HSP

will transform High Energy Time Domain Astrophysics

High Resolution Energetic X-ray Imager SmallSat Pathfinder

Cosmic Explosions from Deaths of Massive Pop-III Stars to Electromagnetic Signature of Gravitational Wave Triggers

CENTER FOR ASTROPHYSICS
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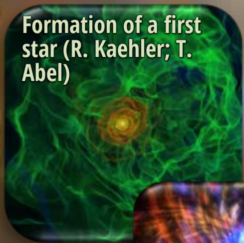
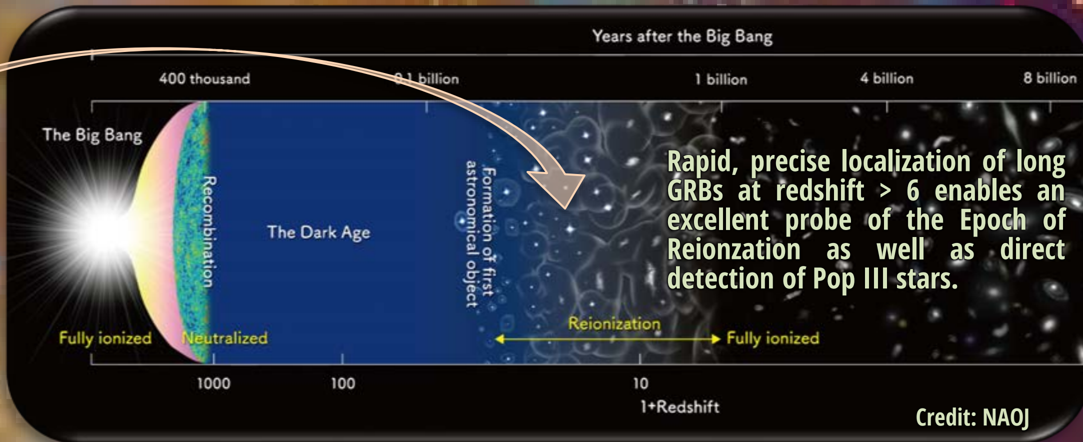
Science

1. Probe the very first (Pop III) stars and the Epoch of Reionization with Long Gamma-Ray Bursts



Formation of a first star (R. Kaehler; T. Abel)

BH formation



Rapid, precise localization of long GRBs at redshift > 6 enables an excellent probe of the Epoch of Reionzation as well as direct detection of Pop III stars.

Credit: NAOJ

Massive metal-poor or metal-free stars are believed to form Pop III stars which eventually collapse to Black Holes, producing long GRBs.

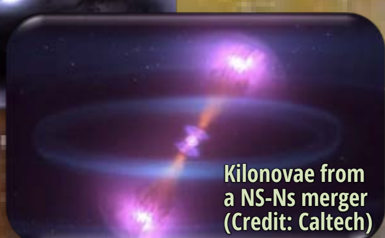
2. Localize short GRBs from LIGO/VIRGO NS-NS and BH-NS mergers to enable studies of r-process production.

3. Measure 2 populations of BH-X-ray Binaries: X-ray images of entire Galactic Bulge *every orbit* to discover flares from BHs "fed" by low mass companions, and Galactic Plane images of BH birth sites to discover "juvenile" BHs fed by high mass binary companions

TDE (Credit: AAS Nova)

4. Measure the mass growth of Supermassive BHs from X-ray flares (in all fields) of Tidal Disruption Events (TDEs) shredding stars passing too close

Gravitational wave from a NS-NS merger (Credit: LIGO, Virgo)



Kilonovae from a NS-Ns merger (Credit: Caltech)

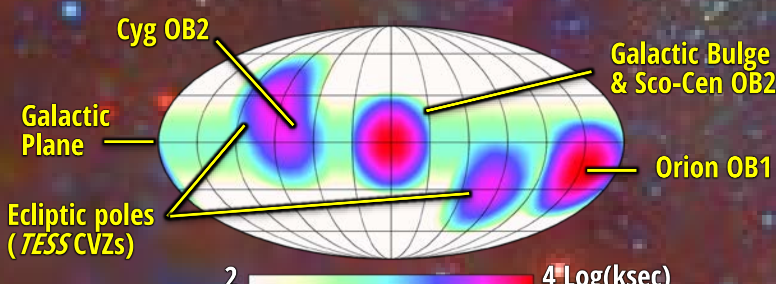
Chandra X-ray Image of the Galactic Center (Credit: CXC)

Jets from a Blazar

5. Measure extreme X-ray Flares from Exoplanet Host Stars, Blazars, Changing Look Quasars and Tidal Disruption Events in *TESS* Continuous Viewing Zones (CVZs) and *all BH-X-ray binaries in LMC* for S.CVZ.

Mission Design as Pathfinder

HSP will be launched into a LEO at 500 km with ~25 deg inclination for 1 year science operation in 2025.



Exposure map: the primary targets include the Galactic Bulge, Orion OB1/Cyg OB2 & Sco-Cen OB2 associations, and *TESS* CVZ fields. When primary targets are unavailable, *HSP* will observe the Galactic Plane.

HSP is a Pathfinder for a 4π (all sky) X-ray Imaging Observatory (*4piXIO*).

Consisting of 32 *HSPs*, *4piXIO* will monitor *all sky all the time* for X-ray transients and GRBs, as a unique resource for *all* Time Domain Astrophysics.

HSP
High Energy Time Domain Astrophysics

High Resolution Energetic X-ray Imager SmallSat Pathfinder

Extreme Flares from Stars, Stellar Black Holes in our Galactic Bulge, and OB associations, and from AGN in the TESS CVZ

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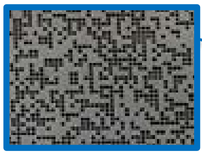
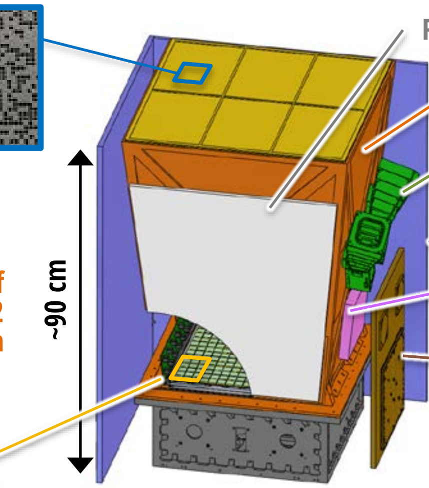
Instruments & Spacecraft

The high resolution X-ray imaging spectrometer on *HSP* is a wide-field hard X-ray (3 – 200 keV) coded aperture telescope with 1024 cm^2 CdZnTe detectors and a Tungsten mask. With 4.7 arcmin resolution covering 36 deg x 36 deg (FWHM), *HSP* localizes transients and GRBs within < 30 arcsec in less than 10 min. The *HSP* spacecraft fits to the ESPA standard class, weighing 96 kg.

The 0.3 mm thick tungsten mask consists of 6 panels. A random pixel pattern is chemically etched with the 0.7 mm pitch (0.05 mm grid), enabling high angular resolution.





Passive side shields with Pb-Sn-Cu-Al layers

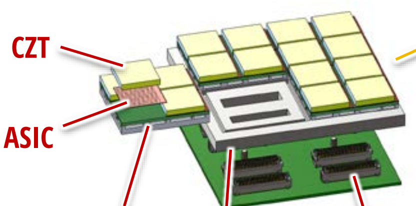
Two star trackers with 90 deg offset

Two body mounted solar panels

Detector MotherBoard (DMB) powers and controls the detector plane and processes its data.

One X-band & two S-band antennas

The 1024 cm^2 detector plane consists of 256 CdZnTe (CZT) detectors. Each 2 x 2 cm^2 crystal is 3 mm thick with 0.6 mm pixels, directly bonded to a NuSTAR ASIC.



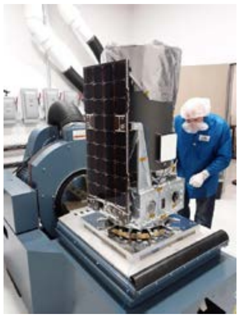
Four CZT + ASIC pairs are mounted on a Detector Crystal Array (DCA) board.

An FPGA Mezzanine Board (FMB) handles 16 DCAs.

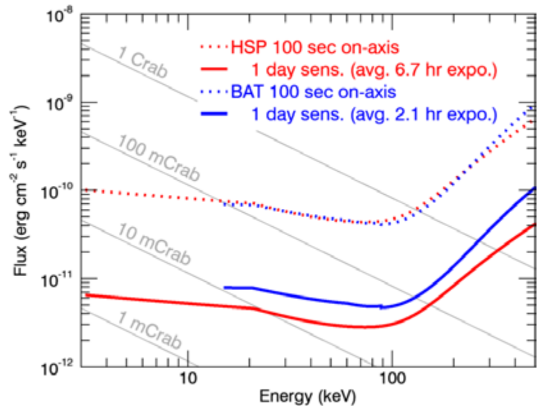
The 64 DCAs and 4 FMBs sandwich a common optical bench.

The *HSP* detector plane enjoys the heritage of *NuSTAR* and *Swift*/BAT. The whole detector plane is passively thermal controlled within 5 – 15 deg C by a radiator and trim heaters.

MicroSat-S5 Spacecraft by Blue Canyon Technologies (BCT)



Fully assembled BCT MicroSat-S5 on a shake table



HSP has a broad band coverage over ~3–200 keV. Its on-axis sensitivity above 15 keV matches *Swift*-BAT's. *HSP*'s daily average sensitivity on the proposed target fields exceeds *Swift*-BAT's by ~3–5x due to dedicated monitoring and a lower energy coverage.

Science & Implementation Team

Management, SOC, MOC

Jonathan Grindlay (Harvard)	PI; GRB Science lead
JaeSub Hong (Harvard)	Project Scientist
Jonathan Schonfeld (SAO)	Project Advisor
Scott Barthelmy (GSFC)	MOC lead
Martin Elvis (SAO)	SOC
NASA Wallops/MPL	Mission Design
Blue Canyon Tech.	Spacecraft

Science Team

James Steiner (SAO)	Co-I; BH-LMXB lead
John Tomsick (UCB)	Co-I; BH-HMXB lead
Chelsea McCloud (SAO)	Co-I; AGN lead
Alan Marscher (BU)	Co-I; Blazar lead

Instruments

Branden Allen (Harvard)	Co-I; Instrument Scientist
Fiona Harrison (CIT)	Co-I; ASIC hardware

Schedule

Launch in 2025 May for 1 year science operation

HSP Mission Timeline	2020	2021	2022	2023	2024	2025	2026
	9 mon		12 mon	18 mon	16 mon	13 mon	6 mon
	Phase A	...	Phase B	Phase C	Phase D	Phase E	F
		Select	PDR	CDR, PER	Payload delivery, HSP S/C delivery	Launch	End of Mission