Debris disc imaging with the E-ELT and ALMA

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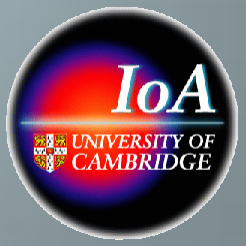
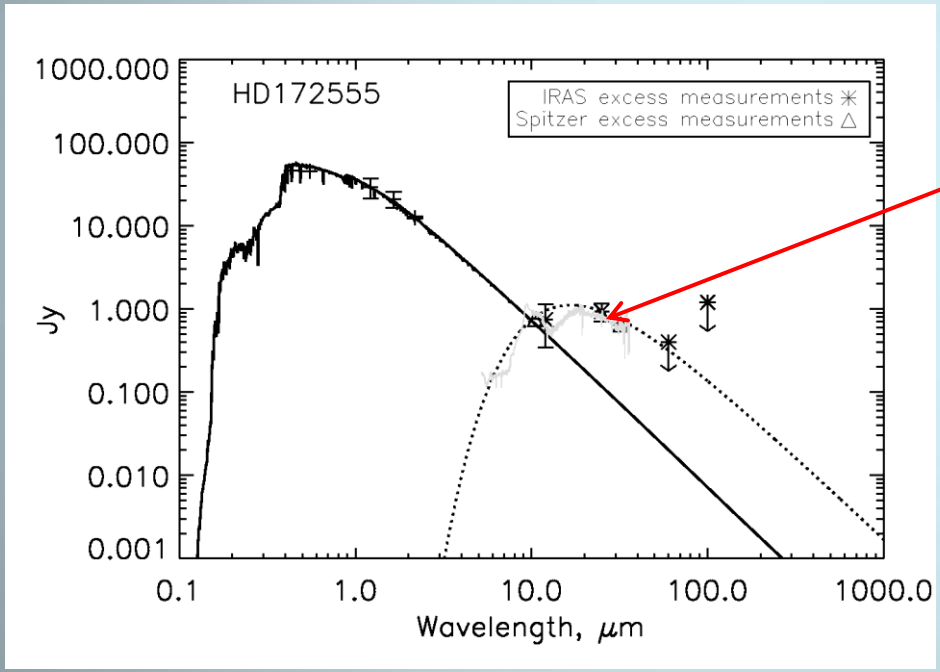


Why image debris discs?

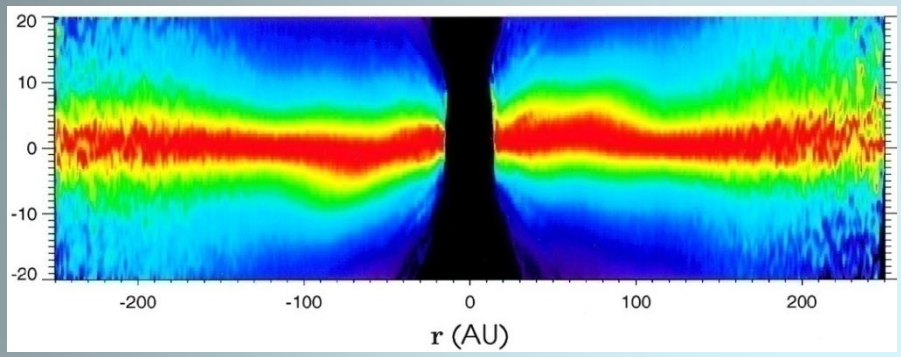
Debris discs are remnants of planet formation, the analogues of the asteroid and Edgeworth-Kuiper belts of the Solar System. Most discovered through photometry.



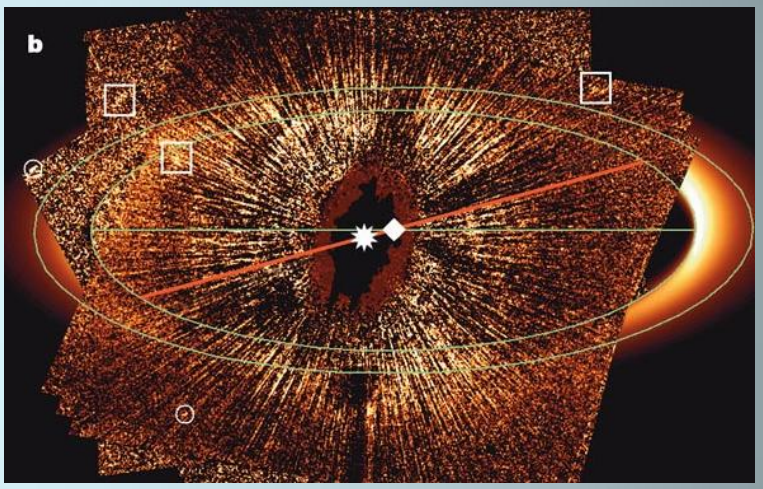
Excess emission above photosphere reveals the presence of dust grains – the result of the collisions between planetesimals or the destruction of comets.

Structure and location can provide insights into the formation and evolution of planetary systems.

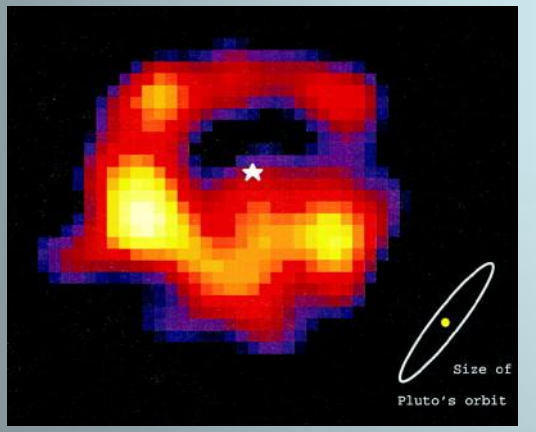
Discs resolved to date



Warps (β Pic, Heap et al. 2004)



Offsets (Fomalhaut, Kalas et al. 2005)

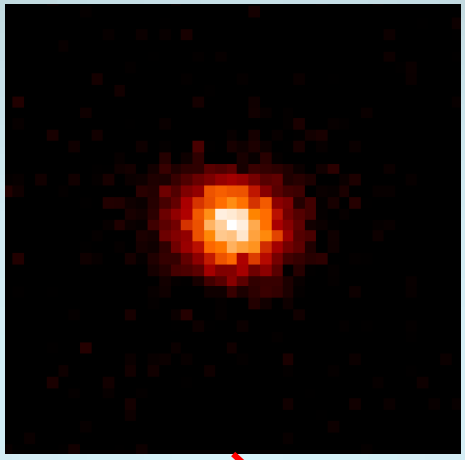


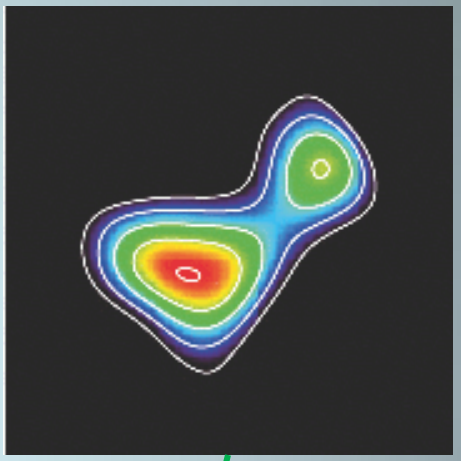
Clumps (ε eridani, Greaves et al. 1998)

Disk structures can be used to predict the existence of planets

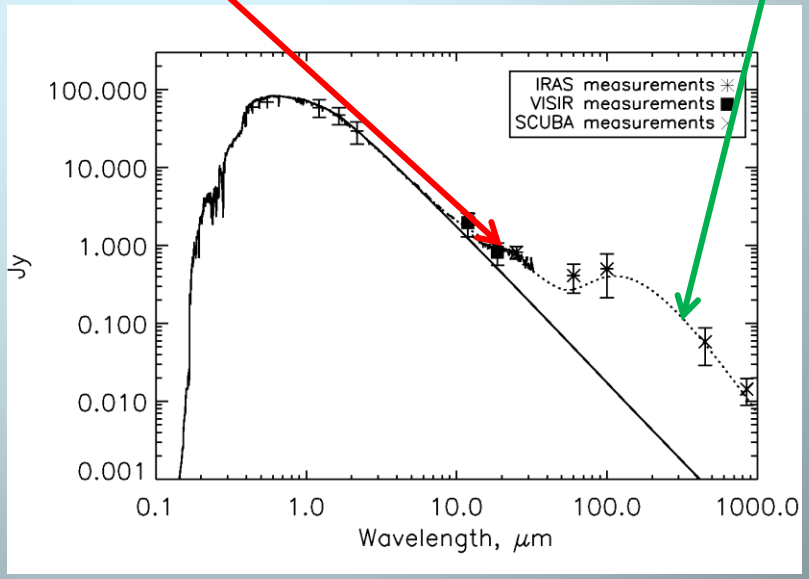
Structure changes with wavelength

Smith, Wyatt and Dent 2008





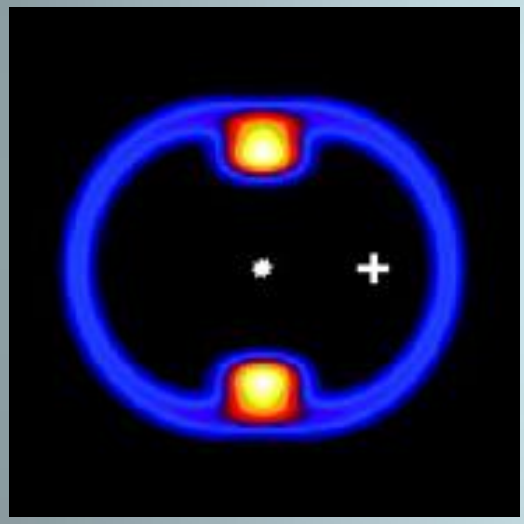
Observations at different wavelengths probe different regions of the disc...



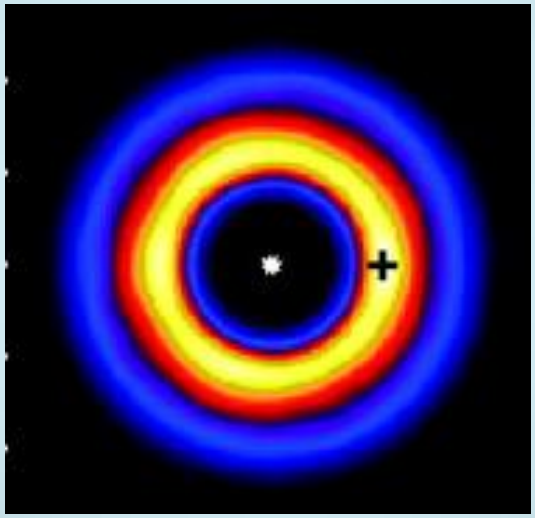
Wyatt et al. 2005

Structure changes with wavelength

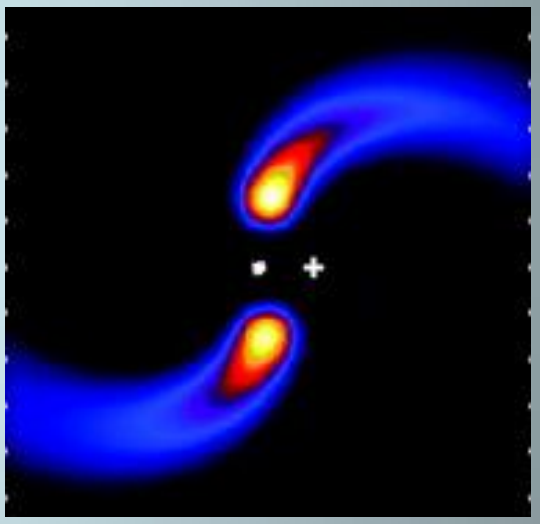
... and different dust grains from the same parent population (Wyatt 2006).



Largest bodies



Radiation pressure

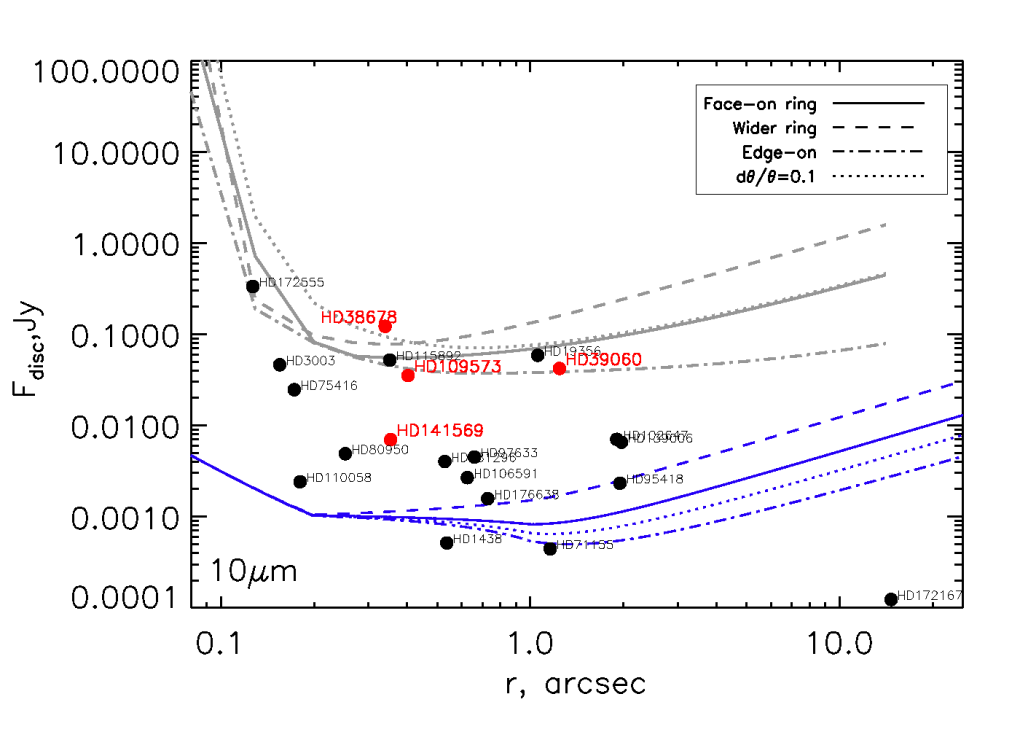


Blow-out grains

Combining the power and wavelength coverage of E-ELT and ALMA will allow a full exploration of the different populations.

The potential of the E-ELT

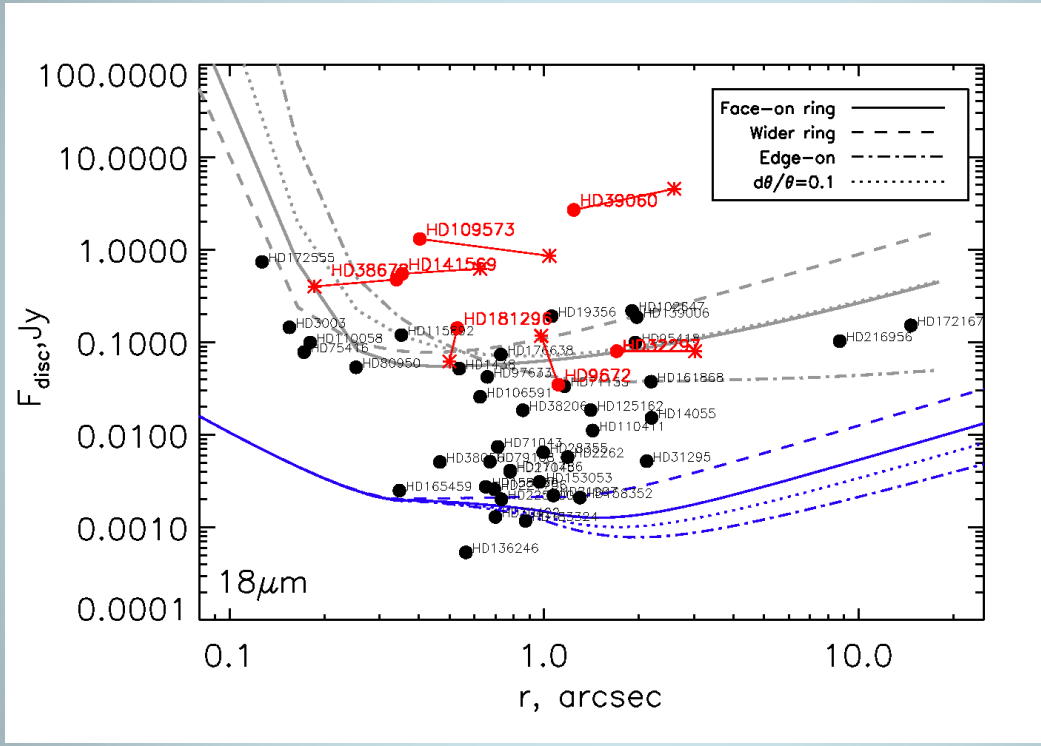
In the thermal regions, important for dust in terrestrial planet regions, the EELT can do much better than current instruments.



In 2 hours of on source integration more of the A star discs known from Spitzer photometry can be resolved on the EELT at N....

The potential of the E-ELT

...but at Q we can do even better!



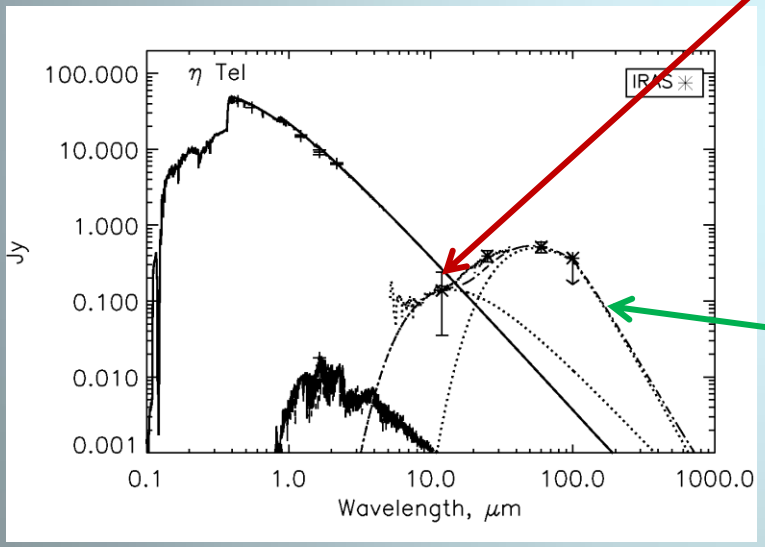
In 2 hours of on source integration most of the A star discs known from Spitzer photometry can be resolved on the EELT.

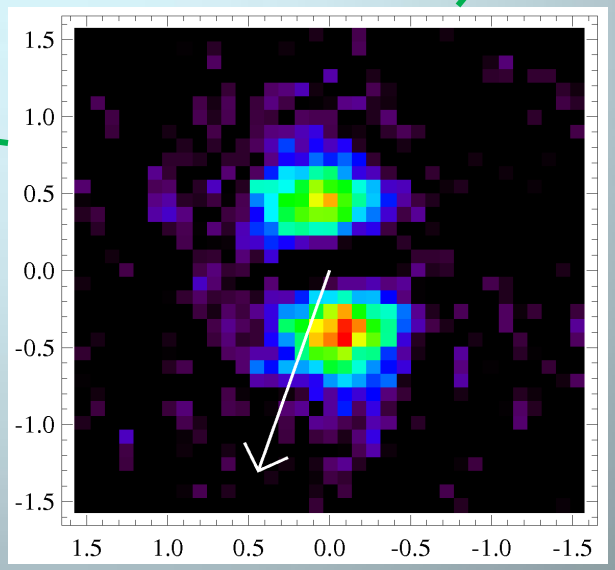
Test self-stirred models of Kenyon and Bromley (2005).

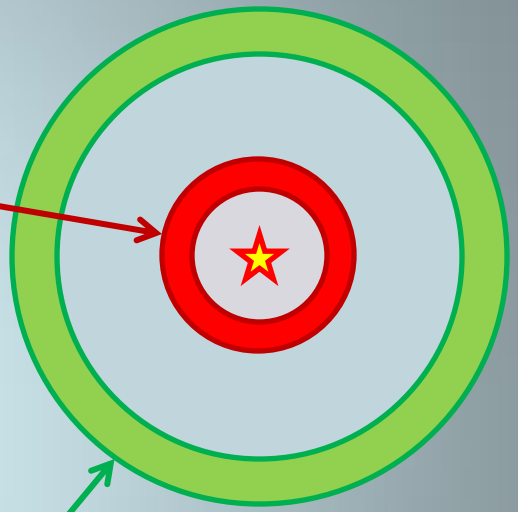
Case study – eta Tel

TReCS imaging at 18um revealed a near edge-on disc at ~24AU. An inner population at ~4AU remains unresolved as yet.

Unresolved inner disc



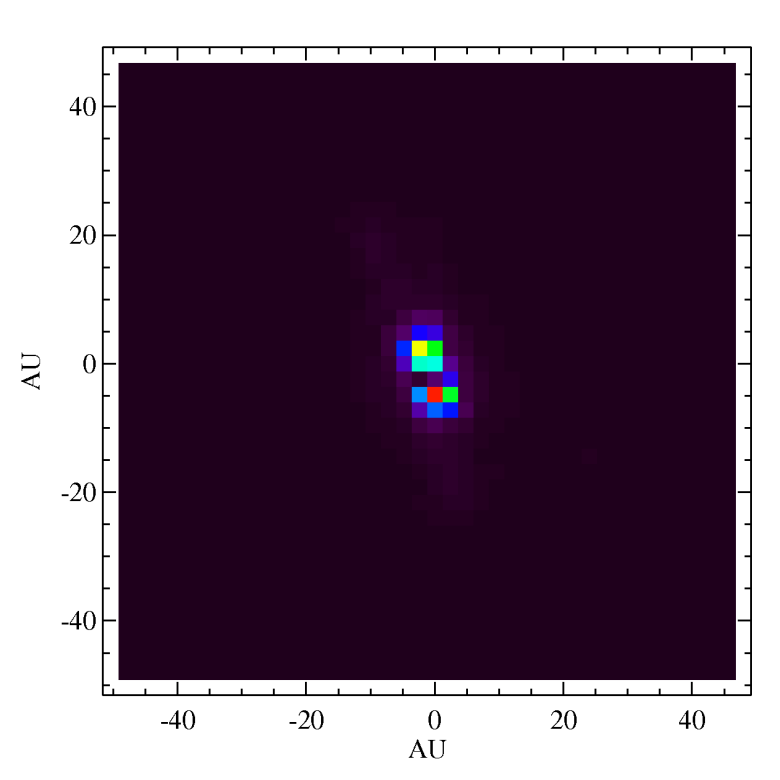


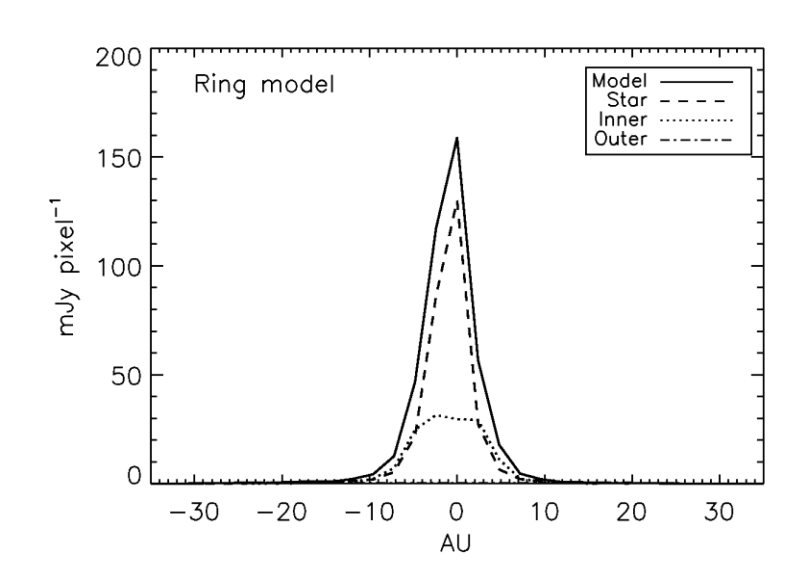


Smith et al. (2009)

Case study – eta Tel

With the resolving power of the E-ELT, we can resolve the inner disc.



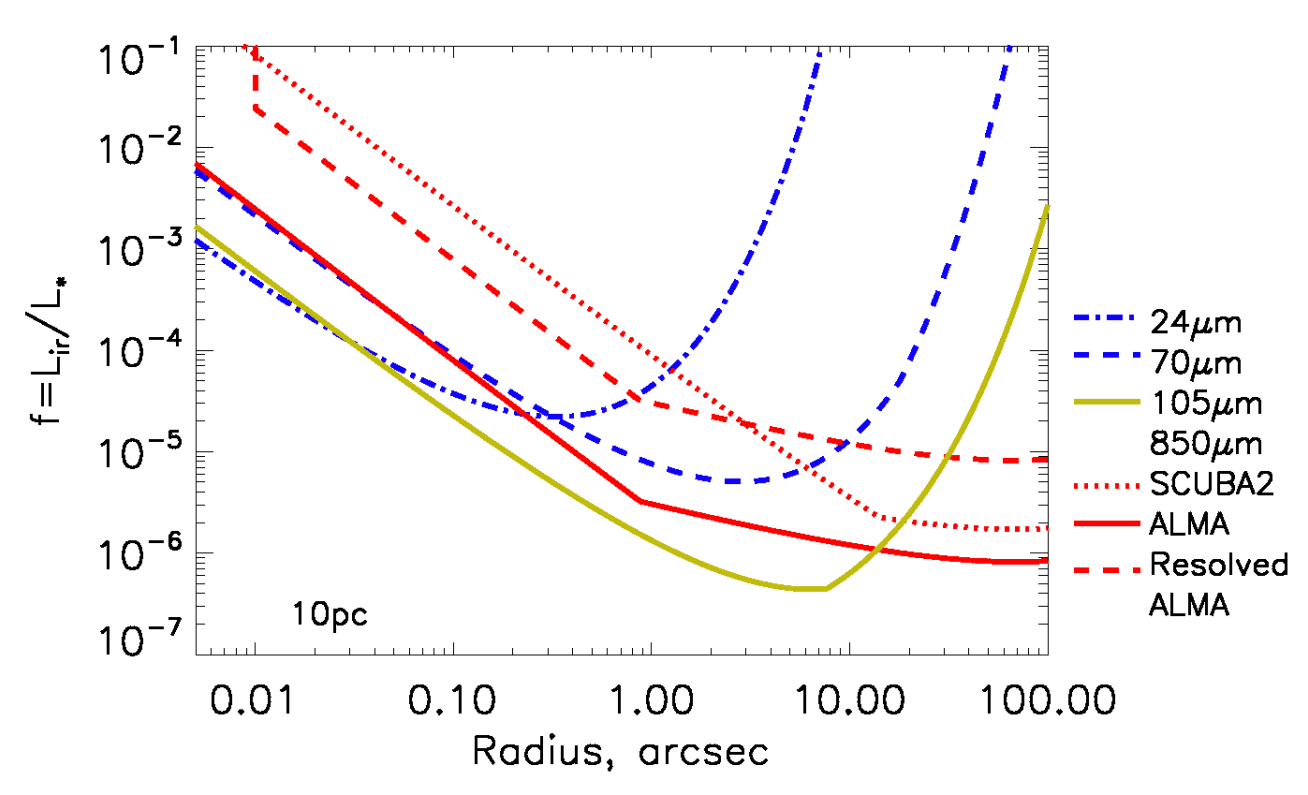


With a stable PSF ($d\theta/\theta \sim 0.1$) we can resolve the inner disc of η Tel. Observation requires only very short integration (~15minutes on source).

Model provided by Laura Churcher

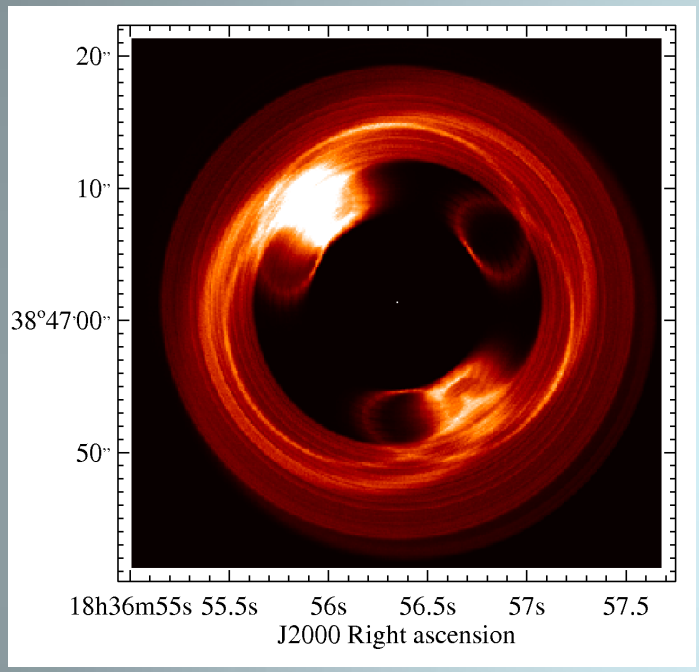
Inner ring could be terrestrial planet formation or asteroid belt. Look for sharp edges and asymmetries – evidence for planets.

The potential of ALMA



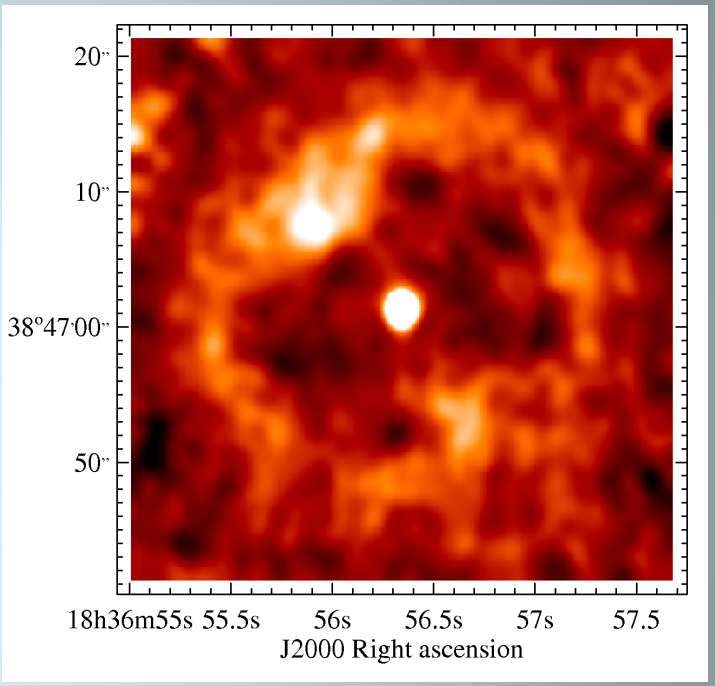
Solid line shows detection limit for discs around Sun-like stars with ALMA. To resolve the emission requires an order of magnitude greater flux.

The Vega debris disc



Disc structure predicted by model of migrating Neptune-mass planet.

Main features can be resolved using ALMA (at 850um).

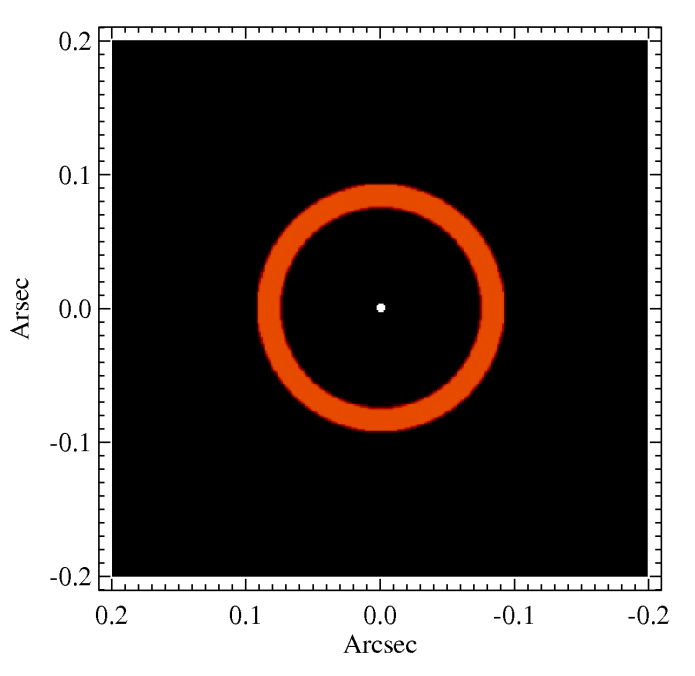


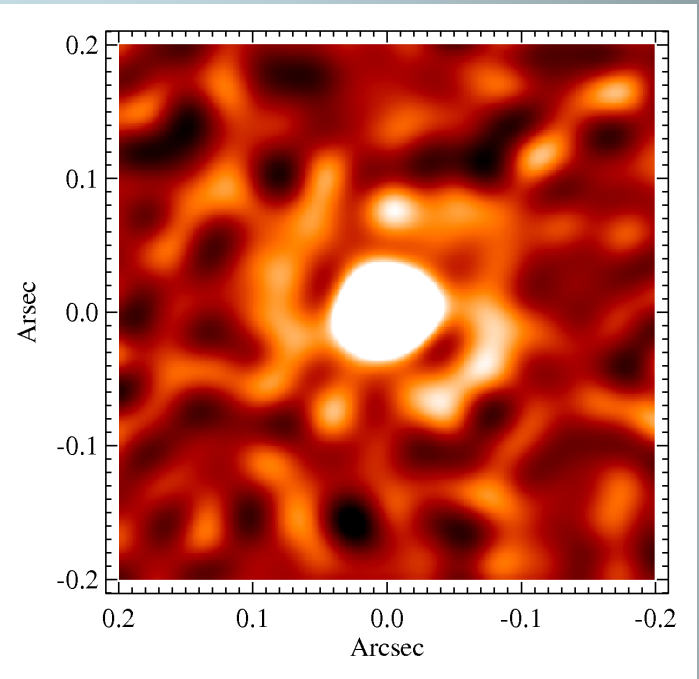
Brightness of star 5.6mJy/arcsec^2. Peak disc brightness 4.6μJy/arcsec^2. Model by Mark Wyatt. Simulations follow work of Rob Reid.

Simulations made with CASA almasimmos tool. Need 12hours of observation across 3 different configurations and ACA to get all the flux.

Orbital motion? Test models of structure formation.

The disc of HD69830





Total flux from the ring, 0.3mJy. Total from the star, 0.43mJy. Simulated observation took 12 hours using multiple configurations.

Resolving the terrestrial planet regions for the first time! Structure can inform models of LHB-like events or recent collisions.

Thanks

- Mark Wyatt, Laura Churcher. IoA Cambridge.
- Rob Reid NRAO.
- Royal Commission for the Exhibition of 1851.