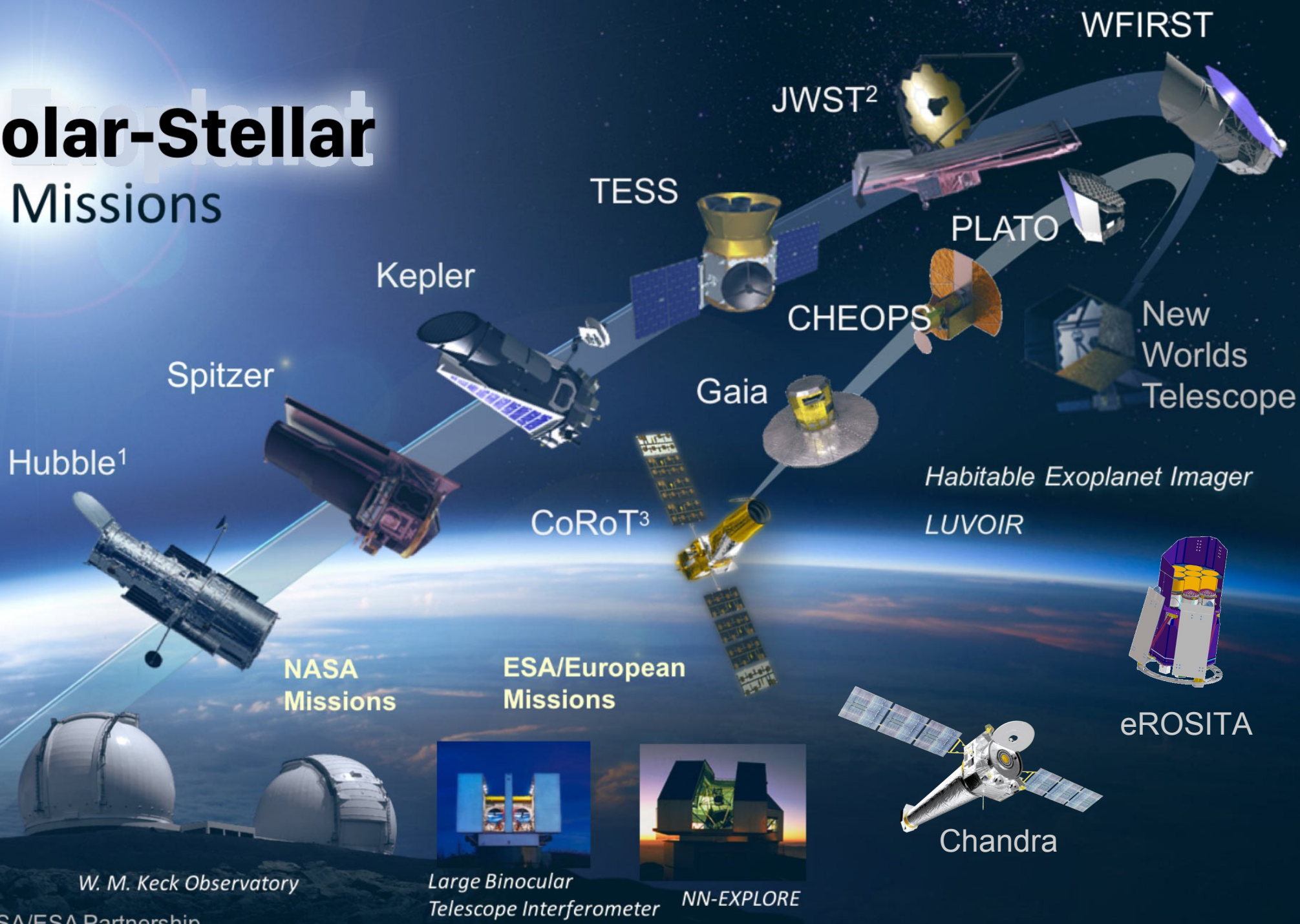


Solar-Stellar Missions



NASA Missions

ESA/European Missions



W. M. Keck Observatory



Large Binocular Telescope Interferometer

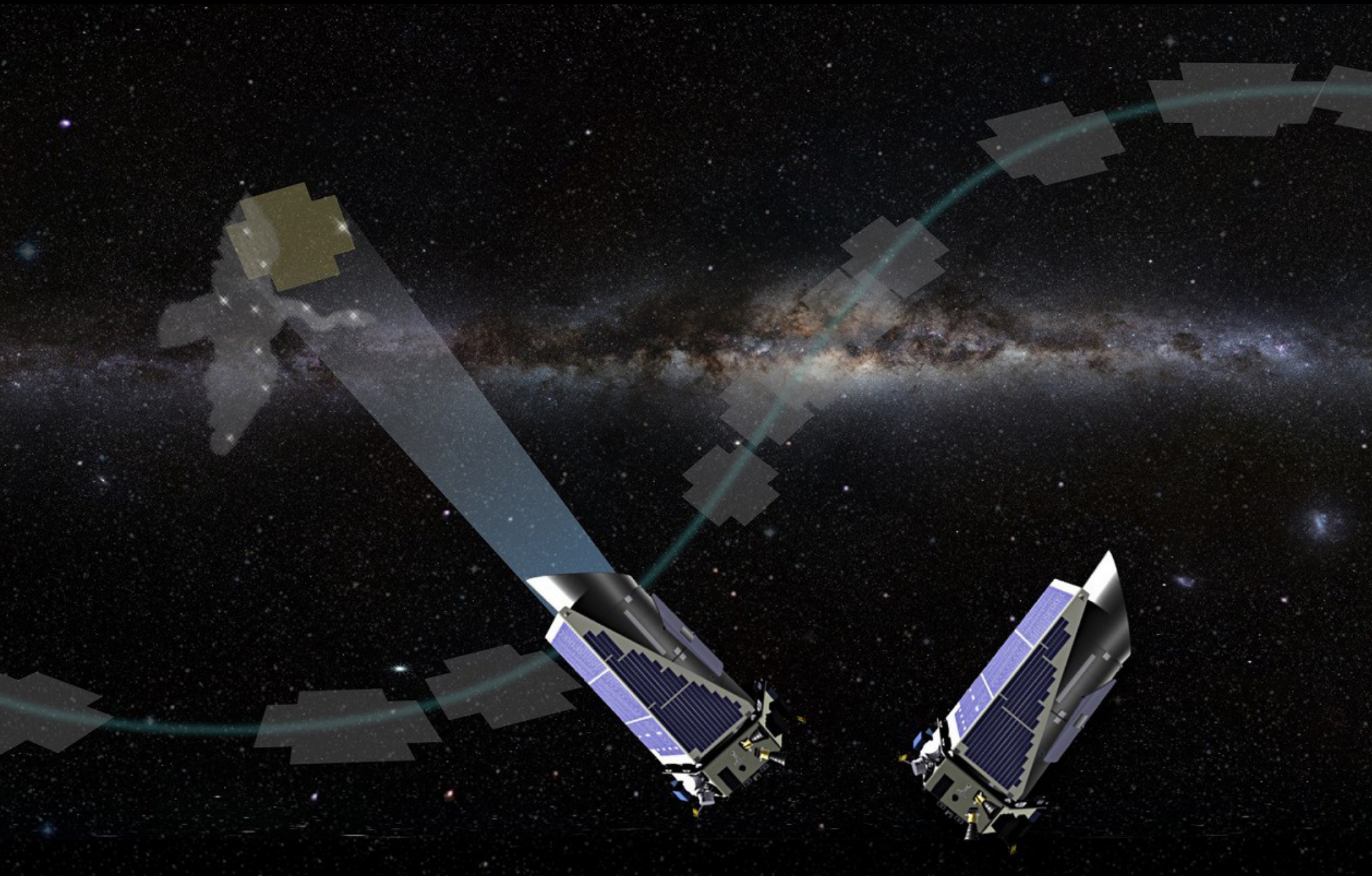


NN-EXPLORE

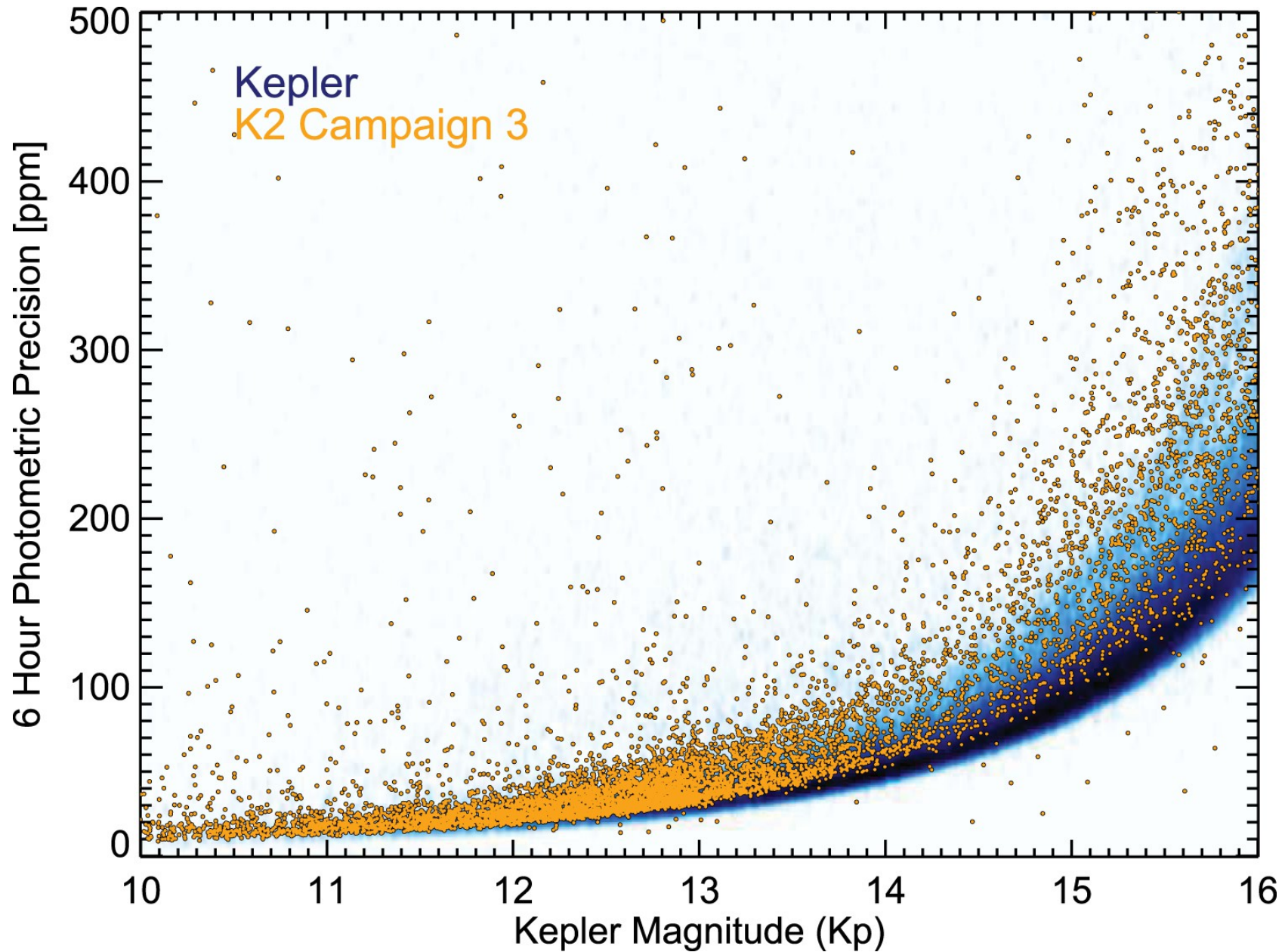
Ground Telescopes with NASA participation

¹ NASA/ESA Partnership
² NASA/ESA/CSA Partnership
³ CNES/ESA

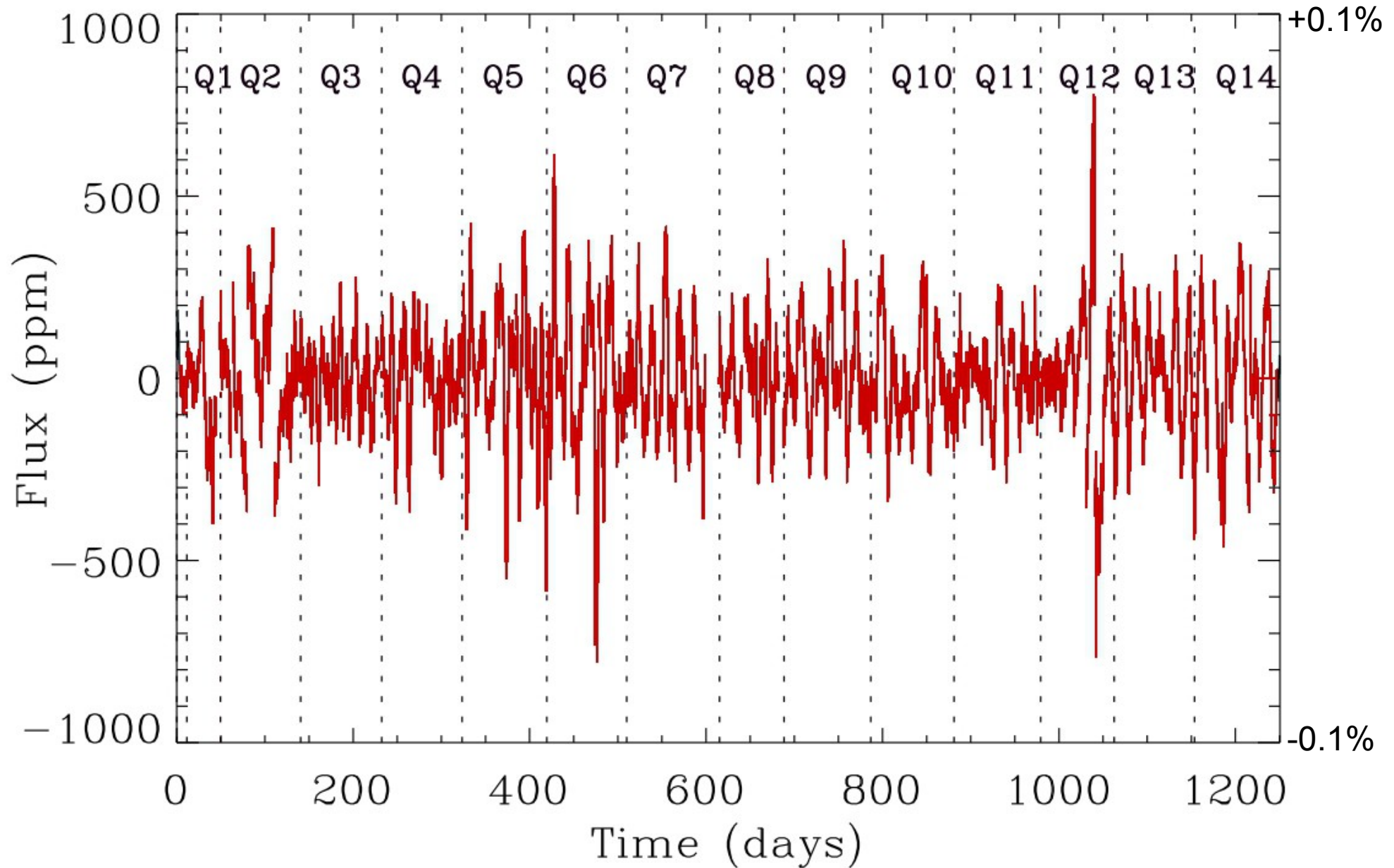
Prologue: the Kepler mission



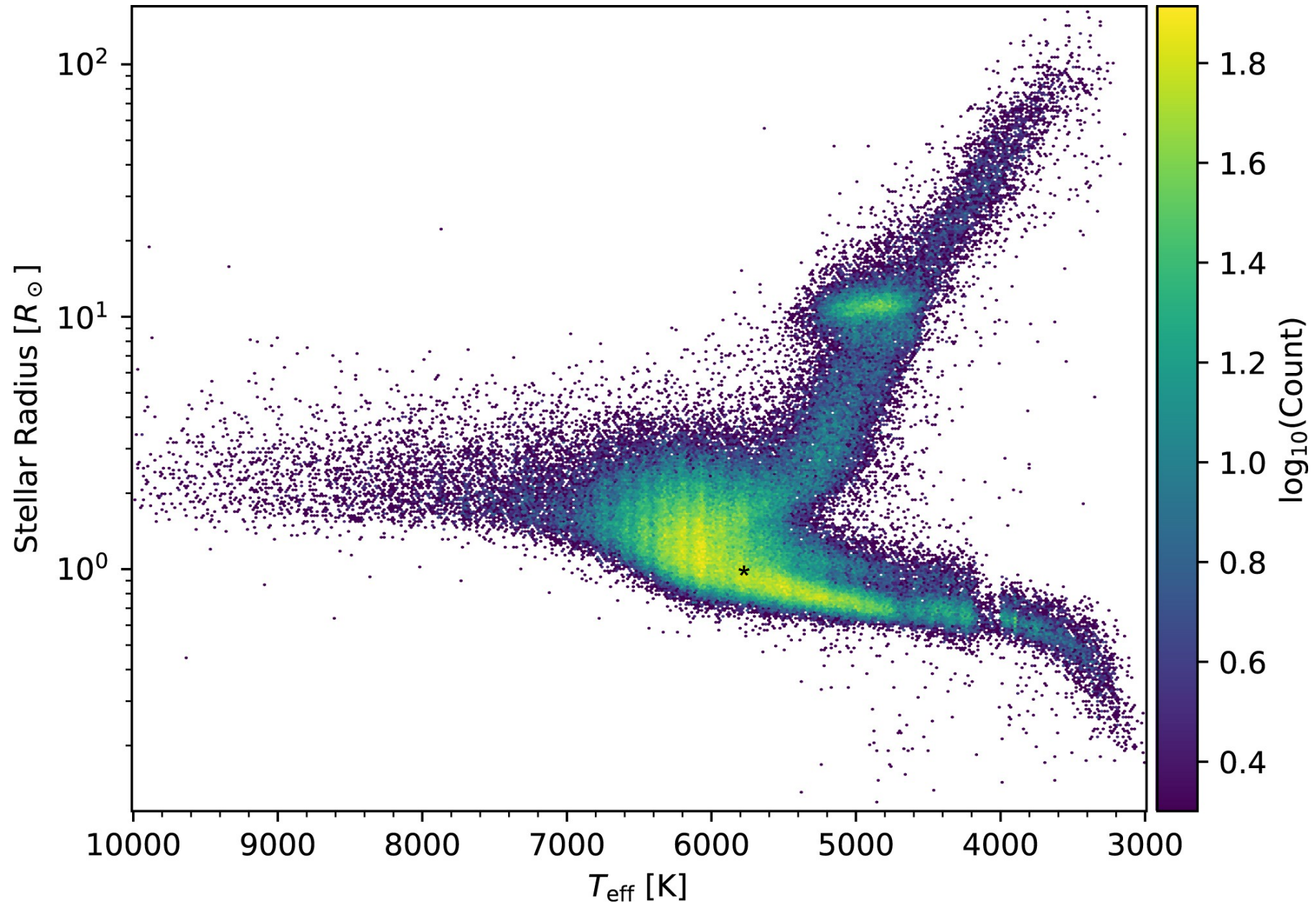
High photometric precision

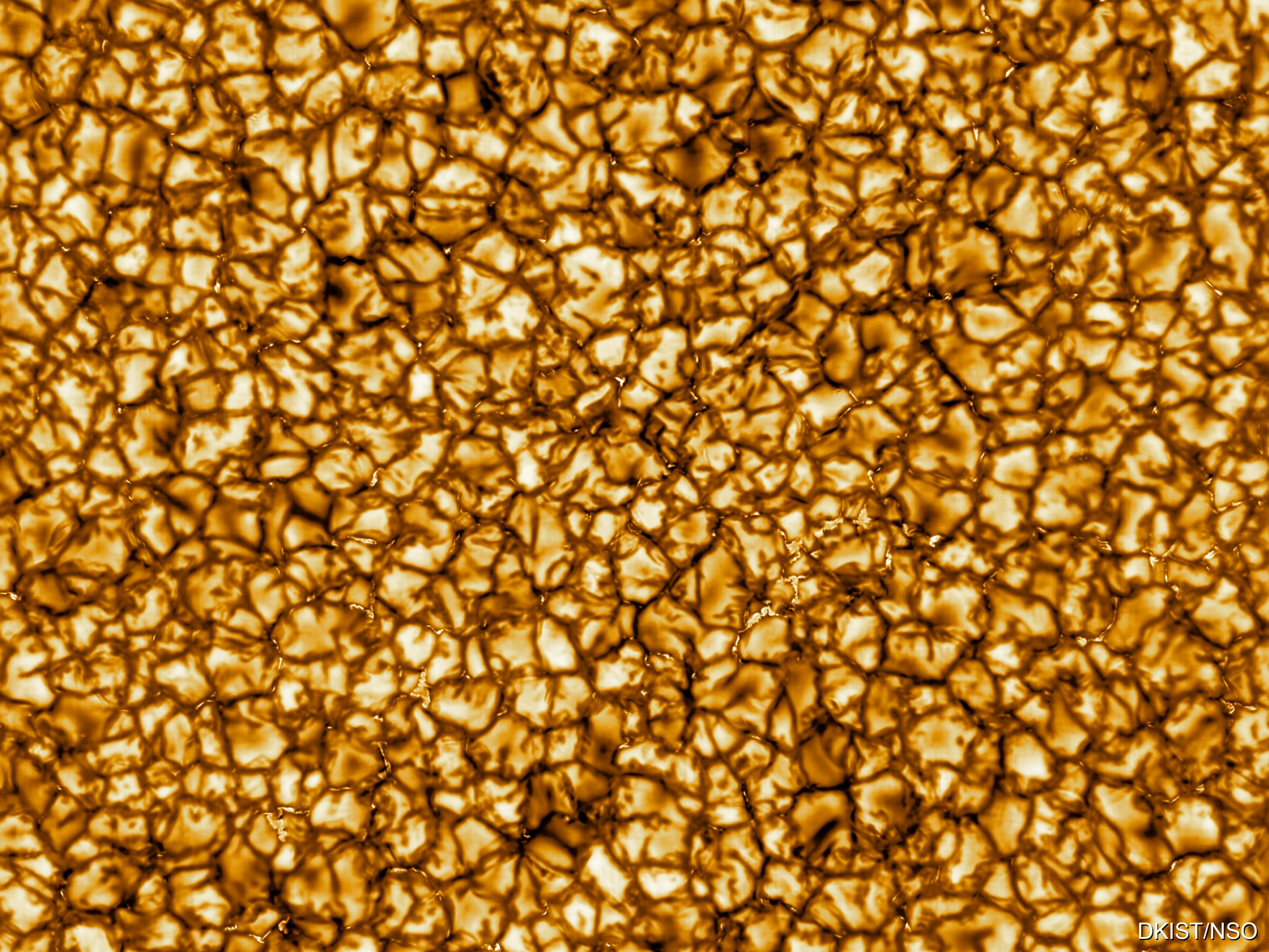


Long continuous monitoring

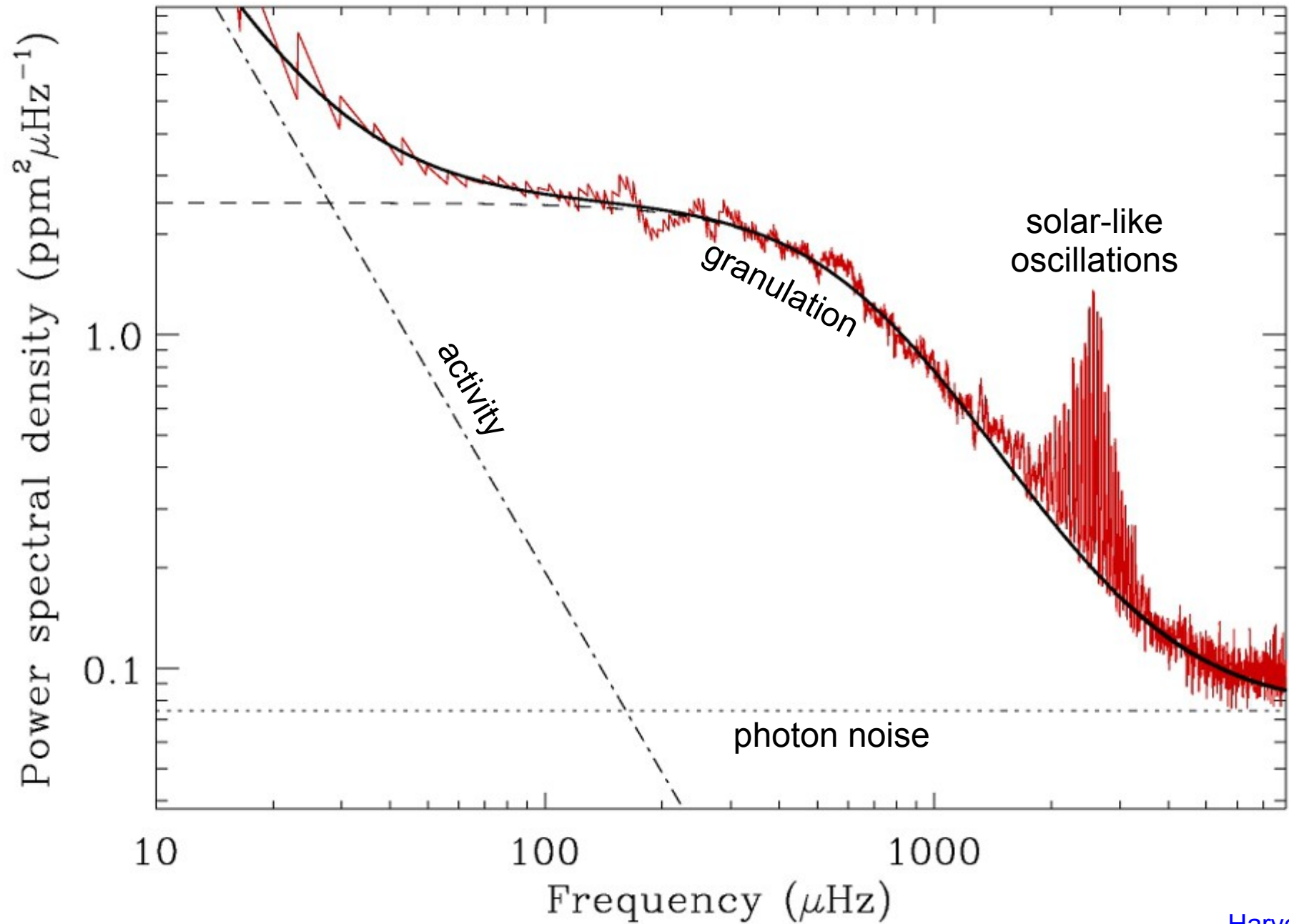


Statistically significant samples

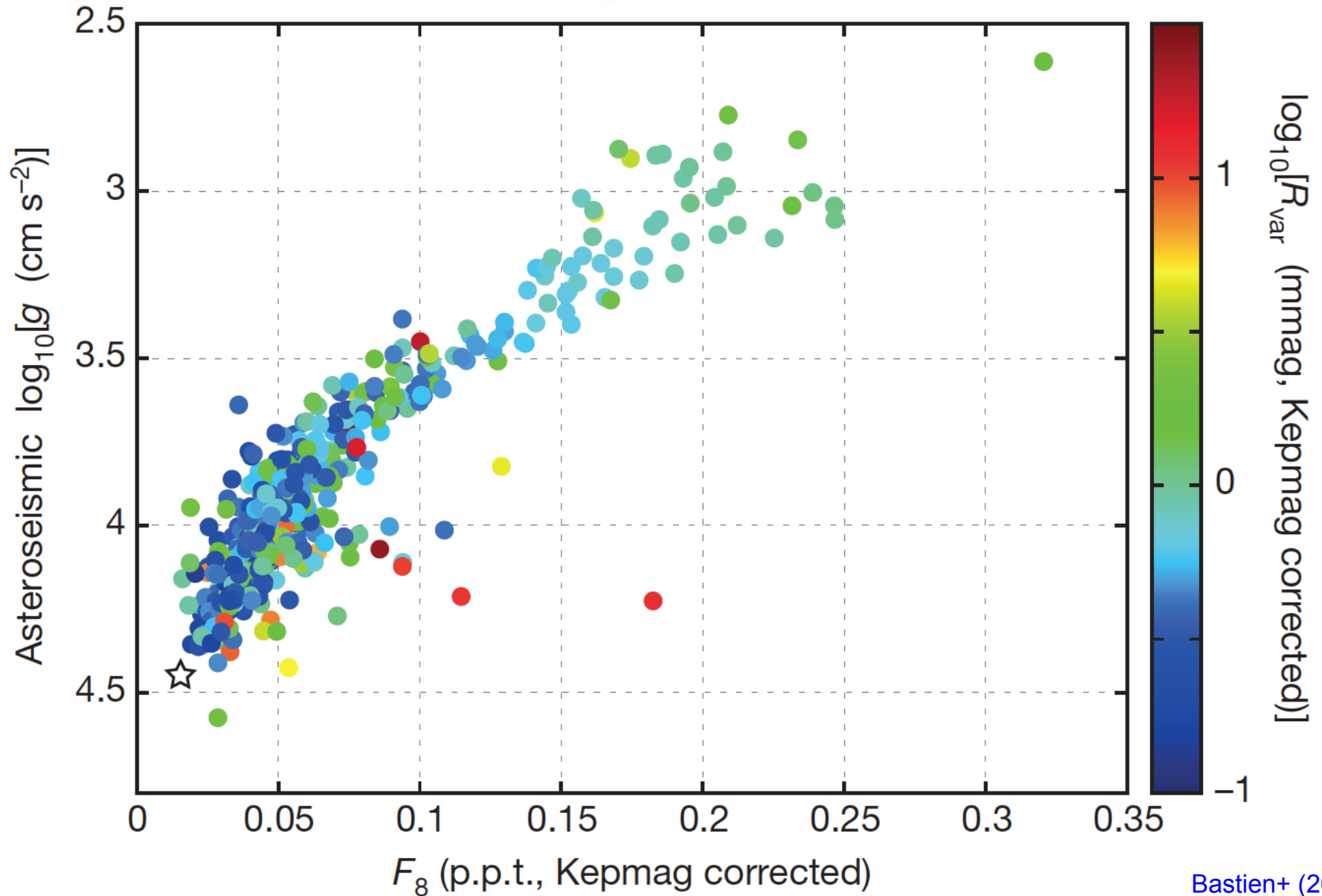




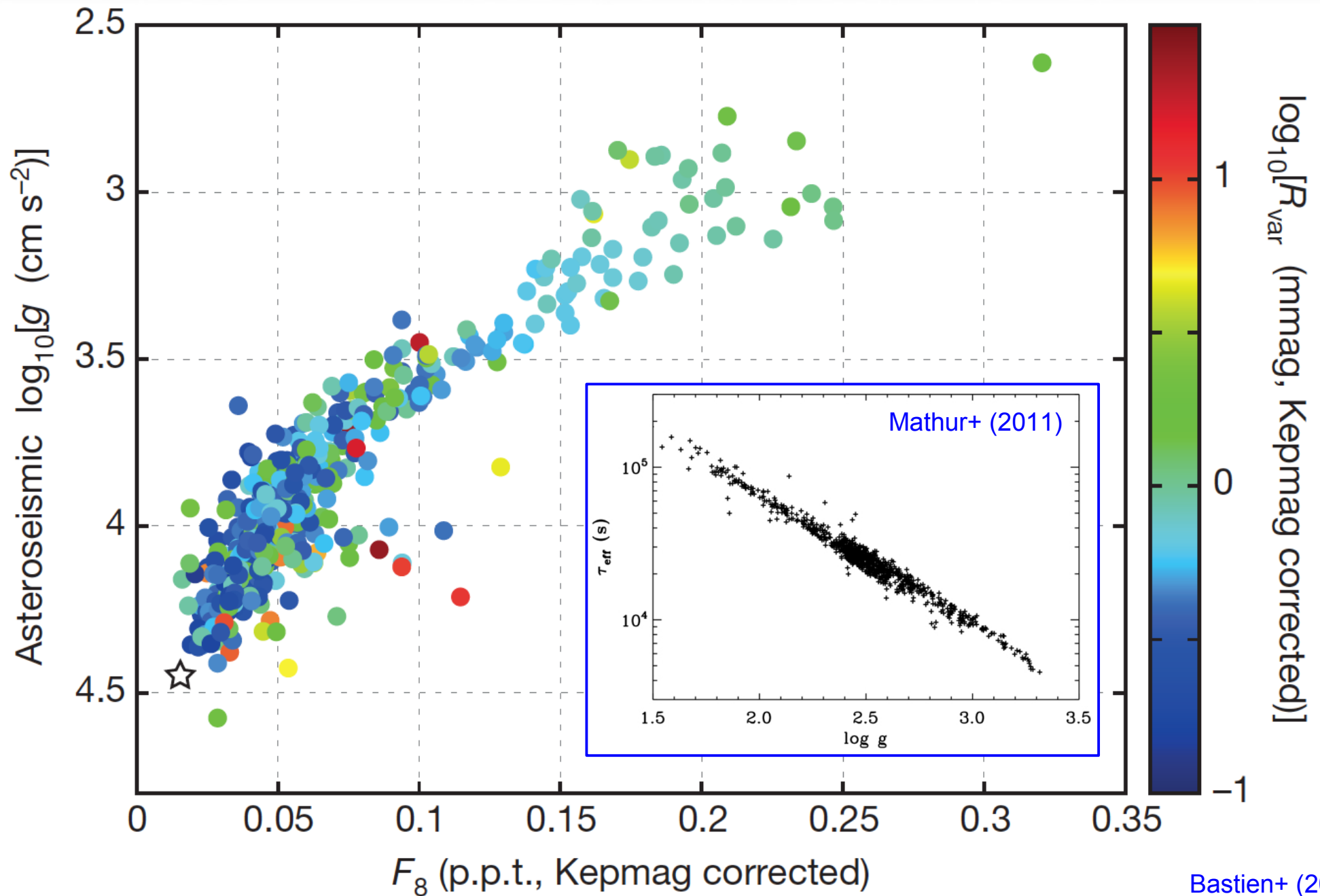
Stellar granulation



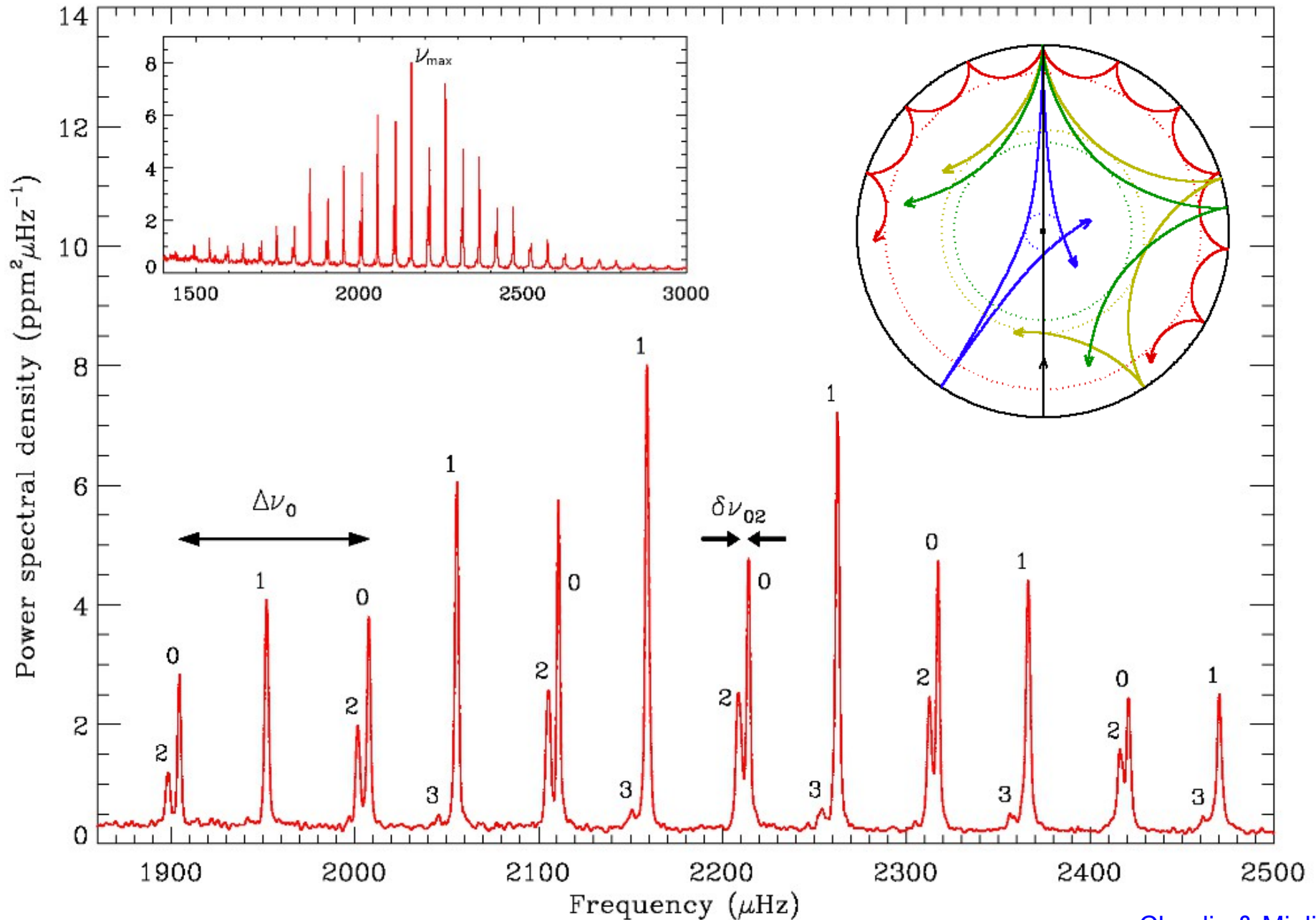
“Flicker” → surface gravity



“Flicker” → surface gravity



Global oscillation properties



Scaling relations → radius, mass

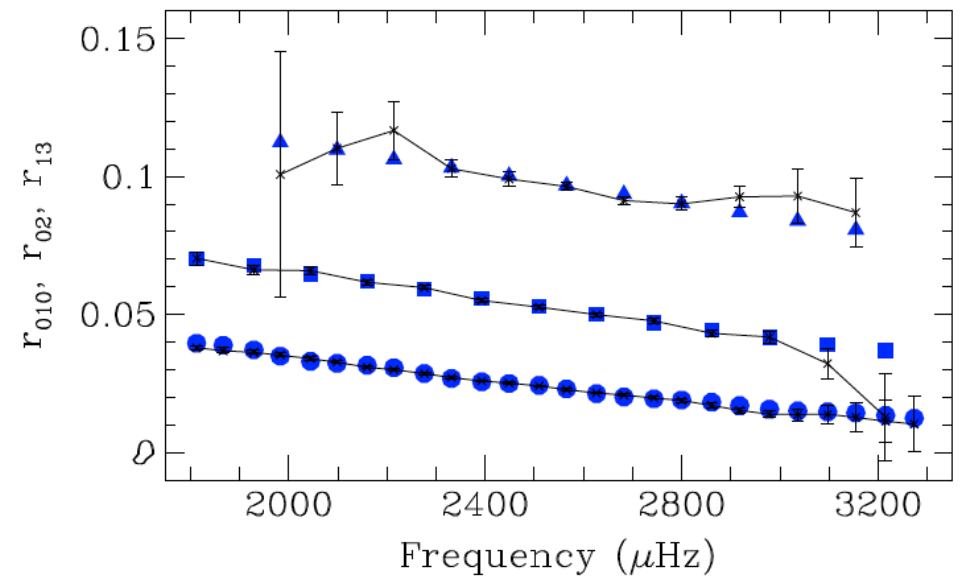
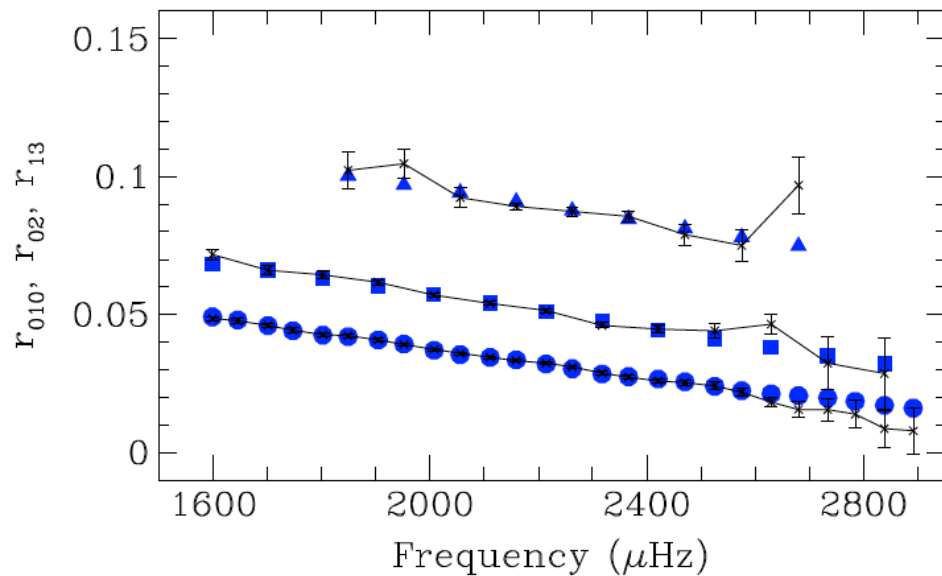
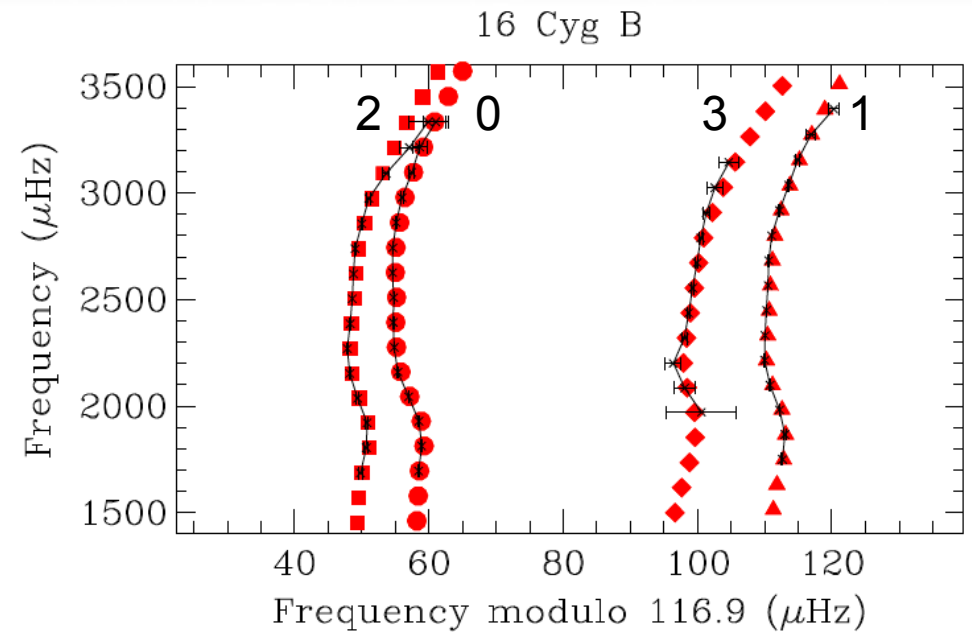
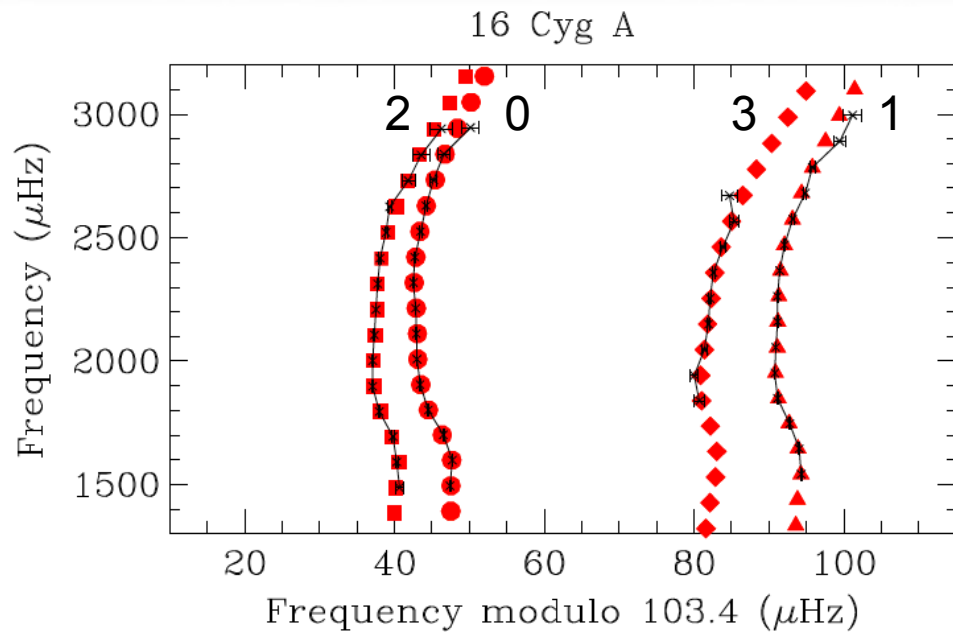
$$\Delta\nu \approx \Delta\nu_{\odot} \left(\frac{M}{M_{\odot}} \right)^{1/2} \left(\frac{R}{R_{\odot}} \right)^{-3/2},$$

$$\nu_{\max} \approx \nu_{\max,\odot} \left(\frac{M}{M_{\odot}} \right) \left(\frac{R}{R_{\odot}} \right)^{-2} \left(\frac{T_{\text{eff}}}{T_{\text{eff},\odot}} \right)^{-1/2},$$

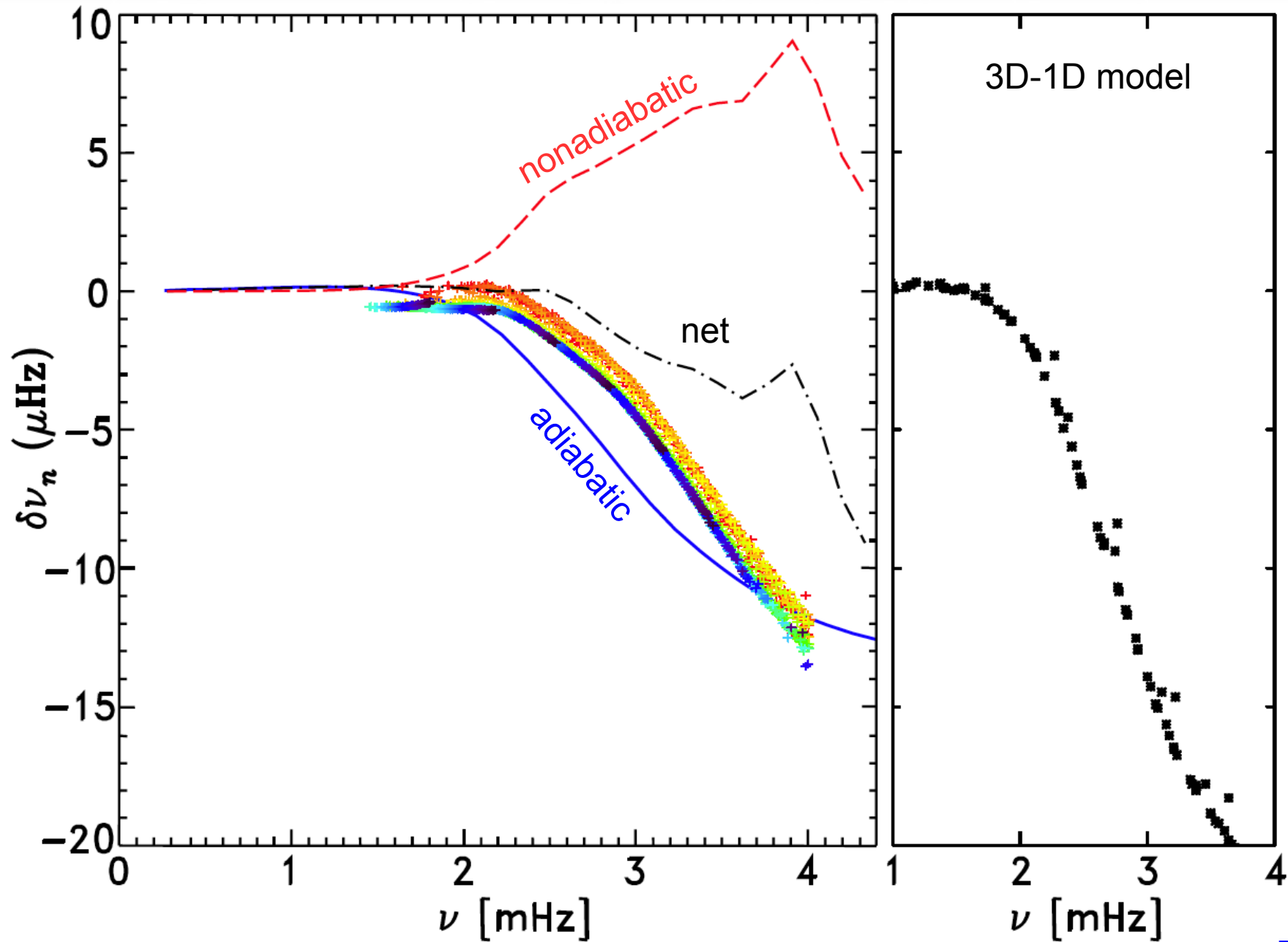
$$R \approx R_{\odot} \left(\frac{\Delta\nu_{\odot}}{\Delta\nu} \right)^2 \left(\frac{\nu_{\max}}{\nu_{\max,\odot}} \right) \left(\frac{T_{\text{eff}}}{T_{\text{eff},\odot}} \right)^{1/2},$$

$$M \approx M_{\odot} \left(\frac{\Delta\nu_{\odot}}{\Delta\nu} \right)^4 \left(\frac{\nu_{\max}}{\nu_{\max,\odot}} \right)^3 \left(\frac{T_{\text{eff}}}{T_{\text{eff},\odot}} \right)^{3/2}.$$

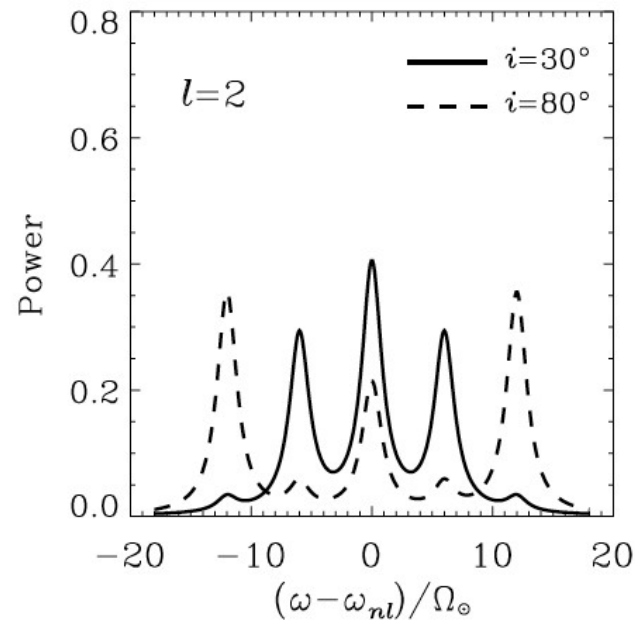
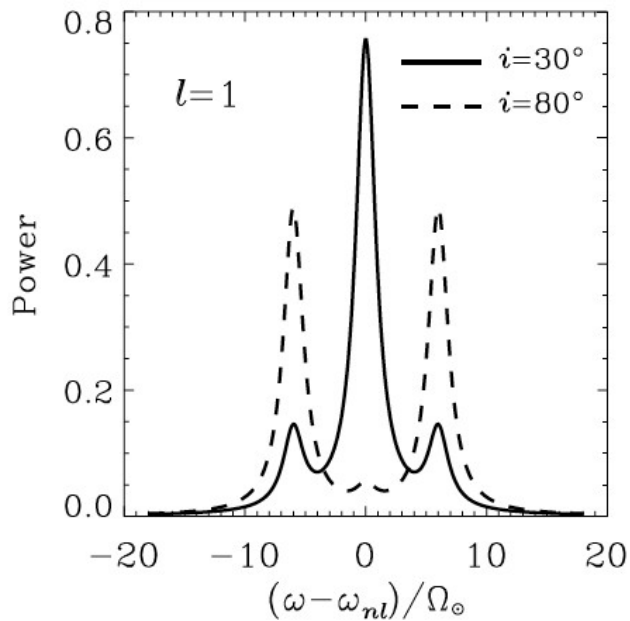
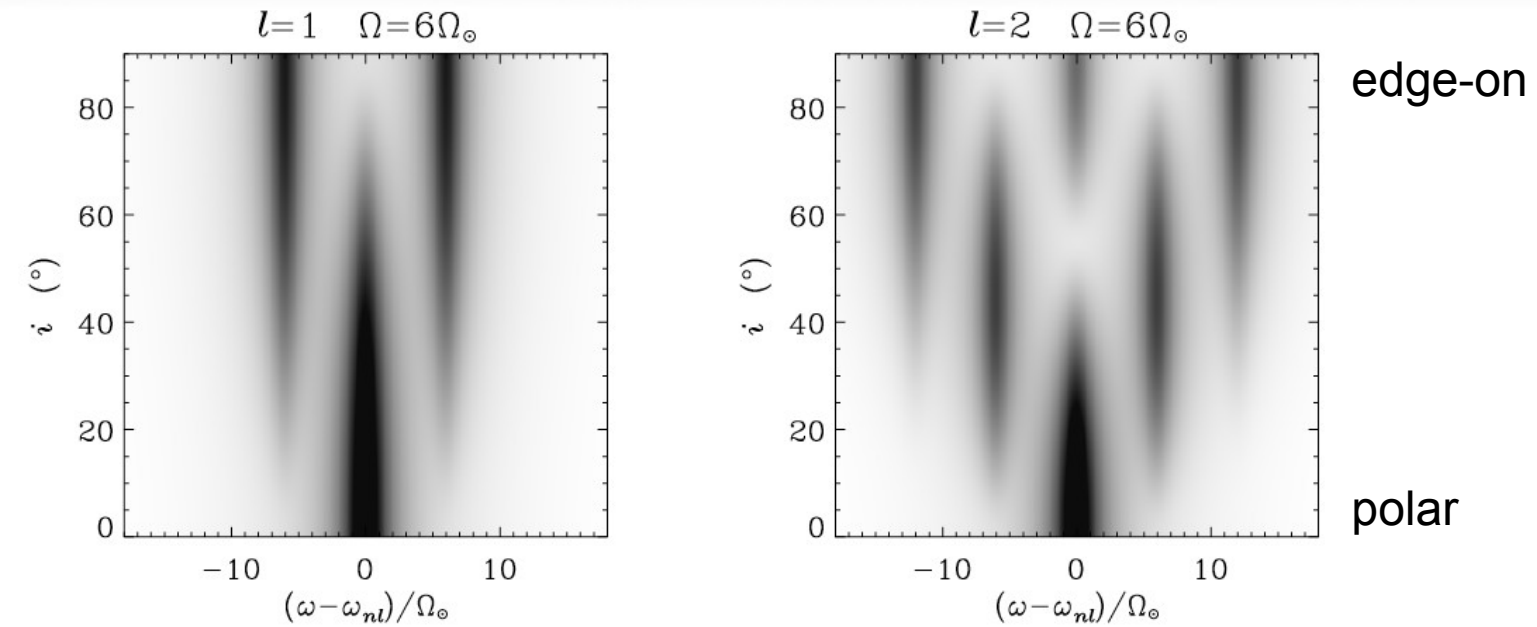
Oscillation frequencies \rightarrow age



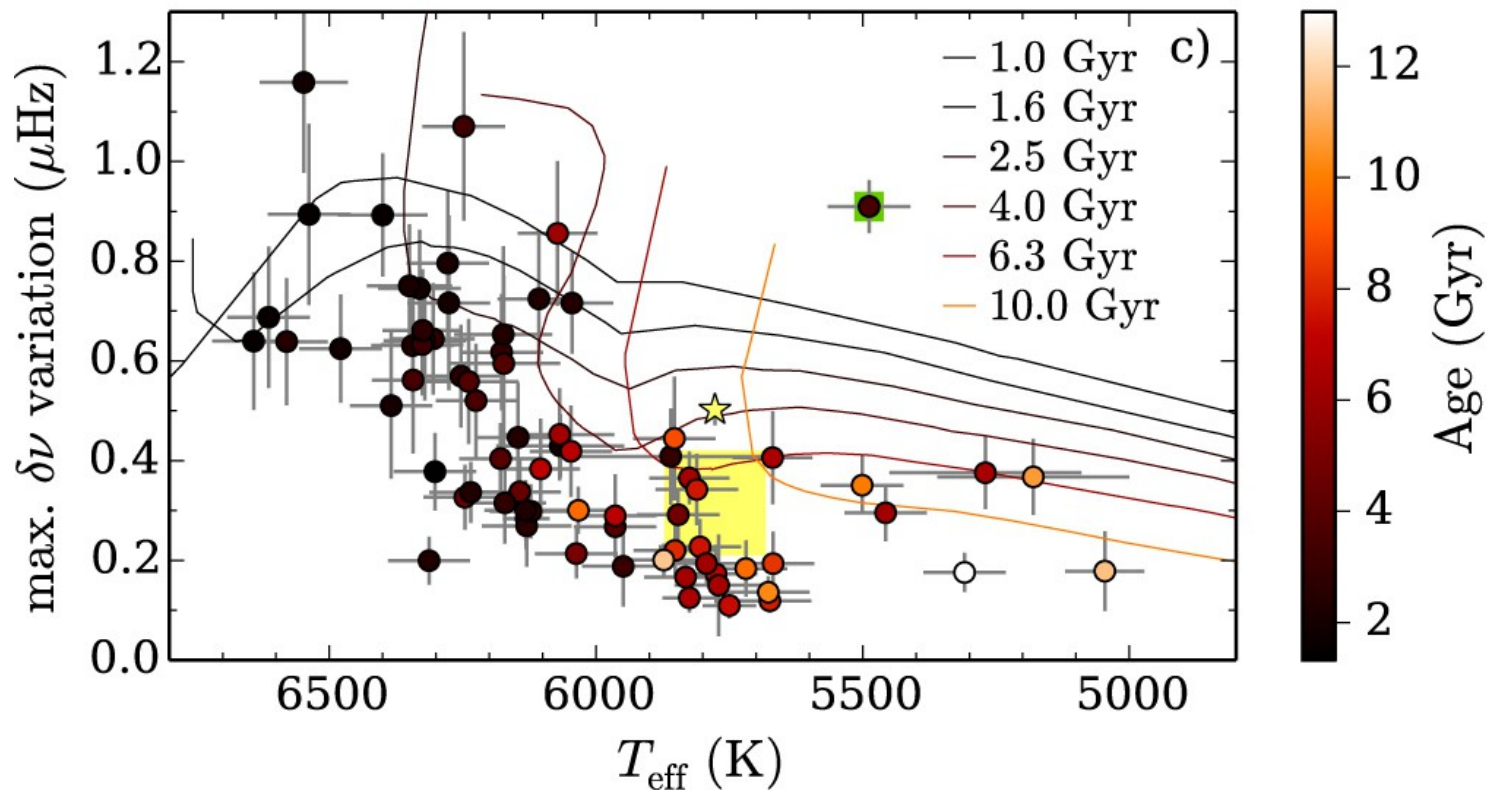
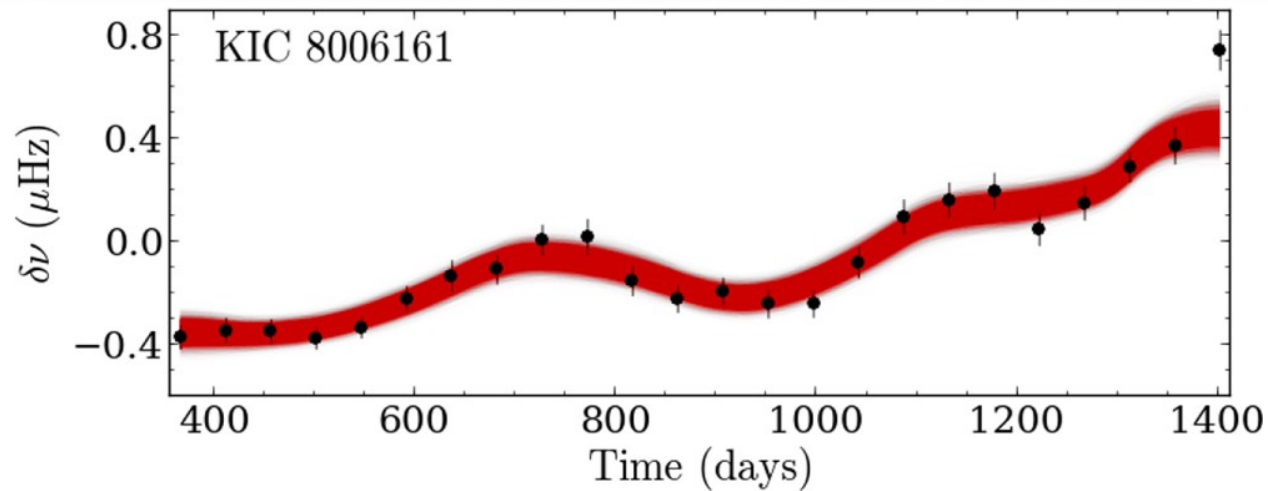
Complication: “surface effects”



Asteroseismic stellar rotation



Asteroseismic magnetic variability



Summary

- Kepler revolutionized solar-stellar studies by gathering high **precision** photometric data, **continuously** over an **extended** time span, for a **large sample** of stars.
- Data with these characteristics probe stellar granulation (**$\log g$**), global asteroseismic properties (**ρ , R , M**), and oscillation mode frequencies (**age, Z , Y , α_{MLT}**).
- With high frequency precision and extended monitoring, asteroseismic data can also constrain stellar rotation (**P_{rot} , i**) and magnetic variability (**P_{cyc}**).