Event Horizon Telescope

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SA3CC Meeting | May 2025





- Started at MIT Haystack Observatory 2003
 - IT Manager and Research Engineer
 - Project operations/deployment/support
- Joined EHT project 2009
 - Commissioning team / Station operator
 - CARMA, LMT, SPT, and NOEMA
 - System repairs and coordination
 - Technical Operations
 - Remote support







The Event Horizon Telescope (EHT) is an array of millimeter and sub-millimeter wavelength telescopes using Very Long Baseline Interferometry (VLBI). The array spans the world creating a telescope with an effective Earth-sized aperture.





Each pair of stations within the array creates a baseline covering the effective Earth-size aperture (bottom left)

Phased array stations like ALMA makes noticeable improvements to the observation coverage (bottom right)









The EHT VLBI backend receives the broadband signal, digitizes it, and records onto data modules.

The data is then shipped to the MIT Haystack Observatory Correlator in Massachusetts, USA and the Max-Planck Institute for Radio Astronomy Correlator in Bonn, Germany for processing.







The correlated data is then put through calibration algorithms to further reduce the data products. Imaging techniques are applied to the calibrated data to generate images such as super massive black holes.



M87 2017



SgrA*



M87 2018



EHT2025 Observing Campaign

April 04 – 14, 2025 Observed 4 of the nights 11 sites participated (ALMA, APEX, GLT, IRAM30m, JCMT, KP, KVN, LMT, NOEMA, SMA, and SMTO)



SMTC





Campaign notes:

- Observations were at 230GHz & 345GHz
- Dual pol and double side band
- Station recorders at 64Gb/s
- Collecting about 700TB raw data per station

Campaign staffing:

- Sites staffed with EHT observers and specialists
- Array Operations Center (AOC) staff located at "ground" level to monitor operations
- Technical Operations Support staffed for remote support during prechecks and operations

Network and data transport activities:

- Real-Time Station monitoring during observations
- Remote access for operations and support
- The VLBI fringe test



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EHT Network and Data Transport Activities

Real-Time Station monitoring:

- Stations are running VLBI monitoring scripts to push station statistics to a central Grafana server
- This central monitoring tool allows the AOC track in real-time during the campaign how the stations are operating

Remote access:

- Remote access to a station allows the Technical Operations Support to assist with troubleshooting the various subsystems during any critical system failures
- Remote operations can allow station staff to configure and operate remotely instead of being onsite which will save on staffing resources

The VLBI fringe test (January 2025/April2025):

- Stations coordinate a target source and send back a small sample of data via networks to a Correlator to confirm fringes
- There are many variables that require precise configuration that can only be confirmed via a fringe test
- This confirmation is a very strong indicator that a station configuration, timing, and setup is good
- Fringe tests can save a station from misconfiguration and "bad data" for an entire campaign



Improving the EHT Research Network

SC24 Conference - November 2024

Collaboration with:

- FIU (Florida International University)
- International Networks @ Indiana University
- University of Hawaii
- MIT Haystack Observatory

Research Networks:

- Internet2
- Pacific Wave
- PIREN
- Northern Crossroads





Improving the EHT Research Network

SC24 Conference - November 2024

- Demonstration of an EHT Fringe Test
 - Network data transfers
 - SMA to Haystack
 - Correlation and Fringe

The EHT is a collaboration of Radio Science Observatories from around the world. We want to extend this collaboration with the Research Educational Networks supporting the Science.







EHT Future and Challenges

Future EHT Science goals:

- Increase of technology to observe higher frequency
 - Increase data recording size and rates
- Increase observation campaign cadence
 - More than annually
- Adding additional stations (KVN Pyongchang, TEA (Canary Islands), AMT (Africa Millimetre Telescope), OVRO)

Challenges:

- The EHT is a large international collaboration with heterogenous array of station
 - Each station has its own unique challenges to support science goals

Complete!

- Research Networks and the Last Mile
 - Faster networks into Correlators for quicker fringe turn around *Haystack 100Gb/s upgrade 2023 2024
 - Increase station network speed and reliability (last mile challenges)



- The EHT campaigns will want to continue to utilize high-speed reliable Research Networks to support international operations and system checks
- The EHT collaboration is continuing to add additional telescopes around the world
- Data transport on larger scales is the long term goal with many challenges along the way
 - Improving large high-speed networks out to remote stations but also to the Correlators
 - Optimizing these networks at an international level requires collaborations with the RENs
- On the short term sending partial data back to Correlators for quick validation will continue to be important as we increase observation cadences
- Improving operations process and procedures for quicker turn-around
- Network quantification and station monitoring is a way to help track any changes in performance and help optimize data transport



Thank you!



