

Greenland Telescope (GLT): Current Status & Future Plan

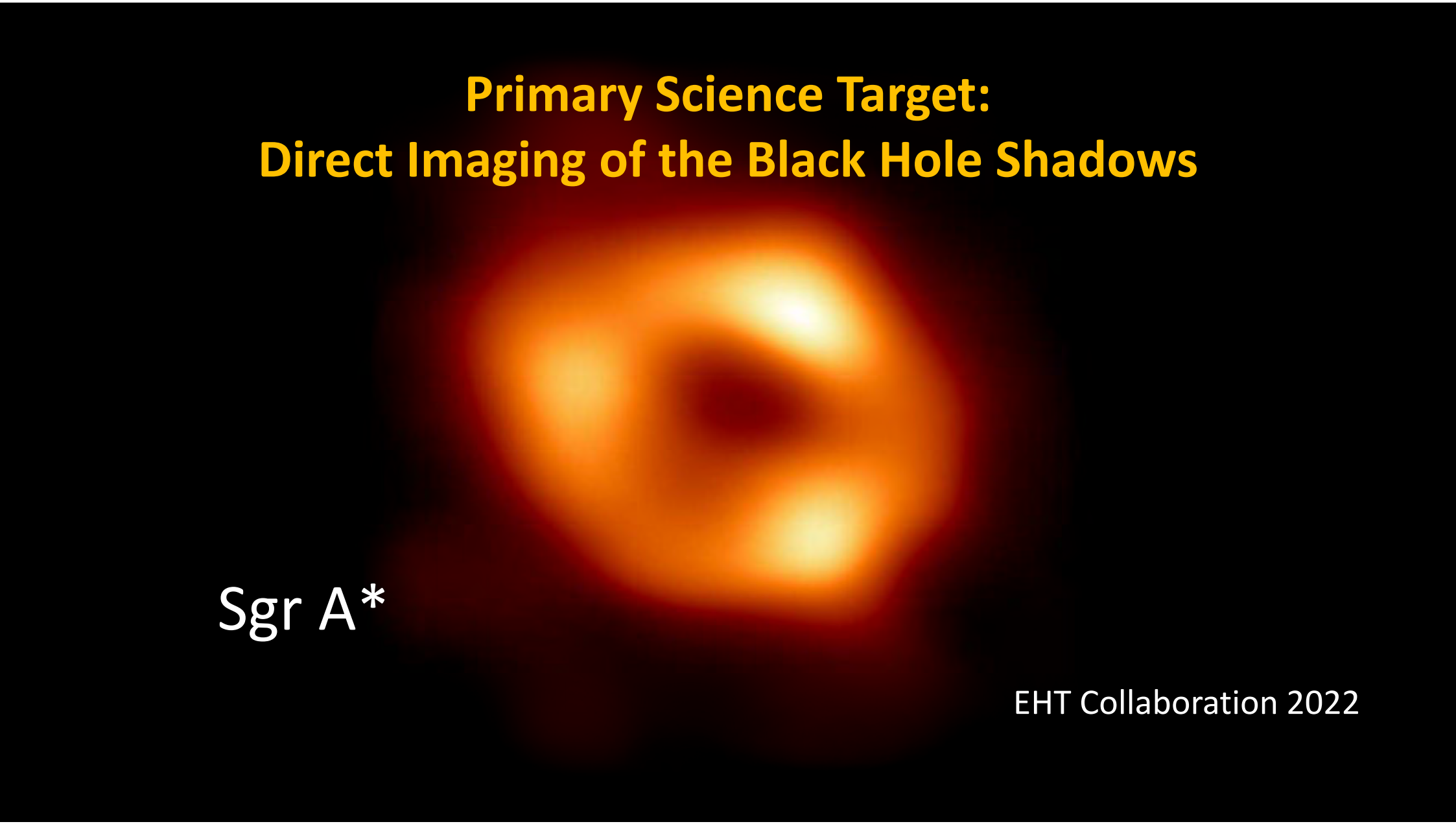
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P.I. of the GLT Project

EHT Taiwan Representative

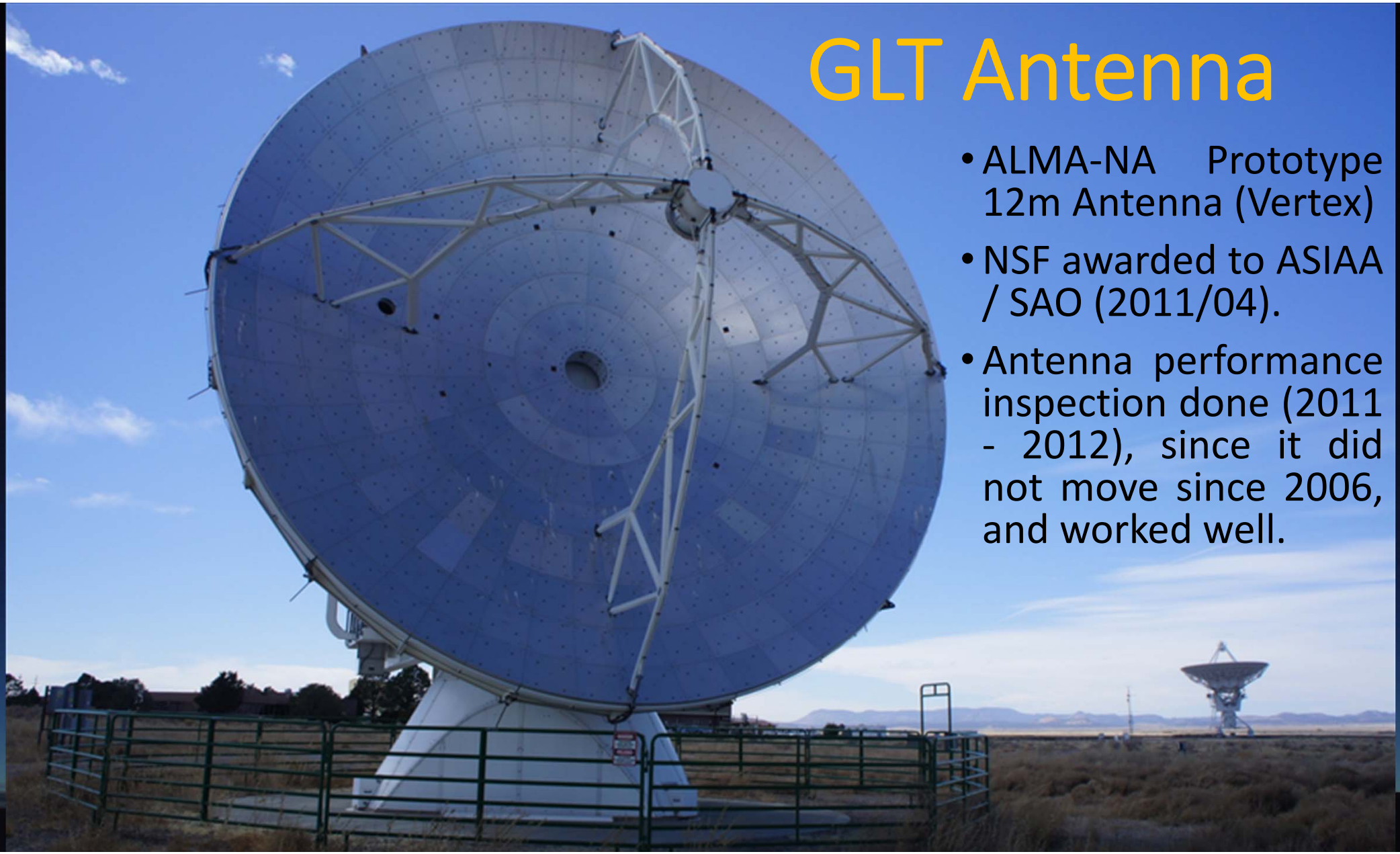
EHT Board Vice-Chair

Primary Science Target:
Direct Imaging of the Black Hole Shadows



Sgr A*

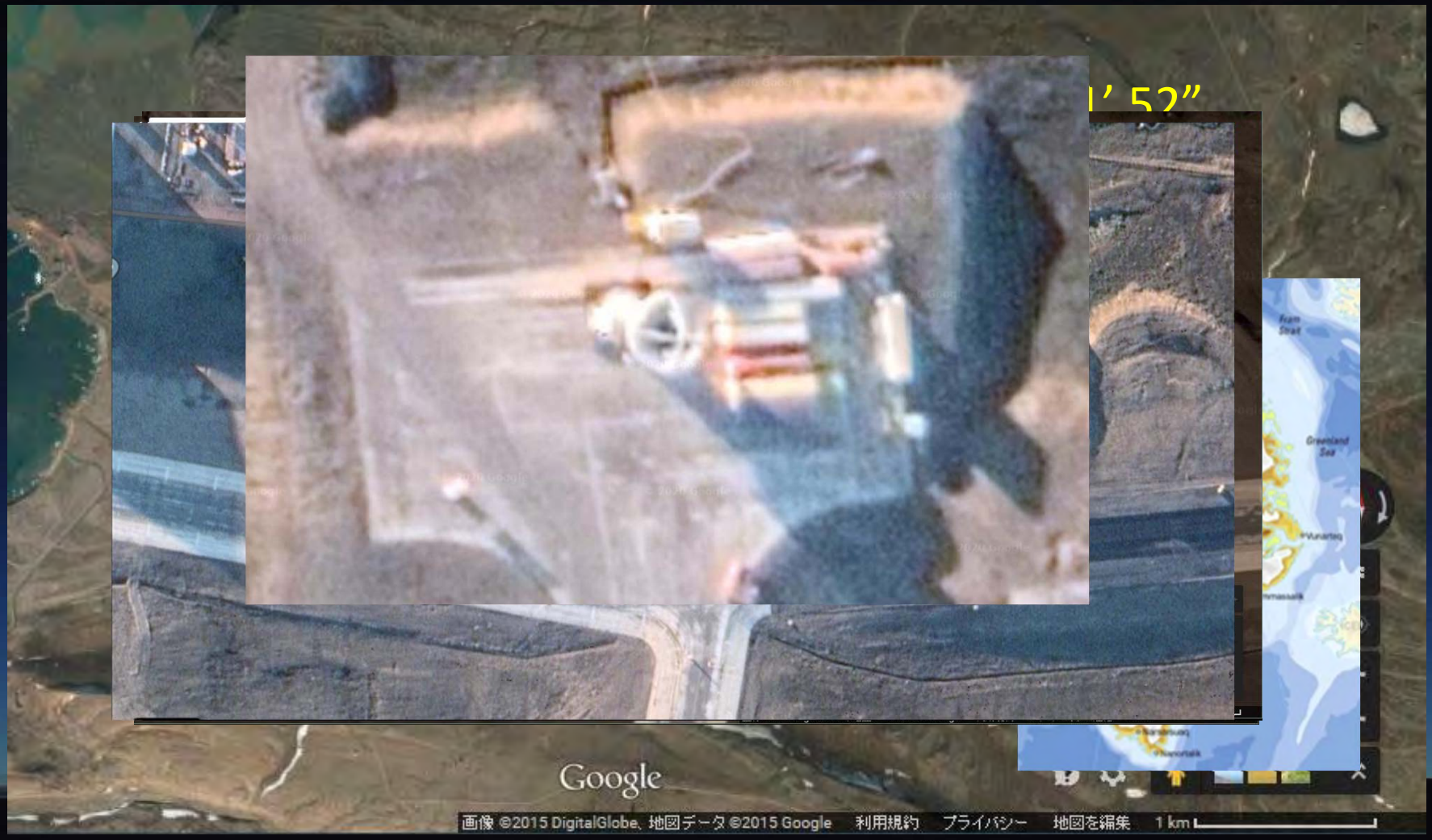
EHT Collaboration 2022



GLT Antenna

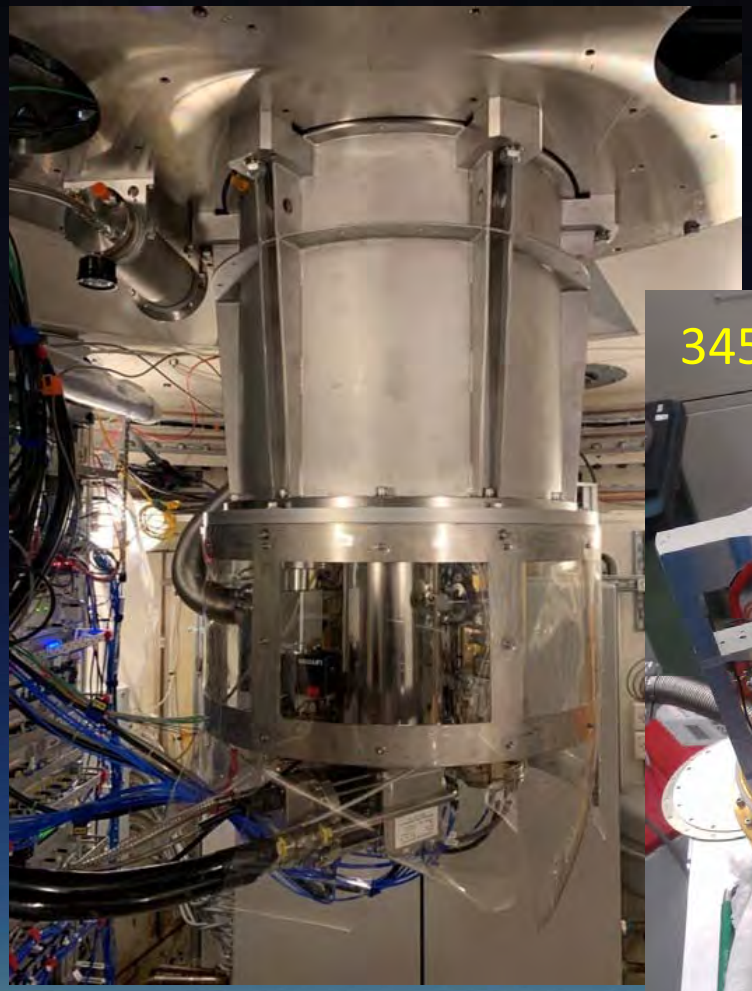
- ALMA-NA Prototype 12m Antenna (Vertex)
- NSF awarded to ASIAA / SAO (2011/04).
- Antenna performance inspection done (2011 - 2012), since it did not move since 2006, and worked well.

US Pituffik Space Base in Greenland

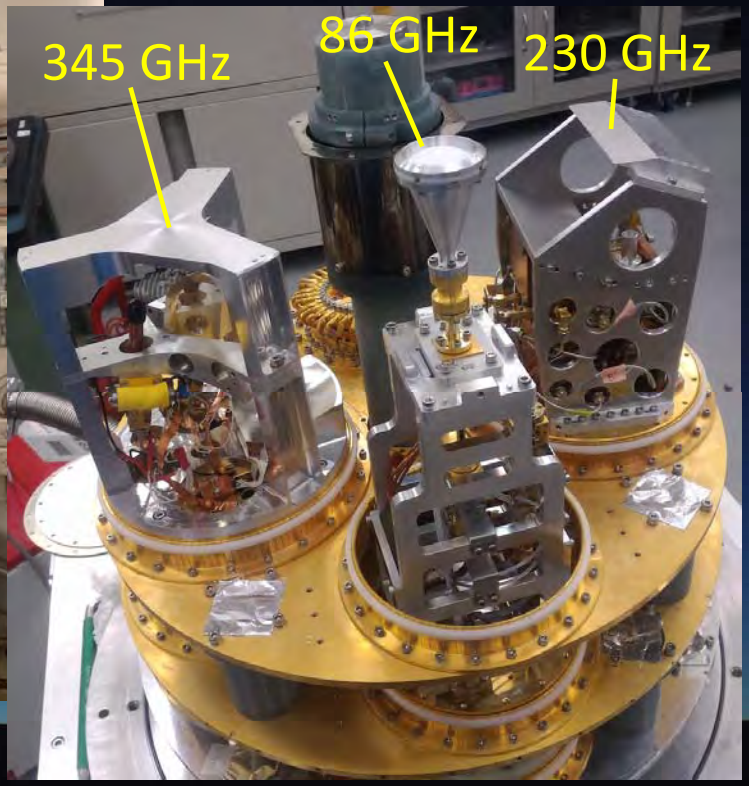


Greenland Telescope (GLT)

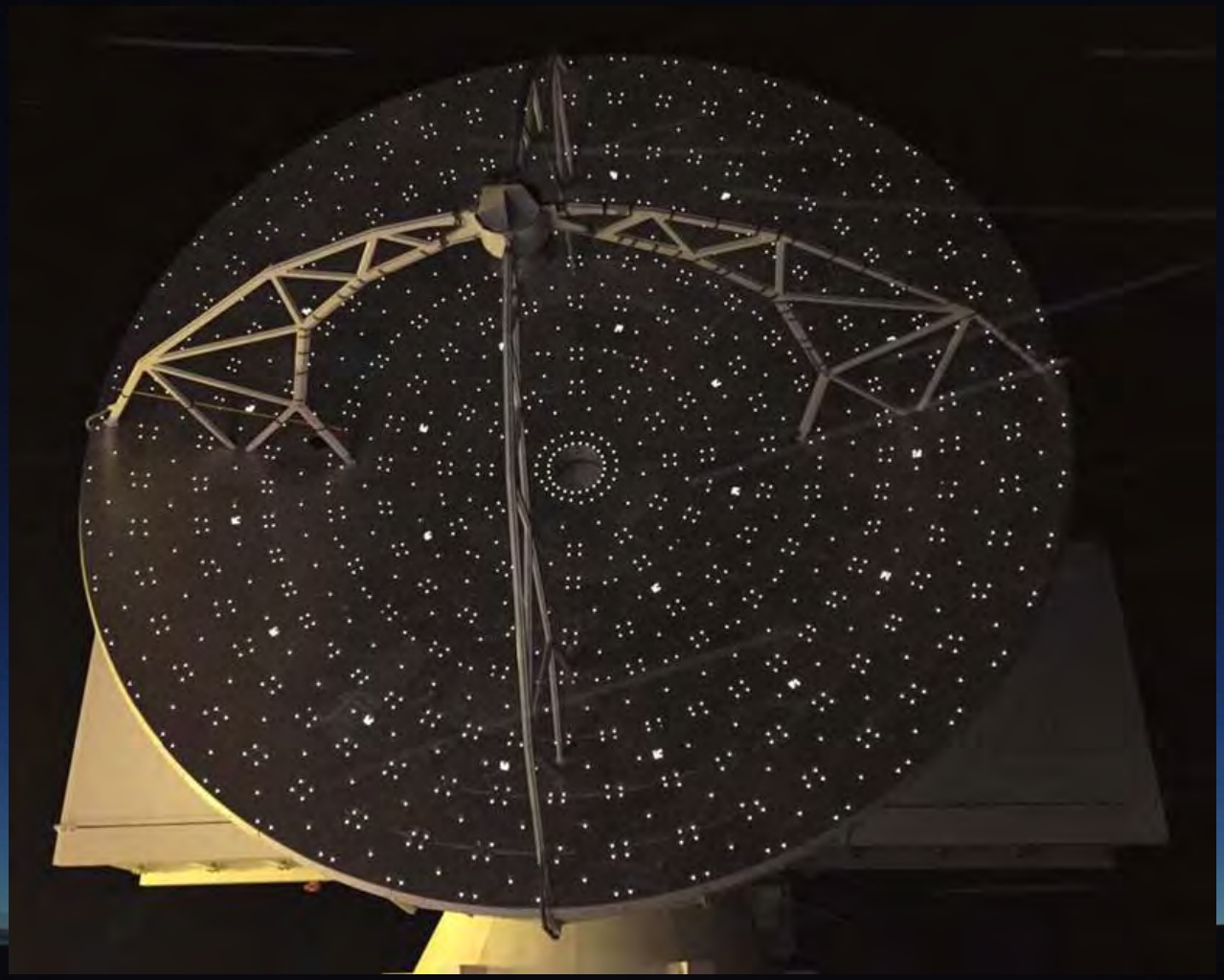




The only Asian telescope operating at the polar region.



Photogrammetry Surface Improvement



- We installed the photogrammetry targets on the telescope surface in 2018 summer.

Holography Surface Improvement

- We finally successfully installed and took the data in 2025 spring.





Transmitter at the South Mountain ridge.

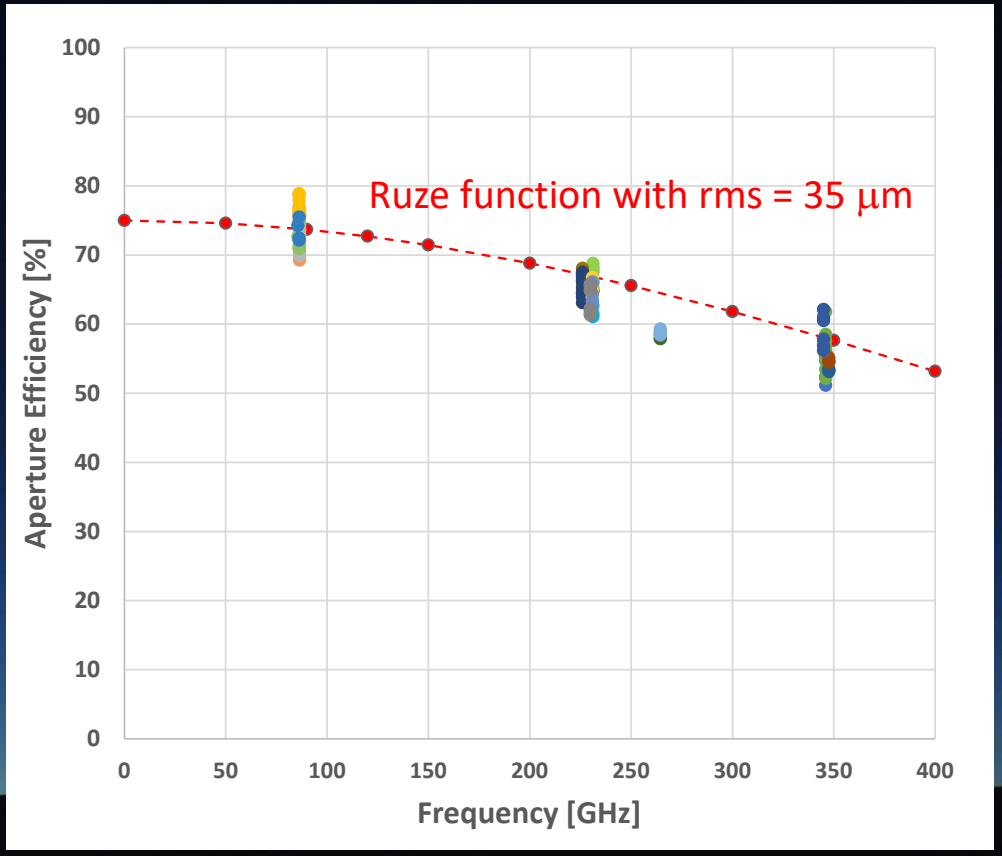


Reference receiver at the back of secondary mirror.

Antenna Efficiency

- Observe bright planets and measure the brightness temperatures, and calculate the antenna efficiency.

- Since 2020, the measured antenna aperture efficiencies at various frequencies are consistent with the surface accuracy of 35 μm.



Article

A ring-like accretion structure in M87 connecting its black hole and jet

Lu, Asada, et al., 2023, Nature, 616, 686

https://doi.org/10.1038/s41586-023-05843-w

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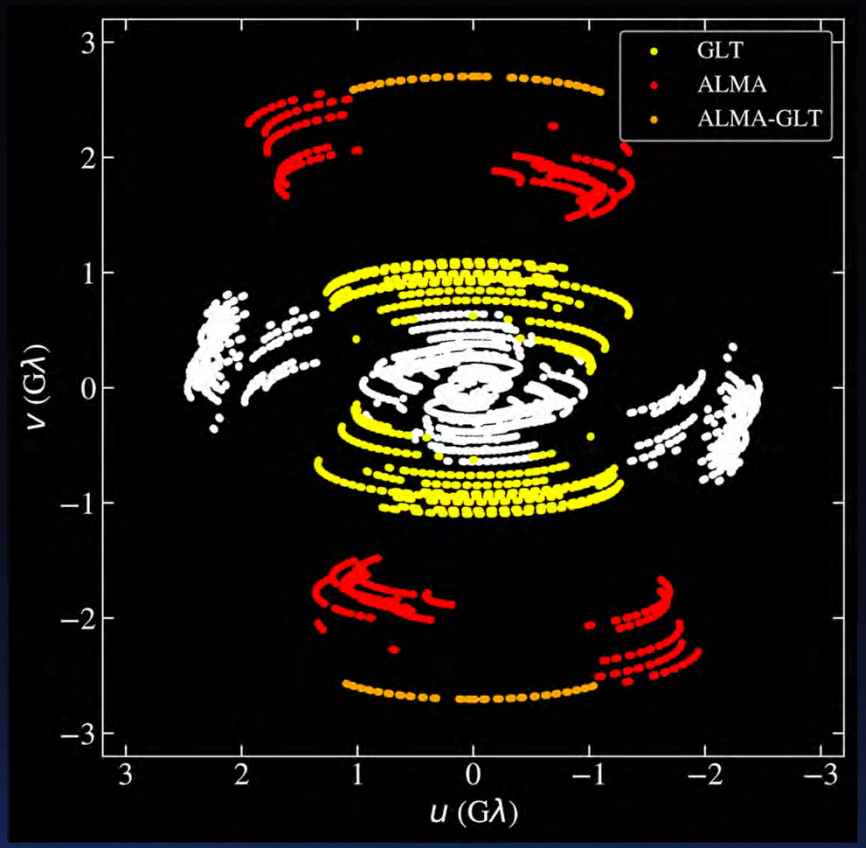
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The nearby radio galaxy M87 is a prime target for studying black hole accretion and jet formation[1,2]. Event Horizon Telescope observations of M87 in 2017, at a wavelength of 1.3 mm, revealed a ring-like structure, which was interpreted as gravitationally lensed emission around a central black hole[3]. Here we report images of M87 obtained in 2018, at a wavelength of 3.5 mm, showing that the compact radio core is spatially resolved. High-resolution imaging shows a ring-like structure of $8.4^{+0.5}_{-1.1}$ Schwarzschild radii in diameter, approximately 50% larger than that seen at 1.3 mm. The outer edge at 3.5 mm is also larger than that at 1.3 mm. This larger and thicker ring indicates a substantial contribution from the accretion flow with absorption effects, in addition to the gravitationally lensed ring-like emission. The images show that the edge-brightened jet connects to the accretion flow of the black hole. Close to the black hole, the emission profile of the jet-launching region is wider than the expected profile of a black-hole-driven jet, suggesting the possible presence of a wind associated with the accretion flow.



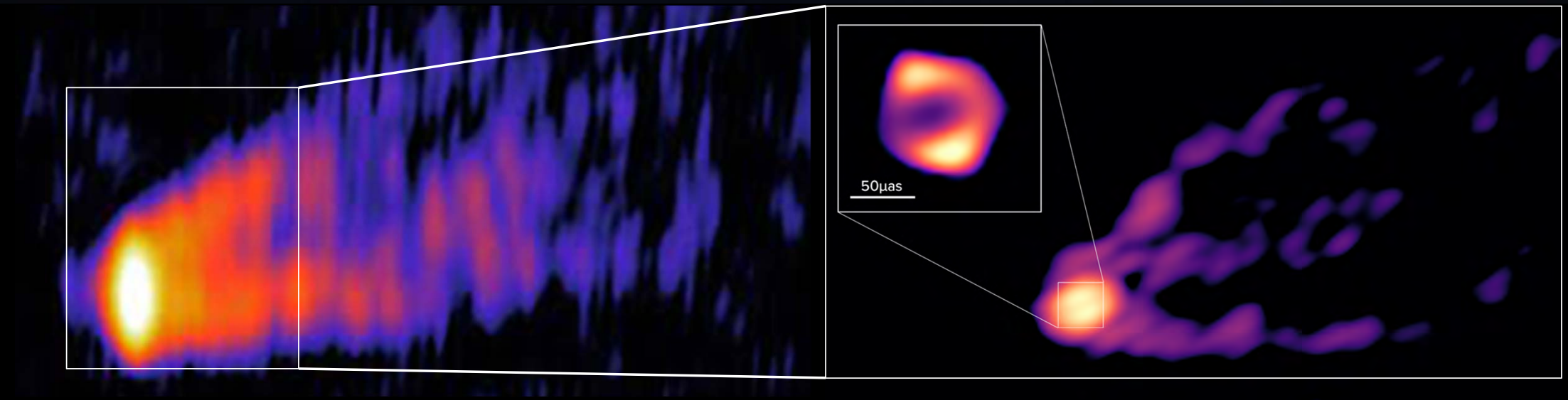
- GMVA+ALMA+GLT: April 14-15, 2018
- 86 GHz VLBI
- 3 Sources: M87, 3C273, & 3C279
- 16 Stations: Eb, On, Mh, Ys, Pv, GLT, GBT, 8 x VLBA, phased ALMA

Improvement by the GLT

M87 @ 86 GHz

Kim et al. 2018

Lu, Asada, et al. 2023



GMVA

GMVA + ALMA + GLT

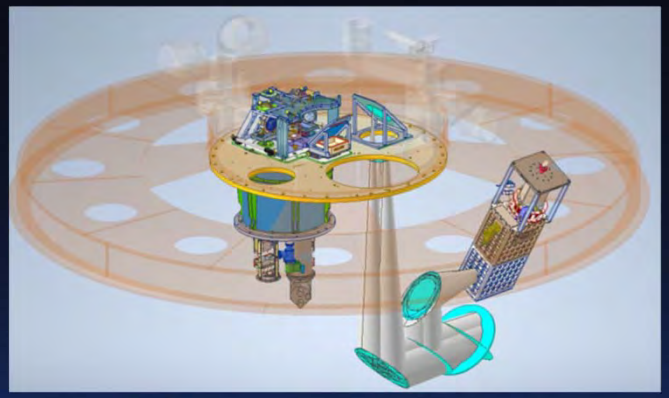
- First-ever image of the spatially resolved accretion flow around a black hole.
- The first-ever simultaneous image of the central engine of Active Galactic Nucleus (black hole, accretion flow, and jet).

GLT Receiver Optics Change



Original receiver configuration.

- Upgraded the GLT receiver optics to accommodate other receivers.



- Almost the same focus positions & pointings.
- First step for simultaneous multi-frequency operation.

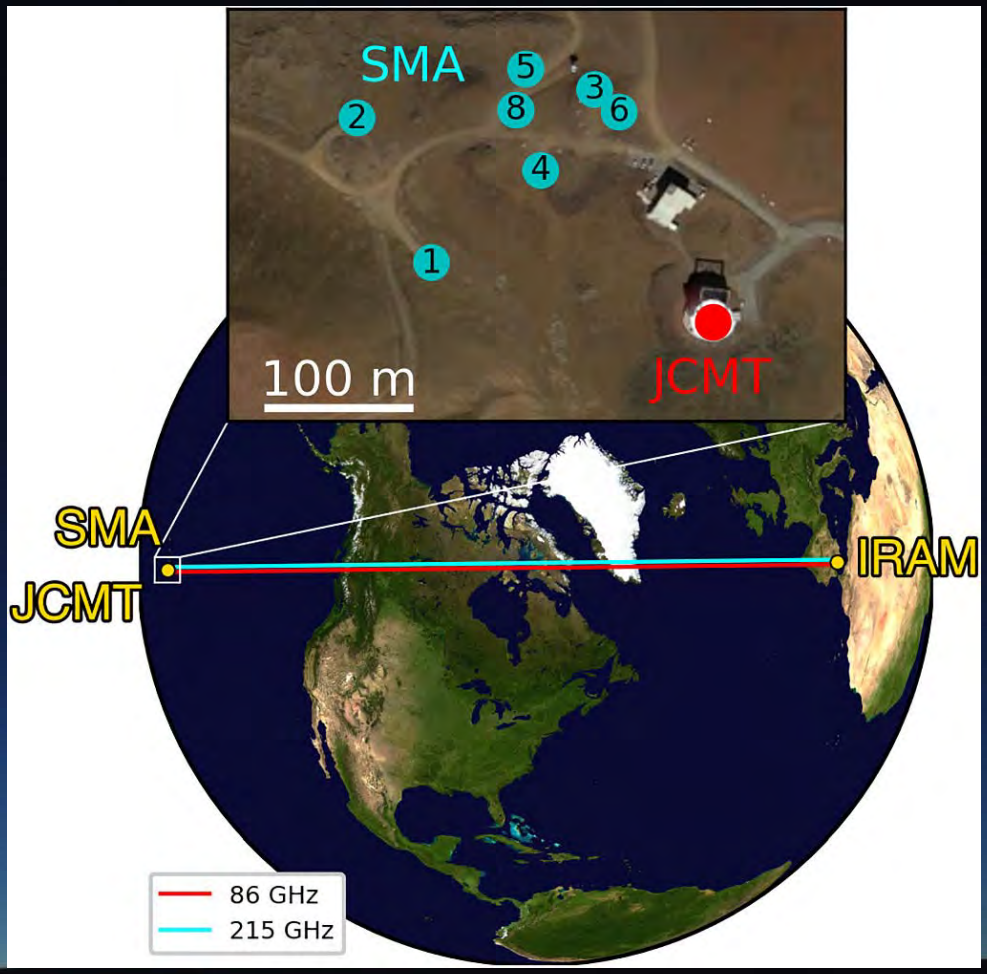


New receiver optics. New VLBI receivers installed.

Frequency Phase Transfer (FPT)

- Calibrate with lower frequency phase information to higher frequency.
- Korean VLBI Network (KVN) regularly uses this method to calibrate their higher frequency data (up to 129 GHz).

- EHT Collaboration members performed the test observations at 86 GHz and 215 GHz using the SMA/JCMT (co-located at Hawaii; SMA at 215 GHz and JCMT at 86 GHz) and the IRAM 30m (possible to observe 86 & 215 GHz simultaneously).



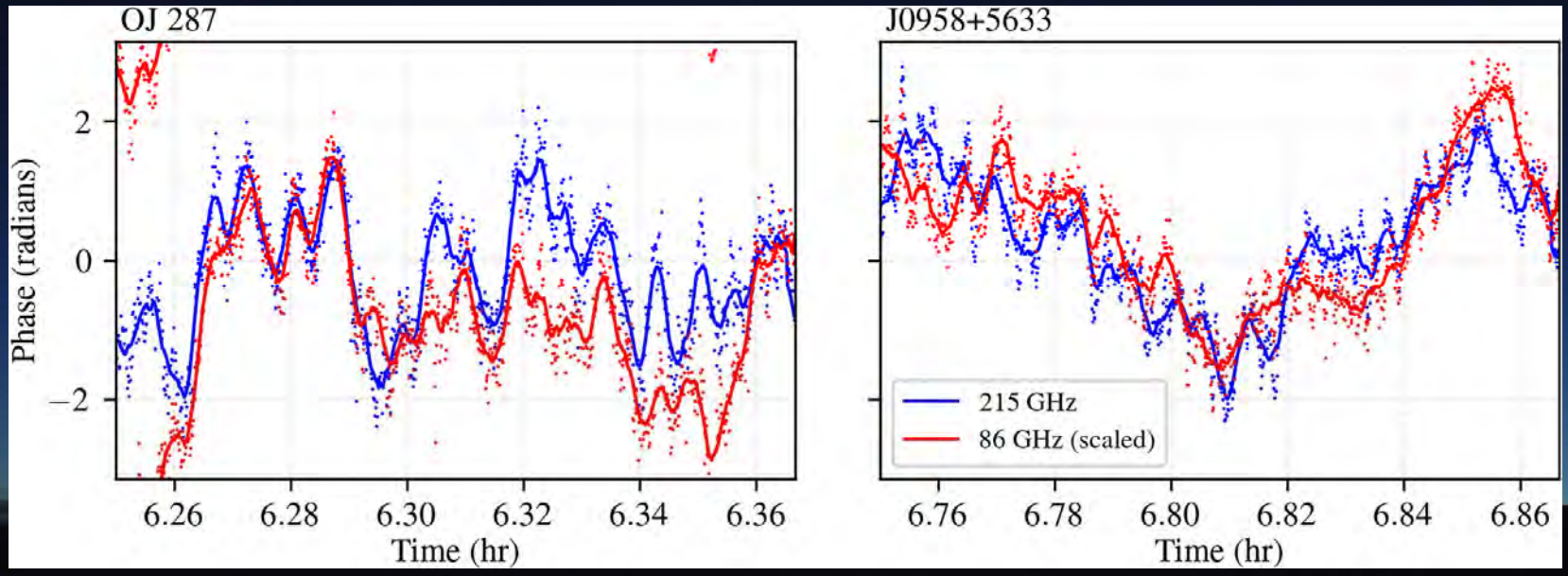
Issaoun et al. 2025, AJ, 169, 229

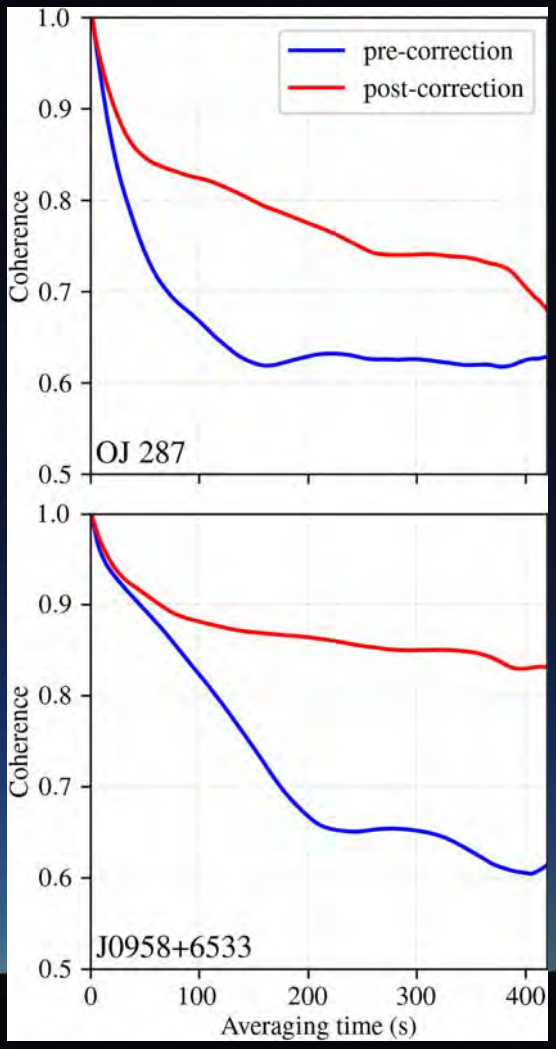
Frequency Phase Transfer (FPT)

Issaoun et al. 2025, AJ, 169, 229

- Overall 215 GHz phase fluctuation could track well with scaled (x2.5) 86 GHz phase.
- 215 GHz phase coherence improved significantly after calibrating with 86 GHz phase.

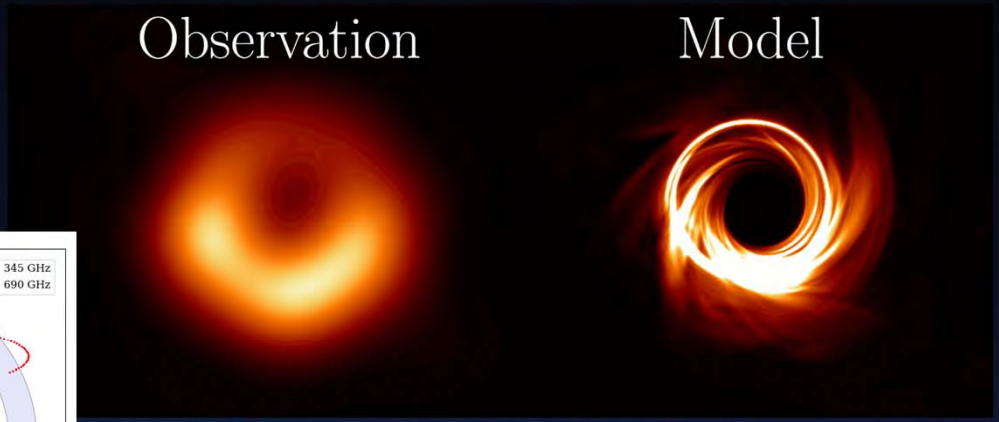
⇨ Useful for future higher frequency observations.

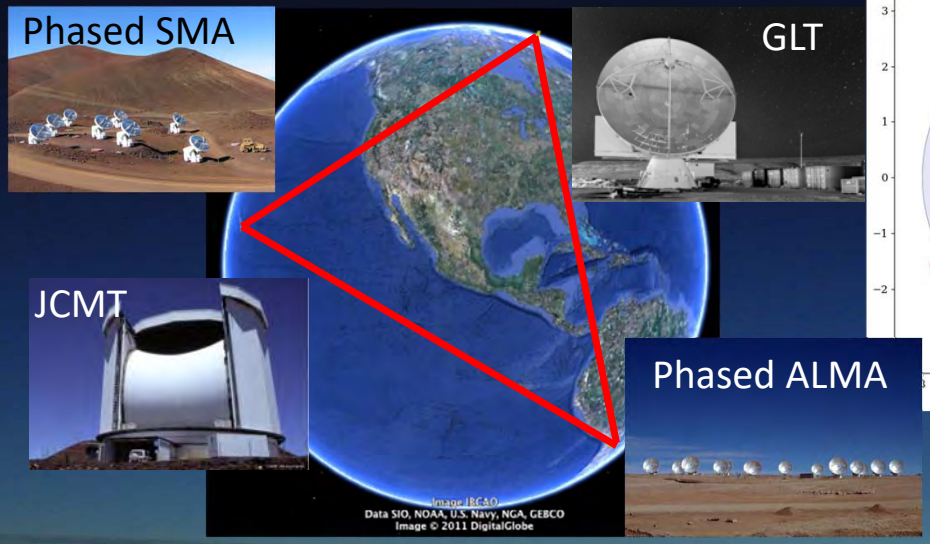


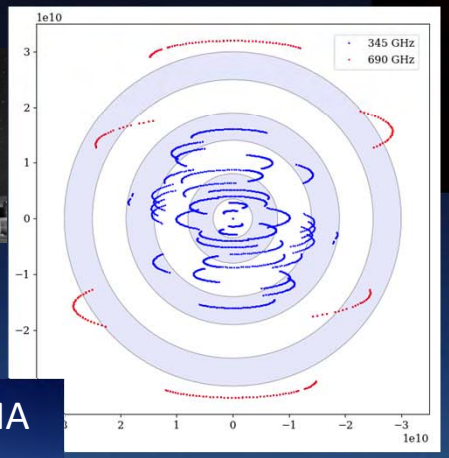


690 GHz VLBI: Science Goal

- Current ultimate goal for the Black Hole Shadow Imaging:
  - Image the “Photon Ring” with higher spatial resolution.
    ⇨ 690 GHz VLBI with multi-frequency synthesis and/or frequency phase transfer.







Baselines are 9,000 km long, and the resolution reaches 3 μas at 690 GHz.

- Currently, many space satellite projects are planning to perform exactly the same science :
  - Black Hole Explorer (BHEX): SAO / NASA
  - Space Array: ESO / ESA
  - Capella: SNU / KASI

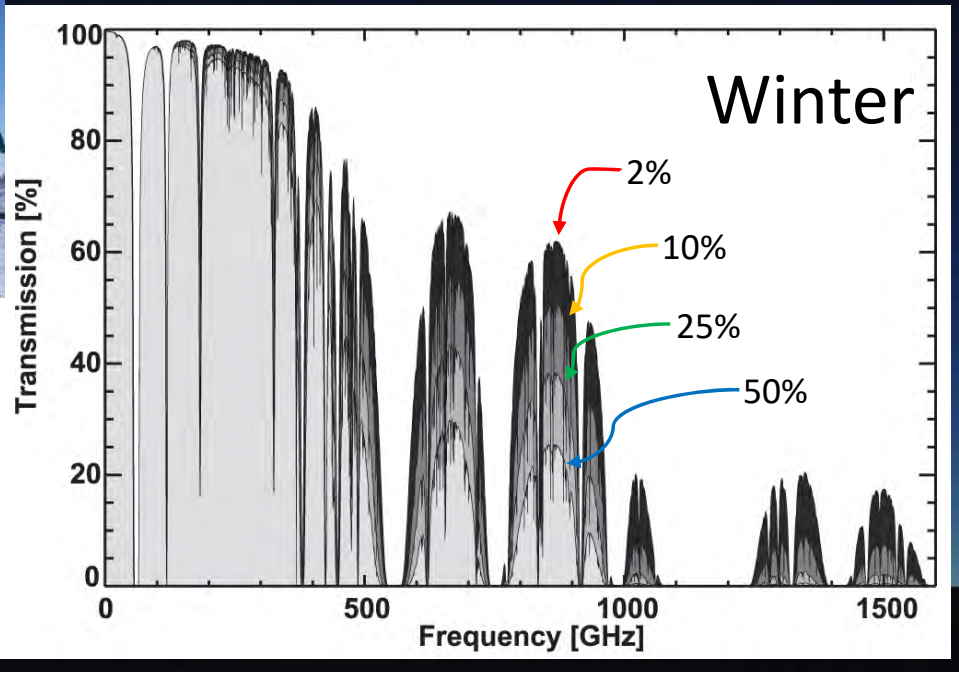
GLT Summit: Toward Higher Resolution

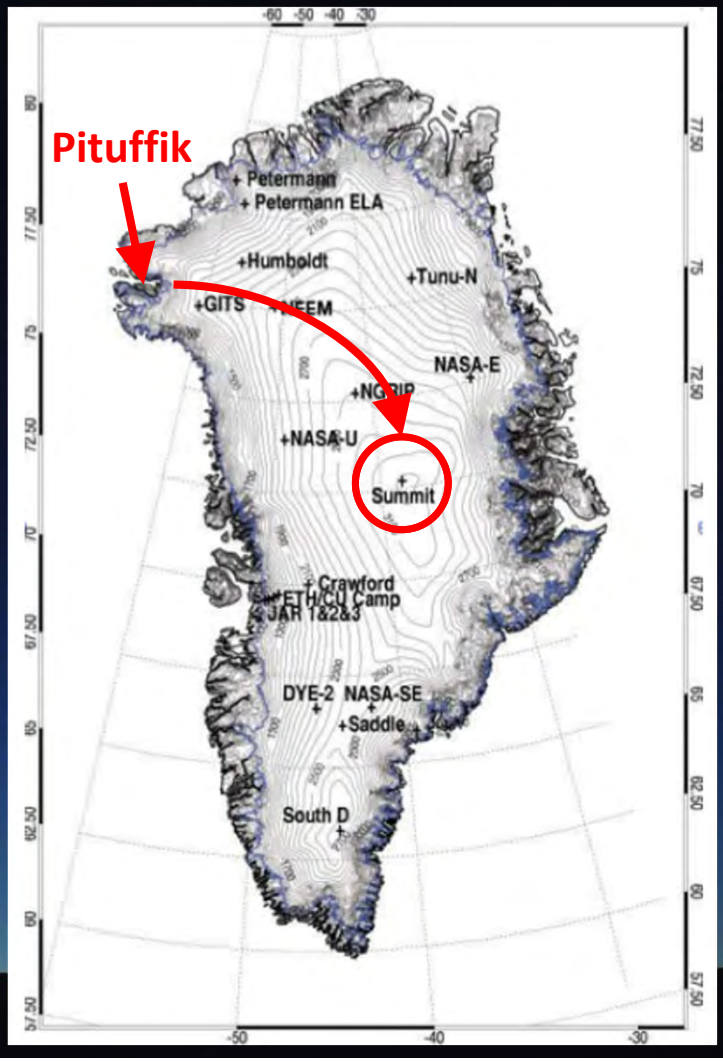
- Established/operated by US NSF & Greenland Government.
  - Atmospheric and weather researches are mainly ongoing.
  - Altitude: 3210m.





Matsushita et al. 2017, PASP, 129, 025001





Summary

- Greenland Telescope (GLT) is the only Asian telescope operating at the polar region.
- GLT provides much longer and unique baselines, and therefore sharper and better quality (high fidelity) images.
- GLT at the Greenland Summit will be able to image the true Event Horizon (the photon ring) around the Black Hole.

