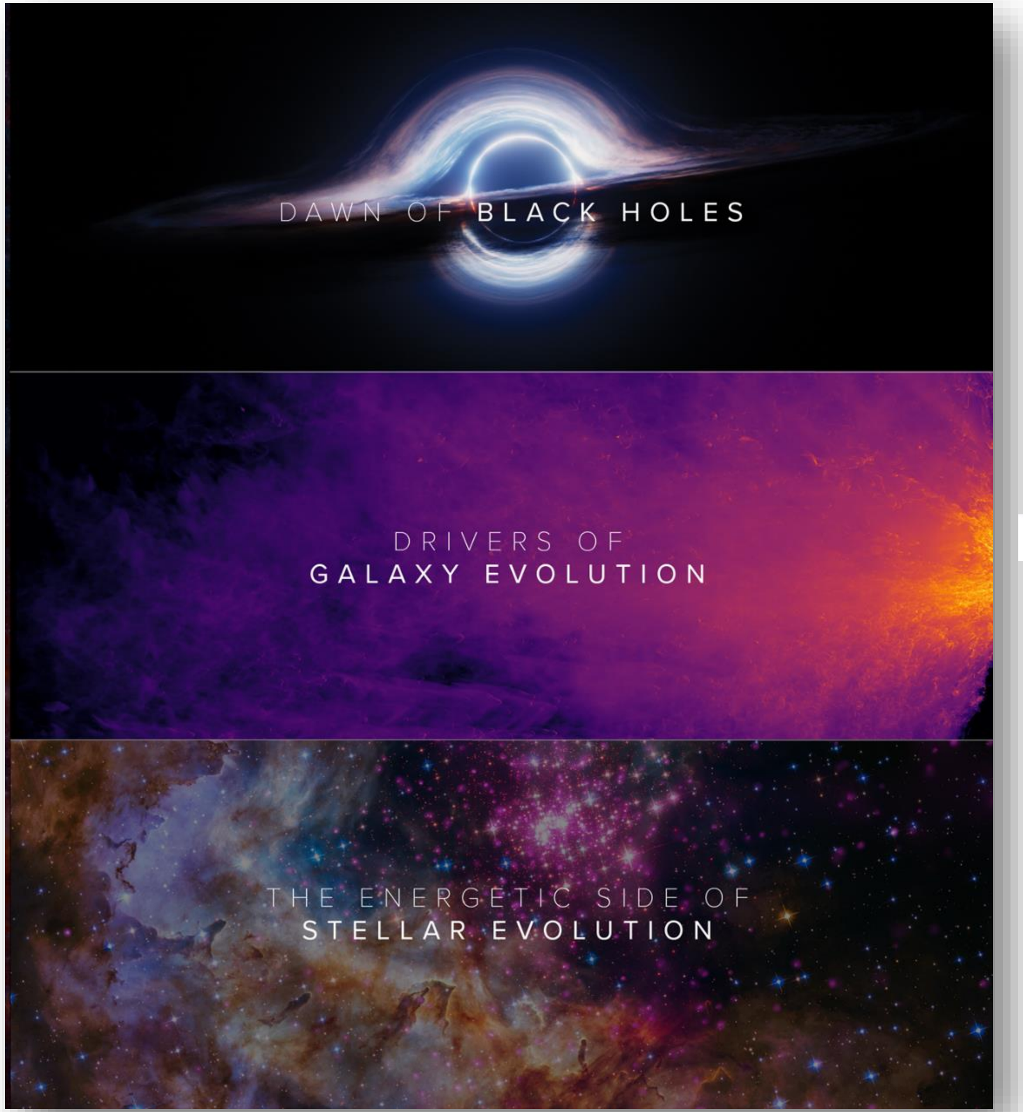
X-RAY OBSERVATORY LYNX

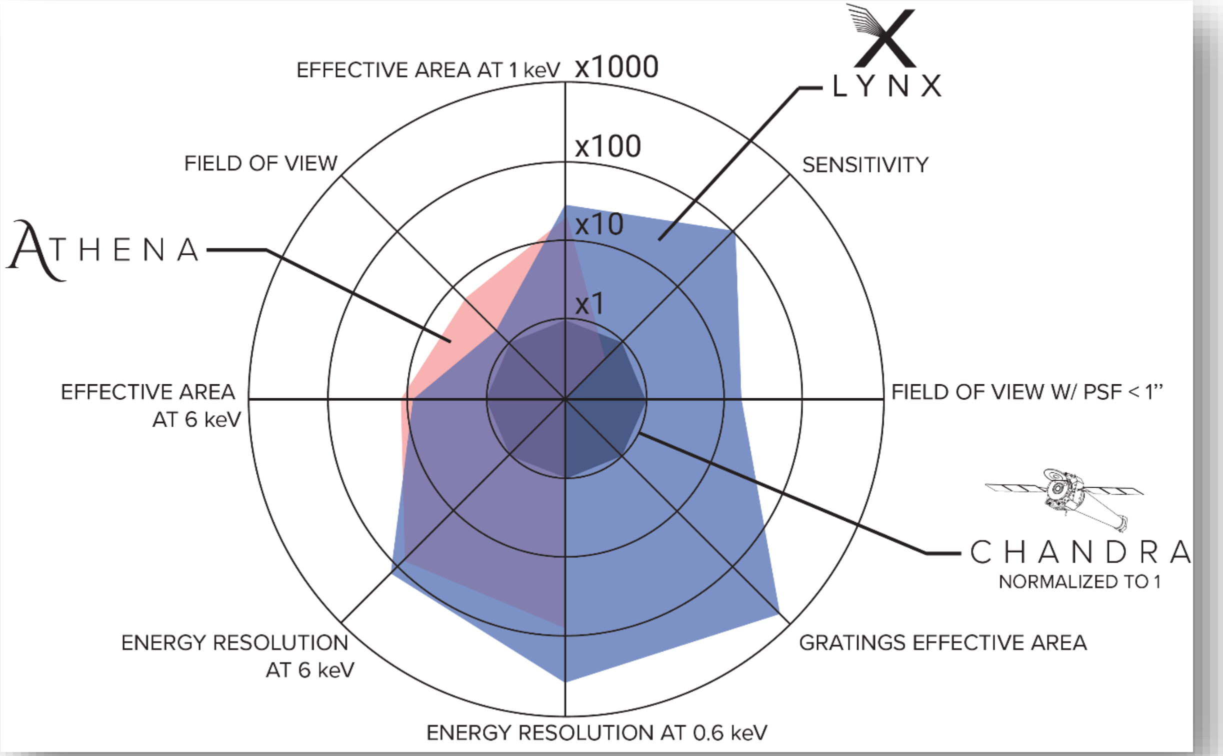
Lynx: SIMPLY DESIGNED FOR MAXIMUM SCIENCE RETURN

J. Gaskin, NASA MSFC

The Space Astrophysics Landscape for the 2020s and Beyond

SCIENCE DRIVEN OBSERVATORY ARCHITECTURE





SCIENCE & PROGRAMMATIC DRIVEN MISSION DESIGN

Mission Risk Class A

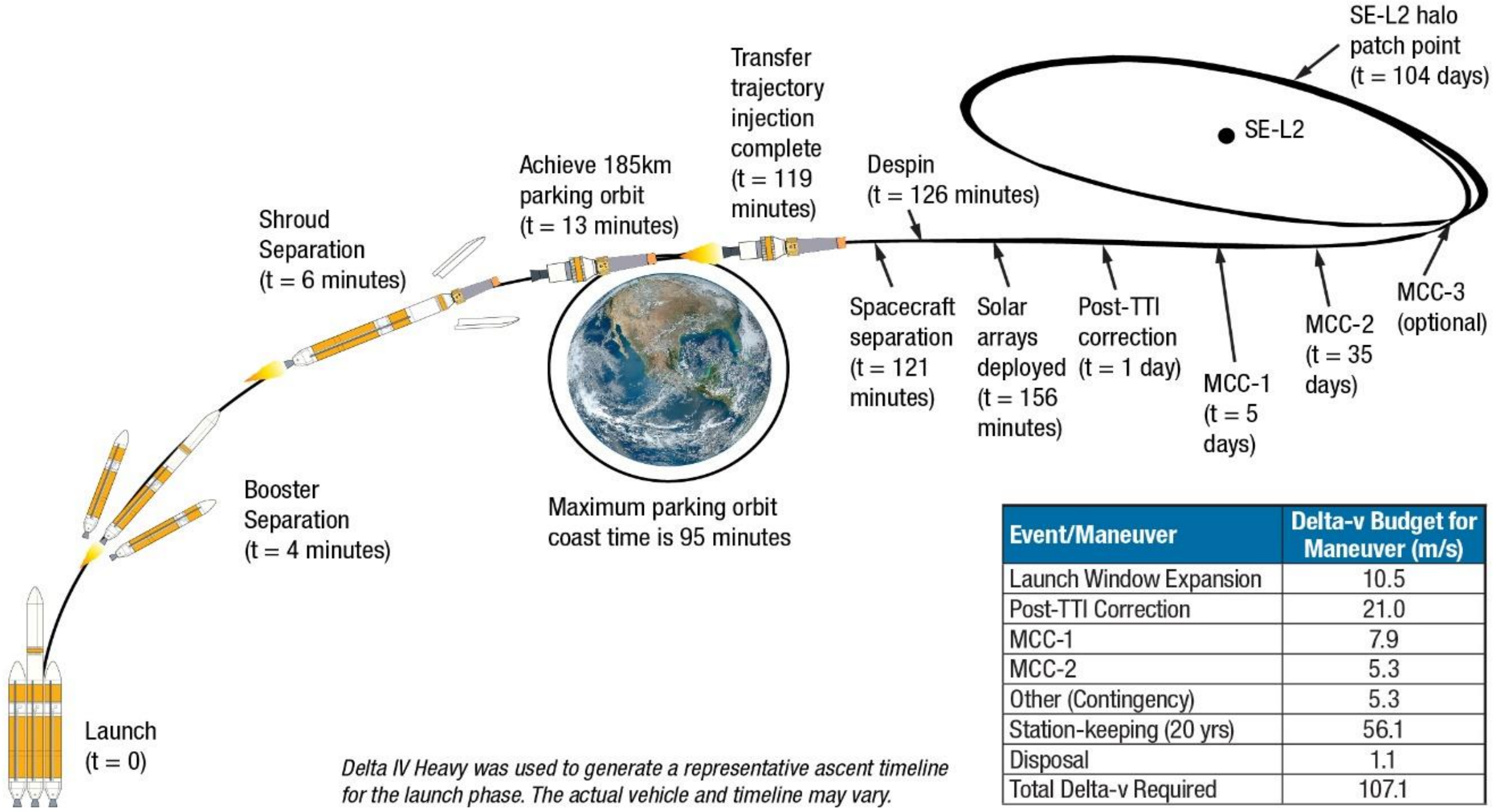
Long Mission Life:
- 5 years baseline
- Provisioned for 20 years
- Provides for in-space servicing

High Observing Efficiency:
- >85%
- Halo around SE-L2

Flexible Launch Vehicle:
- Heavy class, 5-m fairing
- SLS co-manifested possible

Relaxed Communication:
- Up to 3 x per day via DSN
- Maximum of 240 Gbits/day
- Downlink Rate 22.2 Mb

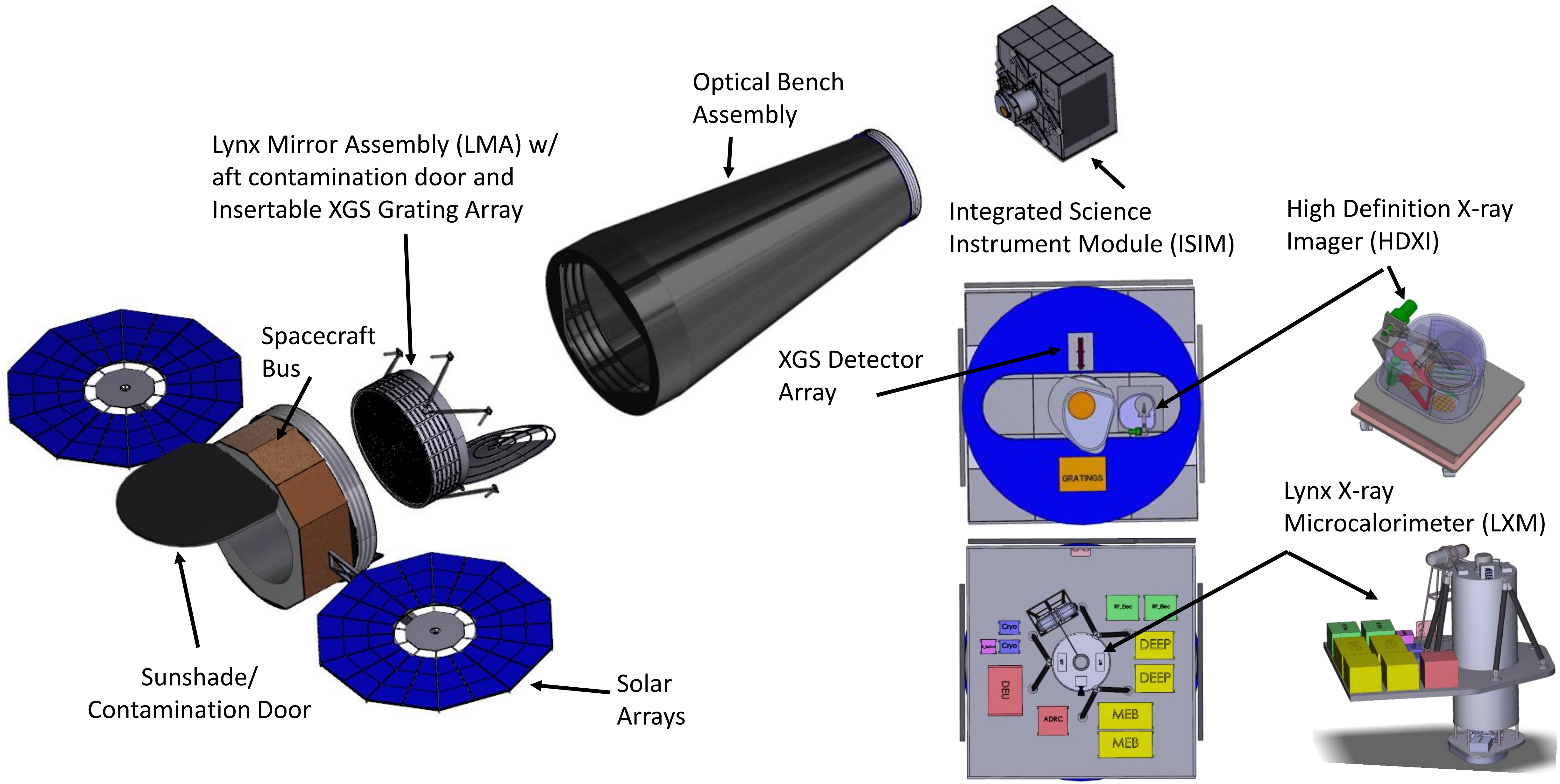
Proven Mission Operations:
- Chandra-like
- General Observer Program



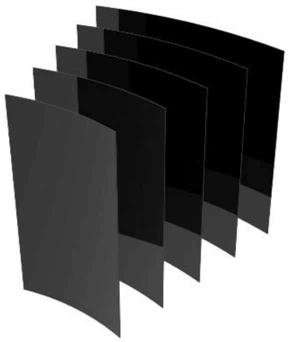
Event/Maneuver	Delta-v Budget for Maneuver (m/s)
Launch Window Expansion	10.5
Post-TTI Correction	21.0
MCC-1	7.9
MCC-2	5.3
Other (Contingency)	5.3
Station-keeping (20 yrs)	56.1
Disposal	1.1
Total Delta-v Required	107.1

Ascent timeline provided by NASA LSP for a Delta-IV Heavy.

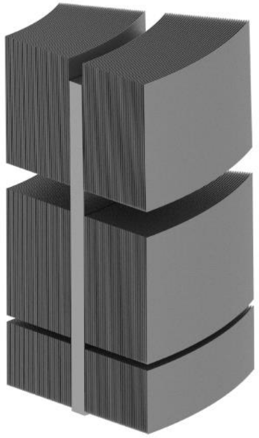
THE LYNX X-RAY OBSERVATORY



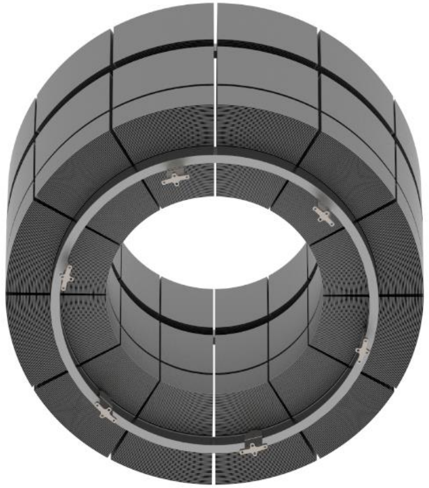
LYNX MIRROR ASSEMBLY – SILICON METASHELL APPROACH



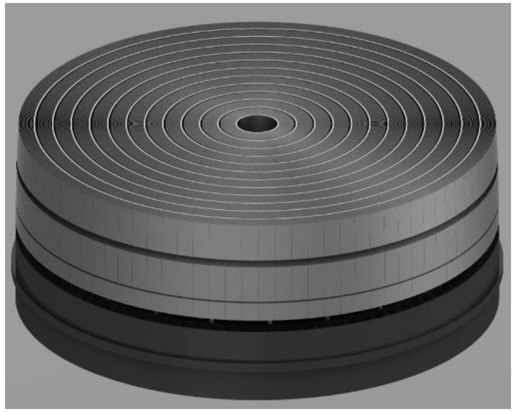
37,492
Segments



611
Modules

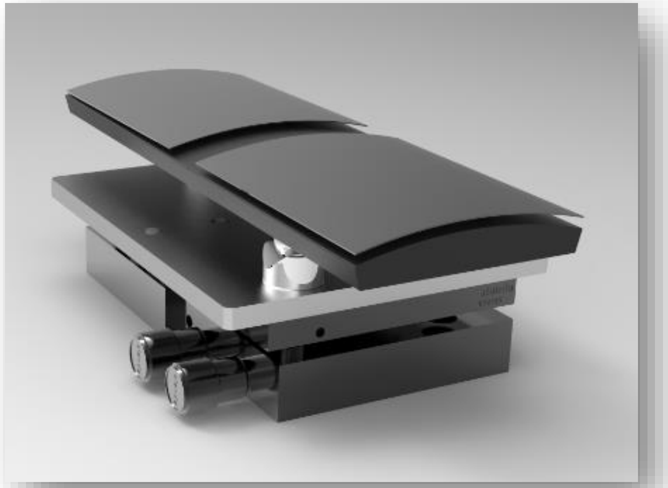


12
Meta-shells



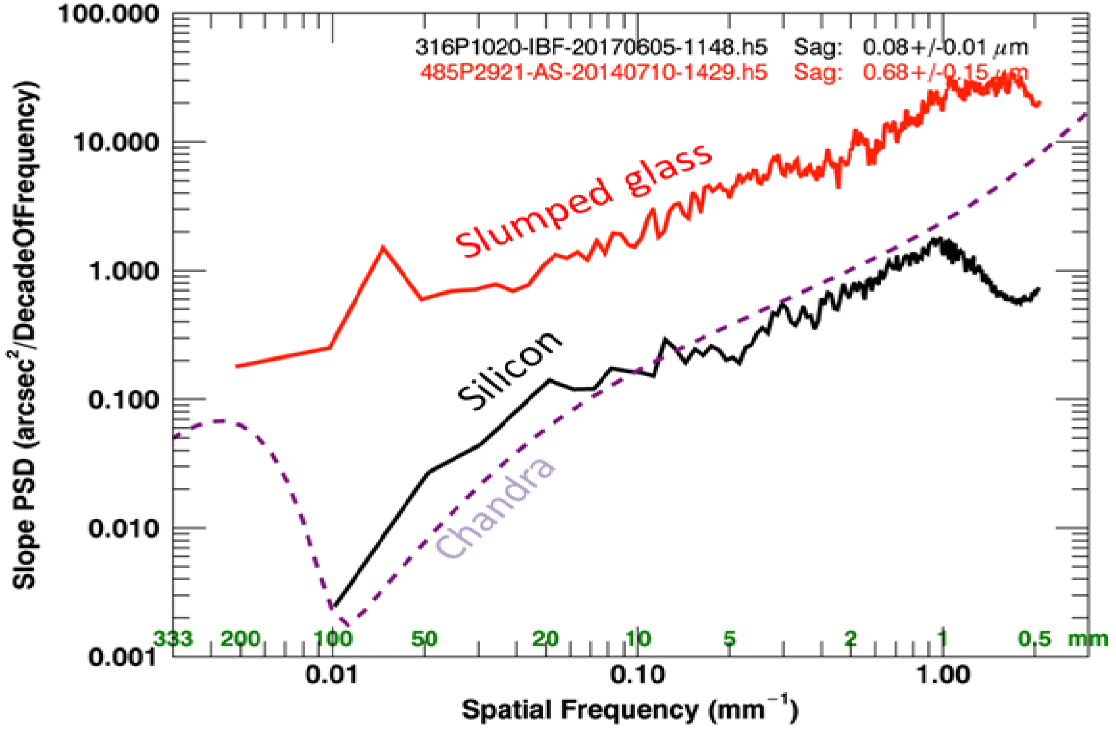
1
Assembly

XMA Parameter	Requirement
Energy Range	0.3–10 keV
Angular Resolution	0.5 arcsec HPD on-axis; < 1 arcsec HPD across the FOV
Grasp **(Effective Area * FOV for <1 arcsecond PSF)**	~600 m^2 $arcminutes^2$
Field of View	10 arcmins radius
Effective Area @ 1 keV	2 m^2

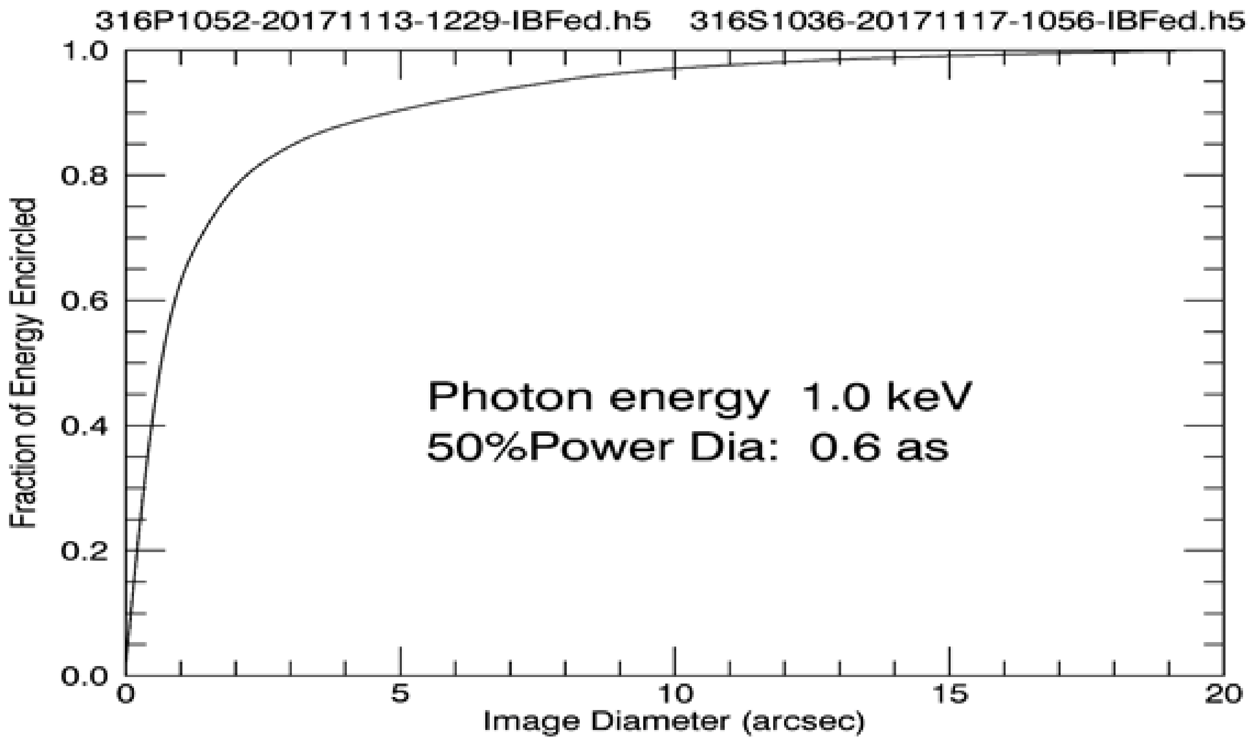


LYNX MIRROR ASSEMBLY – SILICON METASHELL OPTICS

- **W. Zhang and Team (NASA GSFC)**

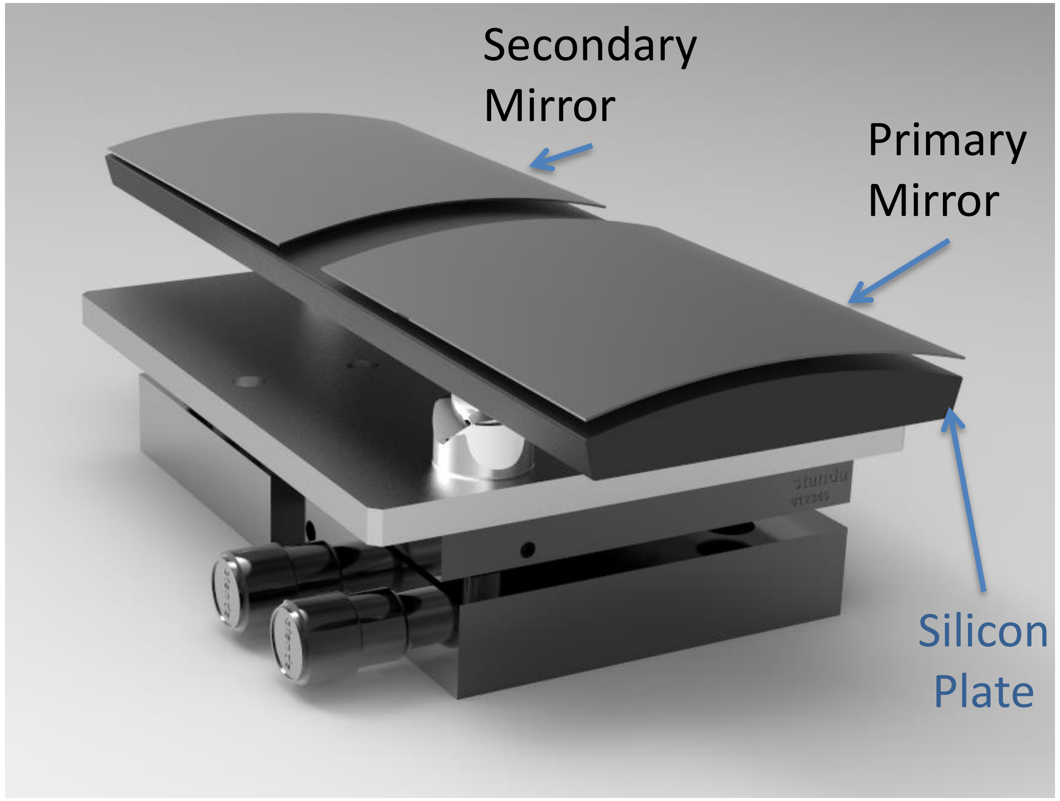


Prediction Based On Optical Metrology

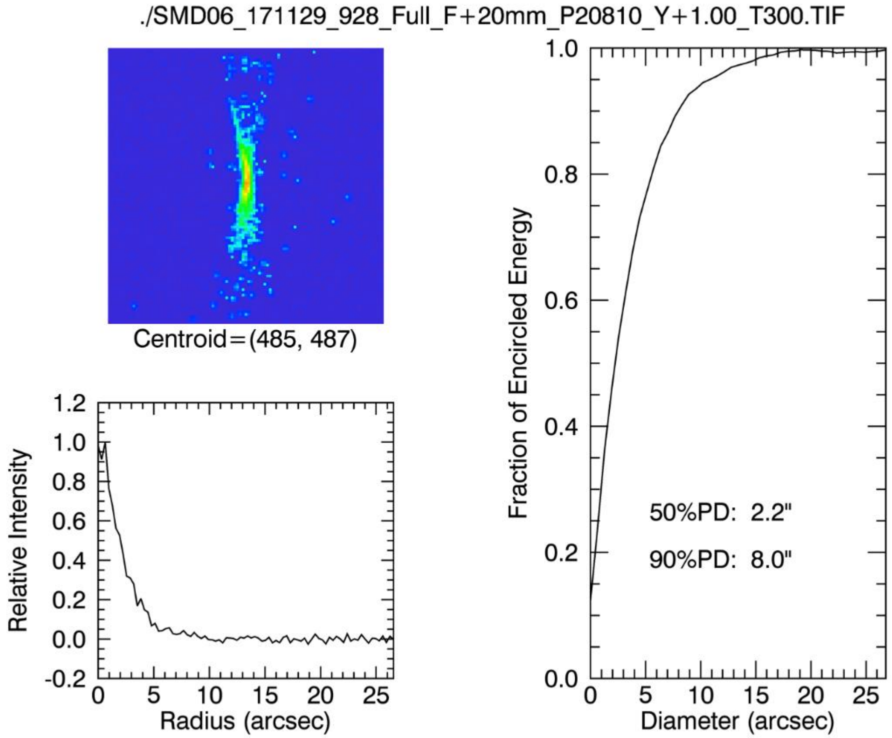


No Development Showstoppers!

X-ray Testing of a Pair of Mirrors



Two uncoated mono-crystalline silicon mirrors aligned and bonded on a silicon platform

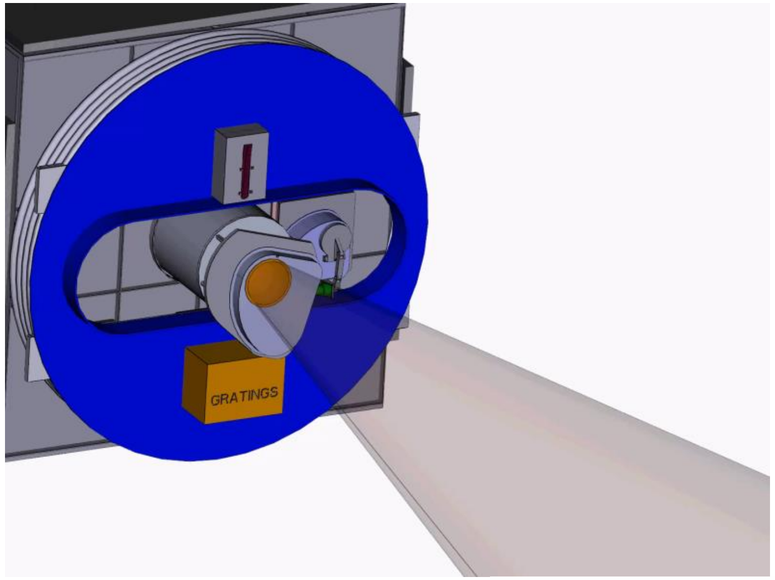


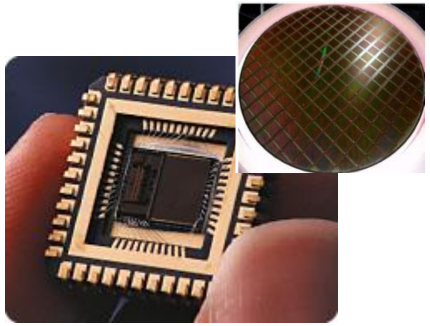
Full illumination with Ti-K X-rays (**4.5 keV**)

HIGH DEFINITION X-RAY IMAGER

High Definition X-ray Imager (HDXI)

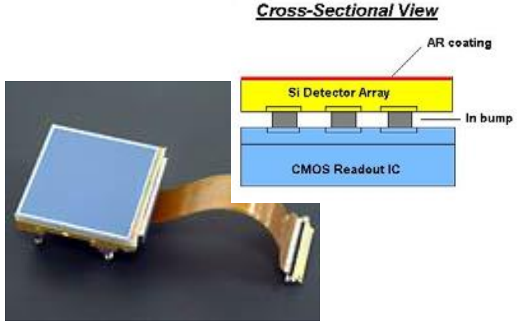
- Lynx Instrument Working Group HDXI Leads: M. Bautz (MIT), R. Kraft (SAO), A. Falcone (PSU)





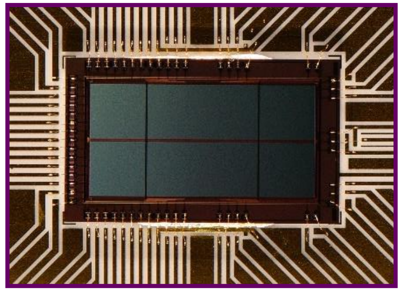
Monolithic CMOS, Sarnoff/SAO & MPE

- High gain (135 μV/e-), low noise (3 e- rms) amplifiers
- PMOS devices ready for X-ray testing with < 1e- rms readnoise and no RTS noise



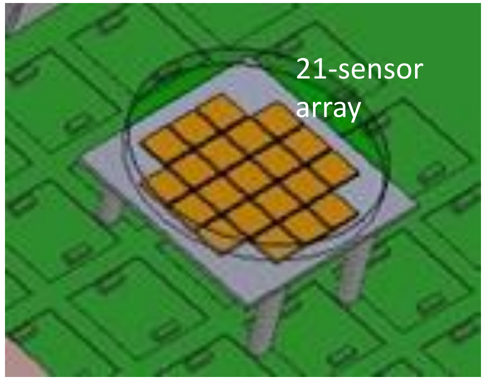
Hybrid CMOS, Teledyne & PSU

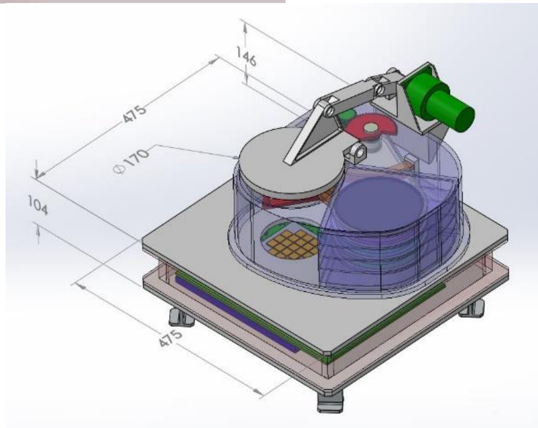
- Achieve ~80 eV (FWHM) energy resolution at 0.5 keV, in-pixel CDS, no crosstalk
- New test devices have achieved event-driven readout
- Latest scaled-up designs include on-chip digitization



Digital CCD with CMOS readout, MIT-Lincoln Laboratory

- Reduced noise & power: -4.6 e^- noise, 25x Chandra -Low power CMOS clock
- Larger (2 Mpix) device in fabrication





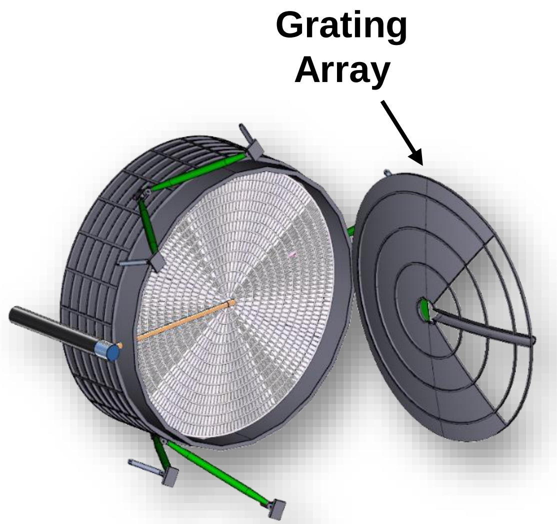
No Development Showstoppers!

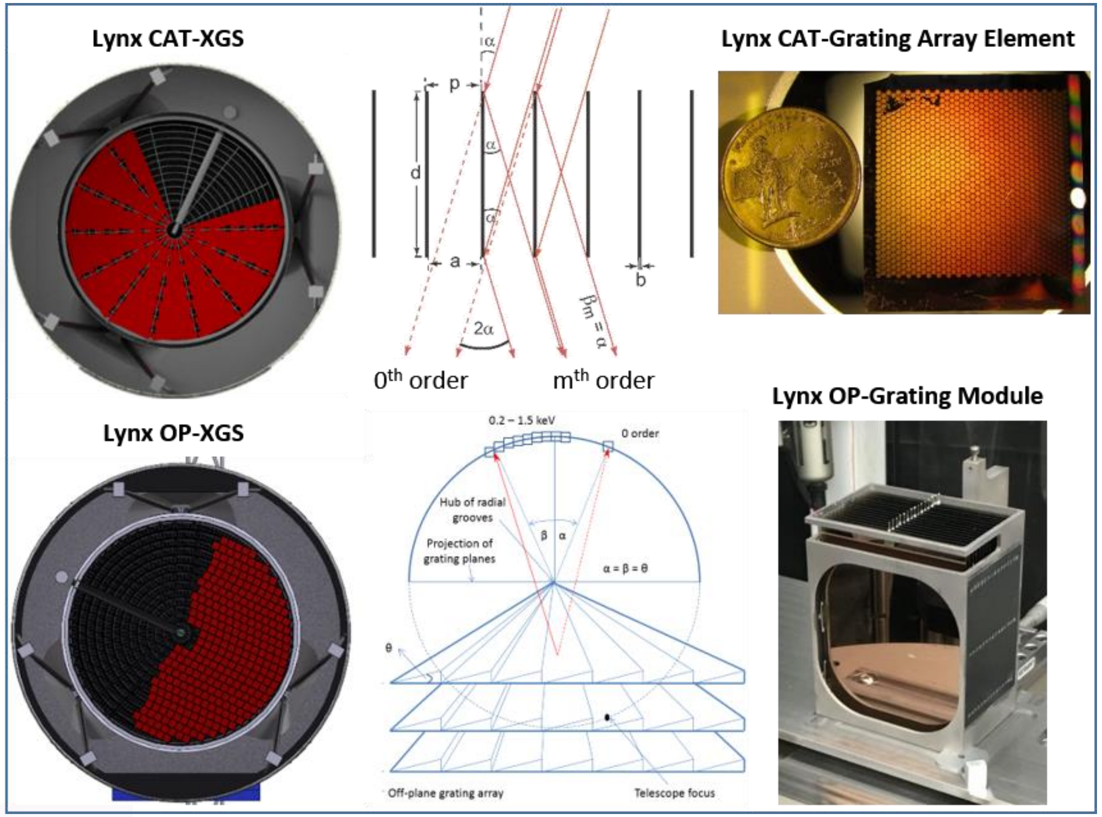
- Pixel size well matched to telescope PSF of 0.5" HPD
- Large, curved, focal plane (22' x 22')
- 0.2-10 keV band, with near unity QE over 0.5-7.0 keV range
- Efficient particle background rejection

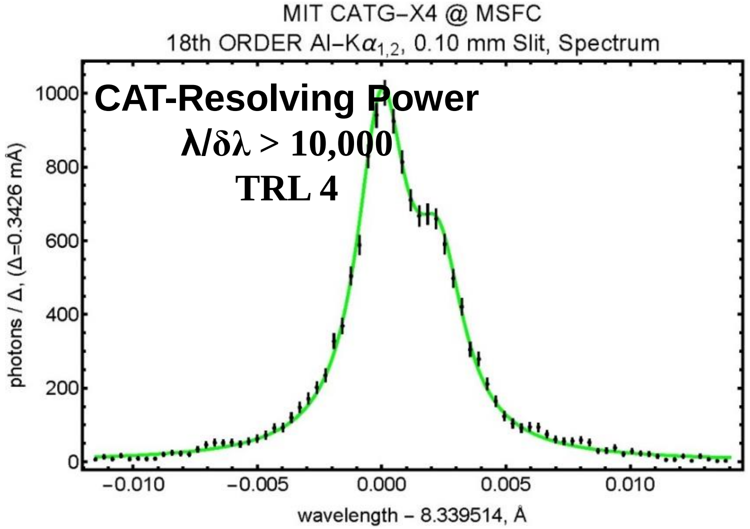
LYNX X-RAY GRATING SPECTROMETER

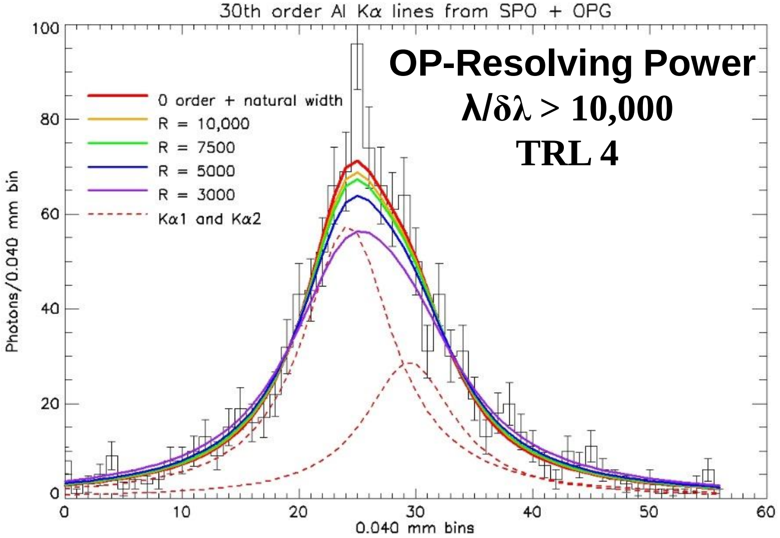
Lynx Instrument Working Group XGS Leads: Ralf Heilmann (MIT), R. McEntaffer (PSU)

No Development Showstoppers!









Effective Area: 4,000 cm^2 @ OVII

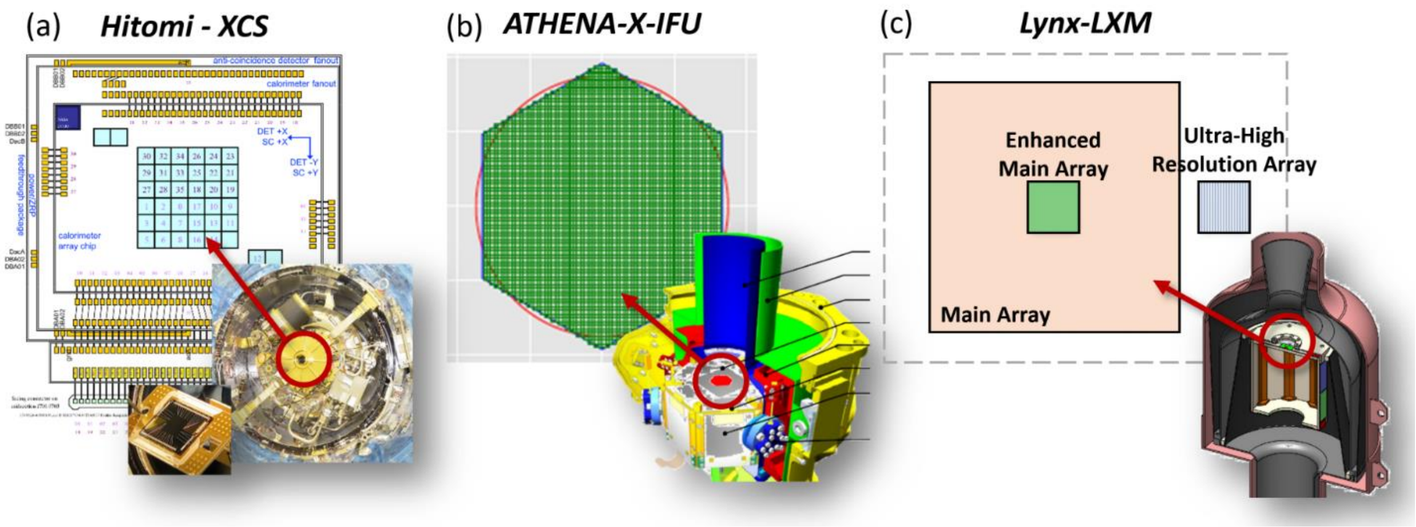
Spectral Resolving Power: R=5,000 (R = 10,00 Goal)

LYNX X-RAY MICROCALORIMETER

36 pixel elements

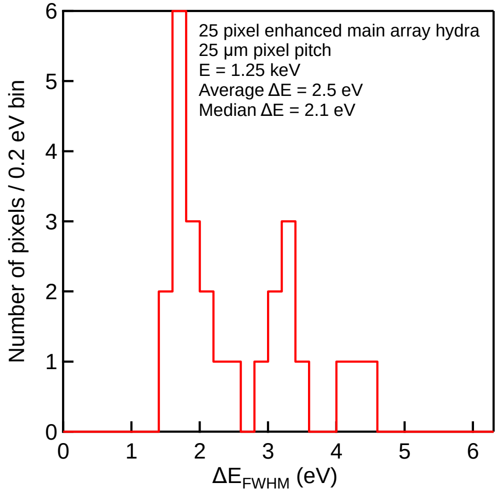
3,840 pixel elements

102,800 pixel elements **(7,568)**



Lynx Instrument Working Group LXM Leads:
S. Bandler (GSFC), M. Eckart (LLNL)

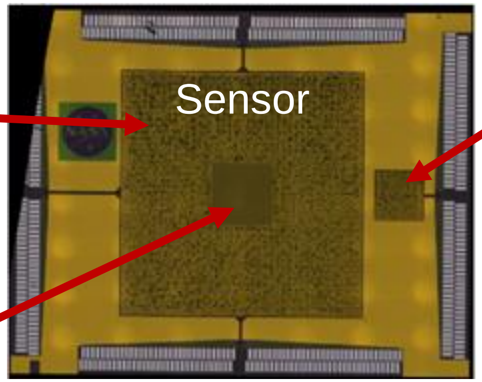
No Development Showstoppers!



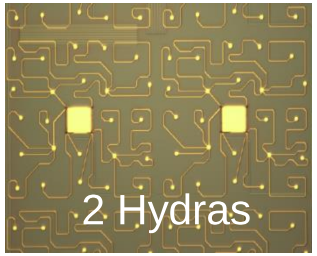
Measured energy resolutions for a 25-pixel EMA hydra at an energy of 1.25 keV

Main Array
- 1” pixels, 5’ FOV,
- 50 µm pixels, hydra-25
- ΔE = 3 eV up to 7 keV
- 86.4 kpix

Enhanced Main Array
- 0.5” pixels, 1’ FOV,
- 25 µm pixels, hydra-25
- ΔE = 3.0 eV up to 7 keV
- 12.8 kpix

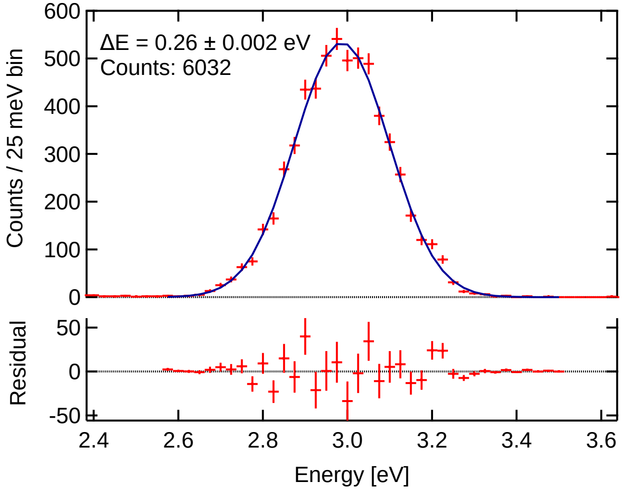


Ultra-High Resolution Array
- 1” pixels, 1’ FOV
- 50 µm pixels, single pixel
- ΔE = 0.3 eV (up to 0.8 keV)
- 3.6 kpix



LXM Prototyping

Measured spectral resolution on a UHR array TES pixel at 3 eV



THE TIME FOR LYNX IS NOW!

Enabling Technologies TRL Assessment Summary

At Decadal Studies Management Team request, the ExEP, PCOS, and COR Program Offices and the Aerospace Corp assessed the TRL of tech gaps submitted by the teams as of Dec. 2016. Assessment was presented June 2017.

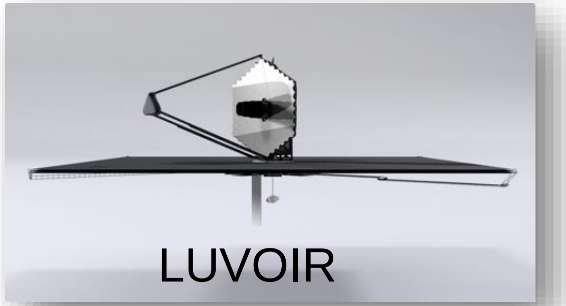
ID	Technology Gap	TRL
1	High-Resolution ‘Lightweight’ Optics	~~2~~ 3 → 4
2	Non-deforming X-ray Reflecting Coatings	3 → 4
3	Megapixel X-ray Imaging Detectors (HDXI)	3 → 4
4	X-ray Grating Arrays (XGS)	4 → 5
5	Large-Format, High Spectral Resolution X-ray Detectors (LXM)	3 → 4

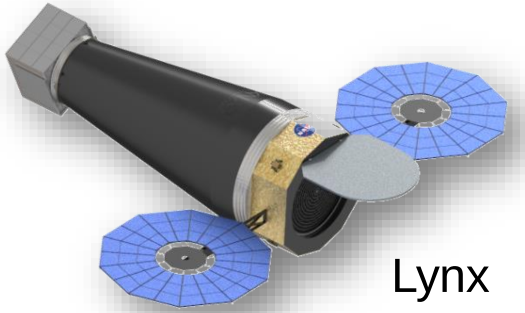
Multiple Technologies (TRL 4 in 2020)

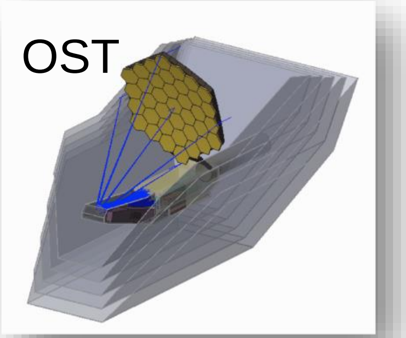
Multiple Technologies (TRL 4 before 2023)

Multiple Technologies (TRL 5 by 2021)

Subsystem Heritage (TRL 4 in 2020)







“One builds large missions not because they can do what a small mission can do better. The large missions can do what a small mission can't do at all."

- Dr. Megan Donahue,

Professor Michigan State University
President American Astronomical Society
Lynx STDT Member