The Gemini NICI Planet-Finding Campaign: The Orbit of the Young Exoplanet beta Pictoris b

ApJ in press

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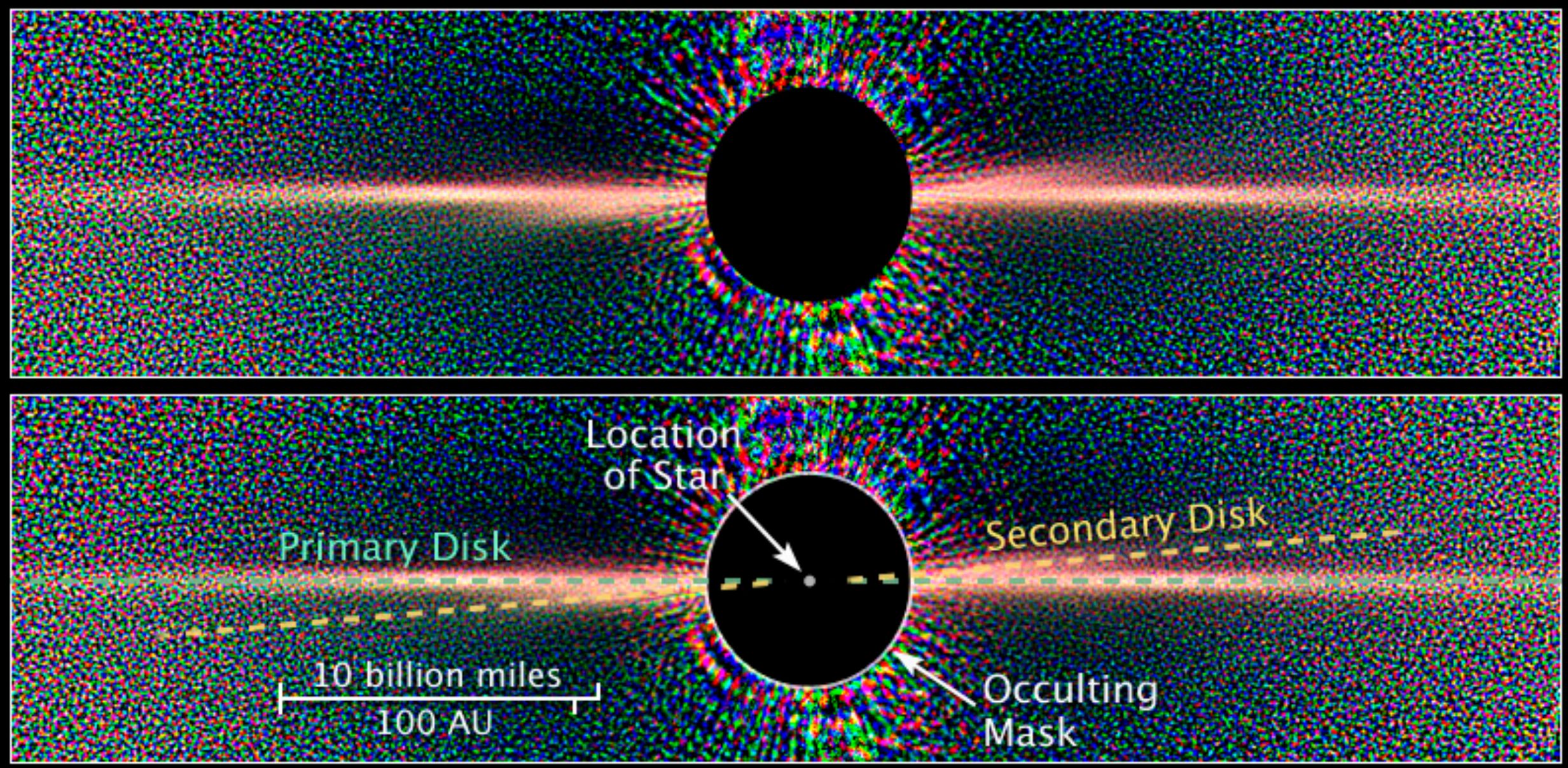
The Disks of beta Pic



Gemini NICI Planet-Finding Campaign

Four-year campaign at Gemini South 8.1m telescope for direct imaging of exoplanets, PI Michael Liu.

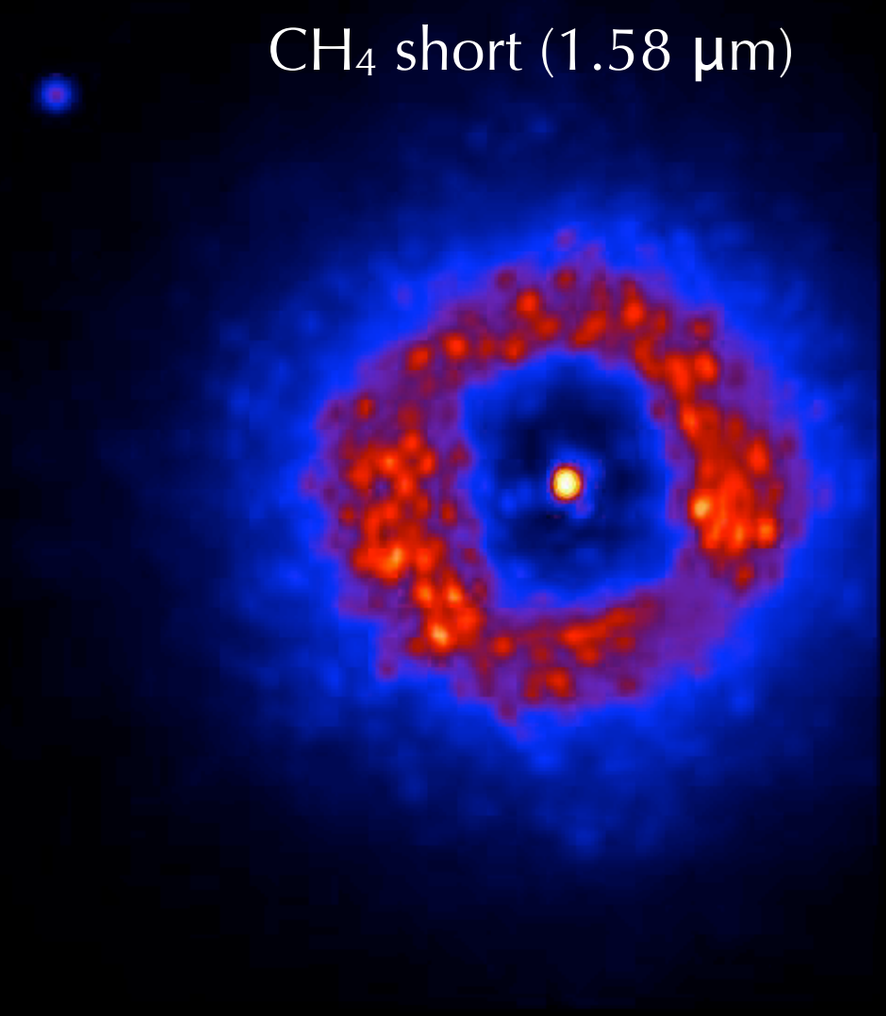
500 queue hours, ~230 young stars

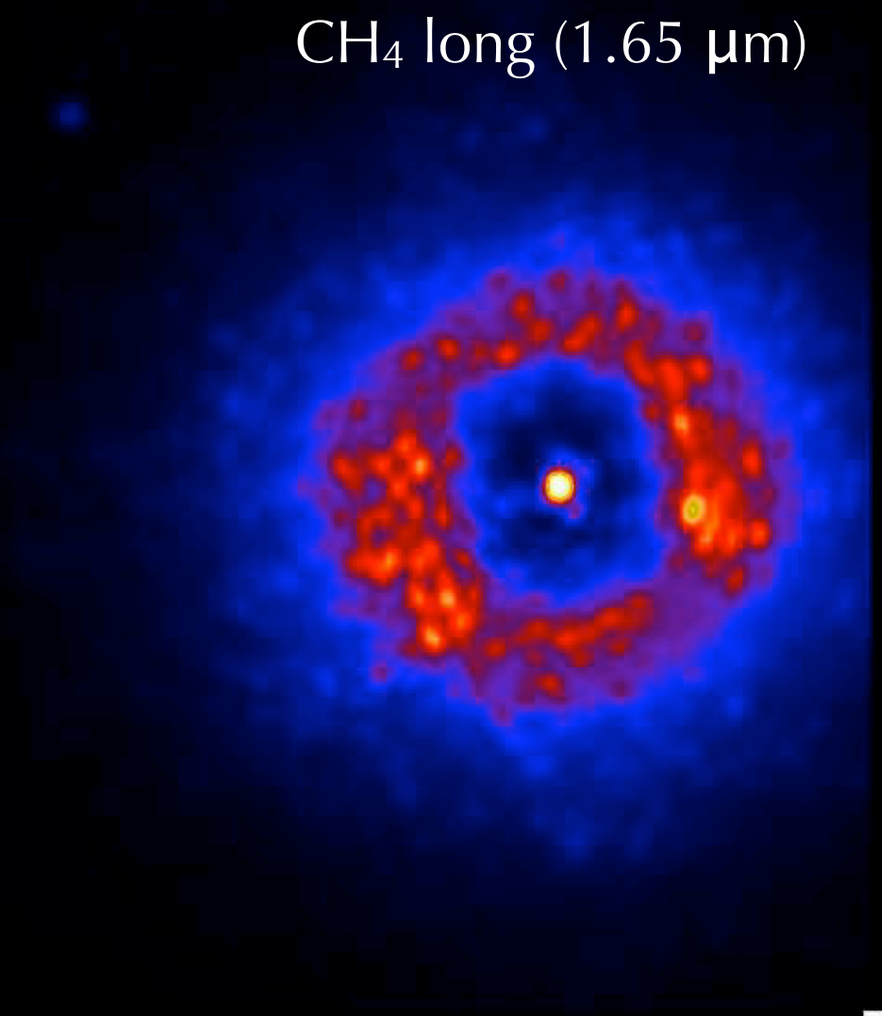
Campaign science questions:

1. What is the **frequency** of gas-giant planets at >5-10 AU?
2. How does planet frequency **depend on stellar mass?**
3. What do the **SEDs** of young planets look like?

Started in December 2008, completion in 2012

NICI = Dedicated exoplanet imager





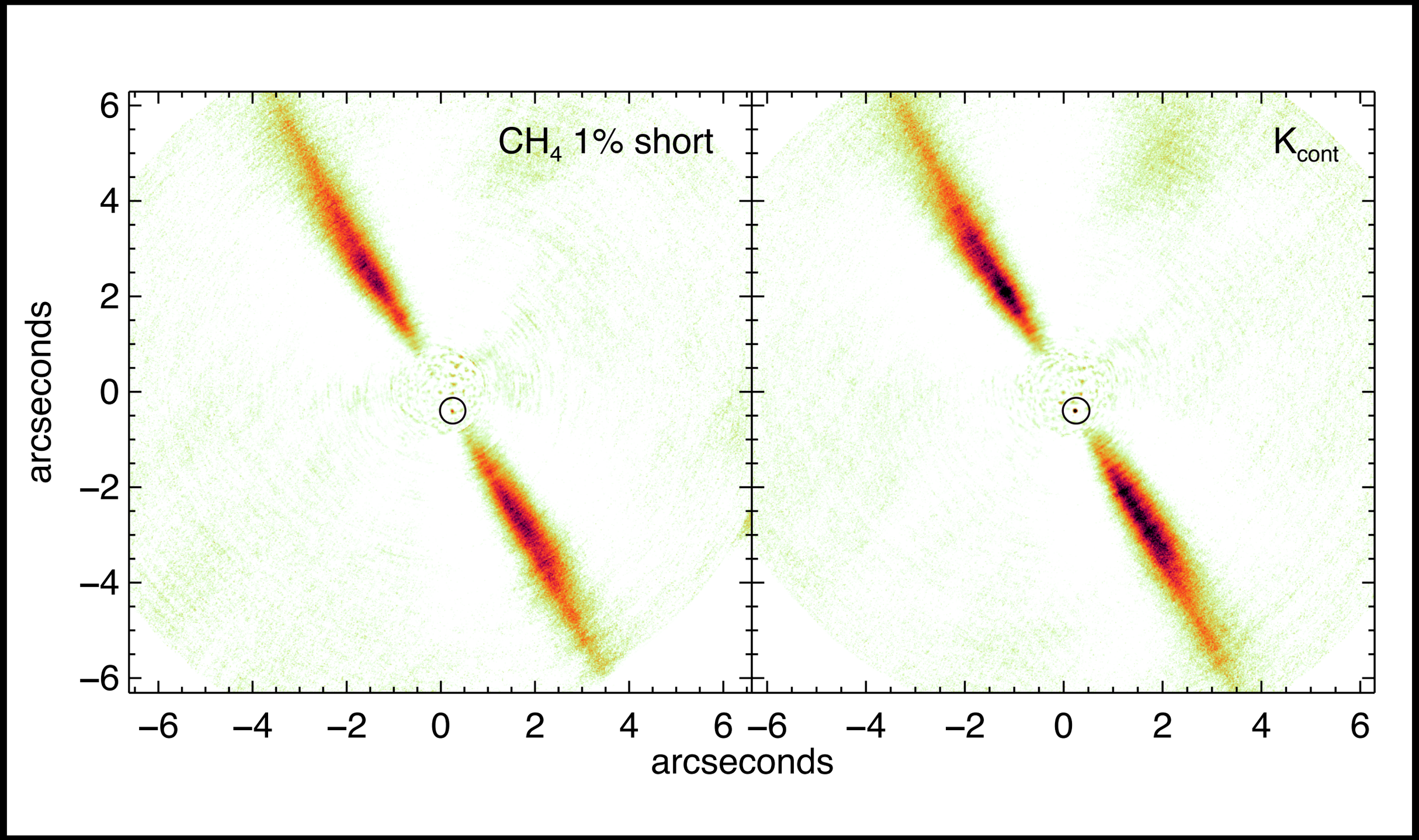
1. High-order NGS AO: UH 85-element curvature system
2. Spectral Differential Imaging (SDI)
3. Roll subtraction (ADI = Angular Differential Imaging)
4. Lyot Corongraphy

On the Trail of beta Pic b

Published astrometric observations of beta Pic b

Instrument	Time Span	Epochs	References
VLT/NACO	2003 - 2013	11	Chauvin+ 2012, Bonnefoy+ 2011, Lagrange+ 2009, 2010, Currie+ 2011, Absil+ 2013
Gemini/NICI	2009 - 2012	7	Nielsen+ 2014, Males+ 2014
Magellan/MagAO	2012	2	Males+ 2014, Morzinski+ 2014
Gemini/GPI	2013	1	Macintosh+ 2014, Bonnefoy+ 2014

The Disk and Planet from NICI



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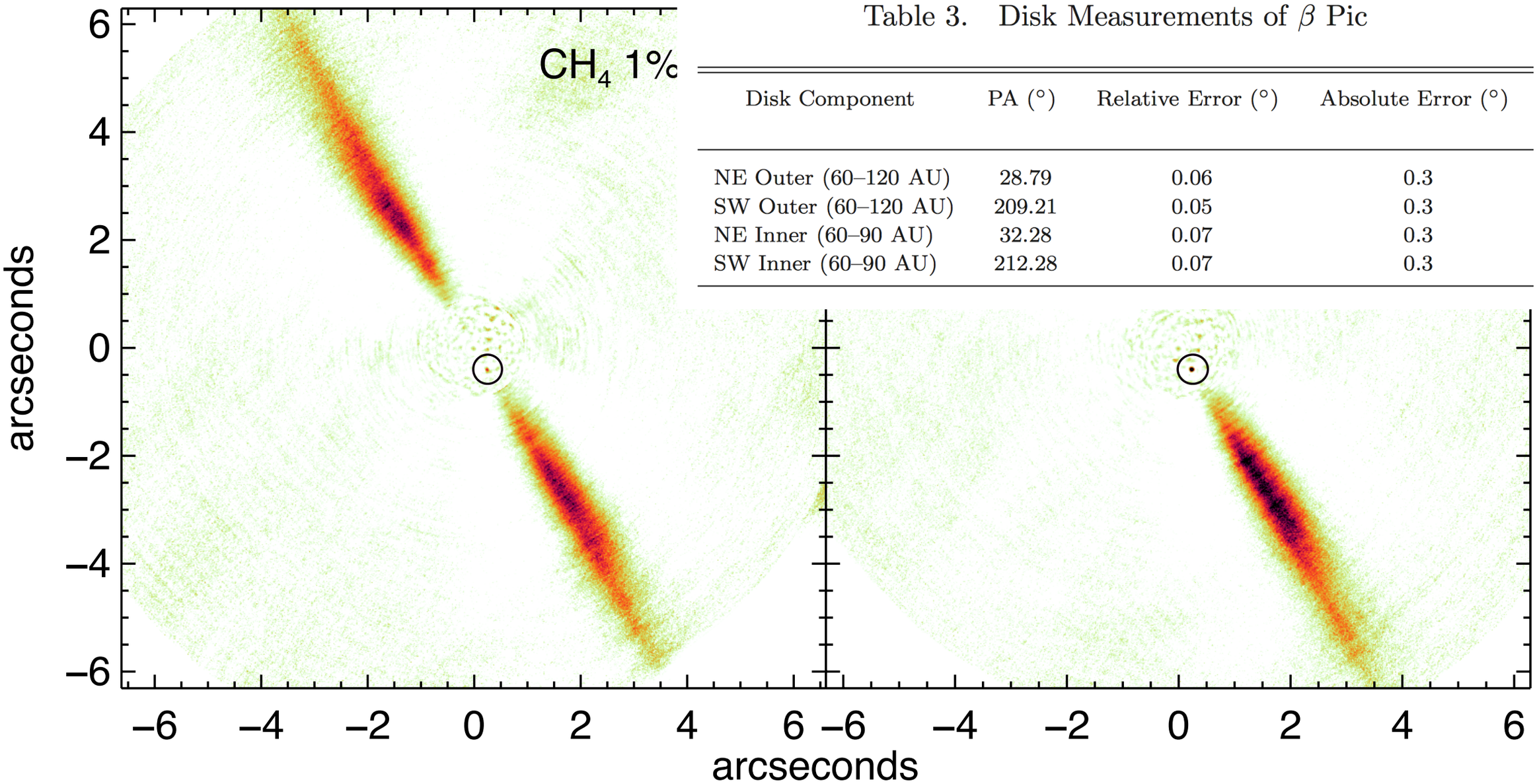

Table 3. Disk Measurements of β Pic

Disk Component	PA (°)	Relative Error (°)	Absolute Error (°)
NE Outer (60–120 AU)	28.79	0.06	0.3
SW Outer (60–120 AU)	209.21	0.05	0.3
NE Inner (60–90 AU)	32.28	0.07	0.3
SW Inner (60–90 AU)	212.28	0.07	0.3

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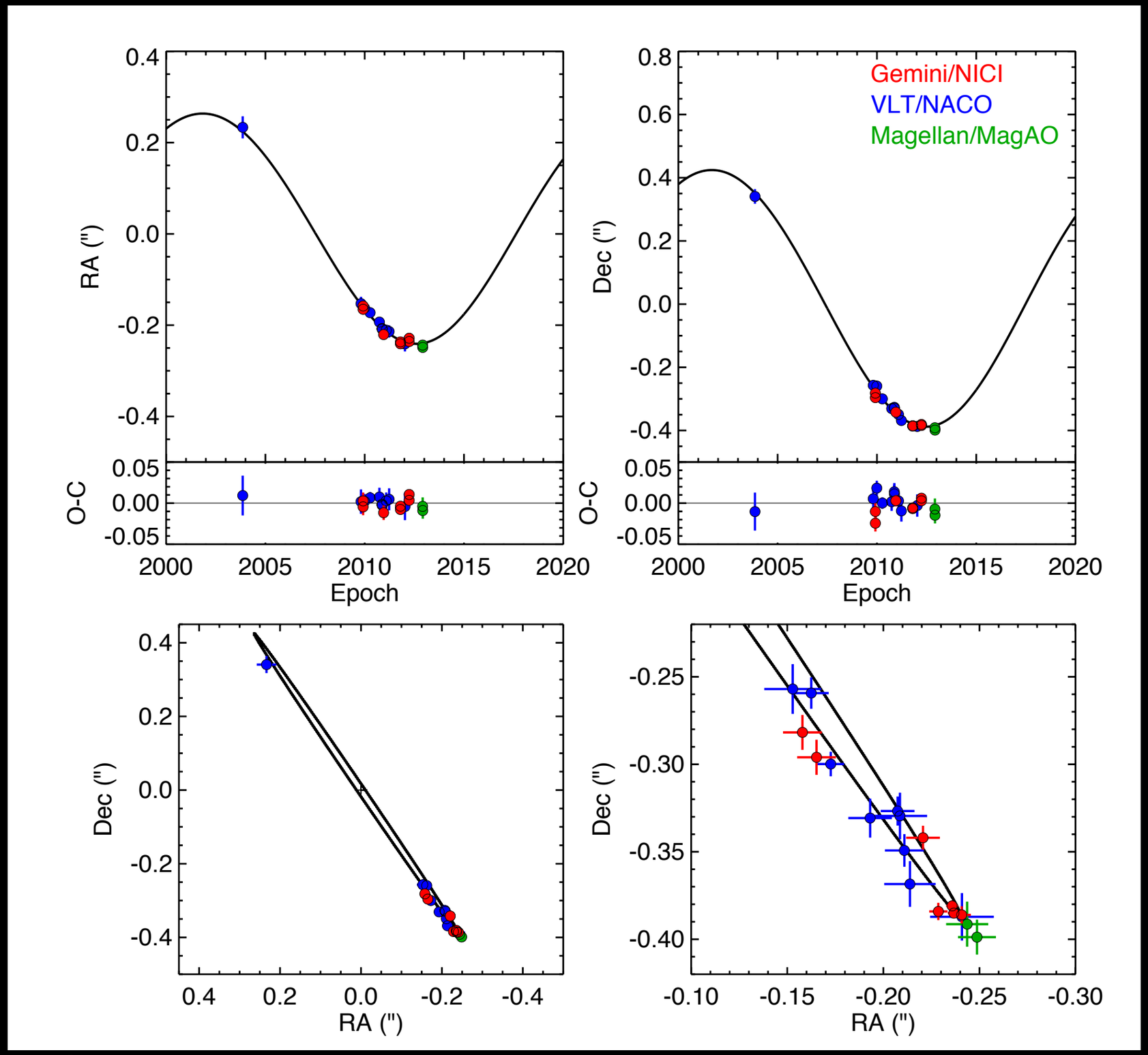
The Orbit of the Young Exoplanet beta Pic b



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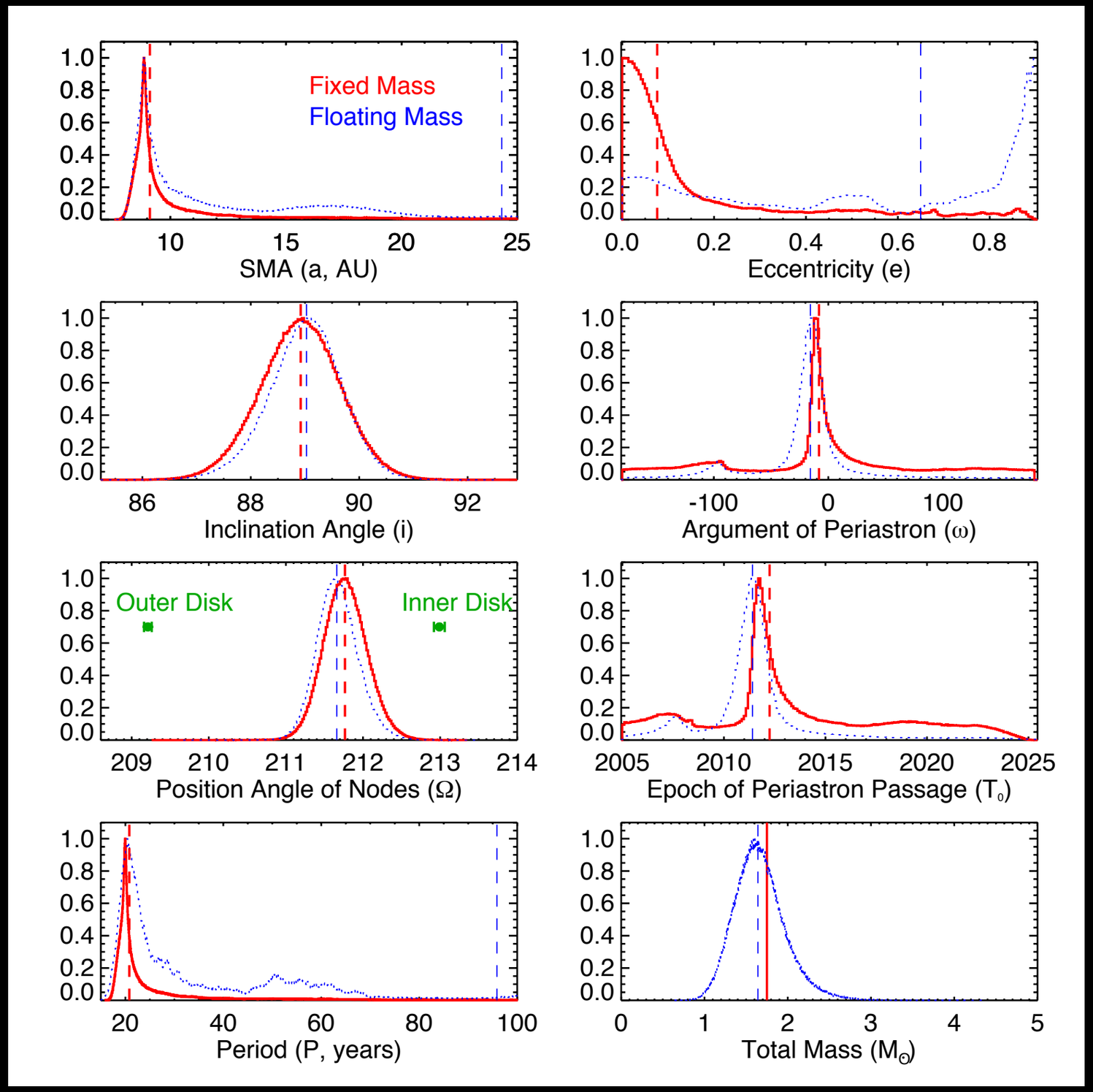

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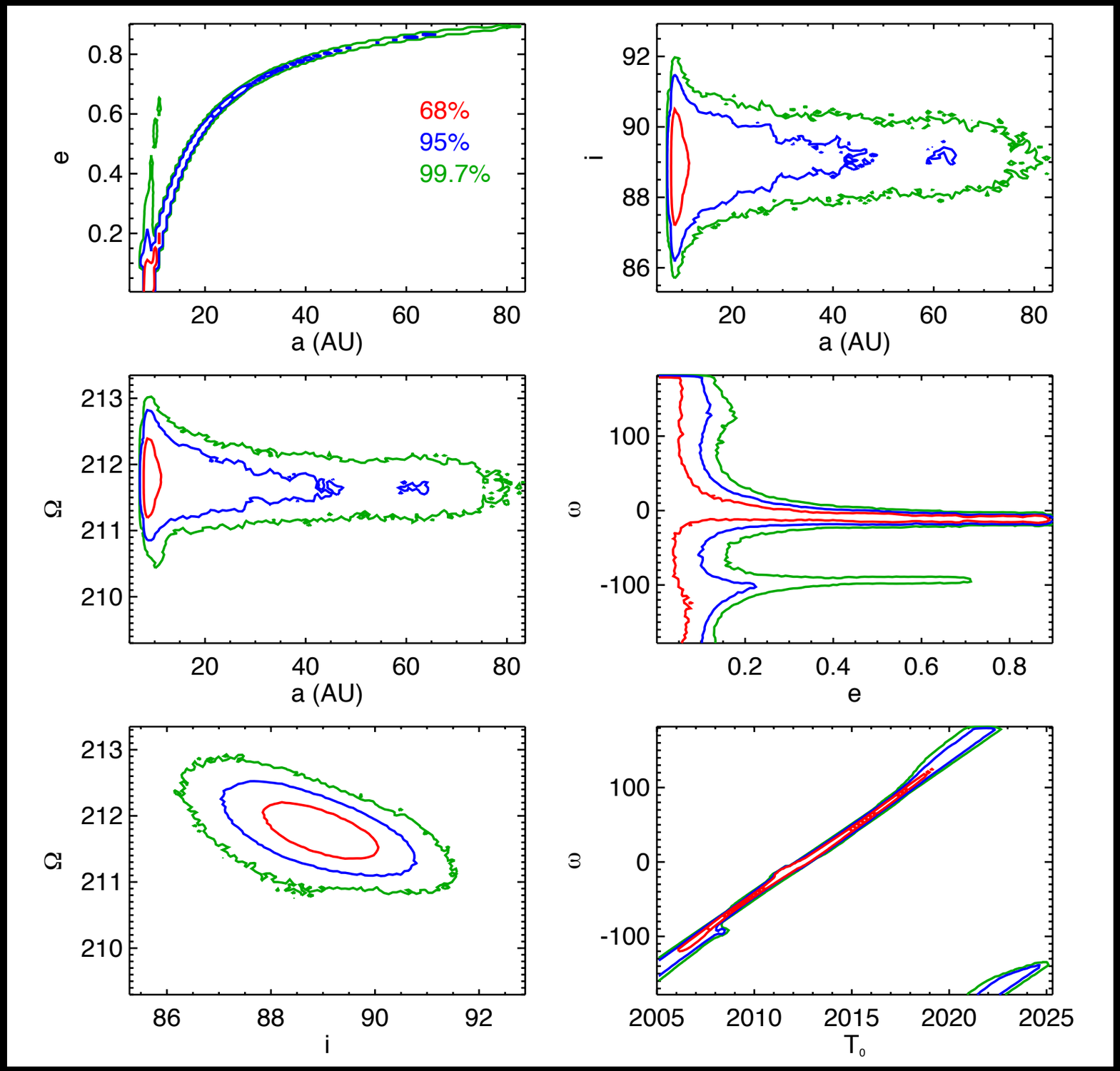

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Conclusions

NICI's partially transparent focal plane mask allows us to observe star, planet, and disk in the same image

beta Pic b orbits in between the main disk and the inner warped disk

The mass of the star beta Pic is 1.76 +/- 0.18 M_sun

Future astrometry (next 1-2 years) will further constrain the orientation of the orbit, mass of the star, likelihood of transit, and orbital period and eccentricity