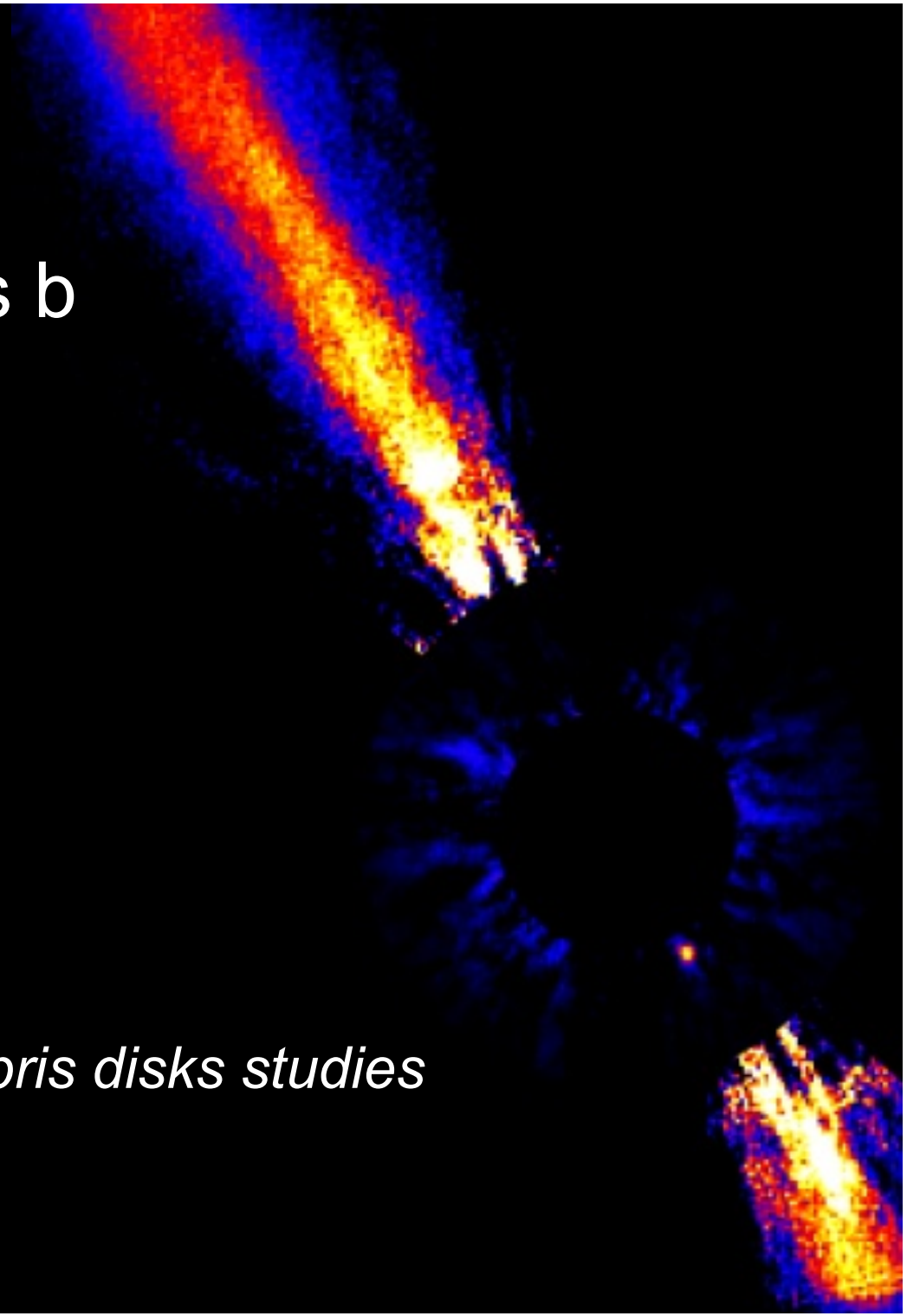
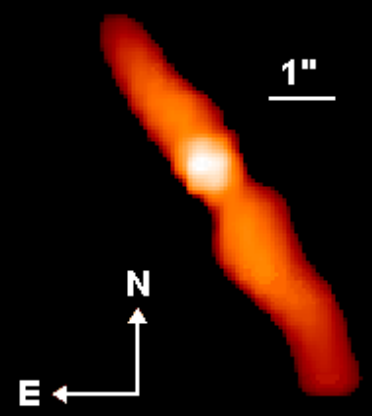
Discovery of β Pictoris b

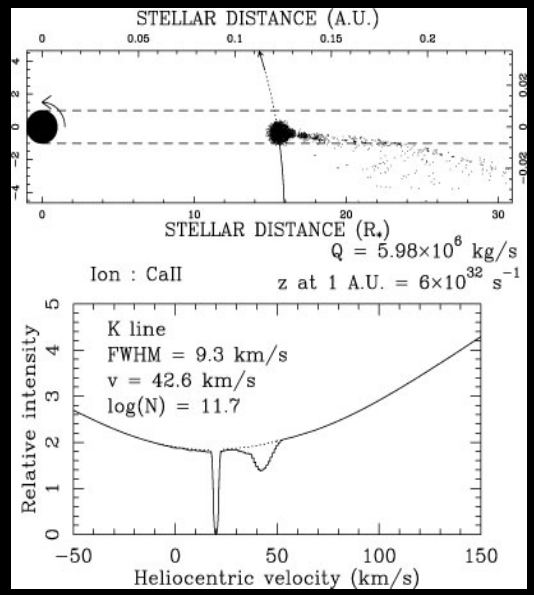
Anne-Marie Lagrange et al

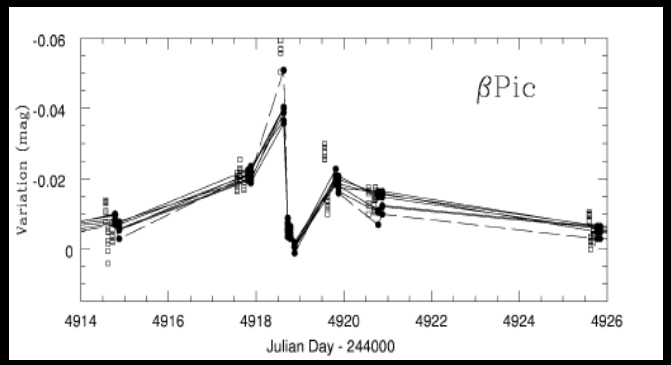


30 years of β Pictoris and debris disks studies
Paris, 9 Sept. 2014

Early indications of planets around β Pic







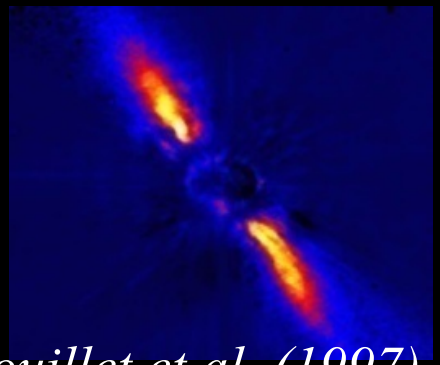
Inner void

Comets

Eclipse 1981

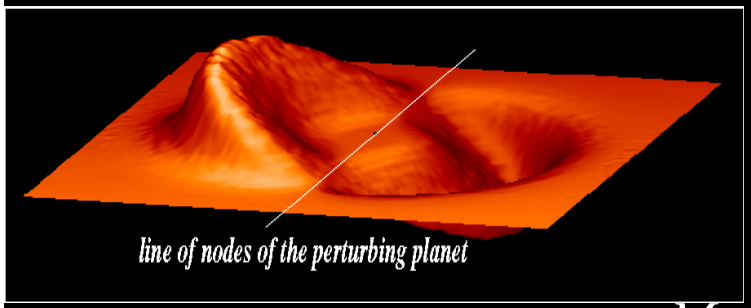
Vidal-Madjar, Lecavelier, Beust, Lagrange, Roberge, Pantin, Lagage, Mouillet, Augereau, Papaloizou, Nelson, Wyatt, ...

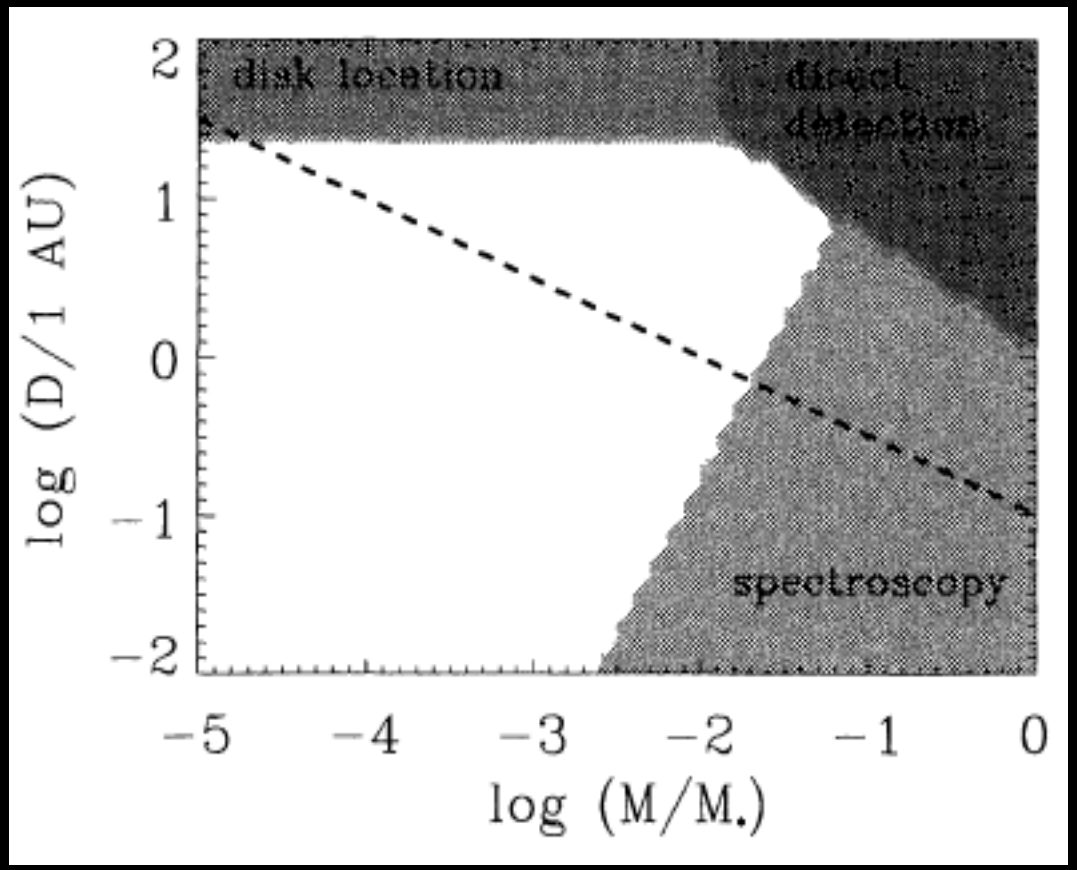
Early indications of planets around β Pic



Mouillet et al. (1997)

Heap et al (2000)

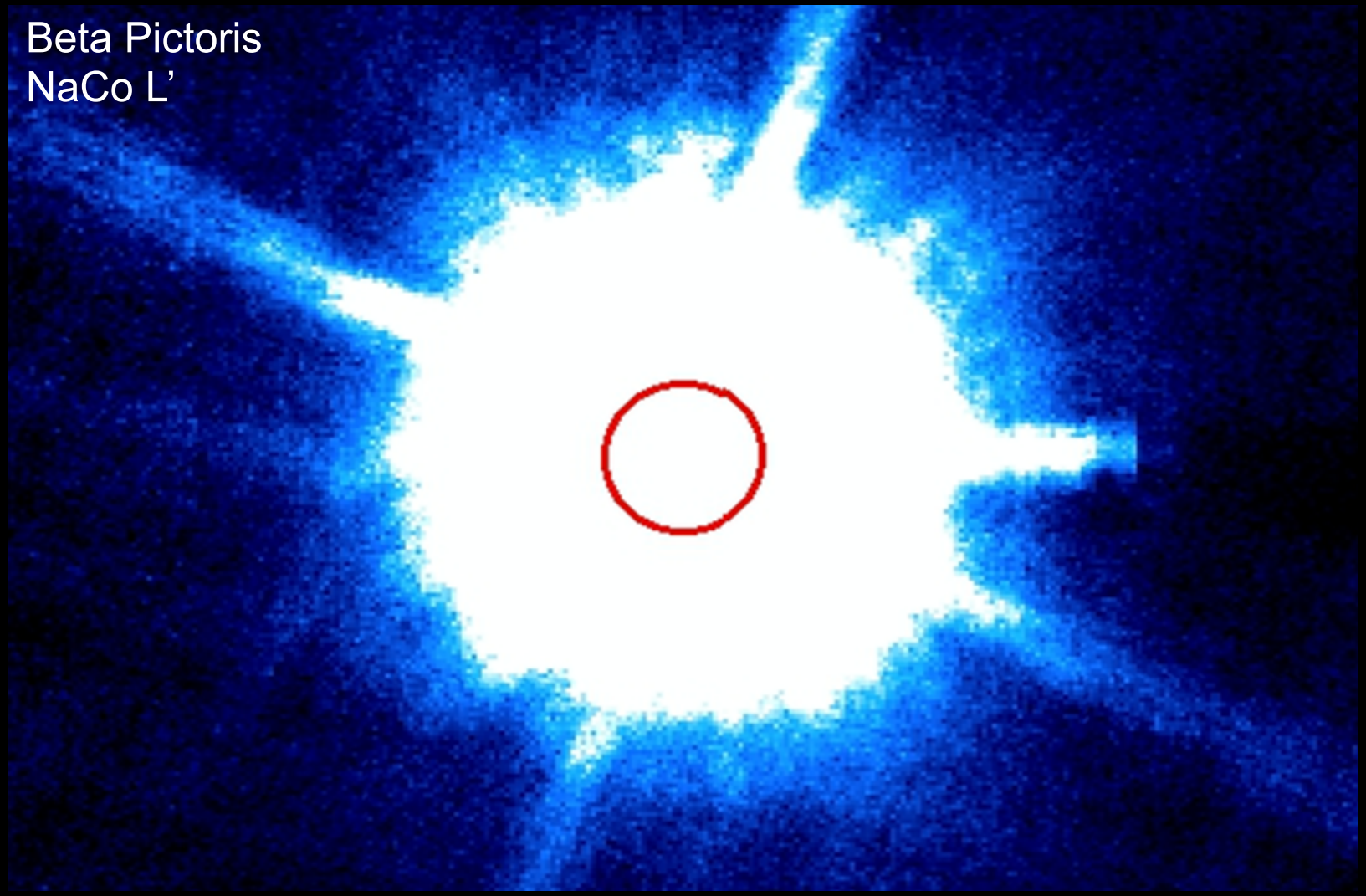




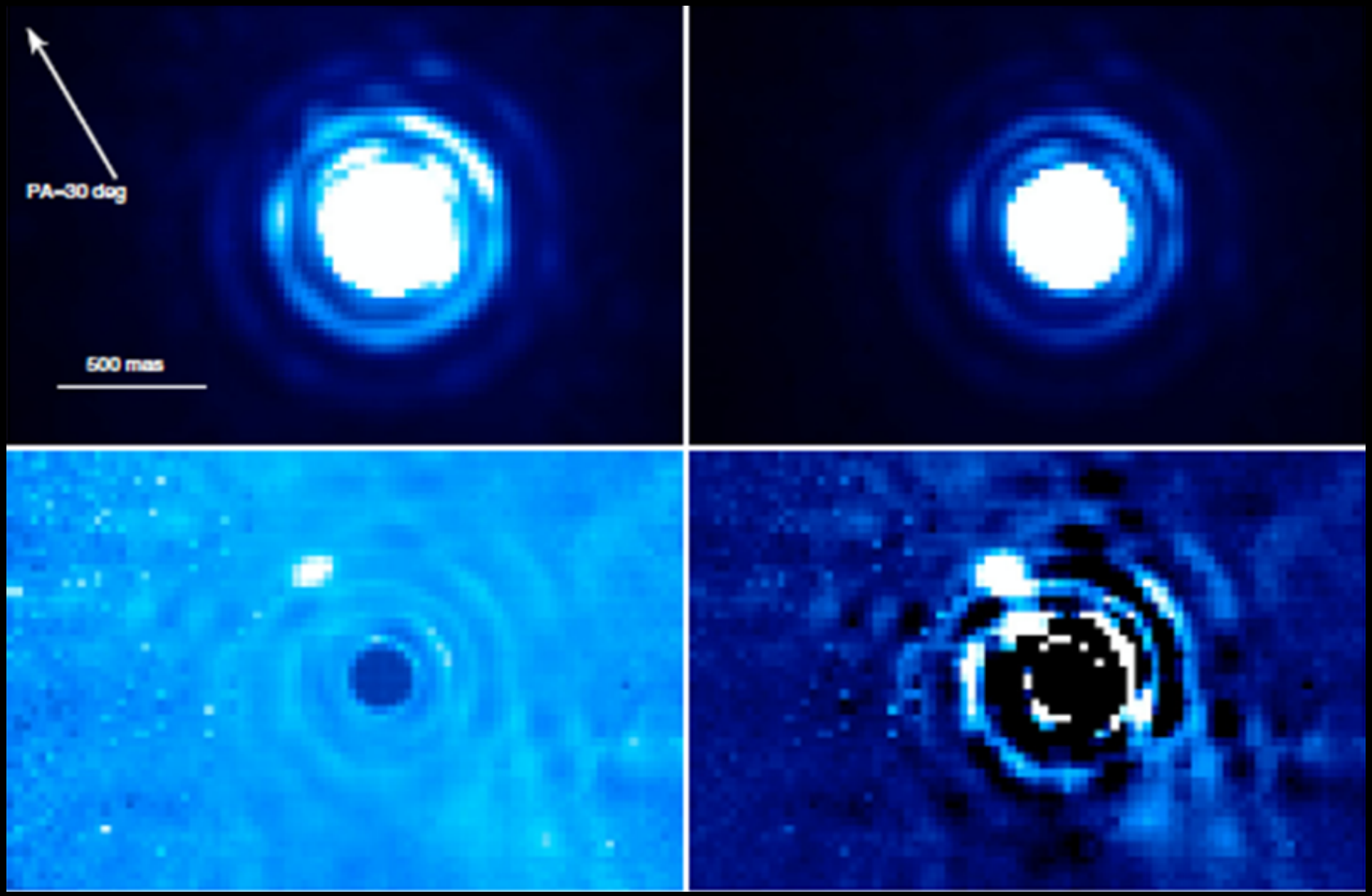
$$\log\left(\frac{R_w}{10\mathrm{AU}}\right) = 0.29\,\log\left(\frac{M}{M_*}\left(\frac{D}{10\ \mathrm{AU}}\right)^2 \frac{t}{t_{\mathrm{unit}}}\right) - 0.2.$$

Mouillet et al. (1997)

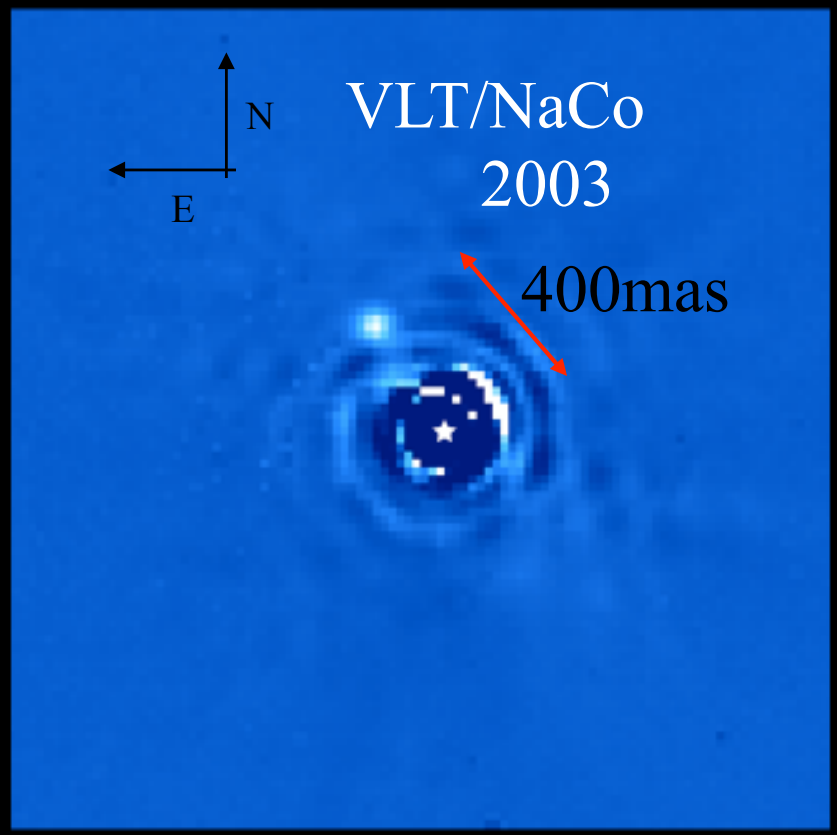
Augereau et al (2000)

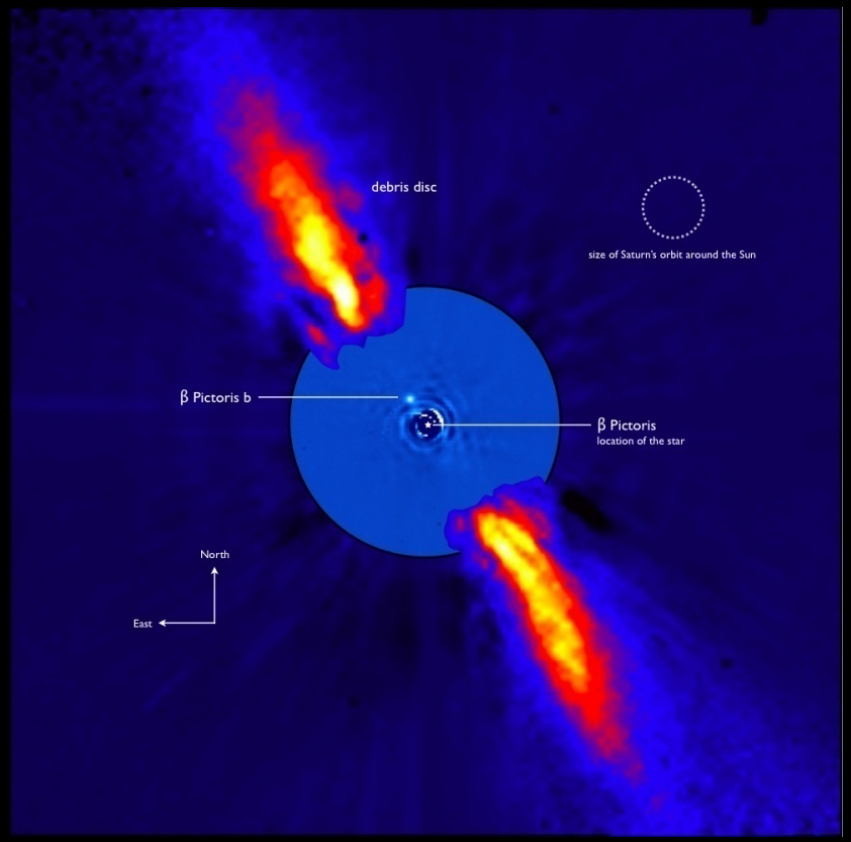


- Luck with observing conditions
- Progress in the understanding of AO data
- Time available


PA~30 deg
500 mas

Planet candidate around β Pictoris





Planet candidate

. ΔL' = 7.7 ± 0.3 => M~9MJup if bound ("hot start")

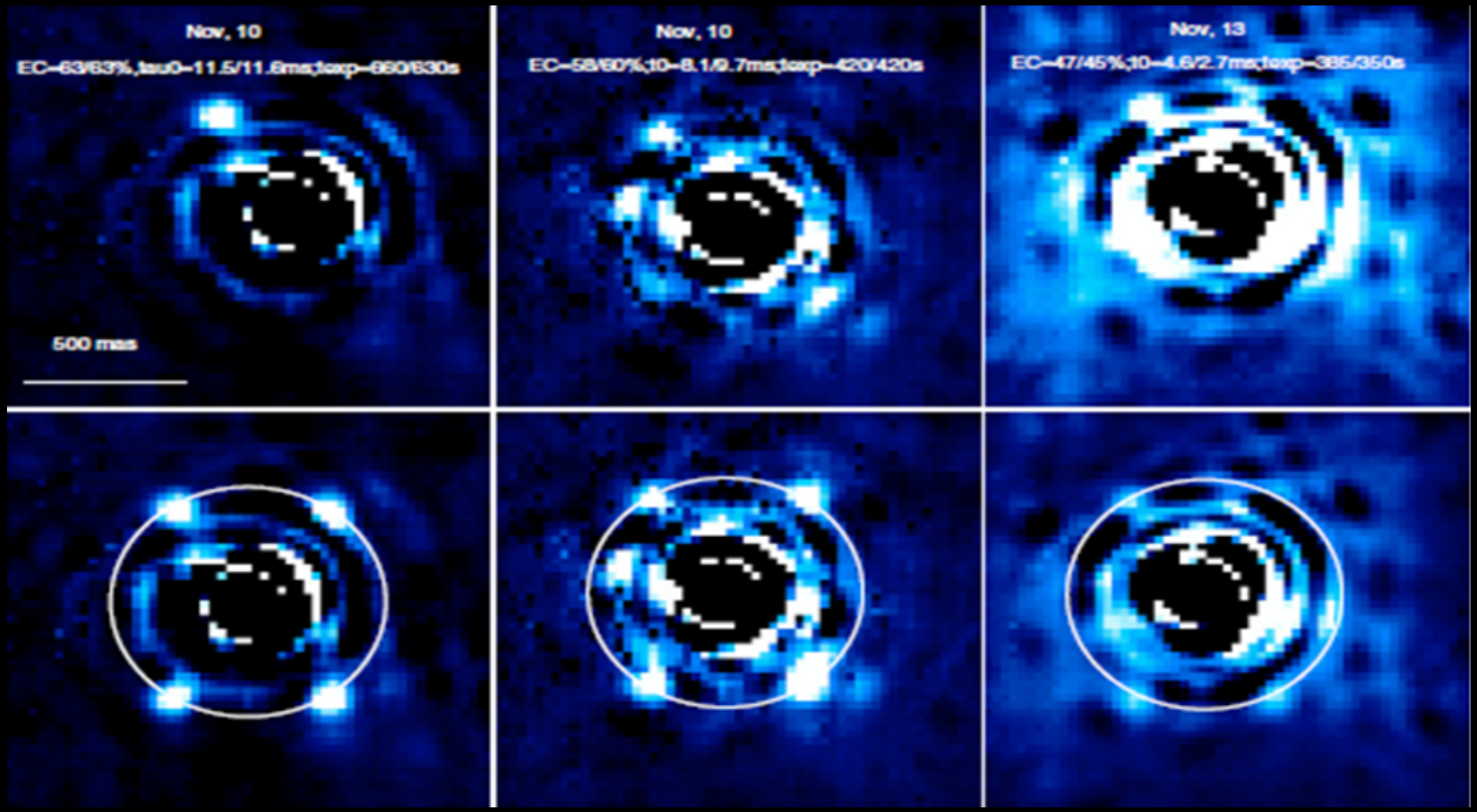
. Sep = 411 ± 8 mas (~8 AU) proj. P.A. = 31.8 ± 1.3° (disk P.A. ~ 31-35°)

• Teff ~1500K

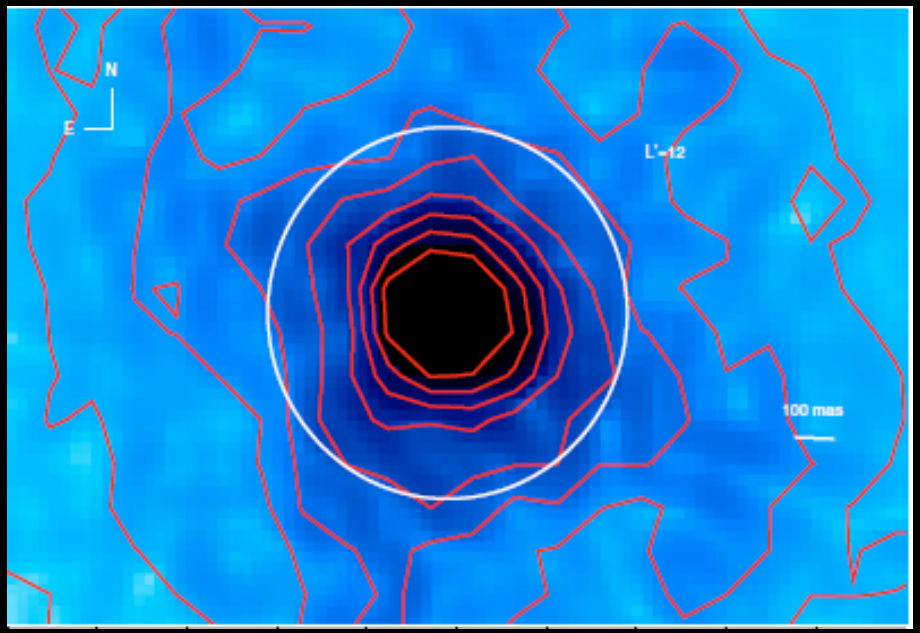
(Age ~12 Myr)

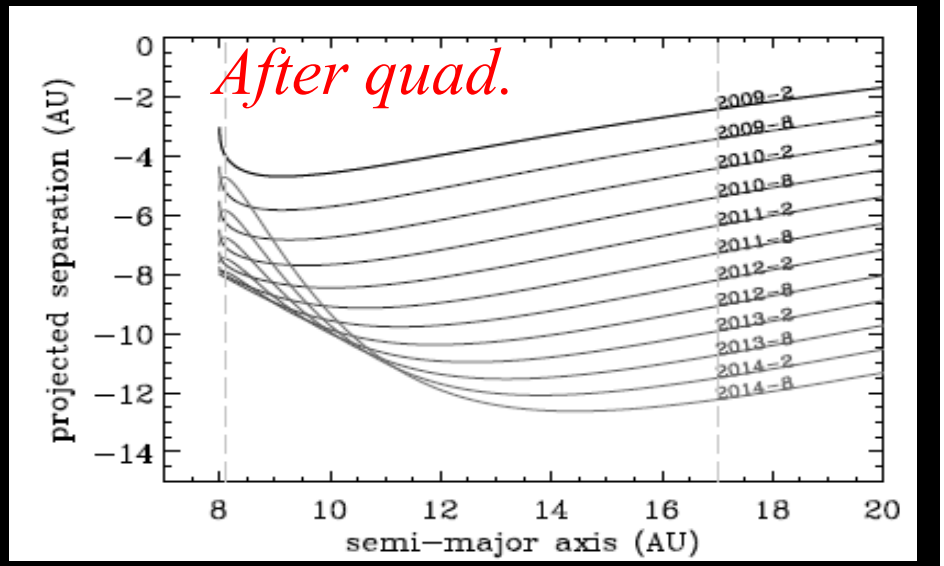
Lagrange et al (2009a)

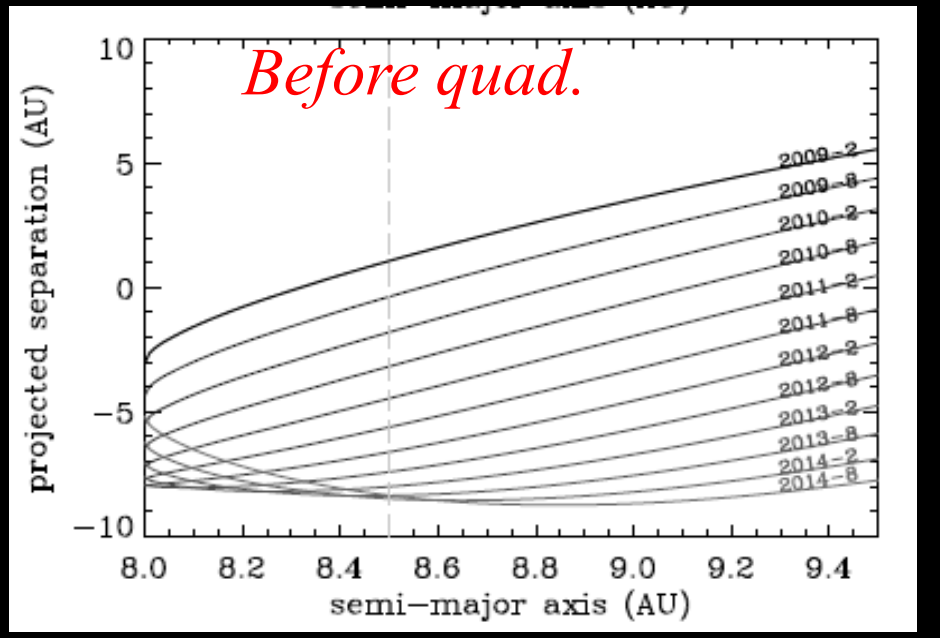
Very good atmospheric conditions mandatory...



February 2009





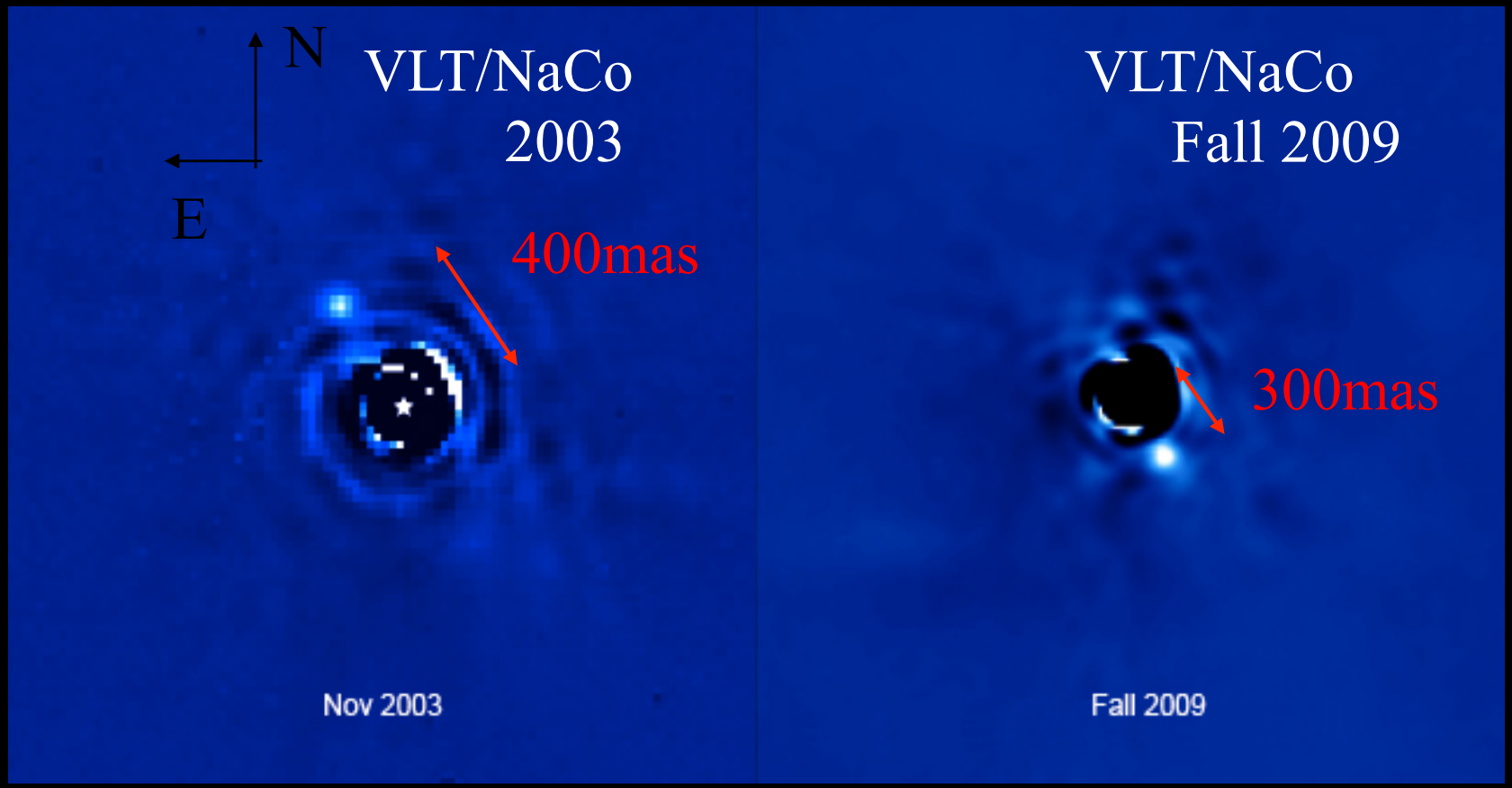


6σ limit

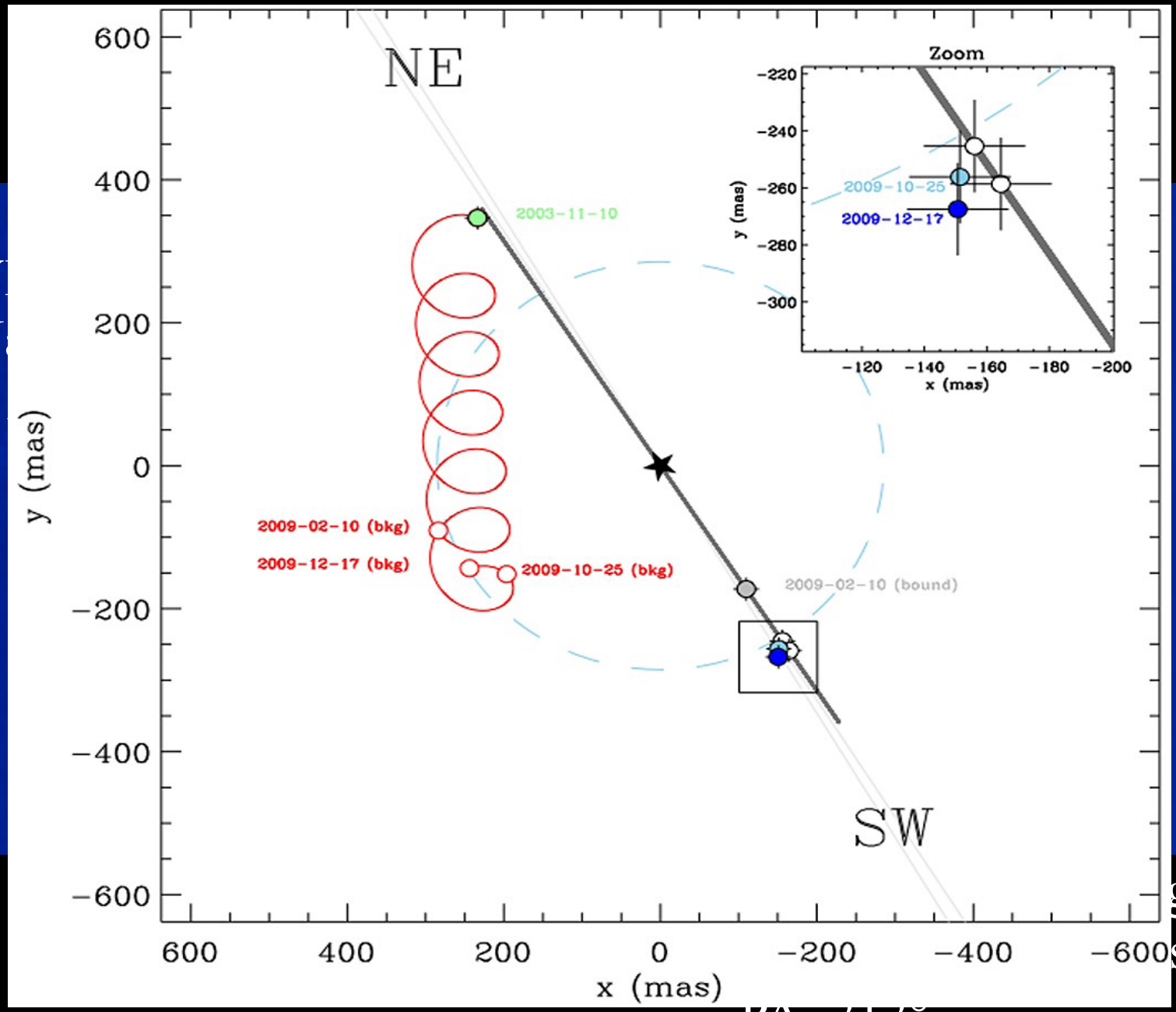
(L_abs=9.8)

Lagrange et al (2009b); see also Fitzgerald and Kalas (2009)

Planet around β Pictoris

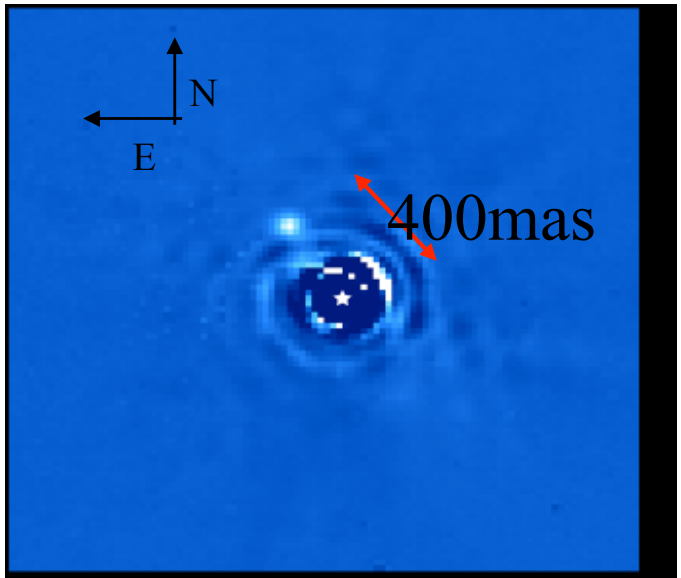


ΔL' = 7.8 +/- 0.2 mag
Sep = 298 +/- 16 mas
PA~212°
Lagrange et al (2010)

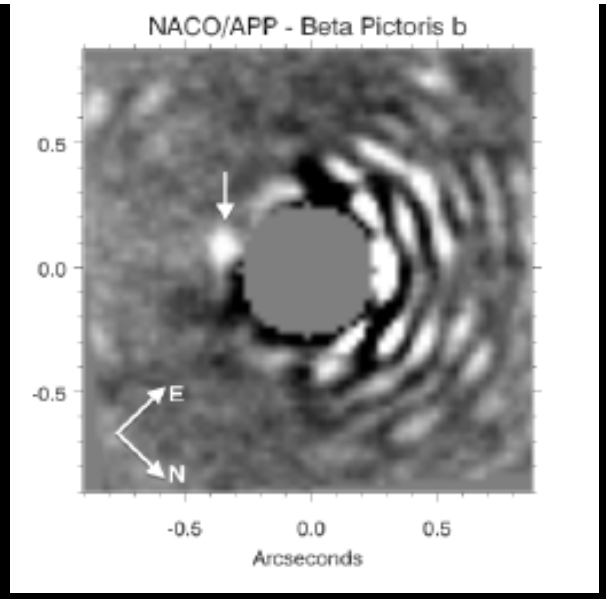


PA~212°

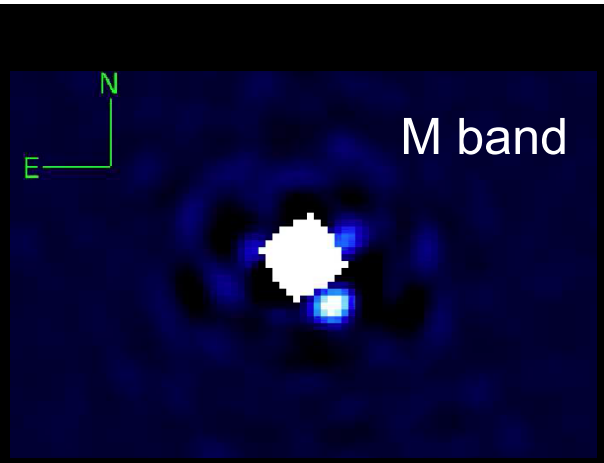
Lagrange et al (2010)



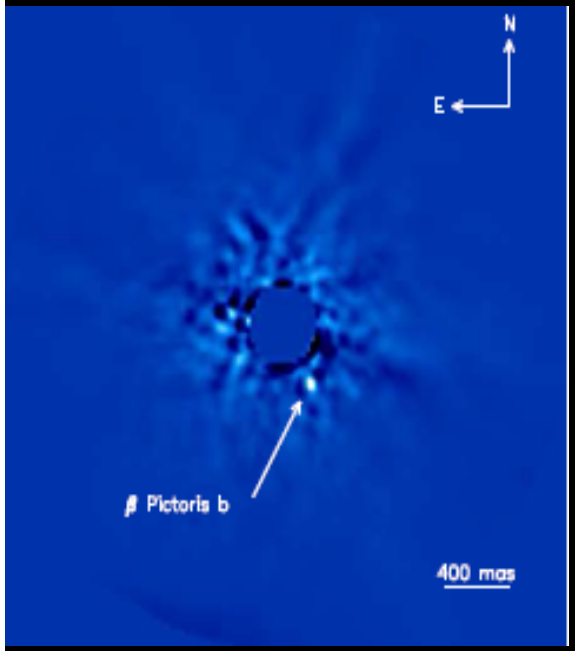
L'

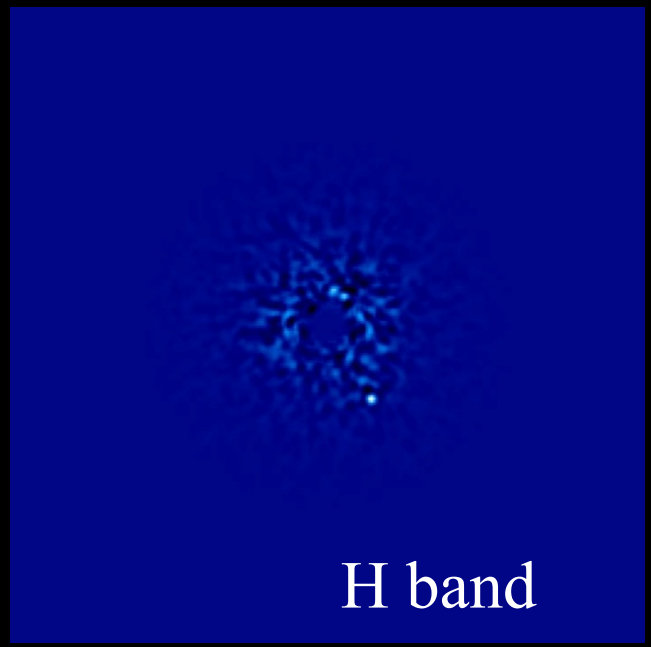


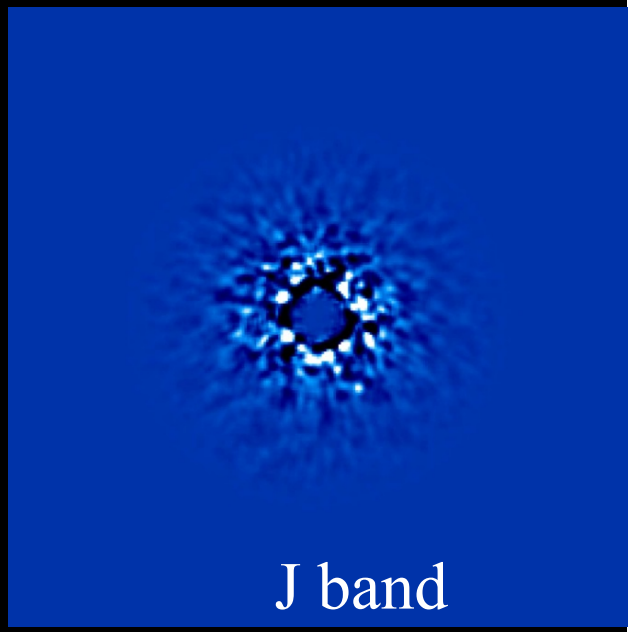
NB4.05 μ *Quanz et al (2010)*



Currie et al (2011)
uncalibrated

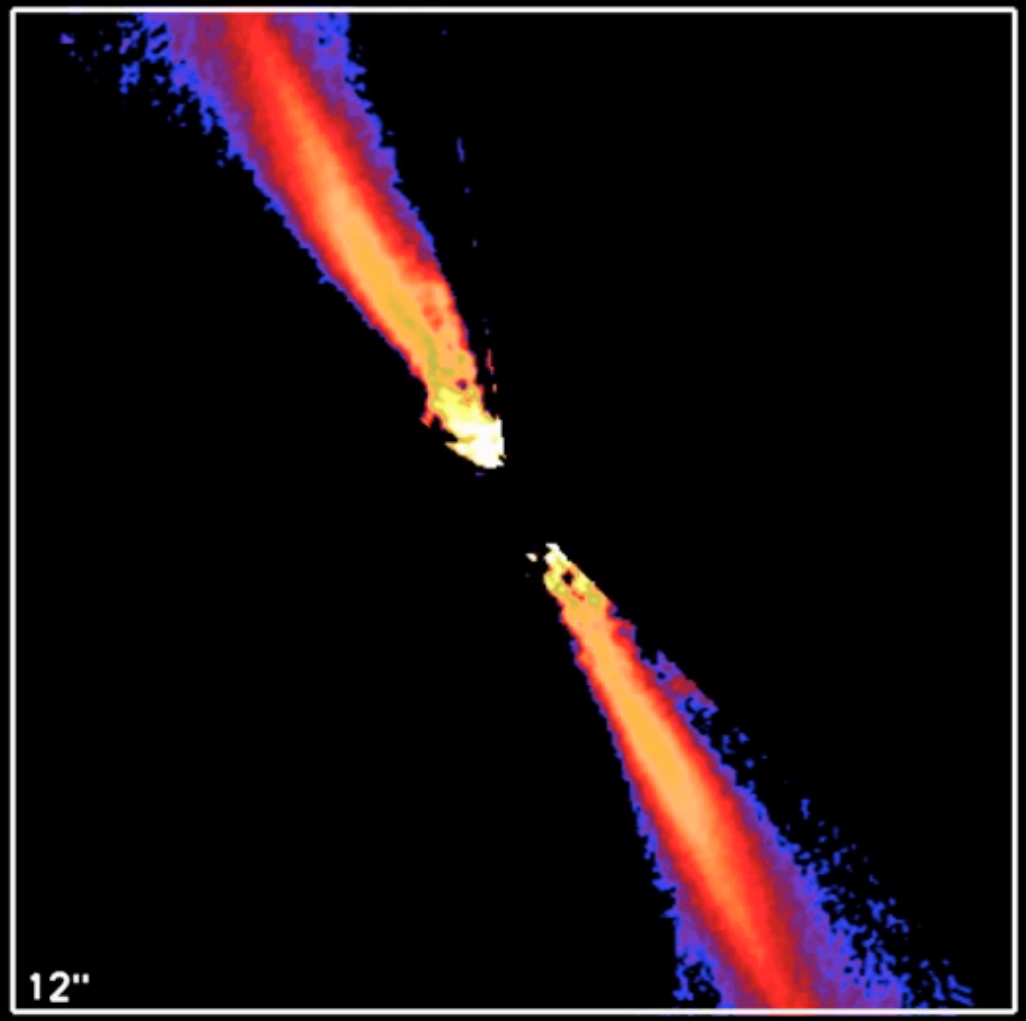






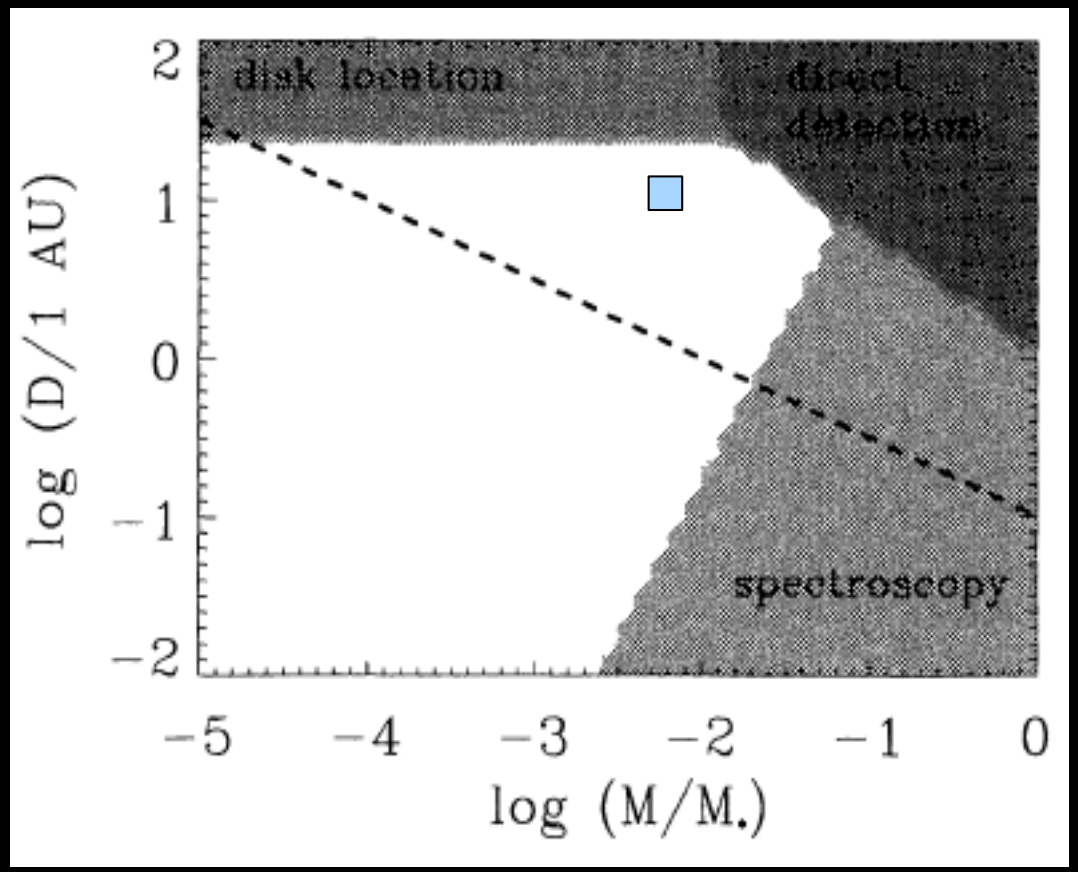
Bonnefoy et al (2011)

(see Bonnefoy's talk)



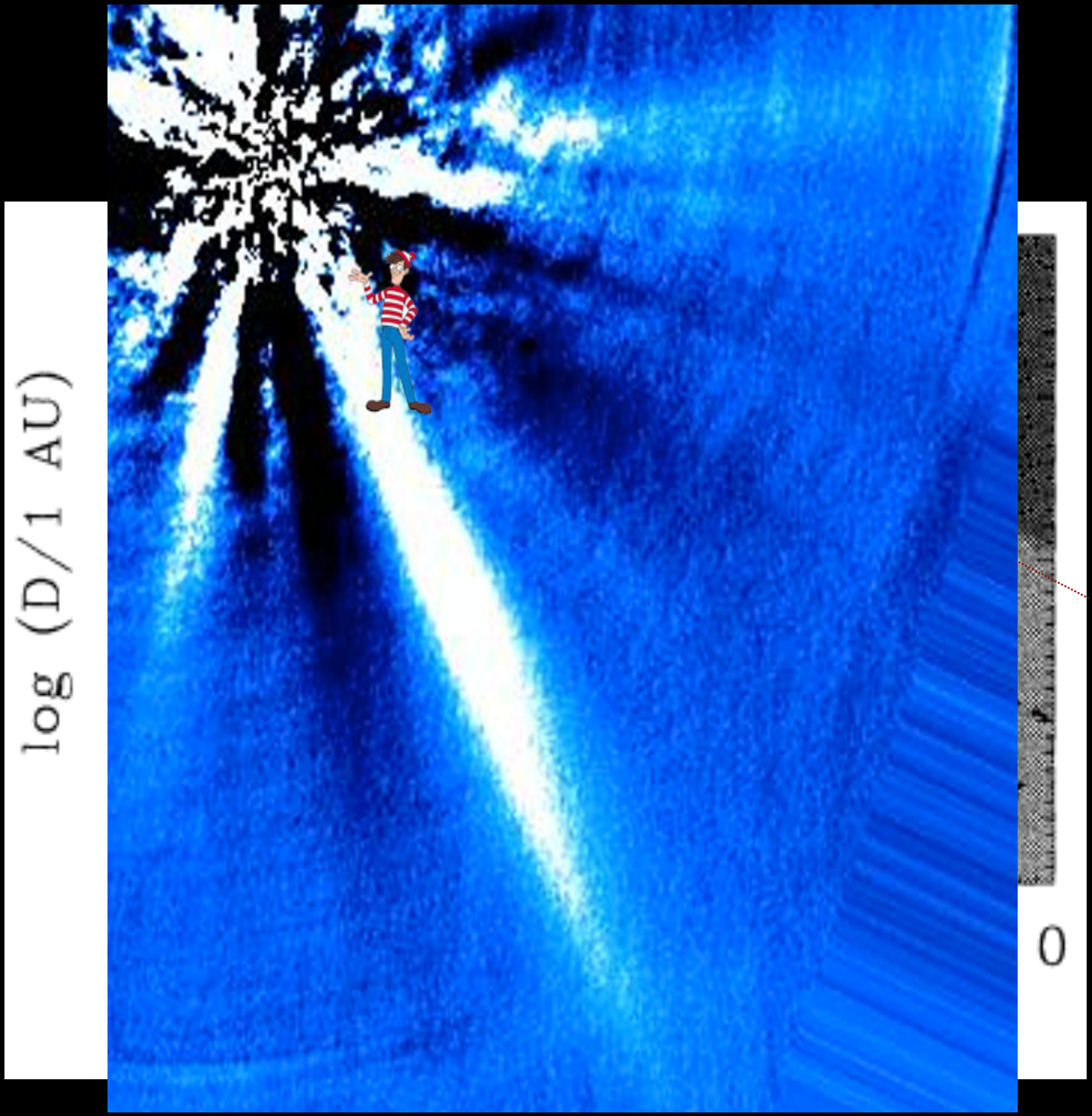
(Lagrange & Boccaletti)

Constraints from the warp modeling

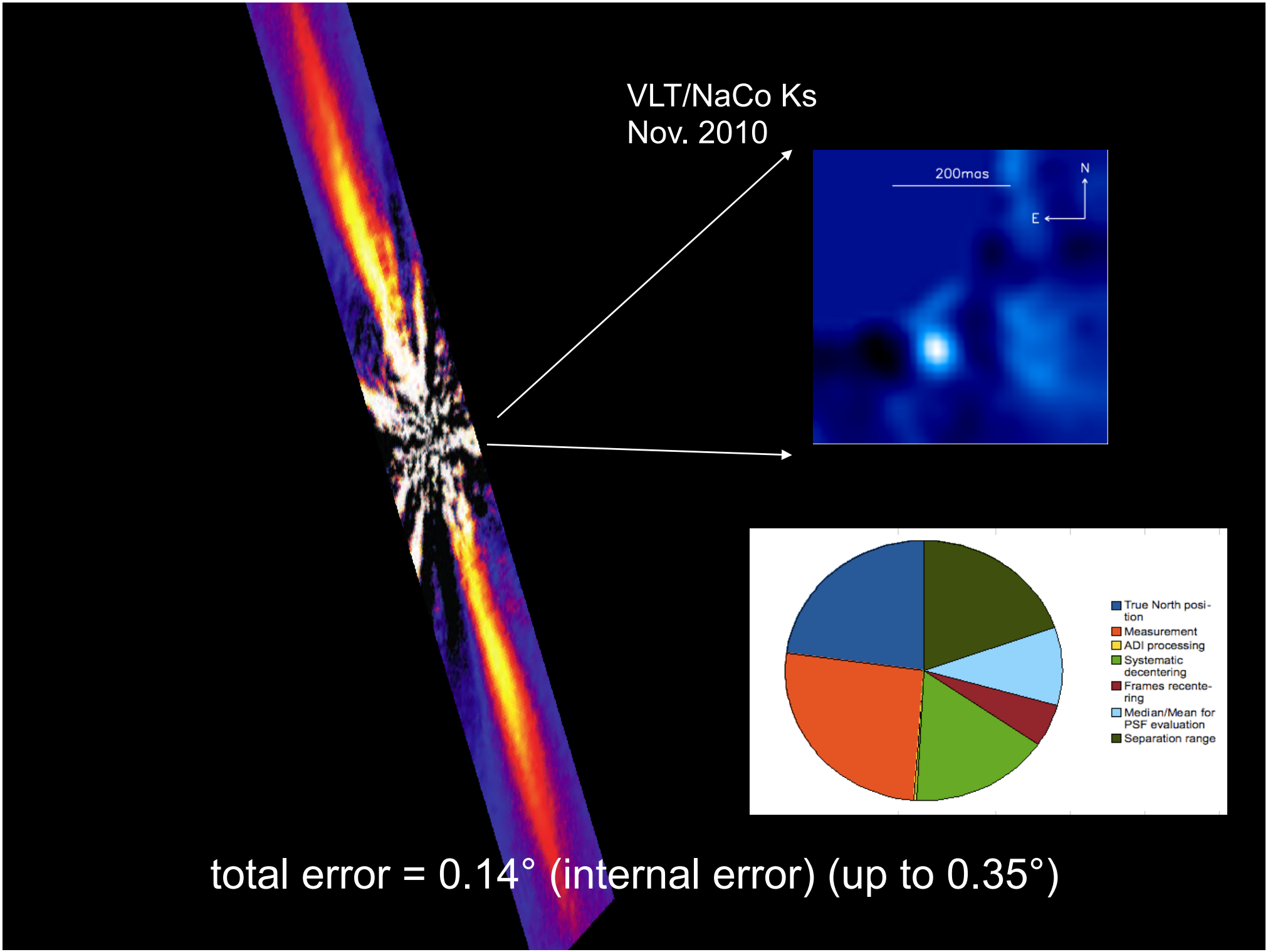


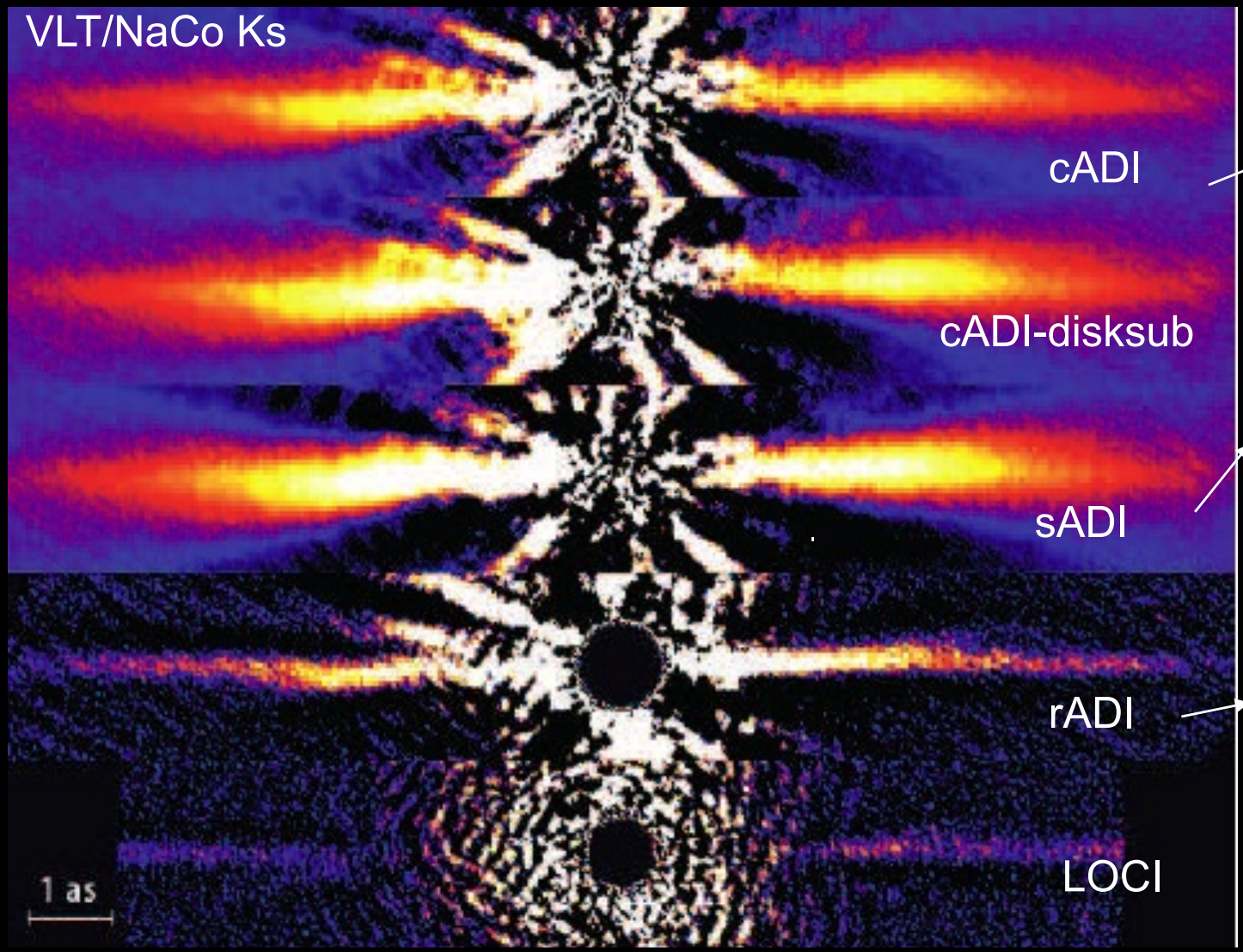
$$\log\left(\frac{R_{\rm w}}{10{\rm AU}}\right) = 0.29\,\log\left(\frac{M}{M_*}\left(\frac{D}{10\ {\rm AU}}\right)^2\frac{t}{t_{\rm unit}}\right) - 0.2.$$

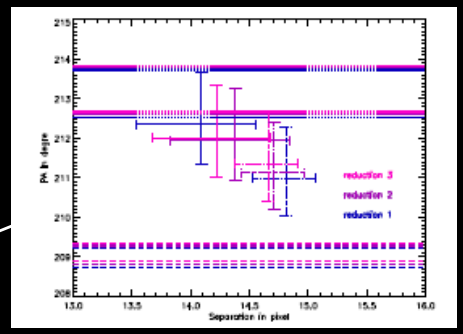
$$\sqrt{(10\ {\rm AU})^3/(GM_*)} \sim 5.2\,y$$

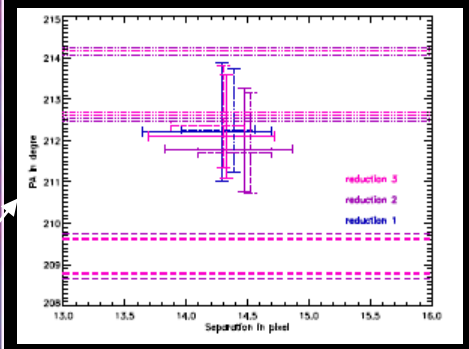


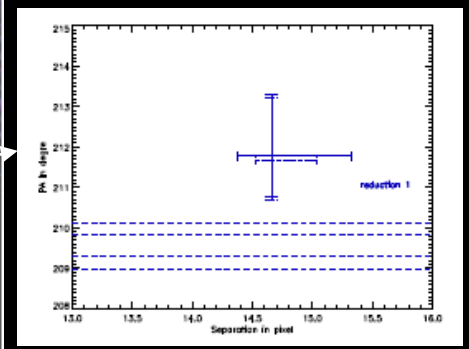
should be located in the warped *disk*


VLT/NaCo Ks
Nov. 2010
200mas
N
E
True North position
Measurement
ADI processing
Systematic decentering
Frames recentering
Median/Mean for PSF evaluation
Separation range
total error = 0.14° (internal error) (up to 0.35°)









β Pic b projected position is not in the main disk

β Pic b de-projected position is not in the main disk

(Lagrange et al, 2012a) *(see also Dawson's talk)*

Beta Pictoris b is probably creating the warp...

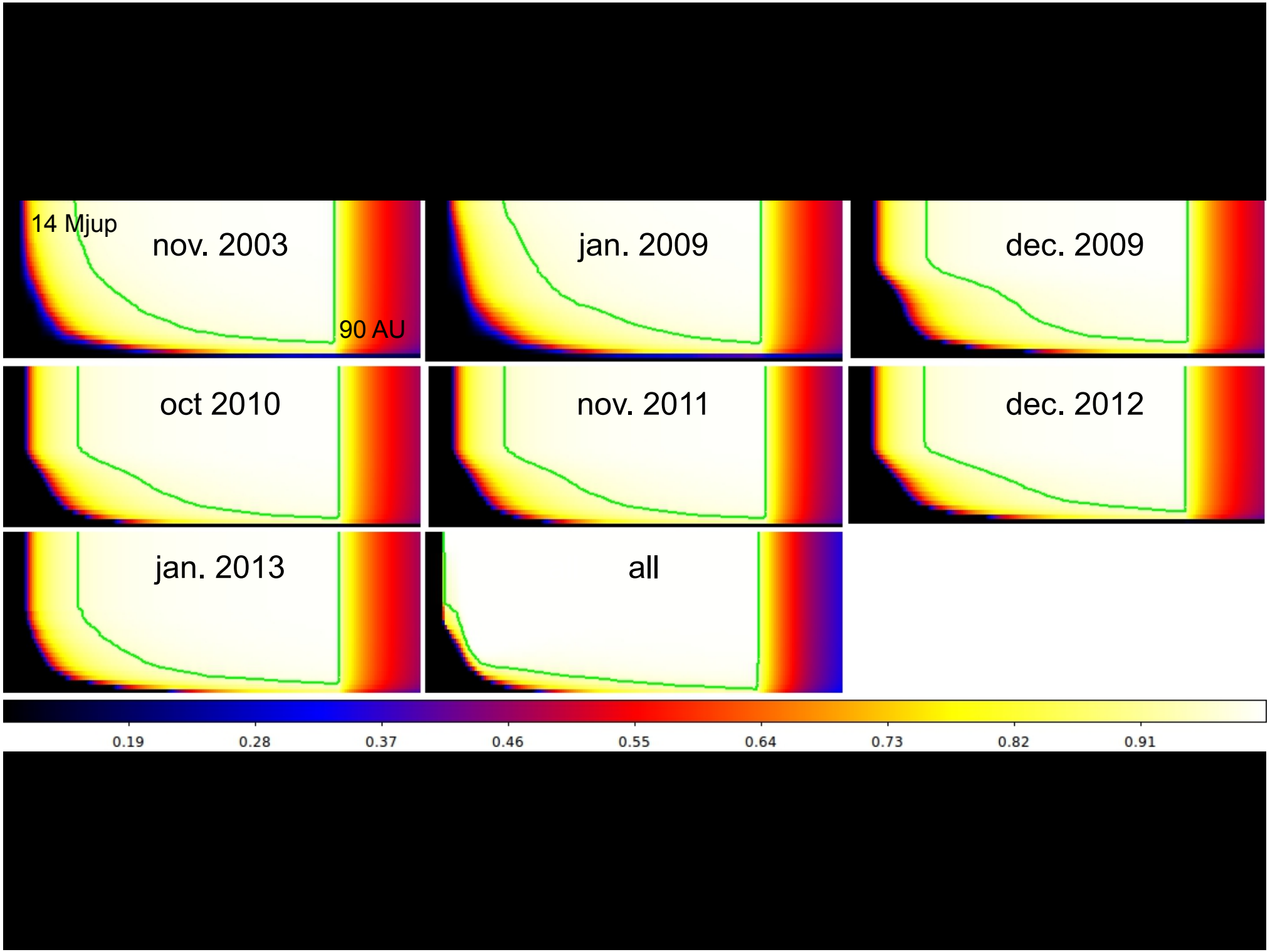
Why is beta Pictoris b on an inclined orbit?

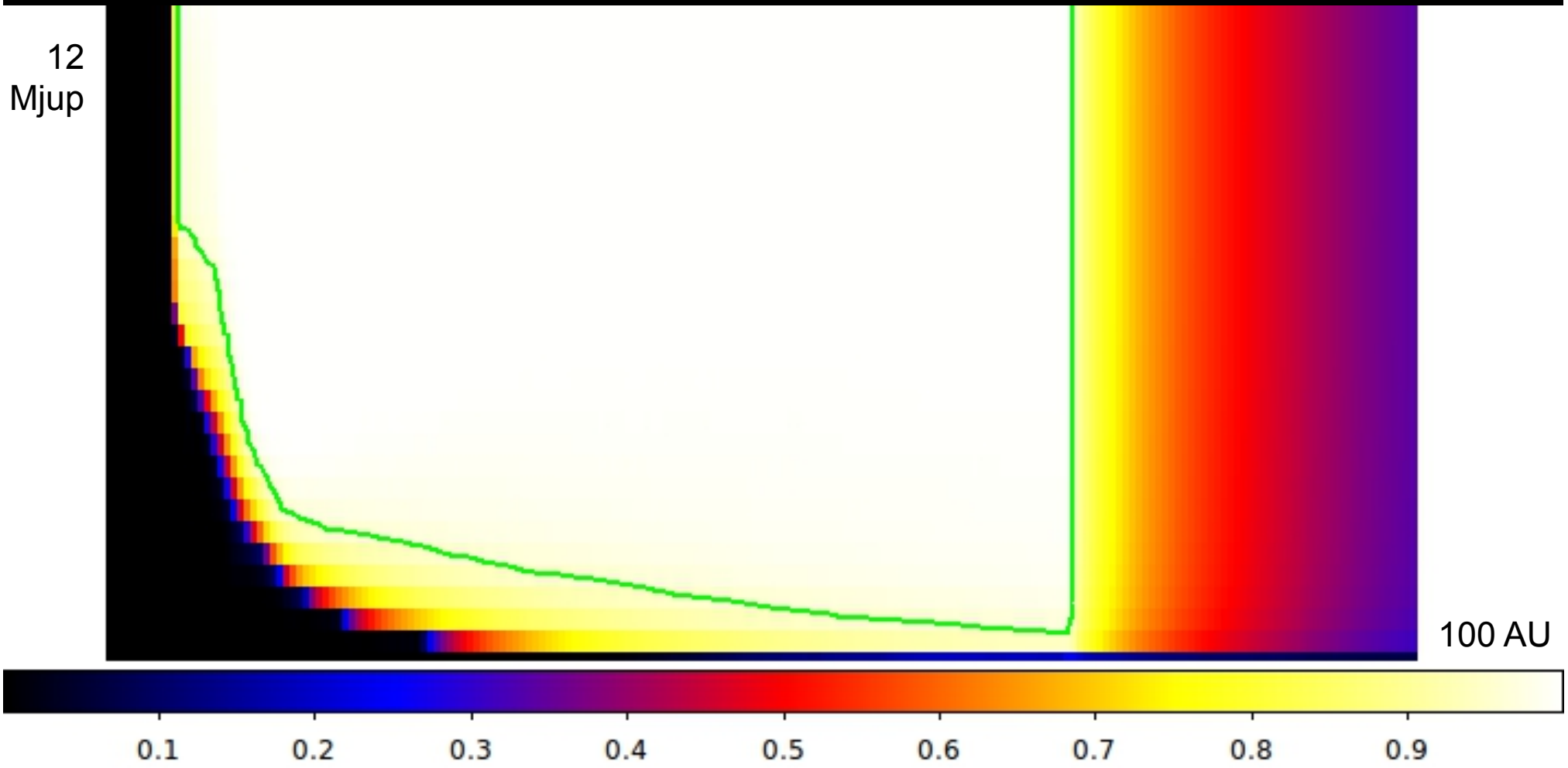
Are there additional planets ?

=> back to old imaging data (2003-2013)

J. Milli, J. Lannier, S. Borgniet

(see Borgniet's talk)


14 Mjup
nov. 2003
90 AU
jan. 2009
dec. 2009
oct 2010
nov. 2011
dec. 2012
jan. 2013
all
0.19
0.28
0.37
0.46
0.55
0.64
0.73
0.82
0.91



Room for sub-Jup planets on wide orbits
and for Jup-mass planets closer to the star