# The Greenland Telescope

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Academia Sinica, Institute of Astronomy & Astrophysics

on behalf of
The GLT Project


Academia Sinica Institute for
Astronomy & Astrophysics

CENTER FOR ASTROPHYSICS
HARVARD & SMITHSONIAN

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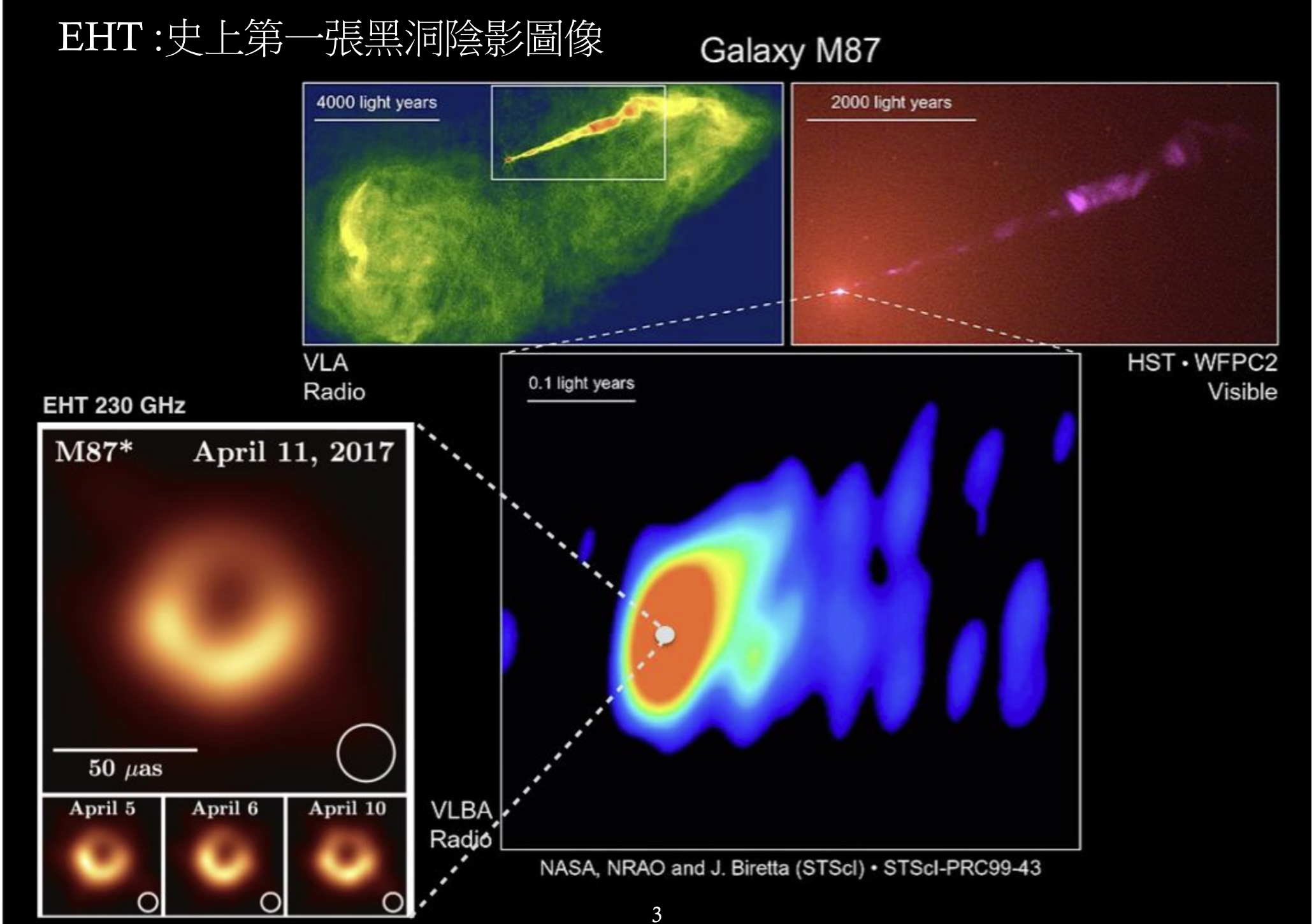
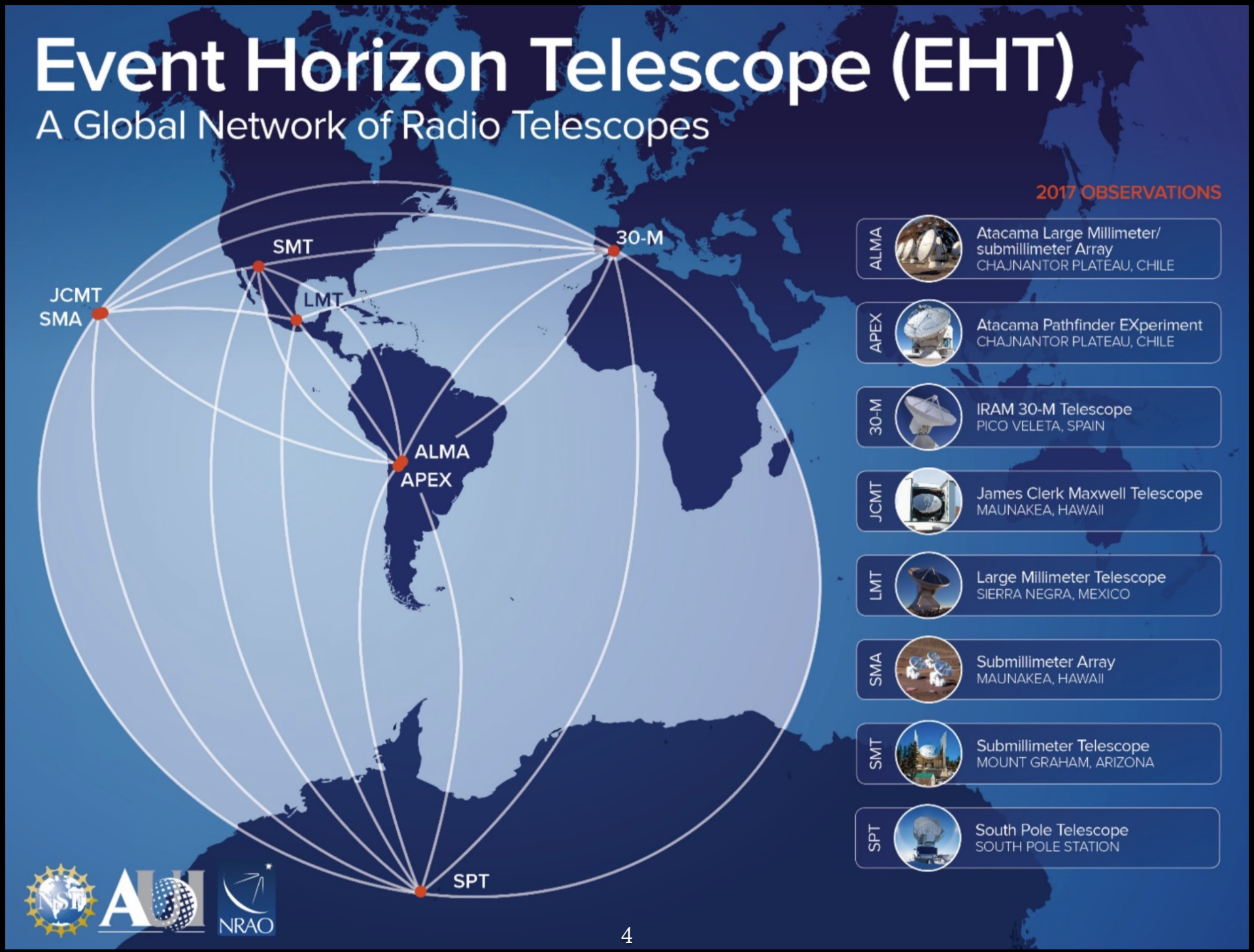
# EHT :史上第一張黑洞陰影圖像



# Event Horizon Telescope (EHT)

## A Global Network of Radio Telescopes




**2017 OBSERVATIONS**

**ALMA** — Atacama Large Millimeter/submillimeter Array
CHAJNANTOR PLATEAU, CHILE

**APEX** — Atacama Pathfinder EXperiment
CHAJNANTOR PLATEAU, CHILE

**30-M** — IRAM 30-M Telescope
PICO VELETA, SPAIN

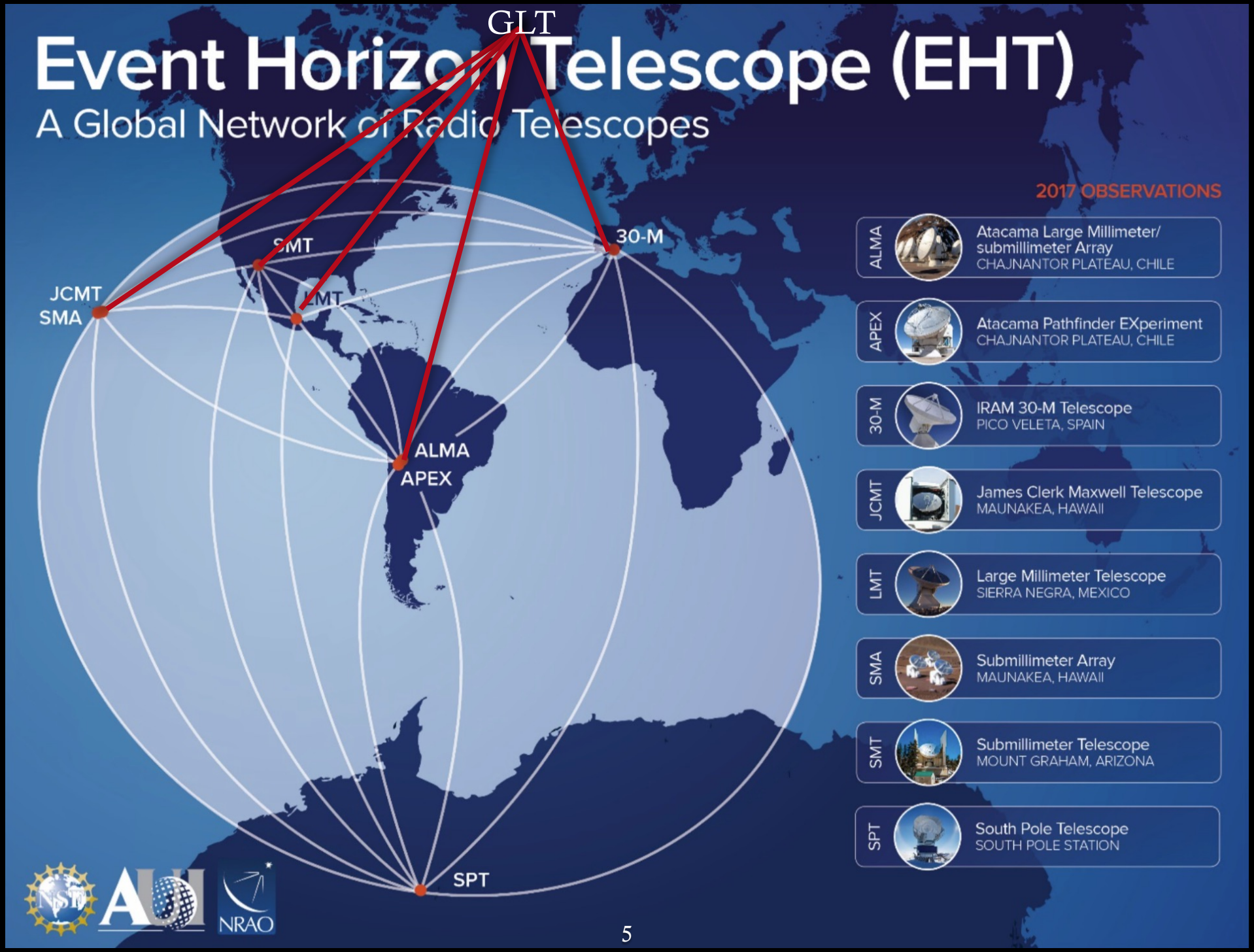
**JCMT** — James Clerk Maxwell Telescope
MAUNAKEA, HAWAII

**LMT** — Large Millimeter Telescope
SIERRA NEGRA, MEXICO

**SMA** — Submillimeter Array
MAUNAKEA, HAWAII

**SMT** — Submillimeter Telescope
MOUNT GRAHAM, ARIZONA

**SPT** — South Pole Telescope
SOUTH POLE STATION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NSF
AUI
NRAO

# Summary

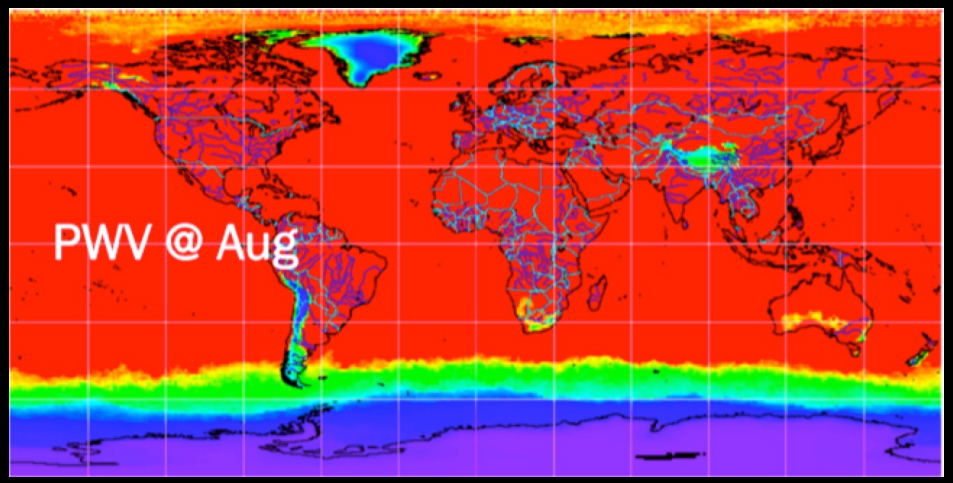
- The Greenland Telescope has been deployed to Thule, Greenland!
- First light in the end of 2017!
- 230 GHz fringe between ALMA and GLT detected (Jan 2018) !
- Joined the Event Horizon Telescope and Global Mm-wave VLBI Array
- VLBI runs since April 2018!
- Fringes detected between GLT and ALMA
- Prepare Deployment to Summit Station

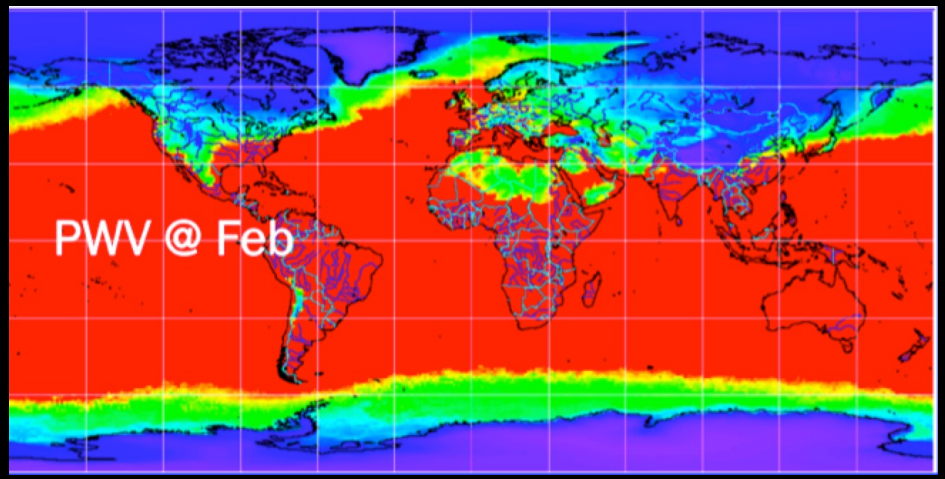
# The GLT History

- A sub-project from Taiwan's participation in NA-ALMA project – To provide a unique VLBI baseline for ALMA
- In 2011, the SAO/ASIAA was awarded with the NA-ALMA prototype antenna.
- Aiming at sub-mm VLBI and THz single-dish at Greenland Summit. （Not Thule）
- Most funding from Taiwan agencies. Rest from SAO.

# Greenland Submit

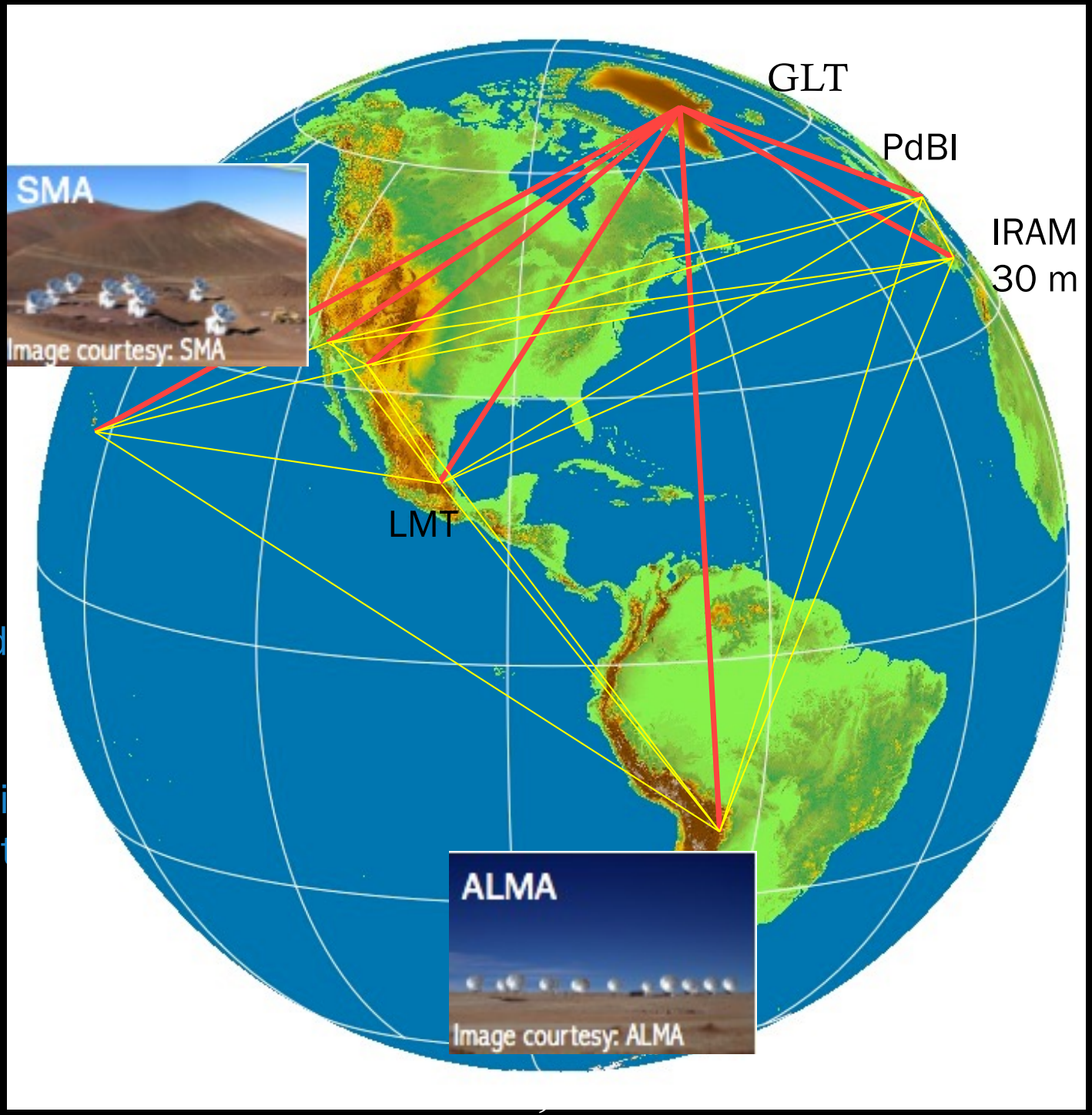
- Criteria for new submm site for VLBI
  - High and dry submm sites
  - Mutual visibility with SMA and ALMA
  - Logistics and accessibility
  - Unique VLBI baseline



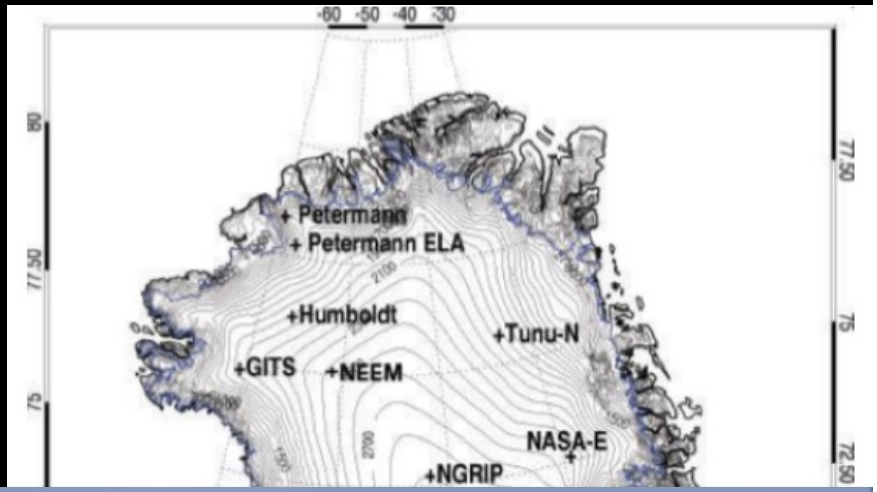

PWV measurements by NASA TERA & AQUA. Red: PWV > 10 mm

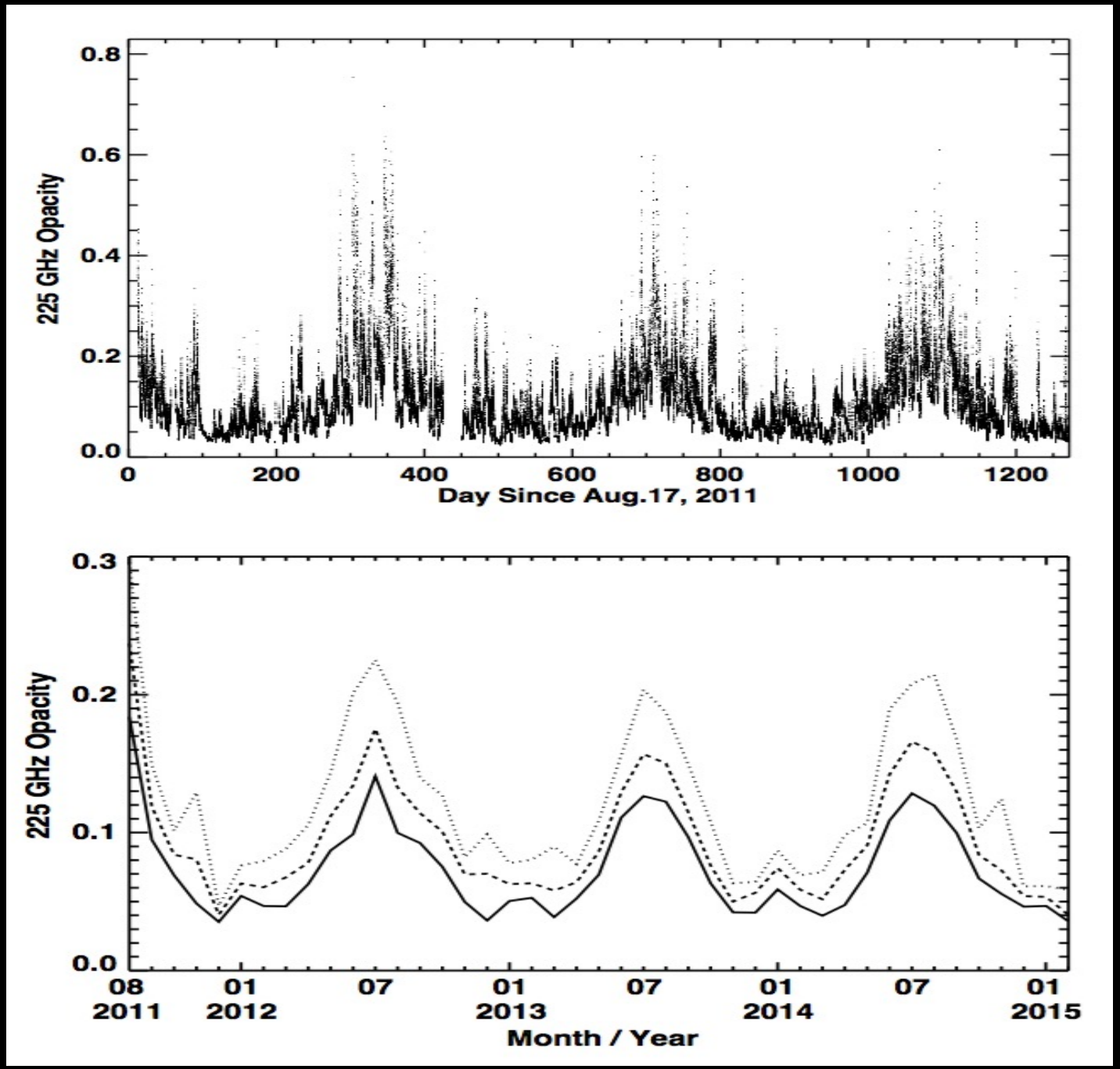
It will provid
9,000 km
baseline,
correspondi
to 20 uas at
345 GHz!!



# Greenland – Summit Station

- Established/operated by US NSF & Greenland Government.
  - Atmospheric and weather researches are main topics. Established in 1989.
  - N72.60°, W38.42°. Altitude: 3210m.
  - Summer: 45 people, Winter: 5 people (3 months shift)
  - Possible to carry things by flights with C-130, etc., or through land.




*Matsushita et al. 2016 PASP*

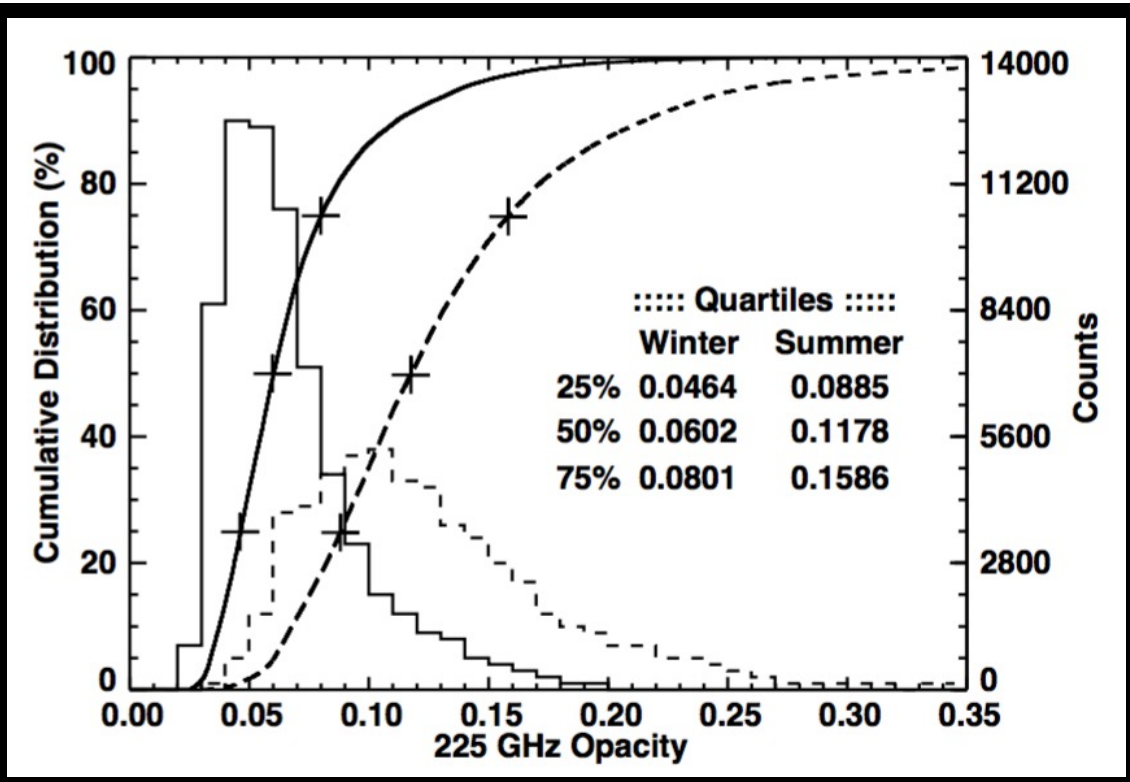



TABLE 1
COMPARISON OF 225 GHz OPACITY QUARTILES BETWEEN THREE SITES.

| Site | Season | Quartiles 25% | 50% | 75% |
|---|---|---|---|---|
| Greenland | Winter | 0.046 | 0.060 | 0.080 |
| | Summer | 0.089 | 0.118 | 0.159 |
| ALMA | Winter | 0.035 | 0.050 | 0.080 |
| | Summer | 0.071 | 0.131 | 0.261 |
| South Pole | Winter | 0.041 | 0.048 | 0.057 |
| | Summer | 0.050 | 0.062 | 0.076 |


TEREX
TEREX


2017 July 24

# Instruments

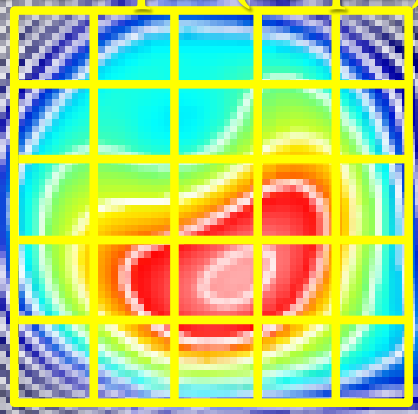
- Phase I: VLBI Operations (First light)
  - ALMA-type Cassegrain optics
  - Single receiver system for VLBI
  - Three-cartridge, ALMA type receiver system
  - 86, 230, and 345 GHz
  - ALMA receiver compatible
- Phase II: VLBI + Single-Dish Observation
  - New optics with selection mechanism
  - VLBI receiver
  - Multi-element Heterodyne Receiver
  - Submm camera

# GLT VLBI Receivers

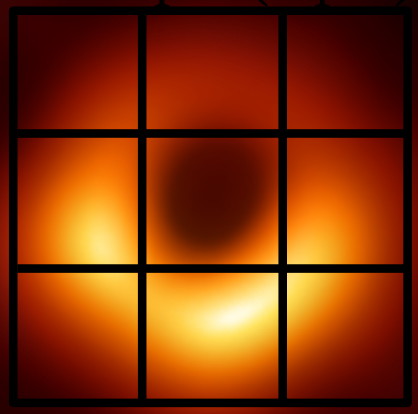
| **Greenland Telescope: First-light Receivers** | | | |
|---|---|---|---|
| **Receiver Specs** | 86 GHz | 230 GHz | 345 GHz |
| **Origin** | ASIAA | OPU-230 | IRAM |
| **Polarization** | Dual Circular | Dual Circular | Dual Linear |
| **LO Range (GHz)** | 80 - 88 GHz | 221 GHz | 275 - 373 GHz |
| **1st Stage Detector** | MMIC | SIS | SIS |
| **Mixing Scheme** | USB after 1st mixer | 2 SB @LO=221.1GHz | 2 SB |
| **# of IF channel** | 2 | 4 @ LO = 221.1 GHz | 4 |
| **IF (GHz)** | 4 – 8 GHz | 4 – 8 GHz | 4 – 8 GHz |
| **VLBI LO freq. (GHz)** | 80.6 | 221.1 | 342.6 |
| **$T_{SSB}$ (K) 80% LO range (All)** | 90 | 70 (110) | 147 (219 ) |

- Current and Future Resolution of EHT

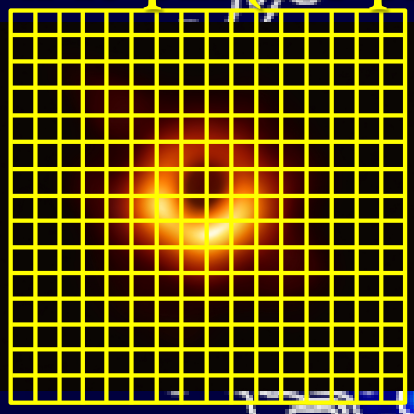
**EHT with GLT**
**220 GHz**
**5 x 5 pix (25 pix)**



EHT 2017
220 GHz
3 x 3 pix (9 pix)



**GLT @ Summit**
**660 GHz**
**15 x 15 pix (225 pix)**



M31 (Andromeda)
Black Hole

We will have much better resolution for black hole shadows in various

We will have better resolution & sensitivity on M87 black hole shadow & jet.