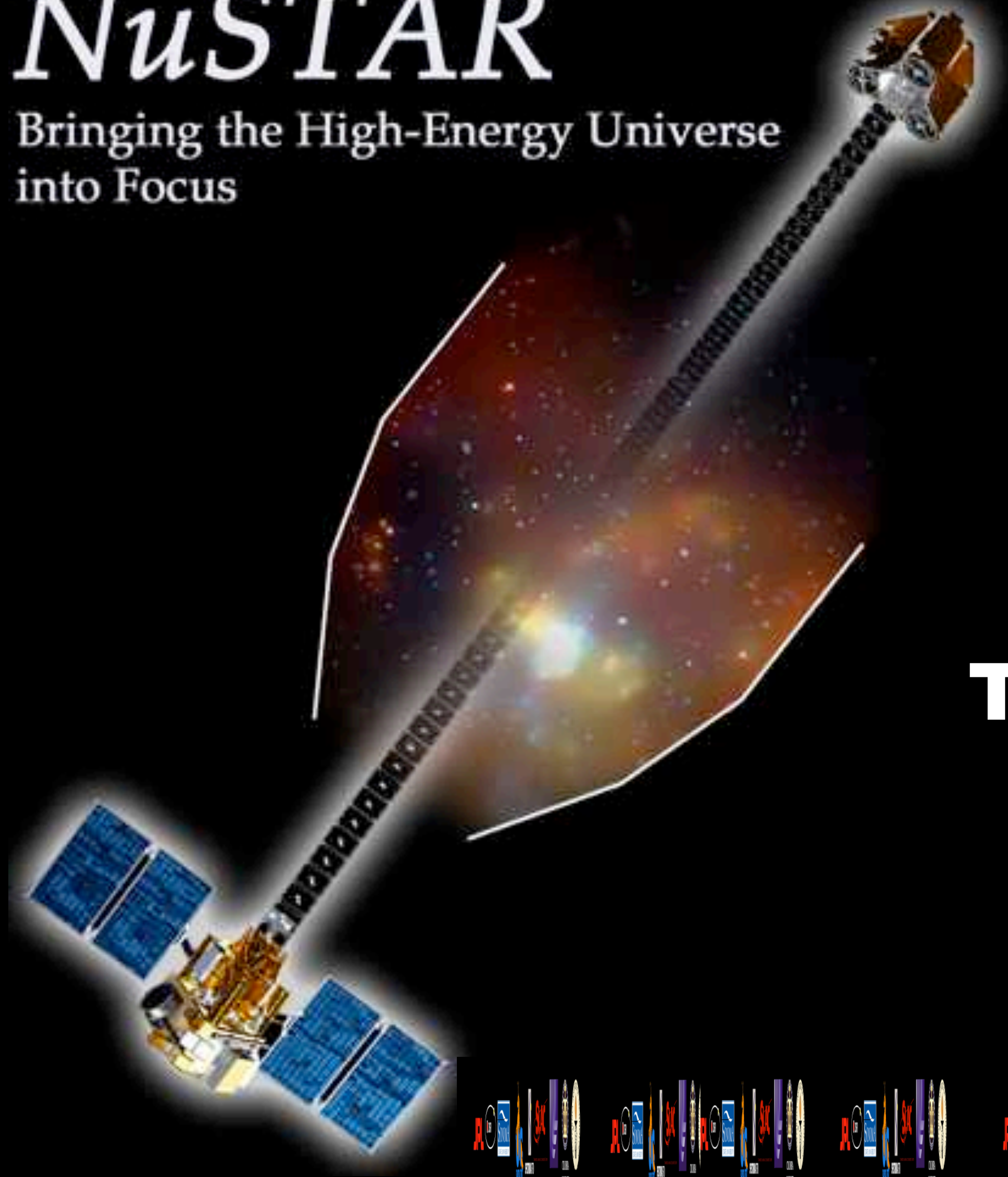
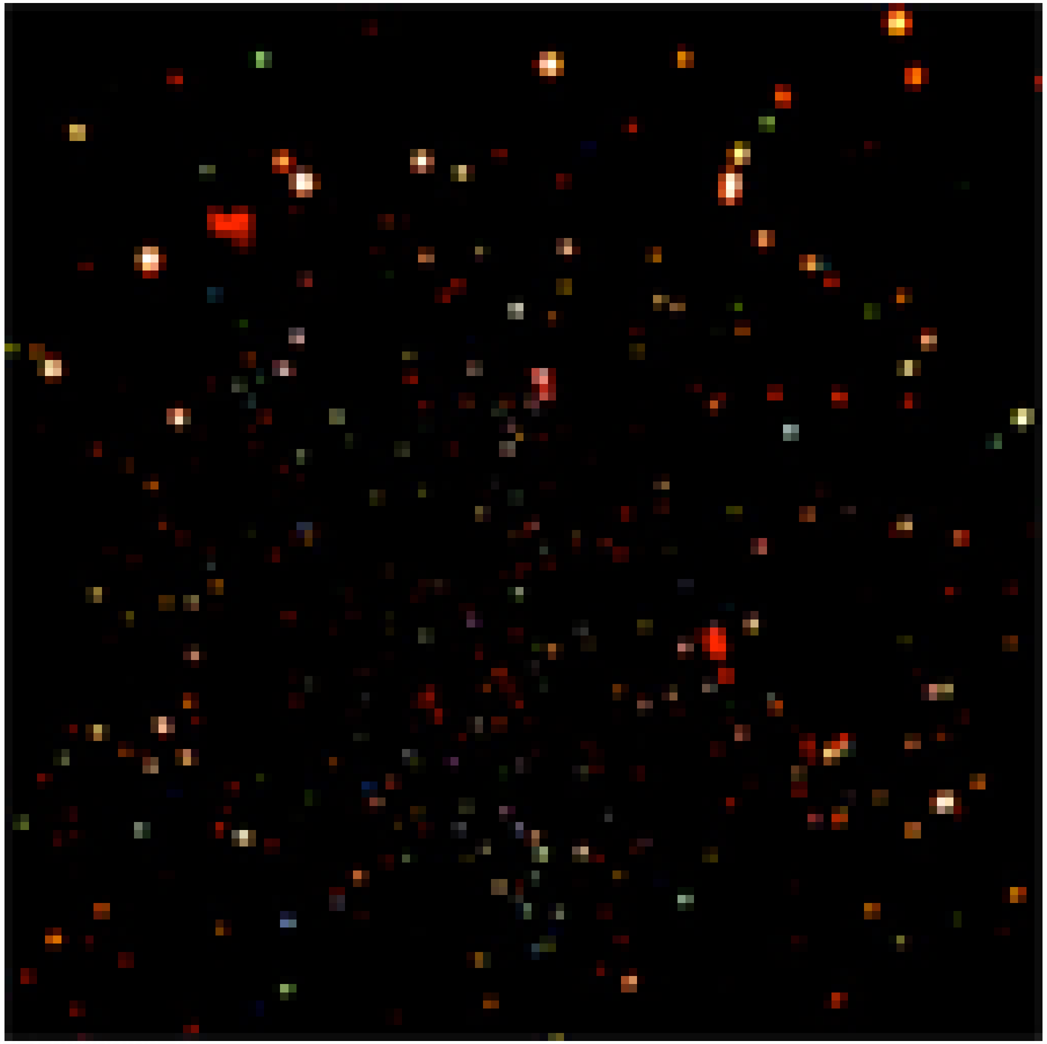
NuSTAR

Bringing the High-Energy Universe into Focus

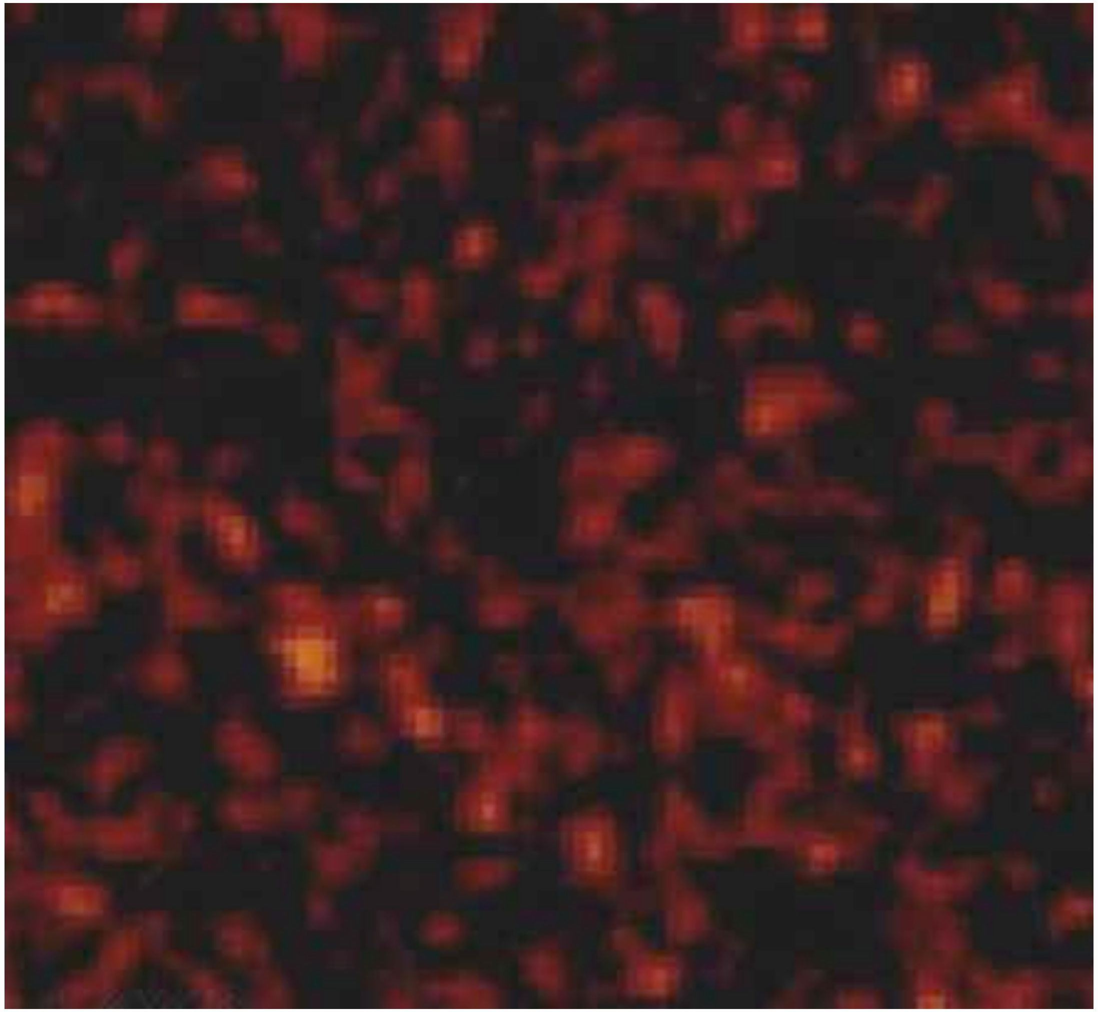


The Nuclear Spectroscopic Telescope Array

Chandra X-ray (0.5 - 8 keV)

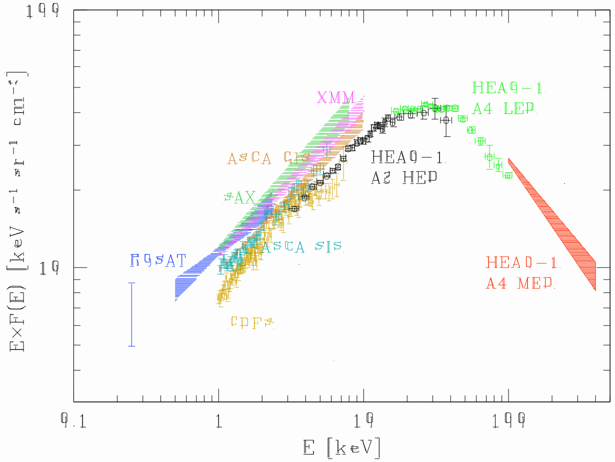


The best view to date of the extragalactic hard X-ray sky

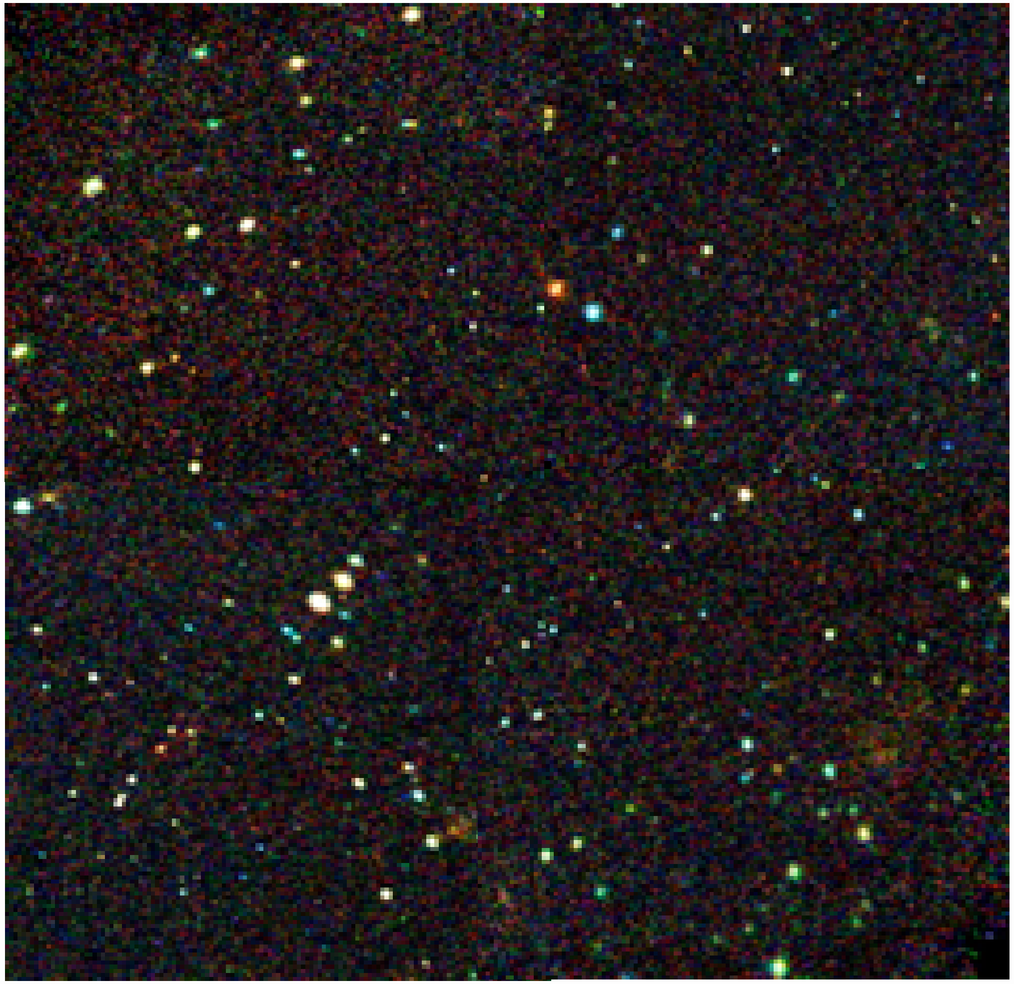


Deep image; 2 x 2 deg with *Integral* IBIS, 20 - 40 keV; dominated by the bright glow of unresolved sources

X-ray background

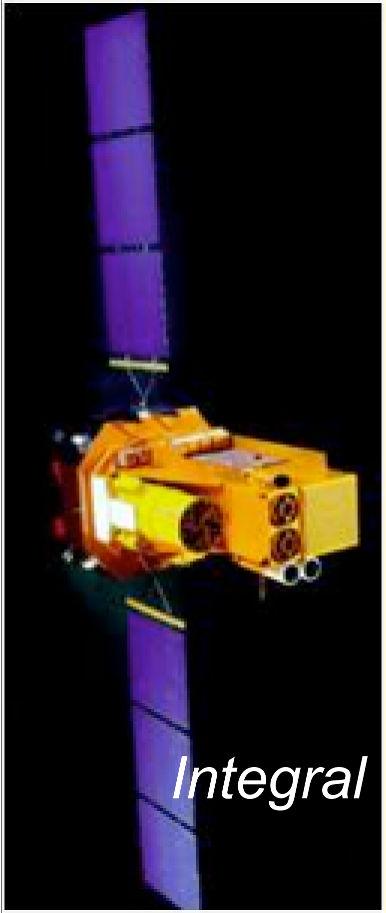


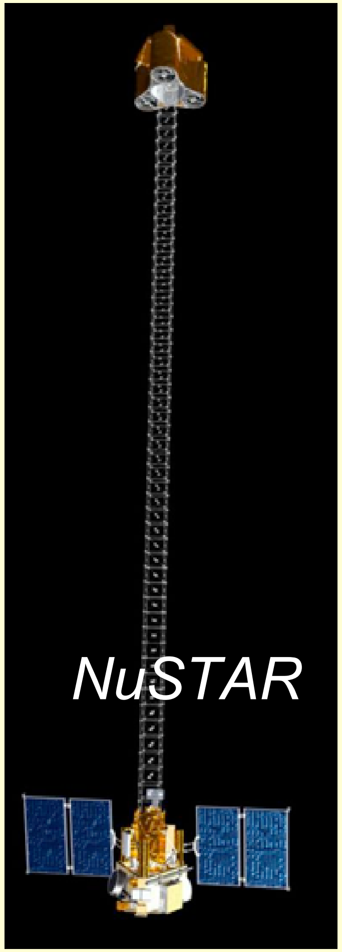
NuSTAR’s map of the hard X-ray sky

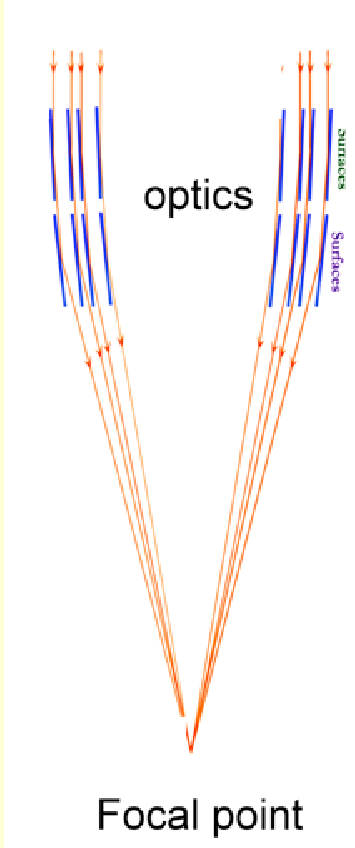


The science driver: to achieve the sensitivity required to resolve and identify sources that make the diffuse background (simulation of 2 x 2 deg with NuSTAR)

NuSTAR's breakthrough is the first use of focusing in the hard X-ray band



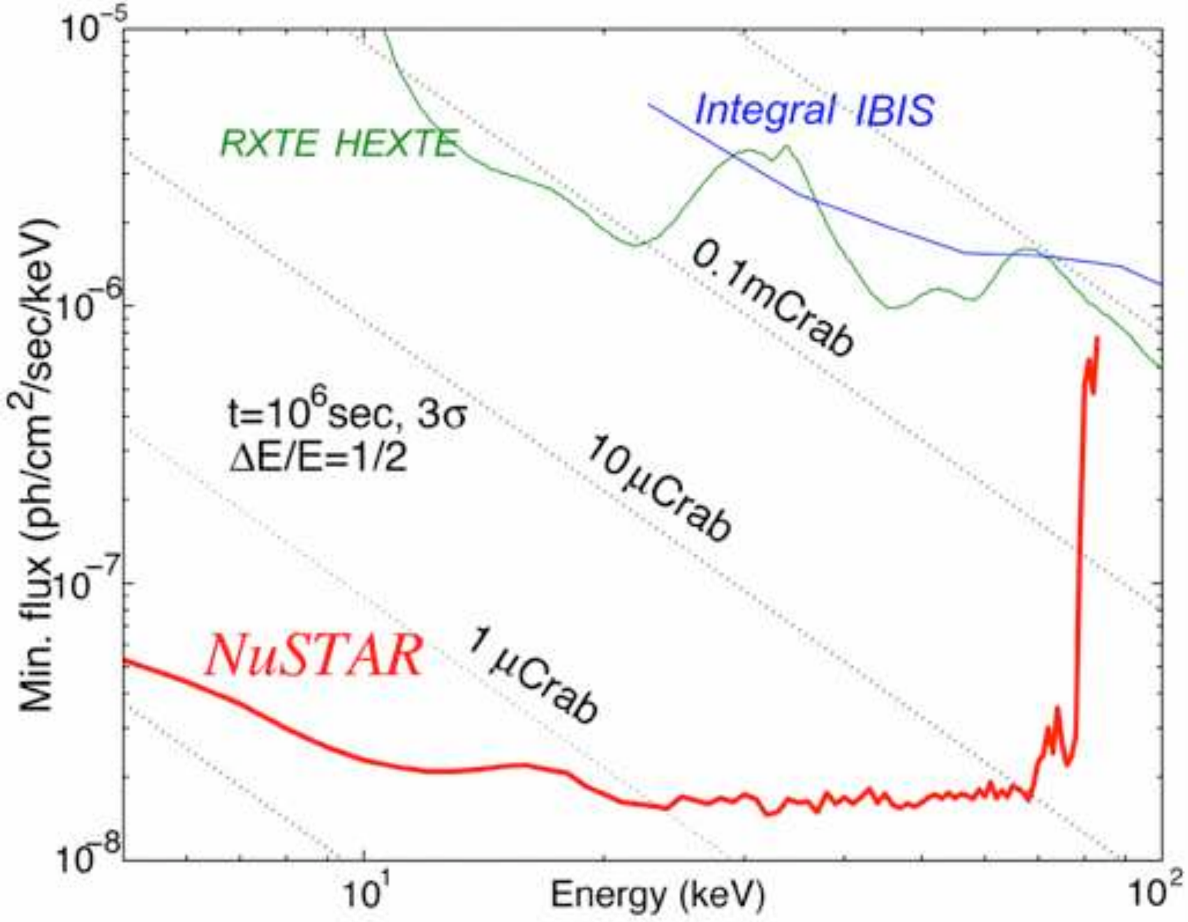




Pinhole camera → Focusing telescope

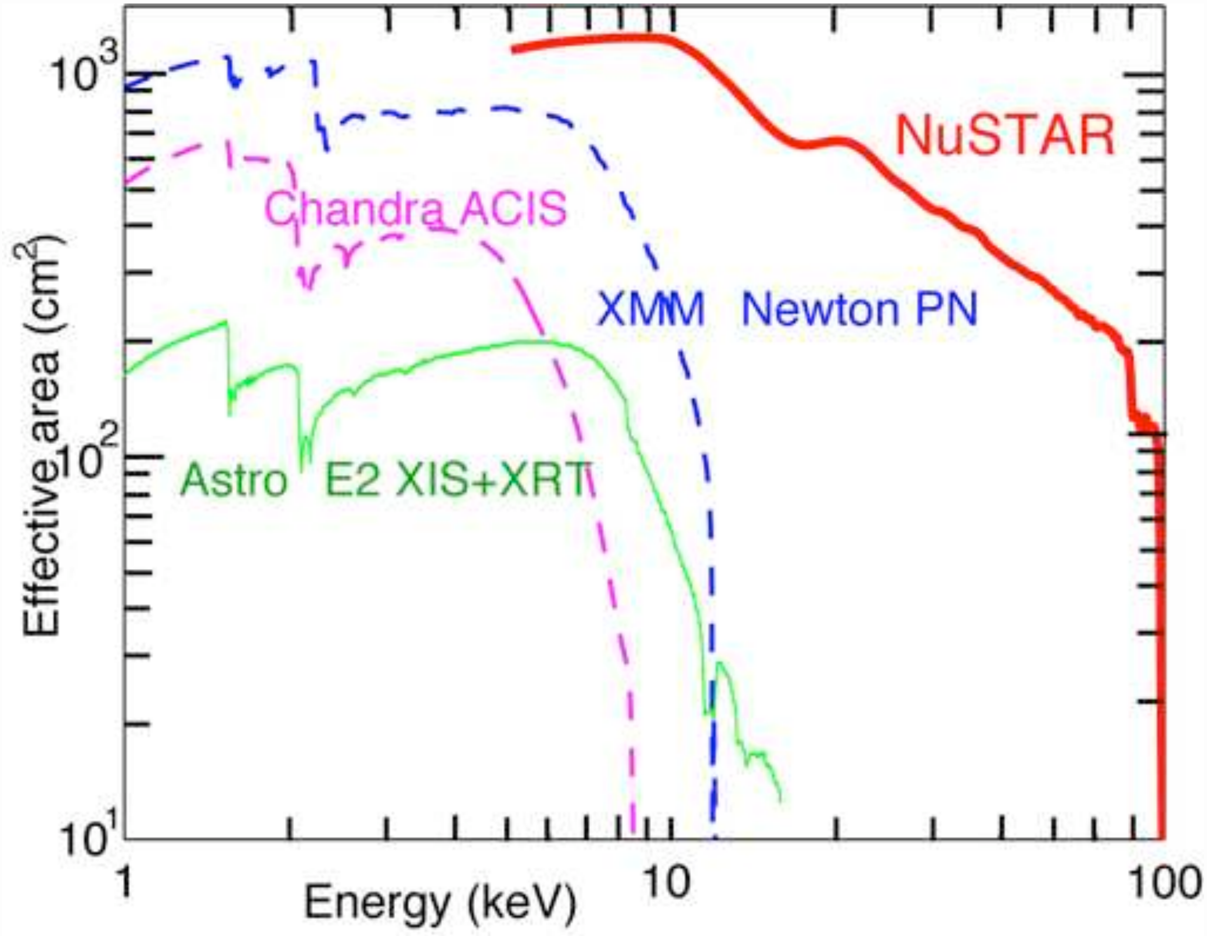
High background, large detector | Low background, compact detector

Exploring the last spectral frontier



- More than an order of magnitude advance in spatial and spectral resolution
- *More than a factor 100 advance in sensitivity!*

NuSTAR Effective Area

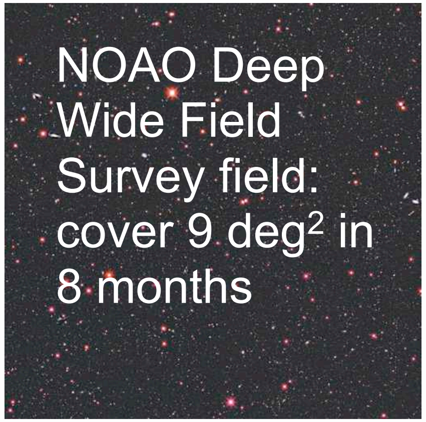


Three primary science questions

- **Question 1**: How are black holes distributed through the cosmos, and how do they influence the formation of galaxies like our own?
  - 15 months surveying regions of the sky
- **Question 2**: How do stars explode and forge the elements that compose the Earth?
  - 6 months mapping young supernova remnants
- **Question 3**: What powers the most extreme active black holes?
  - 3 months monitoring extreme black holes
- 10 months science reserve; discovery followup; community access

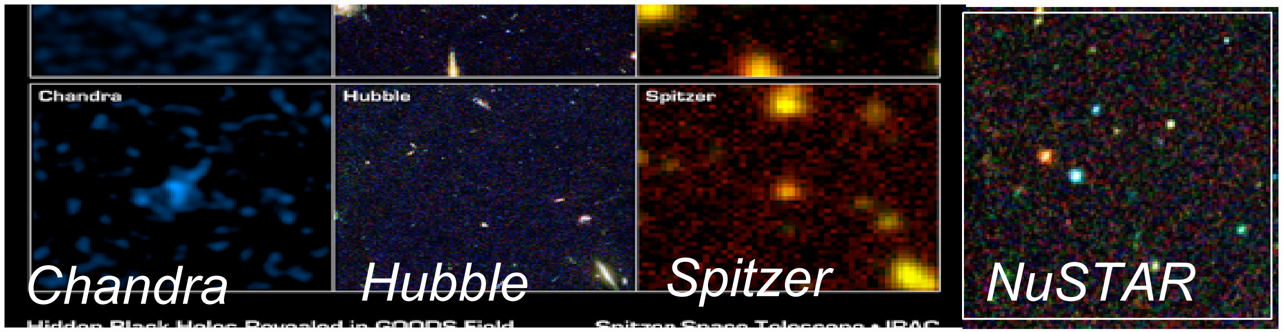
How many obscured black holes are there?

NuSTAR will map the distribution of obscured supermassive black holes,

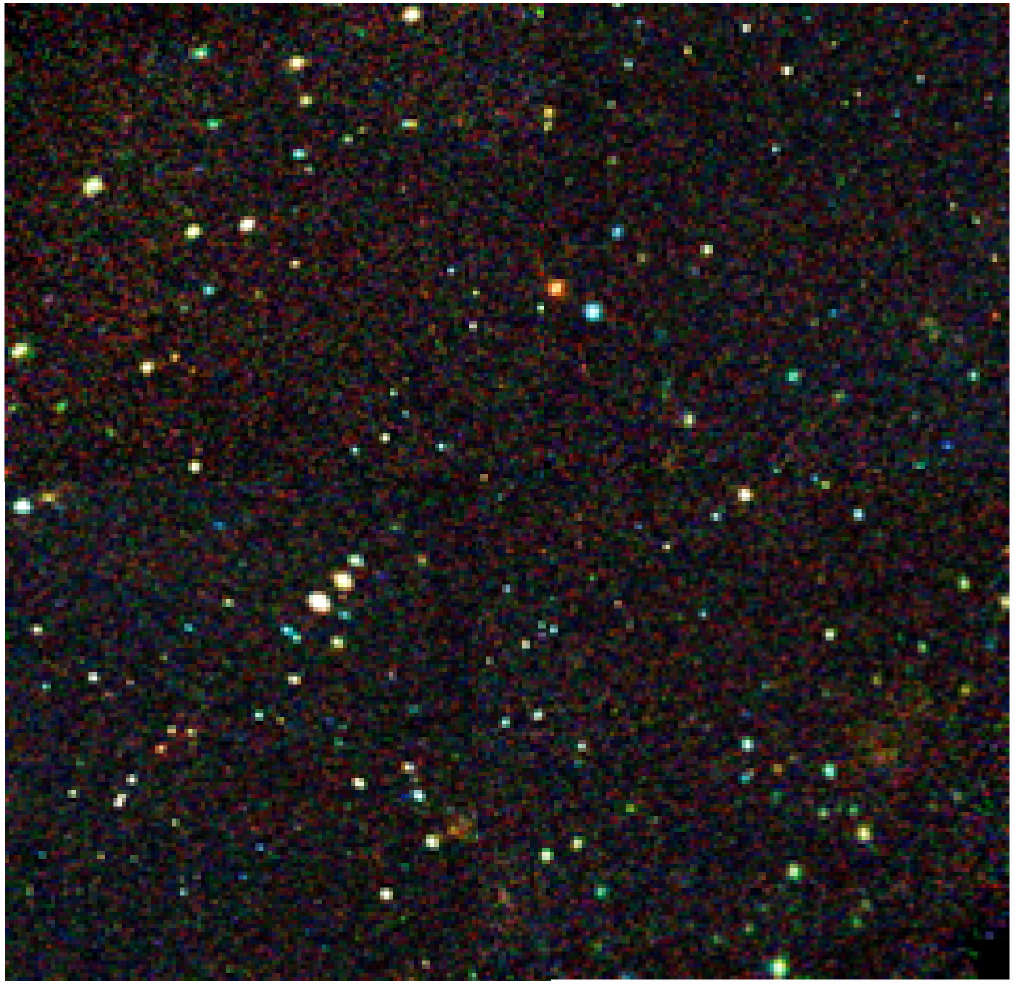


Detect hundreds of black holes in the hard X-ray

charting their evolution across cosmic time to learn how black holes influence the growth of galaxies and cosmic structures



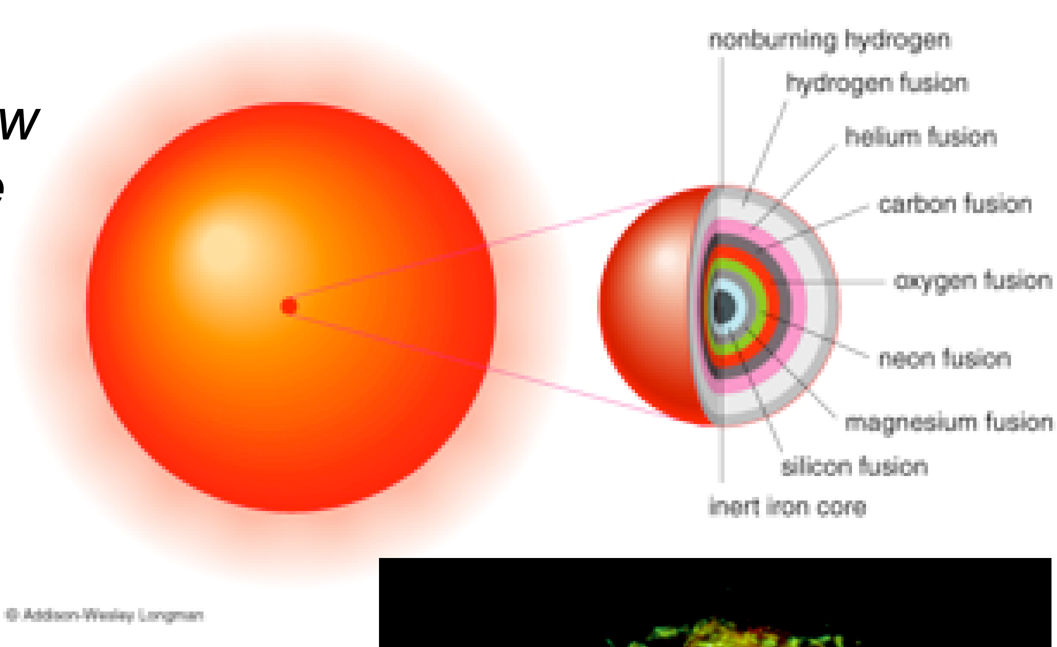
NuSTAR’s map of the hard X-ray sky

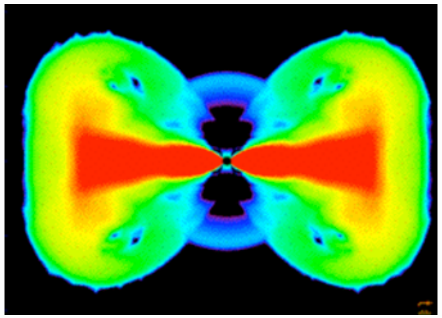


Simulation of one of *NuSTAR*’s survey fields: 2 x 2 degrees in 2 months in NOAO Deep Wide-Field Survey extragalactic field

Goal 2: To map young remnants to understand how stars explode and distribute the elements

NuSTAR will be a new tool for looking inside of a supernova.

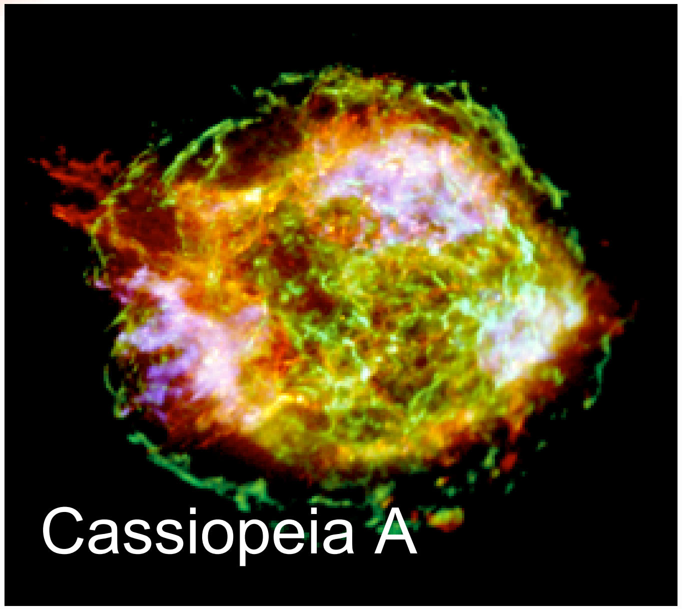




The explosion (theory)

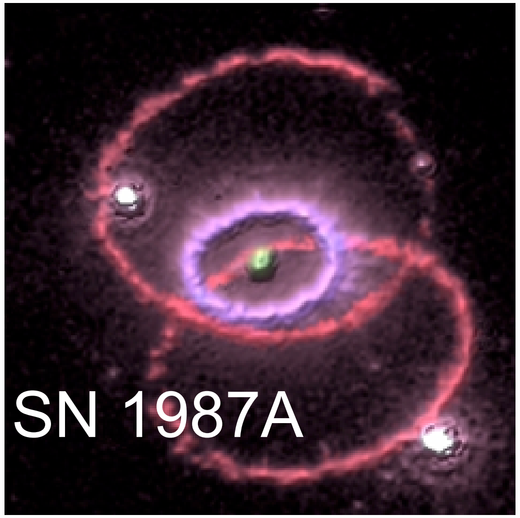
?

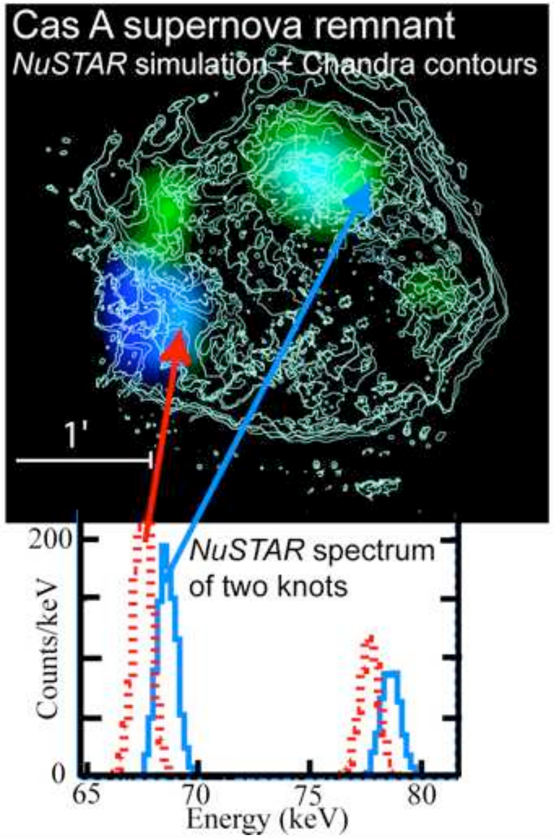
The remnant



How do stars explode and how are the elements made?

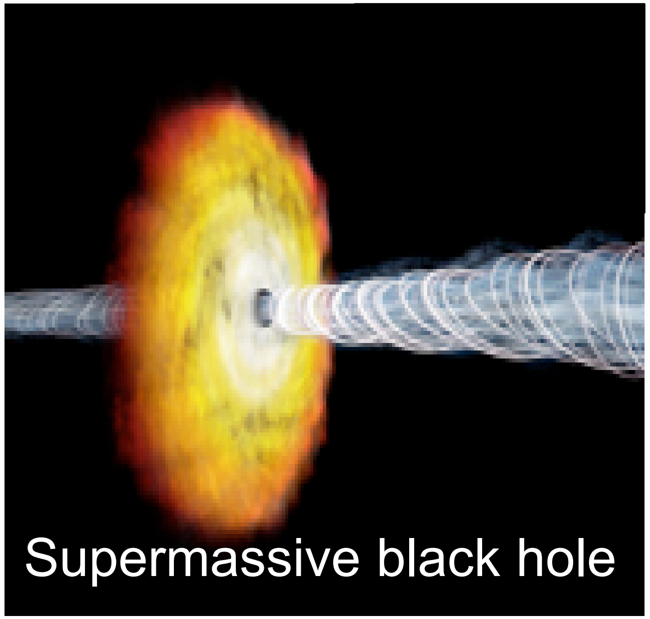
NuSTAR will measure and map (where extended) the ^{44}Ti lines at 68 and 78 keV in historic remnants: Tycho, Cas A and SN1987A (6 months total)





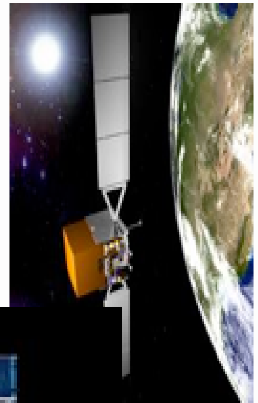
Goal 3: To explore extreme environments

NuSTAR will team with NASA's Gamma-ray Large Area Space Telescope (GLAST) and TeV telescopes to perform "temporal tomography" of giant particle accelerators

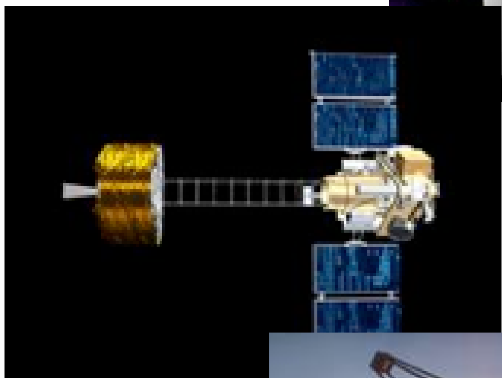


Simultaneous observations with

GLAST



NuSTAR



TeV telescopes

How do giant particle accelerators work; how does matter behave in extreme environments?

Coordinated, pointed observations;
3 months integration

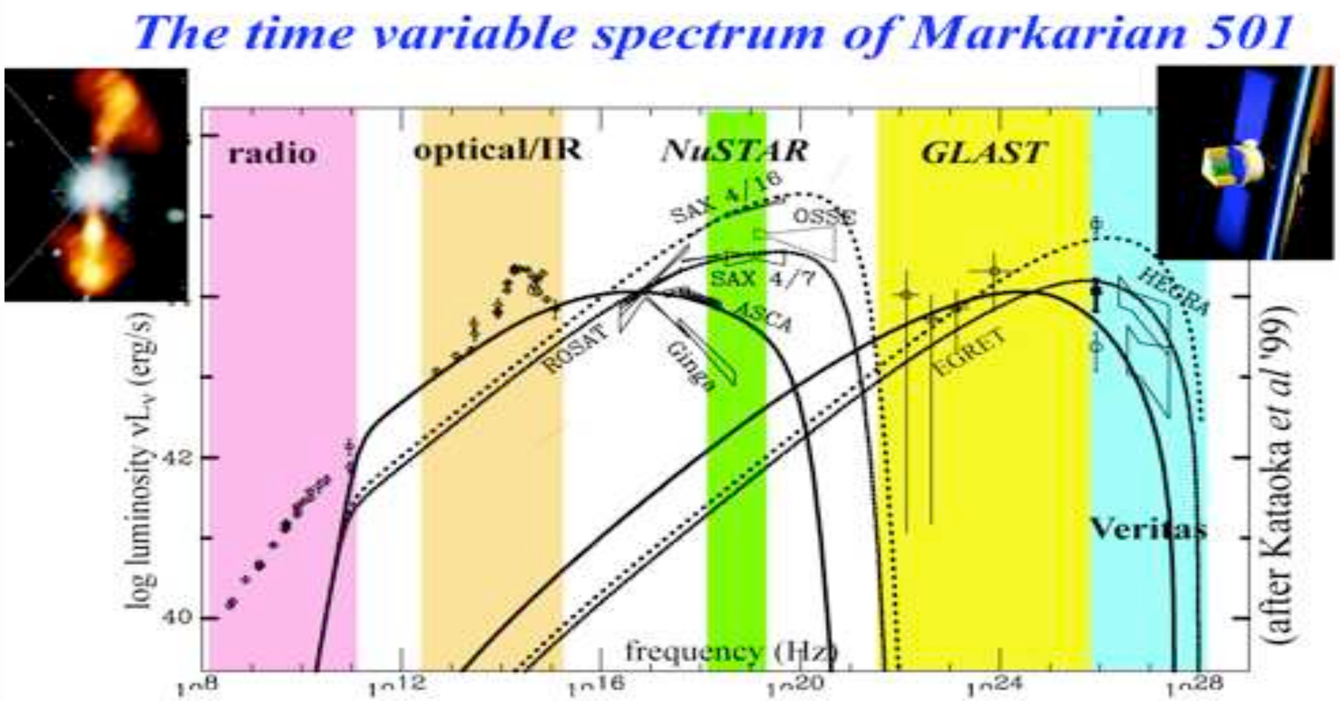
High quality continuous 10-day lightcurves for 5 TeV blazars

High quality 30-day lightcurve sampling for 5 *GLAST* blazars

Positioning of other *GLAST* objects

Hess, Veritas

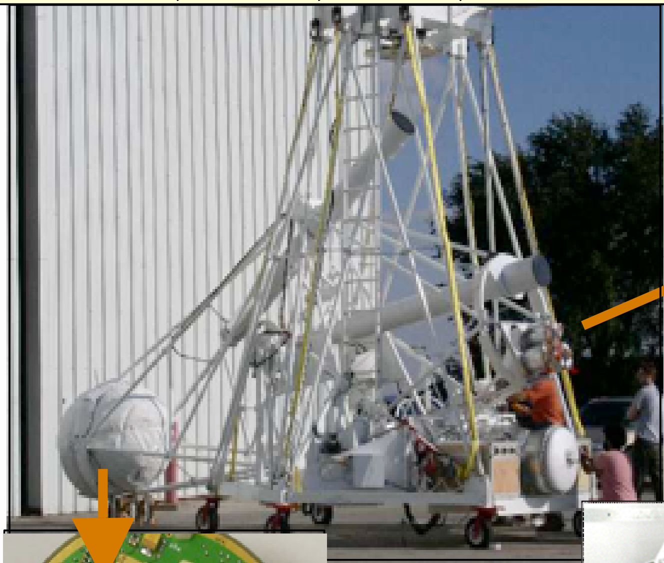
GLAST



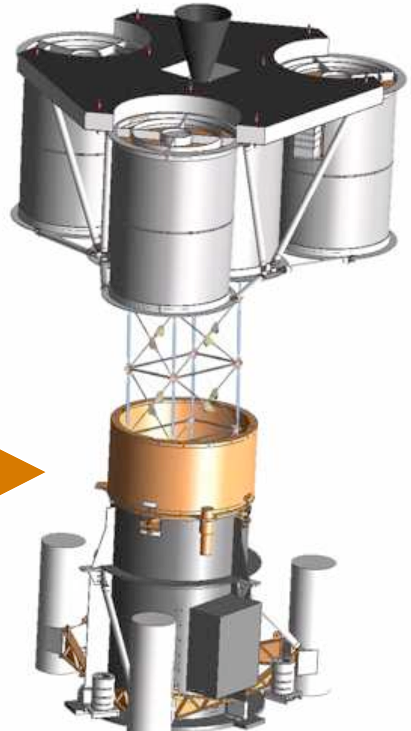
Example: *GLAST's* measurements of Compton radiation in the blazar Markarian 501 are greatly enhanced by *NuSTAR's* simultaneous measurements of the time variable synchrotron peak (SSC model is shown). Together, they strongly constrain physical models.

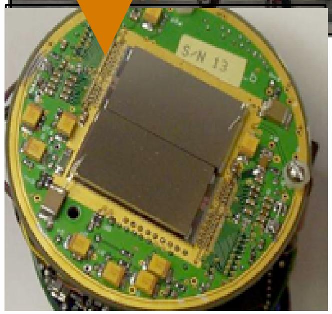
Three key technologies developed by NASA

HEFT Balloon Payload; Caltech, Columbia, DSRI, LLNL, Stanford

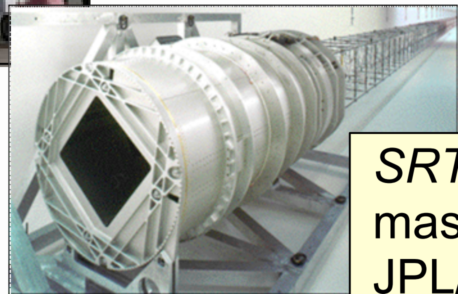


Hard X-ray optics





Solid state hard X-ray detector



SRTM mast JPL/Able

NuSTAR Payload

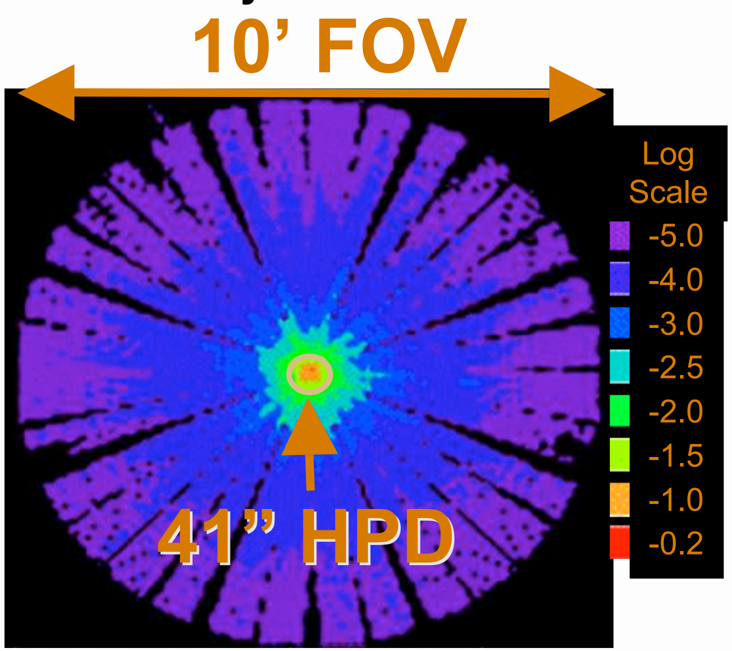
Technologies fully developed by *NuSTAR* team over 10 years. A success of NASA's SR&T program, and the *Shuttle Radar Topography Mission* (*SRTM*).

NuSTAR optics

Formed glass coated with W/SiC (outer layers) & Pt/SiC (inner layers) for response up to 80 keV

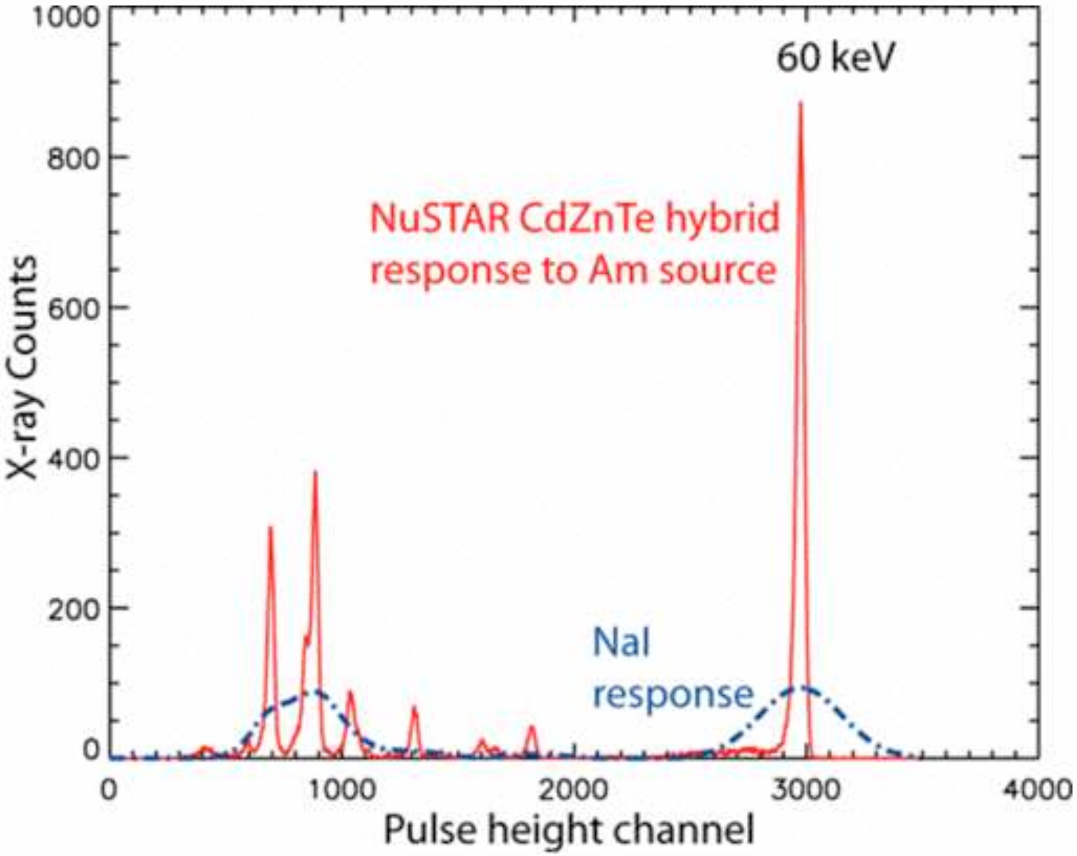
- <1’ HPD (41” nominal) performance based on prototype characterization @ 8 and 40 keV
- Effective area based on measured reflectance vs energy at ESRF synchrotron facility

Recent HEFT flight validates throughput measurements



CdZnTe hybrid resolution

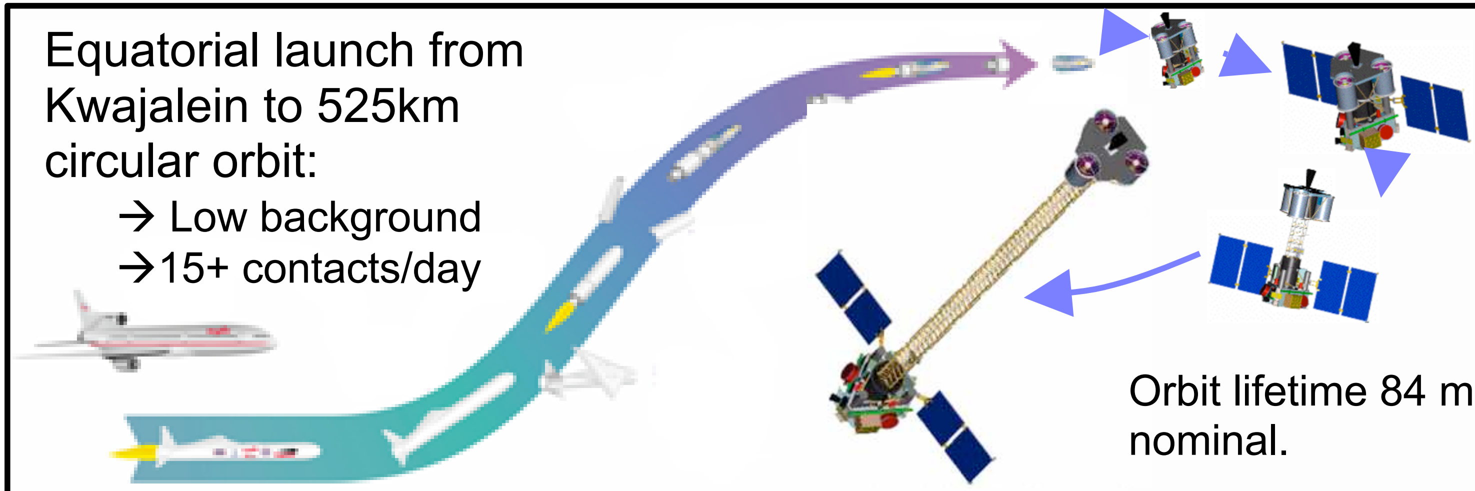
The CdZnTe hybrid: 900 eV FWHM spectral resolution - measure doppler shifts of 1000 km/s for 68 keV ^{44}Ti



NuSTAR mission implementation

Equatorial launch from Kwajalein to 525km circular orbit:

→ Low background
→15+ contacts/day

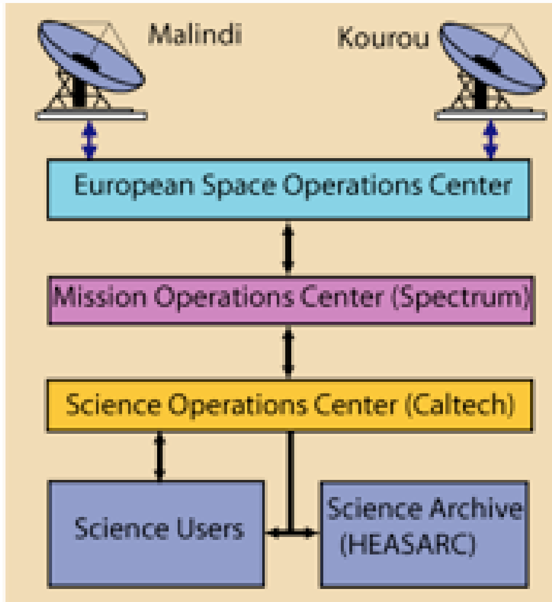


Orbit lifetime 84 months nominal.

<u>Mission Profile</u>:

Long pointed observations of survey fields, specific science targets, TOOs.

Daily data downlinks, infrequent uplinks.

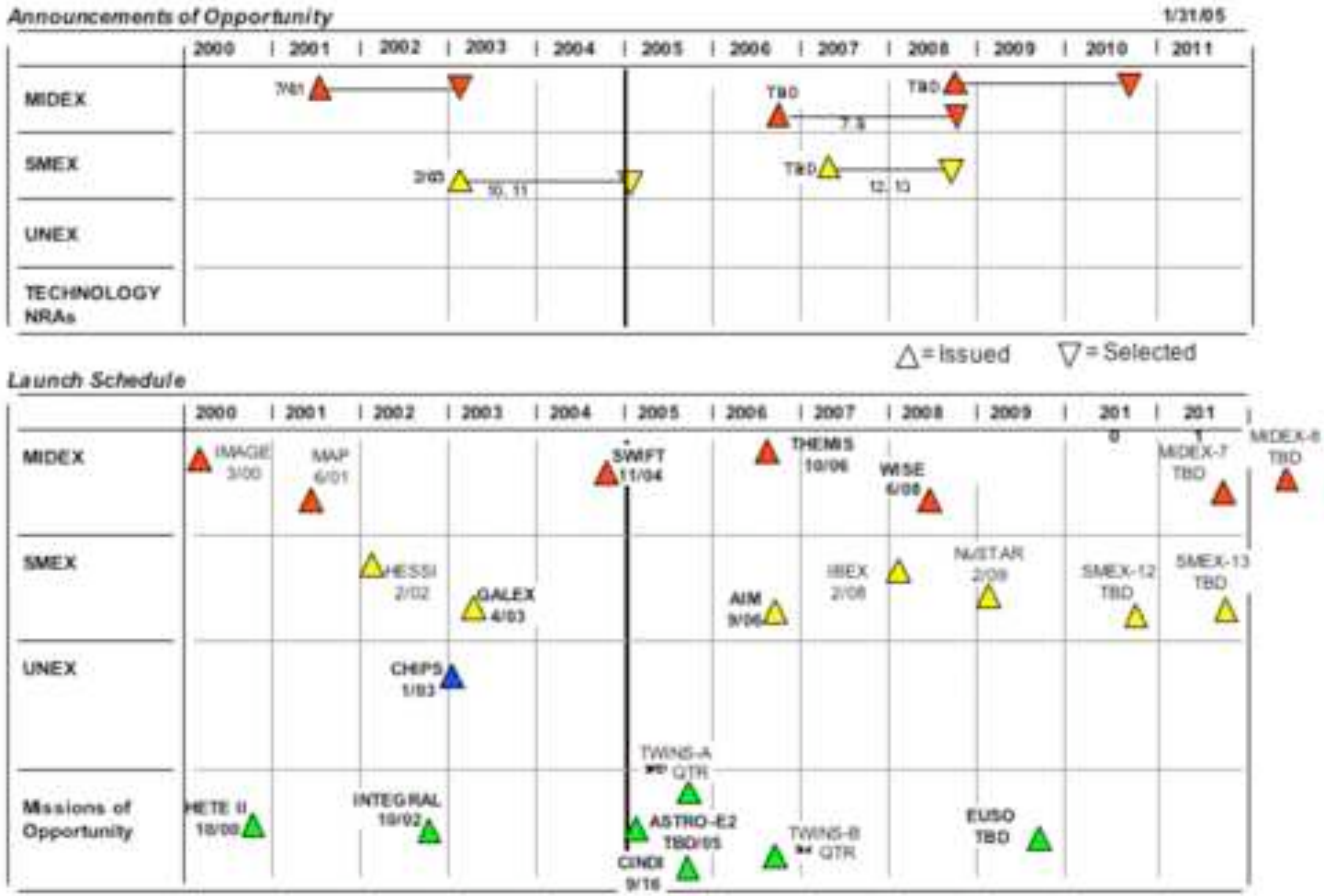


NuSTAR History

- Proposed to NASA SMEX program, June 2003
- Selected as one of five (out of 29 proposals) for competitive Phase A, November 2003
- Selected January 2005
- Currently in extended Phase A, with initial confirmation review in February, 2006
- Scheduled launch, 2/2009

Nuclear Spectroscopic Telescope Array (NuSTAR)

Explorers Schedule



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