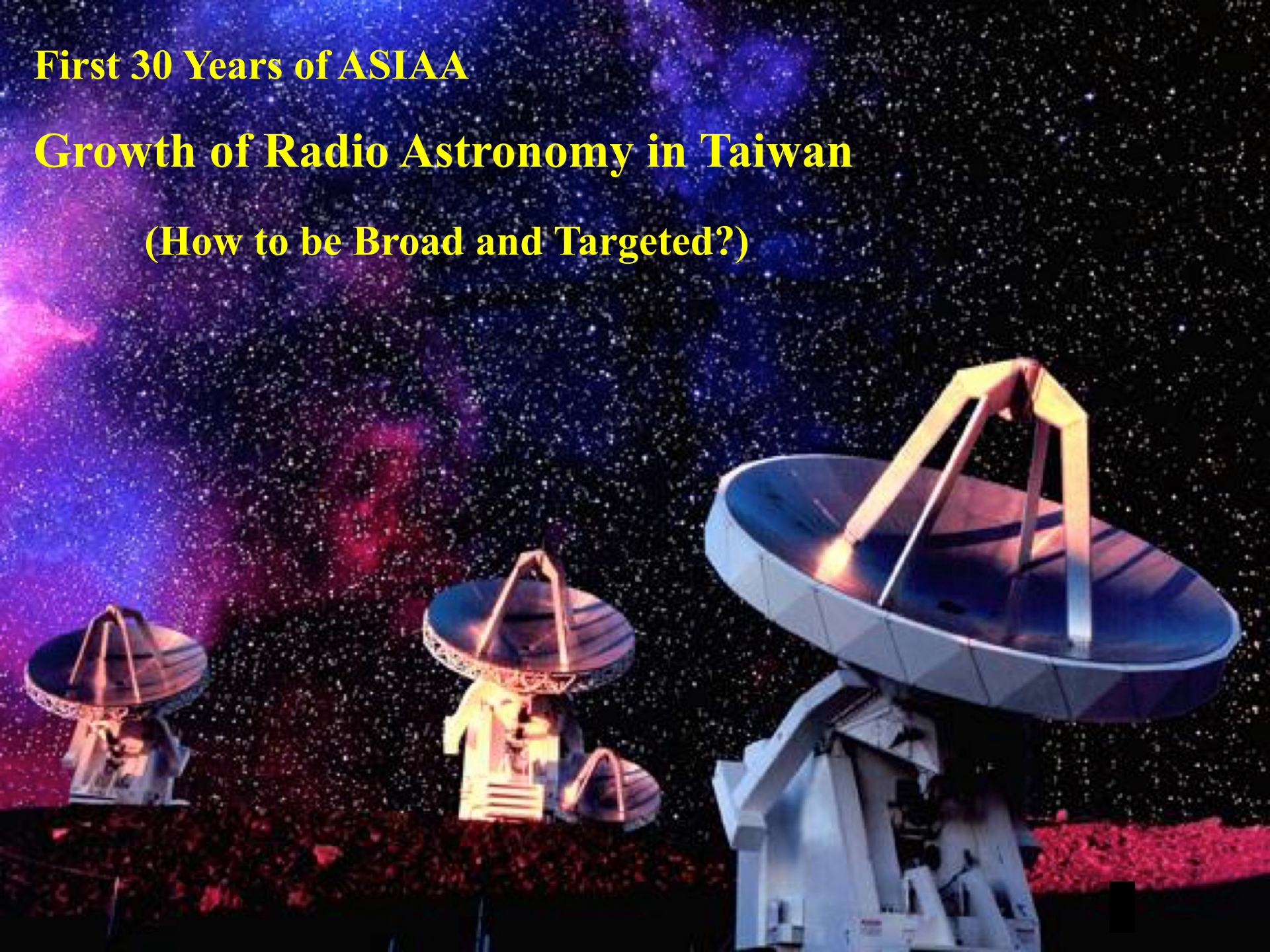
First 30 Years of ASIAA

Growth of Radio Astronomy in Taiwan

(How to be Broad and Targeted?)



Our Early Strategy in the 1990's

- **Form team: in Taiwan and Abroad**
- **Seek Partners to Ensure Success: use old friends, join projects which we know**
- **Choose Interferometry: Leverage Money**
- **Choose Path: BIMA—SMA**
- **Start Training Program Abroad: BIMA**
- **Target: Recruit Personnel: Fred Lo**
- **Target: Build Instrument: SMA**
- **First Recruits: Chen Ming-Tang, Wang Ming-Jye Chen Chi-Chung, Jeremy Lim, Minho Choi, Nagayoshi Ohashi**
- **Later Recruits: Wang Wei-Hao, Lin Li-Hwai, Lin Yen-Ting, Chang Tzu-Ching, Ciska Kemper, Keiichi Asada, Sherry Suyu**

Some Numbers

- **Population:** Taiwan (23M) ~46% of Korea
- **GDP:** Taiwan (669B) ~41% of Korea
- **ASIAA:** 1 of 31 Academia Sinica Institutes/Centers
- **History:** ~28 years (Institute since 2010)
- **Personnel:** ~200 (~31 PIs); ~50 students
- **Budget:** ~15M $

- **Story:** In Targeted Field, small group with
  - » small budget, can forge to the frontier
  - » in a small time period

Taiwan Instrument Projects

- **Radio:** SMA --- AMiBA --- ALMA --- GLT — BURSTT


(2003)


(2009)


(2013)


(2017)

- **Optical:** TAOS-1 --- CFHT/WIRCam --- Subaru/HSC

(2004) (2005) (2012)


TAOS-2

(2018)


SPIROU

(2018)


PFS

(2021)


ELT/METIS

(2026)

Moving to SubMillimeter

ASIAA Builds 2 of the 8 elements

Mauna Kea: 4000m

Dust: $S_\nu \propto \nu^4$

For ν^2 Dust Emissivity
Rayleigh-Jeans Limit for
Blackbody Radiation

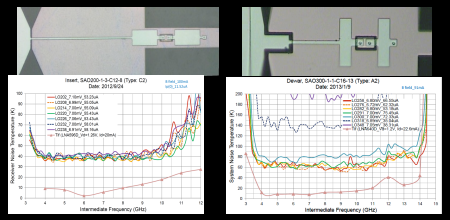
Spectral Lines: $S \propto \nu^5$

For Optically Thin Lines
Einstein A $\propto \nu^3$
Integrated Line Intensity

SMA (2003)

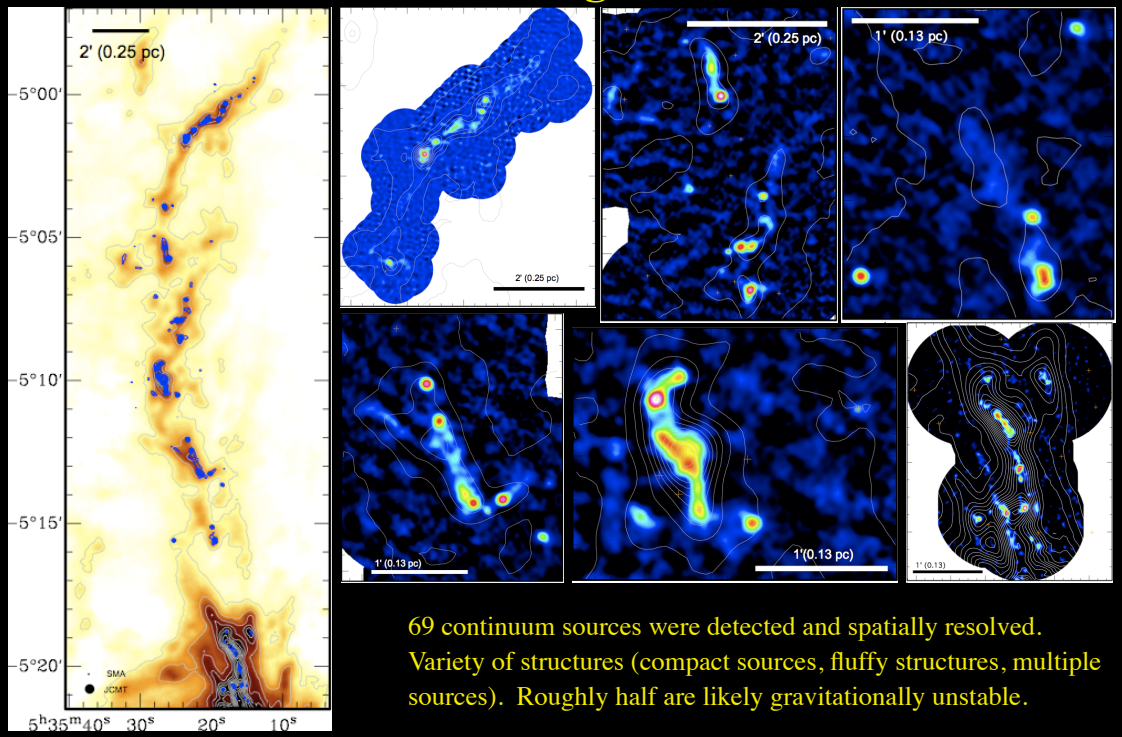
(2011-2022): 93 1st Author Papers

Upgrades Underway: Wide BW, Dual Polarization, Multi-Pixel



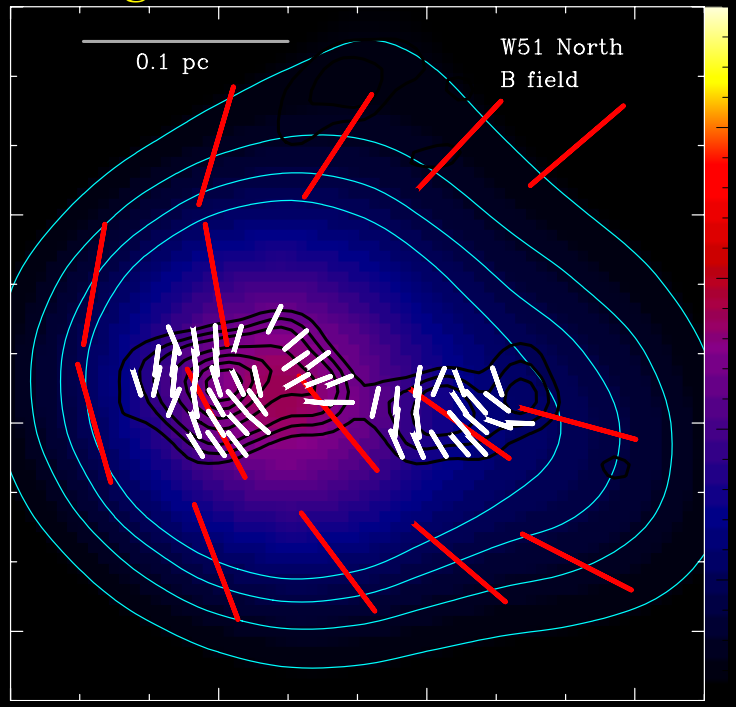
Left: 230GHz band mixer and its performance.
Right: 345 GHz band mixer and its performance.
All SMA 230 GHz receivers upgraded with our mixers.

Orion Filaments Imaged at 0.8 mm



69 continuum sources were detected and spatially resolved. Variety of structures (compact sources, fluffy structures, multiple sources). Roughly half are likely gravitationally unstable.

Magnetic Fields in W51 North

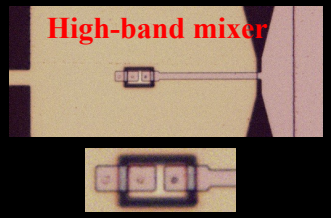


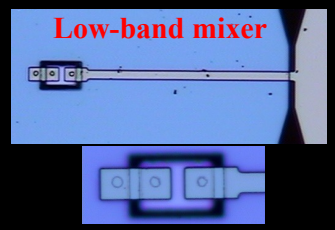
Embedded Sources within Gas Fillaments (Takahashi)

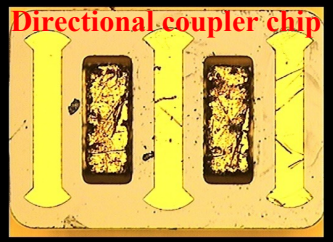
B Fields Resolved at 0.8 mm (Tang)

Clean Room Facility and Devices (2022)

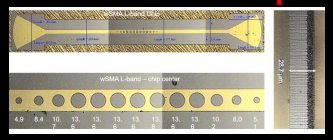
wSMA chips







LO attenuator chip

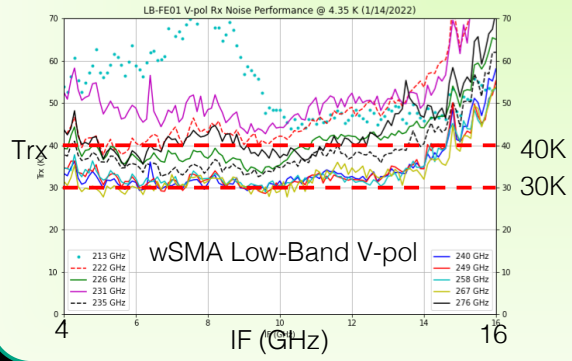


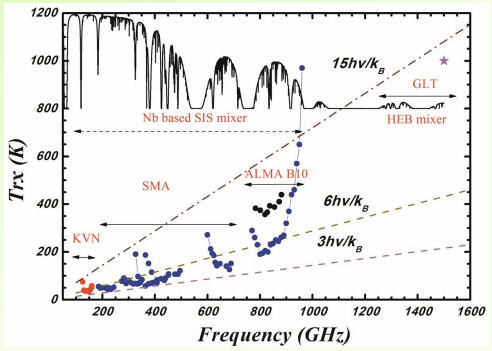
Facility and Technology

- Clean room: Class 100 and Class 1000
- SIS junction based devices – mixer, JTWPA
- NbN ultrathin film based device – HEB mixer, KITWPA, SNWSPD
- Thin Si-substrate device – Directional coupler, LO attenuator
- Membrane device – microlamp (FIR), integrated sub-mm circuit

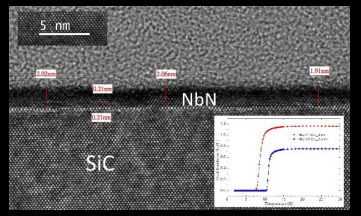
Projects

- SMA receiver – wide IF bandwidth (4-20 GHz)
- ALMA band-10, KVN high-band, JCMT 350 HARP
- THz receiver – GLT
- Integrated compact receiver array – New initiative

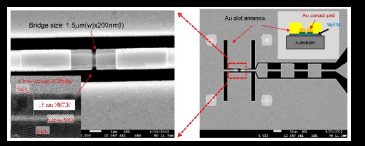




NbN ultrathin film

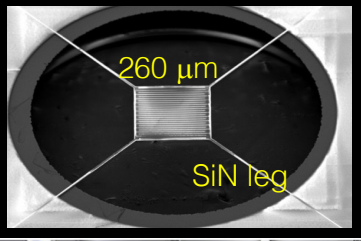


NbN HEB mixer

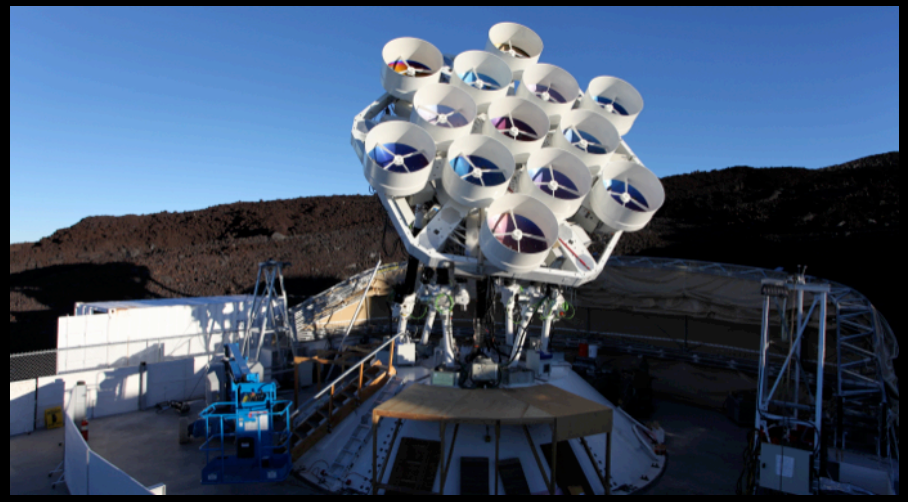


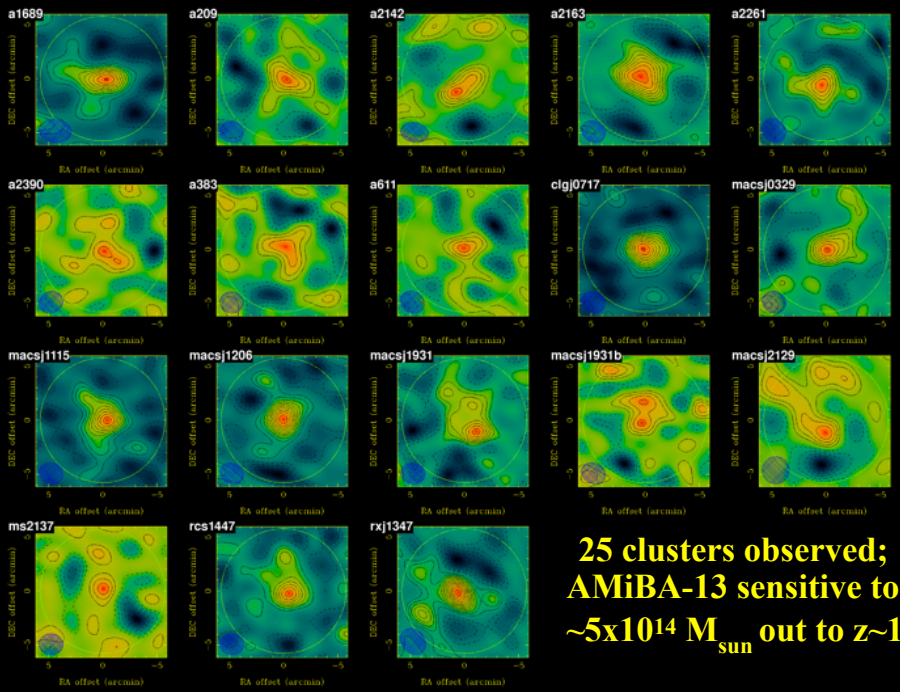
Dual Pol 345 GHz mixer

μ-lamp SAFARI/SPICA



AMiBA (2009)



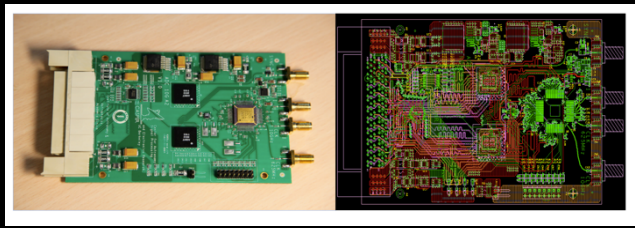


25 clusters observed; AMiBA-13 sensitive to ~5×10^{14} M_{sun} out to z~1

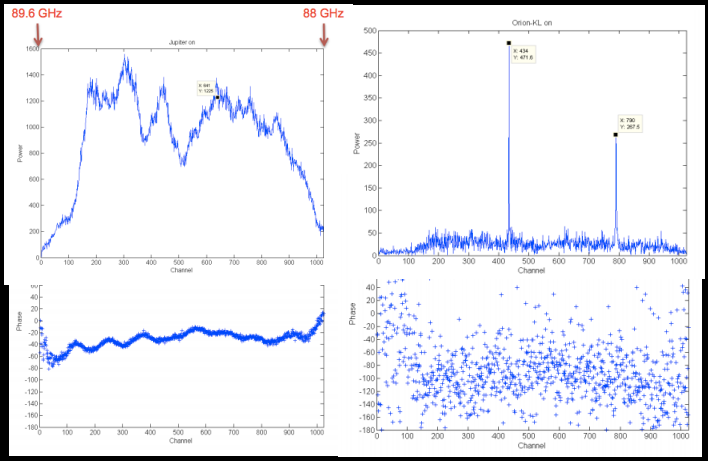
Transitioned to AIM-CO and BURSTT

Developed: miniaturized MMIC LO modules , receivers, new digital correlator with 5GSps ADC

Waveguide LO module vs MMIC LO module



ASIAA fully populated 10GSps ADC



1 Baseline Correlator Test: Bandpass and HCN, HCO+

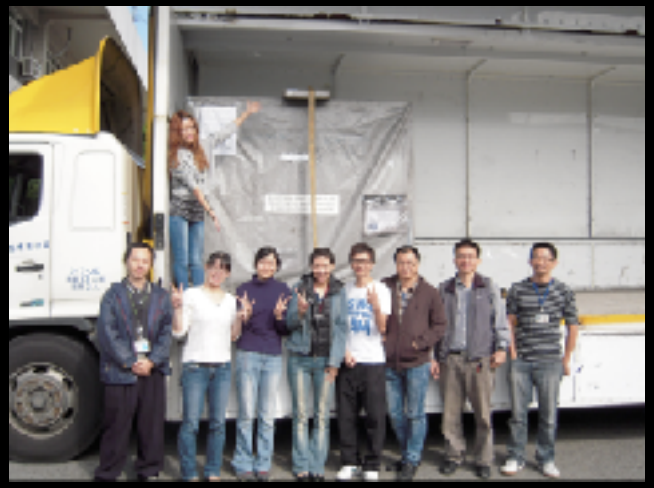
ALMA Deliveries (2014)

Delivered 26th EA Front End System (12.12), 1 Testing Line (03.13)

1 of 2 Test Lines shipped to Chile

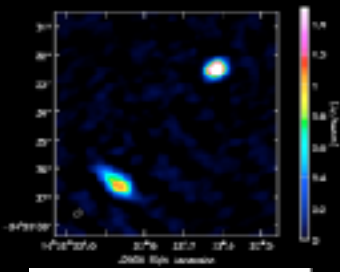
Last FE System in Chile

Nutator "Lily" Acceptance Test



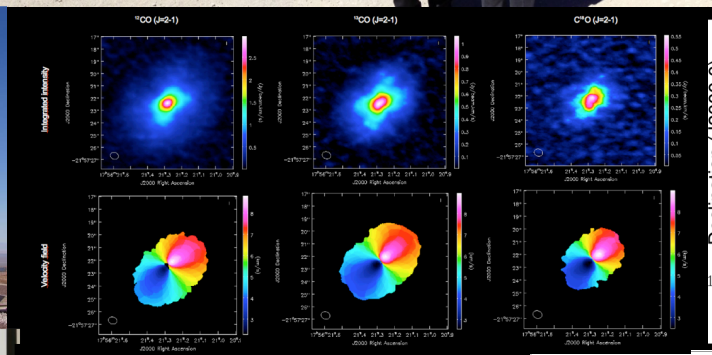
26h FE being shipped at EA-FEIC

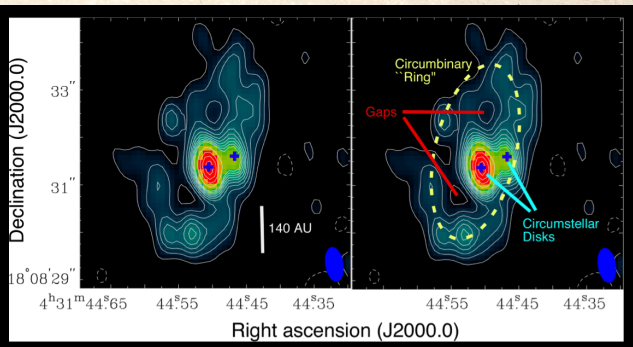
Data Reduction Workshop at NTNU

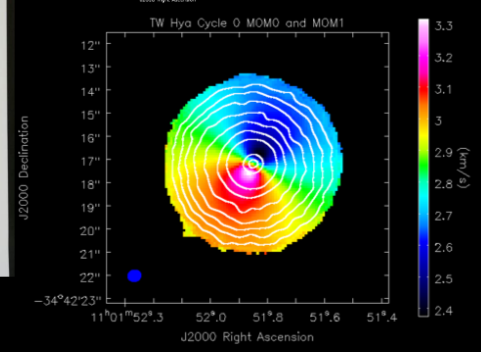


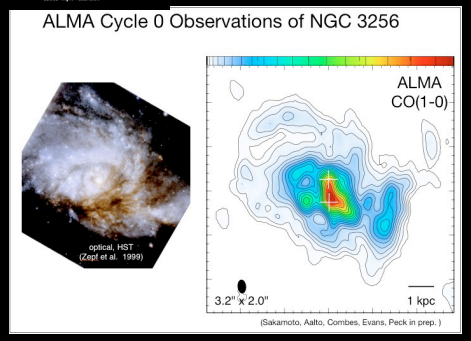
Commissioning Studies

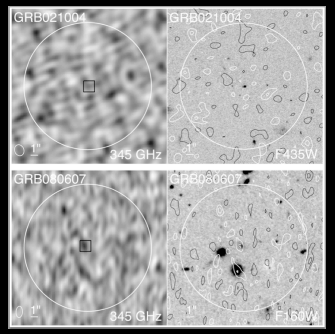
ALMA Inaugurated (3.2013)





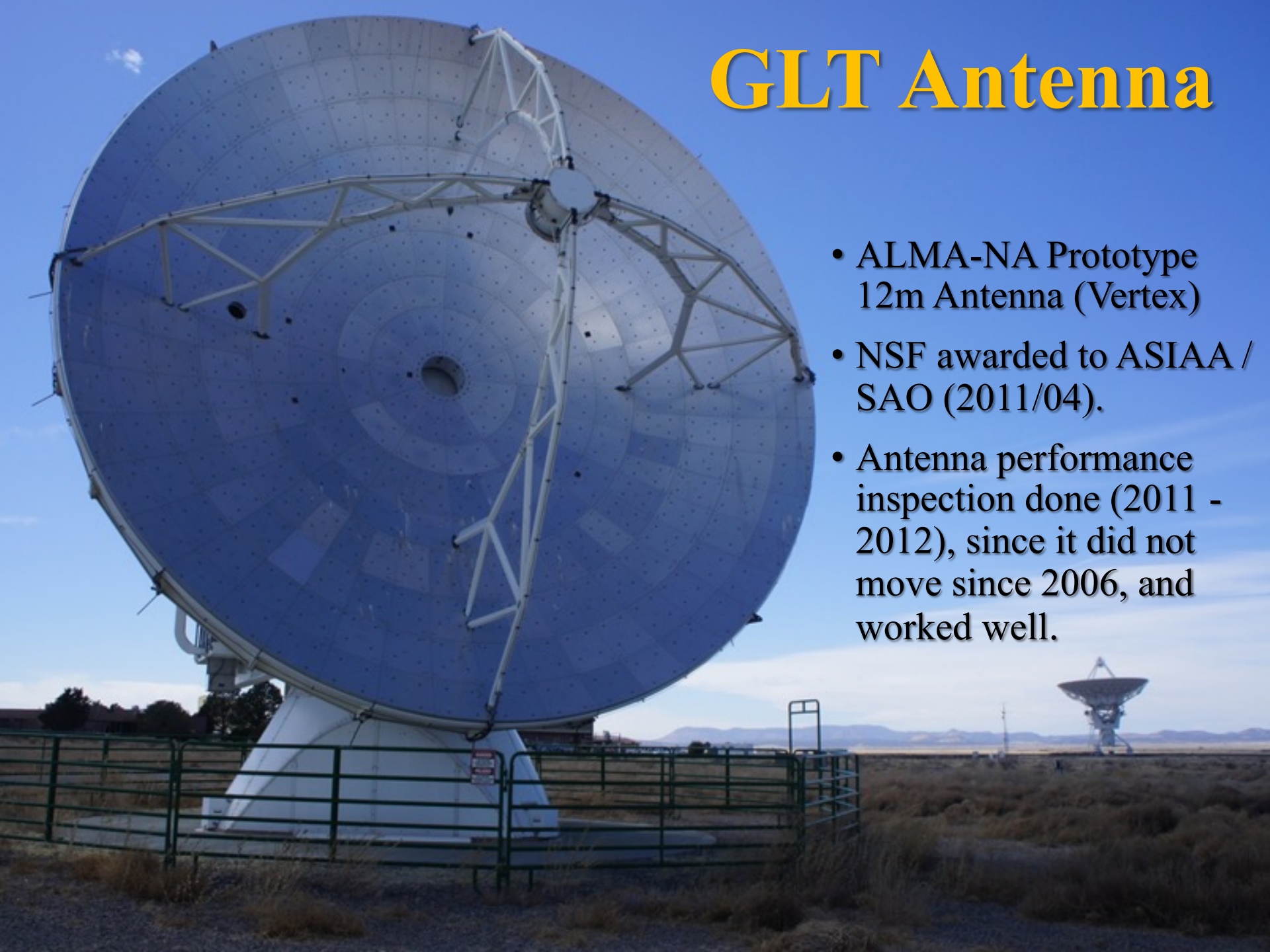






Taiwan budget: 3%

ALMA proposals: 7%

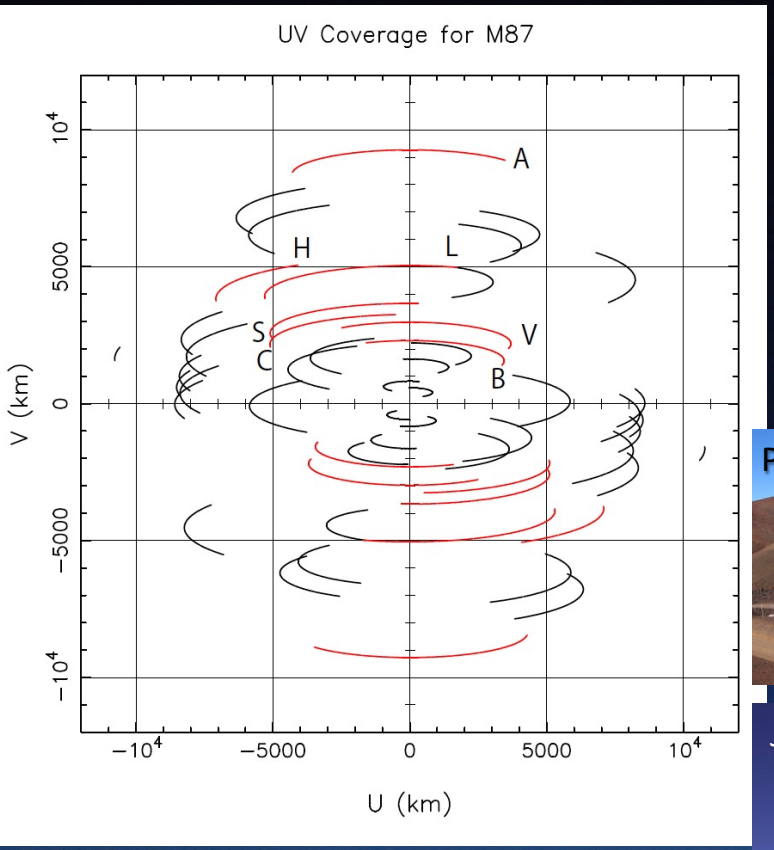


GLT Antenna

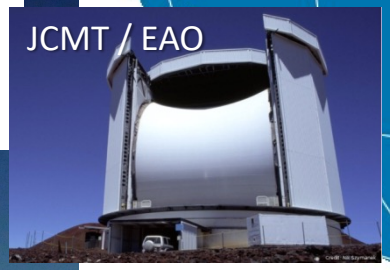
- ALMA-NA Prototype 12m Antenna (Vertex)
- NSF awarded to ASIAA / SAO (2011/04).
- Antenna performance inspection done (2011 - 2012), since it did not move since 2006, and worked well.

Expected uv Coverage with GLT

Very Long Baseline Interferometry (VLBI)



uv coverage for M 87 with GLT, ALMA, SMA/JCMT, LMT, SMT, CARMA, IRAM 30m, and PdBI. Baselines with GLT are shown in red.



Arrival in Greenland 07.16.16

Assembly of Antenna Mount 09.10.16





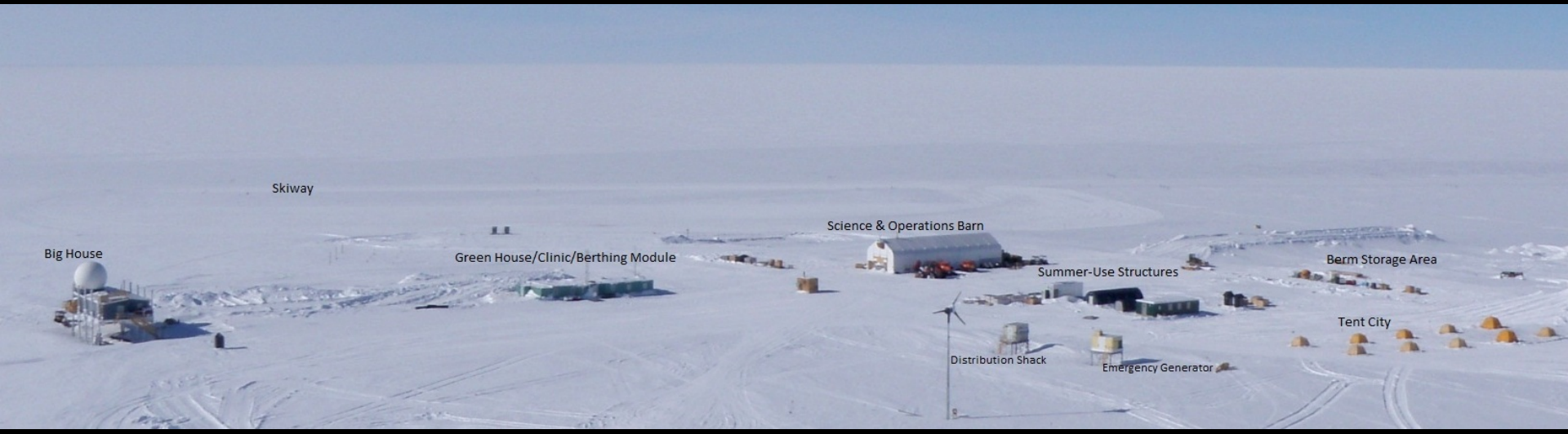


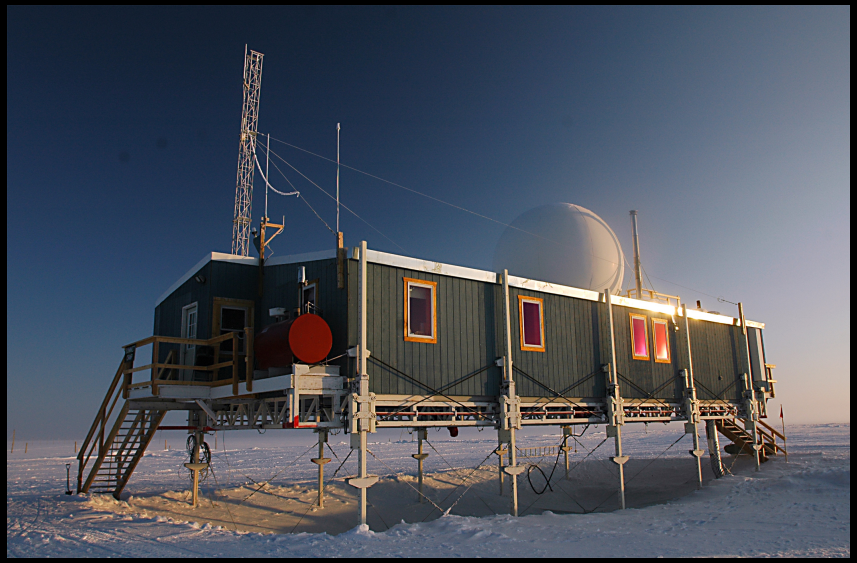



Fully Assembled Telescope 08.2017

TARGET: SUMMIT STATION GREENLAND

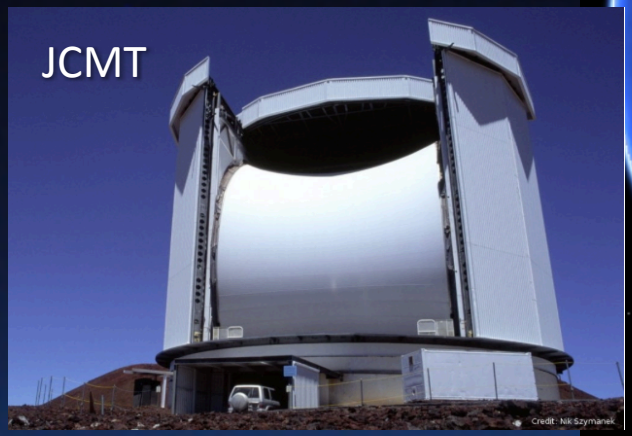
N 72.5, W 38.5, altitude: 3200 m






In 2024?

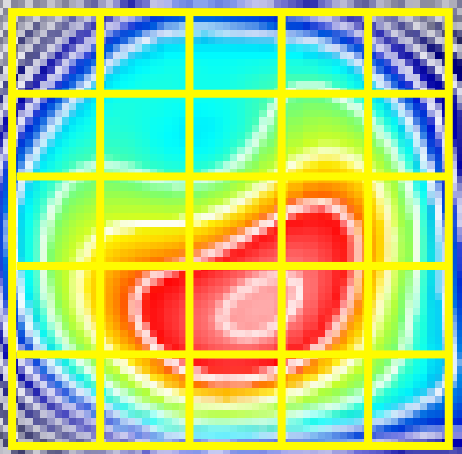
GLT Baselines at 660 GHz



Baselines are 9,000 km long, and
the resolution reaches 10 μas at 660 GHz.

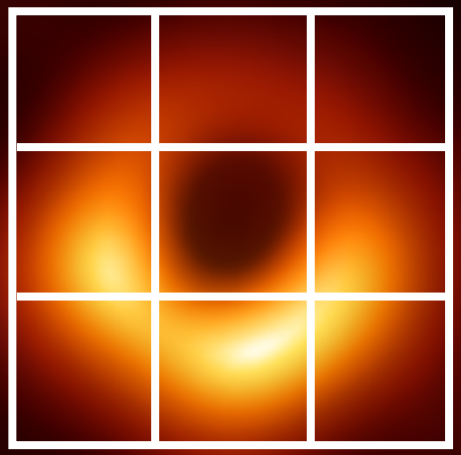
Current and Future Resolution of EHT

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

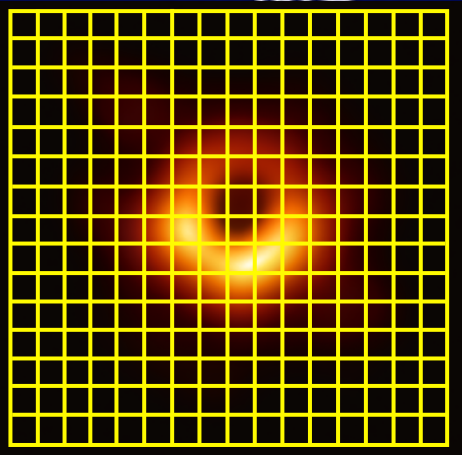


We will have better resolution & sensitivity on M87 black hole shadow & jet.

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



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



M31 (Andromeda)
Black Hole

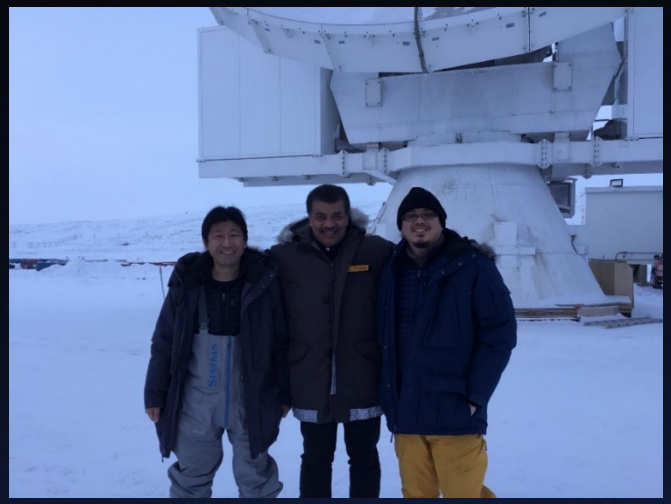
We will have much better resolution for black hole shadows in various galaxies.

VIP Visits to the GLT

2018/10/29

The Prime Minister of Denmark

Niel deGrasse Tyson 2018/03/15
(Carl Sagan in 21th Century)



Nikolaj Coster-Waldau 2018/08/09
(Jaime Lannister of Game of Thrones)

Barbara Barret 2019/11/29
(Secretary of US Air Force & Smithsonian Institution Board Member)

East Asian Observatory

- **History of Development: Established 2014**
- **Model: Asian Counterpart to ESO**
- **EAO Members: NAOC, NAOJ, KASI, ASIAA, NARIT**
- **Goals and Aspirations: Jointly Enable Future Dreams**
- **Current Status: Operating JCMT**
- **Current Plans: Building Regional Consensus**
- **Future Plans: Expand EAO Membership**


EAO/JCMT