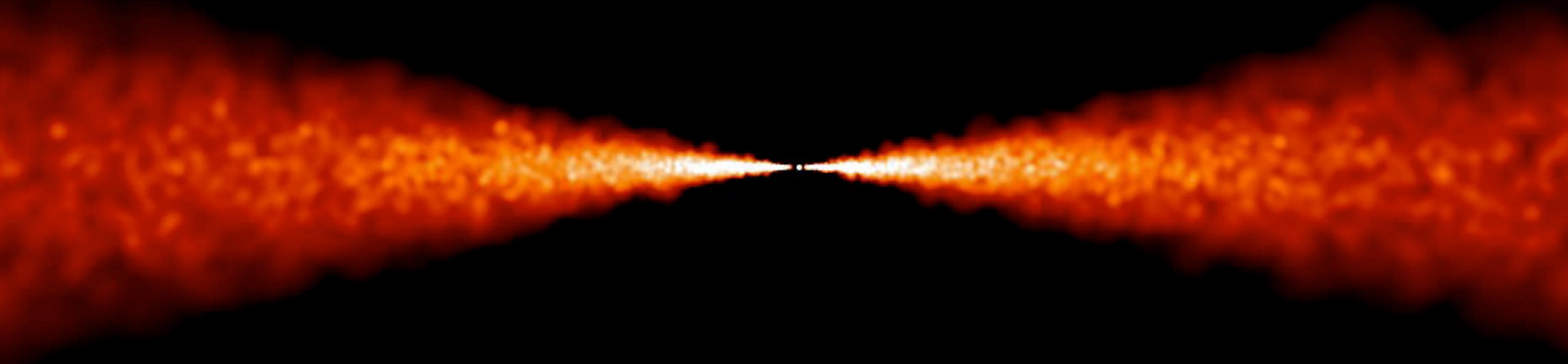


Does TW Hya host a misaligned planet?



Rebecca Nealon with
Christophe Pinte, Richard
Alexander, Daniel Mentiplay,
Giovanni Dipierro,
Chris Nixon and Rebecca Martin

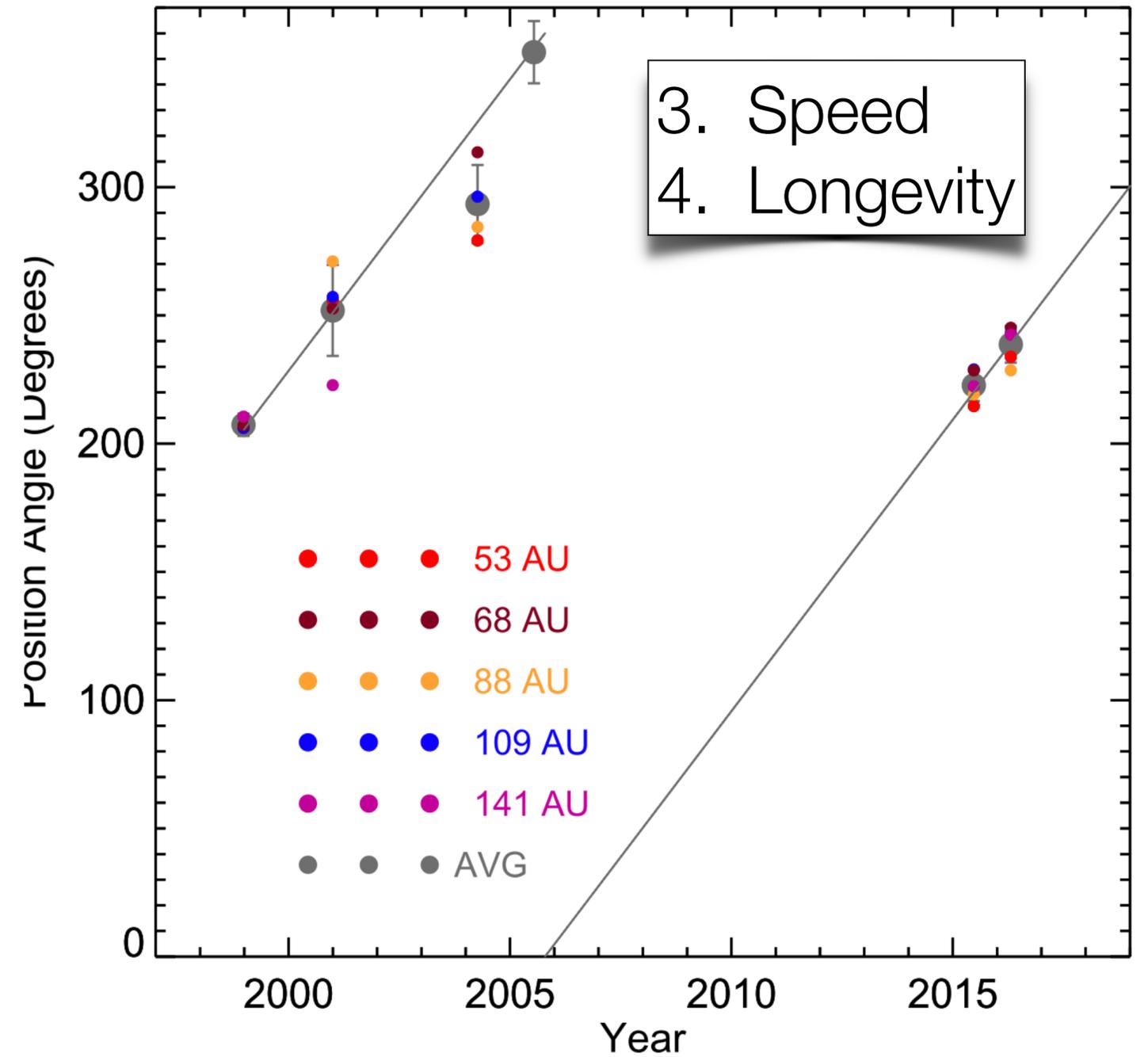
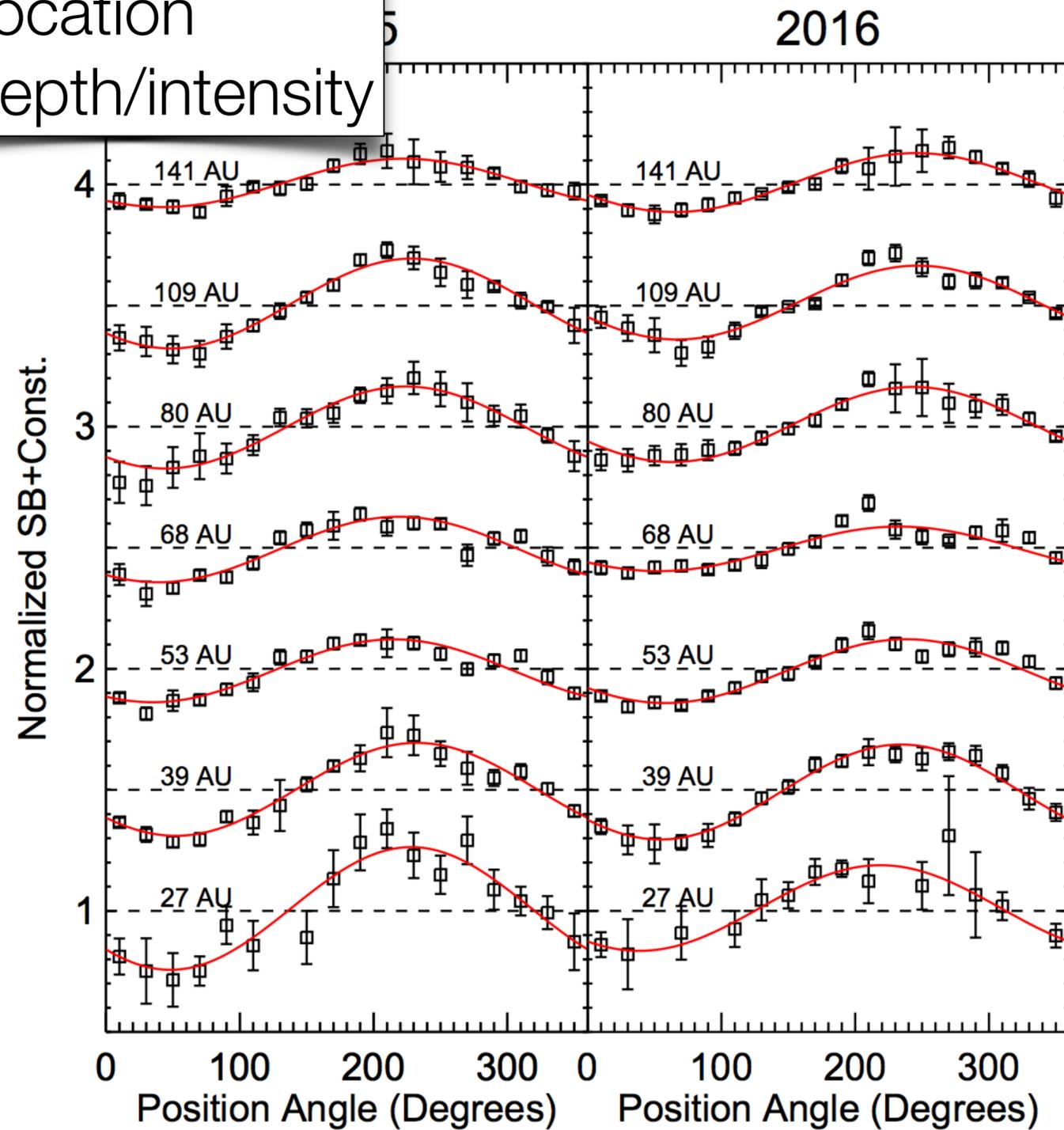


UNIVERSITY OF
LEICESTER



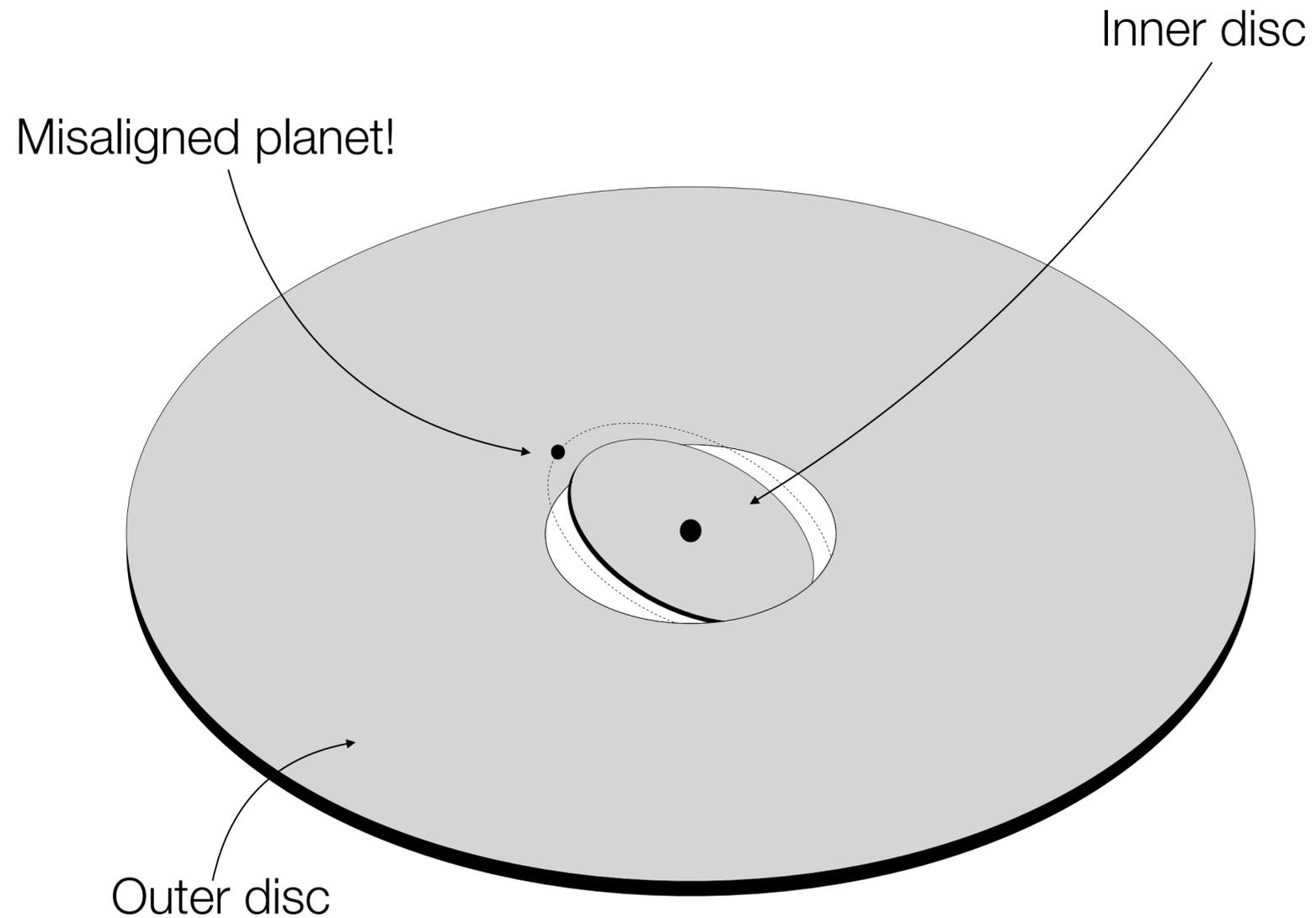
The shadowy case of TW Hya

- 1. Location
- 2. Depth/intensity



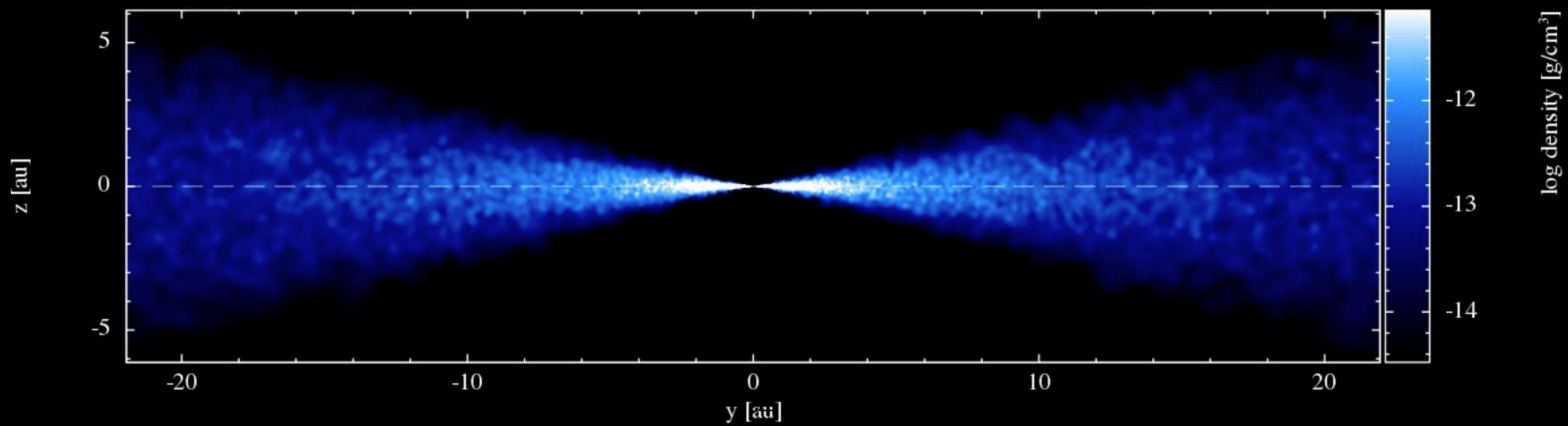
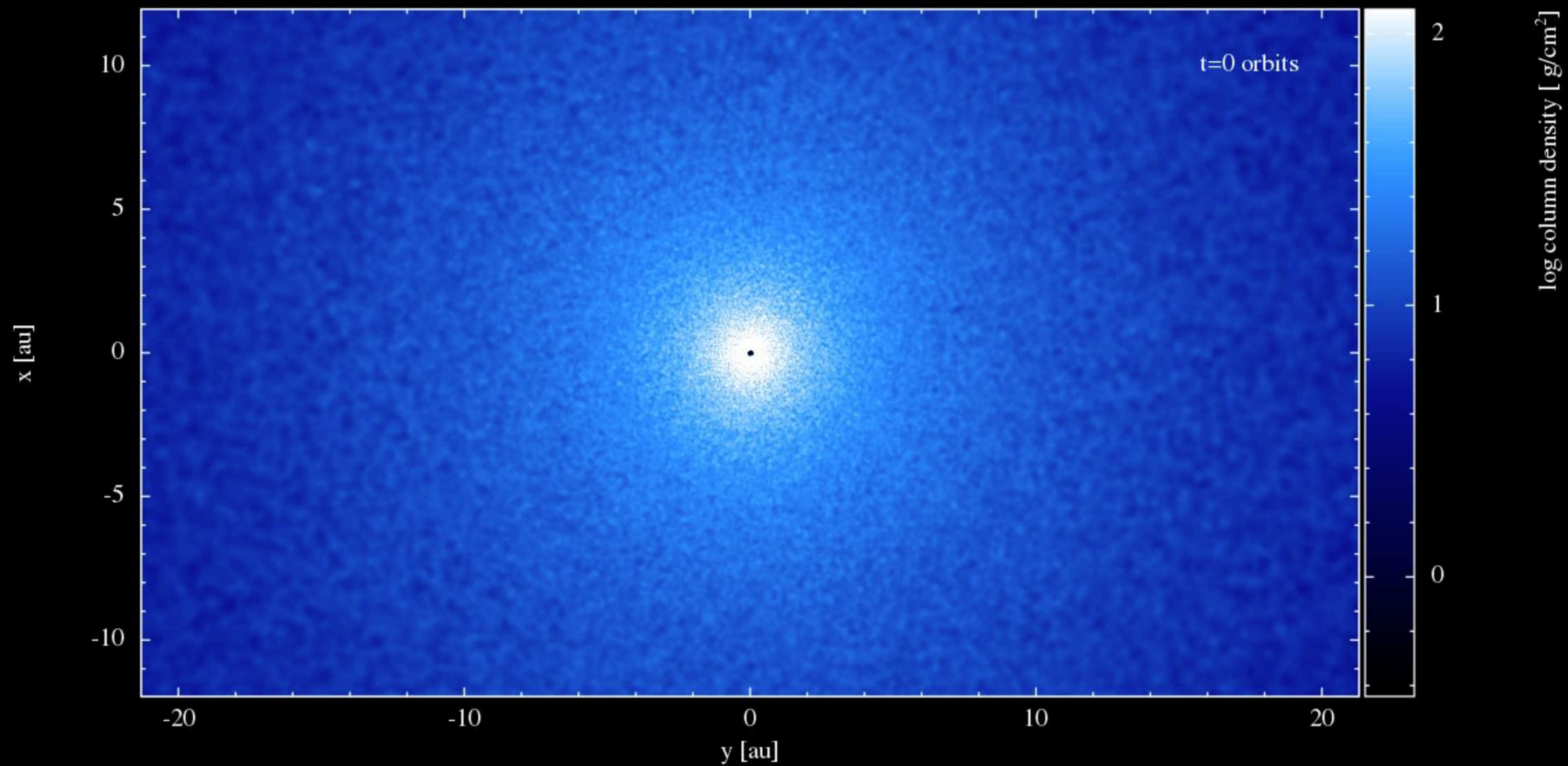
(Debes et al. 2017 + Poteet et al. 2018)

The shadowy case of TW Hya

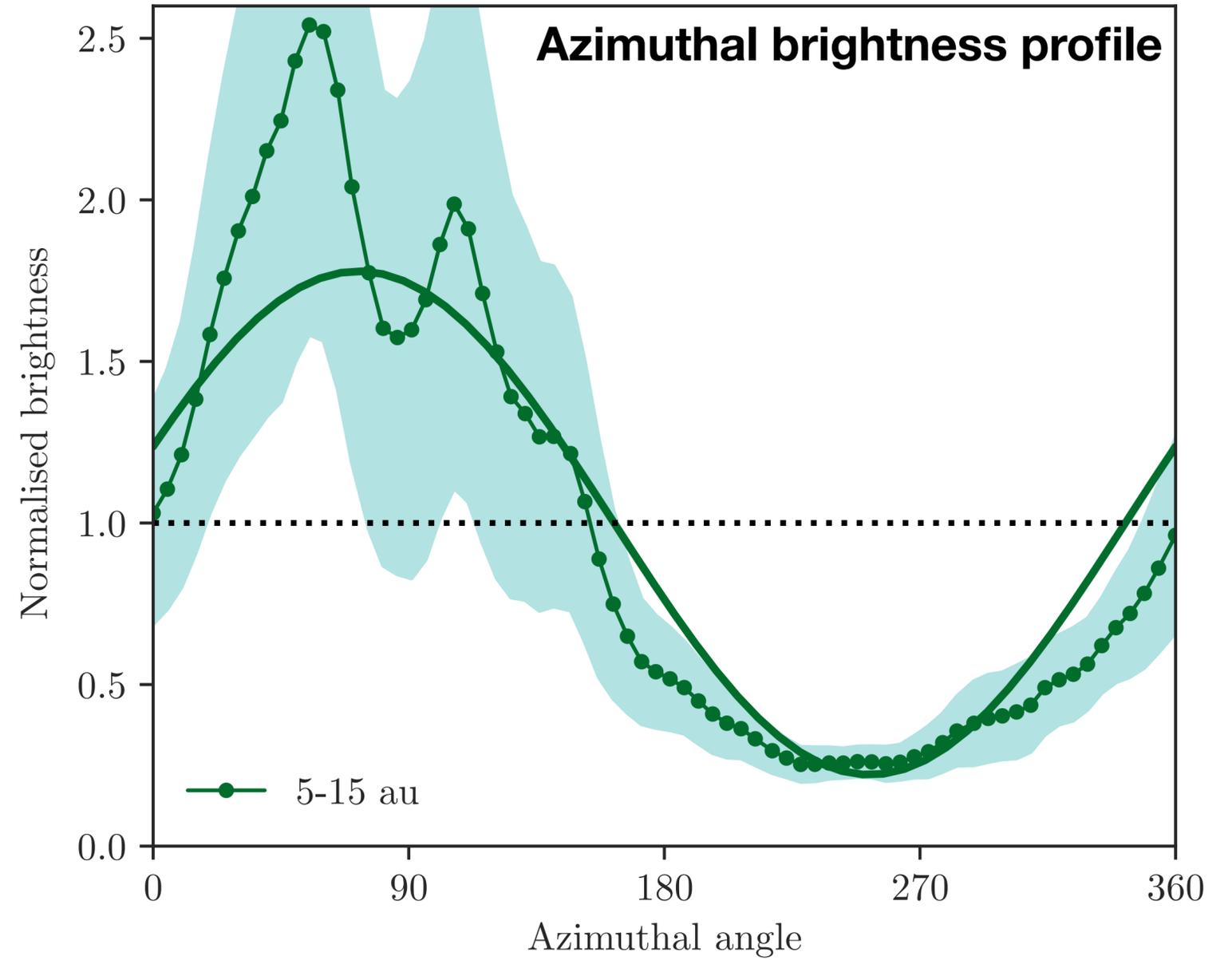
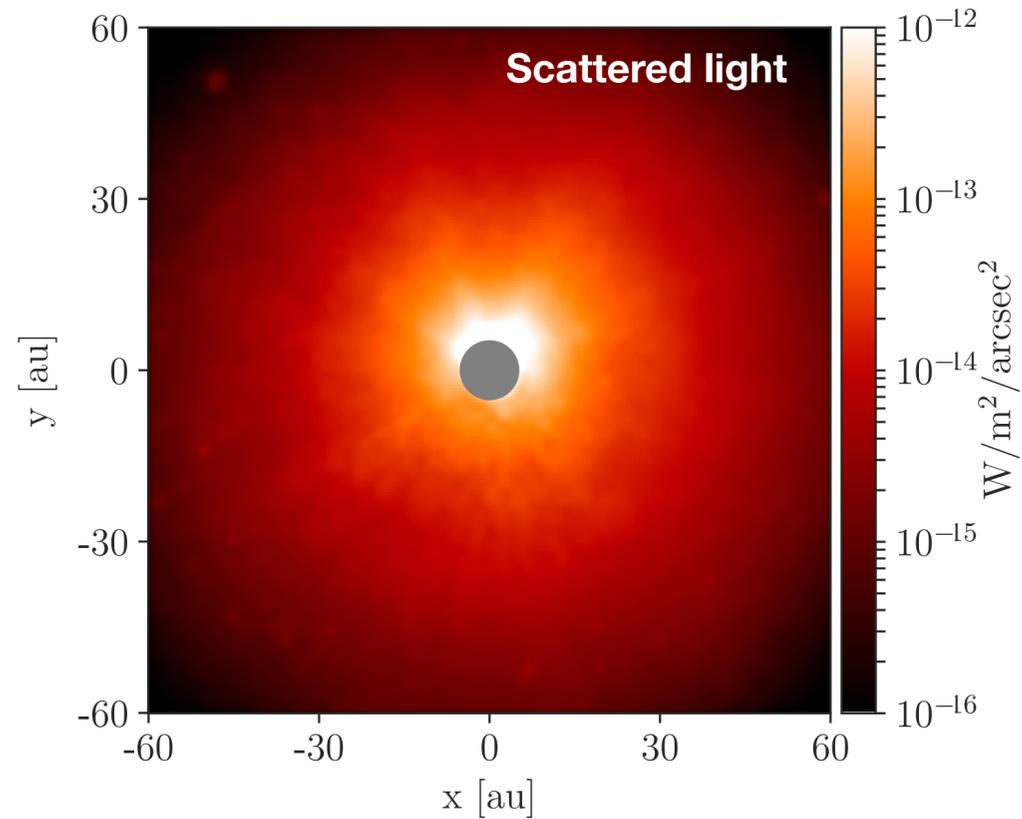
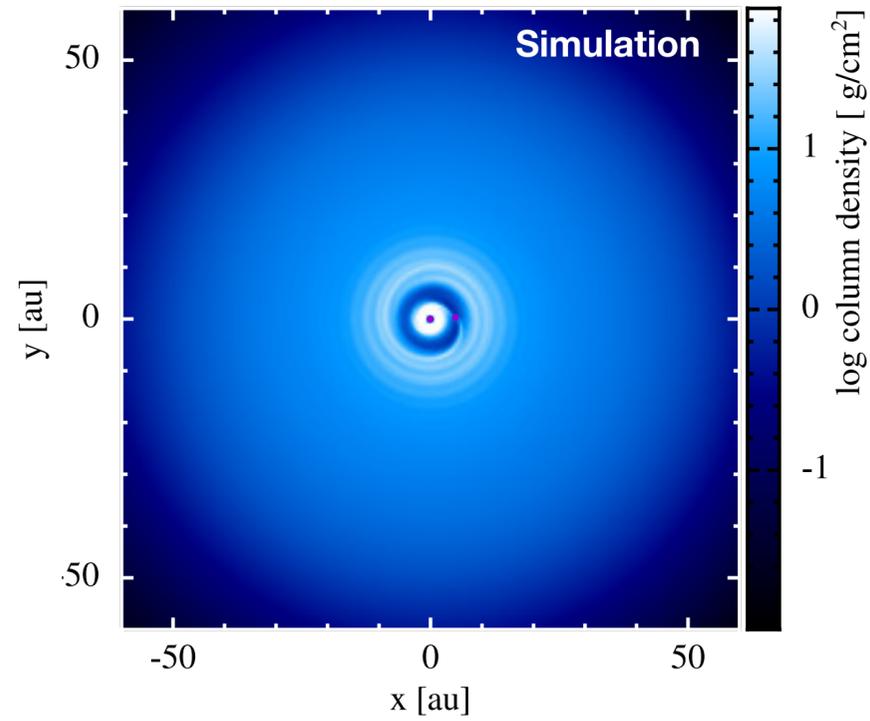


(Dramatic schematic)

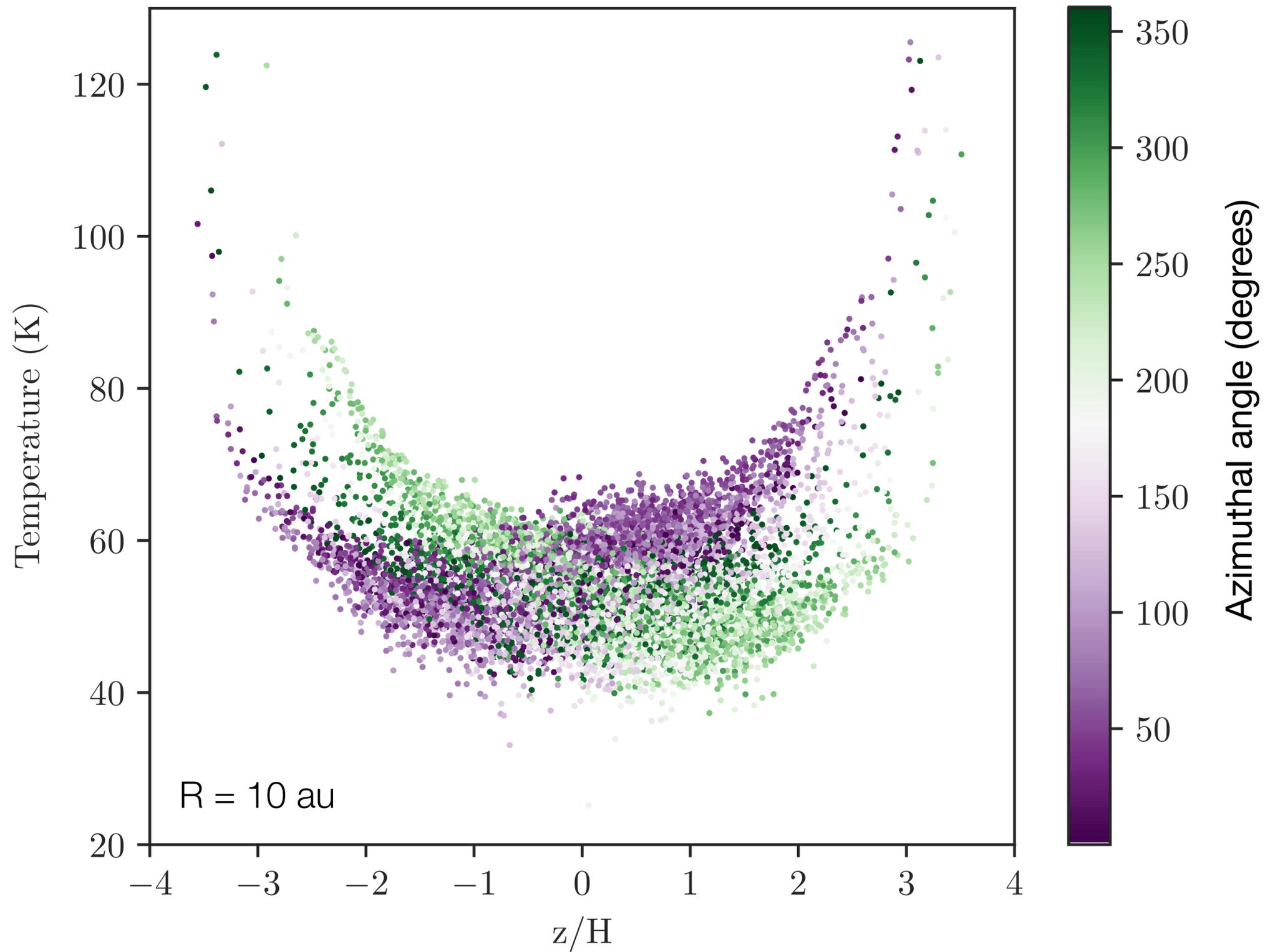
- Planet is misaligned to **both** the inner and outer disc
- This causes inner disc to be tilted to outer disc, casting a shadow
- Misaligned planet causes inner disc to precess such that shadow moves with the precession rate



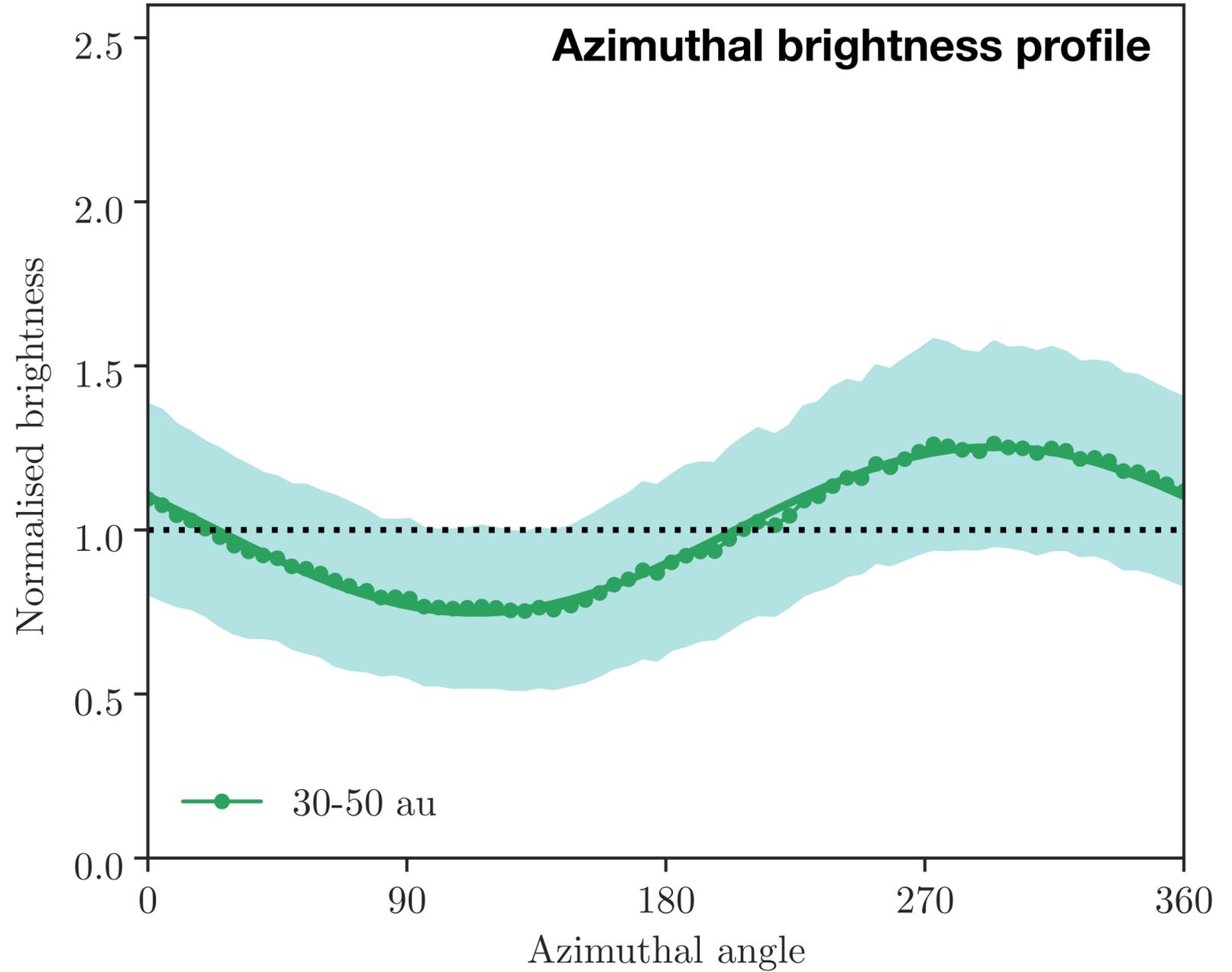
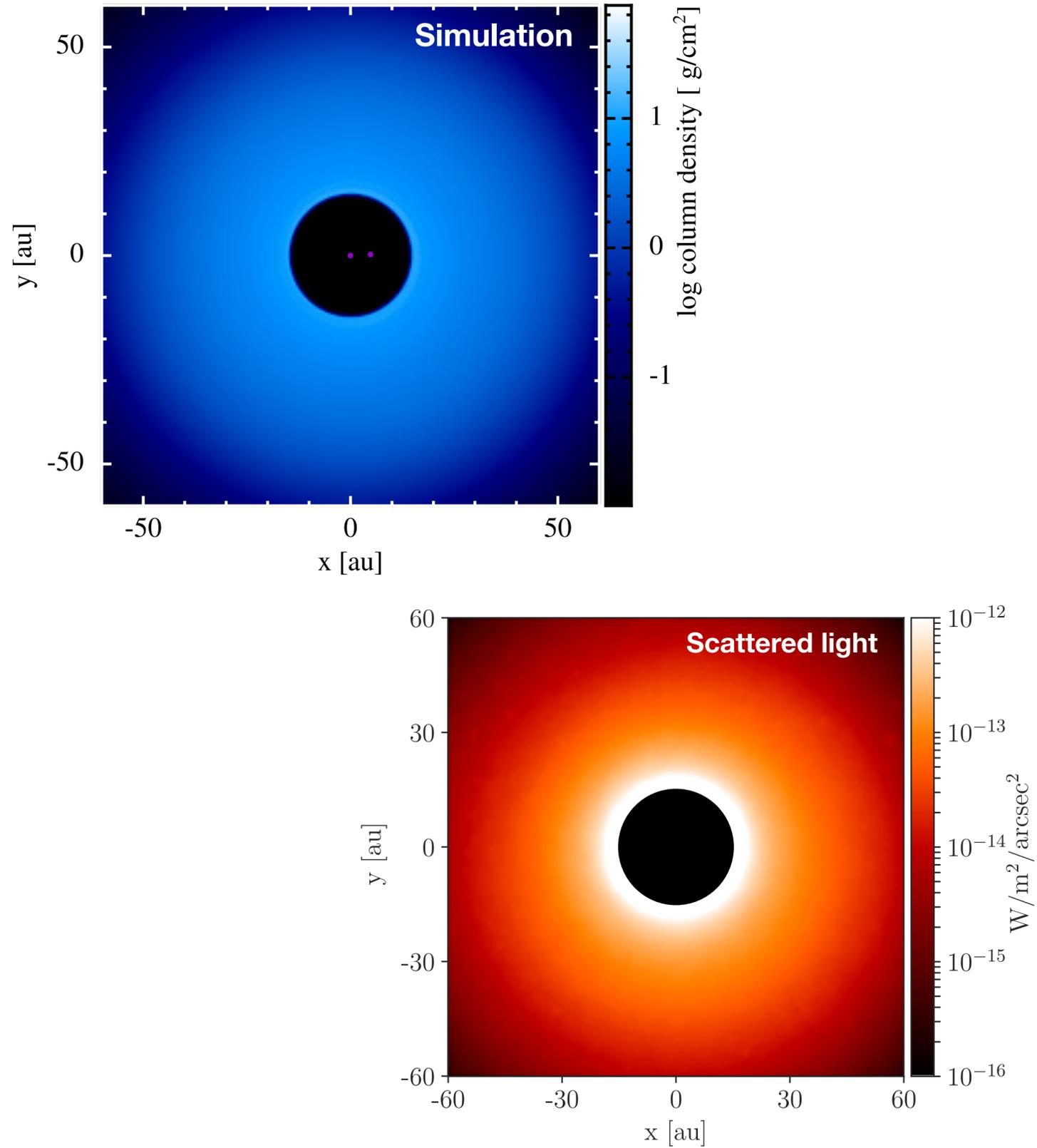
Measuring the shadow



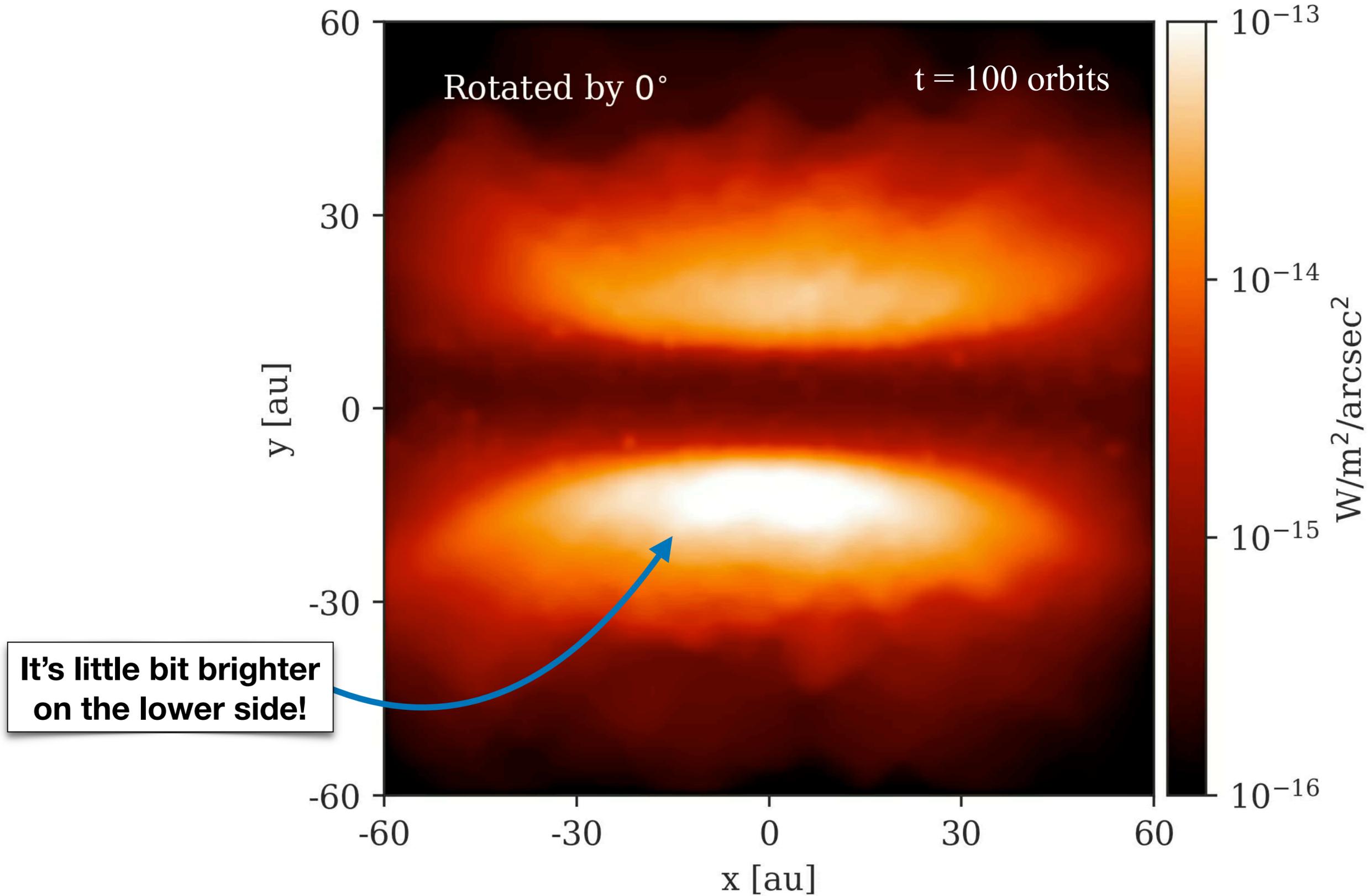
It's cooler in the shade



Measuring the warp



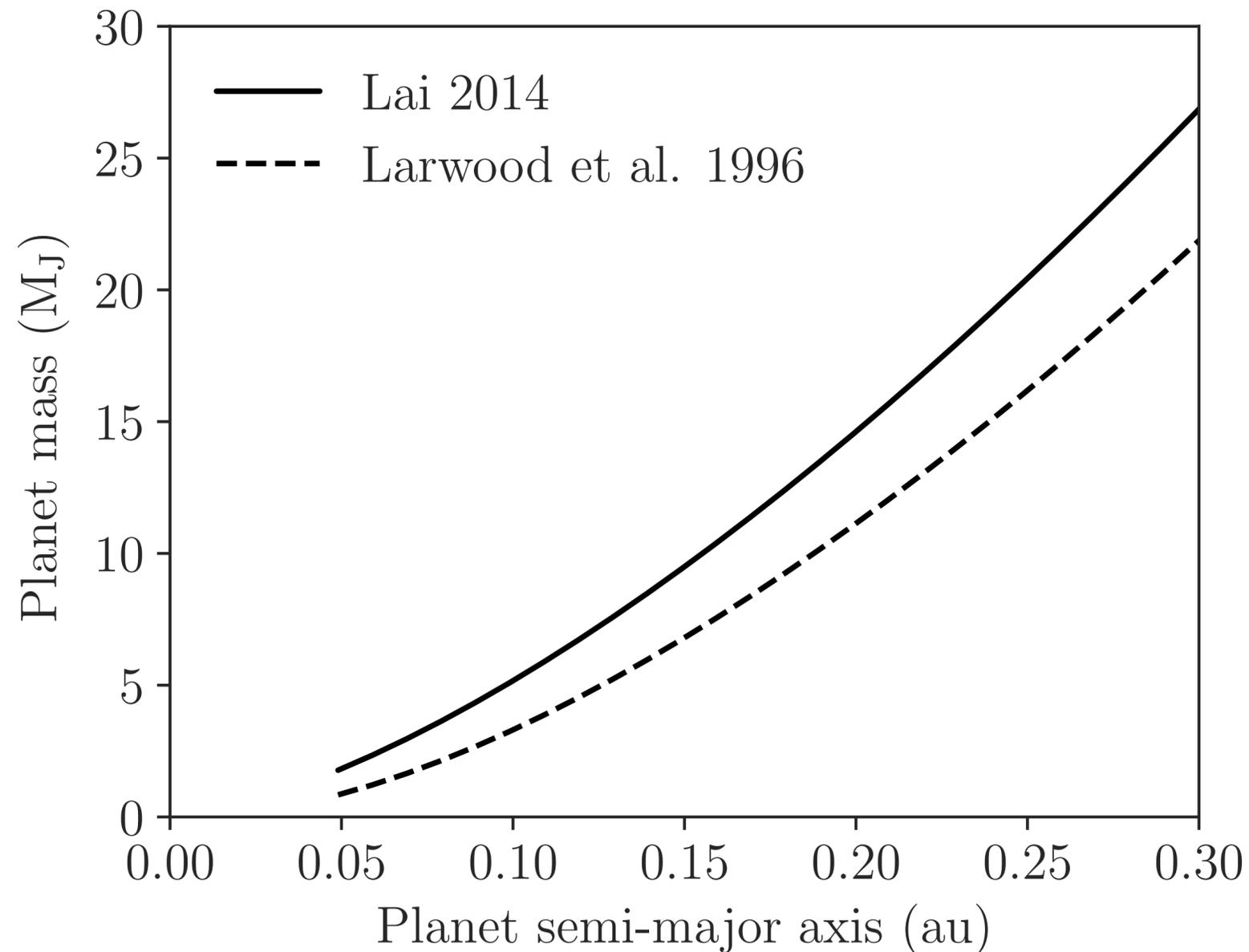
Seeing the warp edge-on



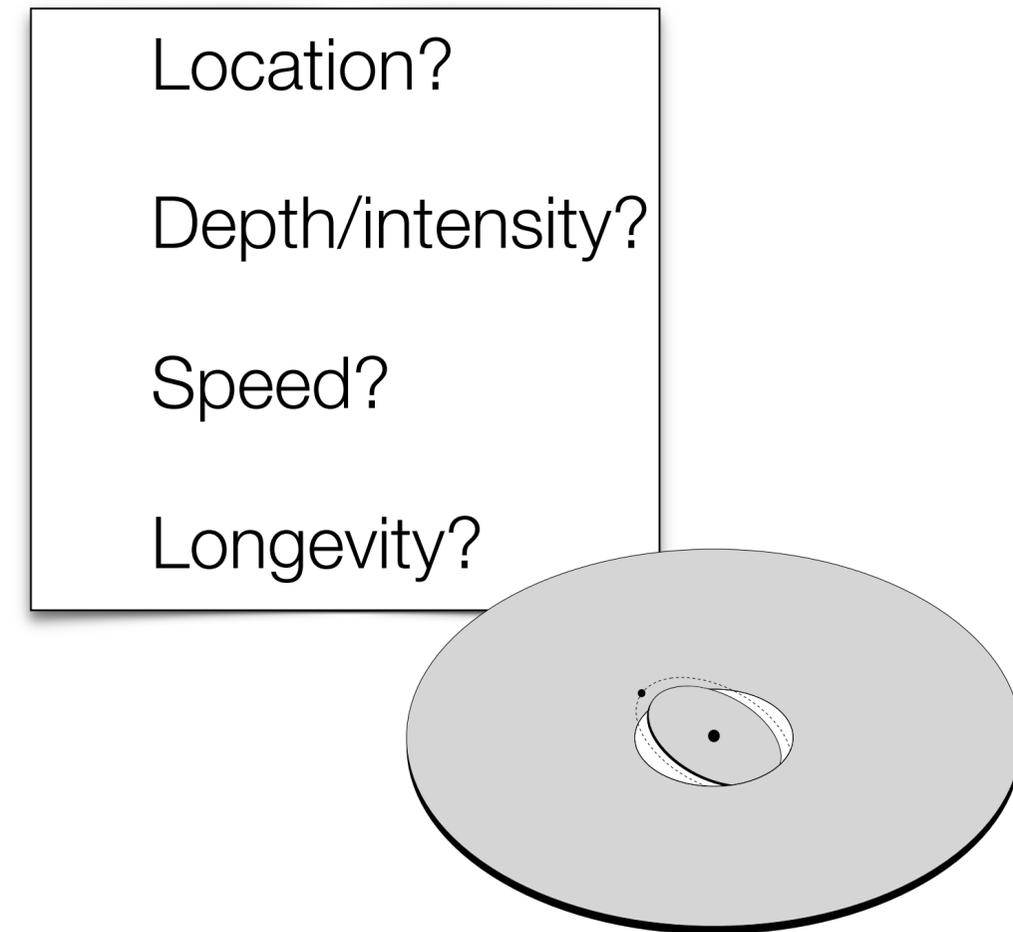
What about TW Hya?

Precession rate:

$$\omega = \frac{3GM_p}{4a^3} \frac{\int \Sigma R^3 dR}{\int \Sigma \Omega_k R^3 dR} \cos i$$



(In agreement with Facchini et al. 2014)



To agree with the observed precession rate, the planet must be **massive** and **close to the truncation** radius of the disc.

What about TW Hya?

Consider the accretion and alignment timescales ...

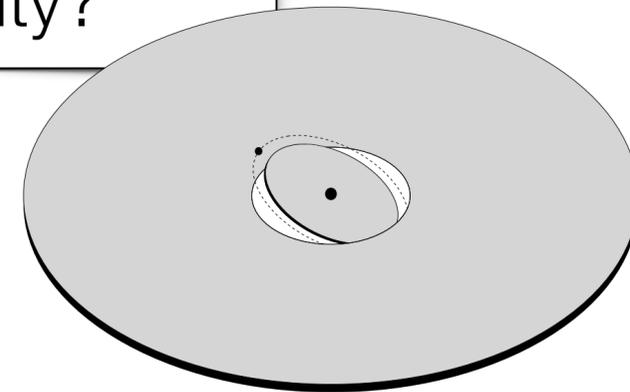
Accretion:

$$\dot{M} \sim 1.8 \times 10^{-9} M_{\odot} / \text{year} \quad (\text{Ingelby et al. 2013})$$

$$t_{\text{accrete}} \sim 10^3 - 10^5 \text{ years}$$

... or $\sim 1\%$ of TW Hya's age.

- 🕶️ Location?
- 🕶️ Depth/intensity?
- 🤔 Speed?
- Longevity?



Alignment: $t_{\text{align}} \sim t_{\text{precess}}$ (Bate et al. 2000)

... or $\lll 1\%$ of TW Hya's age.

A precessing disc driven by a misaligned planet is unlikely to be observed in TW Hya as it is a **very short-lived feature**.

The moving shadow in TW Hya is **not likely** to be caused by a **precessing disc** governed by **misaligned planet**.

- 
- The tightest constraints are the time-scales, which suggests that this scenario would be very short lived and thus, unlikely to be observed
 - Azimuthal variation in the observed flux may be caused by a
 - Shadow cast from a structure in the inner disc regions
 - Disc warp that indicates the presence of a misaligned companion
 - A planet massive enough to misalign the inner disc **must** drive an outer disc warp
 - An outer disc warp should be observable, even if the disc is edge-on
 - Misaligned stellar magnetic field? Something orbiting at 5 au?

