

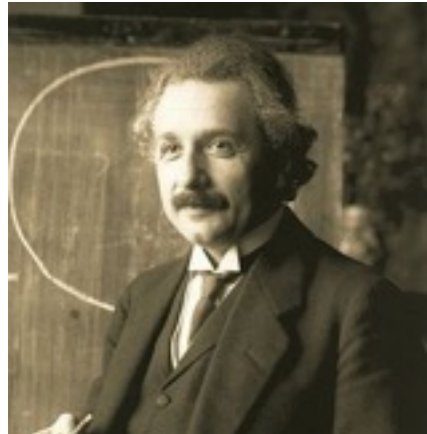
Summary of Event Horizon Telescope



Event Horizon Telescope

Mahito Sasada (NAOJ)
and EHT team

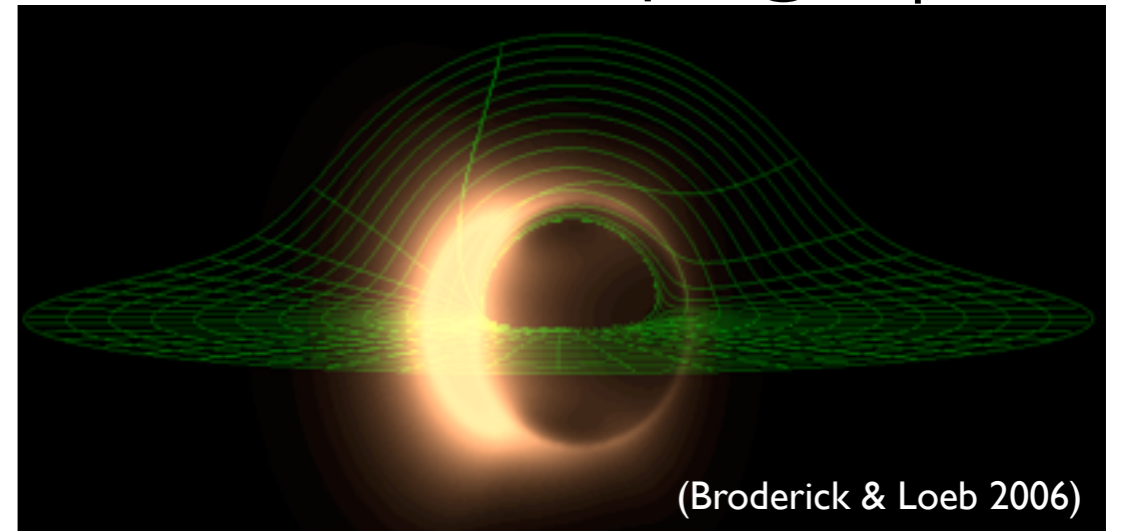
The Shadow of Black Hole



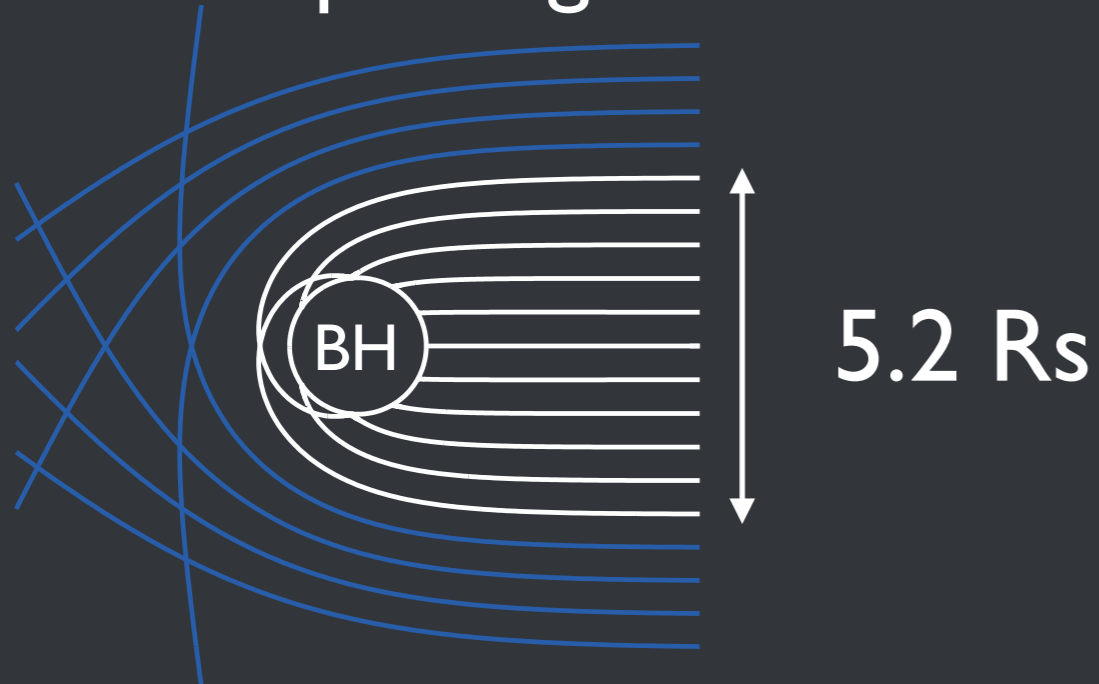
- Light cannot escape from the black hole
- The black hole makes a shadow

Sgr A* ~ 0.1 AU ($4 \times 10^6 M_{\text{solar}}$):

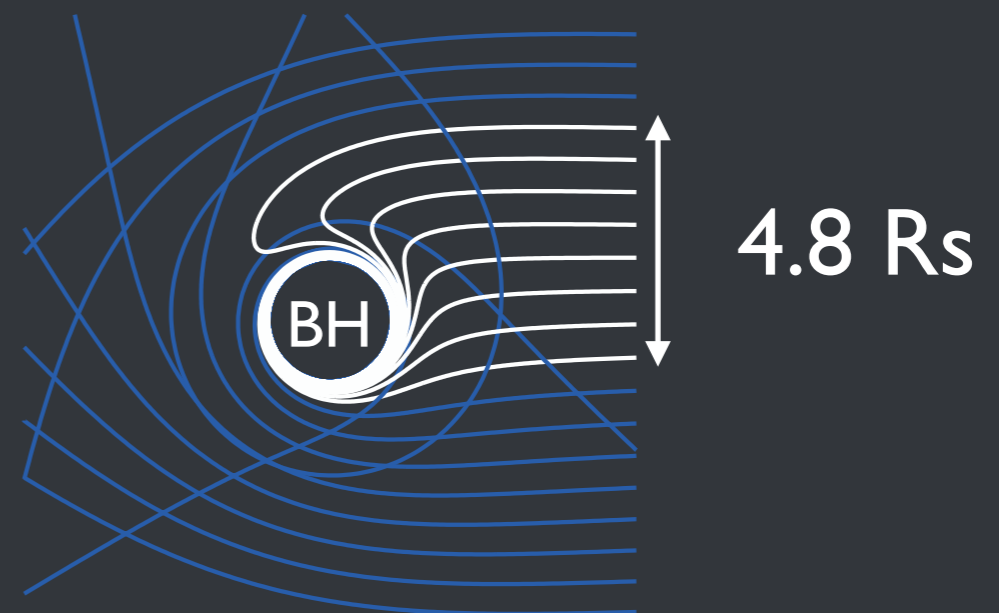
$10 \mu\text{as}$ @ 8 kpc



Non-spinning Black Hole



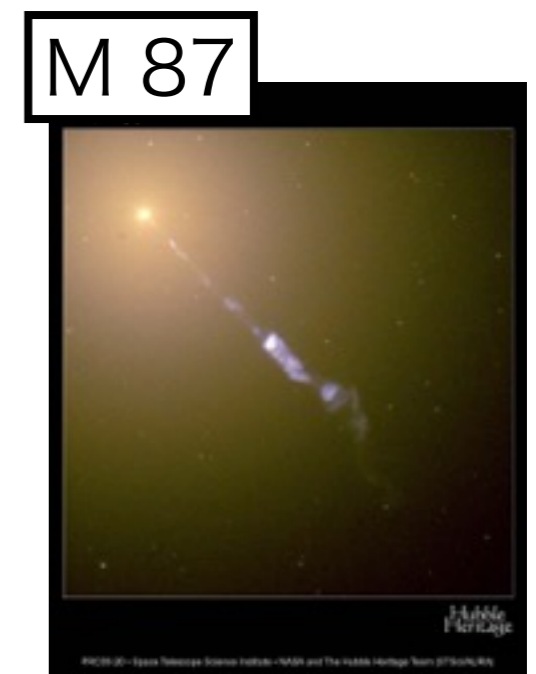
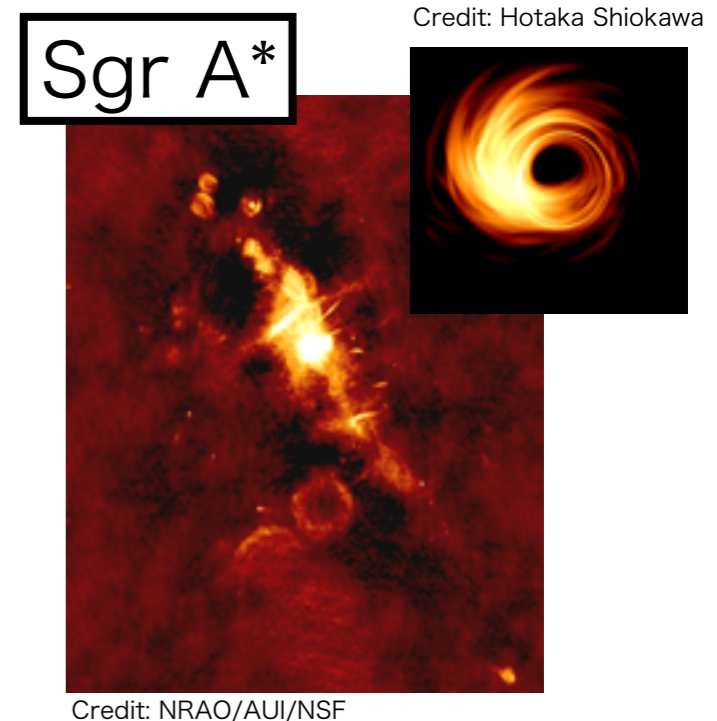
Maximumly spinning BH



(Courtesy of Hung-Yi Pu)

Sizes of Black-Hole Shadow

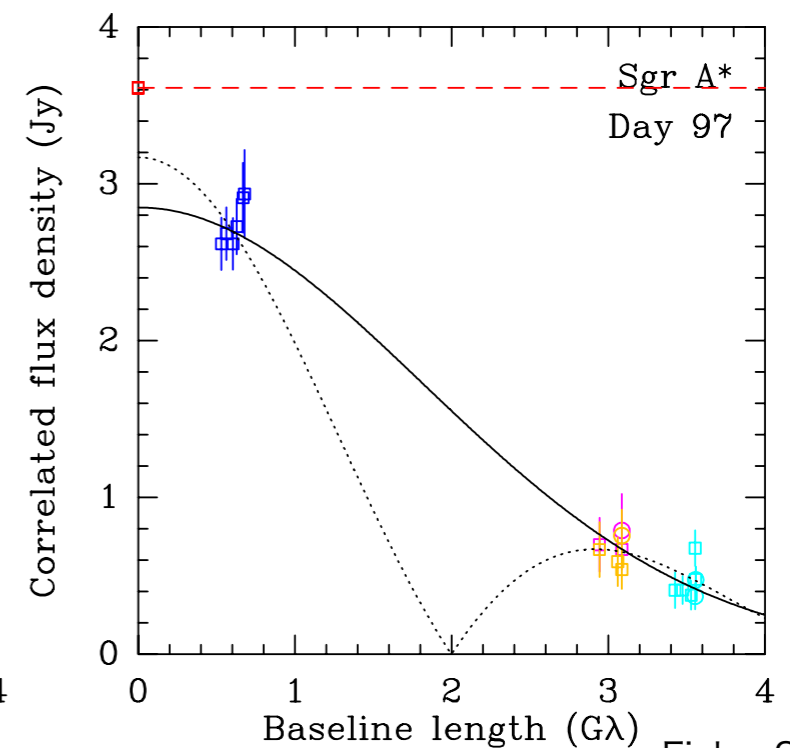
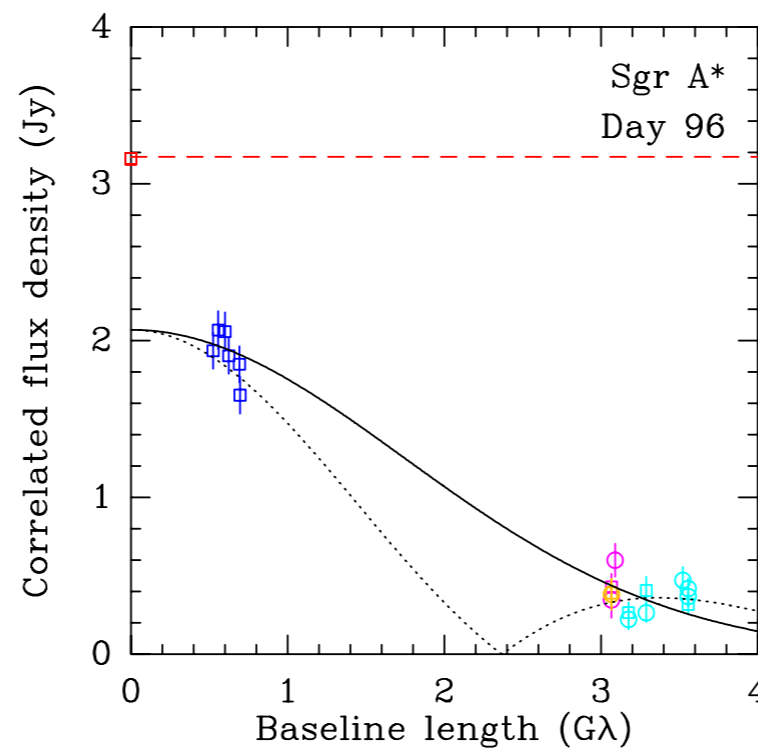
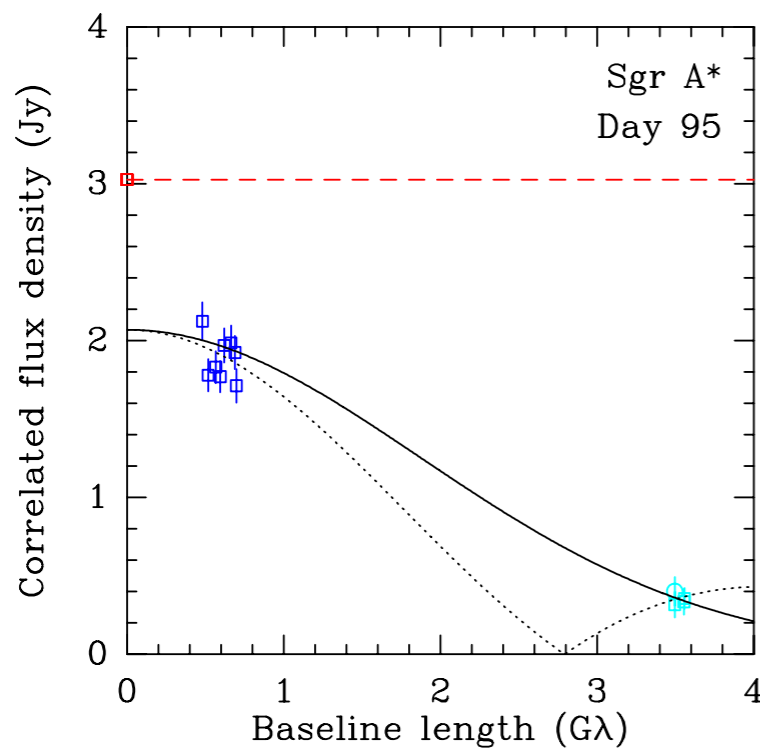
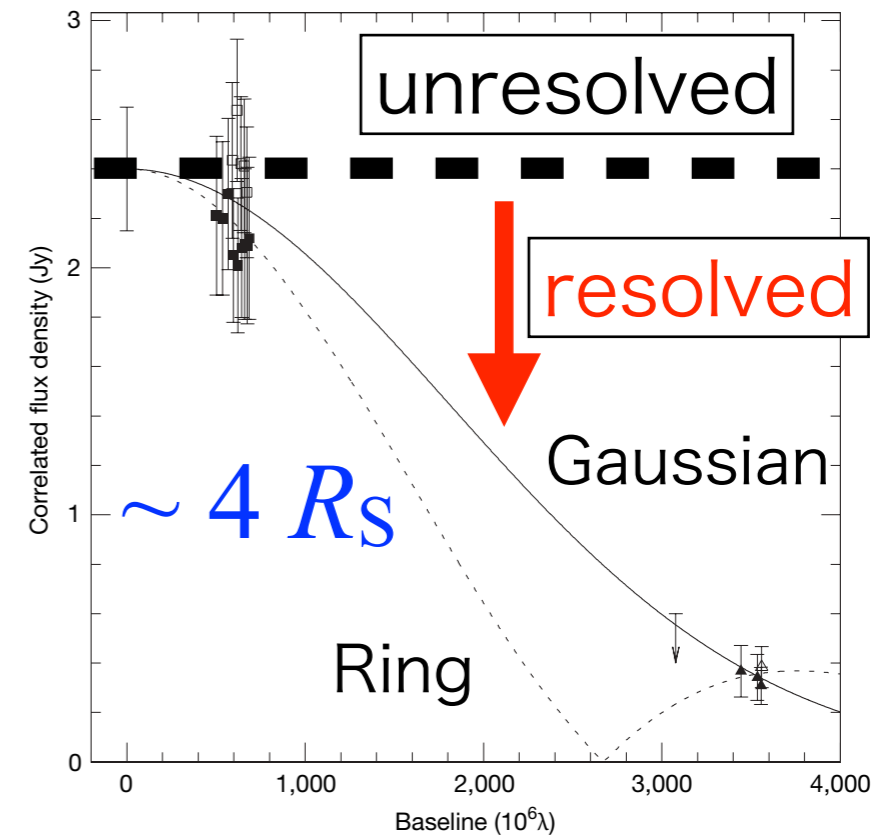
Source	BH Mass (M_{solar})	Distance (Mpc)	Angular radius of R_s (μas)
Sgr A* Galactic Center	4×10^6	0.008	10
M87 Virgo A	$3 - 6 \times 10^9$	17.8	3.6 - 7.3
M104 Sombrero Galaxy	1×10^9	10	2
Cen A	5×10^7	4	0.25



Results of Early Observations: Sgr A* ①

- Compact emission region
- Gaussian or ring models
- Compact emission is variable on ISCO scale.

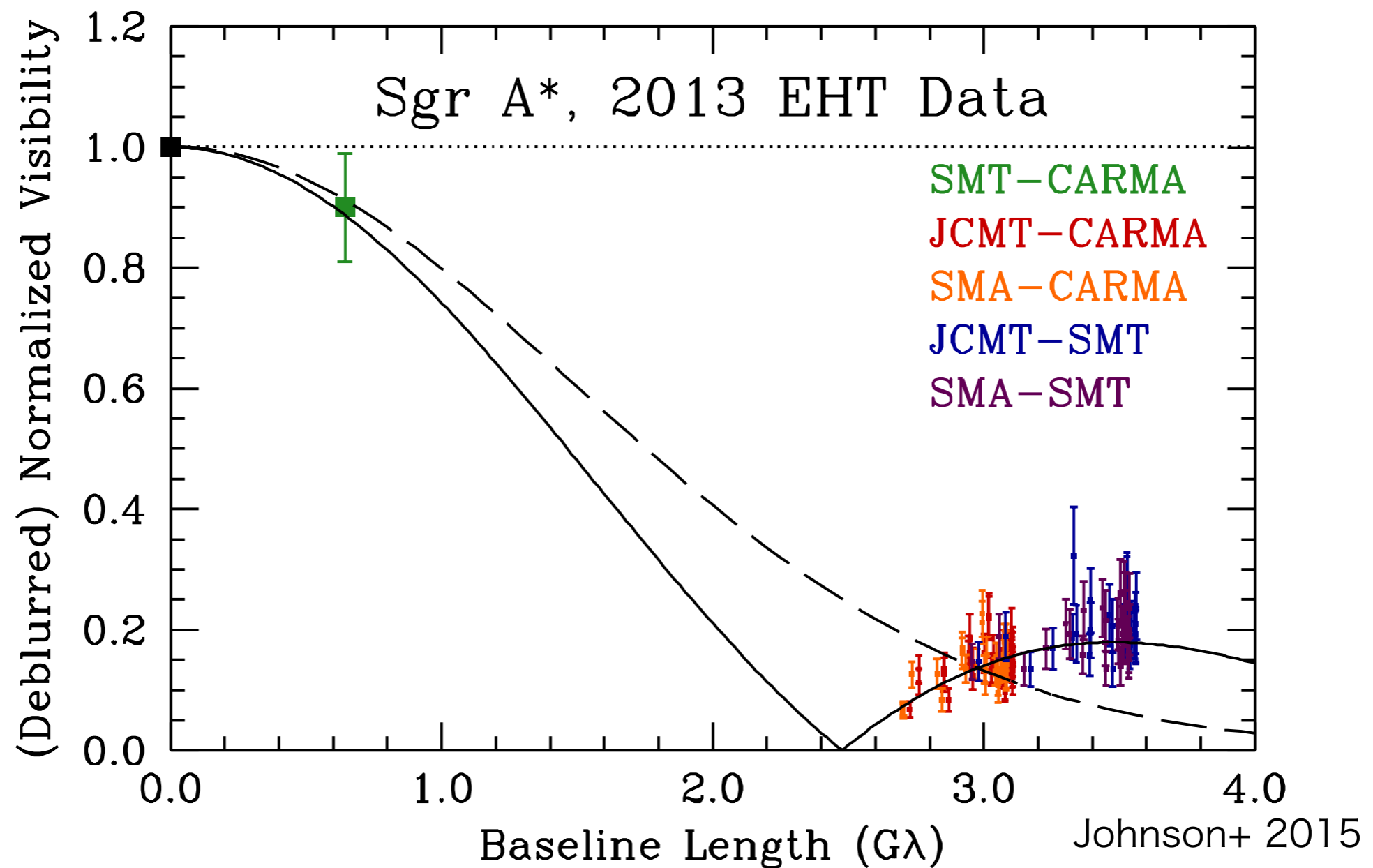
Doeleman+ 2008



Fish+ 2011

Results of Early Observations: Sgr A* ②

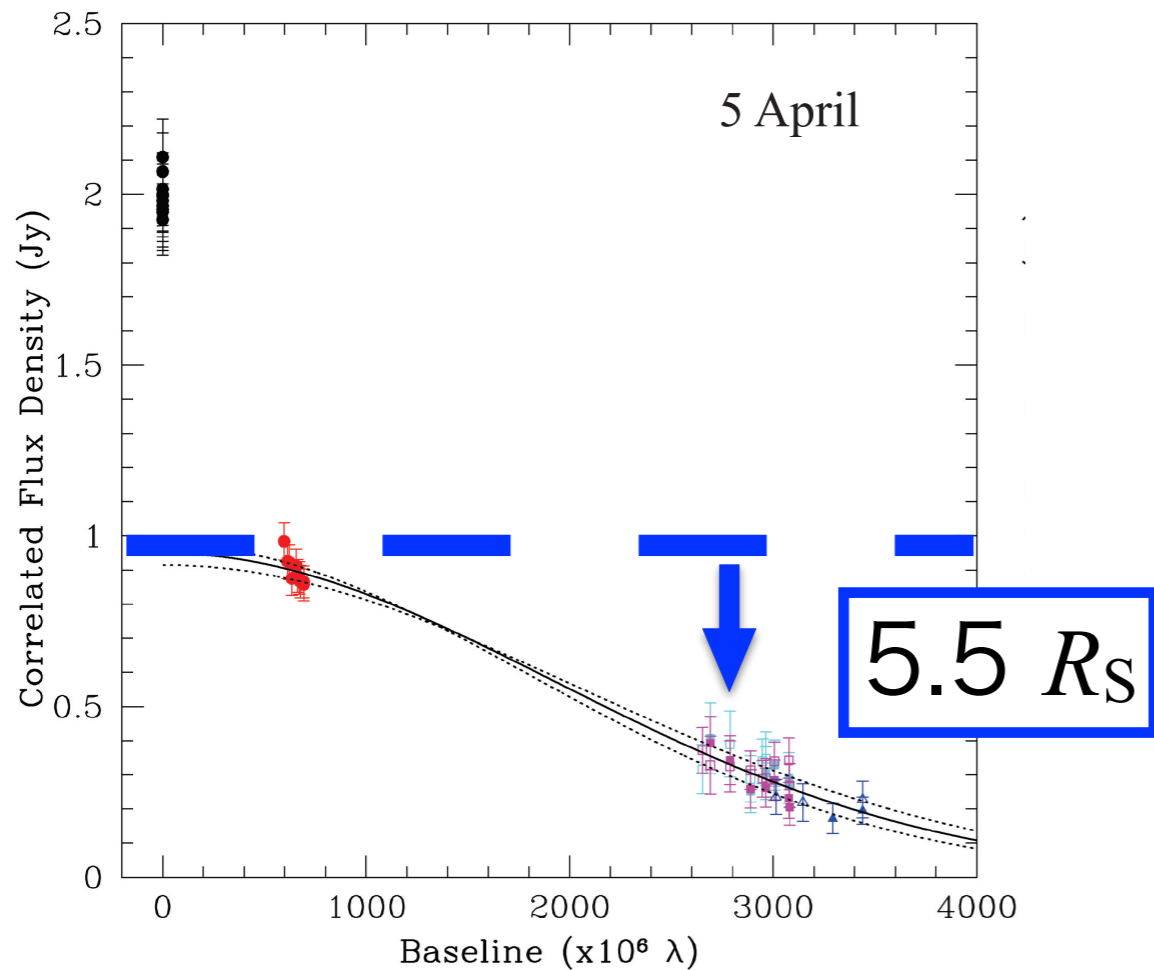
Discovery of non-Gaussianity in the structure



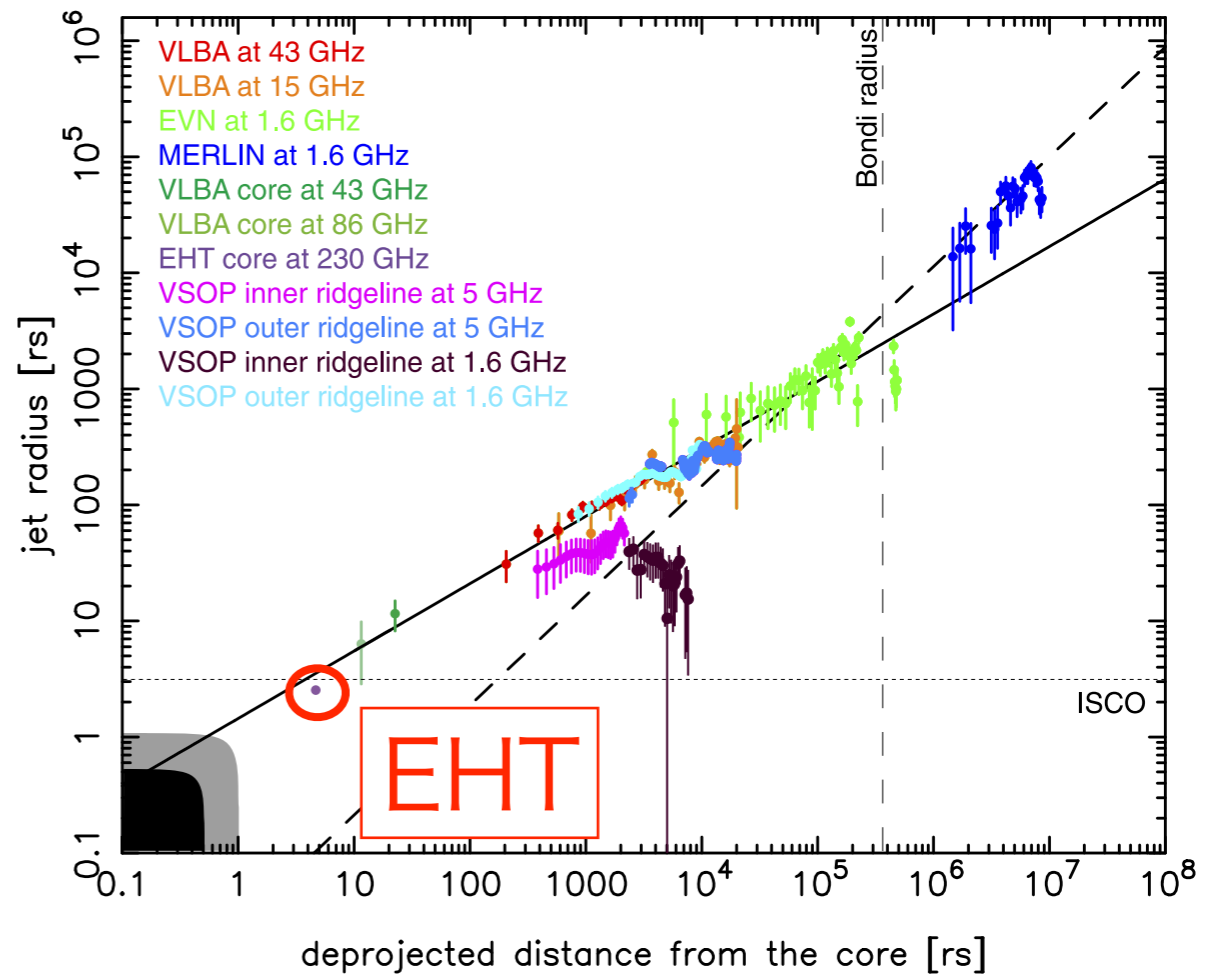
Results of Early Observations: M87 ①

The emission region is very compact.

Consistent with the parabolic collimation profile of the jet



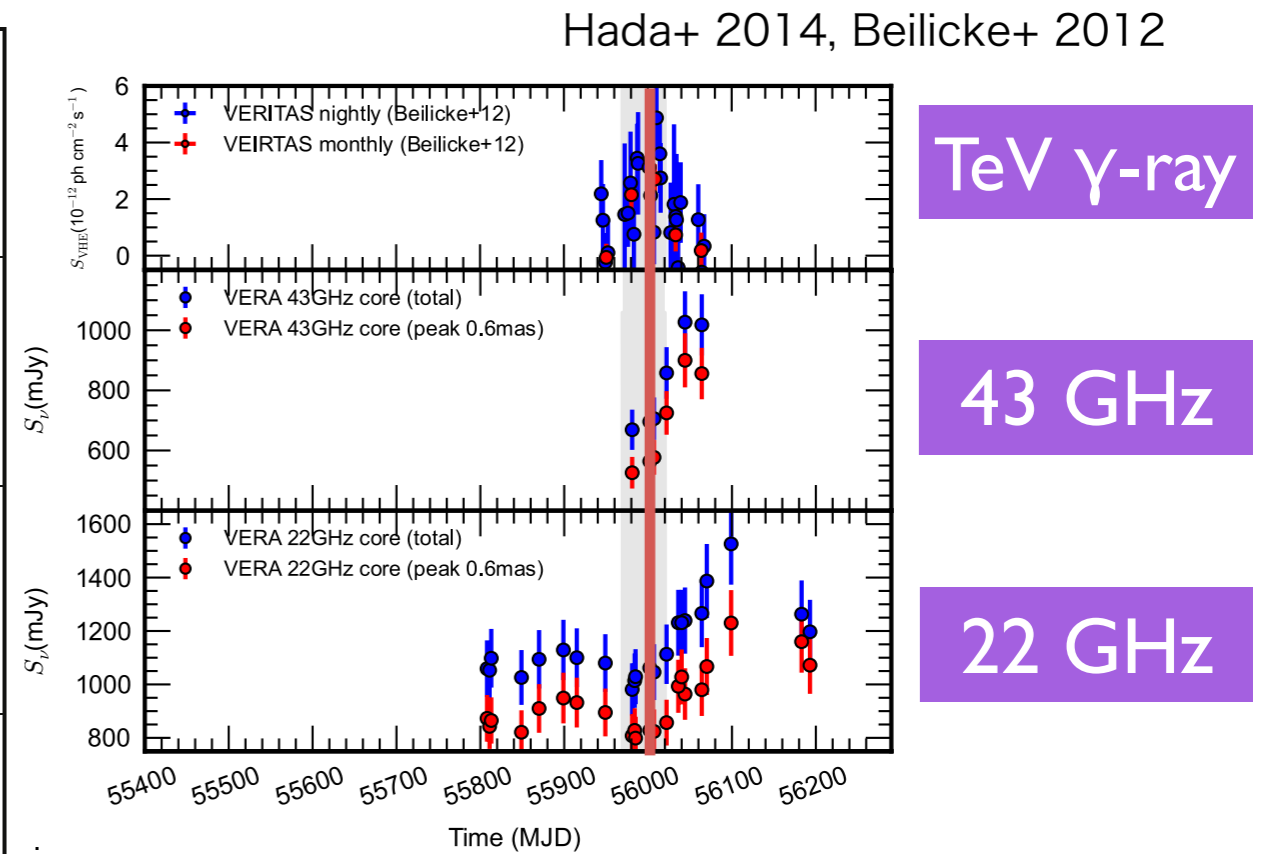
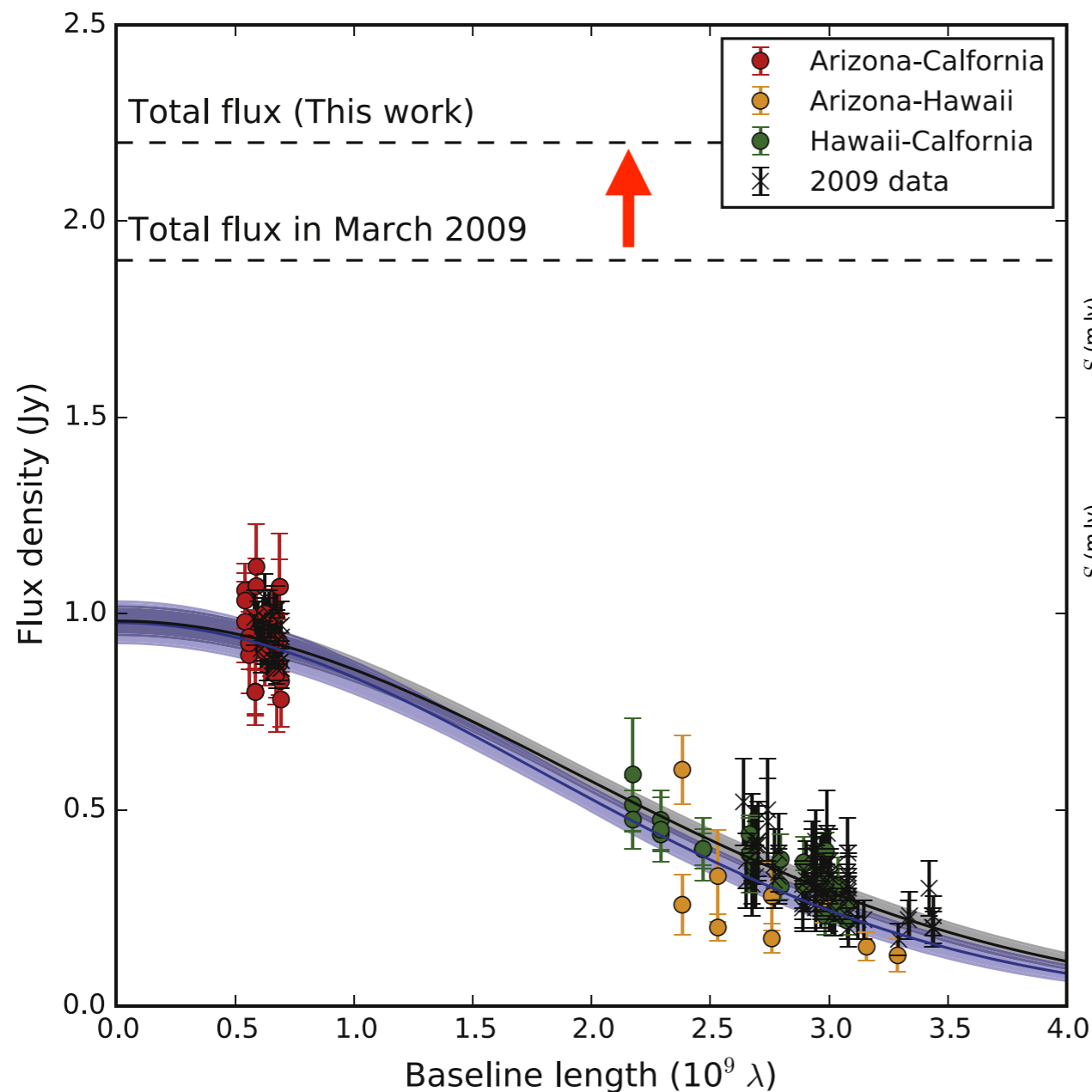
Doeleman+ 2012



Asada & Nakamura 2012, Doeleman et al. 2012
Nakamura & Asada 2013, Hada et al. 2013, 2016
Asada et al. 2016, Nakamura+ in prep.

Results of Early Observations: M87 ②

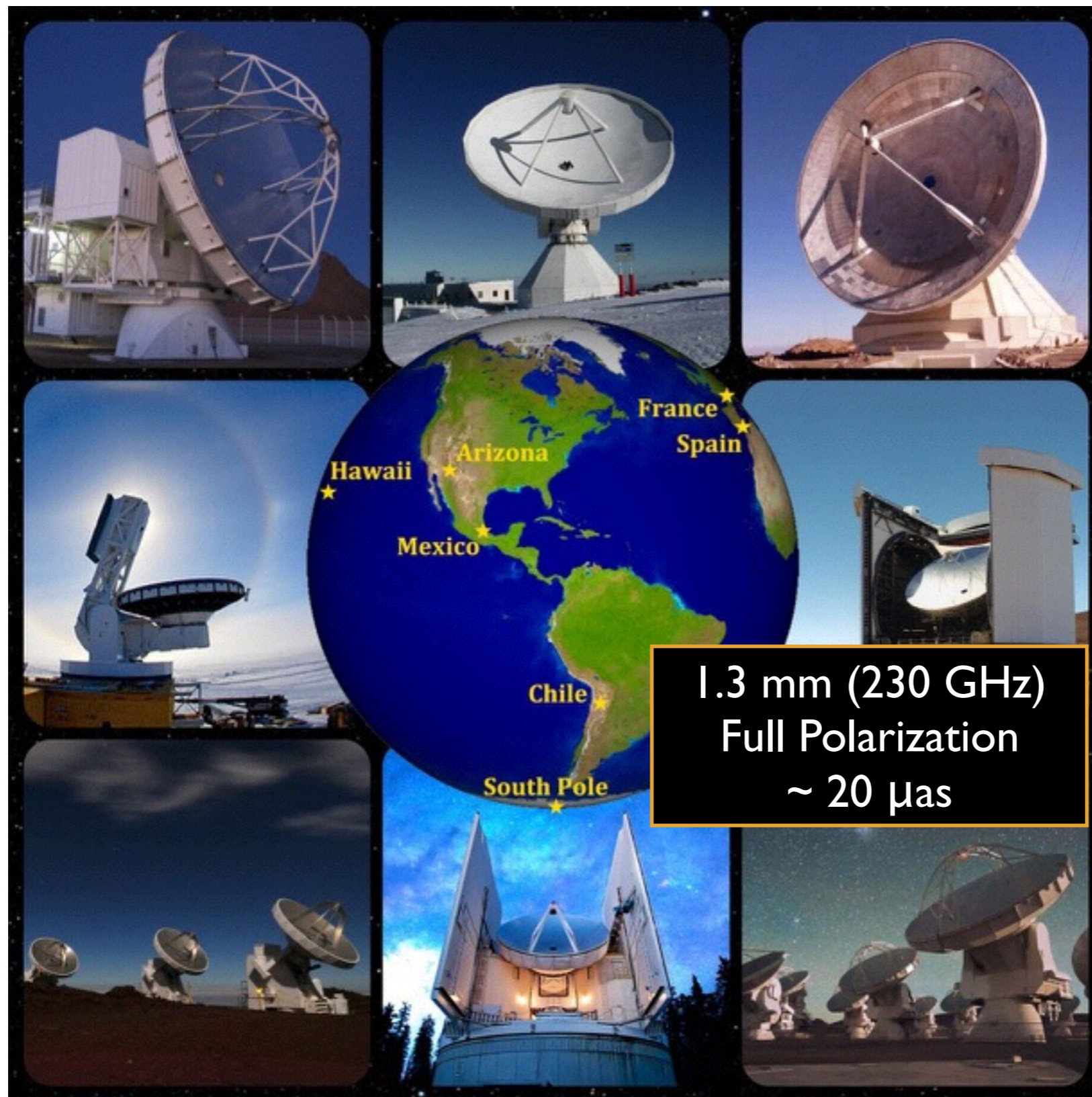
Event Horizon Scale structure is stable during an enhanced TeV gamma-ray state (2012)



TeV emission region $\sim 20 - 60 R_s$

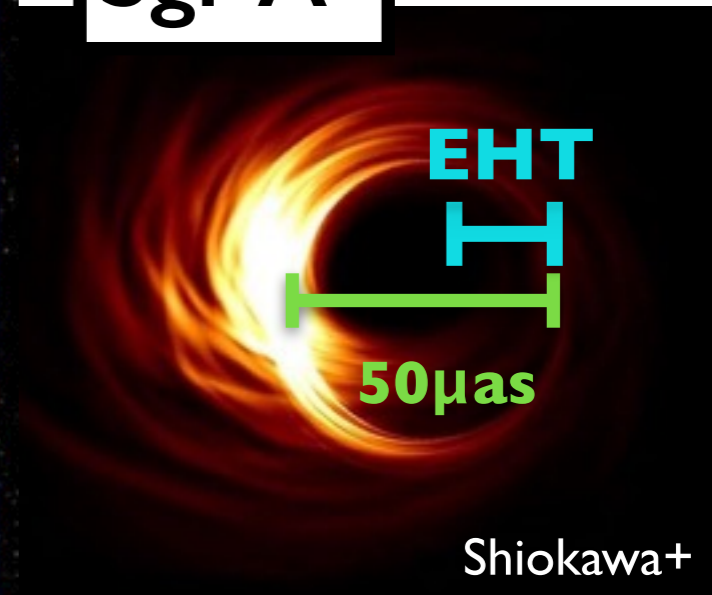
Akiyama+ 2015

Arrays in April 2017

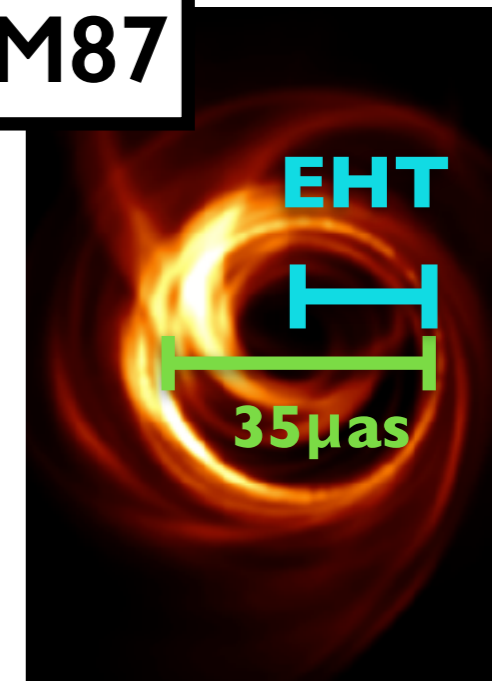


1.3 mm (230 GHz)
Full Polarization
~ 20 μs

Sgr A*



M87



Moscibrodka, Dexter+17

Additional telescopes in April 2017

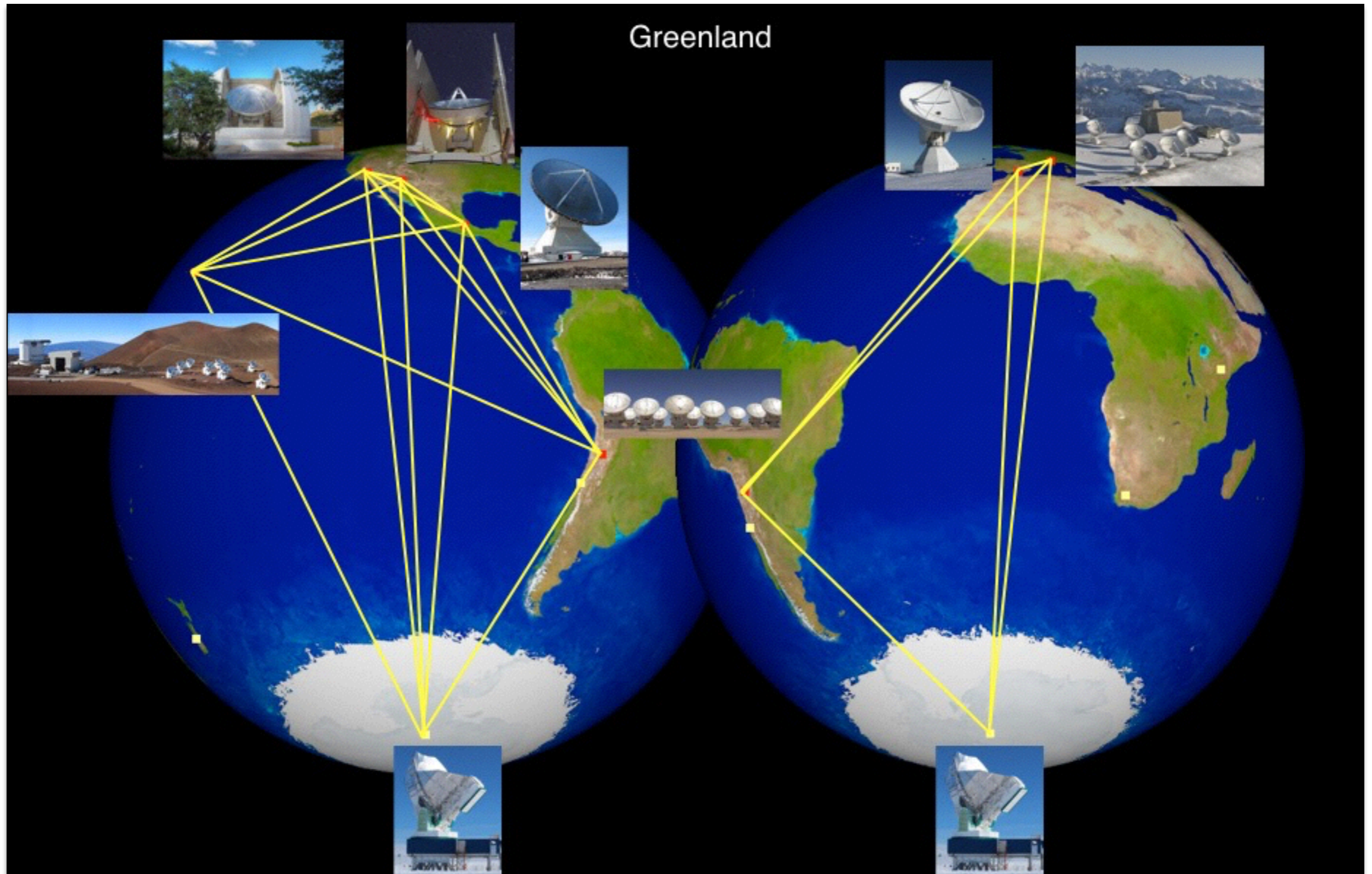
ALMA



SPT



Configuration in 2017/2018



Interviews in NHK and others

NHK



<http://www.nhk.or.jp/ohayou/digest/2017/04/0411.html>

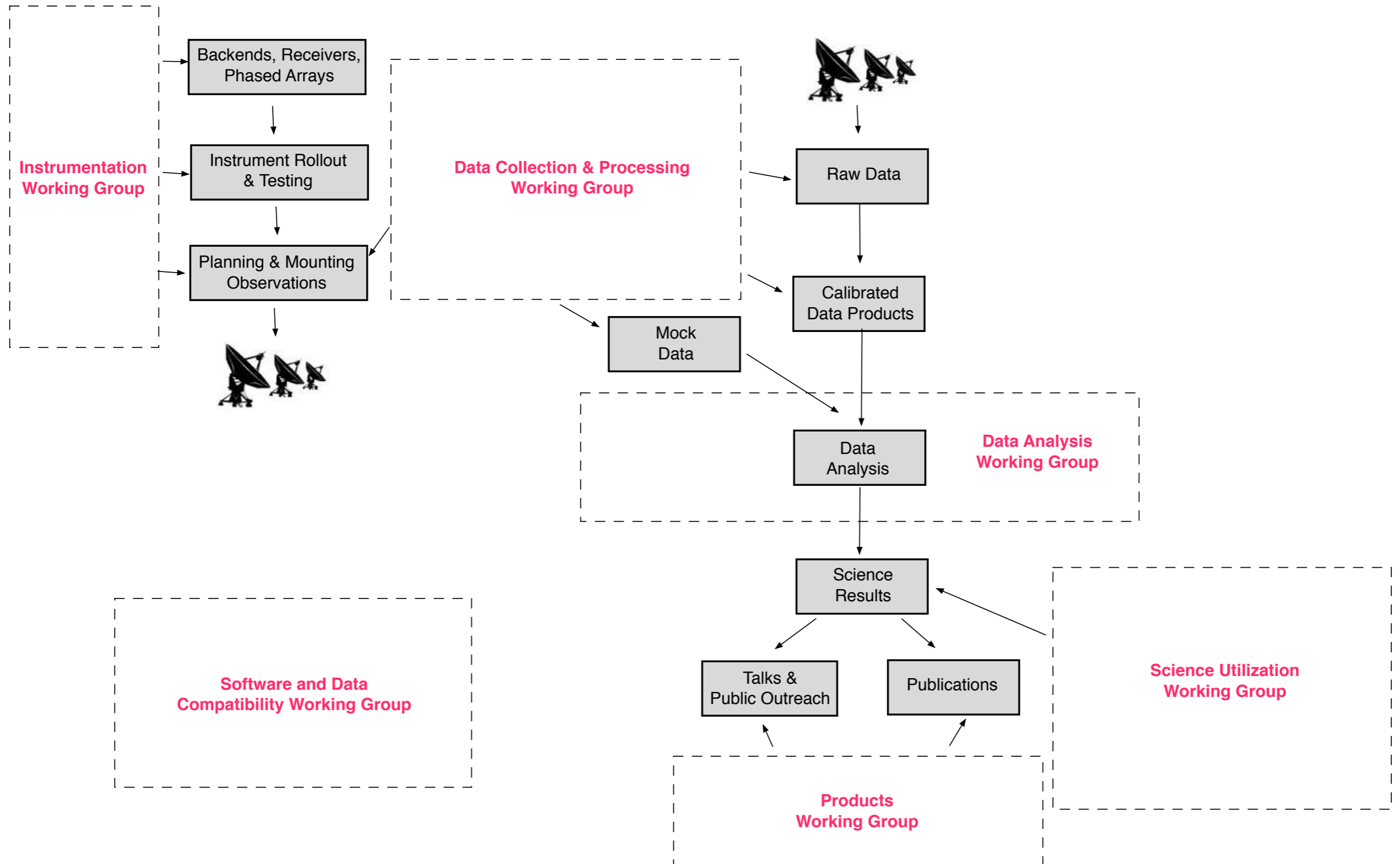
BBC



<http://www.bbc.com/news/science-environment-38937141>

Reduction and analysis of the 2017th data is ongoing.

EHT Working Teams



EHT Teams and Coordinators

EHT WORKING GROUP MEMBERSHIP – MARCH 1, 2017

Working Group	Task	Coordinating Members
Instrumentation	Instrumentation	Gopal Narayanan, Jonathan Weintraub
	Integration & Testing	Alan Roy, Andre Young, Satoki Matsushita
	Monitor & Control	Daan van Rossum, Nimesh Patel
Data Collection & Processing	Proposal Coordination	Michael Johnson, Eduardo Ros, Keiichi Asada, Sera Markoff, +MT
	Science Operations	Vincent Fish, Thomas Krichbaum
	Correlations	Walter Alef, Geoff Crew
	Synthetic Data Generation	Vincent Fish, Roger Dean
	Calibration & Error Analysis	Lindy Blackburn, Ilse van Bemmelen
Data Analysis	Imaging	Michael Johnson, Kazu Akiyama
	Scattering	Geoff Bower, Ramesh Narayan
	Time Variability	Dan Marrone, Atish Kamble
Near Horizon Science Utilization	Theoretical Models & Simulations	Charles Gammie, Yosuke Mizuno, Hung-Yi Pu
	Model Comparison & Feature Extraction	Feryal Ozel, Jason Dexter
	Parameter Definition	Heino Falcke, Keiichi Asada
Beyond Horizon Science Utilization	Multiwavelength Science	Sera Markoff, Kazuhiro Hada
	Active Galactic Nuclei	Thomas Krichbaum, Svetlana Jorstad, Neil Nagar

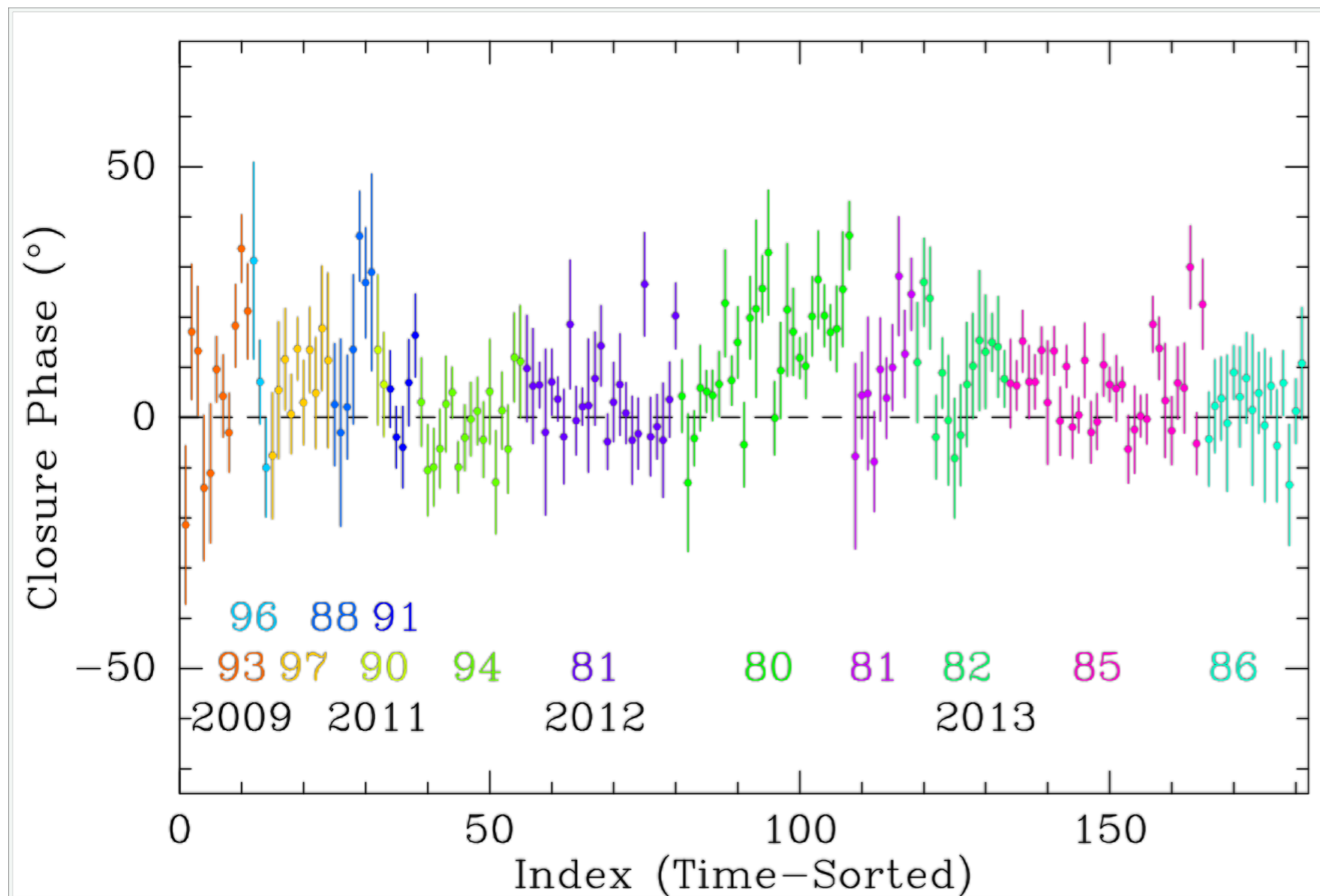
Summary

- The EHT project is progressing, and makes a lot of scientific results.
 - The compact region close to the black hole shadow is detected by EHT observations in Sgr A*. The region of this compact emission is in good agreement with the ring model.
 - There is a compact region in the jet of M87. The region was not associated with the gamma-ray variability.
- The 2017th observation was performed. The reduction and analysis is ongoing.

Backup

Results of Early Observations: Sgr A* ③

Discovery of asymmetry in the structure



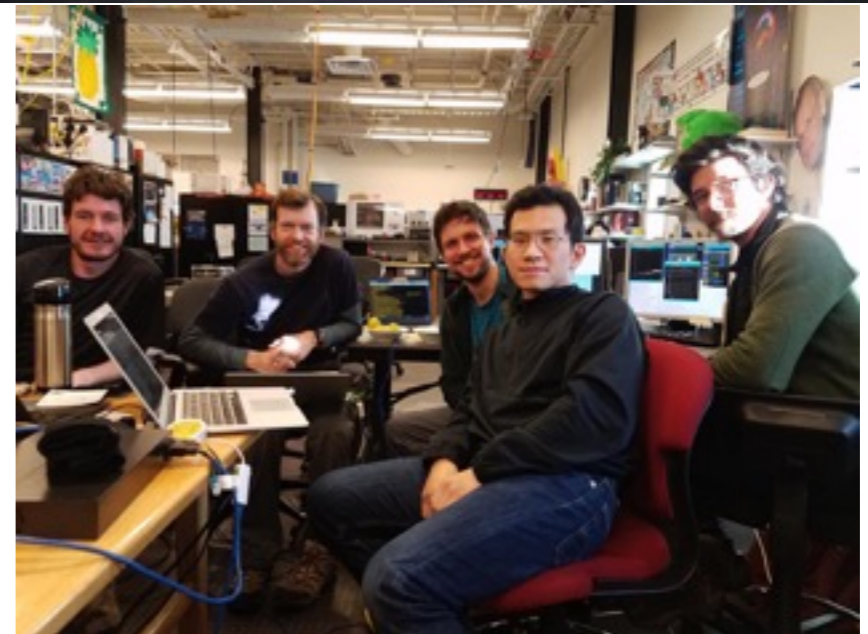
Fish+ 2016
Broderick+ 2016

Additional telescopes in April 2017

ALMA



SPT



List of Array

1. Arizona Radio Observatory (ARO)
2. Submillimeter-wave Astronomy (SMT)
3. Atacama Pathfinder EXperiment (APEX)
4. Atacama Submillimeter Telescope Experiment (ASTE)
5. IRAM 30-meter telescope
6. James Clerk Maxwell Telescope (JCMT)
7. The Large Millimeter Telescope (LMT)
8. The Submillimeter Array (SMA)
9. Atacama Large Millimeter/Submillimeter Array (ALMA)
10. South Pole Telescope