A few facts about black holes

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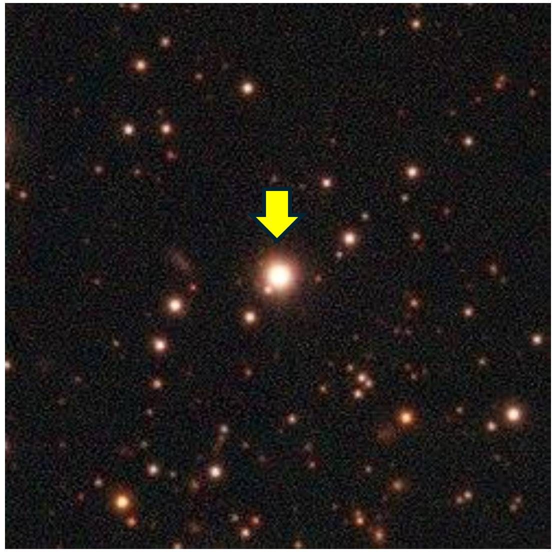
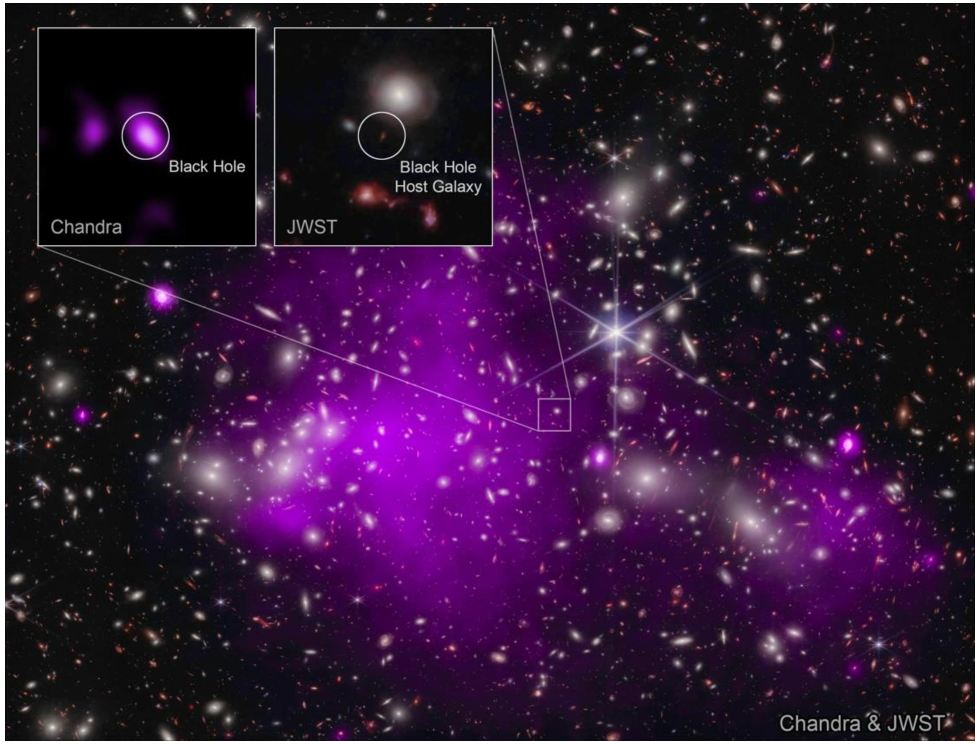
- The closest known black hole is a component of the binary system Gaia BH1, about 1500 l.y. from the Earth. The system includes a main sequence star and a stellar mass black hole. The system is visible in the constellation Ophiucus.



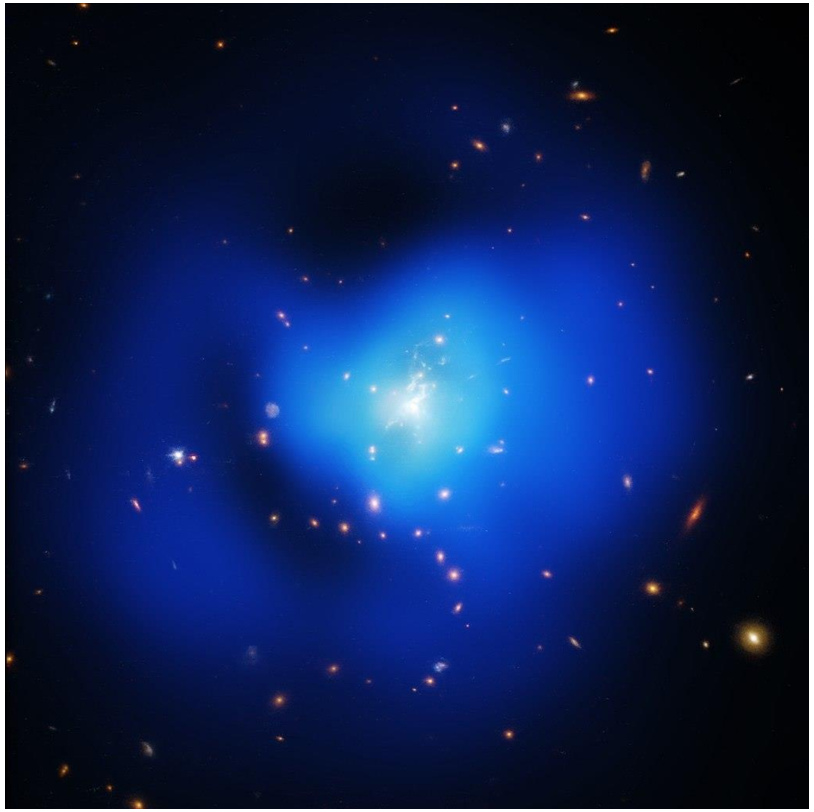
- Astronomers found the most distant black hole ever detected in X-rays (in a galaxy dubbed UHZ1), at a distance of 13.2 billion l.y., using the Chandra and Webb space telescopes. X-ray emission is a telltale signature of a growing supermassive black hole. This result may explain how some of the first supermassive black holes in the universe formed. This image shows the galaxy cluster Abell 2744 that UHZ1 is located behind, in X-rays from Chandra and infrared data from Webb, as well as close-ups of the black hole host galaxy UHZ1.

  X-ray: NASA/CXC/SAO/Ákos Bogdán; Infrared: NASA/ESA/CSA/STScI; Image Processing: NASA/CXC/SAO/L. Frattare & K. Arcand
  https://www.nasa.gov/missions/chandra/nasa-telescopes-discover-record-breaking-black-hole/



- The most massive black hole observed is located in the nucleus of the Phoenix A galaxy, with an estimated mass about 100 x 10^9 solar masses. Another heavy-weight lies at the center of the quasar TON 618 (abbreviation of Tonantzintla 618), about 66 x 10^9 solar masses.

- Most Milky Way-sized galaxies have monster black holes at their centers. Our is called Sagittarius A*, and it has a mass about 4 million solar masses.

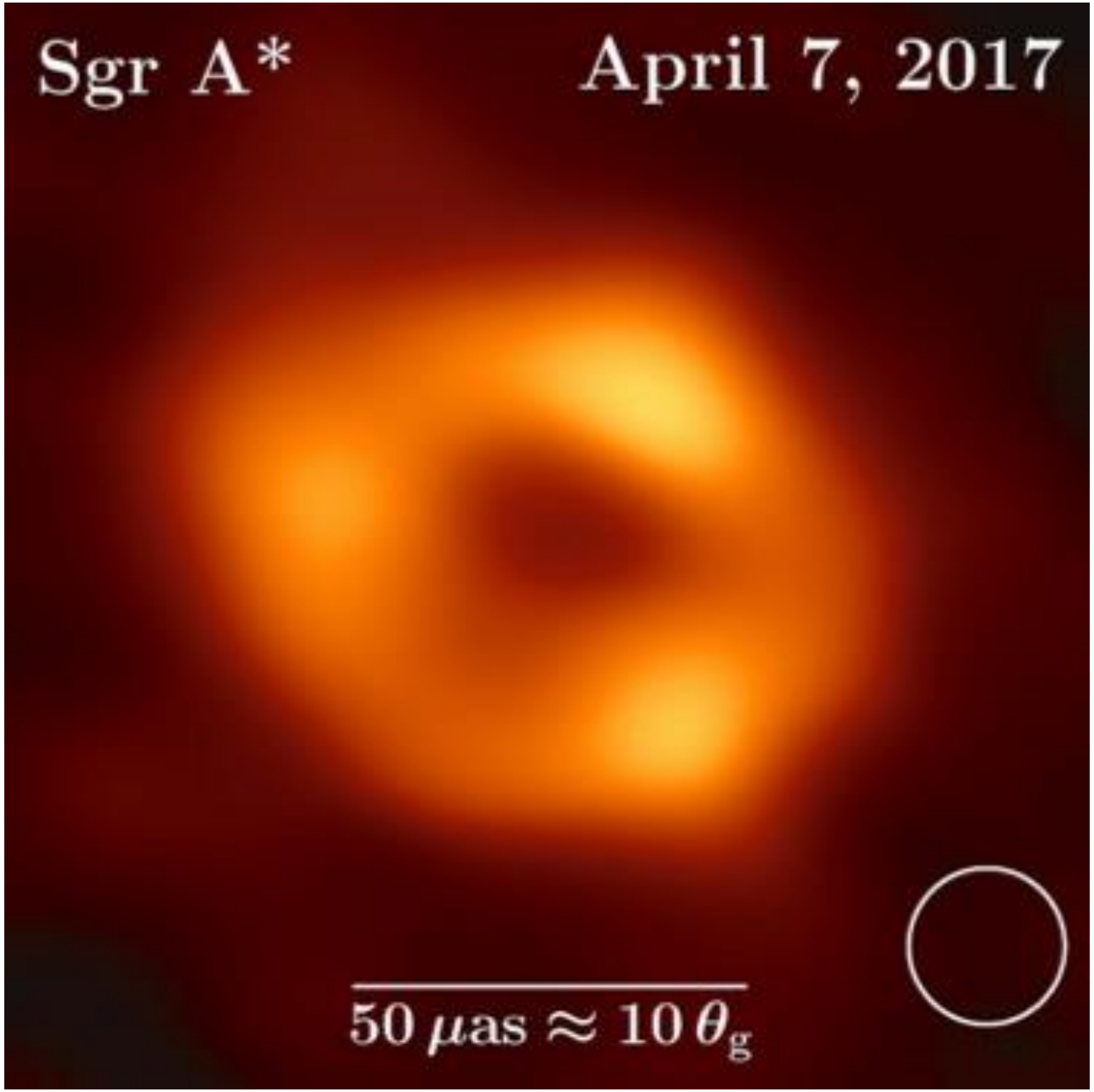


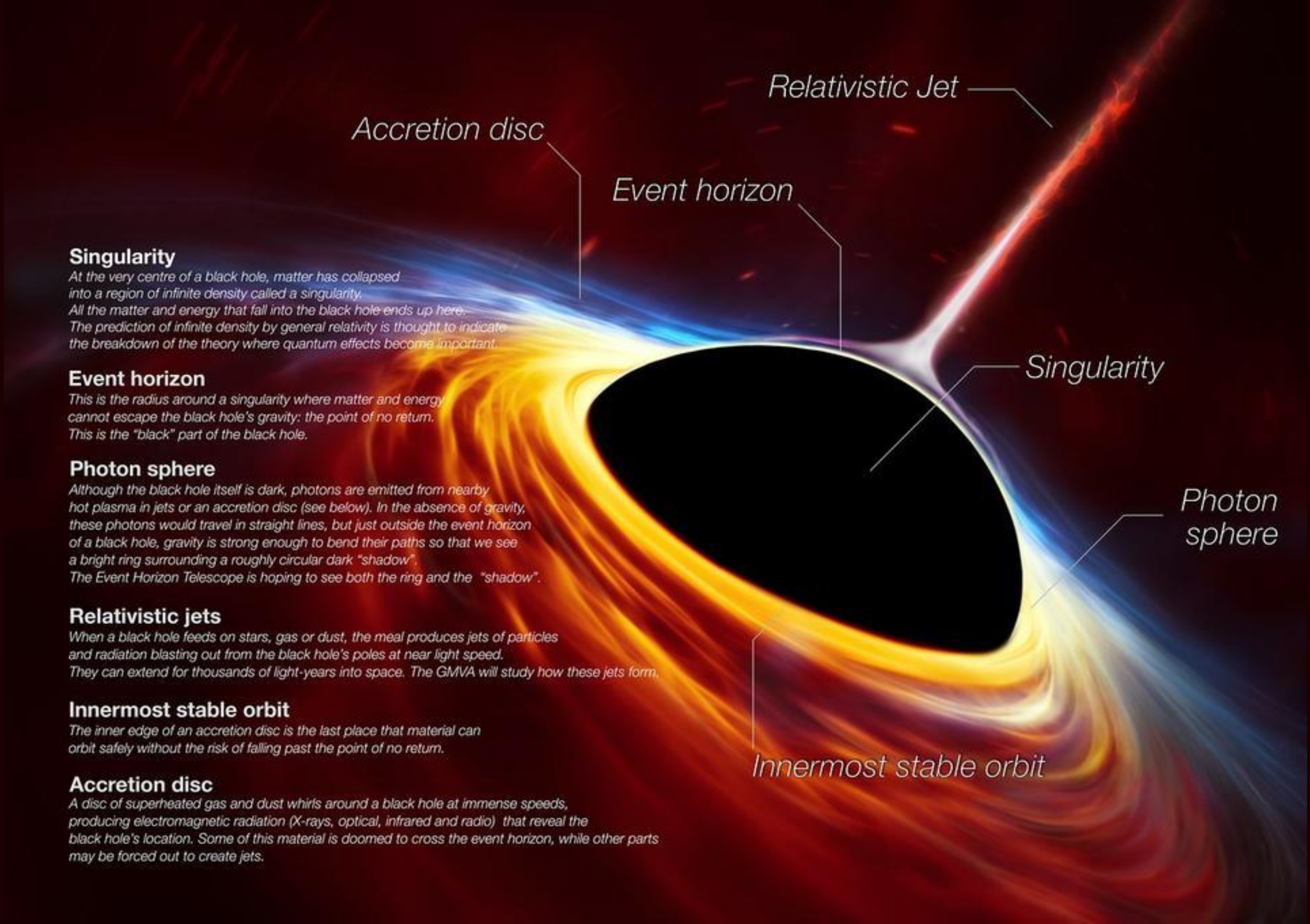
New observations of the galaxy cluster SPT-CLJ2344-4243 at X-ray, ultraviolet, and optical wavelengths are helping astronomers better understand this extraordinary system. Chandra data (blue) reveal large cavities in the X-rays, which have been combined in this composite image with optical data from Hubble (red, green, and blue). Astronomers think these X-ray cavities were carved out of the surrounding gas by powerful jets of high-energy particles emanating from near a supermassive black hole in the central galaxy of the cluster. Massive filaments of gas and dust, which extend for 160,000 to 330,000 lights years, surround the X-ray cavities.

X-ray: NASA/CXC/MIT/M.McDonald et al; Optical: NASA/STScI - https://chandra.harvard.edu/photo/2015/phoenix/

The first image of the Galactic Center black hole, Sagittarius A*, obtained by the Event Horizon Telescope (EHT). Identified nearly 50 years ago as the nearest supermassive black hole candidate and among the most studied astrophysical objects, Sgr A* is the ultimate laboratory for black hole astrophysics.

(From https://iopscience.iop.org/journal/2041-8205/page/Focus_on_First_Sgr_A_Results, see also https://eventhorizontelescope.org/blog/astronomers-reveal-first-image-black-hole-heart-our-galaxy)




Relativistic Jet
Accretion disc
Event horizon
Singularity
Photon sphere
Innermost stable orbit
Singularity
At the very centre of a black hole, matter has collapsed into a region of infinite density called a singularity. All the matter and energy that fall into the black hole ends up here. The prediction of infinite density by general relativity is thought to indicate the breakdown of the theory where quantum effects become important.
Event horizon
This is the radius around a singularity where matter and energy cannot escape the black hole's gravity: the point of no return. This is the "black" part of the black hole.
Photon sphere
Although the black hole itself is dark, photons are emitted from nearby hot plasma in jets or an accretion disc (see below). In the absence of gravity, these photons would travel in straight lines, but just outside the event horizon of a black hole, gravity is strong enough to bend their paths so that we see a bright ring surrounding a roughly circular dark "shadow". The Event Horizon Telescope is hoping to see both the ring and the "shadow".
Relativistic jets
When a black hole feeds on stars, gas or dust, the meal produces jets of particles and radiation blasting out from the black hole's poles at near light speed. They can extend for thousands of light-years into space. The GMVA will study how these jets form.
Innermost stable orbit
The inner edge of an accretion disc is the last place that material can orbit safely without the risk of falling past the point of no return.
Accretion disc
A disc of superheated gas and dust whirls around a black hole at immense speeds, producing electromagnetic radiation (X-rays, optical, infrared and radio) that reveal the black hole's location. Some of this material is doomed to cross the event horizon, while other parts may be forced out to create jets.

Growing catalogue

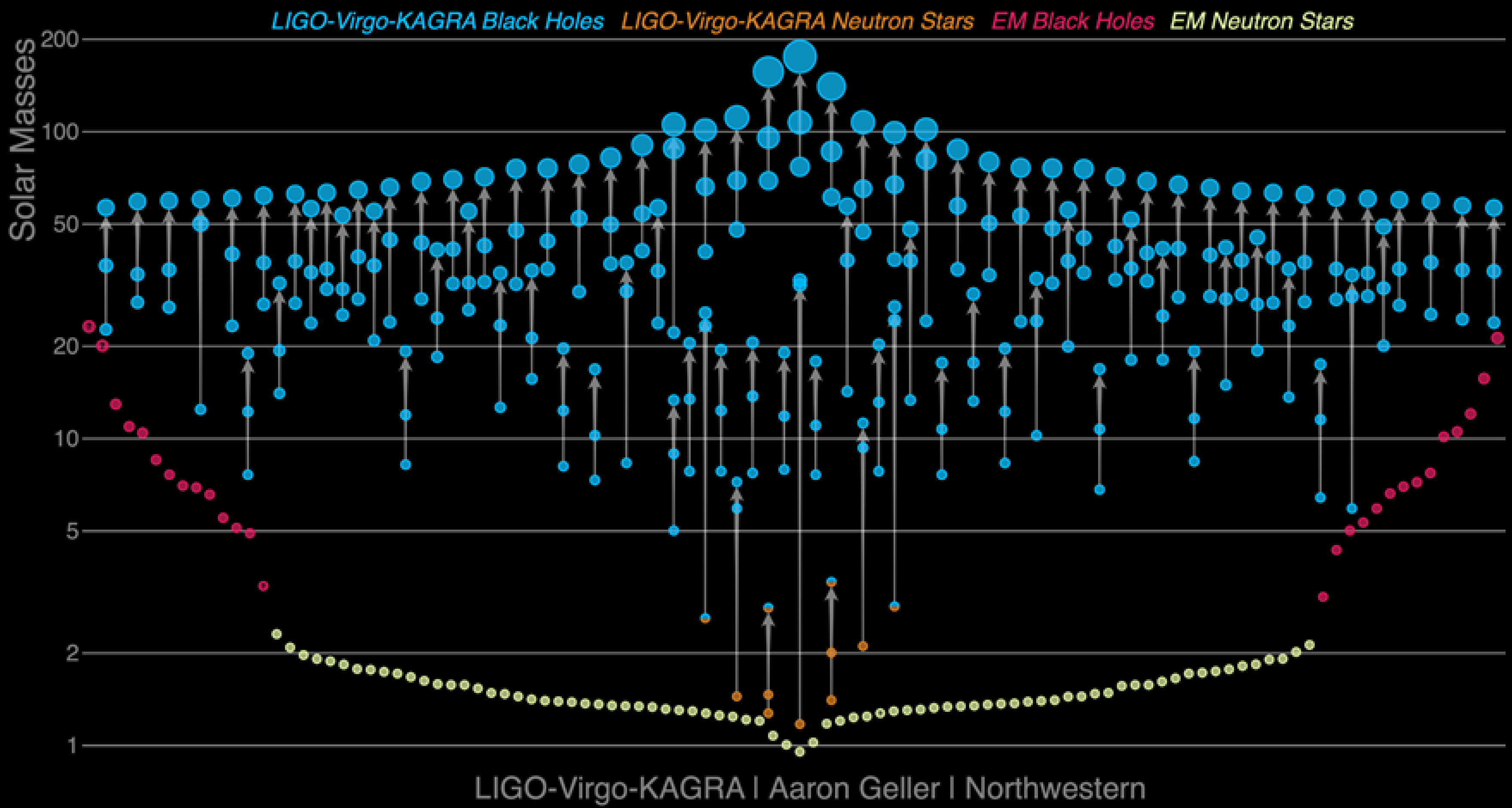
GWTC-3 adds **35** events with more than 50% probability of an **astrophysical** source

Total number of candidates is 90

Most are binary black holes **(BBHs)**

Some are neutron star–black hole binaries **(NSBHs)**

Two are binary neutron stars **(BNSs)**



Black hole population in the Universe

- Science summary of LVK paper https://ligo.org/science-summaries/O3bAstroDist/
- Extremely large number of BHs in galaxies

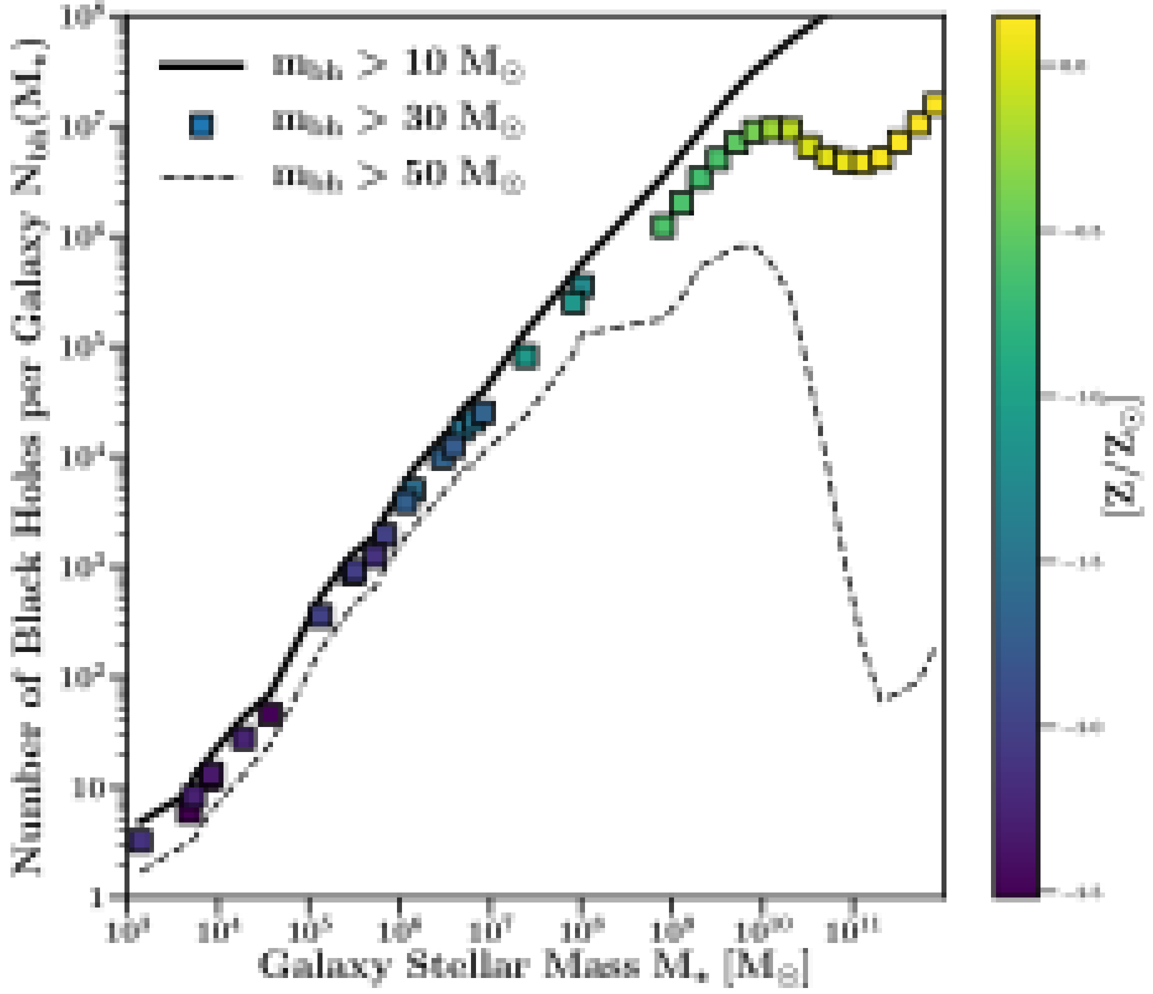


Figure 2. The number of remnant black holes per galaxy as a function of galaxy stellar mass, $N_{bh}(M_*)$, for black holes of mass $m_{bh} > 10$, 30 or 50 $M_\odot$. The squares (corresponding to 30 $M_\odot$ black holes) are colour coded by the median galaxy metallicity. We see that for low metallicities, $N_{bh} \propto M_*$ in all cases. For the most massive black holes (30, 50 $M_\odot$), the relation breaks when galaxies become too metal rich to produce remnants in proportion to their total stellar mass – these black holes form only in the low-Z tail of the distribution. At the highest stellar masses, the relations begin to rise again, when the relation between M_* and Z becomes flat.

From Elbert et al, MNRAS 473, 1186 (2018)

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The Black Hole Mass Function Across Cosmic Times. I. Stellar Black Holes and Light Seed Distribution

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… estimated number of black holes in the Universe, about 4 x 10^{19}

https://www.youtube.com/watch?v=nJ4d4QEDOYM