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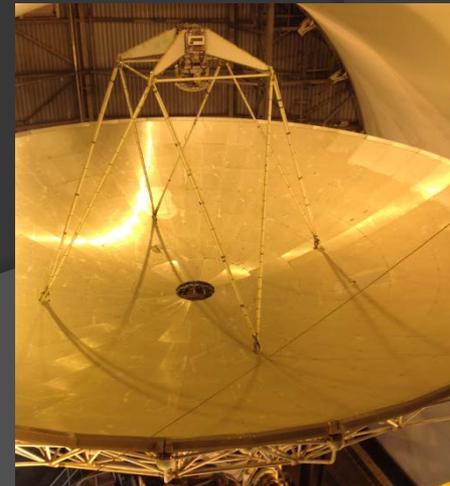
**JCMT AS
A MM/SUBMM VLBI
STATION**

James Clerk Maxwell Telescope (JCMT)



- ⦿ Diameter: 15 m
- ⦿ Surface Accuracy: 24 μm
- ⦿ Location: Mauna Kea, Hawaii
 - 19°49'22.2" N, 155°28'37.0" W
 - Altitude: 4092 m

- ⦿ JCMT re-started its operation under East Asian Observatory (EAO) since Mar. 1, 2015. Director is Paul Ho.



Past mm-VLBI with JCMT

Sgr A*
Size $\approx 40 \mu\text{as}$
($\approx 4 r_{\text{sch}}$)

Doeleman et al. (2008)



Vir A* (M 87)
Size $\approx 40 \mu\text{as}$
($\approx 5 r_{\text{sch}}$)

Doeleman et al. (2012)

nature

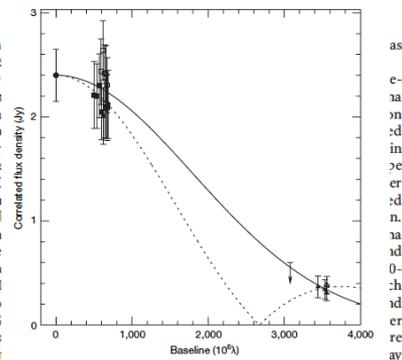
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LETTERS

Event-horizon-scale structure in the supermassive black hole candidate at the Galactic Centre

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The cores of most galaxies are thought to harbour supermassive black holes, which power galactic nuclei by converting the gravitational energy of accreting matter into radiation¹. Sagittarius A* (Sgr A*), the compact source of radio, infrared and X-ray emission at the centre of the Milky Way, is the closest example of this phenomenon, with an estimated black hole mass that is 4,000,000 times that of the Sun^{2,3}. A long-standing astronomical goal is to resolve structures in the innermost accretion flow surrounding Sgr A*, where strong gravitational fields will distort the appearance of radiation emitted near the black hole. Radio observations at wavelengths of 3.5 mm and 7 mm have detected intrinsic structure in Sgr A*, but the spatial resolution of observations at these wavelengths is limited by interstellar scattering⁴⁻⁷. Here we report observations at a wavelength of 1.3 mm that set a size of 37⁺¹⁰ microarcseconds on the intrinsic diameter of Sgr A*. This is less than the expected apparent size of the event horizon of the presumed black hole, suggesting that the bulk of Sgr A* emission may not be centred on the black hole, but arises in the surrounding accretion flow.



Scienceexpress

Reports

Jet Launching Structure Resolved Near the Supermassive Black Hole in M87

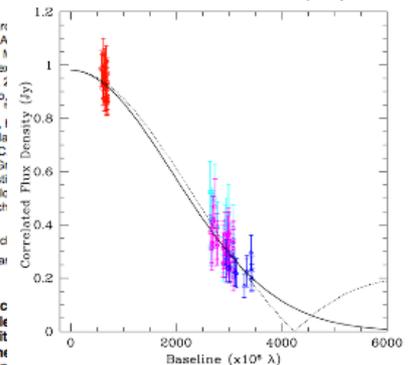
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Approximately 10% of active galactic nuclei exhibit relativistic powered by accretion of matter onto super massive black hole measured width profiles of such jets on large scales agree wit collimation, predicted structure on accretion disk scales at th not been detected. We report radio interferometry observation

scales for extragalactic jet sources. High-resolution radio interferometry of these sources at cm wavelengths is limited by optical depth effects that obscure the innermost accretion region. For these reasons, it remains unclear if jet formation requires a spinning black hole (5, 6), and if so, whether jets are more likely to be formed when the orbital angular momentum of the accretion flow is parallel (prograde) or anti-parallel (retrograde) to the black hole spin (7, 8). To address these questions, we have assembled a Very Long Baseline Interferometry (VLBI) array operating at a wavelength of 1.3 mm, the Event Horizon Telescope (9), where AGN become optically thin, and



JCMT Receivers

⊙ Heterodyne Receivers

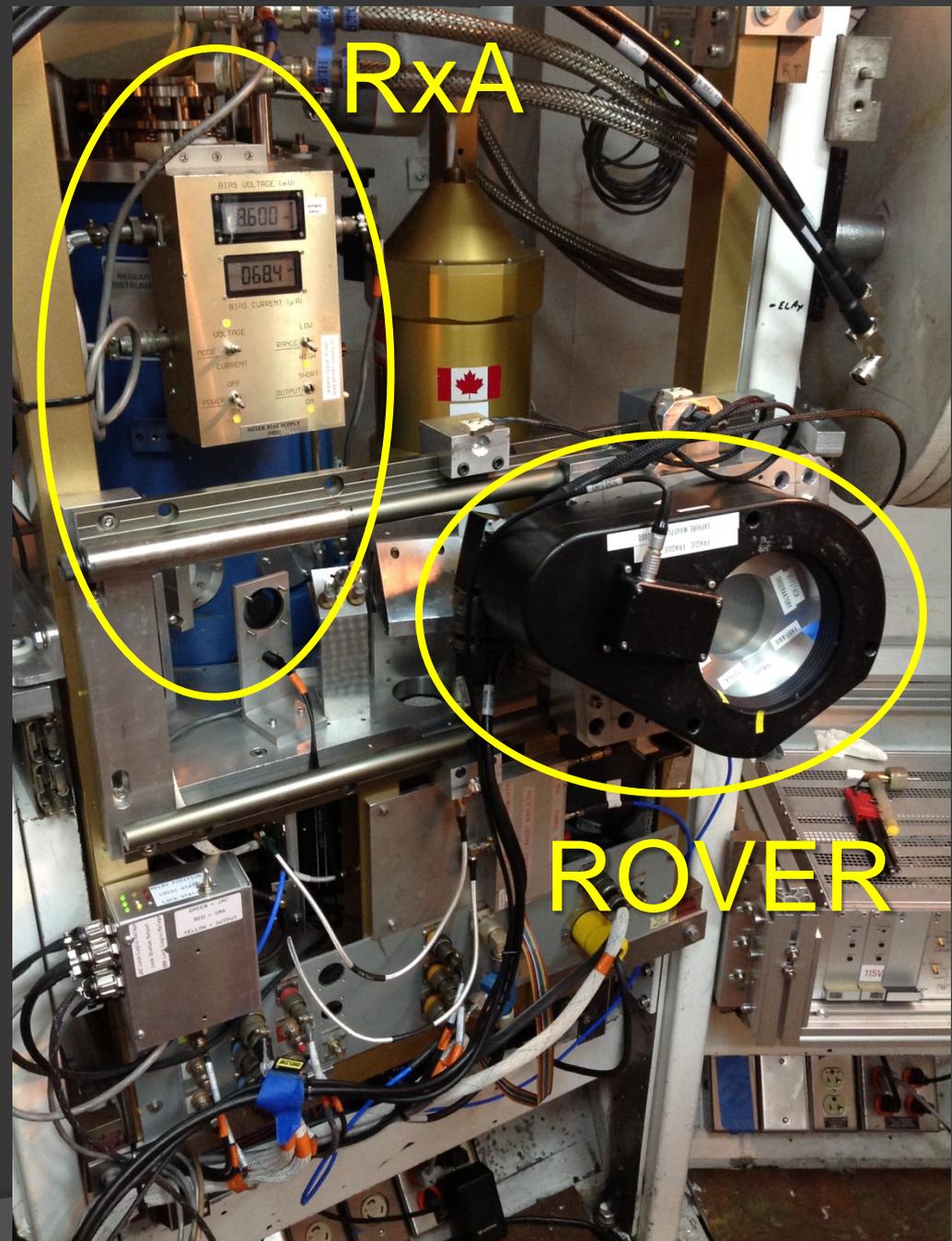
- RxA (230 GHz single pixel receiver)
 - Tunable range: 211.5 - 276.5 GHz (gap at 251 - 253 GHz)
 - DSB, BW ~ 2 GHz, IF = 4 GHz
 - $\eta_{mb} = 0.57$, $\eta_{fss} = 0.66$.
- HARP (Heterodyne Array Receiver Program)
 - 16 SIS mixer array (SSB)
 - Tunable range: 325 - 375 GHz
 - BW ~ 2 GHz, IF = 5 GHz
 - $\eta_{mb} = 0.64$, $\eta_{fss} = 0.75$

⊙ Continuum Receivers

- SCUBA-2
 - 10,000 pixel bolometer camera
 - Operating simultaneously at 450 μm and 850 μm

RxA

- The oldest receiver in JCMT.
- Need to fill liquid nitrogen and liquid helium constantly.
- LO can be locked using both JCMT generated and SMA generated reference signals.
- **JCMT is looking for some lab(s) to replace with a latest technology receiver.**
- ROVER is a polarizer to create circular polarization signal for RxA.



Location of Hydrogen Maser

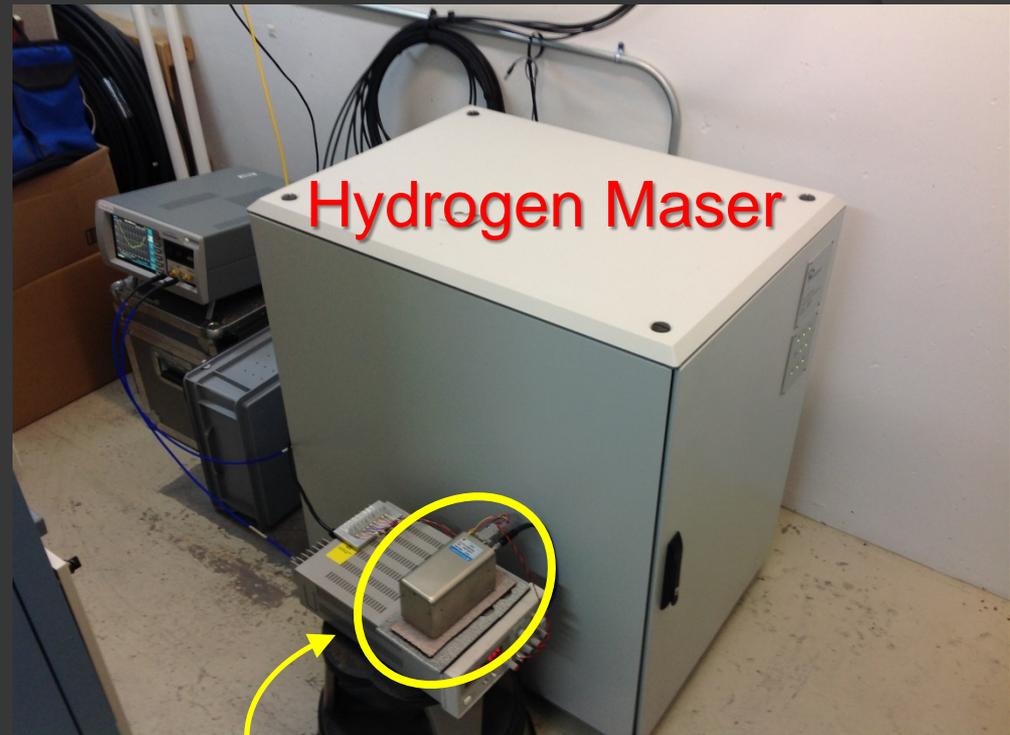


Mar.17, 2015



Reference Signal

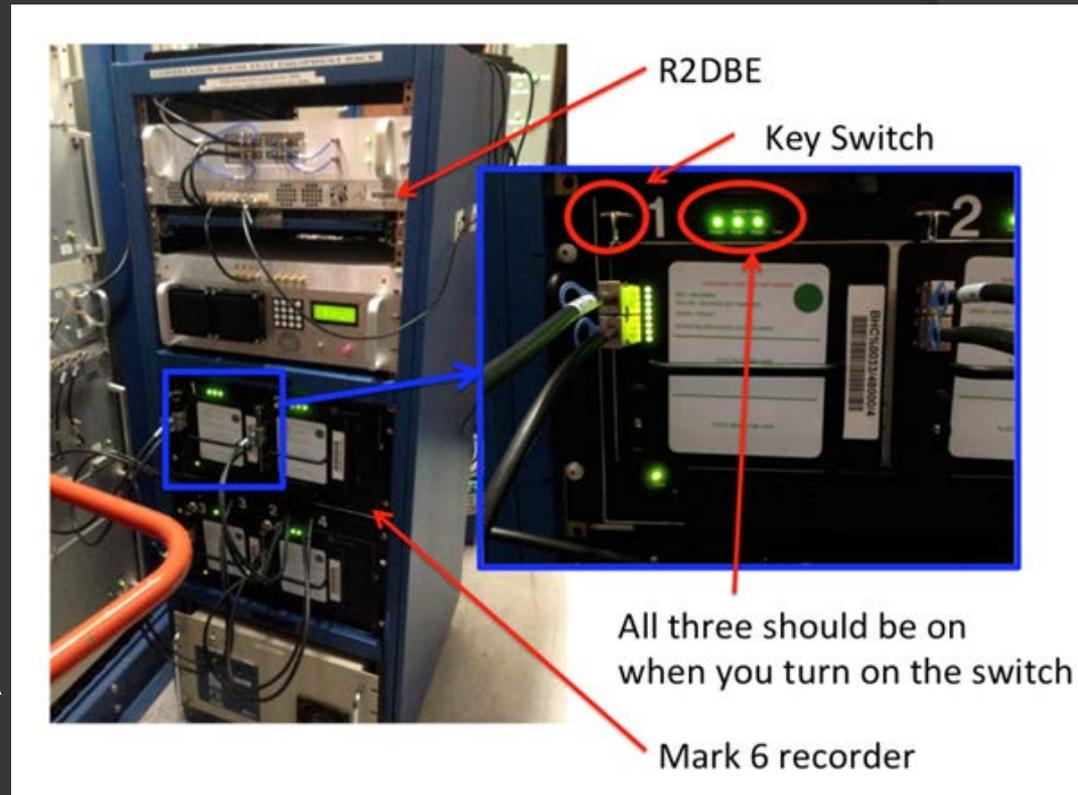
- Hydrogen Maser
 - Located at the vault of the SMA building.
 - It is for both SMA and JCMT VLBI.
 - This signal is sent to JCMT via SMA Antenna 5 IF2 (high frequency IF) backend.
 - When high frequency IF is in use for the normal SMA operation, the Hydrogen Maser signal cannot be used for JCMT.



Crystal Oscillator

VLBI Backends

- R2DBE and Mark 6 recorder have been used for the last EHT 2015 observation.
- Brought by MIT Haystack Observatory.
- Located at the SMA correlator room.



Problems for JCMT VLBI

- ⦿ JCMT stand-alone VLBI has never been done.
 - Reference signal, backends, and some of the cables are shared with the SMA.
 - This is a historical reason, since the VLBI mode is using the eSMA mode system.
 - Currently, reference and IF signals sent out via SMA Antenna 5 IF2 (high frequency IF) backend.
 - Backends belong to MIT.
 - There is no VLBI backends that belong to SMA or JCMT.
 - Not clear whether MIT supports EAO VLBI activities.
 - No signal injection system for JCMT.
 - JCMT-VLBI mode always work with SMA, so always check fringes with SMA.
 - Currently under discussion with SMA engineers.

Confliction with SMA

- ⦿ JCMT VLBI needs to use 1 IF backend to send out the reference signal to JCMT, and receive the IF signal back to SMA.
 - If SMA is in the use of
 - 2 frequency mode,
 - 1 frequency mode with the wide band (4 GHz BW) mode, then we cannot use JCMT VLBI mode.
 - If SMA is in the use of
 - 1 frequency mode with the narrow band mode, then OK.
- ⦿ **The most popular SMA observation modes are the first 2 modes, so it is almost hopeless to use JCMT as a stand-alone VLBI station, independent from the usual SMA operation under this configuration.**

How to avoid this problem?

- ◎ Use eSMA mode and VLBI together with SMA.
 - Fringe check can be done before VLBI, so very convenient.
 - Need to obtain both JCMT and SMA observation time. (i.e., need to submit proposals to both observatories)
 - Need extensive help of the SMA scientists and engineers in both Hawaii and Cambridge.
- ◎ Move H-Maser, backends, & recorders to JCMT.
 - At this moment, it is not clear whether JCMT observational building has a temperature controlled and motion stable room.
 - Note that most of the JCMT observational building moves together with the telescope.
- ◎ Use new/available cable to send the H-Maser signal directly to JCMT
 - Currently under discussion with SMA engineers.

The Biggest Problem of JCMT

(Message from the EAO Director Paul Ho)

◎ **Need budget!!!**

- JCMT totally lacks the operation budget.
- EACOA contribution from each region is basically for normal JCMT operation (i.e., single-dish mode).
- 1 night observation costs US\$ 20,000.
- Usually, VLBI needs 2-3 nights or more, different from the normal JCMT single-dish observations.
- If some groups are going to ask VLBI observations for more than a few nights, those groups need to bring in significant amount of budget to JCMT.

Summary

- ⦿ JCMT VLBI mode is working even JCMT moved to EAO.
- ⦿ JCMT VLBI mode is highly relying on SMA.
- ⦿ VLBI backends need to be brought in to SMA for each observation.
- ⦿ There is a confliction with the SMA normal operation.
- ⦿ To avoid this, it needs special technical consideration, which is under discussion with SMA engineers.
- ⦿ If some of the receiver labs can replace RxA to the latest receiver, it would be welcome.
- ⦿ **Need budget!!!**