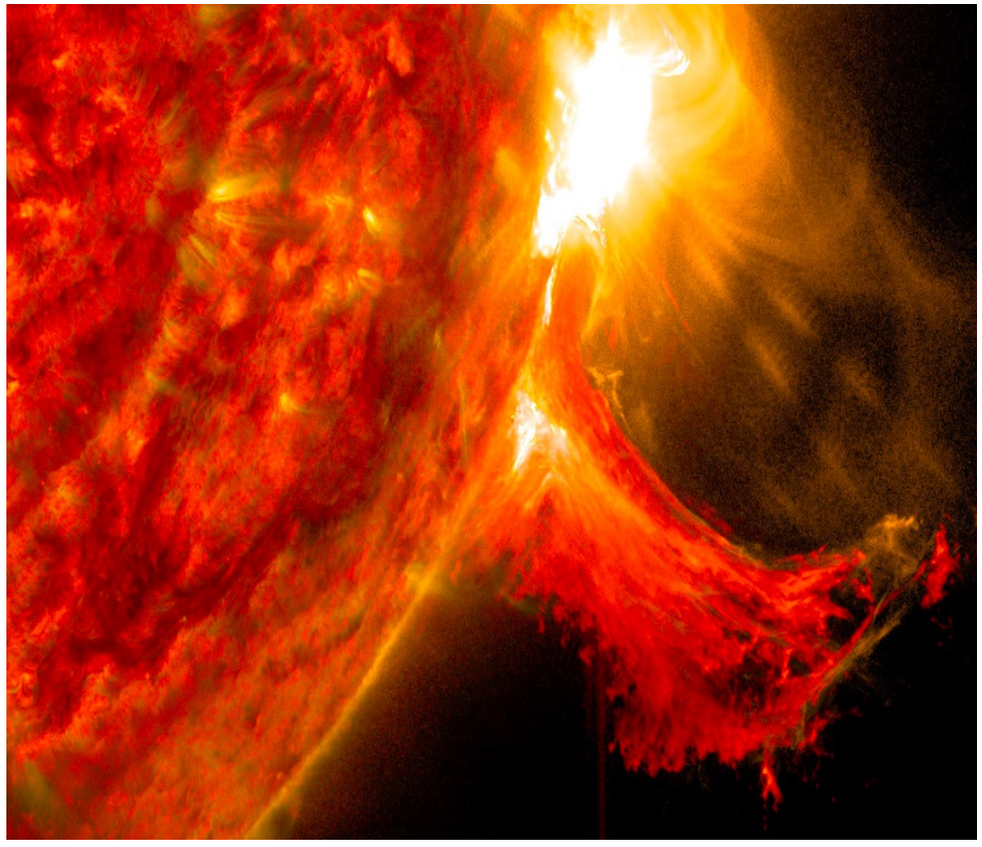
Searching for Quasi Periodic Pulsations in flares from low mass stars using TESS data

Gavin Ramsay (Armagh, UK); Dmitrii Kolotkov (Warwick, UK); Gerry Doyle (Armagh); Lauren Doyle (Warwick)

Abstract: We have searched the light curves of low mass stars with TESS 2 min cadence data in Cycles 1 & 2 for Quasi Periodic Pulsations (QPPs). We identified 11 flares from 7 stars which have QPPs with periods ranging from ~10 min to 70 min. We use several methods for determining the loop length of the flares and find they can extend to a handful of stellar radius. Based on scaling relationships we determine the magnetic field strength in the coronal loops and compare the loop lengths to distance to the habitable zone for the host star.

QPPs from Solar observations

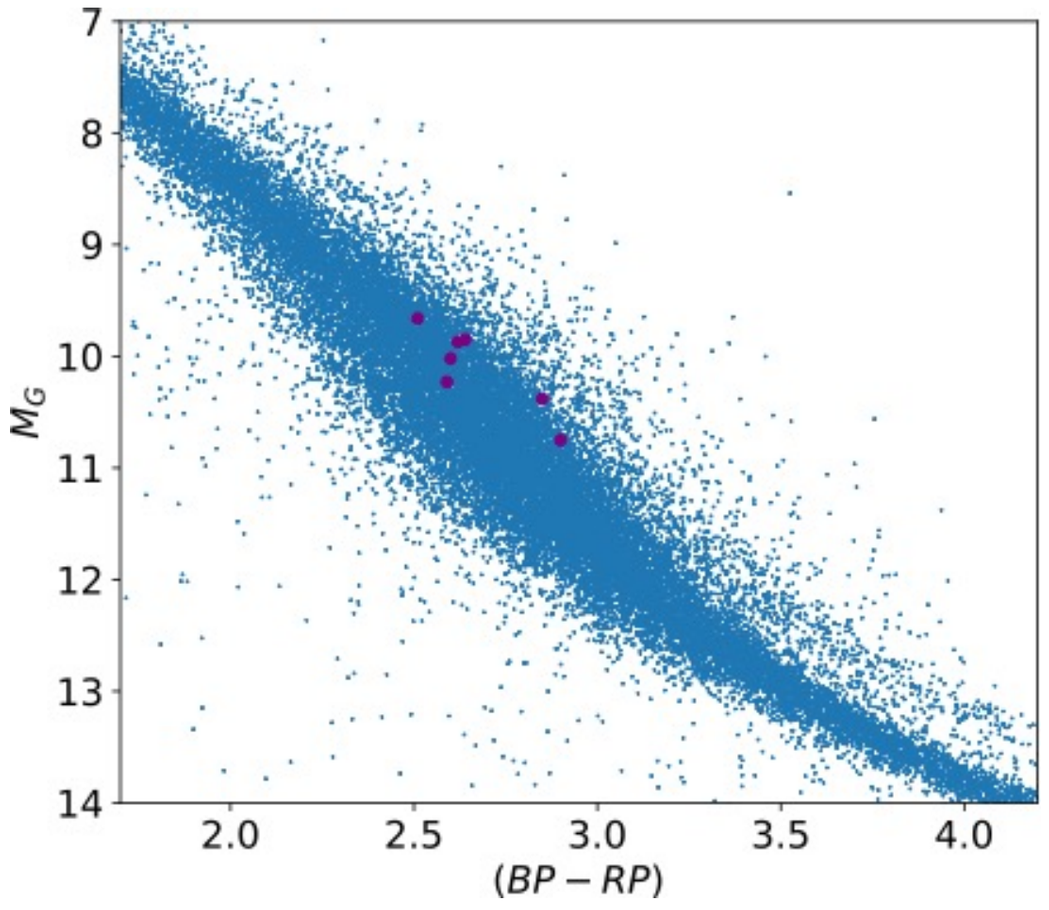
QPPs have been seen in Solar Flares at optical, X-ray and radio wavelengths and enables physical conditions in the flare region to be determined and the nature of flare to be better understood.



Solar Flare observed using Solar Dynamic Observatory NASA/SDO

QPPs from low mass stars

Using TESS 2 min data from Cycles 1 & 2 we searched the light curves of 15437 low mass stars for high (>0.5 mag) amplitude flares. We identified candidate QPPs from 11 flares from 7 low mass stars. We show the stars position in the Gaia HRD below.



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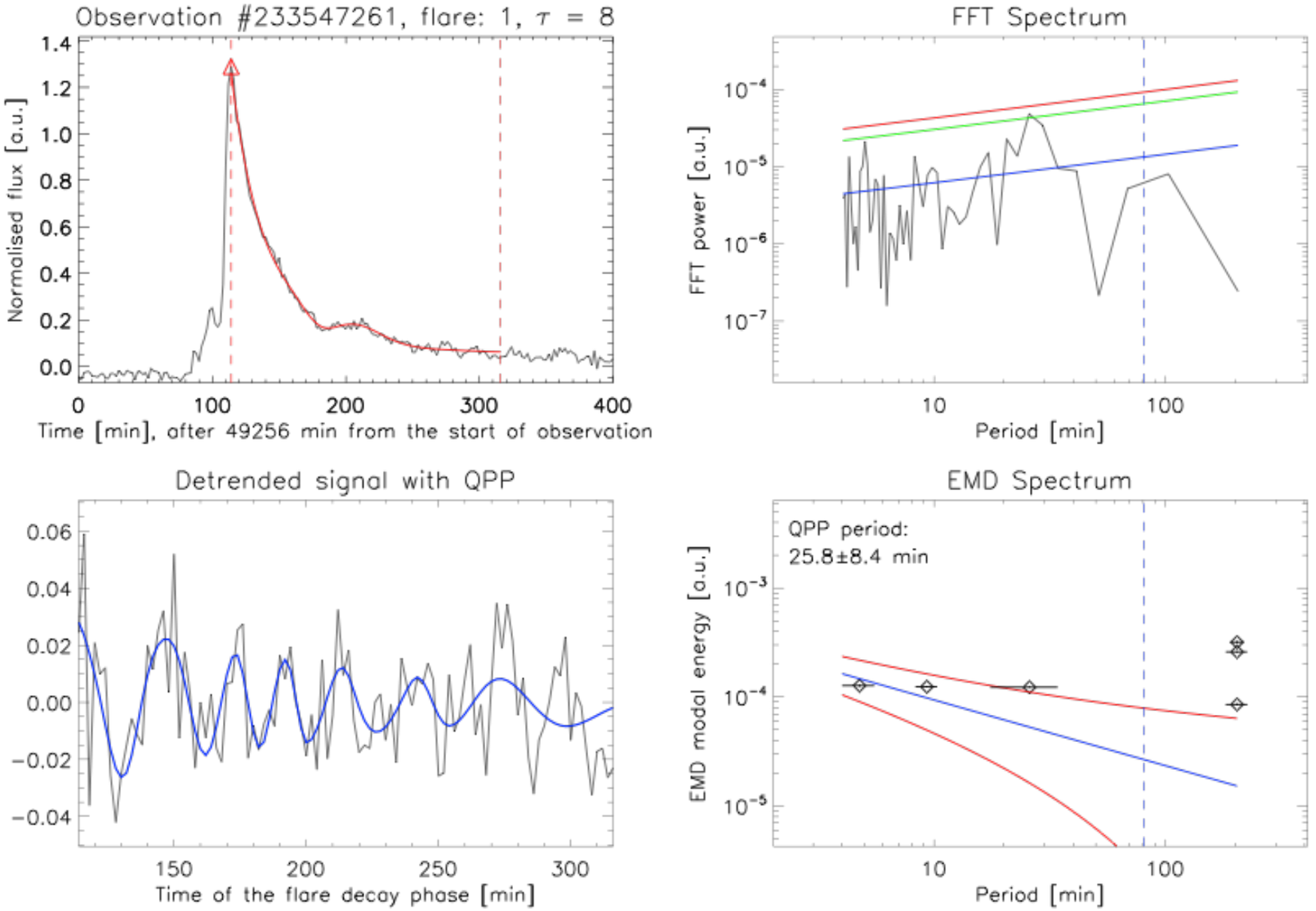
Using the methods set out in Broomhall+2019 we tested the significant of the candidate QPP events and confirmed their presence and determined the period of the QPP. The event shown below has a period of ~26 min. The periods ranged from ~10 min to ~70 min with one showing a multi-mode QPP.



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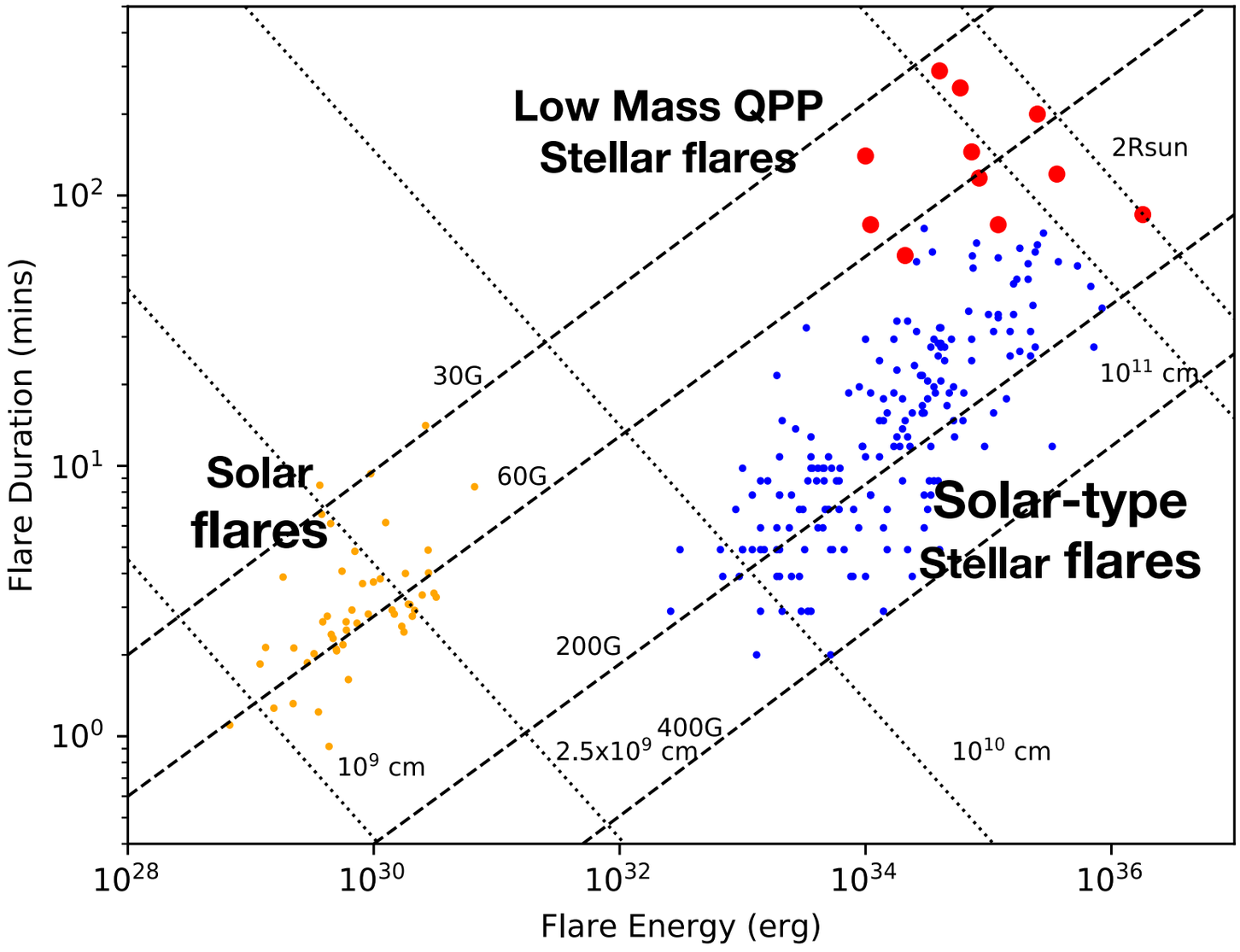
We determine the length of the loops using several approaches. Assuming they are caused by compressive standing slow magneto-magneto-acoustic oscillations we can use the formula to the right —>

$$\mathrm{Period(sec)} = \frac{l_{\mathrm{slow}}\ (\mathrm{Mm})}{7.6 \times 10^{-2} N \sqrt{T(\mathrm{MK})}}$$



We also use the scaling relationships of Namekata+2017 to estimate the length of the flare loops. They are typically the same size — or in some cases much greater — than the stellar radius. The loop lengths determined using different approaches gives loop lengths consistent to ~2.

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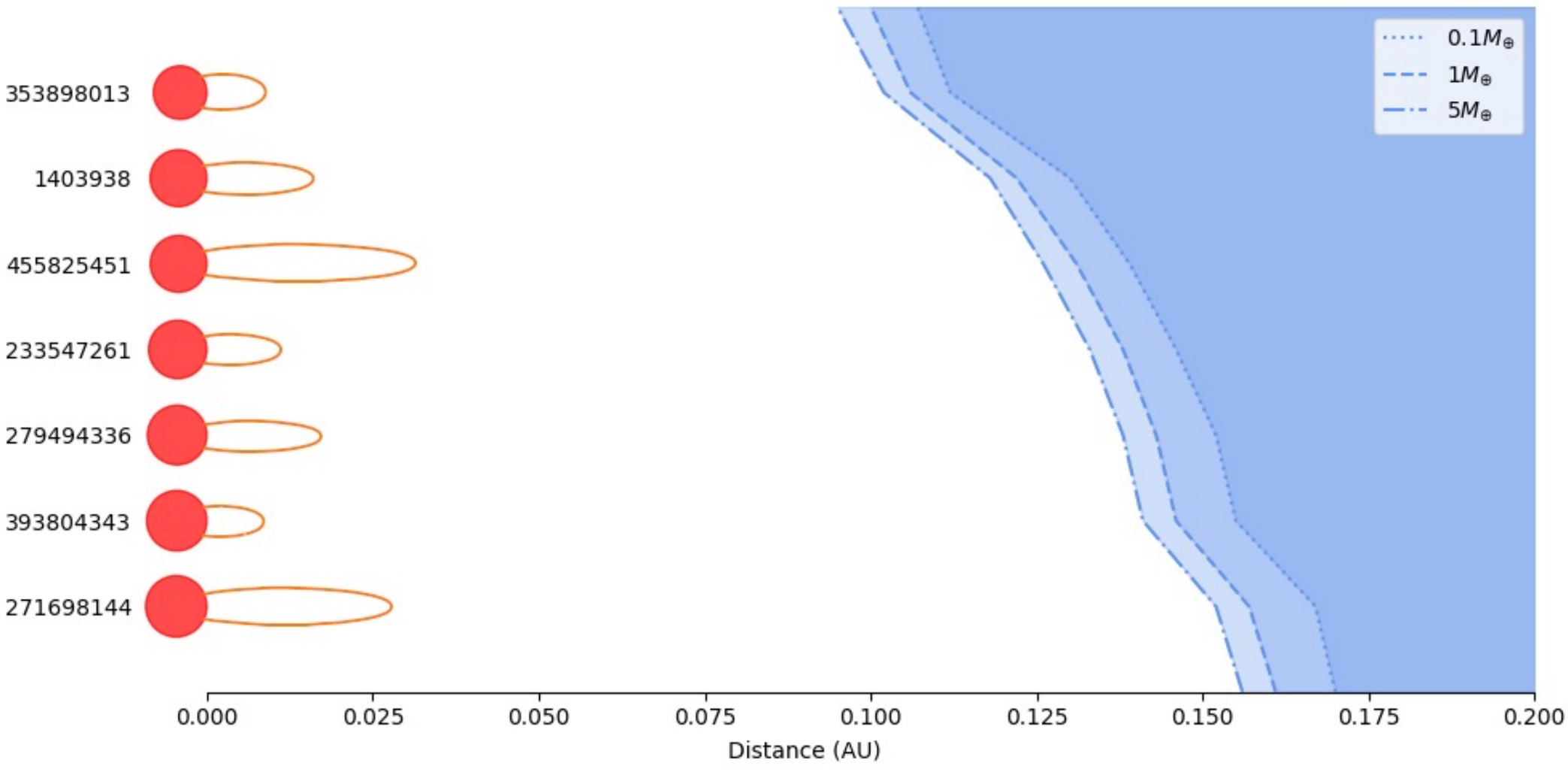
The loop length of the QPP events compared to Habitable Zone region (no exoplanets are currently known around these stars). The loop can be a handful of times greater than the stellar radius, indicating potential Stellar Planet Interactions.



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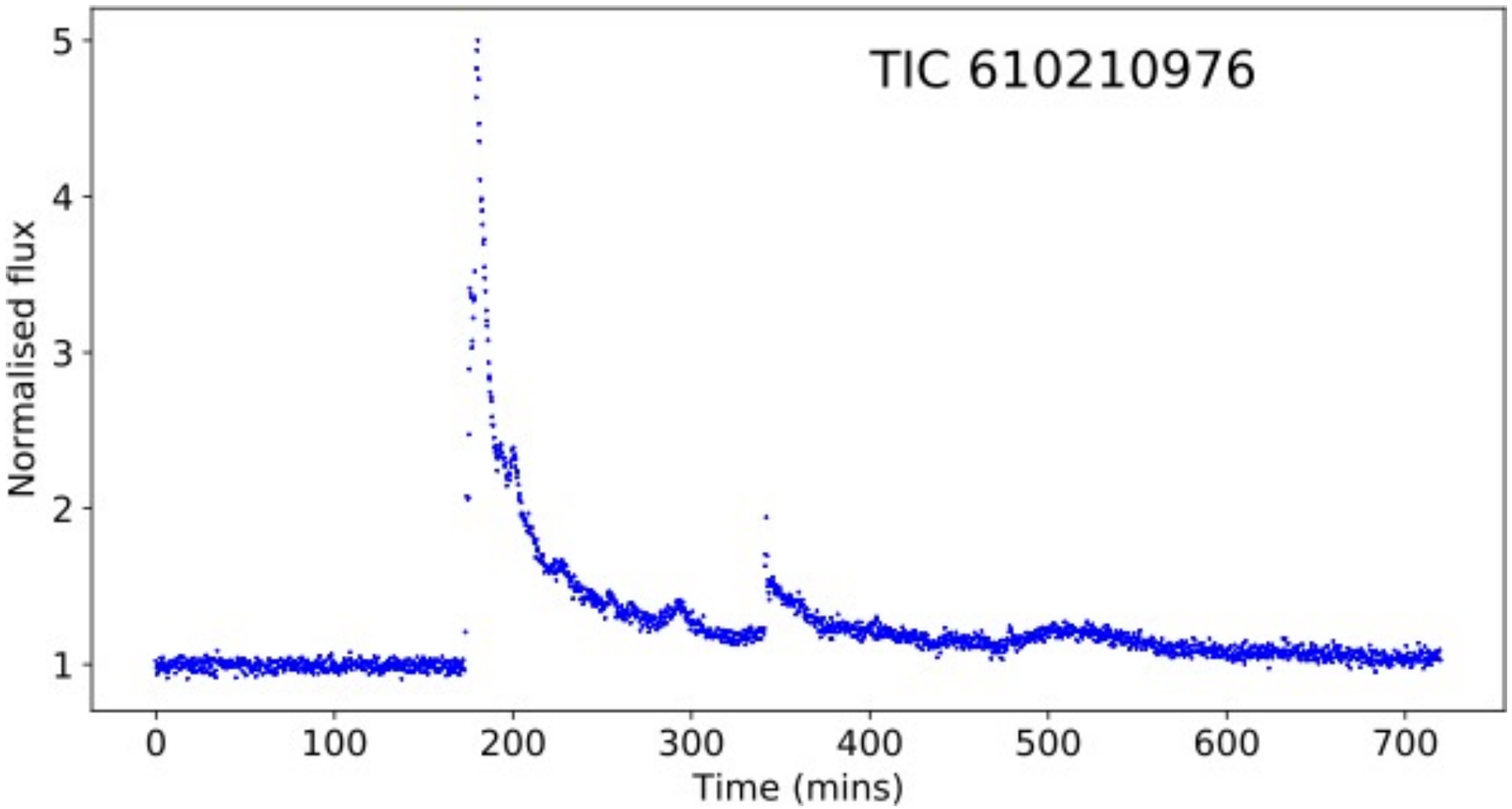
Cycle 3 and 20 sec cadence data

Data with 2 min cadence limits the detection of QPPs with periods shorter than ~10 min. Data with 20 sec cadence may reveal QPPs of shorter duration. The light curve of TIC 610210976 with 20 sec cadence shows a complex flare light curve. There are ~1500 low mass stars observed in 20 sec cadence in Cycle 3.



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