
SAINT
MARY'S
COLLEGE
of CALIFORNIA

Stepping Stones to TFOP

Experience of the Saint Mary's College Geissberger Observatory

2018 AAVSO Annual Meeting, Flagstaff, AZ
November 16, 2018

Ariana Hofelmann and Brian Hill
Geissberger Observatory
Department of Physics & Astronomy
Saint Mary's College of California

Stepping Stones to TFOP

- Establishing Goals
    - Age of Large Surveys
- Easy Targets
    - Eclipsing Binaries
- Equipment Upgrades
    - Mount and Imaging Train
- Harder Targets
    - Known Exoplanets
- TFOP Sub Group 1
    - Application Materials
- TFOP Submissions
    - False Positives
- Looking Ahead
    - Trickle then a Bonanza

Acknowledgements and Bibliography

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AAVSO 105th Annual Meeting, November 10-12, 2016, Burlington, MA

The Age of Large Surveys

Joey Rodriguez, Harvard Smithsonian Center For Astrophysics

The Crucial Role of Amateur-Professional Networks in the Golden Age of Large Surveys

Ryan Oelkers, Vanderbilt University

The Transiting Exoplanet Survey Satellite

Charles Alcock, Harvard-Smithsonian Center for Astrophysics

The Role of Small Telescopes in the Upcoming Era of the Giant Magellan Telescope and other Extremely Large Telescopes

David Ciardi, NASA Exoplanet Science Institute, IPAC/Caltech

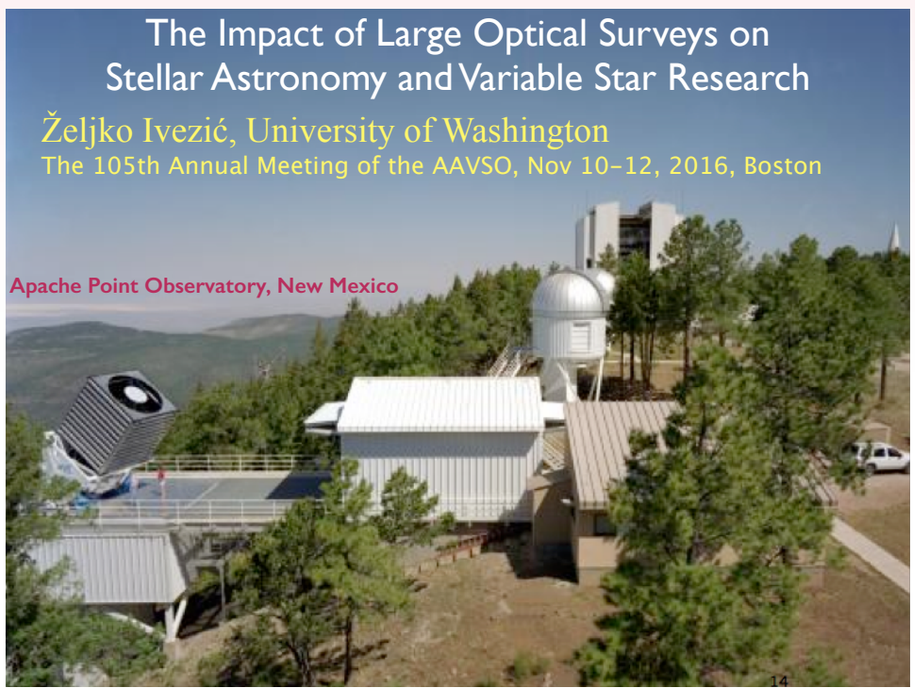
Kepler and K2: Spawning a Revolution in Astrophysics from Exoplanets to Supernovae

Dennis Conti, AAVSO Exoplanet Section Chair

Advances in Exoplanet Observing by Amateur Astronomers

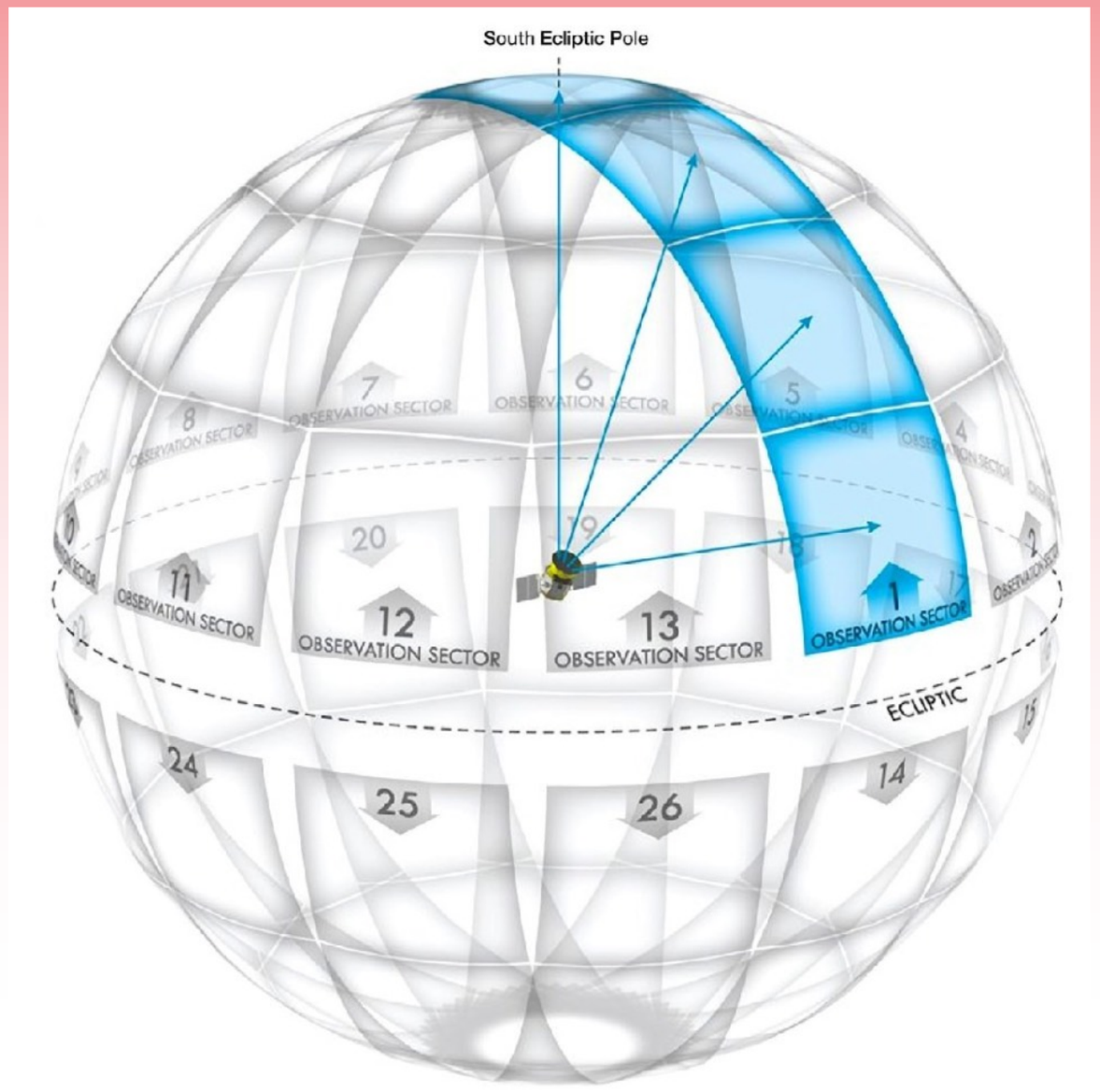
Zeljko Ivezik, University of Washington

The Impact of Large Optical Surveys on Stellar Astronomy and Variable Star Research



TESS Survey Pattern

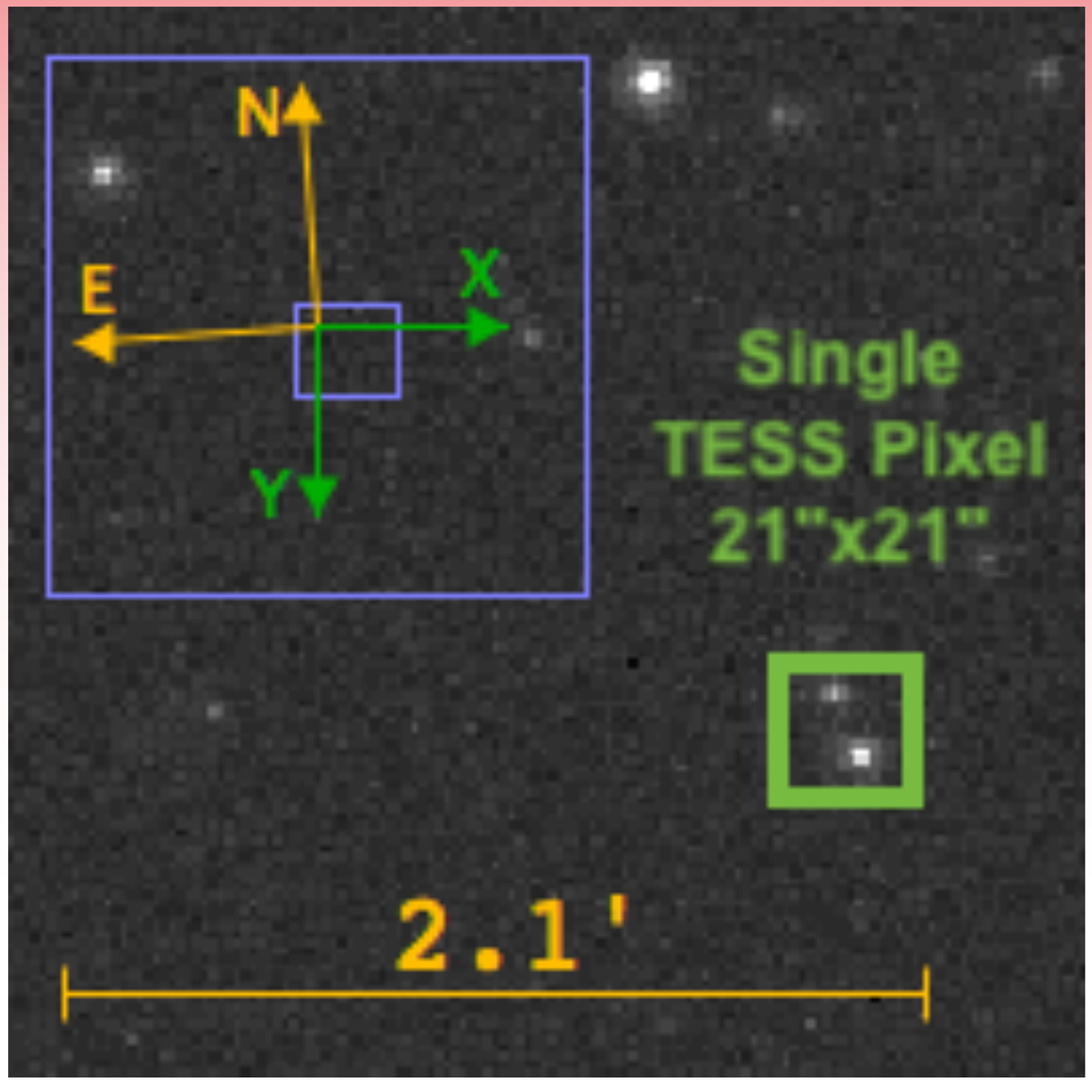
- Aboard TESS are four 105mm f/1.4 telescopes, each imaging 24°x24°.
- In total a "sector" is 24°x96°.
- Each sector observed for 27 days.
- First 13 sectors mostly in southern hemisphere.
- Meaning of "mostly" will be covered later.



Source: TESS Science Support Center

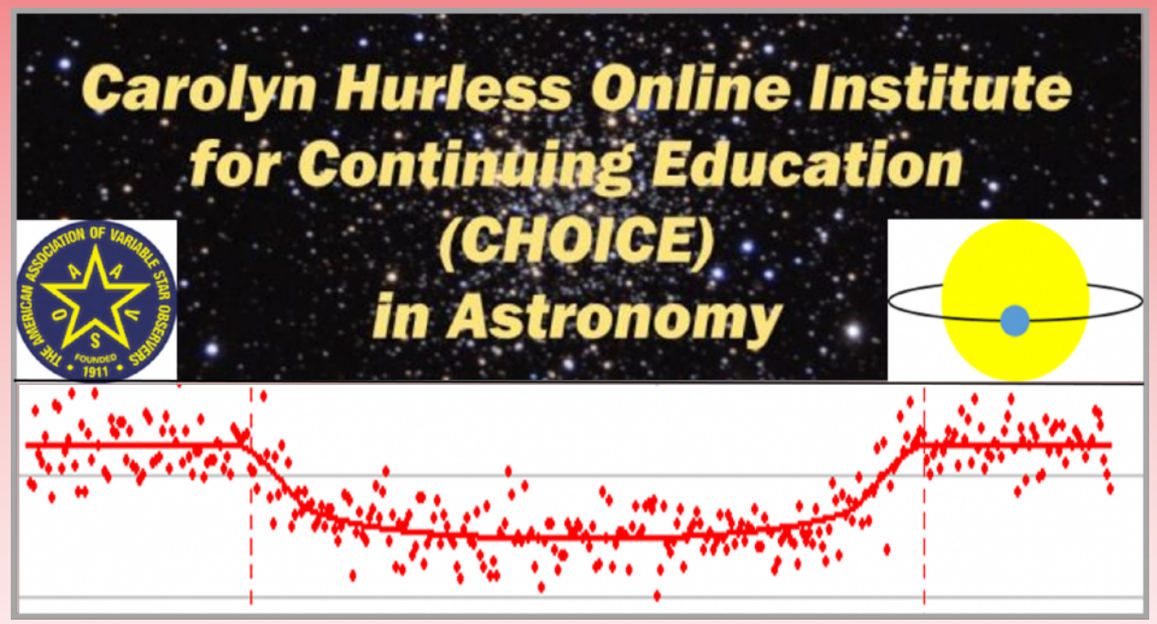
TESS Pixels

- Single TESS Pixel is 21 arc seconds
- At Saint Mary's, our "seeing" is typically 5 arc seconds FWHM (full-width half-maximum)
- Photo at right taken with portable gear at Barcroft Field Station. FWHM: 3 arc seconds.
- For TESS, everything in the green square is a single shade of gray!



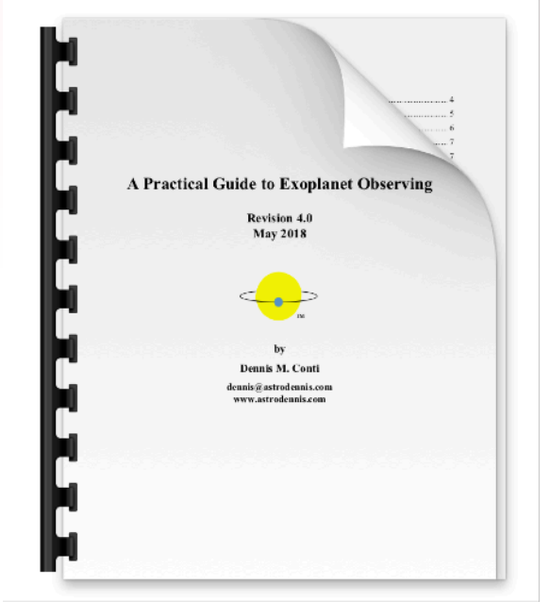
Dennis Conti, Chair, AAVSO Exoplanet Section

A CHOICE Course on Exoplanet Observing



https://www.aavso.org/new-exoplanet-choice-course

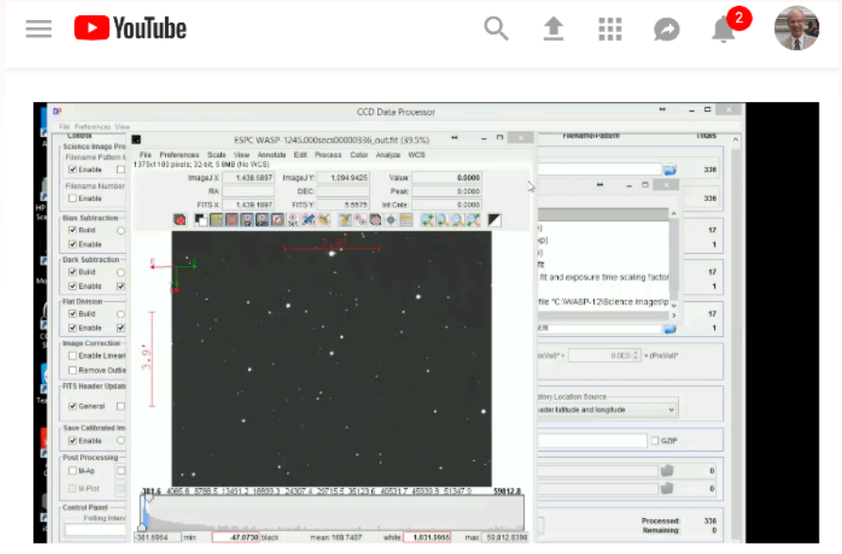
Guide and Resources: www.astrodennis.com



Sample Exoplanet Transit Images and AstroImageJ Configuration Files:

- Bias.zip
- Darks.zip
- Flats.zip
- ScienceImages.zip
- Measurements_Template.zip

CHOICE Course Tutorials



Module 7B: Image Calibration using AstroImageJ

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An Eclipsing Binary in Aquila

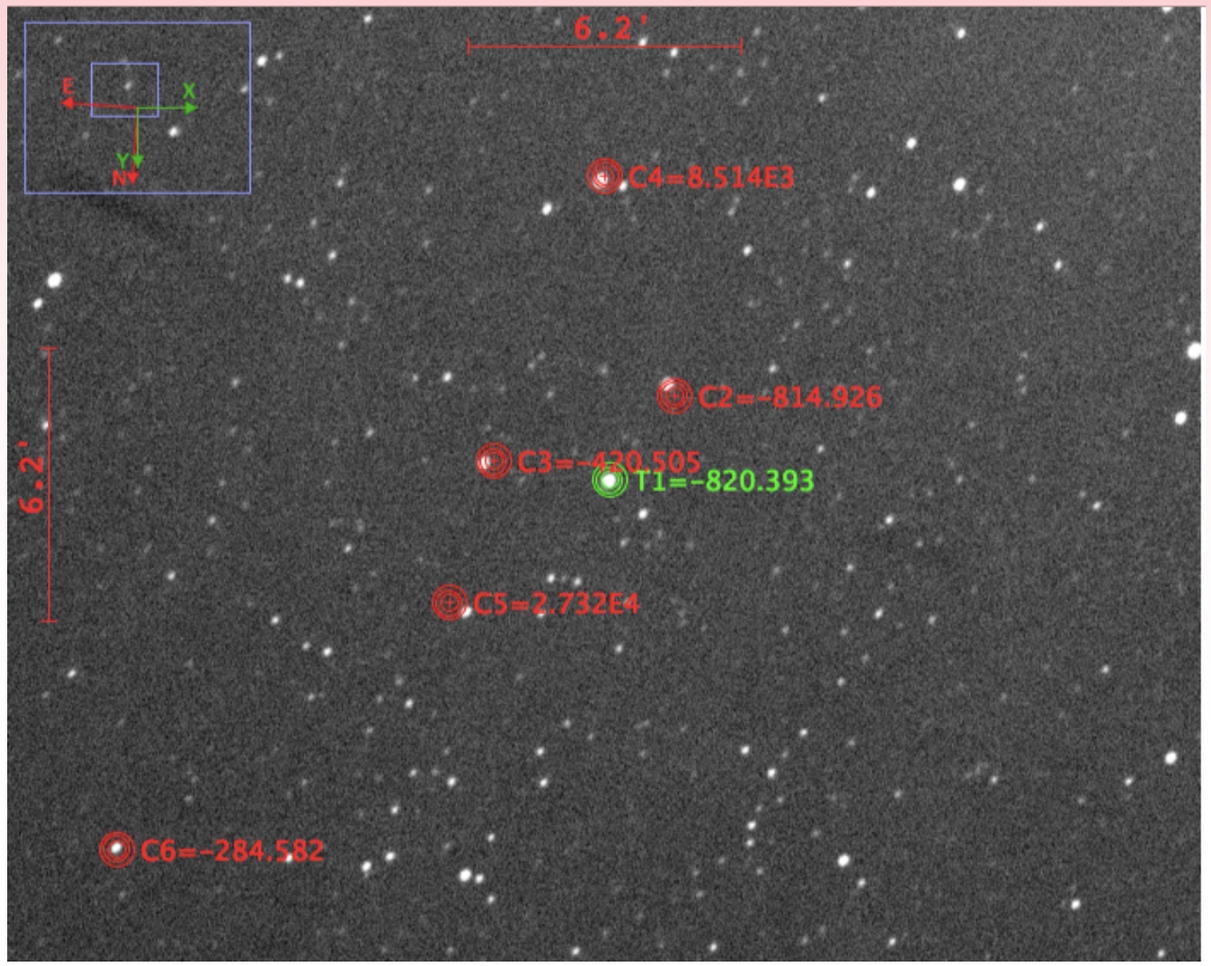
OO AQL

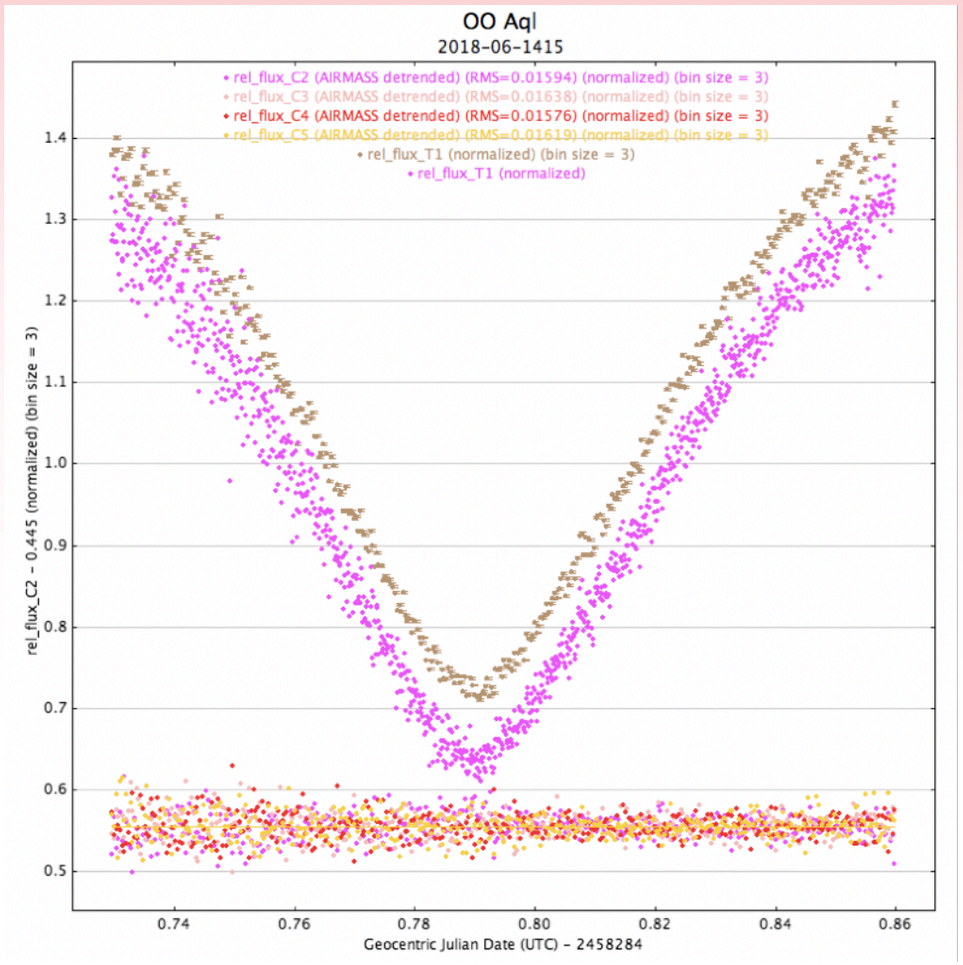
This is a magnitude 7 binary star system in Aquila. 1147 images were taken at 6-second exposures over 3 hours.

Stellarvue 115T on Losmandy GM8

An Eclipsing Binary in Aquila

Below left is one of the 1147 images. The target OO AQL is in green as T1. The comparison stars are in red as C2 to C6. Aperture photometry was performed in AstroImageJ. Below right is the light curve showing a 50% light drop at mid-eclipse.





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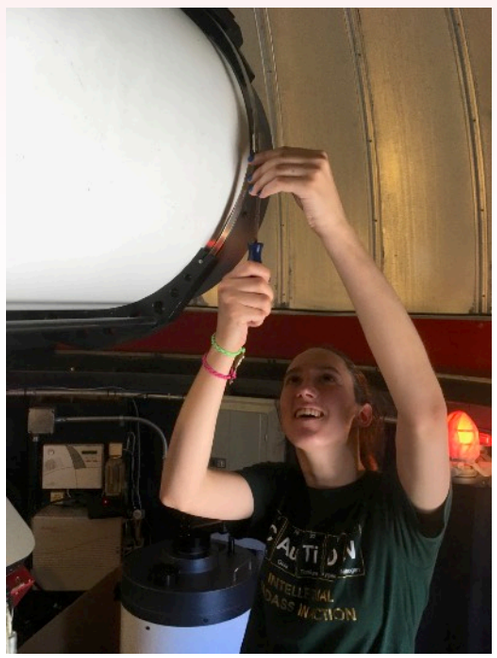
Mount Electronics Upgrade

Software Bisque Paramount ME MKS 5000 Control System

Good-bye RS-232.
Hello USB.



Imaging Train Upgrade

Optec NGC 316 Reducer/Flattener

Starlight Xpress
Lodestar X2 Autoguider

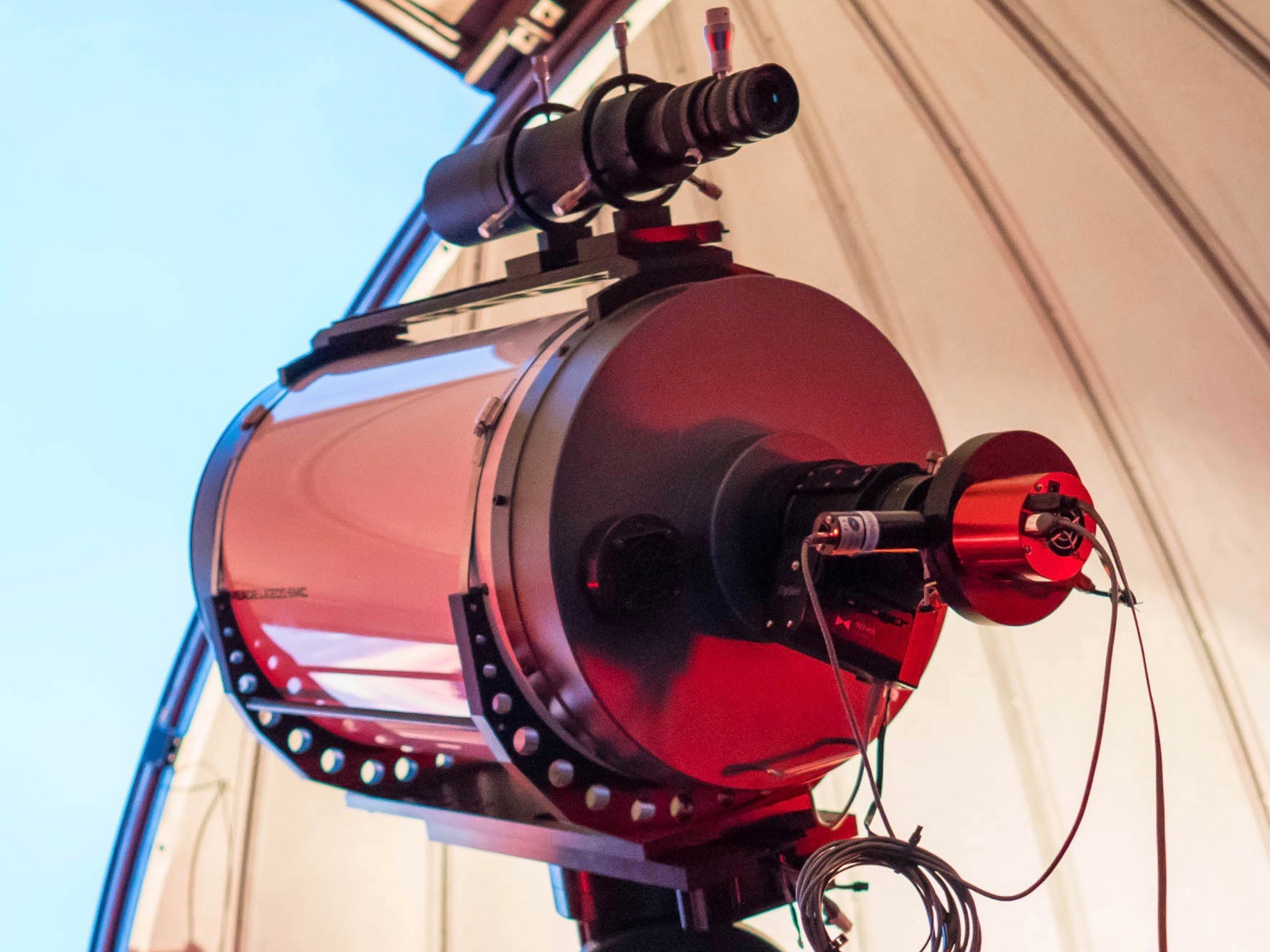
ZWO ASI1600 MM-Cooled
CMOS Camera

Gerd-Neumann
D420 Aurora Flat-Field Panel

Optec TCF-S3i Temperature-Compensated Focuser

Starlight Xpress Mini USB Filter Wheel

Astrodon Clear Blue-Blocking
and Sloan g' r' i' and z' Filters



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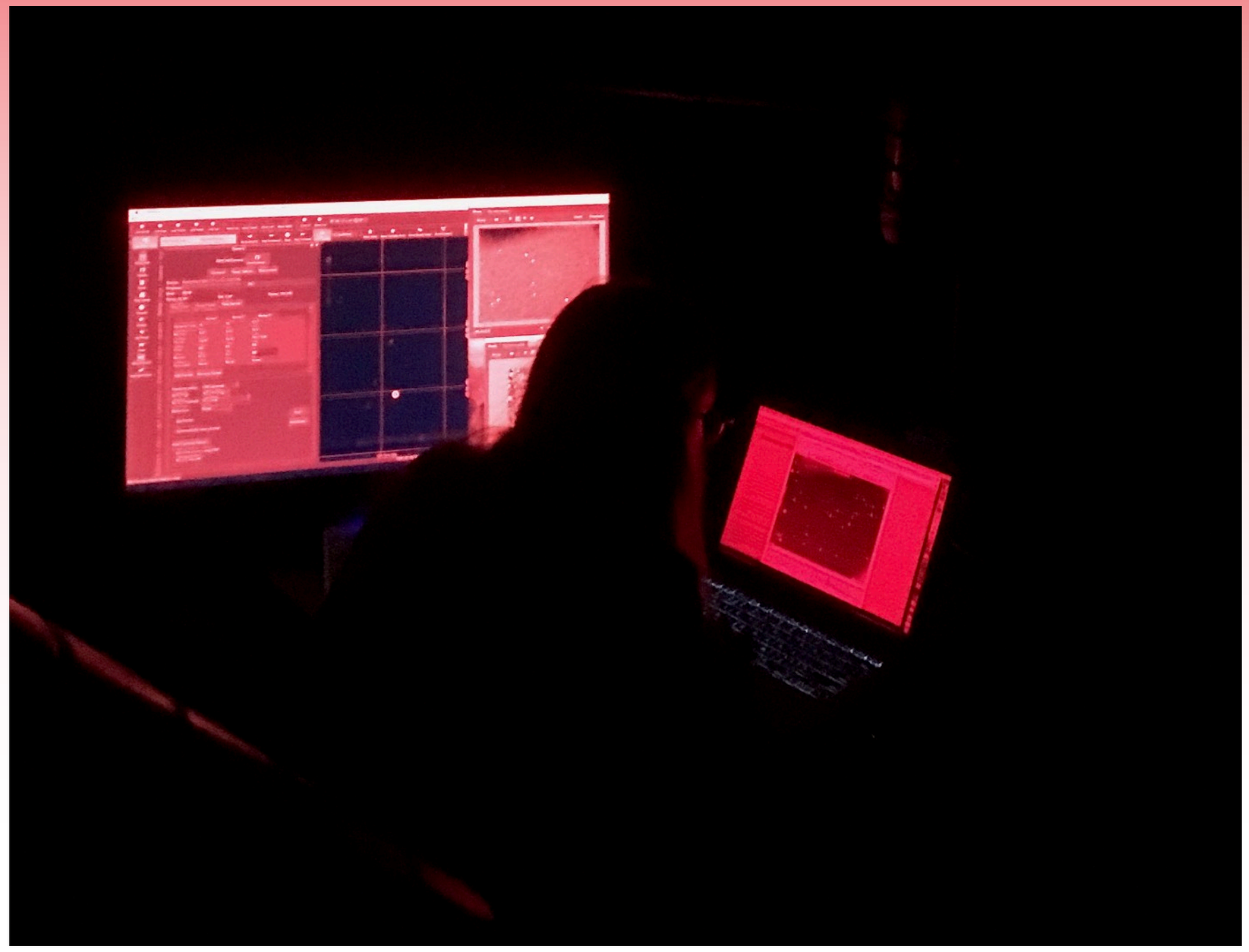
An Exoplanet in Draco

TrES-2

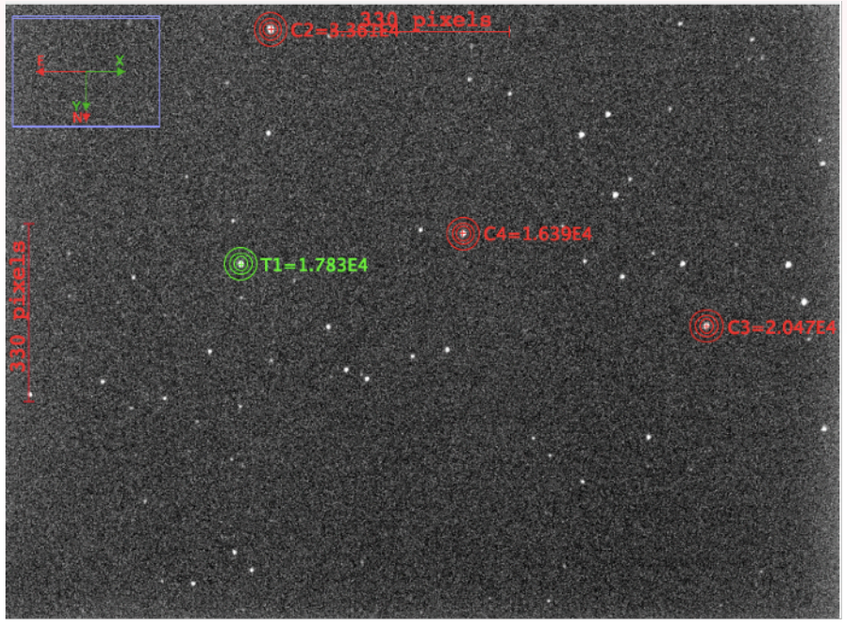
This is an exoplanet in a Vmag 11.4 binary star system between Cygnus and Draco. 541 images were taken over 2 1/4 hours using 15-second exposures.

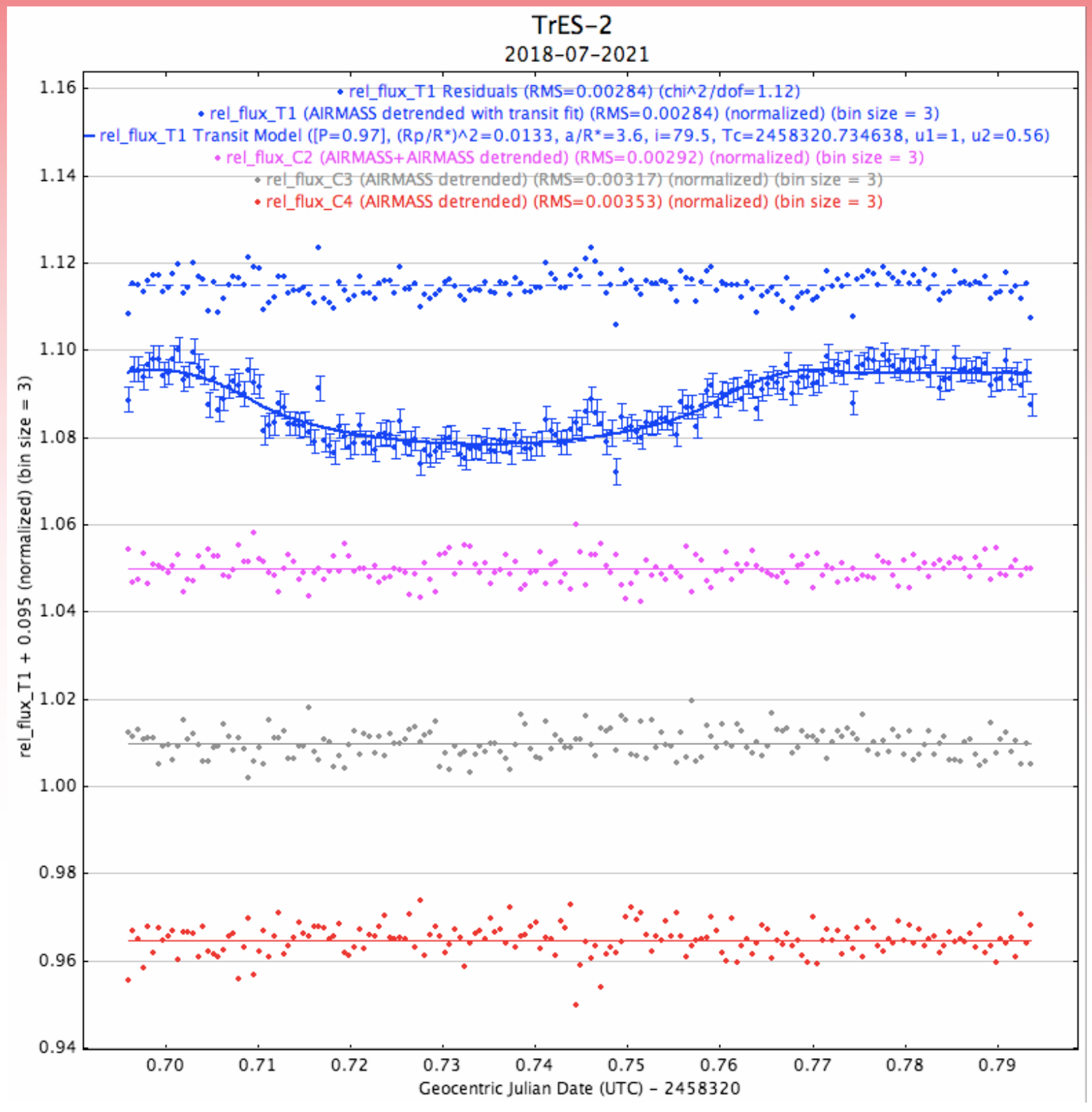


Operator's Console, Meade 0.4m on Paramount ME

An Exoplanet in Draco

Below is one of the 541 images. The target TrES-2 is in green as T1. The comparison stars are in red as C2, C3, and C4. To the right is the light curve showing a 1.6% light drop at mid-eclipse.





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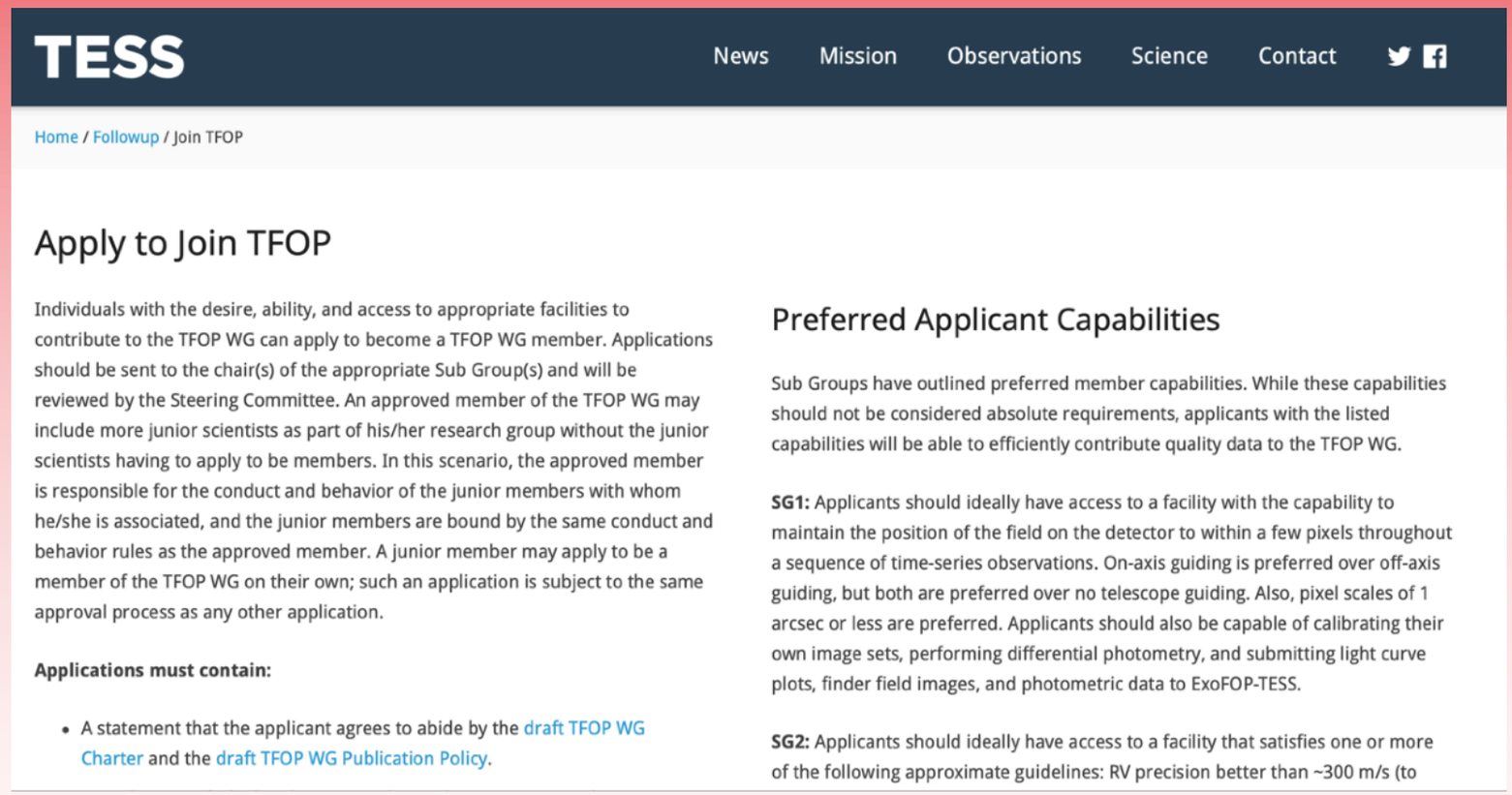
TFOP Application Process



TESS

News Mission Observations Science Contact

Home / Followup / Join TFOP

Apply to Join TFOP

Individuals with the desire, ability, and access to appropriate facilities to contribute to the TFOP WG can apply to become a TFOP WG member. Applications should be sent to the chair(s) of the appropriate Sub Group(s) and will be reviewed by the Steering Committee. An approved member of the TFOP WG may include more junior scientists as part of his/her research group without the junior scientists having to apply to be members. In this scenario, the approved member is responsible for the conduct and behavior of the junior members with whom he/she is associated, and the junior members are bound by the same conduct and behavior rules as the approved member. A junior member may apply to be a member of the TFOP WG on their own; such an application is subject to the same approval process as any other application.

Applications must contain:

- A statement that the applicant agrees to abide by the draft TFOP WG Charter and the draft TFOP WG Publication Policy.

Preferred Applicant Capabilities

Sub Groups have outlined preferred member capabilities. While these capabilities should not be considered absolute requirements, applicants with the listed capabilities will be able to efficiently contribute quality data to the TFOP WG.

SG1: Applicants should ideally have access to a facility with the capability to maintain the position of the field on the detector to within a few pixels throughout a sequence of time-series observations. On-axis guiding is preferred over off-axis guiding, but both are preferred over no telescope guiding. Also, pixel scales of 1 arcsec or less are preferred. Applicants should also be capable of calibrating their own image sets, performing differential photometry, and submitting light curve plots, finder field images, and photometric data to ExoFOP-TESS.

SG2: Applicants should ideally have access to a facility that satisfies one or more of the following approximate guidelines: RV precision better than ~300 m/s (to

https://tess.mit.edu/followup/apply-join-tfop/

Application Contents

- Statement of Abidance with Policies
- Sub Group Interest
- Background and Expected Contribution
- Instrument and Observatory Description
- Instrument Availability
- Local Team Availability

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TTF, ExoFOP TESS, TOI and TOC

Wed. 08-08-2018 (local) Nautical twilight 04:12 - 12:15 (UTC)	TIC 462382587 Add to TOC Finding charts: Annotated, SkyMap; Info: ExoFOP TESS, Simbad, Gaia, TIC, VSX; Airmass plot, ACP plan		11.02 Moon 6% @149°		08:40—10:03—11:26 ±0:16	2:47	8339.861 8339.919 8339.977	54°, 42°, 26°	216°, 241°, 258°	+1.4, +2.7, +4.1	20:20:17.00 +07:04:56.0	9.43	31	4		Not observed yet.

Once approved you will have early (NDA'd) access to information from:

- TTF (TESS Transit Finder) *(sample TTF entry above and sample annotated finder chart to right)*
- ExoFOP TESS (Exoplanet Follow-up Observing Program)
- TOI Alerts (TESS Objects of Interest)

Using this information, identify promising targets for your observatory. Then enter your observing plan for the next 1-2 nights using:

- TOC (TESS Observation Coordinator)

TOC Conformance - 1st False Positive

TIC 462382587

This is a "Priority 4" target imported into the TESS Transit Finder (TTF) from the KELT false positive catalog. The star has Vmag 10.9.

841 images were taken at 20-second exposures across 5 hours.

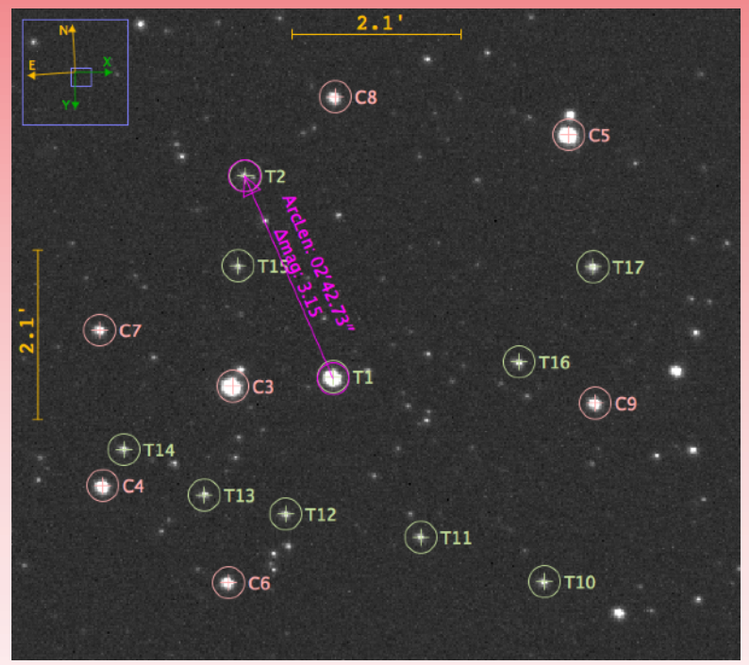
Stellarvue 130T on Paramount MYT
at Barcroft Field Station

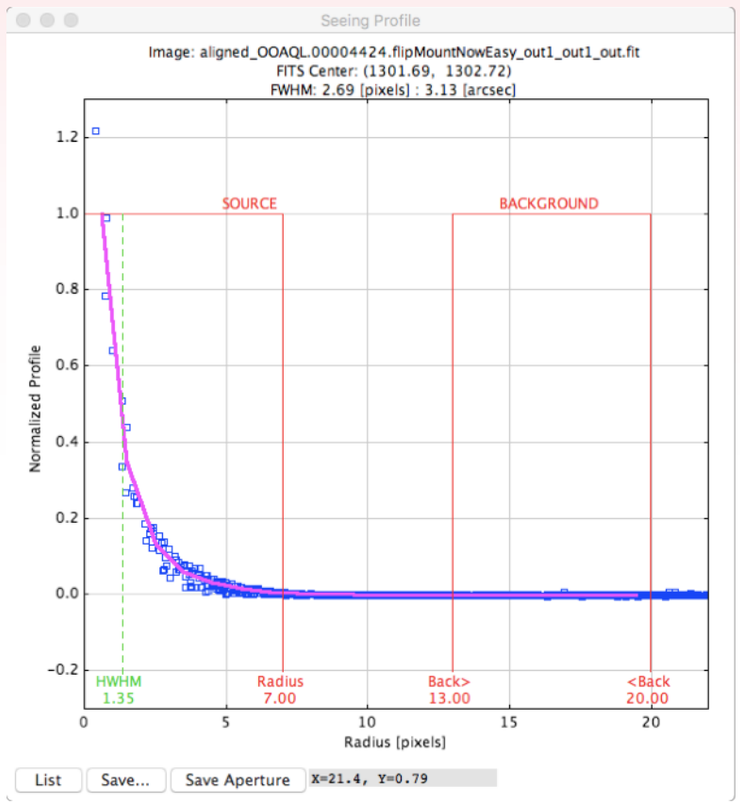
TOC Conformance - 1st False Positive

9 Work Products For Each Submission

- Full Field (png or jpg)
- Zoomed-in Field *(shown at upper right)* (png or jpg)
- Seeing Profile *(shown at lower right)* (png or jpg)
- Plate-solved FITS file (fits)
- Apertures for Target and Comparison Stars (AstroImageJ format)
- Plot Configuration Used to Produce Final Light Curve (AstroImageJ format)
- Measurements File (xls)
- Light-Curve *(shown in subsequent slide)* (png)
- Observation Notes (txt)

As a TFOP SG1 member, you will adhere to TFOP SG1 Observation Guidelines summarized and authored by Dennis Conti and reviewed by Karen Collins, TFOP SG1 Chair. This guide is designed to help all team members achieve uniform results.

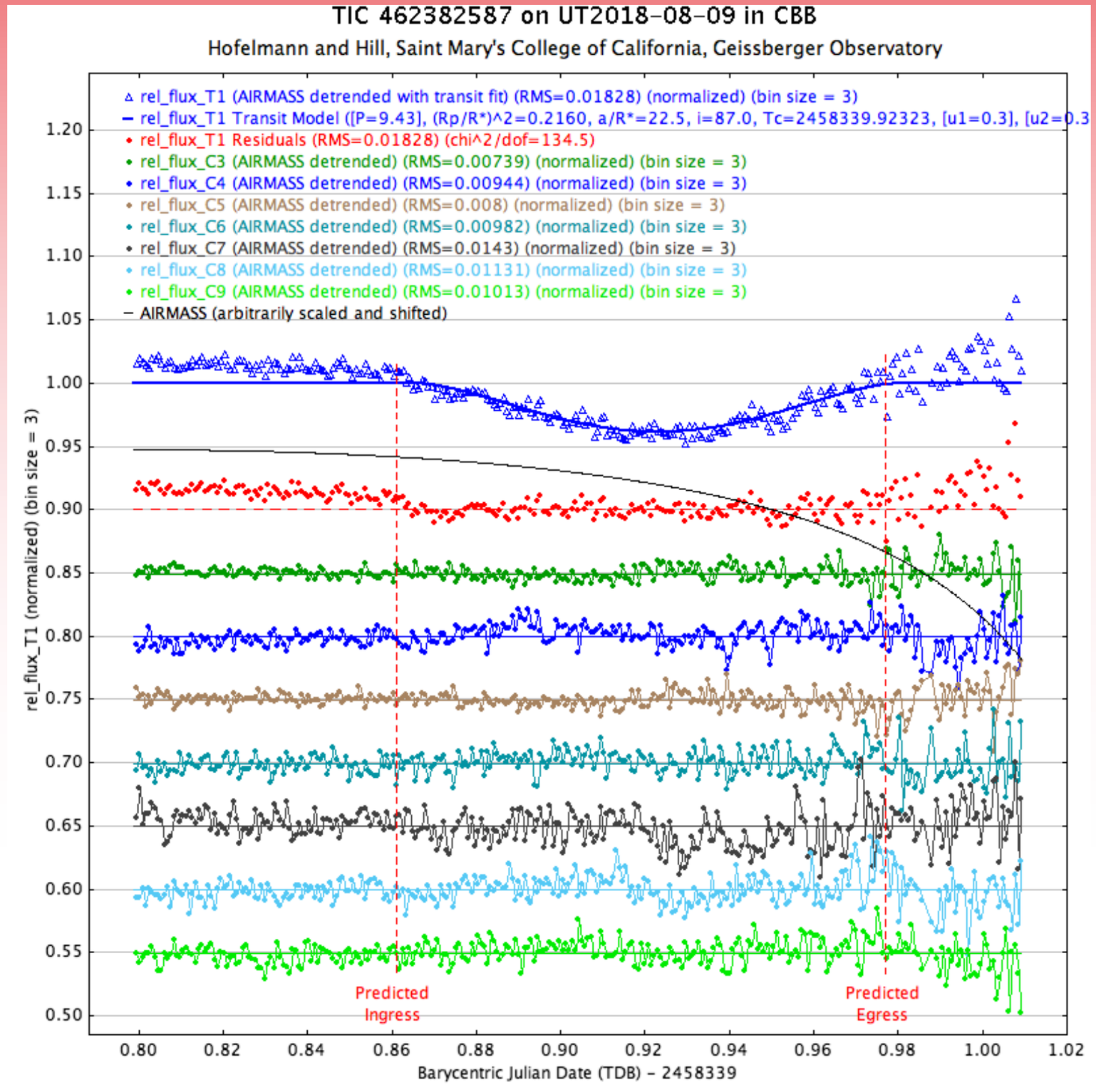




TOC Conformance - 1st False Positive

- We observe ~45 ppt (parts per thousand) flux deficit on target at mid-transit.
- This is consistent with what was found by the KELT team.[1]
- Fit parameters give stellar radius approximately 5.3x radius of Jupiter.[1]
- This is well above the typical 2.5x radius of Jupiter upper limit that is consistent with a planetary interpretation.[1]

[1] Karen Collins, private communication, 2018-10-20.

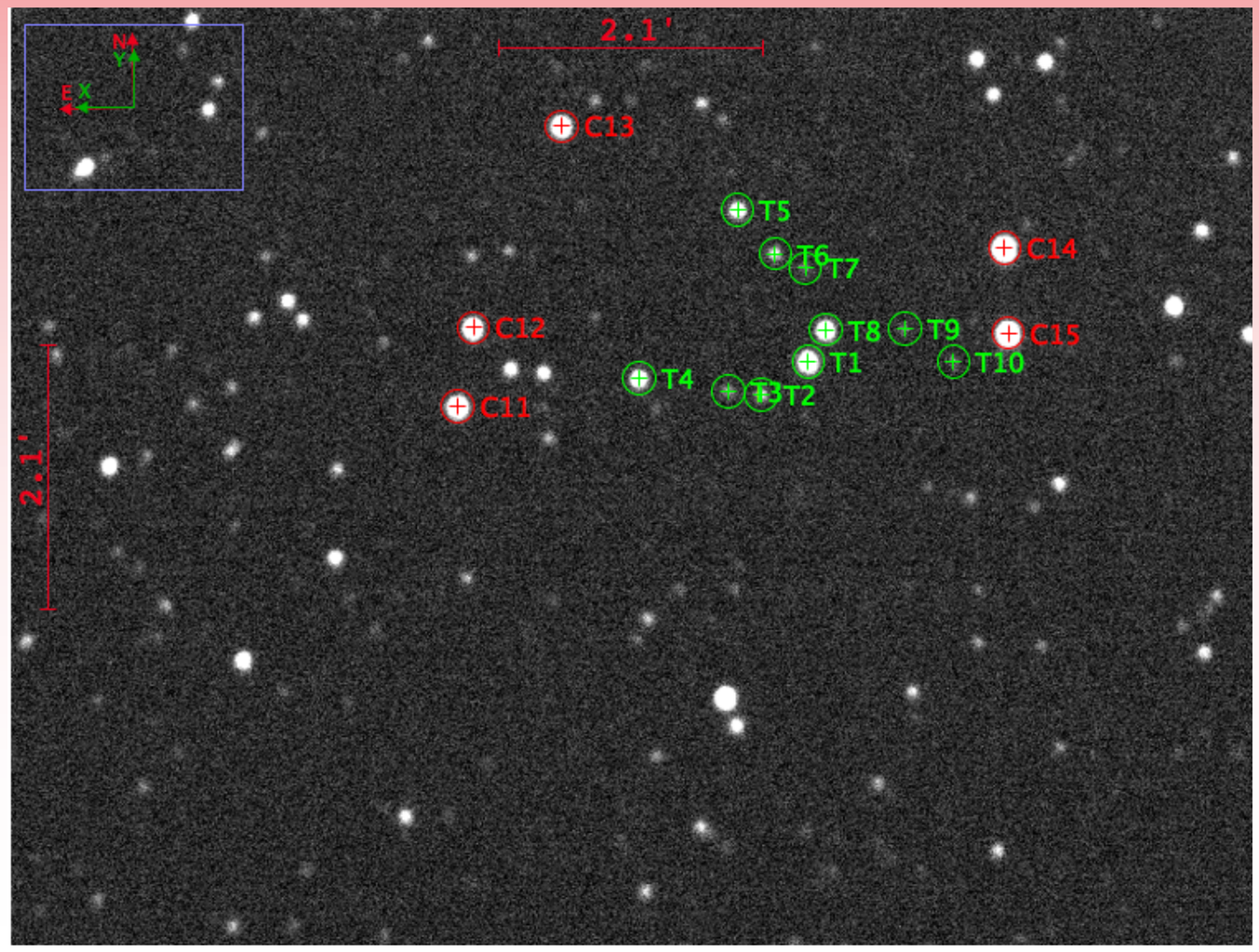


TOC Conformance - 2nd False Positive

TIC 100234546

This is another "Priority 4" target imported into the TTF from the KELT false positive catalog. The star has Vmag 11.4.

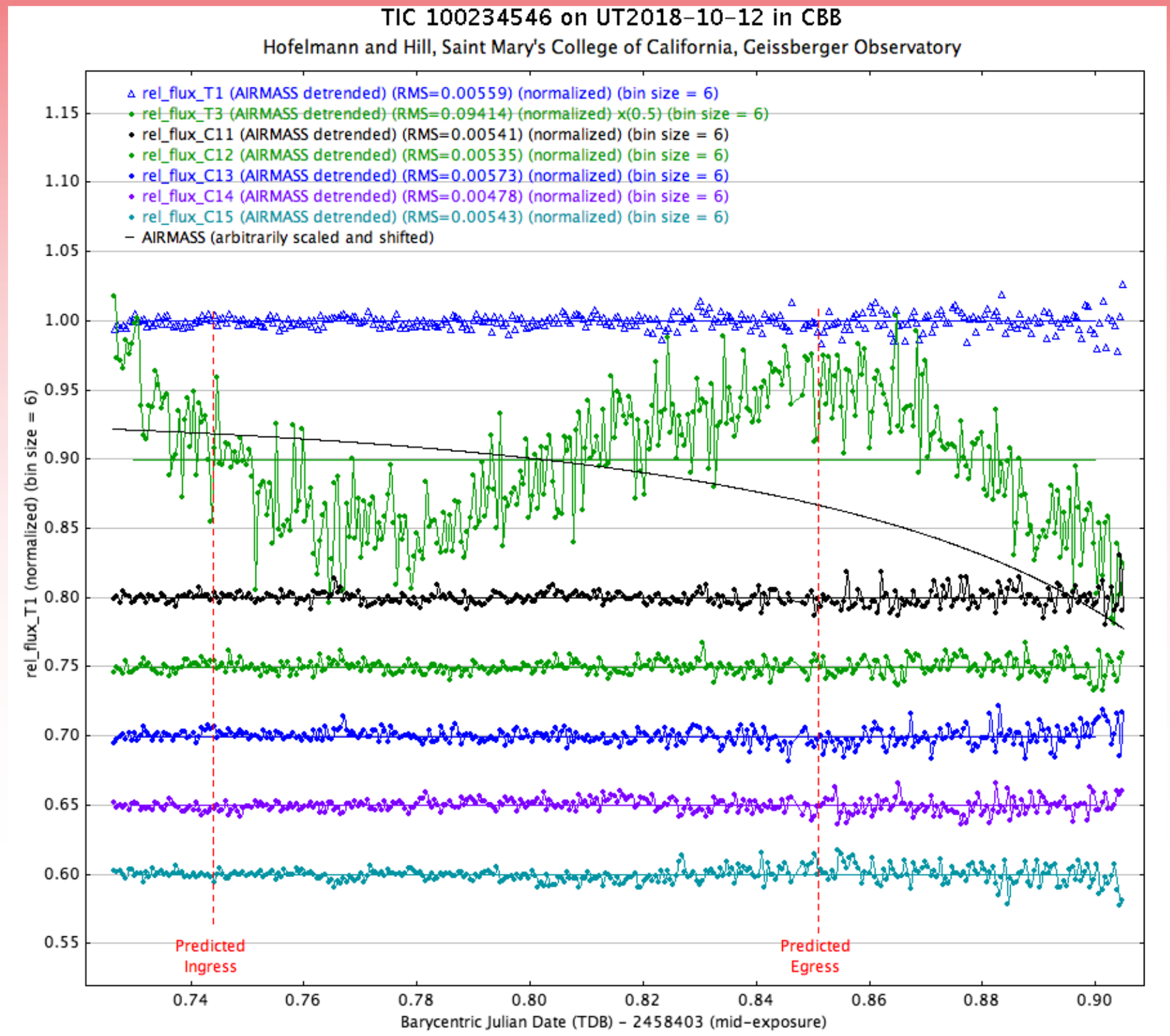
2037 images were taken at 5-second exposures across four hours.



Meade 0.4m on Paramount ME
with MKS 5000 Control System

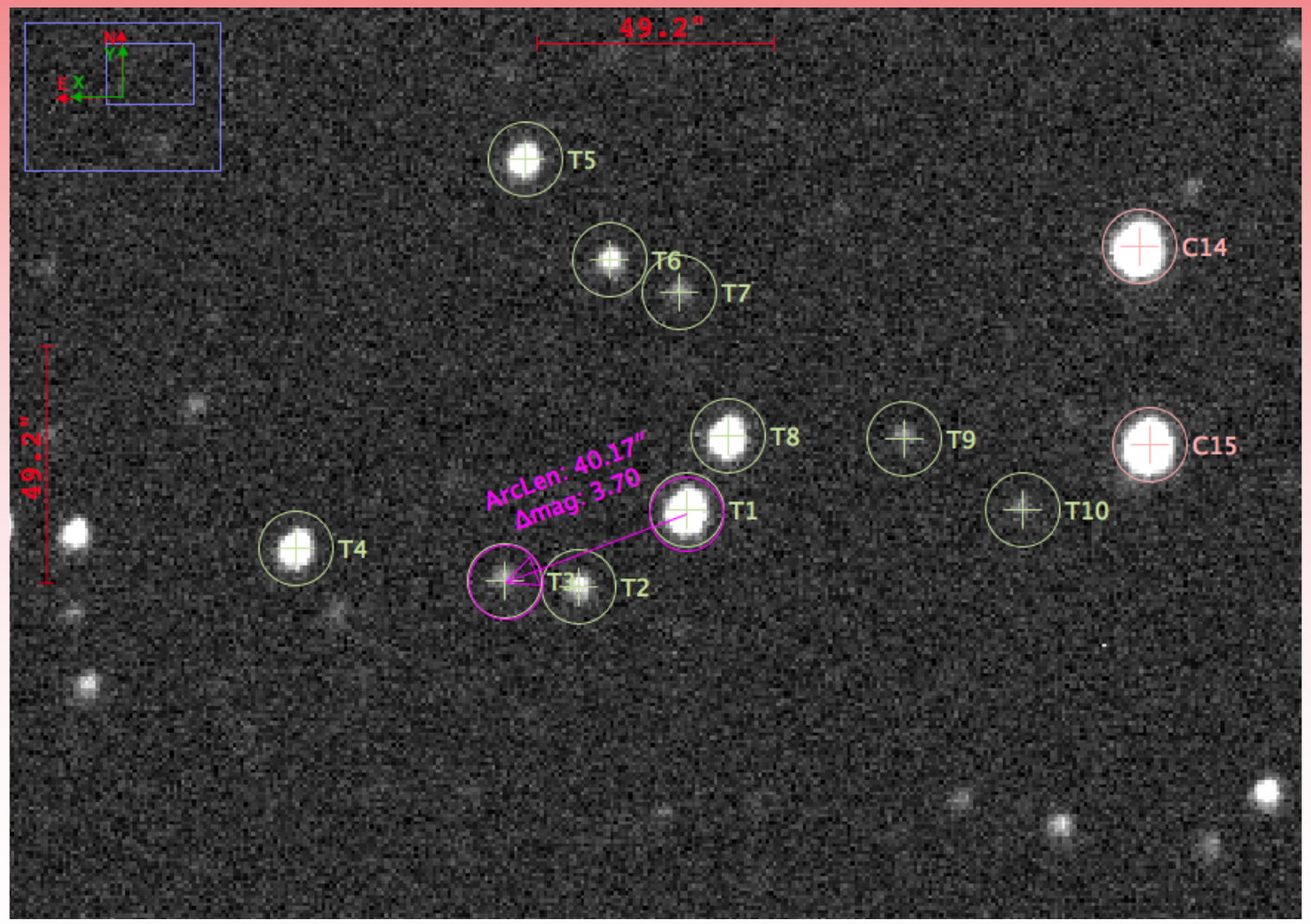
TOC Conformance - 2nd False Positive

- Target star T1 has no transit observed.
- Comparison stars C11 to C15 are flat.
- Nearby star T3 shows a large fluctuation.
- In this plot the fluctuations of star T3 have been reduced in scale by 50%.



TOC Conformance - 2nd False Positive

- T3 is 40 arc seconds away and 3.7 magnitudes dimmer than the target.
- The period of T3 is consistent with the period predicted for the exoplanet transit.
- A good example of a nearby eclipsing binary creating a false positive.



Zoomed-in Field Showing Relationship of T3 to T1

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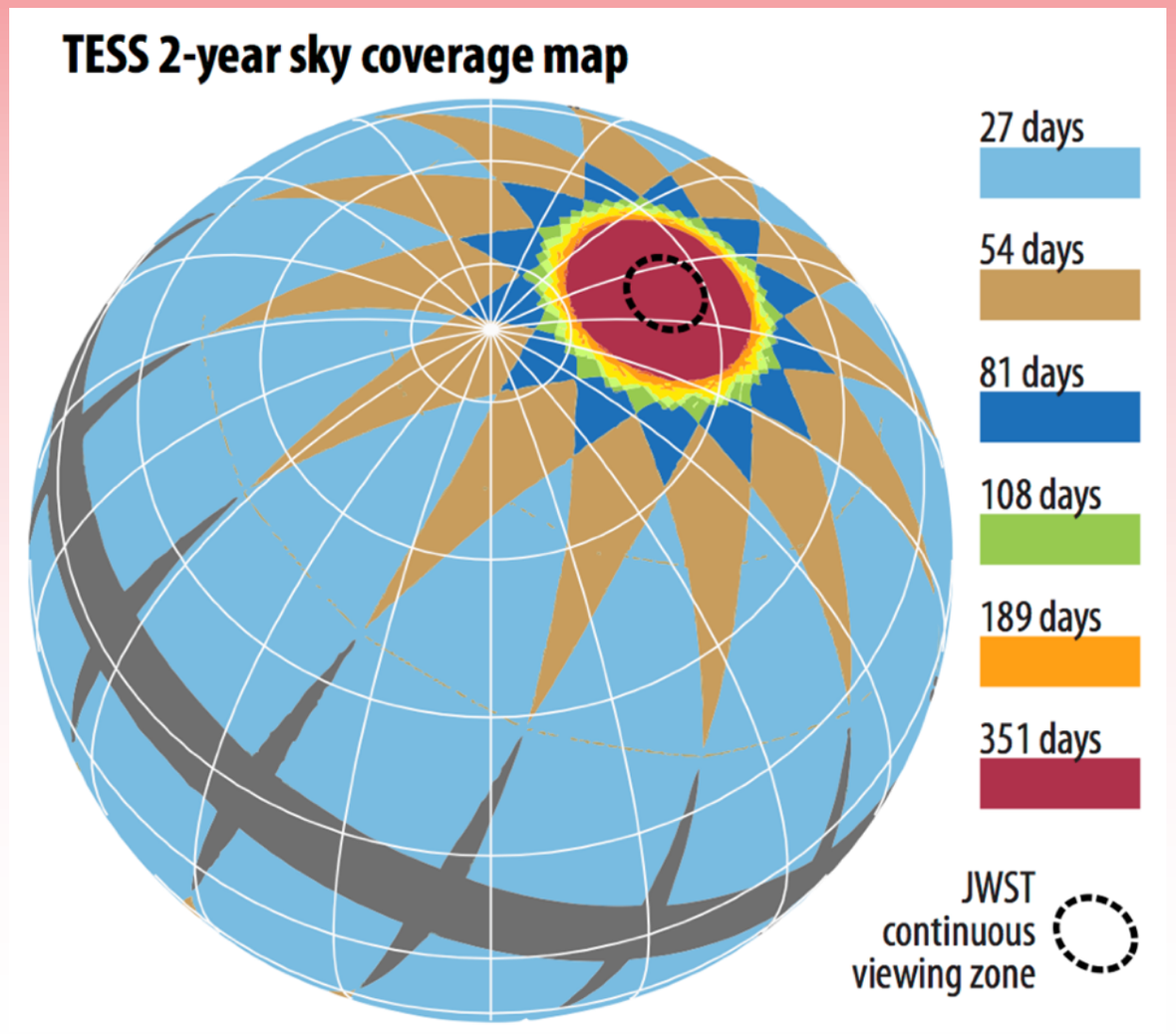
Looking Ahead — Trickle in December



Source: TESS Science Support Center

- Southern hemisphere TFOP SG1 members are already making many transit observations on every night.
- Northern hemisphere TFOP SG1 members as far north as Texas have made observations of a few targets low on the southern horizon.
- In the meantime, K2 follow-on mission targets are being shared via the TTF.
- Apologies to southern-hemisphere observers for our northern-hemisphere-centric view.

Sector	Begin Obs	End Obs	Orbits	S/C RA,Dec,Roll	Cam 1 (RA, Dec)
4	10/19/18	11/15/18	15, 16	55.0070, -36.6420, -157.1698	41.8084, -2.7600
5	11/15/18	12/11/18	17, 18	73.5382, -31.9349, -168.9483	67.0563, 3.5339
6	12/11/18	1/7/19	19, 20	92.0096, -30.5839, 178.6367	92.8145, 5.4079
7	1/7/19	2/2/19	21, 22	110.2559, -32.6344, 166.4476	118.1810, 2.5749
8	2/2/19	2/28/19	23, 24	128.1156, -37.7370, 155.3091	142.3675, -4.1754

NB: Camera 1 Declinations

Source: TESS Schedule of Operations

- Camera 1's declination is marginally positive November-February (Sectors 5-7).

Looking Ahead — Bonanza Fall 2019

- The year-long bonanza of positive declination targets starts Fall 2019 (Sectors 14-26)!
- Prospective TFOP SG1 members still have the better part of a year to set up!

Acknowledgements

- Funders! All of the work shown was made possible by funders, specifically:
  - Saint Mary's College School of Science
  - Saint Mary's College Olowin Memorial Project
- So grateful to manufacturers! These people don't just make products — their expert support was essential to assembling a system that can achieve sub-1% transit-depth photometry, especially:
  - Hollywood General Machining (Losmandy GM8 mounts)
  - Software Bisque (Paramount MYT and ME mounts)
  - Starlight Xpress (Lodestar X2 autoguider and USB mini filter-wheel)
  - Stellarvue (SV115T and SV130T apochromatic triplets)
  - Optec (NGC 316 flattener/reducer and TCF-S3i focuser)
- Researchers! These people are investing huge amounts of time creating opportunity for prospective TFOP members, especially:
  - Jessie Christiansen, NASA Exoplanet Science Institute
  - Karen Collins, Harvard-Smithsonian Center for Astrophysics
- AAVSO Community! Without these meetings we simply wouldn't have known what science our observatory is best suited for, especially:
  - Dennis Conti, Exoplanet Section Chair
  - The AAVSO Staff

Bibliography

Stepping Stones to TFOP

Web-accessible documentation:

- A Practical Guide to Exoplanet Observing, Revision 4.2, Dennis M. Conti
- AstroImageJ 2.4.1 User Guide plus Getting Started with Differential Photometry
- AstroImageJ Cookbook, Grady Boyce and Dennis Conti
- Exoplanet Observing for Amateurs, Second Edition (plus), Bruce L. Gary

Web-based tools:

- Eclipsing Binary Ephemeris, Milwaukee Astronomical Society
- Exoplanet Transit Database, Variable Star Section, Czech Astronomical Society

Online training:

- Exoplanet Observing CHOICE Course, AAVSO

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