

# KIC 008416523

## Q1-17 DR25 TCE Parameters

TCE	Run Type	KOI?	Period (Days)	Epoch (BKJD)	Depth (ppm)	Duration (Hours)	MES	SNR	$R_{\star}$ ( $R_{\odot}$ )	$T_{\star}$ (K)	$R_p$ ( $R_{\oplus}$ )	$S_p$ ( $S_{\oplus}$ )
008416523-01	OBS	4441.01	0.683677	131.667293	134.7	0.778	12.5	20.2	0.75	5016	1.08	1575.45
008416523-02	OBS	No	0.683676	132.006911	149.8	0.759	13.2	22.9	0.75	5016	1.14	1575.45

## Robovetter Results

TCE	Run Type	Disp	Score	N	S	C	E	Comments
008416523-01	OBS	PC	1.00	0	0	0	0	MOD_SEC_DV—MOD_SEC_ALT—PLANET_PERIOD_IS_HALF_ALT—HAS_SEC_TCE
008416523-02	OBS	FP	0.00	1	1	0	0	IS_SEC_TCE

**Notes:** OBS = Observed. INJ = Injected. INV = Inverted. SCR = Scrambled.

N = Not Transit-Like. S = Stellar Eclipse. C = Centroid Offset. E = Ephemeris Match.

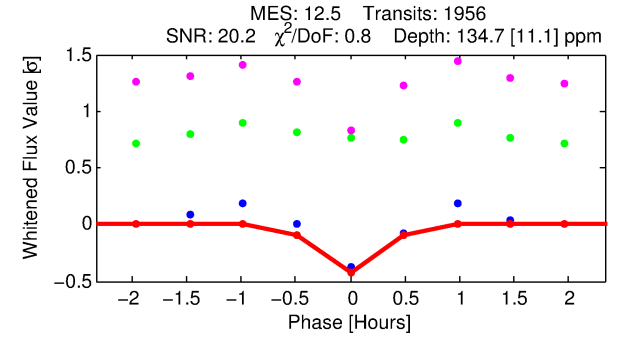
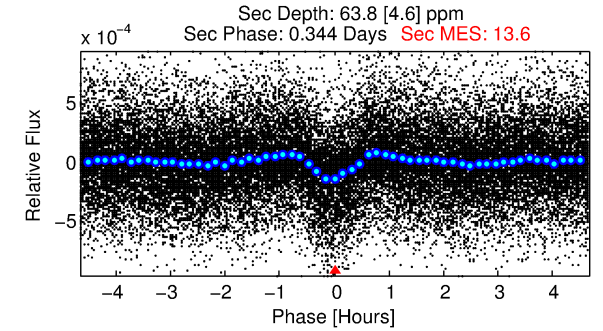
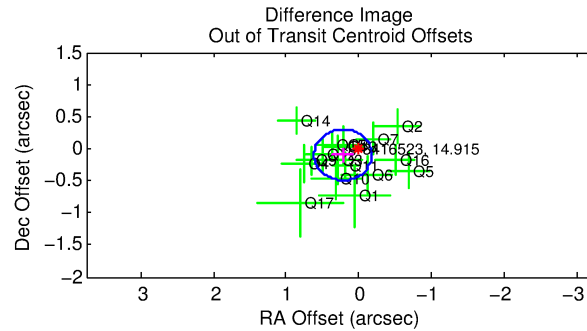
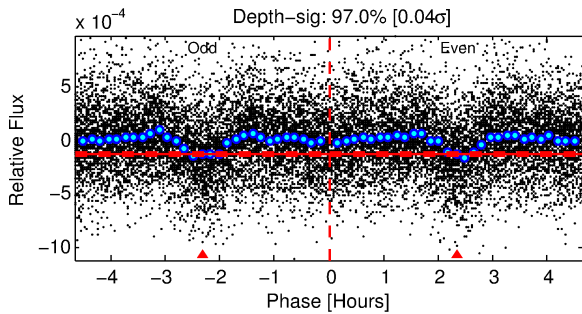
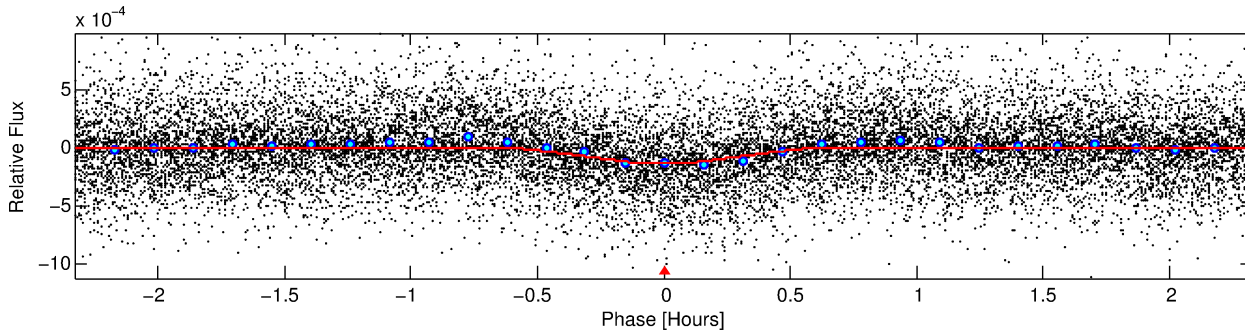
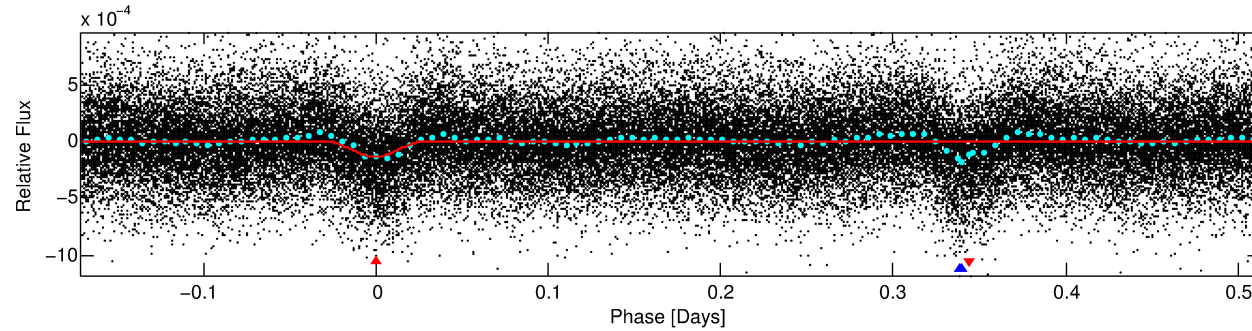
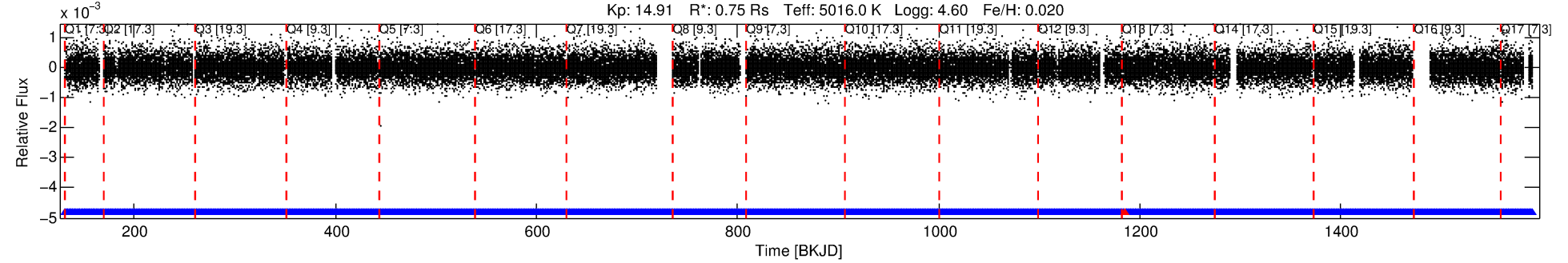
See [http://exoplanetarchive.ipac.caltech.edu/docs/API\\_kepcandidate\\_columns.html#proj\\_disp\\_col](http://exoplanetarchive.ipac.caltech.edu/docs/API_kepcandidate_columns.html#proj_disp_col) for comment definitions.

## Ephemeris Match Information For 008416523-01

No Significant Match Found

# DV One-Page Summary

KIC: 8416523 Candidate: 1 of 2 Period: 0.684 d  
KOI: K04441.01 Corr: 0.861



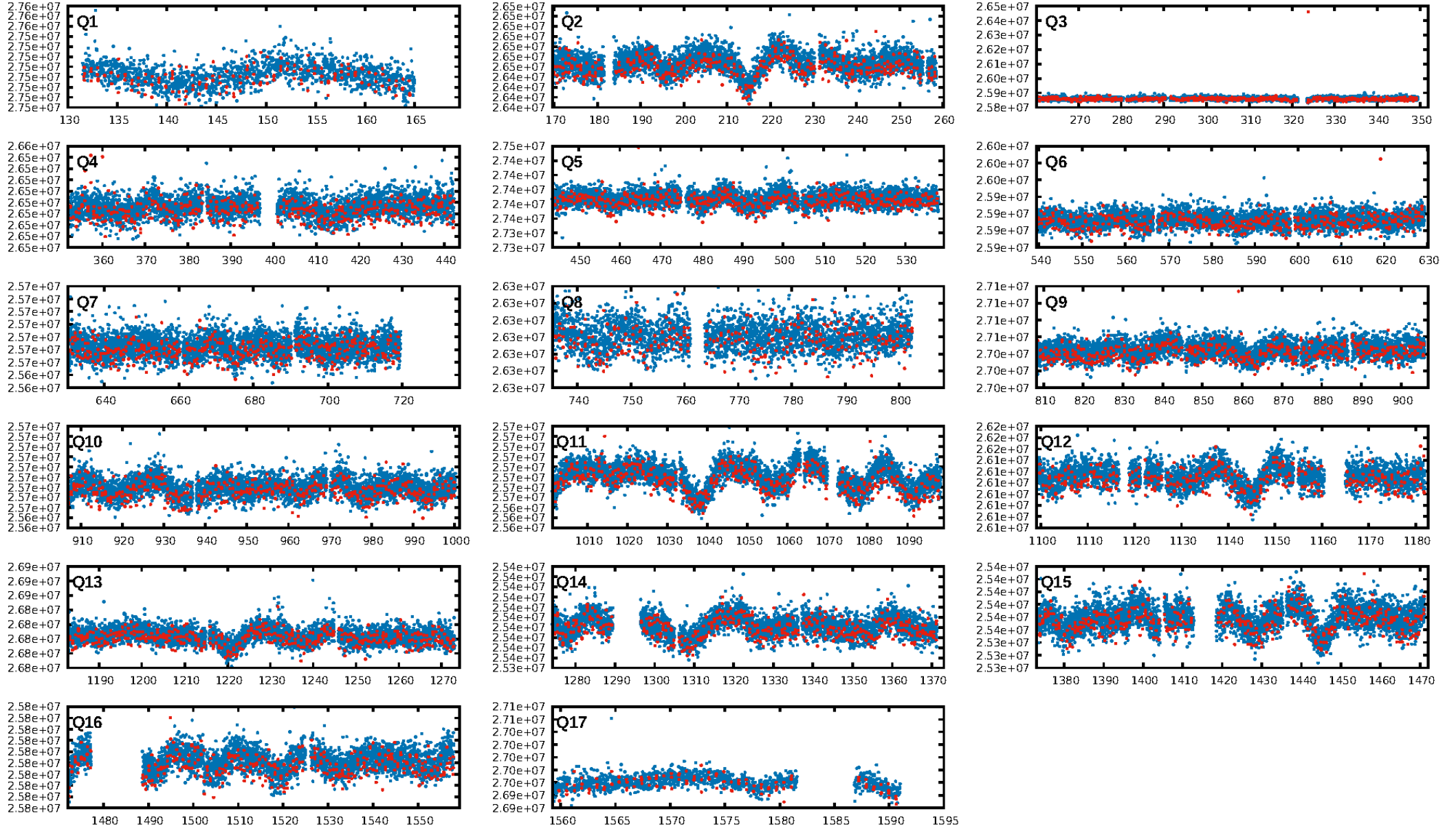
## DV Fit Results:

Period = 0.68368 [0.00001] d  
Epoch = 131.6673 [0.0007] BKJD  
Rp/R\* = 0.0132 [0.0041]  
a/R\* = 3.26 [3.63]  
b = 0.90 [0.27]  
Seff = 1575.45 [281.55]  
Teq = 1606 [72] K  
Rp = 1.08 [0.36] Re  
a = 0.0142 [0.0013] AU  
Ag = 6.08 [3.89] [1.31 $\sigma$ ]  
Teffp = 3900 [621] K [3.67 $\sigma$ ]

## DV Diagnostic Results:

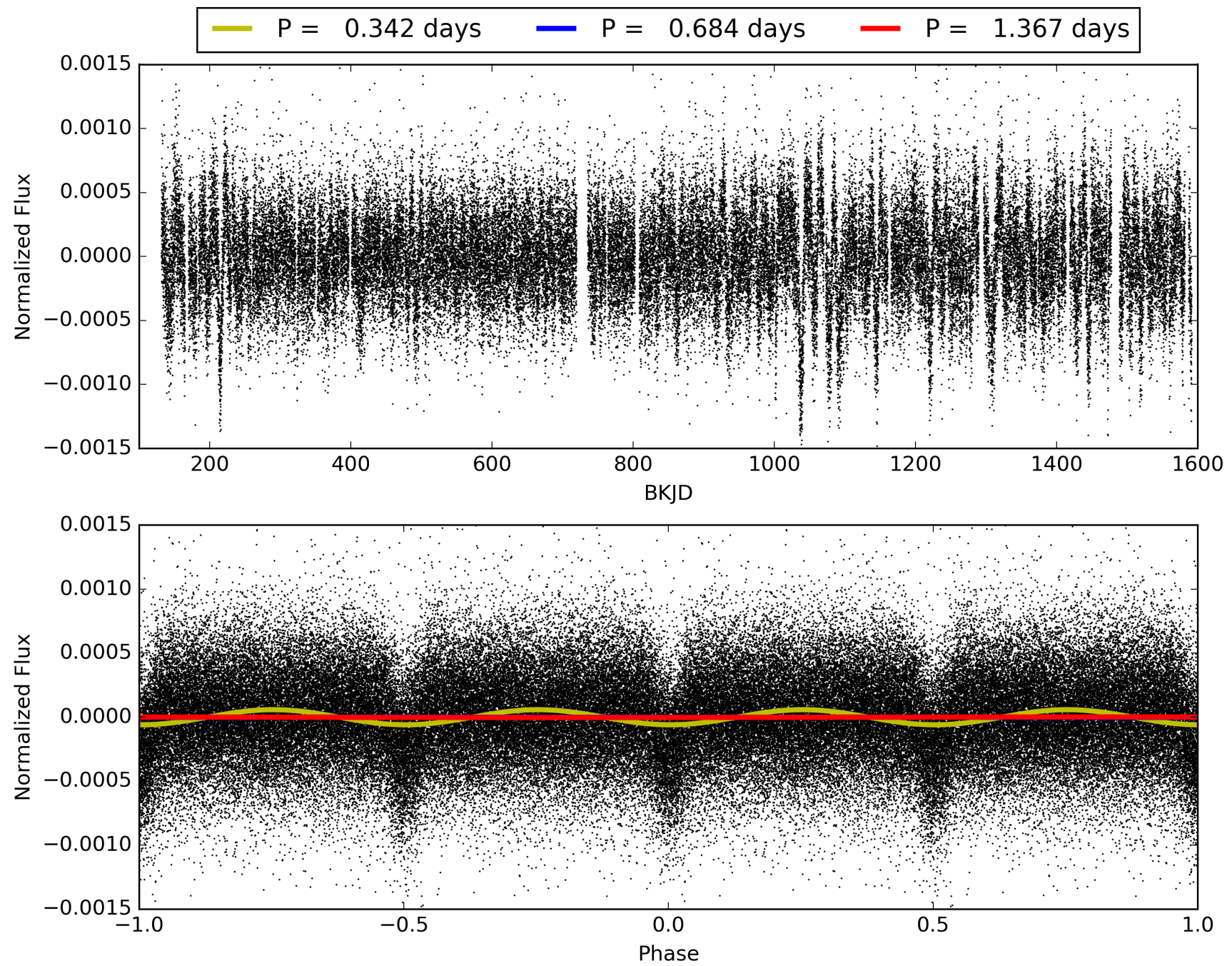
ShortPeriod-sig: 0.0% [0.00 $\sigma$ ]  
LongPeriod-sig: N/A  
ModelChiSquare2-sig: N/A  
ModelChiSquareGof-sig: N/A  
Bootstrap-pfa: 5.84e-39  
RollingBand-fgt: 1.00 [1868/1869]  
GhostDiagnostic-chr: 5.704  
Centroid-sig: 0.0%  
Centroid-so: 1.762 arcsec [3.24 $\sigma$ ]  
OotOffset-rm: 0.242 arcsec [1.83 $\sigma$ ]  
KicOffset-rm: 0.278 arcsec [2.08 $\sigma$ ]  
OotOffset-st: 4/4/4/5 [17]  
KicOffset-st: 4/4/4/5 [17]  
DiffImageQuality-fgm: 1.00 [17/17]  
DiffImageOverlap-fno: 1.00 [17/17]

# TCE 008416523-01, PDC Light Curves



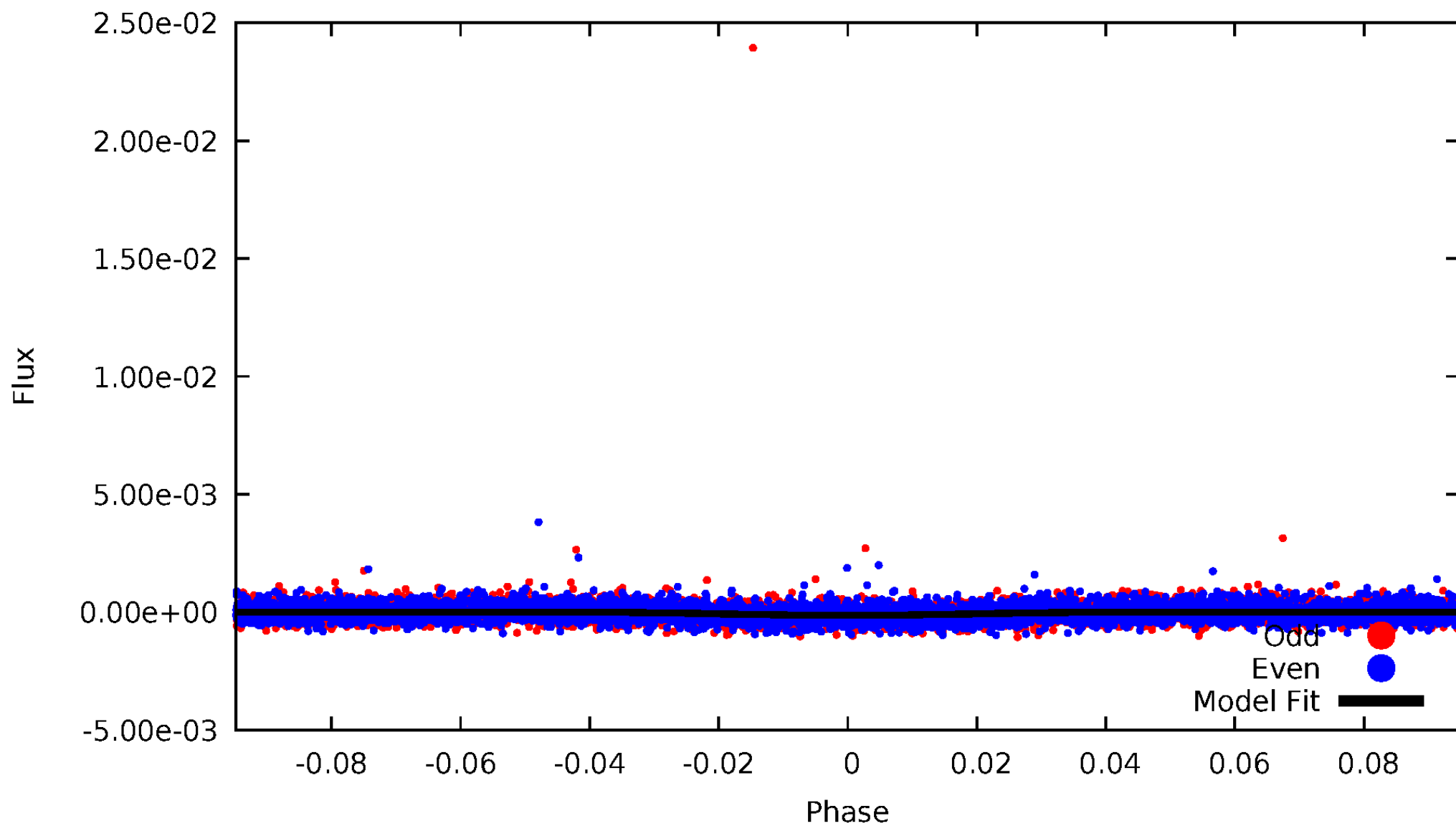


TCE 008416523-01



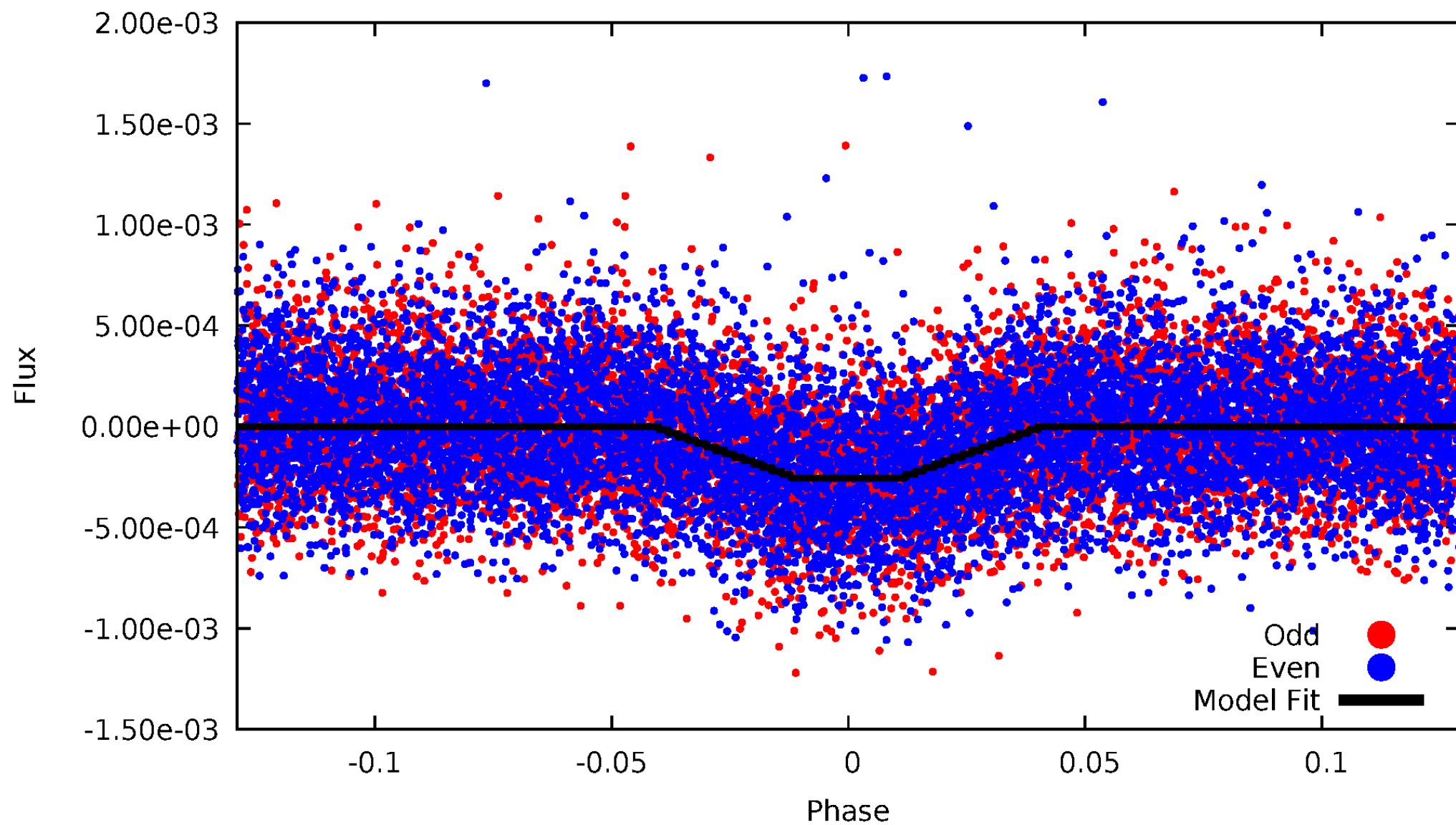
# DV Odd/Even

TCE 008416523-01

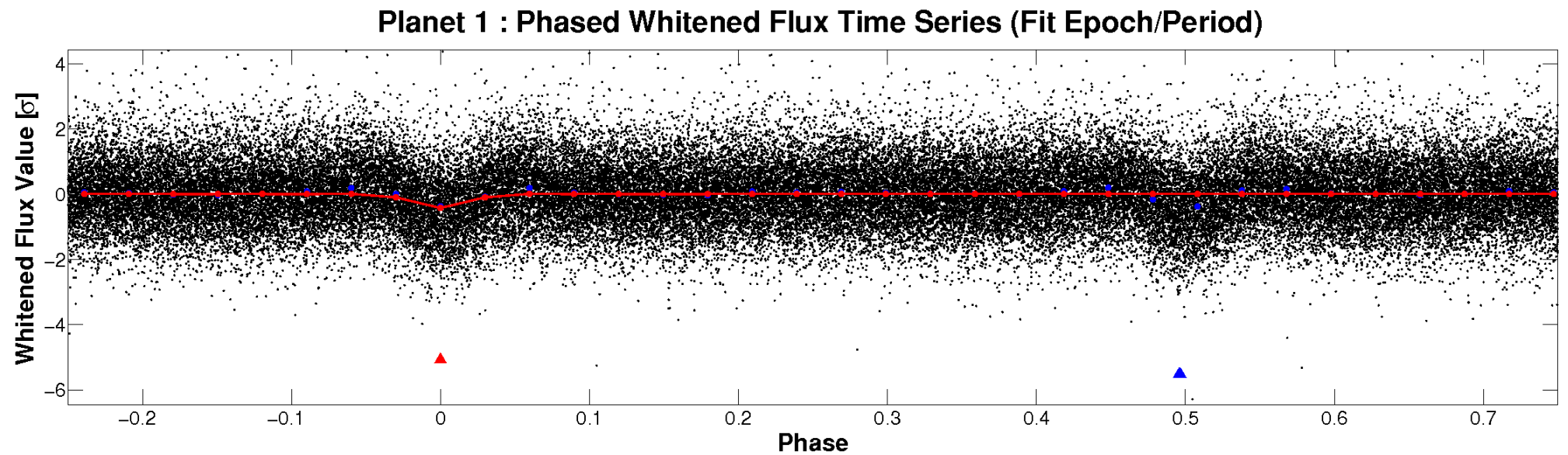
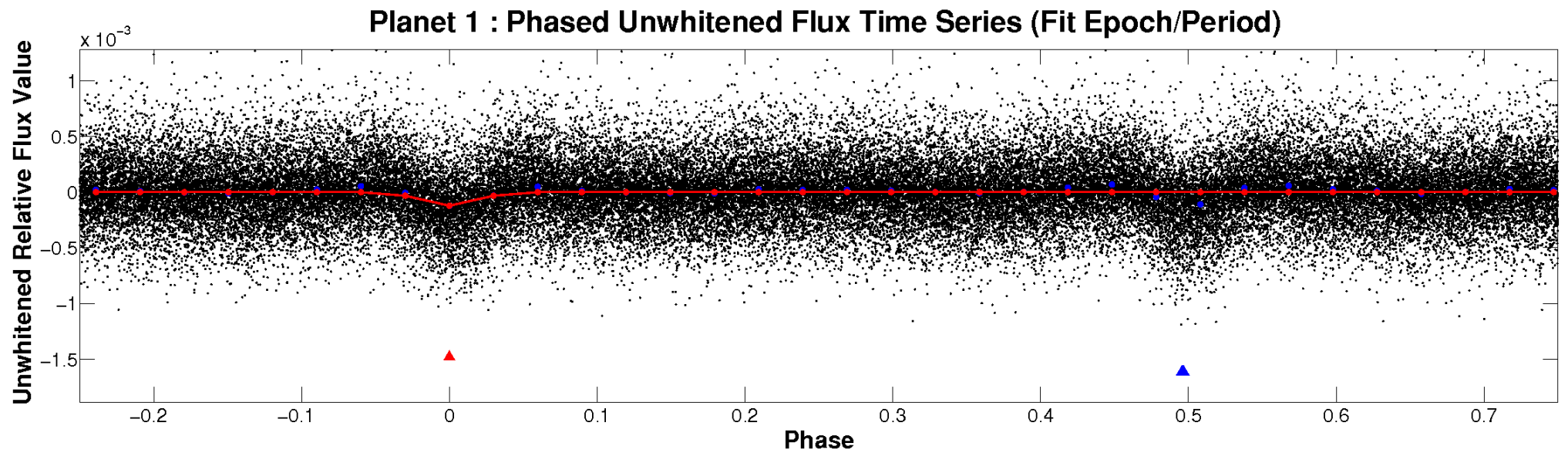


# ALT Odd/Even

TCE 008416523-01



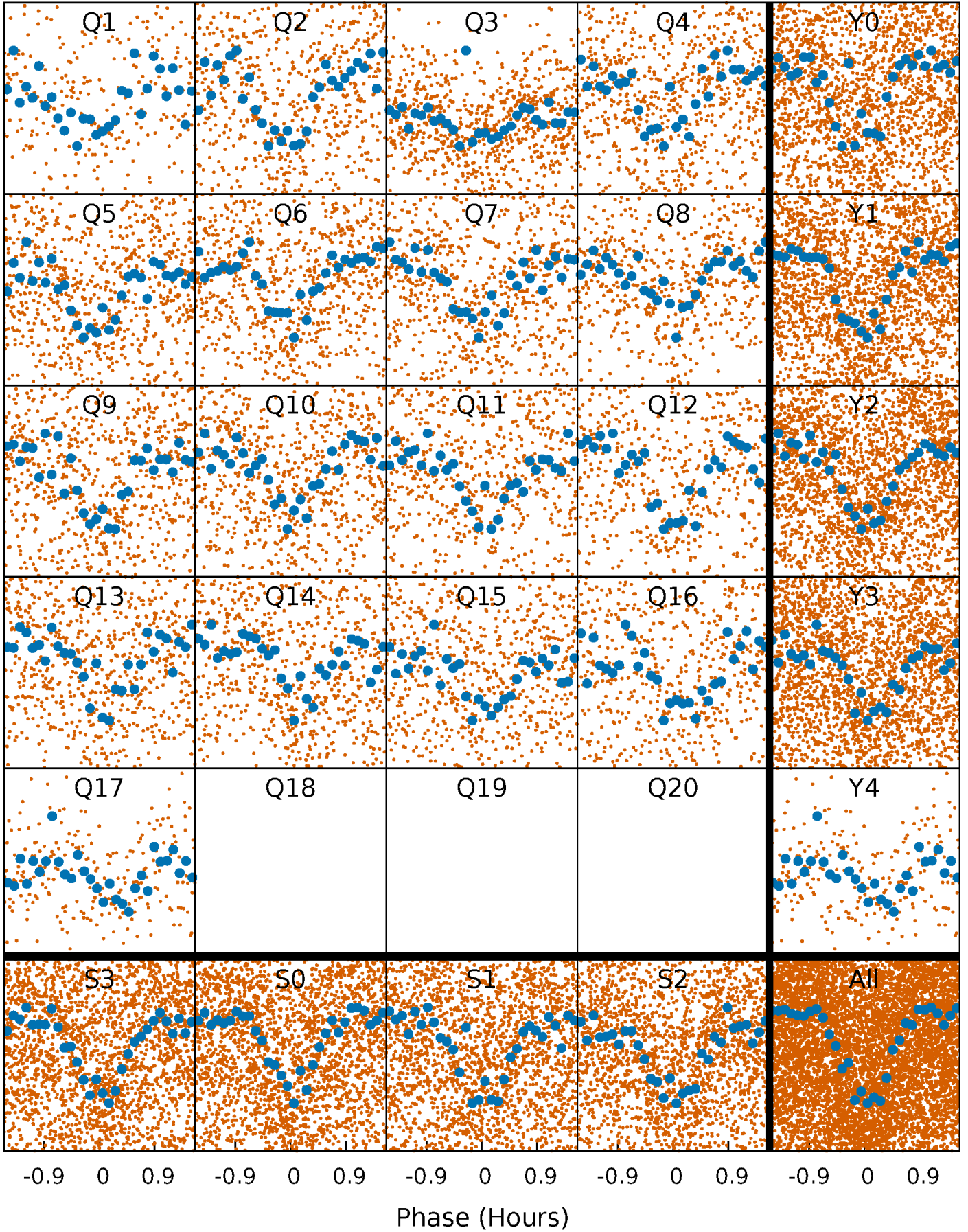
# Non-Whitened Vs. Whitened Light Curve





# PDC Quarter-Phased Transit Curves

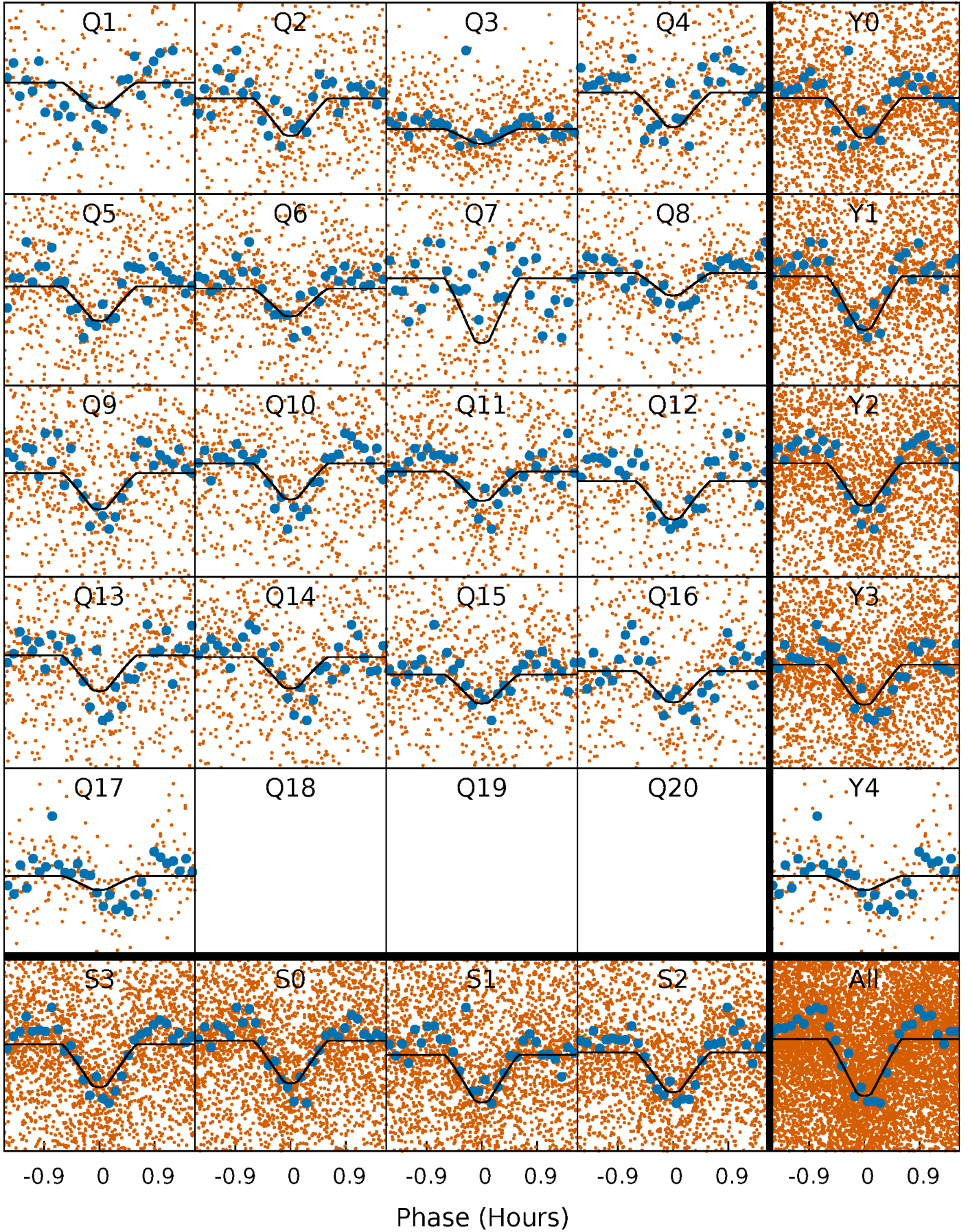
TCE 008416523-01   P= 0.683677 Days    $T_0=131.667293$  (BKJD)





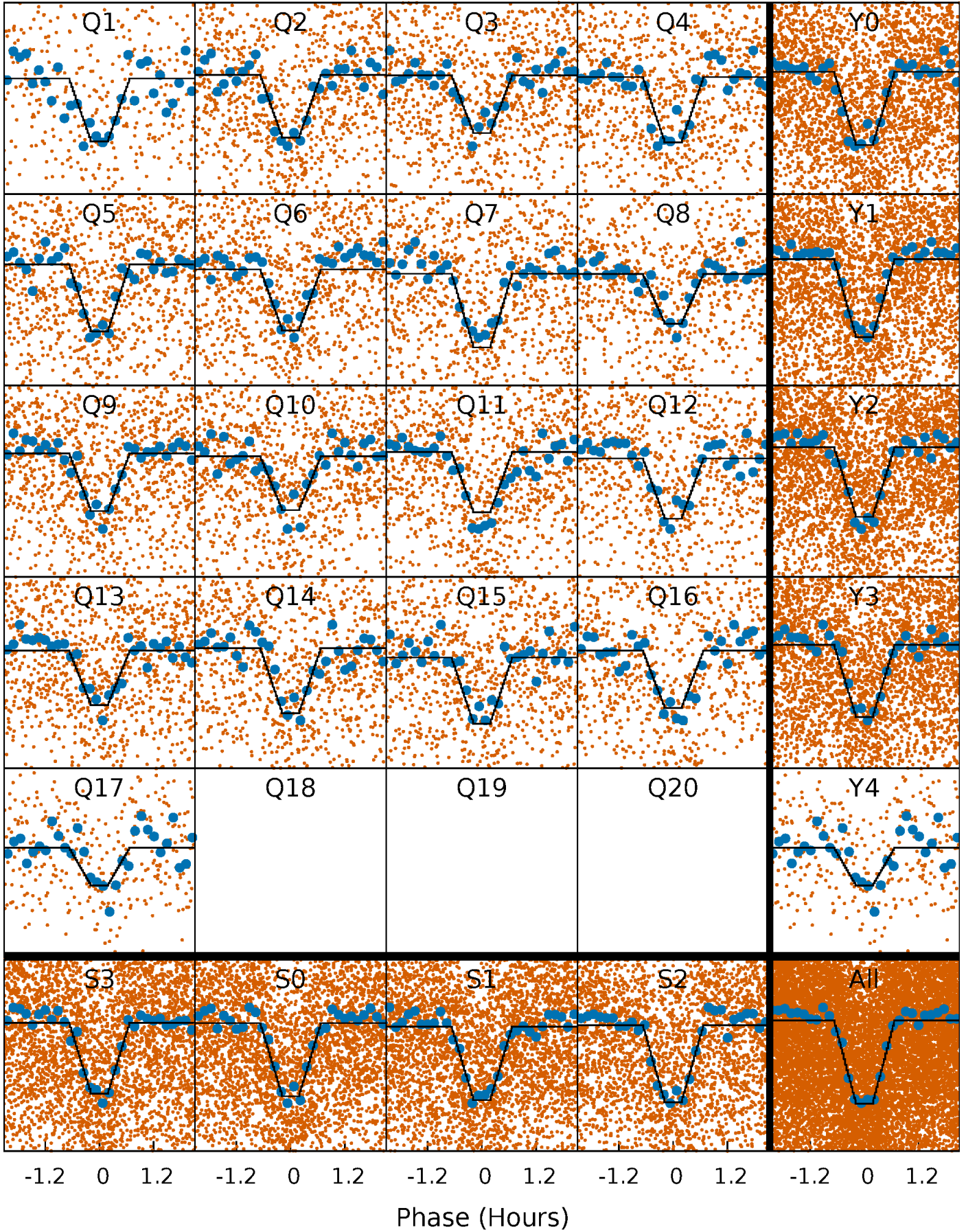
# DV Quarter-Phased Transit Curves

TCE 008416523-01   P= 0.683677 Days    $T_0=131.667293$  (BKJD)



# Alt. Detrend Quarter-Phased Transit Curves

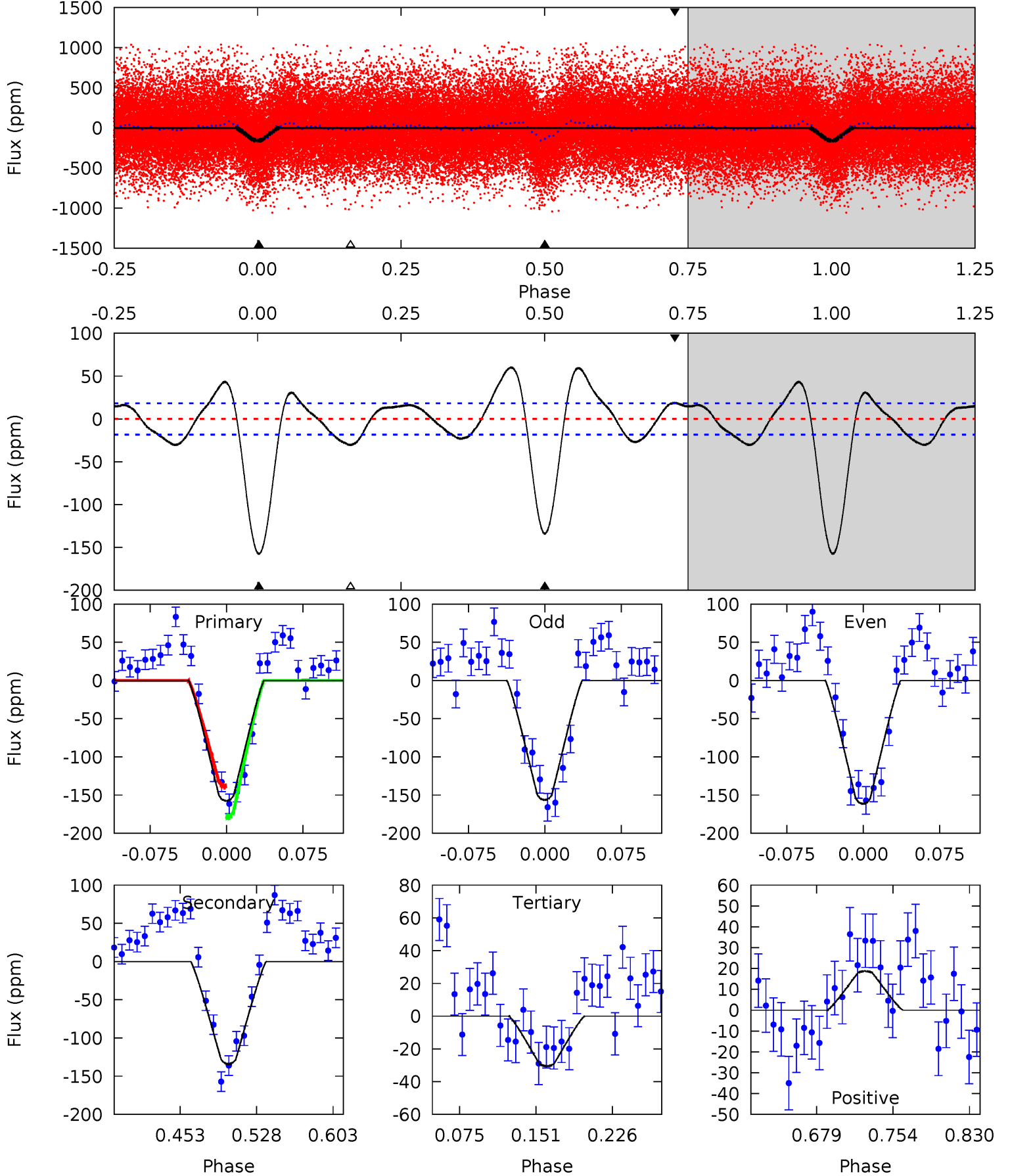
TCE 008416523-01 P= 0.683681 Days  $T_0=131.663538$  (BKJD)



# DV Model-Shift Uniqueness Test

008416523-01, P = 0.683677 Days, E = 130.983616 Days

Pri	Sec	Ter	Pos	FA <sub>1</sub>	FA <sub>2</sub>	F <sub>Red</sub>	Pri-Ter	Pri-Pos	Sec-Ter	Sec-Pos	Odd-Evn	DMM	Shape	TAT
39.8	33.9	7.69	4.72	4.62	1.78	4.56	32.1	35.1	26.2	29.2	0.62	0.93	0.28	5.05

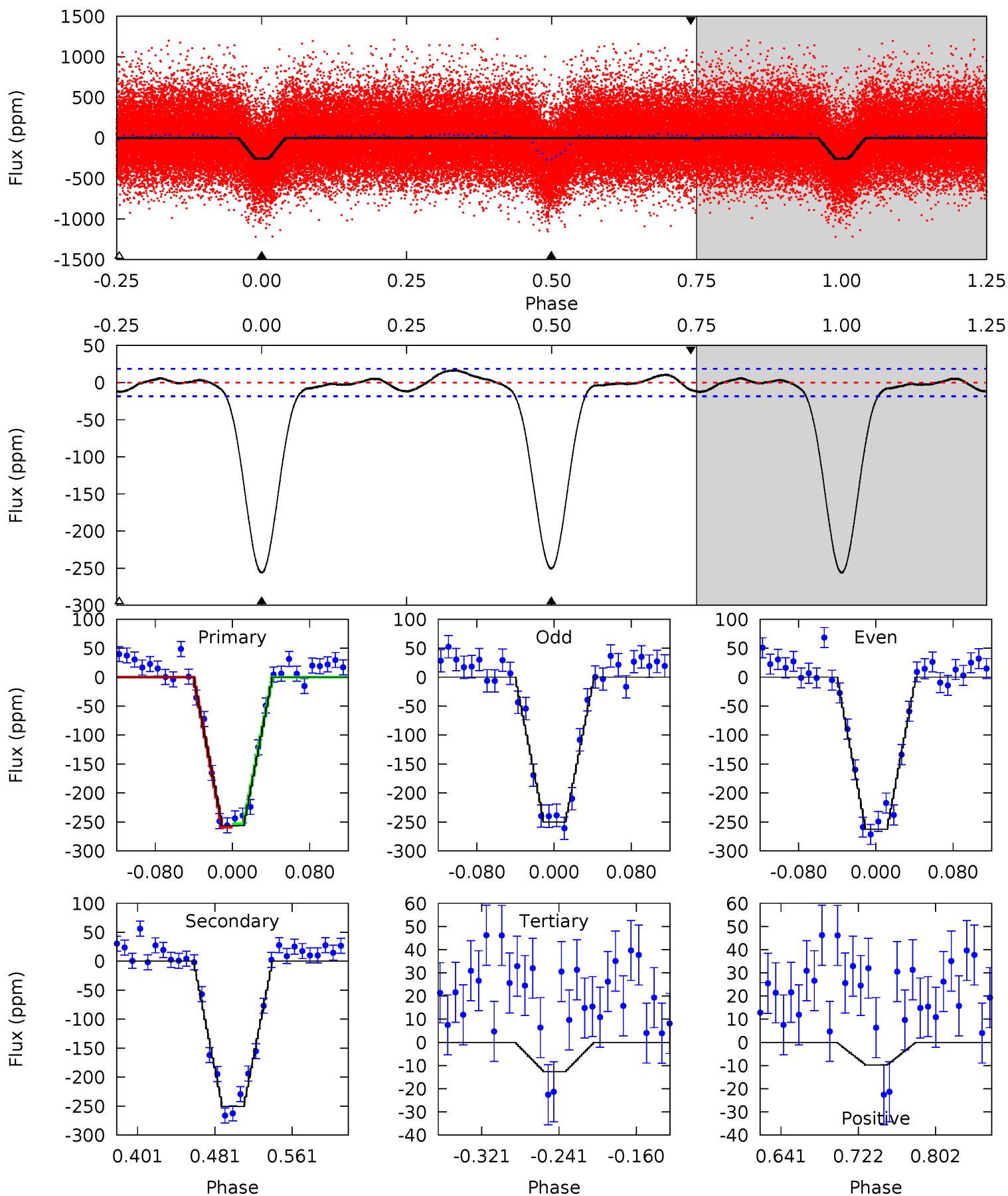




# Alt Model-Shift Uniqueness Test

008416523-01, P = 0.683681 Days, E = 130.979857 Days

Pri	Sec	Ter	Pos	FA <sub>1</sub>	FA <sub>2</sub>	F <sub>Red</sub>	Pri-Ter	Pri-Pos	Sec-Ter	Sec-Pos	Odd-Evn	DMM	Shape	TAT
63.8	62.4	3.15	-2.43	4.61	1.75	1.67	60.6	66.2	59.3	64.9	1.54	0.98	0.06	0.76





### Stellar Parameters For KIC 008416523

	$T_{\text{eff}}(K)$	$\log(g)$	[Fe/H]	$R (R_{\odot})$	$M(M_{\odot})$	$p_{\star} (\text{g}\cdot\text{cm}^{-3})$
	$5016^{+151}_{-136}$	$4.601^{+0.030}_{-0.070}$	$0.020^{+0.250}_{-0.300}$	$0.747^{+0.086}_{-0.058}$	$0.817^{+0.057}_{-0.078}$	$2.759^{+0.430}_{-0.651}$
	+3%/-3%	+1%/-2%	+1250%/-1500%	+12%/-8%	+7%/-10%	+16%/-24%
Source	PHO1	KIC0	KIC0	DSEP		

KIC = Kepler Input Catalog; PHO = Photometry; SPE = Spectroscopy; AST = Asteroseismology  
 TRA = Transits; DESP = Dartmouth Models; MULT = Multiple Models

### Secondary Eclipse Parameters for KIC 008416523-01 / KOI 4441.01

Detrend	Depth (ppm)	$R_p (R_{\oplus})$	$T_{\text{max}} (K)$	$T_{\text{obs}} (K)$	$A_{\text{obs}}$
DV	$-134 \pm 4$	$1.09^{+0.34}_{-0.36}$	$2268^{+88}_{-75}$	$4727^{+896}_{-493}$	$12^{+15}_{-5}$
Alt.	$-251 \pm 4$	$1.34^{+0.35}_{-0.33}$	$2268^{+79}_{-70}$	$4947^{+697}_{-460}$	$15^{+11}_{-6}$

$T_{\text{max}}$  = Theoretical Maximum Planetary Temperature

$T_{\text{obs}}$  = Observed Planetary Temperature (Assuming A=0.3)

$A_{\text{obs}}$  = Observed Albedo (Assuming T=0)

If a secondary eclipse is present, the system is likely an EB if  $T_{\text{obs}} \gg T_{\text{max}}$  AND  $A_{\text{obs}} \gg 1.0$

## DV Centroid Data

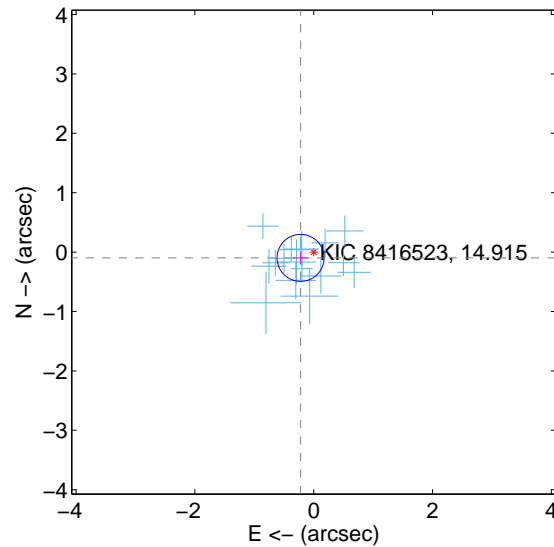
Supplemental centroid analysis for 008416523-01. Kepler magnitude: 14.91. Transit SNR 20.16

There are 17 quarters with good PRF difference image offsets

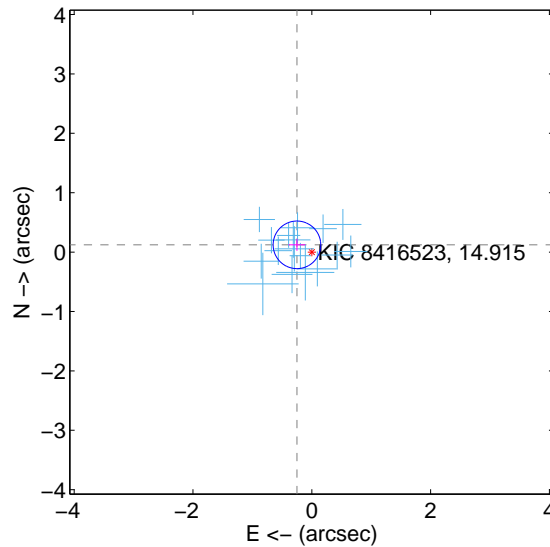
The direct PRF centroid is offset from the target star catalog position by about 0.32 arcsec

	Distance in arcsec	Distance / $\sigma$	$\Delta$ RA	$\Delta$ Dec
PRF-fit source offset from OOT	$0.242 \pm 0.132$	1.83	$0.221 \pm 0.137$	$-0.097 \pm 0.100$
PRF-fit source offset from KIC position	$0.278 \pm 0.134$	2.08	$0.250 \pm 0.140$	$0.122 \pm 0.100$
photometric centroid source offset	$1.76 \pm 0.54$	3.24	$1.62 \pm 0.53$	$-0.70 \pm 0.61$

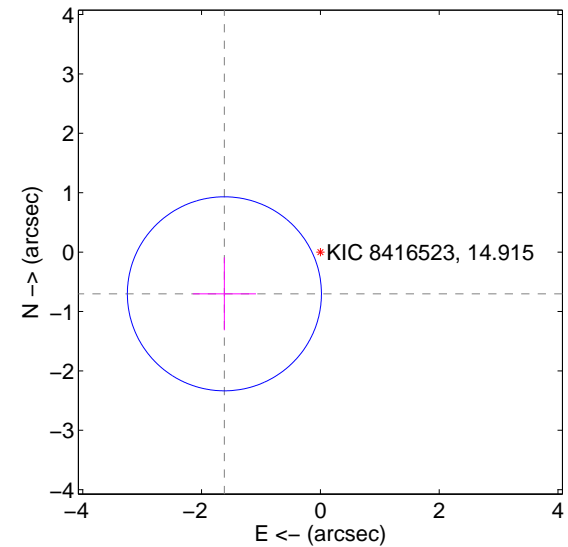
offset from difference PRF-fit to OOT PRF-fit



offset from difference PRF-fit to KIC position

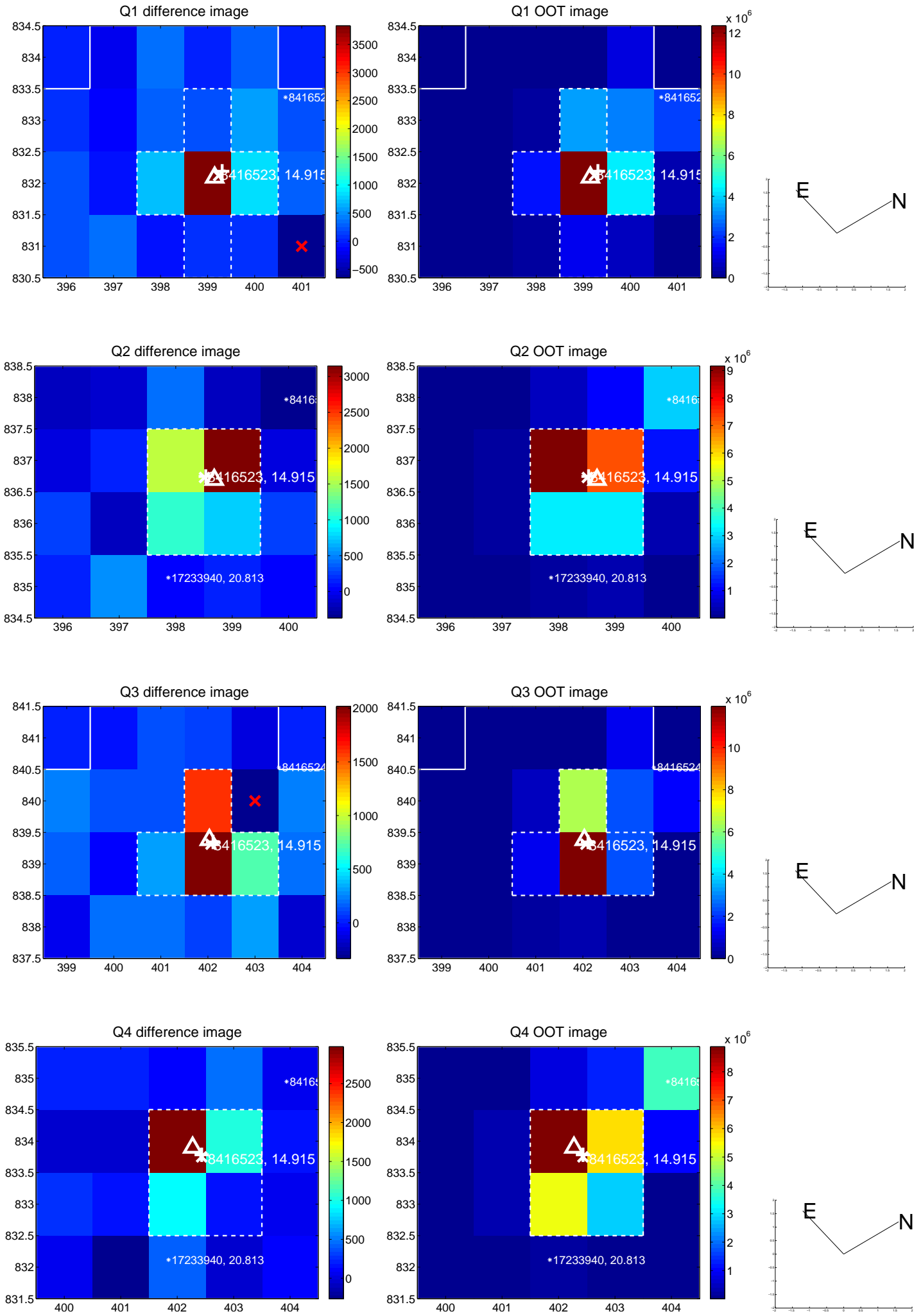


offset from photometric centroids

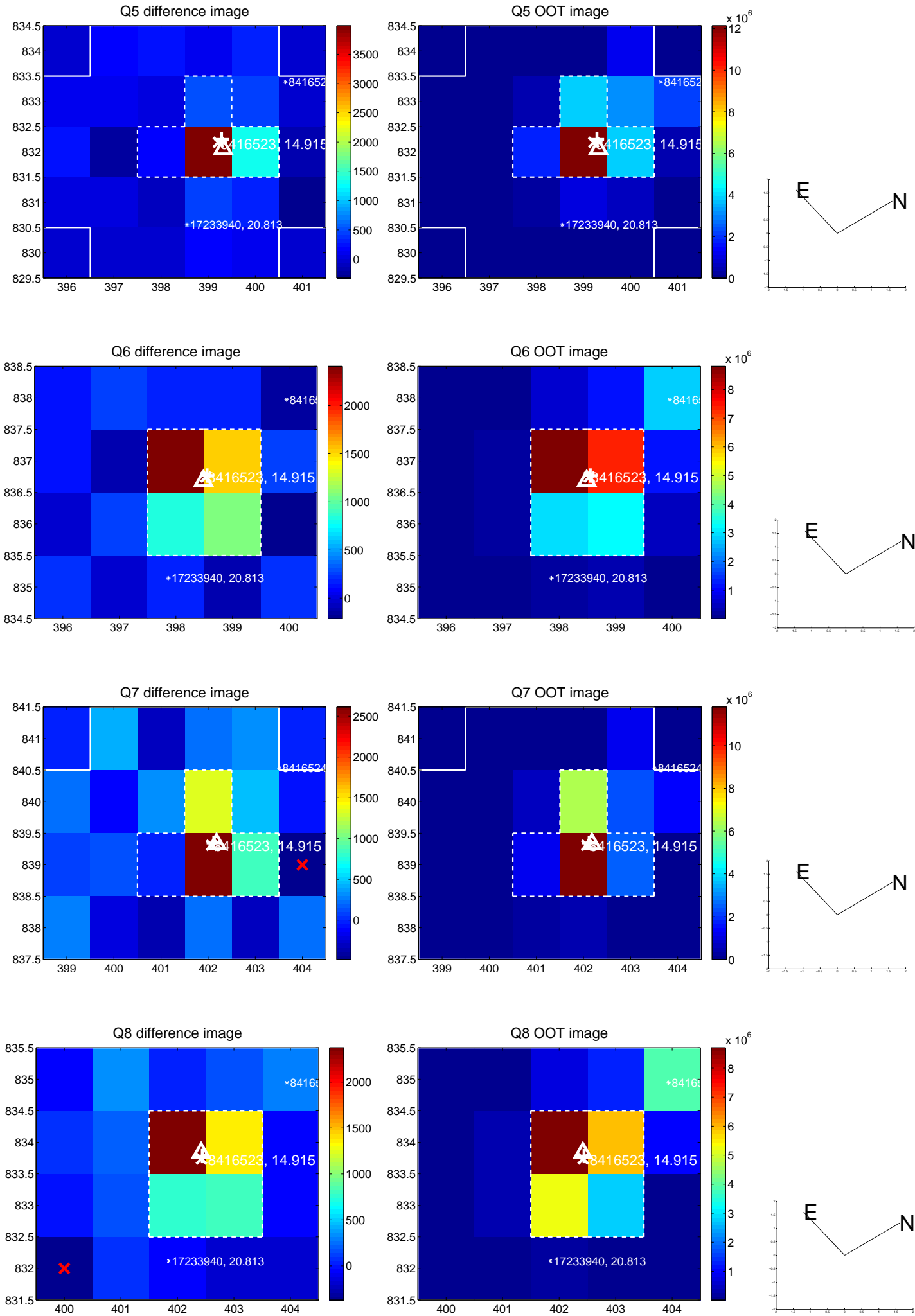


Centroid source offsets from the target star reconstructed from PRF and photometric centroids. **Sky blue crosses: good quarterly centroid offsets; Vermillion crosses: bad quarterly centroid offsets**; magenta cross: average over quarters. Length of the crosses: one- $\sigma$  uncertainty. Blue circle: three- $\sigma$ . Red \*: target star. Blue \*: Other stars. Text next to a star gives its KIC ID and kepmag. KIC IDs > 15,000,000 are from the UKIRT catalog.

white  $\times$ : KIC target position; +: OOT centroid;  $\triangle$ : difference centroid. red  $\times$ : large negative pixel value.

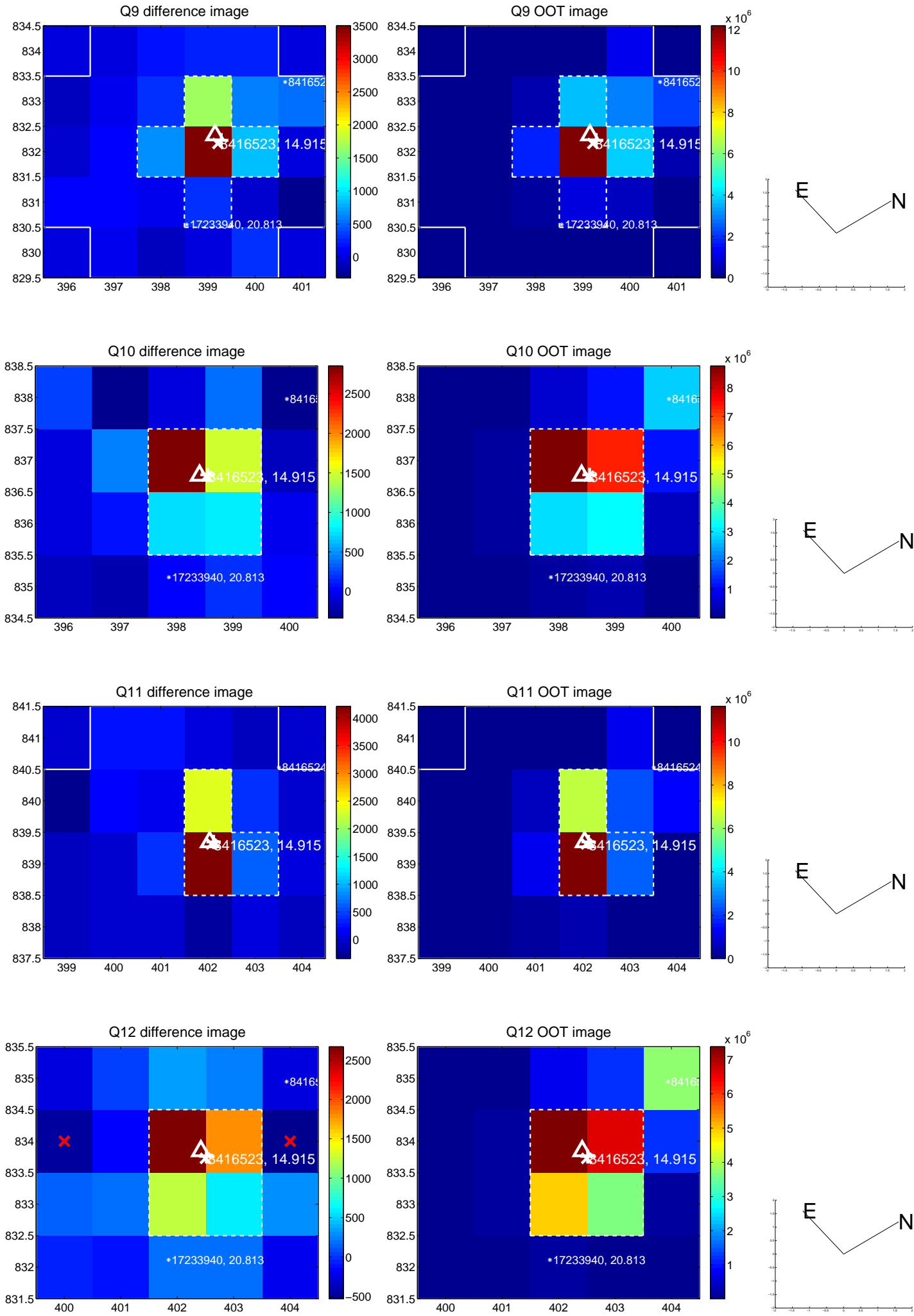


white  $\times$ : KIC target position; +: OOT centroid;  $\triangle$ : difference centroid. red  $\times$ : large negative pixel value.

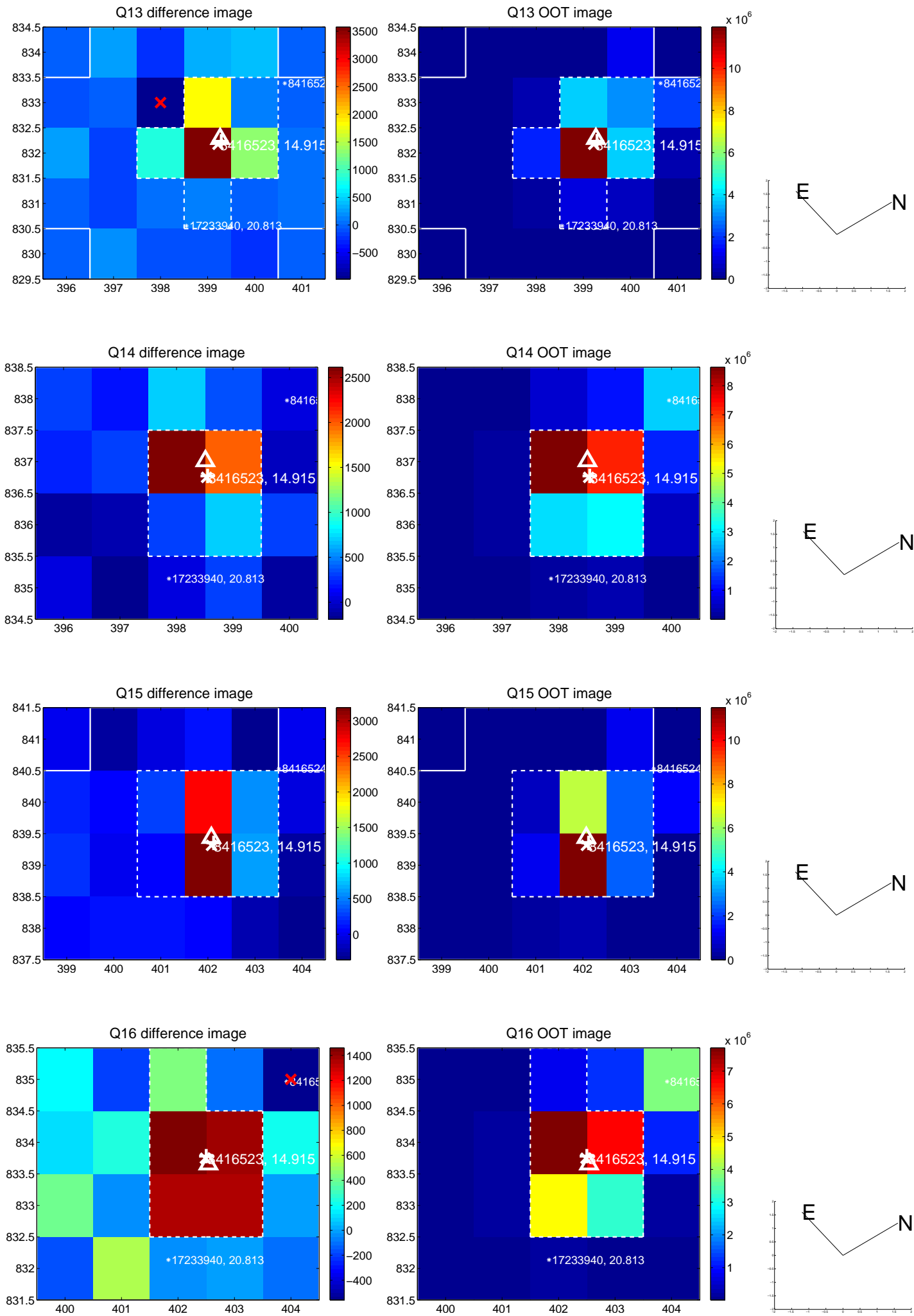




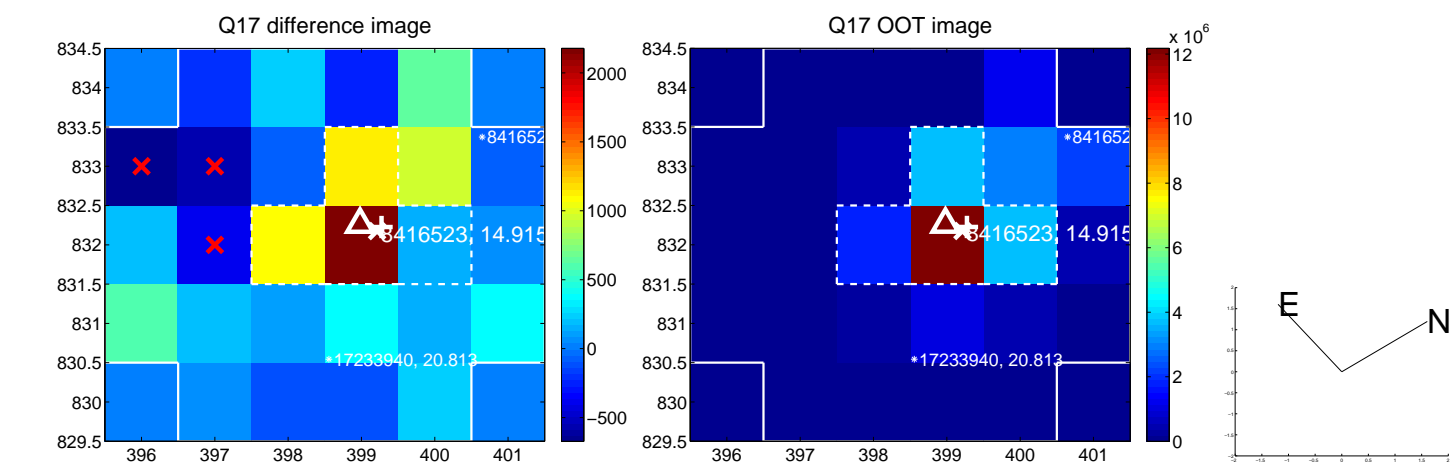
white  $\times$ : KIC target position; +: OOT centroid;  $\triangle$ : difference centroid. red  $\times$ : large negative pixel value.



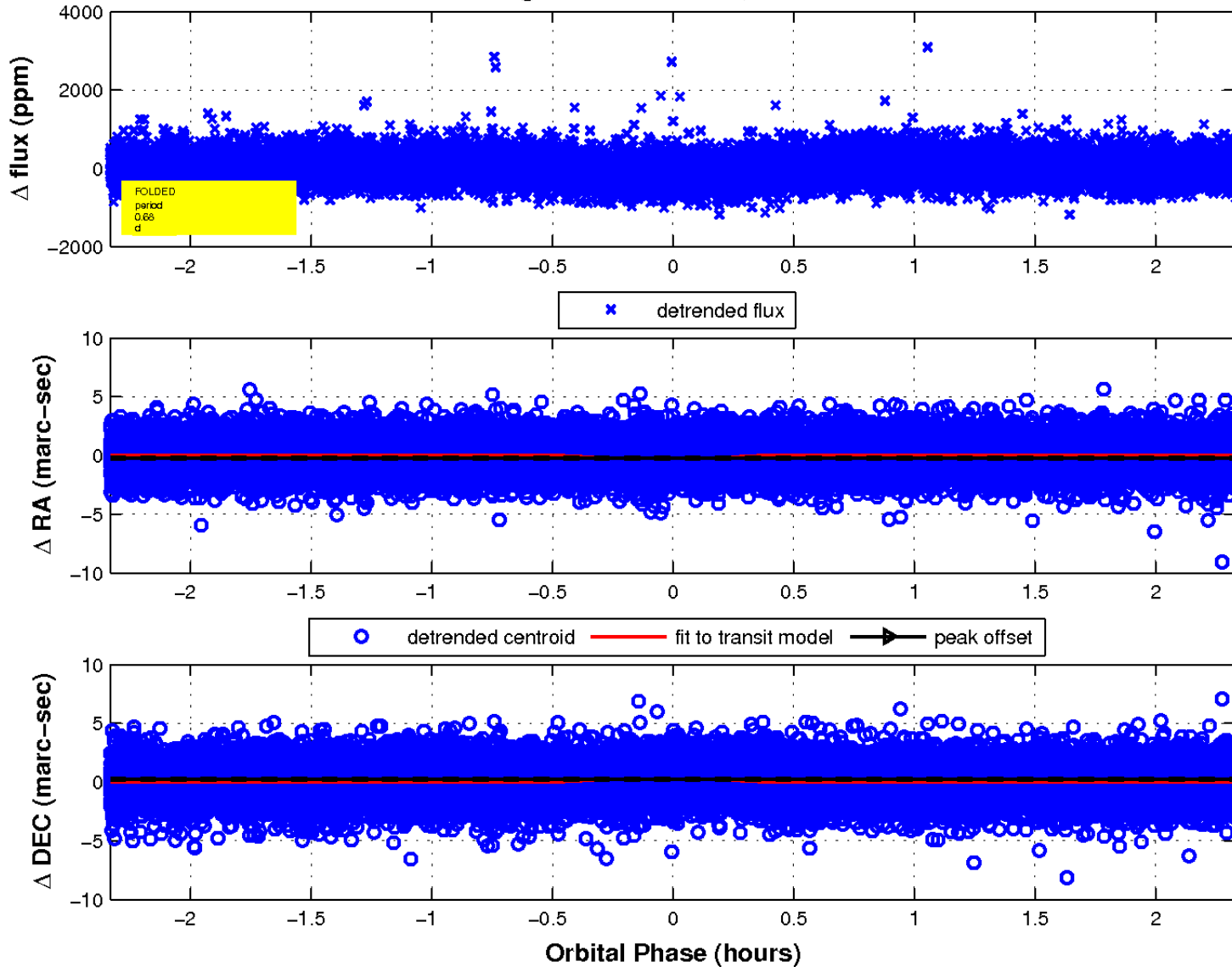
white  $\times$ : KIC target position; +: OOT centroid;  $\triangle$ : difference centroid. red  $\times$ : large negative pixel value.



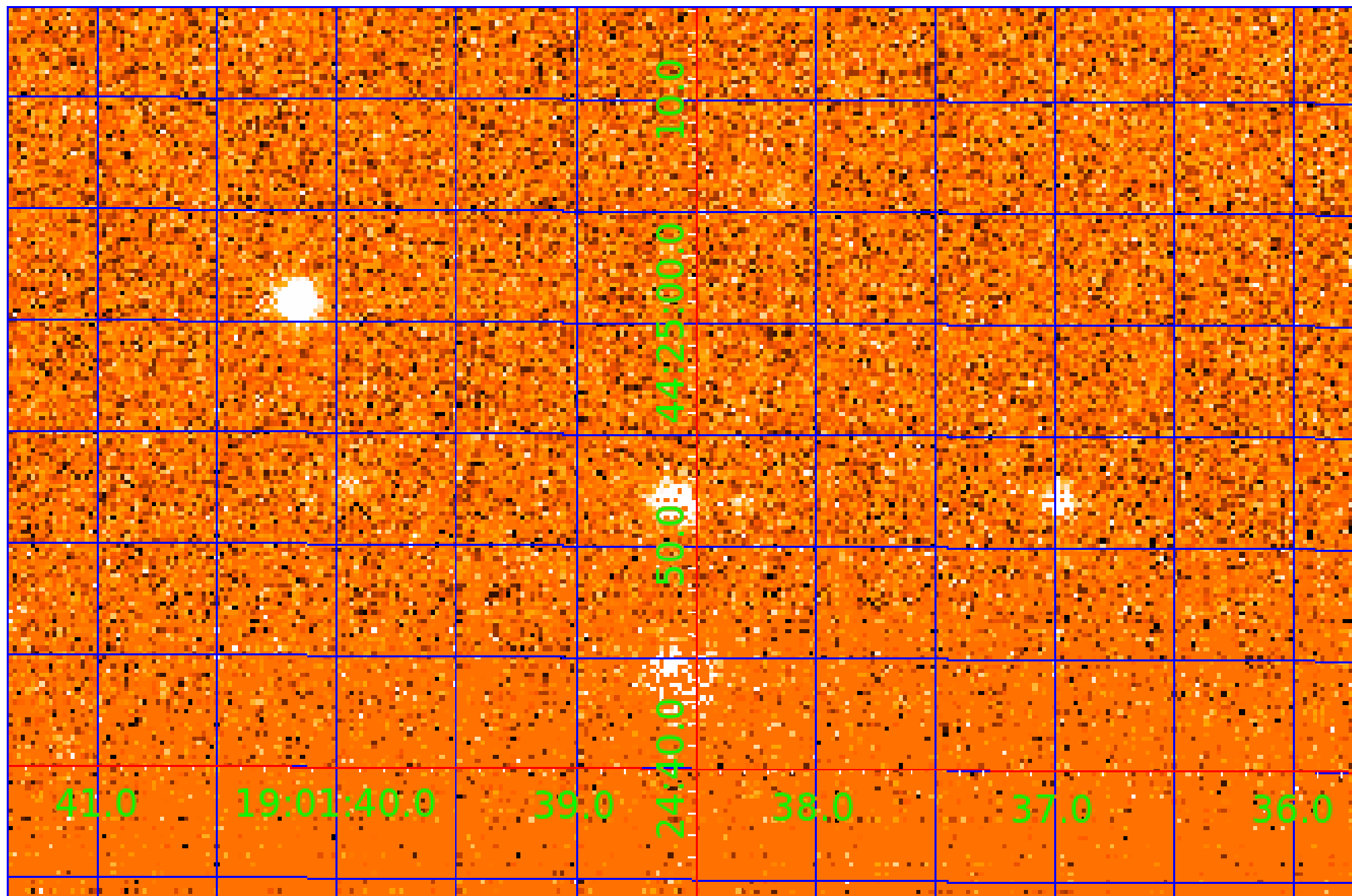
white  $\times$ : KIC target position;  $+$ : OOT centroid;  $\Delta$ : difference centroid. red  $\times$ : large negative pixel value.



fluxWeightedCentroids, Planet 1 of 2



# UKIRT Image





# KIC 008416523

## Q1-17 DR25 TCE Parameters

TCE	Run Type	KOI?	Period (Days)	Epoch (BKJD)	Depth (ppm)	Duration (Hours)	MES	SNR	$R_{\star}$ ( $R_{\odot}$ )	$T_{\star}$ (K)	$R_p$ ( $R_{\oplus}$ )	$S_p$ ( $S_{\oplus}$ )
008416523-01	OBS	4441.01	0.683677	131.667293	134.7	0.778	12.5	20.2	0.75	5016	1.08	1575.45
008416523-02	OBS	No	0.683676	132.006911	149.8	0.759	13.2	22.9	0.75	5016	1.14	1575.45

## Robovetter Results

TCE	Run Type	Disp	Score	N	S	C	E	Comments
008416523-01	OBS	PC	1.00	0	0	0	0	MOD_SEC_DV—MOD_SEC_ALT—PLANET_PERIOD_IS_HALF_ALT—HAS_SEC_TCE
008416523-02	OBS	FP	0.00	1	1	0	0	IS_SEC_TCE

**Notes:** OBS = Observed. INJ = Injected. INV = Inverted. SCR = Scrambled.

N = Not Transit-Like. S = Stellar Eclipse. C = Centroid Offset. E = Ephemeris Match.

See [http://exoplanetarchive.ipac.caltech.edu/docs/API\\_kepcandidate\\_columns.html#proj\\_disp\\_col](http://exoplanetarchive.ipac.caltech.edu/docs/API_kepcandidate_columns.html#proj_disp_col) for comment definitions.

## Ephemeris Match Information For 008416523-02

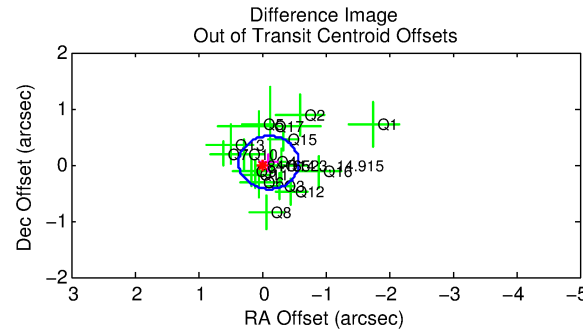
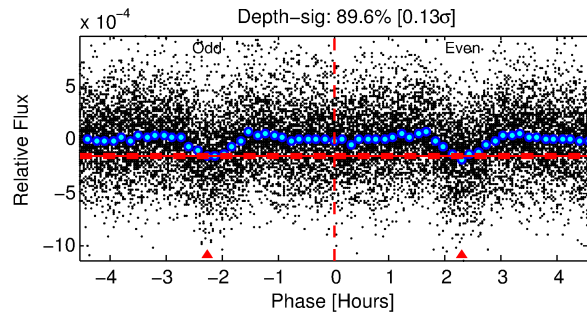
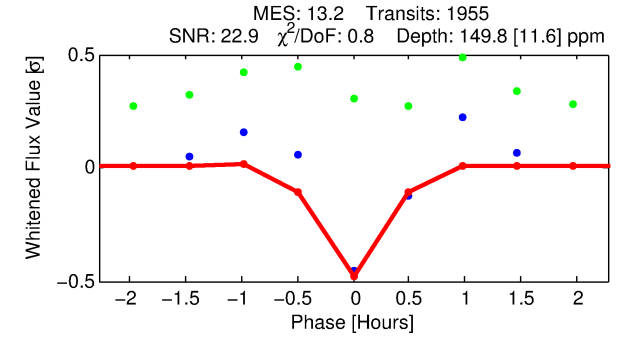
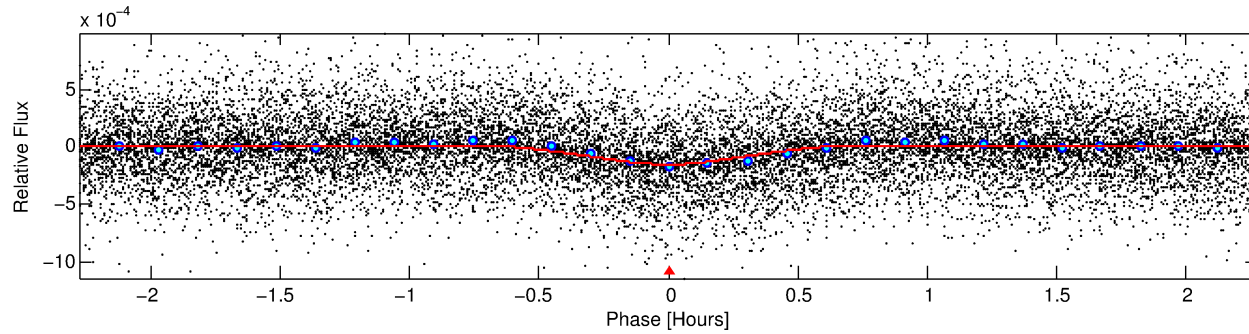
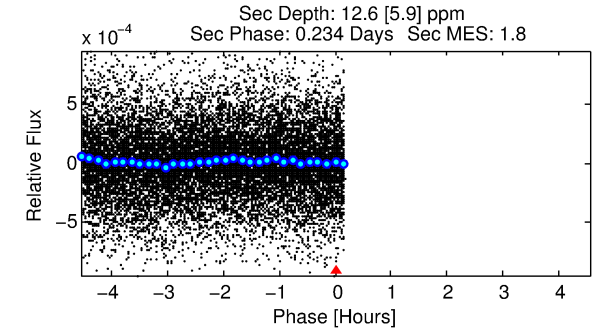
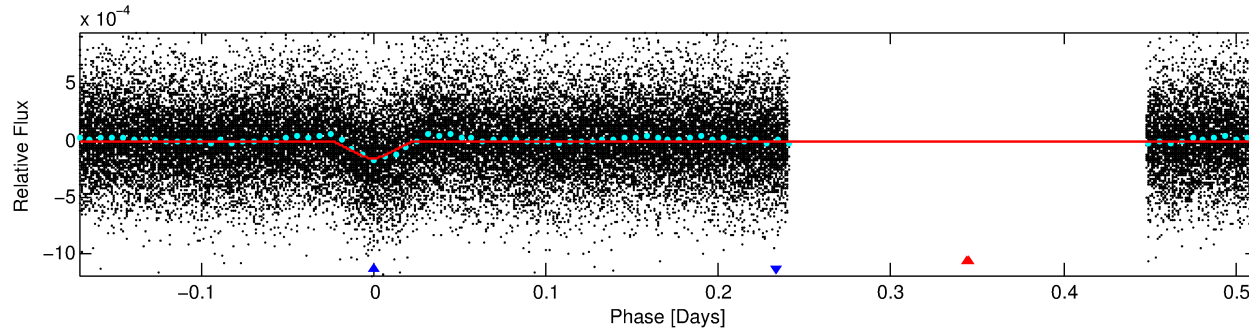
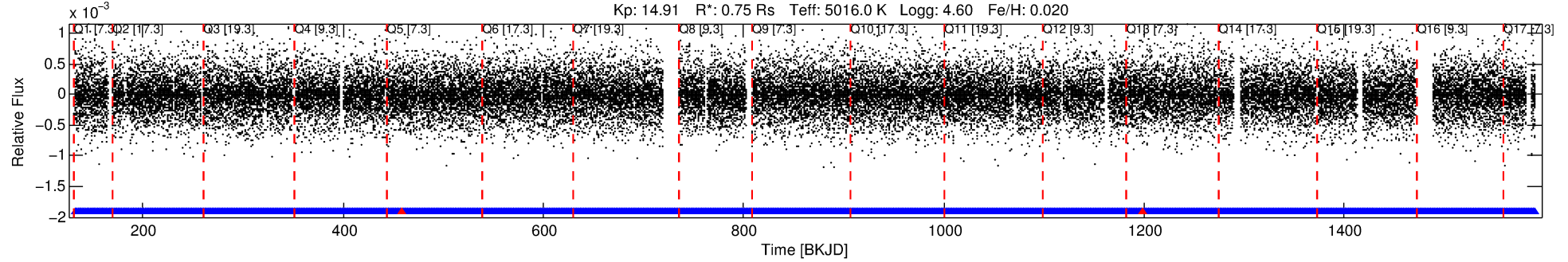
No Significant Match Found

# DV One-Page Summary

KIC: 8416523 Candidate: 2 of 2 Period: 0.684 d

KOI: K04441 Corr: No Ephemeris Match

Kp: 14.91 R\*: 0.75 Rs Teff: 5016.0 K Logg: 4.60 Fe/H: 0.020



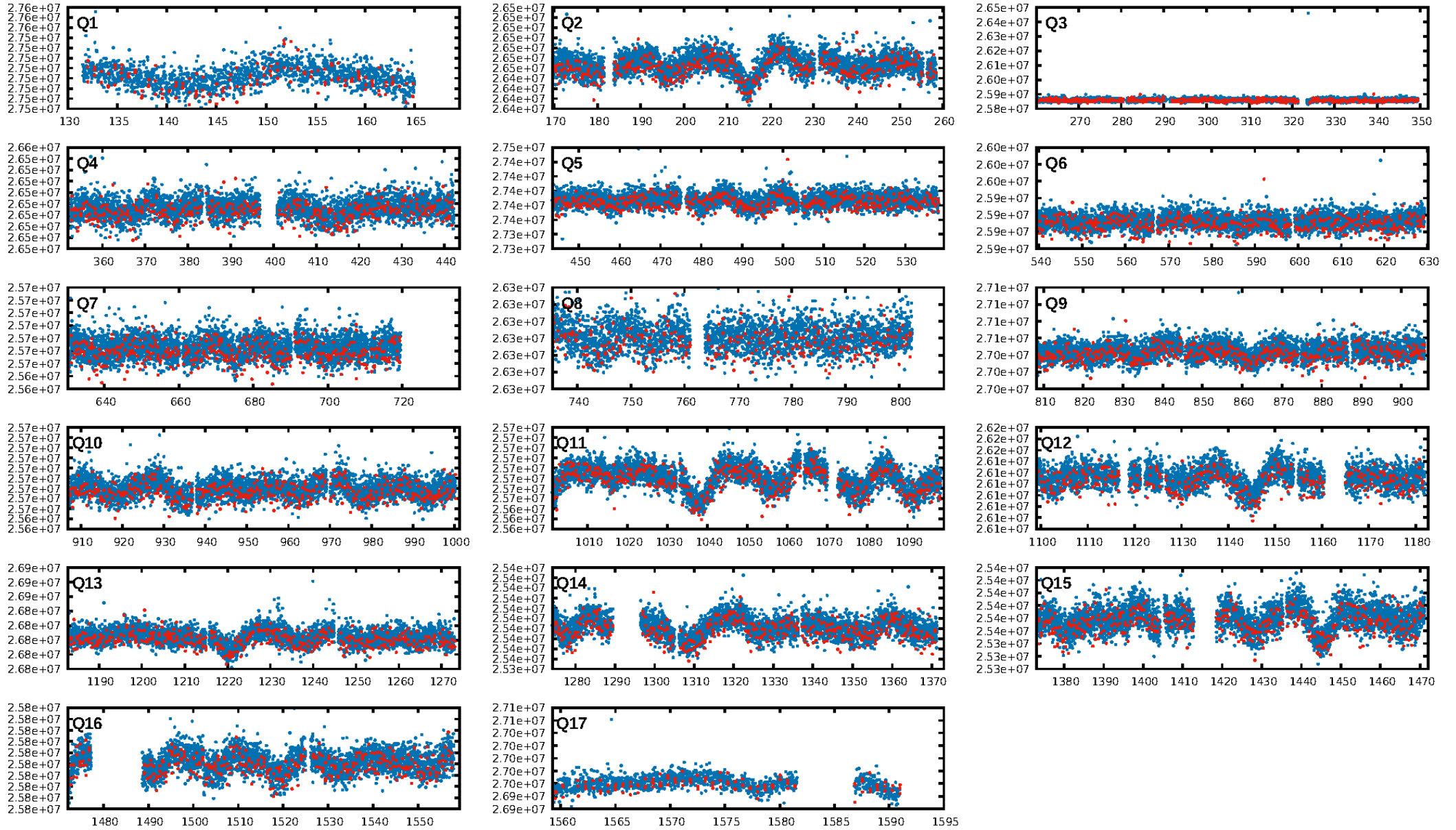
## DV Fit Results:

Period = 0.68368 [0.00000] d  
Epoch = 132.0069 [0.0006] BKJD  
Rp/R\* = 0.0140 [0.0043]  
a/R\* = 3.33 [3.66]  
b = 0.90 [0.26]  
Seff = 1575.45 [281.55]  
Teff = 1606 [72] K  
Rp = 1.14 [0.37] Re  
a = 0.0142 [0.0013] AU  
Ag = 1.08 [0.84] [0.09σ]  
Teffp = 2530 [491] K [1.86σ]

## DV Diagnostic Results:

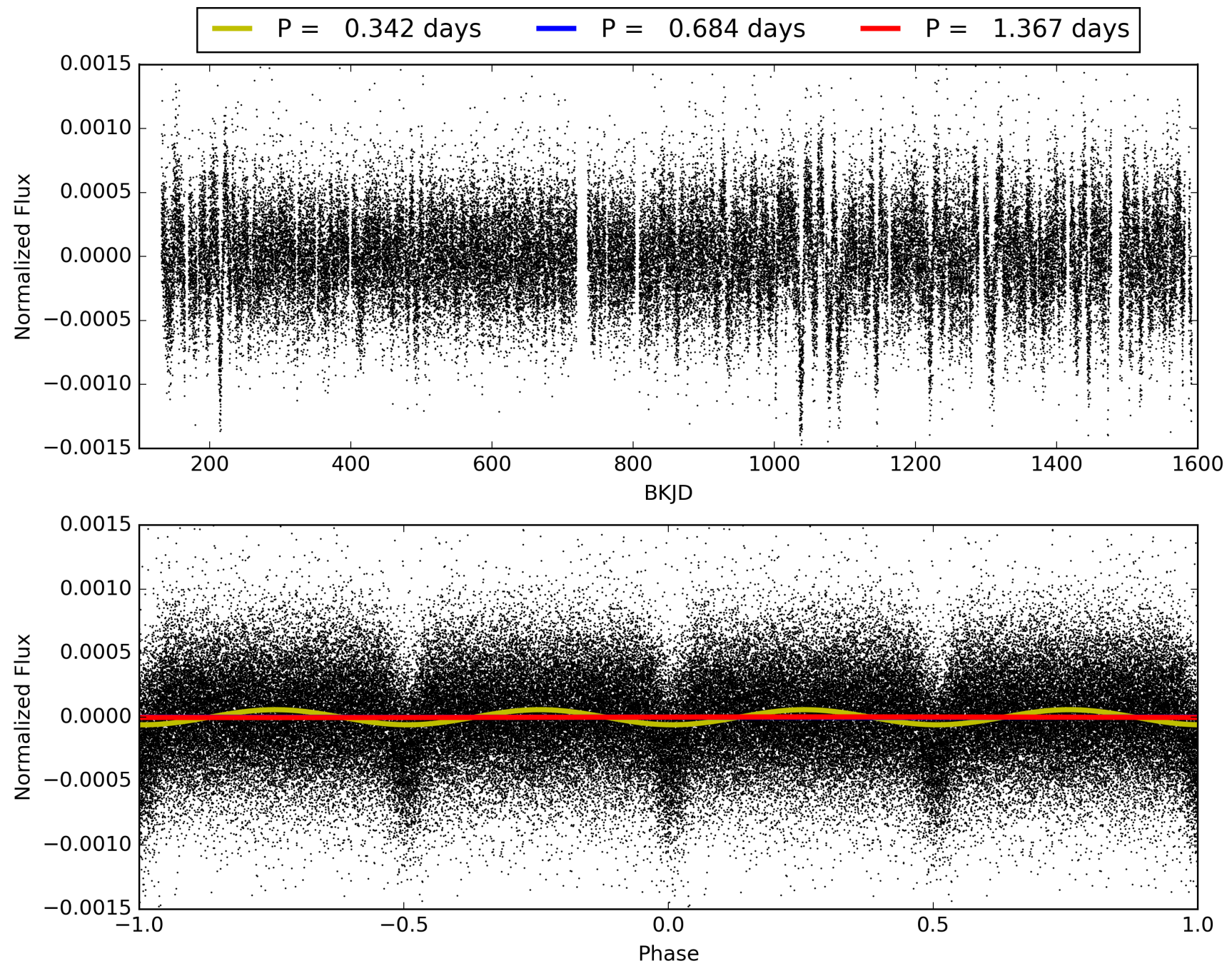
ShortPeriod-sig: N/A  
LongPeriod-sig: 0.0% [0.00σ]  
ModelChiSquare2-sig: N/A  
ModelChiSquareGof-sig: N/A  
Bootstrap-pfa: 1.09e-42  
RollingBand-fgt: 1.00 [1865/1867]  
GhostDiagnostic-chr: 6.561  
Centroid-sig: 0.0%  
Centroid-so: 2.233 arcsec [4.03σ]  
OotOffset-rm: 0.113 arcsec [0.72σ]  
KicOffset-rm: 0.245 arcsec [1.65σ]  
OotOffset-st: 4/4/4/5 [17]  
KicOffset-st: 4/4/4/5 [17]  
DiffImageQuality-fgm: 1.00 [17/17]  
DiffImageOverlap-fno: 1.00 [17/17]

# TCE 008416523-02, PDC Light Curves





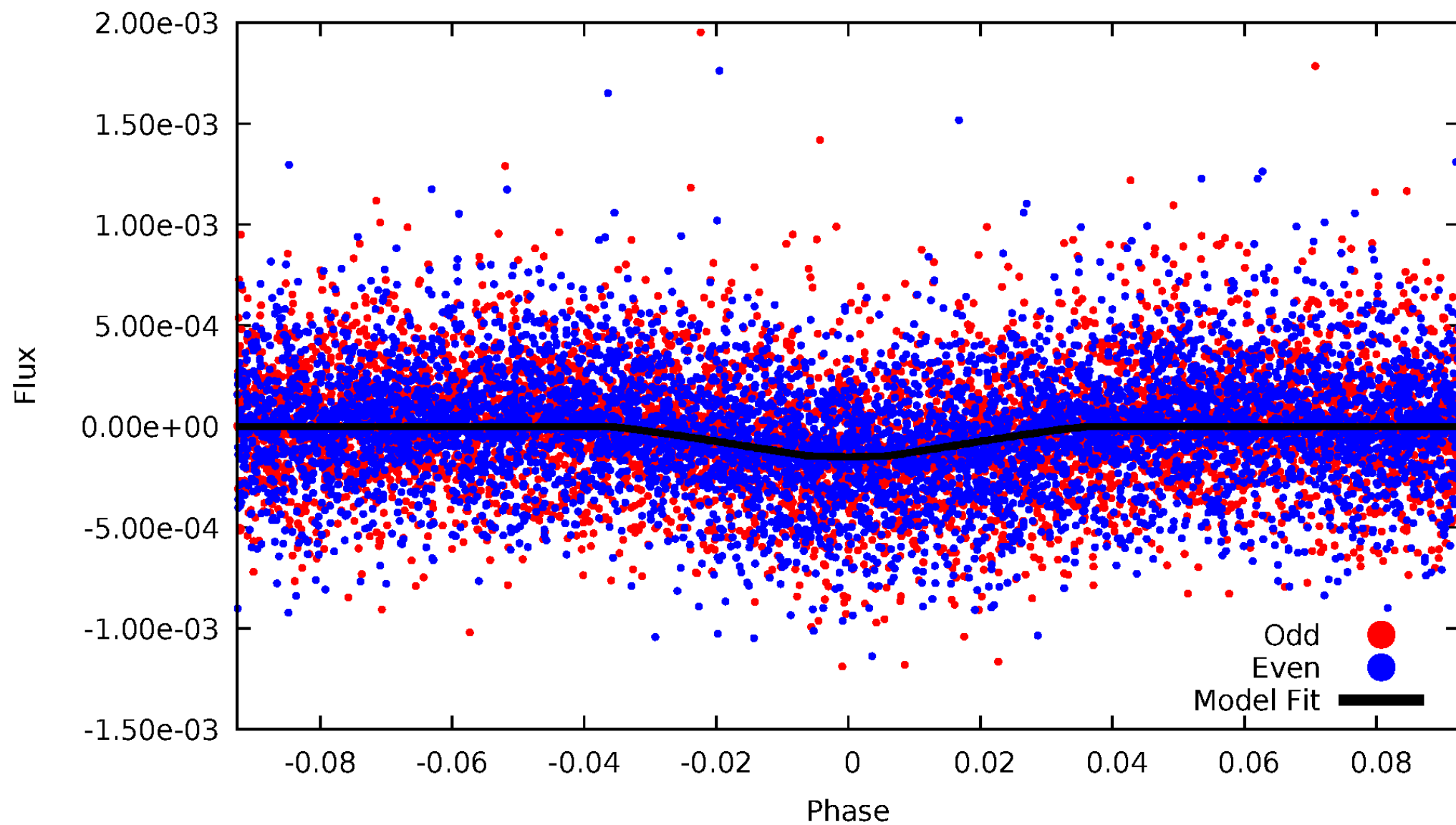
# TCE 008416523-02





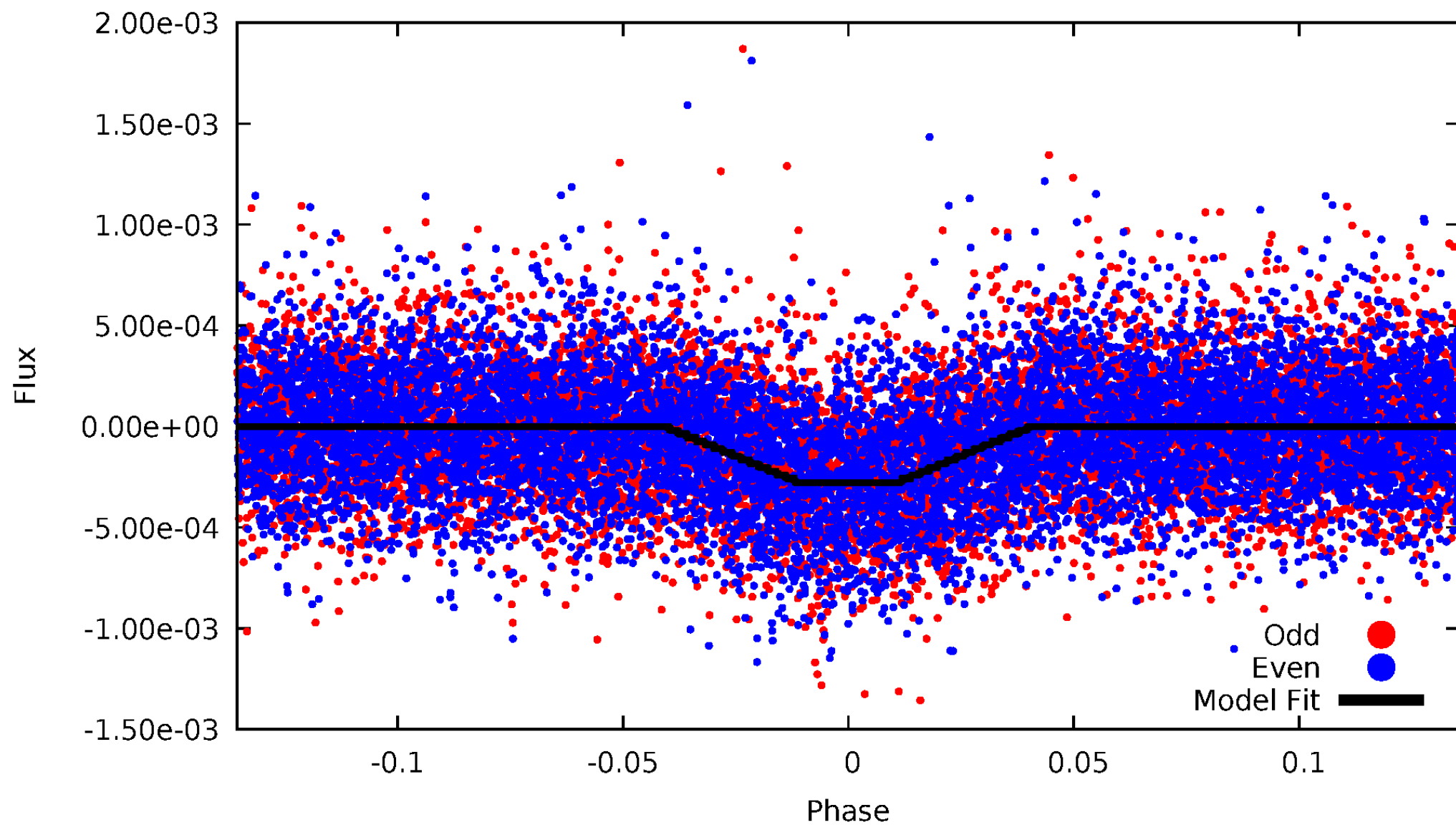
# DV Odd/Even

TCE 008416523-02



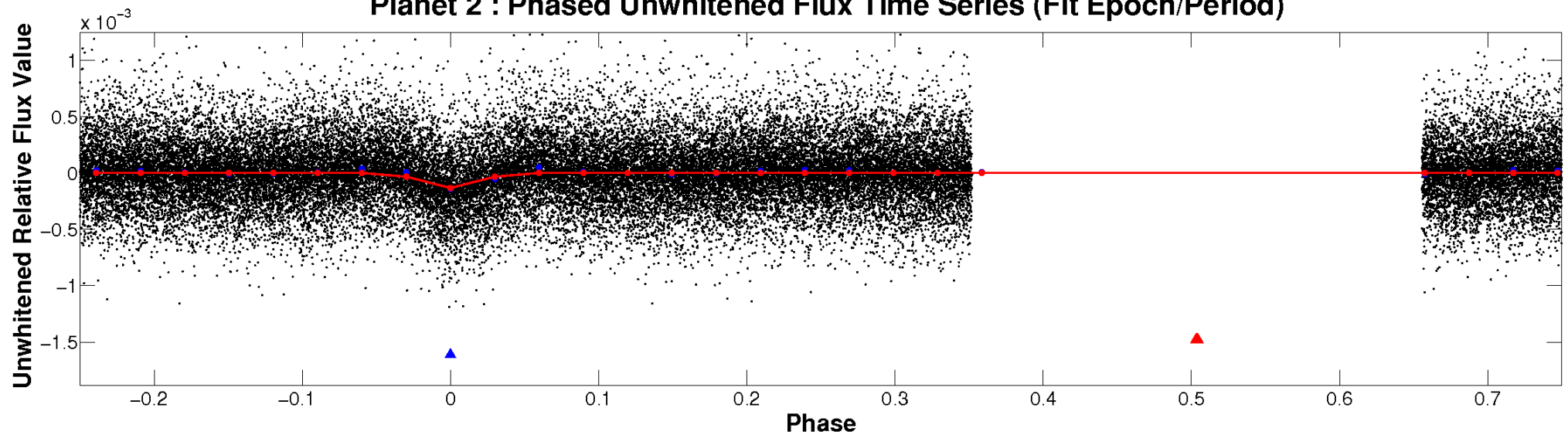
# ALT Odd/Even

TCE 008416523-02

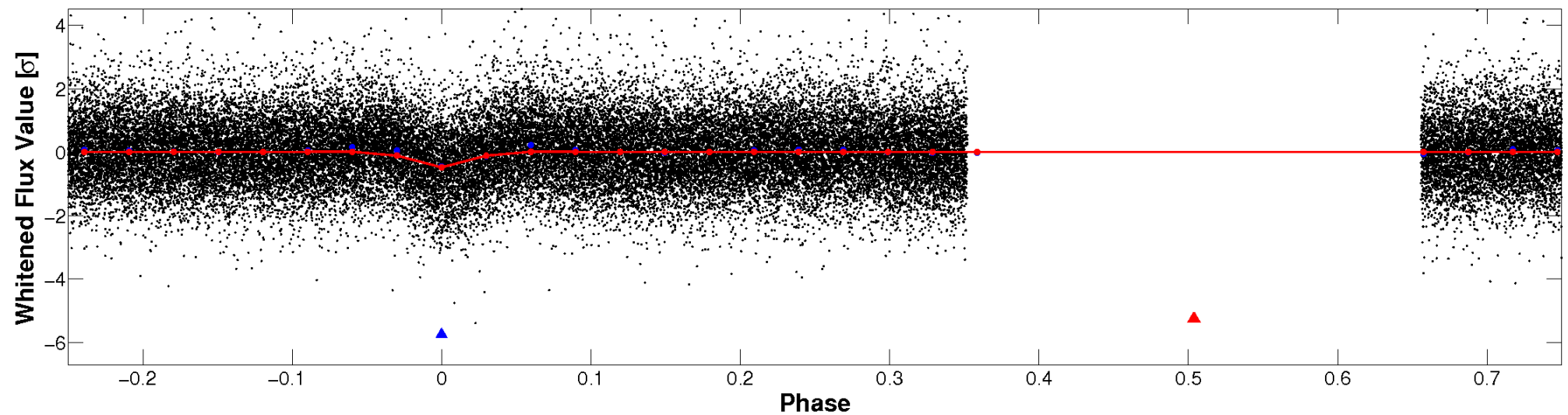


# Non-Whitened Vs. Whitened Light Curve

## Planet 2 : Phased Unwhitened Flux Time Series (Fit Epoch/Period)

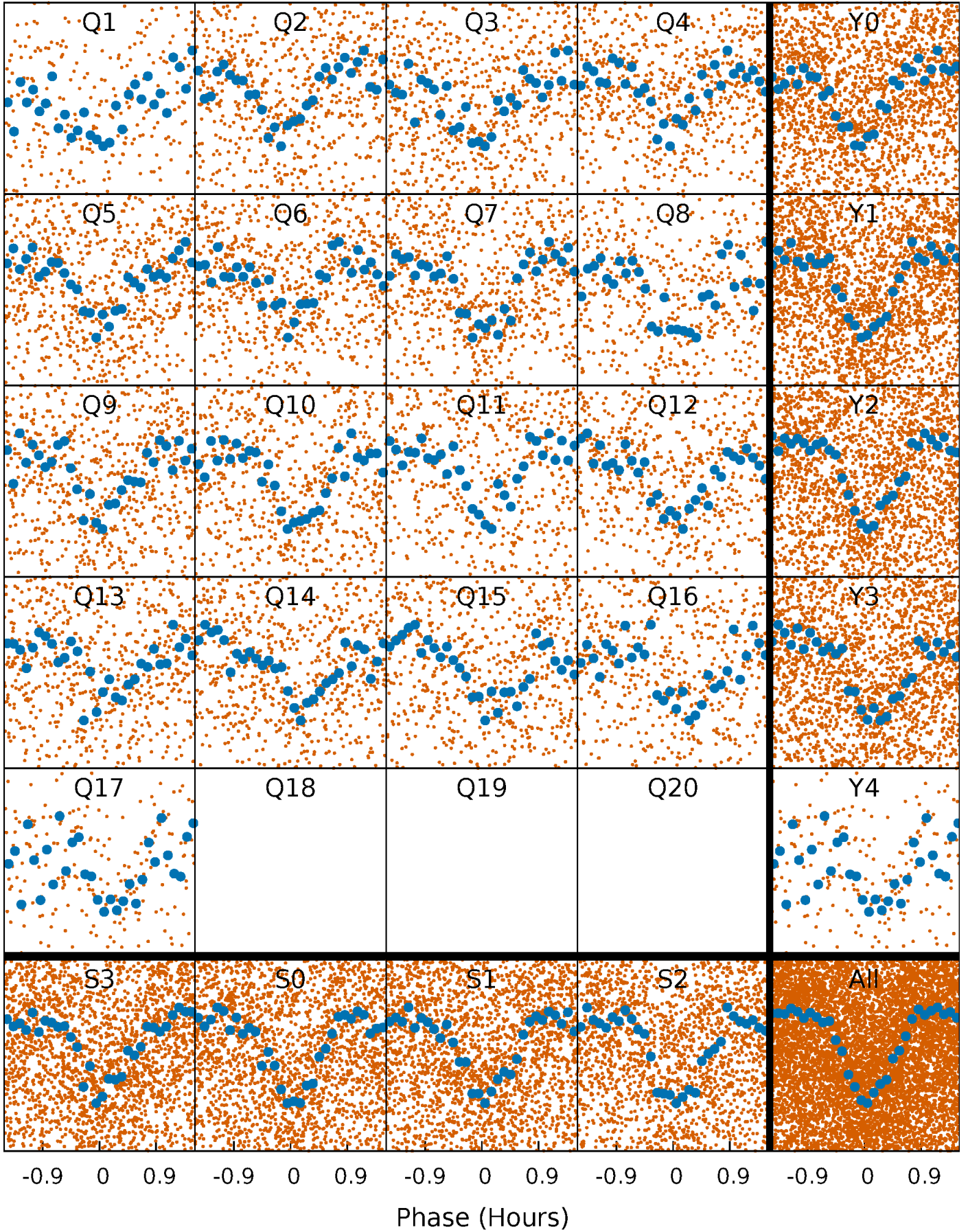


## Planet 2 : Phased Whitened Flux Time Series (Fit Epoch/Period)



# PDC Quarter-Phased Transit Curves

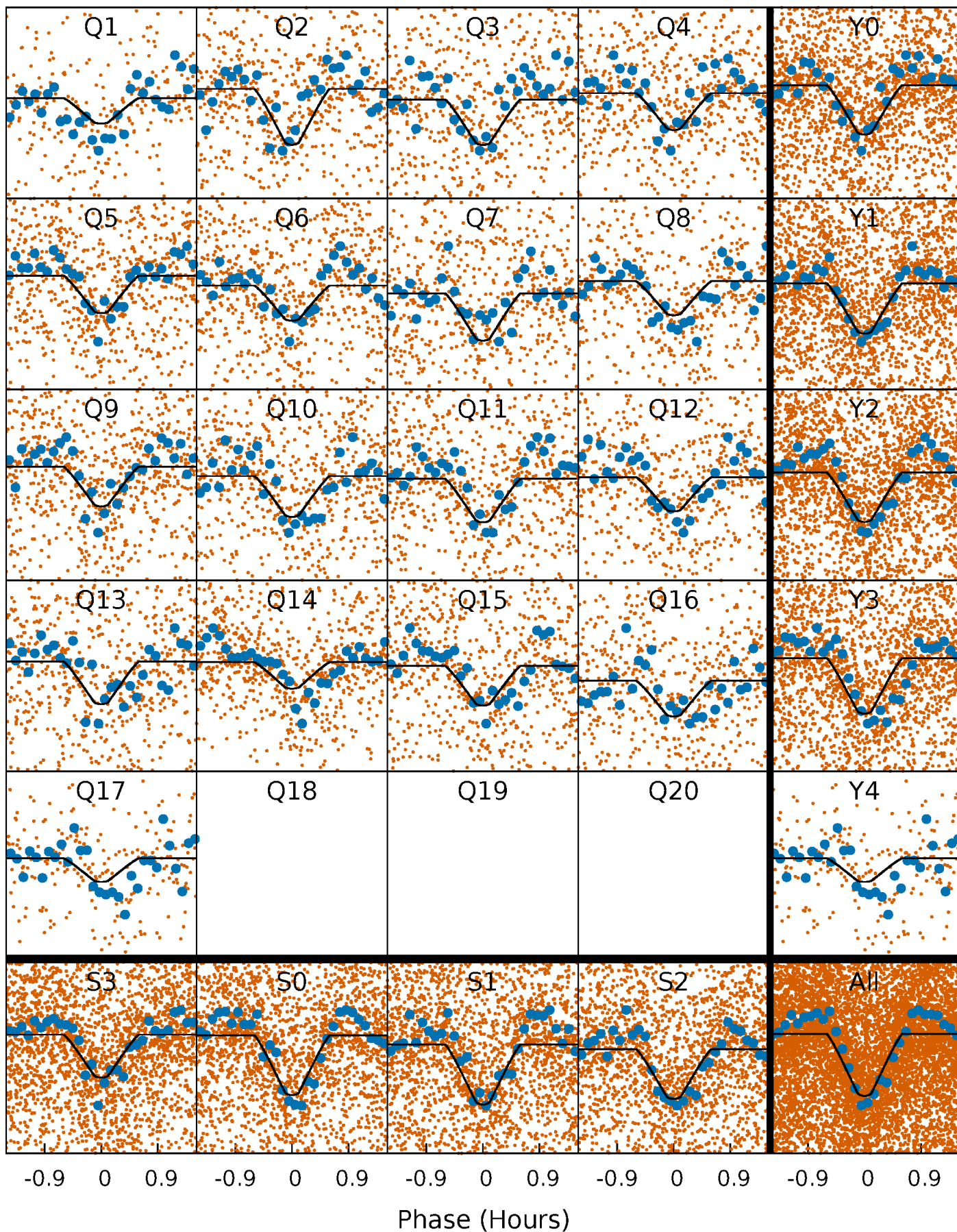
TCE 008416523-02   P= 0.683676 Days    $T_0=132.006911$  (BKJD)





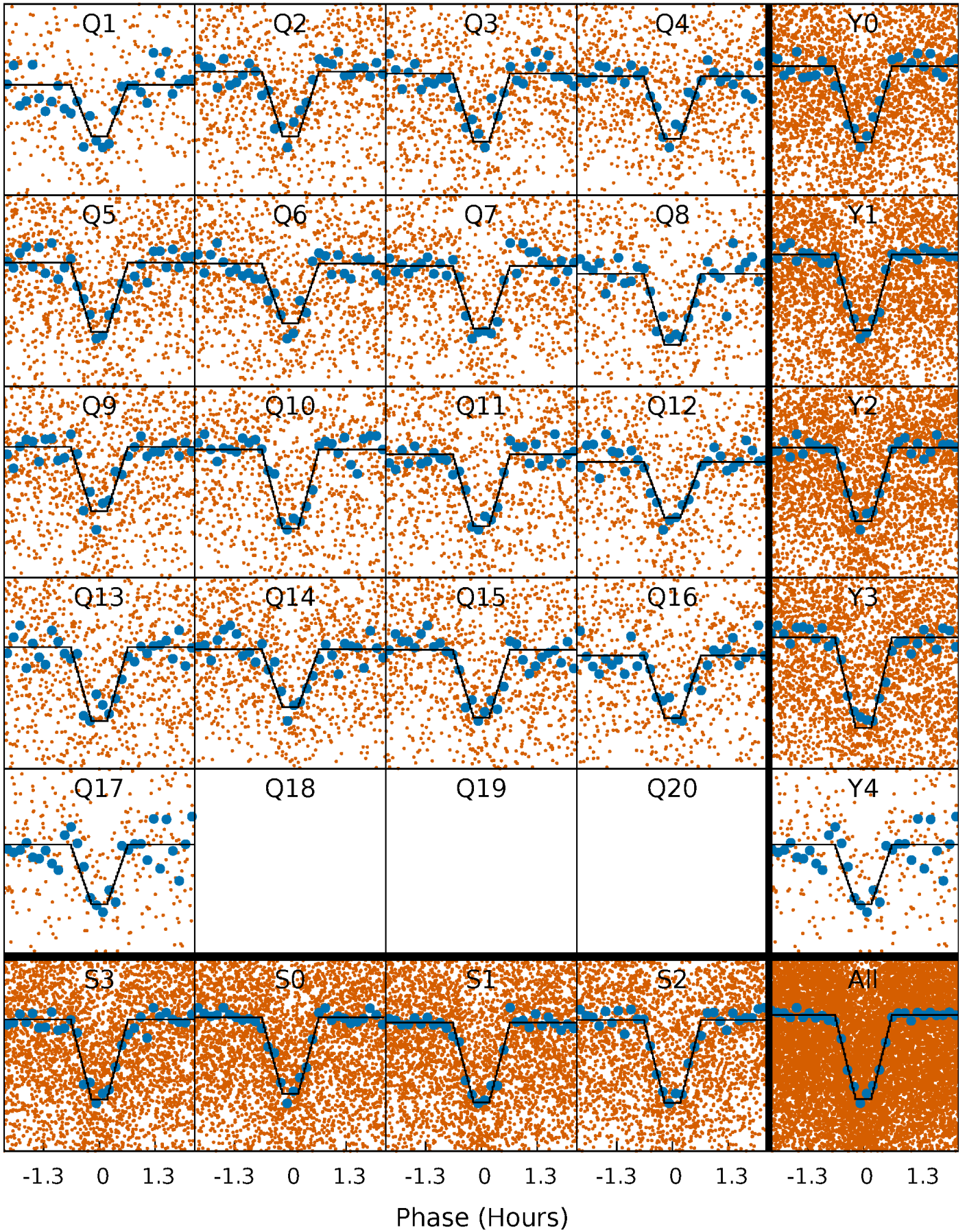
# DV Quarter-Phased Transit Curves

TCE 008416523-02 P= 0.683676 Days  $T_0=132.006911$  (BKJD)



# Alt. Detrend Quarter-Phased Transit Curves

TCE 008416523-02 P= 0.683681 Days  $T_0=132.004946$  (BKJD)

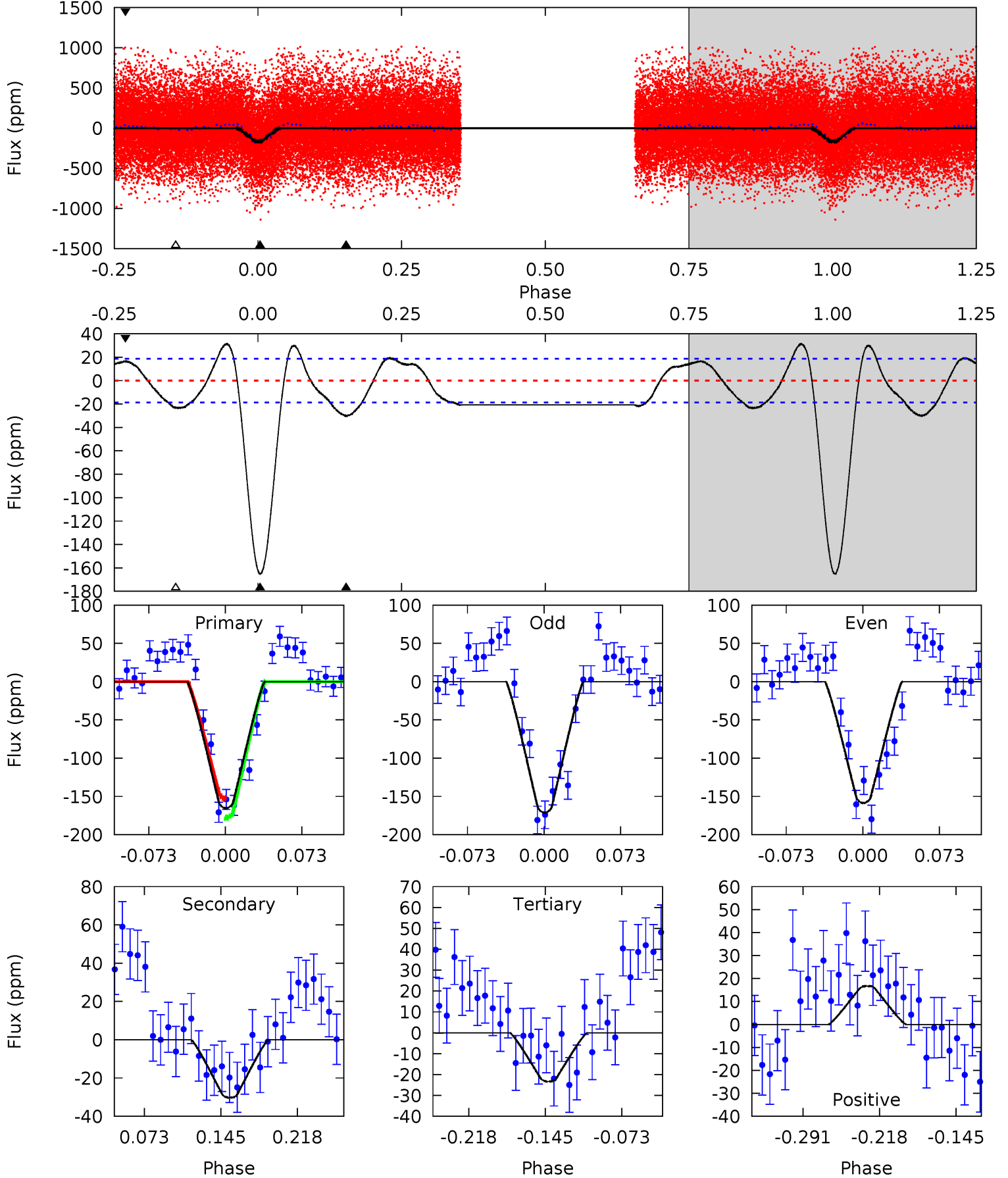




# DV Model-Shift Uniqueness Test

008416523-02, P = 0.683676 Days, E = 131.323235 Days

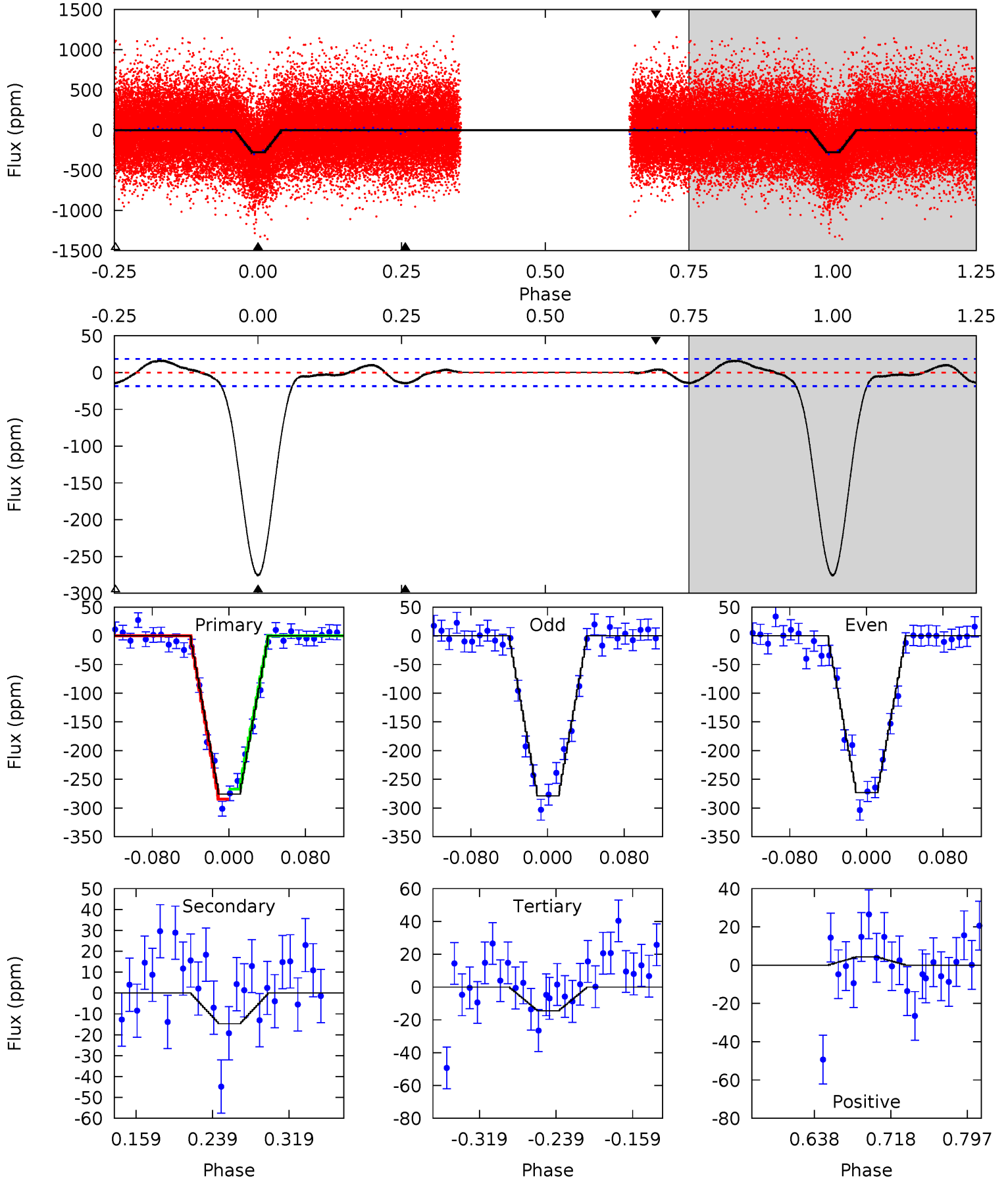
Pri	Sec	Ter	Pos	FA <sub>1</sub>	FA <sub>2</sub>	F <sub>Red</sub>	Pri-Ter	Pri-Pos	Sec-Ter	Sec-Pos	Odd-Evn	DMM	Shape	TAT
40.9	7.49	5.78	4.14	4.63	1.79	3.58	35.1	36.8	1.71	3.35	1.57	1.00	0.16	3.16



# Alt Model-Shift Uniqueness Test

008416523-02, P = 0.683681 Days, E = 131.321265 Days

Pri	Sec	Ter	Pos	FA <sub>1</sub>	FA <sub>2</sub>	F <sub>Red</sub>	Pri-Ter	Pri-Pos	Sec-Ter	Sec-Pos	Odd-Evn	DMM	Shape	TAT
68.8	3.67	3.60	1.06	4.61	1.75	1.86	65.2	67.7	0.07	2.61	0.69	1.00	0.06	2.14



### Stellar Parameters For KIC 008416523

	$T_{\text{eff}}(K)$	$\log(g)$	[Fe/H]	$R (R_{\odot})$	$M(M_{\odot})$	$p_{\star} (\text{g}\cdot\text{cm}^{-3})$
	$5016^{+151}_{-136}$	$4.601^{+0.030}_{-0.070}$	$0.020^{+0.250}_{-0.300}$	$0.747^{+0.086}_{-0.058}$	$0.817^{+0.057}_{-0.078}$	$2.759^{+0.430}_{-0.651}$
	+3%/-3%	+1%/-2%	+1250%/-1500%	+12%/-8%	+7%/-10%	+16%/-24%
Source	PHO1	KIC0	KIC0	DSEP		

KIC = Kepler Input Catalog; PHO = Photometry; SPE = Spectroscopy; AST = Asteroseismology  
 TRA = Transits; DESP = Dartmouth Models; MULT = Multiple Models

### Secondary Eclipse Parameters for KIC 008416523-02 / KOI

Detrend	Depth (ppm)	$R_p (R_{\oplus})$	$T_{\text{max}} (K)$	$T_{\text{obs}} (K)$	$A_{\text{obs}}$
DV	$-30 \pm 4$	$1.14^{+0.38}_{-0.35}$	$2266^{+82}_{-76}$	$3513^{+498}_{-353}$	$2.508^{+2.792}_{-1.091}$
Alt.	$-15 \pm 4$	$1.38^{+0.37}_{-0.37}$	$2263^{+89}_{-70}$	$2832^{+394}_{-330}$	$0.824^{+0.836}_{-0.331}$

$T_{\text{max}}$  = Theoretical Maximum Planetary Temperature

$T_{\text{obs}}$  = Observed Planetary Temperature (Assuming A=0.3)

$A_{\text{obs}}$  = Observed Albedo (Assuming T=0)

If a secondary eclipse is present, the system is likely an EB if  $T_{\text{obs}} \gg T_{\text{max}}$  AND  $A_{\text{obs}} \gg 1.0$

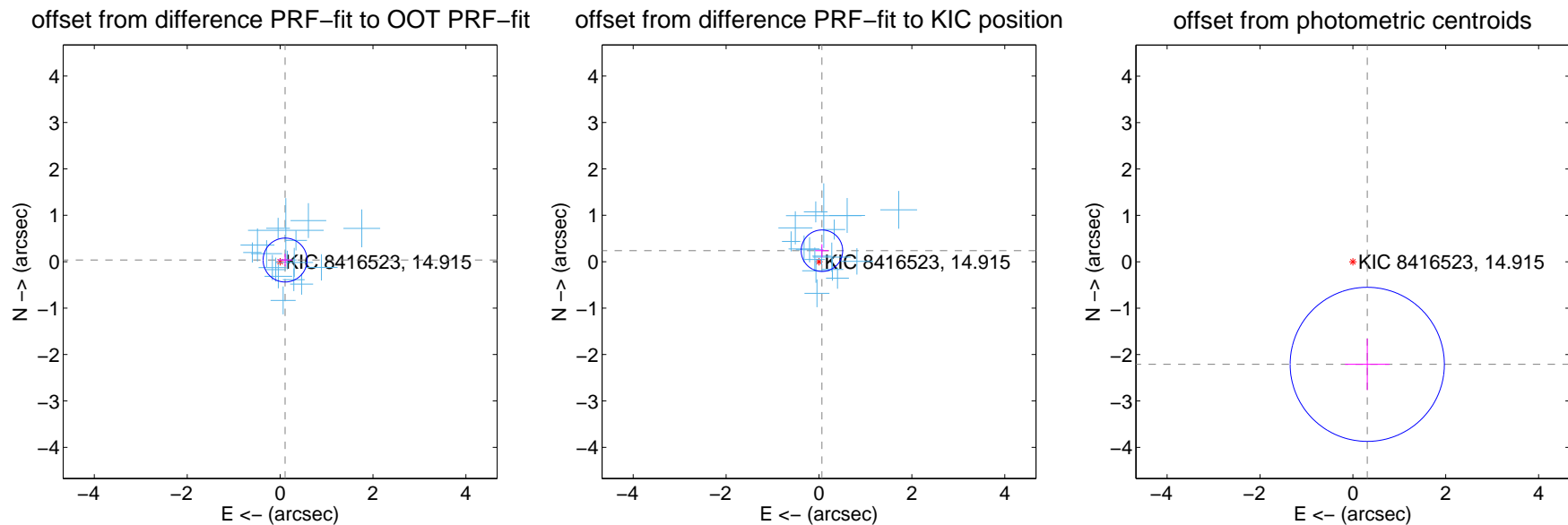
## DV Centroid Data

Supplemental centroid analysis for 008416523-02. Kepler magnitude: 14.91. Transit SNR 22.93

There are 17 quarters with good PRF difference image offsets

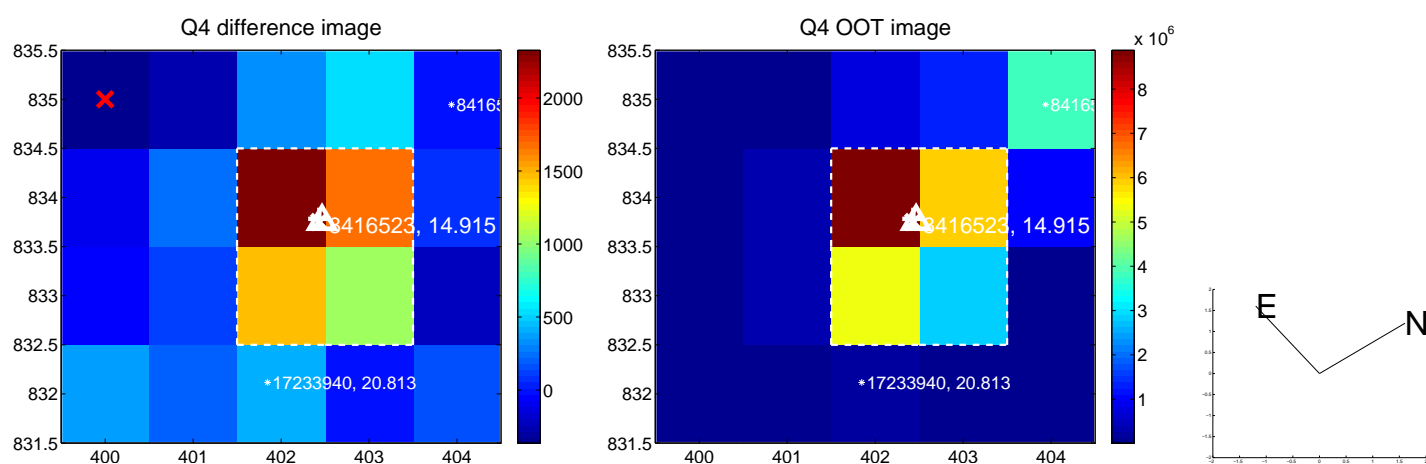
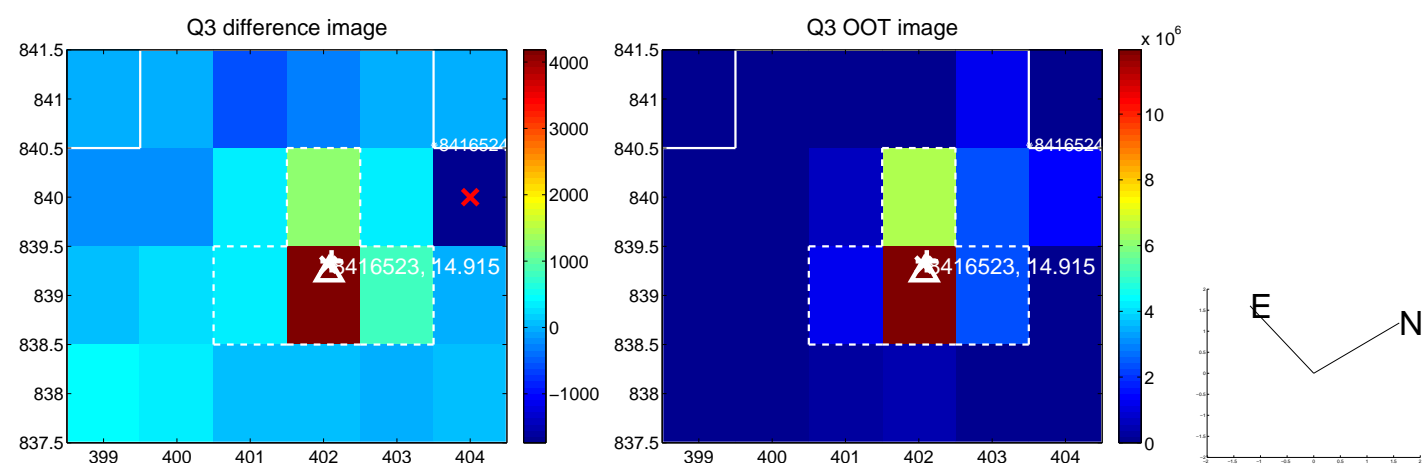
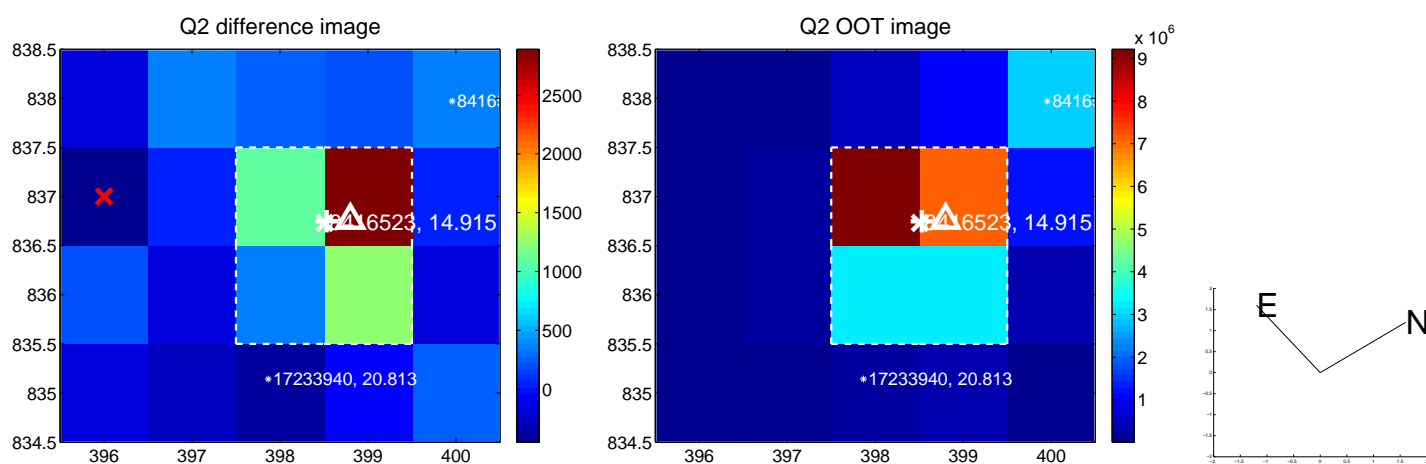
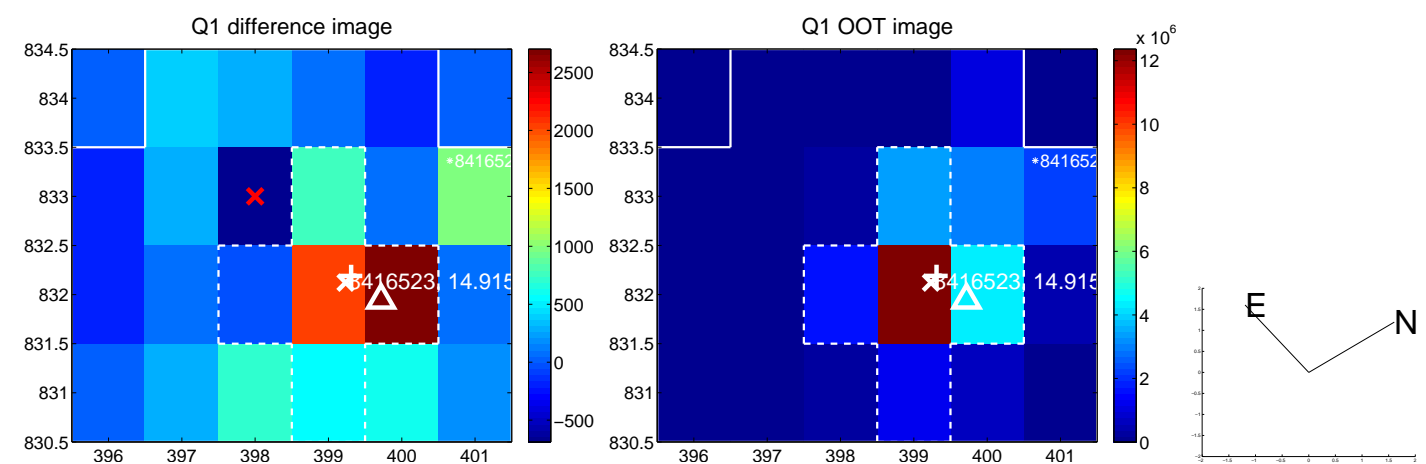
The direct PRF centroid is offset from the target star catalog position by about 0.32 arcsec

	Distance in arcsec	Distance / $\sigma$	$\Delta$ RA	$\Delta$ Dec
PRF-fit source offset from OOT	$0.113 \pm 0.158$	0.72	$-0.108 \pm 0.154$	$0.036 \pm 0.136$
PRF-fit source offset from KIC position	$0.245 \pm 0.149$	1.65	$-0.064 \pm 0.143$	$0.237 \pm 0.141$
photometric centroid source offset	$2.23 \pm 0.55$	4.03	$-0.31 \pm 0.48$	$-2.21 \pm 0.55$

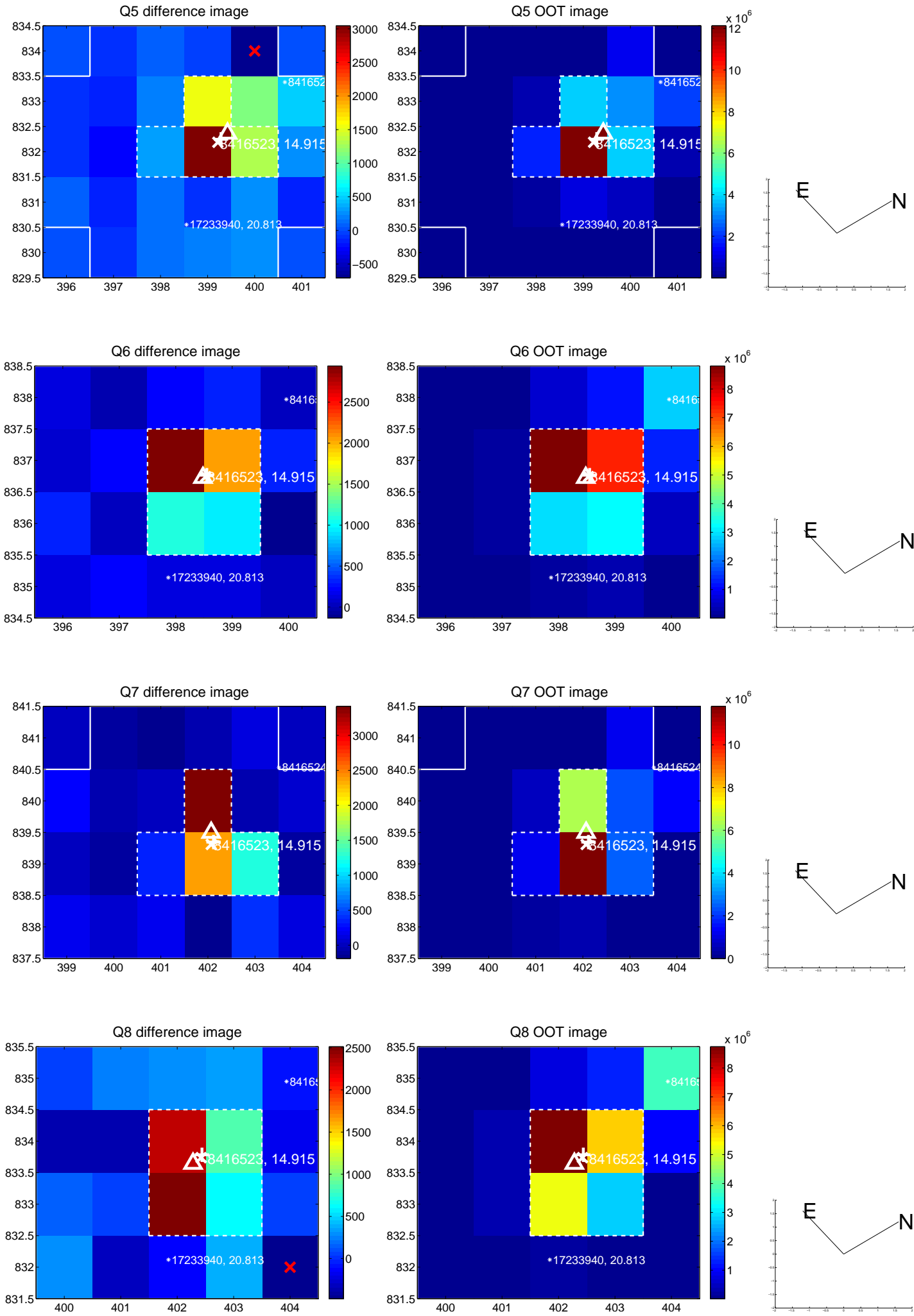


Centroid source offsets from the target star reconstructed from PRF and photometric centroids. **Sky blue crosses: good quarterly centroid offsets; Vermillion crosses: bad quarterly centroid offsets**; magenta cross: average over quarters. Length of the crosses: one- $\sigma$  uncertainty. Blue circle: three- $\sigma$ . Red \*: target star. Blue \*: Other stars. Text next to a star gives its KIC ID and kepmag. KIC IDs > 15,000,000 are from the UKIRT catalog.

white  $\times$ : KIC target position;  $+$ : OOT centroid;  $\triangle$ : difference centroid. red  $\times$ : large negative pixel value

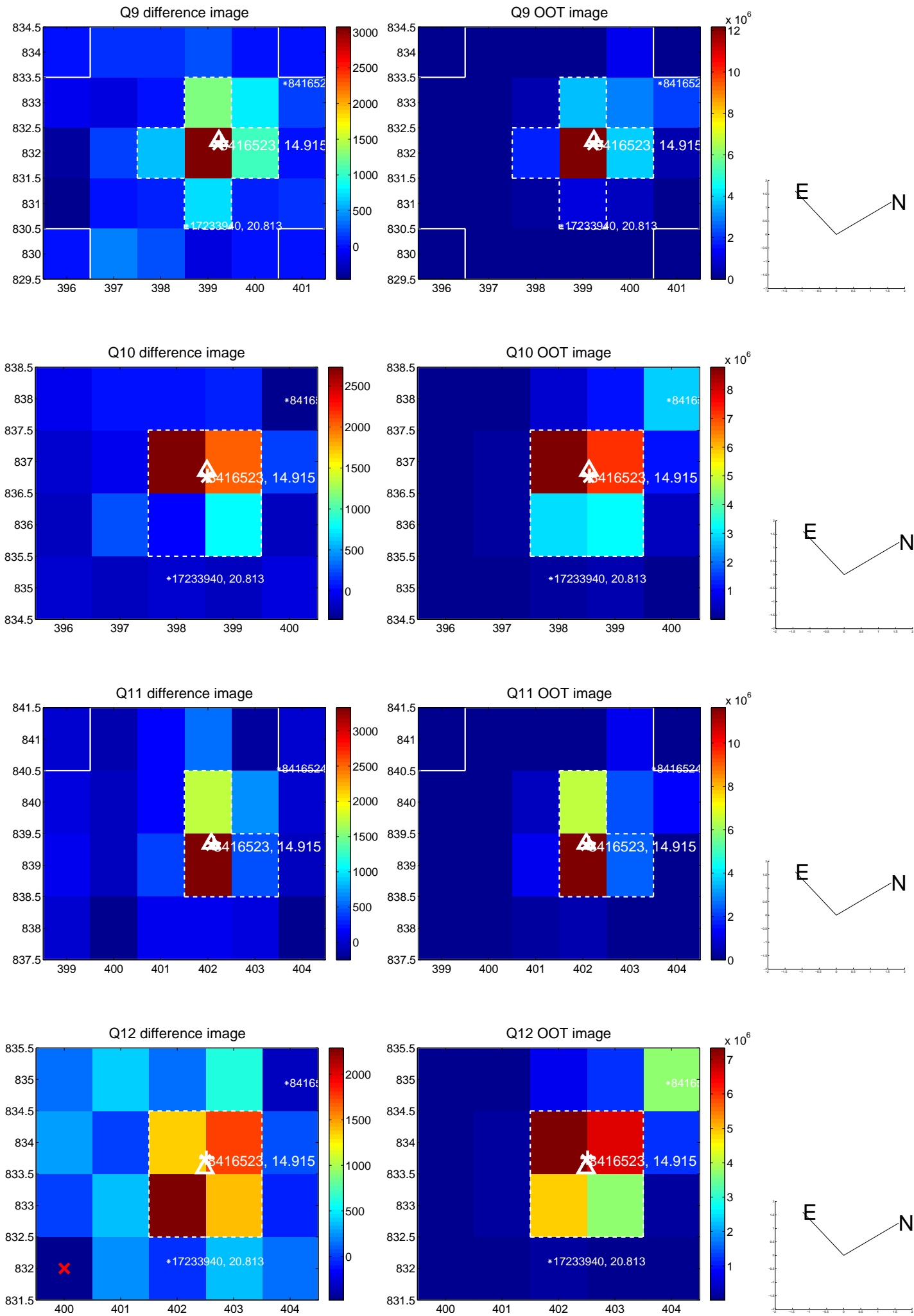


white  $\times$ : KIC target position; +: OOT centroid;  $\triangle$ : difference centroid. red  $\times$ : large negative pixel value.

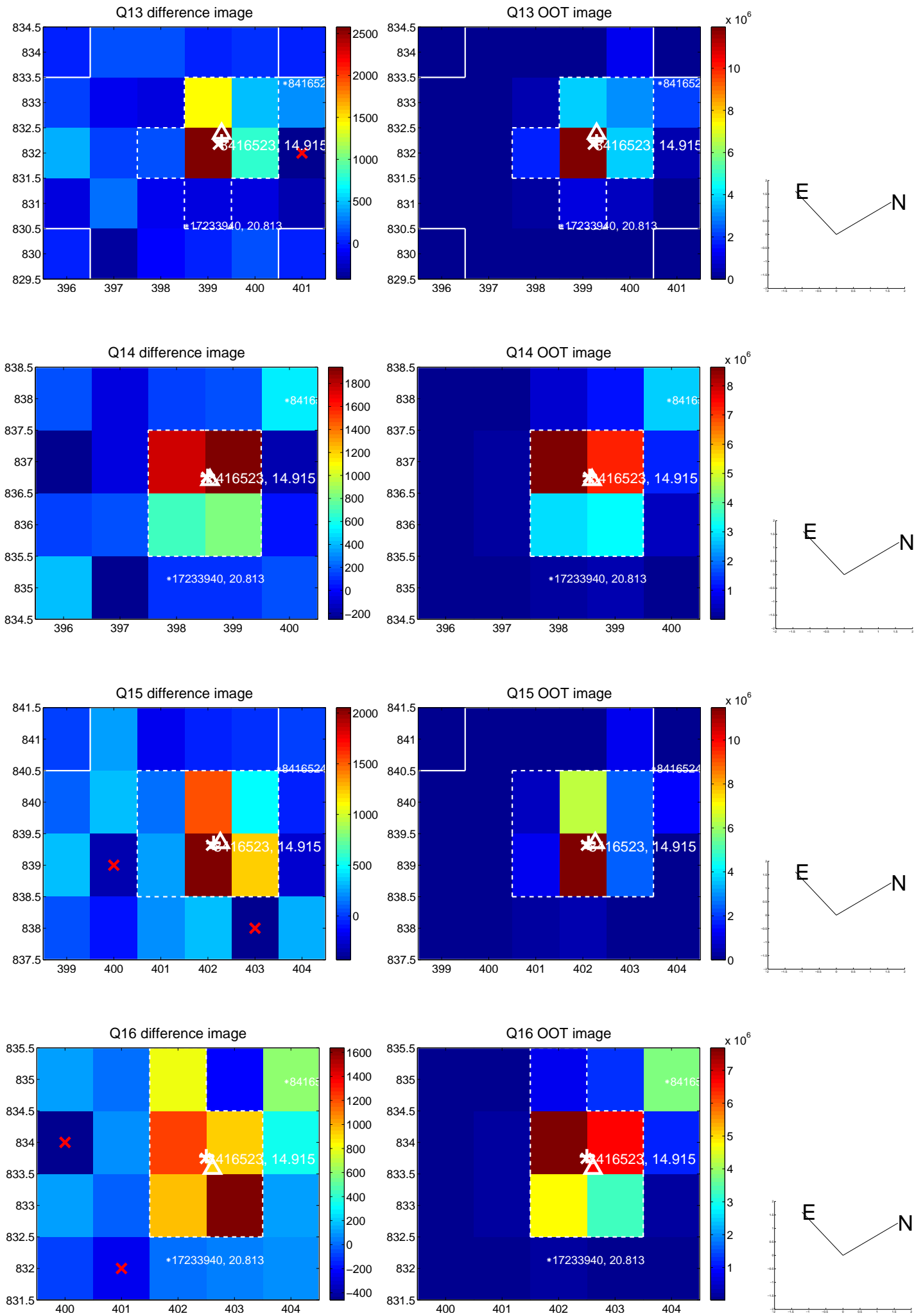




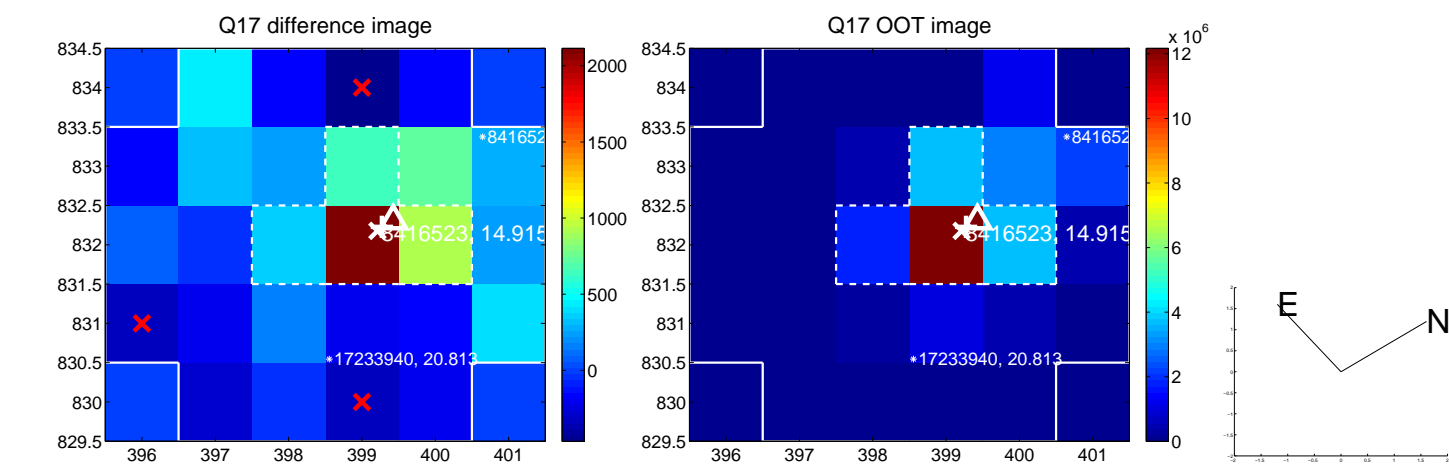
white  $\times$ : KIC target position; +: OOT centroid;  $\triangle$ : difference centroid. red  $\times$ : large negative pixel value.



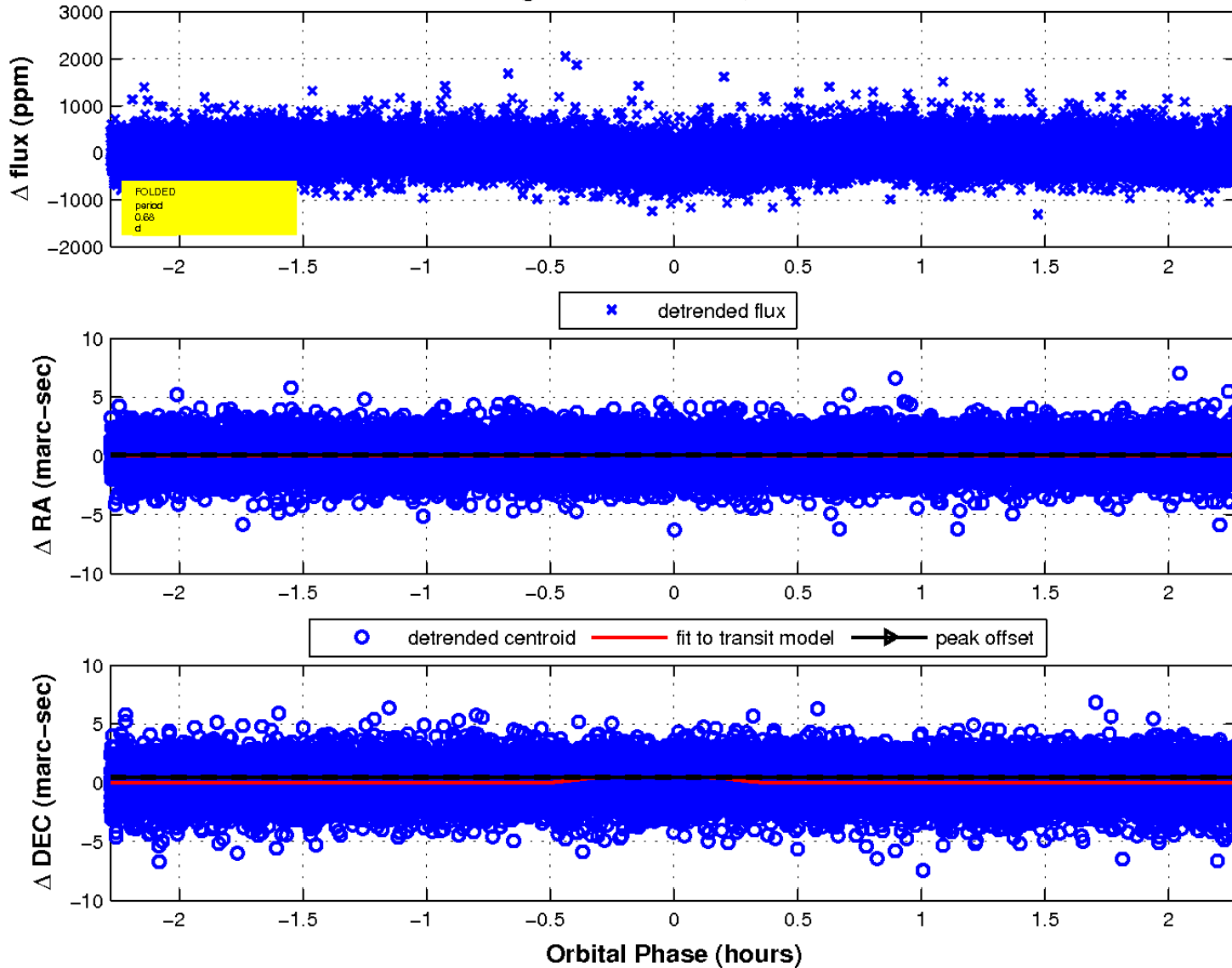
white  $\times$ : KIC target position; +: OOT centroid;  $\triangle$ : difference centroid. red  $\times$ : large negative pixel value.



white  $\times$ : KIC target position;  $+$ : OOT centroid;  $\triangle$ : difference centroid. red  $\times$ : large negative pixel value.



fluxWeightedCentroids, Planet 2 of 2



# UKIRT Image

