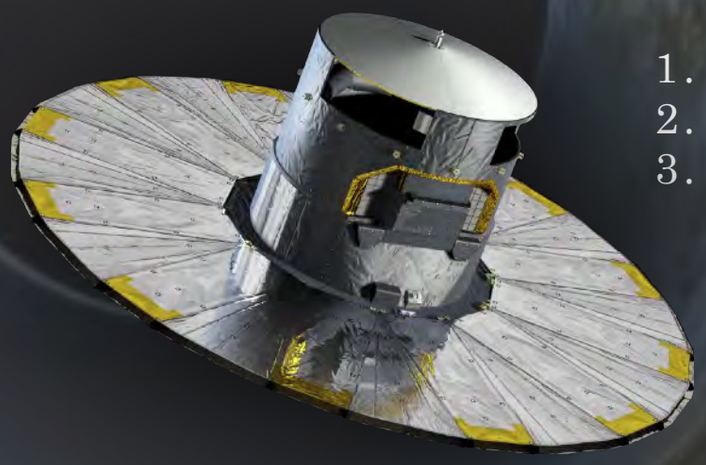
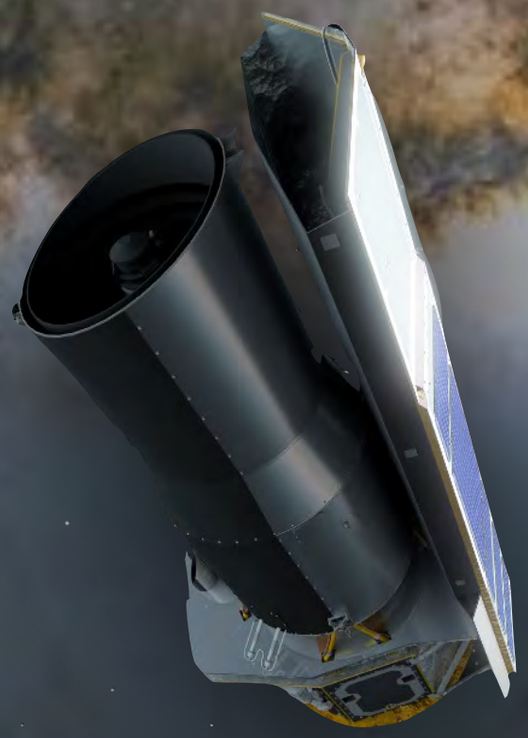
Massive lens candidates from Spitzer & Gaia

Kris Rybicki[1], Yossi Shvartzvald[1], Jennifer Yee[2],
Sebastiano Calchi Novati[3], Eran Ofek[1] et al.

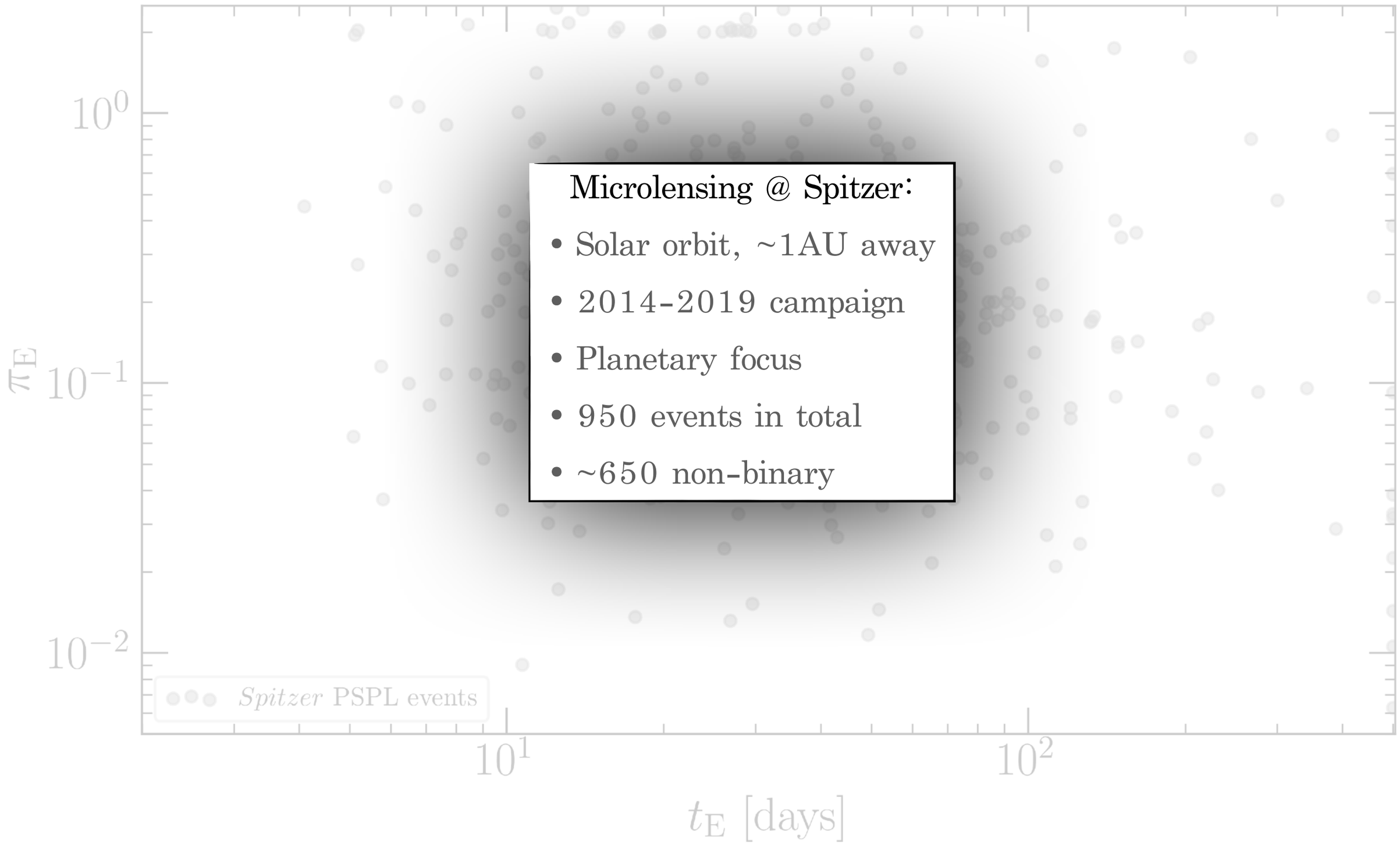
1. Weizmann Institute of Science
2. Center for Astrophysics | Harvard & Smithsonian
3. Infrared Processing and Analysis Center



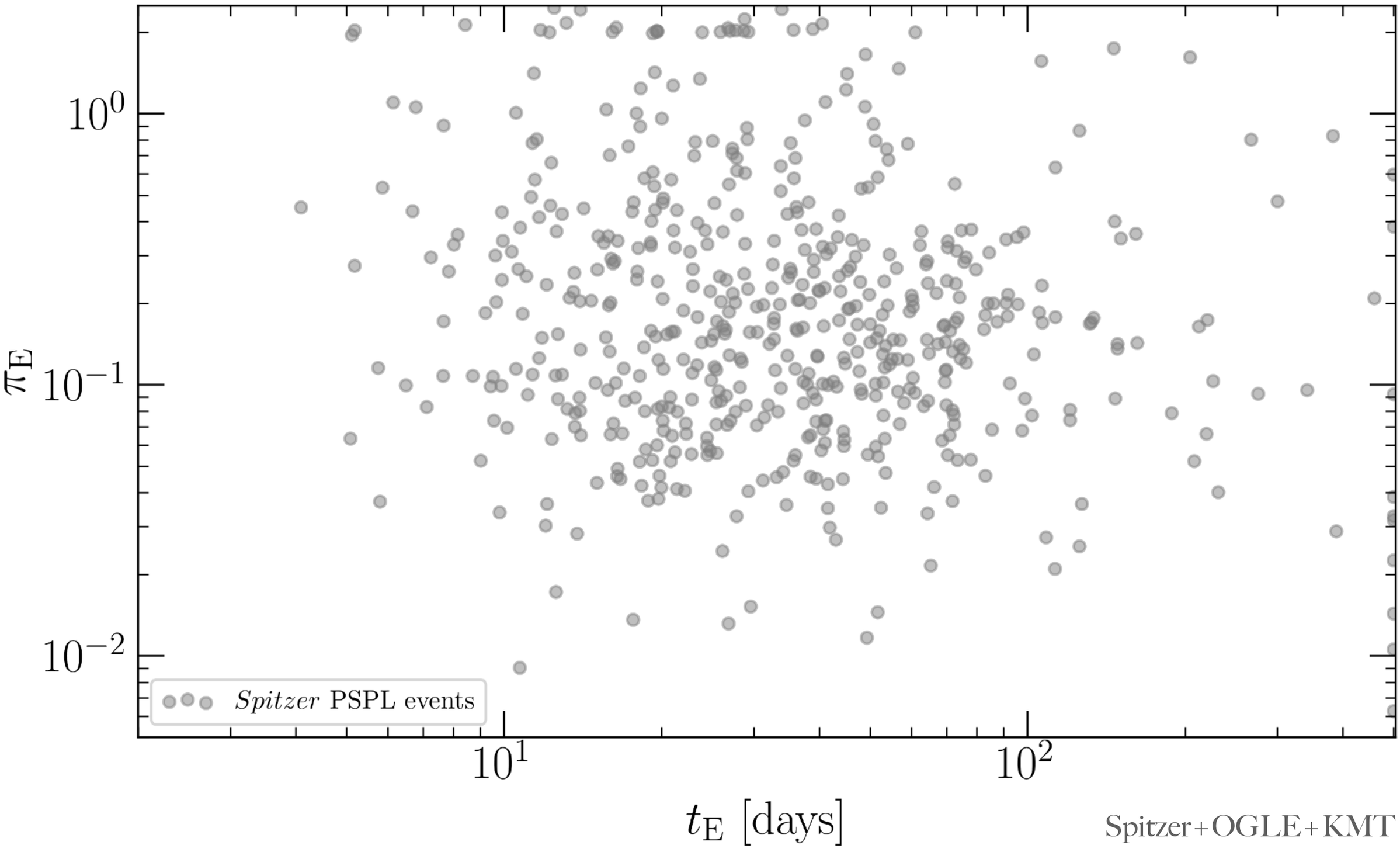


1st February 2024, 26th Microlensing Conference, LLNL, Livermore, USA

Initial analysis of the full Spitzer sample: π_E – t_E plane



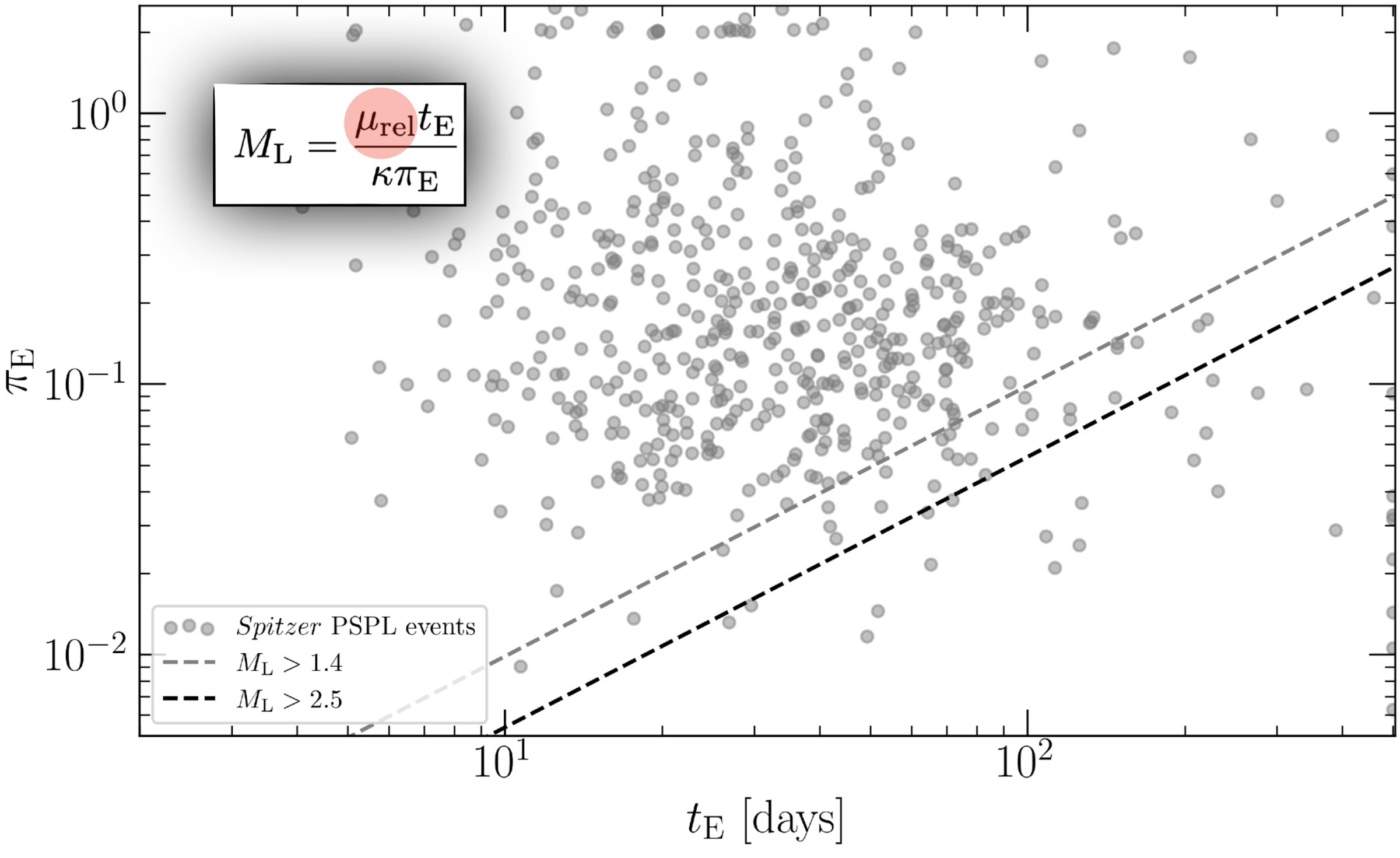
Initial analysis of the full Spitzer sample: π_E – t_E plane



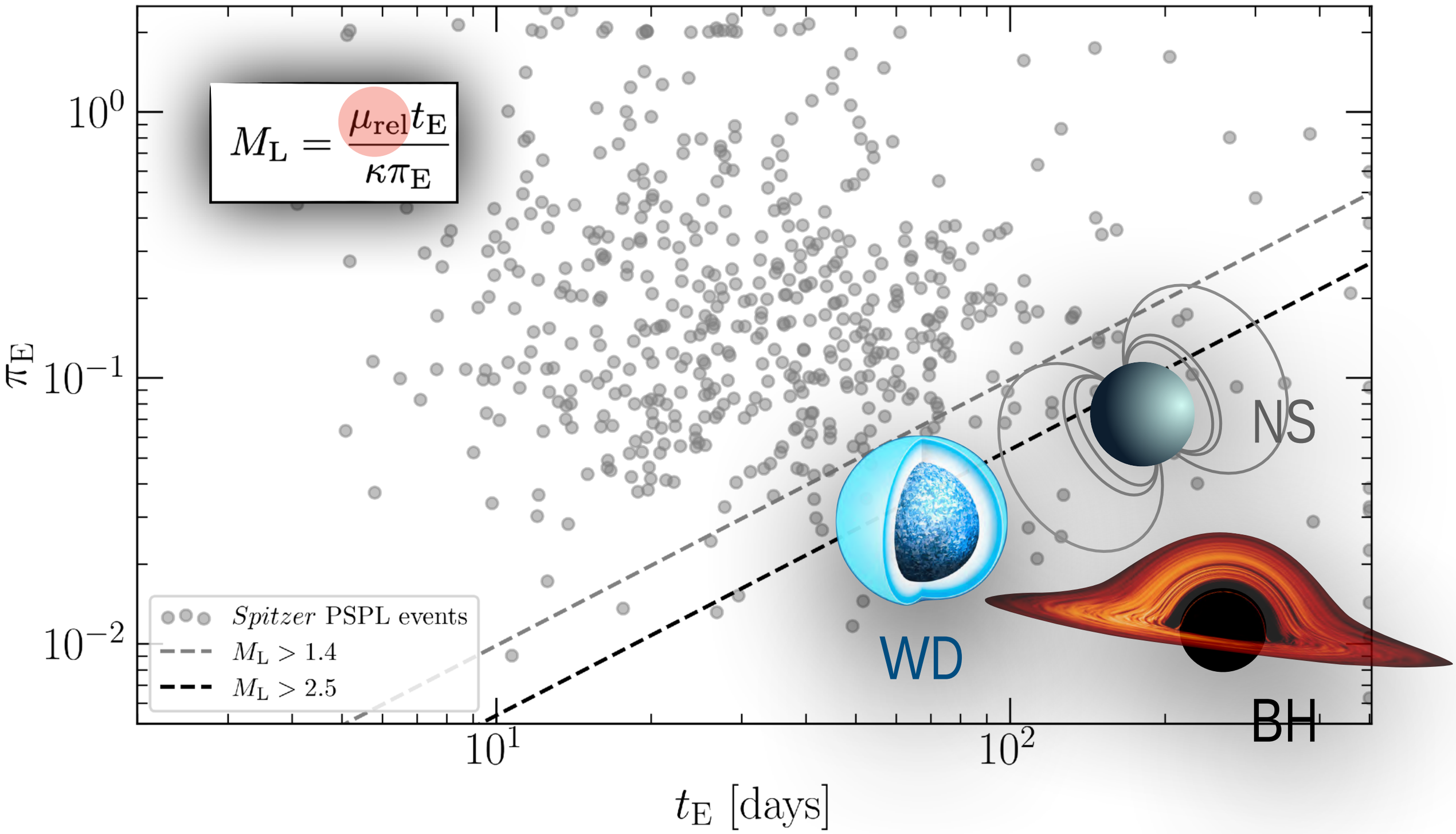
Initial analysis of the full Spitzer sample: π_E - t_E plane

WEIZMANN INSTITUTE OF SCIENCE

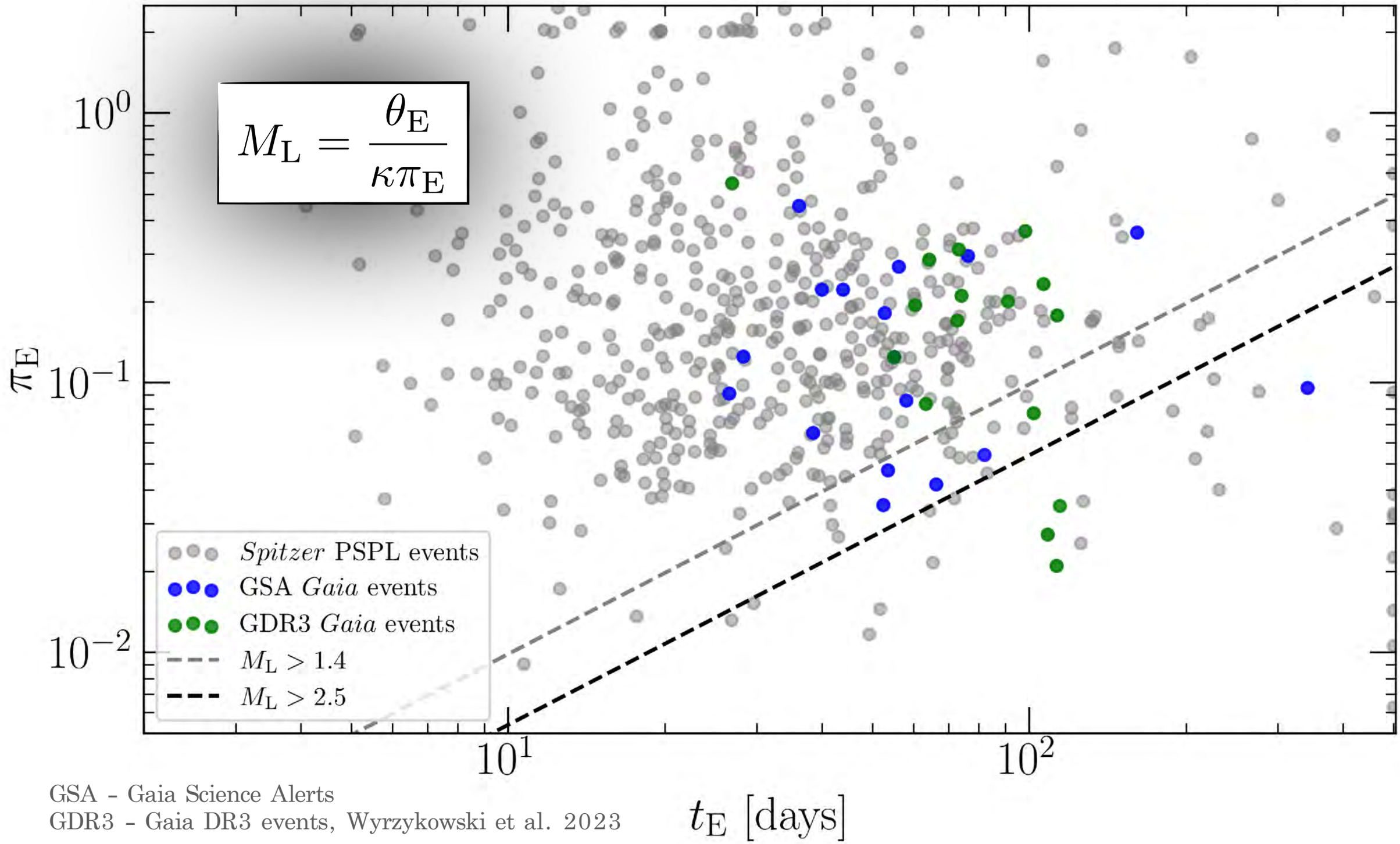
$$M_L = \frac{\mu_{rel} t_E}{\kappa \pi_E}$$



Initial analysis of the full Spitzer sample: π_E - t_E plane

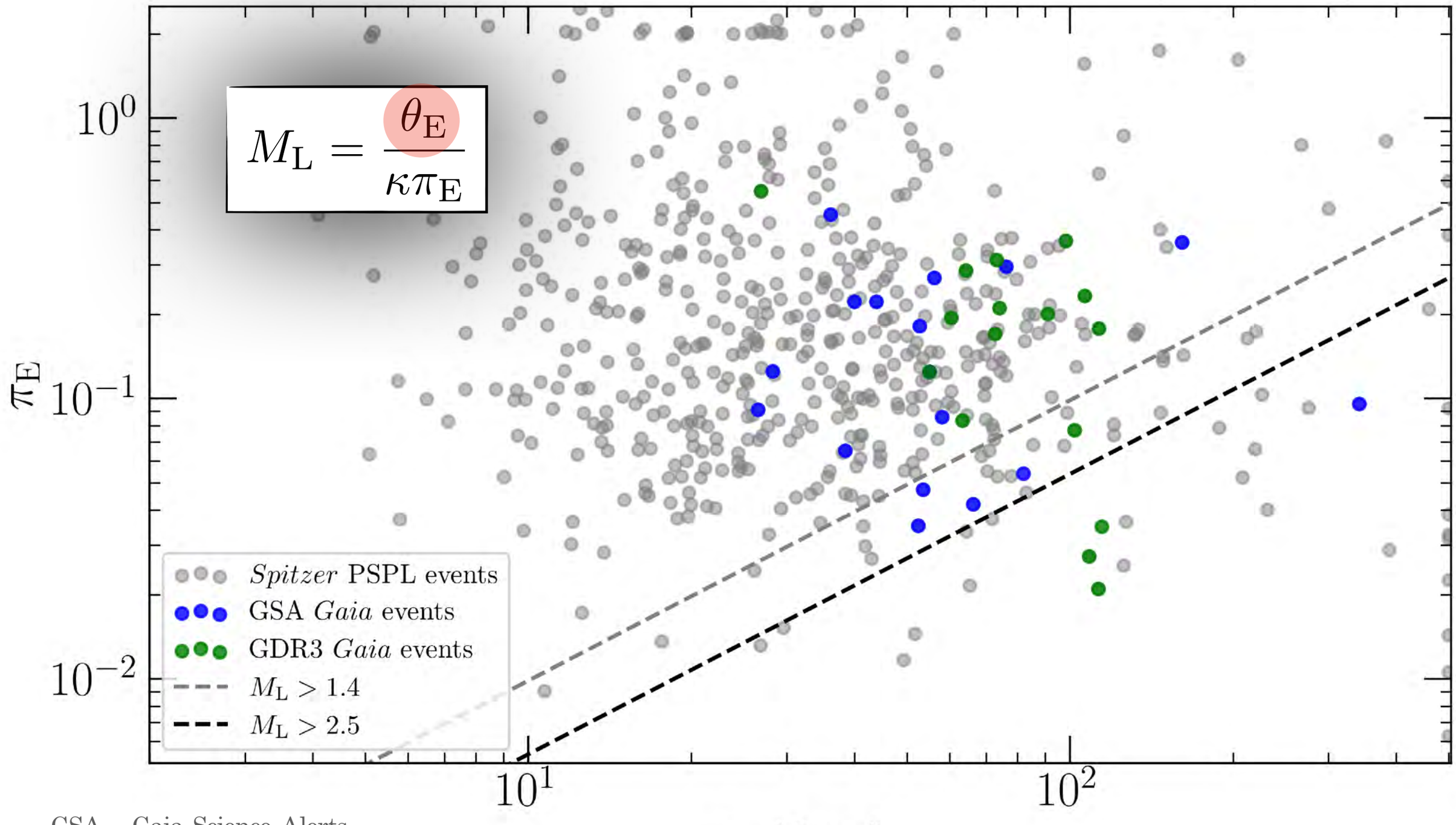


Initial analysis of the full Spitzer sample: π_E – t_E plane



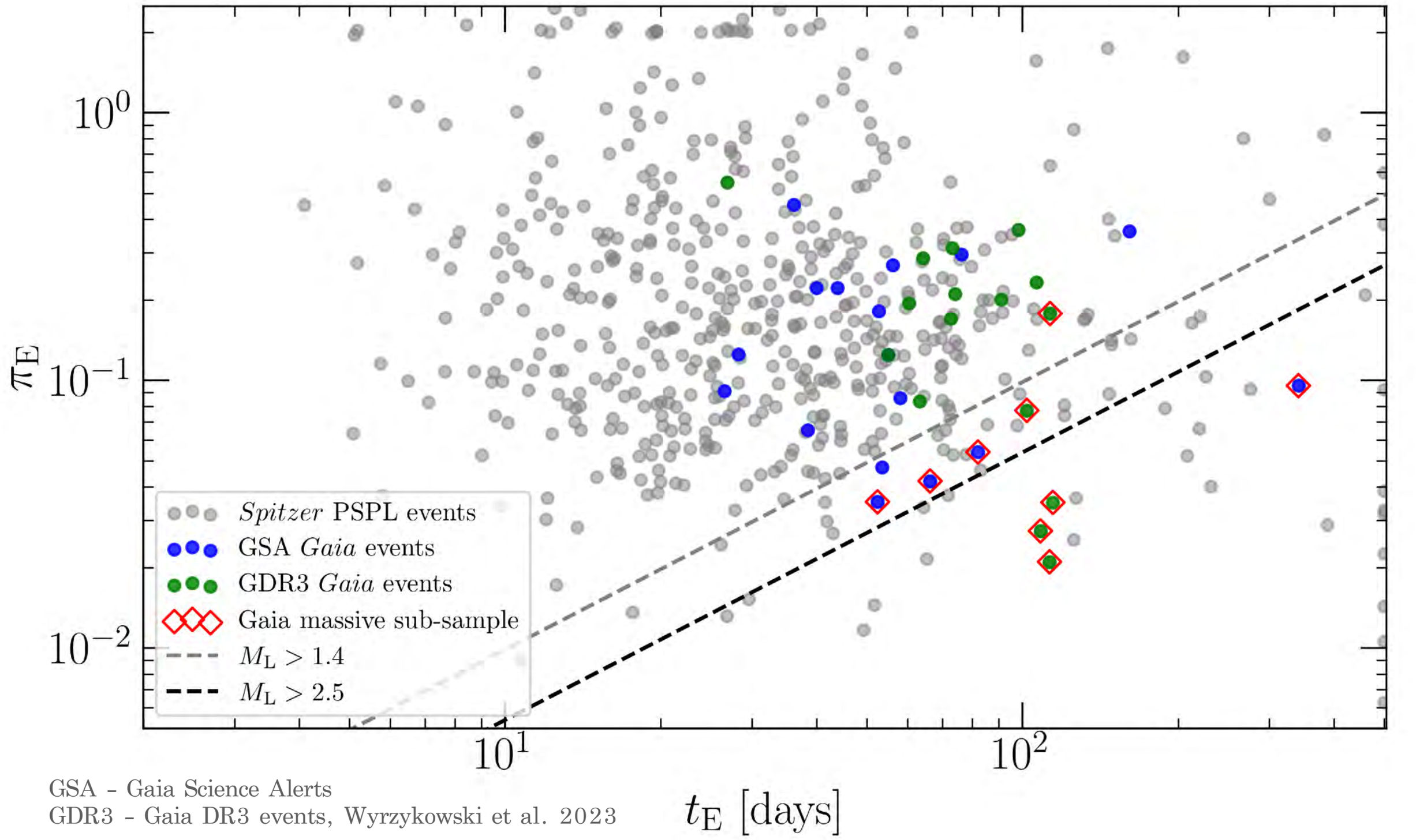
GSA - Gaia Science Alerts
GDR3 - Gaia DR3 events, Wyrzykowski et al. 2023

Initial analysis of the full Spitzer sample: $\pi_{\rm E}$ – $t_{\rm E}$ plane



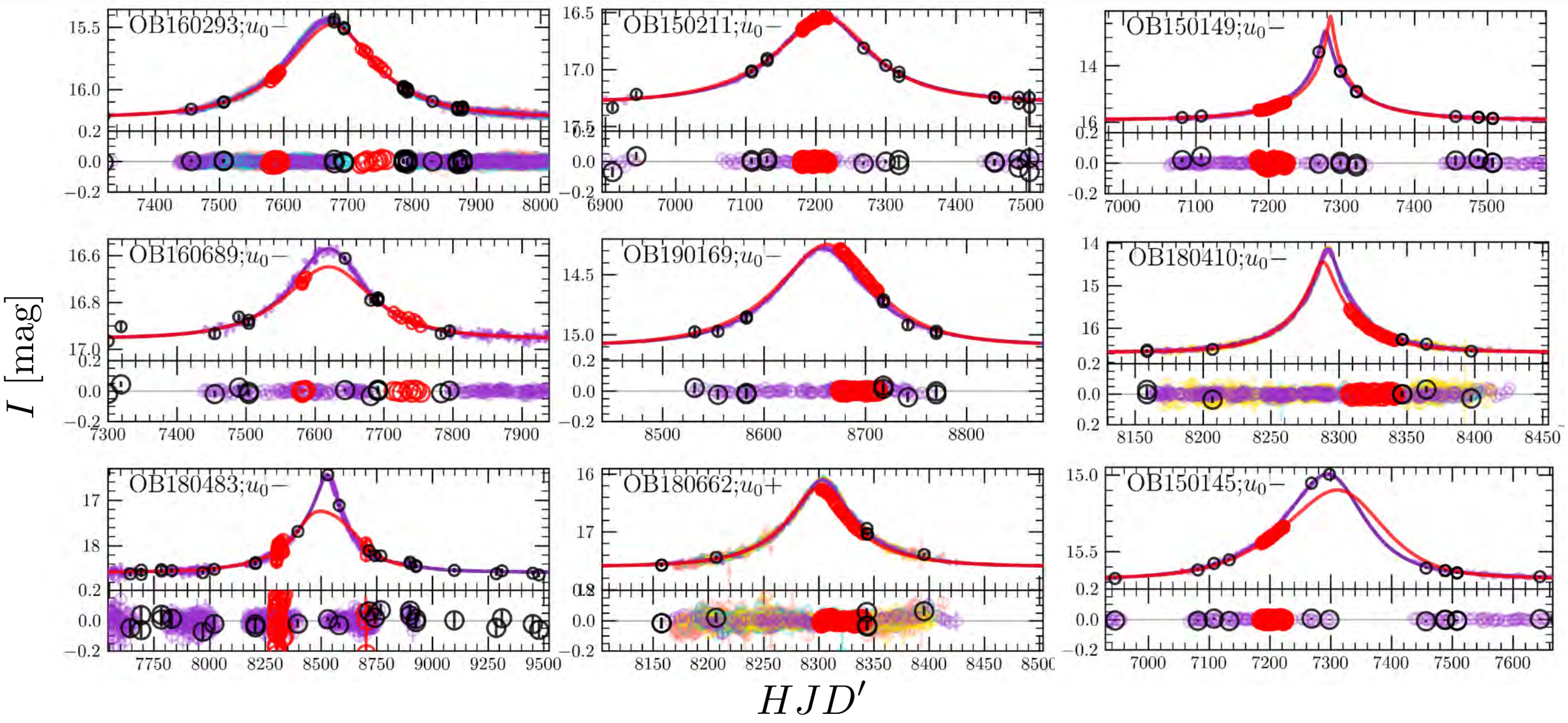
GSA - Gaia Science Alerts
GDR3 - Gaia DR3 events, Wyrzykowski et al. 2023

Candidates selection: Massive Gaia lenses



GSA - Gaia Science Alerts
GDR3 - Gaia DR3 events, Wyrzykowski et al. 2023

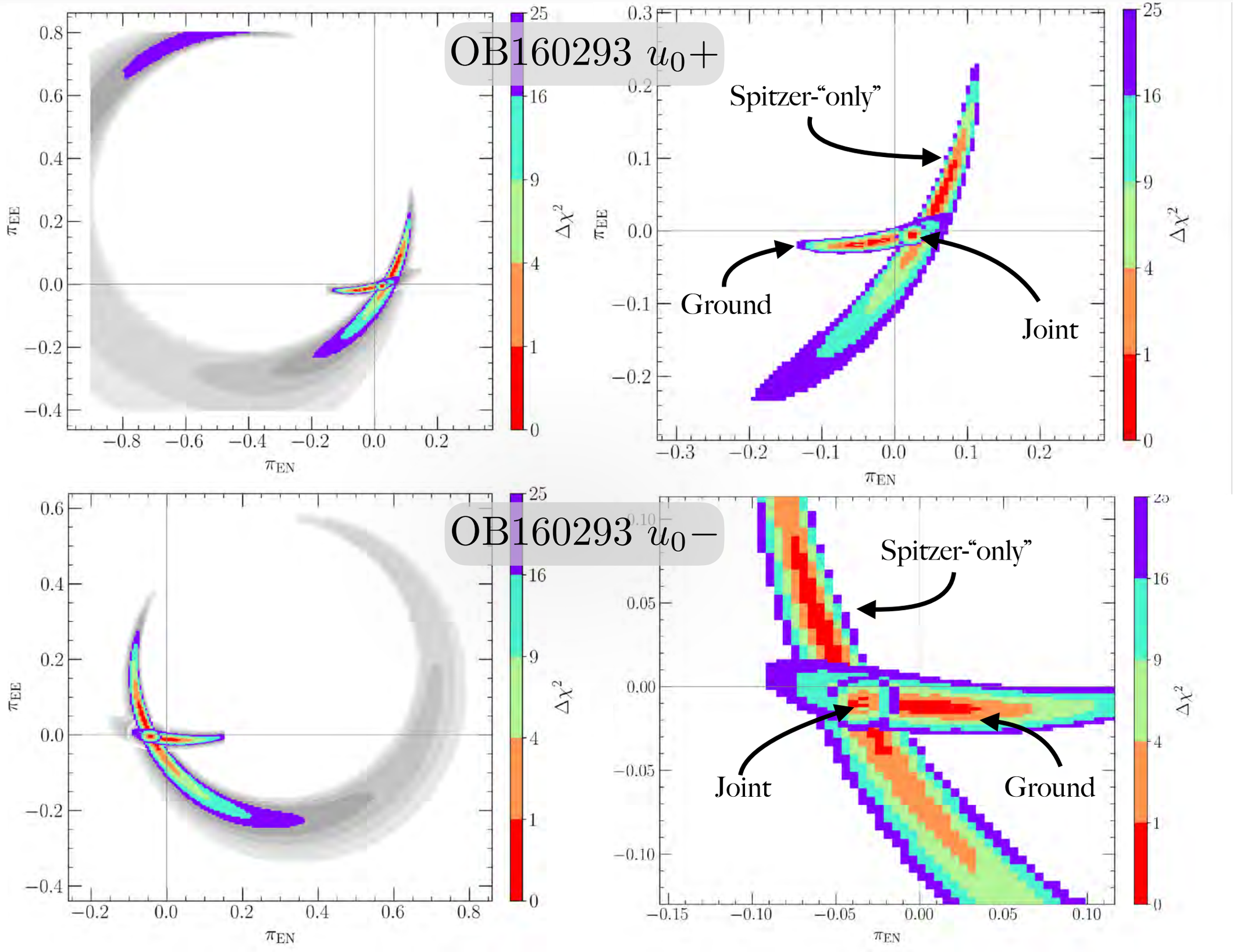
Selected events



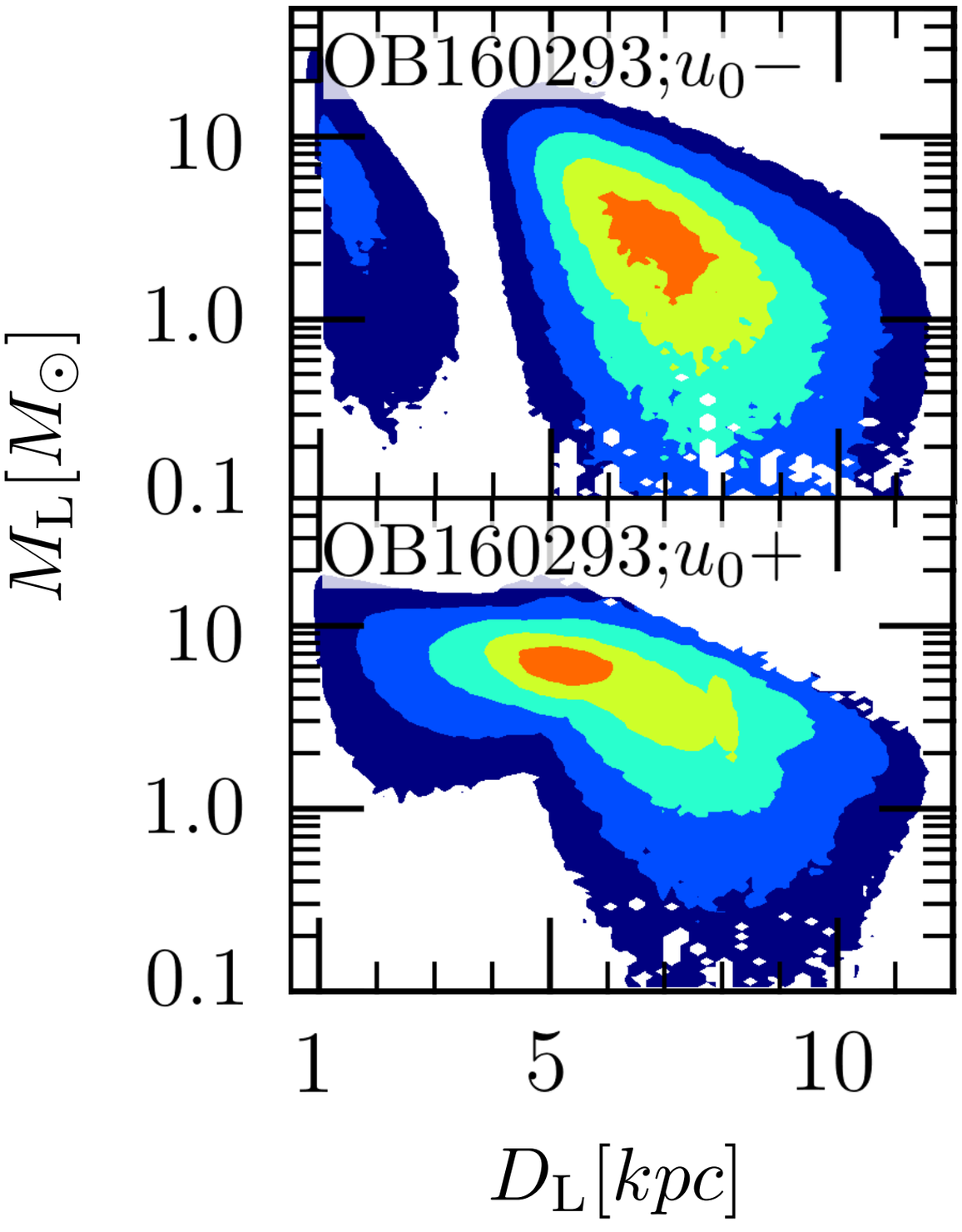
- Survey data: OGLE(all), KMT(5) and MOA(1)
- Most of the events have $t_{\rm E} \gtrsim 100$ days and $\pi_{\rm E} \lesssim 0.1$
- If the lenses are dark, they make good stellar remnants candidates as

$$M_{\rm L} = \frac{\mu_{\rm rel} t_{\rm E}}{\kappa \pi_{\rm E}} = 1.35 M_\odot \frac{\mu_{\rm rel}}{4\, mas/yr} \frac{t_{\rm E}}{100\, d} \frac{0.1}{\pi_{\rm E}}$$

Refining parallax measurement



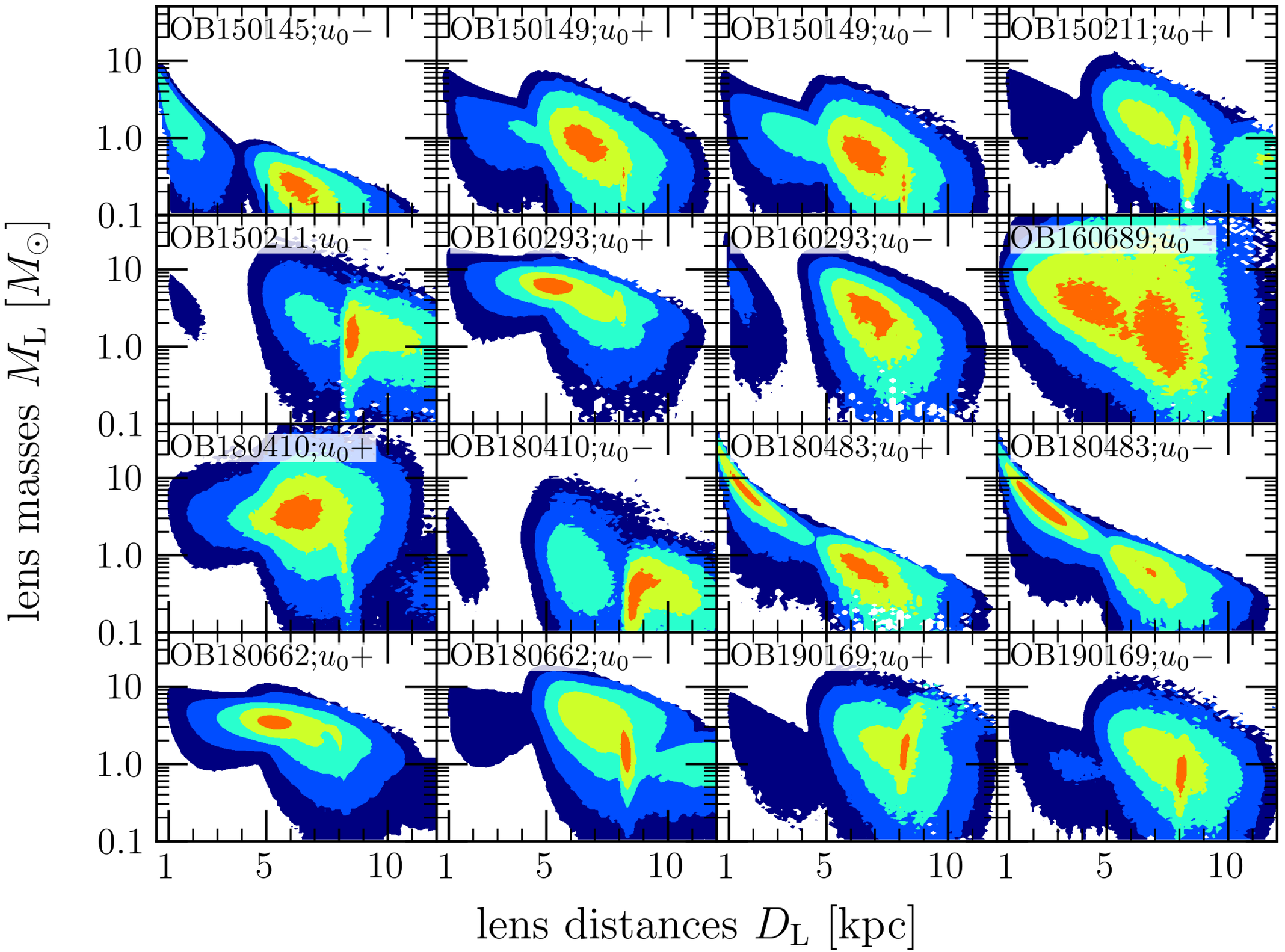
Mass and distance estimates



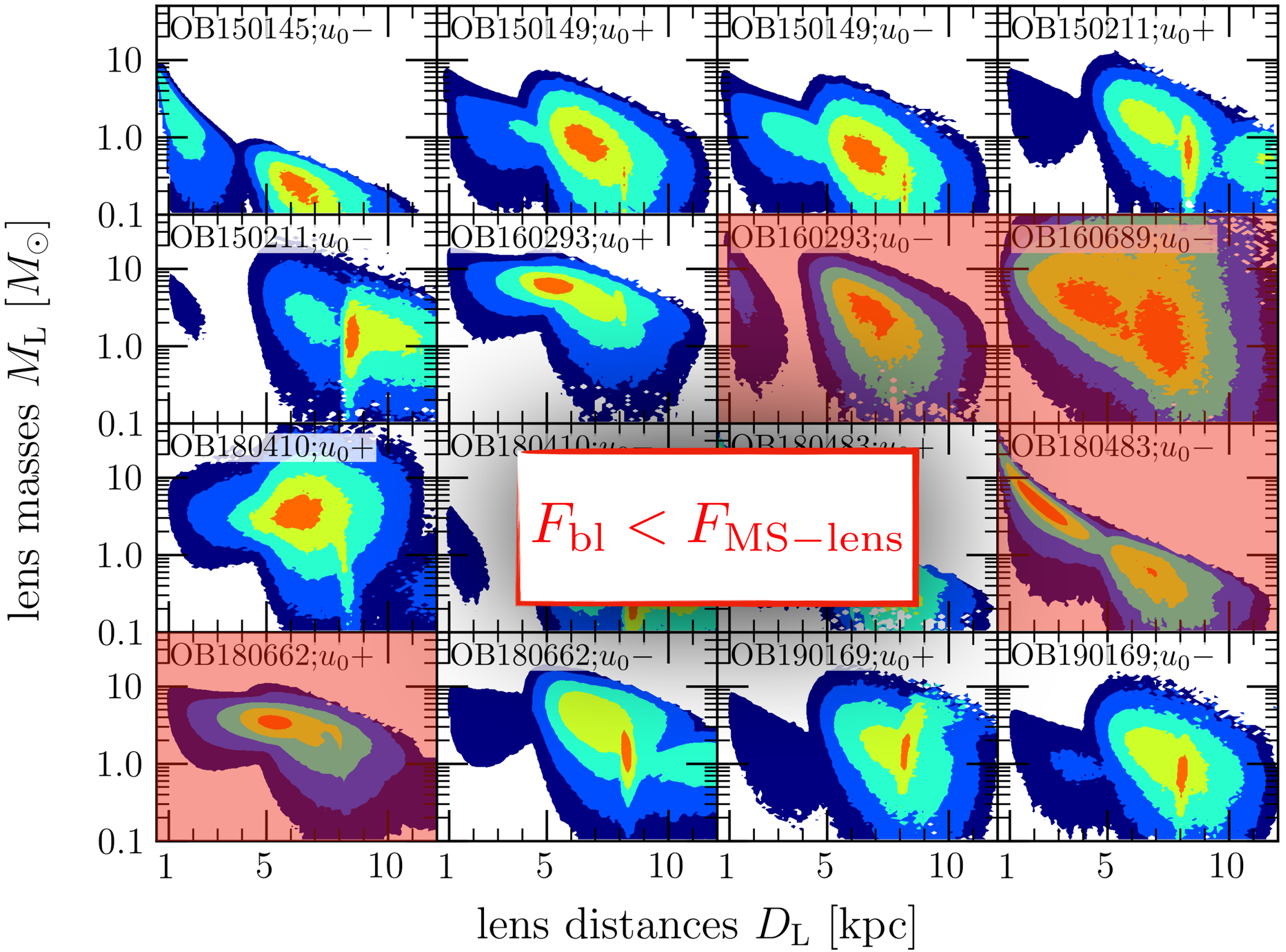
$$M_{\rm L} = \frac{\mu_{\rm rel} t_{\rm E}}{\kappa \pi_{\rm E}}$$

- Galactic model (Han&Gould 2003, Batista et al. 2011) used to estimate lens masses and distances, following Mróz&Wyrzykowski 2021, utilising the DLC software (Howil et al. in prep.)
- Gaia proper motions taken into account for low-blending events (all but one)
- Extinction taken into account
- Kroupa mass function (α=-2.35)

Mass and distance estimates



Mass and distance estimates



Verification using Gaia

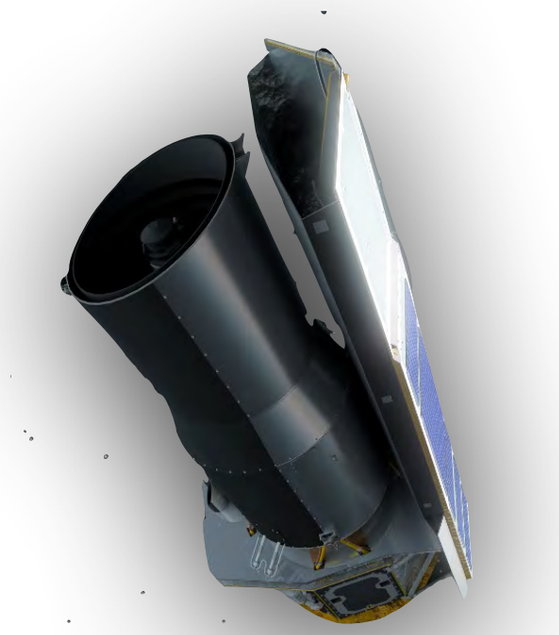
Selected dark remnants candidates can potentially be verified by the Gaia mission:

$$M_{\mathrm{L}} = \frac{\theta_{\mathrm{E}}}{\kappa \pi_{\mathrm{E}}}$$

Verification using Gaia

Selected dark remnants candidates can potentially be verified by the Gaia mission:

$$M_{\mathrm{L}} = \frac{\theta_{\mathrm{E}}}{\kappa \pi_{\mathrm{E}}}$$

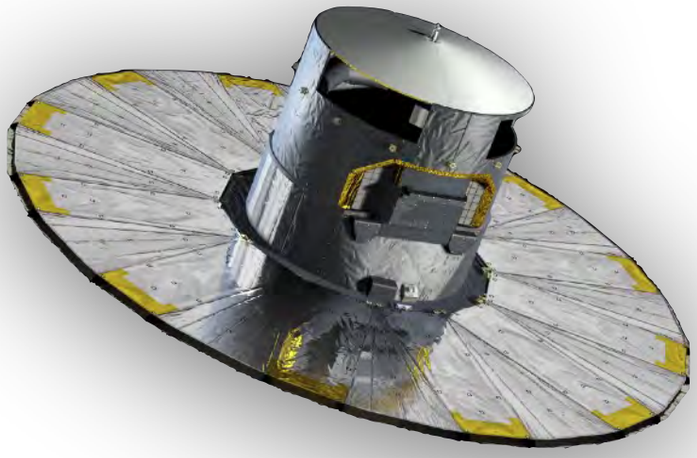


Spitzer/ground photometry

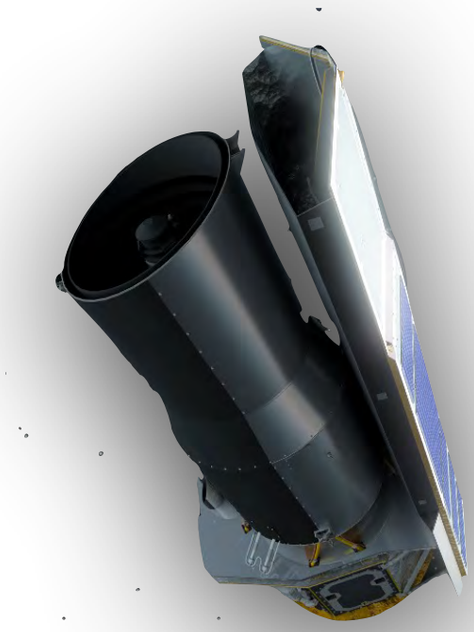
Verification using Gaia

Selected dark remnants candidates can potentially be verified by the Gaia mission:

Gaia astrometry



$$M_{\rm L} = \frac{\theta_{\rm E}}{\kappa \pi_{\rm E}}$$

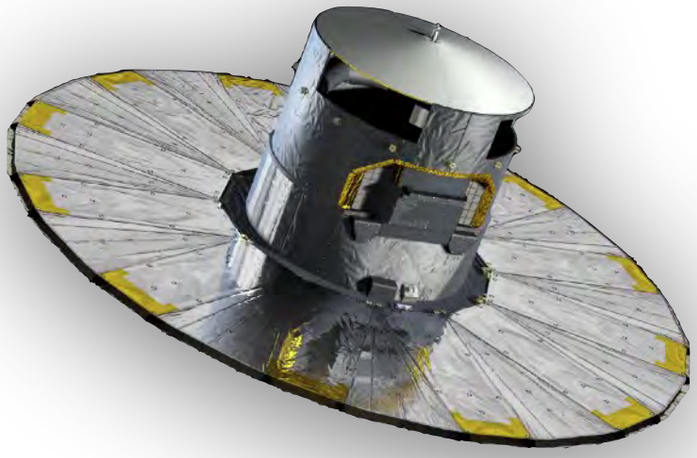


Spitzer/ground photometry

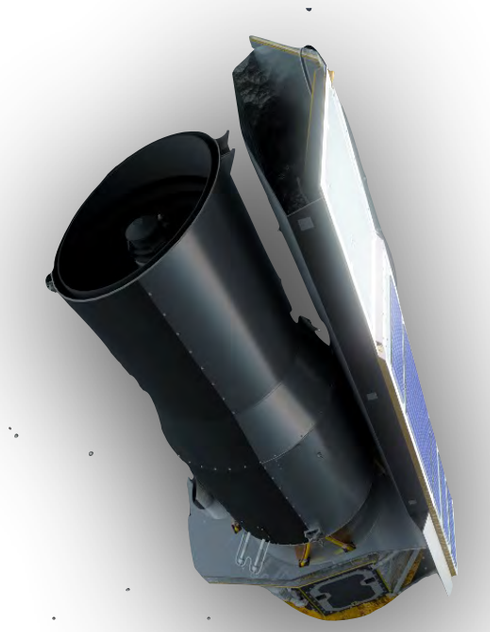
Verification using Gaia

Selected dark remnants candidates can potentially be verified by the Gaia mission:

Gaia astrometry



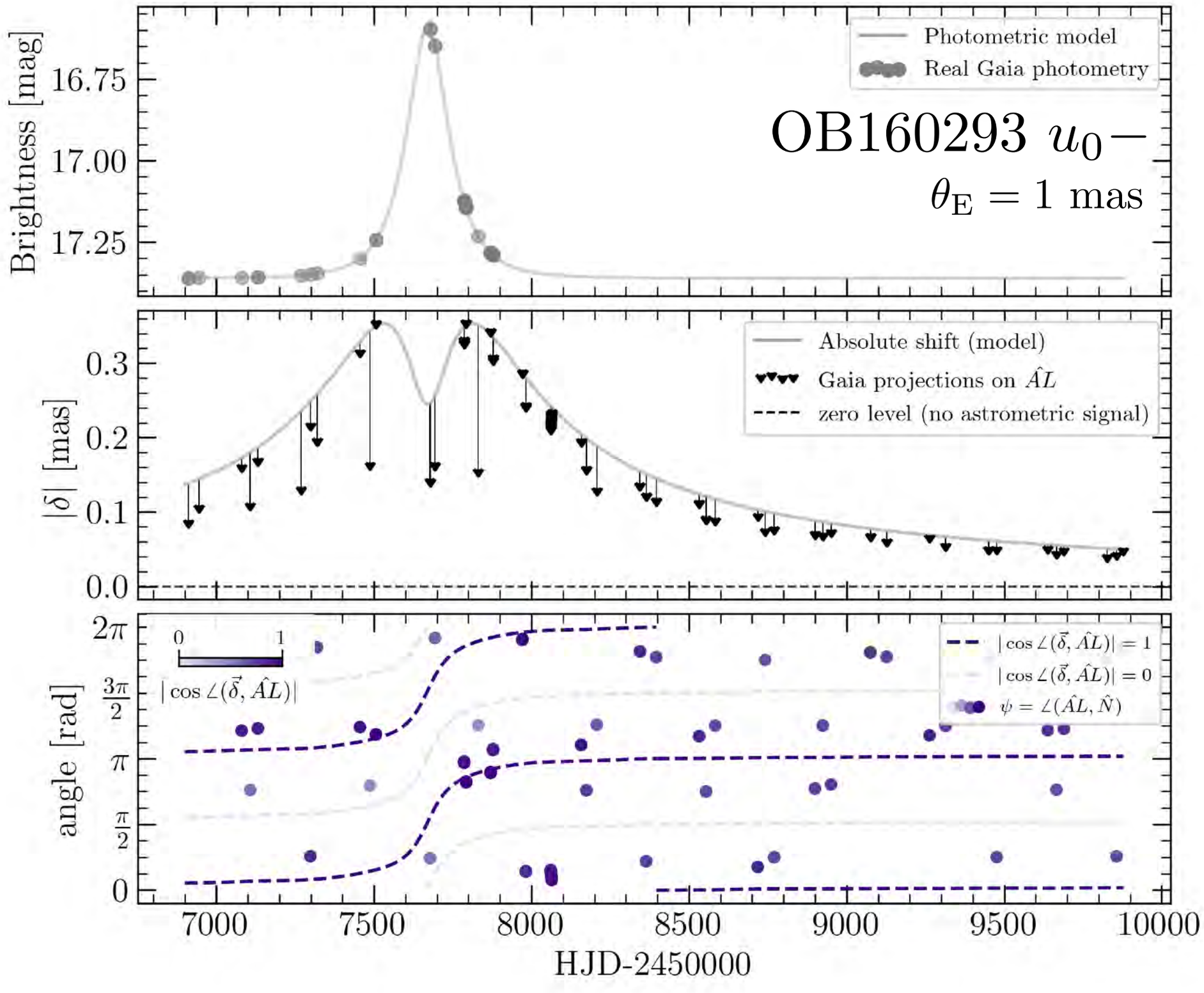
$$M_{\rm L} = \frac{\theta_{\rm E}}{\kappa \pi_{\rm E}}$$



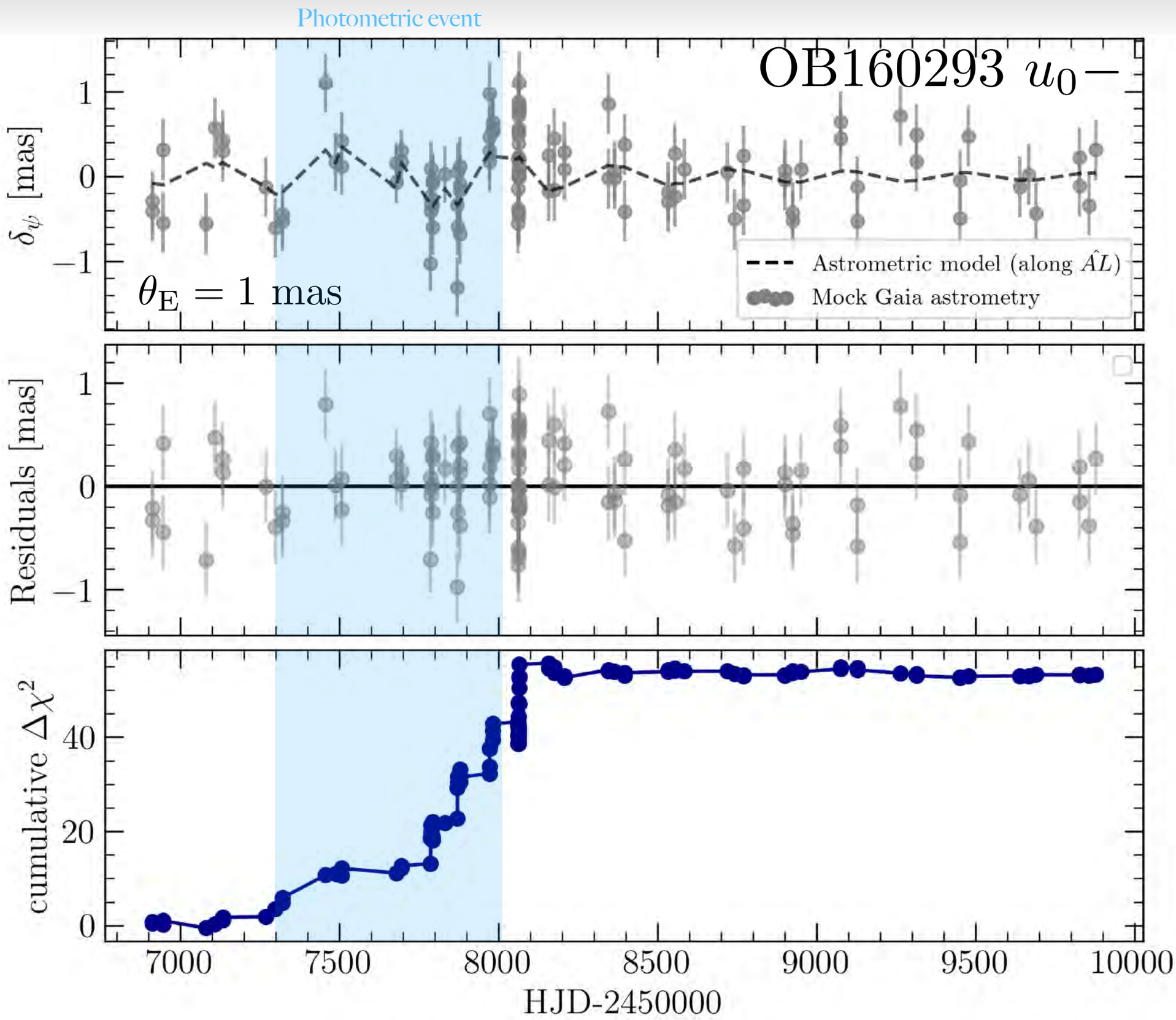
Spitzer/ground photometry

Only 1D astrometric measurements will be available for our candidates . . .

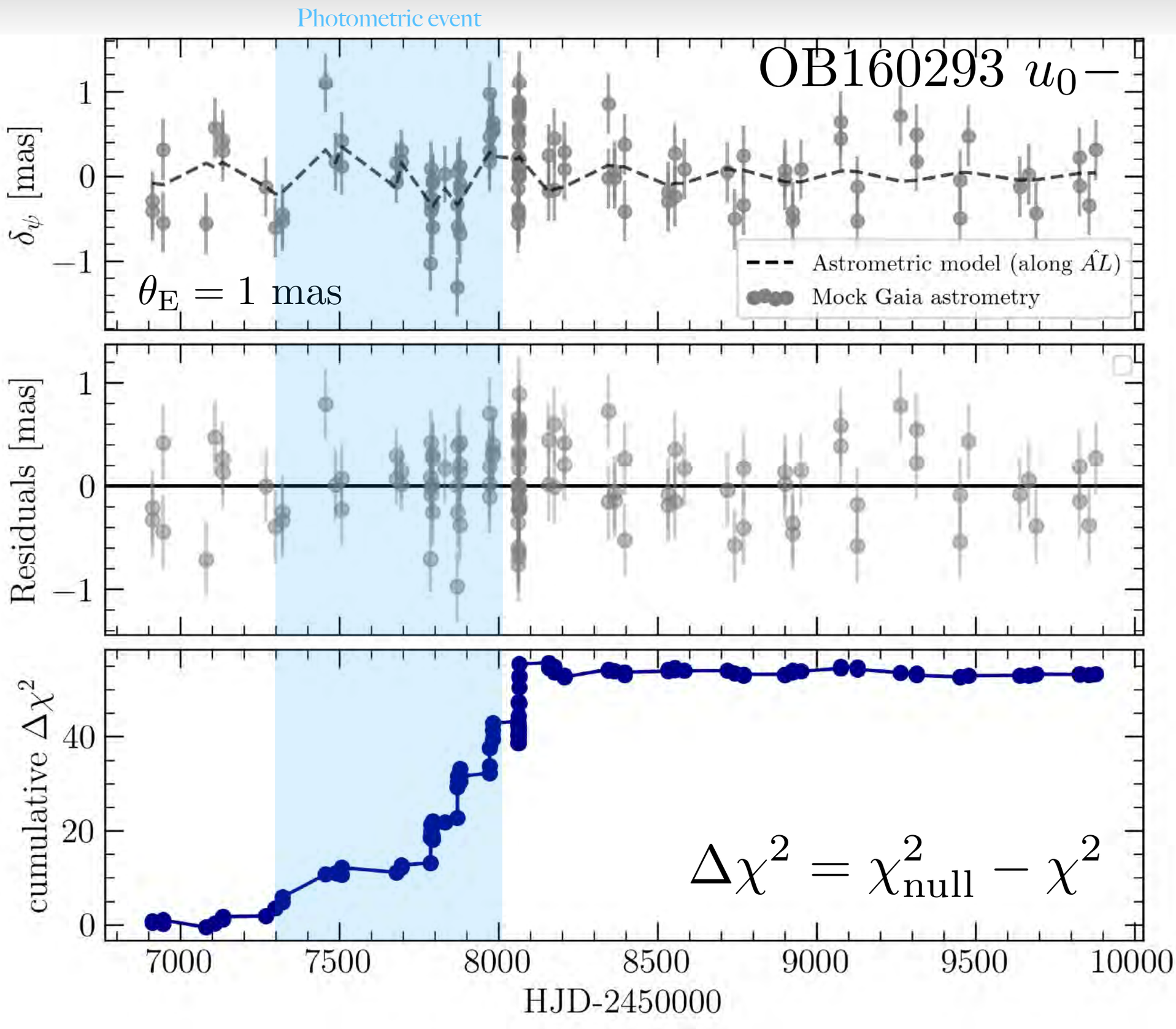
Gaia 1D astrometry predictions



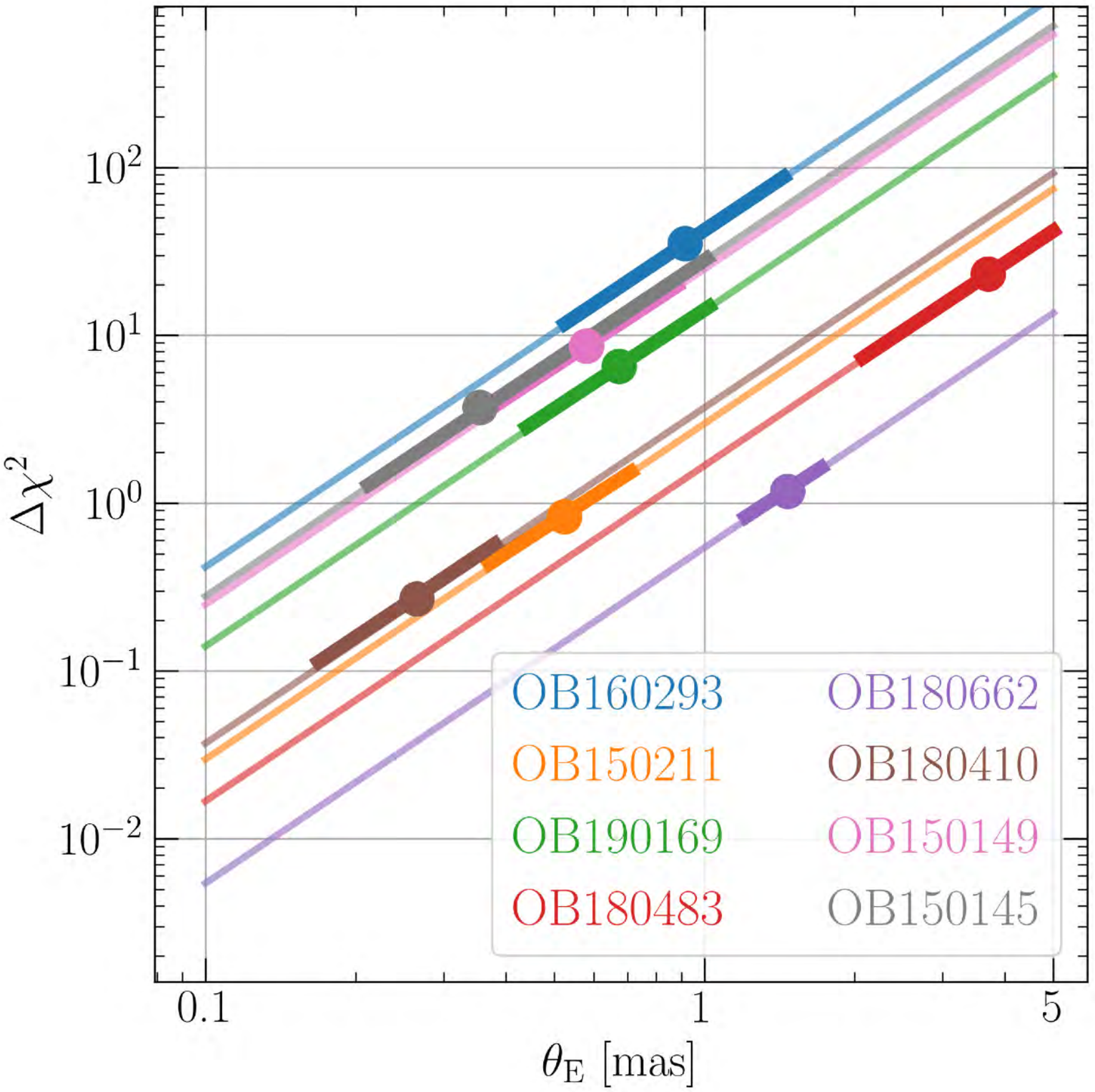
Gaia 1D astrometry predictions



Gaia 1D astrometry predictions



Detectability of the astrometric signal

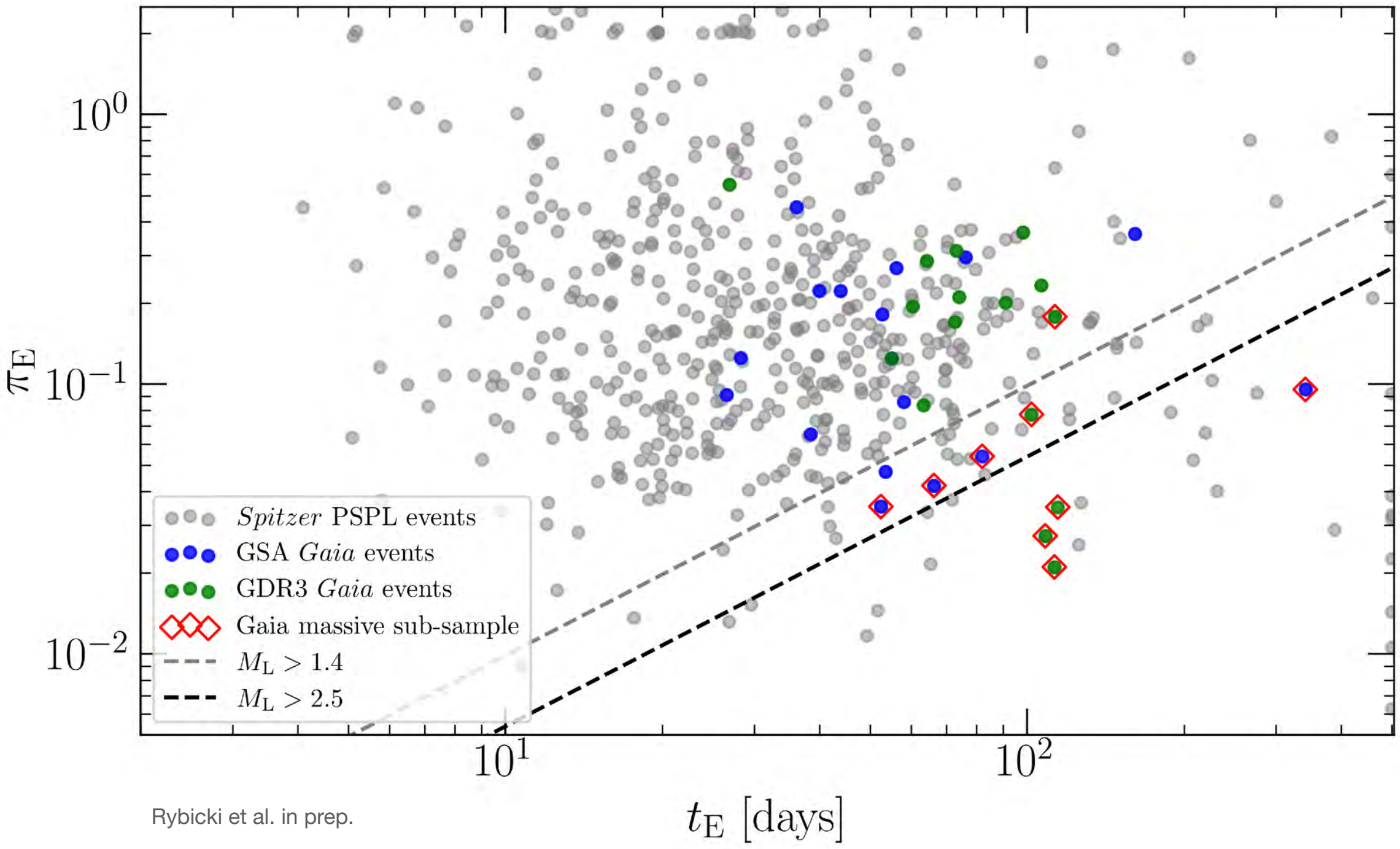


- We use $\Delta\chi^2$ as a detectability measure
- The relation from θ_E can be inferred
- Using mass estimates one can identify verifiable events
- (OB160689 is heavily blended and thus omitted in our Gaia predictions)

Summary

Summary

A unique, large sample of Spitzer events is being investigated

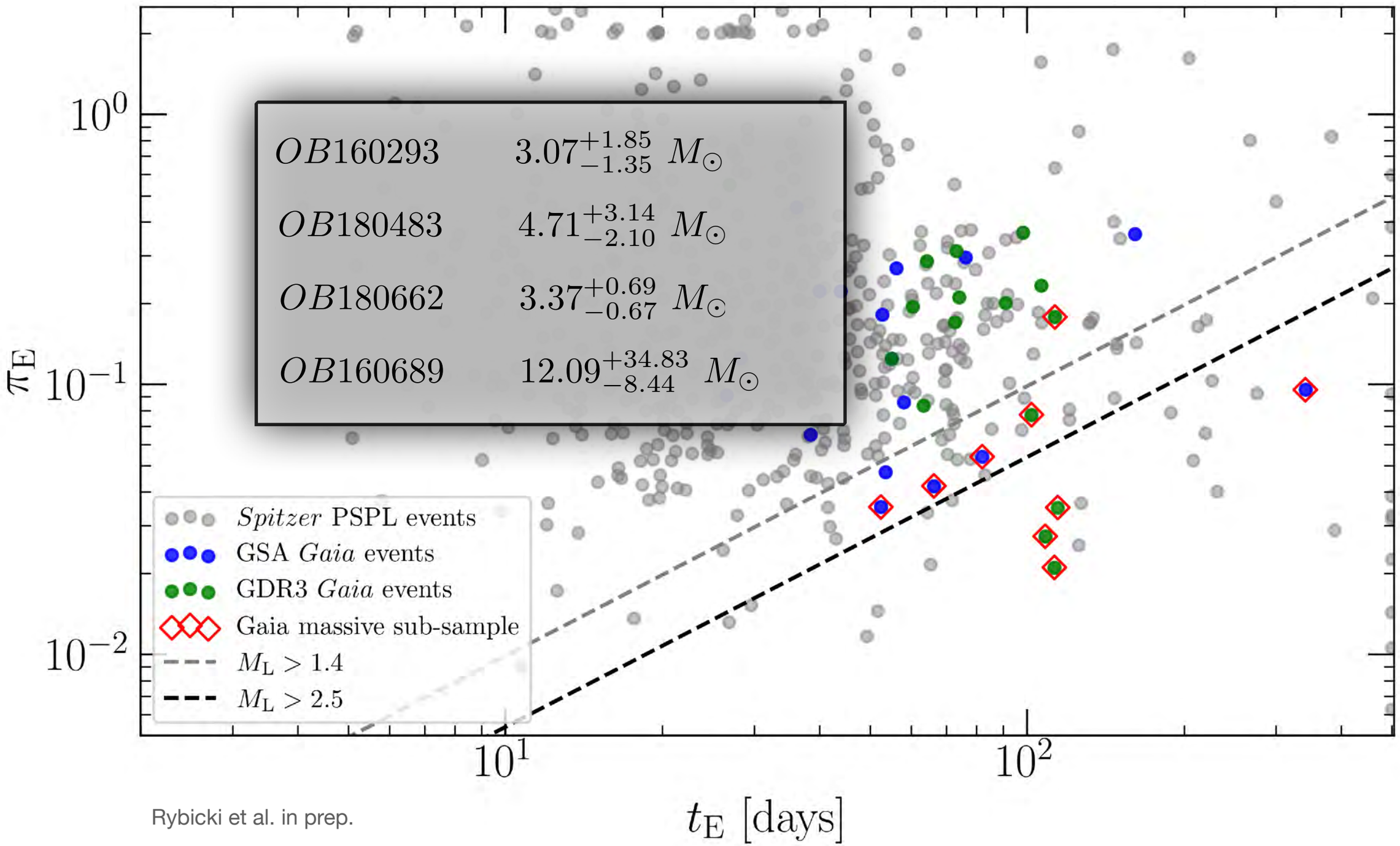


Rybicki et al. in prep.

Summary

A unique, large sample of Spitzer events is being investigated

Four dark lens candidates were found in Spitzer+Gaia events



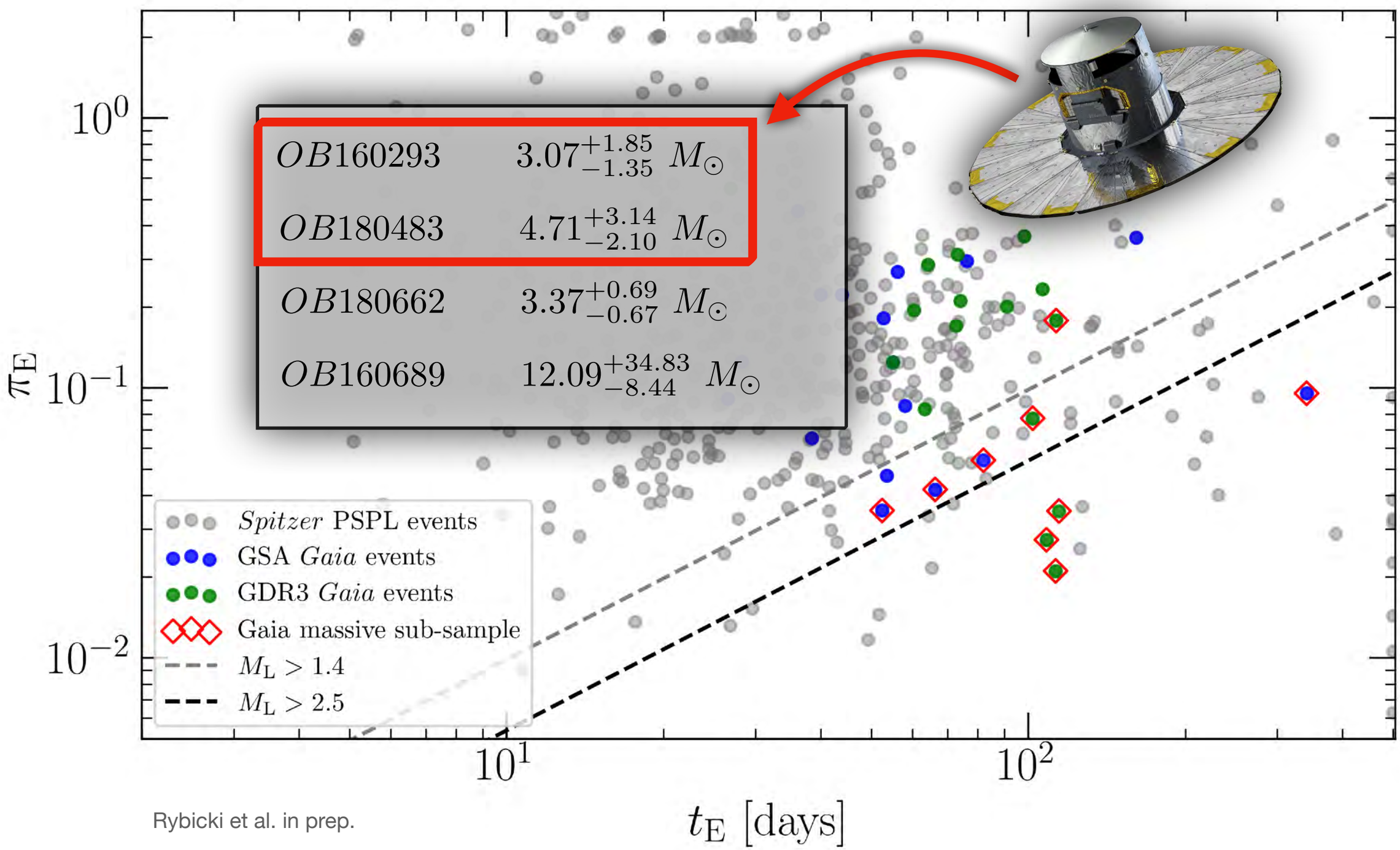
Rybicki et al. in prep.

Summary

A unique, large sample of Spitzer events is being investigated

Four dark lens candidates were found in Spitzer+Gaia events

Gaia astrometry should be able to identify at least two of them



Rybicki et al. in prep.