HERO: A Balloon-Borne Focusing Hard X-Ray Telescope

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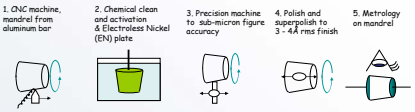
The HERO Program

- HERO is an evolutionary balloon payload featuring hard-x-ray focusing optics.
- The optics, focal plane detectors, optical bench, and pointing and aspect systems were all designed and fabricated at NASA/MSFC
- The payload utilizes shallow-graze-angle electroformed-nickel replicated optics coated with iridium to provide good high energy response.
- Currently, the payload features 96 mirror shells giving around 80 cm^2 of effective collecting area up to 45 keV, and more than 40 cm^2 up to 60 keV.
- The HERO payload is designed to observe in a relatively unexplored region of the x-ray waveband.
- HERO's next flight will be from Alice Spring, Australia in Fall 2009.

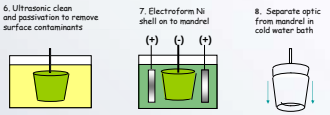
Optics Fabrication

The HERO optics, the heart of the instrument, are fabricated at MSFC using an electroformed-nickel-replication technique. In this, nickel shells are deposited on a super-polished and figured mandrel, from which they are later released through differential thermal expansion. The figure below shows the steps in the electroforming process.

Mandrel Preparation

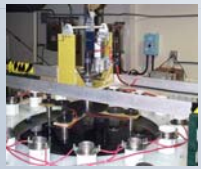


Shell Fabrication



A finished HERO mandrel (left) and a HERO mandrel being polished (right)

Multipart plating tank (left) and some finished HERO mirror shells (right



HERO Mirror Module (1 of 8)

Figure below shows a single HERO mirror module with 12 concentrically nested mirror shells

HERO Instrument Specification

The HERO instrument consists of 8 optics modules and 8 corresponding focal plane detectors, housed in a 6-m-long cylindrical optical bench. The bench is mounted in a gondola that provides pointing, power, telemetry and protection. Below are the details of the key instrument components.

Optics

Item	Value
Mirror modules	8
Number of shells per module	12
Focal length	6 m
Inner shell diameter	5 cm
Outer shell diameter	9.4 cm
Shell length (total)	60 cm
Shell thickness	250 μm
Shell material	NiCo alloy (75/25)
Prescription	Conical approximation to Wolter-1
Shell coating	Ir, 60 nm
Resolution (average over 8 modules)	25 arcsec HPD
System total effective area	80, 40 cm^2 (40,60 keV)

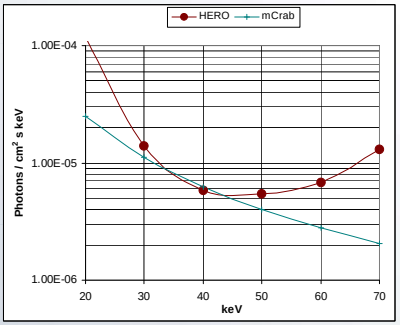
Figure below shows the flight mirror modules (with 12 nested shells each) mounted in the front of the optical bench. Each module has its own tip/tilt mounting mechanism to permit alignment, and Kapton-covered band heaters for thermal control. A protective cap covers the assembly in flight.

Detectors

Item	Value
Number of detectors	8
Type	Gas scintillation proportional counter
Fill gas	Xe/He (96/4) @ 10^5 pa
Gas depth	5 cm
Sensitive diameter	5 cm
Readout system	Hamamatsu position sensitive photomultiplier
Spatial resolution (FWHM)	400 μm (40 keV)
Energy resolution (FWHM)	4% (40 keV)
Efficiency	98% (40keV), 89% (60 keV)

HERO expected sensitivity

The figure below gives the expected sensitivity for the HERO balloon payload in the configuration detailed above, assuming a float altitude of 40 km. Data are 5 σ continuum sensitivity (dE/E=0.5), for 3.10^4 sec observations. A line corresponding to 1 mCrab (1/1000 of the Crab Nebula) is also included for comparison

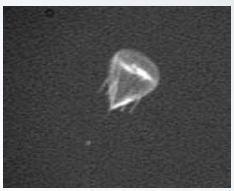


HERO Gondola

The HERO balloon payload, shown below, features a carbon-fiber optical bench and an alt-azimuth gyroscopically-controlled pointing system with differential GPS for coarse positioning and a pair of day/night star cameras for fine positioning and after-the-fact precise attitude reconstruction

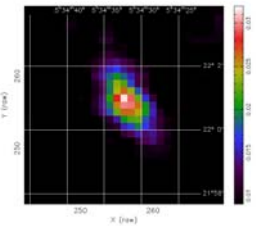
HERO Flight Operations

The sequence of pictures below shows the HERO balloon payload in New Mexico. At the top left is the gondola in the Columbia Scientific Balloon Facility (CSBF) hangar, undergoing pointing tests. To the right of this is the payload on the CSBF launch vehicle, then below are images of HERO after launch and during ascent.



Flight Data, May 2007

The figure below shows data obtained during an 1800-sec observation of the Crab Nebula supernova remnant (20-60 keV) on May 28, 2007. Approximately 1500 source photons were detected. Some residual effects due to telescope motion are still being removed so that he wings of the source extension in the top left to bottom right diagonal plane, the azimuthal pointing direction for the payload, may be sliahtlv exaaaerated.



Future Flight Plans

The next flight of the HERO payload is currently scheduled for September 2009, from Alice Springs, Australia. The prime science for this flight will be a high-angular-resolution map of the Galactic Center region. Three additional shells will be added to each module for this flight, increasing the payload effective area by about 25%.