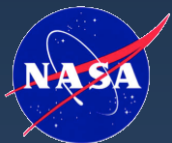




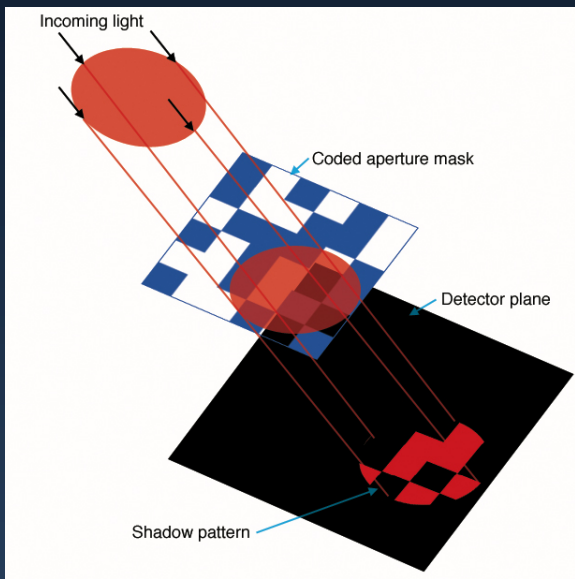
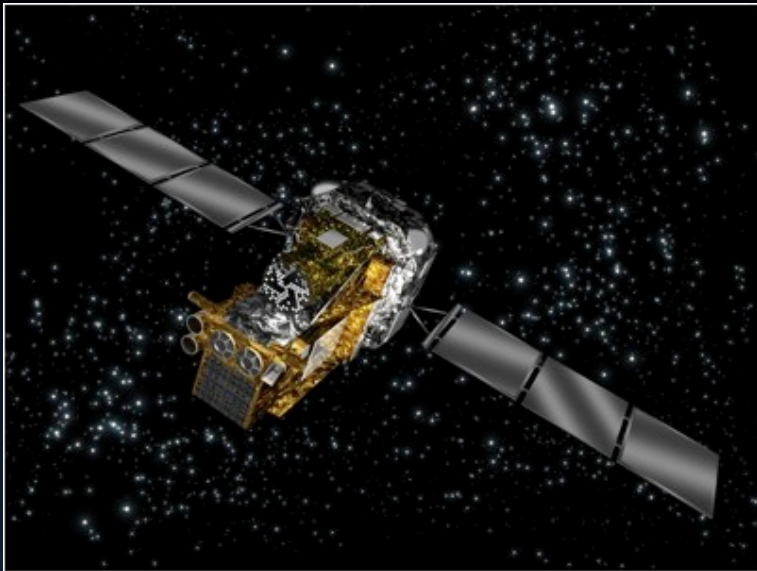
NuSTAR

The Nuclear Spectroscopic Telescope Array
Measuring Obscuration in the Local Universe

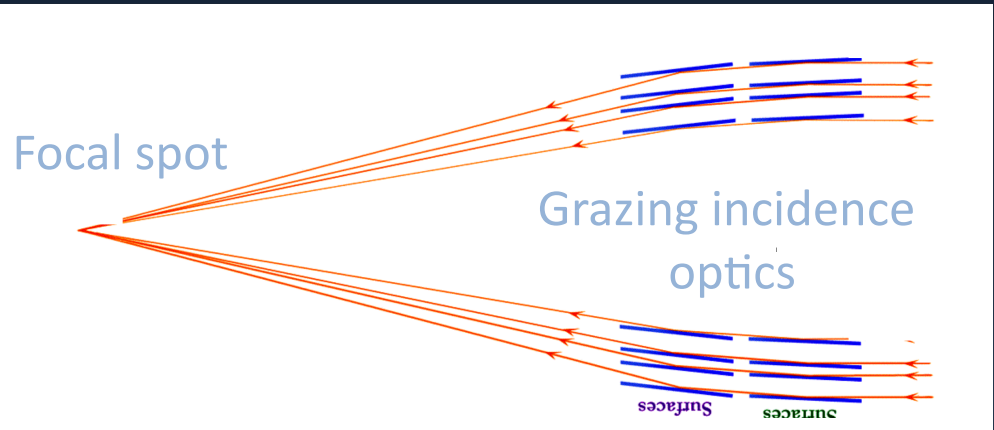
Fiona Harrison

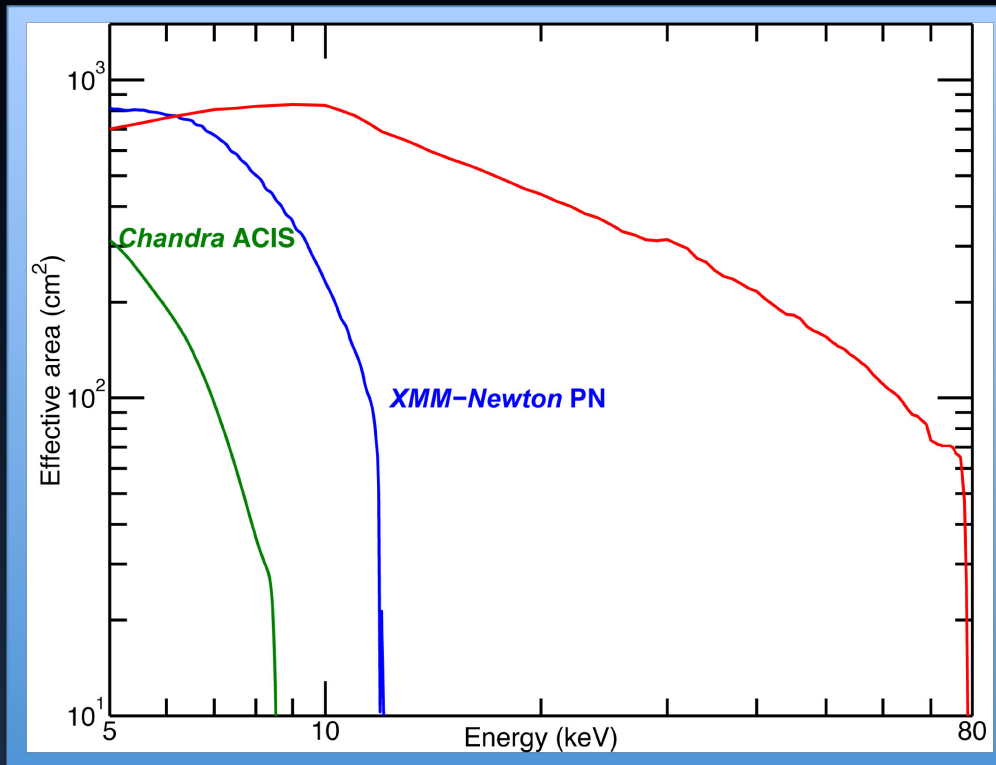


INTEGRAL, Swift BAT



NuSTAR





NuSTAR two-telescope total collecting area

Satellite (instrument)	Sensitivity
INTEGRAL (ISGRI)	~0.5 mCrab (20-100 keV) with >Ms exposures
Swift (BAT)	~0.8 mCrab (15-150 keV) with >Ms exposures
NuSTAR	~0.8 μ Crab (10-40 keV) in 1 Ms

Sensitivity comparison

1 Ms Sensitivity

3.0×10^{-15} erg/cm²/s (6 – 10 keV)
 1.2×10^{-14} (10 – 30 keV)

Imaging

HPD ~50"
FWHM 10"
Localization 2" (1-sigma)

Field of View

FWZI 12.5' x 12.5'
FWHI 10' @ 10 keV
8' @ 40 keV
6' @ 68 keV

Timing

relative 100 microsec
absolute 30 msec

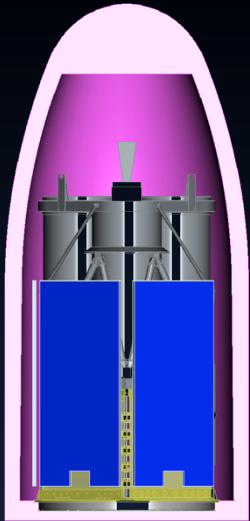
Spectral response

threshold 2.5 keV
 ΔE @ 6 keV 0.6 keV FWHM
 ΔE @ 60 keV 1.0 keV FWHM

Target of Opportunity

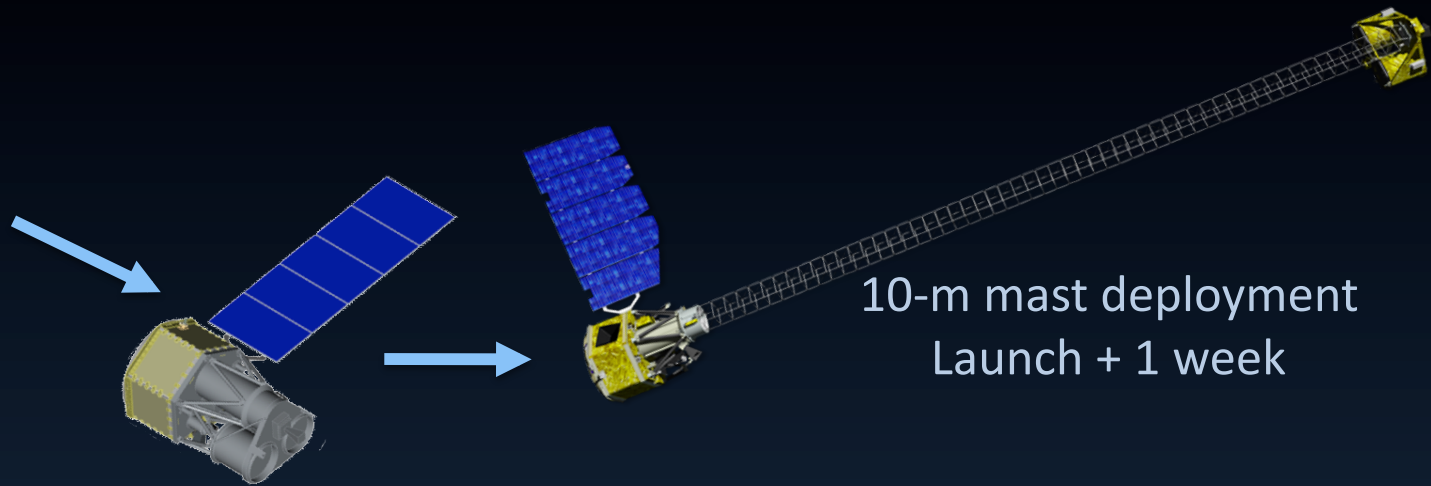
response <24 hr (reqmt)
typical 6-8 hours
85% sky accessibility

Mission Profile

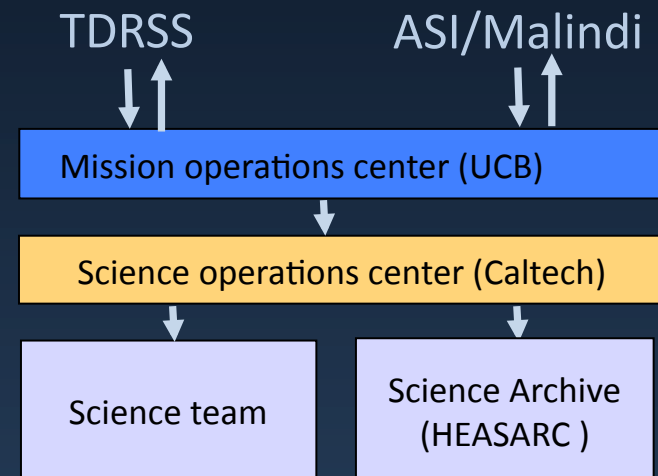


Pegasus XL
Feb 3 2012

6° inclination 550 x 600 km
Low background
55% observing efficiency



10-m mast deployment
Launch + 1 week



2-year baseline science mission

Baseline Science Mission

Key science goal	Observations	Time (weeks)
Locate massive black holes	Deep and wide-field extragalactic surveys (GOODS S, COSMOS, BAT-shallow)	23
Study the population of compact objects in our Galaxy	Survey Galactic Center and other fields of varied ages (spiral arms, bulge)	20
Explosion dynamics and nucleosynthesis in core collapse and 1a SNe	Pointed observations of young ($\tau < 500$ yr) remnants – Cas A, SN1987A, GX1+9 ToO observations of nearby SN1a	22
Understanding relativistic jets in supermassive black holes	Contemporaneous multiwavelength observations of GeV/TeV blazars	6
Other Objectives	Observations	Time
Varied	In final planning stage	33

Extragalactic Surveys

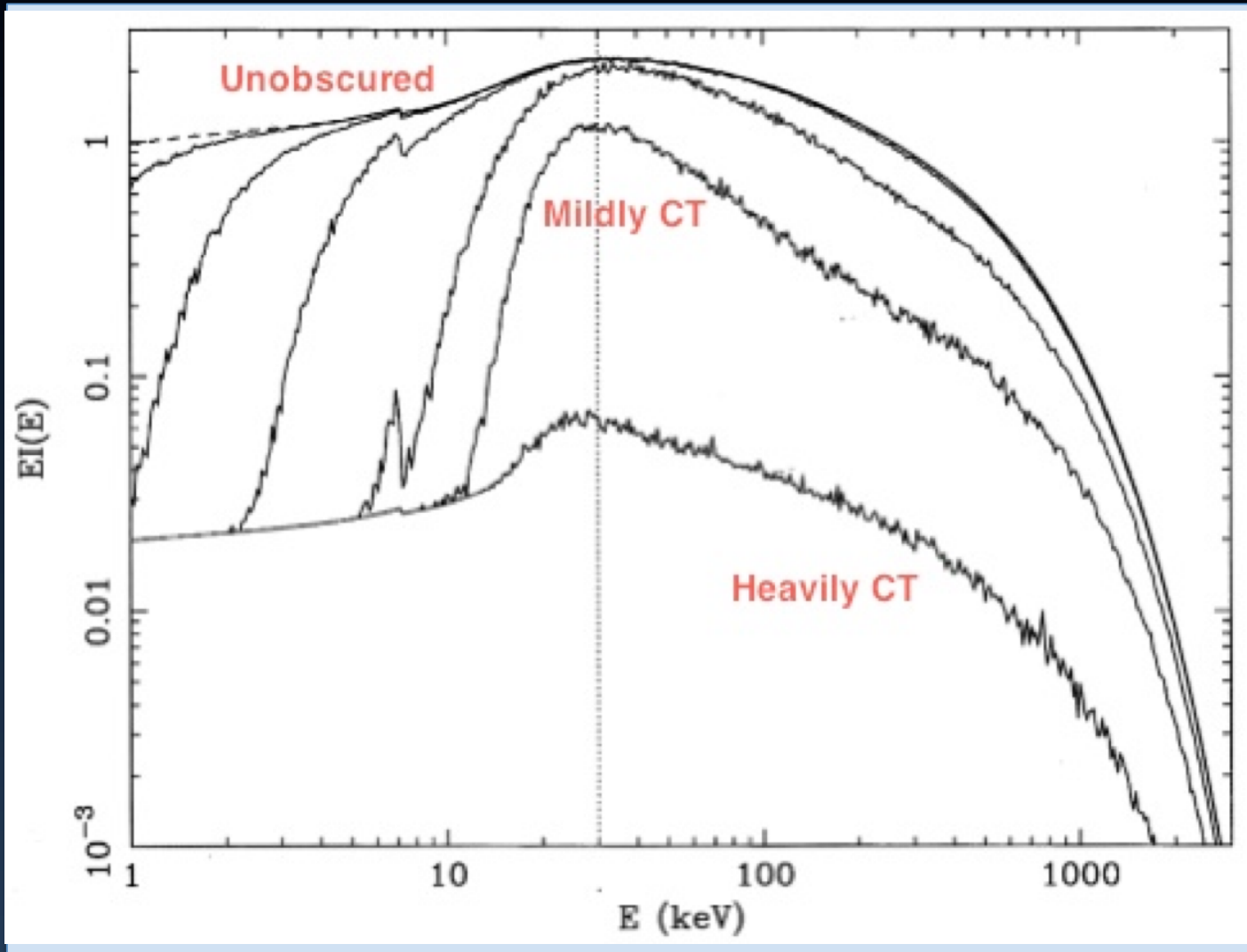
How did black holes grow as a function of redshift?

Does the obscured AGN fraction increase with redshift
(from $0 < z < 2$)?

Do the most heavily obscured AGN reside in specific
host-galaxy environments?

What AGN populations dominate the X-ray
background at 30 keV?

X-ray Absorption in AGN



Extragalactic Survey Fields

COSMOS+E-CDFS-S - > 1 deg² @ > 50ksec/pixel

$L = 10^{44}$ erg/s (10 – 30 keV) to $z \sim 2$, $L = 10^{42}$ erg/s for CDFS

AGN/host evolution up to $z \sim 2$

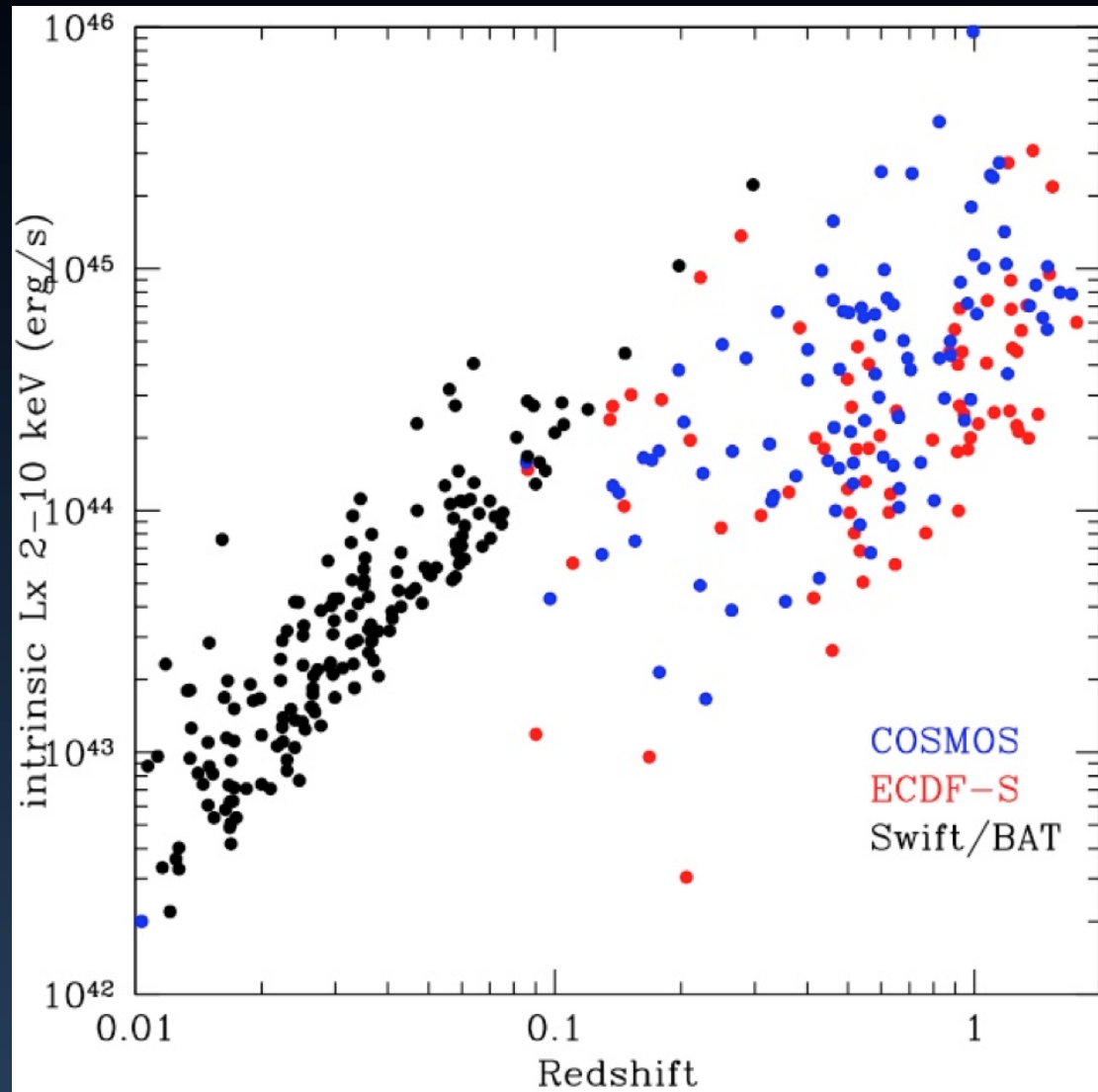
BAT sources @ 5ksec/exposure to cover 3 deg² to $L \sim 10^{13}$

Constrain the spectral characteristics of the local AGN population

Serendipitous survey connecting BAT/INTEGRAL to NuSTAR

See Ballantyne et al. 2011 ApJ

Extragalactic Surveys



High SNR Observations of Obscured AGN

Understand the nature of absorbing medium in obscured AGN

geometry, size, composition, (existence) of torus

Study range of known nearby objects ranging from Compton thick to obscured

NGC 1068, NGC 7674, NGC 3393 (HCT)

Mrk 3, Ciercinus, NGC 4945 (MCT)

NGC 1365m NGC 1365 (BCT)

What is the AGN Contribution to ULIRGS?

“IR Quasars”

trace building of stellar mass in galaxies

1000x more common at $z > 2$ than today

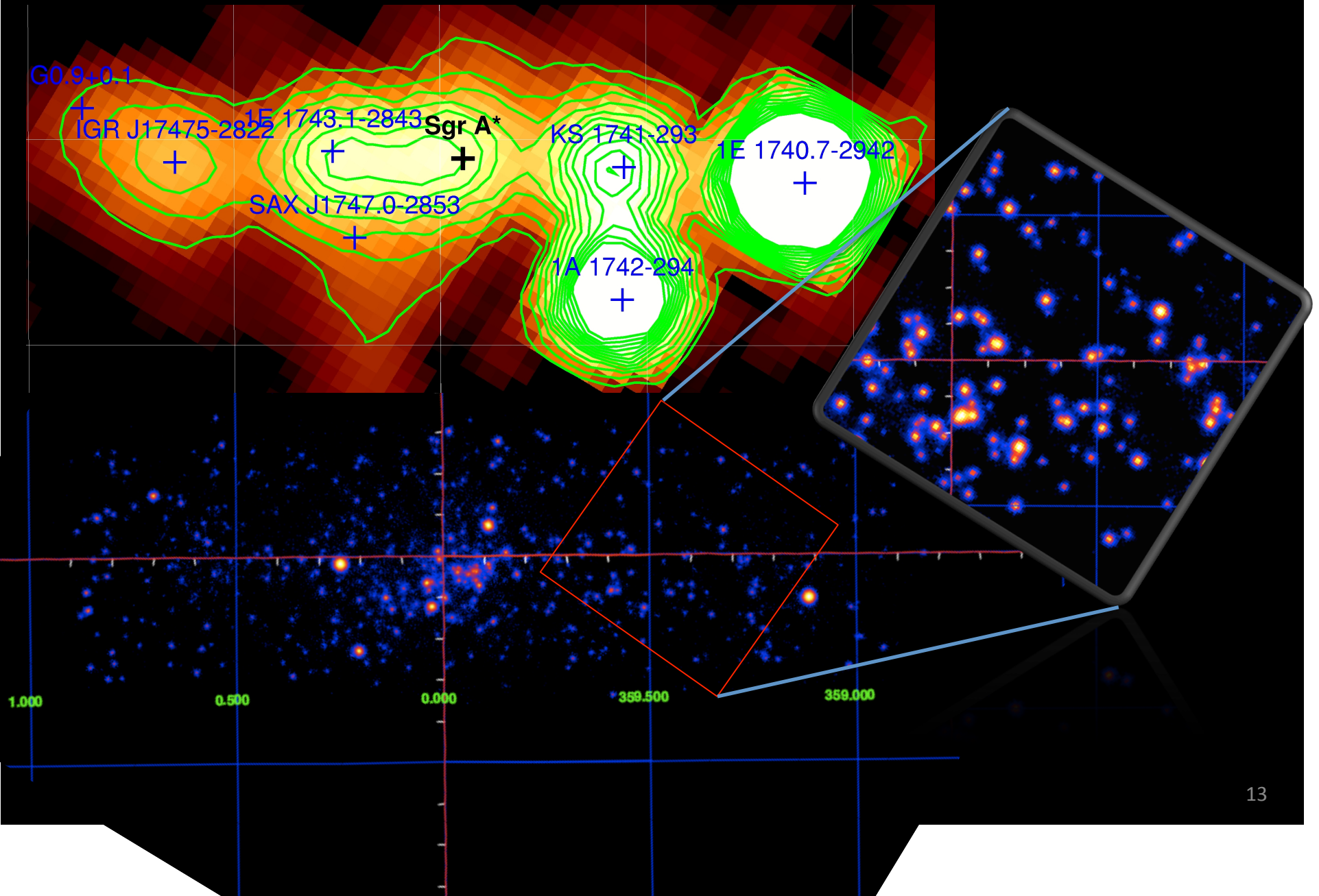
At $z > 2$ – average star forming galaxy is a ULIRG

What makes ULIRGs shine?

Need extinction-robust way to measure AGN luminosity

Sample of 15 nearby ULIRGs to determine AGN contribution

Galactic Surveys



Population Studies

Galactic chronology/understanding evolution/end states of binaries - HMXBs (~ 10 MYr) CVs (Gyr)

Spiral arms (Norma) vs. GC vs. Bulge

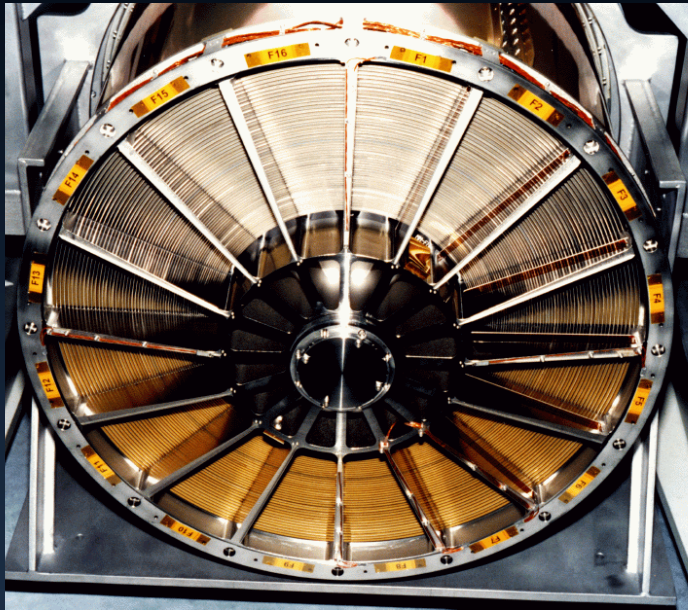
Fraction of HXMBs with BH vs. NS

Estimating NS/NS, SN/BH, BH/BH populations

“Other” Science

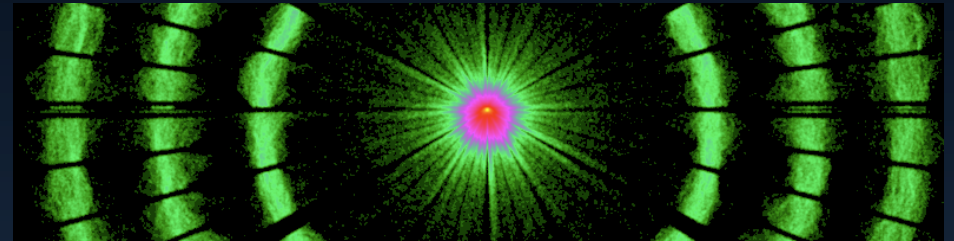
- Planetary Wind Nebulae
- Supernova Ia ToO
- Magnetars
- X-ray Binaries
- Pulsars
- Gamma-ray binaries
- Flaring protostars
- Sun
- AGN physics
- Starburst galaxies
- Galaxy clusters
- Blazars
- Radio galaxies
- Ultra-Luminous X-ray Sources

Optics

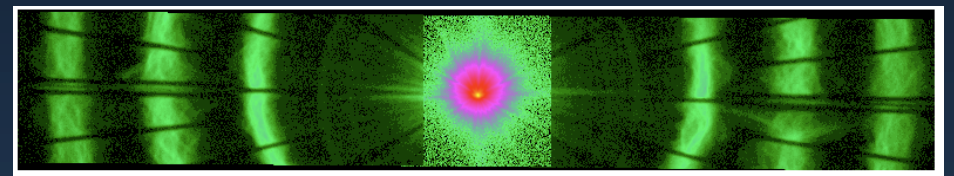


Depth-graded multilayer coated optics – 133 shells

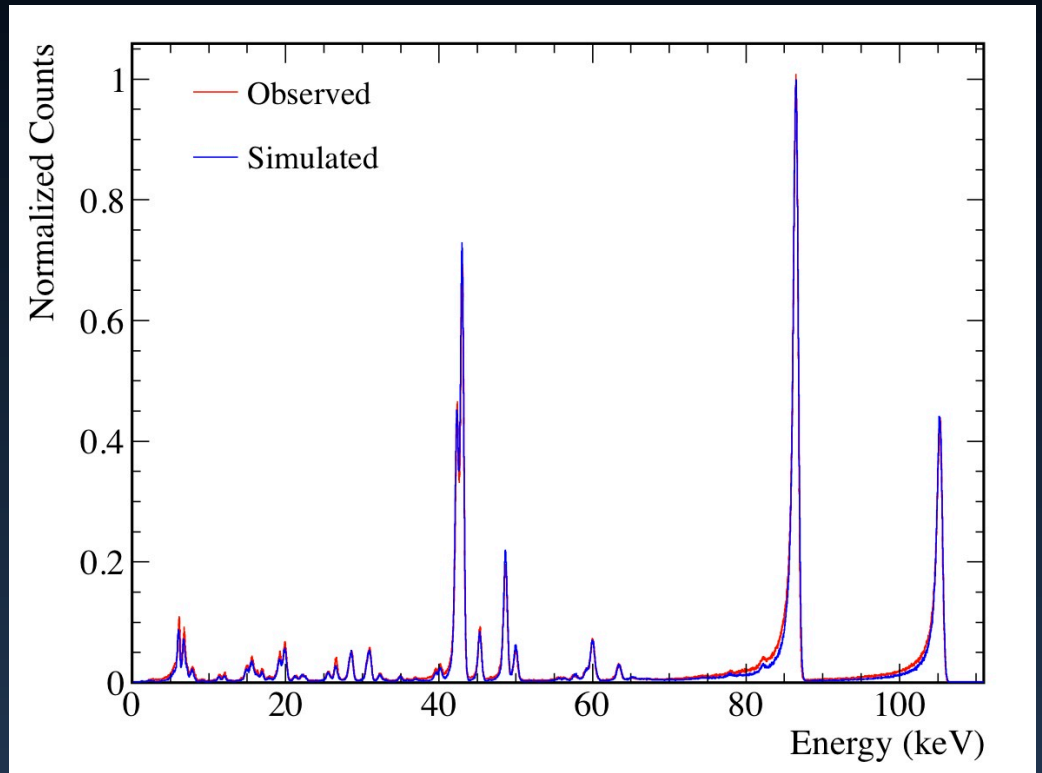
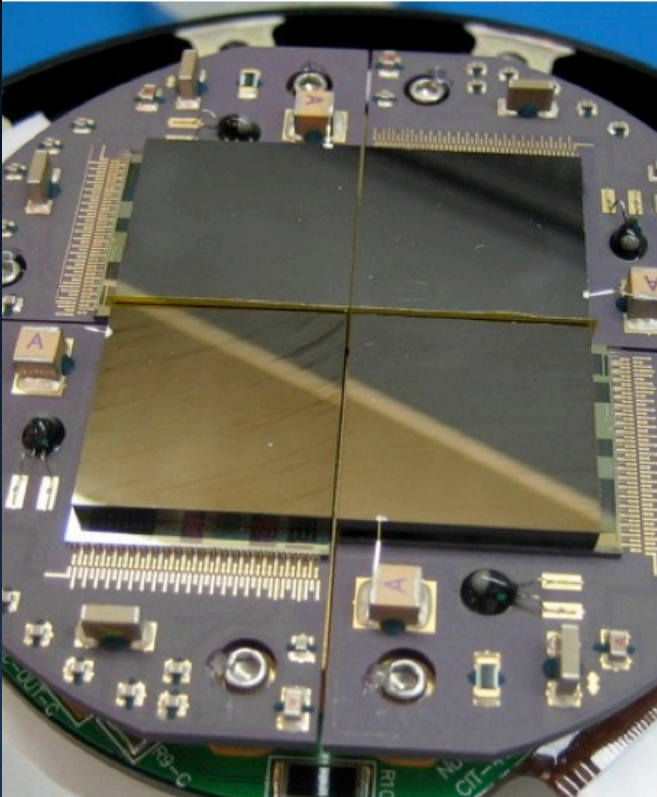
Simulated

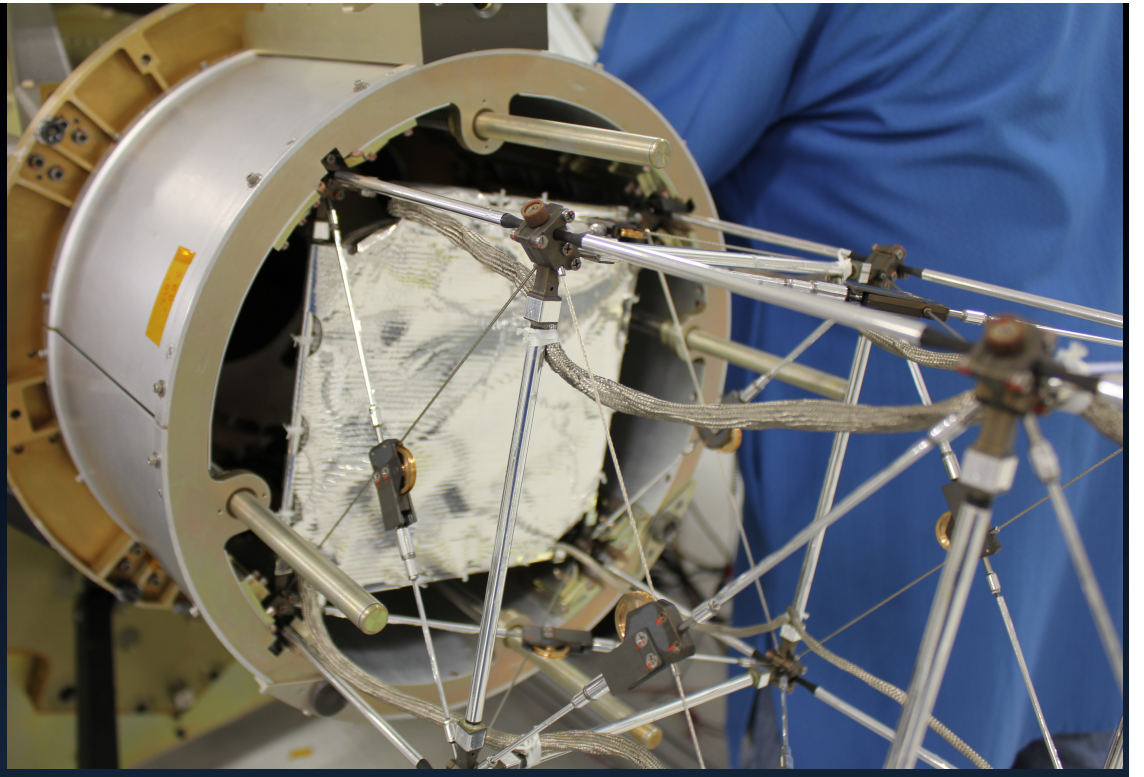
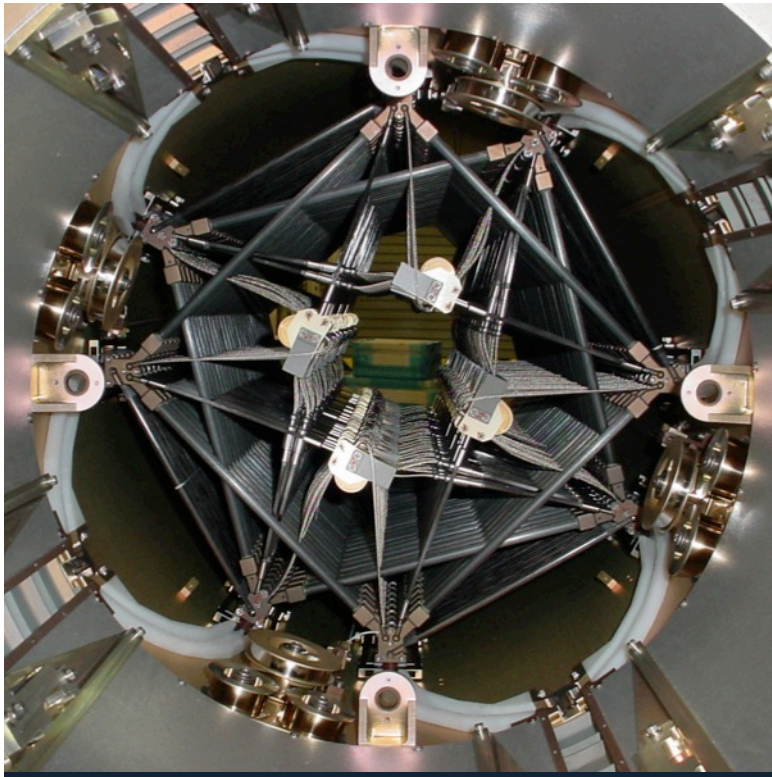


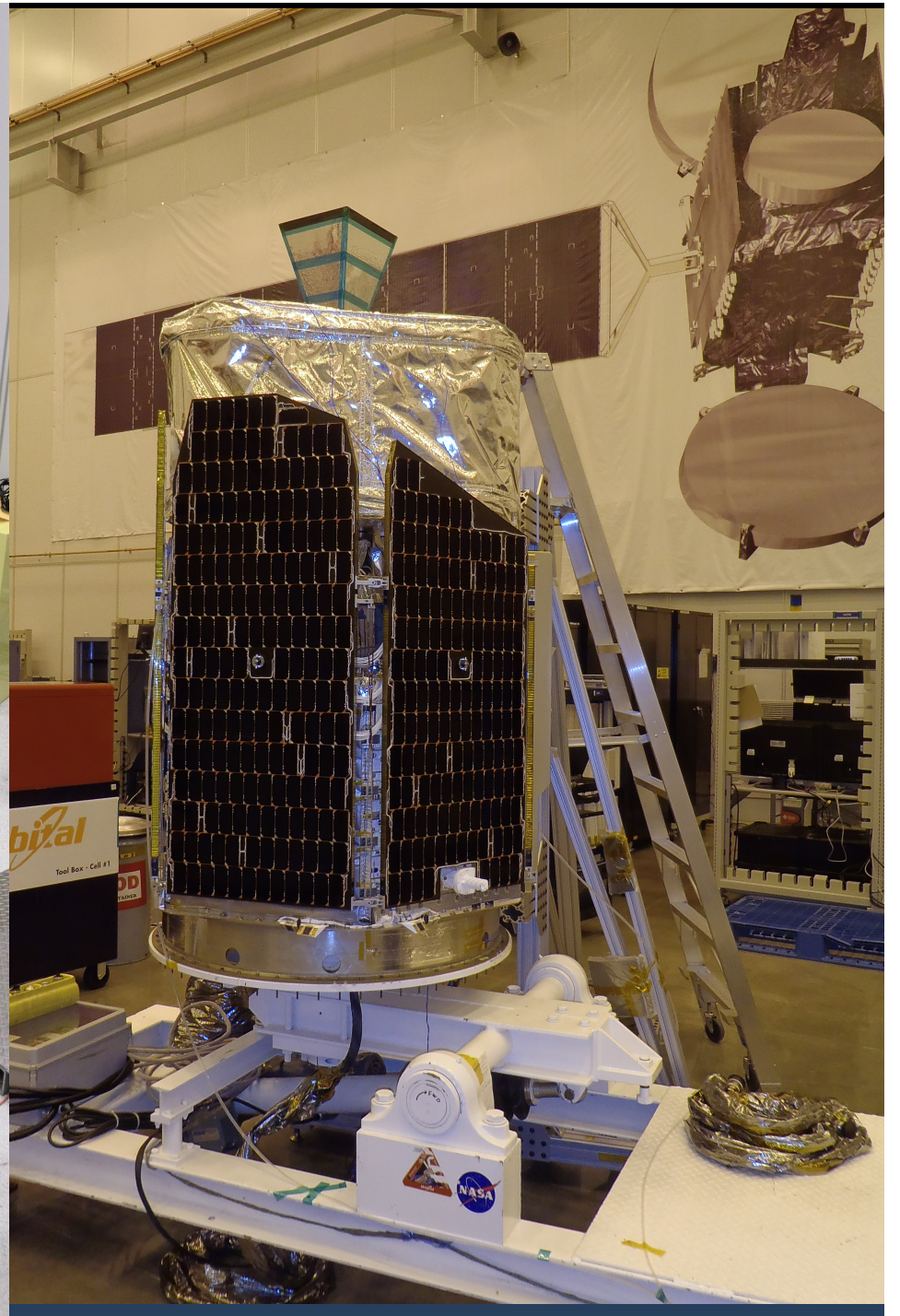
Calibration data



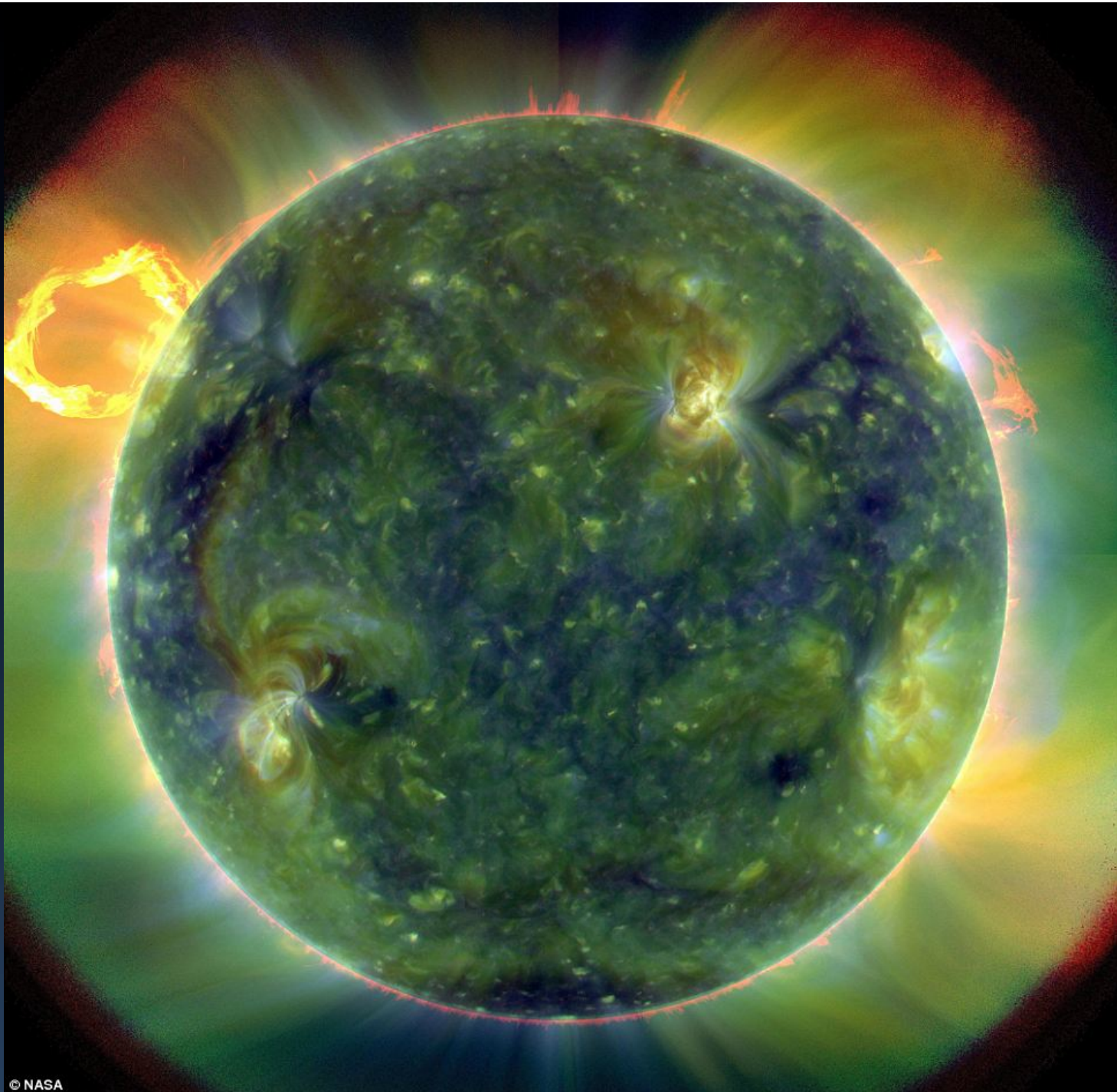
Focal Plane



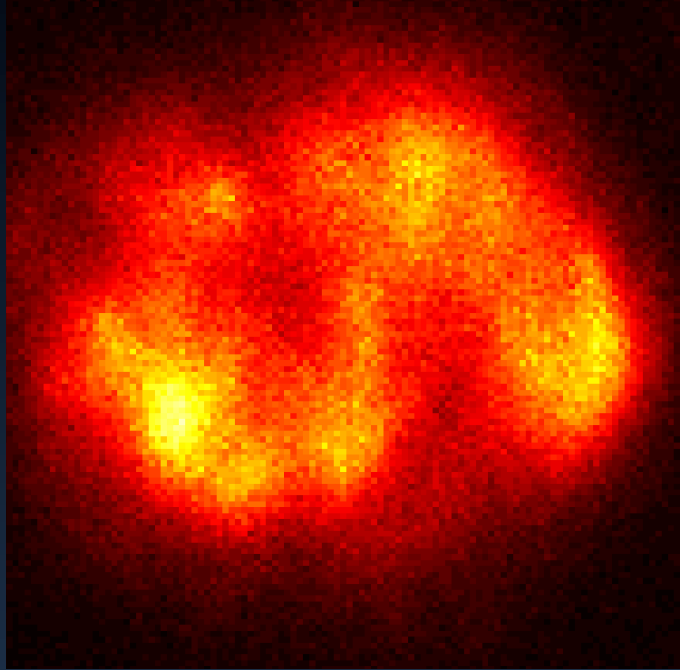




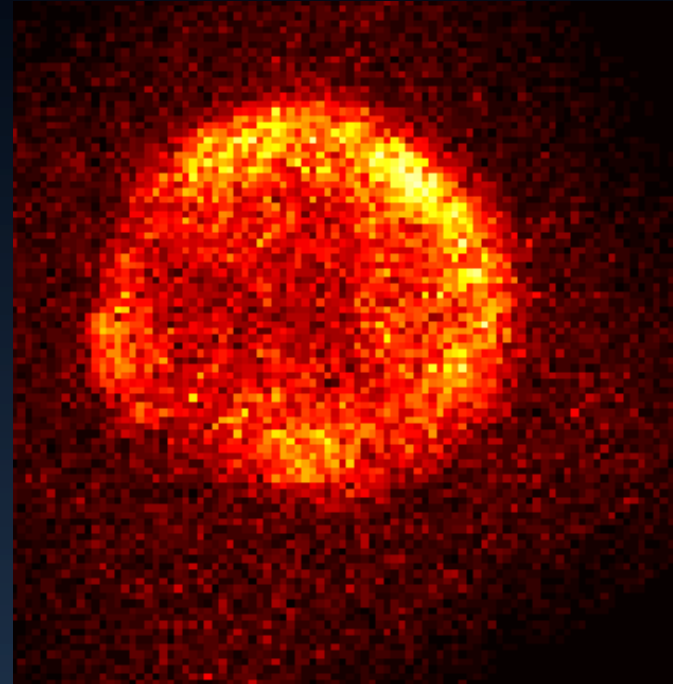
<http://www.nustar.caltech.edu>



Supernova Remnants



Cas A (> 10 keV) 1 Msec



Tycho (> 10 keV) 200 ksec

See poster by Zoglauer et al.