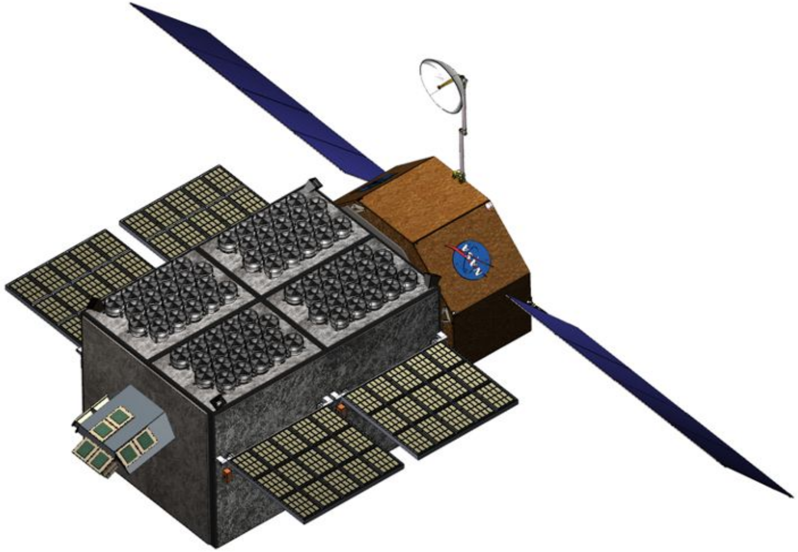
STROBE-X

Revealing fundamental physics via the life cycles of compact objects and the dynamic Universe



https://strobe-x.org

Science Overview

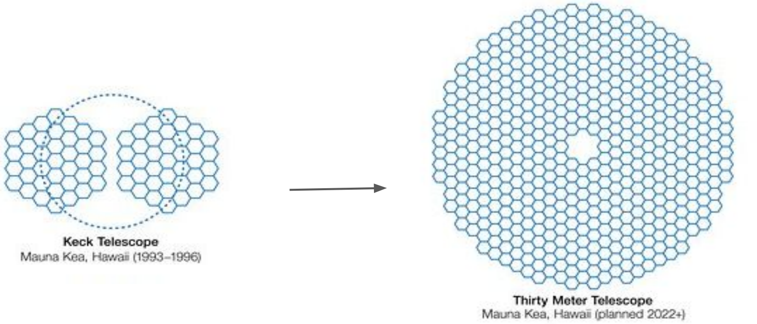
STROBE-X will measure the most fundamental physical parameters of compact objects, revealing how they form, grow, and die; and will be a critical high energy component of the decade of time domain surveys.

- STROBE-X will uniquely **apply multiple techniques to constrain mass and spin for both stellar and supermassive black holes**.
- STROBE-X will make **precise measurements of neutron star radii** and probe their spin evolution up to the fastest rates.
- STROBE-X will **monitor the X-ray sky for transients and variability** that will reveal multi-messenger counterparts, trigger pointed observations, and characterize long term evolution of sources.

Also contributes more broadly to stellar physics, galaxy groups and clusters, accretion physics, and even some Solar System science.

STROBE-X

Transformational Capabilities



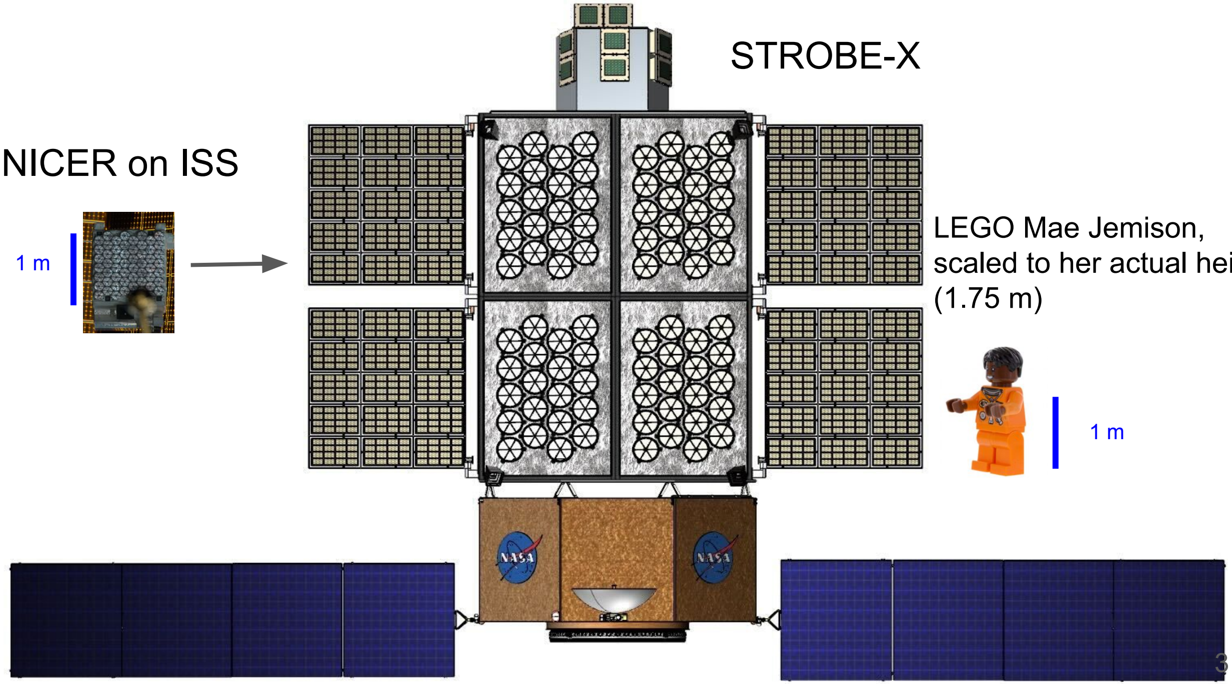
Order of magnitude improvement in sensitivity, effective area, and throughput

Detailed understanding comes from high photon rates and requires collecting area and ability to handle bright sources.

NICER on ISS

1 m

STROBE-X



LEGO Mae Jemison, scaled to her actual height (1.75 m)

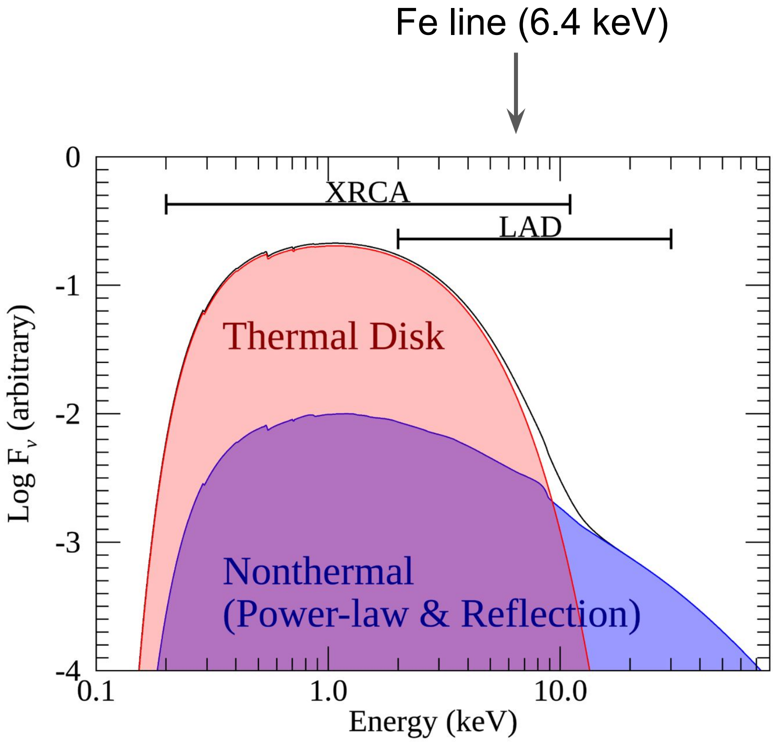
1 m

STROBE-X

Transformational Capabilities

Simultaneous broad-band coverage of **both soft and hard X-ray bands** with similar sensitivity

A **highly responsive and flexible observatory** with these capabilities will enable a tremendous breadth of science and serve a large community



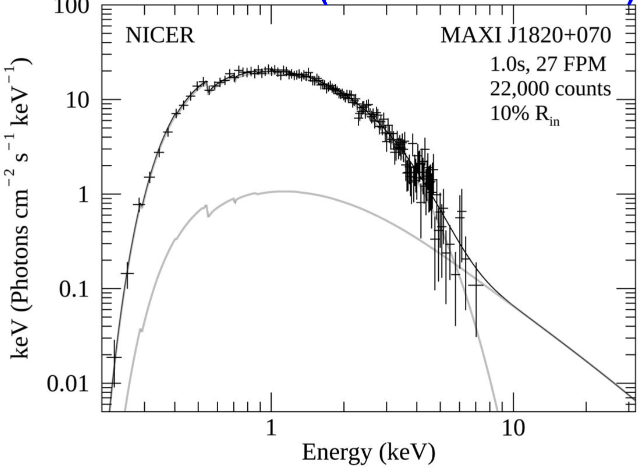
STROBE-X

Transformational Measurements

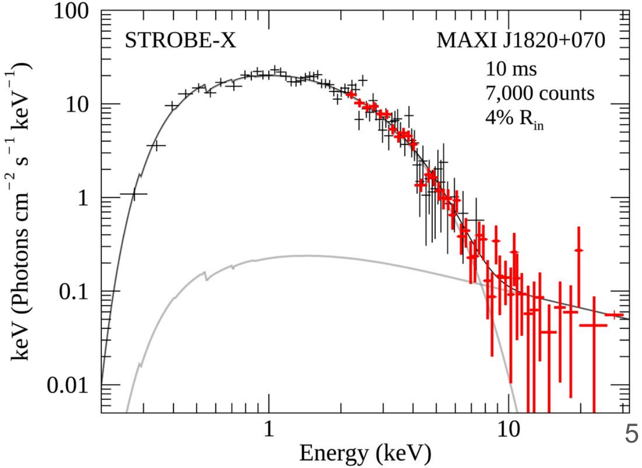
Probe an extreme dynamic range in **timescales** (microseconds to years, with dense sampling - not just occasional visits) and **fluxes** (from faint pulsars to the brightest sources in the sky).

Transform from individual spectra to **spectral "movies"** of what is going on at the dynamical timescales in many sources. You must have the collecting area to make measurements on short timescales (jet launching, recombination, state change, spin period, precession period).

NICER in 1 second (viscous timescale)



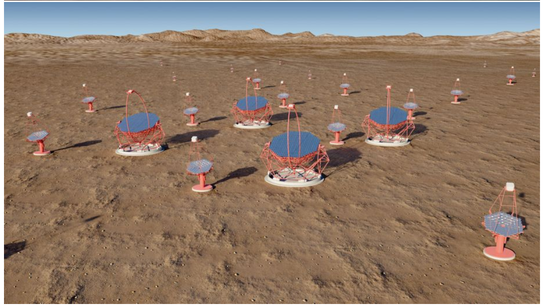
STROBE-X in 0.01 s (dynamical timescale)

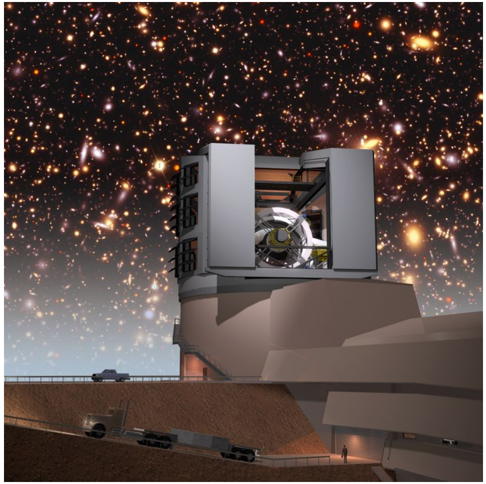


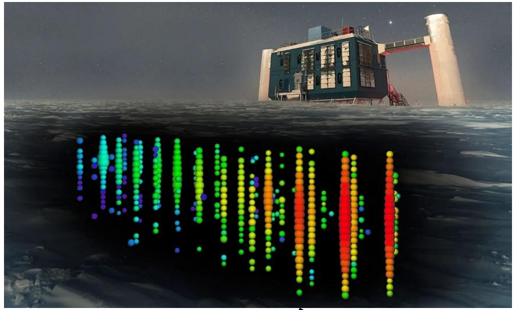
STROBE-X

Powerful synergies with upcoming facilities multiply science return

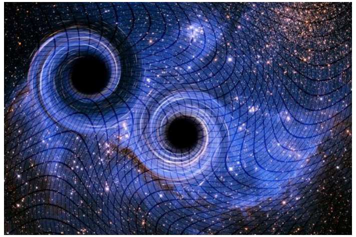
Bright source capability and high throughput will ***validate black hole spin measurement techniques****, enabling Athena to apply lower-count-rate methods with confidence.*





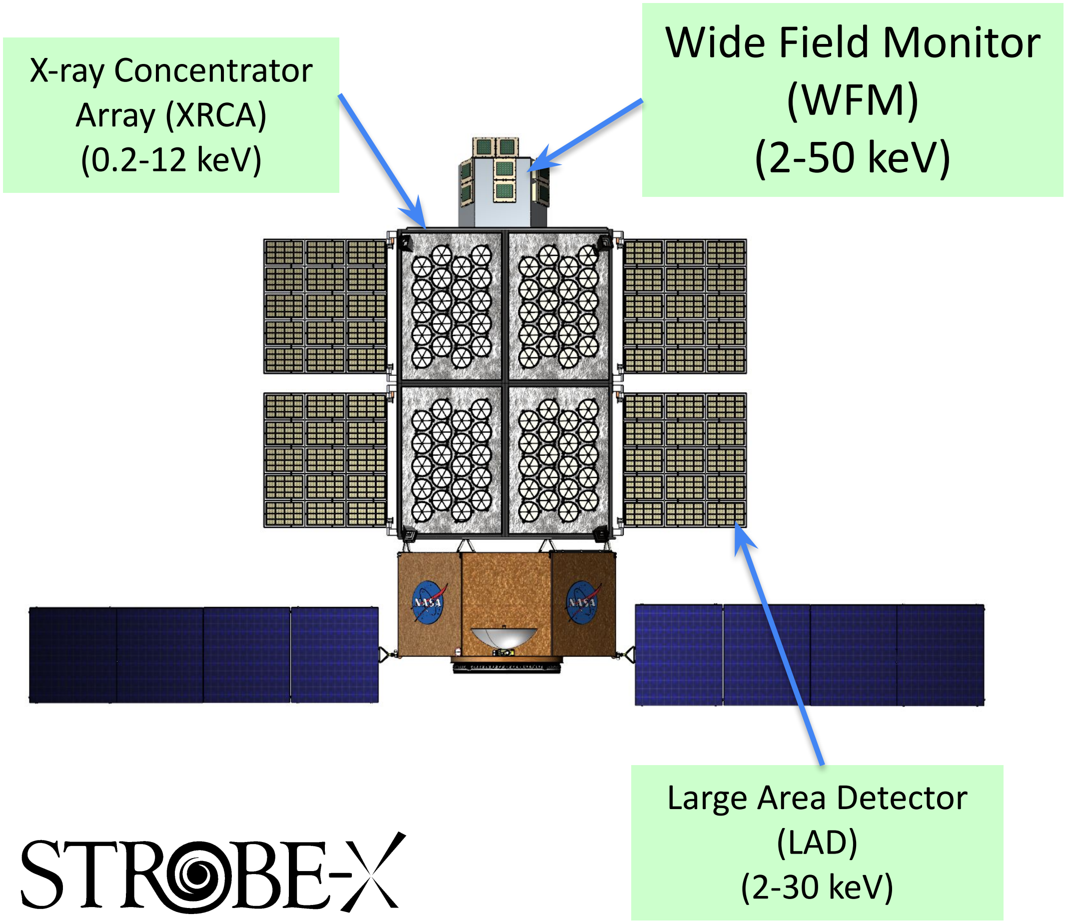


Instantaneous wide field sensitivity, along with deeper monitoring capability from pointed instruments, make STROBE-X the ***ideal partner for wide field transient surveys*** *from radio, through optical, gamma-rays to neutrinos and gravitational waves.*



STROBE-X

Mission Implementation

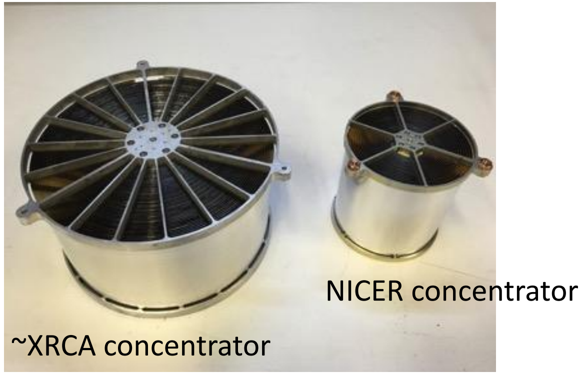


- Combines **wide field monitoring** with **two narrow FOV instruments** covering soft and hard X-ray
- Component technologies already available with **high heritage** from prior missions
- Highly **modular design improves reliability** at reduced cost and allows easy scaling, and integration schedule flexibility
- **No moving parts** after deployment other than solar panels
- **LEO** orbit at low inclination
- Agile spacecraft with rapid slew and autonomous repointing
- CONOPS:
  - Pointed observations scheduled and uploaded regularly (daily–weekly)
  - WFM triggers or other TOOs can temporarily interrupt planned observations

STROBE-X

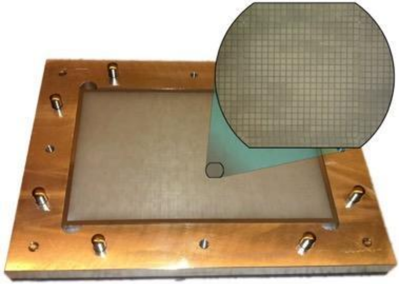
X-ray Concentrator Array (XRCA)

- Scaled up version of NICER concentrators with NICER SDDs
    - Focal length of 3 m for enhanced throughput >2.5 keV
    - Inexpensive single-bounce foil optics: large areas w/ low background
    - Energy resolution: 85-175 eV FWHM
    - 80 XRCA units gives effective area @ 1.5 keV: >2.0 m^2 **(> 10X NICER)**
- Low background, high throughput
- Sensitive timing and spectroscopy of thermal emission and iron line region



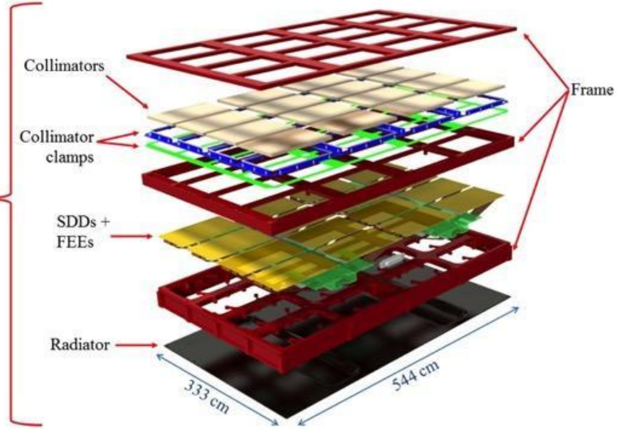
Large Area Detector (LAD)

Silicon Drift Detector (SDD)



Glass micropore collimator

LAD module

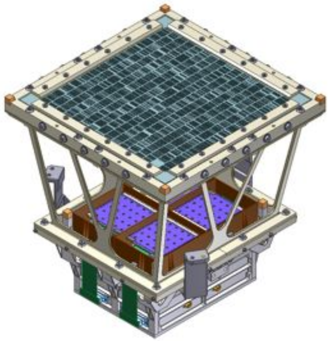


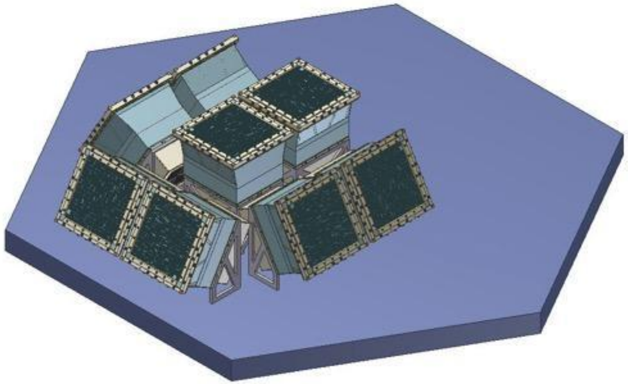
- Based on SDDs and lightweight microcapillary plate collimators developed for ESA's LOFT
  - Energy resolution: 200–500 eV FWHM
  - 60 modules gives effective area @ 6.4 keV **>6 m^2** (**~10x RXTE**)
- High time resolution and good energy resolution over the **2–30 keV** range
  - Optimized for sensitivity at the iron line, with resolution to resolve and counts to measure photon lags
  - Best sensitivity to QPOs, burst oscillations and other phenomena most prominent in harder X-rays
  - Sensitive to non-thermal emission and Compton hump

STROBE-X

Wide Field Monitor (WFM)

- SDDs similar to LAD with finer pitch
- Energy resolution: 300 eV FWHM
- 1.5D wide-field coded mask imager
- Two cameras rotated by 90° give 2D positions
- Four camera pairs give **instantaneous FoV: >1/3 of sky**; 50% of sky accessible to LAD
- 1 day sensitivity of 2 mcrab, with source localization of 1 arcmin
- **Continuous viewing, not scanning** gives sensitivity to transients from milliseconds to years
- Identifies new transients and source states for main instruments, while monitoring long-term source behavior for a large fraction of the sky
- Onboard processing can **trigger autonomous repoint** for GRBs, supernova shock breakouts, superbursts, etc.





STROBE-X

Current Status

- Our plan had been for GSFC to be the lead center for STROBE-X. They did not have sufficient internal resources to do so, despite recognizing the scientific merit and technical maturity of our proposal.
- We are organizing a partnership with SwRI to take over as PI to lead the proposal and manage the program. SwRI has proven capabilities to run large NASA programs, e.g. New Horizons and Lucy missions.
- The STROBE-X science team is active and going strong, under Tom Maccarone’s leadership.

Mission & Instrument Parameters

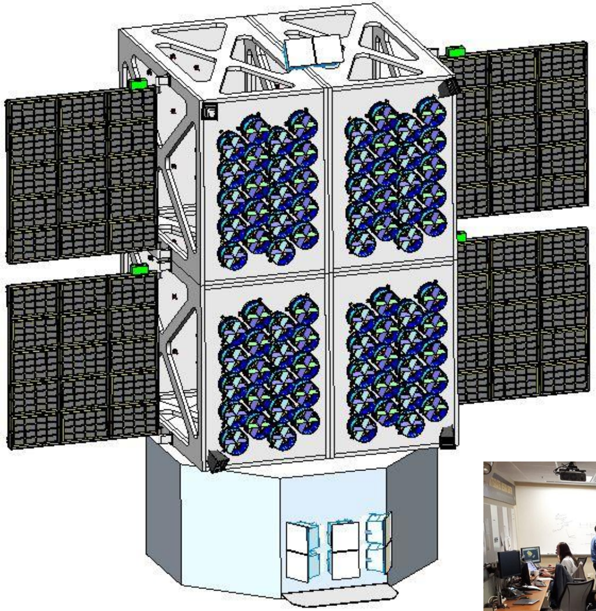
STROBE-X	
Total Mass	4998 kg
Orbit	LEO, 550 km altitude, 10° inclination
Total Power	3141 W
Attitude Control	3-axis stabilized, slew 15°/min
Solar Avoidance	45 deg
Total Cost (FY18 $)	$880M
Wide Field Monitor (WFM)	
# of Camera Pairs	4
FOV/Camera Pair	70° × 70° FWHM
Energy Range	2–50 keV
Energy Resolution	300 eV FWHM
Sensitivity (1 s)	600 mcrab
Sensitivity (1 day)	2 mcrab
Sky Coverage (Instantaneous)	4.1 sr
Angular Resolution	4.3 arcmin
Position Accuracy	1 arcmin

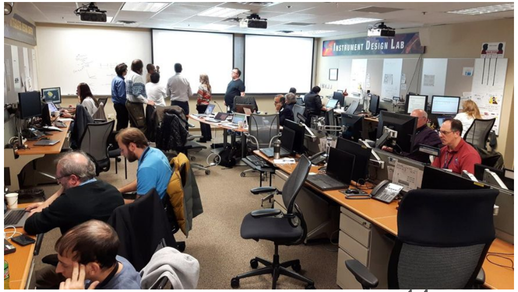
X-ray Concentrator Array (XRCA)	
Energy Range	0.2–12 keV
Effective Area (cm^2 @ 1.5 keV)	21,760 cm2
Energy Resolution	85 – 175 eV FWHM
Time Resolution	100 ns
Collimator	4 arcmin FWHM
Background Rate	2.2 c/s
Count Rate on Crab (0.2-10 keV)	148,000
Large Area Detector (LAD)	
Energy Range	2–30 keV
Effective Area (cm^2 @ 10 keV)	51,000 cm2
Energy Resolution	200 – 300 eV FWHM
Time Resolution	10 μs
Collimator	1° FWHM
Count Rate on Crab (2-30 keV)	156,000
Background Rate	822 c/s (5 mcrab)

STROBE-X

Instrument Design Lab (Nov 2017)

- Developed detailed instrument design
- Optical bench made out of composite structure, reducing mass and improving stiffness and thermal distortions
- Deployment mechanism for LAD panel designed, no concerns
- Detailed cost model for instruments





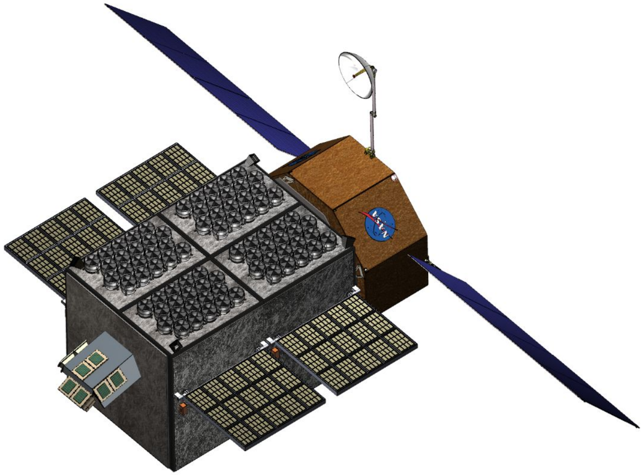
STROBE-X

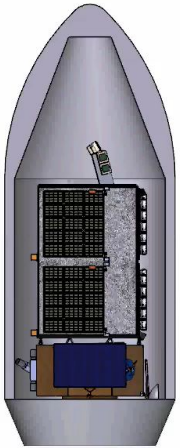
Parallelism/Redundancy

- Design in quadrants allows optimized I&T flow
  - Provides Schedule flexibility
  - Parallel structures sized to be integrated with smaller and simpler alignment/testing GSE and smaller/simpler engineering units
- Reliability
  - Can lose up to 30% of LAD modules or XRCA telescopes and still meet goals
- Cost minded
  - Can use COTS parts (with upscreening) to reduce costs, without high risk, proven approach by NICER

Mission Design Lab (April 2018)

- Complete spacecraft design
- Moved WFM to top, removing need for sunshade
- Designed to minimize moment of Inertia to maximize slew rates with existing/proven ACS systems
  - Control Moment Gyros (CMGs) give 15 deg/min slew rate
- **Includes autonomous repoint capability for WFM triggers**
- TDRSS Ka band gives 300 Mbps telemetry downlink
- TDRSS S-band gives rapid burst alerts to ground and TOO commanding





STROBE-X