Comments on Mikako Matsuura's claim for the presence of a large amount of cold dust in the ejecta of SN 1987A

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1. Detection of an emission at 10μm from the ejecta (October 2003 to December, 2010)
2. Energy budget with dust at $80<T<100$ K agreed at day 1316 with theory and still does.
3. Cold dust was not present at day 1316

- When did this cold dust appear?
- Origin and heating mechanism?
- Could warm and cold dust co-exist in the ejecta?

How does the presence of dust manifest itself?
(FOR AN OBSERVER!....)

There are several ways in which the presence of dust may be shown to be associated with supernovae. Each individually may not be unequivocal concerning its precise location and time of origin. This is mainly due to the facts that (i) an infrared excess doesn't indicate unambiguously the presence of dust (line emissions) and (ii) although dust can form in the ejecta, it may also form or be already present in the CSM. SN1987A provided the means of examining these methods.

Possible dust indicators.

- 1. Early presence of molecules
- 2. Blueward line shifts.
- 3. Light curves:
    1. Decrease in visual light curves.
    2. Increase in IR emission.
    3. <u>+ NO</u> Effects on Bolometric light curve.

Dust in or near other SNe has used some but never all these methods.

Evidence for Dust Formation in SN 1987A

Blueward lime shifts

Dust preceded by molecule formation. CO, SiO <150 days

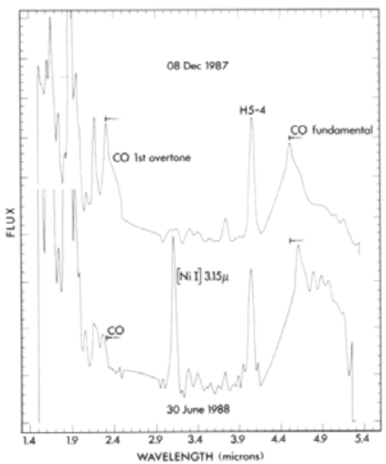
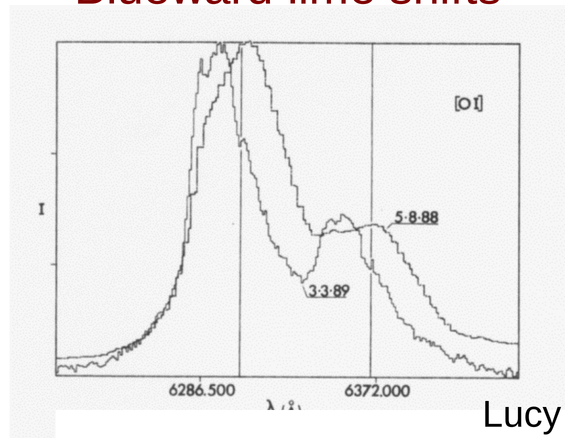
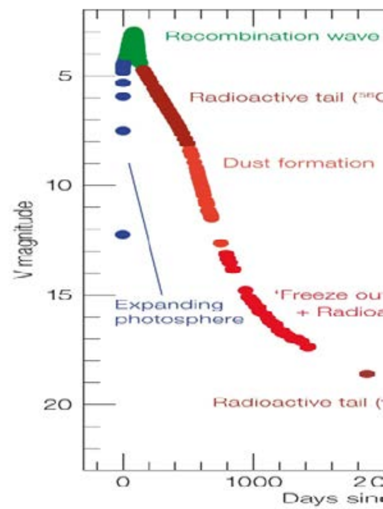


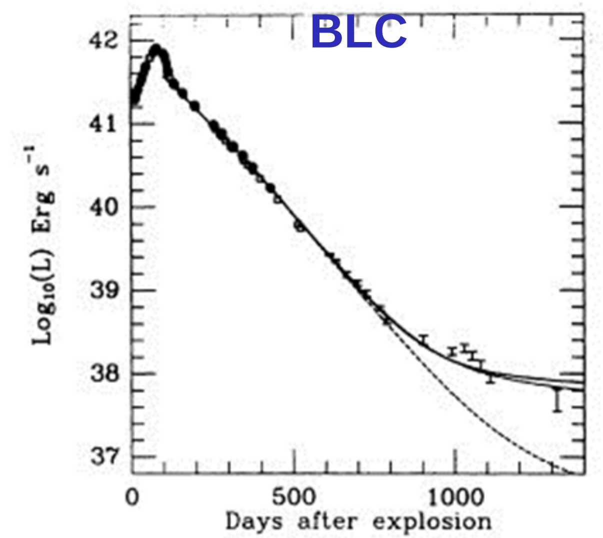
Fig. 7. CVF spectra from 1.4–5.4 μ of SN 1987A at 2 epochs. Note the temporal evolution of the strength of the fundamental and first overtone bands of CO, and the way in which the strength of the [Ni I] 3.12 μ has changed.

Danziger & Bouchet, 1989



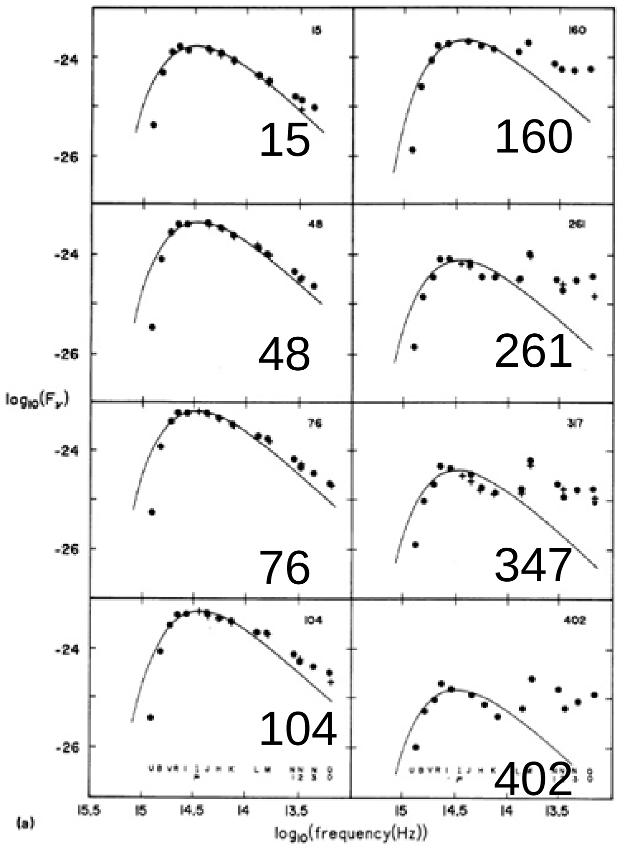
Lucy et al., 1989

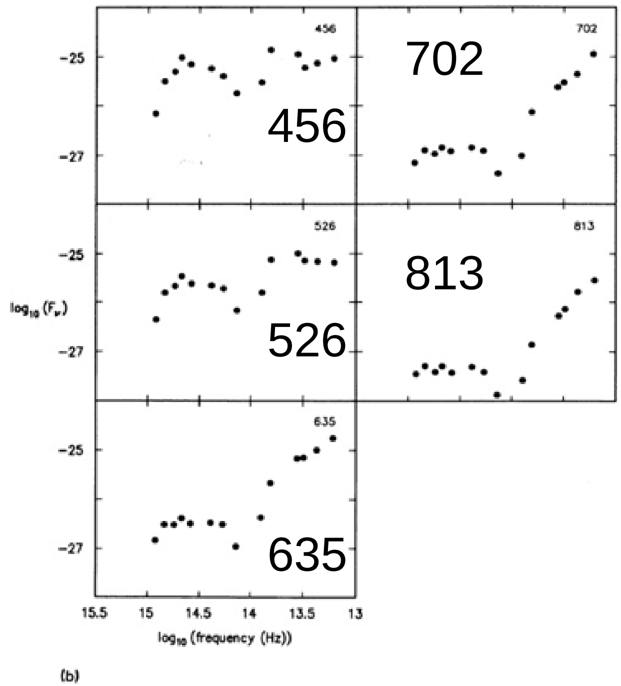


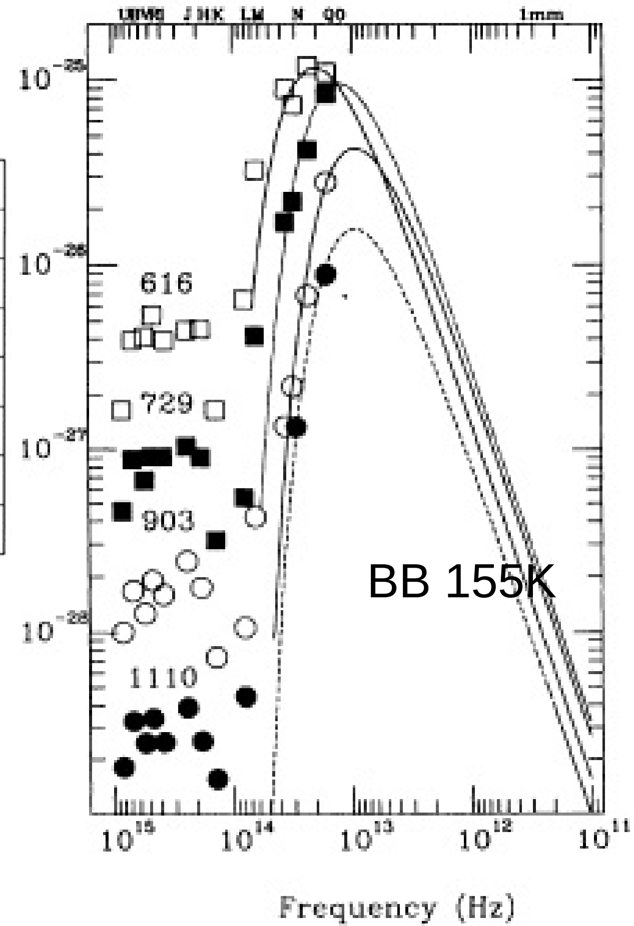


Suntzeff & Bouchet, 1990

In SN 1987A, an IR excess was apparent at ~ 100 day which was due to CO and SiO molecules.
Dust appeared at ~ 400 day, CO and SiO still prominent in the spectrum.
At day 1110 the SED could be fitted with a black body curve at T = 155 K

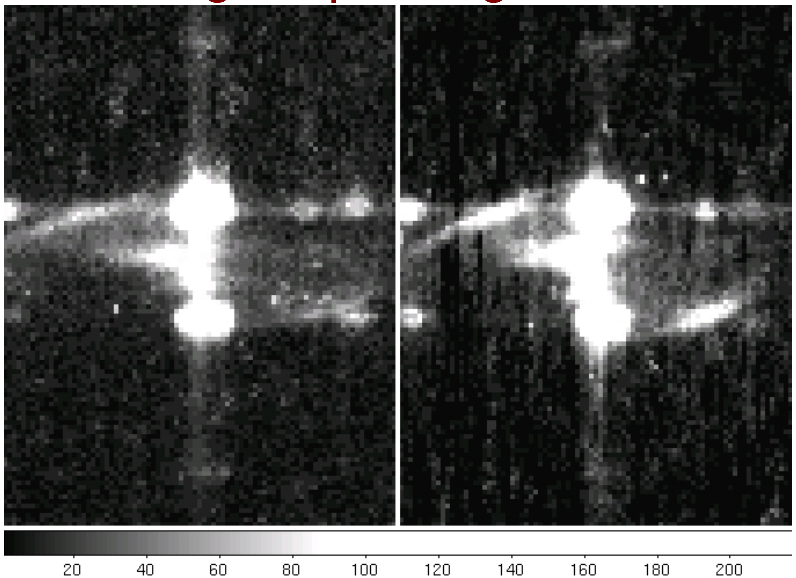






Suntzeff & Bouchet, 1990
Bouchet, Danziger, Lucy, 1991

2009 STIS spectrum of SN87A showing Halpha region



Central part (debris) shows blue (approaching) extends to ~4000 km/s. Red extension not apparent: Dust in ejecta blocks far side receding.

(SAINTS; France et al., 2010)

SN1957D in M83 Type Ib/c,II

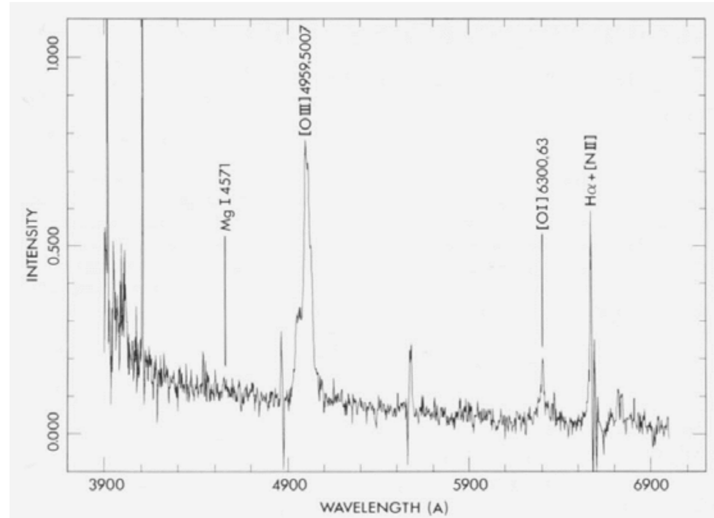


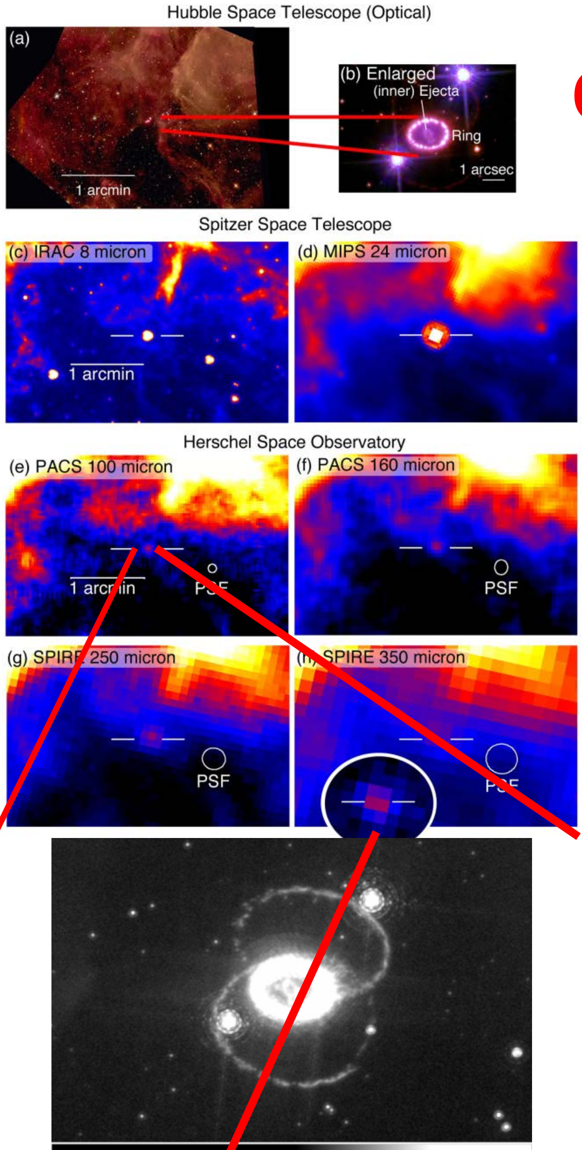
Figure 2: *Spectrum of SN 1957d. Wavelength identifies features discussed in the text, since the redshift of M83 is only 500 km s^{-1}.*

Blue shift 650km/s of [OIII]

➔ Dust remains after 30 years

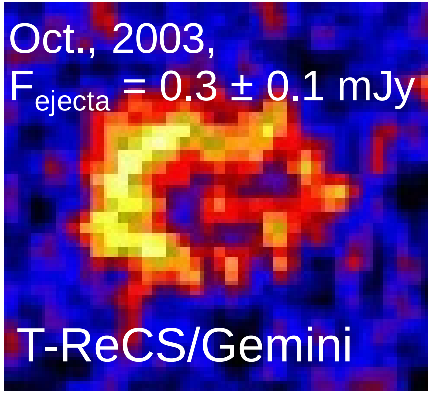
Our last observations in the visible show that dust is still present in the ejecta

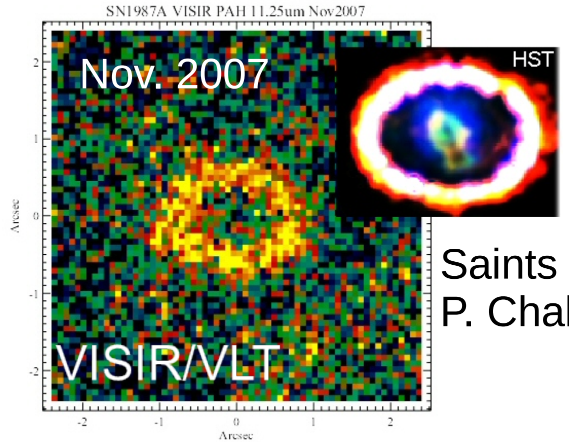
Central emission detected at 10 μm!!



$M_{dust,ejecta}$ = 0.4 – 0.7 $M_{\odot}$, 17<T<23 K

Matsuura et al., 2011

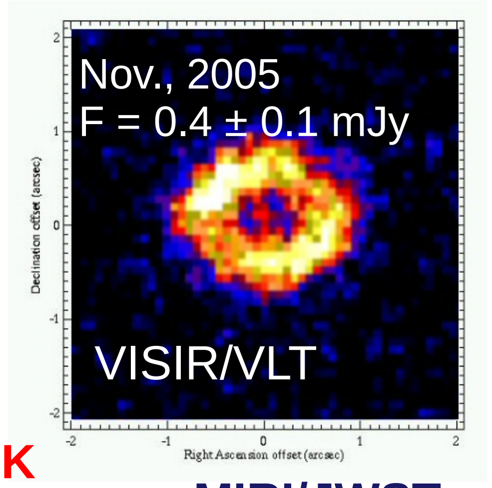


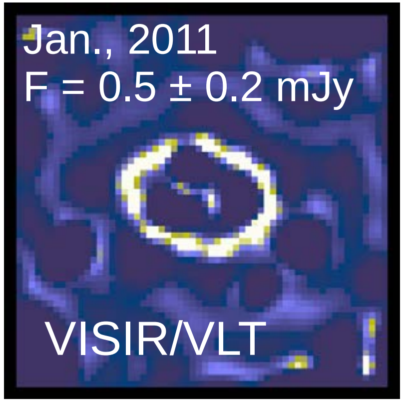


Saints & P. Challis

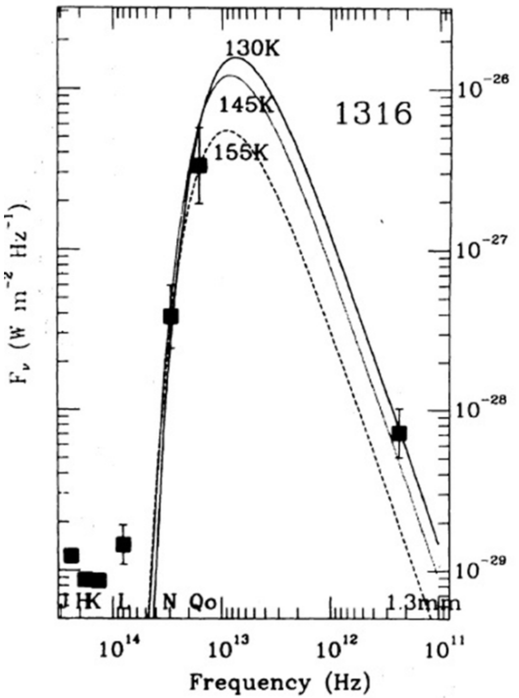
Bouchet et al., 2004, 2006:

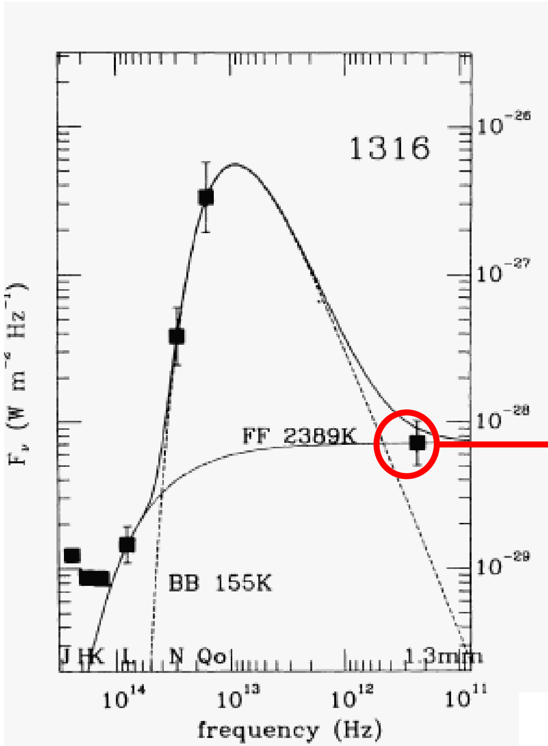
$M_{dust,ejecta} = 10^{-4} - 2\ 10^{-3}\ M_{\odot}$, 80<T<100K



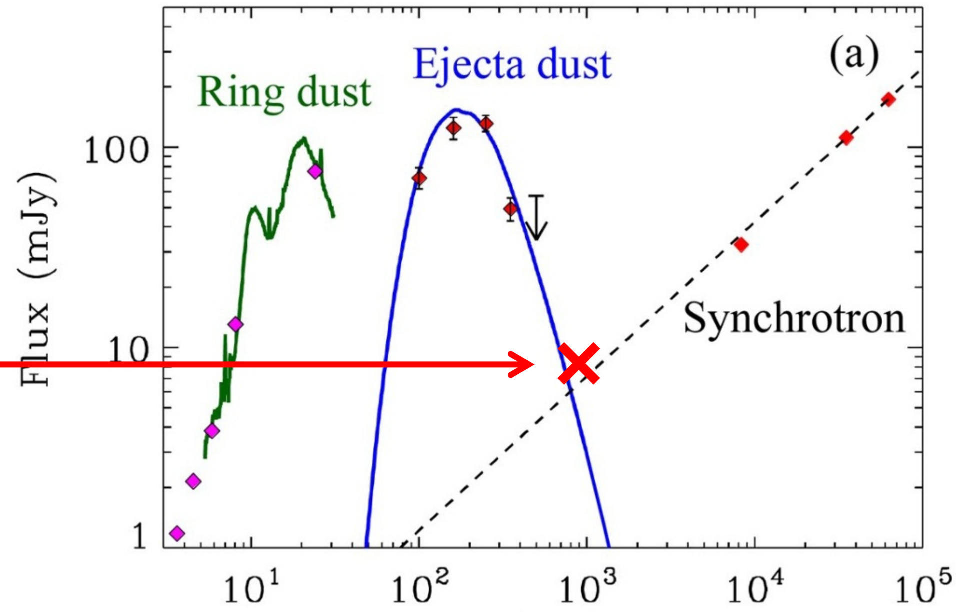


MIRI/JWST : 1μJy @ 10 μm (10σ, 10,000s)





Matsuura et al., 2011



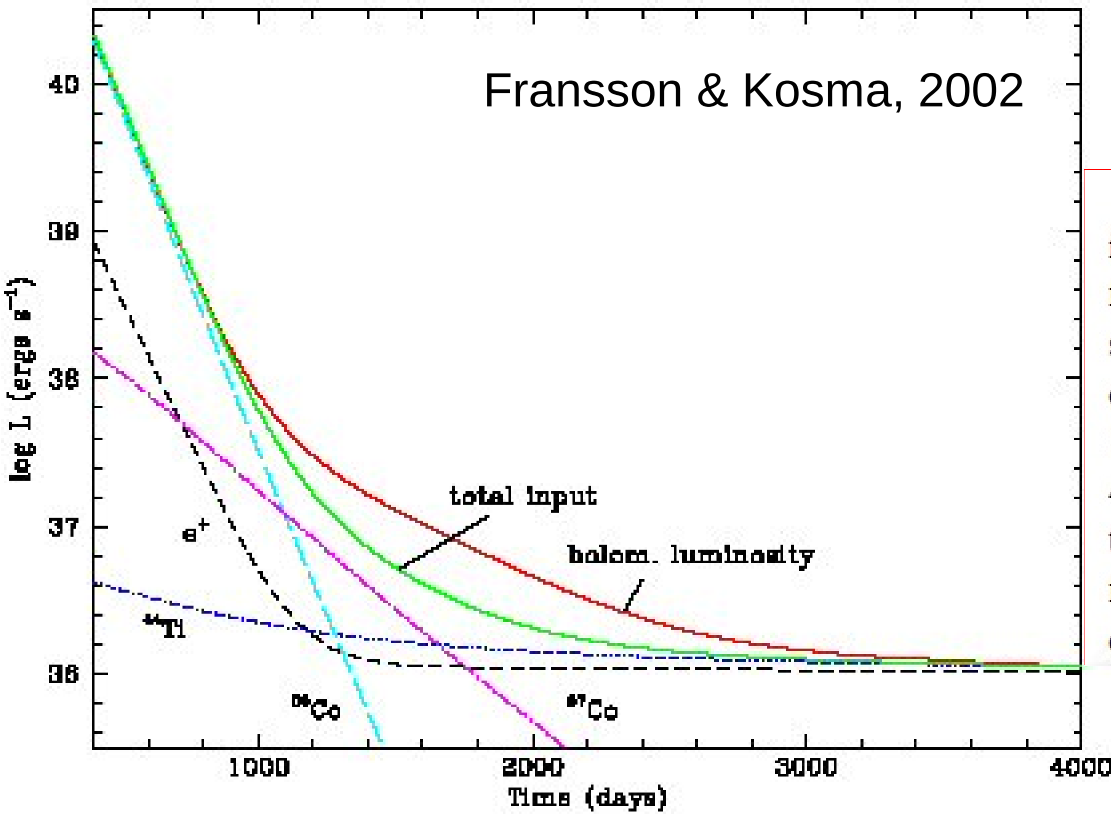
IR Spectrum for day 1316.
Note L & 1.3mm fluxes.
Mass of radiating dust.~3x10^{-4}Msun.
Also type of dust silicates or C?
(featureless spectrum).

Bouchet, Danziger, Lucy, 1991
Bouchet & Danziger, 1993
Suntzeff & Bouchet, 1990

The derived dust mass is about 10^3 times larger and about twenty times colder than that measured at mid-infrared wavelengths around 600 days after the explosion, soon after it first condensed out of the ejecta (*15*, *16*). Far-infrared and submm observatories with Herschel's sensitivity did not exist at that time. It is possible this submm dust mass existed at day 600.

➔ At day 1316, SEST measurement

The energy budget (bolometric light curve) was exactly as expected from radioactive decays ➔ rules out the possibility that cooler dust was also present at that time.



We obtained photometry from the processed Herschel images (Table 1) (*27*), assuming SN1987A is unresolved; the fluxes are plotted in Fig. 2A. There are two peaks in the spectral energy distribution (SED), one near 20 μm and the other at 150–200 μm (Fig. 2A). The total luminosity from 100–500 μm is approximately 220 $L_\odot$. The mid-infrared (5–40 μm) luminosity is 1200 $L_\odot$ (epoch of 7983 days) (*20*) and the x-ray luminosity is ~500 $L_\odot$ (8012 days) (*28*). Thus, the far-infrared/submm emission we detected is an important component of this SN's SED.

Matsuura et al., 2011

both from CS Ring!

Matsuura et al., 2011 ➔ $L_{100\text{-}500\mu m}$ = 8.5 E+35 Erg s^{-1}

Bouchet et al., 2006 ➔ $L_{5\text{-}30\mu m}$ = 1.3 E+36 Erg s^{-1} (at day 1316, ~90% of total luminosity)

Radioactivity + X-raying of the ejecta (Larsson et al., 2011) ➔ L_{bol} ≈ 1.7 E+36 Erg s^{-1}

?????