

COSMIC MAGNETIC FIELDS

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M87

Virgo Galaxy Cluster

M86

M84

M87

Charles Messier "Catalogue des Nébuleuses & des amas d'Étoiles",
Connaissance des Temps, 1784 (published 1781), pp. 227-267

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DATE des OBSERVATIONS.	Numéros des Nébuleuses	ASCENSION DROITE.		DÉCLINAISON.	Diamètre en degrés & min.
		En Temps.	En Degrés.		
		H. M. S.	D. M. S.		
1781. Mars 18	86.	12. 15. 5	183. 46. 21	14. 9. 52 B	
18	87.	12. 19. 48	184. 57. 6	13. 38. 1 B	
18	88.	12. 21. 3	185. 15. 49	15. 37. 51 B	
18	89.	12. 24. 38	186. 9. 36	13. 46. 49 B	
18	90.	12. 25. 48	186. 27. 0	14. 22. 50 B	
18	91.	12. 26. 28	186. 37. 0	14. 57. 6 B	
18	92.	17. 10. 32	257. 38. 3	43. 21. 59 B	0. 5

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1784.

N. des Nébul.	Détails des Nébuleuses & des amas d'Étoiles. <i>Les positions sont rapportées ci-contre.</i>
86.	Nébuleuse sans étoile, dans la Vierge, sur le parallèle & très-près de la nébuleuse ci-dessus, n. ^o 84; ses apparences les mêmes, & l'une & l'autre paroissent dans le même champ de la lunette.
87.	Nébuleuse sans étoile, dans la Vierge, au-dessous & assez près d'une étoile de huitième grandeur, l'étoile ayant même ascension droite que la nébuleuse, & sa déclinaison étoit de 13 ^d 42' 21" boréale. Cette nébuleuse paroissoit de la même lumière que les deux nébuleuses n. ^{os} 84 & 86.
88.	Nébuleuse sans étoile, dans la Vierge, entre deux petites étoiles & une étoile de la sixième grandeur, qui paroissent en même-temps que la nébuleuse dans le champ de la lunette. Sa lumière est une des plus foibles & ressemble à celle rapportée dans la Vierge, n. ^o 58.
89.	Nébuleuse sans étoile, dans la Vierge, à peu de distance & sur le parallèle de la Nébuleuse ci-dessus rapportée, n. ^o 87. Sa lumière étoit extrêmement foible & rare, & ce n'est pas sans peine qu'on peut l'apercevoir.
90.	Nébuleuse sans étoile, dans la Vierge: sa lumière aussi foible que la précédente, n. ^o 89.
91.	Nébuleuse sans étoile, dans la Vierge, au-dessus de la précédente n. ^o 90: sa lumière encore plus foible que celle ci-dessus.
<i>Nota.</i> La constellation de la Vierge, & sur-tout l'aile boréale est une des constellations qui renferme le plus de Nébuleuse: ce Catalogue en contient treize de déterminées: savoir, les n. ^{os} 49, 58, 59, 60, 61, 84, 85, 86, 87, 88, 89, 90 & 91. Toutes ces nébuleuses paroissent sans étoiles: on ne pourra les voir que par un très-beau ciel, & vers leurs passages au Méridien. La plupart de ces nébuleuses m'avoient été indiquées par M. Méchain.	
92.	Nébuleuse, belle, apparente, & d'une grande lumière, entre le genou & la jambe gauche d'Hercule, se voit

M87
NGC 4486
HST ACS/WFC

Heber Curtis (1918)

4486 12 25.8 +12 57 Exceedingly bright; the sharp nucleus shows well in 5^m exposure. The brighter central portion is about 0'.5 in diameter, and the total diameter about 2'; nearly round. No spiral structure is discernible. A curious straight ray lies in a gap in the nebulosity in p.a. 20°, apparently connected with the nucleus by a thin line of matter. The ray is brightest at its inner end, which is 11" from the nucleus. 20 s.n.

15,000 light-years
4600 parsecs

57"

F814W I
F814W V



JET OF M87

- optical emission from AGN jets is linearly polarized
- strong argument for synchrotron radiation
- optical polarization:
optically thin
no Faraday rotation

M87 (Baade 1956)

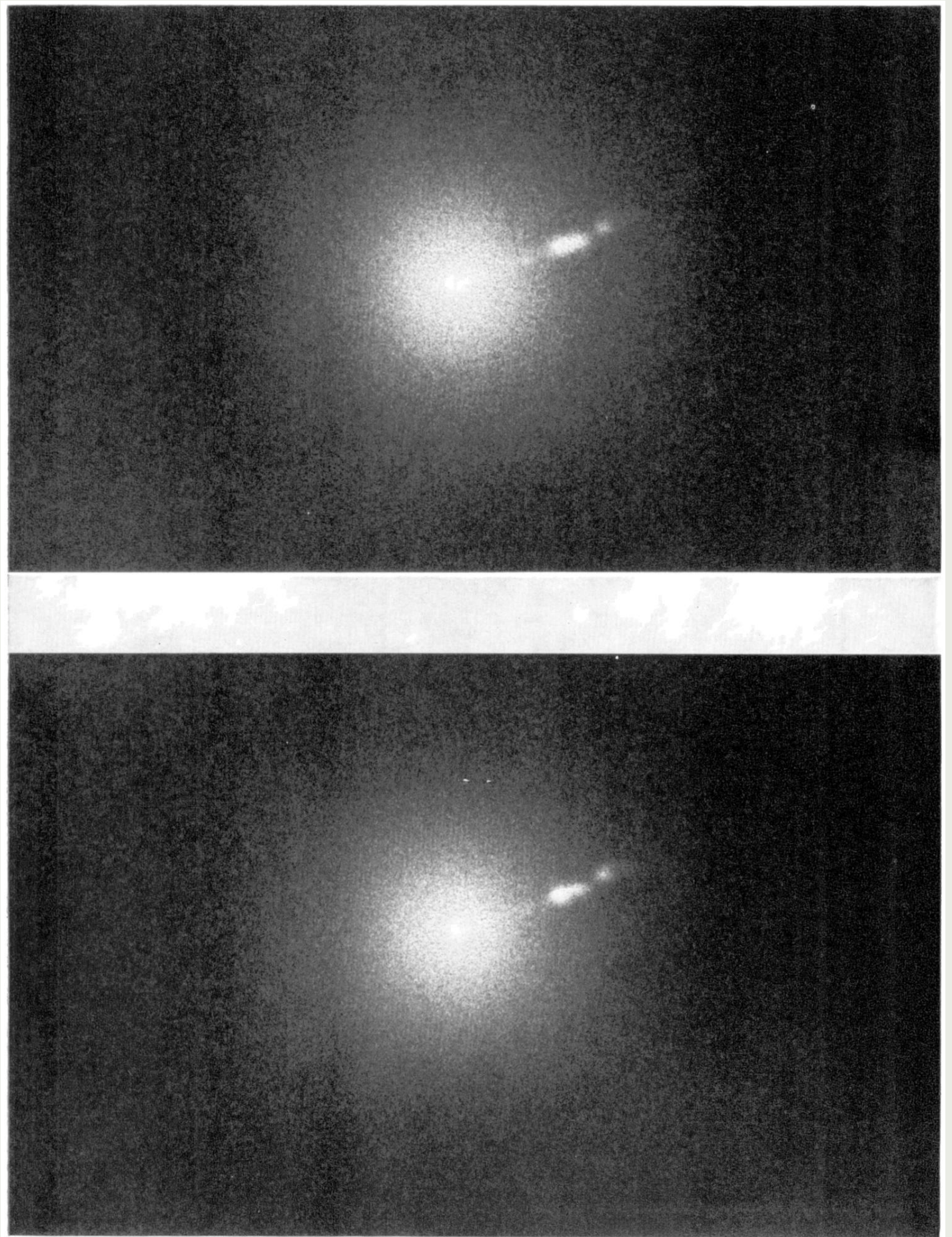
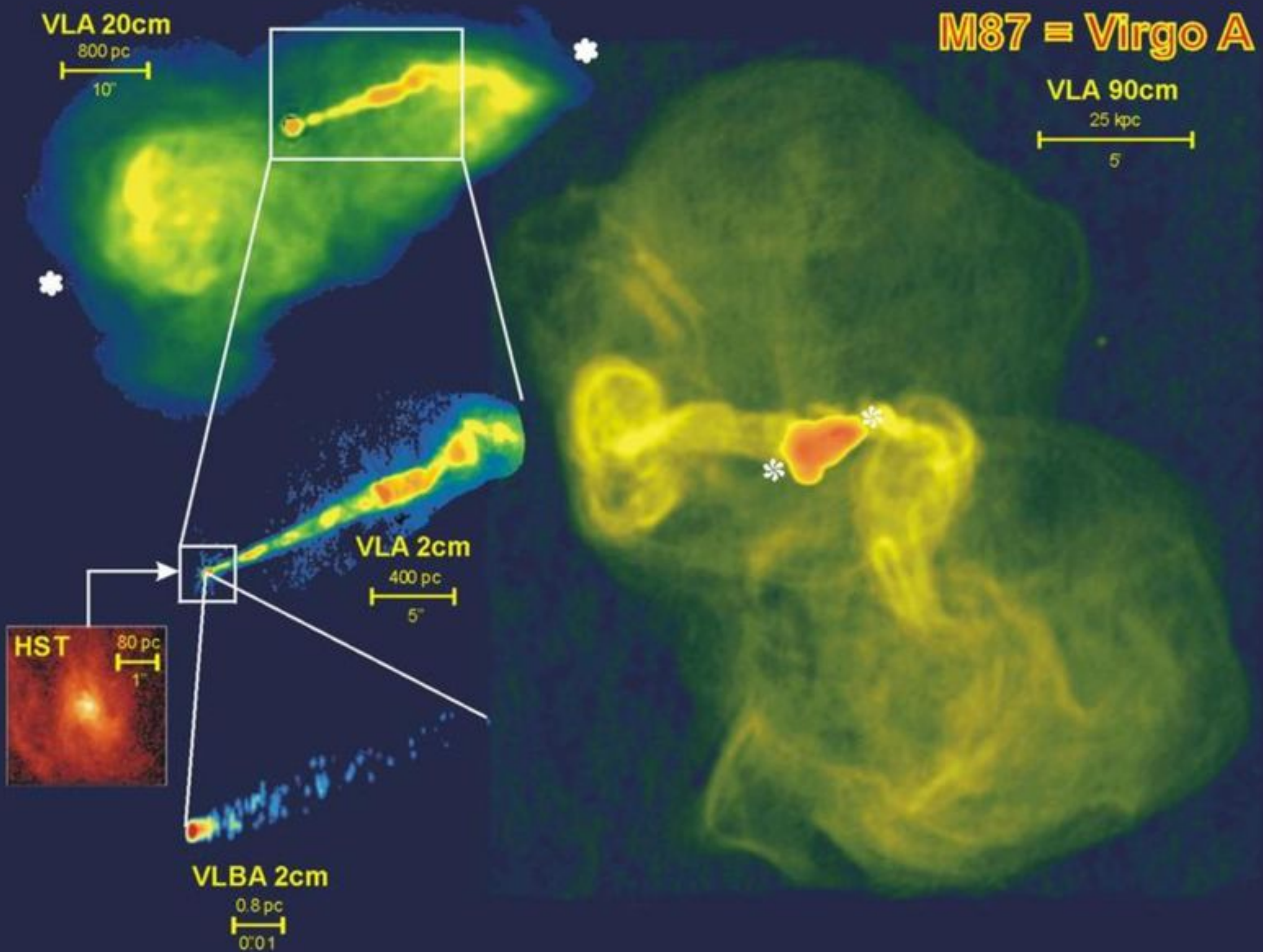
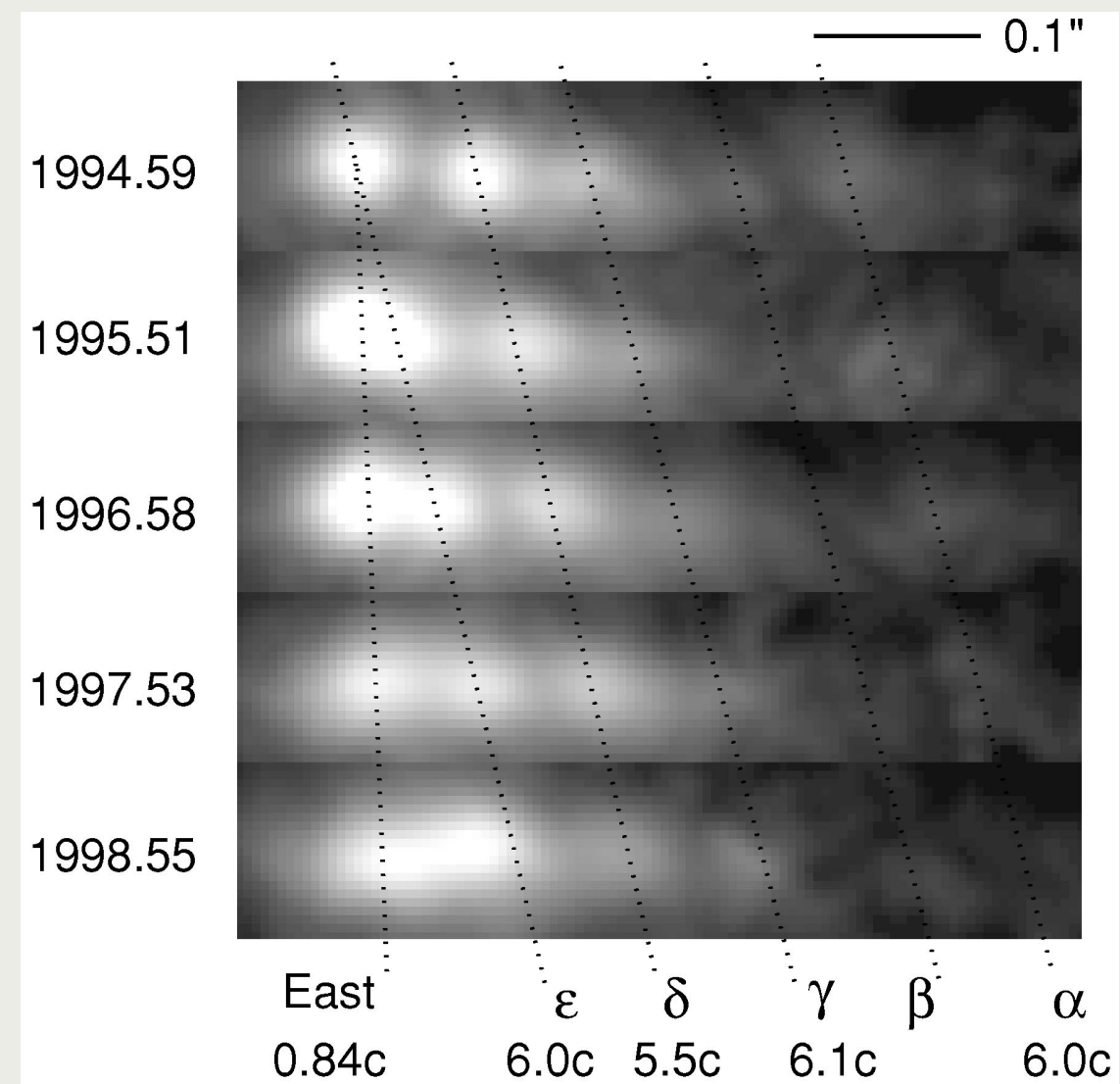
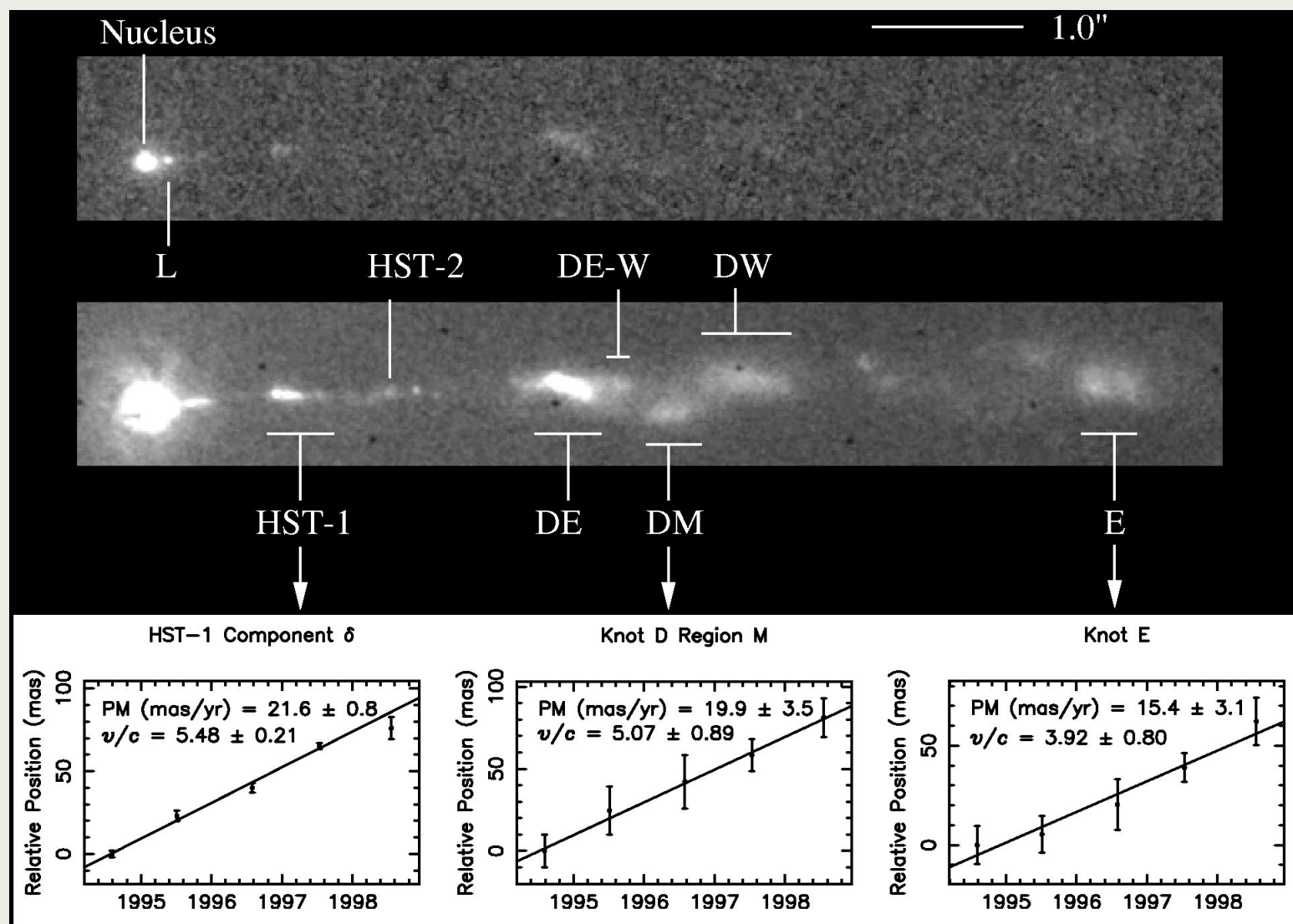


FIG. 1.—*Upper picture* maximum transmission of electric vector in position angle 200° . *Lower picture*: maximum transmission of electric vector in position angle 290° .

M87 = Virgo A

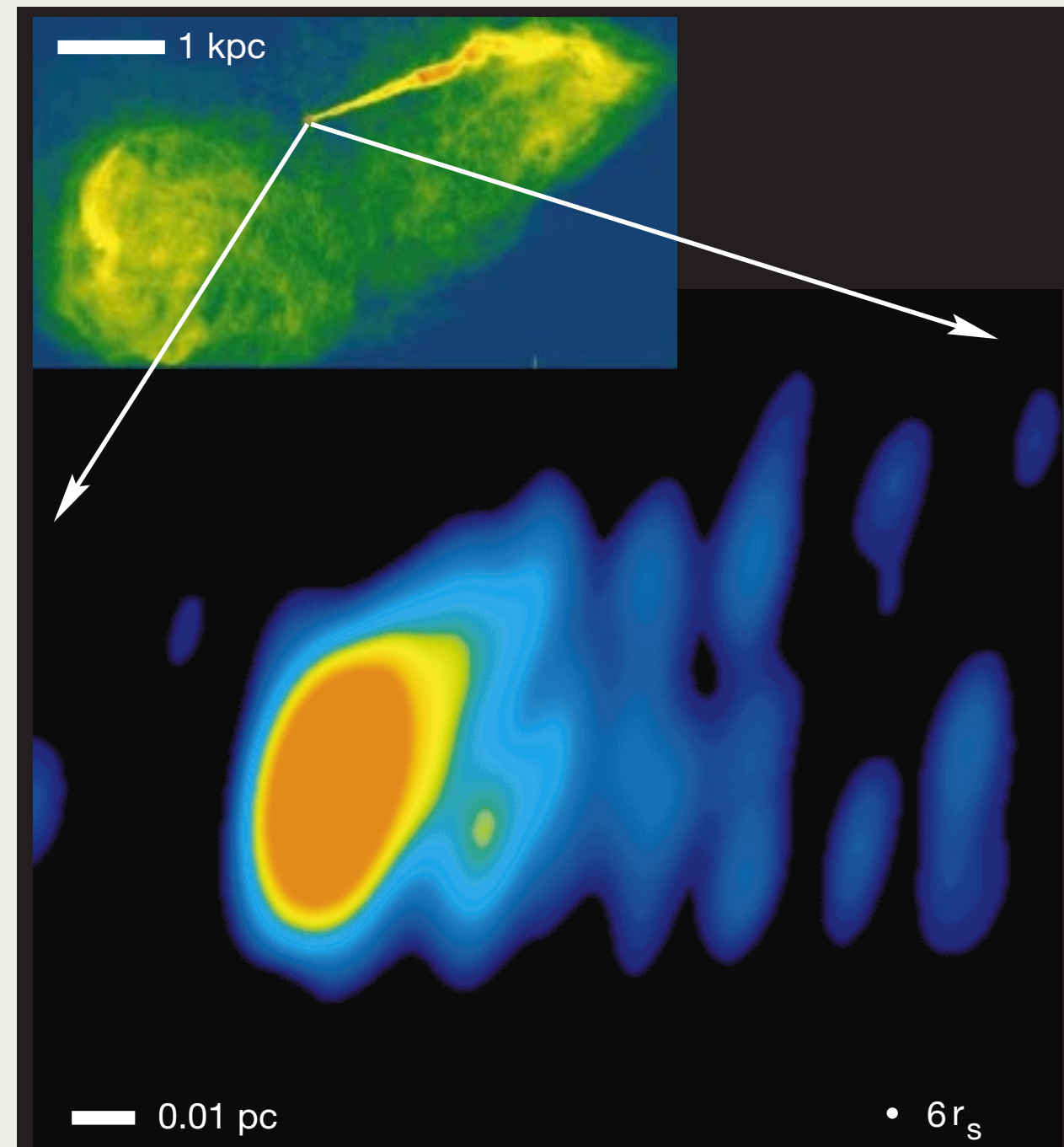
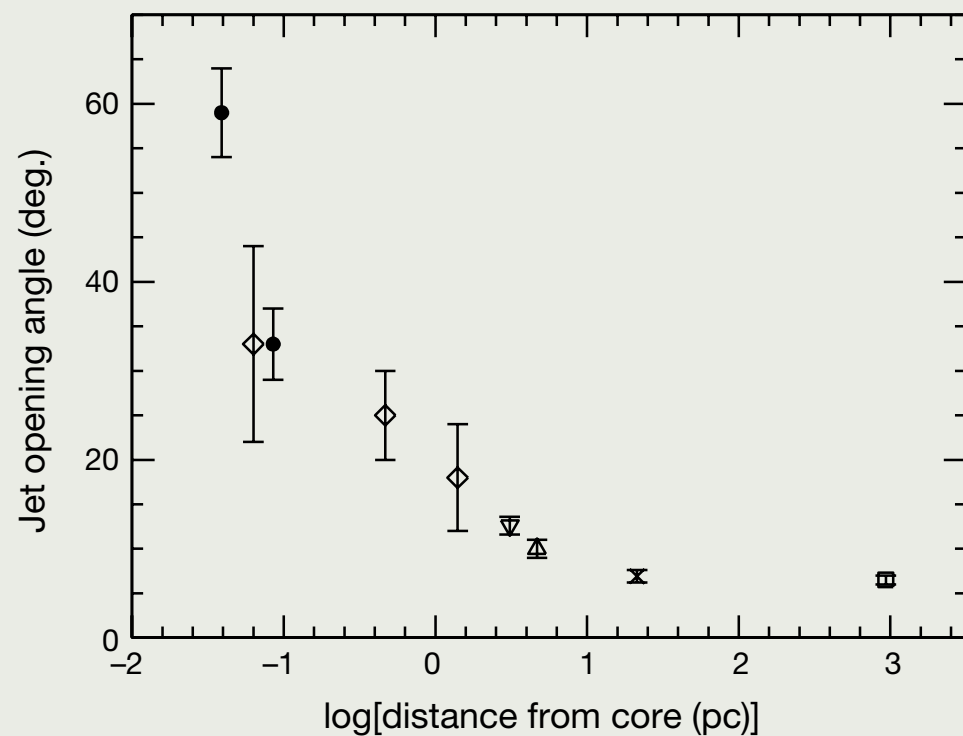
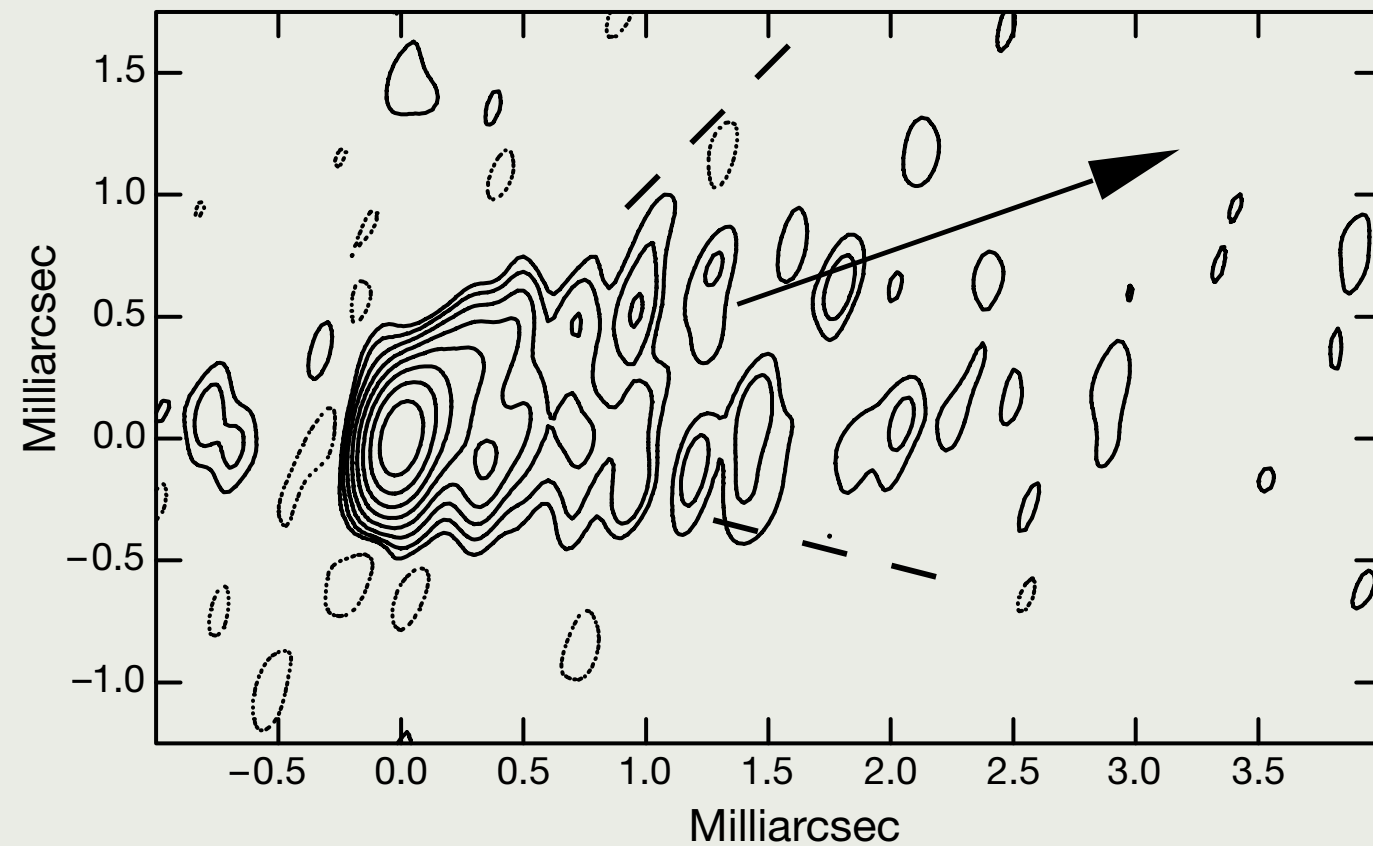


OPTICAL KNOTS WITH HST: SUPERLUMINAL MOTIONS

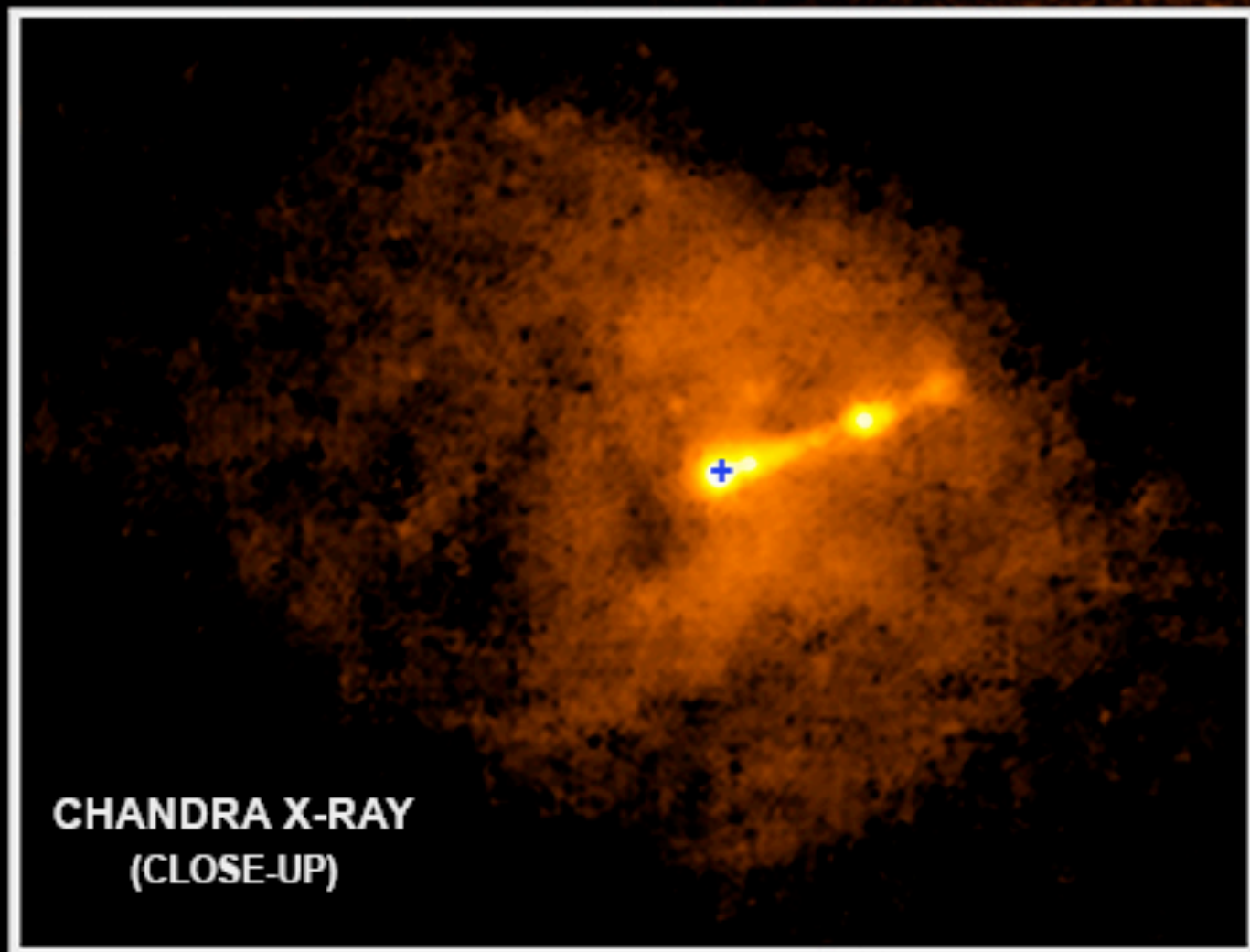
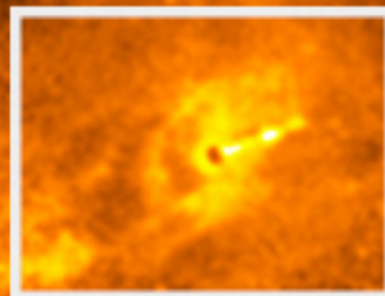


Biretta et al. (1999)

VLBA AT 7MM: RESOLVING THE COLLIMATION ZONE



Junor, Biretta & Livio (1999)



CHANDRA X-RAY
(CLOSE-UP)

NASA/CXC
Villanova University/J. Neilsen
(2019)

CHANDRA X-RAY
(WIDE-FIELD)

M87

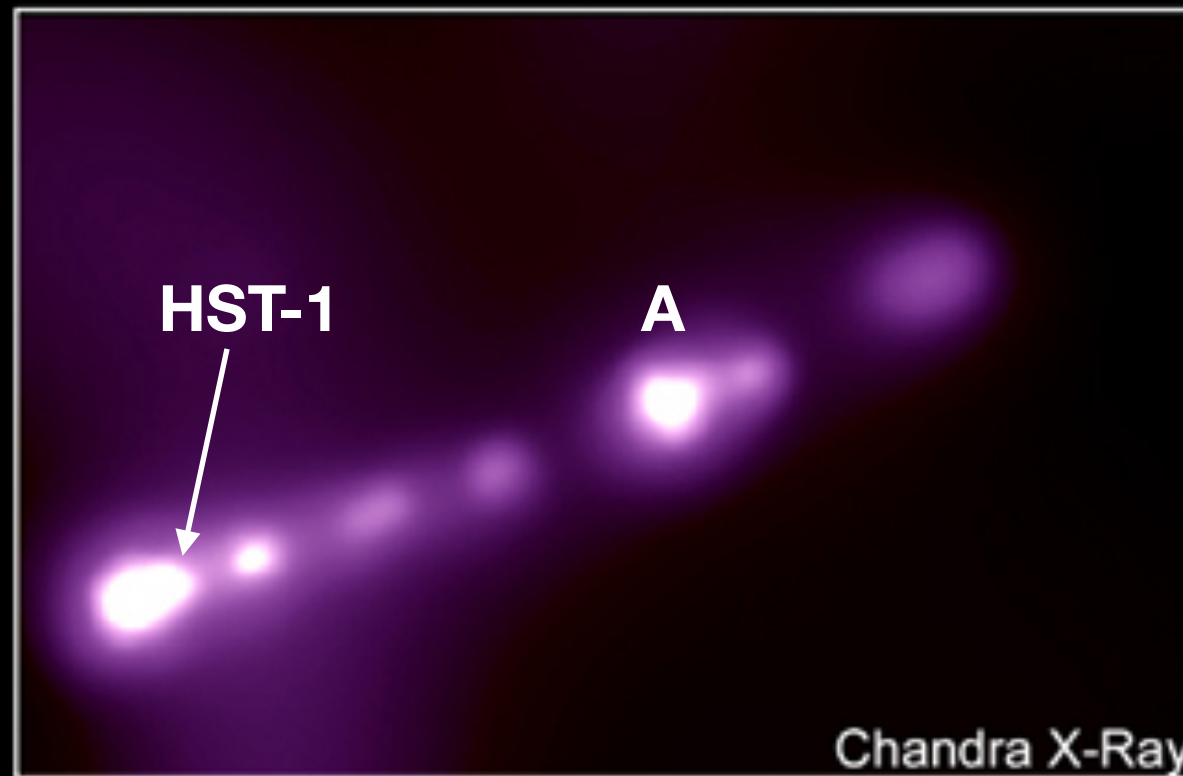
Radio ■ VLA

Visible ■ *Hubble* + R. Gendler

X-ray ■ *Chandra*



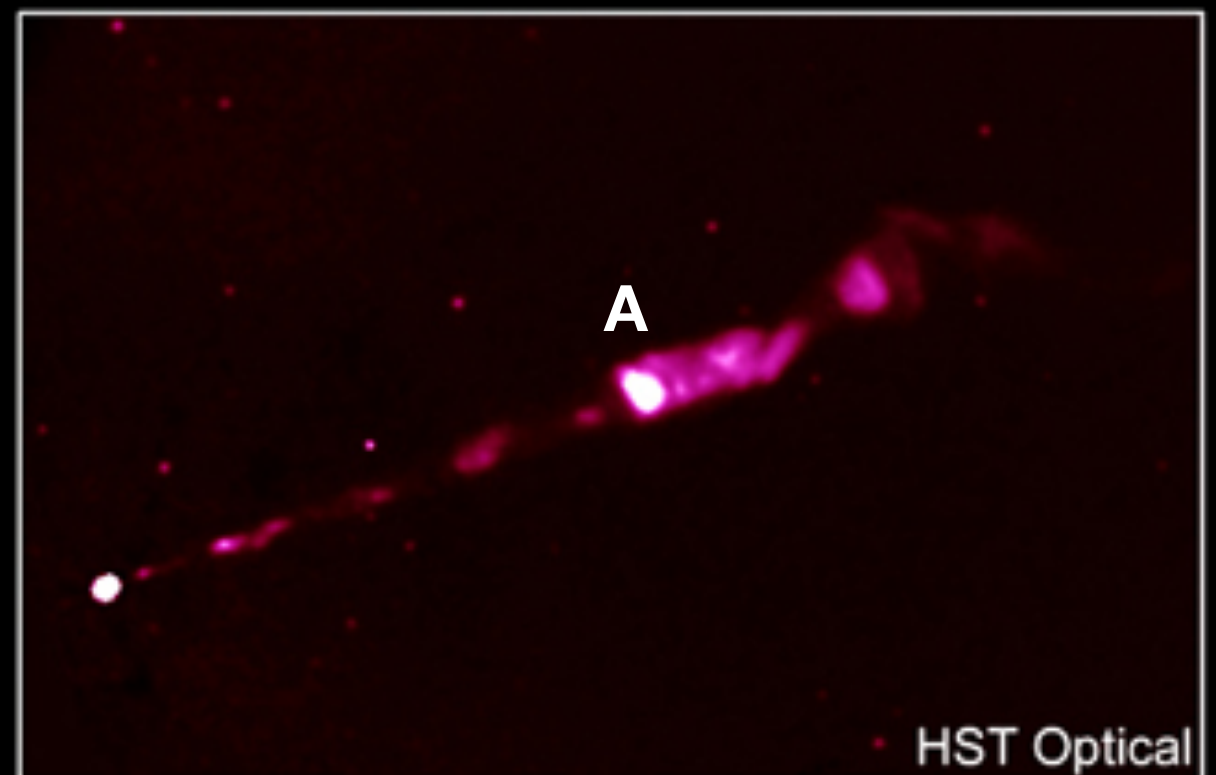
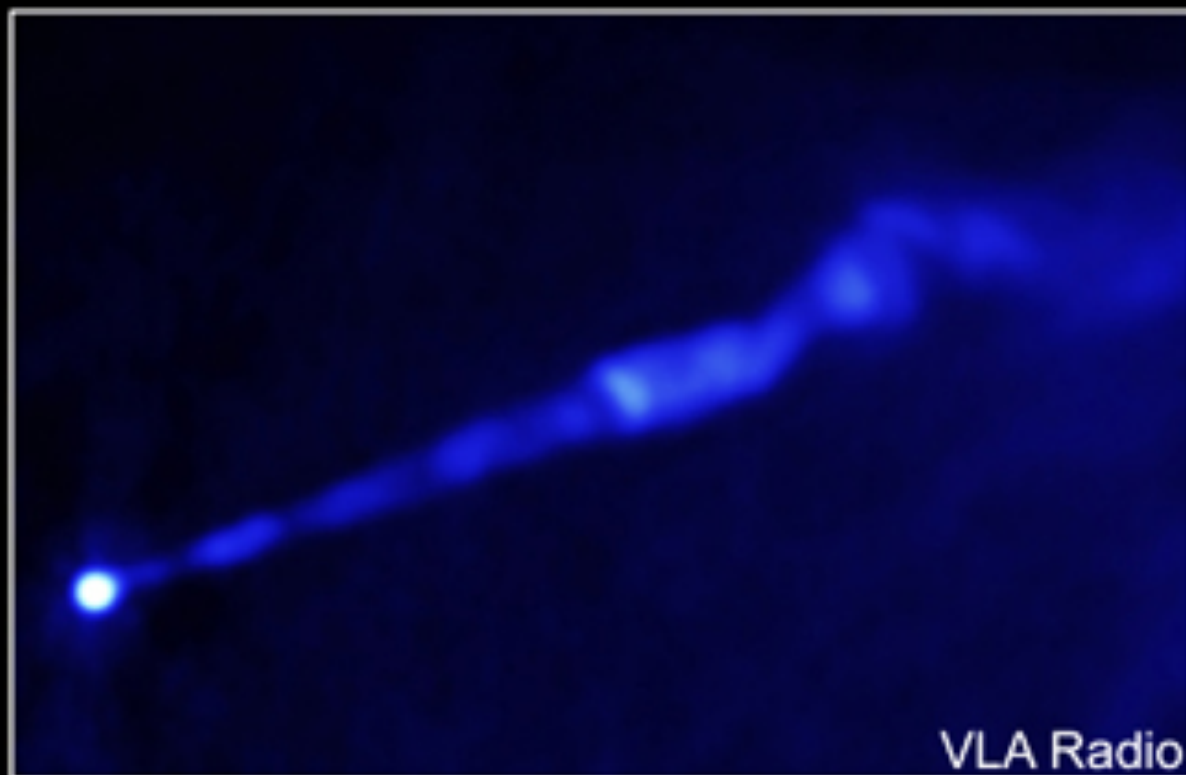
M87 jet - kpc scales



HST-1:
0.86 as
~ 70 pc

A: 12 as
~ 0.99 kpc

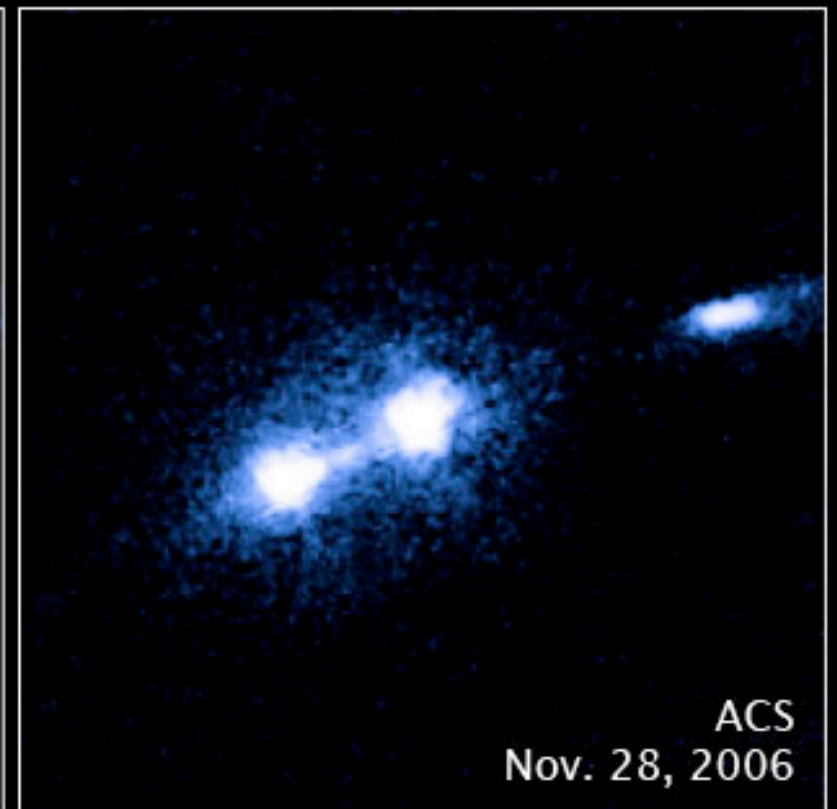
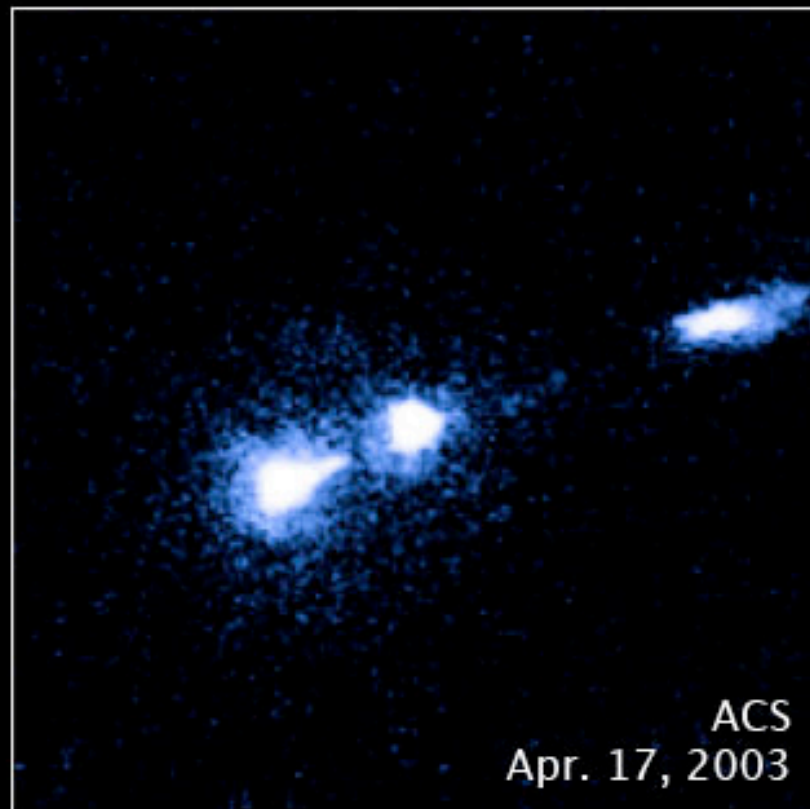
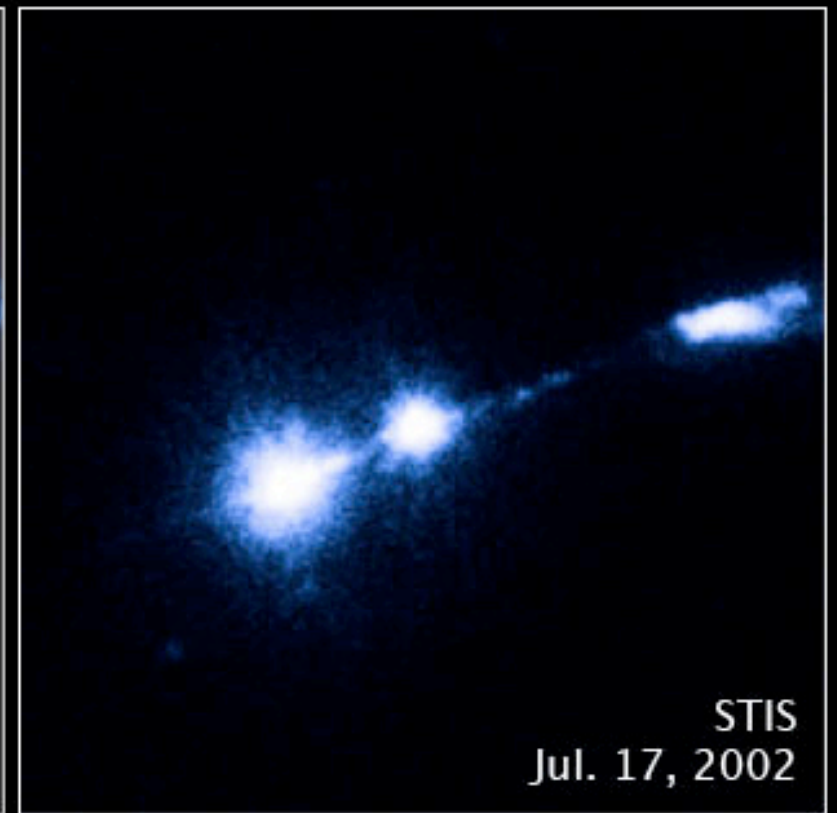
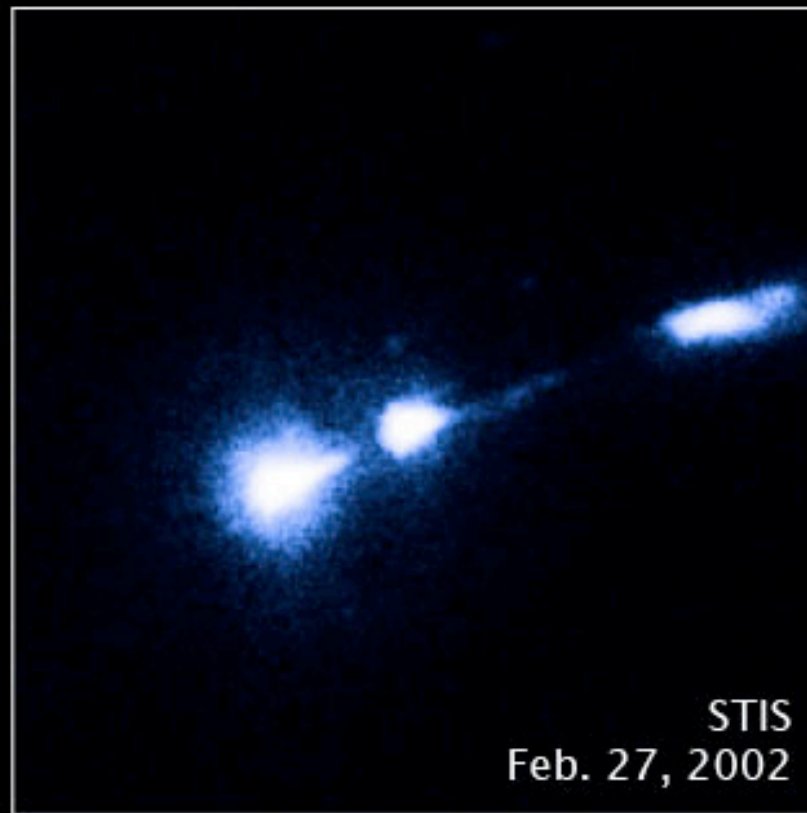
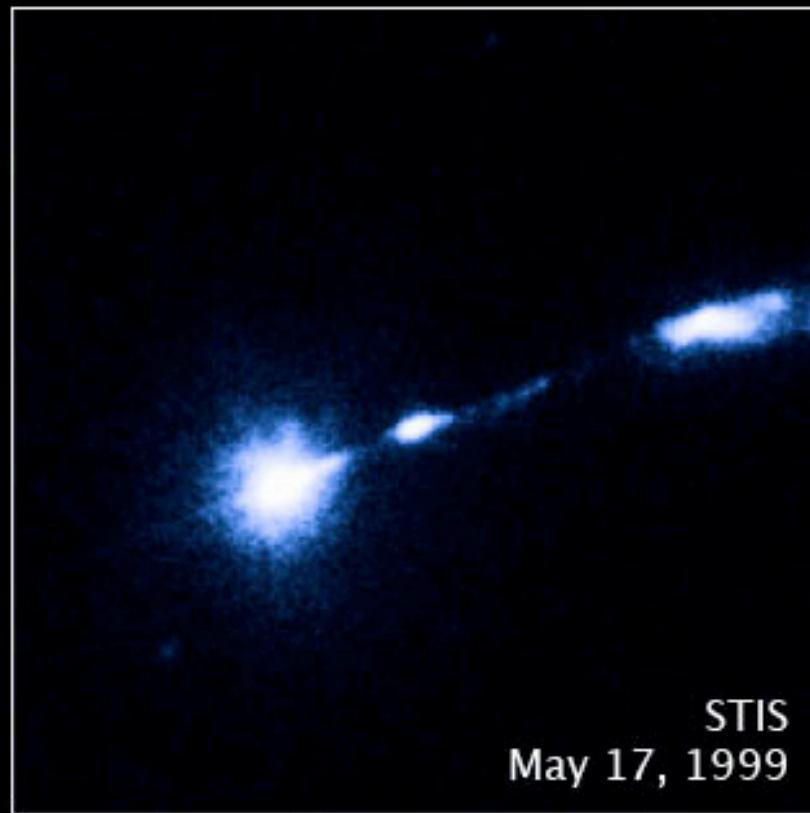
CXC 2001



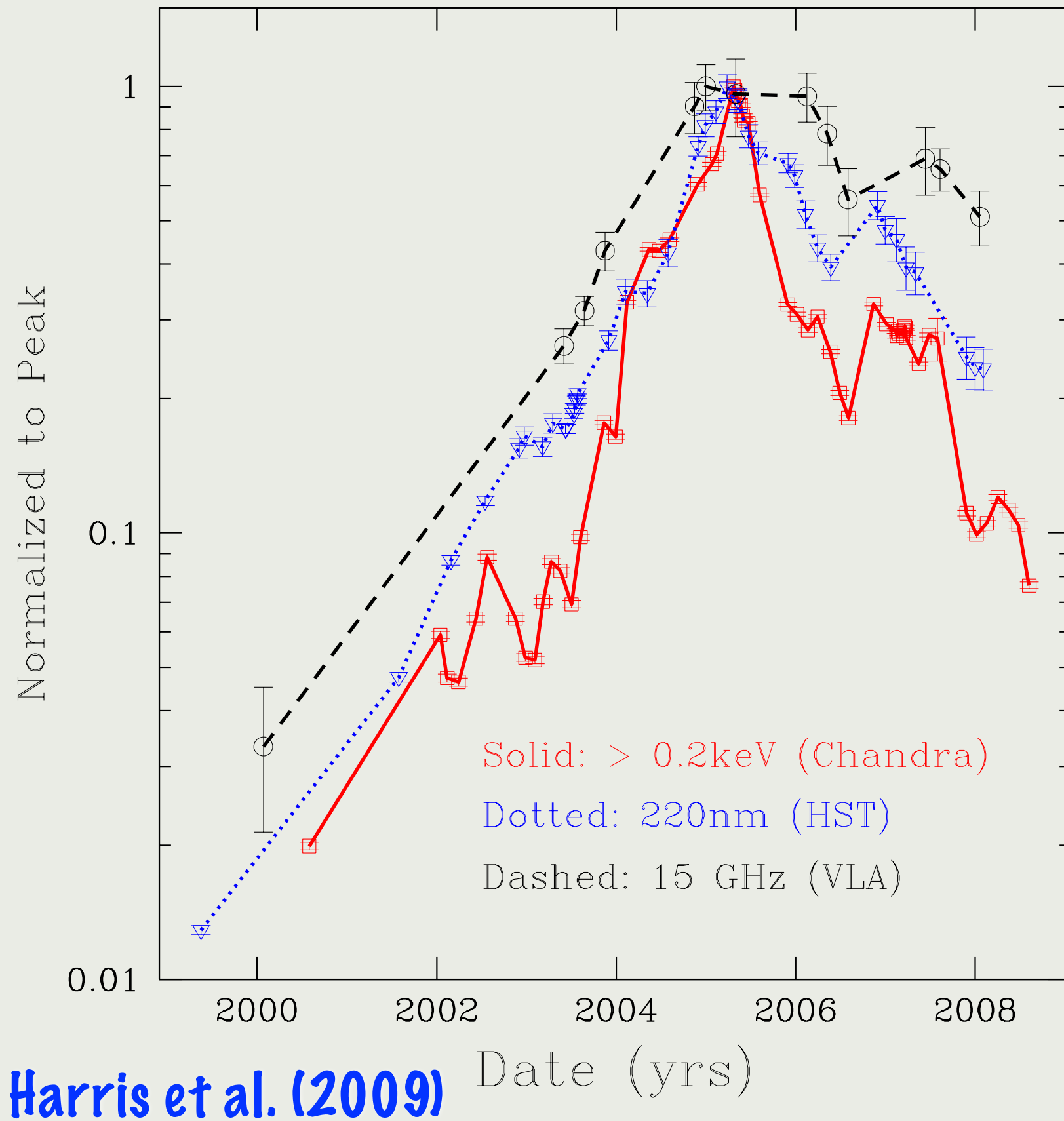
FLARING HST-1 KNOT

M87 Nucleus and Bright Knot in Extragalactic Jet

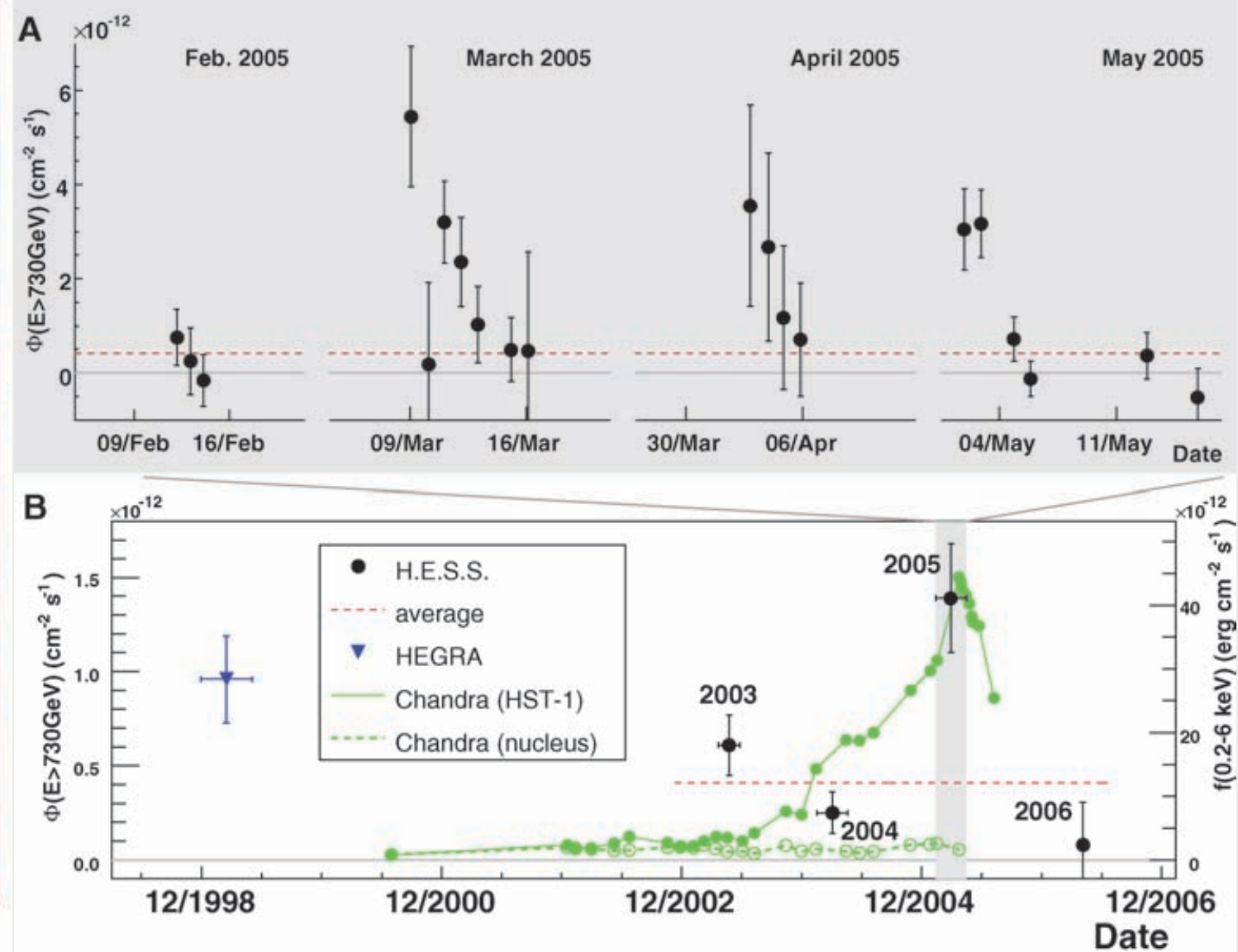
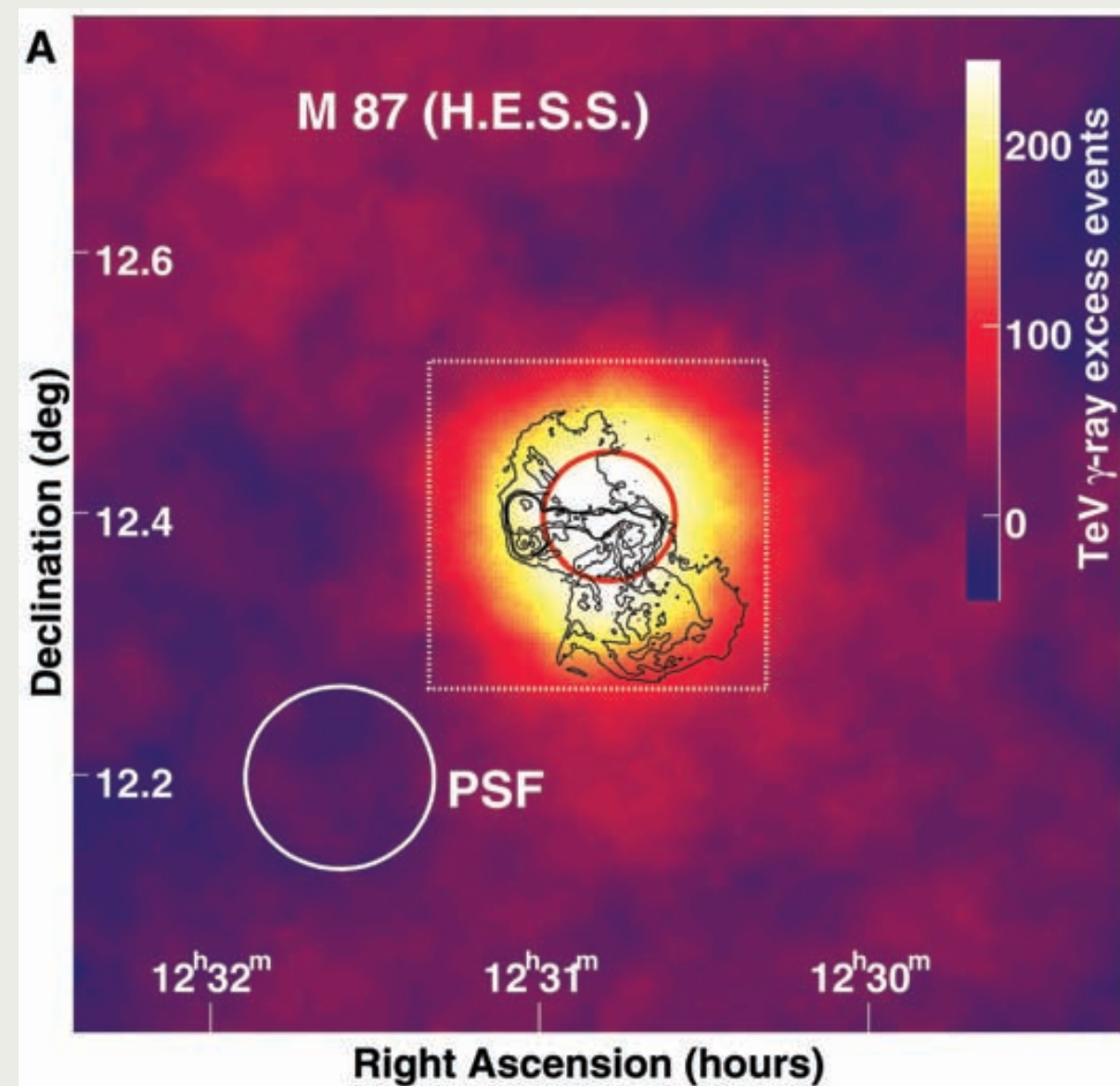
HST • STIS/MAMA • ACS/HRC



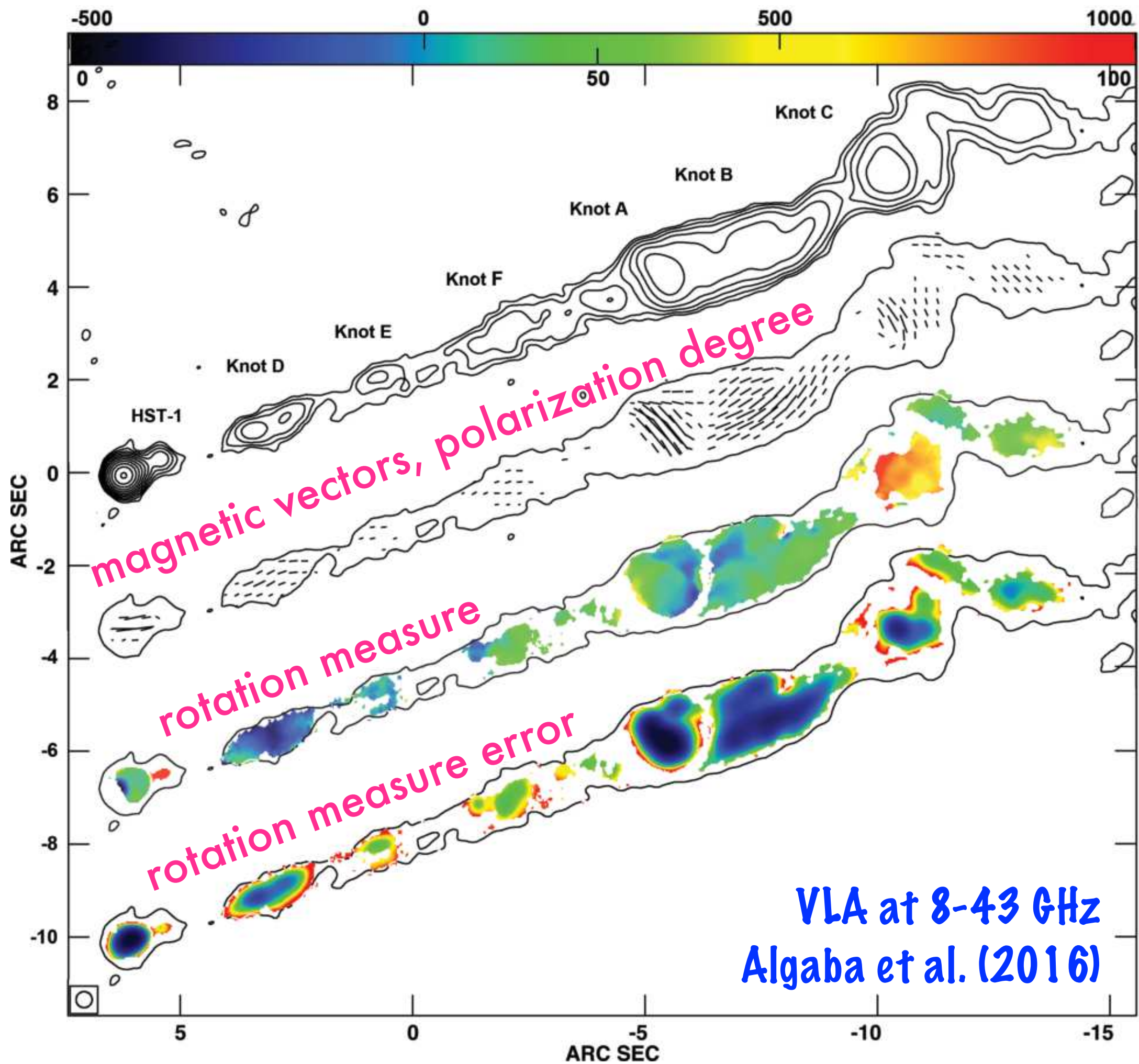
FLARING HST-1 KNOT



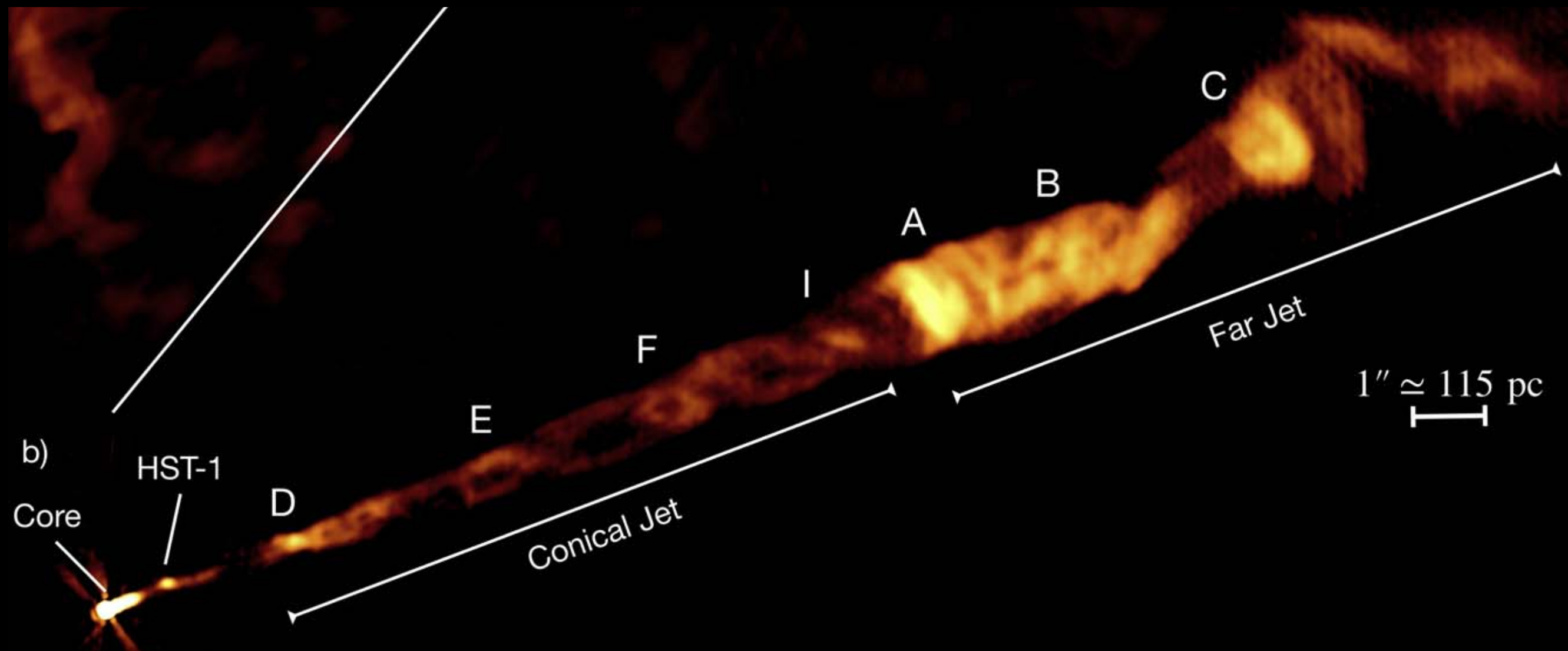
TEV GAMMA RAYS



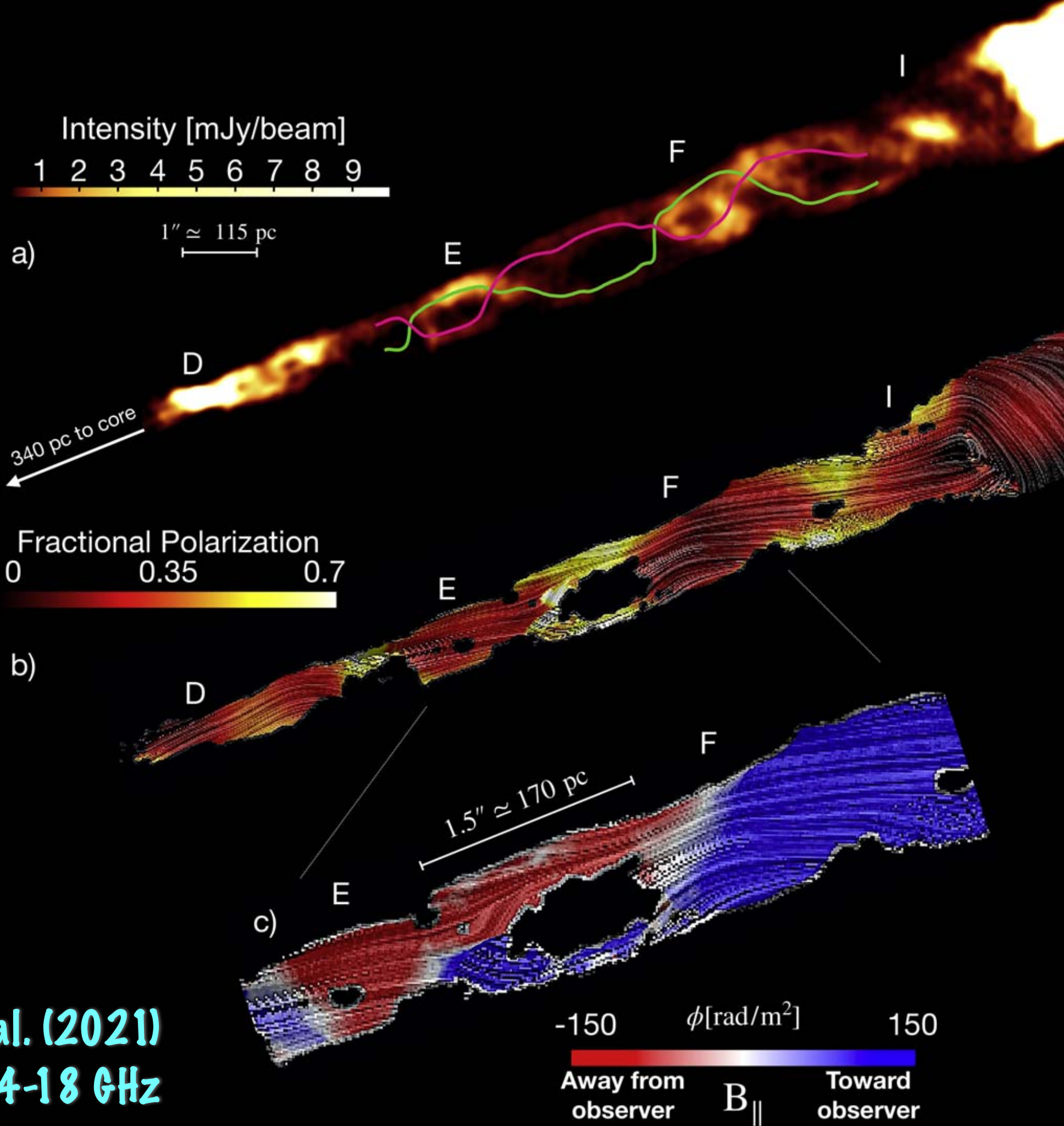
Aharonian et al. (2006)



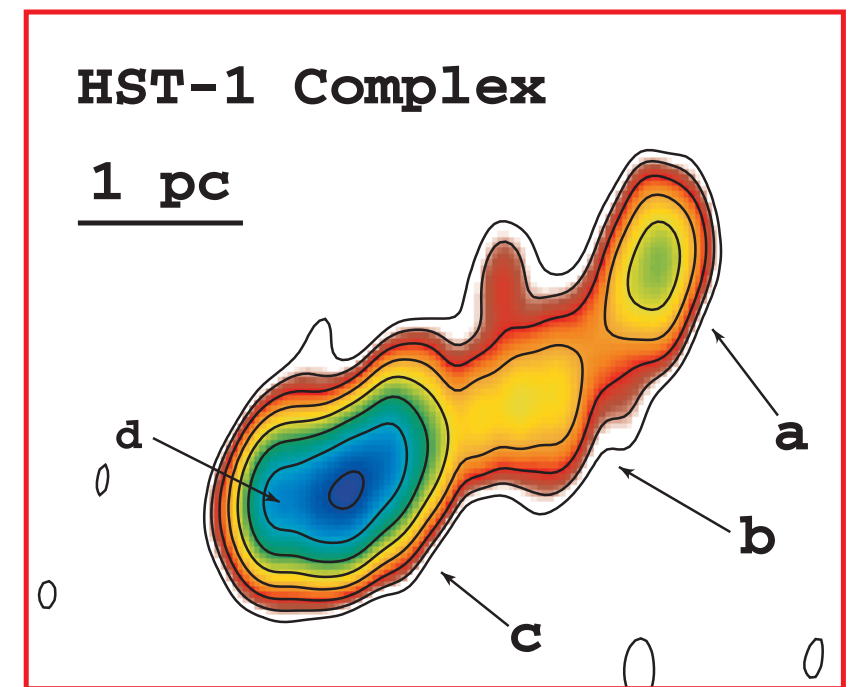
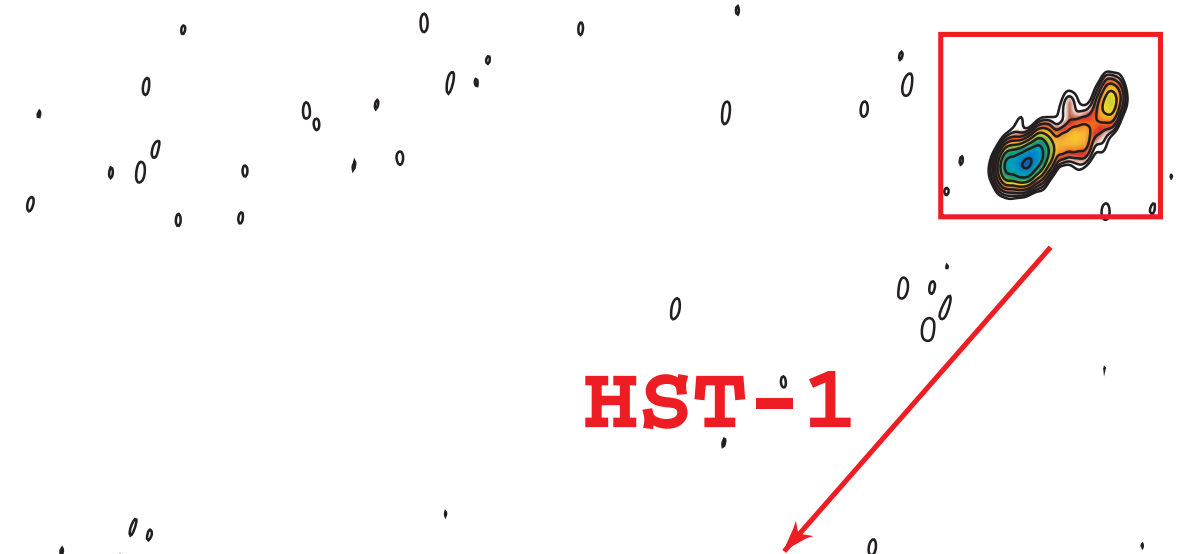
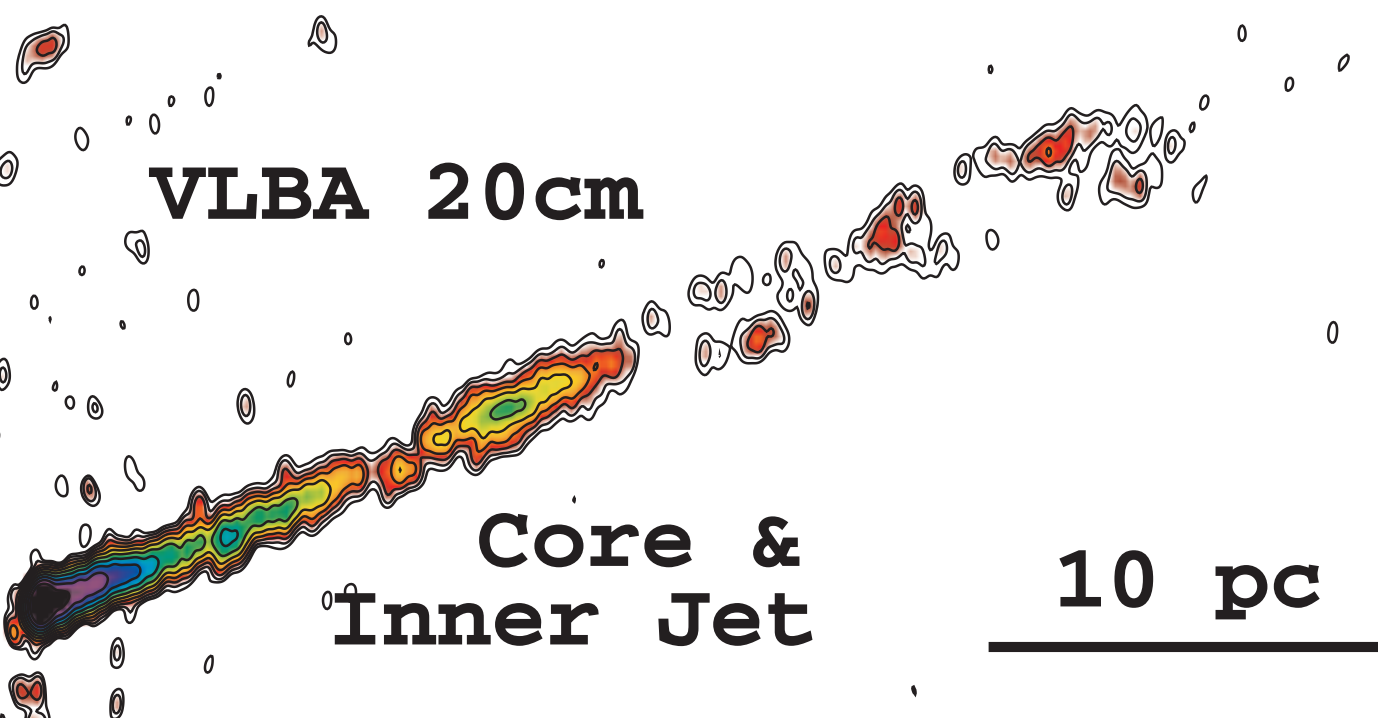
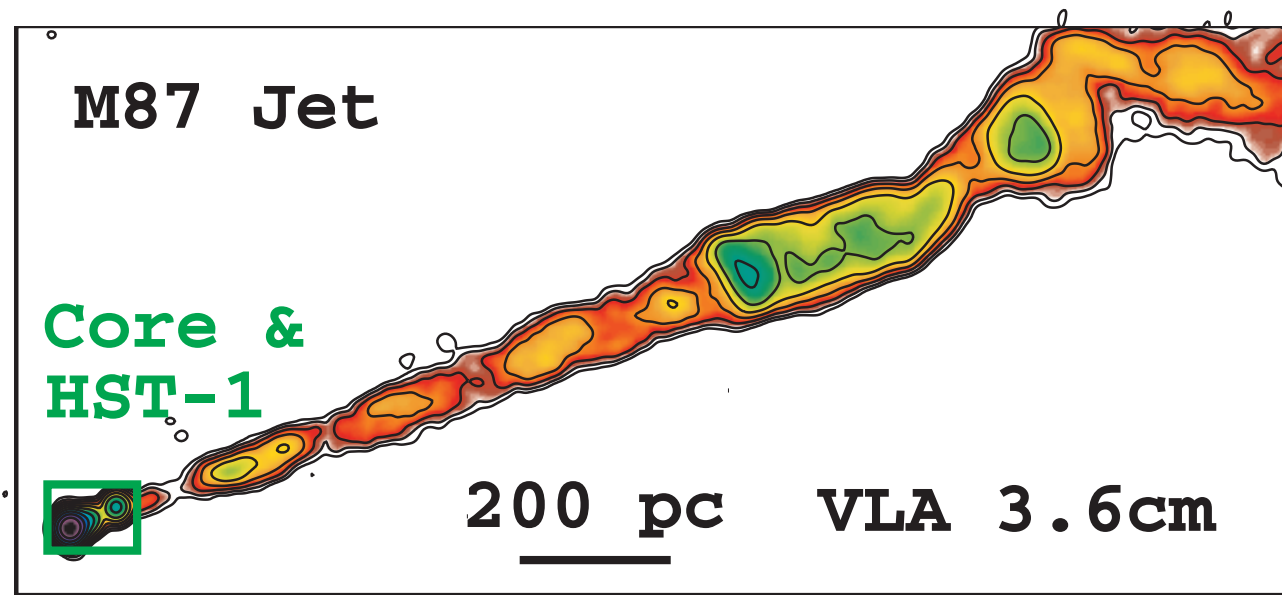
JET OF M87: RADIO



Pasetto et al. (2021)
JVLA at 4-18 GHz



Pasetto et al. (2021)
JVL A at 4-18 GHz

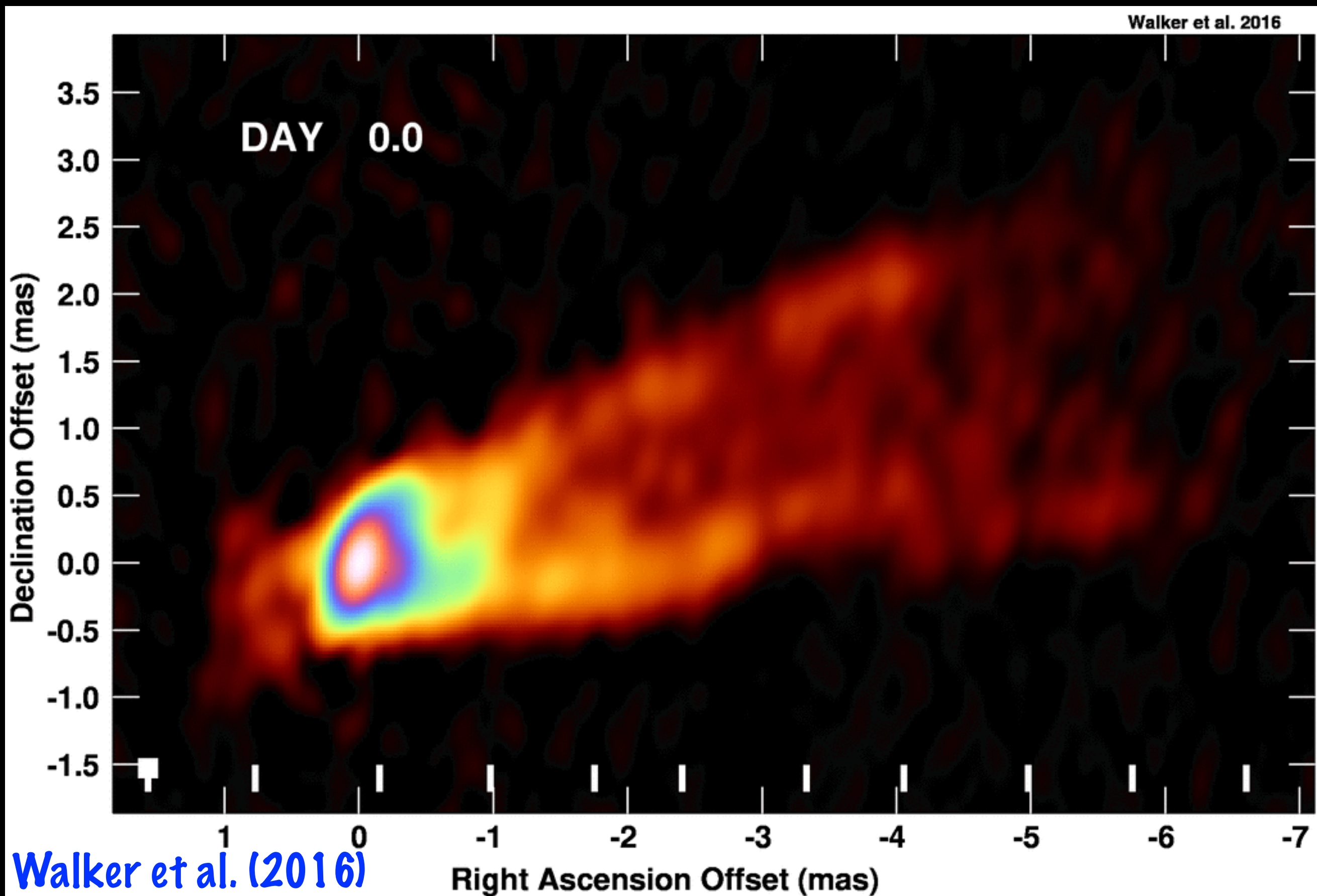


Cheung, Harris & Stawarz (2007)

jet position angle ~ 288 deg

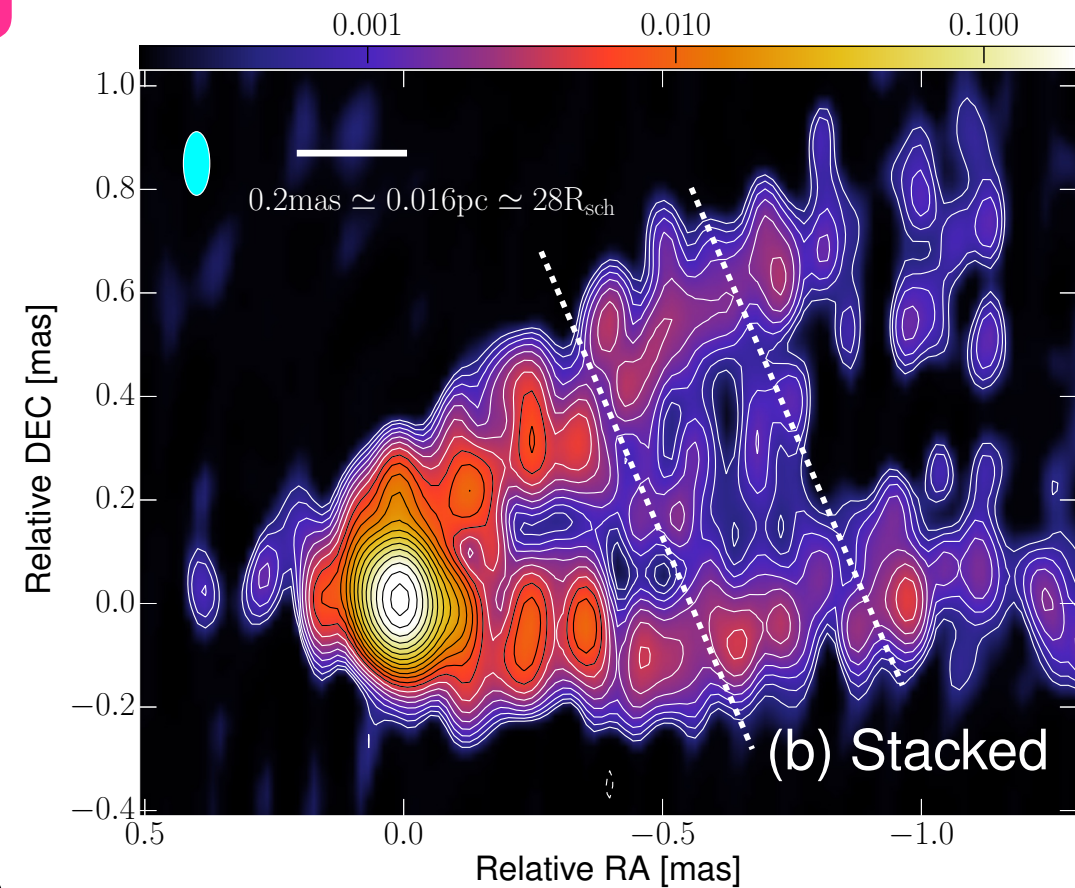
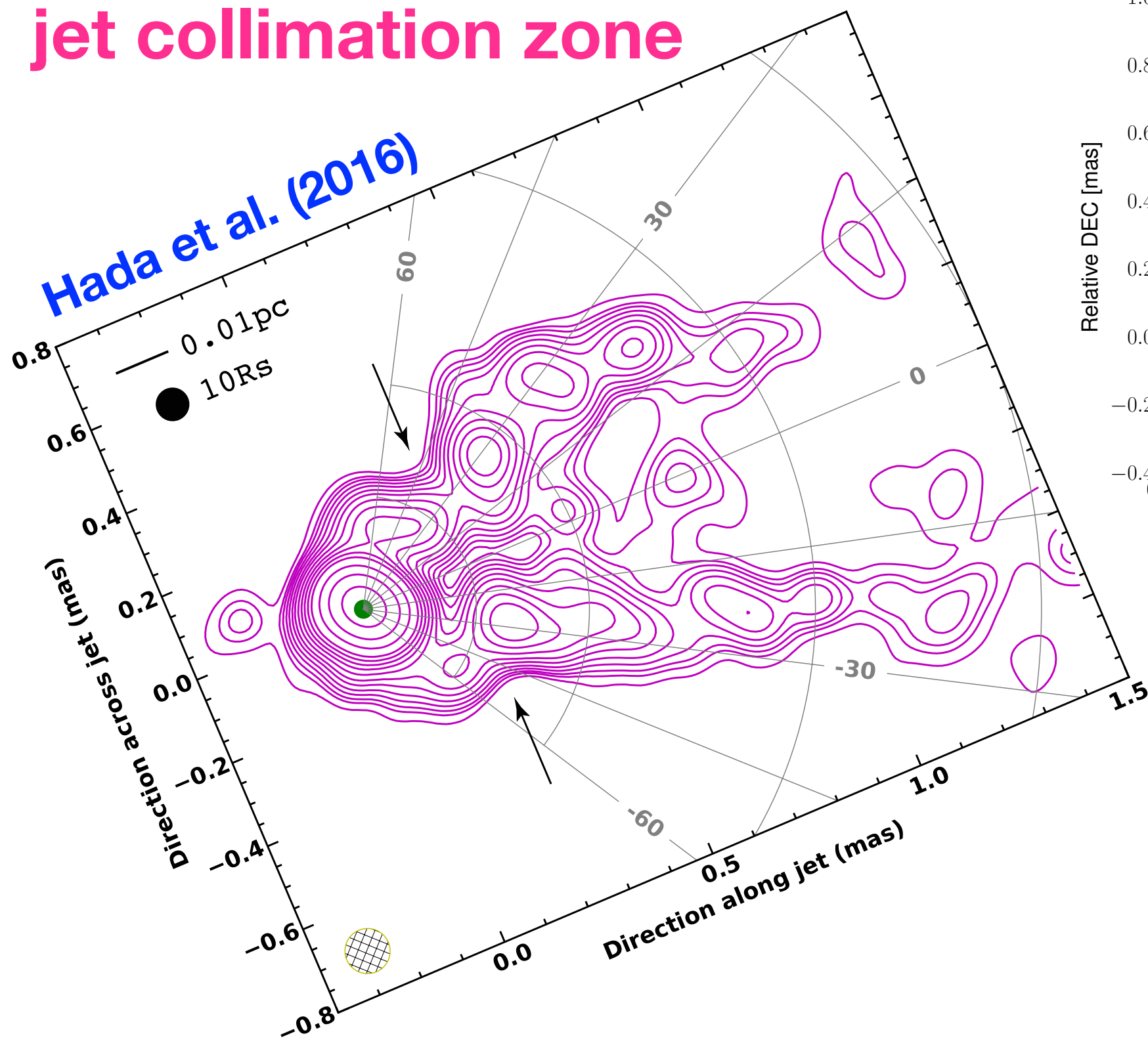
jet viewing angle ~ 18 deg

M87: VLBI AT 7MM



86 GHz (3.5 mm)

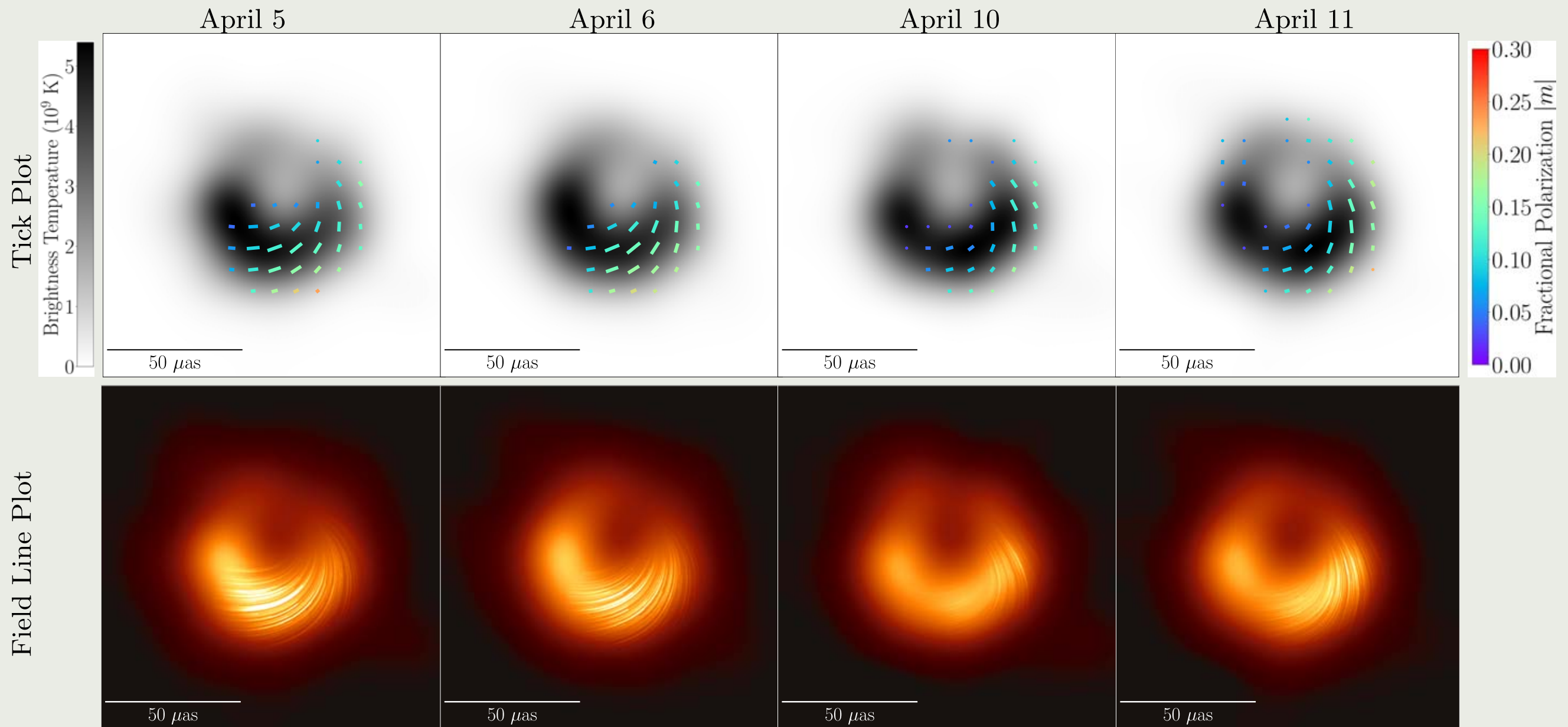
broad opening angle $\pm 60^\circ$
jet collimation zone



Kim et al. (2018)

jet / core
brightness ratio
 ~ 25

M87: EVENT HORIZON TELESCOPE: POLARIZATION



EHT Paper VII (2021)

M87 CRESCENT ORIENTATION

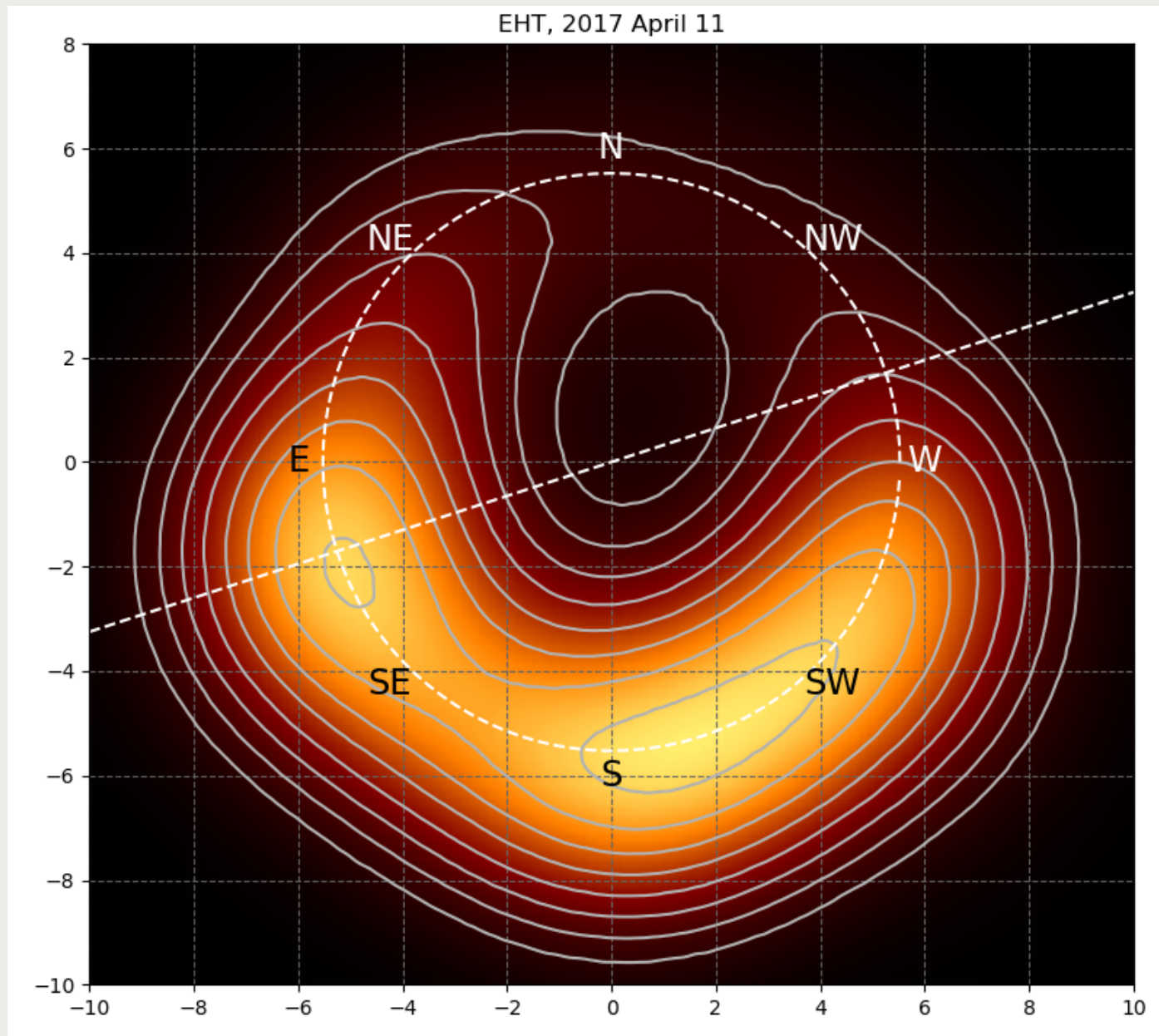
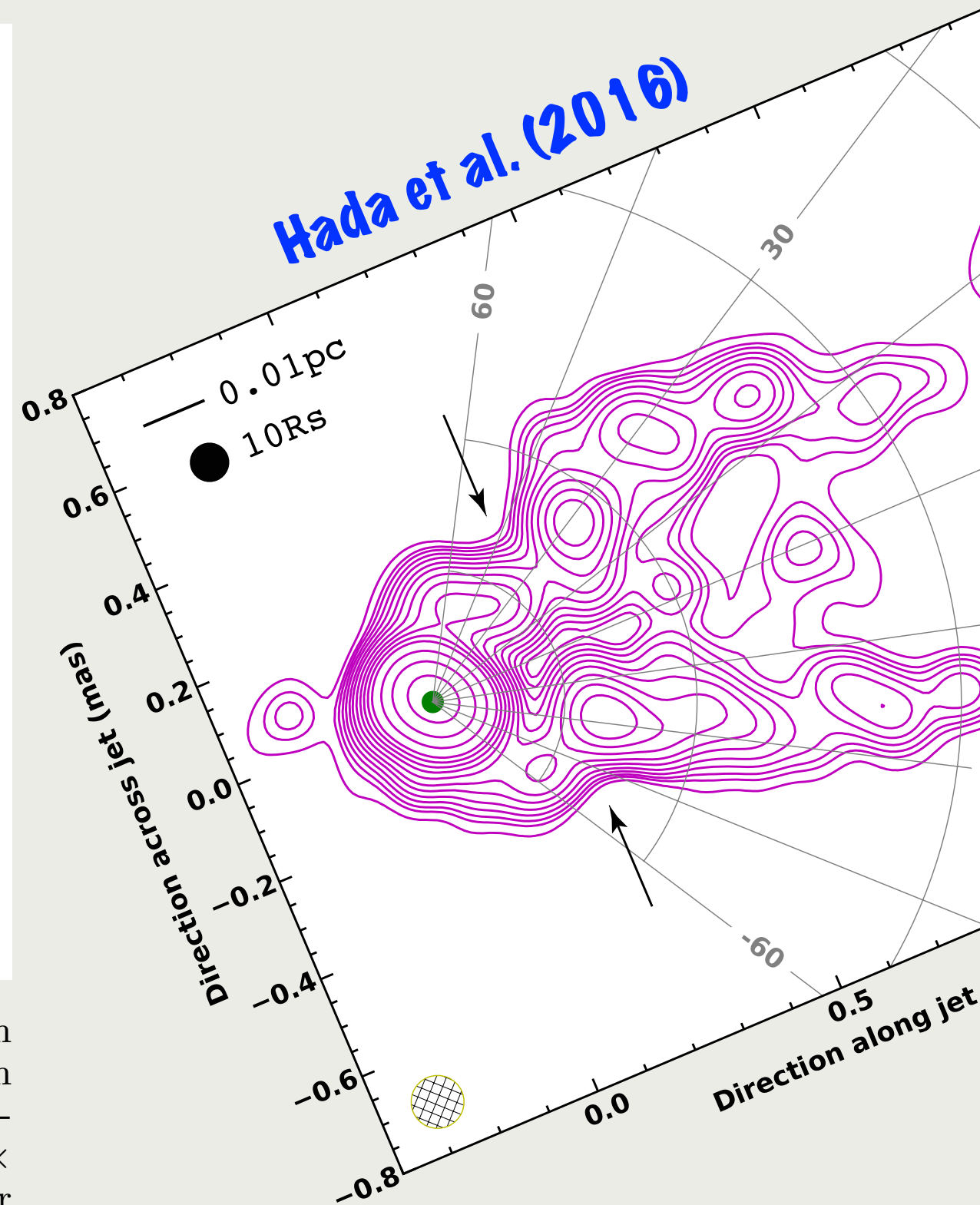
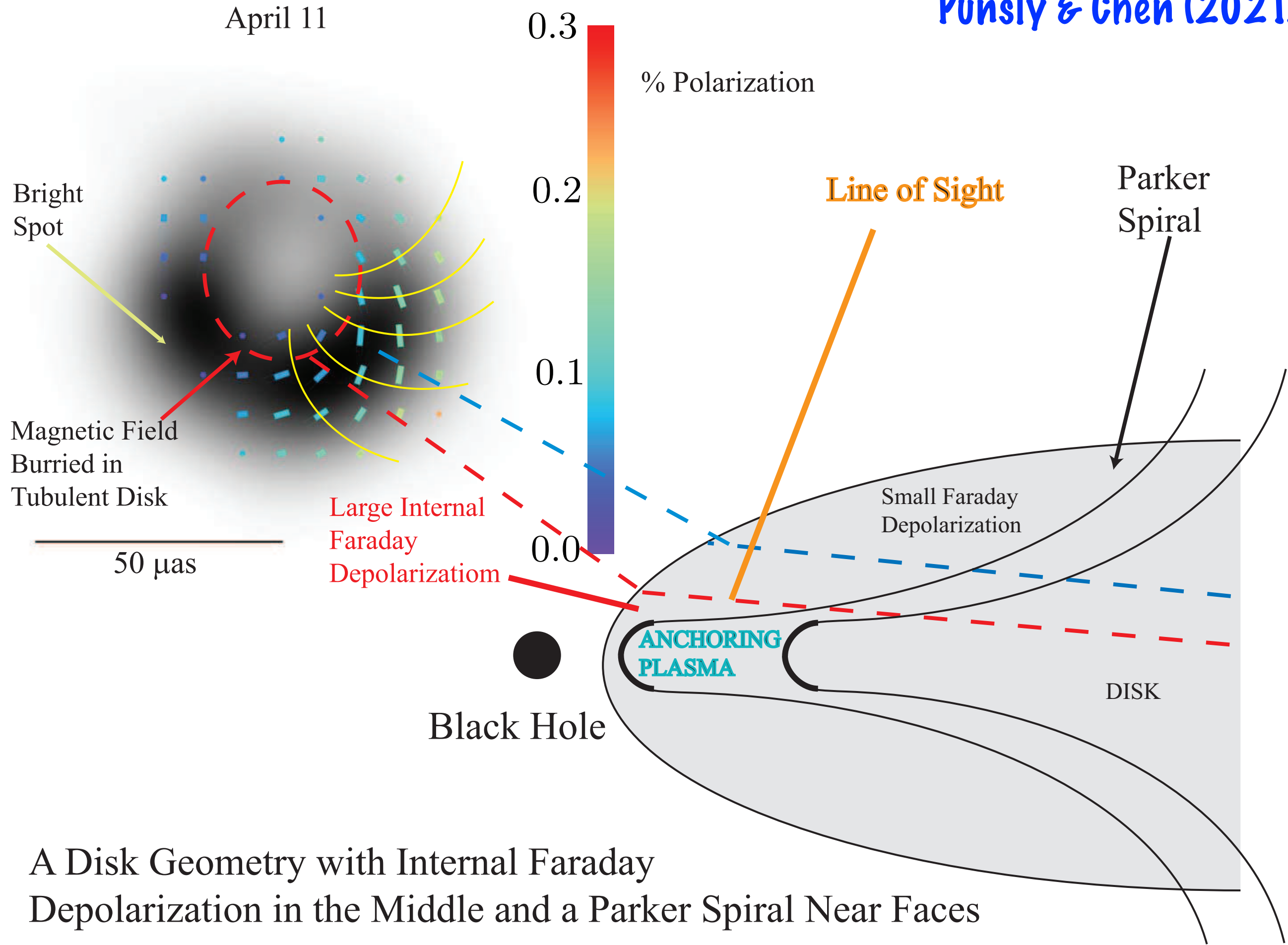


Fig. 1. Image of BH M87* at 1.3 mm wavelength obtained on April 11, 2017 by the Event Horizon Telescope (adapted from Fig. 3 in [EHT Collaboration 2019a](#)). The grey contour levels correspond to brightness temperature values of $(2, 2.5, 3, \dots, 5.5) \times 10^9$ K. The white dashed lines indicate a photon ring of diameter $42 \mu\text{as}$ equivalent to $\simeq 11M$, and the position angle of large-scale jet $\text{PA} = 288^\circ$ (NWW). The units of the grid are the angular size of the M87* gravitational radius $\theta_g \simeq 3.8 \mu\text{as}$.



KN, Sikora & Róžańska (2020)

April 11



A Disk Geometry with Internal Faraday Depolarization in the Middle and a Parker Spiral Near Faces

Size of the Milky Way (100.000 ly)



10 arcsec
|
(3.000 ly)

VLA 1.5 GHz

0,001 arcsec
|
(0,3 ly)

VLBA 43 GHz

100 arcsec
|
(30.000 ly)

LOFAR 0.05 GHz

0,00001 arcsec
|
(0,003 ly)

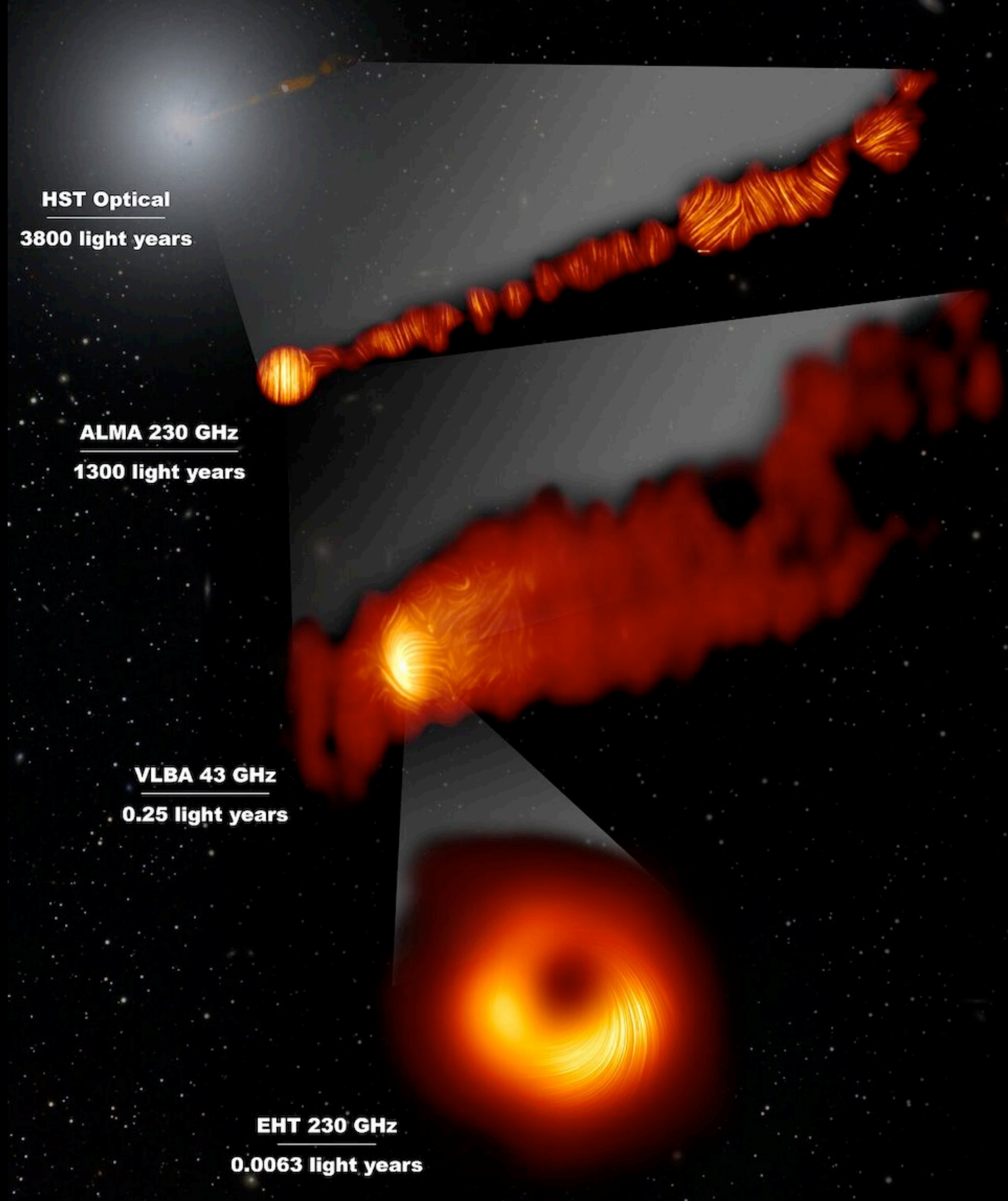
EHT 230 GHz

HST Optical
3800 light years

ALMA 230 GHz
1300 light years

VLBA 43 GHz
0.25 light years

EHT 230 GHz
0.0063 light years



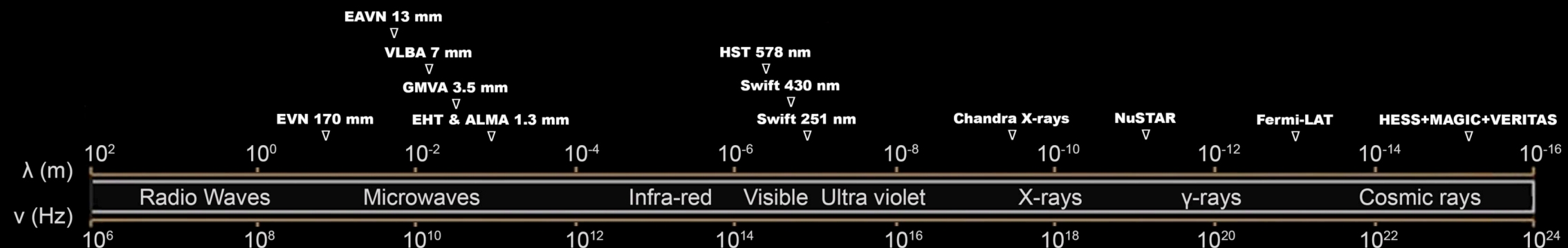
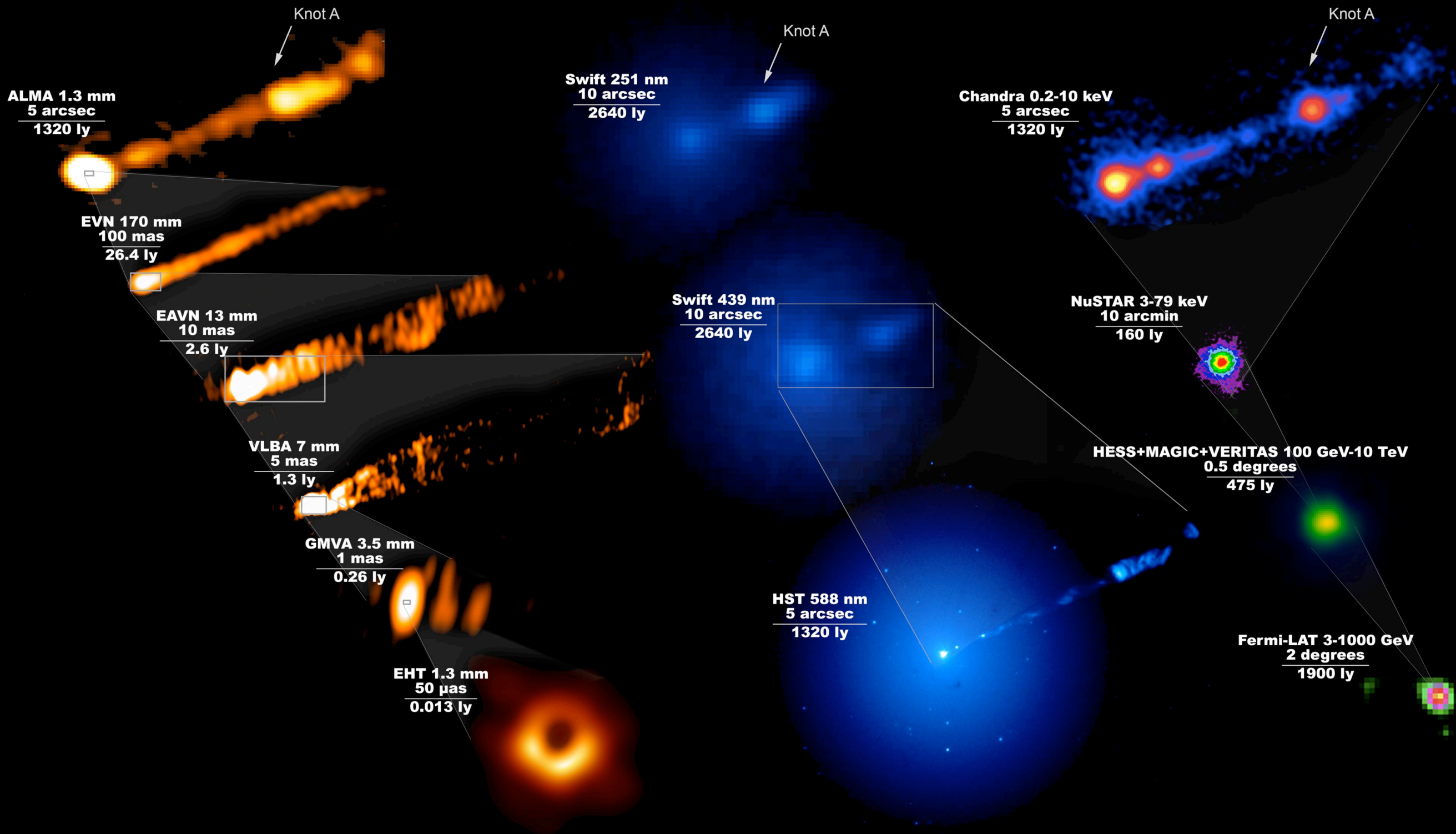


Image Credit: The EHT Multi-wavelength Science Working Group; the EHT Collaboration; ALMA (ESO/NAOJ/NRAO); the EVN; the EAVN Collaboration; VLBA (NRAO); the GMVA; the Hubble Space Telescope; the Neil Gehrels Swift Observatory; the Chandra X-ray Observatory; the Nuclear Spectroscopic Telescope Array;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