

Rare insight into the progenitors of Type Ia supernovae from a double detonation

Las Cumbres Observatory
University of California, Santa Barbara

Estefania Padilla Gonzalez
epadillagonzalez@ucsb.edu



Type Ia Supernovae – distance indicators

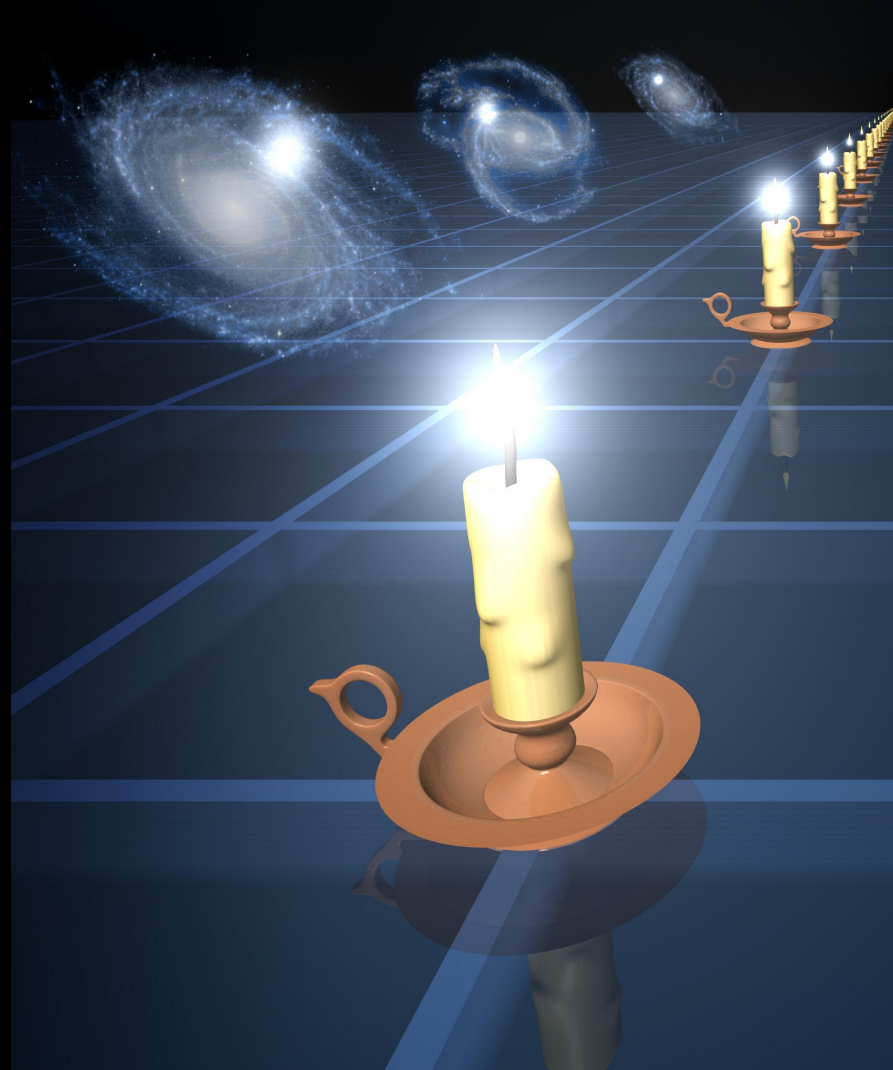


Illustration credit: JPL

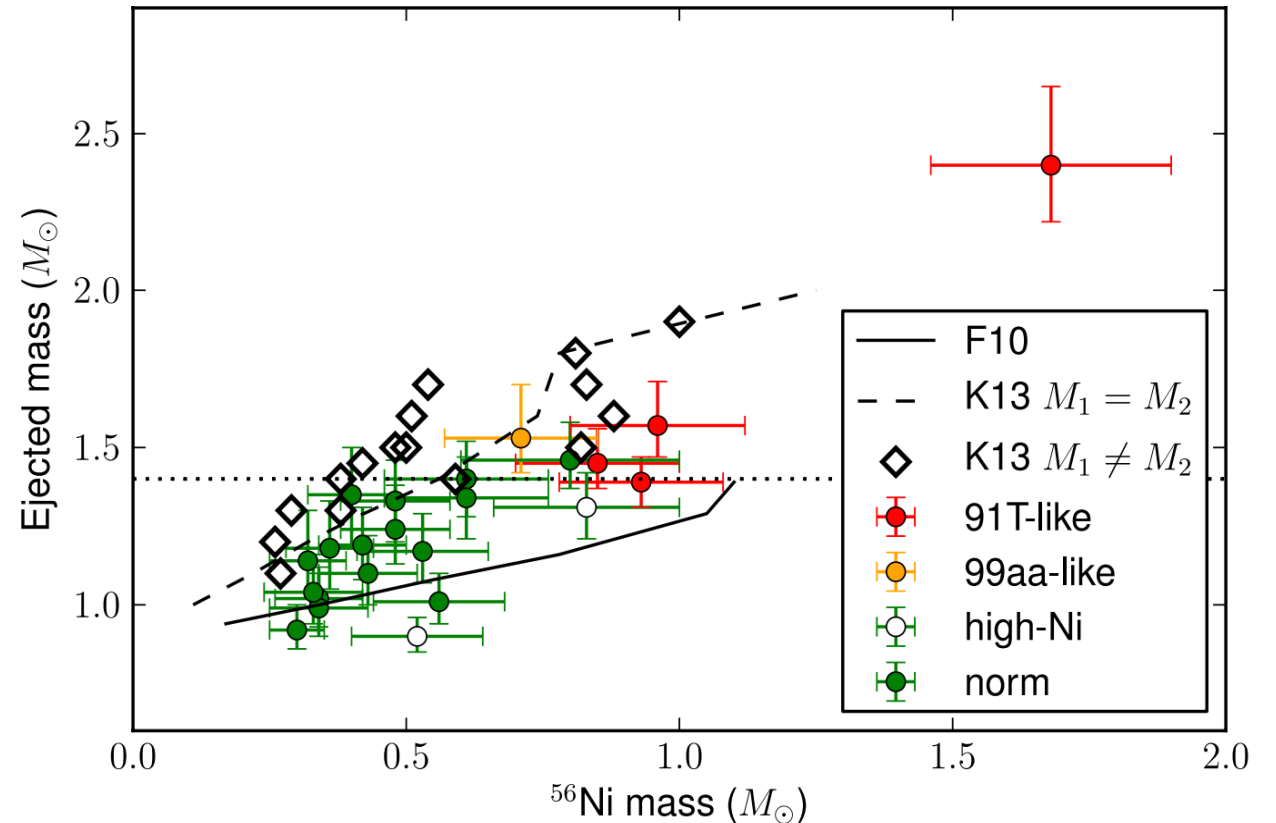
What are SNe Ia?

- They are explosions of a white dwarf star in a binary system, but how it is triggered is not well understood.
- Historically believed to be triggered when the white dwarf approaches the Chandrasekhar mass limit (1.4 times the mass of the Sun), which should result in an explosion in the core.



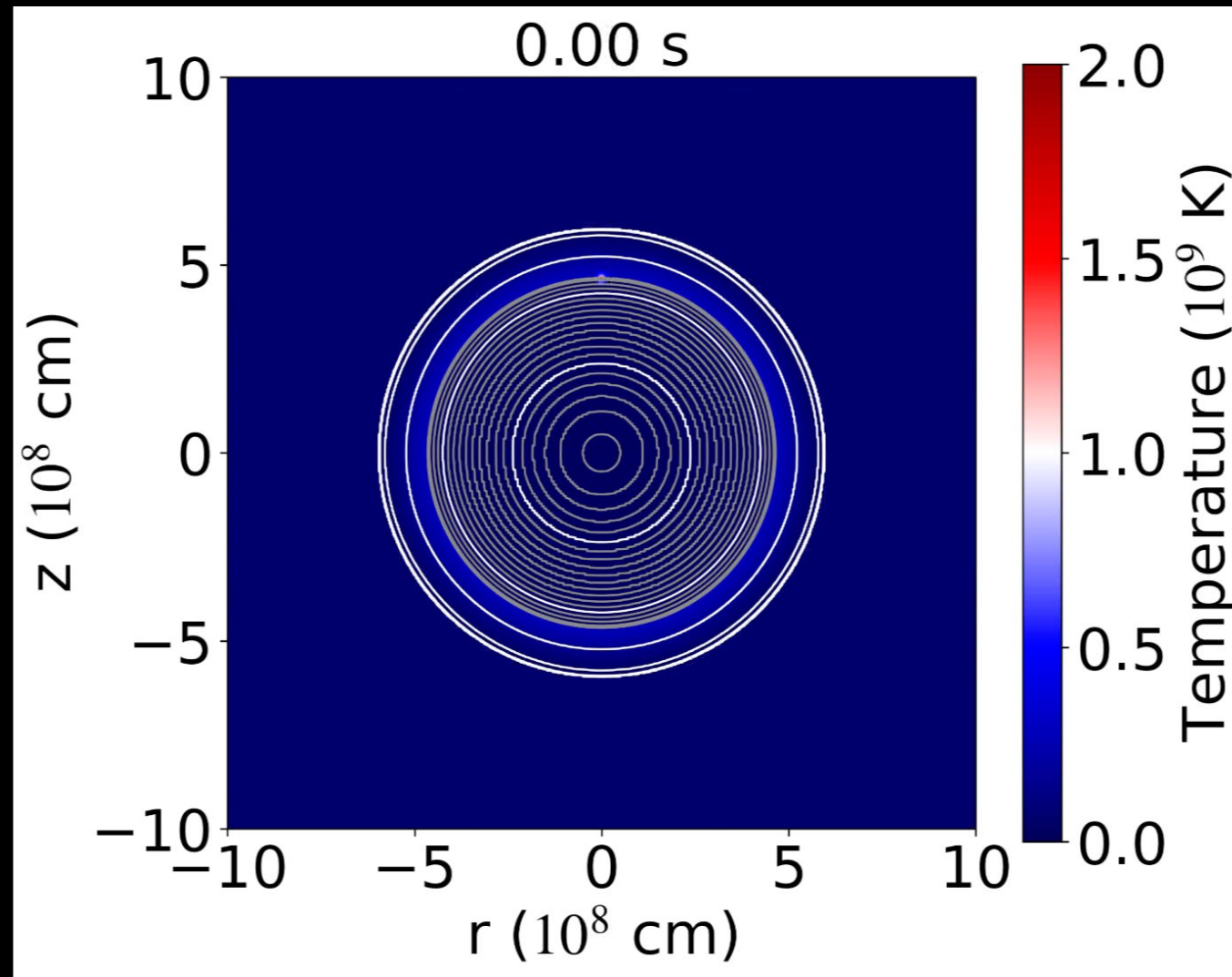
Mass of ejecta calculations

- Based on comparing lightcurve widths to simulations, other studies have found that about 50% of SNe Ia have ejecta less massive than the Chandrasekhar mass limit.
- Not widely accepted because simulations of sub-Chandrasekhar mass explosions do not match colors or spectra of normal SNe Ia.



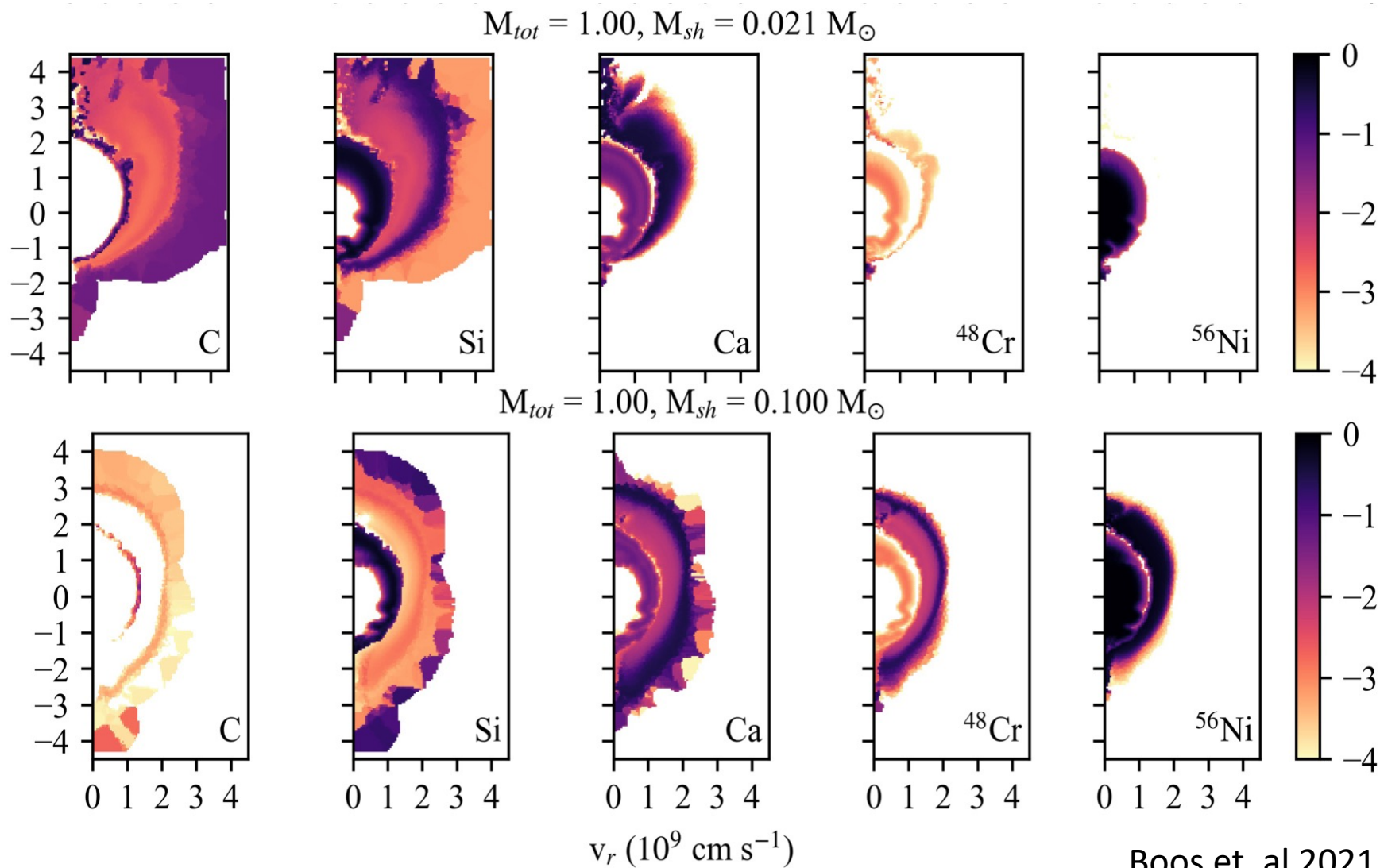
Scalzo et. al 2014

Explosion mechanisms of double detonations

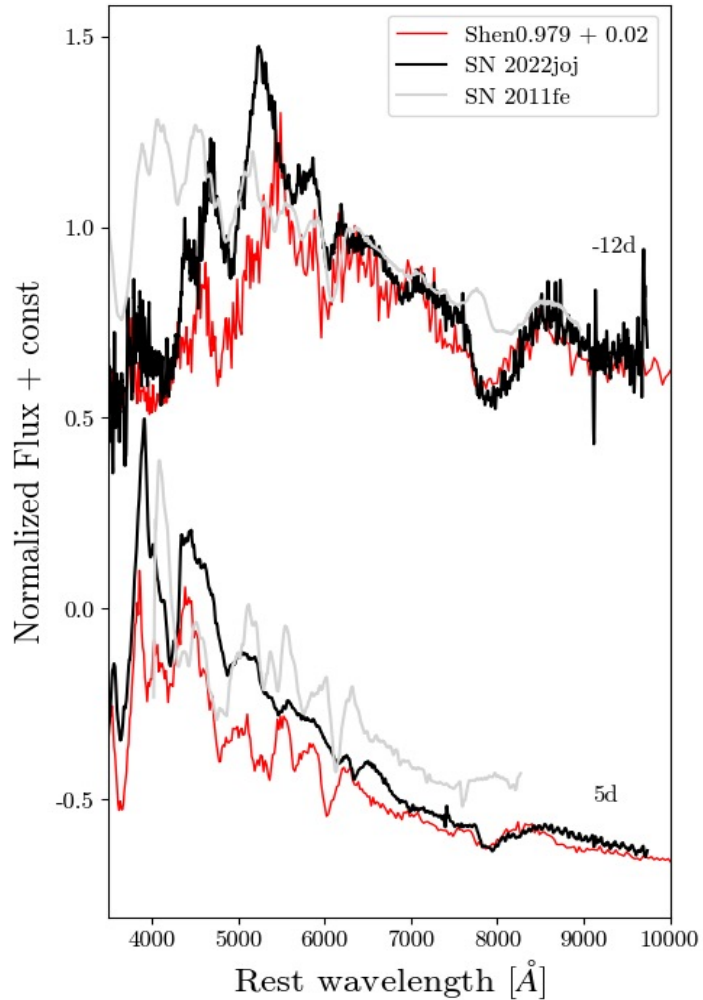


Boos et. al 2021

Double detonation models



Evidence of a double detonation



Redder

Bluer

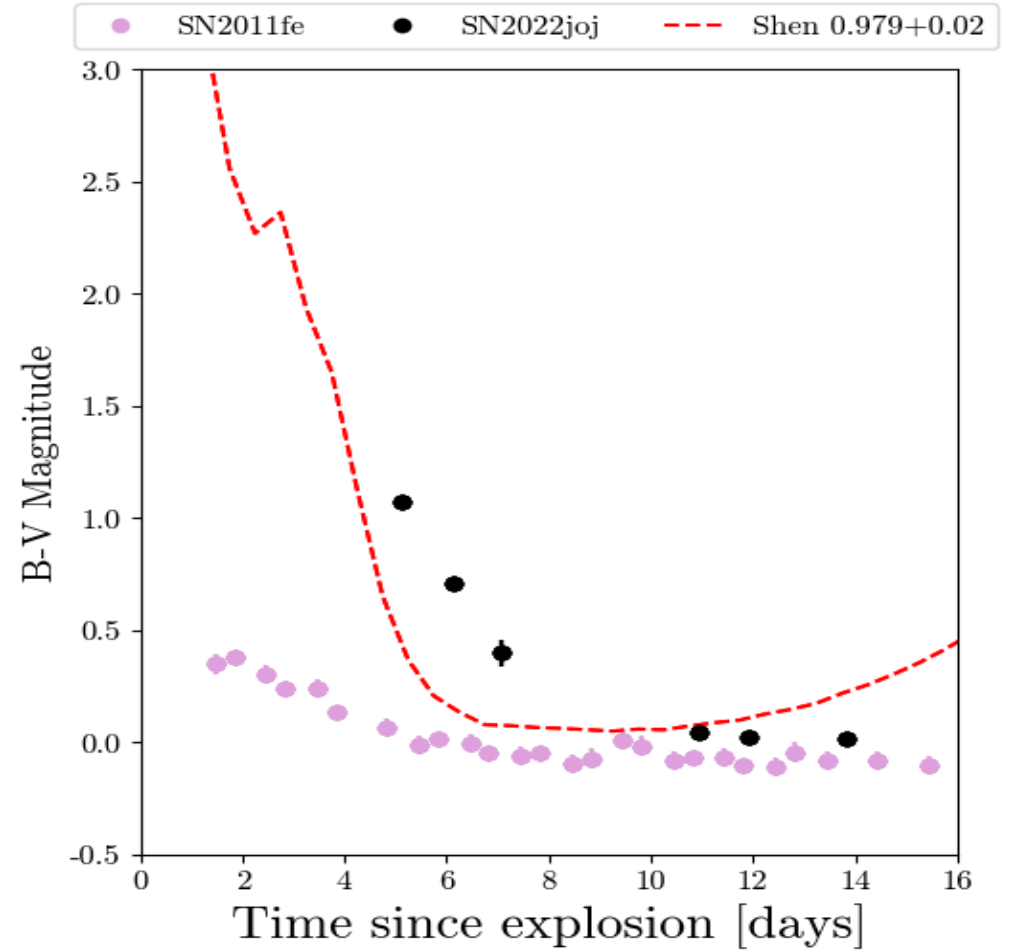


Table of all double detonations thin/thick

Thick helium shell

Name	Mass of WD	Mass of shell	Citations
OGLE 13	0.6	0.2	Inserra et. al 2015
SN 2016hnk	0.6	0.2	Jacobson-Galan et. al 2020 Galbany et. al 2019
SN 2016dgs	0.8	0.1	Dong et. al 2022
SN 2018byg	0.75	0.15	De et. al 2019
SN 2019eix	0.75	0.15	Padilla-Gonzalez et. al 2023a

Thin helium shell

Name	Mass of WD	Mass of shell	citations
MUSSES1604D	1	0.05	Jiang et. al 2017
SN 2018aoz	1	0.01	Ni et. al 2022
SN 2022joj	1	0.02	Padilla-Gonzalez et. al 2023b

Conclusions

- SN 2022joj is our best evidence yet for thin helium shell double detonation as the triggering mechanism for a SN Ia.
- From Scalzo et. al 2014, up to 50% of SNe Ia come from Sub-Chandrasekhar mass WDs.
- Since in the thin shell case evidence disappears after hours or days, evidence of double detonation might have been missed.
- Double detonations may be much more common than previously thought, perhaps explaining half or more of Type Ia SNe.