

University of Oregon Undergraduate Research TESS Follow-up at the Pine Mountain Observatory

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Introduction

Pine Mountain Observatory (PMO) is a mid-sized observatory owned and operated by the University of Oregon. Since joining the TESS Follow-up Observing Program (TFOP) Sub Group for Seeing-Limited Photometry (SG1) in September of 2023, PMO's team of undergraduate researchers has used their 0.35m telescope to conduct 11 observations of exoplanet candidates, submitting high-precision photometry to the SG1 collaboration. We look forward to expanding our exoplanet program and enhancing our SG1 submissions through new partnerships with other TFOP contributors.

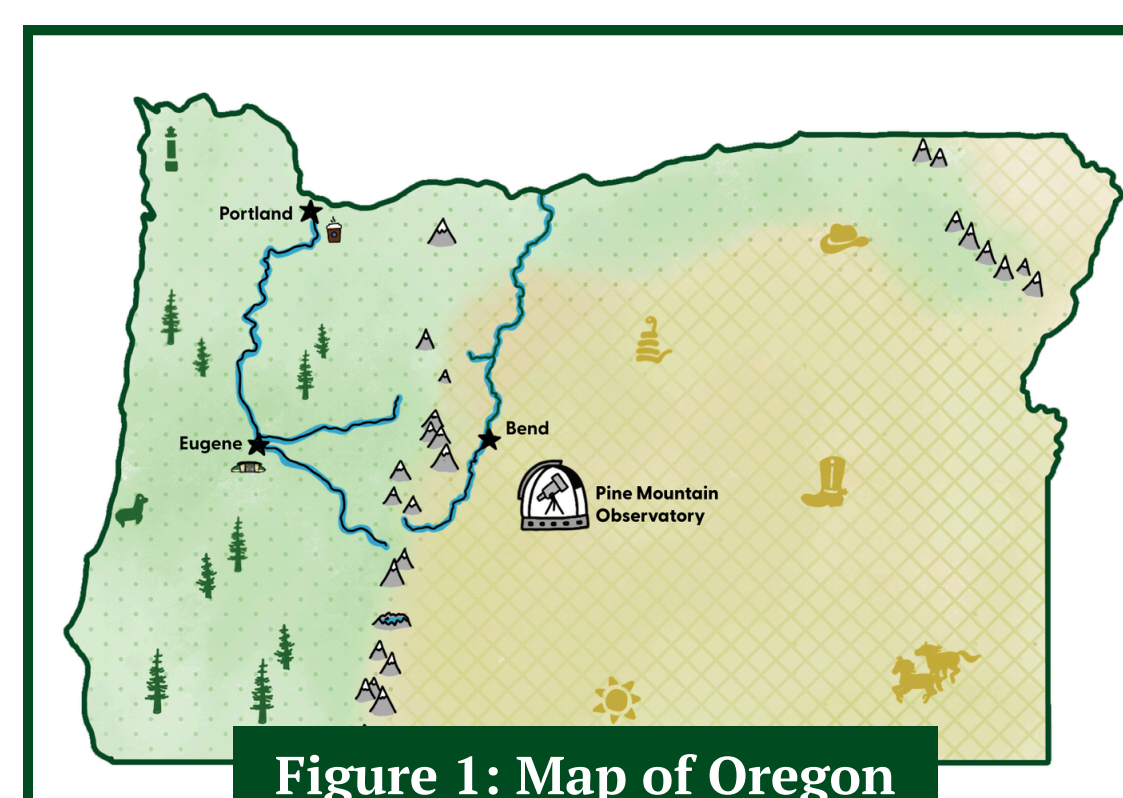


Figure 1: Map of Oregon

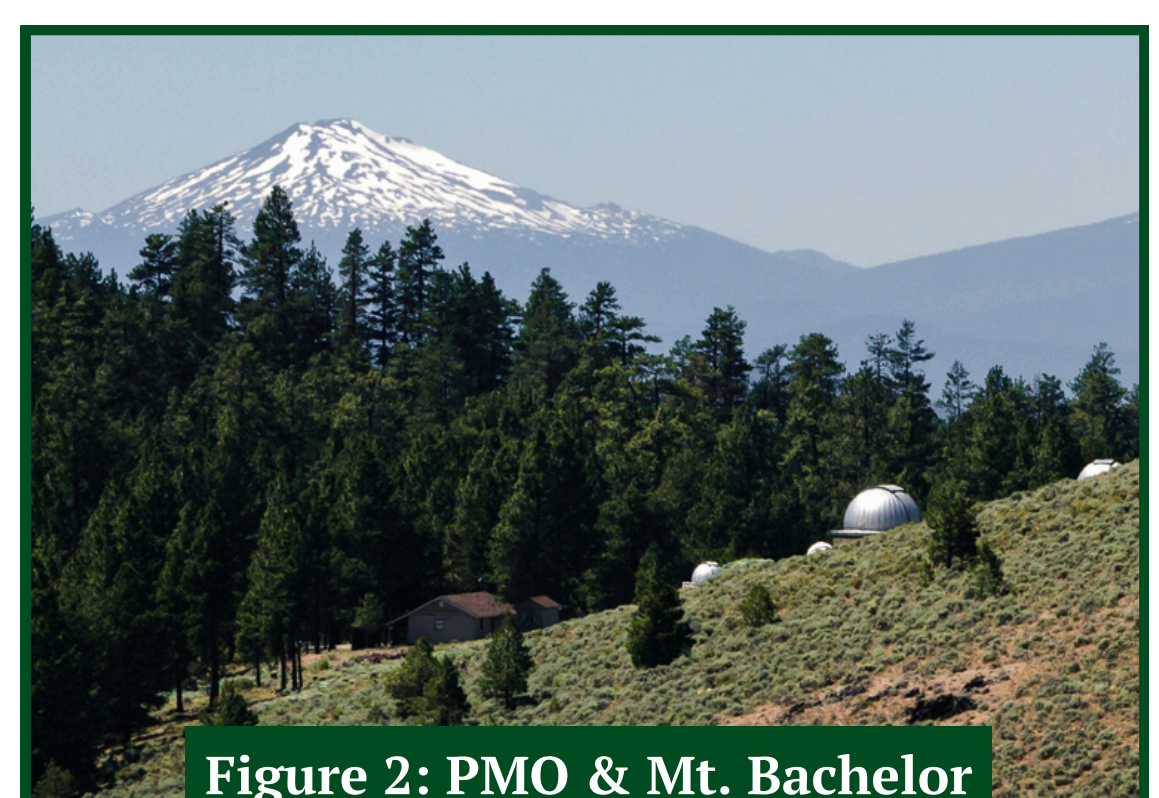


Figure 2: PMO & Mt. Bachelor

Our Facility

PMO is located in the heart of Central Oregon's arid high desert at an elevation of 1,920m [Figure 1, 2]. Observing season at PMO typically begins mid-spring and lasts through late fall. Central Oregon is extremely dark. Typical seeing at PMO is $\sim 2.4''$ while the background sky brightness is near 21 mag / sq arcsec.

In addition to supporting multiple undergraduate research projects, PMO is open to the public two weekends a month in the summer. Deeply involved with community and K-12 outreach, PMO averages ~ 1500 visitors a season.

Two of PMO's 5 telescopes are equipped for remote observations which are frequently conducted from a control room at the main UO campus in Eugene.

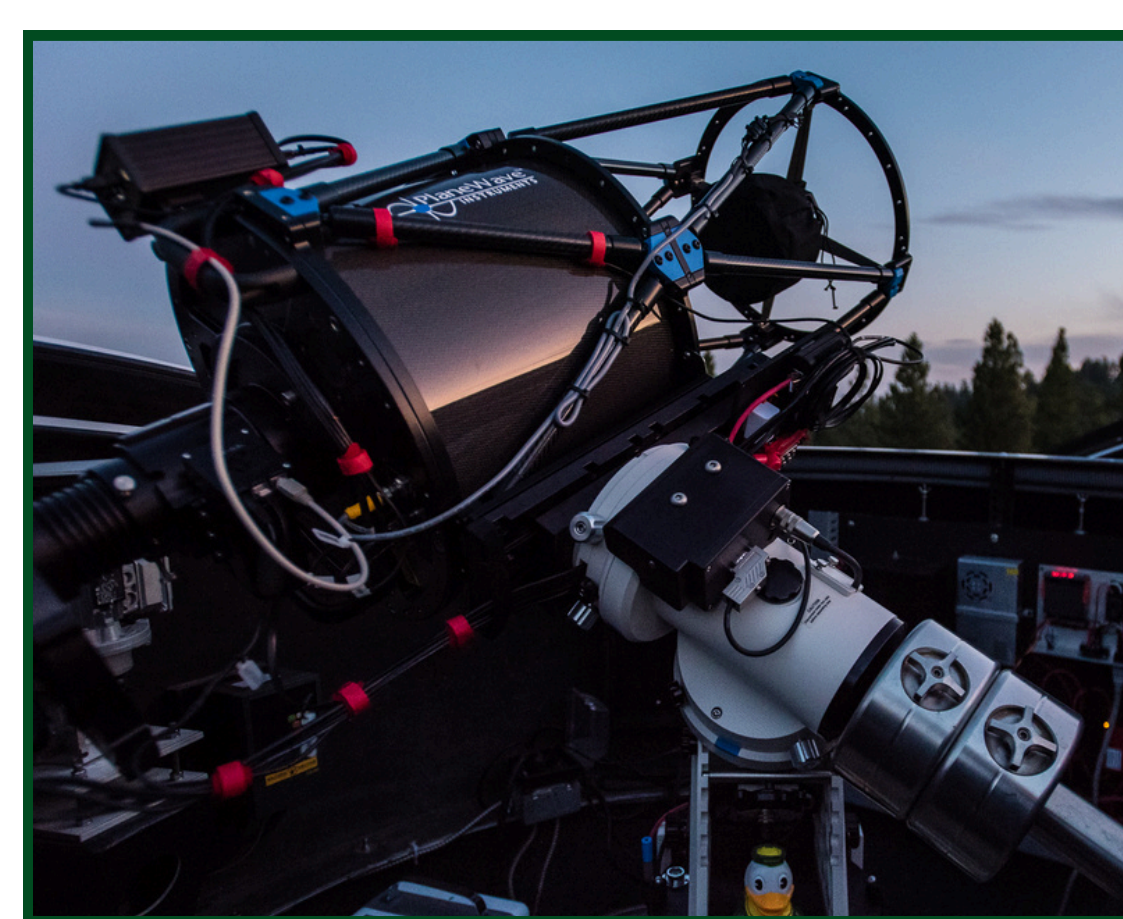


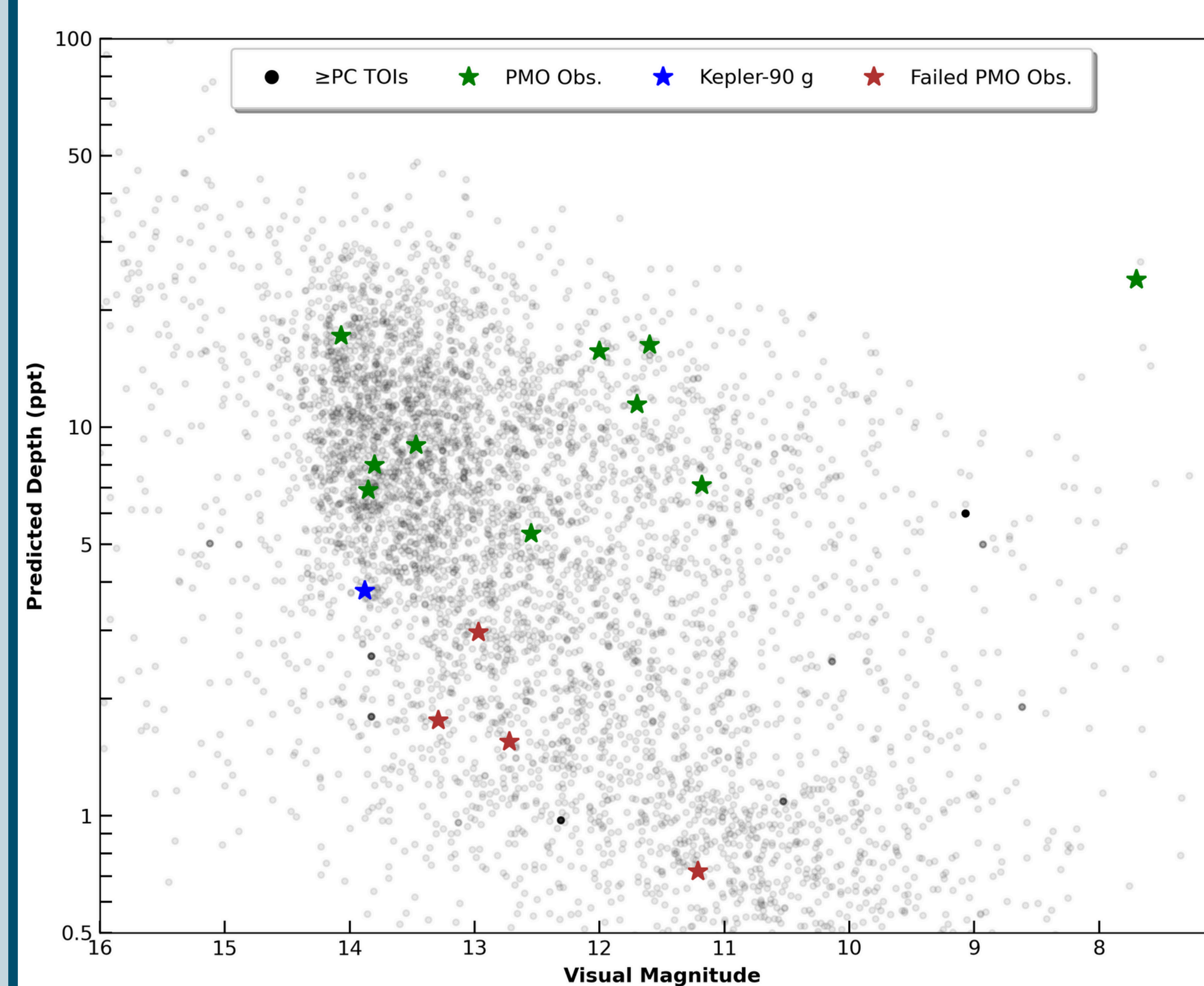
Figure 3: PMO's 0.35m 'Robbins' telescope

Aperture	0.35m
f-ratio	f / 7.2
Pixel Scale	0.96 "/px
FOV	49' x 49'

Research

Research at PMO is carried out by a team of UO undergraduates using the observatory's 0.35m Planewave-CDK 'Robbins' telescope. Our group's main focus is contributing to TFOP, but our other undergraduate-led projects include Kuiper Belt object occultations, 3-D modeling of asteroid shapes through light curve analysis, and open cluster age determination.

Figure 4: Transit Depth vs. Target Vmag



Observations

From target selection to SG1 submission, every aspect of PMO observations are carried out by undergraduate students.

Our observations to date make us confident in PMO's ability to make strong detections of targets $\lesssim 14$ V with $\gtrsim 5$ ppt events. As shown in Figure 4, these limits allow us to observe a large range of TOIs.

Under good sky conditions, we can make highly precise detections, classified by SG1 as observations with resulting All model RMS ≤ 1 ppt/10min. Under exceptional conditions, we expect to achieve enough sensitivity to push our confident detection limit to ~ 2 ppt @ $V \approx 14$

Light Curve Analysis

Our analysis pipeline utilizes MaximDL and AstroImageJ [2] to reduce our raw data and produce the photometry and light curves that we share with SG1. To generate accurate light curves, we obtain timing information from the TTF [3] and use other sources recommended by SG1 to calculate remaining user-specified parameters and model priors [4].

Results

Of our eleven observations since joining SG1, seven successful detections have been shared with the collaboration. The remaining failed observations were all severely weather affected.

Two of our SG1 submissions, part of a special call in May 2024, were used with data from other SG1 members to recover the transit of Kepler-90 g, whose ephemeris had degraded significantly due to TTVs. The joint analysis of these data will be presented in Shaw et al. (2024) [5].

Future Goals

We expect the pace of our SG1 submissions to increase as our team implements better target selection and observational practices and gains more experience with transit observations.

As soon as mid-August, we hope to install a new imaging system on PMO's 0.6m telescope. Currently the workhorse of PMO public nights, recommissioning this telescope for active research will expand the scope of our TFOP contributions.

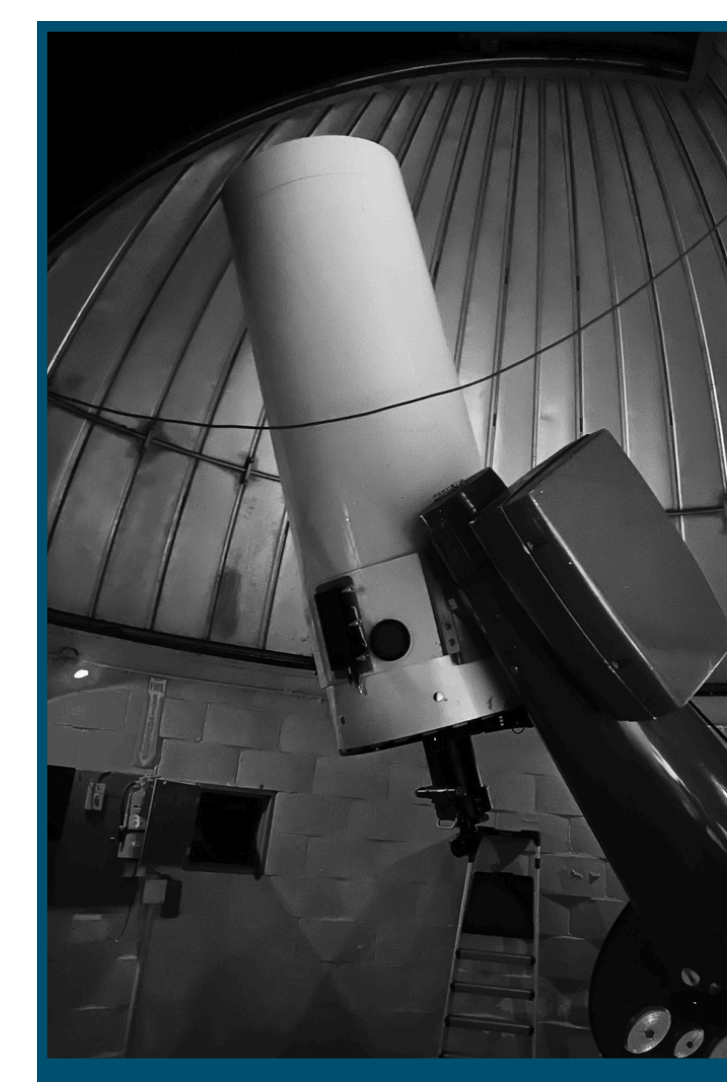
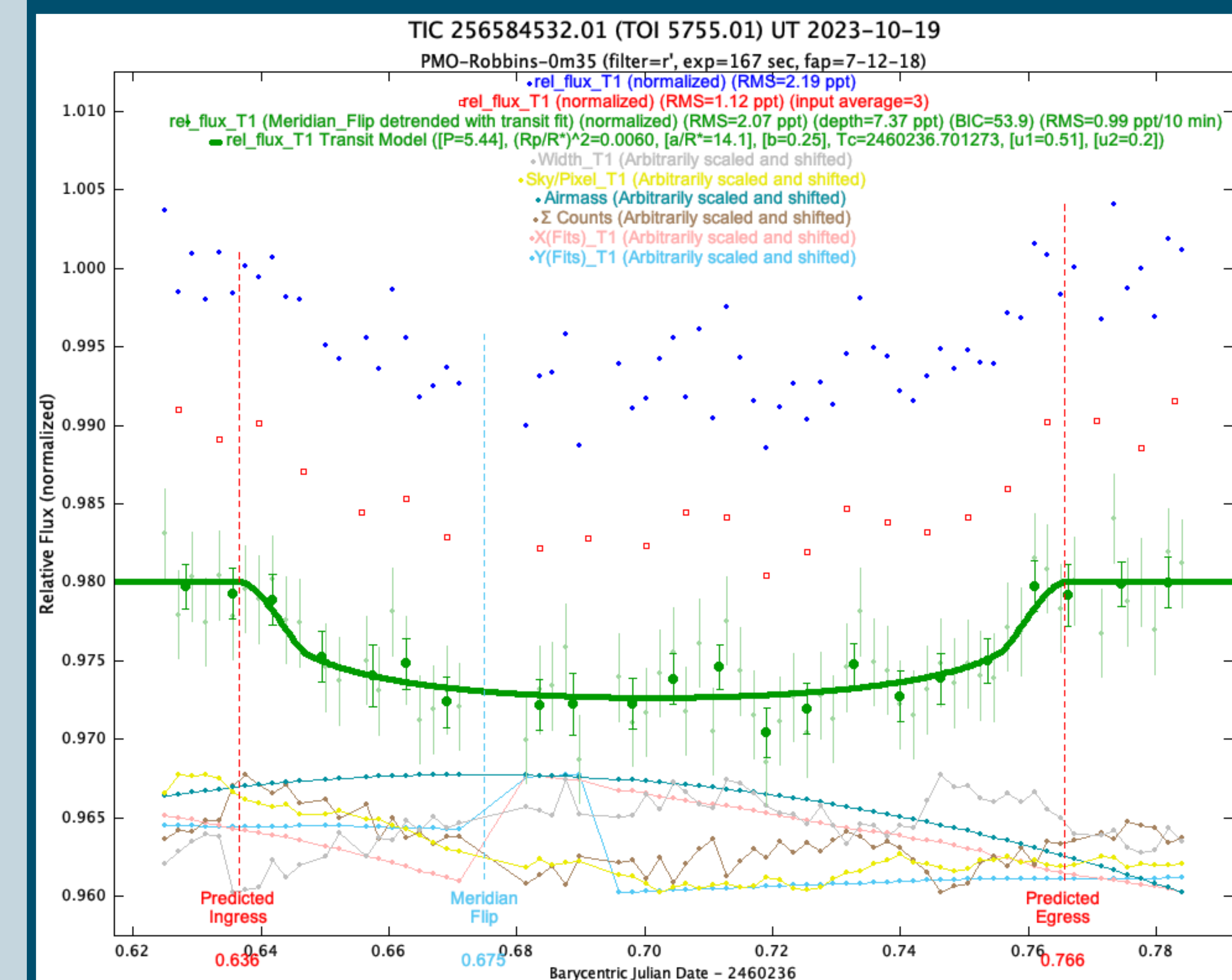


Figure 6: PMO's 0.6m

Figure 5: PMO Light Curve of Typical SG1 Target



References

- [1] Pine Mountain Observatory, <https://pmo.uoregon.edu>
- [2] Collins, K. A., Kielkopf, J. F., Stassun, K. G., & Hessman, F. V. 2017, AJ, 153, 77, doi: 10.3847/1538-2881/153/2/77
- [3] Jensen, E. L. N. 2013, Tapir: A Web Interface for Transit/Eclipse Observability, Astrophysics Source Code Library, ascl:1306.007.
- [4] Eastman, J., Gaudi, B. S., & Agol, E. 2013, PASP, 125, 83. doi:10.1086/669497
- [5] Shaw, D, Weiss, L. M., Agol, E., et al. 2024, In Preparation, arXiv:2407.XXXXX

Acknowledgments

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