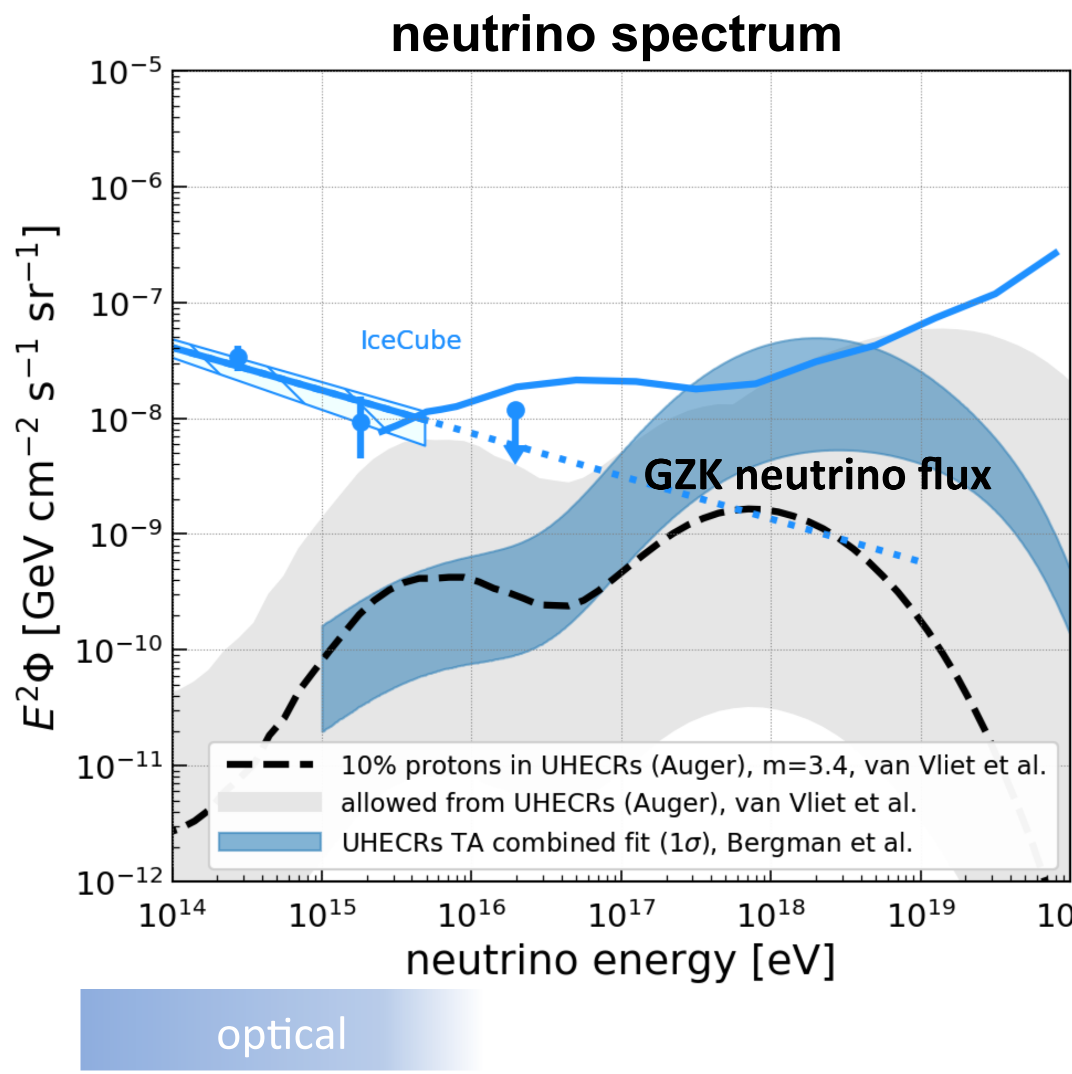


Going to ultra-high energies

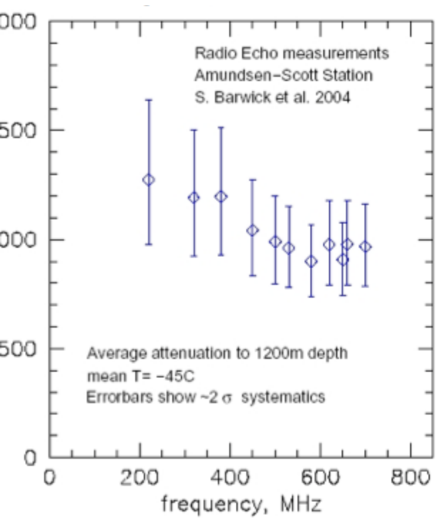
Low interaction cross section of neutrinos

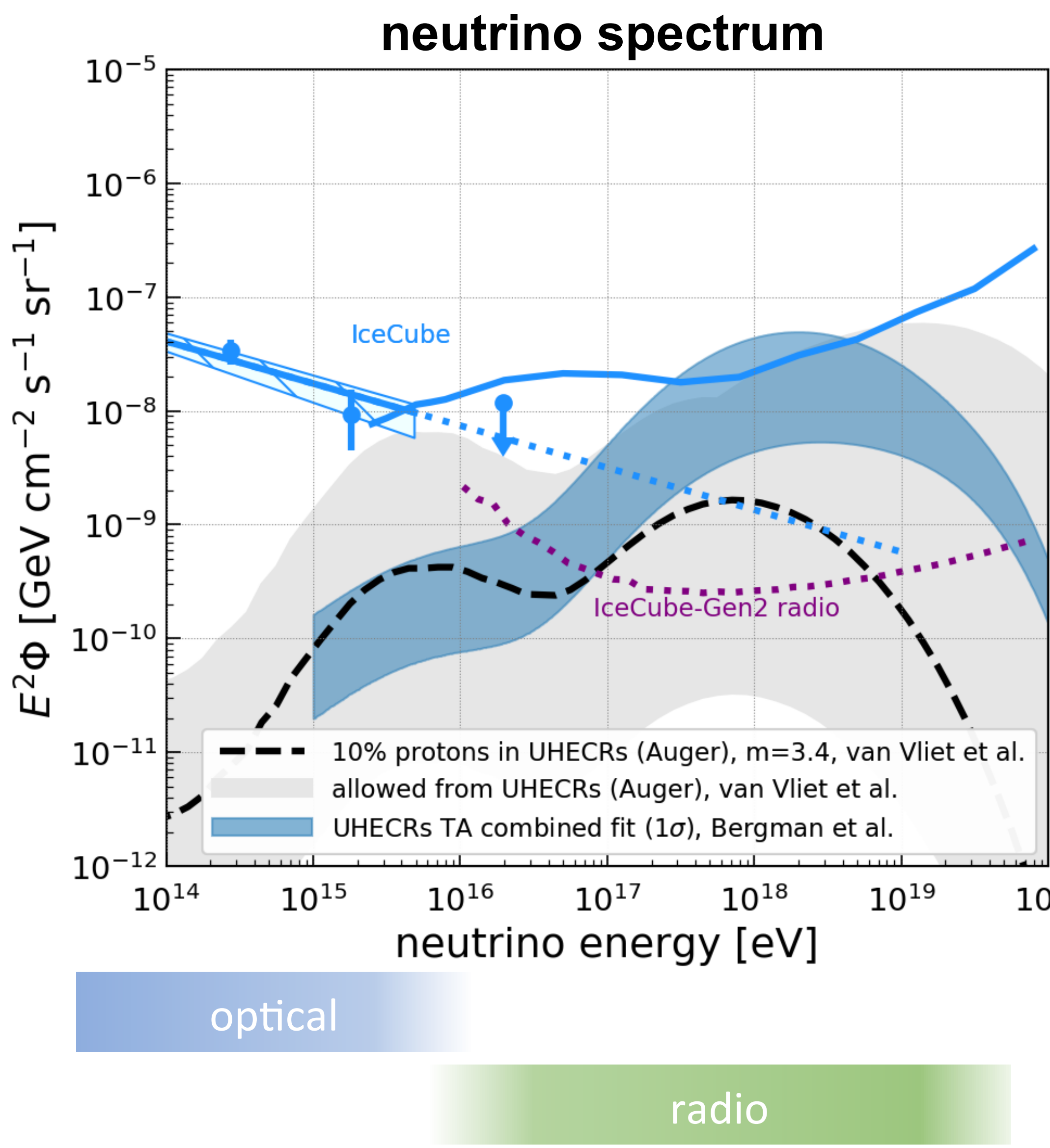
Very low neutrino flux

→ Very large volumes needed for reasonable rates

Solution: radio technique

- Large volumes at no cost: Antarctic ice
- Ice transparent to radio waves (L ~ 1km)
- A single radio station has 1km³ effective volume (comparable to IceCube)





Experimental Landscape

ANNA test bed
2 shallow stations at

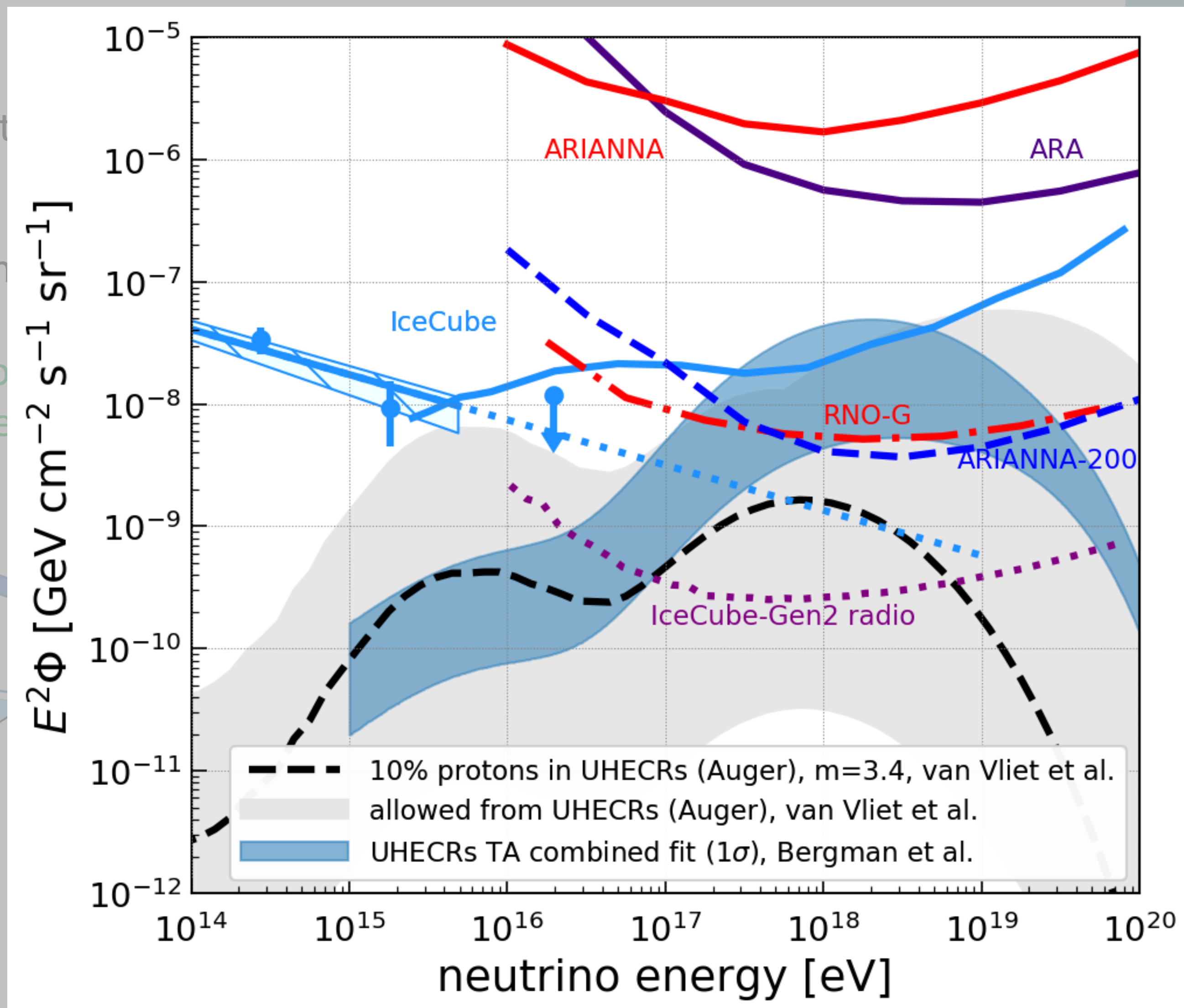
A
x 200m deep station

o technology develo
ied; hardware prove

past

IA

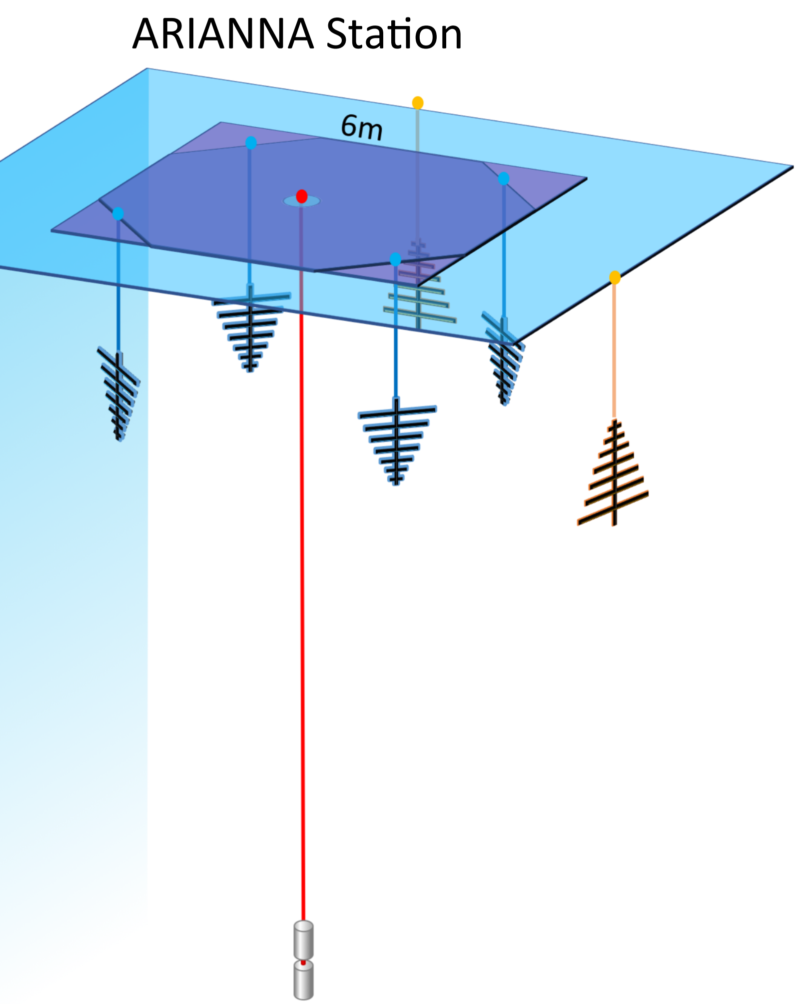
RNO-G

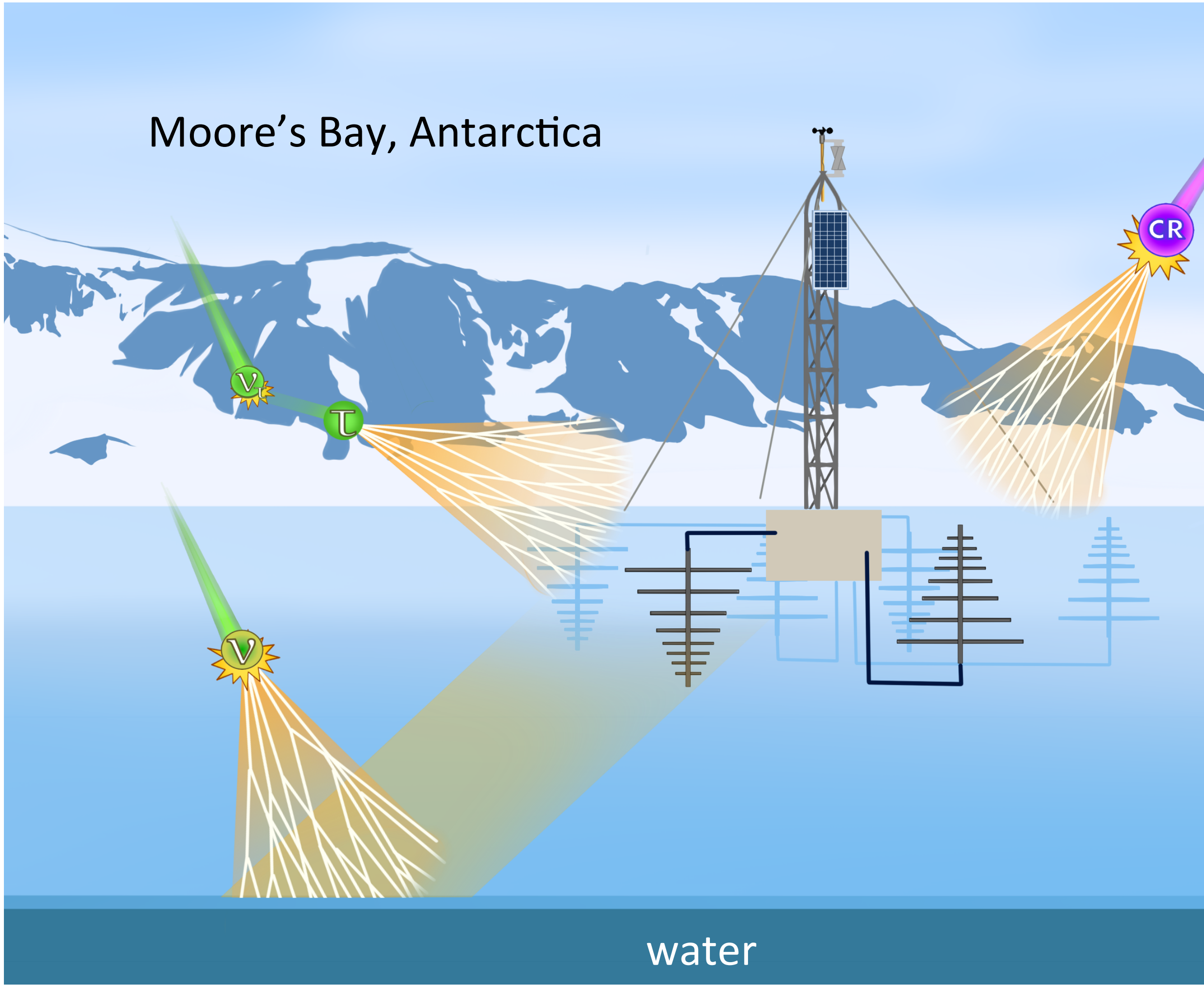


IceCube-Gen2
300+ detector static
South Pole
hybrid array of deep
shallow stations

stian Glaser, VLVNT 2021

ARIANNA Detector Concept

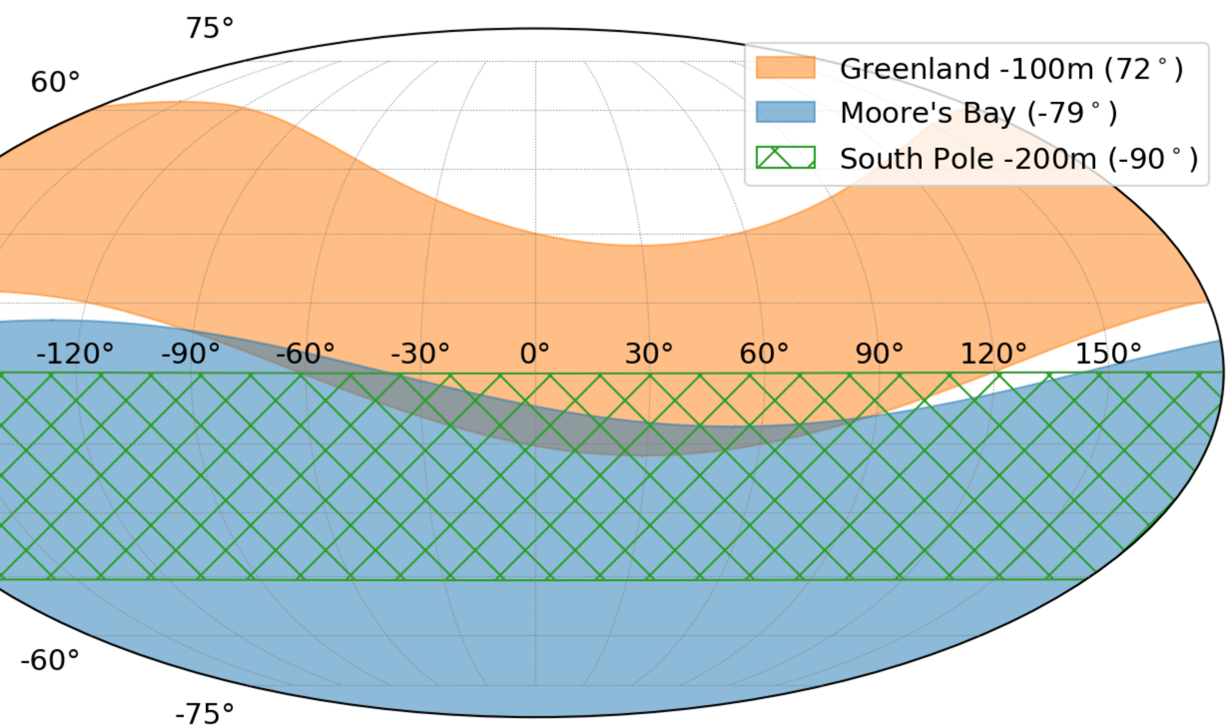




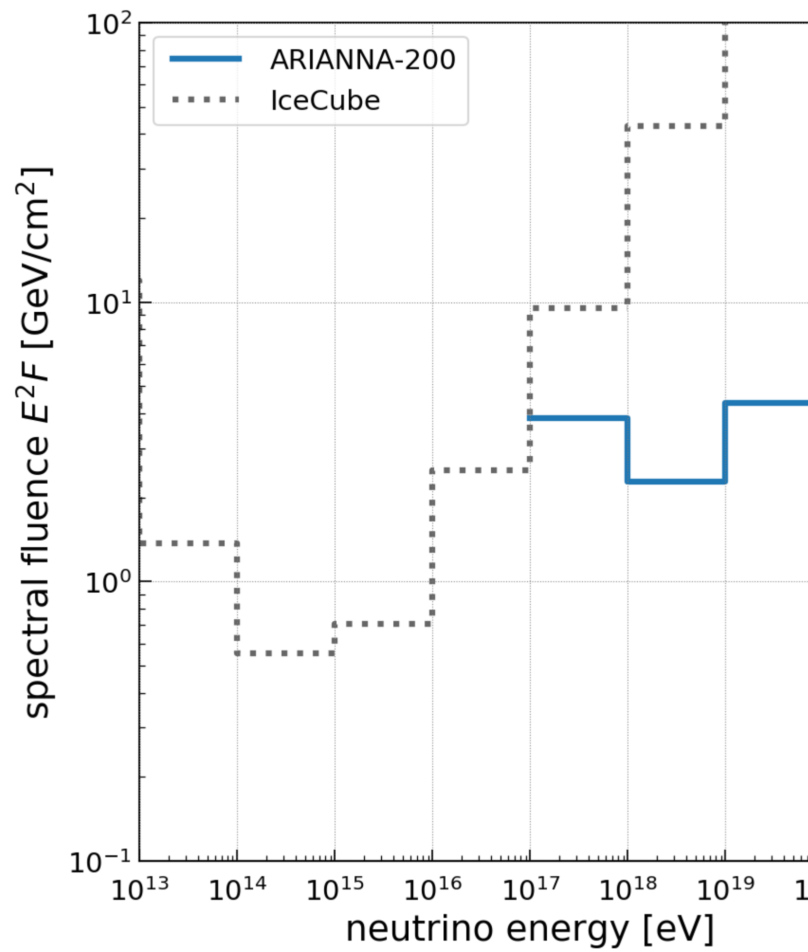
ARIANNA white paper: arXiv:2004.09841

ARIANNA at Moore's Bay, Antarctica (200 stations)

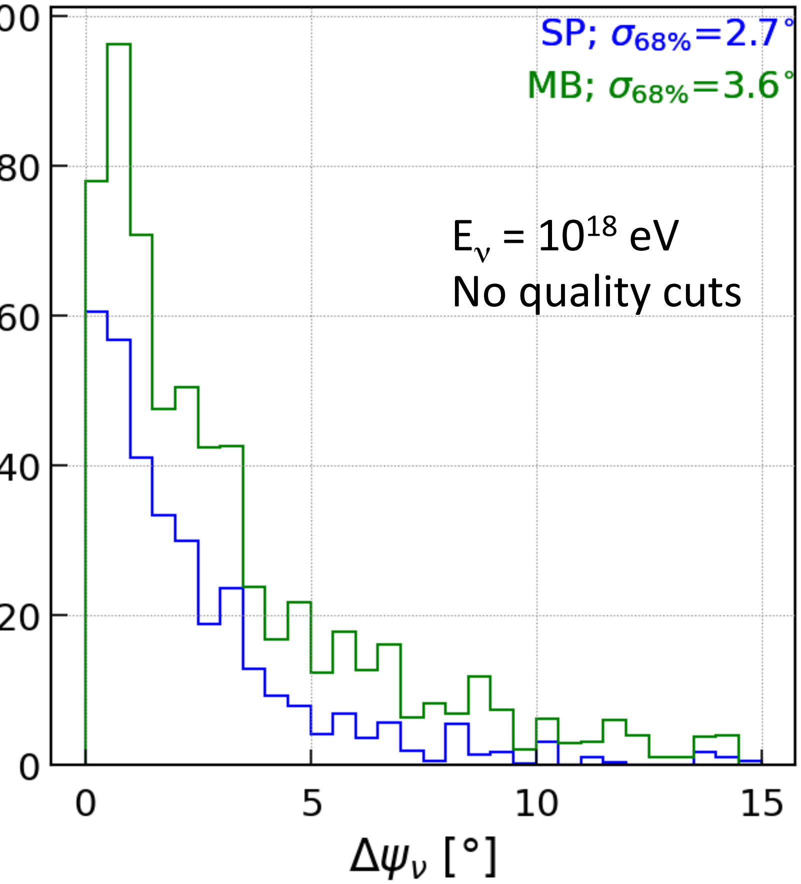
Sky Coverage



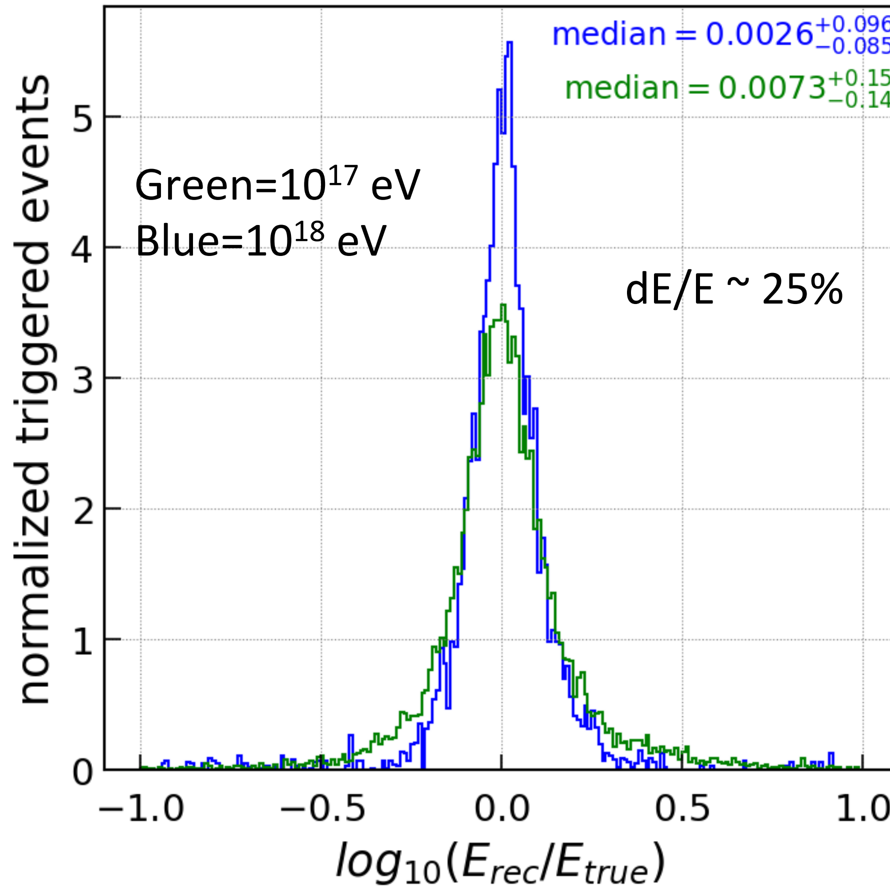
Fluence Limits



Direction and shower energy resolution



nce between reconstructed and true angular direction

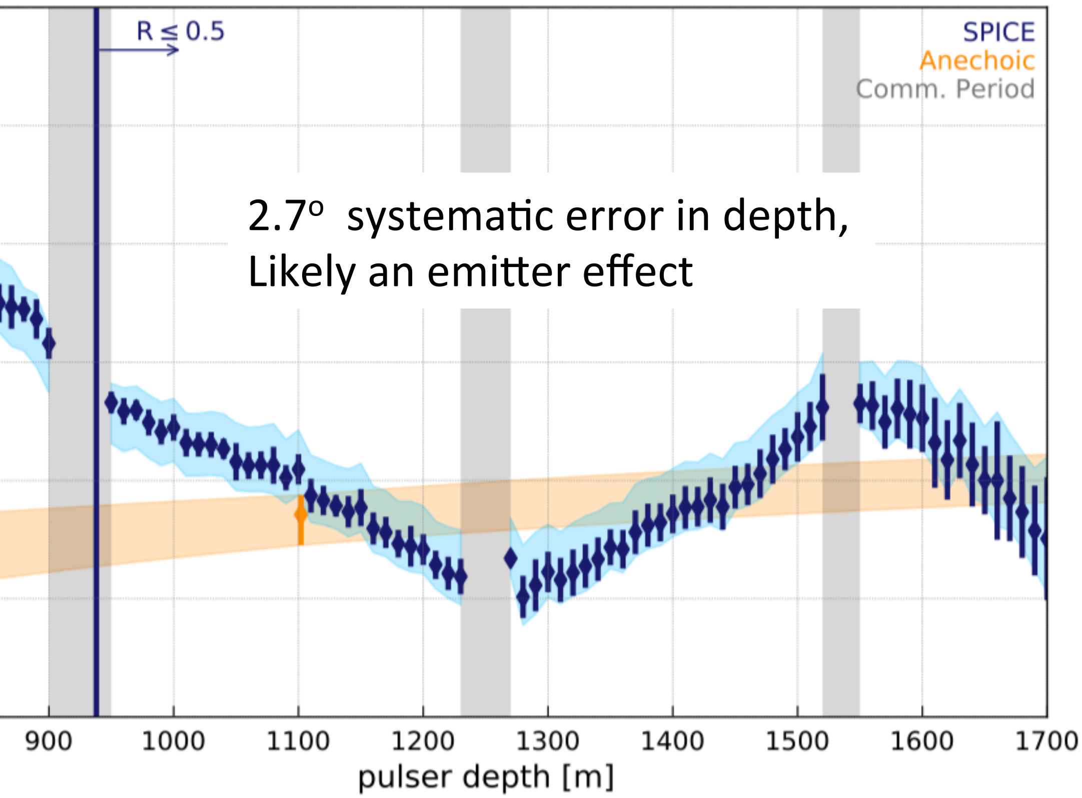


Shower Energy Resolution

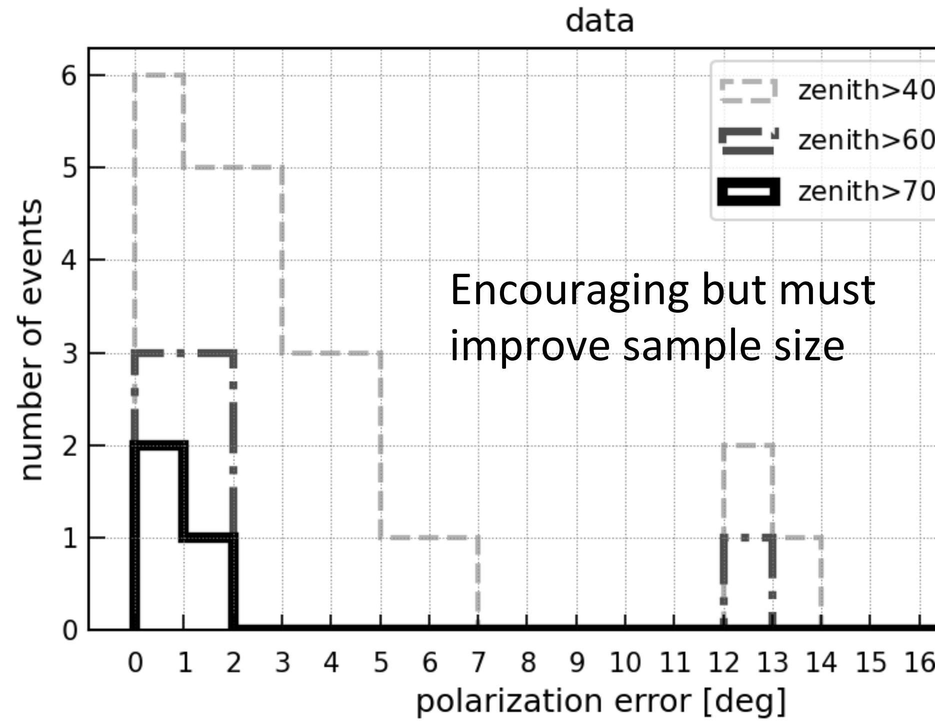
S. Barwick, PoS (ICRC2021) 1151
G. Gaswint, UC Irvine, PhD, 2021

Verification Studies of Polarization

Pulser Studies at South Pole



Cosmic Ray Polarization



S. Barwick, PoS (ICRC2021) 1151

L. Zhao, PoS (ICRC2021)1156

Background Considerations

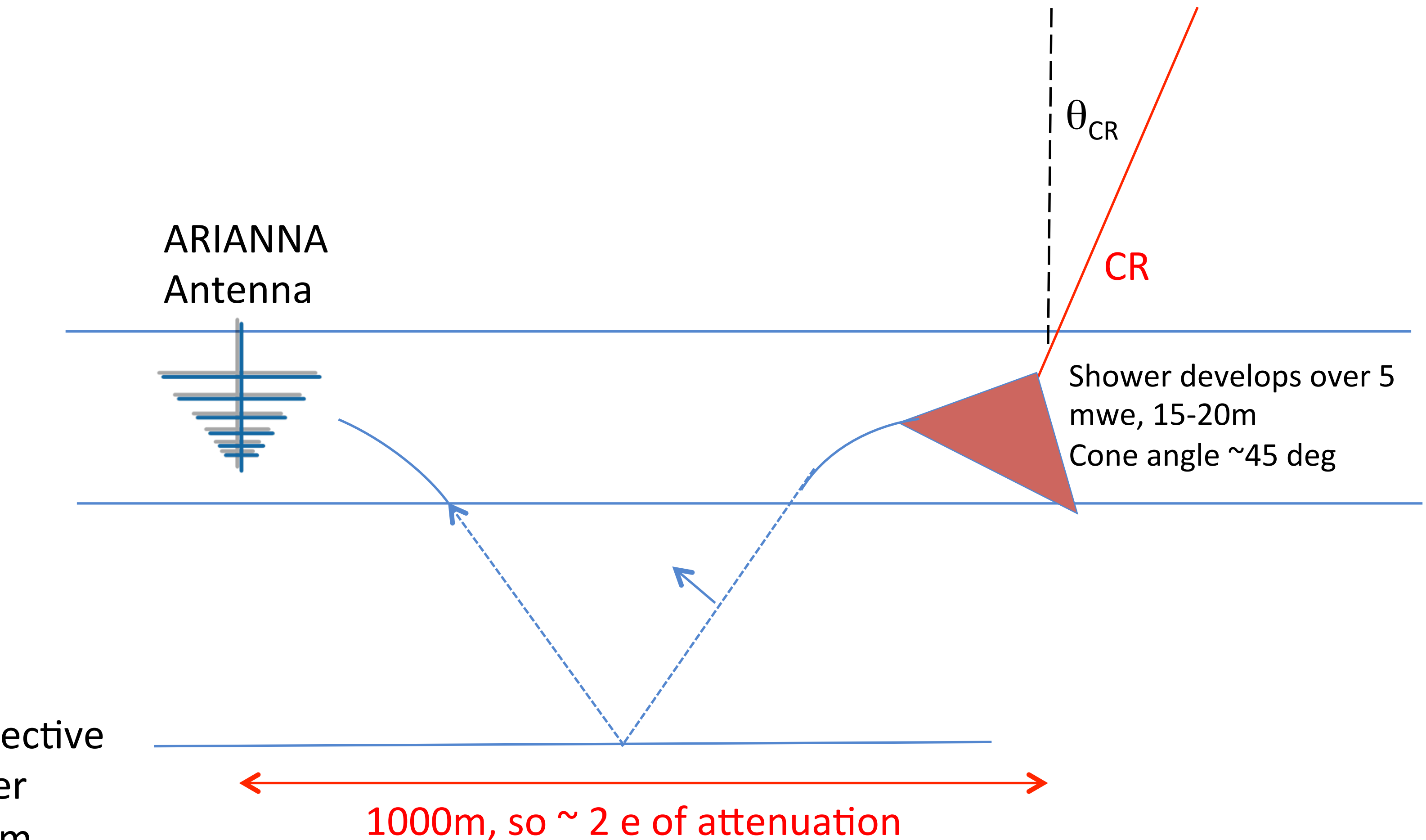
uture radio arrays are designed to increase sensitivity by 10^4 relative to limits by pilot arrays such
RIANNA HRA and ARA

Must identify and reject rare, and potentially, unforeseen background events

ecent work

- Atmospheric muon induced EM showers within the ice – rates are thought to be small in ARIA
  but the errors in the calculation are considerable (D. Garcia-Fernandez, et al. arxiv 2003.13
- Radio pulse that is created in the atmosphere by CR, and reflects from the bottom water-ice s
  - Near vertical CR will not be detected by upward LPDA (footprint too small)
  - Reconstructed vertex of emission will be outside the ice medium
- Shower cores that reach the ice surface will induce an Askaryan-like signal at the surface. See S
  Kockere et al, contribution 101319. It too can reflect off the bottom water-ice surface.

CR Shower Core that reach surface

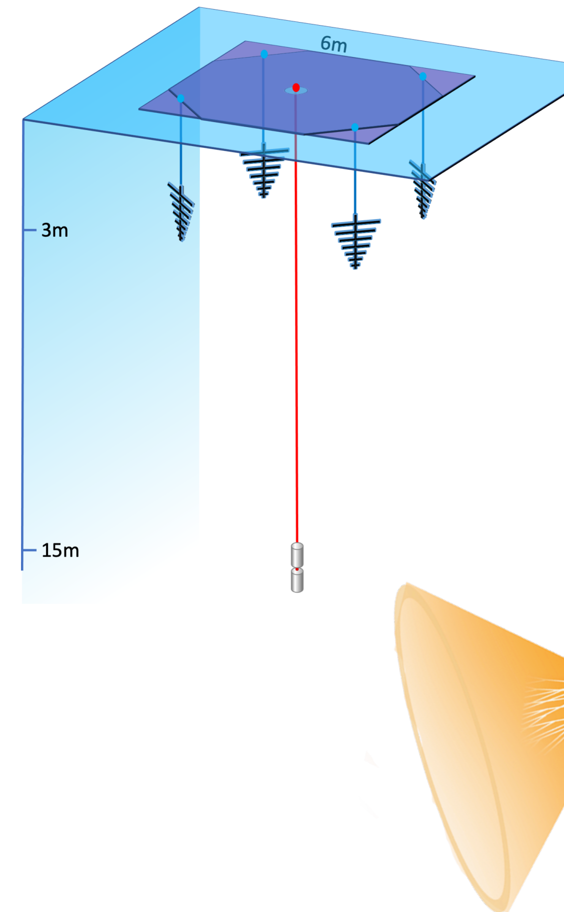


Relatively little ene
survives to sea-lev

Relatively small fra
particles in residua
are close enough t
shower axis to pro
Askaryan emission

Good understandi
reflective properti
water-ice surface,
combined with DN
place vertex withi
of surface, where
interactions are ex

Summary



ARIANNA test bed detector

- autonomous, independent, shallow detector stations
- proof-of-concept of radio technique to measure UHE neutrinos
- shallow station design part of RNO-G and IceCube-Gen2

Neutrino direction reconstruction

- in-situ verification of
  - signal direction and ice properties (syst. uncertainty 0.3°)
  - polarization (syst. uncertainty 1°-2.7°)
- end-to-end test of reconstruction using MC simulations
  - 3° statistical uncertainty for all triggered events

Good angular resolution of shallow detector stations will enable

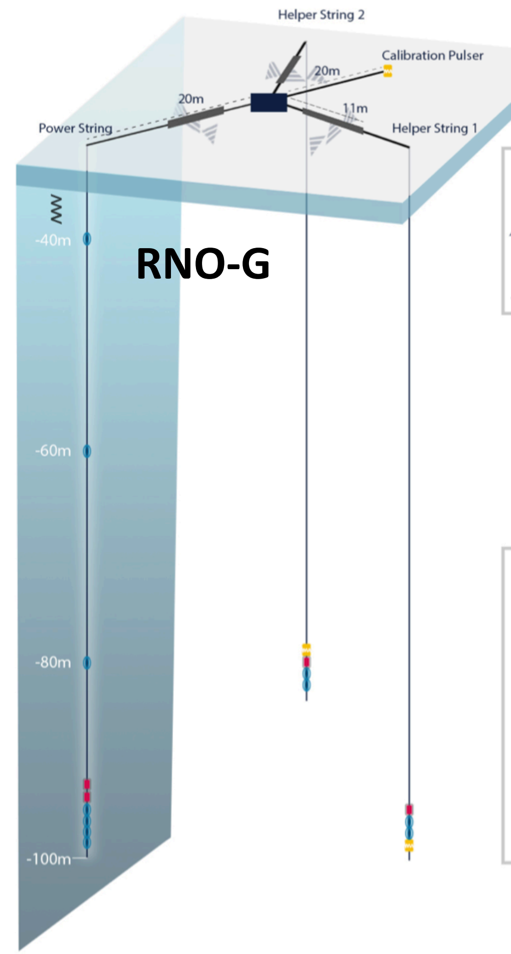
- multi-messenger alerts for follow up observations
- source search

Rare, or unforeseen, BGs associated with CRs, etc must be studied and mitigation strategies demonstrated. The ARIANNA detector provides this opportunity.

Backup Slides

The End

Experimental Landscape



ANNA test bed

2 shallow stations at Moore's Bay + South Pole

A

x 200m deep stations at South Pole

o technology developed and
fied; hardware proven reliable

RNO-G

- 35 detector stations in Greenland
- first deployment summer 2021

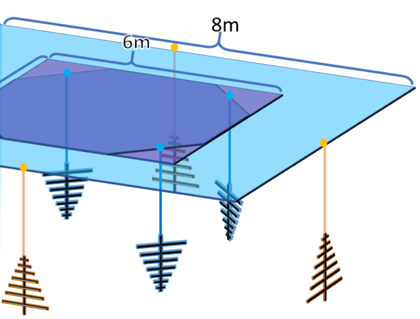
ARIANNA-200

- 200 shallow detector stations at Moore's Bay
- funding decision pending

past

now

future



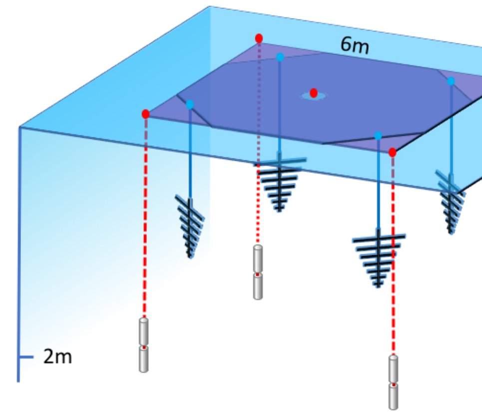
IA

IceCube-Gen2

- 300+ detector static South Pole
- hybrid array of deep shallow stations

ARIANNA collaboration, JINST 15
G. Gaswint, PhD

In-situ test of signal direction reconstruction

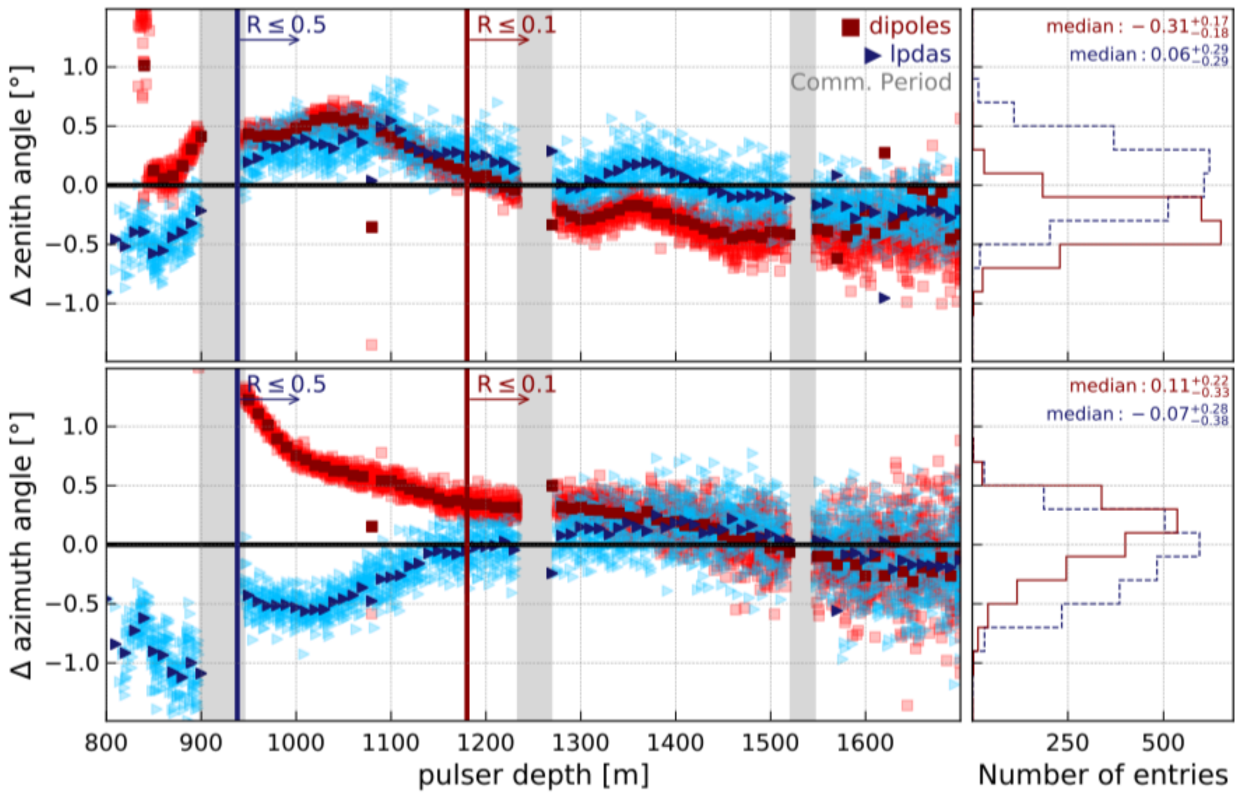


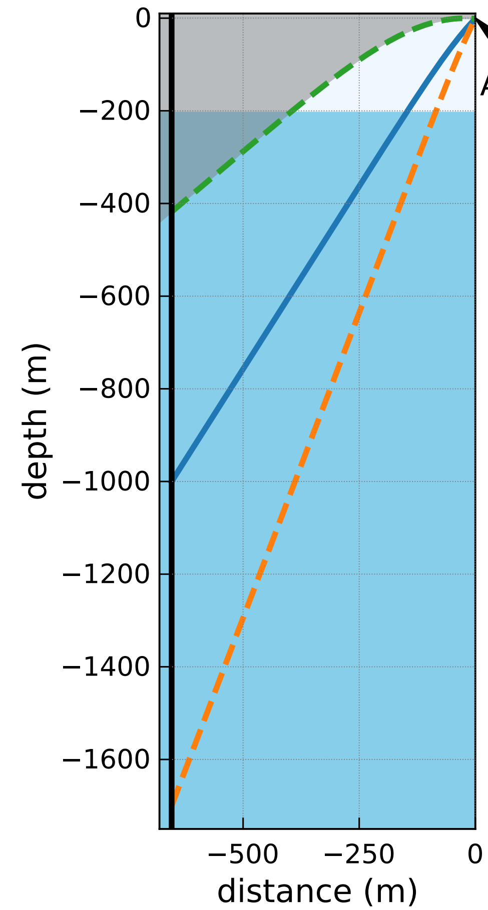
Calibration measurement at South Pole

- Transmitter lowered into SPICE hole (1700m deep)

Ice properties well understood

- Direction measured independently by dipoles (Vpol) and LPDAs (Hpol)
- Bending of signal trajectories in firn corrected with < 0.3° precision





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ARIANNA collaboration, JINST 15
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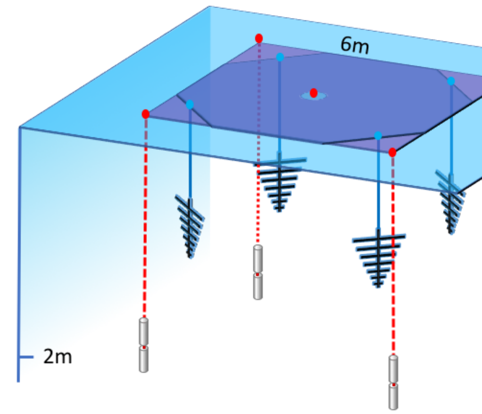

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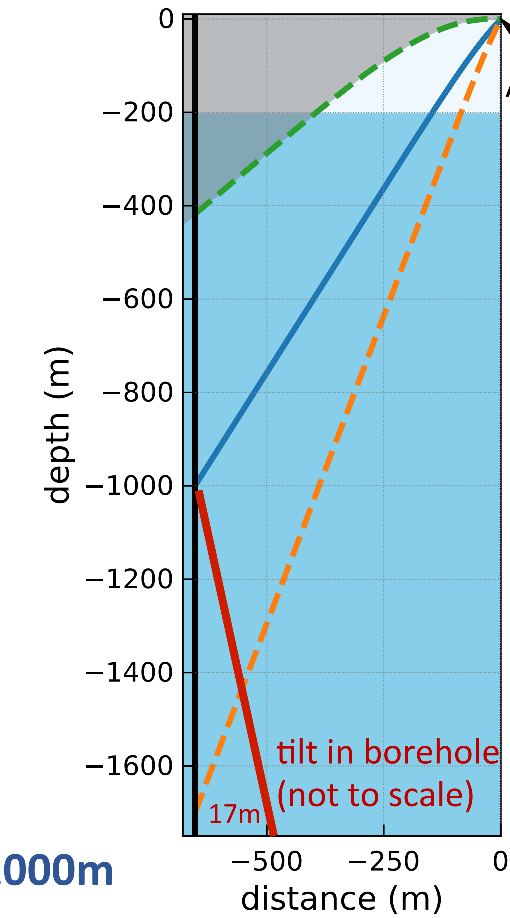

Measurement even sensitive to 1° tilt in borehole below 1000m