

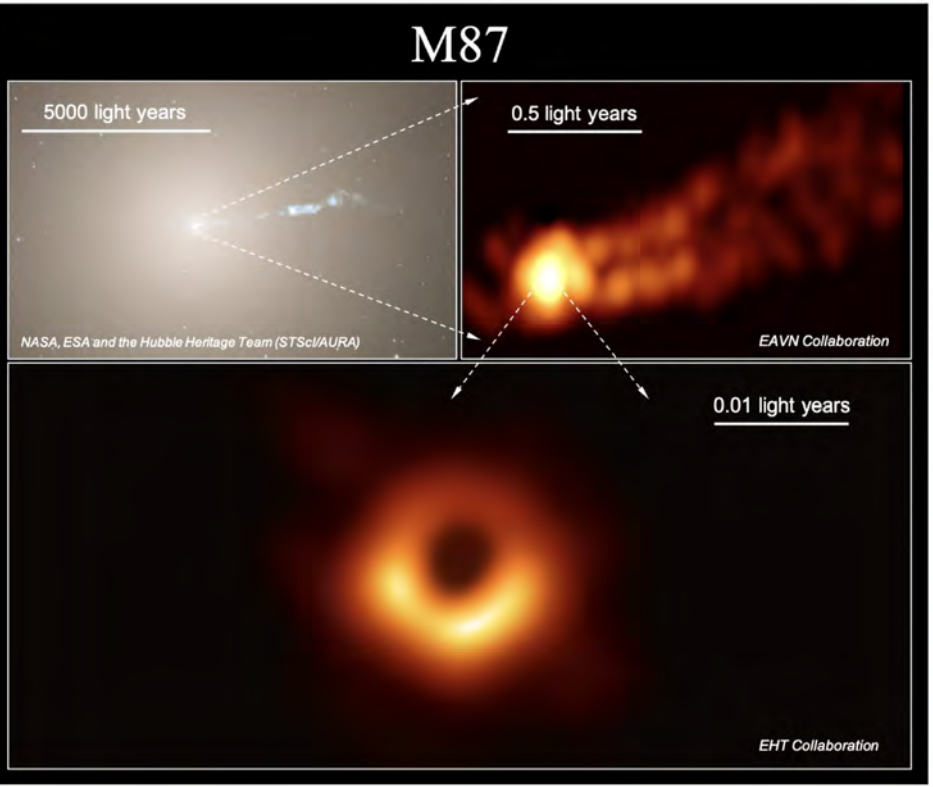
The Black Hole Explorer (BHEX): Mission Overview

Shoko Koyama (Niigata University)
On behalf of BHEX-Japan Science WG

EAMA11 @ Niigata, 2025 Dec. 12

Image: Joseph Farah

EHT captured the 2 largest black hole shadows!!

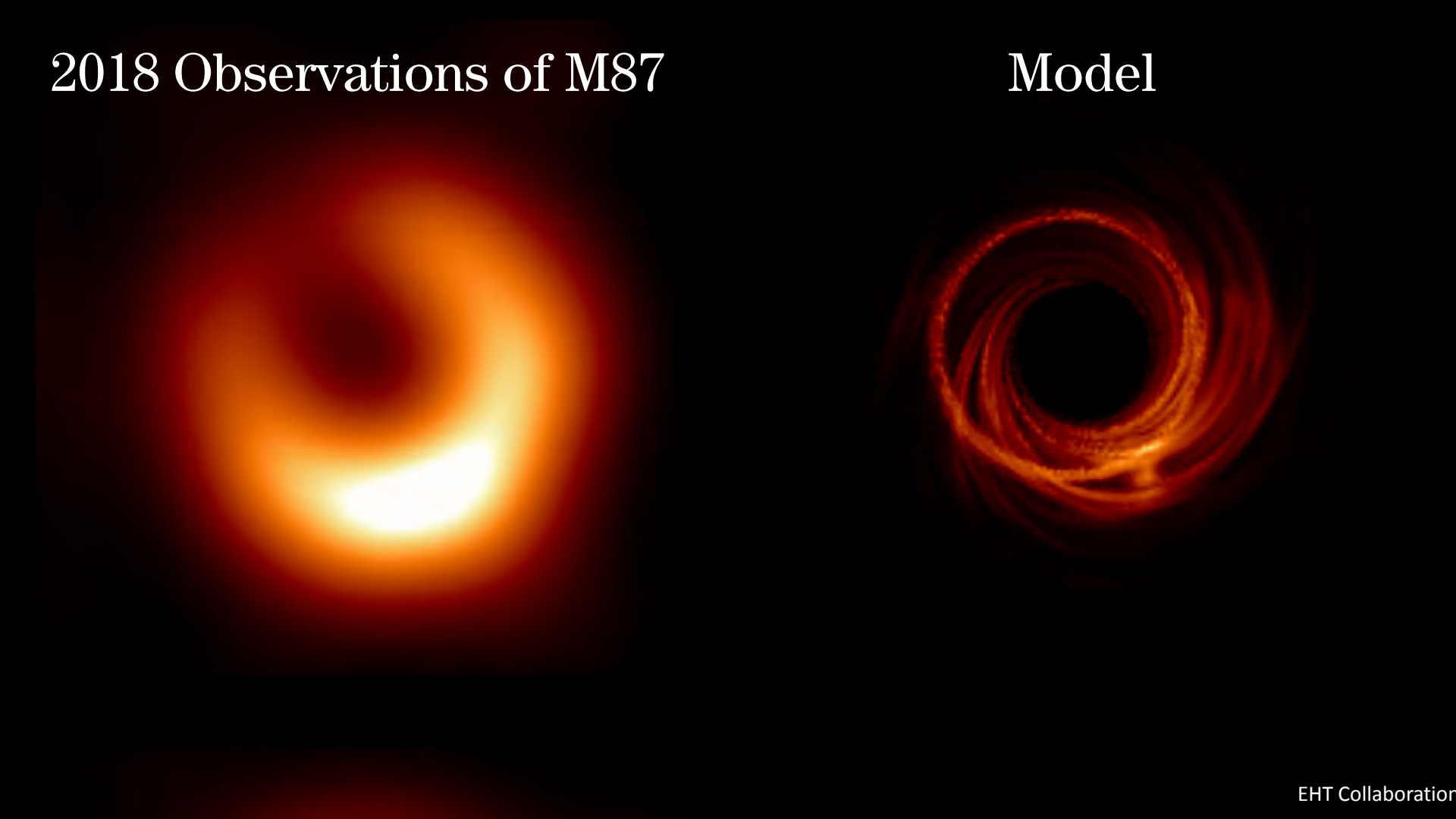




2017 Observations

2018 Observations of M87

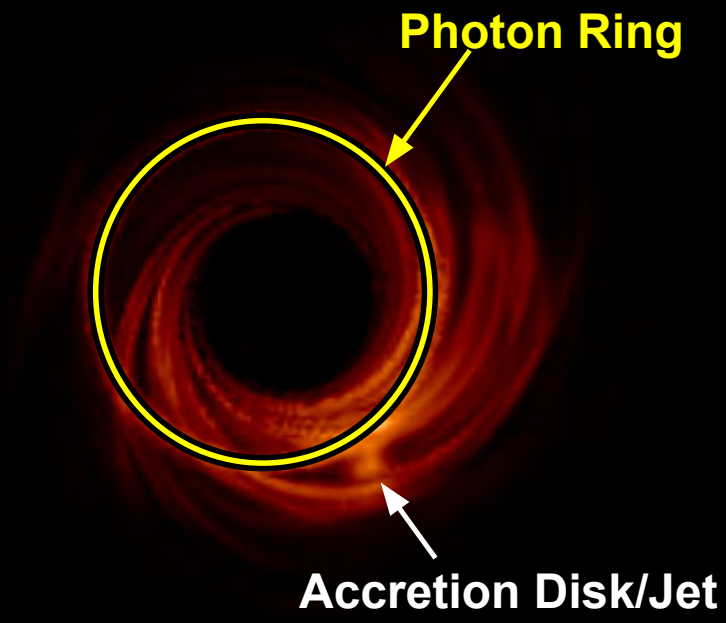
Model



EHT Collaboration

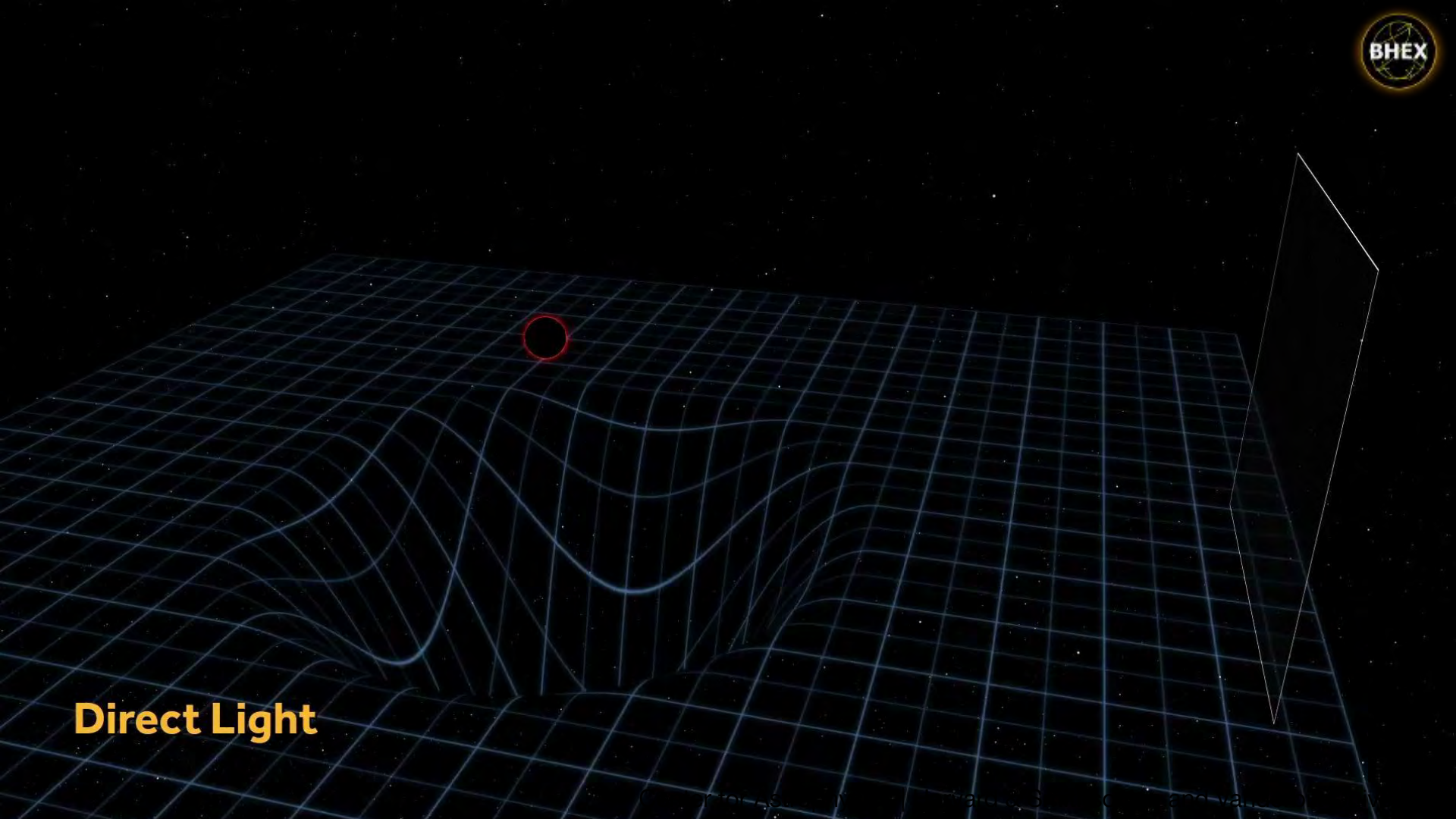
2018 Observations of M87

Model



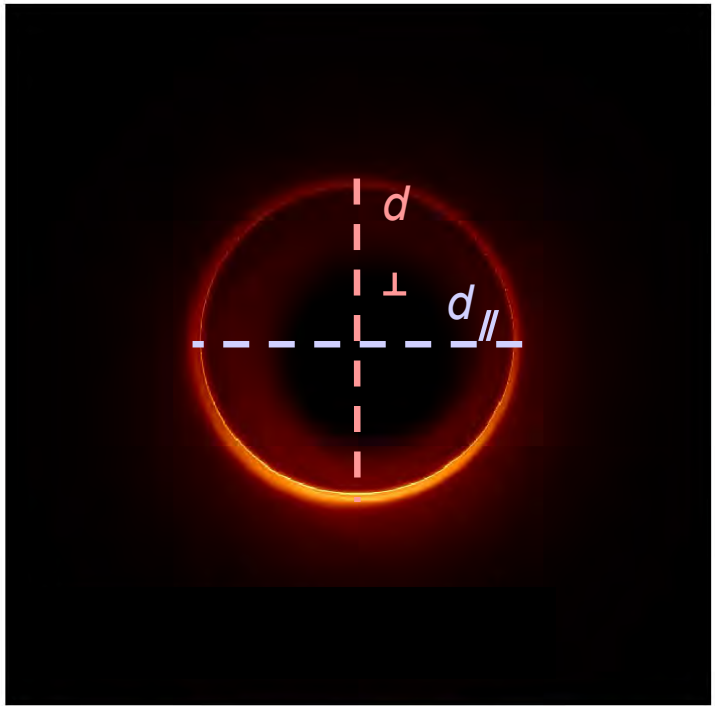
EHT resolution is not enough to separate the photon ring and the surrounding astrophysical emission

EHT Collaboration

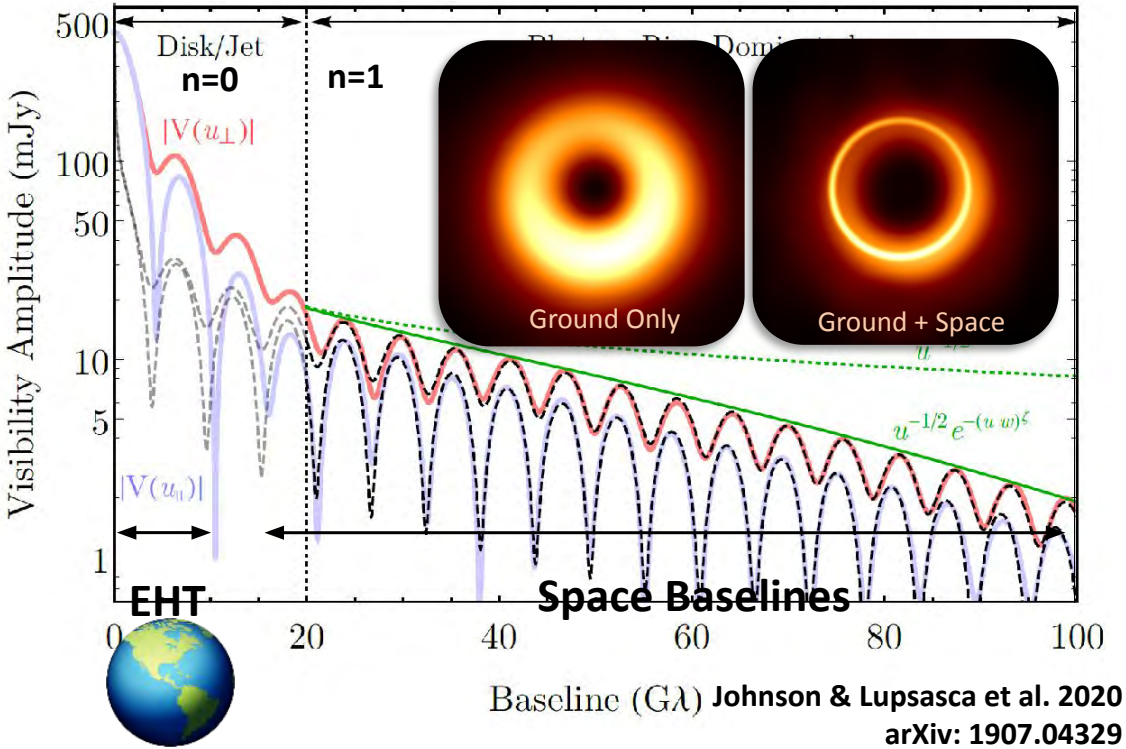

BHEX
Direct Light

Why Space? Long Baselines Isolate the Photon Ring!

Model



Simulated Visibilities

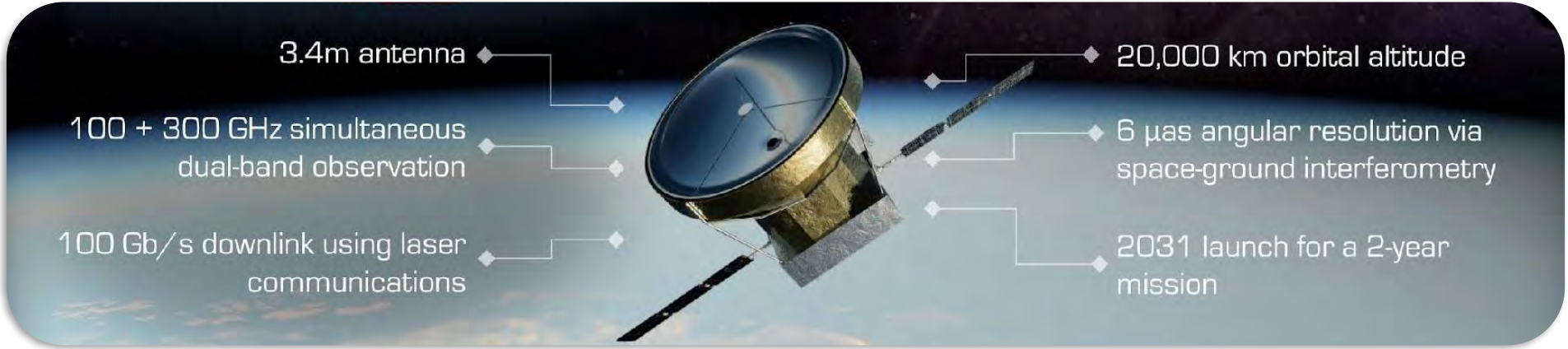


Johnson & Lupsasca et al. 2020
arXiv: 1907.04329

Longer ground-space baselines are dominated by the *n = 1* photon ring

A <u>single</u> long ground-space baseline can measure the photon ring!

The BHEX Mission



CENTER FOR ASTROPHYSICS HARVARD & SMITHSONIAN

THE UNIVERSITY OF ARIZONA

LINCOLN LABORATORY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VANDERBILT UNIVERSITY

JAXA

LOCKHEED MARTIN

BLACK HOLE INITIATIVE

NRAO National Radio Astronomy Observatory

MIT HAYSTACK OBSERVATORY

NAOJ National Astronomical Observatory of Japan

NIST

BHEX-Japan Science Working Group

JAXA/ISAS BHEX-JP WG was approved in 2025 June, ~50 members from ~20 institutions



K. Akiyama
MIT/NAOJ MIZ



M. Honma
NAOJ MIZ



A. Doi
ISAS/JAXA



Y. Uzawa
NAOJ ATC



K. Hada
Nagoya City U.



H. Nagai
NAOJ ALMA



Y. Akiyama
Yamaguchi U.



K. Niinuma

Project management, Cryocooler design study

SIS Prototyping

Ground station study

Demography

K. Akiyama



S. Koyama
Niigata U.



Y. Hagiwara
Toyo U.



T. Kawashima
Ichinoseki NCT



K. Ohsuga
Tsukuba U.



Y. Tsunetoe
SHAO



A. Higuchi
Musashino U



H. Sano
Gifu U.

AGN (observations)

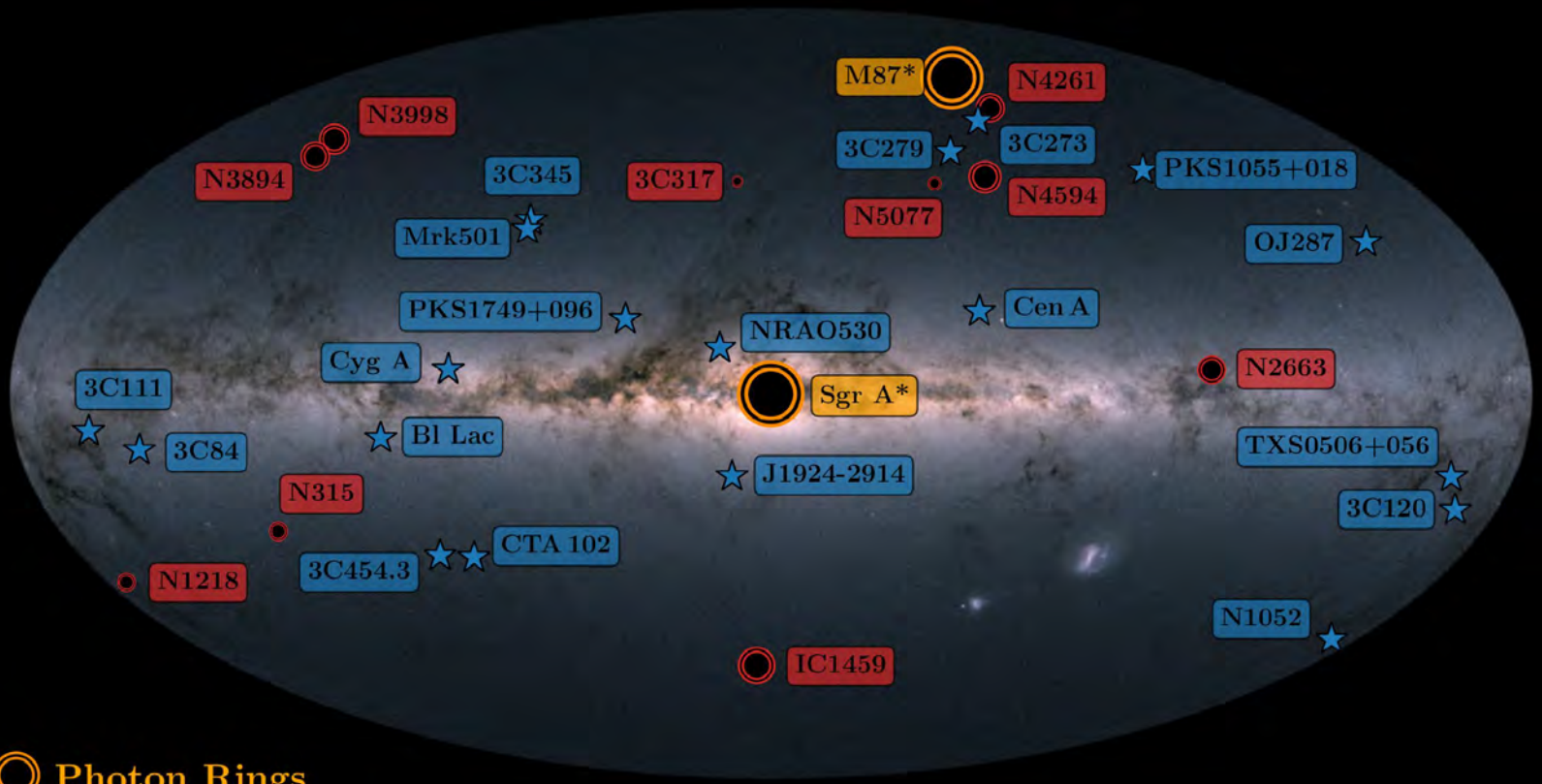
Photon Ring (theory)

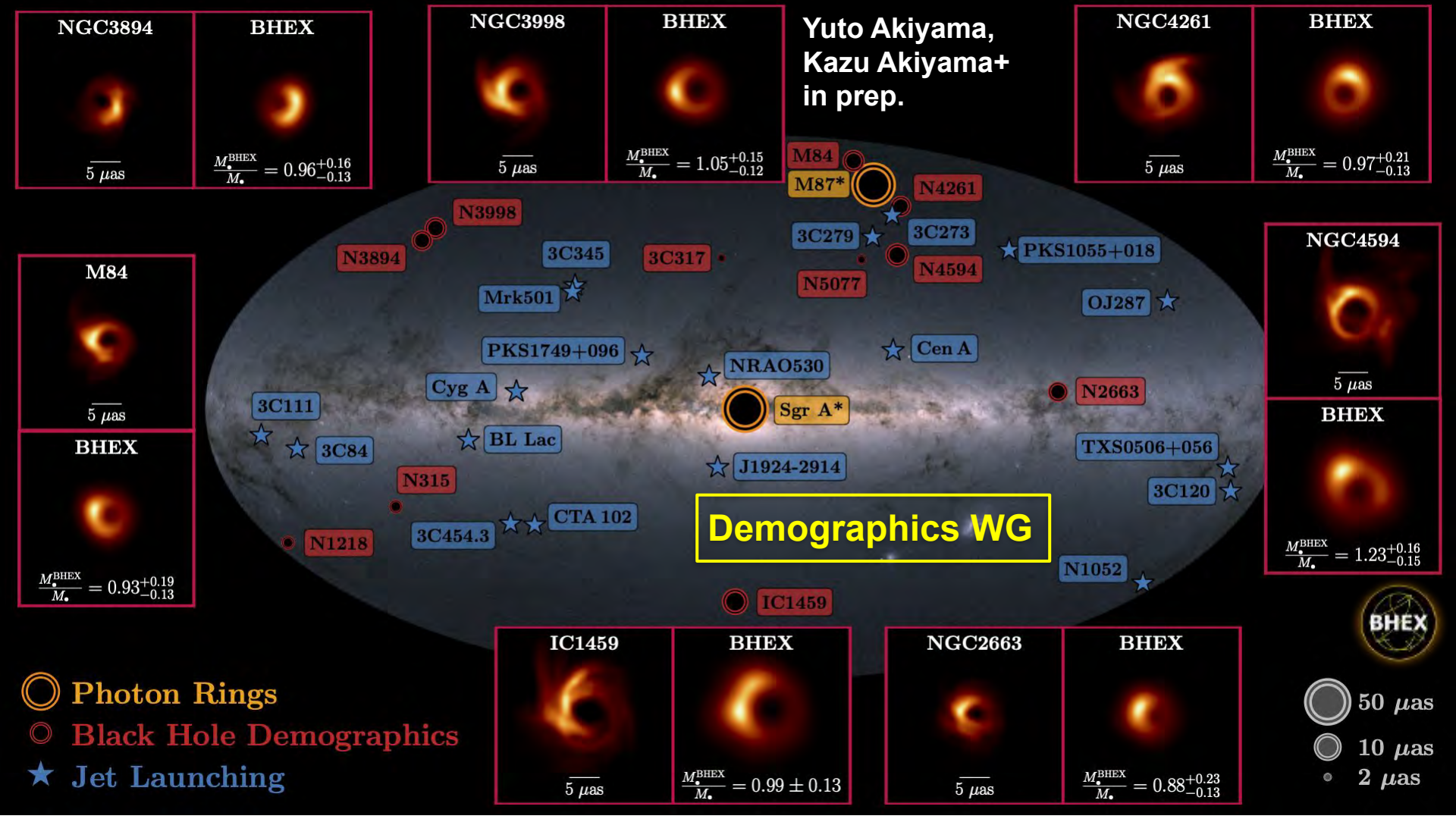
Single Dish

Image credit: M. Wielgus

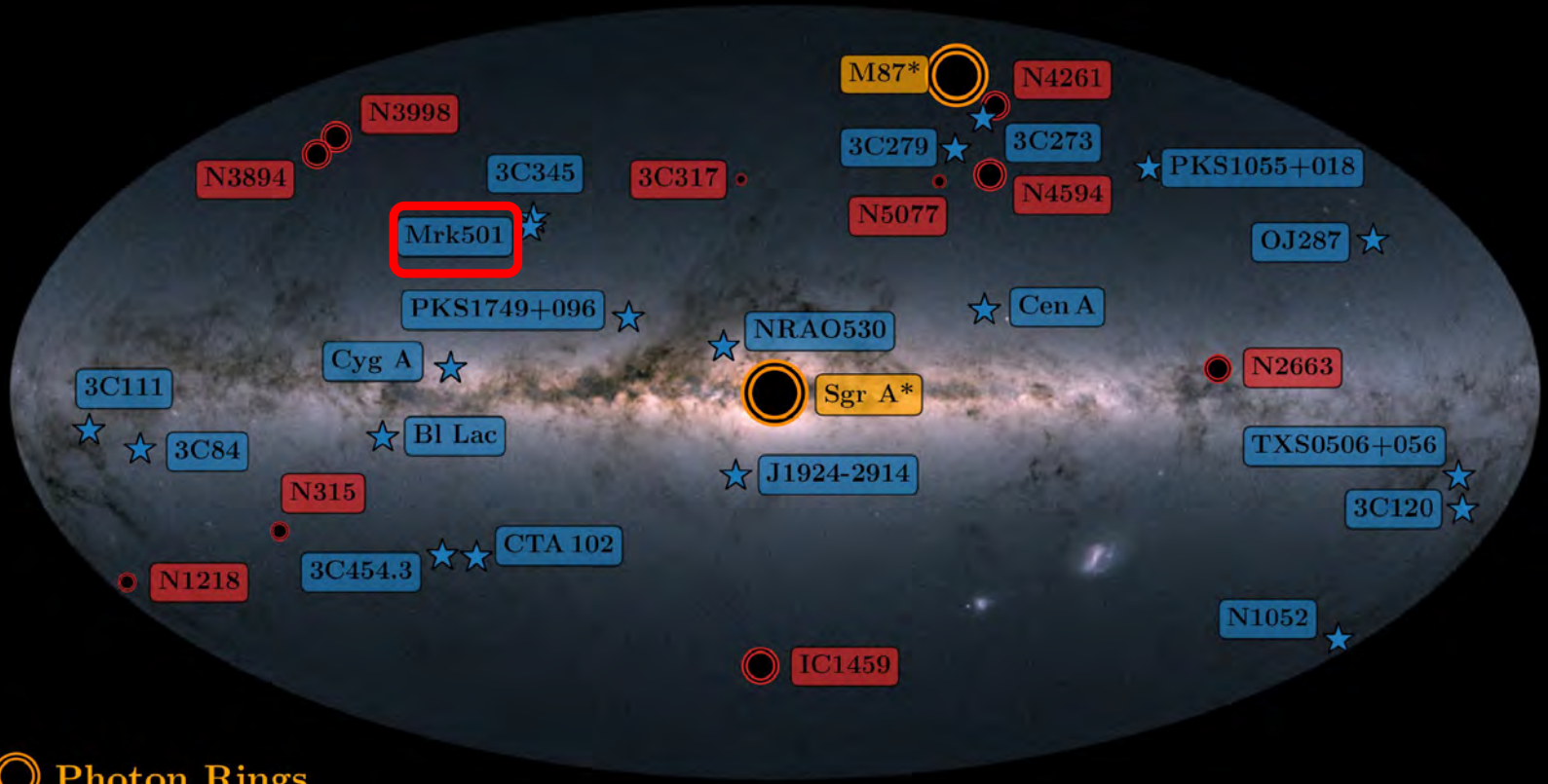
Johnson+24

BHEX: Revealing the Dynamic, Multi-Messenger Sky

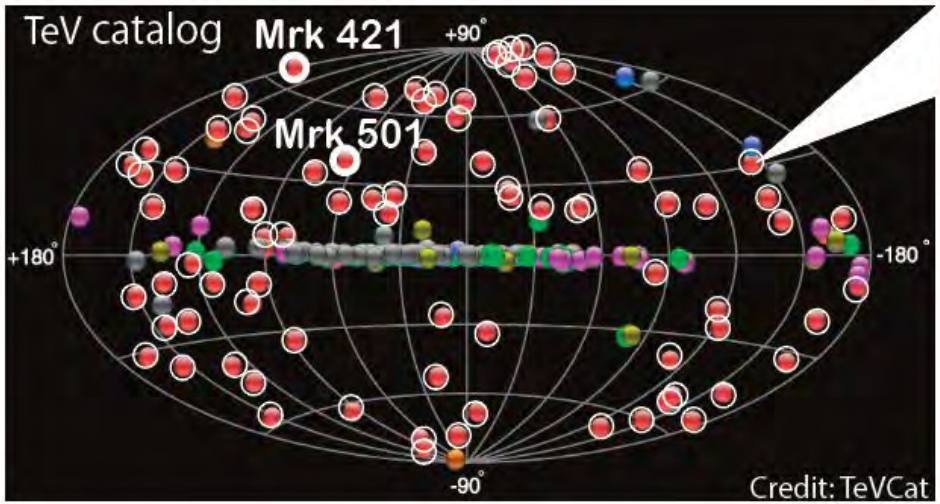


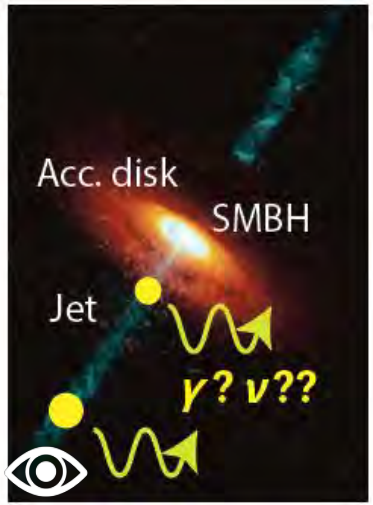

NGC3894
BHEX
5 μas
$\frac{M_\bullet^{\rm BHEX}}{M_\bullet} = 0.96^{+0.16}_{-0.13}$
NGC3998
BHEX
5 μas
$\frac{M_\bullet^{\rm BHEX}}{M_\bullet} = 1.05^{+0.15}_{-0.12}$
Yuto Akiyama,
Kazu Akiyama+
in prep.
NGC4261
BHEX
5 μas
$\frac{M_\bullet^{\rm BHEX}}{M_\bullet} = 0.97^{+0.21}_{-0.13}$
M84
5 μas
BHEX
$\frac{M_\bullet^{\rm BHEX}}{M_\bullet} = 0.93^{+0.19}_{-0.13}$
M84
M87*
N4261
3C279
3C273
PKS1055+018
N3998
N3894
3C345
3C317
N5077
N4594
Mrk501
OJ287
PKS1749+096
Cen A
NRAO530
Cyg A
N2663
3C111
Sgr A*
BL Lac
3C84
TXS0506+056
N315
J1924-2914
3C120
CTA 102
3C454.3
N1218
N1052
IC1459
Demographics WG
NGC4594
5 μas
BHEX
$\frac{M_\bullet^{\rm BHEX}}{M_\bullet} = 1.23^{+0.16}_{-0.15}$
BHEX
IC1459
BHEX
5 μas
$\frac{M_\bullet^{\rm BHEX}}{M_\bullet} = 0.99 \pm 0.13$
NGC2663
BHEX
5 μas
$\frac{M_\bullet^{\rm BHEX}}{M_\bullet} = 0.88^{+0.23}_{-0.13}$
Photon Rings
Black Hole Demographics
Jet Launching
50 μas
10 μas
2 μas

BHEX: Revealing the Dynamic, Multi-Messenger Sky

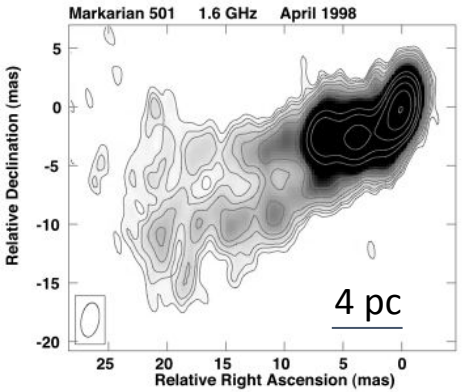


Core-size measurement of nearby γ-ray blazars





Mrk 501 with
VSOP 1.6 GHz



Giroletti+04

$$R \sim 1.3 \times 10^{17}\,\mathrm{cm} \left(\frac{\delta}{10}\right)\left(\frac{t_{\mathrm{var}}}{5\mathrm{days}}\right)$$

→ >~20 μas for Mrks 501
Mrk 501 was observed once with EHT 230 GHz in 2022

$$R \sim 1.3 \times 10^{16}\,\mathrm{cm} \left(\frac{\delta}{10}\right)\left(\frac{t_{\mathrm{var}}}{0.5\mathrm{days}}\right)$$

e.g., Abdo+11, Hirashita+16

→ ~6 μas for Mrks 501 → BHEX 230/345 GHz

BHEX can potentially resolve the intra-day variable high-energy emission region
Locating it through multi-wavelength monitoring of these sources

The Black Hole Explorer

BHEX is a mission to extend submillimeter interferometry into space, delivering the sharpest images

- First direct imaging of a supermassive black hole's photon ring
- Targeting a 2026 NASA Small Explorers proposal, to launch after 2031
- JAXA BHEX Working Group was formally approved and established this year

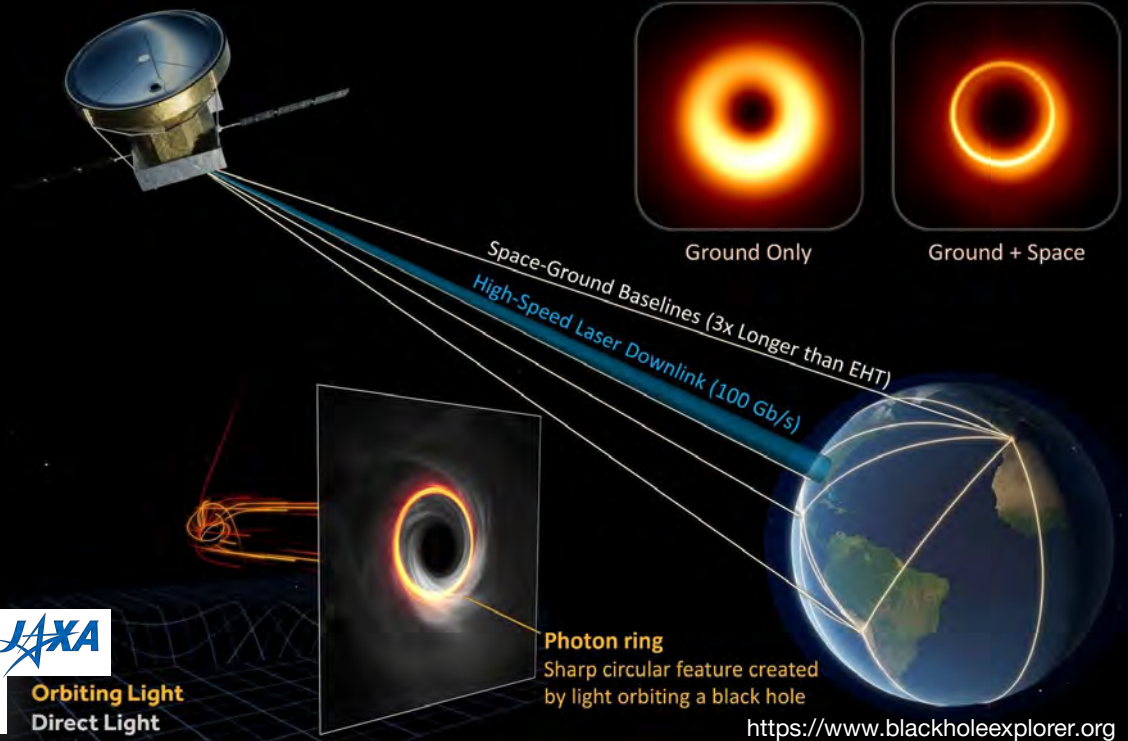
We greatly appreciate the support from Asia!!

Science Goals

- Discover a black hole's photon ring
- Make direct measurements of a black hole's mass and spin
- Reveal the shadows of a population of supermassive black holes

Necessary Parameters for Space-VLBI

- High radio frequencies (>100 GHz)
- Orbits of at least ~20,000 km
- High-speed (~100 Gb/s) downlink



https://www.blackholeexplorer.org