Event Horizon Telescope Fact Sheet

The Event Horizon Telescope Collaboration

The Event Horizon Telescope (EHT) is an international collaboration aiming to capture the first ever image of a black hole by creating a virtual Earth-sized telescope. This will test Einstein's Theory of General Relativity in an extreme regime. The EHT consortium consists of 13 stakeholder institutes with about 200 participants in Europe, Asia, Africa, North and South America. The director of the EHT project is Dr. Sheperd S. Doeleman (Harvard-Smithsonian Center for Astrophysics).

The technique applied for the EHT observations is called very-long-baseline interferometry (VLBI). VLBI enables the highest resolutions in astronomy by coupling a number of radio telescopes distributed across the Earth. This method is used for the investigation of the direct environment of supermassive black holes in the heart of active galaxies, in particular jets of high-energy particles emitted from the central regions. In the framework of the EHT project it will become possible to directly image the central black holes in addition to the jets. This is achieved by observations at shorter radio waves of only 1.3 mm wavelength. The resolution of the world-wide network of radio telescopes at that wavelength corresponds to the size of a tennis ball in the distance of the moon.

To minimize the impact of the Earth's atmosphere at that wavelength, the observations are only possible at high-altitude and dry sites like the Atacama desert in Chile, the Sierra Nevada in southern Spain, high volcanoes at Hawaii or even the South Pole.

The Atacama Large Millimeter/submillimeter Array (ALMA), with its 66 dishes, greatly aids the sensitivity of the array. The total collecting area of ALMA corresponds to a radio telescope with an equivalent diameter of 84 meters, compared to the usual millimeter-wave radio telescope diameters of 10 to 30 meters. After a preparation phase of several years, the EHT observed with ALMA (37 antennas) for the first time in April 2017, and again in April 2018. The April 2017 observations were also the first to include the South Pole Telescope, which doubles the north-south extent of the array, and therefore the resolution.

VLBI data sets are combined in dedicated supercomputers, the so-called "correlators". Two correlators are used for the combination of the EHT data, at the Haystack Observatory in

Westford, Massachusetts, USA and the Max Planck Institute for Radio Astronomy in Bonn, Germany. The data are then processed, calibrated, analysed and imaged by dedicated teams of scientists using novel computational tools developed by the collaboration.

Following the correlation stage, the VLBI data are calibrated to remove imperfections and artificial variations, and then processed into images or modeled to extract interesting physical properties. The interpretation of these data are aided by extensive numerical simulations of the environments of black holes, and through analysis of synthetic data.

EHT stakeholder institutes (in alphabetical order)

- Academia Sinica Institute of Astronomy and Astrophysics (ASIAA), Taipei, Taiwan R.O.C. -- https://www.asiaa.sinica.edu.tw/
- East Asian Observatory (EAO), international -- https://www.eaobservatory.org/
- Goethe-Universität Frankfurt, Germany -- http://www.goethe-university-frankfurt.de/
- Haystack Observatory, Massachusetts Institute of Technology, Massachusetts, USA -- https://www.haystack.mit.edu/
- Institut de Radioastronomie Millimétrique (IRAM), Grenoble, France, and Granada, Spain -- http://www.iram-institute.org/
- Large Millimeter Telescope Alfonso Serrano (LMT), Mexico -- http://www.lmtgtm.org/
- Max-Planck-Institut für Radioastronomie (MPIfR), Bonn, Germany -- https://www.mpifr-bonn.mpg.de/
- National Astronomical Observatory of Japan (NAOJ), Tokyo, Japan -- https://www.nao.ac.jp/
- Perimeter Institute, Waterloo, Ontario, Canada -- https://www.perimeterinstitute.ca/
- Radboud Universiteit Nijmegen, The Netherlands -- https://www.ru.nl/
- Smithsonian Astrophysical Observatory (SAO), Massachusetts, USA -- https://www.cfa.harvard.edu/sao
- University of Arizona, Tucson, Arizona, USA -- https://www.arizona.edu/
- University of Chicago, Illinois, USA -- https://www.uchicago.edu/

The EHT Campaign in April 5–14, 2017

- 8 observatories at 6 geographical locations (see list below)
- 5 nights of observations in excellent weather, recording for approximately 8 hours per observatory per night

- data rate 32 Gbit/sec, approximately 3500 TB of raw data recorded to disks

- Observatories:
  - Atacama Pathfinder Experiment (APEX)
    - Cerro Chajnantor, Chile
    - altitude: 5100 m
    - single dish, 12-m diameter
  - Atacama Large Millimeter/submillimeter Array (ALMA)
    - Cerro Chajnantor, Chile
    - altitude: about 5000 m
    - array of fifty-four 12-m diameter and twelve 7-m diameter dishes (most commonly thirty-seven 12-m antennas in 2017, giving a collecting area equivalent to a 70-m diameter dish)
    - international partnership between Europe, the United States, Canada, Japan, South Korea, Taiwan, and Chile
  - IRAM 30-meter Telescope
    - Pico Veleta, Spain
    - altitude: 2850 m
    - single dish, 30-m diameter
    - operated by IRAM
  - South Pole Telescope (SPT)
    - South Pole Station, Antarctica
    - altitude: 2800 m
    - single dish, 10-m diameter
  - James Clark Maxwell Telescope (JCMT)
    - Maunakea, Hawaii, USA
    - altitude: 4100 m
    - single dish, 15-m diameter
  - Large Millimeter Telescope "Alfonso Serrano" (LMT)
    - Sierra Negra, Mexico
    - altitude: 4600 m
    - single dish, 50-m diameter (inner 32-m diameter illuminated in 2017)
  - Submillimeter Array (SMA)
    - Maunakea, Hawaii, USA
    - altitude: 4100 m
    - array, eight dishes, 6-m diameter each (most commonly six dishes in 2017)

- Submillimeter Telescope (SMT)
  - Mount Graham, Arizona, USA
  - altitude: 3100 m
  - single dish, 10-m diameter

- Scientific Targets:
  - The Galactic Center (Sagittarius A*, or Sgr A*) — main EHT target
    - distance: 25,000 light-years
    - constellation "Sagittarius"
  - Messier 87 (M87, Virgo A) — main EHT target
    - active galaxy at the center of the Virgo cluster of galaxies
    - distance: 55 million light-years
    - constellation "Virgo"
  - Southern Galaxy Centaurus A, at a distance of 13 million light-years in the constellation "Centaurus"
  - Quasar OJ 287, in a distance of 3.5 billion light-years in the constellation "Cancer"
  - Elliptical galaxy NGC 1052, in a distance of 63 million light-years in the constellation "Cetus"
  - Quasar 3C 279, in a distance of 5 billion light-years in the constellation "Virgo"