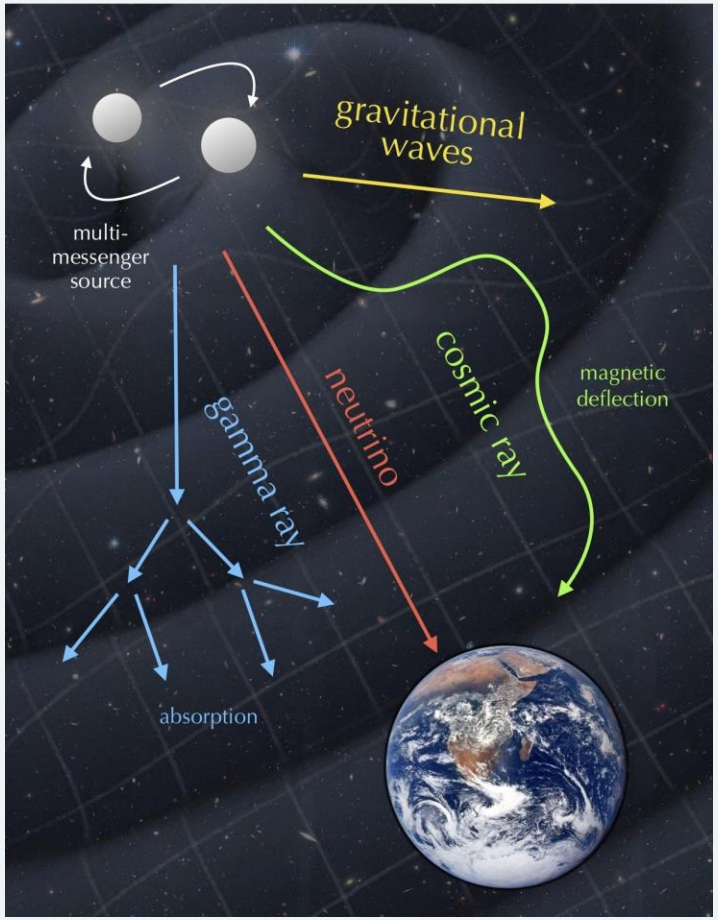
HTC in the Search for Very High Energy Neutrinos with Trinity

Lily Grace Sheram
For the Trinity Collaboration

Trinity

Very High Energy Neutrinos



Credit: Niels Bohr Institute
University of Copenhagen

Probe otherwise opaque regions of cosmic particle accelerators.

Offer a unique way of studying:

- **Jet formation close to the event horizon of SMBH.**
- **Ultra-high-energy cosmic rays.**
- **The evolution of the Universe.**
- **New physics BSM.**

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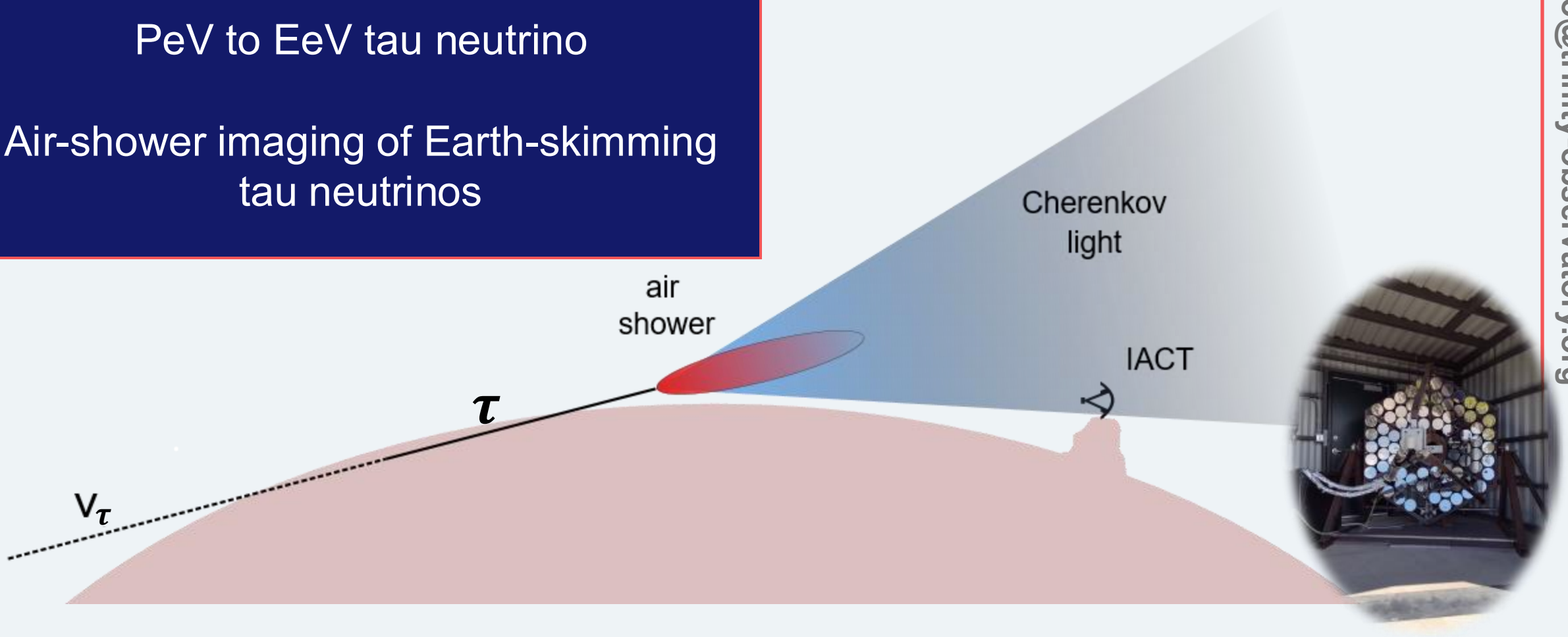
Trinity Detection Concept

PeV to EeV tau neutrino

Air-shower imaging of Earth-skimming tau neutrinos



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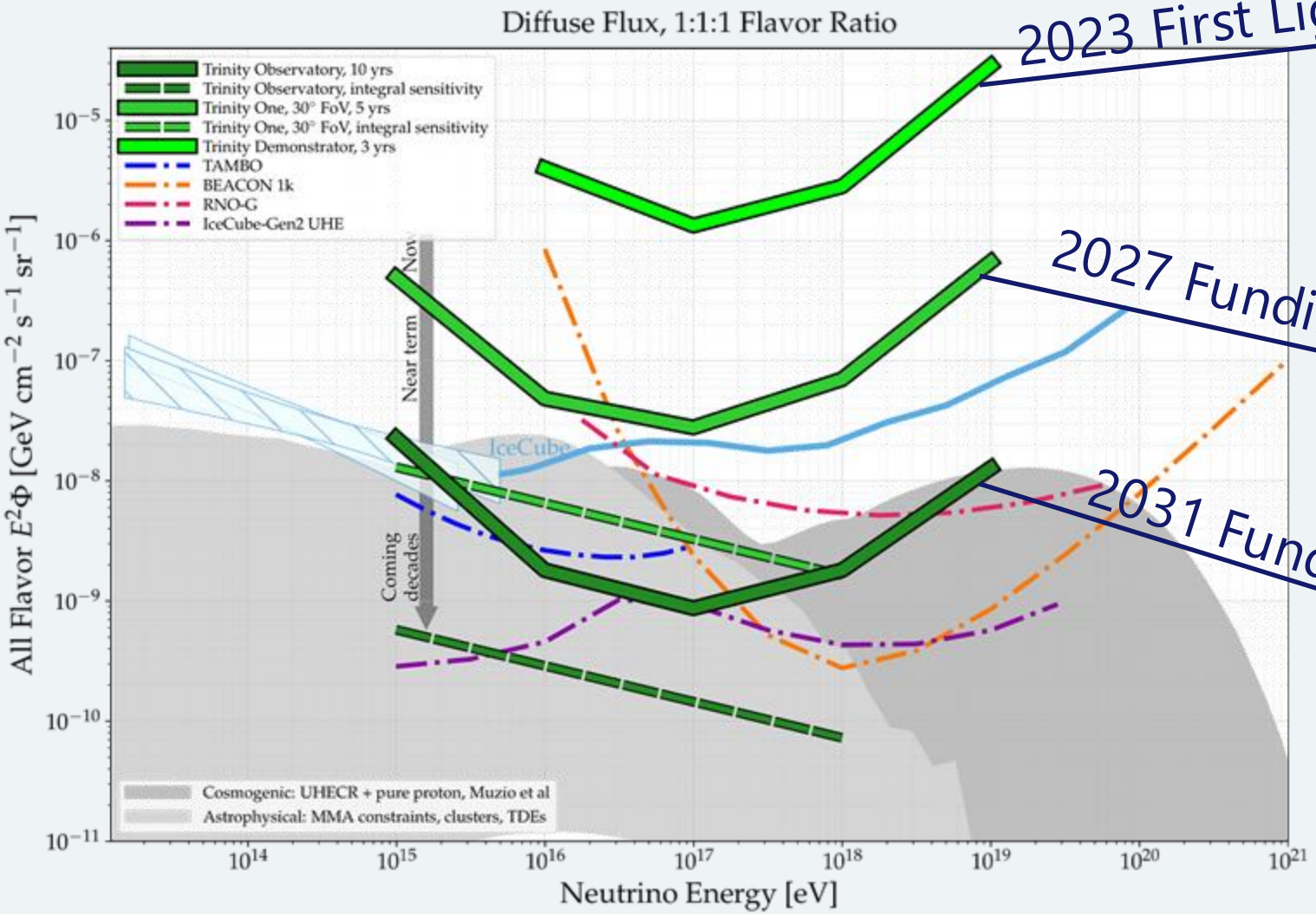
Trinity Timeline



Adapted from Snowmass 2022

2023 First Light

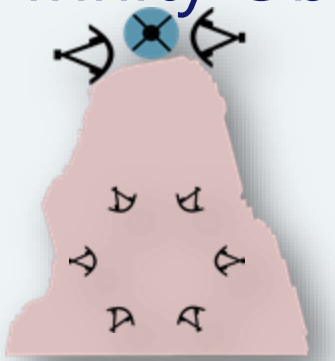
Demonstrator

2027 Funding?

Trinity One

2031 Funding?

Trinity Observatory



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Trinity Demonstrator Data

Data Taking Period	October 2024-Dec 2025
Hours Observed	1204
Hours Analyzed	554
Data Volume	735 GB
Trigger Rate	1 Hz
Triggered Events	1.2 Million

Deployed on Friso Peak, Utah
In October 2023

Camera paper: [arXiv:2406.08274]
Commissioning paper: [arXiv:2503.11864]

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HTC Analysis Chain

- Data stored on OSDF

- Analysis run on OSPool

Computing Resources

Process	CPUs	Memory	Disk Space	Jobs Run Per Night
Data Merging	1	3 GB	4 GB	50 - 400
Calibration	1	1 GB	20 GB	1
Image Cleaning	1	1 GB	2 GB	50 - 400

Run Times

Data Set	Run Time
Single Night	~1 Hour
152 Nights: Single Computer With OSpool	 ~152 Hours ~30 Hours

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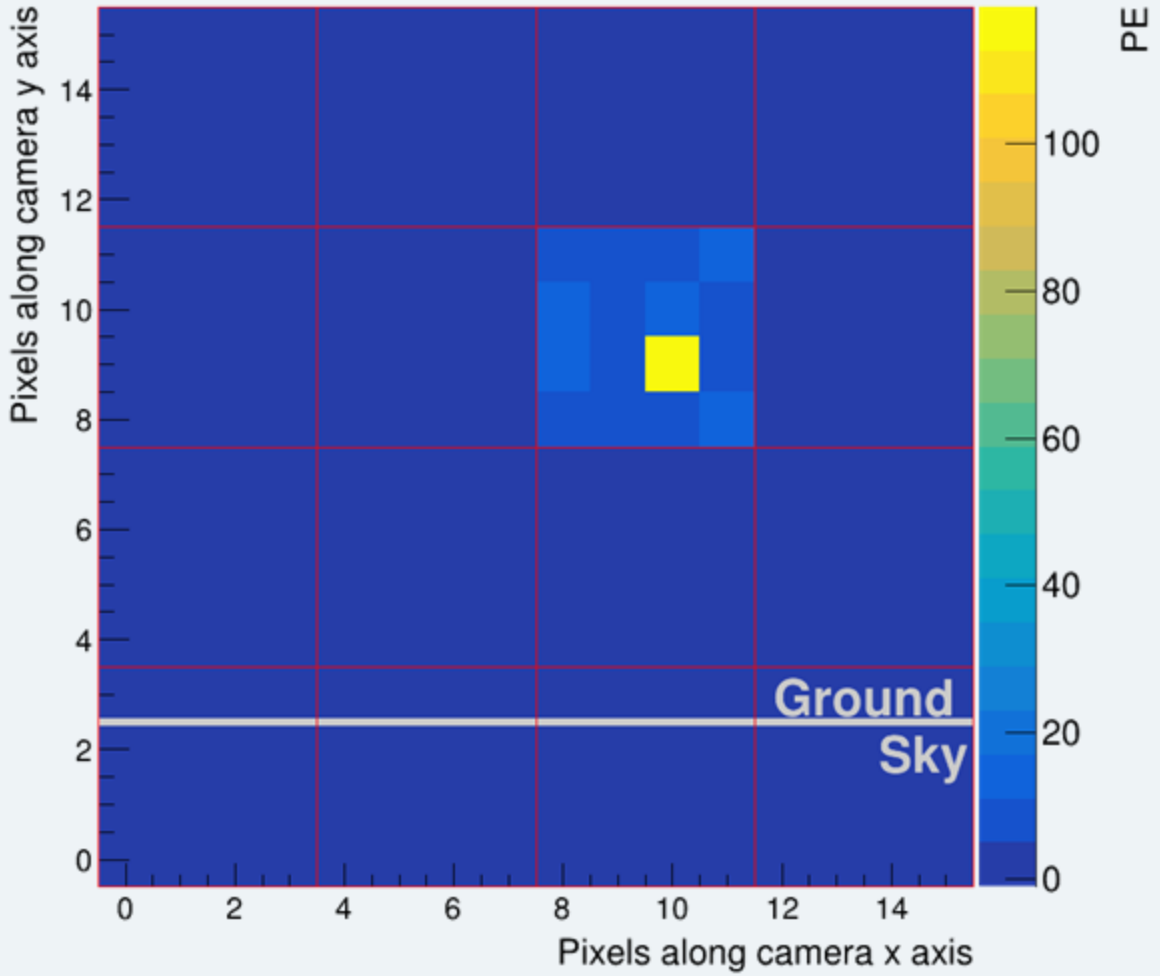
Demonstrator Results

- Events reduced from 1.2 million to 2193.
- Majority were night sky background events and were rejected.
- Remaining events caused by muons.



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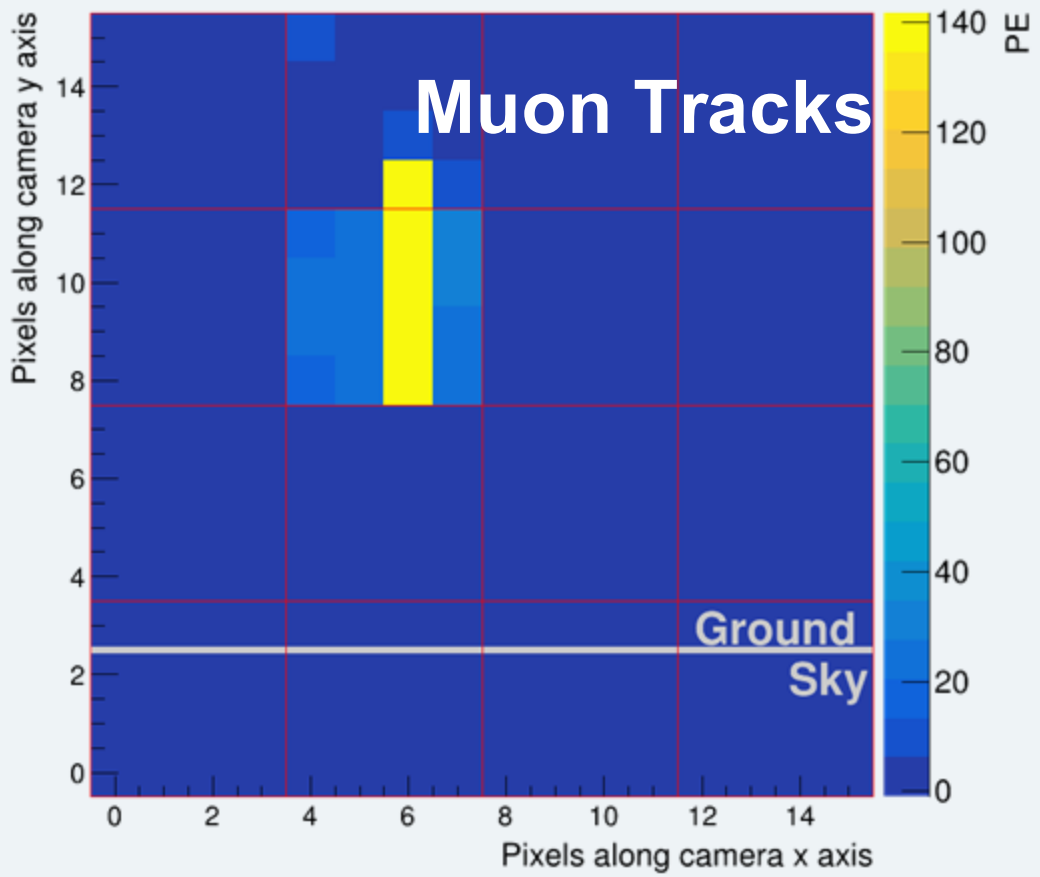
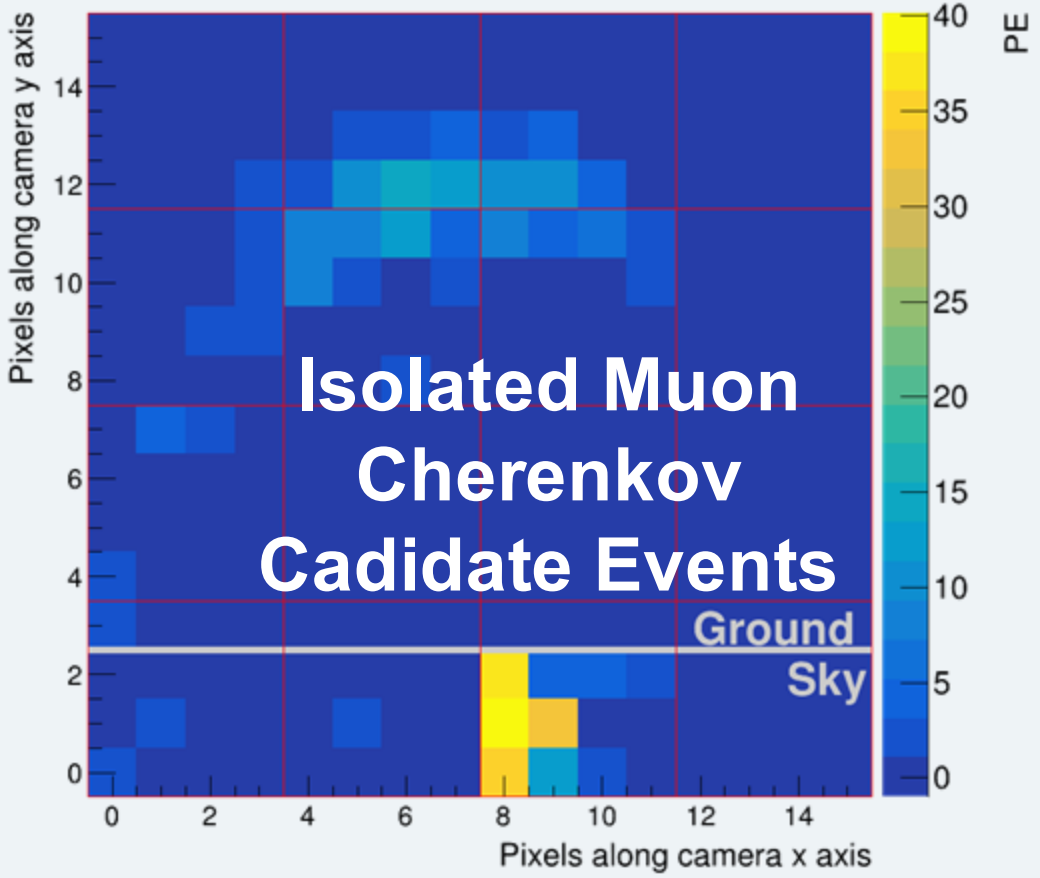
Event Characterization





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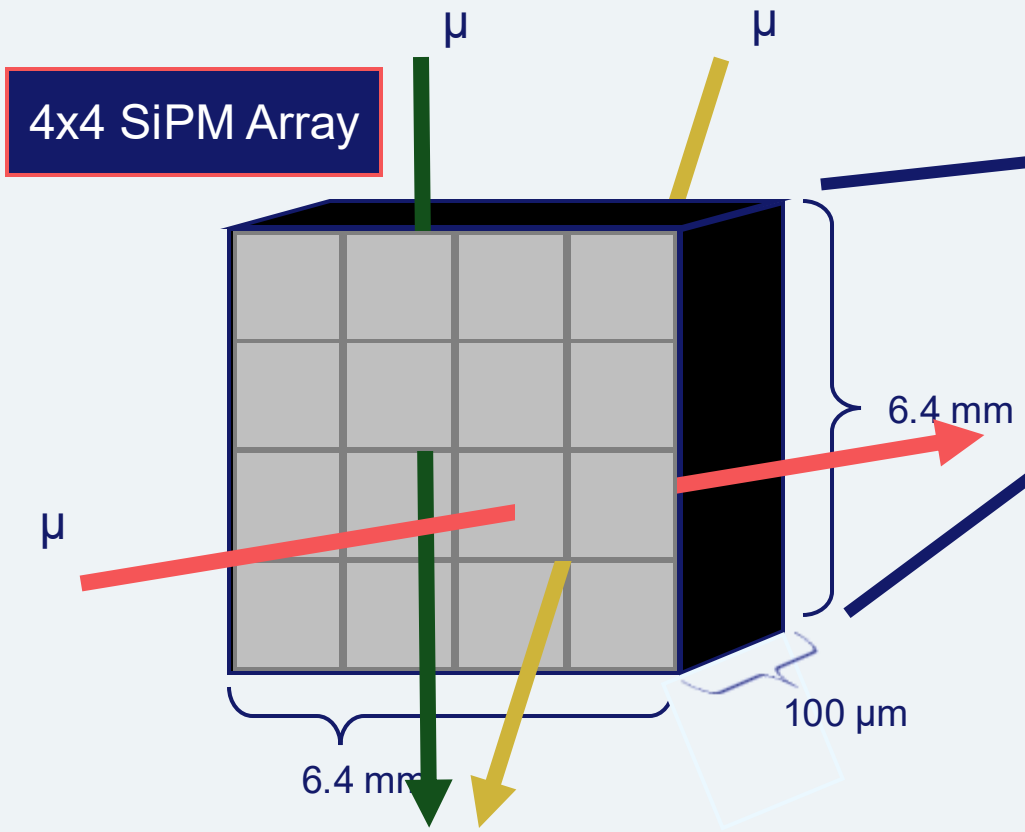
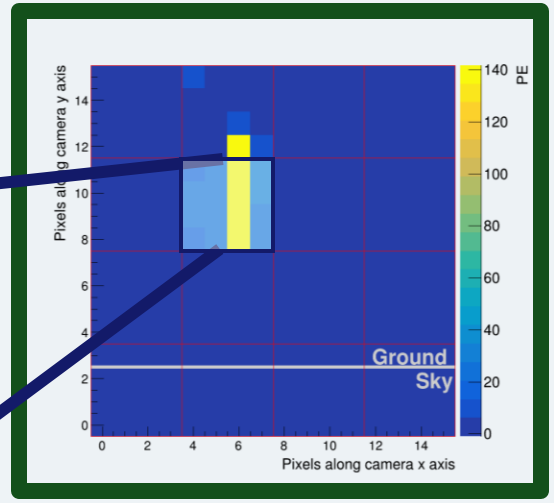
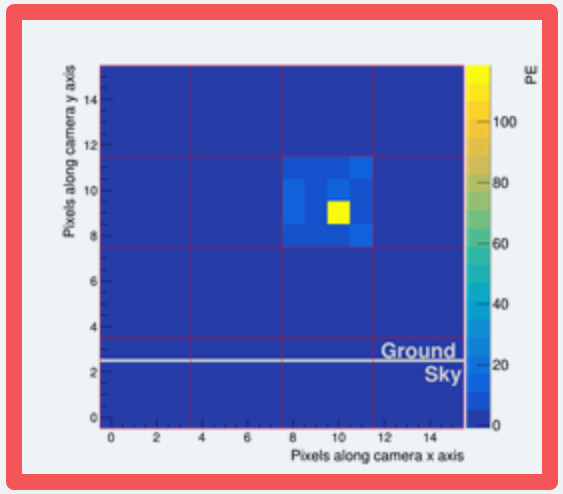
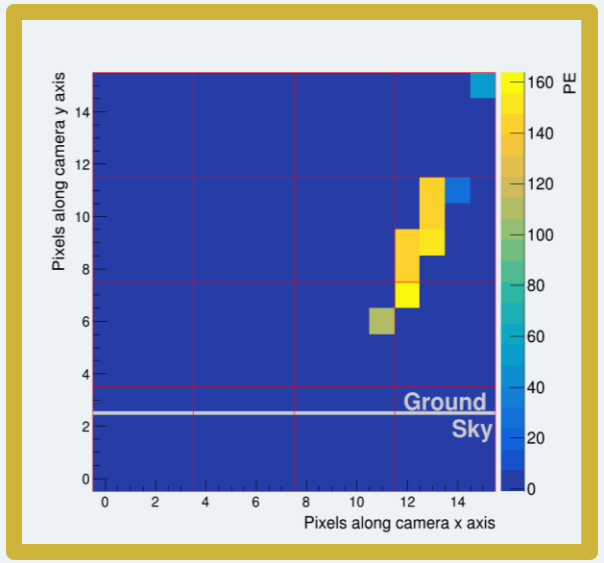
Muon Track Events









2177 Muon Track Events
3.9 ± 0.1 event per hour

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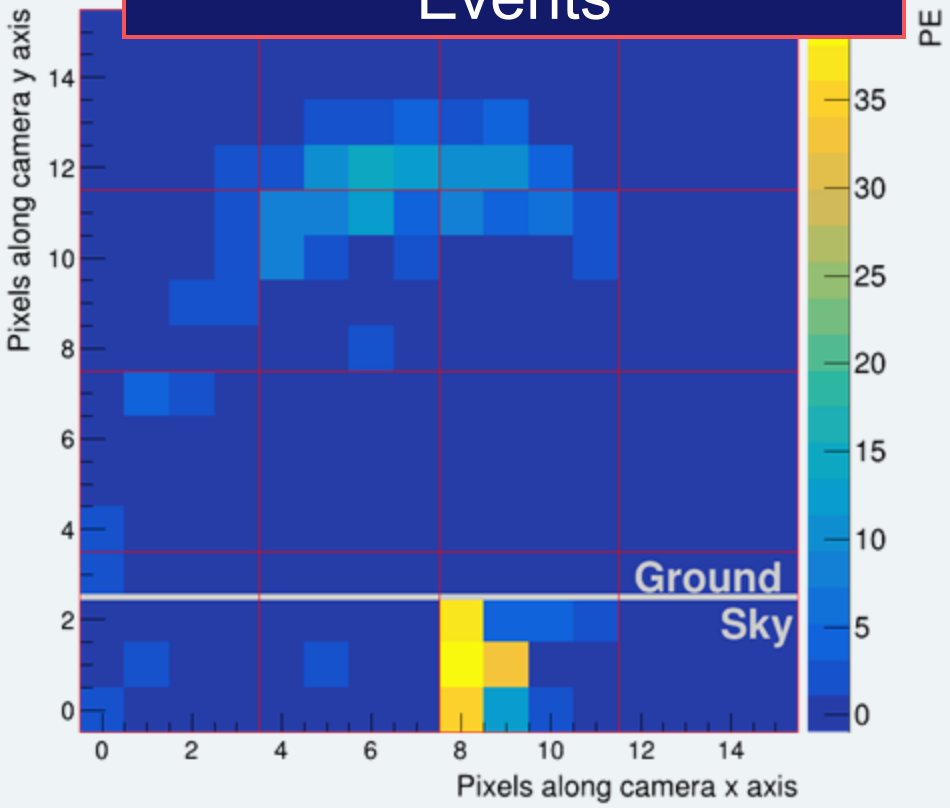
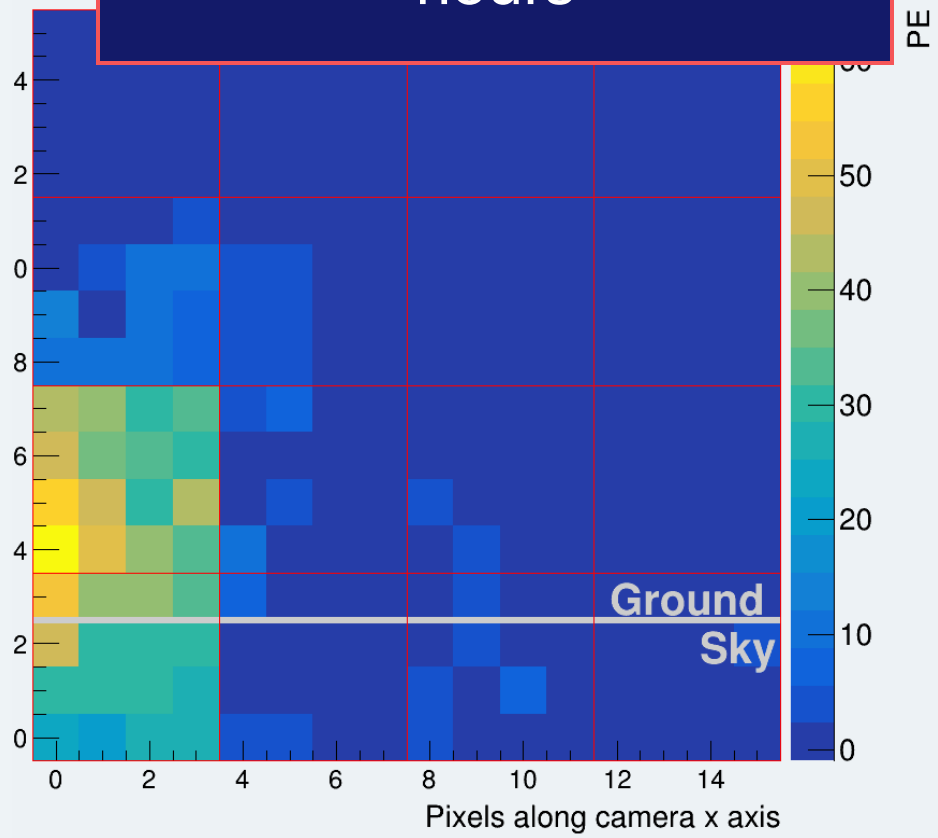
Event Characterization

16 Isolated Muon Cherenkov Candidate Events



1 ± 0.13 event per 34 hours



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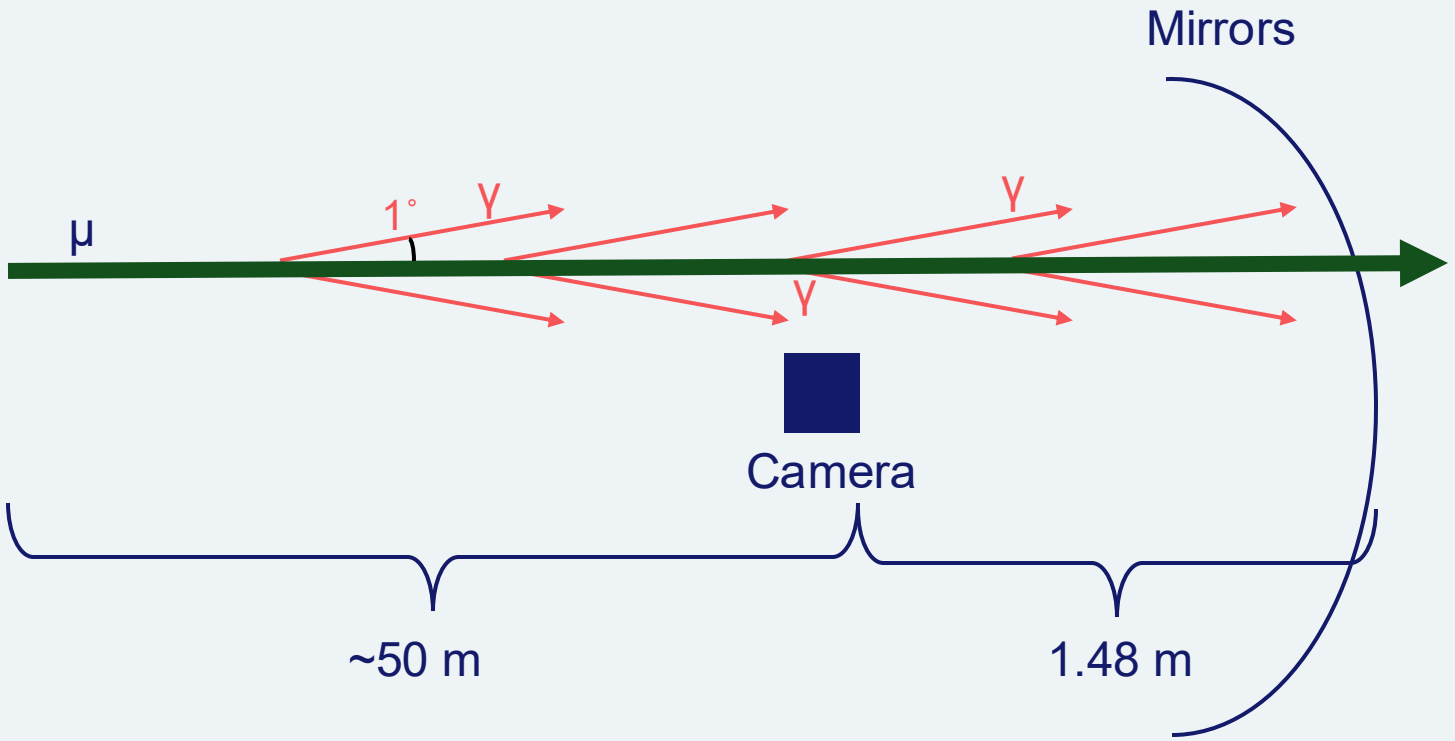
Local Muon Cherenkov Event



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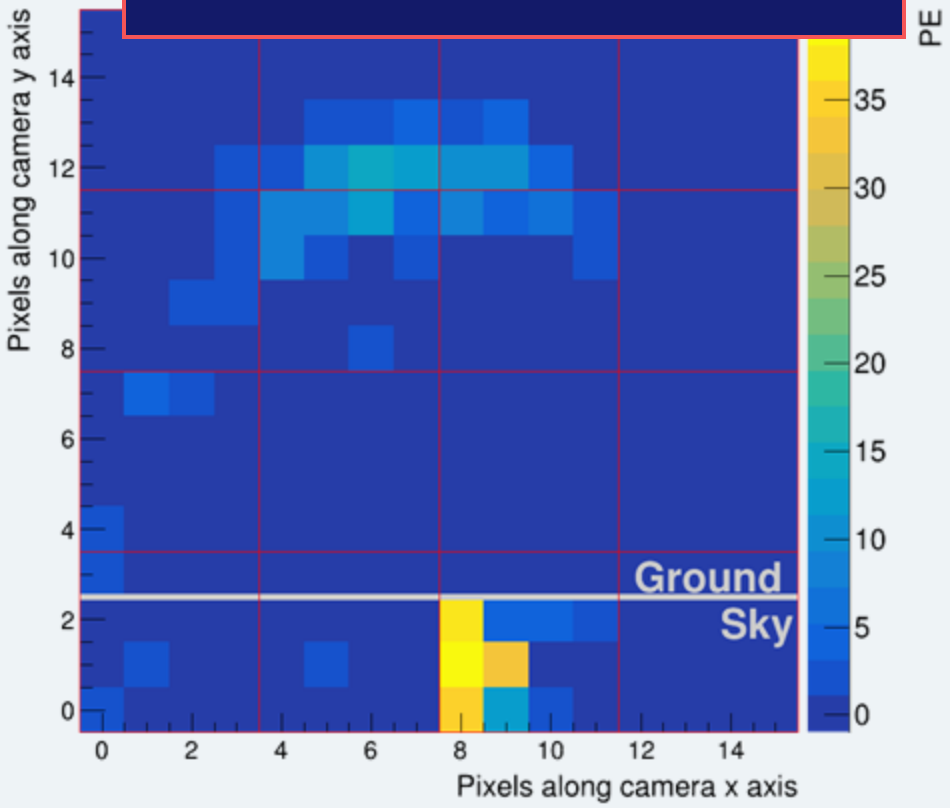
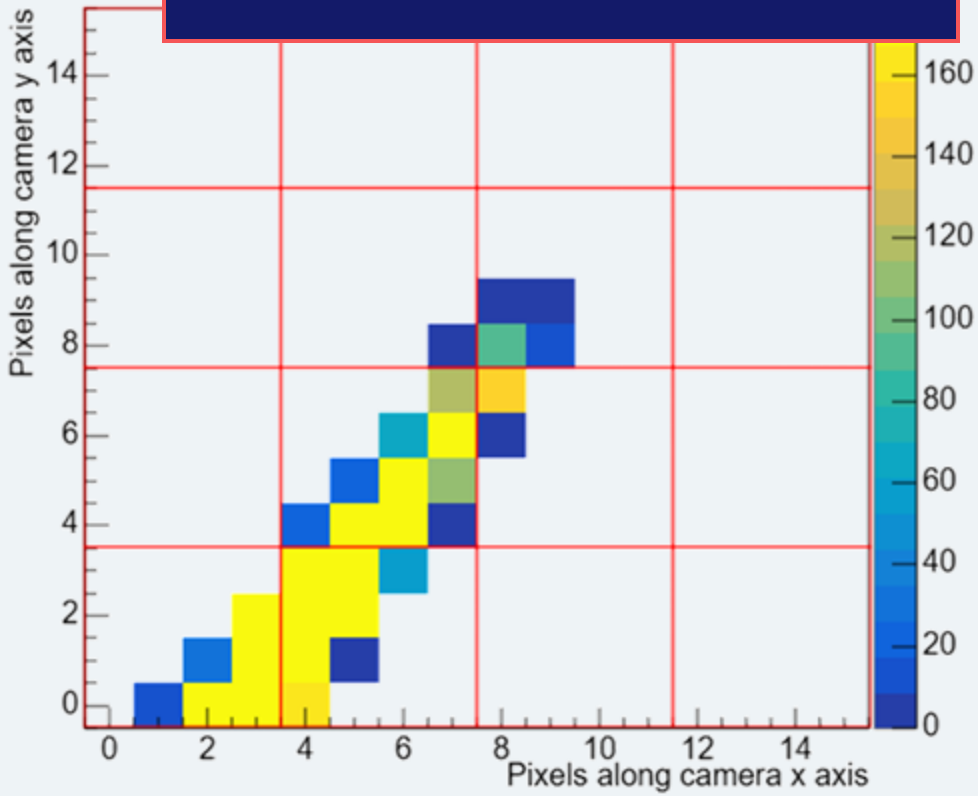
Event Characterization

Muon Cherenkov Candidate Event



Sample Simulated Neutrino Event



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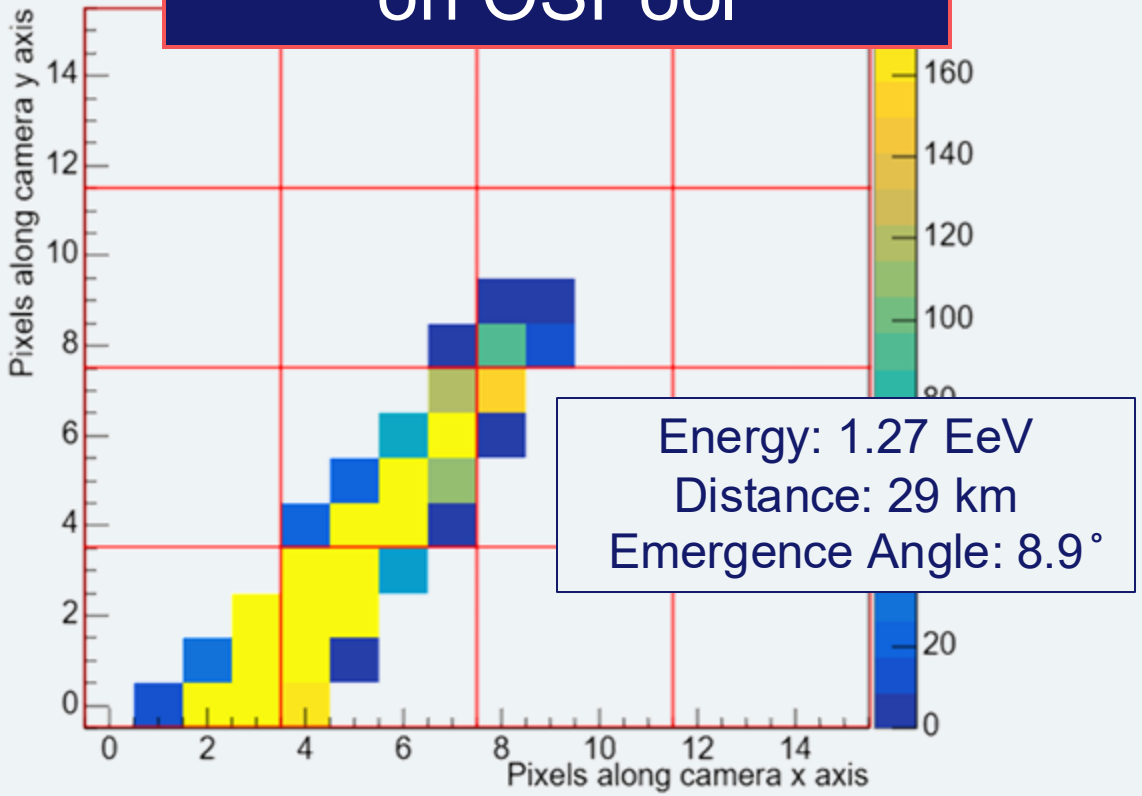
Simulations

- Event Reconstruction
  - Direction and energy
- Detection efficiencies
  - Effective Areas
- Study systematic uncertainty
- Design studies for Trinity One

100s of millions of simulated events run on OSPool



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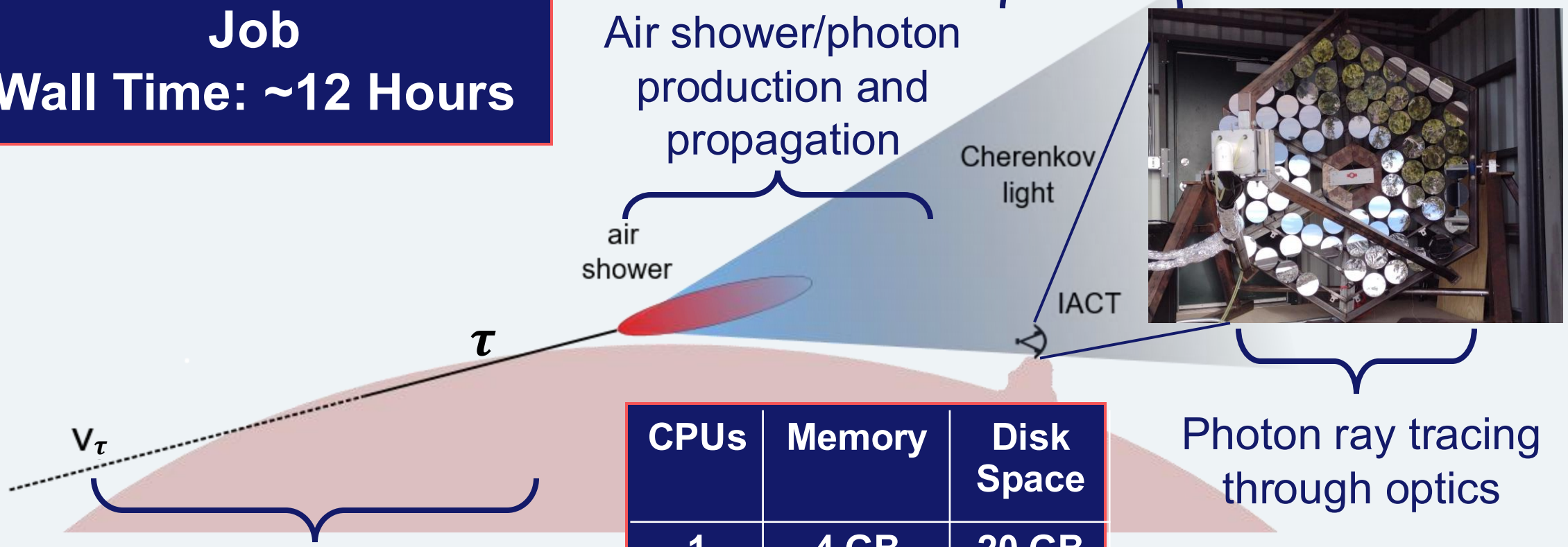
Tau Neutrino Simulation Chain

200 Air Showers Per Job
Wall Time: ~12 Hours

Camera response, trigger, and readout

Air shower/photon production and propagation



Photon ray tracing through optics

Neutrino interaction and tau decay

CPUs	Memory	Disk Space
1	4 GB	20 GB

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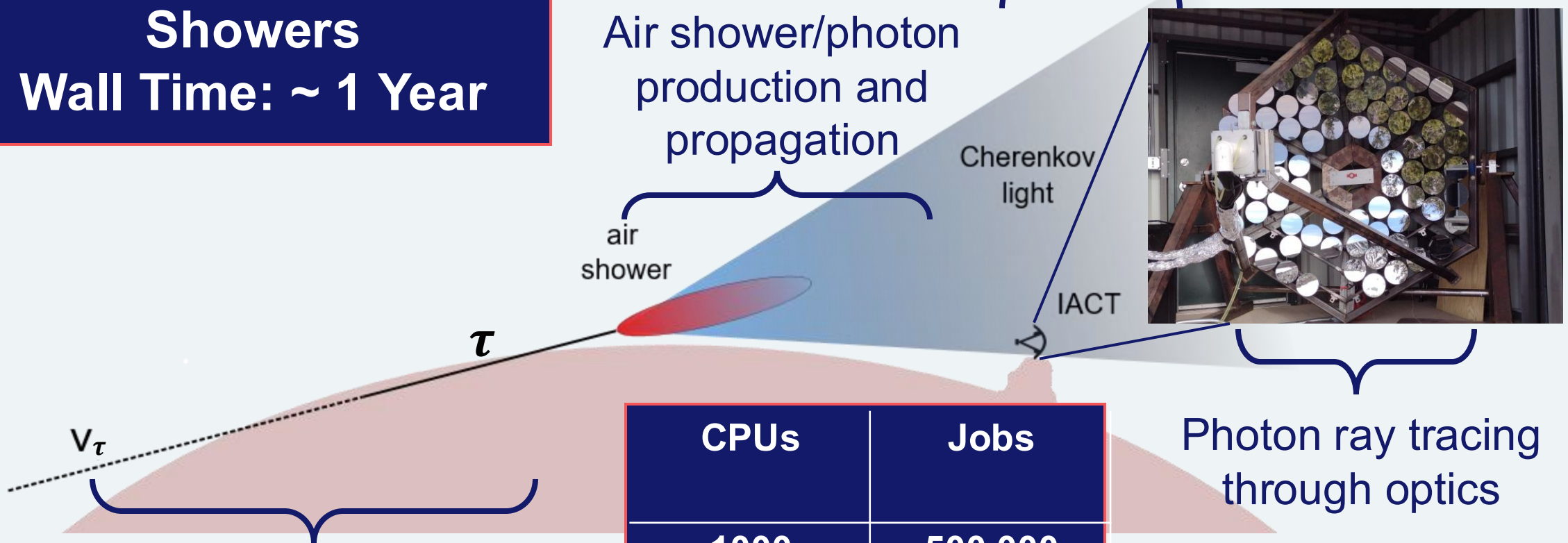
Tau Neutrino Simulation Chain

100 Million Air Showers
Wall Time: ~ 1 Year

Camera response, trigger, and readout

Air shower/photon production and propagation



Photon ray tracing through optics

Neutrino interaction and tau decay

CPUs	Jobs
1000	500,000

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Summary

- Trinity Observatory: Array of IACTs designed to detect tau neutrinos in the PeV to EeV energy range via Earth-Skimming techniques.
- Demonstrator running and ready for Trinity One.
- Use OSPool for large computational needs of data analysis and simulations.
- Setting up large scale simulations on OSPool.

Trinity Website

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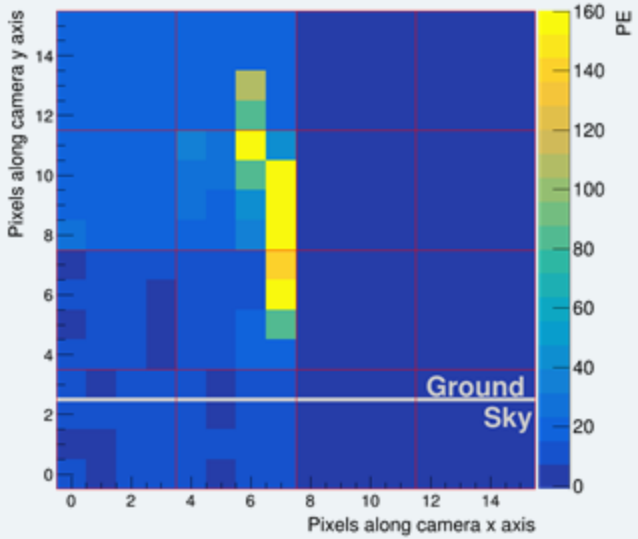
THANK YOU, OSG AND OSPOOL!!

From your friends at Trinity

Direct Muon Hits

Door Closed

Plastic Scintillator Detectors



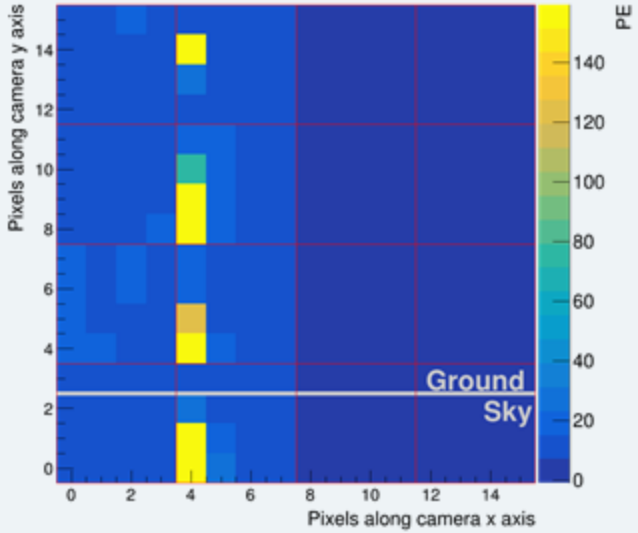
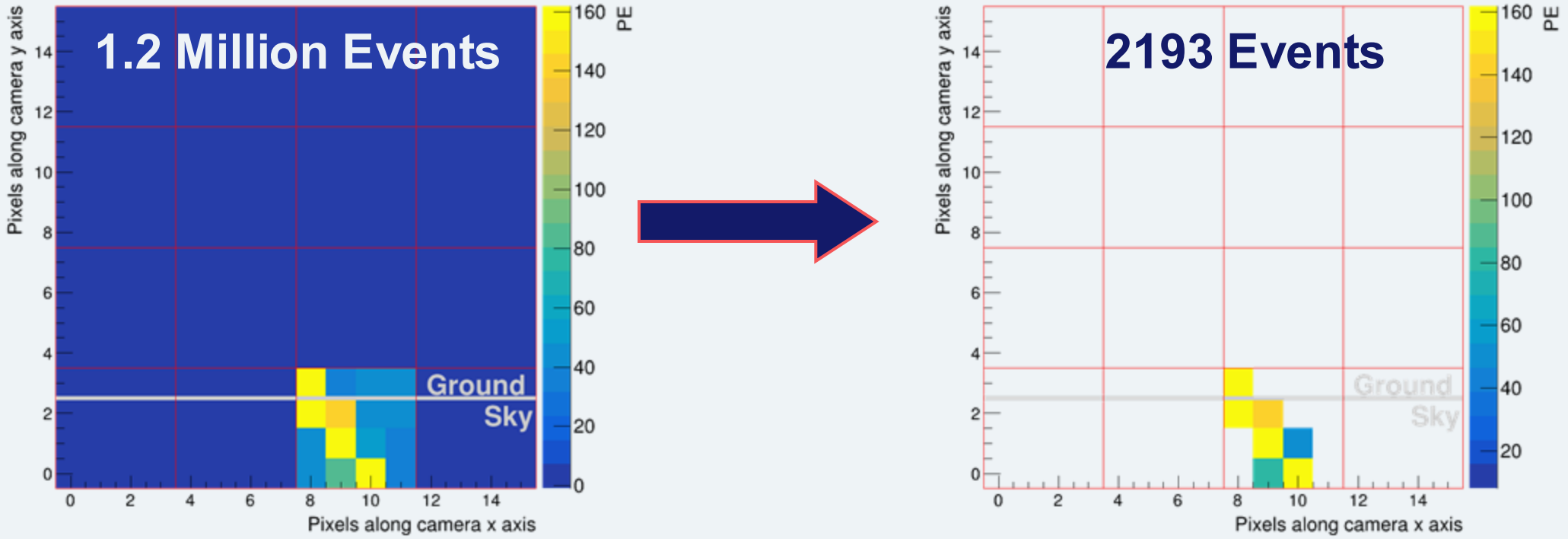


Image Cleaning

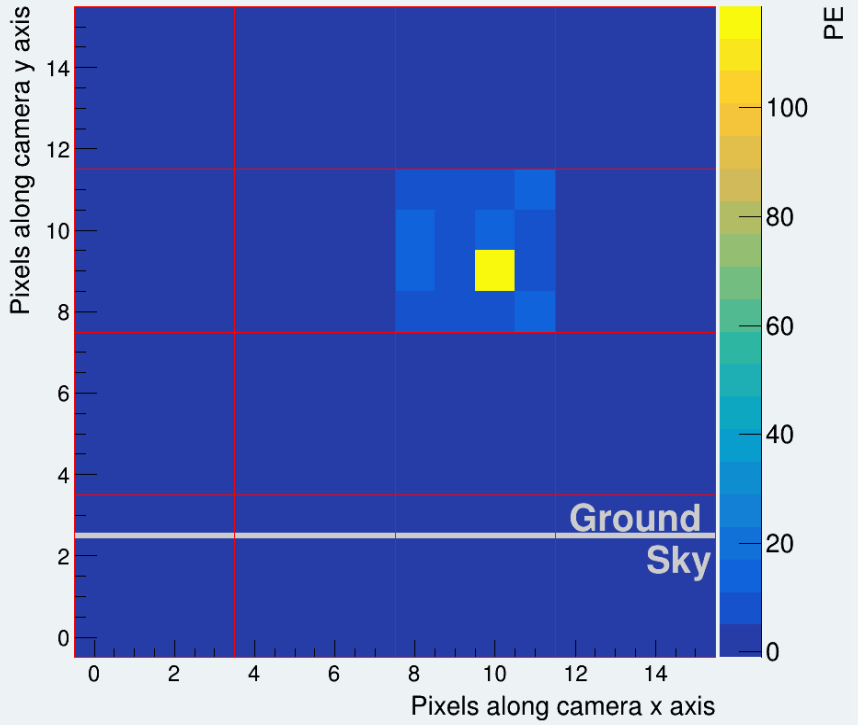
- Reject background events based on topology
- Remaining events left for further analysis
- From visual analysis, no neutrino events observed in this dataset



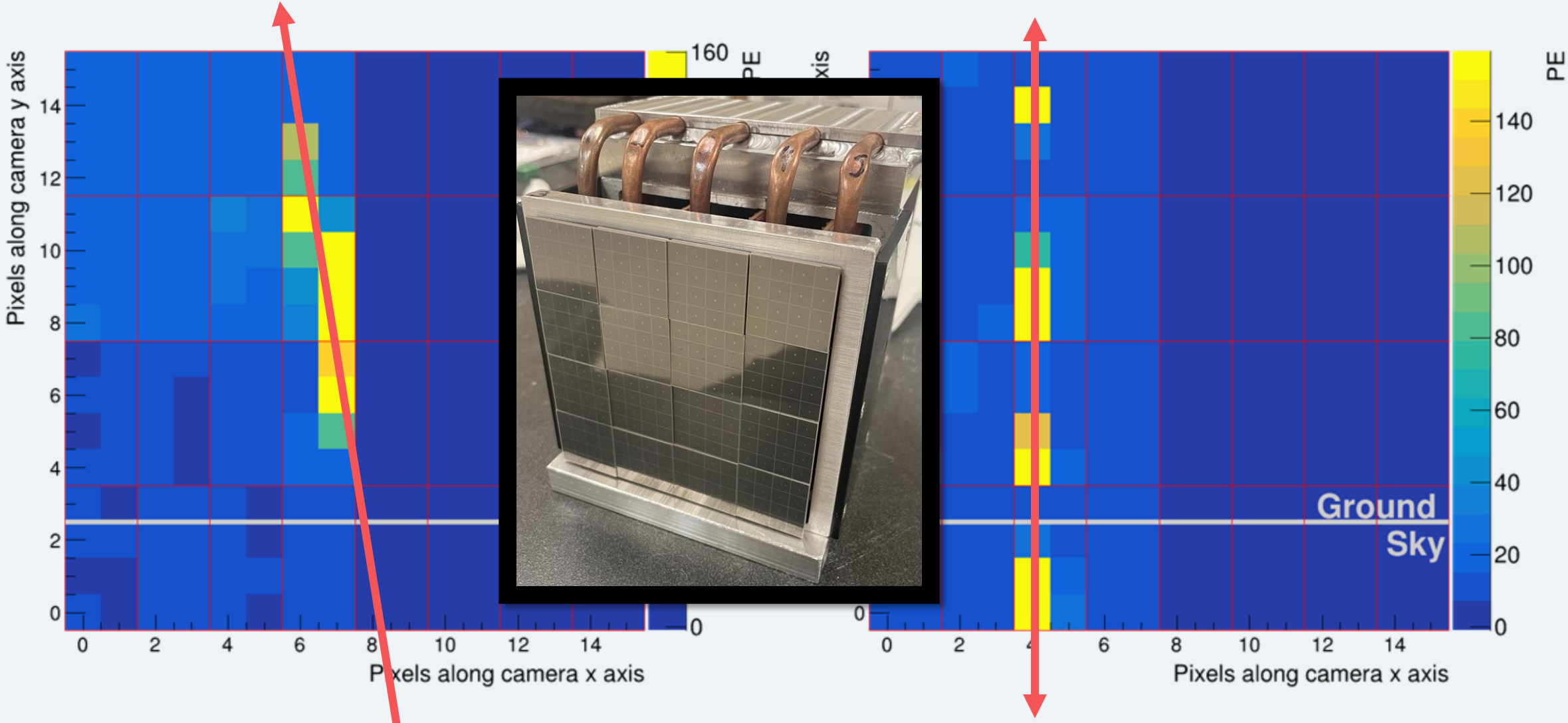
Data Taking

- ~7 hours' worth of data in 2- minute increments every night
- Records events that trigger the camera's readout
- Raw data consists of hundreds of GBs of data files
- This data needs to be stored, merged, and calibrated
- Dominated by night sky background and requires thorough image cleaning

Sample Camera Output



Background: Sample Events



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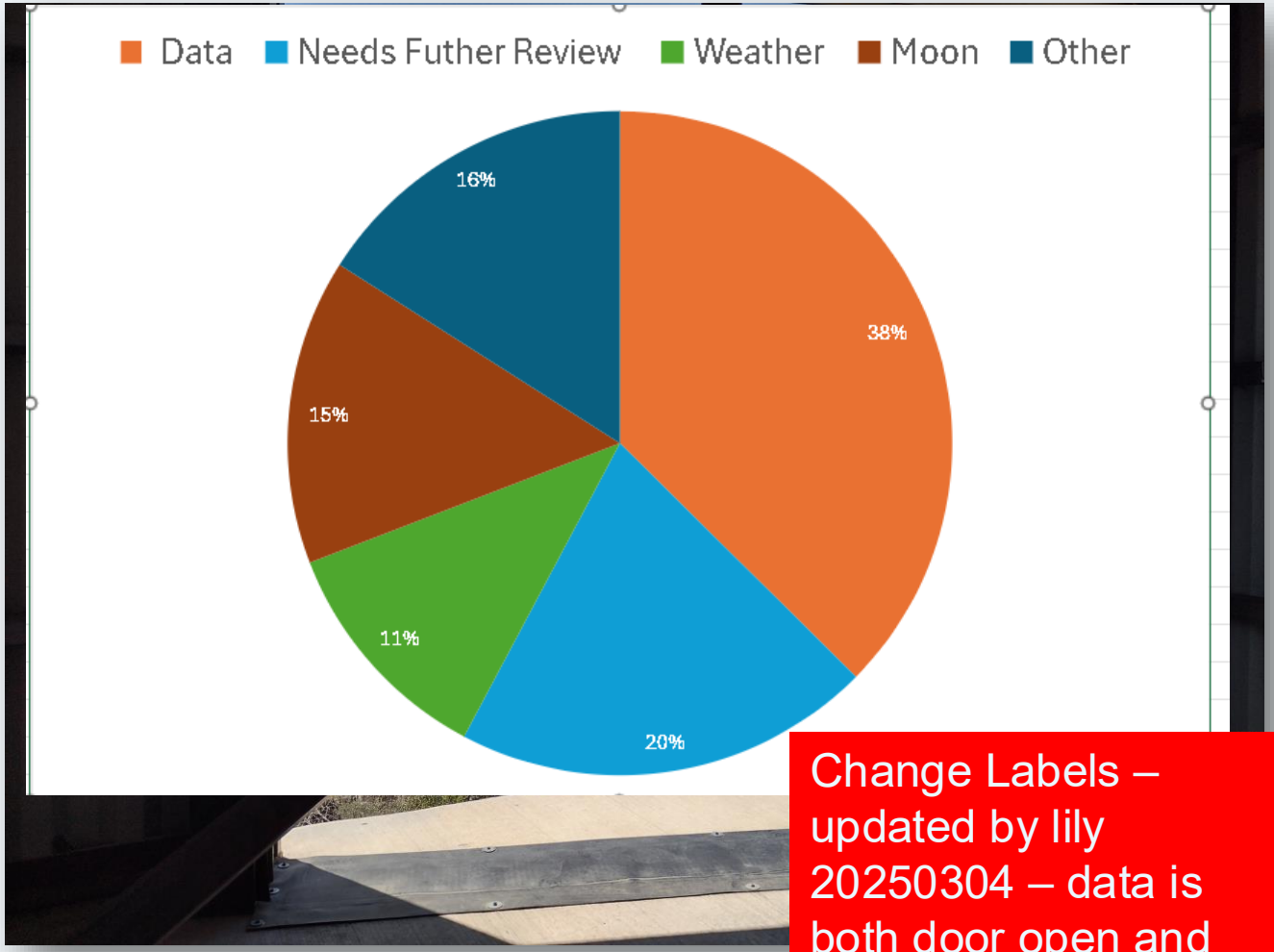
Data Set

Data Taking Period	October 2024-Dec 2025
Hours analyzed	546/Door Closed see lily?
Triggered Events	4/lily Million



Change Labels – updated by lily 20250304 – data is both door open and closed together

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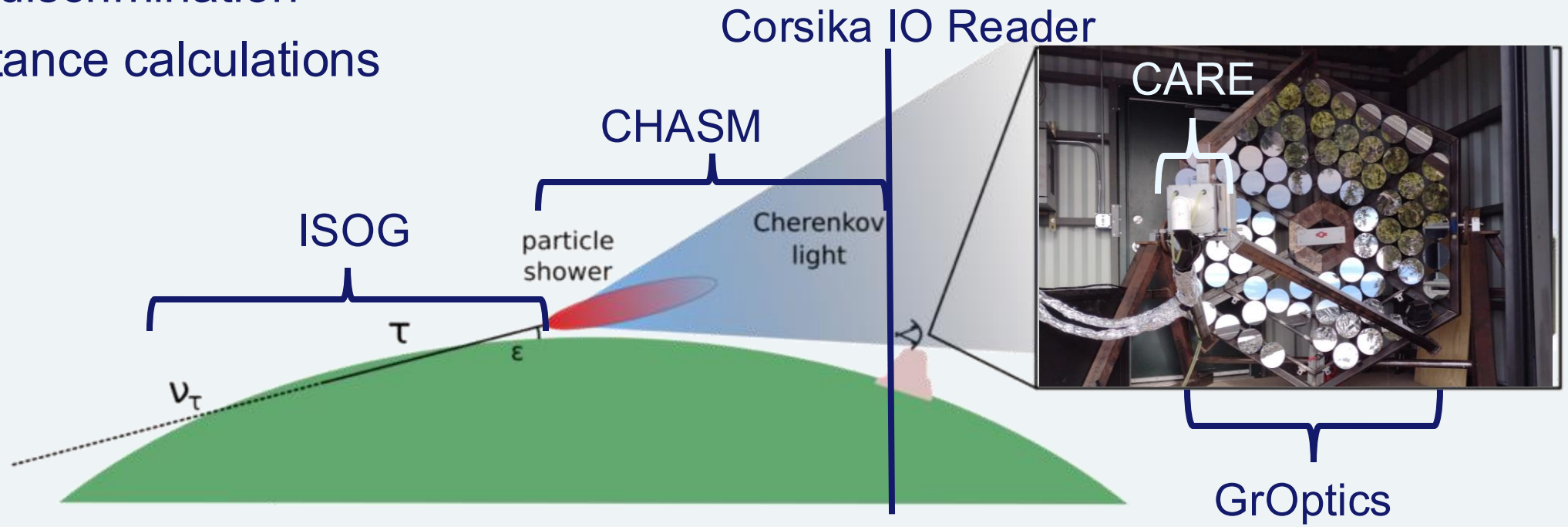
Tau Neutrino Simulation Chain

- Event discrimination
- acceptance calculations



ISOG ——— Neutrino interaction and tau decay
CHASM ——— Airshower photon production and propagation
Corsika IO Reader — Conversion to GrOptics Standard
GrOptics ——— Photon ray tracing through telescope optics
CARE ——— Camera response, trigger and readout

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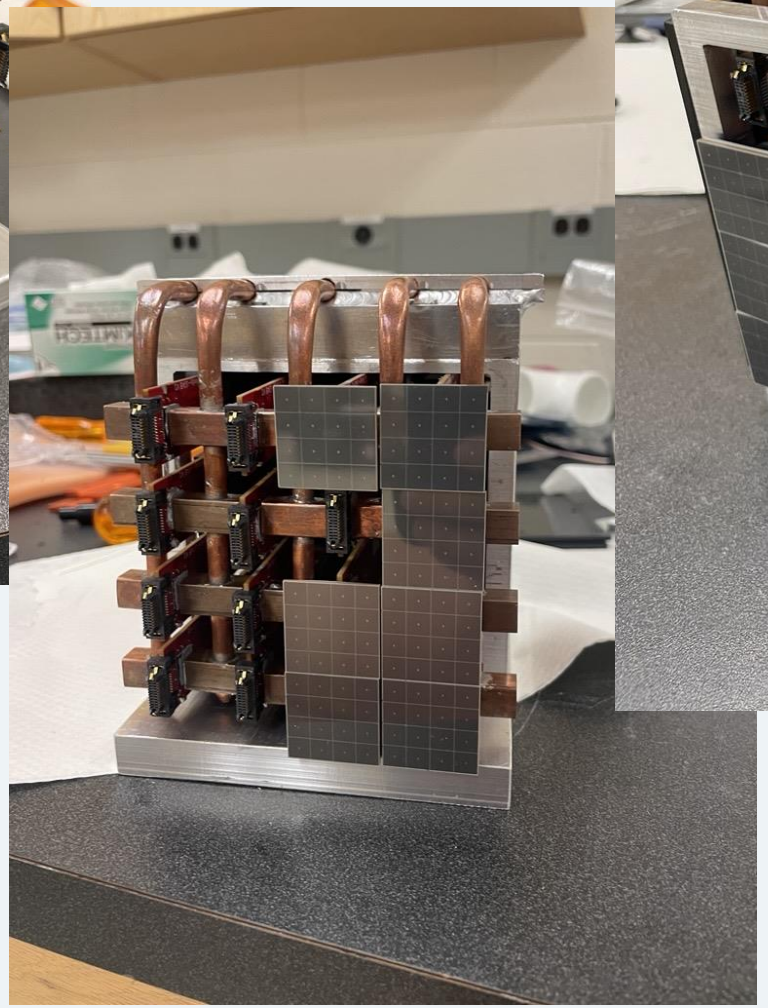

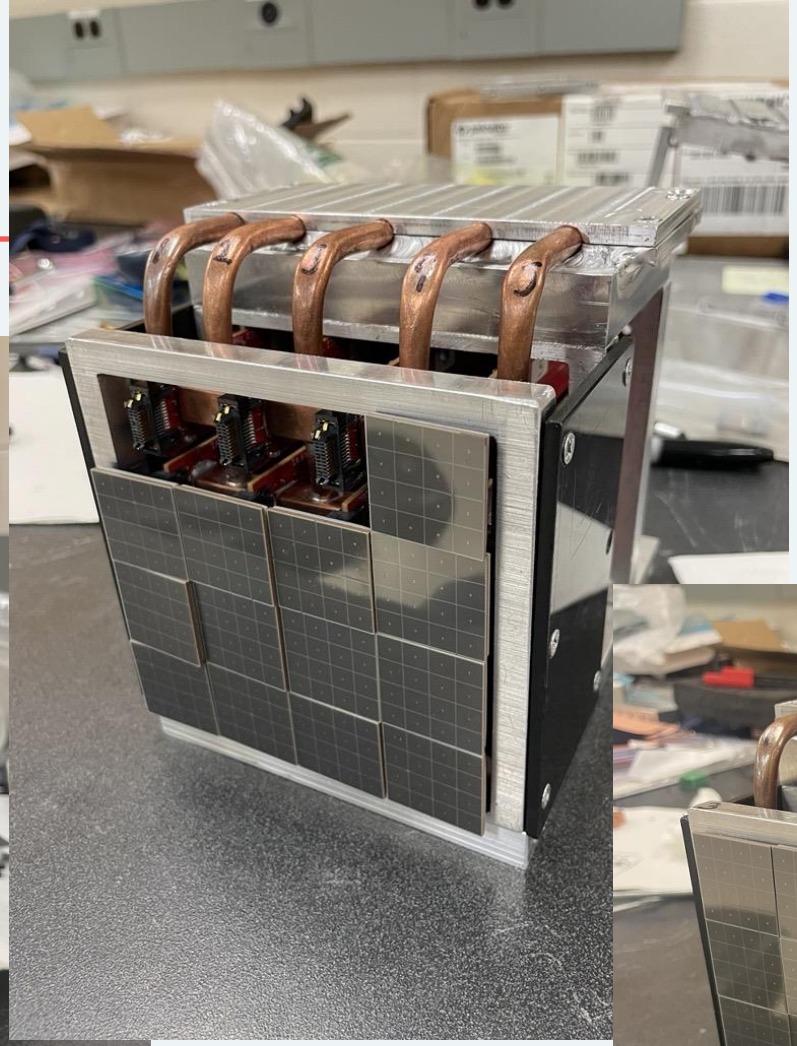

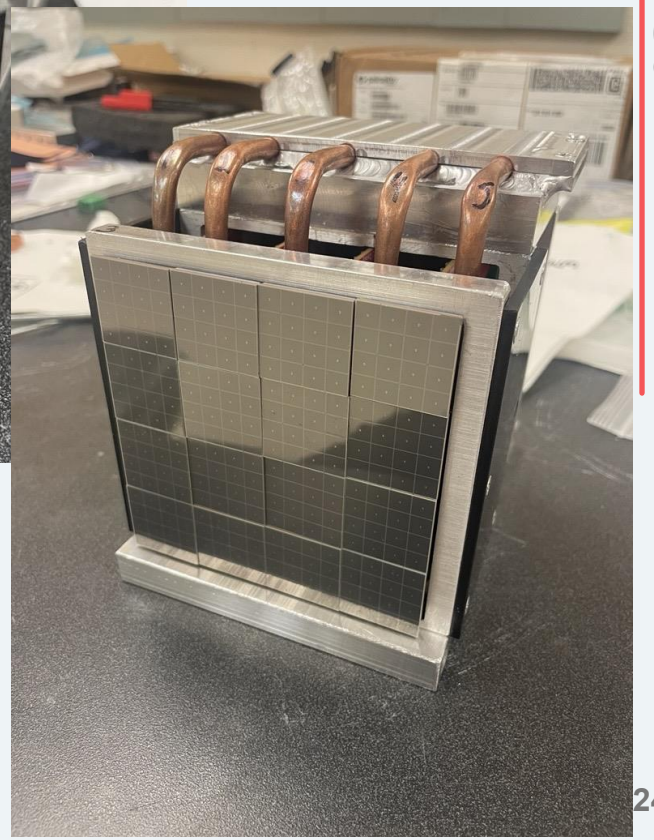

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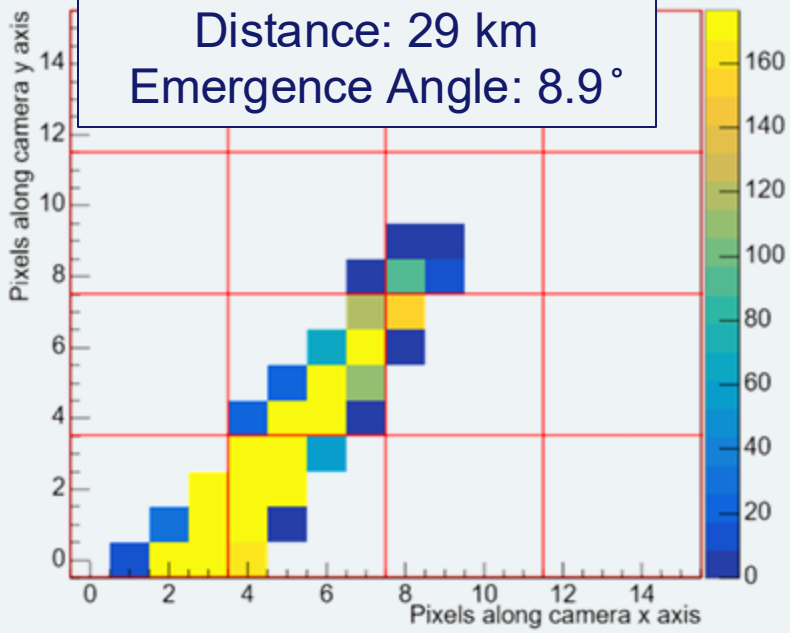
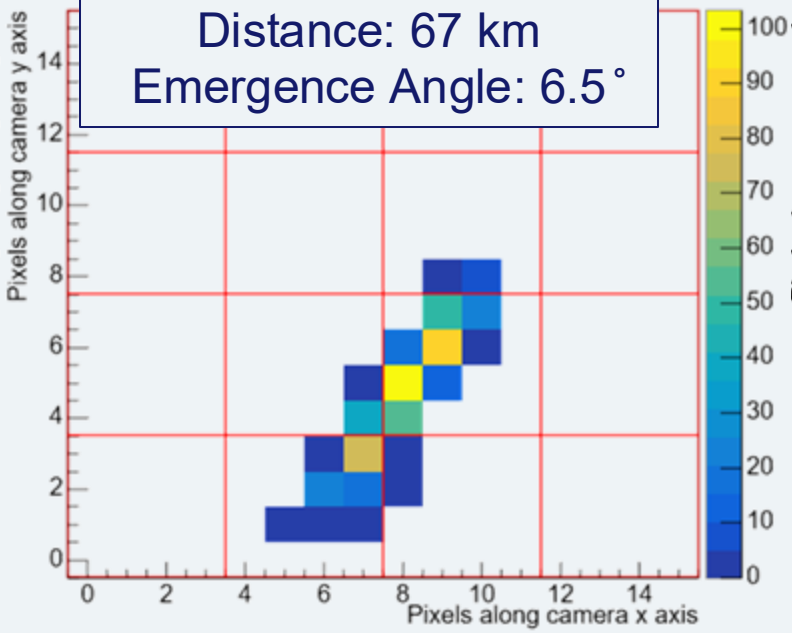
Simulation Gallery:

Sample simulated events

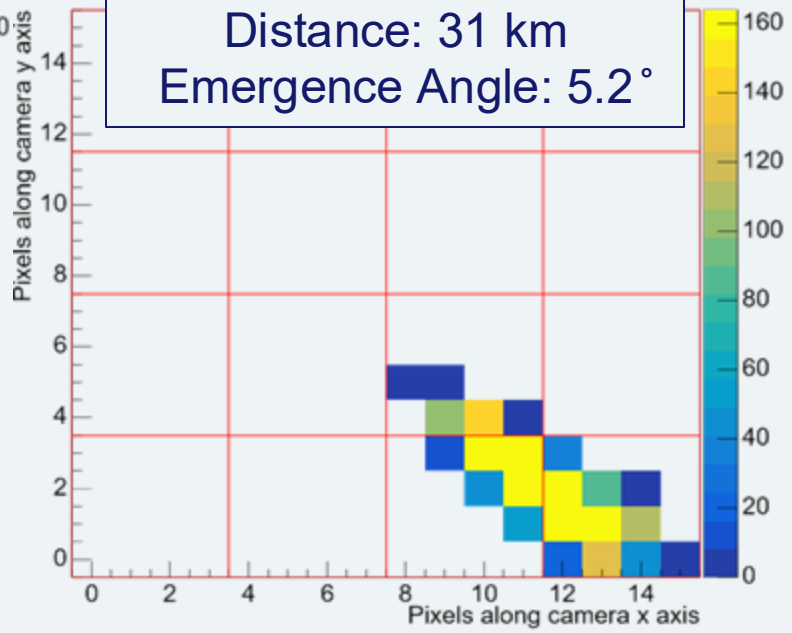
Energy: 1.27 EeV
Distance: 29 km
Emergence Angle: 8.9°



Energy: 367 PeV
Distance: 67 km
Emergence Angle: 6.5°

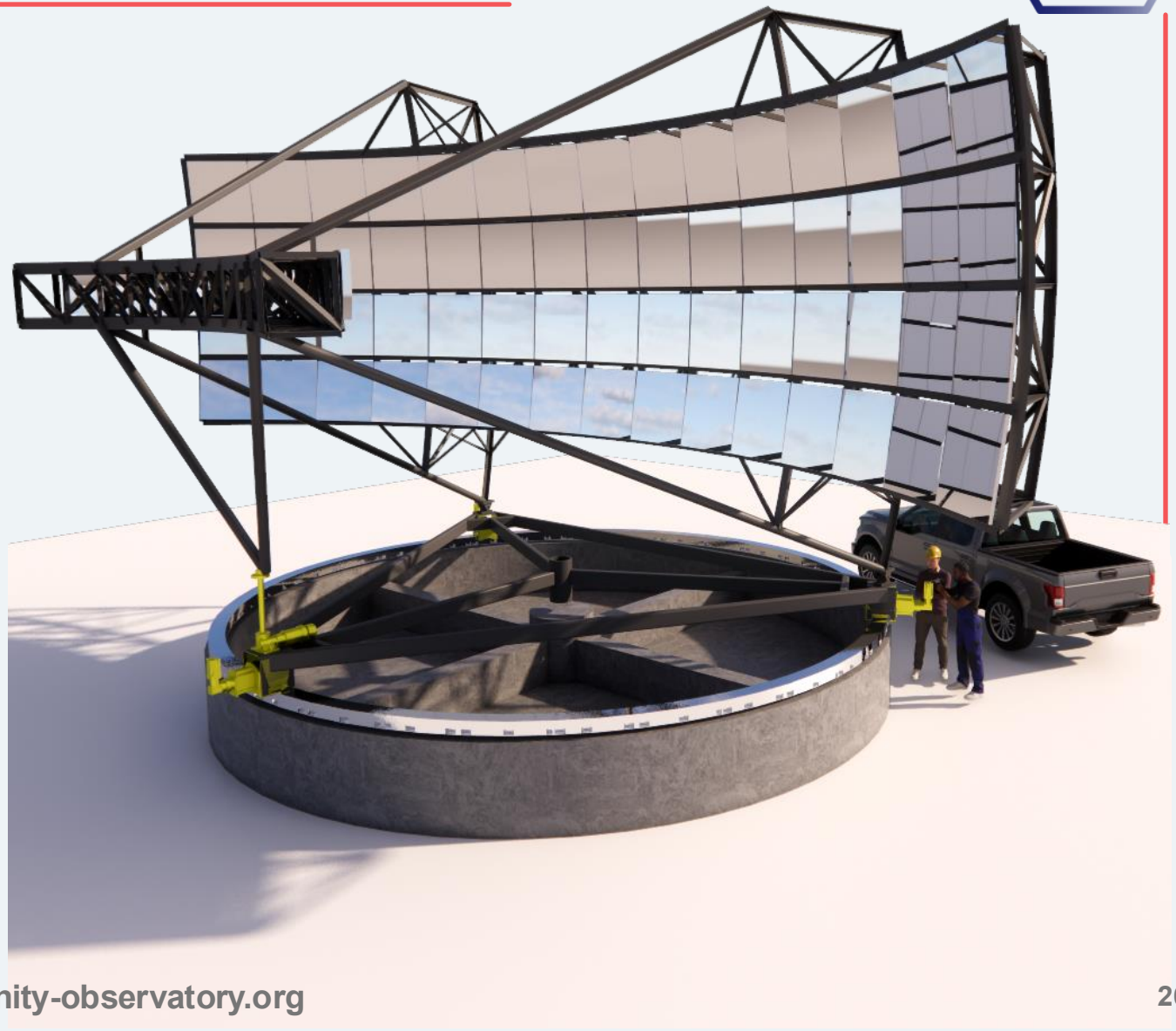


Energy: 123 PeV
Distance: 31 km
Emergence Angle: 5.2°



Next Step: Trinity One

- First telescope of the Trinity Observatory
- Will have significantly higher volume of data than the Demonstrator by a factor of 50



Trinity website