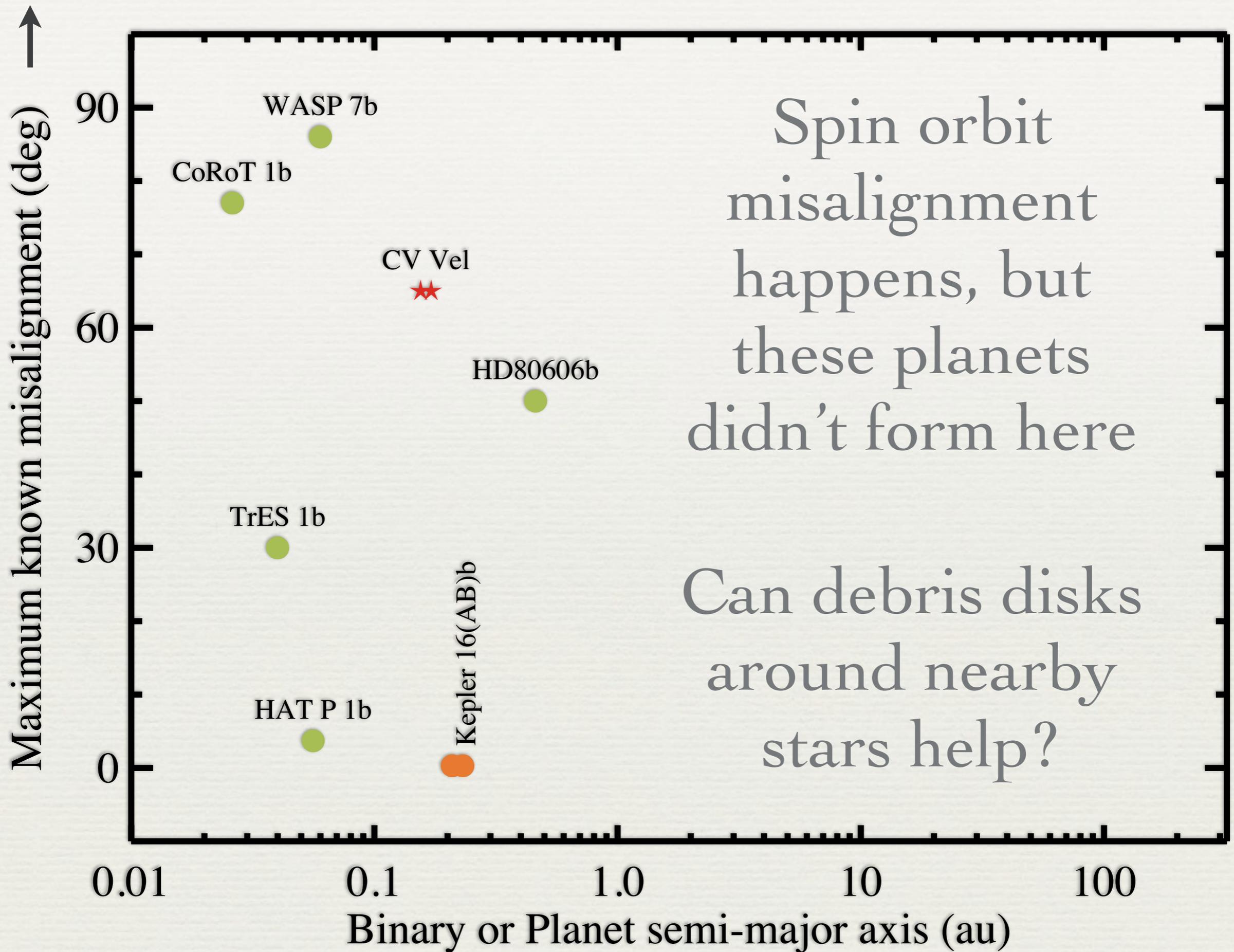




A wider view of planetary system alignment

Grant Kennedy, IoA, Cambridge
+ Wyatt & Greaves in UK
+ Herschel DEBRIS team

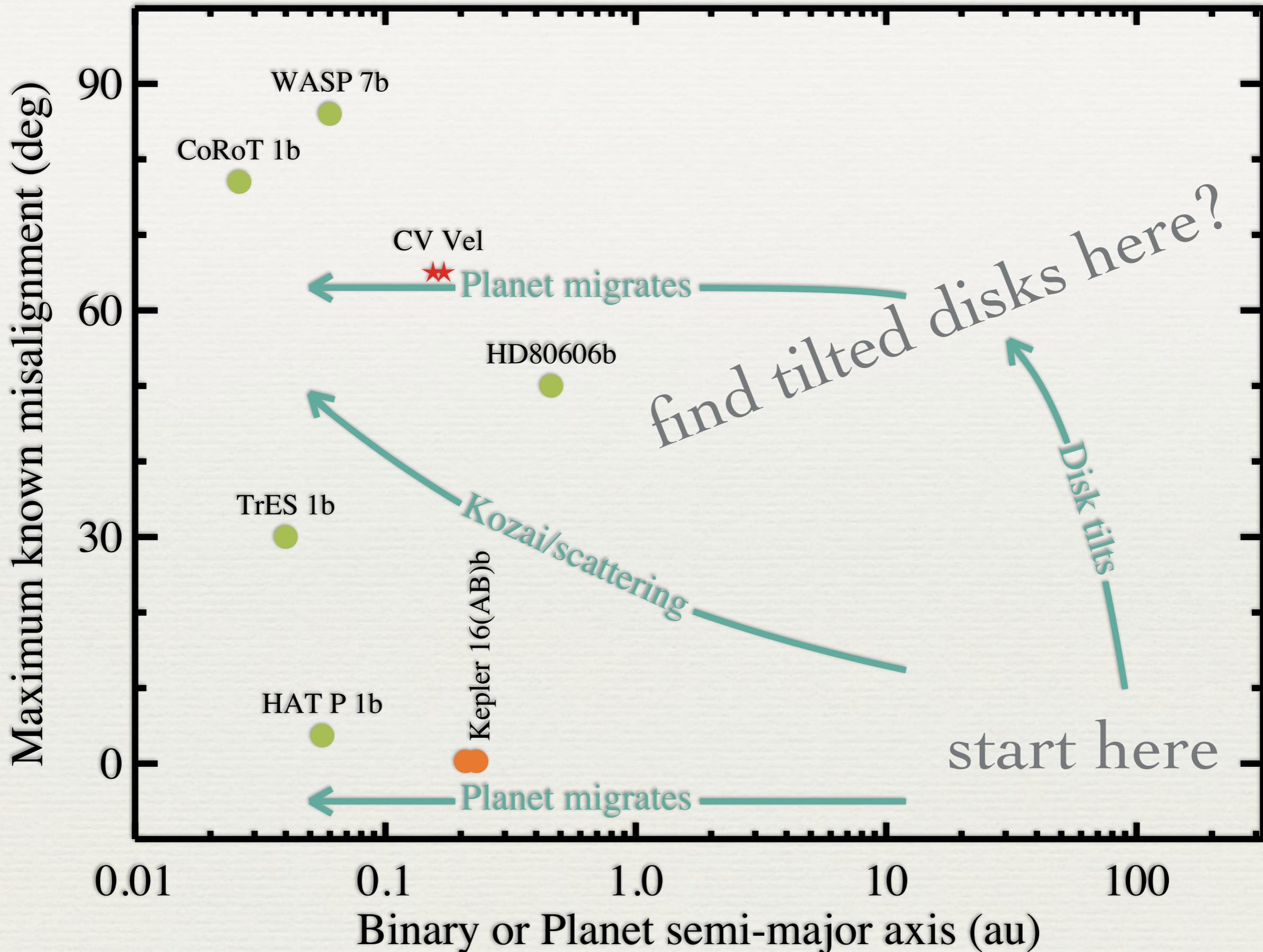


data from www.physics.mcmaster.ca/~rbeller

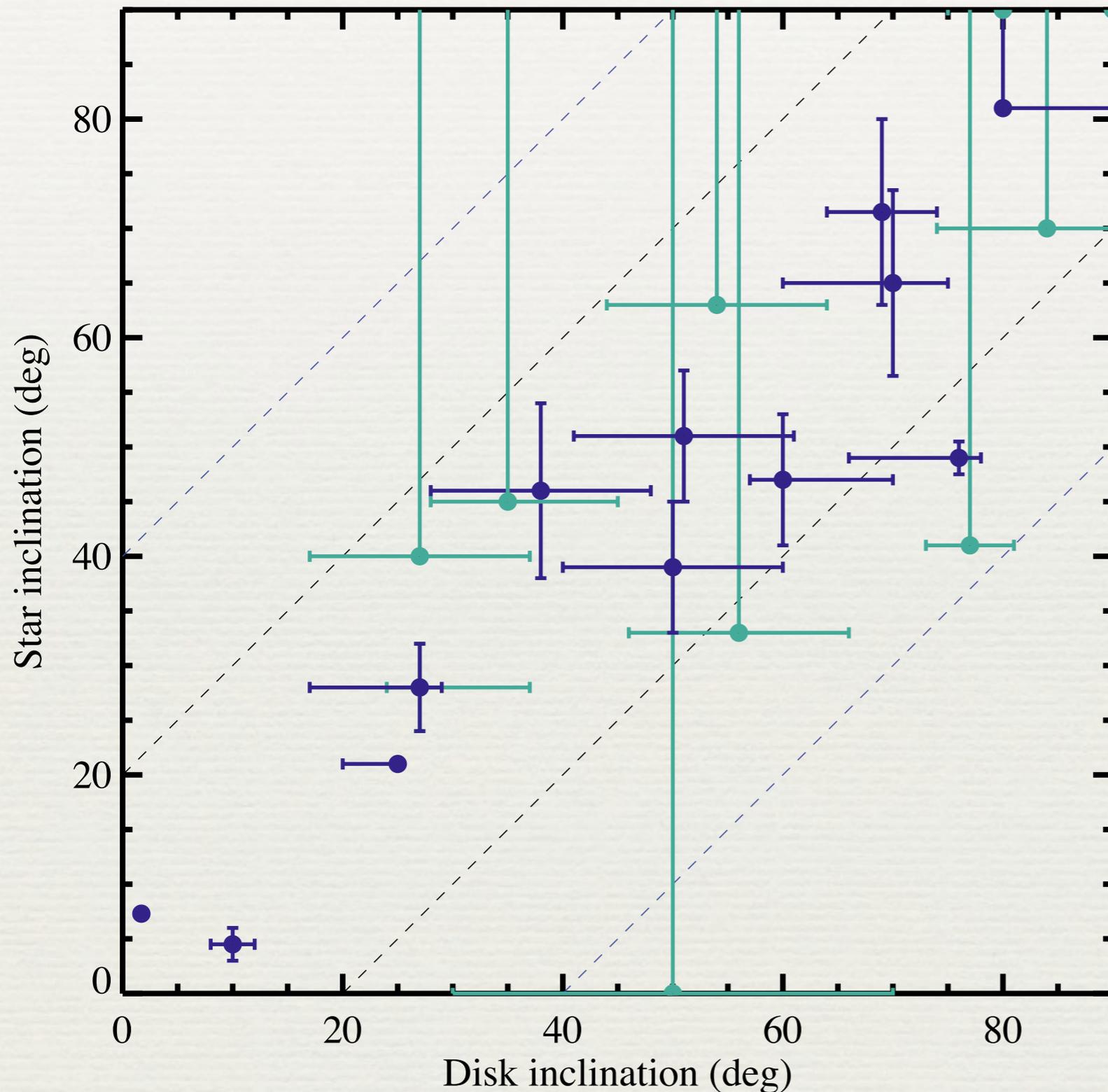
“normal” planet formation



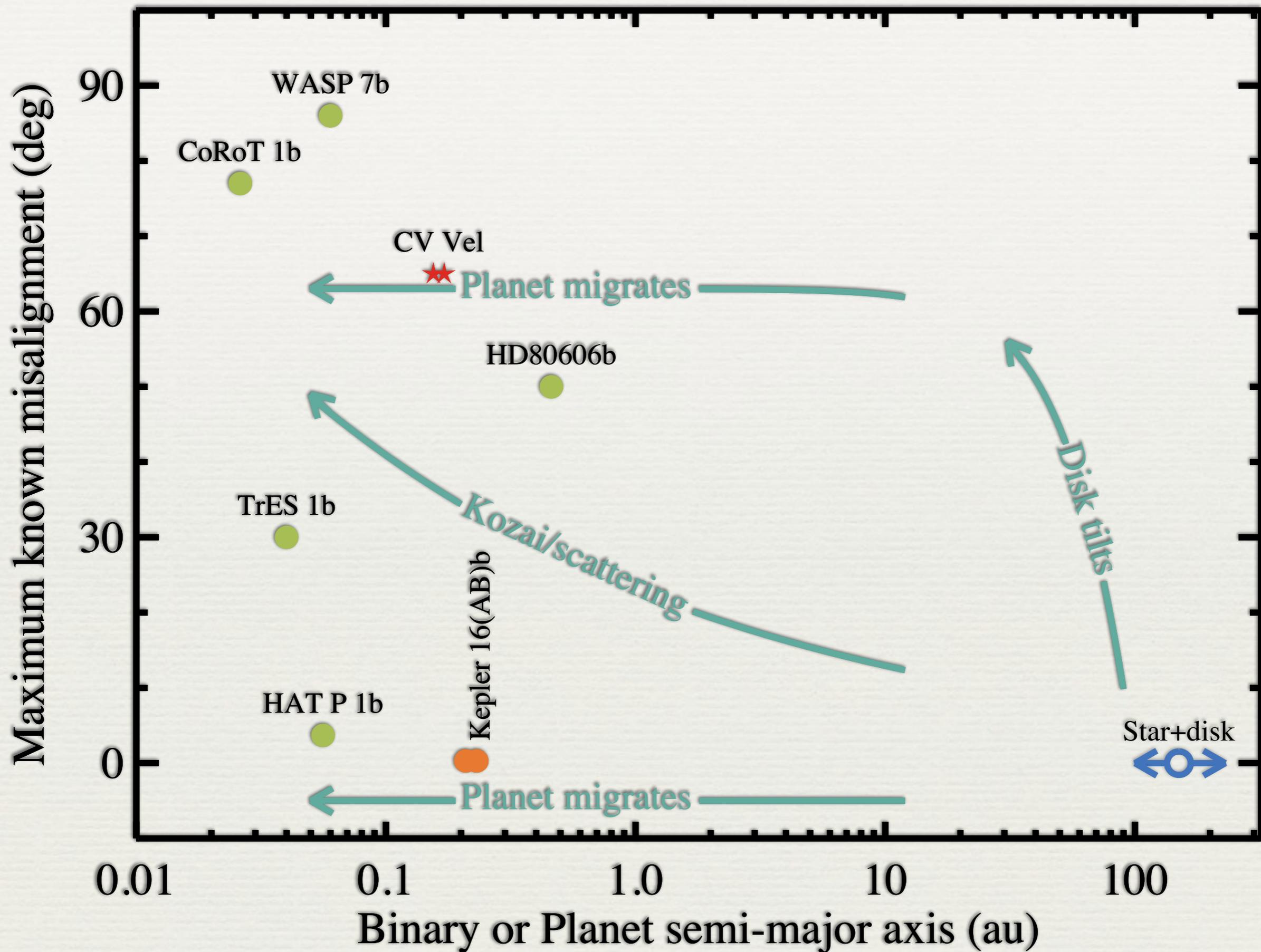
debris disk
(Kuiper belt analogue)
has i of PPD at dispersal



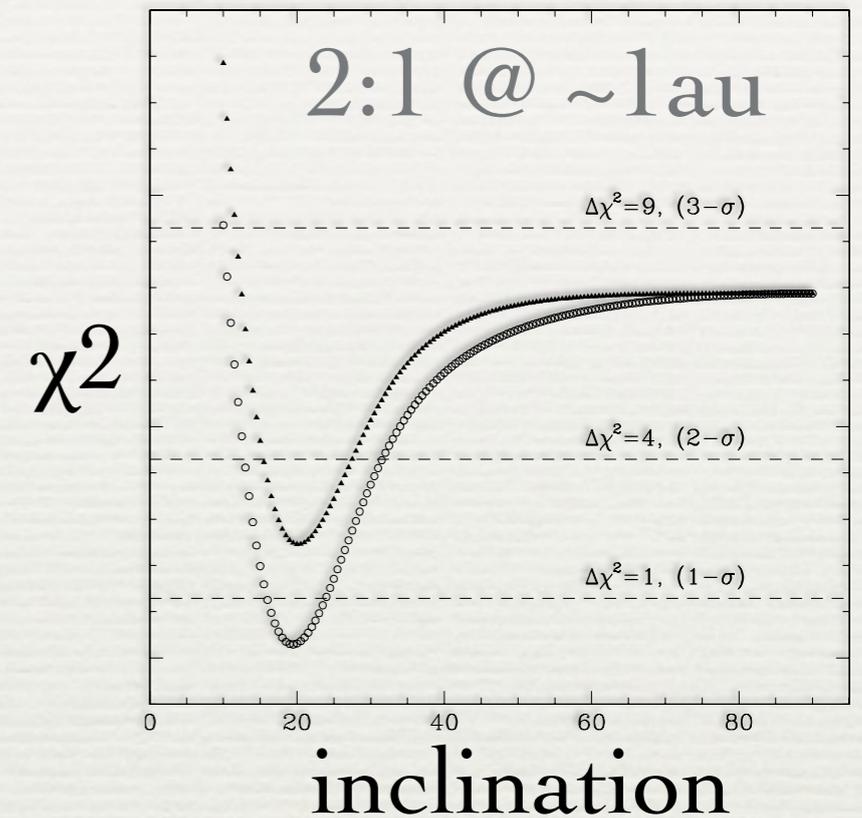
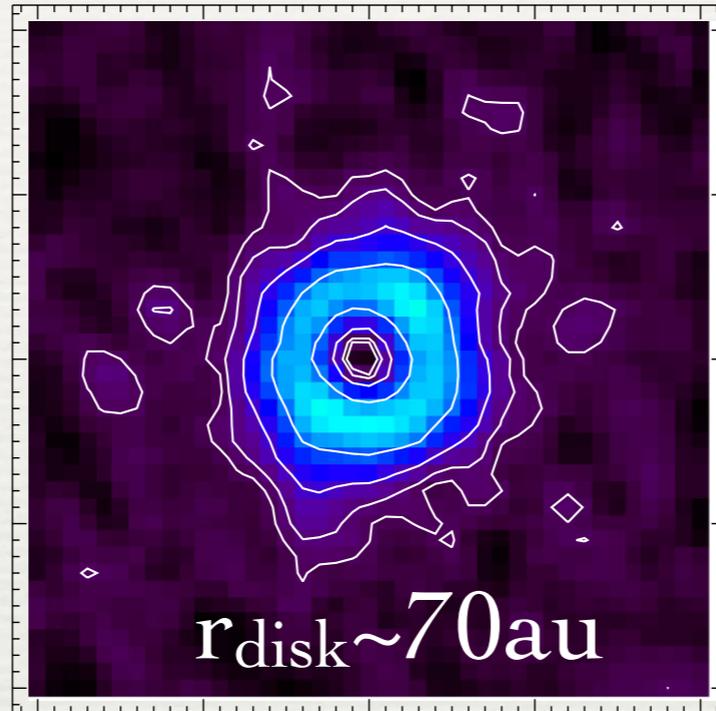
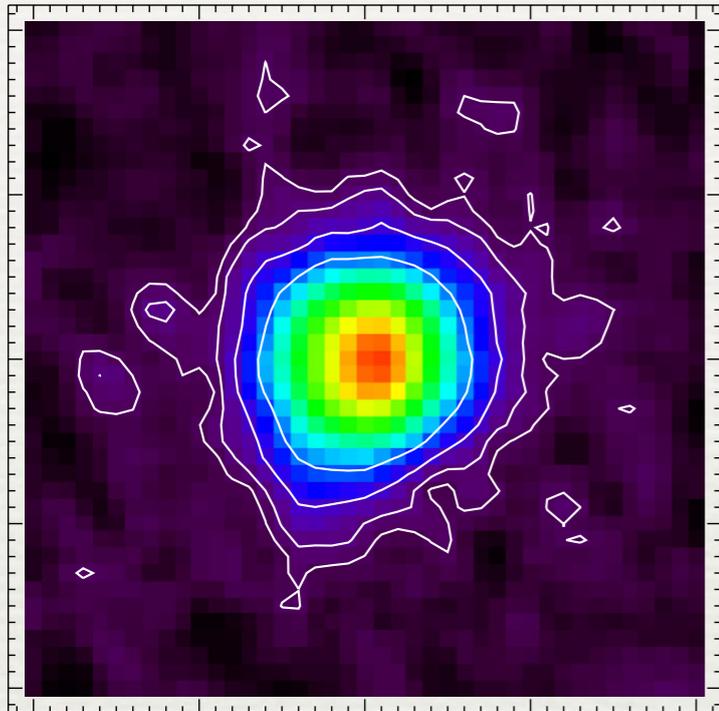
Stellar spin - disk alignment



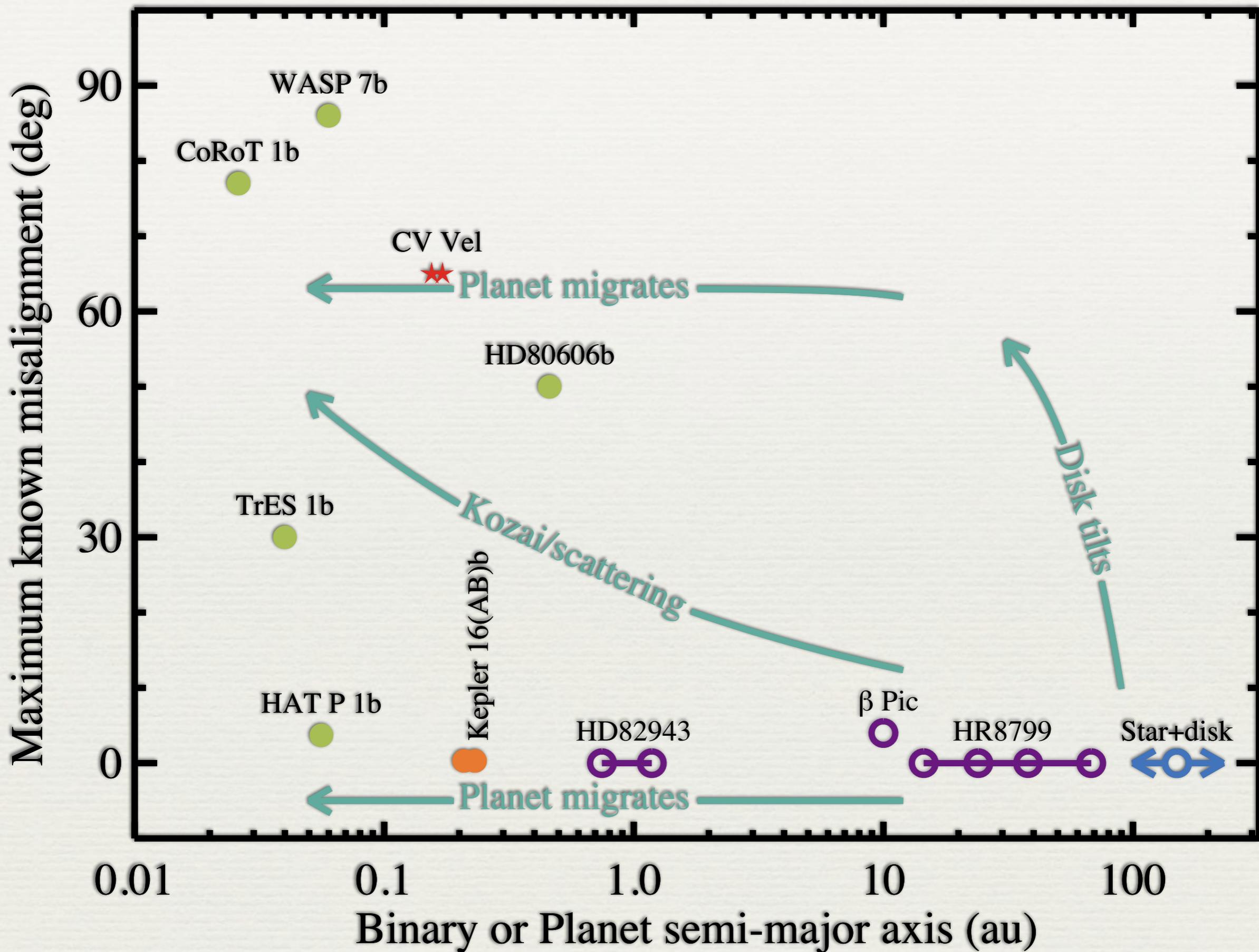
- ◆ No disk “tilting” by companions
- ◆ BUT a tilted debris disk may be easily destroyed by the companion
- ◆ Need to study implications of tilting after gas disk dispersal



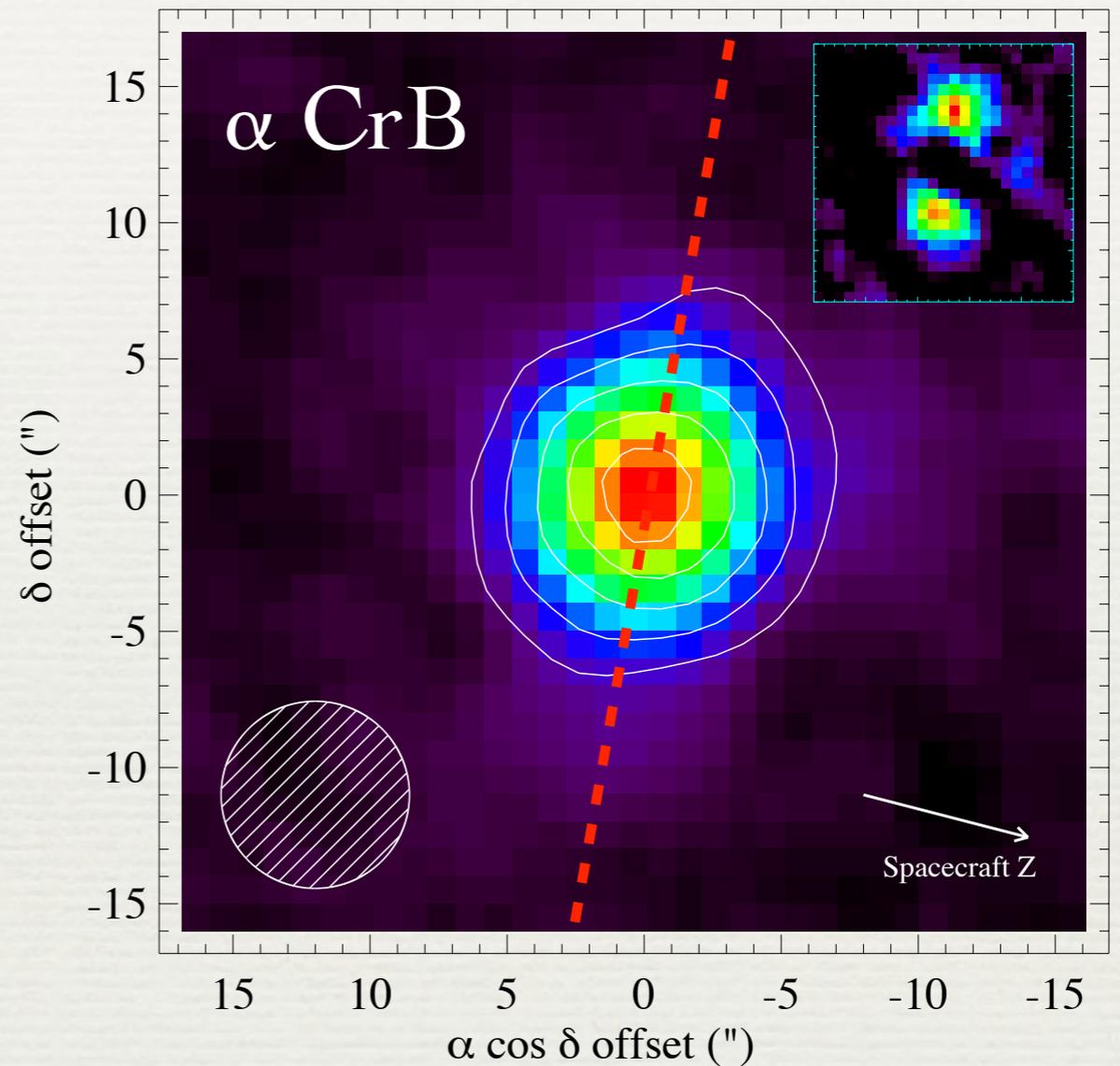
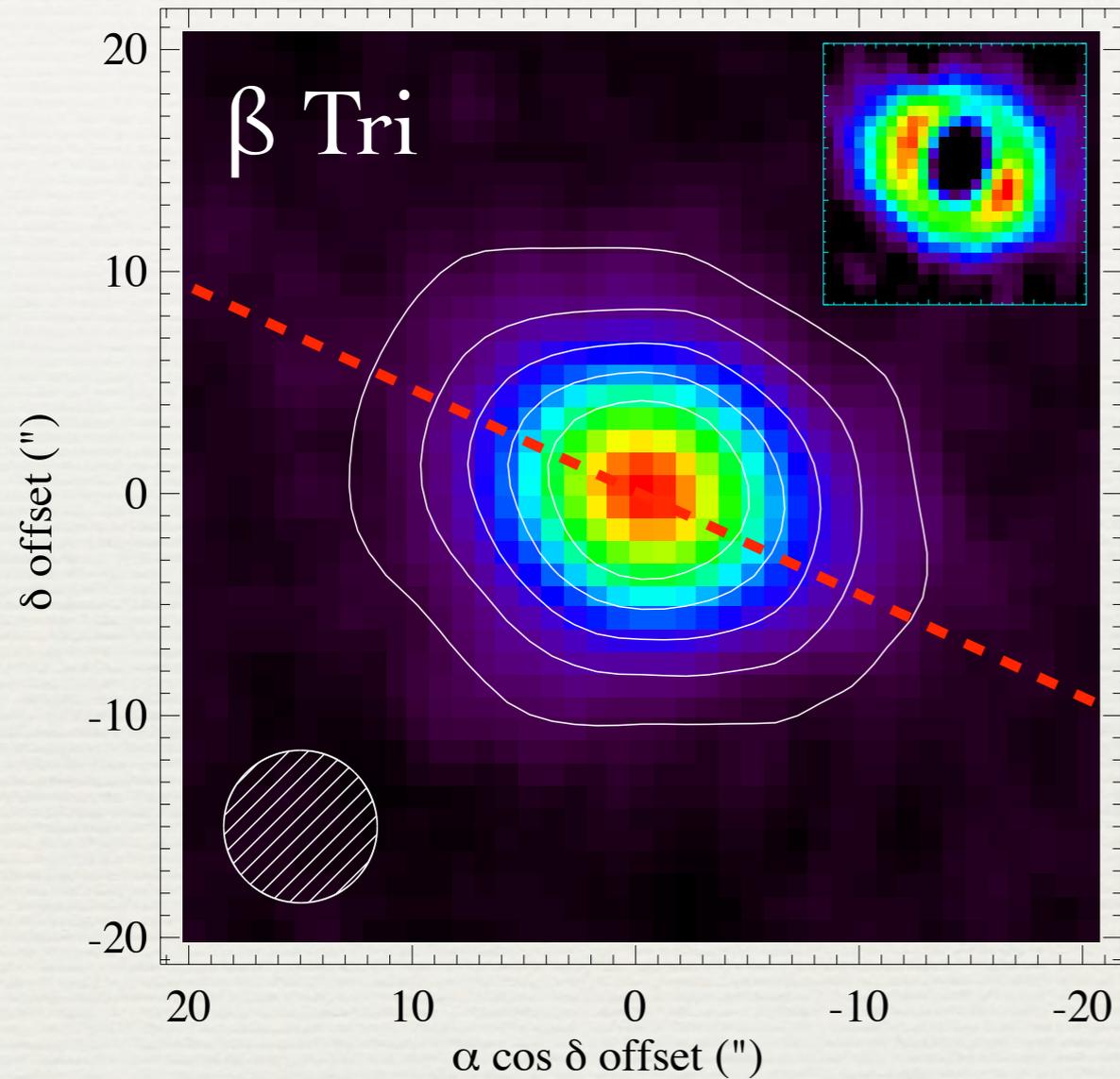
Star-planets-disk alignment



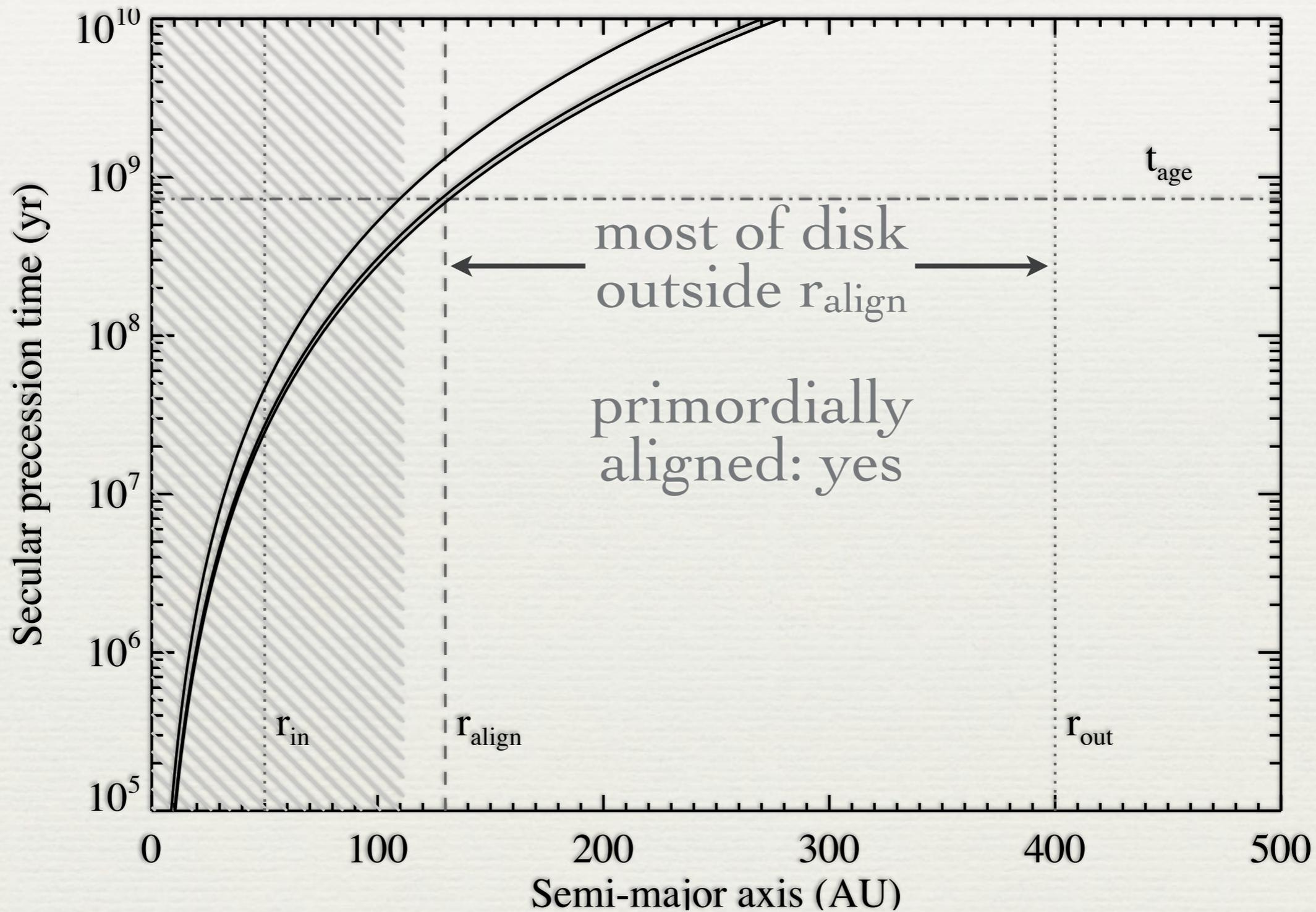
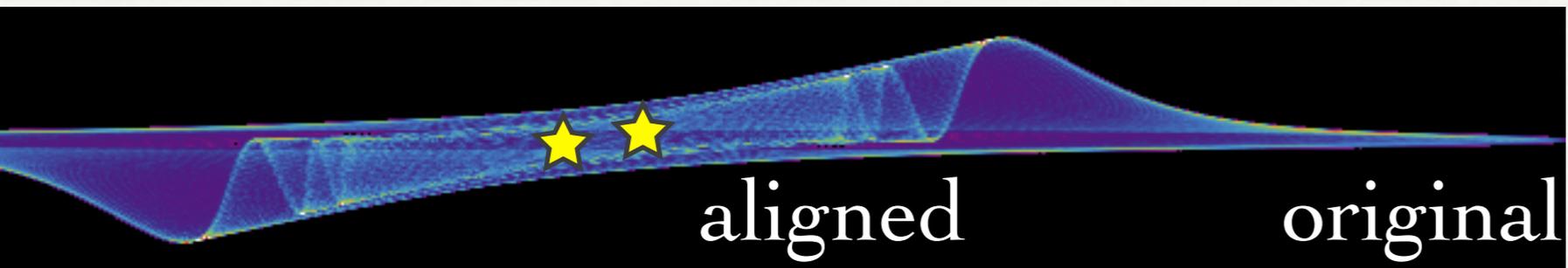
- ♦ >10 years of RV to see planet interactions ($\sim 5M_{\text{Jup}}$)
- ♦ HD 82943 near to pole-on - system-wide alignment

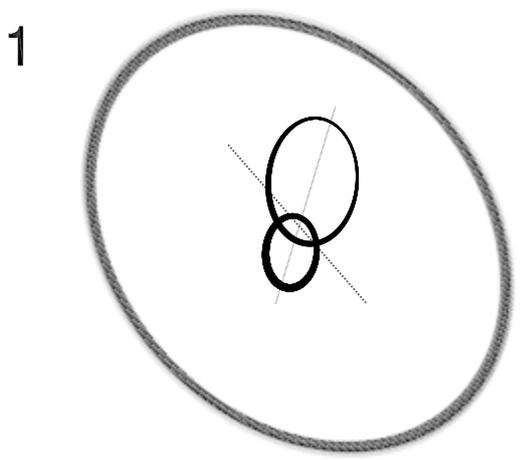


Binary-disk alignment



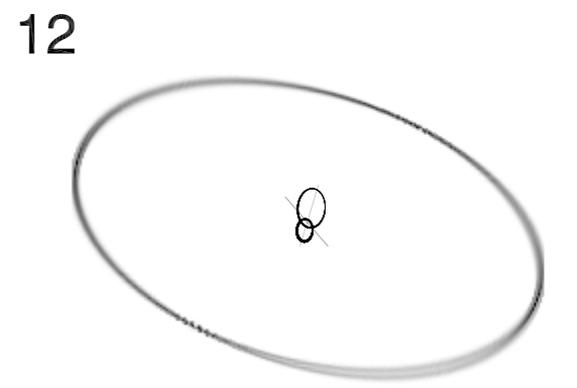
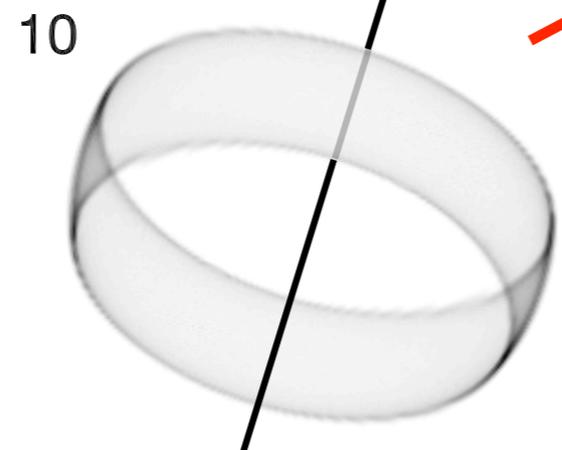
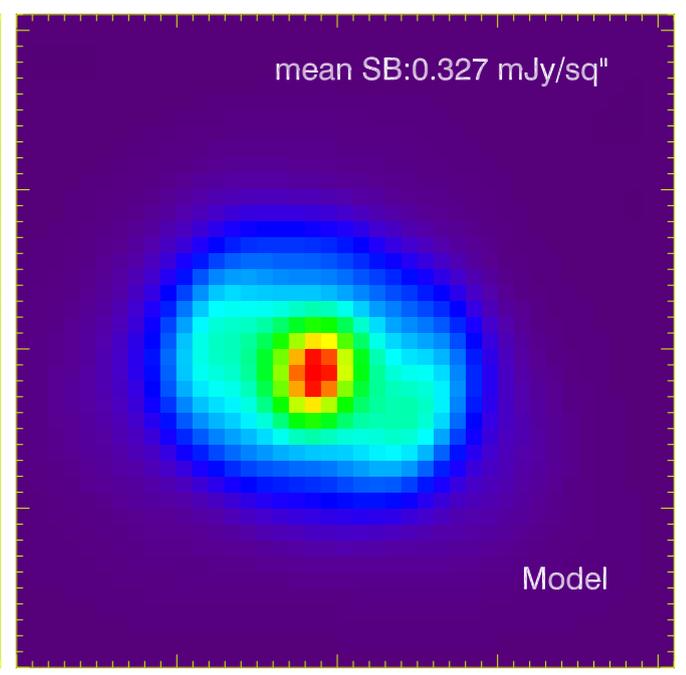
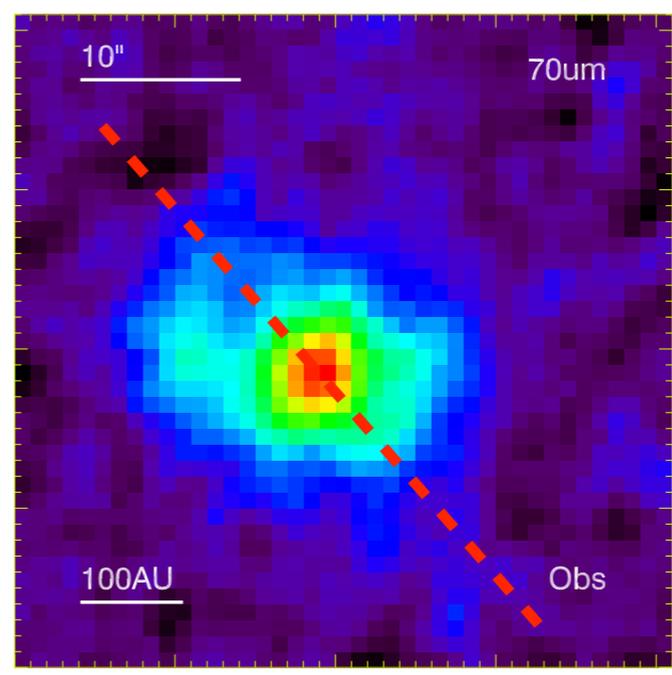
close binaries: P = weeks/months
circumbinary planets - alignment expected?

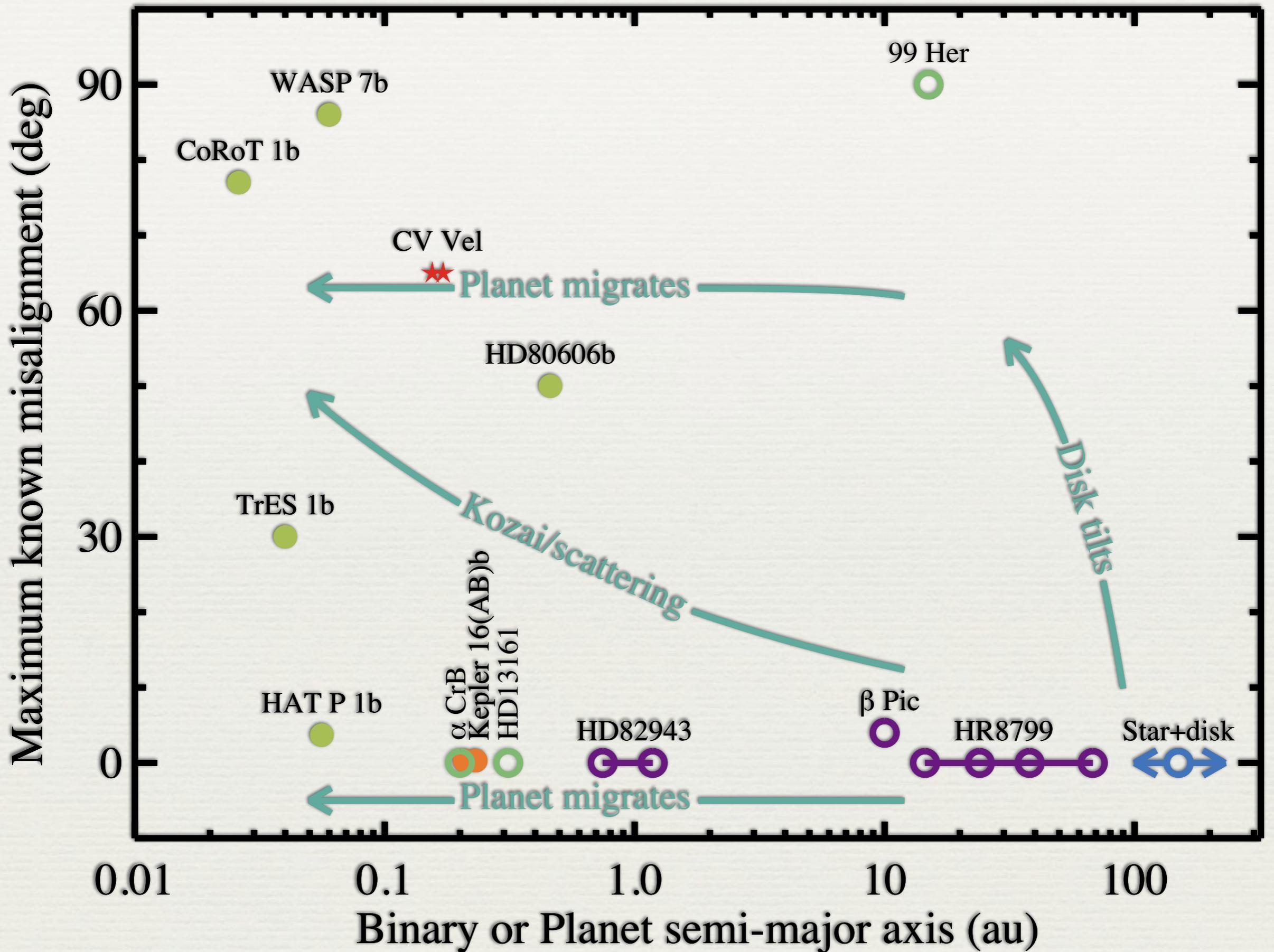




99 Her, 15au:
2 parameter
model

how? stellar
interaction?







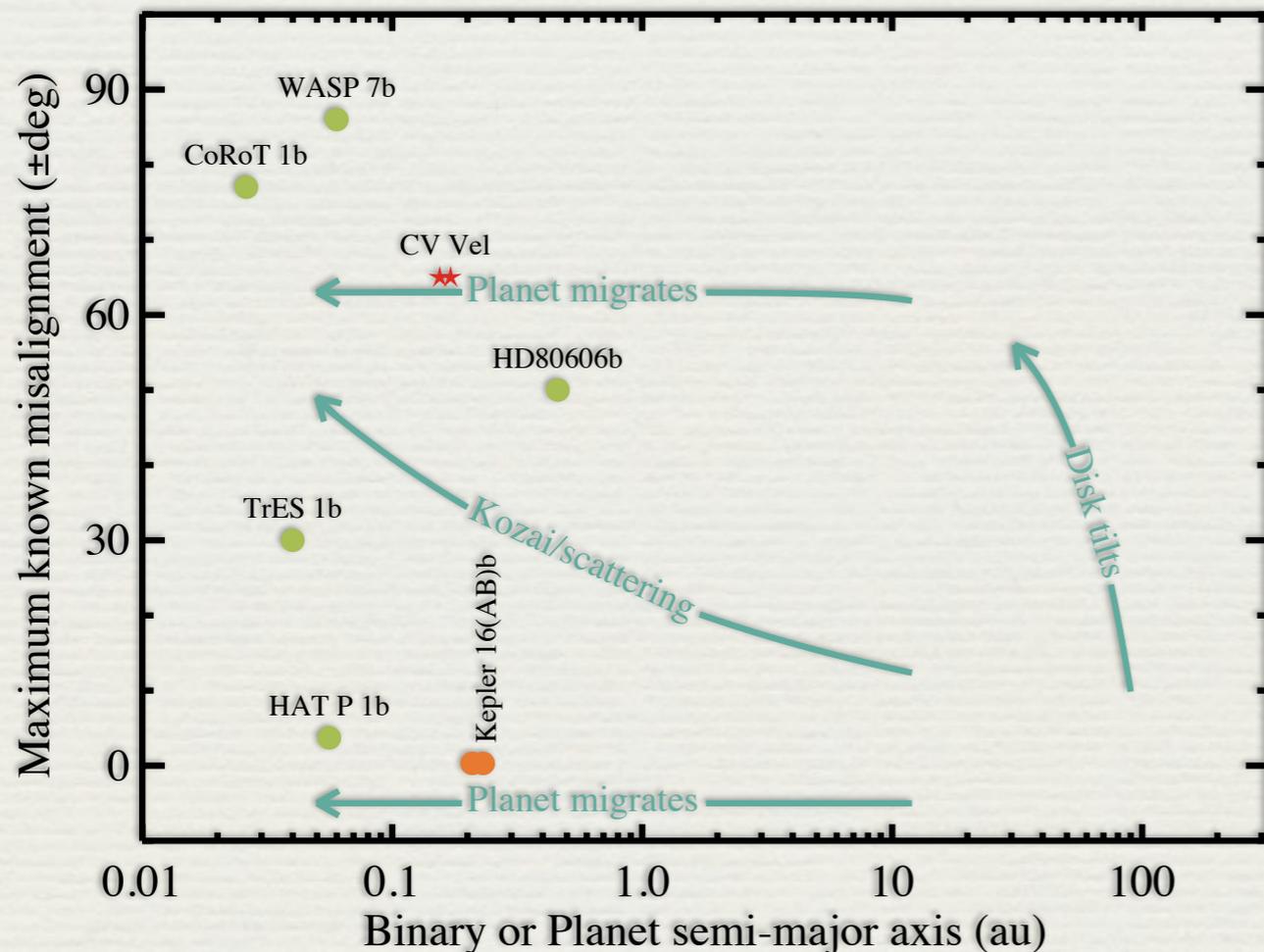
Outlook



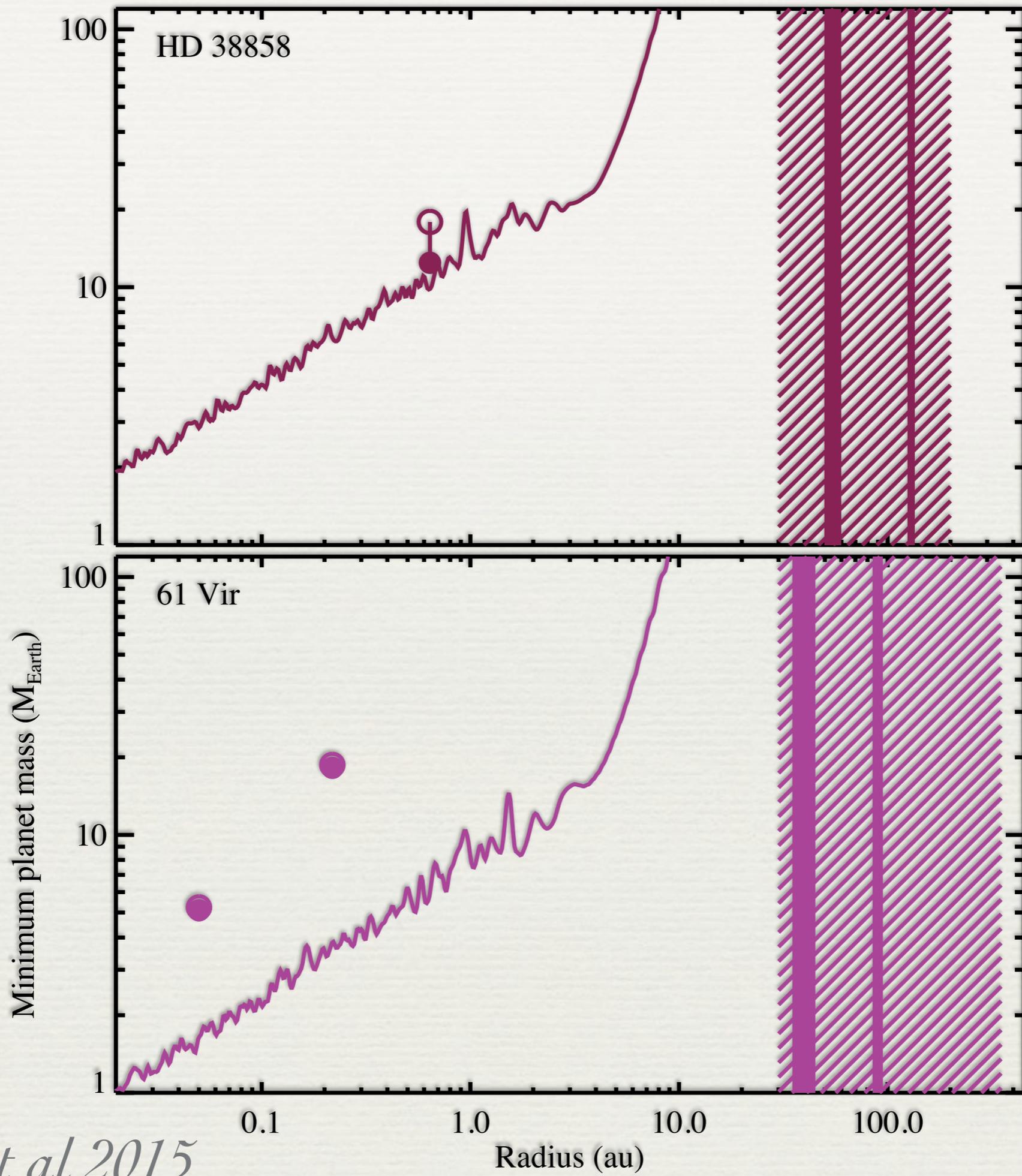
- ◆ Generally infer peaceful history, 99 Her the exception
- ◆ Alignment the norm so far - but so was early RM work
 - ◆ Need more star inclinations - beyond $v \sin i$, P , R_{star}
 - ◆ Disk tilting inferences have caveats - models
- ◆ Circumbinary planets - form in aligned disks?
- ◆ Planet+disk systems rare - no transit+disk systems yet
 - ◆ Need disk/planet characterisation, planet discovery
 - ◆ Best prospect: GAIA astrometry

Debris disks trace the plane of primordial disk

How do their geometries and structures help?

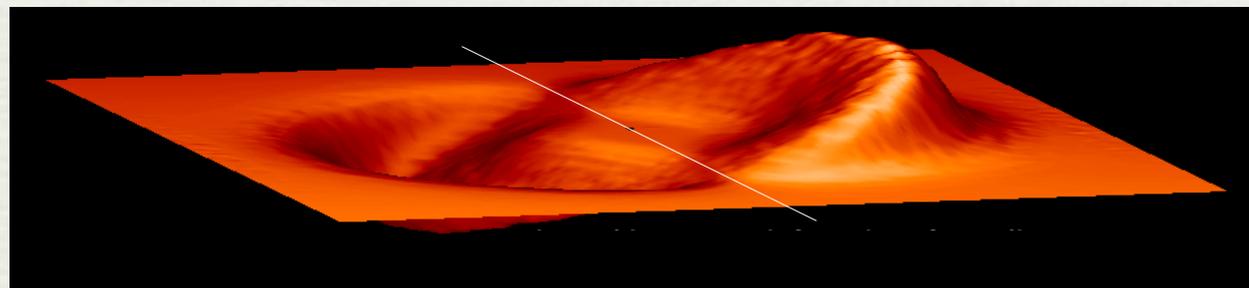
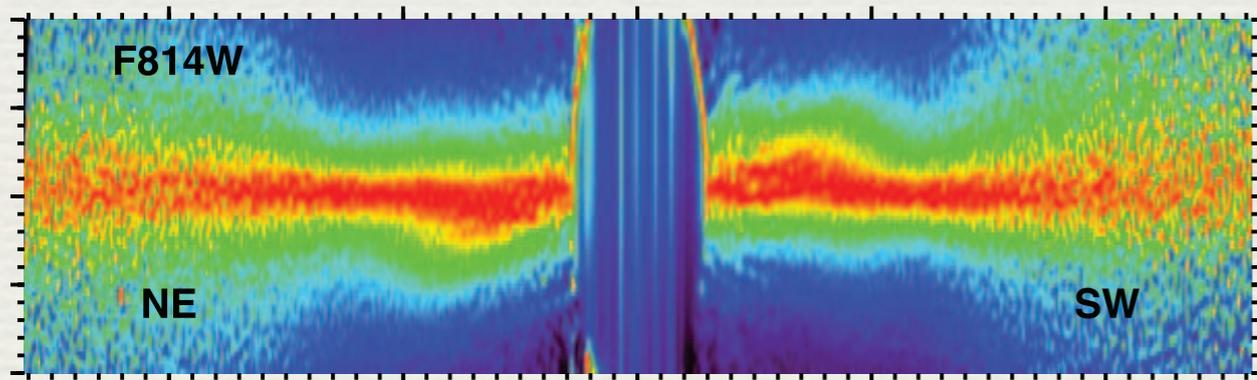
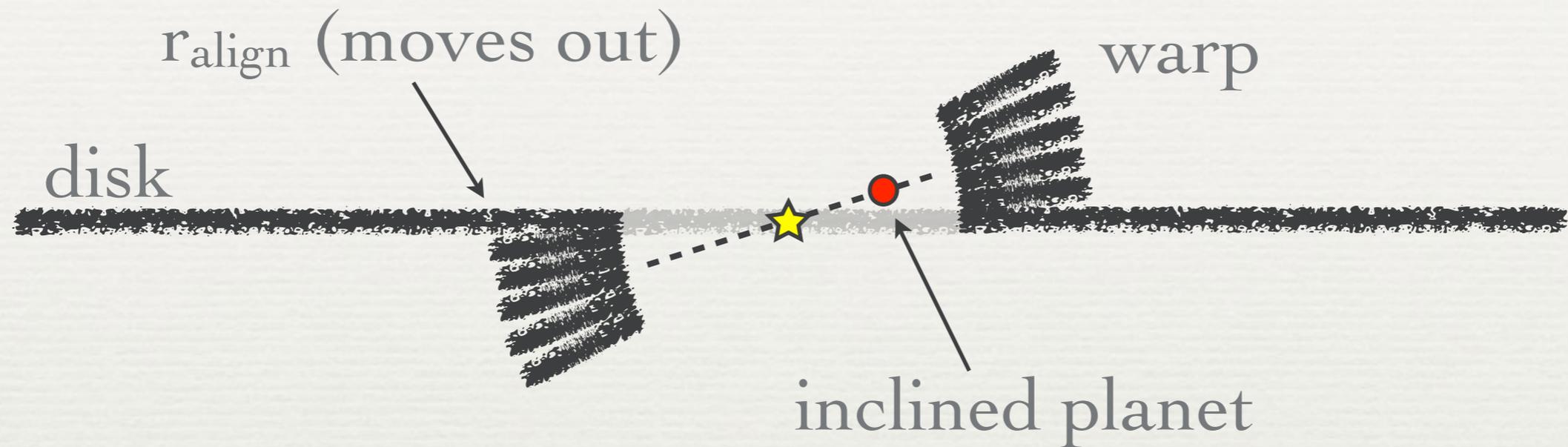


- ◆ Really start there?
- ◆ Circumbinary case?
- ◆ What can we test?
- ◆ What will we test?

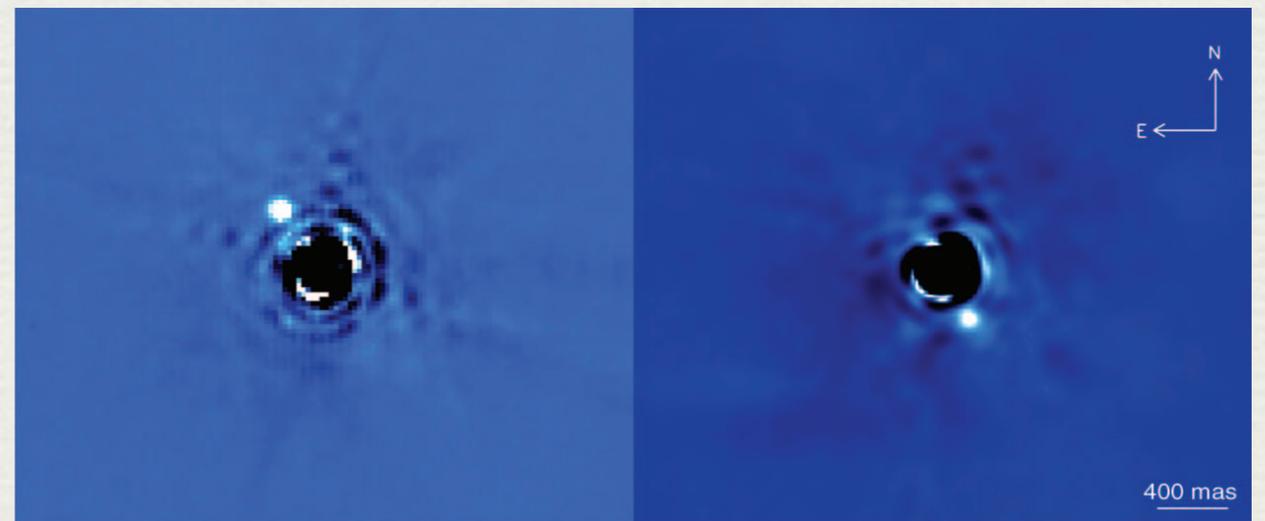


Debris disks feel planets

particles inclined w.r.t. planet



Augereau et al 2001



Lagrange et al 2010

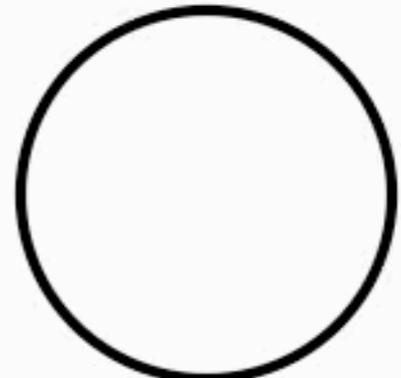
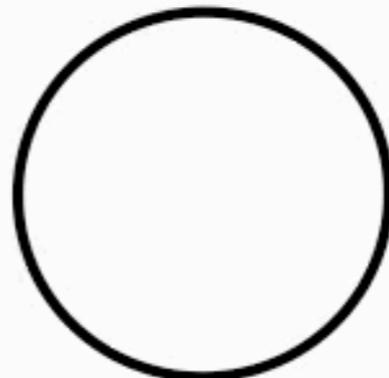
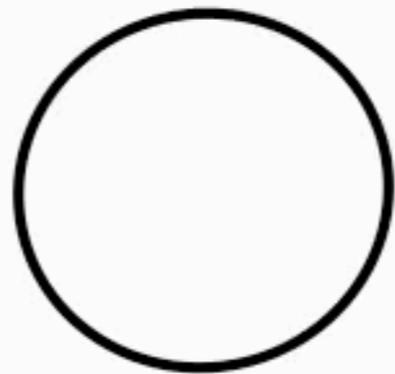
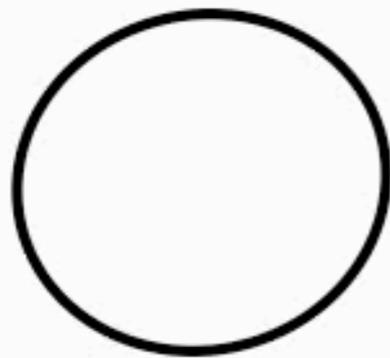
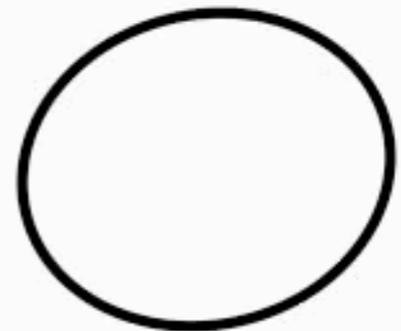
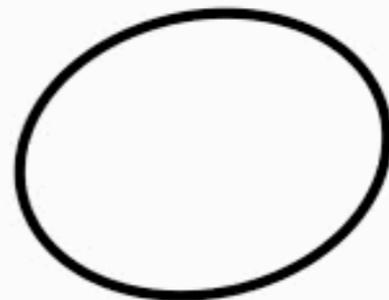
Circumbinary dynamics

coplanar



×
pericenter

$e=0.77$



polar

