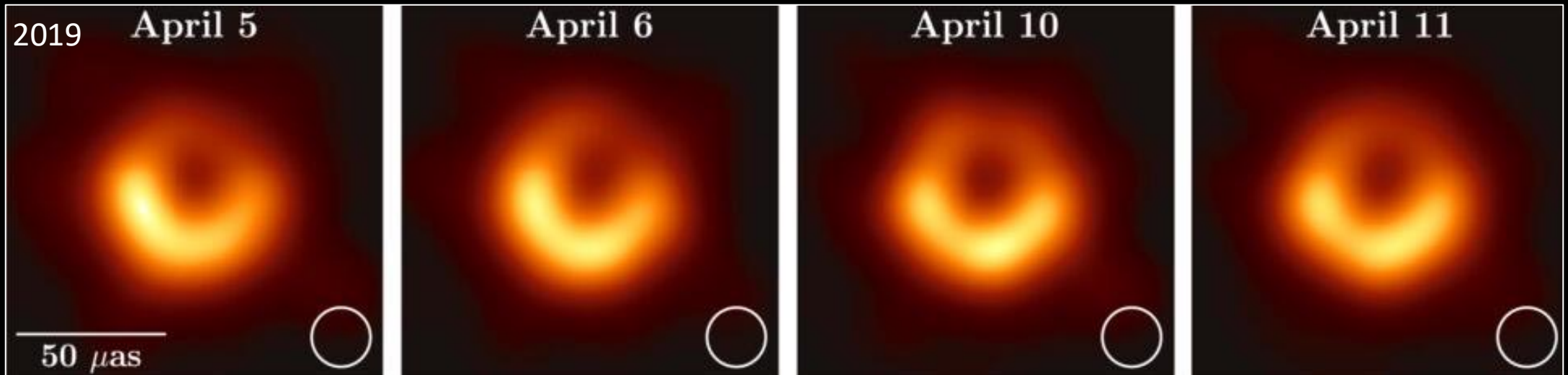




Event Horizon Telescope



Jason SooHoo - Technical Operations
MIT Haystack Observatory



SA3CC Meeting | May 2026





About Me

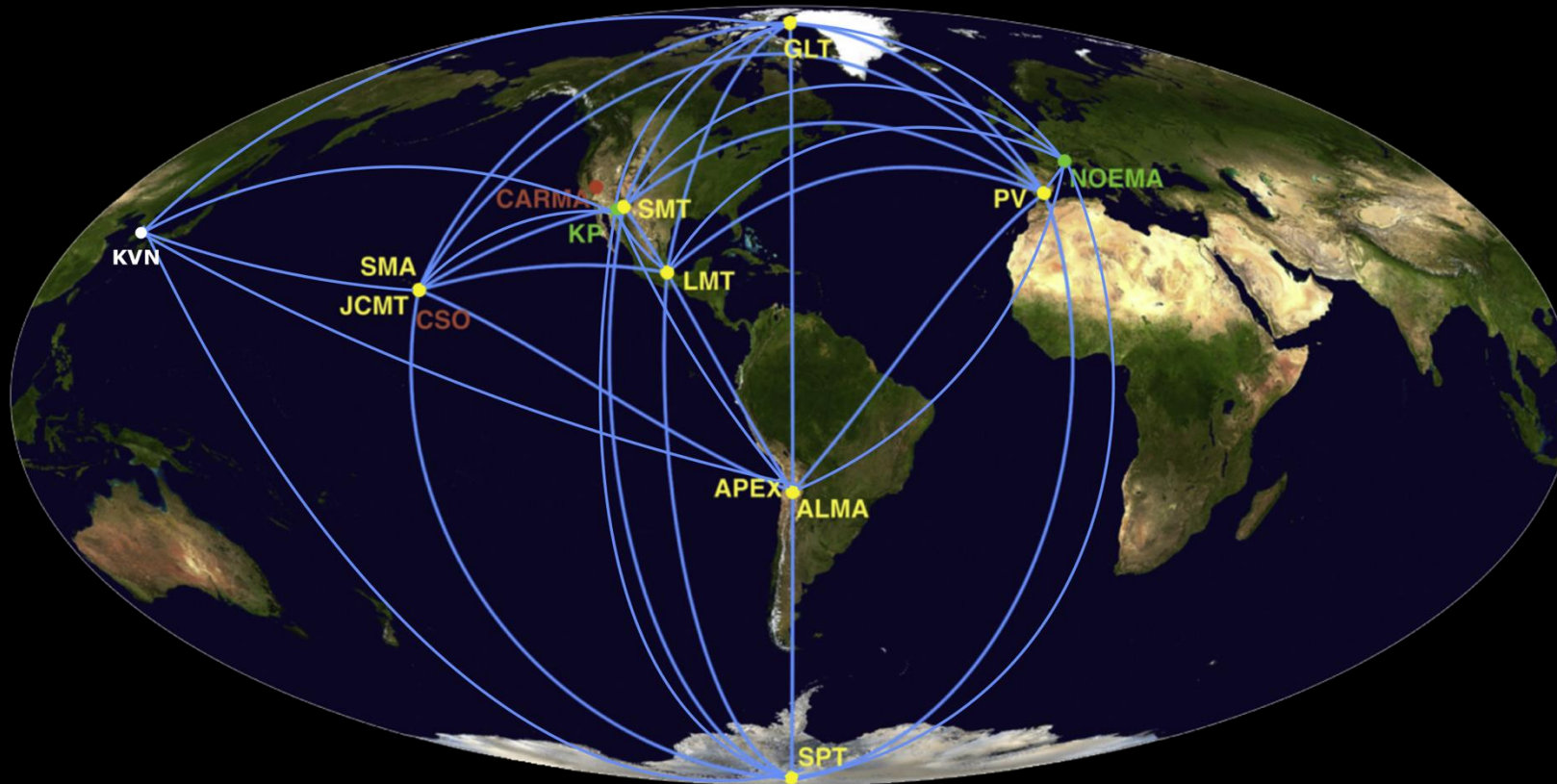
- Started at MIT Haystack Observatory 2003
 - IT Manager and Research Engineer
 - Project operations/deployment/support
- Joined EHT project 2009
 - Commissioning team / Station operator
 - CARMA, LMT, SPT, and NOEMA
 - System repairs and coordination
 - Technical Operations
 - Remote support
 - Network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





The EHT

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.

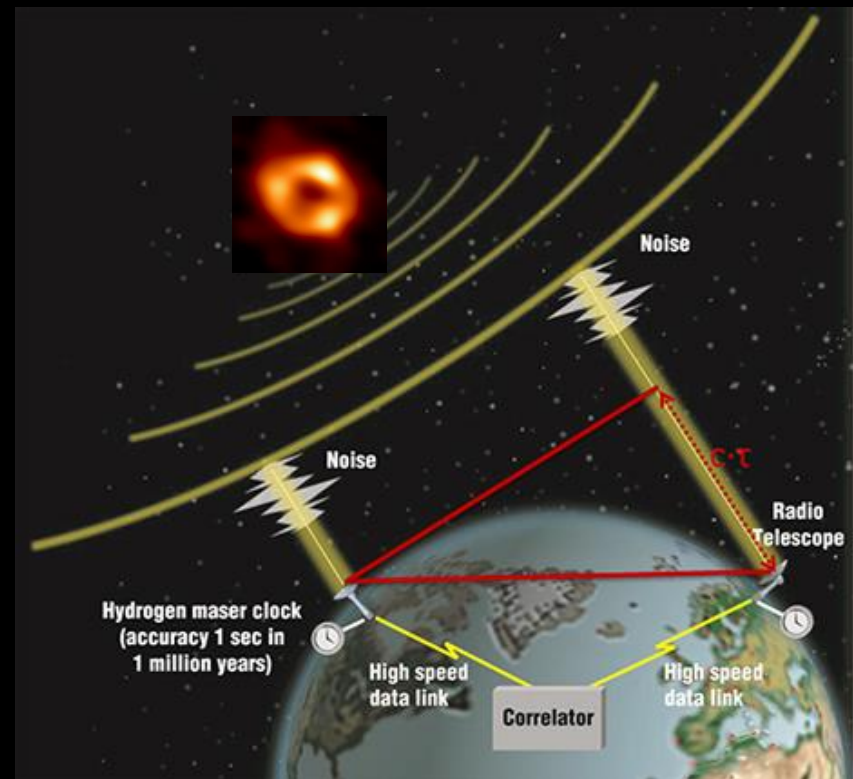
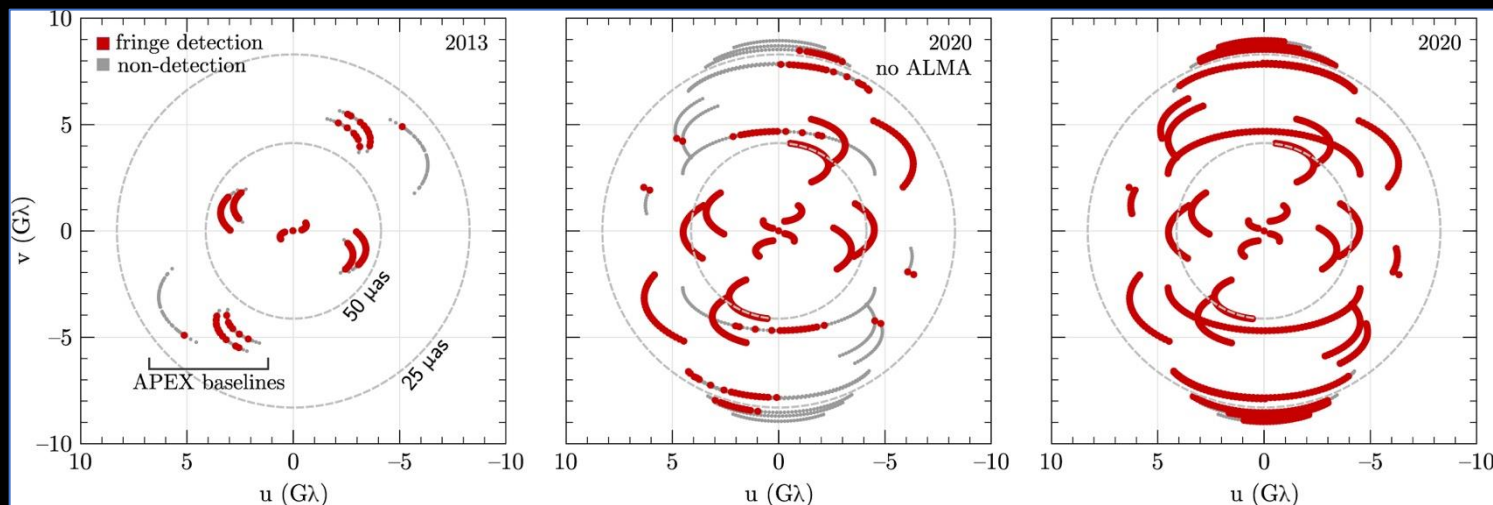
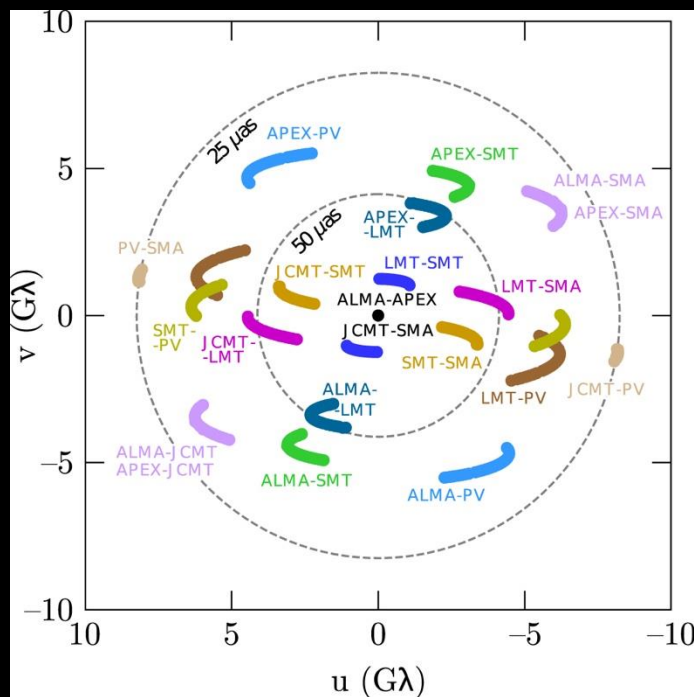




The EHT

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

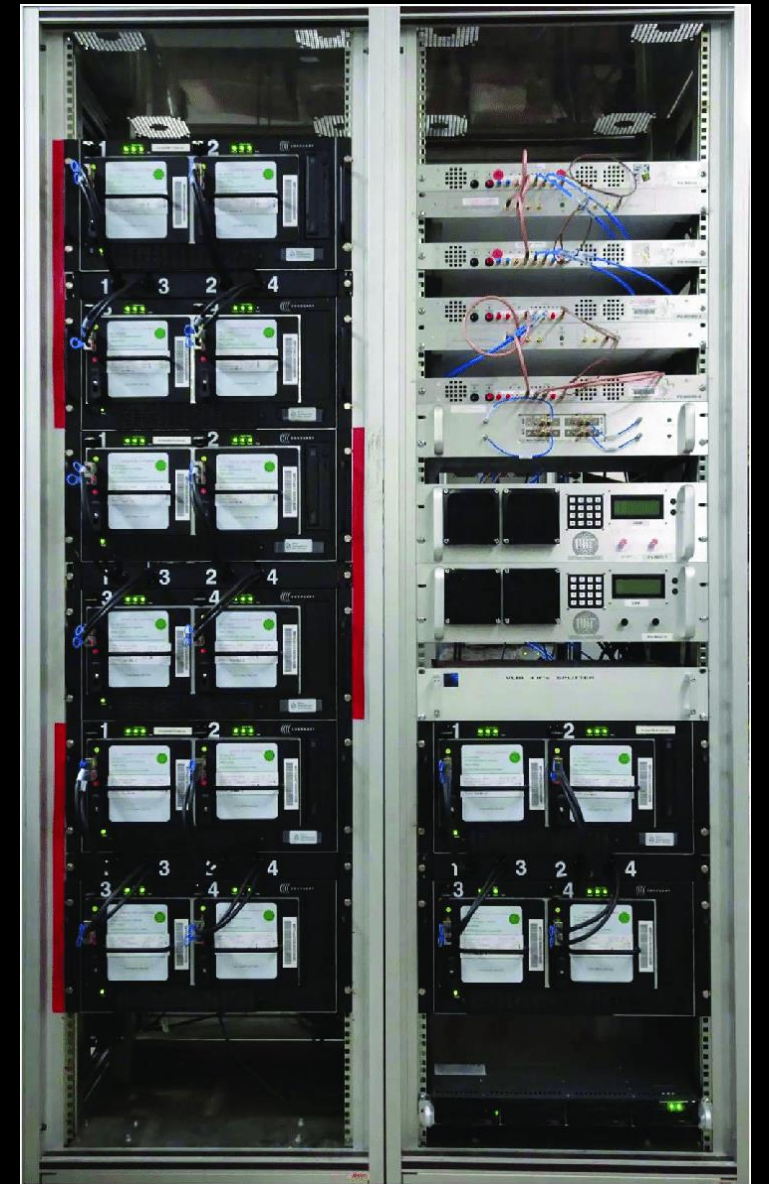
Phased array stations like ALMA makes noticeable improvements to the observation coverage (bottom right)



The EHT

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

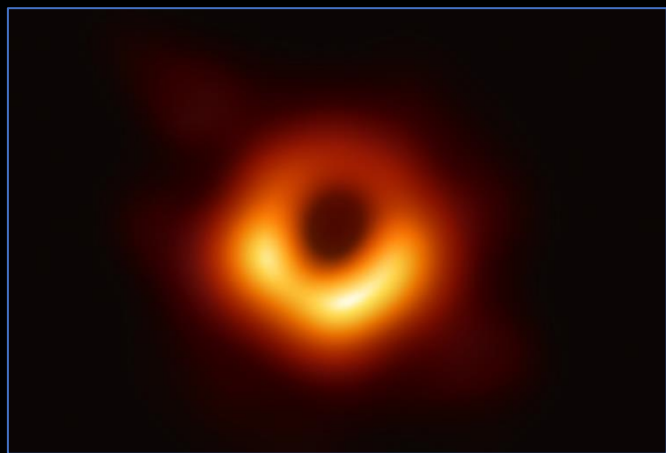
The data is then shipped to the MIT Haystack Observatory Correlator in Massachusetts, USA and the Max-Planck Institute for Radio Astronomy Correlator in Bonn, Germany for processing.



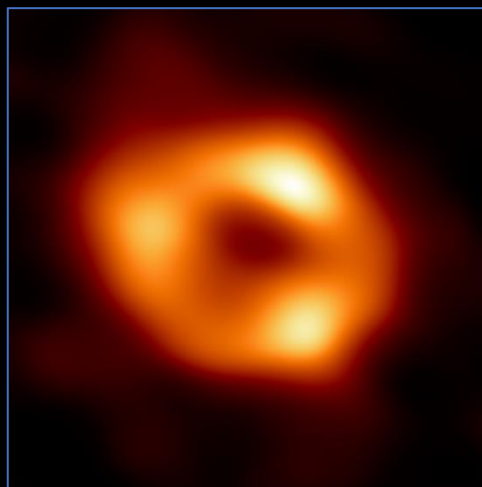


The EHT

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

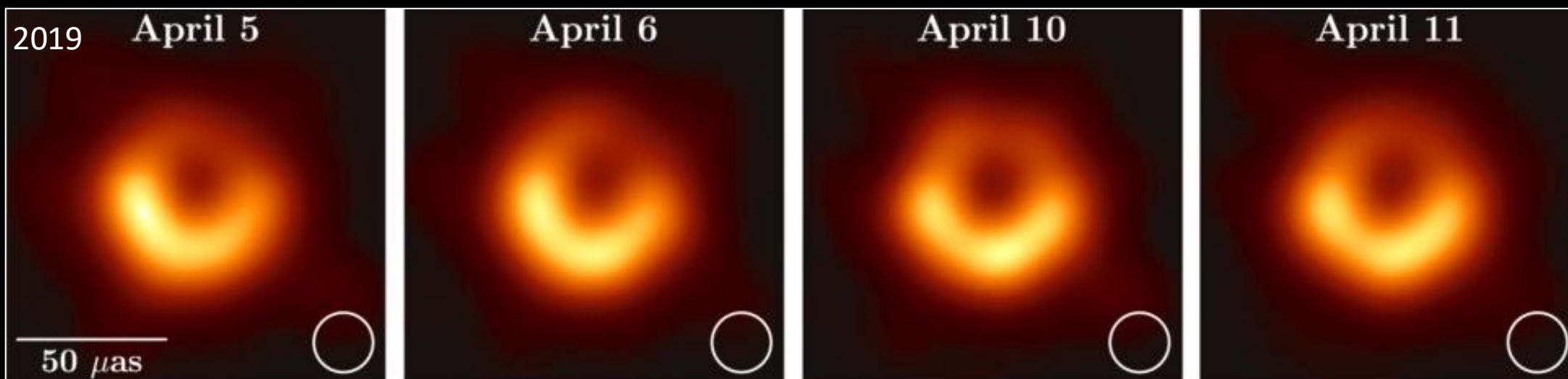


SgrA*



M87 2018

M87



THE EVENT HORIZON TELESCOPE PRESENTS

THE M87 MOVIE CAMPAIGN



STARRING ONE SUPERMASSIVE BLACKHOLE IN THE GALAXY MESSIER 87, GENERAL RELATIVITY, THE TELESCOPE OPERATORS, THE IMAGING WORKING GROUP, VERY LONG BASELINE INTERFEROMETRY, THE CORRELATION TEAMS, GRAVITATIONAL LENSING, COSMIC RADIO WAVES, RECEIVER ENGINEERS, THE THEORY GROUP, AND THE LAWS OF PHYSICS

FEATURING ATACAMA LARGE MILLIMETER, SUBMILLIMETER ARRAY, ATACAMA PATHFINDER EXPERIMENT, GREENLAND TELESCOPE, JAMES CLERK MAXWELL TELESCOPE, KITT PEAK 12-METER TELESCOPE, KOREAN VLBI NETWORK, LARGE MILLIMETER TELESCOPE, NORTHERN EXTENDED MILLIMETER ARRAY, PICO VELETA 30-METER TELESCOPE, SUBMILLIMETER ARRAY, SUBMILLIMETER TELESCOPE



EHT Campaigns

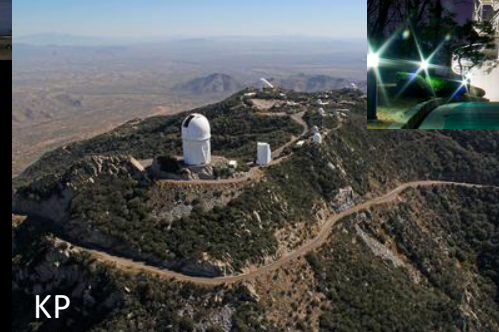
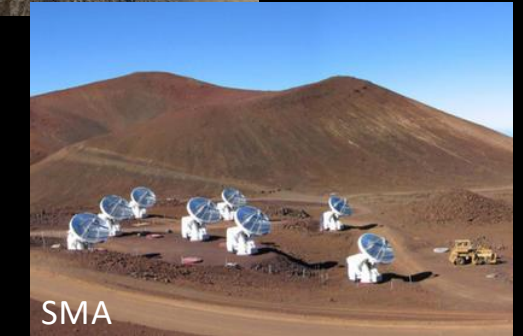
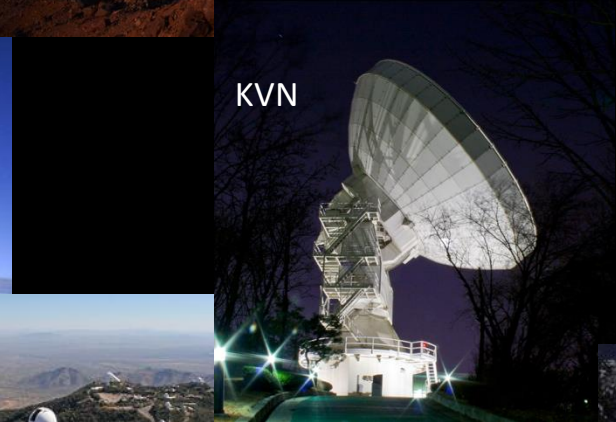
EHT2026 Observing Movie Campaign

March 08 – May 9, 2026

Observation twice weekly, 5-10hr sessions

11 sites participated

(ALMA, APEX, GLT, IRAM30m, JCMT, KP, KVN, LMT, NOEMA, SMA, and SMTO)





EHT 2026 Campaign

Campaign notes:

- Observations were at 230GHz
- Dual pol and double side band
- Station recorders at 64Gb/s
- 17 Sessions, Collecting about ~5.1PBytes raw data

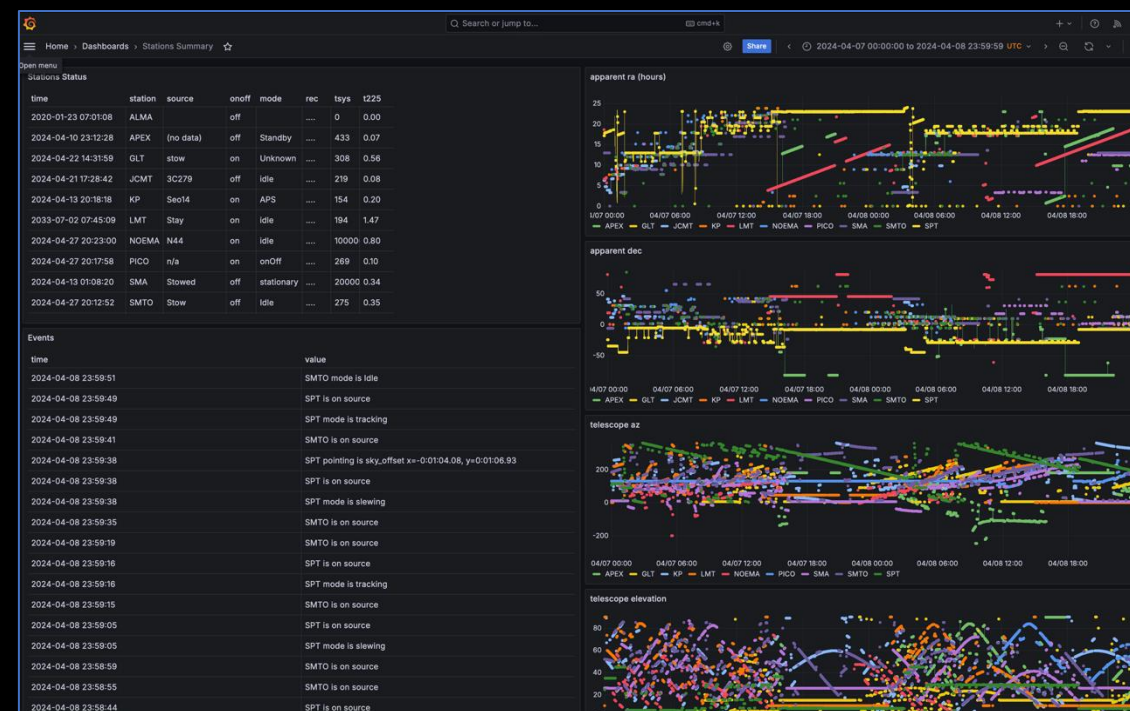


Campaign staffing:

- 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 during campaign:

- Real-Time Station monitoring during observations
- Remote access for operations and support
- Pre-Check Fringe tests throughout campaign.





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 Pre-Check fringe tests:

- During the campaign, portions of scans were sent back to the Correlator for processing. This was to verify data quality and site configuration.
- By identifying any issues early, allows time for a station to make corrections before the next session.



EHT Network and Data Transport Activities

The Pre-Check fringe testing results:

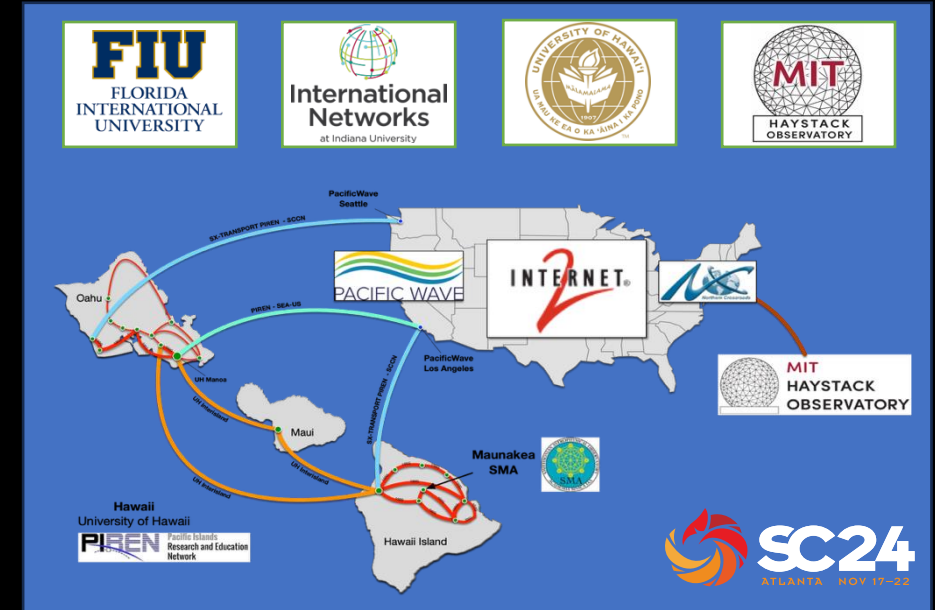
- Findings
 - Network Transfer
 - 11Mbps – 150Mbps from stations to Haystack
 - 500Mbps from Bonn to Haystack
 - European stations faster to Bonn and then hopped to Haystack
 - Data Processing Results
 - Processing turnaround took days for transfer and correlation
 - Station configuration issues were identified and resolved
 - Bands were flipped in cabling, fortunately no data was loss as can be corrected in processing
 - Timing offsets were adjusted to tighten alignment
 - Intermittent hardware failures resolved with spare equipment on site.
- Takeaways
 - Discovering site issues early in a campaign allows sites to repair/resolve the issue for the remaining campaign. And better understanding of the data quality being taken.
 - By improving network resource availability, would reduce turn around time which allows for faster recovery



EHT Network and Data Transport Activities

Outside of EHT Observing Campaign

- In 2024, We participated in the SC2024 conference demonstrating the Pre-Check Test
- Since then we have been exploring ways to characterize the network and develop a dashboard to monitor performance of the EHT Research Network.
- We are building EHT Network Performance Nodes (NPNs) that will be installed at EHT stations that will monitor and map the network performance.
- We are reaching out to the research networks supporting the EHT stations to help characterize and improve pre-check tests as well as installing an EHT NPN onsite or as close to the endpoint.
- This will allow us to characterize the EHT Research Network from a dashboard interface overseeing overall network performance at the EHT Array Operations Center (AOC).





EHT Future and Challenges

Future EHT goals:

- Continue to increase technology by increasing bandwidth and speeds
- This will increase data recording speeds and size
- Develop a robust research network to support data checks and tests.

Challenges and goals ahead:

- Funding and support
- We are a large international collaboration of institutions and organizations
 - Each area has its own challenges within and finding commonality of support and resource
- Research networks
 - An international collaborations with many research network organizations to bridge network resources and availability



Summary/Mission

- 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



Event Horizon Telescope

Thank you!

