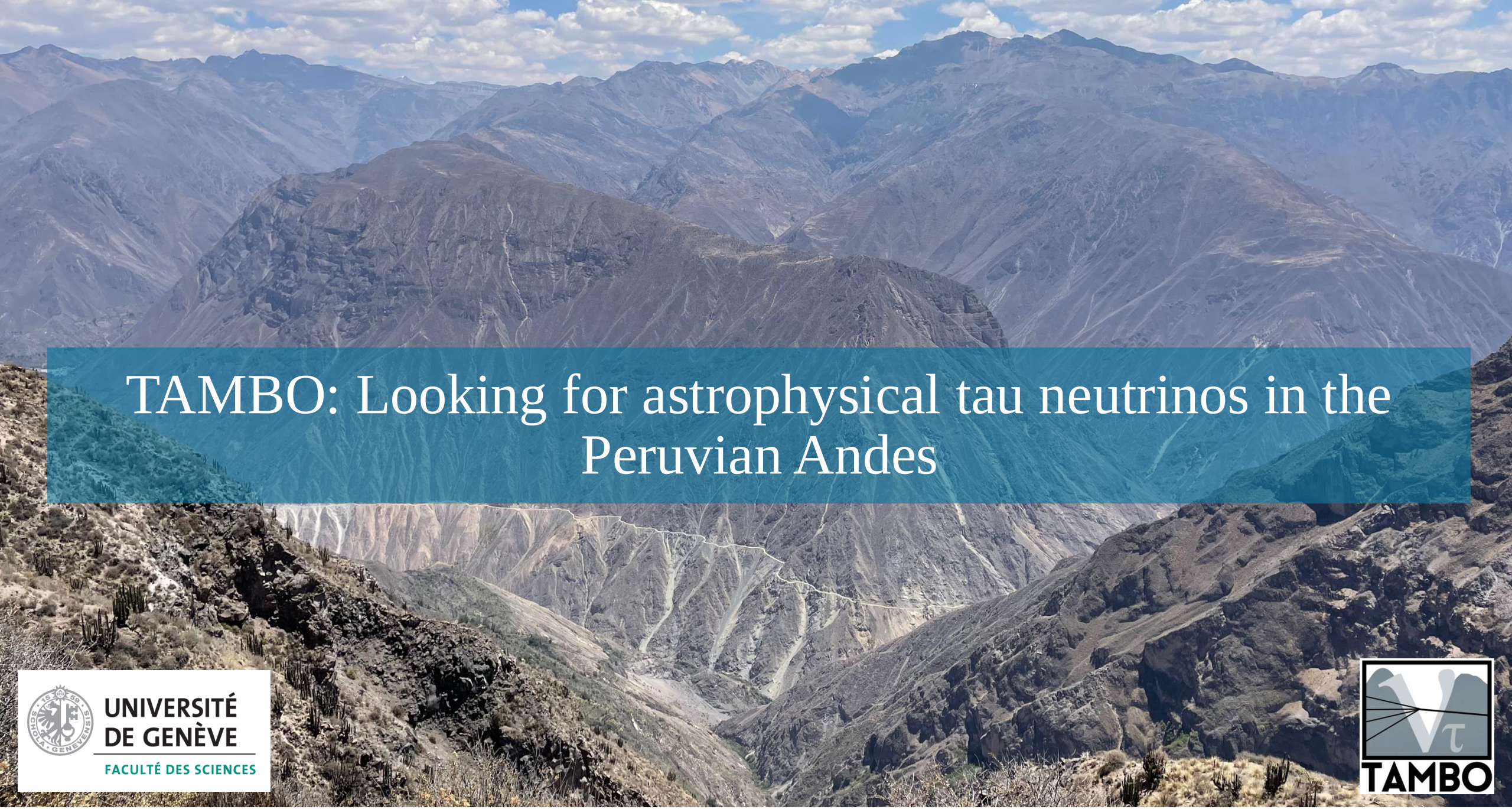


TAMBO: Looking for astrophysical tau neutrinos in the Peruvian Andes

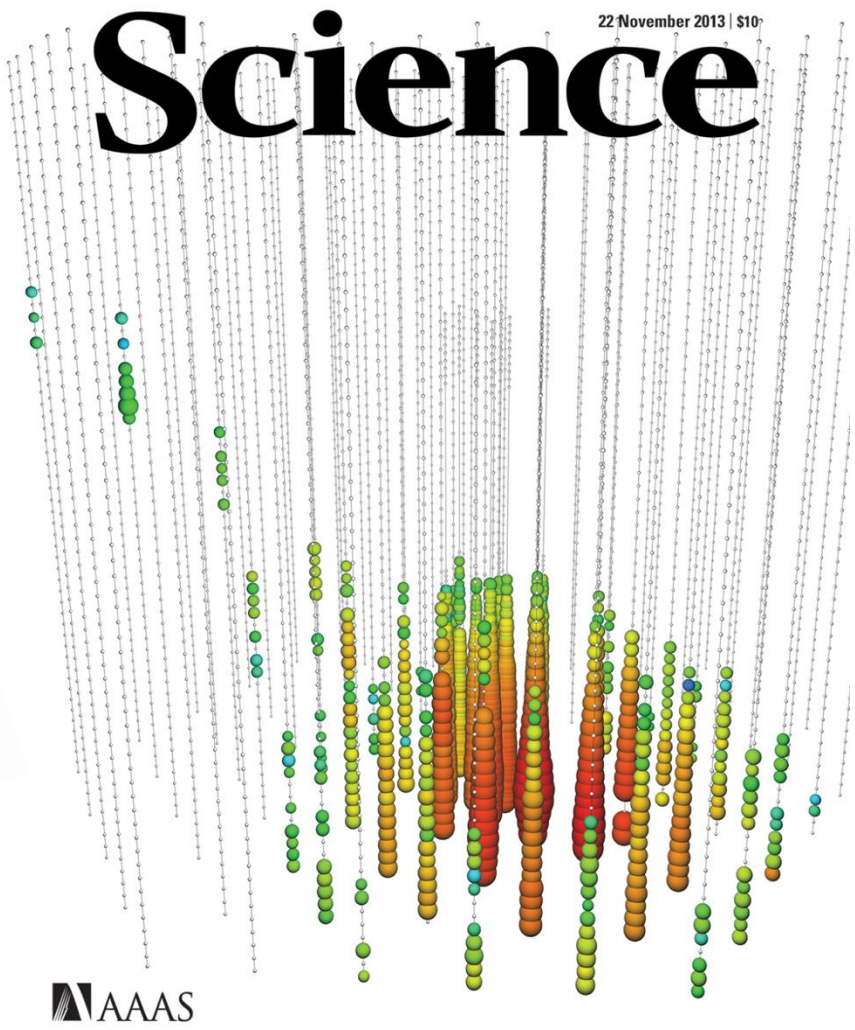
Robert-Mihai Amarinei, University of Geneva (CH) on behalf of the *TAMBO* collaboration

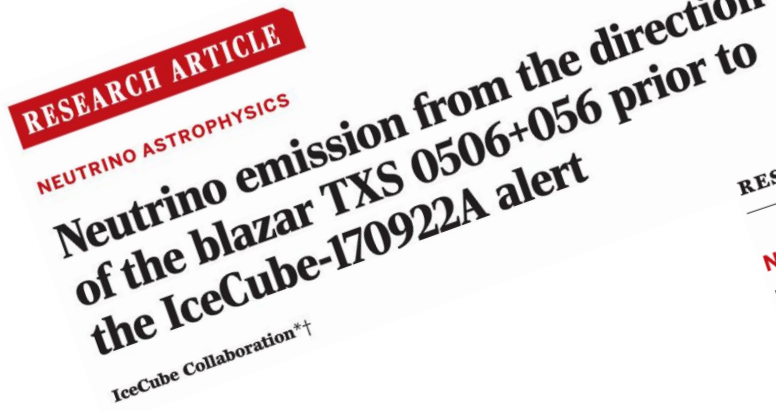
Recent history of astrophysical neutrinos

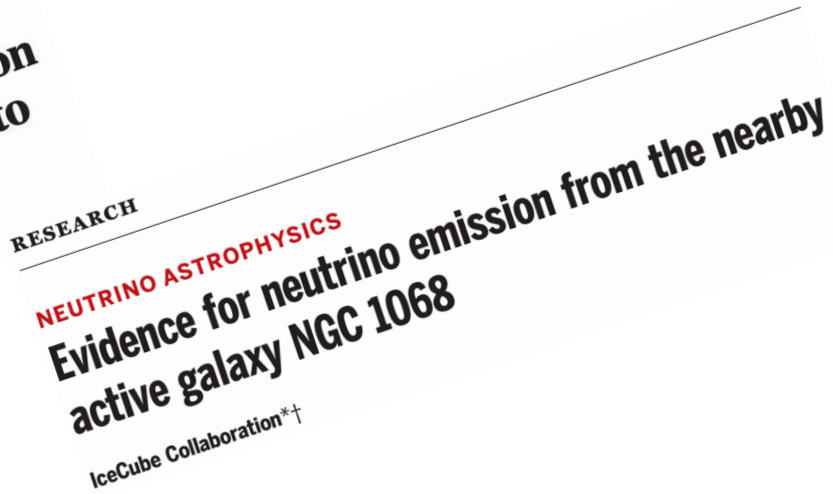
Last decade has seen major discoveries in astrophysical neutrino community

- IceCube – diffuse astrophysical neutrino flux 2013 [1]
- IceCube pin points astrophysical neutrino sources [2,3]
- PeV neutrino detection [4], Multiple tens of PeV event (preliminary) KM3NeT [6]

Credits [1]



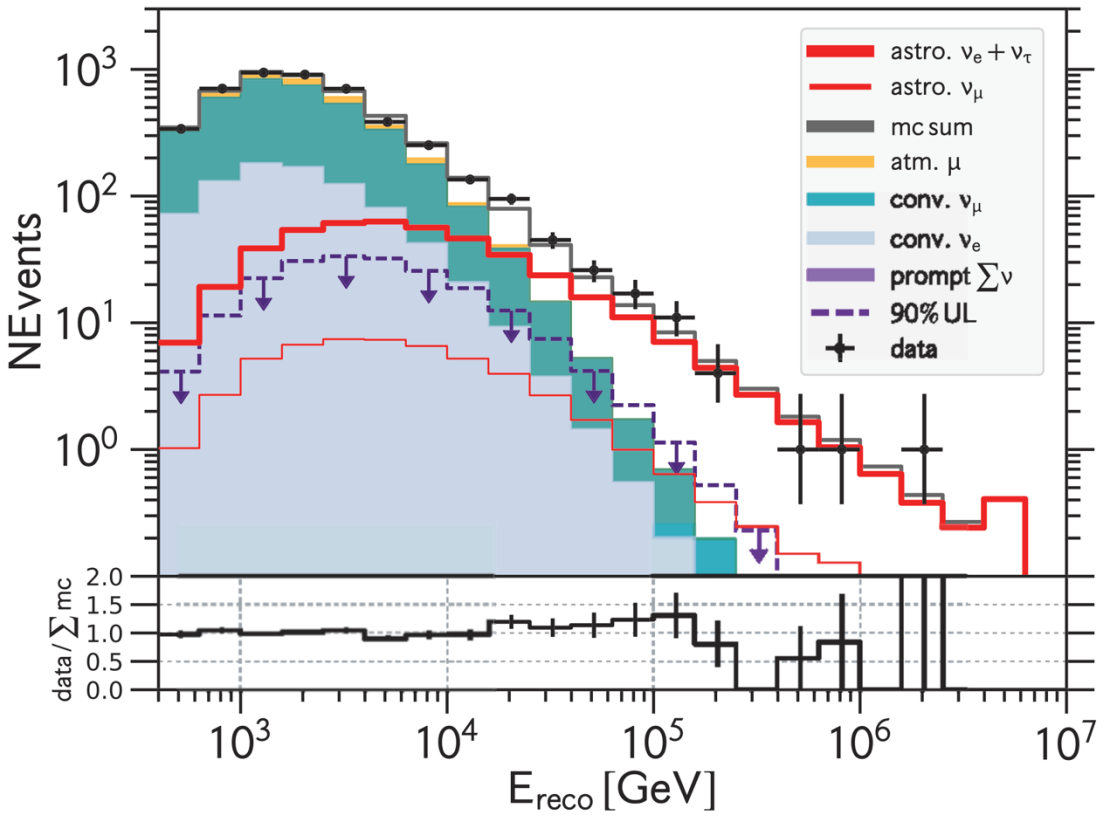




Lessons from the Diffuse Astrophysical Neutrino Flux

- Astrophysical neutrinos → Neutrinos originating beyond our solar system.
- Flux: $E^{-\gamma}$, $\gamma \approx 2.5$ (γ)
  - "Spectral index", $\gamma \approx 2.5$ [7]
  - Spectral index encodes information about particle production mechanism… Active Galactic Nuclei (AGN), Gamma Ray Burst (GRB)
  - The aim is to measure flux for different energy bands and flavours…
  - Spectral index also sensitive to atmospheric or astrophysical

Credits [7]



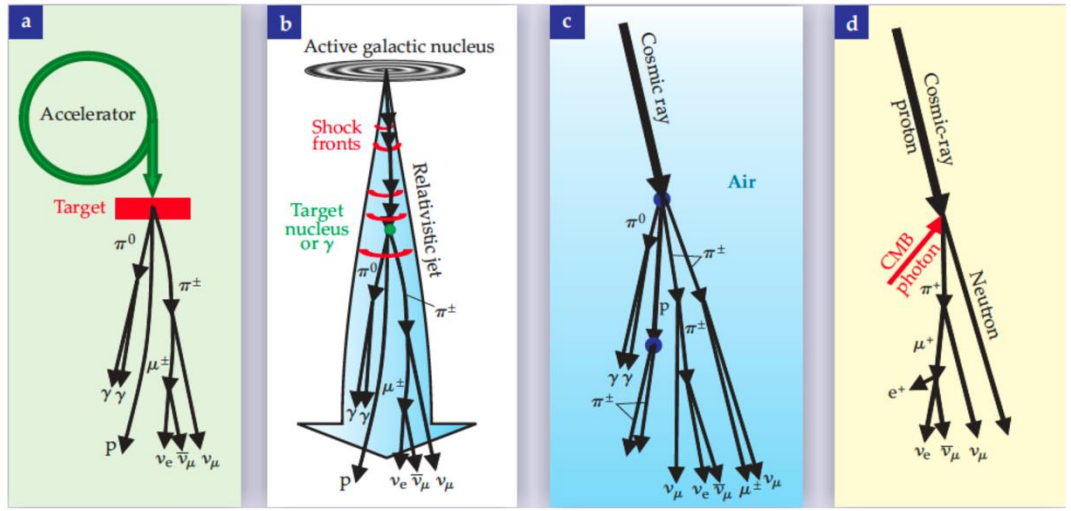
See also preliminary results from KM3NeT present by J. Coelho at Neutrino2024

Neutrino Flavour Ratio

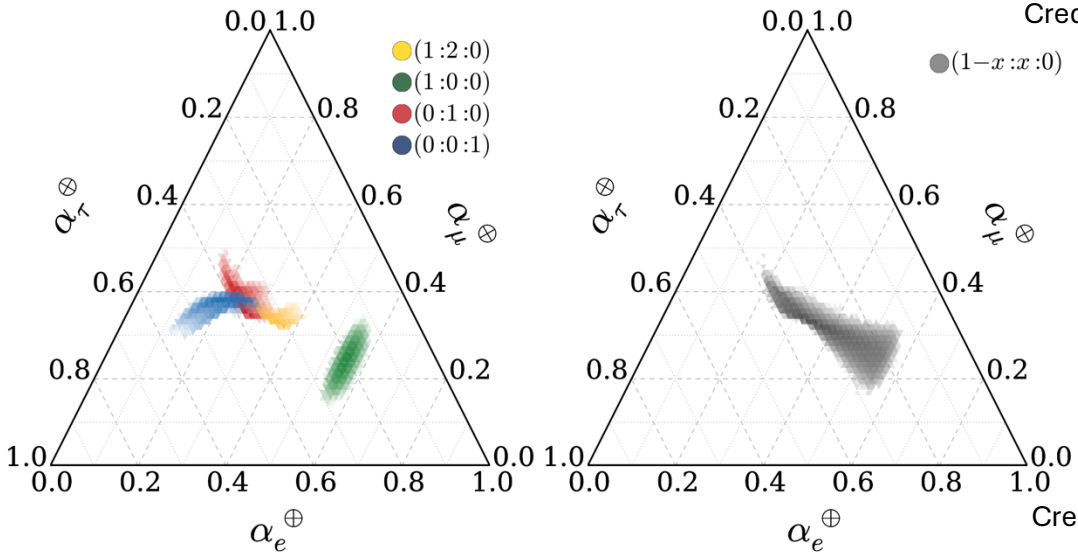
- Are neutrinos arriving at Earth in equal amount for each flavour?
  - Simple question… deep implications
  - Most common model predicts at source: $(f_e:f_\mu:f_\tau)_s = (1:2:0)_s$
  - Pions: $\pi^{\pm} \rightarrow \mu^{\pm} + \nu_\mu \rightarrow e^{\pm} + \nu_e + \nu_\mu$

Bottom plot

- What to expect at Earth for four different models
  - $(1:2:0)_S \rightarrow (1:1:1)_\oplus$
  - $(0:1:0)_S$ or $(1:0:0)_S$ or $(0:0:1)_s$ would imply new other channels.



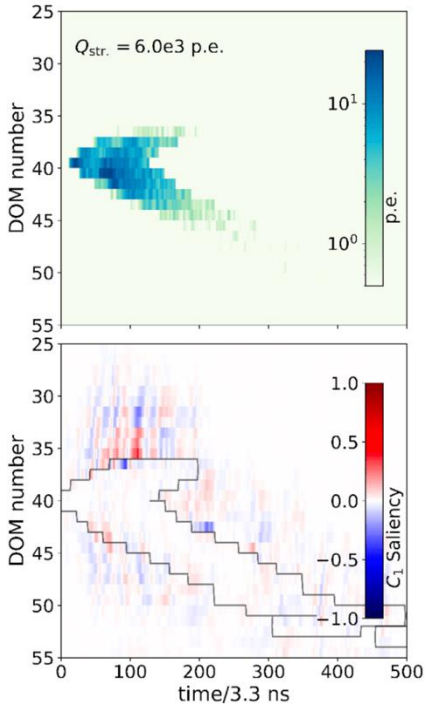
Credits [9]



Credits [8]

Current results

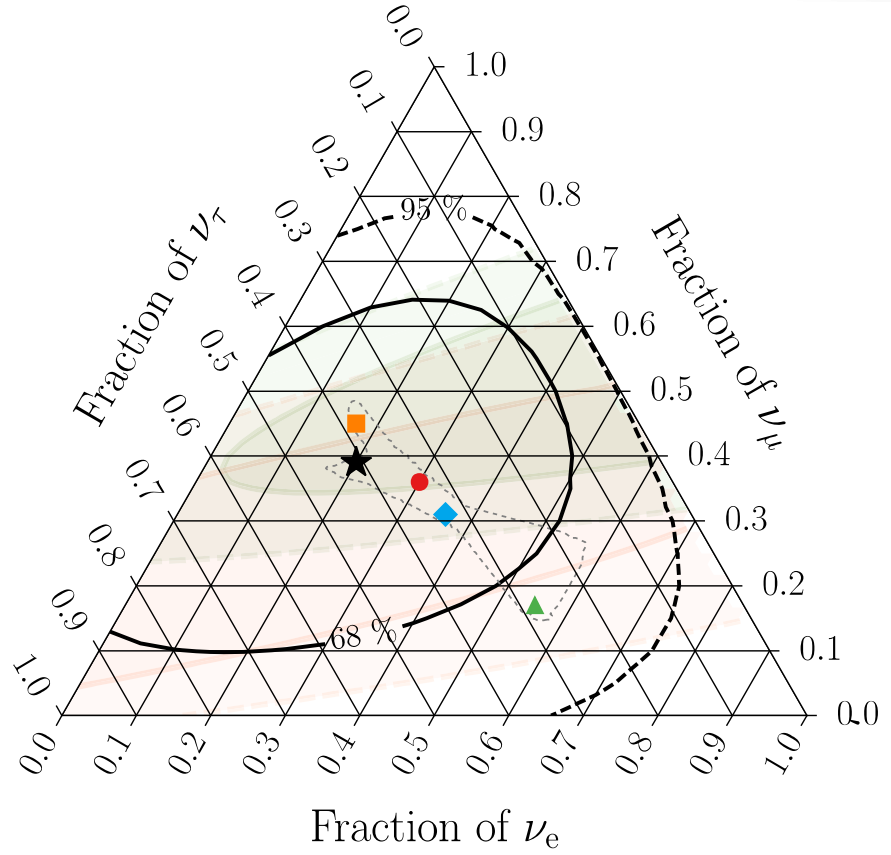
IceCube can detect all flavours.



Distinguishing between electron and tau neutrinos is difficult…

Only 7 tau-like astrophysical neutrinos detected ‘to date’.

Credits [5]



HESE with ternary topology ID
Best fit: 0.20 : 0.39 : 0.42
Global Fit (IceCube, APJ 2015)
Inelasticity (IceCube, PRD 2019)
3ν-mixing 3σ allowed region

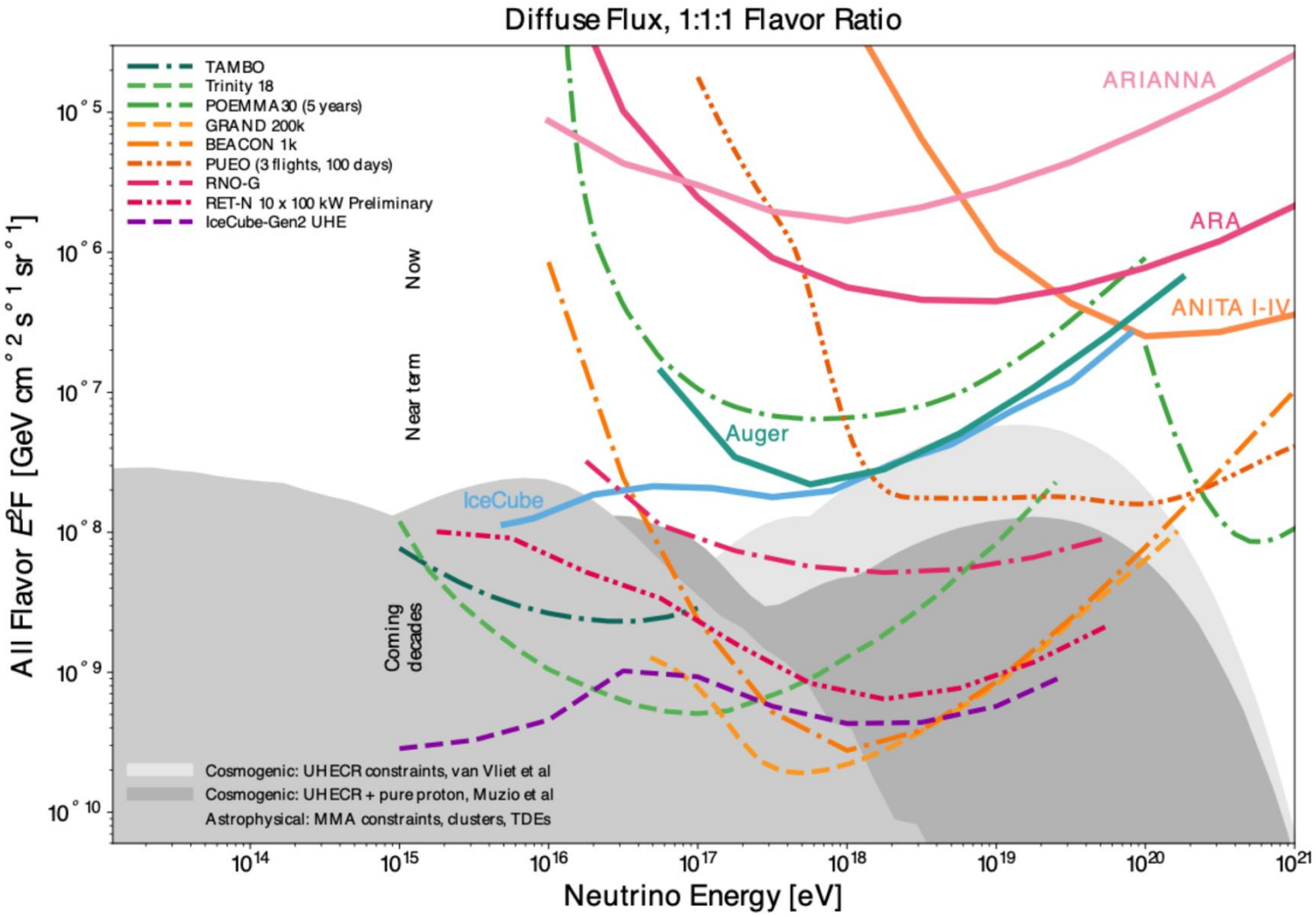
$\nu_e : \nu_\mu : \nu_\tau$ at source $\rightarrow$ on Earth:
0:1:0 $\rightarrow$ 0.17 : 0.45 : 0.37
1:2:0 $\rightarrow$ 0.30 : 0.36 : 0.34
1:0:0 $\rightarrow$ 0.55 : 0.17 : 0.28
1:1:0 $\rightarrow$ 0.36 : 0.31 : 0.33

“Though the best-fit exclusion composition is (0.2 : 0.39 : 0.42) , the limits are consistent with any composition at source…”

Next generation observatories

Community very well prepared for > 100 PeV

- Not a lot of effort to bridge the gap between ~ PeV and 100 PeV
- The flavour identification is still a problem…



Next generation observatories

Community very well prepared for > 100 PeV

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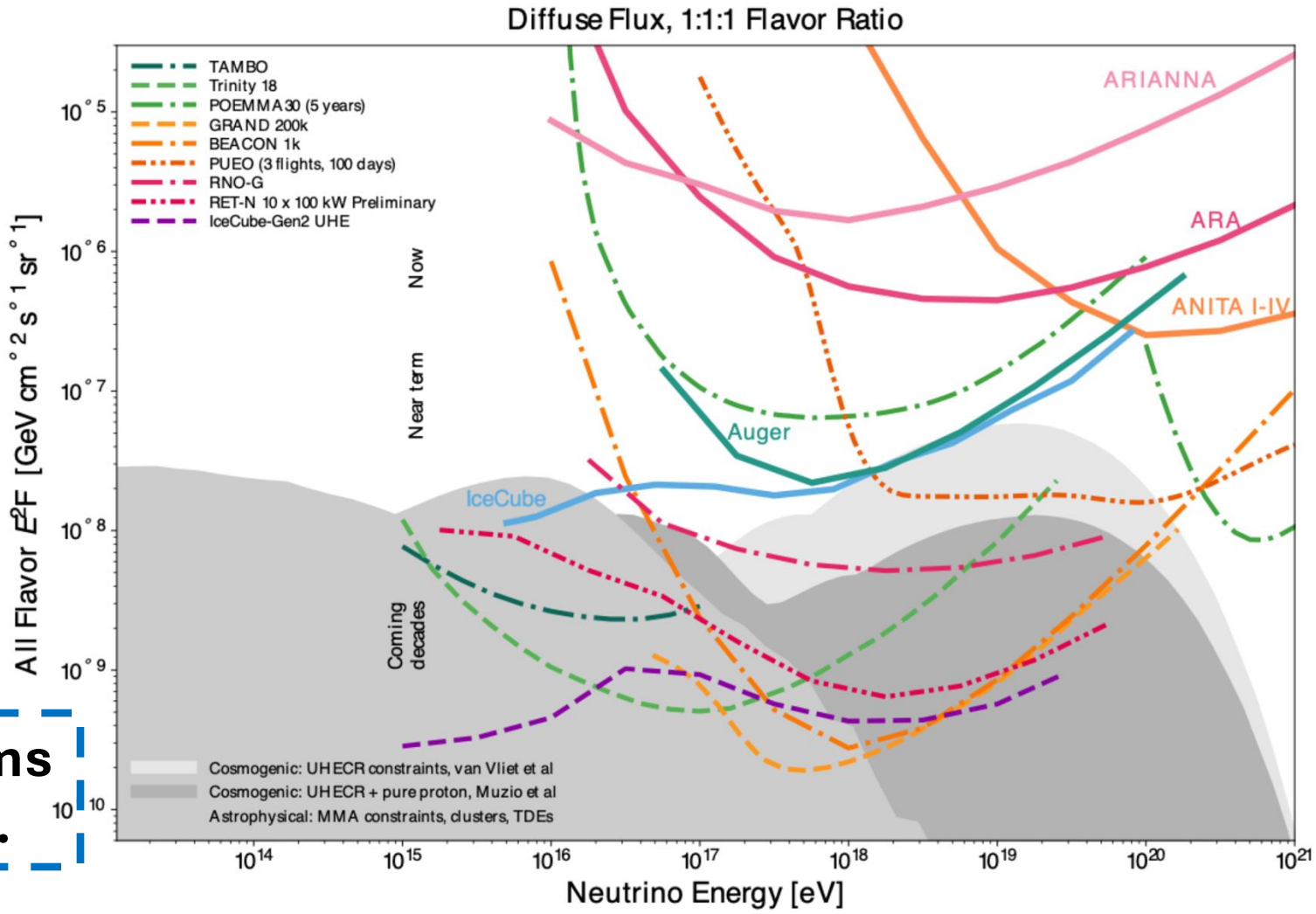
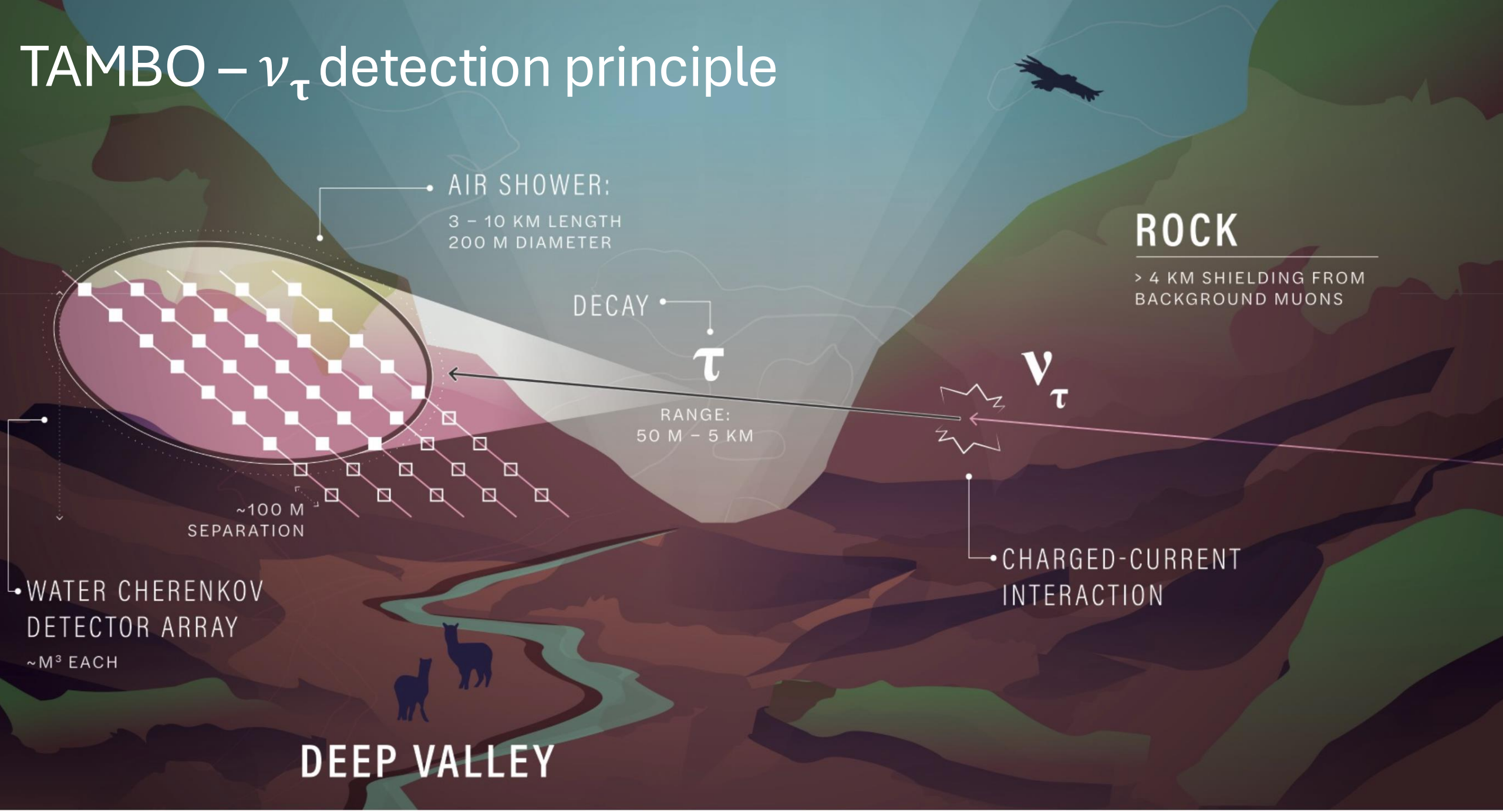
TAMBO tackles these two problems through an innovative approach.

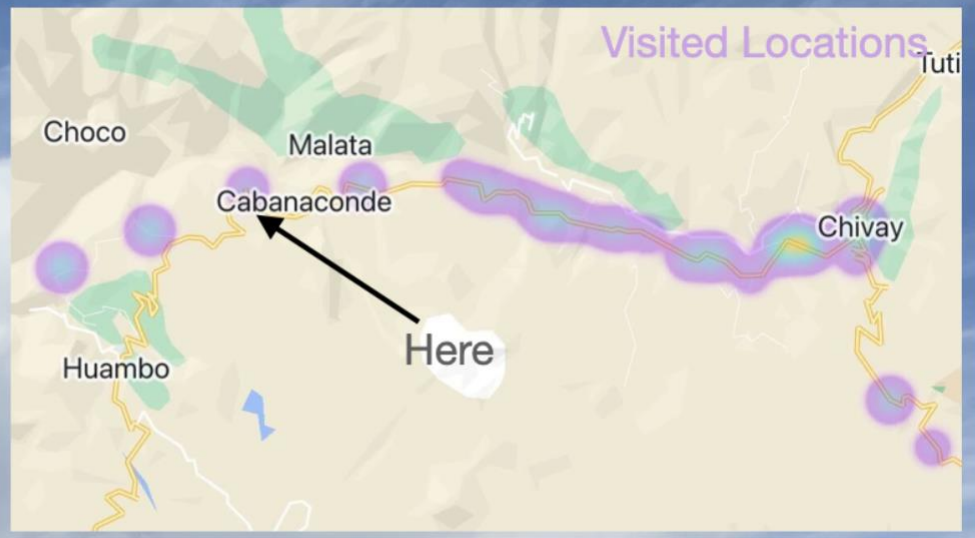


TAMBO – ν_τ detection principle



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

Baseline design



22 k detector modules

150 m spacing

~ km wide

1.5 m^2 module area

One order of magnitude better acceptance

TAPAY Town

CABANACONDE

Proposed TAMBO Location

τ

ν_τ

Slide adapted from A. Garcia's talk

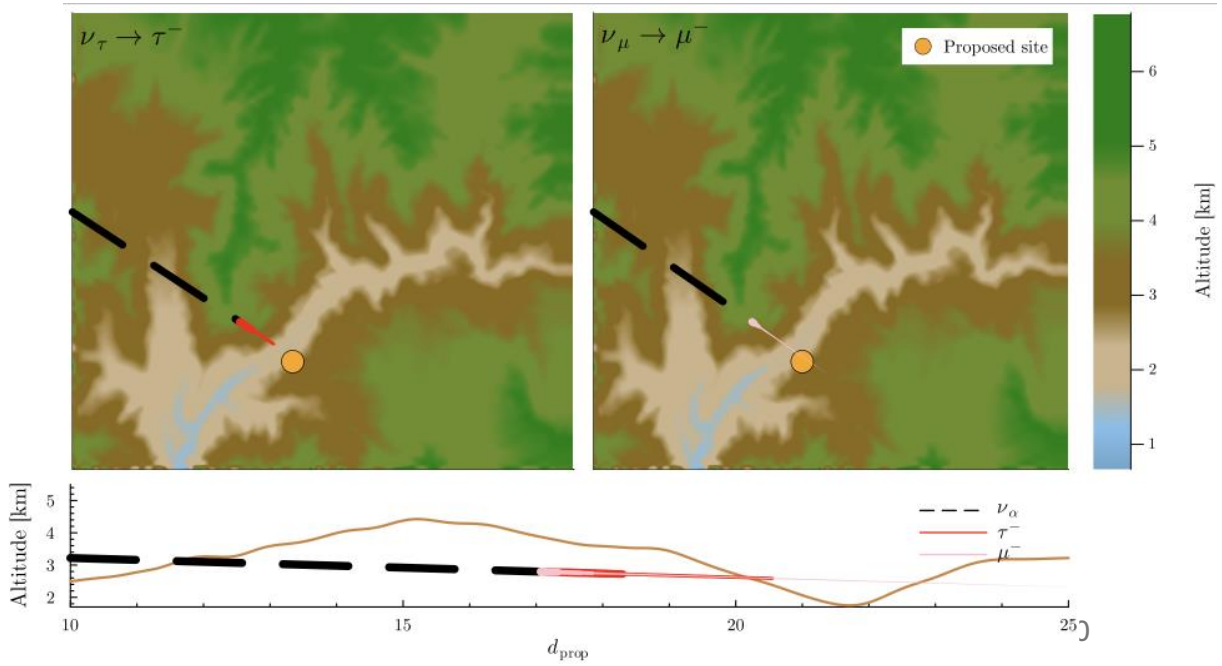
TAMBO - Simulation

A complex simulation is developed covering all physics from primary neutrino to detector response.

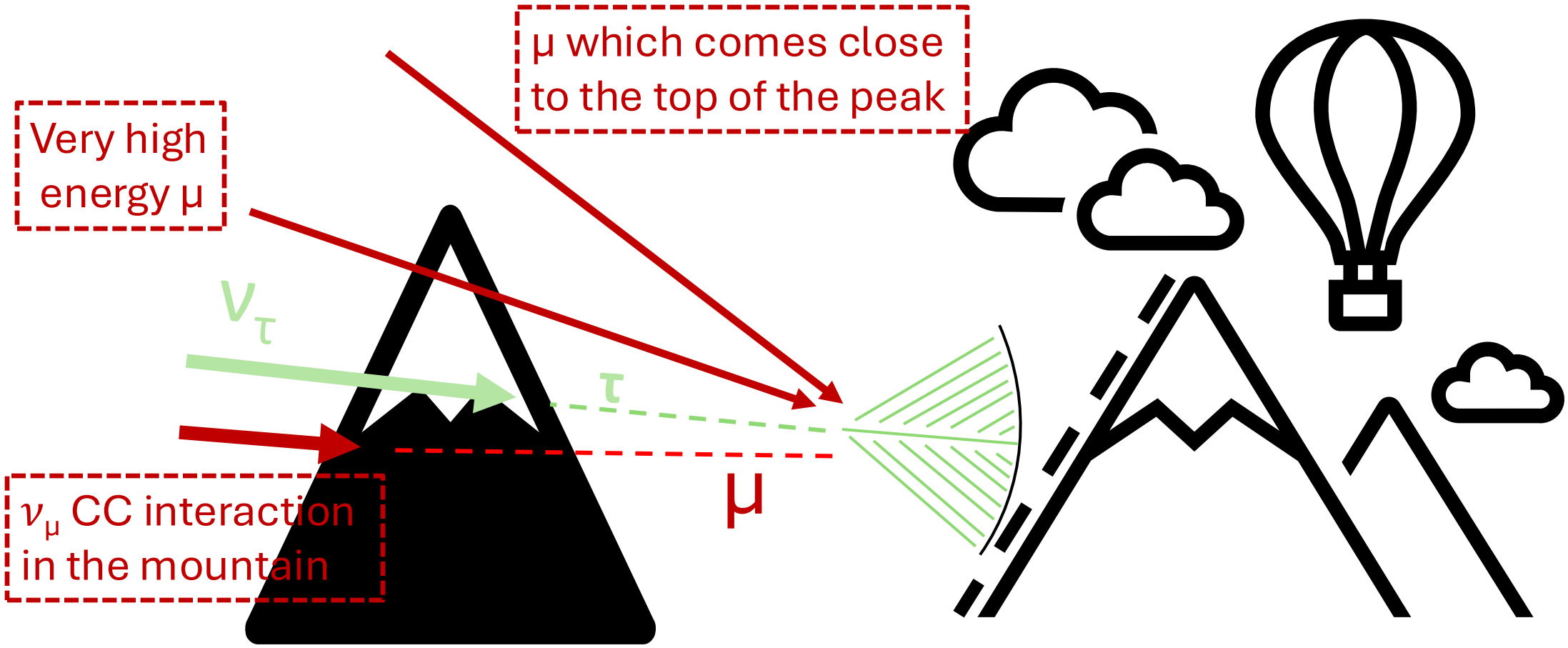
- Event injection: primary neutrino energy, CC interaction in rock
- **τ** lepton propagation (PROPOSAL):

  Energy losses, ν_{τ} recombination
- Event weighting:

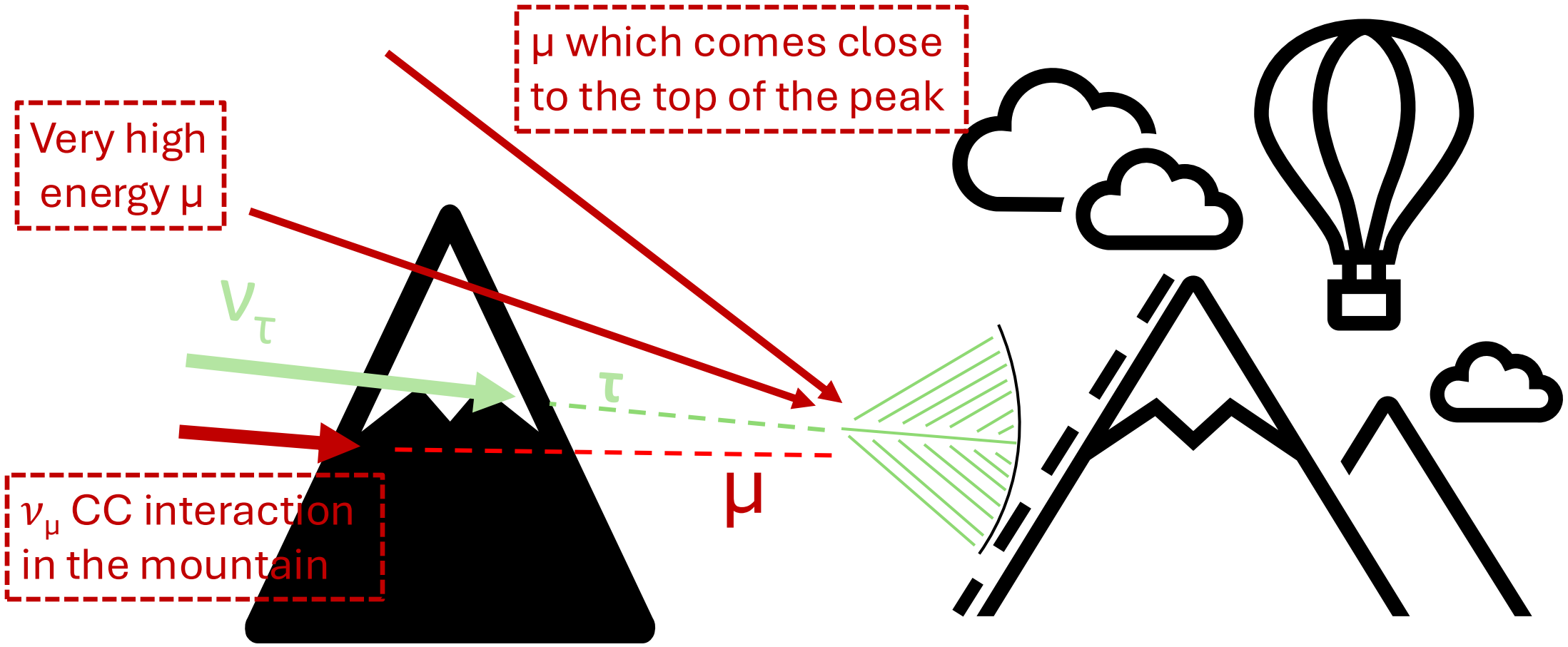
  Correct for “unphysical assumptions”
- Detector response.



TAMBO - Backgrounds



TAMBO - Backgrounds



Backgrounds can be reduced through angular cuts (or they are very rare - 2/century).

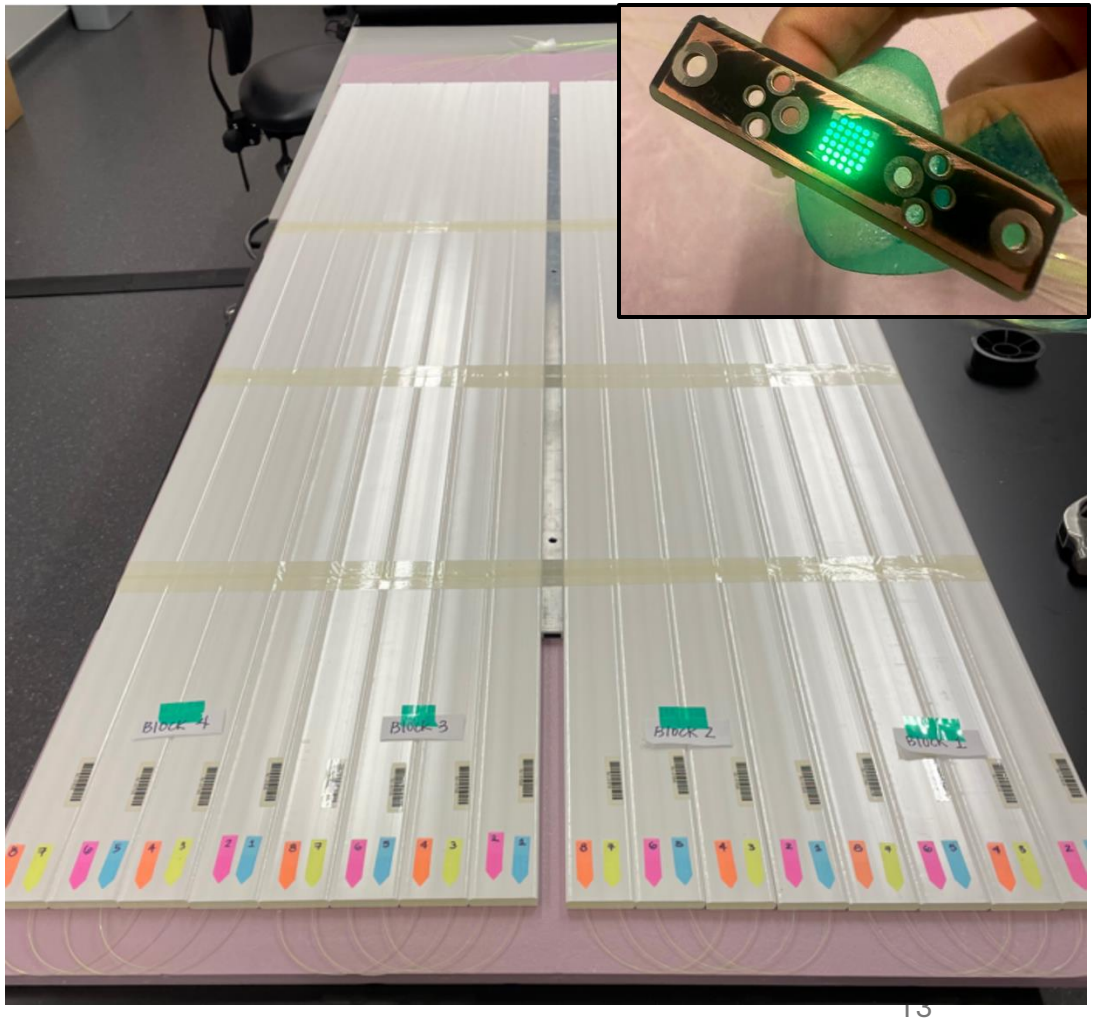
TAMBO – First Module Prototype

TAMBO comprises 22000 modules:

- Water Cherenkov vs plastic scintillator
- ~ns time resolution for 1° angular resolution
- No R&D needed to reach goals
- However, needs to be scalable and easy do deploy on a mountain face.

Current prototype:

- Plastic scintillator (1cm thick) with wavelength shifter
- 1.5 m^2 area
- Readout by SiPM array.



TAMBO – Engaging with the local community

Colca Valley at the fore-front of science:

- Strong support from local officials
- Partnership with local universities
- Engaging the local community in the construction of TAMBO.

Photo Credit: Universidad Nacional de San Agustin de Arequipa

TAMBO

Robert-Mihai Amarinei, University of Geneva (CH) on behalf of the *TAMBO* collaboration

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