TESS Yield
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Some notes on the TESS exoplanet yield

aka the prioritization function may not be optimal

I'm making some notes here on my assessment on the TESS yield. The original idea was to write a paper, which I still think is a good idea, but I think some of the issues should be looked at on a more rapid timeframe.

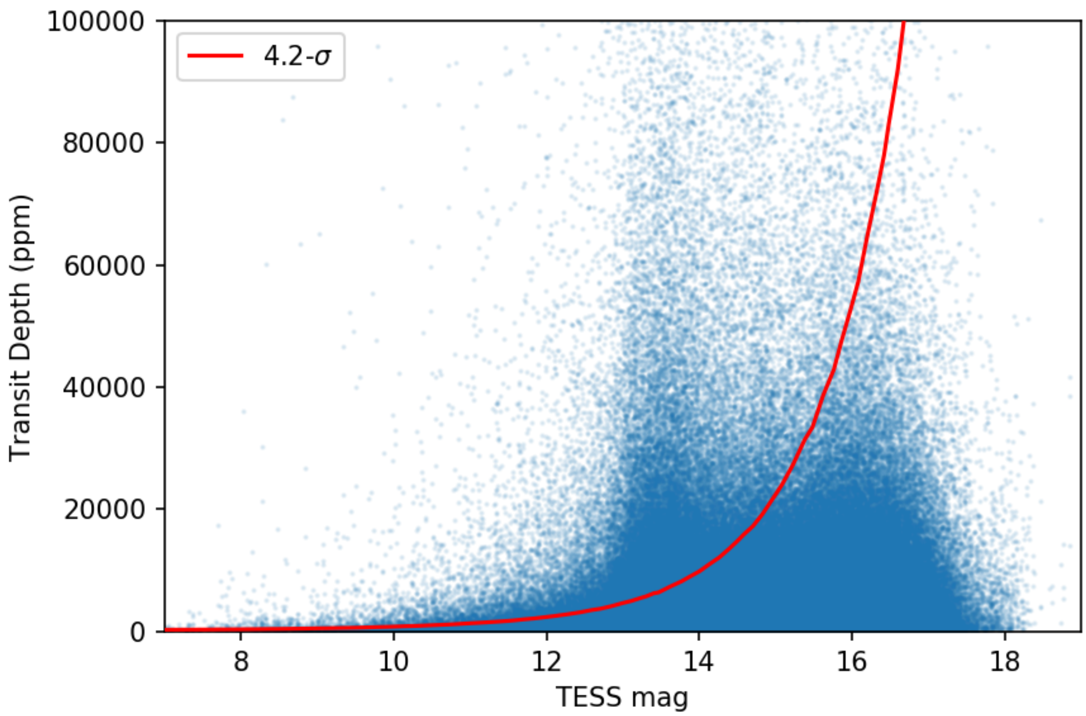
What I have done can be summarized as so: I take the TIC4 catalog. I split the catalog into 13 segments (like an orange) with poles at the ecliptic north/south, and then further split these segments along the ecliptic equator, yielding 26 segments, half in the north and half in the south. I then select 400,000 highest priority targets evenly distributed amongst these 26 segments (so ~15,000 per segment). This priority is based on the PRIORITY column from the TIC/CTL.

Then each star in this sample gets assigned zero or more planets. The number of planets is drawn from a Poisson function, for M-dwarfs the lambda=2.5 and for hotter stars it is 0.689. So stars can have multiple planets. Each planet gets an orbital period and radius based on occurrence rate statistics (either from Dressing or Fressin). Then I assign random inclination, although planets in the same system have the same inclination. The observation length is taken assuming that the launch is March 20. I then also calculate transit duration, transit depth (and diluted transit depth using the contamination column).

I calculate the 1-hour noise level using the values from Ricker 2016 (I very carefully read off the figure). I correct the noise level to account for the different transit duration but multiplying but the sqrt of the duration.

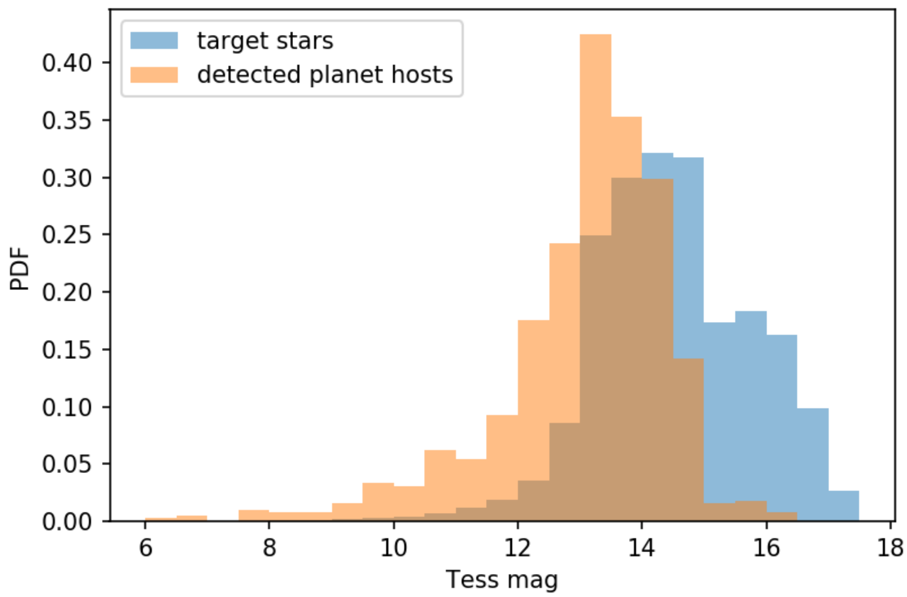
Finally, I check to see if diluted transit depth * the sqrt(Number of transits) / 7.3 [sigma needed for detection] is greater than the duration corrected noise level, also that the impact parameter is less than 1.0 and that we see at least 3 transits.

Ok what do I see? I don't think it looks too great. I estimate that we will find ~800 planets. This is obviously lower than we were expecting. Why is this? I think it has to do with the properties of the stars that are prioritized. The short answer is that they are too faint. Below is an image showing the brightness of stars and the transit depth of planets that orbit those stars. I'm showing all planets, not just those that transit in my simulation because this gives us better statistics. The red line shows the 4.2-sigma detection limit [which is 7.3 \ sqrt(3) for 3 transits].

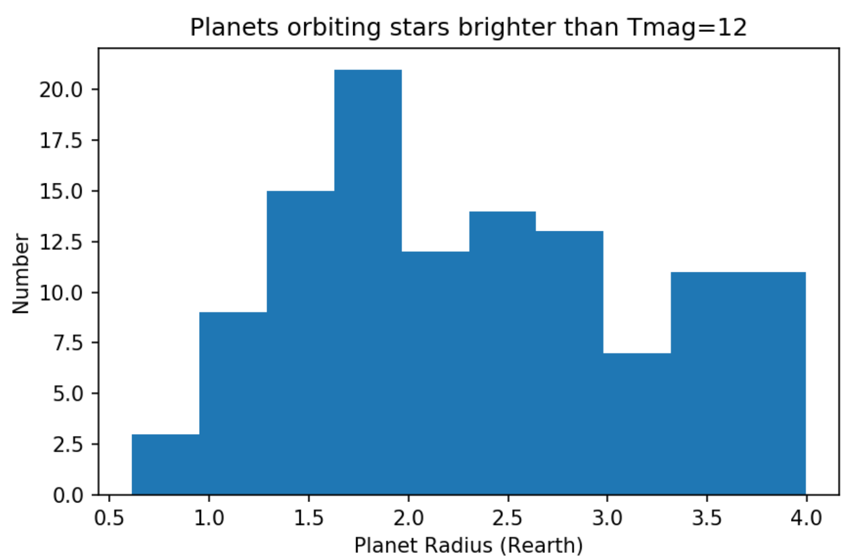


The majority of M-dwarfs are below the red line. I think what this is showing is that despite most of our targets being M-dwarfs we are not really sensitive to planets orbiting these stars. With the ongoing uncertainty about focus, it is likely that our precision at the faint end will get worse than is presented here.

To reinforce this I have attached a plot showing the distribution of brightness of stars that are observed vs where planets are detected. We don't really detect planets orbiting the faint stars.



Ok, so now I looked at ho this impacts level-1 requirements. For mission success we need to measure the masses of 50 planets via RV smaller than 4.0 Rearth. I estimated as measurable with RV as orbiting stars brighter than Tmag=12.0. We *can* go fainter but that is hard to do and telescope time goes up considerably. I estimate that we get 116 planets smaller than 4.0 Rearth and brighter than Tmag=12. I don't know if this is enough to get 50 masses. I've put a plot below showing the distribution of radii of these planets.



Ok, finally, so good news. While we detect relatively few planets orbiting cool stars, the small number we detect consist of a few gems. By this I mean good JWST targets. See the plot below.