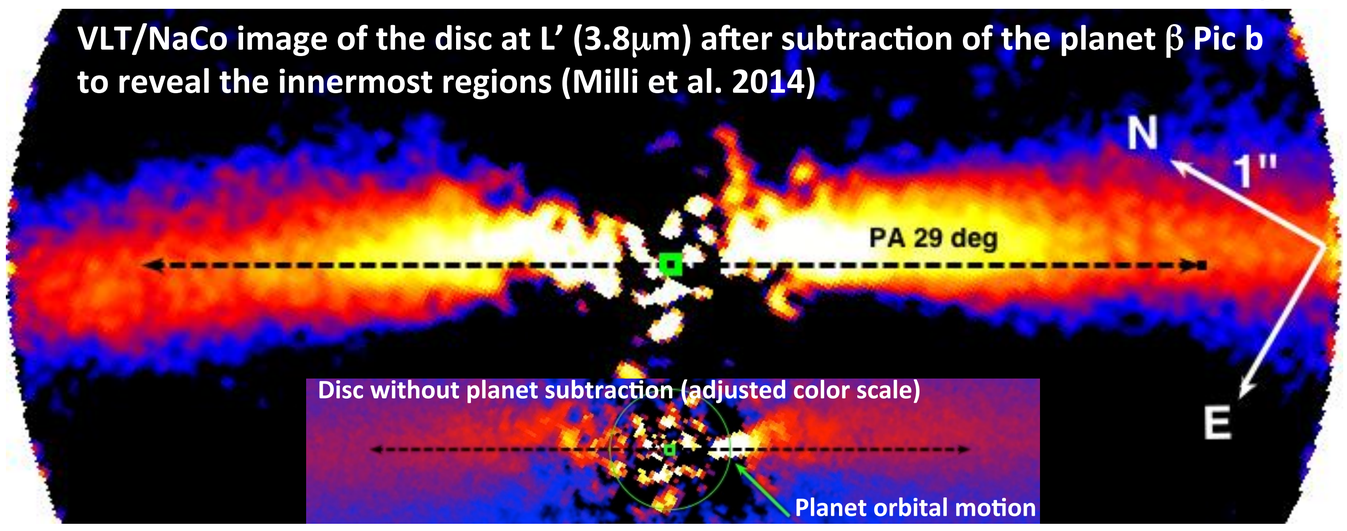
Deep imaging of β Pictoris at L': asymmetries in the disc and constraints on planets

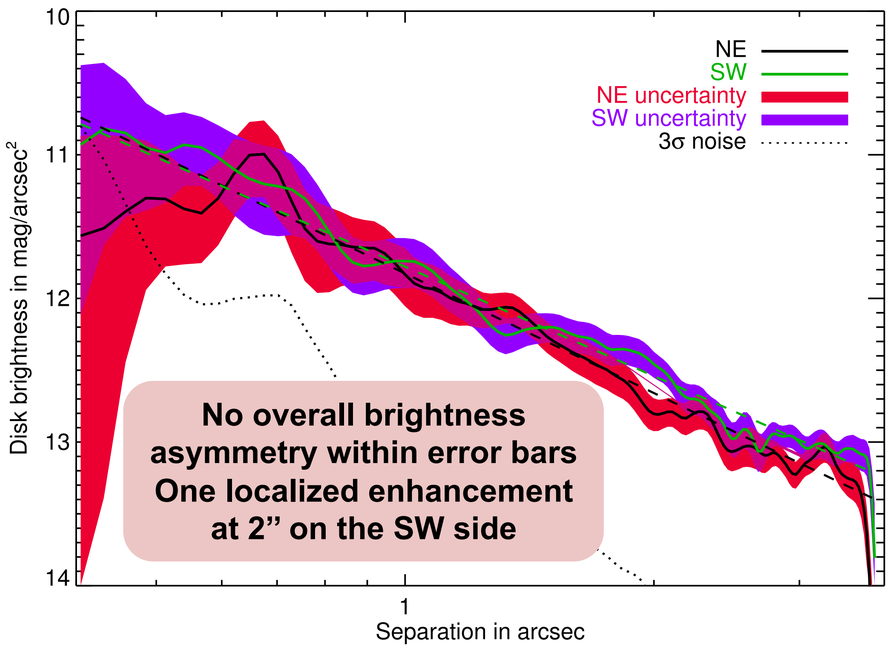
Julien Milli*, Dimitri Mawet, David Mouillet, Olivier Absil, Anne-Marie Lagrange, Julien Girard, Jean-Charles Augereau, Anthony Boccaletti, Justine Lannier, Miriam Keppler
ESO/IPAG – Alonso de Cordova 3107 Vitacura, Santiago Chile
* jmilli@eso.org

1. The disc revealed in its innermost regions at the location of the planet

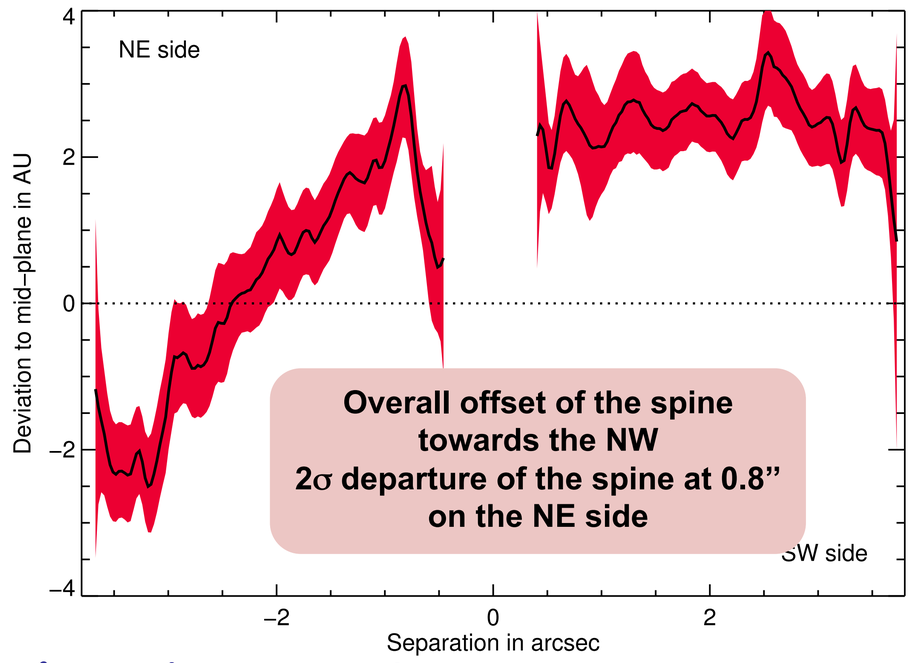


We demonstrate here the potential of VLT/NaCo at L' (3.8μm) in Angular Differential Imaging (ADI). We detect the β Pictoris disc above 5σ between 0.4" and 3.8", after combining data from 7 epochs or 3.1 years. To avoid the smearing of the planet due to its orbital motion within this time span (green arrow), we subtracted the planet from the 7 datasets. We used a star subtraction technique based on PCA (Soummer et al. 2012) and corrected for ADI biases by iterating. We implemented a forward modeling approach to constrain the dust distribution.

Disk surface brightness



Spine position



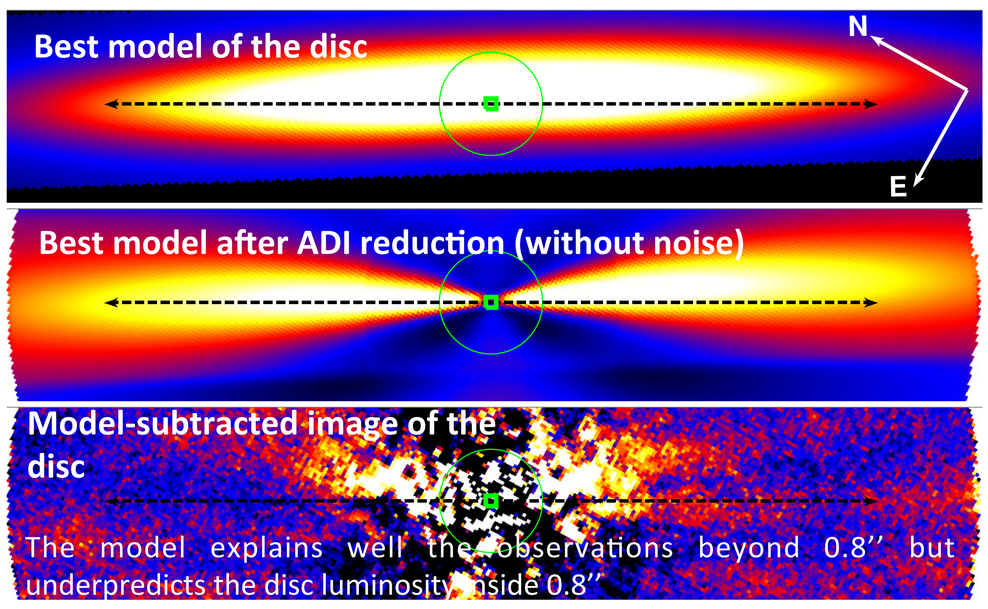
The spine is not a straight line passing through the star: the disc is bowed with a curvature to the NW direction. This is interpreted as anisotropic scattering combined with a slight inclination (~86°) of the disc.

The warped and main components of the disc cannot be decomposed as done at Ks in Lagrange et al 2012 due to the lowest dynamical range at L'. The position angle of the disc measured between 3" and 3.8" is 30.8° / 211.0° confirming that our view is a superimposition of both components.

2. Two disc models to explain the observations

a) Single disc model

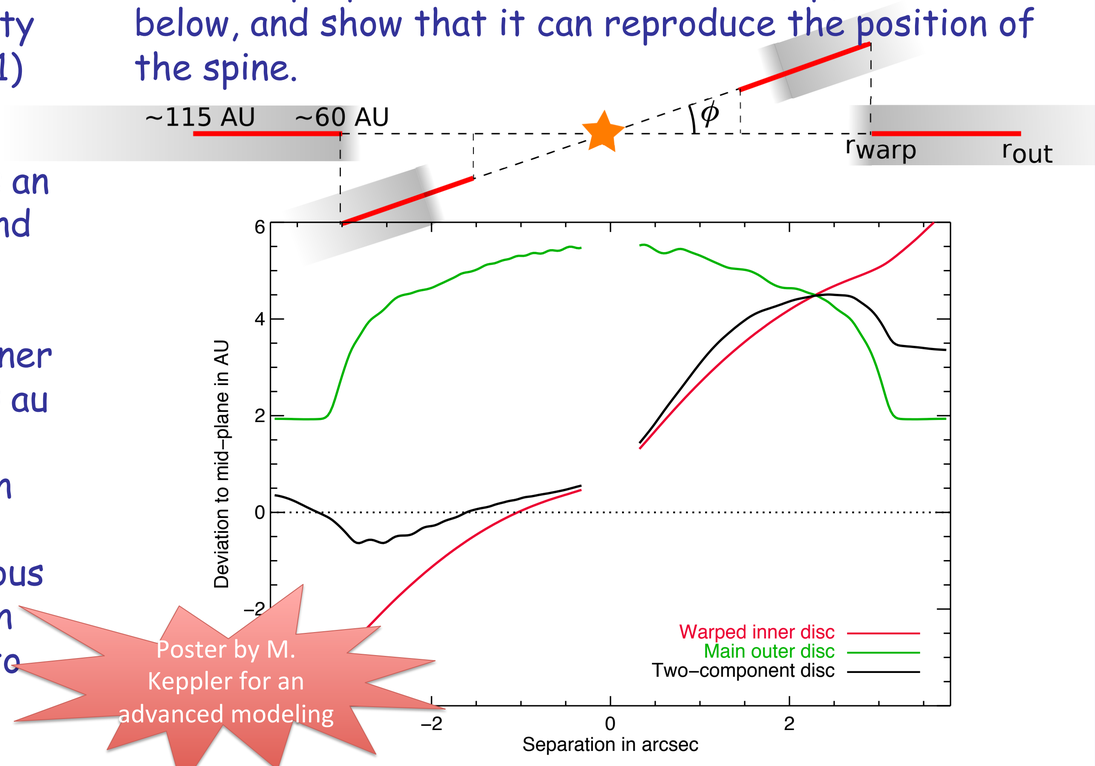
To derive disc parameters free from biases introduced by ADI and constrain the density distribution, we built scattered light images using GRaTeR (Augereau et al 1999) based on a grid of azimuthally symmetric surface density distributions compatible with the early modeling work of Augereau et al (2001) and the ALMA observations (Dent et al. 2014).



The best model has an inclination of 86° and an anisotropic coefficient g=0.36. The index of the inner power law inside 60 au is 1.5 and suggests that dust lies within the inner 20AU as suggested by previous observations (Pantin et al. 1997, Okamoto et al. 2004).

b) Disc with an inner warped component

In a second step, we keep the same radial distribution and dust properties but introduce a warp, as sketched below, and show that it can reproduce the position of the spine.

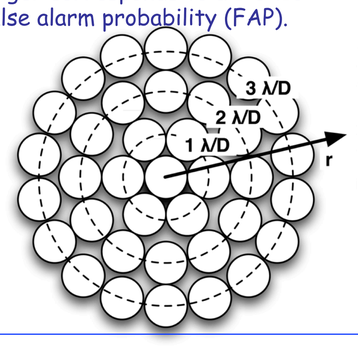


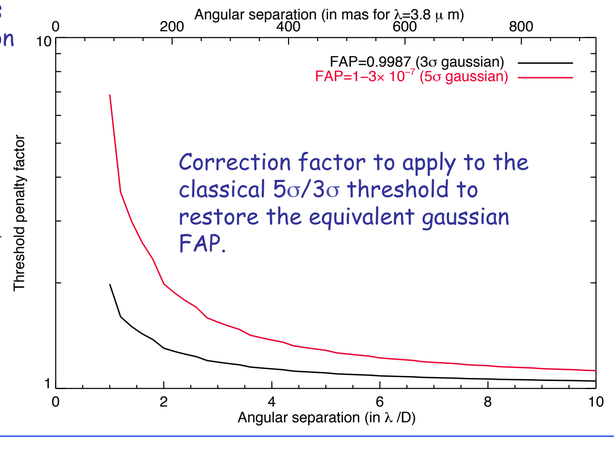
Poster by M. Keppler for an advanced modeling

3. New constraints on additional planets using small sample statistics formalism

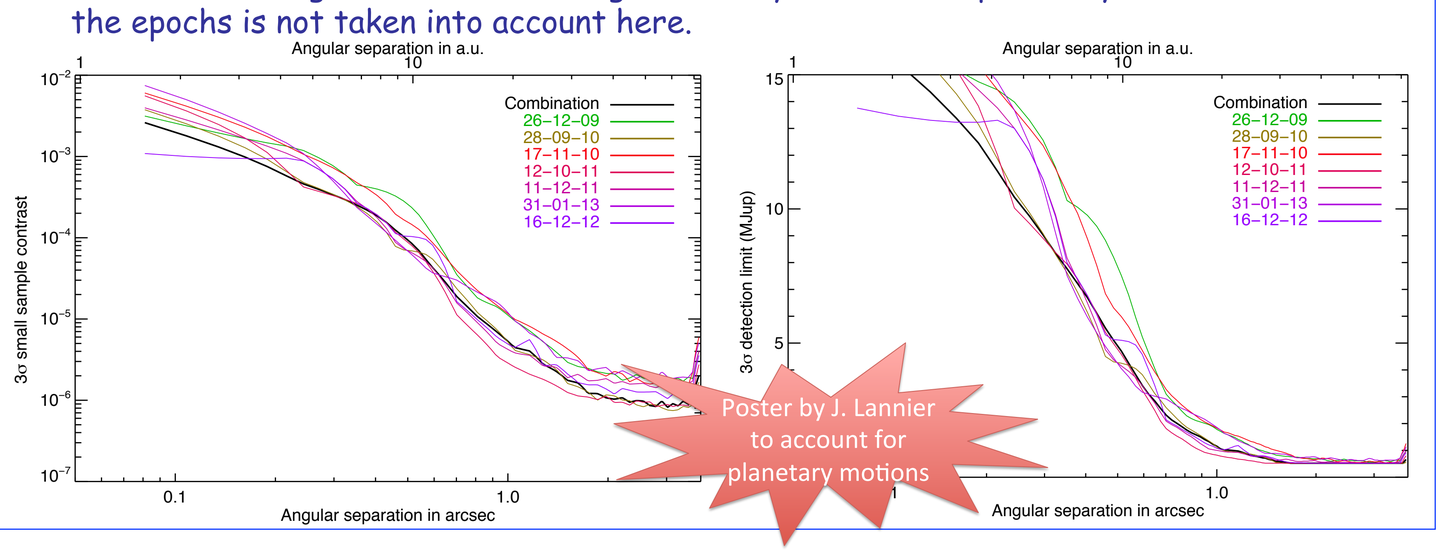
We used these deep multi-epoch observations to set constraints on planets. As we probe regions very close to the star, we adopted the formalism of small sample statistics (Mawet et al. 2014) to preserve the confidence level.

The number of resolution elements (circles) is small at short separation and a classical 5σ threshold no longer corresponds to a 1-3x10^{-7} false alarm probability (FAP).





Detection limits, corrected for ADI flux losses and small sample statistics, converted into masses using COND03 with an age of 20 Myrs. Potential planetary motion between the epochs is not taken into account here.



Poster by J. Lannier to account for planetary motions