GRAVITATIONAL LENSES AS HIGH-RESOLUTION TELESCOPES

Anna Barnacka
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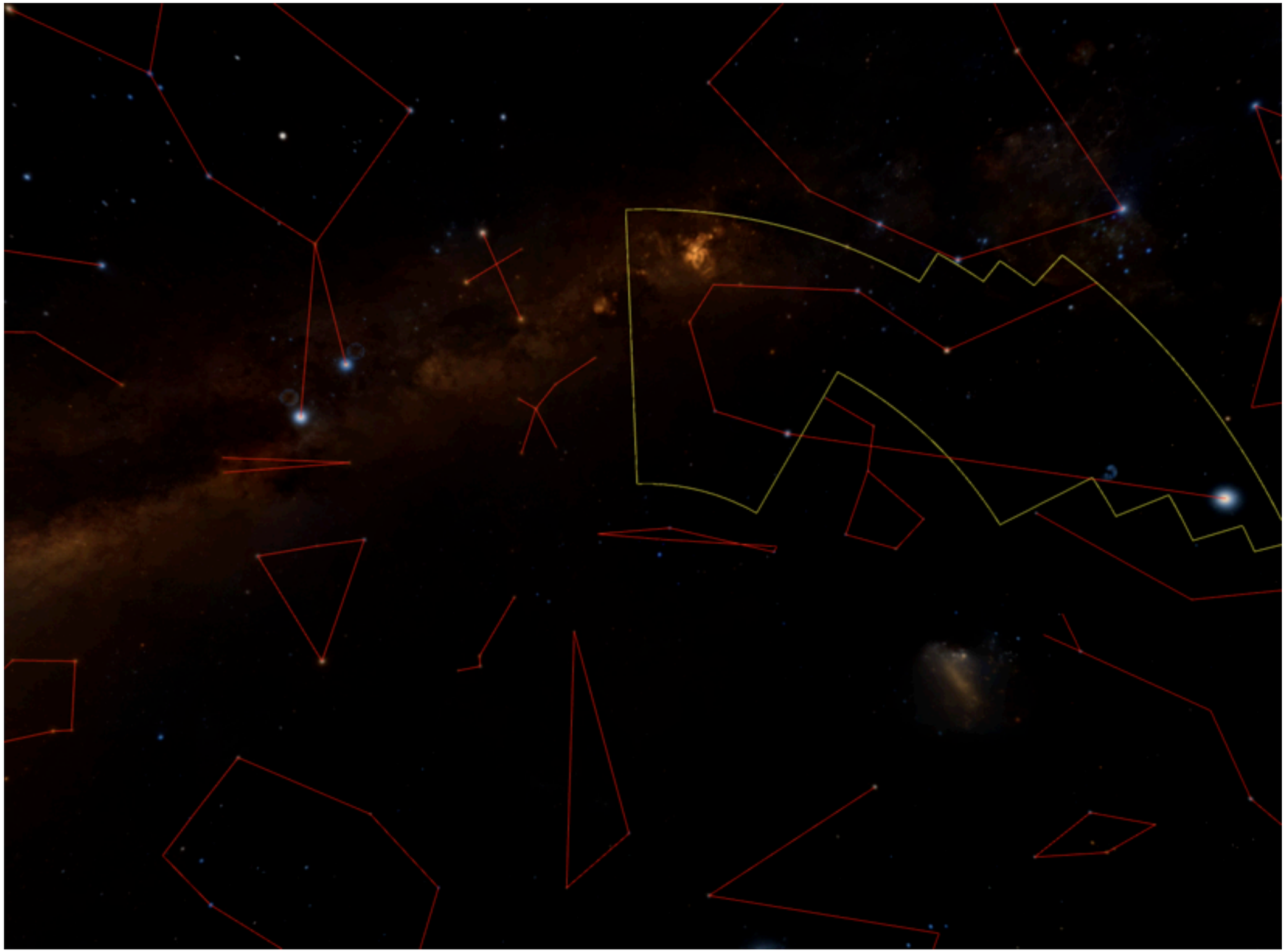
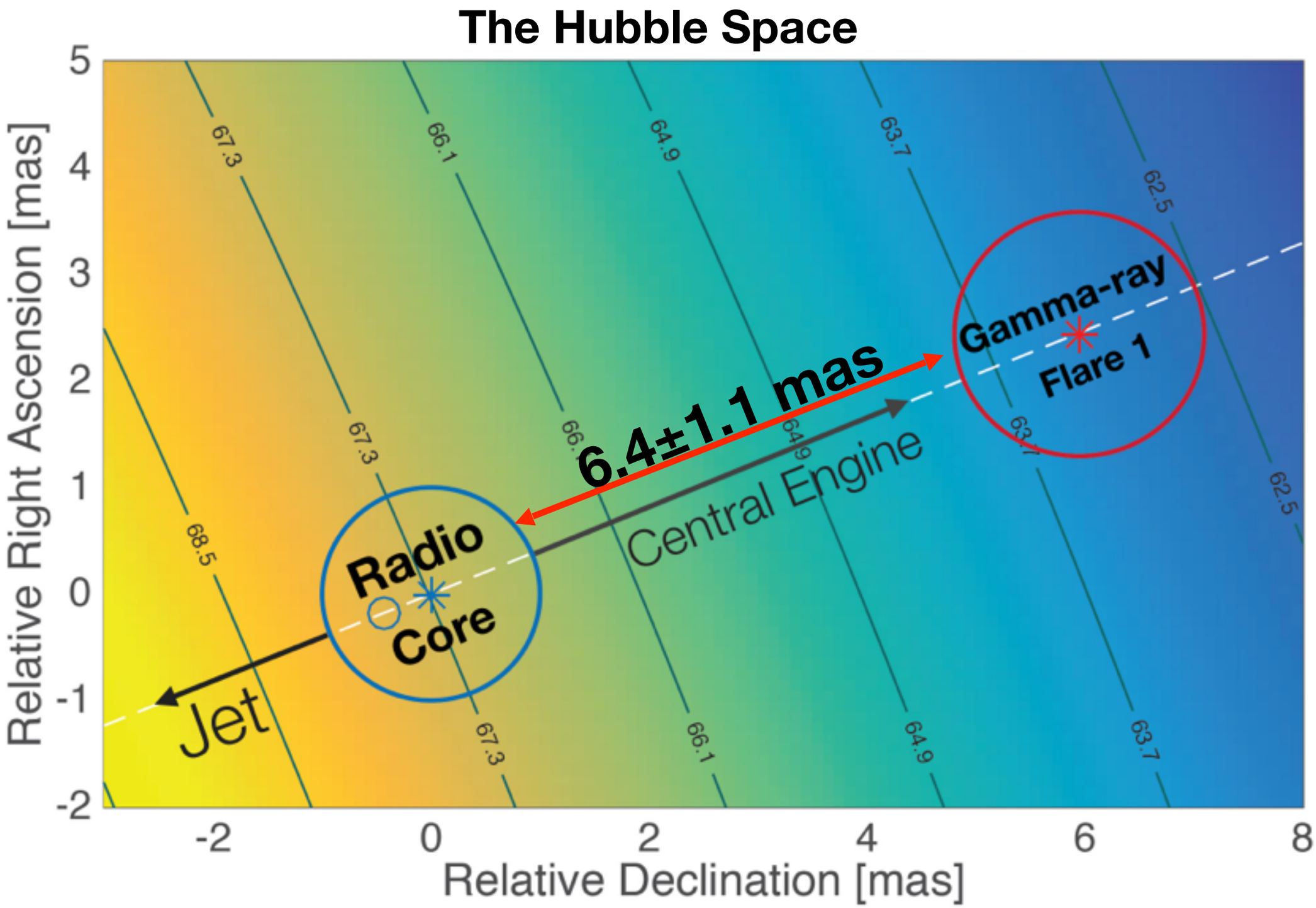
JOURNEY TO INNER REGION OF M87



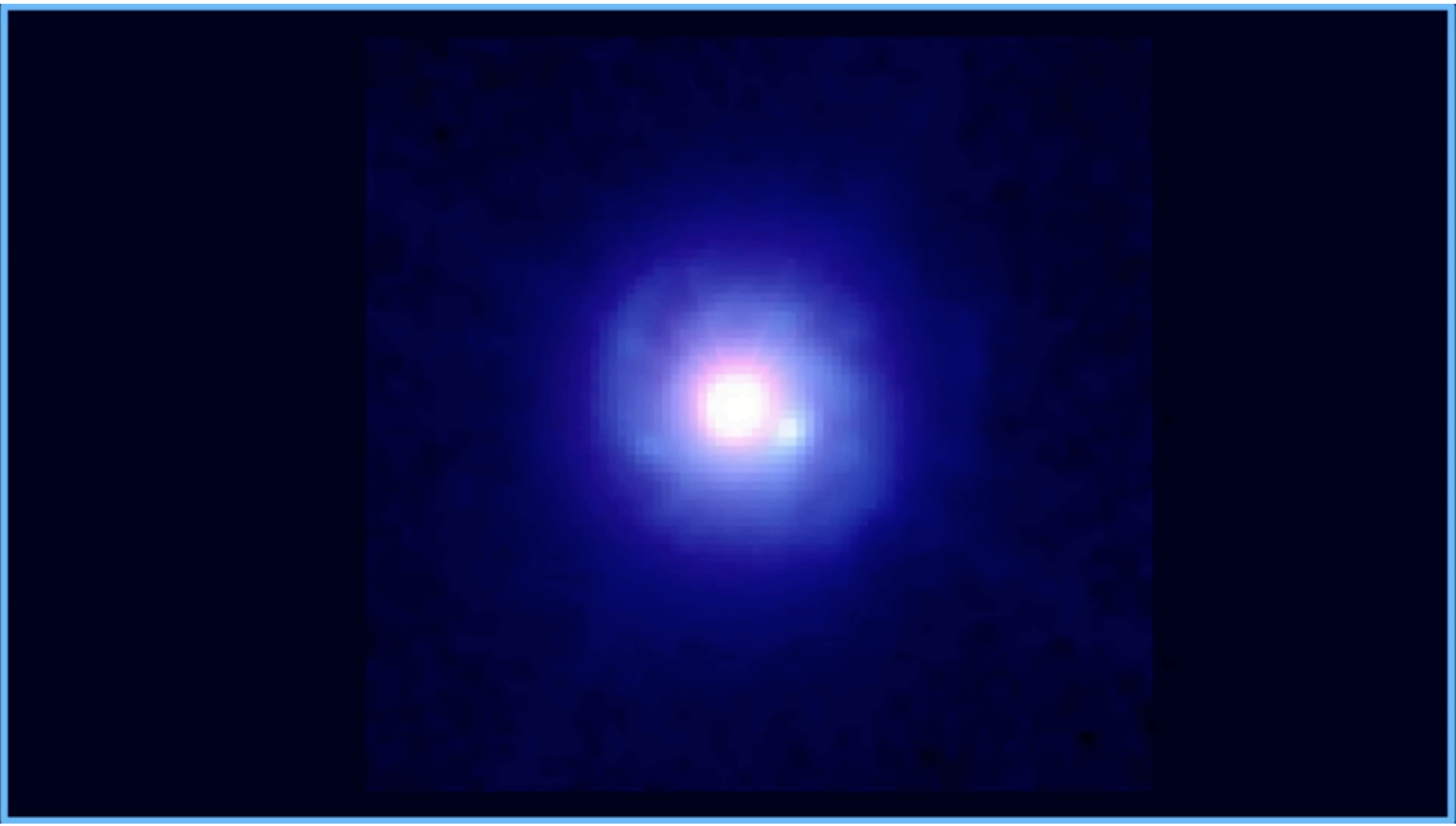
Journey created with **World Wide Telescope**

OFFSET: RADIO CORE – SUPERMASSIVE BLACK HOLE



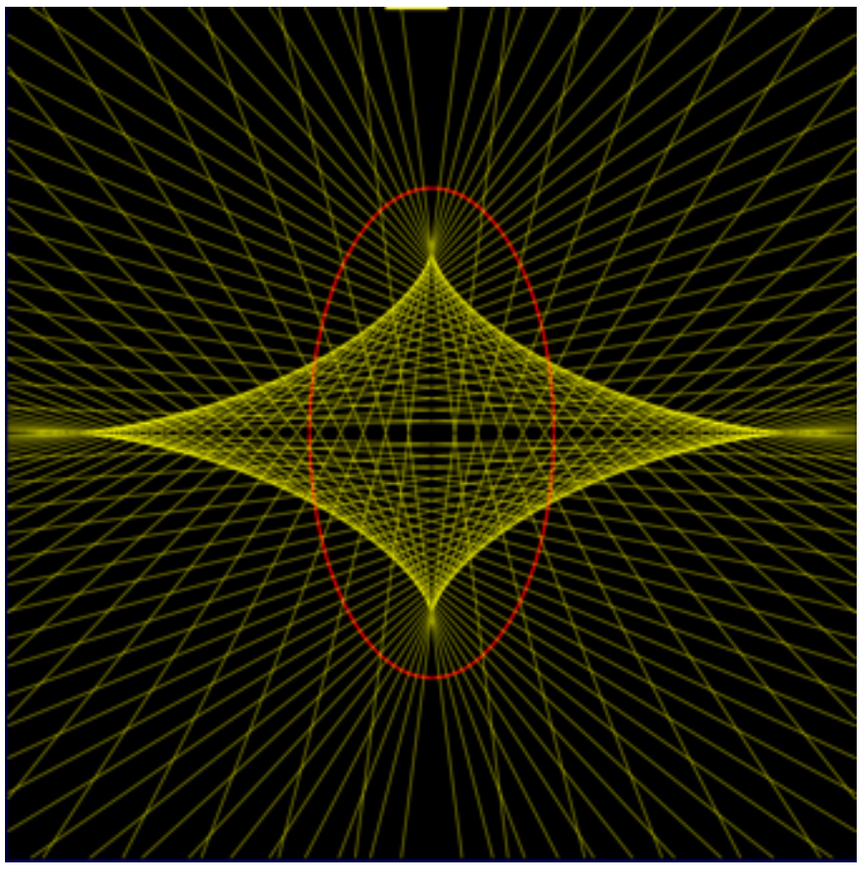
Barnacka et al. 2016, ApJ, 821, 58

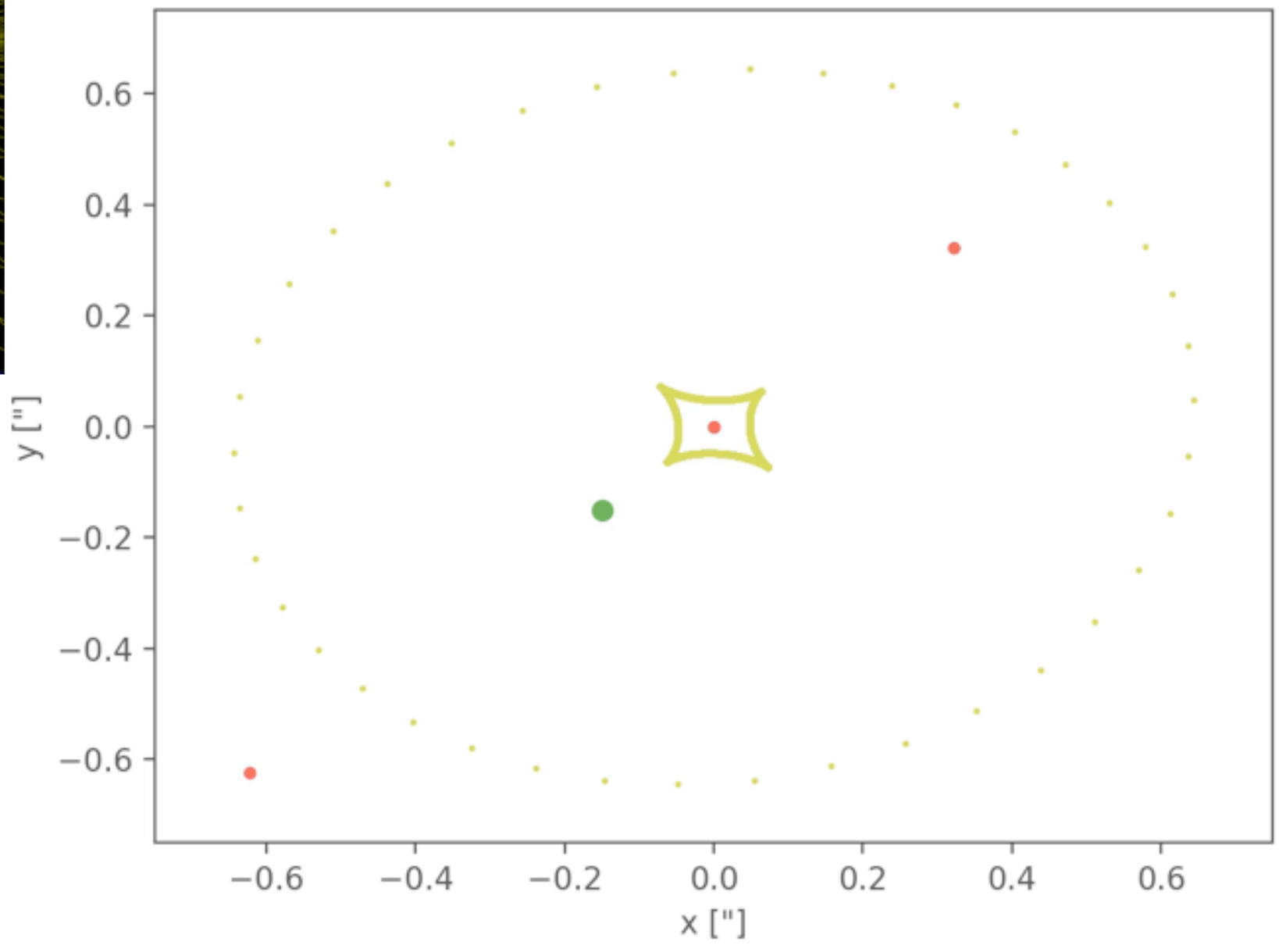
GALAXIES AS COSMIC LENSES



Credit: NASA's Goddard Space Flight Center

SOURCE CLOSE TO THE CAUSTIC OF THE LENSING GALAXY

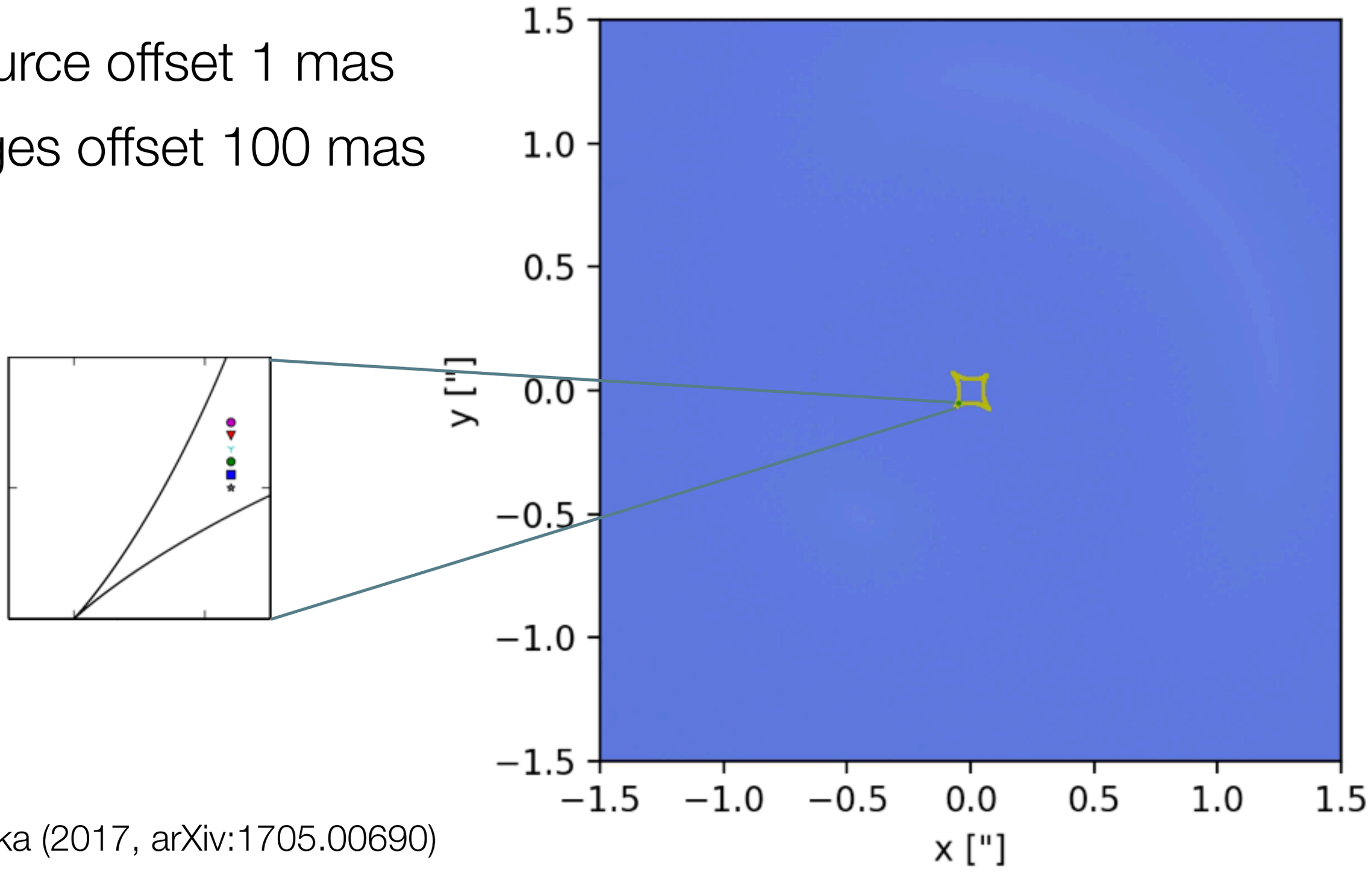




TOY MODEL: SOURCES CLOSE TO THE CAUSTIC

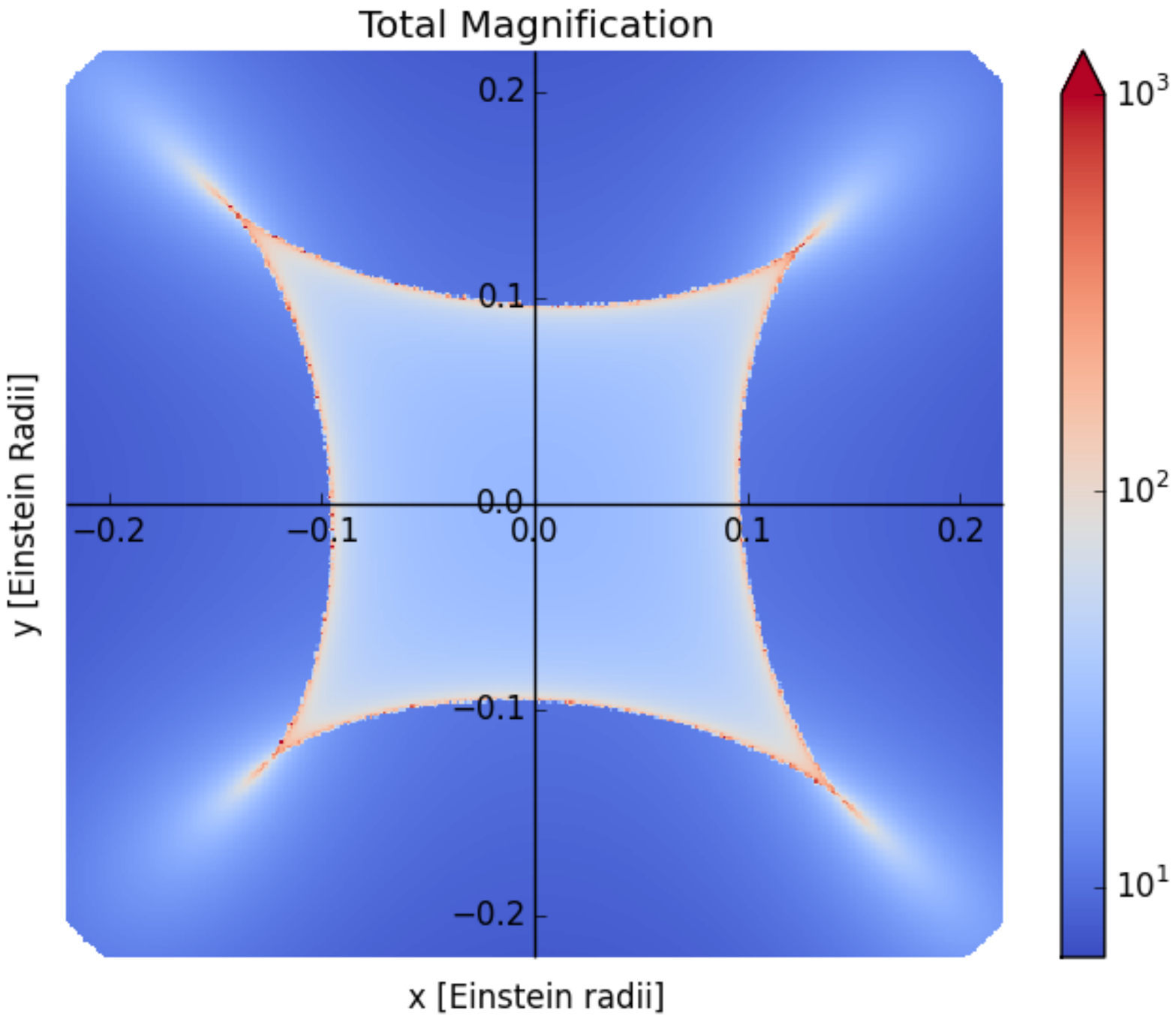
Source offset 1 mas

Images offset 100 mas



Barnacka (2017, arXiv:1705.00690)

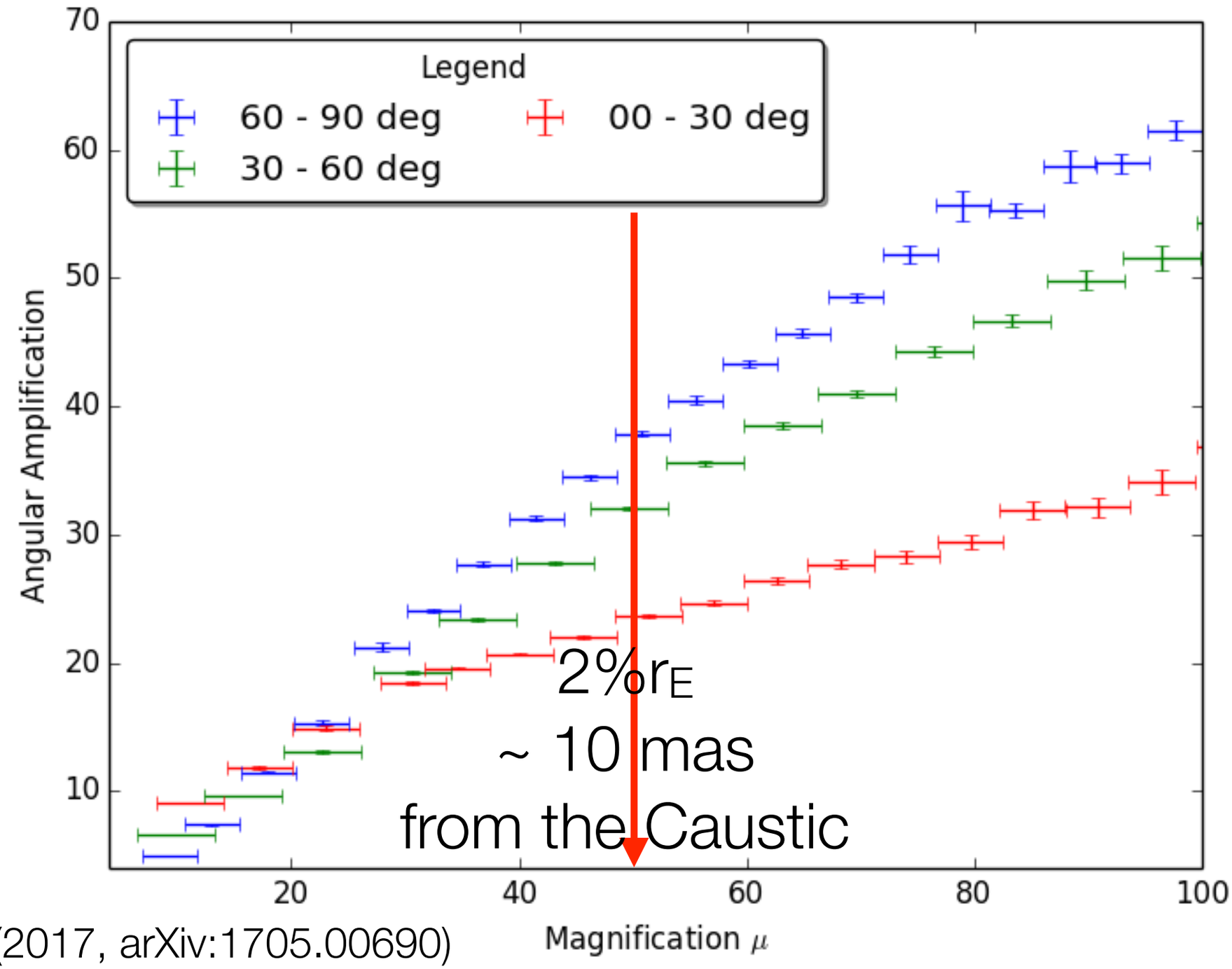
FLUX MAGNIFICATION IN CAUSTIC REGION



Barnacka (2017, ApJ, arXiv:1705.00690)

ANGULAR AMPLIFICATION IN CAUSTIC REGION

Monte Carlo Simulations of **10^6** pair of offset sources



Barnacka (2017, arXiv:1705.00690)

LENSED QUASARS IN CAUSTIC CONFIGURATION

8 out of 20

JVAS/CLASS

EUCLID AND SKY SYNERGY

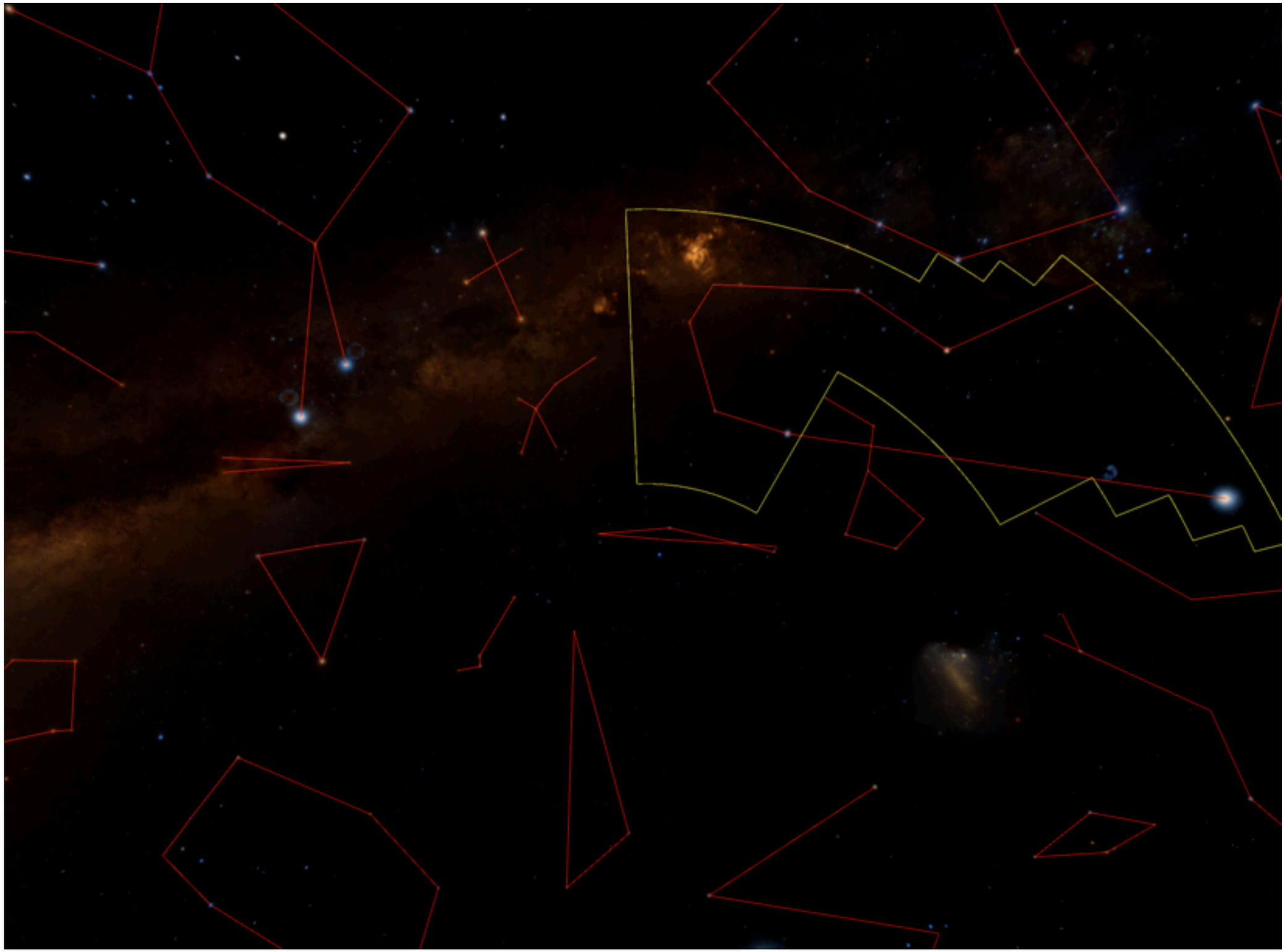
In near future: observations of more than **10^5** strongly lensed flat spectrum radio-loud quasars

SUMMARY

Barnacka Anna (2017, ApJ)

- Caustic Configuration:
  - >50 x Flux Magnification
  - >50 x Angular Amplification
  - Resolution ~ a few mas
- Currently: dozen of sources
- Near future: SKA and Euclid dozen of thousands of sources
- Insight into:
  - Inner parts of active galaxies at high redshifts
  - Physical origin of offsets
  - Identify the most distant quasars
  - Follow-up observations with JWST or ELT

JOURNEY TO INNER REGION OF M87



Journey created with **World Wide Telescope**: Special thanks to Philip Rosenfield

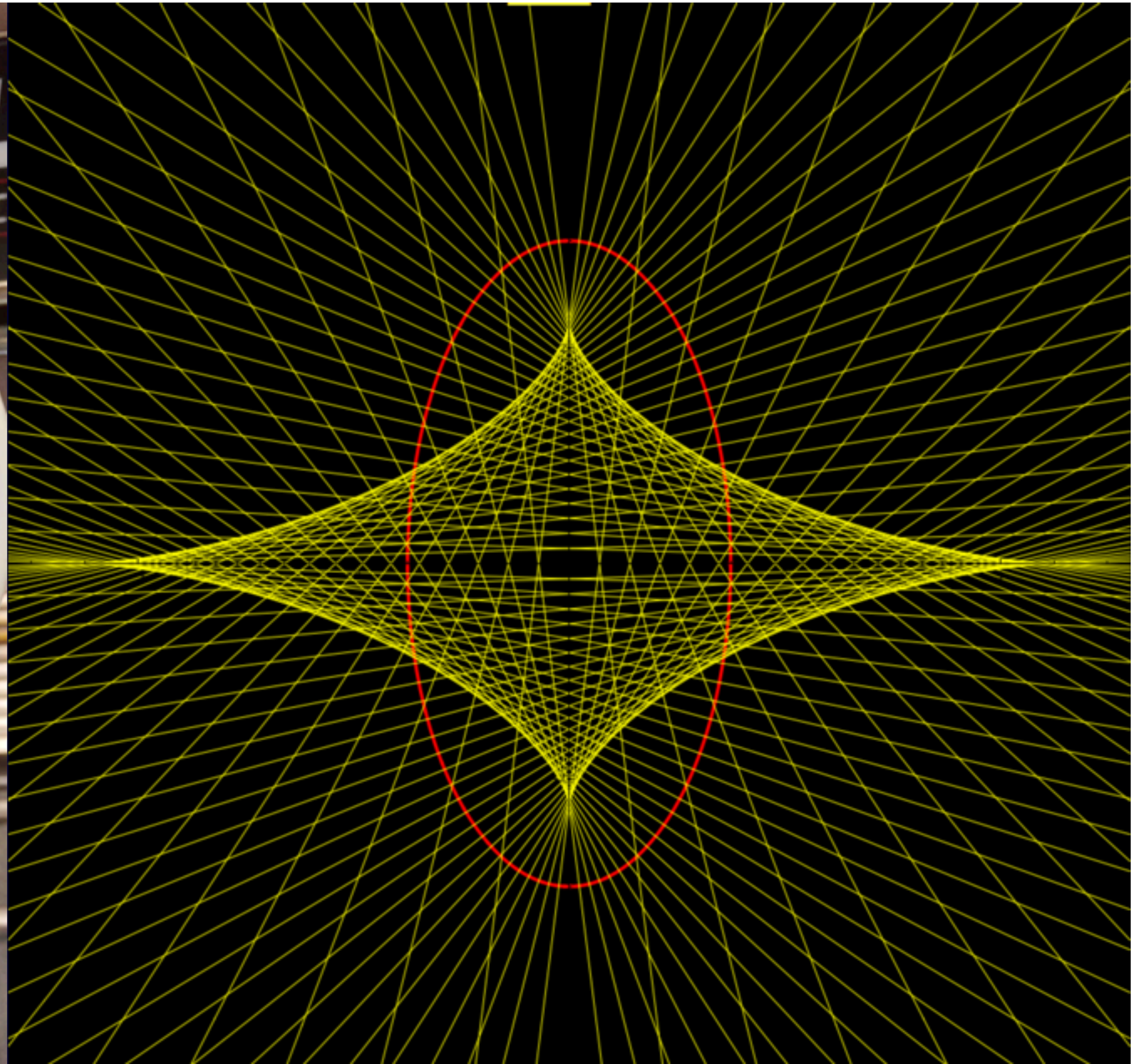
GAIA–VLBA OFFSETS

Table from Petrov & Kovalev (2017)

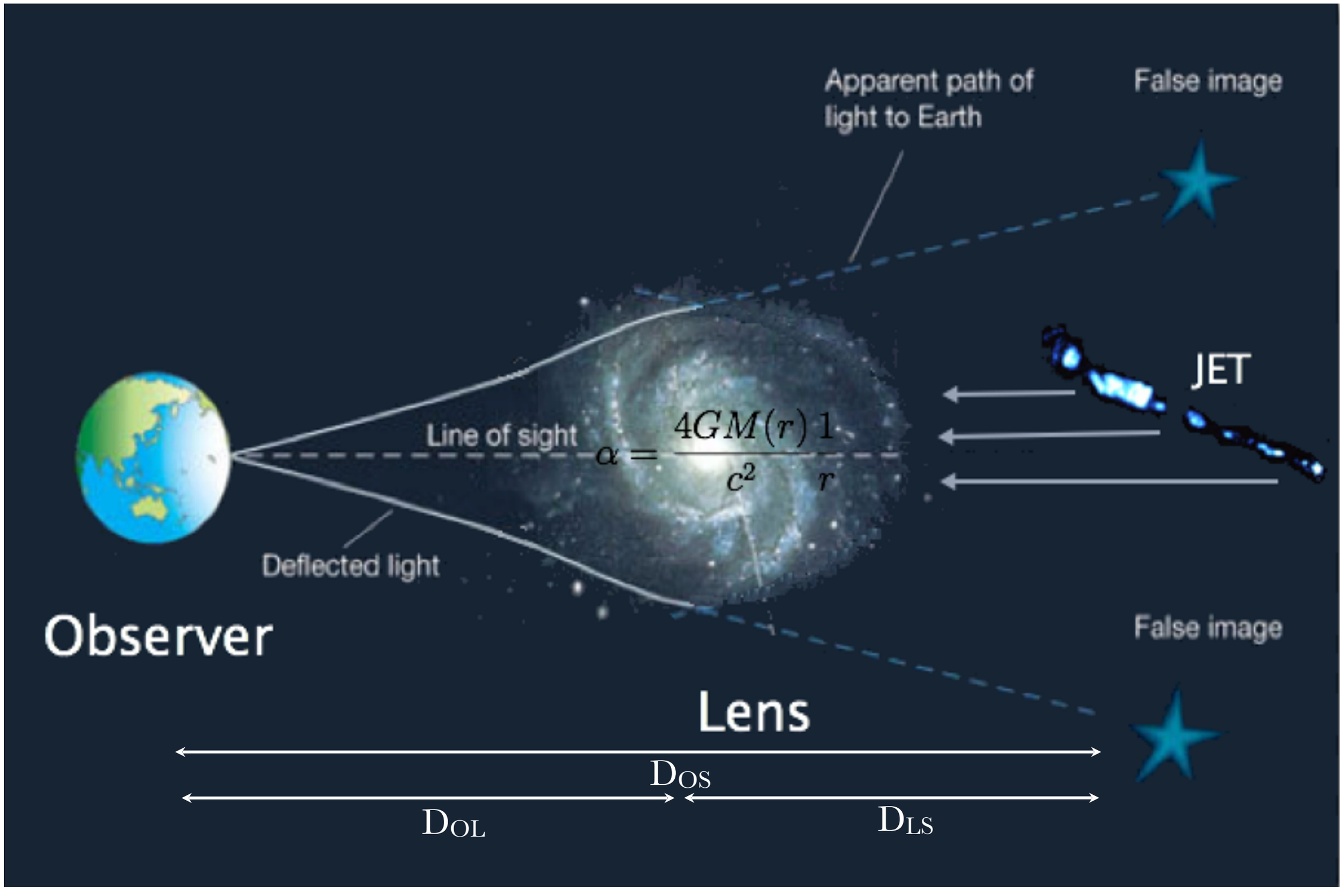
The first four rows of the table of **384 VLBI/*Gaia*** matches with statistically significant offsets: probability of false association (PFA) less than 0.0002 and the random noise probability (RNP) less than 0.01. The fifth column contains the normalized arc lengths, and two last columns contain positions of *Gaia* minus VLBI over right ascensions, including cos δ factor and declination.

VLBI ID	*Gaia* ID	PFA	RNP	*q*	*dα* (mas)
RFC J0000−3221	*Gaia* 2314315845817748992	4.47×10^{-8}	2.47×10^{-22}	20.78	−6.51
RFC J0004−0802	*Gaia* 2441584492826114432	3.58×10^{-6}	4.14×10^{-03}	4.73	−21.39
RFC J0005+3820	*Gaia* 2880735411259458048	1.98×10^{-7}	5.03×10^{-08}	10.80	5.77
RFC J0008−2339	*Gaia* 2337107759788510464	2.01×10^{-8}	5.84×10^{-06}	8.84	1.17
...					

CAUSTIC OF ELLIPTICAL LENSES

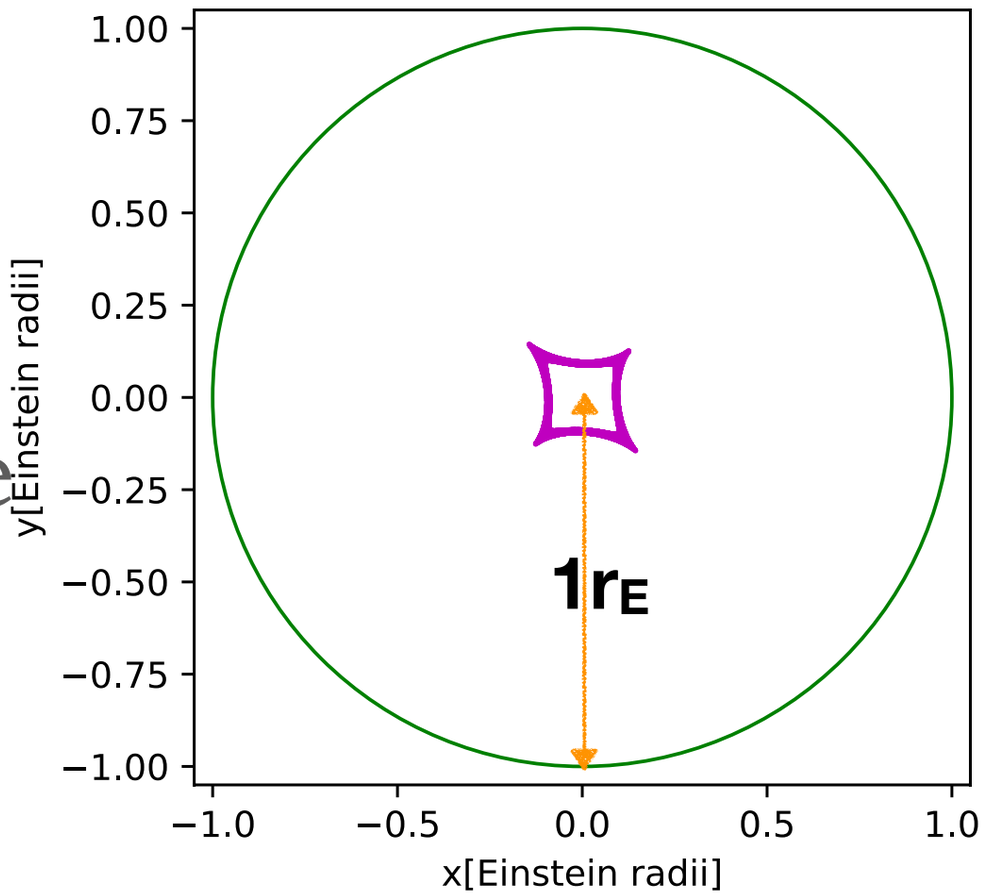


M87 Gravitationally Lensed?



PROBABILITY OF CAUSTIC CONFIGURATION

- Elliptical lens e=0.2
  - lens z=0.5, source z=2
- Caustic Length ~2.1 rE
  - Probability that a source will be with 2%rE from the Caustic is ~ **1%**
- Magnification bias
  - Magnification close to the caustic > 50
  - Probability > **8%**



SOURCE CLOSE TO THE CAUSTIC OF THE LENSING GALAXY