



# The Trinity Neutrino Observatory: Probing the PeV-EeV Neutrino Sky



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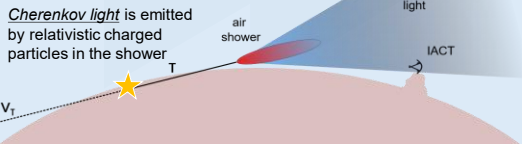
## Trinity Science Case

We search for very-high-energy (PeV-EeV) neutrinos that are expected to come from astrophysical sources. Theories of high-energy neutrino origins include supernovas, blazars, supermassive black holes with/without jets, and gamma-ray bursts.

**Challenges:** The astrophysical PeV-EeV neutrino flux is expected to be extremely weak.

## Detection Technique

1. A tau neutrino enters Earth (shallow angle  $< 10^\circ$ ).
2. The neutrino interacts in Earth's crust, producing a tau.
3. The emerging tau decays, initiating a particle shower in the lower atmosphere, producing Cherenkov light.
4. The telescope images Cherenkov light from the shower.
5. The neutrino energy and arrival direction is reconstructed from the recorded image.



**Detector Configuration [1]:** Telescope(s) located at about 3000 m altitude and pointed at the horizon

**Development Phases:**

1. Trinity Demonstrator - current stage.
2. Trinity One - first full telescope, start of funding expected in 2027
3. Trinity Observatory - 18 telescopes, 2032?

## Trinity Demonstrator

Located: Frisco Peak, UT; 1 m<sup>2</sup> light collection area;  
4° x 4° Field of View (FOV);  
256 pixels camera; 0.24° angular resolution [1].

**Goals:**

1. Validate detection concept.
2. Characterize background.

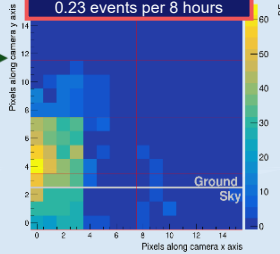
**Collected Data [2]:**

- 546 hours (8 hours of observation per night).
- Oct 2024 – Dec 2025.
- 3.98 millions events.
- Clear night sky.

## Demonstrator's Events

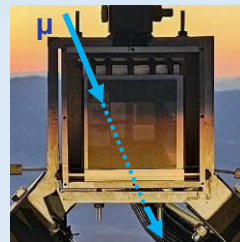


"Fuzzy" Recorded Event  
0.23 events per 8 hours



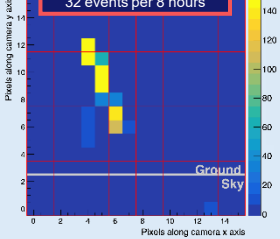
**Background Events [2]:**

- 16 isolated muon Cherenkov candidates: create a "fuzzy" image on the camera.
- 2090 tracks: muons interacting with the camera.



PE is photoelectrons.  
The trigger condition is at least 20 PE in one pixel [1].

Muon Track  
32 events per 8 hours



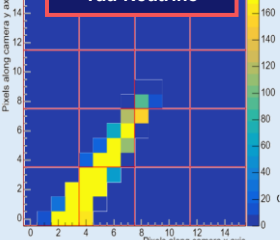
## Tau Neutrino Simulation

**Tau neutrino event simulated by CHASM [3]:**

- Energy: 1.27 EeV
- Distance: 29 km
- Emergence Angle: 8.9°

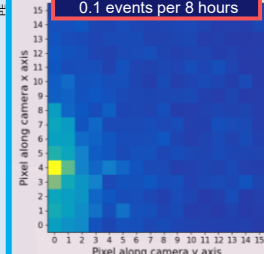
**No neutrino event observed yet.**

Tau Neutrino

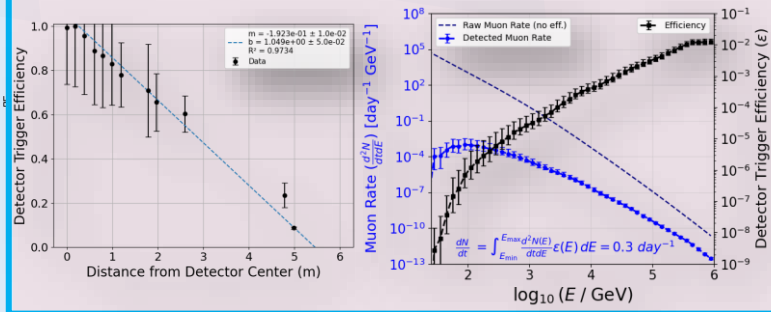


## Muon Simulation

Simulated Muon  
0.1 events per 8 hours



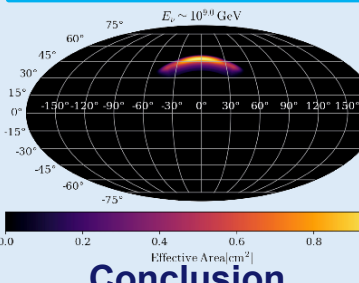
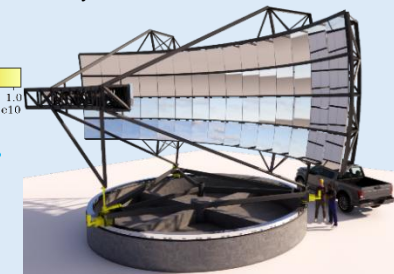
- **High-energy muons** arriving within the FOV can trigger the Demonstrator.
- **3 millions** muons were simulated with CORSIKA8 [4].
- Used full detector simulation to determine the trigger efficiency.
- The expected muon flux is computed by MCEq [5].
- Combined MCEq flux with the trigger efficiency to estimate the muon rate.
- Estimated muon rate is  $0.1^{+0.16}_{-0.05}$  muons per 8 hours



## Outlook: Trinity One

Location: Frisco Peak, Utah  
36 m<sup>2</sup> light collection area; 5° x 60° FOV;  
13,200 pixel camera; 0.15° angular resolution.

- 60° horizontal FOV.
- Rotates in azimuth, about 65% of the sky is accessible.
- Potential to observe the first PeV-EeV Trinity tau neutrinos.



## Conclusion

- The Demonstrator was successfully installed and is operational.
- All background events are identified as coming from single muons and can be suppressed at analysis level.

[1] M. Bagheri et al. Nucl. Instrum. Meth. A 1080 (2025) 170769  
 [2] S. Stepanoff ... K. Tran et al. PoS ICRC2025 (2025) 1188  
 [3] I. Buckland and D. Bergman, PoS ICRC2023 (2023) 325  
 [4] J.M. Alameddine et al. Astropart. Phys. 182 (2026) 103265  
 [5] A. Fedynitch et al. EPJ Web Conf. 99 (2015) 08001  
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