

# A Search for Transit Timing Variations (TTVs) in WASP-5b

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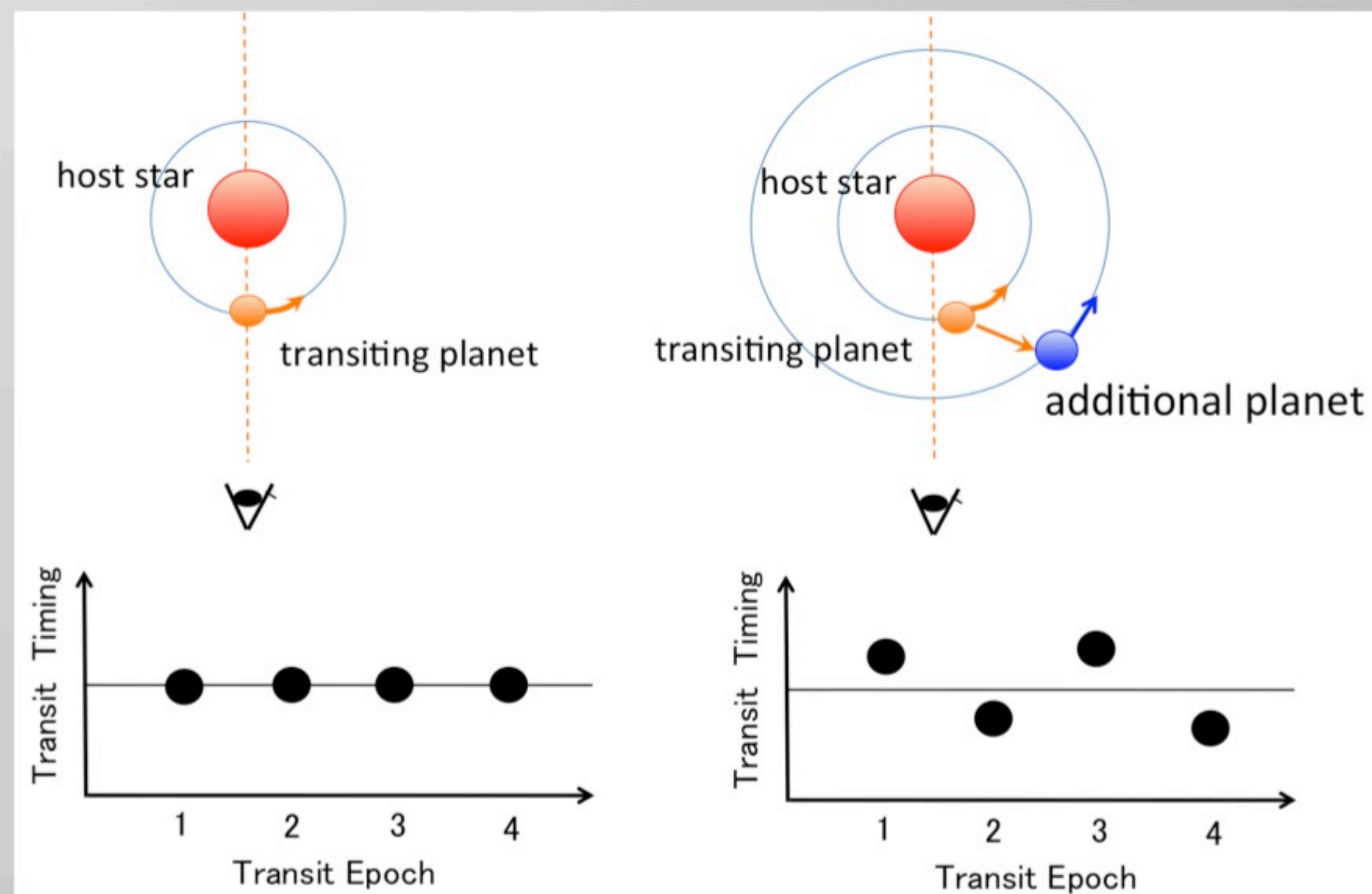


Fig 1. Schematics of the transit timing variations (TTVs) method.

Transit timing variations (TTVs) can be used to detect an additional planet existing around a transiting planet (Fig 1). This method has high sensitivity to planets in mean motion resonances (MMRs) with transiting planets.

We observed 7 transits of a transiting hot Jupiter, WASP-5b, by using the 61-cm B&C telescope located at Mt. John observatory in New Zealand (Fig 2). Combined with previous works, we found that the transit timings do not match a constant period at  $3.7 \sigma$  conf. (Fig 3). Although this might be due to a perturbing planet, we could not find any unique model of the mass and the orbital elements for the hypothetical secondary planet.

Alternatively, we placed upper limits on the mass of the second planet as a function of period ratio by 3-body numerical calculations, assuming coplaner and circular orbit of the second planet. As a result, we excluded the existence of  $2 M_{\text{Earth}}$  or more massive planets in 1:2 and 2:1 MMRs with WASP-5b at  $3 \sigma$  conf. (Fig 4).

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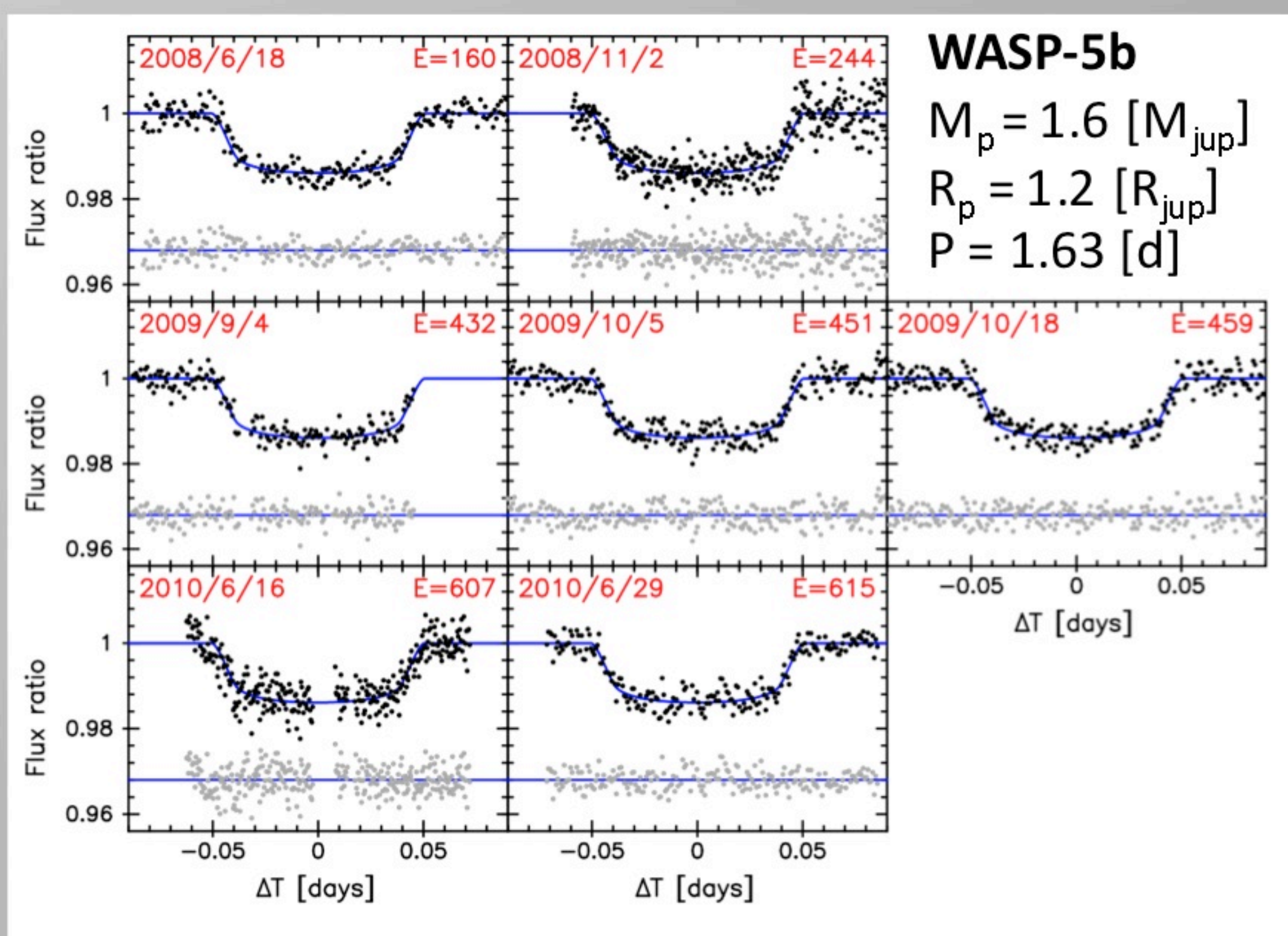


Fig 2. Light curves of the observed transits of WASP-5b (Black dots). Blue lines show the best-fit model and gray dots show the residuals.

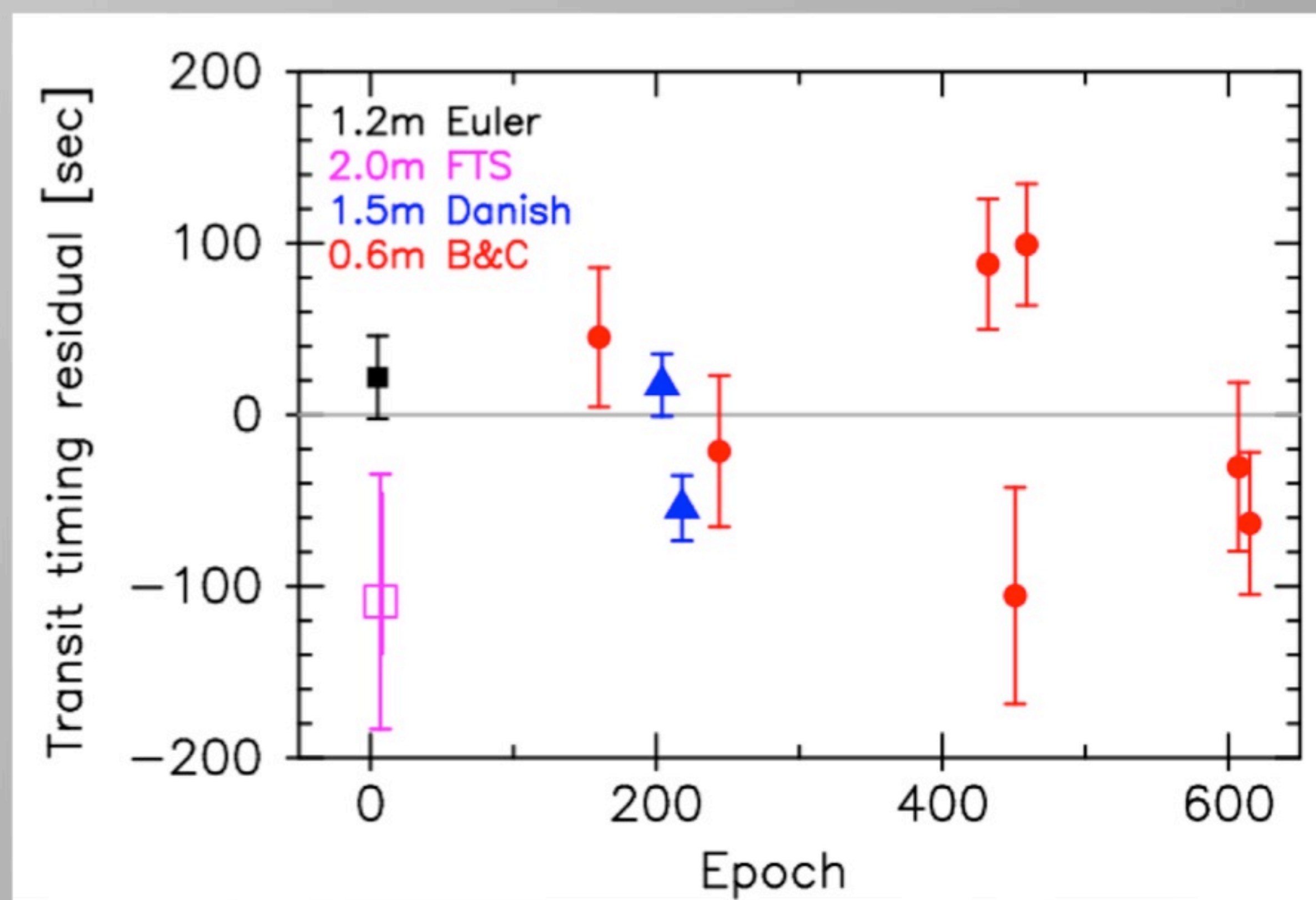


Fig 3. Transit timing residuals from a linear ephemeris for WASP-5b. The red points represent the data from B&C, and the others are those from the previous works (Anderson+ 2008, Southworth+ 2009). The  $\chi^2/dof$  for a linear fit is 32.2 / 9.

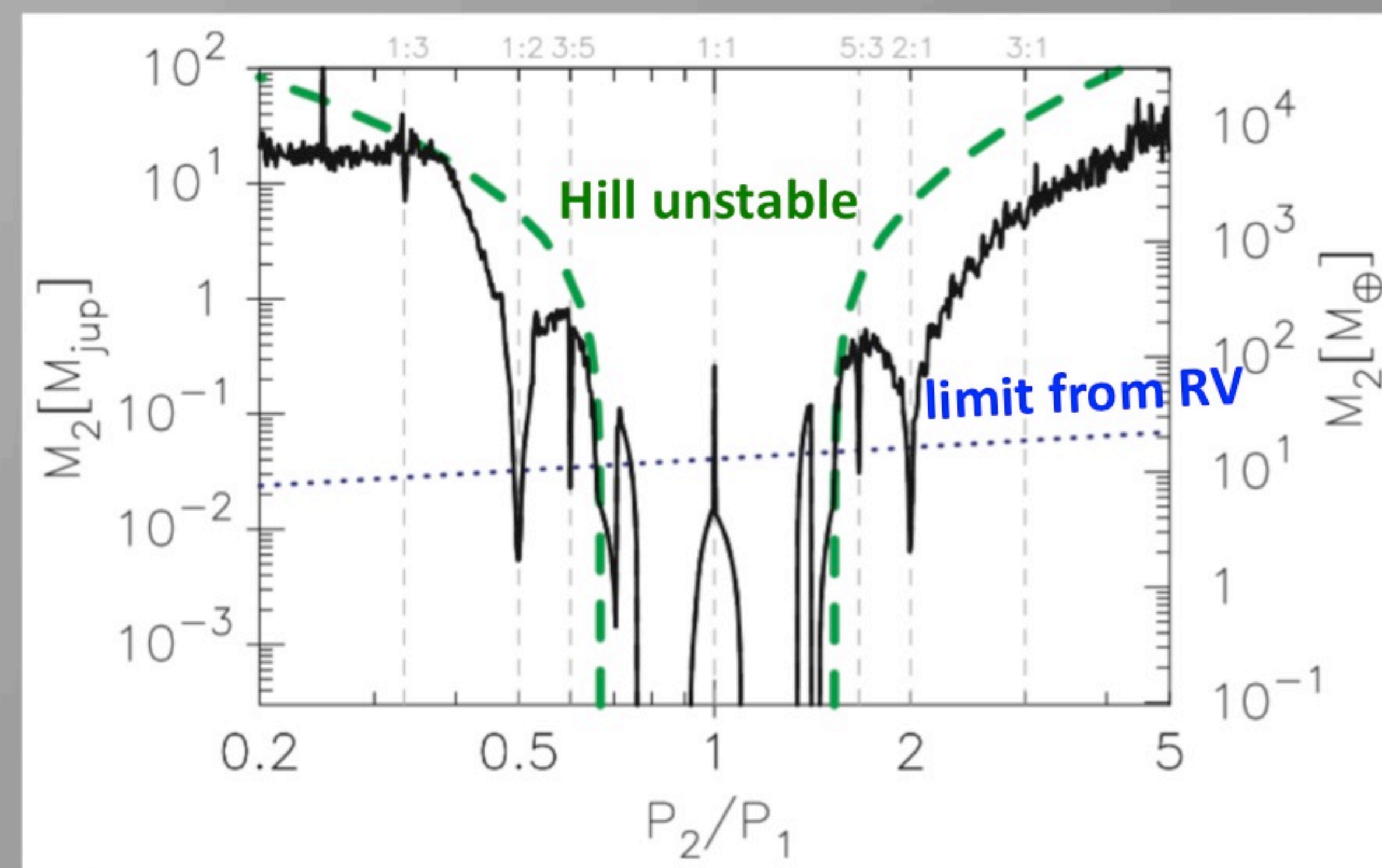


Fig 4. Calculated  $3\text{-}\sigma$  upper limits on the mass of the hypothetical secondary planet as a function of the period ratio (black line). Blue dotted line represents limits from the RV observations. Green dashed line shows the boundary of Hill-stable region.