

# PTFO 8-8695b: A Transiting T-Tauri Planet Candidate

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Optical Obs.; <sup>10</sup>Spitzer Science Ctr.

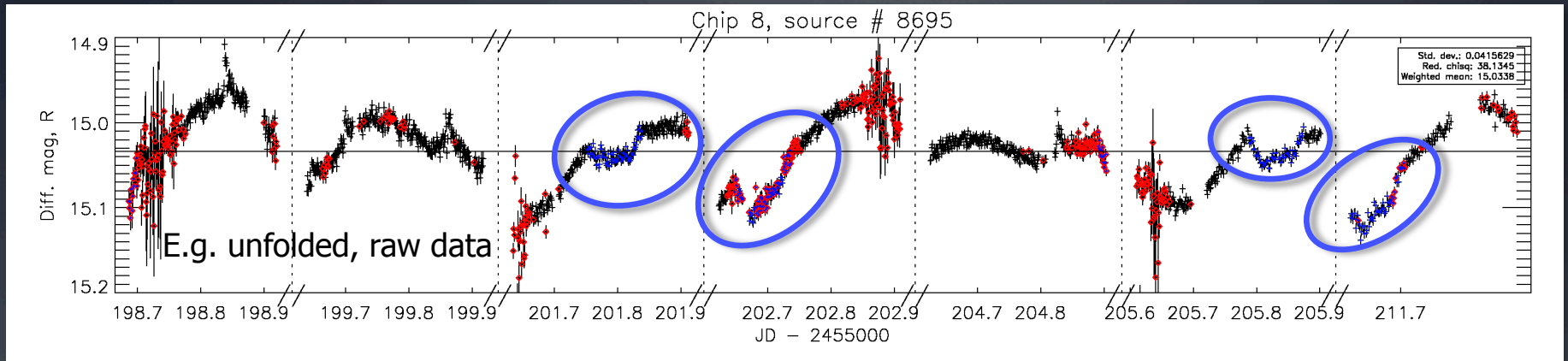
Sagan Symposium, November 8-9 2012

# PTF Orion

- Young transit search using Palomar Transient Factory
- Centered on 7-10Myr old 25-Ori region
- R-band, ~80s cadence, diff. photometry
- Observed ~17 clear nights Dec `09, 7 clear nights Dec `10
- ~7,000 exposures, ~110,000 light curves total

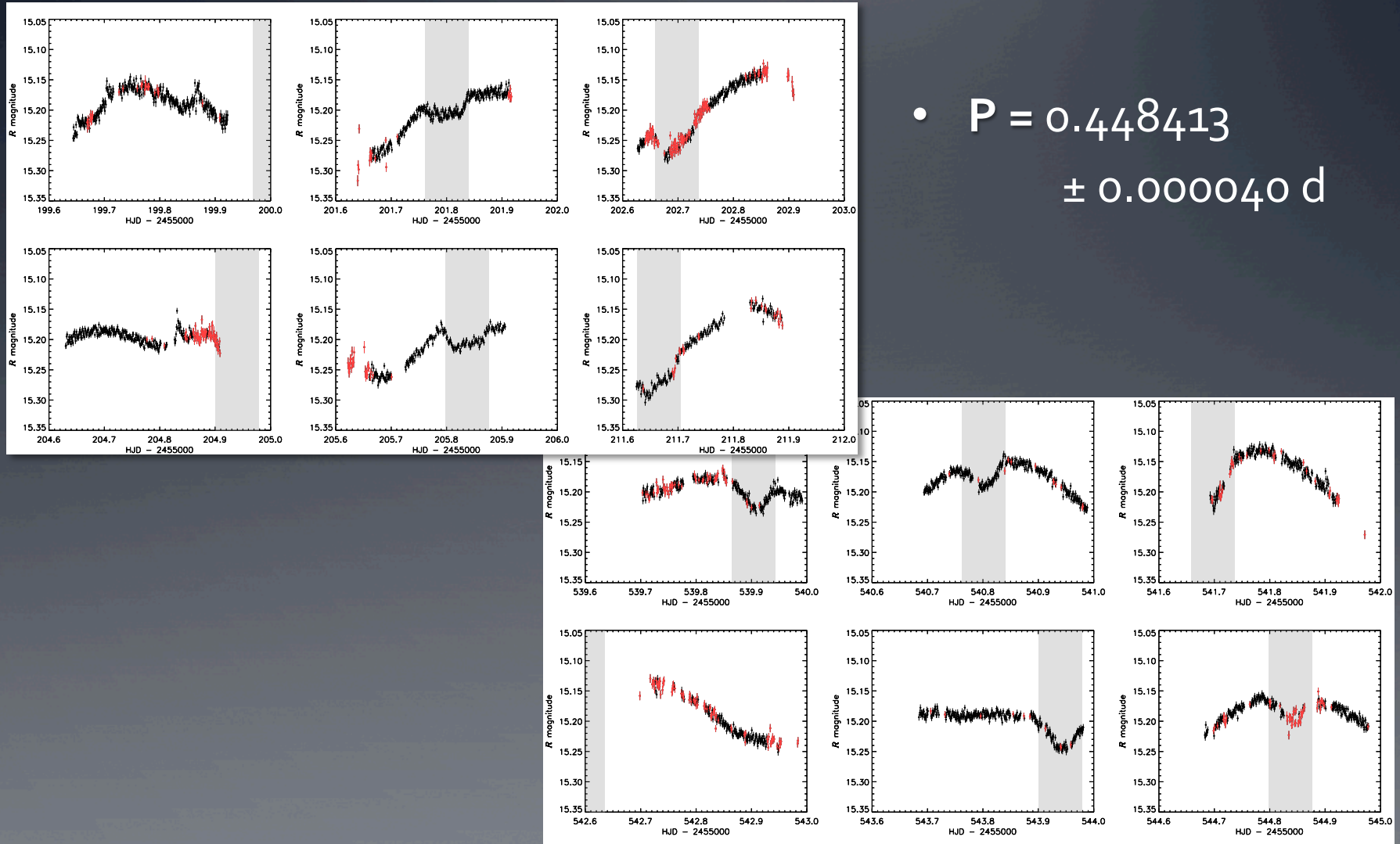


# PTFO 8-8695



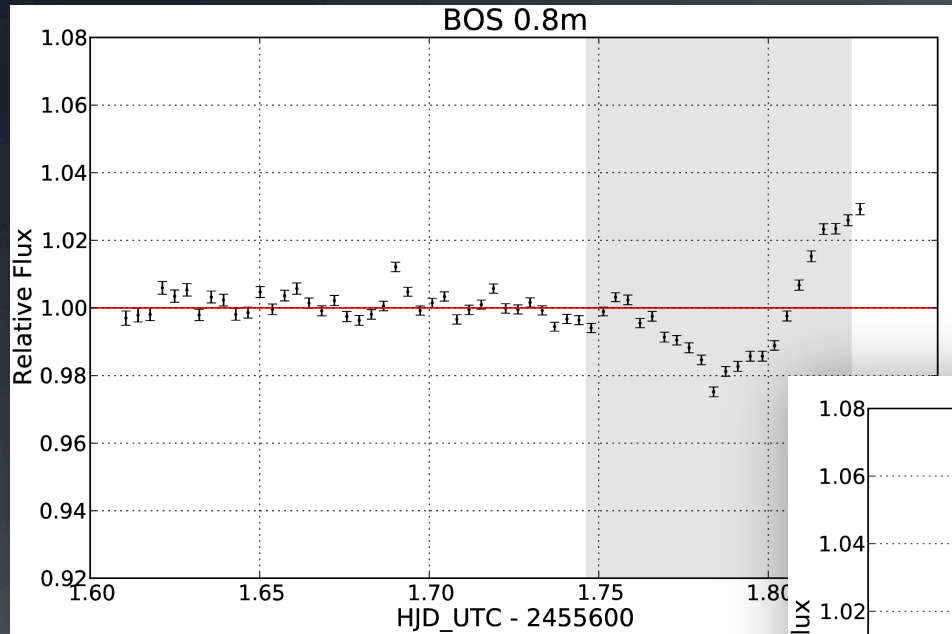
- Known WTTS (Briceno et al., AJ, 2005)
- $V = 16.3$  mag, median  $R = 15.2$  mag
- $M_3$ ,  $\sim 2.7$  Myr old
- $\sim 0.4M_{\odot}$ ,  $1.39R_{\odot}$

# Regular transit window

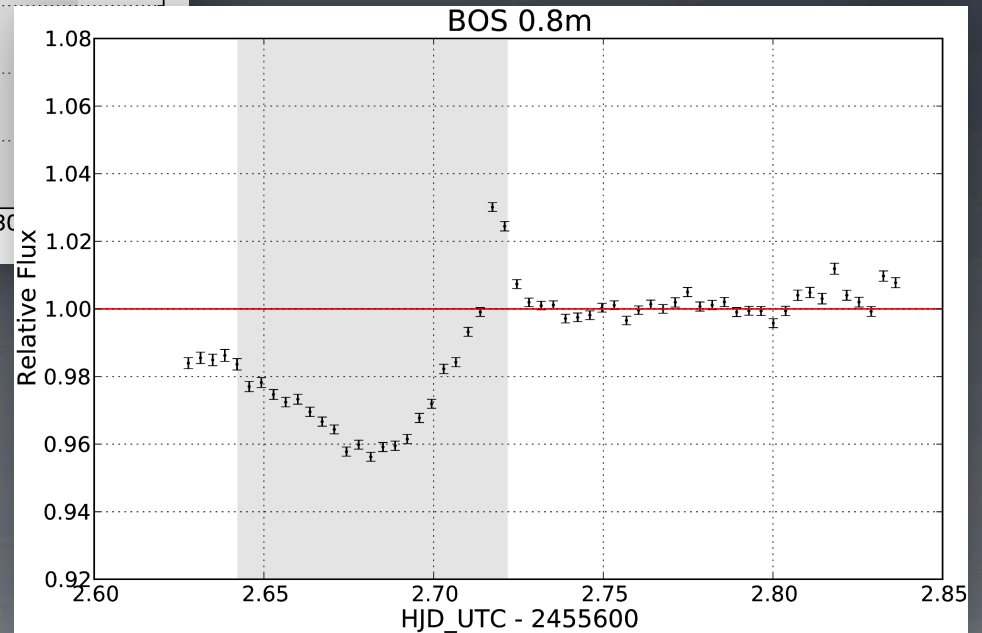


- $P = 0.448413 \pm 0.000040 \text{ d}$

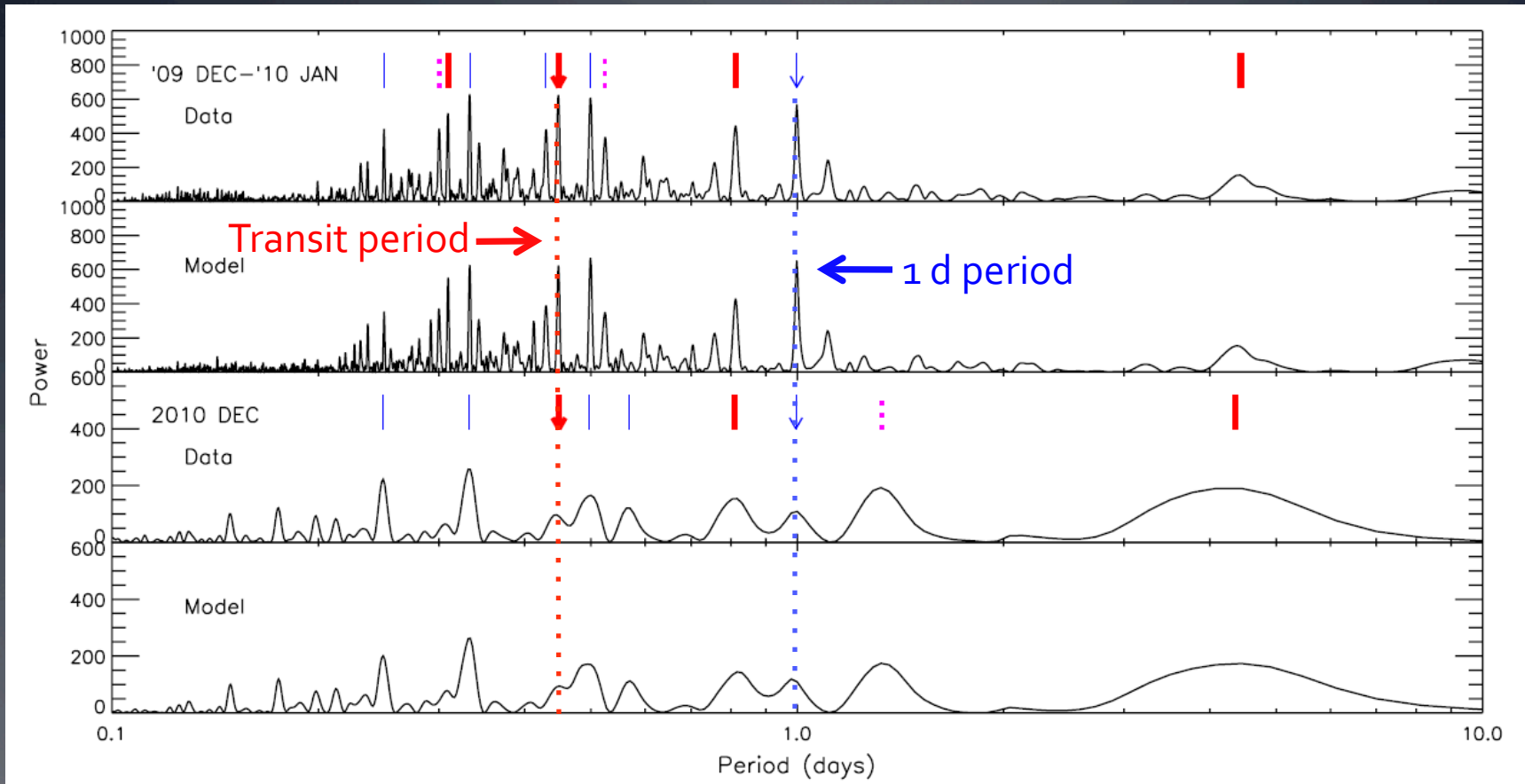
# LCOGT follow-up



Clear filter, Byrne  
Observatory 0.8m

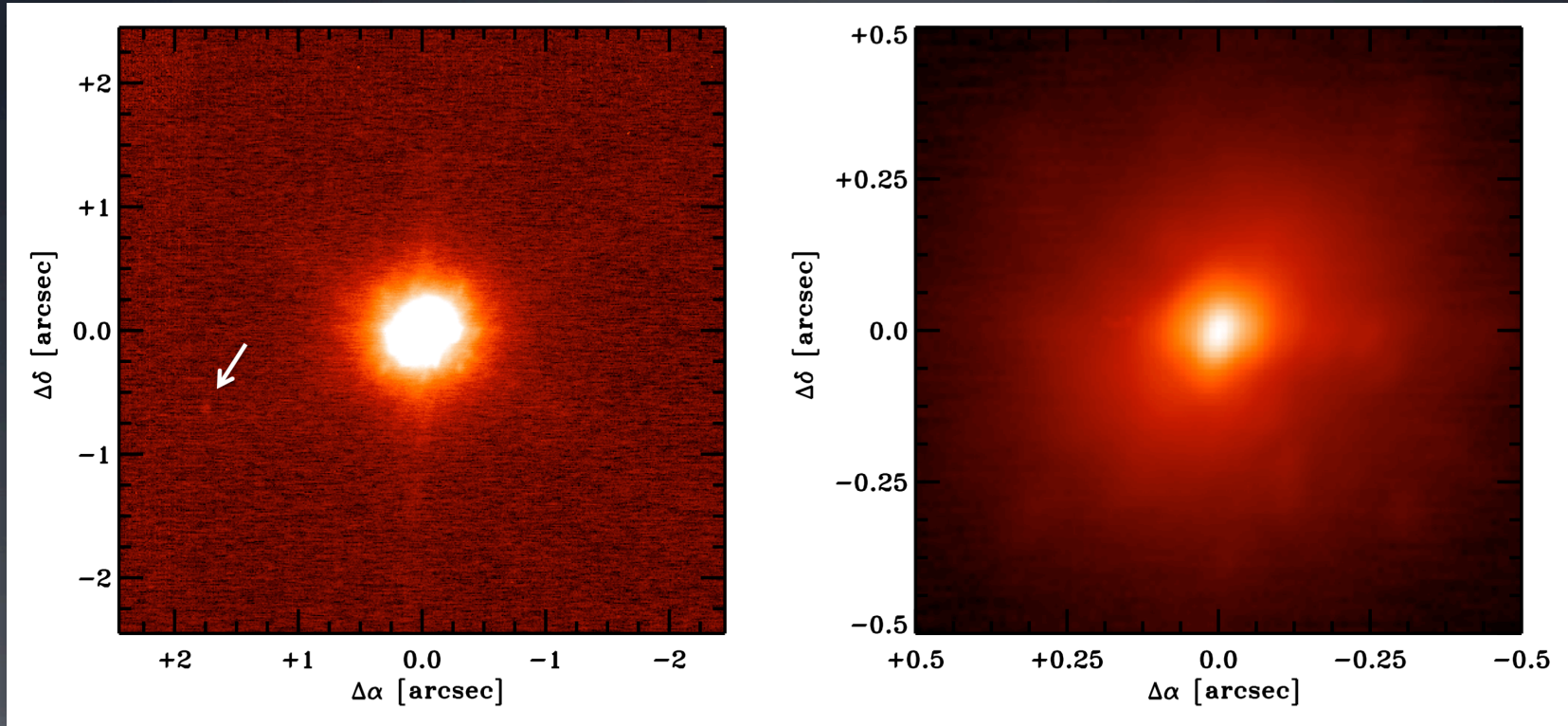


# Periodogram analysis



- All other peaks are aliases
- Effect of transit in models is small + no other periodicities evident
- => **Star/orbit co-rotation** – *prob. not background binary*

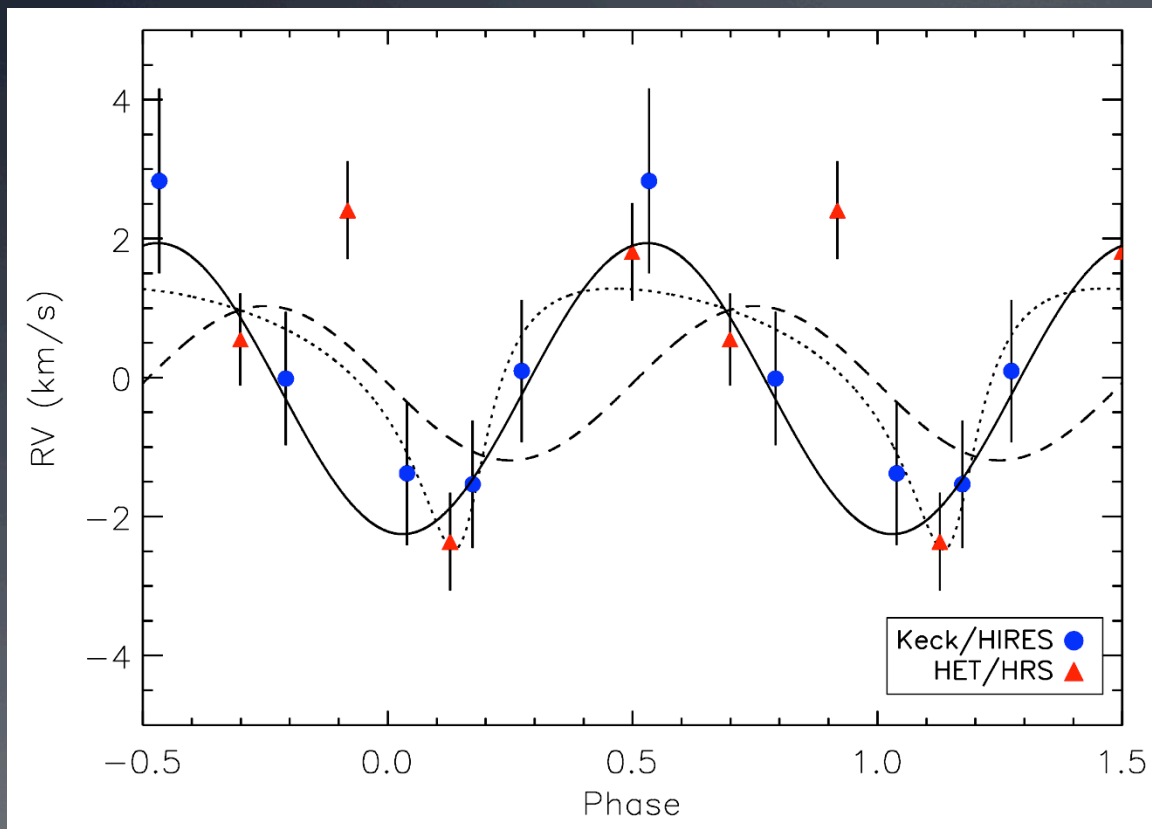
# Keck AO follow-up



- Single faint additional source (left)
- 1.8" separation, 6.96mag fainter
- *Source cannot account for transits*

# Keck+HET RV follow-up

## RV Folded on Transit Period



— Circular fit, fixed to transit phase

⋯ Eccentric fit, fixed to transit phase – *maybe unlikely?*

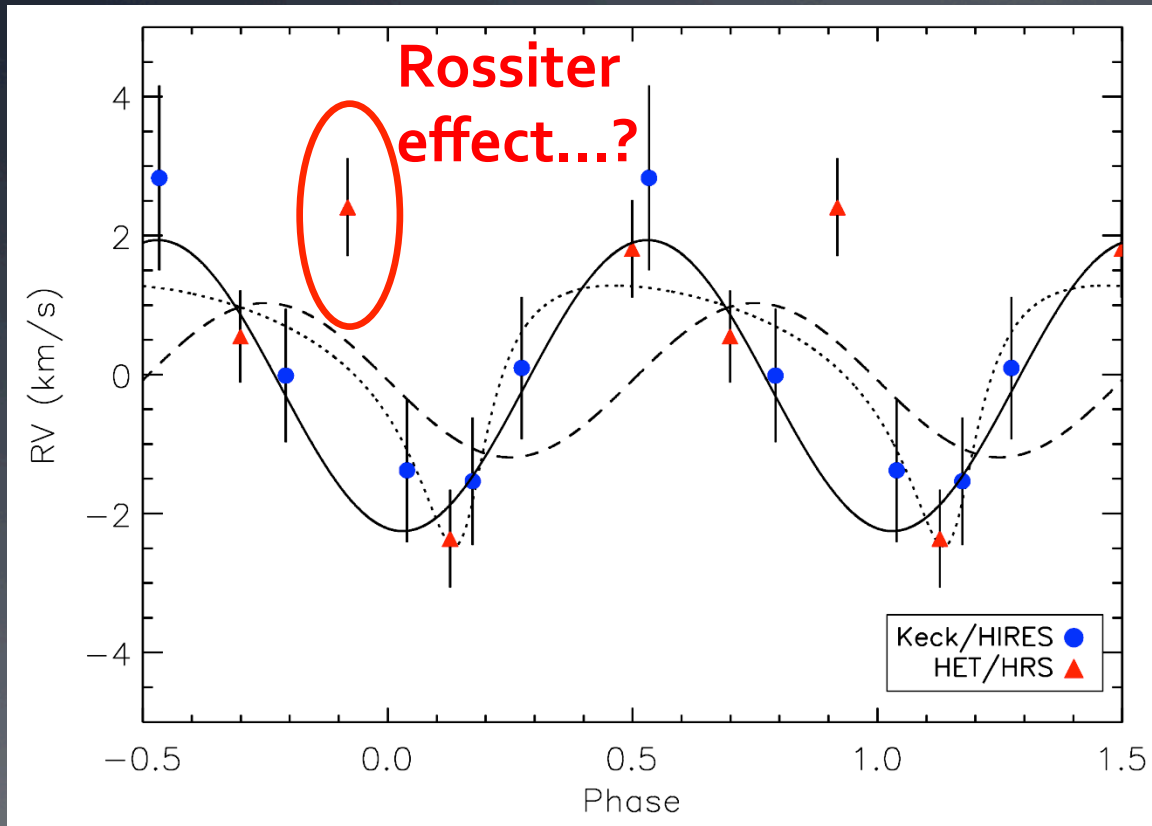
— Sinusoidal (circular) fit, floating phase

- Signal probably dominated by star spots since out of phase
- Upper limit,  $M_p \sin i \leq 4.8 \pm 1.2 M_{\text{Jup}}$



# Keck+HET RV follow-up

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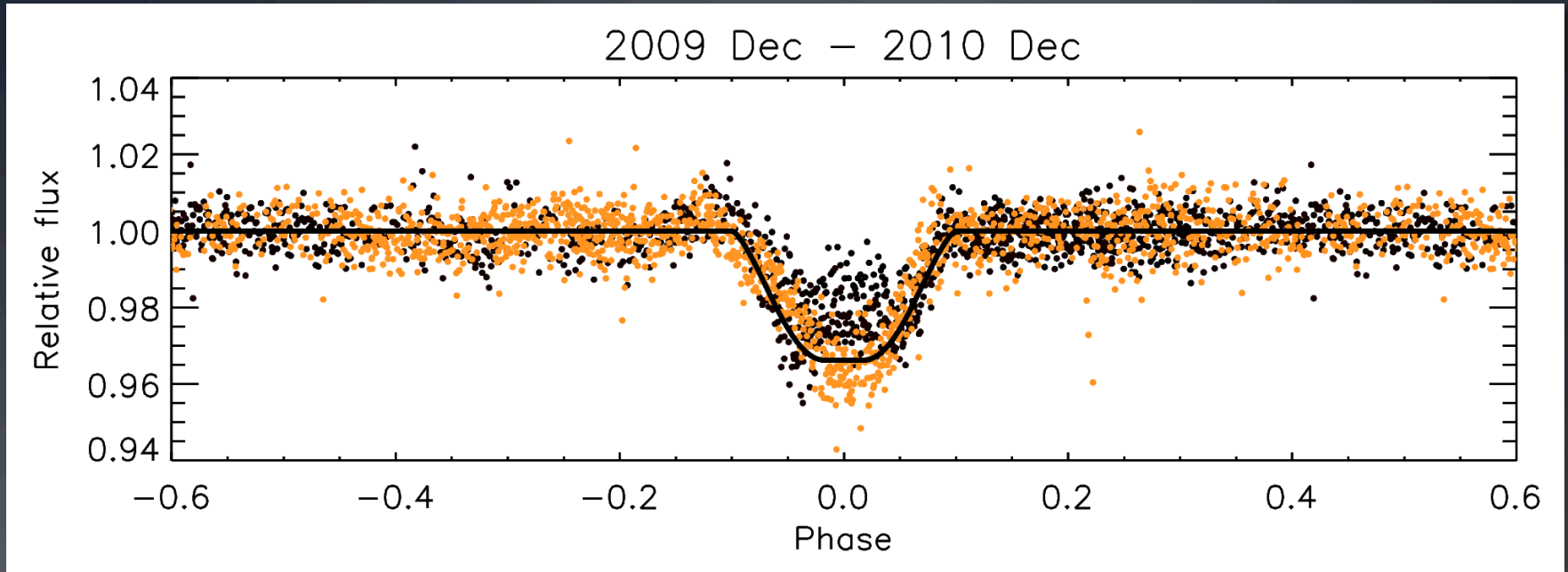
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— Sinusoidal (circular) fit, floating phase

- Signal probably dominated by star spots since out of phase
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# Transit fitting

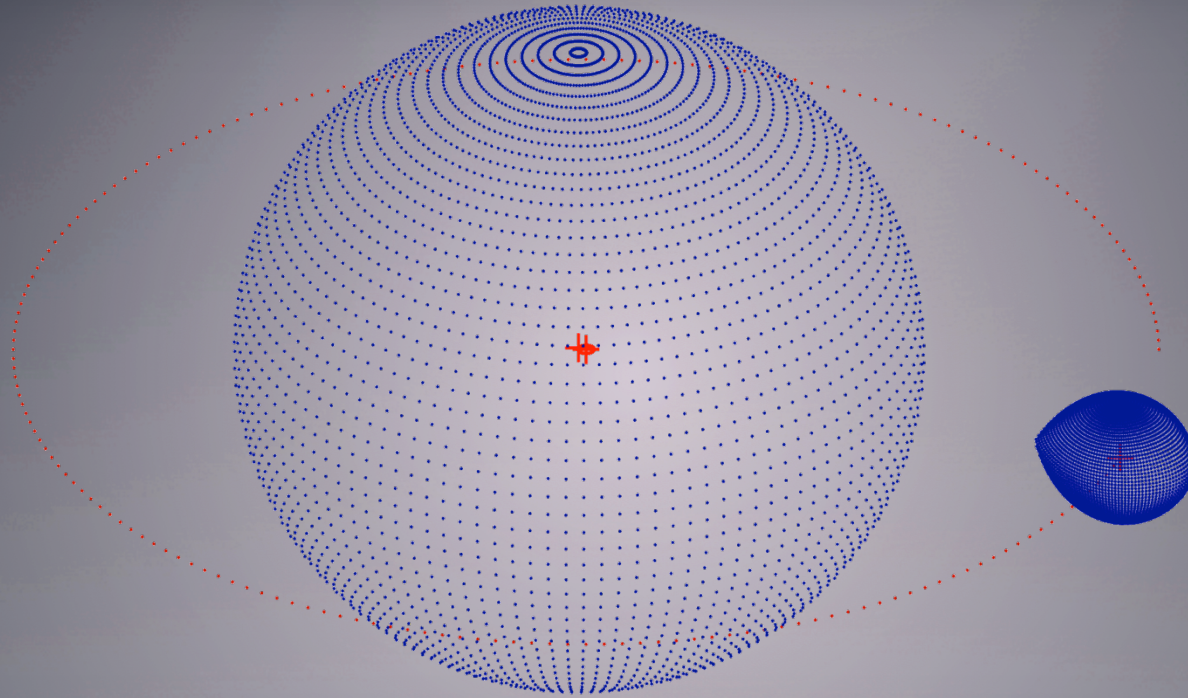
## Detrended and folded light curve



- Transit shape is v. difficult to model with star spots

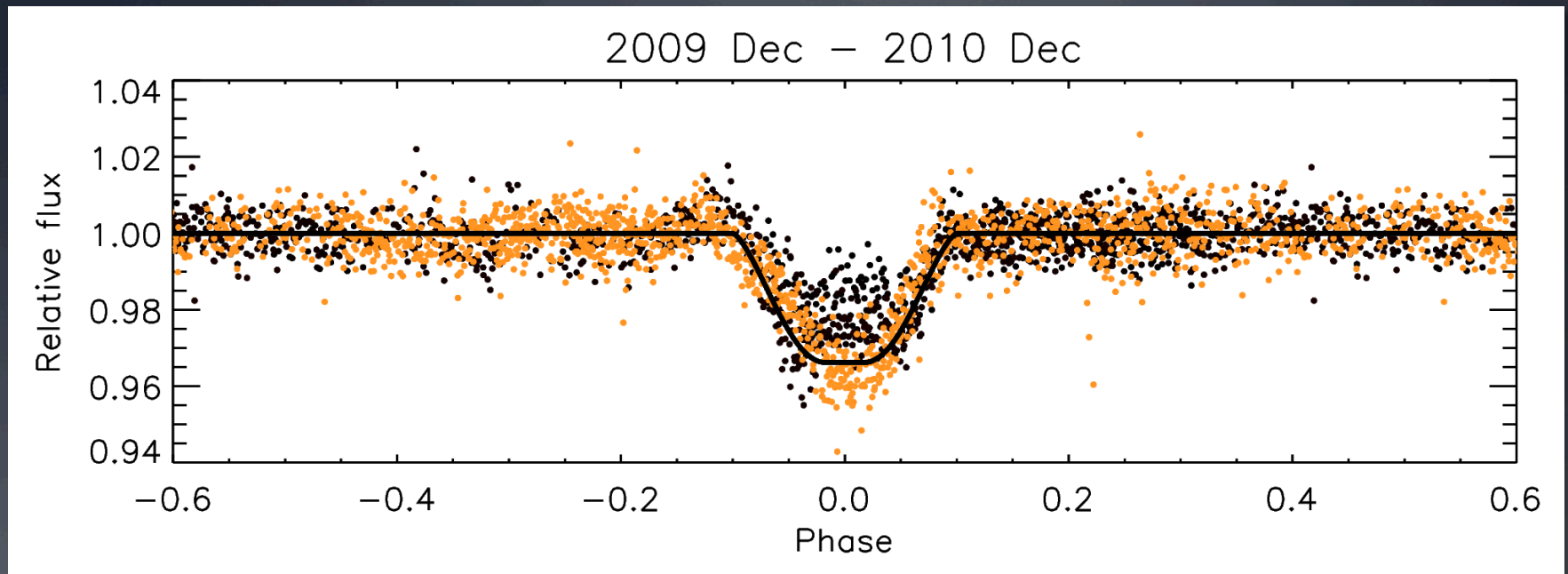
# Vital Stats

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- 2.7Myr M<sub>3</sub> WTTS
  - $P \approx 0.4484\text{d}$
  - $R_p \approx 1.9R_{\text{Jup}}, M_p \leq 5.5M_{\text{Jup}}$
  - $i \approx 62^\circ$
  - Co-rotating star
  - V. close to Roche limit – *may be actively losing mass.*
-

# A puzzle – transit shape change?

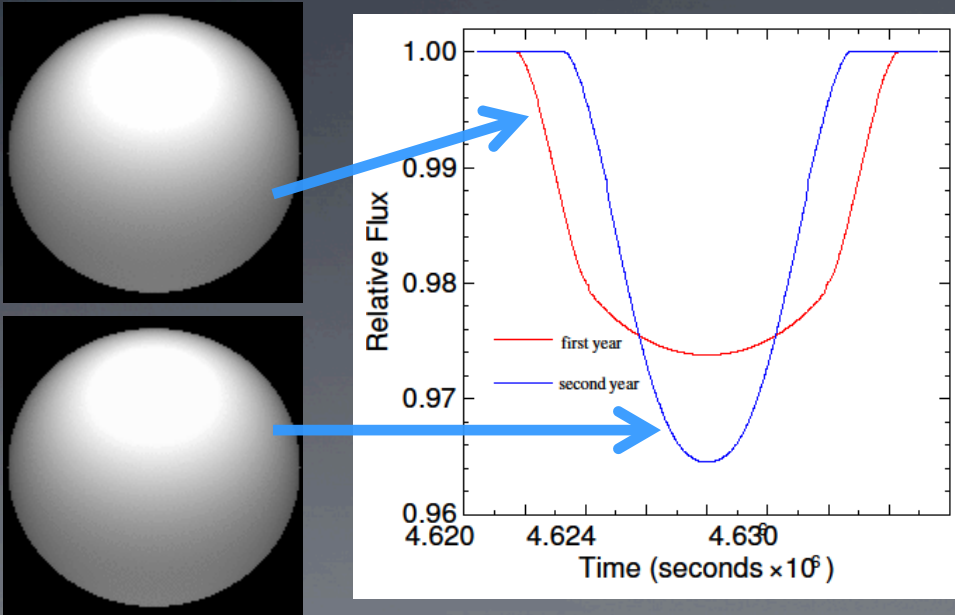


- Black = 1<sup>st</sup> yr, orange=2<sup>nd</sup>
- Change in orbital geometry...?

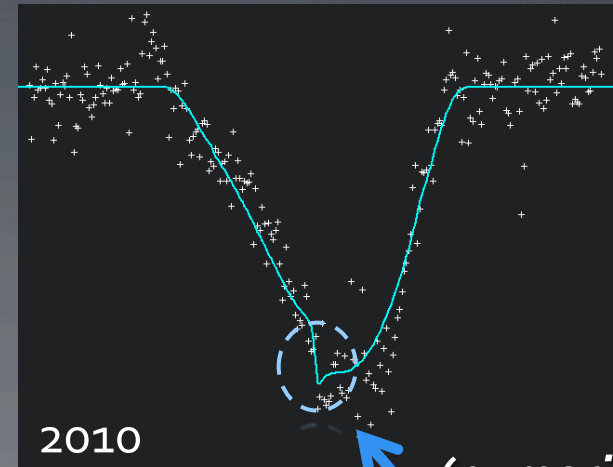
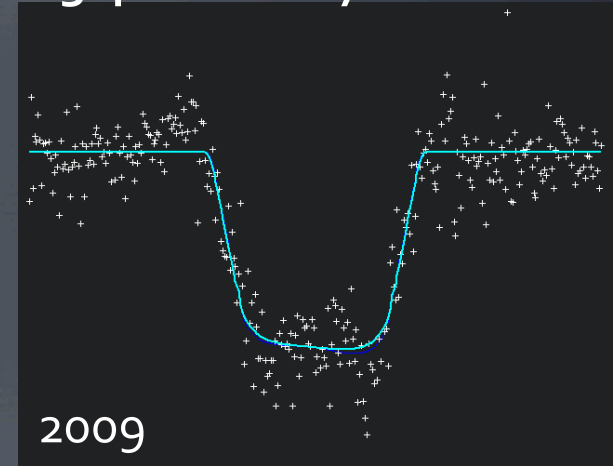
# Precession + Gravitational Darkening...?

- Star is fast rotator => *oblate*
- Significant grav. darkening
- If orbit oblique, precession expected on timescale  $\sim 100$  d – about right...

E.g. effect of grav. darkening w/ fast rotator



E.g. preliminary fits to data



Courtesy Jason Barnes, U. Idaho

(numerical artifact)

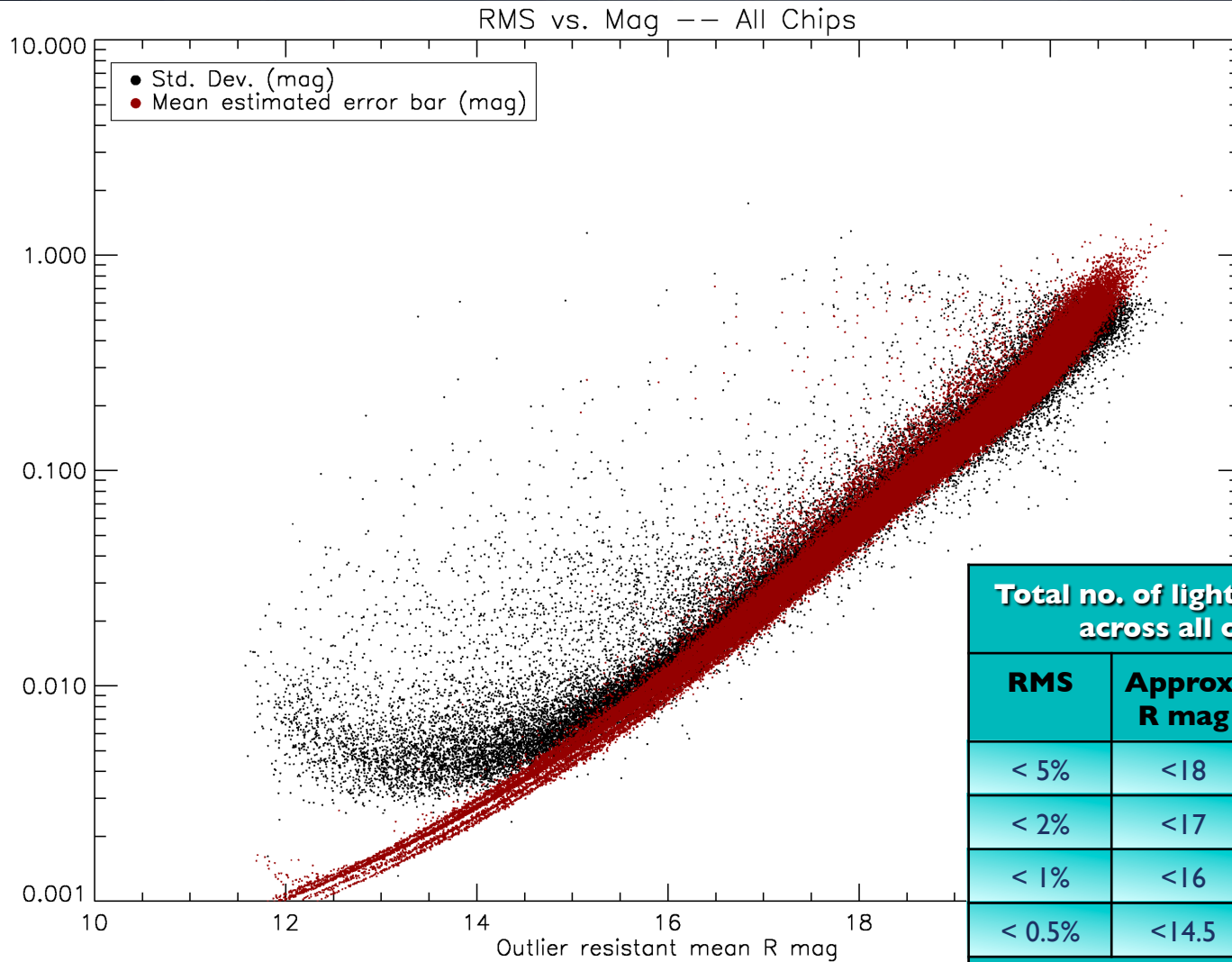
# Summary

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- PTFO 8-8695b – a candidate T-Tauri planet
  - ~2.7Myr-old
  - $P \approx 0.4484\text{d}$ ,  $R_p \approx 1.9R_{\text{Jup}}$ ,  $M_p \leq 5.5M_{\text{Jup}}$
  - AO -> no significant blends
  - Co-rotating => background binary unlikely
  - VERY close to Roche limit – **poss. losing mass/evaporating!**
  - Change in transit shape in ~1yr? Why...?
  - More follow-up multi-band photometry may help mitigate star-spots
  - Follow-up RV -> catch Rossiter McLaughlin effect?
  - Investigating transit models including precession/gravitational darkening.
  - **Potentially a unique object for constraining formation theories**

Backup slides

# Results - rms precision



**Total no. of light curves w/precision, across all chips. (approx.)**

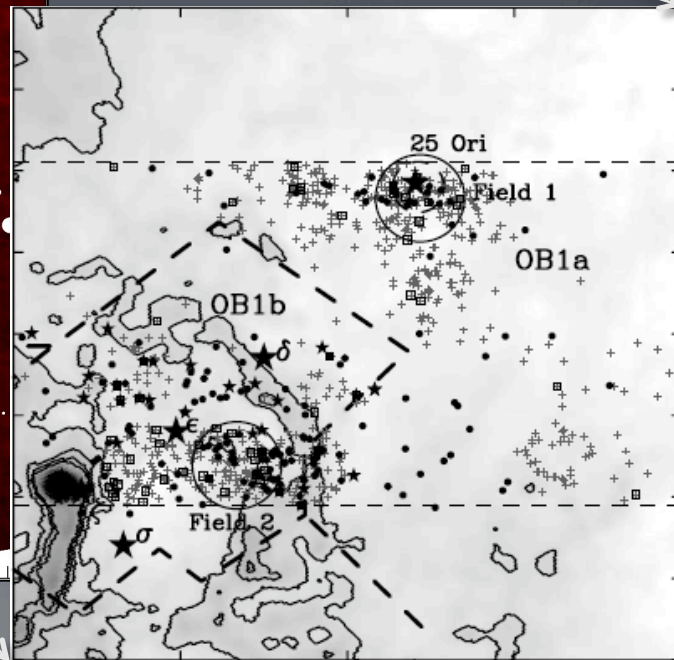
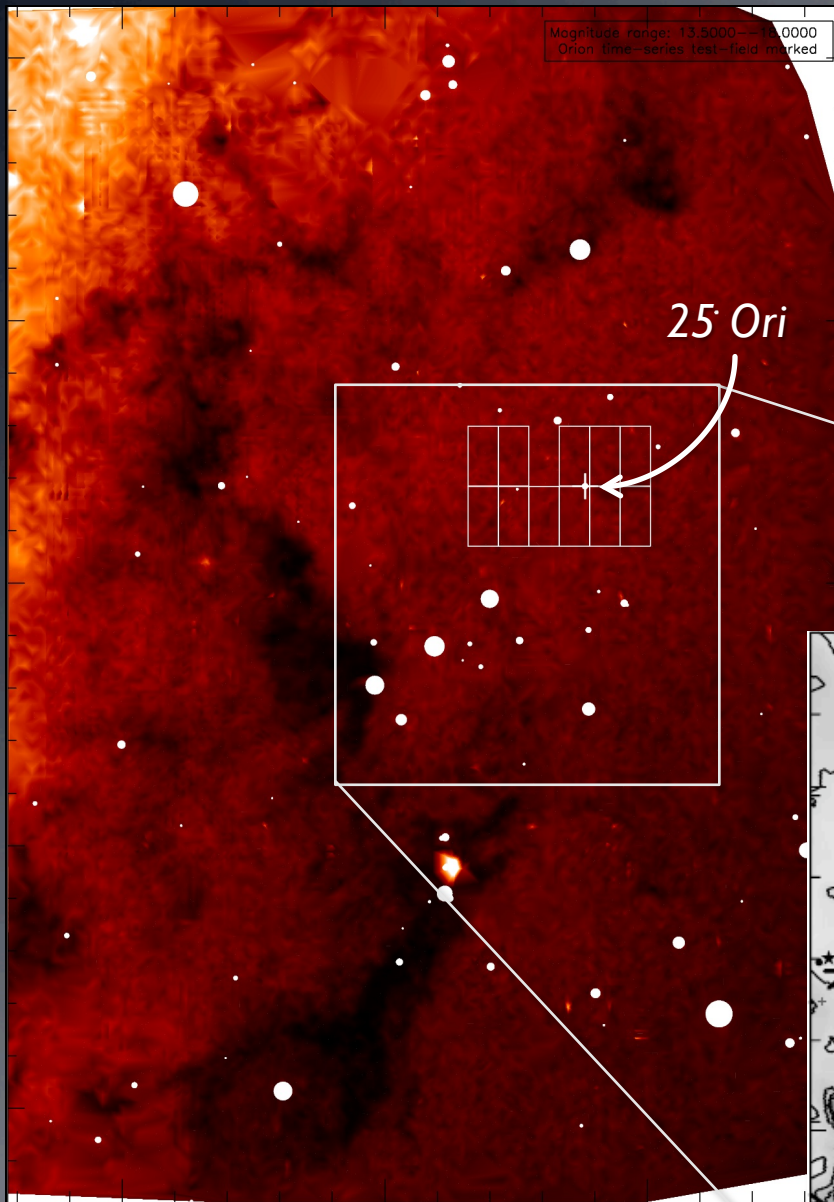
<b>RMS</b>	<b>Approx. R mag</b>	<b>Number</b>	<b>Fraction</b>
< 5%	<18	30951	27%
< 2%	<17	16505	14%
< 1%	<16	8869	7.6%
< 0.5%	<14.5	2198	1.9%

**Total 116,285 light curves**



# PTF Orion

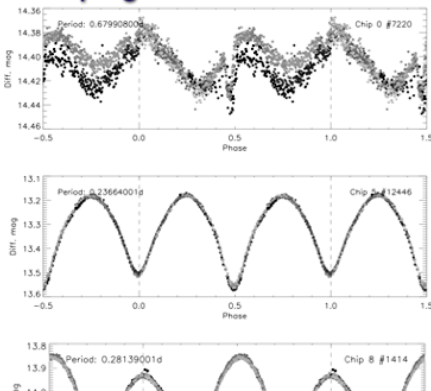
- Primarily search for young planets
- Field centred on 25 Ori
- ~7-10Myr old region
- Known grouping of TTS



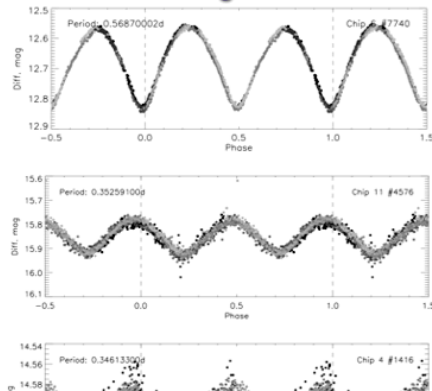
Briceño et  
al., *ApJ*  
2007

# E.g. periodic variables (rms > 3x error bar)

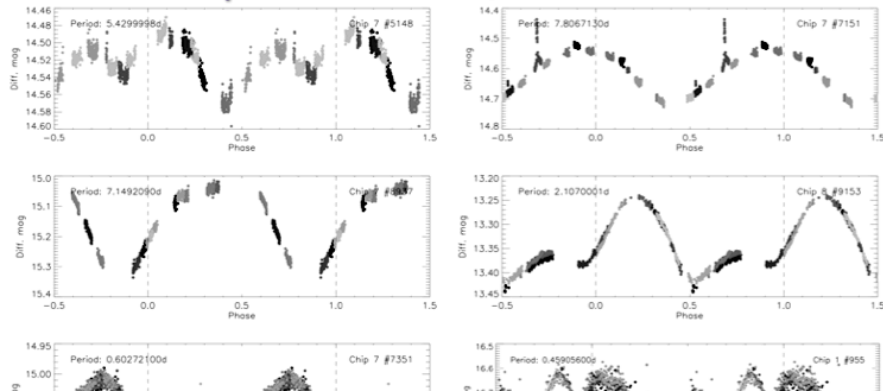
## Eclipsing binaries



## Sinusoidal/ambiguous

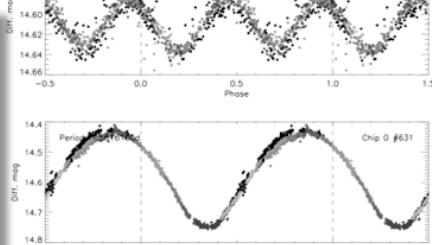


## Spotted/TTS/unidentified, etc.



## Total variable light curve types from visual inspection

Type	No. found
Binary	82
Pulsating	18
Clear flaring	44
Sinusoidal, ambiguous	68
Periodic, non-sinusoidal, (spots/unidentified/etc.)	95
Irregular	31
Currently unclassified	~200
<b>Total</b>	<b>~530</b>



## Pulsating

