



Georgia Tech College of Sciences
Center for Relativistic
Astrophysics



Trinity

Exploring High-Energy Neutrinos with the Trinity Demonstrator: Observations and Initial Analysis

Sofia Stepanoff
For the Trinity Collaboration



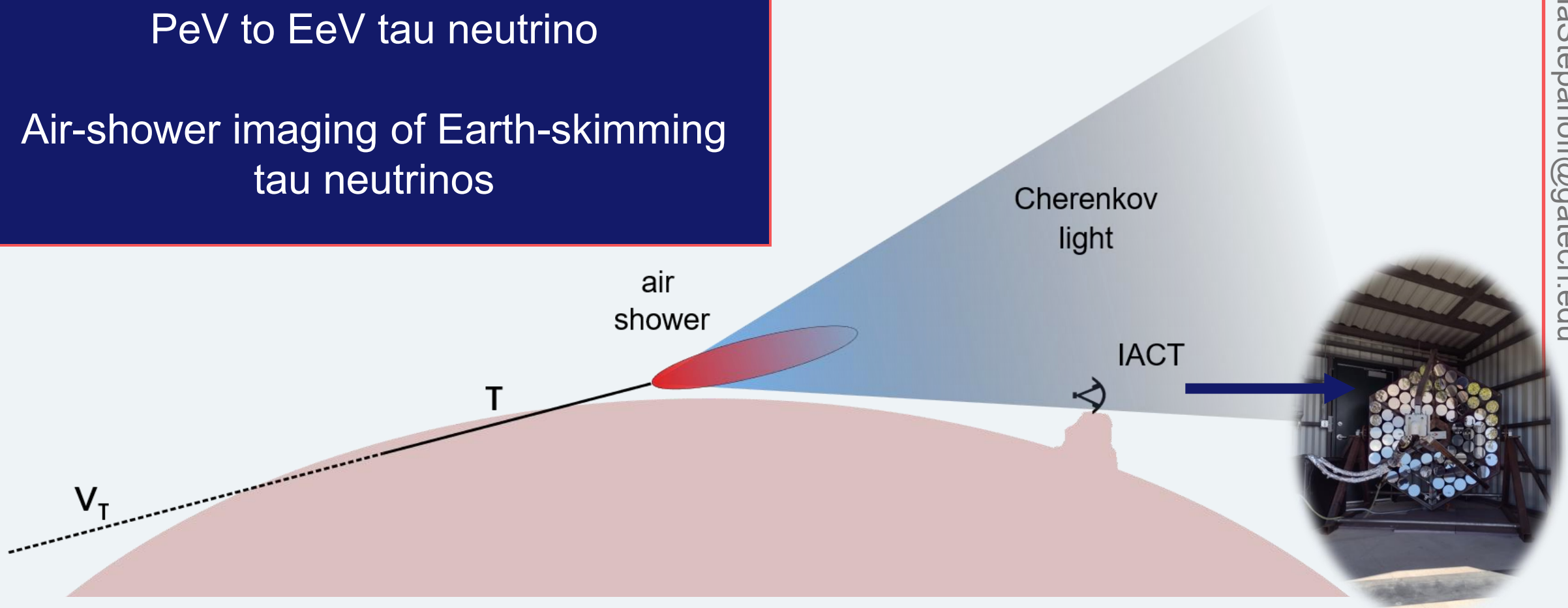
Trinity Detection Concept



SofiaStepanoff@gatech.edu

PeV to EeV tau neutrino

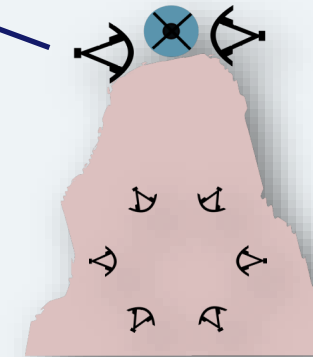
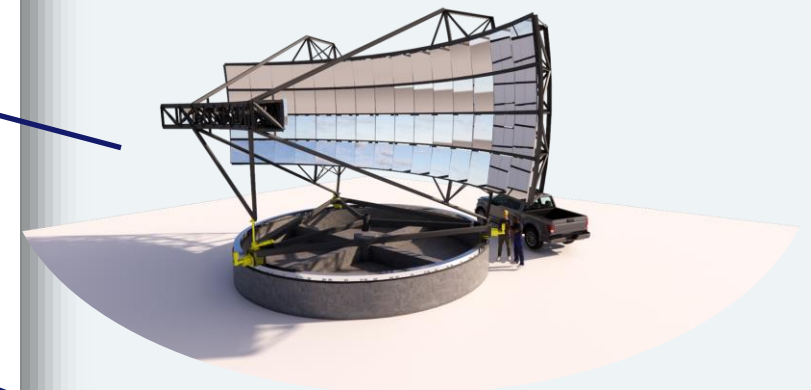
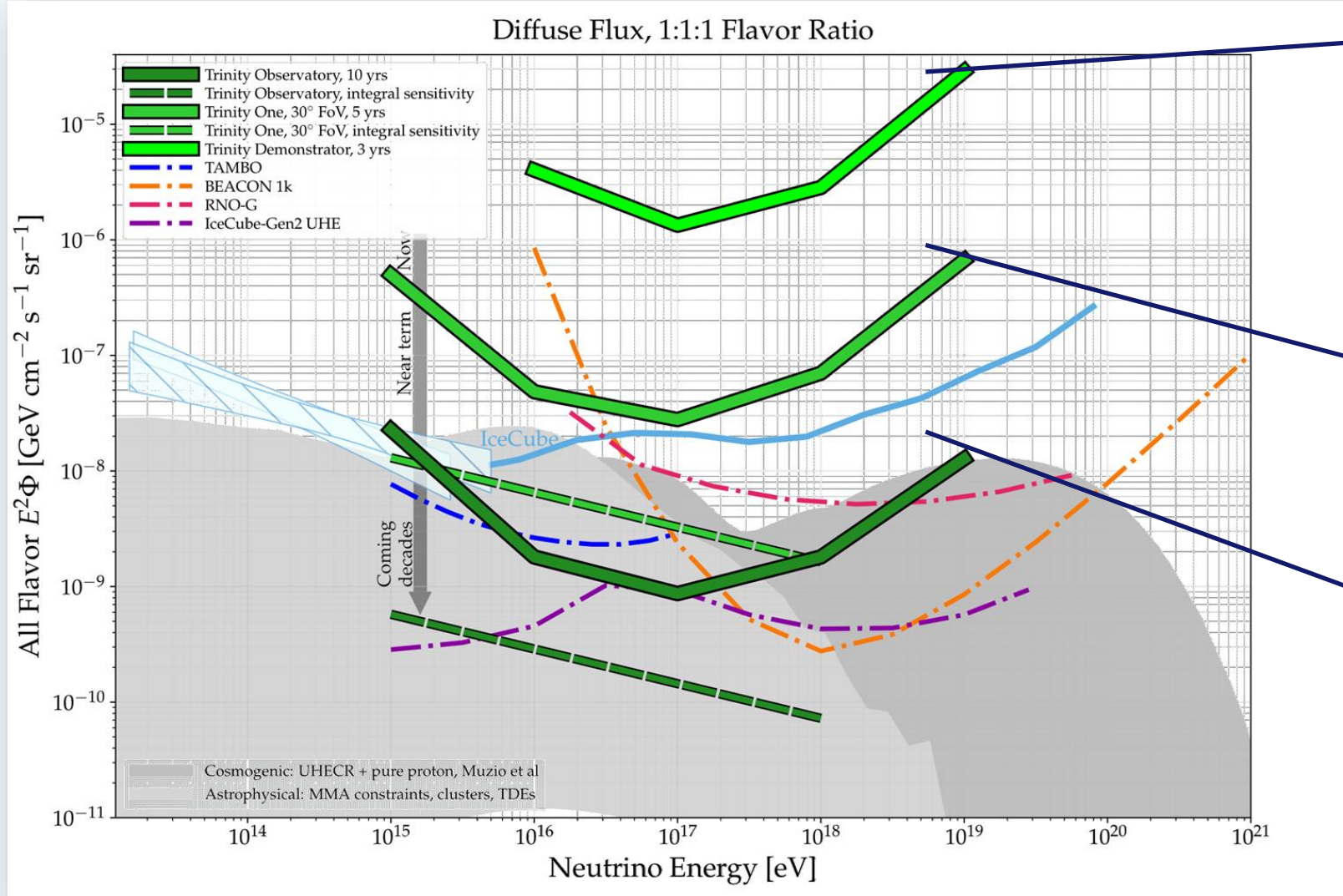
Air-shower imaging of Earth-skimming
tau neutrinos



Trinity Sensitivity



SofiaStepanoff@gatech.edu





SofiaStepanoff@gatech.edu

Trinity Demonstrator

- Backgrounds
- Analysis
- Simulation Chain
- Long-term stability
- Remote Operations

Camera paper: [arXiv:2406.08274]

Commissioning paper: [arXiv:2503.11864]

NBI Summer School 7 July 2025



Deployed on Friso Peak, Utah in October 2023

trinity-observatory.org



Trinity Demonstrator

- FOV: $3.8^\circ \times 3.8^\circ$
- Pixels: 256
- Angular Resolution: 0.24°
- Mirror Area: 1.36m^2
- Sampling Speed: 100MS/s

Camera paper: [arXiv:2406.08274]

Commissioning paper: [arXiv:2503.11864]

NBI Summer School 7 July 2025



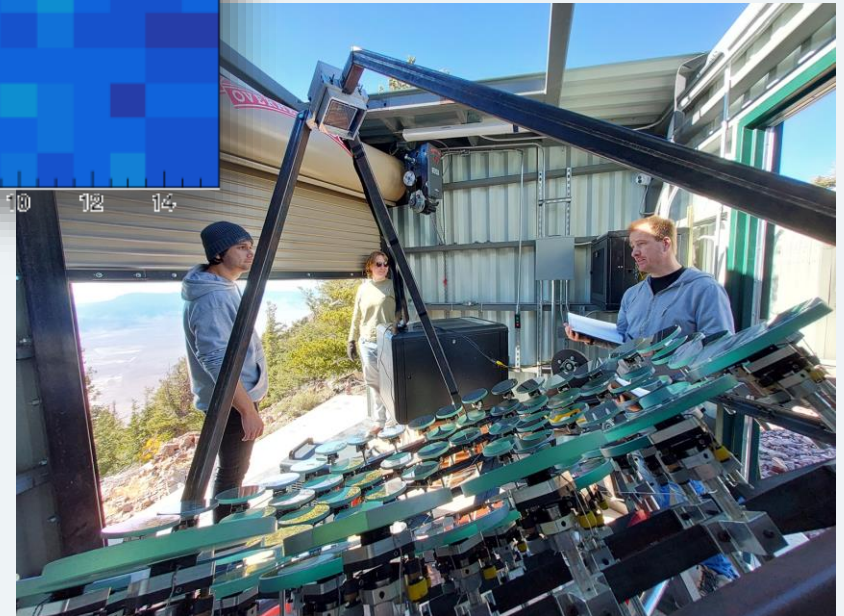
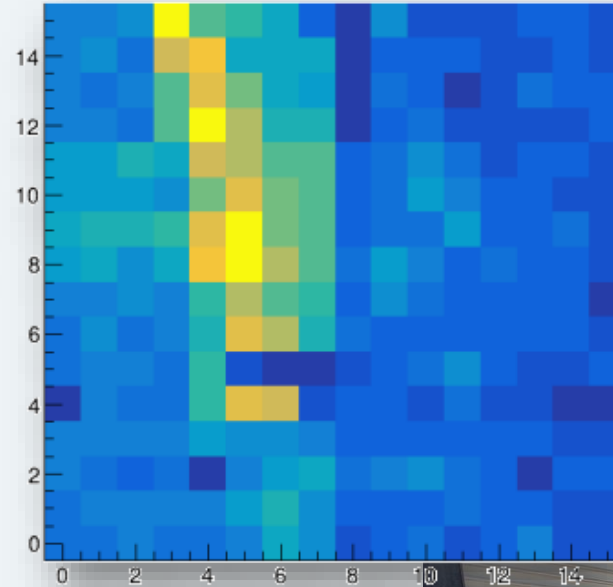
Commissioning



- Aligning optics
- Signal calibration
- Trigger calibration
- Remote operation

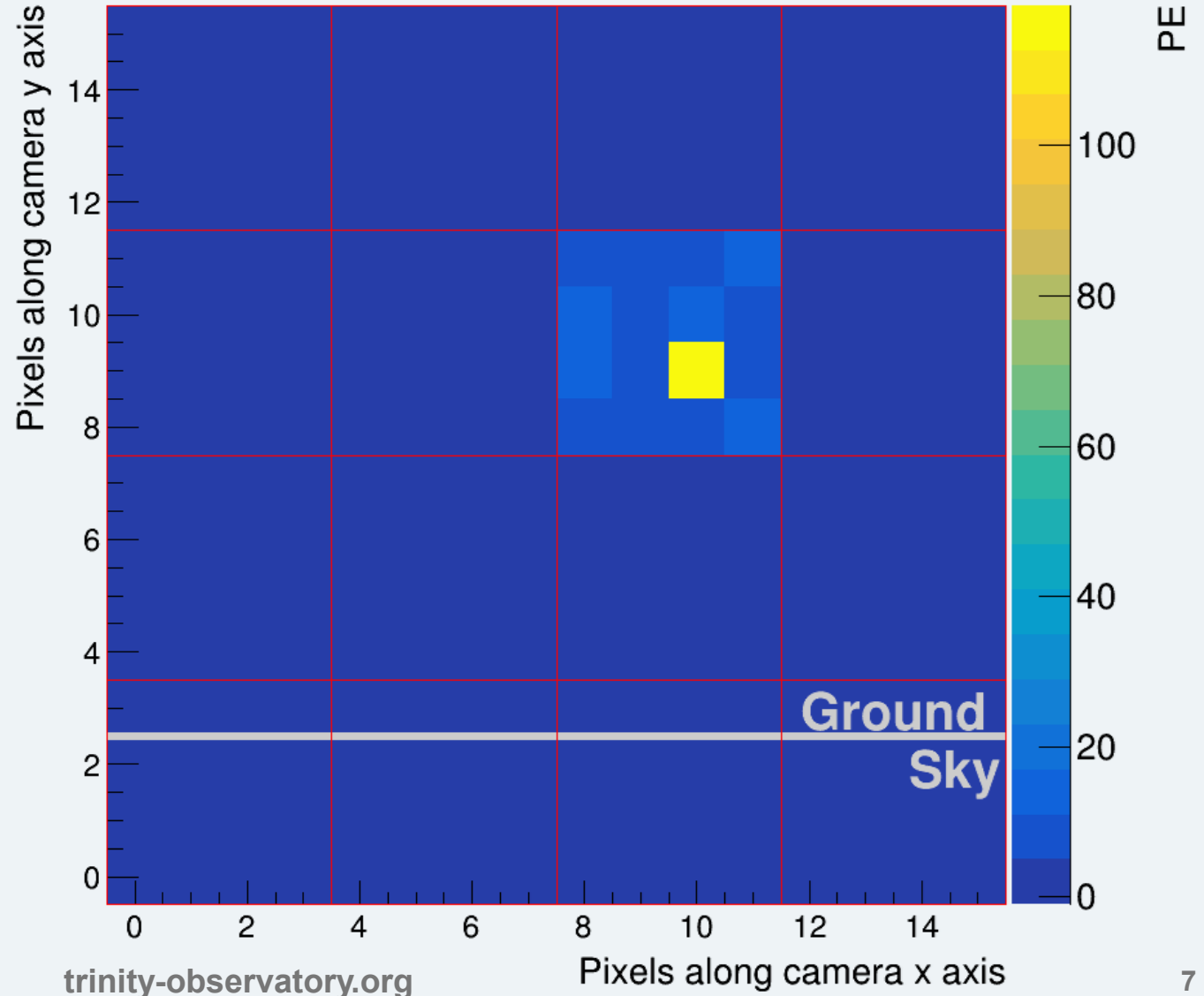


Horizon Imaged on SiPMs



Trigger

- Record any event as soon as the signal in one pixel goes above 20 PE
- Average trigger rate of 0.5 HZ



SofiaStepanoff@gatech.edu

Data Set



Collection Period	October 2024-June 2025
Hours	346
Triggered Events	10^6



SofiaStepanoff@gatech.edu

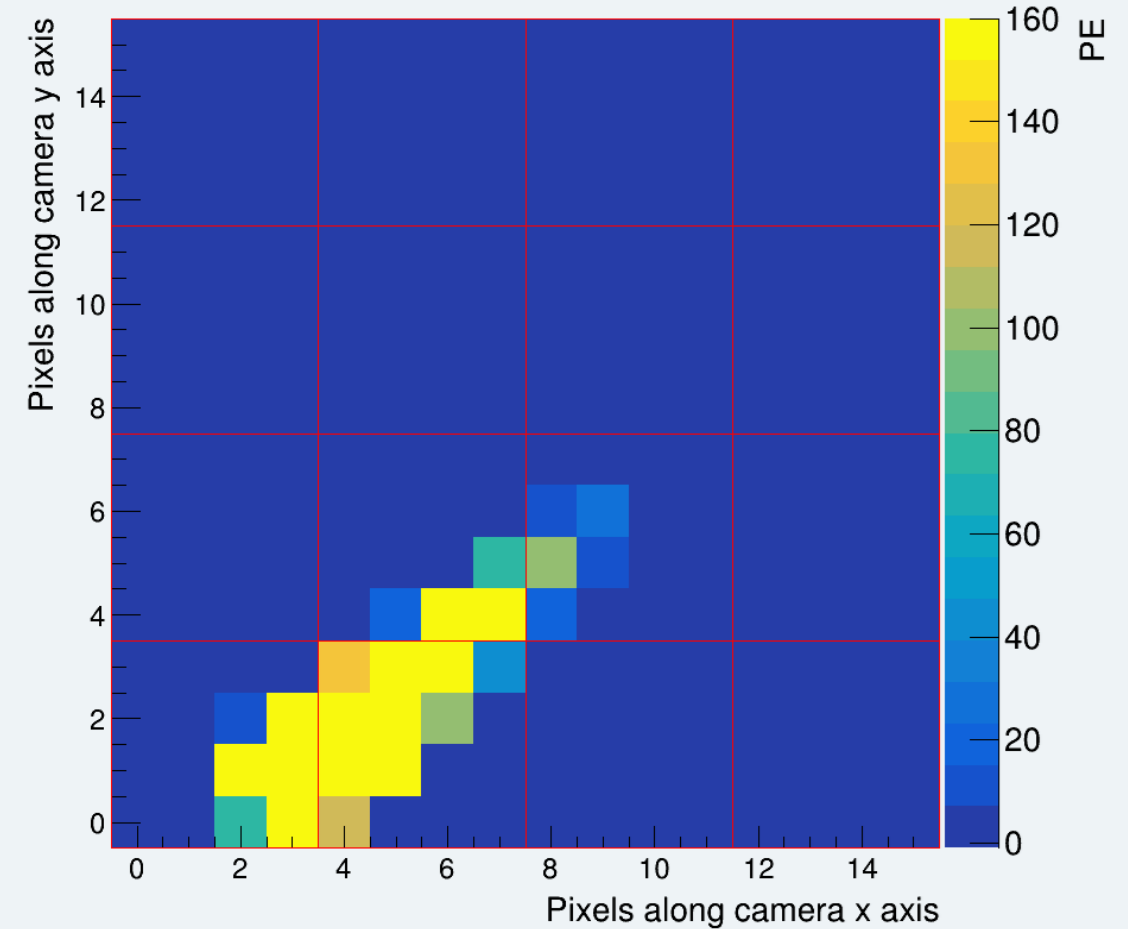
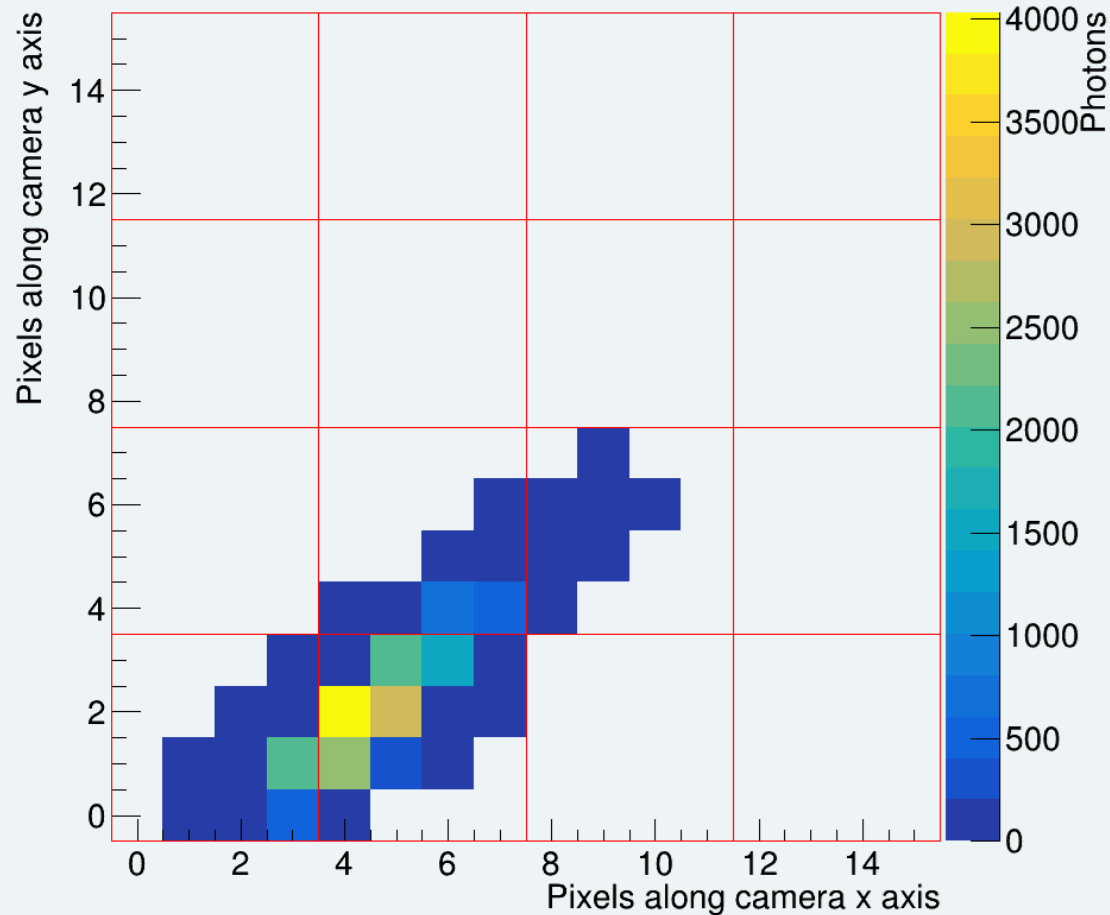
Image Cleaning



Simulated Gold-Plated Event

Energy: 414 PeV, Distance: 170 km, Emergence Angle: 1.75°

Expected Camera Response



SofiaStepanoff@gatech.edu

Image Cleaning



SofiaStepanoff@gatech.edu

Core Pixel Selection

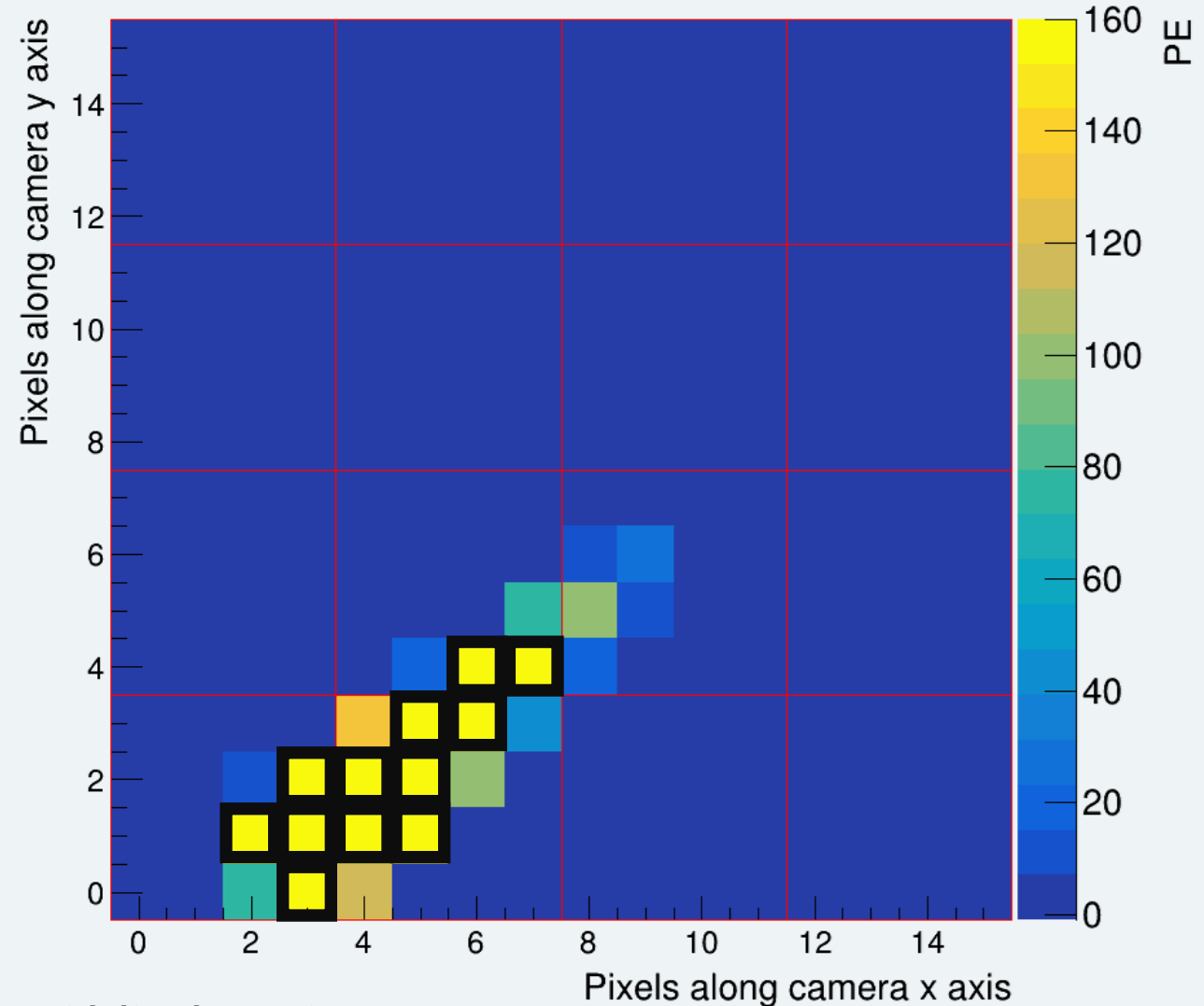


Image Cleaning



SofiaStepanoff@gatech.edu

Boundary Pixel Selection

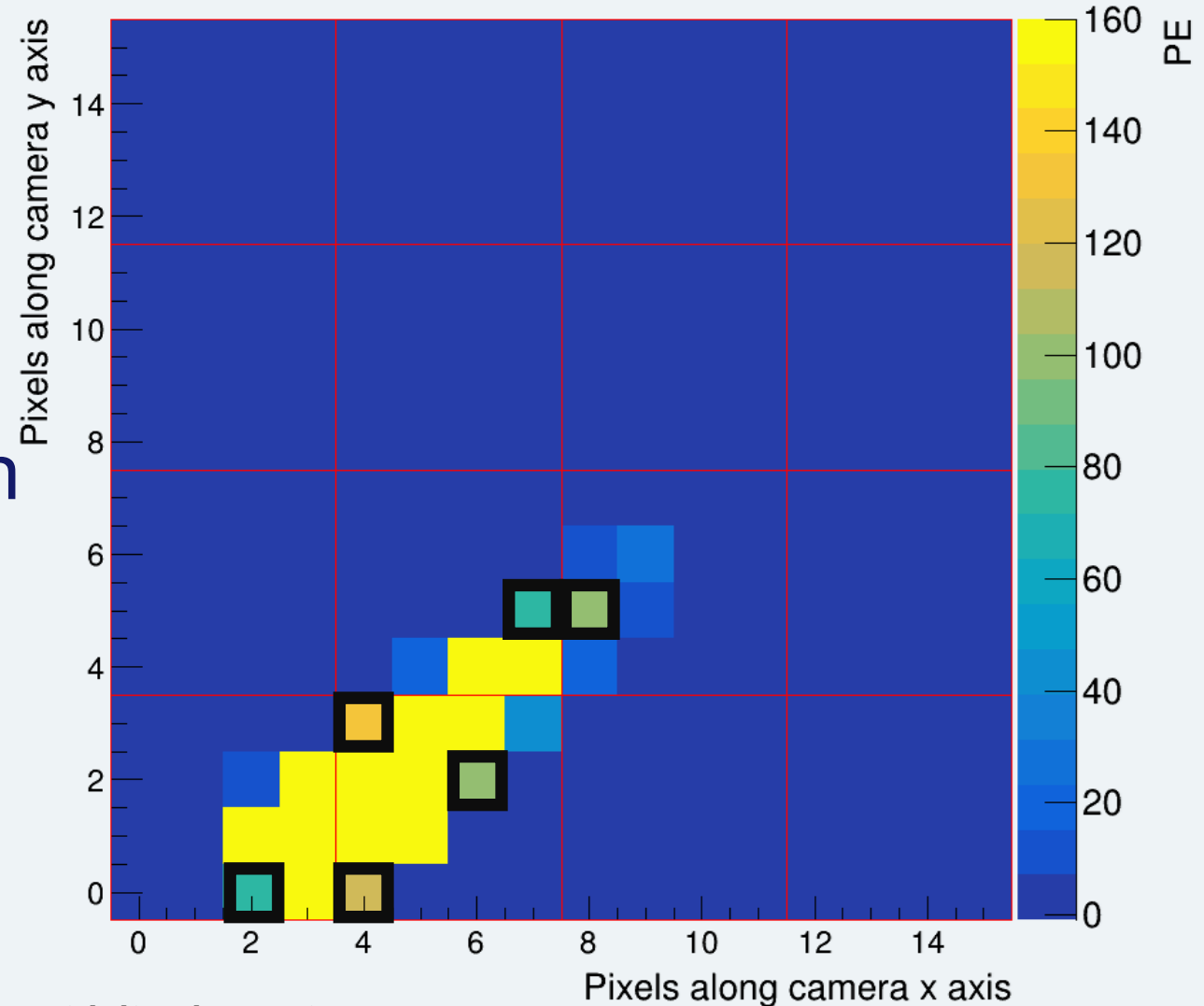
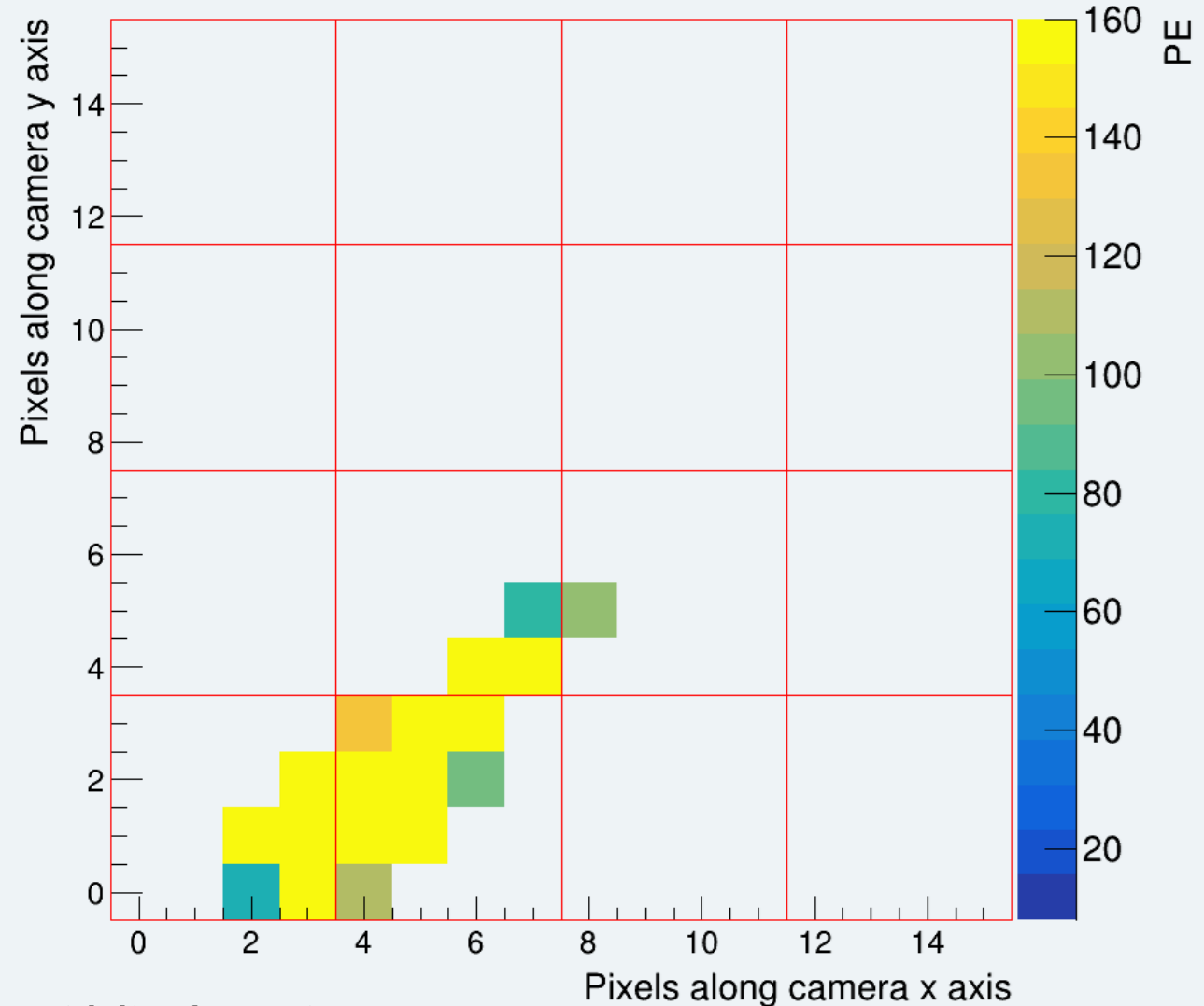


Image Cleaning



SofiaStepanoff@gatech.edu

Cleaned Event



Event Selection



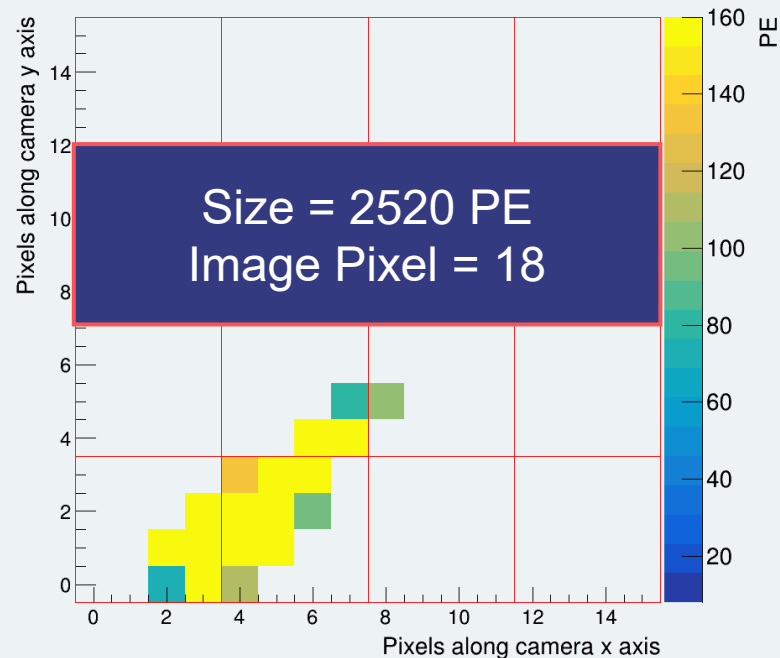
SofiaStepanoff@gatech.edu

Size:

Sum signal of all pixels in the cleaned image

Image Pixels:

Pixels in the cleaned image



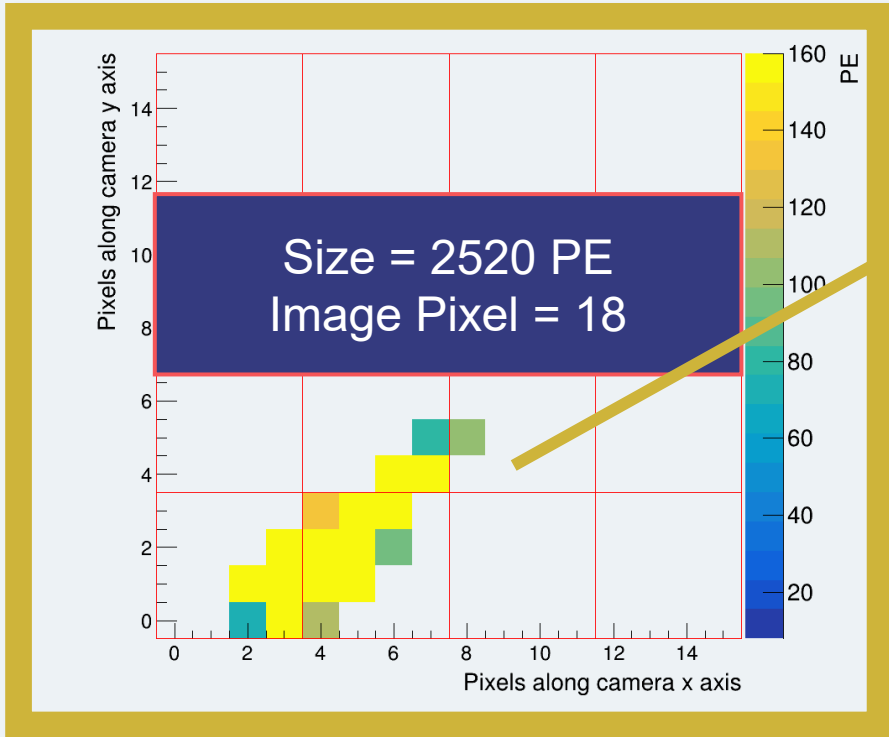
Event Selection

Size:

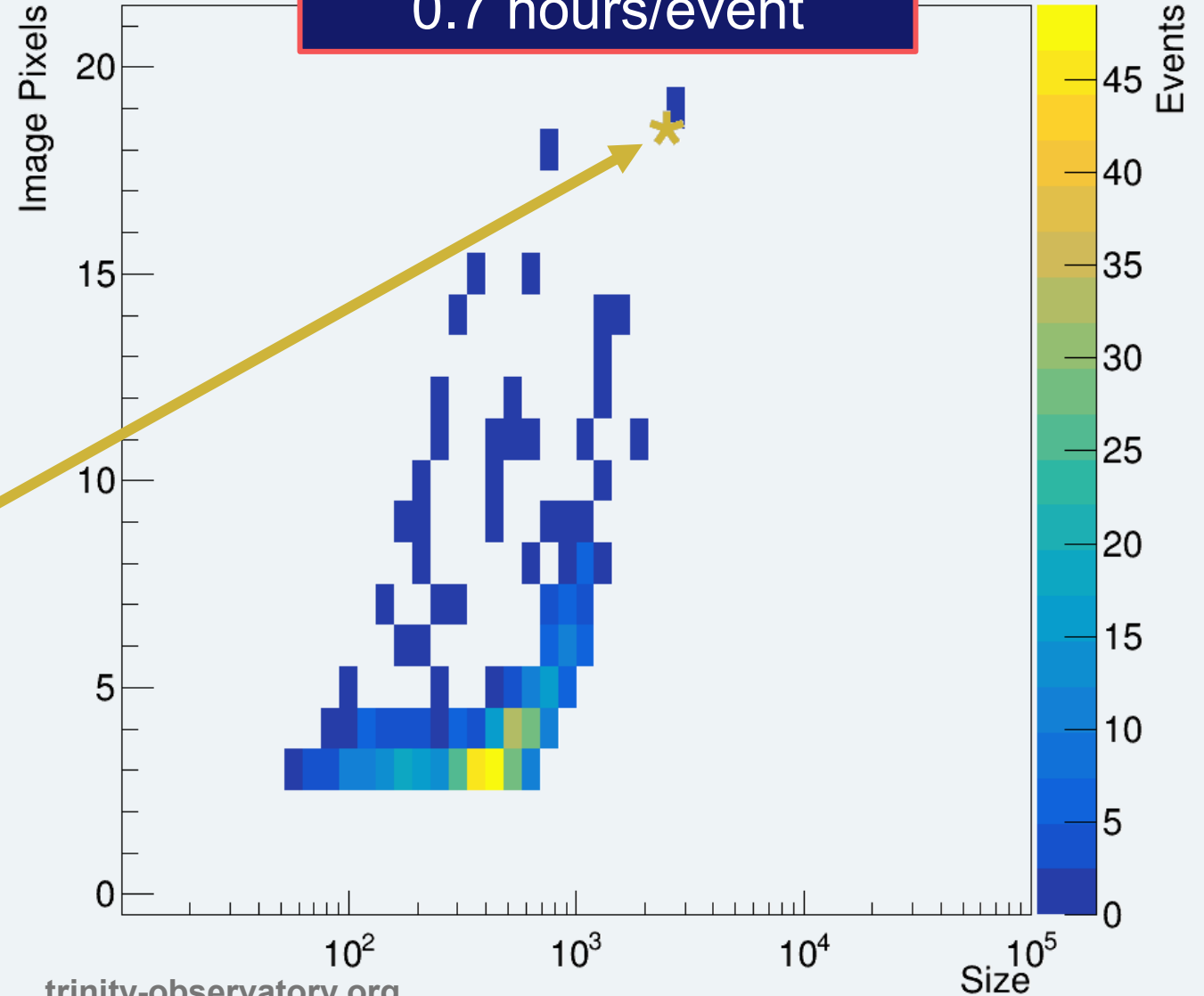
Sum signal of all pixels in the cleaned image

Image Pixels:

Pixels in the cleaned image



497 events
0.7 hours/event

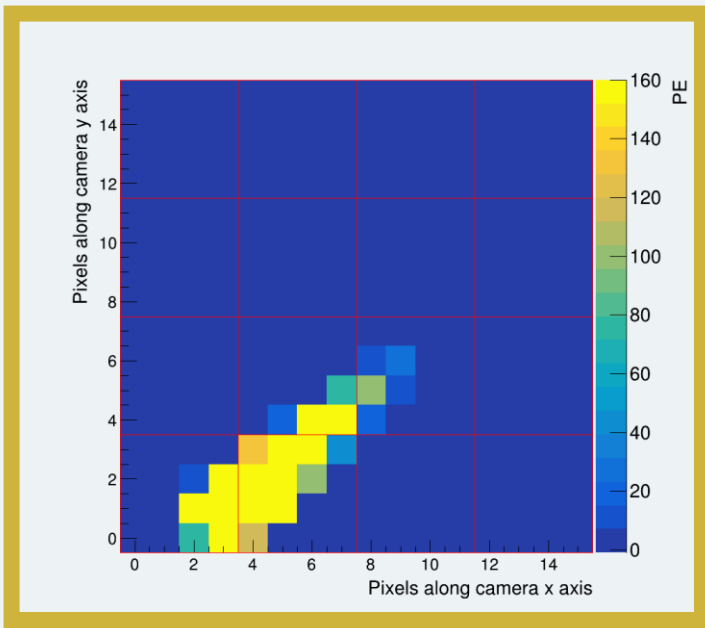


SofiaStepanoff@gatech.edu

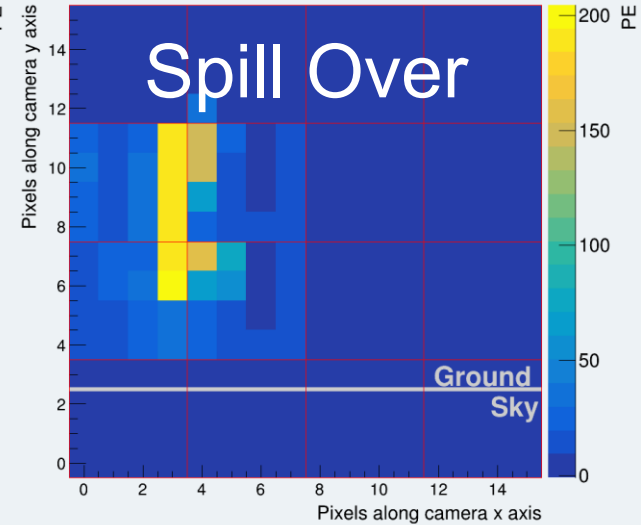
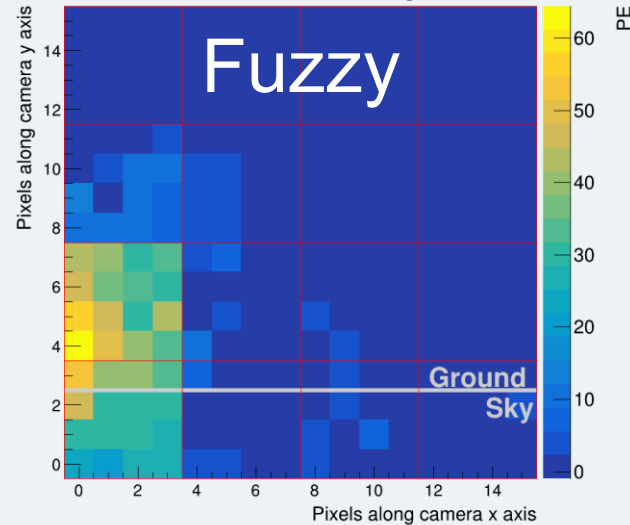
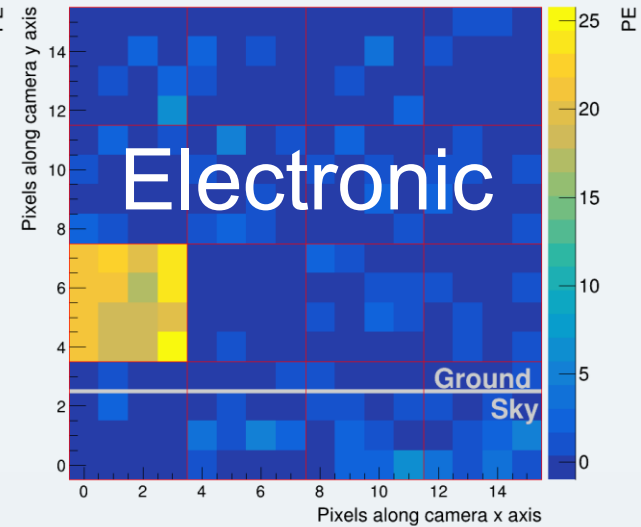
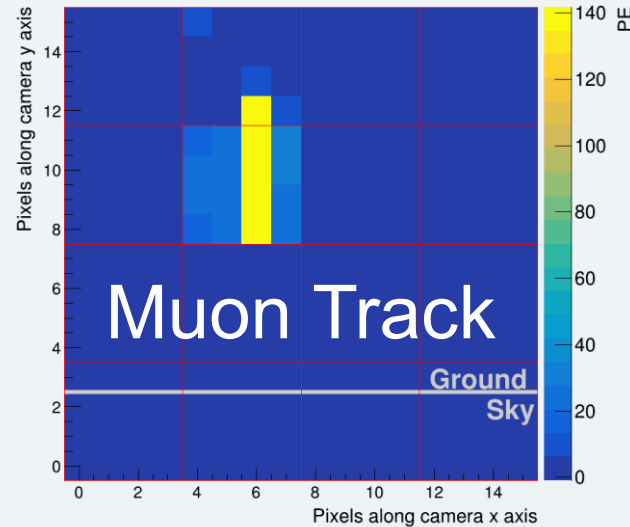
Event Gallery: Types of Events



SofiaStepanoff@gatech.edu

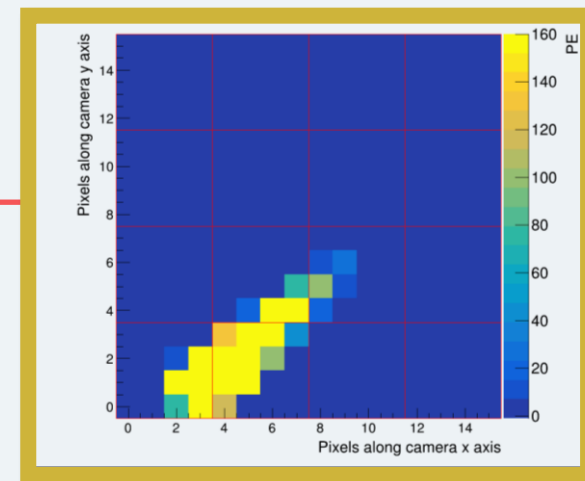


Gold Plated Simulation Event

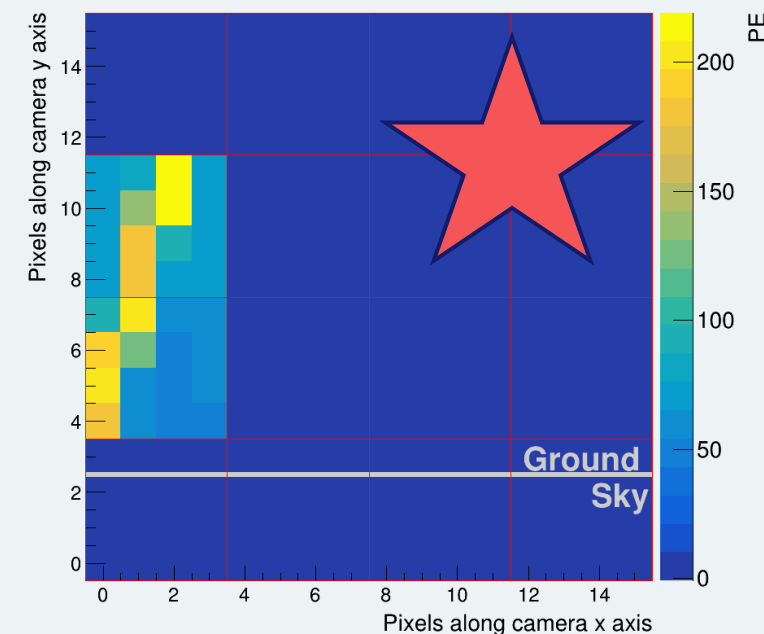
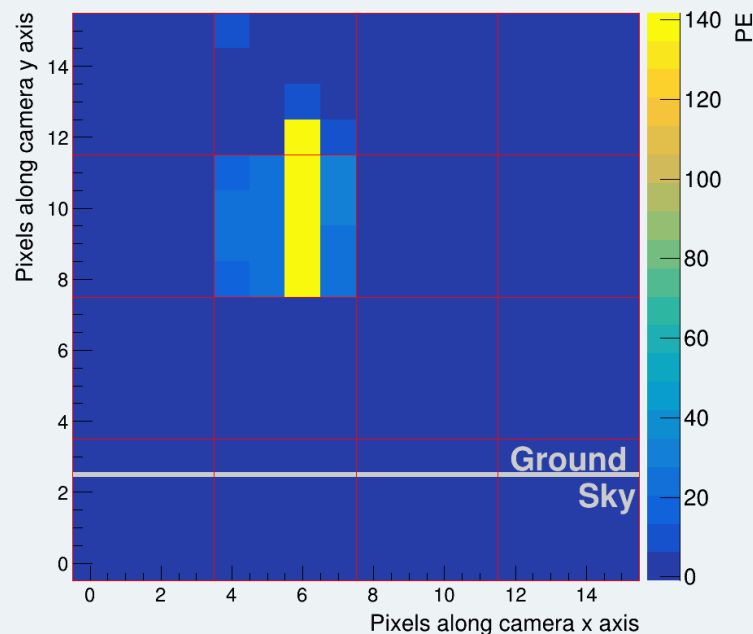
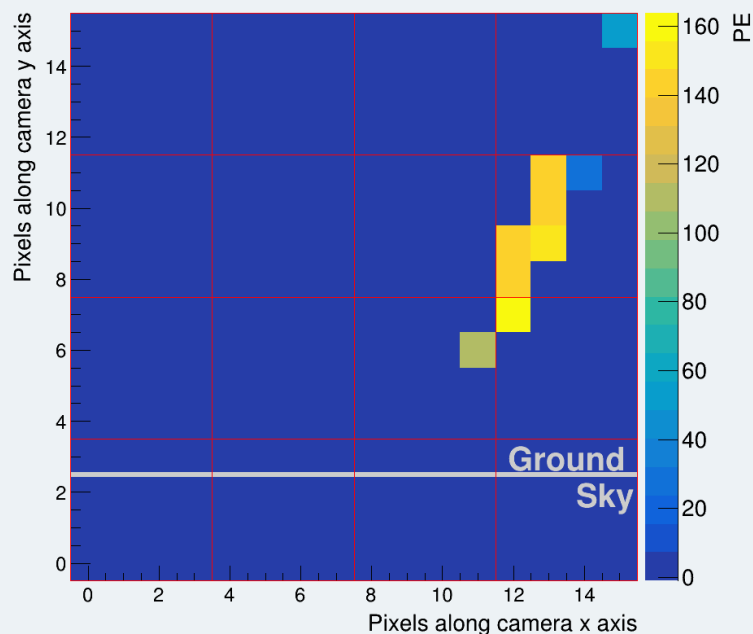


Event Gallery:

461 Muon Tracks Events
0.8 Hours/Event



SofiaStepanoff@gatech.edu



Direct Muon Hits

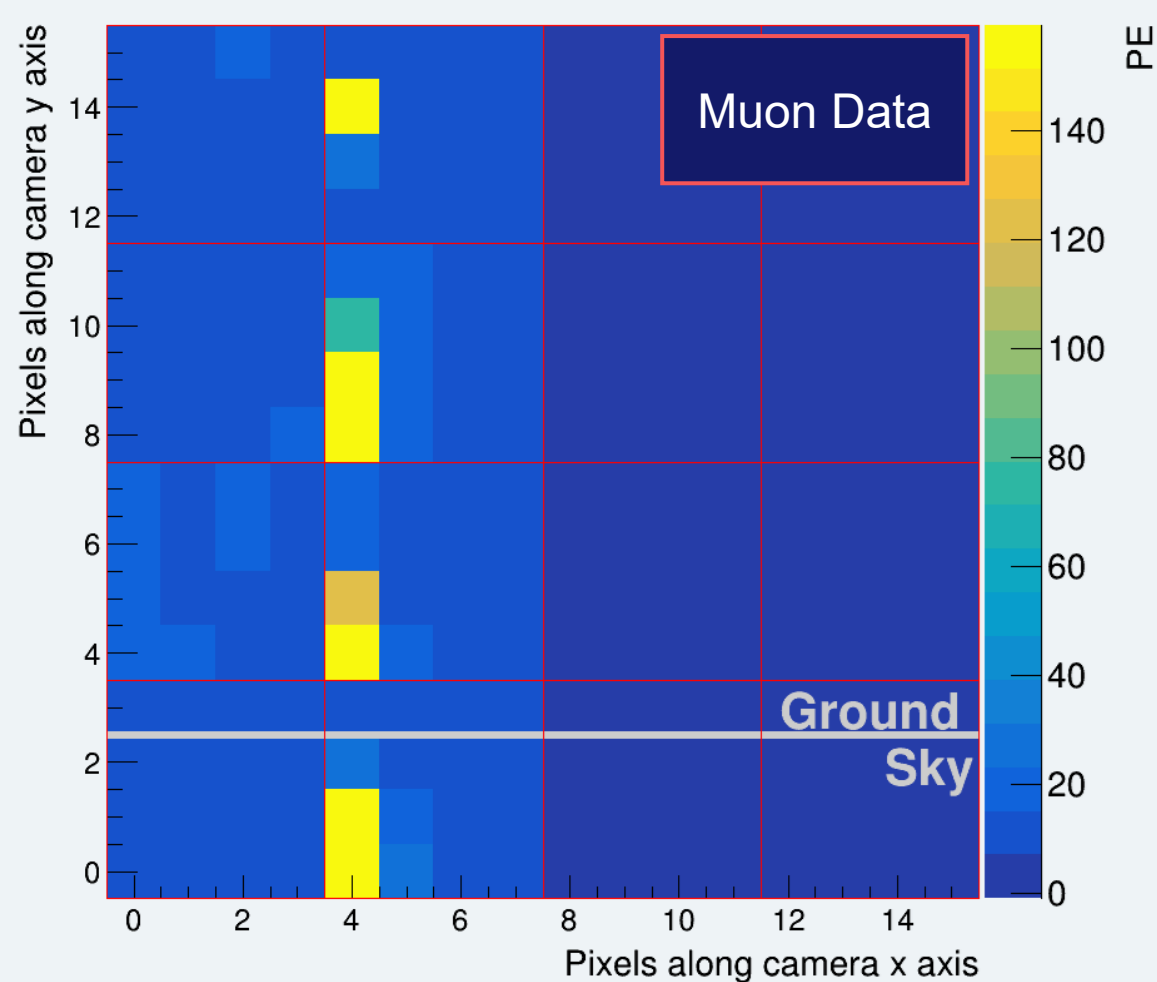
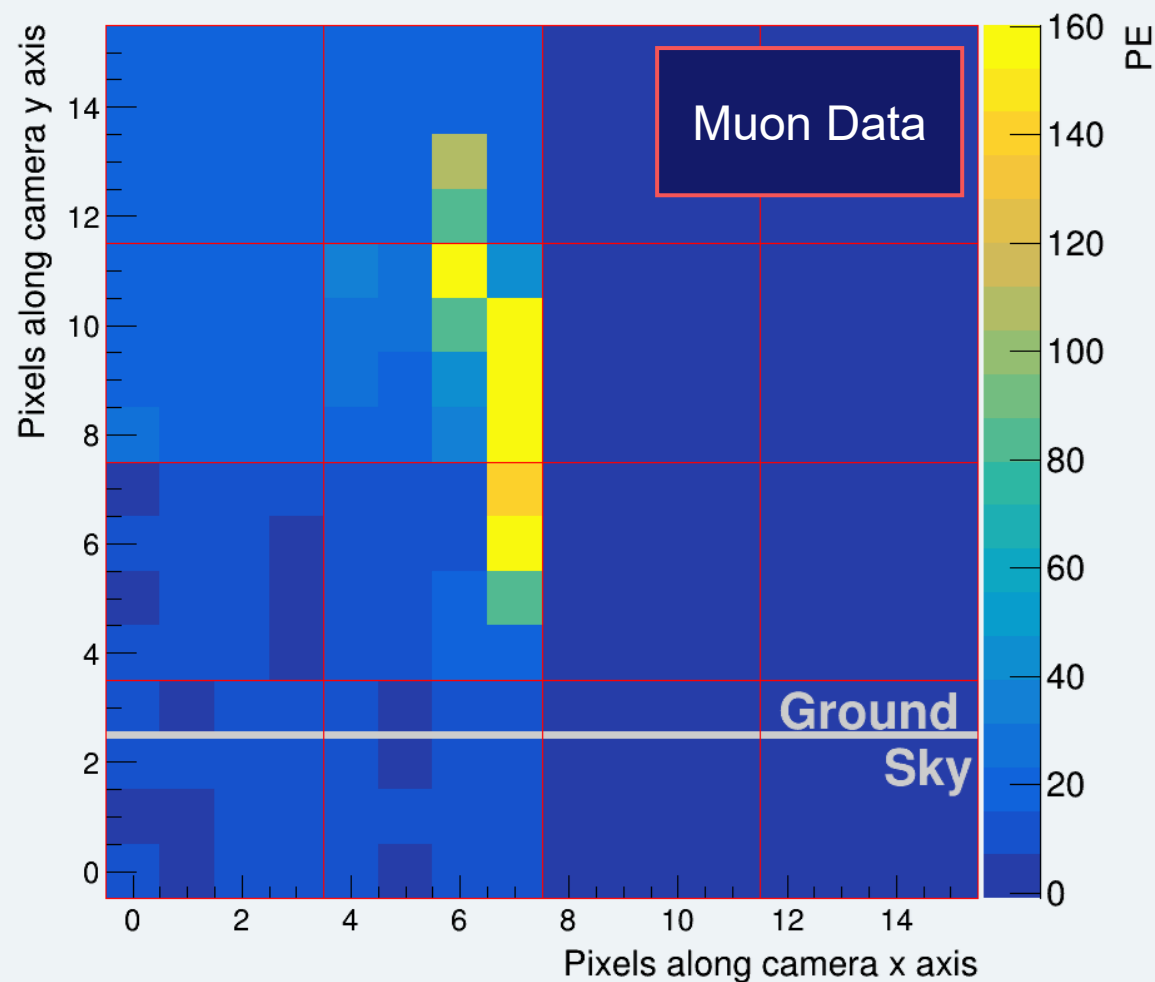


SofiaStepanoff@gatech.edu

Plastic Scintillator Detectors



Direct Muon Hits: Sample Events



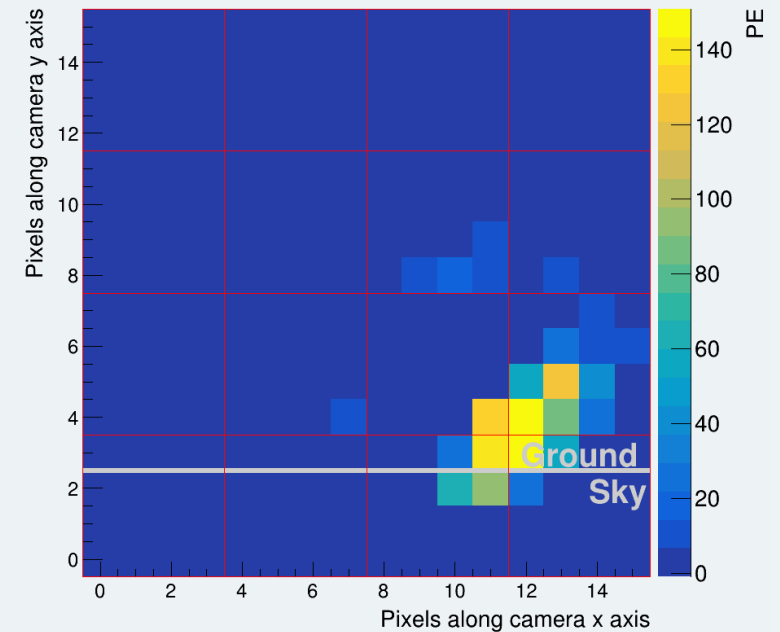
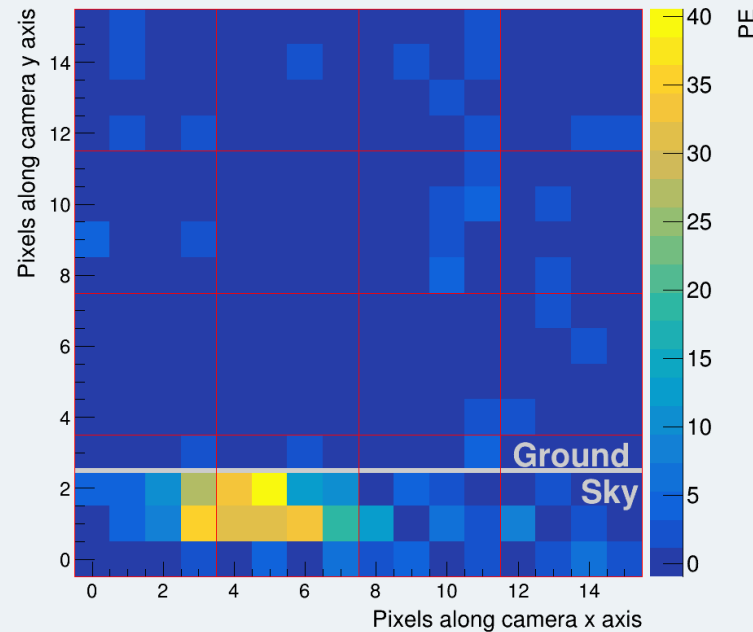
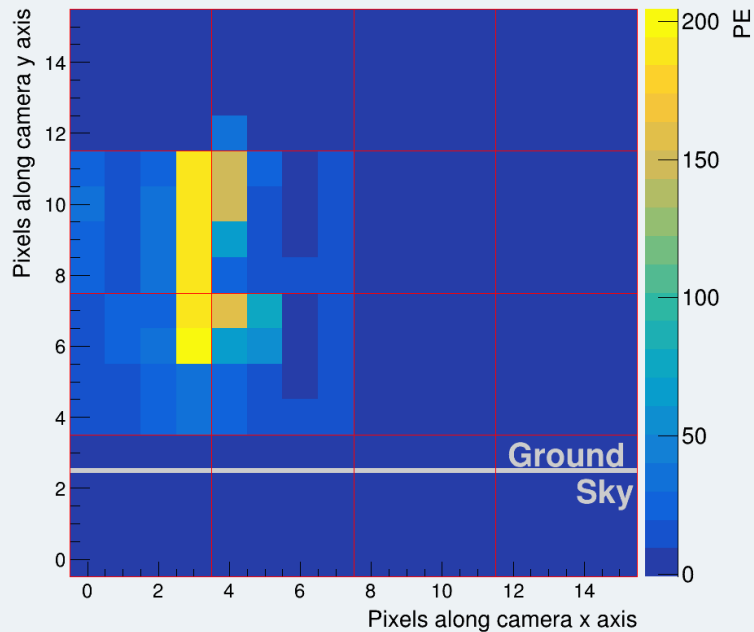
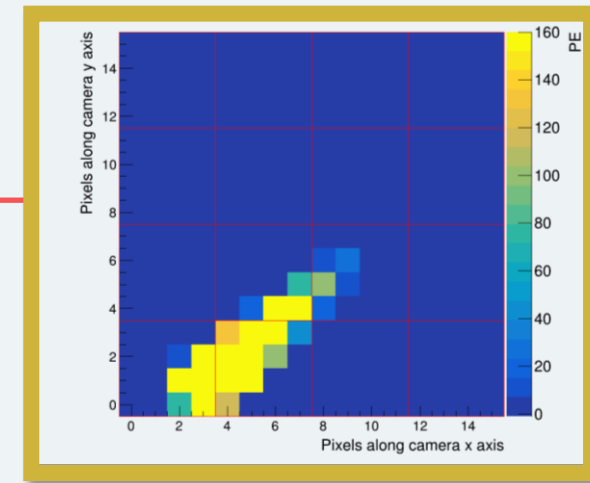
SofiaStepanoff@gatech.edu

Event Gallery:

15 Spill Over Events
23 Hours/Events

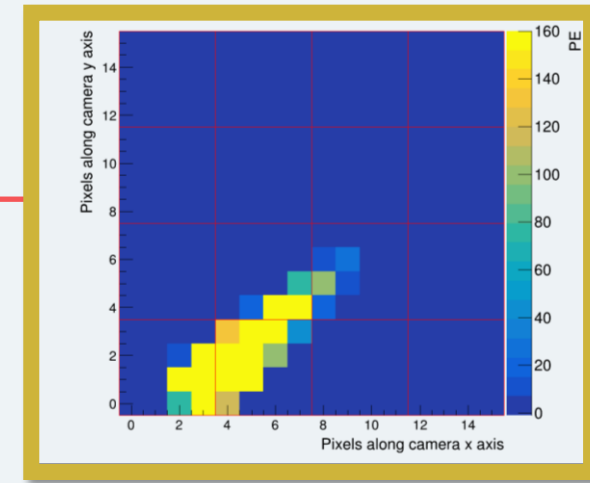


SofiaStepanoff@gatech.edu

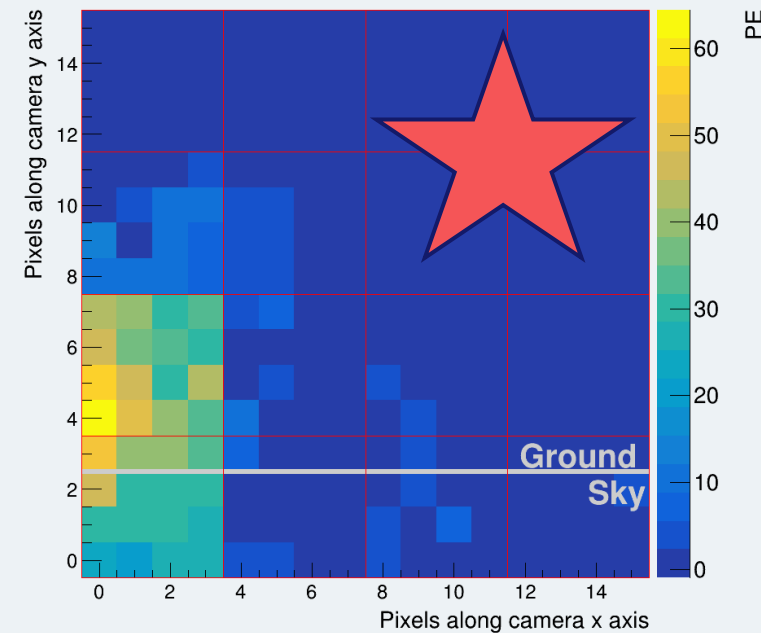
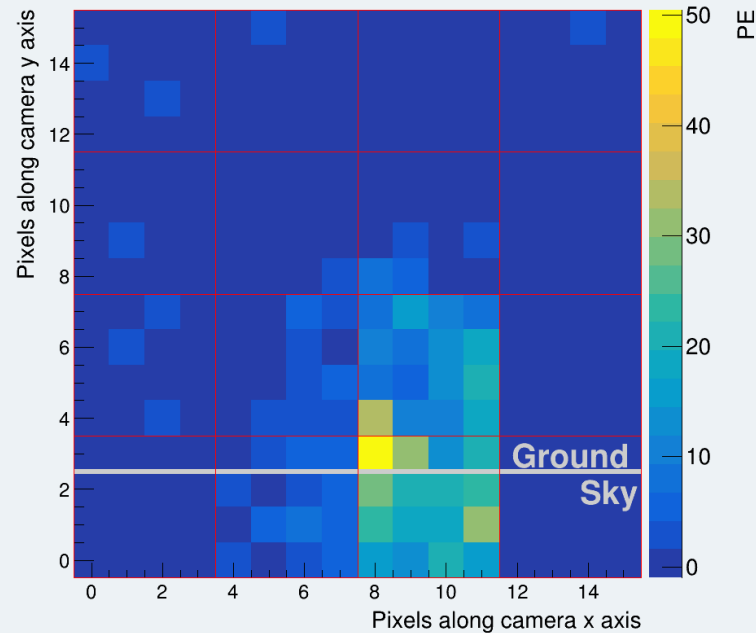


Event Gallery:

2 Fuzzy Events
173 Hours/Event

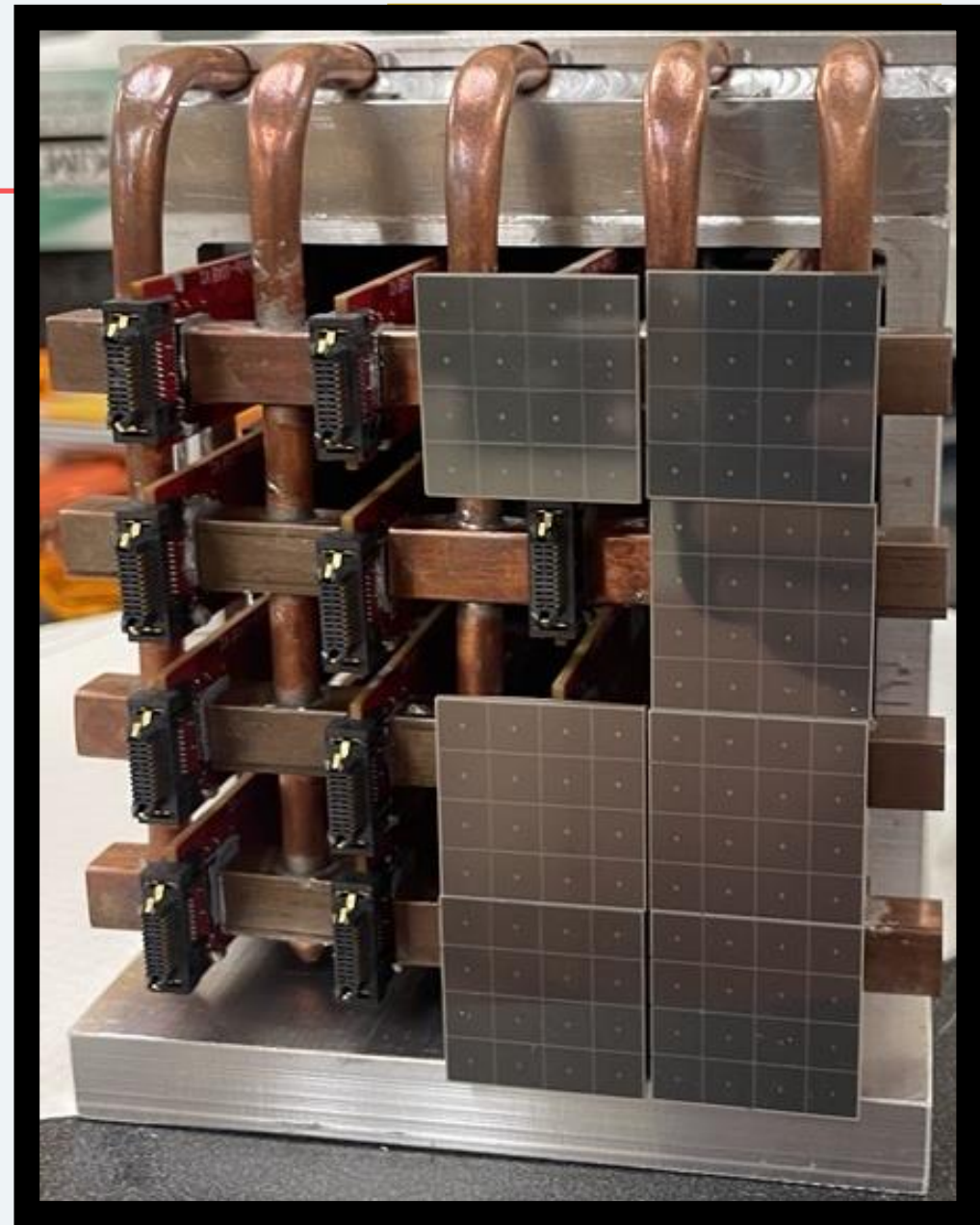
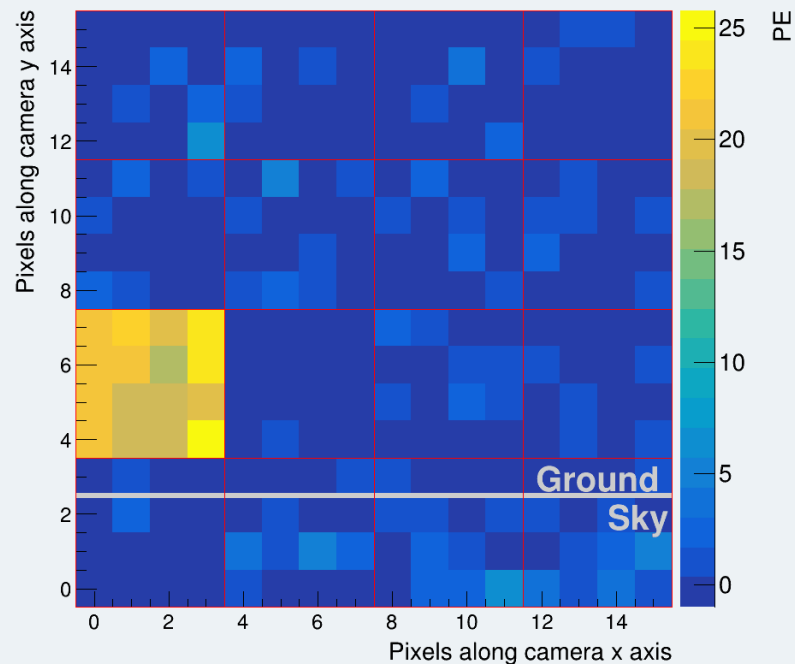


SofiaStepanoff@gatech.edu



Event Gallery:

19 Electronics Events

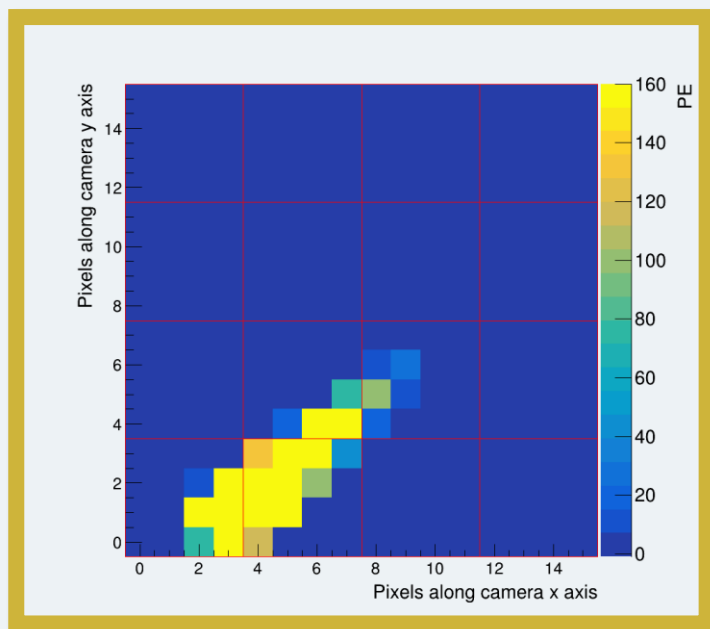


SofiaStepanoff@gatech.edu

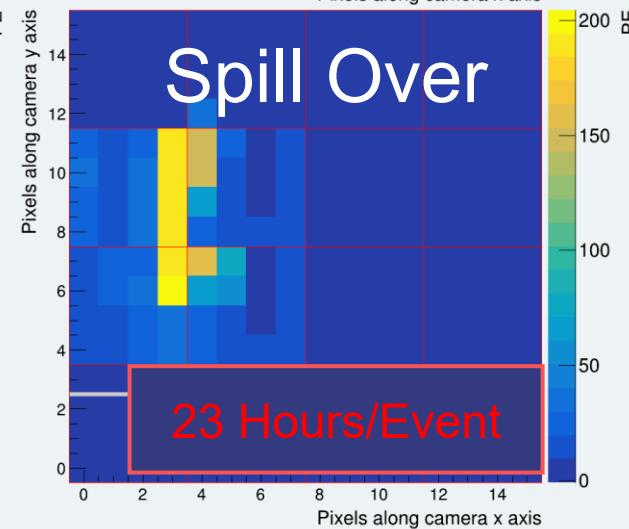
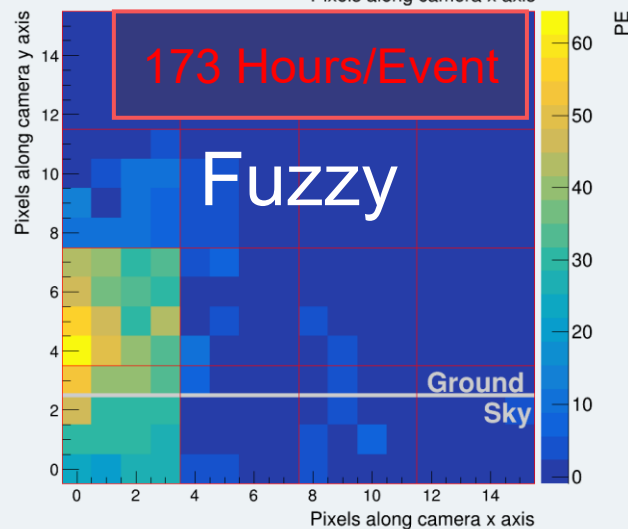
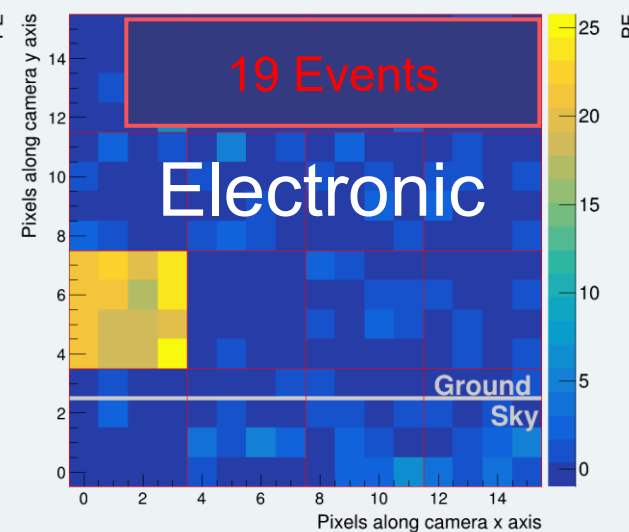
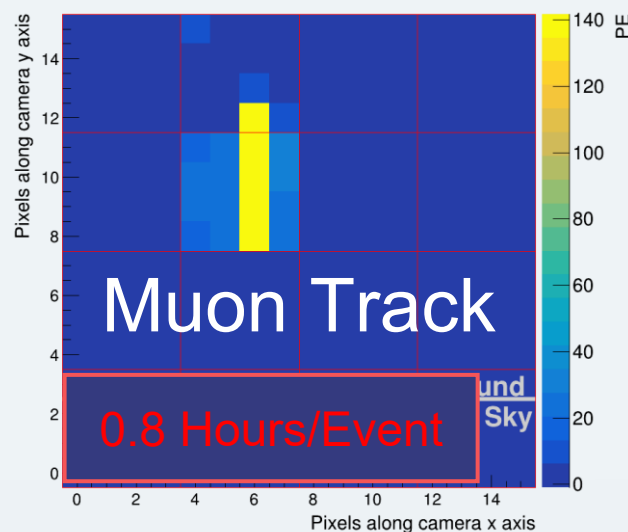
Event Gallery: Types of Events



SofiaStefanoff@gatech.edu



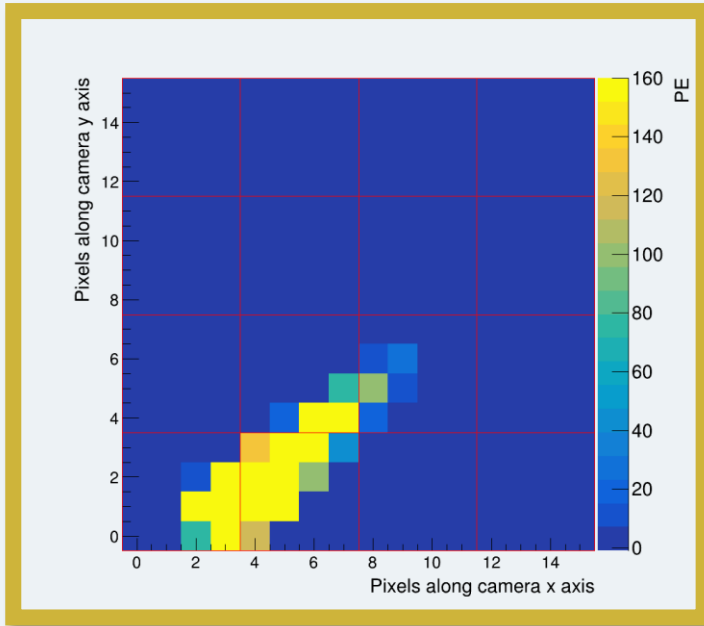
Gold Plated Simulation Event



Event Gallery: Types of Events

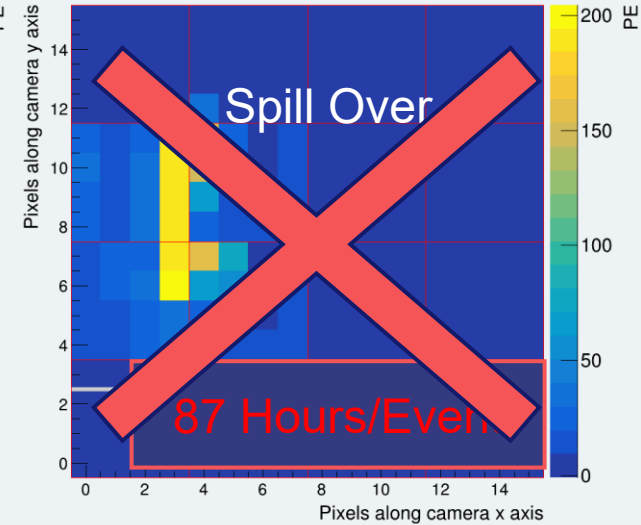
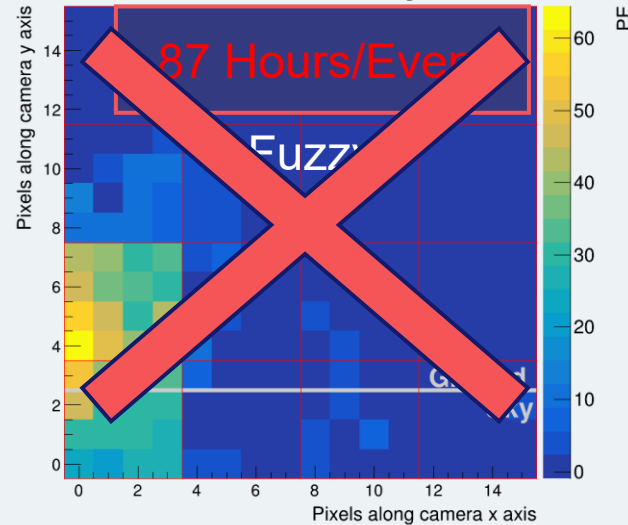
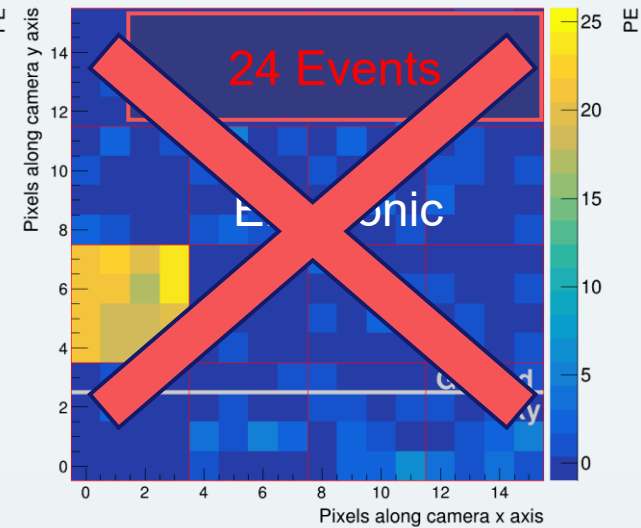
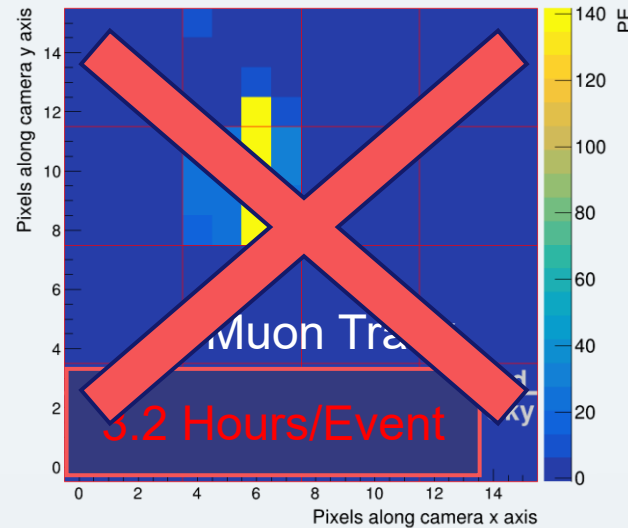


SofiaStepanoff@gatech.edu



Gold Plated Simulation Event

No Background Events



Outlook



SofiaStepanoff@gatech.edu

- Include data affected by weather
- Simulate our acceptance
- Calculate limit on diffuse neutrino flux
- Look Towards Trinity One

Camera paper: [arXiv:2406.08274]

Commissioning paper: [arXiv:2503.11864]

NBI Summer School 7 July 2025

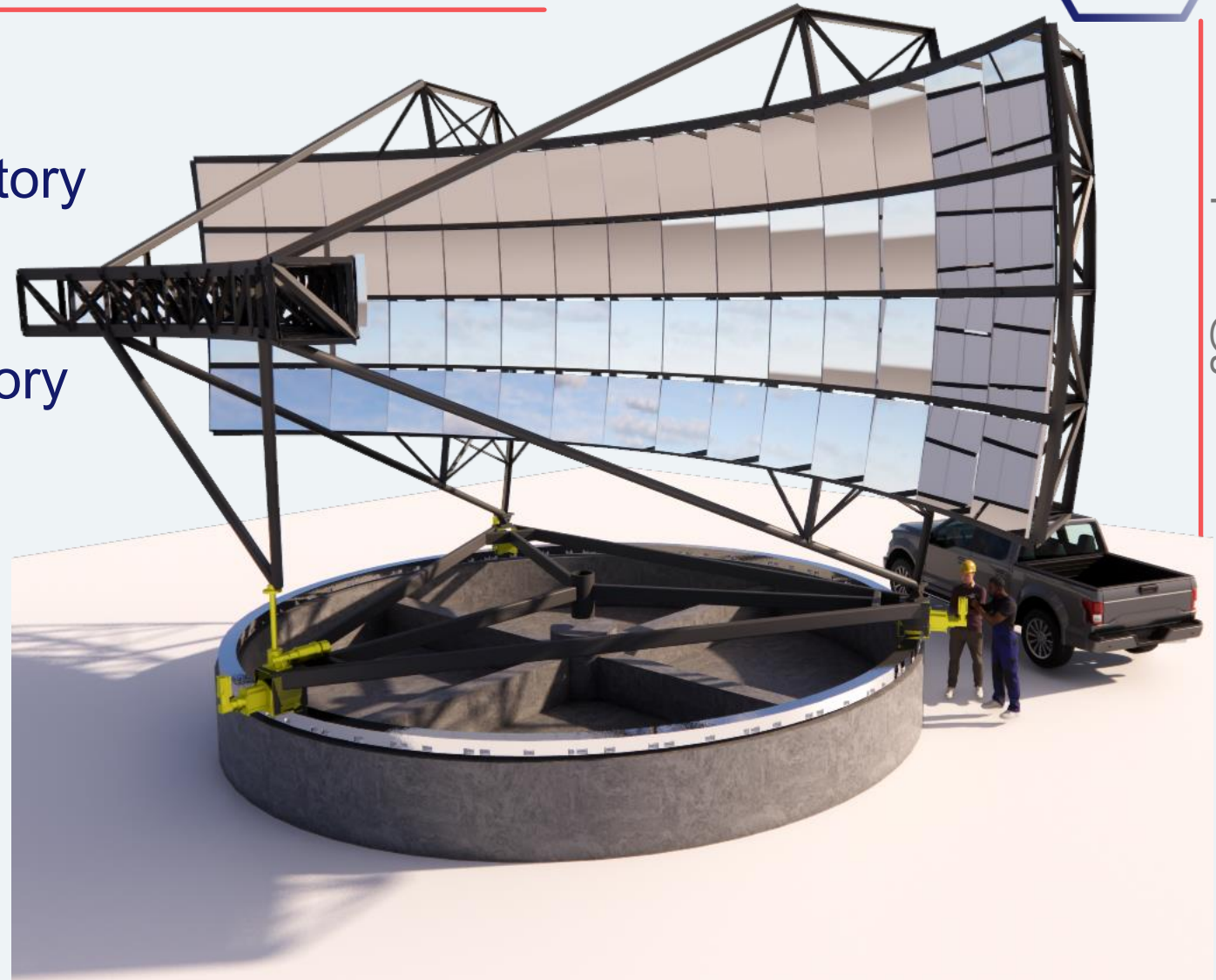
trinity-observatory.org



Outlook: Trinity One



- First telescope of Trinity Observatory
- Rotates in azimuth
- Excellent point source sensitivity
- Planned to be an Open Observatory



SofiaStepanoff@gatech.edu

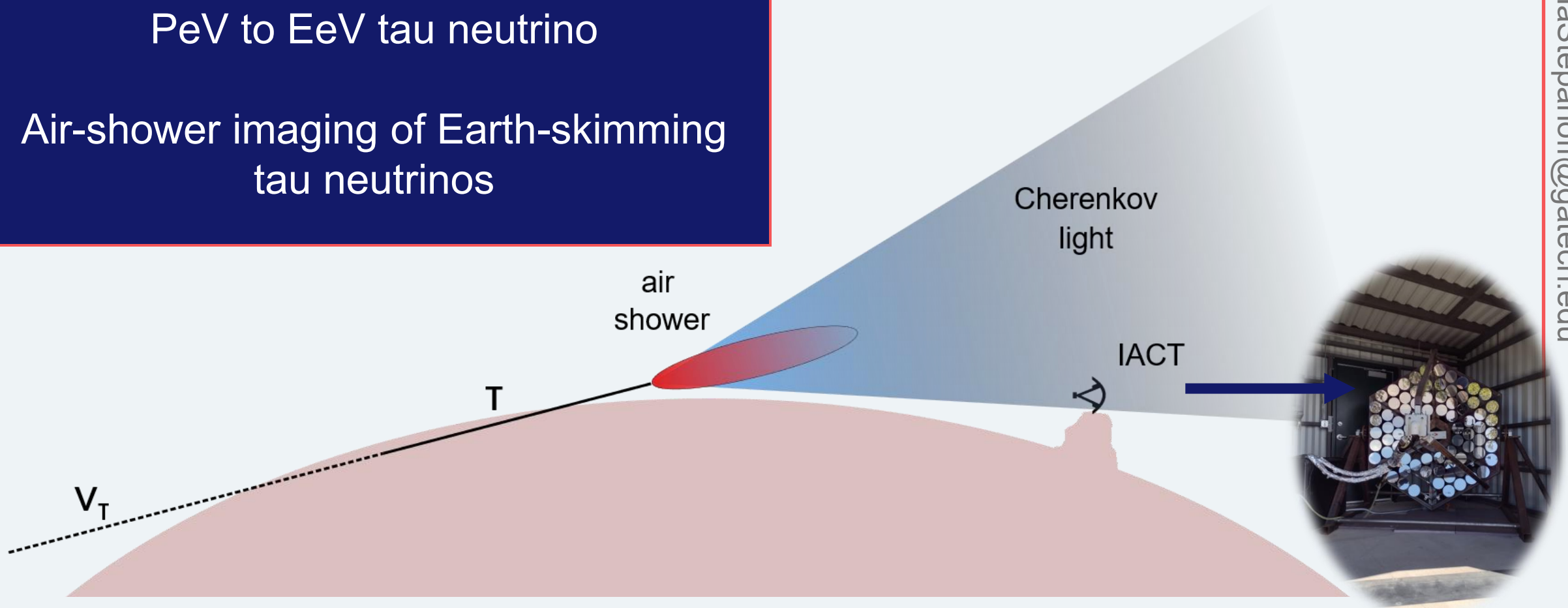
Trinity Detection Concept



SofiaStepanoff@gatech.edu

PeV to EeV tau neutrino

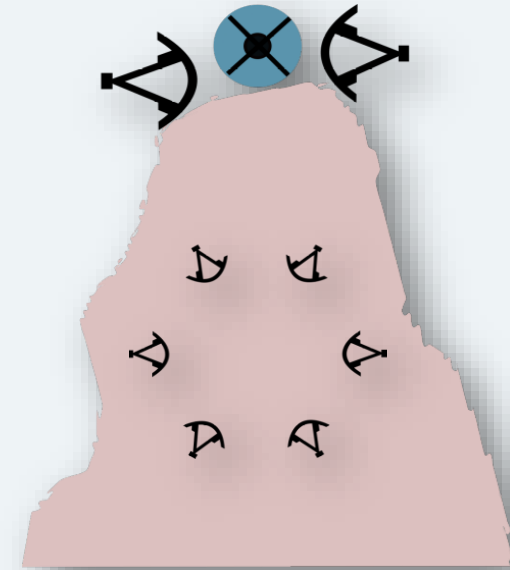
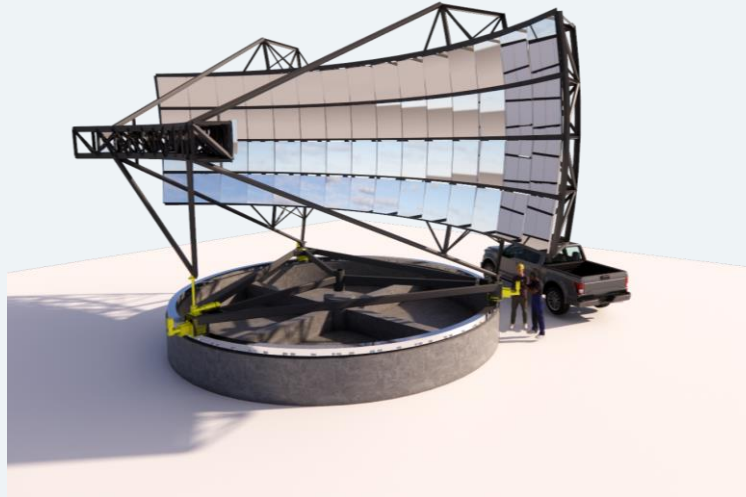
Air-shower imaging of Earth-skimming
tau neutrinos



Trinity Timeline



SofiaStepanoff@gatech.edu



Demonstrator Funding

Trinity One Funding

Trinity Observatory Funding

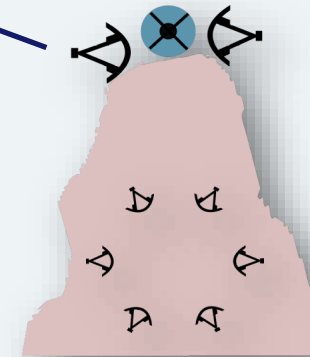
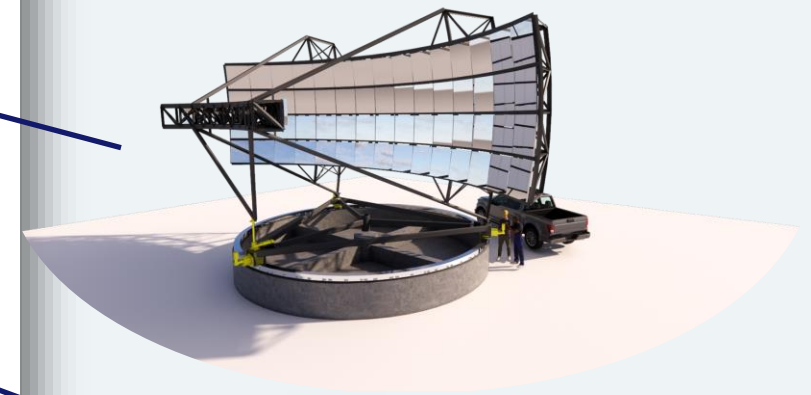
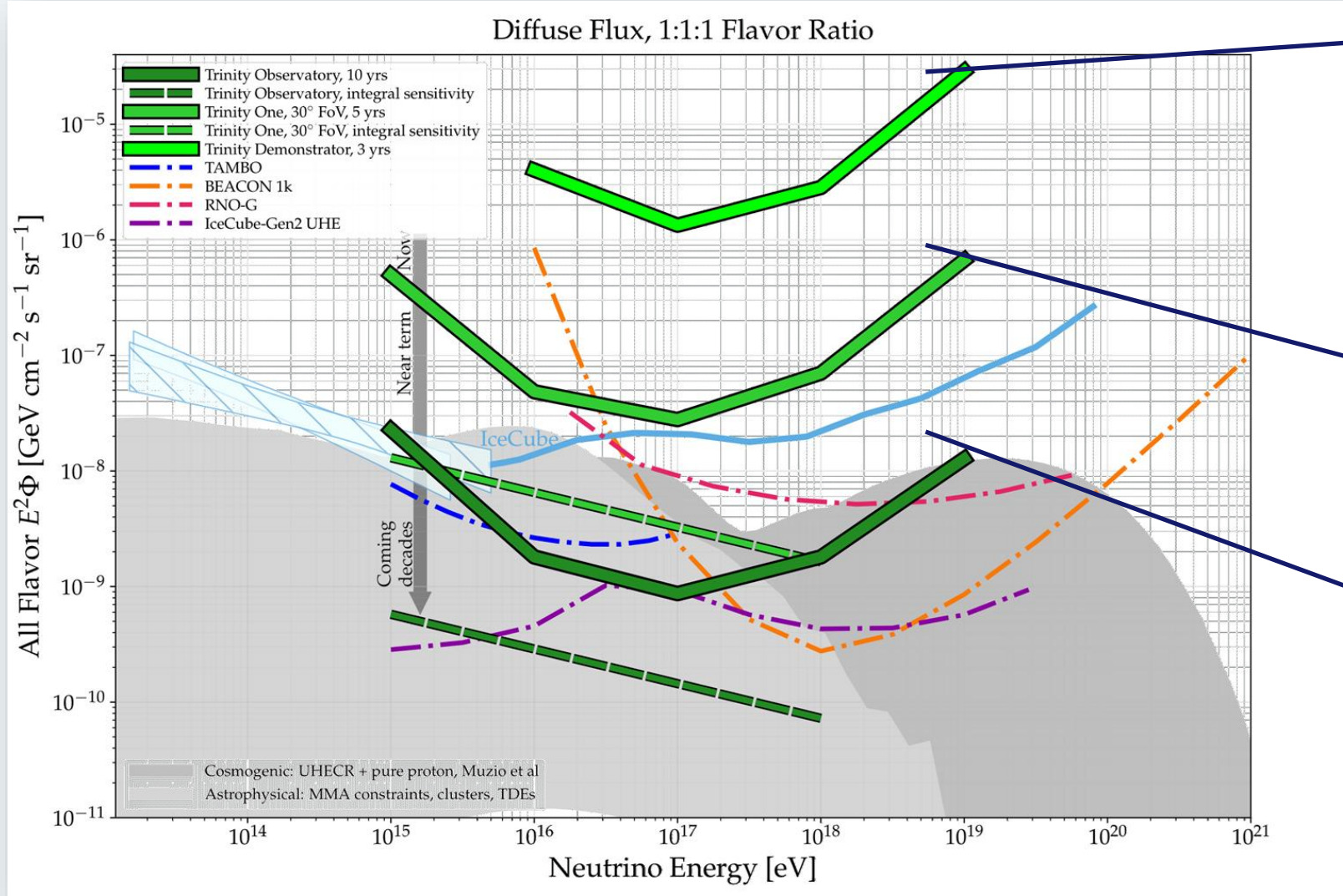


Demonstrator First Light

Trinity Timeline

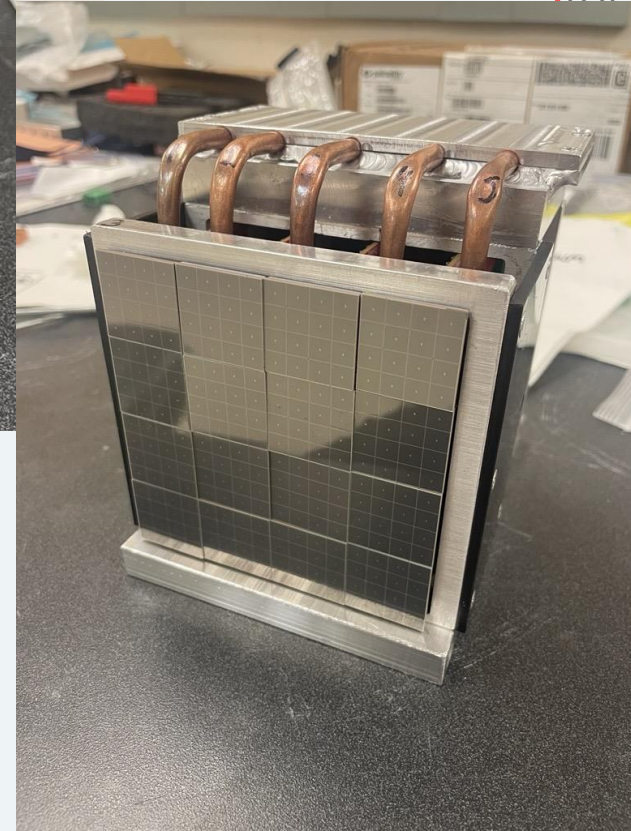
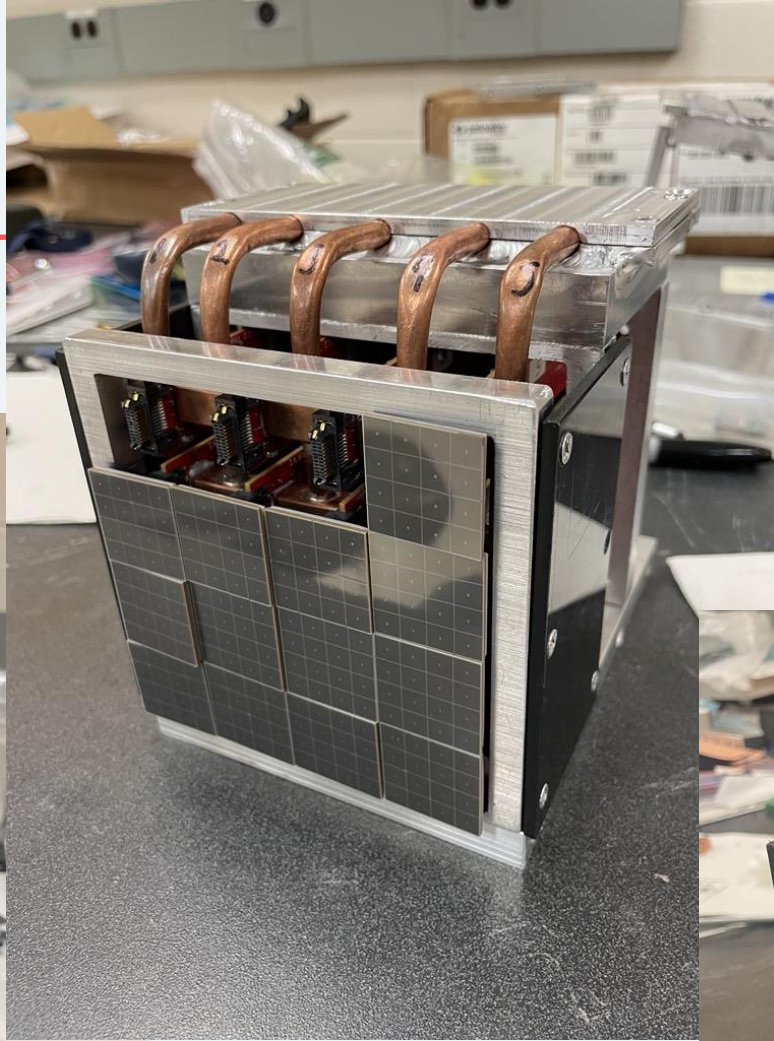
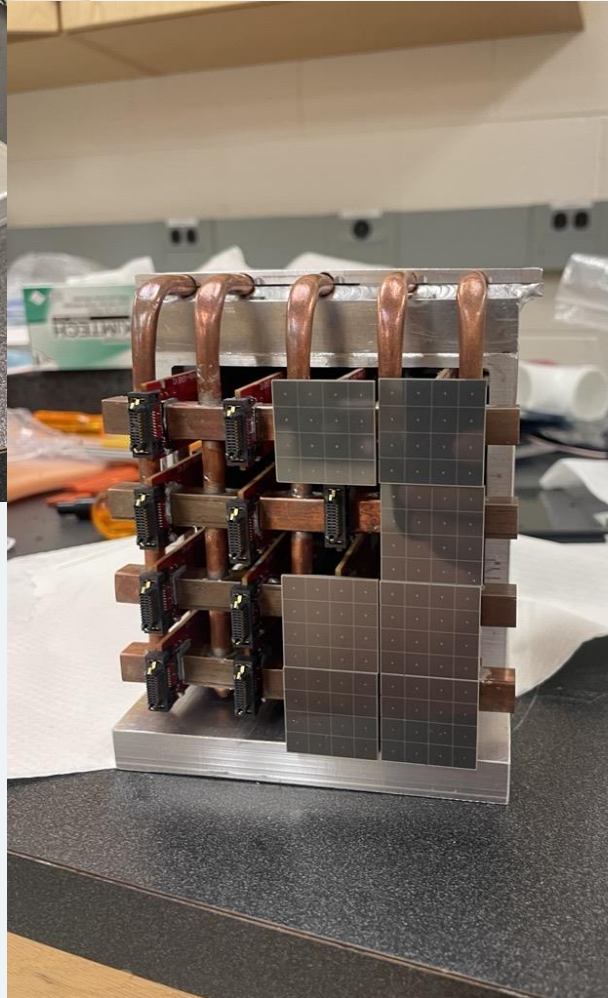


SofiaStepanoff@gatech.edu





SofiaStepanoff©



7/17/2025 ICRC 2025

ry.org

Optical Alignment

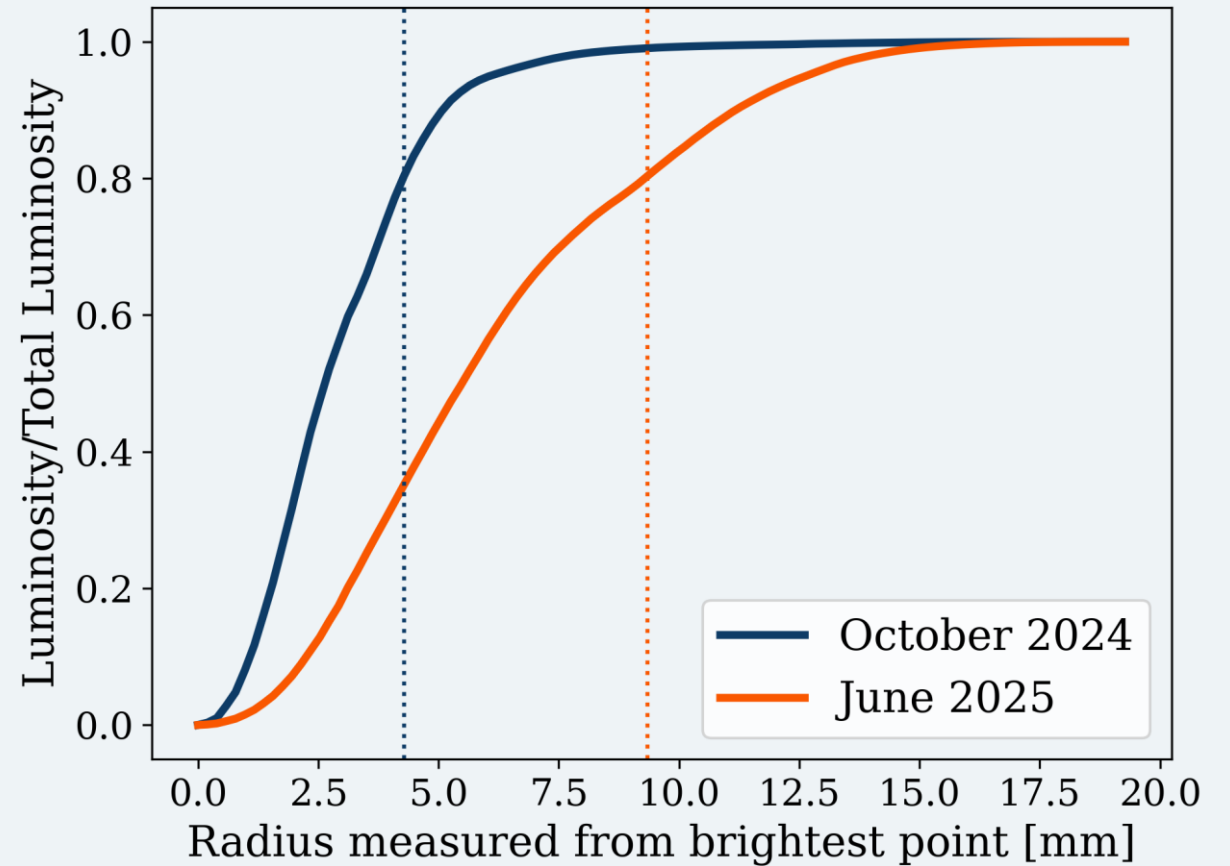


SofiaStepanoff@gatech.edu

80% containment radius of 2.1mm



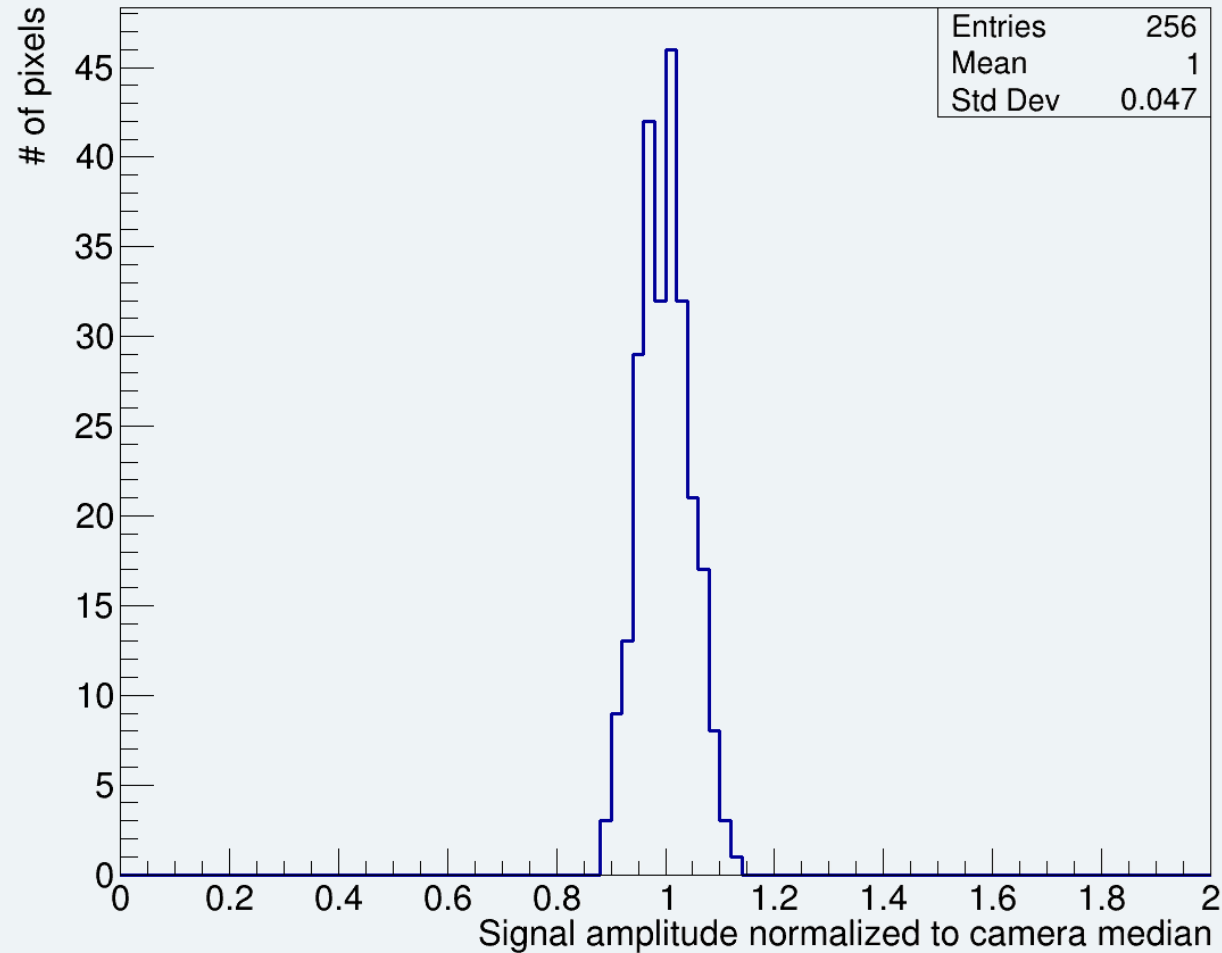
Horizon Imaged on SiPMs



Camera Gain Flat-Fielding



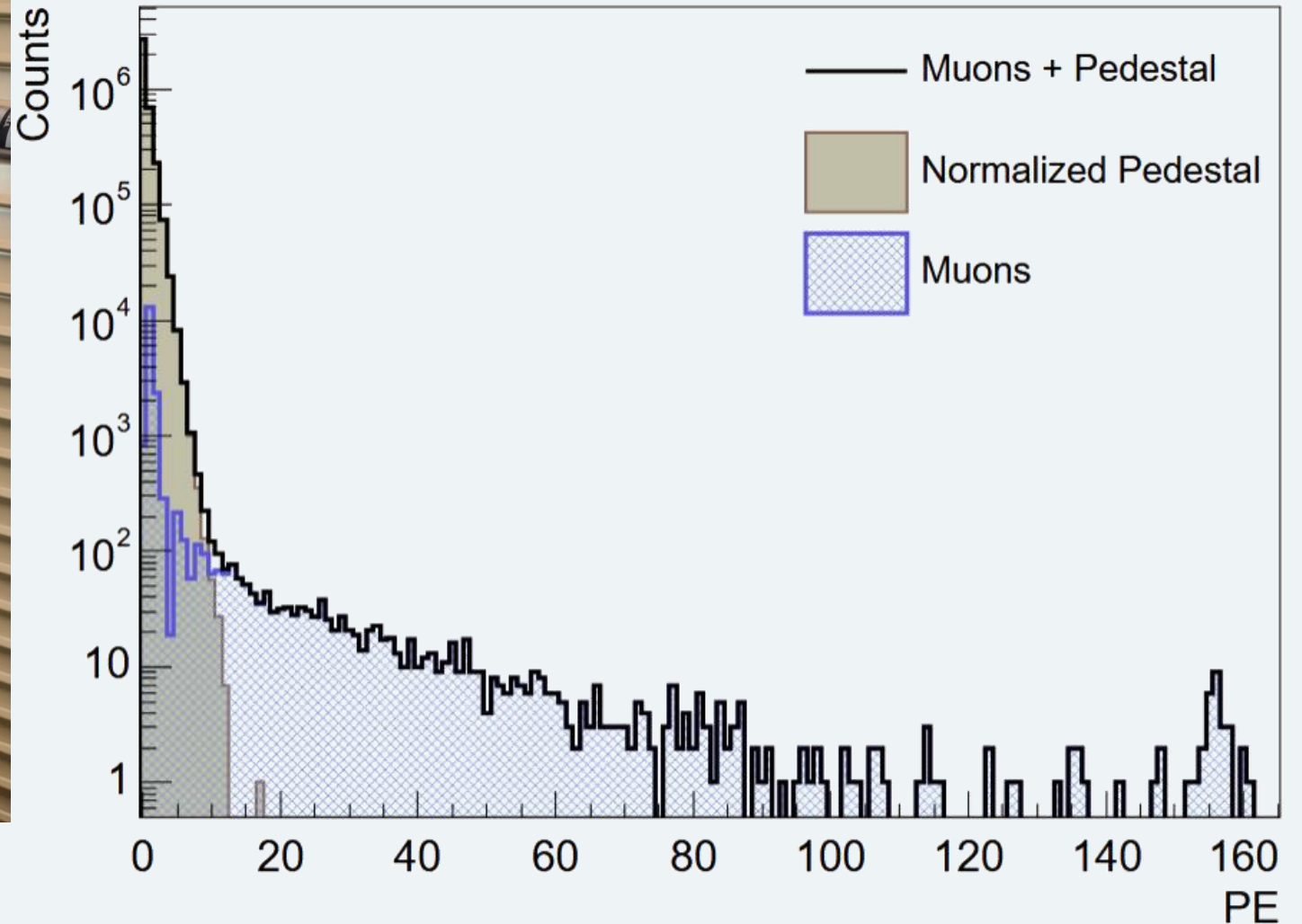
- HV gain flat-field within 5% std



Direct Muon Hits

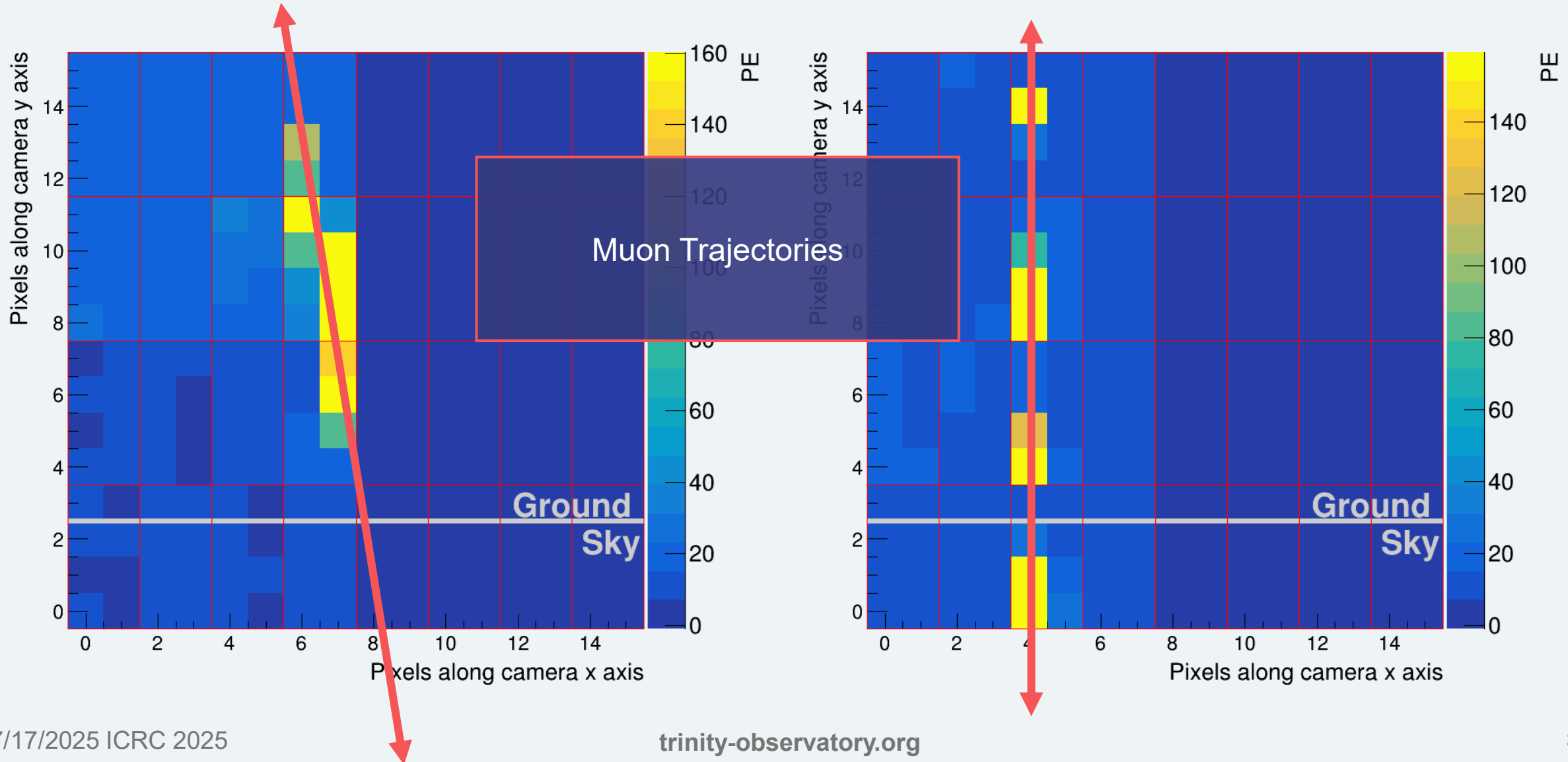


Data Collection for Vertical
Muon Paddles: 2 hours



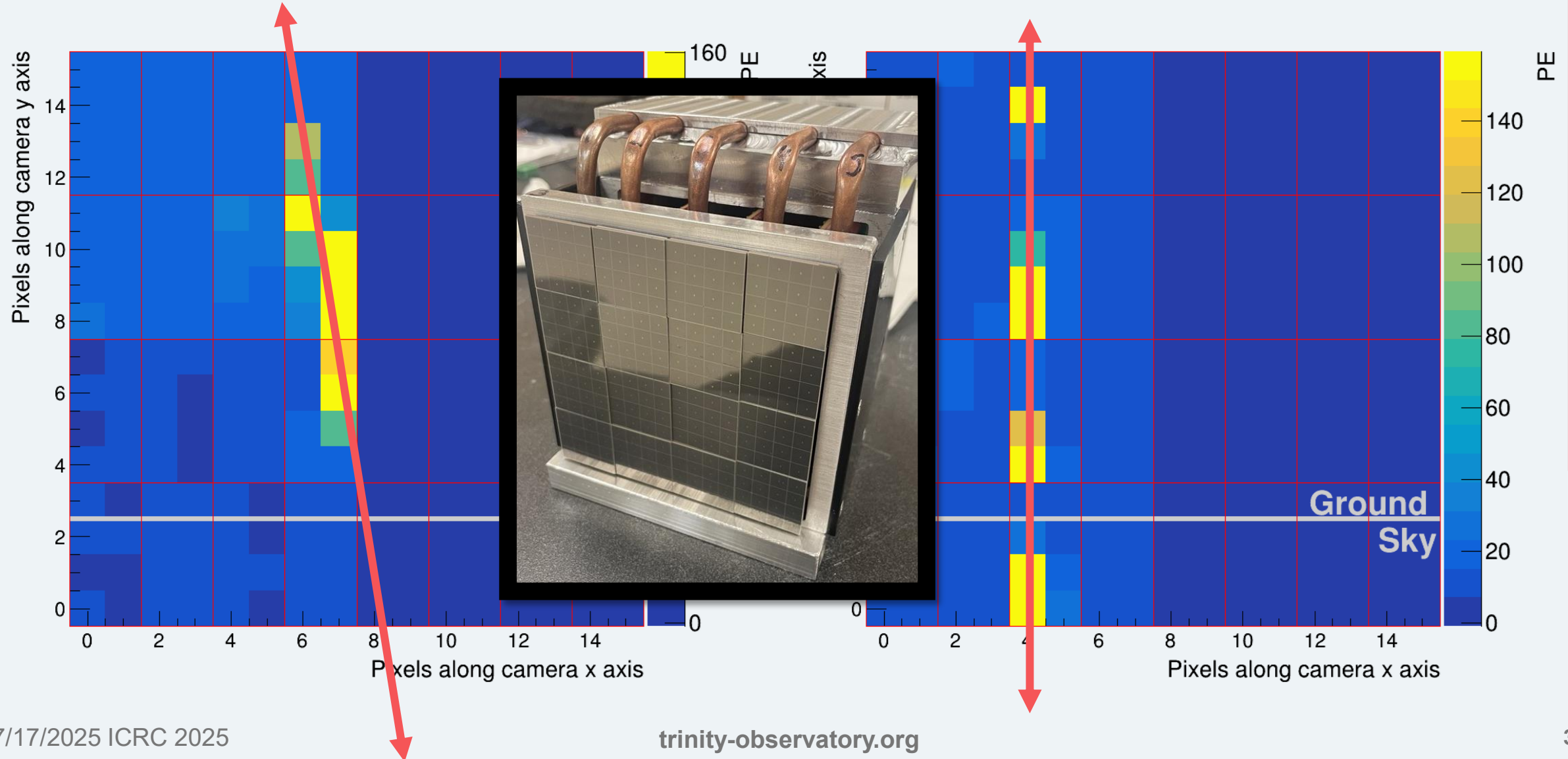
SofiaStepanoff@gatech.edu

Background: Sample Events



SofiaStepanoff@gatech.edu

Background: Sample Events



SofiaStepanoff@gatech.edu

Background: NSB



SofiaStepanoff@gatech.edu

Background: Sub-Showers

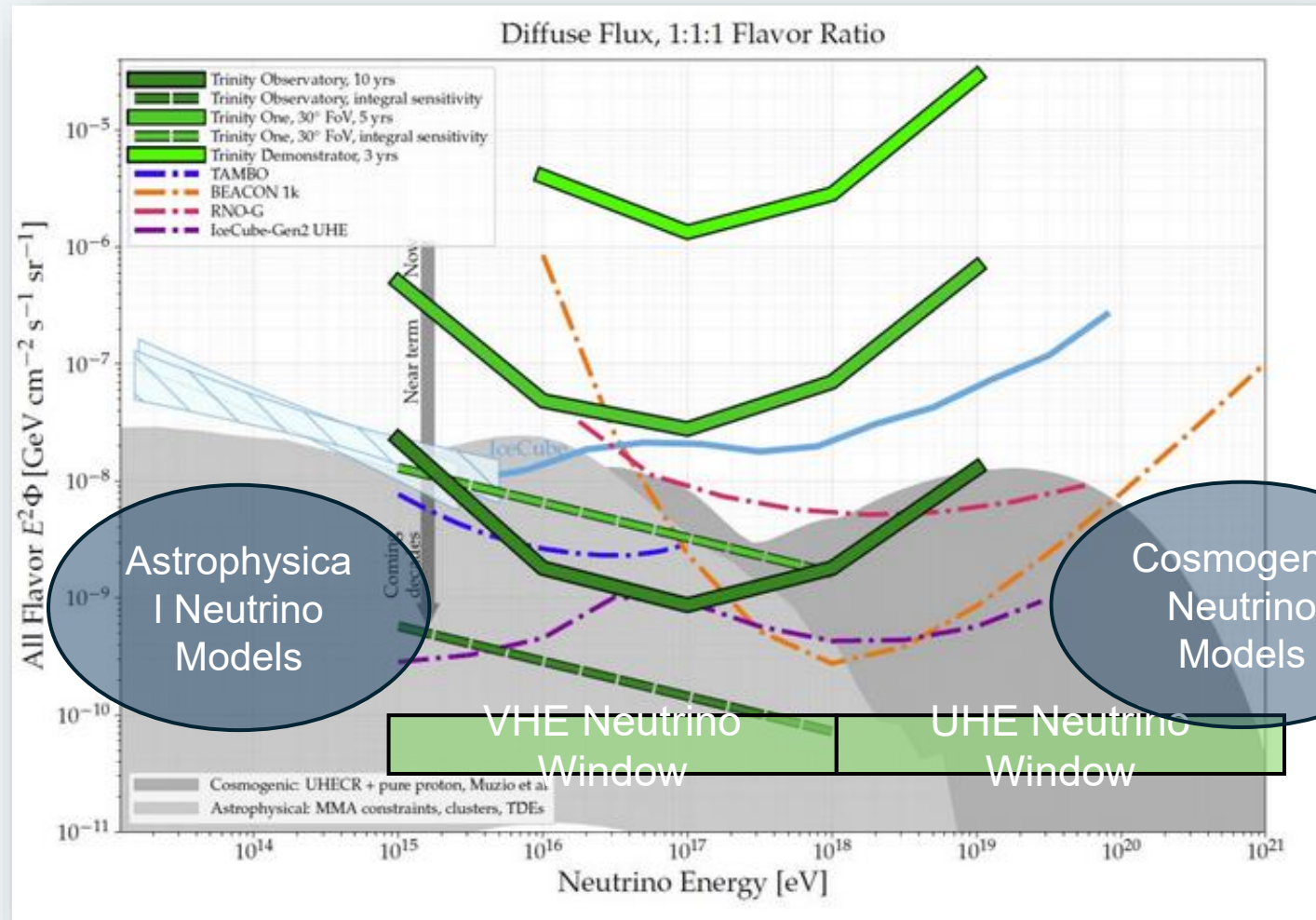


SofiaStepanoff@gatech.edu

The VHE/UHE Neutrino Window



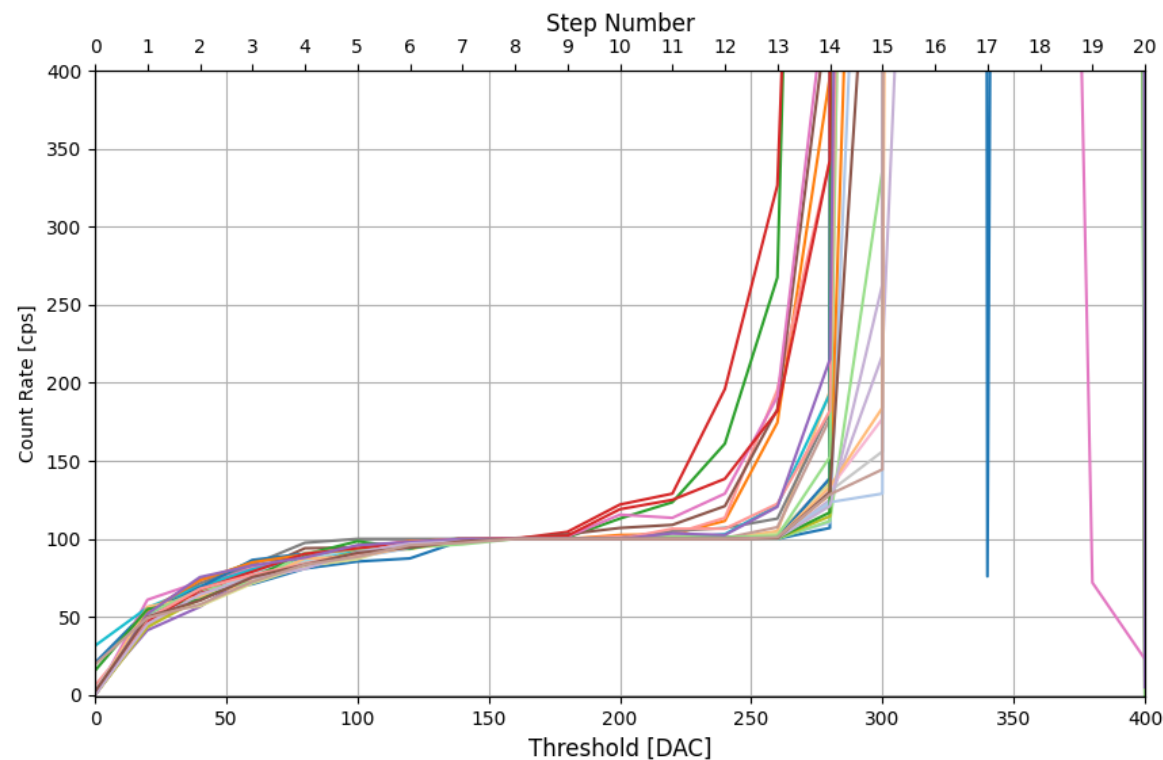
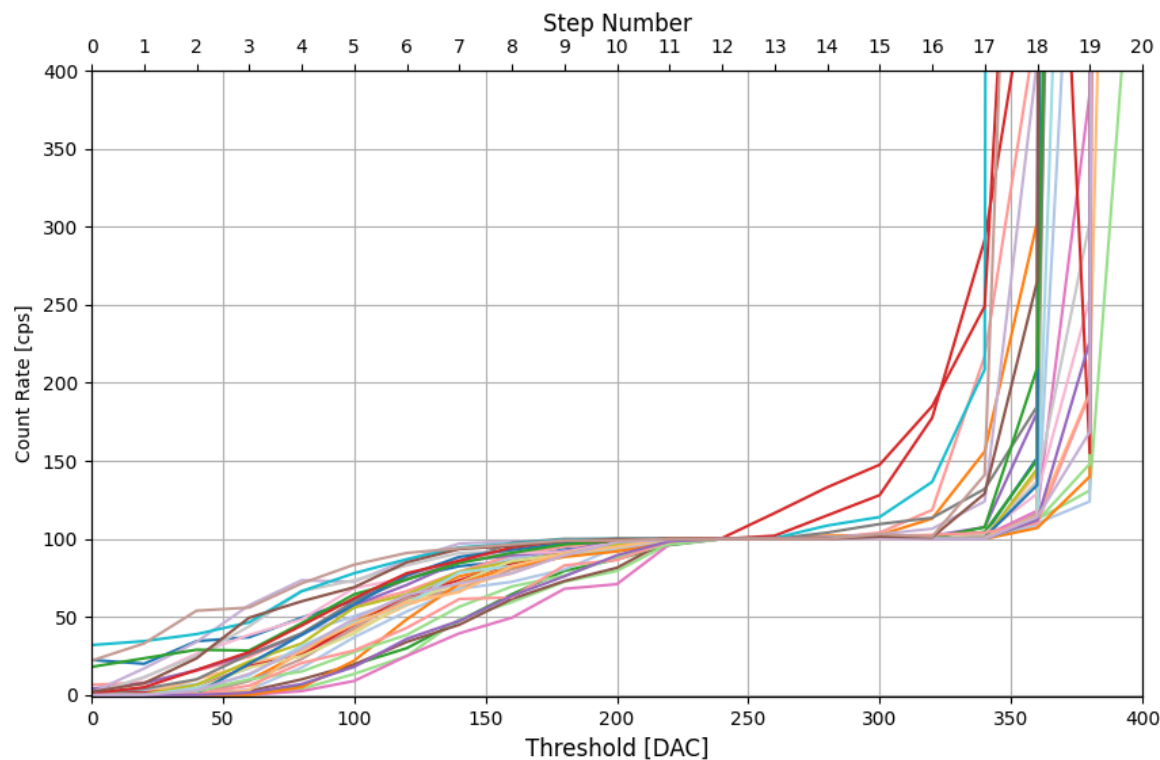
SofiaStepanoff@gatech.edu



Trigger flat-fielding



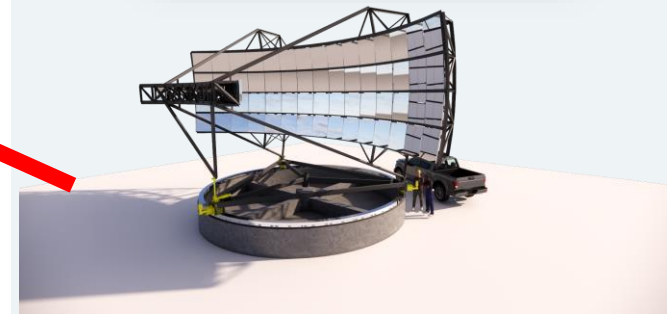
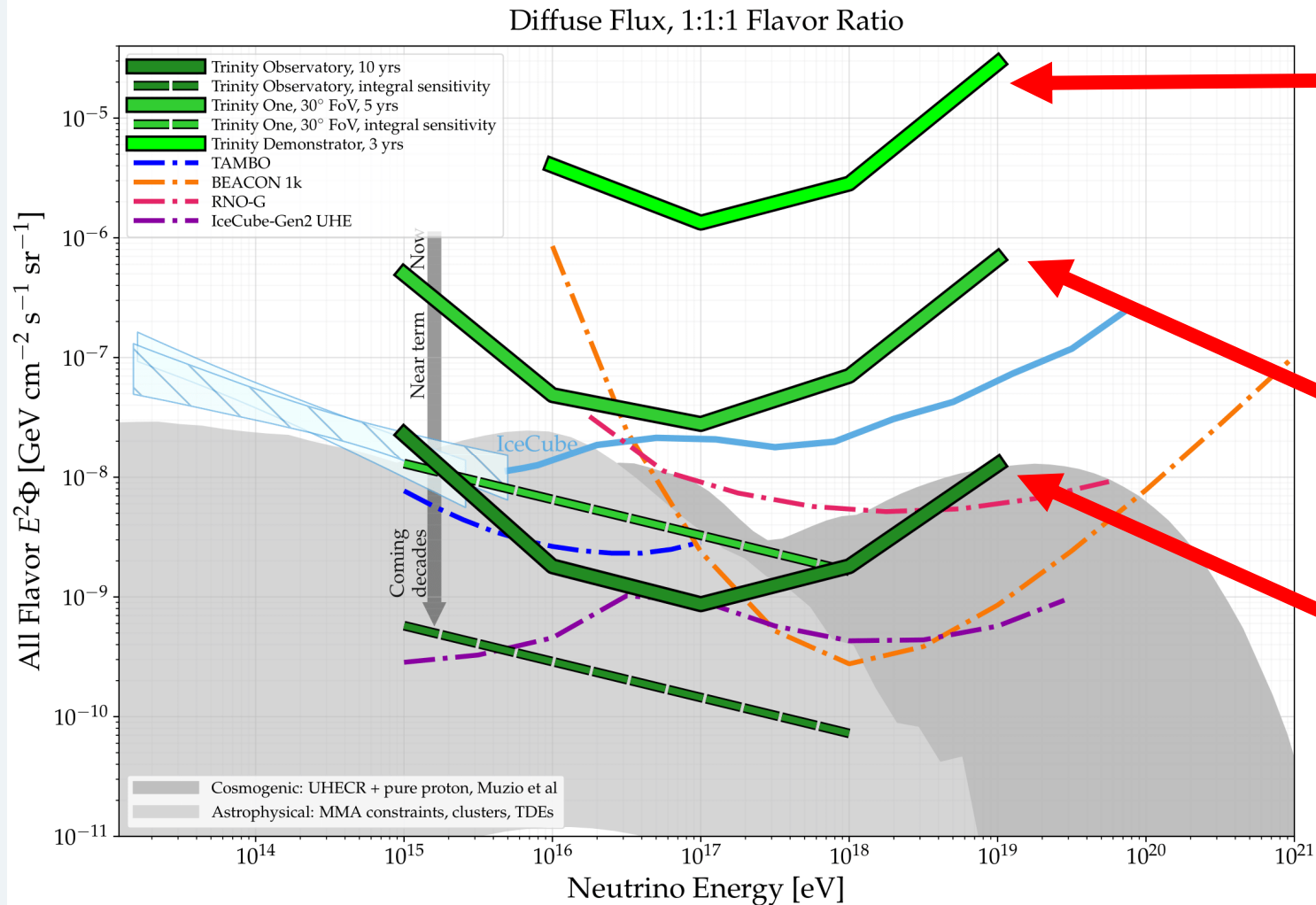
- Normal observing conditions:
 - Trigger threshold: 20 PE
 - Trigger rate: < 0.5 Hz



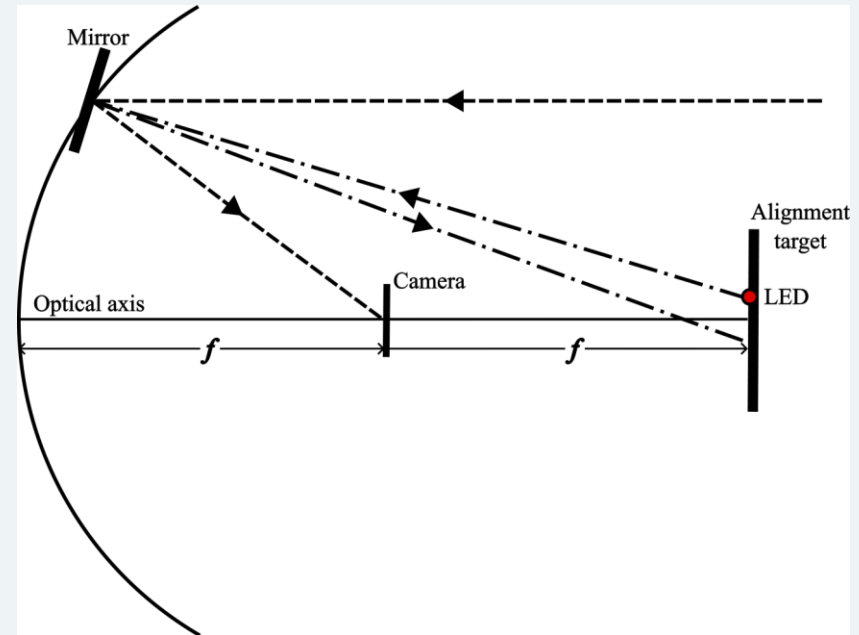
The VHE/UHE Neutrino Window



SofiaStepanoff@gatech.edu



Trinity
Observatory

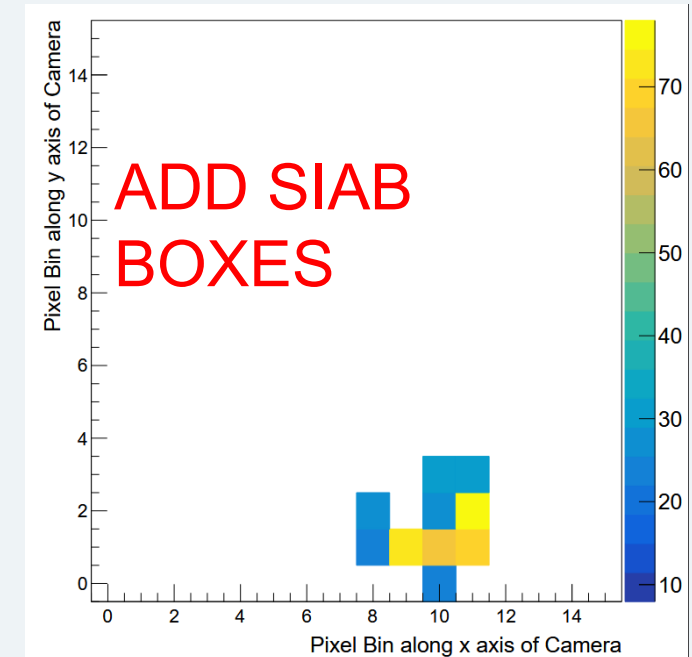
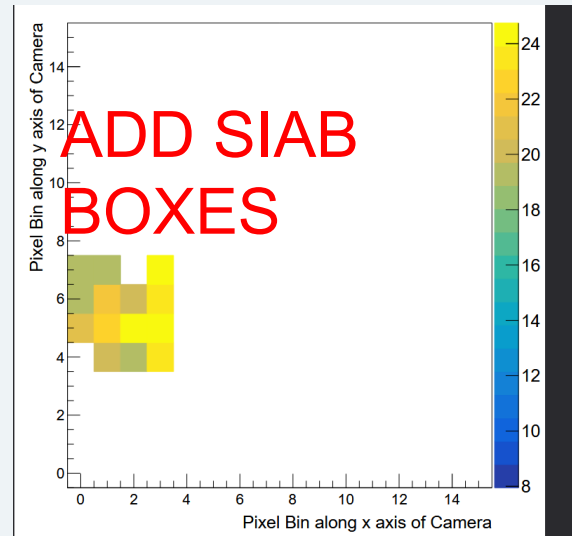
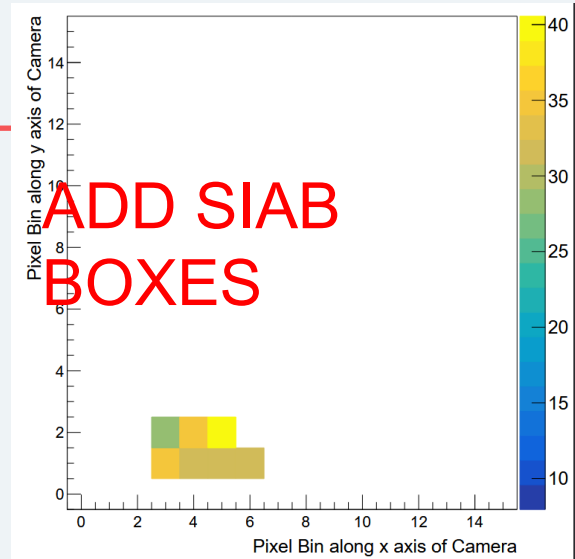
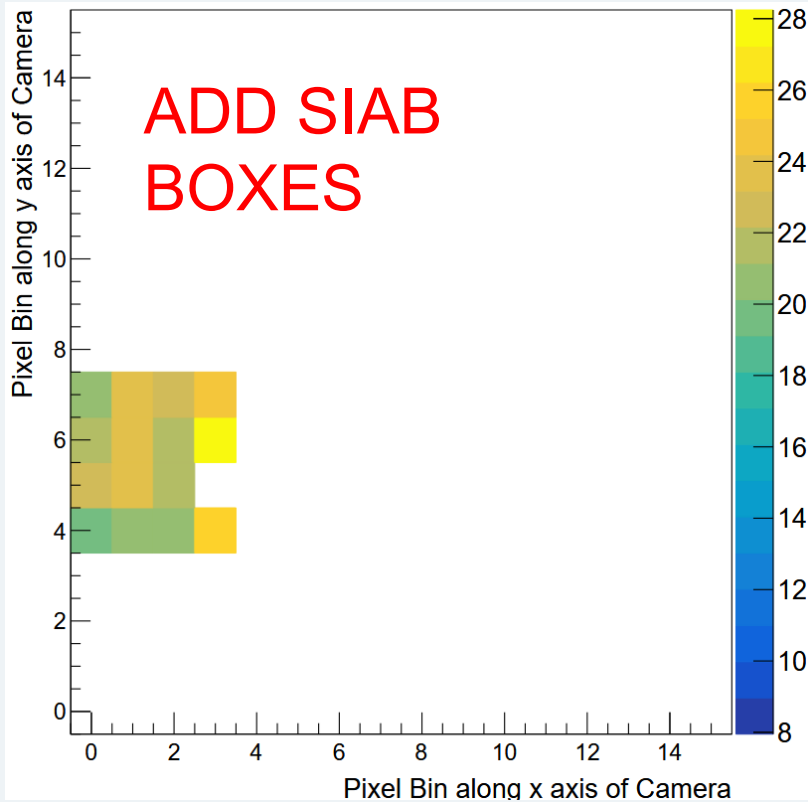


Event Gallery



SofiaStefanoff@gatech.edu

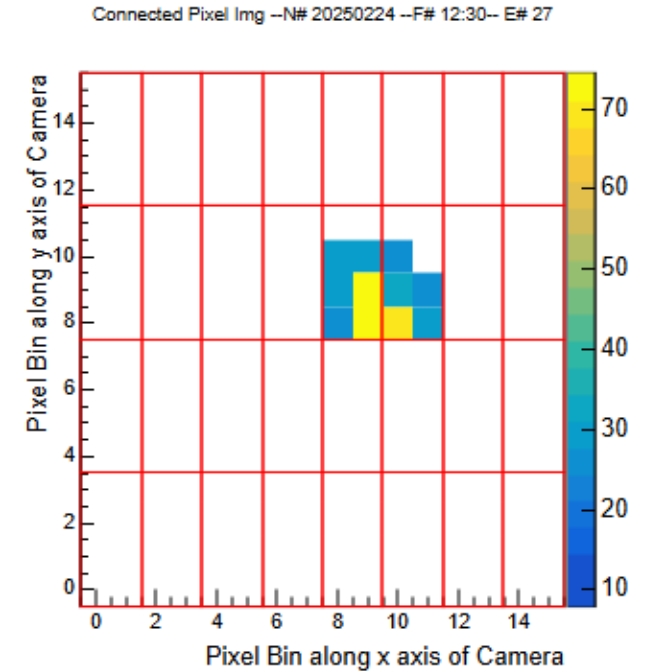
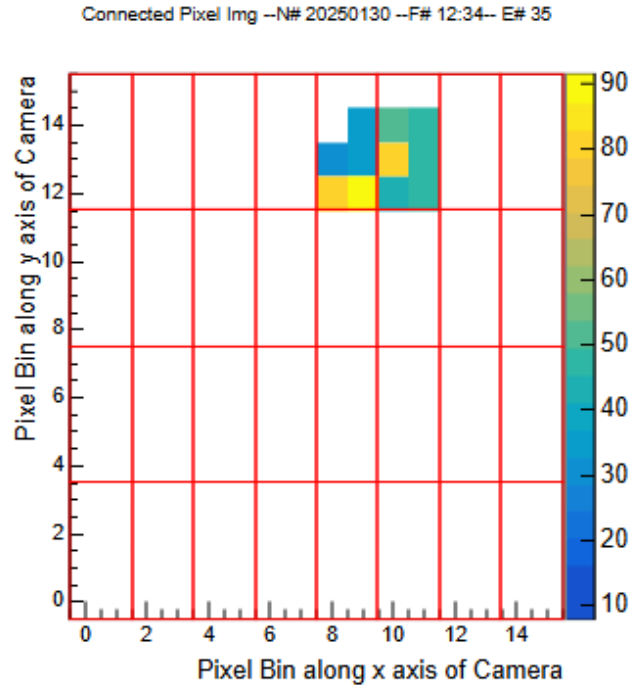
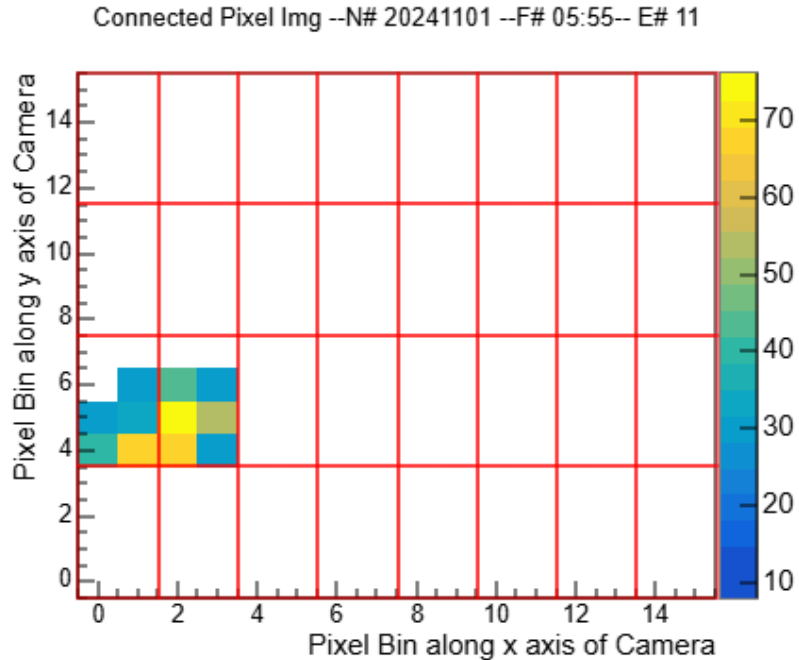
Blob Events



Event Gallery



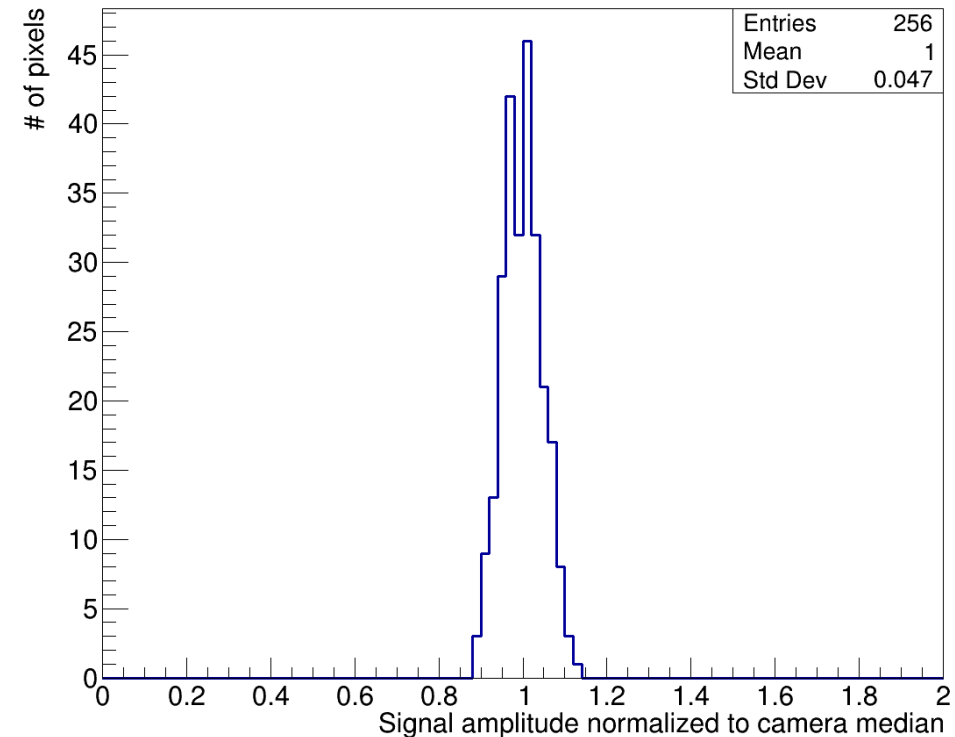
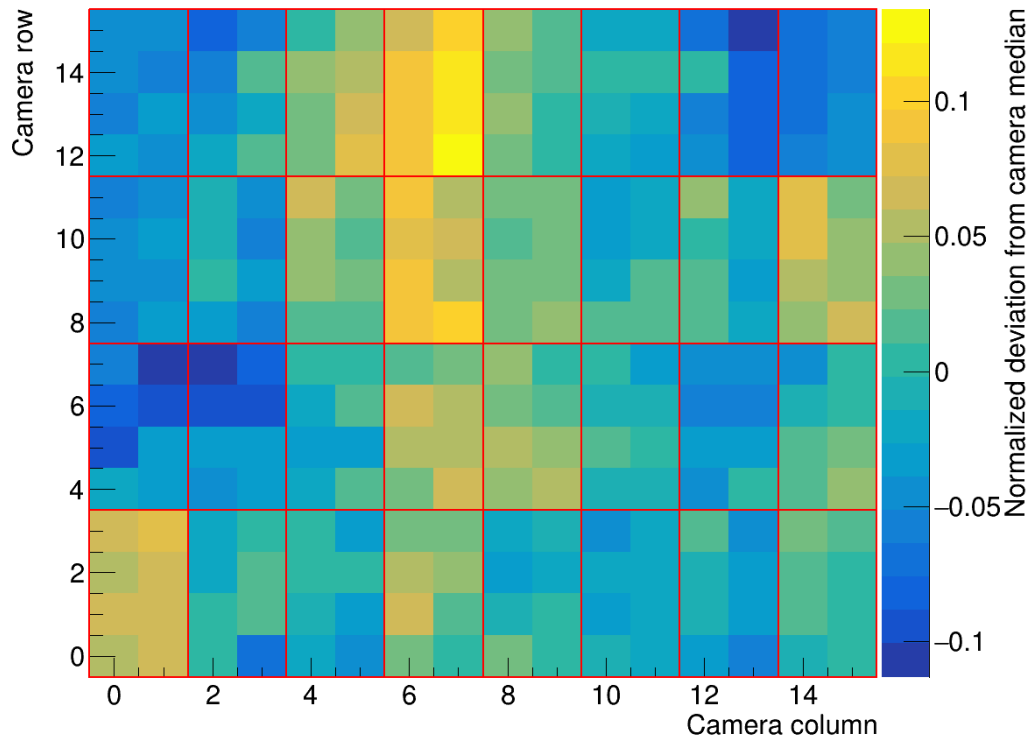
Bright Cluster with Crosstalk



Camera flat-fielding



- HV gain flat-fielded within 5% std



Event Selection



SofiaStepanoff@gatech.edu

Size cut at 5 Image Pixels

Number after event selections
128 events
2.9 Hours/Event

