

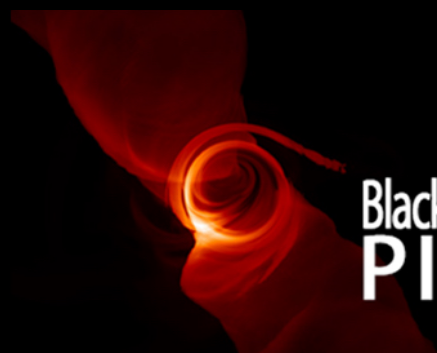
M87

The Sharpened View of AGN with the Event Horizon Telescope

Dimitrios Psaltis
& The EHT Collaboration

Georgia Tech

Sgr A*

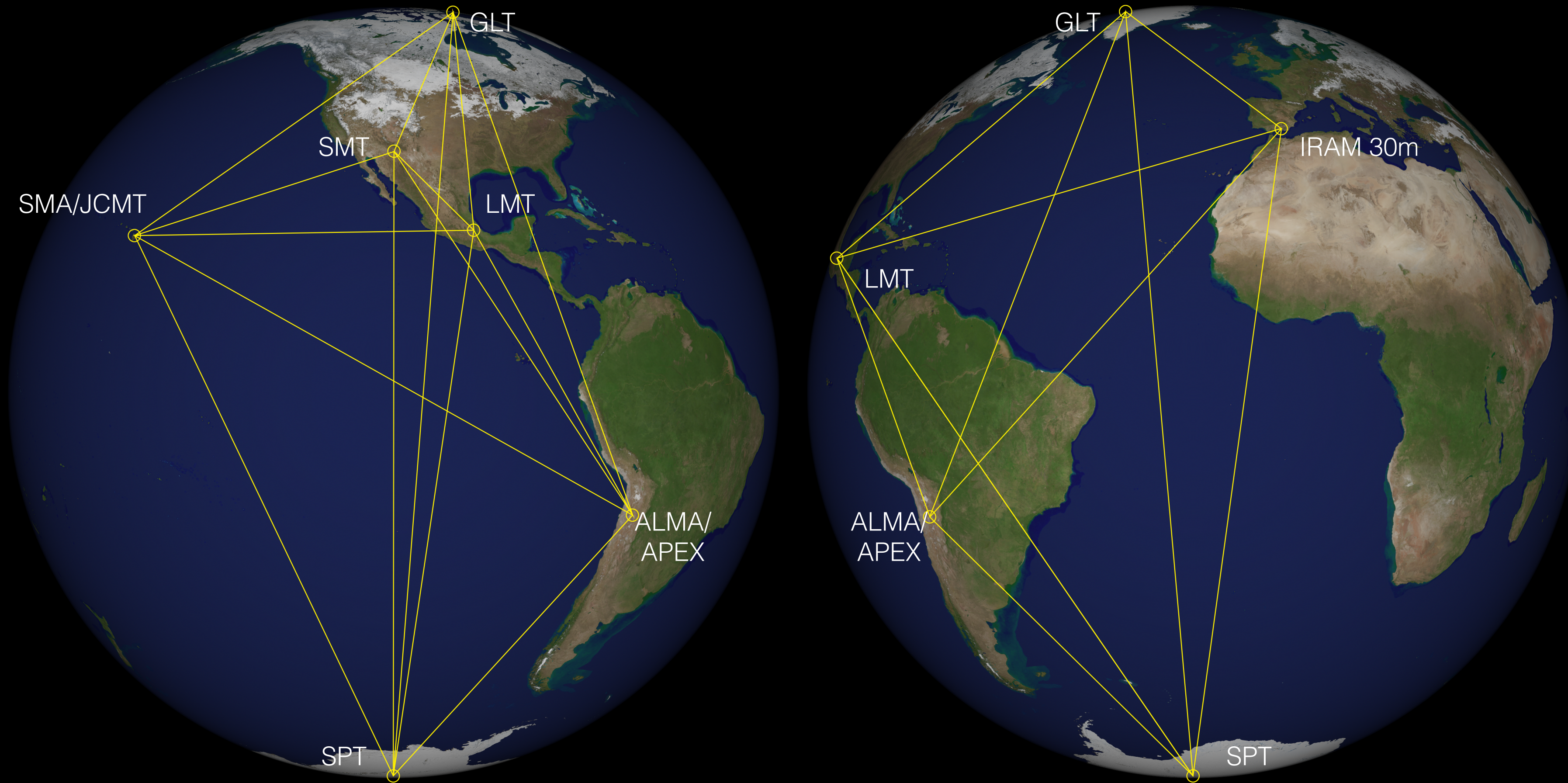


Black Hole
PIRE



Event Horizon Telescope

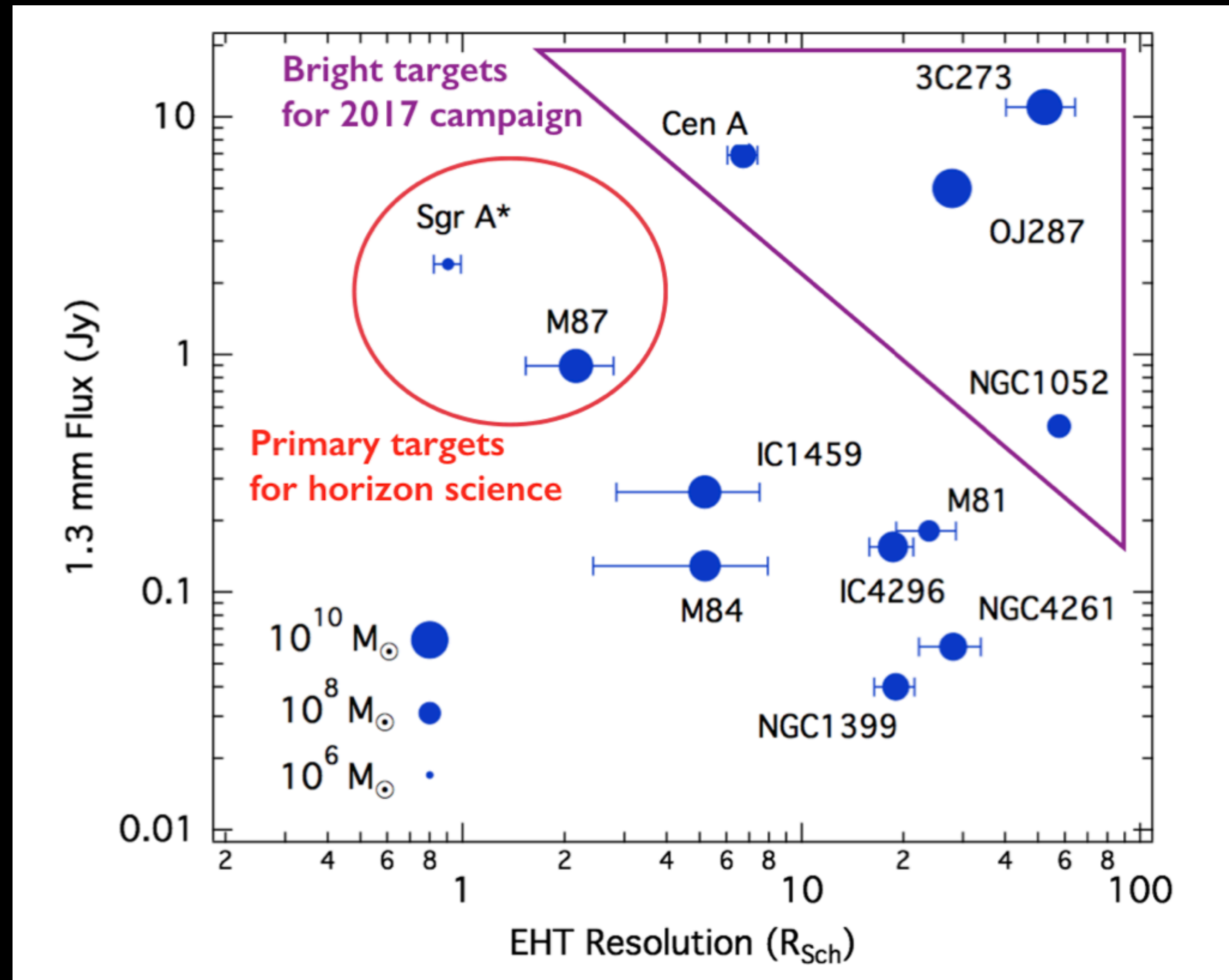
The Event Horizon Telescope in 2018-2021



credit D. Marrone (UA)

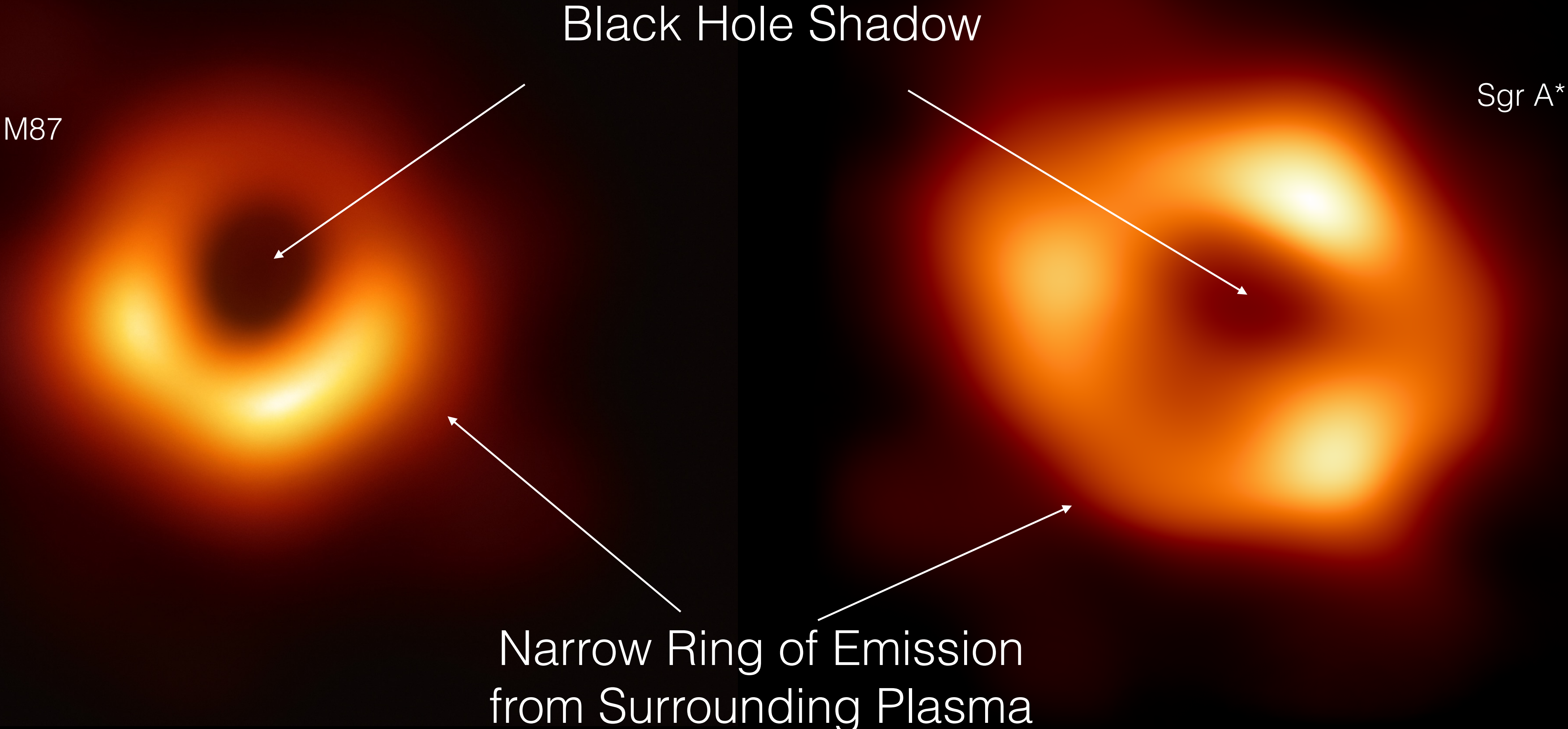


The targets of the 2017 Campaign

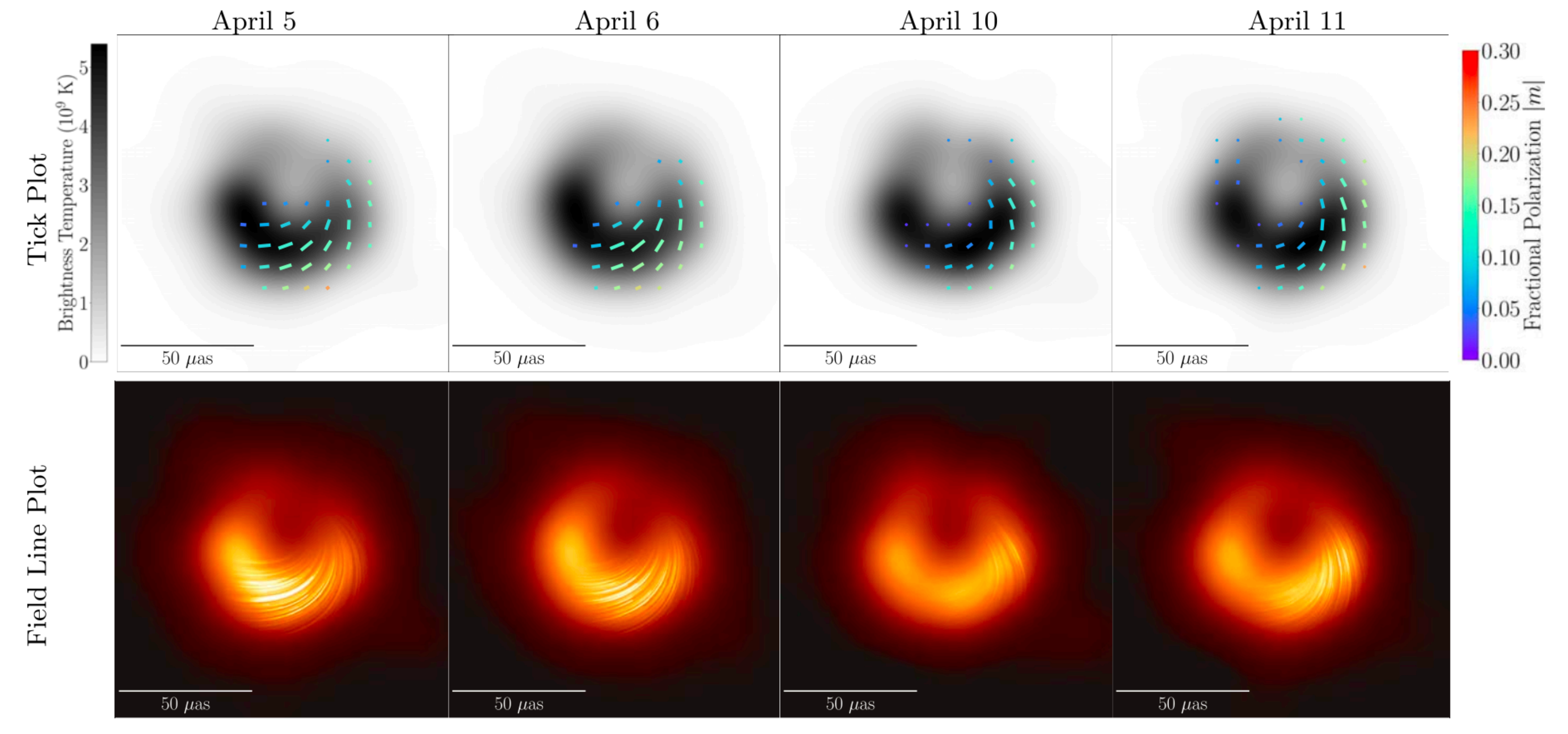


Psaltis 2019

What I will not talk about today:



What I will not talk about today (II):



EHT M87 Paper VII, VIII 2021

Polarization of the M87 Image

Multiwavelength imaging of the M87 jet

Algaba et al. 2021

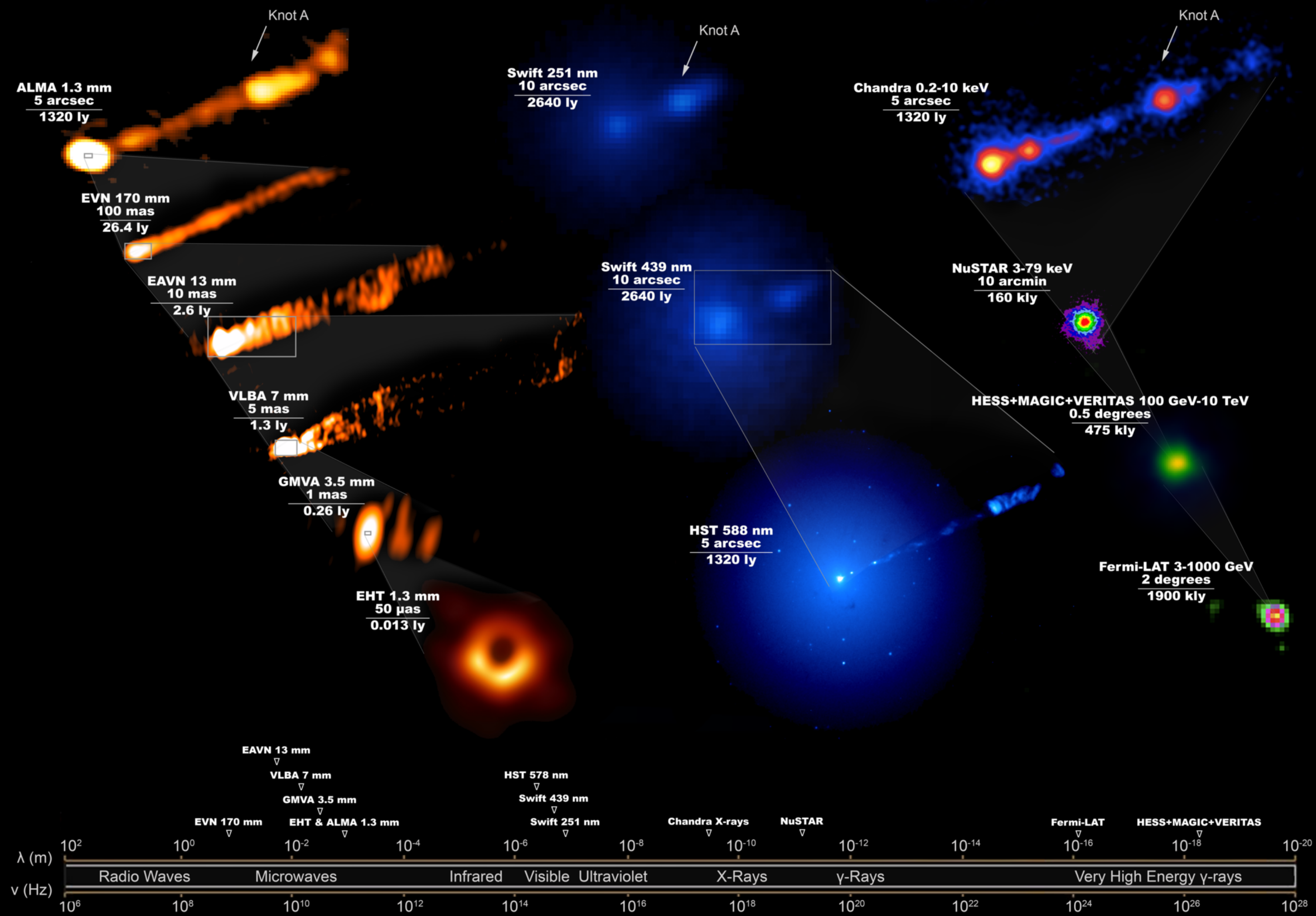
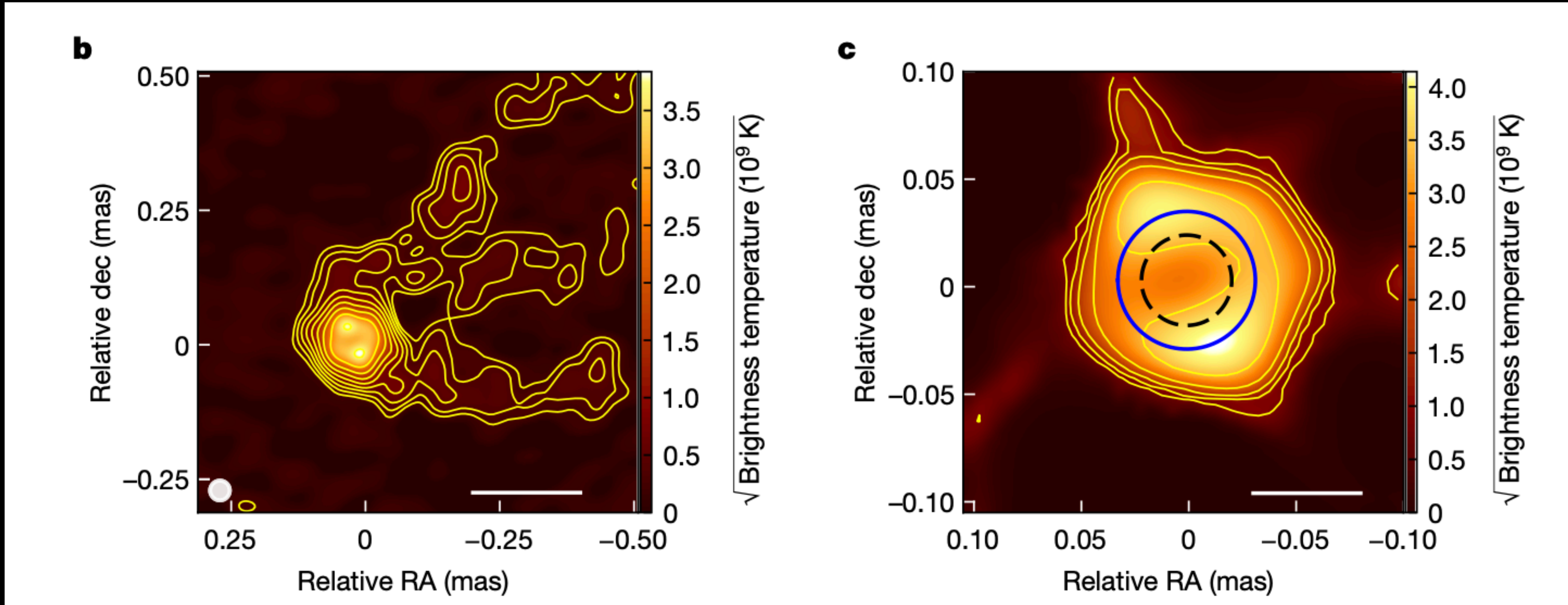


Image Credit: The EHT Multi-wavelength Science Working Group; the EHT Collaboration; ALMA (ESO/NAOJ/NRAO); the EVN; the EAVN Collaboration; VLBA (NRAO); the GMVA; the Hubble Space Telescope; the Neil Gehrels Swift Observatory; the Chandra X-ray Observatory; the Nuclear Spectroscopic Telescope Array; the Fermi-LAT Collaboration; the H.E.S.S. collaboration; the MAGIC collaboration; the VERITAS collaboration; NASA and ESA. Composition by J. C. Algaba



Connecting the jet to horizon-scale images

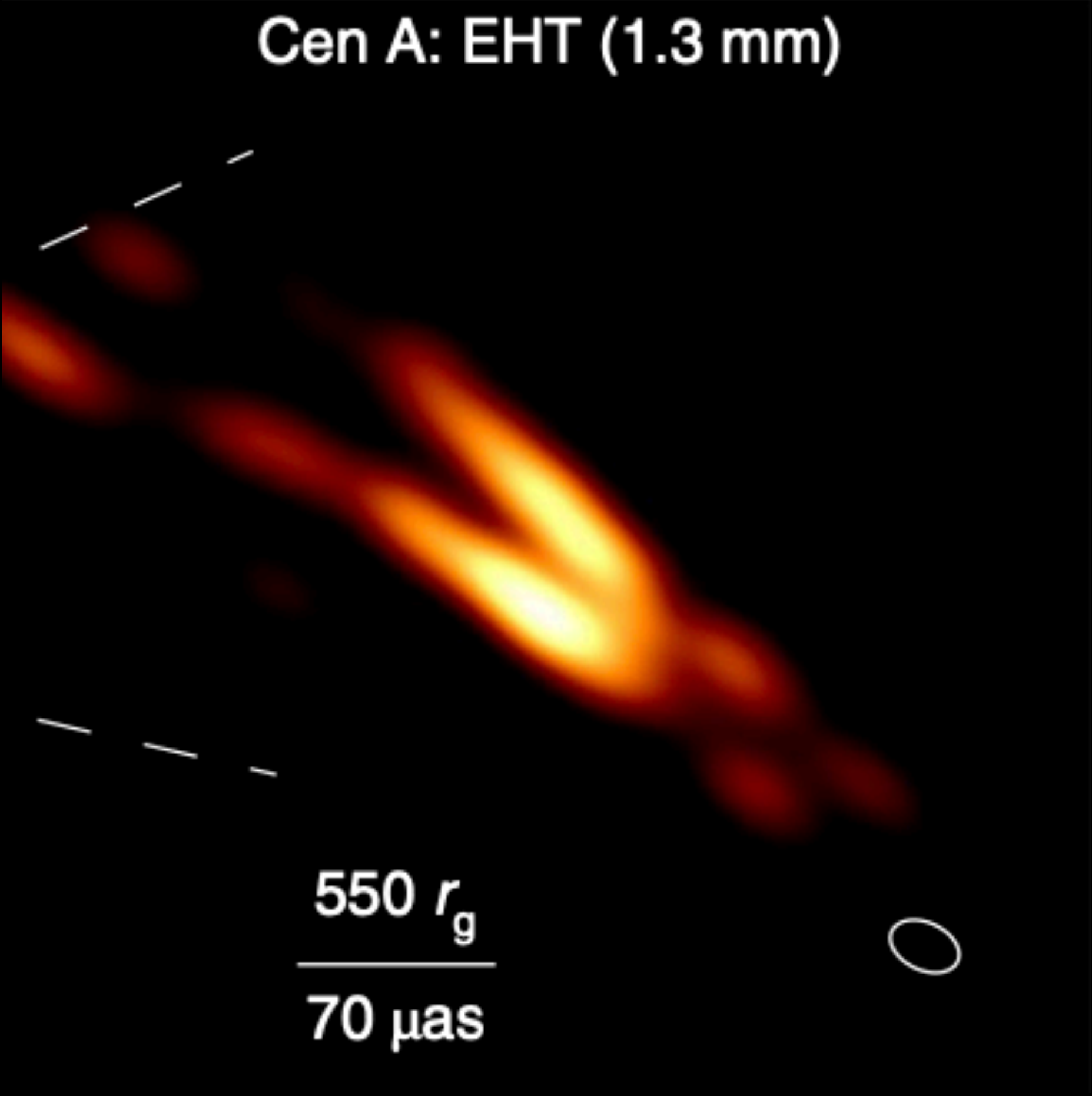
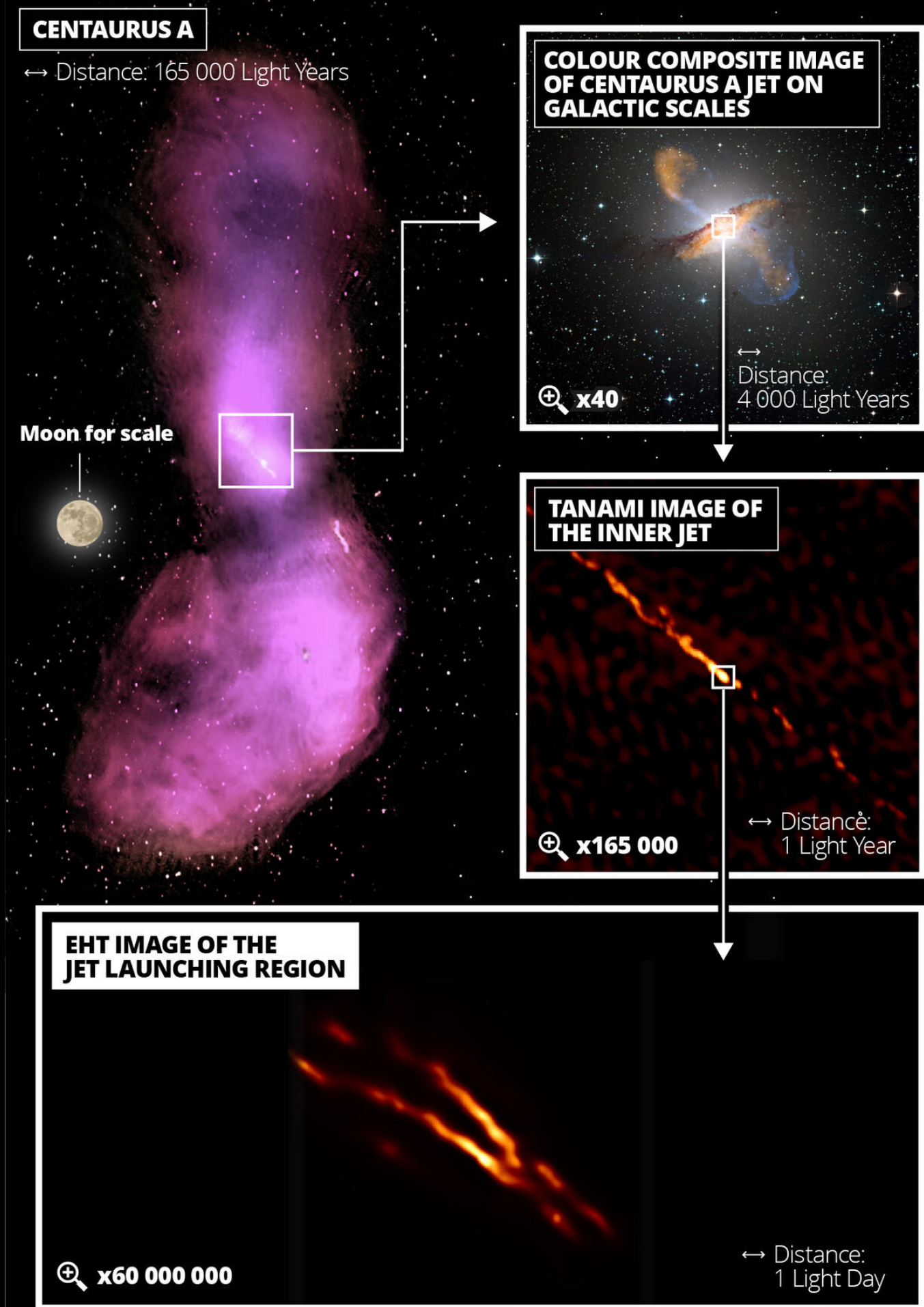


Lu et al. 2023

3.5mm

The hollow jet of Cen A

Zooming into the heart of Centaurus A



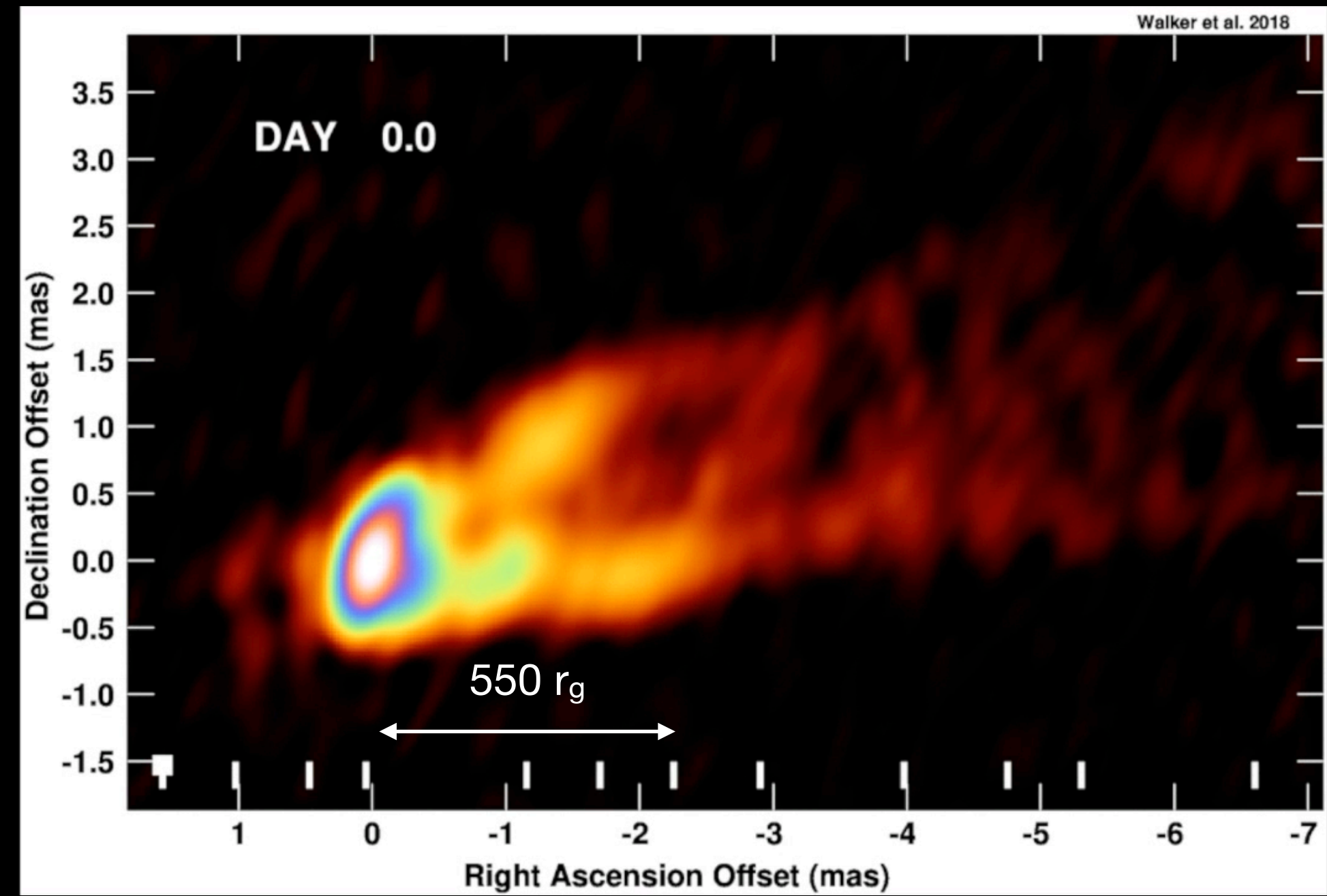
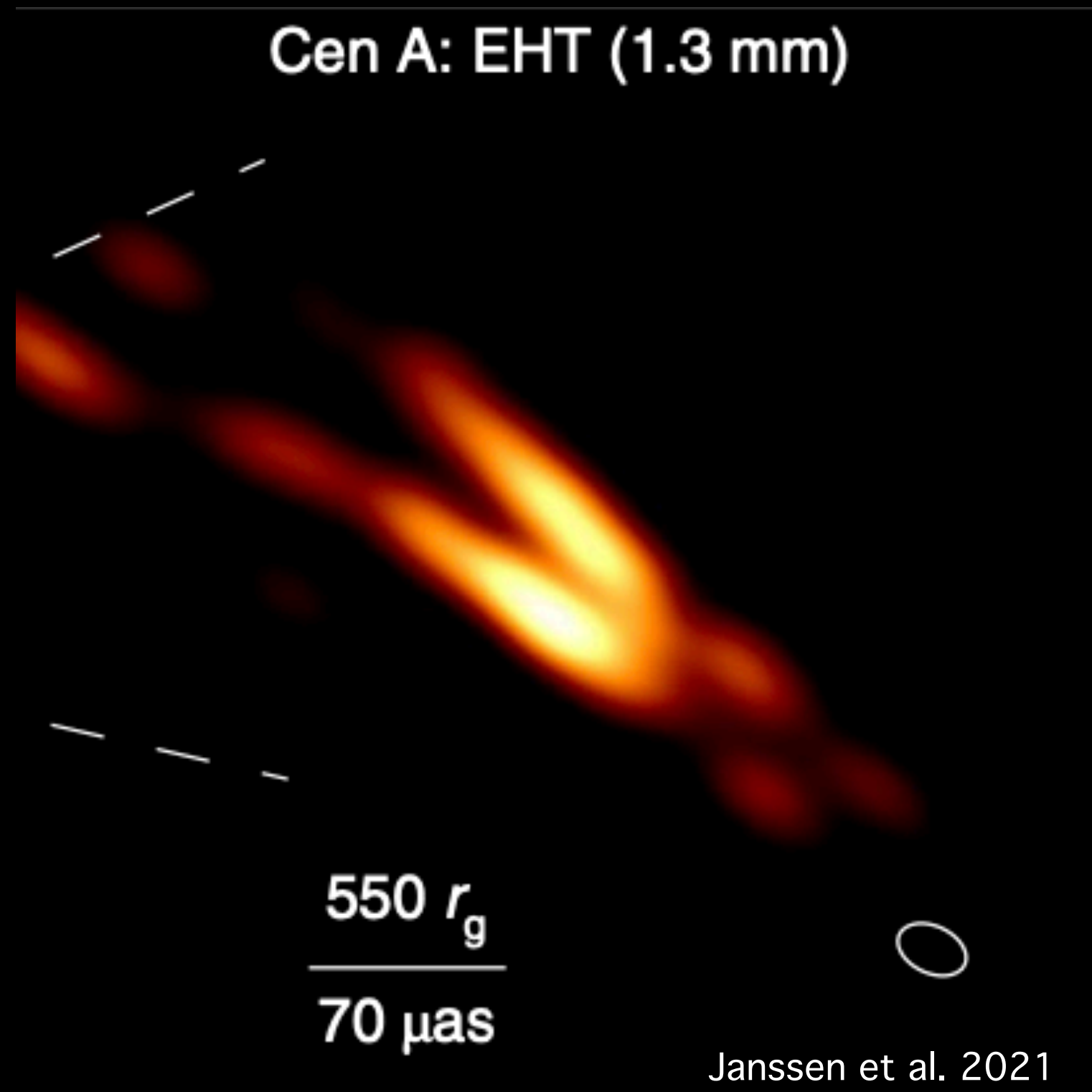
Janssen et al. 2021



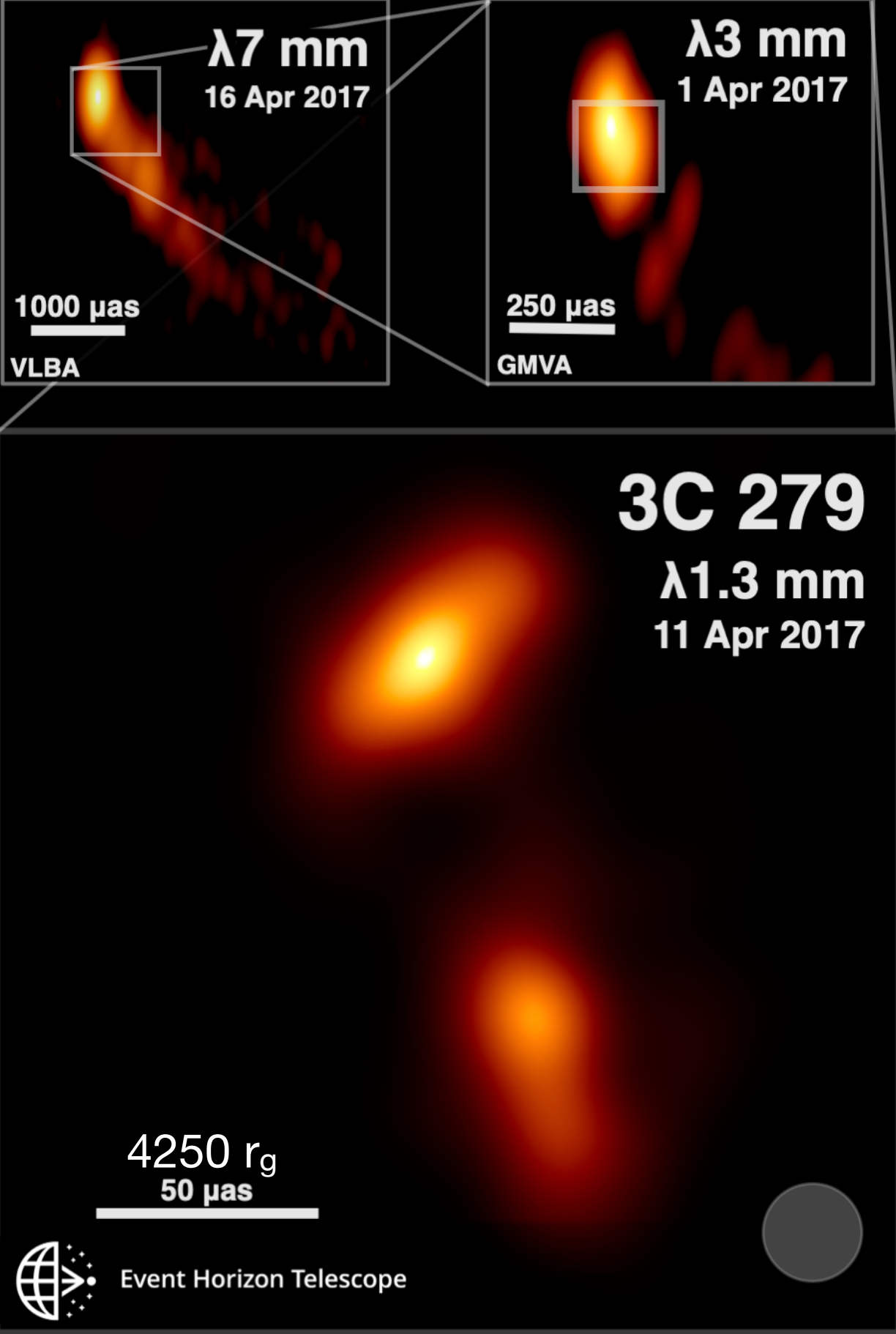
Radoud University



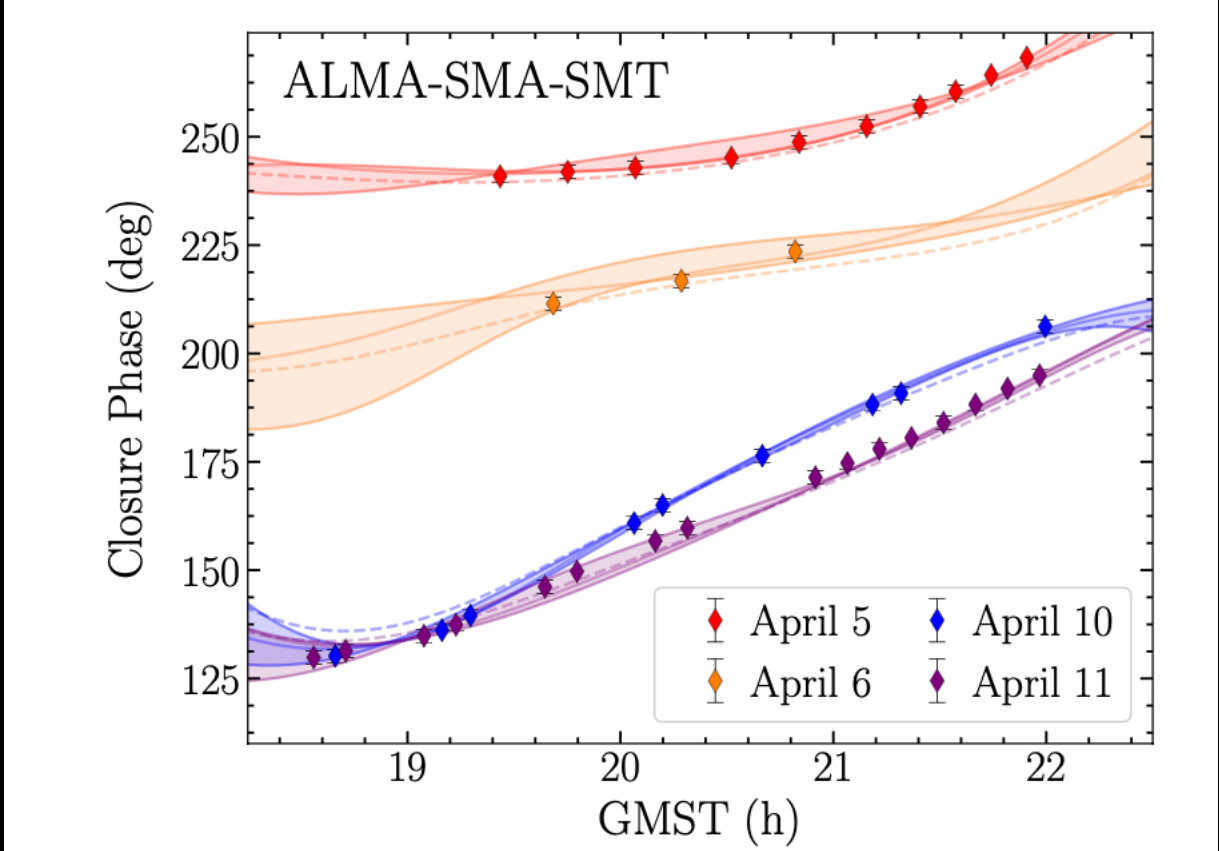
Event Horizon Telescope



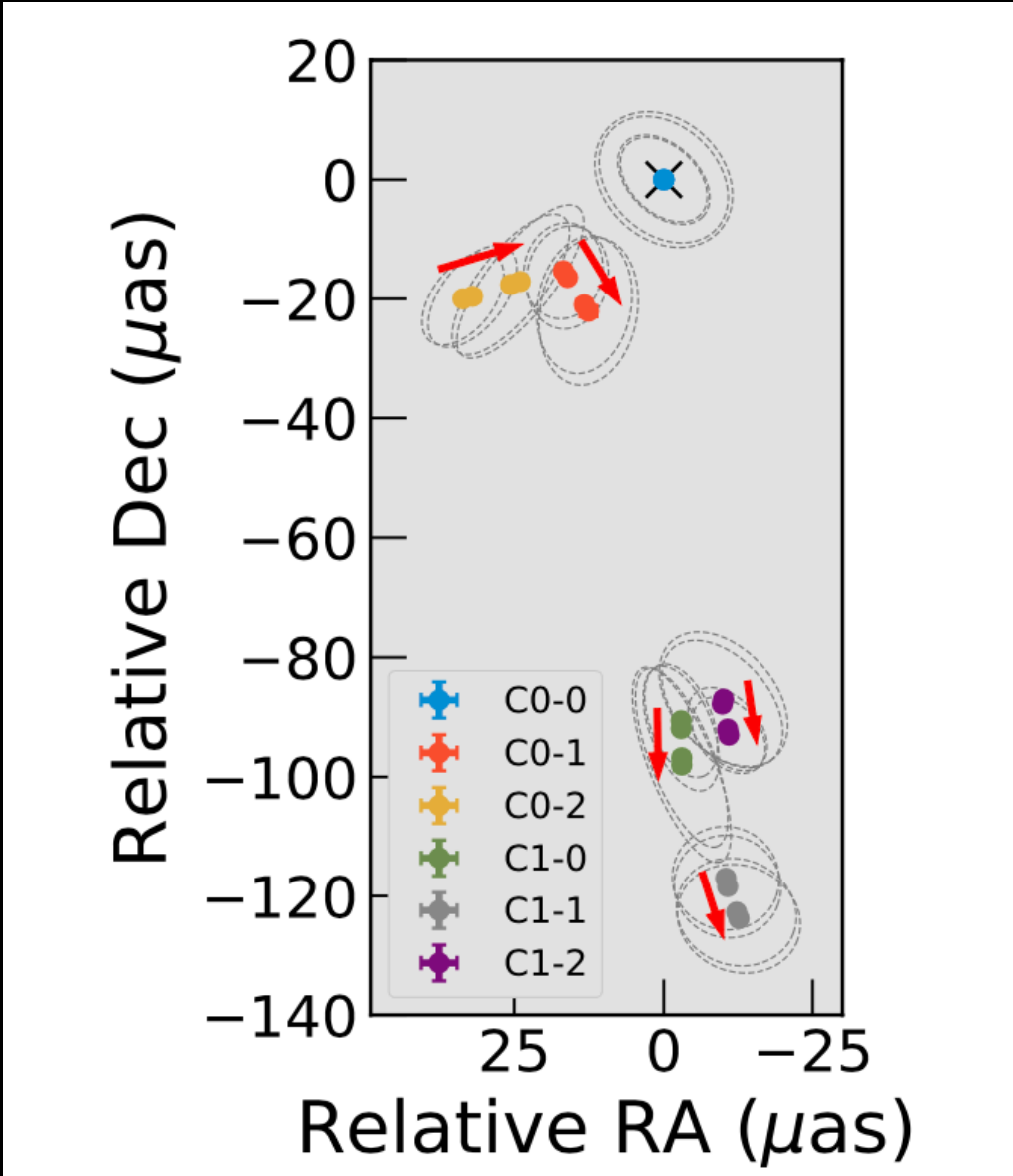
The Evolving and Twisted Jet of 3C279



Kim et al. 2020

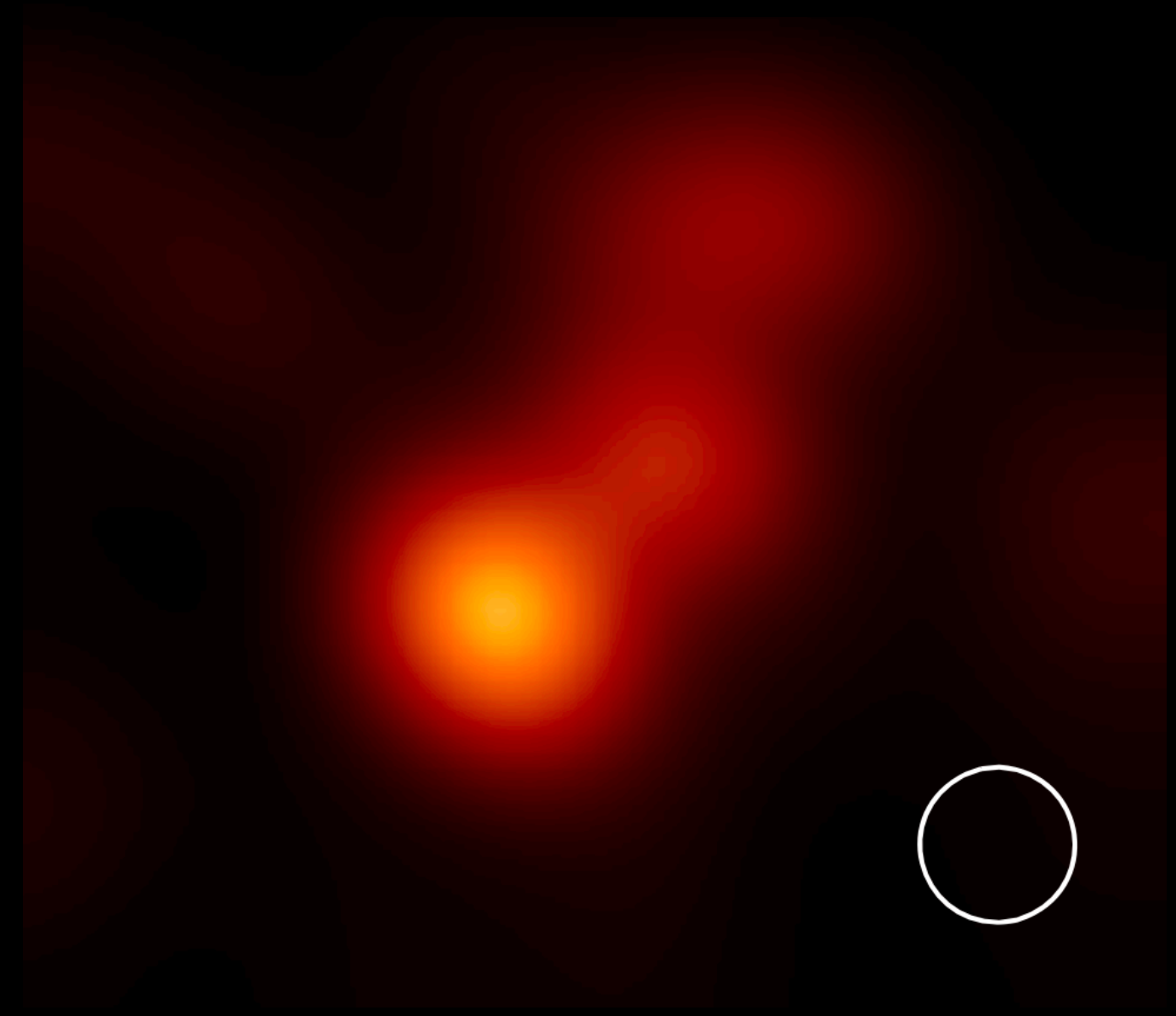


Apparent speeds of 15-20c



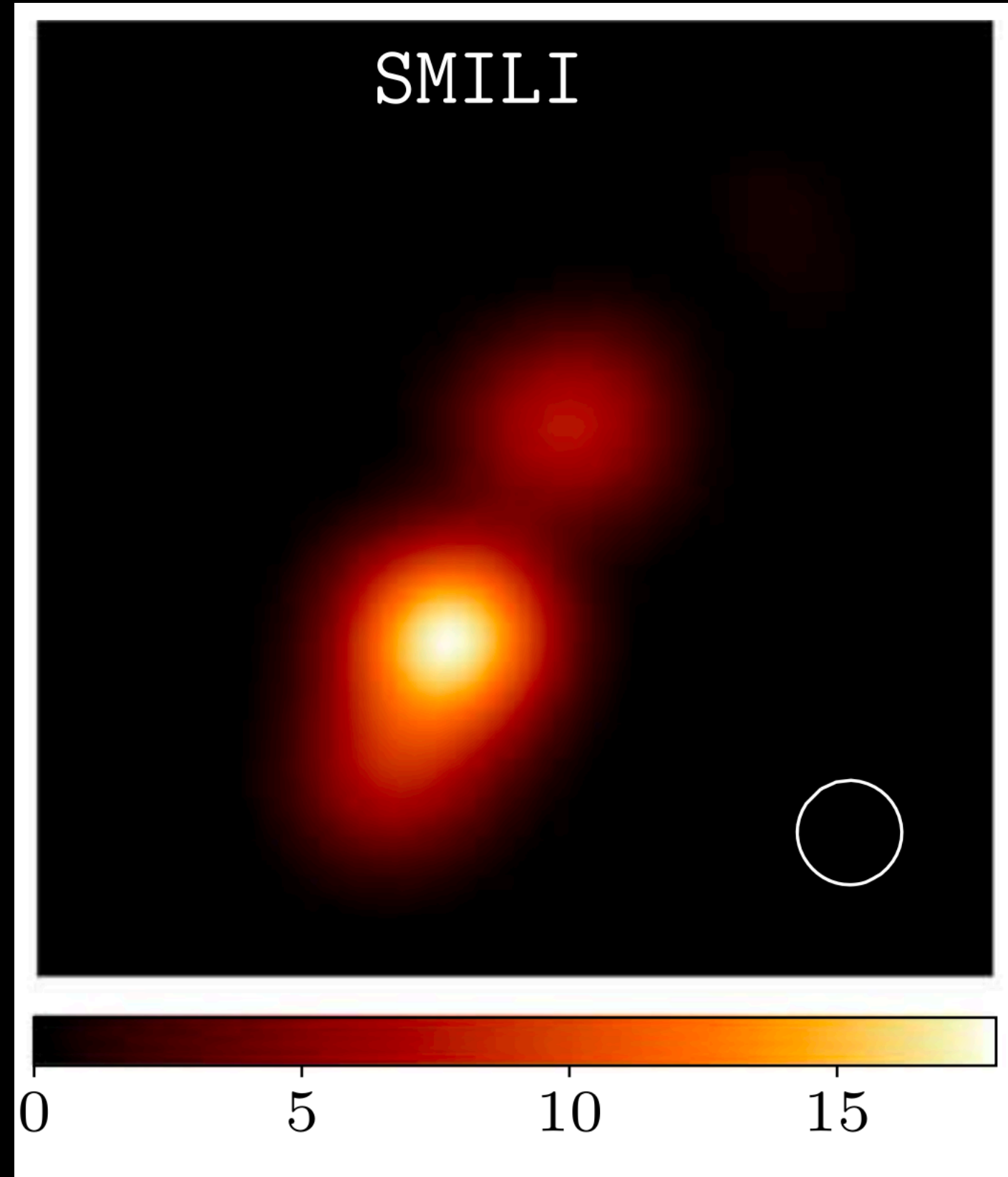
The knotty and bent jets in J1924-2914 and NRAO530

J1924-2914 (1.3mm)



Issaoun et al. 2022

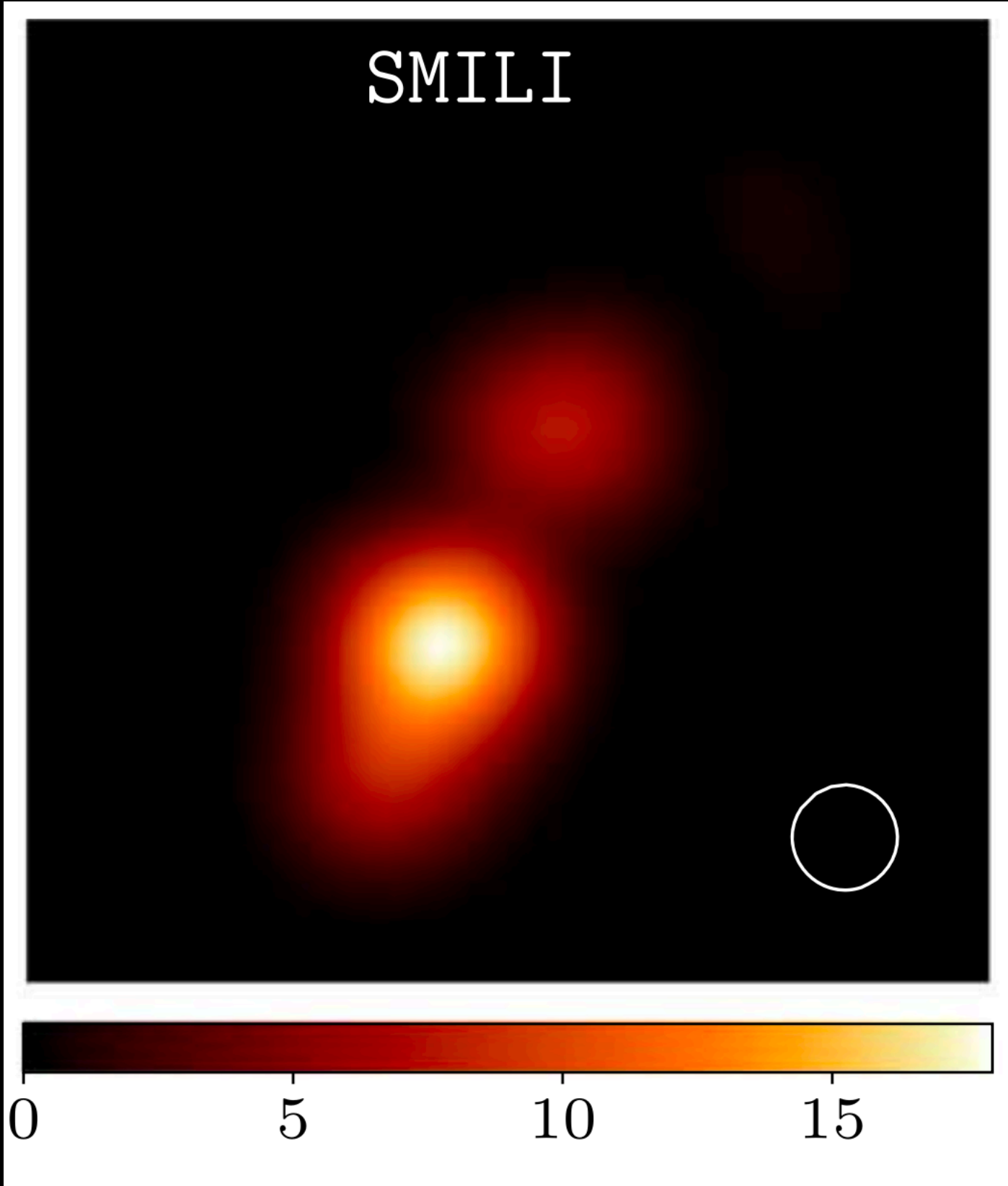
NRAO 530



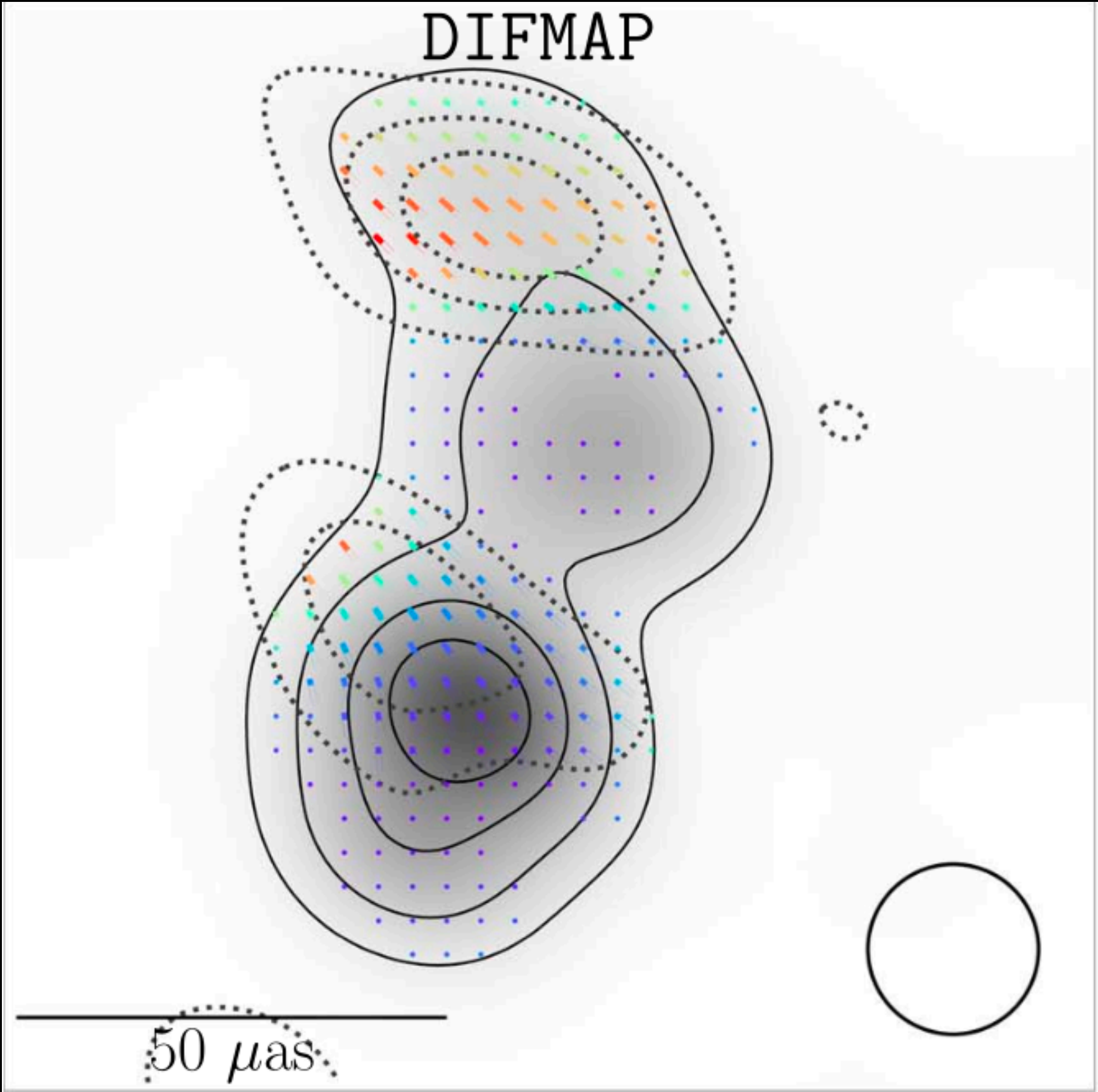
Jorstad 2023

Polarization in the bent jet of NRAO 530

NRAO 530

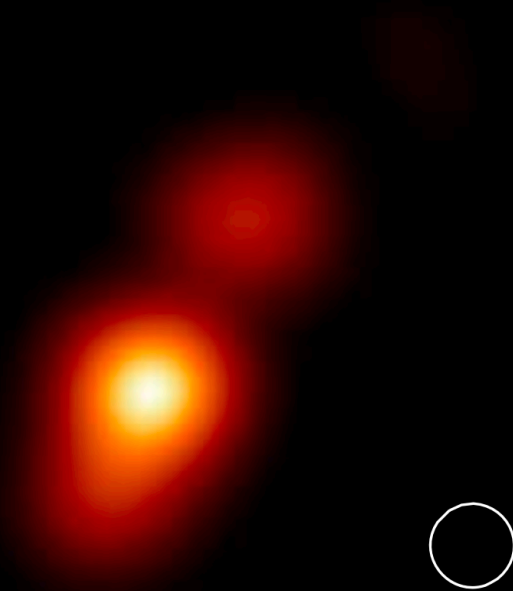


Jorstad 2023

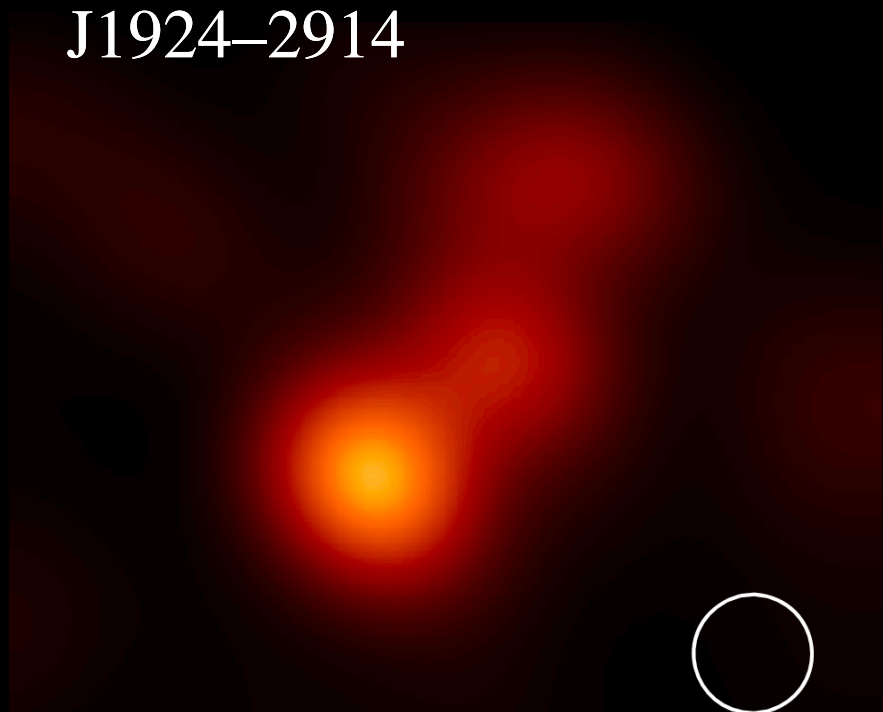


The Sharpened View of AGN with the Event Horizon Telescope

NRAO 530

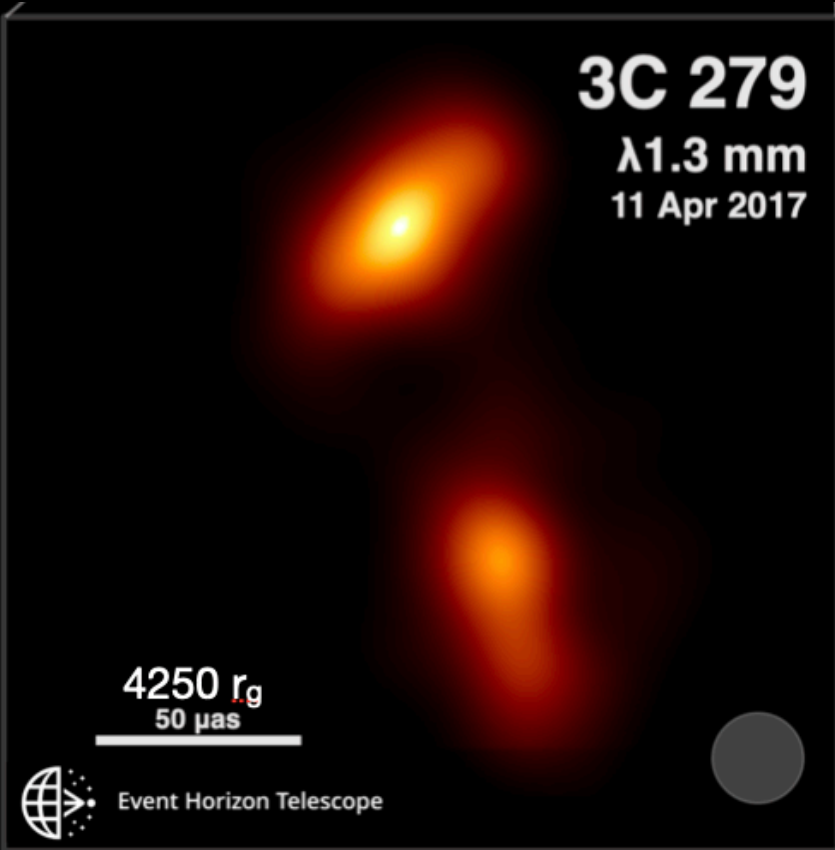


J1924-2914

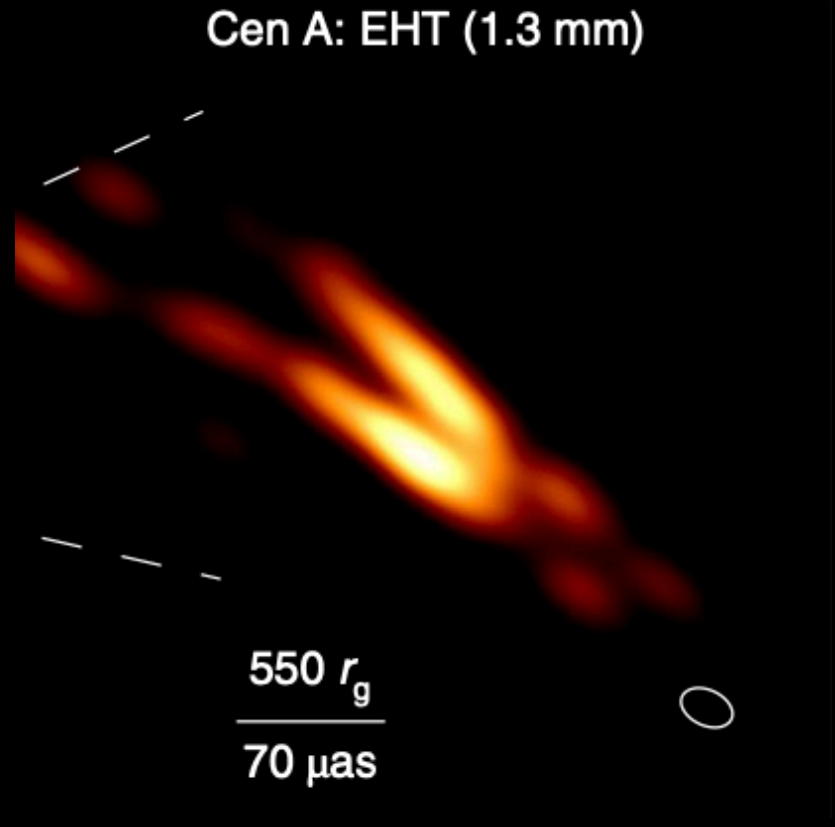


3C 279

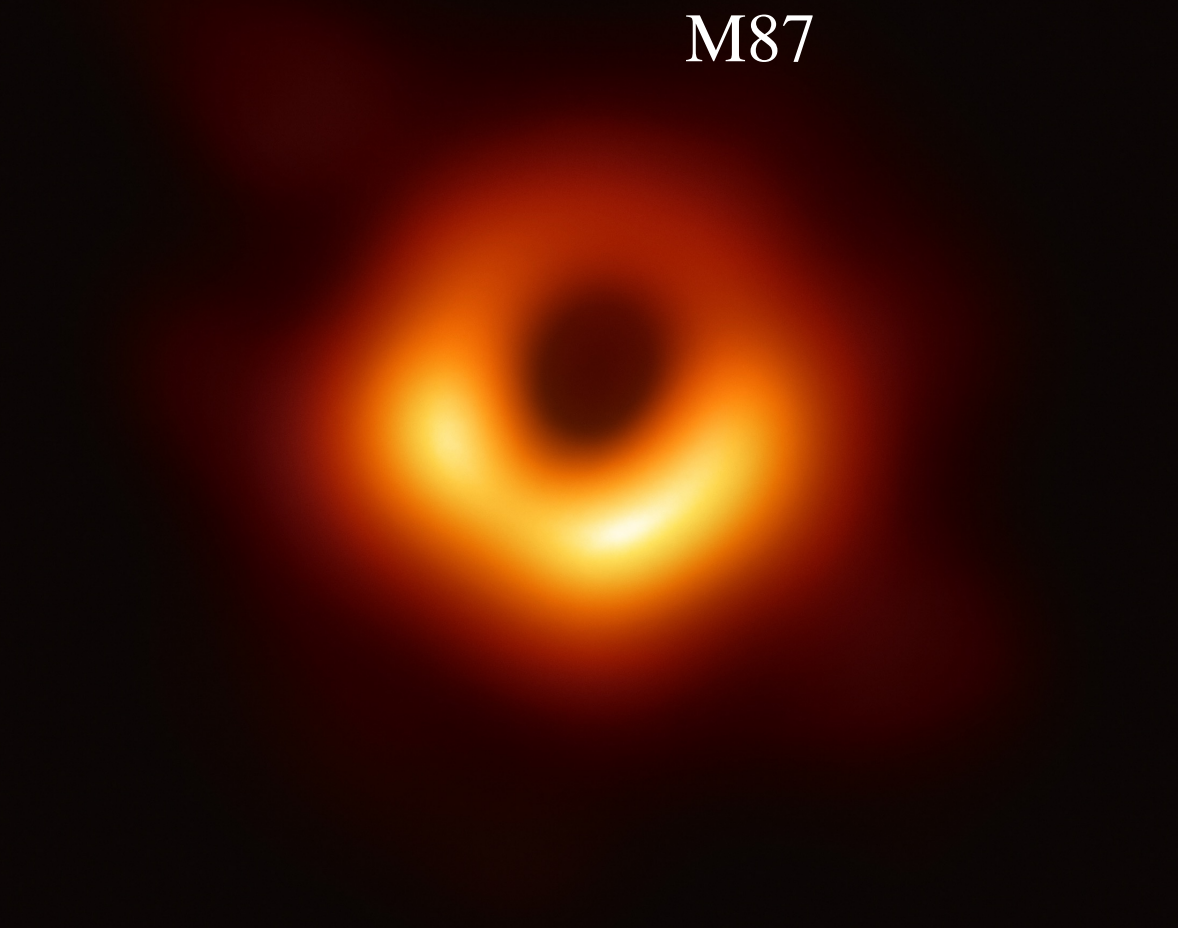
$\lambda 1.3 \text{ mm}$
11 Apr 2017



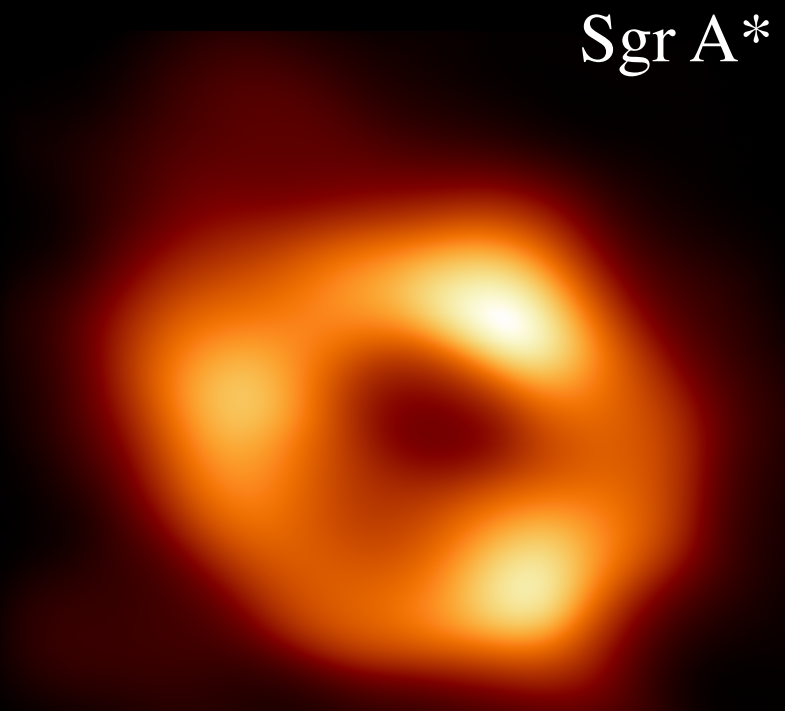
Cen A: EHT (1.3 mm)



M87



Sgr A*

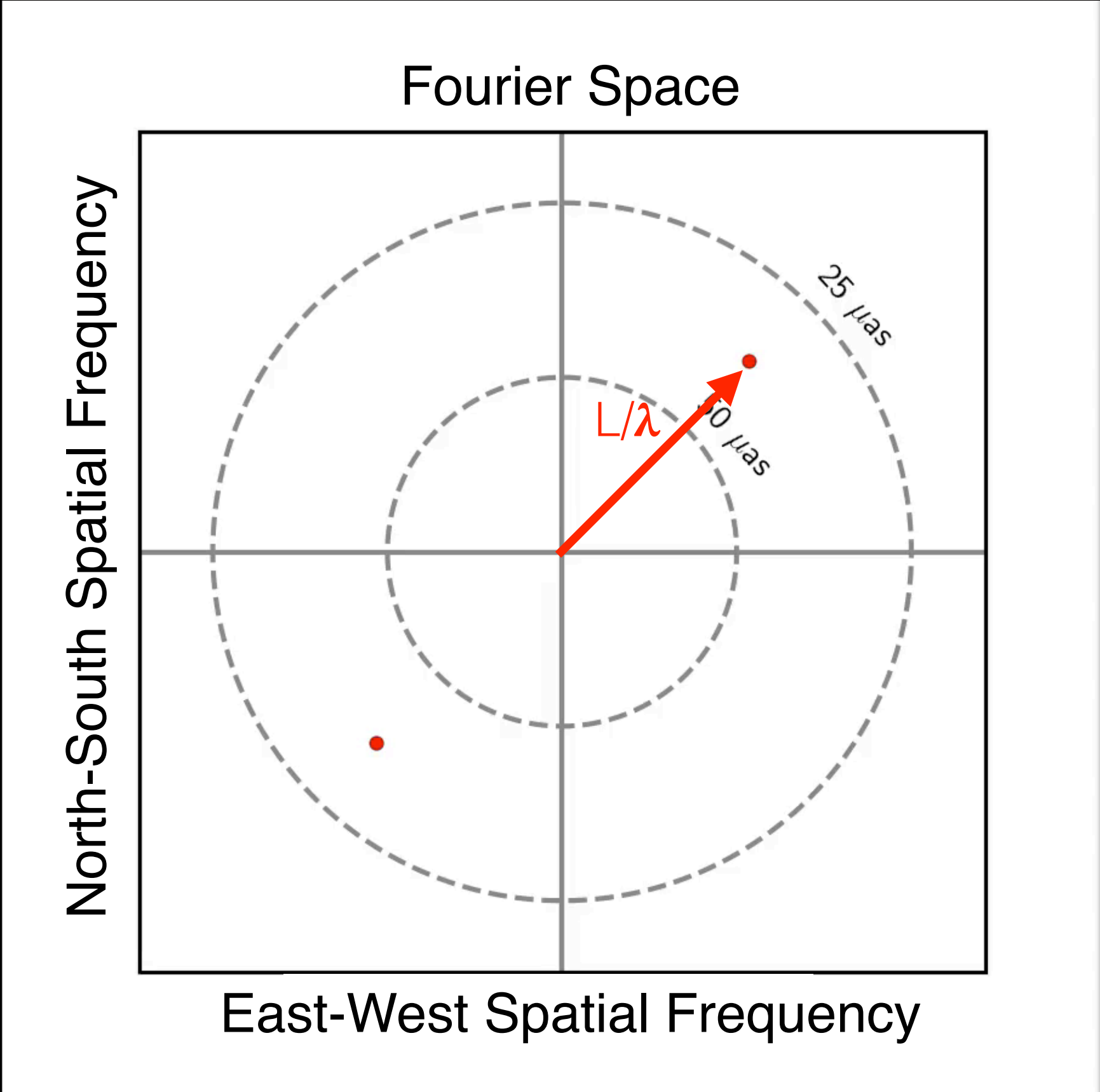
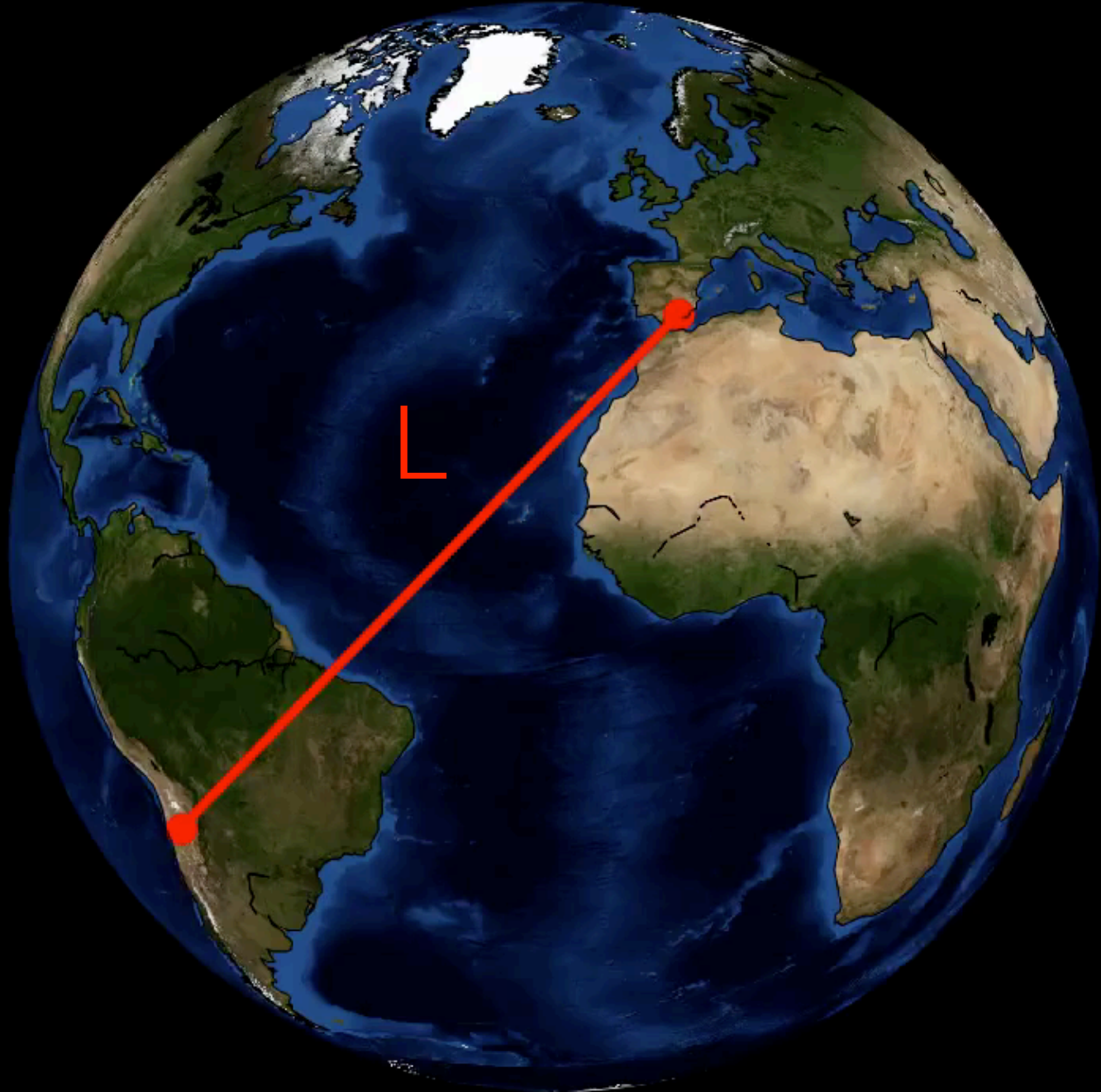








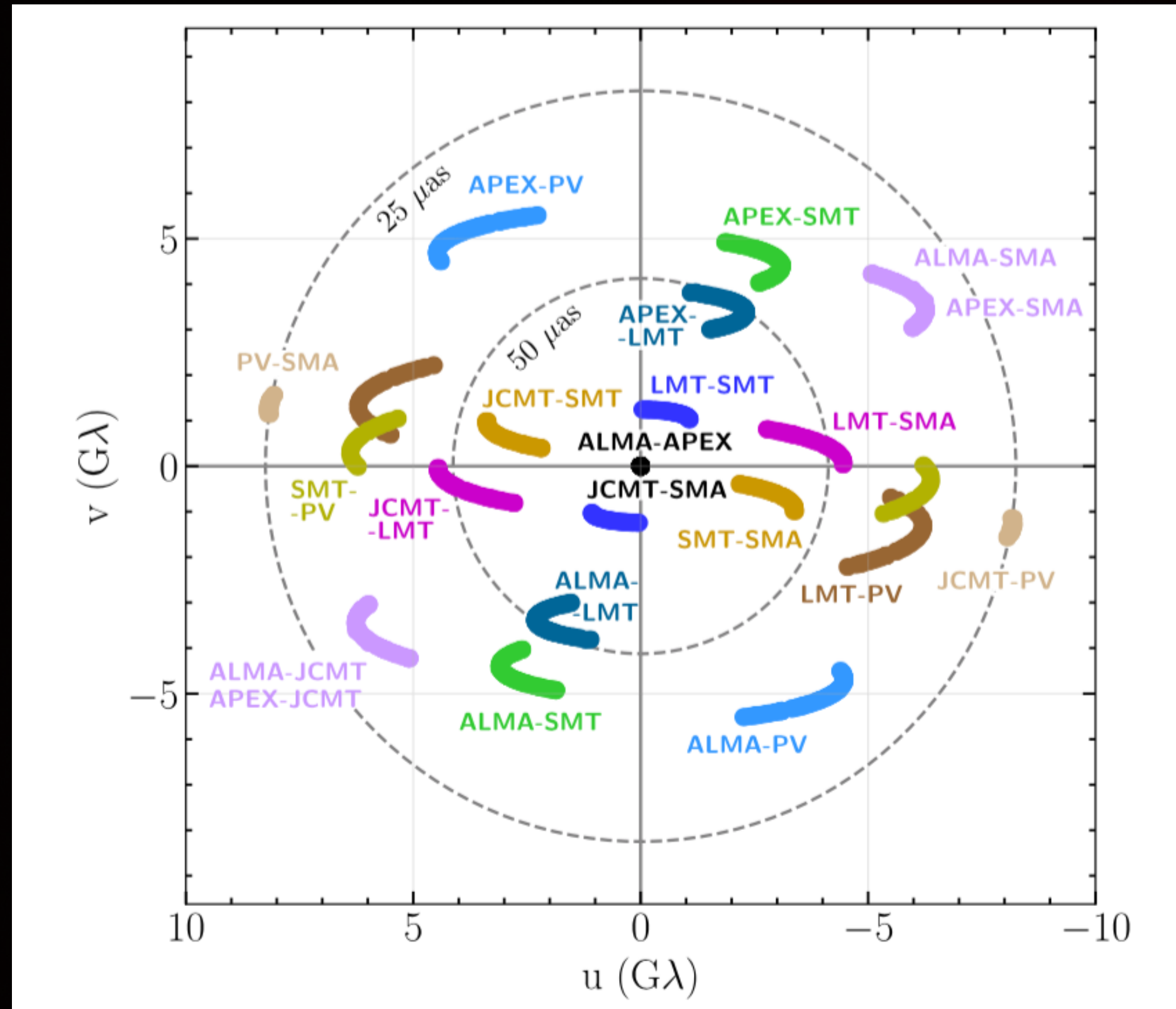
Aperture Synthesis Interferometry



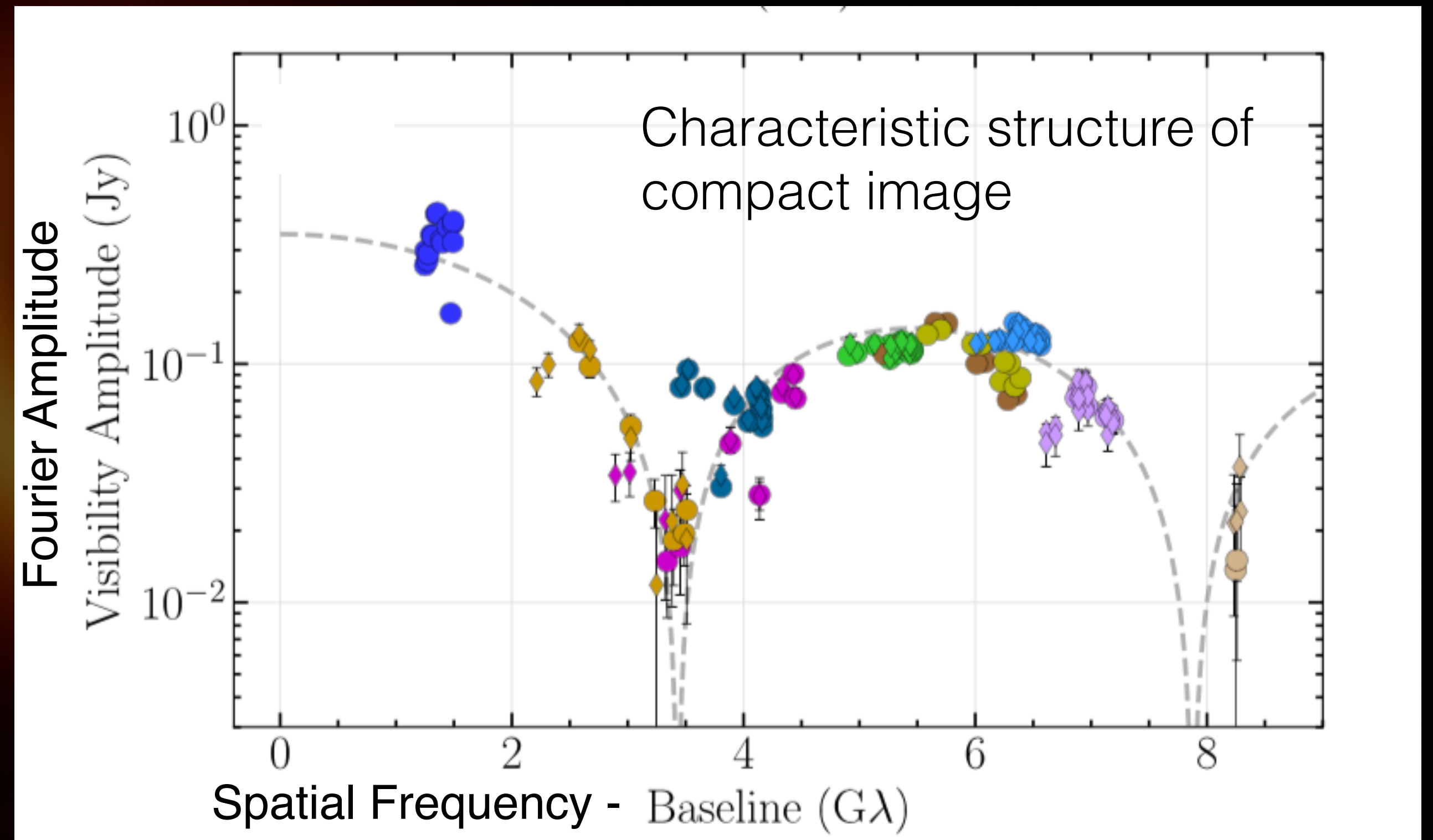
Credit: Michael Johnson

Each telescope pair measures the complex Fourier component of the image at a spatial frequency. The Earth's rotation increases coverage of Fourier space

2017 EHT M87 Data

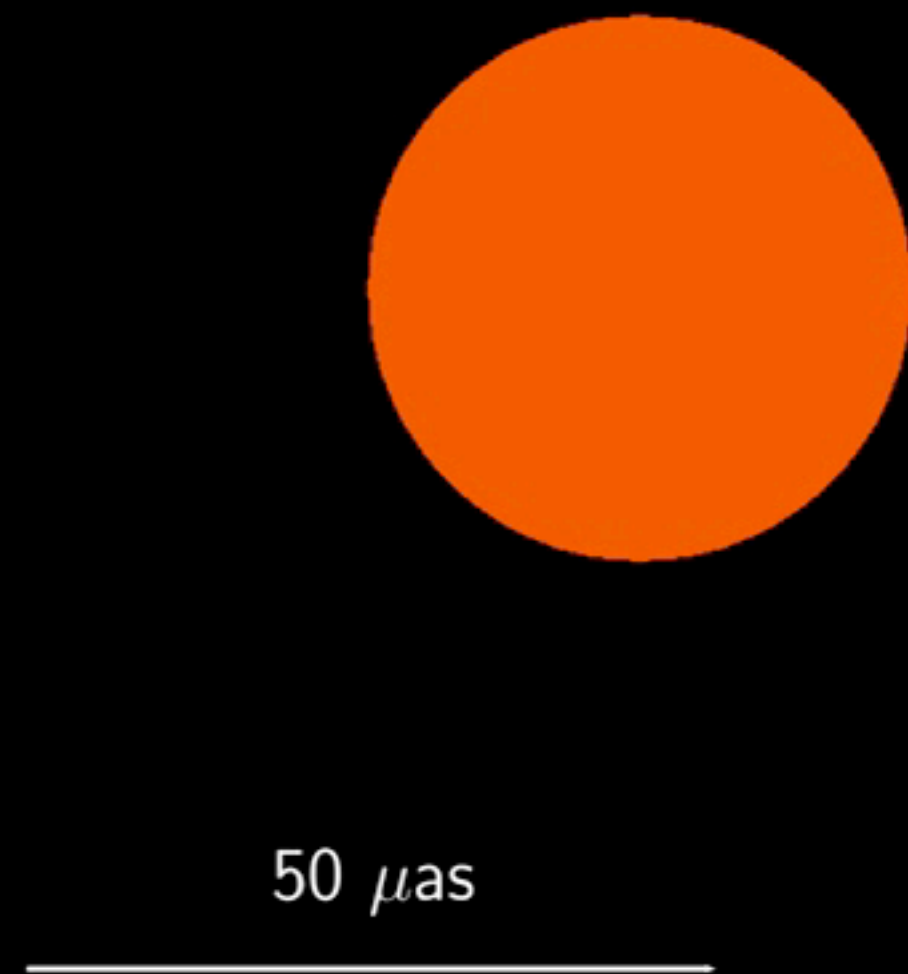


Fourier Space

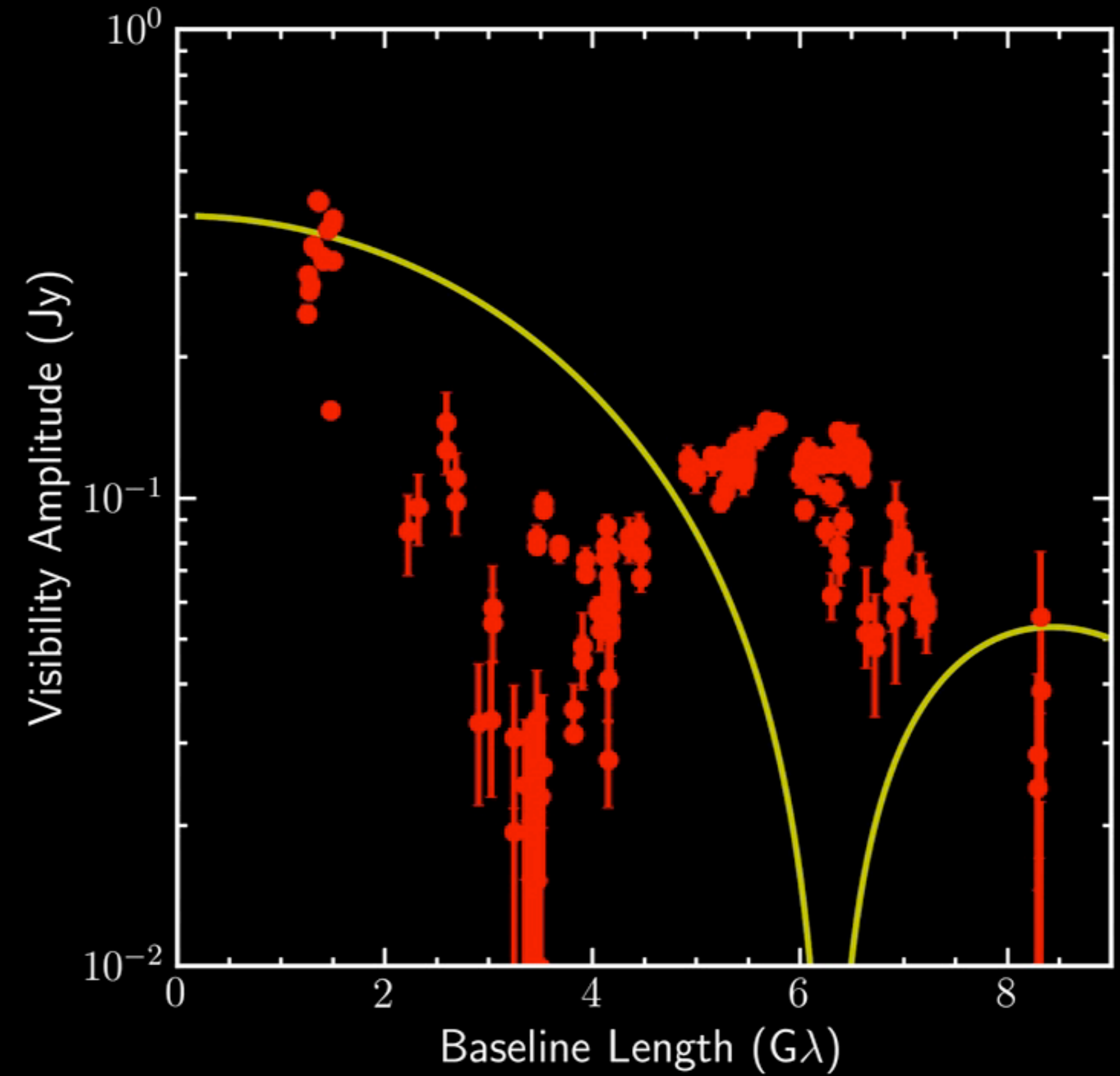


Salient Features of the Visibility Data

Image Space



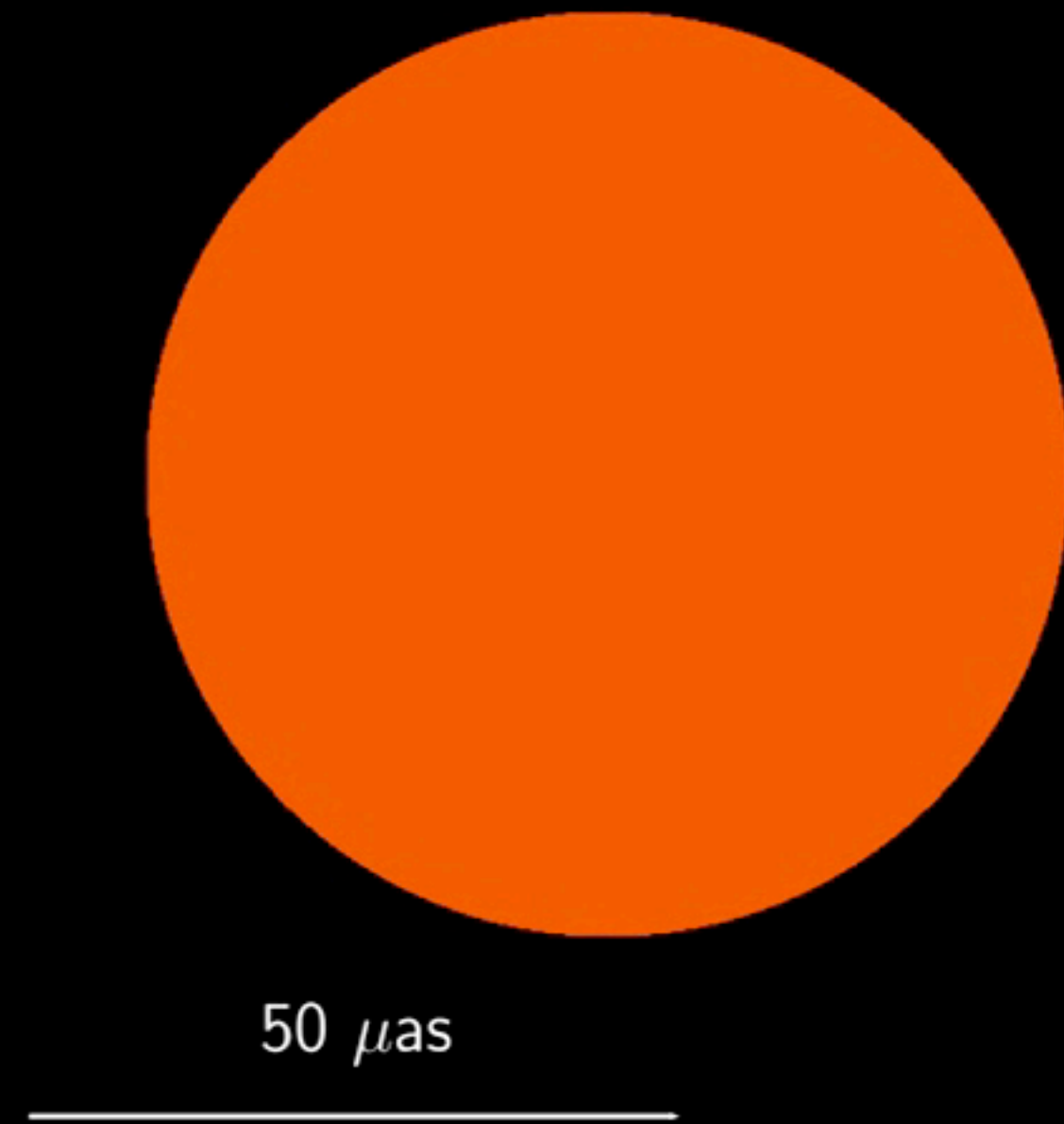
Fourier Space



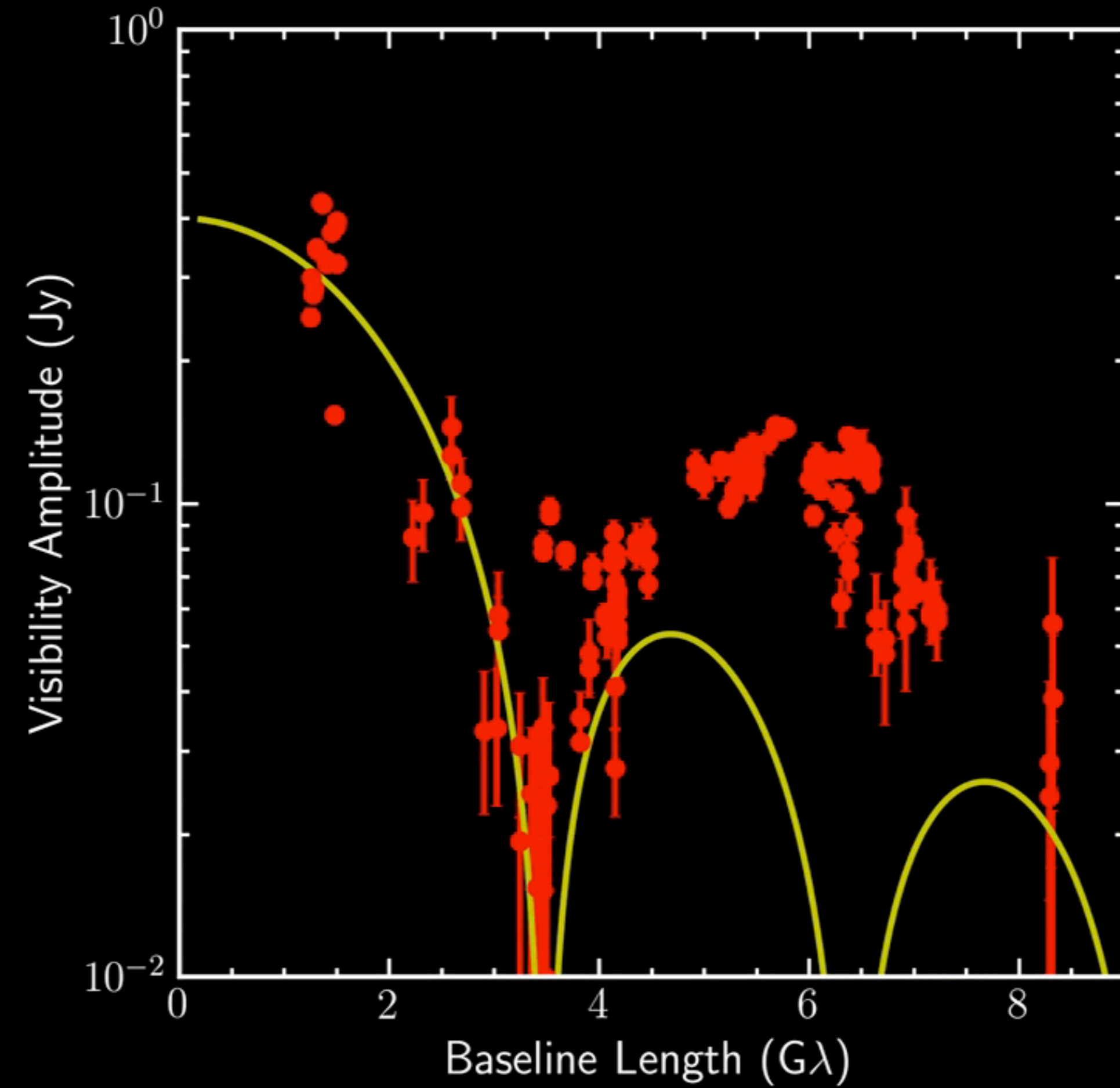
Location of First Minimum Determines Image Diameter

Salient Features of the Visibility Data

Image Space



Fourier Space



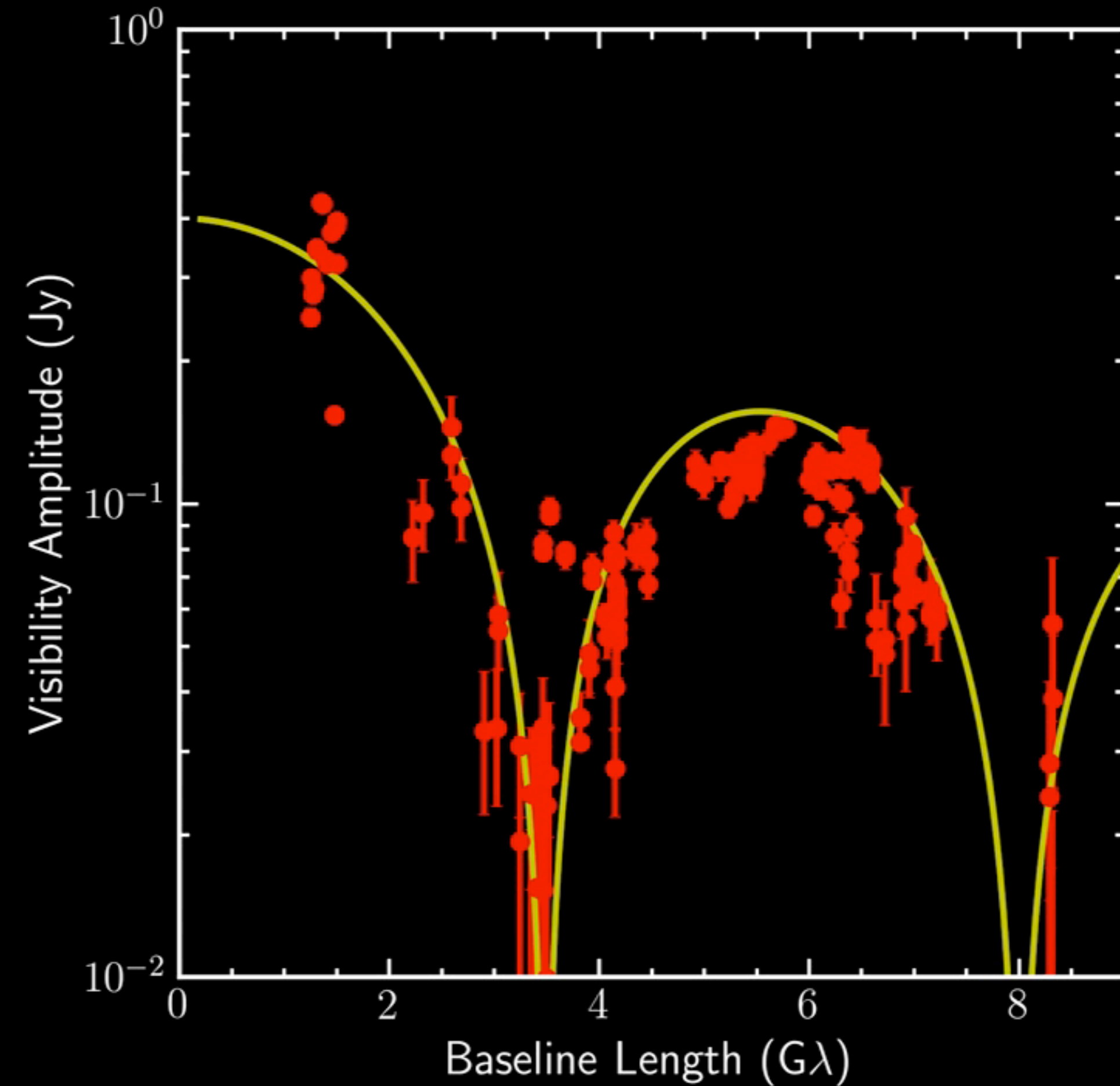
Location of Second Minimum Defines Central Brightness Depression

Salient Features of the Visibility Data

Image Space



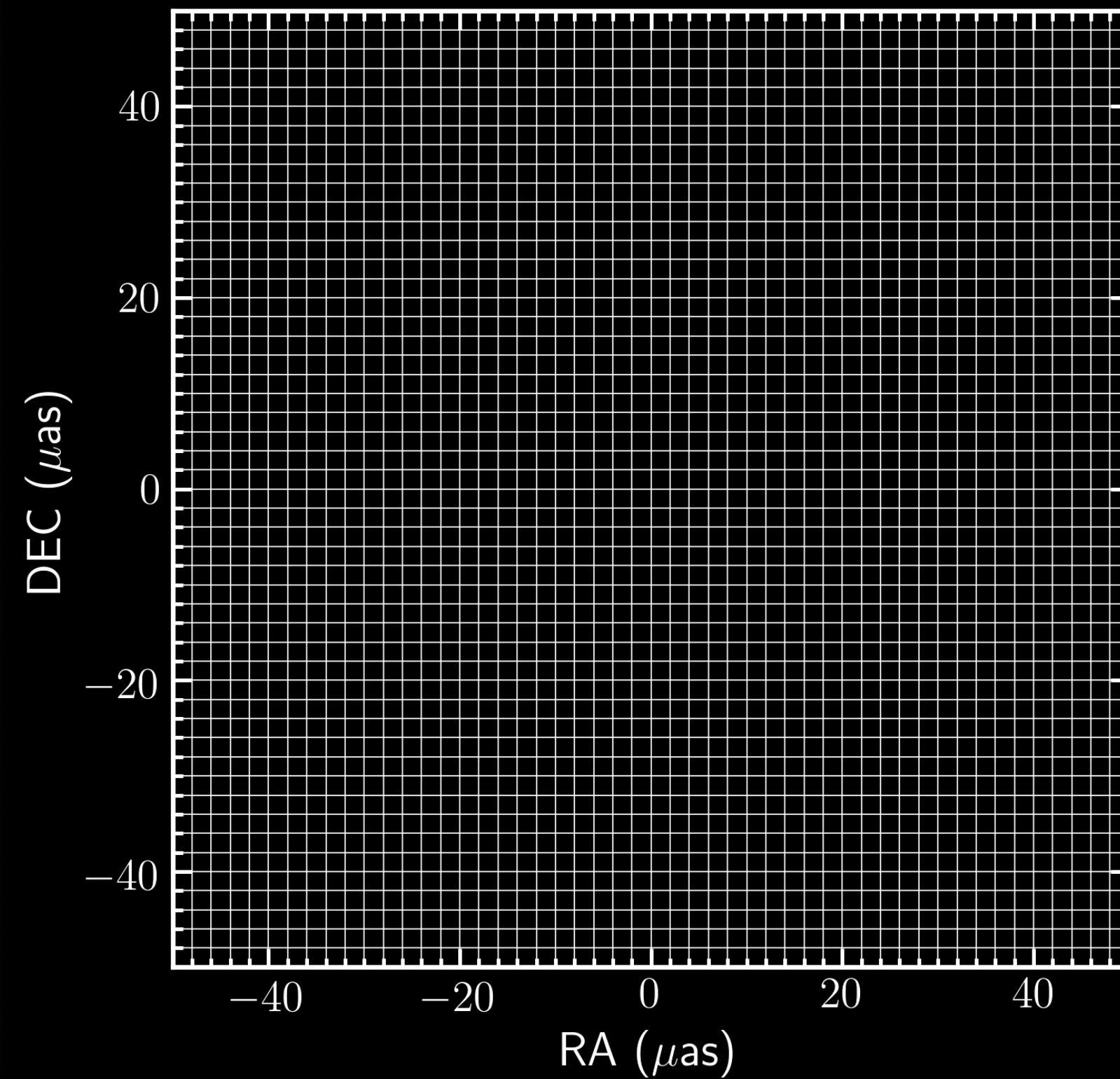
Fourier Space



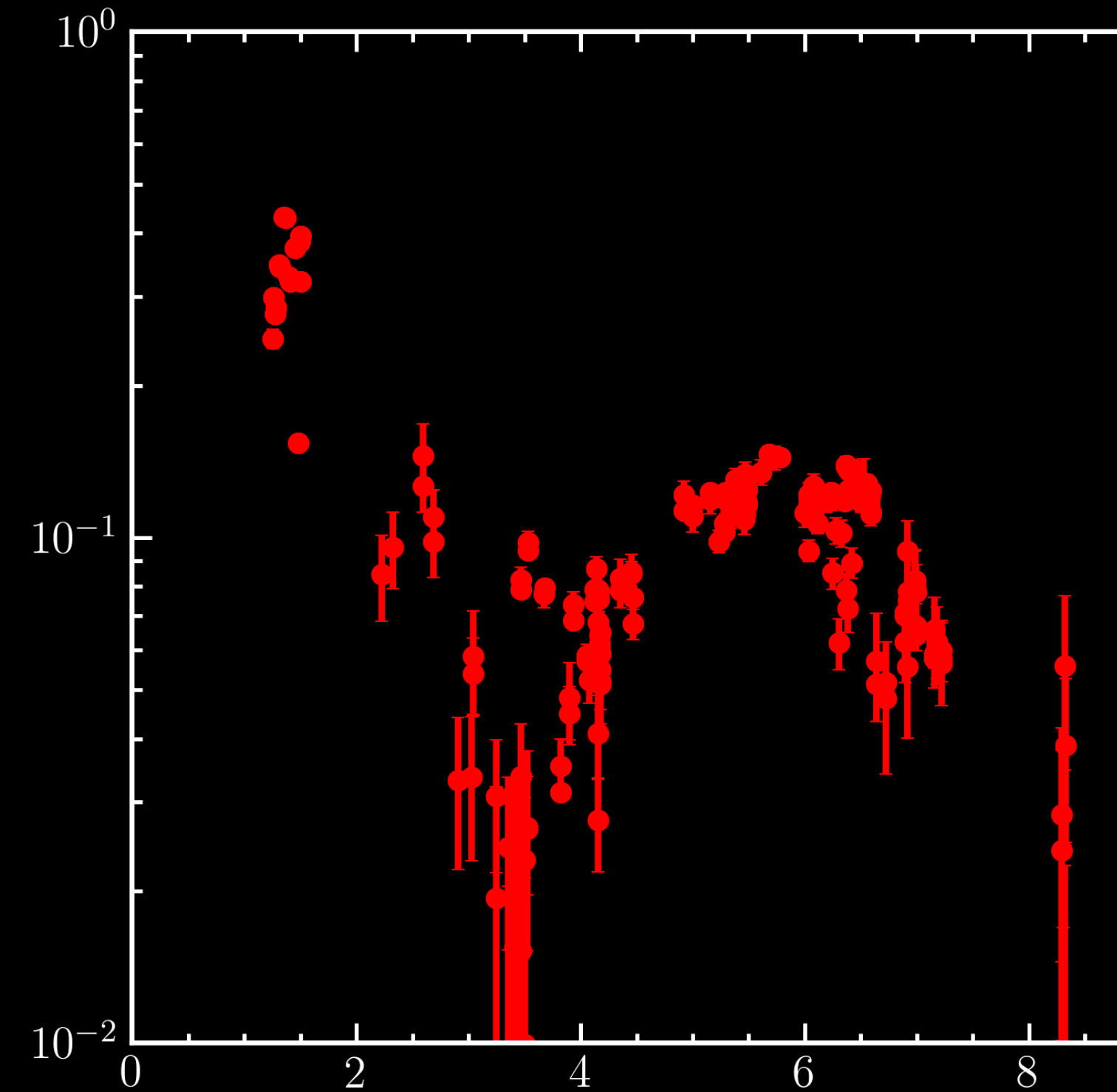
Height of Secondary Peak Determines Ring Width

From Data to Images: Regularized Max Likelihood Methods

Image Space

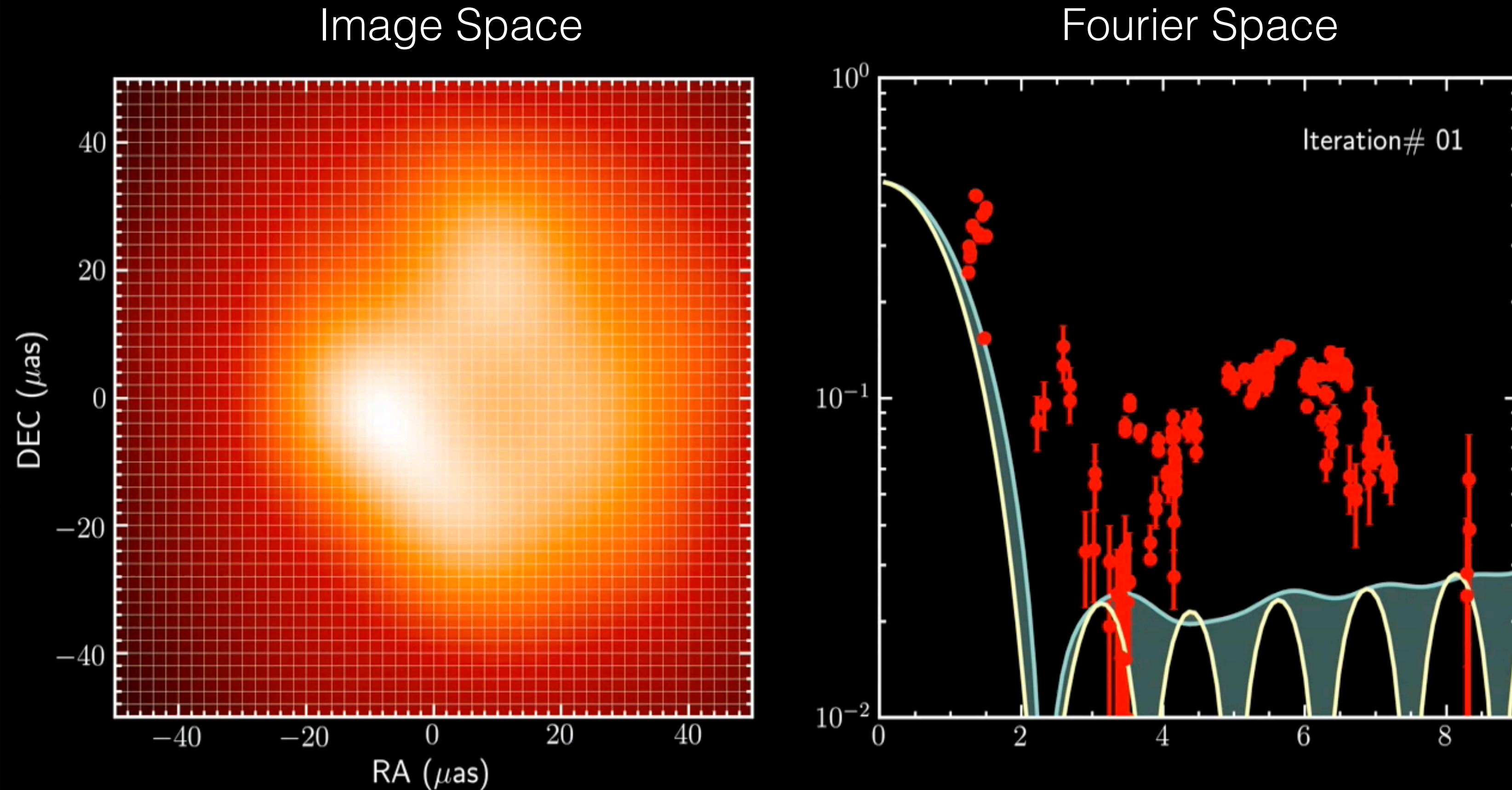


Fourier Space



Pixel-based model

From Data to Images



Pixel-based model

Iterate to minimize $\chi^2 = \frac{(\text{data-model})^2}{\text{error}^2} + \text{weight} * \text{regularizer}$

EHT, Imaging WG
EHT Paper IV, 2019

The multiwavelength imaging and spectroscopy of the M87 jet

Algaba et al. 2021

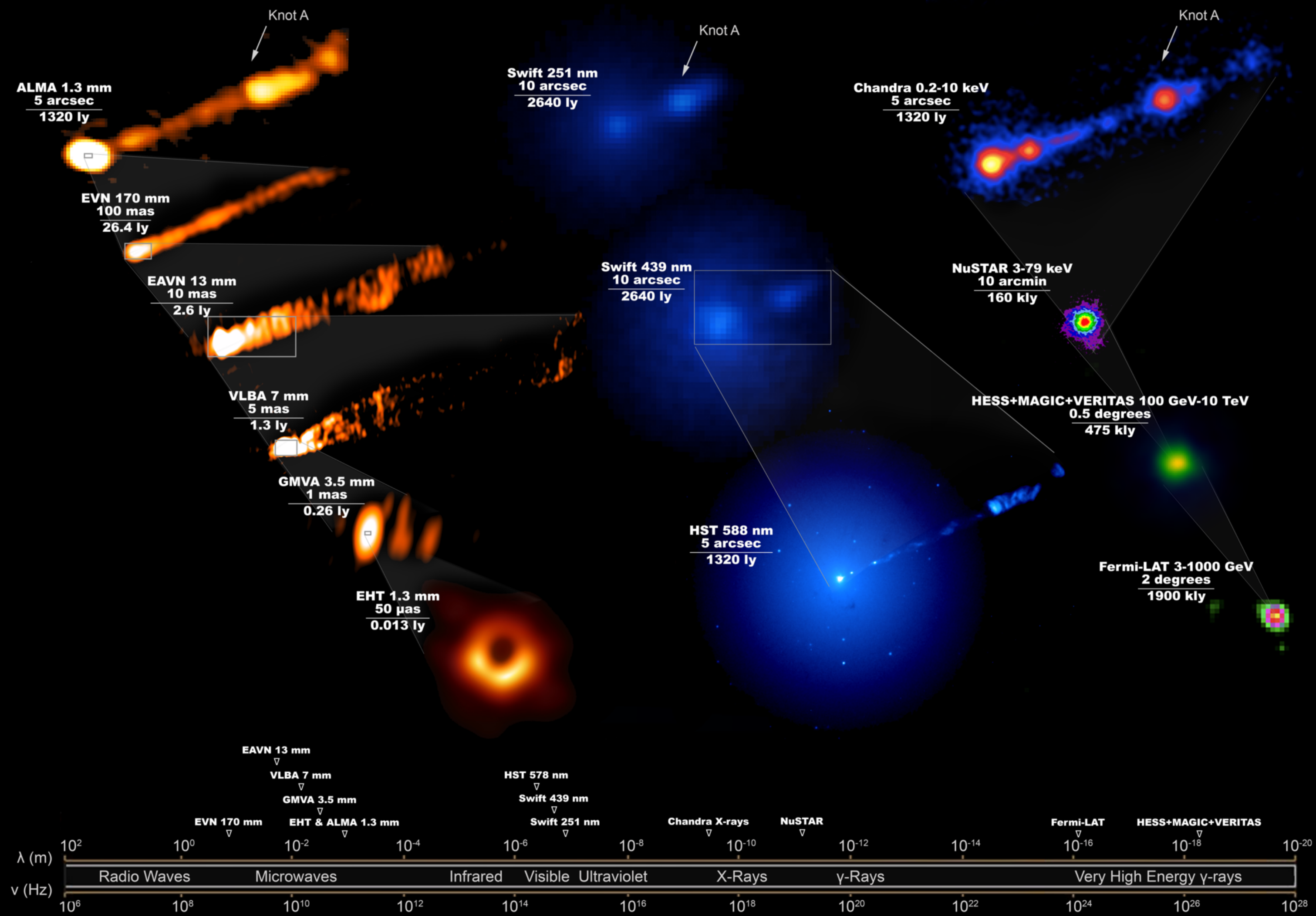
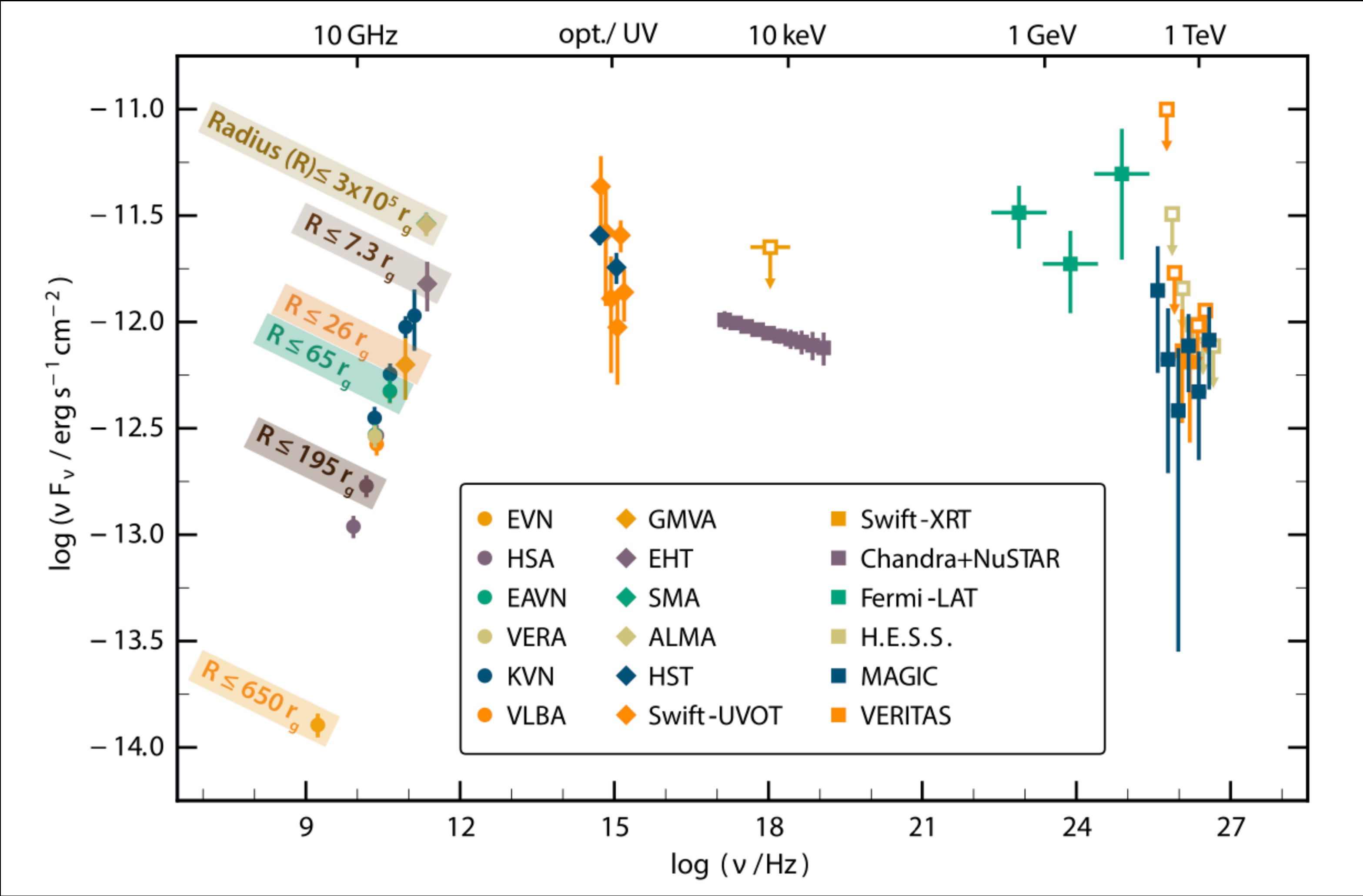


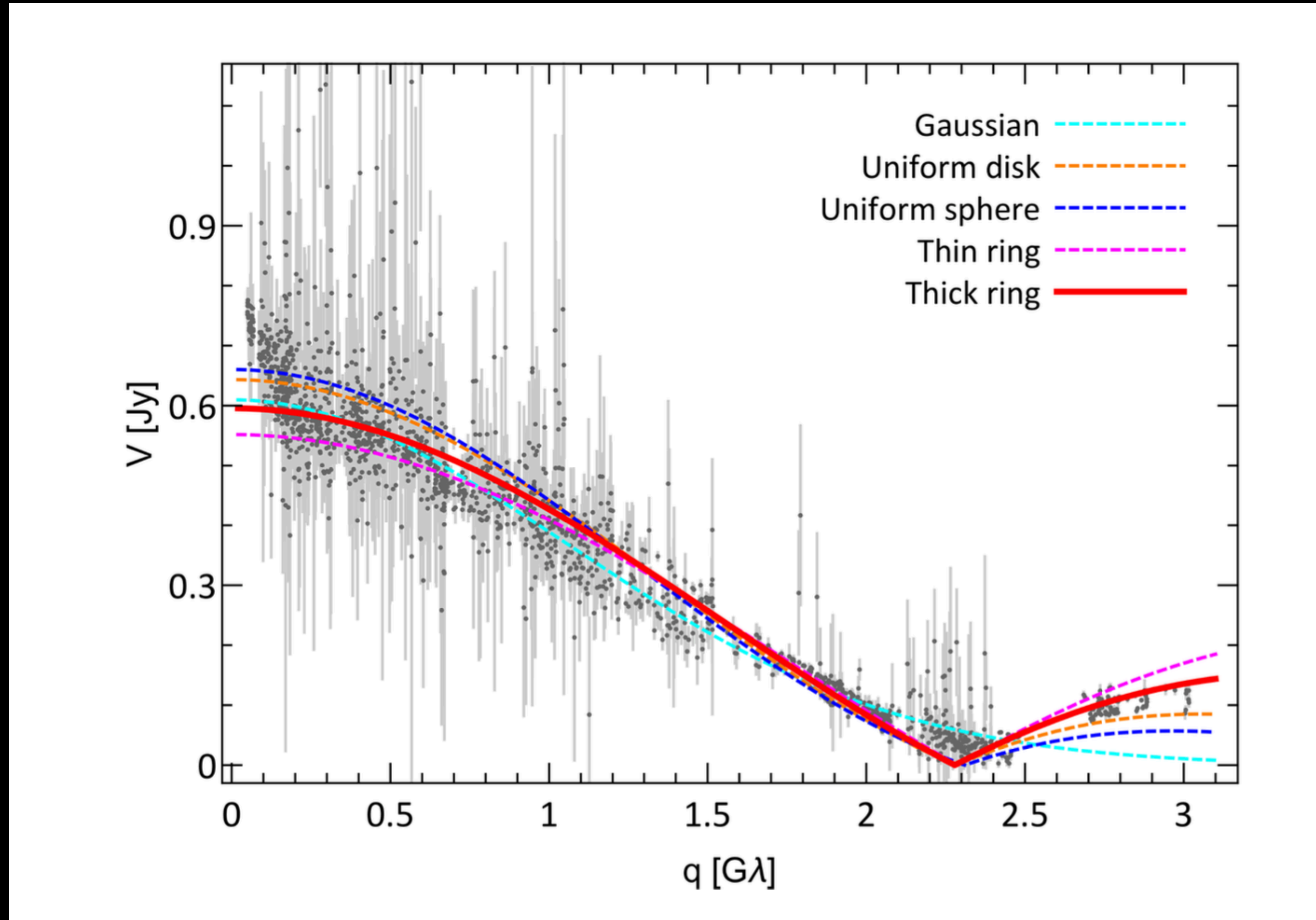
Image Credit: The EHT Multi-wavelength Science Working Group; the EHT Collaboration; ALMA (ESO/NAOJ/NRAO); the EVN; the EAVN Collaboration; VLBA (NRAO); the GMVA; the Hubble Space Telescope; the Neil Gehrels Swift Observatory; the Chandra X-ray Observatory; the Nuclear Spectroscopic Telescope Array; the Fermi-LAT Collaboration; the H.E.S.S. collaboration; the MAGIC collaboration; the VERITAS collaboration; NASA and ESA. Composition by J. C. Algaba



The multiwavelength imaging and spectroscopy of the M87 jet

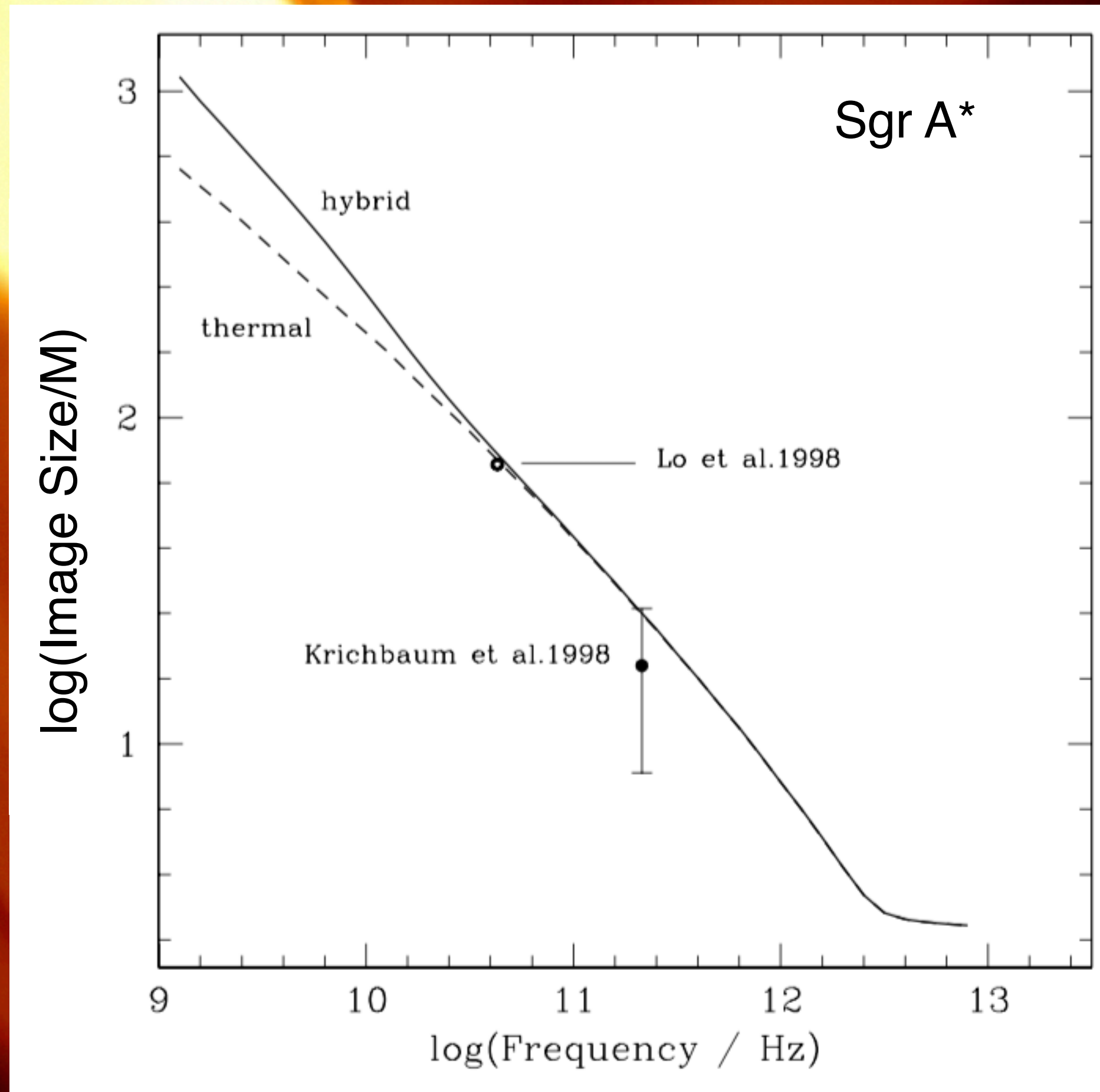


Connecting the jet to horizon-scale images



What is the optimal wavelength of observation?

@ 1 cm



credit: CK Chan

Ozel, Psaltis, Narayan 2000

based on Ozel, Psaltis, Narayan 2000