Data Validation (DV) Report
for TESS ID 102069549
Sectors 2 - 2

This Data Validation Report was produced in the
TESS Science Processing Operations Center (SPOC) Pipeline
at NASA Ames Research Center

04-Oct-2018 15:05:10 Z

Contents

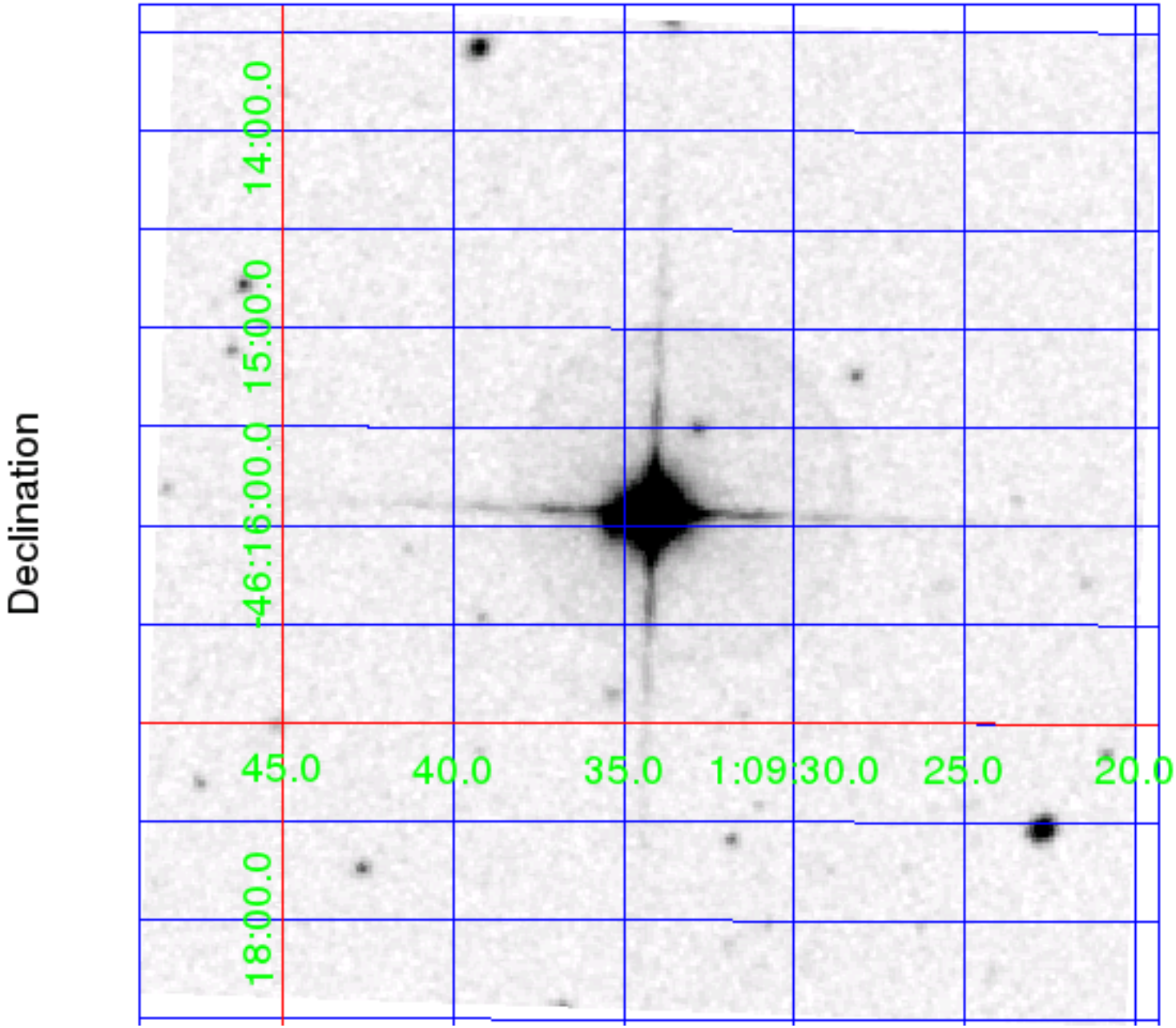
1 Summary

Target Properties	Value	Uncertainty	Units	Provenance
Catalog ID	102069549			
TOI ID	-			
TESS Name	-			
RA	17.39248600	0	degrees	TIC7
Dec	-46.26557200	0	degrees	TIC7
Magnitude	7.917	0.018		TIC7
Radius	3.314	0.404	Solar radii	TIC7
Effective Temperature	5588	127	Kelvin	TIC7
log(g)	4.438	0	cm/sec^2	Solar
[M/H]	-0.540	0.09	Solar metallicity	TIC7
Stellar Density	1.000	0.000	Solar density	Solar
Limb Darkening Coefficient 1	0			
Limb Darkening Coefficient 2	0			
Limb Darkening Coefficient 3	0			
Limb Darkening Coefficient 4	0			
Number of Planet Candidates	1			
TOI Model	-			
TESS Names Model	-			
External TCE Model	-			
Software Revision	spoc-3.3.37-20181001			
Date Report Generated	04-Oct-2018 15:05:10 Z			

Sector	Target Table	Camera/ CCD	Crowding Metric	Flux Fraction
2	129	2:2	0.9999	0.9239

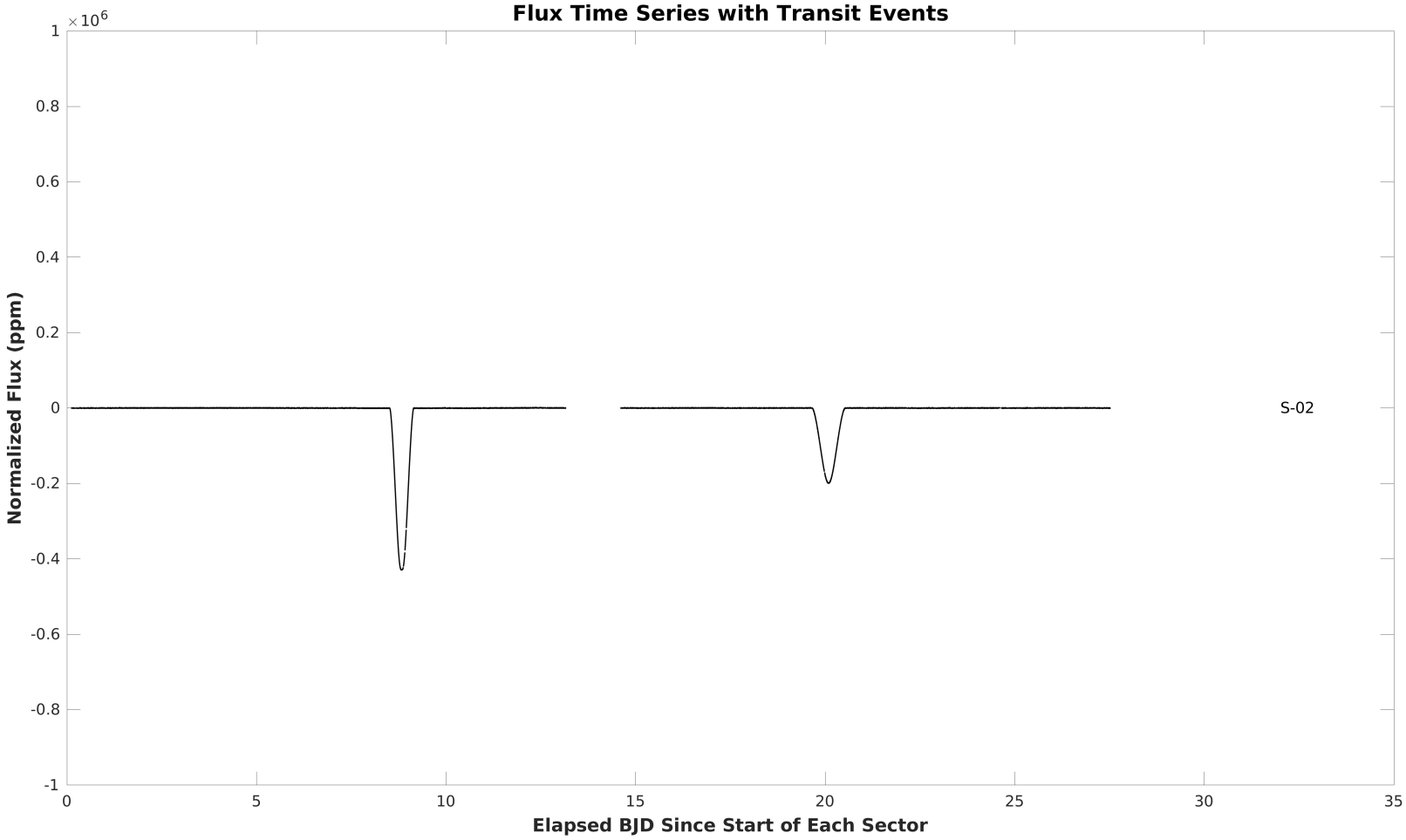
Planet Candidate	TOI ID	TESS Name	TOI Correlation	Period (days)	Period Ratio	Epoch (BTJD)	Semi-major Axis (AU)	Radius (Re)	Seff	Teq (K)	False Alarm	Suspected EB
1	-	-	-	11.258	1.00	1362.824	0.22	88.9	200.7	960	N/A	true

2 Survey Image

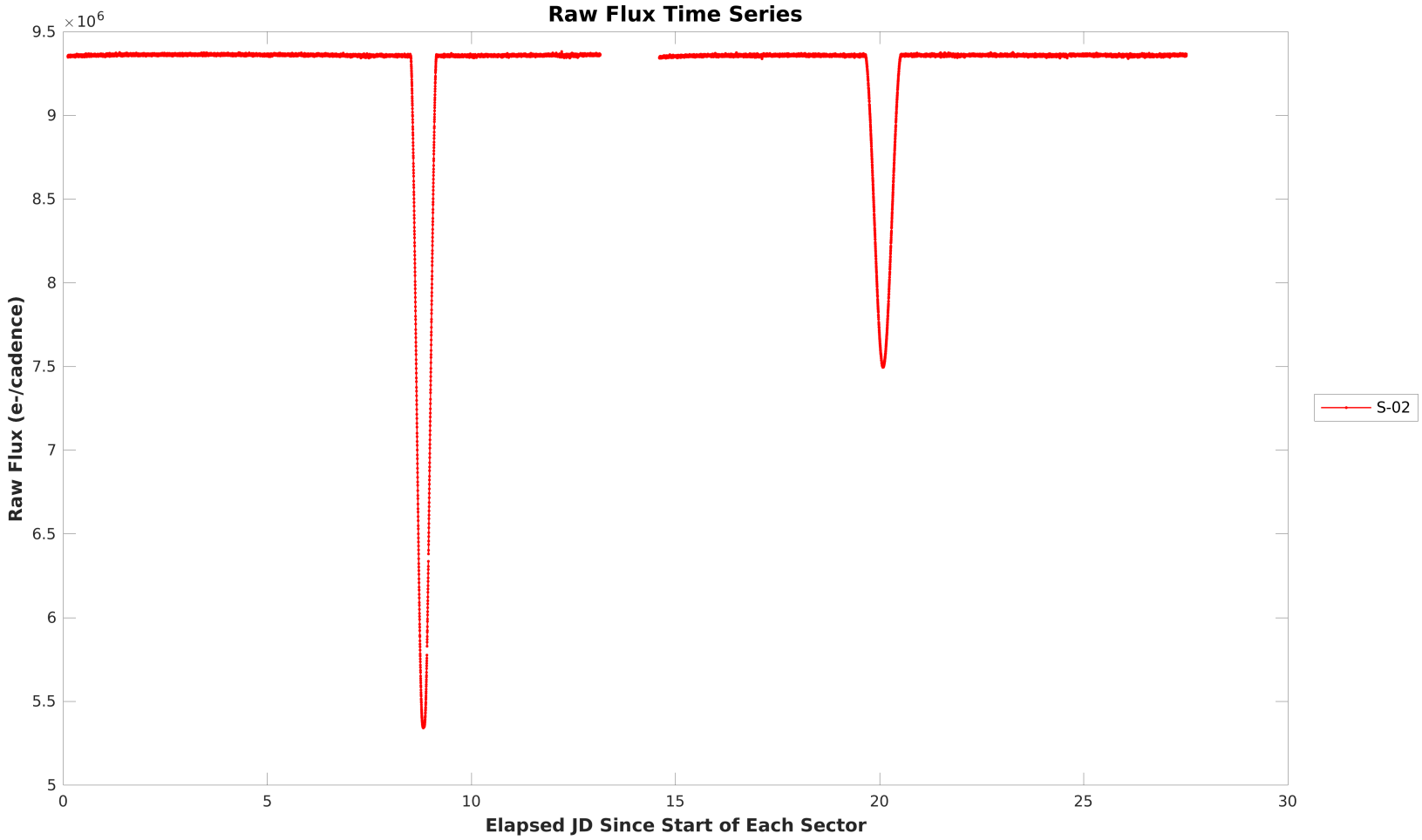


Digitized Sky Survey (DSS) red image. The 5' x 5' image is centered on the J2000 coordinates of target (102069549).

3 Flux Time Series



Summary plot of sector-stitched flux time series and transits for target 102069549, marked with DV fitted epoch/period (or TPS epoch/period if fit was not successful). Transits of identified planets are labeled with epoch BTJD and orbital period. For the data of sector 2, target table 129, start BJD is 2458354.
Open `./summary-plots/0000000102069549-00-flux-dv-fit-02-129.fig`



Summary plot of raw flux time series. For the data of sector 2, target table 129, start JD is 2458354.
Open `./summary-plots/0000000102069549-00-raw-flux-02-129.fig`

4 Dashboards

Planet Candidate 1

<table>
<tr><td rowspan="2">Model Fitter</td><td colspan="2">Stellar Radius
N/A</td><td rowspan="2">Core Aperture Correlation Statistic
Value = 672.08
Significance = 100.00%
Halo Aperture Correlation Statistic
Value = 164.30
Significance = 100.00%
Core/Halo Ratio
Ratio = 4.09</td><td rowspan="2">Ghost Diagnostic Test</td></tr>
<tr><td colspan="2">Period = 11.3 days
Depth = 0 ppm
Planet Radius = N/A
Semi-major Axis = N/A
Effective Stellar Flux = N/A
Equilibrium Temperature = N/A
Chi-squared/DoF = N/A
SNR = N/A
Planet candidate suspected to be an EB</td></tr>
<tr><td rowspan="2">Eclipsing Binary Discrimination Test</td><td colspan="2">Odd-Even Depth Comparison Statistic
Value = N/A
Significance = N/A</td><td>Offsets Relative to Out of Transit Centroid
Source RA Offset = -1.84e-01 ± 2.50e+00 arcsec (-0.07 σ)
Source Dec Offset = 1.59e-02 ± 2.50e+00 arcsec (0.01 σ)
Source Offset Distance = 1.85e-01 ± 2.50e+00 arcsec (0.07 σ)
Offsets Relative to TIC Position
Source RA Offset = -2.36e-01 ± 2.50e+00 arcsec (-0.09 σ)
Source Dec Offset = 4.82e-02 ± 2.50e+00 arcsec (0.02 σ)
Source Offset Distance = 2.41e-01 ± 2.50e+00 arcsec (0.10 σ)</td><td>Difference Image Centroid Offsets</td></tr>
<tr><td>Shorter Period Comparison Statistic
Value = N/A
Significance = N/A</td><td>Longer Period Comparison Statistic
Value = N/A
Significance = N/A</td><td>False Alarm = N/A
Transit Count = N/A
Max Multiple Event Statistic = 2604.1</td><td>Bootstrap Test</td></tr>
</table>

Summary of model fitter results and validation test results for target 102069549, planet candidate 1. In general, green denotes that the candidate is likely a planet, while red denotes that the candidate is unlikely to be a planet. Cyan denotes that no data is available. The color of the Model Fitter block is: green, when the SNR of the fit is greater than or equal to 10; yellow, if the SNR is greater than or equal to 7.1 but less than 10; red, if the SNR is less than 7.1 or if the fitter failed. The color of the Ghost Diagnostic Test and Eclipsing Binary Discrimination Test blocks are: green, when the significance is within 2-sigma; yellow, when the significance is between 2- and 3-sigma; red when the significance is greater than 3-sigma. The color of the Difference Image Centroid Offsets block is: green, when the max offset distance sigma is less than or equal to 2; yellow, when the max sigma is between 2 and 3; red when the max sigma is greater than 3. The color of the Bootstrap Test block is green whenever the false alarm probability is less than 10^{-12}, low enough to limit the total number of false alarms from a four year mission to less than one. If the false alarm probability is greater than 10^{-12}, the color of the Bootstrap Test block is: green, when the false alarm probability is less than or equal to the CCDF of a Gaussian distribution at the observed maximum multiple event statistic; yellow when the false alarm probability is between 1 and 2 times that of a Gaussian distribution at the max multiple event statistic; and red when the false alarm probability is more than 2 times that of a Gaussian distribution at the max multiple event statistic.

5 Pixel Level Diagnostics

To reduce clutter, the catalog IDs in the difference images have been replaced by indices representing distance from the target star. The mapping between the indices and the catalog IDs is found in a table at the end of this section.

5.1 Planet Candidate 1

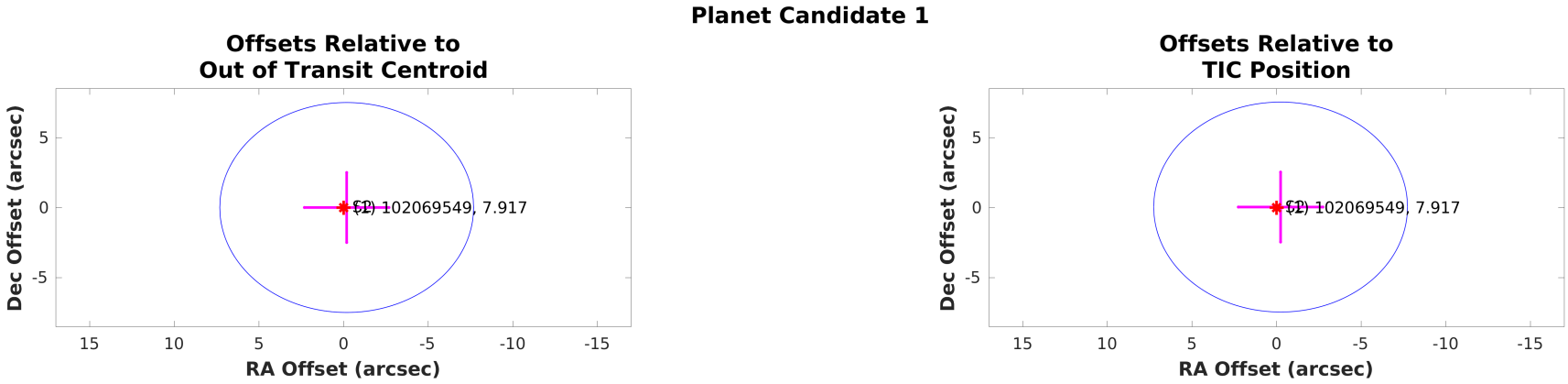
Multi-Sector Average PRF Fit of the Difference Images

Mean offset from the PRF fit to the out of transit image

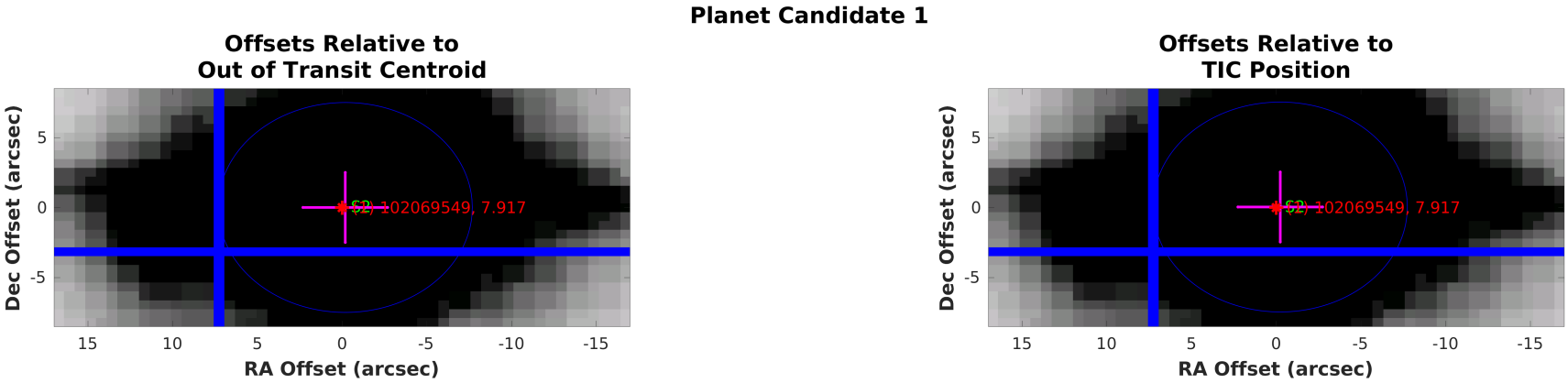
	RA	Dec	Units
Offset	$-0.1844 \pm 2.50e+00$	$0.0159 \pm 2.50e+00$	arcseconds
Offset/σ	-0.07	0.01	
Offset Distance	$0.1851 \pm 2.50e+00$		arcseconds
Offset Distance/σ	0.07		
3σ Radius	7.5000		arcseconds

Mean offset from the TIC RA and Dec

	RA	Dec	Units
Offset	$-0.2357 \pm 2.50e+00$	$0.0482 \pm 2.50e+00$	arcseconds
Offset/σ	-0.09	0.02	
Offset Distance	$0.2405 \pm 2.50e+00$		arcseconds
Offset Distance/σ	0.10		
3σ Radius	7.5000		arcseconds



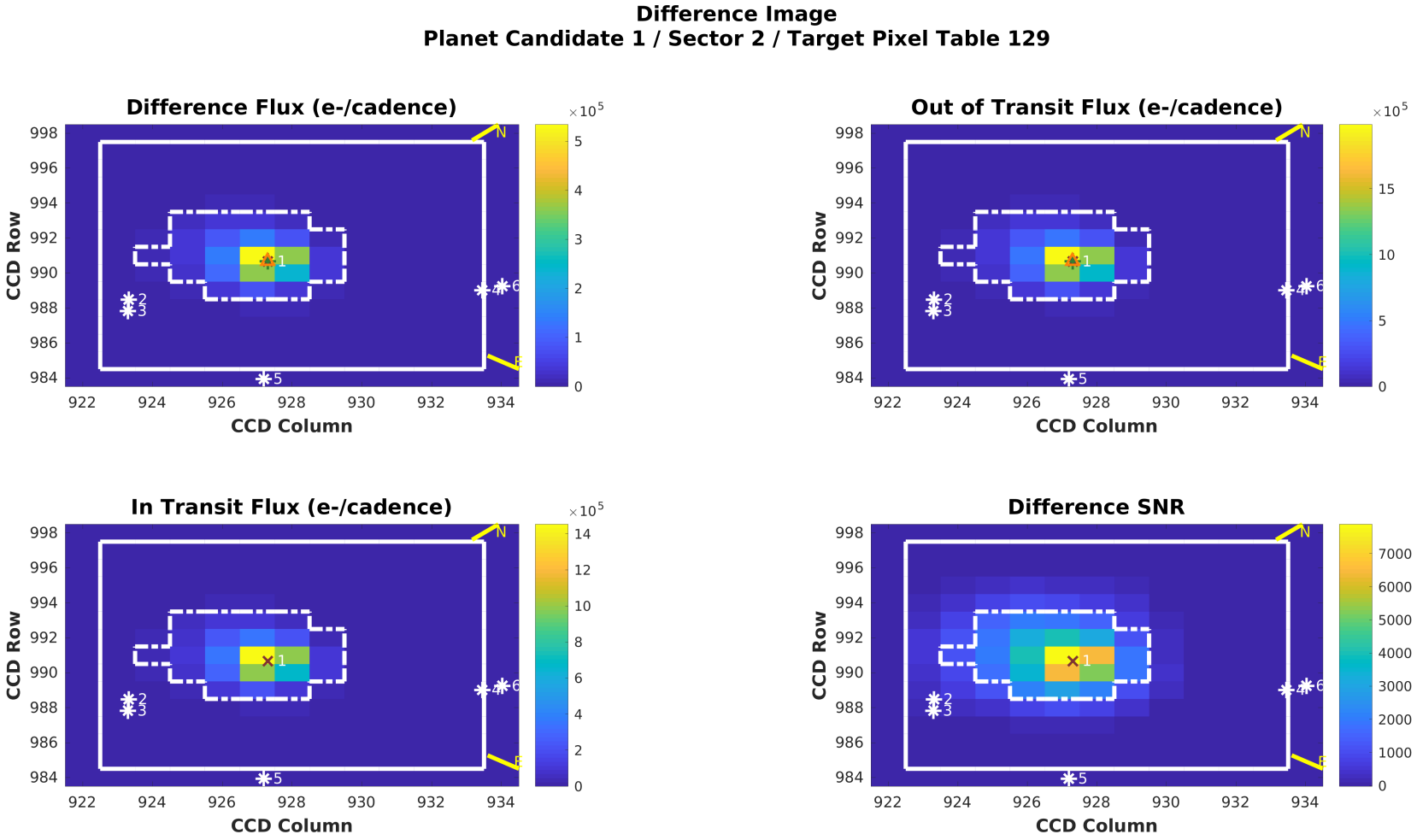
Difference image centroid offsets for target 102069549, planet candidate 1. Left: difference image PRF centroid offsets in RA and Dec with respect to the per sector out-of-transit centroids for the given target. Right: difference image PRF centroid offsets in RA and Dec with respect to the TC coordinates of the given target. Symbol key: green cross: per sector centroid offsets with 1-sigma error bars in RA and Dec; magenta cross: robust weighted mean offset over all sectors with 1-sigma error bars in RA and Dec; blue circle: 3-sigma radius of confusion for weighted mean offset; red asterisk: location of target star; blue asterisk: location of other TIC objects in the neighborhood. TIC ID and magnitude are noted in the text associated with each marked object. A constant error term of 2.5000 arcseconds has been added in quadrature to the computed uncertainty in the RA and Dec components of the robust mean offset.
Open `./planet-01/difference-image/0000000102069549-01-difference-image-centroid-offsets.fig`



Difference image centroid offsets for target 102069549, planet candidate 1, diplayed on survey image for given target. Left: difference image PRF centroid offsets in RA and Dec with respect to the per sector out-of-transit centroids for the given target. Right: difference image PRF centroid offsets in RA and Dec with respect to the TIC coordinates of the given target. Symbol key: green cross: per sector centroid offsets with 1-sigma error bars in RA and Dec; magenta cross: robust weighted mean offset over all sectors with 1-sigma error bars in RA and Dec; blue circle: 3-sigma radius of confusion for weighted mean offset; red asterisk: location of target star; blue asterisk: location of other TIC objects in the neighborhood. TIC ID and magnitude are noted in the text associated with each marked object. A constant error term of 2.5000 arcseconds has been added in quadrature to the computed uncertainty in the RA and Dec components of the robust mean offset.
Open `./planet-01/difference-image/0000000102069549-01-difference-image-centroid-offsets-survey.fig`

Difference Image Summary Metrics

Number of Difference Images	Number of Metrics	Number of Good Metrics	Fraction of Good Metrics	Quality Threshold
1	1	1	1.0000	0.70



Difference image for target 102069549, planet candidate 1, sector 2, target pixel table 129. Upper left: difference between mean flux out-of-transit and in-transit; upper right: mean out-of-transit flux; lower left: mean in-transit flux; lower right: difference between mean flux out-of-transit and in-transit after normalizing by the uncertainty in the difference for each pixel. The optimal aperture is outlined with a white dash-dotted line in each panel and the target mask is outlined with a solid white line. Symbol key: x: target position from TIC RA and Dec converted to CCD coordinates via motion polynomials; *: position of nearby TIC objects converted to CCD coordinates via motion polynomials; +: PRF-fit location of target from out-of-transit image; triangle: PRF-fit location of transit source from the difference image. Number of transits = 2; number of valid in-transit cadences = 463; number of in-transit cadence gaps = 6; number of valid out-of-transit cadences = 1763; number of out-of-transit cadence gaps = 39. Difference image quality metric = 1.00 (good).
Open `./planet-01/difference-image/0000000102069549-01-difference-image-02-129.fig`

PRF Fit of the Difference Image

Offset from the PRF fit to the out of transit image

	Row	Column	Units	RA	Dec	Units
Out of Transit Image Centroid	$990.67 \pm 7.64e-06$	$927.30 \pm 7.66e-06$	pixels	$17.39287921 \pm 6.69e-07$	$-46.26555807 \pm 6.93e-07$	degrees
Difference Image Centroid	$990.68 \pm 5.62e-05$	$927.30 \pm 5.66e-05$	pixels	$17.39280511 \pm 7.34e-07$	$-46.26555365 \pm 7.70e-07$	degrees
Offset	$0.0065 \pm 5.67e-05$	$-0.0064 \pm 5.71e-05$	pixels	$-0.1844 \pm 2.49e-03$	$0.0159 \pm 3.73e-03$	arcseconds
Offset/σ	113.94	−111.50		−74.01	4.27	
Offset Distance	$0.0091 \pm 5.47e-05$		pixels	$0.1851 \pm 2.48e-03$		arcseconds
Offset Distance/σ	165.85			74.49		

Offset from the TIC RA and Dec converted to pixels via motion polynomials

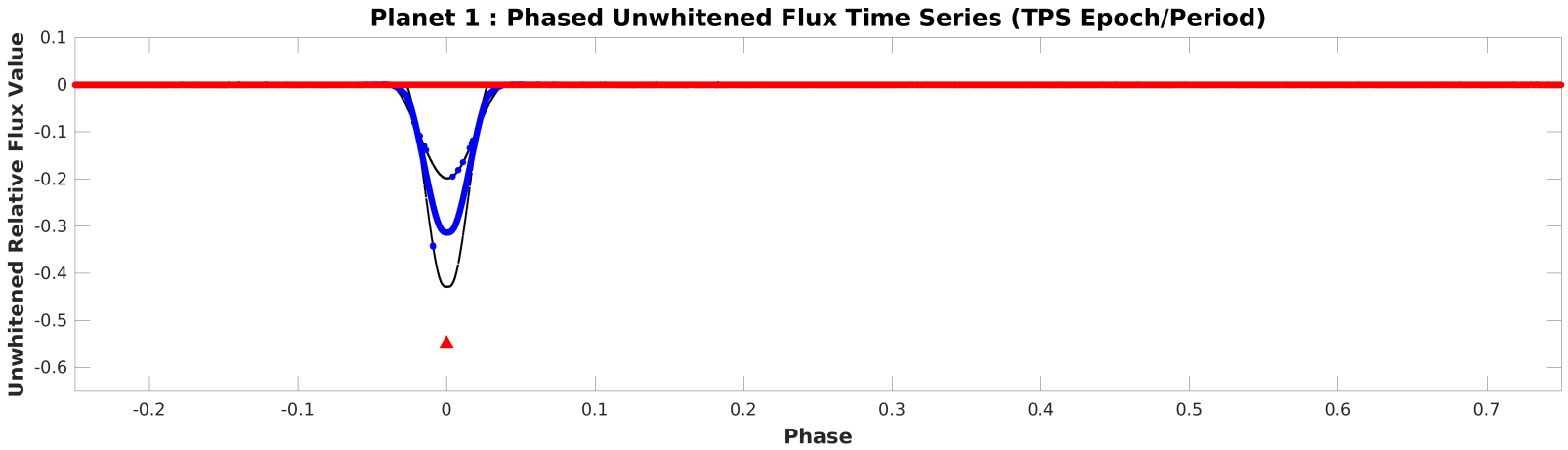
	Row	Column	Units	RA	Dec	Units
TIC Reference Centroid	$990.67 \pm 1.24e-04$	$927.30 \pm 1.13e-04$	pixels	$17.39289980 \pm 0.00e+00$	$-46.26556703 \pm 0.00e+00$	degrees
Difference Image Centroid	$990.68 \pm 5.62e-05$	$927.30 \pm 5.66e-05$	pixels	$17.39280511 \pm 7.34e-07$	$-46.26555365 \pm 7.70e-07$	degrees
Offset	$0.0093 \pm 1.36e-04$	$-0.0073 \pm 1.27e-04$	pixels	$-0.2357 \pm 1.83e-03$	$0.0482 \pm 2.77e-03$	arcseconds
Offset/σ	68.15	−57.43		−128.93	17.38	
Offset Distance	$0.0118 \pm 1.32e-04$		pixels	$0.2405 \pm 1.91e-03$		arcseconds
Offset Distance/σ	89.51			126.04		

5.2 Difference Image TIC Key

Index	Catalog ID	Mag	RA (degrees)	Dec (degrees)	Distance (arcsec)
1	102069549	7.917	17.39289980	-46.26556703	0.00
2	102069553	17.371	17.37946800	-46.29020300	94.78
3	102069555	17.262	17.38280566	-46.29316645	102.48
4	102069546	18.584	17.44015200	-46.24970600	130.73
5	102069556	16.903	17.42779024	-46.29558382	138.63
6	102069545	17.194	17.44249421	-46.24648930	141.25
7	102069554	14.320	17.34484740	-46.29216562	153.20

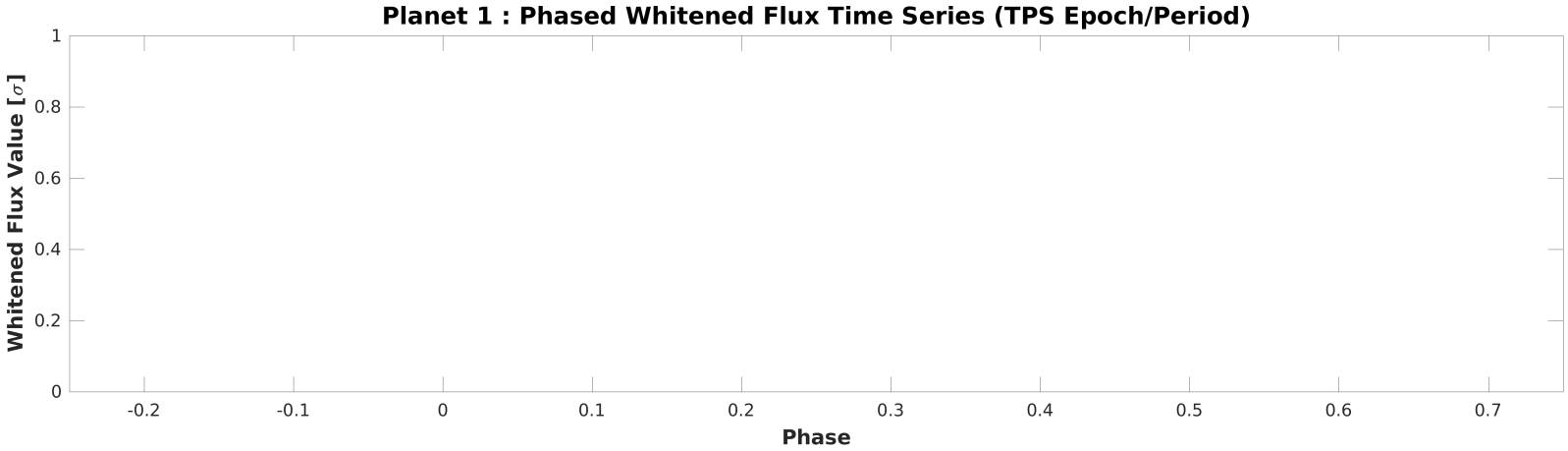
RA, Dec and Distances are corrected for proper motion. This table may not contain all of the objects shown.

6 Phased Light Curves

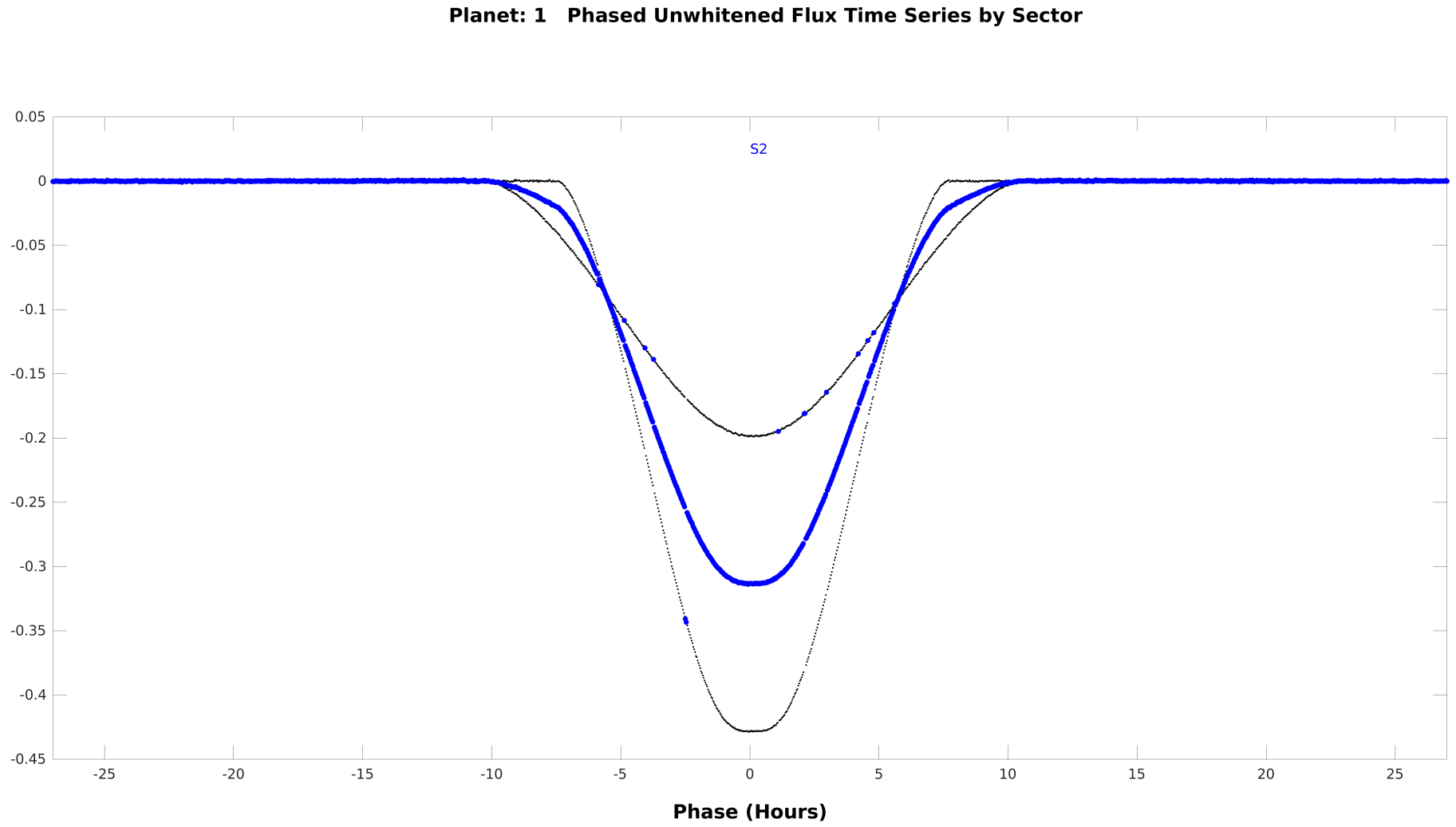


Phased unwhitened flux time series is plotted in black dots. When all transits fit completed with full or secondary convergence, the phase is determined with the fitted epoch and period; otherwise, the phase is determined with the TPS epoch and period. The values of the phased unwhitened flux time series averaged in one cadence wide bins are plotted in bigger blue dots. When all transits fit completes with full or secondary convergence, the averaged values of the phased unwhitened fitted model light curve are plotted in red dots. Transit event markers in different colors indicate the locations of the transits of all planet candidates. The transits of the same planet candidate are labeled with the markers of the same color, for example, blue markers for transits of plane candidate #1, red markers for transits of planet candidate #2, etc.

Open `./summary-plots/0000000102069549-01-phased-unwhitened-flux-time-series.fig`



Phased whitened flux time series is plotted in black dots. When all transits fit completed with full or secondary convergence, the phase is determined with the fitted epoch and period; otherwise, the phase is determined with the TPS epoch and period. The values of the phased whitened flux time series averaged in one cadence wide bins are plotted in bigger blue dots. When all transits fit completes with full or secondary convergence, the averaged values of the phased whitened fitted model light curve are plotted in red dots. Transit event markers in different colors indicate the locations of the transits of all planet candidates. The transits of the same planet candidate are labeled with the markers of the same color, for example, blue markers for transits of plane candidate #1, red markers for transits of planet candidate #2, etc.
Open `./summary-plots/0000000102069549-01-phased-whitened-flux-time-series.fig`



Phased unwhitened flux time series by sector for target 102069549, planet candidate 1. Period = 11.2583 days; transit epoch = 1362.8242 BTJD.
Open `./summary-plots/0000000102069549-01-phased-unwhitened-flux-time-series-by-sector.fig`

7 Planet Candidate 1

7.1 Model Fitter: All Transits

Model Characteristic	Name
Transit Model	mandel-agol_geometric_transit_model
Limb Darkening Model	claret_tess_nonlinear_limb_darkening_model

TCE Parameter	Value	Units
Trial Transit Pulse Duration	9.0	hours
Transit Epoch	1362.8241982	TJD
Orbital Period	11.2583303	days
Maximum SES	2853.9	
Maximum MES	2604.1	
Robust Statistic	1909.9	
Chi Square Goodness of Fit Statistic (DoF)	2339636.8 (529)	
Chi Square2 Statistic (DoF)	983081.7 (361018.6)	
Threshold for Desired PFA		

DoF: Degrees of Freedom

Parameter	Estimated Value	Units
Orbital Period		days
Transit Epoch		BTJD
Transit Depth	0	ppm
Transit Duration		hours

DoF: Degrees of Freedom

```
This planet candidate is suspected to be an eclipsing binary.  The transit depth is greater than or equal to 250000 ppm.
```

7.2 Model Fitter: Reduced Parameter Fit Results

```
No reduced parameter fit results available.
```

7.3 Model Fitter: Trapezoidal Fit Results

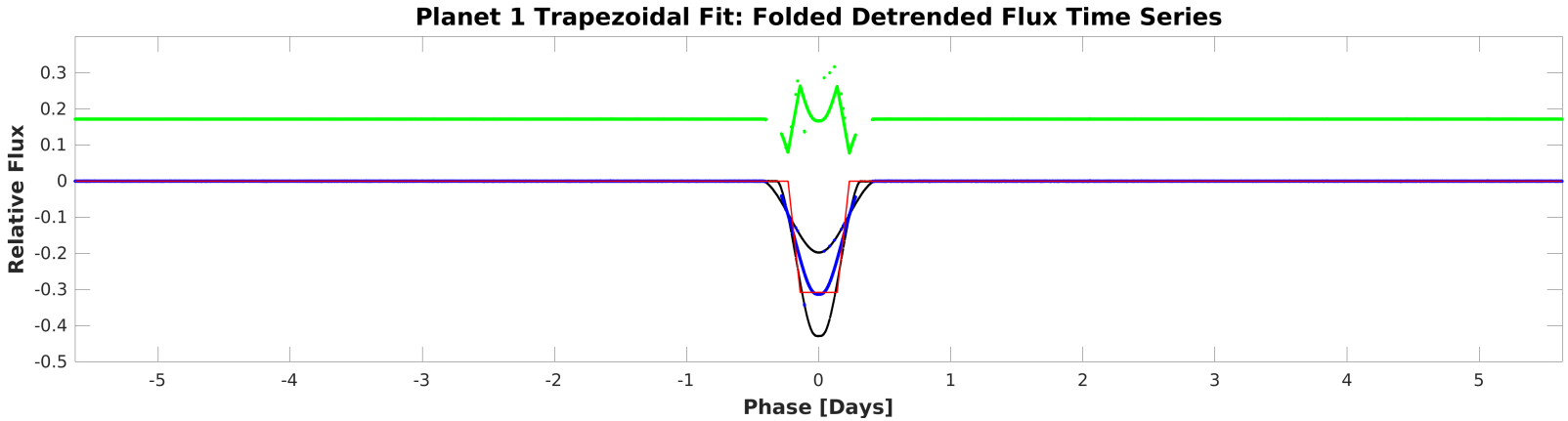
Model Characteristic	Name
Transit Model	trapezoidal_model
Limb Darkening Model	

TCE Parameter	Value	Units
Trial Transit Pulse Duration	9.0	hours
Transit Epoch	1362.8241982	TJD
Orbital Period	11.2583303	days
Maximum SES	2853.9	
Maximum MES	2604.1	
Robust Statistic	1909.9	
Chi Square Goodness of Fit Statistic (DoF)	2339636.8 (529)	
Chi Square2 Statistic (DoF)	983081.7 (361018.6)	
Threshold for Desired PFA		

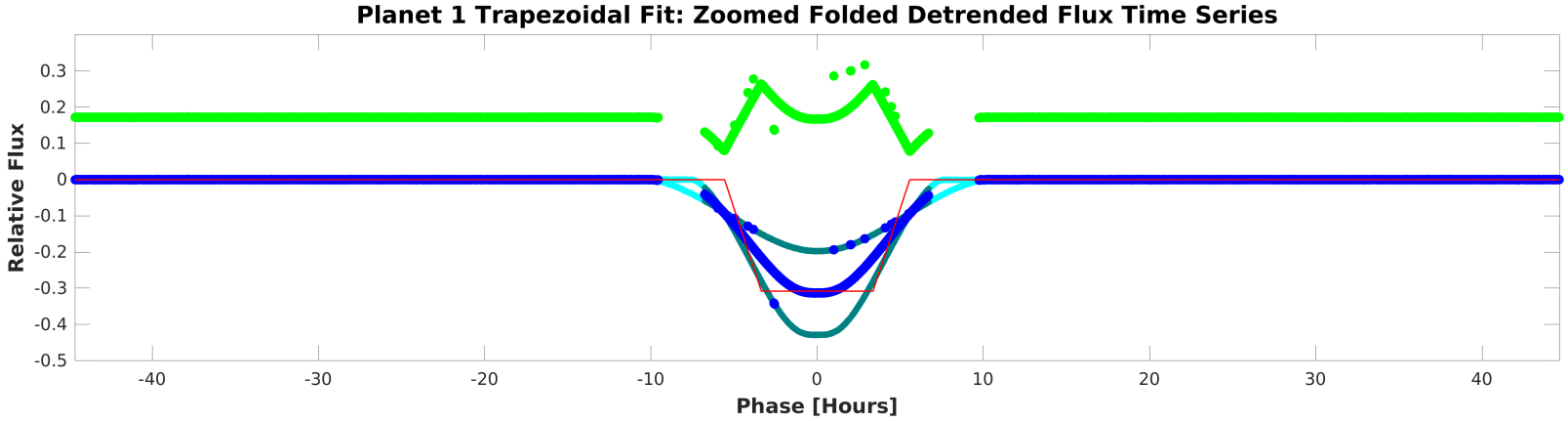
DoF: Degrees of Freedom

Parameter	Value	Uncertainty	Units
SNR	17816.9		
Orbital Period	11.2583303		days
Transit Epoch	1362.8283458		BTJD
Transit Depth	308100		ppm
Transit Duration	14.8819		hours
Transit Ingress Duration	5.9542		hours
Model Chi Square Statistic (DoF)	44181679.0 (3871)		

DoF: Degrees of Freedom



Folded detrended flux time series for CatId 102069549, Planet candidate 1 and folded trapezoidal model light curve.
Open `./planet-01/planet-search-and-model-fitting-results/trapezoidal-model-fit/0000000102069549-01-all-trapezoidal.fig`



Zoomed folded detrended flux time series for CatId 102069549, Planet candidate 1 and folded trapezoidal model light curve.
Open `./planet-01/planet-search-and-model-fitting-results/trapezoidal-model-fit/0000000102069549-01-all-trapezoidal-zoomed.fig`

7.4 Validation Tests

The Centroid Test and Eclipsing Binary Discrimination Test are chi-squared hypothesis tests. For these tests, a significance of 100% favors a planet, while 0% indicates an unlikely planet.

7.4.1 Weak Secondary Test

Result	Value	Uncertainty	Units	Statistic in Sigmas	Significance (%)
Orbital Period	11.2583		days		
Transit Duration	9		hours		
Maximum MES	2604.1				
Secondary Phase	-1.2847		days		
Secondary MES	67.1				
Minimum Phase	-0.94722		days		
Minimum MES	-134.7				
Median MES	0.1				
MAD MES	1.0631				
Robust Statistic	63.8				
Secondary Depth	8454.7	3.1110e+02	ppm		
Geometric Albedo	N/A	N/A		N/A	N/A
Planet Effective Temperature	N/A	N/A	Kelvin	N/A	N/A

7.4.2 Eclipsing Binary Discrimination Test

```
No eclipsing binary discrimination test results available.
```

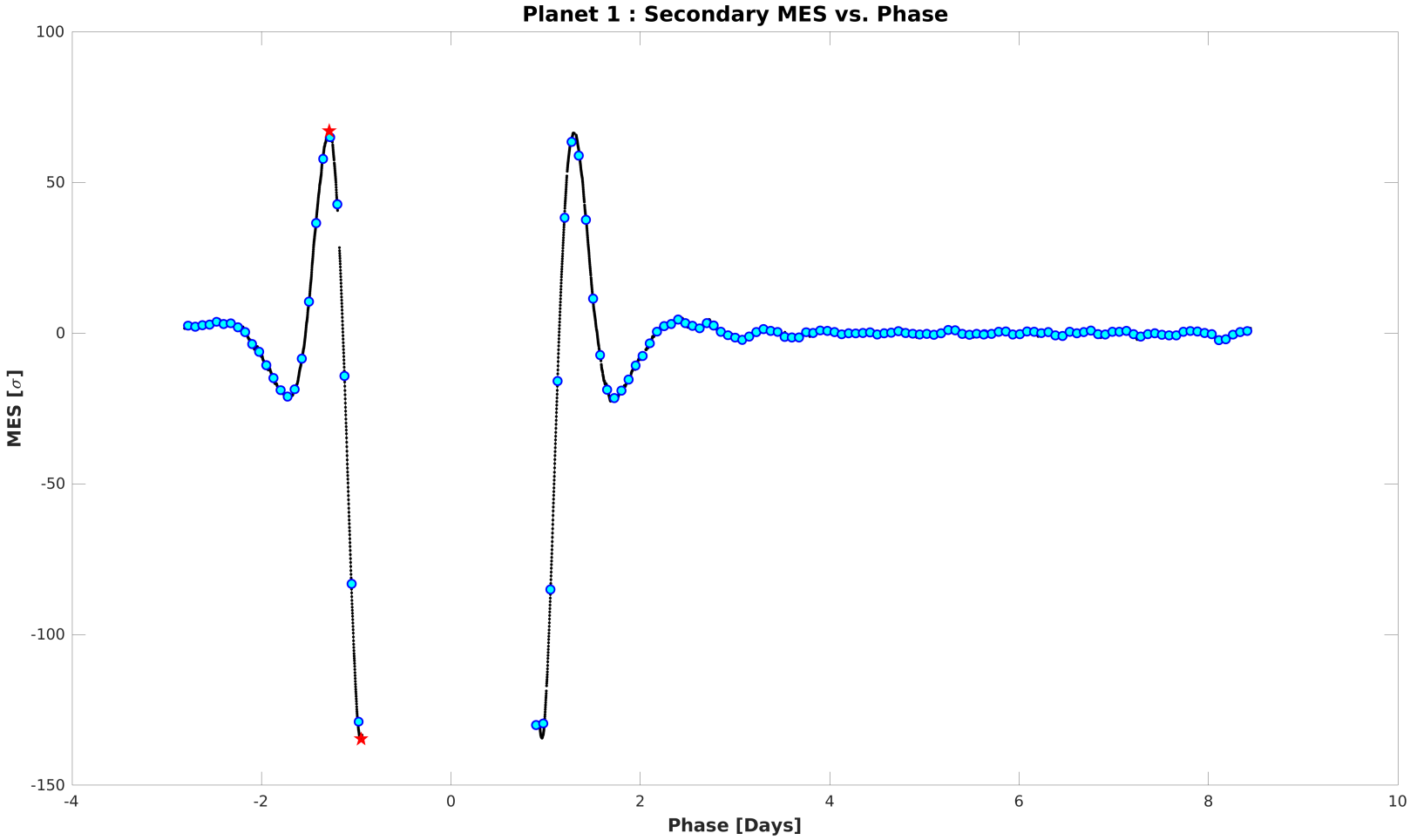
7.4.3 Bootstrap Test

```
No bootstrap results available.
```

7.4.4 Ghost Diagnostic Test

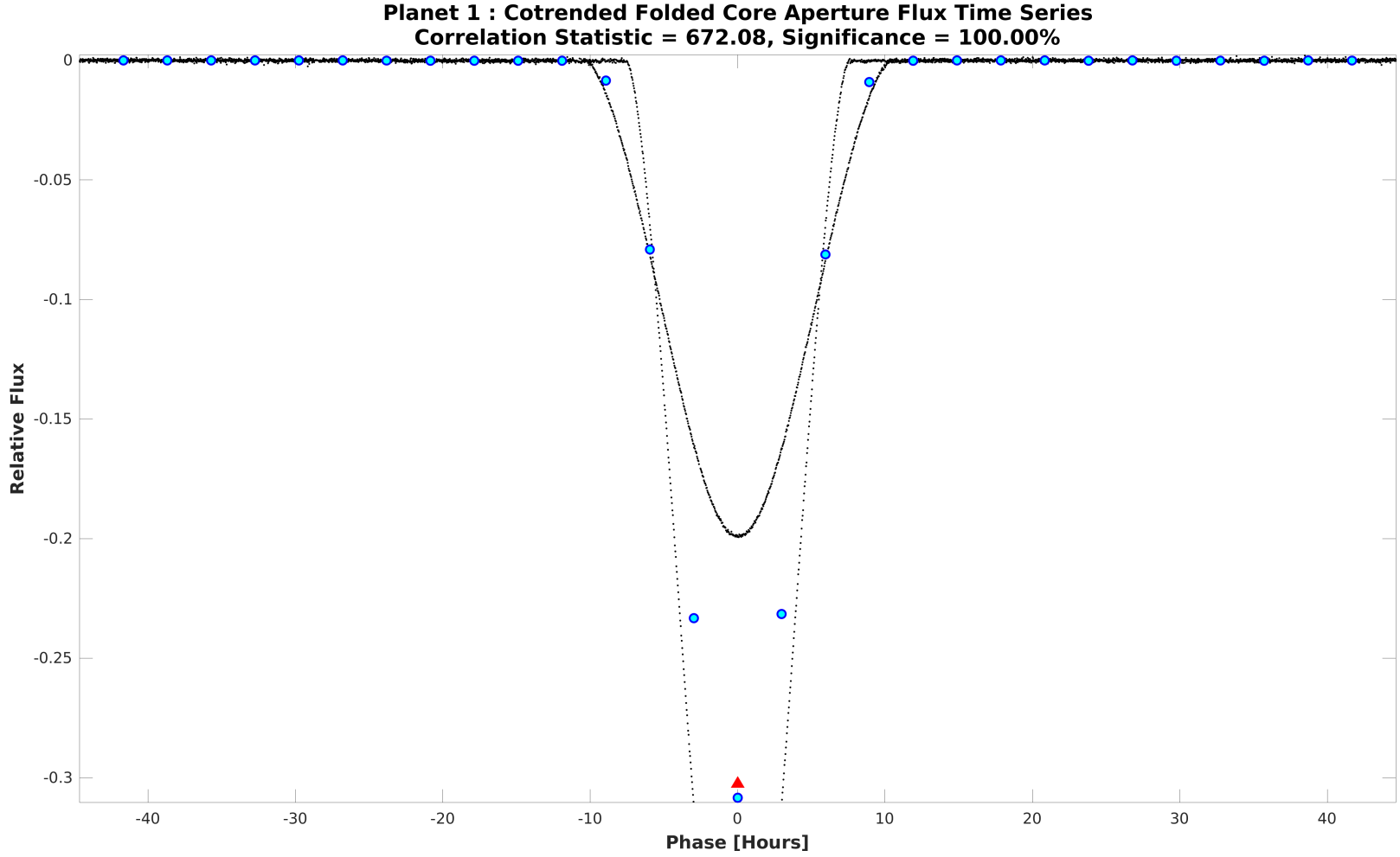
Result	Value	Significance (%)
Maximum MES	2604.1	
SNR	N/A	
Core Aperture Statistic	6.7208e+02	100.00
Halo Aperture Statistic	1.6430e+02	100.00
Ratio of Core/Halo Aperture Statistics	4.0907e+00	

7.4.5 Validation Test Figures



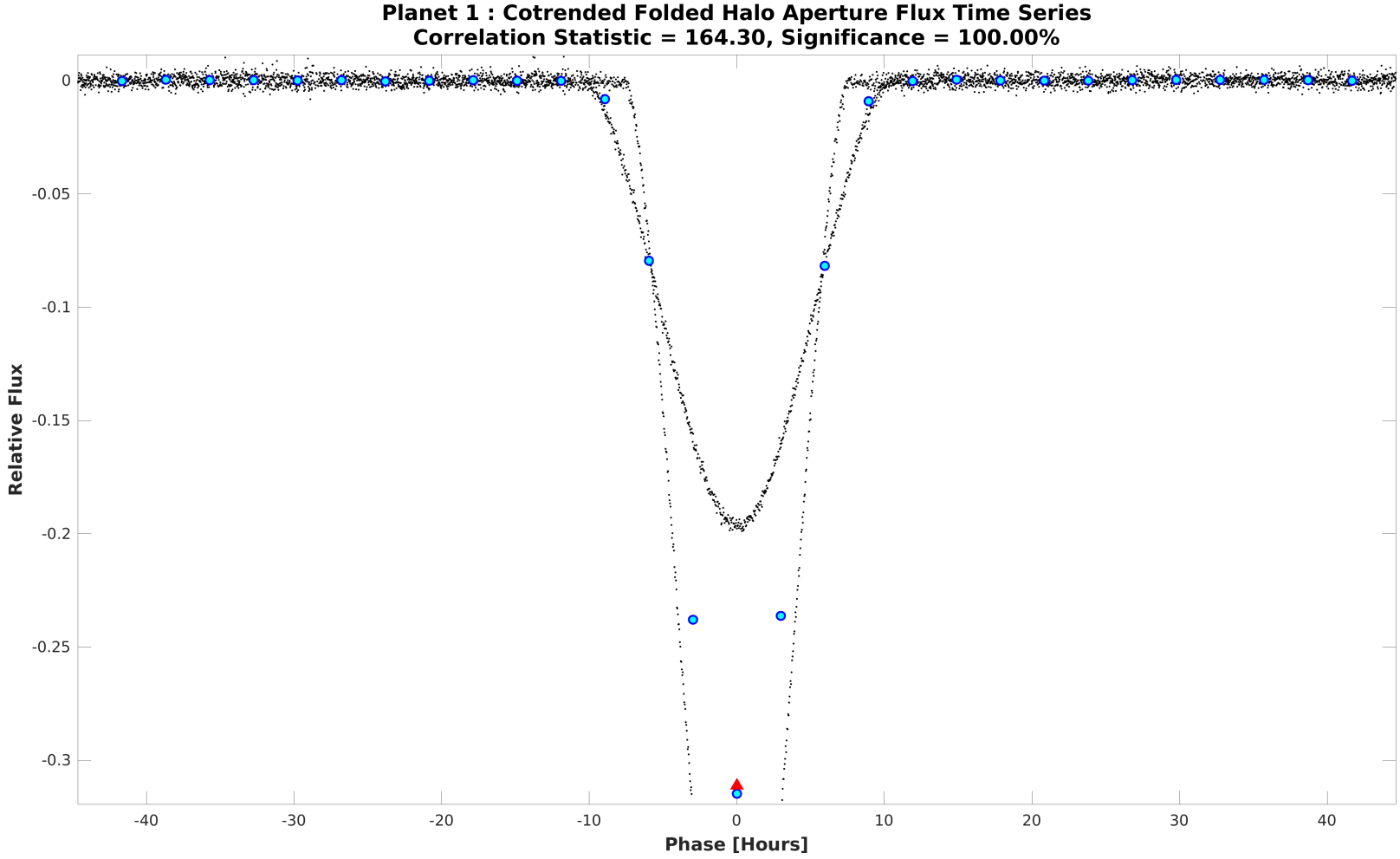
The primary event has been set to zero and both the max and min of the resulting MES vs. Phase are marked with a red star. The best matched pulse duration in hours is 9. The maximum secondary MES and corresponding phase are 67.1047 and -1.2847 days respectively. The minimum secondary MES and corresponding phase are -134.6893 and -0.94722 days respectively.
Open `./planet-01/report-summary/0000000102069549-01-weak-secondary-diagnostic.fig`

No figures named 0000000102069549-01-bootstrap-false-alarm.fig are available.



Optical ghost diagnostic core aperture flux time series for target 102069549, planet candidate 1. The unwhitened time series is phase folded at the orbital period associated with the planet candidate and centered on the epoch of the first transit. The time series was first cotrended against spacecraft engineering data, motion proxies, and/or cotrending basis vectors (CBVs) to remove systematic effects. Flux time series data represent the mean per pixel flux in the core or haloaperture; phase folded data points are shown in the figure with black dots. Binned and averaged phase folded flux values are marked with filled blue circles. The unwhitened transit model light curve is displayed in the figure with a red line. The value and significance of the core aperture correlation statistic are displayed in the figure title if the statistic was successfully computed.

Open `./planet-01/ghost-diagnostic-results/0000000102069549-01-core-unwhitened-cotrended-zoomed-model.fig`



Optical ghost diagnostic halo aperture flux time series for target 102069549, planet candidate 1. The unwhitened time series is phase folded at the orbital period associated with the planet candidate and centered on the epoch of the first transit. The time series was first cotrended against spacecraft engineering data, motion proxies, and/or cotrending basis vectors (CBVs) to remove systematic effects. Flux time series data represent the mean per pixel flux in the core or haloaperture; phase folded data points are shown in the figure with black dots. Binned and averaged phase folded flux values are marked with filled blue circles. The unwhitened transit model light curve is displayed in the figure with a red line. The value and significance of the halo aperture correlation statistic are displayed in the figure title if the statistic was successfully computed.

Open `./planet-01/ghost-diagnostic-results/0000000102069549-01-halo-unwhitened-cotrended-zoomed-model.fig`

Appendix A Planet Candidate 1

A.1 Model Fitter: All Transits

This planet candidate is suspected to be an eclipsing binary. The transit depth is greater than or equal to 250000 ppm.

A.2 Model Fitter: Odd & Even Transits

Parameter	Odd Transits Estimated Value	Even Transits Estimated Value	Units	Difference / ‖Uncertainty‖
Orbital Period			days	0.0000
Transit Epoch			BTJD	0.0000
Transit Depth			ppm	0.0000
Transit Duration			hours	0.0000

DoF: Degrees of Freedom

This planet candidate is suspected to be an eclipsing binary. The transit depth is greater than or equal to 250000 ppm.

A.3 Eclipsing Binary Discrimination Test

No figures named 0000000102069549-01-eclipsing-binary-discrimination-tests.fig are available.

Appendix B Alerts

Time	Severity	Message
1396.1230	warning	TCE identified as eclipsing binary and eclipses successfully gapped (target=1, catId=102069549, planet=1, component=fitter)
1396.1278	warning	TOI matching is disabled (target=1, catId=102069549, component=performDvToiMatching)
1396.1278	warning	Falling back to trapezoidal model fit results to support difference imaging (target=1, catId=102069549, planet=1, component=generateDvDifferenceImages)
1396.1280	warning	Planet is suspected to be an eclipsing binary, will not proceed with bootstrap (target=1, catId=102069549, planet=1, component=bootstrap)
1396.1281	warning	Falling back to trapezoidal model fit results to support diagnostic test (target=1, catId=102069549, planet=1, component=ghostDiagnosticTests)