JWST Survey of Dusty Supernovae: Late-Time Dust Properties Decades Post-Explosion

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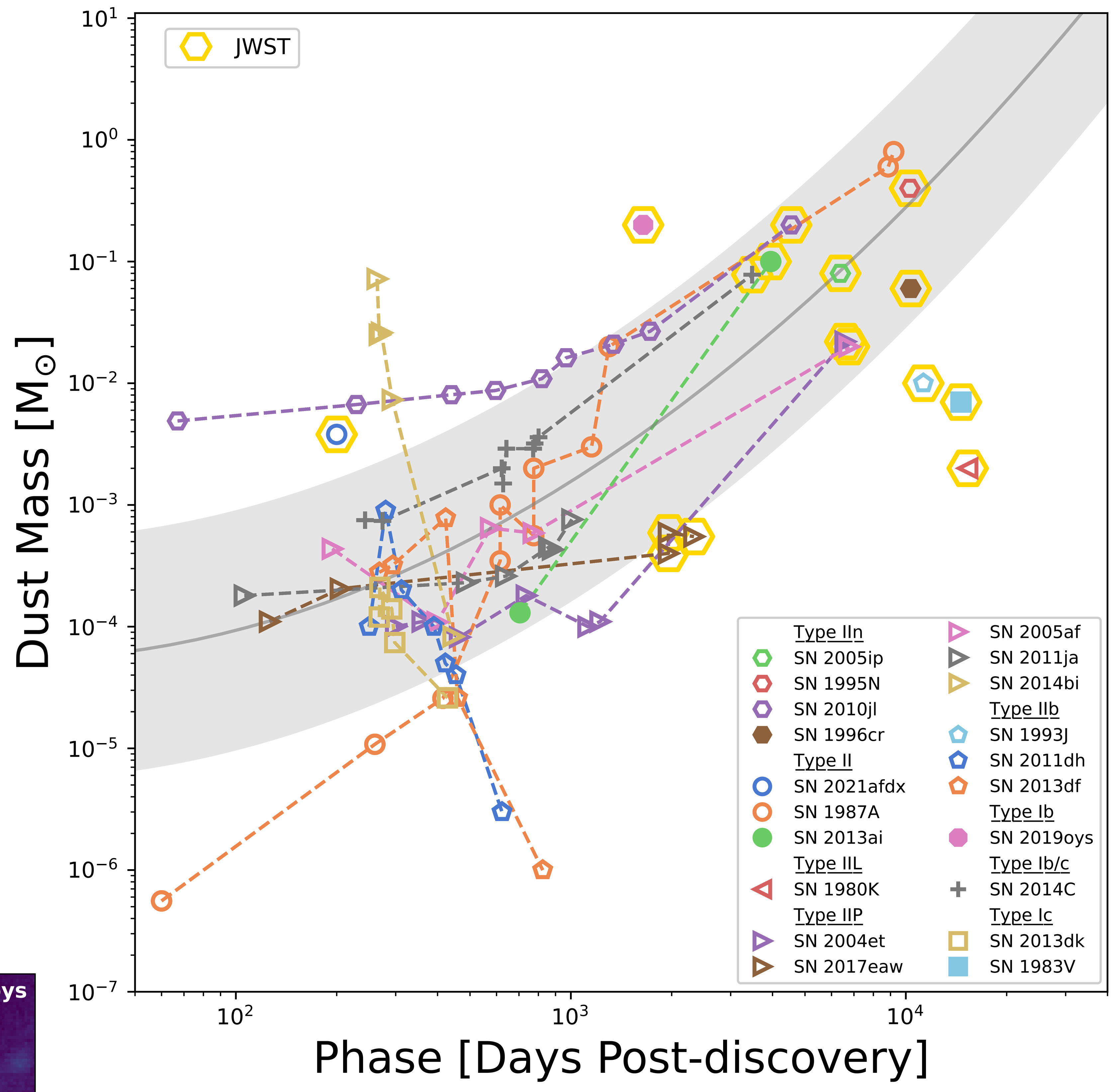
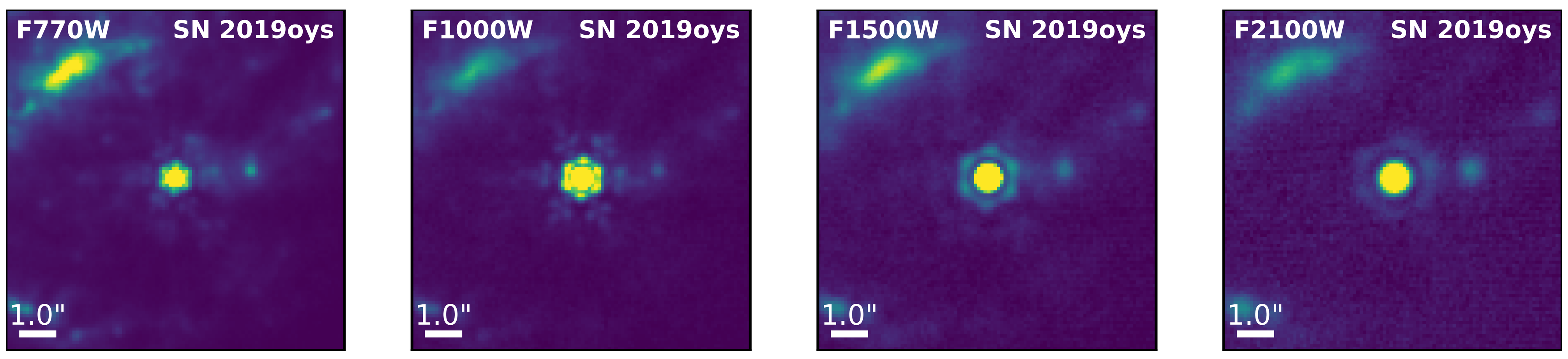
Motivation

While Supernovae (SNe) shine brightly on timescales of months to years in the optical, studies in the mid-ir with the Spitzer Space Telescope have revealed that SNe can remain bright for ~1-5 years post explosion due to illuminated dust in their circumstellar environment. The majority of dusty SNe were observed during the Spitzer warm mission, limiting our understanding of these events to wavelengths of 3.6 and 4.5 μm. The total dust yield was left unconstrained since the colder temperature dust (~150 K), which likely contains the bulk of the dust-mass, was beyond the reach of Spitzer. With its broader wavelength coverage and enhanced sensitivity, JWST has revolutionized our view of years- to decades-old dusty supernovae, enabling robust dust-mass measurements at late phases only previously possible for the nearest SN, SN 1987A. Recent papers on SNe 2004et, 2017eaw, 1993J, and others have shown significant dust yield 0.01-0.1 $M_\odot$. Dust observed at these phases directly traces pre-SN mass loss and provides constraints on the late stages of massive star evolution. Several questions remain and the phase space of such observations (dust temperature, yield, and SN age) is still poorly explored or understood. Here we present results of our JWST Cycle 2 PID 3921, JWST Cycle 3 PID 6356 and JWST Cycle 4 PID 8883 surveys. Previous studies have hinted at an empirical trend of increasing dust mass with SN phase, out to more than 30 years post-explosion. While intriguing, these analyses have never been truly self-consistent due to a paucity of available observations, mixed methodologies and limited wavelength coverage. We will present our JWST survey progress, the largest of its kind with measured dust properties and limits from JWST MIRI multi-wavelength observations for dozens of SNe. In addition, we will present exciting individual results for SN 1983V, SN 1996cr and SN 2013ai with rich multi-facility datasets, each with large dust yields of 0.01-0.1 $M_\odot$. This newly characterized dusty SN population serves as a powerful tracer of pre-SN mass loss and can offer important constraints on the late stages of massive star evolution and even the progenitor star itself.

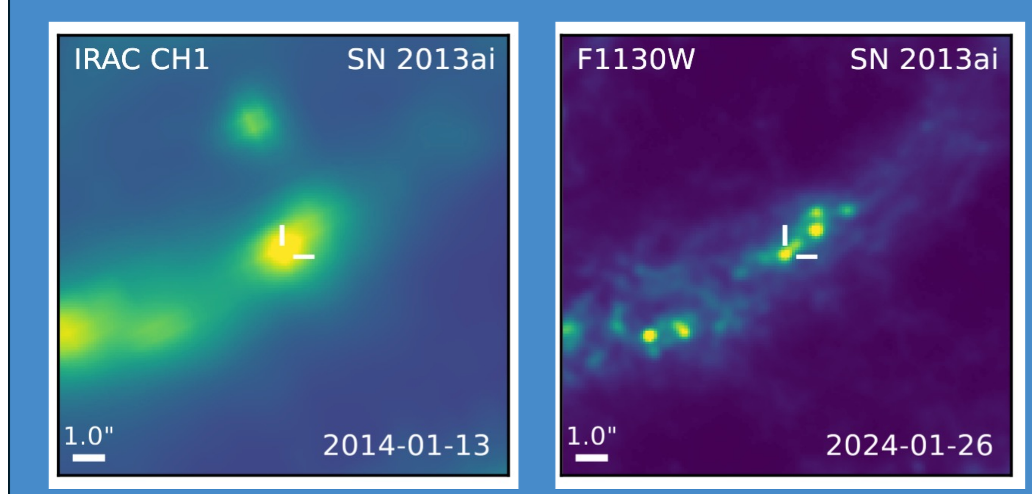


Mid-IR dust mass measurements as a function of time for extragalactic SNe. JWST measurements are highlighted in gold hexagons. This figure shows an apparent trend of increasing mass with time. The dust mass measurements of SN 1983V (Kressy et al. 2026, in preparation) and SN 2013ai (Moore et al. 2026, in preparation) are compared to Spitzer multi-epoch observations from Szalai et al. 2019, and JWST measurements for SN 1995N (Clayton et al. 2025), SN 1993J (Szalai et al. 2025), SN 2021afdx (Hosseinzadeh et al. 2023), SN 2005af (Sarangi et al. 2025), SN 1980K (Zsíros et al. 2024), SNe 2004et and 2017eaw (Shahbandeh et al. 2023), SN 2014C (Tinyanont et al. 2025), SN 2005ip (Shahbandeh et al. 2025), and SN 2010jl (Smith et al. 2026).

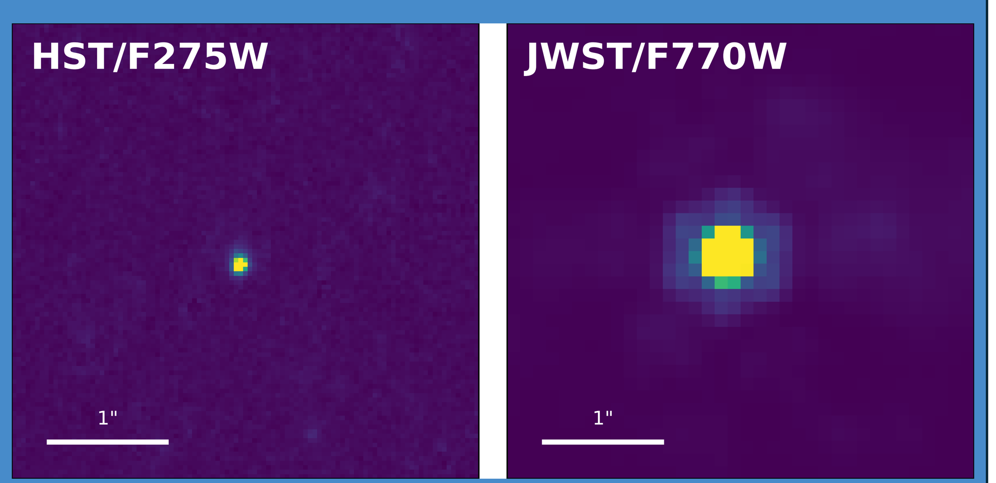


Source Identification

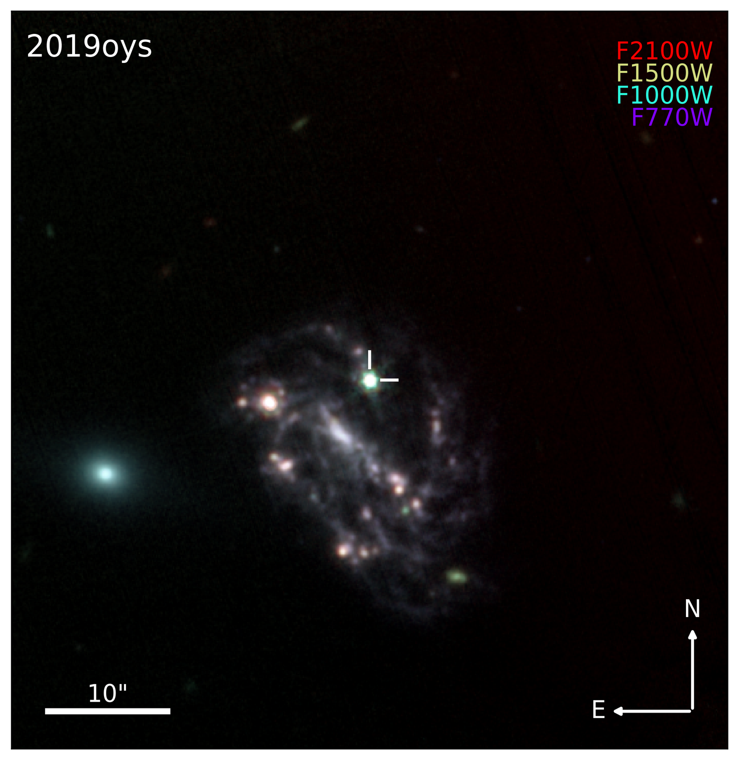
Precise relative alignment of MIRI images to HST, NIRCam, and Spitzer imaging using JHAT Rest et al. (2023).

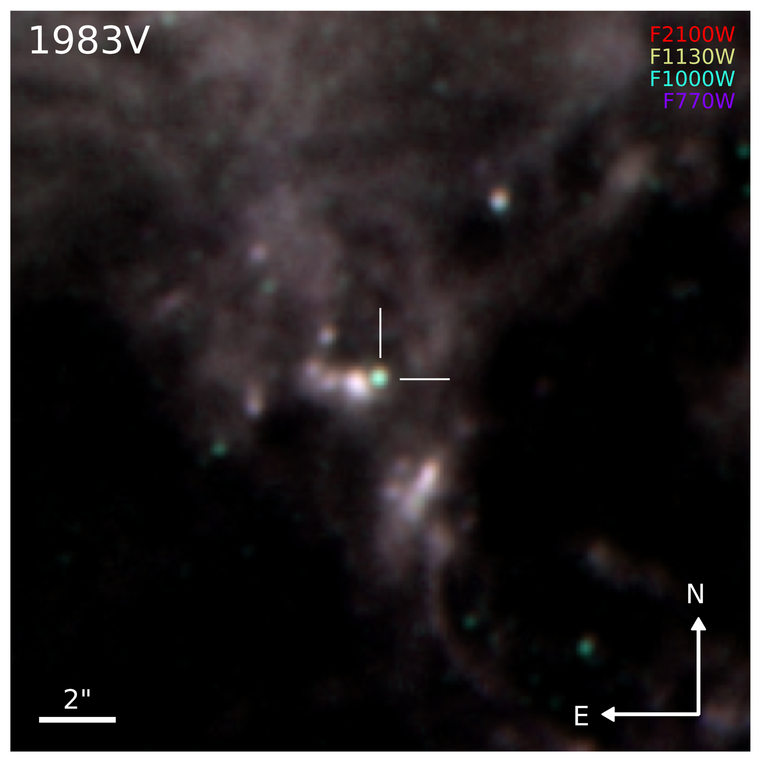


Mid-IR images of SN 2013ai (Peculiar Type II) observed approximately a decade apart. The Spitzer image (left) has been resampled to match the JWST F1130W image (right).



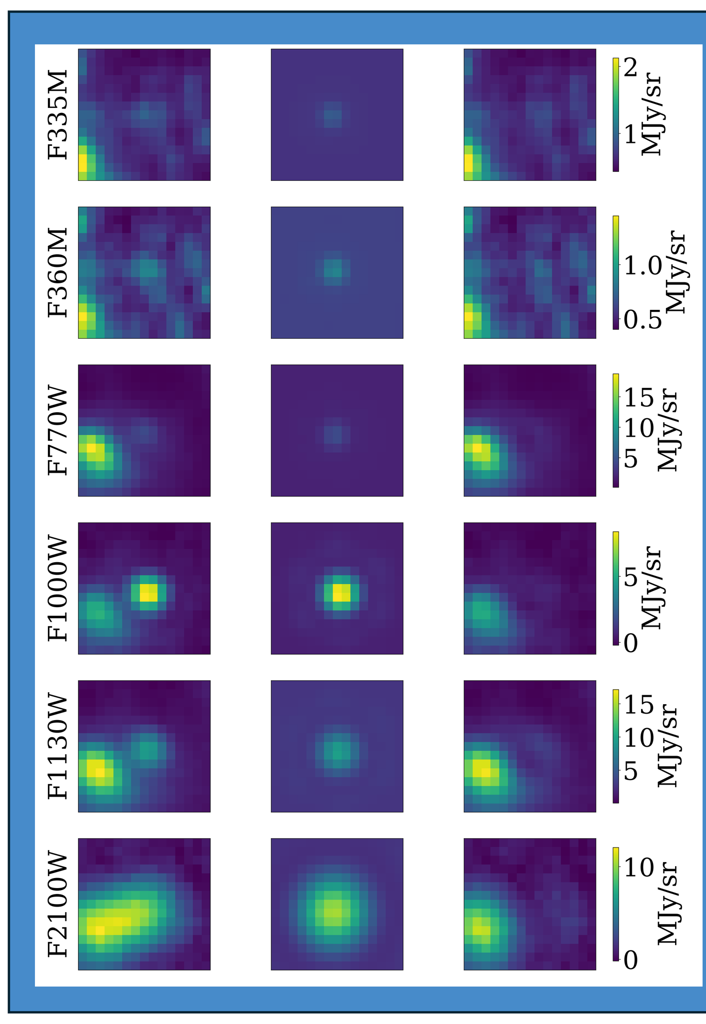
(Left) HST/F275W detection of SN 2019oys (Type Ib) at ~850 days from discovery (Fremling+2026) and JWST/MIRI detection at ~1400 days (right).



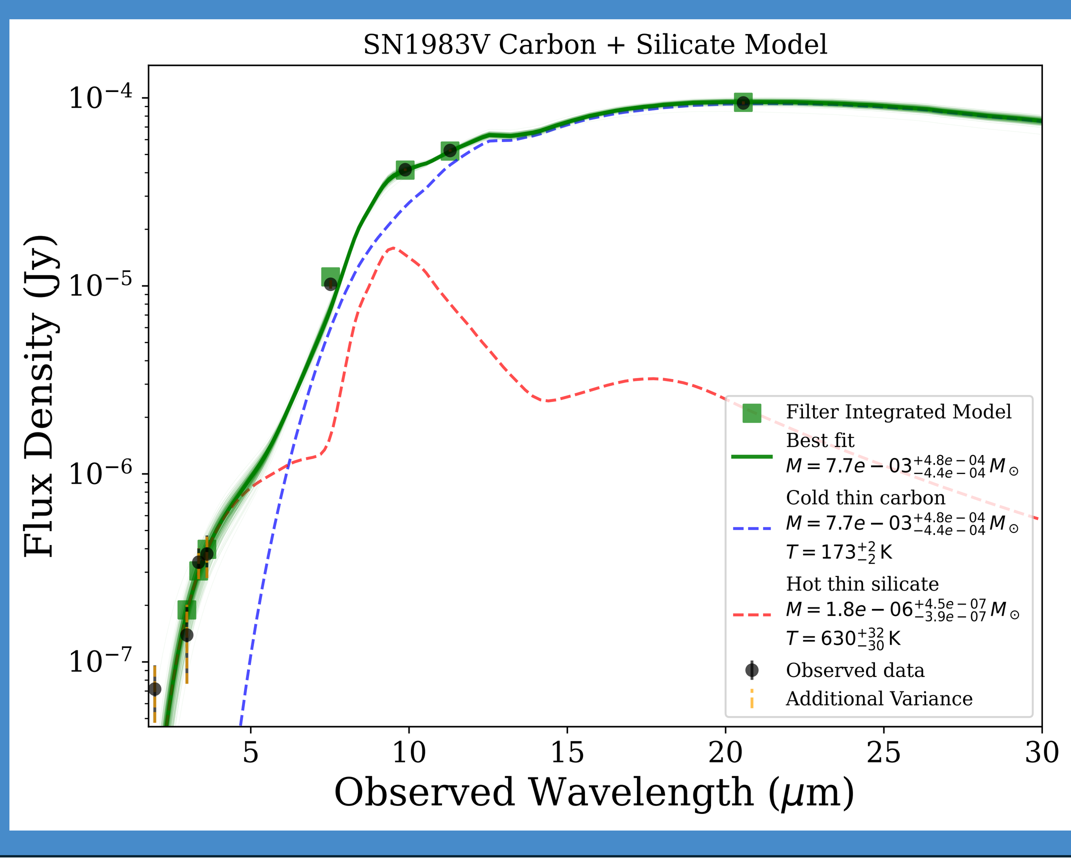


Dust Origin

The source of large amounts of dust in high redshift galaxies is uncertain. Core-collapse SNe (CCSNe) have been considered possible sources of dust in the early universe. Among CCSNe, Type IIP SNe are plentiful enough that they could account for the observed dust at high redshifts. Models of expanding SNe IIP ejecta succeed in condensing out sufficient quantities of dust. If the dust is new, it may condense in the expanding SN ejecta or form between the forward and reverse shocks. New dust continuously cools so that reservoirs build up and are detectable at longer wavelengths. Mid-IR telescopes have previously lacked the sensitivity at both late times (>1 year post-explosion) and longer wavelengths (i.e., >10 μm) to detect old, cold dust reservoirs.



Forced Photometry and Modelling



We perform Photometry with the space-phot python package (Pierel 2025). We fit the SED using several dust models. Following methods used for SNe 2004et and 2017eaw (Shahbandeh et al. 2023). In a simplified picture, observations and models of dust formation in SN ejecta, both support the presence of O-rich dust species in the form of Mg-silicates, and C-rich dust species such as amorphous carbon or graphite. We simultaneously fit the dust mass, temperature, composition, and opacity using the dustysn python package (Gomez et al. 2025)

Conclusions

SN 1983V and SN 2013ai, SN 1996cr were recovered from archival and targeted JWST observations, exemplify what is possible with one epoch and a few non-ideal filters. To do a proper study, we need a comprehensive, statistically significant data set, including upper limits on dust from non-detections. It is still an open question why some SNe have large dust yields and others do not. A large sample will show and what fraction of SNe do/don't produce/illuminate dust.

There is still much work to do in order to understand the dusty late-time lives of SNe including the mechanism powering their long-lived luminosity and the dust origin. We have highlighted here only a small number from sample of many dozens, with more SNe to be observed during JWST Cycles 4 and 5.

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