Multimessenger signals from supernovae interacting with confined dense circumstellar matter

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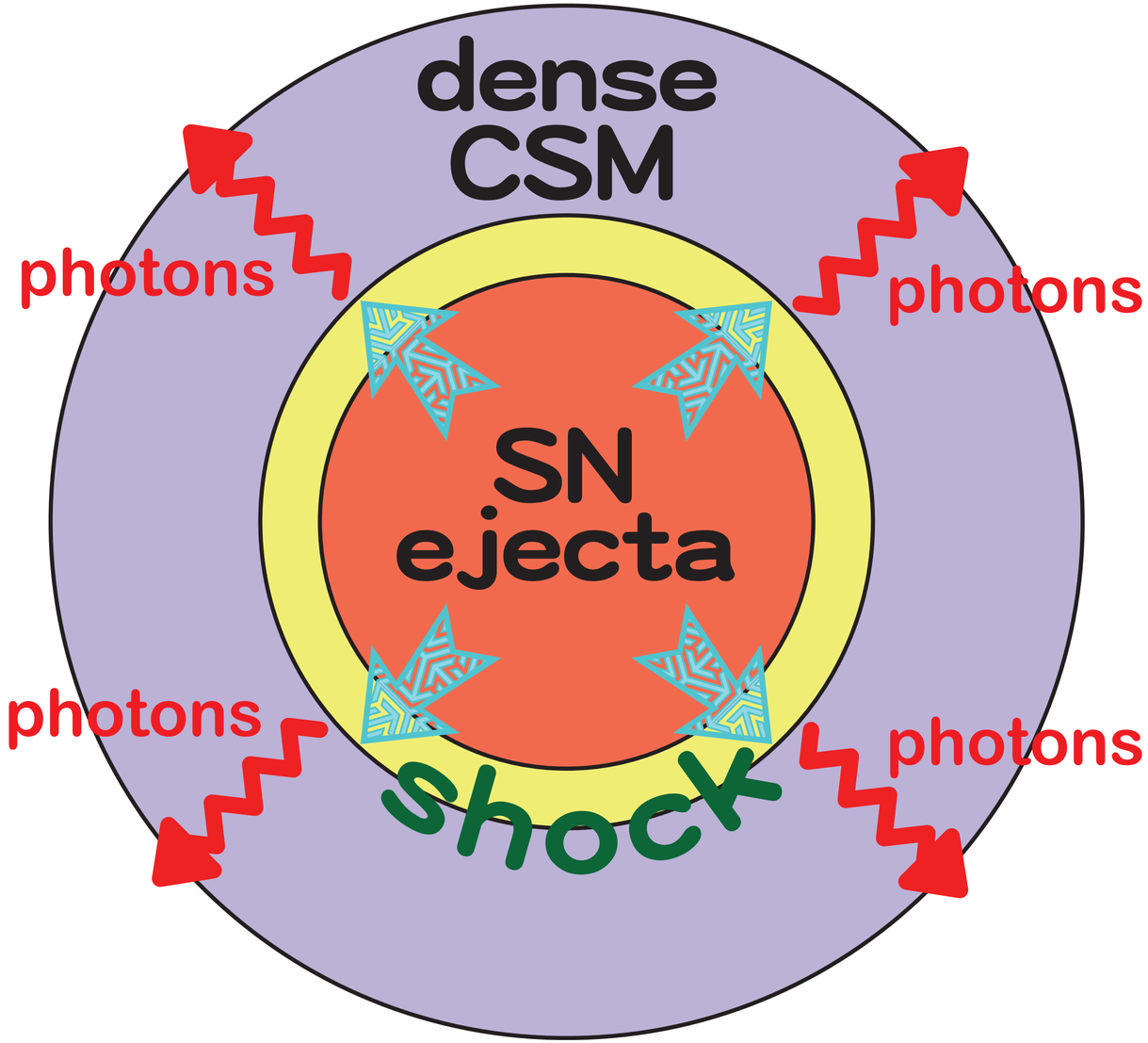
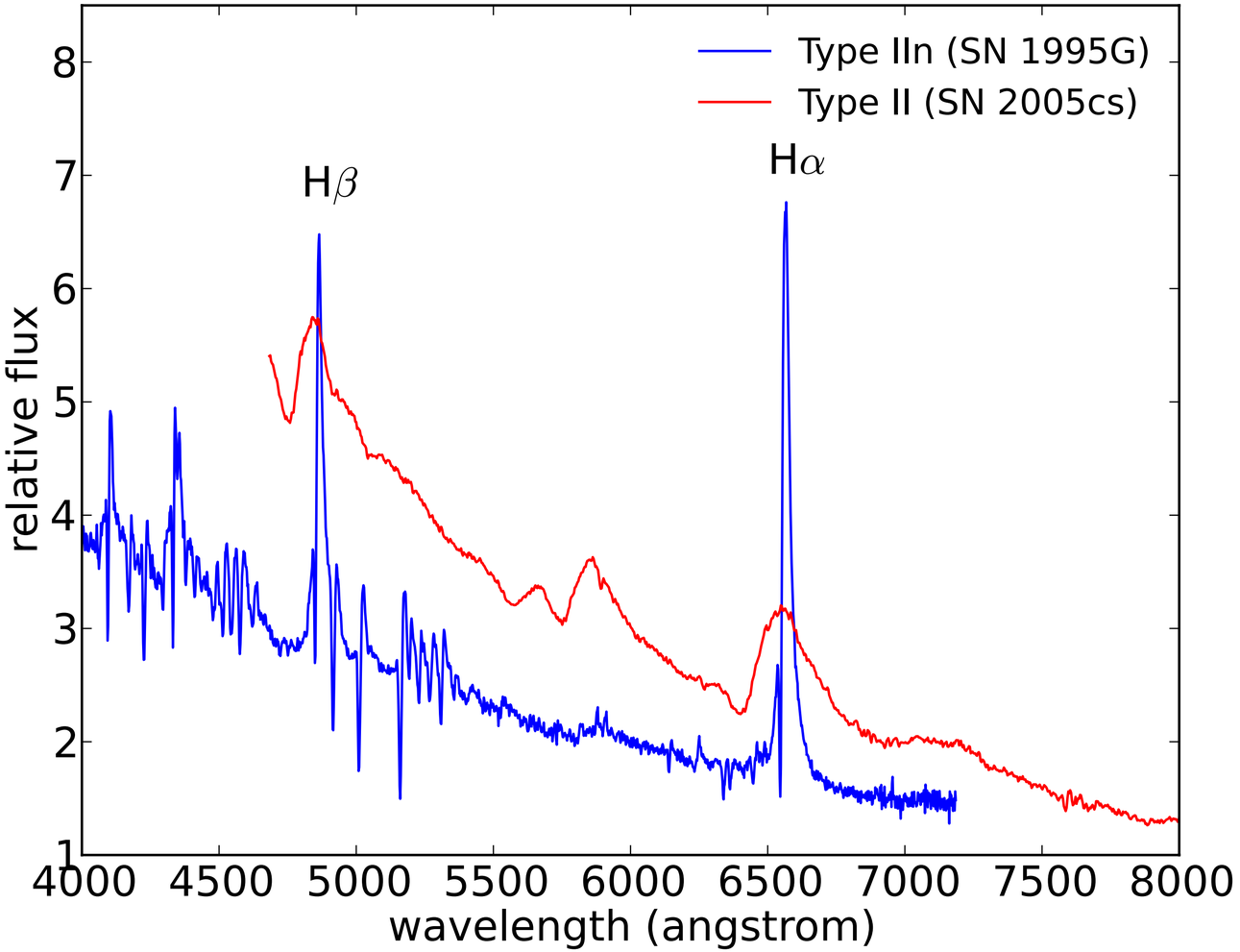
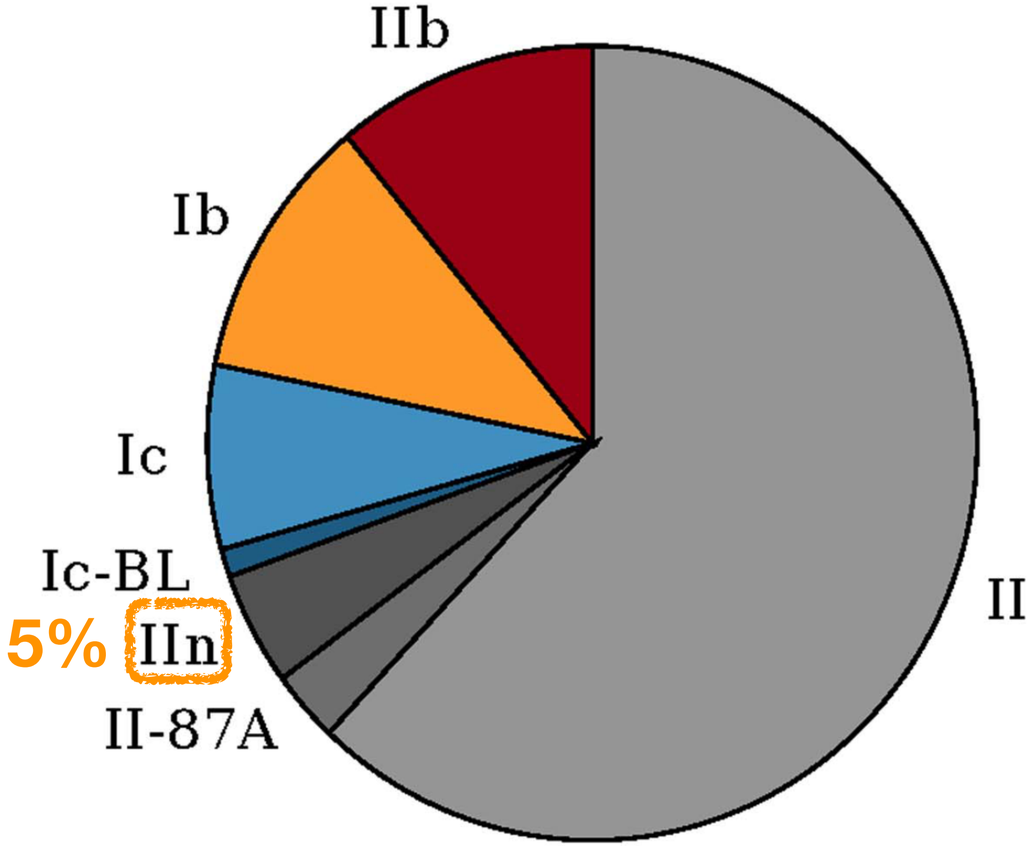
Supernovae interacting with dense circumstellar matter (CSM)



Supernovae interacting with dense circumstellar matter (CSM)

Type IIn: “n” from narrow

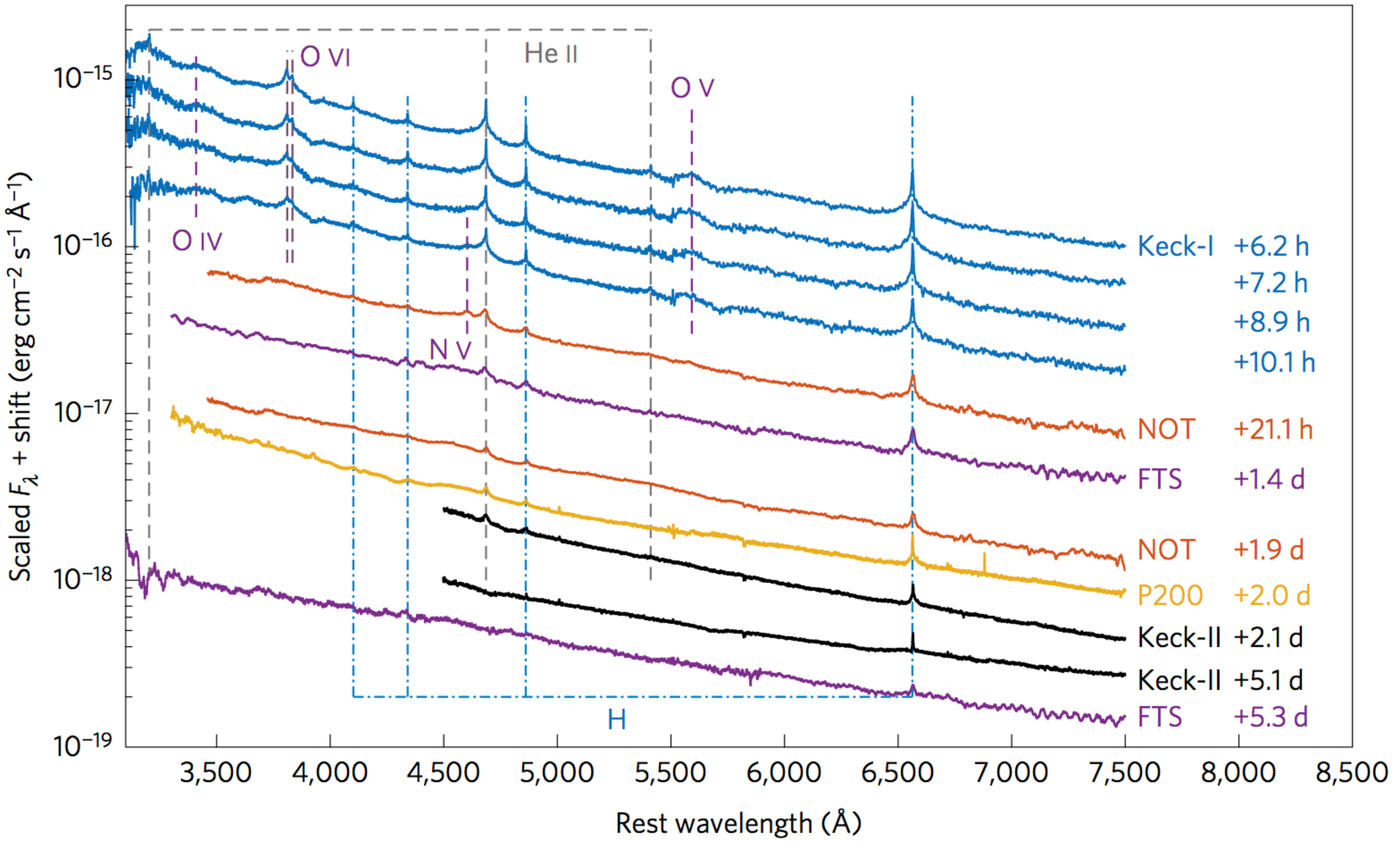




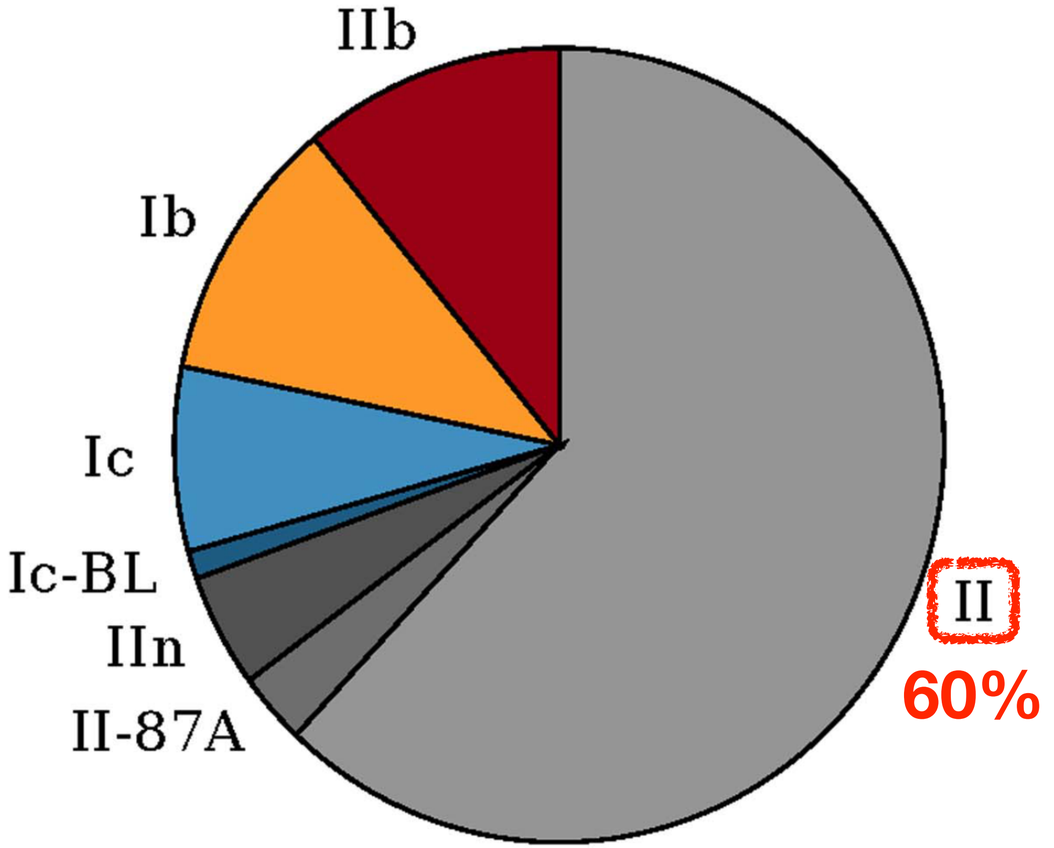
Shivvers et al. (2017)

Typical Type II supernovae show “IIn” signatures for a short time

Type II SN 2013fs



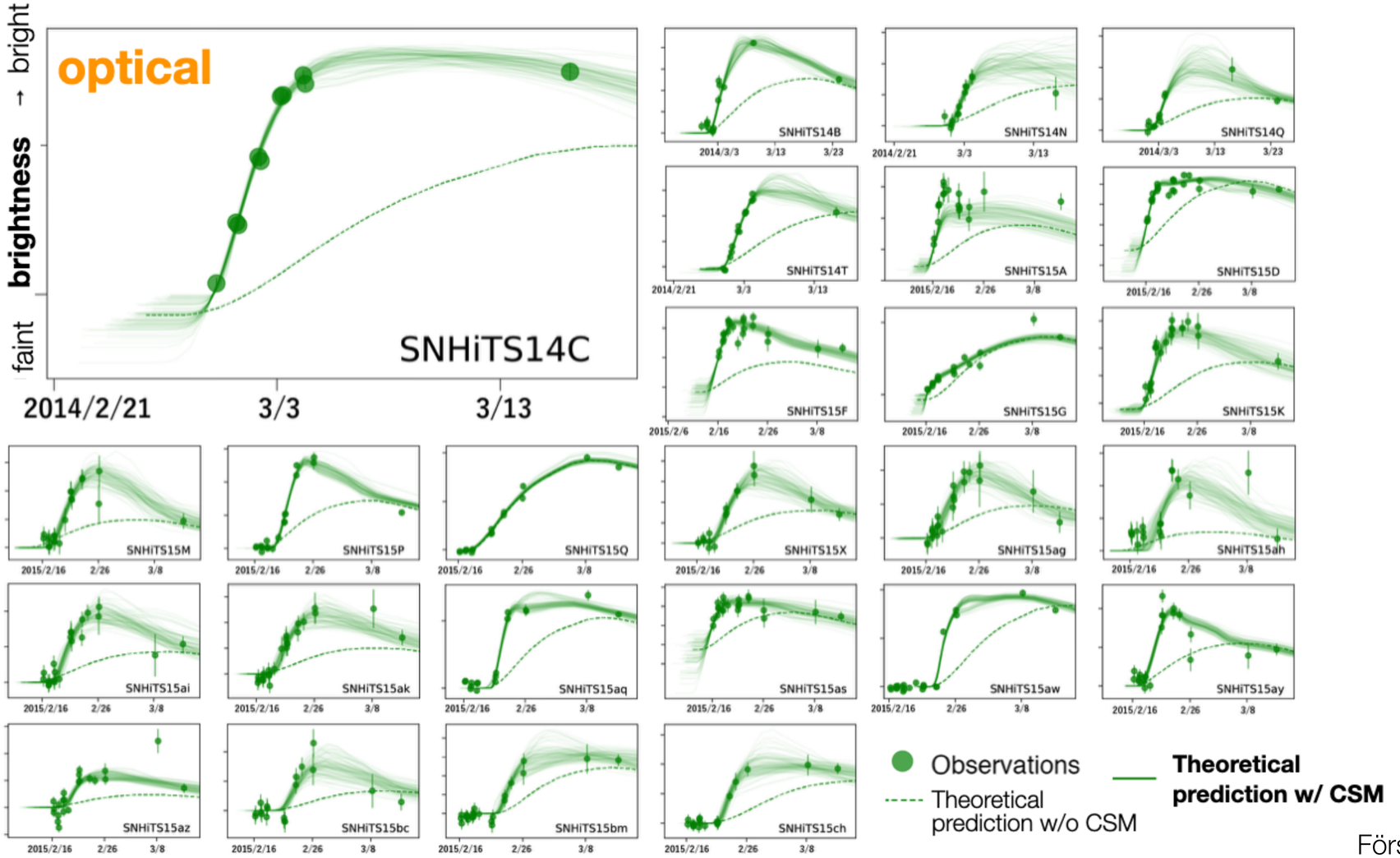
Yaron et al. (2017)



Shivvers et al. (2017)

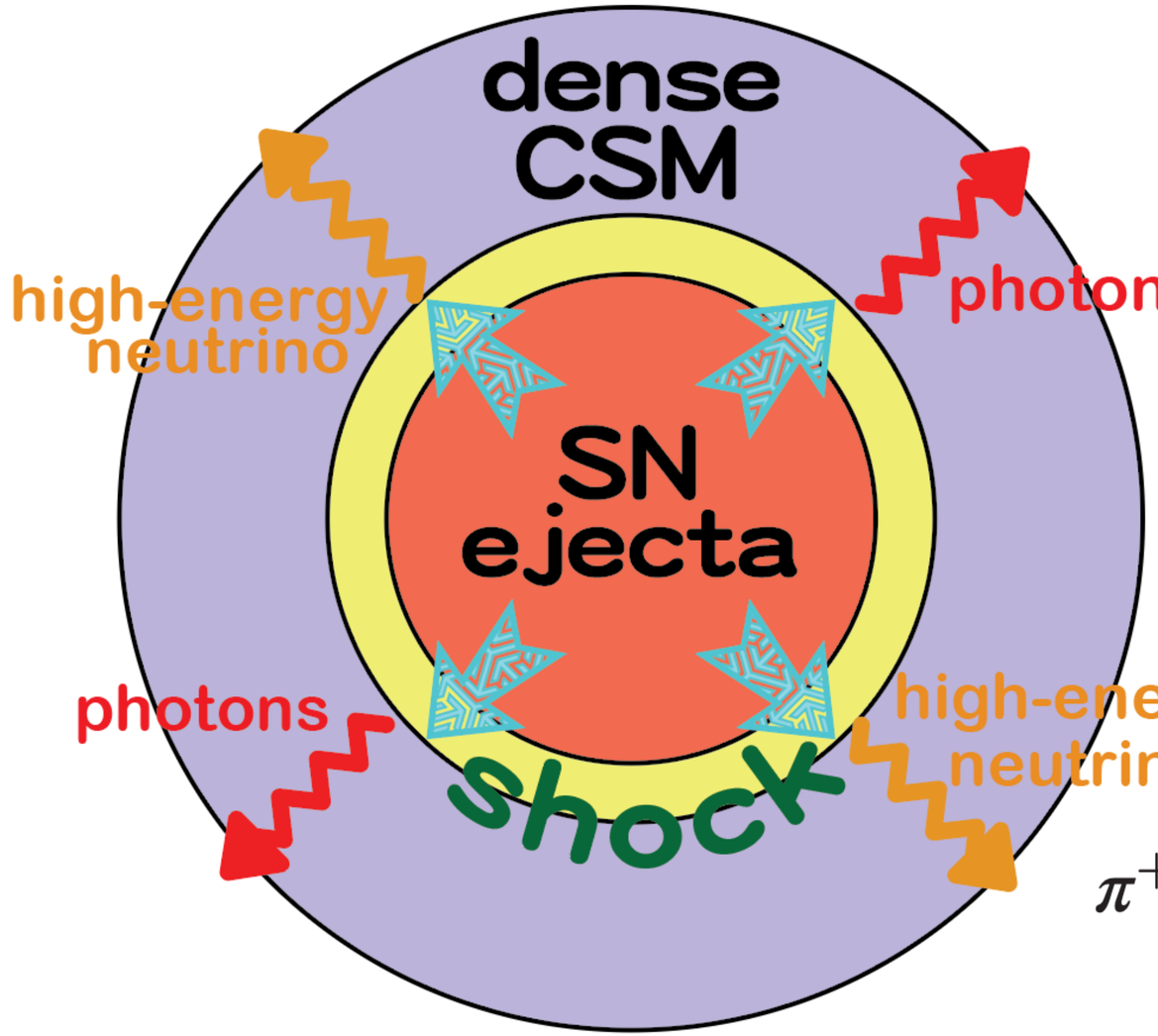
Type II SN light curves affected by dense confined CSM

more than 80% of Type II SNe show dense CSM signatures in light curves



Förster, Moriya, et al. (2018)

Strong high-energy neutrino emission from the CSM interaction



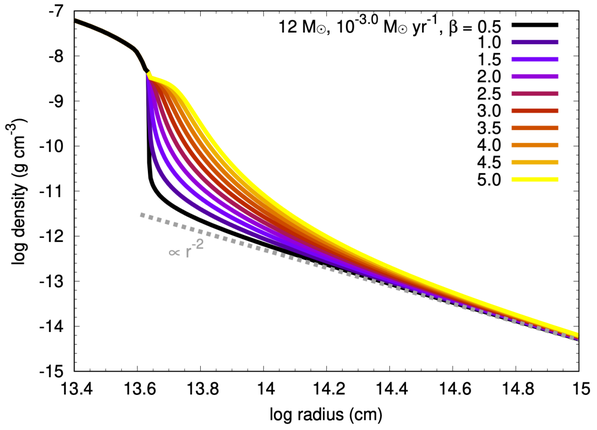
$$\pi^+ \rightarrow \mu^+ \nu_\mu \rightarrow \nu_\mu \bar{\nu}_\mu \nu_e e^+$$

cf. Murase (2018)

A grid of Type II SN models for systematic parameter estimations

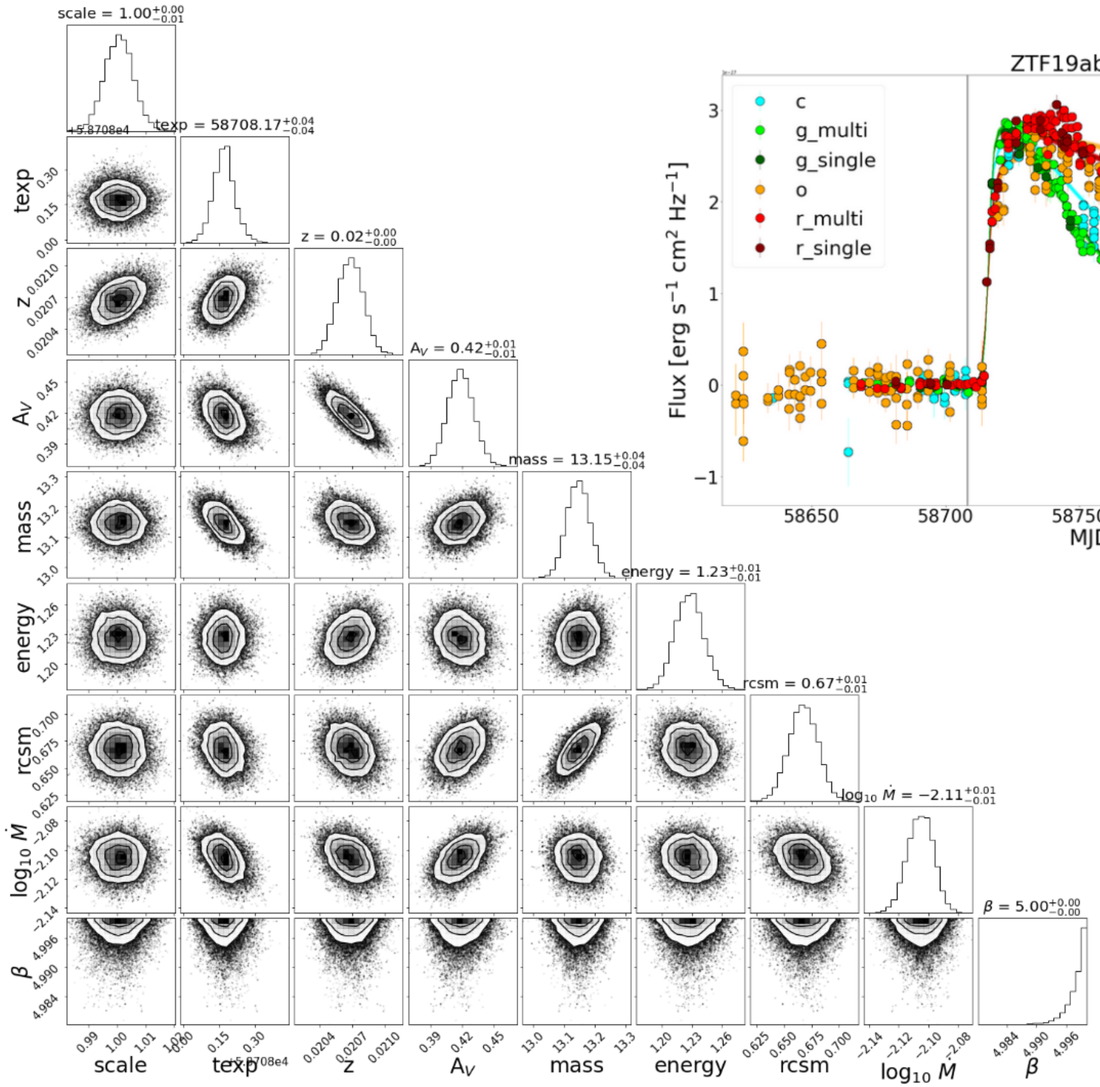
- We computed 228,016 synthetic Type II SN light curve models (Moriya et al. 2023)
  - **progenitor mass**: 10, 12, 14, 16, 18 Msun (Sukhbold et al. 2016)
  - **explosion energy**: 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5 B
  - **^{56}Ni mass**: 0.001, 0.01, 0.02, 0.04, 0.06, 0.08, 0.1, 0.2, 0.3 Msun
    - mixed up to a half mass of hydrogen-rich envelopes
  - **mass-loss rate**: $10^{-5.0}$, $10^{-4.5}$, $10^{-4.0}$, $10^{-3.5}$, $10^{-3.0}$, $10^{-2.5}$, $10^{-2.0}$, $10^{-1.5}$, $10^{-1.0}$ Msun/yr
    - wind velocity is 10 km/s
  - **CSM radius**: 1e14, 2e14, 4e14, 6e14, 8e14, 1e15 cm
  - **wind structure β**: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0

$$v_{\rm wind}(r) = v_0 + (v_\infty - v_0)\left(1 - \frac{R_0}{r}\right)^\beta$$



- radiation hydrodynamics simulations performed by the STELLA code (e.g., Blinnikov et al. 1999)
  - one-dimensional but ***multi-frequency (1 A to 50,000 A***, 100 frequency bin in a log scale)

Characterizing Type II SN light curves

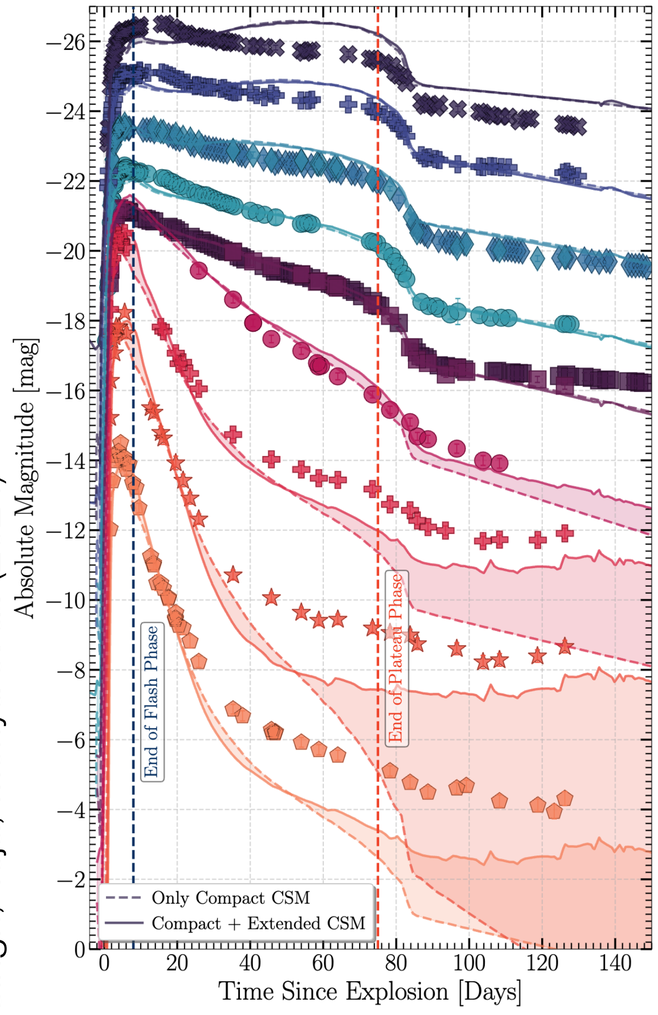


+ neutrino emission!

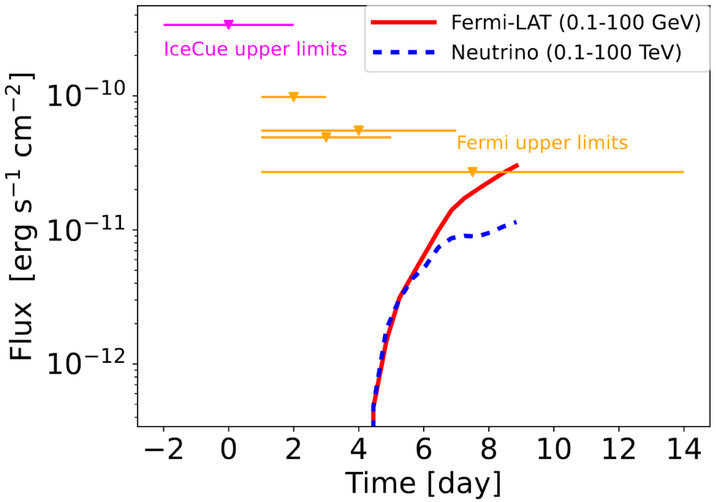
Silva-Farfán et al. (2024)

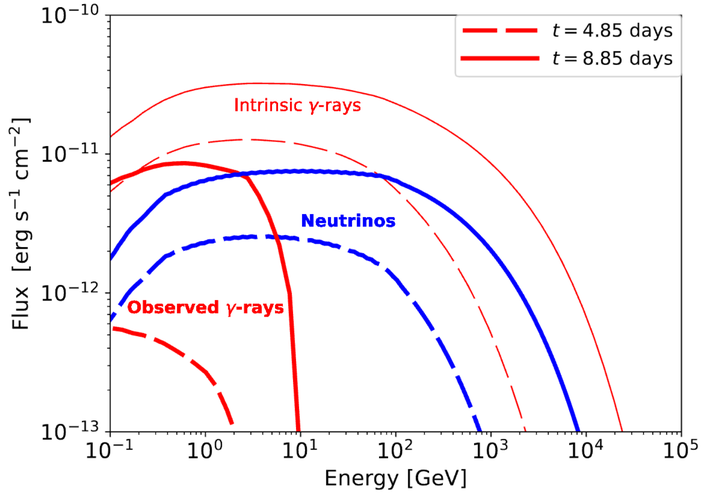
A test case: Type II SN 2023ixf

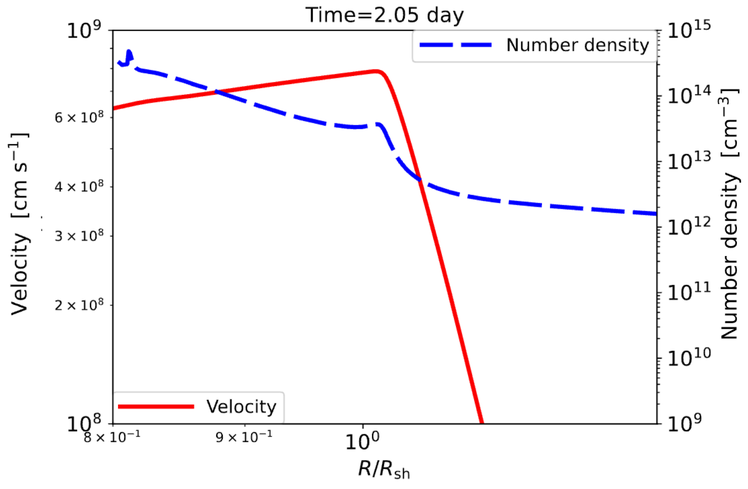
SN 2023ixf: one of the most nearby Type II SN in the last decade

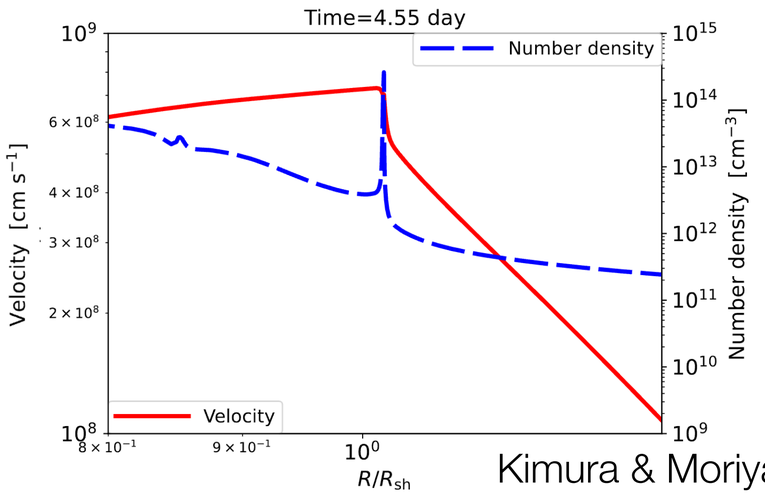


Singh, Teja, Moriya et al. (2024)



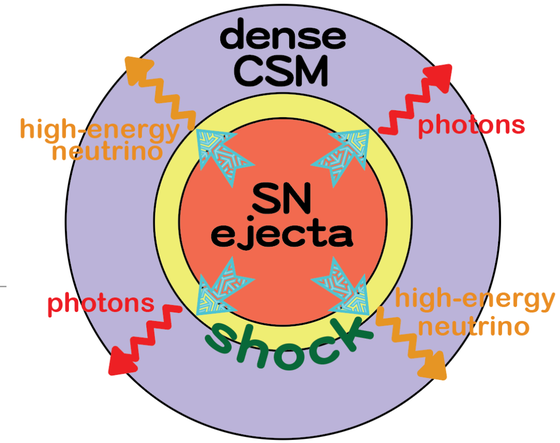






Kimura & Moriya (2024)

Summary & Future



Most Type II SNe have confined dense CSM and can emit high-energy neutrinos.

We aim to construct a grid of Type II SN neutrino emission models based on the existing model grid.

Our idea has been verified by modeling SN 2023ixf.

We will start constructing the neutrino emission model grid with Kimura-san, Yamazaki-san, Ide-san (Yamazaki-san's student at Aoyama Gakuin U.).