Cold Discs around Nearby Stars. A Search for Edgeworth-Kuiper Belt Analogues

Carlos Eiroa

(Universidad Autónoma de Madrid)

on behalf of the DUNES consortium

DUNES People

Olivier Absil, David Ardila, Jean-Charles Augereau, David Barrado, Amelia Bayo, Charles Beichman, Geoffrey Bryden, William Danchi, Carlos del Burgo, Carlos Eiroa, Davide Fedele, Malcolm Fridlund, Misato Fukagawa, Beatriz M. Gonzalez, Eberhard Grun, Ana M. Heras, Inga Kamp, Alexander Krivov, Ralf Launhardt, Jeremy Lebeton, Rene Liseau, Torsten Lohne, Rosario Lorente, Jesus Maldonado, Jonathan Marshall, Raquel Martinez, David Montes, Benjamin Montesinos, Alcione Mora, Alessandro Morbidelli, Sebastian Muller, Harald Mutschke, Takao Nakagawa, Goran Olofsson, Goran Pilbratt, Ignasi Ribas, Aki Roberge, Jens Rodmann, Jorge Sanz , Steve Sertel, Enrique Solano, Karl Stapelfeldt, Philippe Thebault, Helen Walker, Glenn White, Sebastian Wolf

DUNES

Dust around Nearby Stars

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

"To detect and to characterize with Herschel faint exo-solar analogues to the Edgeworth-Kuiper belt (EKB)"

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

DUNES: Herschel OTKP

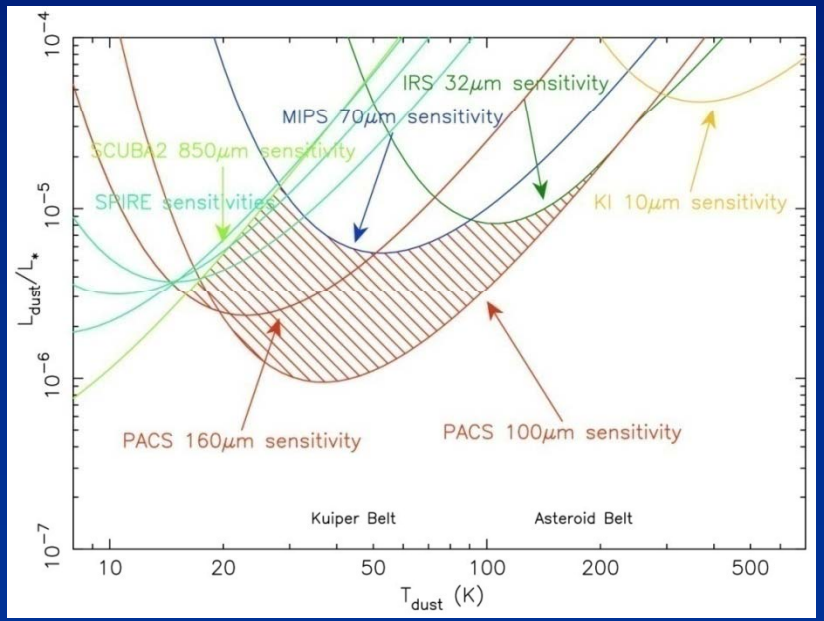
-Herschel has several advantages wrt to previous space facilities:

:: small beam, large mirror
- larger resolution, less confusion, fainter discs

:: sensitive to $\lambda > 70\ \mu m$

- PACS 100 μm: best for faint discs in the range ~ 20–100 K
:: Optimal: 30 – 40 K
- L_{dust}/L_{star} ~ few times 10^{-7}

EKB: $L_{dust}/L_{\odot} \sim 10^{-6}$–$10^{-7}$



Detection limits (10σ PACS100) for a G5V star at 20 pc versus T_{dust}

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

(details Augereau & Krivov's talks)

Sample +observing strategy

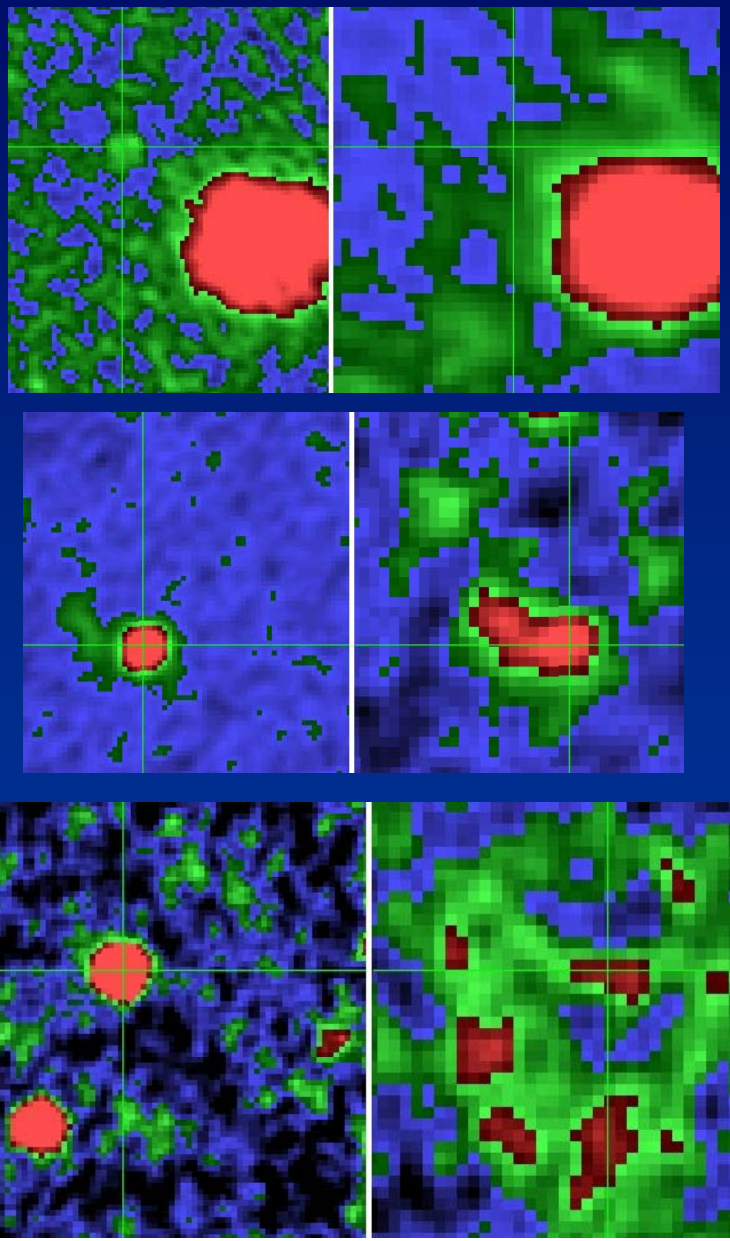
- **Sample:** 133 FGK main sequence stars
  - d < 20 pc
  - stars with known planets (d<25 pc)
  - Spitzer debris discs (d<25 pc)
  - (+ 106 stars shared with OTKP DEBRIS)

    ✓ Volume (20 pc) 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

Confusion

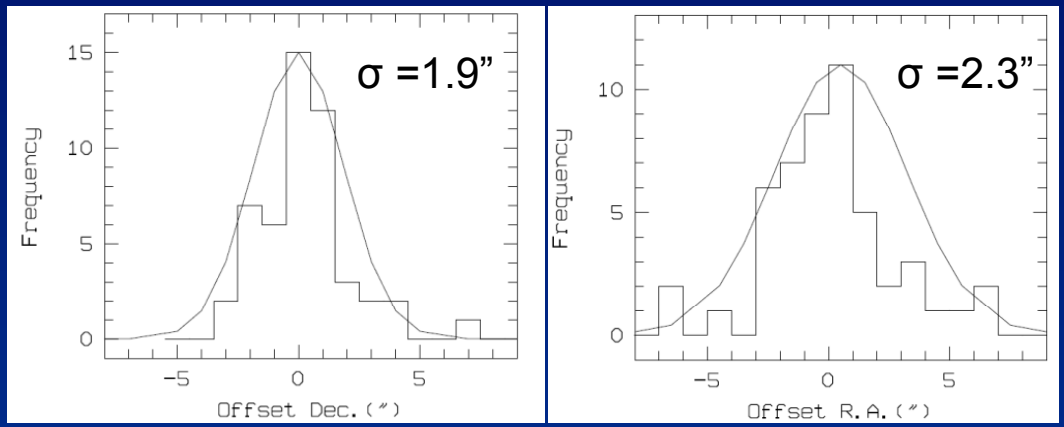
- **Coincidental alignment:**
  - ✓ **potential problem for:**
    - flux estimates
    - identification of target stars
      + "associated extended emission"
- **Confusion by:**
  - extragalactic objects
  - field stars
  - extended ism structures, e.g. cirrus



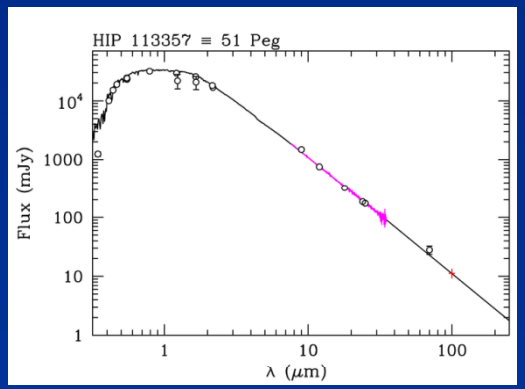
Dealing with confusion

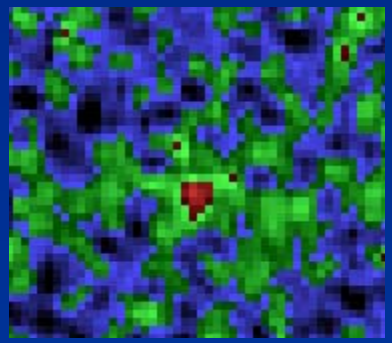
- Source counts , per unit of area and flux range (e.g. Berta et al. A&A 518, L30)

- Pointing



- Photospheric prediction





Pos. Offset

~ 6.5”

::: 2 excess sources with coincidental alignment chance ~ 1%

Results: Summary (31-8-2010)

	F-type	G-type	K-type	Total
Observed	11	21	18	50
Non-excess	5	13	12	30
Excess **(New)**	6 **(1)**	7 **(3)**	4 **(4)**	17 **(8)**
Resolved **(New)**	3 **(2)**	4 **(3)**	1 **(1)**	8 **(6)**
Cold discs	**1**	**3**	**4**	**8**
+ Planets (excess)	1	3	2	6 (1)
"Peculiar"		1	2	3

✓ **Cold discs: 160 μm excess (some with faint 100 μm excess)**

→ **Poster by Marshall**

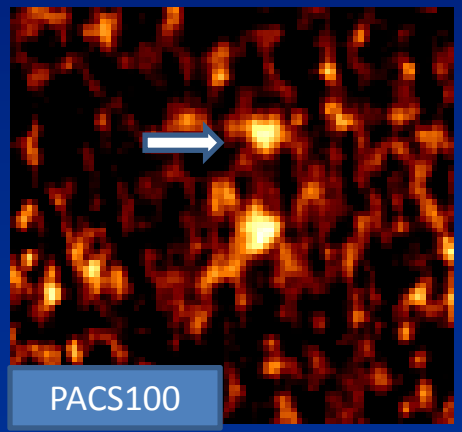
!!! Numbers in the table could change a bit

Non-excess stars

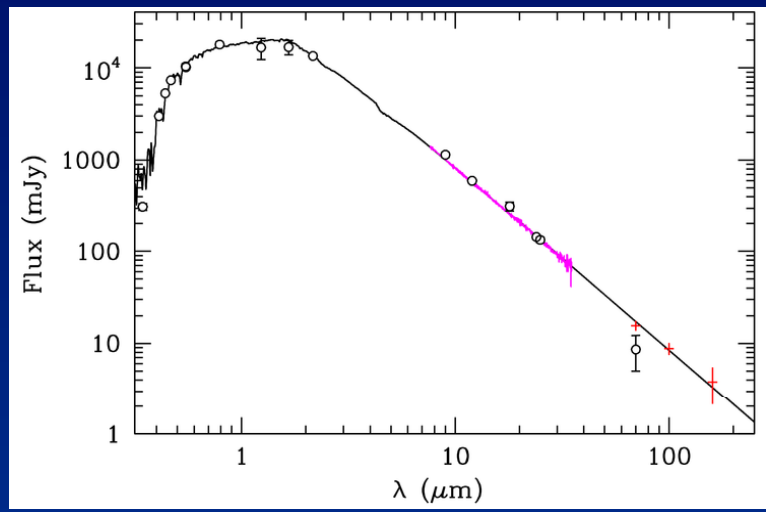
- **Fractional luminosity:**
(upper limit, 1 σ statistical noise)

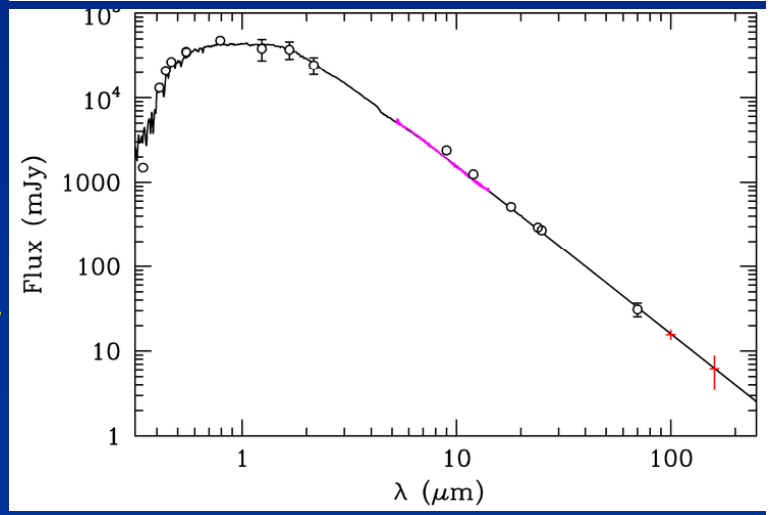
$L_{dust}/L_{star} \leq 2\times10^{-7} - 10^{-6}$

function of:
- T_{eff}
- distance
- integration time
- T_{dust} = 40 K

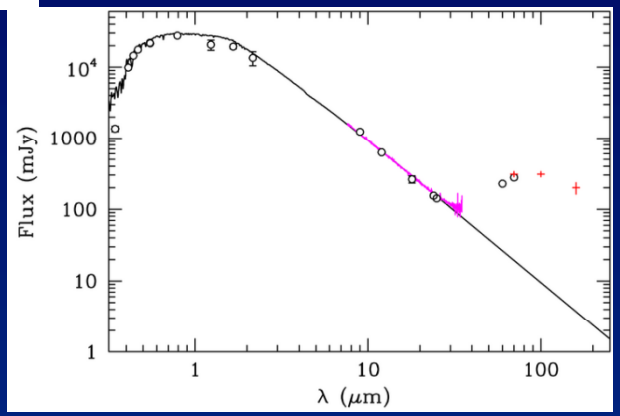


F_{100} = 9.8±1.2 mJy

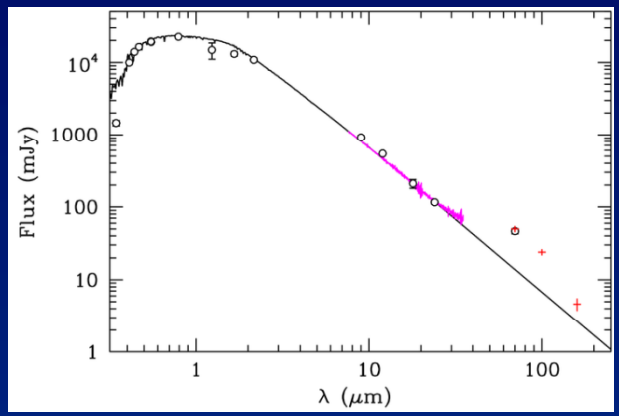




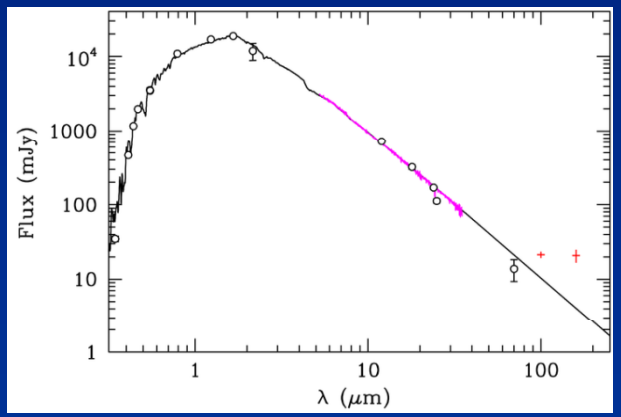
Discs: Large variety of SEDs



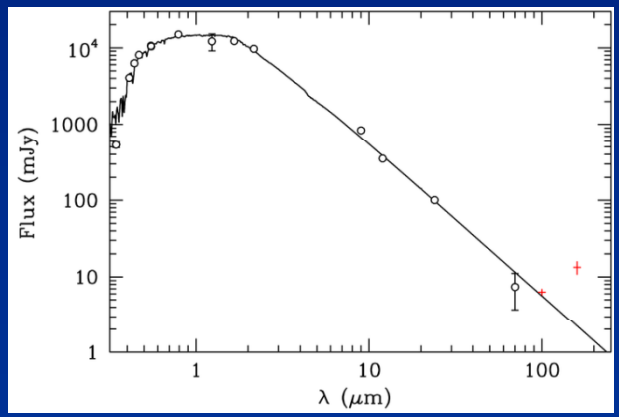
Very prominent excesses at all λs – all well resolved



Ring-like SEDs



Small 100 μm excess

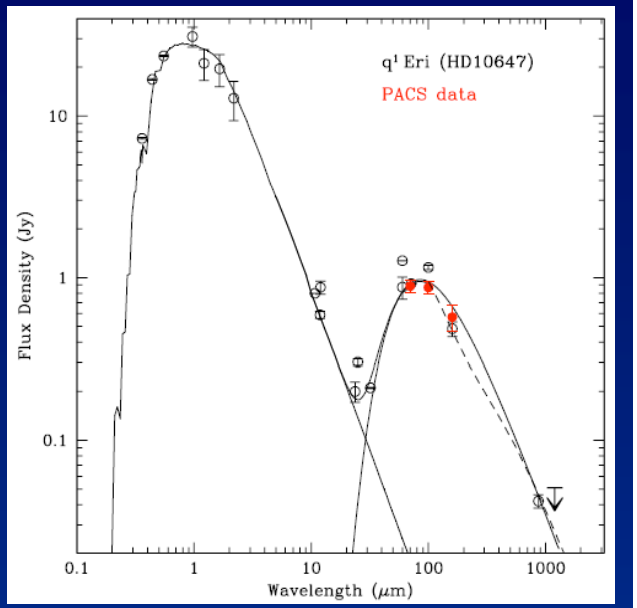


Only 160 μm excess

Very cold discs: T < 30 K

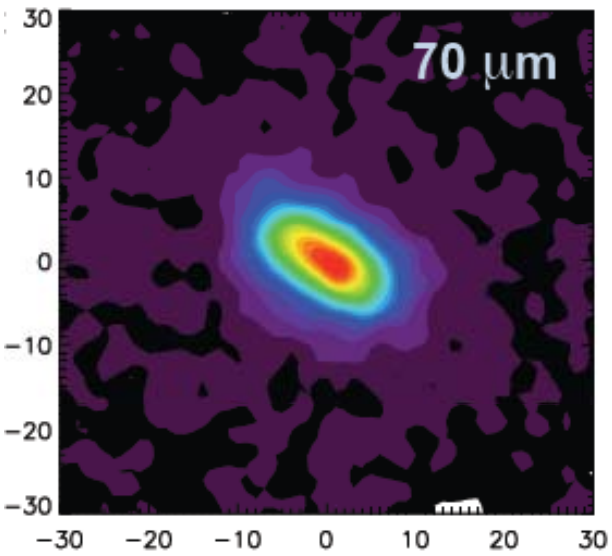
q^1 Eri: resolved disc (known)

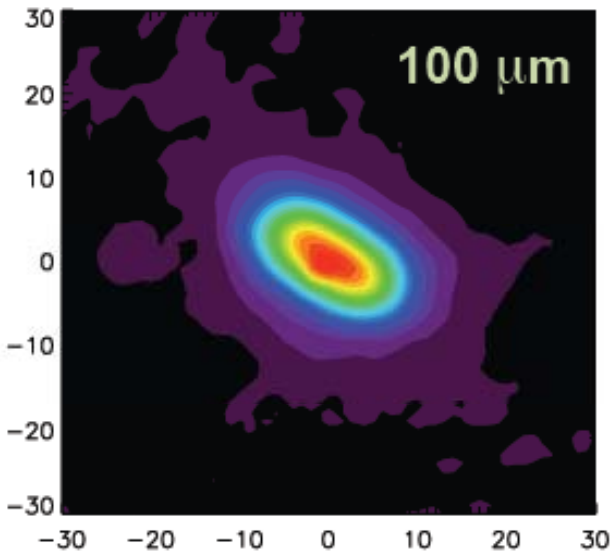
- F8/9V, d=17.35 pc, 1.2 $L_\odot$, Age ~ 2 Gyr,
- 0.9 M_J planet at 2 AU

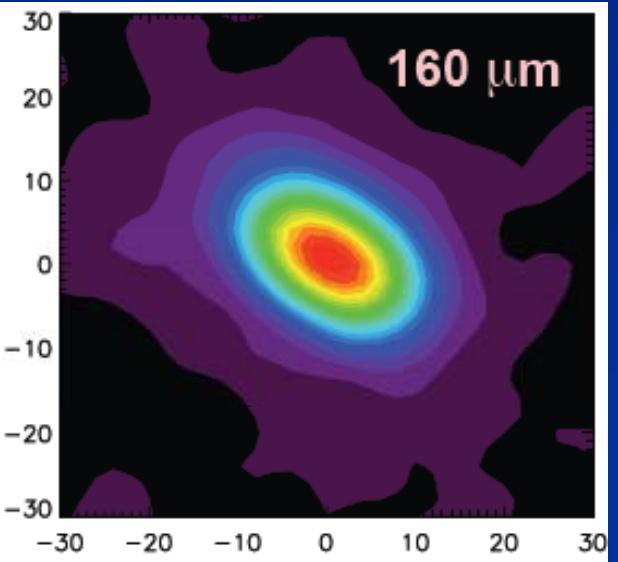


➢ q^1 Eri debris disc: unprecedented detail
- 40 AU wide ring at ~ 85 AU
- i ~ 63° (assuming circular shape)
- T_{dust} ~ 60 K
- L_{dust}/L_{star} ~ 10^{-4}

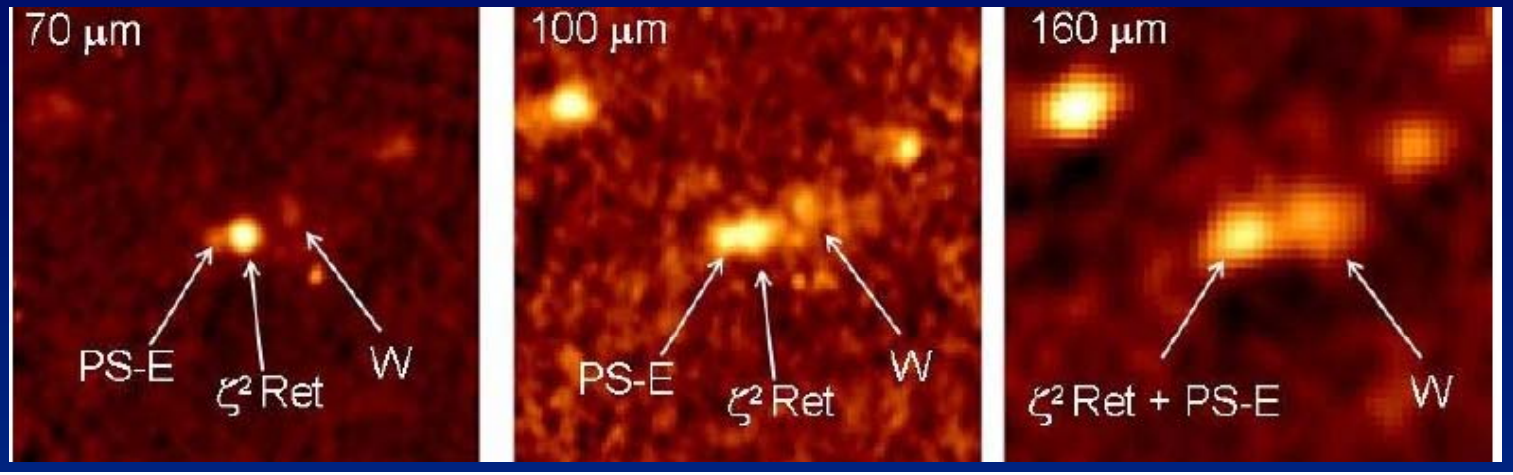
- Liseau et al., A&A
Augereau et al., in prep. + talk; Müller, poster

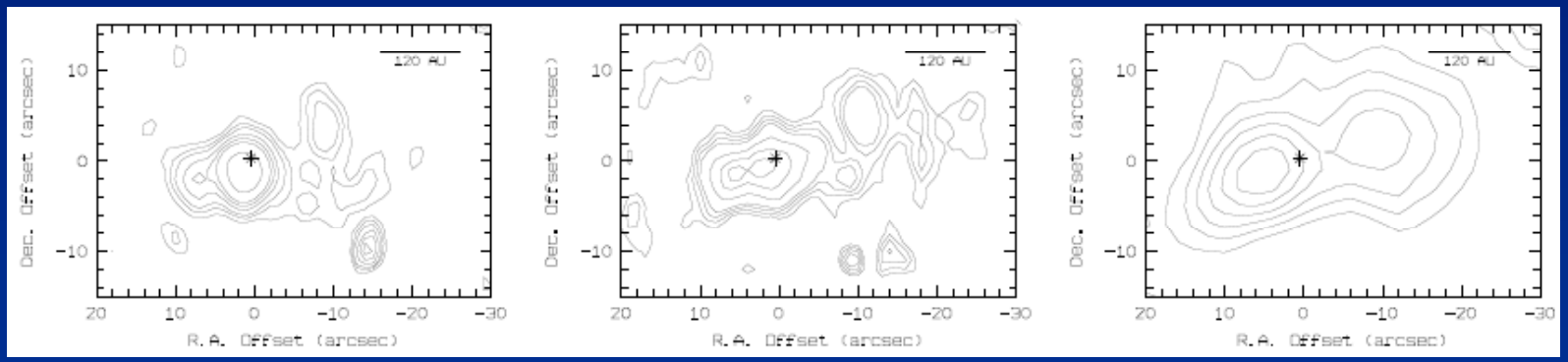


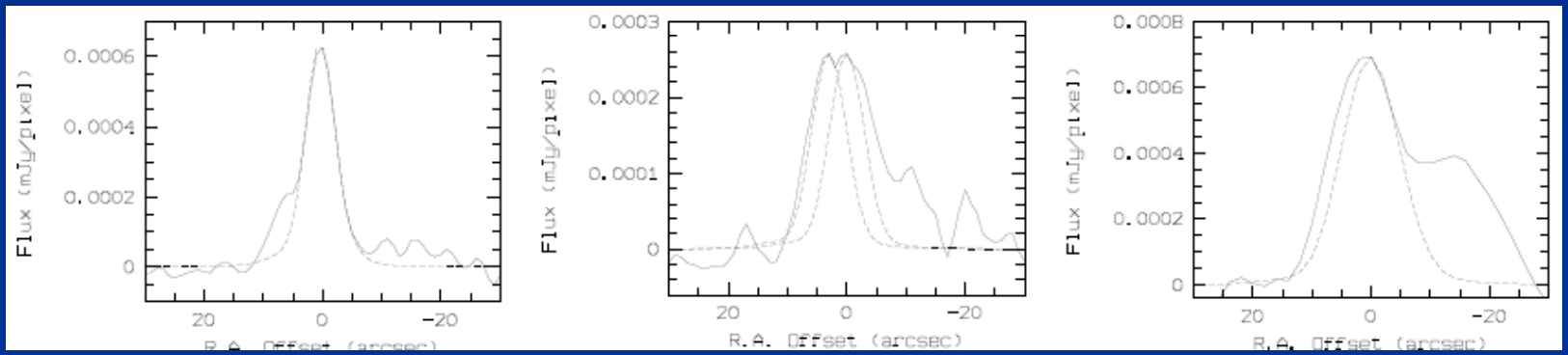




ζ^2 Ret: new resolved disc

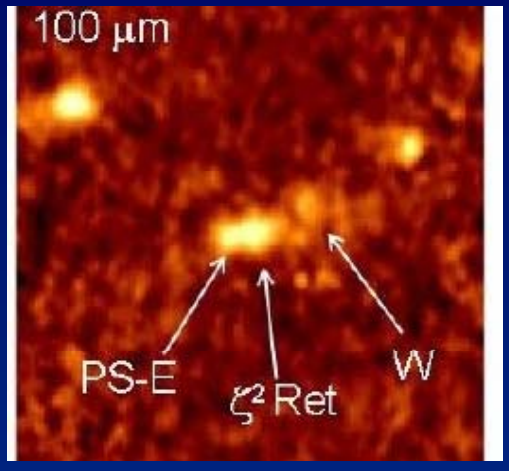






ζ^2 Ret

G1V, d = 12.03 pc, 0.97 $L_\odot$, Age ~ 3 Gyr

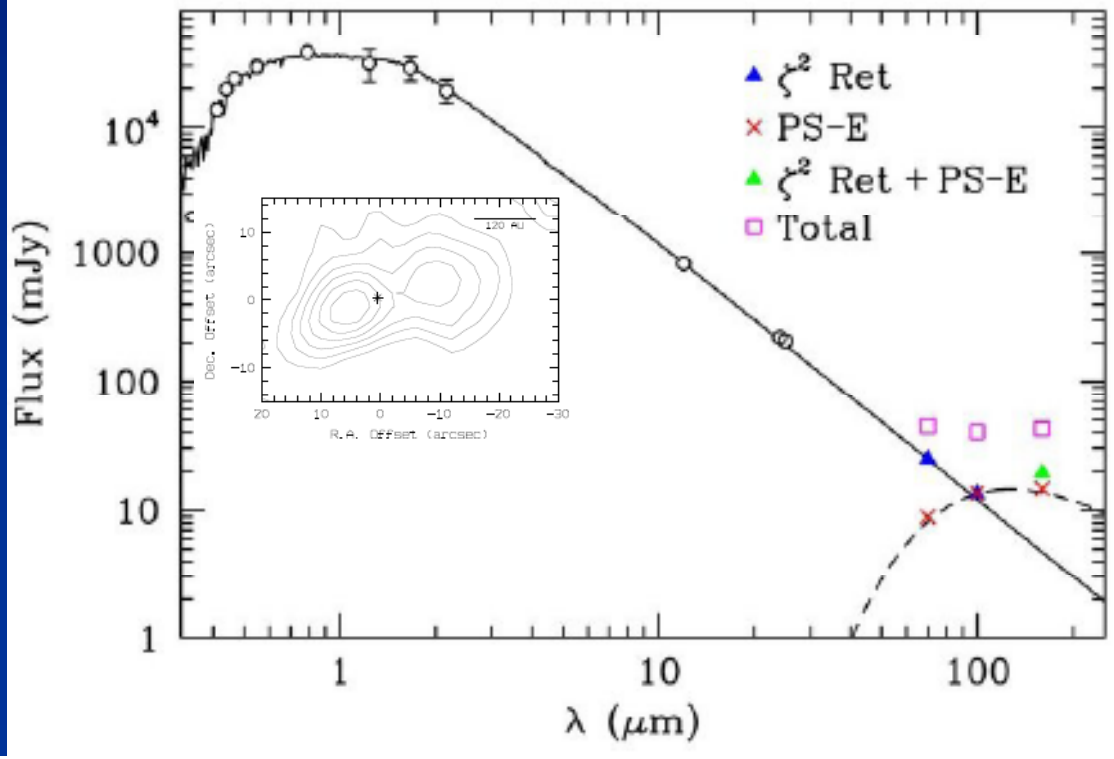


ζ^2 Ret debris disc:

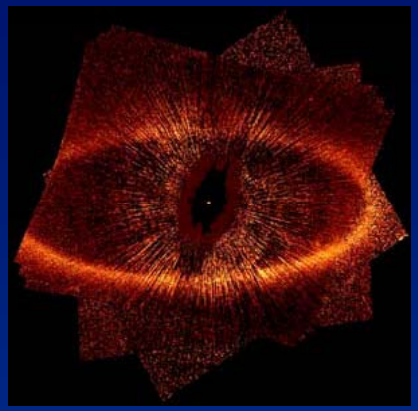
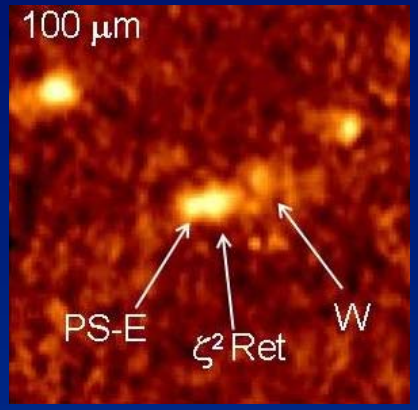
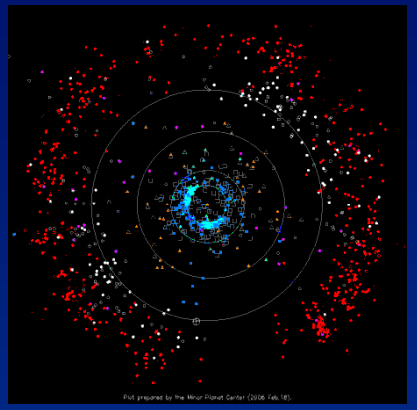
- Eccentric dust ring-like structure of ~ 100 AU semi-major axis and e ~ 0.3
- T_{dust} ~ 40 K
- $L_{dust}/L_* \approx 10^{-5}$

✓ Asymmetry: signature of an unseen planet?

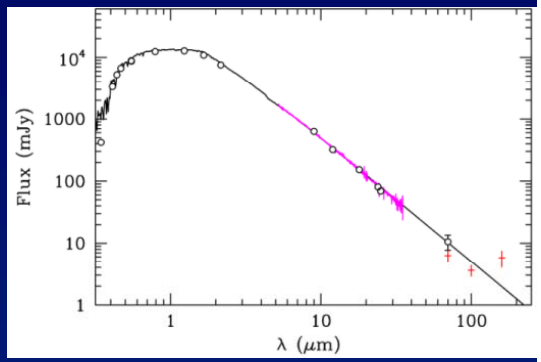
Eiroa et al., A&A
Thebault et al., in prep.



ζ^2 Reticuli
comparison with similar systems

	Fomalhaut	ζ^2 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
DISC	$L_{dust}/L_* \sim 10^{-4}$ $T_{dust} \sim 75$ K 135-160 AU	$L_{dust}/L_* \sim 10^{-5}$ $T_{dust} \sim 30$-40 K 70-120 AU	$L_{dust}/L_* \sim 10^{-6}$ - 10^{-7} $T_{dust} \sim 40$ K 40-55 AU
PLANET	Fomalhaut b e = 0.1	??? e = 0.3 ?	Neptune e = 0.01

Cold discs



- Some stars with excesses at 160 μm only

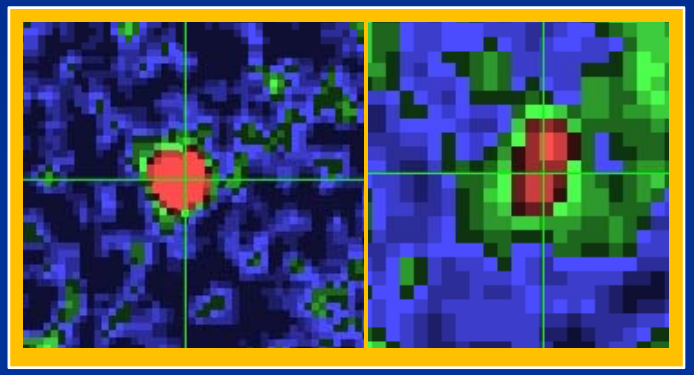
➔ Cold ($T_{dust} \lesssim 30$ K), faint ($L_{dust}/L_{star} \sim 6\times10^{-7} - 10^{-5}$) dust discs

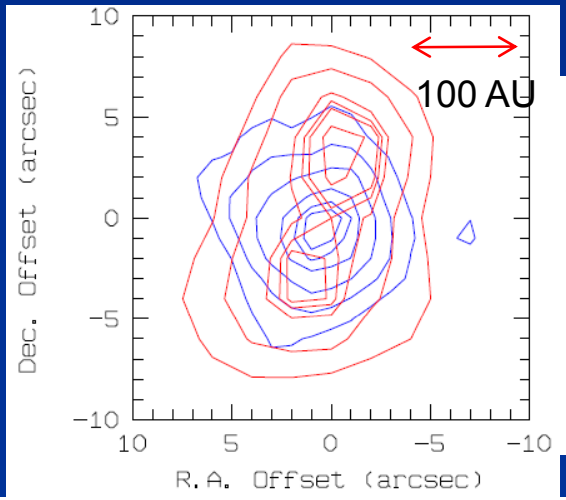
✓ Modelling is challenging → Krivov´s talk

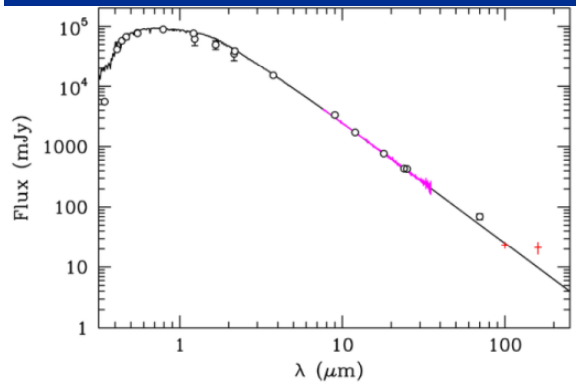
✓ New physical regime - different to all previously observed debris discs

- Modelling work in progress

➢ Brand new DUNES/HERSCHEL result !!!







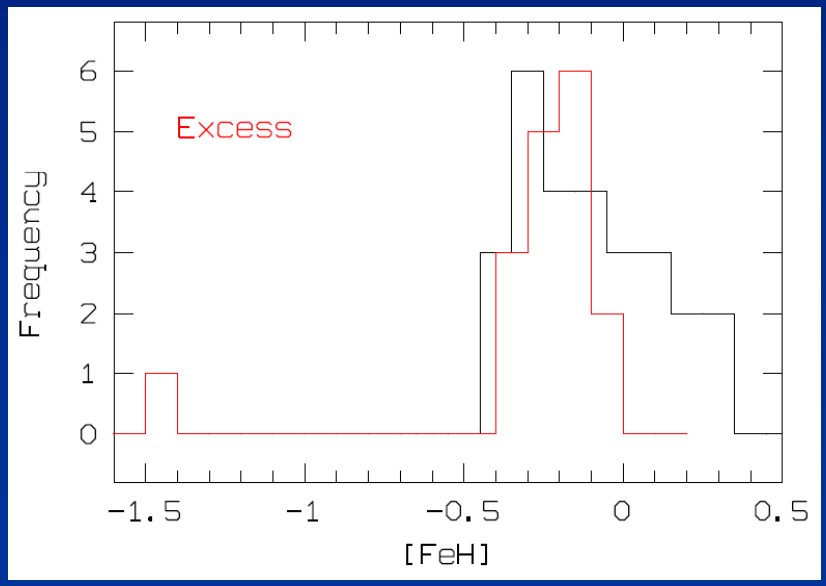
Trends?

- **Relationships with stellar properties**

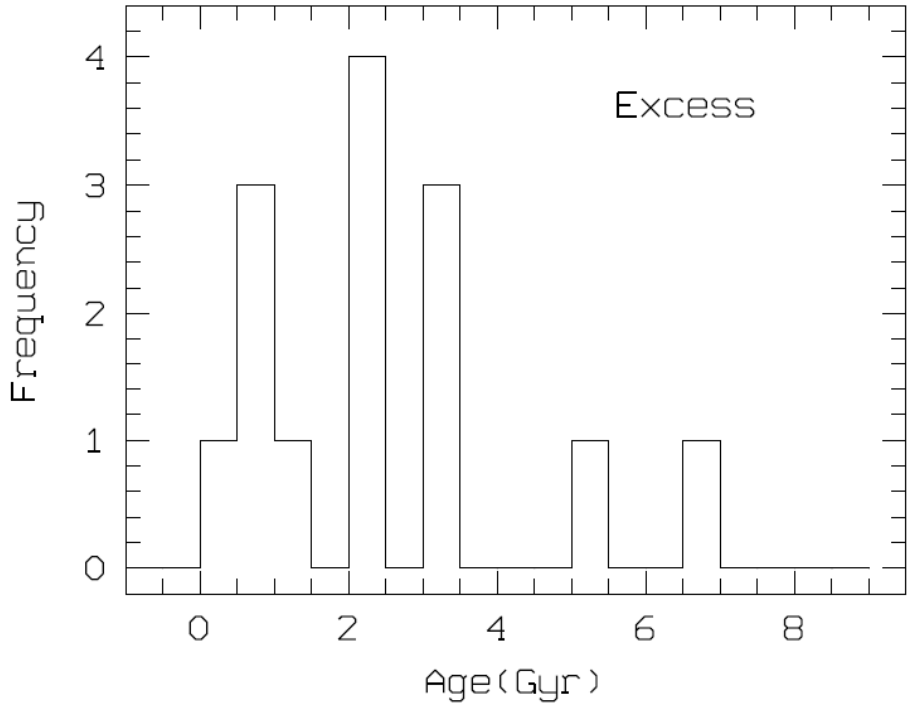
  -- Observed sample still small for statistics

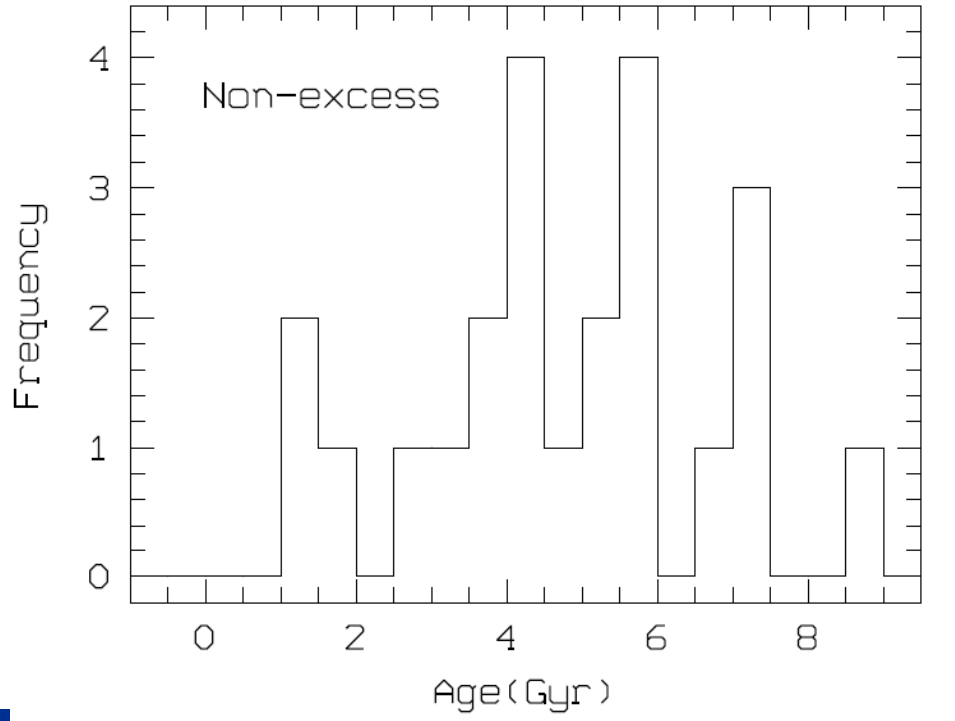
  -- But we have started the exercise

- ✓ **Metallicity:**



Trends: Stellar age?





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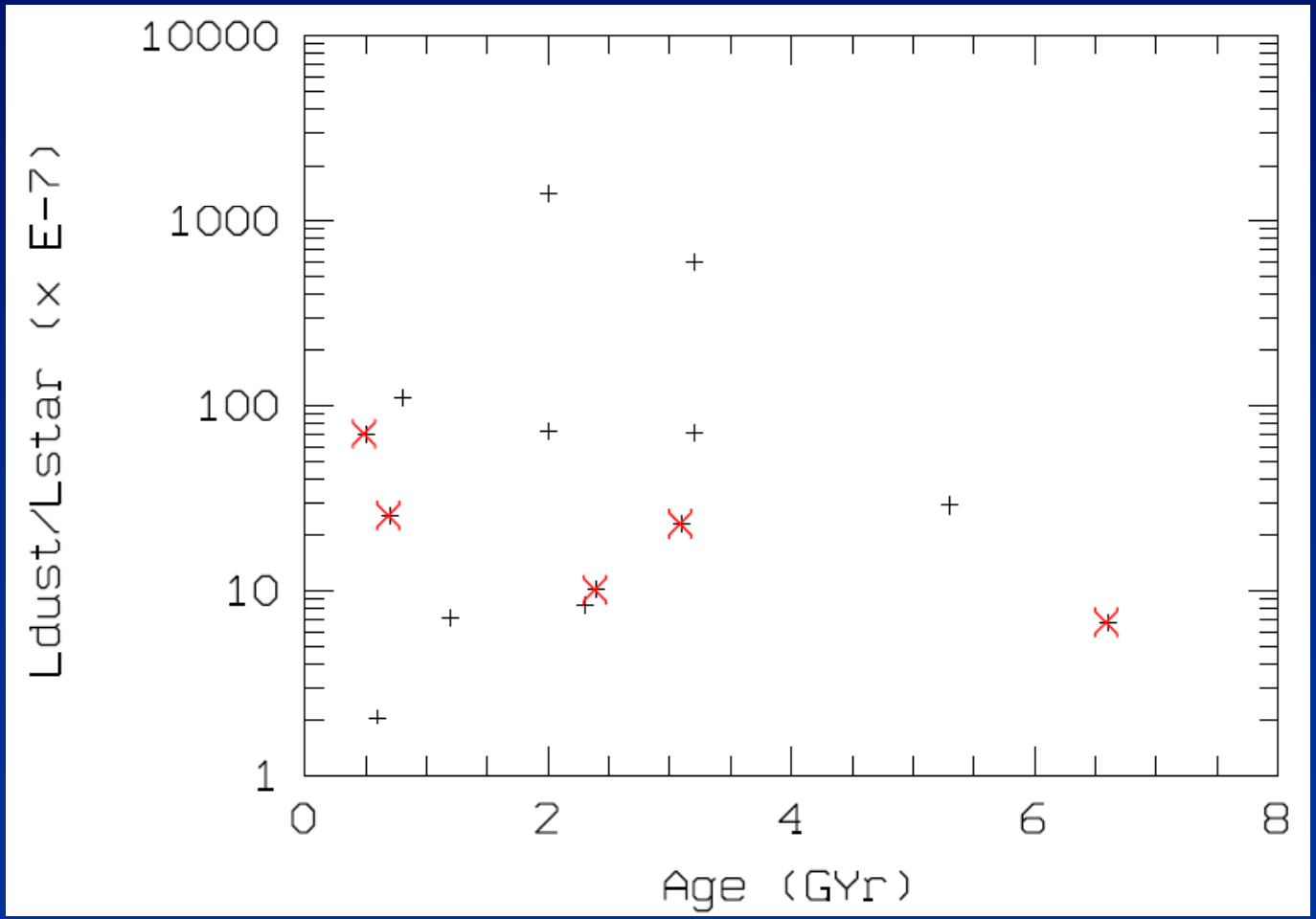


Summary/Conclusions
(preliminary: ~ 1/3 sample observed)

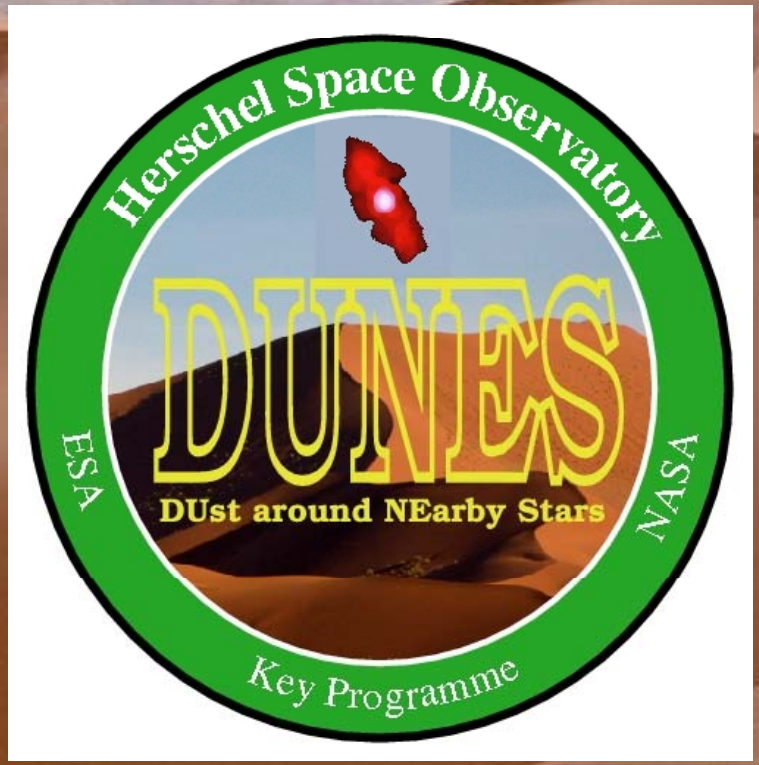
- 100% detections at 100 μm → strategy is satisfactory
- ~ 1/3 debris discs (doubled previous statistics)
- Large number of resolved discs (x 3 times previous number) with unprecedented details
- ~ EKB flux levels achieved
- "New class" of debris discs: 160 μm-only excesses

  ::: Very cold discs, T < 30 K, faint discs which might represent a new physical regime.

  ::: More often in late-type stars ?

✓ DUNES objectives are being accomplished

Herschel is indeed a nice toy



Thank you