An Andean Deep-Valley Detector for High-Energy Tau Neutrinos

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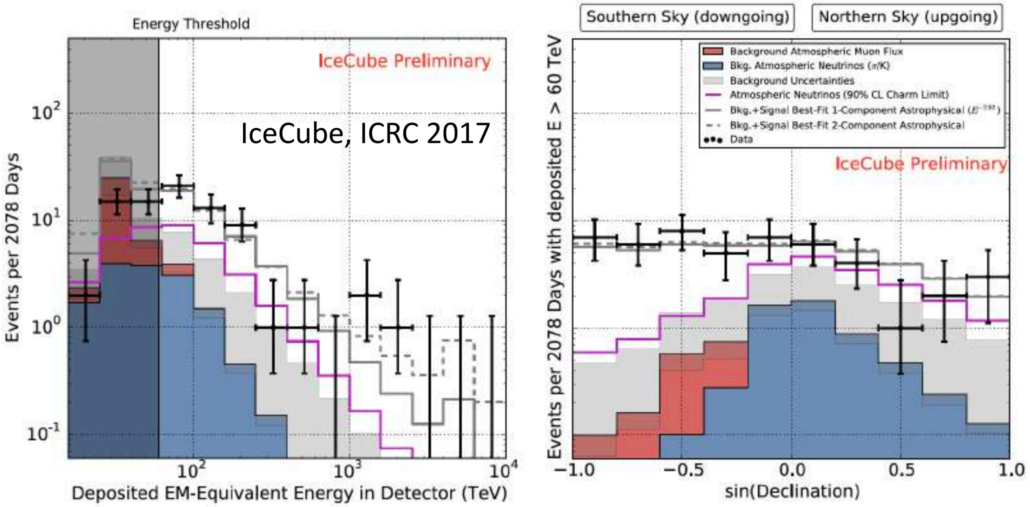
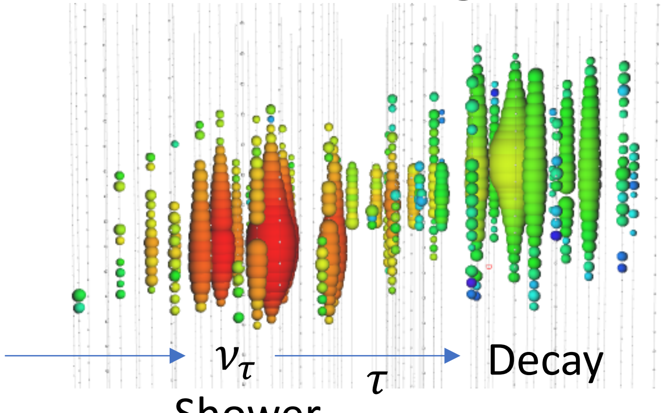
Motivation

- IceCube has discovered an astrophysical flux up to 10 PeV (>5σ).

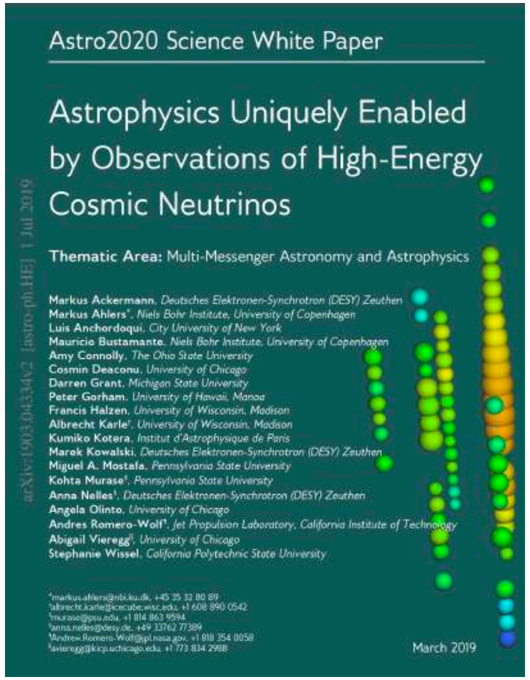


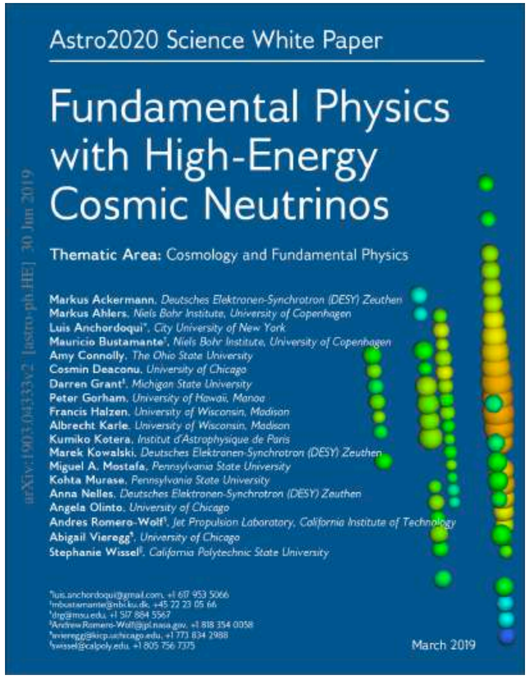
- IceCube: excellent muon neutrino ID but tau identification is consistent with background.

Example of IceCube double bang event expected from tau neutrinos.



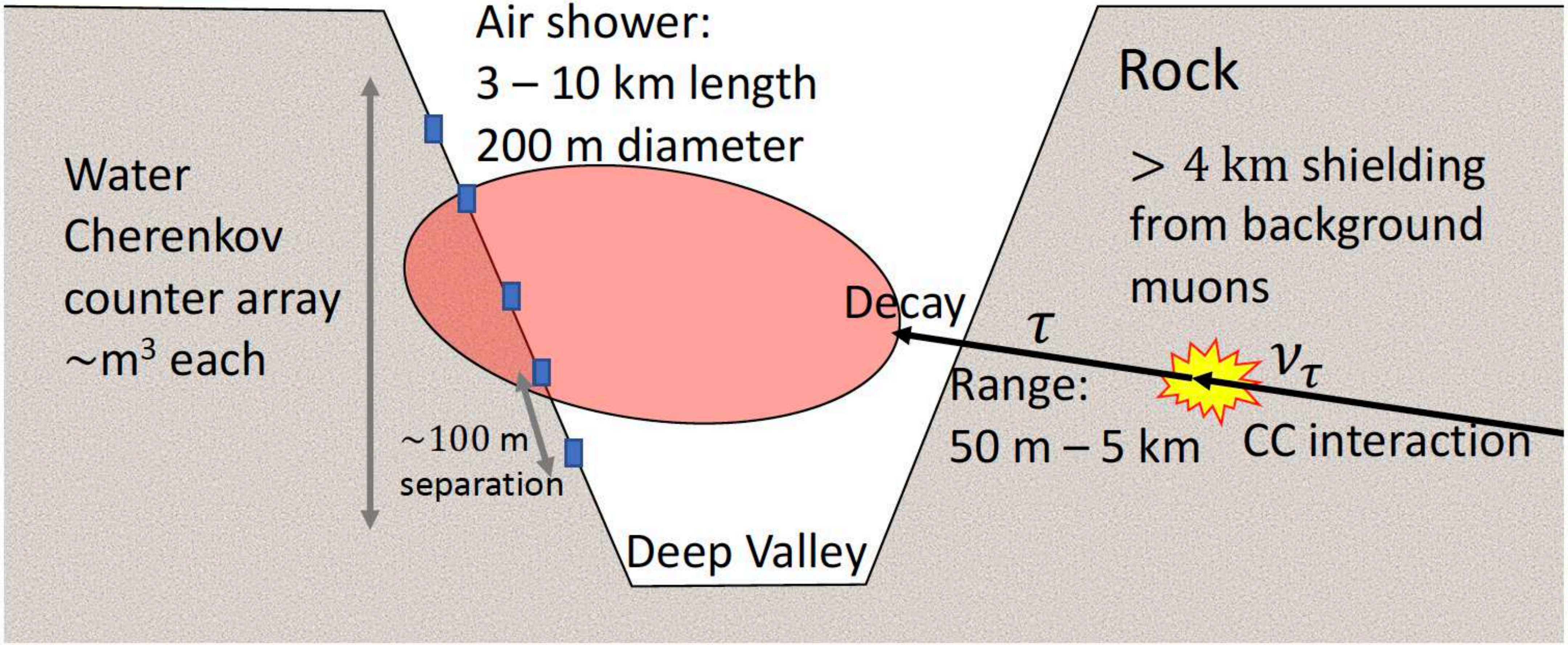
- Tau neutrinos are a critical messenger for interpreting properties of astrophysical objects and searching for new physics.





How can be build a detector more sensitive to high energy tau neutrinos?

Deep Valley Tau Neutrino Detector



- Mountains shield against other backgrounds.
- High energy astrophysical muons can act as a background but with 20 ν_τ : 1 ν_μ.

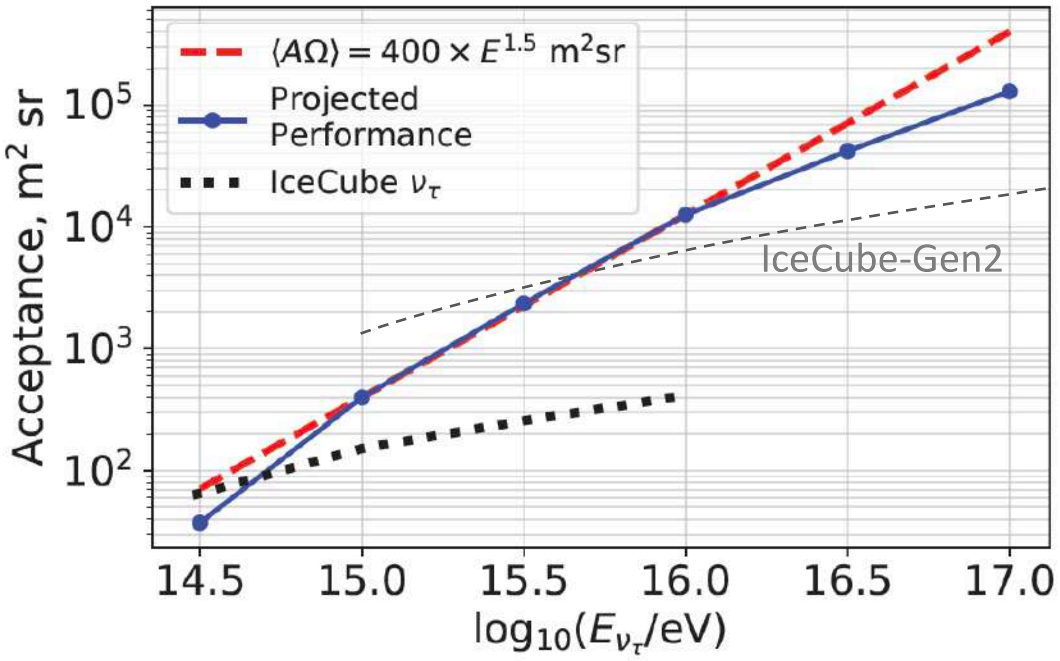
Why the Colca Canyon?

- 3.2 km altitude canyon with approximately the right valley width for tau range.
- Road access with water supply for Cherenkov detectors in the river.
- Towns nearby provide infrastructure for power and logistics.

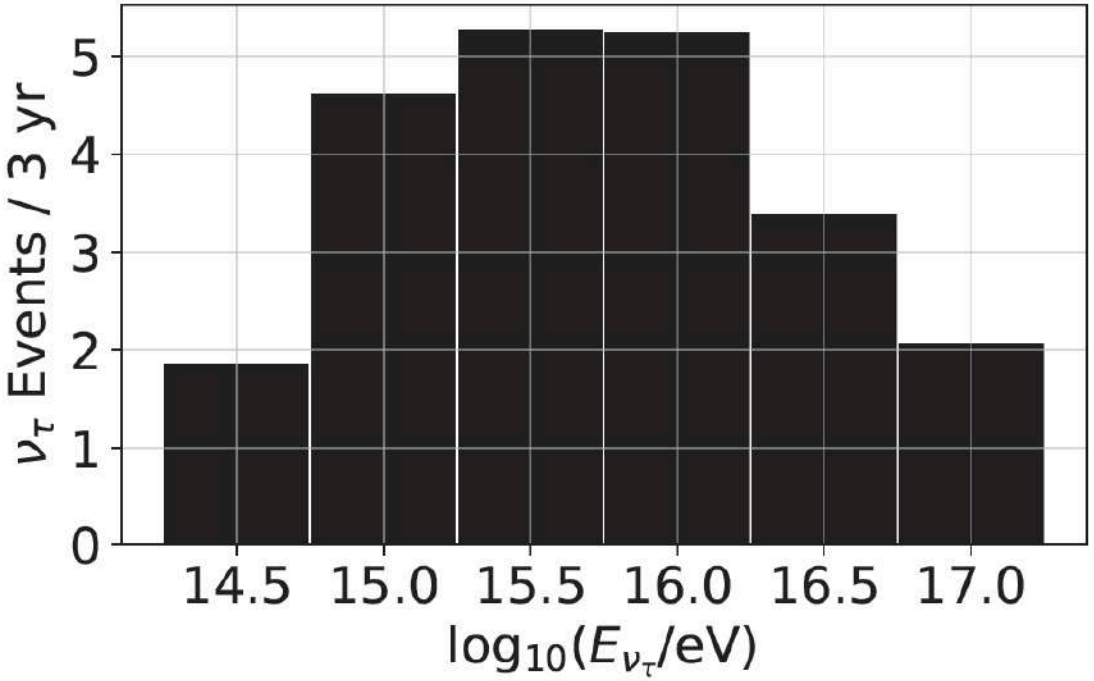
Length: ~70 km; Depth: ~3.2 km + adjacent canyons

Expected Performance

- Initial sizing to match IceCube's sensitivity at 1 PeV
- Requires ~30,000 detectors (~1m^3 water) w/ 125 m apart.
- Sensitivity increases significantly for higher energies



- With this size of array ~21 events/3 yrs expected.
- A 4x smaller array is sufficient to discover tau the astrophysical flux.



Science Objectives

Upcoming developments:

- Finalizing detector studies over the next year.
- Initializing prototype design next year.
- Developing strategy to optimize science return as the detector is being built.

Objective	Physical Parameters	Observatory Requirements
(O1) Determine whether high-energy neutrino sources continue to accelerate particles above 10 PeV.	Sensitivity of $\geq 5\sigma$ to the τ component of the flux extrapolated from IceCube data for energies 1 - 100 PeV	Diffuse τ neutrino flux acceptance $\langle A\Omega \rangle \geq 400\ \mathrm{m}^2\ \mathrm{sr} \times E_{\mathrm{PeV}}^{3/2}$ between 1-10 PeV and > 10 times IceCube between 10-100 PeV. Integrated sky coverage > 0.5 sr. Energy resolution: neutrino $\Delta E/E \leq 1.0$, air shower $\Delta E/E \leq 0.8$ (both 1σ) Tau air-shower direction resolution $\leq 1°$. Tau neutrino flavor identification >95% confidence per event. Point source effective area $\langle A \rangle \geq 300\ \mathrm{m}^2 \times E_{\mathrm{PeV}}^{3/2}$ (peak) with instantaneous sky coverage > 0.1 sr.
(O2) Characterize the astrophysical sources of the neutrino flux between 1-10 PeV by measuring the τ component.	Sensitivity to the diffuse τ neutrino flux at energies between 1-10 PeV with efficient flavor identification.	
(O3) Constrain the particle acceleration potential of point source transients observed with multi-messenger probes.	Point source flux of τ neutrinos as a function of energy.	