The Lynx Observatory:
A Concept for a Next Generation X-ray Telescope

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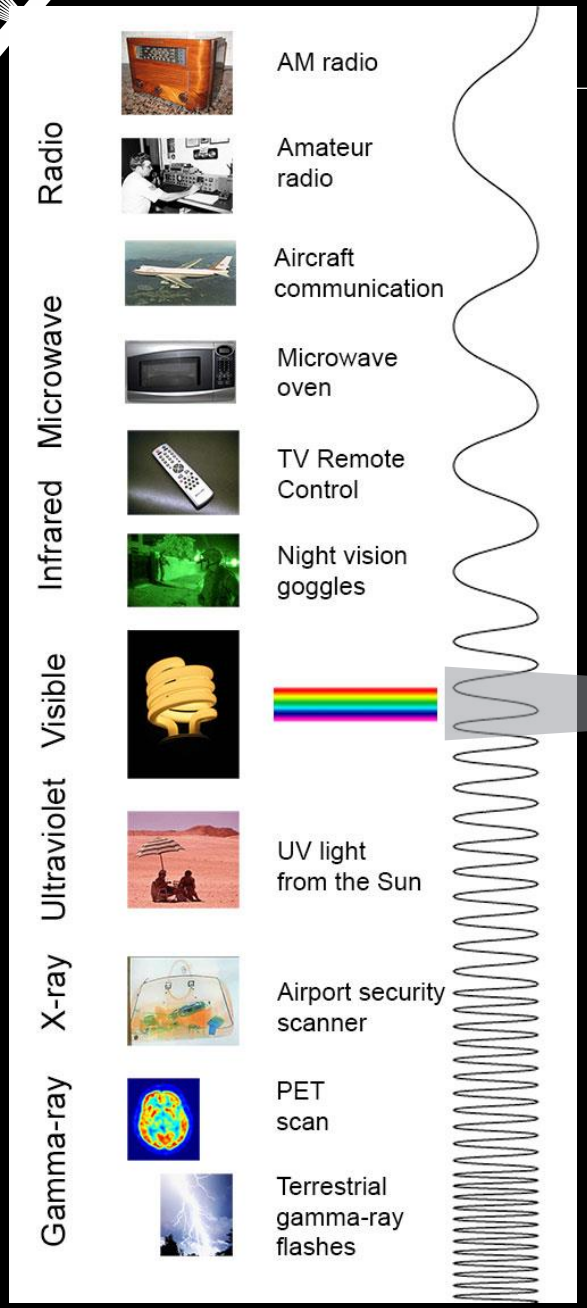
NASA MSFC

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

THE INVISIBLE UNIVERSE



Each wavelength provides different information.

X-RAYS FROM EARTH

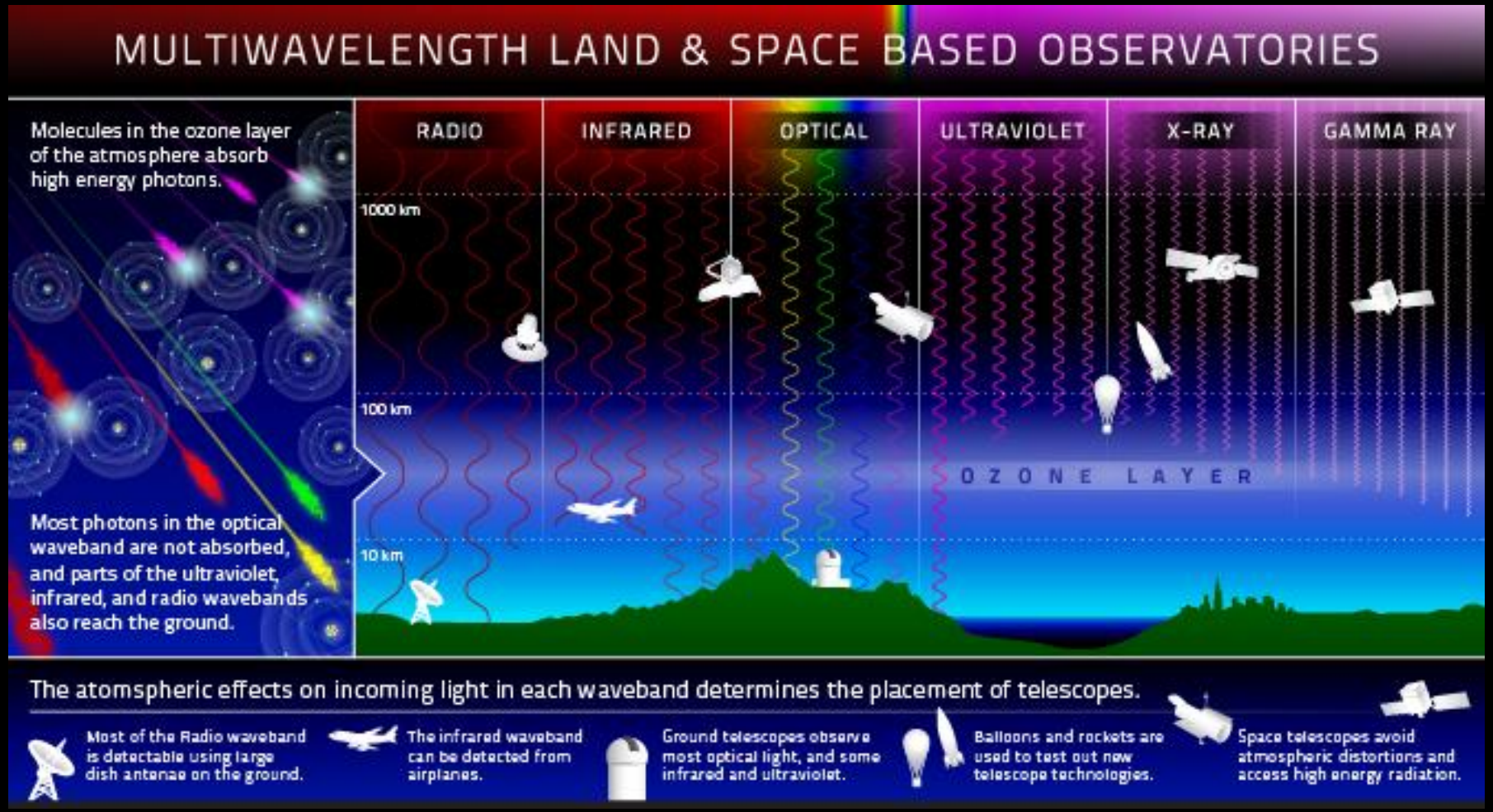
We are surrounded by naturally-occurring radioactive elements in the soil and stones.

Uranium

Radium

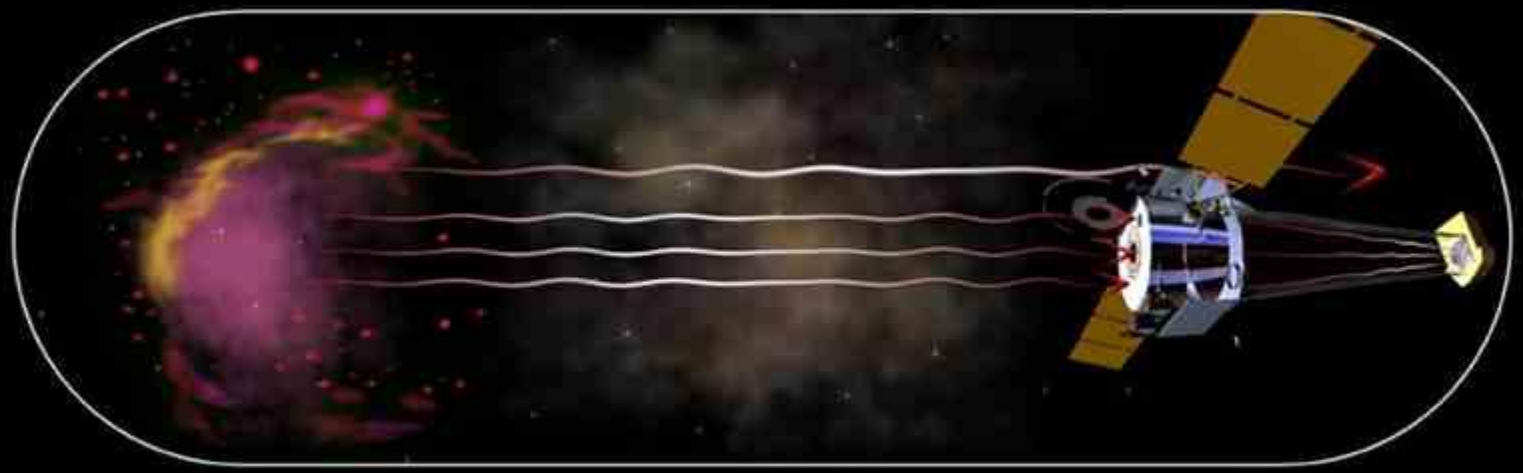
We have radioactive elements (Potassium 40, Carbon 14, Radium 226) in our blood or bones.

OUR UNIVERSE IS BRIGHT



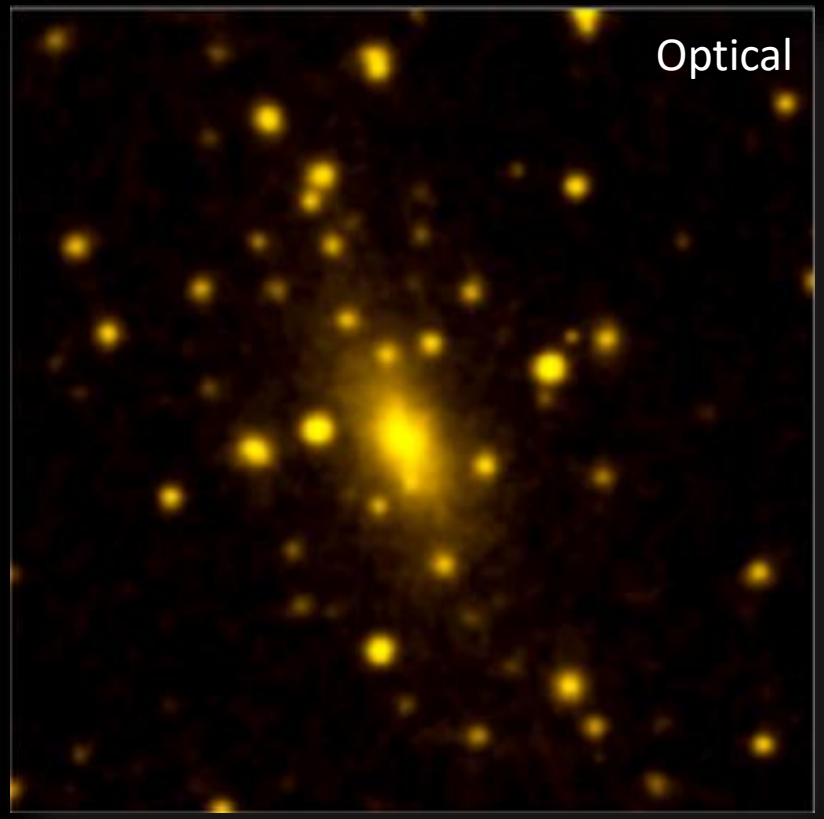
Staying Alive!

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!

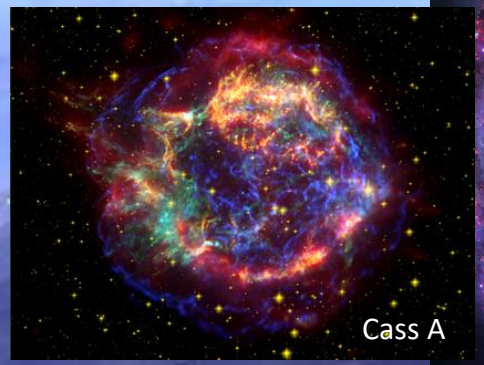
Milky Way Central Region

Jupiter

NGC 4258 (M106)

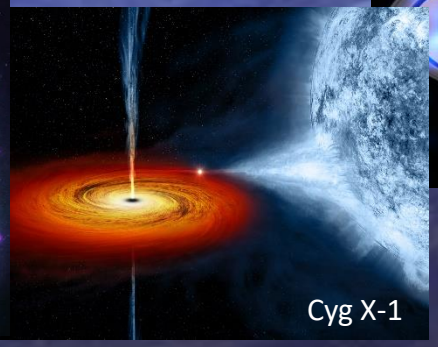
NGC 6357

Whirlpool Galaxy (M51)



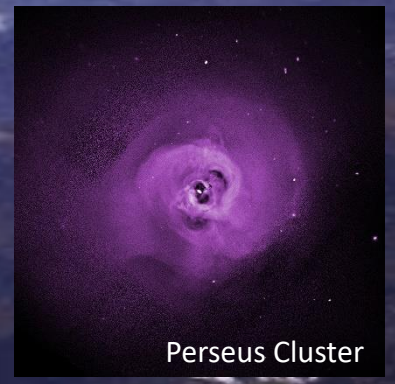
Cass A

Crab Nebula



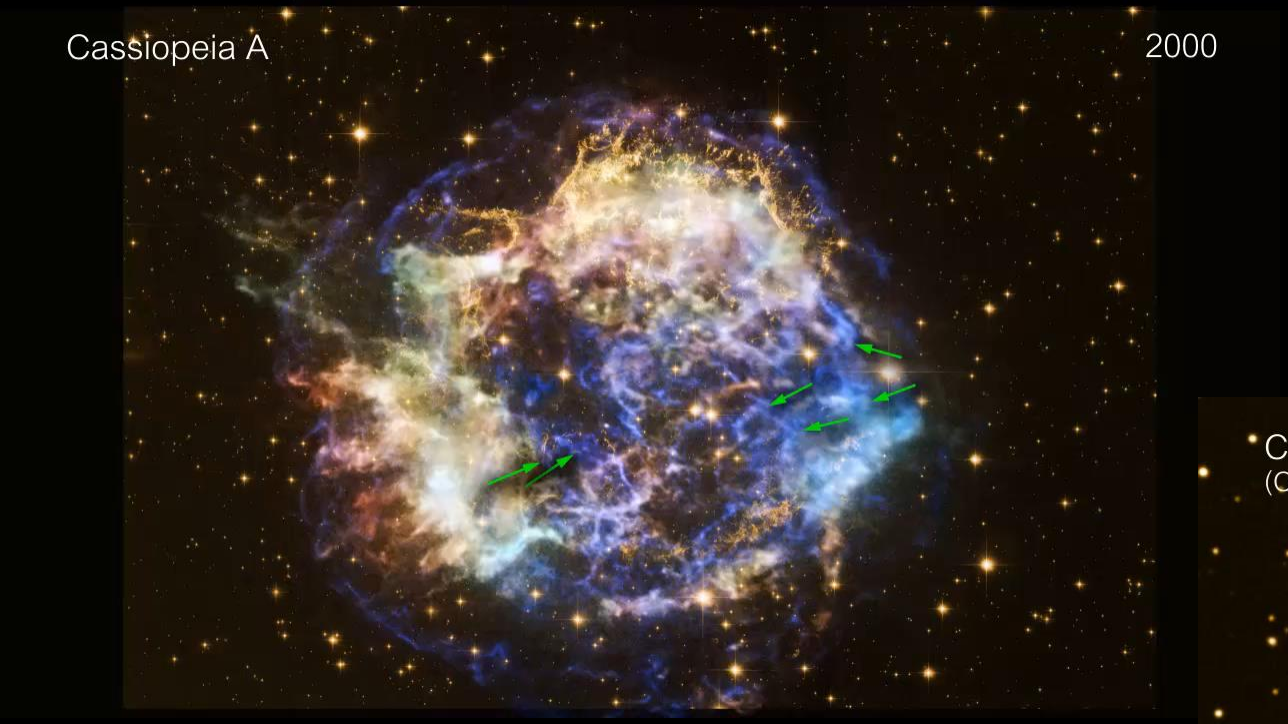
Cyg X-1

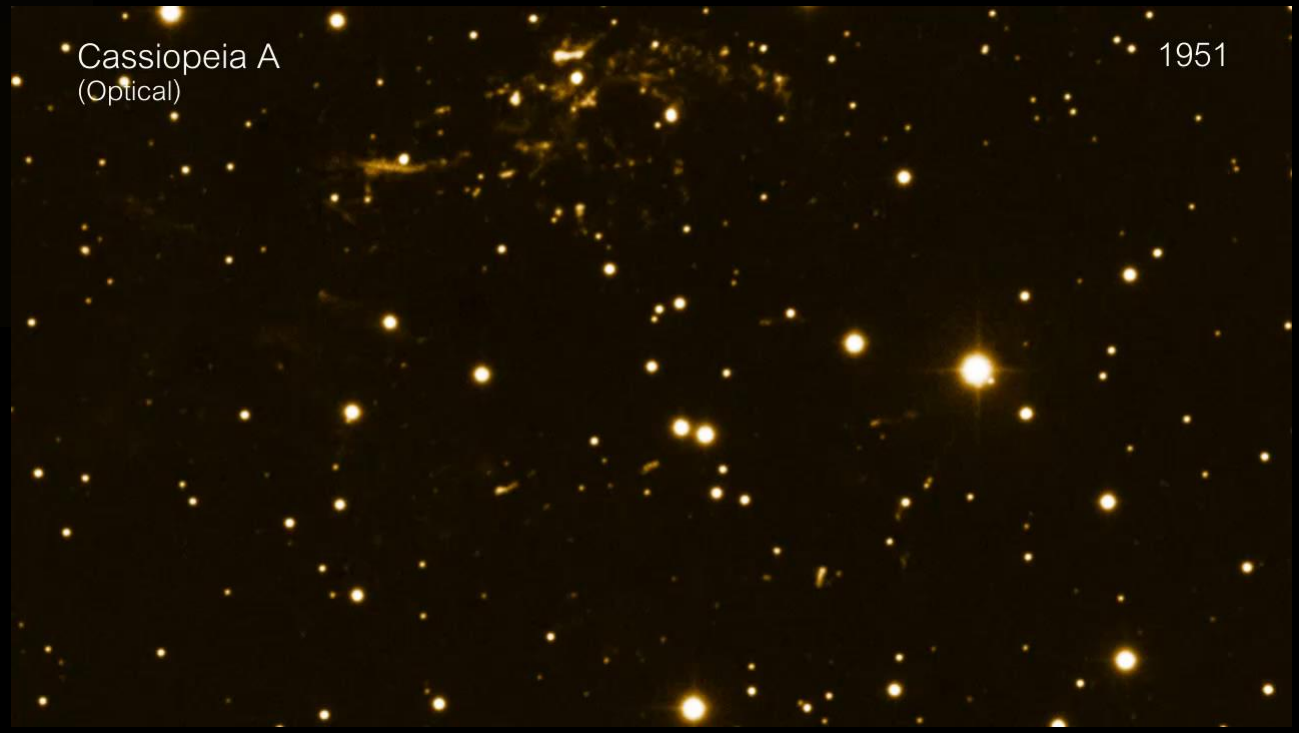
Saturn



Perseus Cluster

CHANDRA'S 20 YEAR ANNIVERSARY

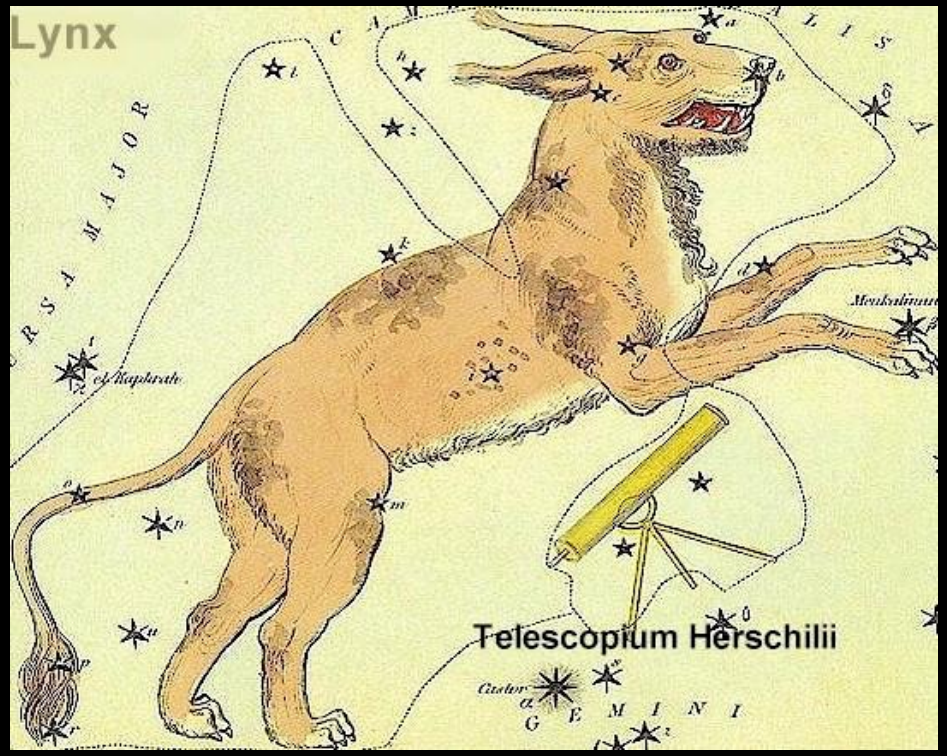




The Chandra data shows how 10-million-degree gas is expanding outward after the explosion that destroyed the star. The movie spans 2000-2013.
[credit: NASA/CXC/SAO]

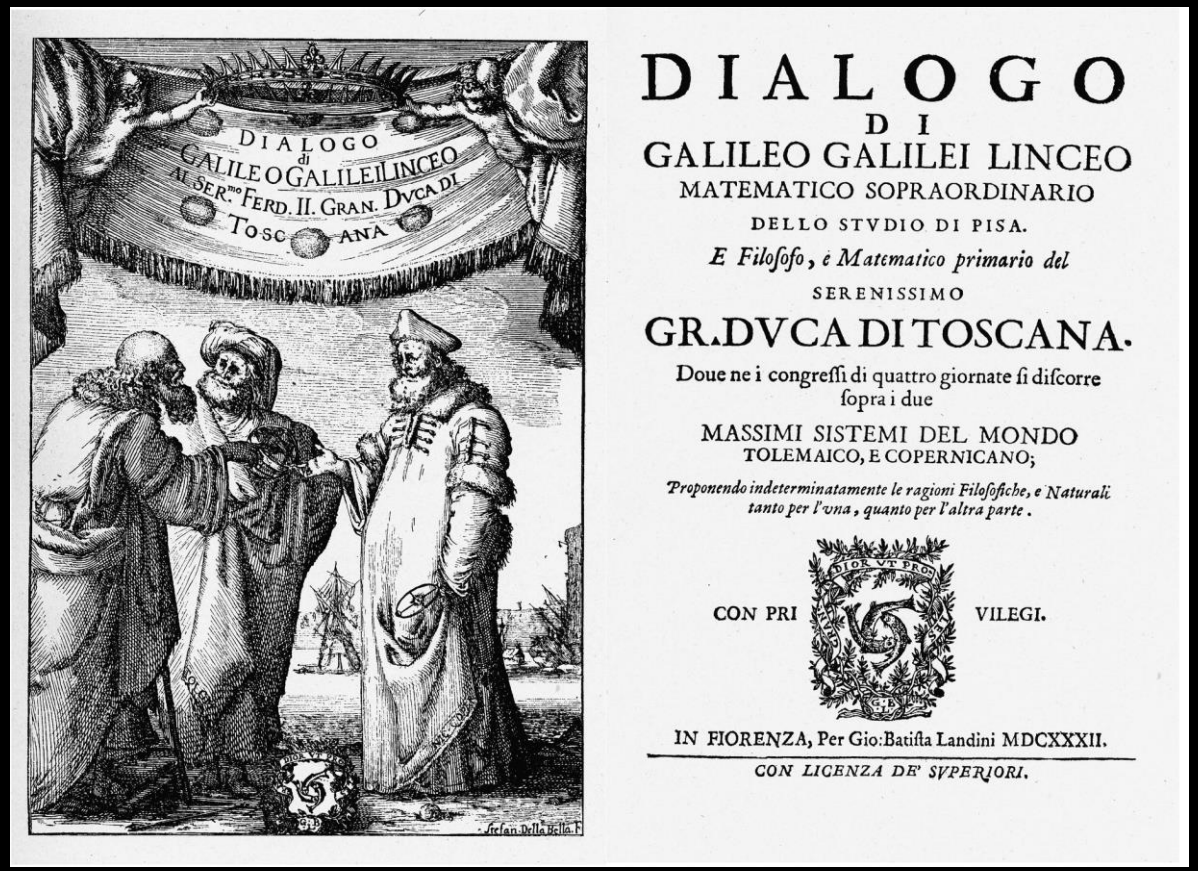
L
Y
N
X

LYNX: THE NEXT GREAT OBSERVATORY



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

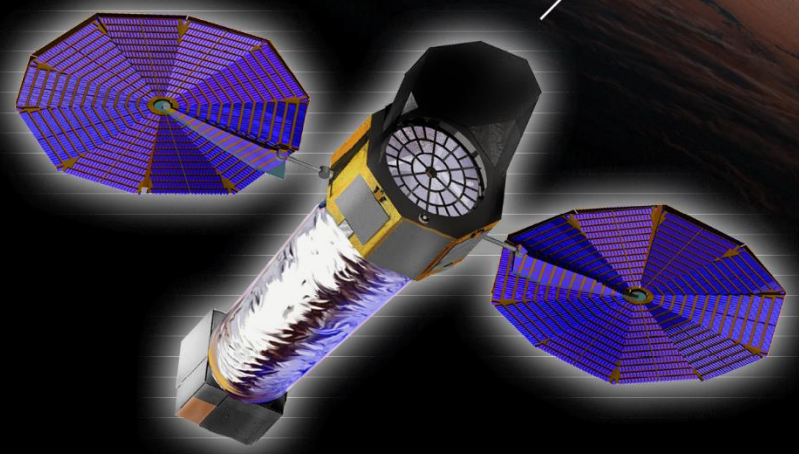
Academy of the ‘Lynx-Eyed’ was founded in 1603 by Federico Cesi. Perform incisive and penetrating investigations of the natural world.



A NEW GREAT OBSERVATORY

X-RAY MIRROR ASSEMBLY

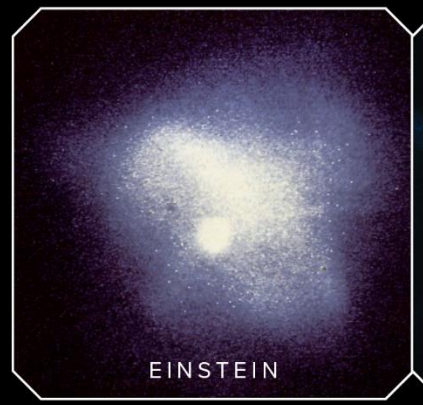
0.5'' Point-Spread Function, stable over a 20 arcminute FoV



HIGH DEFINITION X-RAY IMAGER

LYNX X-RAY MICROCALORIMETER

X-RAY GRATINGS SPECTROMETER



EINSTEIN

CHANDRA

HIGH DEFINITION X-RAY IMAGER

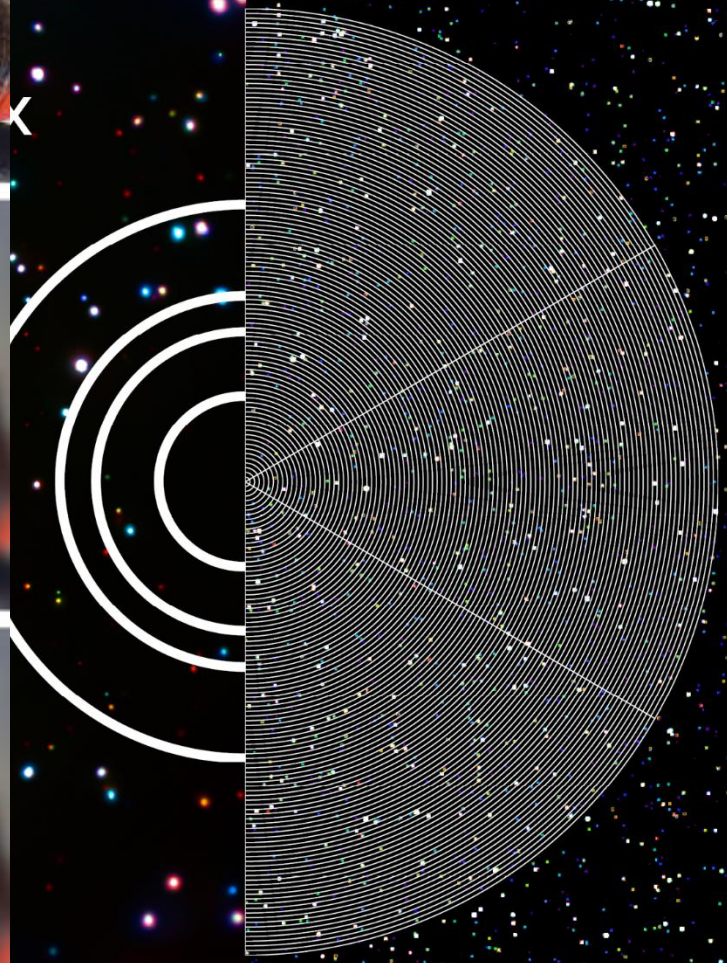
Designed for exquisite imaging and wide surveys, the HDXI is an active pixel array covering a 20' x 20' field of view with subarcsecond imaging.

LYNX X-RAY MICROCALORIMETER

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

X-RAY GRATINGS SPECTROMETER

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

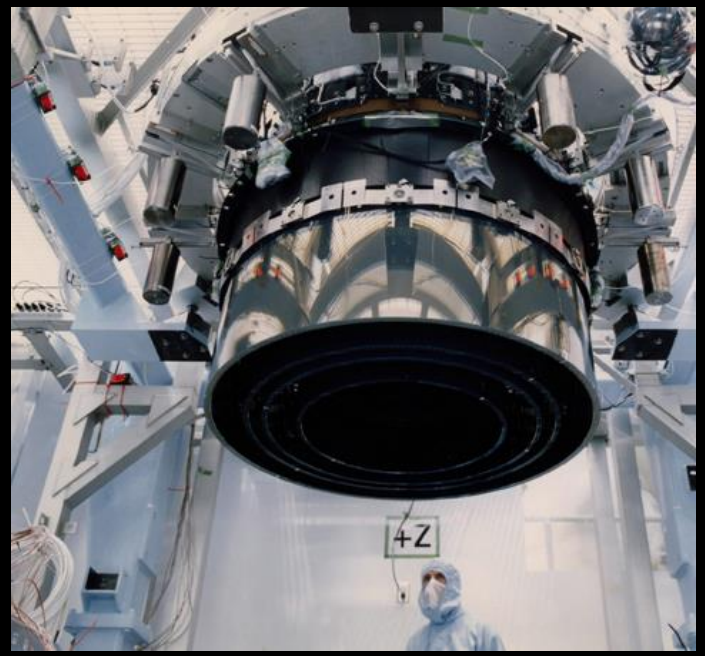


50x higher throughput while maintaining *Chandra's* angular resolution.

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.

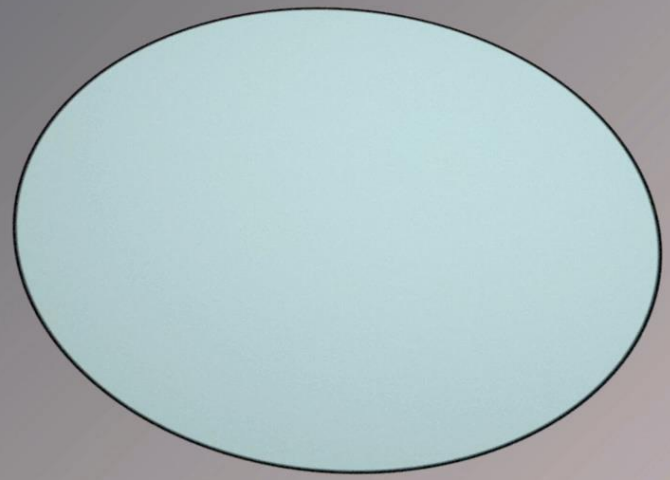
FOCUSING X-RAY OPTICS



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

BLACK HOLE DAWN

Simulated Deep Fields
Illustris-TNG

New Record Breaking Quasars

J1342+0928; z=7.54; 800 million Msun!

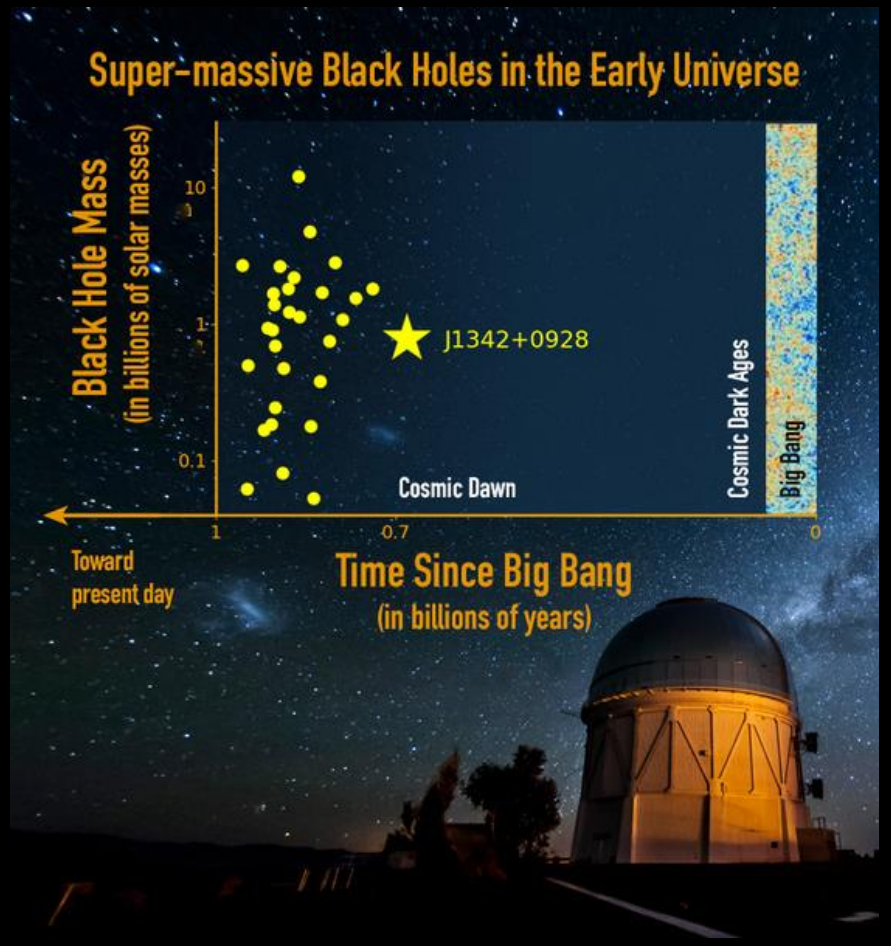
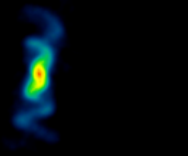


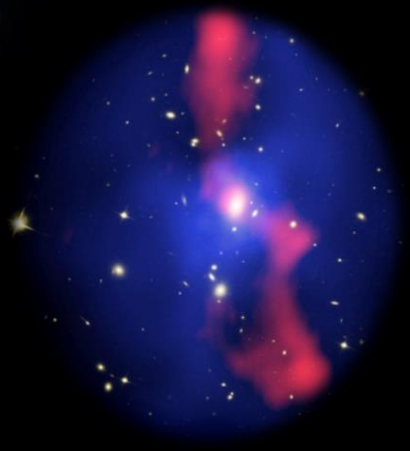
Image credit: Jinyi Yang/UA; Reidar Hahn/Fermilab;
M. Newhouse/NOAO/AURA/NSF



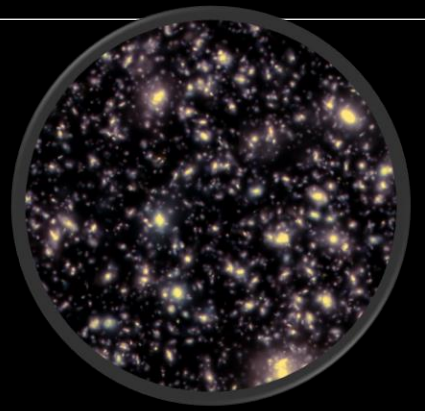
Stellar Mass

Intermediate Mass

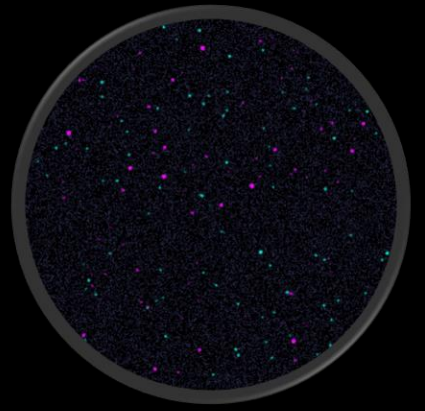
Massive



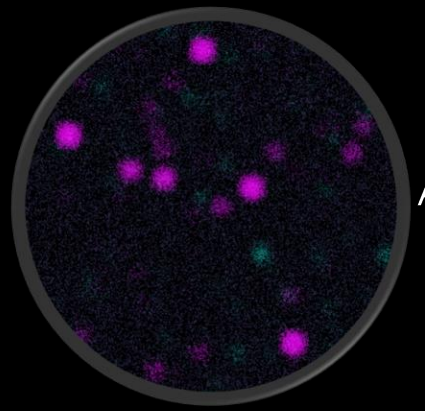
Supermassive



JWST

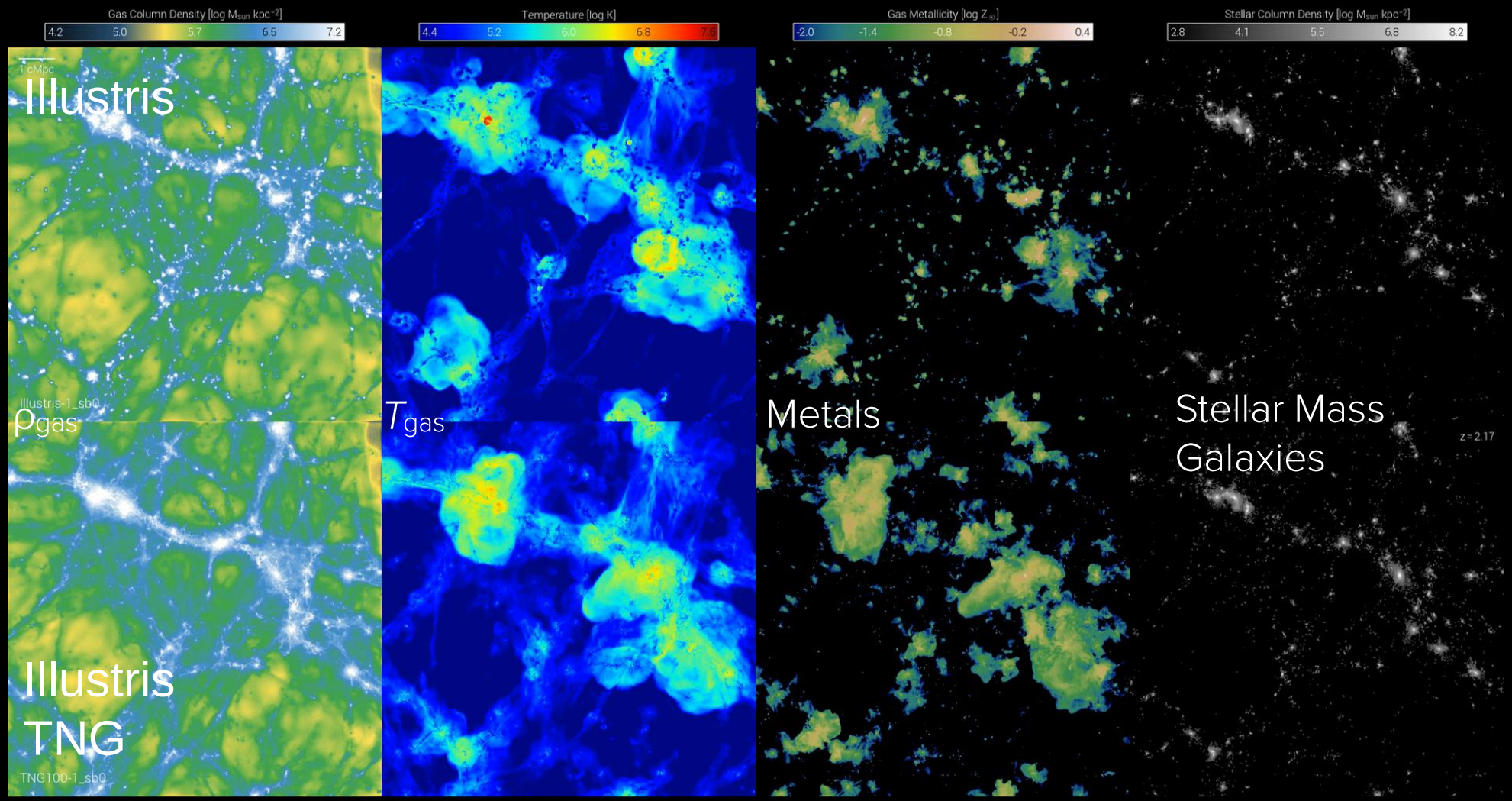


Lynx



ATHENA

ENGINES OF CHANGE

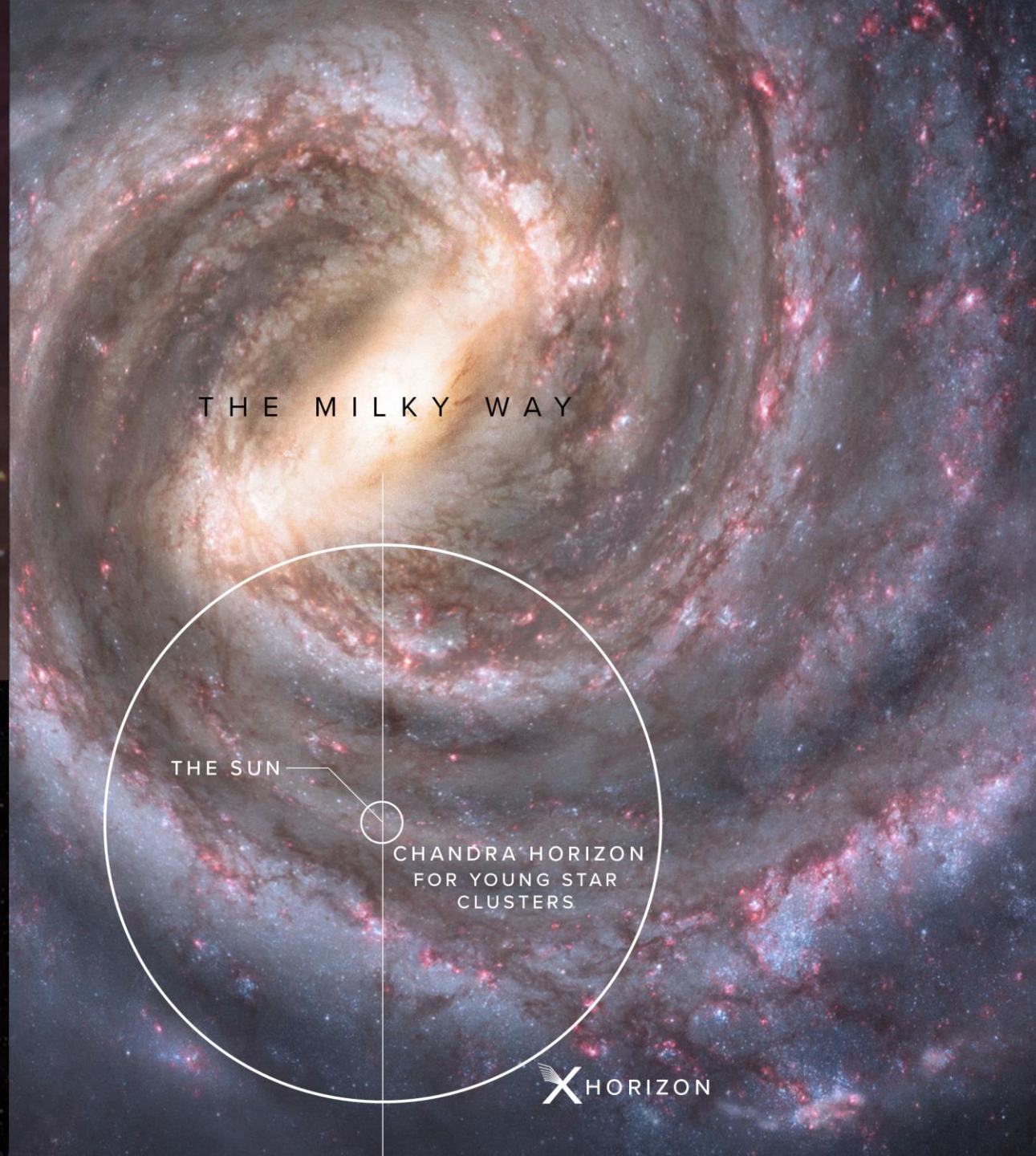


Same Numerics, Different Physics

Indistinguishable Galaxies

THE DISTANT LIGHT OF
INFANT SUNS

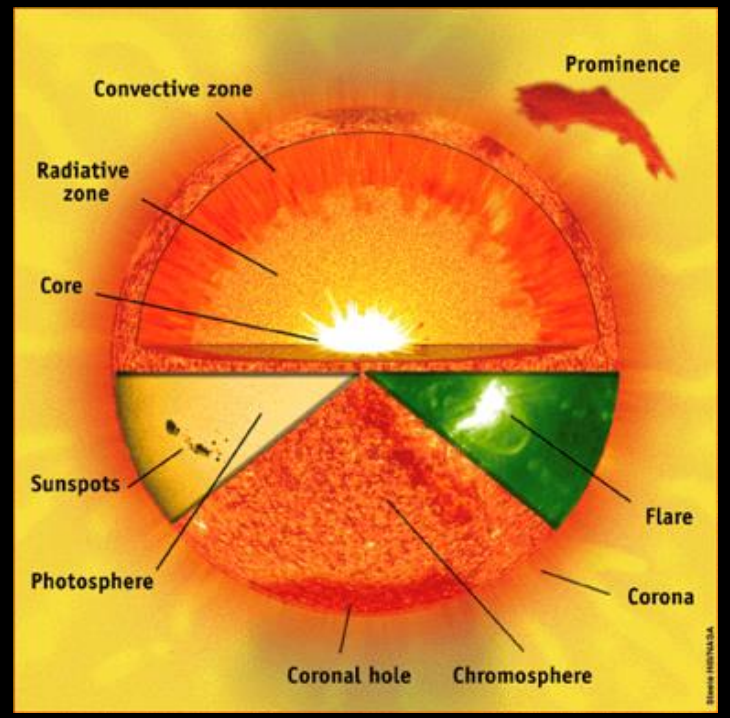
WORLDS BEYOND OUR OWN



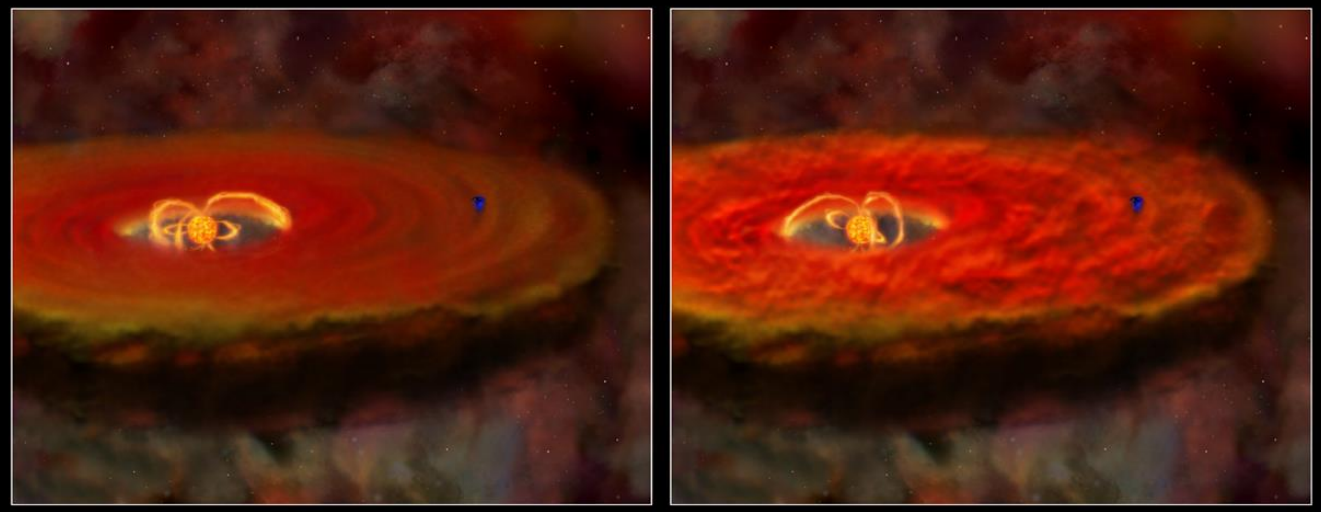
HIDDEN LIGHT OF SUNS

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?

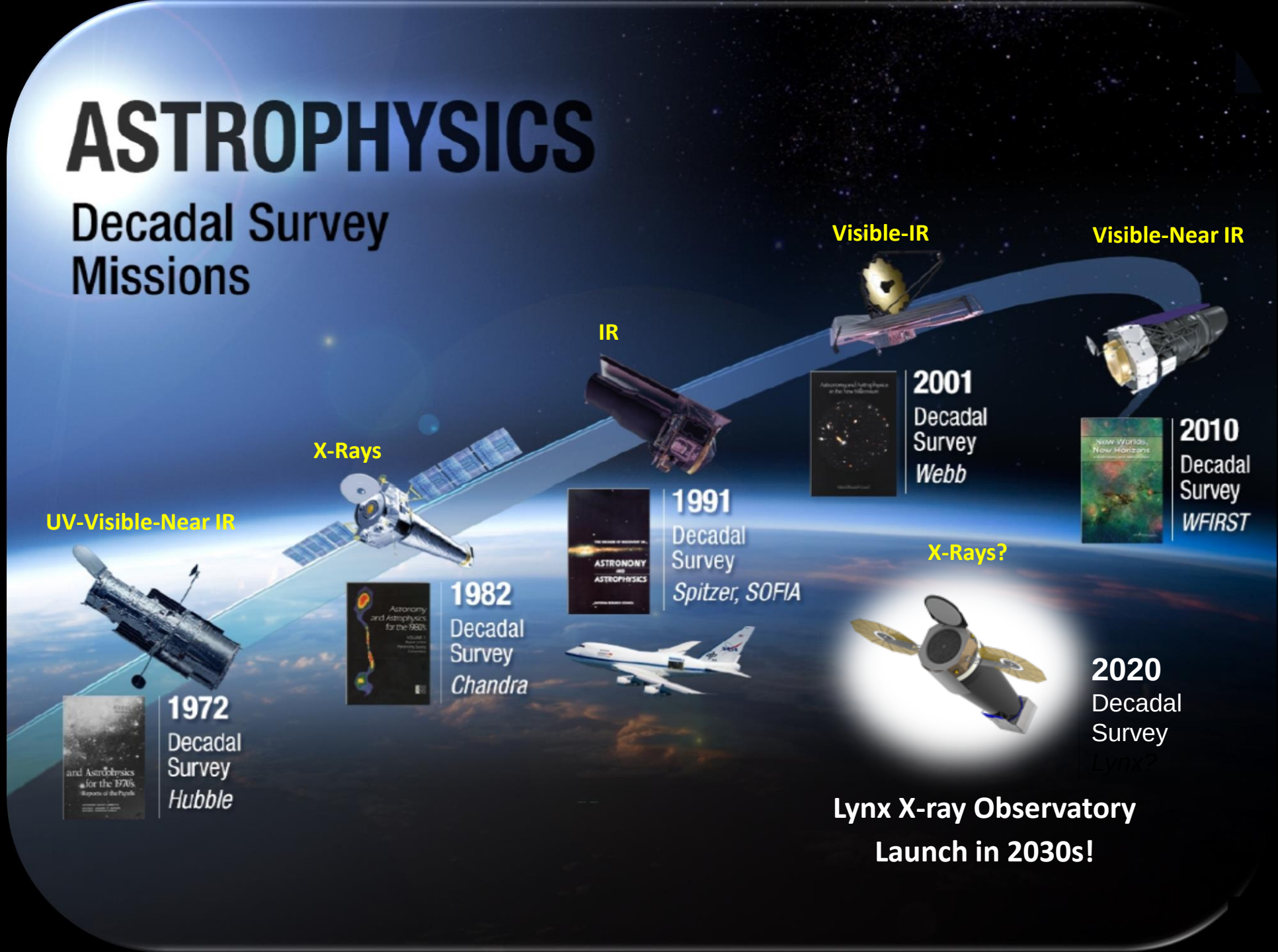


The star's magnetic field creates an ecosystem which helps to set the environment that planets (and life) experience (Lingam & Loeb 2018) Stellar magnetospheres influence the inner edge of the traditional habitable zone (Garaffo et al. 2016, 2017).

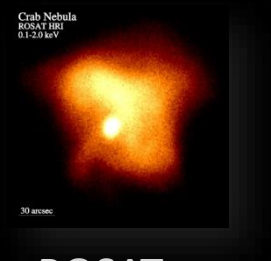
- Systematic change of T_{max}, E_{flare}, $L_{x,max}$ on flares of stars with varying mass, age, magnetic configuration as input to evolution of planetary irradiation
- Influence of energetic particles inferred from line profiles

Credit: R. Osten

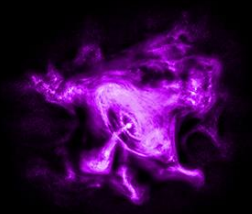
Next steps


ASTROPHYSICS
Decadal Survey
Missions
UV-Visible-Near IR
X-Rays
IR
Visible-IR
Visible-Near IR
X-Rays?
1972
Decadal
Survey
Hubble
1982
Decadal
Survey
Chandra
1991
Decadal
Survey
Spitzer, SOFIA
2001
Decadal
Survey
Webb
2010
Decadal
Survey
WFIRST
2020
Decadal
Survey
Lynx?
Lynx X-ray Observatory
Launch in 2030s!

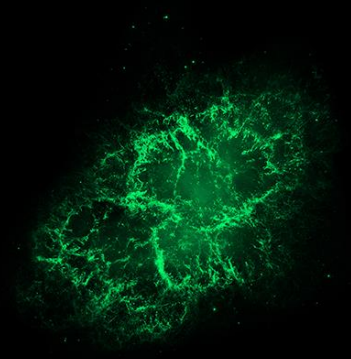
THE CRAB NEBULA



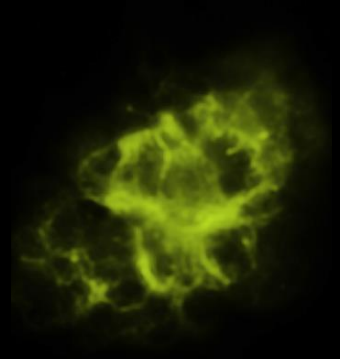
ROSAT
(X-ray)
Resolution: 5 arcsec



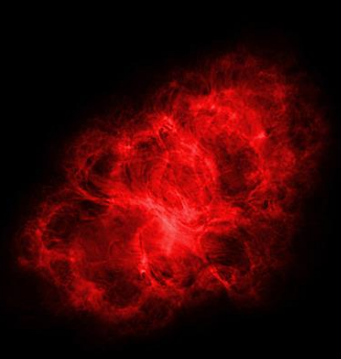
Chandra
(X-ray)
Resolution: 0.5 arcsec



Hubble
(visible)
Resolution: 0.05 arcsec



Spitzer
(IR)

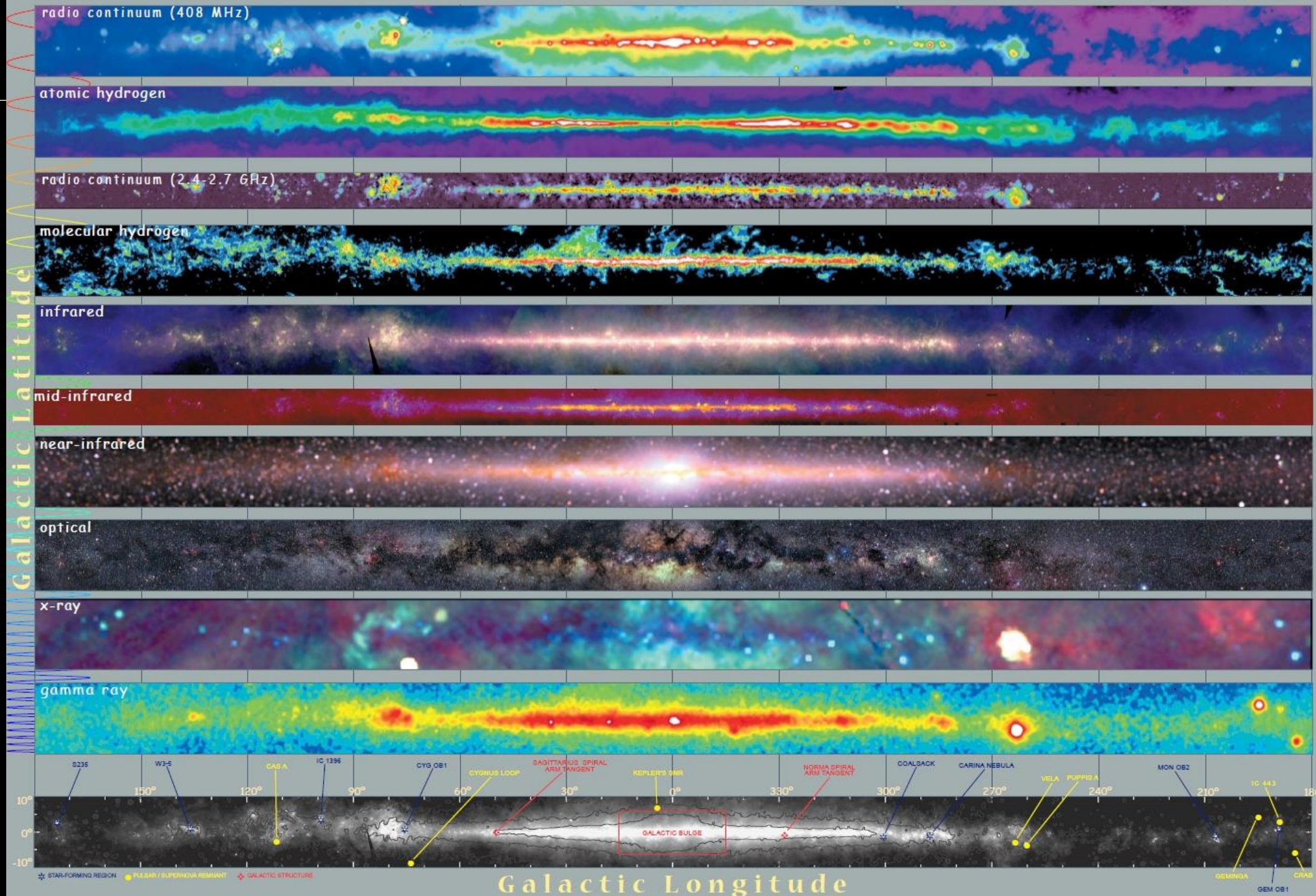


VLA
(radio)

XMM-OM
(UV)


+ MIDEX/MO (2023), SMEX/MO (2025), etc.
Spitzer 8/25/2003
Kepler 3/7/2009 10/30/2018 EOM
Formulation
Implementation
Primary Ops
Extended Ops
WFIRST Mid 2020s
Euclid (ESA) 2022
Webb 2021
Chandra 7/23/1999
XMM-Newton (ESA) 12/10/1999
TESS 4/18/2018
NuSTAR 6/13/2012
Swift 11/20/2004
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
Revised February 21, 2019
+ 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

https://www.vice.com/en_us/article/pgg9gm/are-cats-spies-sent-by-aliens-motherboard-examines-a-favorite-internet-conspiracy-theory

THANK YOU!

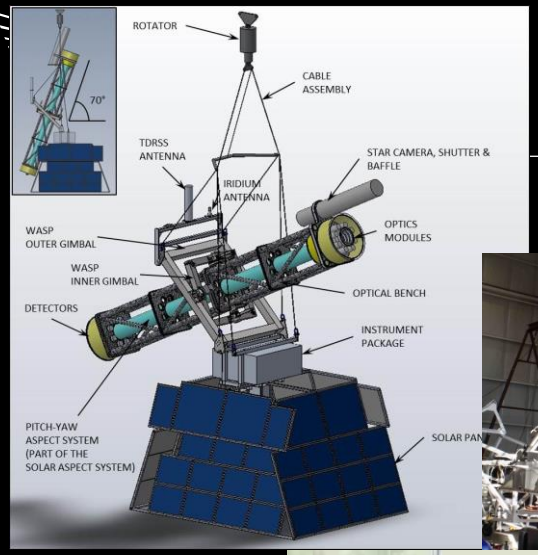
Dr. Jessica A. Gaskin

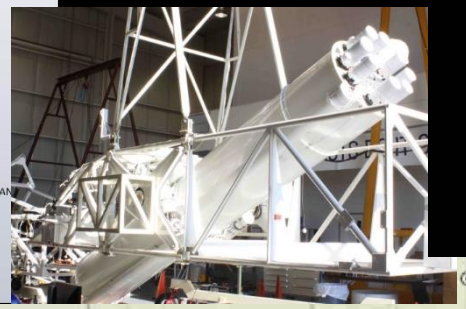
https://wwwastro.msfc.nasa.gov/lynx/

https://www.lynxobservatory.com

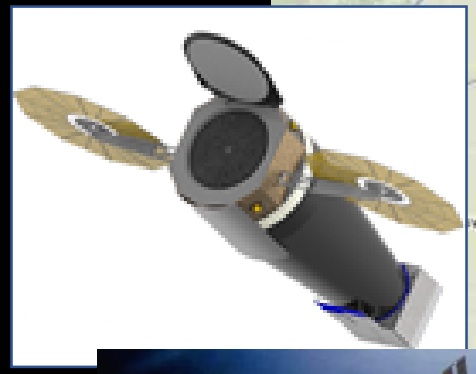
https://chandra.harvard.edu/

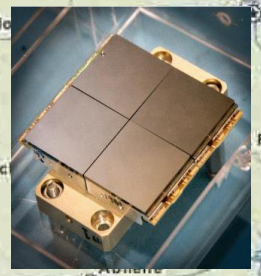
All Things Big and Small

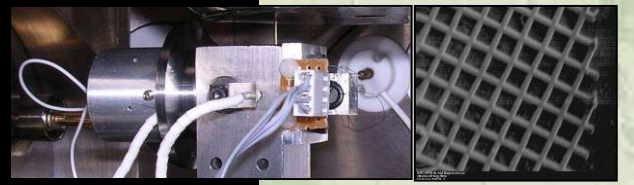


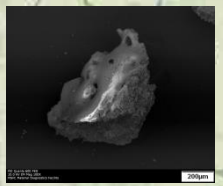


40 km Above the Earth!









Dr. Jessica Gaskin

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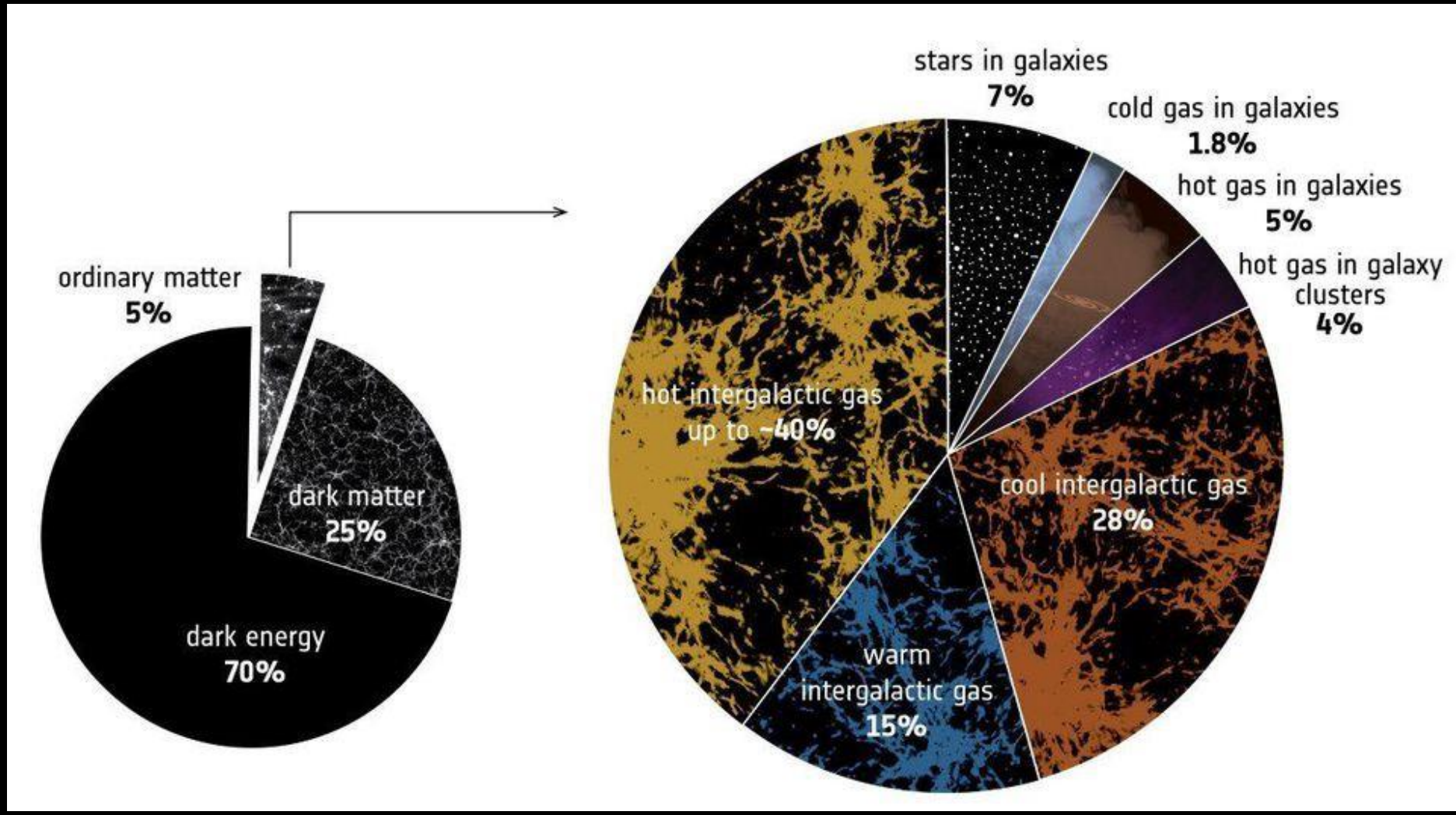
MARSHALL SPACE FLIGHT CENTER

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)