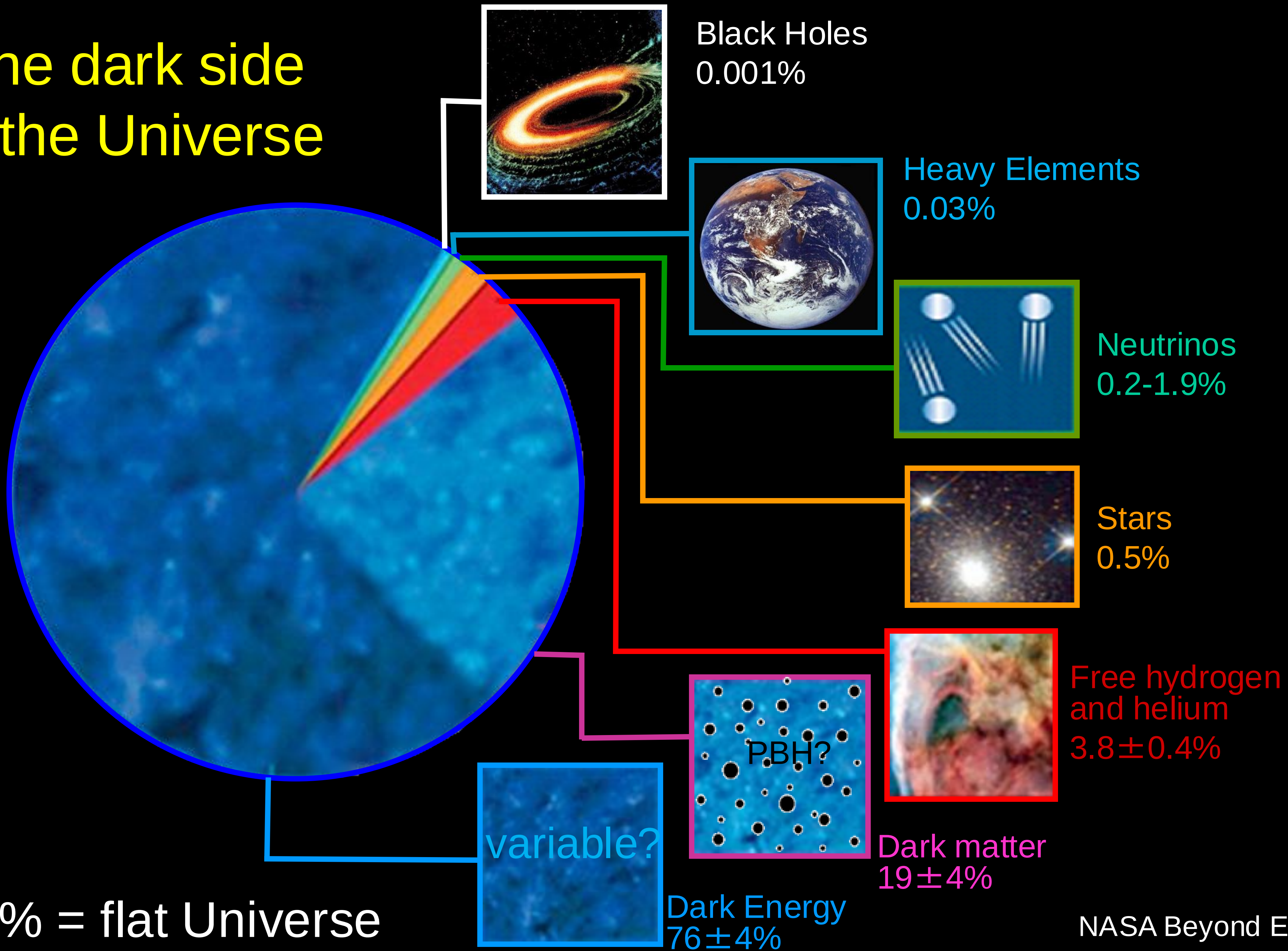
Opening new windows to the Universe

Inauguration Ceremony for the new MPG Semiconductor Laboratory
Günther Hasinger, Designated DZA Founding Director
7. October 2024, Garching

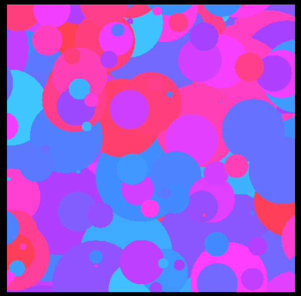
The dark side of the Universe



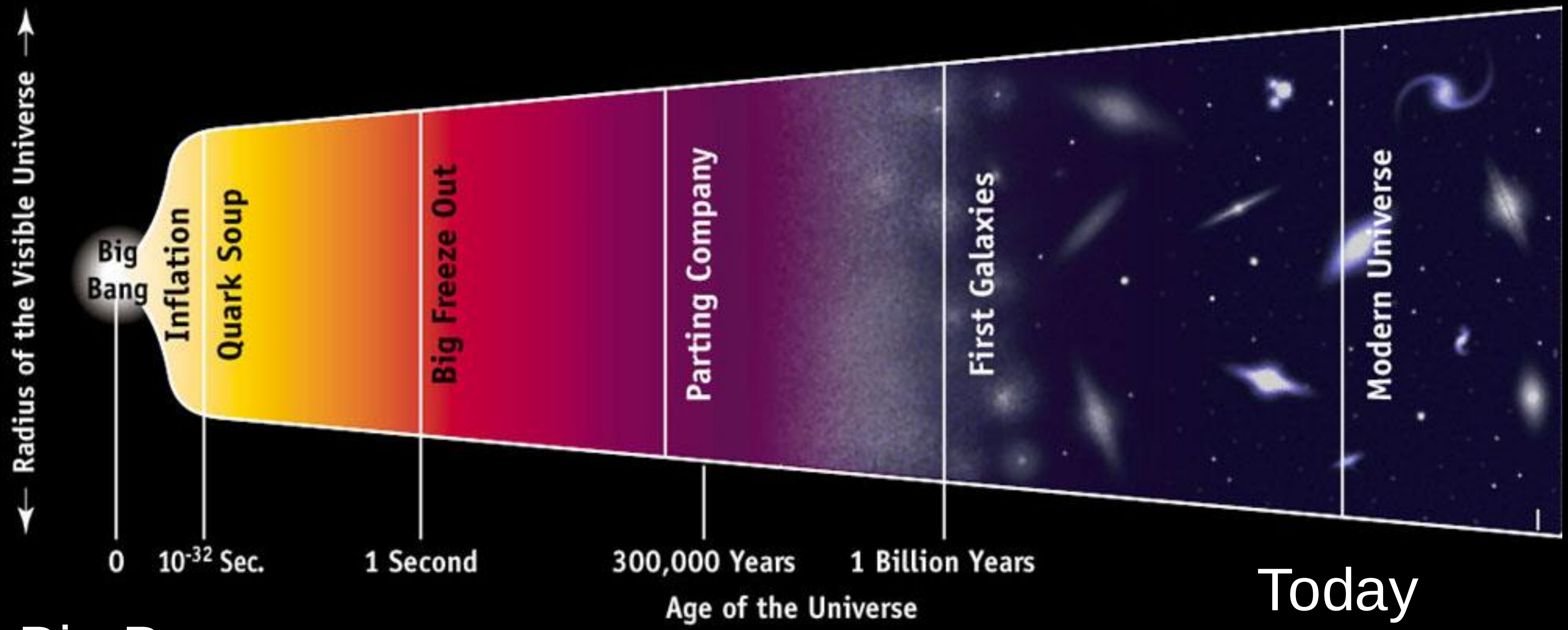
100% = flat Universe

NASA Beyond Einstein

The cosmic timeline



Quantum fluctuations of space-time



Big Bang

Today

13.7 Bio Years

Modern cosmological simulations

„On solid ground“

The German Center for Astrophysics
Science. Technology. Digitisation.

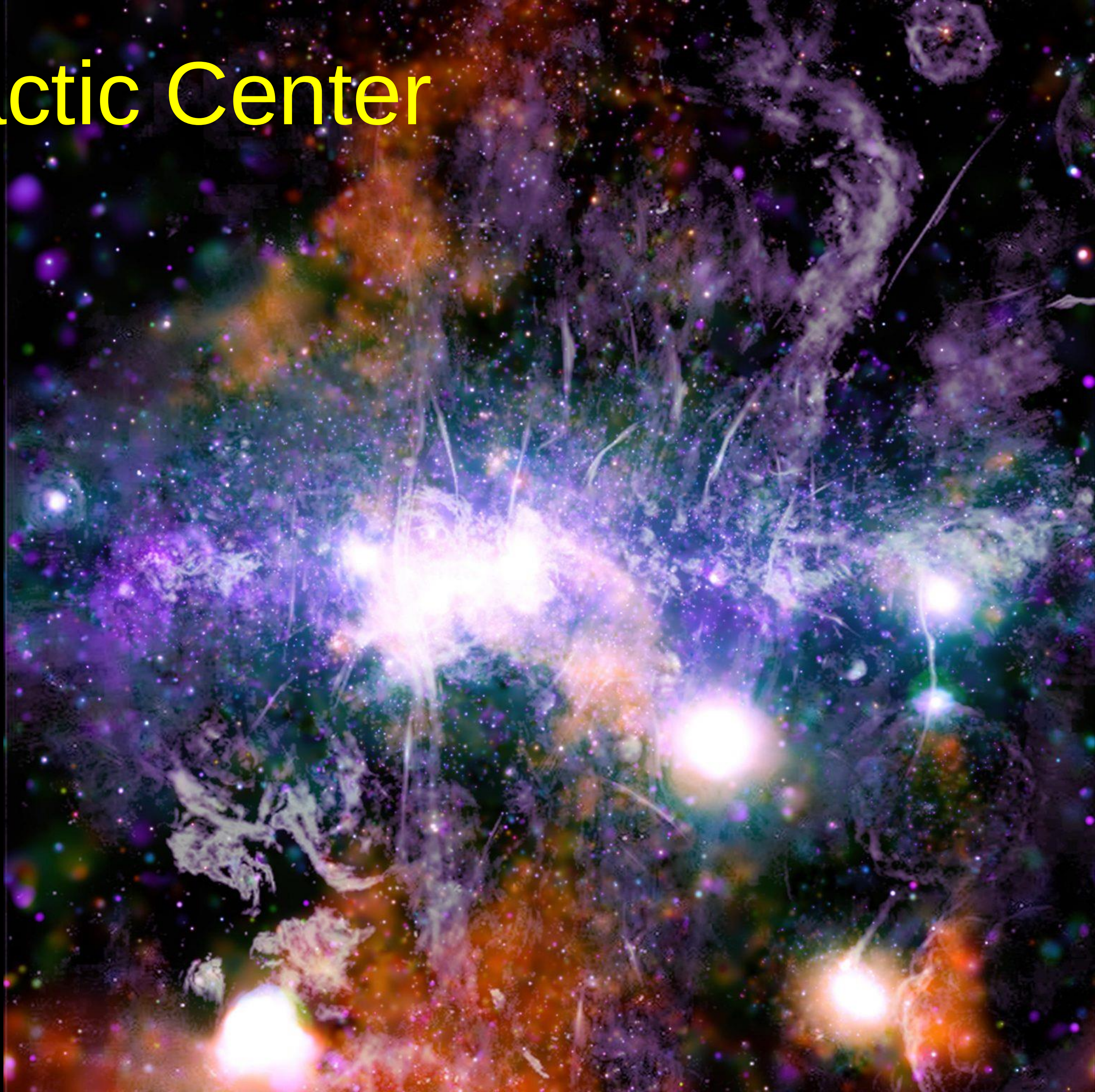
DZA

In the beginning we concentrate on large international projects in radio and gravitational wave astronomy.

Square Kilometre Array South Afrika/Australia

First MeerKAT-Plus Antenna in South Africa

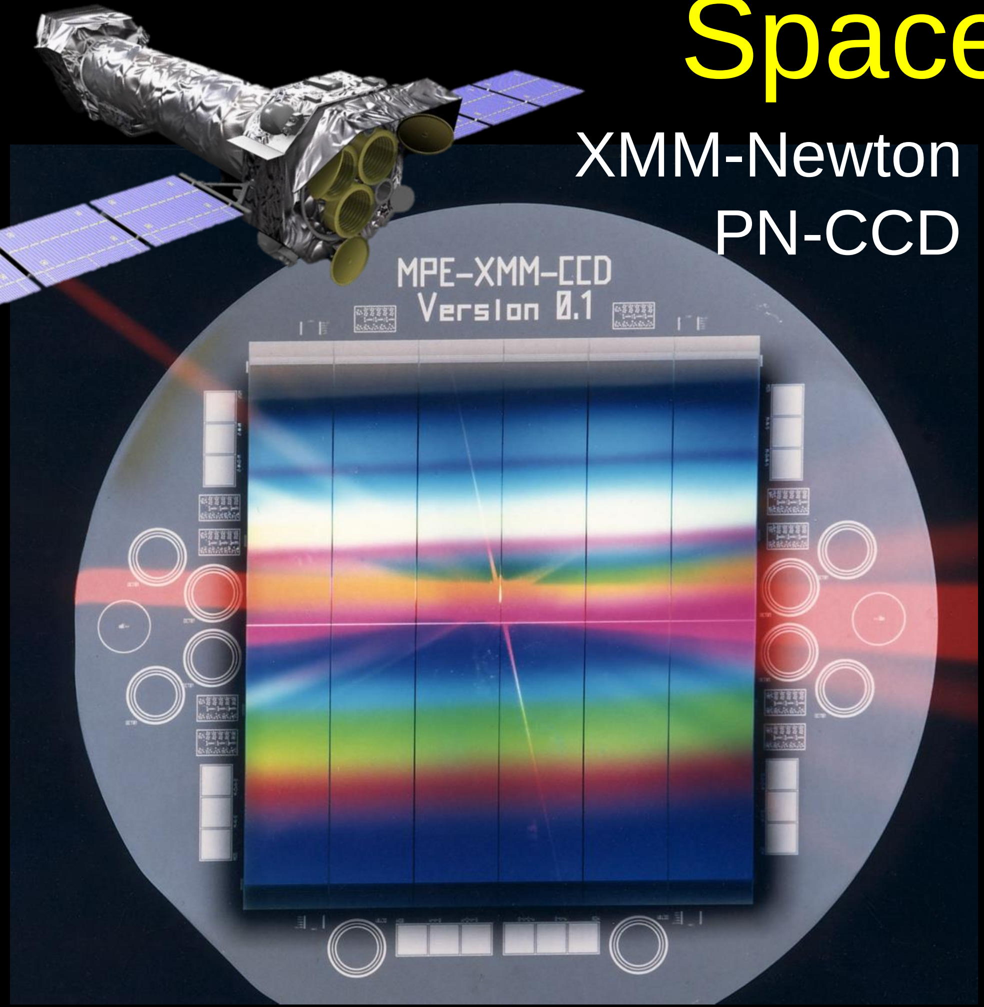
Galactic Center



The incredible richness of phenomena at the center of our Galaxy is revealed by this superposition of the MeerKAT radio mosaic (grey) with Chandra‘s X-ray view in orange, green and purple showing increasing X-ray energies.
Credit: X-ray: NASA/CXC/UMass/Q.D. Wang; Radio: NRF/SARAO/MeerKAT

Space Heritage of the MPG HLL

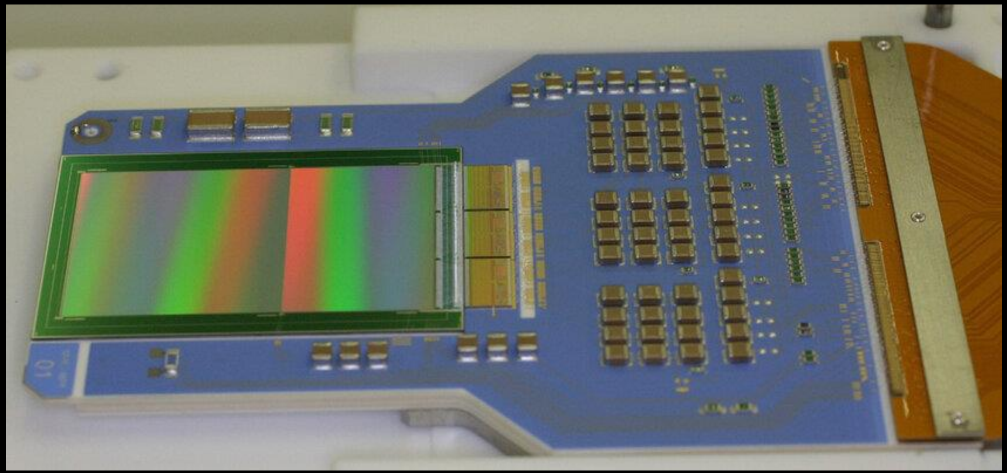
XMM-Newton
PN-CCD



L. Strüder et al. (2001) "The European Photon Imaging Camera on XMM-Newton: The pn-CCD Camera", *Astronomy & Astrophysics* 365, 18 (>2600 citations on Google Scholar)

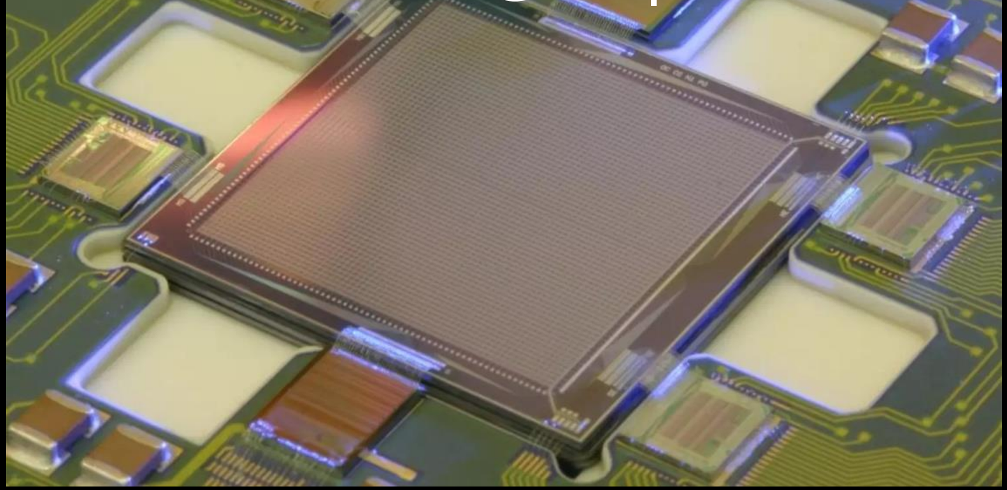
Working flawlessly in orbit since 25 years!
Foundation for MPG HLL

eROSITA PN-CCD



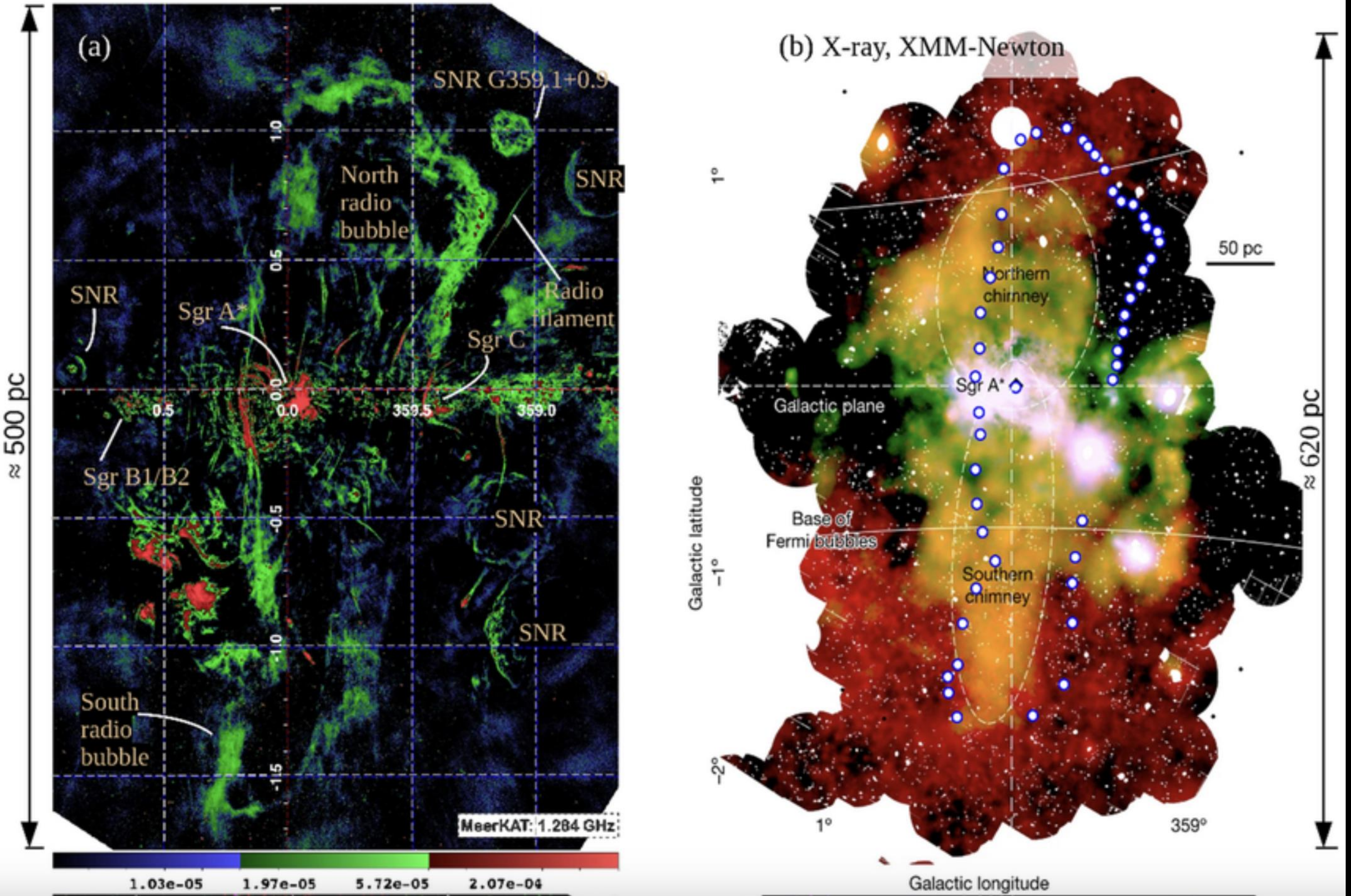
Flying since 2019 on Russian SRG Mission

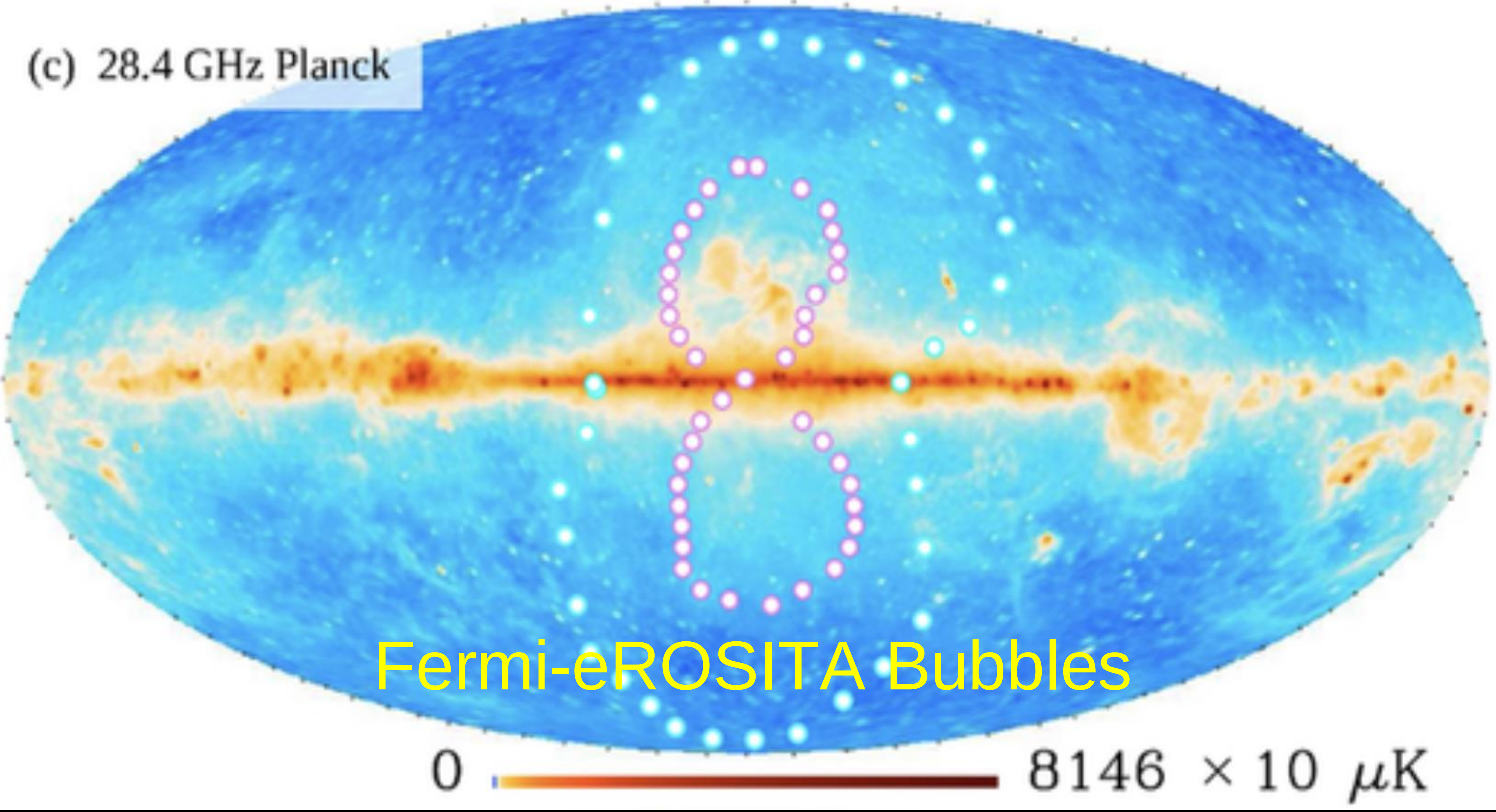
MIXS DEPFET @ Bepi-Colombo



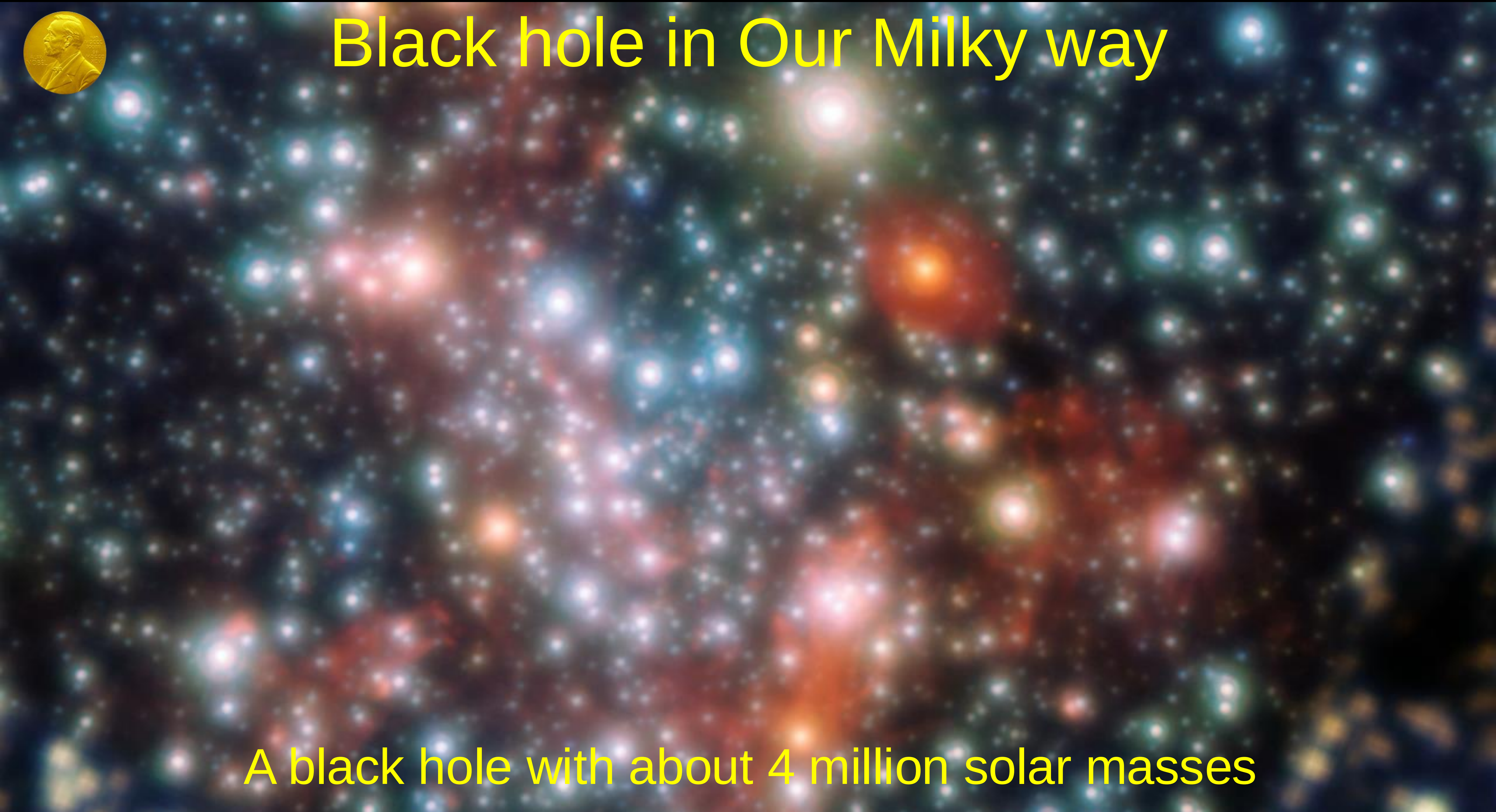
Launch 2018, Prototype for ESA ATHENA

XMM-Newton


(a)
SNR G359.1+0.9
North radio bubble
SNR
Radio filament
SNR
Sgr A*
Sgr C
Sgr B1/B2
SNR
SNR
South radio bubble
0.5
0.0
359.5
359.0
1.0
0.5
0.0
-0.5
-1.0
-1.5
MeerKAT: 1.284 GHz
≈ 500 pc
1.03e-05
1.97e-05
5.72e-05
2.07e-04
(b) X-ray, XMM-Newton
50 pc
Northern chimney
Sgr A*
Galactic plane
Base of Fermi bubbles
Southern chimney
1°
−1°
−2°
Galactic latitude
1°
359°
Galactic longitude
≈ 620 pc

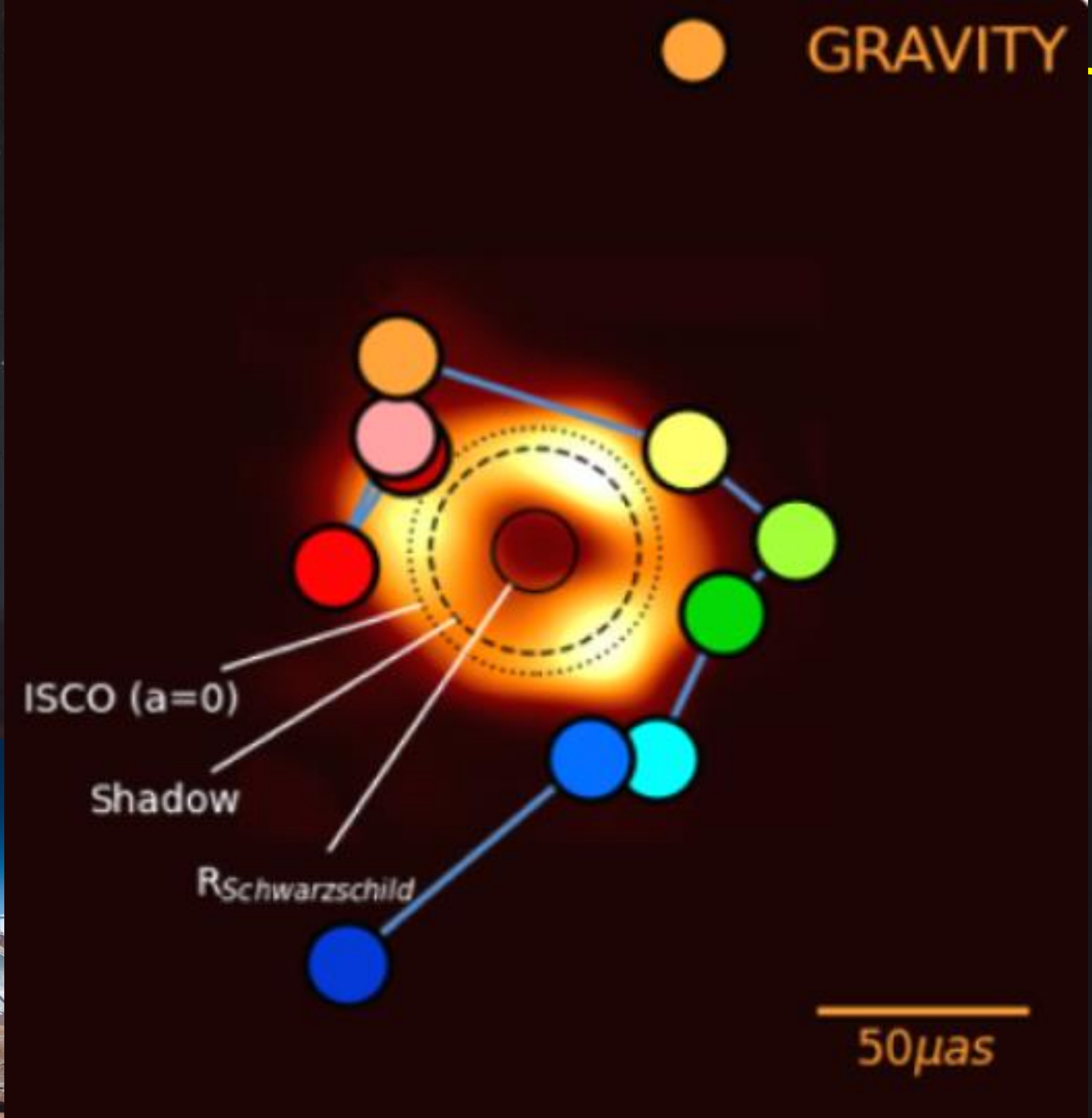

(c) 28.4 GHz Planck
Fermi-eROSITA Bubbles
0
8146 × 10 μK

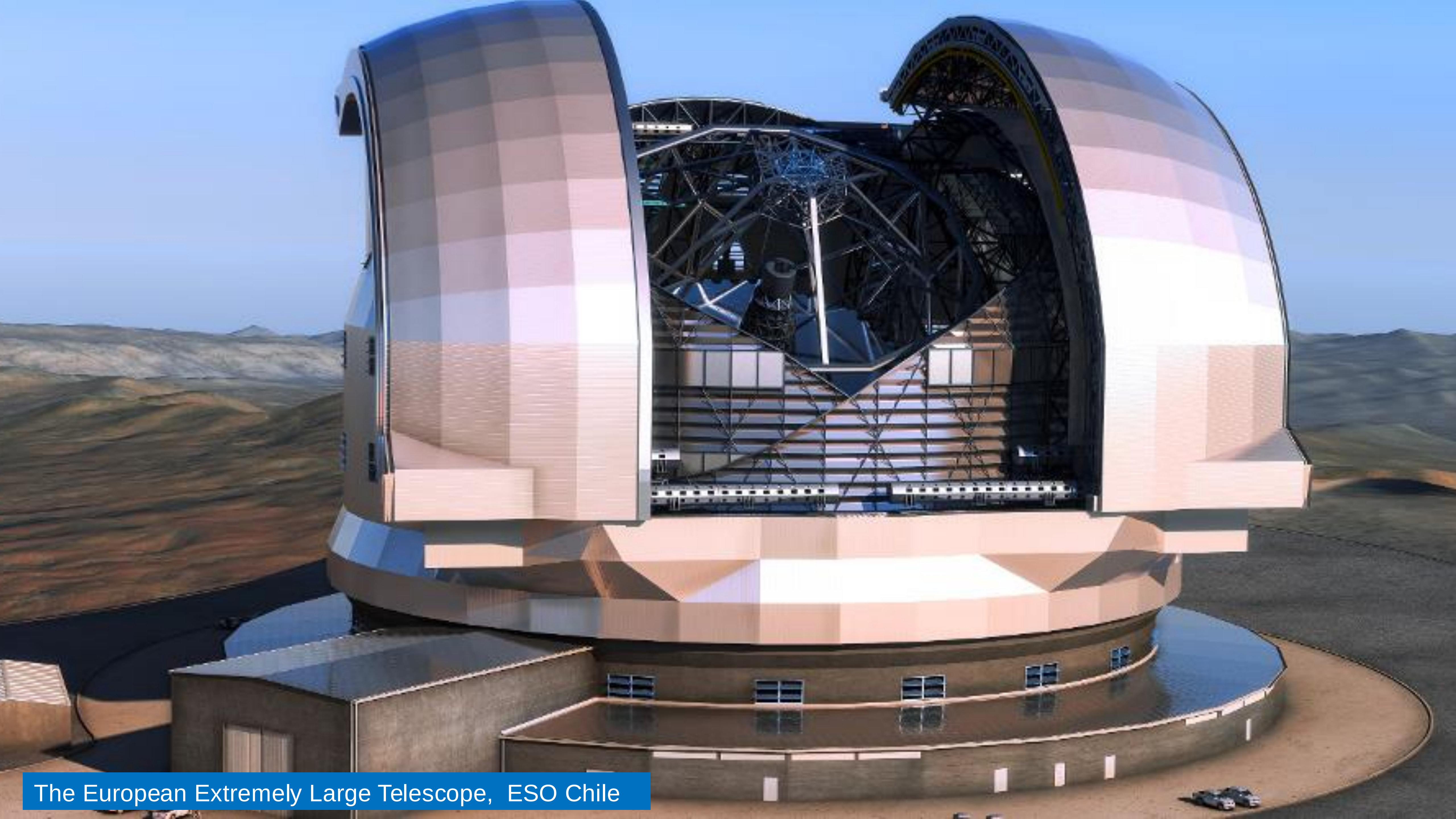
Black hole in Our Milky way



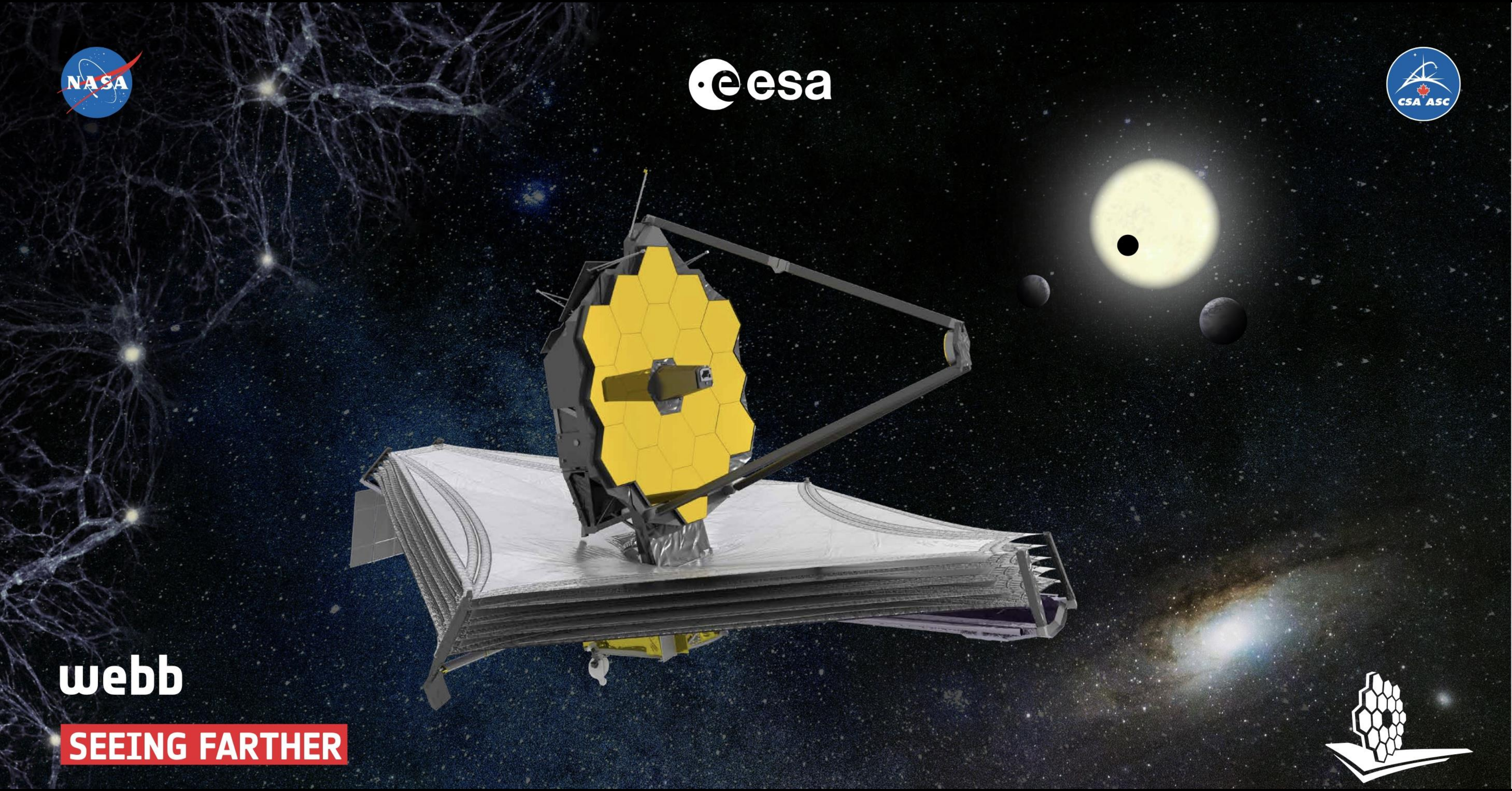
A black hole with about 4 million solar masses

Th … rizon





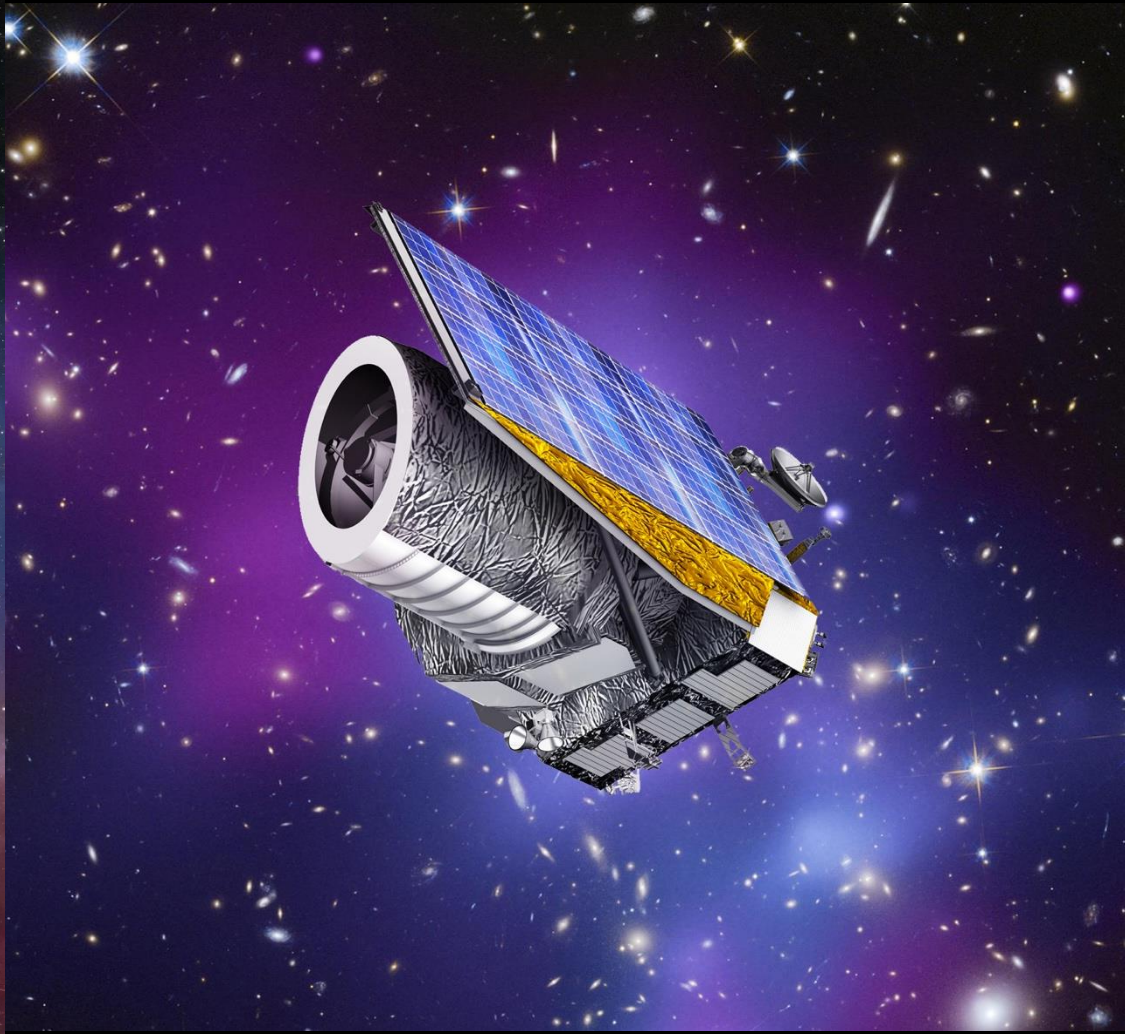
The European Extremely Large Telescope, ESO Chile


webb
SEEING FARTHER

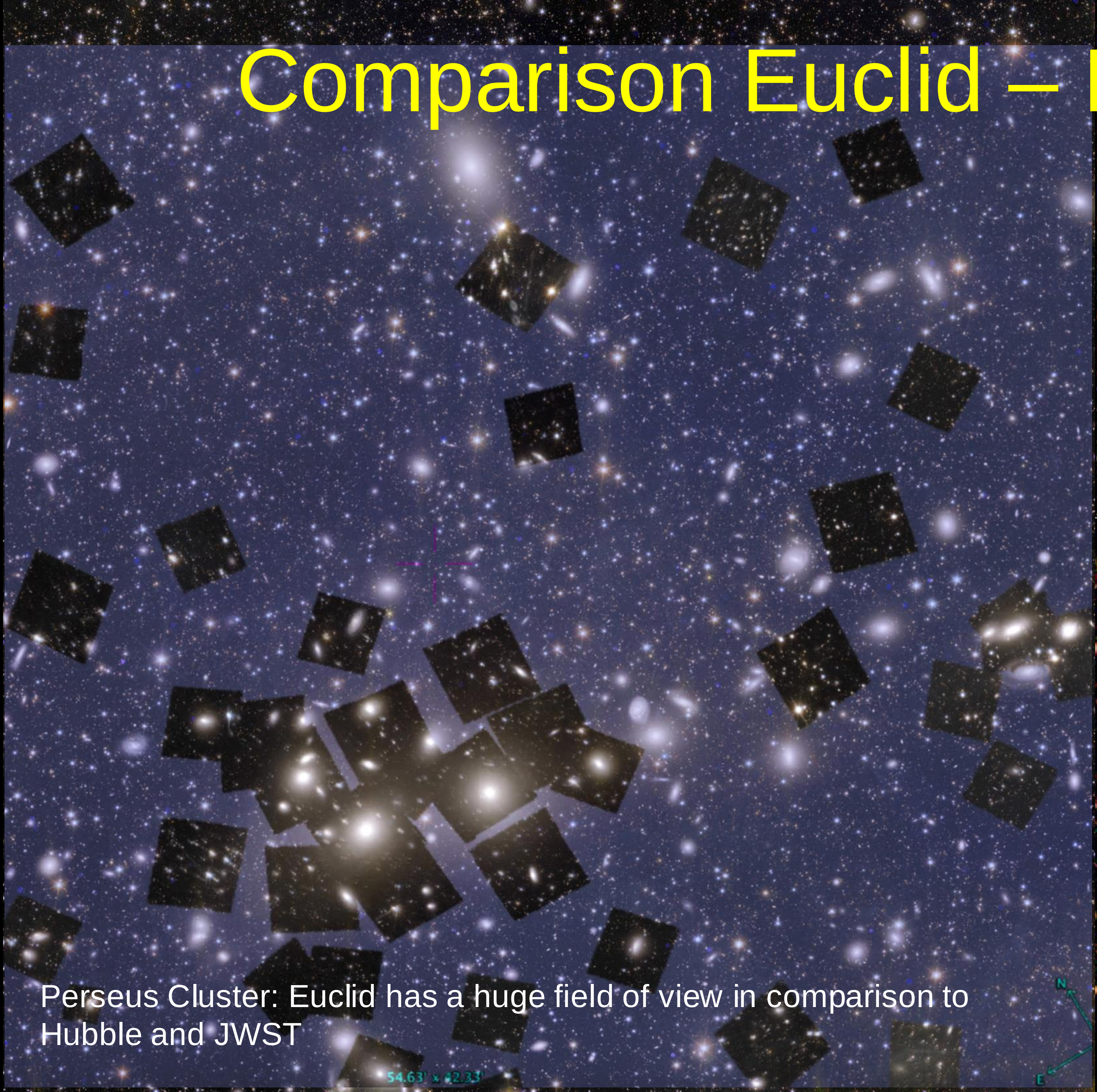
First Images of the ESA Mission Euclid

Horsehead Nebula in Orion

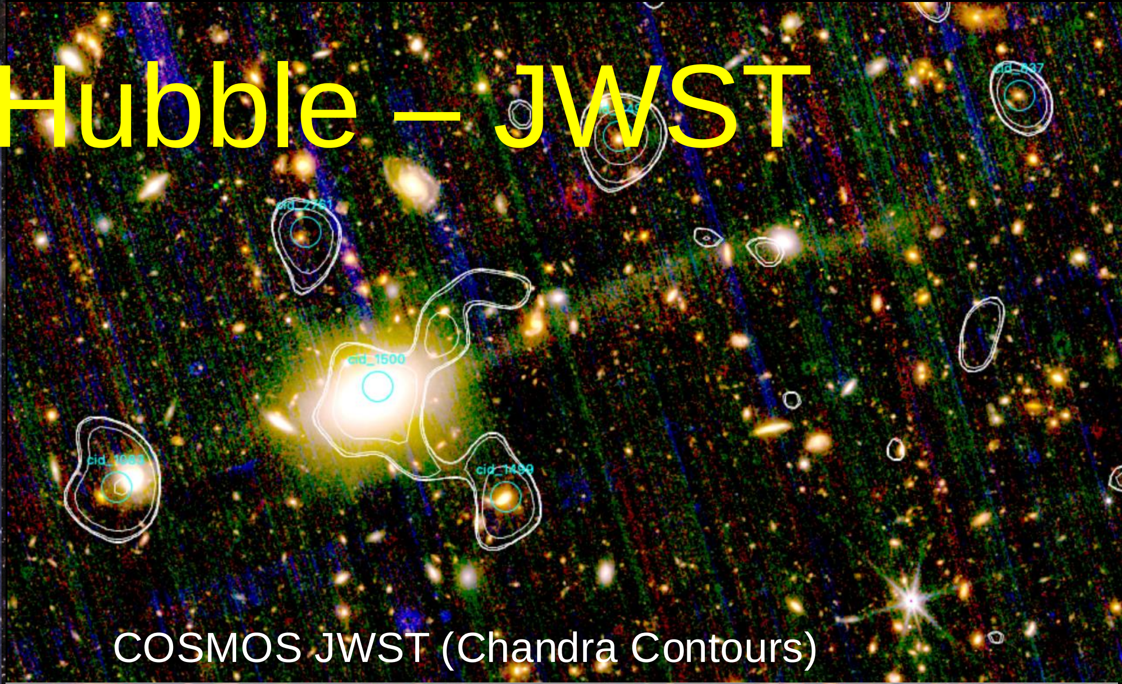
ESA/Euclid/Euclid Consortium/NASA, image processing by J.-C. Cuillandre (CEA Paris-Saclay), G. Anselmi,



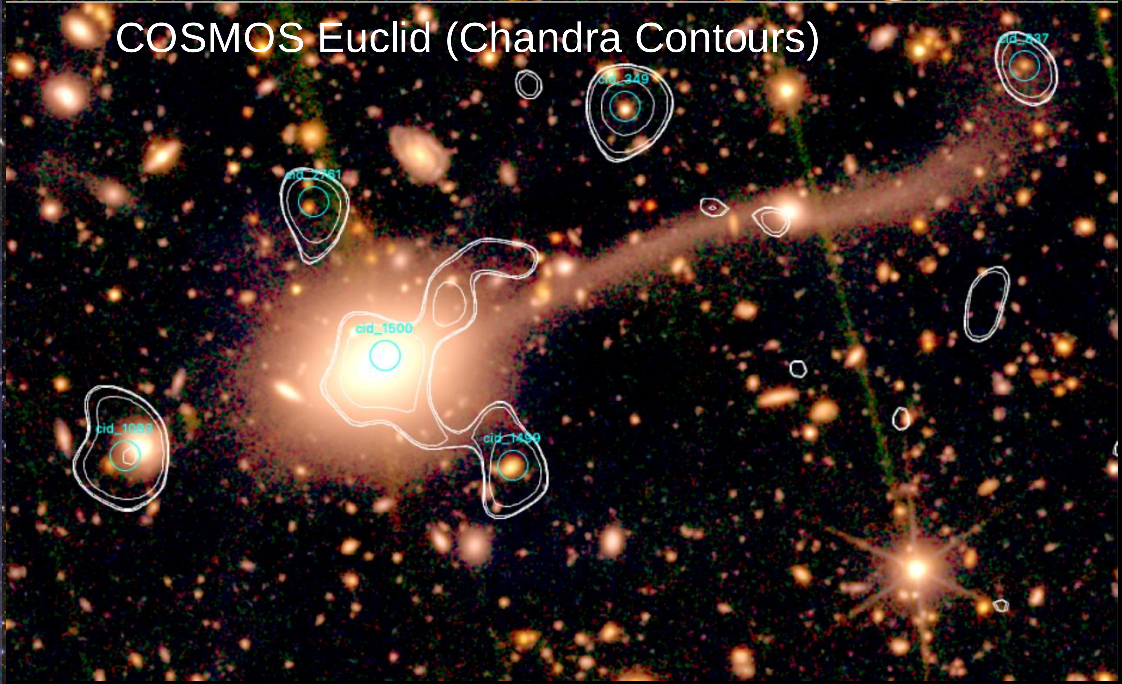
Comparison Euclid – Hubble – JWST



Perseus Cluster: Euclid has a huge field of view in comparison to Hubble and JWST



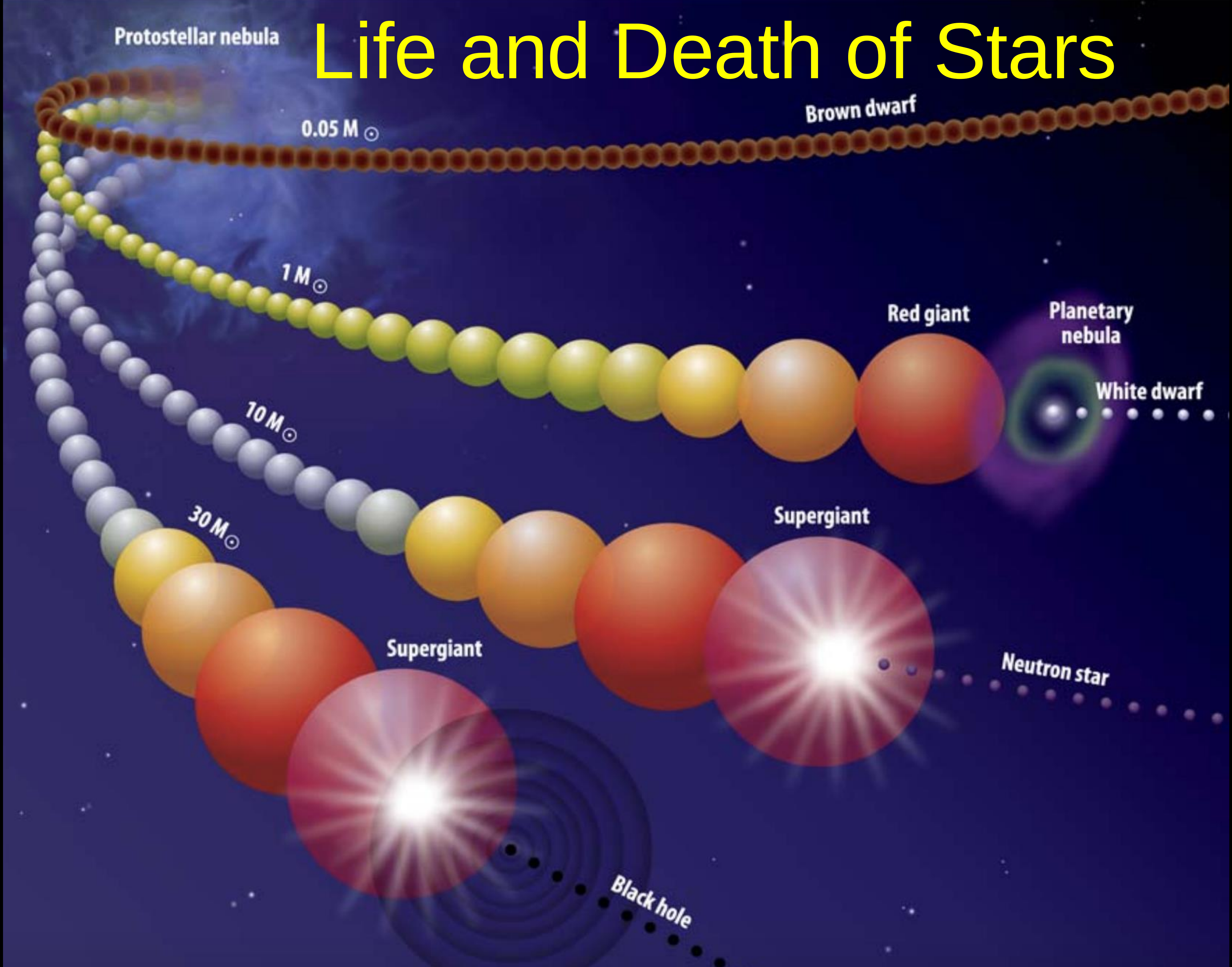
COSMOS JWST (Chandra Contours)



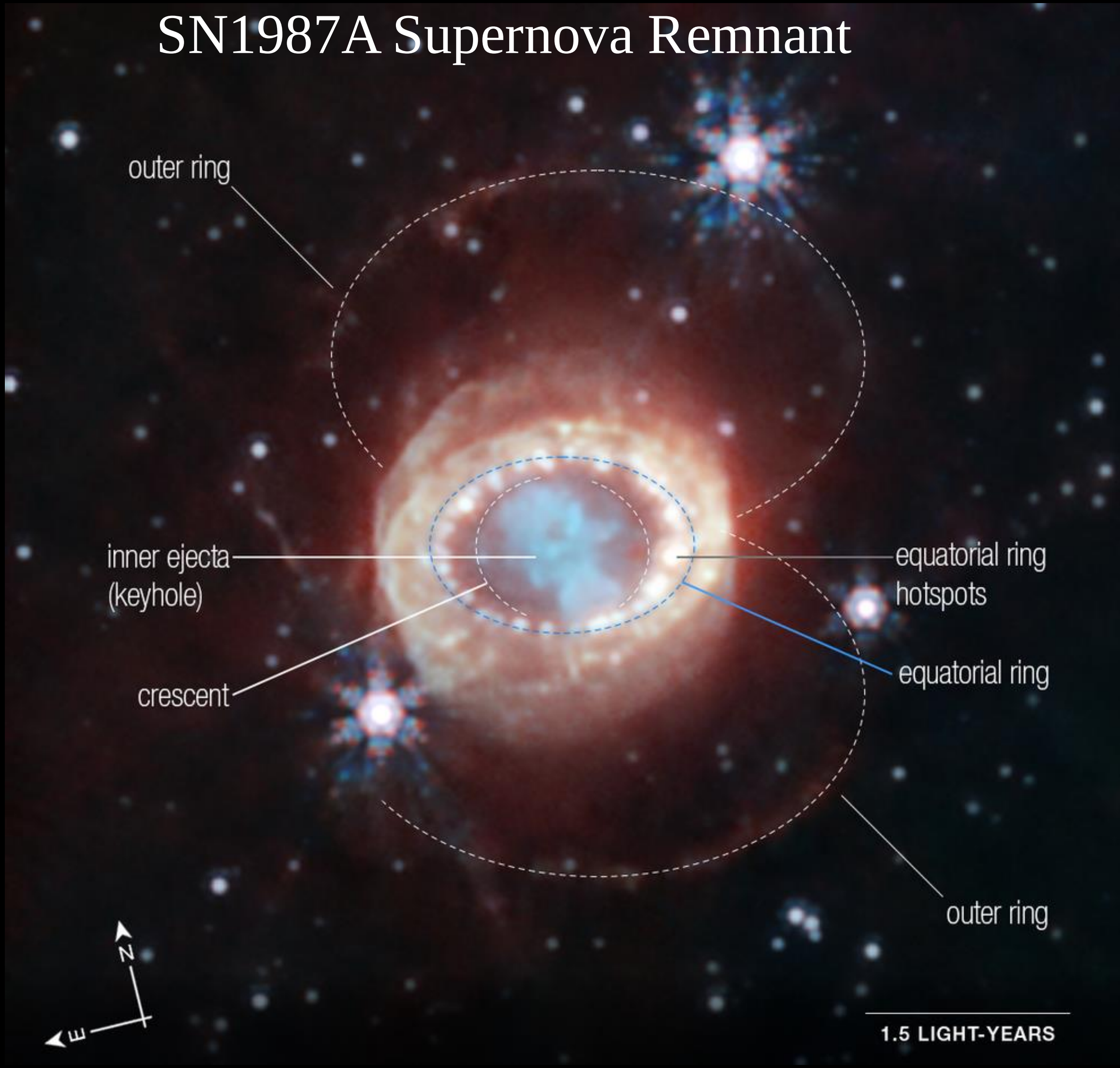
COSMOS Euclid (Chandra Contours)

Euclid is very sensitive to low surface brightness

Life and Death of Stars

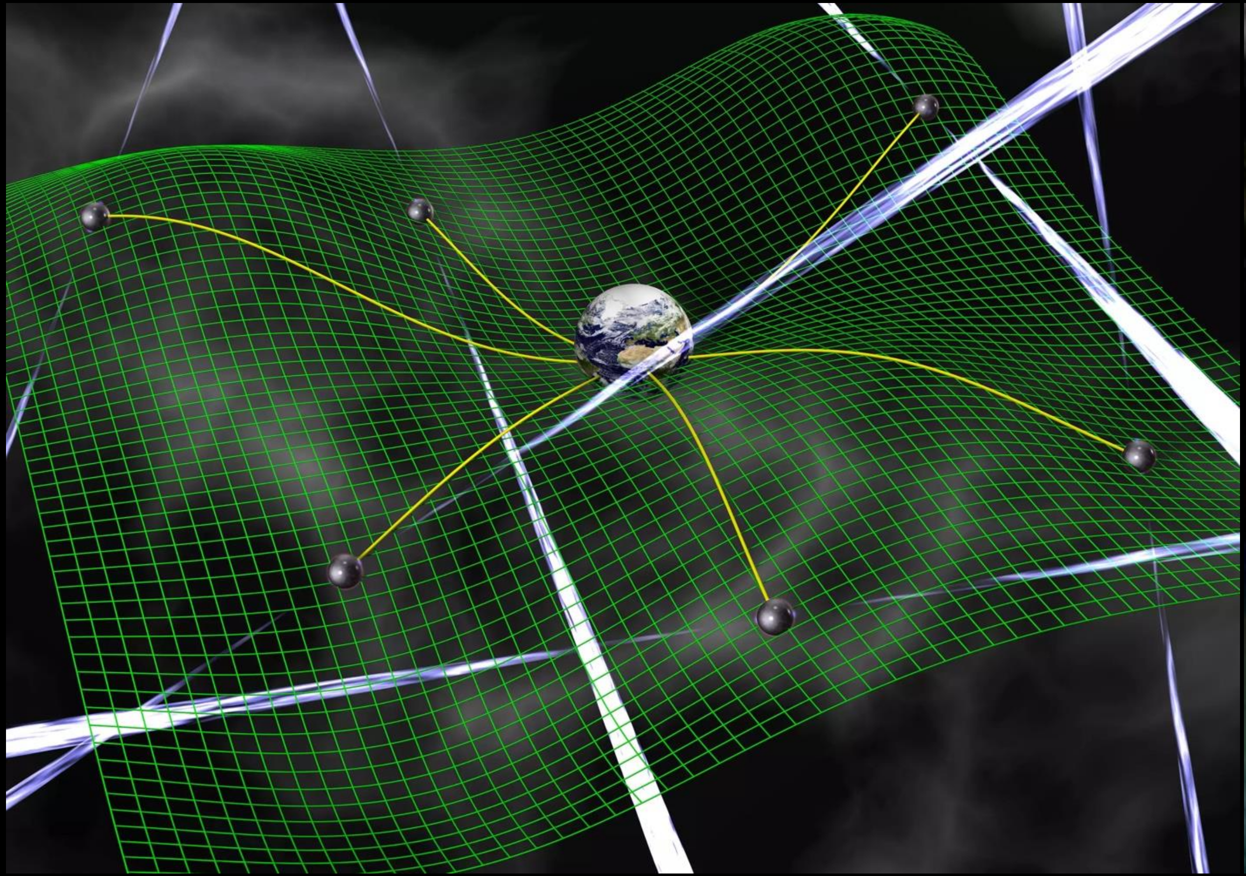


Final stages of stellar evolution



Neutron Stars

Pulsar Timing Arrays

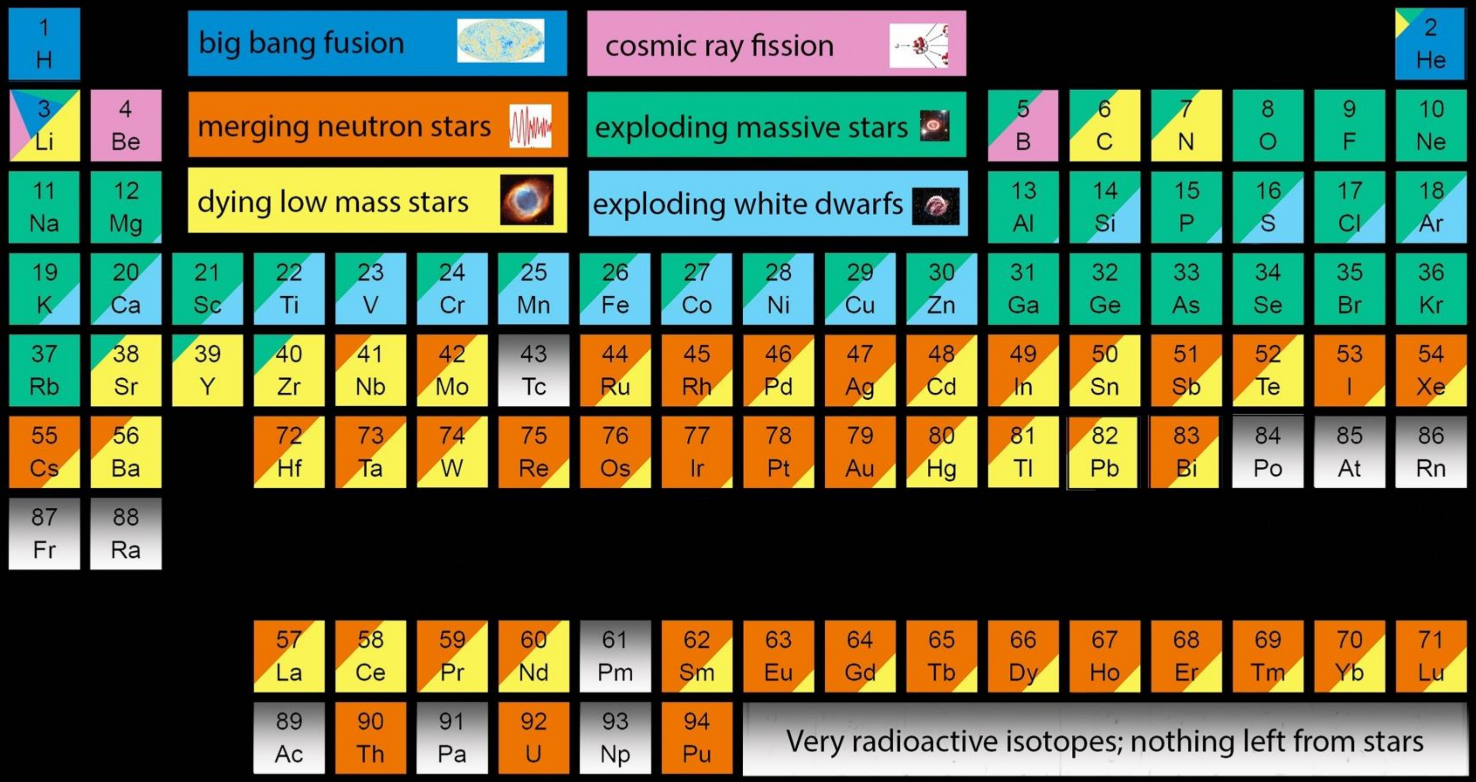


David Champion/Max Planck Institute for Radio Astronomy

Aurore Simonnet, NANOGrav collaboration

First significant signals of a gravitational wave background detected in 2023 !

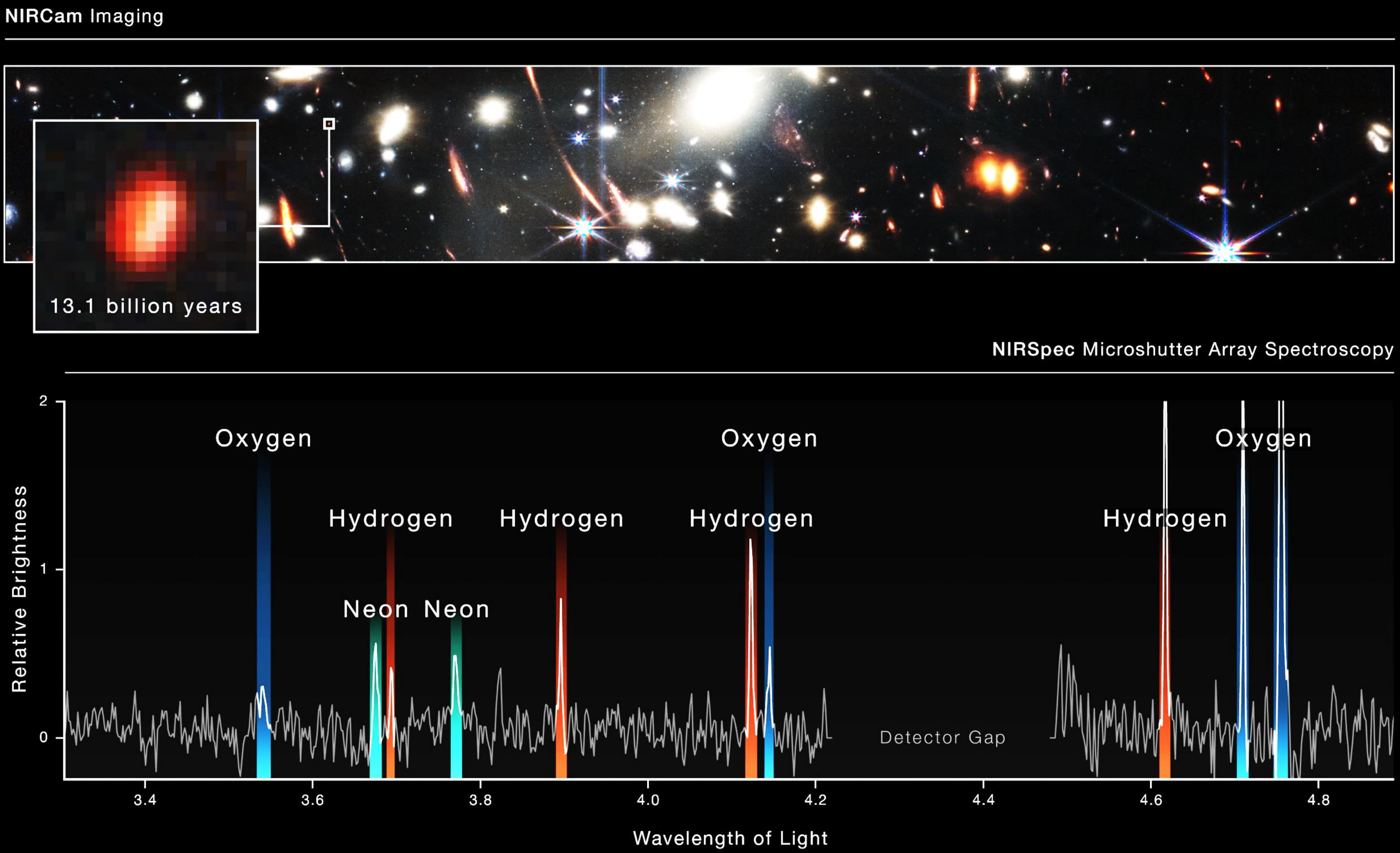
Fundamental new physics and chemistry



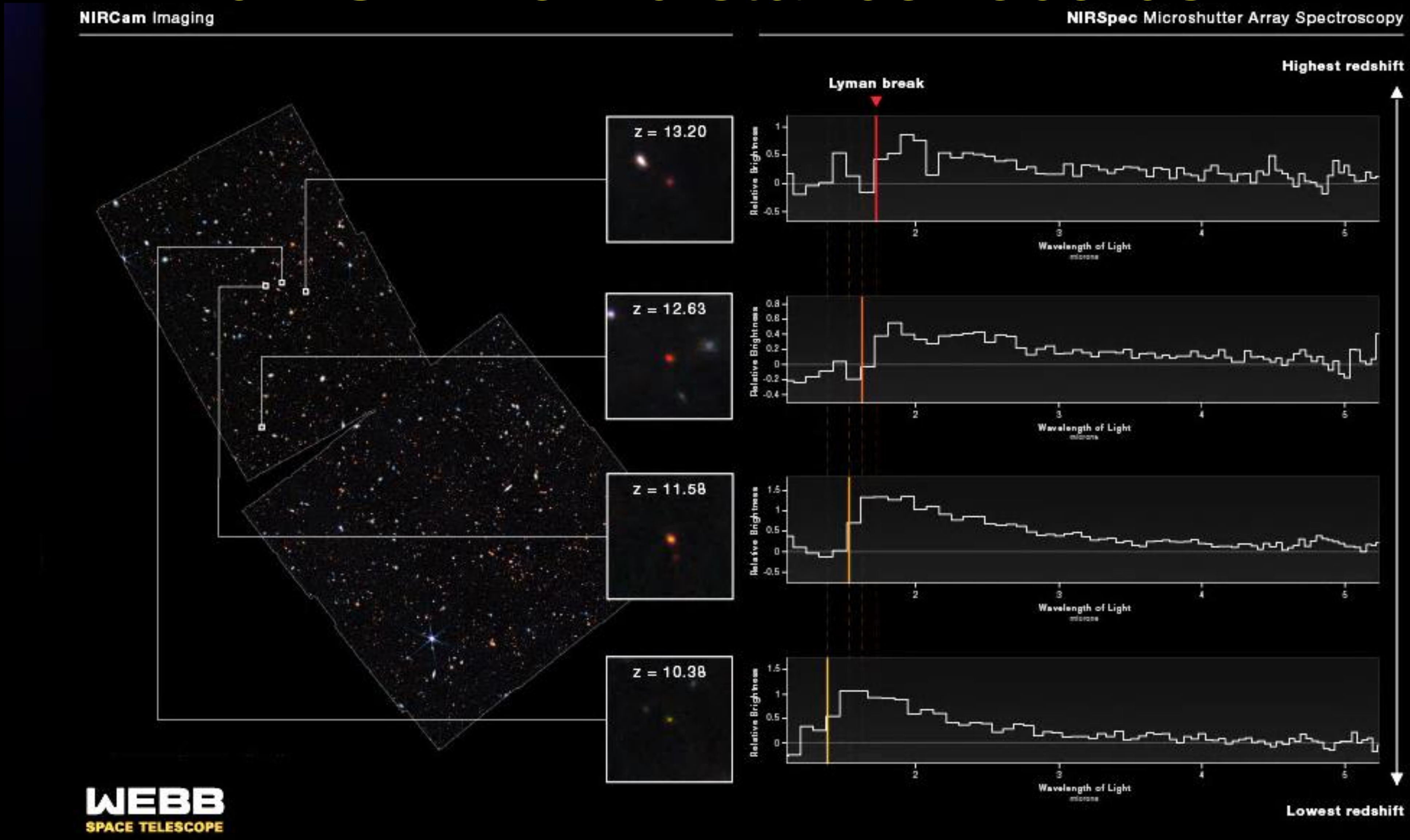
We are made of star dust, but also of neutron star dust!

First deep JWST images

JWST Spectroscopic Confirmation



JWST: new distance records!



325 Myr

346 Myr

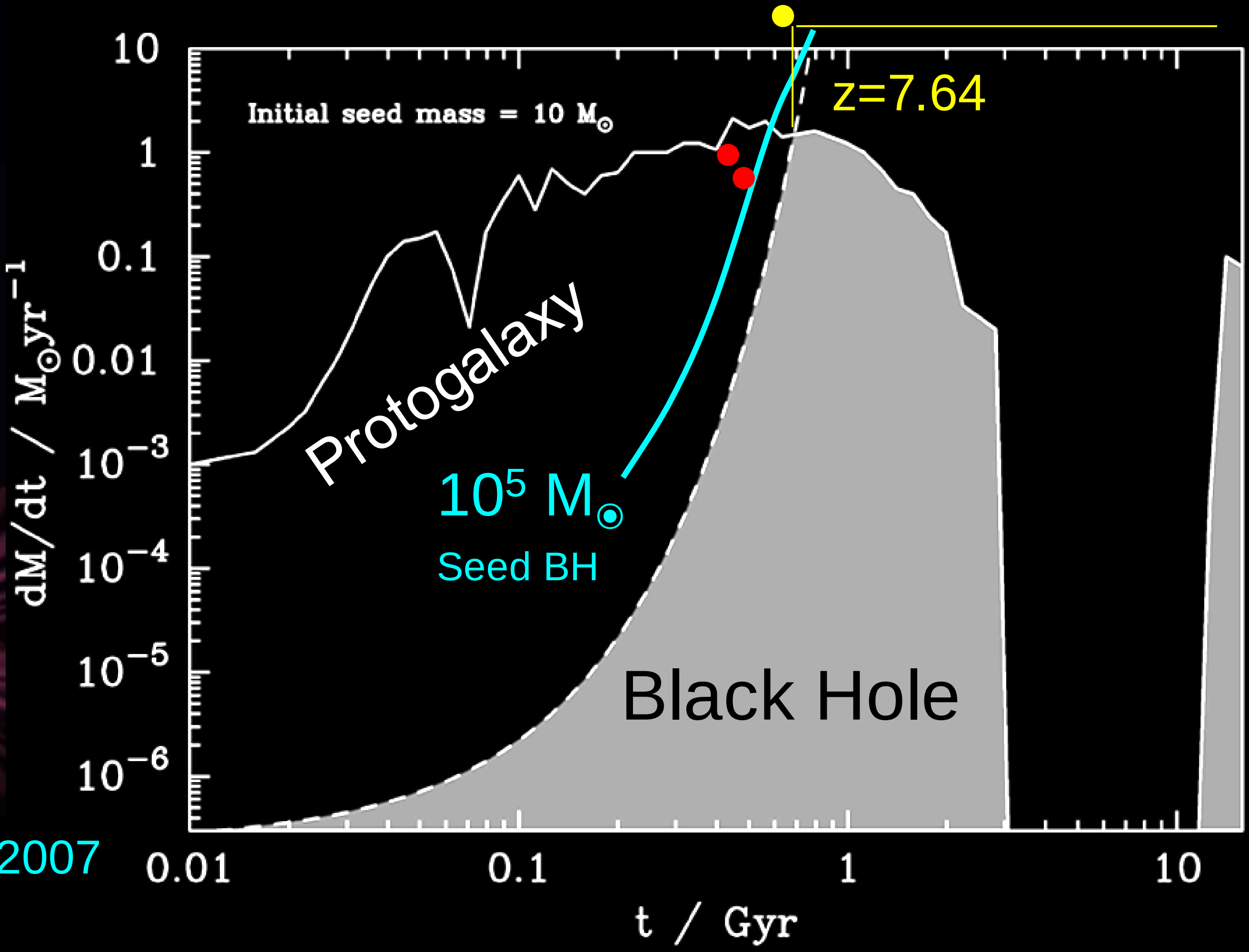
390 Myr

454 Myr

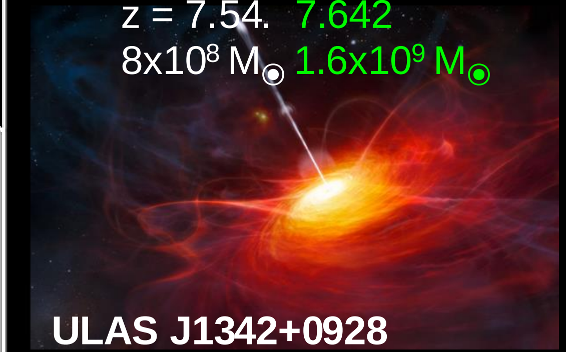
after the Big Bang

These galaxies exist much earlier than previously anticipated. Several of these “little red dots” already include supermassive active black holes.

Formation of the earliest supermassive black holes



10^9 $M_\odot$
known QSOs



ULAS J1342+0928
(Bañados et al. 2018)

J0313-1806
(Wang et al. 2021)

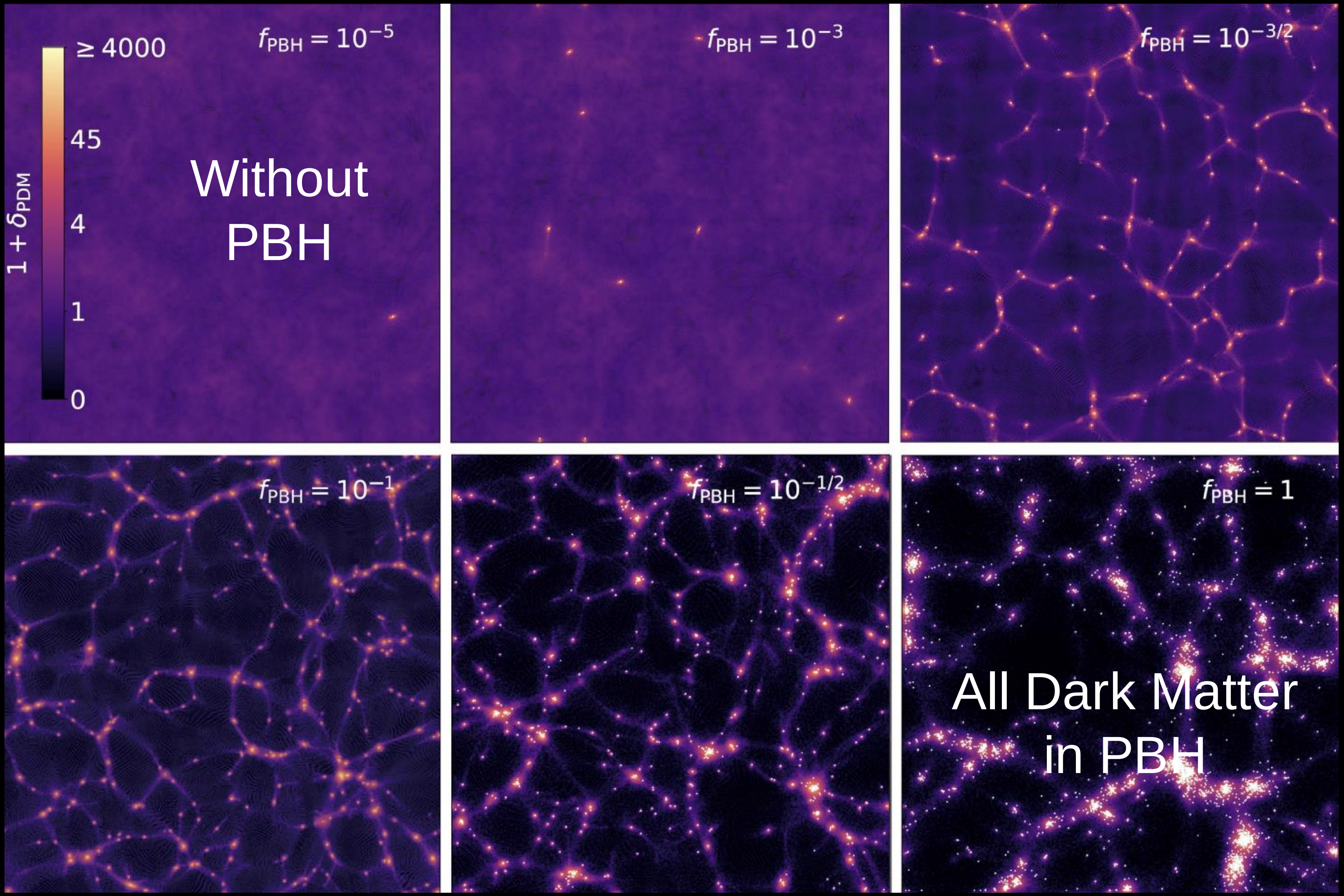
Larsen et al. 2023 & Goulding et al. 2023: JWST discoveries of most distant BHs at z=9&10.1 at 10^{7-8} $M_\odot$

Li, Hernquist, et al. 2007

Archibald et al., 2001

We need massive (10^{5-7} $M_\odot$) seed Black Holes in the early Universe !
These could be primordial Black Holes

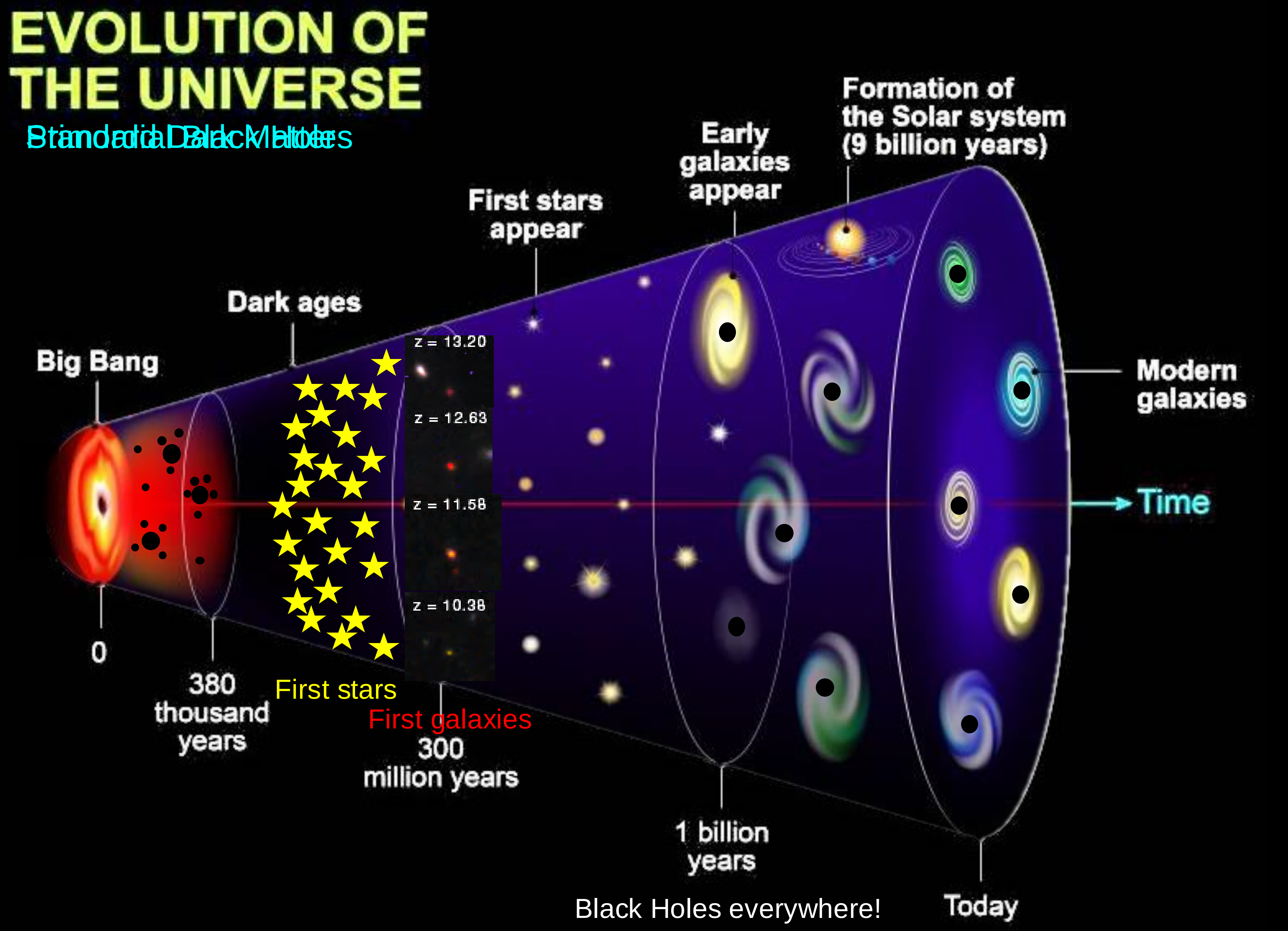
Large scale cosmic structure grows faster with PBH



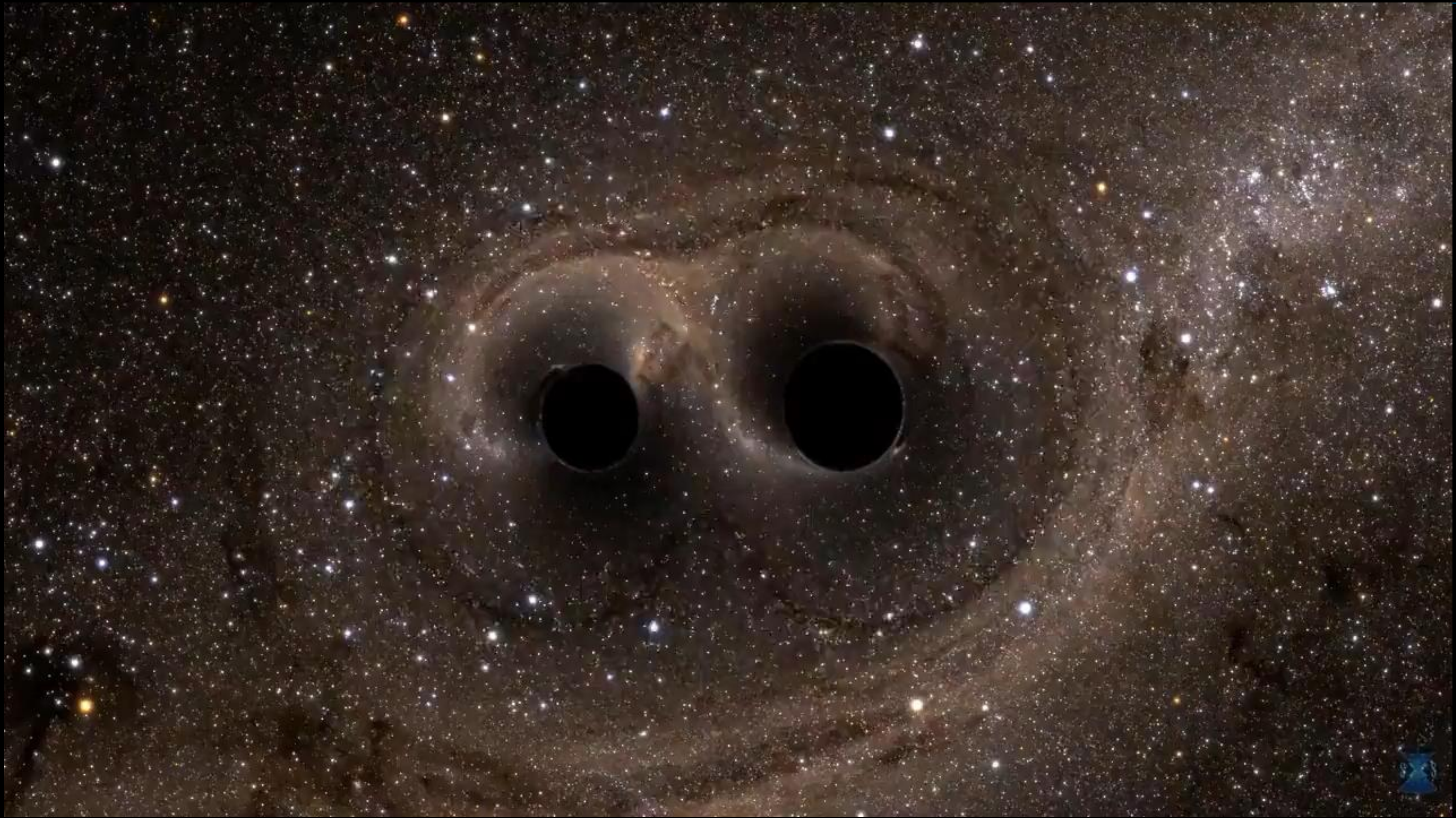
z=99:
17 Mio years after the Big Bang

Earlier large-scale structure development enables faster galaxy formation

D. Inman and Y. Ali-Haïmoud, Early structure formation in primordial black hole cosmologies, Phys. Rev. D 100, 083528 (2019), arXiv:1907.08129


EVOLUTION OF
THE UNIVERSE
Standard Dark Matter
Primordial Black Holes
Big Bang
Dark ages
First stars appear
Early galaxies appear
Formation of the Solar system (9 billion years)
Modern galaxies
Time
z = 13.20
z = 12.63
z = 11.58
z = 10.38
0
380 thousand years
First stars
First galaxies
300 million years
1 billion years
Today
Black Holes everywhere!

PBH model can be tested studying BH mergers

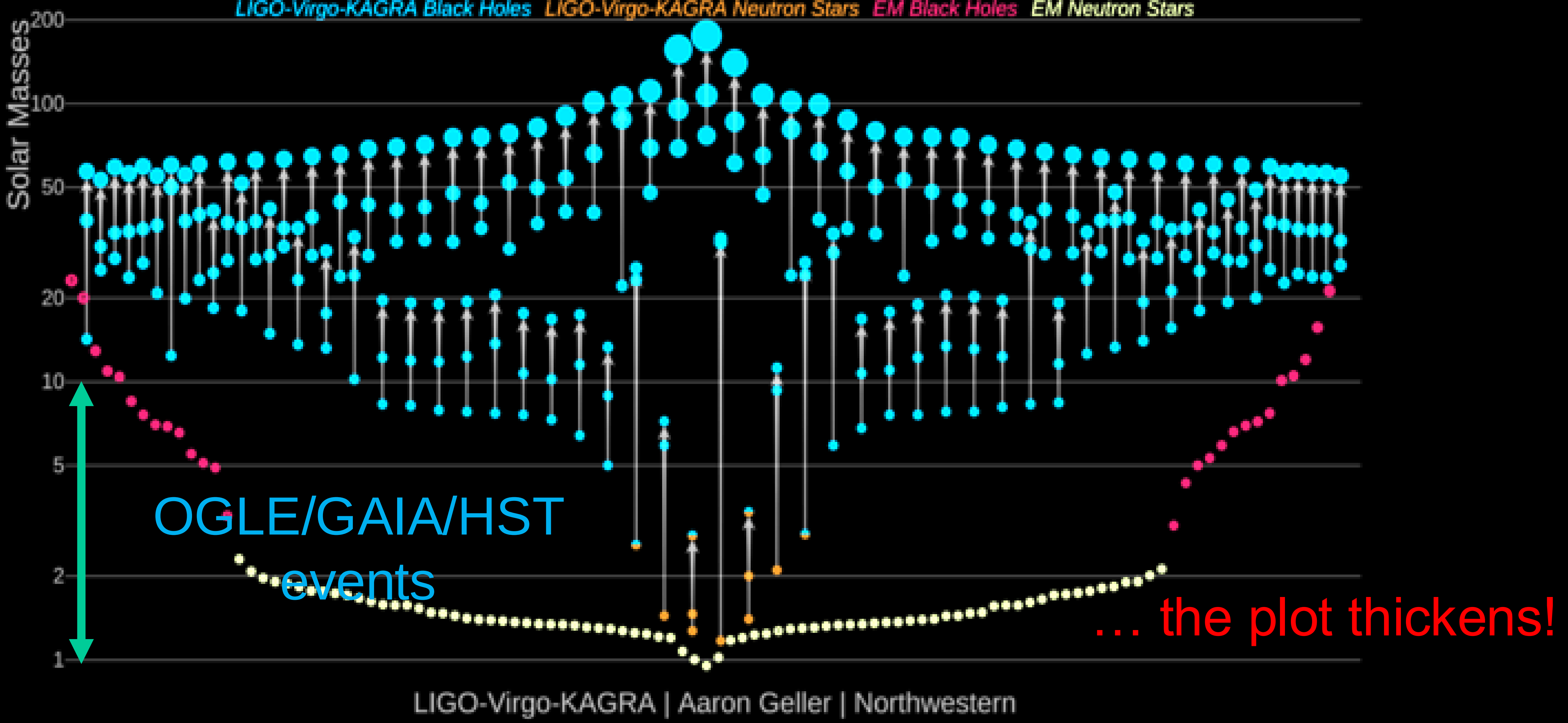


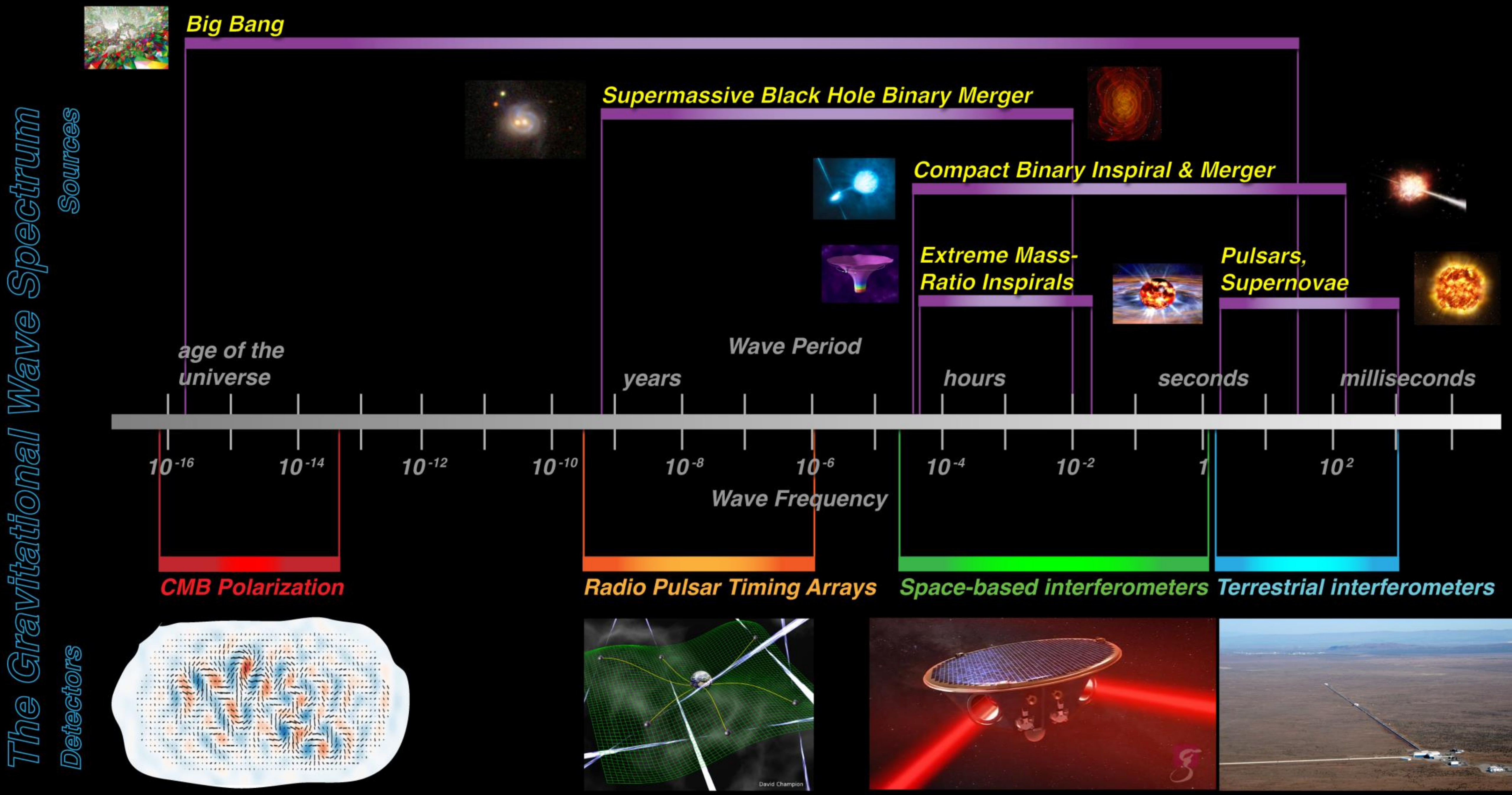
Simulation of the merger of two black holes.

LIGO/Virgo/Kagra/GEO O4 run since May 2023. About 2 events per week!

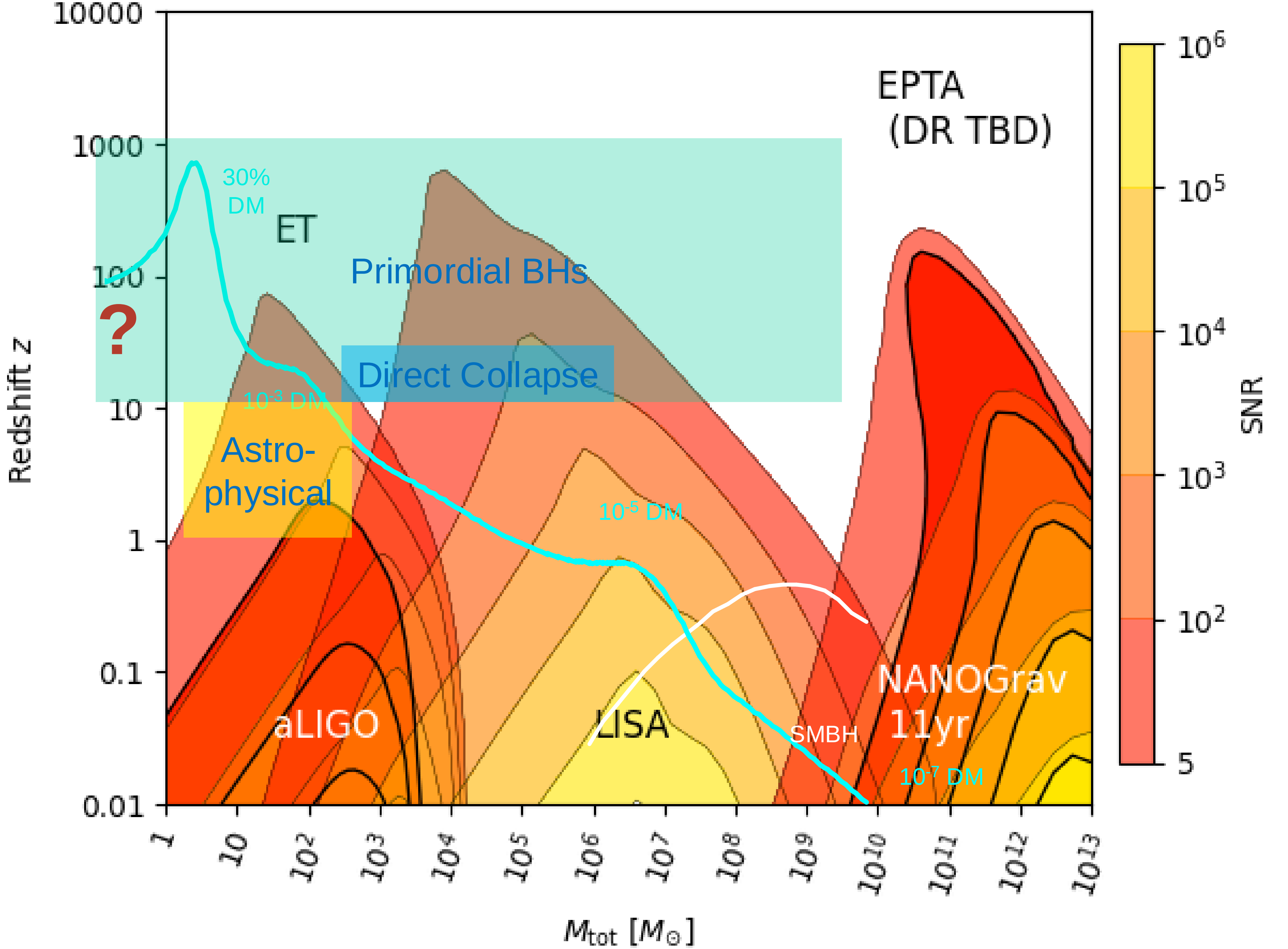
Similar effects expected for larger masses at longer gravity wavelengths.

Masses in the Stellar Graveyard



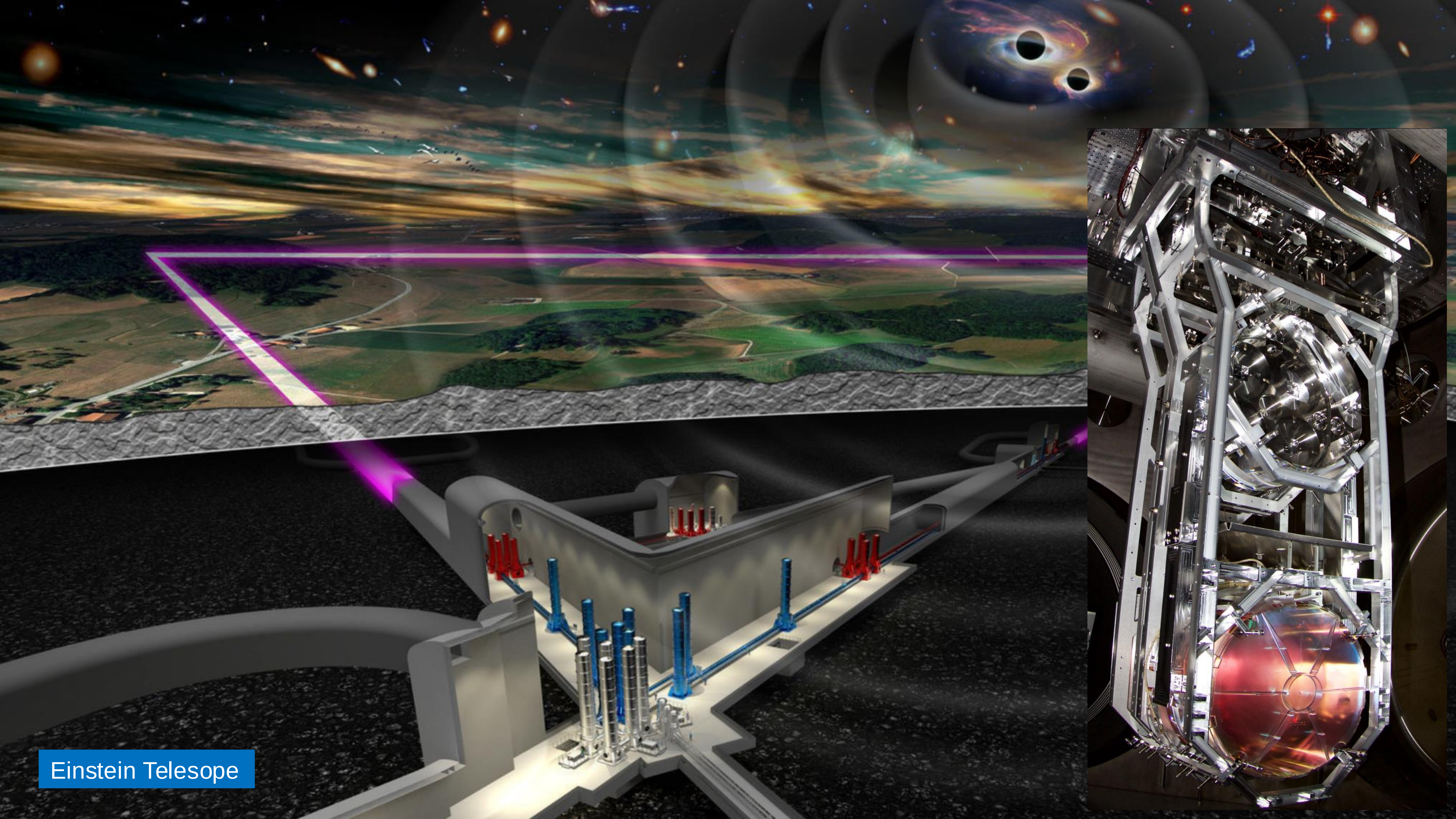


Credit: NASA/J. I. Thorpe



Sensitivity for BH-BH mergers

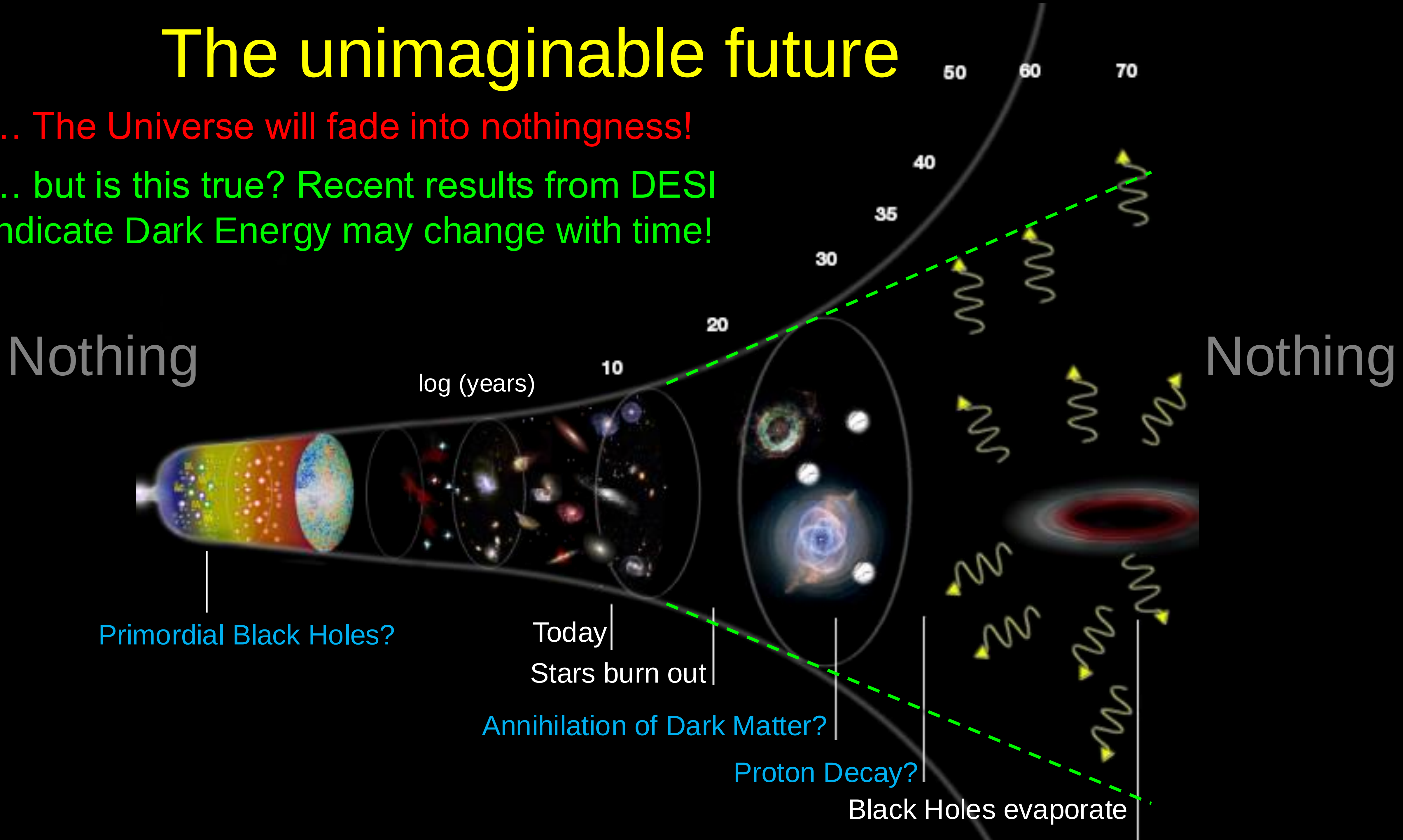
Future gravitational wave observatories can unambiguously discriminate between astrophysical and primordial black holes.


Einstein Telesope

The unimaginable future

… The Universe will fade into nothingness!

… but is this true? Recent results from DESI indicate Dark Energy may change with time!




Many thanks for your attention!