

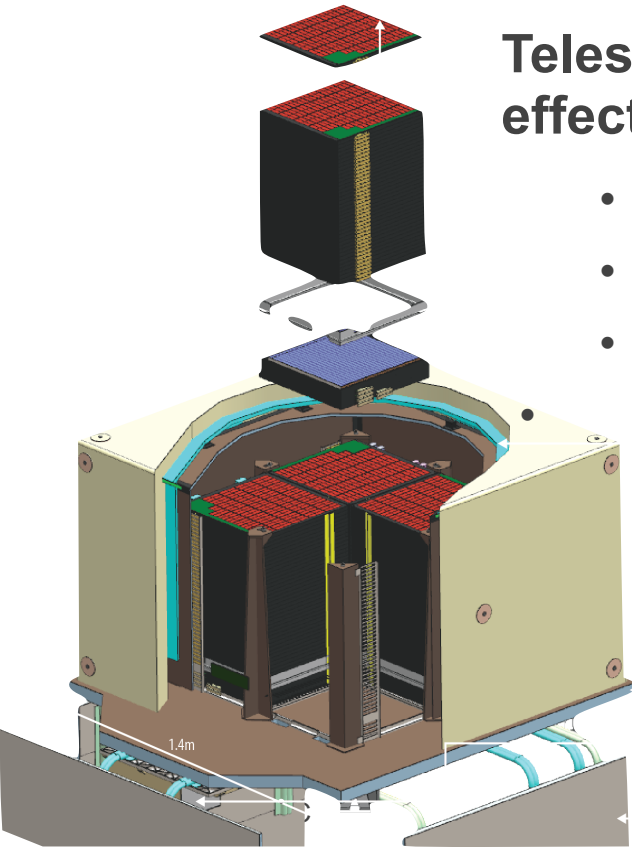


Next-Generation Wide-Field Gamma-Ray Observatories

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ASTRA Day 2: Gamma Ray
September 2, 2026



Gamma-ray observatory successor to LAT in the MeV

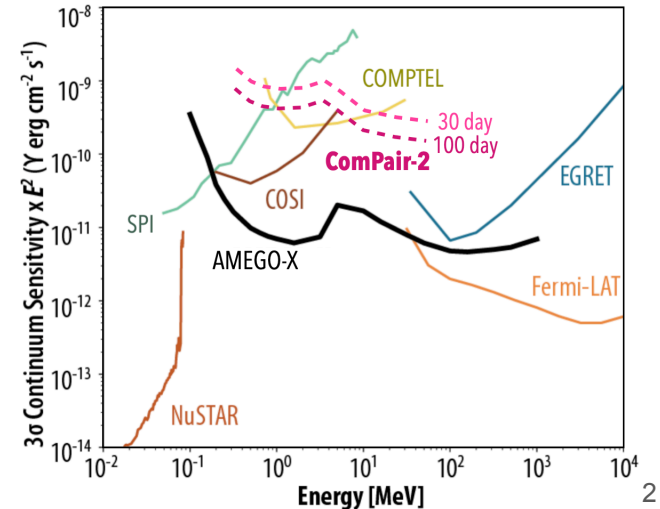


Telescope optimized for angular resolution and effective area spanning the MeV Gap

- Tracker (40 layers silicon pixel detectors - AstroPix)
- Calorimeter (6 layers CsI bars)
- Anti-Coincidence Detector

**Proposed AMEGO-X
as 2021 MIDEX**

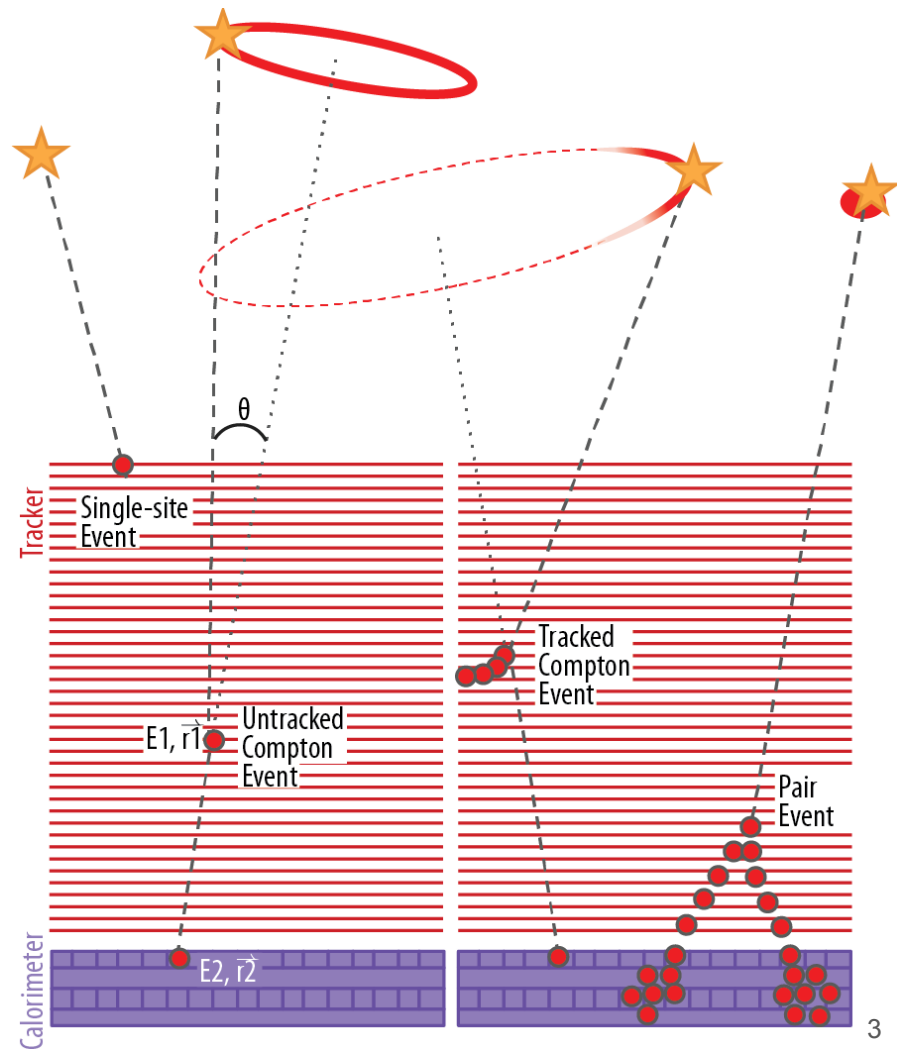
<https://doi.org/10.1117/1.JATIS.8.4.044003>



Detection Technique

The Tracker and Calorimeter together characterize gamma-rays with 3 distinct detection techniques:

- **Single-site events** increase the sensitivity and low energy response (<100 keV) for transients only
- **Untracked** and **Tracked Compton events** provide imaging <10 MeV, where the energy (E) and position (r) of interactions are used to determine the initial Compton scatter angle (θ)
- **Pair events** enable imaging >10 MeV using the same detection techniques as Fermi-LAT



Requirements

Energy Range	25 keV - 1 GeV
Energy Resolution	5% FWHM @ 1 MeV; 17% (68% containment half width) @ 100 MeV
Point Spread Function	4° FWHM @ 1 MeV; 3° (68% containment) @ 100 MeV
Localization Accuracy	Transient: 1° (90% CL radius) Persistent: 0.6° (90% CL radius)
Effective Area	1200 cm ² @ 100 keV 500 cm ² @ 1 MeV 400 cm ² @ 100 MeV
Field of View	2 π sr (<10 MeV) 2.5 sr (>10 MeV)

The Next Generation of Silicon: Monolithic Active Pixel Sensors

The future is CMOS!

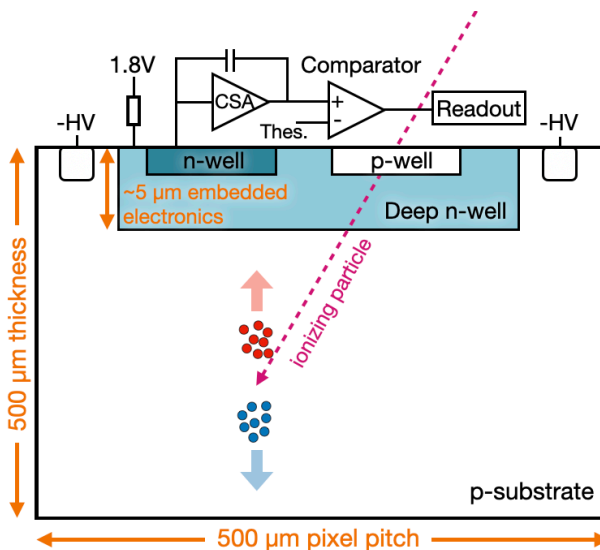
AstroPix is a **monolithic CMOS silicon detector** with joint functionalities: charge collection/amplification/readout co-integrated in substrate in pixel matrix

Benefits over current technology

Less passive material: readout integrated within detector substrate

Lower energy thresholds than daisy-chained strip detectors → scalable to large arrays!

Lower cost: CMOS processes are mass produced, fewer steps of integration

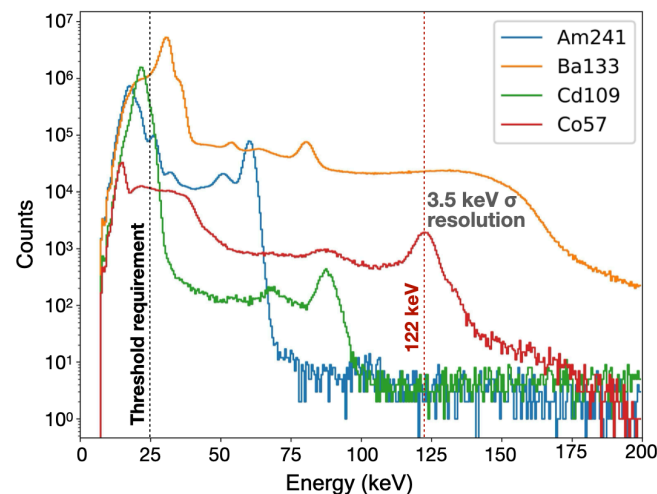
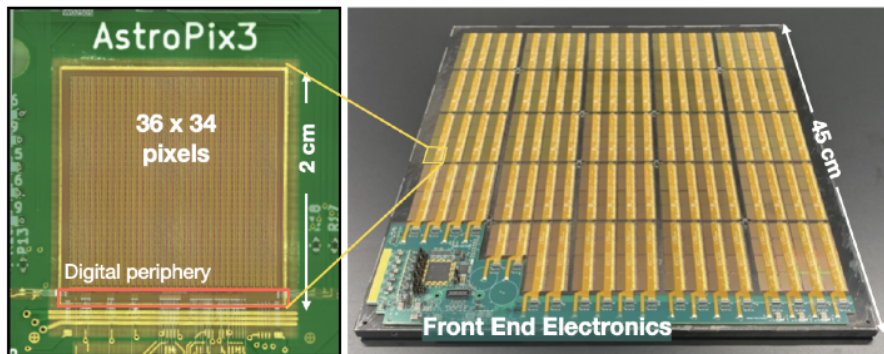
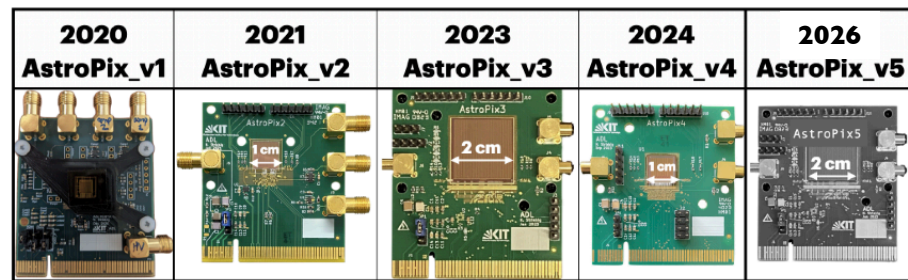


Perić et al NIMA (2007)

What do you identify as the most critical or key enabling technology?

Tracker with AstroPix (GSFC/ANL)

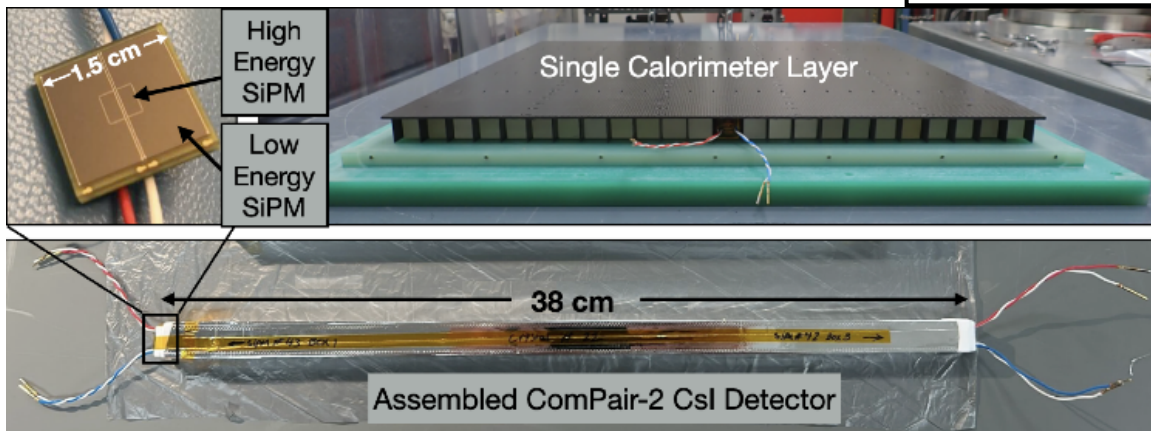
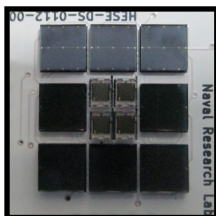
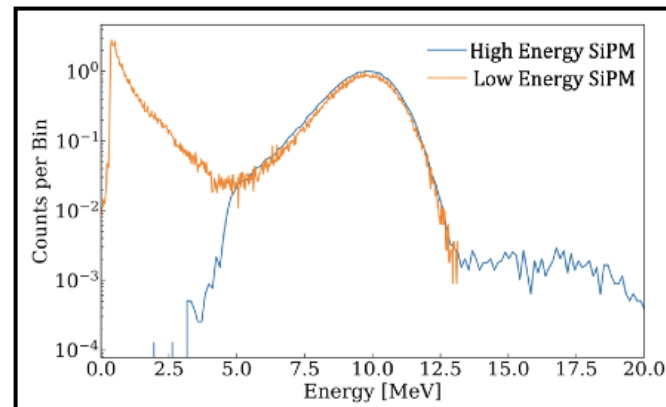
- Custom silicon pixel design by Karlsruhe Institute of Technology
- Iterative improvements working towards AMEGO-X requirements
 - e.g. reduced power consumption 2 orders of magnitude: $<2 \text{ mW/cm}^2$
- Large arrays integrated for ComPair-2 balloon-borne prototype



What do you identify as the most critical or key enabling technology?

Dual-gain Csl Calorimeter (NRL)

- Custom dual-gain SiPMs with different microcell sizes designed by FBK
 - initial prototyping with SensL COTS SiPMs
 - dynamic range of single Csl bar 100 keV to 400 MeV!
- 2 cm resolution along the length of each $1.5 \times 1.5 \times 39 \text{ cm}^3$ bar
- Custom IDEAS readout electronics underway

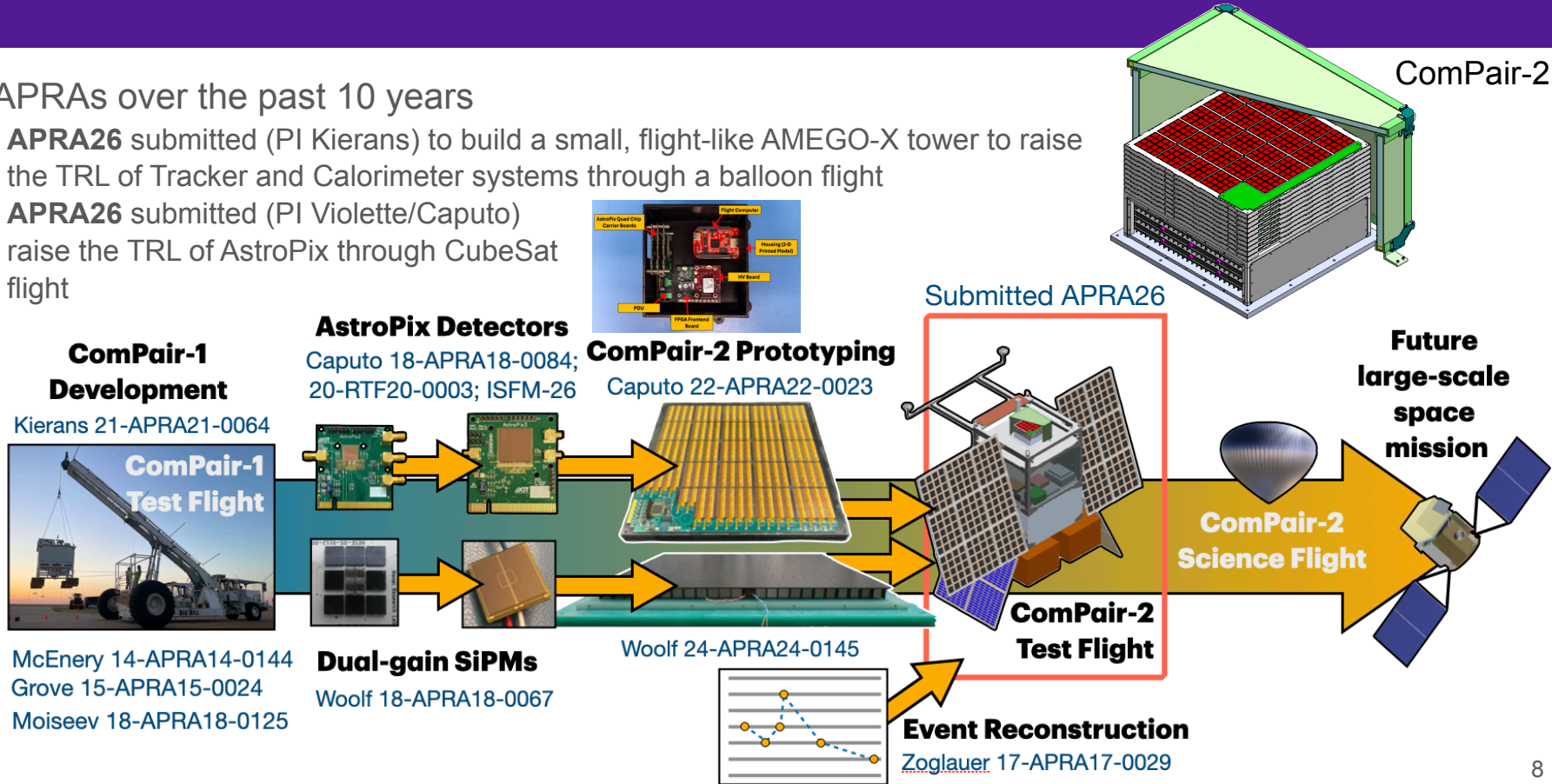


<https://doi.org/10.1117/12.3017619>

What does your high-level technology development plan look like?

9 APRAs over the past 10 years

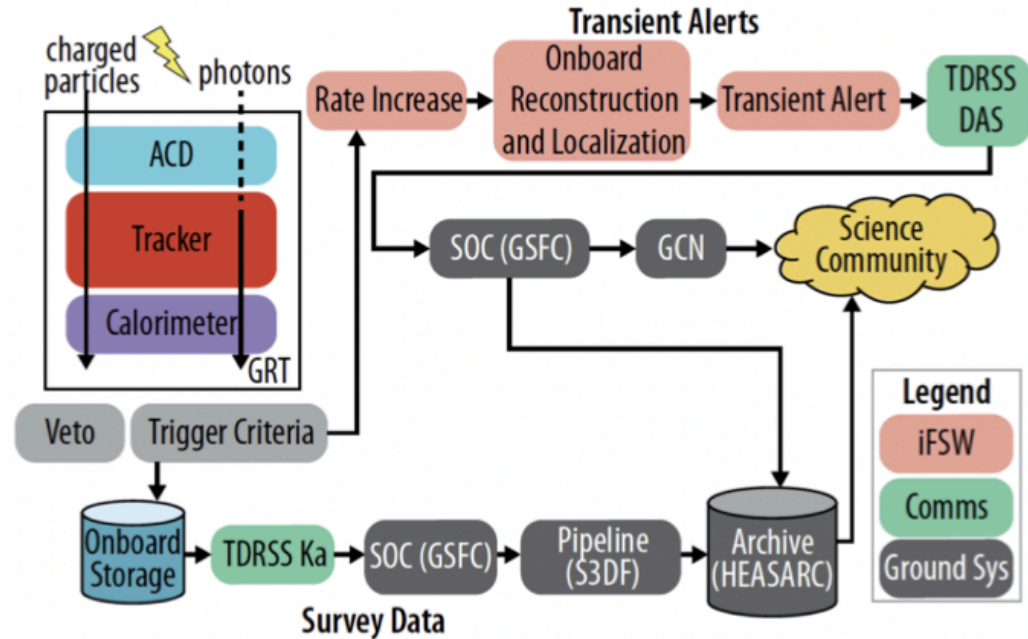
- **APRA26** submitted (PI Kierans) to build a small, flight-like AMEGO-X tower to raise the TRL of Tracker and Calorimeter systems through a balloon flight
- **APRA26** submitted (PI Violette/Caputo) raise the TRL of AstroPix through CubeSat flight



Drivers for spacecraft?

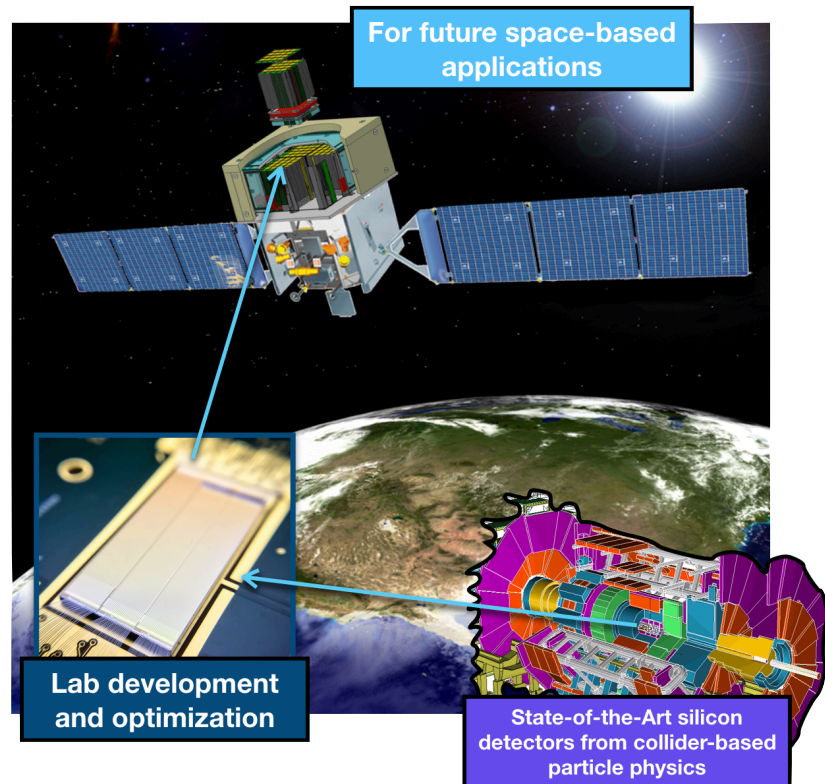
- **Orbit:** AMEGO-X assumed low inclination ($< 5^\circ$) LEO for lowest/stable background environment
 - L2 orbit would allow for reduced background and larger FOV
- **Mass:** 1000 kg
- **Power:** 1 kW
- **Comms:** 20 GB daily data downlink
 - Rapid (< 30 s) data downlink for transients

All of the above is subject to change/
optimization for a future large scale mission



How does your implementation strategy leverage external capabilities — specifically commercial industry advancements, the Artemis infrastructure or strategic partnerships?

- Department of Energy
 - Decades of investments in CMOS Silicon Pixel detectors for particle detectors
 - Integration of AstroPix into ePIC detector (for DOE)
- CMOS Silicon foundries for device fabrication
- International investment in silicon devices (Germany, Japan, Korea, Italy)
- Data analysis improvements: Machine learning event reconstruction (MEGAlib PI Zoglauer - SSL Berkeley) and Italy



Summary

- The AMEGO-X concept was optimized for angular resolution and effective area aiming to fill the MeV Gap
- Our technologies have a mid- to high-TRL with a path for prototyping and development
- The design is reconfigurable to optimize for different performance parameters and cost

