Tomo-e Gozen
超新星
ショックブレイクアウト観測

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KONAN UNIVERSITY

5^{th} Jul 2017

木曽シュミットシンポジウム

甲南大実習

Tomo-eを実習にどう使うか？

2017/2/23-27

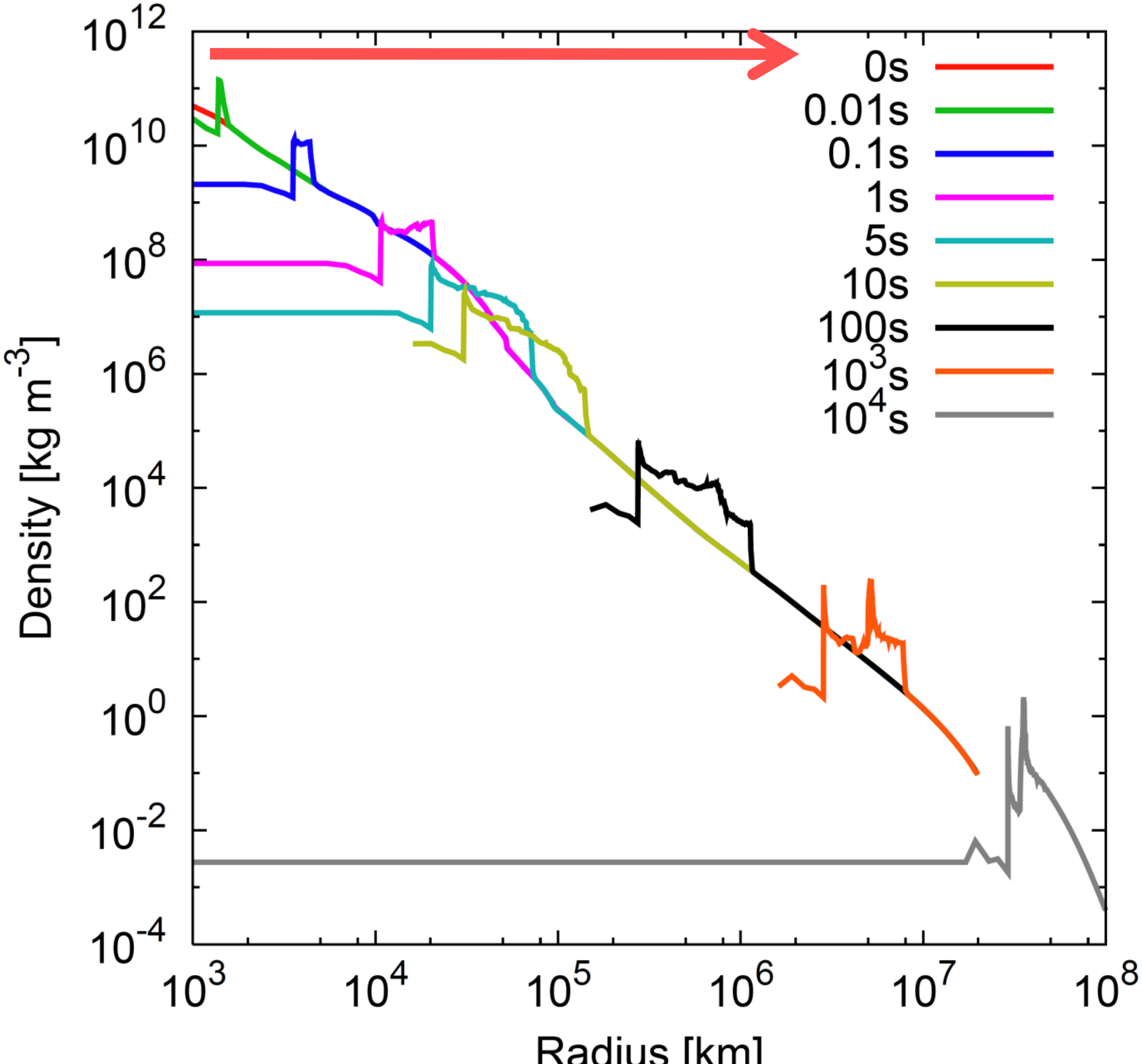
参加者5名

今年もよろしくお願いします。

今年は観測希望の学生がいる見込みです。

SN shock breakout survey

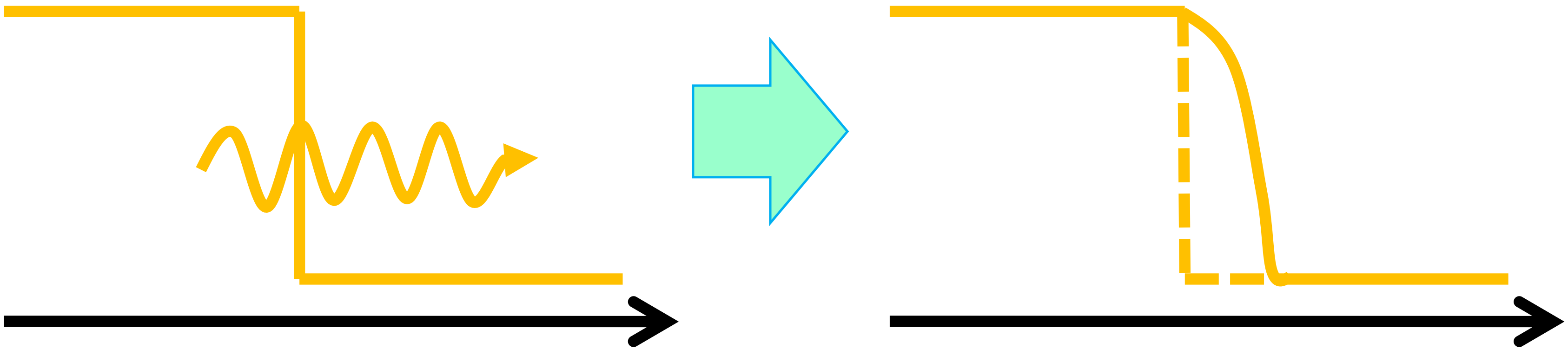
Shock wave in the stellar mantle



Radiation dominate after the shock wave and radiation are fully coupled with matter.

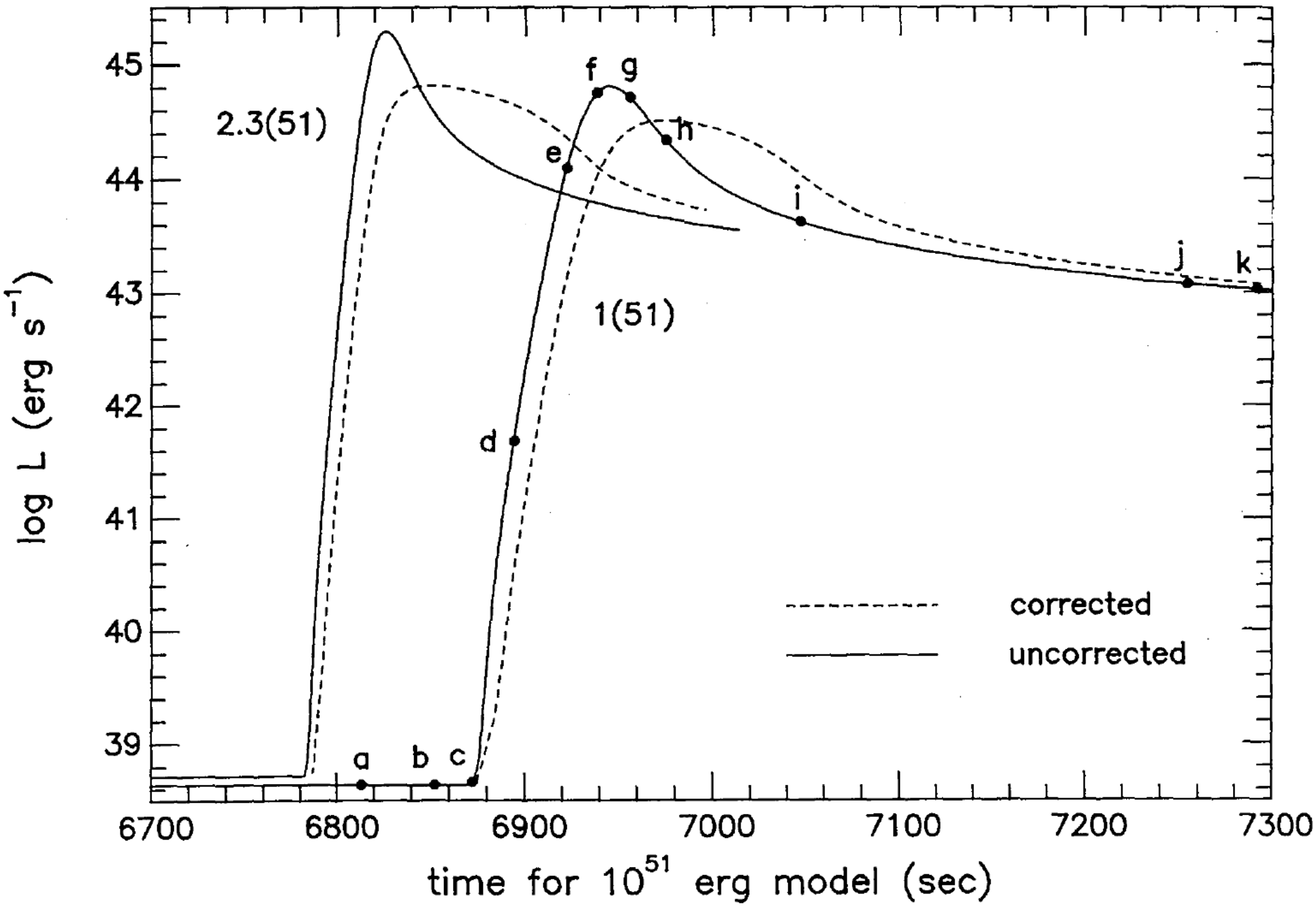
When the shock wave approaches the stellar surface,

- Shock velocity: v_{sh}
- Diffusion velocity of radiation: c/τ
- If $c/\tau > v_{sh}$ (typically, $\tau < c/v_{sh} \sim 10$),

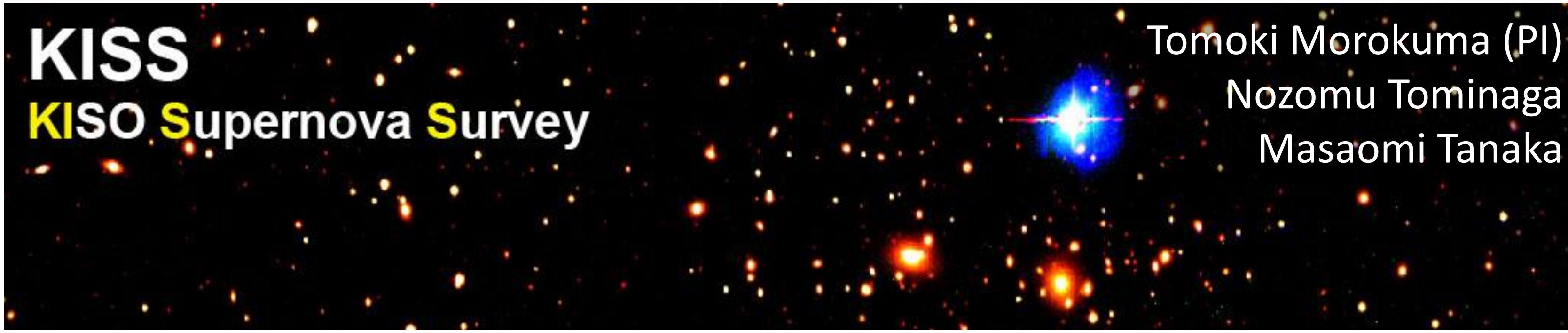


- Radiation partially affects matter and vice versa.
- Radiation hydrodynamics and >=2 temperatures are required.

Shock Breakout
(Ensman & Burrows 92)



KIso Supernova Survey -KISS-

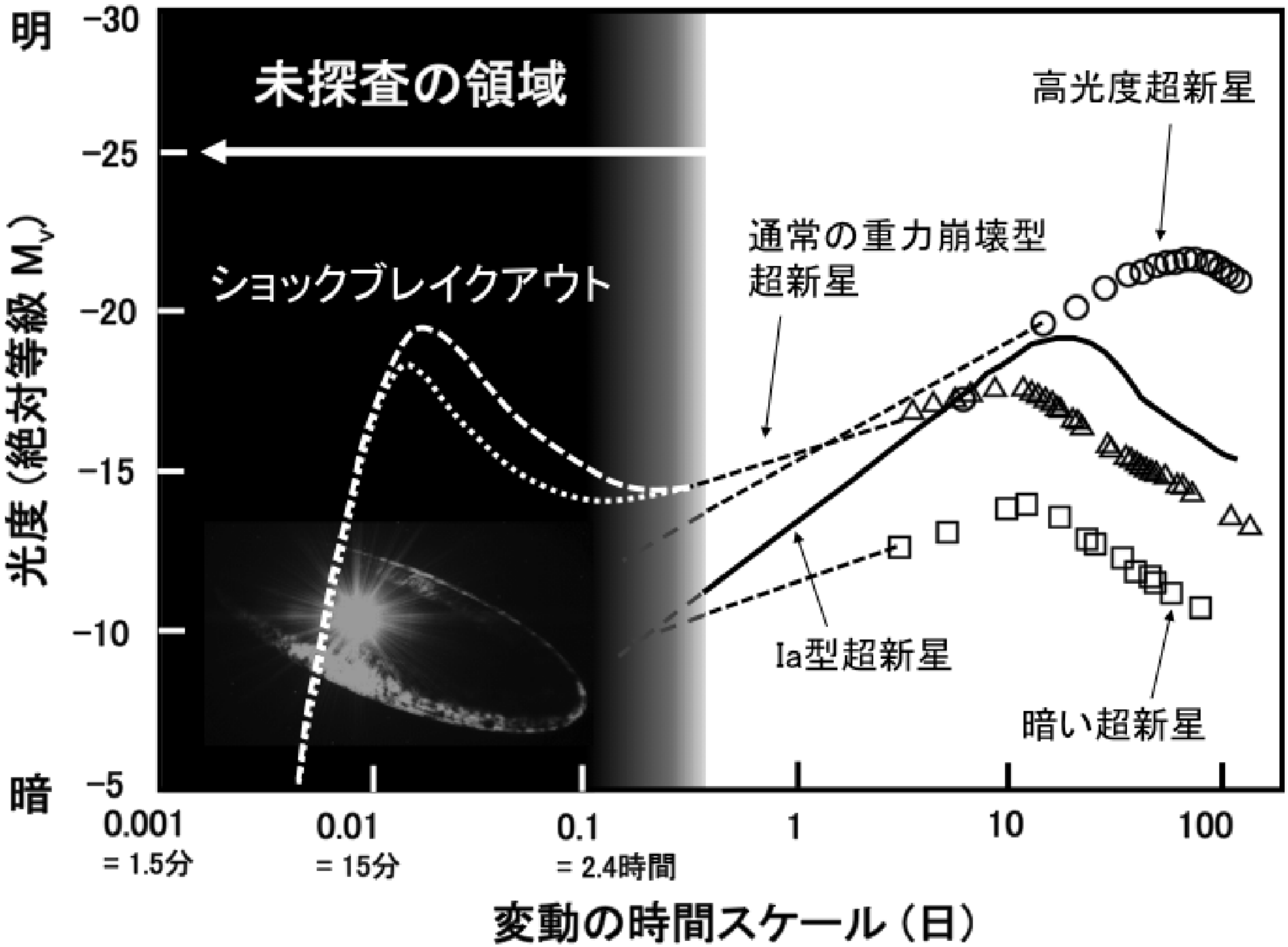


Experience of KISS

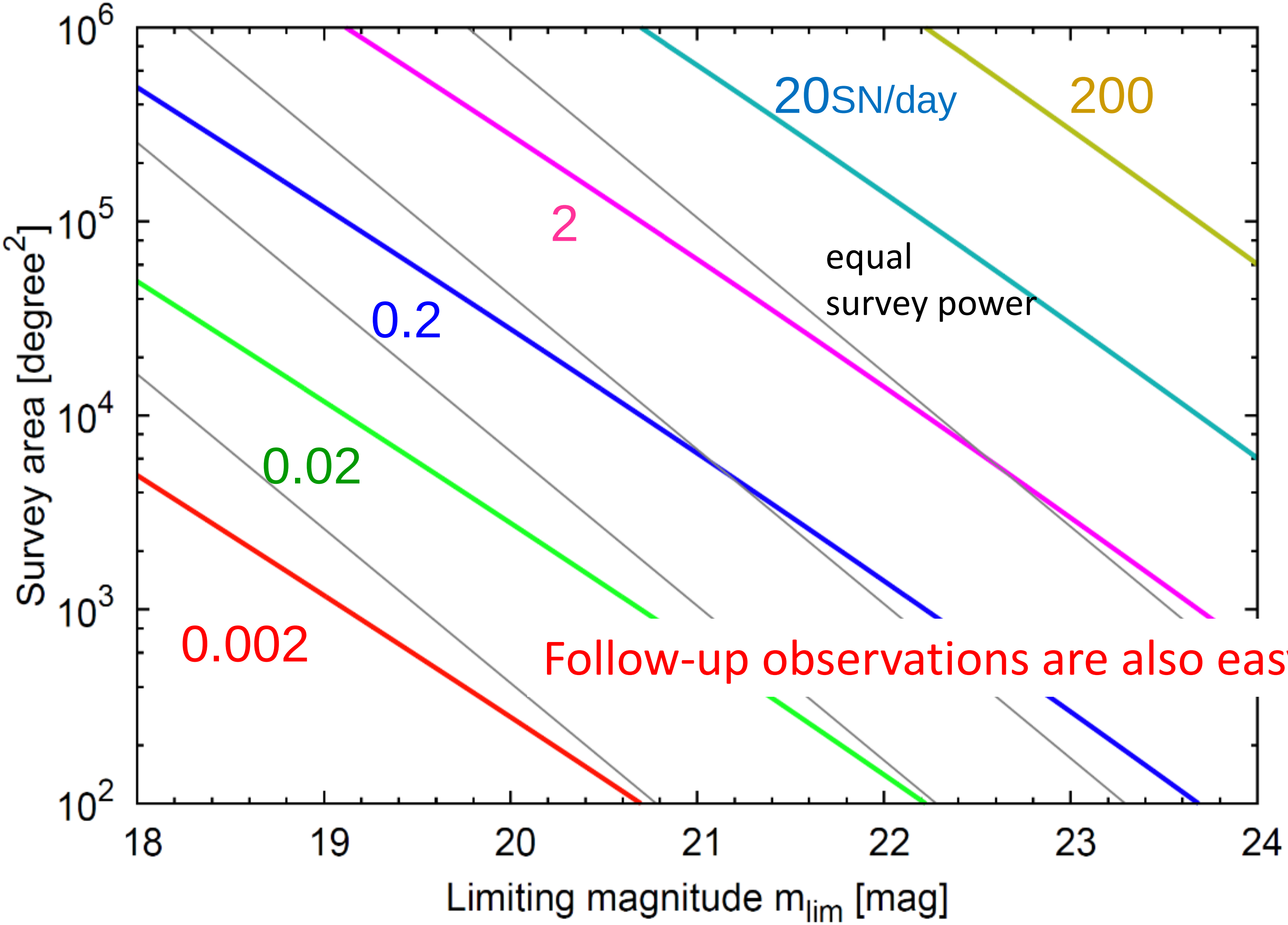
- ~several shock breakout/3yrs were expected.
- But, we could not find a shock breakout.
  - Limiting magnitude (~20mag) was shallower than expected (~21mag).
  - The estimation was too optimistic, e.g., overhead, detection efficiency, ….
- There are many unidentified supernova candidates.
  - 180sec with KWFC is too deep for follow-up observation.
  - We might miss interesting by-products.

- The “handmade” survey taught/is teaching us what the SN survey is. It greatly helps/will help SN surveys with HSC/Tomo-e.

Tomo-e wide-shallow high-cadence SN survey



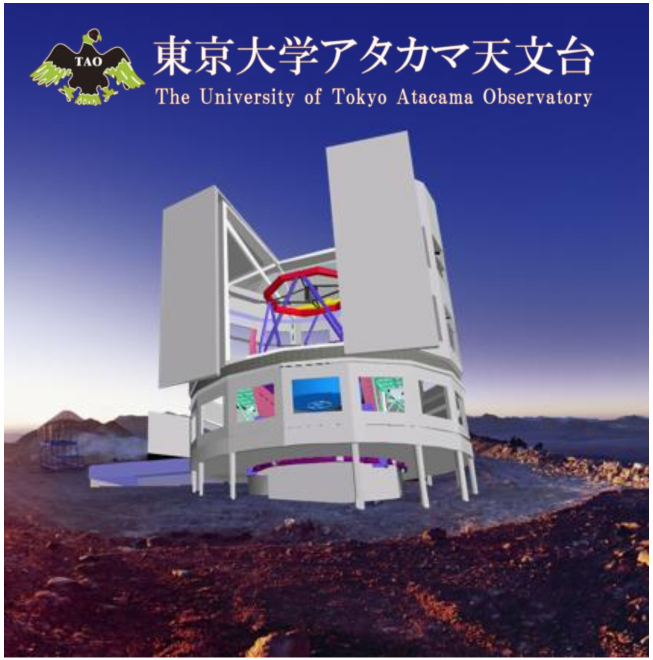
A wide and shallow survey is efficient to discover nearby transients



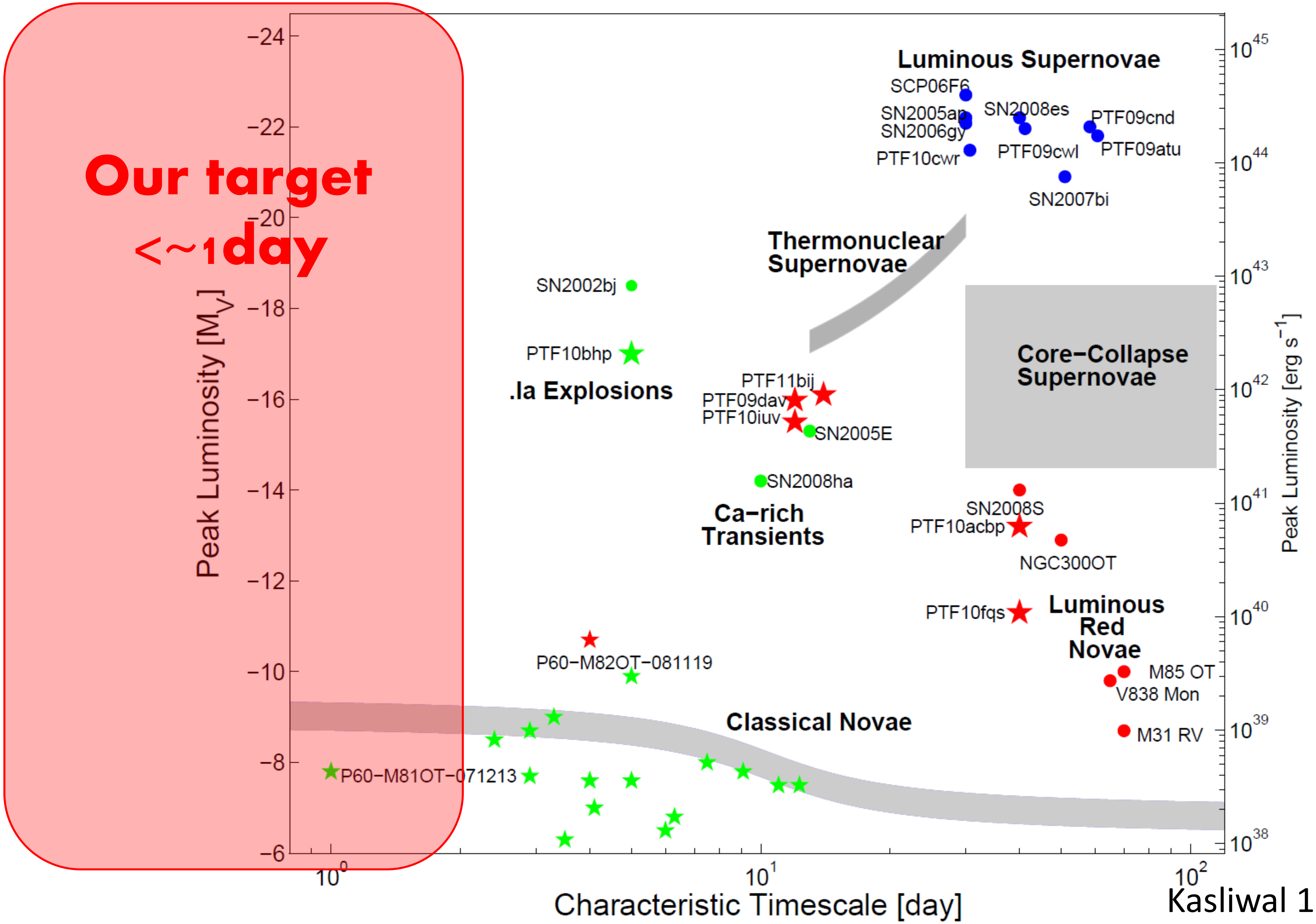
Follow-up observations are also easy.

NT+11

Follow-up observations



Timescale of transients



Kasliwal 11

Presupernova information is lost with time

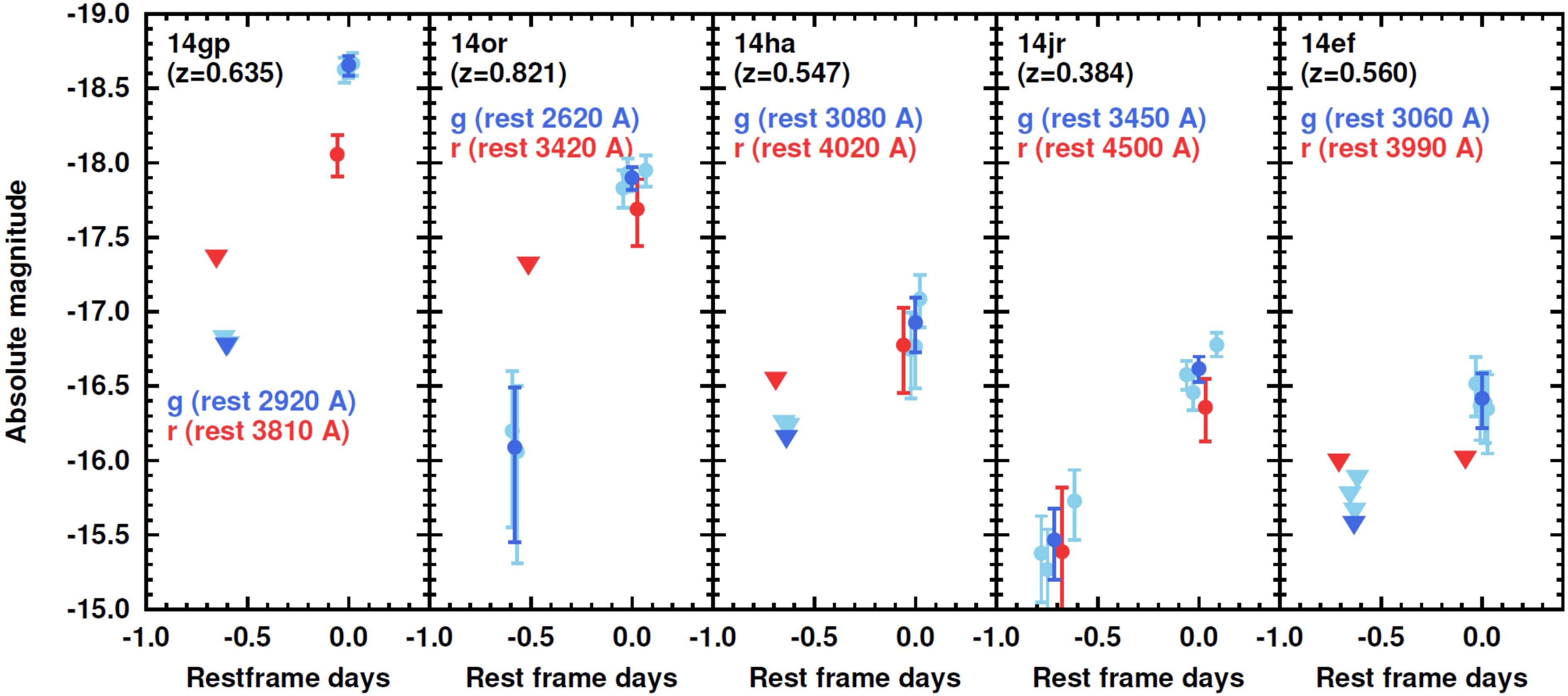
- Shock velocity: $v_{sh} \sim 10^4$km/s

- Stellar structure: $R_{star} \sim 500R_{\odot} \sim 3.5\text{x}10^8$km
  - $t < R_{star}/v_{sh} \sim 10$hr

- CSM structure: $v_{wind} \sim 10\text{-}100$km/s
  - $t < t_{wind} \text{ x } v_{wind}/v_{sh} \sim 0.001\text{-}0.01\ t_{wind}$
  - E.g., wind at 10yr prior to SN explosion can be addressed only by an observation until 3-30days after the explosion

- A study on early SNe Ia is led by Jiang Jian.

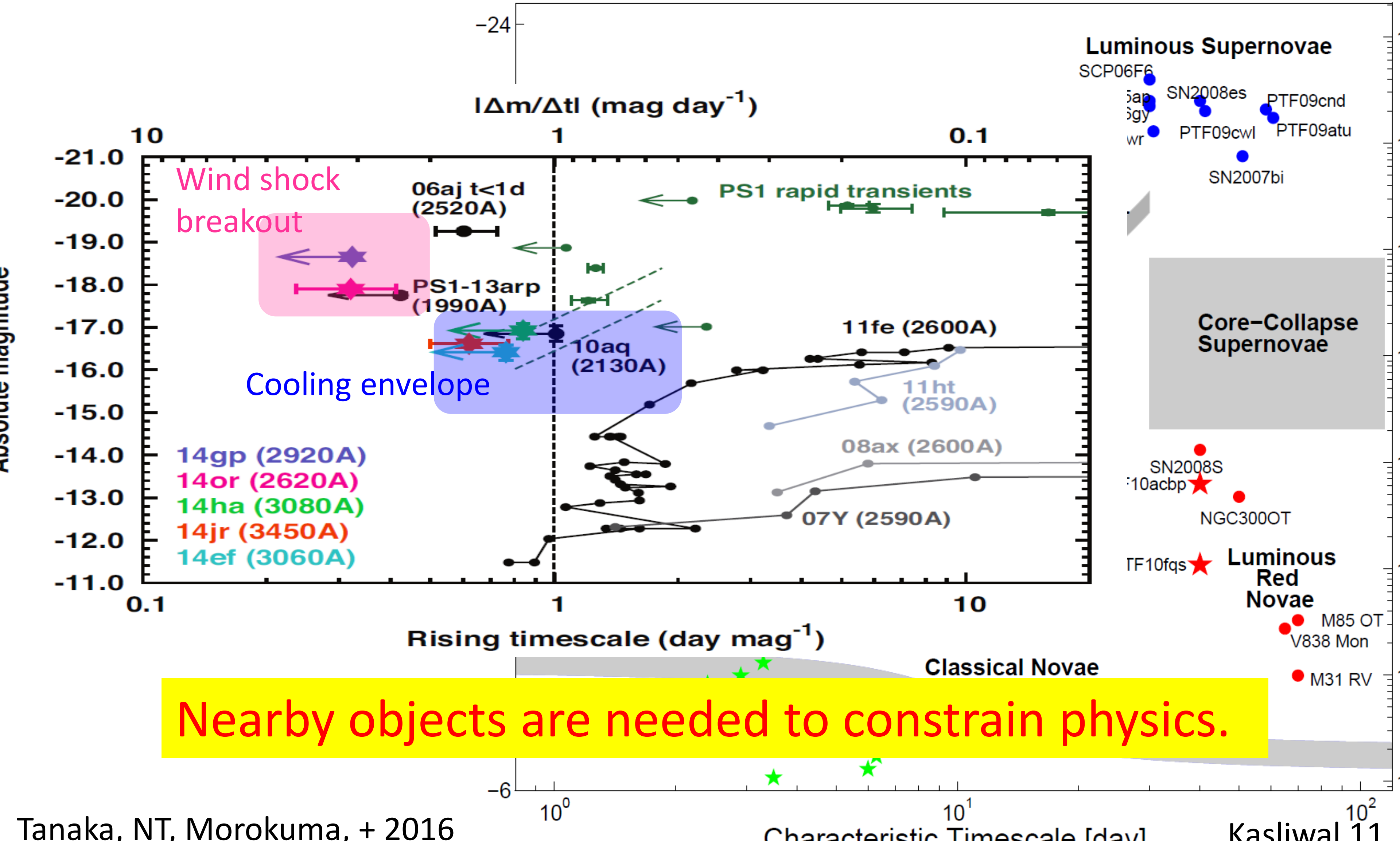
Rapidly rising transients with HSC



>9% of CCSNe could have rapid rise.

Tanaka, NT, Morokuma, + 2016

High-cadence surveys open up a new frontier

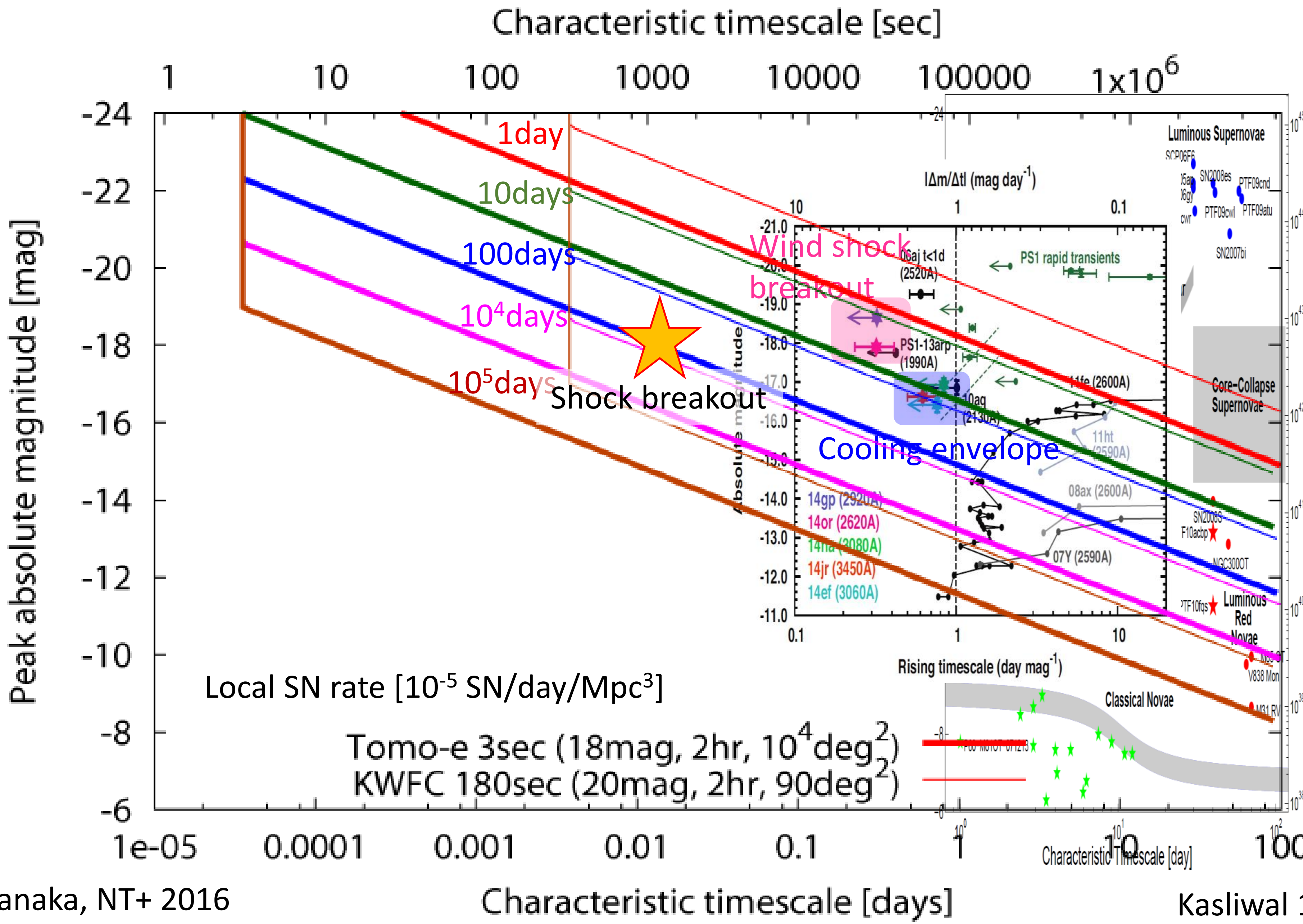


Nearby objects are needed to constrain physics.

Tanaka, NT, Morokuma, + 2016

Kasliwal 11

Tomo-e opens a new frontier



Tanaka, NT+ 2016

Kasliwal 11

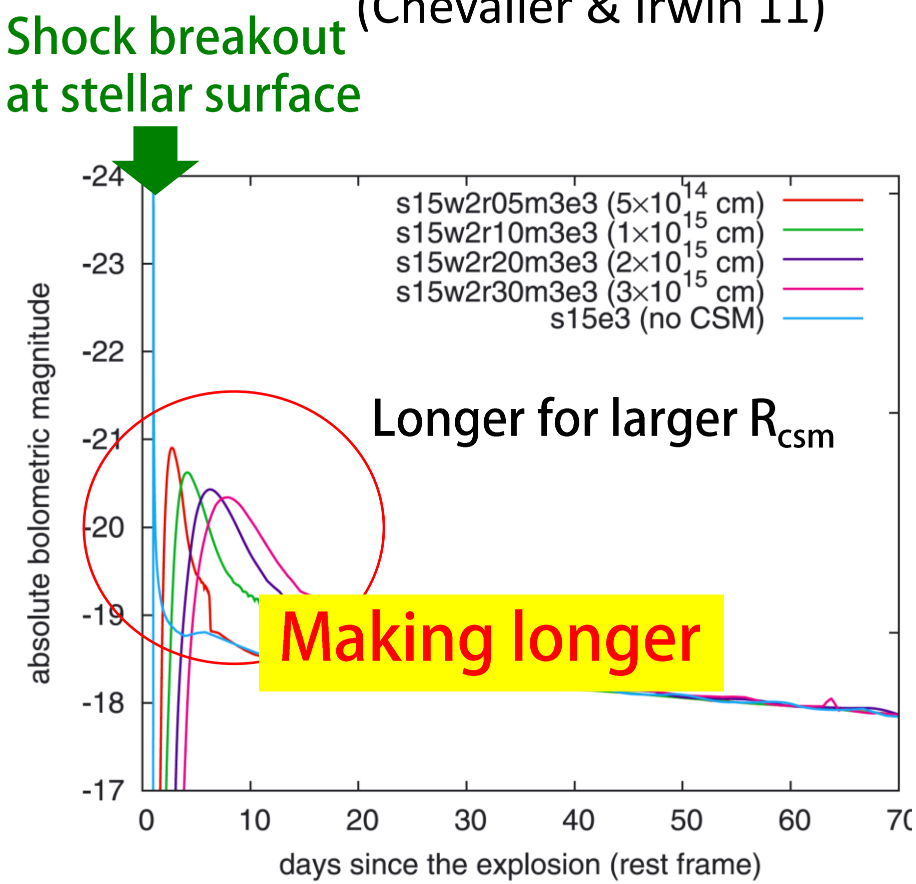
Origin of rapid rising

- Wind shock breakout

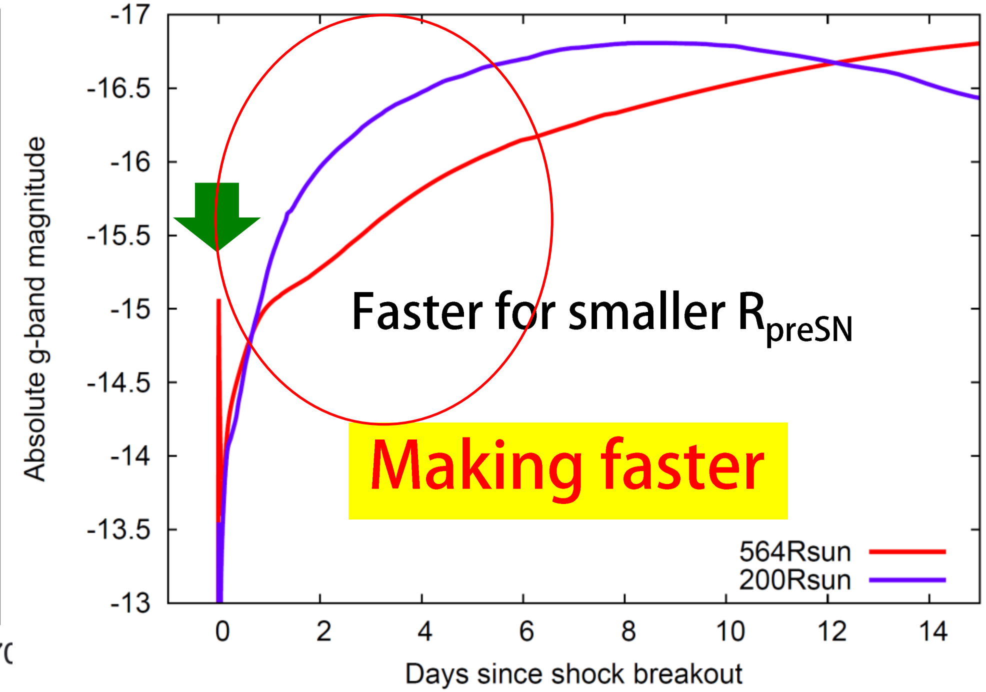
(Chevalier & Irwin 11)

- Cooling envelope

(Nakar & Sari 10; Rabinak & Waxman 11; Shussman+16; Sapir & Waxman 16)

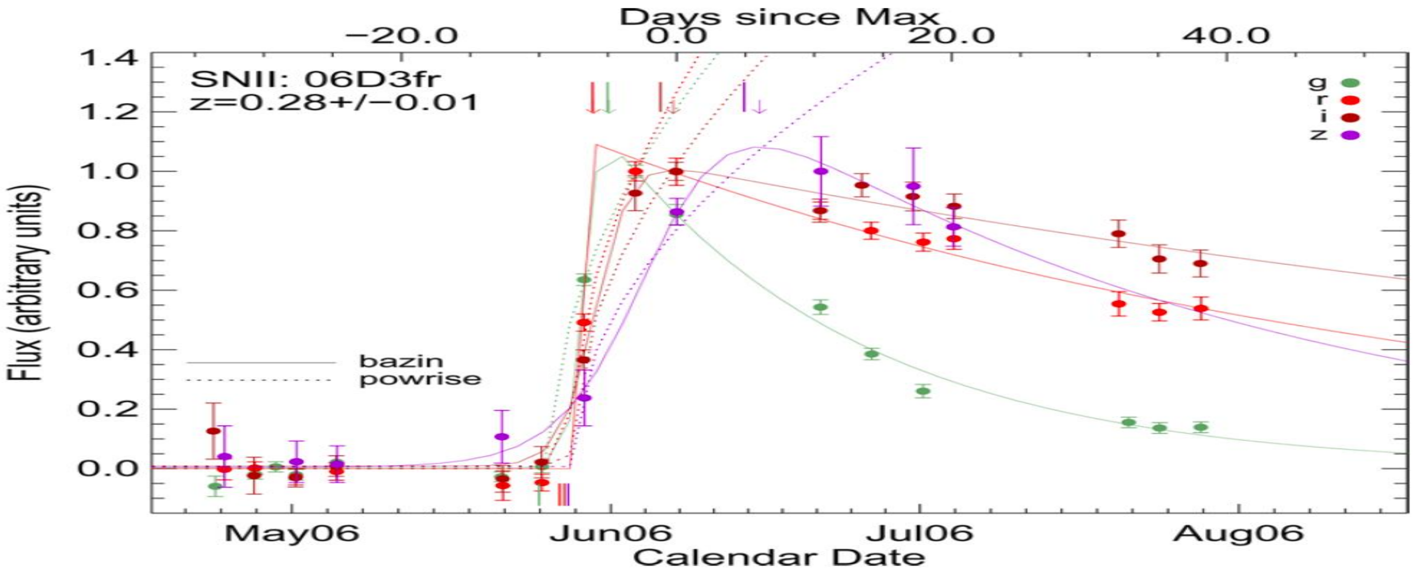


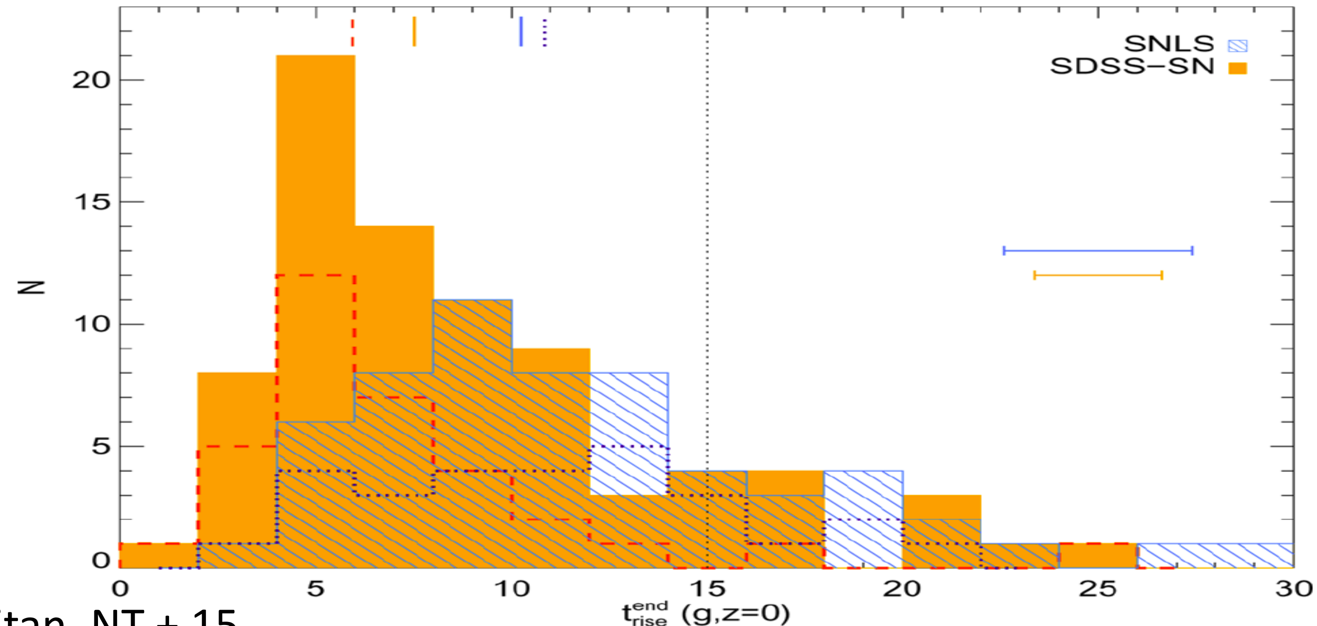
Moriya, NT+11



González-Gaitán, NT+15

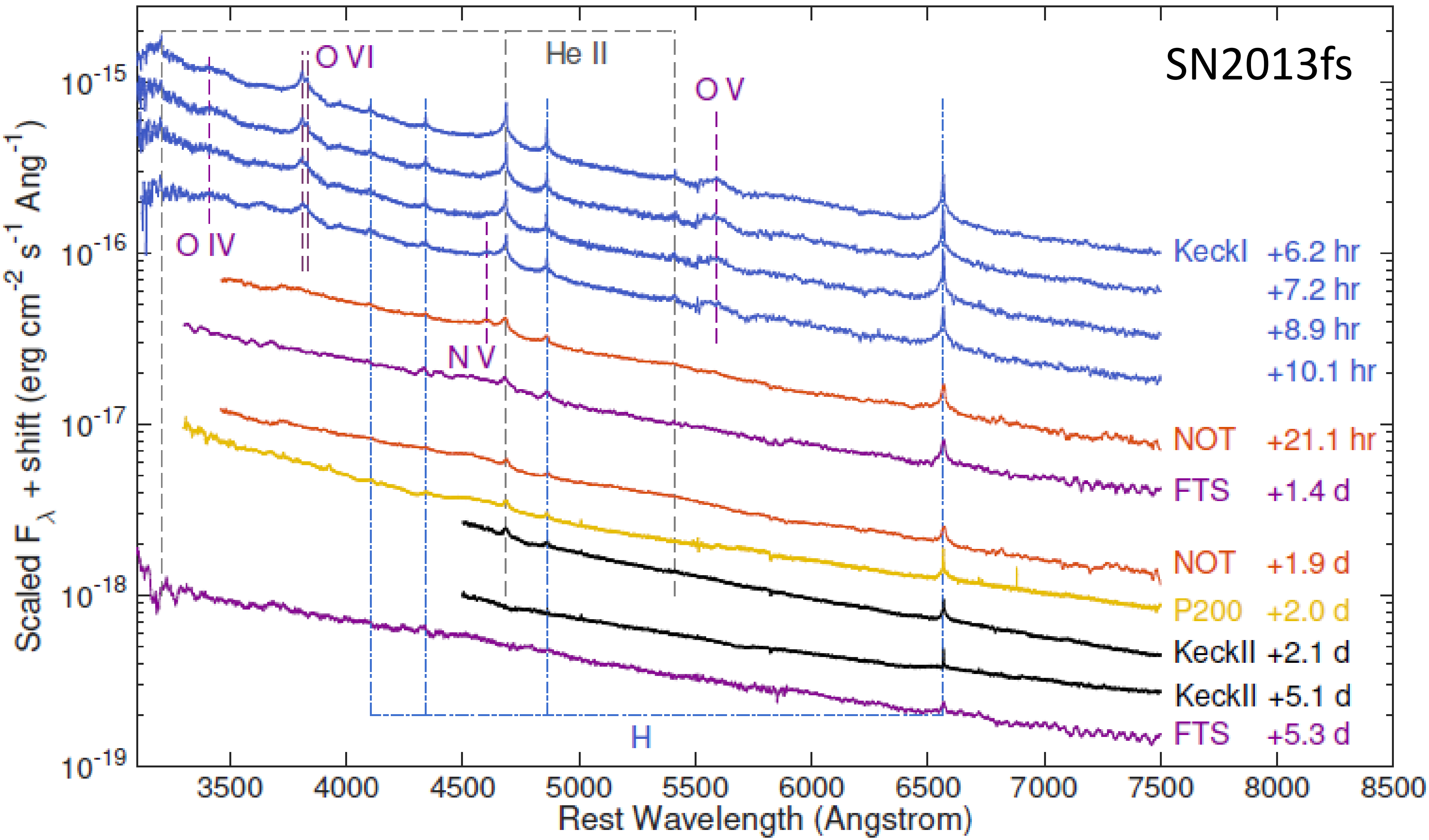
Rising of Type II supernovae





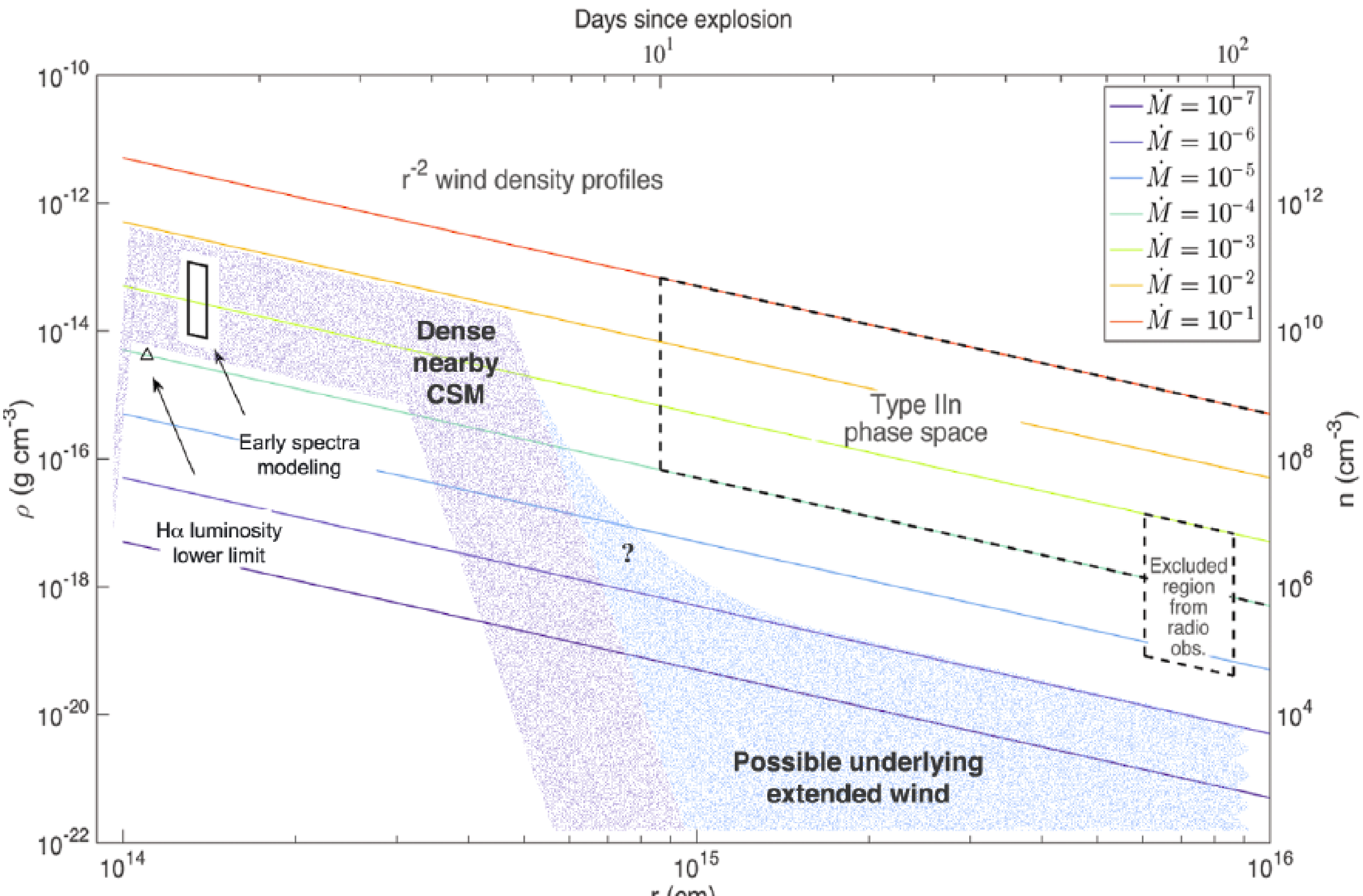
Gonzalez-Gaitan, NT + 15

SN2013fs -evidence of dense CSM-



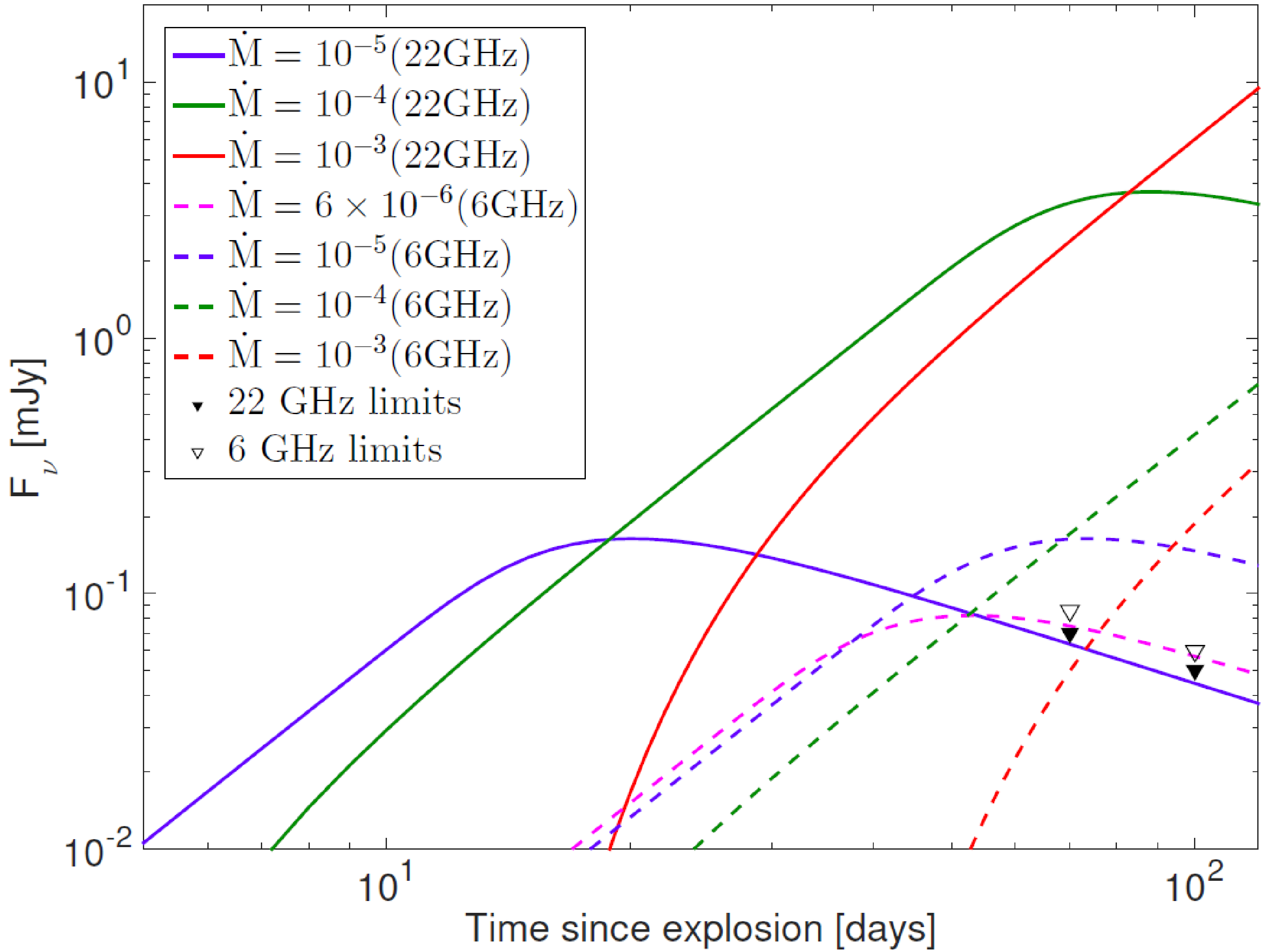
Yaron+17

SN2013fs -structure of CSM wind-

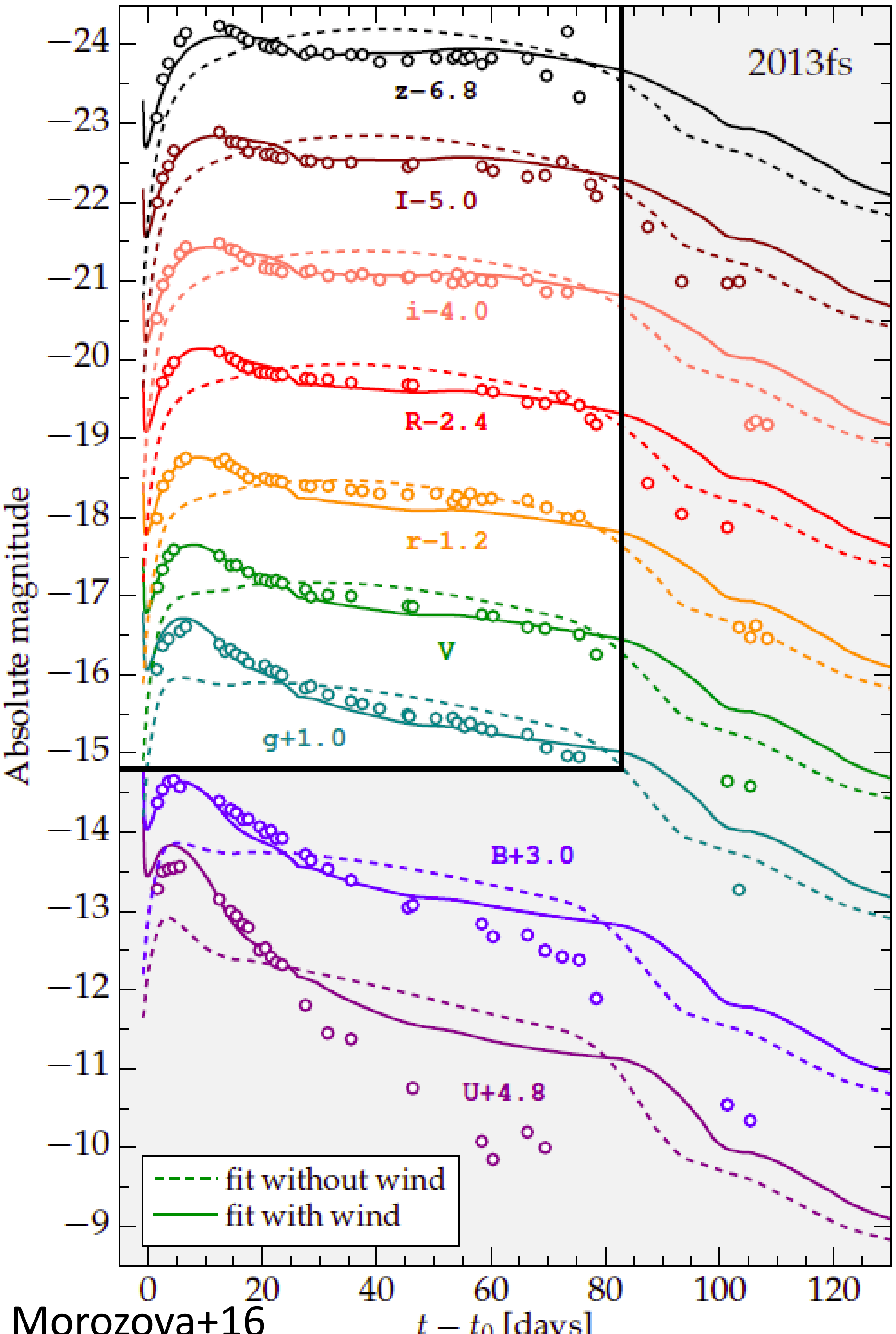


Yaron+17

SN2013fs -strict upper limit in radio-

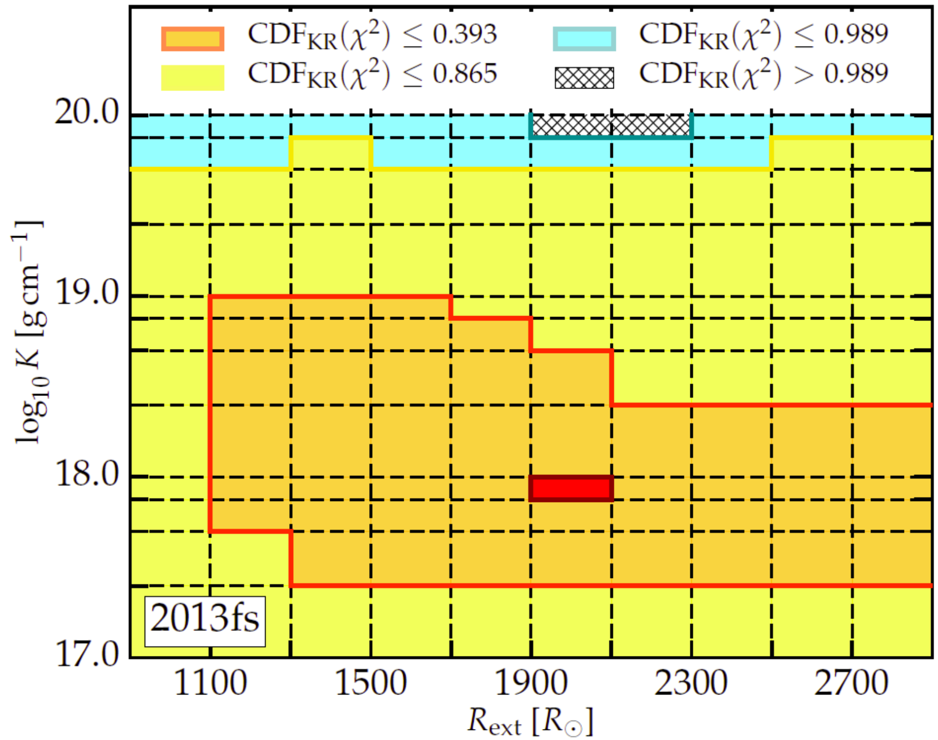


Yaron+17



Morozova+16

LC modeling of SN2013fs



Mass loss rate:
$2M_\odot$/yr for v_{wind}=100km/s

Summary

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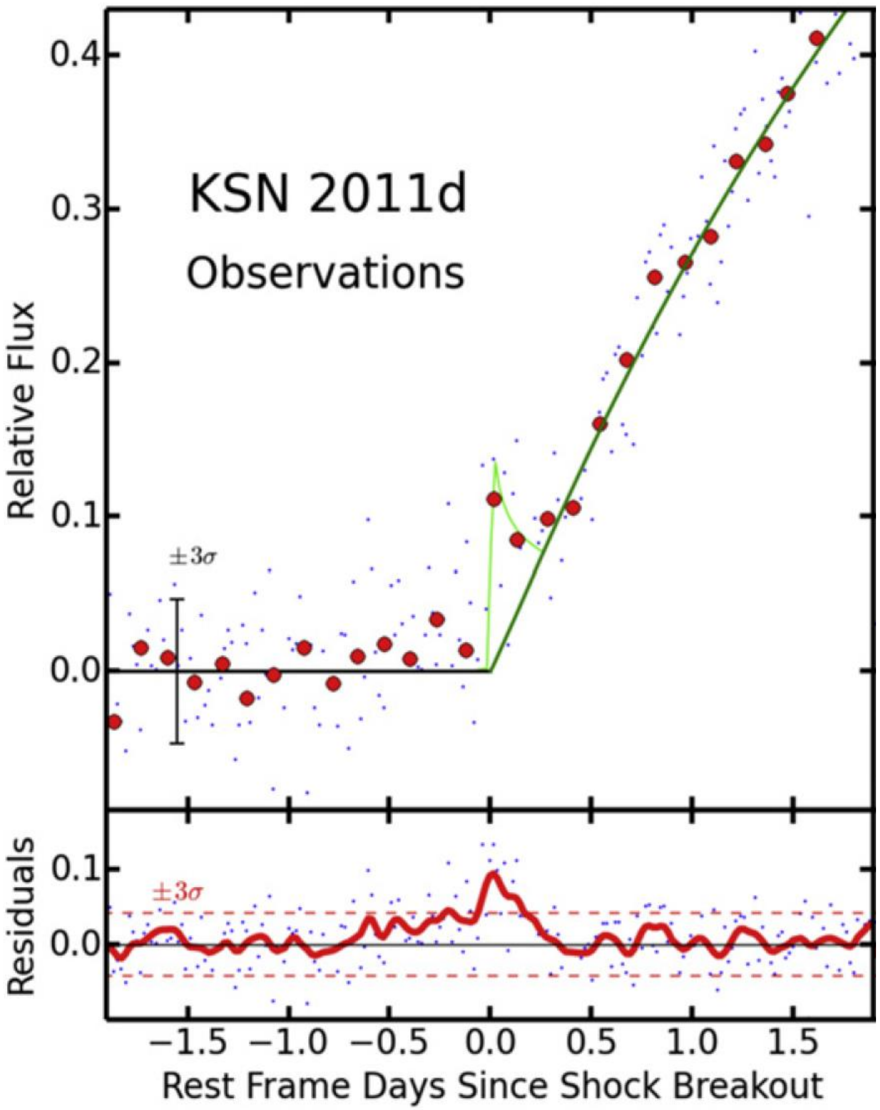
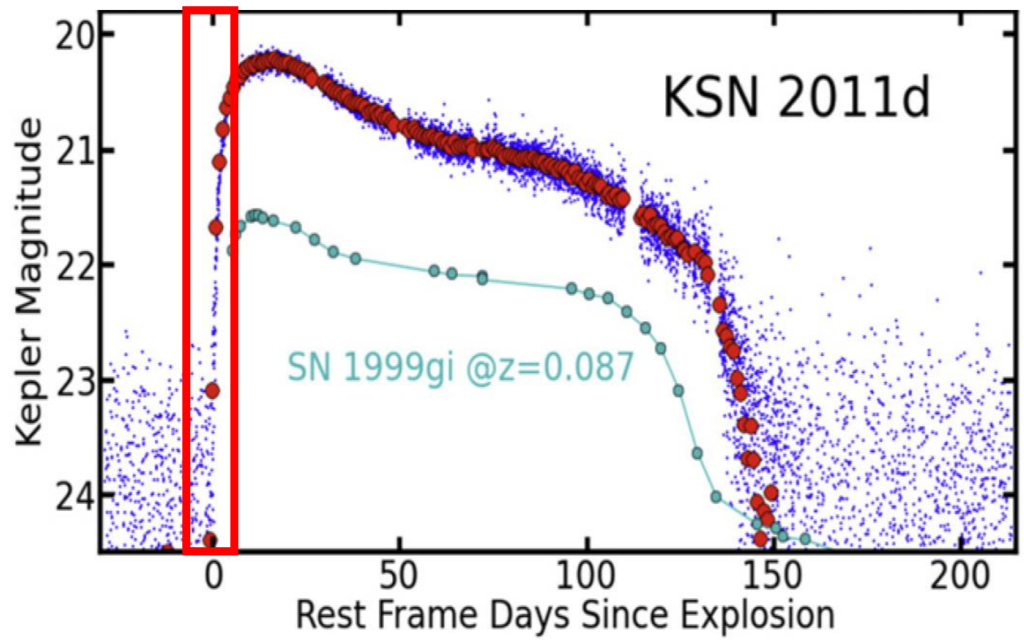
  - 今年度もよろしくおねがいします。
- Tomo-e SN shock breakout survey
  - A wide and shallow survey is efficient to discover nearby transients.
  - Follow-up observations are much easier than KISS.
  - Address the final fate of massive stars with not only shock breakout at the stellar surface, but also wind shock breakout and cooling envelope.

KSN2011d -Shock breakout in optical?-





500 galaxies

30min cadence

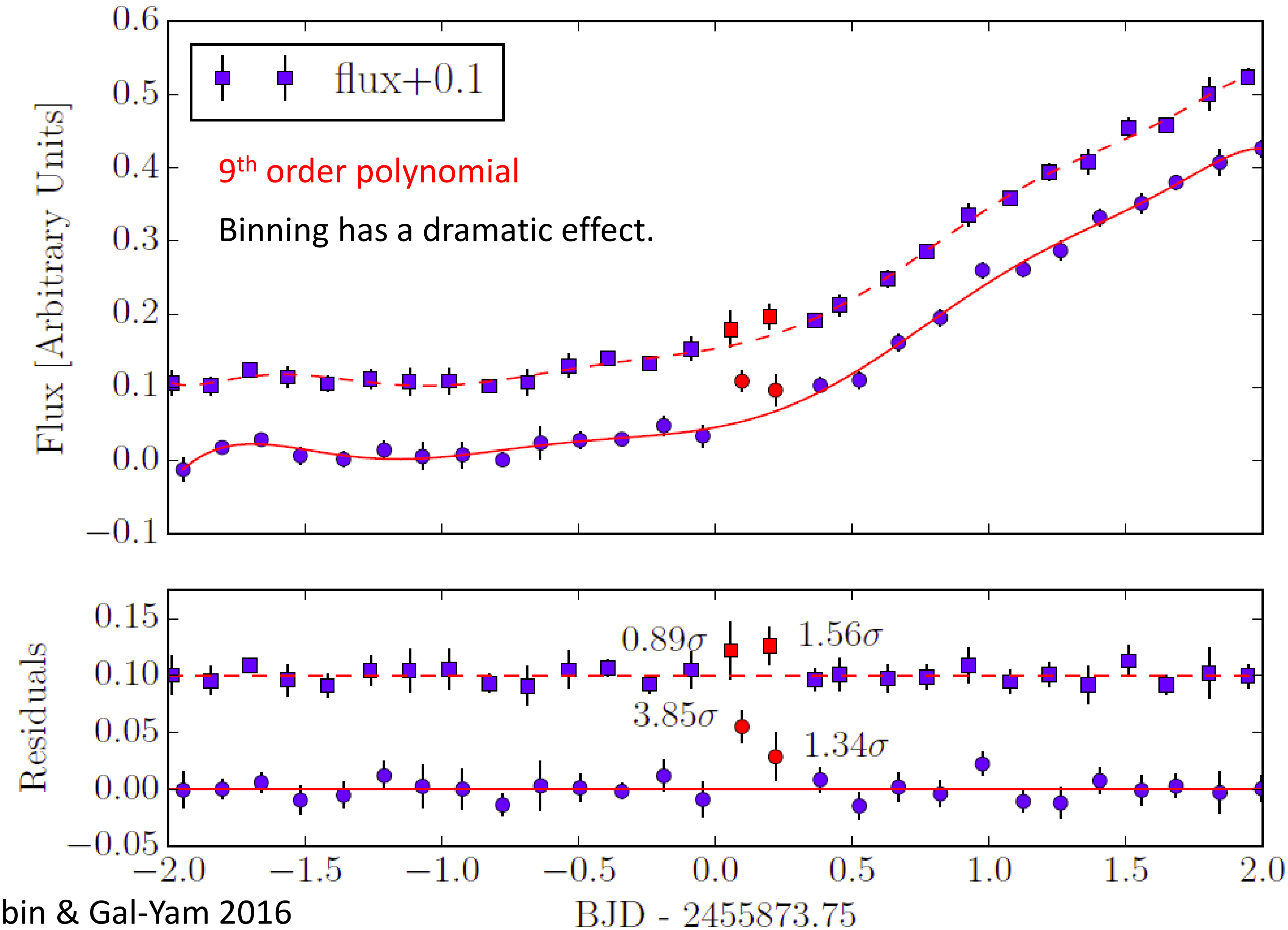
t_{rise}: 13.3 +- 0.4days

E=2x10^{51}ergs

R=490+-20$R_{\odot}$

Garnavich + 2016

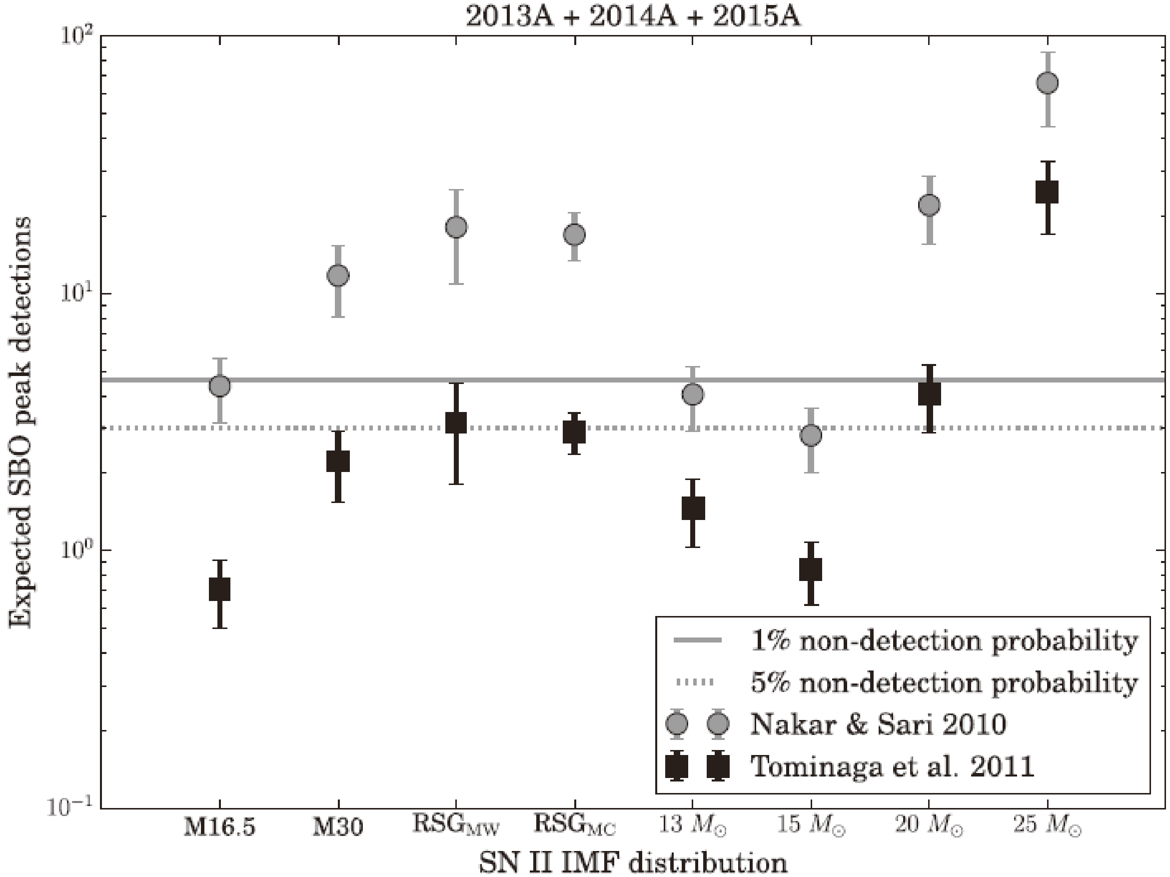
However,



Rubin & Gal-Yam 2016

High Cadence Transient Survey (HiTS) with CTIO/DECam

- 14 nights in 2013A, 2014A, and 2015A
- No shock breakout is detected.



Forster+16

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  - Address the final fate of massive stars with not only shock breakout at the stellar surface, but also wind shock breakout and cooling envelope.
- Detection of shock breakout of nearby Type IIP supernova in optical bands is NOT realized, yet.