TAMBO: Searching for ν_τ in the Peruvian Andes

Will Thompson

Tau2023

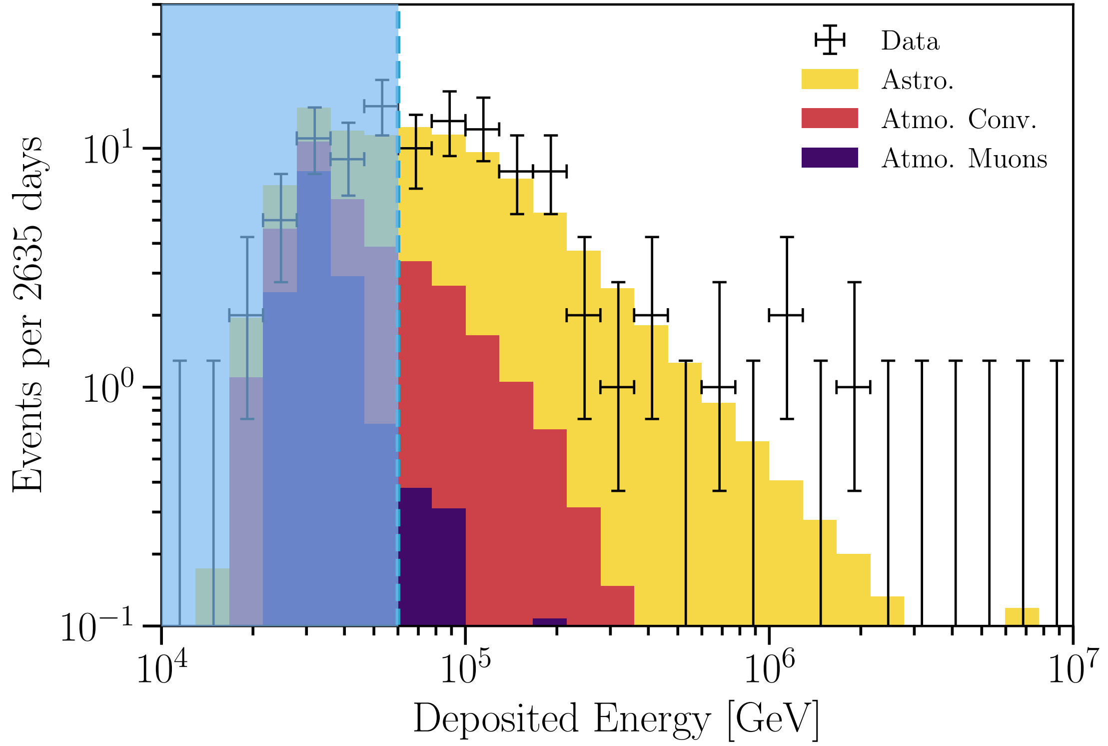
December 7th, 2023

HARVARD

TAMBO

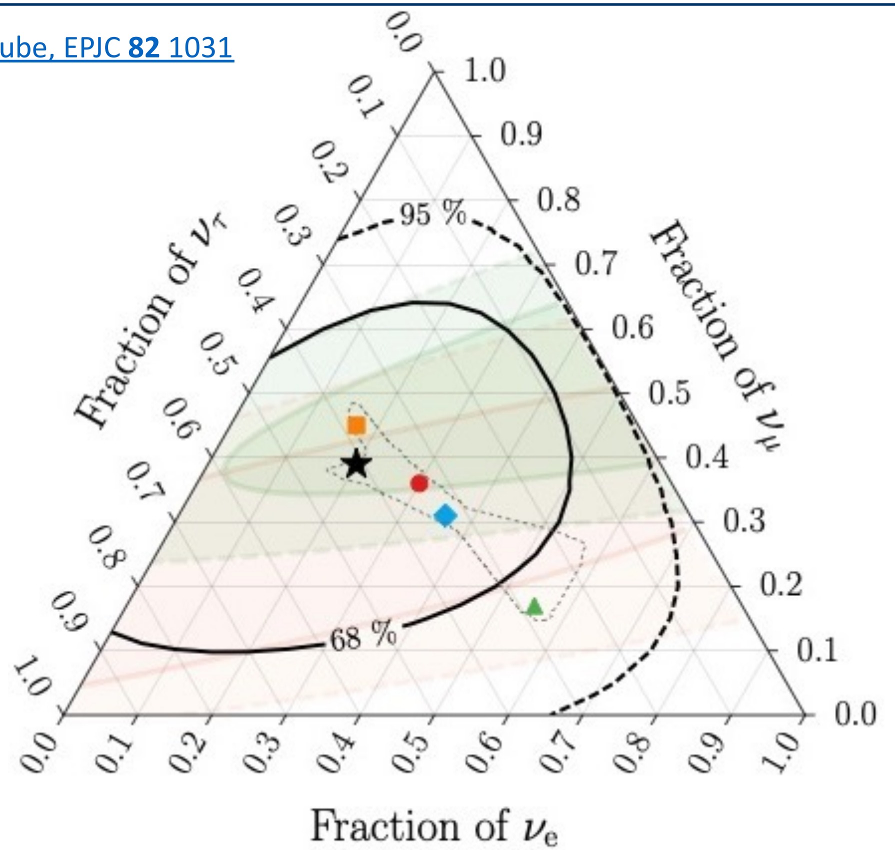
Open Questions in Neutrino Astronomy

IceCube, PRD **104** 022002



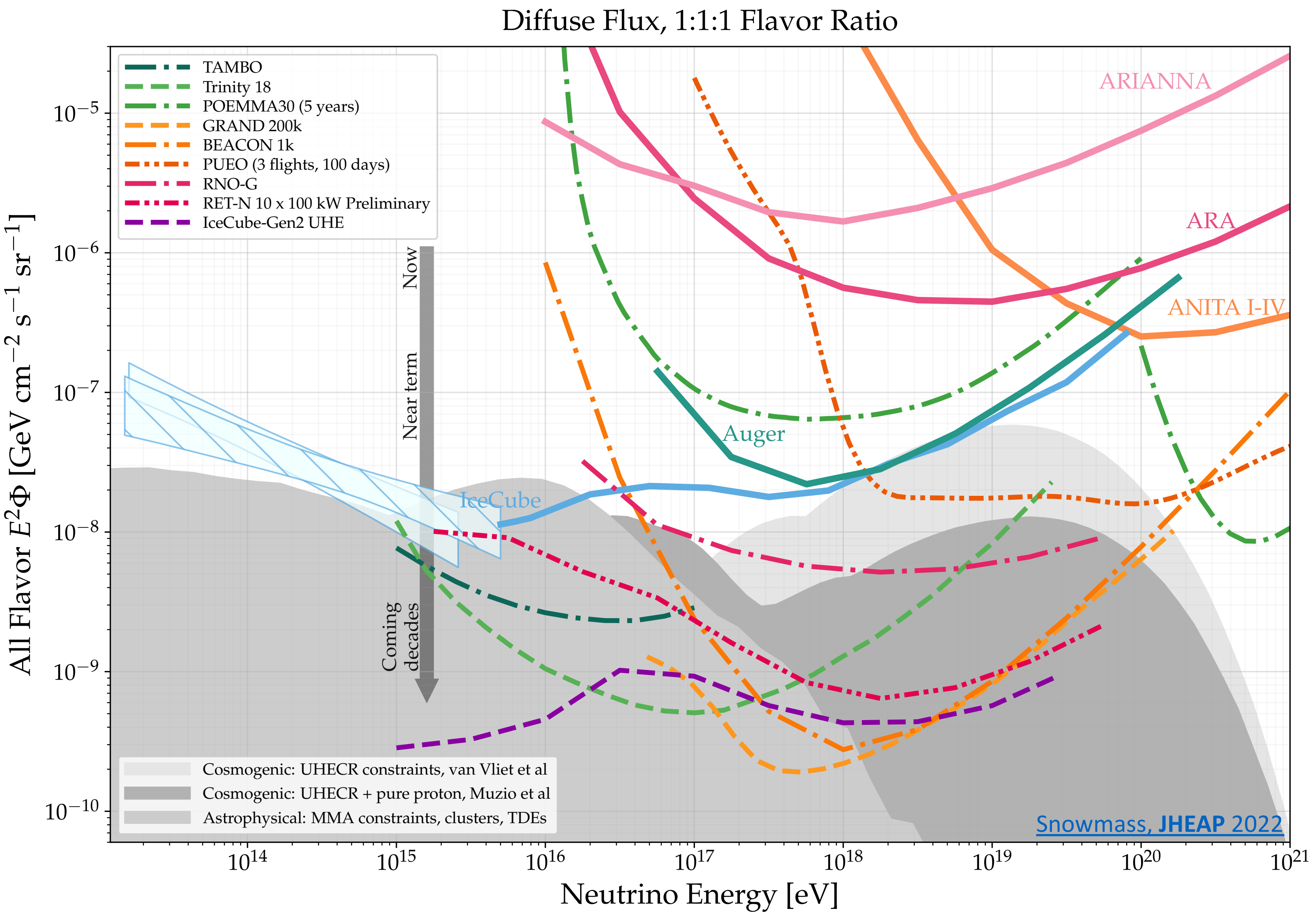
- Diffuse astrophysical flux discovered by IceCube
- Is there a high energy cutoff?

IceCube, EPJC **82** 1031

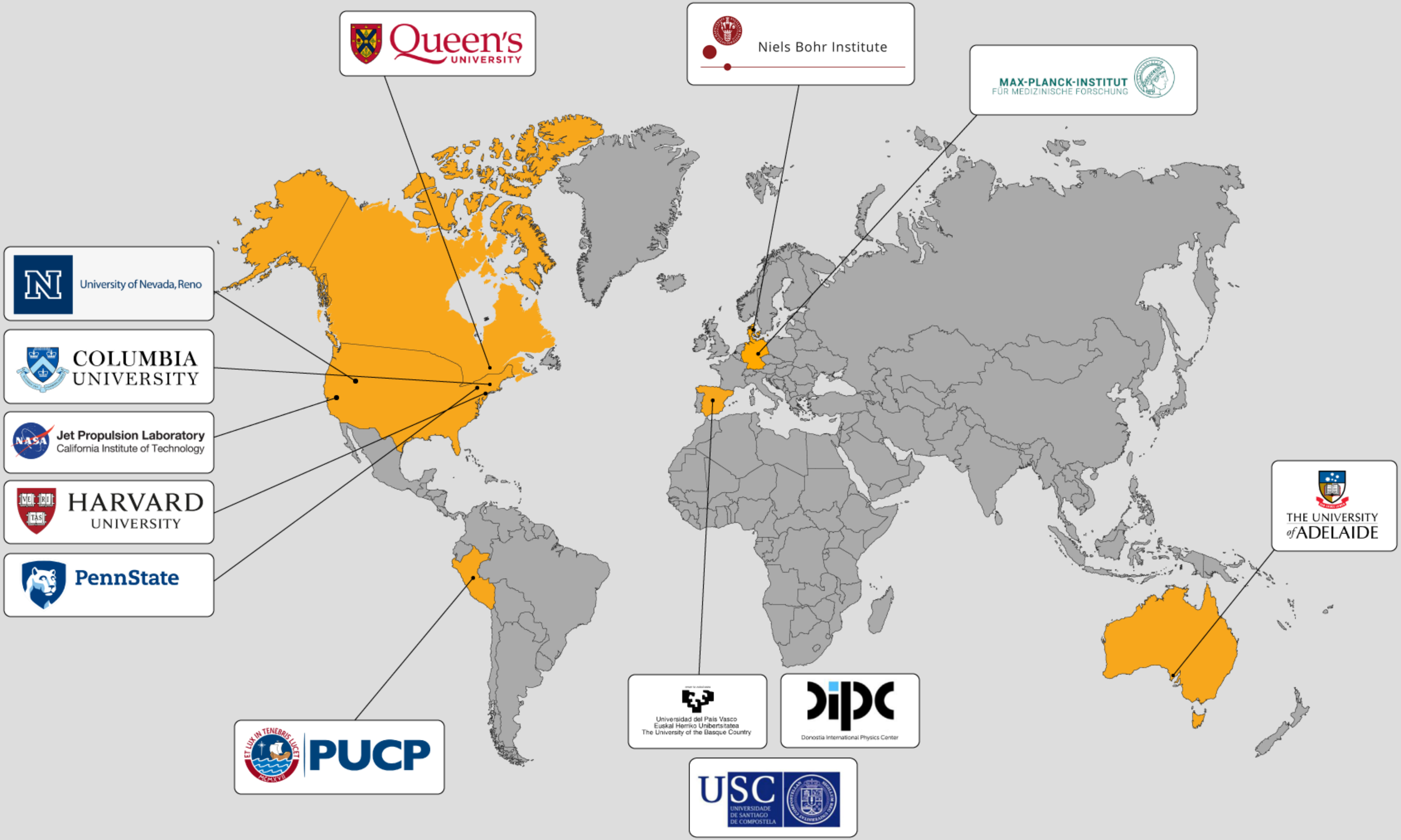


- Astrophysical flavor ratio can probe new physics
- How can we better constrain these measurements?

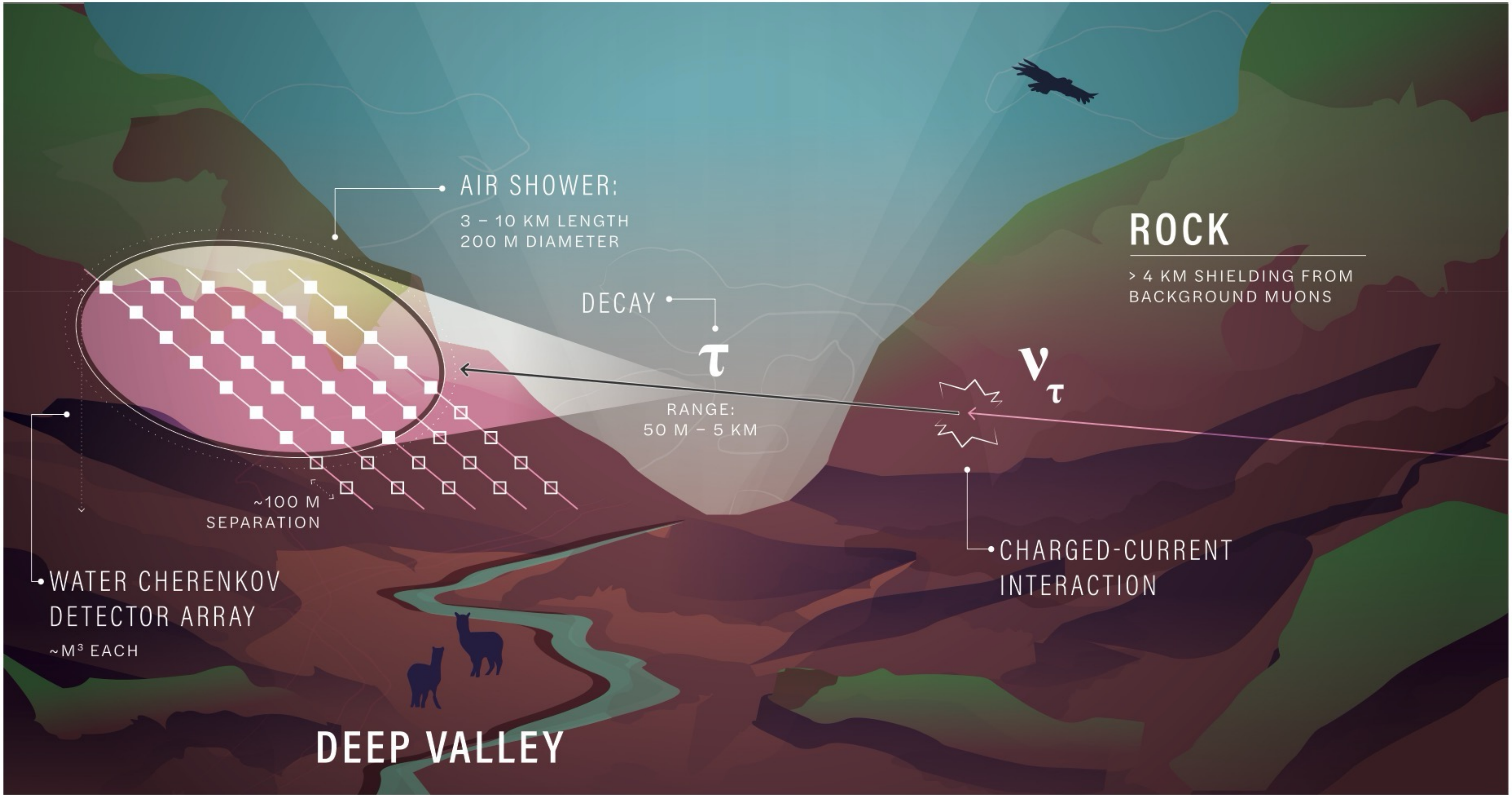
Next-Generation Prospects



- Community has heeded call for UHE neutrino observatories
  - But fewer experiments planned for 1-100 PeV
- TAMBO will:
  - Bridge the gap between HE & UHE observatories
  - Perform unambiguous measurement of astrophysical ν_τ flux



Queen's University
Niels Bohr Institute
MAX-PLANCK-INSTITUT FÜR MEDIZINISCHE FORSCHUNG
University of Nevada, Reno
COLUMBIA UNIVERSITY
Jet Propulsion Laboratory
California Institute of Technology
HARVARD UNIVERSITY
PennState
THE UNIVERSITY of ADELAIDE
PUCP
Universidad del País Vasco
Euskal Herriko Unibertsitatea
The University of the Basque Country
DIPC
Donostia International Physics Center
USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

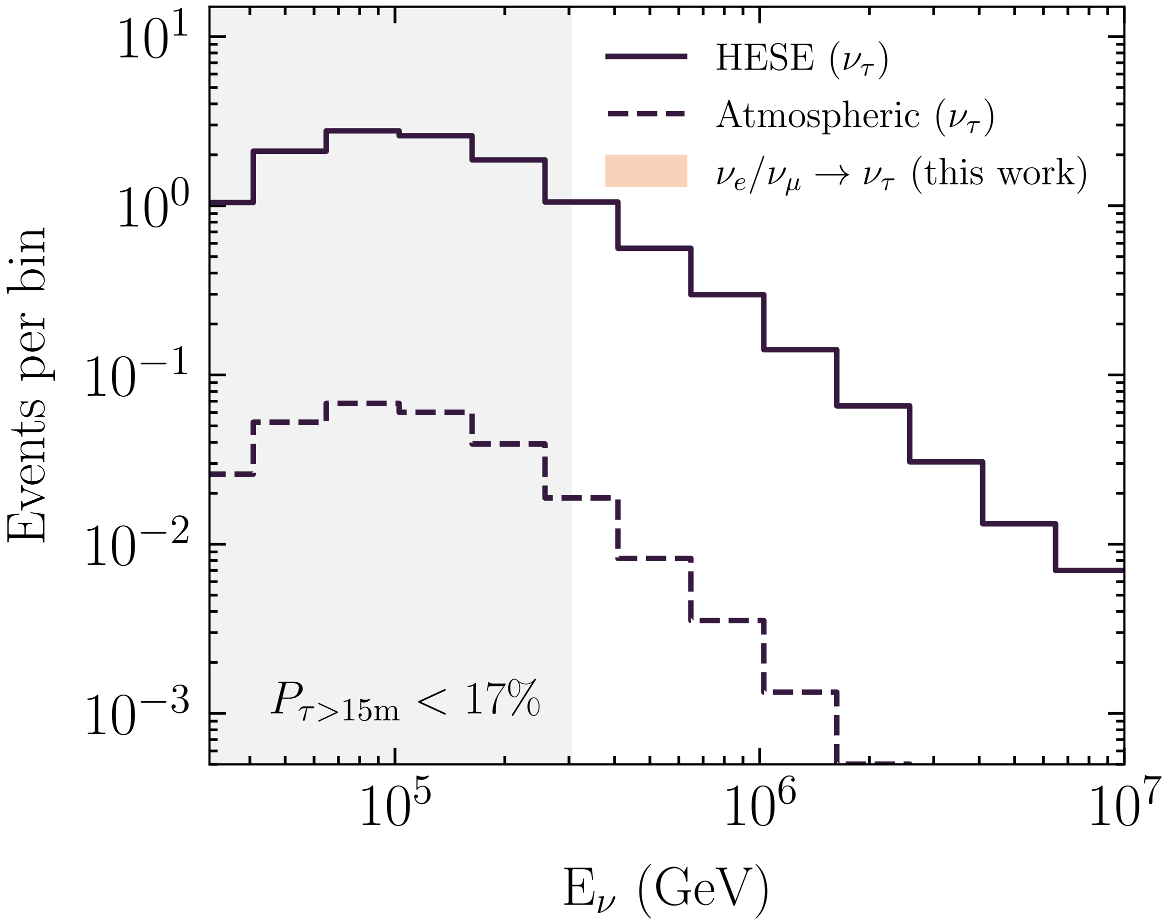


TAU AIR-SHOWER MOUNTAIN-BASED OBSERVATORY (TAMBO) · COLCA VALLEY, PERU

Why ν_τ?

- Complementary to water- & ice-Cherenkov detectors
  - ν_e/ν_τ discrimination difficult for many neutrino telescopes
- τ decay provides distinctive air-shower signature
- ν_τ provide high-purity astrophysical neutrino sample

A. Garcia Soto *et al.* PRL **128** 171101 (2022)

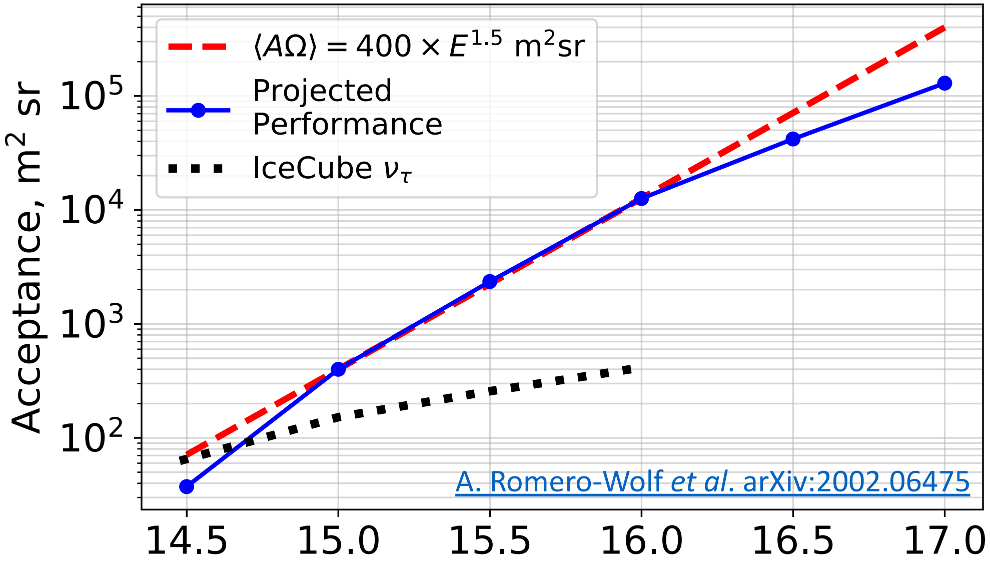


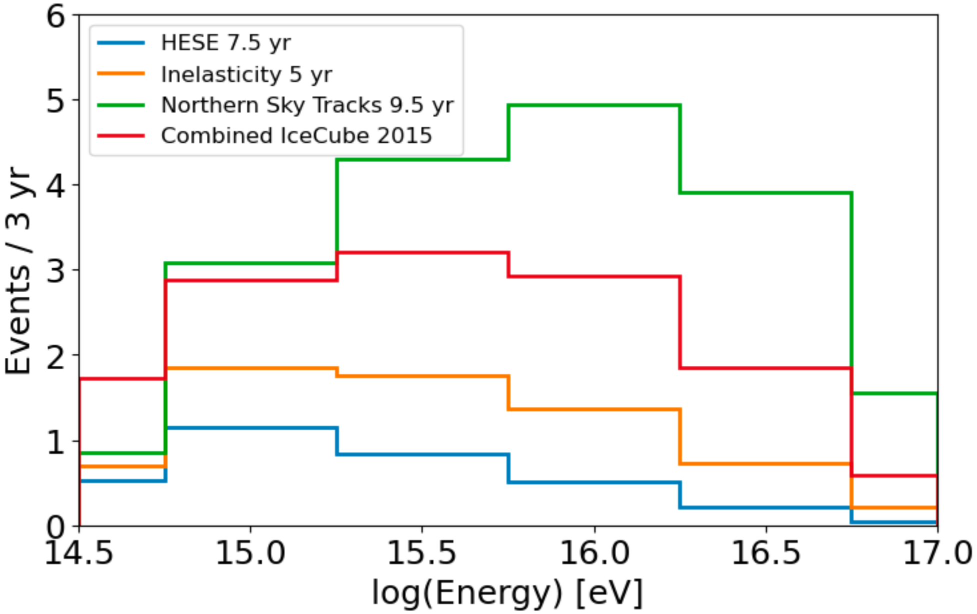
TAMBO Objectives

Physics Objective	Observatory Requirement
Determine if ν sources accelerate particles to >10 PeV	>5σ sensitivity to extrapolated IceCube flux from 1-100 PeV
Characterize 1-10 PeV flux by measuring ν_τ component	Efficient τ-flavor discrimination
Constrain multimessenger point source transients' properties	Tau angular resolution of $\lesssim 1°$

What Can We See with TAMBO?

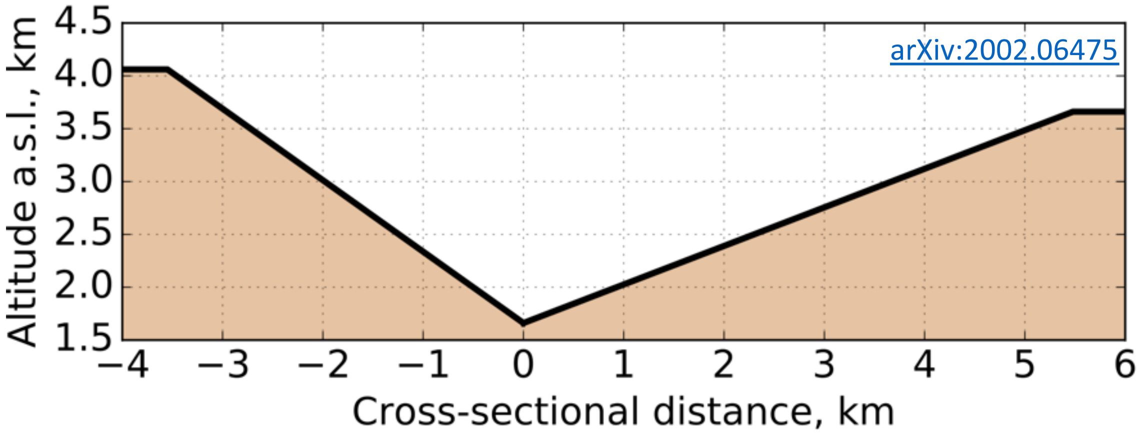
- Baseline design: 22k detectors, 150 m spacing
- Probe diffuse spectrum from 1-100 PeV
- Synergistic flavor ratio measurements
    - ν_τ discrimination difficult for many neutrino telescopes
- Dark matter from the Galactic Center
- Unique geometry for cosmic ray measurements





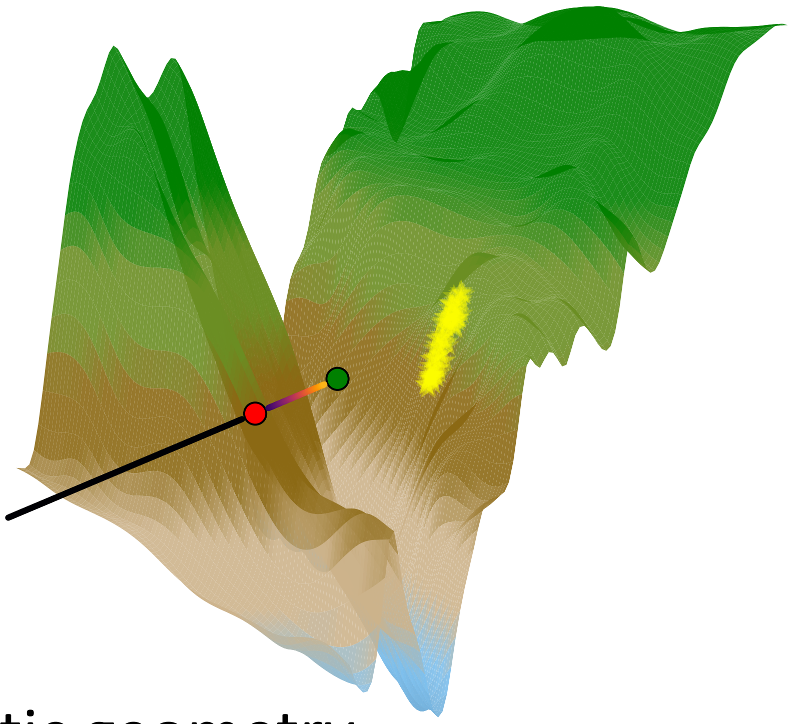
Developing Full Simulation

Preliminary Simulation



- Simplified geometry
- No treatment of τ energy losses
- Approximation of air shower physics

Full Simulation

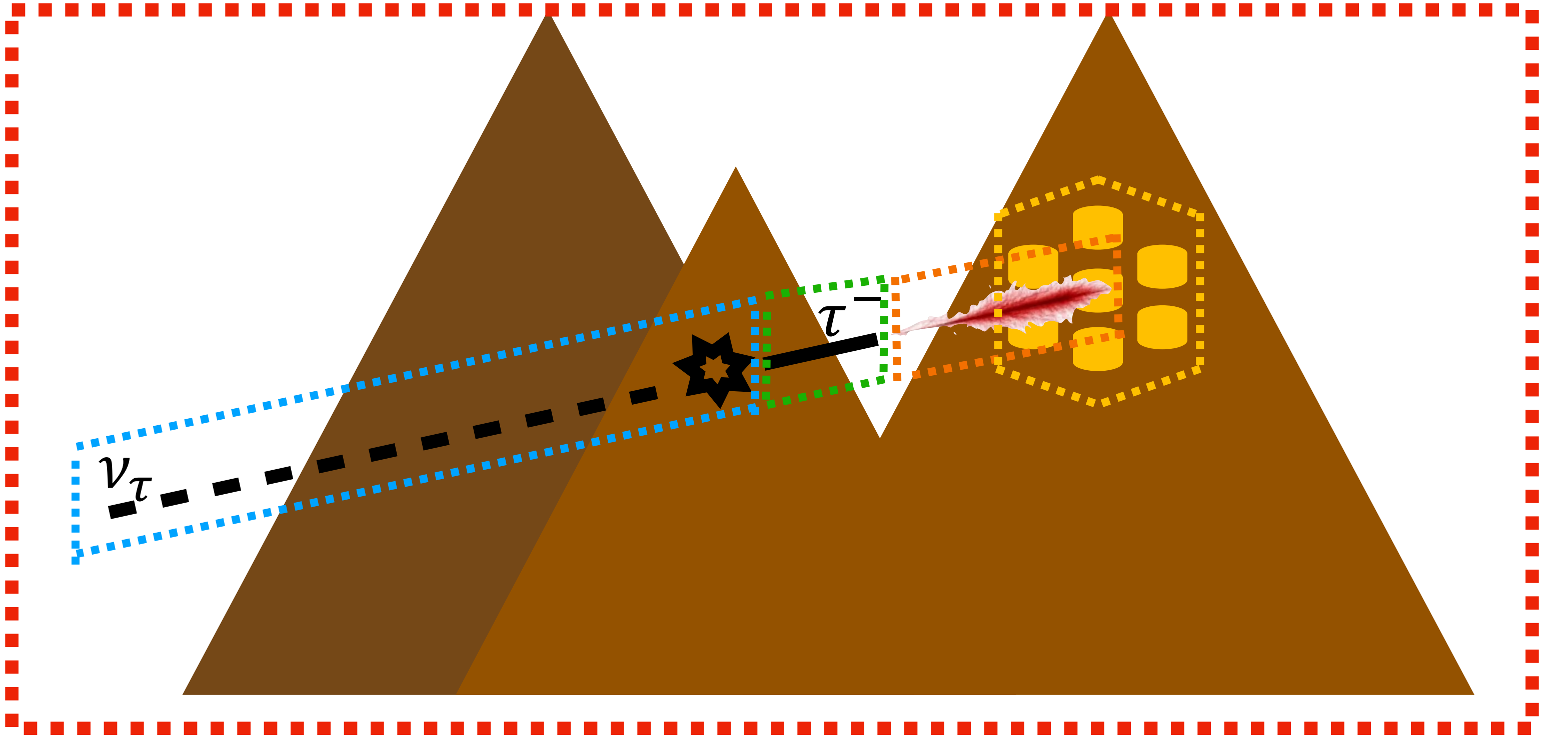


- Realistic geometry
- Full treatment of τ energy losses
- Air shower simulation with CORSIKA 8

Overview of Simulation Framework

Jeff Lazar

Pavel Zhelnin



Initial neutrino injection: Select initial neutrino properties, *i.e.* energy, direction, interaction vertex, *etc.*

Charged lepton propagation: Propagate outgoing charged lepton, accounting for energy losses and decay, to find decay point

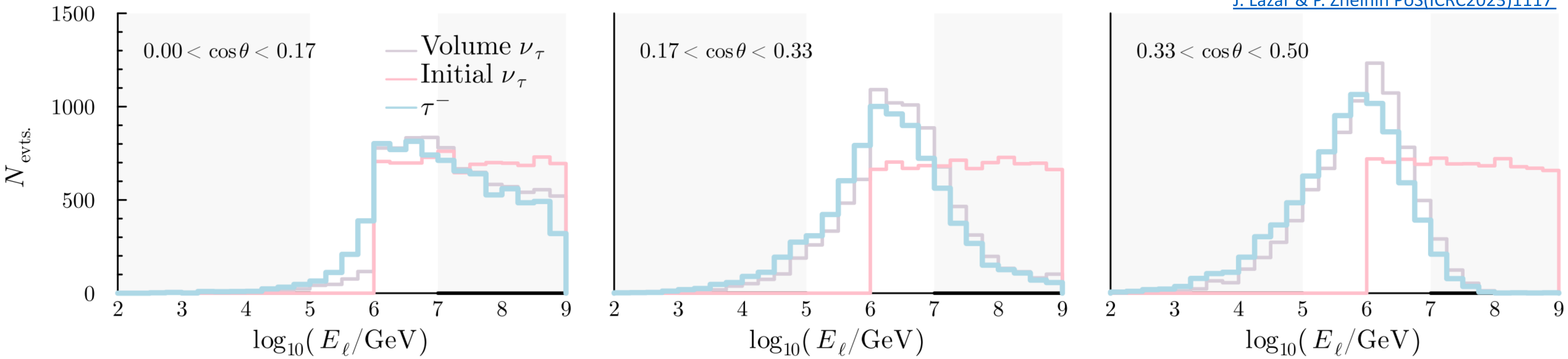
Air-shower simulation: Model shower development from lepton decay

Detector response: Simulate internal hardware to model what we will see

Event weighting: Remove unphysical remnants from selection of initial neutrino properties

Taking Advantage of Tau Regeneration

J. Lazar & P. Zhelnin PoS(ICRC2023)1117



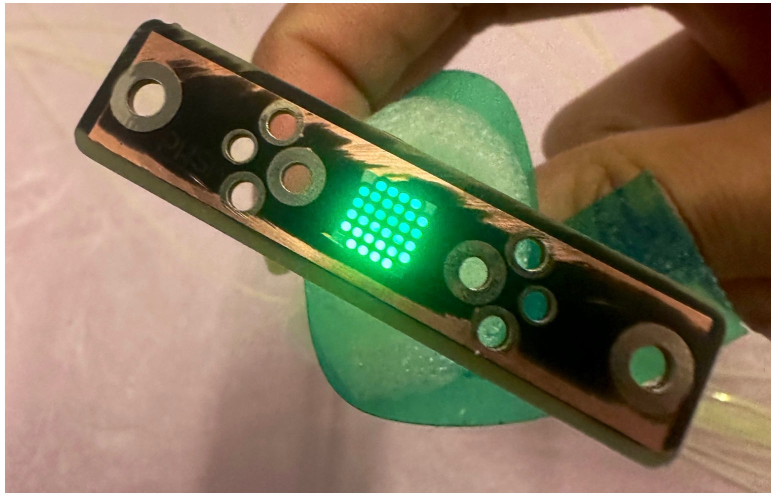
- Incoming ν_τ can undergo several $\nu_\tau \leftrightarrow \tau$ conversions in the Earth
- Updated simulation handles tau regeneration via `TauRunner`
- Results in higher rates than predicted by preliminary simulation

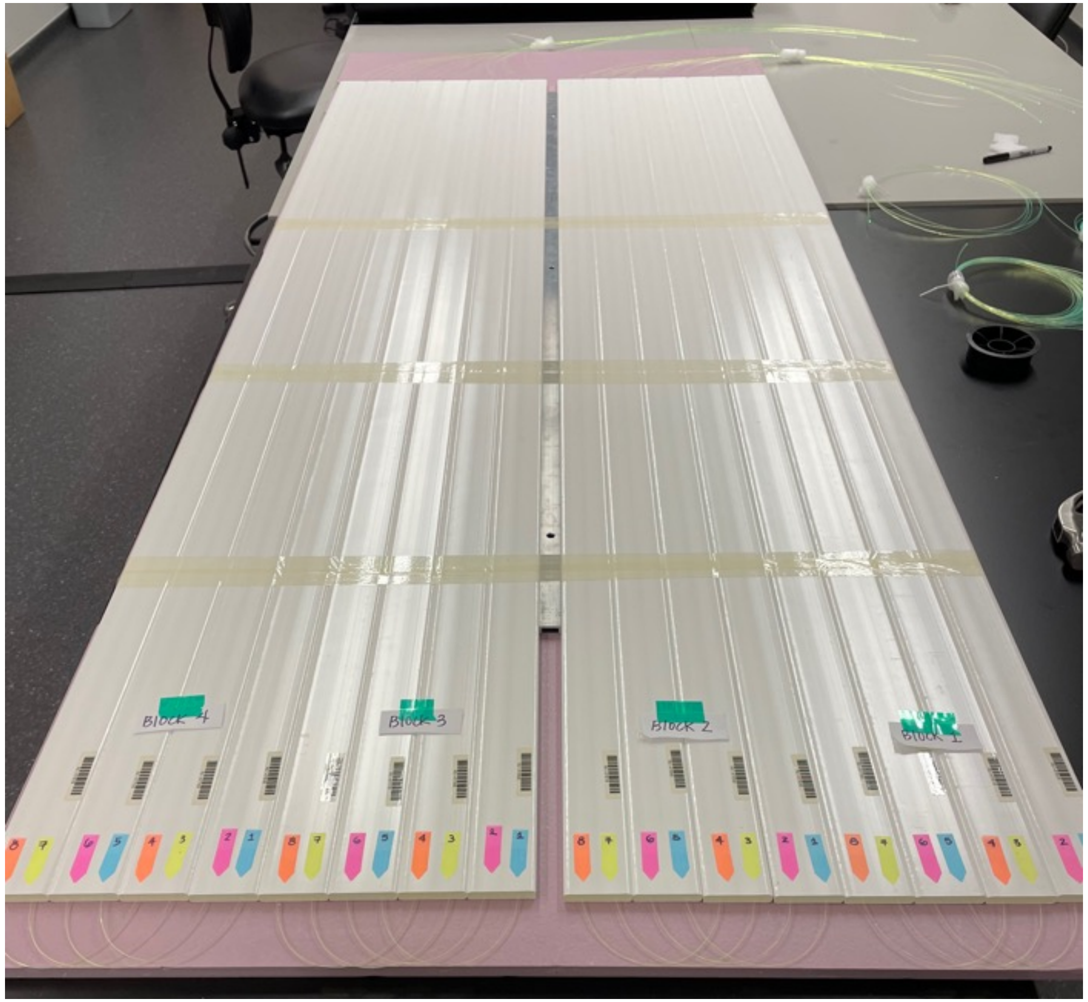
Detector Research & Development

- Detector technology: either water Cherenkov or plastic scintillator
  - No new technology development needed!

- Special considerations for TAMBO:
  - Difficulty of deploying detectors in canyon
  - Cost of producing thousands of detectors

Diyaselis Delgado





Community Partnership

Photo Credit: Universidad Nacional de San Agustin de Arequipa

- Met with Peruvian & local officials last autumn
- Developing workshop to help scientists interface & form partnership with local communities
- Aim to engage local community as partners

Summary

- TAMBO will bridge gap between HE and UHE astrophysical neutrino experiments
- Enables searches for new physics via flavor ratio measurements
- Fully-featured simulation nearing completion
- Development of prototype detectors underway
- Interested in joining? Contact (me || Carlos Argüelles) at will_thompson@g.harvard.edu, carguelles@g.harvard.edu

Thanks for your attention!