TESSSONG: The Brightest Northern Stars

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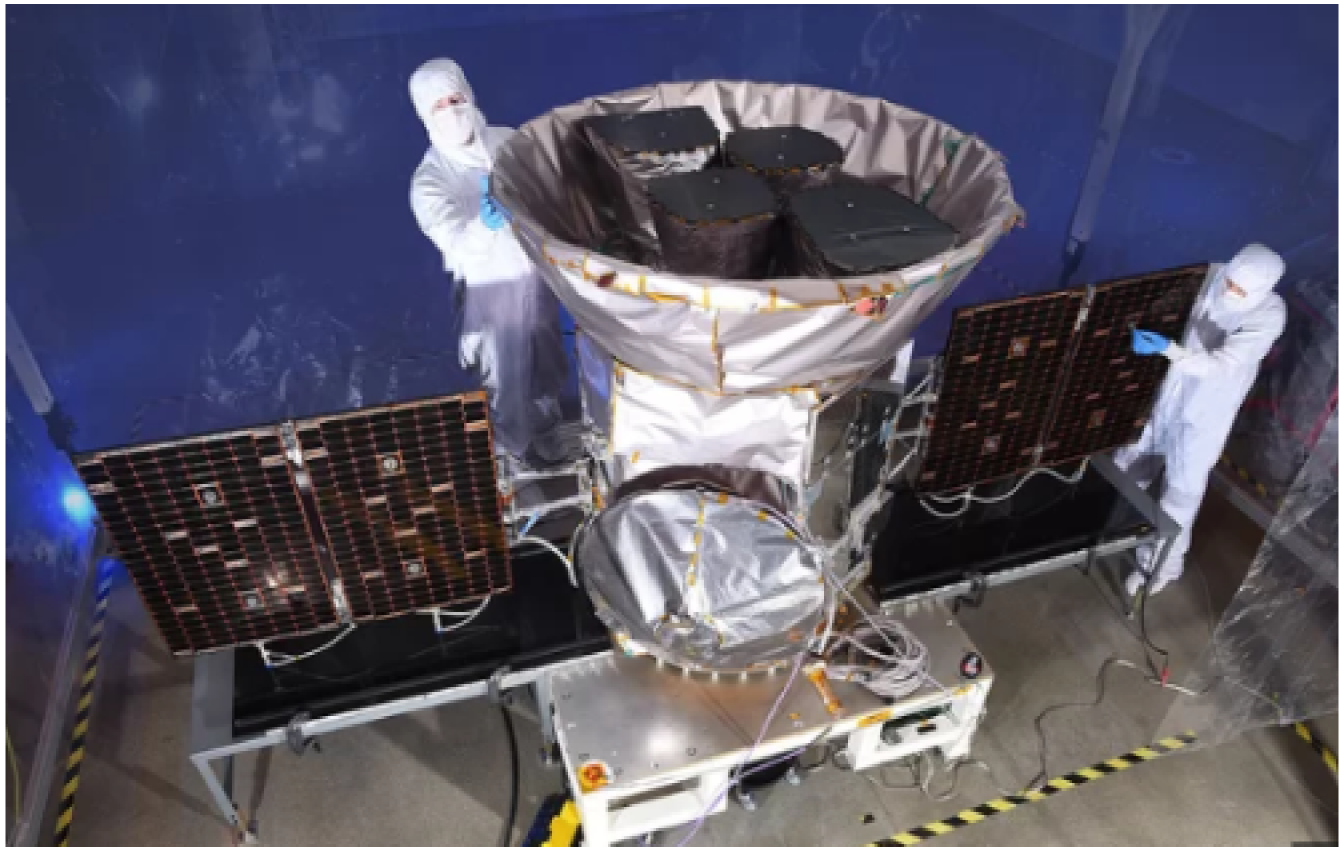
TESS mission

- Trasiting Exoplanet Survey Satellite (TESS, Ricker et al. 2015)
- Searching for transiting planets around stars brighter than V~12
- Using 4 independent wide-angle telescopes
- Three-year NASA mission
- Launched on April 18, 2018, and started operations on July 25
- Survey divided into 26 sectors, each 24 x 96 deg2
- Exotic, highly-eccentric orbit: perigee at 100,000 km, apogee at 400,000 km, and a 2-week orbital period

TESS mission

- Preselected stars get 1 min cadence, others 30 min
- Expected to identify some 3000 new planets and provide excellent asteroseismic data on giant stars (Campante et al. 2016)
- 1st planet, around Southern star pi Mensae (V=5.65; δ ~ -60), already announced! (Gandolfi et al. 2018)

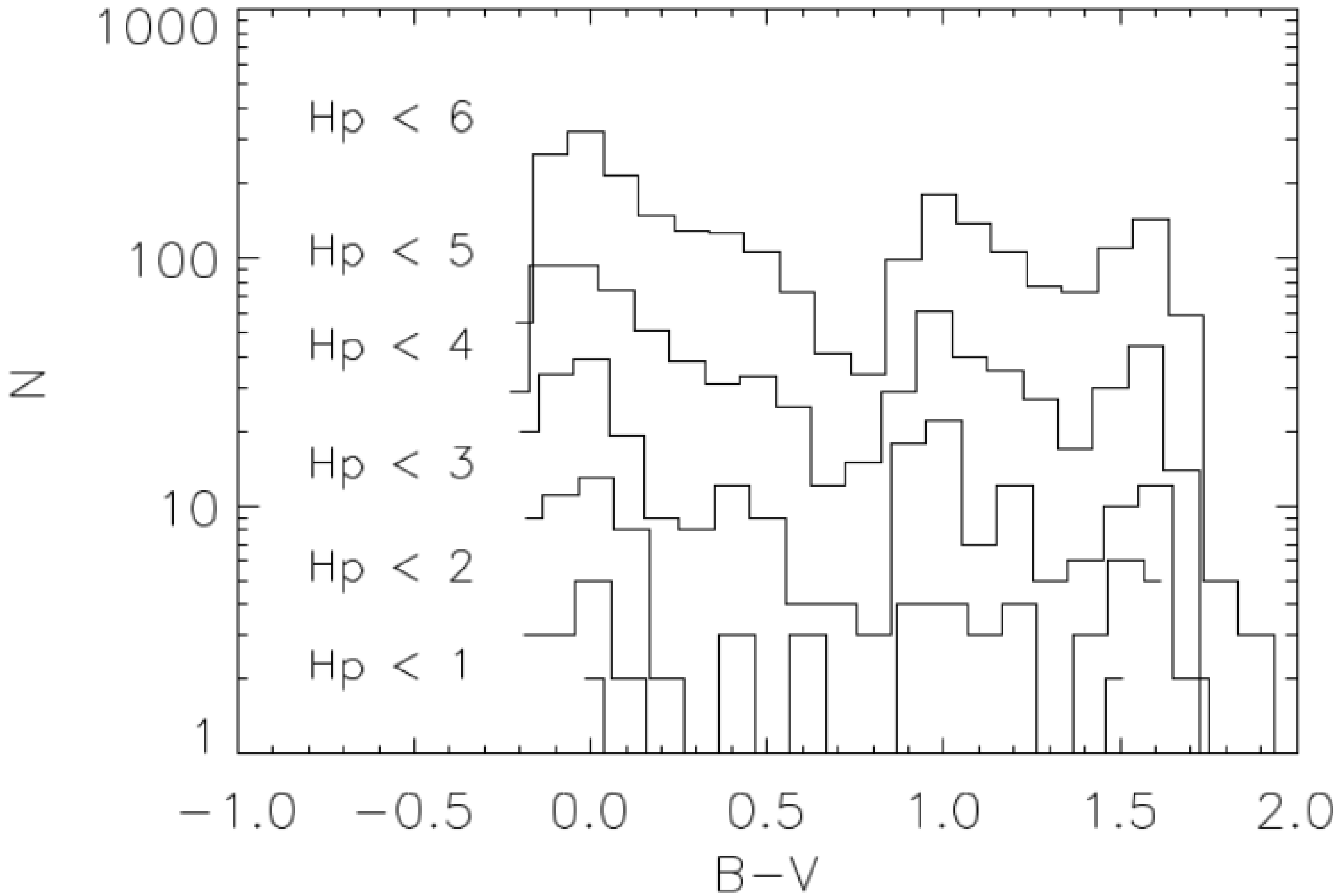


TESSSONG: a homogeneous catalog

- Most exciting planets, arguably, around bright stars amenable to extreme-S/N high-cadence spectroscopy from the ground
- Good targets for detailed spectroscopy with SONG: broad coverage (440-690 nm) and high resolution (100,000)
- Many have high-resolution data already, but heterogeneous, from many different instruments
- Nice sample for establishing standards -- bright stars (will) enjoy exquisite astrometry from Gaia and interferometric angular diameters

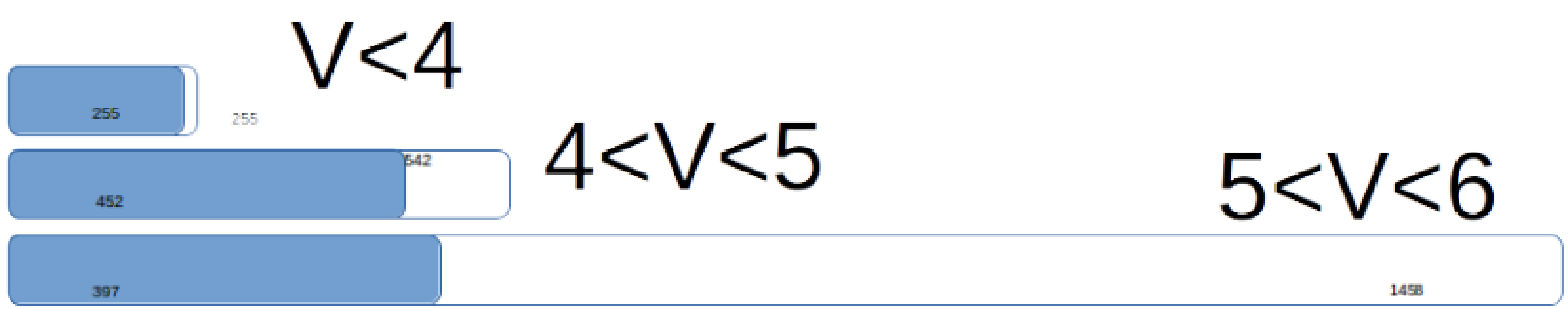
TESSSONG: sample

- There are 7, 22, 82, 255, 797 and 2510 stars at $\delta > -10$ deg brighter than V = 1, 2, 3, 4, 5 and 6



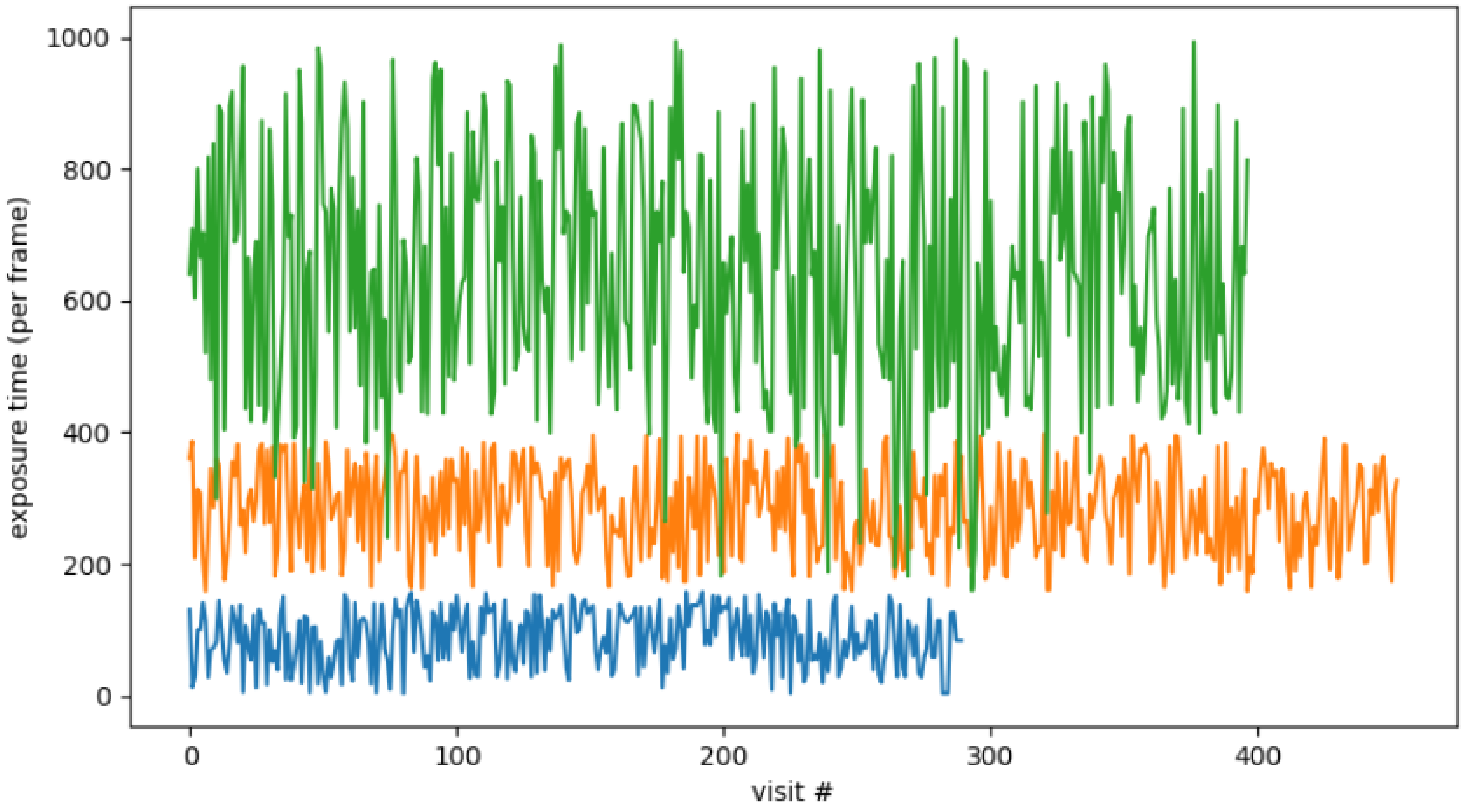
TESSSONG: observations

- Pilot program started in p05, included 290 visits to 255 (V<4) unique stars
- Continued in p06, included 453 visits to 452 (V<5) stars
- Continued in p07, included 397 visits to the same number of (V<6) stars
- Continues in p08
- p05-p06-p07 included 1104 unique stars (about 40% of all at $\delta > -10$ deg)
- Typically 3 exposures, each exceeding a median S/N>100



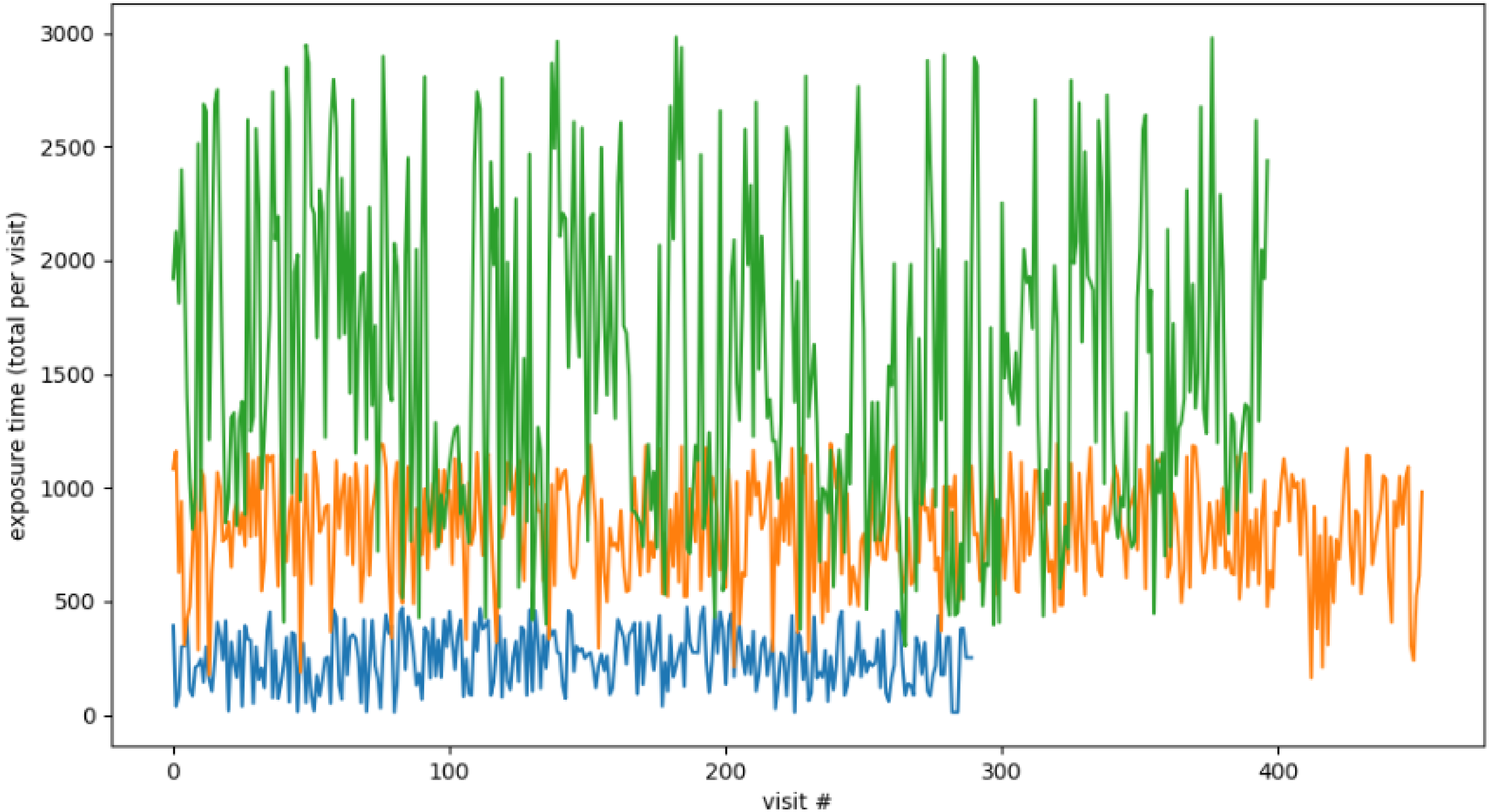
TESSSONG: observations

- Exposure time per frame (usually 3 frames per visit): blue, orange, green correspond to p05 (V<4), p06 (V<5), and p07 (V<6), respectively



TESSSONG: observations

- Exposure time per visit (multiple visits to same object are rare): blue, orange, green correspond to p05 (V<4), p06 (V<5), and p07 (V<6), respectively



TESSSONG: analysis

- Automated analysis highly desirable: repeatable, comprehensive, and ideal for large samples
- This model has alredy been successfully applied on APOGEE (R~30,000 H-band spectra)
- FERRE code (github.com/callendeprieto/ferre) * n-dimensional * fast (optimization and interpolation on a precomputed grid of synthetic spectra) * flexible (can derive all parameters in the grid, or fix some)

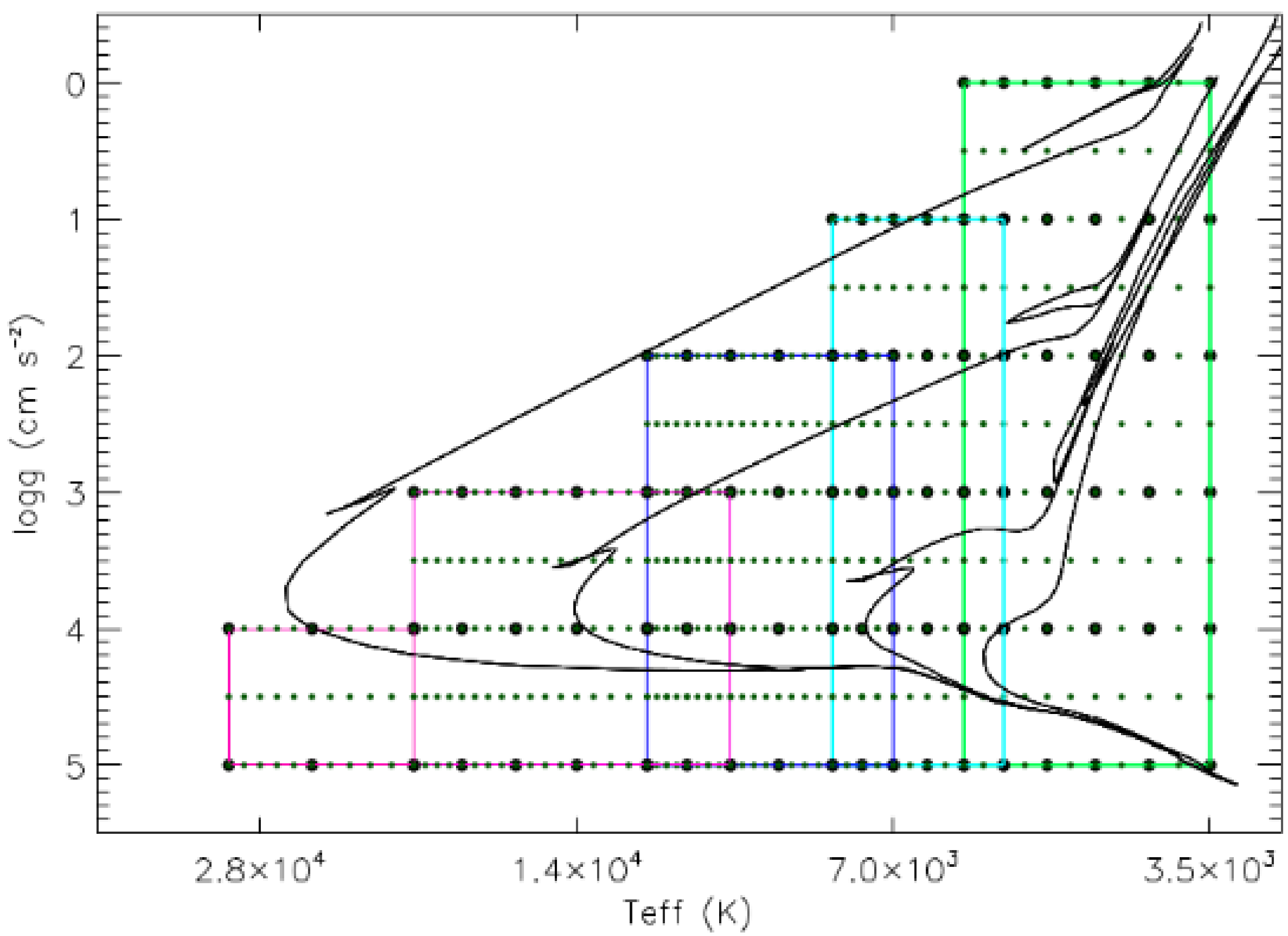
FERЯE

Models

- Plane-parallel models based on the latest ATLAS9 model atmospheres (Meszaros et al. 2014; APOGEE-ATLAS models)
- LTE spectral synthesis performed with ASSET (Koesterke 2009)
- Continuum opacities from the Opacity Project and the Iron Project
- Scattering included

Models

- 3500< Teff < 30,000 K; split in 5 overlapping Teff blocks (higher Teff, lower minimum logg)
- A *coarse* collection (Teff,logg,[Fe/H]; large filled circles in the figure) and a *fine* one (Teff,logg,[Fe/H],micro,[alpha/Fe]; small filled circles). All published recently (Allende Prieto et al. 2018, A&A 618, 25)

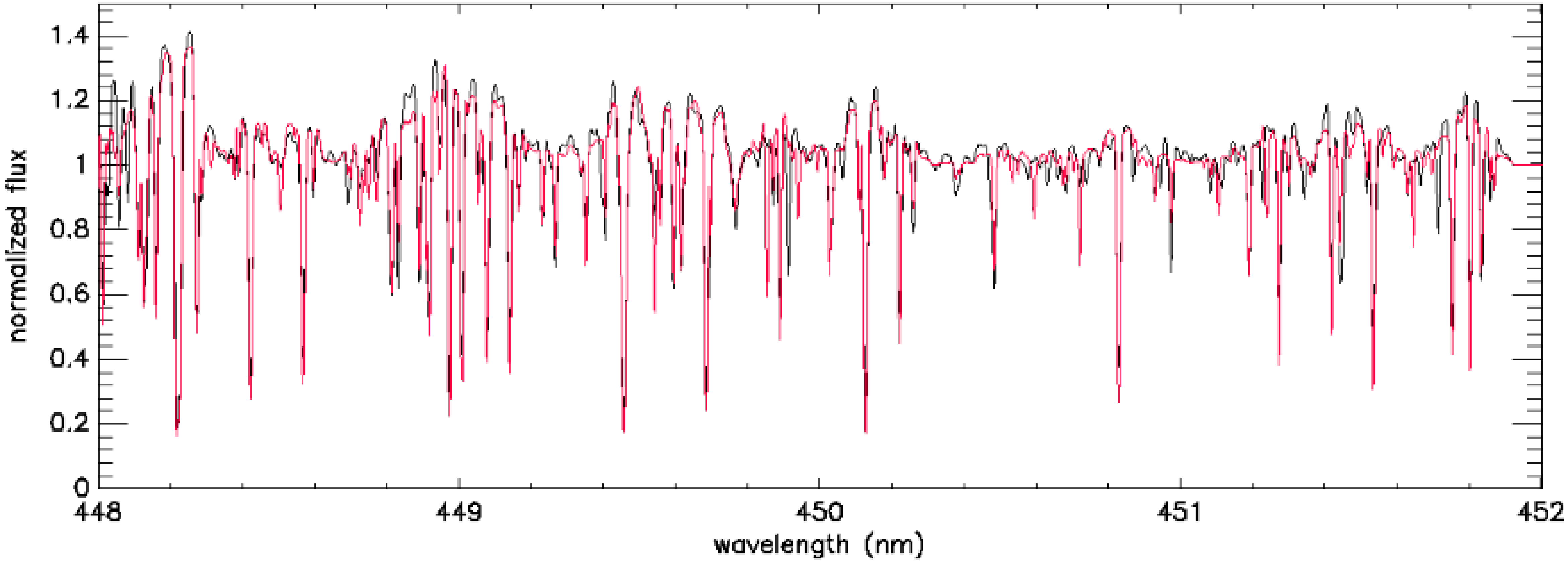


Tests

- Tests performed on SONG spectra from Arcturus and the Sun (solar telescope built and coupled to SONG by Pere L. Palle)
- Selected 7 orders (apertures 4, 6, 14, 17, 23, 41 and 45) for which, analyzed in isolation, we derived parameters relatively free from systematic errors for both stars
- Adopted the coarse grids to start with (3 params being derived: Teff, logg and [Fe/H])
- Handled all the orders as separate spectra: fitted all simultaneously but did not attempt to merge overalapping wavelength regions
- Continuum normalization using a running mean filter. Same procedure applied to data and models

Tests: the Sun

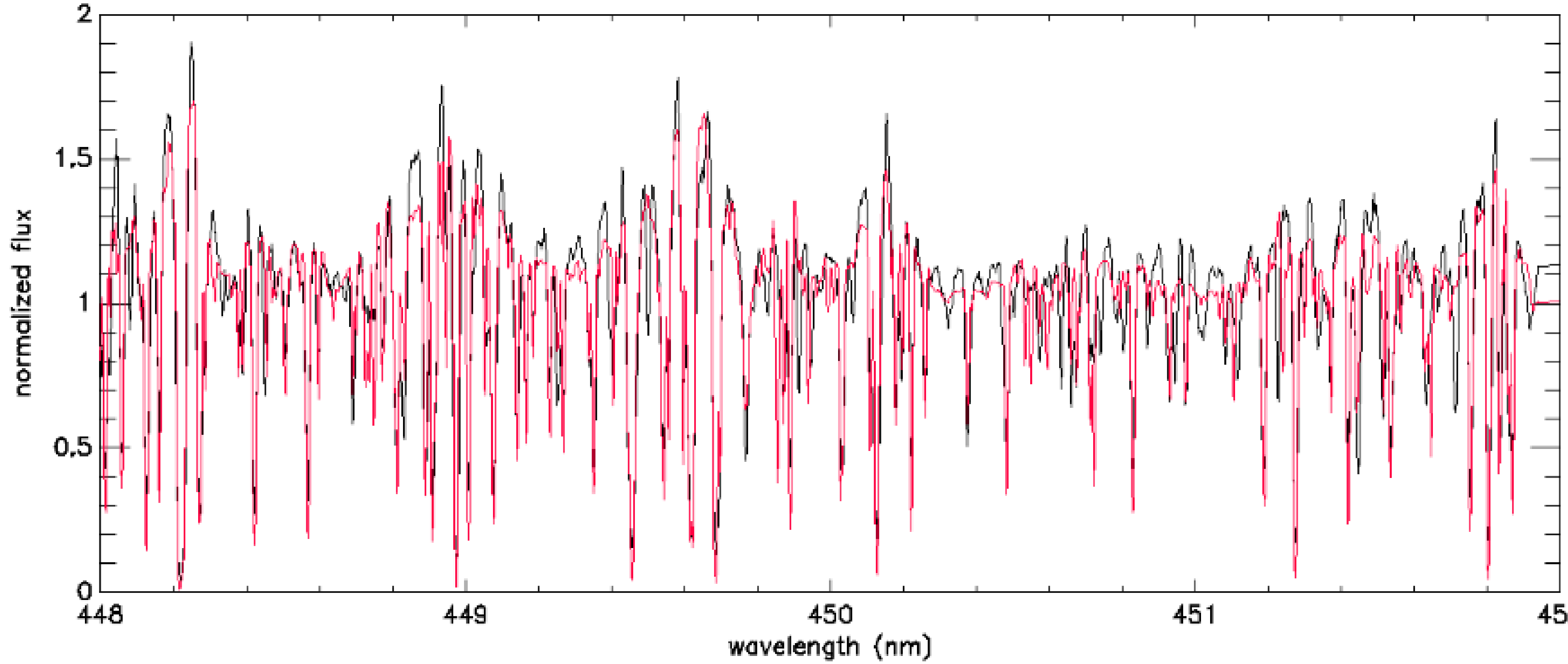
- Parameters: [Fe/H]=0, Teff=5772 K, logg=4.437
- Retrieved (model = red line) : [Fe/H]=-0.3   5790   4.71



Only 4th aperture (one order) shown in Figure, but 7 orders simultaneously fit

Tests: Arcturus

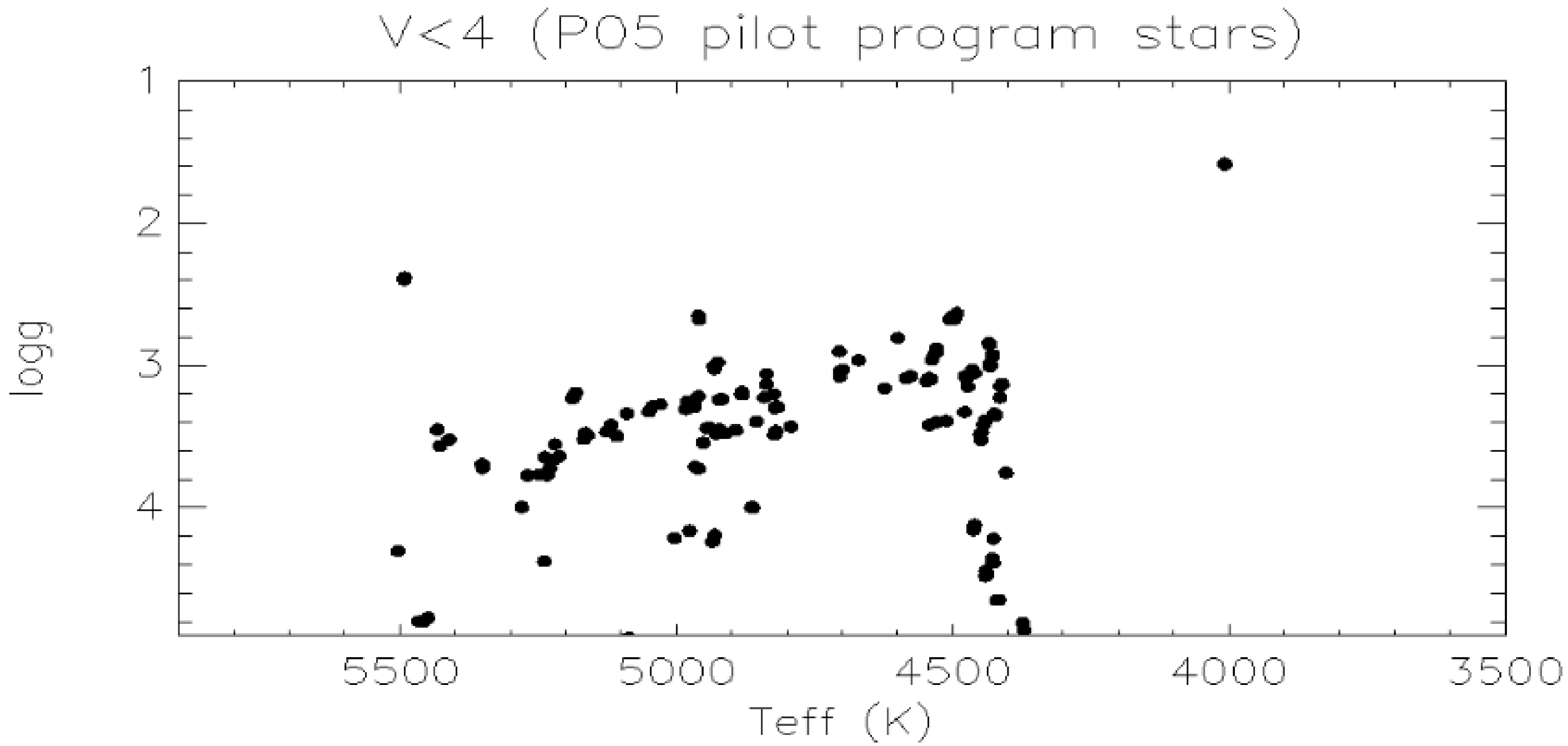
- Parameters: [Fe/H]=-0.7, Teff=4300 K, logg=1.7
- Retrieved (model = red curve) : [Fe/H]=-0.7 4418 2.7



Only 4th aperture (one order) shown in Figure, but 7 orders simultaneously fit

Tests: P05 sample

- Doppler shifts measured by cross-correlation against the solar spectrum
- Focused on the **cool** stars (Teff<6000 K) for which reasonably good fittings were obtained
- Note the multiple exposures (usually triads of points in a group/visit)



Conclusions so far ...

- Good quality in general, but some percentage (10-20%) of bad data (presumably clouds)
- We're basically done taking data for V<5, and 40% done for V<6 (27% for 5<V<6). Two semesters to go!
- A homogeneous analysis likely to work for *cool* (Teff< 7000 K) stars, warmer ones will need closer attention
- Systematics significant, but likely to reduce upgrading to finer grids (micro-turbulence is now 1.5 km/s for all stars!)
- Prototype fitting code done in IDL/GDL but will move to python for production
- Goal is to produce a code that will robustly run on all *cool* SONG targets automatically
- Uncertainties estimated from inversion of the curvature matrix are underestatimated: residuals are dominated by systematic errors in model spectra