# SCExAO/CHARIS HIGH- CONTRAST, MULTI-WAVELENGTH IMAGING OF THE BD+45°598 DEBRIS DISK

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## INTRODUCTION

**Debris Disks:** These are dust-rich, gas-depleted disks around young stars.Over several million years, the primordial disk gets used up as the dust collects together to form planetesimals. These planetesimals collide and re-populate the disk with a second generation of dust, forming debris disks

**SCExAO:** Extreme adaptive optics system optimized for detecting planets at very small separations.

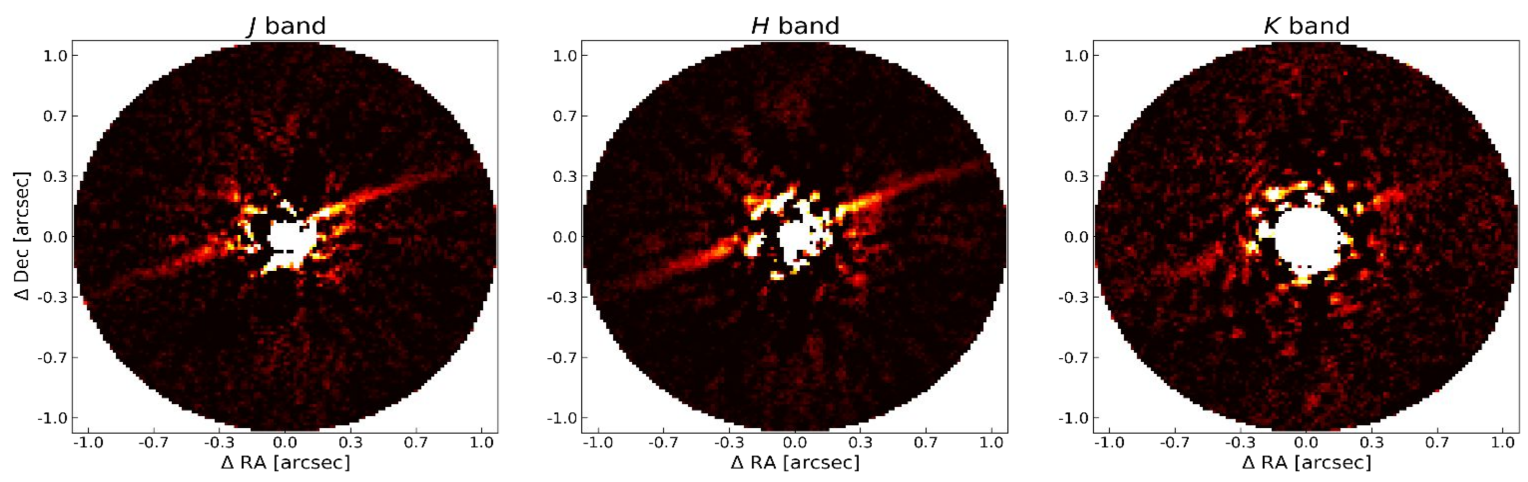
**CHARIS:** An integral field unit which enables to take images in multiple wavelengths and study wavelength dependent properties of the disk.

**High Contrast Imaging:**

1. Adaptive Optics- Corrects distortions in the wavefront due to atmospheric turbulence.
2. Coronagraphy- Reduces the starlight directly by controlling the diffraction inside the telescope using elements at focal and pupil plane
3. Differential Imaging- Disentangles the starlight from circumstellar signal

**BD45°598:** A young, Li-rich K1 type star with T = 5280 ± 100 K and L = 1.4 L☉. It is a member of the β Pic moving group with an age of 23 ± 3 Myr. The disk, discovered by Hinkley et al. 2021, is well suited to study the early evolution of debris disks and search for forming planets.

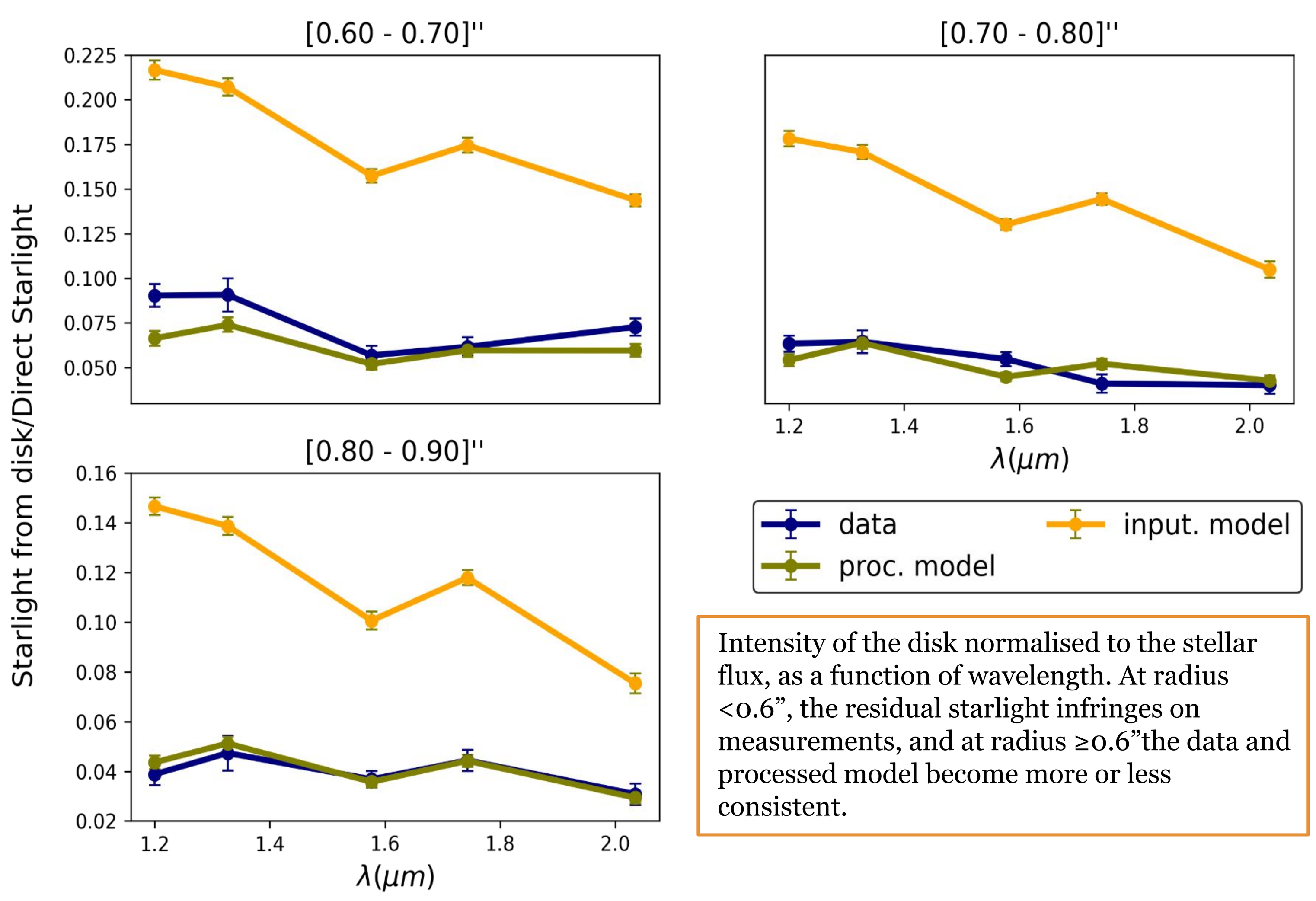
## POST PROCESSING RESULTS




Above are images of the disk post ADI-ALOCI PSF subtraction with wavelength channels median-combined within J, H, and K bands. SNR ~2.8-7.5 along the spine of the disk.

The disk was detected in most wavelength channels. Some channels have been excluded in the median combined images as they lie outside the nominal J,H,K bands and are affected by telluric absorption.

## COLOR GRADIENT



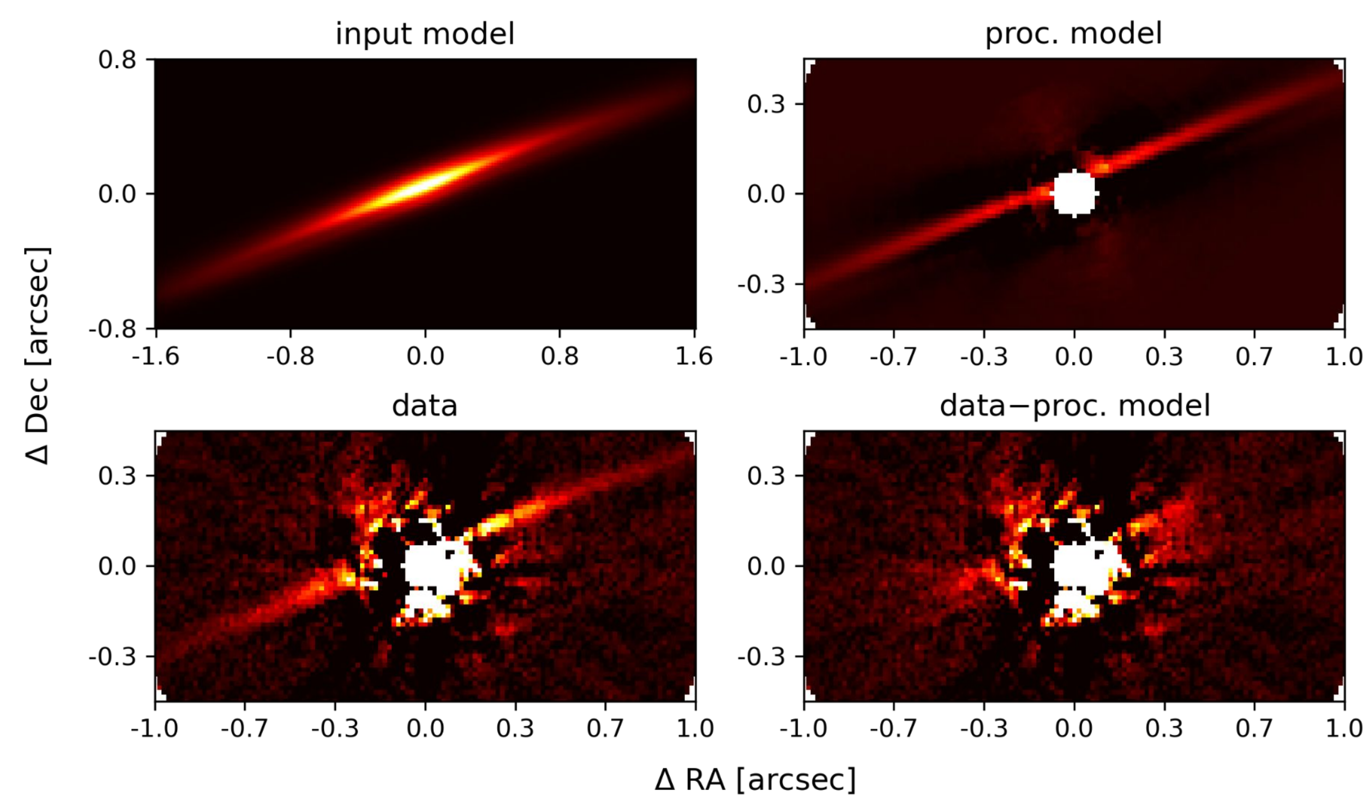

Intensity of the disk normalised to the stellar flux, as a function of wavelength. At radius <0.6", the residual starlight infringes on measurements, and at radius ≥0.6"the data and processed model become more or less consistent.

The intensity is higher in the bluer wavelength. The ratios of fractional intensity at 1.2 μm to that at 2.1 μm amounts to 1.51 ± 0.05, 1.70 ± 0.09, and 1.94 ± 0.11 for the respective radial distances in the above figure. Relating this to the result of simulations presented in Boccaletti et al. (2003), the minimum disk grain (composed of graphite, amorphous, and crystalline silicates) size can be inferred to be ~0.1 μm for a porosity of 0, assuming a -3.5 power law.

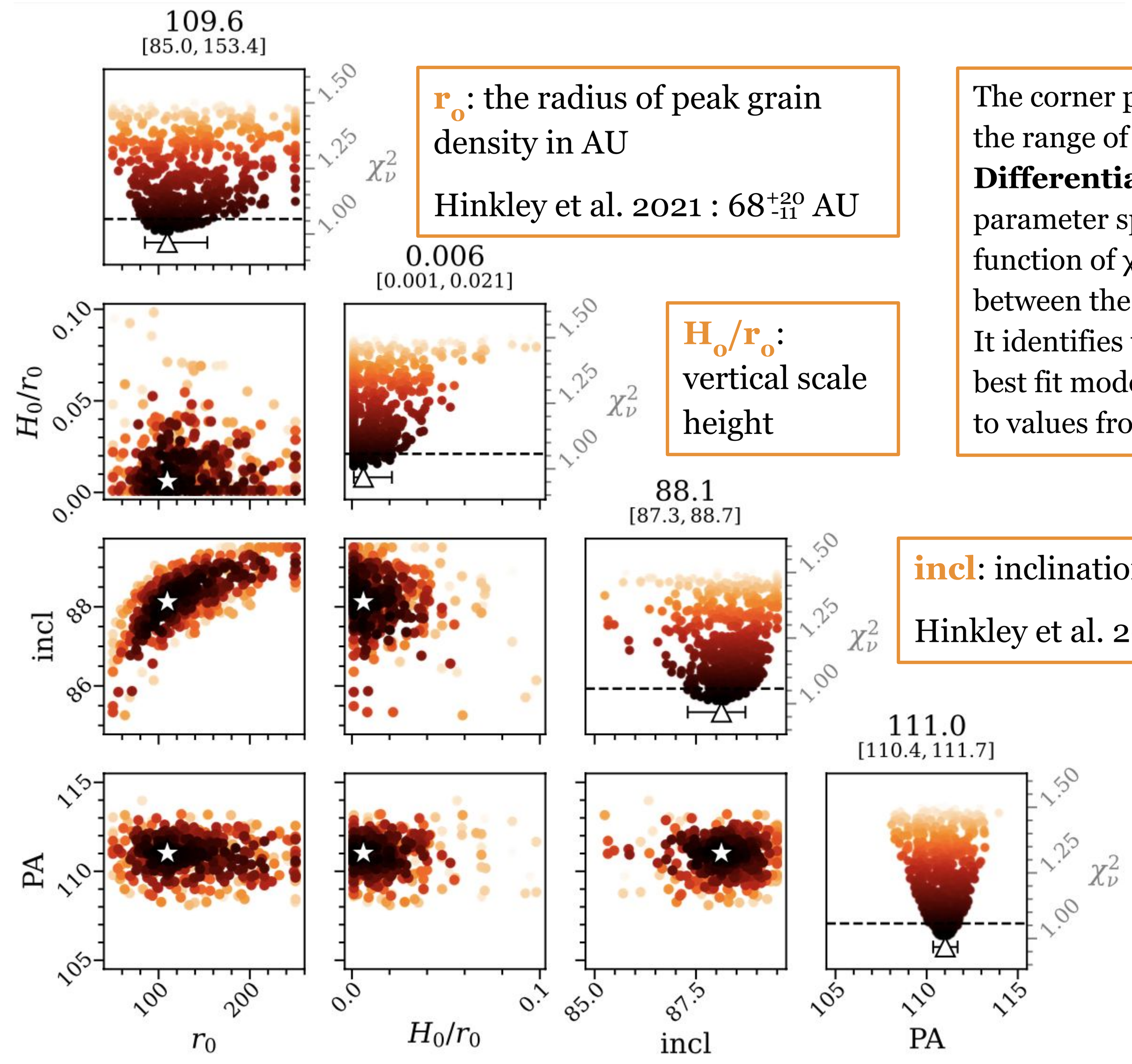
## DATA PROCESSING

Data extracted as 22 x 201 x 201 data cubes → Sky-subtraction → Image cube registration → Spectrophotometric Calibration → Point spread function (PSF) subtraction using the ADI-ALOCI algorithm

## FORWARD MODELLING




- **input model**: the best fitted synthetic disk which is the input model convolved with the instrumental PSF prior to forward modeling
- **proc model**: the model disk post forward modeling, ie the synthetic equivalent of the wavelength collapsed image of the disk after PSF subtraction
- **data**: the wavelength collapsed, PSF subtracted image of the disk
- **data-proc model**: the residual for the data product and the synthetic disk model post processing. The minimal residual suggests our model closely matches the data.




$r_o$: the radius of peak grain density in AU

Hinkley et al. 2021 : $68^{+20}_{-11}$ AU

$H_o/r_o$: vertical scale height

incl: inclination in degrees

Hinkley et al. 2021 : $86.11^{+2.2}_{-2.0}$ degrees

PA: position angle in degrees

Hinkley et al. 2021 : 110.2±1.20 degrees

The corner plot on the left displays the range of values explored by **Differential Evolution** in the parameter space, the solution as a function of $\chi^2_v$ and the correlation between the different parameters. It identifies the parameters for the best fit model, which we compare to values from Hinkley et al. 2021.

We find that the disk is highly inclined, like the original results. However, the radius derived here is larger than the original value. The difference in radius is harder to understand since the dust was modeled as a narrow ring in both works. The width of the ring is not well constrained for highly inclined disks, but the larger radius that we find suggests an extended disk. The difference in radius can be explained as follows:

1. The scattered light model of the disk is fitted for J, H, and K bands in this study, whereas Hinkley et al. (2021) fits the model for data only at 2.2μm. The shorter wavelengths we probe could be sensitive to an outer halo of smaller grains not visible in the 2.2 μm data.
2. The two studies assumed different scattering phase functions, which can affect the derived disk parameters.

SCAN ME

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