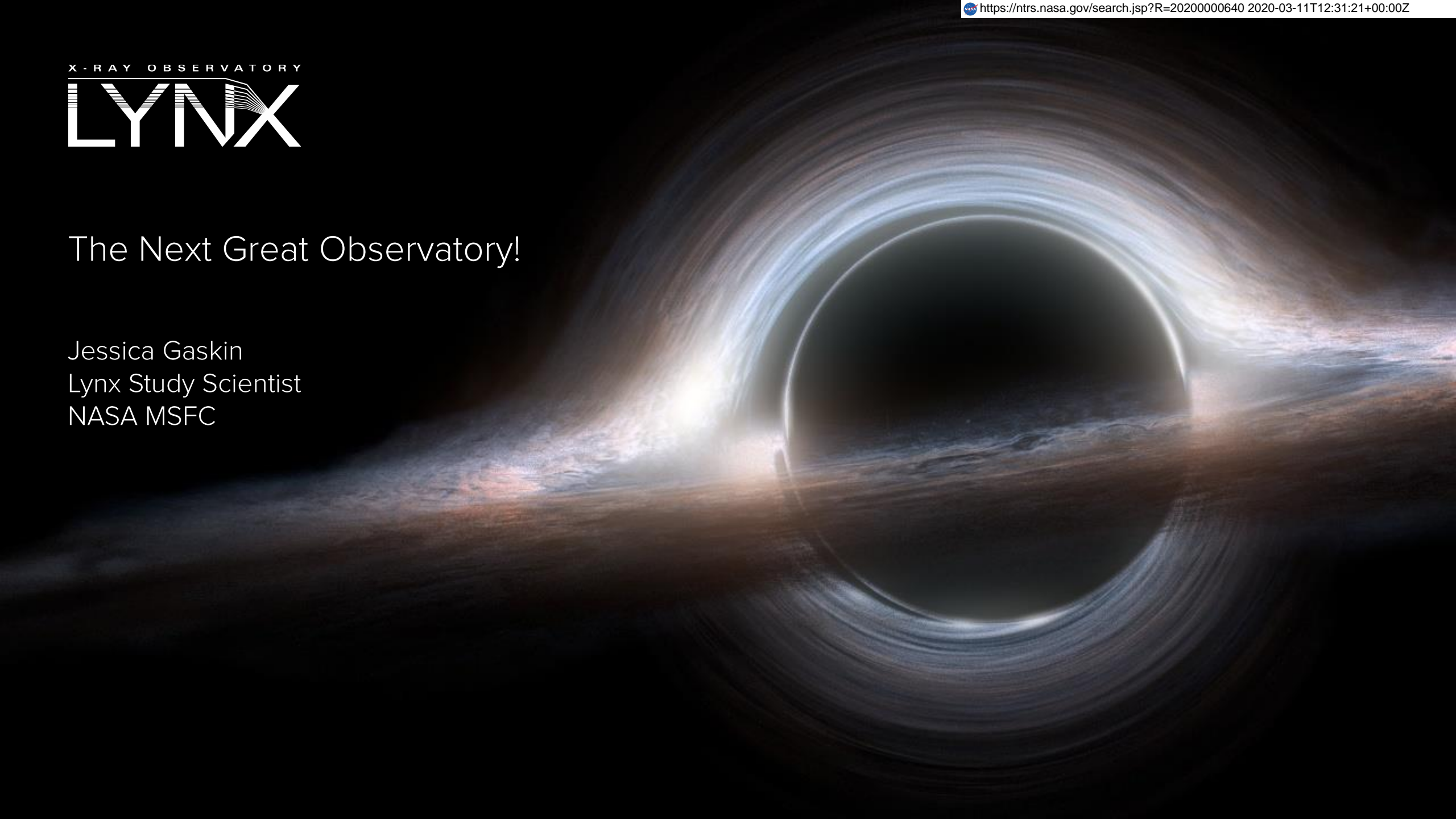




The Next Great Observatory!

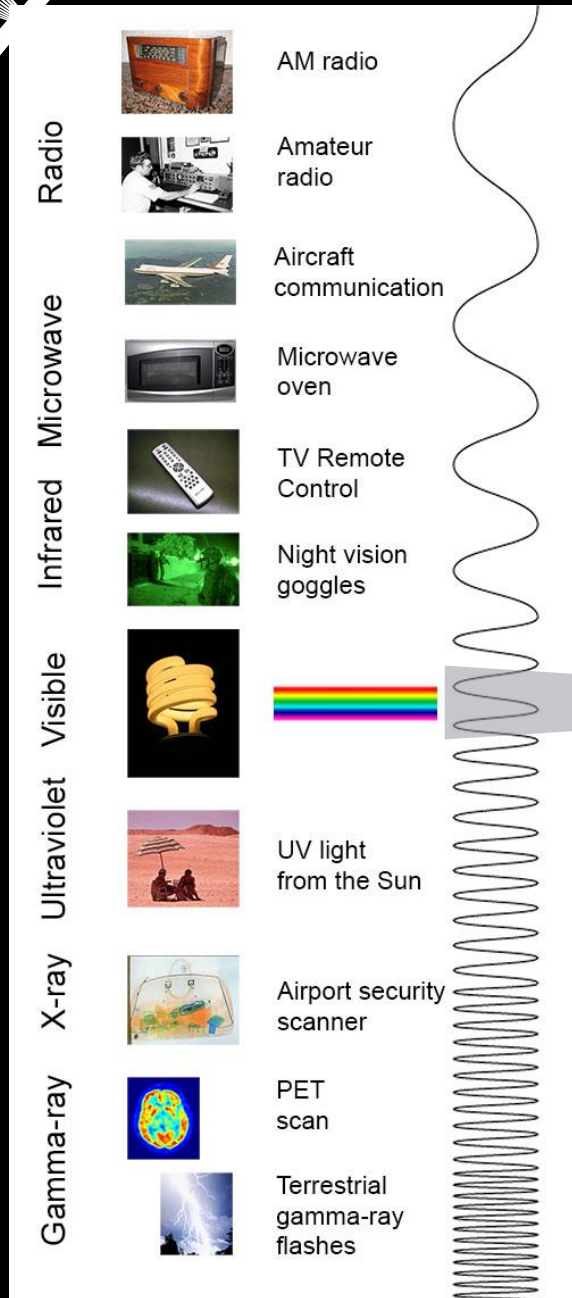
Jessica Gaskin
Lynx Study Scientist
NASA MSFC



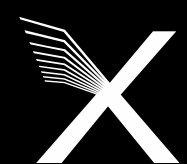
“Light, Light, The visible
reminder of invisible
light” – T.S. Eliot



THE INVISIBLE UNIVERSE



Each wavelength provides different information.



X-RAYS FROM EARTH



We are surrounded by naturally-occurring radioactive elements in the soil and stones.

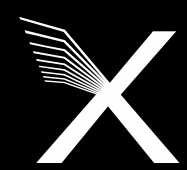


Uranium

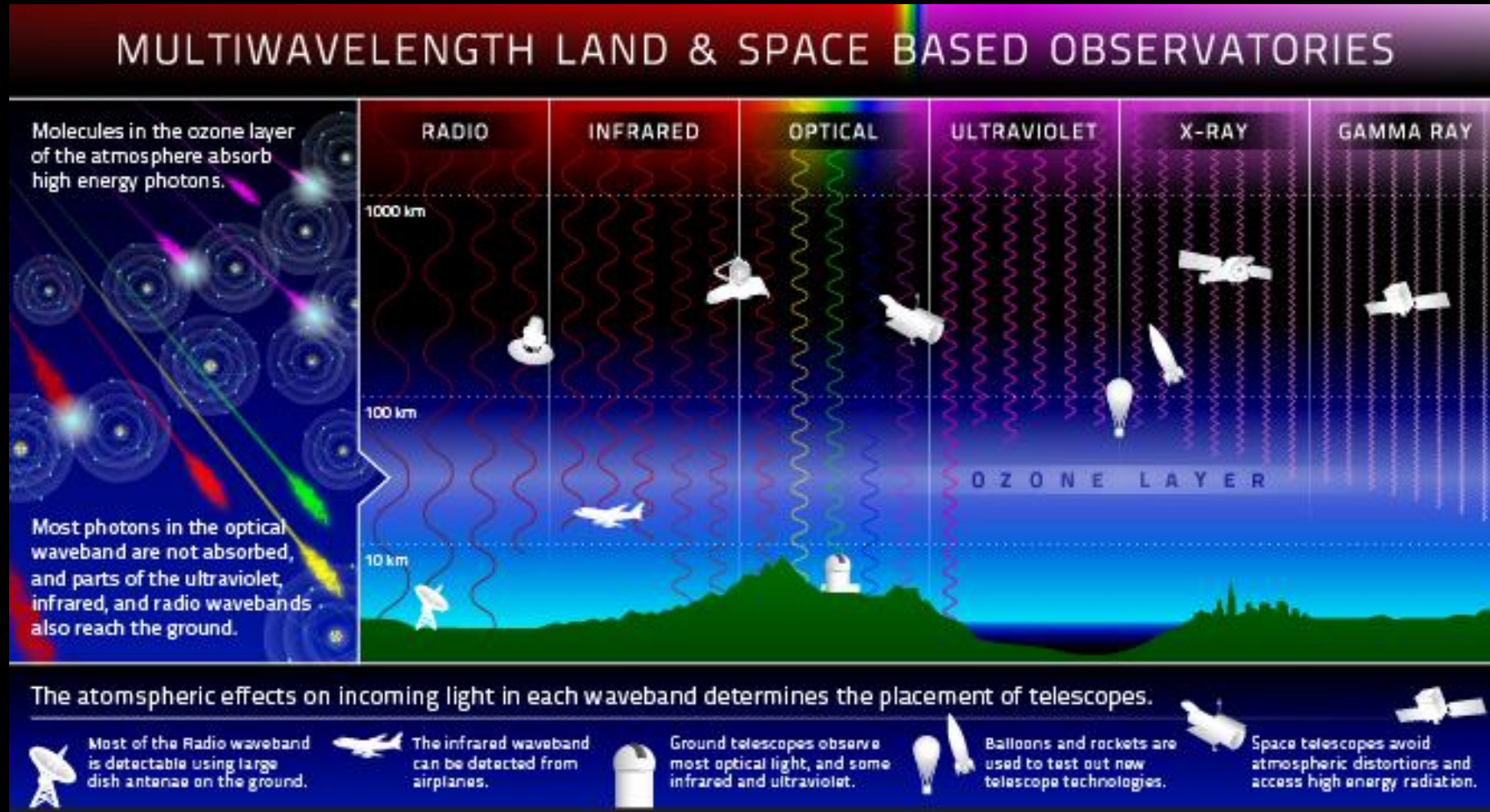
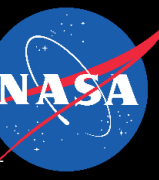


Radium

We have radioactive elements (Potassium 40, Carbon 14, Radium 226) in our blood or bones.



OUR UNIVERSE IS BRIGHT

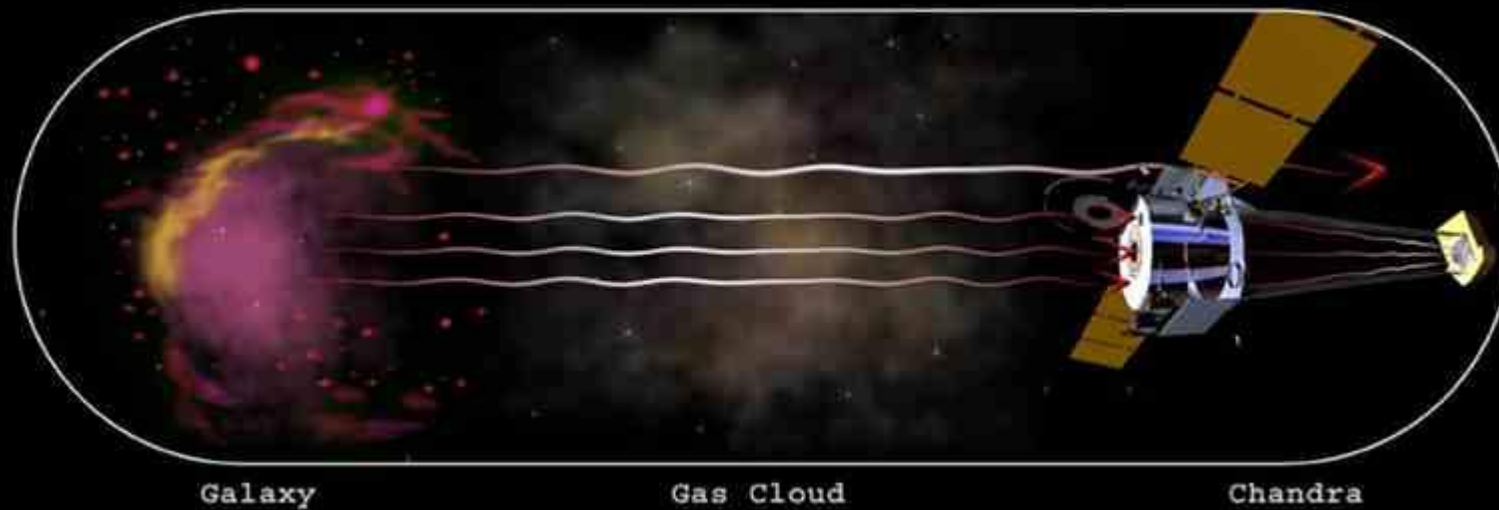


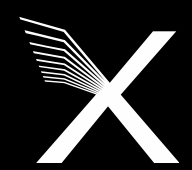
Staying Alive!



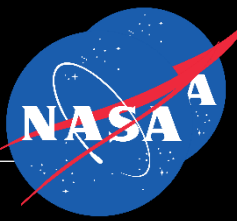


If our atmosphere blocks out X-Rays,
how can we see them?

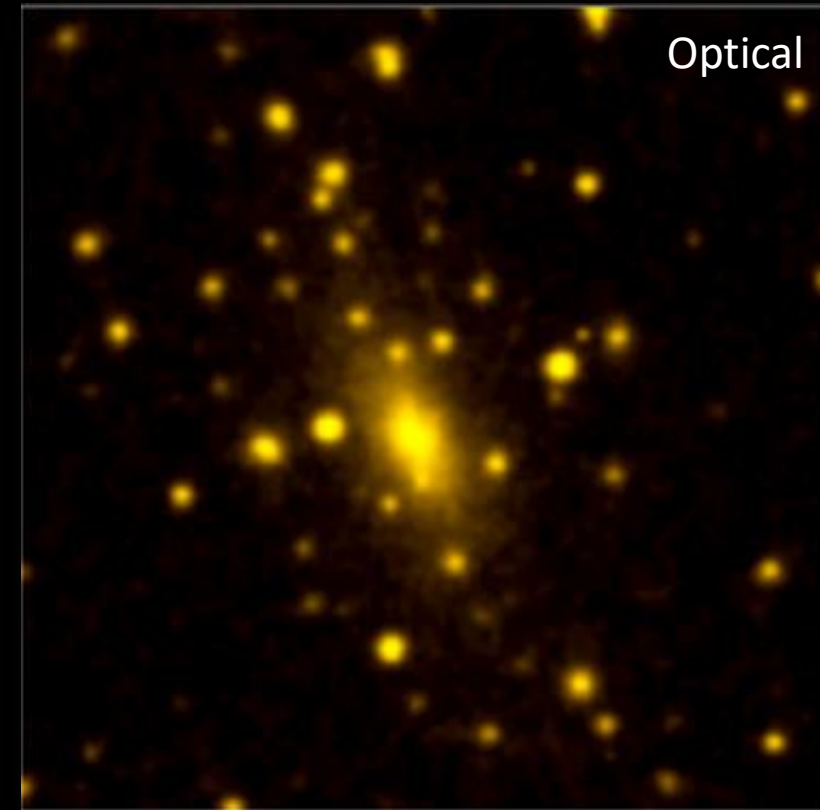




THE IMPORTANCE OF X-RAY ASTRONOMY



Galaxy Cluster
Abell 2029



- Most of the matter that we “see” in the universe is via its X-ray emission
- The bulk of this matter is the hot, X-ray-emitting gas in the great galaxy clusters
- Every known class of astronomical object, from comets to quasars, is also an X-ray source

CHANDRA X-RAY OBSERVATORY



Chandra can detect and image X-ray sources that are billions of light years away.
This focusing power is equivalent to the ability to read a newspaper at a distance of half a mile!



2 OCT 2011

Jupiter



NGC 4258 (M106)



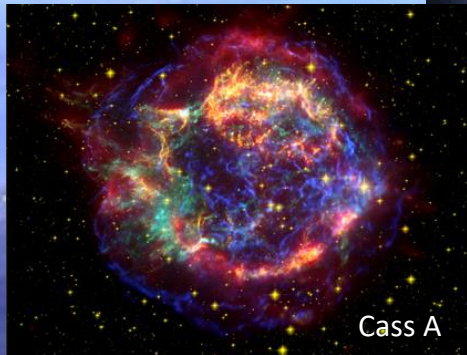
NGC 6357



Milky Way Central Region



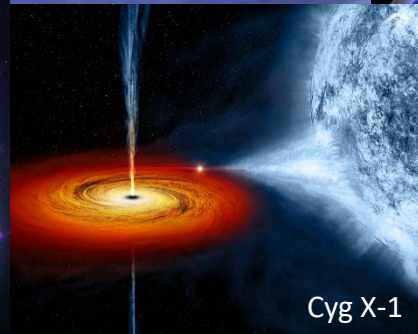
Crab Nebula



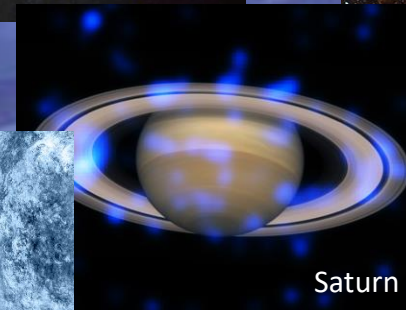
Cass A



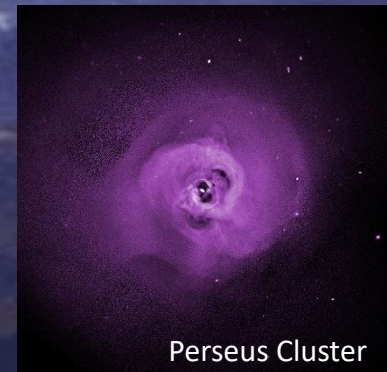
Whirlpool Galaxy (M51)



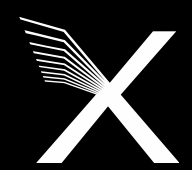
Cyg X-1



Saturn



Perseus Cluster

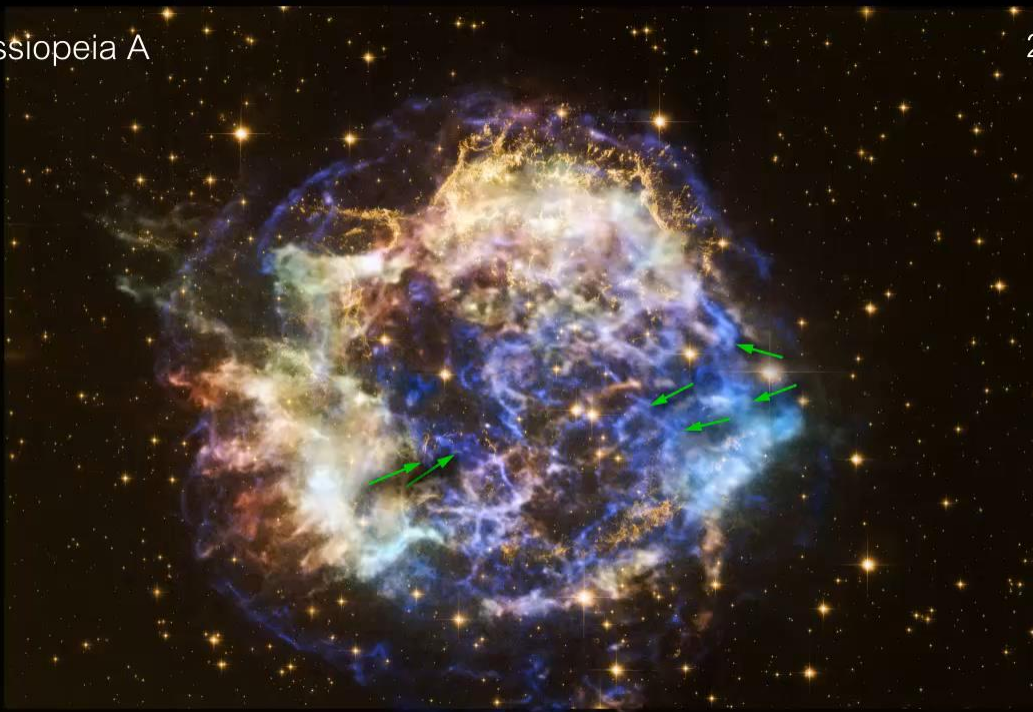


CHANDRA'S 20 YEAR ANNIVERSARY



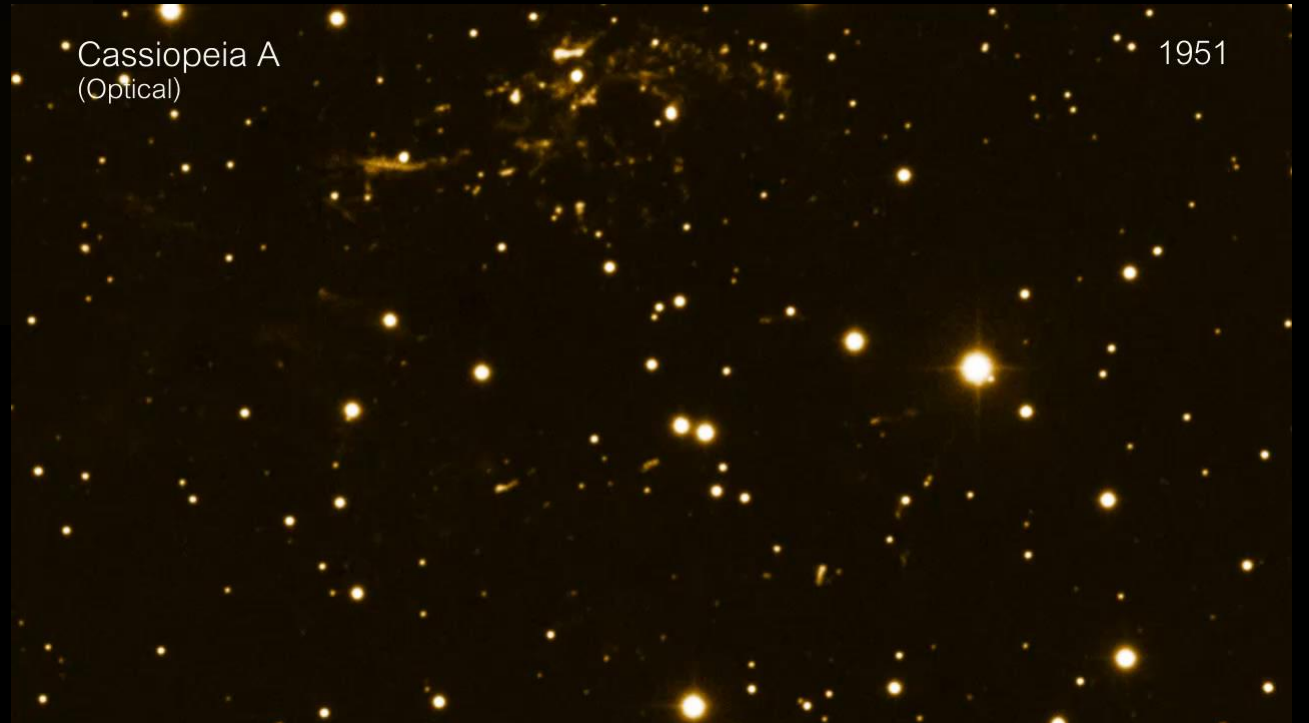
Cassiopeia A

2000



Cassiopeia A
(Optical)

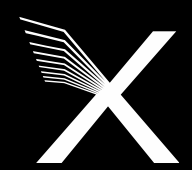
1951



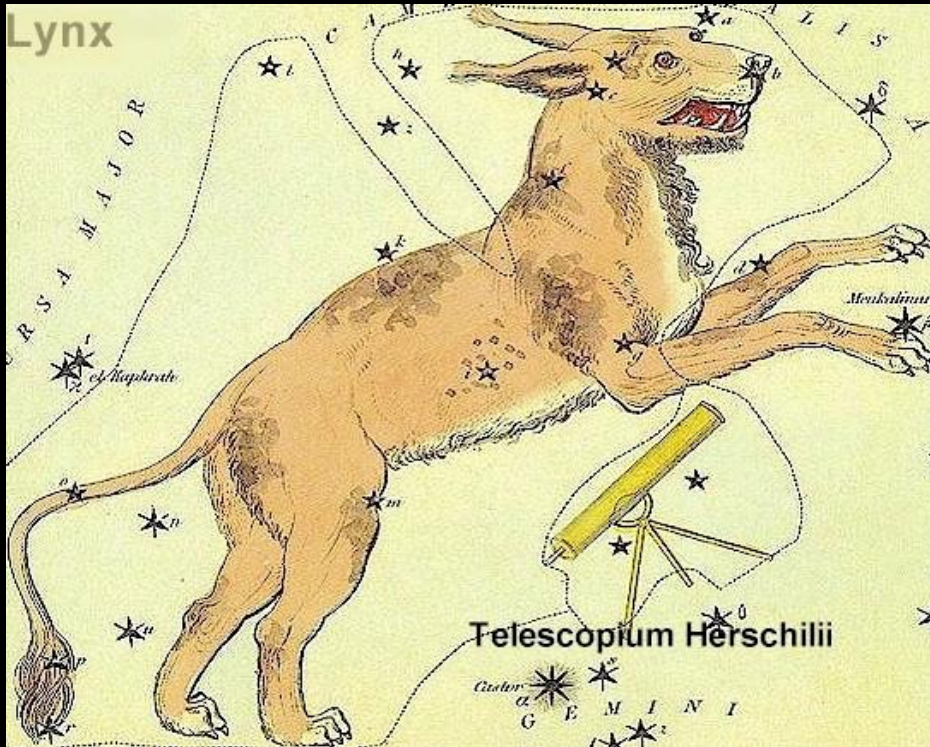
The Chandra data shows how 10-million-degree gas is expanding outward after the explosion that destroyed the star. The movie spans 2000-2013.
[credit: NASA/CXC/SAO]

L
Y
N
X



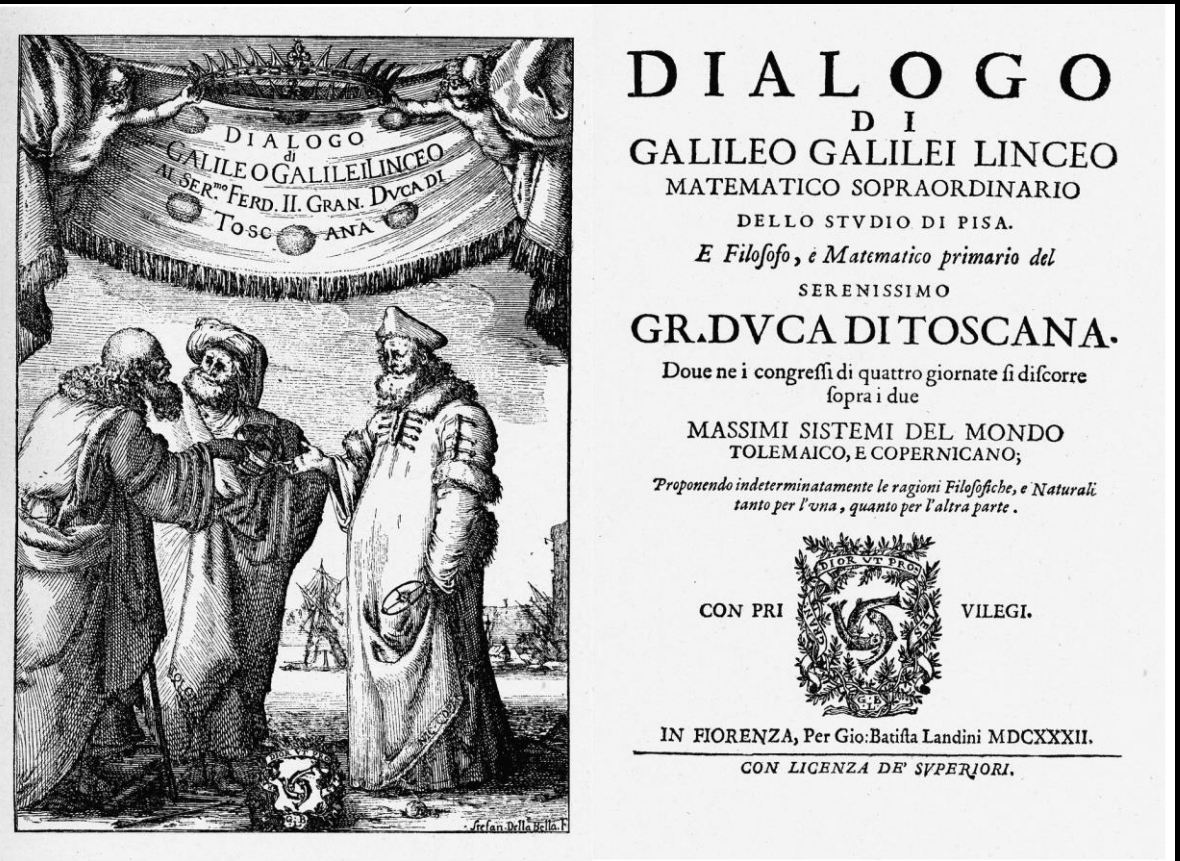


LYNX: THE NEXT GREAT OBSERVATORY



Academy of the 'Lynx-Eyed' was founded in 1603 by Federico Cesi. Perform incisive and penetrating investigations of the natural world.

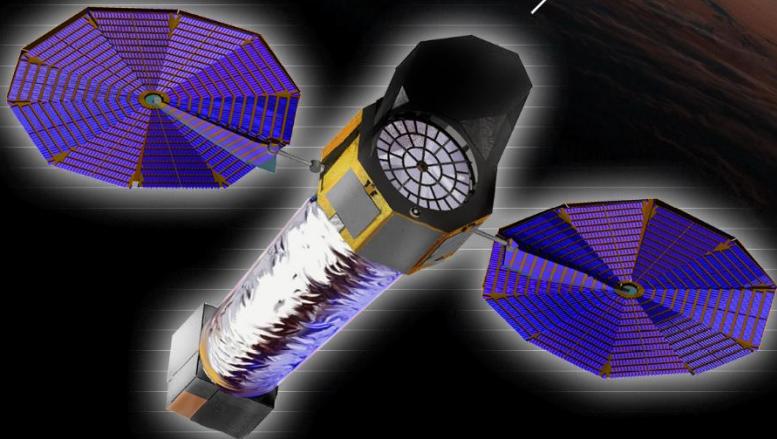
A symbol of great insight in many cultures - with the ability to see through solid objects to reveal the true nature of things.



A NEW GREAT OBSERVATORY

X-RAY MIRROR ASSEMBLY

0.5" Point-Spread Function,
stable over a 20 arcminute FoV



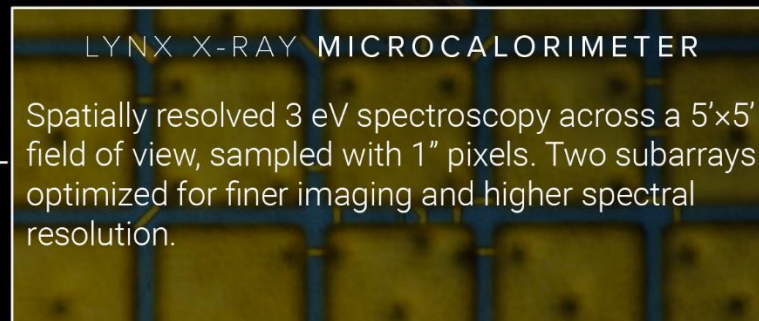
HIGH DEFINITION X-RAY IMAGER

Designed for exquisite imaging and wide surveys, the HDXI is an active pixel array covering a 20' x 20' field of view with subarcsecond imaging.



LYNX X-RAY MICROCALORIMETER

Spatially resolved 3 eV spectroscopy across a 5'x5' field of view, sampled with 1" pixels. Two subarrays optimized for finer imaging and higher spectral resolution.



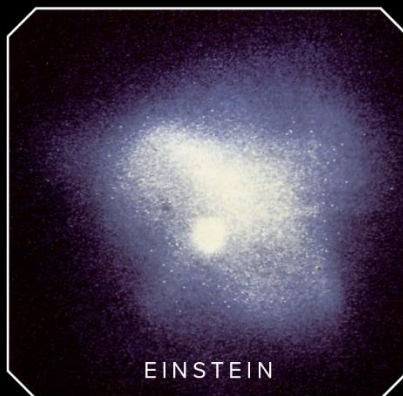
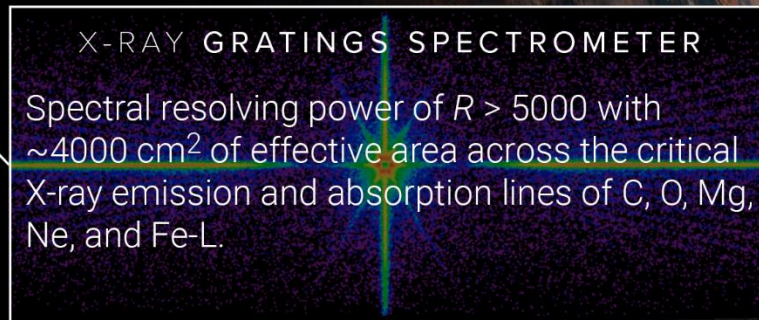
HIGH DEFINITION X-RAY IMAGER

LYNX X-RAY MICROCALORIMETER

X-RAY GRATINGS SPECTROMETER

X-RAY GRATINGS SPECTROMETER

Spectral resolving power of $R > 5000$ with $\sim 4000 \text{ cm}^2$ of effective area across the critical X-ray emission and absorption lines of C, O, Mg, Ne, and Fe-L.



EINSTEIN

CHANDRA

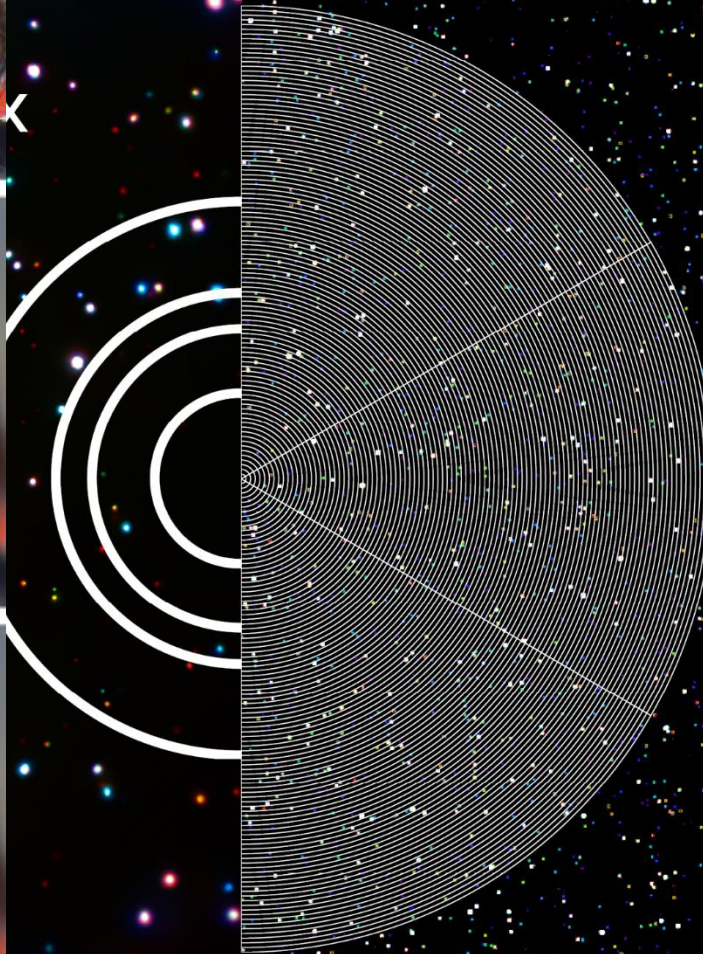
Lynx



Chandra



“Other” X-ray Telescopes



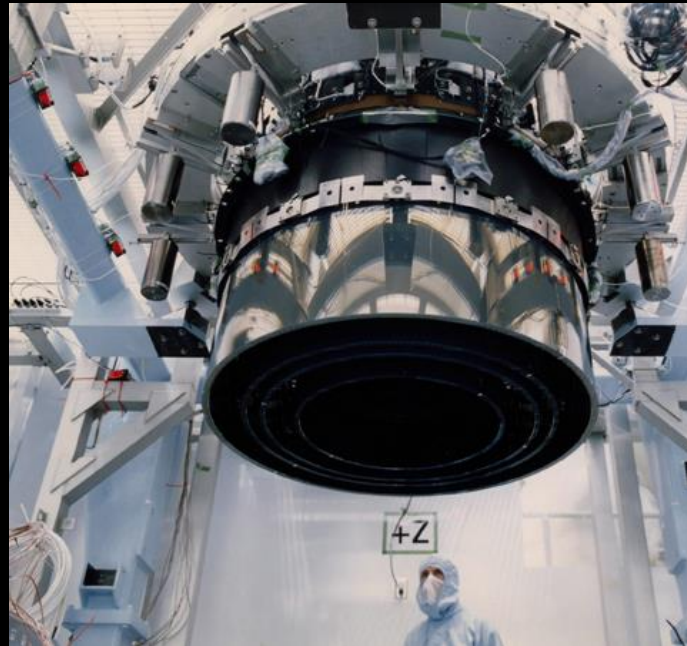
50x higher throughput while maintaining *Chandra's* angular resolution.

Like going from your 8” backyard telescope to a 10-m Keck.

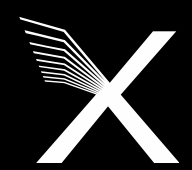
What takes Chandra 8 weeks, Lynx can do in ~1 day for deep surveys.



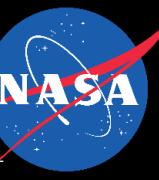
FOCUSING X-RAY OPTICS



Like skipping stones off
of a (calm) body of water



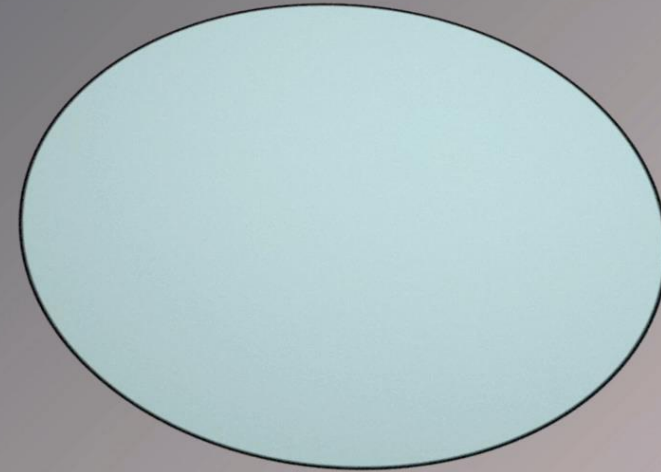
LYNX X-RAY OBSERVATORY



Lynx Mirror Assembly has a 3m diameter



JWST Primary Mirror: 6.5 m



Lynx Mirror: 25 m
to 3 m diameter assembly



THE SCIENCE

Lynx is designed to pursue three science pillars.

There are ample resources for many other programs, including those unexpected today.

It will be a discovery platform for all.

WWW.HIDDENCOSMOS.ORG



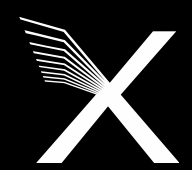
DAWN OF BLACK HOLES



DRIVERS OF
GALAXY EVOLUTION



THE ENERGETIC SIDE OF
STELLAR EVOLUTION



BLACK HOLE DAWN

Simulated Deep Fields
Illustris-TNG



New Record Breaking Quasars

J1342+0928; $z=7.54$; 800 million M_{sun} !

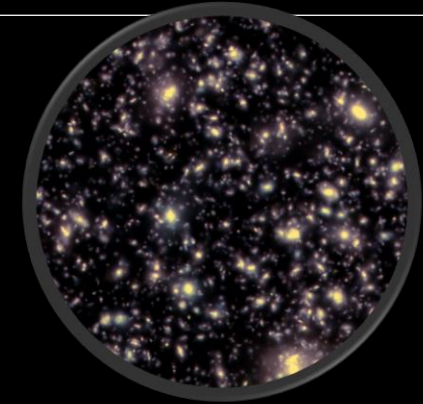
Stellar Mass

Intermediate Mass

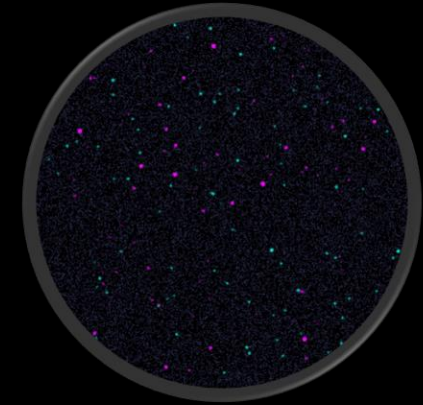
Massive

Supermassive

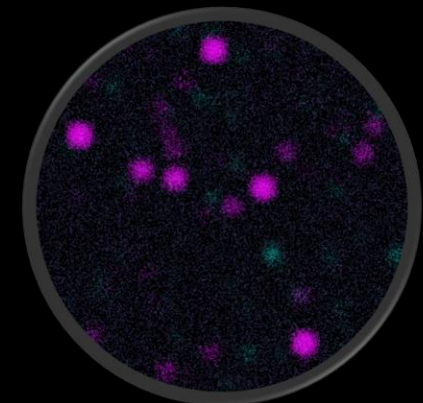
Super-massive Black Holes in the Early Universe



JWST

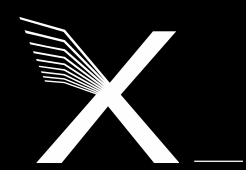


Lynx

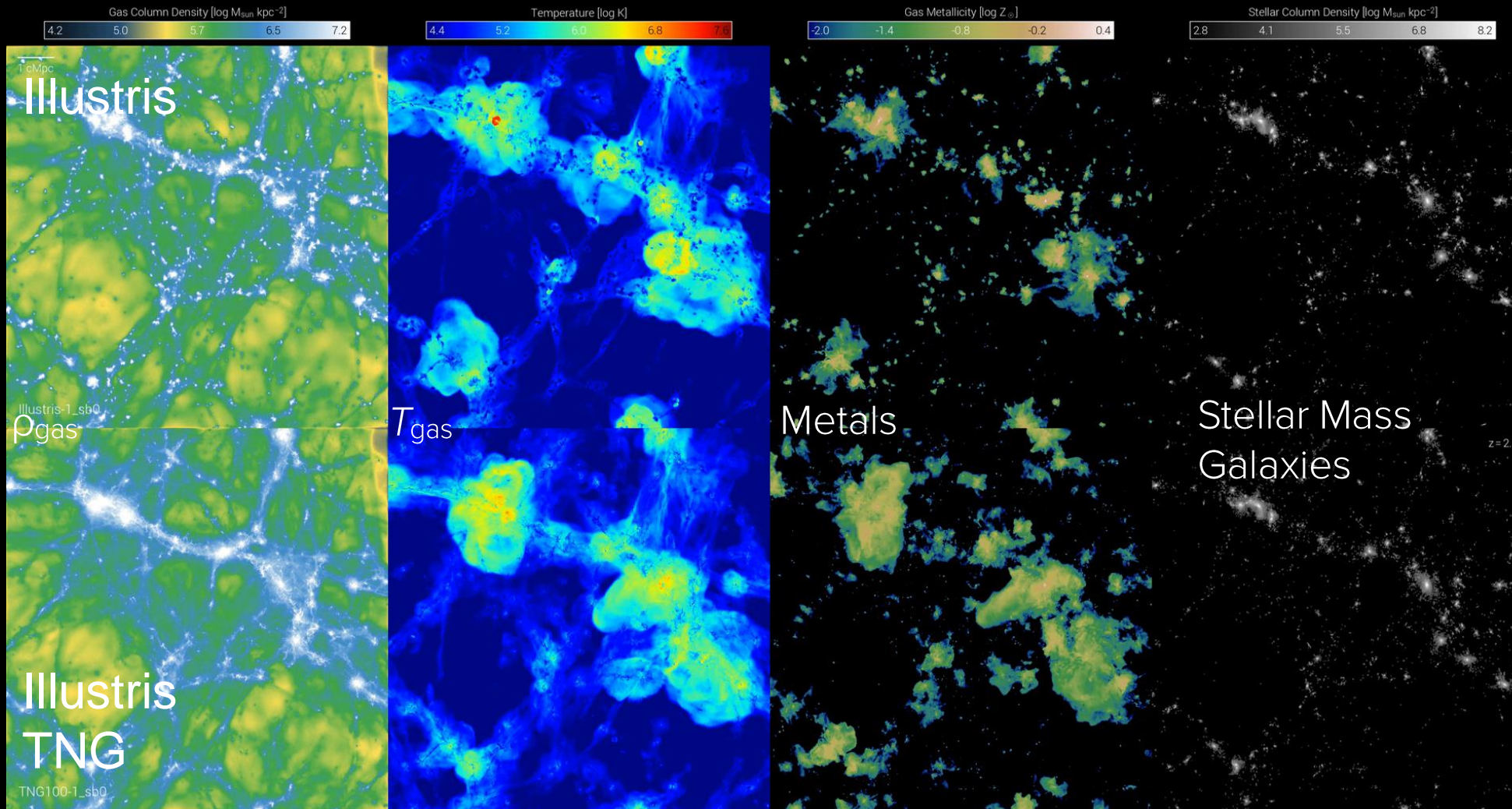
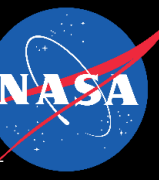


ATHENA

Image credit: Jinyi Yang/UA; Reidar Hahn/Fermilab;
M. Newhouse/NOAO/AURA/NSF



ENGINES OF CHANGE



Same Numerics, Different Physics

Indistinguishable Galaxies



THE DISTANT LIGHT OF
INFANT SUNS



WORLDS BEYOND OUR OWN



THE MILKY WAY

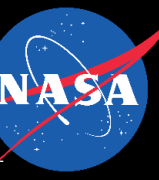
THE SUN

CHANDRA HORIZON
FOR YOUNG STAR
CLUSTERS

X HORIZON



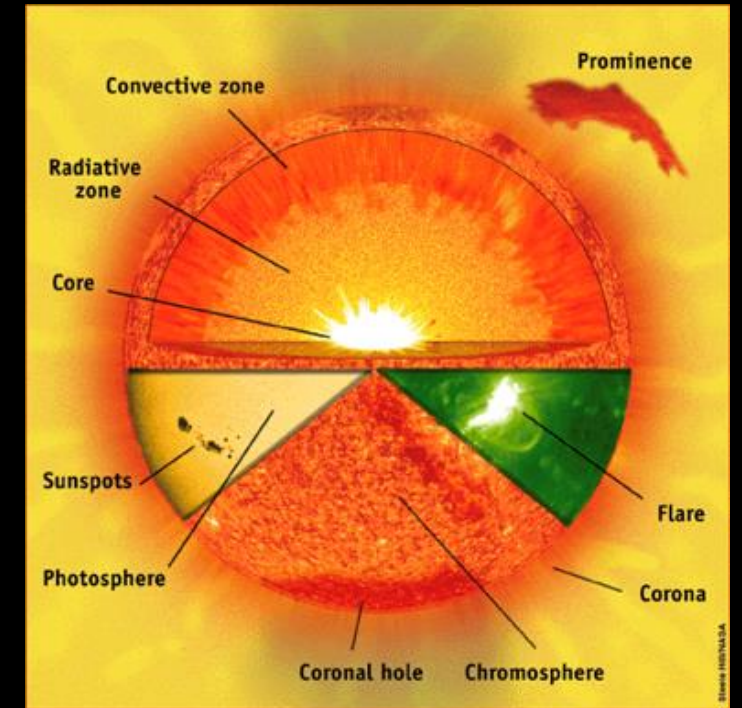
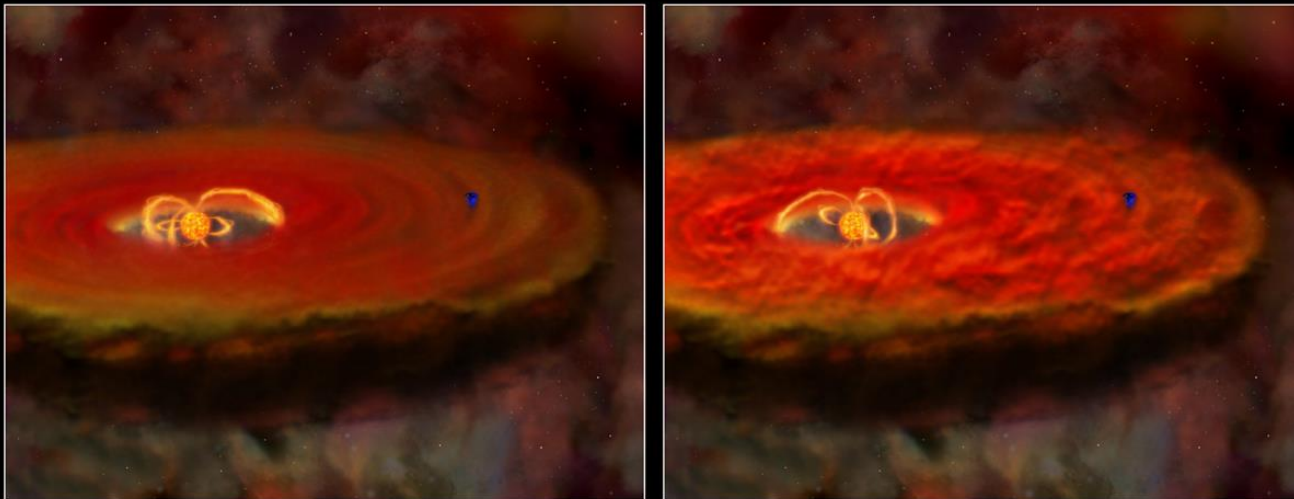
HIDDEN LIGHT OF SUNS



Where do planets form? Where do they migrate?

- X-ray spectra of young stars show more than accretion plus magnetic activity
- X-rays implicated in rapid heating of protoplanetary disks
- After stars lose their disks X-ray surveys are the only way to find young stellar objects

How do the characteristics of flares change with time and what impact does this have on exoplanet conditions?



The star's magnetic field creates an ecosystem which helps to set the environment that planets (and life) experience (Lingam & Loeb 2018) Stellar magnetospheres influence the inner edge of the traditional habitable zone (Garaffo et al. 2016, 2017).

- Systematic change of T_{\max} , E_{flare} , $L_{x,\max}$ on flares of stars with varying mass, age, magnetic configuration as input to evolution of planetary irradiation
- Influence of energetic particles inferred from line profiles

Credit: R. Osten

N
e
x
t

S
t
e
p
s

ASTROPHYSICS

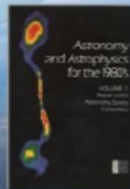
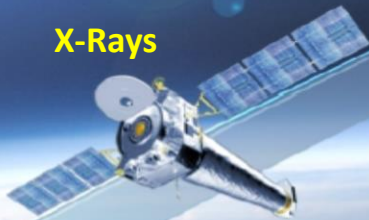
Decadal Survey Missions

UV-Visible-Near IR



1972
Decadal Survey
Hubble

X-Rays



1982
Decadal Survey
Chandra

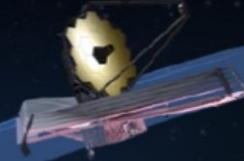
IR



1991
Decadal Survey
Spitzer, SOFIA



Visible-IR



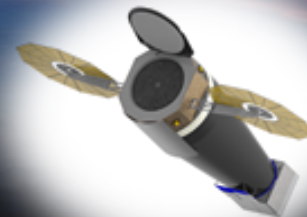
2001
Decadal Survey
Webb

Visible-Near IR



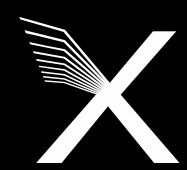
2010
Decadal Survey
WFIRST

X-Rays?

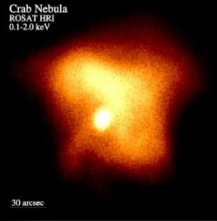


2020
Decadal Survey
Lynx

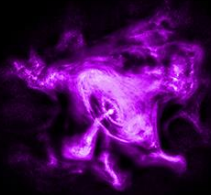
Lynx X-ray Observatory
Launch in 2030s!



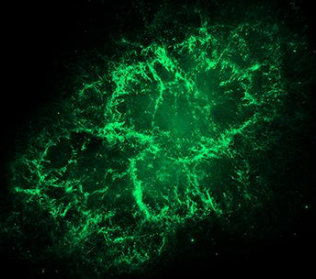
THE CRAB NEBULA



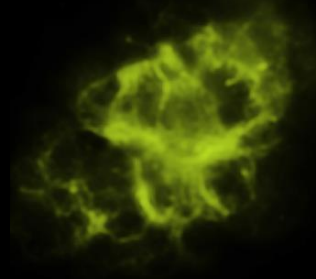
ROSAT
(X-ray)
Resolution: 5 arcsec



Chandra
(X-ray)
Resolution: 0.5 arcsec



Hubble
(visible)
Resolution: 0.05 arcsec



Spitzer
(IR)



VLA
(radio)



XMM-OM
(UV)

+ MIDEX/MO (2023),
SMEX/MO (2025), etc.

- Formulation
- Implementation
- Primary Ops
- Extended Ops

Spitzer
8/25/2003

Kepler
3/7/2009
10/30/2018 EOM

WFIRST
Mid 2020s

Euclid (ESA)
2022

Webb
2021

Chandra
7/23/1999

XMM-Newton (ESA)
12/10/1999

TESS
4/18/2018

Swift
11/20/2004

NuSTAR
6/13/2012

Fermi
6/11/2008

IXPE
2021

XRISM (XARM) (JAXA)
2022

SPHEREx
2023

Hubble
4/24/1990

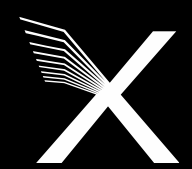
ISS-NICER
6/3/2017

ISS-CREAM
8/14/2017
2/15/2019 EOM

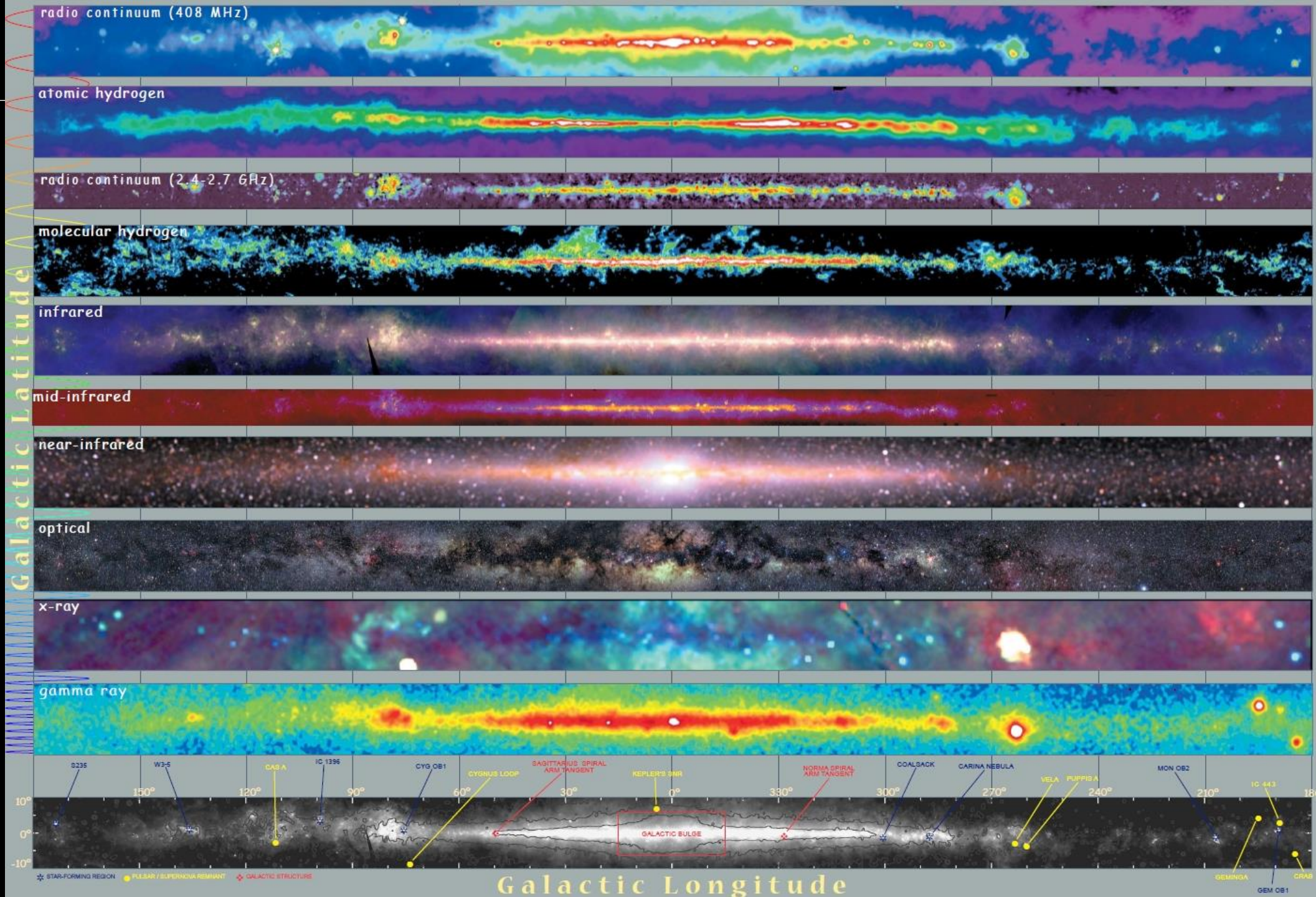
GUSTO
2021

SOFIA
Full Ops 5/2014

+ Athena (late 2020s),
LISA (mid 2030s)



THE MILKY WAY





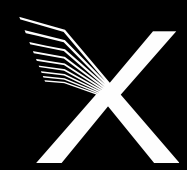
Gravitational Waves

Gamma-rays
(magenta)

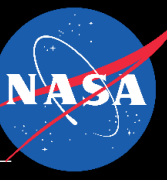
Ultraviolet
(violet)

Optical & Infrared
(blue-white to red)

X-Ray Jet
(blue)

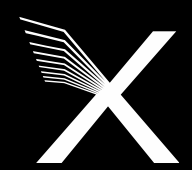


WHAT IS THE NEXT BIG QUESTION?



The right answer is seldom as important as the right question.
– K. Thorne

The Renaissance of Multi-wavelength
Astronomy has Begun!



Are Cats Spies Sent by Aliens?

If you hold a cat's ears back and describe what you see, it is a perfect match to the classic "grey alien," with its almond-shaped eyes, small mouth, and small nose.

Obviously true. See below.

LEFT TO RIGHT, IMAGES VIA [FLICKR](#) AND [WIKIMEDIA COMMONS](#)





THANK YOU!

Dr. Jessica A. Gaskin

<https://www.wastro.msfc.nasa.gov/lynx/>

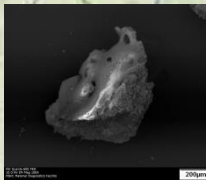
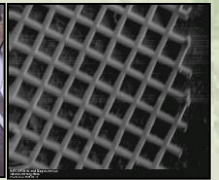
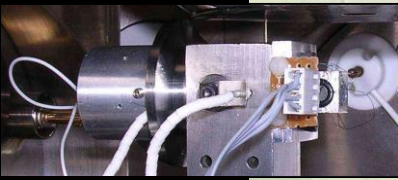
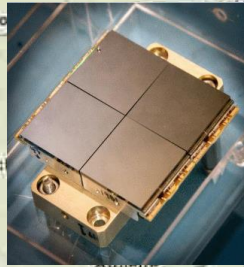
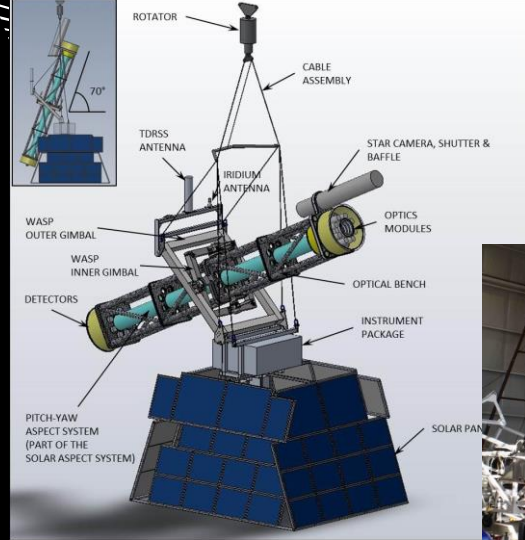
<https://www.lynxobservatory.com>

<https://chandra.harvard.edu/>

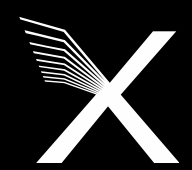


All Things Big and Small

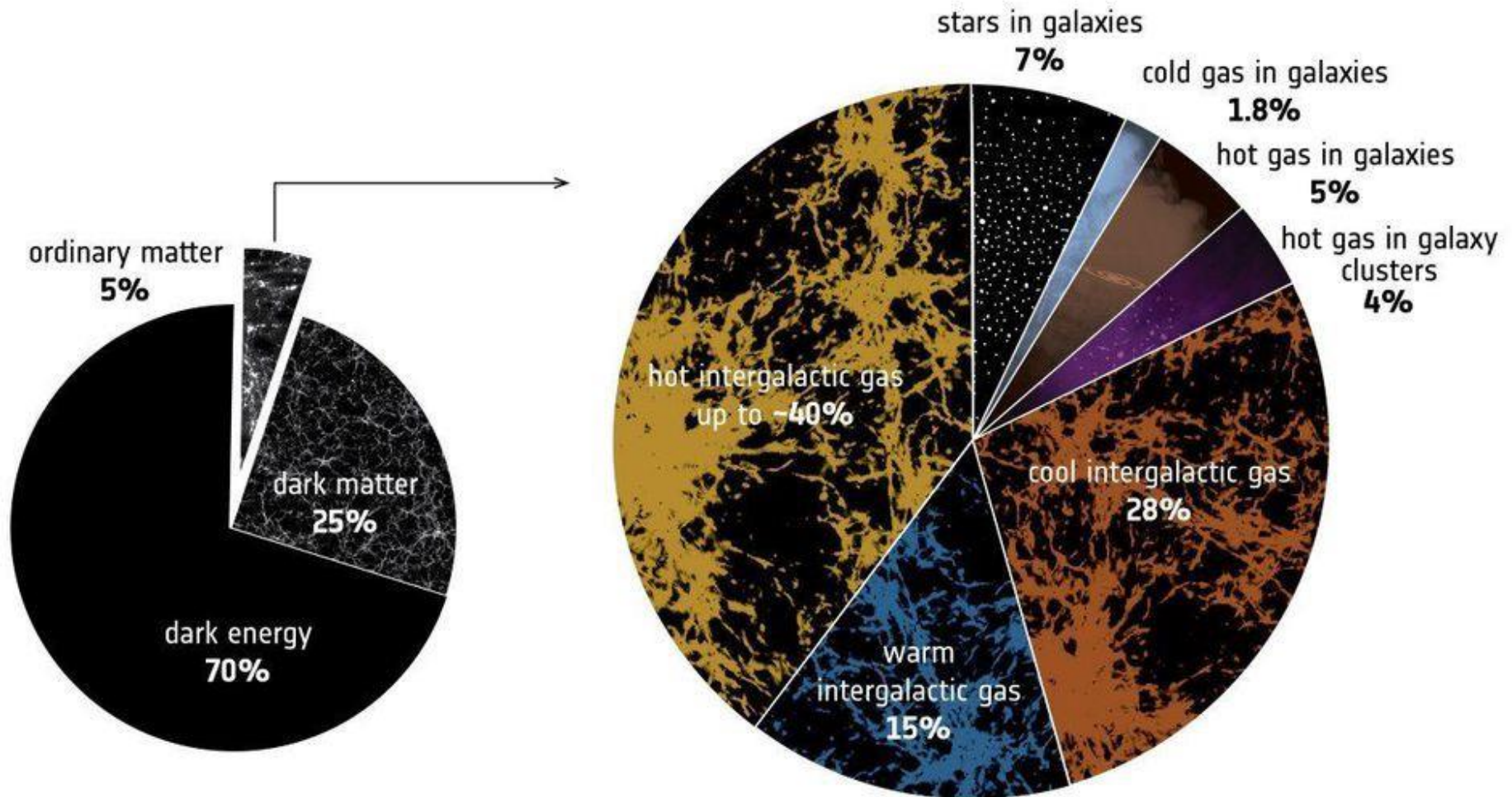
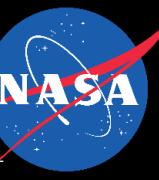
40 km Above the Earth!

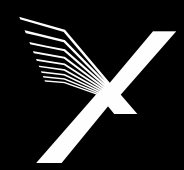


BACKUP SLIDES



DARK ENERGY & DARK MATTER





MAPPING THE COSMIC WEB



Illustrations and composition: ESA / ATG medialab; data: ESA / XMM-Newton / F. Nicastro et al. 2018; cosmological simulation: Princeton University/Renyue Cen)

