

# Exploring High-Magnification Microlensing Events from Gaia

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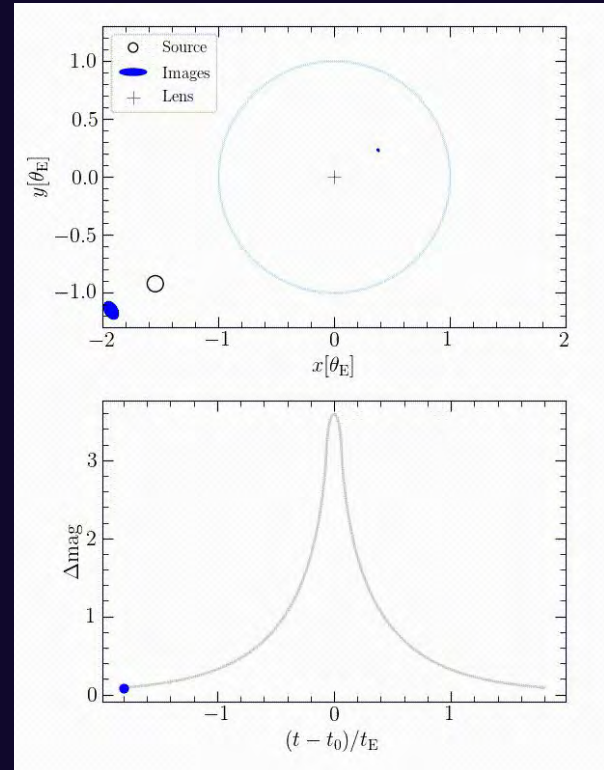
University of Warsaw

Livermore, 1 February 2024

# Measuring lens mass and distance

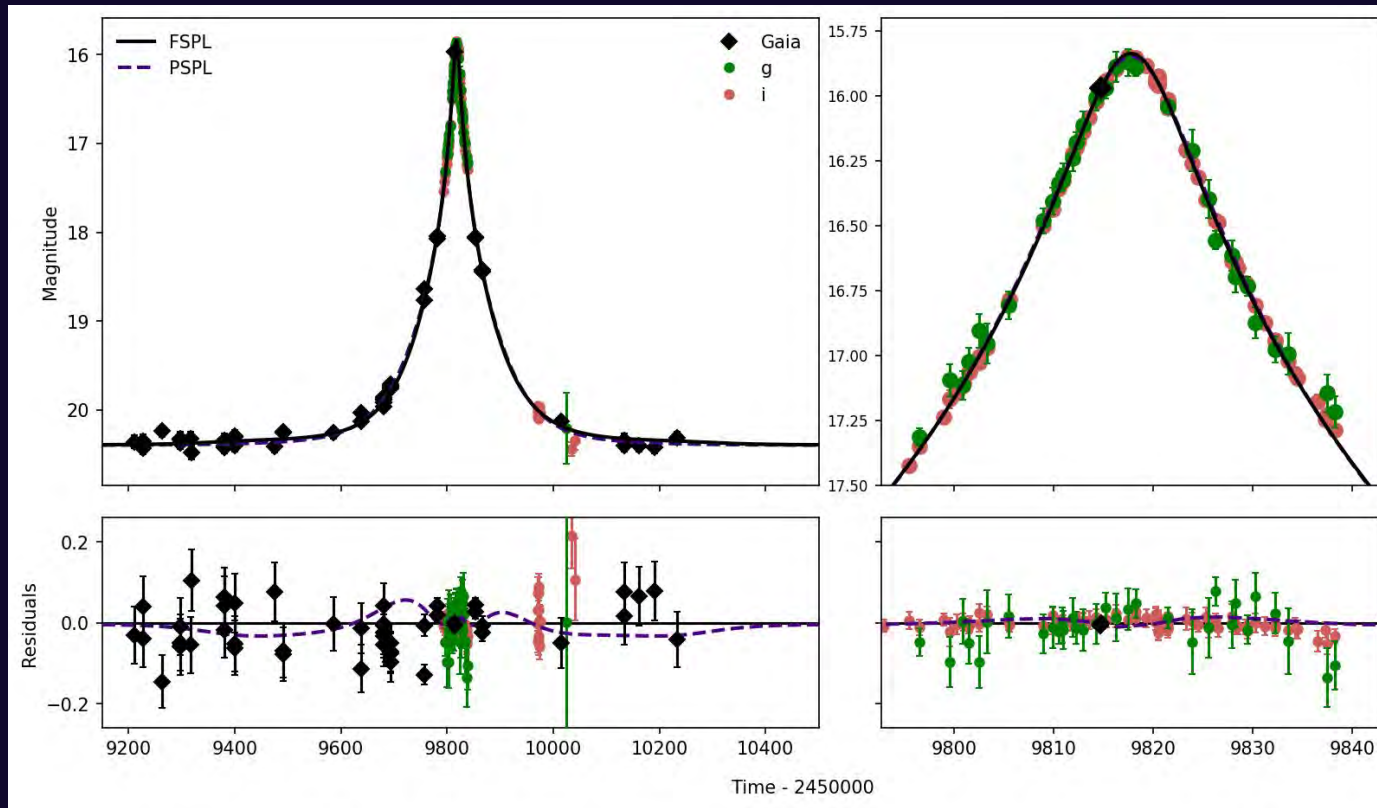
$$M = \frac{\theta_E}{\kappa \pi_E}$$

$$D_L = \left( \theta_E \pi_E + \frac{1}{D_S} \right)^{-1}$$



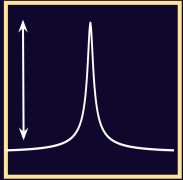
# Gaia22crr: high magnification but no FS effect

$$\rho = \frac{\theta_*}{\theta_E}$$

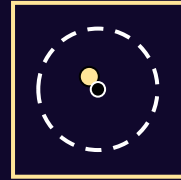


Can we constrain the lens mass in this case?

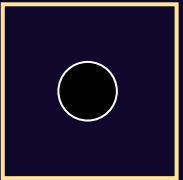
# Events studied



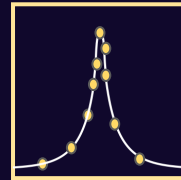
**High magnification** ( $\Delta m \geq 3.3^m$ )



**Small FS effect** ( $\rho < u_0$ )



**Dark lens** ( $f_s \geq 0.9$ )



**Well sampled curve**

5 events found

## Data

- Gaia
- OGLE
- ZTF
- ATLAS
- Ground based observatories



BHTOM2

*bhtom.space*

## Modeling

emcee, MulensModel



# Method

Empirical  
colour-angular  
diameter relations  
(*Adams et al. 2019,*  
*Boyajian et al. 2014*)

$$\Theta_*$$

$$\theta_E \geq \frac{\rho_{lim}}{\theta_*}$$

Photometric curve

$$\rho_{lim}$$

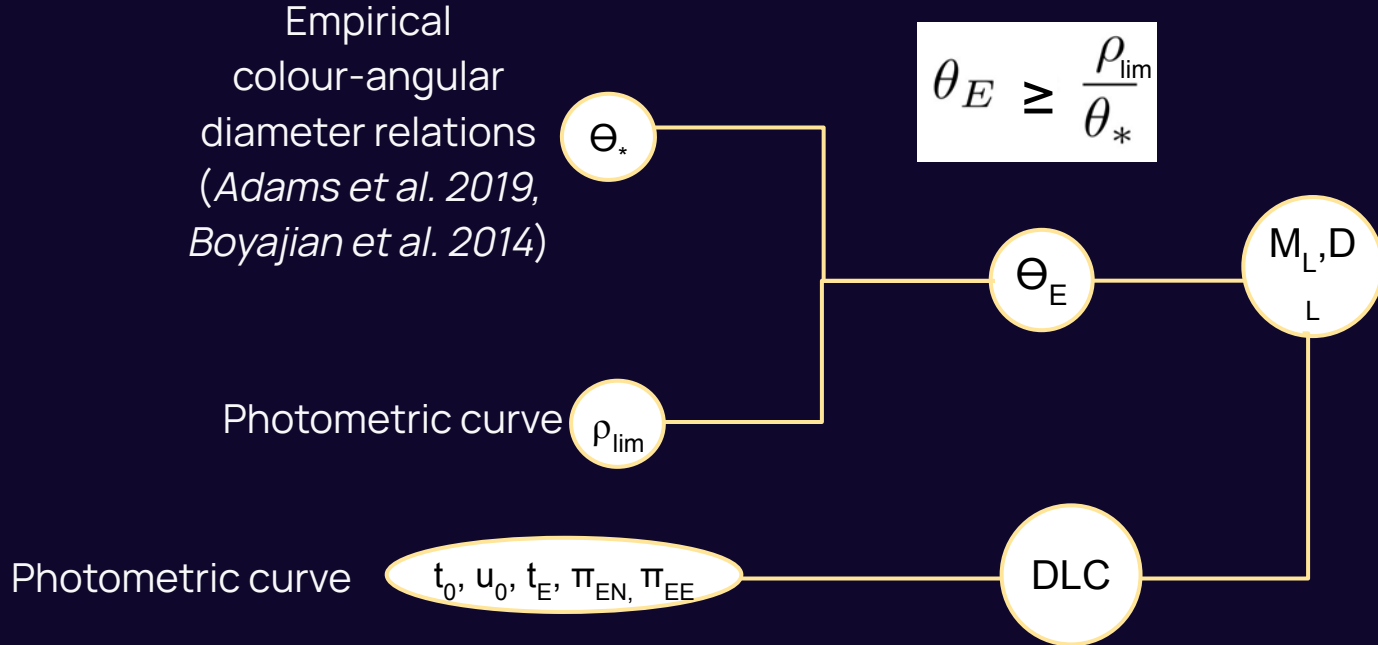
$$\Theta_E$$

$$M_{L,D}$$
$$L$$

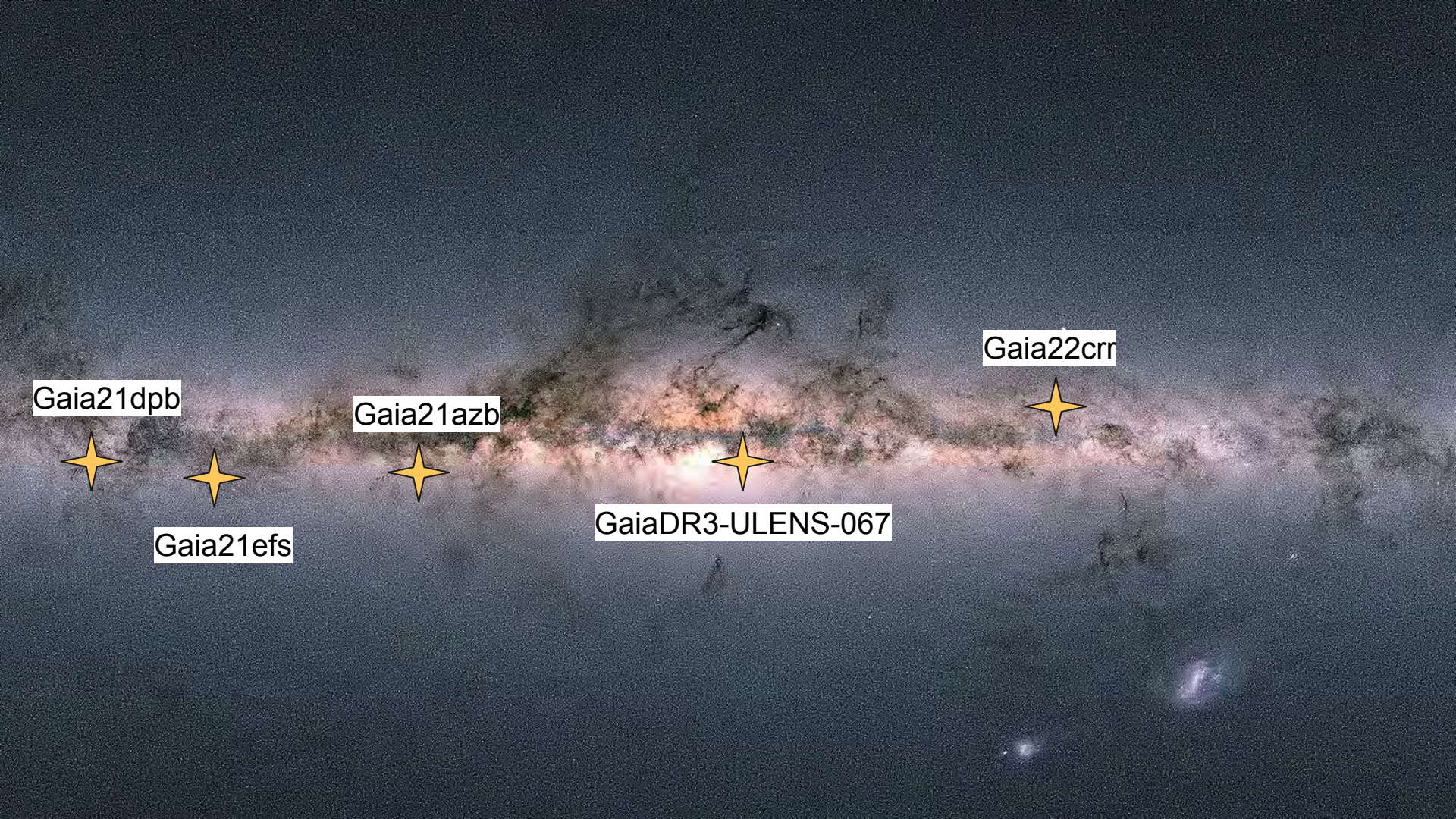
Photometric curve

$$t_0, u_0, t_E, \pi_{EN}, \pi_{EE}$$

$$DLC$$







Gaia21dpb

Gaia21azb

Gaia21efs

GaiaDR3-ULENS-067

Gaia22crr



# Low mass limits



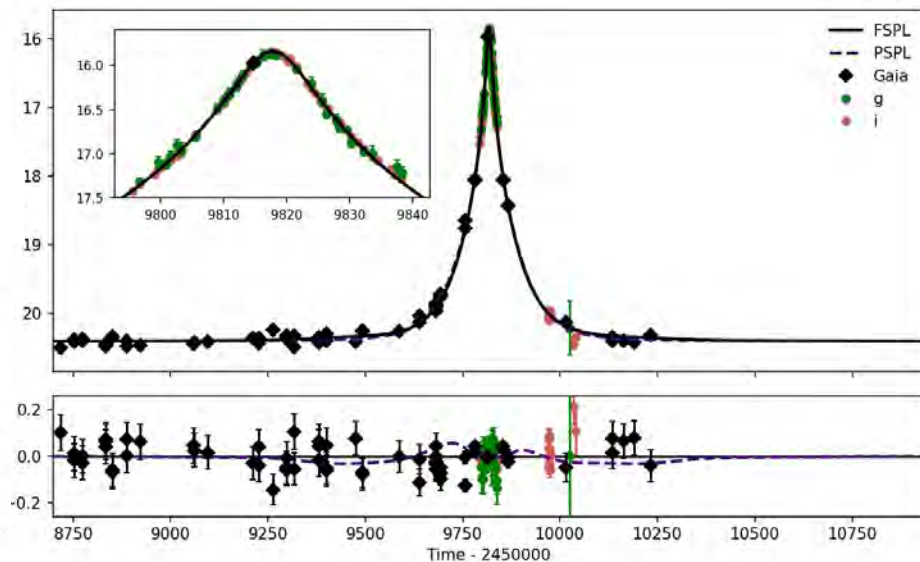
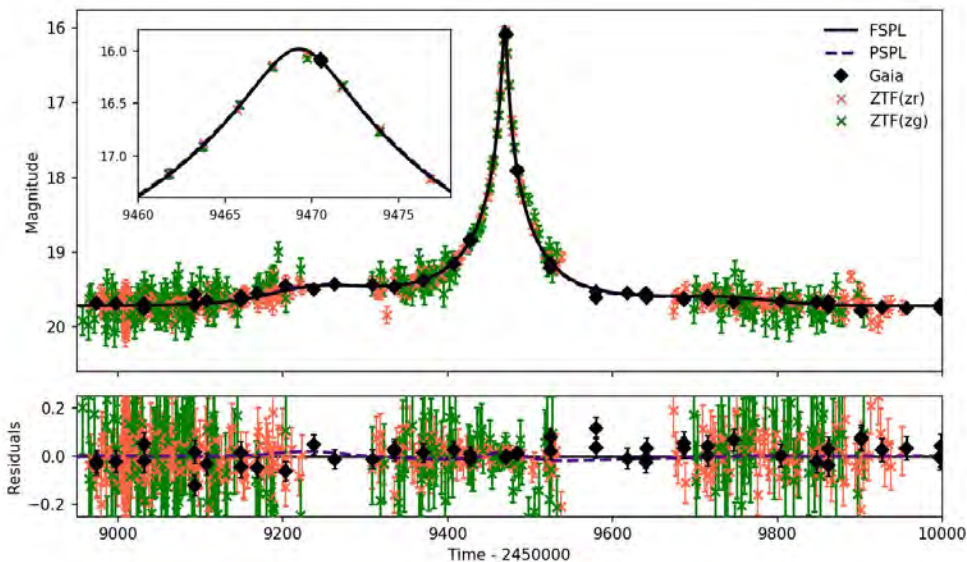


# Gaia21dpb

$$M_L \geq 0.04 M_\odot, \rho \leq 0.025$$

# Gaia22crr

$$M_L \geq 0.10 M_\odot, \rho \leq 0.014$$



$$\Theta_E \geq \sim 0.15 \text{ mas}, \pi_E \sim 0.3$$



# Higher mass limits

Gaia21dpb



Gaia21efs

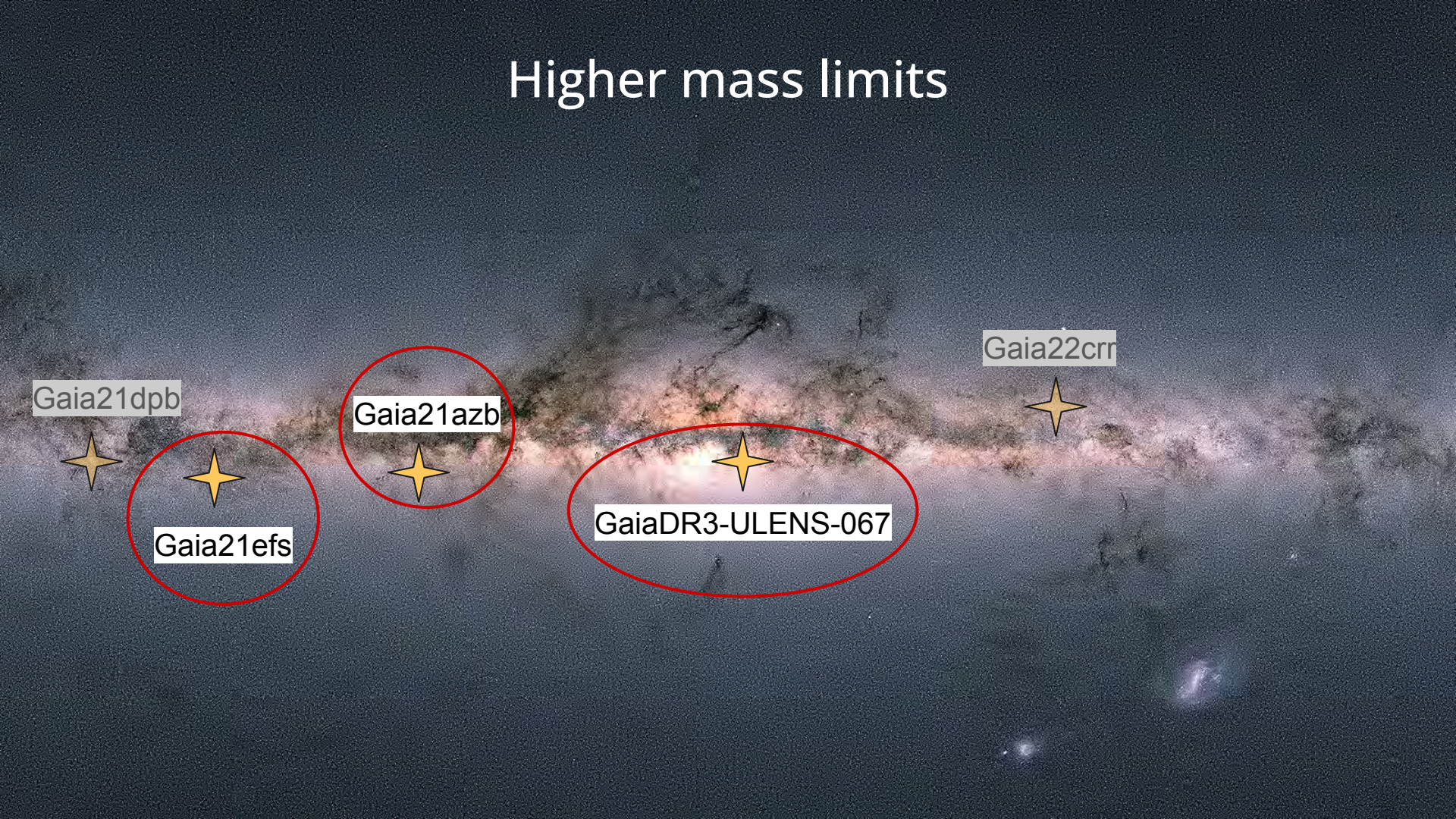
Gaia21azb



GaiaDR3-ULENS-067



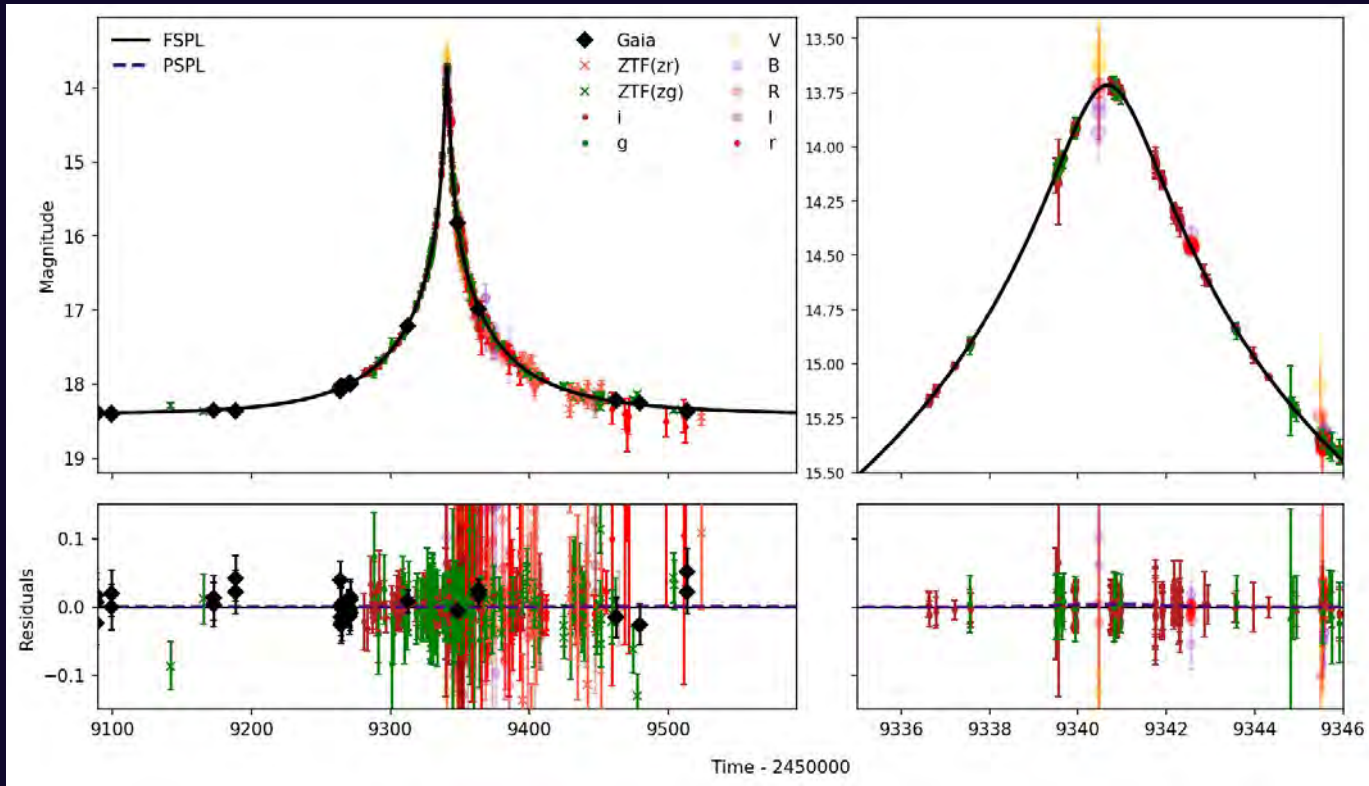
Gaia22crr





# Gaia21azb

$\Theta_E \geq 0.77$  mas,  $\rho \leq 0.008$



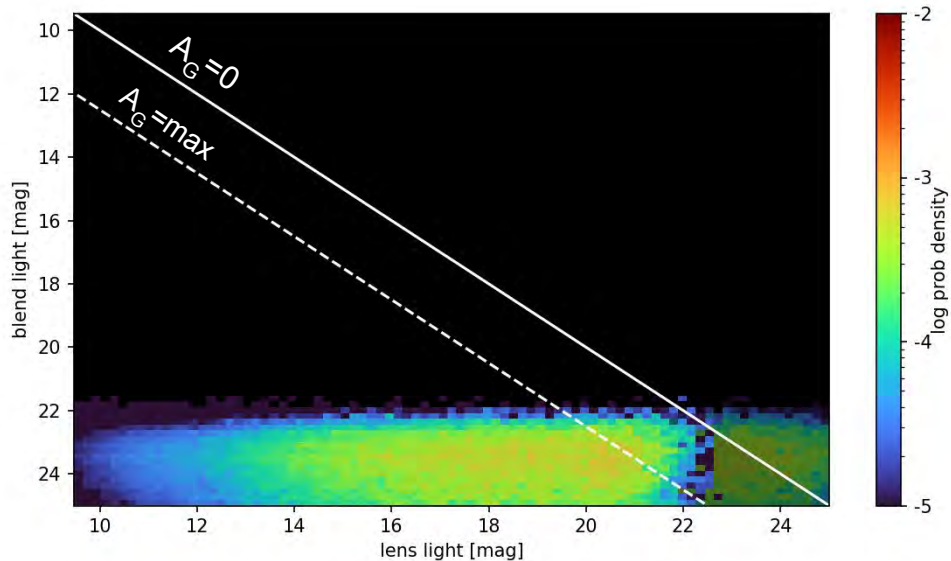
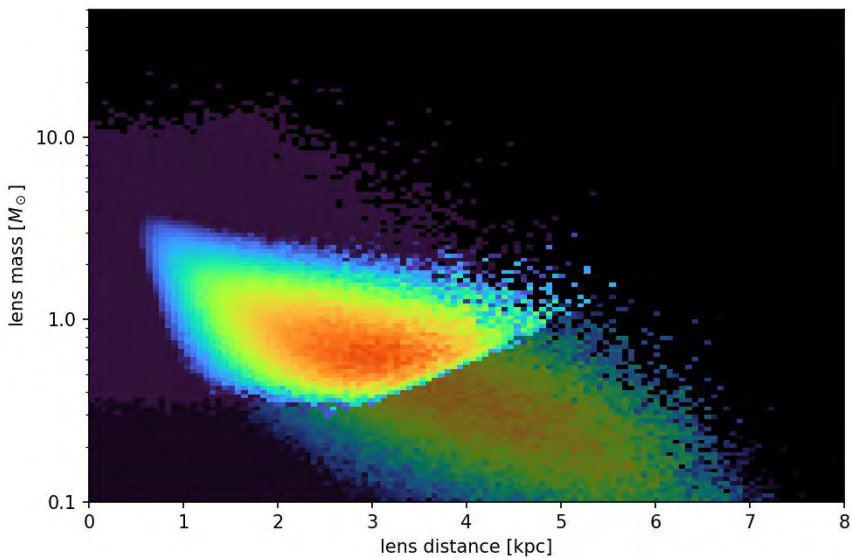


# Gaia21azb – DLC

$$M_L \sim 0.85 M_\odot$$

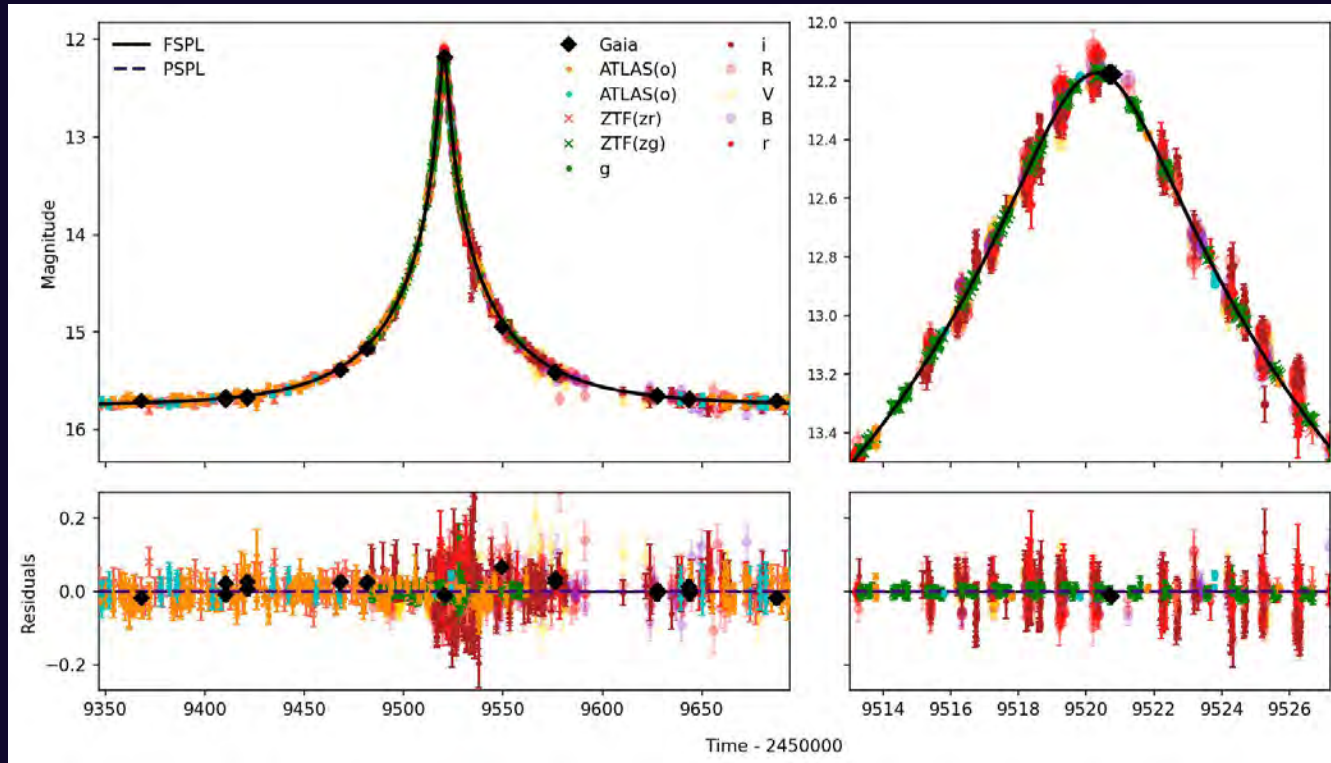
(median mass)

Dark lens prob.: 98-100%



# Gaia21efs

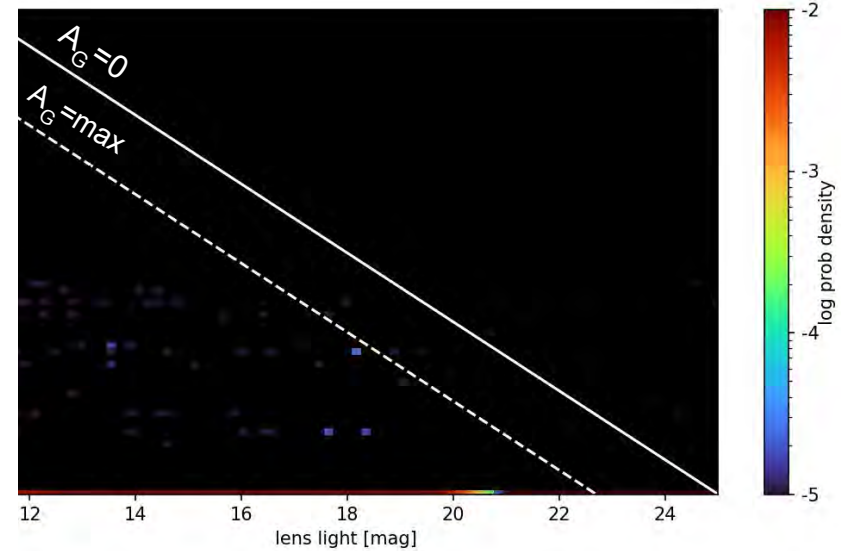
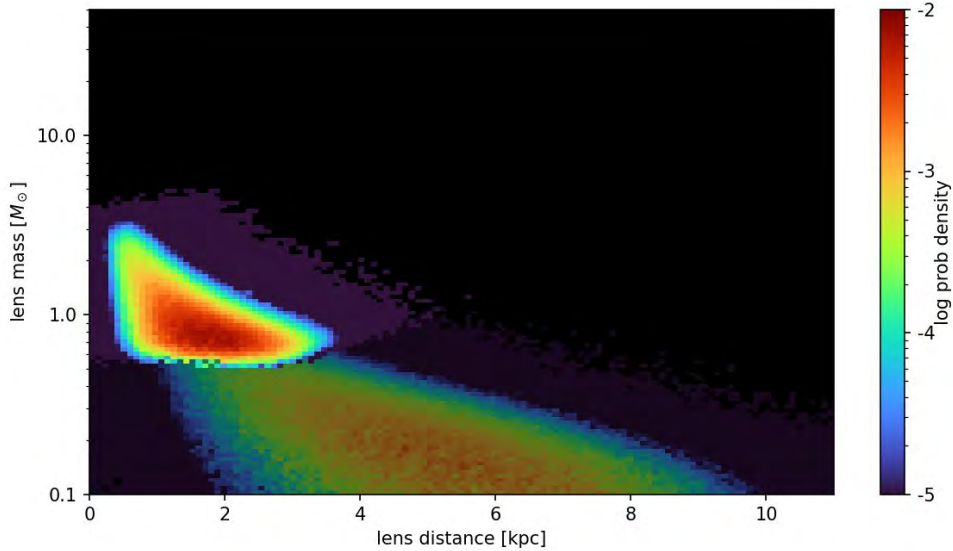
$$\Theta_E \geq 1.12 \text{ mas}, \rho \leq 0.015$$



# Gaia21efs – DLC

$$M_L \sim 0.87 M_\odot$$

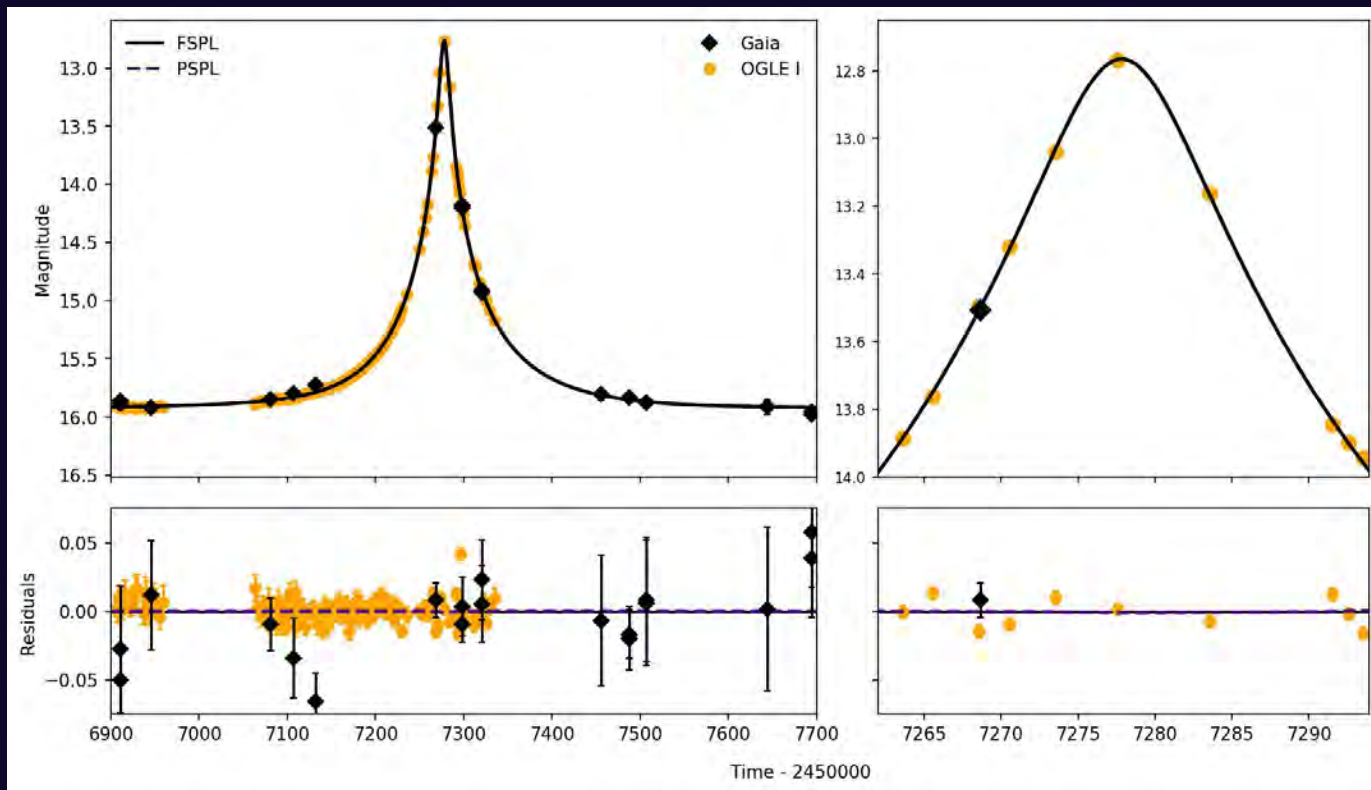
Dark lens prob.: 99-100%





# GaiaDR3-ULENS-067 / OGLE-2015-BLG-0149

$$\Theta_E \geq 0.47 \text{ mas}, \rho \leq 0.027$$

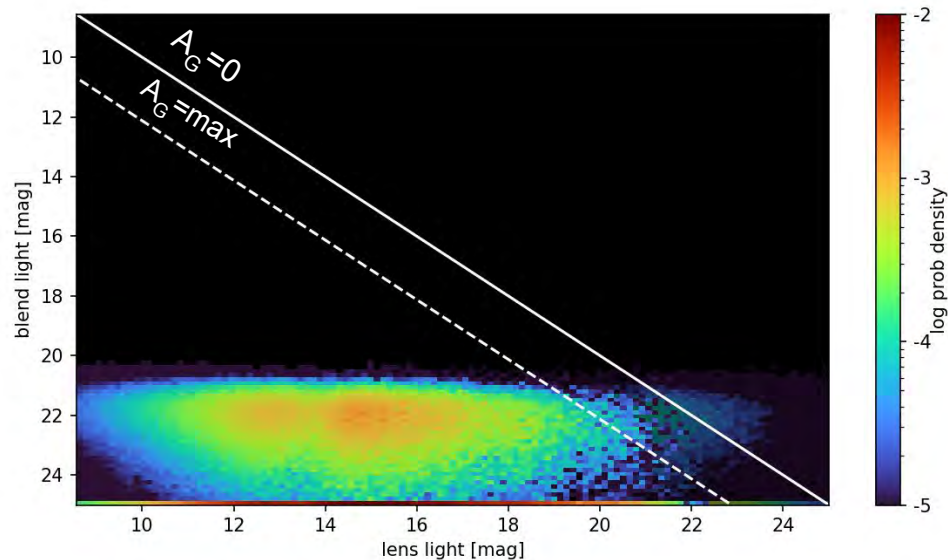
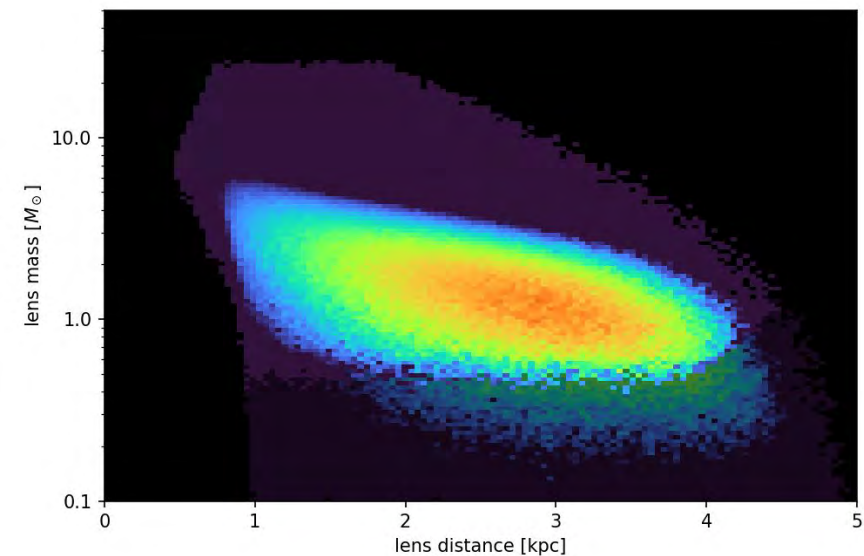


# GaiaDR3-ULENS-067 – DLC

$$M_L \sim 1.5 M_\odot$$

(median mass)

Dark lens prob.: 99-100%



## Summary

- I presented high-magnification microlensing events without the finite source effect...
- ...and the method I used to constrain the lens masses
- 5 events analyzed:
  - 2 events have low lens mass limits
  - 2 events have lens masses  $\sim 0.9 M_{\odot}$
  - 1 event have lens mass  $\sim 1.5 M_{\odot}$

**Thank you!**

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