TAMBO

Searching for astrophysical ν_τ in the Andes

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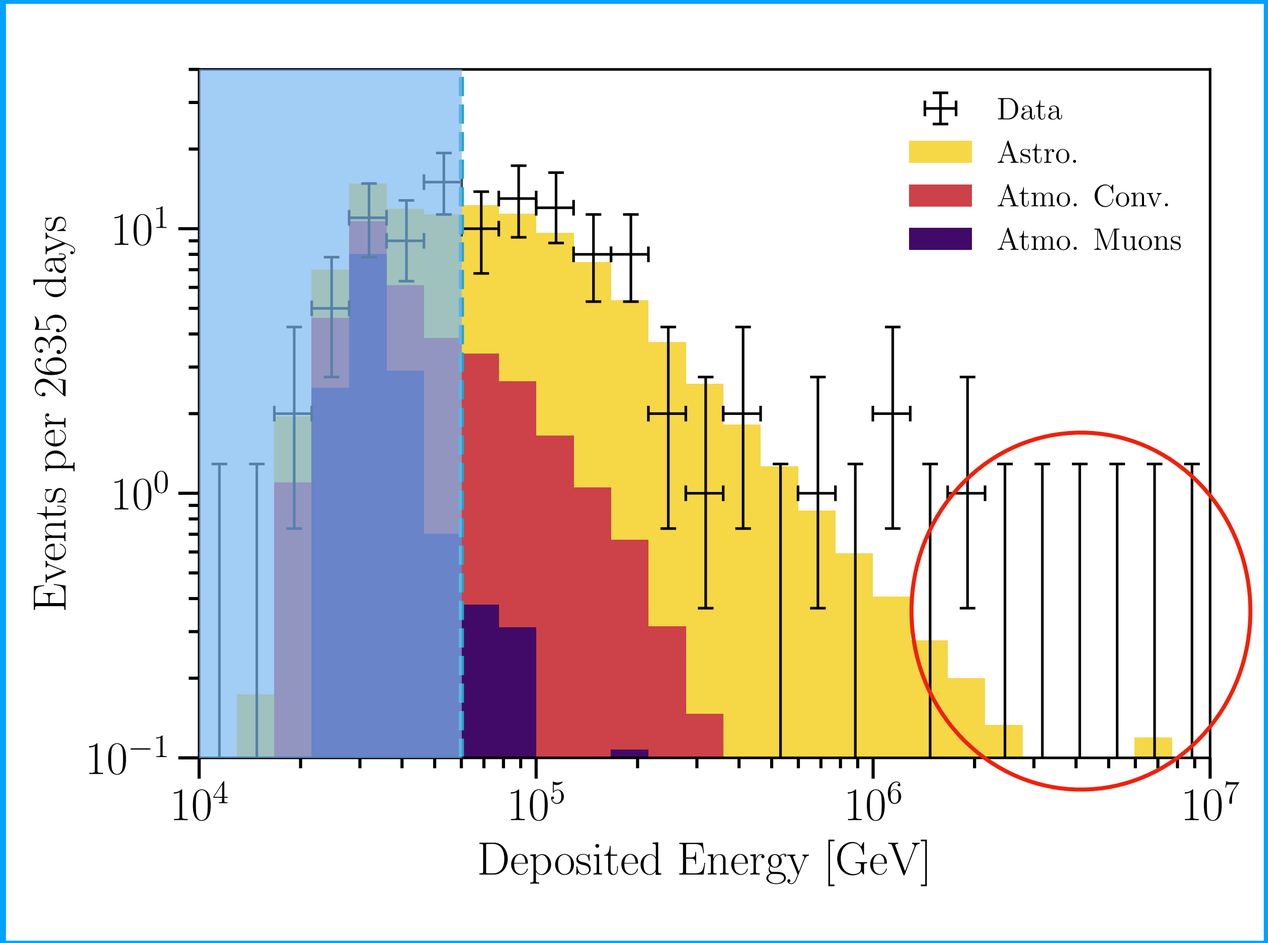
Astrophysical Neutrino Astronomy

- IceCube has observed a diffuse astrophysical flux
- There is evidence of some astrophysical sources (e.g. TXS event)
- However we're plagued by low statistics at higher energies (> ~ 1 PeV)
- ν_τ component is lacking with only 2 candidates in 10 yrs

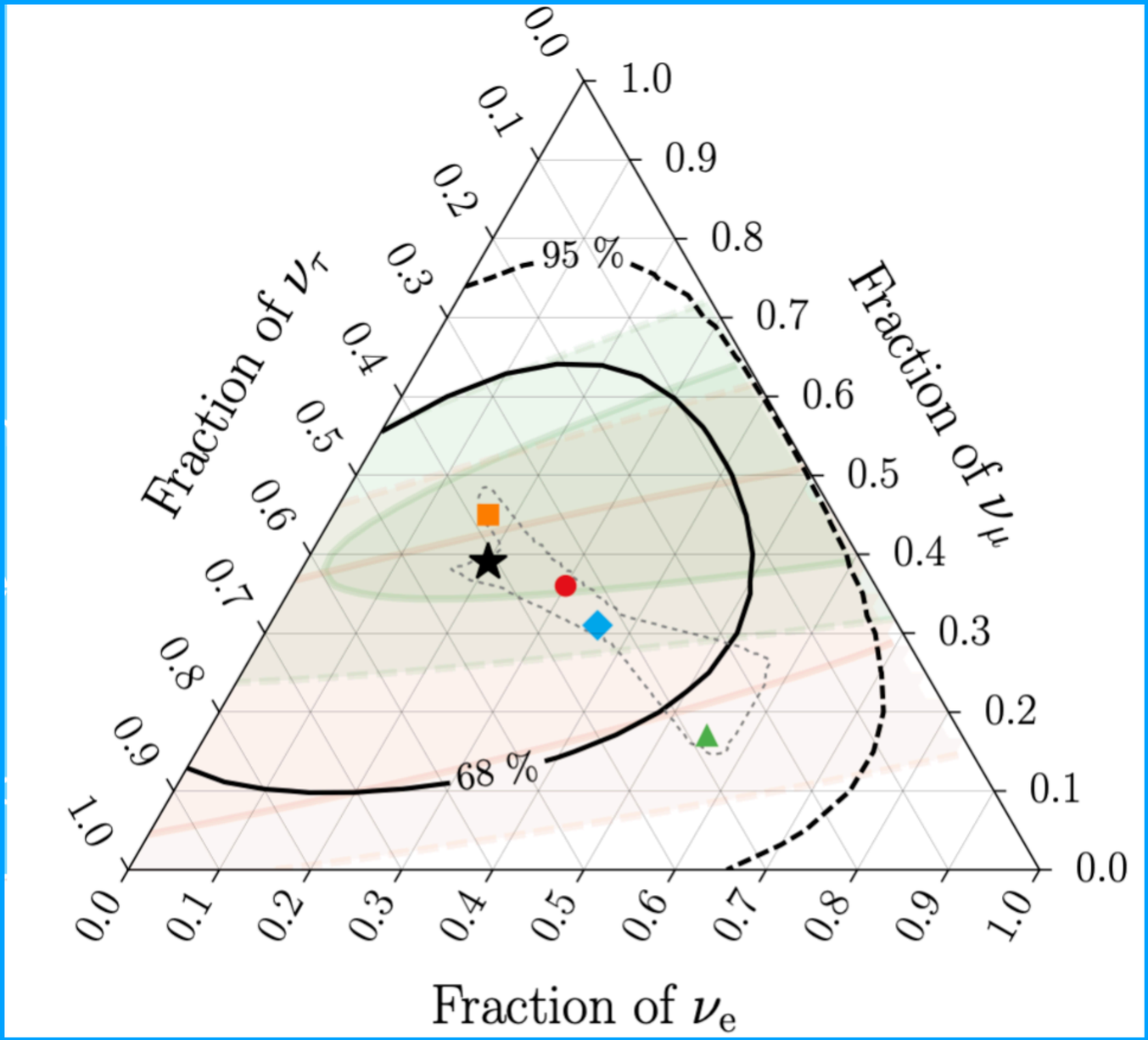


IceCube Collaboration, PhysRevD.104.022002

Why ν_τ matters

Particle Physics and Flavor measurement

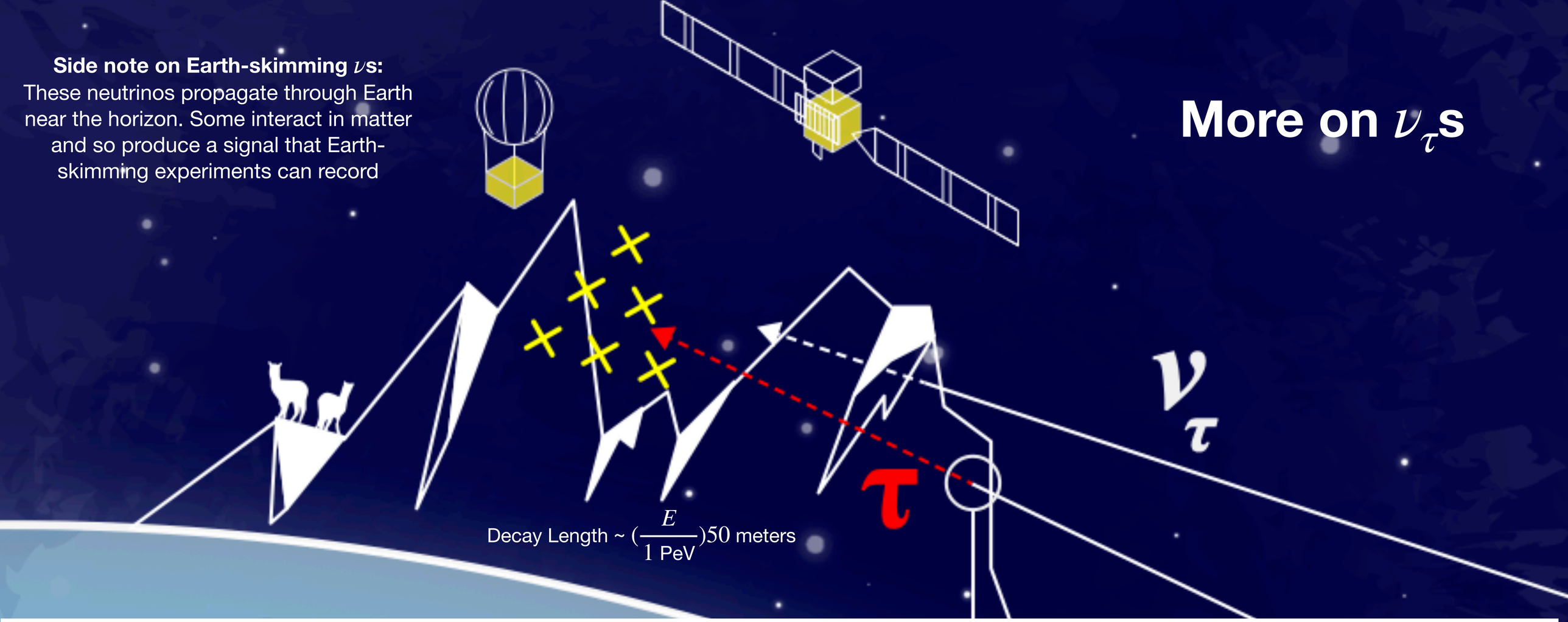
- Assuming standard ν oscillation means 1:1:1 ($\nu_e : \nu_\mu : \nu_\tau$) at Earth
- No bonafide evidence of tau component in diffuse flux measurements (only 2 candidates in 10 years)
- To explain lack of “tau-ness” possible BSM scenarios could be considered



IceCube Collaboration, arXiv:2011.03561

More on ν_τs

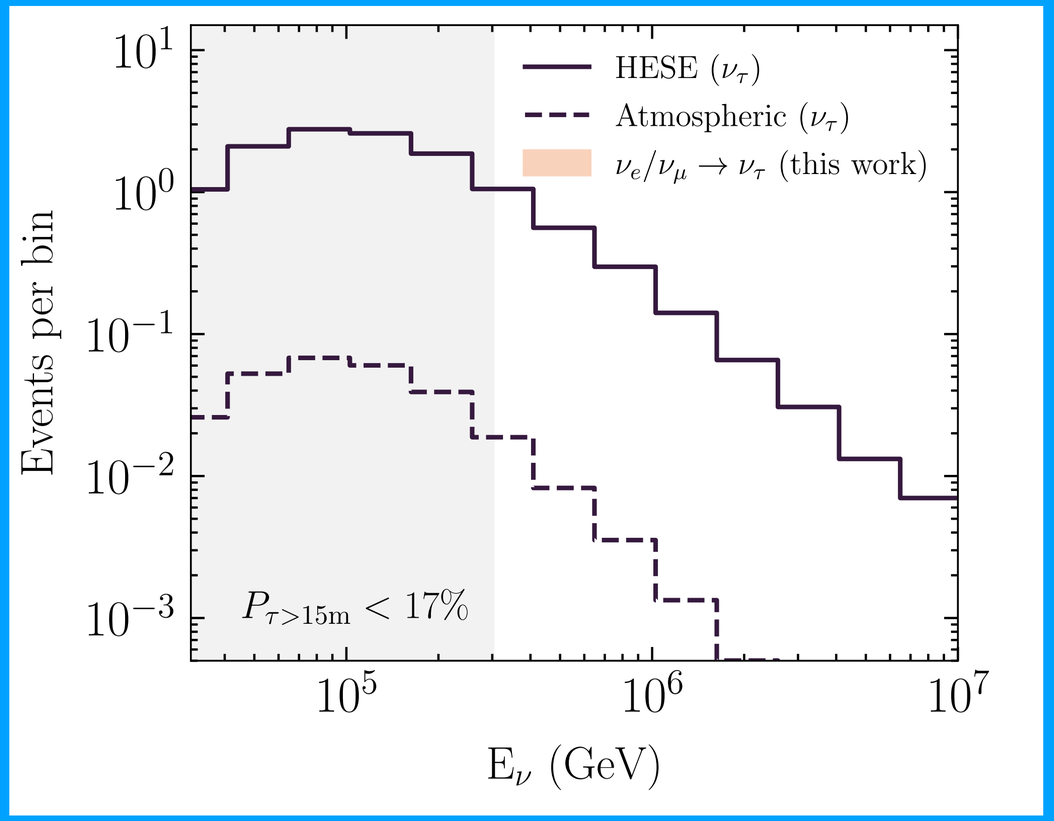
Side note on Earth-skimming νs:
These neutrinos propagate through Earth near the horizon. Some interact in matter and so produce a signal that Earth-skimming experiments can record

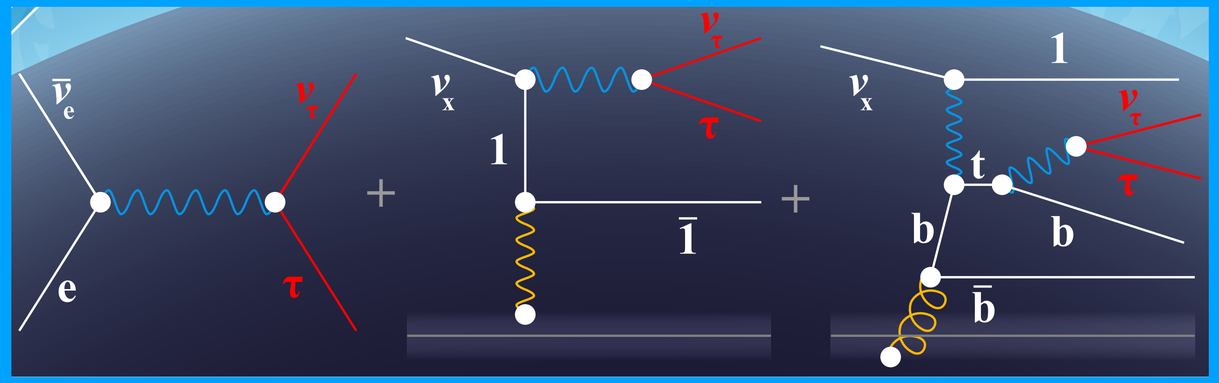


- Earth-skimming experiments have been designed to probe GZK energy regime
- They look for tau leptons emerging from the surface and decaying in the atmosphere
- Better constrain cosmogenic origins through air shower resolution of decay

ν_τ benefits
And backgrounds

- Basically background-less
  - They're rarely produced in the atmosphere
  - Standard oscillations are suppressed at E > 100 GeV
  - EXCEPT…
- ν_μ and ν_e can produce ν_τ τ in Earth
- At 1 PeV and greater this is a significant contribution (1-10% events)





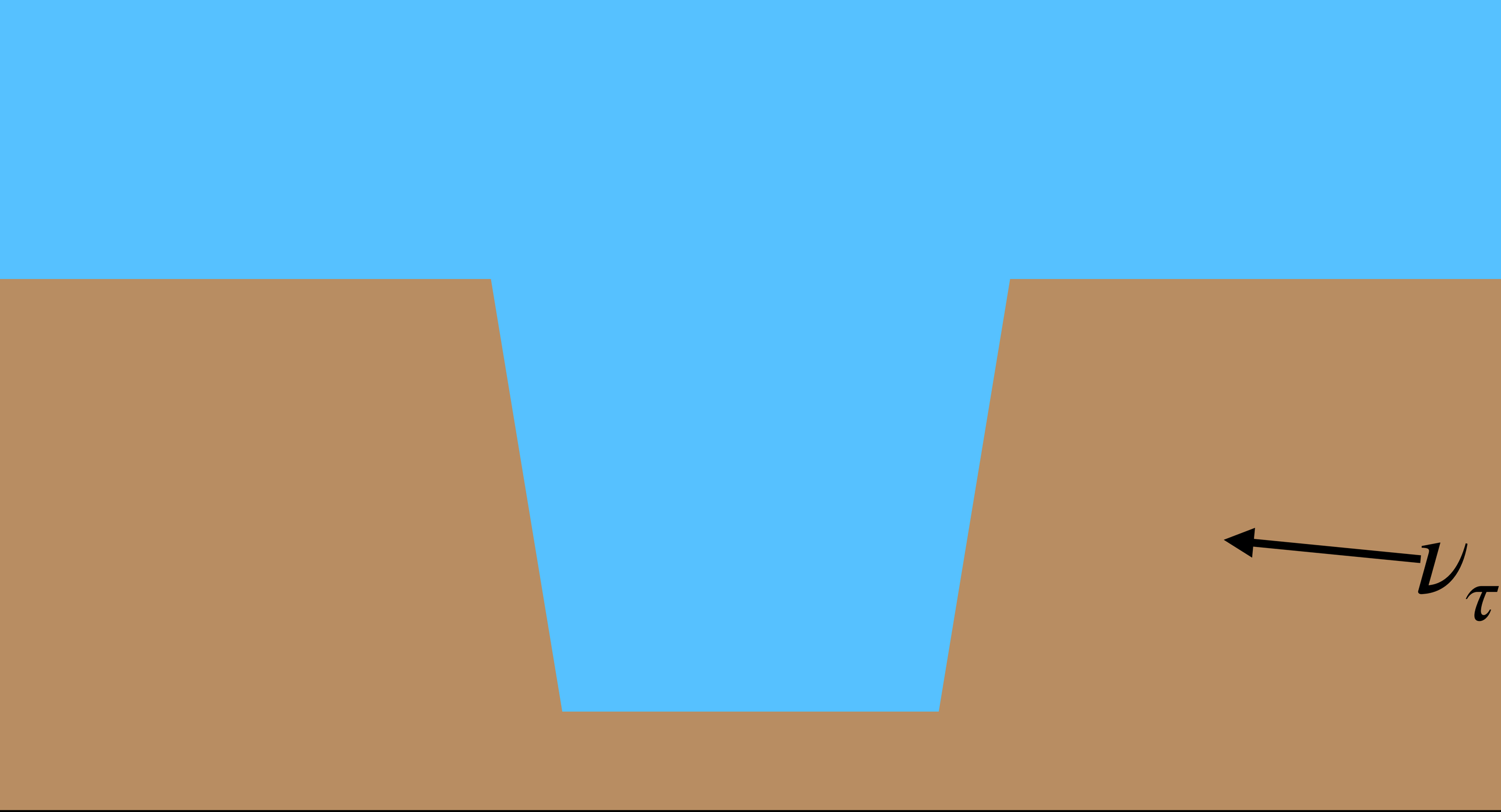
For more info on this effect check this paper out:
Garcia-Soto et al., PhysRevLett.128.171101

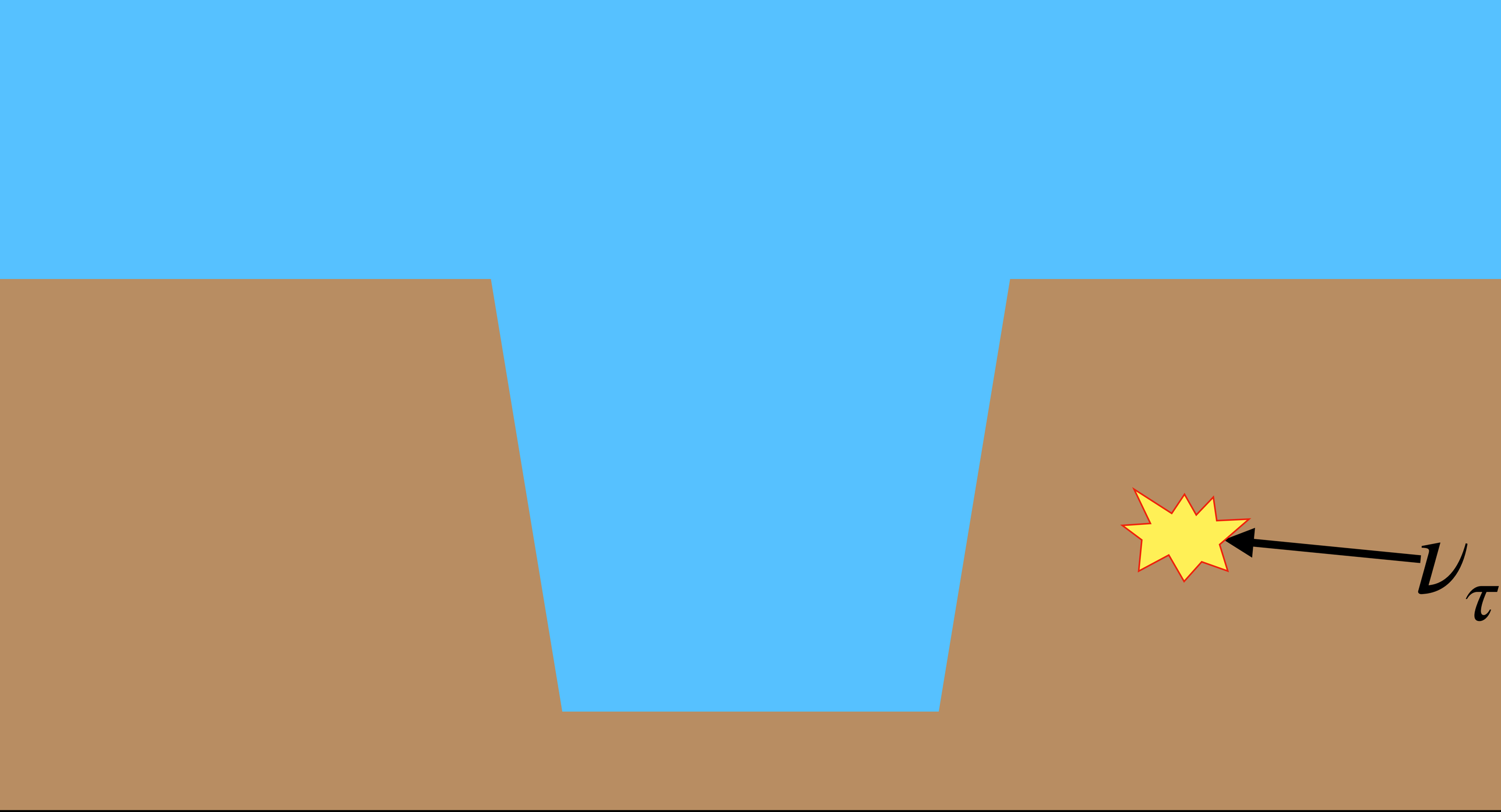
TAMBO!

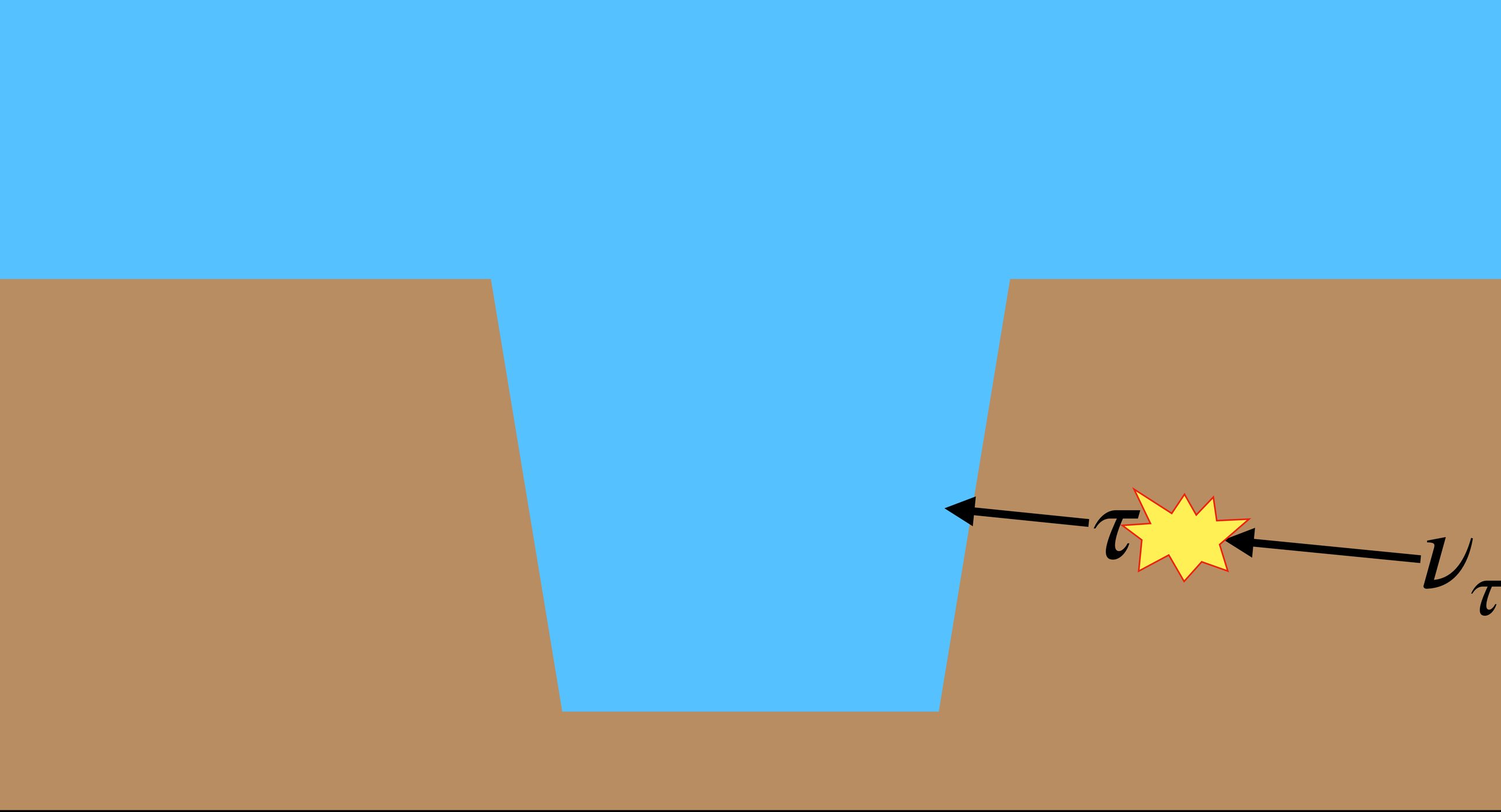
Tau Air Shower Mountain-Based Observatory

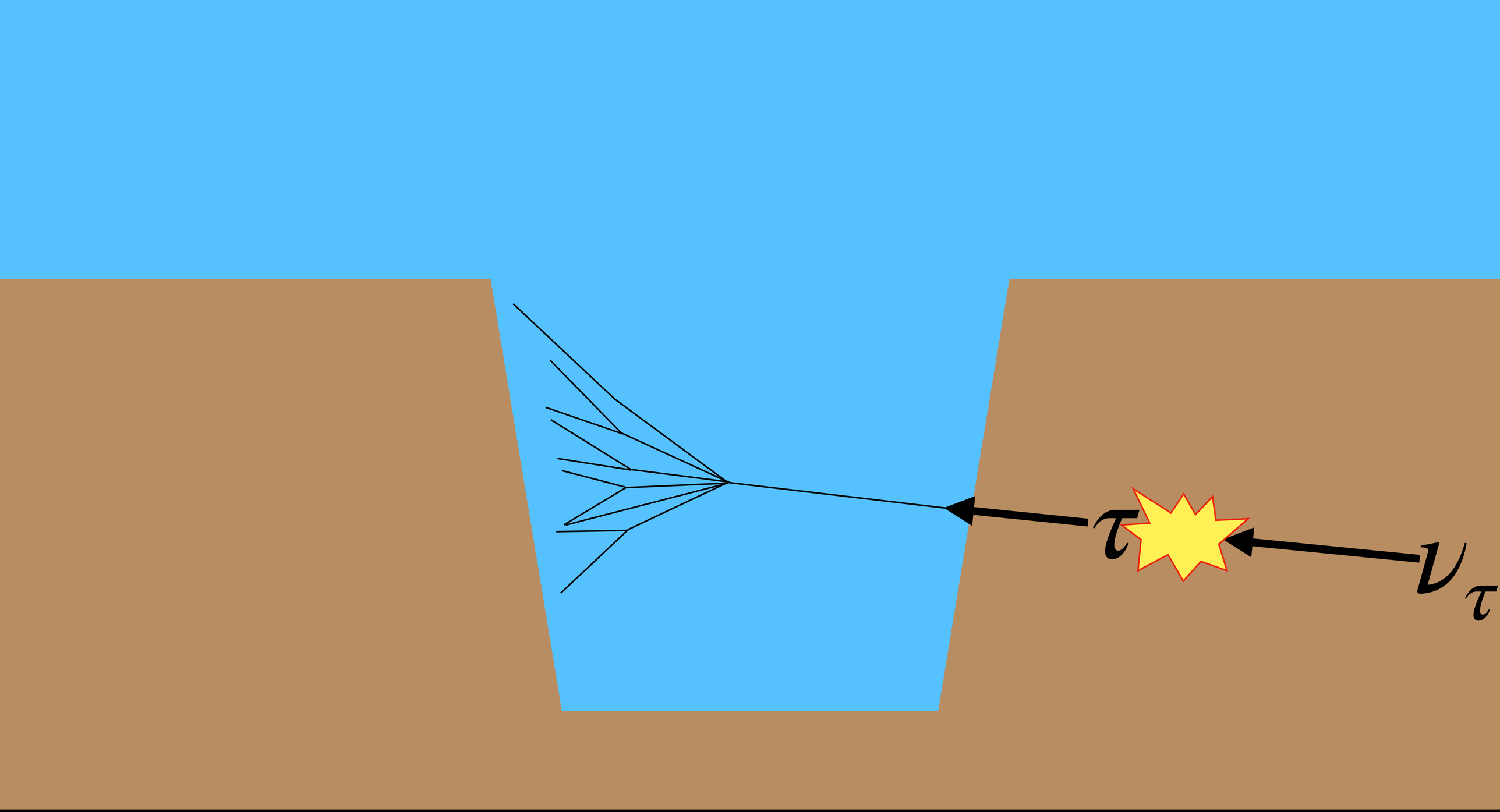
- A deep-valley Earth-skimming ν_τ detector to be deployed in the Colca canyon in Peru
- ν_τ detection in the 1-100 PeV band
- Goals are:
  - Astrophysics - probe GZK energy regime + point sources
  - Particle Physics - discern flavor composition to check for BSM scenarios

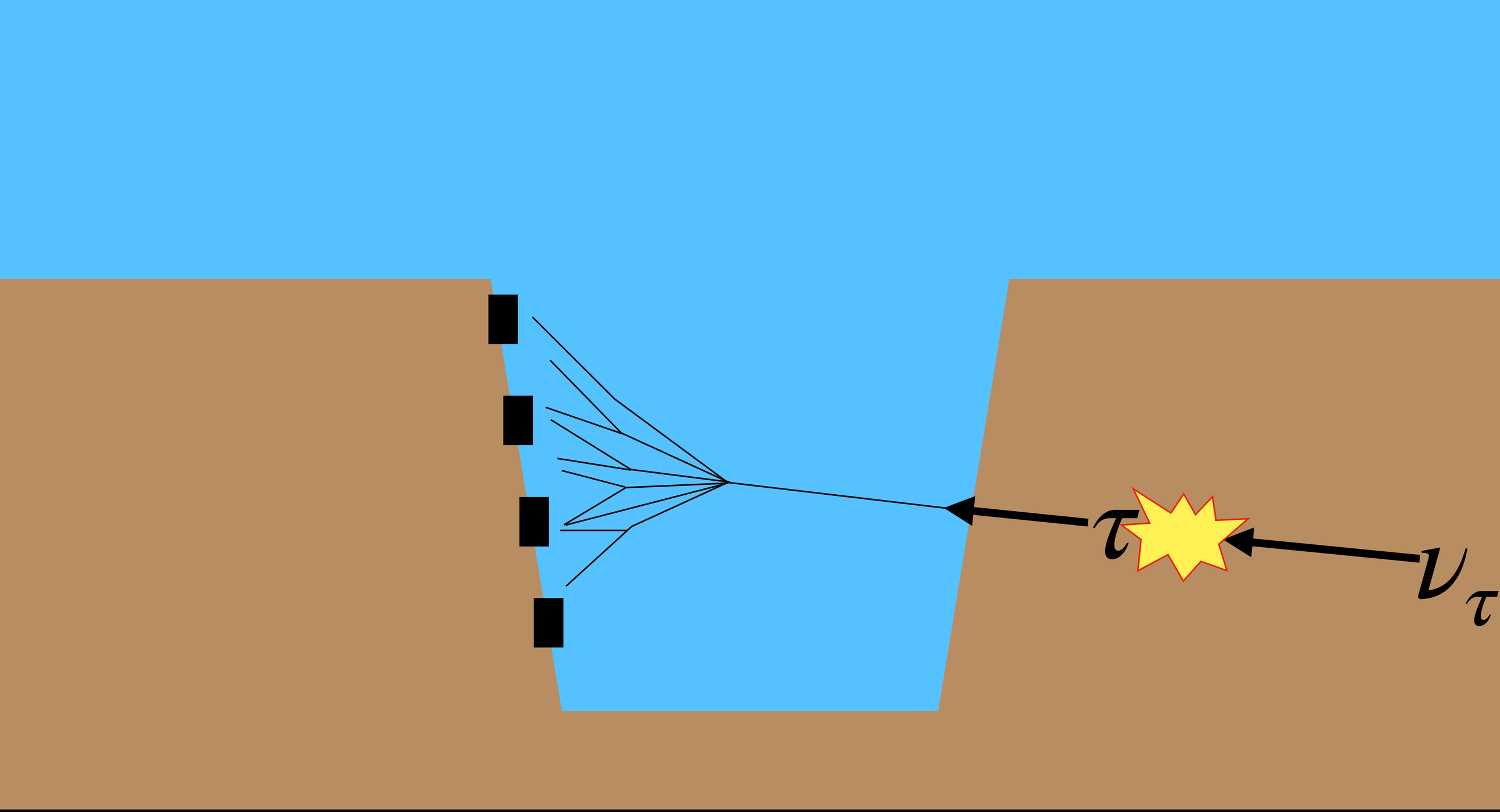
So how does it work?


ν_τ

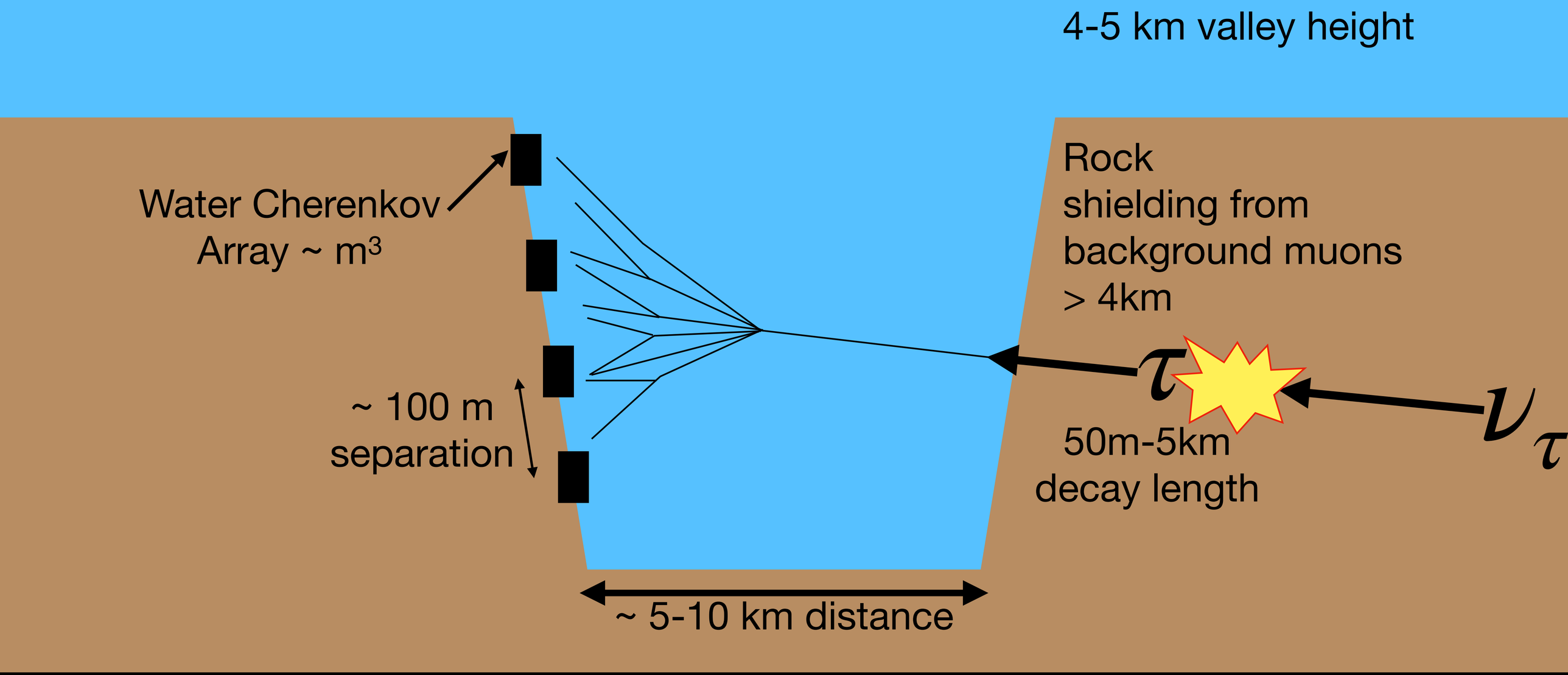

ν_τ

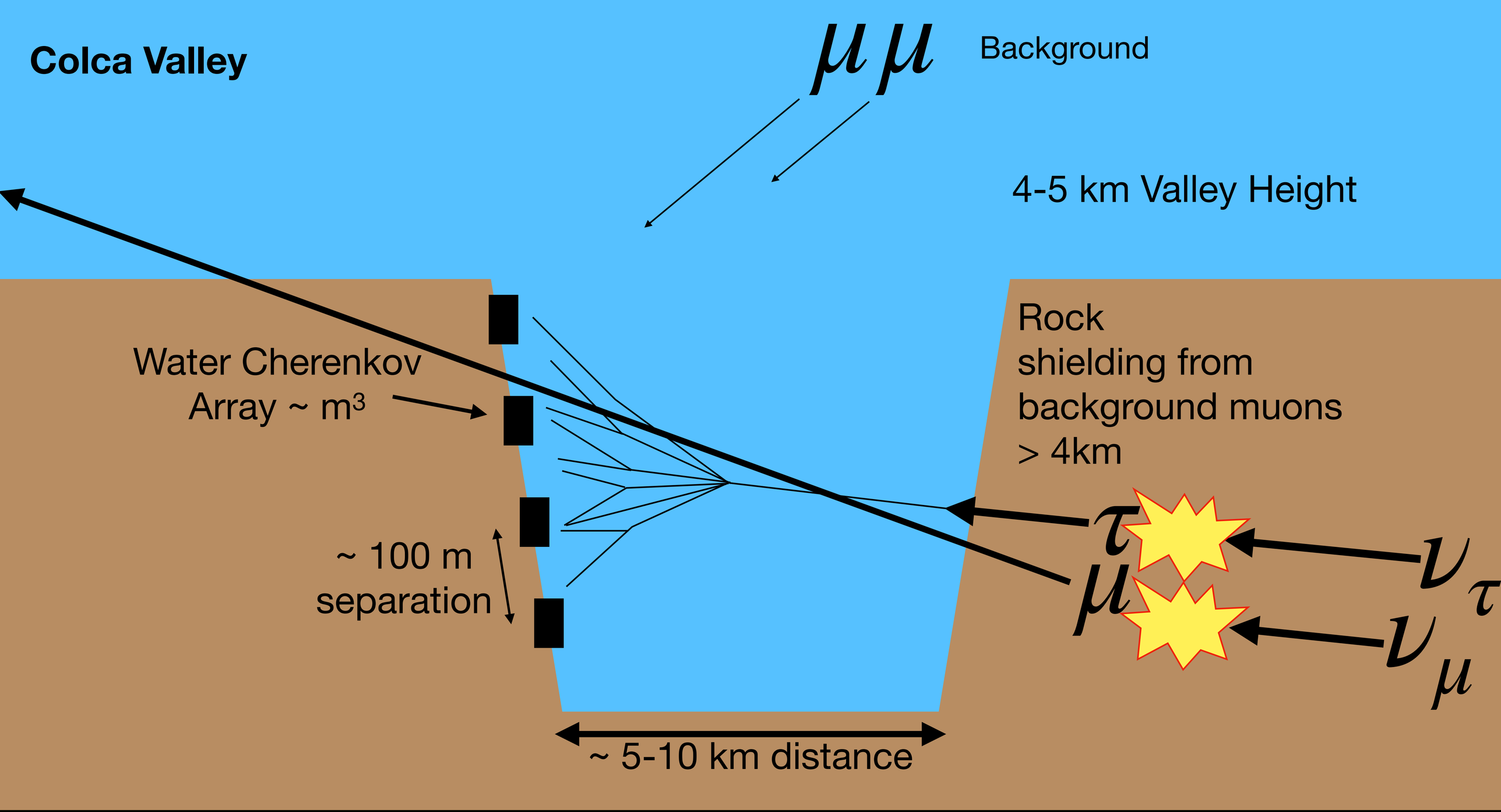

τ
ν_τ


τ
ν_τ


τ
ν_τ

Colca Valley

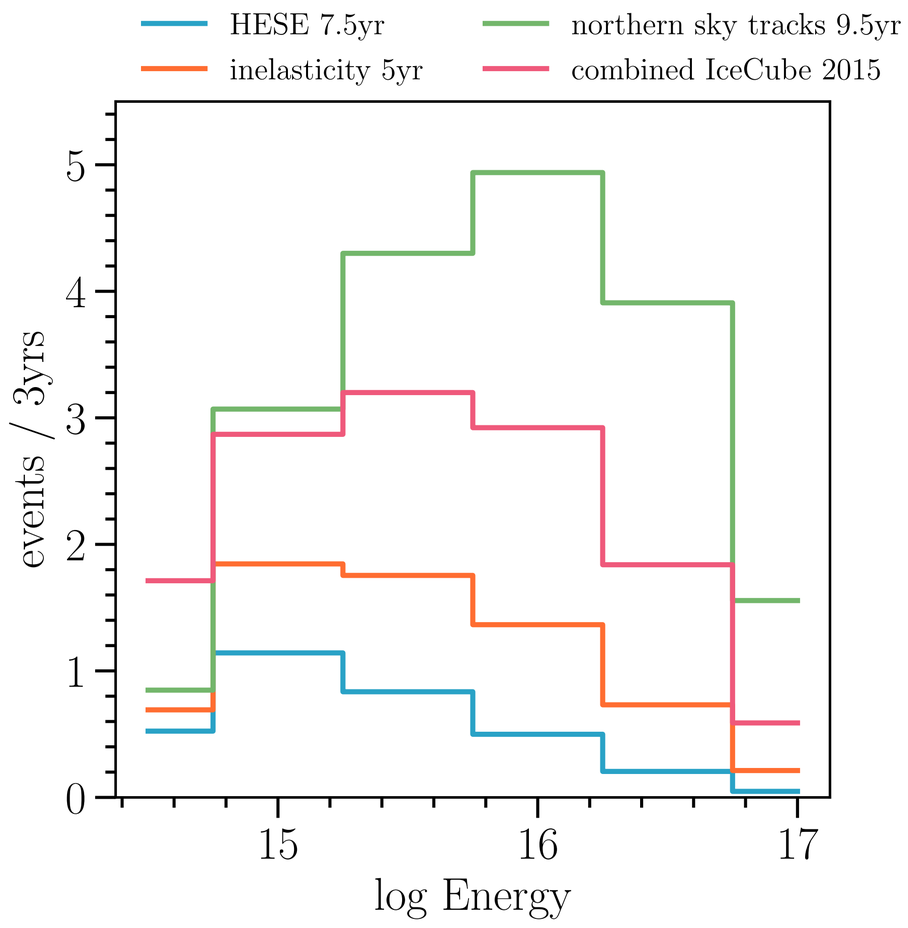



Colca Valley
$\mu\mu$
Background
4-5 km Valley Height
Water Cherenkov
Array ~ m³
~ 100 m
separation
Rock
shielding from
background muons
> 4km
τ
μ
ν_τ
ν_μ
~ 5-10 km distance

Backgrounds

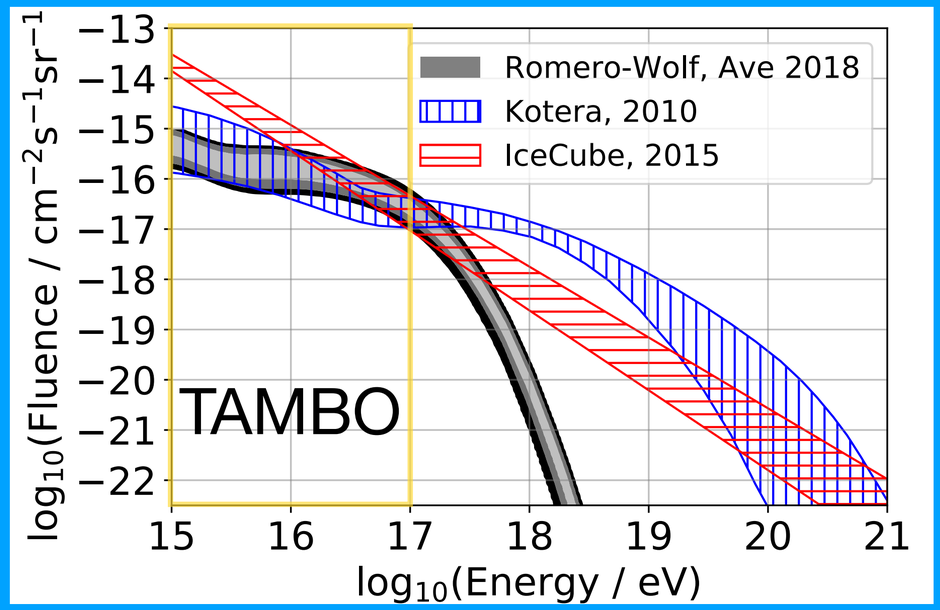
- Small showers and vertical muons mimicking tau air showers
  - Coincidence tagging with nearby detectors and ns timing of PMTs
- Cosmic ray showers near mountain air border
  - 8 degree zenith cut with horizon eliminates this background to less than < 0.1 events in 3 yrs
- Prompt ν_μs and high energy ν_μs produced by cosmic ray showers before the mountain
  - Regions >4km of rock already made by cosmic ray cut will reduce background to less than 1 event in 20 tau events

Expected Performance



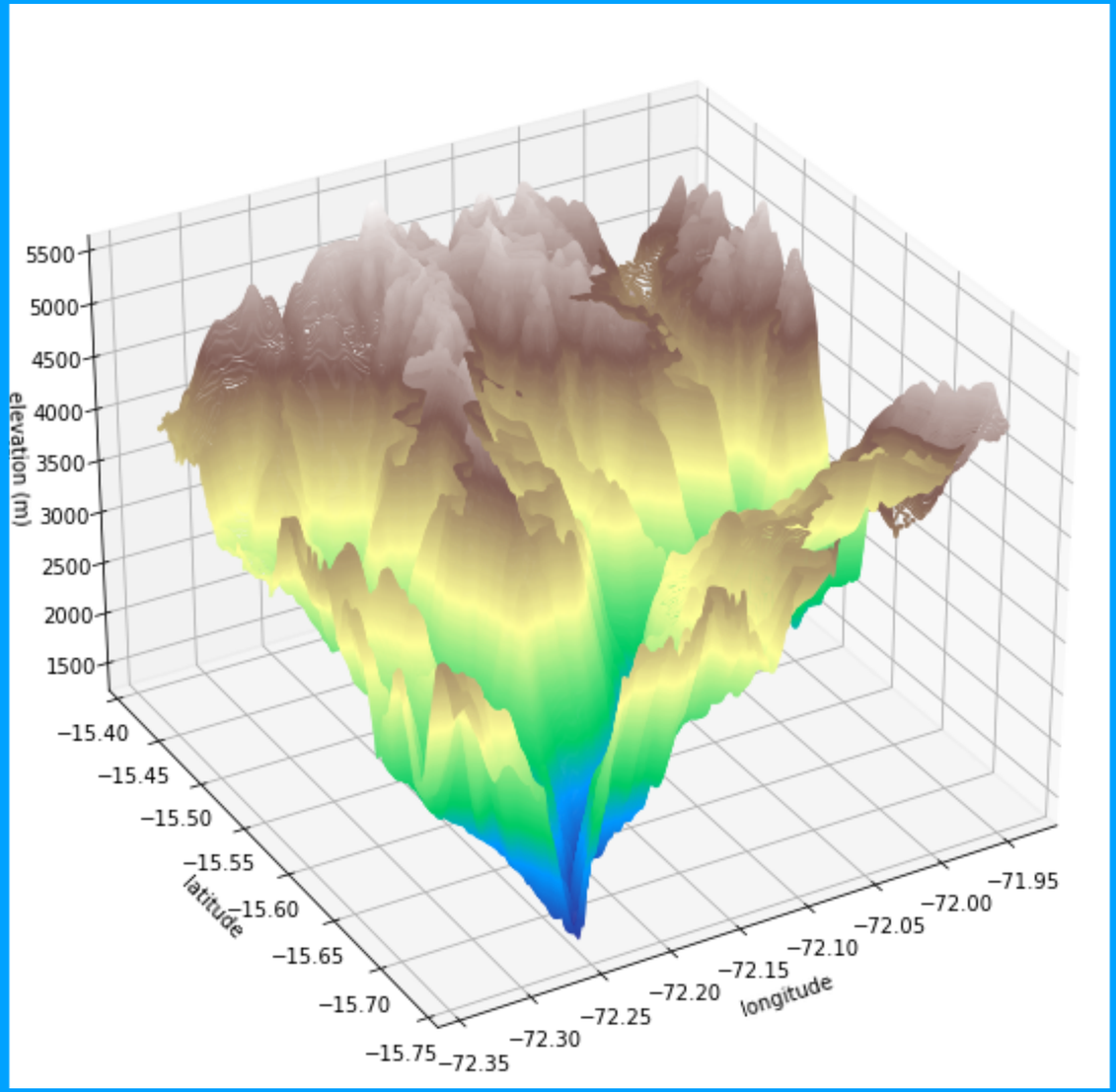
TAMBO Event Rate

- Optimized for PeV energies to improve measurements of astrophysical flux
- 13 events per 3 years of operation with a peak at 3 PeV



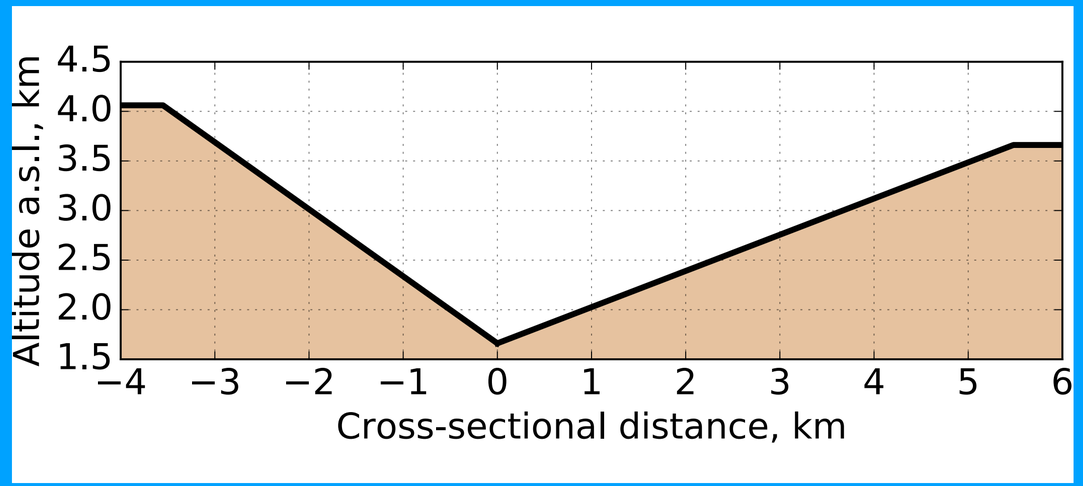
Romero-Wolf et al., arXiv:2002.06475v1

Current Work



https://www.gpsvisualizer.com/elevation

- Stitching together MC stages
- Geant4 + Corsika + TauRunner
- Plastic scintillators vs. Water Cherenkov



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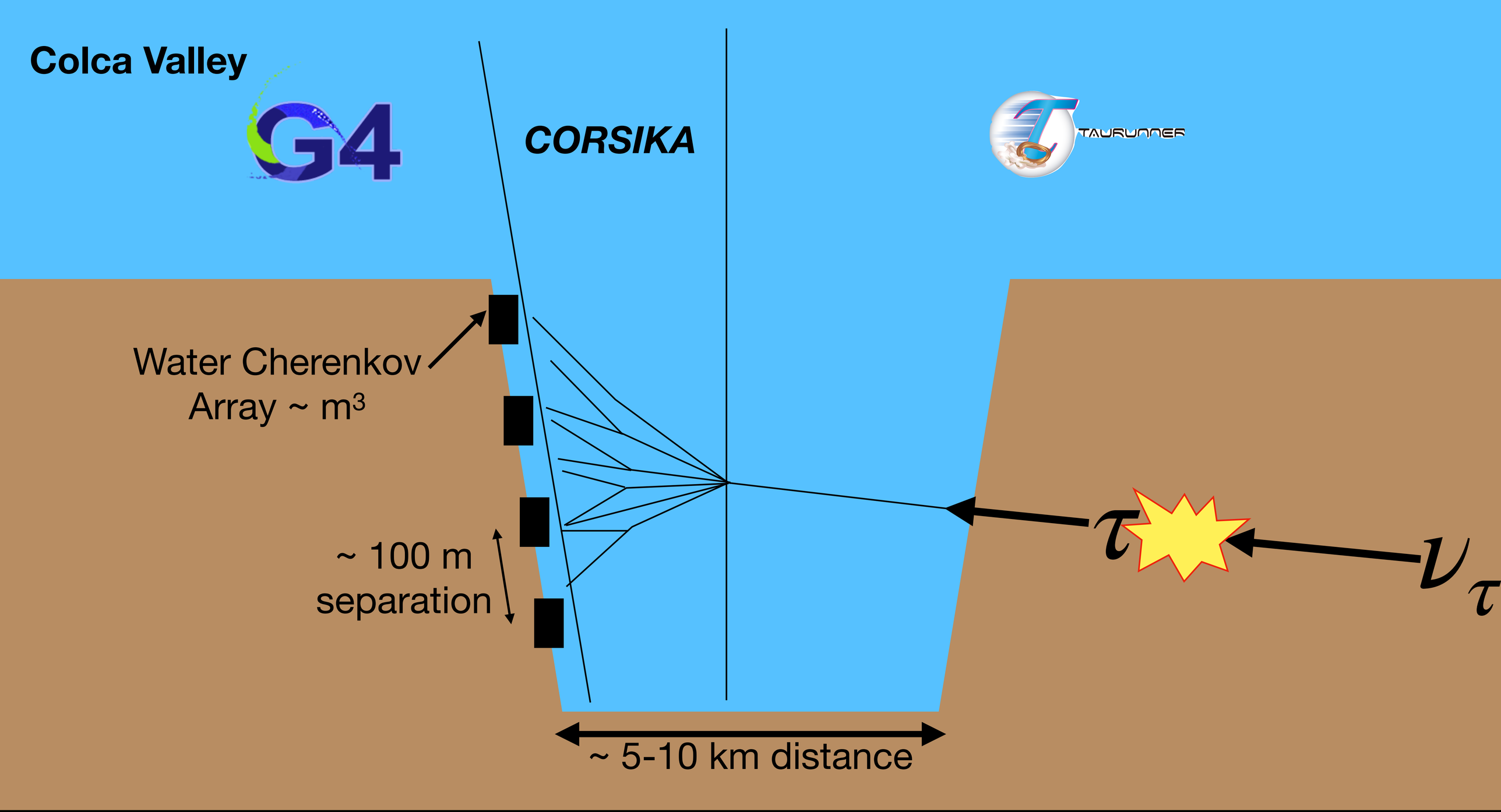
MC Details

- **TauRunner** -> run ν_τ propagation through Earth, simulate ν_τ interaction, τ propagation in the atmosphere
- **CORSIKA** -> τ decay air showers
- **GEANT4** -> detector effects of measuring showers
- Most of the MC is being patched together using Julia (check it out)

TauRunner: j.cpc.2022.108422

GEANT4: https://doi.org/10.1016/S0168-9002(03)01368-8
CORSIKA: arXiv:1902.02822
Julia: https://julialang.org

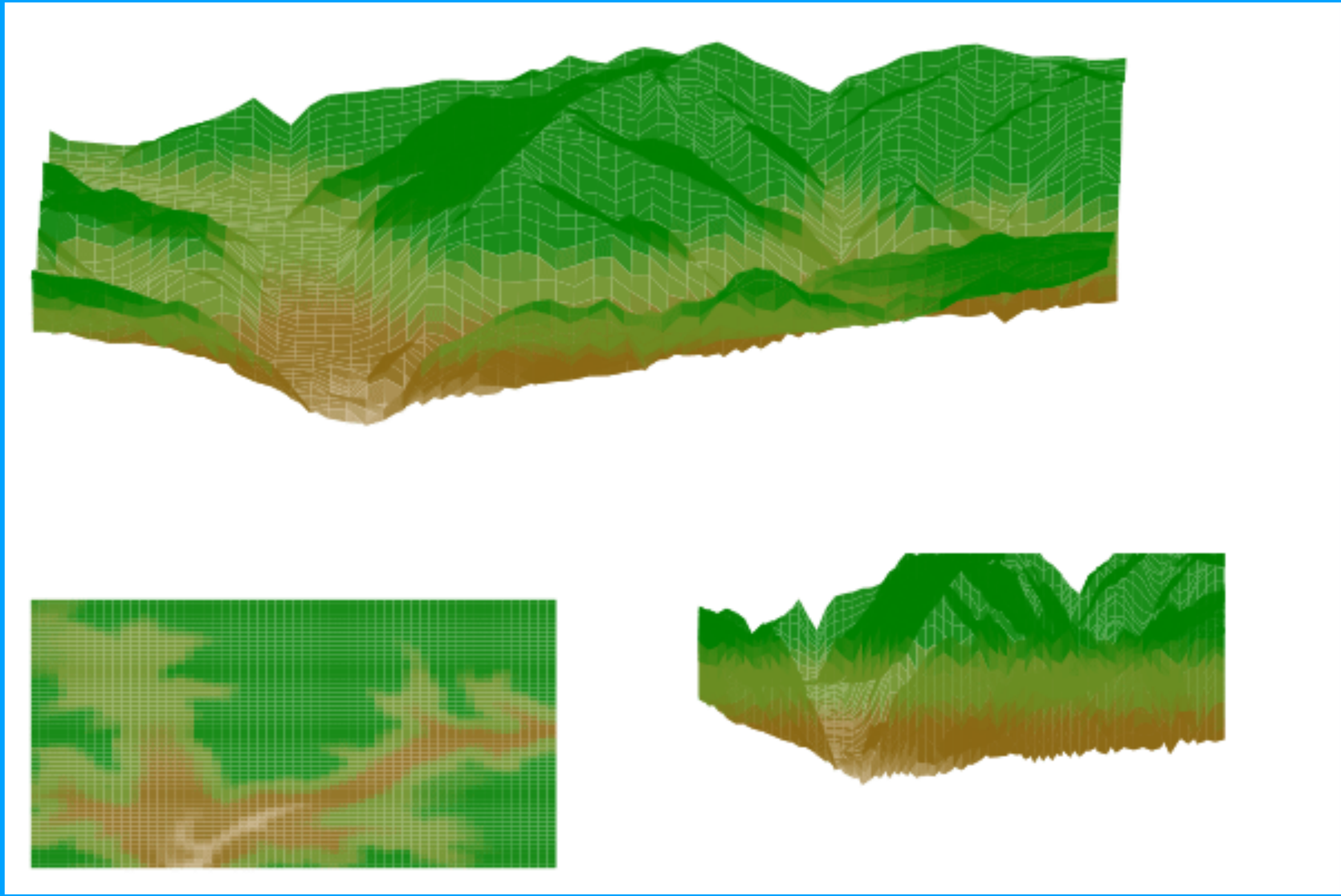

Colca Valley
G4
CORSIKA
TAURUNNER
Water Cherenkov
Array ~ m³
~ 100 m
separation
τ
ν_τ
~ 5-10 km distance

Summary + Outlook

- TAMBO aims to achieve increased ν_τ sensitivity at 1-100 PeV
- And aid in constraining point sources
- We're looking for collaborators: email: carguelles@fas.harvard.edu

Thank you! Questions?

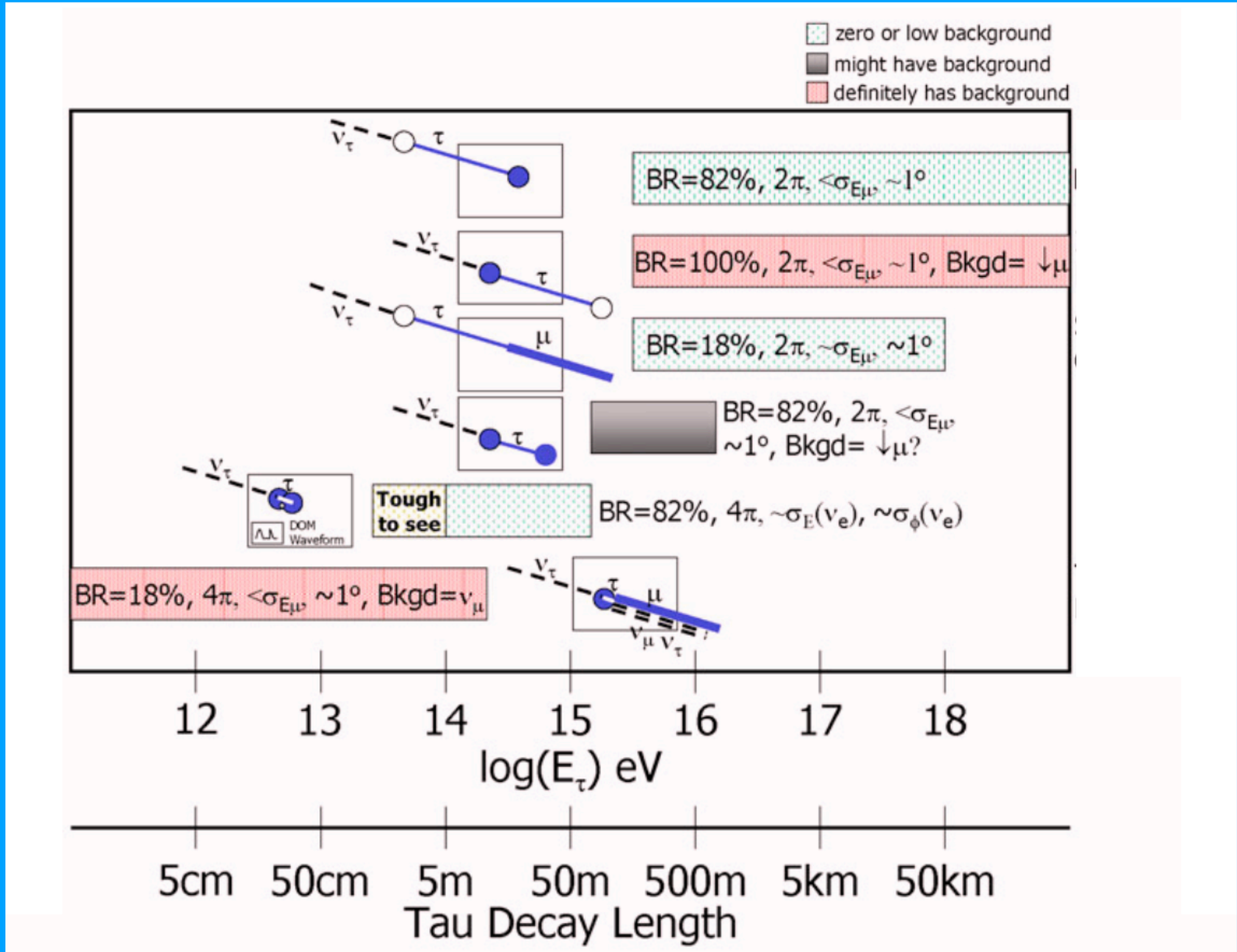
Gif Animation of simulated particle



Courtesy of Jeff Lazar

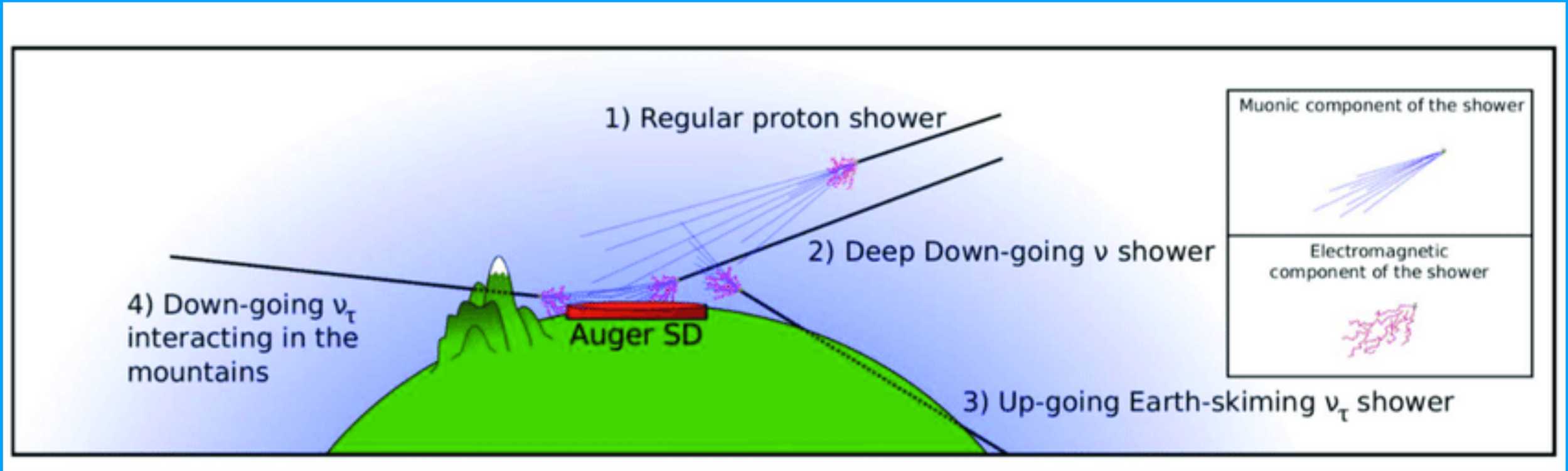
Backup

Different Tau Morphologies



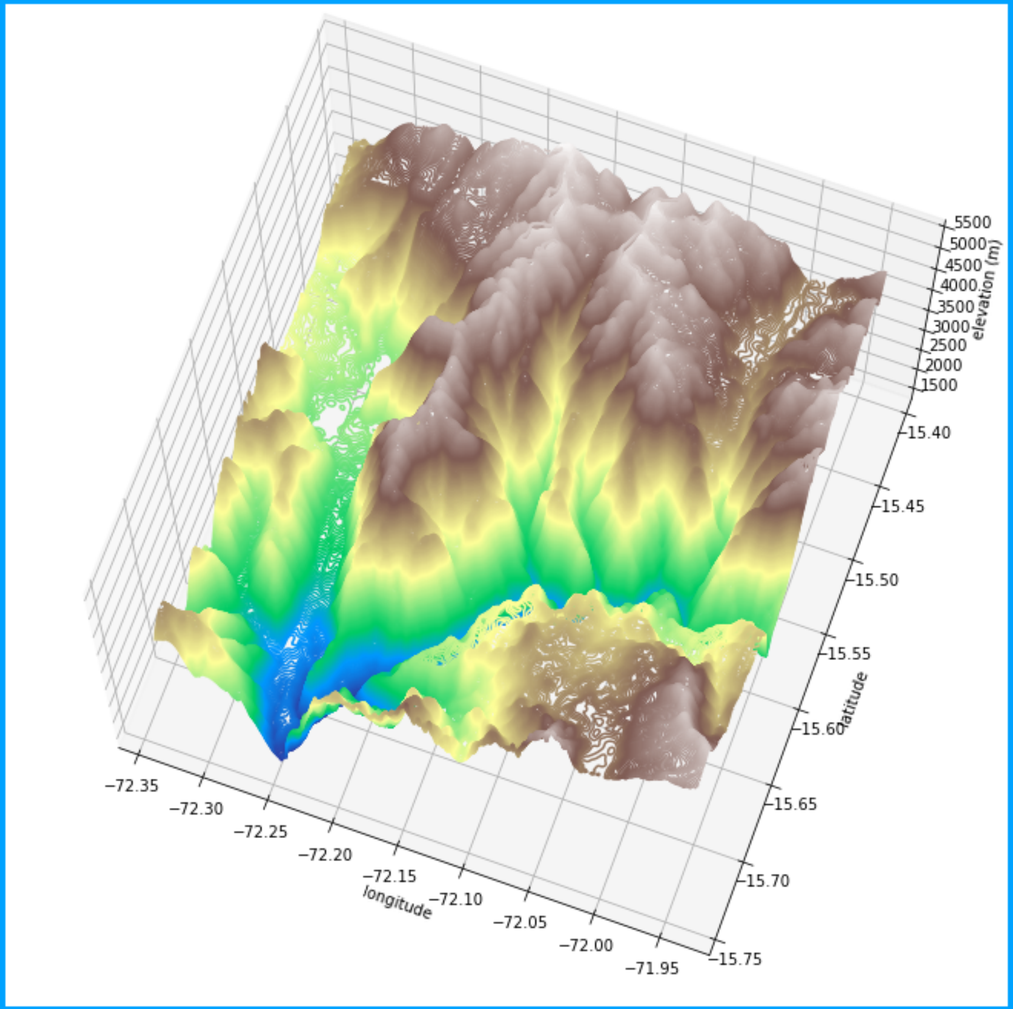
D F Cowen and the IceCube Collaboration 2007 J. Phys.: Conf. Ser. 60 048

More on Earth - skimming Neutrinos



Auger Collab, arXiv:1107.4809

Dark Matter too




FLEX
APE
ν_τ spectrum
1 PeV - 100 PeV
TAMBO