DUNES

DUst around NEarby Stars

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on behalf of the DUNES consortium

DUNES

- Herschel Open time Key Programme with the aim of studying cold dust disks around nearby solar-type stars

-Tools: PACS photometry at 70, 100, 160 μm
SPIRE photometry at 250, 350, 500 μm

DUNES People

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Background. I

- IR excesses around MS stars was one of the main IRAS discoveries

  - Debris disks: dust disks continuously replenished by collisions of large bodies

  - Second generation disks in the sense that dust grains in debris disks are not primordial since the lifetime of dust grains (against destructive collisions, Poynting- Robertson drag, radiation pressure) is much shorter than the age of the stars

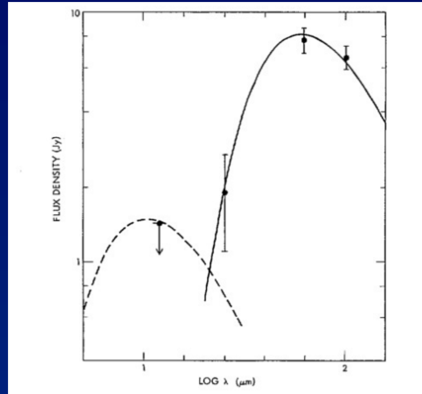


FIG. 1.—Energy distribution of the infrared excess from α Lyr.

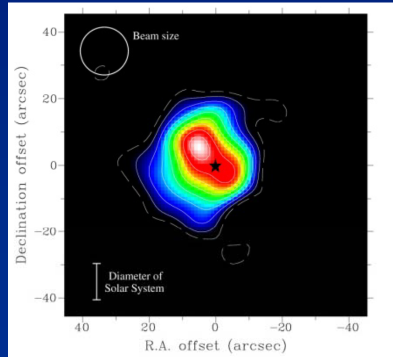
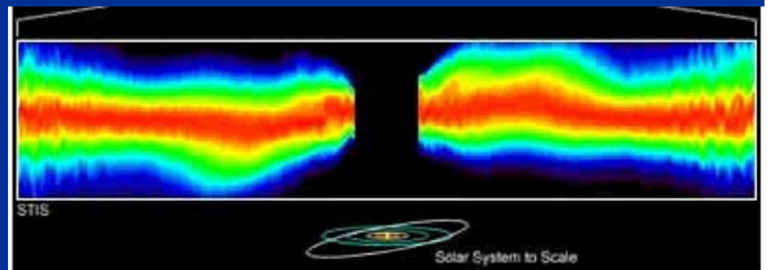
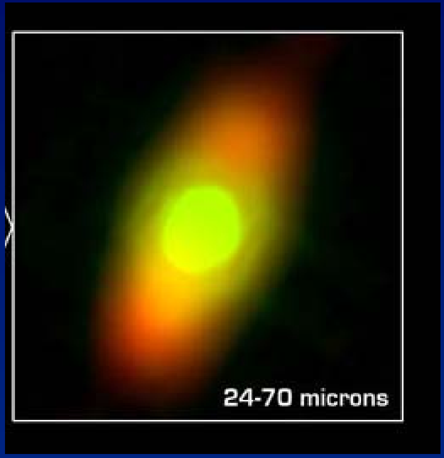


Figure 3. 850 μm image of Vega, annotated as in Figure 1.



Background. II

- Great impact of Spitzer, e.g.:
  - Debris disks incidence from A to M type stars
  - Age distribution
  - Presence of planets



- Spitzer limitations:
  - Poor spatial resolution → some fundamental disk parameters are poorly constrained (resolved images are required)
  - Large beam (confusion) → relatively bright disks
    $L_{dust}/L_* \gtrsim$ several times 10^{-6} (~ 10^{-7} Solar System KB)
  - Not sensitive to λ > 70 μm → limit the detection of cold disks

✓ **Herschel overcomes those limitations:**
- **small beam**
- **sensitive to $\lambda > 70$ μm**

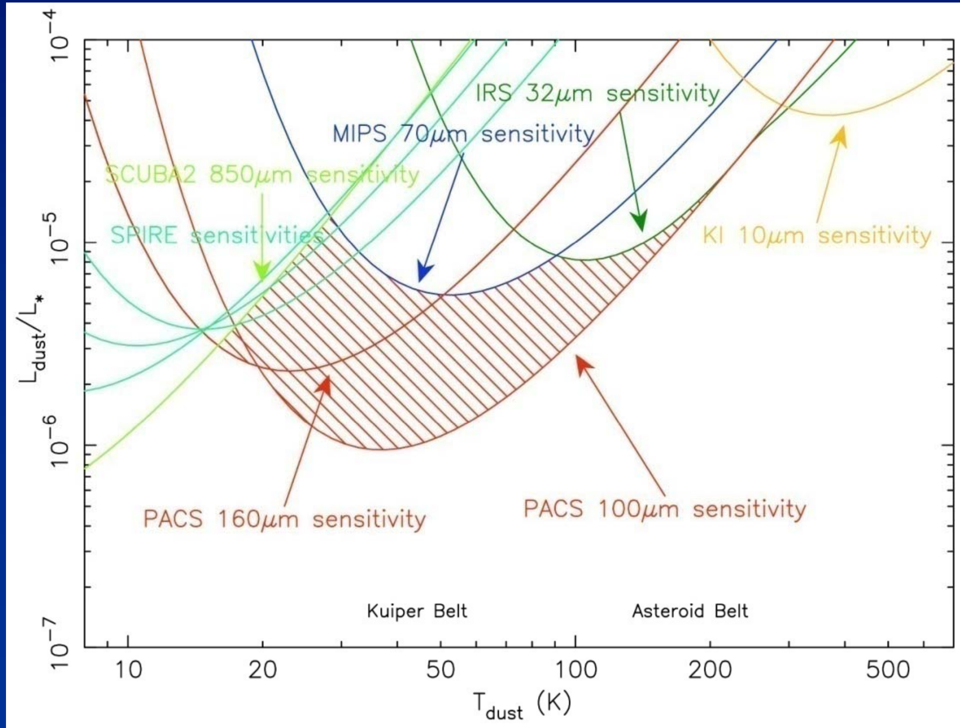
DUNES: Herschel OTKP

-Main Goal: detect and characterize faint exo-solar analogues to the Edgeworth-Kuiper belt (EKB)

- PACS 100 μm: best for faint disks in the range ~ 20–100 K
  Optimal: 30 – 40 K

- L_{dust}/L_{star} ~ few times 10^{-7}

  EKB: $L_{dust}/L_{\odot} \sim 10^{-7}$



Detection limits for a G5V star at 20 pc versus dust temperatures

Further Objectives

i. dependence of planetesimal formation on stellar mass
ii. collisional and dynamical evolution of exo-EKBs
iii. presence of exo-EKBs versus presence of planets
iv. dust properties and size distribution in exo-EKBs.

✓ **Formation and evolution of planetary systems**

➢ Data analysis and interpretation by using a variety of modelling tools/codes including:
- radiative
- collisional
- dynamical

(Augereau/Krivov's talk, this meeting)

Sample +observing strategy

- **Sample:** 133 FGK stars
  - d < 20 pc
  - stars with known planets (d<25 pc)
  - Spitzer faint debris disks (d<25 pc)
- + 106 stars shared with DEBRIS

✓ Volume limited sample

- **Strategy:** to integrate as long as needed to reach the 100 μm photospheric flux, only constrained by background confusion
  - F_* (100 μm) $\gtrsim$ 4 mJy
  - EKB analogue at 10 pc, 100 μm: ~ 7 – 10 mJy

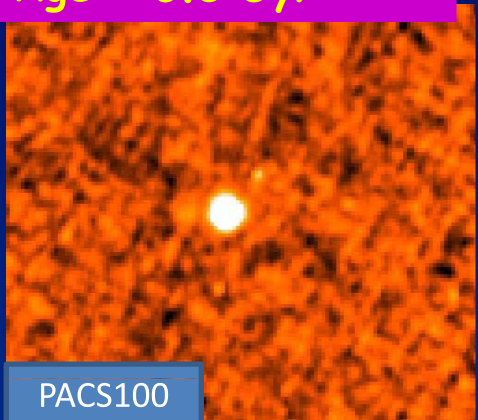
DUNES SDP

Several critical points: e.g. sensitivity, PSF, faint emission in the presence of a "bright" point source, resolution of extended emission

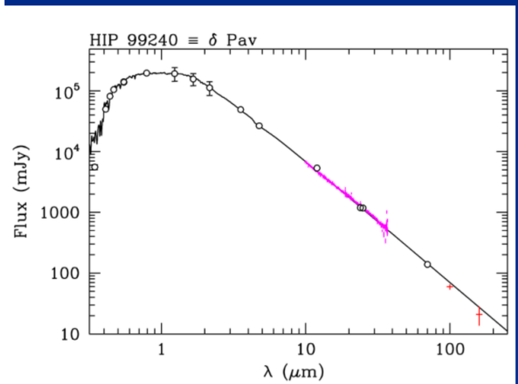
Task	Target	Obs. Mode	Photospheric flux [mJy]	
Sensitivity	51 Peg	PACS100 PS	10.8	
Sensitivity	HR 8501	PACS100 SM	10.9	
PSF	δ Pav	PACS100 SM PACS70 SM	68.7	
Spitzer 70μm excess	ζ^2 Ret	PACS100 PS (PACS70+100 SM)	12.1	:: routine phase
Extended disk	q^1 Eri	PACS100 PS+SM PACS70 PS SPIRE SM	7.5	

δ Pav, 51 Peg, HR 8501

G5V, d=6.11 pc,
Age ~ 6.5 Gyr

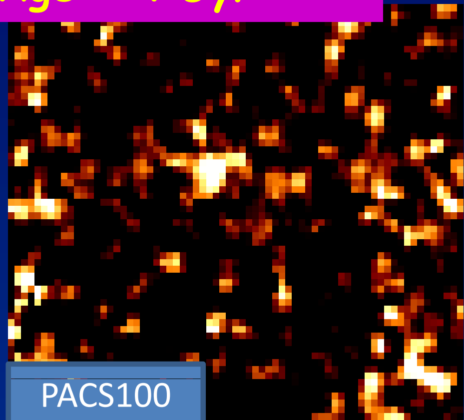


F_{100} = 59.6±1.1 mJy

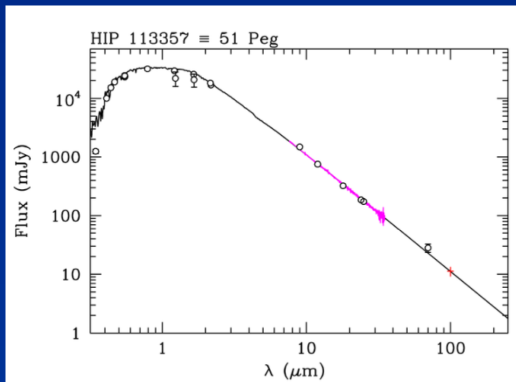


$L_{dust}/L_{star} \lesssim 3 \times 10^{-7}$

G5V, d=15.6 pc,
Age ~ 4 Gyr

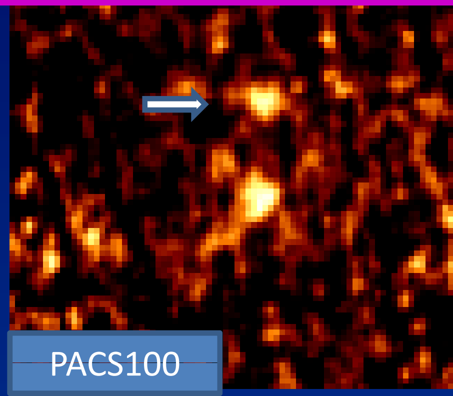


F_{100} = 11.3±1.7 mJy

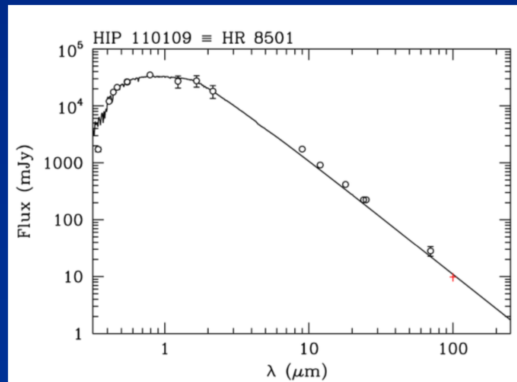


$L_{dust}/L_{star} \lesssim 5 \times 10^{-7}$

G5V, d=13.79 pc,
Age ~ 5.5 Gyr



F_{100} = 9.8±1.2 mJy

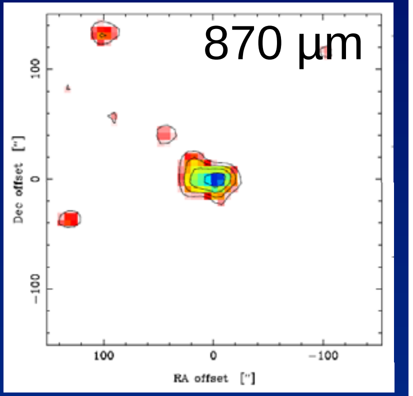


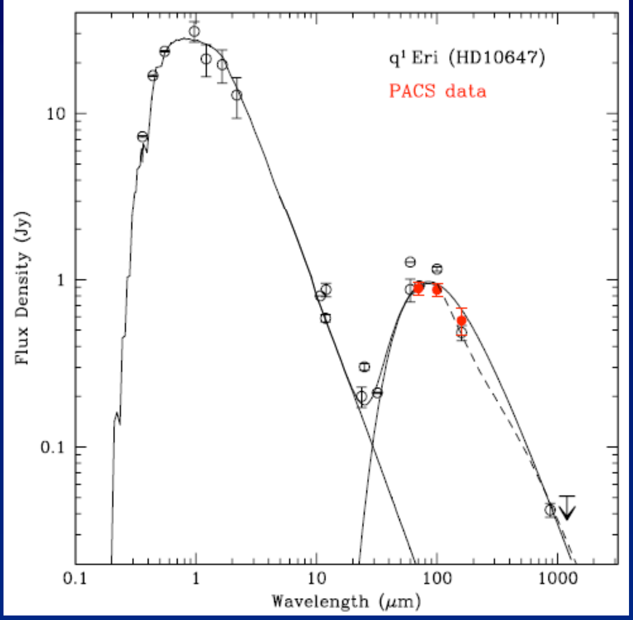
$L_{dust}/L_{star} \lesssim 3 \times 10^{-7}$

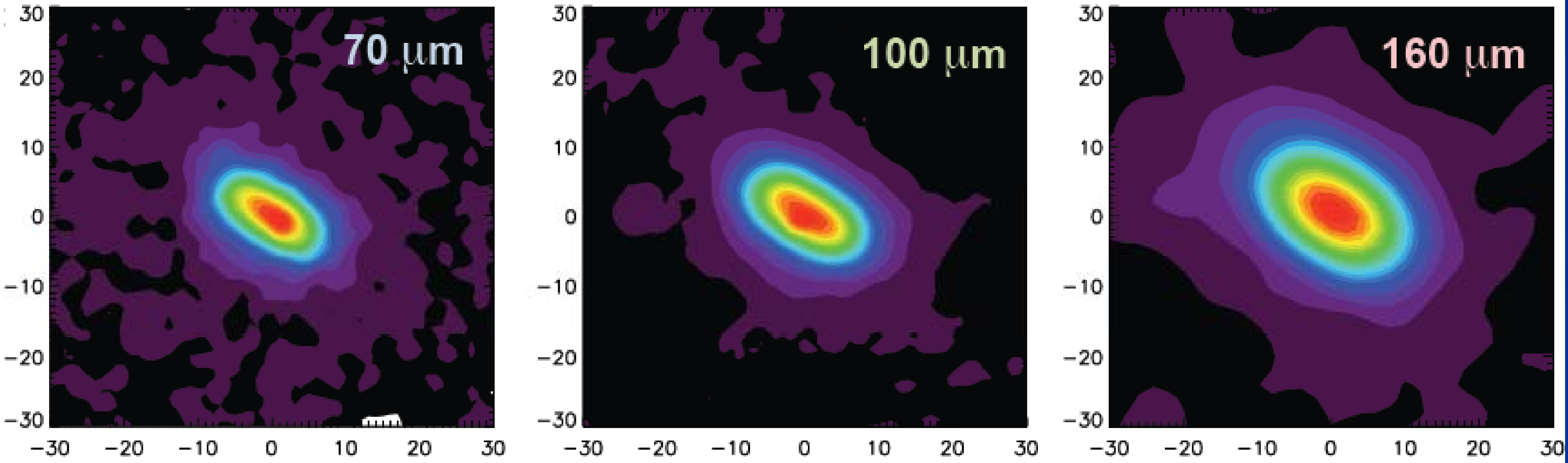
q1 Eri

- F8/9V, d=17.35 pc, 1.2 $L_{\odot}$, Age ~ 2 Gyr,
- 0.9 M_J planet at 2 AU

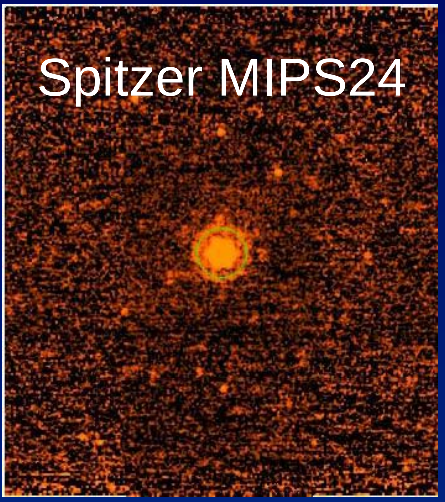
- F(Spitzer, 70 μm) = 863 mJy
- R_{Disk} (870 μm) ~ 320 AU
- L_{dust}/L_* ~ 10^{-4}
- **Poster P1.28, Liseau**
  + Augereau/Krivov's talk





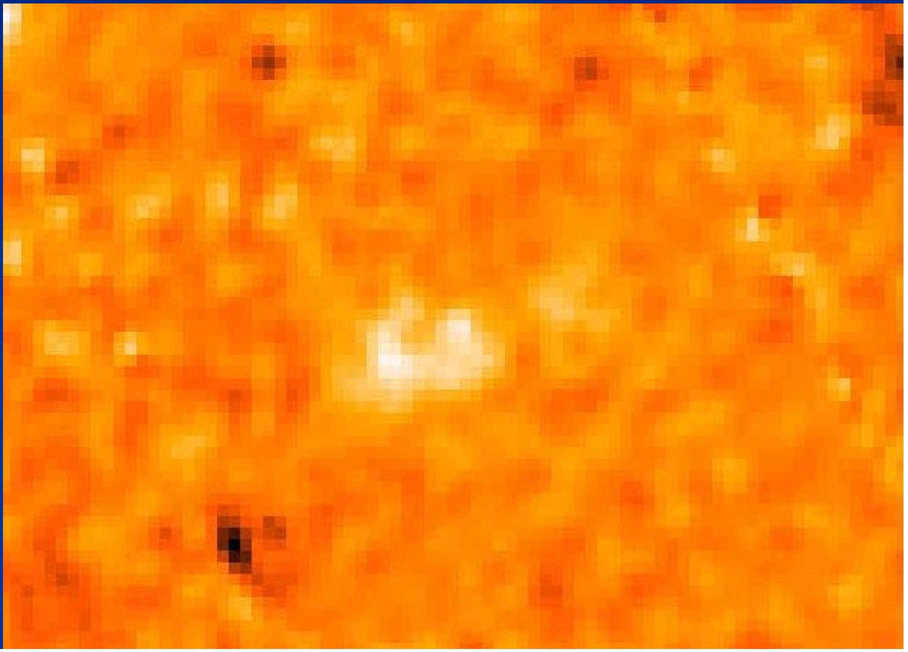


ζ^2 Reticuli

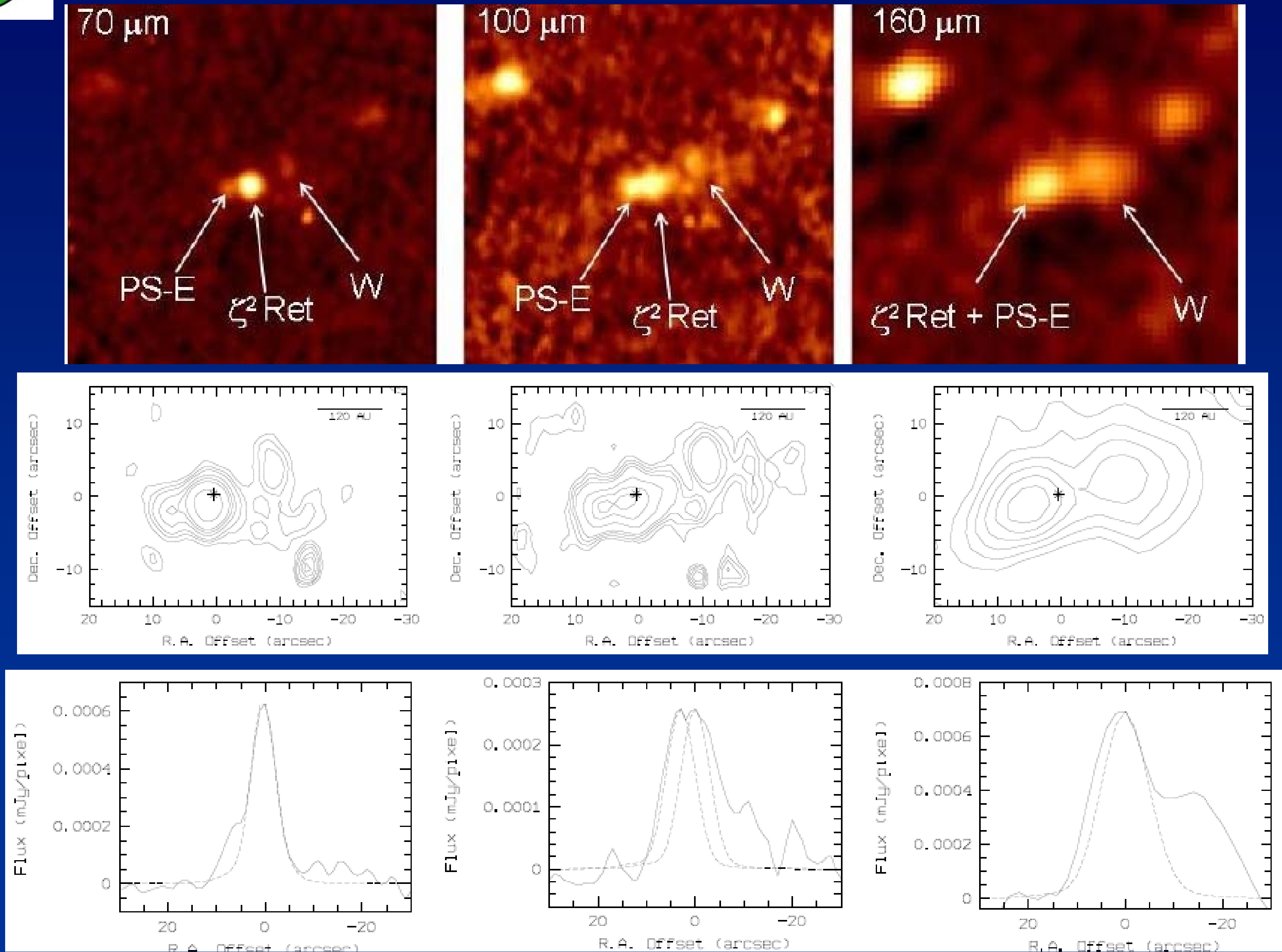


- G1V, d = 12.03 pc, 0.97 $L_\odot$, Age ~ 3 Gyr
- F_* (70 μm) = 24.7 mJy
  F(Spitzer, 70 μm) = 45.4 mJy
- F(predicted, 100 μm) = 12.1 mJy

PACS 100 : Point Source observing mode (SDP data)

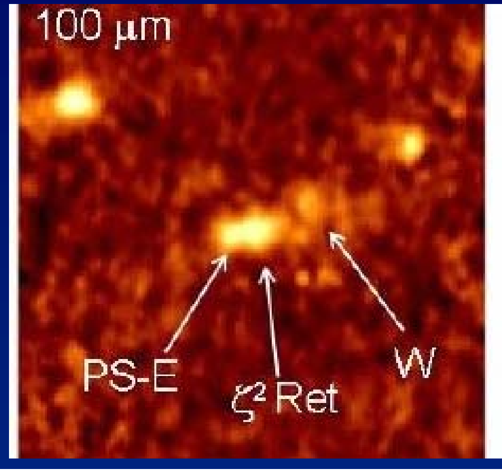


ζ^2 Ret: PACS



ζ^2 Ret

	F(70)	F(100)	F(160)
ζ^2 Ret	24.9	13.4	
PS-E	8.9	13.5	
ζ^2 Ret + PS-E			19.4
Total	44.5	40.4	42.6



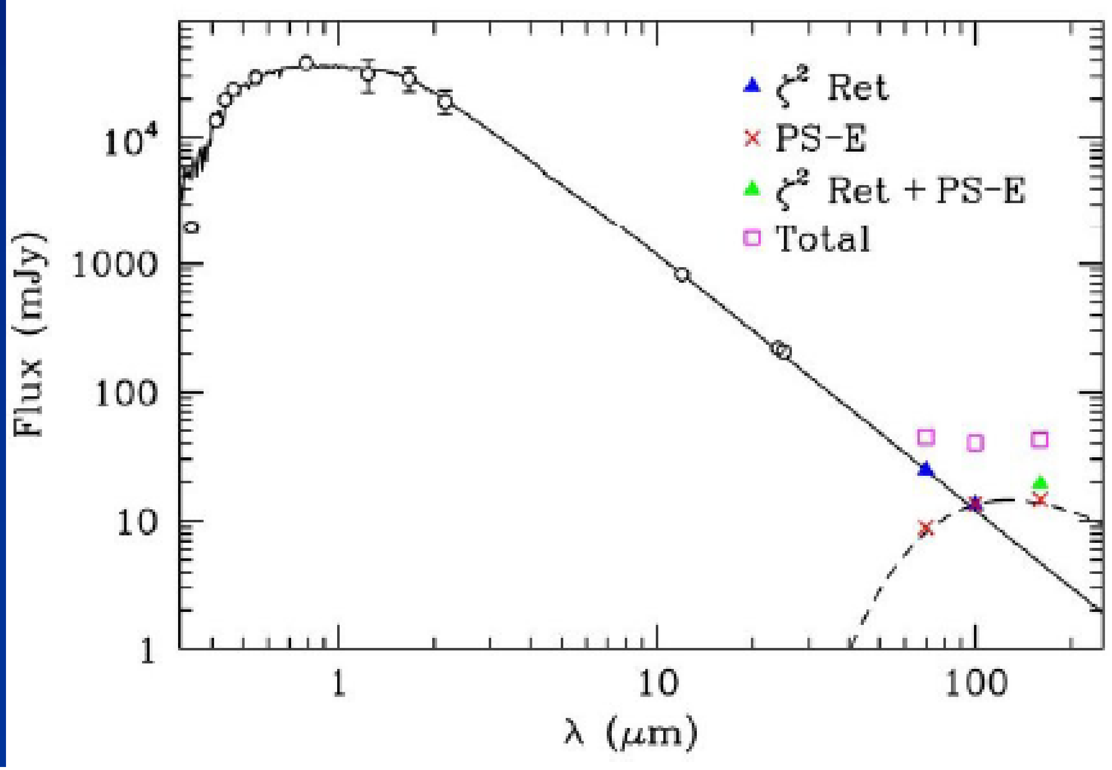
- Color Temperatures :

(PS-E) = 40 K → non-stellar

T(W) ~ 30 – 40 K

-Total fractional luminosity:

$L_{dust}/L_{*} \approx 10^{-5}$



ζ^2 Ret

Interpretation:

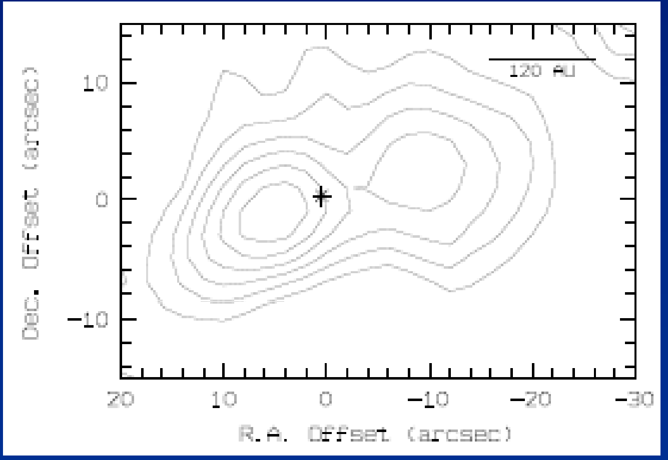
✓ PS-E and W reveal dust at T ~ 30 – 40 K surrounding ζ^2 Ret at ~ 70 AU and ~ 120 AU, respectively
- consistent with BB grains at ~ 100 AU from the star

✓ 160 μm image suggests a flattened disk-like structure

✓ 70 and 100 μm suggest it is ring like

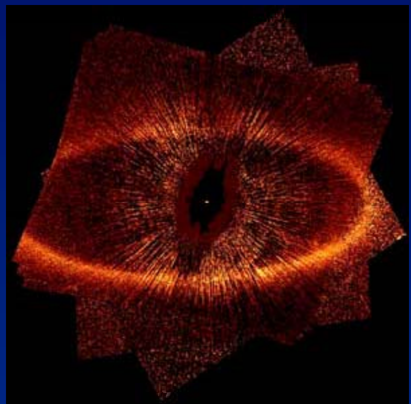
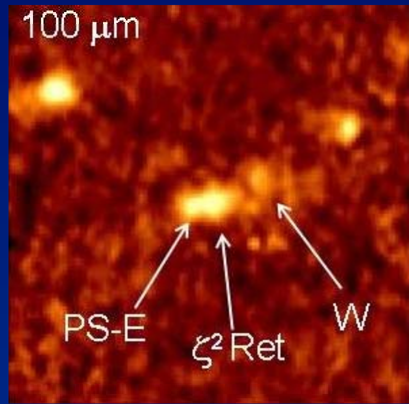
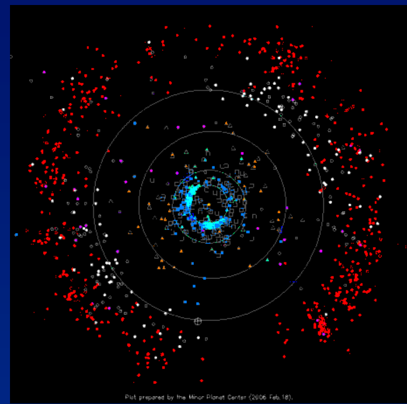
✓ East-West asymmetry suggests an eccentricity e ~ 0.3

✓ Asymmetry may indicate an unseen planet

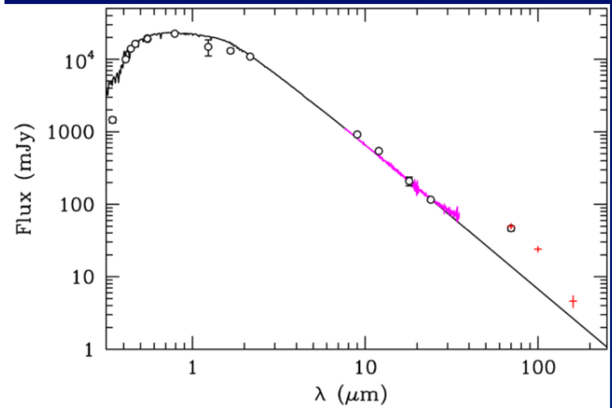


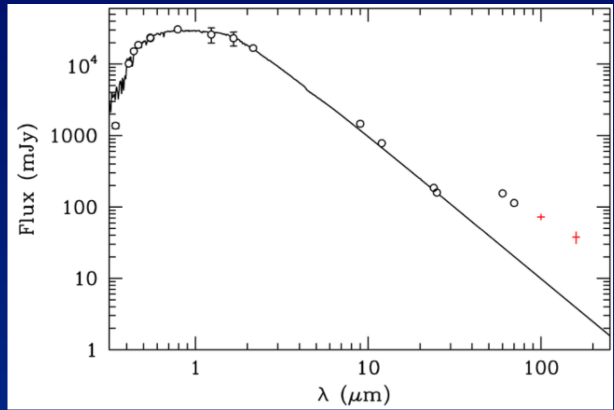
➢ **Detailed analysis to be carried out with the DUNES modelling toolbox**

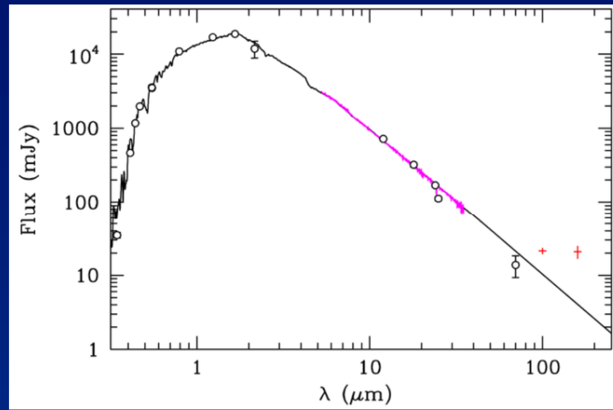
ζ² Reticuli
comparison with similar systems

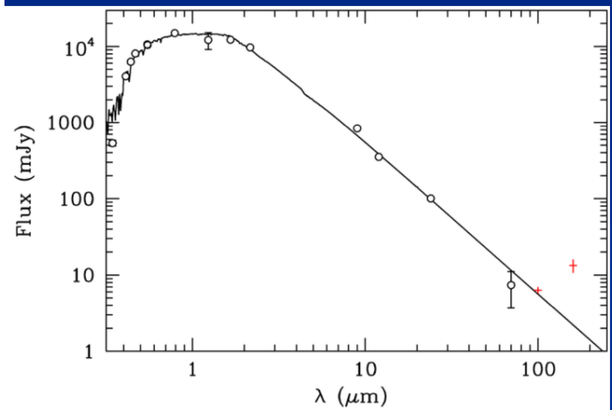
	Fomalhaut	ζ² Ret	Sun
			
STAR	A3 V 2.1 $M_\odot$ 16 $L_\odot$ ~0.2 Gyr old	G1 V 1.0 $M_\odot$ 1.0 $L_\odot$ ~ 3 Gyr old	G2 V 1.0 $M_\odot$ 1.0 $L_\odot$ 4.5 Gyr old
DISK	$L_{dust}/L_* \sim 10^{-4}$ $T_{dust} \sim 75$ K 135-160 AU	$L_{dust}/L_* \sim 10^{-5}$ $T_{dust} \sim 30\text{-}40$ K 70-120 AU	$L_{dust}/L_* \sim 10^{-6}$ $T_{dust} \sim 40$ K 40-55 AU
PLANET	Fomalhaut b e = 0.1	??? e = 0.3 ?	Neptune e = 0.01

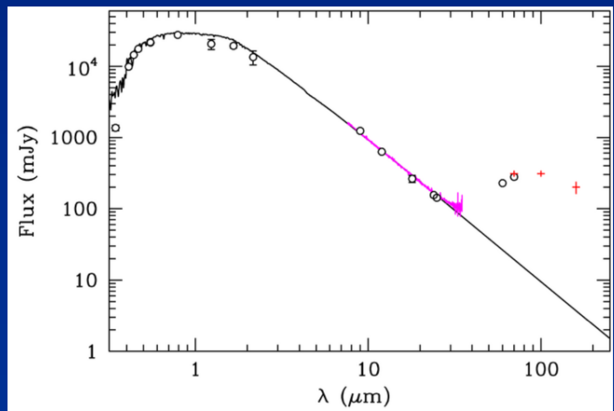
Additional Preliminary Results
(routine phase)

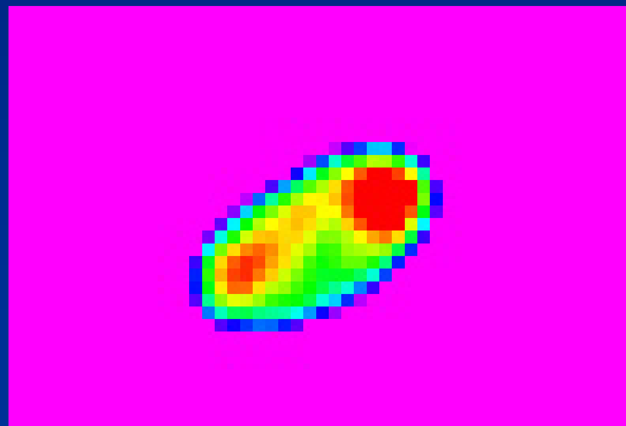












Summary/Conclusions
(preliminary)

- ~ **13 % of the sample observed**
  - 100% detections at 100 μm → strategy is satisfactory
  - ~ 75% detections at 160 μm (more than expected)
  - ~ 35% 100 μm excesses
  - Few stars with excesses at 160 μm only: "unexpected" → very cold disks, T < 30 K
  - 3 well resolved disks
  - ~ Kuiper Belt flux levels achieved

✓ **DUNES objectives will be fulfilled**

Herschel is a nice toy

Thank you