Status on the Greenland Telescope (GLT) Project and its science

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Objectives of SMBH studies

1. Direct imaging of Supermassive Black Hole Shadow
2. GR study under strong gravity field
3. Nature of Accretion flows
4. Origin of Relativistic jets

Yun, K. & Pu, H.-Y.

Possible SMBH Shadow Targets

Source	Sgr A*	M 87	Cen A
BH Mass	$0.045 \times 10^8\ M_\odot$	$66\ (35) \times 10^8\ M_\odot$	$0.45 \times 10^8\ M_\odot$
Distance	0.008 Mpc	16.7 Mpc	3.4 Mpc
r_s	11 μas	8 (4) μas	0.3 μas
Size of Shadow	52 μas	40 (20) μas	1.5 μas

requirements	Sgr A*	M 87	Cen A
Baseline [@ 230]	5,000 km	6,000 (12,000) km	180,000 km
[@ 345]	3,500 km	4,000 (8,000) km	100,000 km
Time scale for non-rotating and rotating BH	30 mins 4 mins	32 days (16 days) 4 days (2 days)	5 hrs 1 hr

M87 *may be* the Best Target, but in the Northern Hemisphere.

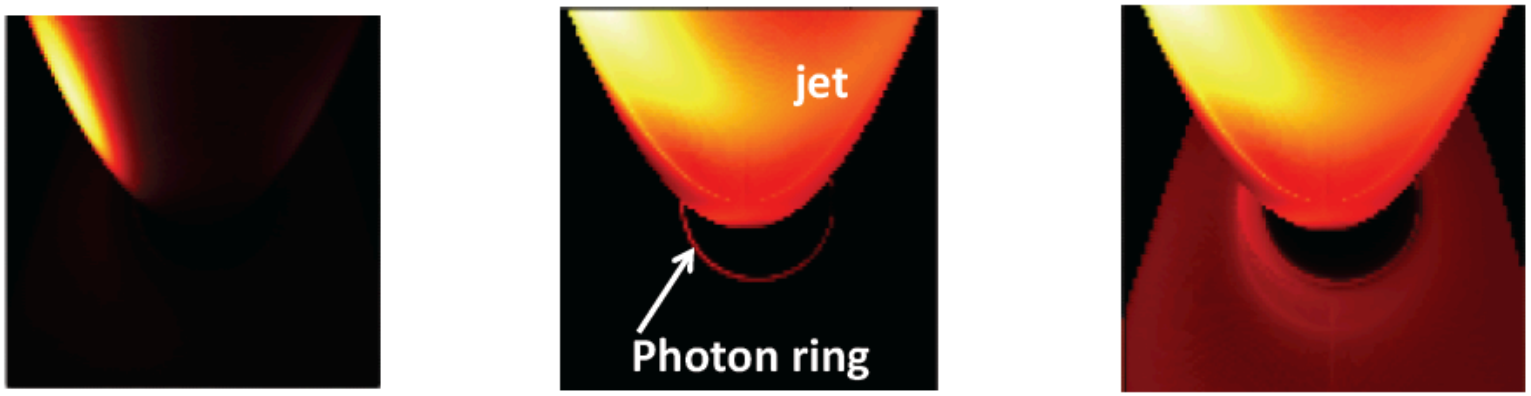
General Relativistic Radiative Transfer

Jet model +

- ray tracing (photon trajectory in curved spacetime)
- dynamics/distribution of surrounding materials (correction of energy/ frequency/ angle)
- radiative transfer (physical process take place locally)

= explore the possible black hole shadow image flexibly

e.g.



non-thermal Synchrotron | thermal Synchrotron | thermal Synchrotron + counter jet

Jet image is sensitive to the electron properties!!

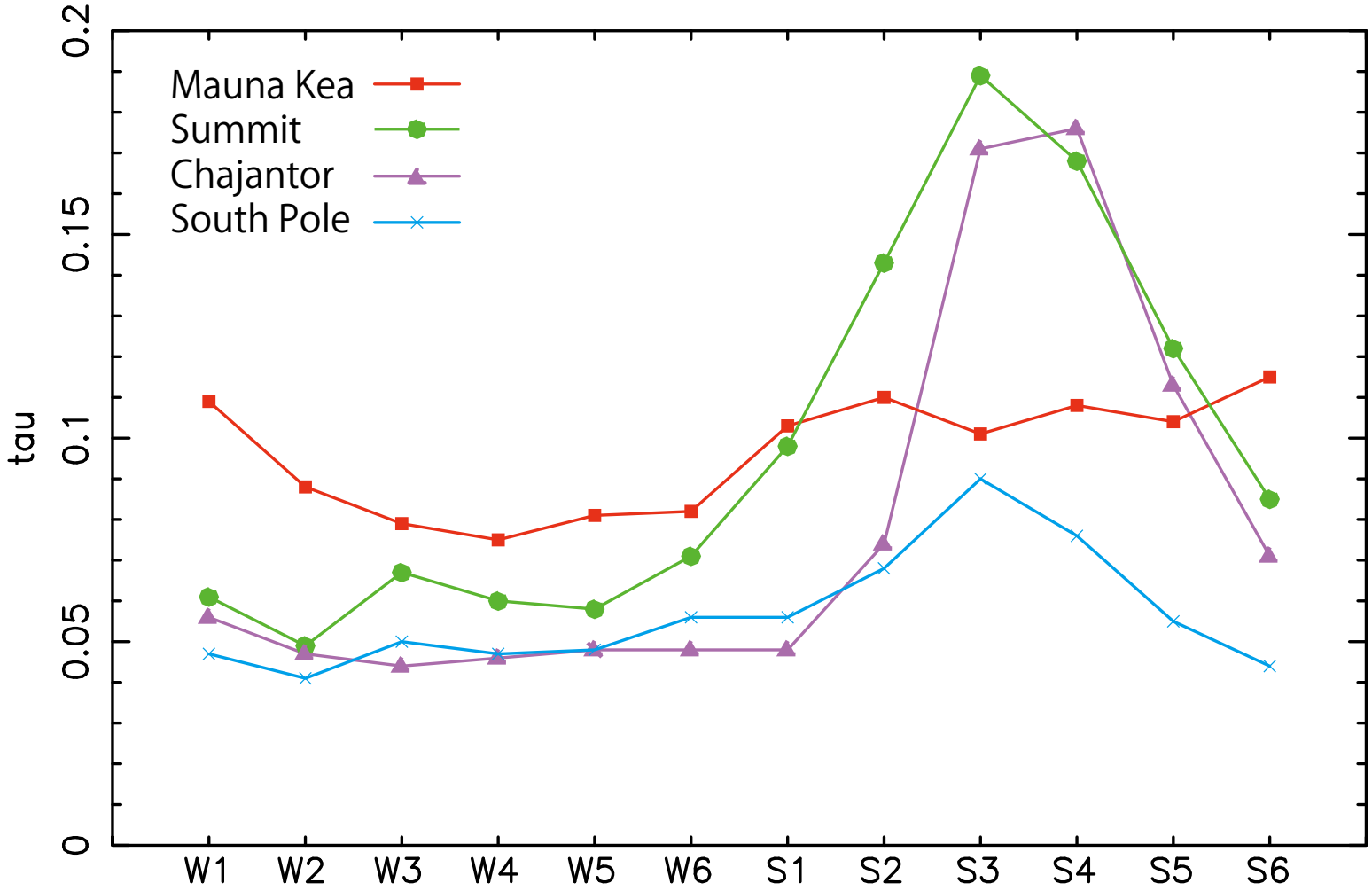
Pu et al. 2015, in preparation

Based on several physical parameters and models, we are preparing templates to interpret the observed image properly and quickly.

Air/Traverse Towards the Summit Station

Facilities at Summit Station

Opacity of submm site



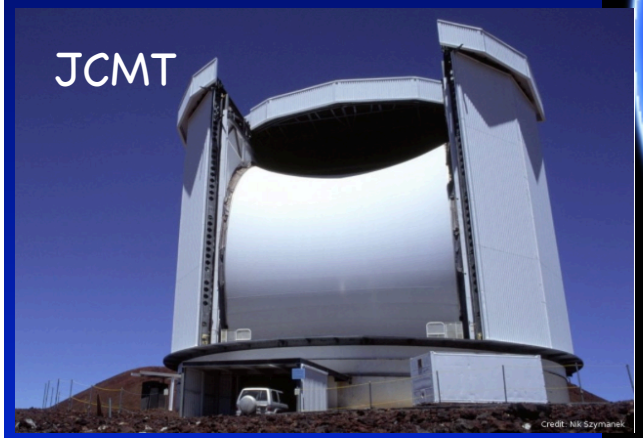
Northern Hemisphere: November.-April; May-October
Southern Hemisphere: May-October; November-April

P. Martin-Cocher et al. 2014, SPIE

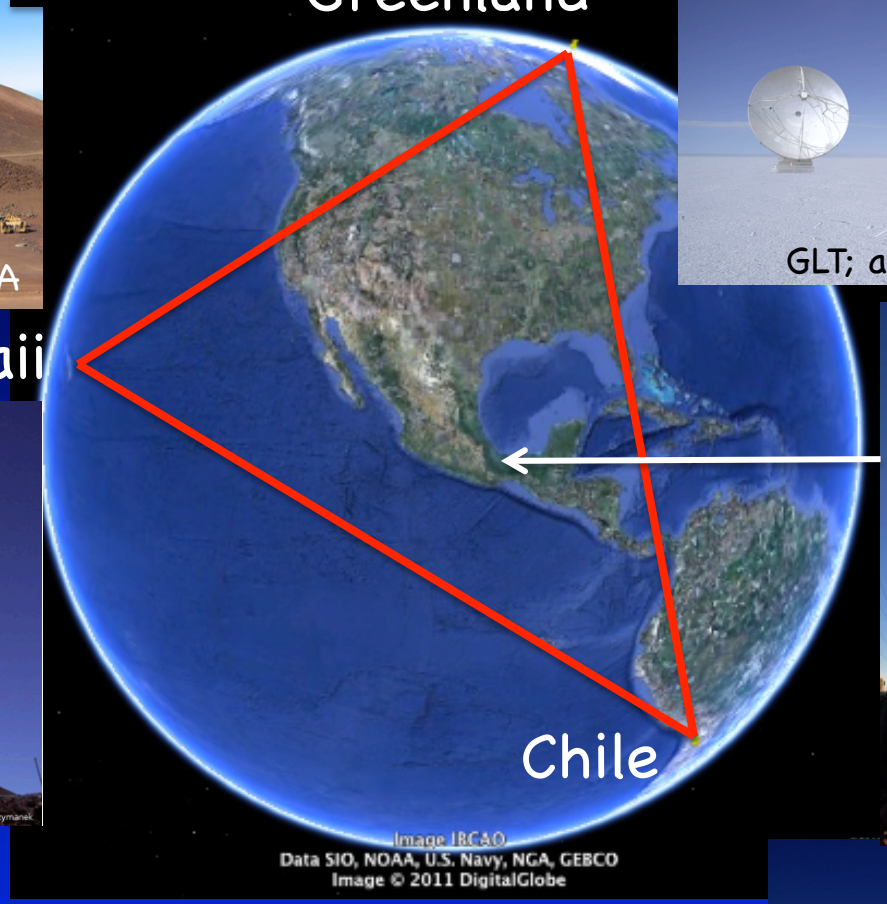
GLT Baselines at 350 GHz and higher

Greenland

Hawaii



EAO



Chile

Baselines are 9,000 km long, and
the resolution reaches 20 μas at 345 GHz.

ALMA Phase up project

Phased ALMA is coming on line soon, providing about one order of magnitude higher sensitivity.

Timeline

- NSF Call for Proposal: 12.2010
- Antenna awarded to ASIAA/SAO: 04.2011
- Antenna inspection: 04.2011
- Antenna power-up, surface check: 07.2011, 01.2012
- Antenna retrofit evaluation: 11.2011 – 03.2012
- Antenna pointing test: 06 – 08. 2012
- Disassembly in Socorro: 09 – 12. 2012
- Antenna retrofitting for cold: 09.2012 – 12.2014
- Antenna to Greenland (Thule): 07. 2016
- Antenna full functioning test (Thule): 10.2016 – 02.2017
- GLT First light in Thule: 01.2017
- GLT VLBI observations in Thule: 2017-2019
- Antenna to Greenland Summit: 03.2019
- GLT Operational on Summit: 10.2019

Areas of collaborations

- Black Hole sciences: NAOJ+, SHAO, ,,,
  - GR, accretion flow, jet launching mechanism, co-evolution w/ galaxy
- Observations: KASI, ,,,
  - Correlations of fringe finding observations at 86 and 230 GHz and with the KVN correlator
  - Data processing, image simulation and analysis
  - Single-dish observations up to THz
- Telescope engineering: OPU, PMO, ,,,
  - Receivers, system in cold environments
- East Asian VLBI Network
  - A lot of experiences for VLBI
  - Expand it w/ JCMT and East Asia Observatory
    - Delingha, KVN, NRO, a new telescope in Tibet?

Summary

- submm VLBI group in ASIAA is pushing the GLT project
- submm antenna has been deployed to Greenland, to form a submm VLBI network aiming at primarily M87 shadow imaging
- There are many areas/items to collaborate

The main facility