PANORAMIC SETI

Panoramic SETI Telescope Deployments at Palomar Observatory

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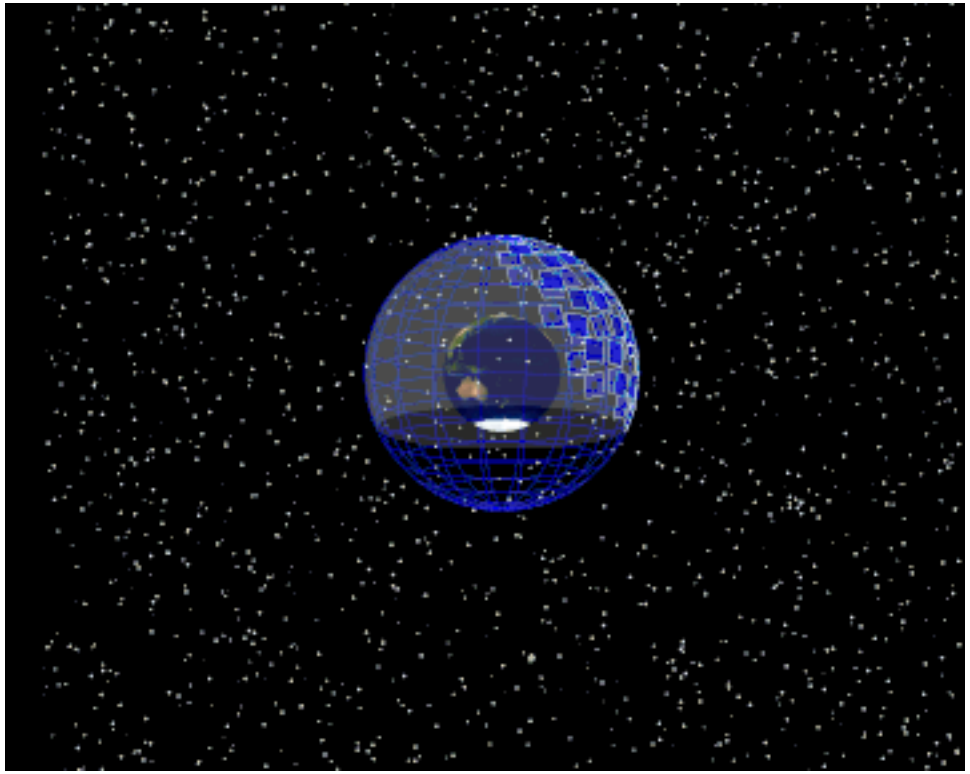
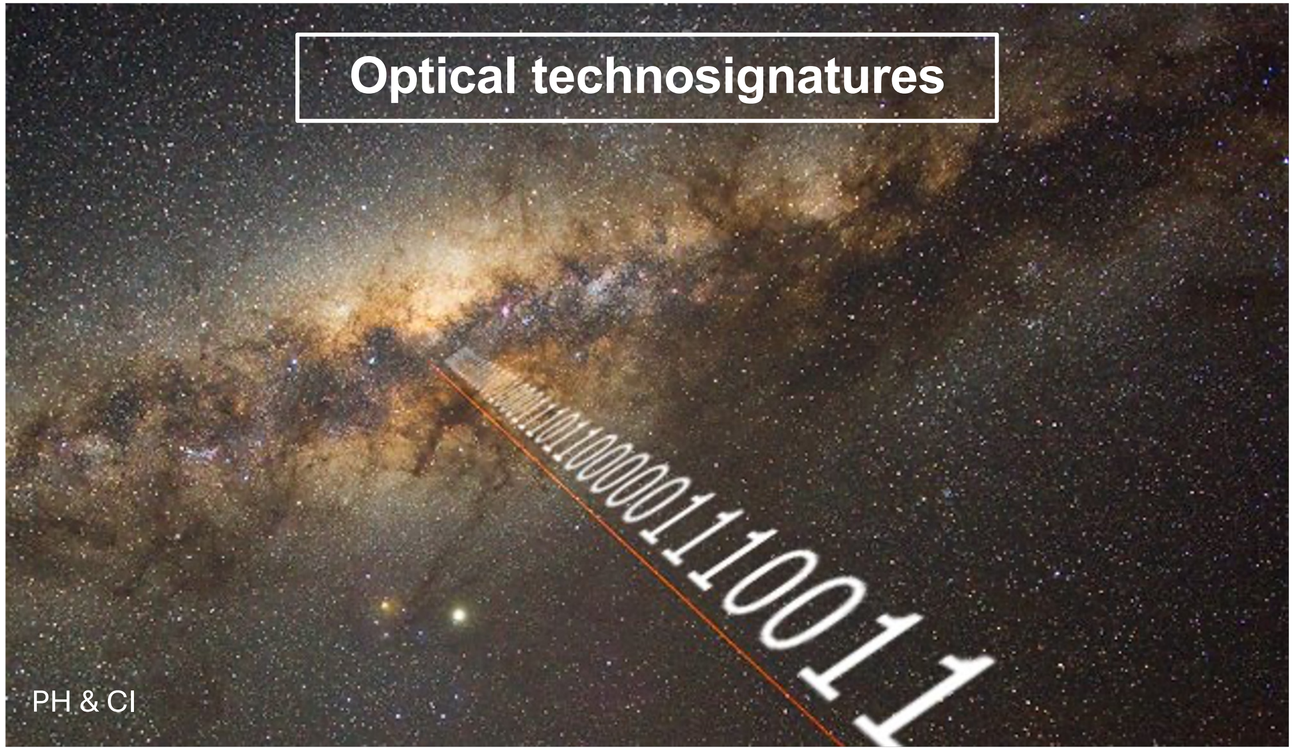
Introduction to
Panoramic SETI (PANOSETI)

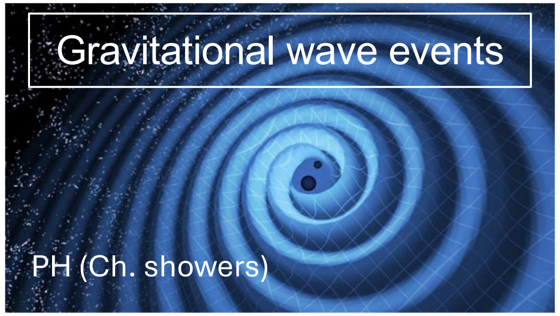
- 🔭 All-sky, all time optical SETI observatory
- 🔭 Maximizing instantaneous sky coverage (>2,000 sq. degrees)
- 🔭 Maximizing duty cycle on sky
- 🔭 Unambiguous detection
- 🔭 Time scales (nanosecond to seconds)

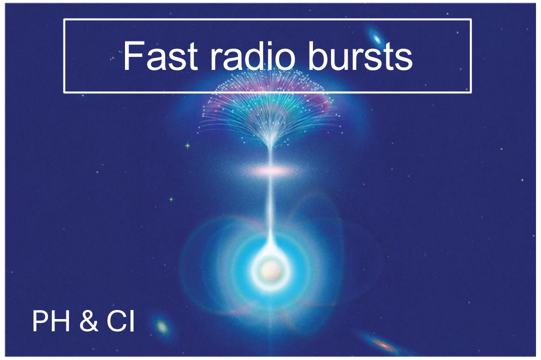


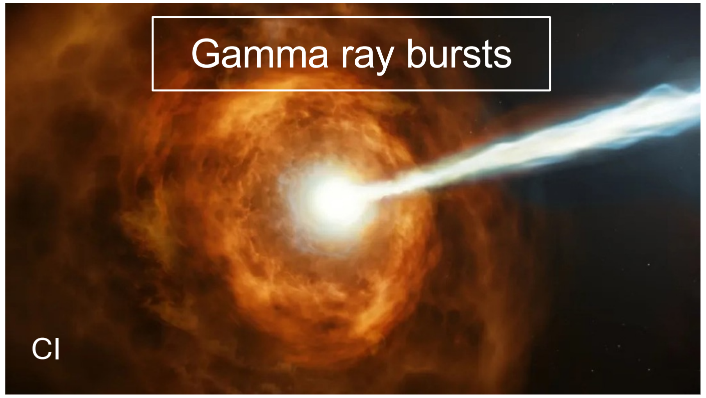
Wright et al. 2018; Maire et al. 2018; Cosens et al. 2018; Li et al. 2019; Wright et al. 2019; Maire et al. 2020; Liu et al. 2020; Brown et al. 2020; Maire et al. 2022; Korzoun et al. 2023

PANOSETI Science Goals









Additional Science:

- Detection of HE particles from Cherenkov showers
- Atmospheric Cherenkov detections of UHE gamma-rays
  - Dark matter annihilation signatures (100 TeV–PeV)

https://phys.org/news/2019-01-nasa-technosignatures-evidence-intelligent-civilization.html
https://www.space.com/gamma-ray-burst.html
https://news.mit.edu/2025/mit-scientists-pin-down-origins-fast-radio-burst-0101
https://www.ligo.caltech.edu/page/what-are-gw

PANO SETI

Telescope

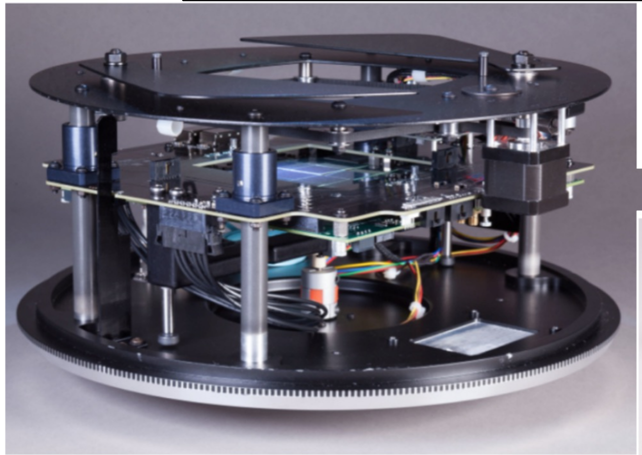
Module

- 0.5 m f/1 Fresnel lens with 32×32 pixel SiPM array
- Wide 10° × 10° FoV
- 20 arcmin/pixel (.31°)

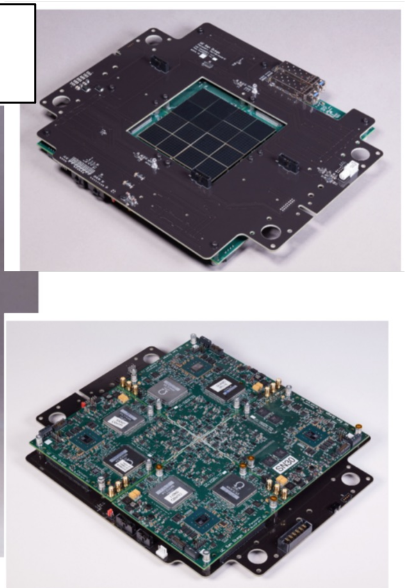
Electronics

- 4x4 Silicon Photomultiplier (SiPMs) arrays (quabos) with 8x8 pixels each (1024 total)
- Readout and digitation via Maroc3A chips
- GNSS & White Rabbit Protocol for timing resolution
- Dual Modes: Pulse Height (ns) & Imaging (μs–s)

PANOSETI telescope module

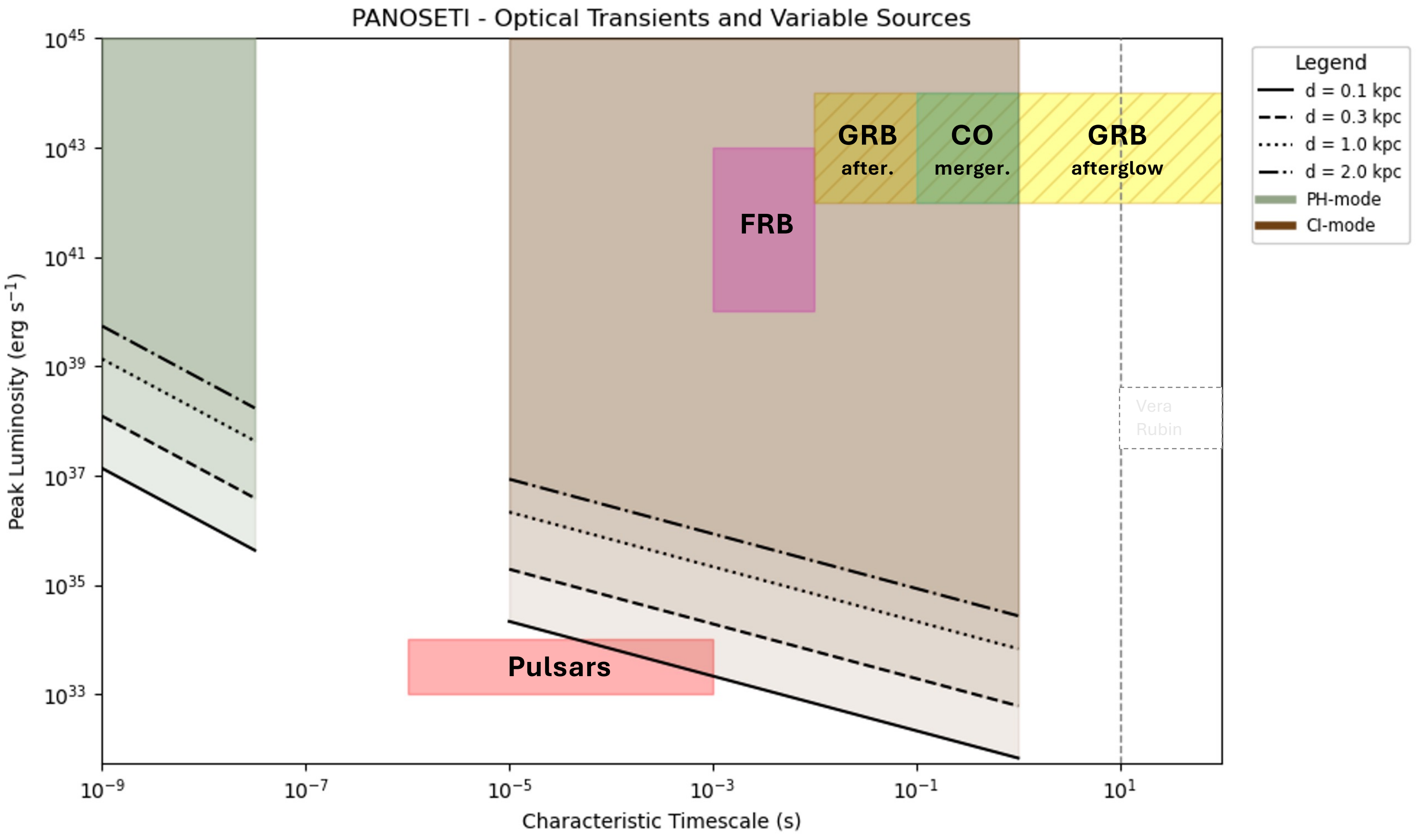


Backend electronics



Fornax enclosure w/PANOSETI module

Optical Transients and Variable Sources



SETI technosignatures → nanosecond laser pulses or other artificial transient signal

Pulsars → μs–ms optical signals from rotating neutron stars (e.g., Crab)

Fast Radio Bursts (FRB) → ms bursts — origin uncertain, no optical counterpart confirmed

GRB Afterglows → bright optical flashes within seconds of gamma-ray bursts

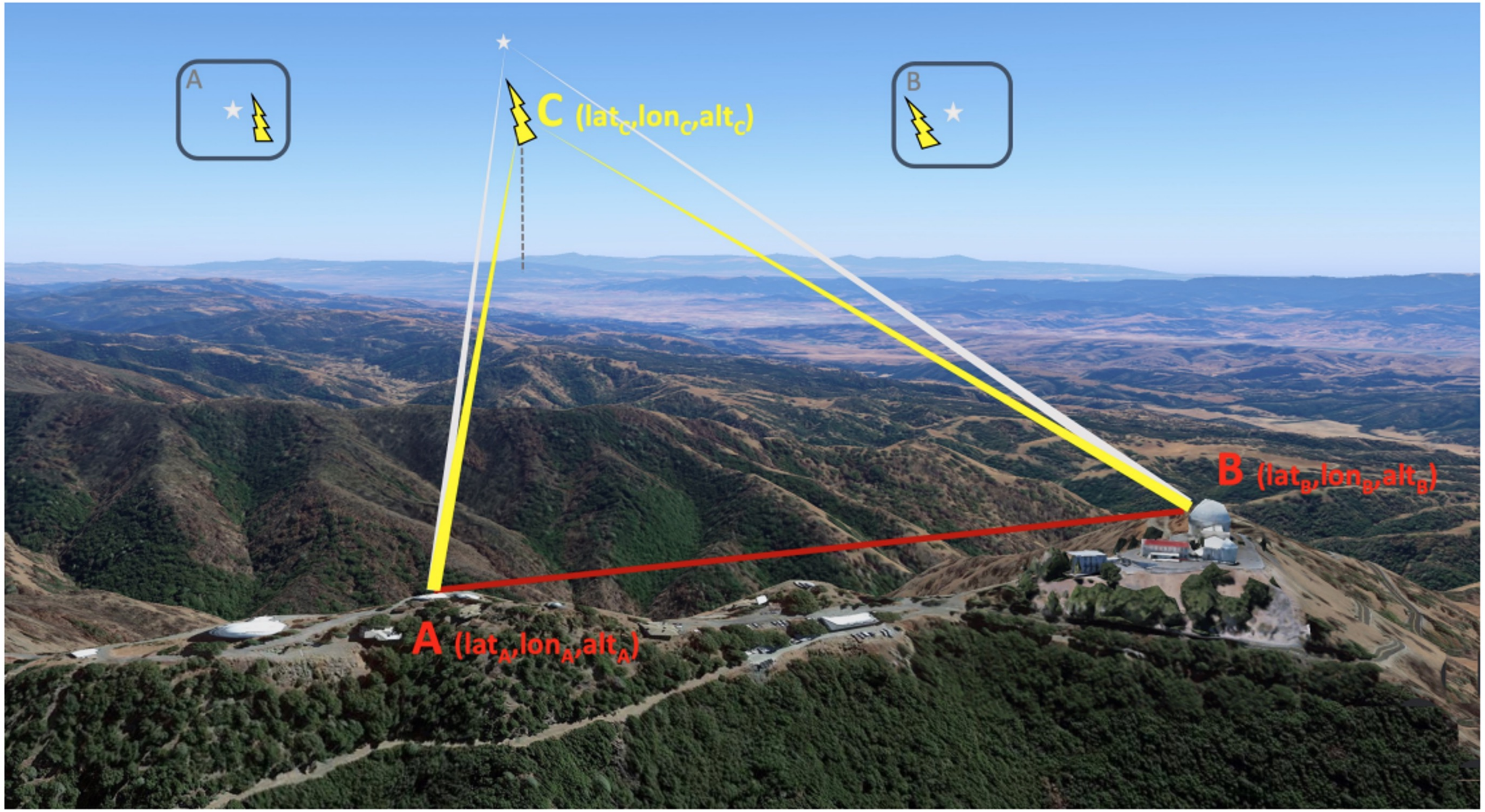
EX: GRB 080319B @ ~5.3 mag

Compact Object Mergers → 0.1–1 s flashes from neutron star/supernova shock breakout

Cherenkov Detections

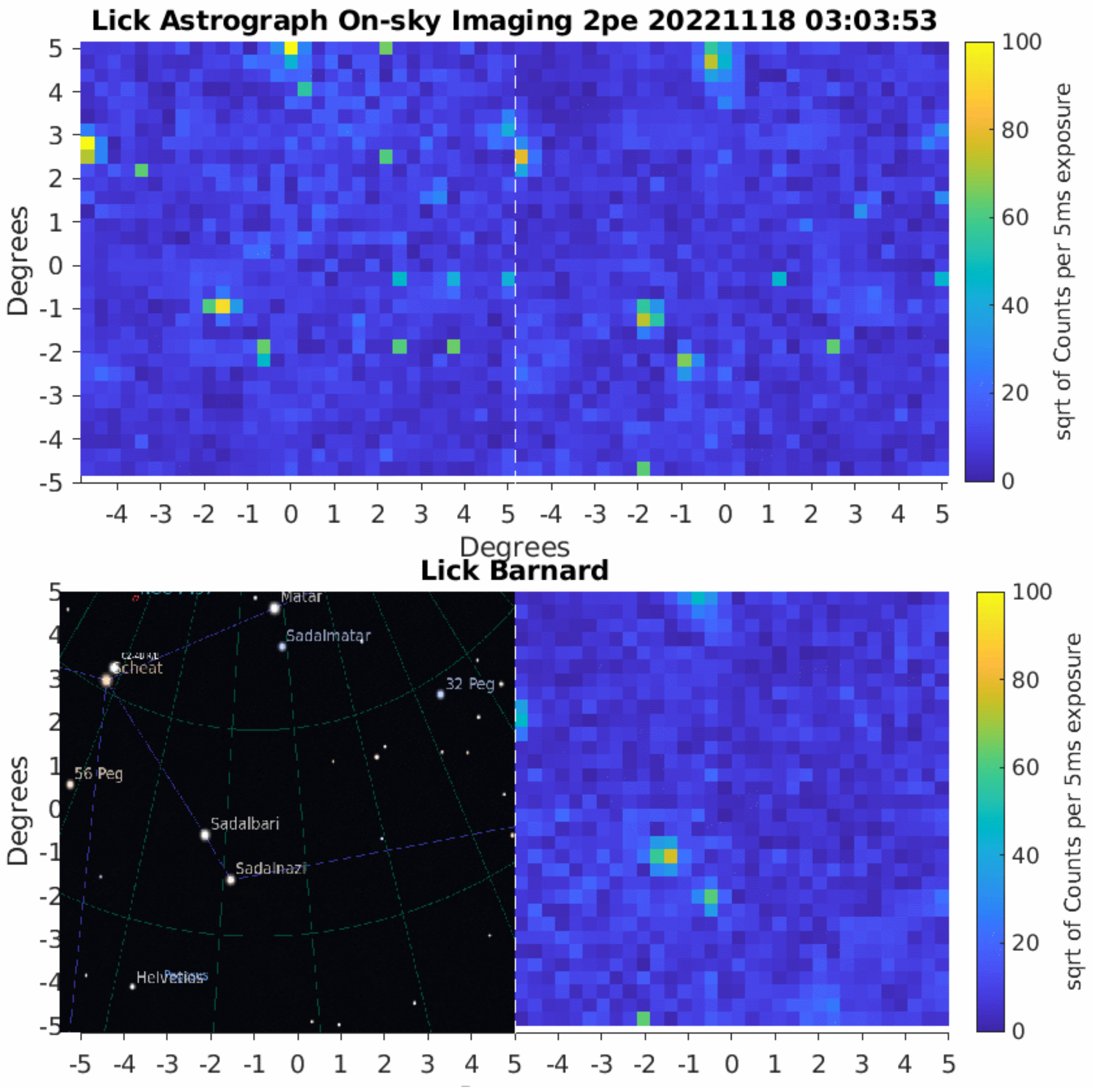
At least **two sites** are critical for unambiguous detection

- Two separate observatories separated by ~1km and looking at the same area of the sky.
- Capable of distinguishing Cherenkov showers and noise sources by parallax and timing.



"Panoramic SETI: on-sky results from prototype telescopes and instrumental design"
https://arxiv.org/abs/2111.11080

PANOSETI verified at Lick Observatory



Key Results:

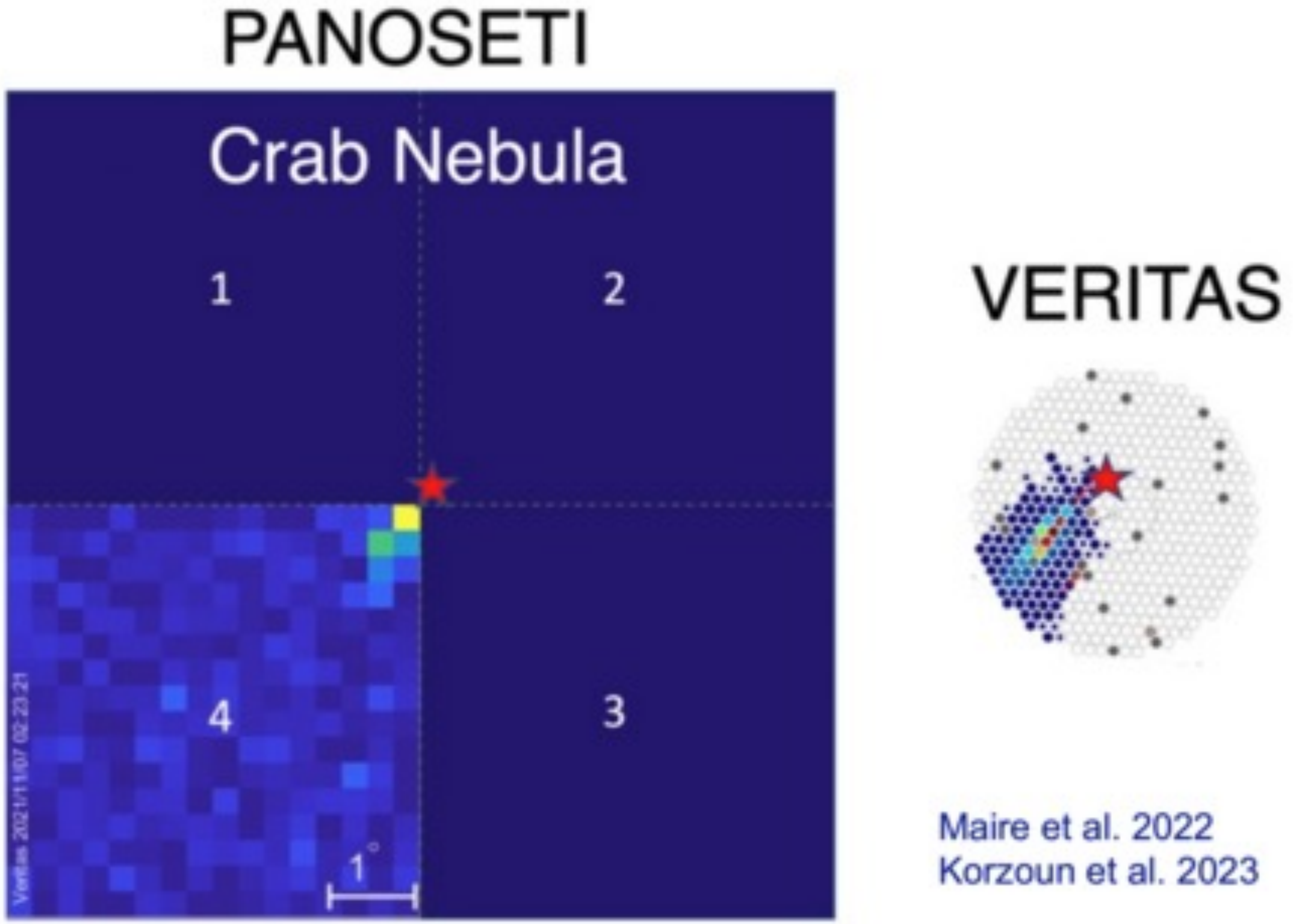
- **Detected Cherenkov events**
- *Timing verified for PANOSETI*
- Observed w/ 1 km baseline → verified parallax and timing

Prototype Sites:

- Previously deployed at Lick: Astrograph (2020), Barnard (2023), Crocker (2024)

PANOSETI detects γ-rays from Crab Nebula with coordinated observations with VERITAS

- PANOSETI ran a blind analysis to distinguish what are potential gamma-ray sources.
- PANOSETI source identification matched in time to gamma-ray detections by VERITAS.
- Reconstructed energy of the primary gamma rays obtained from data analysis was 14.8, 36.1 and 50.6 TeV.

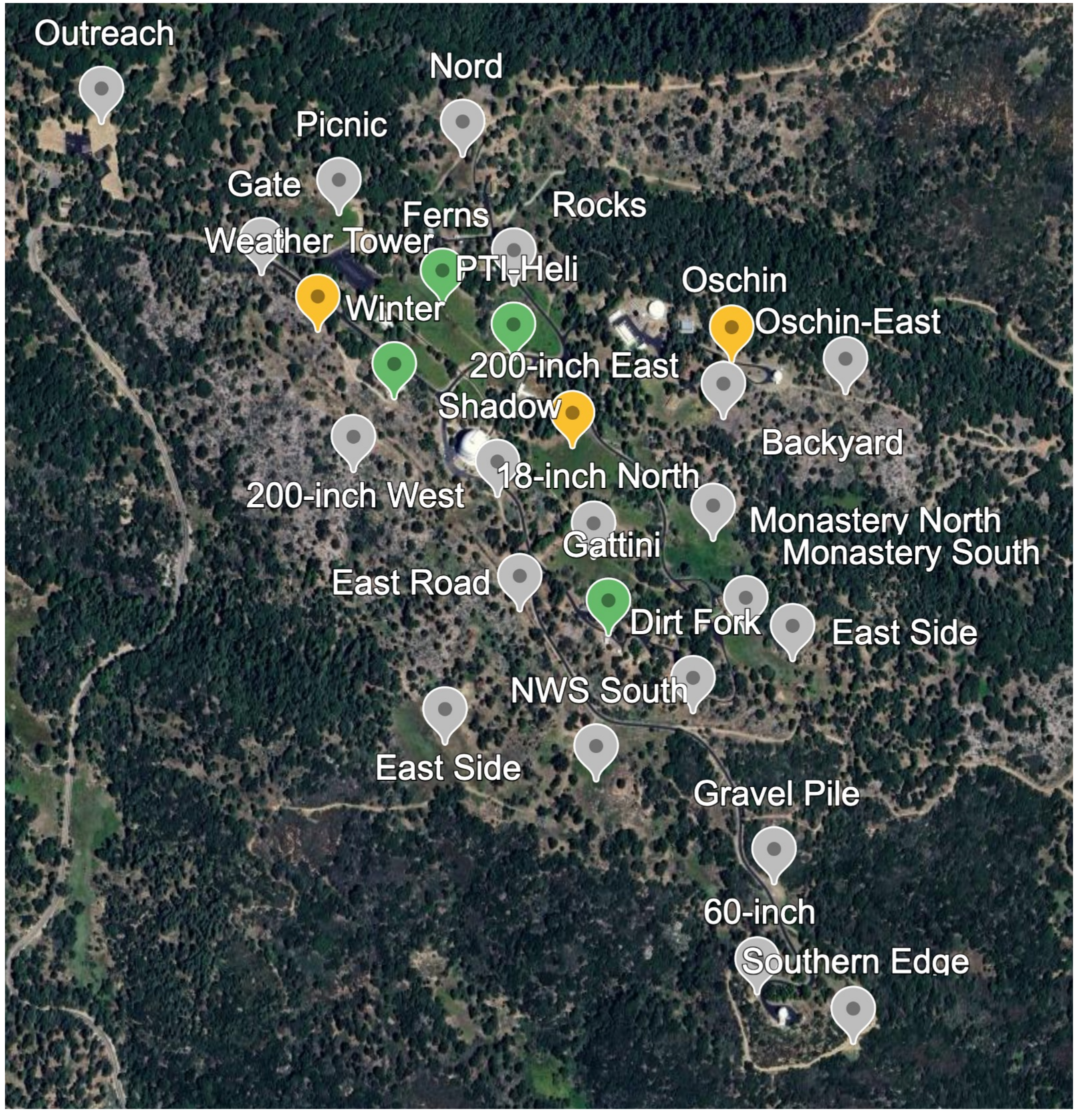


Maire et al. 2022
Korzoun et al. 2023

Developing PANOSETI with multiple sites at Palomar Observatory

PANO SETI

- ❑ **Green – Upcoming sites**
  - Actively developing 4 sites in 2025
- ❑ **Yellow – Developing sites**
  - 2-3 additional sites in 2026; up to 30
  - Modeling of baselines and costing occurring now
- ❑ **Grey – Potential other sites**
  - Investigating additional sites
  - Consideration is baseline and ease for power and fiber

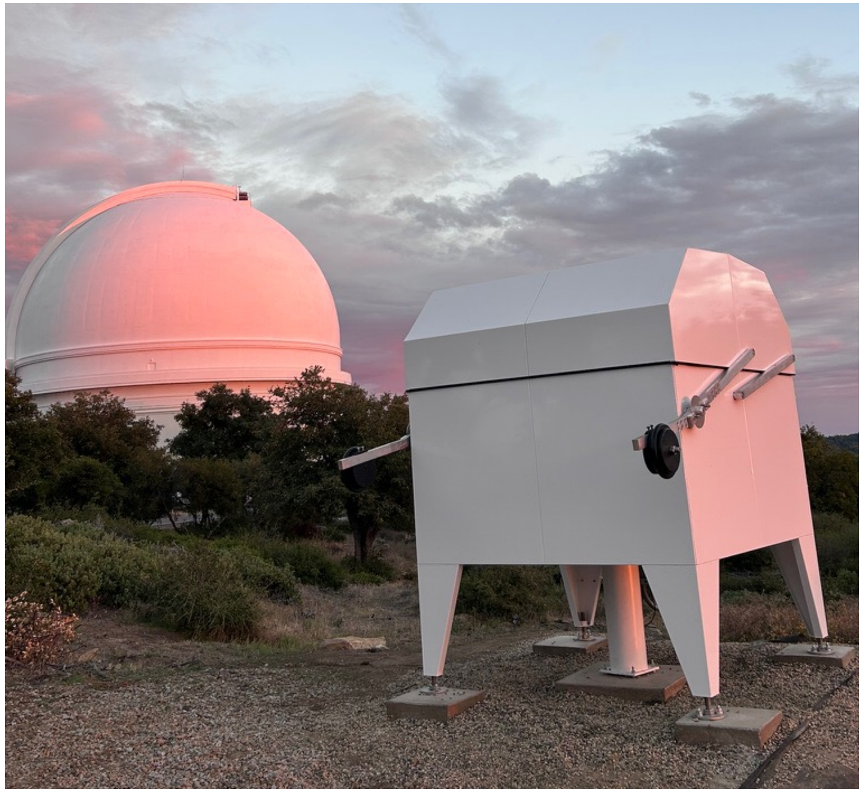


European Research Council
Established by the European Commission

Deployment and operation of the first 6 telescopes are funded by the Dark100 project, financed by the ERC to 2029.

PANOSETI deployments at Palomar Observatory → **Three sites commissioned (Fall 2025)**

FERN



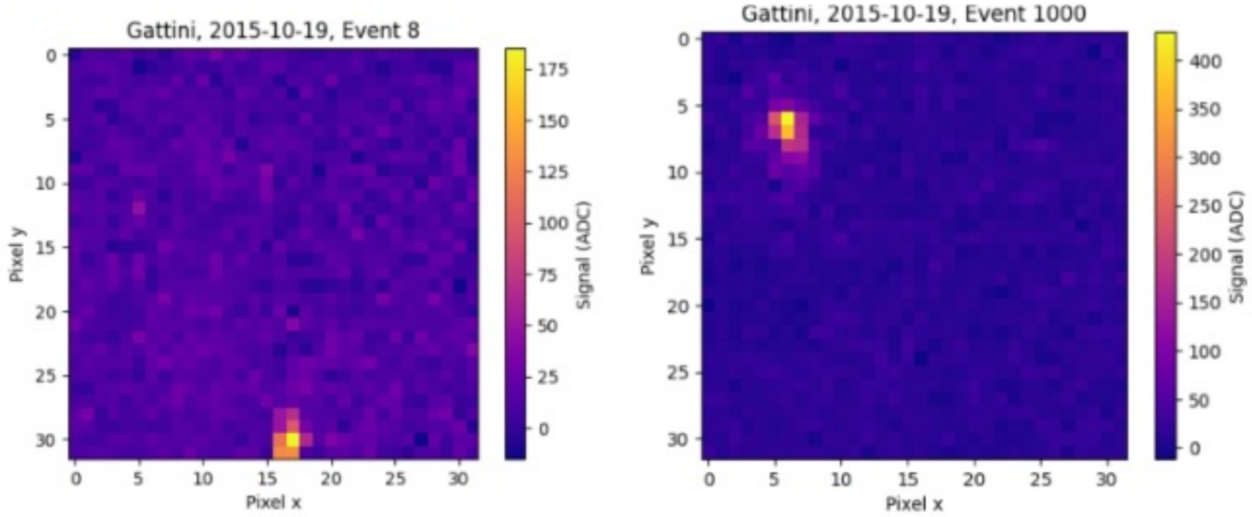
WINTER

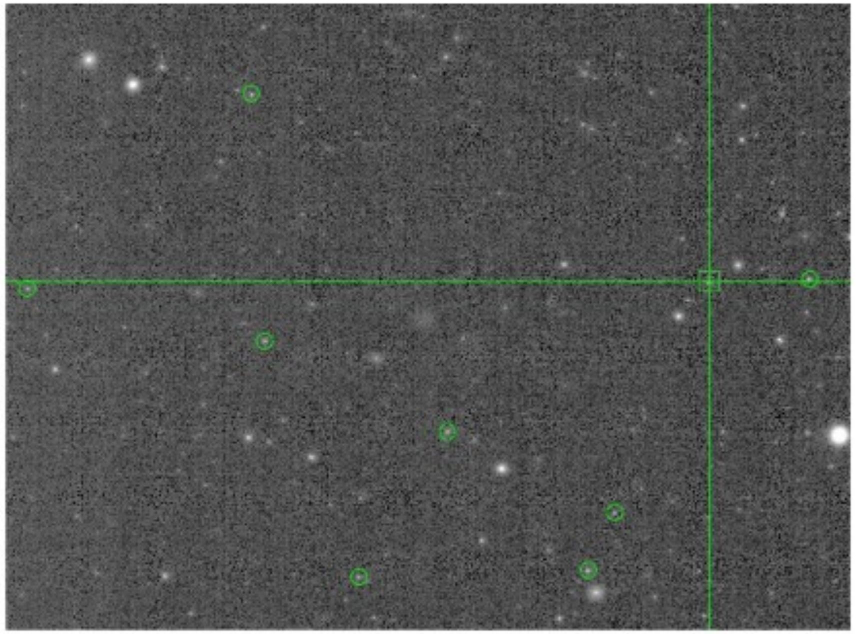
PTI

Palomar Commissioning: **Initial Data**

PANO SETI

- **Crab Nebula successfully observed** using a **single PANOSETI telescope.**
- **First Cherenkov events detected** — confirming system sensitivity.
- **Guider corrections implemented** to compensate for mount tracking uncertainties.
- **Stable timing performance:** constant offset, **no measurable drift.**





Conclusion & Future

PANOSETI is in deployment phase and offers:

New phase space for technosignatures science

- Currently optimizing our figure of merit of technosignatures survey
  - Sensitivity with "false alarm rate"
  - Field of view with N telescopes and duty cycle per field, e.g, optimizing for galactic plane

Real-time, high-cadence transient and ultra-high energy discovery

- Yielding a scalable, cost-effective Cherenkov gamma-ray observatory
- Opening up a new phase space in time-domain astrophysics (ns–ms)

PANOSETI f2f, August 2025

References

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- Sheikh, S. Z. (2021) Observational and Theoretical Studies of Radio Technosignatures and Pulsars. Dissertation. Pennsylvania State University.
- PANOSETI: Wright et al. 2018; Maire et al. 2018; Cosens et al. 2018; Li et al. 2019; Wright et al. 2019; Maire et al. 2020; Liu et al. 2020; Brown et al. 2020; Maire et al. 2022; Korzoun et al. 2023

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