Debris Disks with PIONIER

Steve Ertel

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Exozodis with PIONIER

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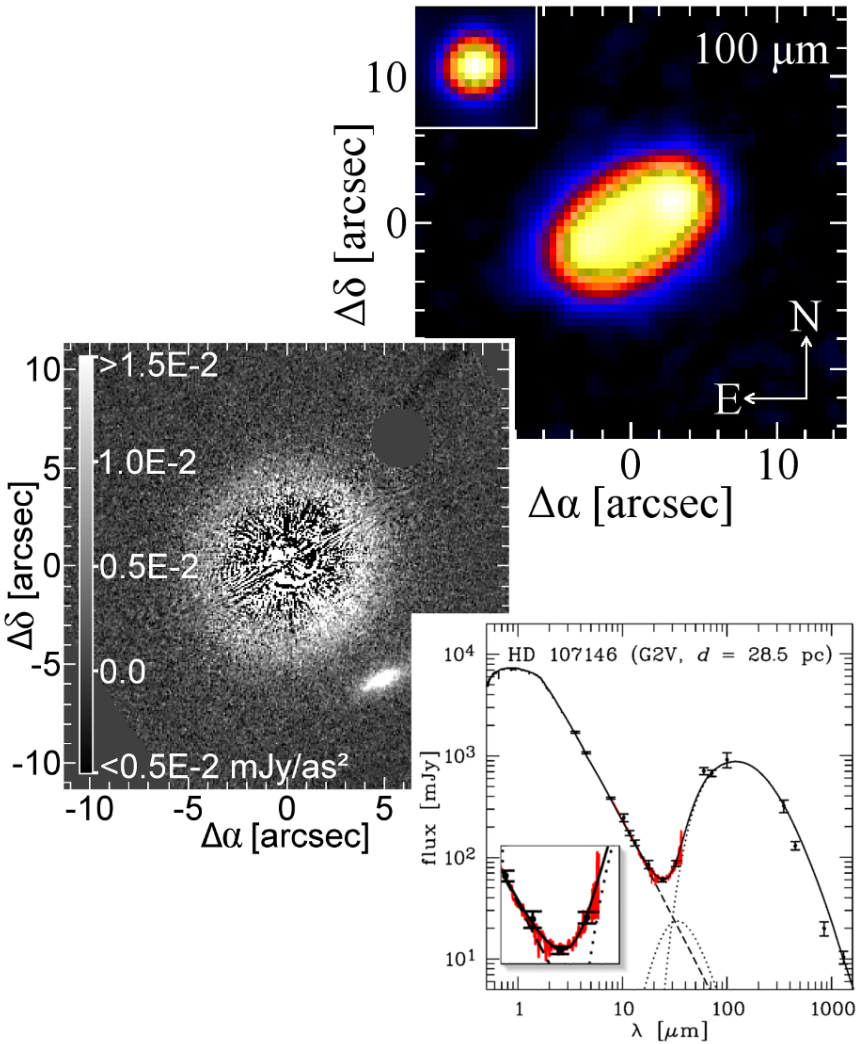
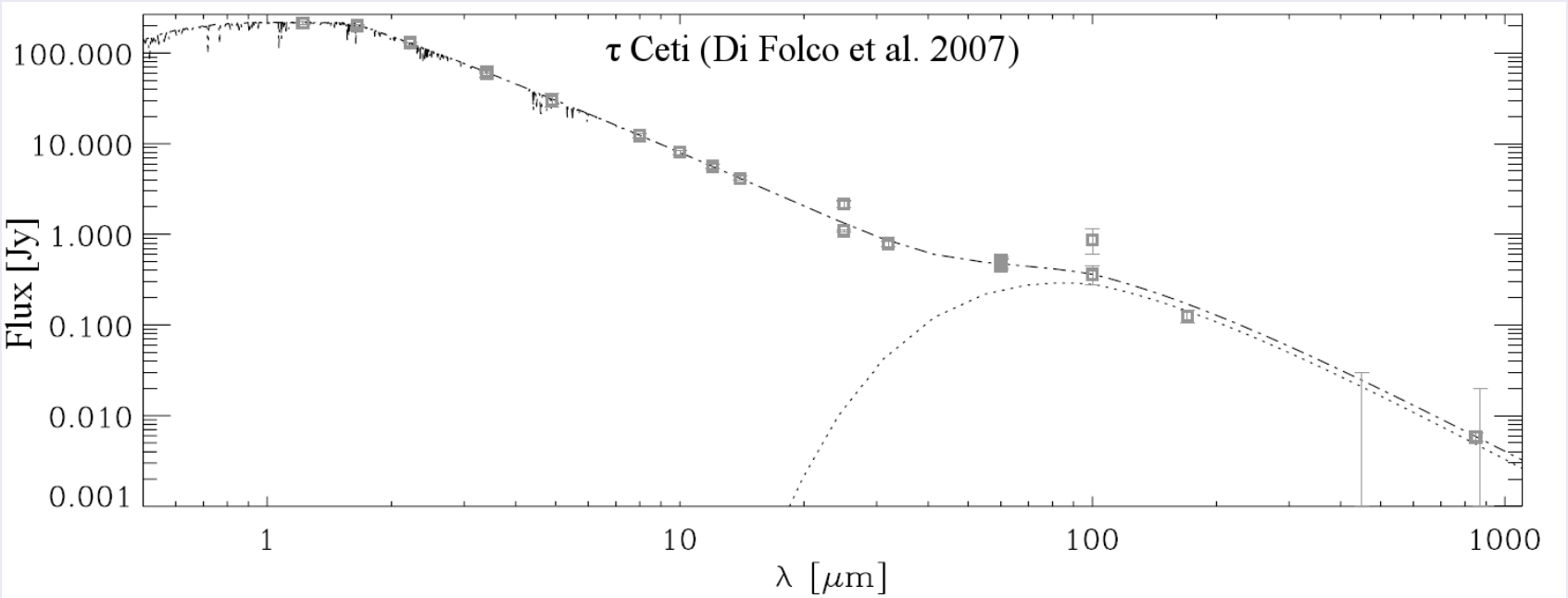

100 μm
10
0
Δδ [arcsec]
N
E
0
10
Δα [arcsec]
10
5
0
-5
-10
>1.5E-2
1.0E-2
0.5E-2
0.0
<0.5E-2 mJy/as²
-10
-5
0
5
Δα [arcsec]
Δδ [arcsec]
HD 107146 (G2V, d = 28.5 pc)
flux [mJy]
λ [μm]
1
10
100
1000

Exozodiacal dust clouds

How to detect exozodis?



- A new unit: 1 zodi = fractional luminosity ($L_{\text{dust}}/L_{\star}$) of our zodical dust
- Spitzer sensitivity (3σ): 100 zodis (70 μm), 1000 zodis (24 μm), 1400 zodis (8 μm)

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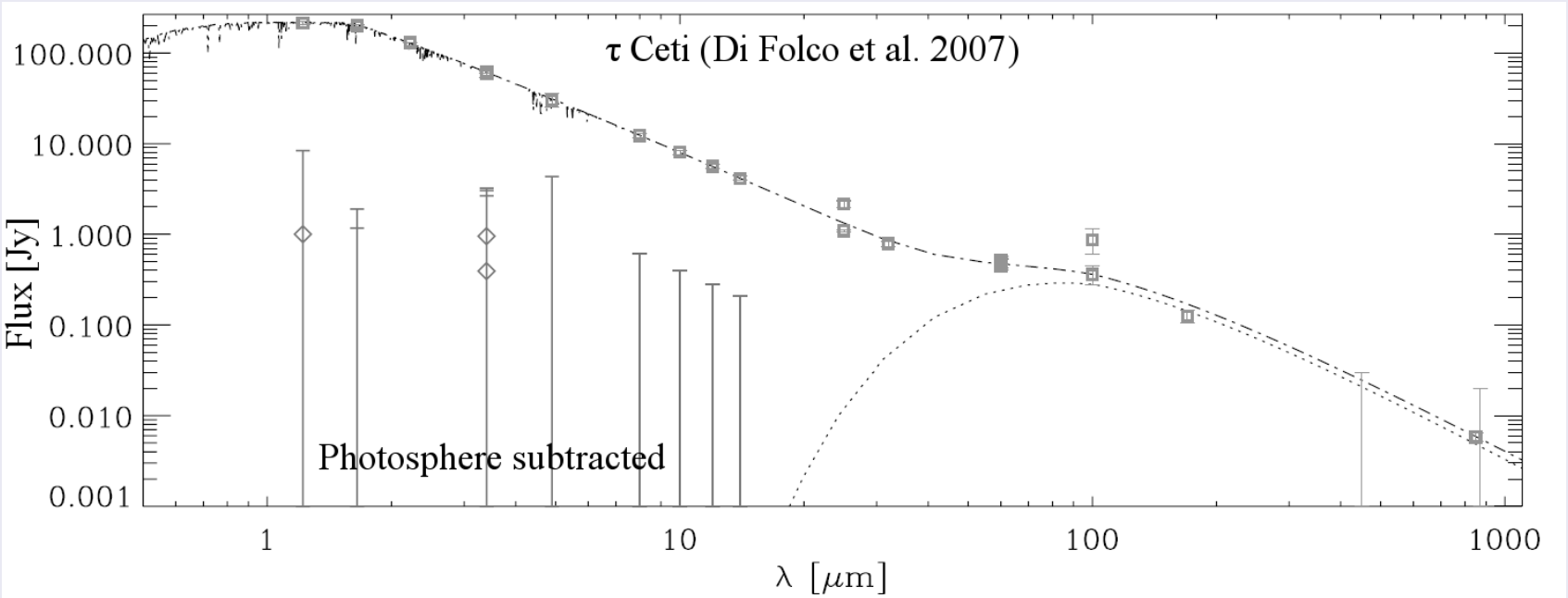

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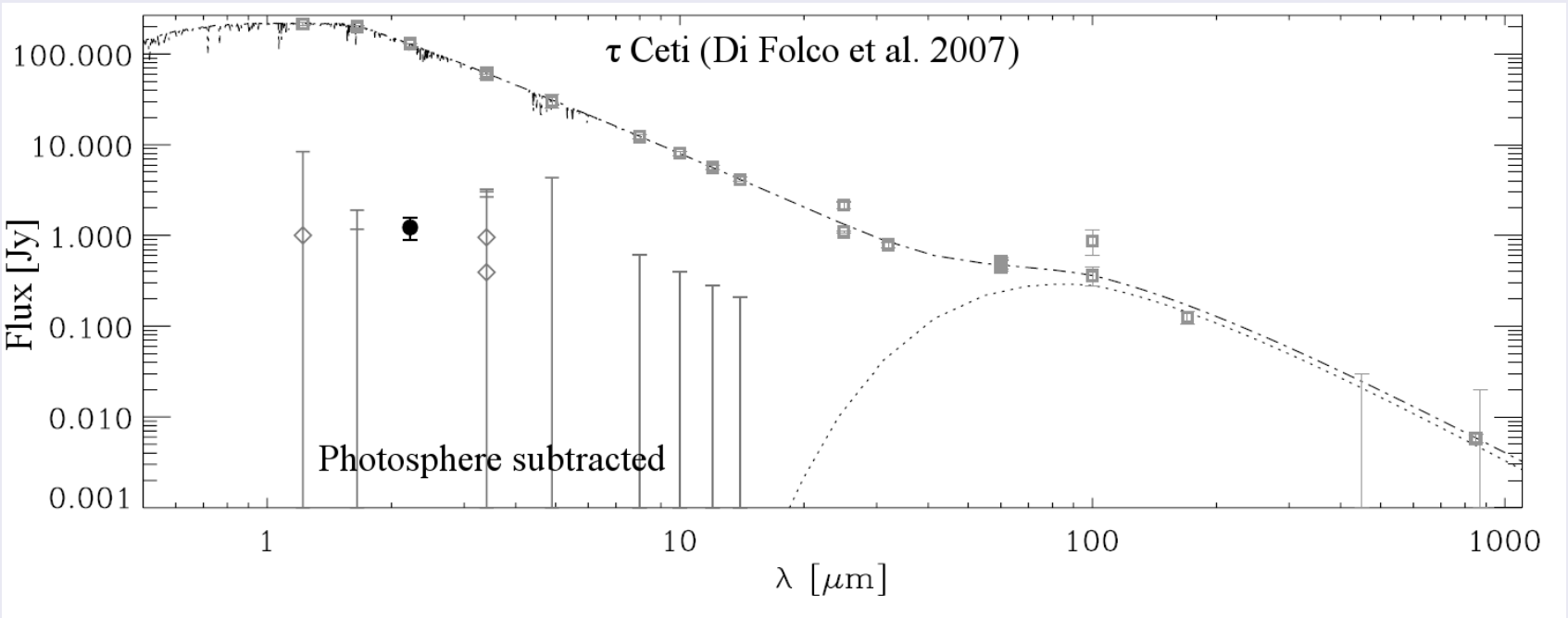
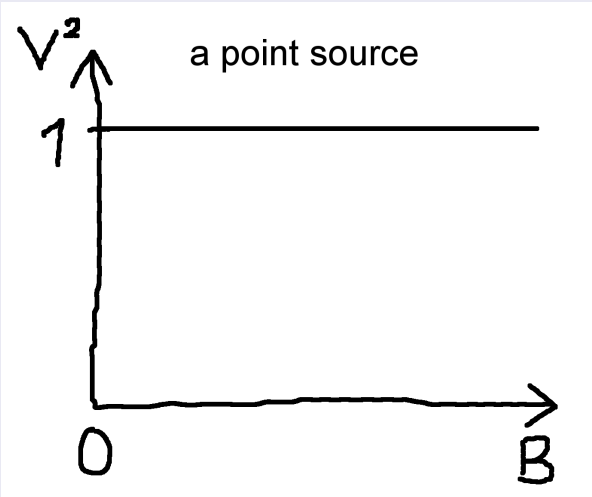
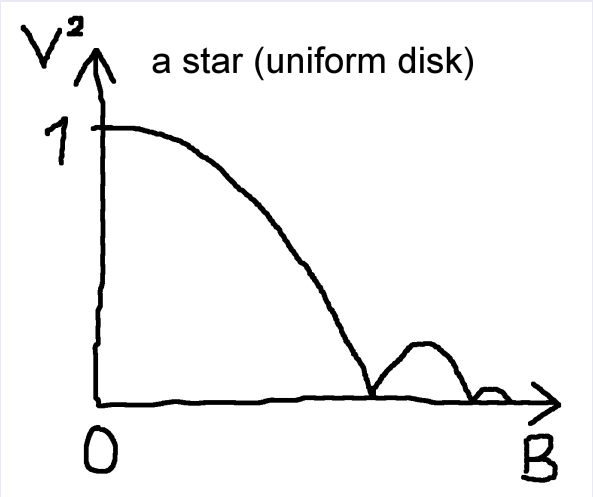
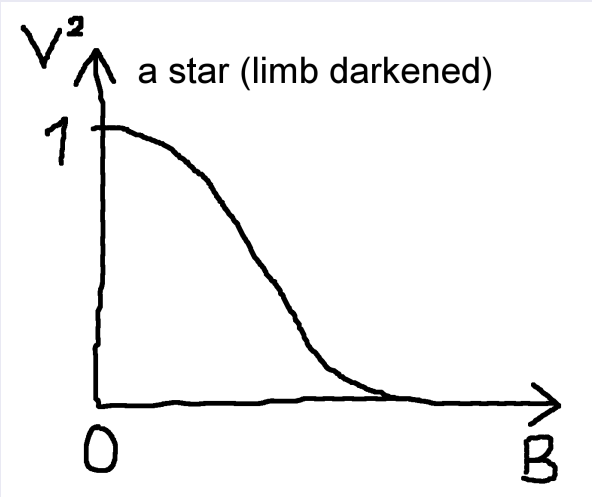


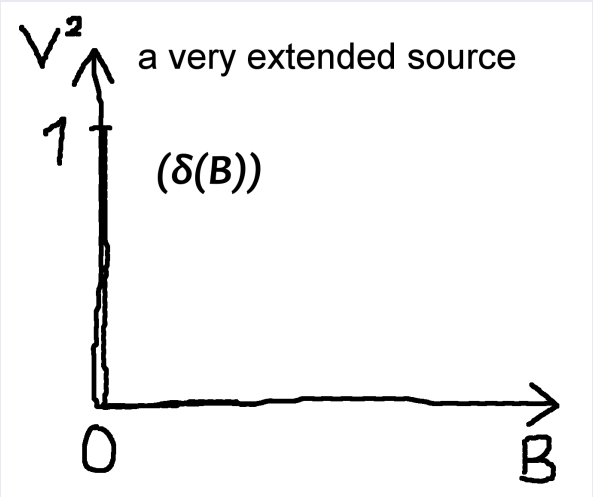
- F_{disk} in the order of 10 mJy to Jy in near-infrared, easily detectable if star was not there
- Disentangle disk & star, measure flux of disk alone with photometric uncertainty of few percent, **but how?**

Interferometric detection of extended circumstellar emission

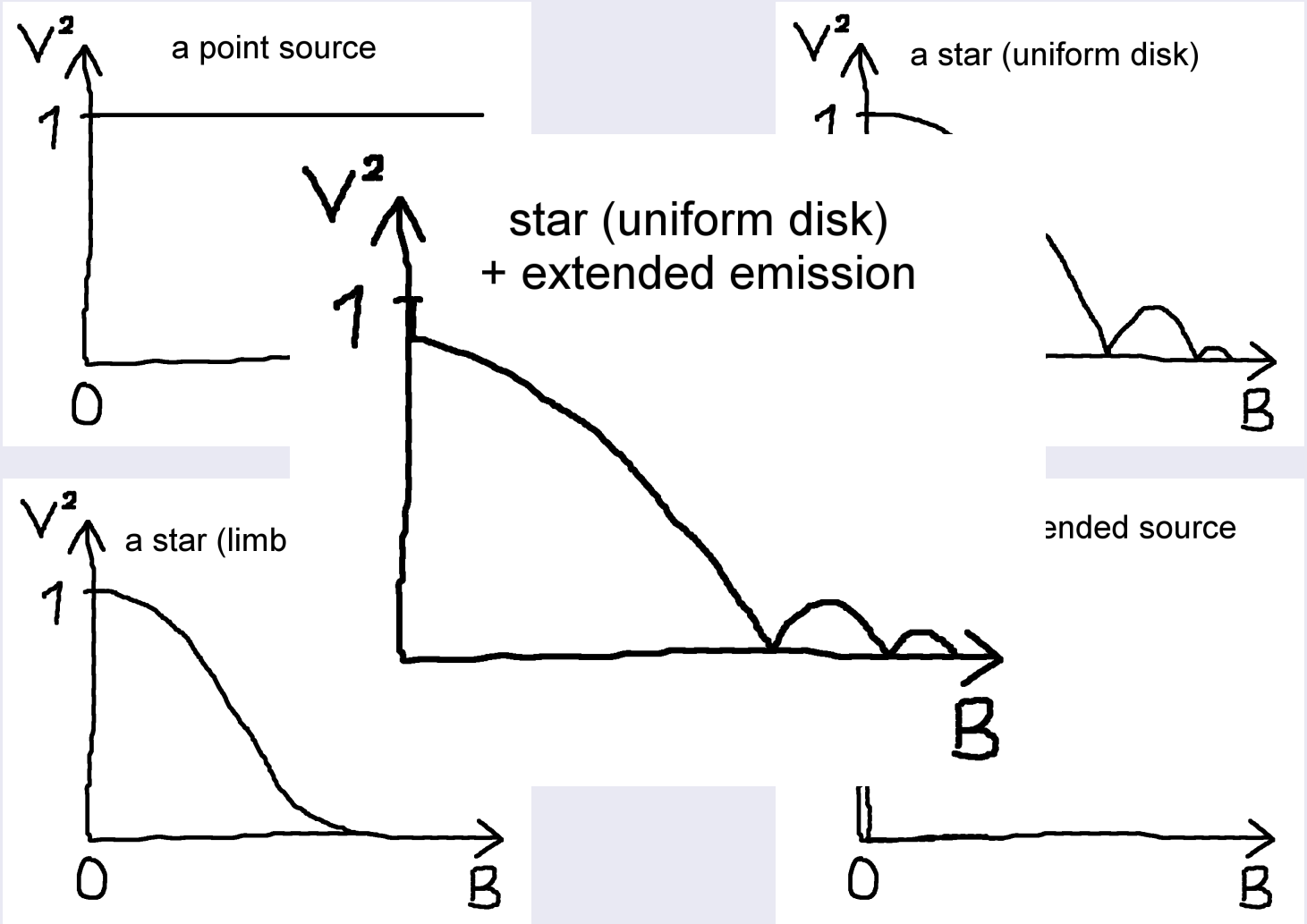




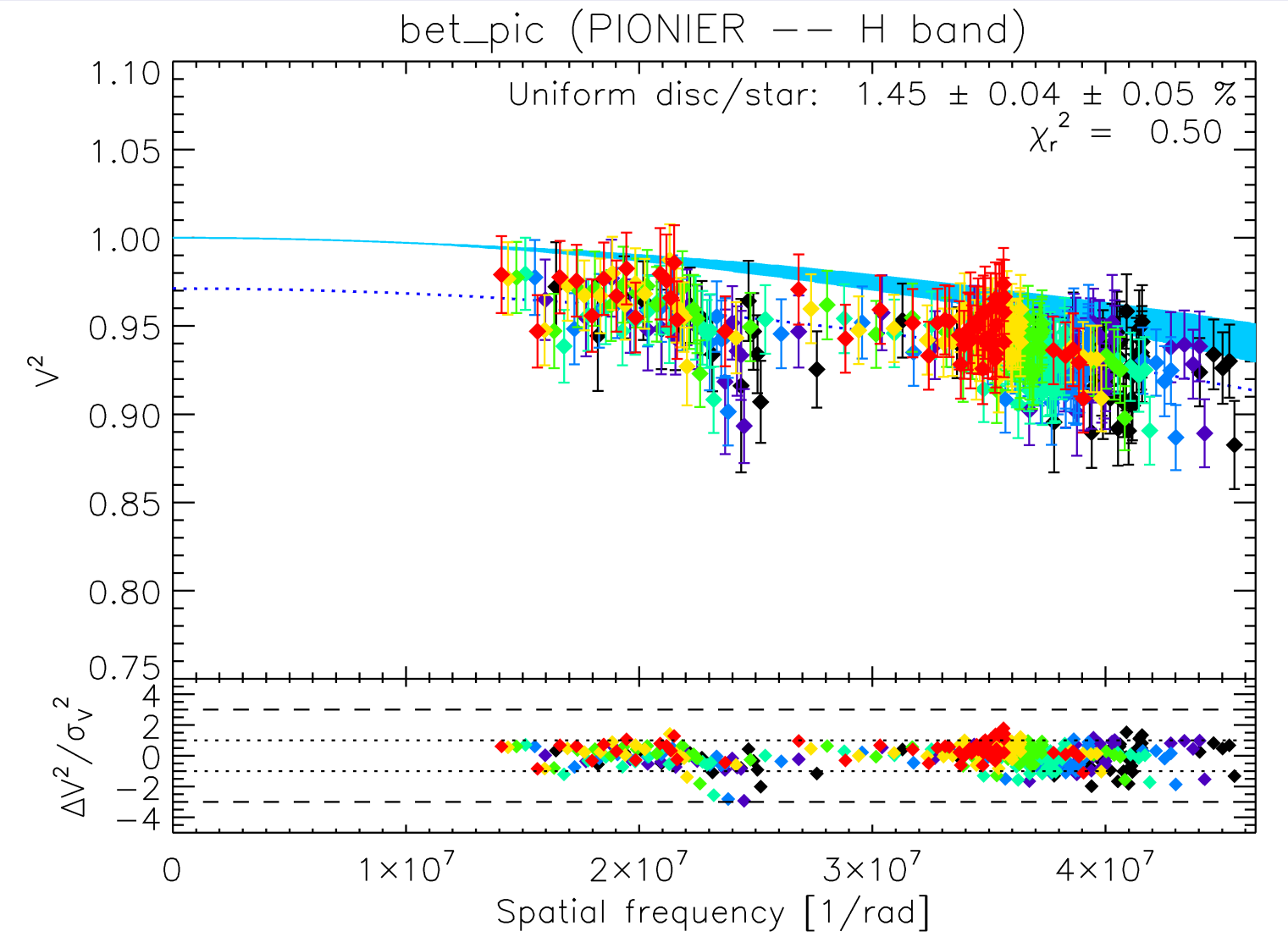




Interferometric detection of extended circumstellar emission



Examples


bet_pic (PIONIER -- H band)
Uniform disc/star: 1.45 ± 0.04 ± 0.05 %
χ_r^2 = 0.50
V^2
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
$\Delta V^2/\sigma_V^2$
4
2
0
−2
−4
0
1×10^7
2×10^7
3×10^7
4×10^7
Spatial frequency [1/rad]

Exozodiacal dust clouds

Possible origins of the dust

Several possible explanations, but all have problems

- Local collisions of large bodies
  - High amount of dust vs. short lifetime of dust and large age of systems

  $\Longrightarrow$ Statistics of frequency/dust mass vs. age
- Recent planetary collision
  - Low probability vs. high detection rate?

  $\Longrightarrow$ Statistics of frequency among stars in general
- Evaporation of comets from outer disk
  - Large number of comets required (Late Heavy Bombardment?)

  $\Longrightarrow$ Statistics of correlation between exozodis and exo-Kuiper belts

$\Longrightarrow$ **Statistics!!!**

The EXOZODI project

Overview

- First **statistical** survey for exozodis
- Northern (CHARA/FLUOR, K band) and southern (VLTI/PIONIER, H band) hemisphere
- ~ 100 stars ($H, K < 5$) with debris disks and same number without (known) debris disks
- Northern sample basically observed (Absil et al., in prep.)
- Observations of southern sample just started (April 2012)
- Additional follow-up observations of detections (color, time variability) and some more detailed studies of single objects
- Interpretation of results through detailed analytical, dynamical and collisional modeling

First results from the northern sample

- Similar detection rate for hot dust as for cold dust, decreasing towards later spectral types
- Cold dust not required for presence of hot dust
- **Strange:** For FGK stars the PRESENCE, for A stars the ABSENCE of cold dust seems to support the presence of hot dust.
- **Note:** Still preliminary results, small number statistics, some biases in northern sample.

The EXOZODI project: PIONIER observations

Observing strategy

- Use shortest baselines, stellar diameters from brightness relations (V to JHK)
- Star is then (mostly) unresolved, errors from brightness relations small
- Exozodi still resolved out (mostly larger than FOV)

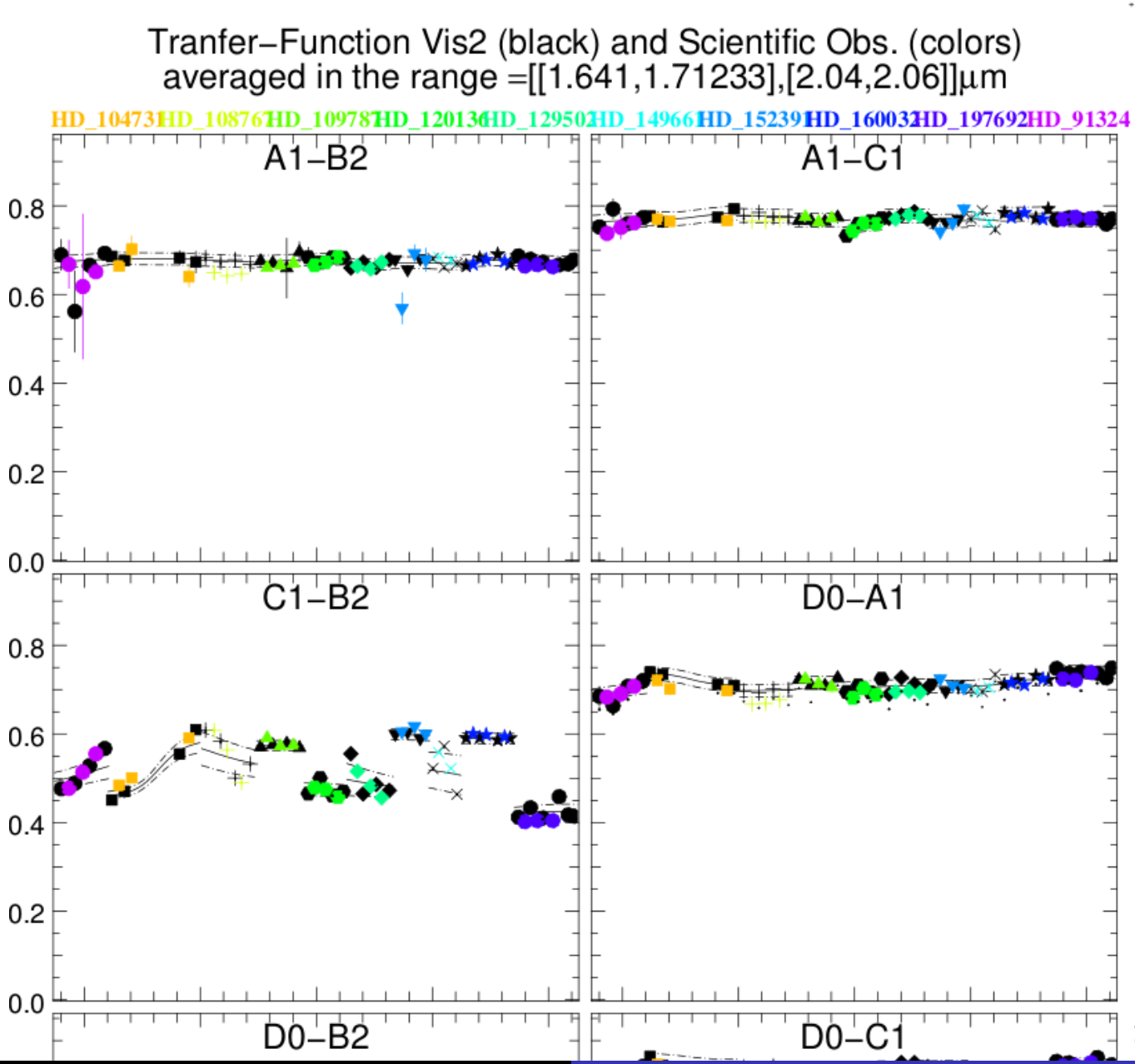
$\Longrightarrow$ Point source + fully extended source

- Typically three shots with calibrators in between, 18 visibilities, cumulative $3\,\sigma$ accuracy $\sim 0.5\%$

Status of observations

- Total of 12 nights necessary (~ 100 stars), 6 granted, 6 proposed for last OT call (decision pending)
- First two nights observed, third lost due to weather, 19 targets, results pending

A technical issue with PIONIER



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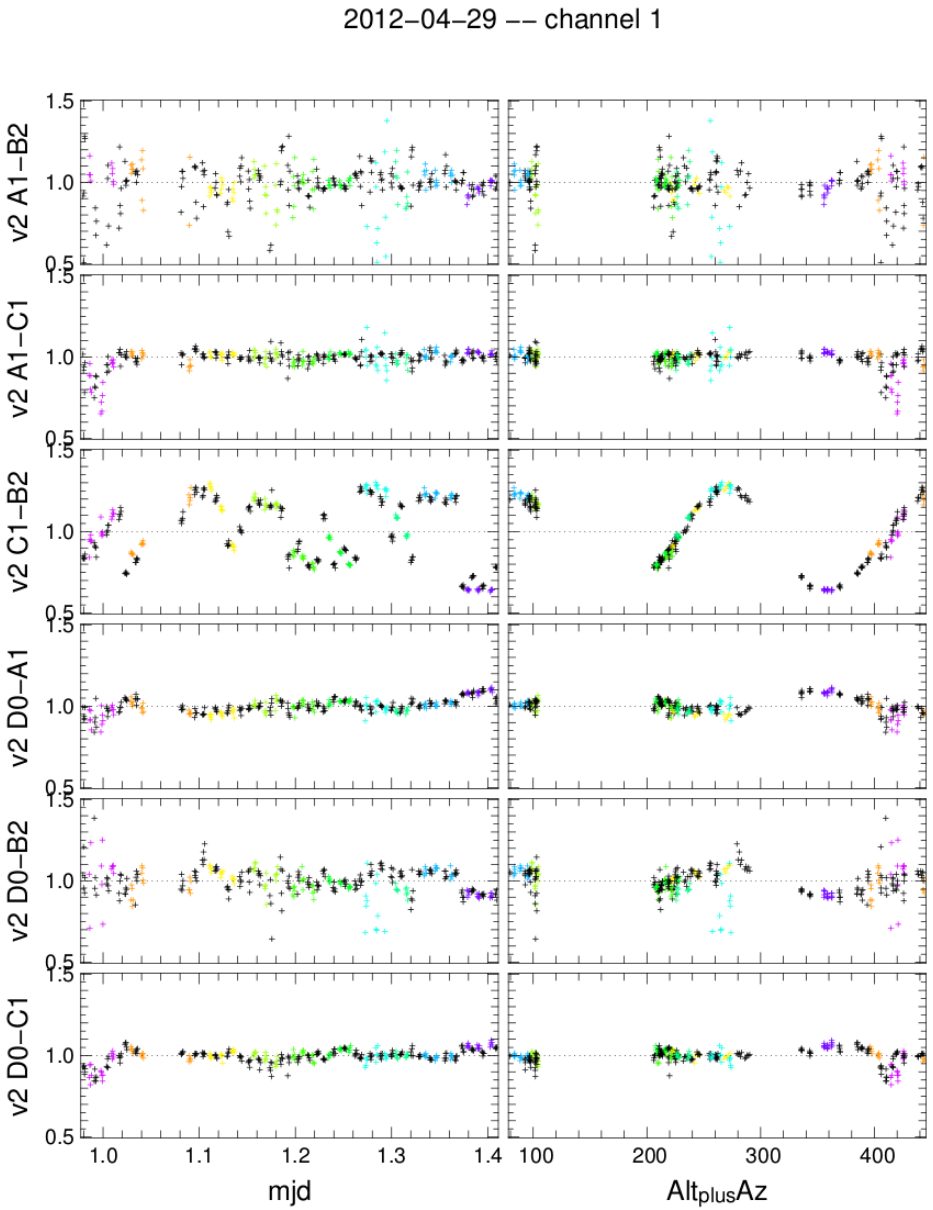

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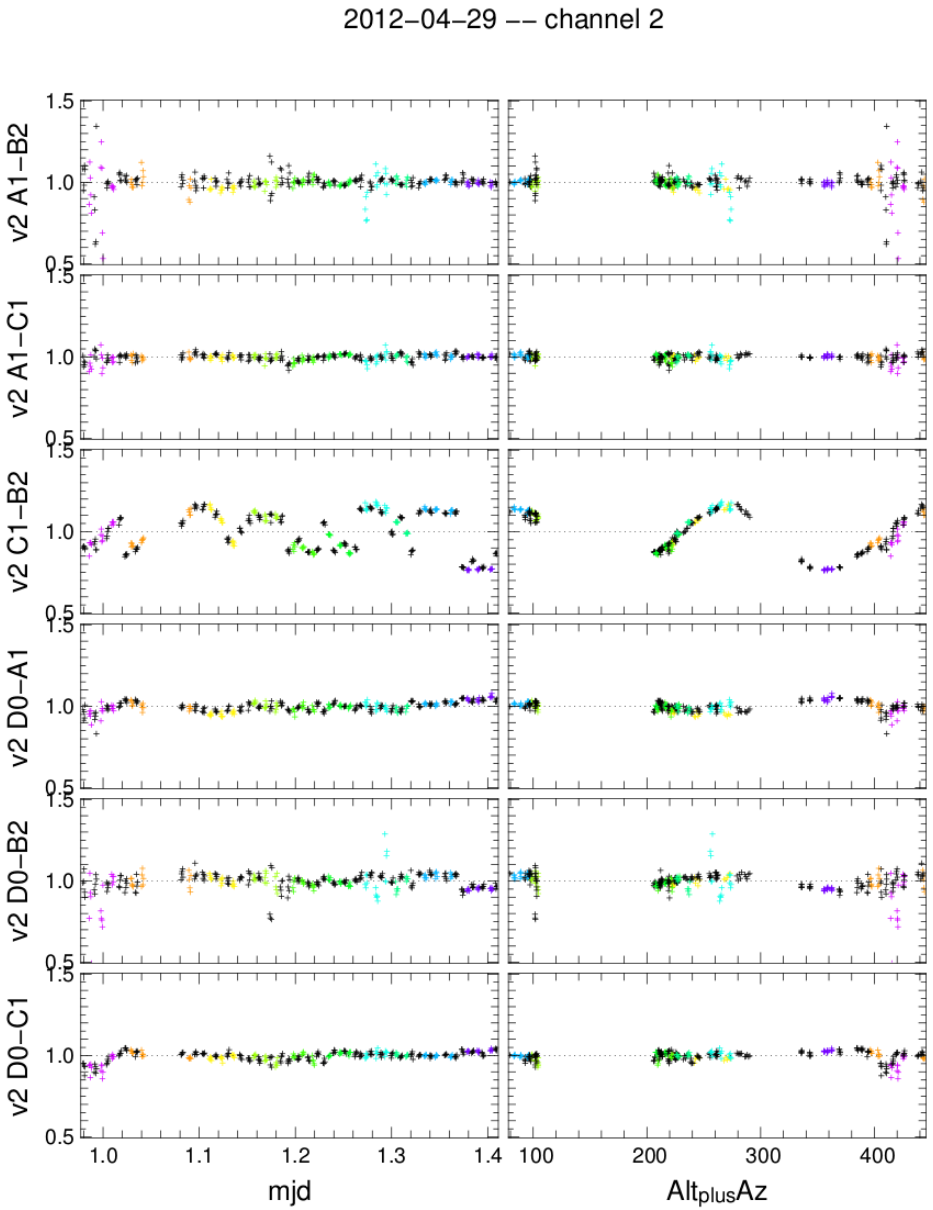

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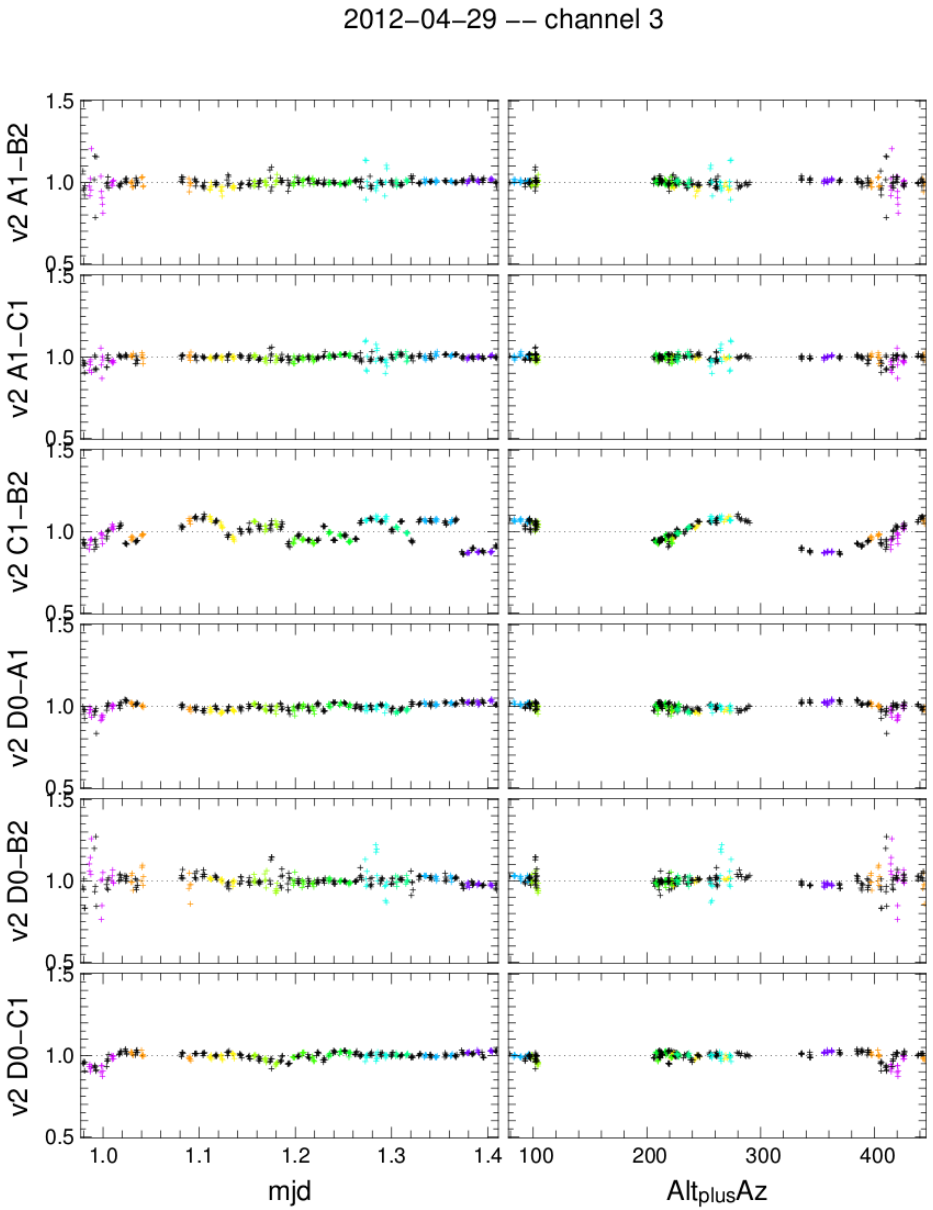

Thank you very much!

The EXOZODI project: PIONIER observations

Sample

- Consider all main sequence stars observed by *Spitzer* at $70\mu\mathrm{um}$ and by *Herschel*
- Separate in debris disk and non-excess stars
- Skip all close binaries ($< 5''$)
- Estimate stellar diameter from brightness relations (V to JHK)
- Skip stars with large diameters (no MS stars?)
- Always observe a debris disk star followed by a most similar non-excess star (most comparable samples)