CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

A Supernovae Origin of Dust?

the submillimetre view

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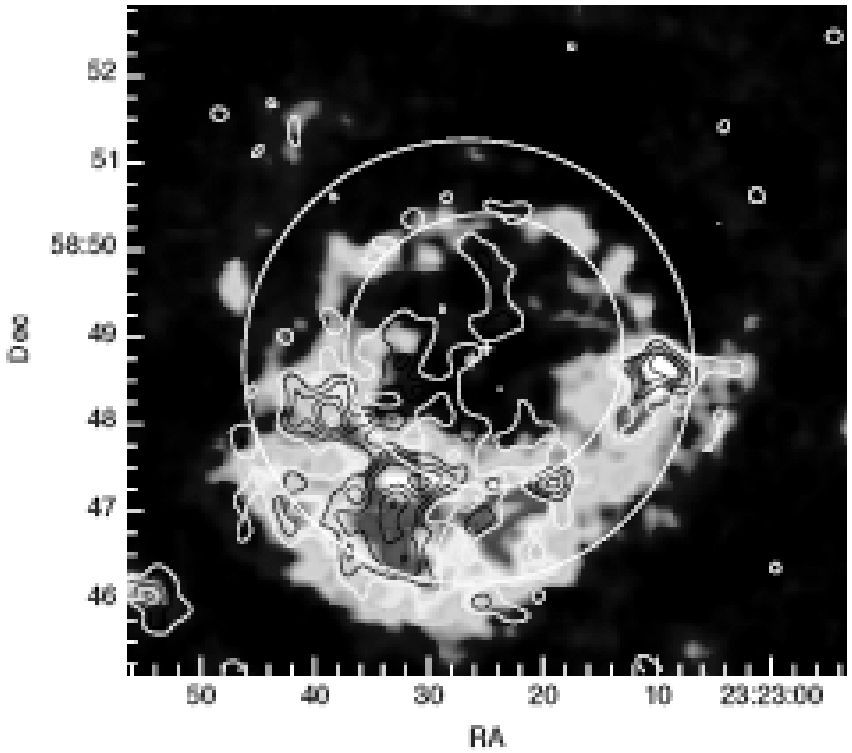
How could cold dust survive?

- 0.01μm dust in 10,000,000 K & n ~ 4cm^{-3} gas ~ 150K
- Diffuse pockets of X-ray gas (density 10 x less ~ 20K)
- Larger grains i.e. 1μm ~ 50K
- Iron whiskers - more conductive, higher absorption
- Dense clumps, self-shielding c.f. SN1987A (Lucy 1991)

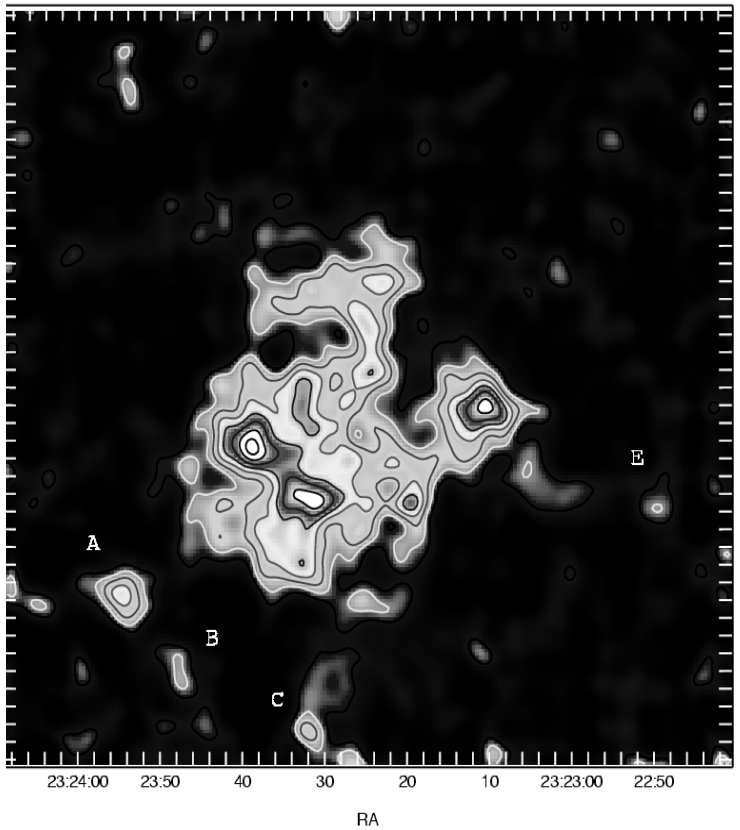
Cassiopeia A with SCUBA

minus synchrotron

850 μm



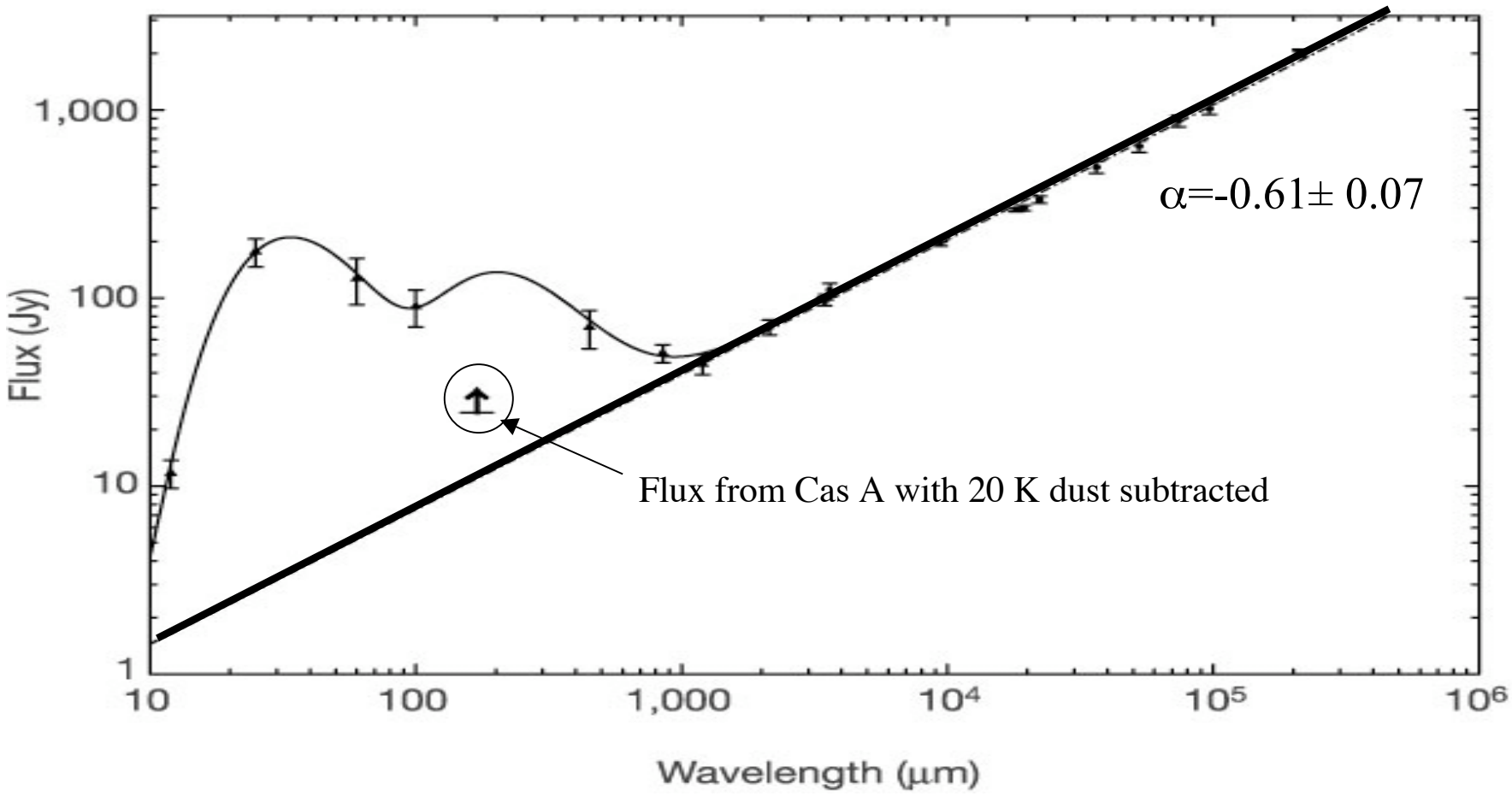
450 μm



$Md > 3\ M_{sun}$

Dunne et al. 2003

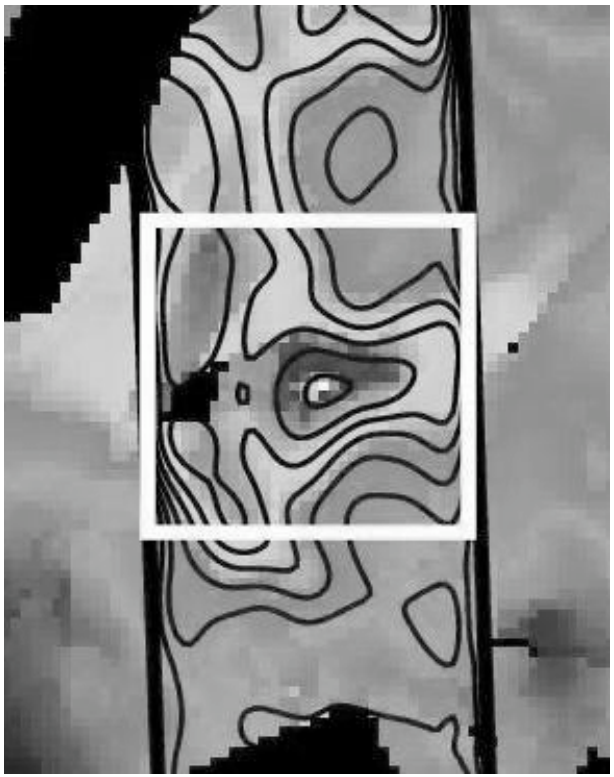
SED Cas A

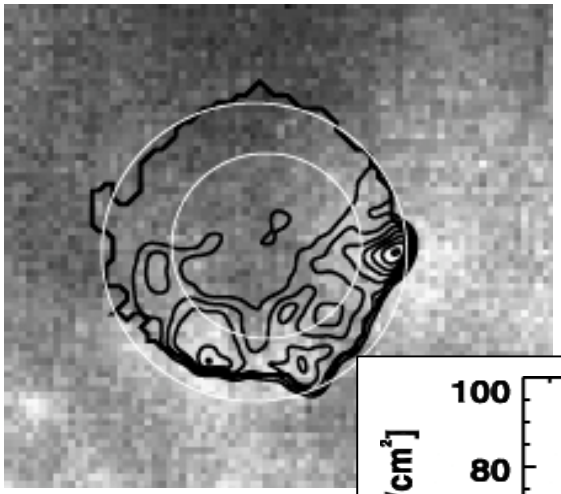

1,000
100
10
1
Flux (Jy)
10
100
1,000
10⁴
10⁵
10⁶
Wavelength (μm)
α=-0.61± 0.07
Flux from Cas A with 20 K dust subtracted

No cold dust in Cas A?

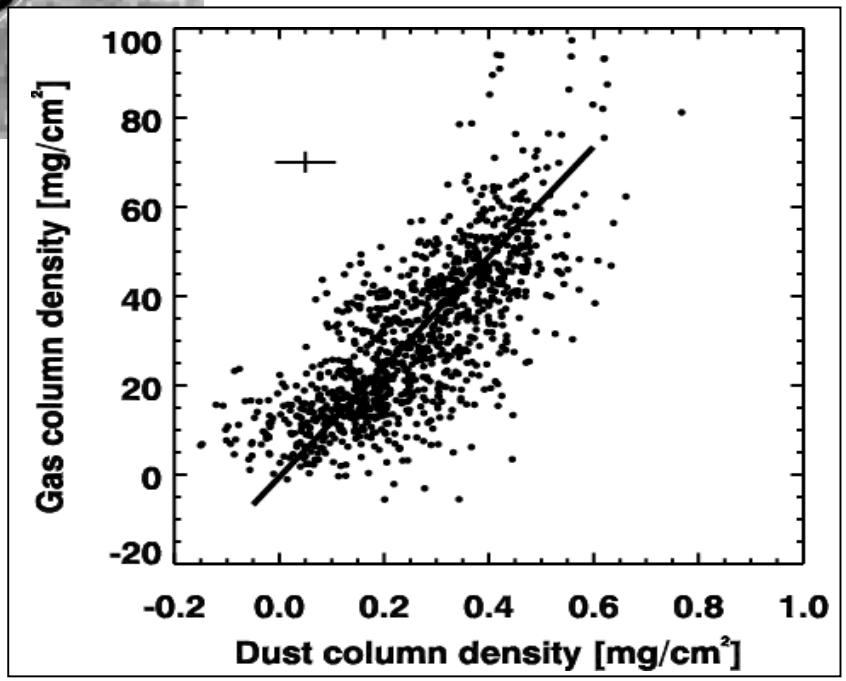
Krause et al. 2004, Nature

160 um + ISO



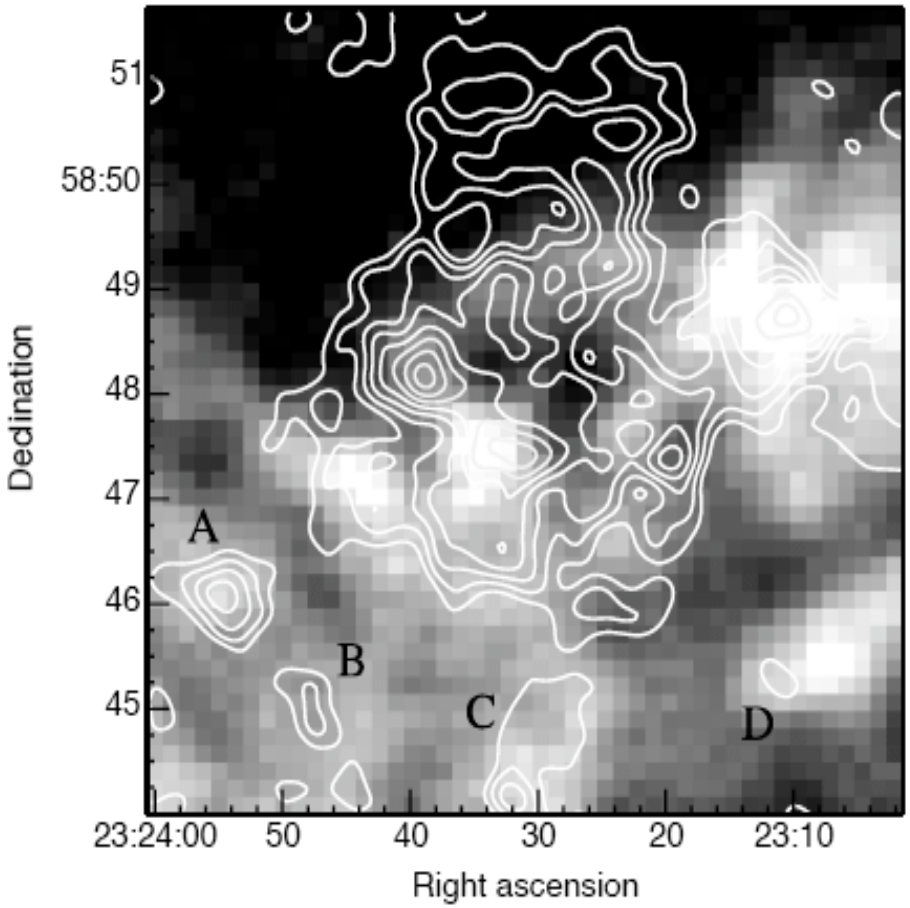


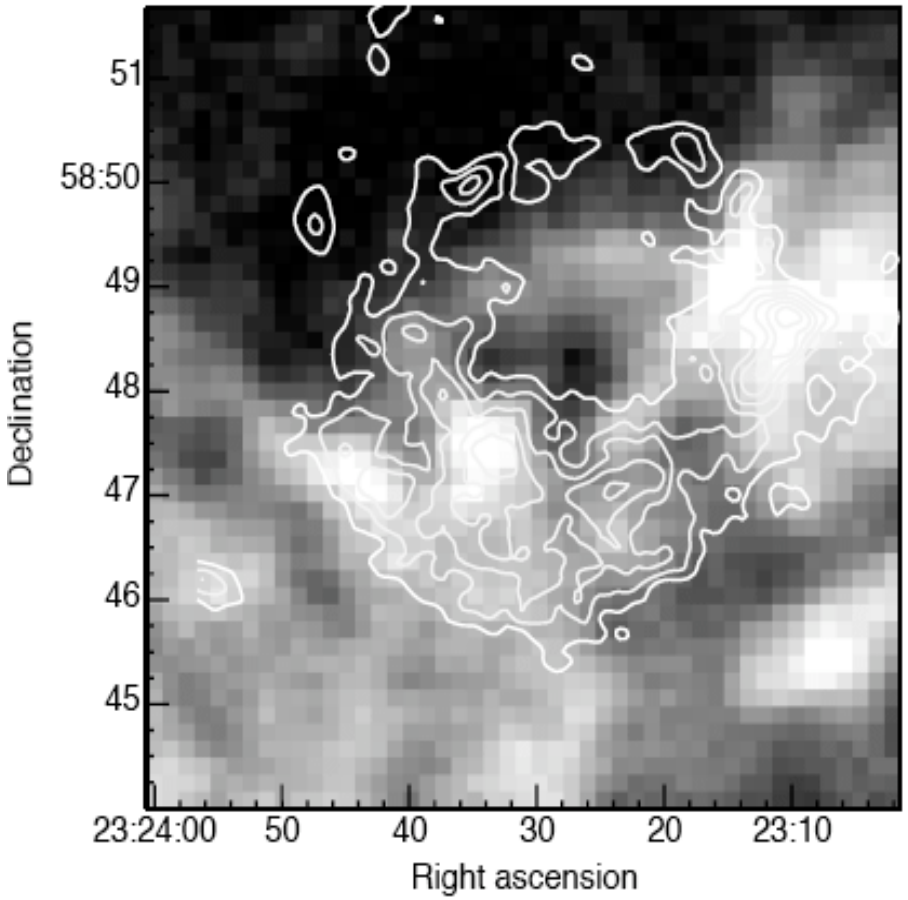
OH absorption



If submm peaks due to cold clouds
$<0.2M_{\odot}$ cold dust within Cas A

How much gas towards Cas A? New CO Analysis





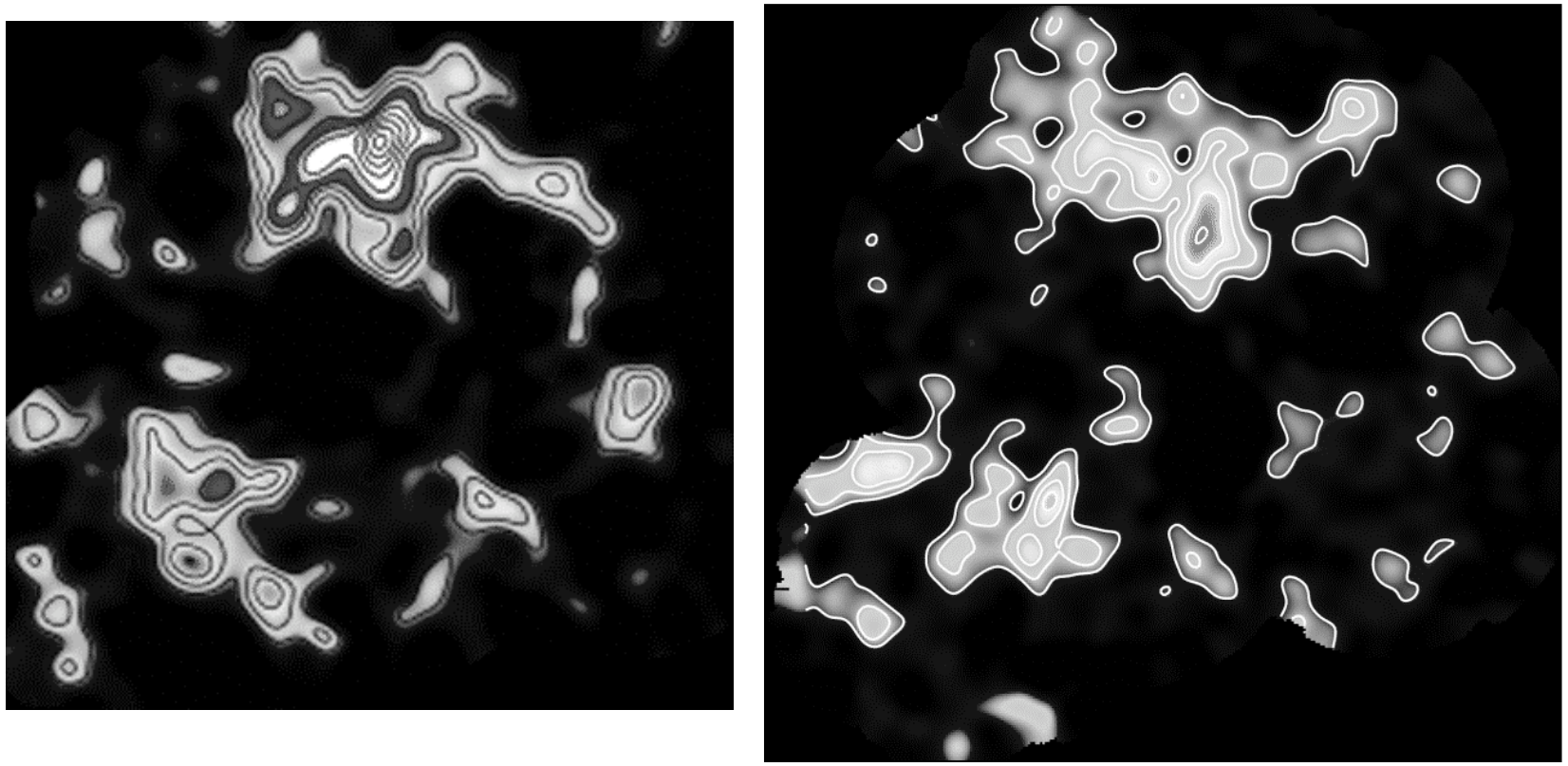
Still 0.2 - 1.0 M_{sun} of dust associated with the remnant

(Eales et al ,in prep)

Cold Dust in Kepler with SCUBA

850 μm

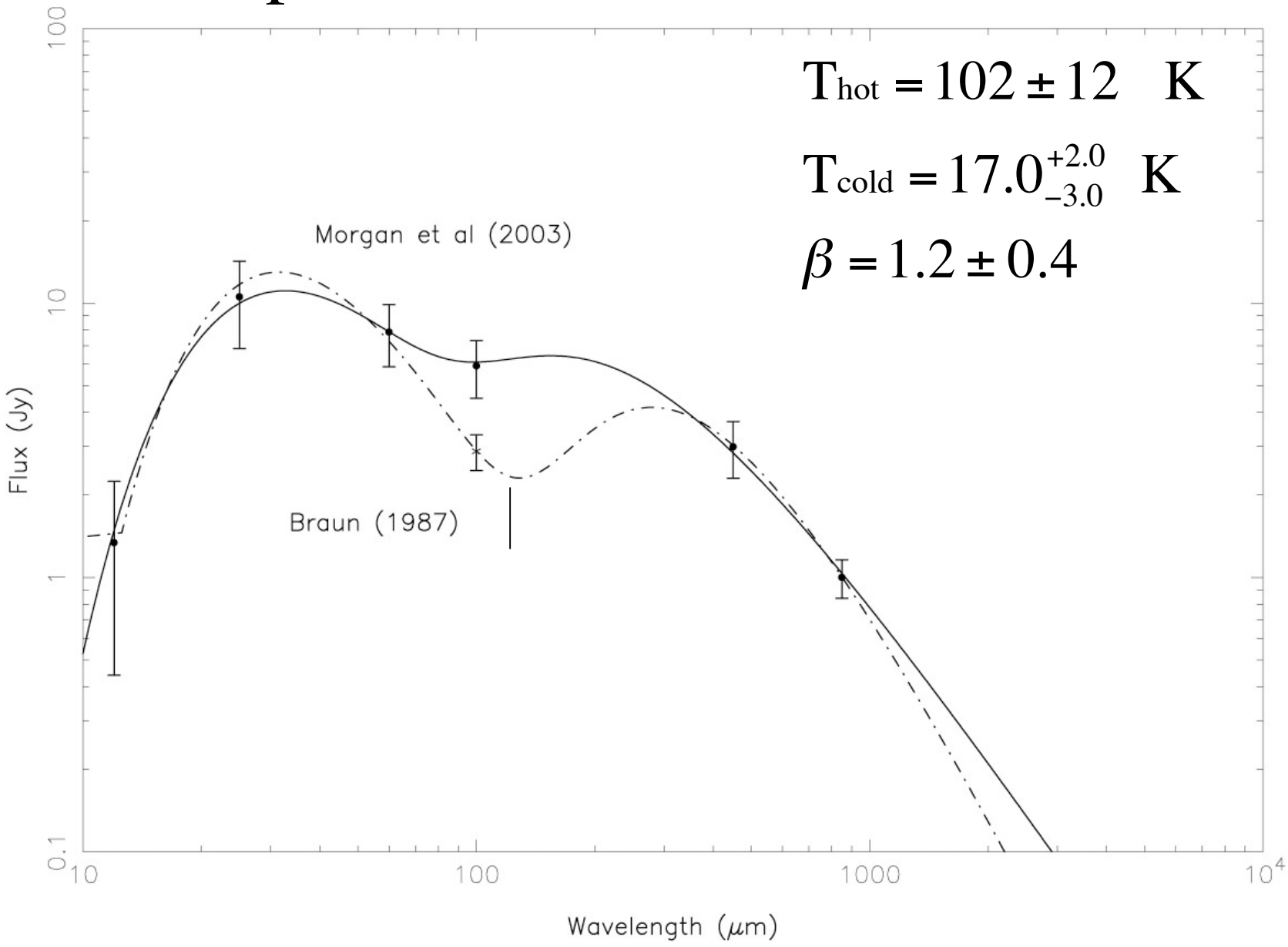
450 μm



$Md \sim 1\text{-}3\ M_{sun}$

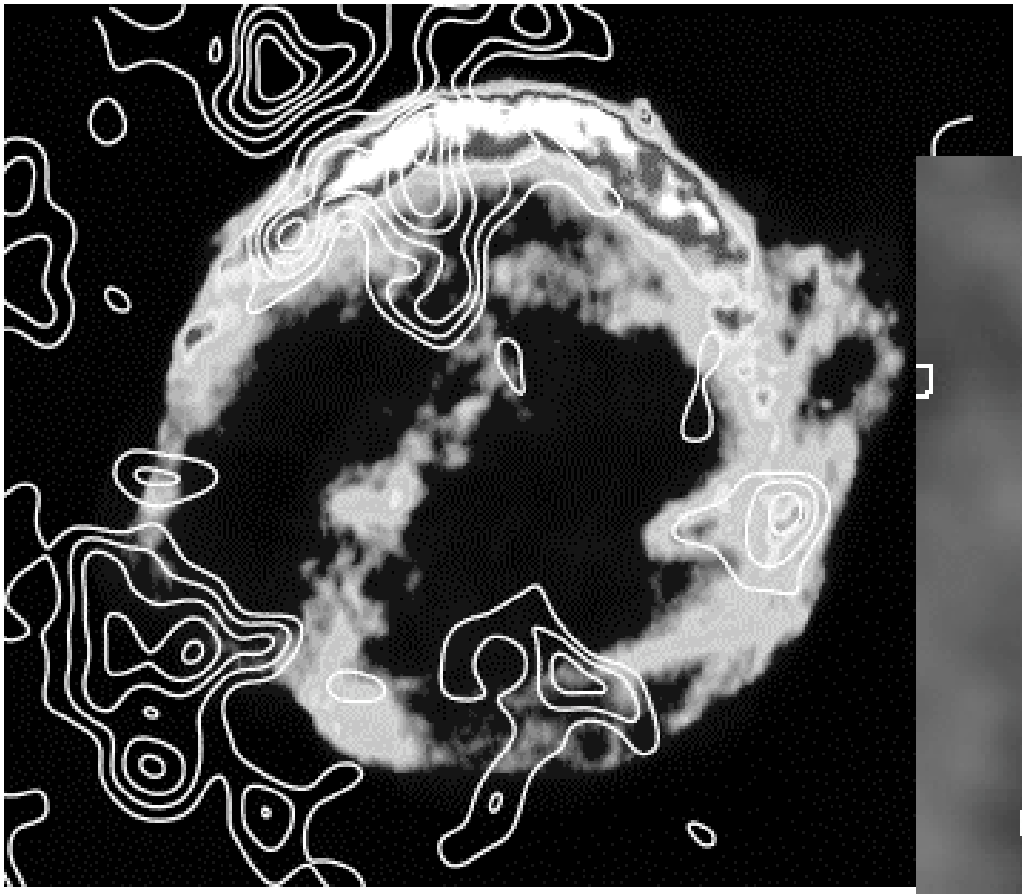
Morgan et al. 2003

SED Kepler

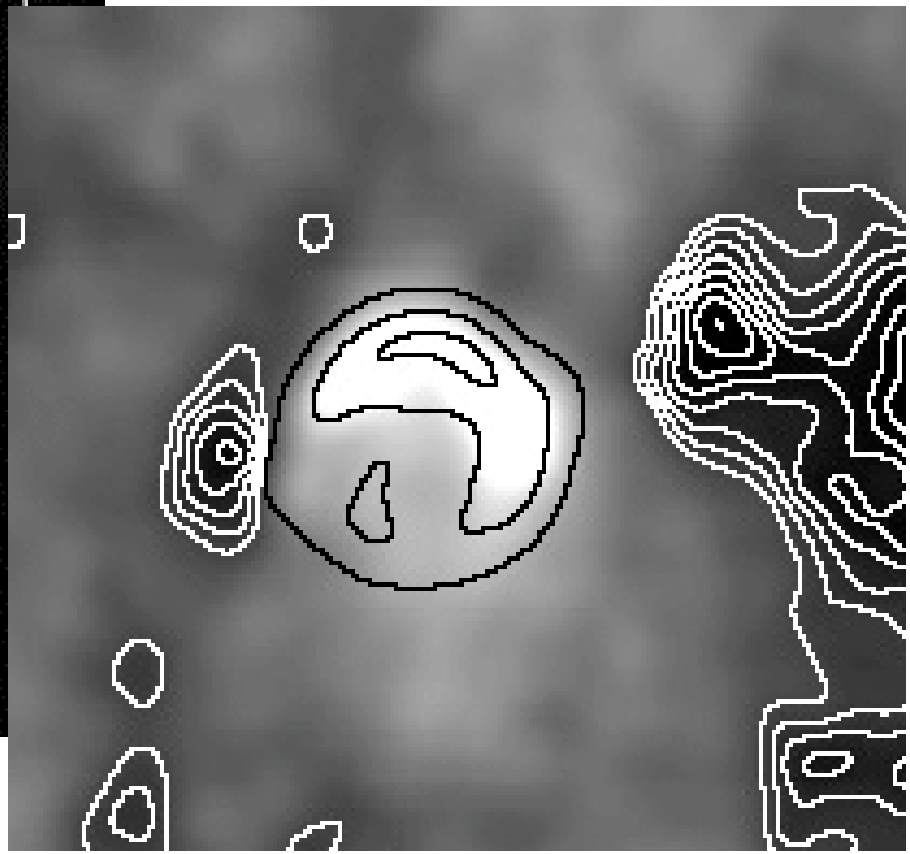

$T_{hot} = 102 \pm 12$ K
$T_{cold} = 17.0^{+2.0}_{-3.0}$ K
$\beta = 1.2 \pm 0.4$
Morgan et al (2003)
Braun (1987)
Flux (Jy)
Wavelength (μm)
100
10
1
0.1
10
100
1000
10^4

Kepler: is the SCUBA emission from the remnant?

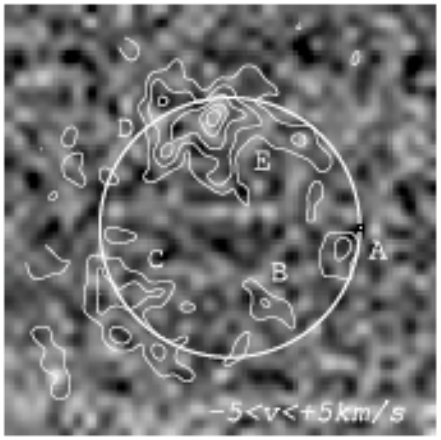
Radio 6 cm (courtesy T Delaney) + SCUBA

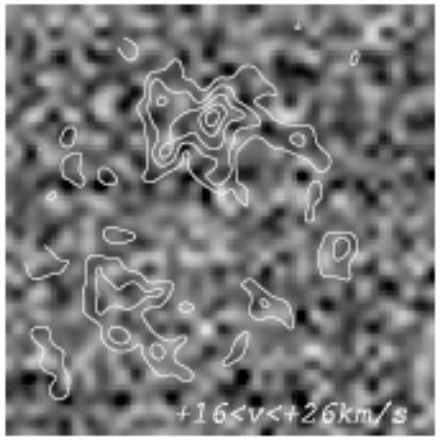


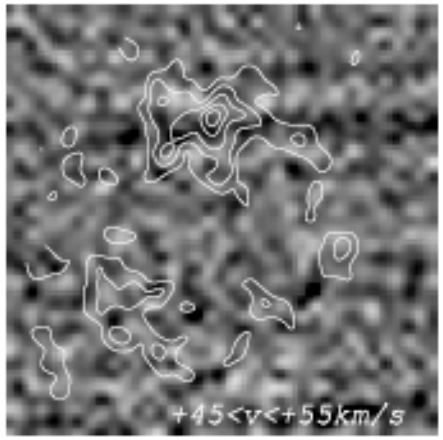
HI emission greyscale, HI contours

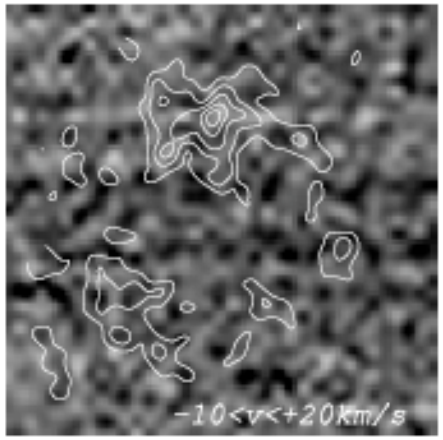


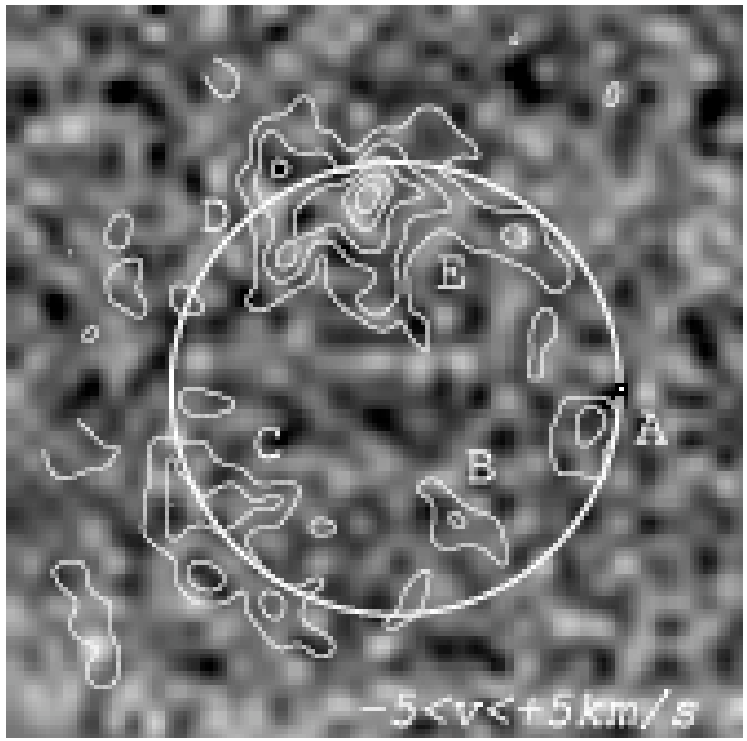
Foreground CO?











We find no signal.

Cloud Name	Dust Mass 850-μm	Gas Mass (CO)	Gas/Dust (CO/850-μm)
A	0.10	< 4.8	< 48
B	0.11	< 4.8	< 44
C	0.22	< 4.4	< 20
D	0.09	< 5.3	< 58
E	0.13	< 4.4	< 34

(Gomez et al, IJA 2007)

Exotic dust grains?

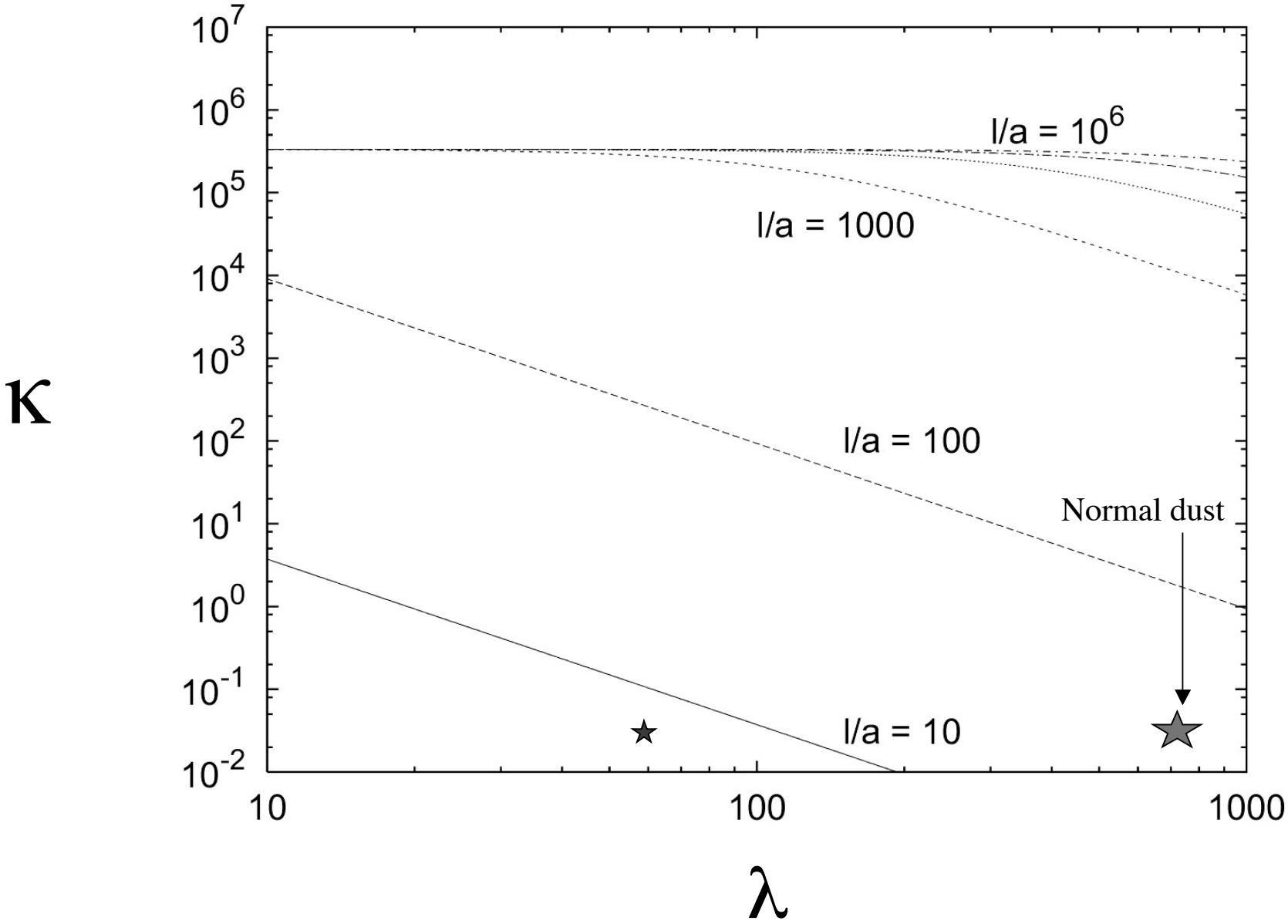
Iron Whiskers

- Elongated grains of iron/graphite (Dwek 2004a, b)
- Efficient emitters at long wavelengths
- Tiny dust mass could explain sub-mm excess
- Modelled radiation and heating of grains in supernova plasma

$$H_d = 2\pi a l n_e (1 - f_r) \left[\int_0^\infty g(E) v(E) E_{dep}(E) dE \right]$$

$$L_d = 4 m_d \int \kappa(\lambda) \pi B(\lambda, T_d) d\lambda$$

Iron Whiskers



Conclusions

- Cold dust scenario not ruled out…yet!

- Cas A dust is contaminated by foreground material but could still be around a solar mass left in the remnant

- We find no clear CO signal towards Kepler - more analysis needed

- If cold dust is iron whiskers, only small amount needed to explain SCUBA flux.

- Herschel & Alma needed…