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Identifying Microlenses in Large, Non-Uniformly Sampled Surveys



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We develop a Galactic model for evaluating microlensing event rates in large-area, synoptic surveys (2).

We use Monte Carlo simulations to compute the microlensing detection efficiency in PTF fields (3).

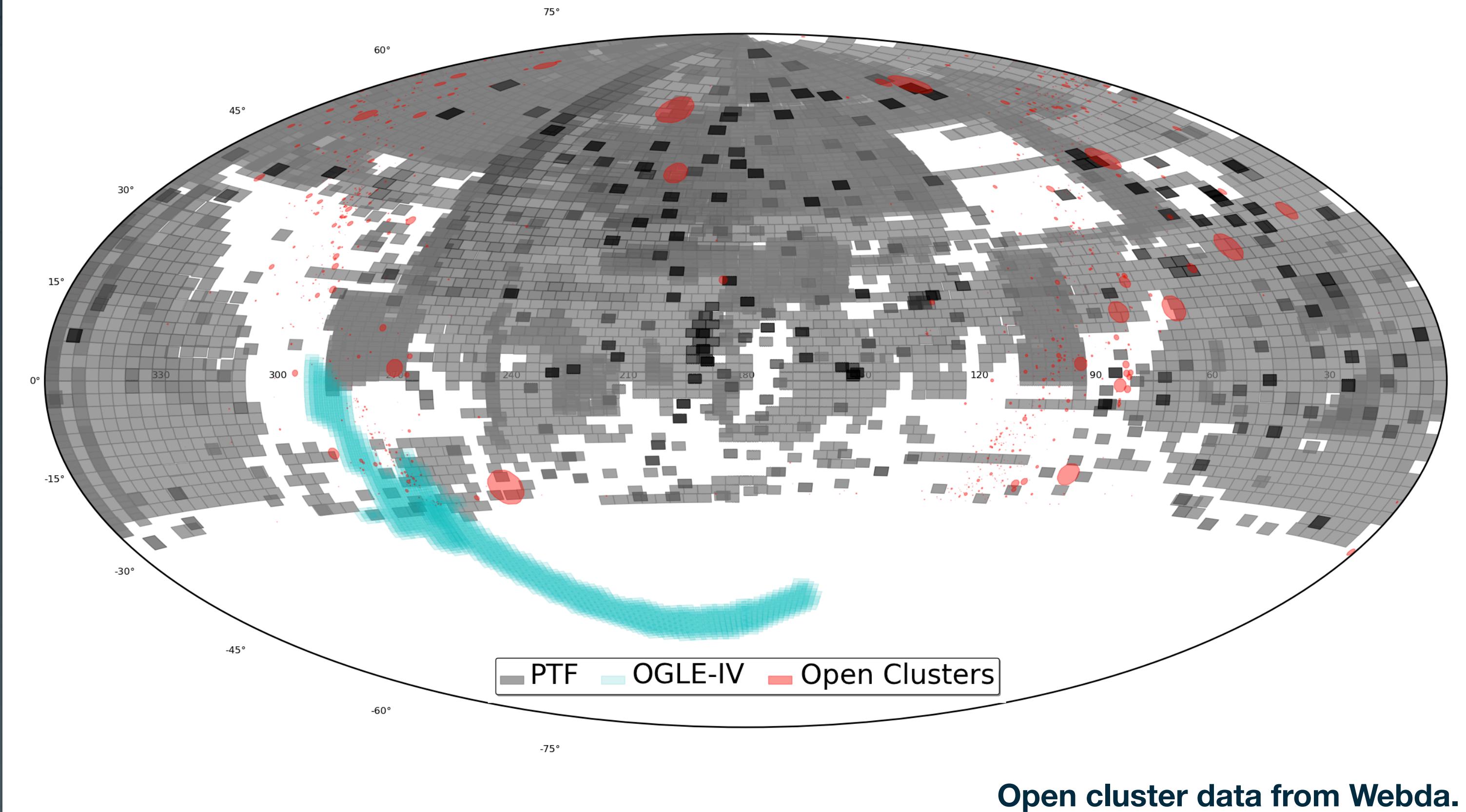
We are exploring statistical methods for improving selection methods to identify transient events in massive light curve databases (4).

1 Will wide-field surveys aid microlens discovery?

- Microlensing is used to discover exoplanets, infer Galactic structure, and search for compact stellar remnants.
- Microlensing surveys usually use high cadence observations of dense stellar fields.
- Wide-field, synoptic surveys, such as PTF, often instead avoid dense regions to prevent blending and source confusion.

- However, the event rate away from the bulge is not well constrained.
- In a step toward accurate, all-sky microlensing rate predictions, we conduct a pilot study with PTF data to evaluate whether open clusters (Figure 1) contribute to the event rate in wide-field surveys.
- As a test case, we consider the high-latitude open cluster Praesepe.

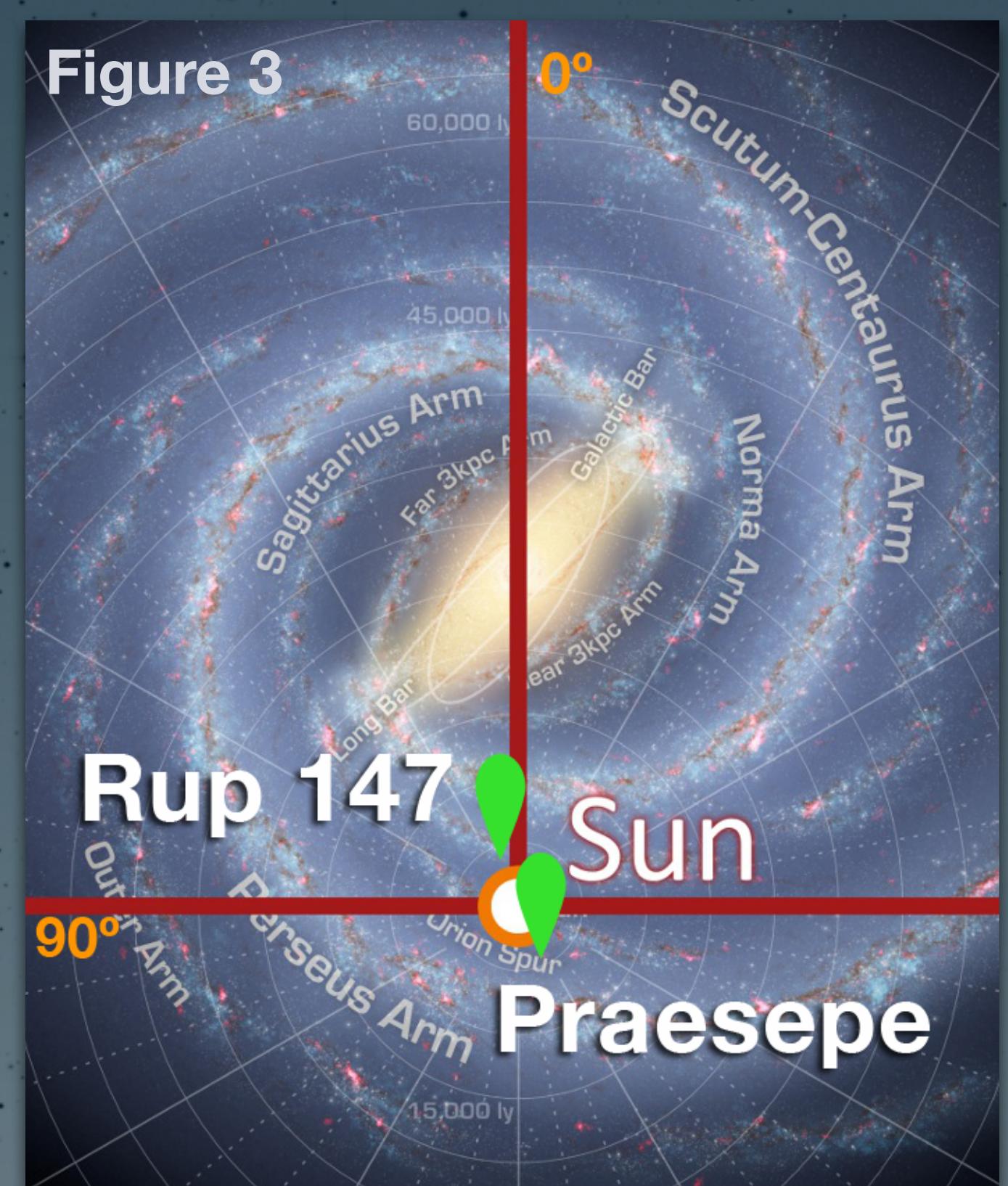
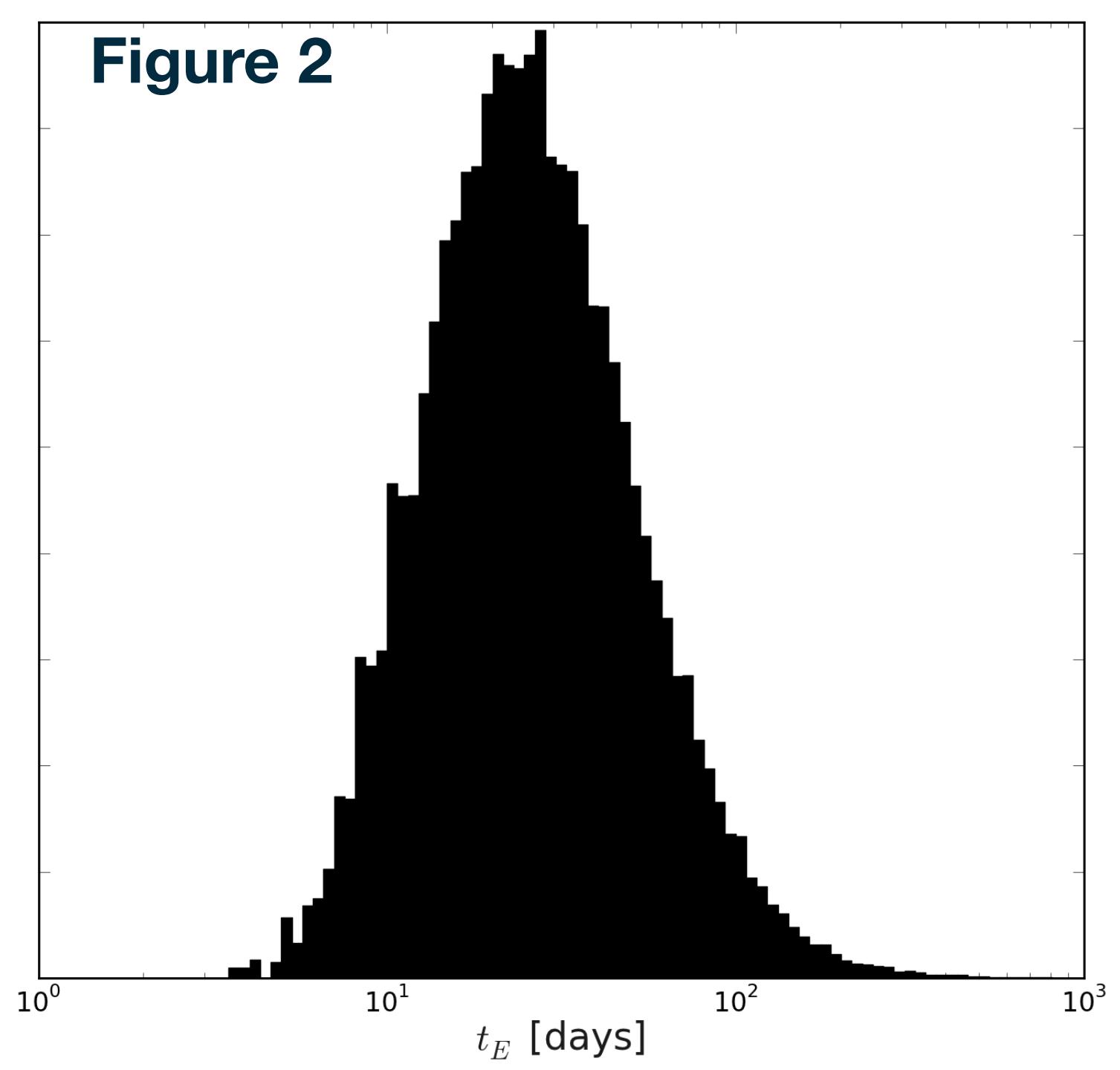
Figure 1 Comparing survey coverage in equatorial coordinates



2 Do stellar clusters affect event rate predictions?

- We construct a Galactic model with:
 - a rotating stellar disk with dispersion,
 - main sequence sources and lenses,
 - dust extinction,
 - stellar clusters.
- Our model computes a total survey event rate on a field-by-field basis and accounts for stellar overdensities.
- We use the Kraus and Hillenbrand (2007) Praesepe catalog to model the event rate and timescale distribution in 28 deg² around the cluster (Figure 2).

Normalized timescale distribution for Praesepe field



3

How does detection efficiency depend on sampling?

- Detection efficiency is the probability that an event will be detected as function of timescale (t_E).
- When the sampling is 'clumpy' (many observations over few nights), the detection efficiency is reduced relative to uniform sampling (Figure 4).

- We inject random microlensing events into the Praesepe light curves and compute the detection efficiency (Figure 5).
- We consider events with peak magnification $A_{\max} > 1.34$ and log-uniform timescales from 1 to 1000 days (Alcock et al. 2000).
- This detection efficiency peaks at $t_E \sim 20$ days, a typical duration for a Galactic disk lensing event.

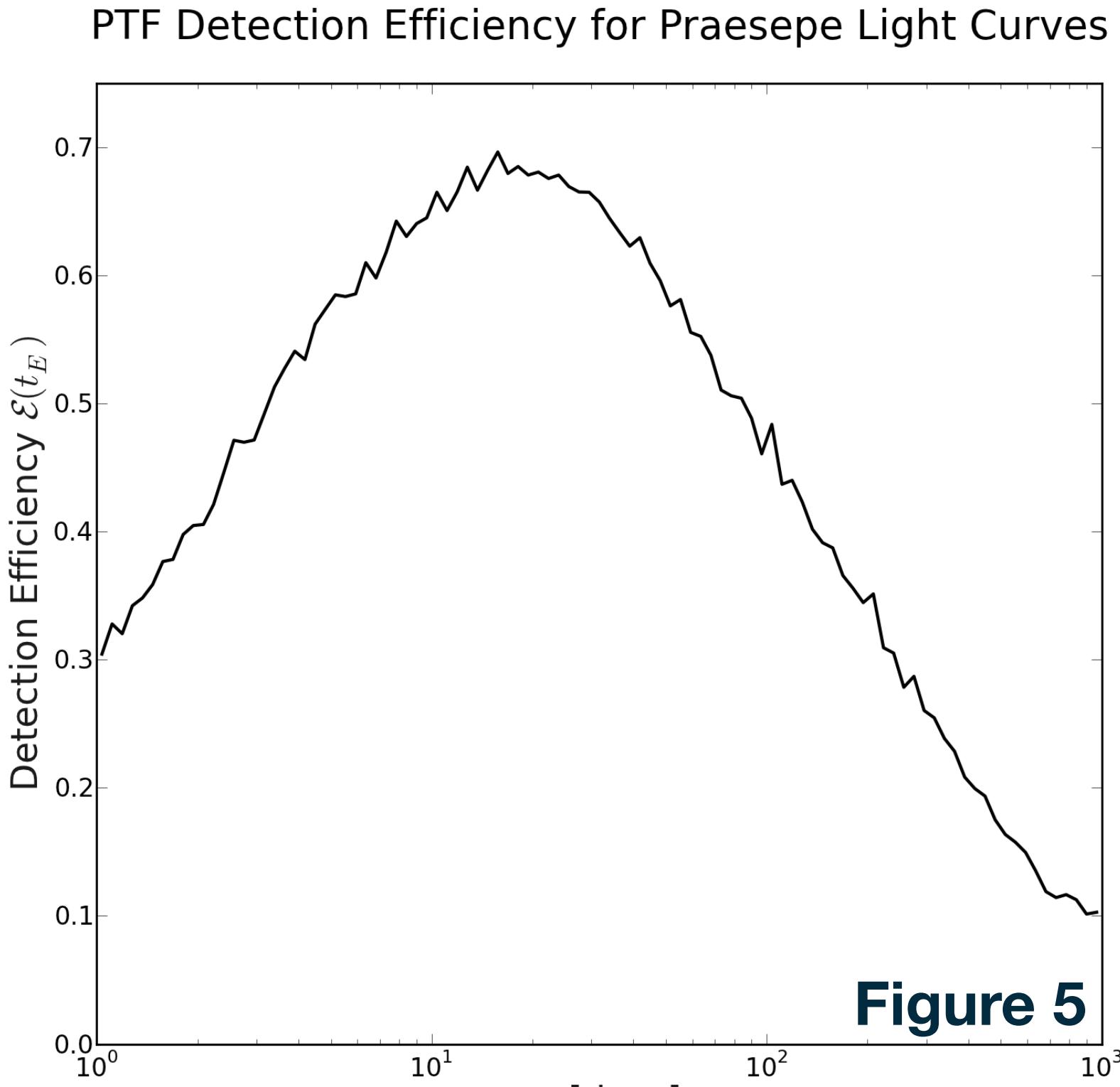
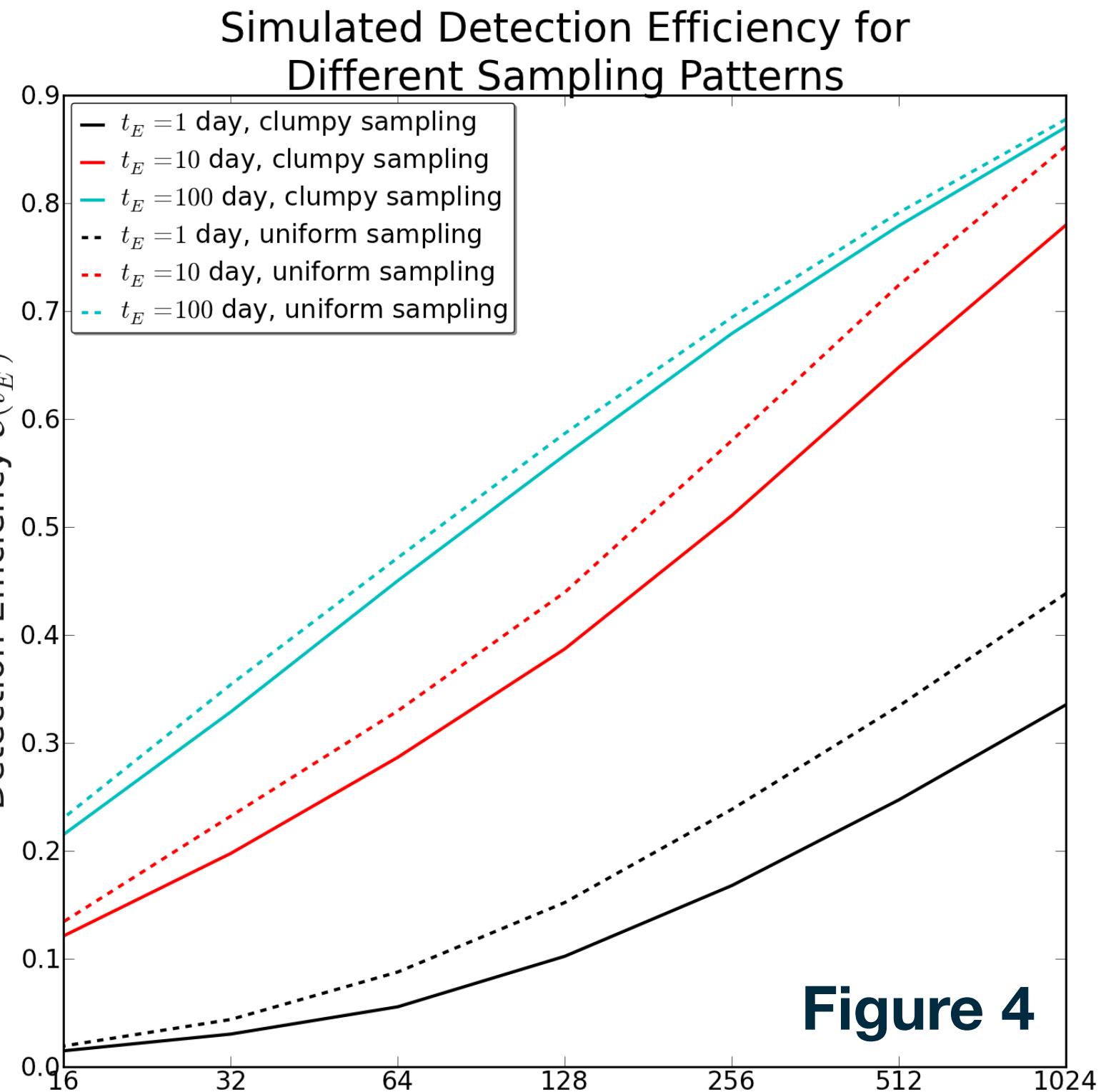


Figure 4

Figure 5

4

Can we improve the detection efficiency in single-color data?

- Previous groups have used a combination of quality cuts and matched filtering to select microlens candidates.
- In Figure 6 we compute variability indices for light curves with and without injected microlensing events.
- These measures have been used to select variable star candidates (Shin et al. 2009).

- The 2σ detection efficiency for each variability index is shown in Figure 7.

$$\eta = \frac{\sum_{n=1}^{N-1} (R_{n+1} - R_n)^2 / (N-1)}{\sigma^2}$$

where R is the PTF R-band magnitude .

(von Neumann 1941)

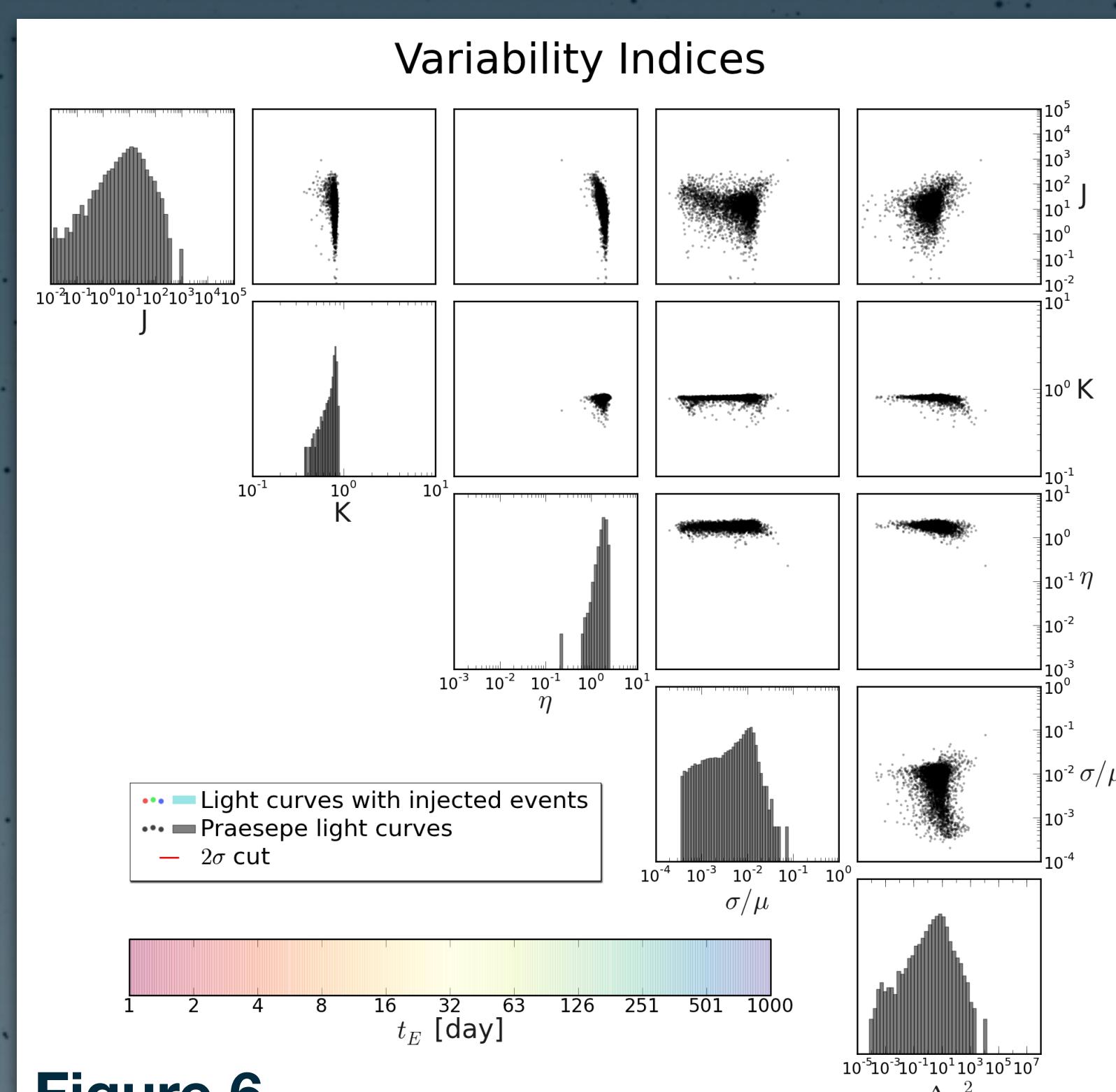


Figure 6

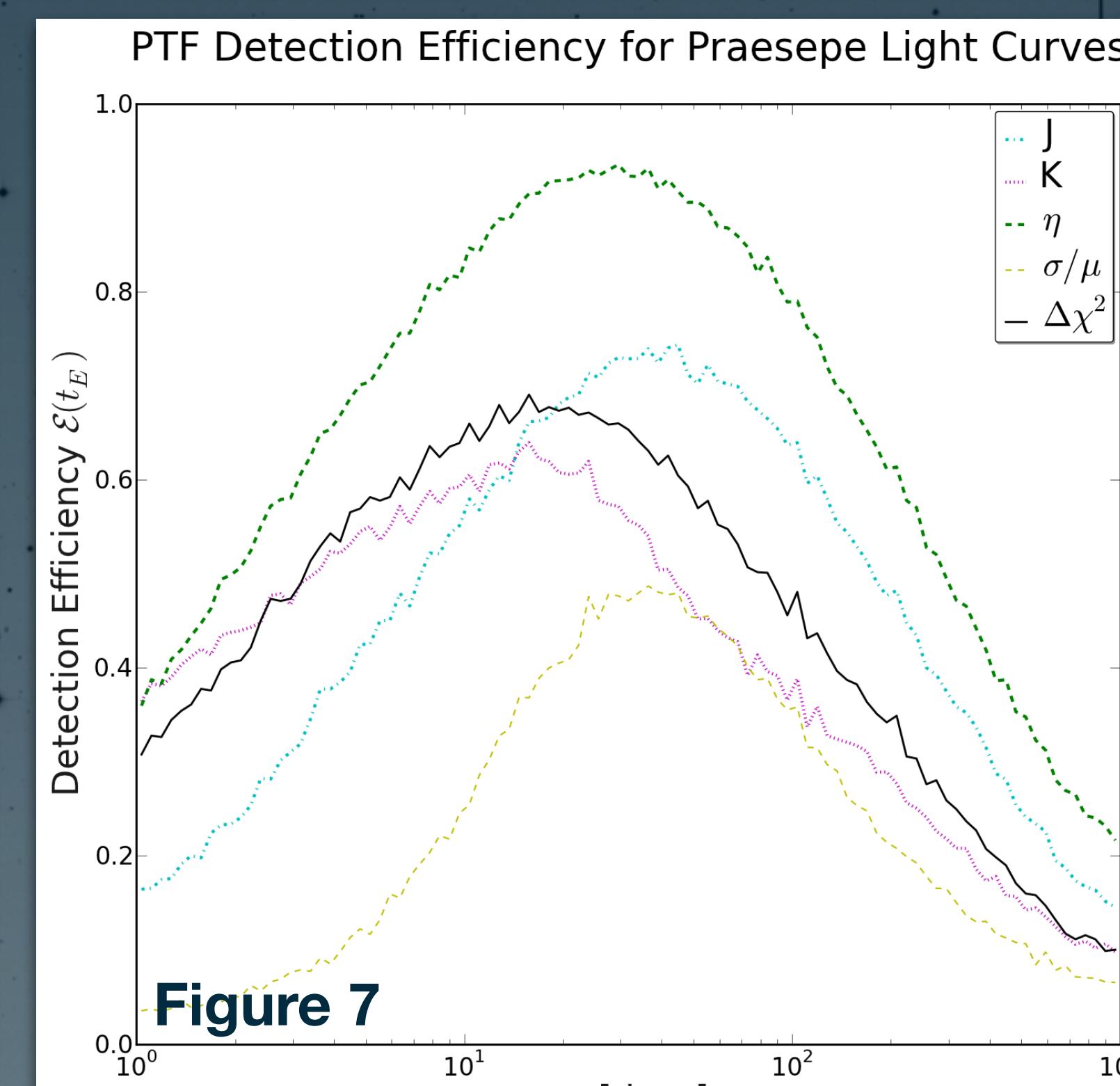


Figure 7