Tomo-eを用いた超新星探査

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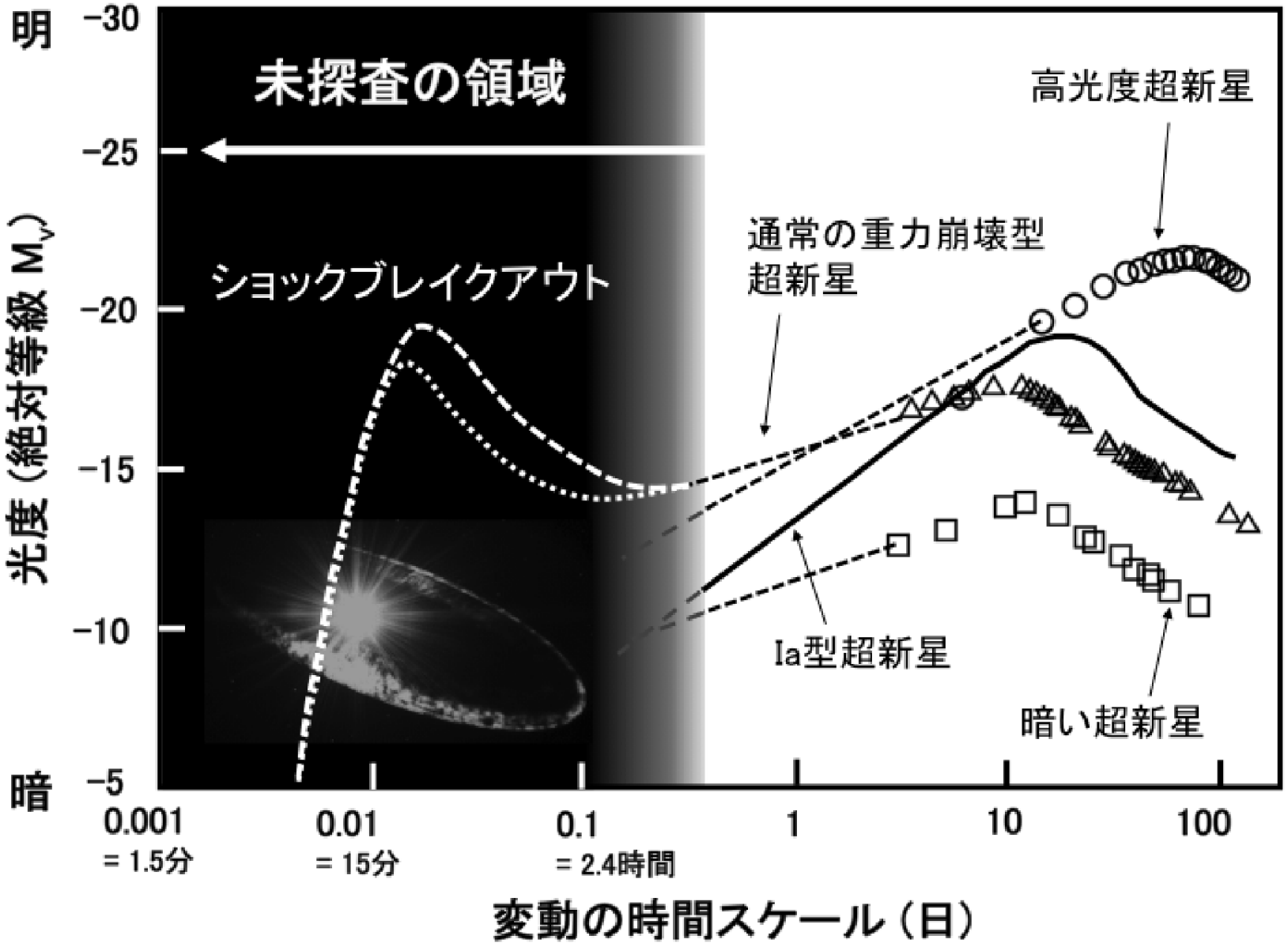
木曽シュミットシンポジウム

Outline

- 甲南大実習
- High-cadence supernova survey
- おまけ
  - All-sky bright metal-poor star survey

High-cadence supernova survey

High-cadence SN survey



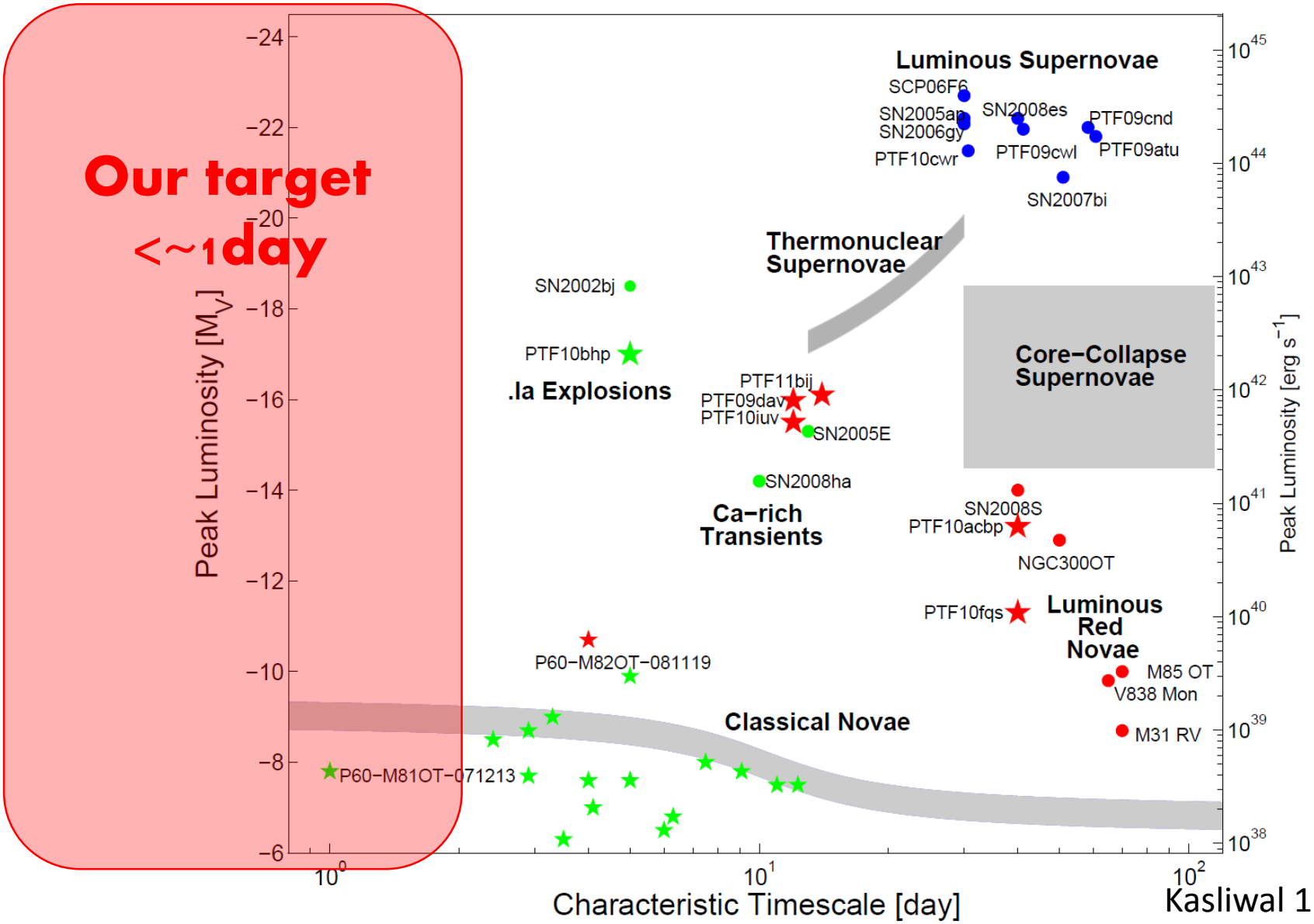
High-cadence SN survey

- Experience of KISS (Morokuma-san's talk)
  - 180sec with KWFC is too deep for follow-up observation
  - Many unidentified supernova candidates
- A wide and shallow survey is essential to discover nearby transients.
- Example of a survey strategy
  - Area: 3000deg^2
  - Limiting magnitude

    18mag (3sec exposure, 30min cadence)

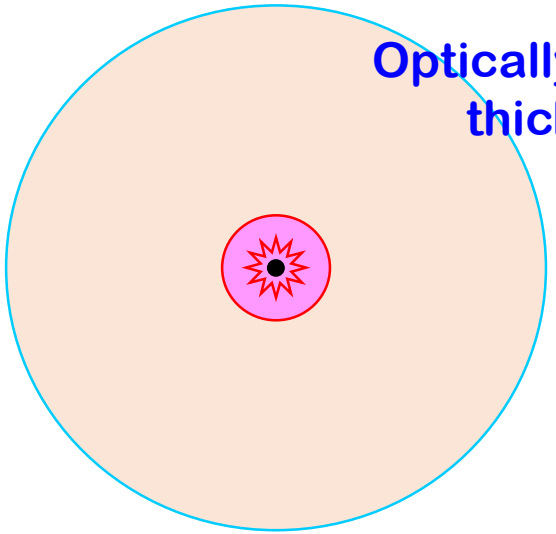
    20mag (180sec exposure, 1day cadence)

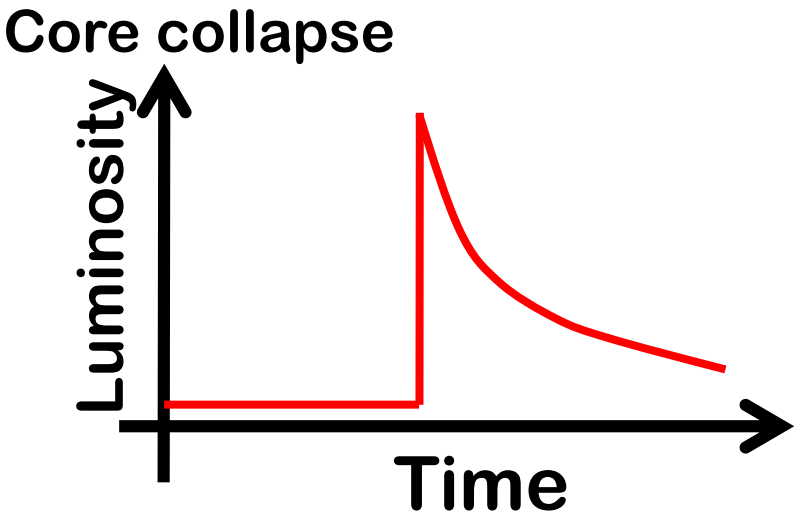
Timescale of transients



Kasliwal 11

Shock breakout





Massive Star (>10$M_\odot$)

e^--capture SNe (8-10$M_\odot$)

Core collapse

Shock formation

At the shock emergence, a stored energy is released as radiation.

Spectra are quasi-blackbody

$$T \sim R^{-3/4} E^{1/4}$$

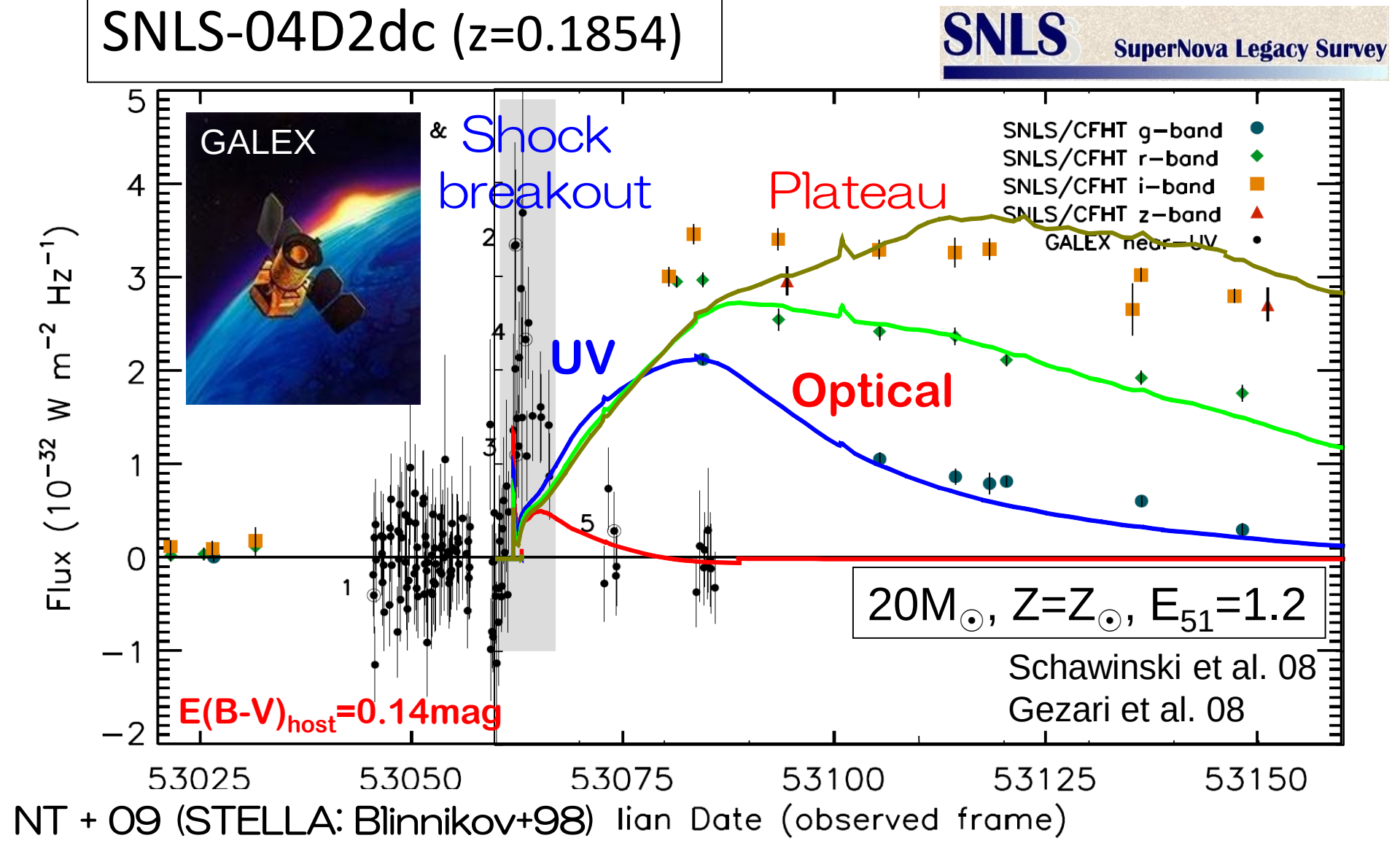
Typical properties

timescale: 1sec ~ 1day

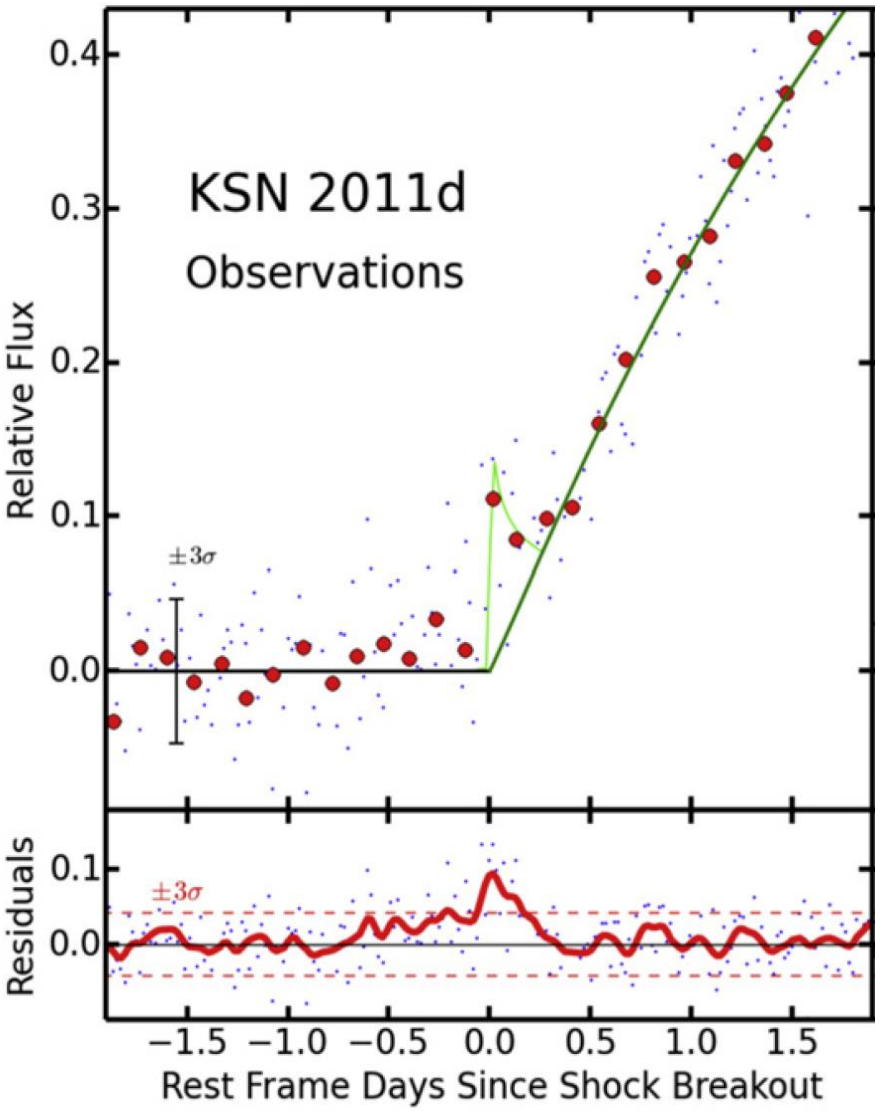
peak wavelength: X-ray ~ UV

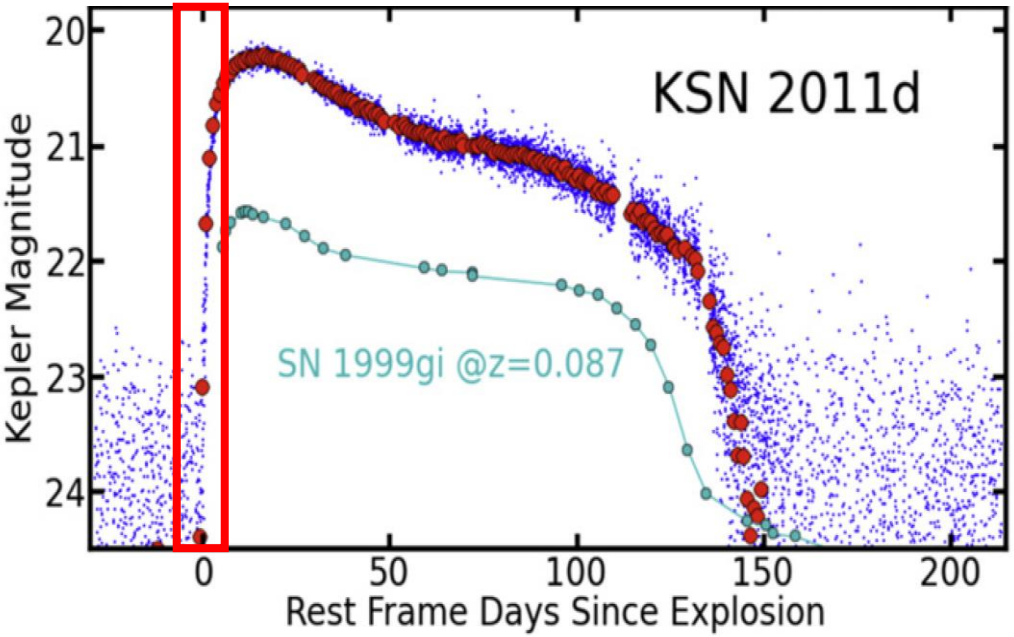
Shock breakouts of Type IIP SN

SNLS-04D2dc (z=0.1854)



Shock breakout detection with Kepler





500 galaxies

30min cadence

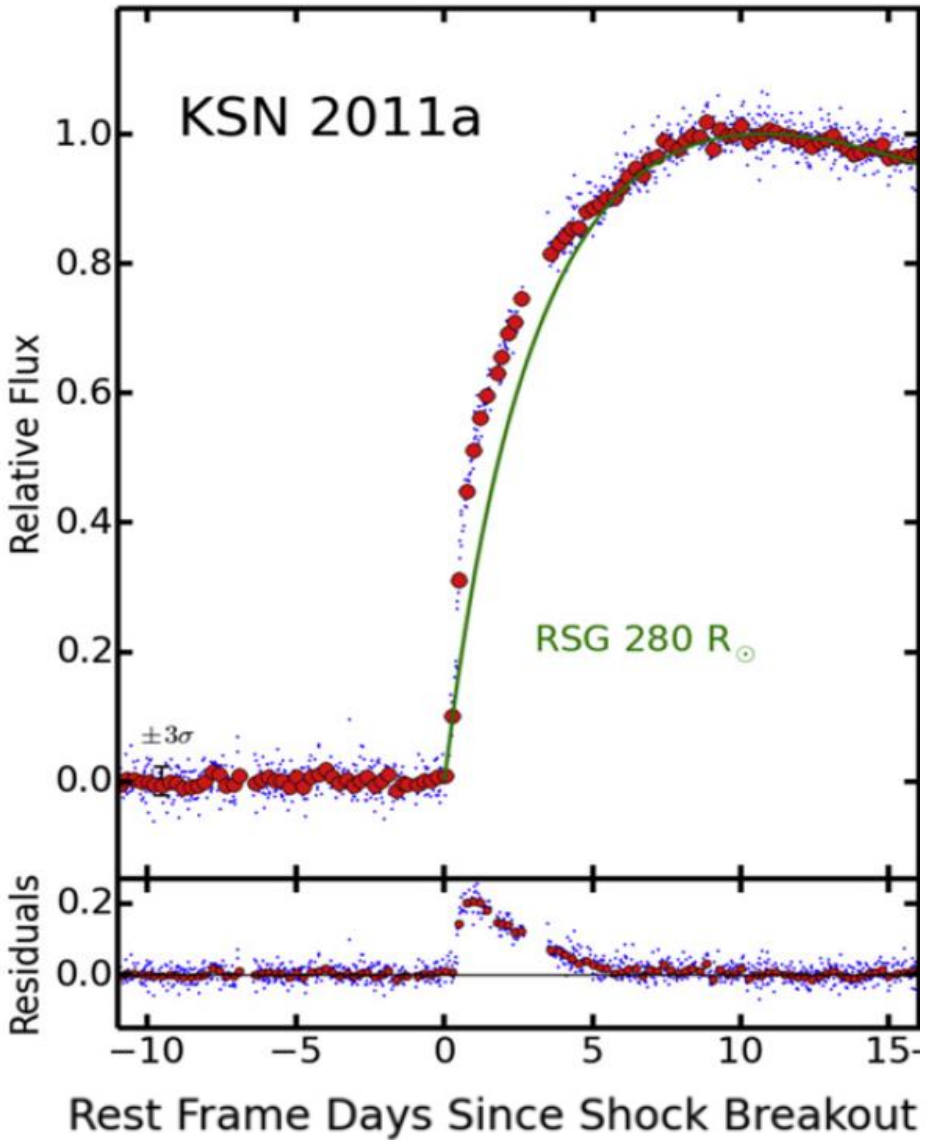
t_{rise}: 13.3 +- 0.4days

E=2x10^{51}ergs

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

Garnavich + 2016

No shock breakout of Kepler SN



Garnavich + 2016

t_{rise}: 10.5 +- 0.4days

$E=2 \times 10^{51}$ergs

$R=280\text{+-}20R_{\odot}$

However,

no filter observation

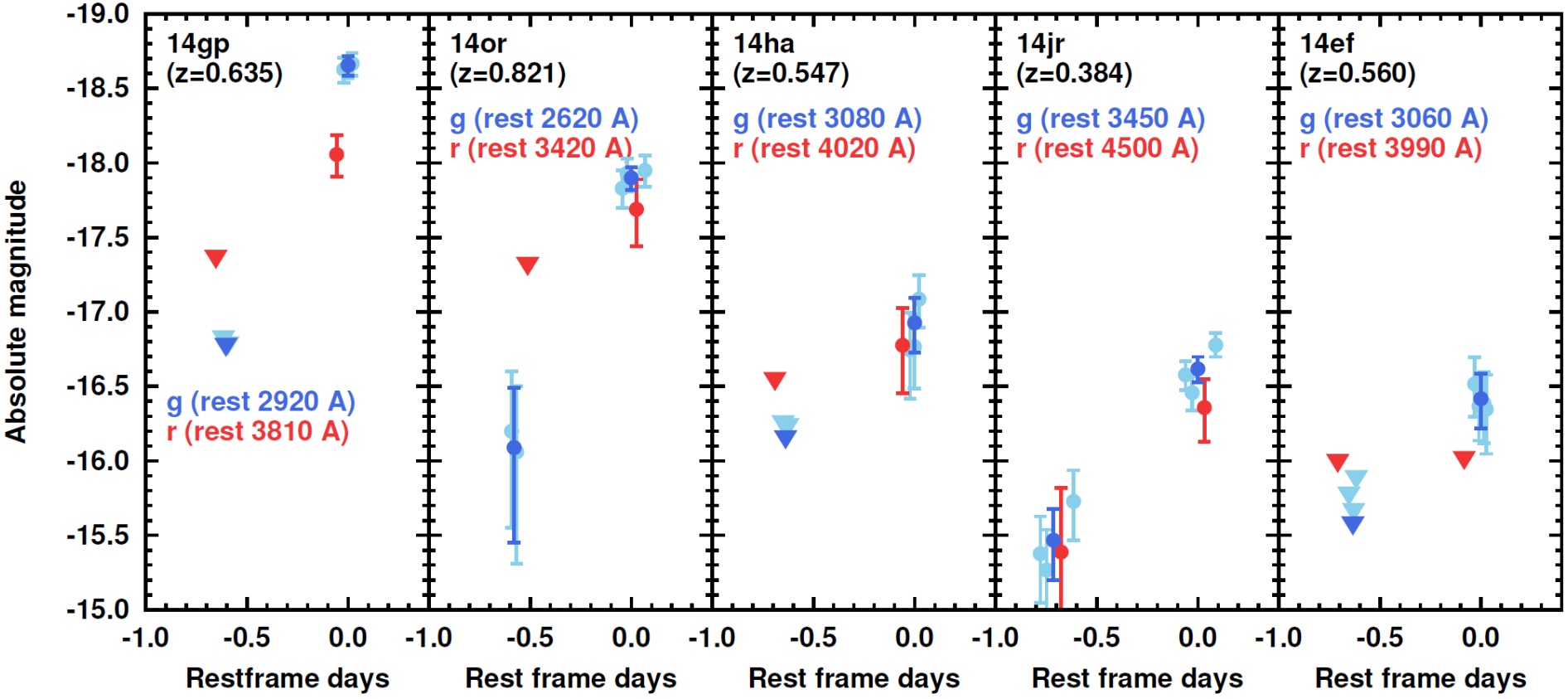
no follow-up observation

no spectroscopy

Realtime transient finding

Prompt follow-up obs.

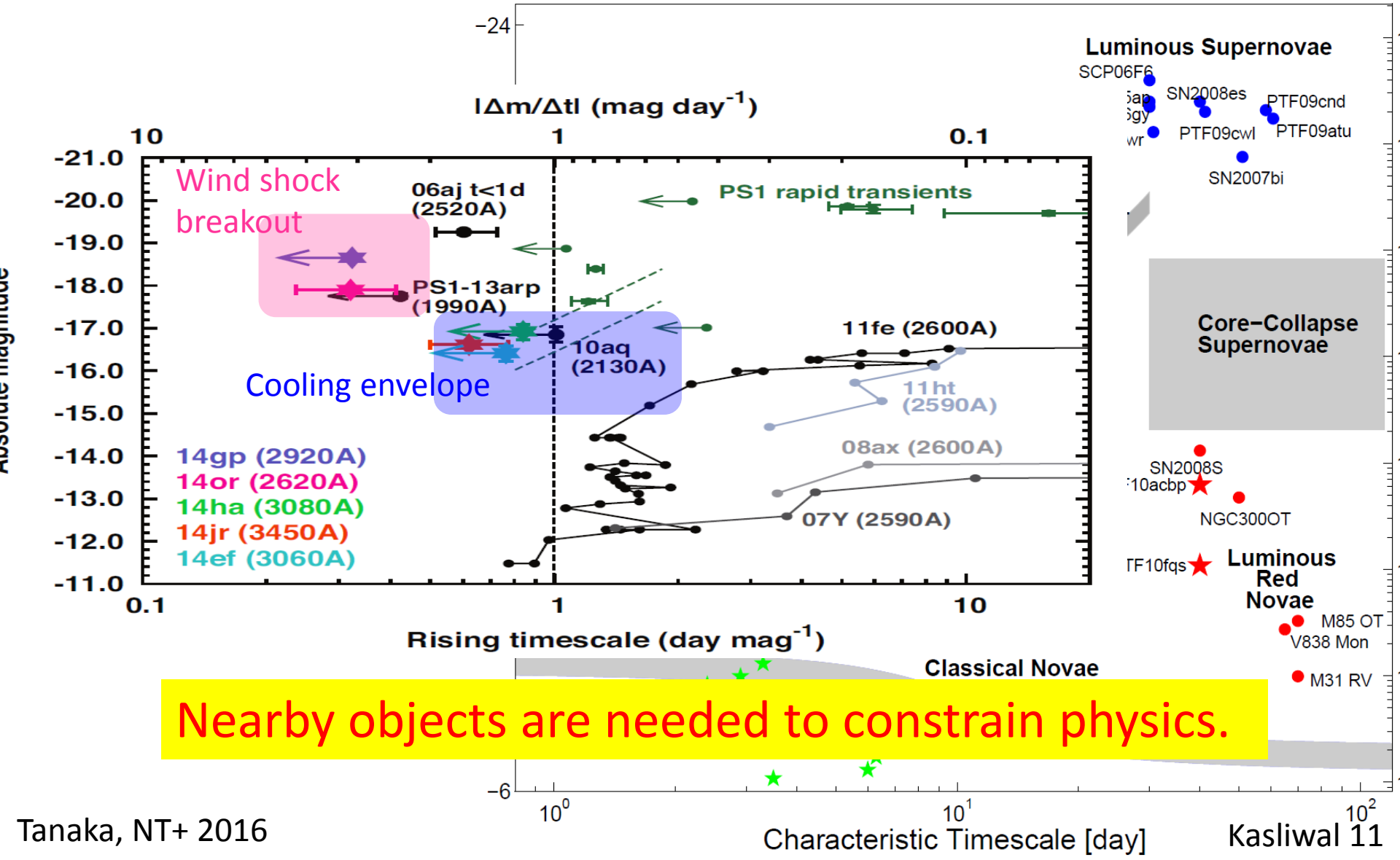
Rapidly rising transients with HSC



>9% of CCSNe could have rapid rise.

Tanaka, NT, + 2016

High-cadence surveys open up a new frontier

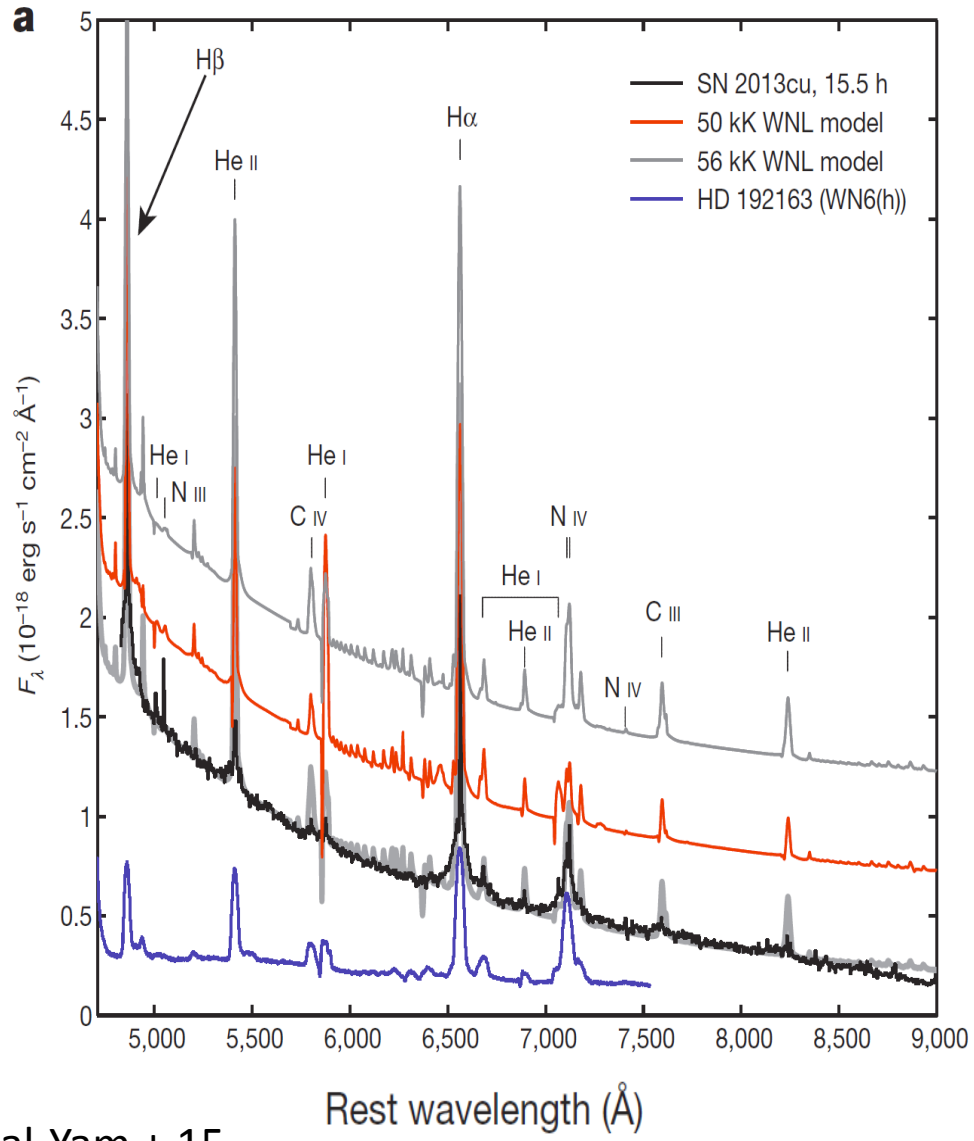


Nearby objects are needed to constrain physics.

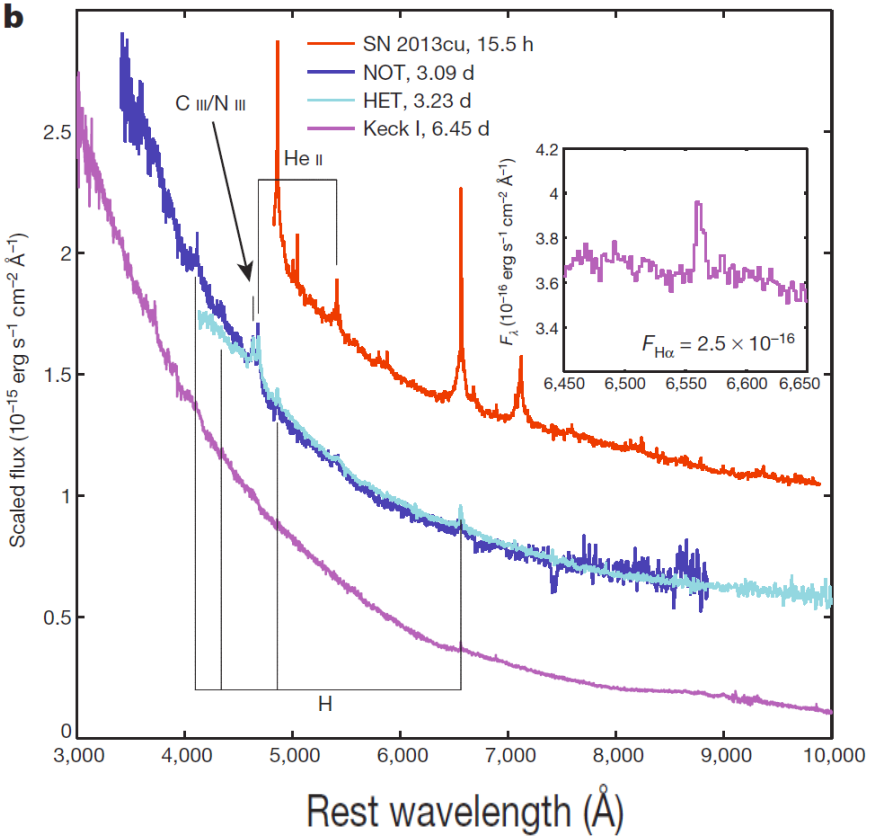
Tanaka, NT+ 2016

Kasliwal 11

Flash spectroscopy

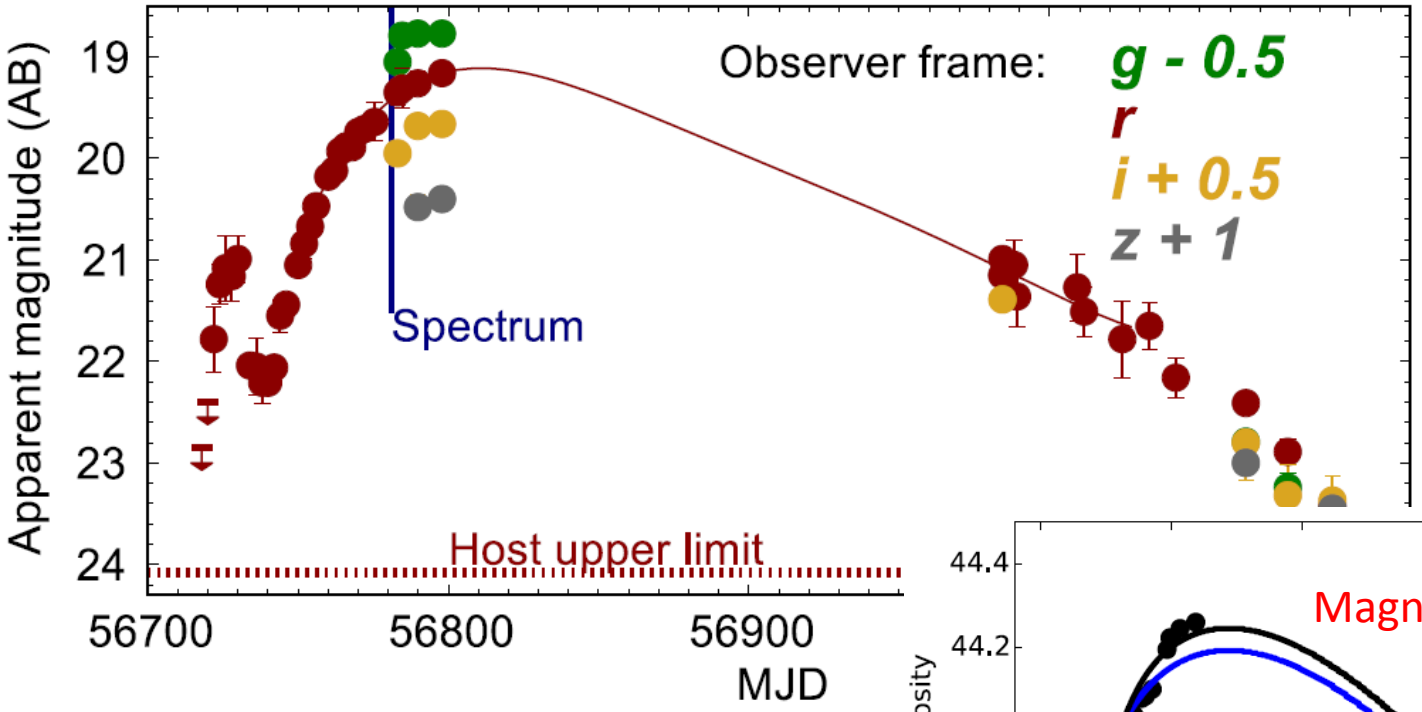


A spectrum of Wolf-Rayet star wind is found in a spectrum of Type IIb SN 2013cu at 15.5hr.

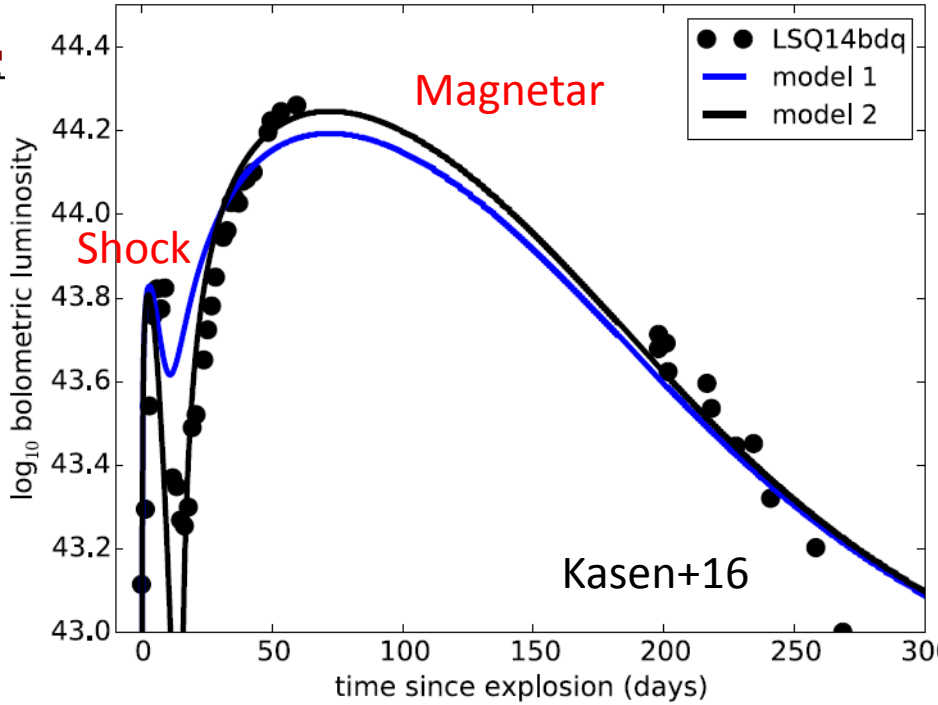


Gal-Yam + 15

Early bump in SLSN



Magnetar model with inefficient thermalization?
Cooling envelope?



Nicholl + 15

High-cadence SN survey

- Example of survey strategy
  - Area: 3000deg^2
  - Limiting magnitude

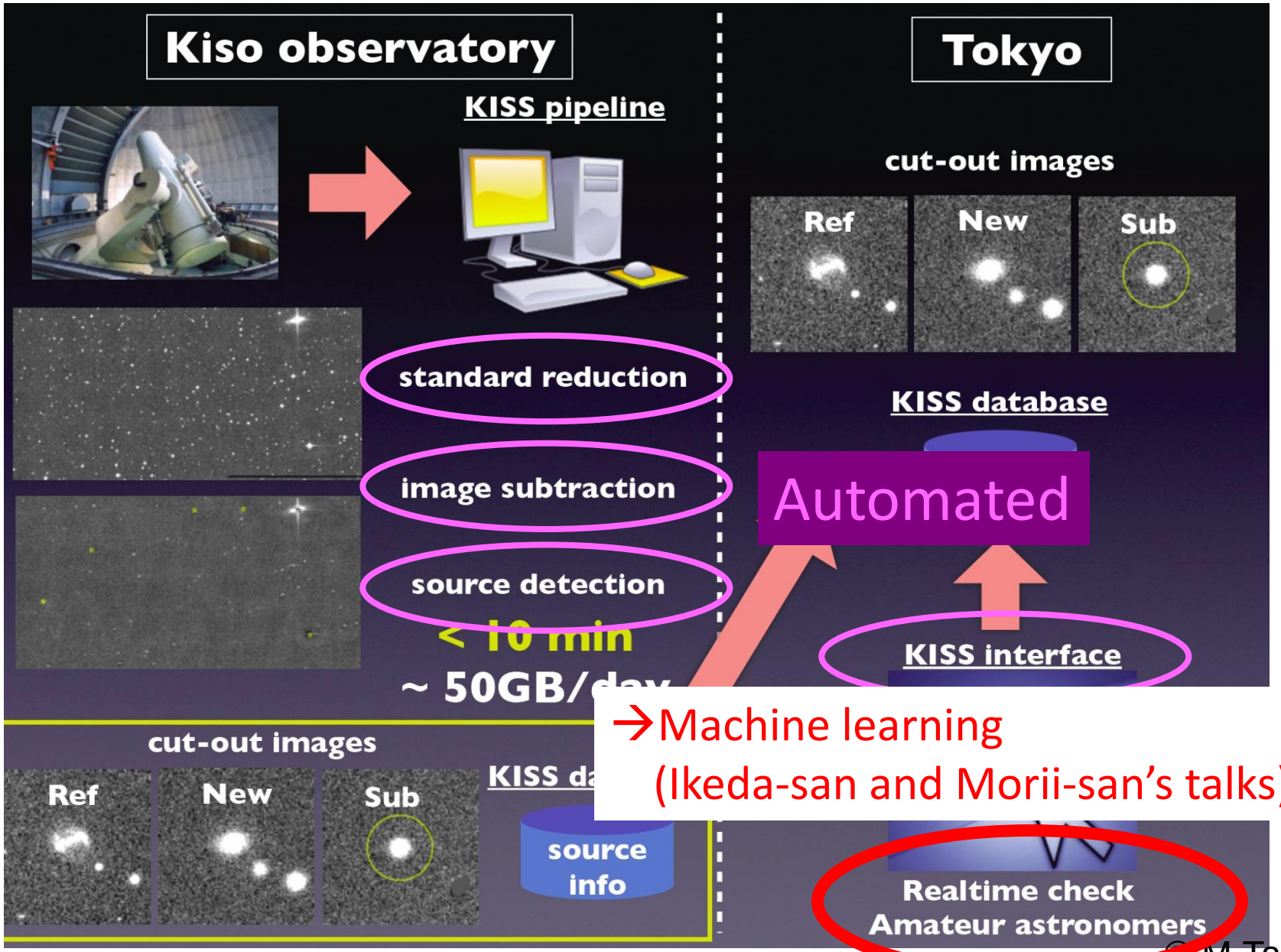
    18mag (3sec exposure, 30min cadence)

    → 10 shock breakouts (50 early SNe)

    20mag (100sec exposure, 1day cadence)

    → 60 nearby superluminous supernovae
- Realtime transient finding
- Prompt follow-up observations

KISS system

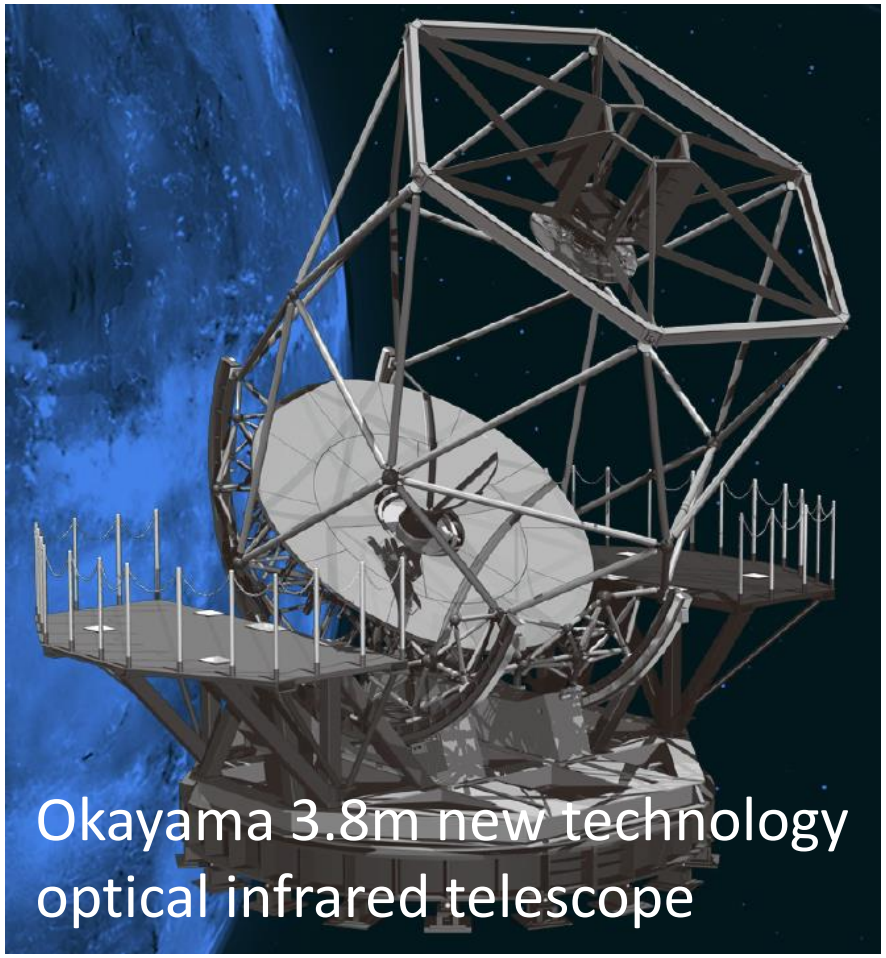


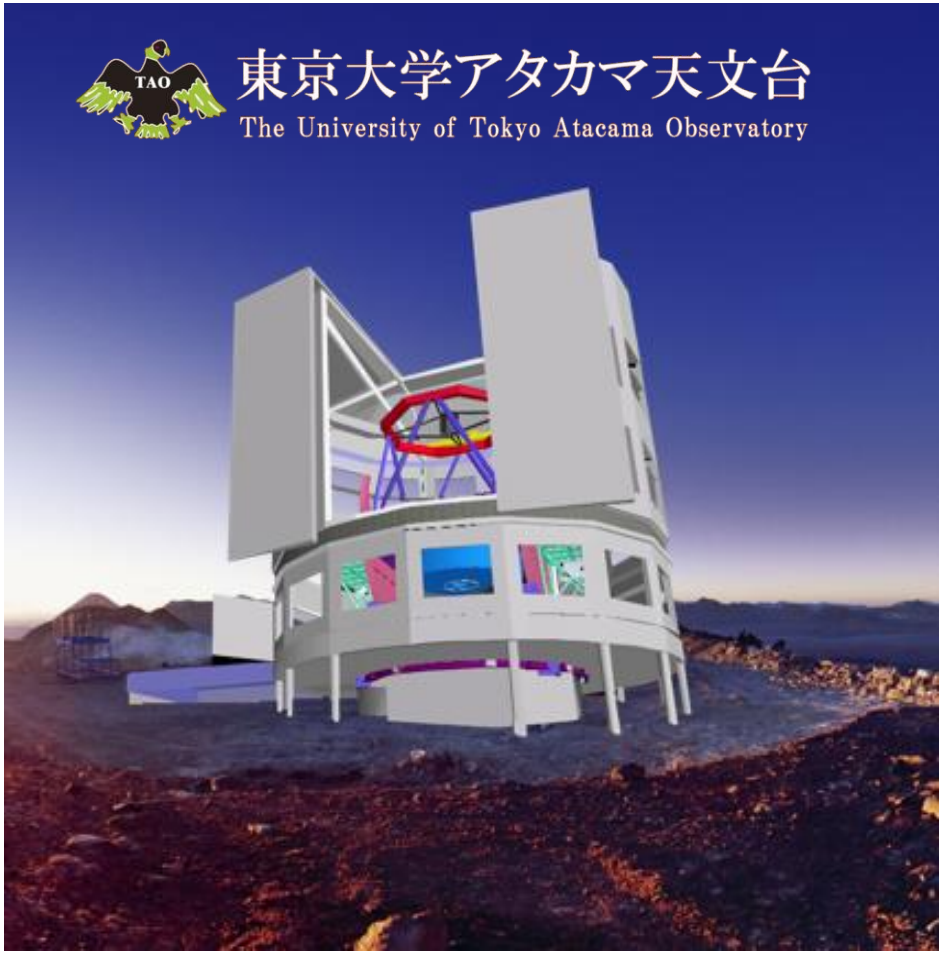
→Machine learning
(Ikeda-san and Morii-san's talks)

KISS collaboration for follow-up obs.

- Japan/Taiwan team
  - Kanata(1.5m)/HOWPol, MITSuME(0.5m), Lulin(1m)
- Rochester Institute of Technology (KPNO 0.9-m)
  - Michael W. Richmond
- Indian Institute of Astrophysics (HCT)
  - Devendra Sahu
- Carnegie Supernova Project (CSP; NOT)
  - Eric Hsiao, Maximilian Stritzinger, Mark Phillips, Nidia Contreras, Francesco Taddia Morrell, Carlos Contreras
- Telescopio Nazionale Galileo (TNG/DOLORES; 3.5m)
  - Paolo Mazzali, Emma Walker, Elena Pian
- SNFactory (UH88/SNIFT)
  - Greg Aldering
- Sternberg Astronomical Institute (Crimea, Moscow)
  - Dmitry Tsvetkov, Nikolay Pavlyuk

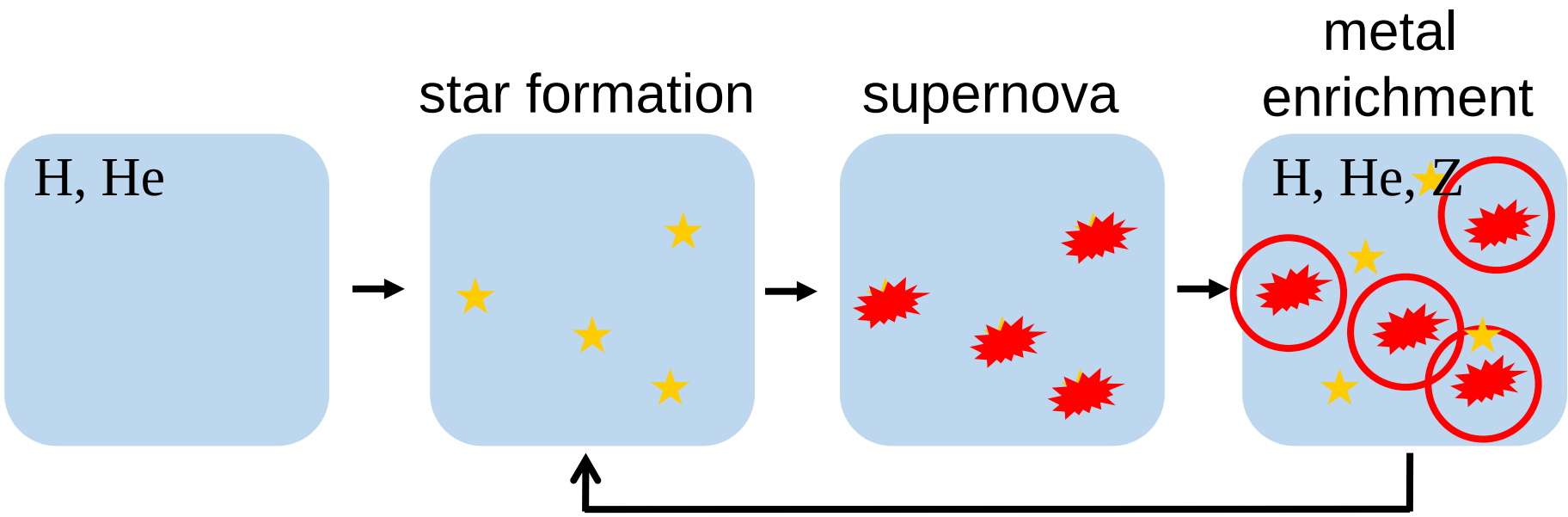
New telescopes for follow-up obs.





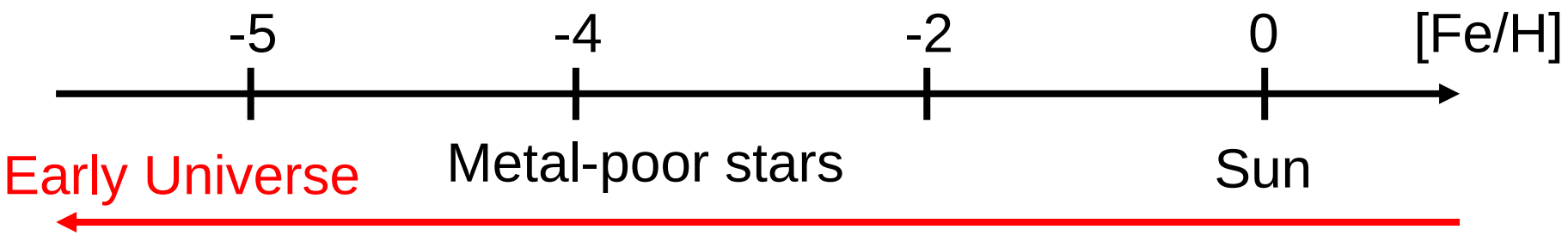
おまけ
All-sky bright metal-poor star survey

Metal-poor stars

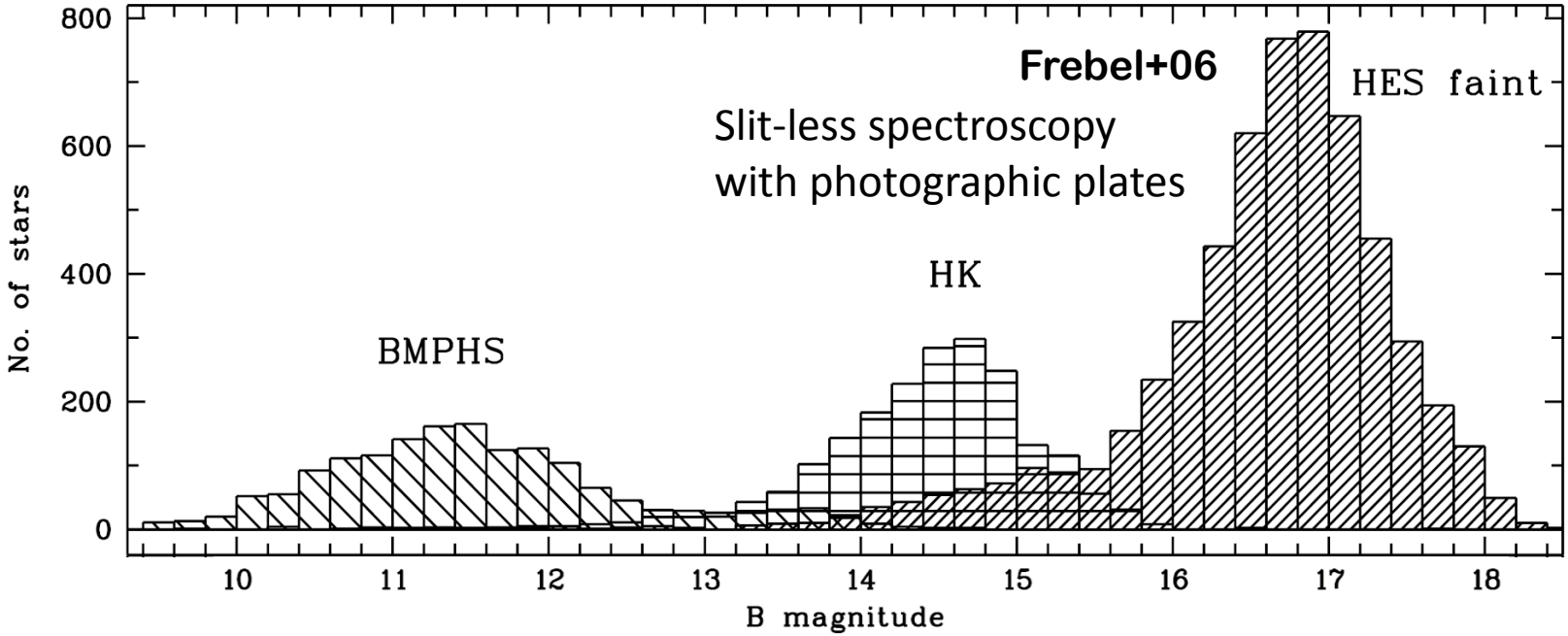


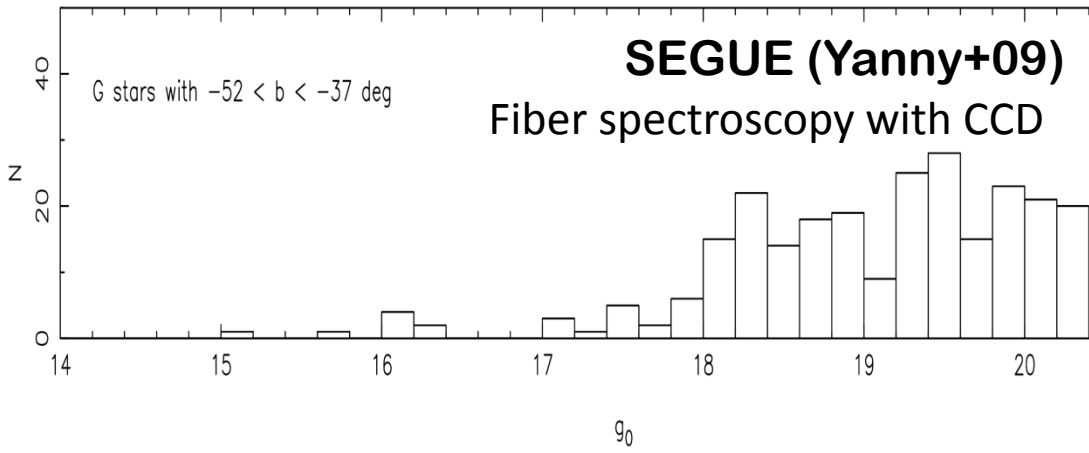
Metallicity increases with time

$[Fe/H] = \log(Fe/H) - \log(Fe/H)_{\odot}$

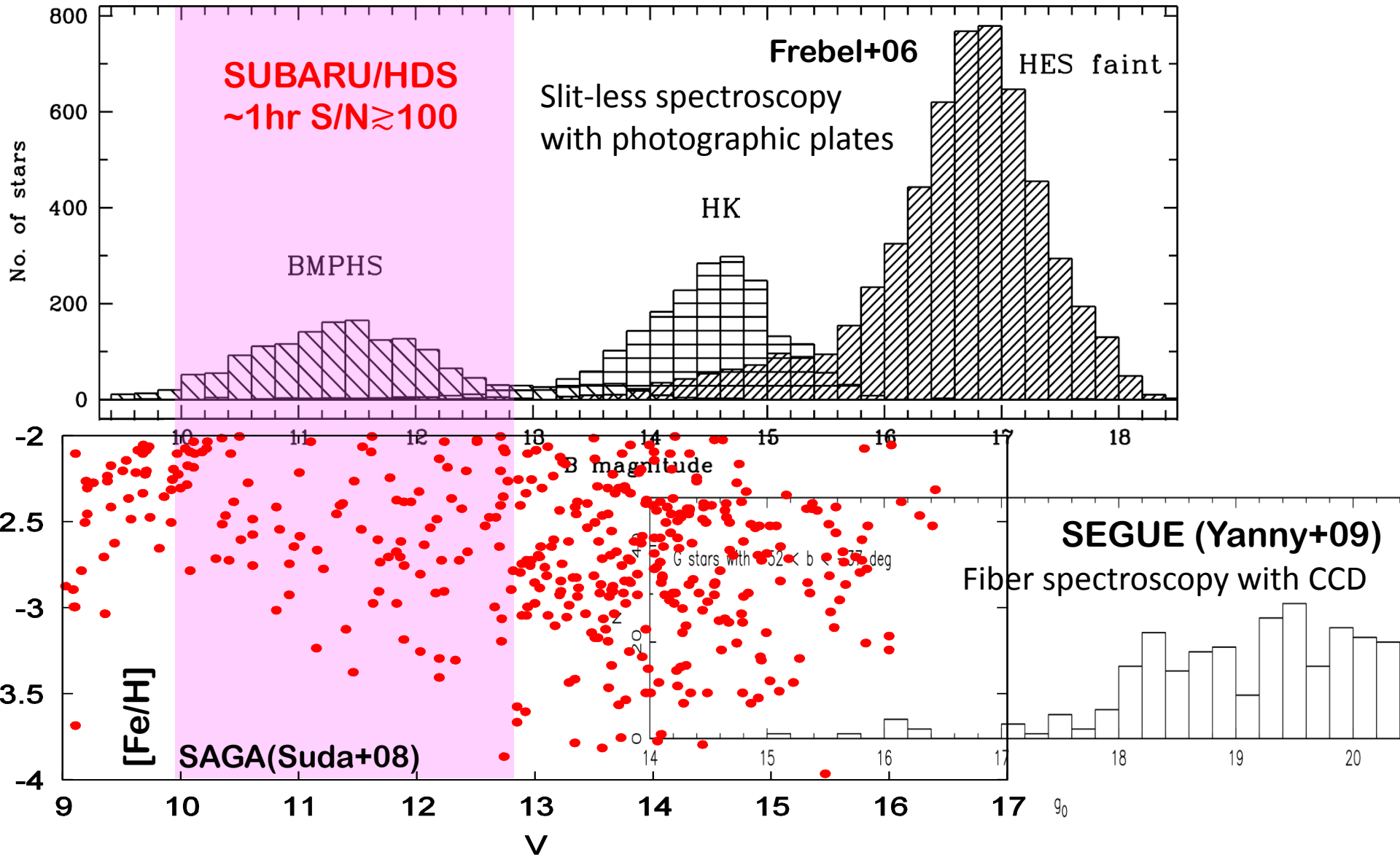


Past surveys





Past surveys



Bright metal-poor stars remain

The Astrophysical Journal, 698:L37–L41, 2009 June 10 doi:10.1088/0004-637X/698/1/L37

2009

BD+44°493: A NINTH MAGNITUDE MESSENGER FROM THE EARLY UNIVERSE; CARBON ENHANCED AND BERYLLIUM POOR*

Hiroko Ito[1,2], Wako Aoki[1,2], Satoshi Honda[3], and Timothy C. Beers[4]

The Astrophysical Journal, 773:33 (17pp), 2013 August 10 doi:10.1088/0004-637X/773/1/33

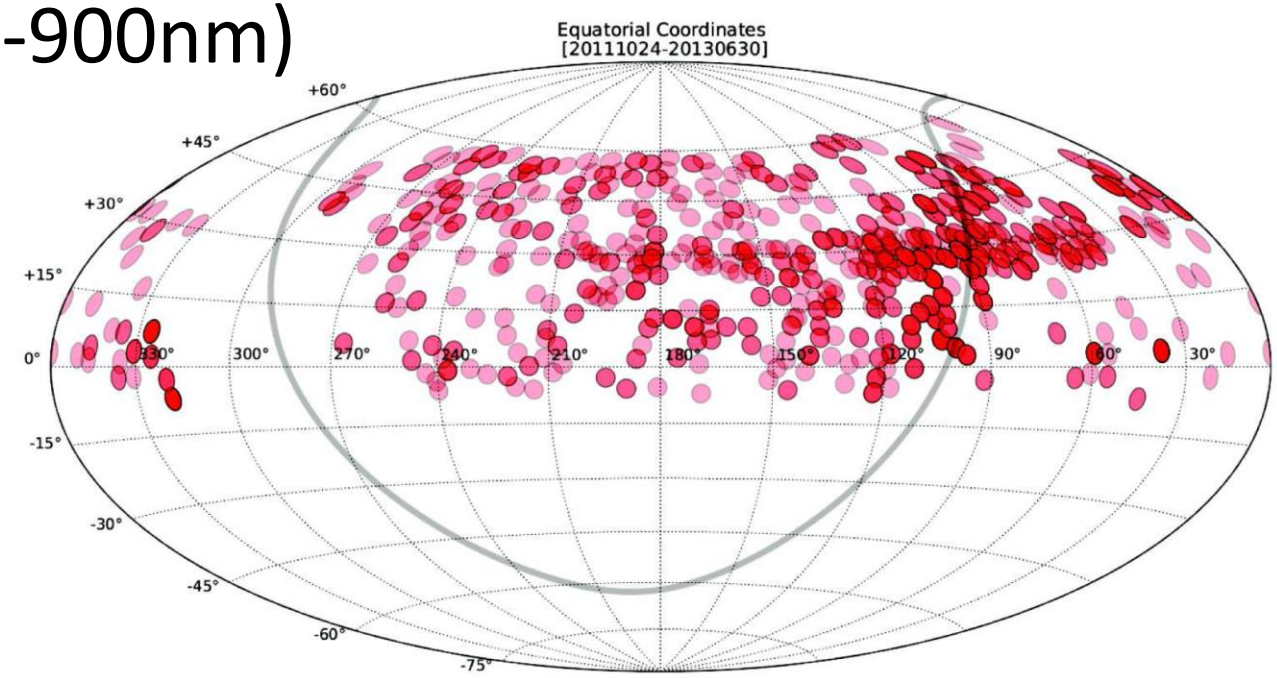
CHEMICAL ANALYSIS OF THE NINTH MAGNITUDE CARBON-ENHANCED METAL-POOR STAR BD+44°493*

Hiroko Ito[1,2], Wako Aoki[1,2], Timothy C. Beers[3,4], Nozomu Tominaga[5,6], Satoshi Honda[7], and Daniela Carollo[8,9]

- 9th magnitude star with [Fe/H] = -3.8 (BD+44°493)
- Upper limit on A(Be), depleted Li abundance
- The origin of BD+44°493 is a faint SN.

LAMOST survey since 2011

- V>12mag
- ~ 800 fibers/deg^2
  - Targets are randomly selected.
- R~1000 (365-900nm)

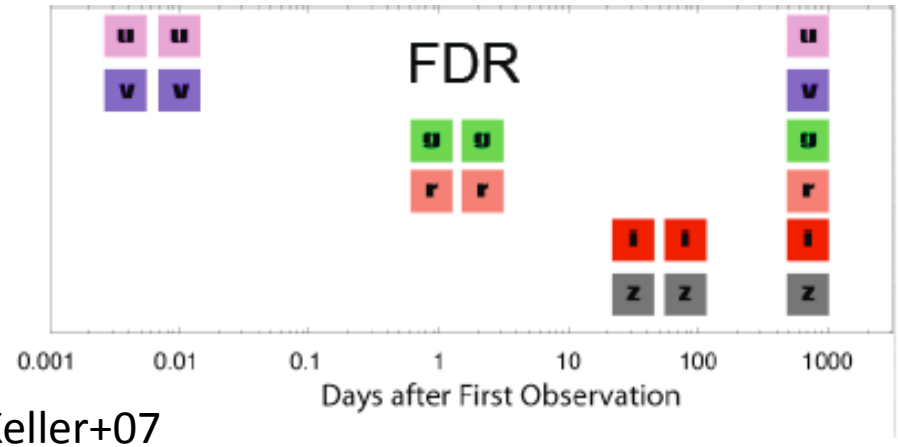


Luo + 15

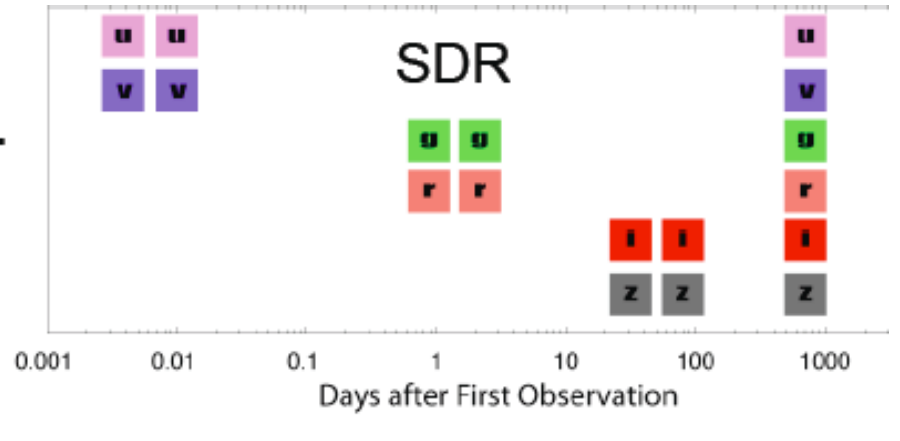
Skymapper survey since 2014

- All 20000 sq. degrees south of equator

	u	v	g	r	i	z
1 EPOCH	19.5	19.5	21.0	21.0	20.0	19.0
SATURATION	10.0	10.5	13.0	13.0	11.0	10.5
EXP. TIME (s)	100	100	100	100	100	100
FINAL DEPTH	20.5	20.5	21.7	21.7	20.7	19.7

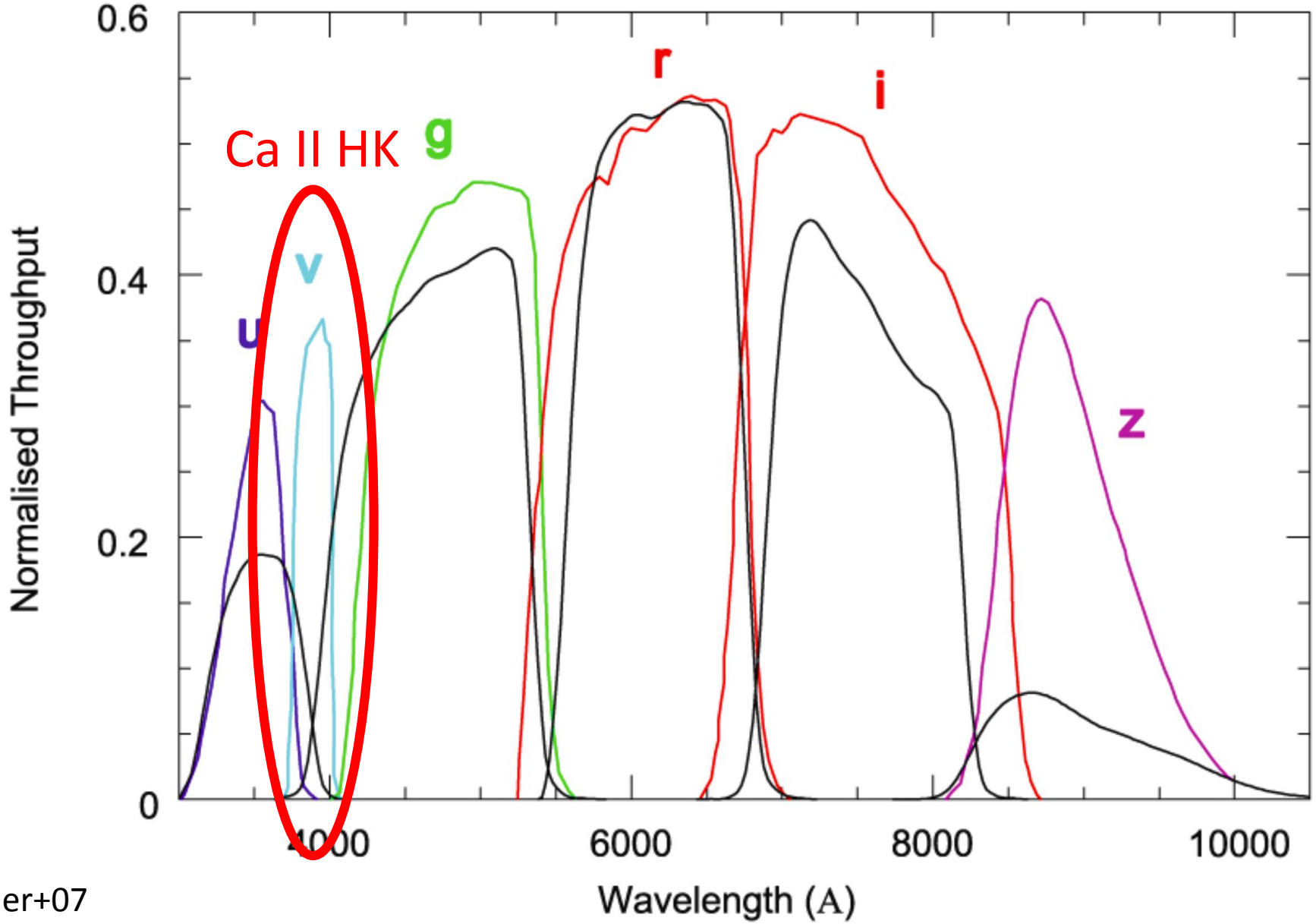


+



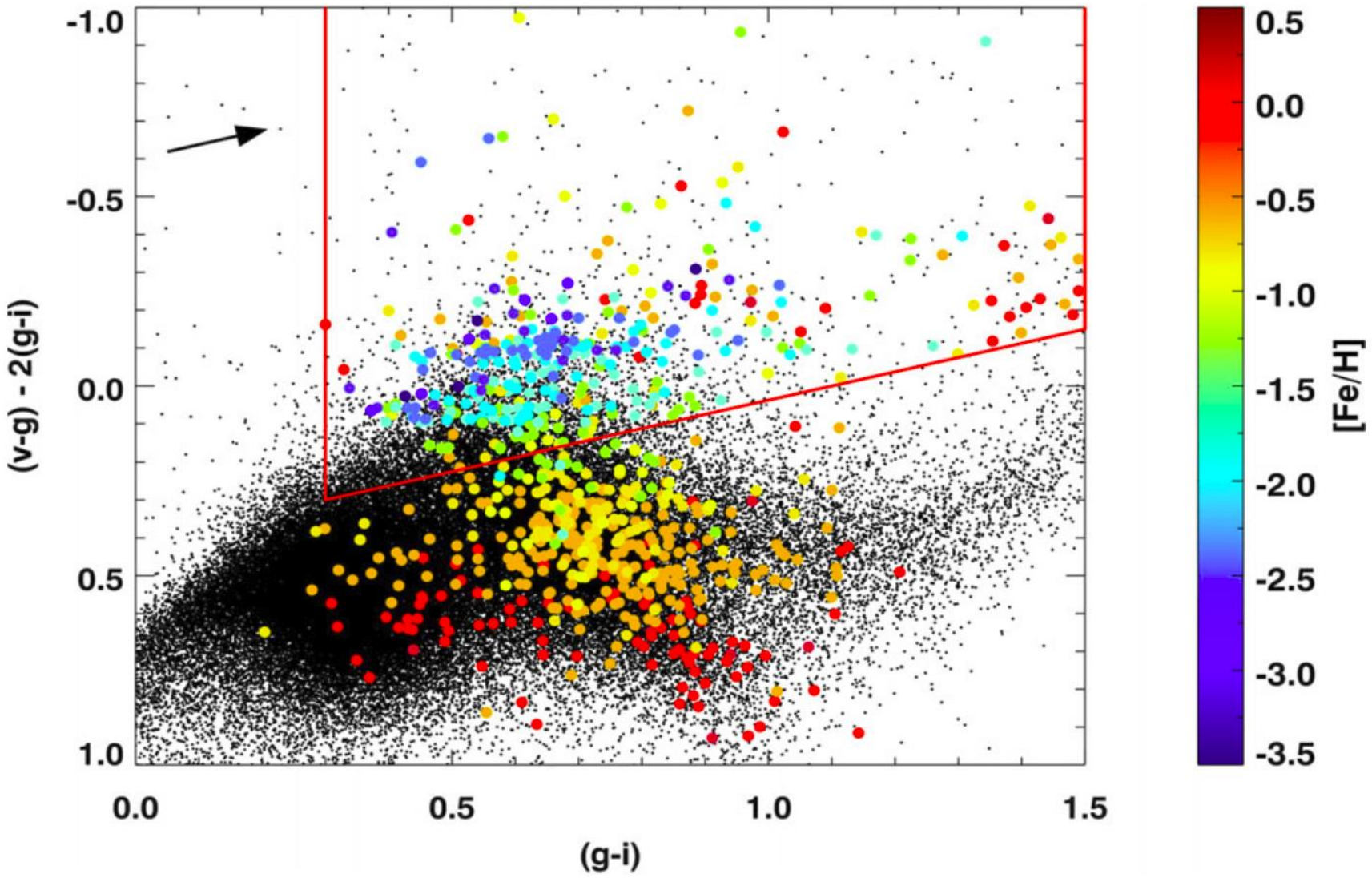
Keller+07

Filter system of skymapper



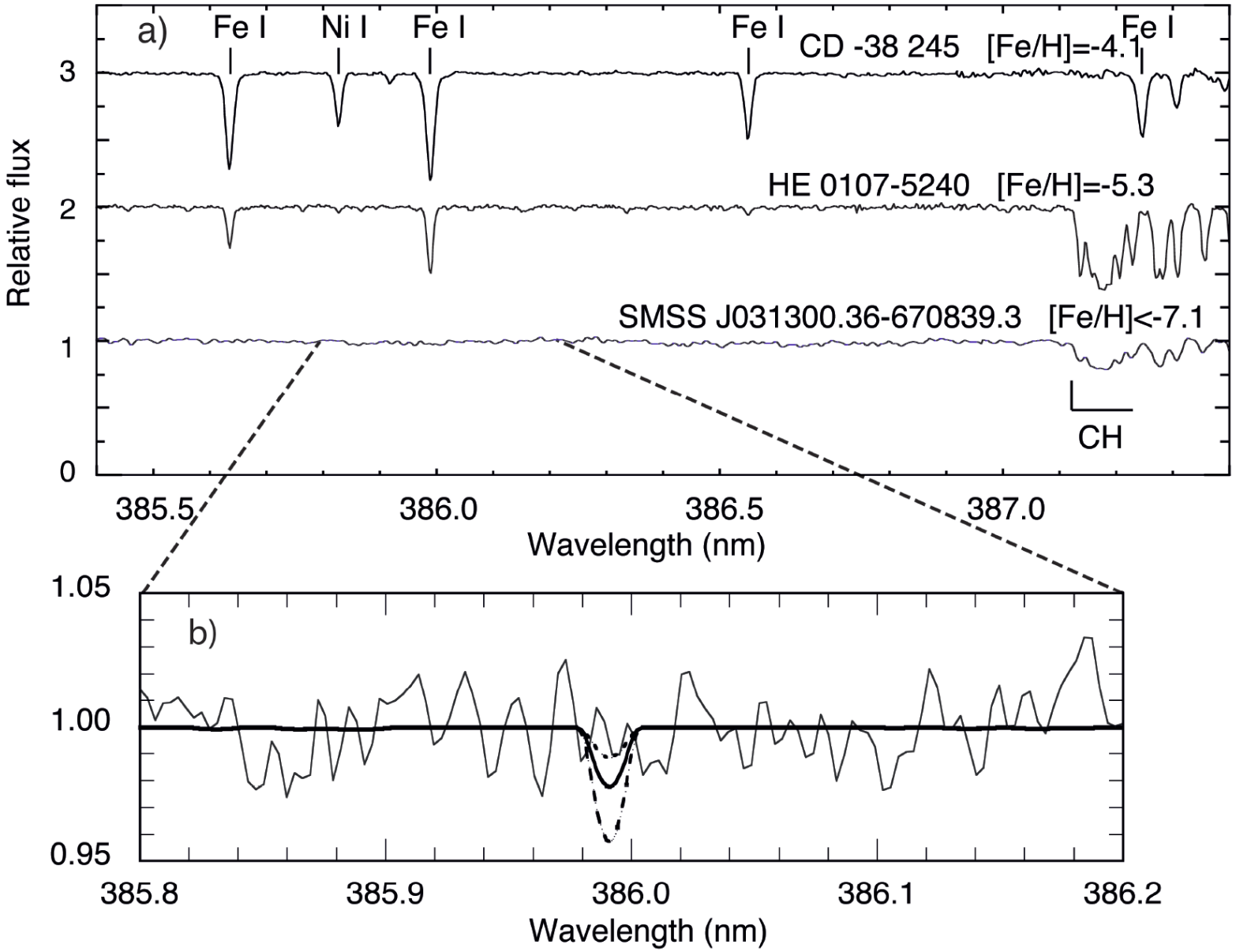
Keller+07

Metallicity vs. color

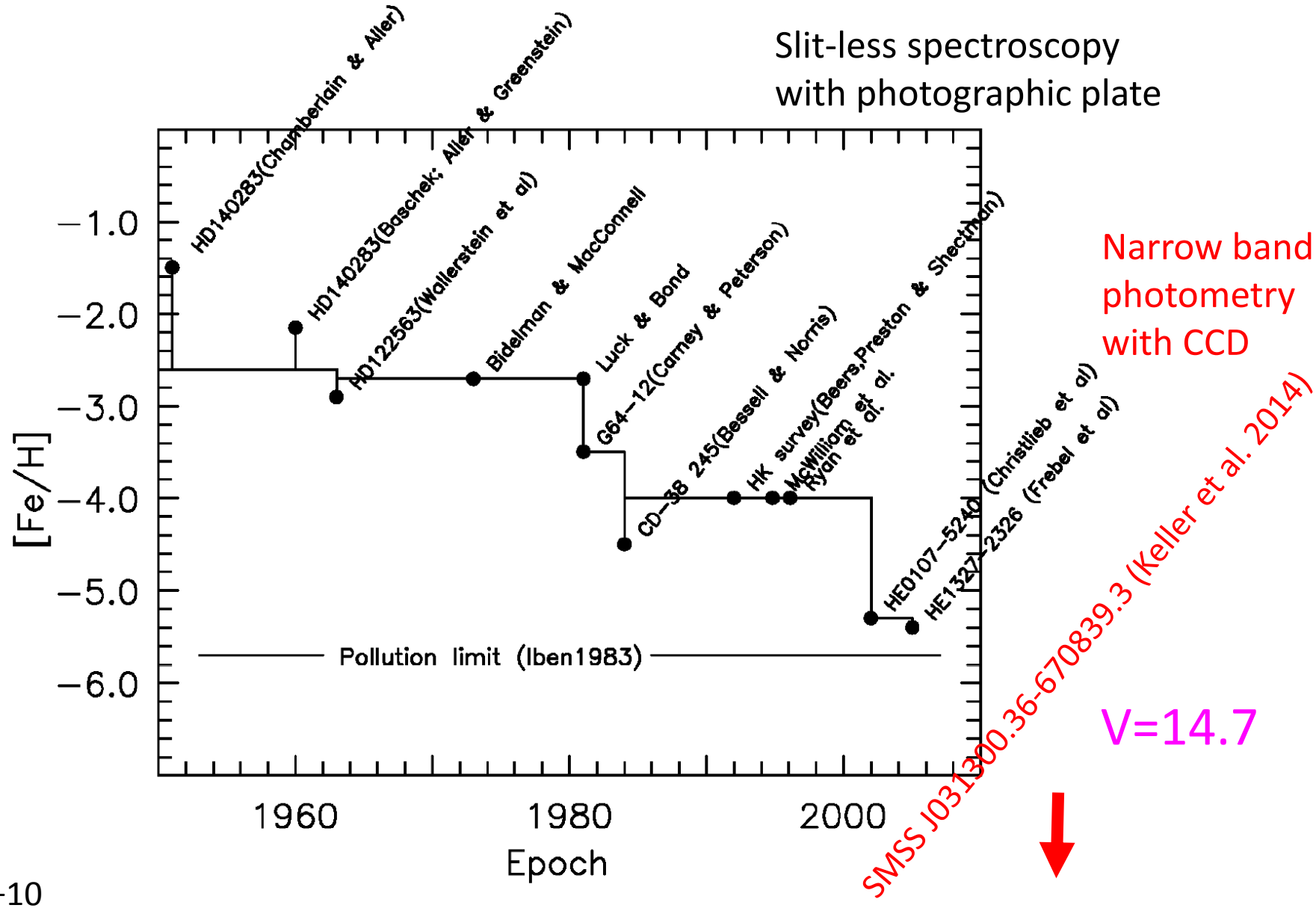


Howes+14

Metal-poor star with the lowest [Fe/H]



Record holders of low [Fe/H]



Yong+10

All-sky bright metal-poor star survey

- Filter: Strömgren v (390nm, [Fe/H]),
  Strömgren G (430nm, [C/Fe])
  with PS1 3π broad-band data
- Limiting magnitude and survey width:
  (no filter, 1night) 18mag 20000deg^2
  → (g/i, 1night) 16mag? 20000deg^2
  (v/G, 1night) 14mag? 20000deg^2
  Differences of band widths are taken into account.
- Area: 20000-30000deg^2
- More realistic estimate is needed.

Summary

- 甲南大実習
  - 今年度もよろしくおねがいします。
- High-cadence supernova survey
  - Filter: no filter / g and r on CMOS chips
  - Limiting magnitude: 18mag (3sec), 20mag (100sec)
  - Area: 3000deg^2
  - Cadence: 30min – 1 day
  - Realtime transient finding (w/ machine learning)
  - Prompt follow-up observation
- All-sky bright metal-poor star survey
  - Filter: Strömgren v, G
  - Limiting magnitude: 14mag? (v, G)
  - Area: 20000-30000deg^2
  - Cadence: no requirement