AIRIS: HIGH-PRECISION OPTICAL FOLLOW-UP TELESCOPE FOR GAMMA-RAY BURST OBSERVATION WITH ADAPT

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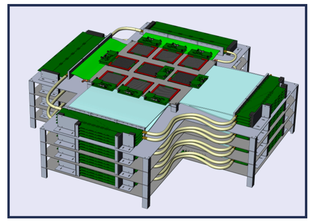
AIRIS delivers ≤30 s **optical follow-up** of **ADAPT** detected **GRBs,** improving localizations from **degrees to sub-arcseconds** and capturing **early afterglow evolution.**

ADAPT: Full Sky Detection of GRBs

ADAPT (Antarctic Demonstrator for the Advanced Particle-astrophysics Telescope) is a NASA ballooning mission led by PI James Buckley, of WashU in St. Louis. Demonstrates a **Compton scattering detector** for future space-based **gamma-ray/cosmic-ray observer**.

- Aims to deliver degree-scale localizations and polarization constraints on fairly short timescales (sub-second to seconds).
- **Not designed for fine localization or on-board optical imaging/follow-up. Optical afterglow detection and evolution is outside its scope.**
- ~1 MeV/cm² fluence with ~7.5° accuracy (68% containment) and ~15° accuracy (95% containment)



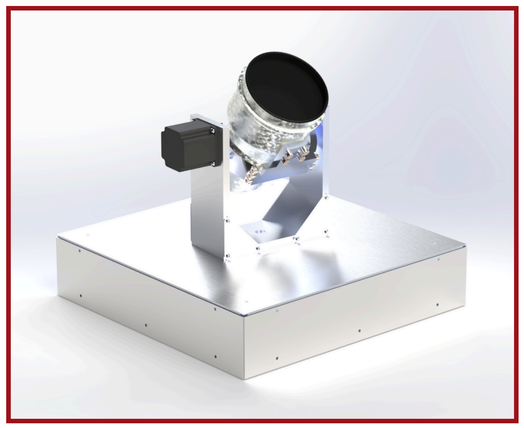
The ADAPT Detector Stack

AIRIS: Telescope for GRB Optical Afterglows

AIRIS (ADAPT Incidence Resolution & Imaging Subsystem) is a fast-slewing optical telescope mounted on the same platform as ADAPT.

- **Goal:** Capture burst optical data within 30 seconds of an ADAPT trigger. AIRIS is designed to reach any point in the sky within ~10 seconds of slewing.
- **Response & localization:** On ADAPT triggers, AIRIS begins an imaging pipeline with stacked exposures to actively search the error region for an optical afterglow.
- **Data products:** Burst localization + time-evolution tracking (early light curves, positions) suitable for rapid follow-up.
- **Community alerts:** Results are pushed to NASA's General Coordinates Network (GCN) to coordinate global, multi-messenger observations.

Lens	**Canon 200mm f/1.8**
Bandpass Filter	**645–675 nm** Suppresses bright blue/green sky; avoids defocus in NIR
Sensor	**Sony IMX455 mono** High QE, single-electron read noise (for stacking)



AIRIS CAD Model

Current Work

- **Target regime**: Early optical afterglows at m ≈ 12–16.
- **Limiting-mag sims**: Physically accurate Python pipeline (PSF + Poisson shot noise + read/readout + thermal noise) with options for 3×3 binning, moving exposures, cosmic-ray hits, and Rayleigh-sky background; to be validated empirically with the flight sensor + lens.
- **Current performance (sim)**: SNR ≥ 3 for m ≲ 14 in ≥10 s effective exposure (non-stacking).
- **Onboard processing**: CMOS → carrier → NVIDIA Jetson GPU for real-time deblur & astrometric registration vs. a stored starmap; short individual exposures enable rapid tiling.
- **Map fusion & detection**: Frames accumulated in HEALPix; probability map compared at each step to the ADAPT localization PDF to flag transient candidates.
- **Follow-up & alerting**: On high-probability detection, AIRIS locks, continues photometry, and issues a GCN alert for community follow-up.

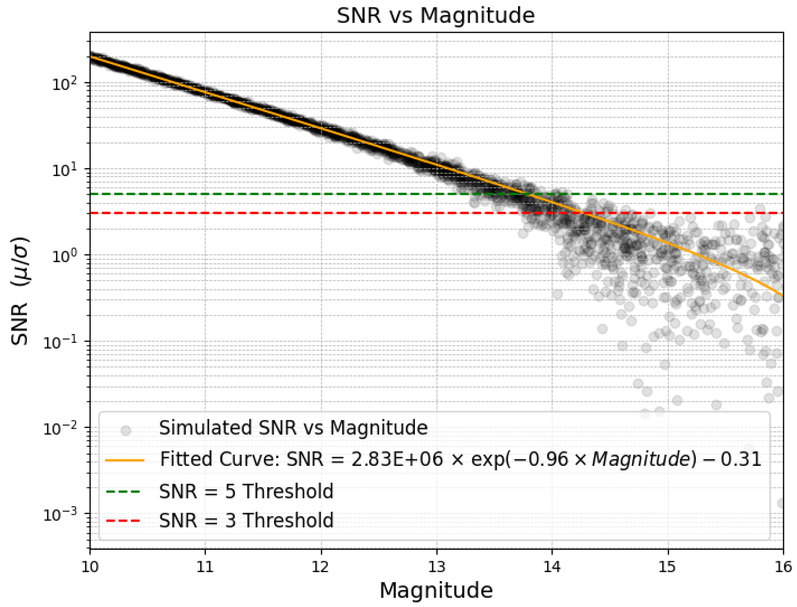


Fig. Simulated SNR vs. magnitude with best-fit curve and detection thresholds at SNR = 3 and 5.

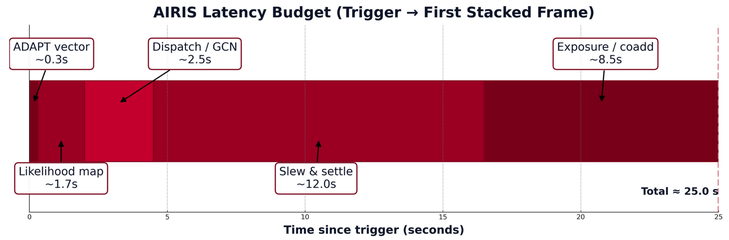
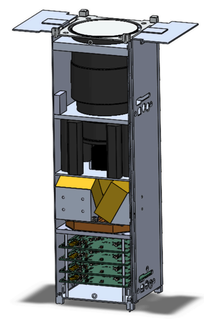


Fig. AIRIS latency budget showing ~25 s from trigger to first stacked frame.

Future Work

- **Algorithm development:** Advance tiling, detection, and ranking for multi-messenger triggers; optimize PSF-matched, variability-aware search.
- **Control system:** ≤30°/s slews, <2 s settle, ≤1″ pointing knowledge; vibration isolation so AIRIS does not disturb ADAPT/gondola.
- **Search algorithm**: Implement and validate an afterglow localization pipeline (HEALPix tiling + candidate scoring + false-positive controls).
- **Software pipeline:** On-Jetson deblur → register → detect → alert; evaluate motion-blur removal and search strategies against injections.
- **Technology demonstration**: De-risk hardware/software to pave the way for WashU's VECTOR CubeSat proposal.



VECTOR CAD Model

Collaborators

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Get in Touch

References