Summary of 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 $\mu$as @ 8 kpc

(Courtesy of Hung-Yi Pu)
# Sizes of Black-Hole Shadow

<table>
<thead>
<tr>
<th>Source</th>
<th>BH Mass ($M_{\odot}$)</th>
<th>Distance (Mpc)</th>
<th>Angular radius of $R_s$ ($\mu$as)</th>
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</thead>
<tbody>
<tr>
<td>Sgr A*</td>
<td>$4 \times 10^6$</td>
<td>0.008</td>
<td>10</td>
</tr>
<tr>
<td>Galactic Center</td>
<td></td>
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<tr>
<td>M87 Virgo A</td>
<td>$3 - 6 \times 10^9$</td>
<td>17.8</td>
<td>$3.6 - 7.3$</td>
</tr>
<tr>
<td>M104 Sombrero Galaxy</td>
<td>$1 \times 10^9$</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Cen A</td>
<td>$5 \times 10^7$</td>
<td>4</td>
<td>0.25</td>
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</table>
Results of Early Observations: Sgr A* ①

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

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)

Flux density (Jy)

Total flux (This work)

Total flux in March 2009

Baseline length ($10^9 \lambda$)

TeV γ-ray

43 GHz

22 GHz

TeV emission region ~ 20 - 60 $R_s$

Akiyama+ 2015

Hada+ 2014, Beilicke+ 2012

Flux density as a function of baseline length. Right panels: correlated flux density as a function of baseline length. Left panel: correlated flux density as a function of baseline length.
Arrays in April 2017

Sgr A*:
- EHT
- 50μas

M87:
- EHT
- 35μas

1.3 mm (230 GHz) Full Polarization
- ~ 20 μas

Moscibrodzka, Dexter+17
Additional telescopes in April 2017

ALMA

SPT
Configuration in 2017/2018
Interviews in NHK and others

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


Reduction and analysis of the 2017th data is ongoing.
EHT Working Teams

Instrumentation Working Group

- Backends, Receivers, Phased Arrays
- Instrument Rollout & Testing
- Planning & Mounting Observations

Data Collection & Processing Working Group

- Raw Data
- Calibrated Data Products
- Mock Data

Data Analysis Working Group

- Data Analysis
- Mock Data

- Science Results
- Talks & Public Outreach
- Publications

Science Utilization Working Group

Software and Data Compatibility Working Group

- Products Working Group
# EHT Teams and Coordinators

## EHT WORKING GROUP MEMBERSHIP — MARCH 1, 2017

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<td>Alan Roy, Andre Young, Satoki Matsushita</td>
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<td>Monitor &amp; Control</td>
<td>Daan van Rossum, Nimesh Patel</td>
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<td>Michael Johnson, Eduardo Ros, Keiichi Asada, Sera Markoff, +MT</td>
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<td>Science Operations</td>
<td>Vincent Fish, Thomas Krichbaum</td>
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<td>Active Galactic Nuclei</td>
<td>Thomas Krichbaum, Svetlana Jorstad, Neil Nagar</td>
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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 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