DISCOVERY AWAITS

CHANDRA'S SCIENCE PLAN FOR 2025

CHANDRA X-RAY CENTER

CHANDRA.SI.EDU

The Chandra X-ray Observatory launches aboard Columbia, July 23, 1999
NASA

Artist's impression of the Chandra X-ray Observatory in orbit. Credit: NASA/CXC/James Vaughan

Twenty-five years ago, NASA's *CHANDRA X-RAY OBSERVATORY* launched aboard the Space Shuttle *Columbia* as the third flagship in NASA's fleet of Great Observatories. Its discoveries have transformed our understanding of the cosmos and our place within it. Today it remains the most powerful X-ray observatory in history, and its unique, once-in-a-generation capabilities act as a force multiplier for effectively every major research observatory on the ground or in space, including the *James Webb Space Telescope*.

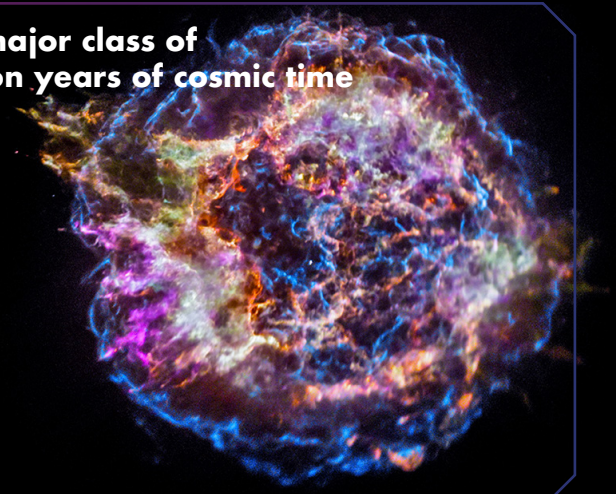
Each year, thousands of explorers from across the globe compete for *Chandra* observing time in a proposal peer review process. We are now delighted to present some highlights of that process for the coming 2025–2026 observing cycle. The full science program can be found at cxc.harvard.edu.

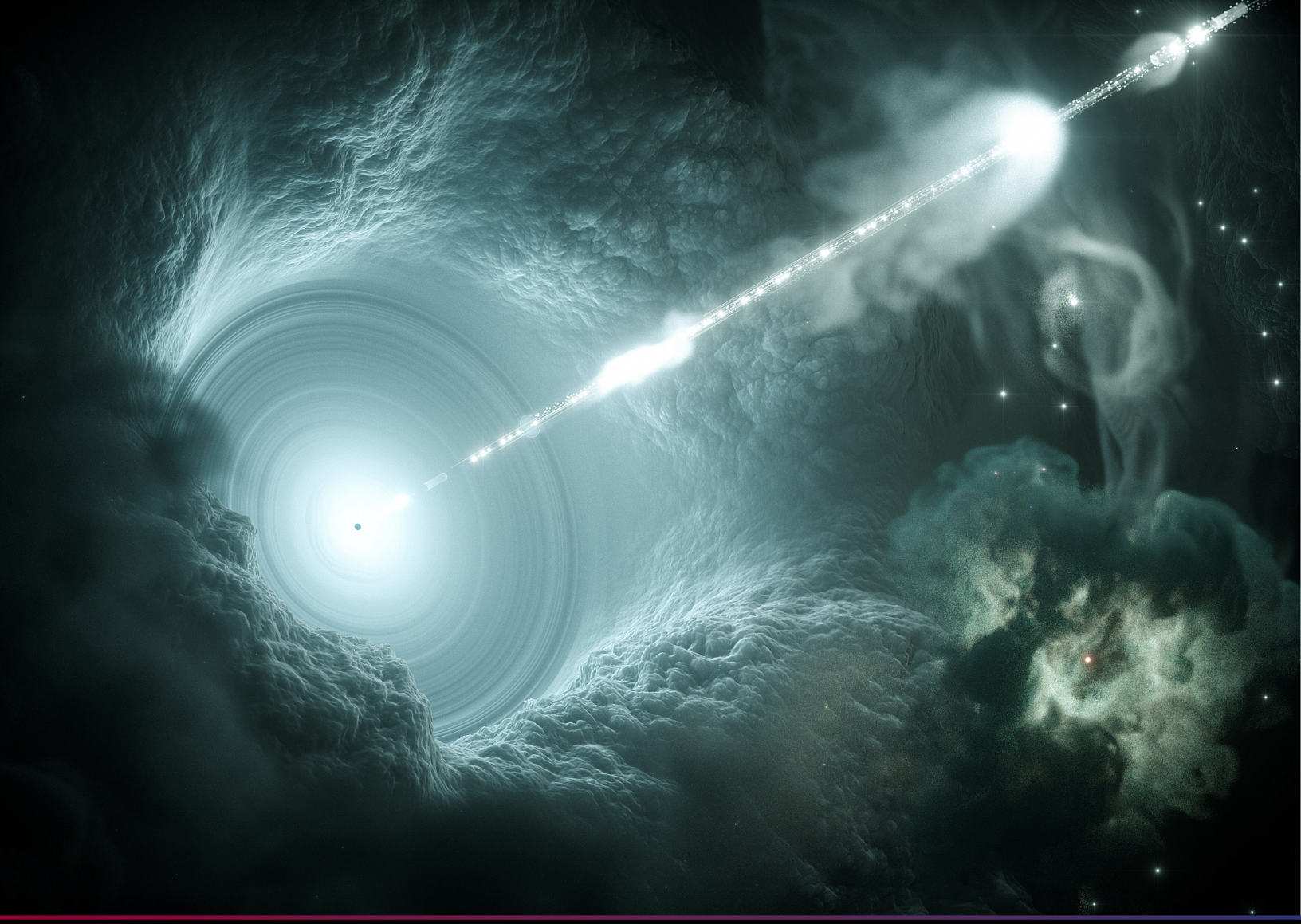
THE PROGRAM AT A GLANCE

CHANDRA CYCLE 26

In 2025, Chandra will observe almost every major class of astrophysical object across more than 12 billion years of cosmic time

107 unique scientific programs
360 unique scientific targets
20 million seconds of observing time
20 programs with major JWST synergy
Dozens of Time Domain programs
Two new Chandra Legacy Programs





An artist's illustration of a supermassive black hole at the center of an accretion disk sending a narrow jet of high-energy particles into space. Chandra *observes these types of objects.* Credit: DESY, Science Communication Lab

BLACK HOLES

***Chandra* has revolutionized our understanding of black holes, including how they were born as seeds in the early Universe, how they grow in the hearts of galaxies, and how that growth orchestrates the evolution of galaxies across cosmic time. This year, *Chandra* will observe dozens of new programs that will enable major advances in our understanding of black holes. We list a sneak peak at just a few of these below.**

APPROVED BLACK HOLE PROGRAMS — CHANDRA CYCLE 26

Disk Wind Spectroscopy in a Bright Black Hole Transient
PI: Dr. Jon Miller, University of Michigan

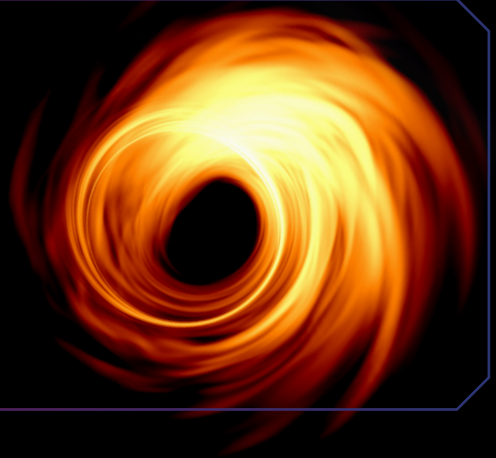
Supermassive Black Hole Growth in Local Low-mass Mergers
PI: Dr. Adi Foord, University of Maryland, Baltimore County

A candidate Runaway Supermassive Black Hole
PI: Dr. Grant Tremblay, Center for Astrophysics | Harvard & Smithsonian

Searching for Winds and Jets in Black Hole State Transitions
PI: Dr. Joey Neilsen, Villanova University | Joint with NuSTAR & Swift

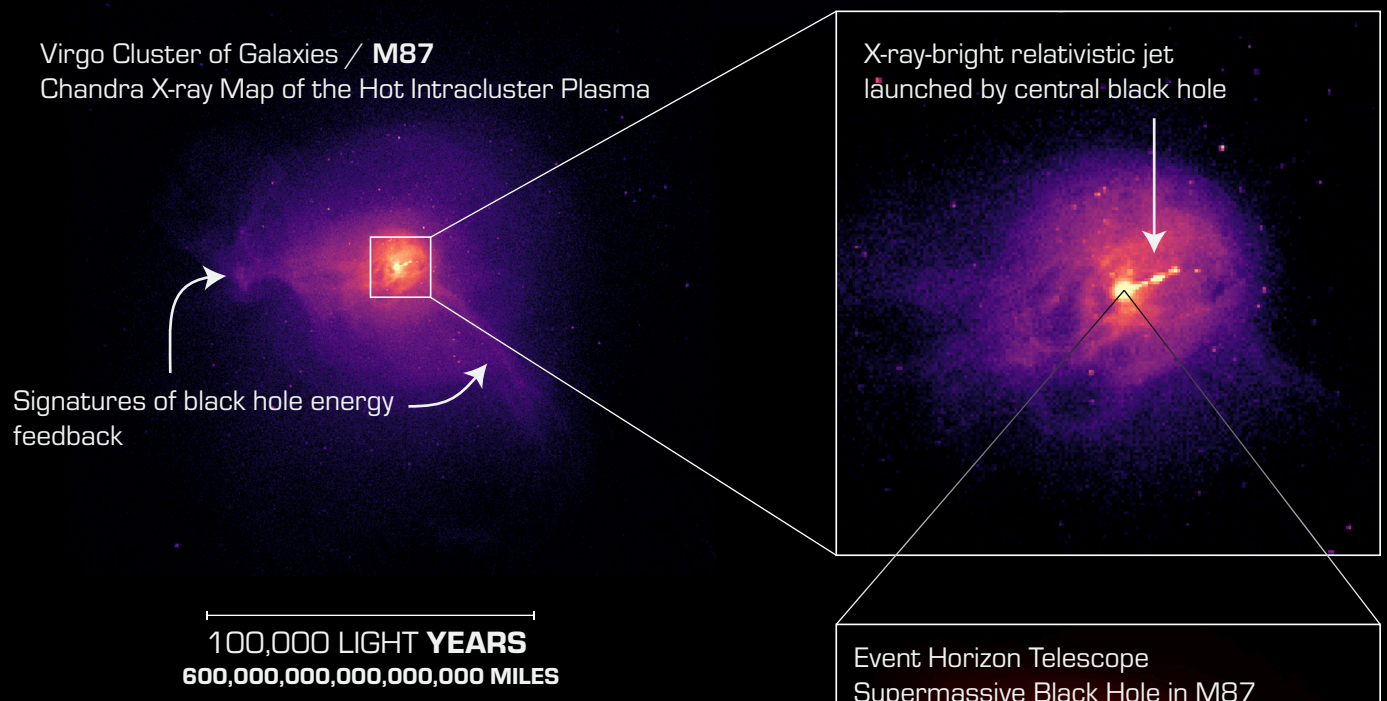
Following a black hole X-ray Transient into Quiescence
PI: Dr. Richard Plotkin, University of Nevada, Reno

...AND DOZENS MORE



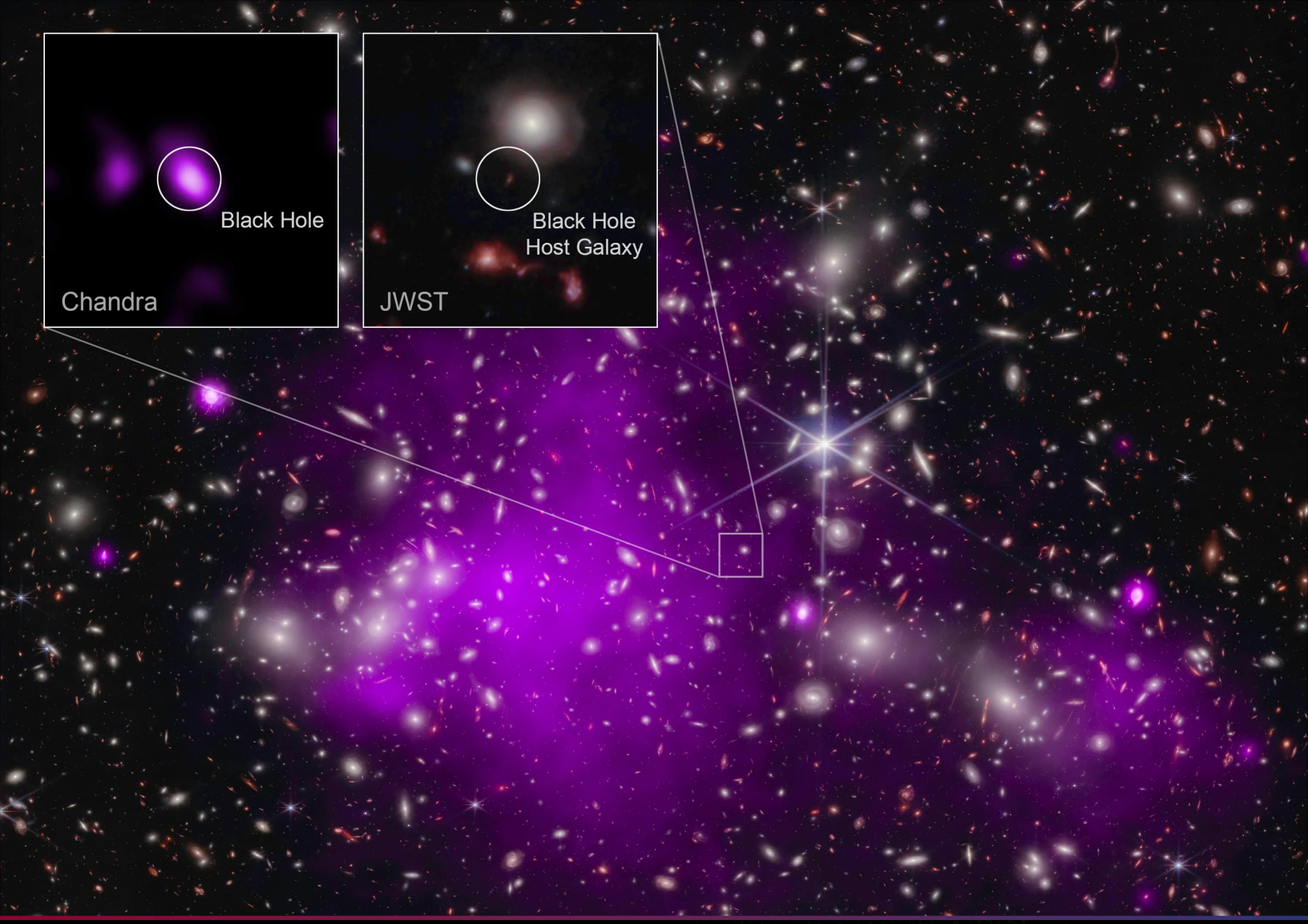
FROM THE EVENT HORIZON TO THE COSMOS

The contrast in scale between a supermassive black hole and the cosmic tempest of shockwaves, relativistic jets, and turbulence that a black hole can create is equivalent to comparing the size of a grape to that of Earth. *Chandra* can observe all of these scales at once.



Because of this, *Chandra* plays a critical role in contextualizing the revolutionary recent observations of black hole shadows from the EVENT HORIZON TELESCOPE. The X-ray data, in combination with the new radio image from the EHT and other observations, will help scientists learn more about high-energy emission and the physics of accretion and ejection at the event horizon, the boundary between what can and cannot escape the gravitational boundary of a black hole.

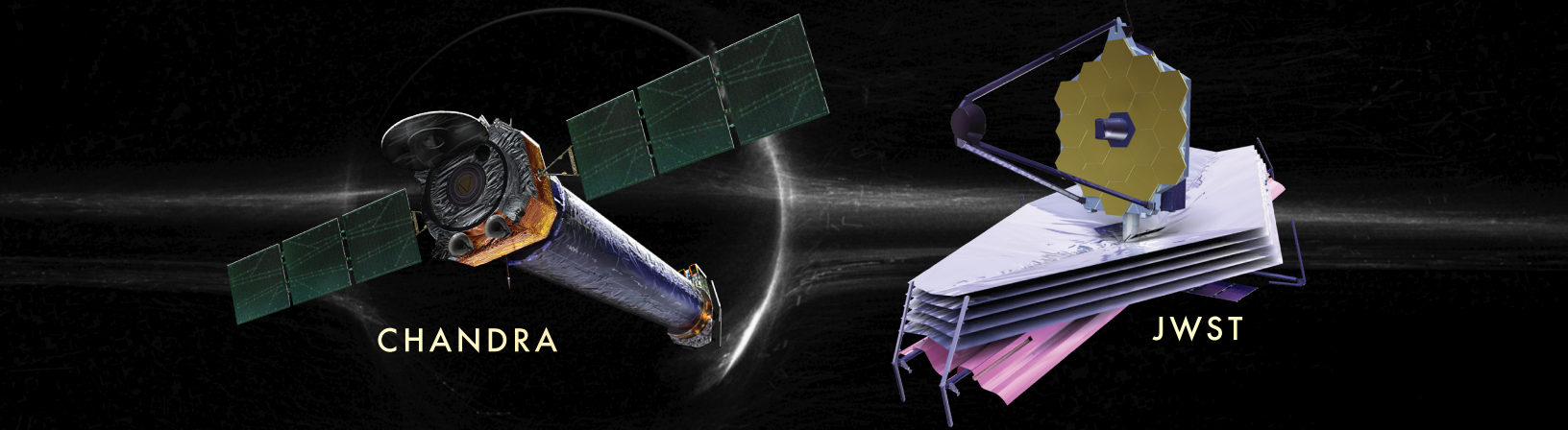
Event Horizon Telescope



This **JWST** *and* **Chandra** *composite image contains the most distant black hole ever detected in X-rays, a discovery possible only with* **Chandra** *(purple). Without* **Chandra**, **JWST** *would not have been able to confirm this result, which may explain how some of the first supermassive black holes in the Universe formed.*

Credit: X-ray: NASA/CXC/SAO/Ákos Bogdán; Infrared: NASA/ESA/CSA/STScI; Image Processing: NASA/CXC/SAO/L. Frattare & K. Arcand

GREAT OBSERVATORY **SYNERGY**



Last year, Chandra and the James Webb Space Telescope combined forces to discover the oldest black hole in the known Universe. Bloomberg News™ named it among the top scientific breakthroughs of the year. This year, both observatories will again force multiply one another in more than 20 programs.

A **Chandra**, **Hubble Space Telescope**, *and* **James Webb Space Telescope** *X-ray/Optical/Infrared composite of M74, a spiral galaxy similar to the Milky Way.*

Credit: X-ray: NASA/CXC/SAO; IR: JWST: NASA/ESA/CSA/STScI; Optical: NASA/ESA/STScI, ESO; Image Processing: L. Frattare, J. Major, N. Wolk, and K. Arcand

In November 2023, the Chandra X-ray Center issued the Chandra Legacy Program (CLP) call for white papers to identify science challenges for which the capabilities of Chandra are absolutely required. A committee reviewed the white papers and recommended two initiatives, and a Call for Chandra Legacy Program Proposals for these initiatives was issued in February 2023. We are excited to announce the following two Legacy Programs whose observations will commence this coming year.

THE COMBINED POWER OF CHANDRA & JWST

CHANDRA LEGACY PROGRAM

A Treasury Survey Probing the Baryon & Energy Cycle and X-ray Binary Evolution in Galaxies at High Angular Resolution

PRINCIPAL INVESTIGATOR: Dr. Smita Mathur, Ohio State University | 2.9 million seconds awarded

In star-forming galaxies, X-rays offer critical probes of binary systems, massive-star remnants, and the hot phase of the interstellar medium (ISM), crucial components for understanding stellar evolution, feedback, and galactic ecosystems. This coming year, *Chandra* will join forces with *Hubble* and *JWST* to observe all remaining galaxies from the Physics at High Angular resolution in Nearby GalaxieS (PHANGS) survey to accompany high-resolution data from *Hubble*, ESO's Very Lage Telescope, ALMA, and, most critically, *JWST*. The survey will link X-ray sources to host stellar and nebular environments, yielding peerless constraints on the formation timescales and properties of a variety of X-ray binary populations, feedback energetics from massive stars, and the connection between hot gas and the other ISM phases. The resulting large *Chandra* dataset will be used to address an array of additional astrophysical problems and will have enduring legacy value as future observatories will continually target PHANGS galaxies.

A deep **Chandra** *image of the Perseus Cluster of Galaxies. The ripples reveal sound waves within the hot plasma that pervades the cluster, a signature of supermassive black hole growth (and its so-called energetic "feedback"). These ripples can be mapped to what is the lowest-known musical note in the Universe (a b-flat, 57 octaves below Middle C).*

Credit: NASA/CXC/GSFC/S.A.Walker, et al.

A BLACK HOLE SYMPHONY

CHANDRA LEGACY PROGRAM

The Sounds of Feedback: Deep and Wide Imaging of the Cool Core of the Perseus Cluster

PRINCIPAL INVESTIGATOR: Dr. Andrew Fabian, University of Cambridge | 3 million seconds awarded

This year, in a nearly five week long observation, *Chandra* will obtain the deepest X-ray observation of a galaxy cluster, the largest gravitationally bound objects in the Universe. The legendary Perseus cluster will serve as a laboratory for better understanding how supermassive black hole feedback energy propagates across the cluster's core. Small-scale ripples in the existing deep *Chandra* imaging could be due to sound waves or turbulence, which can be distinguished by X-ray tests that only *Chandra* can provide. This will be achieved using so-called "hardness ratio maps." Meanwhile, the cluster harbors incomprehensibly vast weather patterns known as "cold fronts," X-ray cavities, and outer turbulence likely driven by hot plasma sloshing across more than a half-million light years. The final ultra-deep image will yield a step change in understanding the transport and dissipation of energy within the X-ray brightest cool core in the Sky, with important ramifications for understanding black hole feedback from the most massive central galaxies in cool core clusters and a legacy for cluster core studies.

An enormous swirling vortex of hot gas in the region surrounding the supermassive black hole at the heart of our Milky Way galaxy. This multiwavelength composite image includes X-ray and near-infrared light captured by **Chandra** *and the* **Hubble** *and* **Spitzer** *Space Telescopes (***Chandra***'s X-ray map is shown in blue, purple, and white).*

Credit: NASA, ESA, SSC, CXC, STScI

OUR MILKY WAY GALAXY

Our home galaxy is a cathedral of exotic phenomena that shine brightly in X-rays, from objects in our own solar system, to gas raining down on compact objects like neutron stars and even black holes, to resplendent nurseries of young stars, and even to impossibly vast X-ray-bright chimneys that extend for thousands of light years above and below the disk of the galaxy.

APPROVED MILKY WAY PROGRAMS — CHANDRA CYCLE 26

Probing Super-Eddington Outflows via Accreting Galactic BeXRBs
PI: Dr. Mark Reynolds, Ohio State University

Why is PSRJ1015-5719's Pulsar Wind Nebula shaped like a Ninja Star?
PI: Dr. Bettina Posselt, University of Oxford

Proper Motions for Gamma-Ray Pulsars
PI: Dr. Roger Romani, Stanford University

Mineralogy of Interstellar Dust towards GX 339-4
PI: Dr. Ioanna Psaradaki, MIT

...AND MANY MORE

A **Chandra**, **JWST**, *and* **Hubble** *composite of the Cassiopeia A supernova remnant.* *Credit: X-ray: NASA/CXC/SAO; Optical: NASA/ESA/STScI; IR: NASA/ESA/CSA/STScI/Milisavljevic et al., NASA/JPL/Caltech; Image Processing: NASA/CXC/SAO/J. Schmidt and K. Arcand*

SUPERNOVA REMNANTS

Chandra **has enabled revolutionary advancements in our understanding of the life and death of stars, mapping the cosmic journey of the very elements that make us.**

APPROVED SUPERNOVA REMNANT PROGRAMS — CHANDRA CYCLE 26

Spatial and Spectral Monitoring of SN 1987A
PI: Dr. Sangwook Park, University of Texas at Arlington

Chandra Observations of a Source-Rich region in NGC 891
PI: Dr. Vikram Dwarkadas, University of Chicago

X-raying the birth of a Neutron Star Binary
PI: Kaustav Kashyap Das, Caltech

A New Epoch of ACIS Imaging of Kepler's SNR
PI: Dr. Brian Williams, NASA's Goddard Space Flight Center

This composite image of the nearby starburst galaxy M82 shows **Chandra** *X-ray data in blue, optical data from* **Hubble** *in green and orange, and infrared data from the* **Spitzer Space Telescope** *in red.*

Credit: X-ray: NASA/CXC/JHU/D.Strickland; Optical: NASA/ESA/STScI/AURA/The Hubble Heritage Team; IR: NASA/JPL/Caltech/University of Arizona/C. Engelbracht

ACTIVE GALAXIES, GALAXY EVOLUTION, & CLUSTERS

Among *Chandra*'s most enduring legacies are multiple revolutions in our understanding of how galaxies form and evolve, and how that evolution is conducted by supermassive black hole growth that takes place within their cores. From extreme giant clusters of galaxies to mysterious phenomena across the gulf of the cosmos, this year we will build on this legacy with cutting-edge programs only possible with *Chandra*.

APPROVED GALAXY EVOLUTION PROGRAMS — CHANDRA CYCLE 26

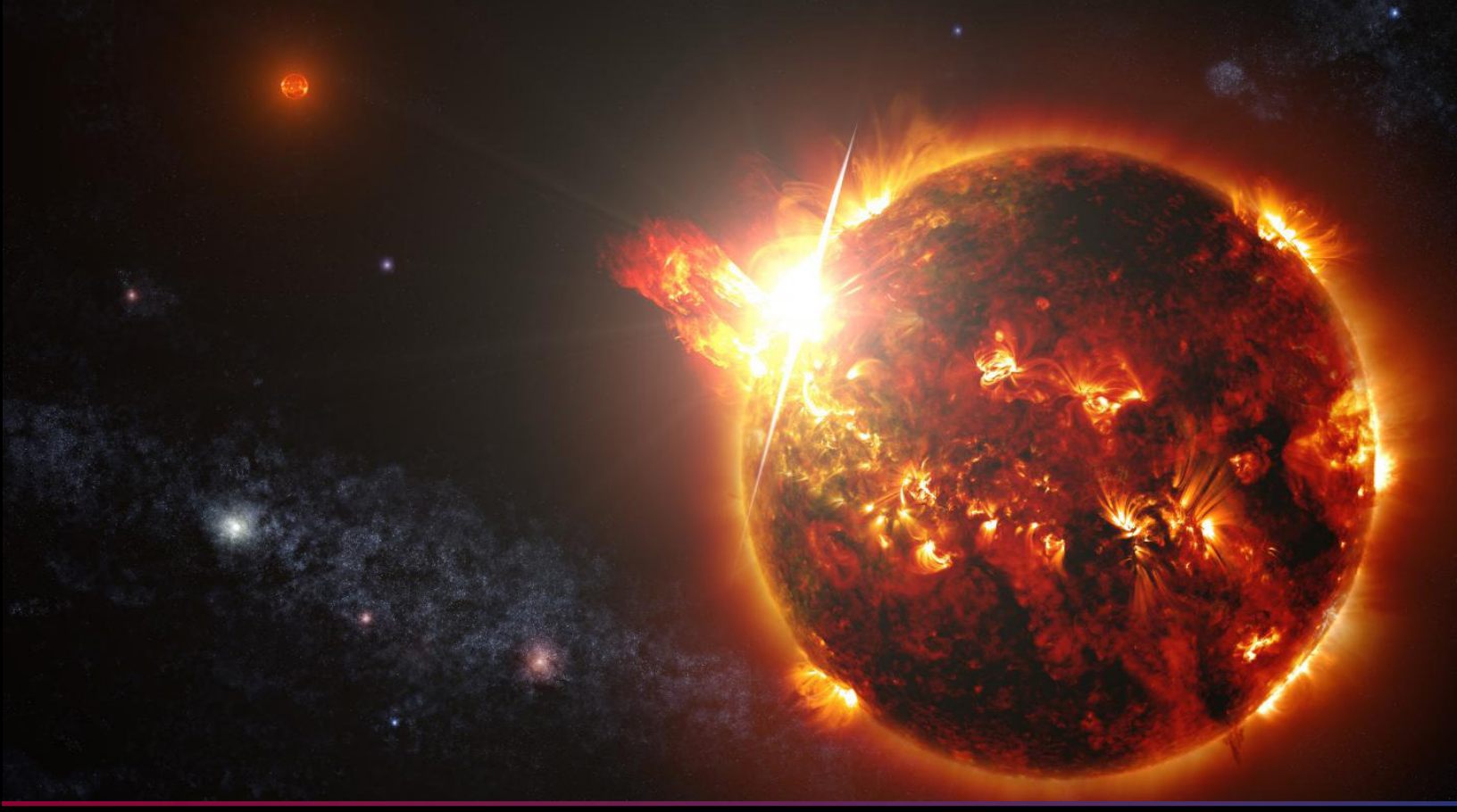
Insights into High Redshift X-ray Emission from Nearby Metal Poor Galaxies
PI: Dr. Bret Lehmer, University of Arkansas | Chandra Large Program

The Spatially Extended Ultra-Fast Outflow (UFO) of the CT AGN NGC 5728
PI: Dr. Giuseppina Fabbiano, Center for Astrophysics | Harvard & Smithsonian

X-ray Nuclear Activity in an Extreme Protocluster
PI: Dr. Yuanyuan Su, University of Kentucky

A New Sample of Dwarf Galaxies with Broad-line AGN
PI: Dr. Amy Reines, University of Montana

...AND DOZENS MORE



An artist's impression of a series of powerful stellar flares. **Chandra** *observations of nearby stars are helping astronomers identify the best targets to search for exoplanets with conditions suitable for life.* *Credit: NASA's Goddard Space Flight Center/S. Wiessinger*

THE SOLAR SYSTEM, EXOPLANETS, & INGREDIENTS FOR LIFE

How active a star is directly affects the formation processes of planets in the disk of gas and dust that surrounds all nascent stars. The most magnetically active young stars quickly clear away their disks, halting the growth of planets. This stellar activity, uniquely measured in X-rays at high angular resolution by *Chandra*, also affects the potential habitability of the planets that emerge after the disk has disappeared. This is one of the many ways in which *Chandra* studies the cosmic origins of life. From X-ray observations of water-bearing comets to aurorae above the poles of Jupiter, the coming year will include major programs on exoplanets, stellar impacts on habitability, and some of the nearest objects to Earth.

APPROVED EXOPLANET & SOLAR SYSTEM PROGRAMS — CHANDRA CYCLE 26

Joining Juno's last Orbits: A Multi-Wavelength Perspective
PI: Seán McEntee, Dublin Institute for Advanced Studies | Joint with Juno Jupiter Mission

Time-resolved Protoplanetary Disk Physics in DQ Tau
PI: Dr. Konstantin Getman, Pennsylvania State University

Measuring the X-ray luminosity a Young Multi-Planet System
PI: Dr. Mackenna Wood, Massachusetts Institute of Technology

The First HRC Image of Eta Car: Refining the Dynamics of the Blast Wave
PI: Dr. Michael Corcoran, Catholic University of America

Star-Planet Connections: Exoplanet Aeronomy with WASP-69
PI: Dr. W. Garrett Levine, Yale University

...AND SEVERAL MORE

This artist's impression shows two tiny but extremely dense neutron stars at the point at which they merge and explode as a kilonova. These rare events produce both gravitational waves, a short gamma-ray burst, and X-ray emission observable by Chandra. *Illustration credit: ESO/University of Warwick/Mark Garlick*

THE TIME DOMAIN & EXOTIC UNIVERSE

Finally, *Chandra* is a keystone for the coming golden age in time domain and multimessenger observations of the ever-changing cosmos. From the X-ray-bright explosions that accompany gravitational wave events detected by Laser Interferometer Gravitational-Wave Observatory (LIGO), to exotic phenomena like pulsars and extreme X-ray counterparts to Gamma-ray bursts, *Chandra* is a Time Domain mission unlike any other, with a power and criticality that will only grow with first light of the Vera Rubin Observatory and the coming launch of the *Nancy Grace Roman Space Telescope*.

APPROVED TIME DOMAIN PROGRAMS — CHANDRA CYCLE 26

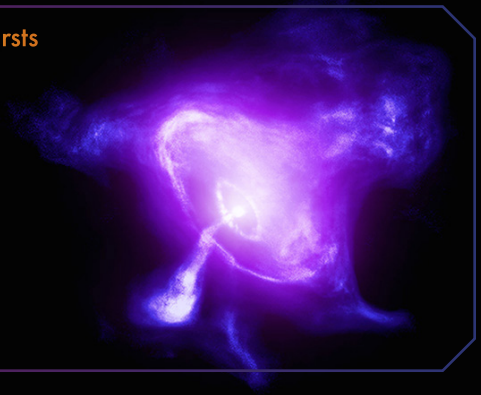
Unveiling the Diverse Late-time X-ray Behavior of Short Gamma-ray Bursts
PI: Dr. Wen-fai Fong, Northwestern University

High Energy Gratings Spectroscopy of Novae
PI: Dr. Kirill Sokolovsky, University of Illinois

A Hunt for X-ray Emission from New Ultra-Long Period Objects
PI: Dr. David Kaplan, University of Wisconsin-Milwaukee

An off-axis view of Compact Binary Mergers
PI: Dr. Brendan O'Connor, Carnegie Mellon University

...AND MANY MORE



Chandra just prior to deployment from the Columbia Payload Bay, July 23, 1999
NASA


THE CHANDRA X-RAY CENTER IS OPERATED FOR NASA BY THE
CENTER FOR ASTROPHYSICS
HARVARD & SMITHSONIAN
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