MODE workshop

(Valencia, Spain)

TAMBO:

Searching for ν_τ in the Peruvian Andes

Alfonso Garcia

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Why neutrino astronomy?

- Neutrinos interact weakly
  - Scape dense environments
  - Point to source
  - Hard to detect -> big detectors

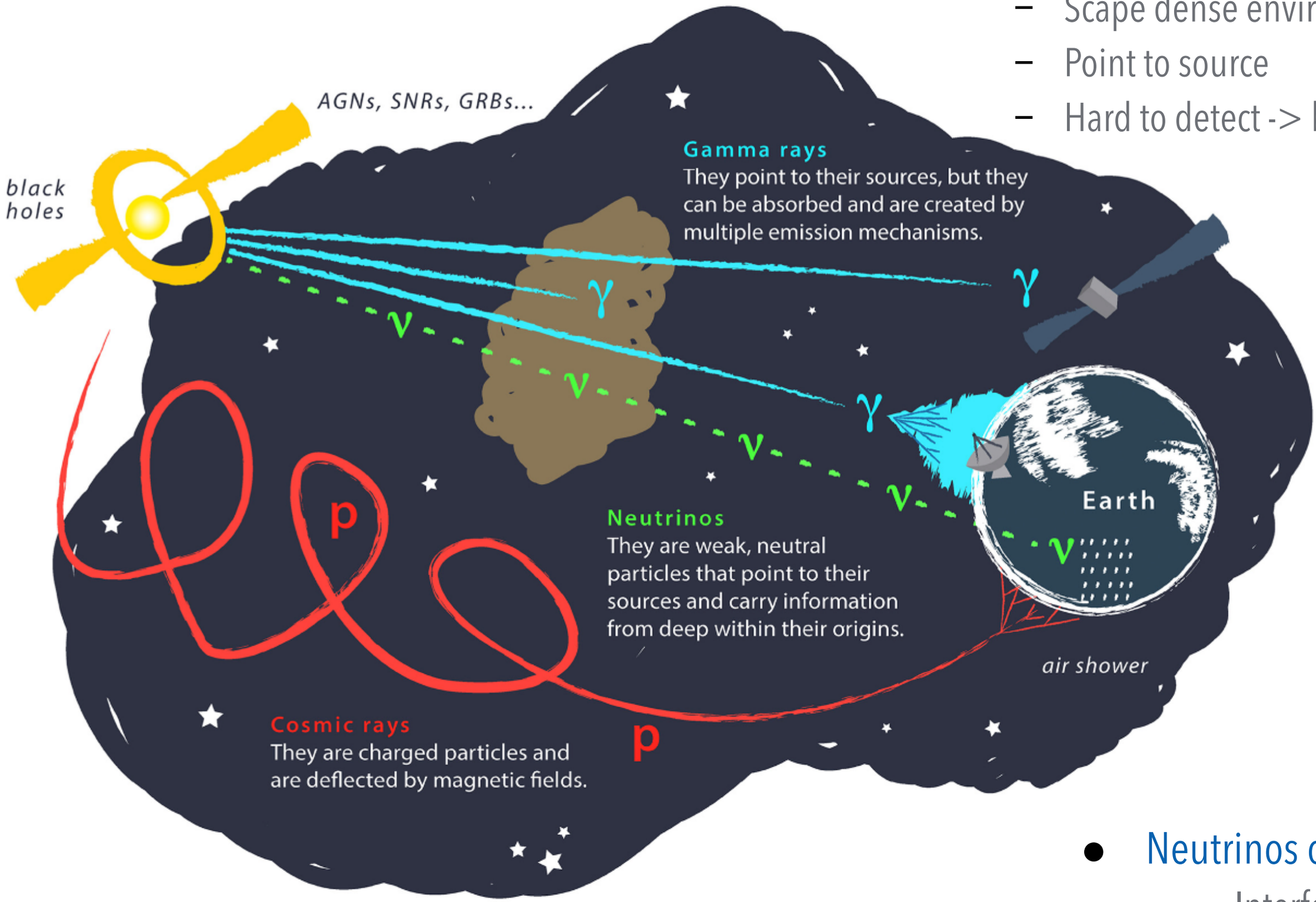
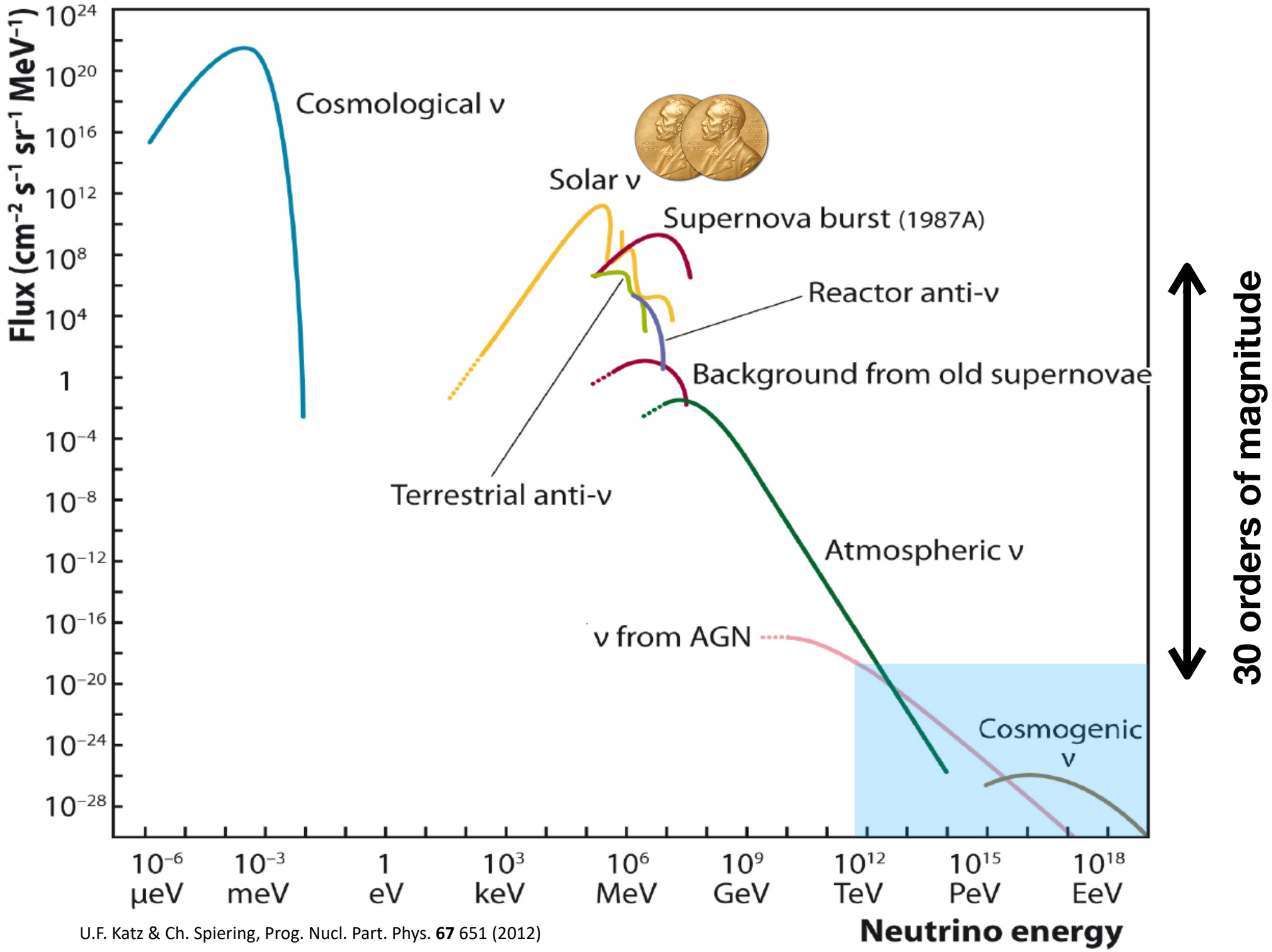


Image Credit: IceCube Collaboration/WIPAC, Juan Antonio Aguilar, and Jamie Yang.

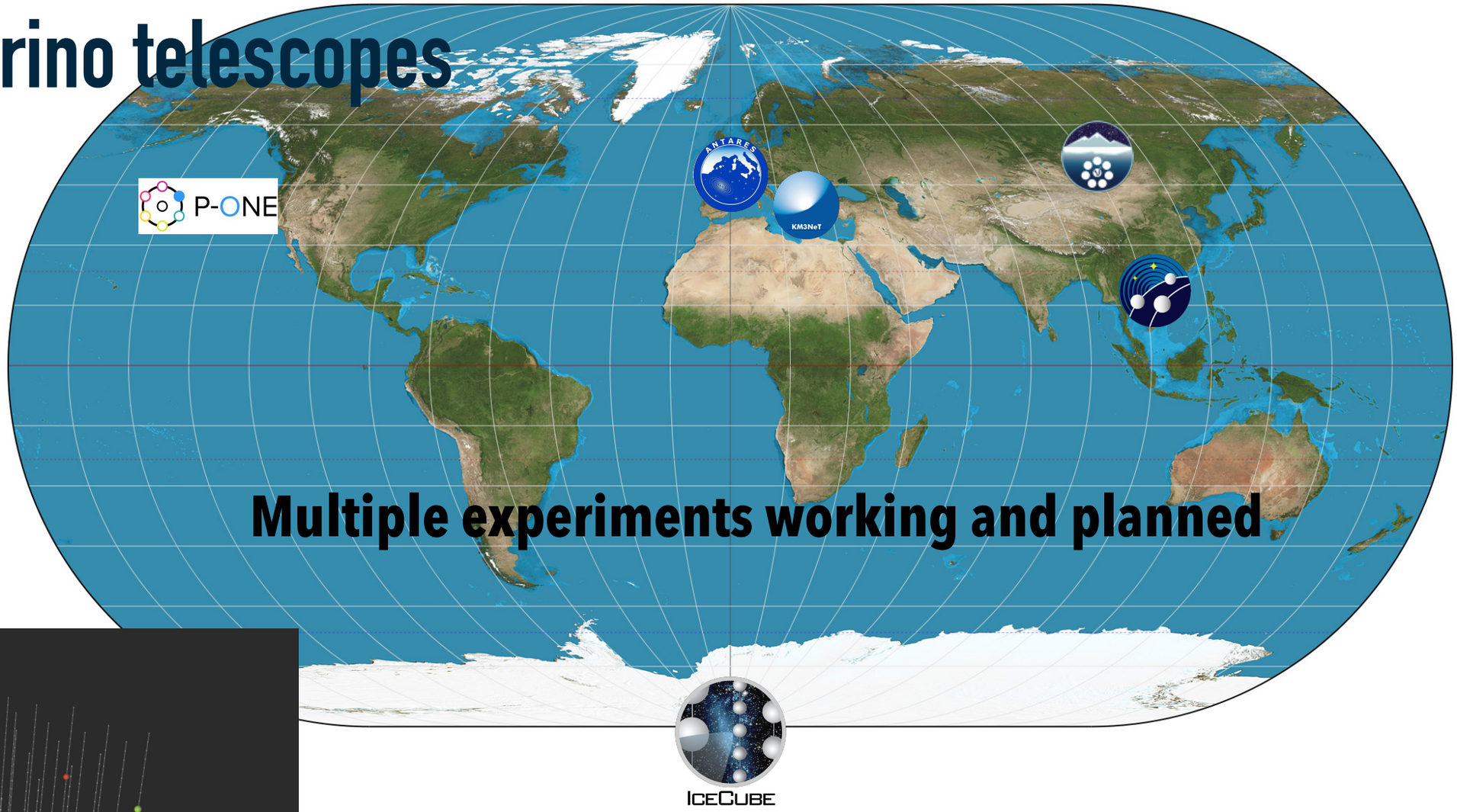
- Neutrinos oscillate
  - Interferometers

Hard to detect and not many…

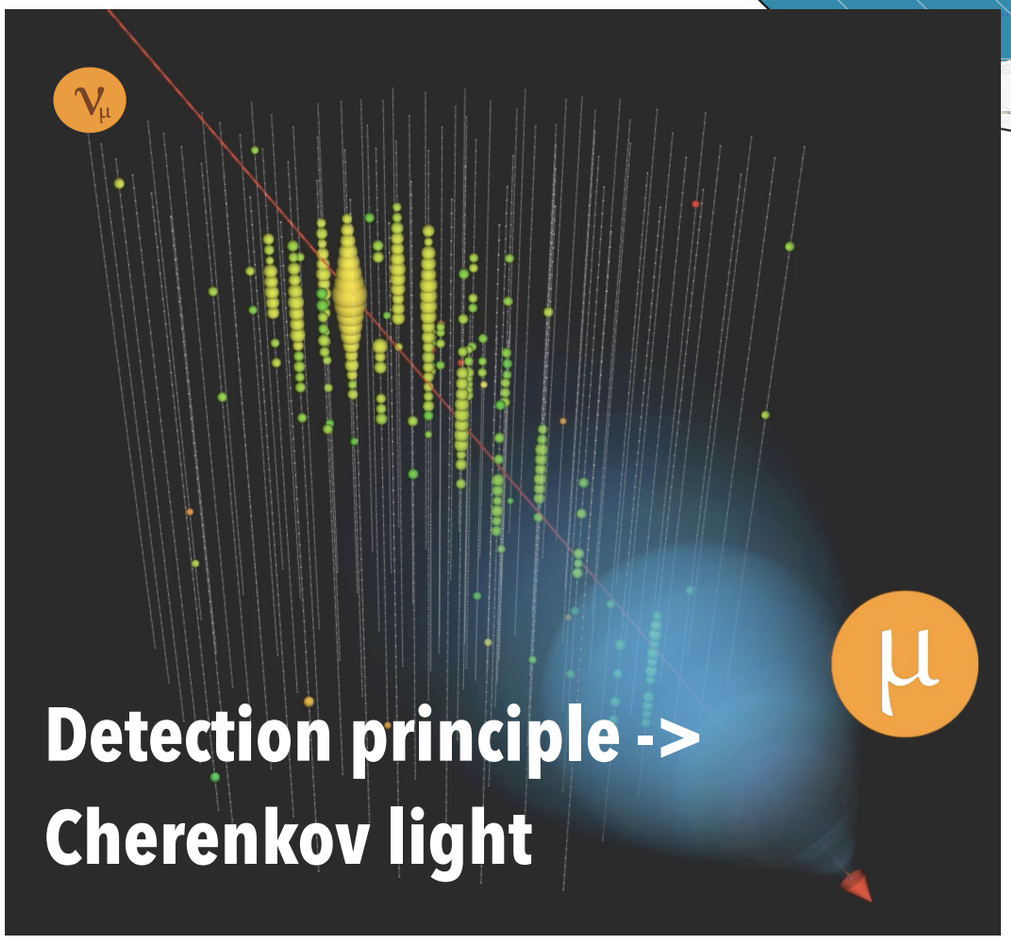


U.F. Katz & Ch. Spiering, Prog. Nucl. Part. Phys. **67** 651 (2012)

(Current) Neutrino telescopes

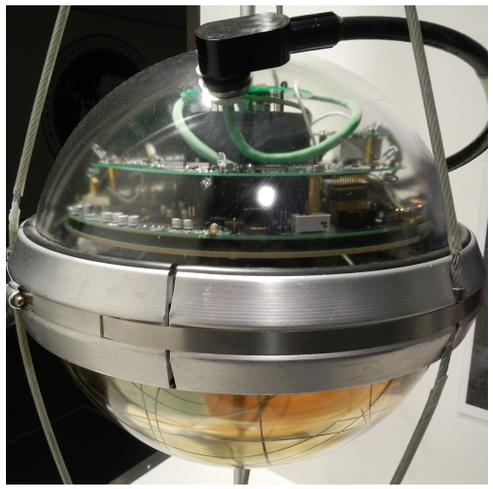


Multiple experiments working and planned



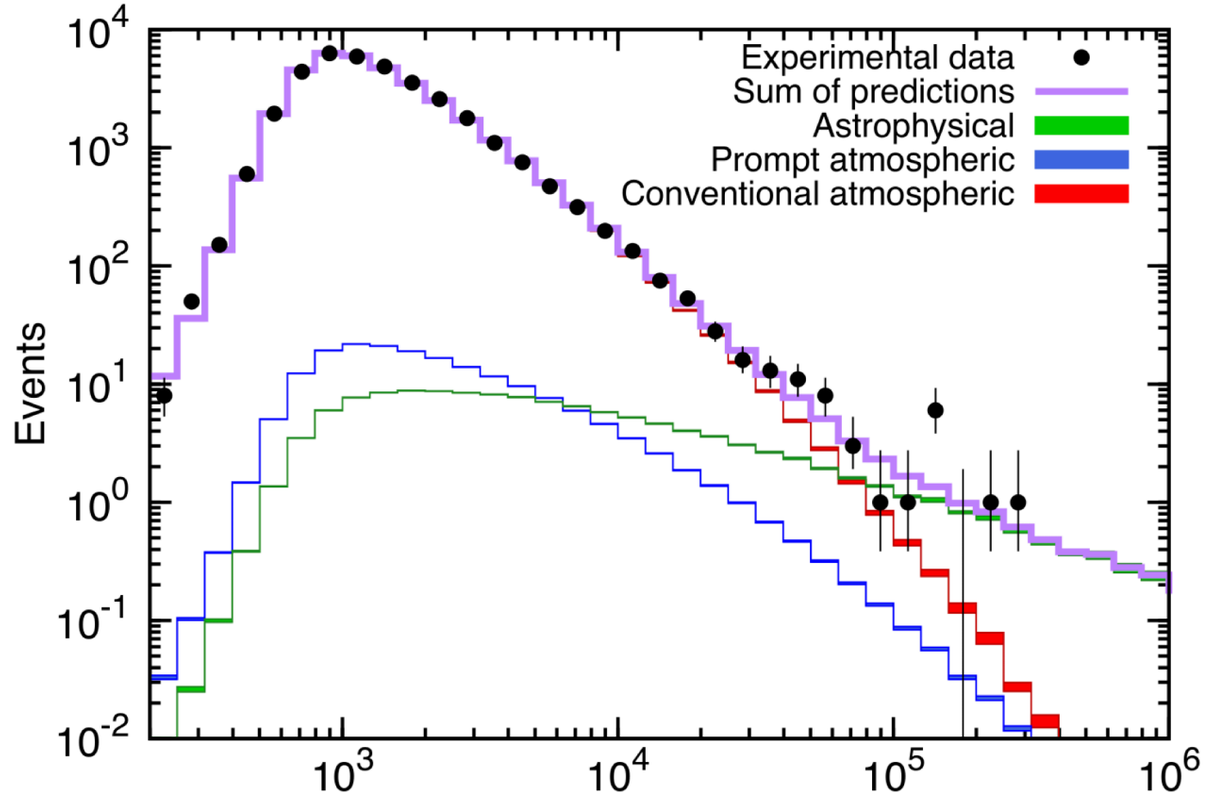
Detection principle -> Cherenkov light

Similar technology -> PMTs

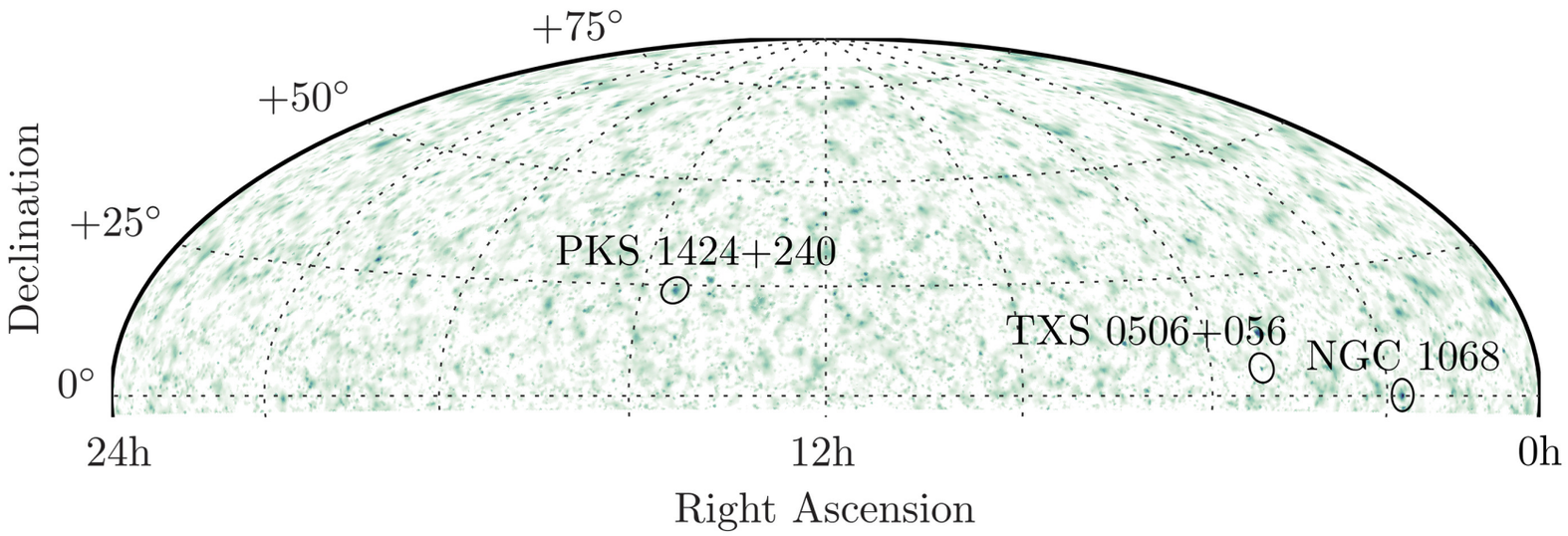


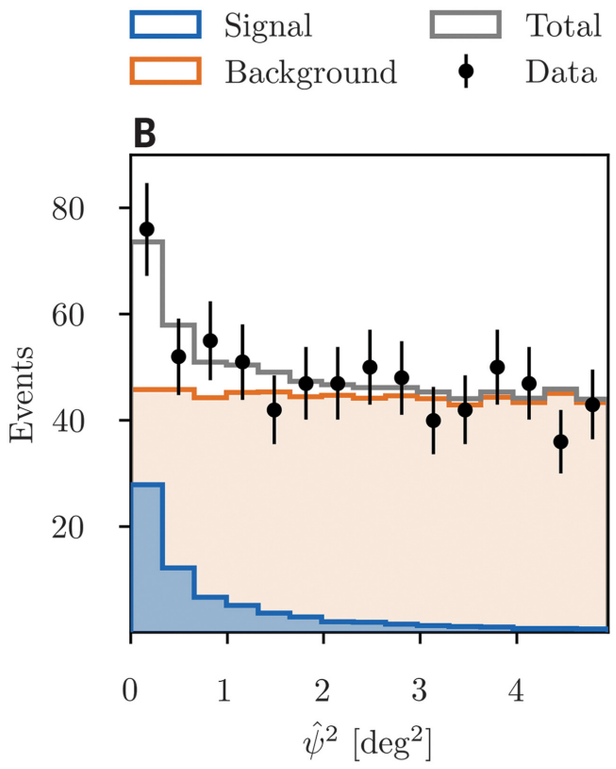
What have we learned?

- High energy neutrinos are produce in the Universe!



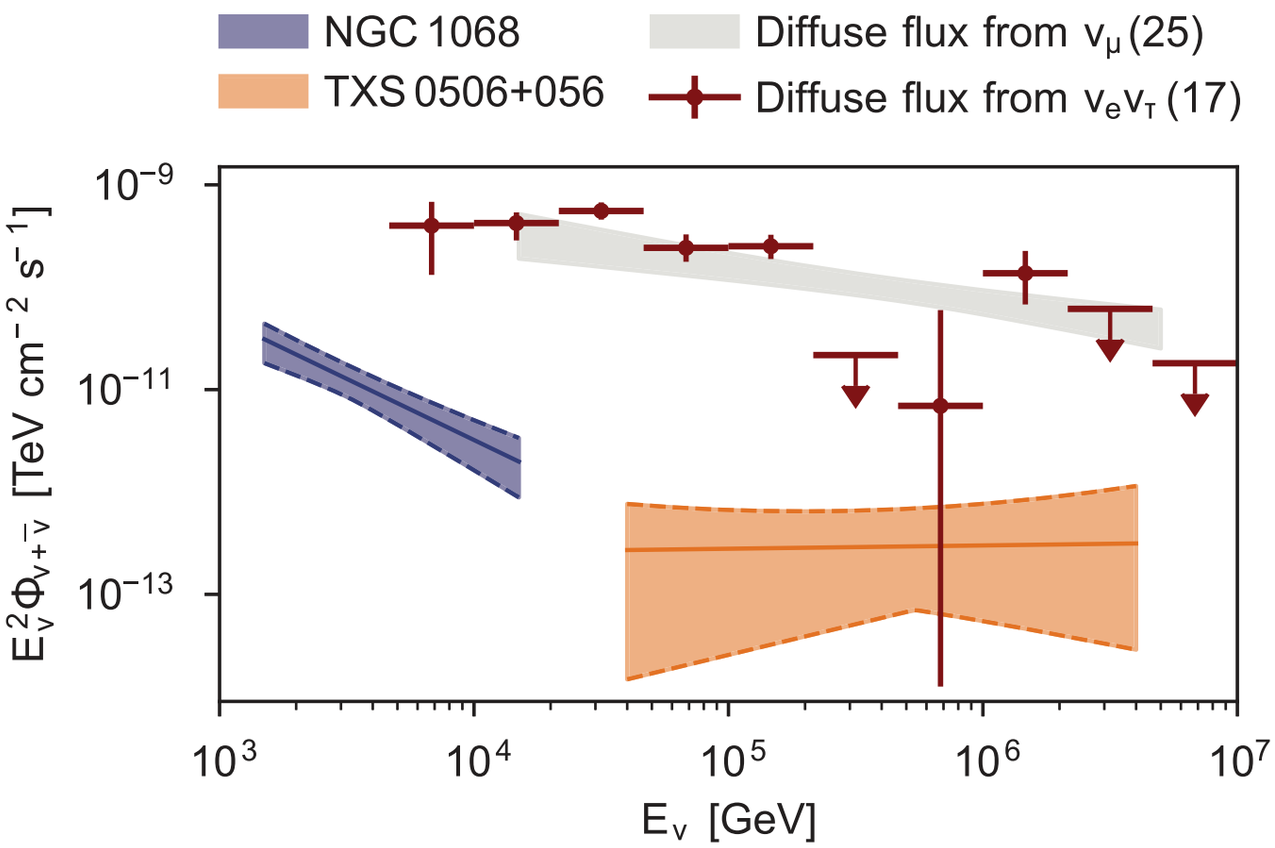
- IceCube has identified the first sources!
  - TXS0506+056 -> blazar
  - NGC1068 -> Seyfert galaxy

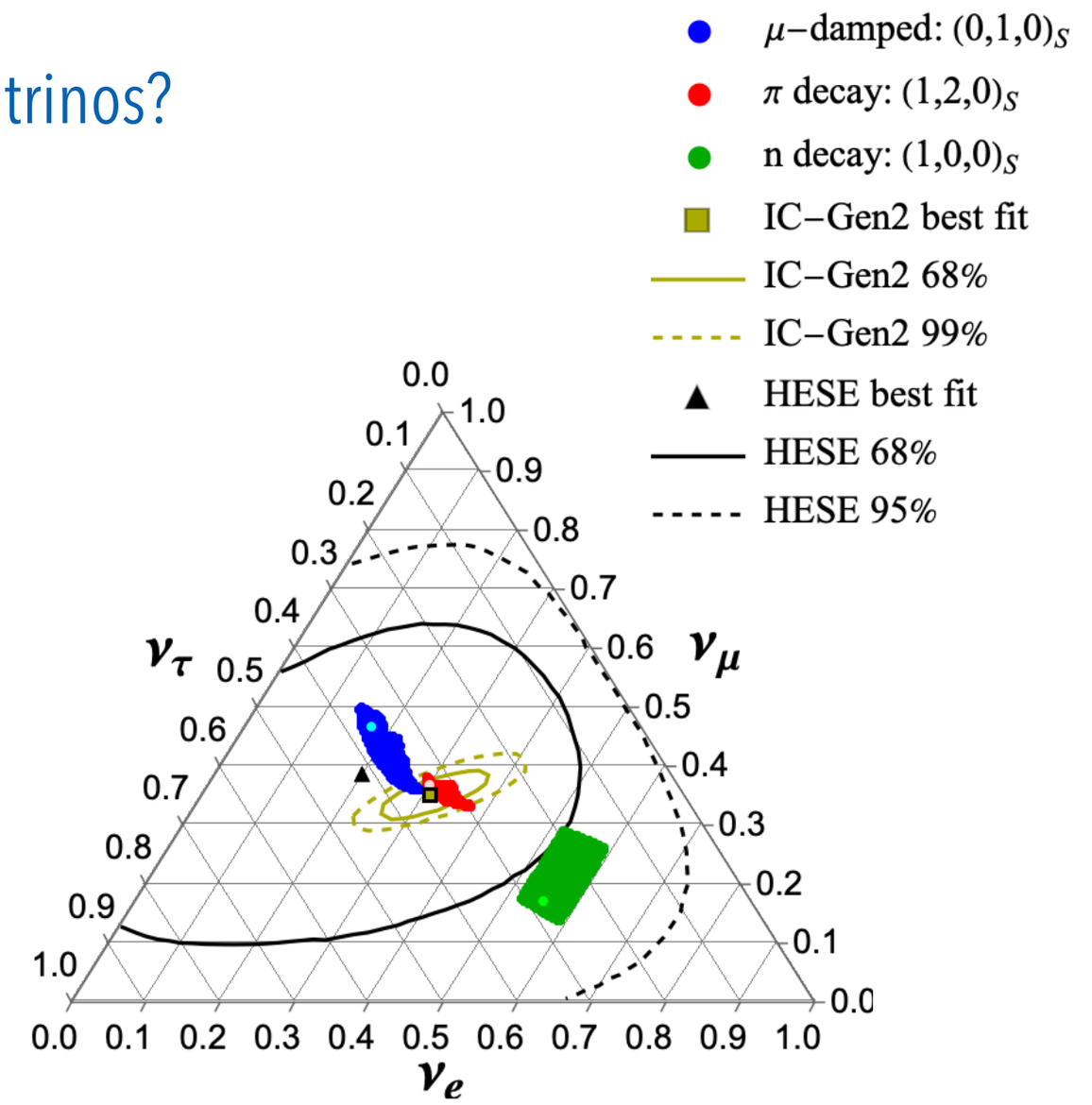




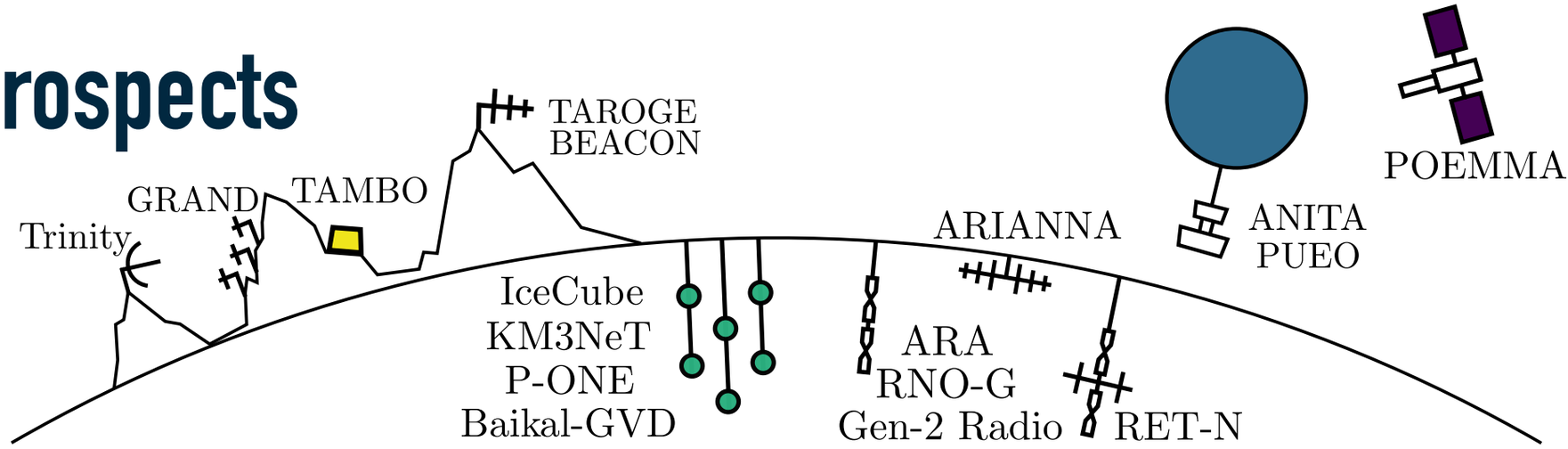
Open questions

- What is producing these neutrinos?
- Are there even higher energy neutrino?
- What is the flavor composition of these neutrinos?

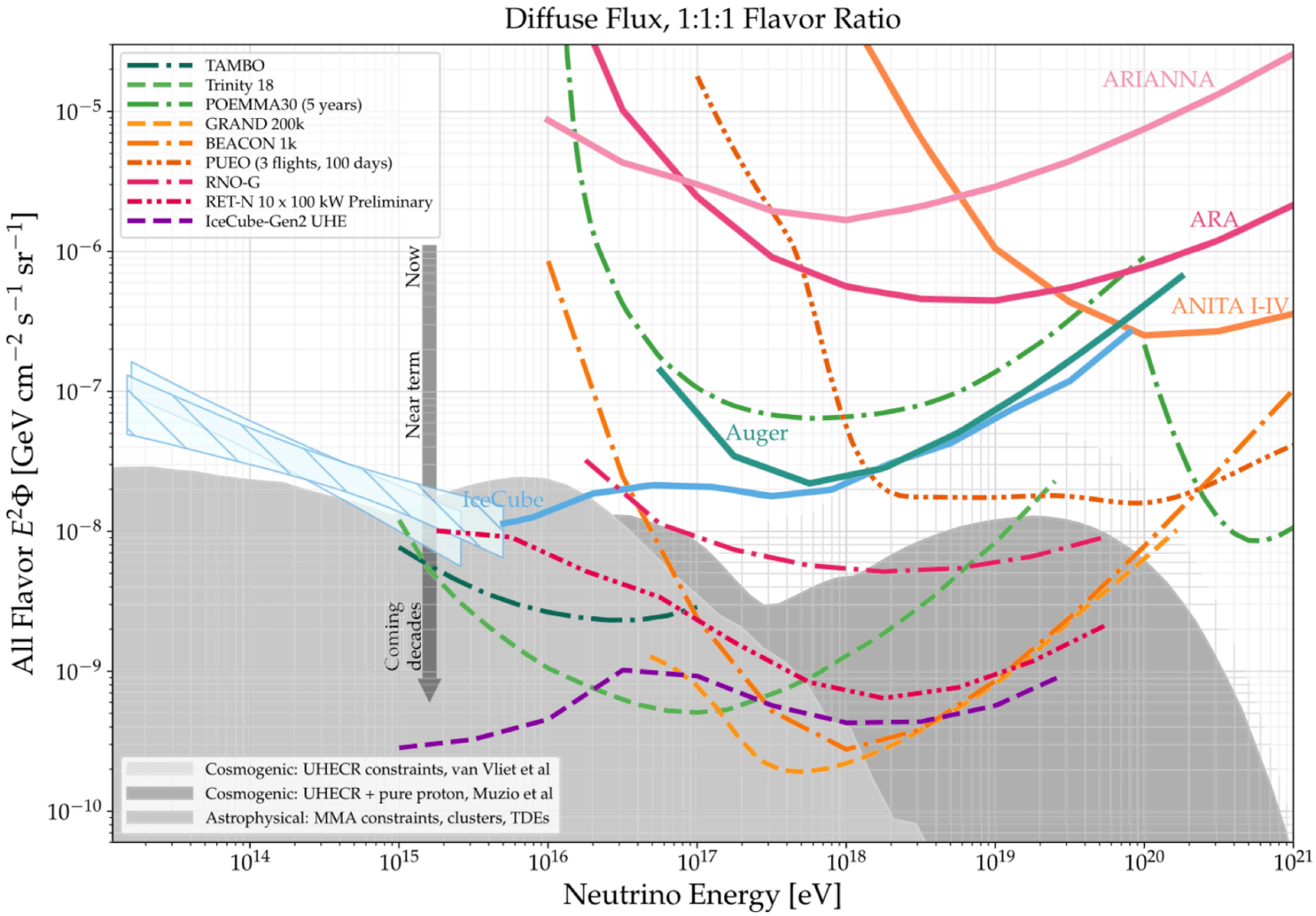




Next-generation prospects



- New designs/technologies to increase the target volume.



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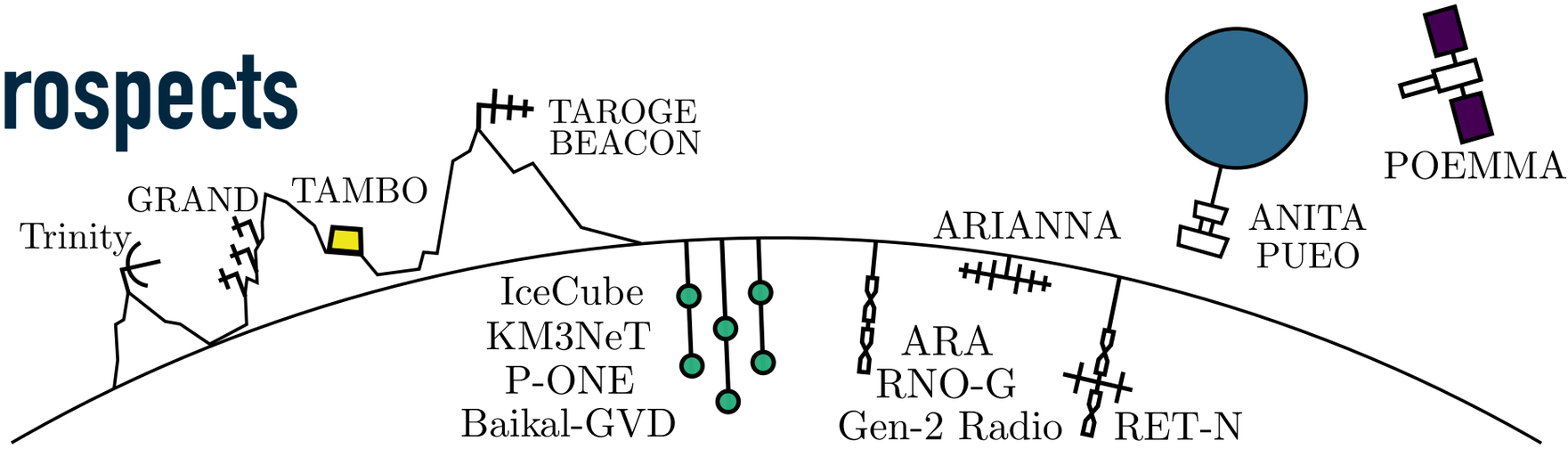

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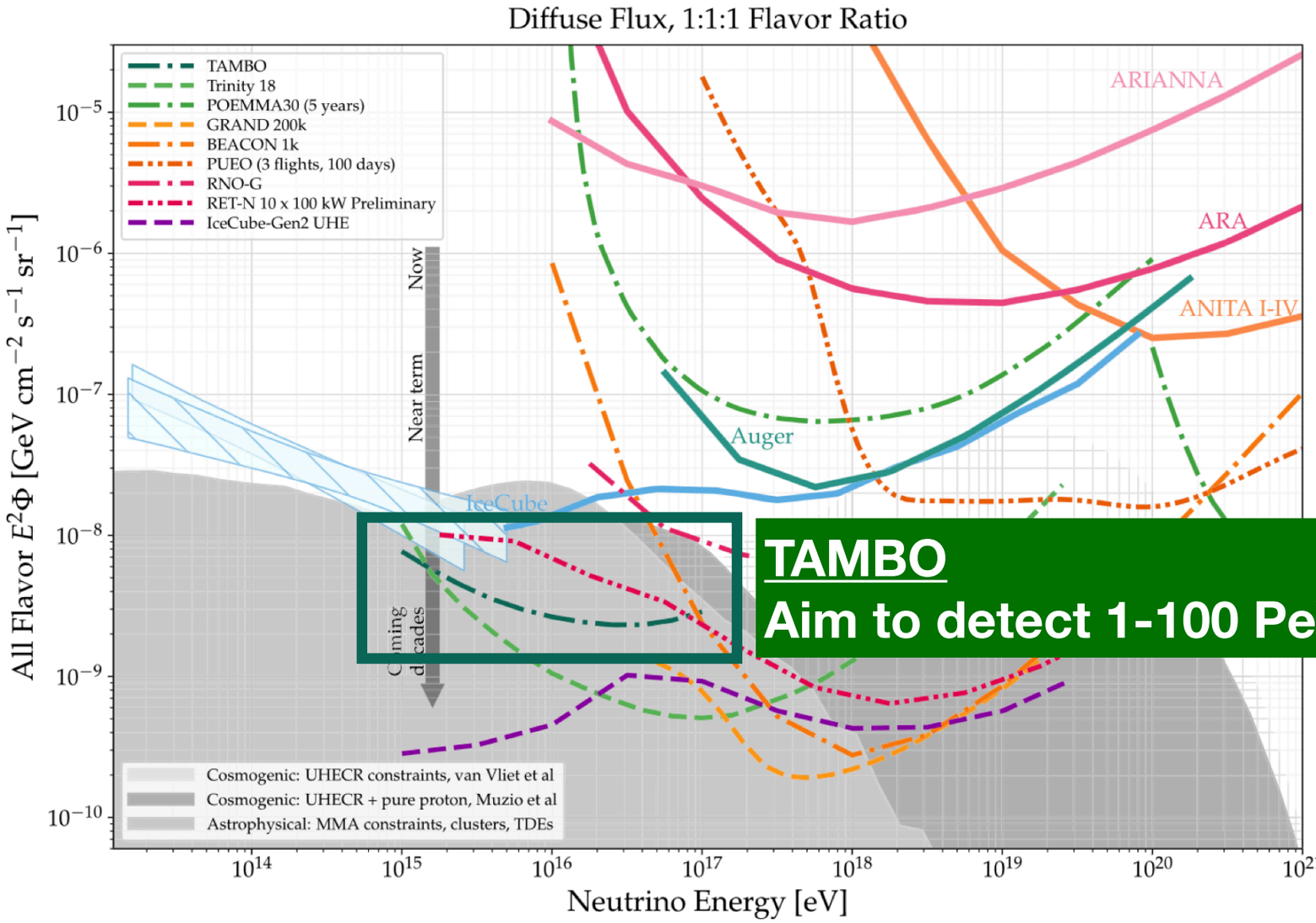
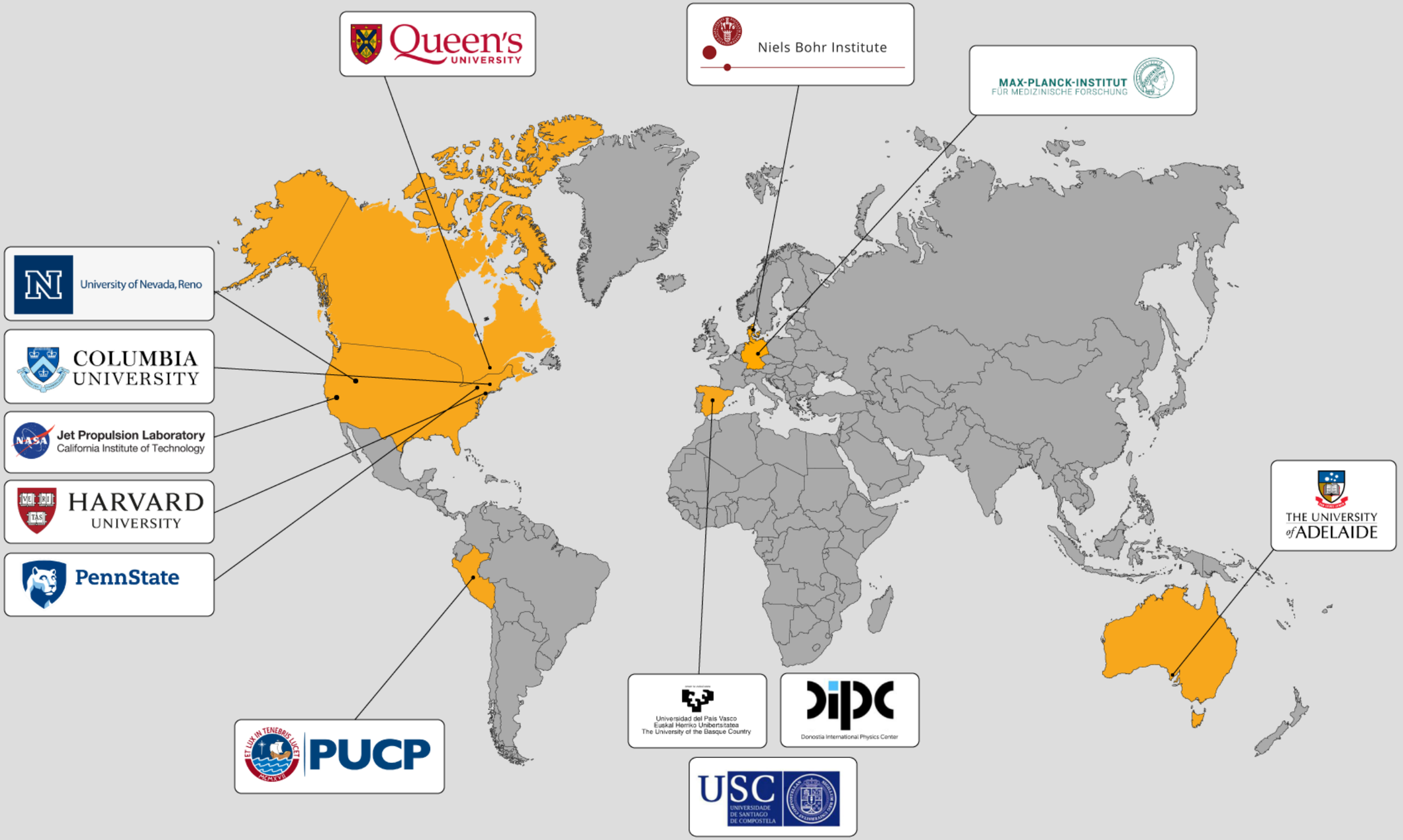
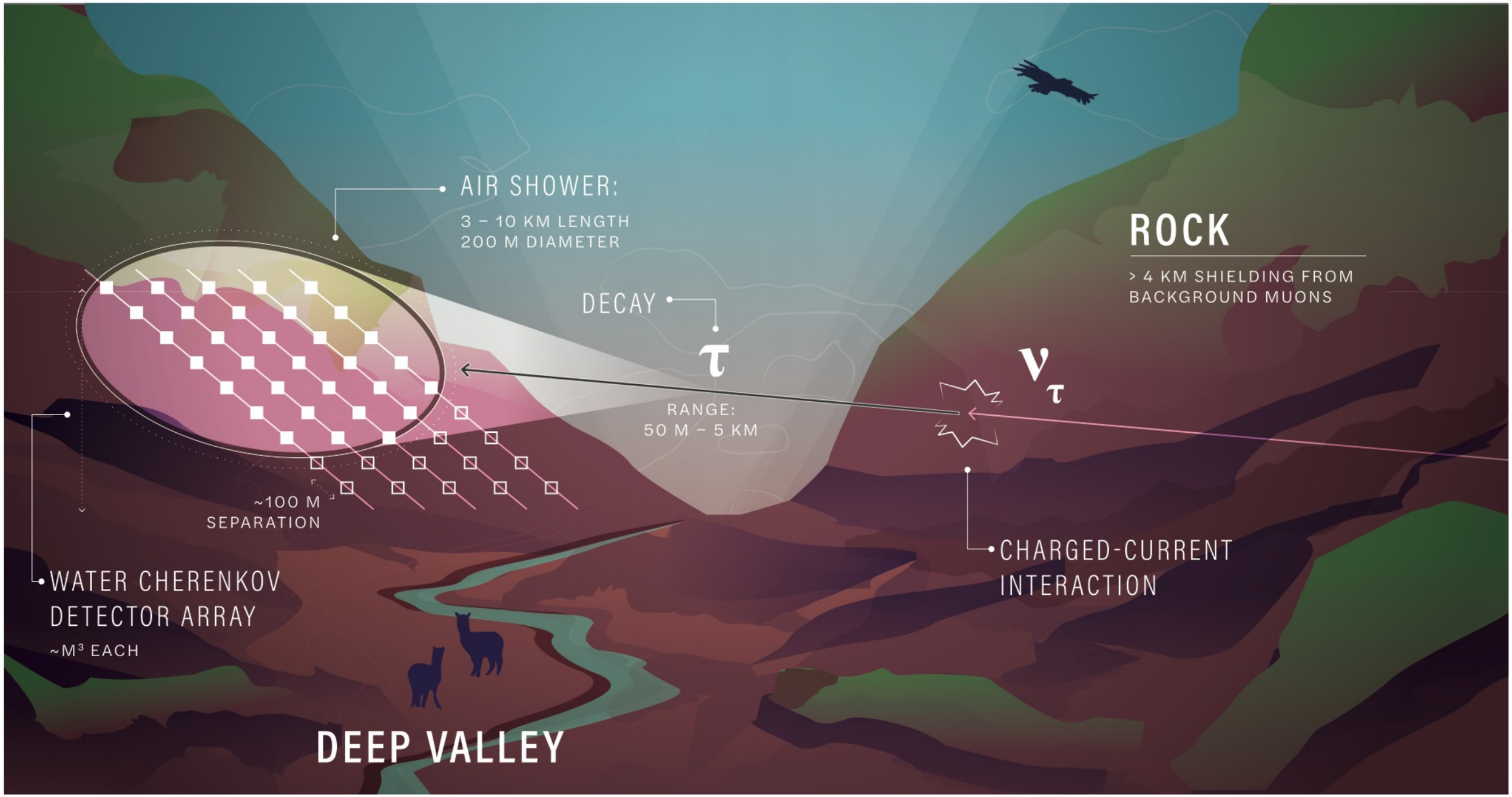
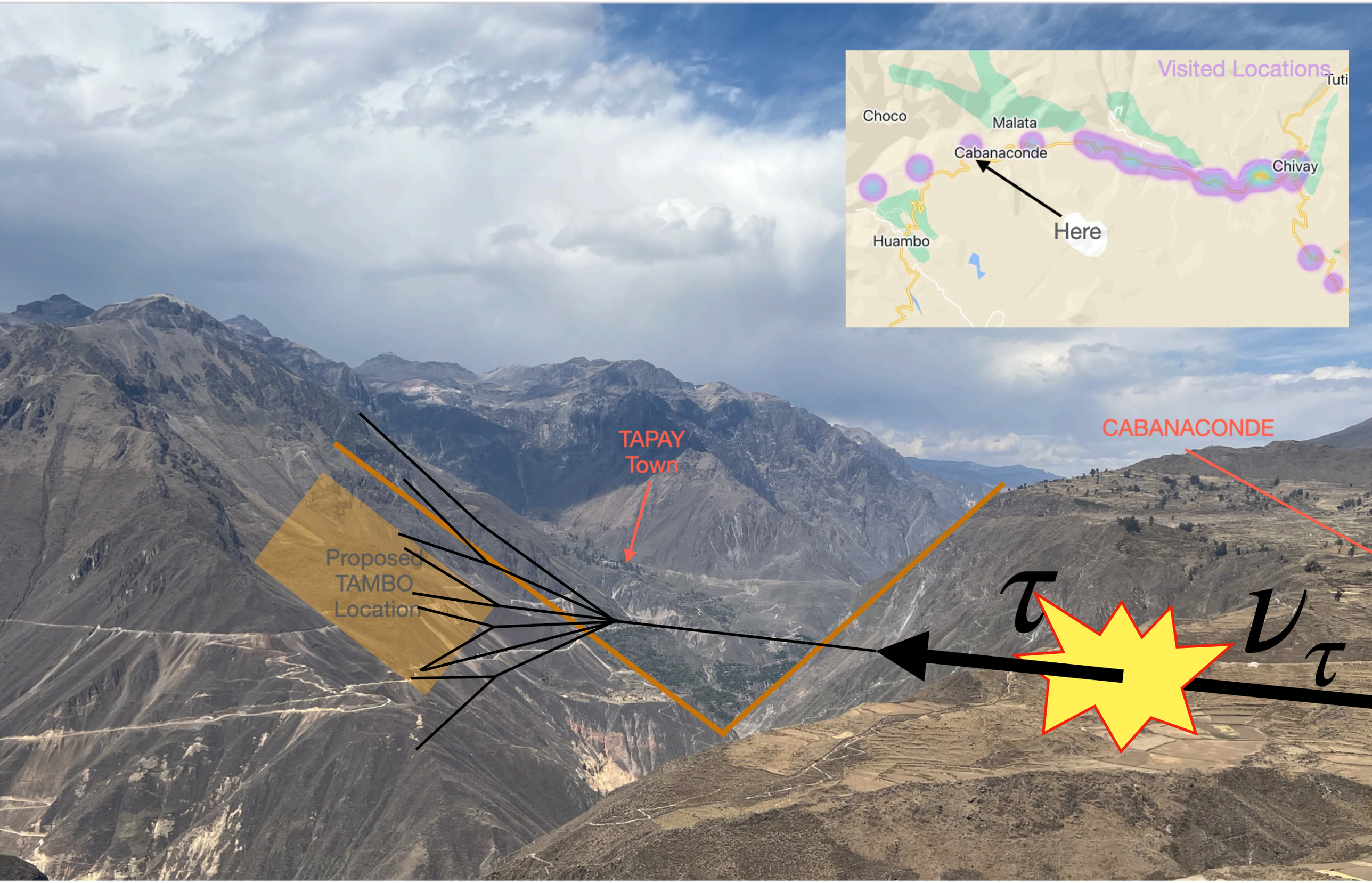


TAMBO
Aim to detect 1-100 PeV ν_τ neutrinos


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
Donostia International Physics Center
USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA



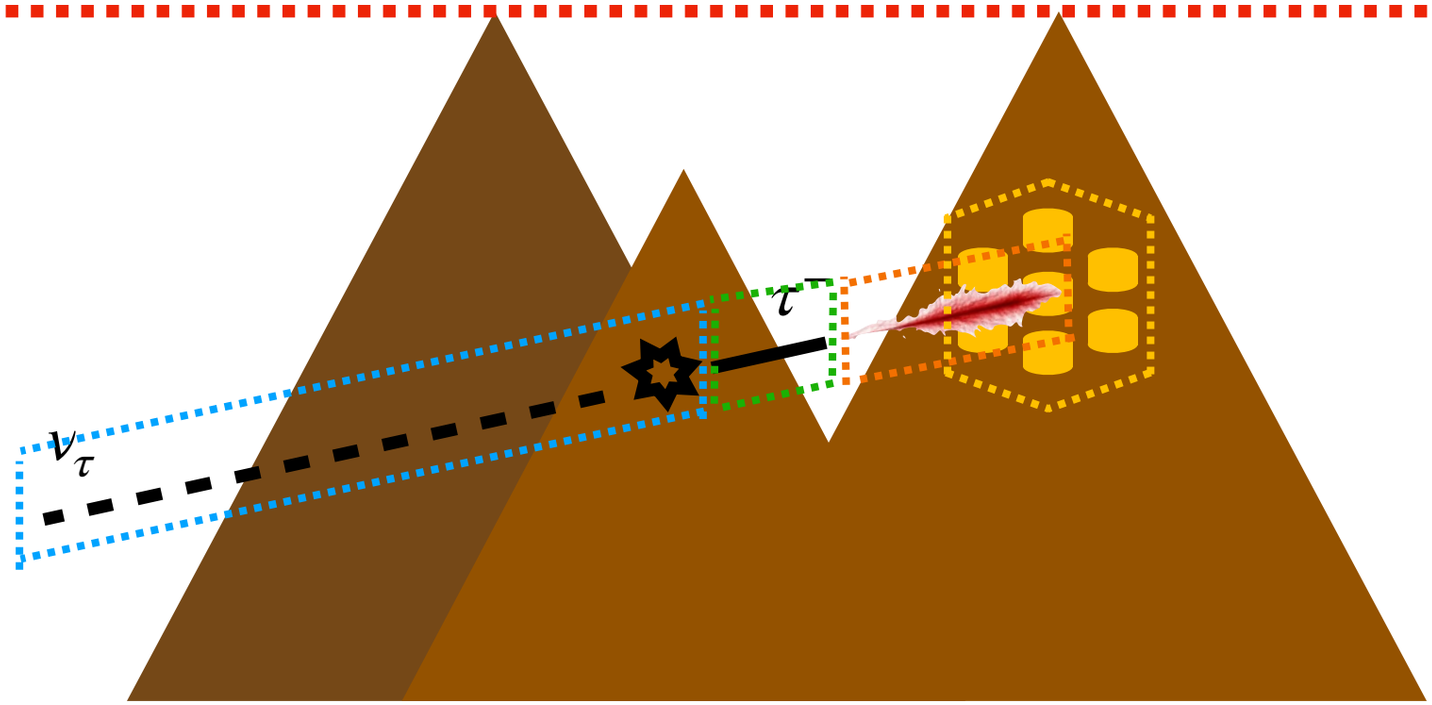
TAU AIR-SHOWER MOUNTAIN-BASED OBSERVATORY (TAMBO) · COLCA VALLEY, PERU


Visited Locations
Choco
Malata
Cabanaconde
Chivay
Here
Huambo
TAPAY
Town
CABANACONDE
Proposed
TAMBO
Location
τ
ν_τ

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

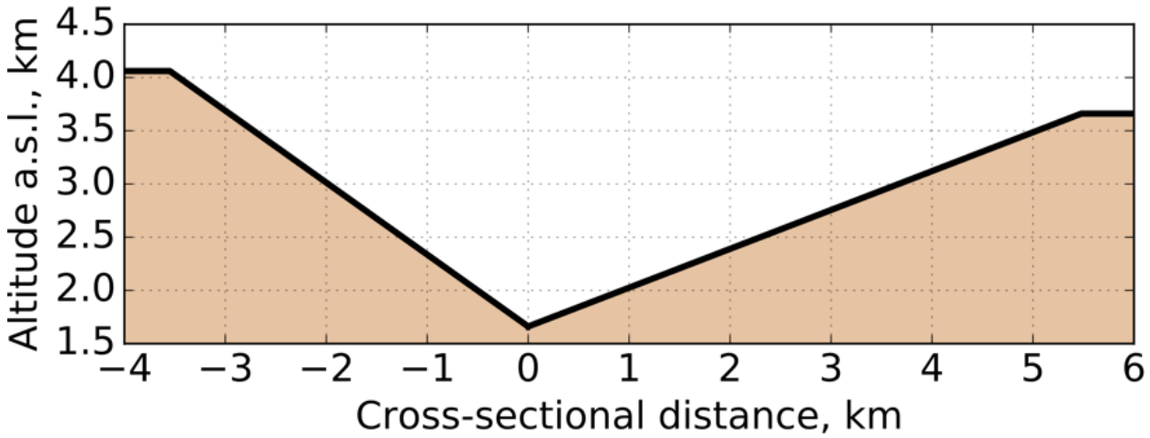
Air-shower simulation: Model shower development from lepton decay

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

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

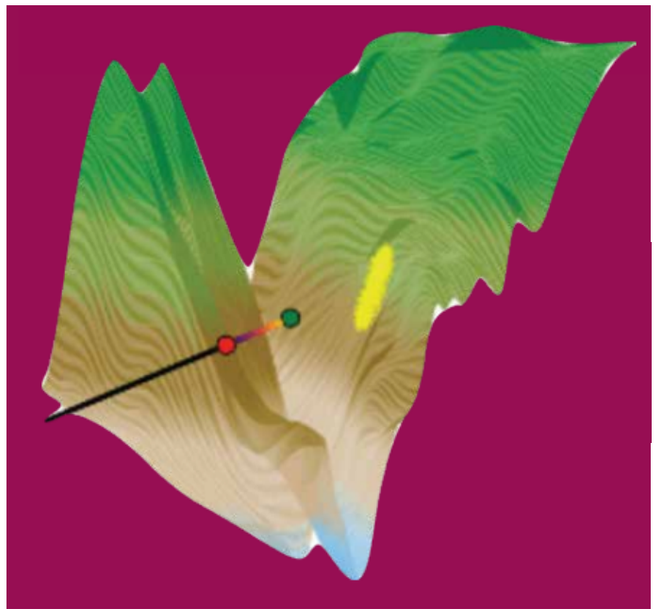
Developing Full Simulation

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

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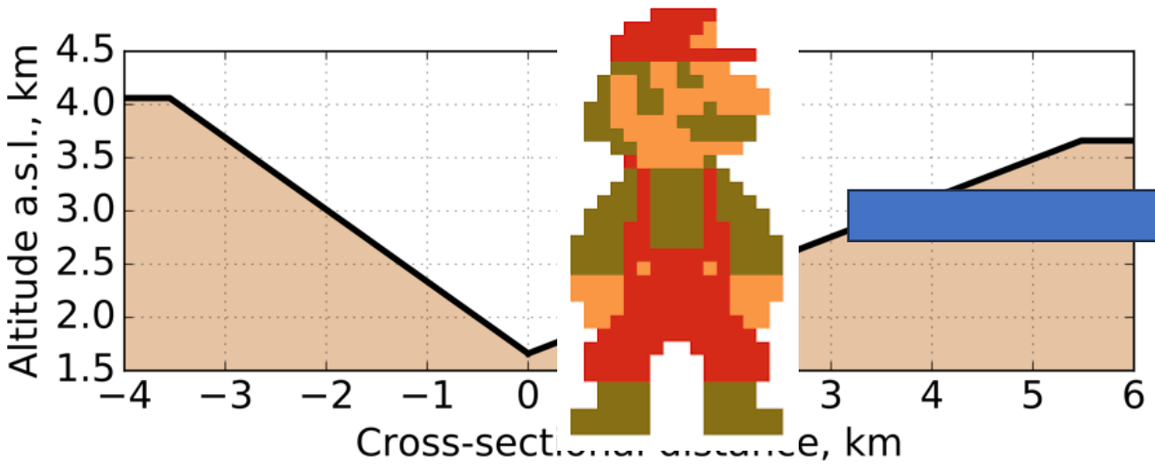

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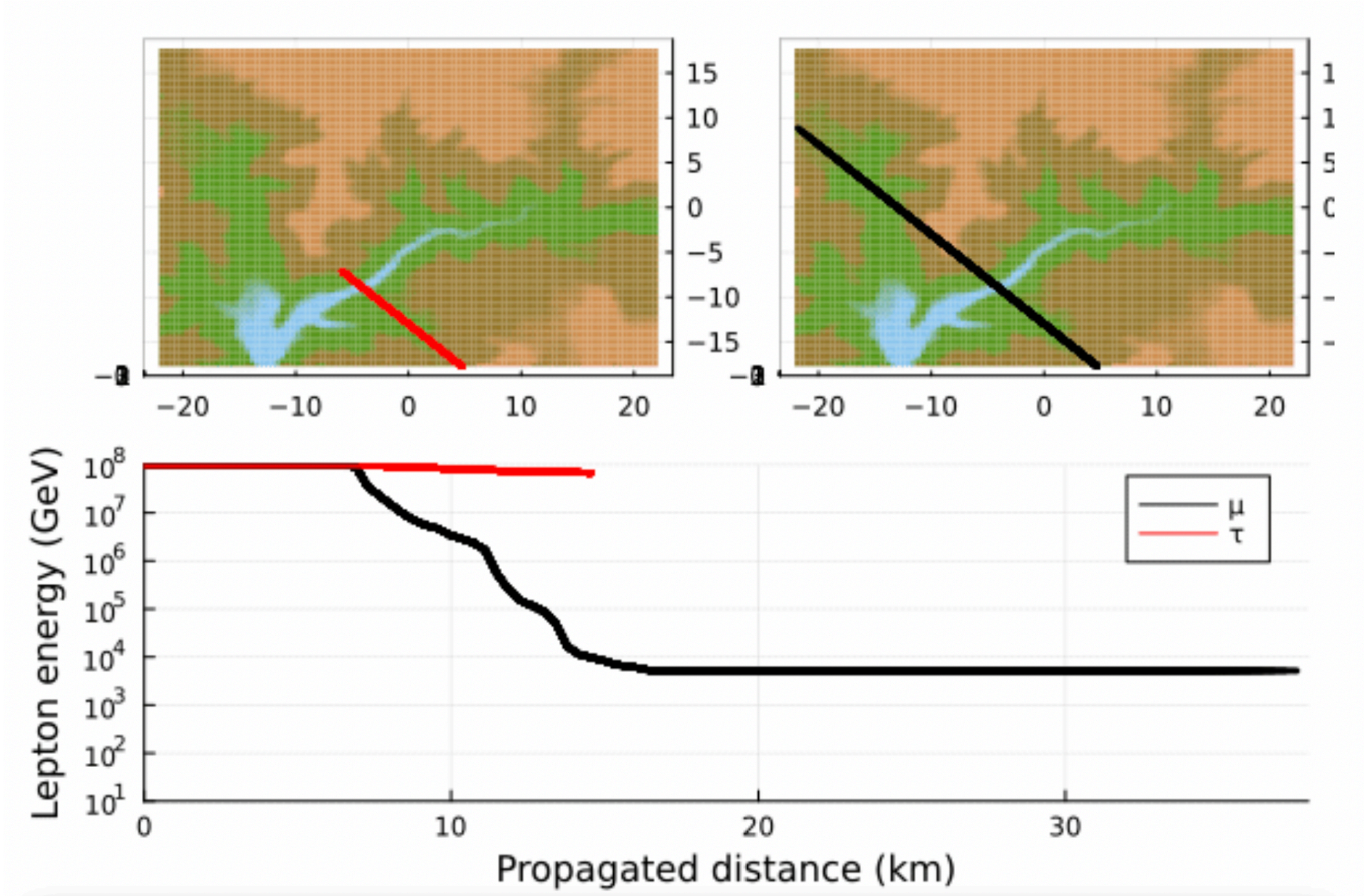
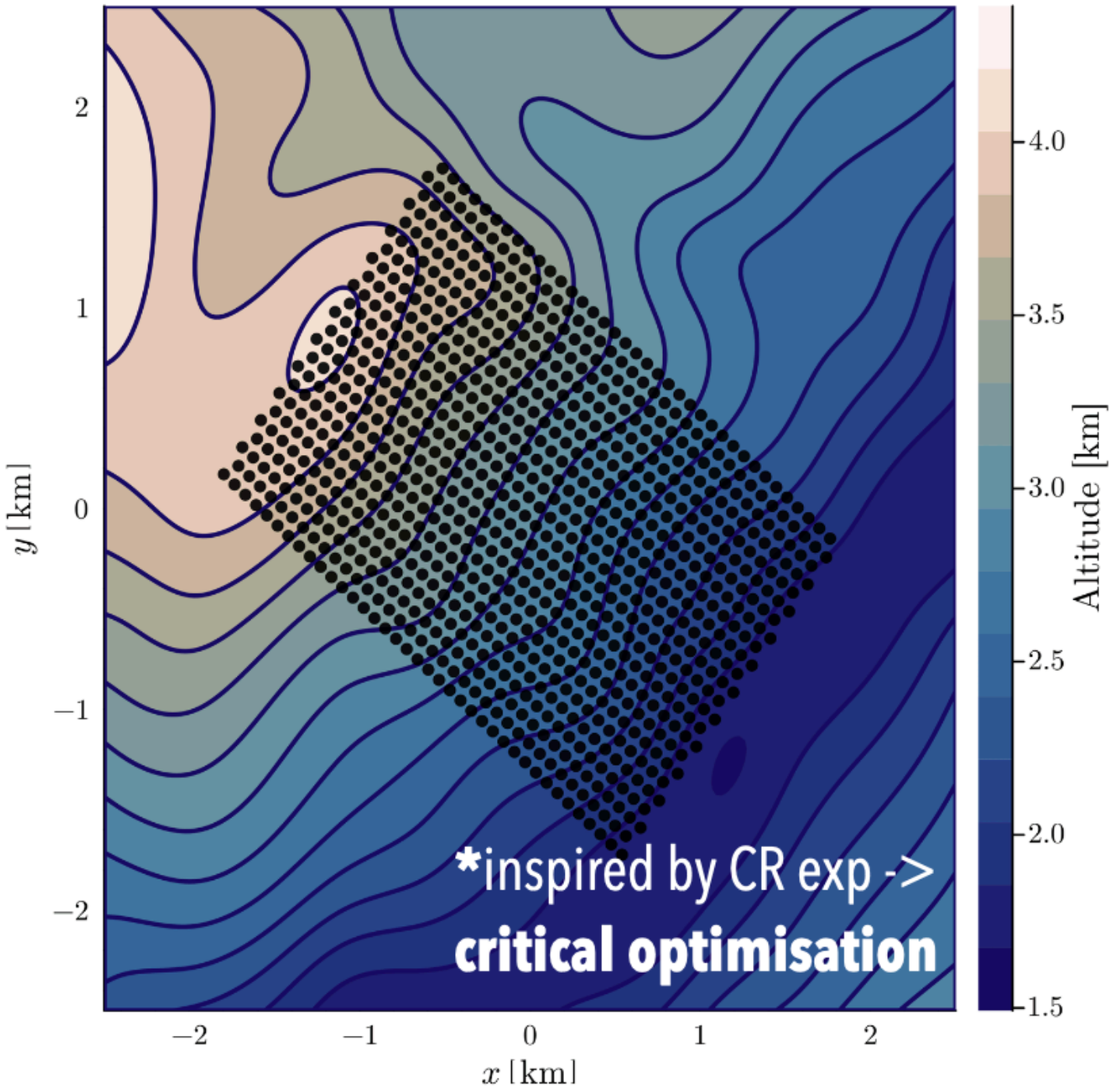


What Can We See with TAMBO?

- Baseline design: O(10k) detectors, 150 m spacing*
- Serve as a pointer for neutrinos telescopes -> **one neutrino one source**
- Probe diffuse spectrum from **1-100 PeV**
- Synergistic **flavor** ratio measurements
- **Unique geometry** for cosmic ray measurements



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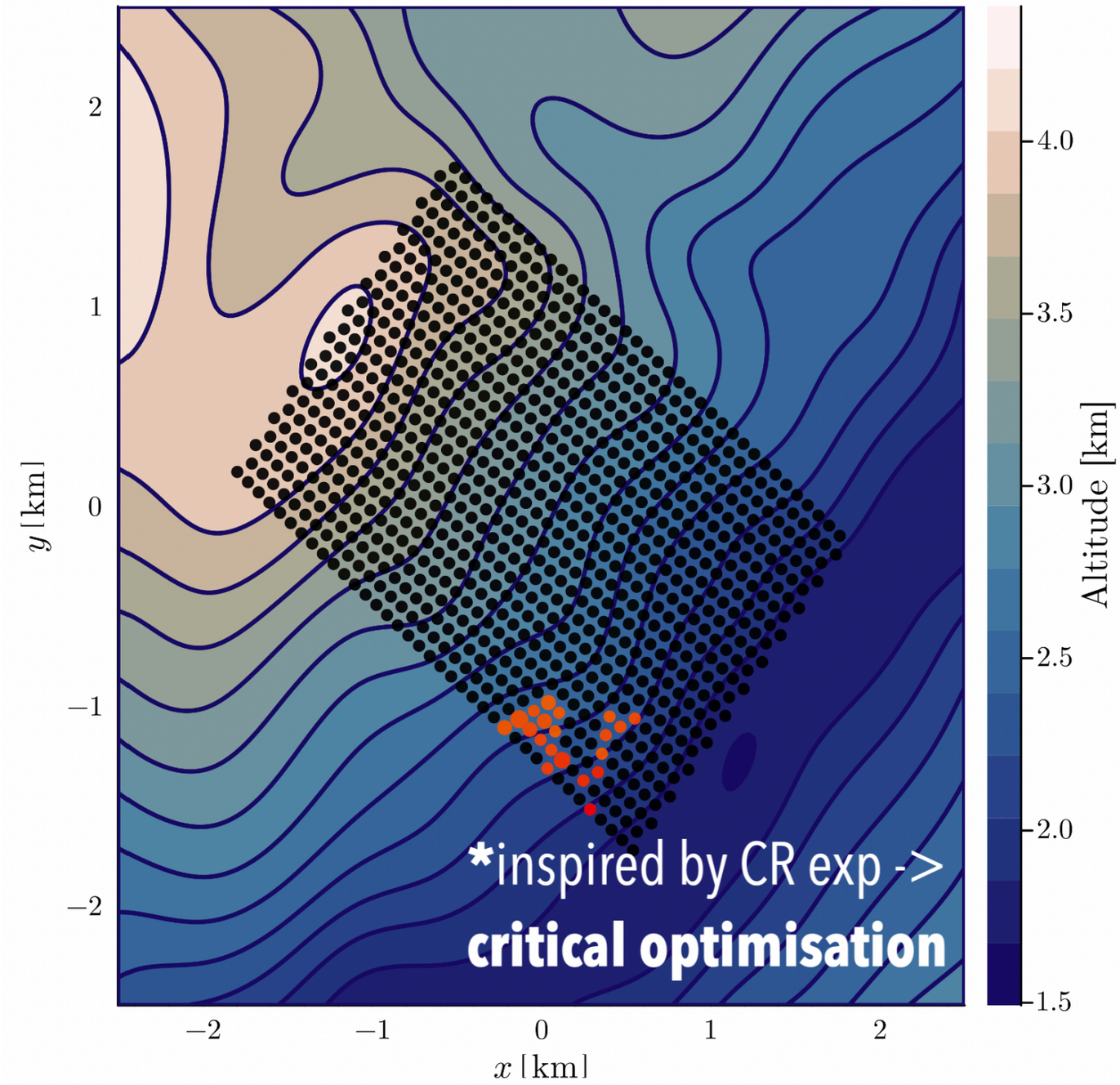

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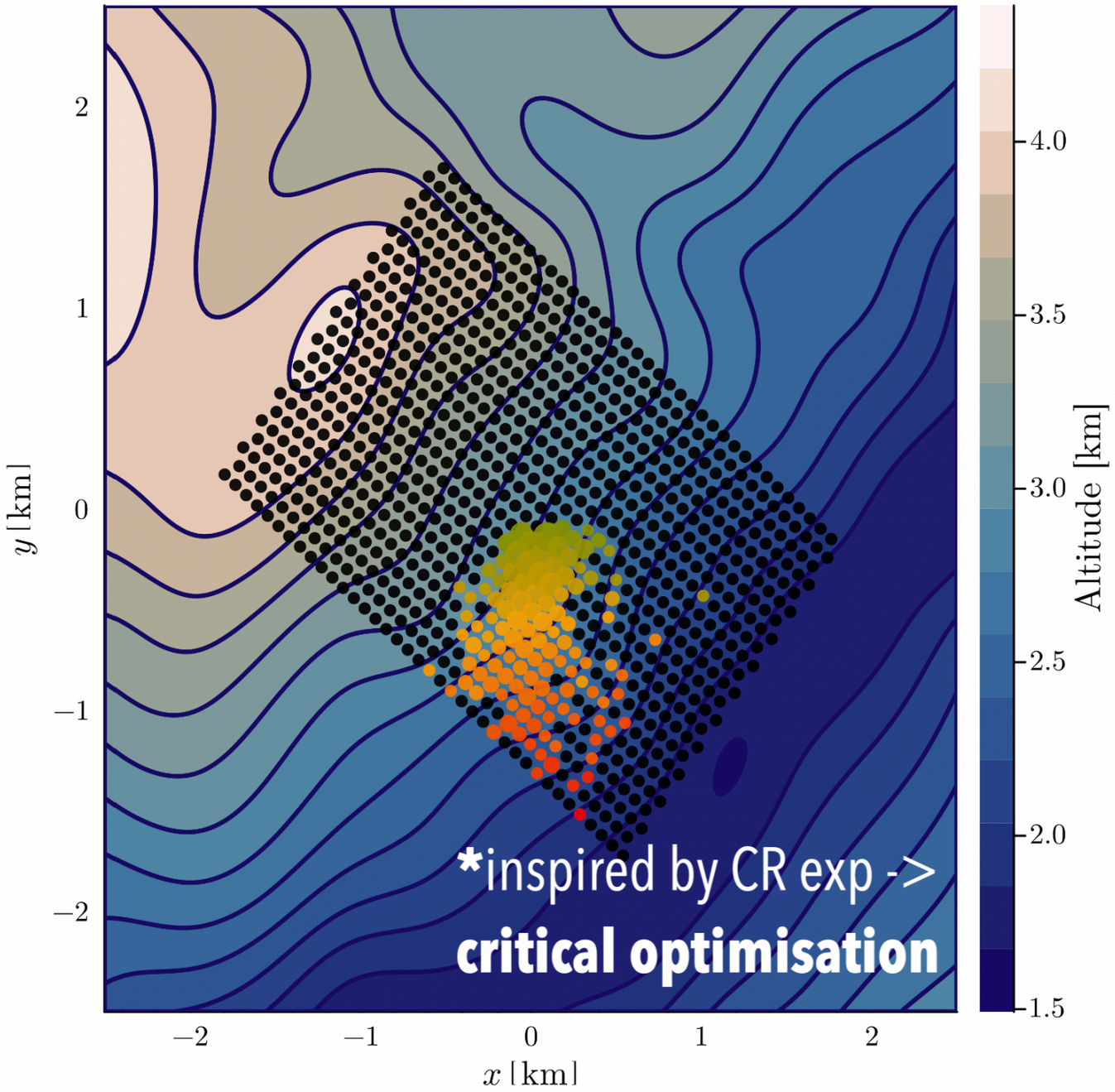

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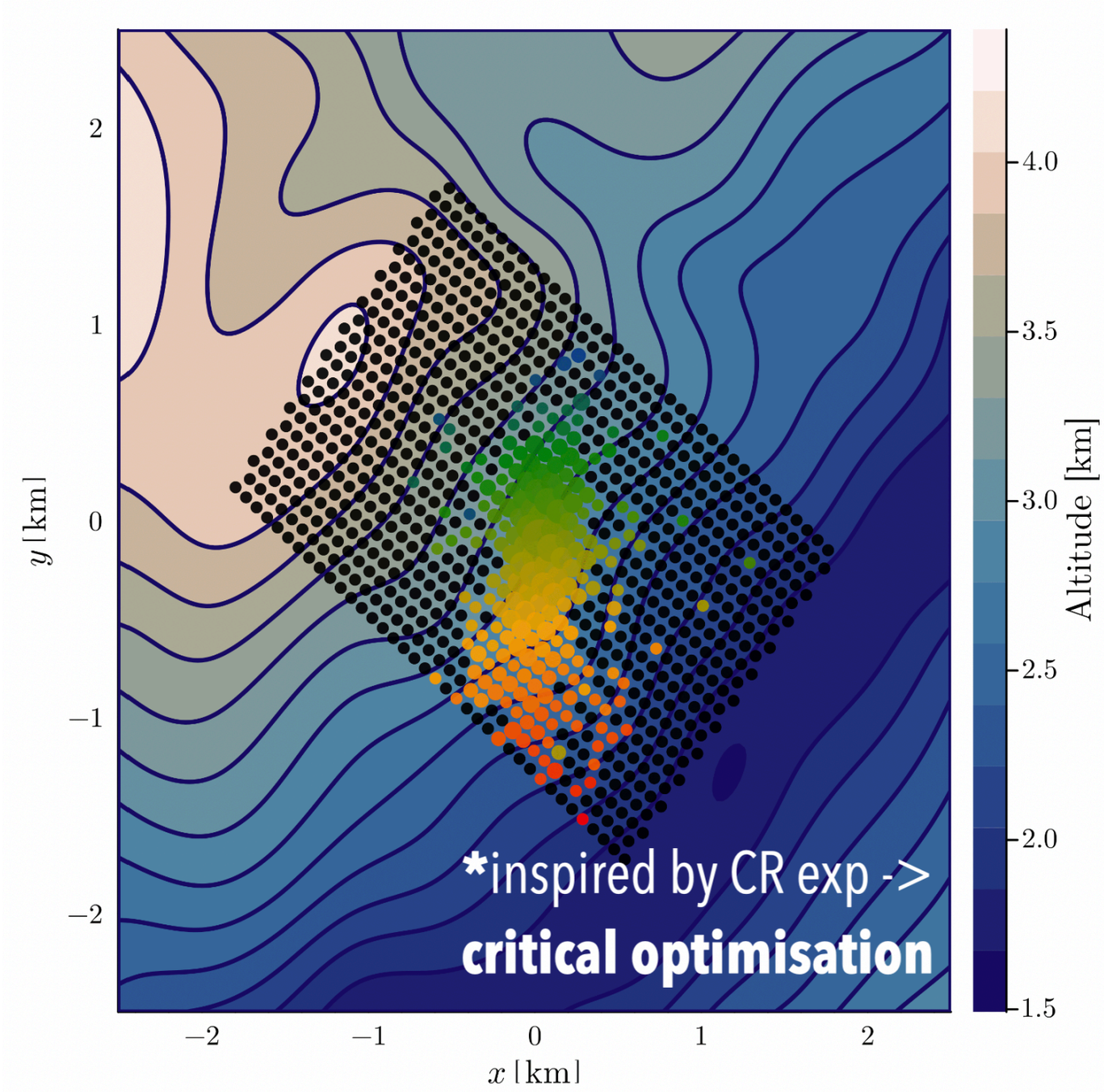
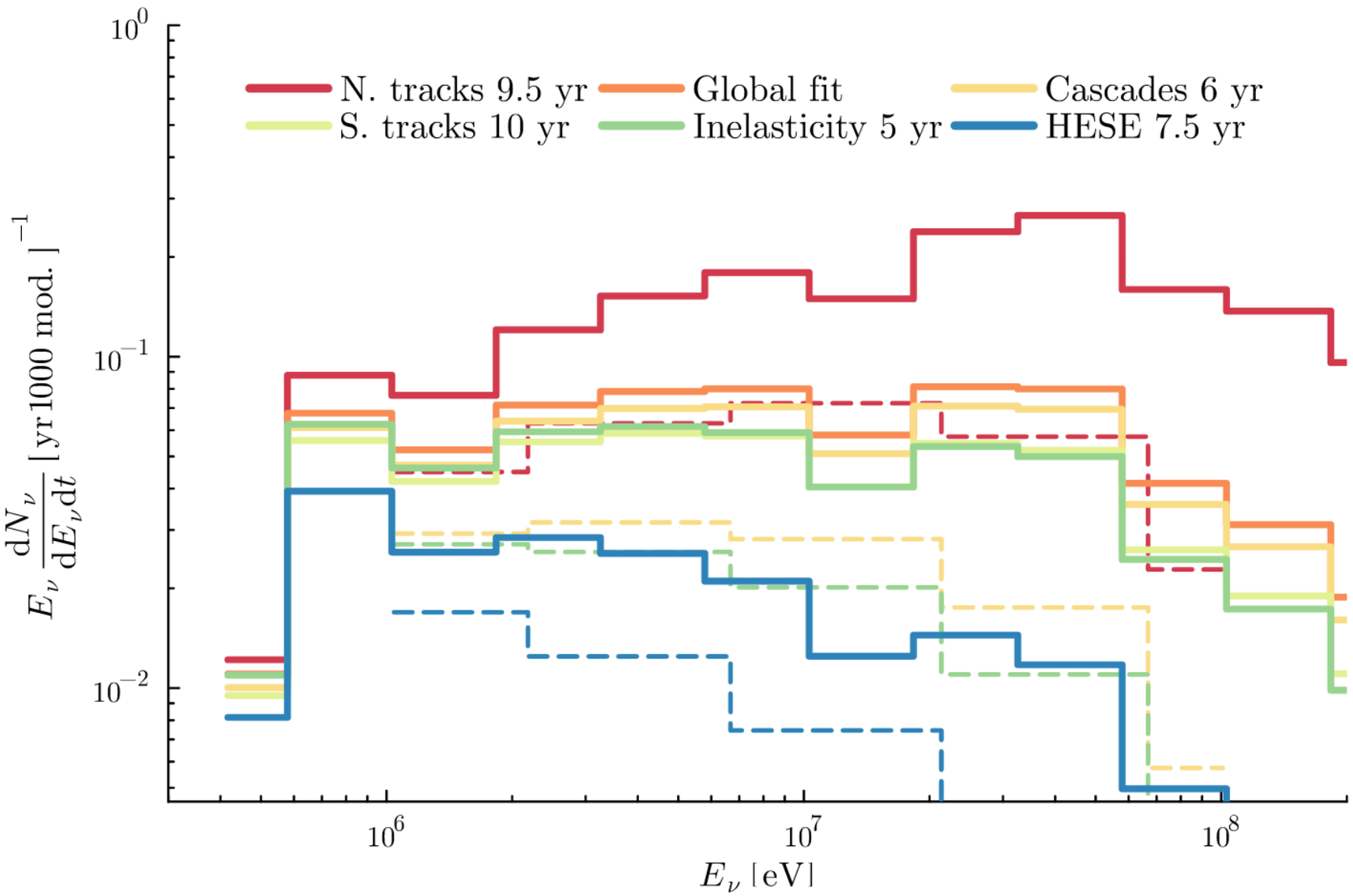


Expected Event Rates

- Updated simulation predicts ~3x higher rates!
- >3σ sensitivity to reject SPL in 3 years with 5000 modules



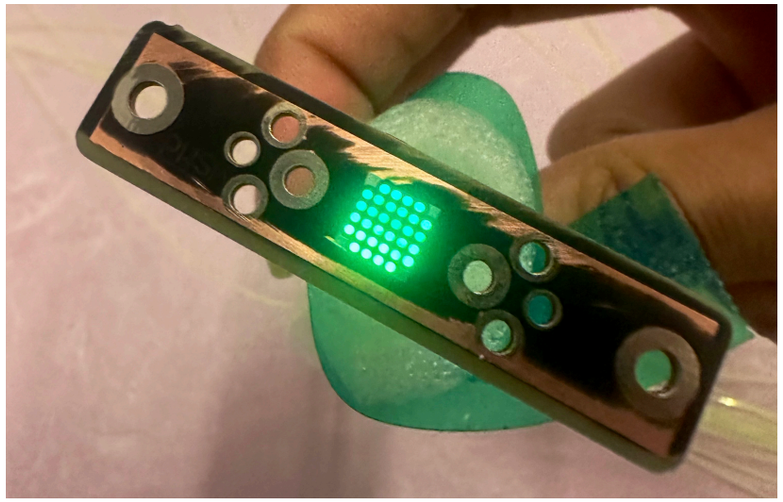
Detector Research & Development

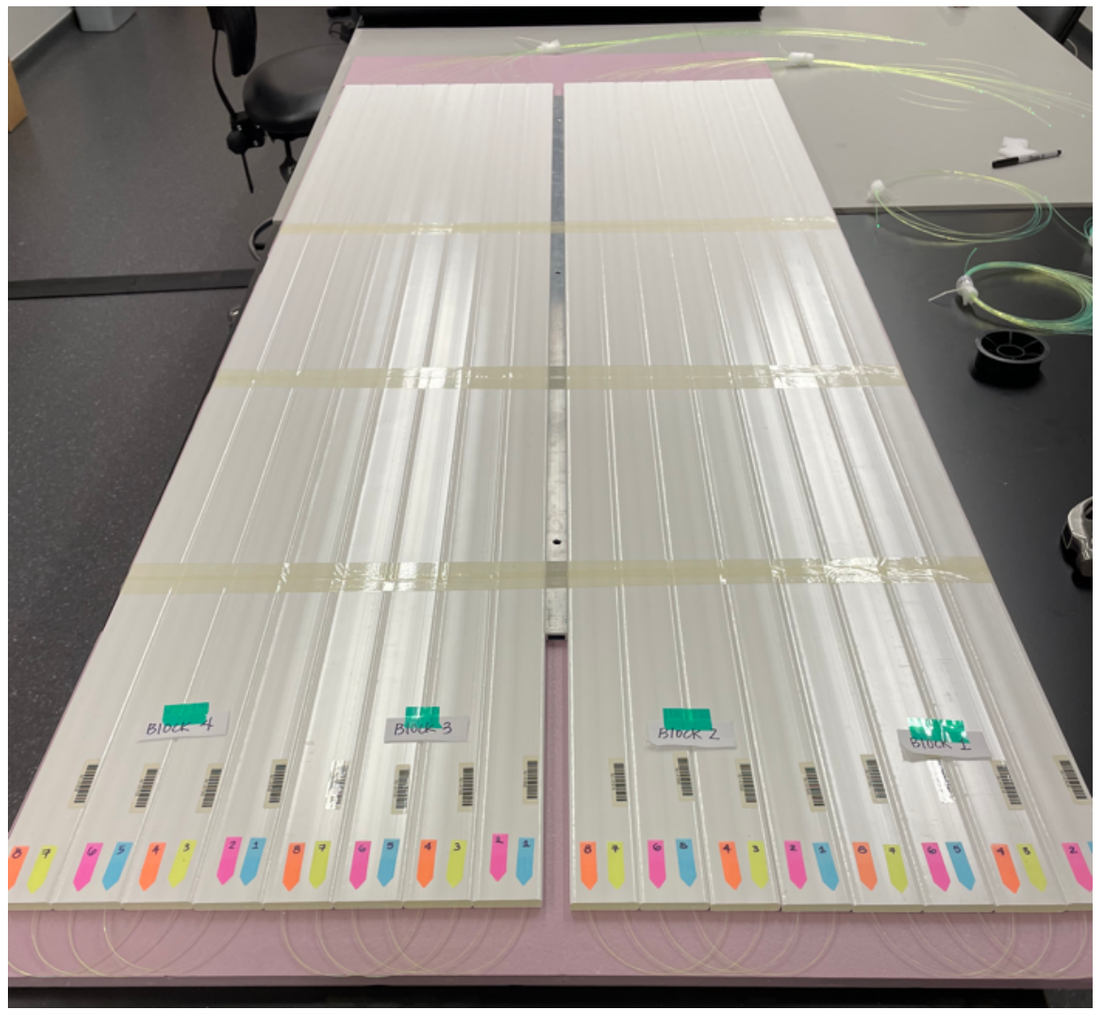
- Detector technology: either water Cherenkov or plastic scintillator
  - No new technology development needed!

- Special considerations for TAMBO:
  - Difficulty of deploying detectors in canyon
  - Cost of producing O(1k) detectors

William Thompson

Diyaselis Delgado

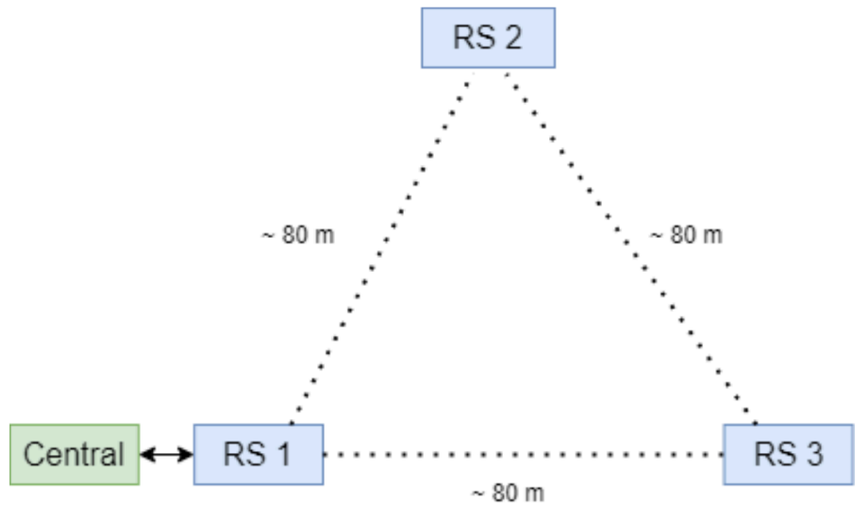


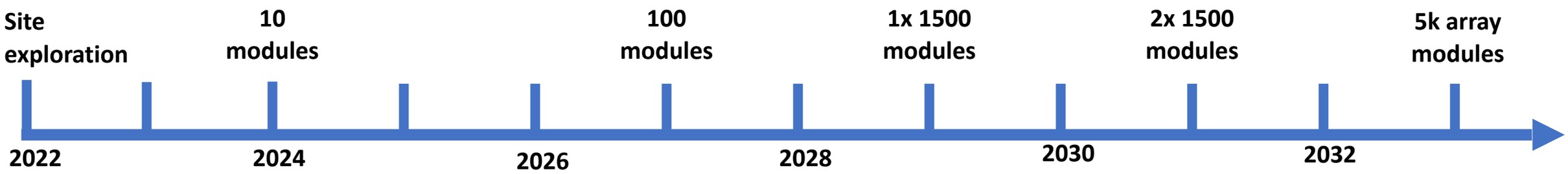


Tentative Timeline

- Initially deploy ~10 modules followed by ~100 modules for R&D
- Full array could be deployed in 1500-module segments
- Expect to see neutrinos in <2 years

Proof of concept





Summary

- TAMBO will **bridge gap** between HE and UHE astrophysical neutrino experiments
- **Fully-featured simulation** nearing completion -> starting developing first ML reconstruction
- Development of **prototype detectors** underway
- **Geometry optimization** through differentiable programming?
- Interested in joining? Contact us!

Thanks!

Community Partnership

- 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

Photo Credit: Universidad Nacional de San Agustin de Arequipa

Hardware Development @ UTEC & PUCP

- Timing system is a primary challenge -> 1° pointing requires ≲ 10 ns resolution over $\mathcal{O}$(km2)
- Wireless timing system under development at UTEC
- Scintillator & timing testbed being built at PUCP