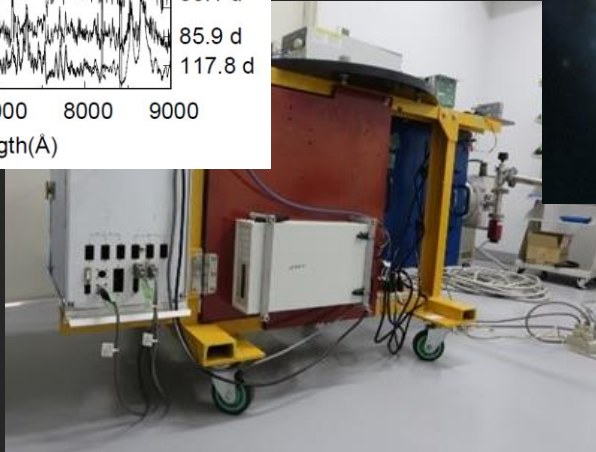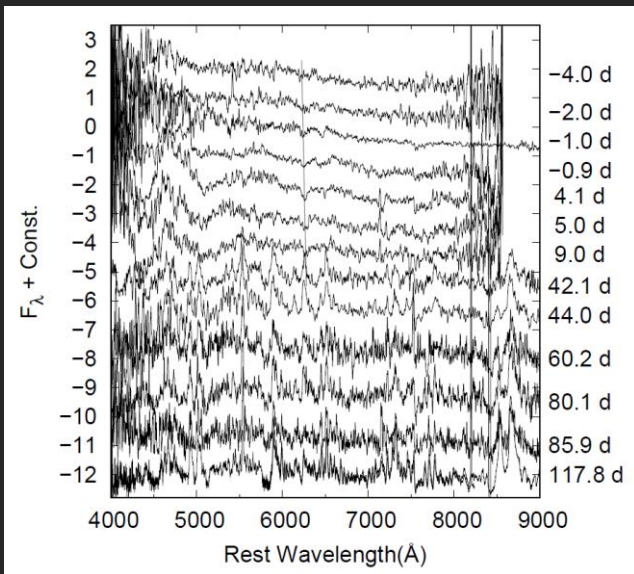# せいめい望遠鏡による
系外突発天体観測プログラム

2023 Seimei UM, 2023.09.12
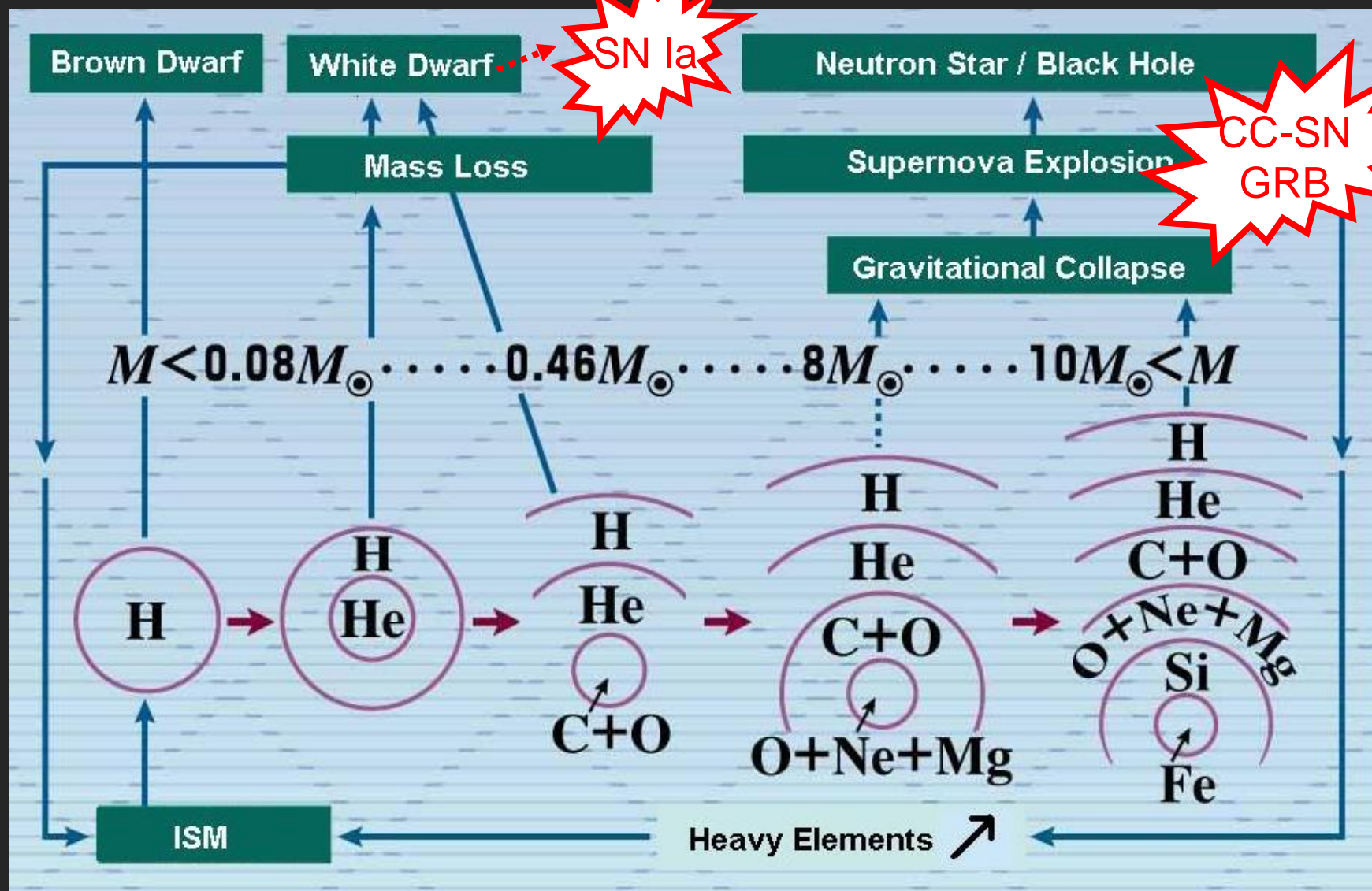

Keiichi Maeda (Department of Astronomy, Kyoto University)

Stellar Evolution and Supernovae (SNe)

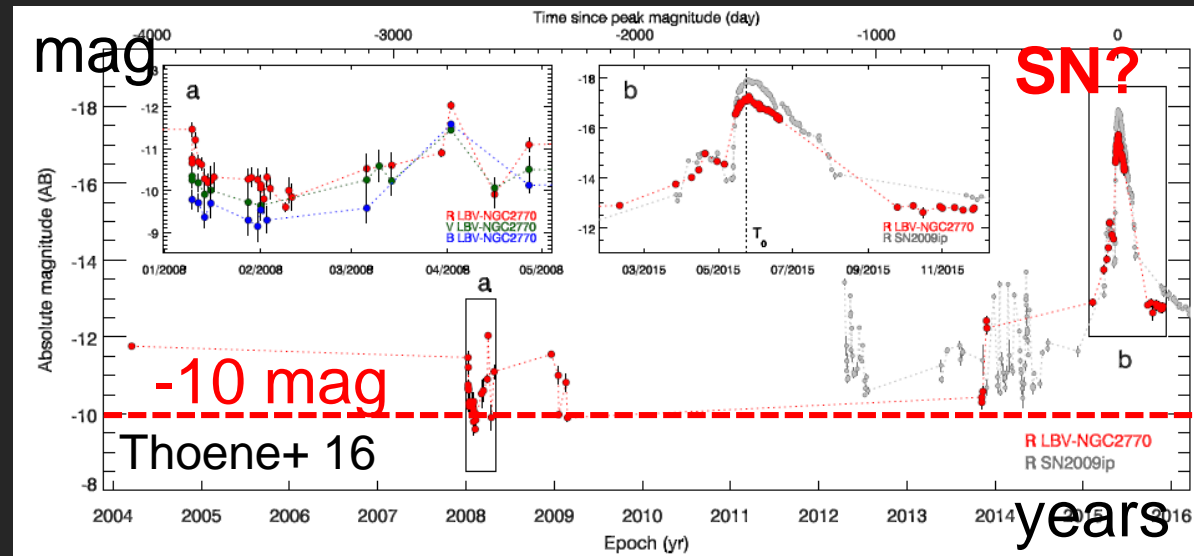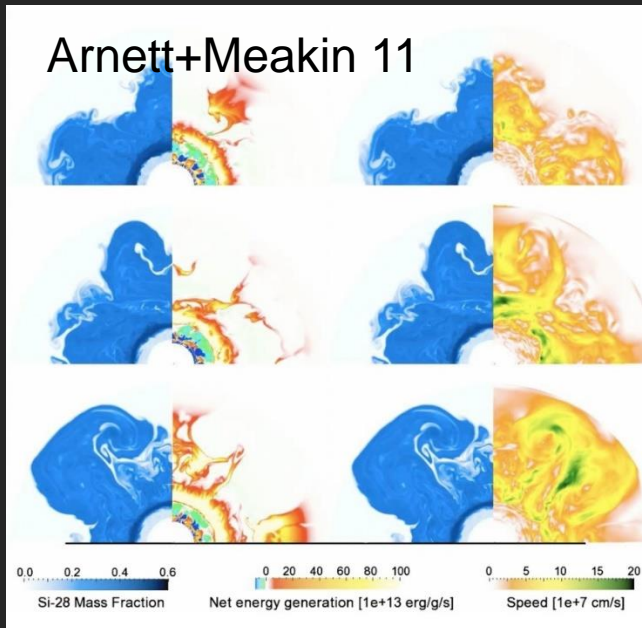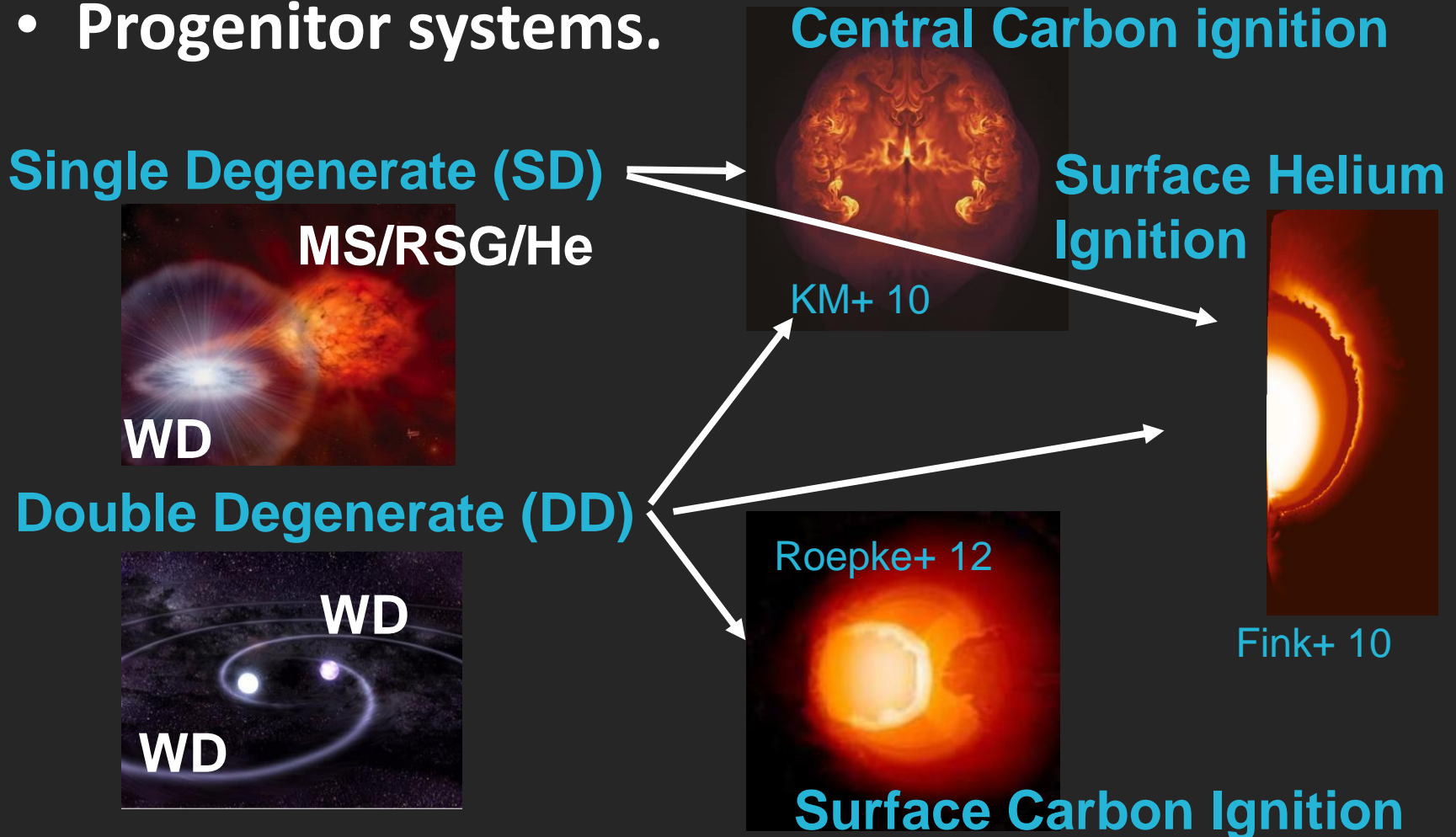# Unresolved problems for Core Collapse SNe (CC SNe)

- **Explosion mechanism.**

- **Final evolution of massive stars (single & binary).**

  – **Progenitor at the time of the explosion.**

  – **Mass loss in the final decades.**

Arnett+Meakin 11

Thoene+ 16

Unresolved problems for SNe Ia

- **Explosion mechanism (multiple paths?).**

- **Progenitor systems.**

Central Carbon ignition

Single Degenerate (SD)

MS/RSG/He

Surface Helium Ignition

KM+ 10

WD

Double Degenerate (DD)

WD

Roepke+ 12

WD

Surface Carbon Ignition

Fink+ 10

Frontiers in Transient Science

Higher cadence

Known transients, but from the beginning.

Unknown short-time scale objects.

Larger samples

Rare types of explosions.

Cooke+ 2015

Extragalactic Transience w/ Seimei: since 2019
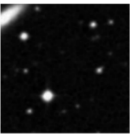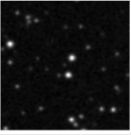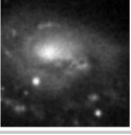
Observing schedule for 3.8-m SEIMEI Telescope (2021A)

ToO：**rapid classification, high-cadence especially at the beginning. Fill in the gap of the classical nights.**
Classical: **(half x 2) / a week, long monitoring.**

Candidate selection for Seimei

Own interface (Kawabata, Nakaoka)

ToO

Tomo-e SN server

Selection
（host galaxy, luminosity…）

Transient Name Server (TNS)

ZTF, PS, ATLAS, …

Papers

Refereed Journals (published + nearly accepted)

- Gangopadhyay, Maeda, Singh et al. 2023, ApJ, (almost) accepted (SN IIb/Ib 2022crv); talk
- Kuncarayakti, Sollerman, Izzo, Maeda, et al. 2023, A&A, in press (SN "Ic-CSM" 2022xxf)
- Uno, Nagao, Maeda, et al. 2023, ApJ, 944, 204 (SN Ia-CSM 2020uem); talk
- Uno, Maeda, Nagao, et al. 2023, ApJ, 944, 203 (SN Ia-CSM 2020uem); talk
- Jiang, Maeda, Kawabata, et al. 2021, ApJL, 923, L8 (over-luminous SN Ia 2020hvf)
- Kawabata, Maeda, Yamanaka, et al. 2021, PASJ, 73, 1295 (SN "Iax" 2019muj)
- Nakaoka, Maeda, Yamanaka, et al. 2021, ApJ, 912, 30 (Ca-rich transient 2019ehk)
- Kawabata, Maeda, Yamanaka et al. 2020, ApJ, 893, 143 ("infant" SN Ia 2019ein)
- Singh, Sahu, Anupama, et al. 2019, ApJL, 882 L15 (SN1987A-like 2018hna)

+ a number of classification reports (mostly Taguchi et al.)

- Taguchi, Maeda, Uno, TNS Class. Rep. 15501 (SN II within 7 hrs of the discovery).
- Taguchi, Uno, Nagao, Maeda, TNS Class. Rep. 14478 (TDE)

One highlight: A new population of SNe within C/O-rich CSM

- Peculiar SN Ic 2022xxf (Kuncarayakti, Izzo, Sollerman, KM+ 2023).
- **Double-peaked light curve (few examples known).**
- **Global observation network, in multi-wavelength.**
- **Explosion of a C+O star, surrounded by C/O-rich CSM (huge mass-loss... challenge to stellar evolution).**
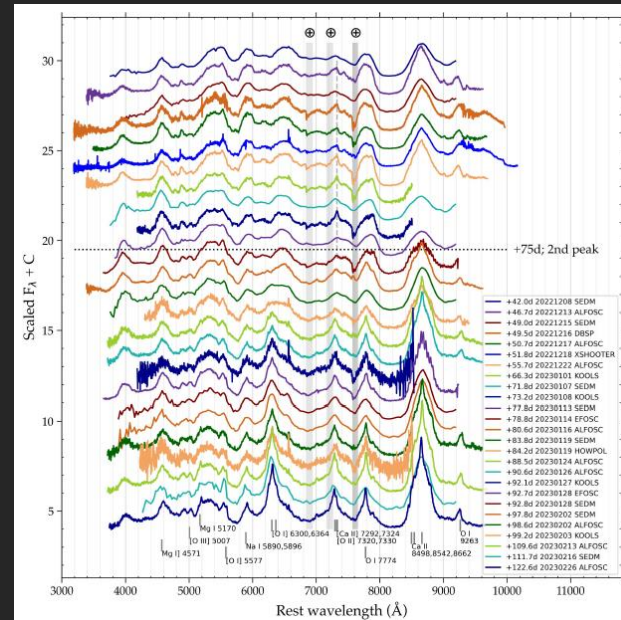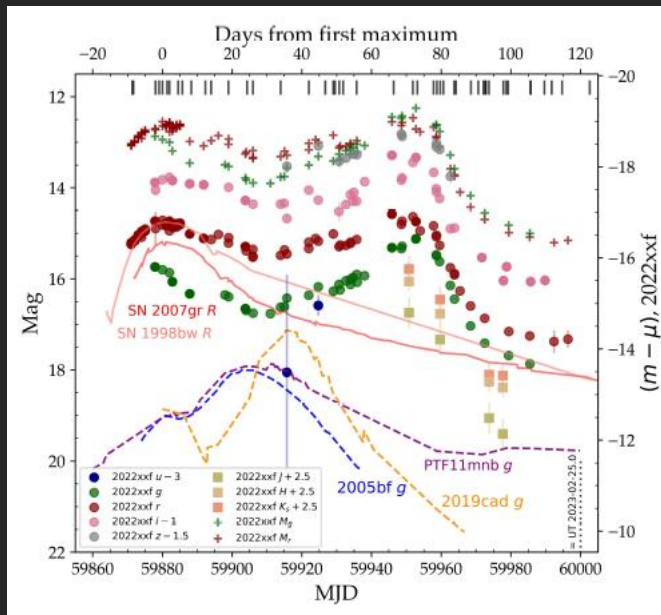
Another example to come; KM+ in prep., w/ Seimei data

Model⇔data development

Model for overluminous SNe Ia

KM+ 2023

Jiang, KM+ 2021
Seimei / Tomo-e
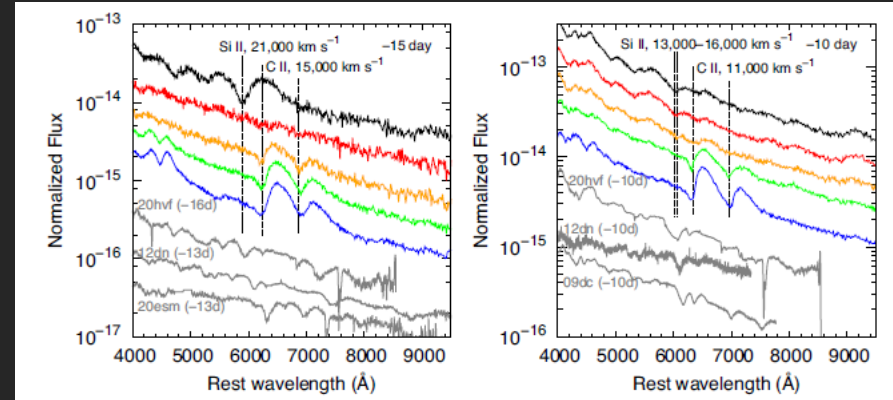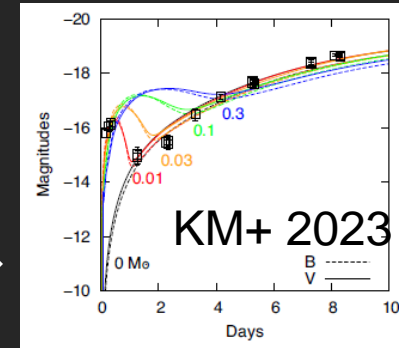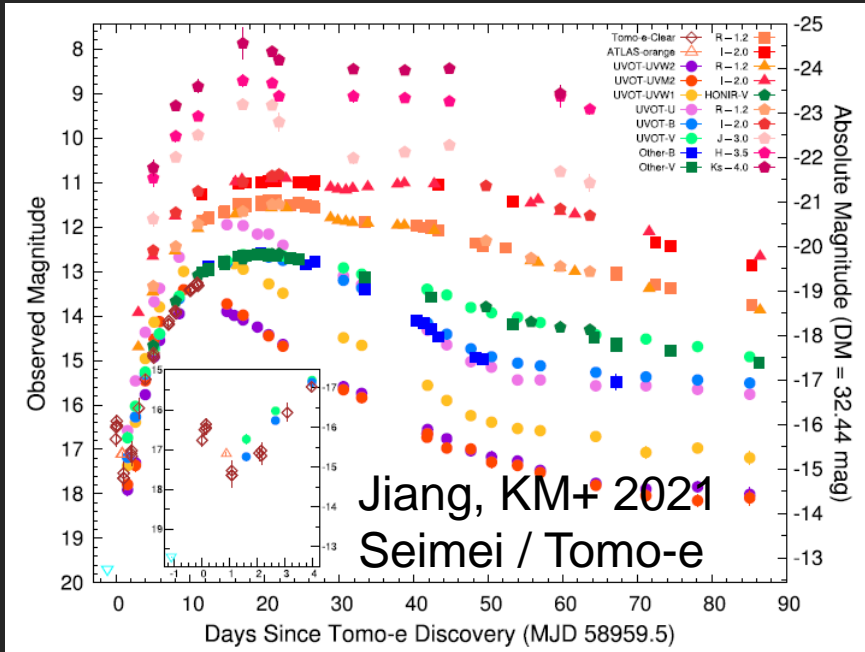
Subaru. JWST

[OI] as a coolant
Dust formation
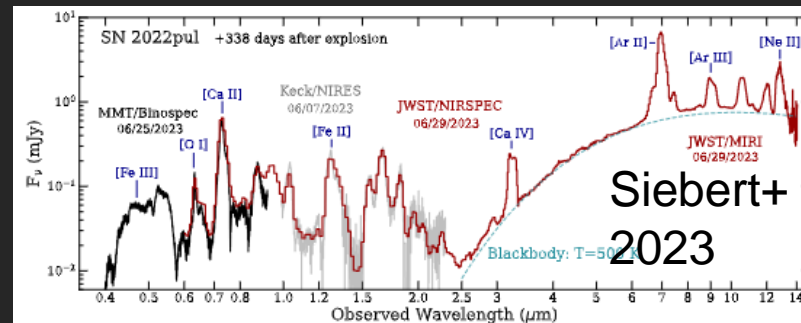
Siebert+ 2023

Siebert+ 2023

Model⇔data development
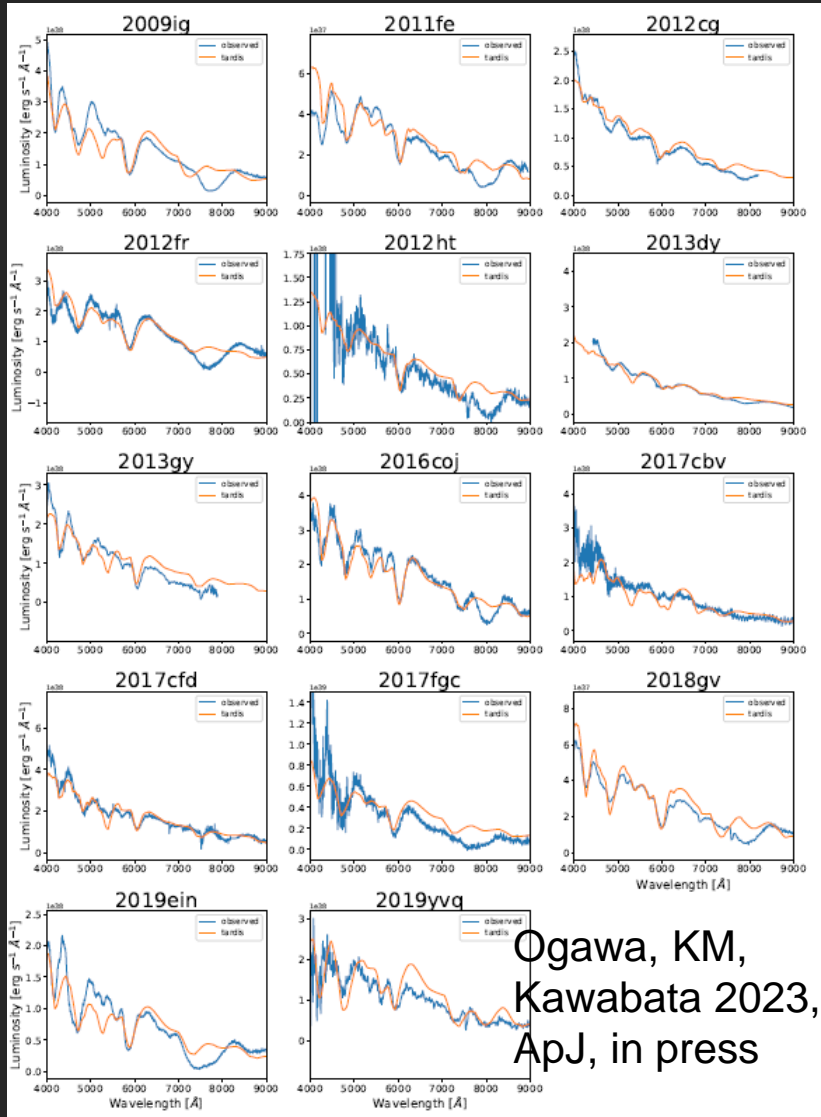
Ogawa, KM, Kawabata 2023, ApJ, in press

Ready to apply to new data

⇨
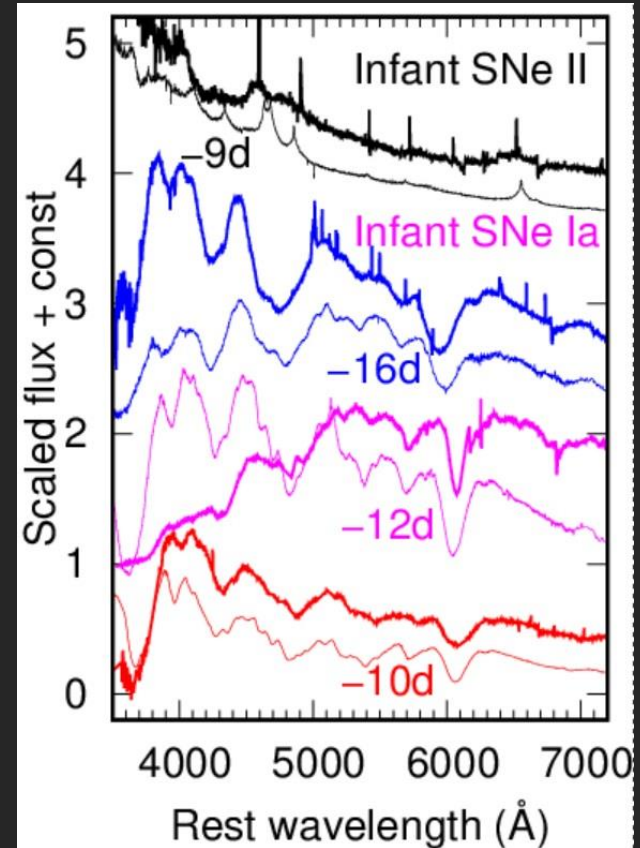
Siebert+ 2023

Infant SNe (by GMOS: KM+)

New direction: TDE & related objects

- Nearest "TDE" classified by Seimei (Taguchi, Uno, Nagao, KM+ 2023).
- **Seimei ⇒ Subaru (polarization).**
- **Strong polarization level, with interesting behaviors.**
- **Probably a "faked" TDE (identifying a new population of AGN?).**

Uno, KM+, in prep.

New Direction: Time-resolved obs.

- 23B-N-CT10 / 23B-K-0015.

- Search for short-timescale variabilities for "extragalactic" transients w/ TriCCS.

- Central engine, newborn NS.

- Targets:
  - Luminous-fast-blue-optical transients (LFBOTs, AT2018cow).
  - TDEs (and TDE-like transients).
  - (very) nearby SNe, NS-NS, NS-BH.
  - GRBs?
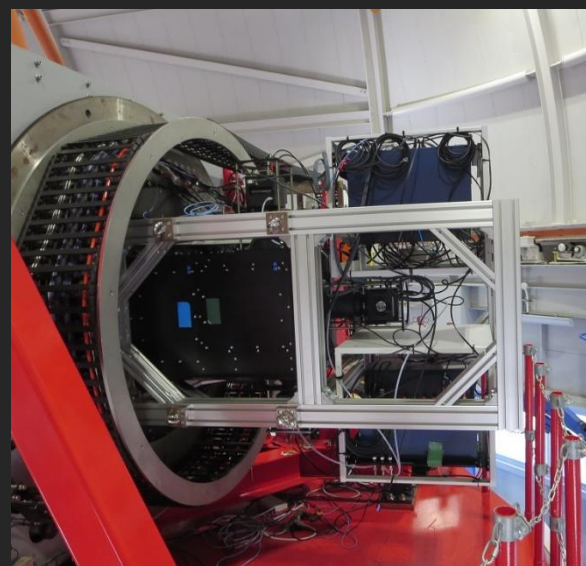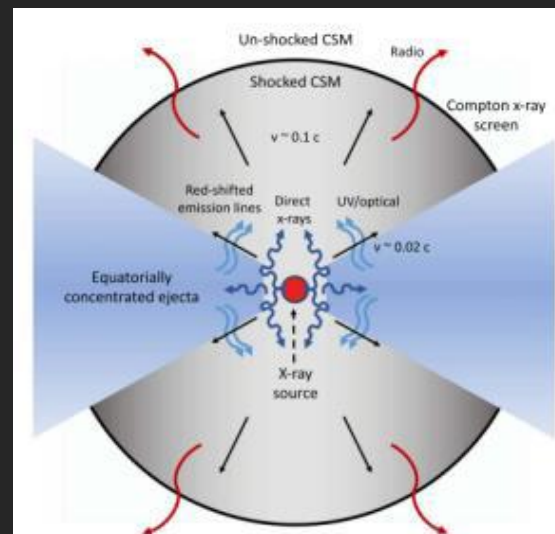
New Direction: 8m to Seimei

- Initial "dark" phase by 8m (e.g., GMOS).

⇔ Later follow-up by Seimei.
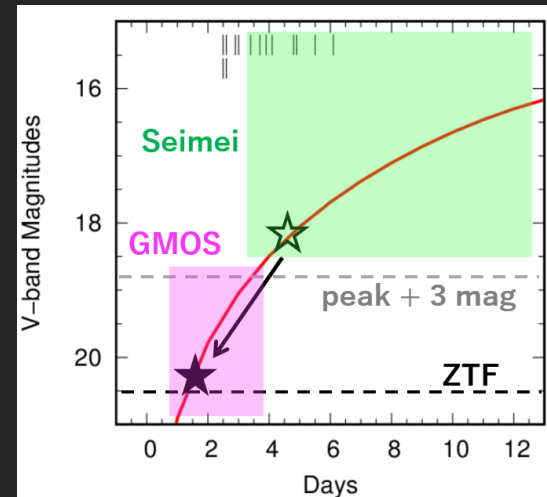
- GMOS-N rToO accepted in S23A.
  – 10 hrs in July-August (maintenance…).
  – Infant SNe "入れ食い" 状態.
    • Our system for the infant SN search and ToO has worked perfectly.
  – Peculiar rapid transient (KM+, in prep.).
  – Unfortunately Semei in the maintenance…
  – **Proven to be very powerful.**
- **Submitted for Subaru⇔Gemini S24A.**
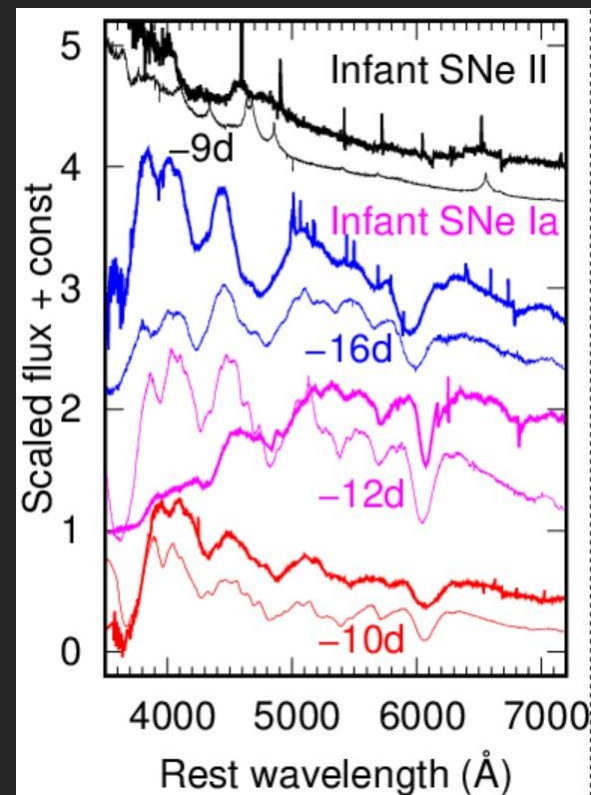
New Direction: multi-wavelength

2022.1.00115.T	Rapid ToO Observations of Nearby Supernovae: Probing The Final Evolution of Massive Stars	Keiichi Maeda	EA	50

2023.1.00305.T	First Light of Nearby Supernovae: Disclosing the Massive Stars' Final Activities		Keiichi Maeda	EA	50
COIs	Tomoki Saito; Takashi Moriya; Rieko Momose; Kenta Fujisawa; Stuart D Ryder; Poonam Chandra; Dan Patnaude; Hanindyo Kuncarayakti; Shiu-Hang Lee; Gaston Folatelli; Tomoki Matsuoka; Esha Kundu; Ji-an Jiang; Tomonari Michiyama; Anna Y. Q. Ho;				
Abstract	Recent observations of core-collapse supernovae (CCSNe) have led to a surprising picture that the massive stars are much more dynamic in the last few years than widely accepted previously; dense circumstellar matter confined in the vicinity of the progenitor (confined CSM) has been inferred. However, the optical emission is biased to pick up extreme CSM with large uncertainty in the interpretation. A quick ALMA ToO will yield unique and unbiased diagnostics. There are only three previous examples for which the nature of the confined CSM has been derived, using the ALMA data within ~5 days since the explosion. Contrary to the previous expectation that the confined CSM is common, a striking diversity has been emerging, but the very small sample does not allow further investigation. Inspired by this proof-of-concept, we propose ToO observations of two CCSNe at Bands 1, 3 and 6; one SN from a compact He or C+O star and another SN from a giant progenitor. This will allow us to study whether the final activity is dependent on the nature of the stars. This project will bring us new and robust information on the yet-unclarified final evolution of massive stars.				

- (As an example) ALMA proposal accepted for infant SNe (one of only 3 ToO proposal accepted for cycle 10).

- So far three papers from the ALMA infant SN program.

- To coordinate w/ Seimei (North vs. South…)

- **New SN just triggered in the north hemisphere (and the queue for Seimei).**

Taguchi, Kawabata, Maeda, …

GW counterpart search with TriCCS

- Developing a system for GW counterpart search/follow-up triggered by LIGO/Virgo alerts (through J-GEM).

- Observing flowchart:
  - J-GEM:
    - Compute the 3D likelihood map for a LIGO/Virgo GW alert.
    - Pickup possible host galaxies from the GLATE catalog, and put ranks.
  - Seimei:
    - Continuously monitor the J-GEM server.
    - Trigger ToO for "good" events (e.g., <100 deg2, NS involved).
    - Execute a automatic-observation script.
      - Observing in the queue mode, visibility vs. association ranking.
    - Reduction pipeline (next page).

- Currently Virgo offline, so few good events.

Kawabata, Taguchi, Maeda, …

TriCCS imaging reduction pipeline

- A new PC installed for the on-site reduction.

- Current features.
  - Dark, Flat, WCS, stacking

    ⇒ Science image.
  - For GW counterpart search, the data are sent to the J-GEM server

    ⇒ difference image

    ⇒ photometry.
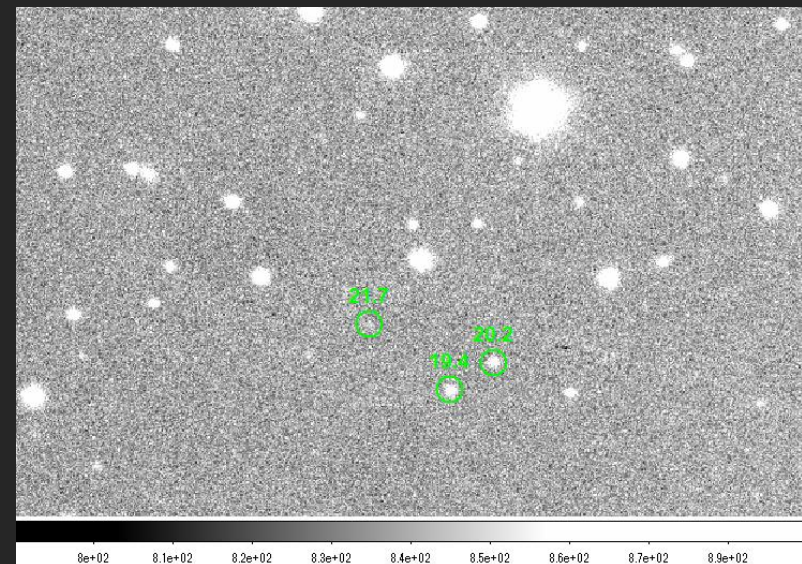
Summary

Accelerated publications for the SN/transient program.

Coupled with the model/theory activities.

New directions/functions:
- TDEs and related phenomena.
- Time-resolved observations for extragalactic transients.
- Seimei ⇒8 m, but also 8m ⇒ Seimei.
- Multi-wavelength, e.g., coordinated with ALMA.

Preparing for multi-messenger:
- GW counterpart search pipeline (Taguchi+).
- TriCCS reduction pipeline (Kawabata+).