



# THE SEARCH FOR IMBHs IN GAIA

new simulations and results

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THE 10TH OPTICON GAIA SCIENCE ALERTS WORKSHOP  
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A black hole with a glowing accretion disk and two powerful jets of light and gas extending outwards. The background is a deep space scene with numerous stars and a nebula in shades of purple and blue.

# The search for IMBHs - a quick reminder

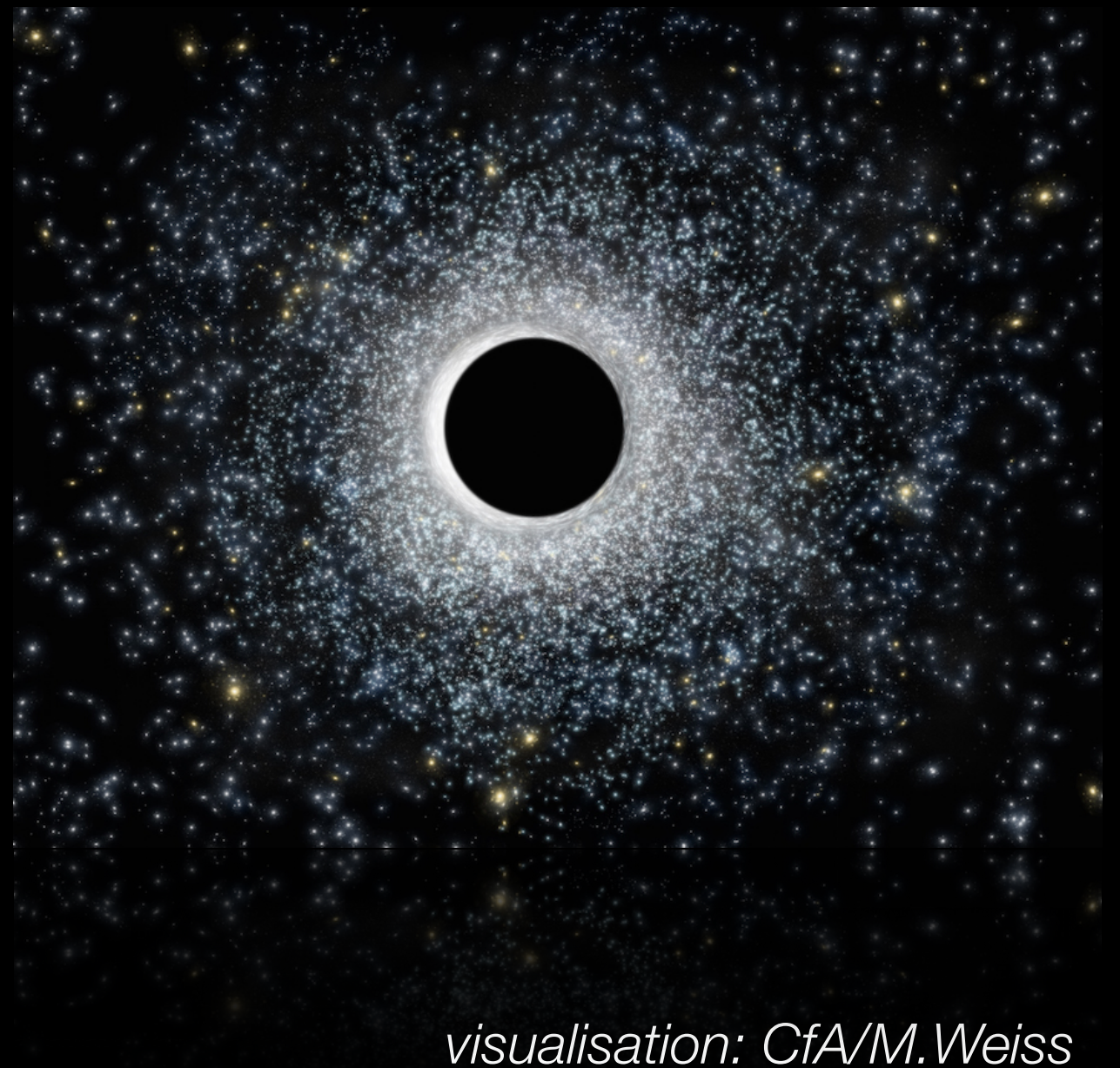


# Intermediate-mass black holes

searches: *dense stellar clusters*

\*  **$10^2 - 10^5 M_{\odot}$**

\* apparent mass gap  
between stellar-mass  
and supermassive



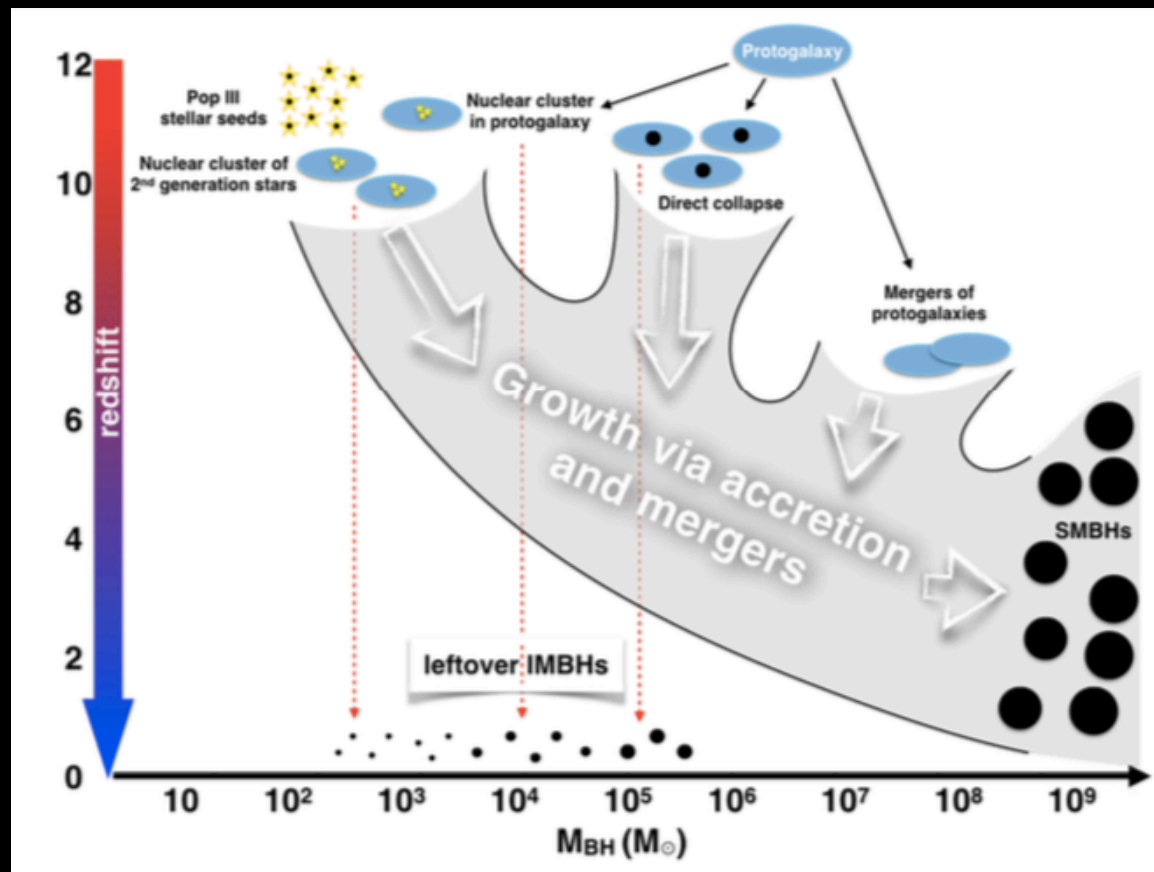
# Intermediate-mass black holes

*Why are they interesting?*

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\* evolution of galaxies

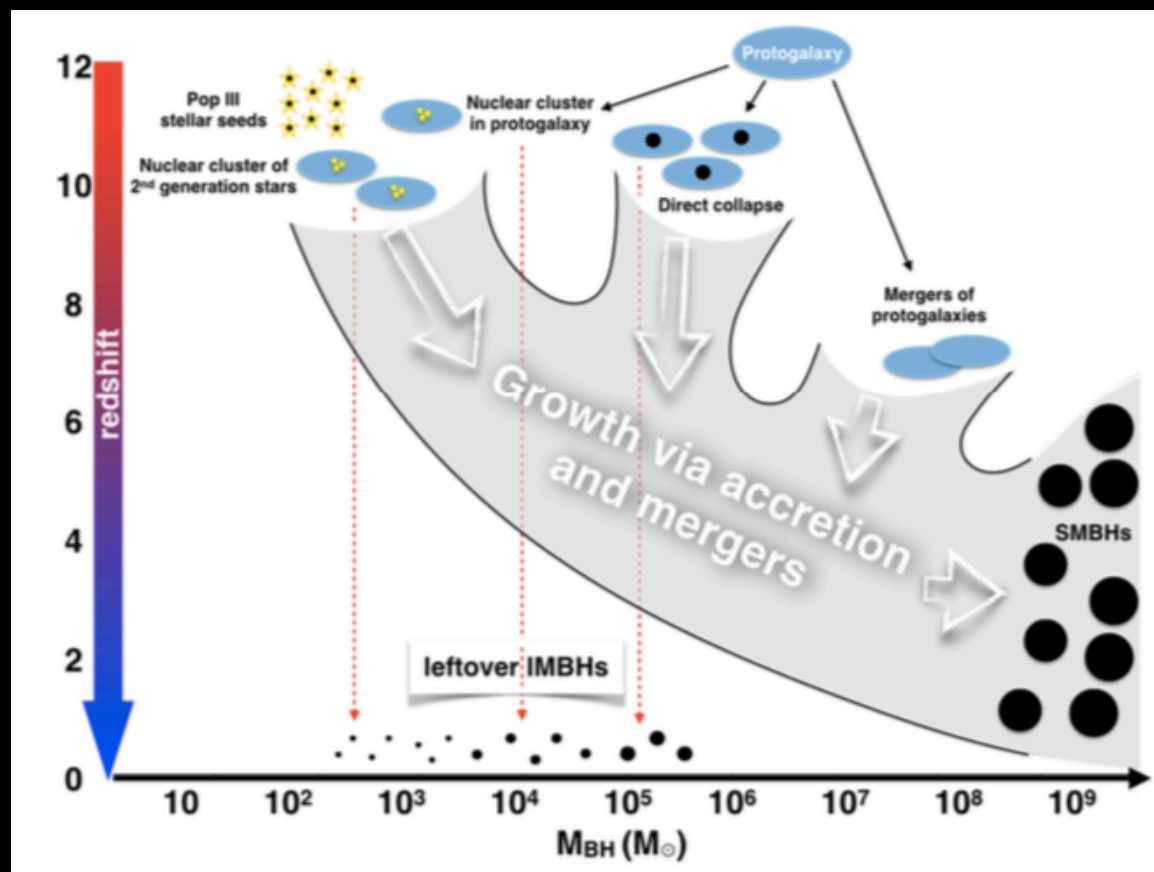


*Mezcua 2017*

# Intermediate-mass black holes

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*Mezcua 2017*

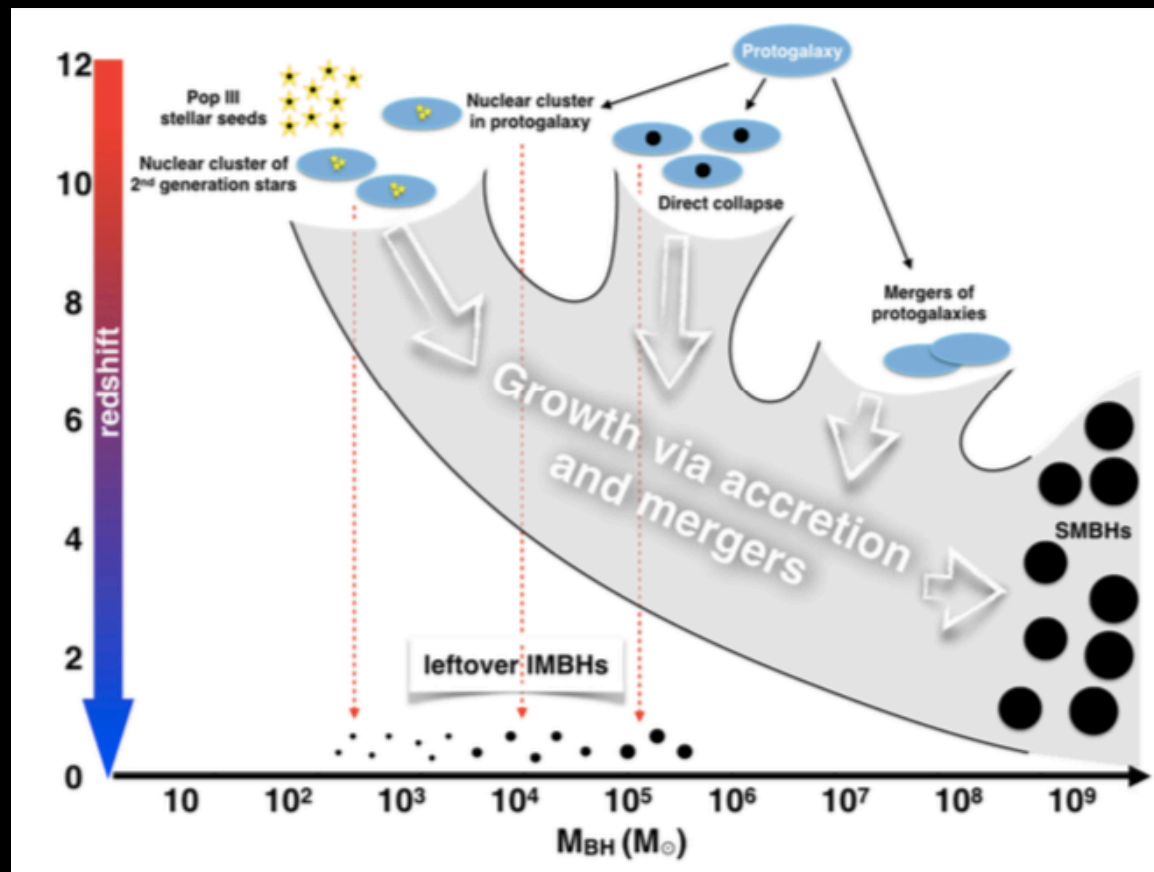


*'SMBH seeds'*

# Intermediate-mass black holes

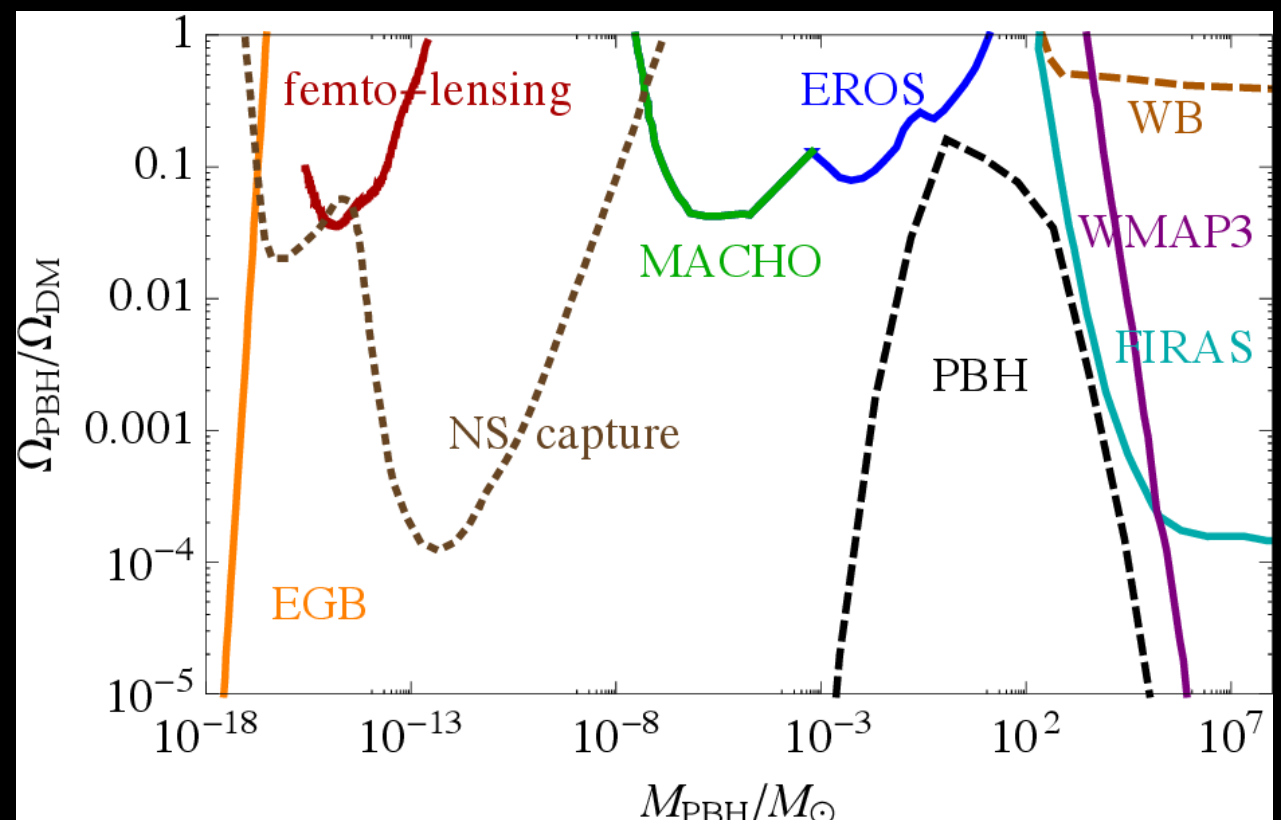
*Why are they interesting?*

\* evolution of galaxies



*Mezcua 2017*

\* primordial black hole (PBH) candidates



*García-Bellido 2017*



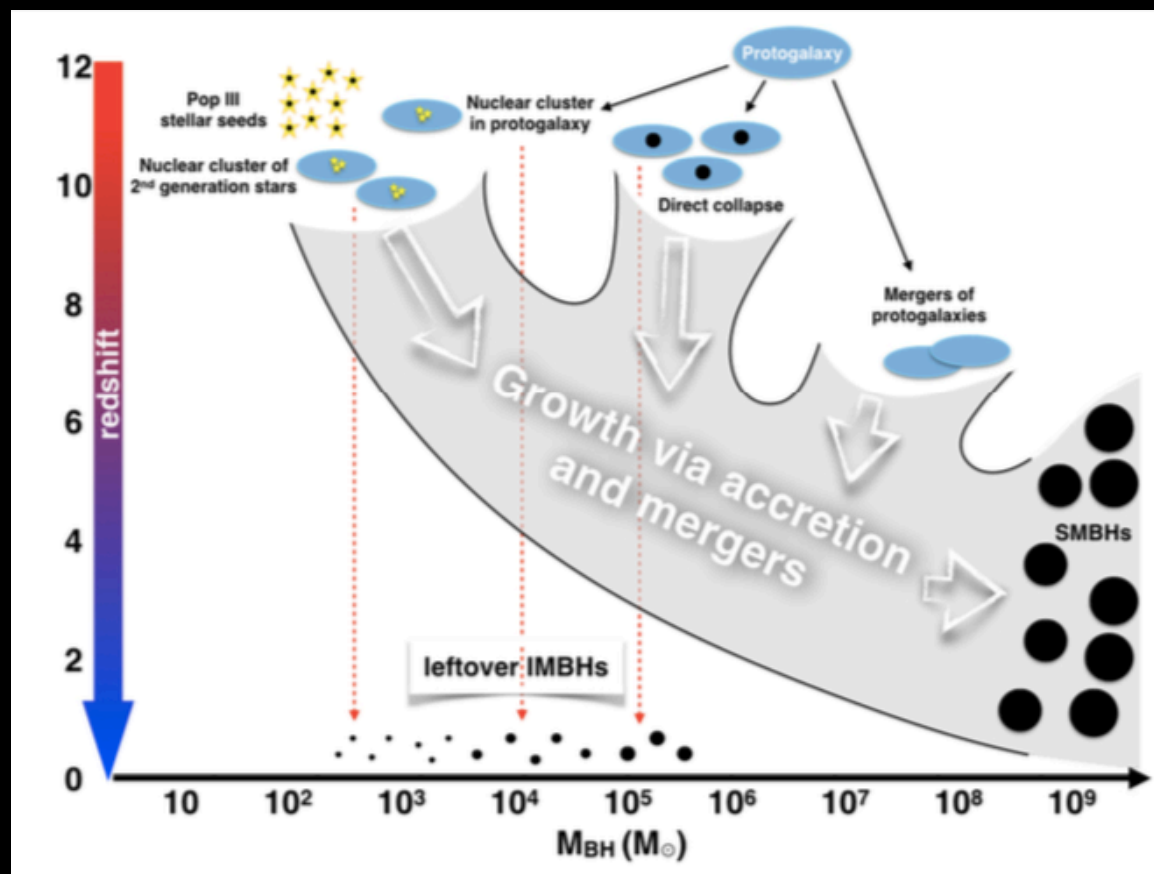
*'SMBH seeds'*



# Intermediate-mass black holes

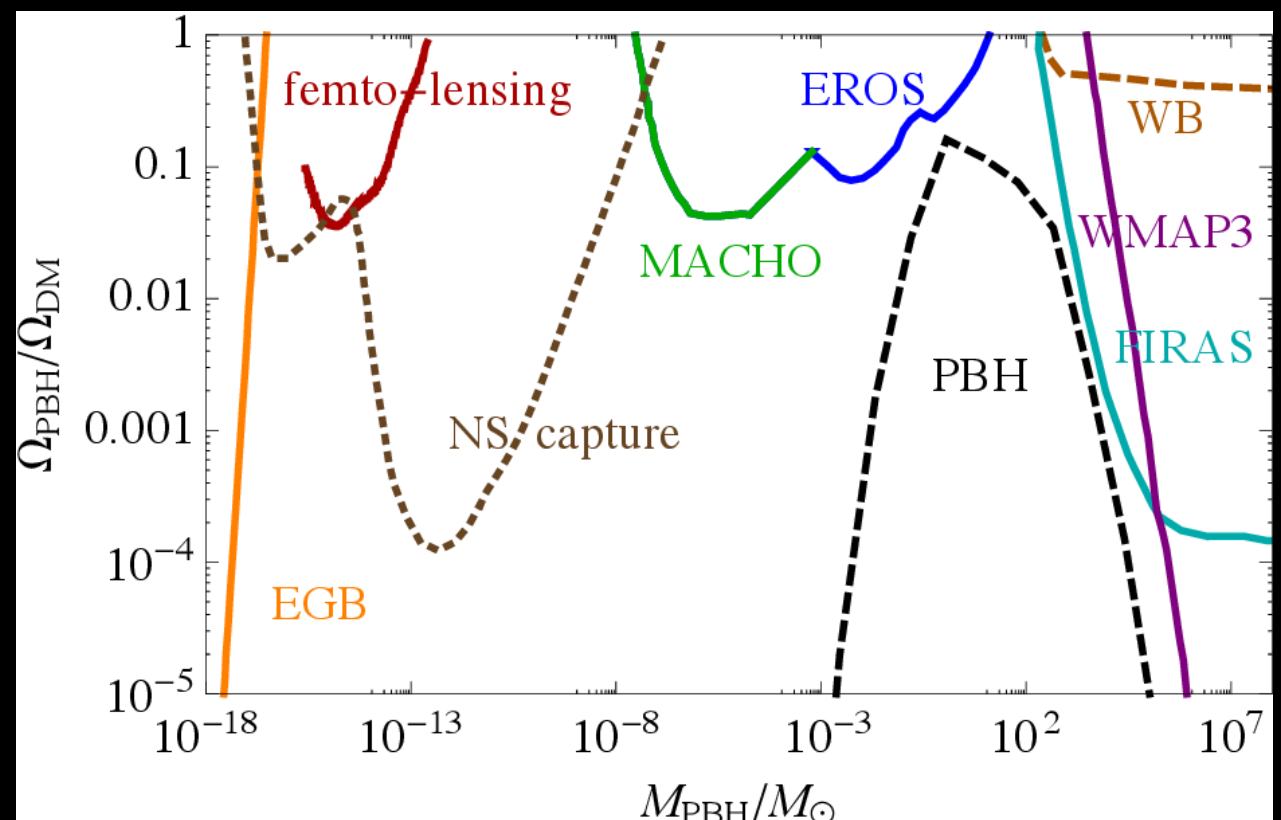
*Why are they interesting?*

\* evolution of galaxies



*Mezcua 2017*

\* primordial black hole (PBH) candidates  
\* dark matter?



*García-Bellido 2017*



*'SMBH seeds'*

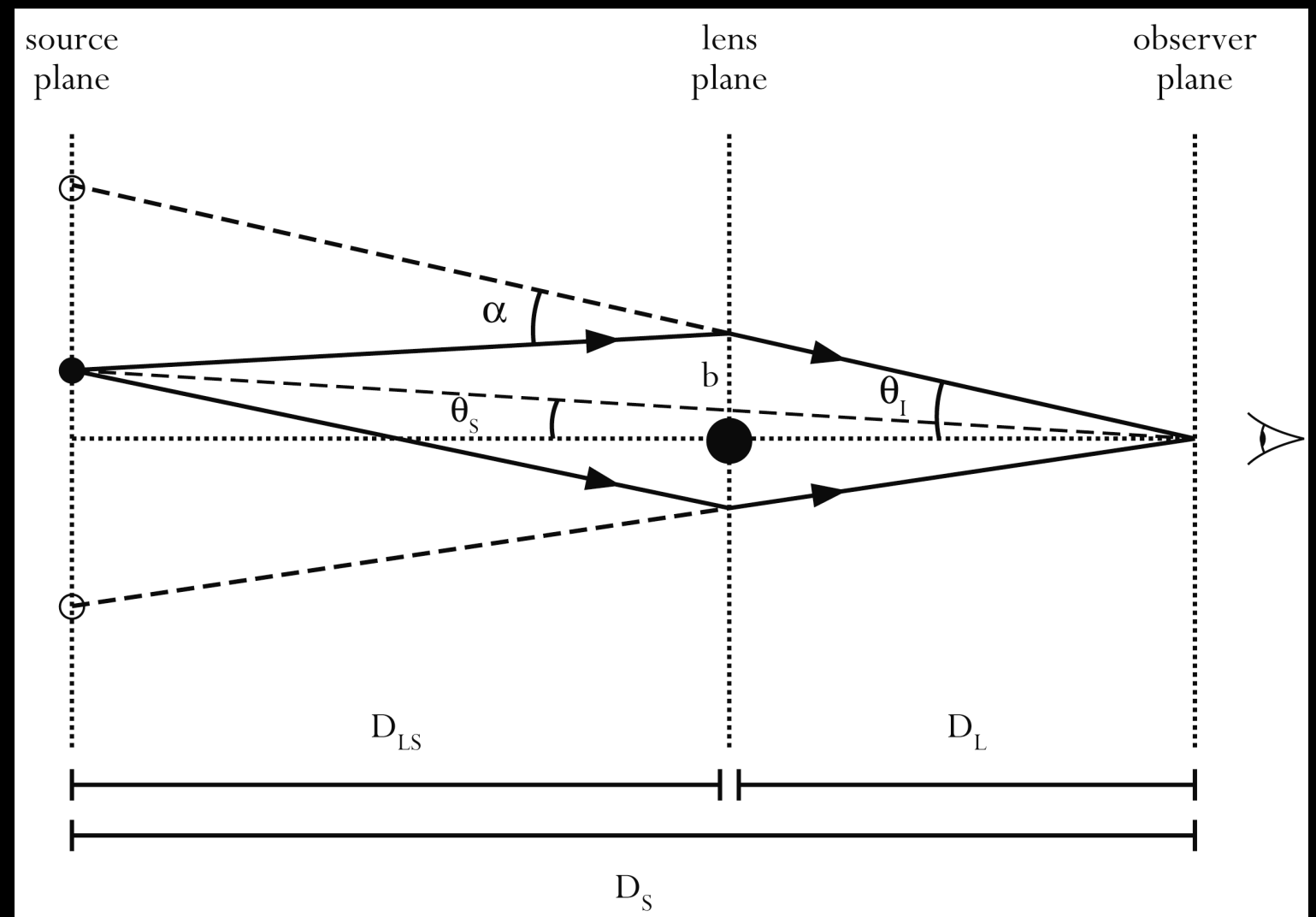



# Intermediate-mass black holes

*Why are they interesting?*

\* astrometric lensing!

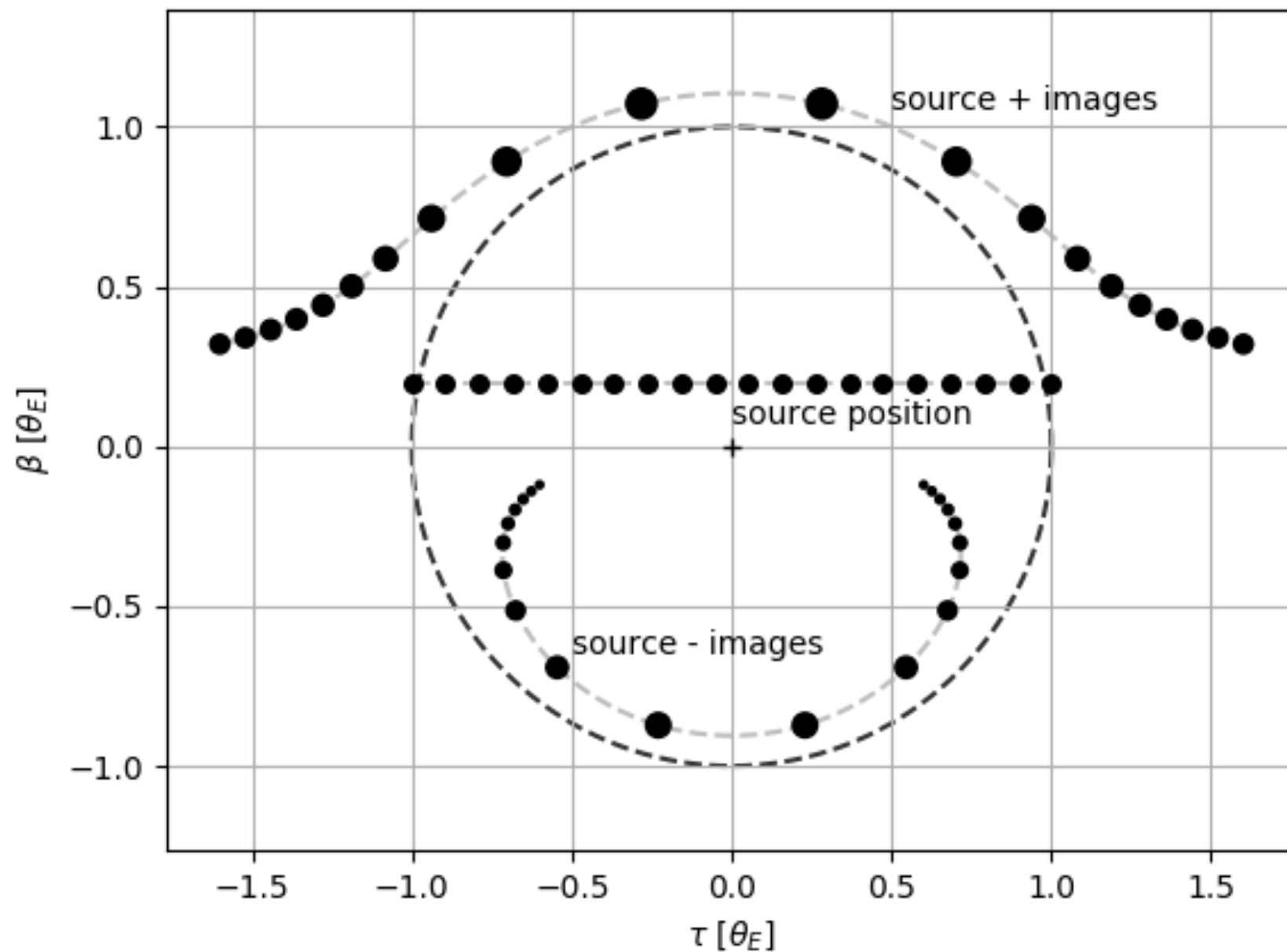
resolvable  
images



A black hole with a glowing accretion disk and a bright jet of light, set against a dark, starry background.

# Lensing by IMBHs

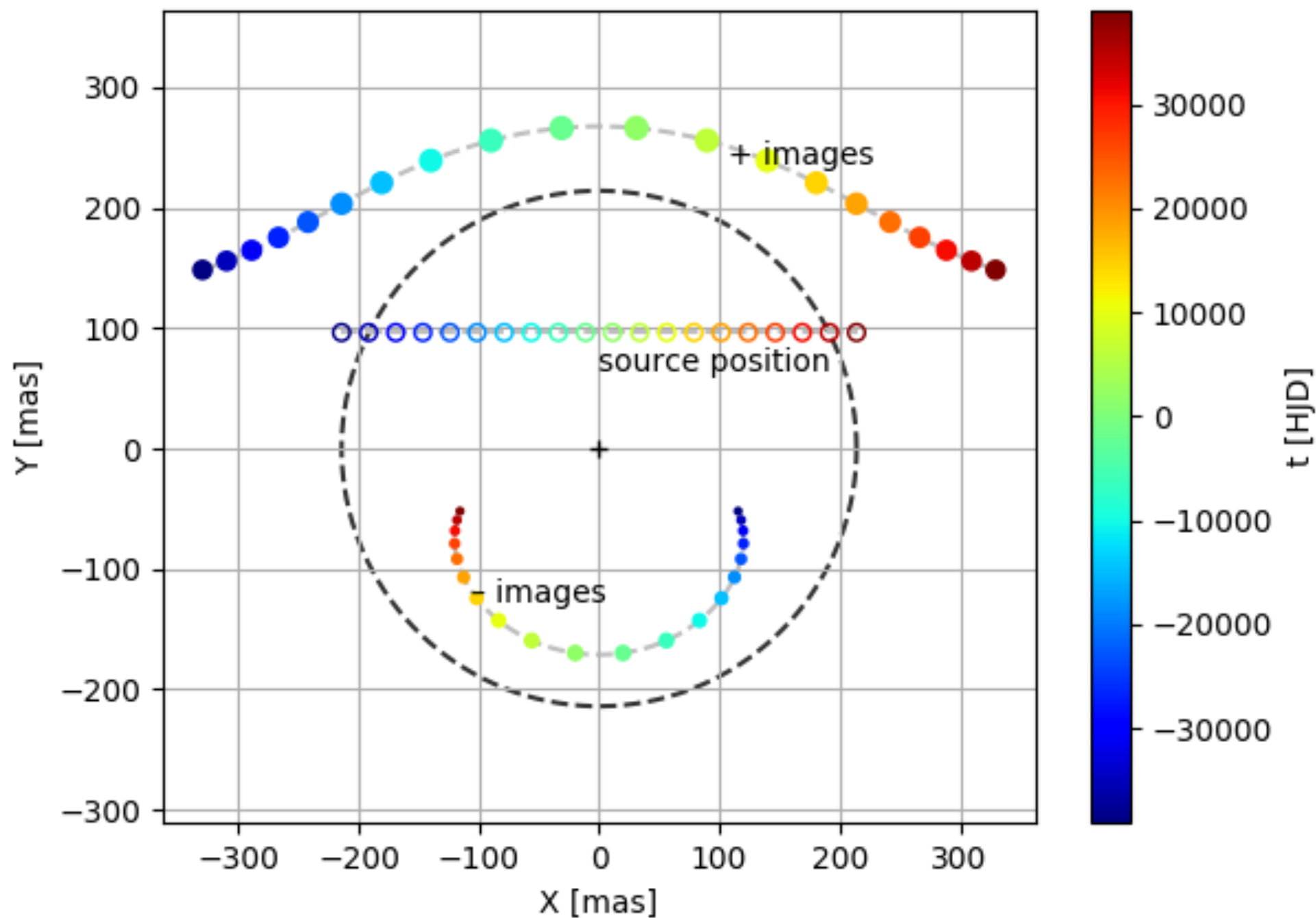
# Geometry of a centi-lensing event



$$\theta_E = \sqrt{\kappa M (\pi_L - \pi_S)}$$



# Resolved events



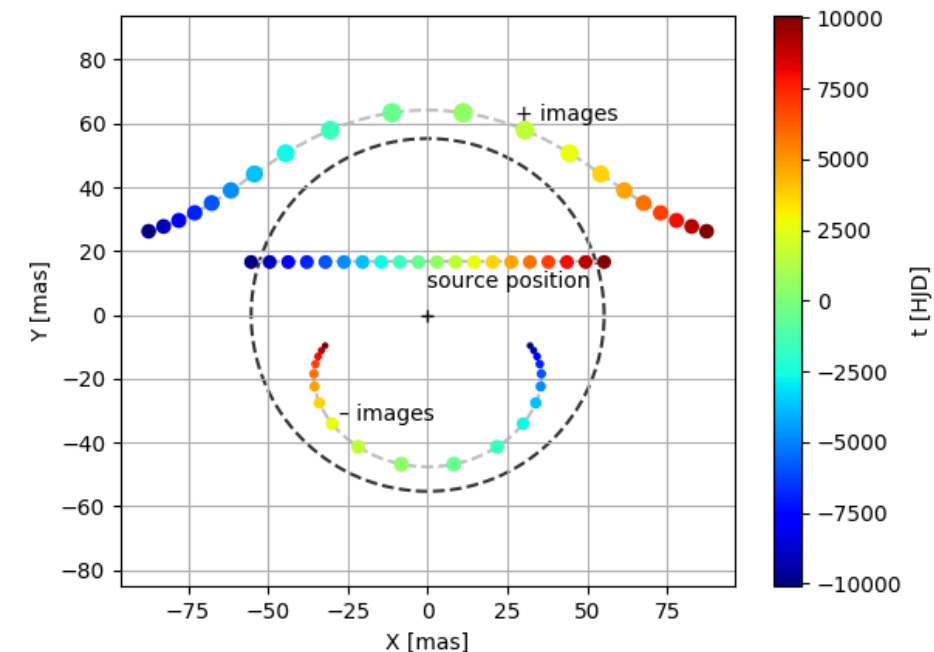
**$M_{\text{Lens}} = 15000 M_{\odot}$**   
 **$D_{\text{Lens}} = 2000 \text{ pc}$**   
 **$D_{\text{Source}} = 8000 \text{ pc}$**   
 **$u_0 = 0.45$**

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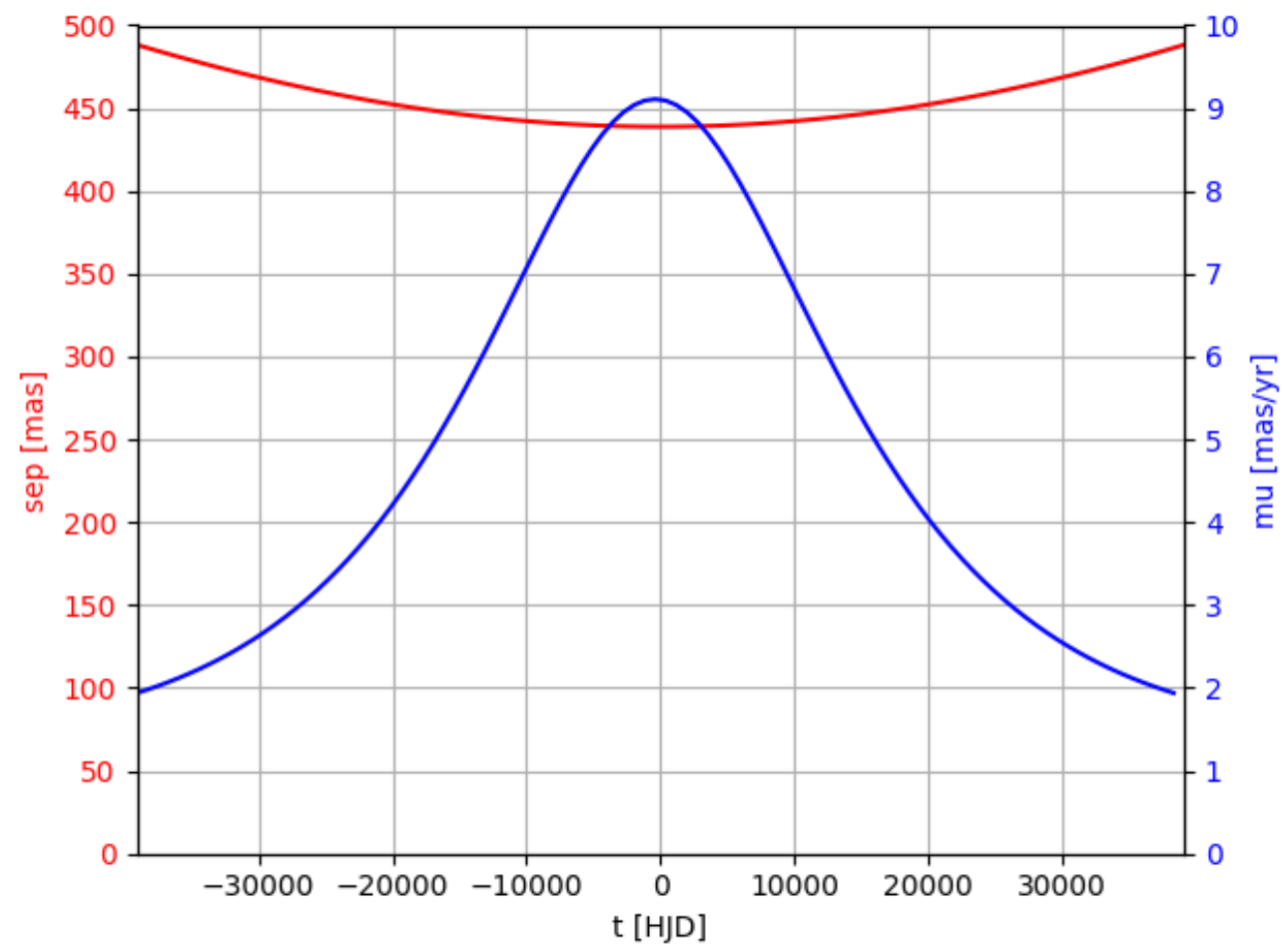
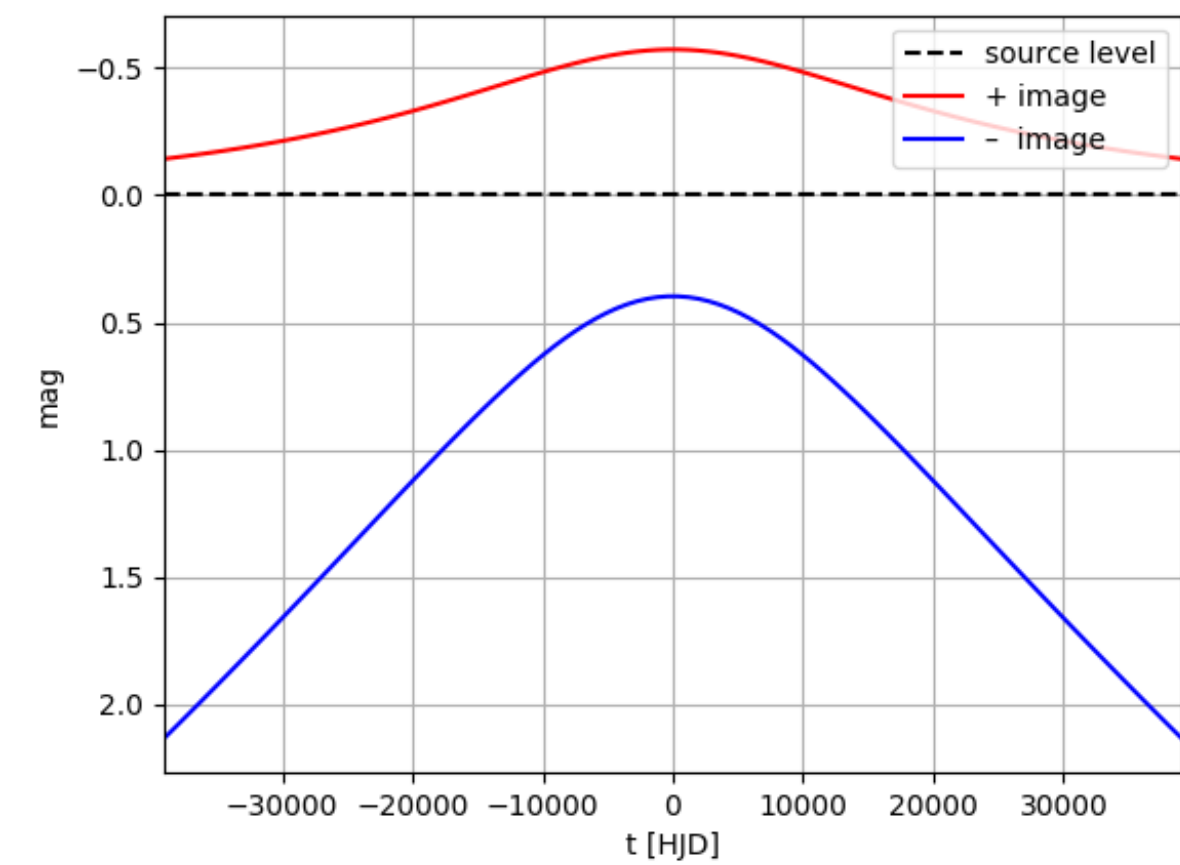
$$D_{\text{Source}} = 8000 \text{ pc}$$

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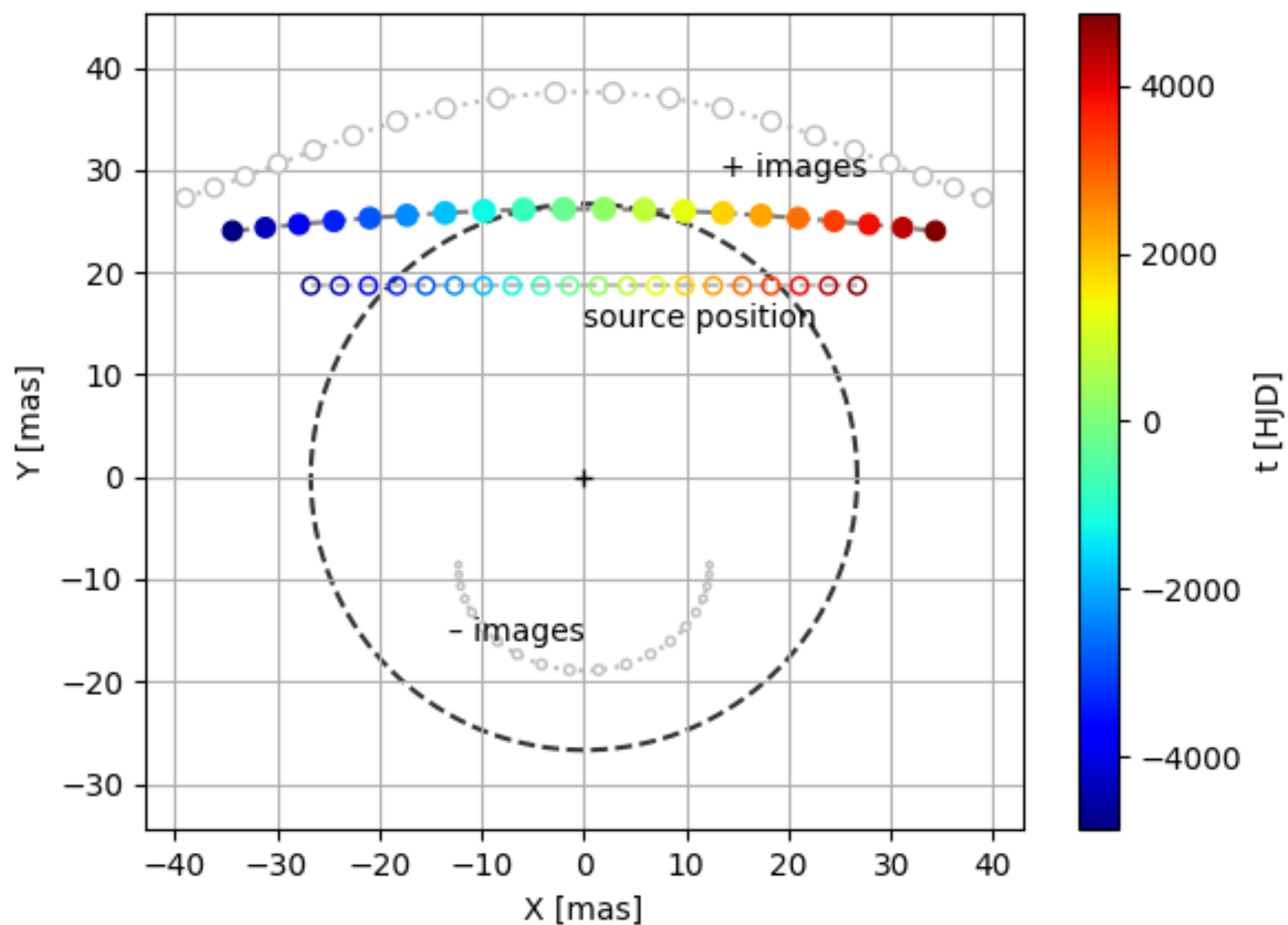


photometry

astrometry

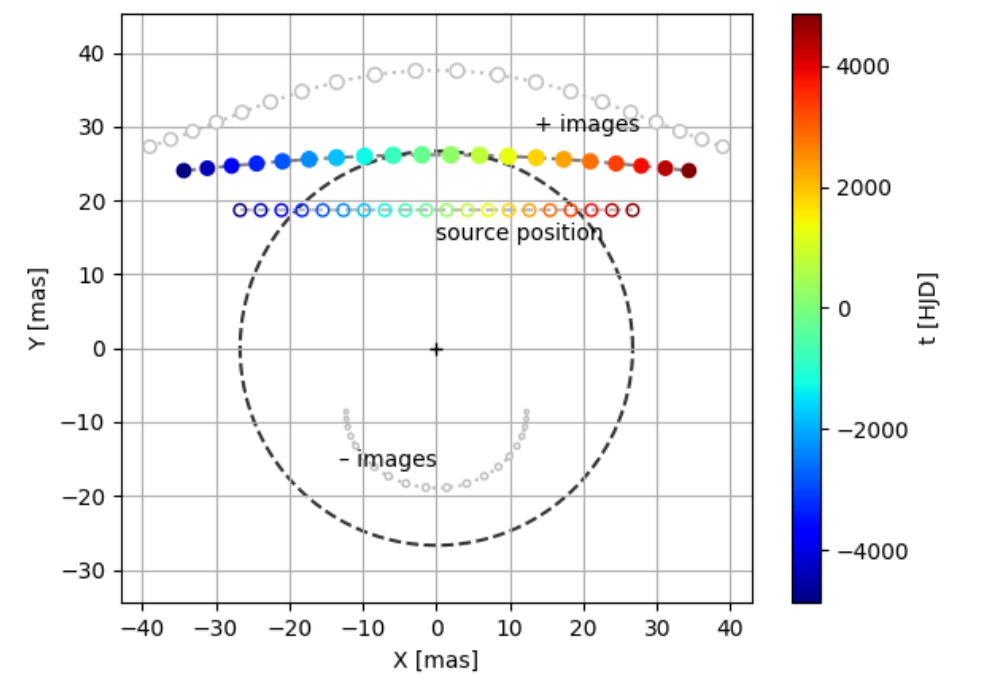


# Centroid events



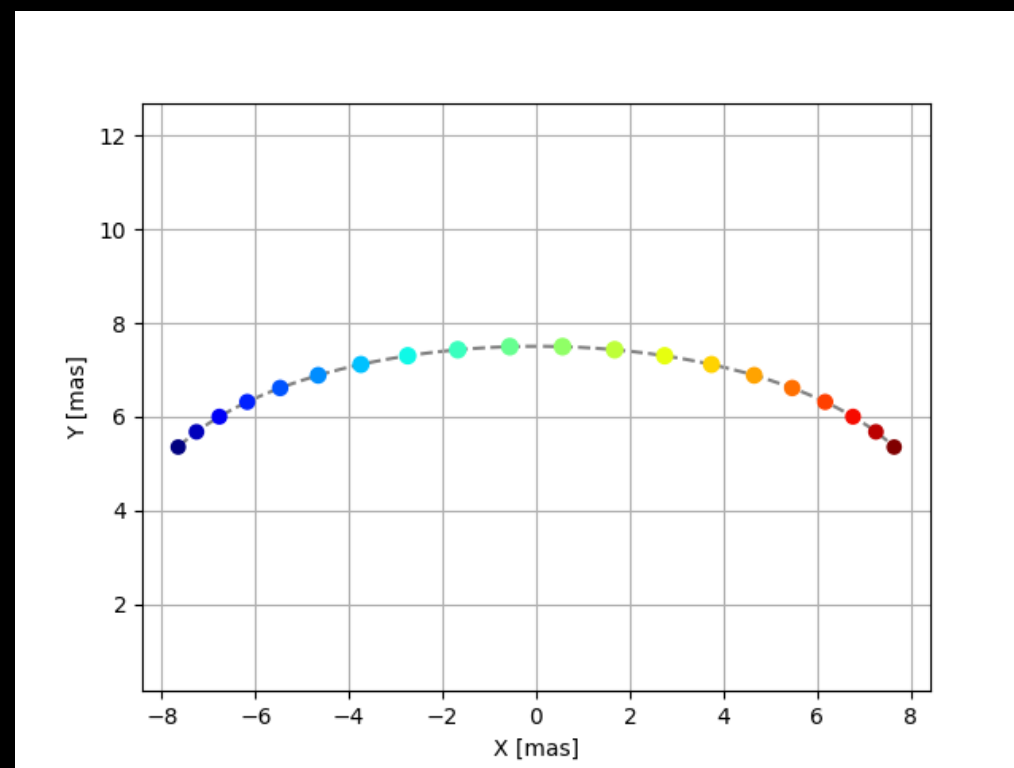
$M_{\text{Lens}} = 100 M_{\odot}$   
 $D_{\text{Lens}} = 1000 \text{ pc}$   
 $D_{\text{Source}} = 8000 \text{ pc}$   
 $u_0 = 0.7$



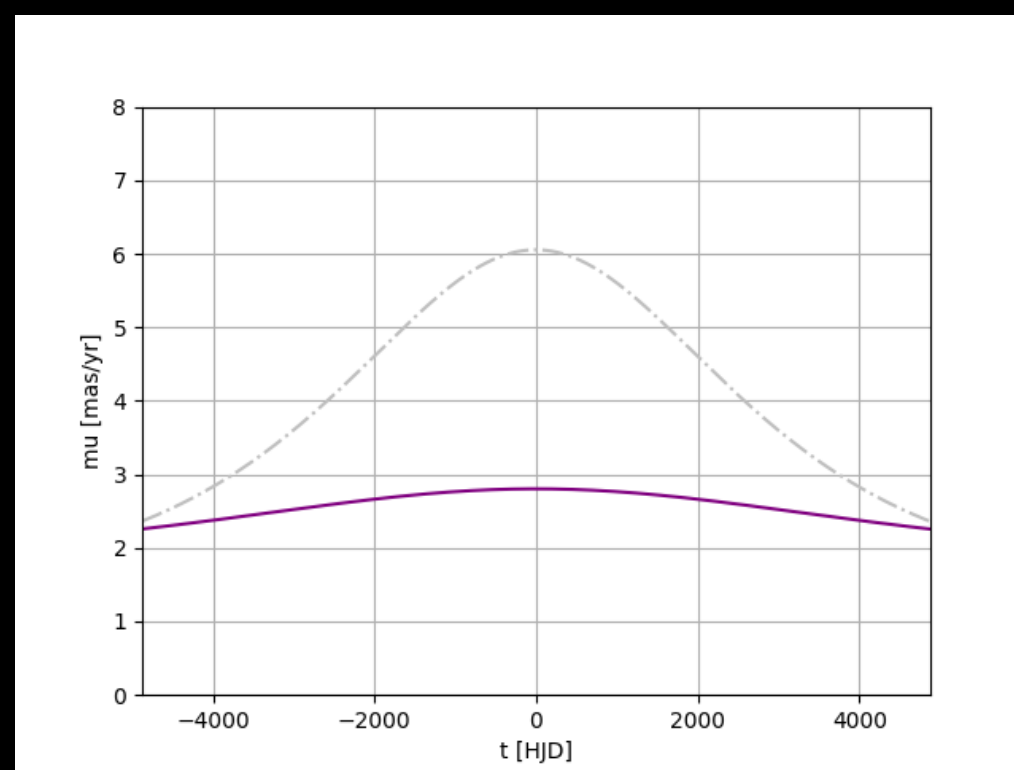
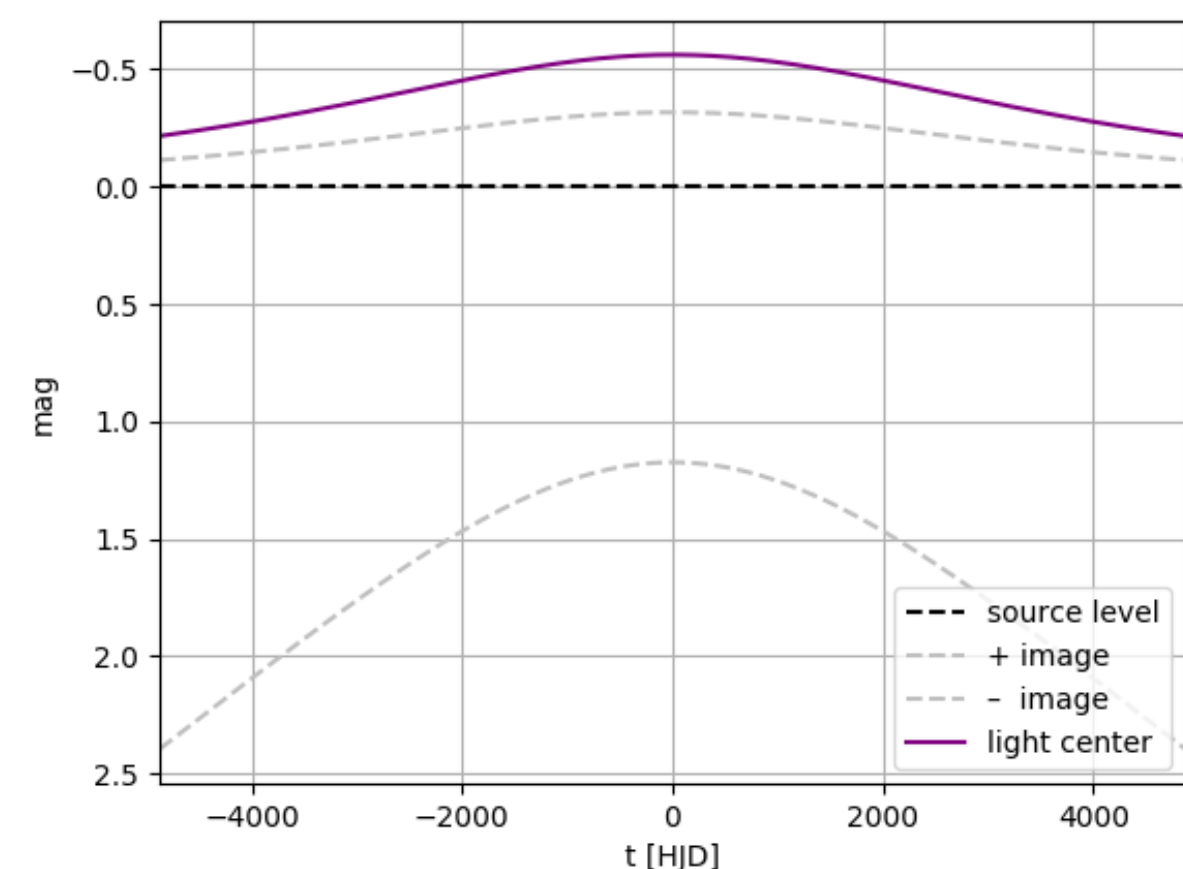


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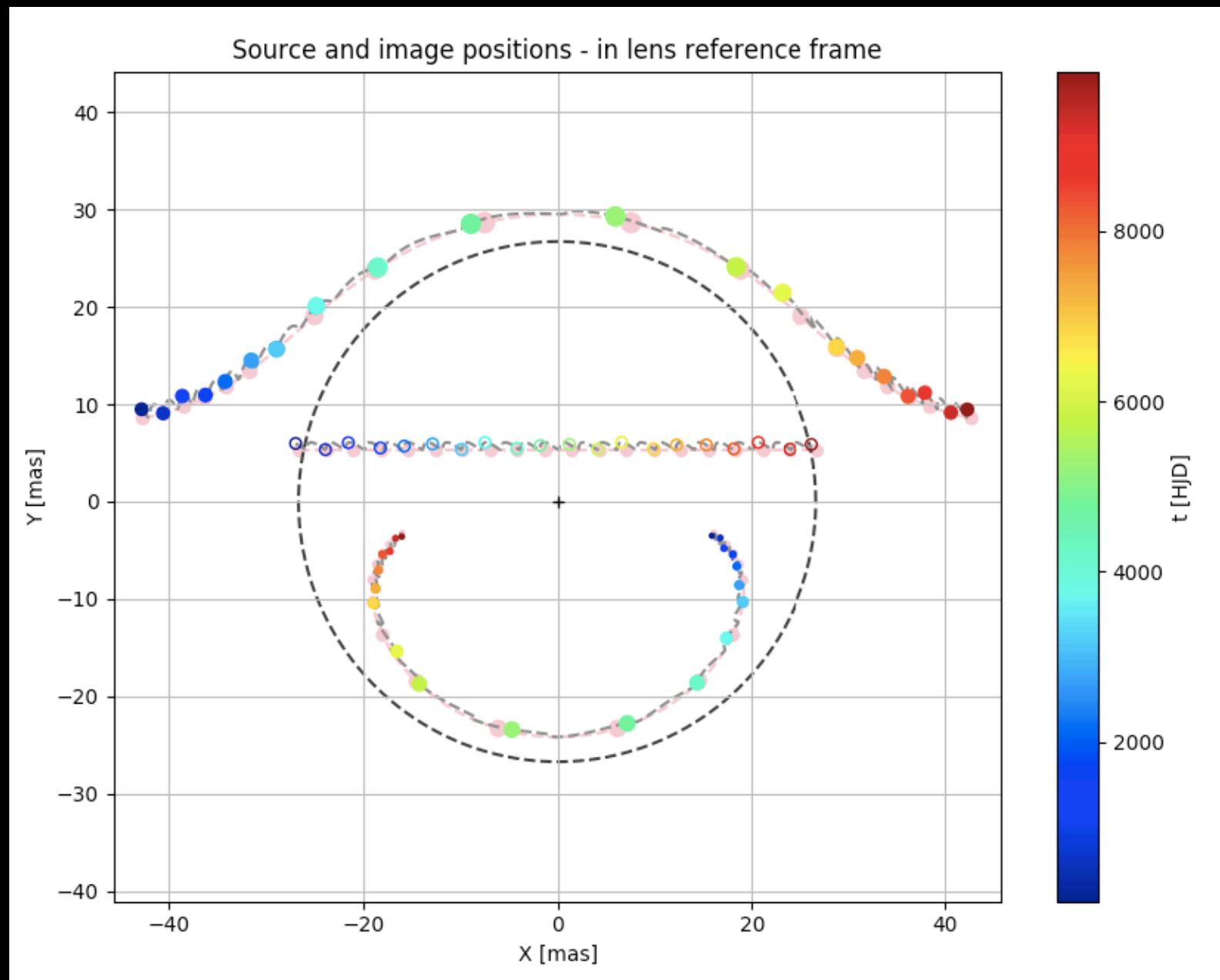
astrometry



photometry



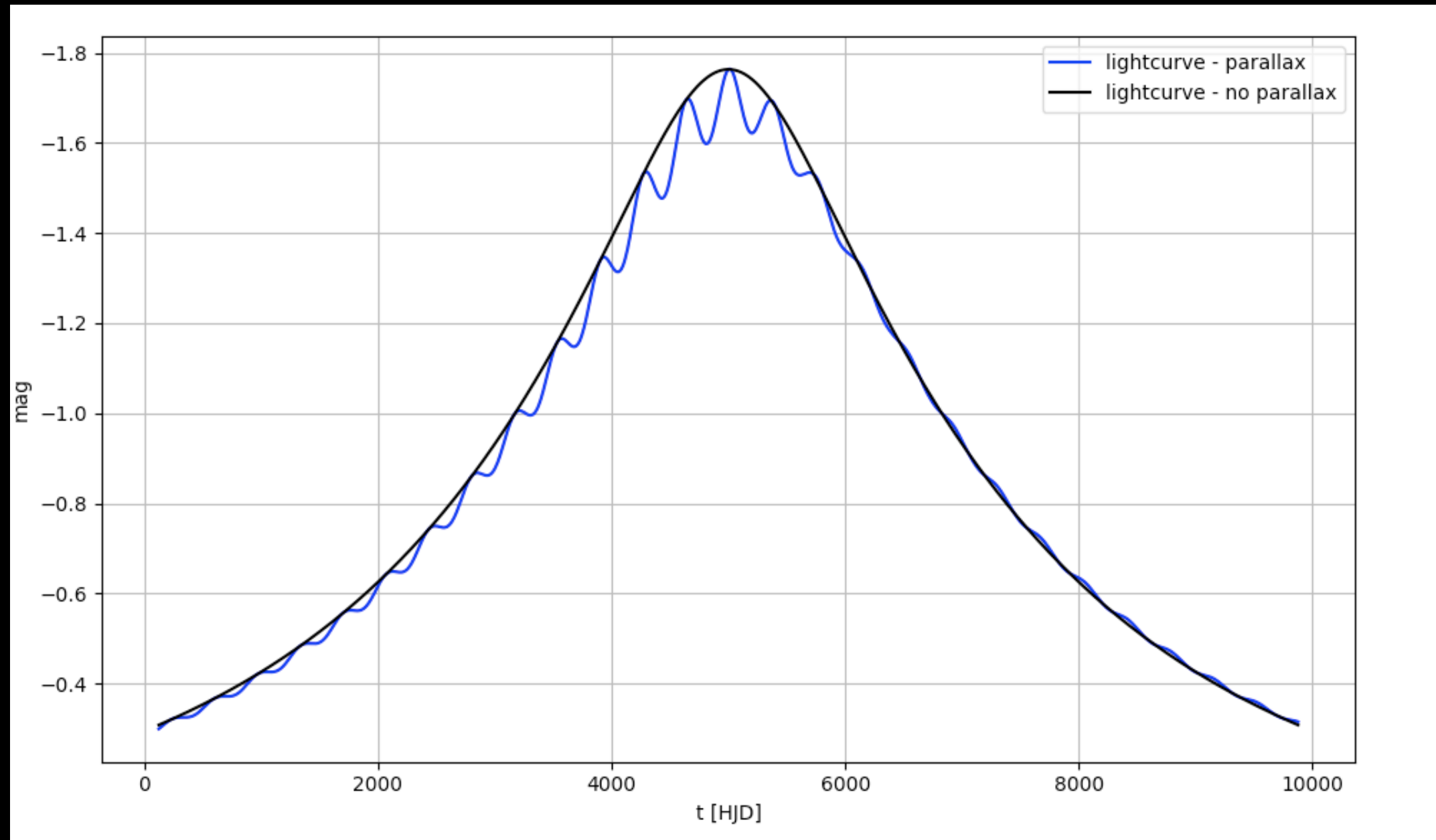
# Parallax effects



$$\theta_E = \sqrt{\kappa M (\pi_L - \pi_S)}$$

—————> the missing ingredient for mass measurement!

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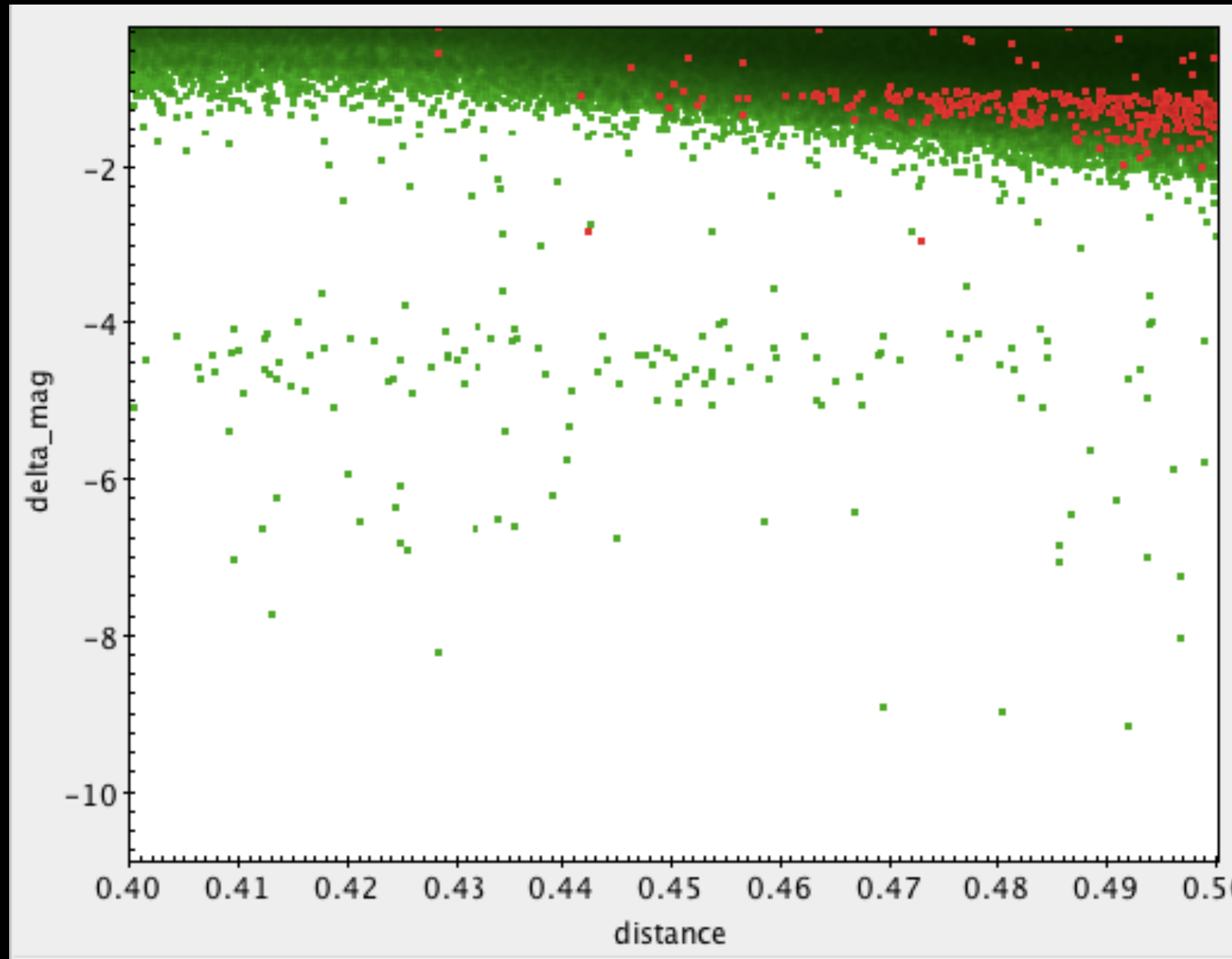


$$\theta_E = \sqrt{\kappa M (\pi_L - \pi_S)}$$

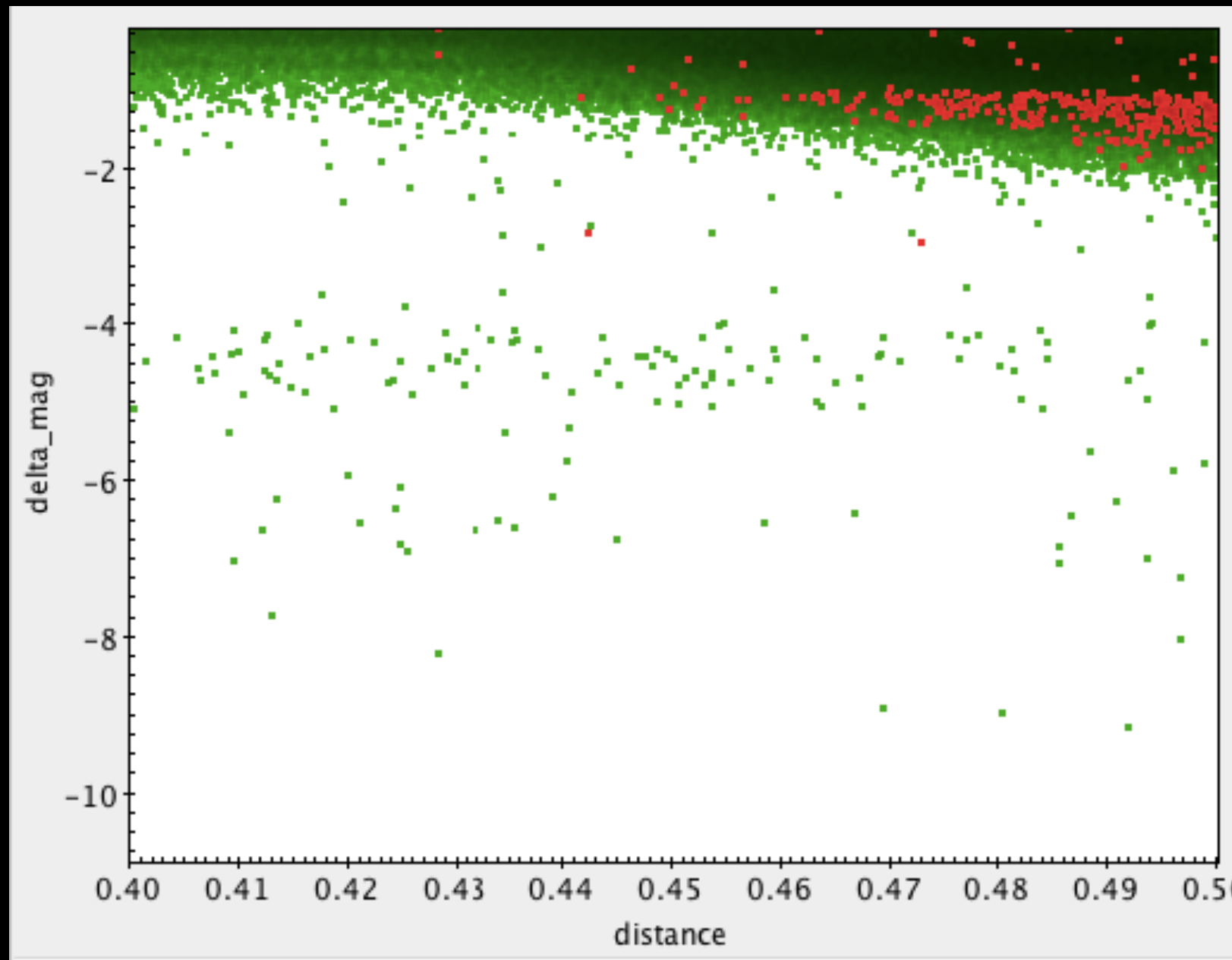
—————> the missing ingredient for mass measurement!



# Gaia DR2 database search...



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...inconclusive :(

The background is a deep space image featuring a dark, star-filled sky. A large, solid black circle is centered in the frame. To the left, there is a horizontal band of orange and yellow light, resembling a nebula or a distant galaxy. To the right, there are wispy, purple and blue clouds of gas or dust. The overall effect is one of vastness and mystery.

Plans for the future



# Searching in Gaia data

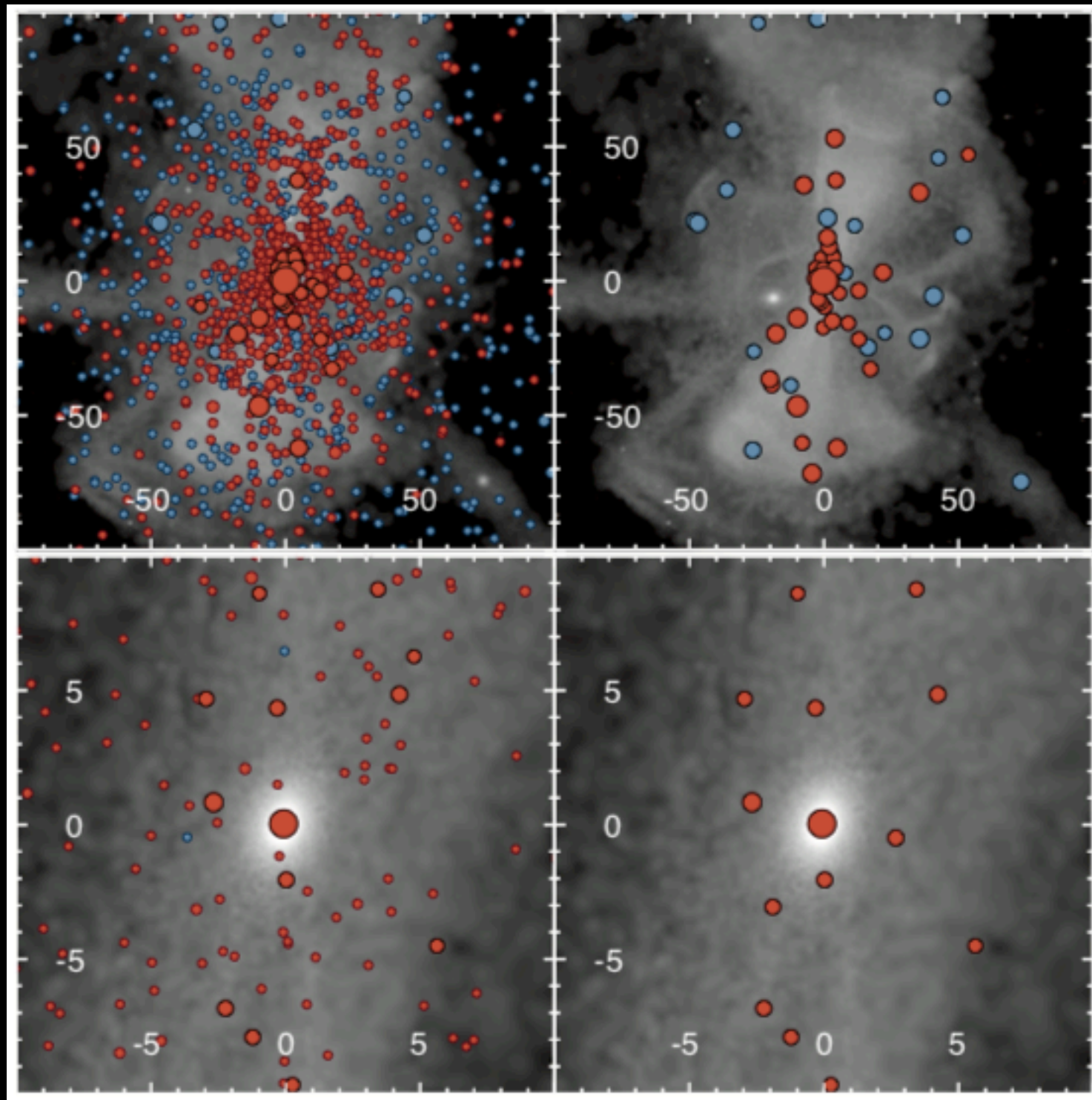
**Gaia EDR3** - Q3 2020

improved astrometry  
ideas to involve other surveys



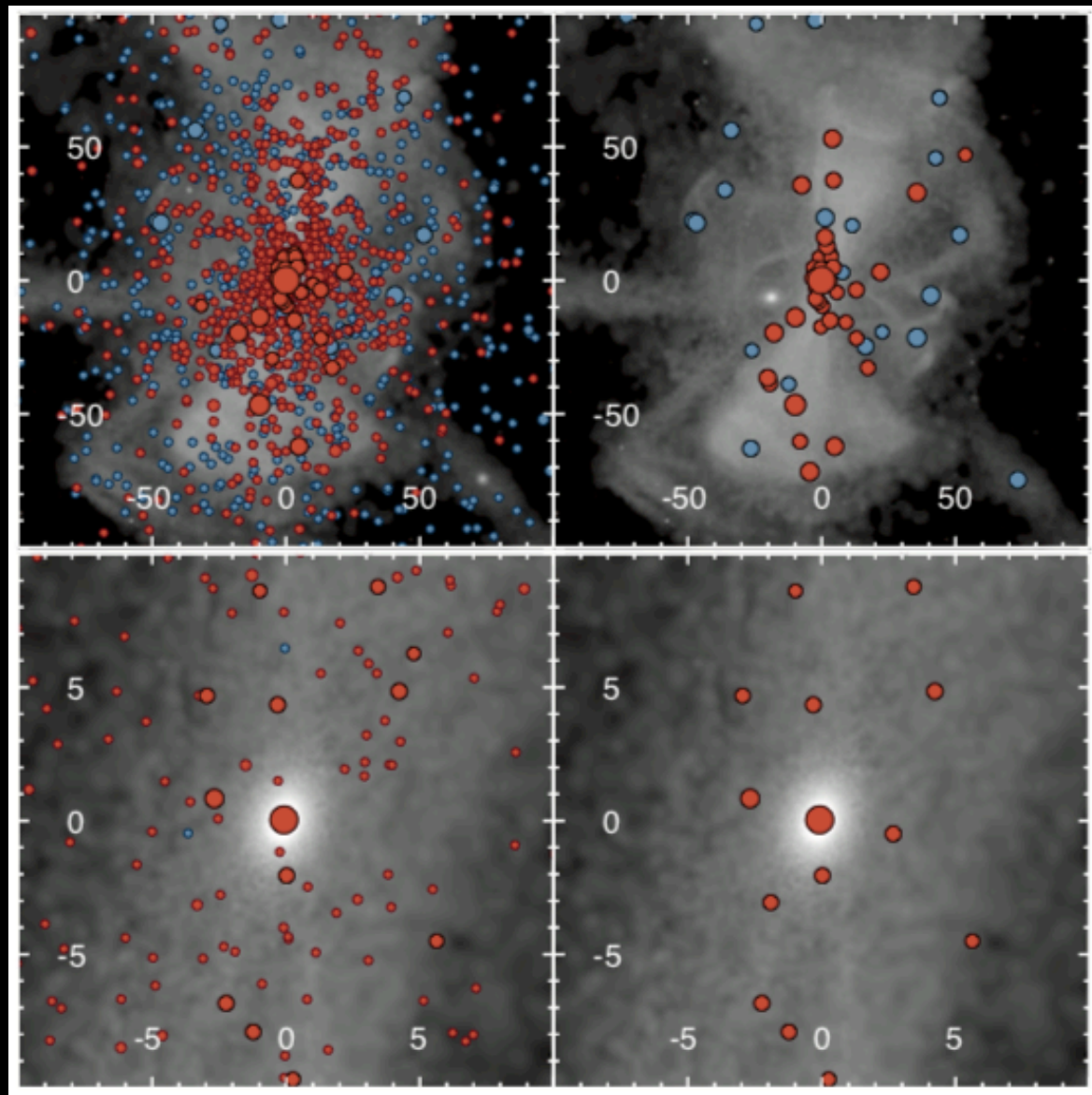


# IMBH distribution in the Milky Way



*Rashkov & Madau 2014*

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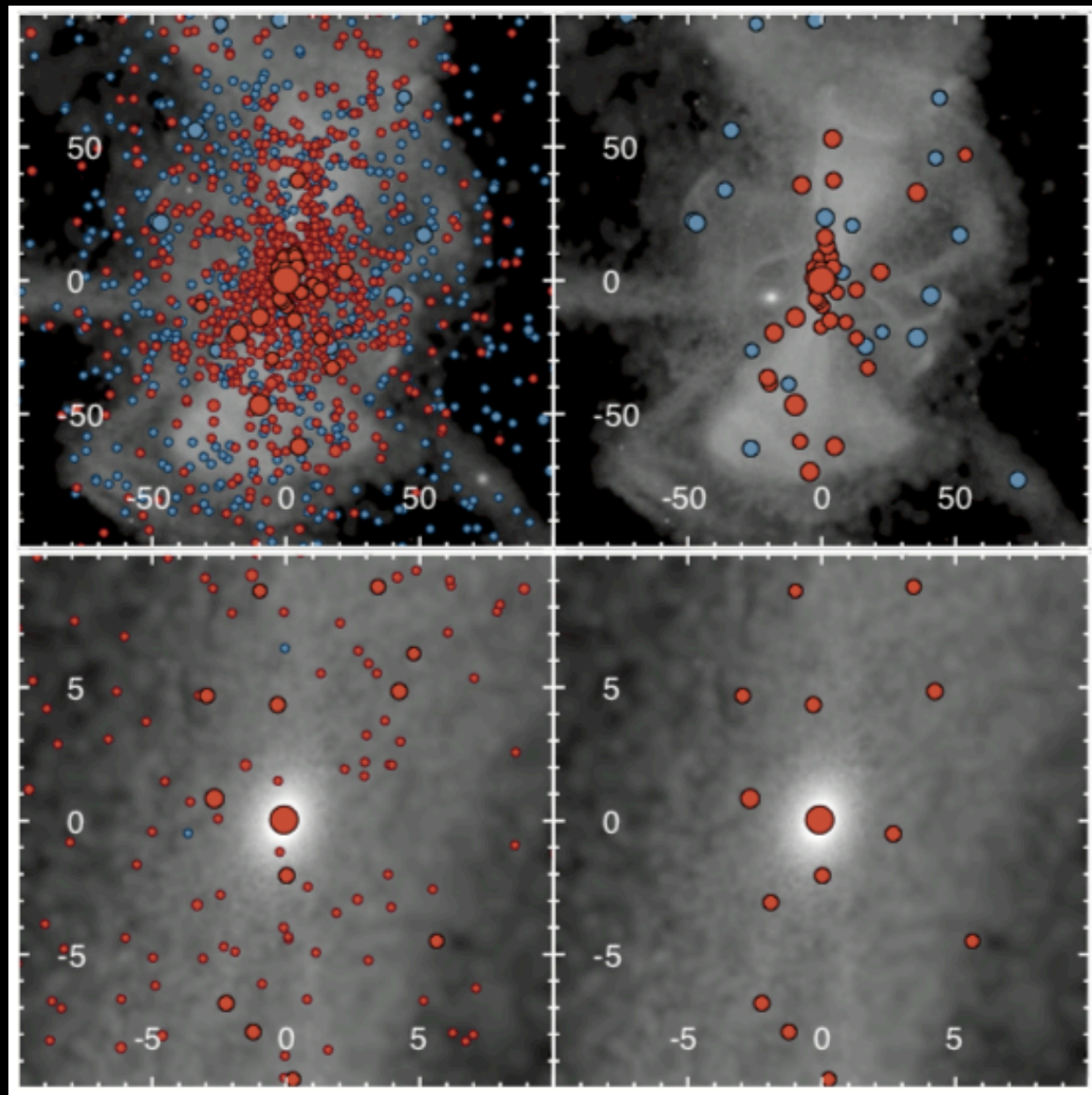


*Rashkov & Madau 2014*

**scales of events  
and astrometric parameters  
(*what we will observe*):**

- angular scale: Einstein radius ( $\theta_E$ )
- timescale: Einstein time ( $t_E$ )
- relative proper motion of images ( $\mu_{\text{im}}$ )

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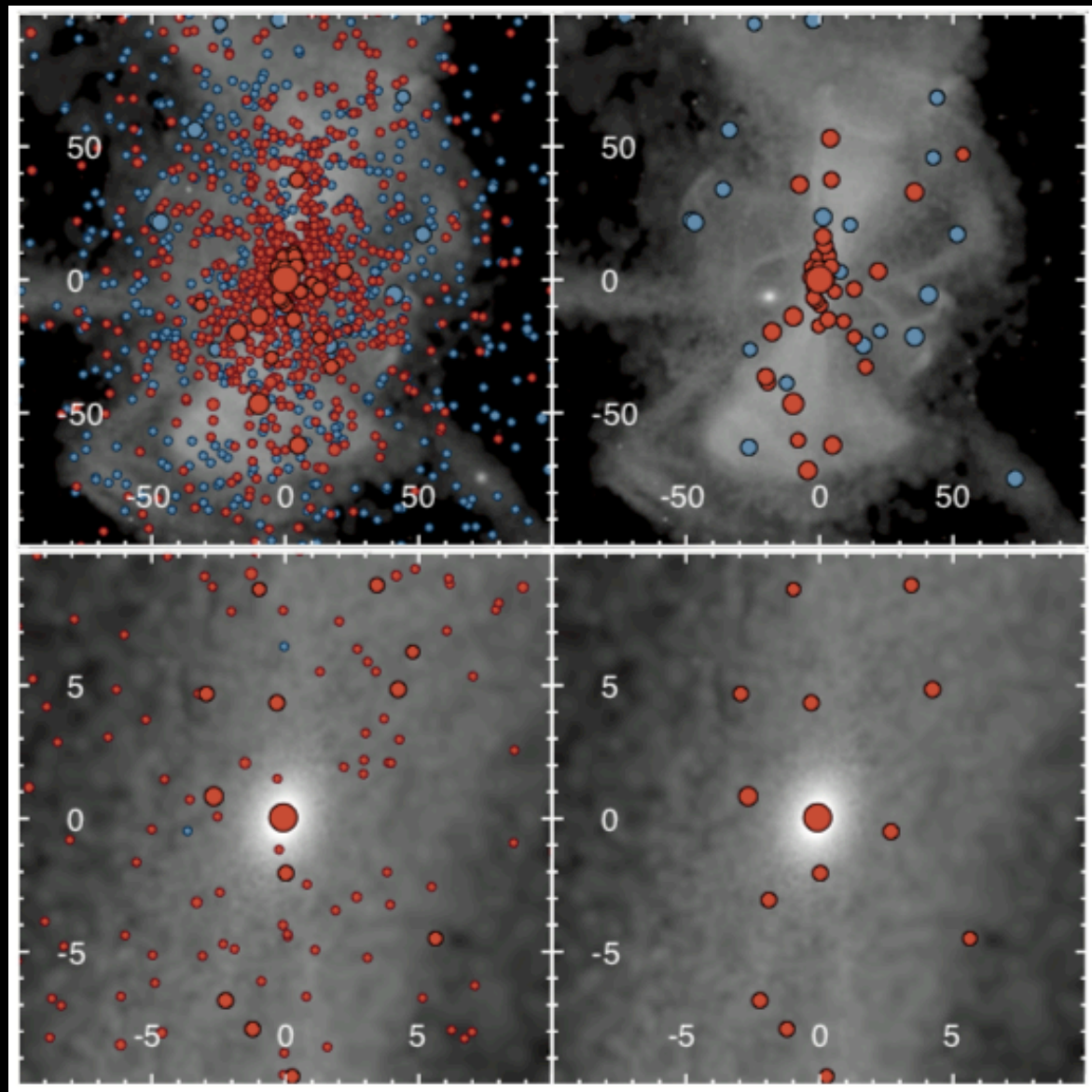
- angular scale: Einstein radius ( $\theta_E$ )
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**parallax corrections  
(*what we will look for  
to measure mass*):**

- lensing parallax ( $\pi_{rel}$ )
- lensing parallax  
in Einstein radius units ( $\pi_{rel}/\theta_E$ )



# IMBH distribution in the Milky Way



*Rashkov & Madau 2014*

→ We will know  
what to look for  
in Gaia EDR3!

# Take-home messages

- \* The search for astrometric lensing events can help find IMBHs
- \* Gaia measurements are crucial for this search!
- \* Cooperation and experience from Gaia Alerts will be valuable



Thank you for your attention!