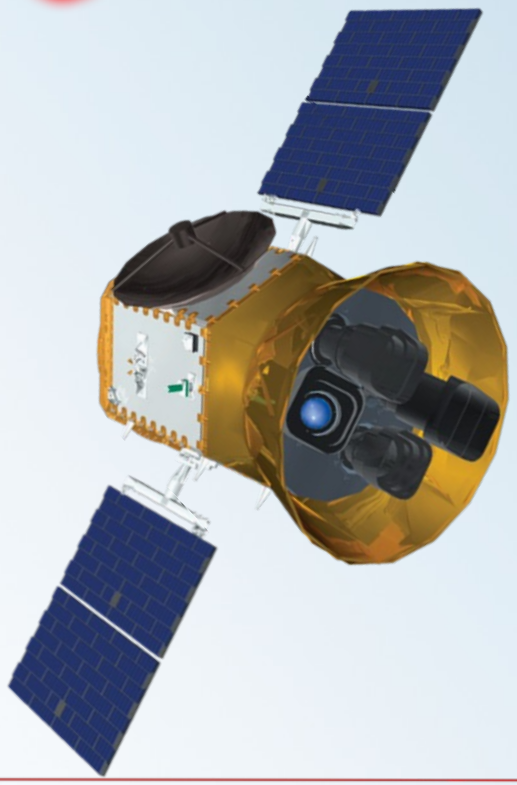
Transiting Exoplanet Survey Satellite



Science Processing Operation Center (SPOC) Processing Status

TESS Science Team Meeting #29

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13 October 2022

Recent Major Activities Since Last Science Team Meeting

- Processing status
- Preparing for EM2 data volume
- Processing throughput
- An update on TESS-SPOC FFI light curves
- Collaboration on applying ExoMiner, a deep learning approach to vetting and validating exoplanets in Kepler data to TESS data using transfer learning

Recent Major Activities Since Last Science Team Meeting

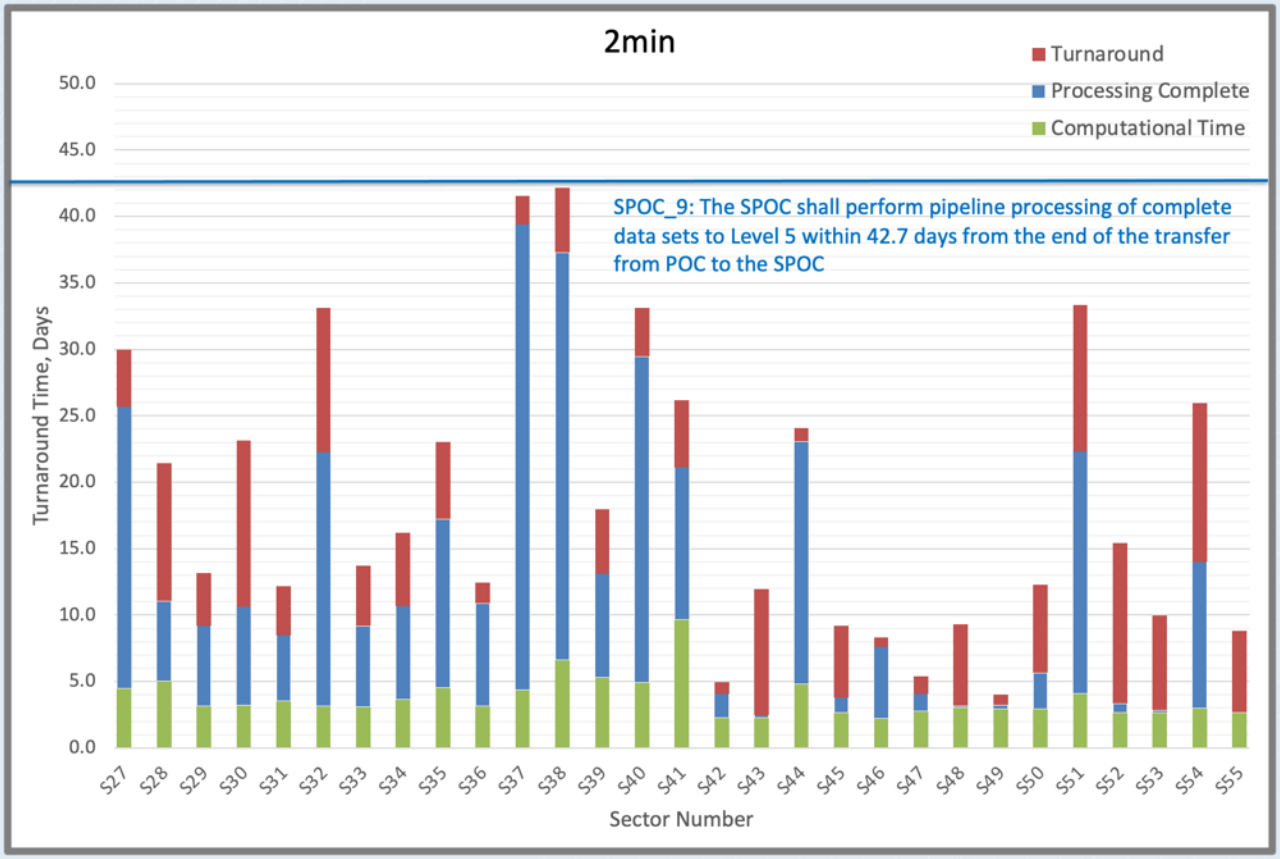
- Sectors through 56 have been processed and staged for DAWG approval
- S14-S26+S40+S55 Multi-sector approved and delivered to POC on 9/28/22
- S56 is pre-staged right now, approval expected by 10/19

Preparing for EM2 Data Volume

- Our dedicated 300-TB 3PAR device filled up at the beginning of 2022
- We are developing detailed plans for migrating the SPOC data store to an existing 1.3-PB NetApp device, nobackupp14, owned by NASA's Advanced Supercomputing division (NAS)
  - *Parts are on order*
  - *Data migration has begun to scratch space*
- Oldest server, tessdb1, is being retired
- A new Rome-based node server is being installed – will be used for expedited processing whenever faster turnaround is needed
- We have lined up a list of sustaining engineering tasks to increase automation of operations and decrease manual effort

2-minute Target Stats

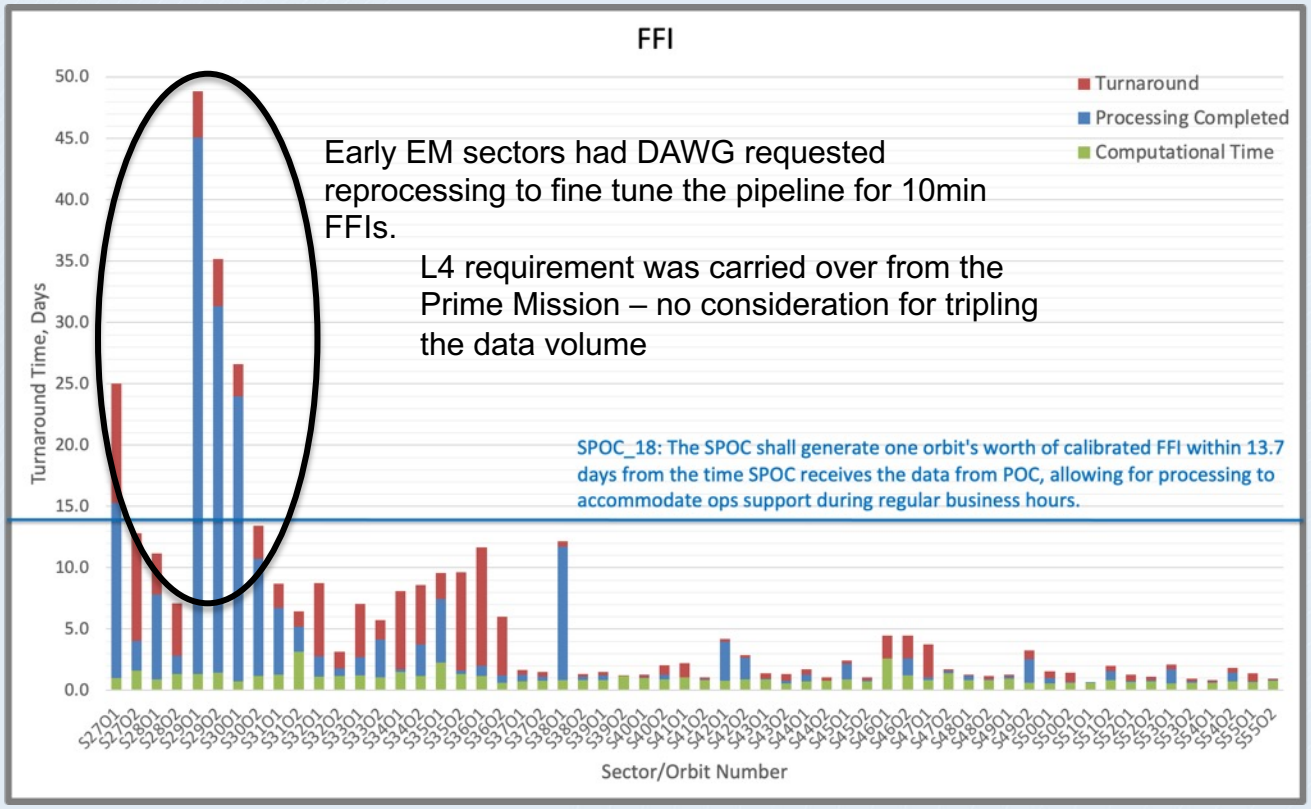
- 2-min computational times trend lower as additional refinements and sustaining engineering are made to the pipeline.
- Typical turnaround times are <10 days



Turnaround time largely dependent on DAWG activities, upstream issues

FFI Stats

- FFI turnaround far exceeds requirements
  - ***Turnaround at end of EM1 was 1 day (S55O2), fastest = 0.6 day (S50O2)***



- Median turnaround of 1.4 days since S38
- Turnaround times for half-orbit EM2 data are comparable at ~1.5 days

Target Selection

FFI Target selection is done in 3 steps:

1) Select all Two-minute targets (up to 20,000/sector, includes 20 sec targets)
2) Select “FFI Include” targets based on TIC parameters:
    - (H mag ≤ 10 OR Distance ≤ 100 pc)
    - crowding metric ≥ 0.5 (at least 50% of flux in aperture due to target)
    - TESS Mag < 16
3) Select field star targets with
    - TESS Mag < 13.5
    - log(g) ≥ 3.5
    - crowding metric ≥ 0.8

Processing load limit is 10,000 targets per CCD (160 K max) for Prime Mission & EM1.
Currently investigating EM2 200-second FFI capabilities

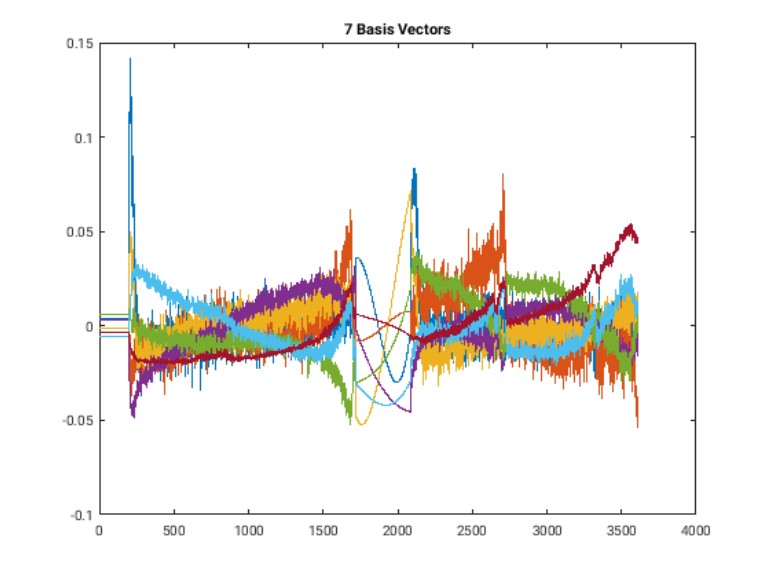
Data Available at MAST (https://archive.stsci.edu/hlsp/tess-spoc)

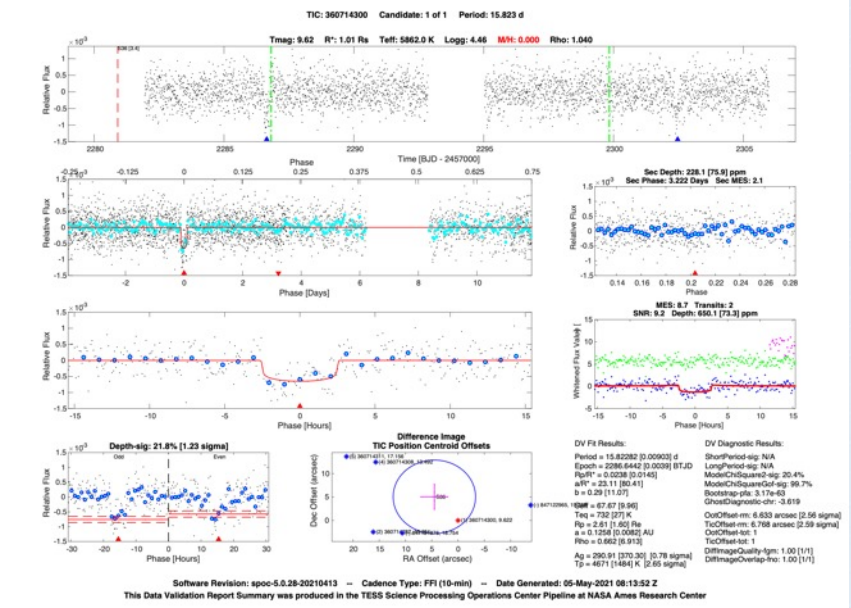
Target Pixel Files: pixels, aperture, background corrected

Light Curves: SAP, PDC-SAP, data quality flags

Data Validation Products (available since S36)
Summary report, mini-report, DV report, DV-xml file

Cotrending Basis Vectors:
Single scale, spike, multi scale (3 bands)





Sectors Available:

Sectors 1 – 35 = Light Curves, Target Pixel Files available at MAST

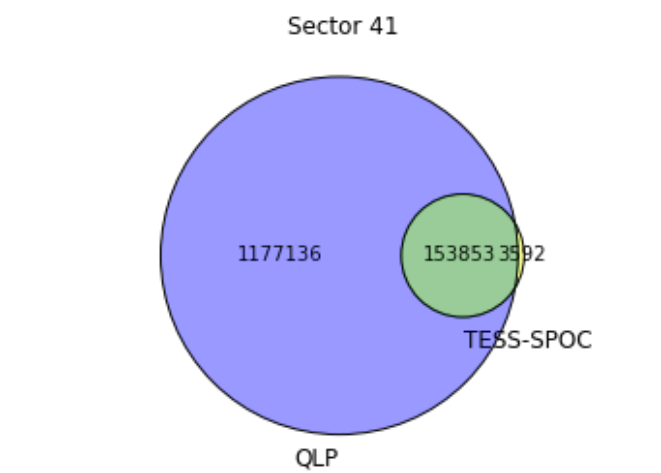
Sectors 36 – 42 = LC, TPFs, Data Validation products available at MAST

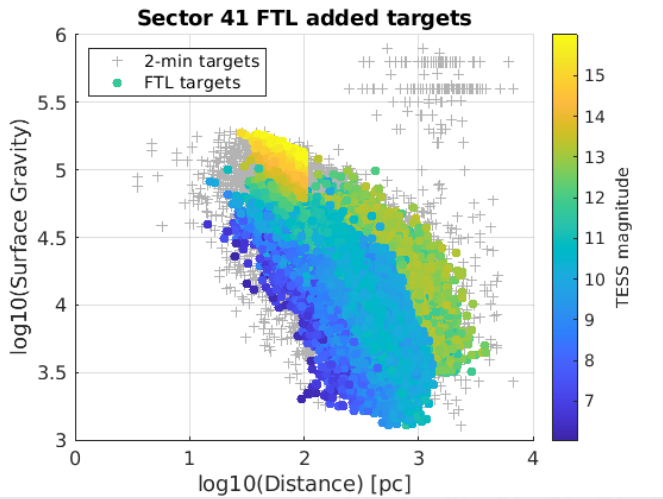
Sectors 43 – 47 = LC, TPF, DV products delivered to MAST

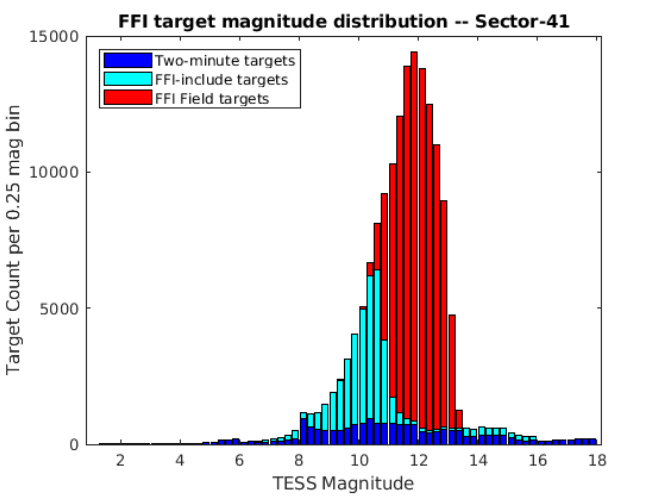
Sectors 48 – 51 = FFI data processed awaiting final review for delivery

Target Distribution

Sector 41:
TESS-SPOC: 157,445 targets (3592 unique)
QLP: 1,330,989 targets



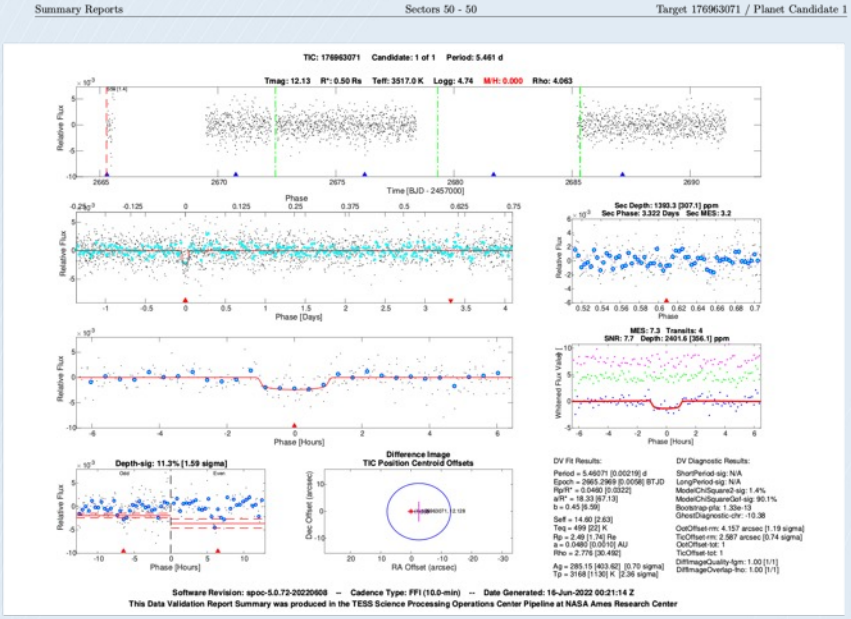


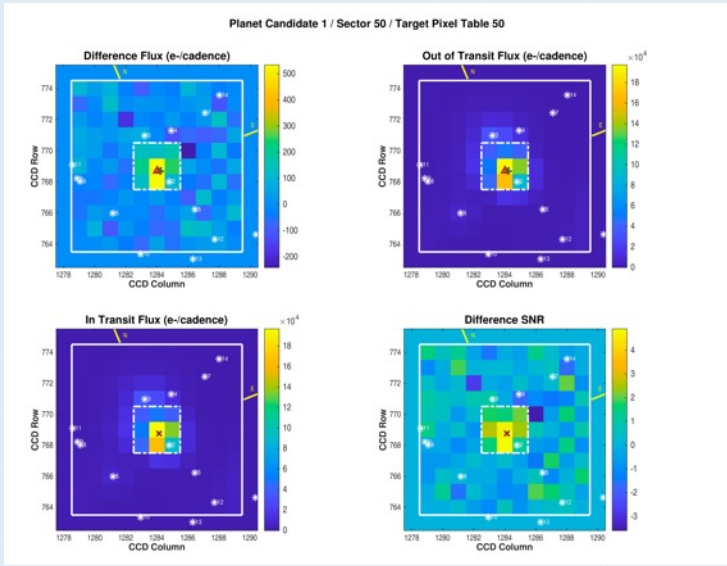


TESS-SPOC FFI

Transit Search Intern project: Kendra T. Nguyen et al. 2022 *Res. Notes AAS,* **6,** 207

- 20 new promising TOIs detected in **S48 – S50**, out of 9257 threshold crossing events
- Radii range from 2.5 – 24 R_E
- Periods range from 0.8 – 17.9 days
- Example below: TIC 176963071, Rp = 2.49 R_E, P = 5.4607 day





Application of ExoMiner to TESS SPOC TCEs

- Collaboration with Hamed Valizadegan and Miguel Martinho in the Intelligent Systems Division at NASA Ames
- Transfer learning: We used different transfer learning strategies that include
  - Pre-training using Kepler data and fine-tuning a subset of layers using TESS data
  - Training ExoMiner by combining Kepler and TESS data
  - Training ExoMiner using TESS data only
  - And a few other baselines (e.g., covariate shift to make the Kepler data distribution more similar to that for TESS)
- Our results show that Kepler data helps the performance.
  - *Current best results* are very encouraging (Precision=0.90 and Recall=0.85).
  - Performance of the best model is not as good as Kepler yet
- *We will soon introduce ExoMiner++ that*
  - *utilizes new diagnostic tests (e.g., difference image and unfolded flux)*
  - *and makes special data preprocessing and some other architectural changes suitable for TESS data.*
- More details will be reported in AAS #241

Conclusions

- Processing is going well
- Processing throughput greatly exceeds requirements
  - *EM2 FFIs can be turned around typically in less than 2 days*
- We have procured a new server and are in process of migrating our data store to a 1.3 PB NetApp device
- We are conducting transit searches in TESS-SPOC light curves: first 20 CTOIs have been identified
- ExoMiner shows great promise for vetting SPOC TCEs
- We are ready to support the extended mission

Hard at Work