Progress in In Situ UHE Neutrino Detectors: Joint Studies on Simulation and Ice

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For the ARA and ARIANNA Collaborations

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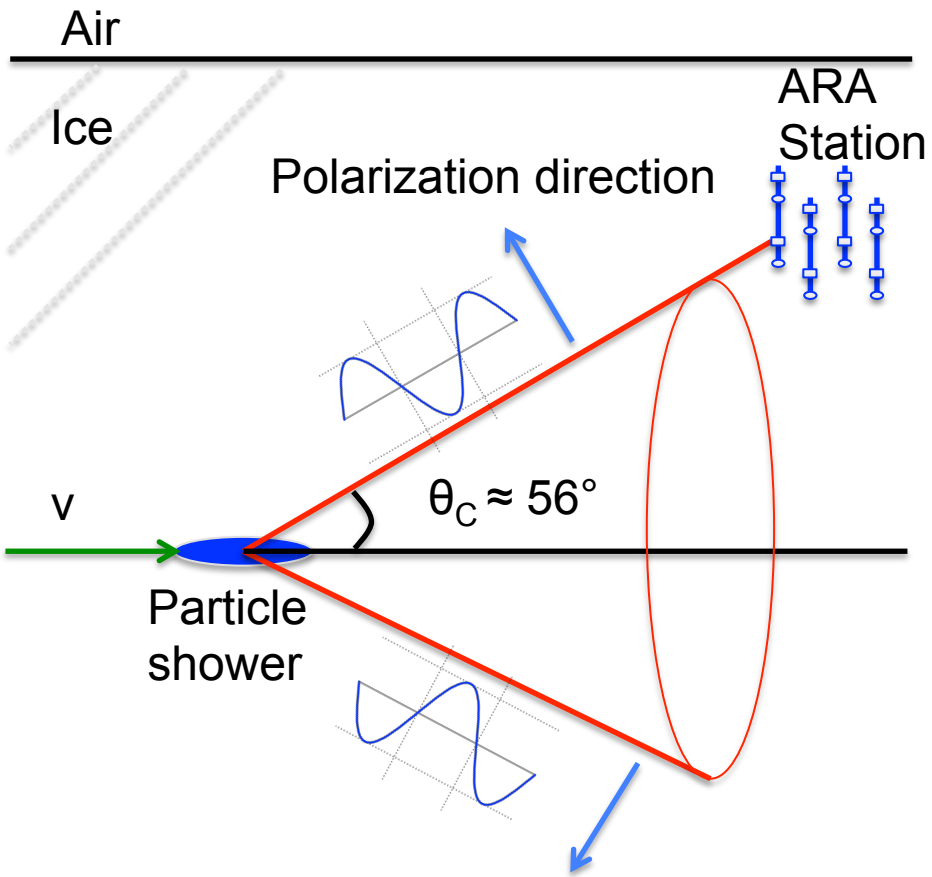
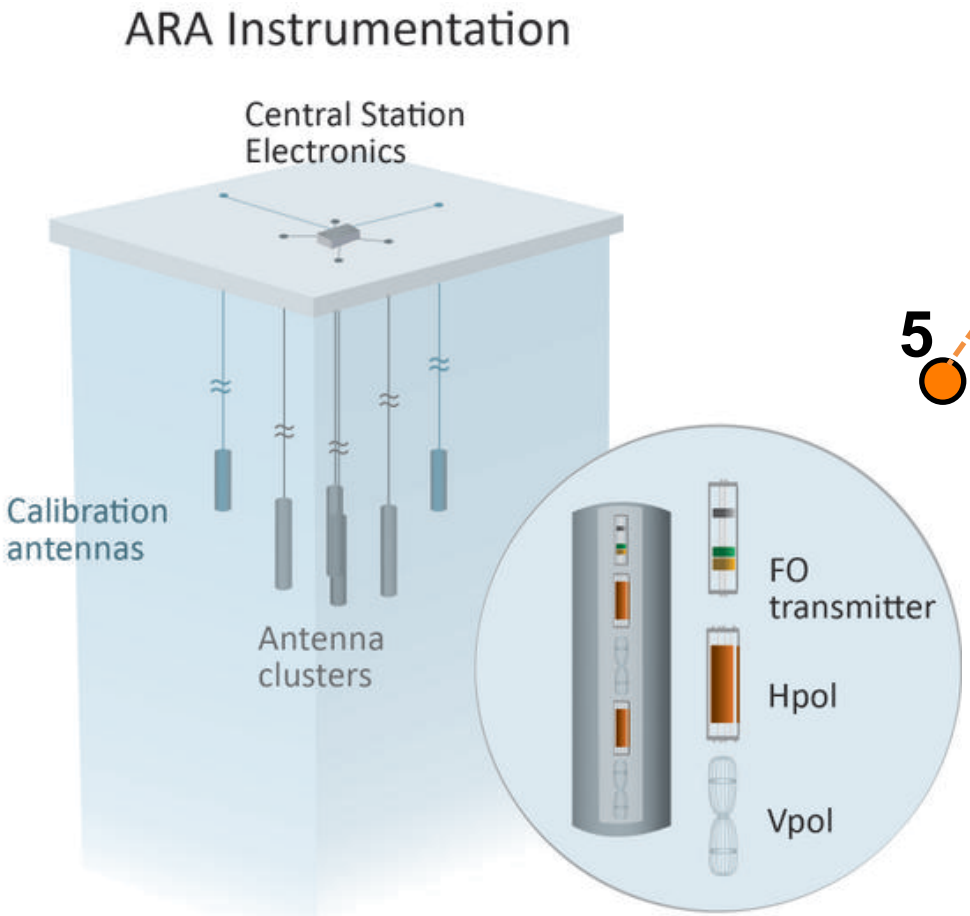
Askaryan Radiation

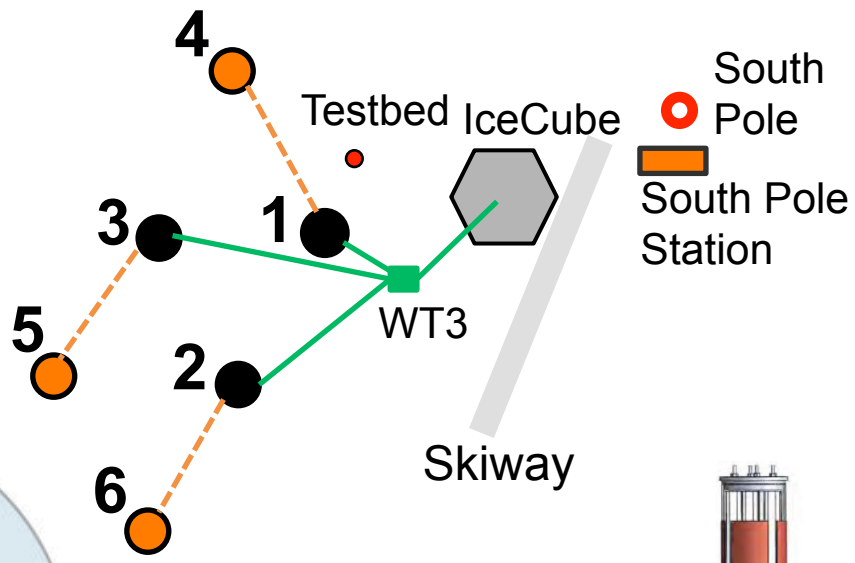
Askaryan Effect:

coherent impulsive radio emission induced by a particle shower in dense dielectric medium



Askaryan Radio Array (ARA)





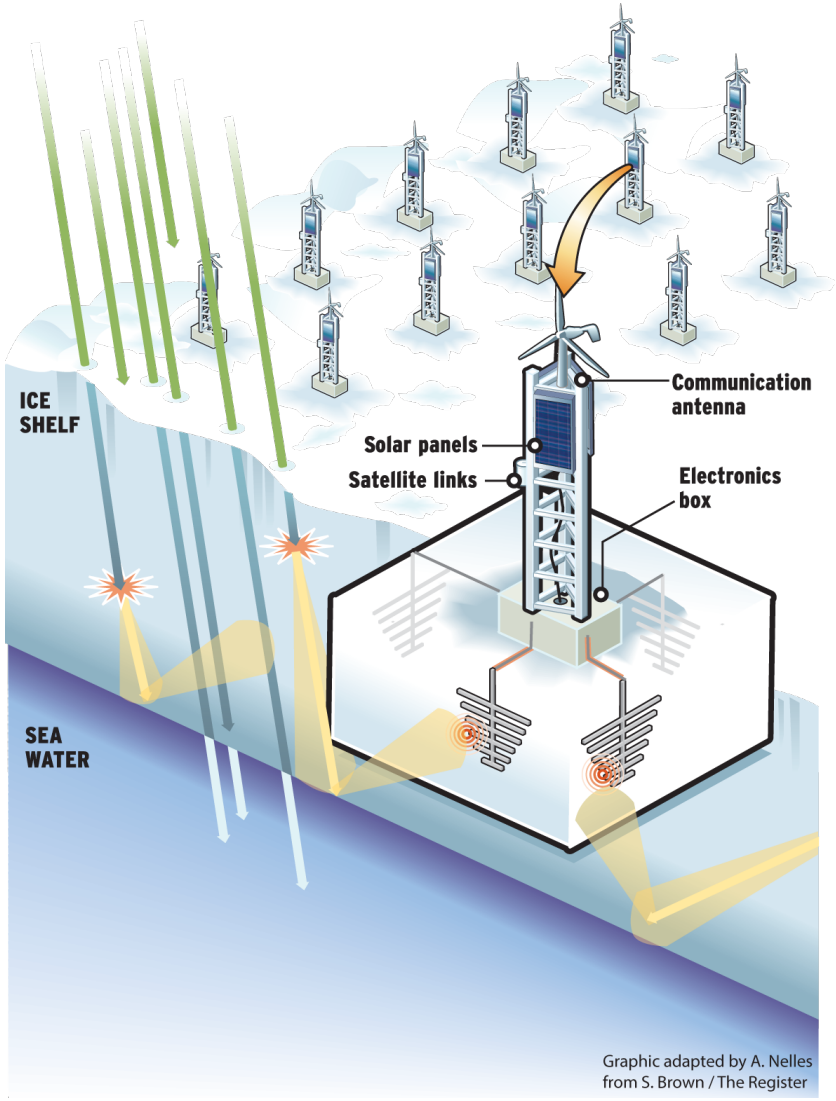
Hpol quad-slotted cylinder antenna

Vpol bicone antenna

- Deep (200m) deployed stations
- See also Brian Clark's talk (earlier)

ARIANNA

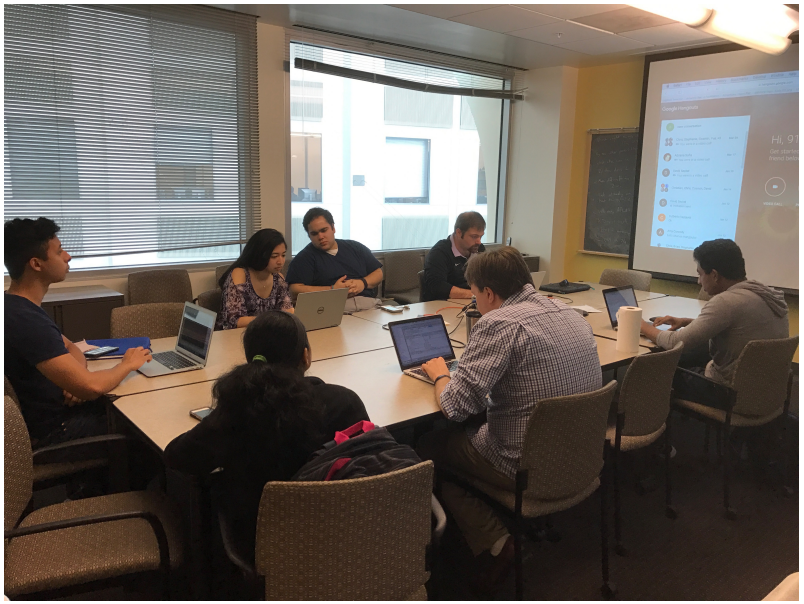
- Antarctic Ross Ice-Shelf Antenna Neutrino Array
- Surface log-periodic dipole antennas
- Reflection from bottom of ice shelf at Moore's Bay
- See talk by Chris Persichilli (next)



Cross-Collaboration

New collaborative effort between ARA and ARIANNA to understand simulation systematics

- UC Irvine
- OSU
- Cal Poly
- Kansas
- Delaware
- Chicago
- Uppsala Univ., Sweden

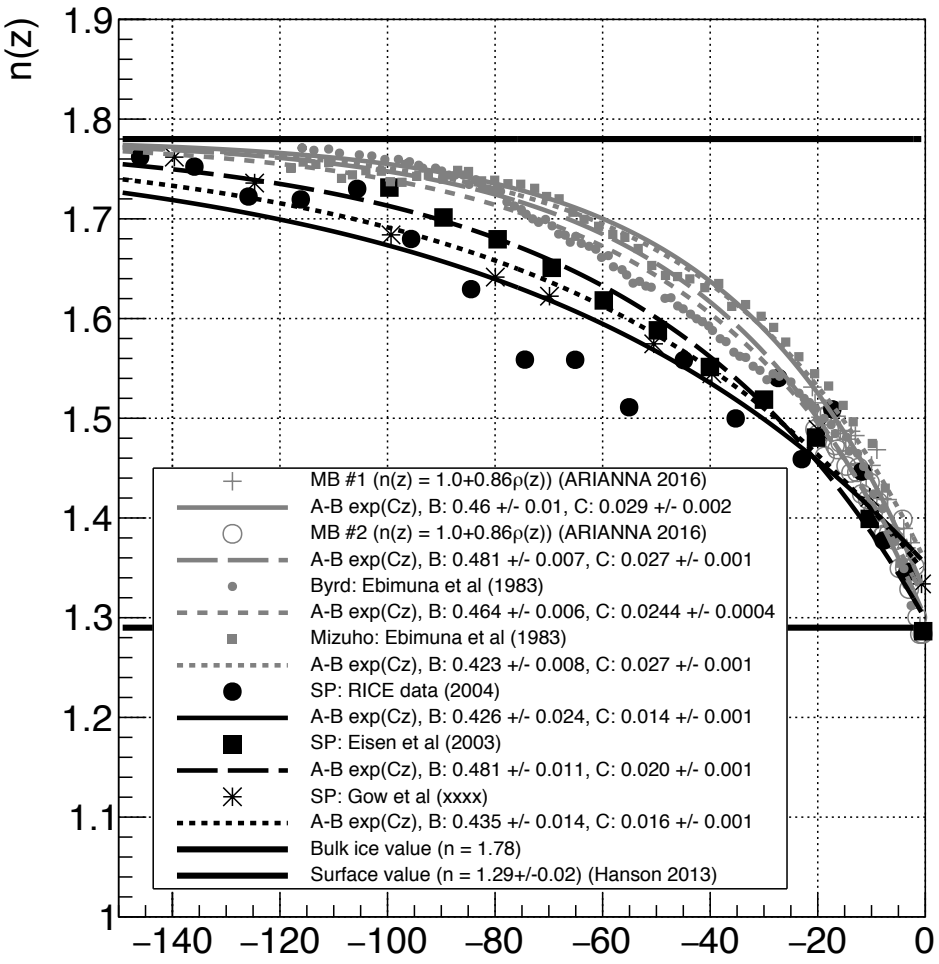


The OSU InIce Simulation Team

ARIANNA:	ShelfMC
ARA:	AraSim

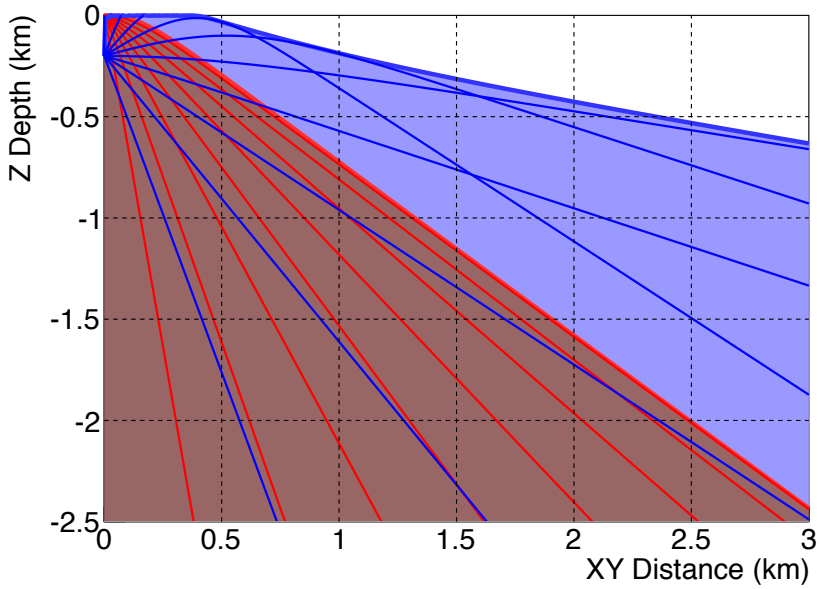
Ice Models

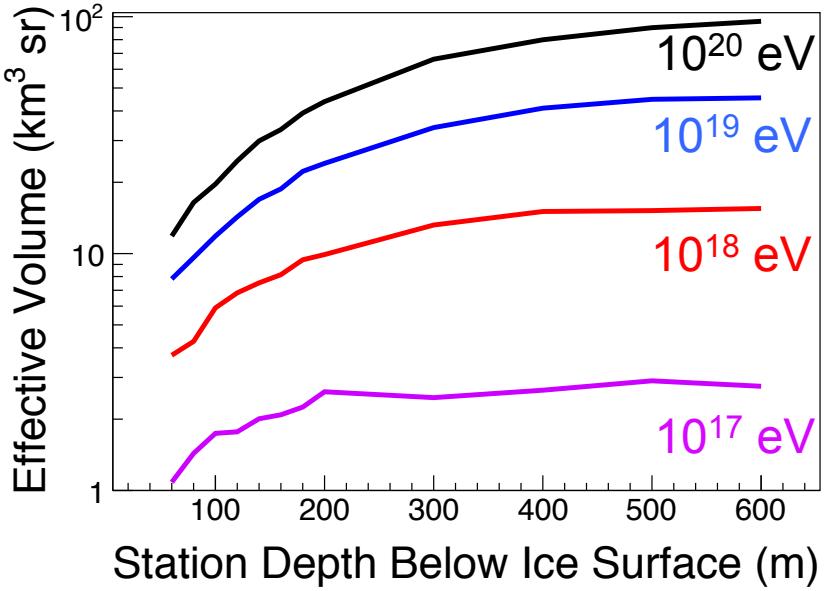
- Firn (compacted snow) – quickly changing n(z)
- Index of refraction modeling
  - Moore's Bay vs South Pole
- Exponential index of refraction fit
  - $n(z) = A - Be^{Cz}$



Compiled by J. Hanson

Shadowing Effect





- Causes curvature in paths of rays in ice
- New measurements may suggest other effects, horizontal propagation – ongoing investigation

Simulation Comparison

AraSim (ARA)	ShelfMC (ARIANNA)
Ray-tracing	Shadow-zone pre-calculated
Time domain	Frequency domain
More flexible	Faster

- Working to compare simulations across detector configuration parameter space
- Find points of common agreement and understand points of disagreement between results

New Results

ShelfMC, AraSim effective volumes **AGREE** (within 10% stat. errrors) for: $E_\nu = 10^{18}$ eV

Mutated the simulations to be similar:

- South Pole n(z)
- 4 bicone antennas
- 2-antenna, 6σ power trigger
- Flat geometry at the surface

Chris Persichilli, UC Irvine

ARA-like

ARIANNA-like

This is the first time the two simulations have attempted to reproduce the same result, and they agree within statistical uncertainties! Yay!

Exploring Parameter Space

Developed scripts to loop over parameter space for ShelfMC/ AraSim:

- Energy
- Distance between antennas
- Depth
- Firn depth

Plan: test where in this parameter space the simulations agree

Hannah Hasan
OSU rising Sophomore

Jude Rajasekera
OSU rising sophomore

Common Interfaces

AraSim/ShelfMC:

- Developing a standard interface for incorporating antenna parameters (measurements, models)

Anna Nelles
UC, Irvine

Stephanie Wissel,
Cal Poly

Plan:

- Develop modular framework for all inputs

Jorge Torres Espinosa,
OSU Grad Student

New Askaryan Model

J.C. Hanson and A. Connolly, Astroparticle Physics, 91 (2017) 75-89.

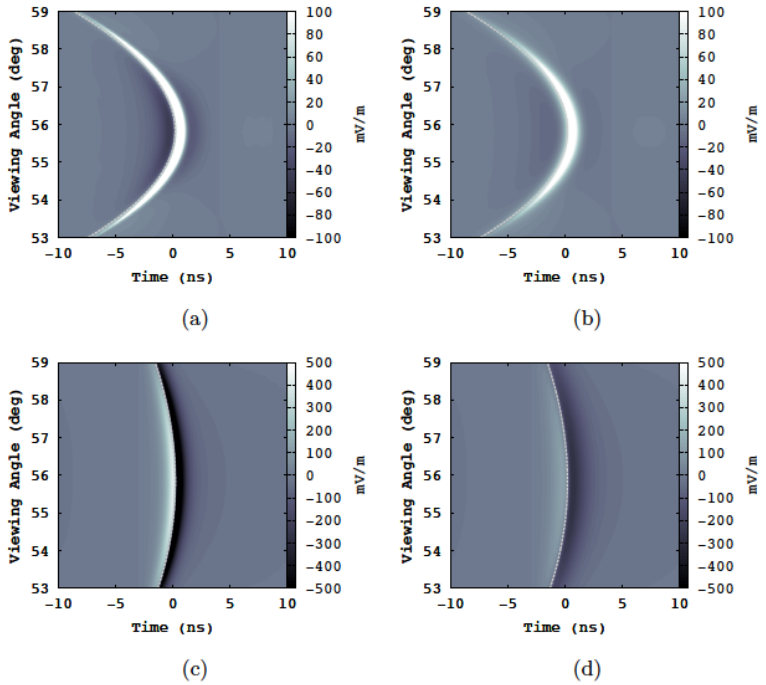


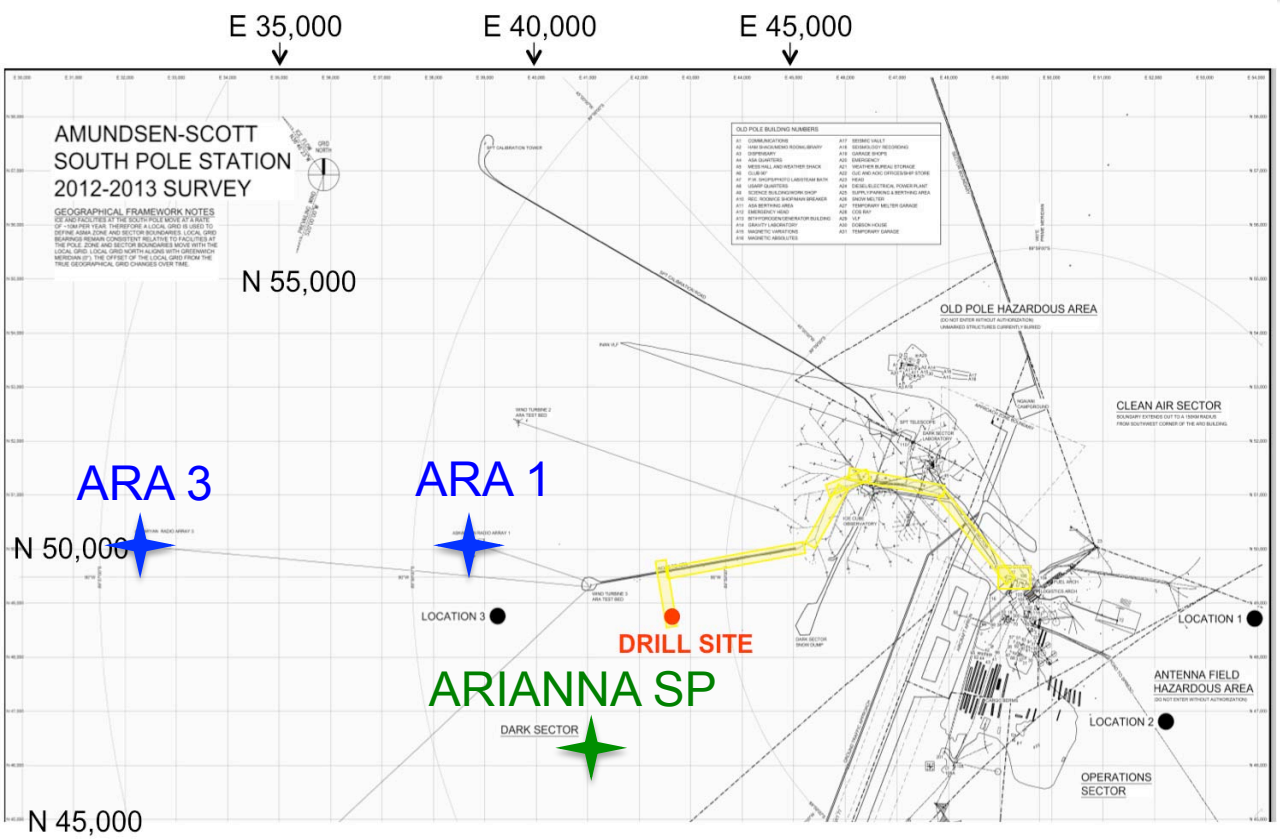
Figure 3: Contours of $\hat{e}_\theta \cdot \mathbf{E}(t)$, for a cascade energy of 1000 PeV. (a) R=1000 m, lateral ICD width of 5 cm. (b) R=1000 m, lateral ICD width of 10 cm. (c) R=200 m, lateral ICD width of 5 cm. (d) R=200 m, lateral ICD width of 10 cm. The LPM effect has been taken into account. See text for details.

Analytical model

Jordan Hanson (OSU, joining Whittier College as faculty)

- Also have other parameterized models
- Working on modular framework to swap models

SPICECORE



- SPIceCore – 1751 m deep core drilled at South Pole
- Glaciological and historical atmospheric research
- Lower RF pulser, observe signal with stations

Future

- Further comparisons to be done between ARIANNA and ARA simulations
  - Further parameter scans
    - Antenna model, attenuation length, antenna geometry
  - Identify any discrepancies
- Plans for improved signal timing, n(z) measurements
  - SpiceCore, surface measurements
- ARIANNA station deployment at South Pole

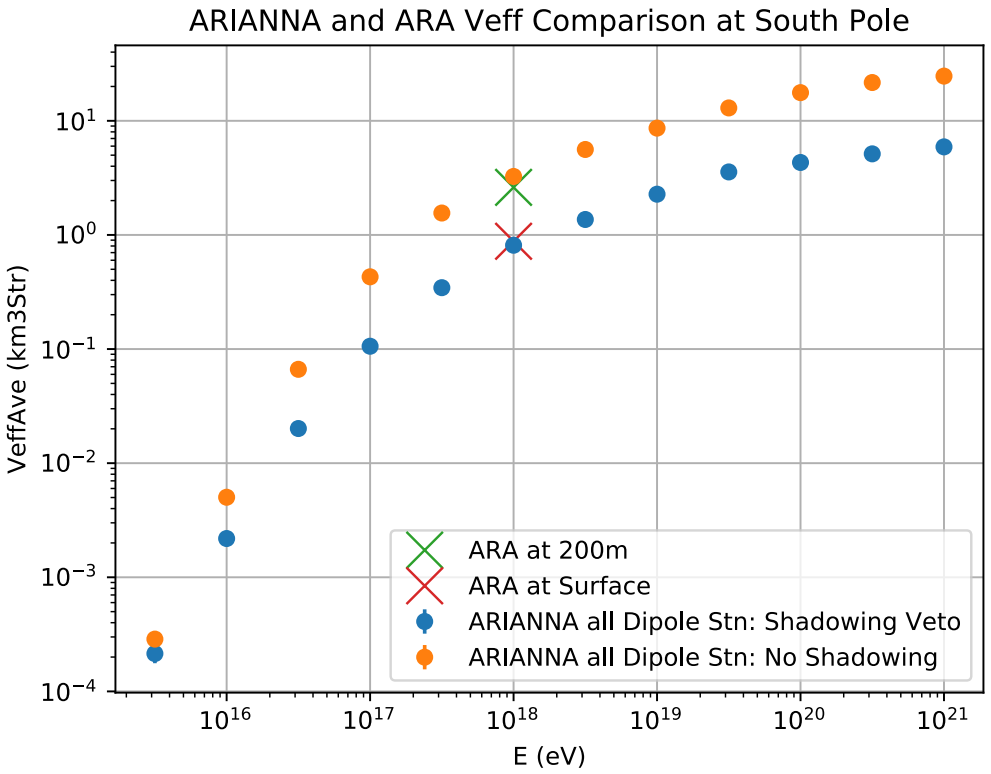
Questions?

Backup slides

Simulation Comparison

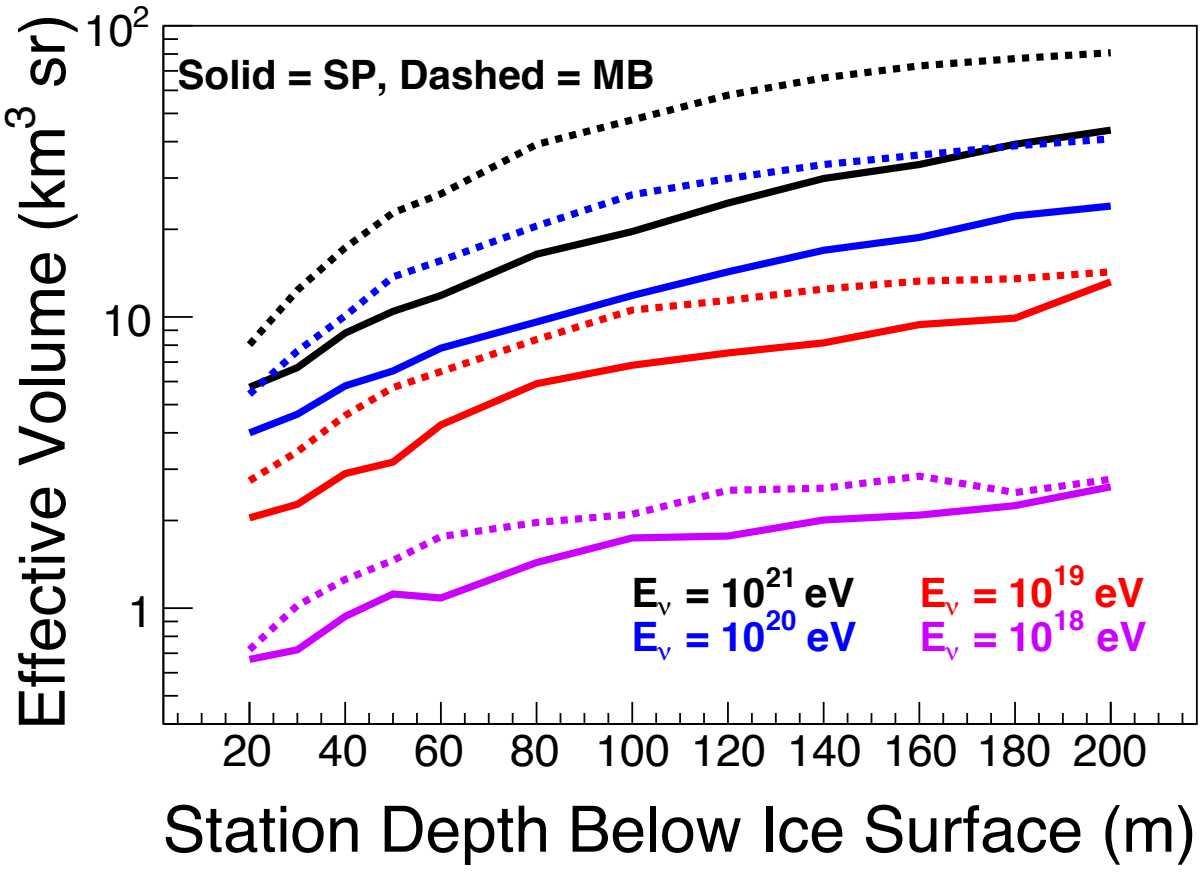
Running parallel configurations

- South pole n(z)
- 4 bicone antennas
- At the surface
- 6σ power trigger with 2-antenna coincidence



SP vs MB Ice Models

Only changing n(z)



Moore's Bay vs South Pole index of refraction models

Attenuation length, ice thickness lower at Moore's Bay