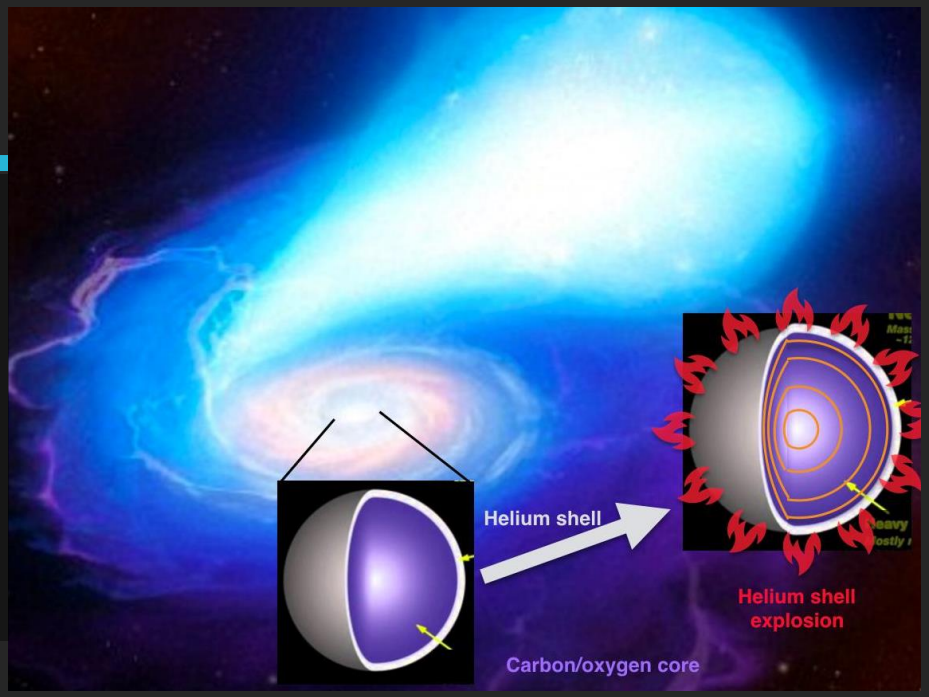
せいめい望遠鏡による近傍超新星の観測



Keiichi Maeda (Kyoto Univ.), Miho Kawabata, Masayuki Yamanaka, Keisuke Isogai, Tatsuya Nakaoka (Hiroshima Univ.), Koji Kawabata, Jian Jiang (U. Tokyo), Tomoki Morokuma, Mamoru Doi, Masaomi Tanaka (Tohoku), Nozomu Tominaga (Konan U.), Takashi Moriya (NAOJ) et al.,

On behalf of the Seimei-Kanata SN follow-up team & Tomo-e Gozen SN team

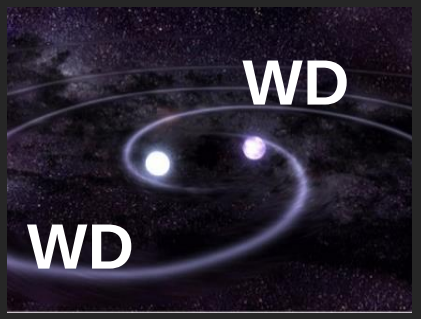
Type Ia Supernovae: Multiple Origins?

Thermonuclear explosion of a white dwarf, but…

Progenitor system(s)?

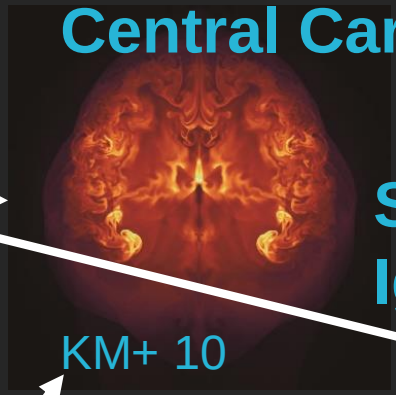
Single Degenerate (SD)

Double Degenerate (DD)



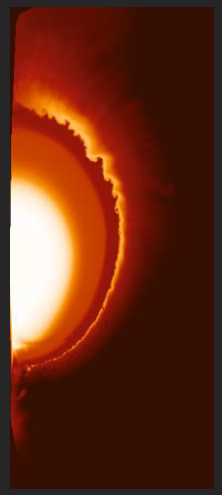
Explosion Mode(s)?

Central Carbon ignition



KM+ 10

Surface Helium Ignition



Fink+ 10

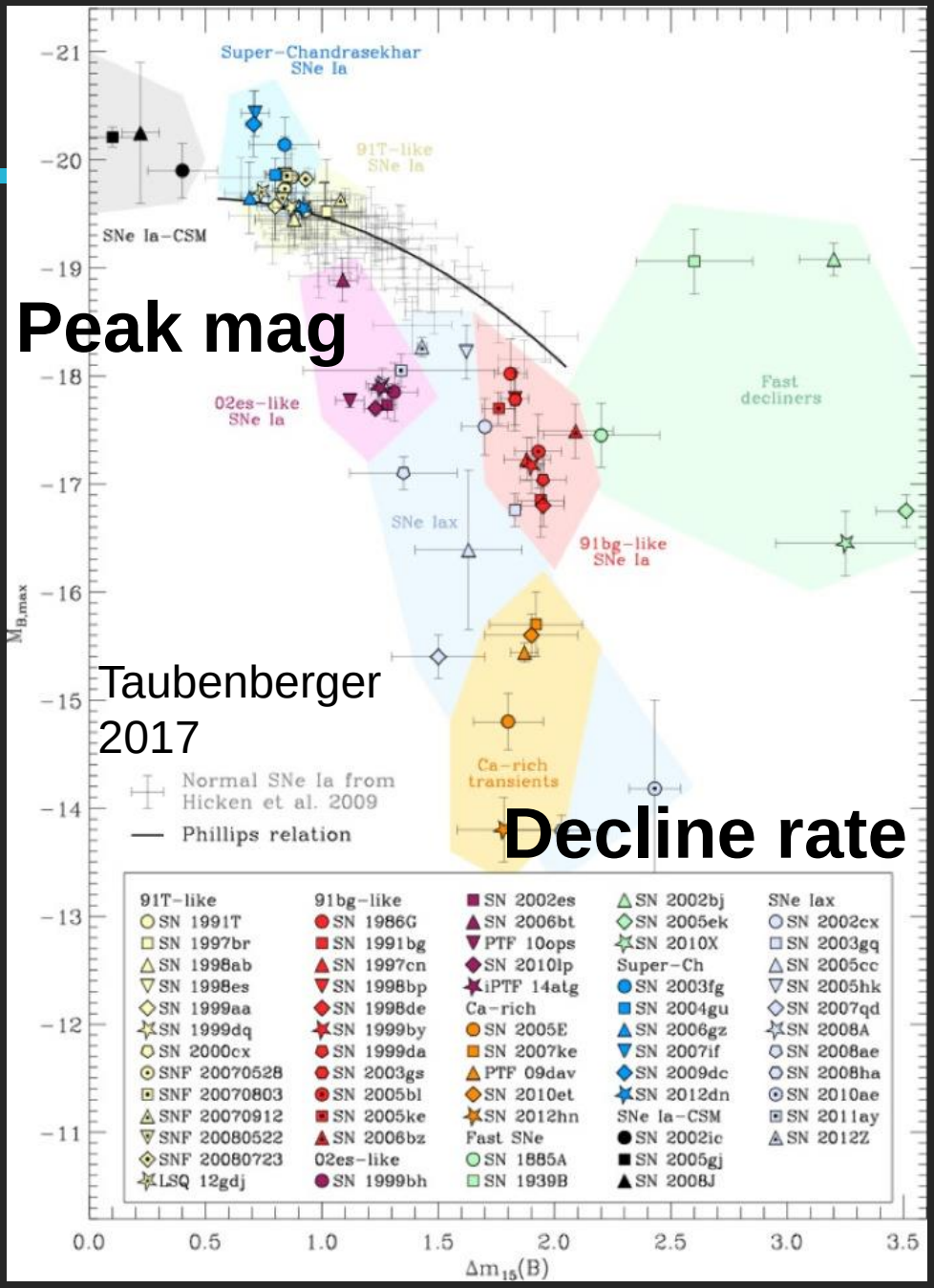
Roepke+ 12

Surface Carbon Ignition

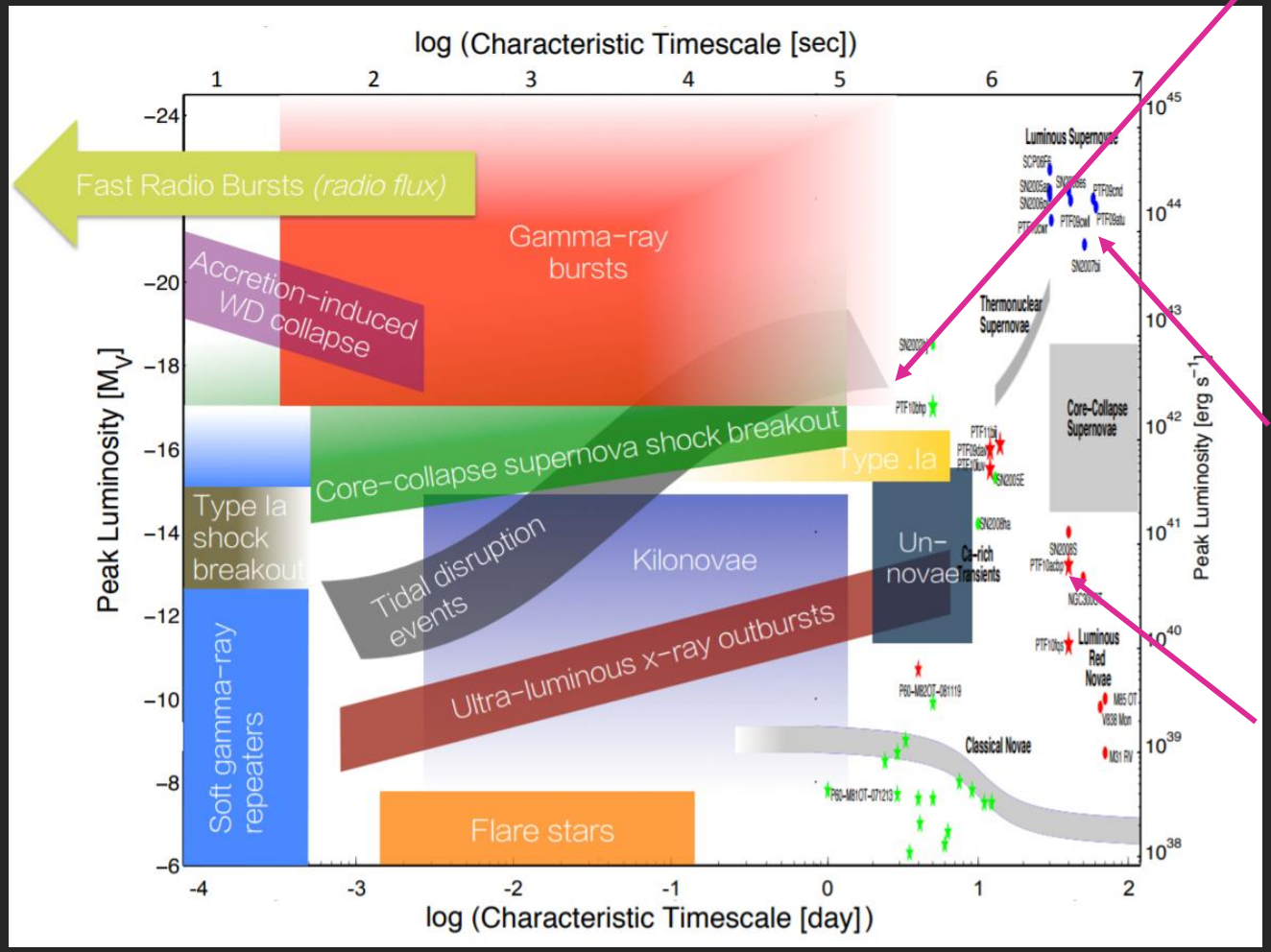
SN Ia diversity

- Standardized candles, but…
- Too much diversity to be a single population.
- Indications for different progenitors/explosions for different classes.

- Bulk standard + rare outliers?
  - No!
- A large fraction of the nearby SNe have turned out to be peculiar beasts. Much more diverse than expected.



Frontiers in Transient Science



Cooke+ 2015

Higher cadence

Unknown short-time scale objects & just after the explosion.

Larger samples

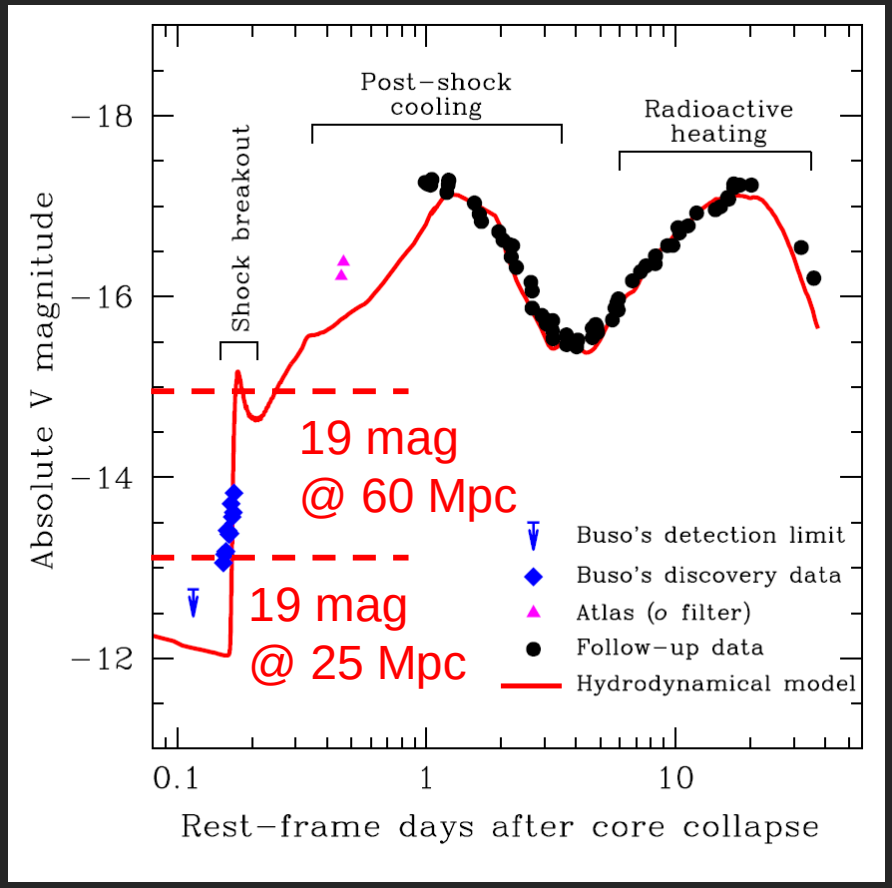
Unknown rare types of explosions.

Deeper

Unknown faint objects & long term evolution.

See the poster by Morokuma et al.

New Time Domain Era



	Tomo-e SN Survey
instrument	Tomo-e Gozen
sensor	CMOS
readout time	~0 sec
period	2018/9-
survey area [deg2]	10,000
cadence	2 hours / 1 day
exposure time / visit	3 sec
depth	18 mag / 19 mag
filter	no (~g+r)
#(SBOs), #(SNe) / yr	5, 1000
data storage	daily-stacked image SN cutout images
reference	-

Catch SNe in the first day.

Tomo-e survey

© Morokuma

Pick up rare examples (with long-term observations).

The Seimei SN/Transient Program

Some numbers © Tanaka *** Numbers for all sky**

Distance (Mpc)	Volume (Mpc^3)	# of galaxies	# of SNe (yr^{-1})	mag (abs mag -15 mag)	mag (abs mag -13 mag)
10	4×10^3	40	0.4	15.0	17.0
30	1×10^5	10^3	10	17.4	19.4
50	5×10^5	5×10^3	50	18.5	20.5
70	1×10^6	1×10^4	100	19.2	21.2
100	4×10^6	4×10^4	400	20.0	22.0
200	3×10^7	3×10^5	3,000	21.5	23.5
500	5×10^8	5×10^6	50,000	23.5	25.5

~ 5 / yr.

~ 50 / yr.

Roughly, ~ 10 classical nights + 10 ToO nights / semester.

soon-after-the-explosion SNe up to ~ 30 Mpc (golden set).

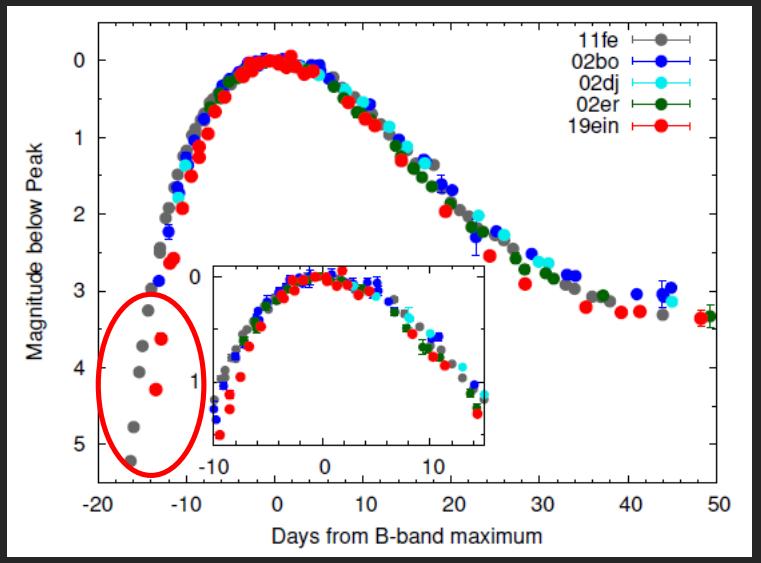
well-characterized SNe up to ~ 70 Mpc (a hunt for outliers).

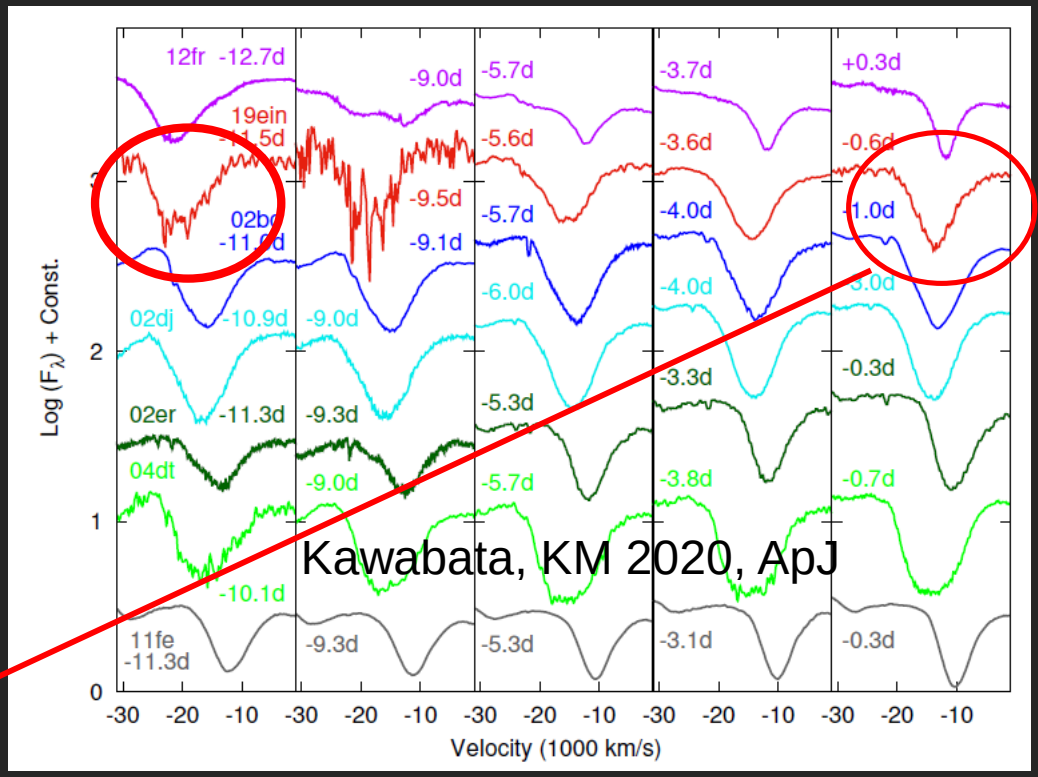
Kawabata-san, Yamanaka-san, Isogai-san, …

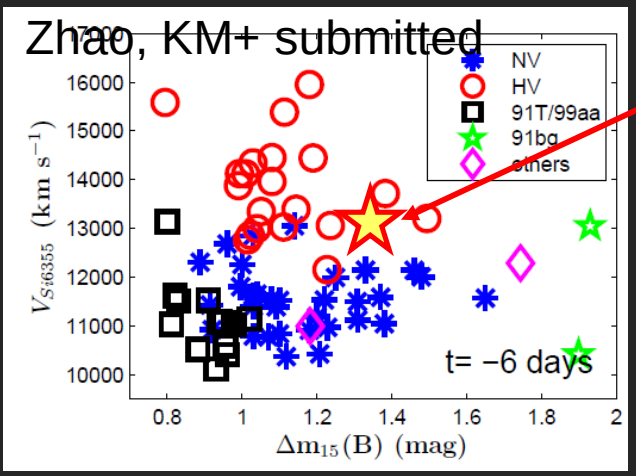
So far mostly fueled by public surveys; Tomo-e to come.

Data taken also within the OISTER

Rapidly evolving + high velocity (HV) SN Ia 2019ein





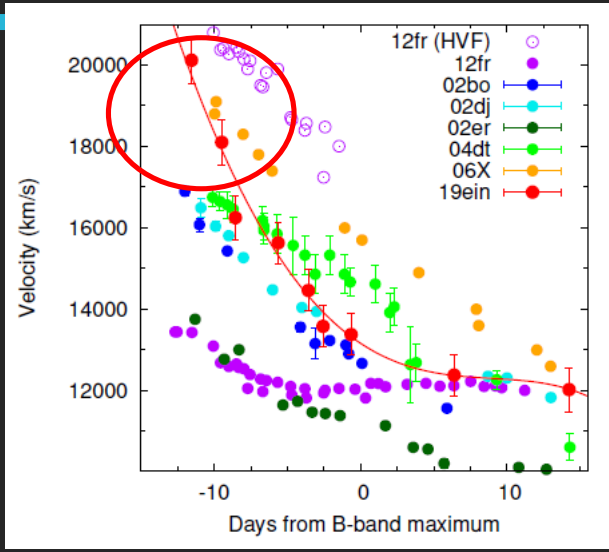


Observations for the most infant phase for HV SNe Ia.

No rapidly-evolving HV SNe well observed in the rising phase before.

“highest velocity” for SN Ia ever observed.

Implications for the SN Ia diversity and the explosion

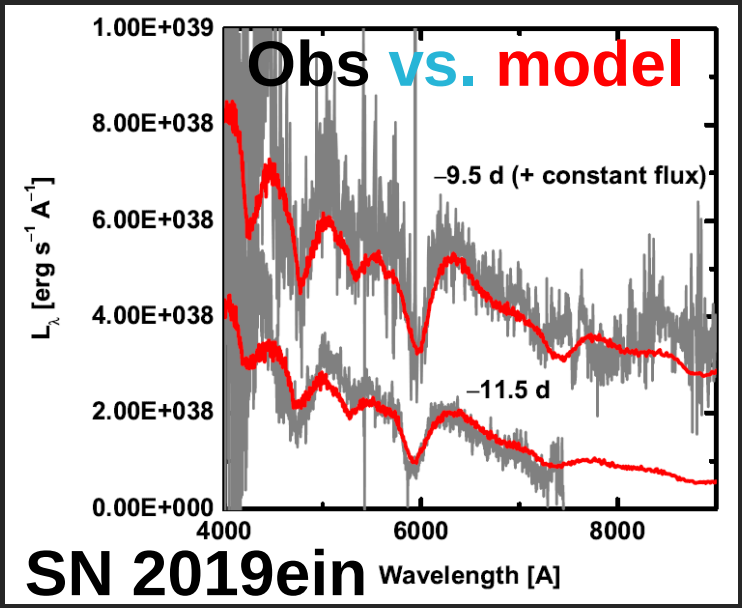


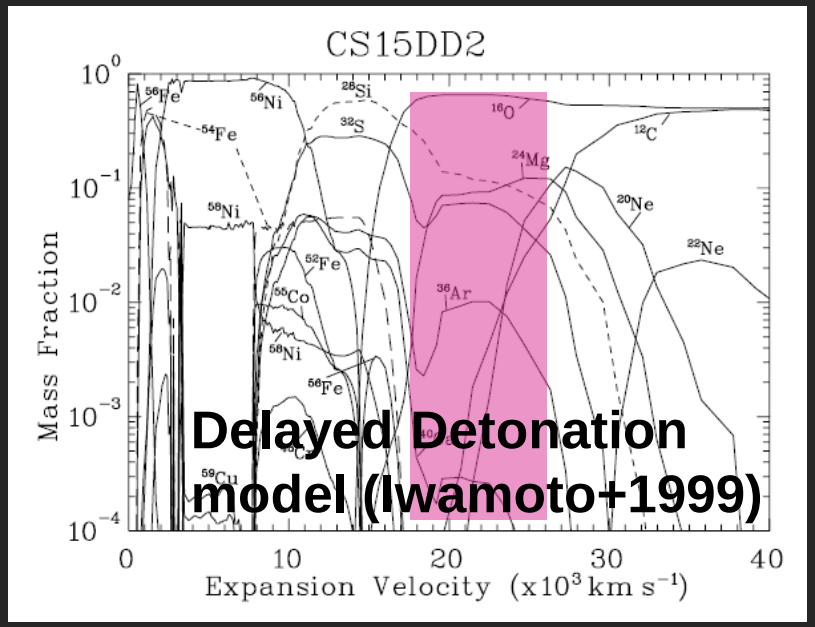
Diversity:

HV SNe are not a one-parameter family; not only the velocity but also the speed of the evolution does matter.

The explosion model:

Extended nuclear burning out to the surface region in HV SNe.





- In the presentation, properties of two SNe Ia were discussed, based on the Seimei/Kanata/Tomo-e data.
- The contents are in preparation, one by Kawabata et al. and the other by Kawabata et al. and Jiang et al.
- These are removed from the online proceedings here.

Future (Spectroscopy) Perspectives

Some numbers © Tanaka *** Numbers for all sky**

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200	3×10^7	3×10^5	3,000	21.5	23.5
500	5×10^8	5×10^6	50,000	23.5	25.5

Now

Full spec + Kools

Full spec + TriCCS

← Infant

Basic

Infant

Basic

Infant

Basic

Infant sample: soon-after-the-explosion SNe (down to -15 mag).

Basic sample: good characterization (a hunt for outliers: -17 mag).

We are now able to find weirdos at a rate of 1 in 50 SNe.

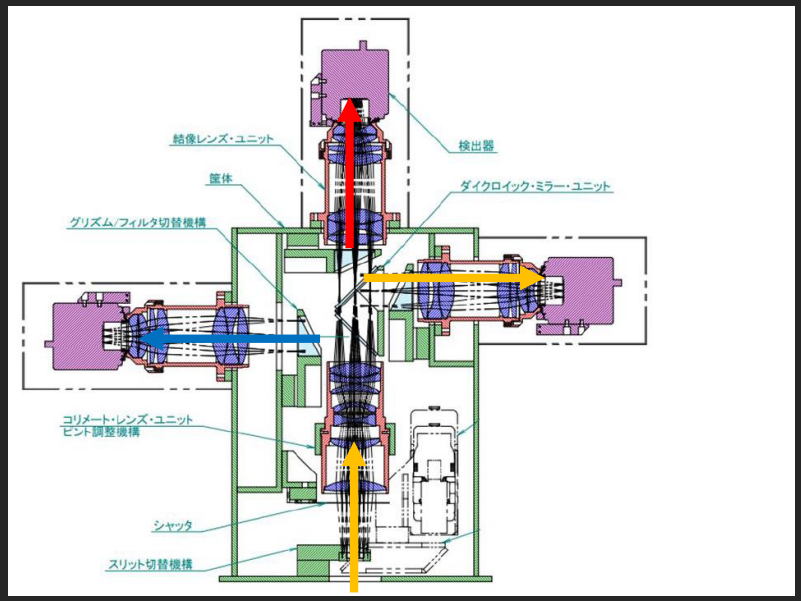
Will be able to do it for 1 / 200 SNe with full-spec Seimei + Kools.

Further down to 1 / 1,000 with TriCCS to come.

Need a number of nights + human resource for science.

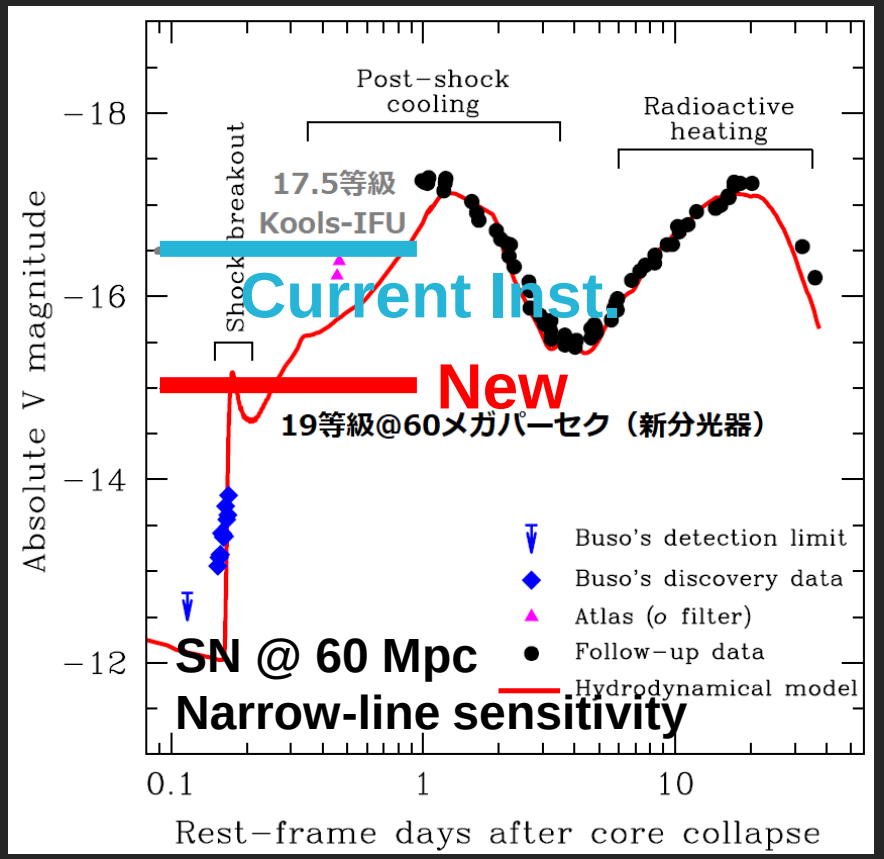
See the talk by Ohta et al.

TriCCS: new imager + spectrograph



3 channel CMOS camera
(fully funded, 2021~)
Imager→spectrograph
(fully funded, 2023~?)
A new postdoc, ~ Apr 2021?
TriCCS pipeline + obs
(Job ad @ ~ Dec 2020)

Spectra @ 1 day for
~ 30 SNe / yr within 60Mpc
(currently <10 SNe reported)



Take Away

- Peculiar beasts **beyond known diversities** have been regularly and routinely found.
- **Infant phase observations routinely performed** with Seimei and Kanata telescopes.
- **New insight** obtained:
  - High velocity SNe: not a single param. family; extended burning.
  - Two other SNe Ia: expanding the diversity; insights into the progenitor systems and the explosion mechanisms.
- Will produce **a complete census** with coming update in Seimei and instrument. **Stay tuned!**