SuperHERO X-ray telescope balloon mission

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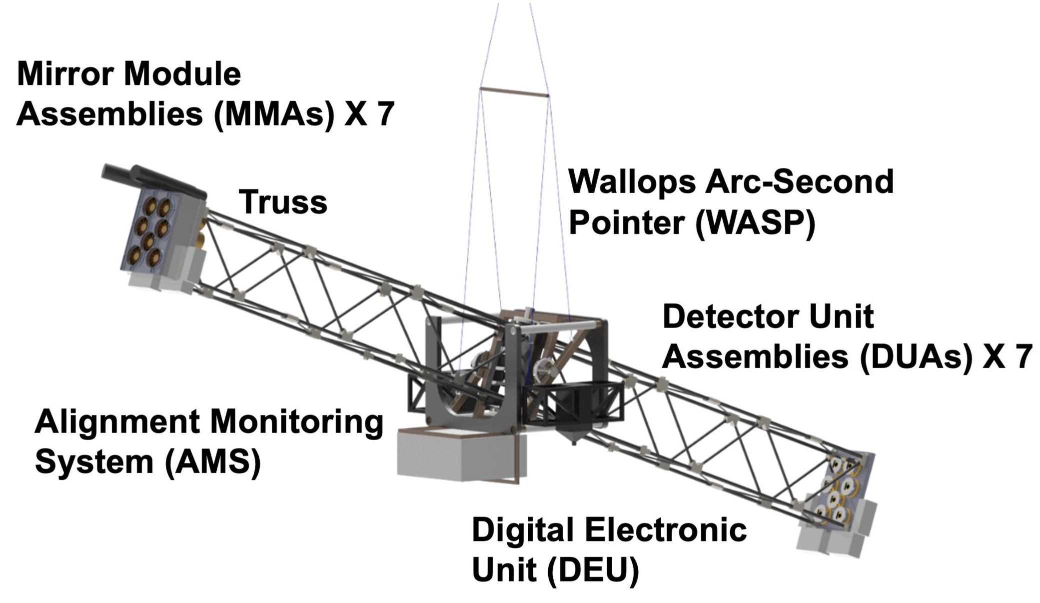
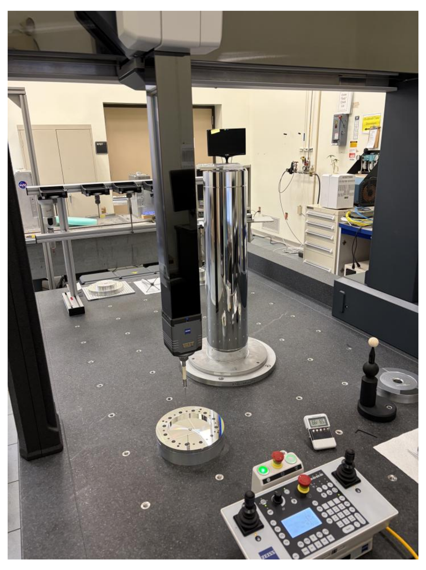
SuperHERO



Super – High Energy Replicated Optics (SuperHERO)[1] is a high-resolution, balloon-borne X-ray telescope currently under development. Selected through NASA's APRA program and led by MSFC, *SuperHERO* is now in the second year of its planned five-year mission. Its key technical objective is to achieve 10-arcsecond half-power diameter (HPD) imaging performance in the hard X-ray band, enabling unprecedented observations above 20 keV. With a planned effective area of 45.5 cm² at 35 keV, *SuperHERO* aims to localize sites of hard X-ray emission from the pulsar wind nebula within the Crab during its first science flight, scheduled for the fall of 2029 from Fort Sumner, New Mexico. To enable expanded science return on future missions, *SuperHERO* is designed to incorporate iterative enhancements in effective area, bandpass, and angular resolution. These improvements will support extended observations on a long-duration balloon platform, where a potential *SuperHERO-LDB* mission can achieve an even greater science yield.

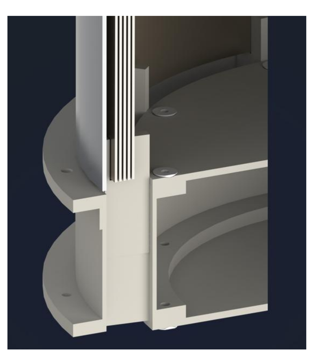
High Resolution X-ray Shell Optics

SuperHERO utilizes MSFC's replicated X-ray optics. Fabricated using the electroformed-nickel-replication (ENR) process, this method begins with machining an aluminum mandrel that is overcoated with high-phosphorus electroless nickel. The mandrel surface is then diamond-turned and polished, using both lathe polishing and deterministic polishing techniques, to produce a high-fidelity negative optical prescription of the desired X-ray mirror. A NiCo shell is subsequently grown on the mandrel in an electroforming bath and later separated through differential thermal contraction by submerging the mandrel–shell assembly into cold water.



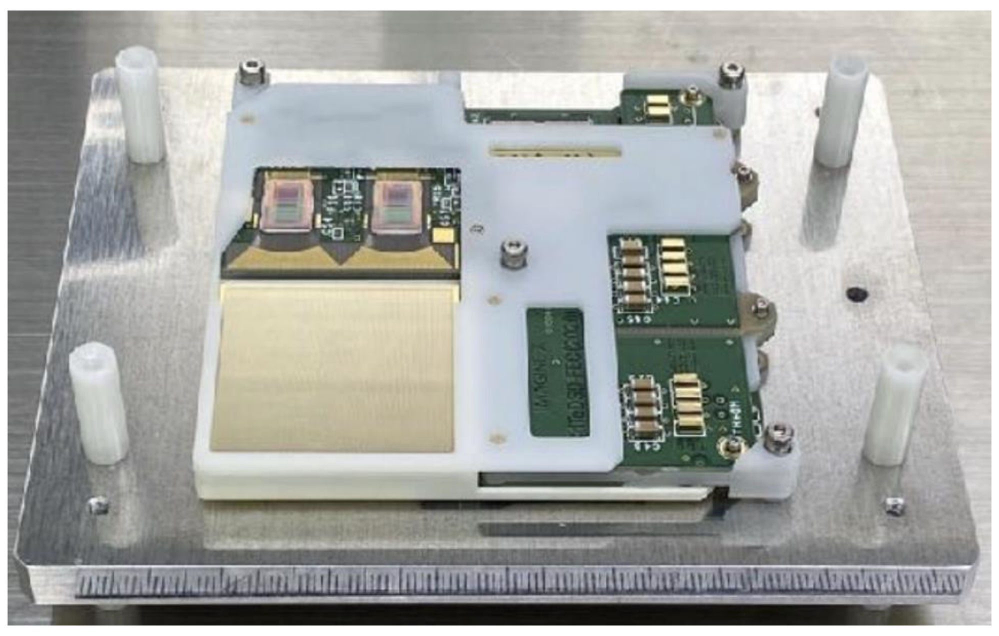
- *SuperHERO* employs a Wolter-I grazing-incidence optical prescription
- Each monolithic mirror shell is 600 mm in total length with a 1 mm wall thickness
- The shell consists of a 300 mm paraboloid segment and a 300 mm hyperboloid segment
- Two mandrels are currently in fabrication with intersection diameters of 200 mm and 203.2 mm.

Mirror Module Assembly



For *SuperHERO's* 2029 science flight, the payload will include seven MMAs, each consisting of two replicated NiCo shells. The MMAs are designed to ultimately accommodate up to five shells, increasing the total effective area to 110 cm² at 35 keV and enabling extended investigations on a long-duration balloon platform.

Focal Plane Detector



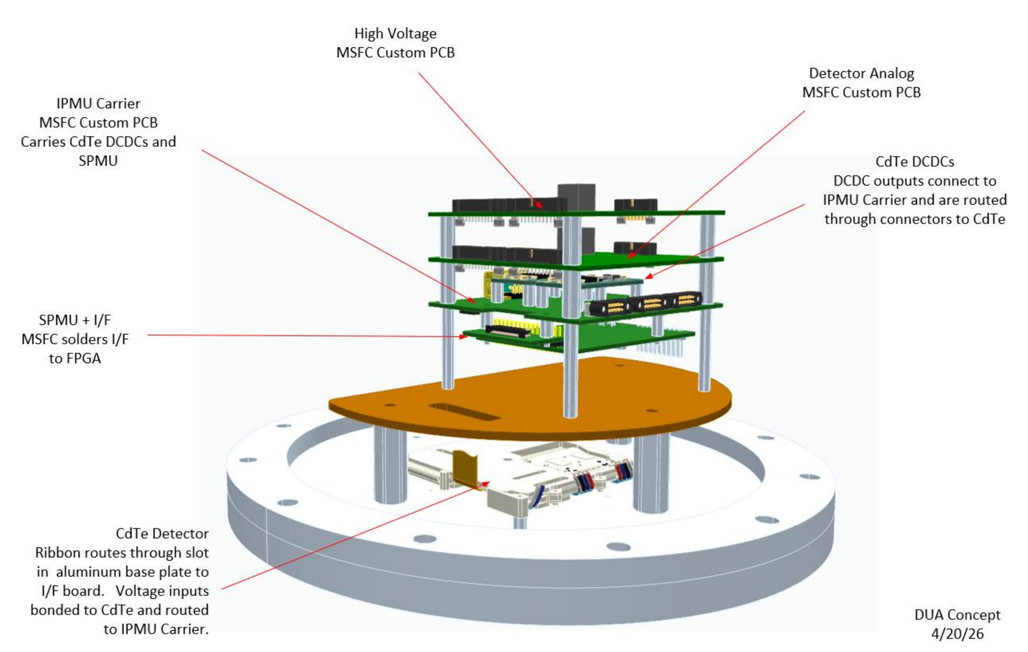
SuperHERO implements Cadmium-Telluride Double-sided Strip Detectors (CdTe-DSDs) for all seven of its hard X-ray focal planes. These high-heritage detectors flew on *Hitomi's* Hard X-ray Imager (HXI)[2,3] and are now commercially available through iMAGINE-X Inc[4].

Key detector characteristics include:

- 1-mm-thick, 34 × 34 mm² CdTe block, abuttable form factor (9.2 arcminute field-of-view)
- 128 platinum cathode and aluminum anode strips patterned on the top and bottom surface
- 250-µm strip pitch
- Operational temperature of –10° C and bias voltage of 300 V

See Adrianah Appleman's poster for testing and performance details [14157-119]

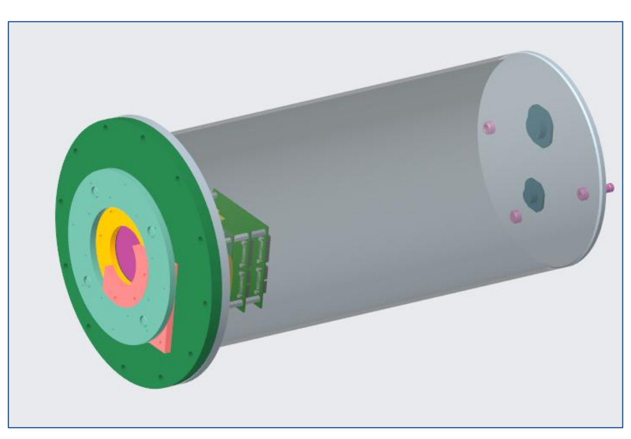
Detector Unit Assembly



DUA front flange

SuperHERO houses each CdTe-DSD focal plane within its own Detector Unit Assembly (DUA). Each DUA provides the mechanical mounting for the focal-plane detector as well as the rear-end electronics board required for readout and control. The DUA is a sealed enclosure filled with 1 atm of dry nitrogen to prevent corona discharge during operation. The DUA is designed to accommodate additional abutted CdTe-DSDs in future missions, allowing the focal plane to expand and fully support *SuperHERO's* 12-arcminute field-of-view.

Detector Test Flight



DUA housing is designed to passively cool the detector to its operational temperature of –10° C, while internal heating elements maintain temperature stability throughout the flight environment.

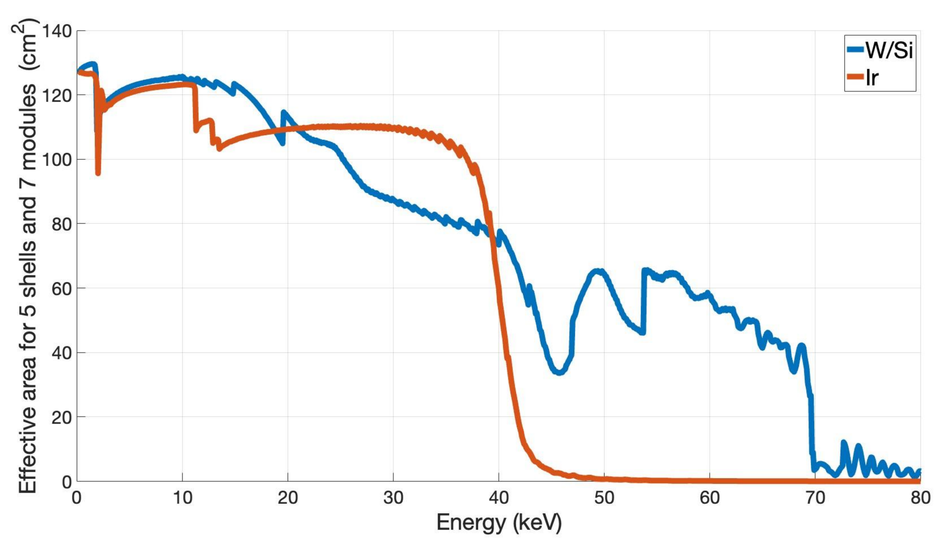
SuperHERO plans to flight-test a single DUA during a piggyback mission in the fall of 2027 to validate predicted aloft electronics performance, assess thermal behavior, and measure the in-flight particle background.

Focal Plane Detector

SuperHERO's 12-m focal length, spanning from the MMAs to the DUAs, will be supported by a carbon-composite truss based on a design previously employed on *XL-Calibur*[5]. To accommodate increased mass for future missions, an asymmetrical truss is being developed in which the pivot point is positioned closer to the MMAs. Stress analysis for this design is currently being performed by Washington University in St. Louis.

A high-heritage onboard alignment monitoring system will measure the relative position between the MMAs and the detectors with a precision of 0.1 mm[6]. The Wallops ArcSecond Pointer (WASP)[7] balloon gondola system will interface with the truss at its pivot point and will provide high-accuracy attitude control and attitude knowledge.

Shell Coatings



SuperHERO will use single-layer Ir coatings on the inner surfaces of its mirror shells, applied via RF sputtering, providing a bandpass from 20 to 40 keV, where the lower-energy cutoff is set by atmospheric absorption. Using a Dual Direct-Cooled Linear DC Magnetron system (Angstrom Sciences, Inc.), future iterations of *SuperHERO* will directly apply depth-graded PtC multilayer coatings to extend the bandpass up to 79 keV [Gurgew, 14146-261].

Summary

SuperHERO is a mission that incorporates mature technologies alongside recent improvements in the resolution of NiCo-replicated X-ray shell optics technology, with the goal of achieving a 10-arcsecond HPD in the hard X-ray telescope bandpass. It is designed to be readily adapted for future missions to maximize its scientific impact. *SuperHERO* is scheduled for its first science flight in fall 2029 from Fort Sumner, New Mexico, where it will observe the Crab pulsar wind nebula and demonstrate better than 10-arcsecond HPD imaging from a balloon platform. The mission will pave the way for future long-duration balloon flights and space-based observatories with enhanced scientific capability, including mission concepts such as *HEROIX* [Thomas, 14146-42].

Discussion-

Join up today to be part of the HEROIX Team

https://forms.gle/62LdpEnwSEZGQBYZ8

[1] Thomas et al. (2025), *The* SuperHERO *(Super – High Energy Replicated Optics) High-Angular Resolution, Hard-X-Ray Telescope.*
[2] Takahashi et al. (2012), *The ASTRO-H (Hitomi) x-ray astronomy satellite.*
[3] Hagino et al. (2018), *In-Orbit Performance and Calibration of the Hard X-ray Imager (HXI) onboard Hitomi (ASTRO-H).*
[4] Takeda et al. (2016), *High-resolution CdTe detectors with application to various fields.*
[5] Abarr, et al. (2021), *XL-Calibur - a second-generation balloon-borne hard X-ray polarimetry mission* "Performance of the
[6] Abarr, et al. (2022), *Performance of the X-Calibur hard X-ray polarimetry mission during its 2018/19 long-duration balloon flight.*
[7]Udinski (2022), *Wallops arc-second pointing (wasp) system.*