Tomo-e Gozen全天サーベイ計画と KOOLS-IFUでの即時追観測提案

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2017/2@京都

http://www.ioa.s.u-tokyo.ac.jp/~tmorokuma/research/WS/201702KOOLSTomoe/ProgramKOOLSTomoe201702.html

2017/7@木曽

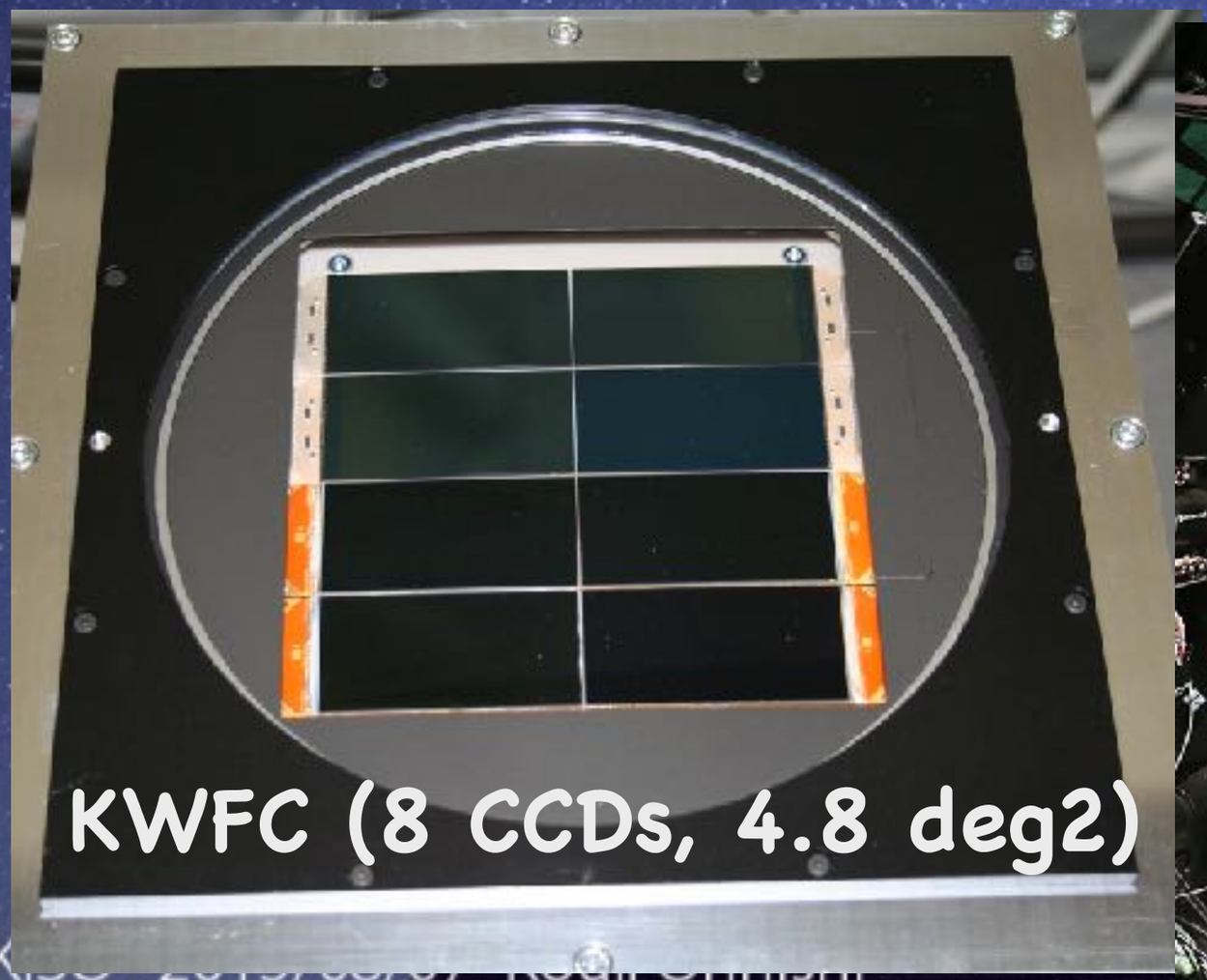
http://www.ioa.s.u-tokyo.ac.jp/kisohp/RESEARCH/symp2017/index.html

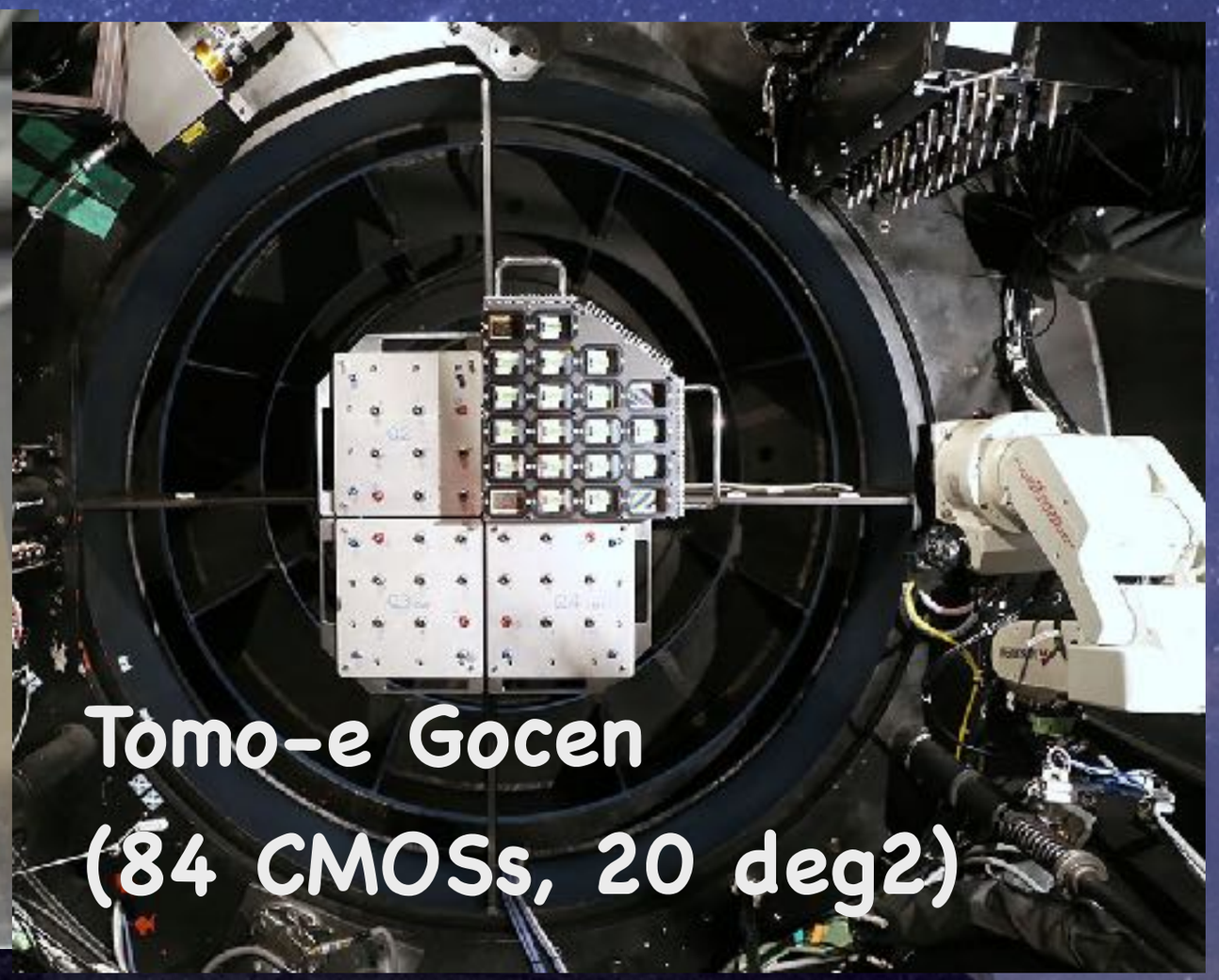
Contents

- What are Kiso Schmidt telescope & Tomo-e Gozen?
- Supernova Shock Breakout / Rapid Transient
- Tomo-e Gozen All-Sky Survey
- Follow-Up Observations w/ KOOLS-IFU
- Summary

Kiso Observatory (The University of Tokyo)

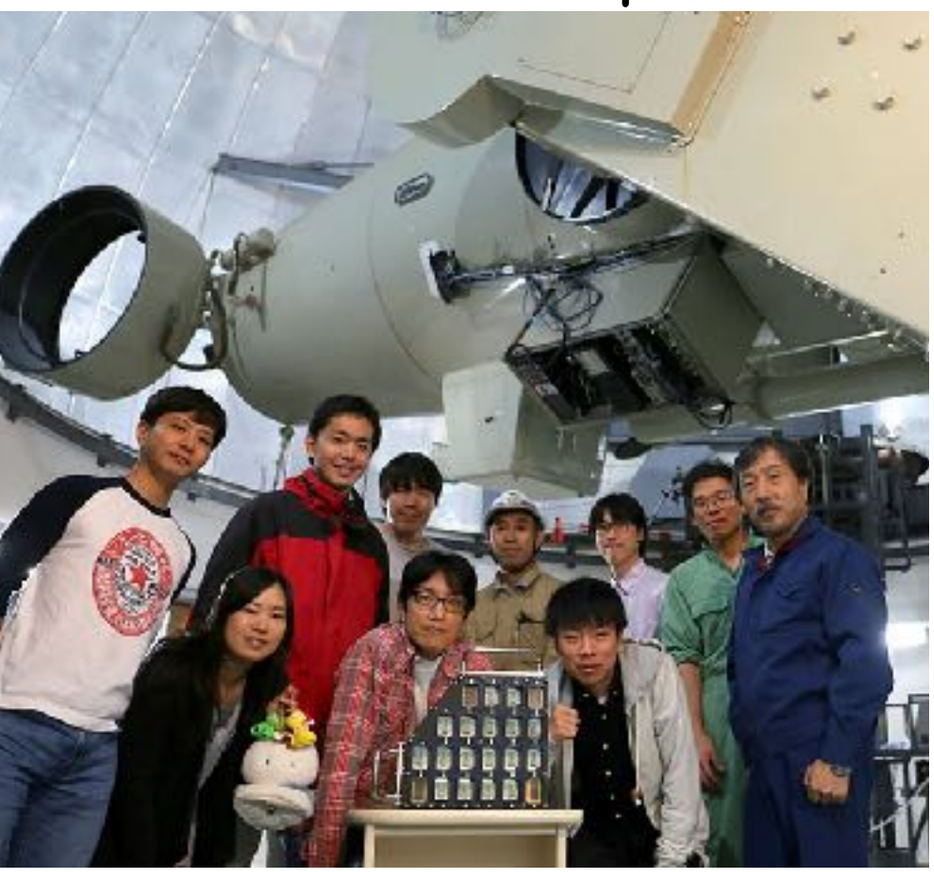
- 105cm Kiso Schmidt telescope (4th largest Schmidt)
- operated since 1974
- open-use until March 2017
- instruments
  - 2012-2018: Kiso Wide Field Camera (KWFC, 8 CCDs, 4.8 deg2)
  - 2018-: Tomo-e Gozen (84 CMOS sensors, 20 deg2)





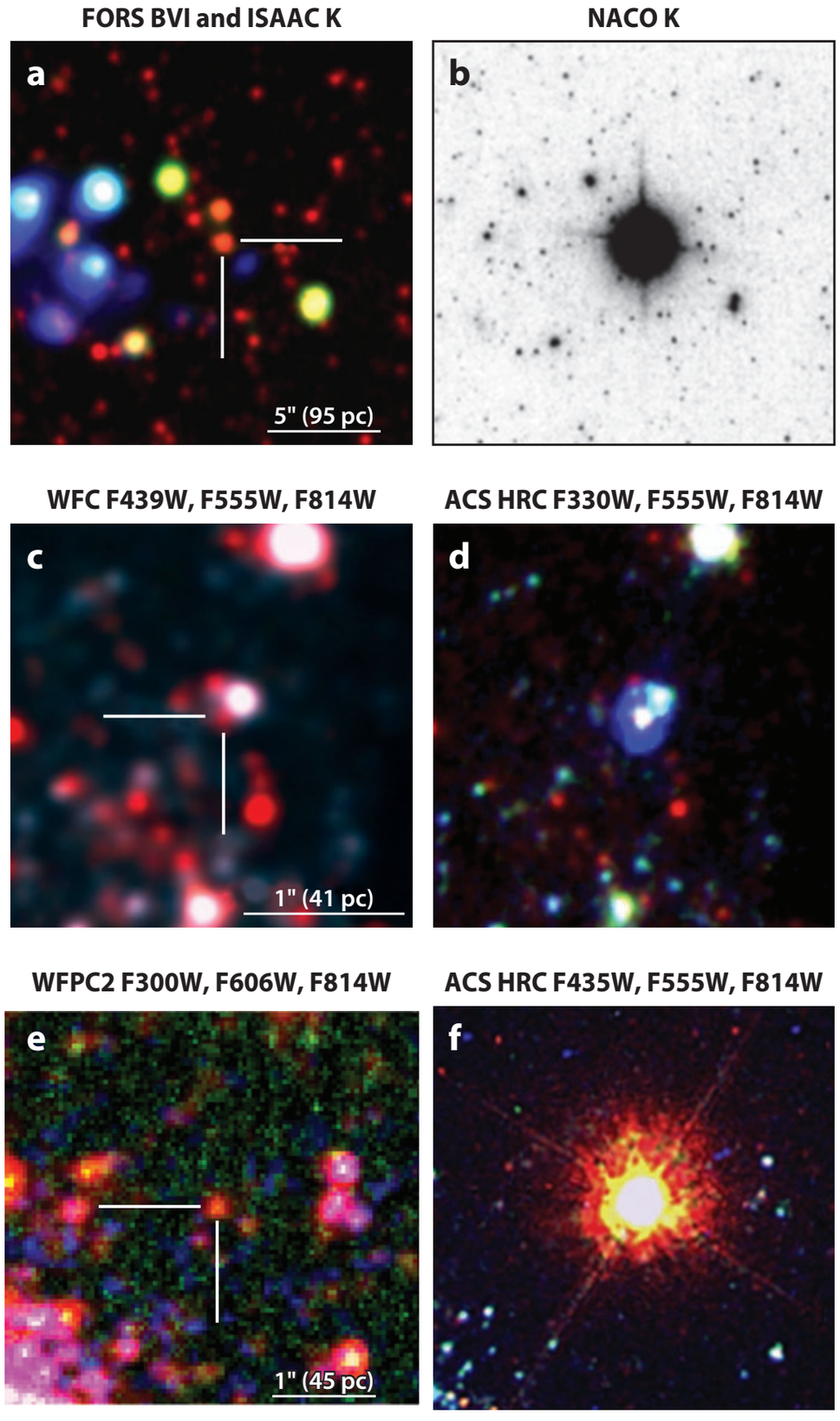
Tomo-e Gozen (巴御前)

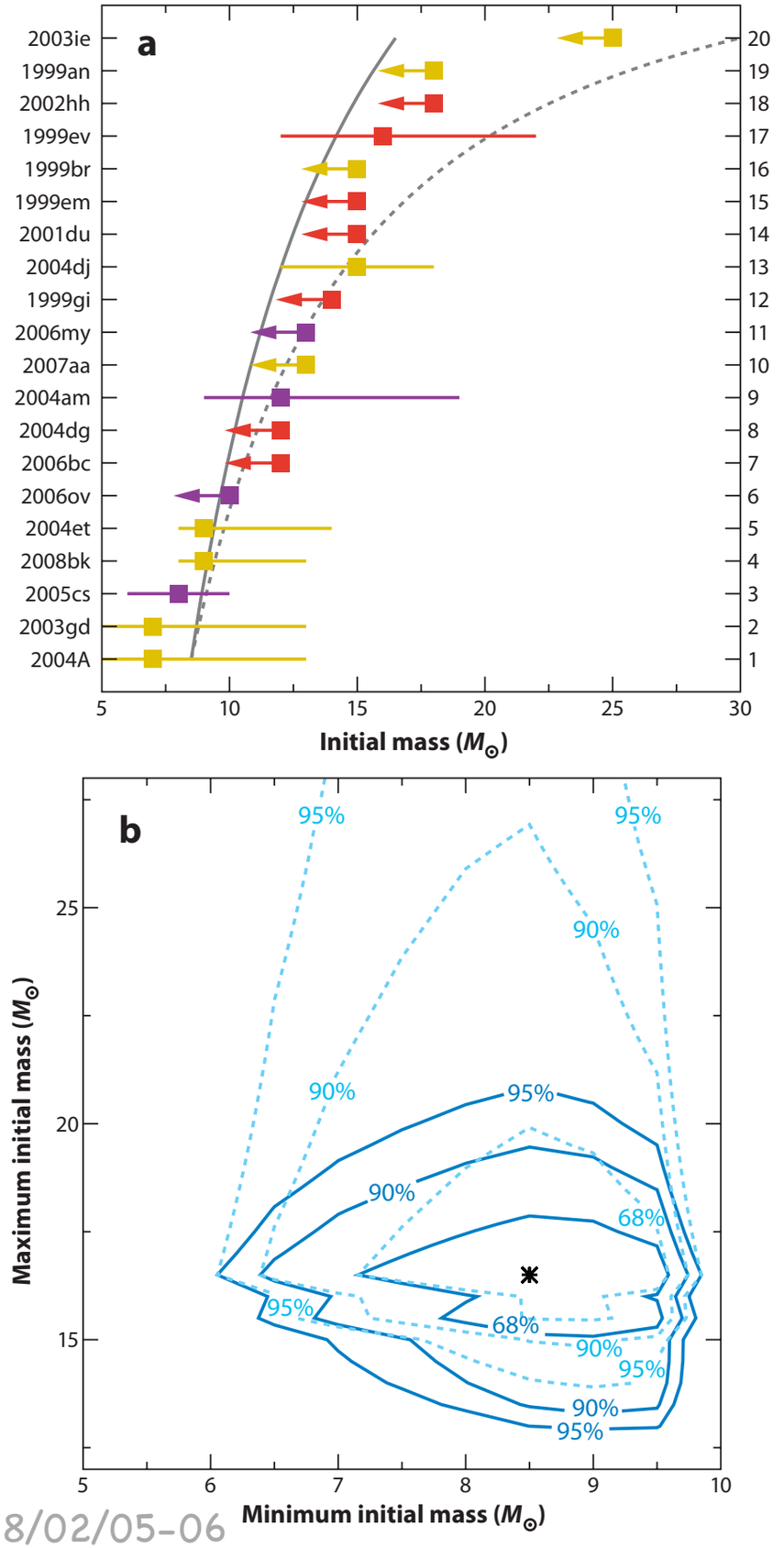
- 84 (=21x4) CMOS sensors
- 20 deg2 (9 deg diameter)
- 2 Hz(-200 Hz) readout
- 30 TB / night
- seconds-hours scale transients
- Sako+2016, Ohsawa+2016, Morii+2017
  - Osawa-kun's talk
- completed early 2019
  - "Q1" (21 chips) from mid-Feb/2018



http://www.ioa.s.u-tokyo.ac.jp/kisohp/NEWS/tomoe_q0_firstlight.html

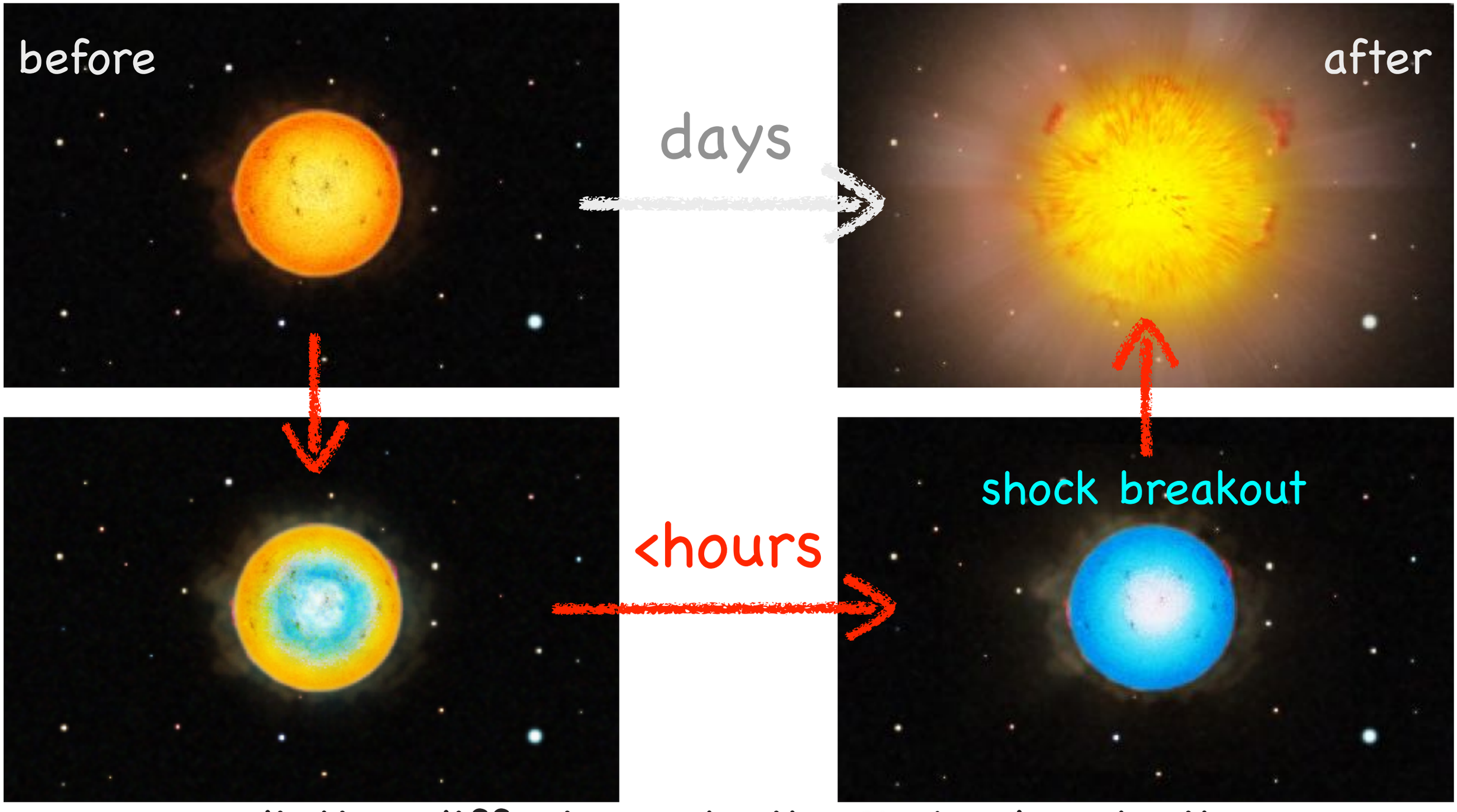
Progenitors of Core-Collapse Supernovae



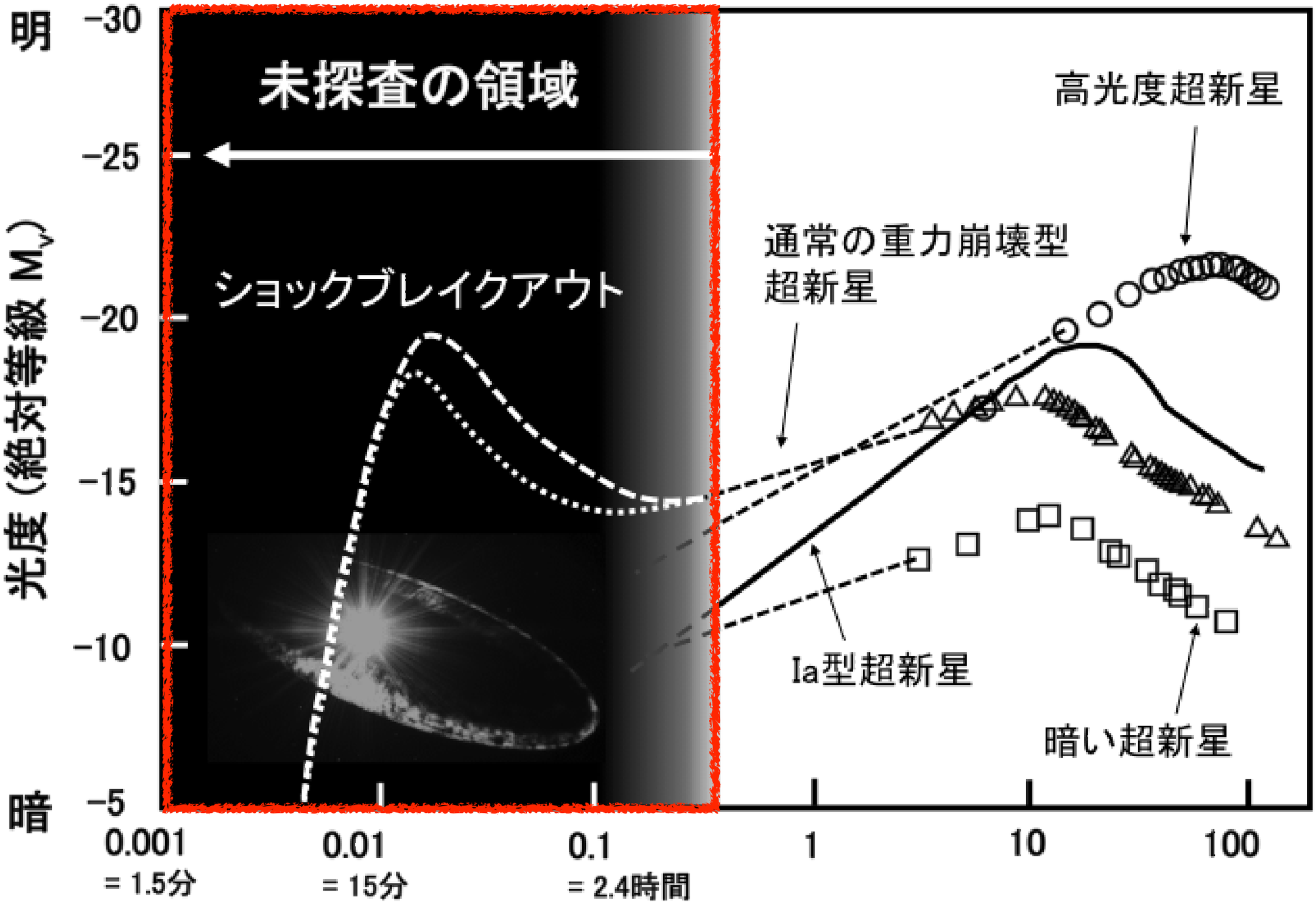


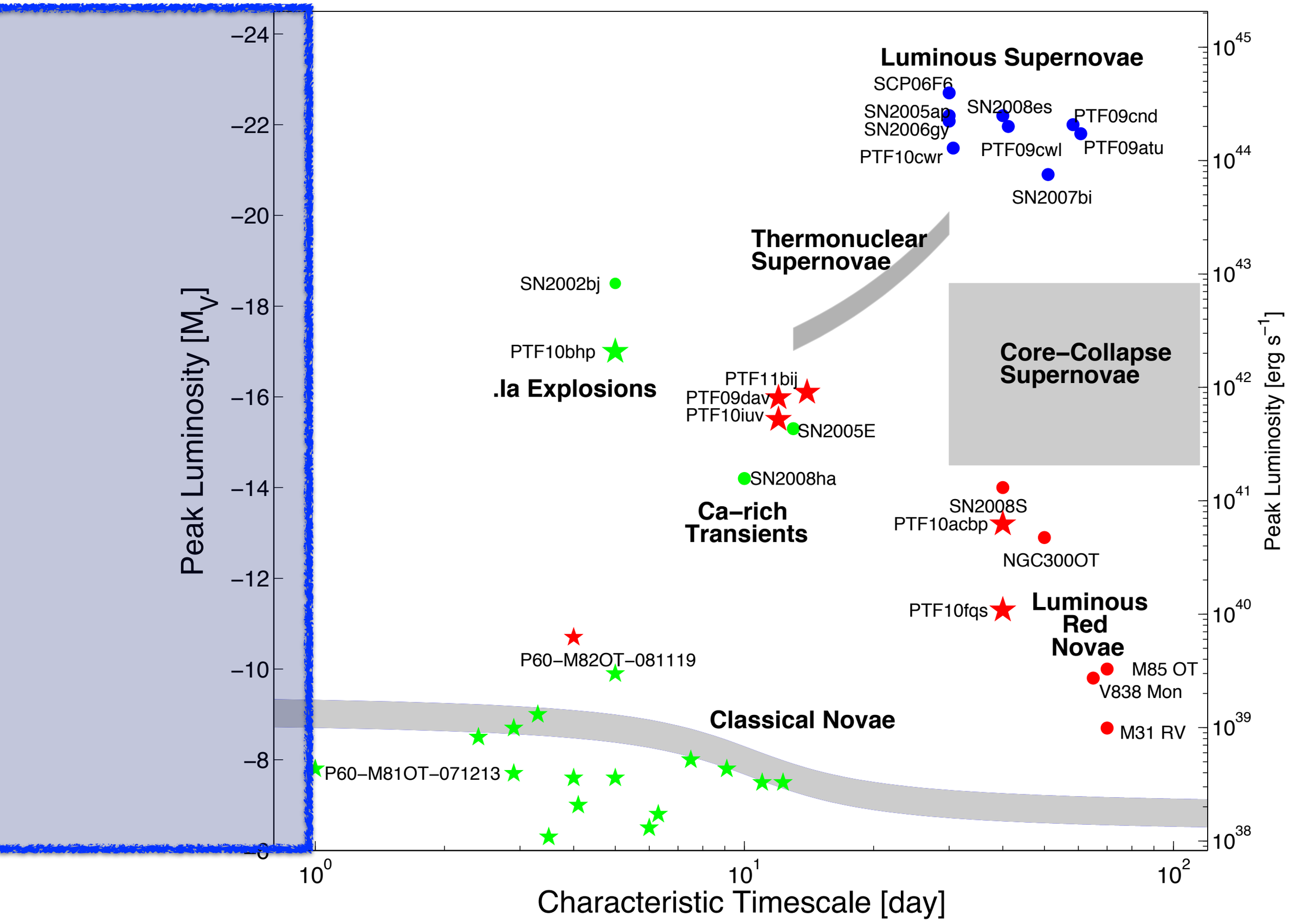
"Moment" of Supernova Explosion

Shock Breakout

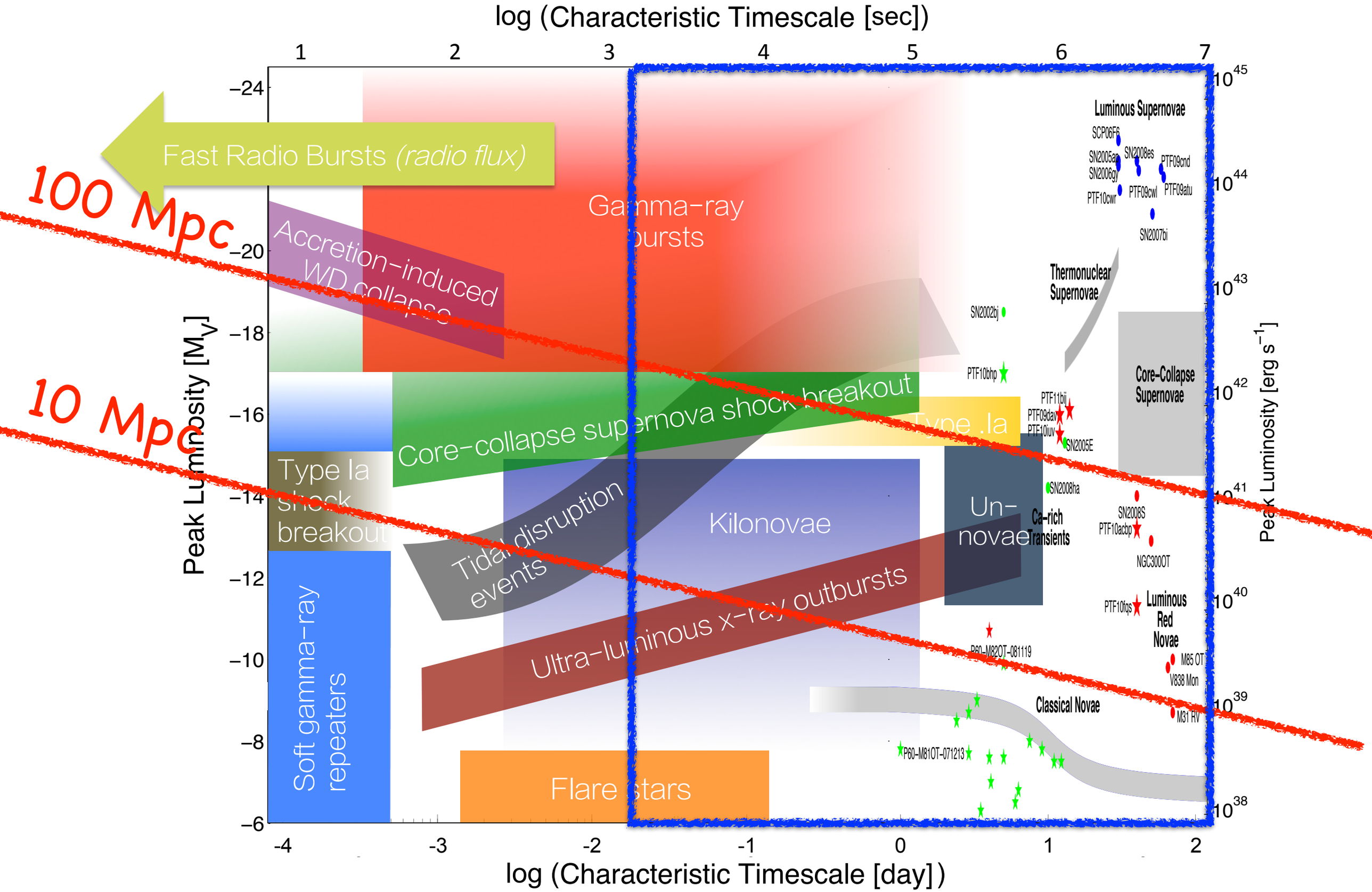


radiation diffusion velocity ~ shock velocity


未探査の領域
ショックブレイクアウト
高光度超新星
通常の重力崩壊型
超新星
Ia型超新星
暗い超新星
明
暗
−30
−25
−20
−15
−10
−5
光度（絶対等級 M_V）
0.001
= 1.5分
0.01
= 15分
0.1
= 2.4時間
1
10
100
変動の時間スケール（日）



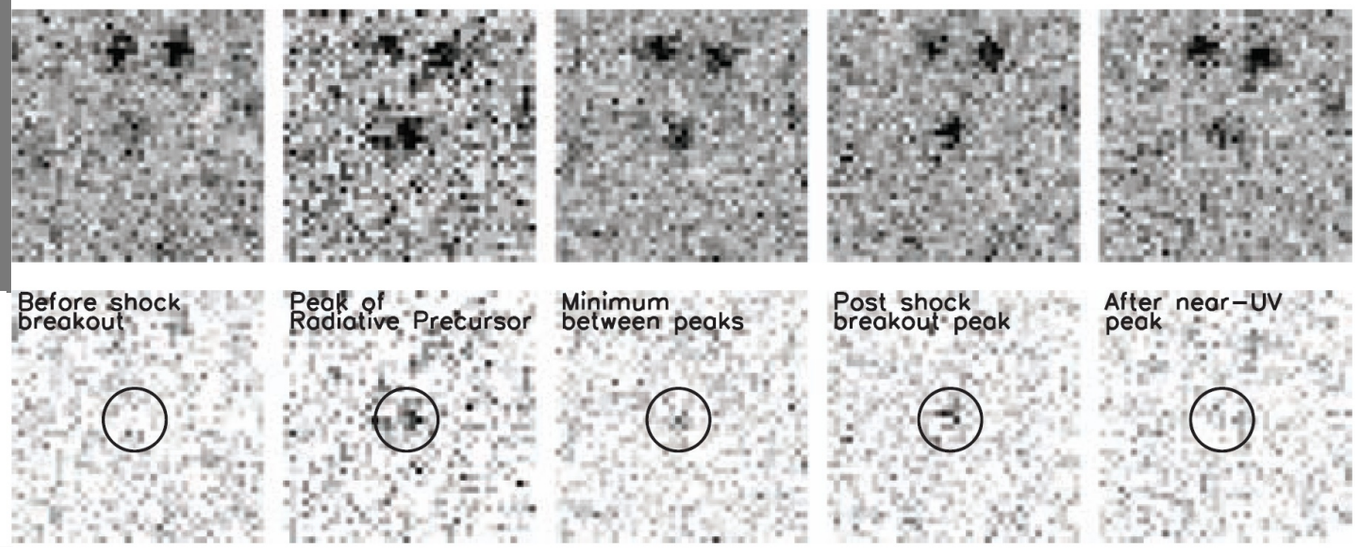
Kasliwal 2011, Cooke (http://www.astro.caltech.edu/~ycao/B&ETalks/B&E_FRBs_Cooke.pdf)



Kasliwal 2011, Cooke (http://www.astro.caltech.edu/~ycao/B&ETalks/B&E_FRBs_Cooke.pdf)

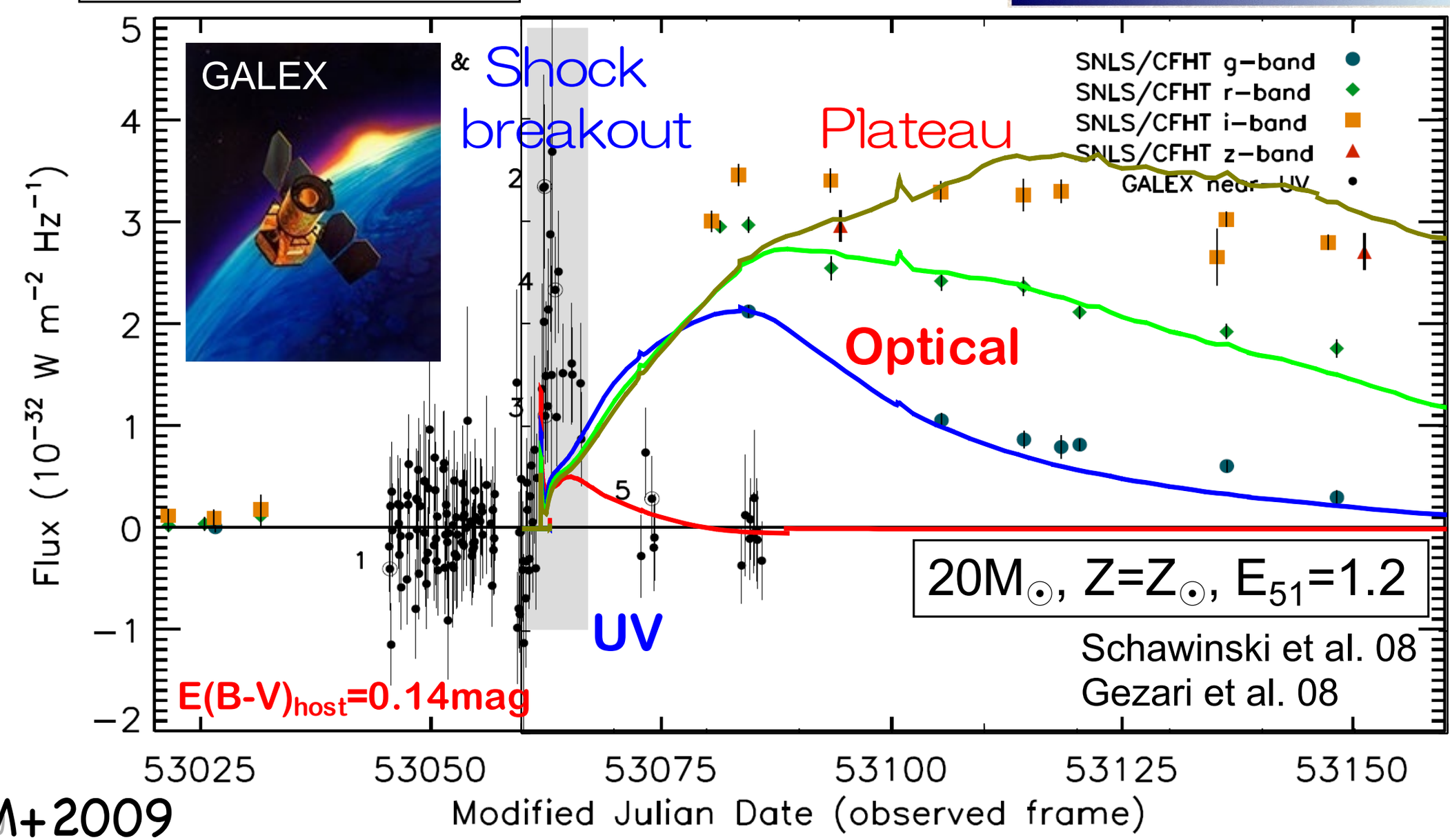
Observation of Shock Breakouts w/ radiation + hydrodyn. model (STELLA, Blinnikov+1998)

Spectra are quasi-blackbody
$$T \sim R^{-3/4} E^{1/4}$$



SNLS-04D2dc

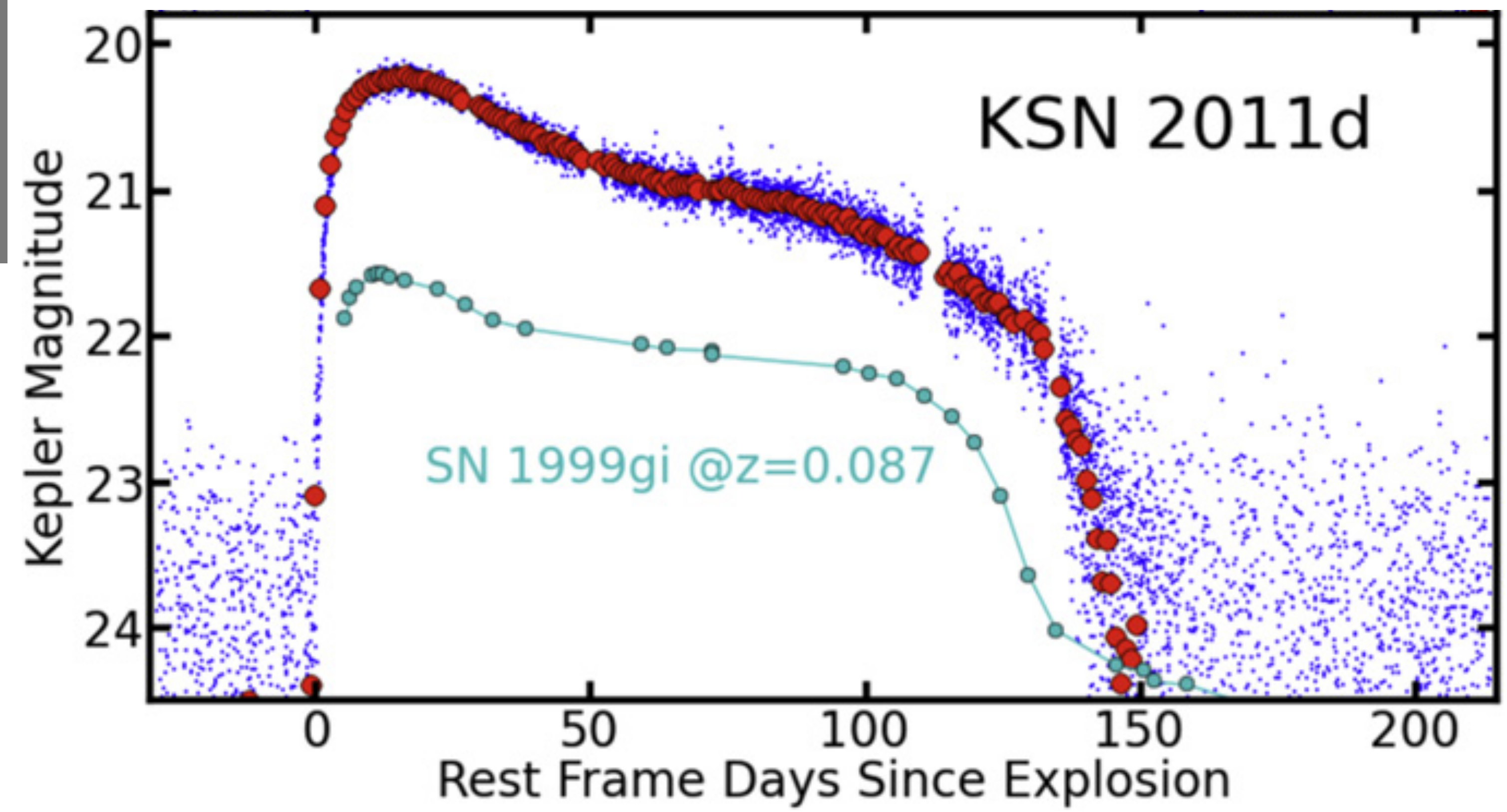
SNLS SuperNova Legacy Su

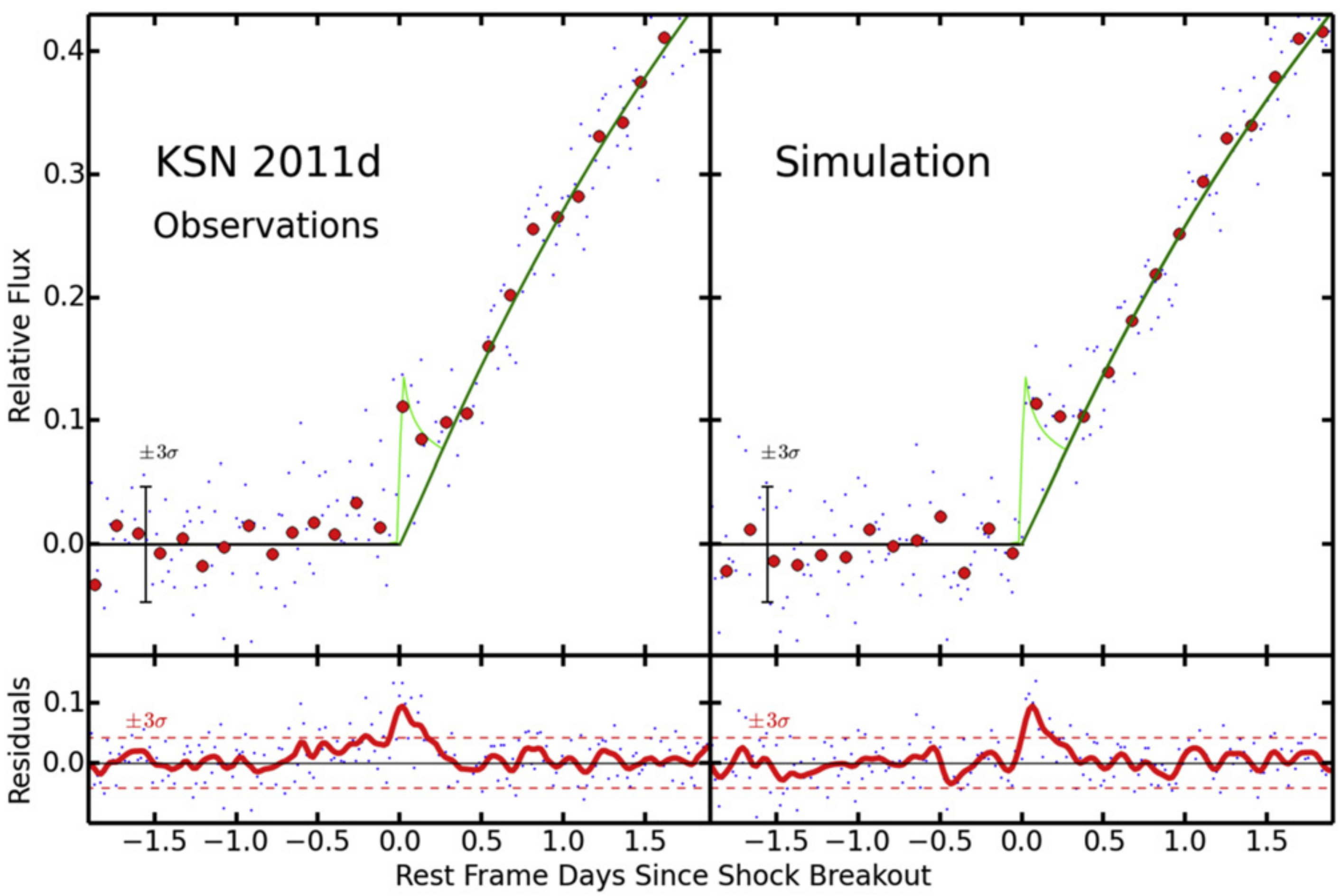


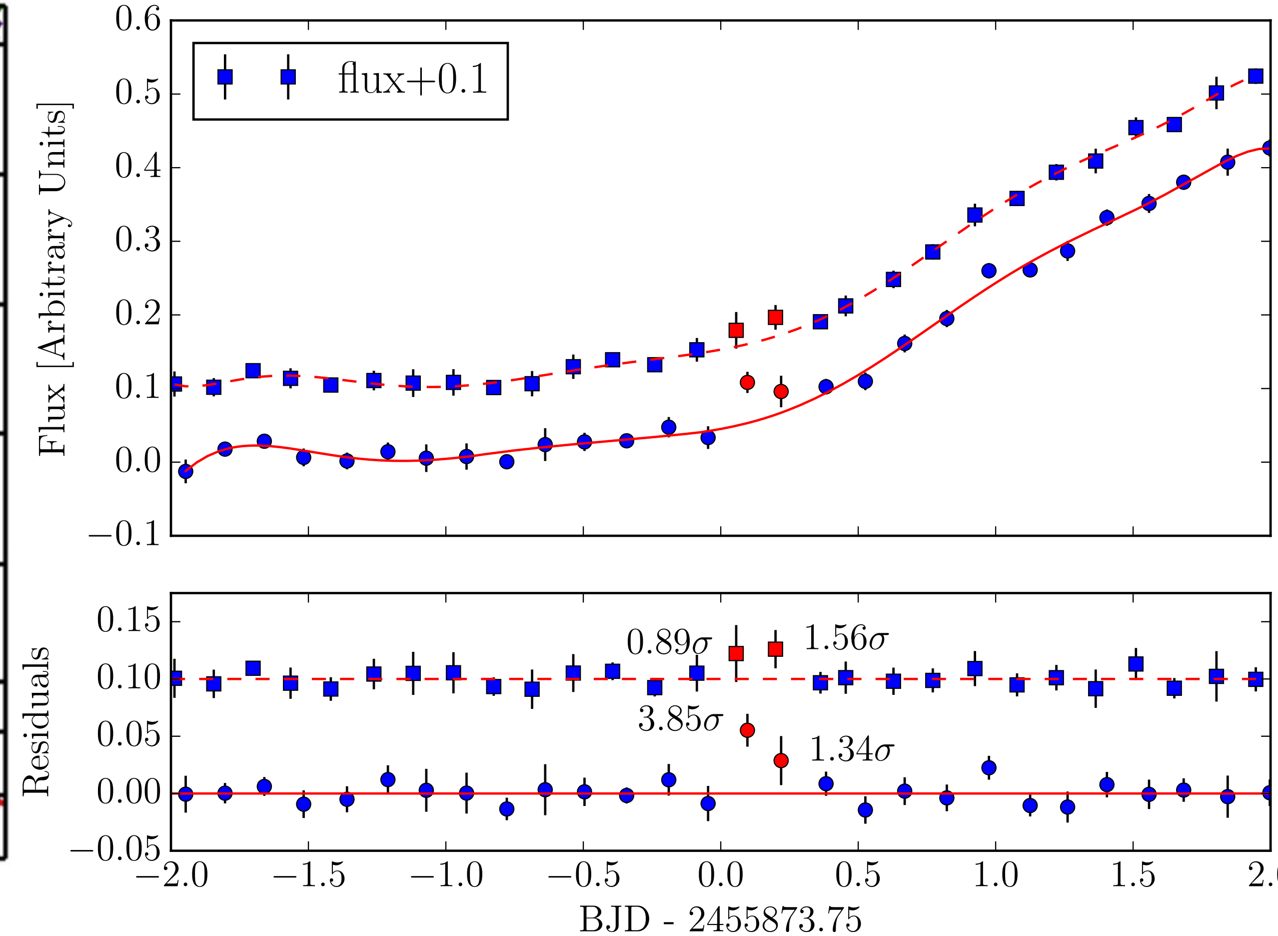
Tominaga, TM+2009

Kepler detected SN IIP Shock Breakouts in optical for the first time???

500 galaxies, 30-min cadence
t_{rise}: 13.3 +/- 0.4 days
E = 2×10^{51} ergs
R = 490 +/- 20 Rsun



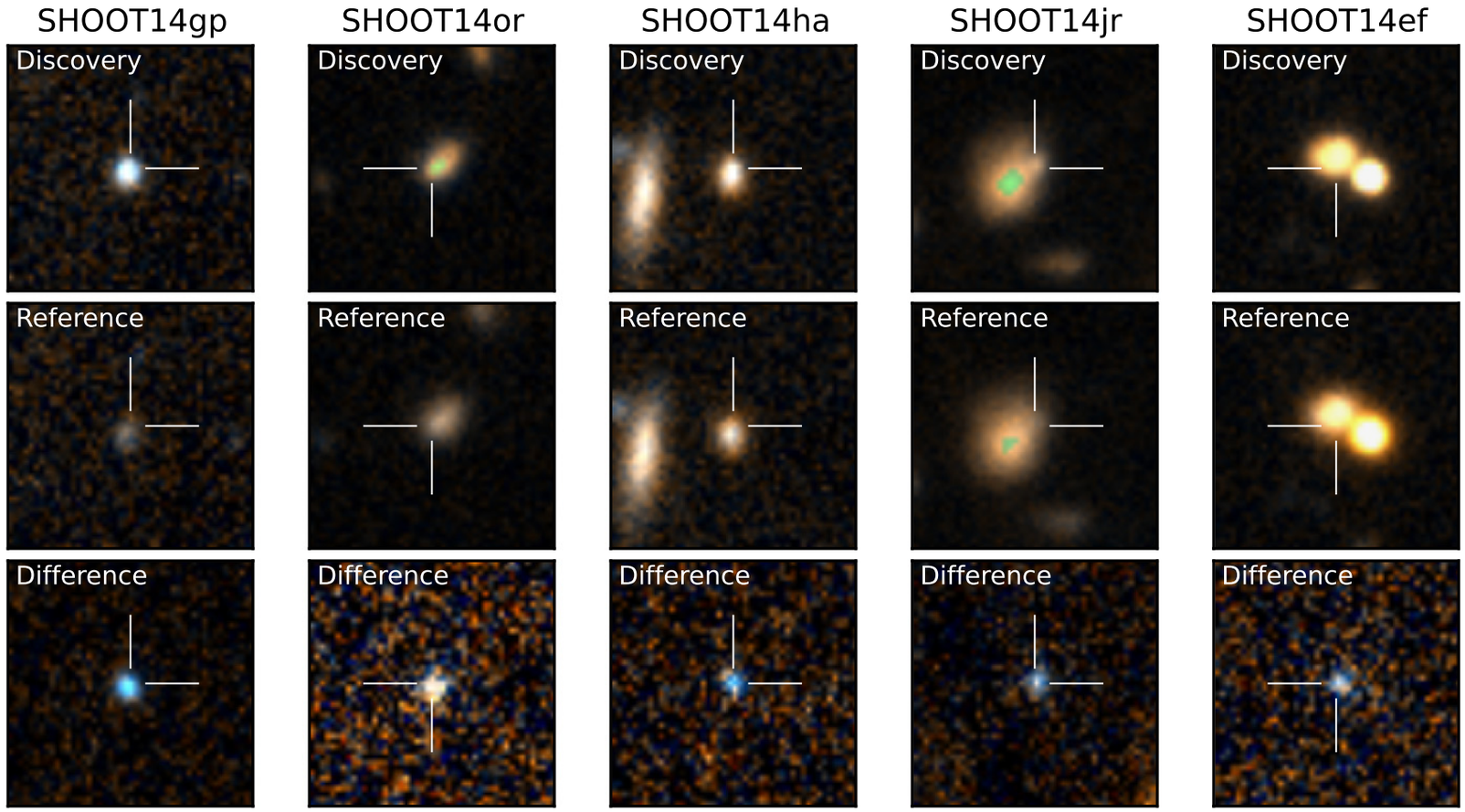


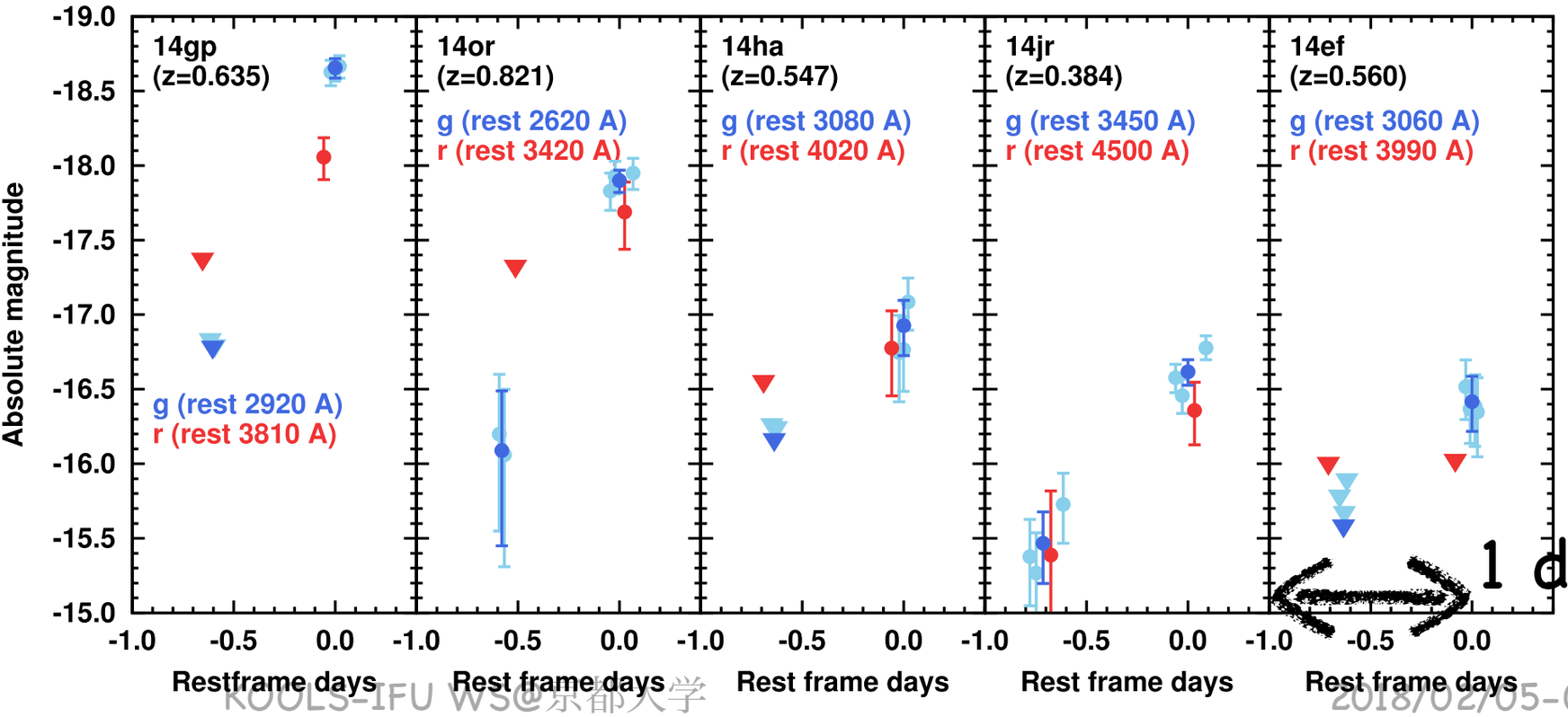


Garnavich+2016

Rubin & Gal-Yam 2017

Rapidly Rising Transients w/ Subaru/HSC



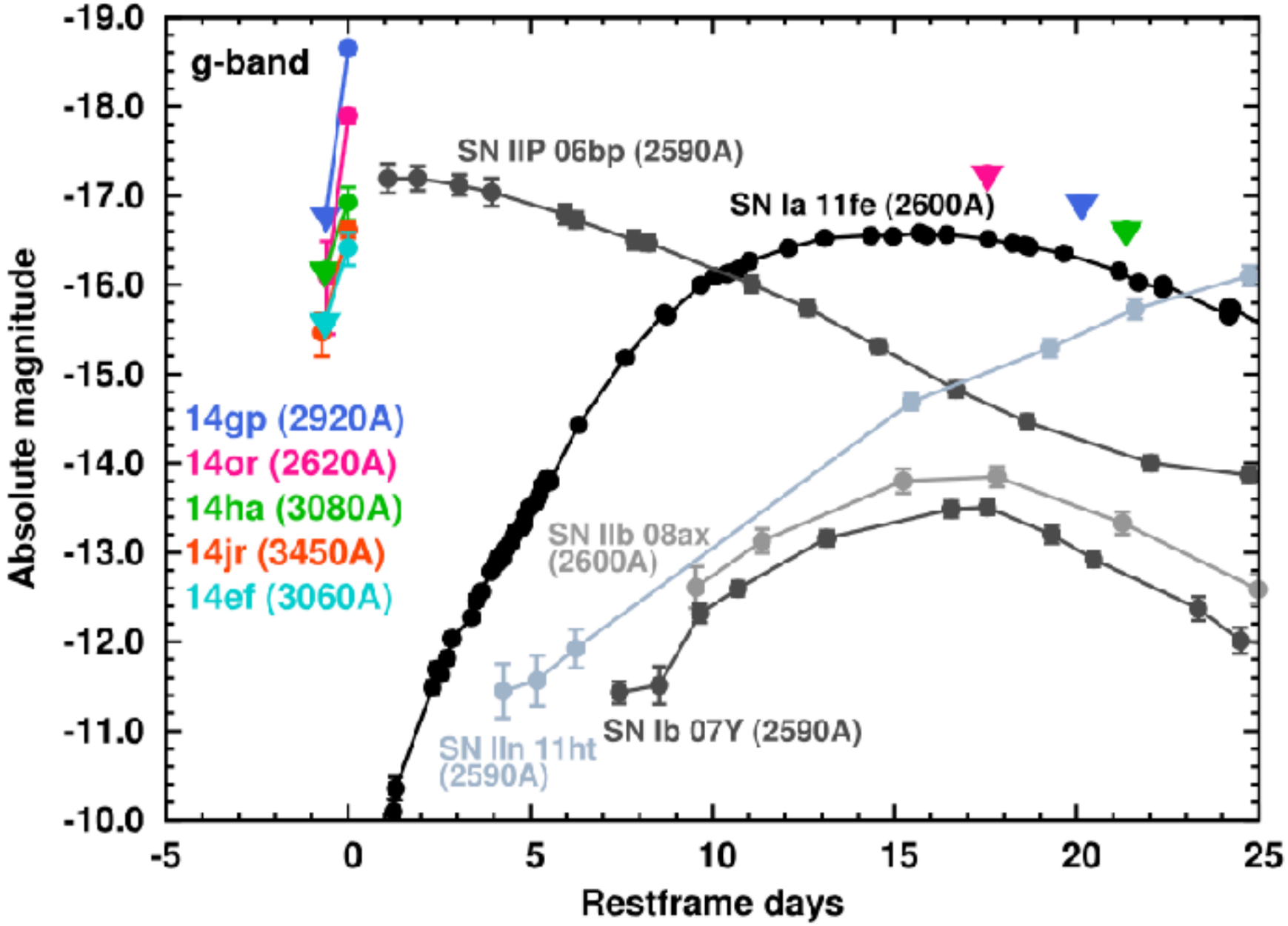


Tanaka, Tominaga, TM+2016

>9% of CCSNe show "rapid rises".

1 mag

1 day

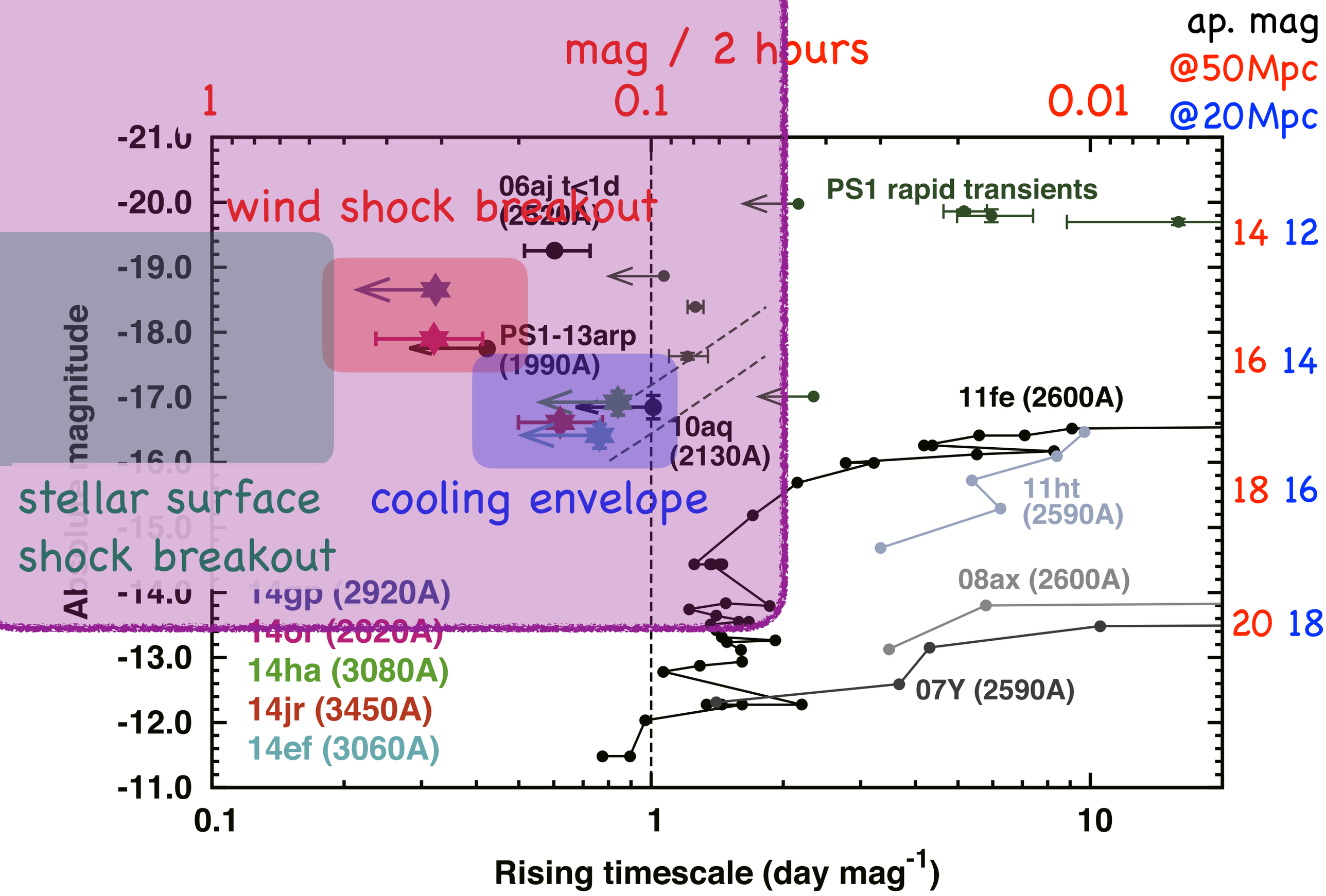


Lower-z, Brighter ==> Higher S/N

Denser Sampling

Quicker Follow-up

Tanaka, Tominaga, TM+2016, Subaru/HSC (e.g, Drout+2014, PS1)



Tanaka, Tominaga, TM+2016, Subaru/HSC (e.g, Drout+2014, PS1)

Tomo-e Gozen All-Sky Survey

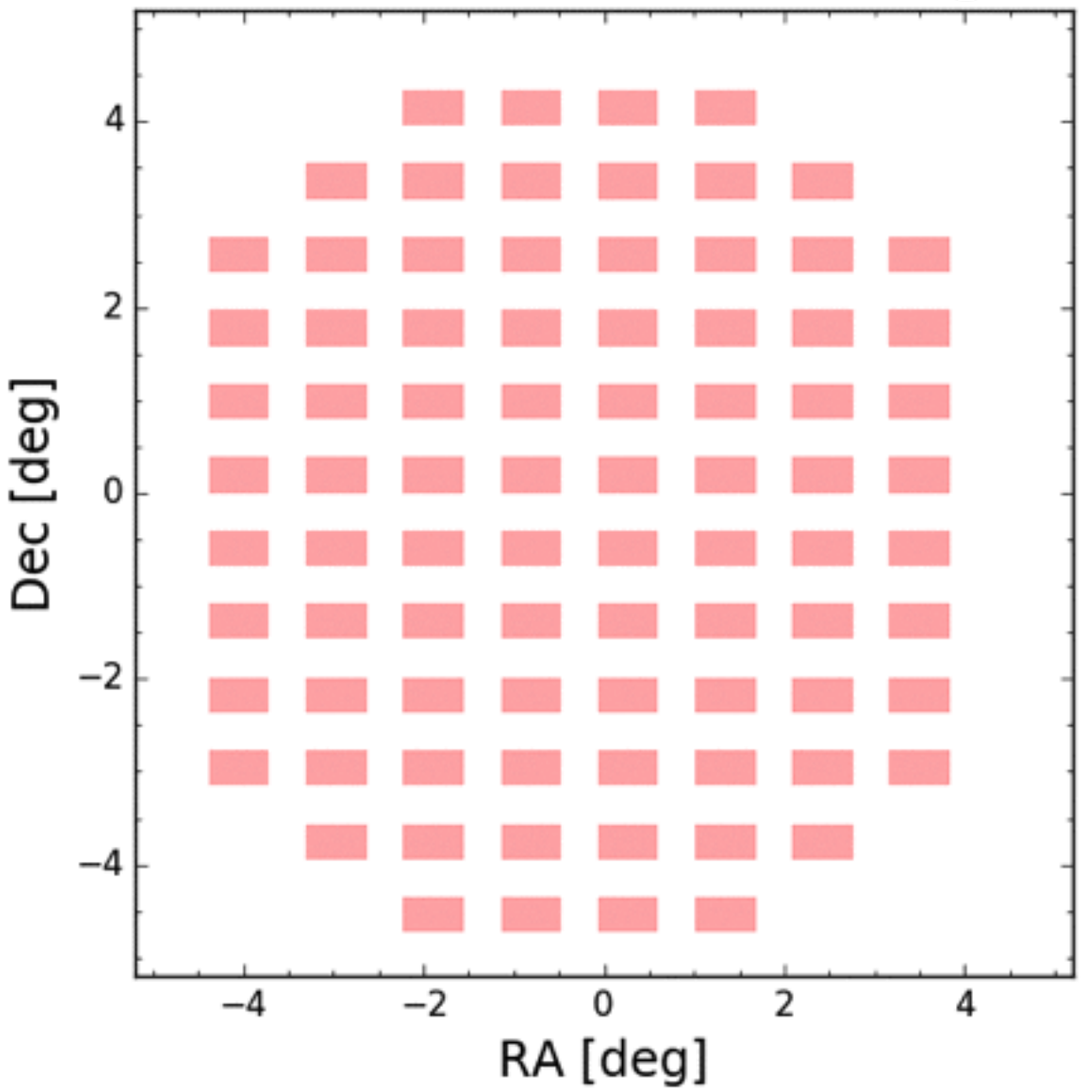
10,000 deg2 - 2 hr cadence - 18 mag depth

10,000 deg2 - 1 day cadence - 19 mag depth

- no filter: effectively g+r bands
- 1 visit
  - 3 sec exposure: [0.5 sec exposure] x 6
    - ~18 mag
    - 2x3 or 2x2 dithering to fill the gaps
    - ~60 deg2 (partially vignetted by ~30%)
- cadence: 2 hours
- survey area (per 2 hours): ~10,000 deg2 (EL>30 deg)
  - EL>15 deg for Galactic center? (Maehara-kun's talk)
- 3-5 times visits per night
  - ~19 mag for daily stacked data
- weather factor: usable (half), photometric (30%)

8.8 deg (diameter)

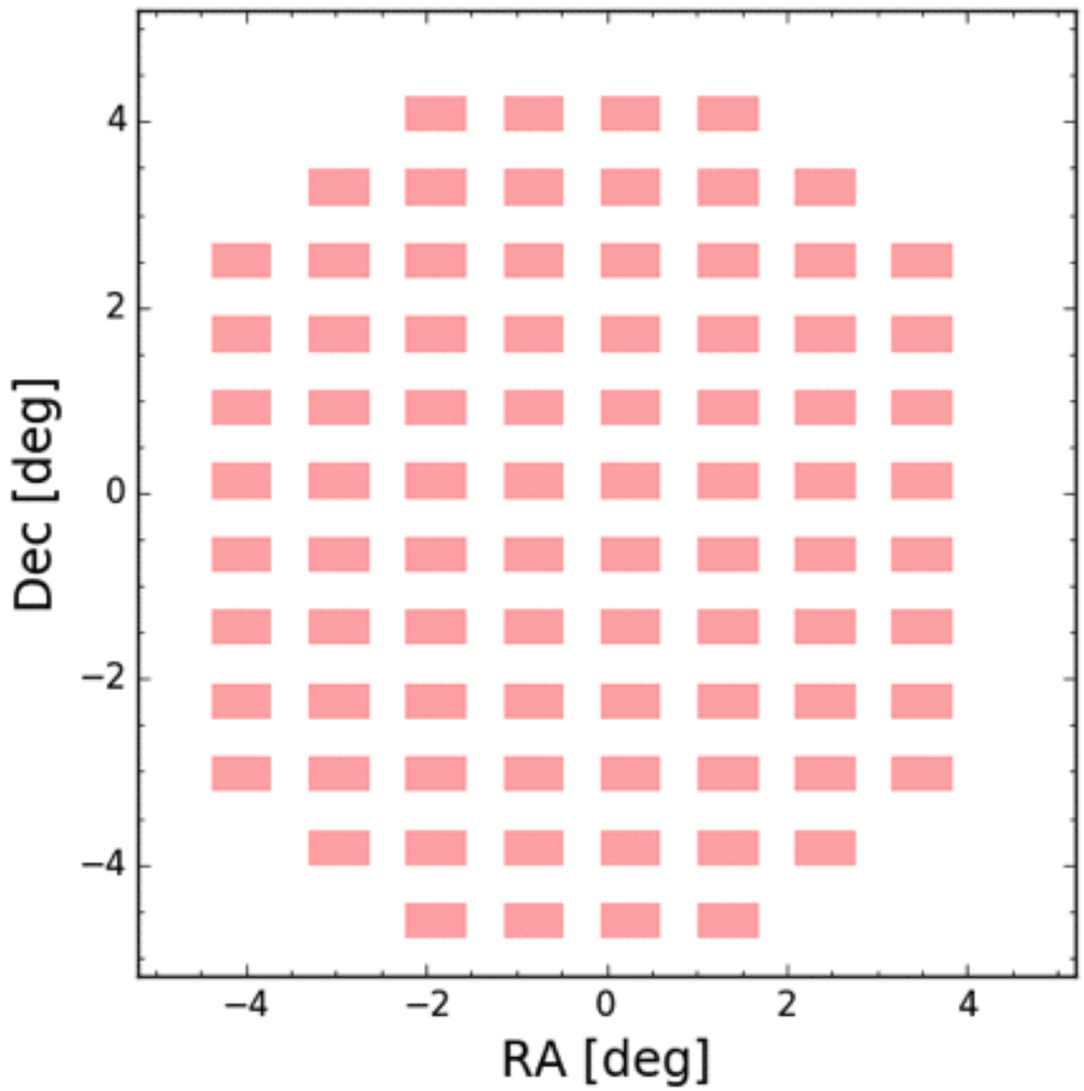
2x2 dithering



small gap

small overlap

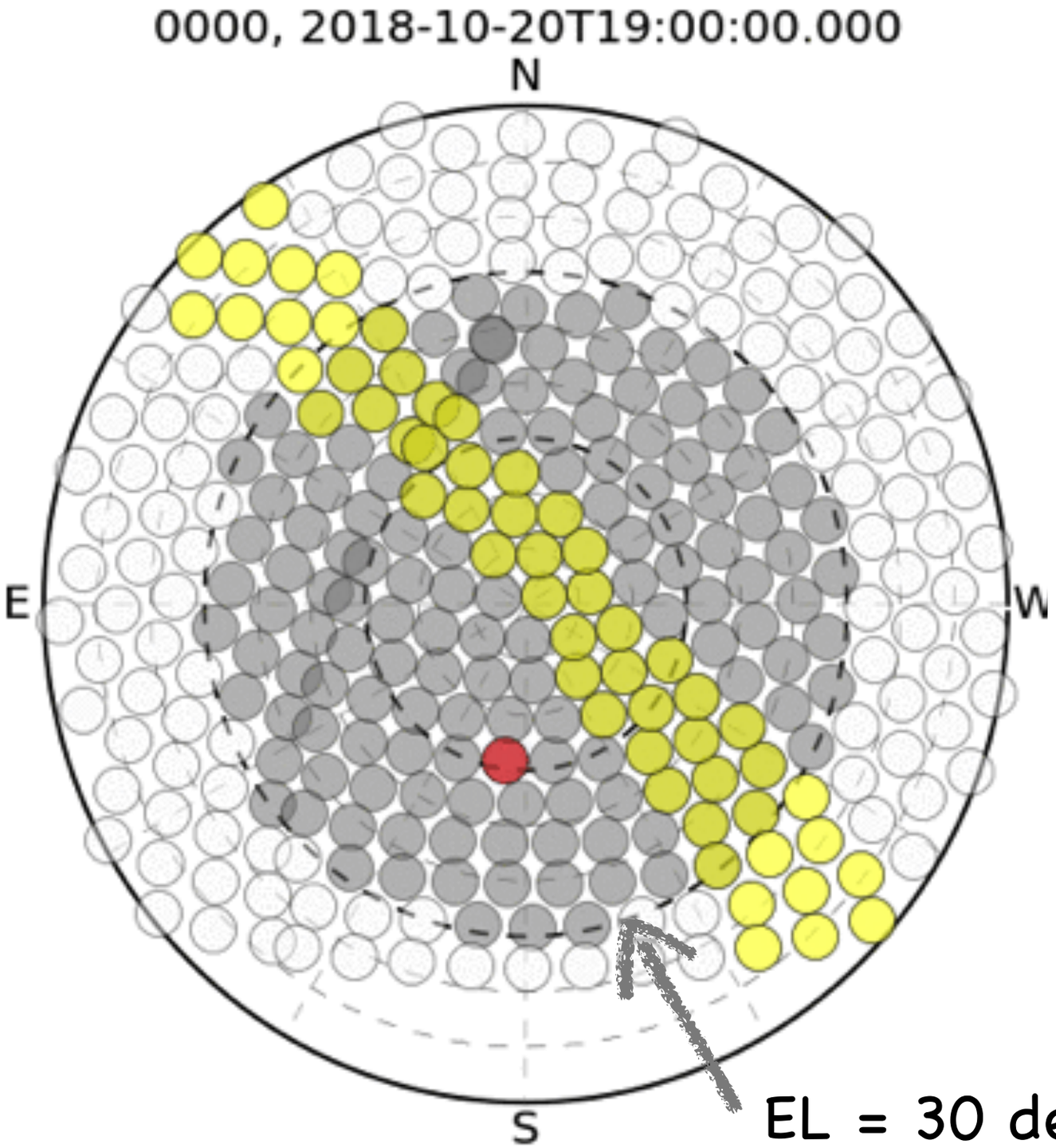
2x3 dithering

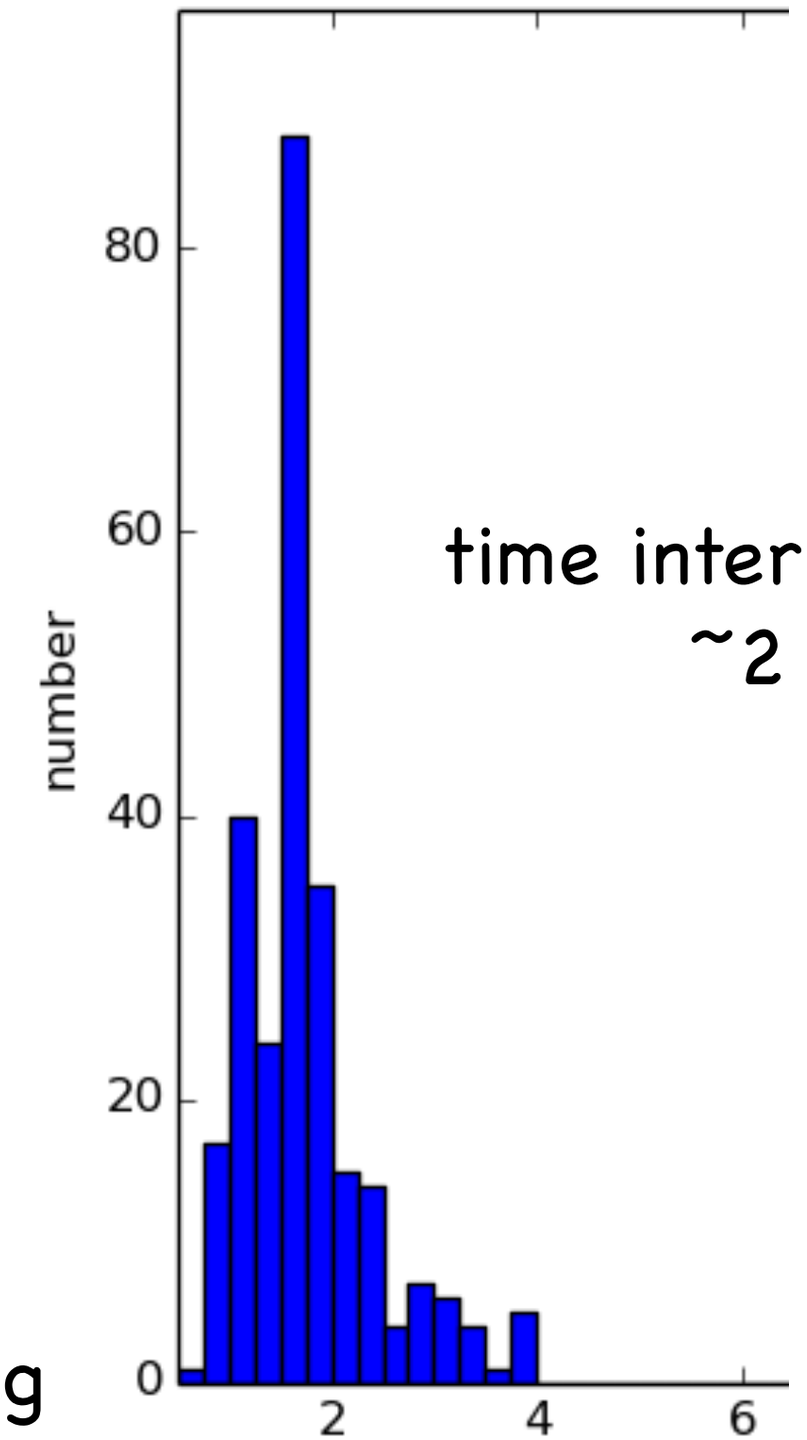


no gap

but large overlap

Survey Simulation





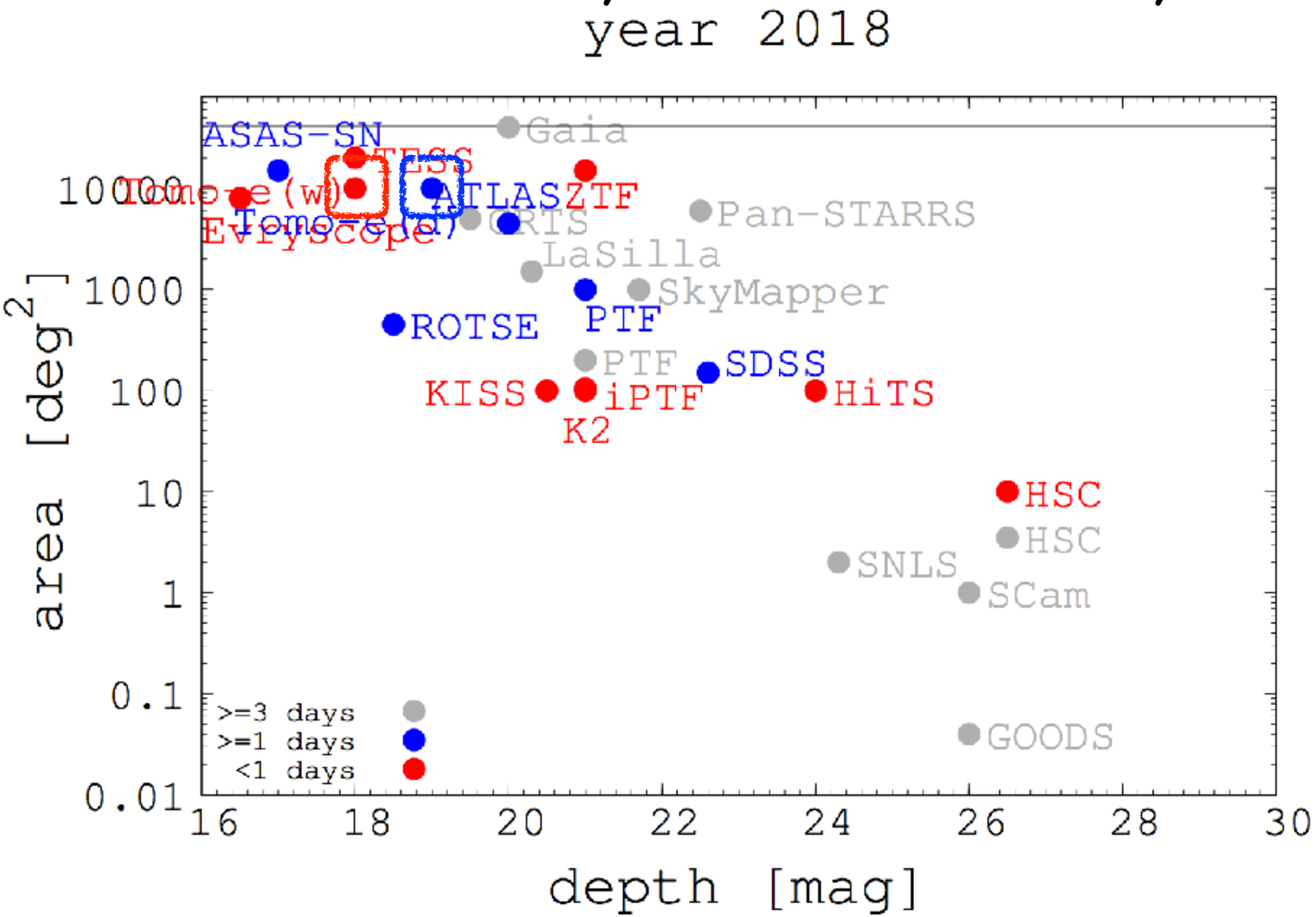
time interval:
~2 hours

Galactic Plane (< +/- 10 deg)

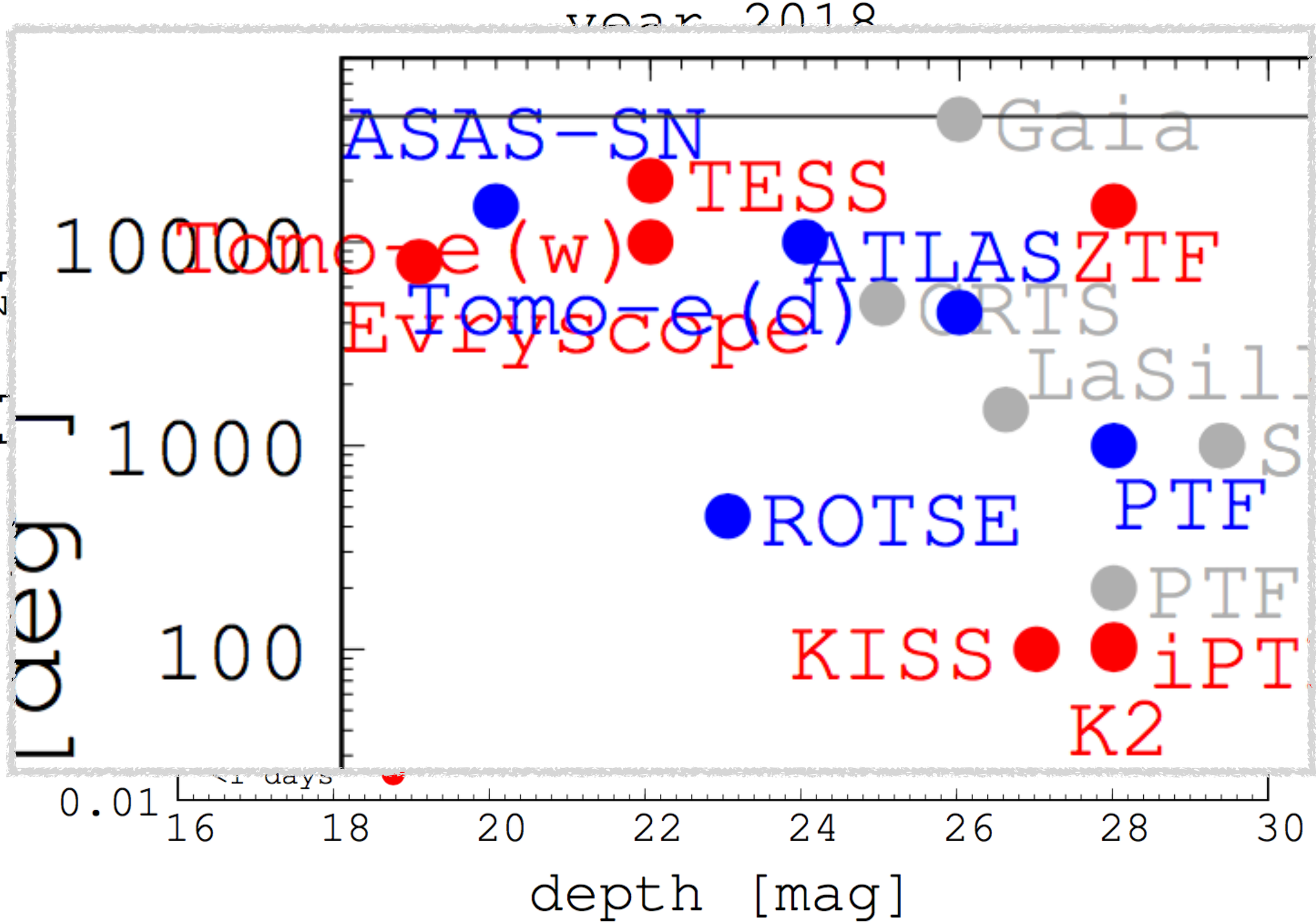
Tomo-e Gozen SN Survey
vs Kiso Supernova Survey (KISS) w/ KWFC

	Tomo-e SN Survey	KISS
instrument	Tomo-e Gozen	KWFC
sensor	CMOS	CCD
readout time	~0 sec	120 sec
period	2018/4-	2012/4-2015/9 (3.5 yrs)
survey area [deg2]	10,000	50-100
cadence	2 hours / 1 day	1 hour
exposure time / visit	3 sec	180 sec
depth	18 mag / 19 mag	20-21 mag
filter	no (~g+r)	g
#(SBOs), #(SNe) / yr	5, 1000	O(0.1)-O(1), 100
data storage	daily-stacked image SN cutout images	all data saved
reference	-	TM, Tominaga, Tanaka+2014

Tomo-e Gozen SN Survey vs other SN surveys



Tomo-e Gozen SN Survey vs other SN surveys



TM, Tominaga, Tanaka+2014

Kiso/~~KWFC~~ observations

Tomo-e Gozen

data transfer

raw images

Tomo-e pipeline

automatic standard data reduction with KWFC data reduction pipeline

reduced images

catalogs@DB

cosmic ray rejection with *L.A.cosmic*, image warping to the SDSS with *wcsremap*, image subtraction with *hotpants*

subtracted images

SN pipeline

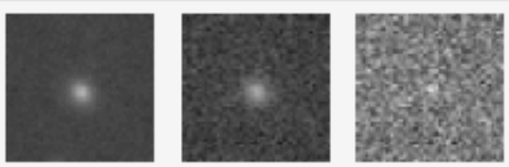
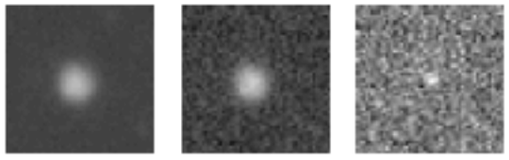
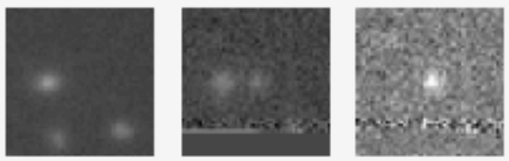
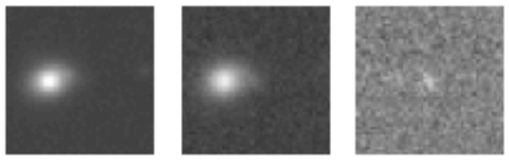
object detection with *SExtractor*

transient candidate catalogs

candidate registration with mysql, multi-wavelength data matching, and visual target screening on web browser

follow-up observations

website for transient candidate (Subaru/HSC)

	Jiang tominaga Tominaga tominaga	20170426 (G = 23.8) 20170427 (I = 22.9) 20170620 (Z = 23.3)			Bogus Bogus or submit
64357 (2110236)	**17drfg** 2017-04-27 show center3 tominaga SN yasuda Suzuki tominaga Yasuda tominaga	149.81743 , 2.08204 20170423 (Z = 25.4) 20170423 (Z = 25.4) 20170427 (I = 25.2)		2 3 0.66 (0.22", COSMOS) 1	SpecCand SN AGN Star SN? AGN? Star? Bogus Bogus or submit
64370 (2087972)	**17drft** 2017-04-27 show SN takahashi yasuda Takahashi tominaga Yasuda tominaga	150.16233 , 2.88858 20170427 (I = 24.1) 20170427 (I = 24.1) 20170427 (I = 24.1)		1 2 0.60 (0.03", UD) 1	SpecCand SN AGN Star SN? AGN? Star? Bogus Bogus or submit
46658 (1534786)	**17cran** 2017-04-26 show SN yamaguchi jiang Jiang tominaga Yamaguchi tominaga	149.29712 , 2.19094 20170420 (Y = 23.7) 20170423 (R = 23.6) 20170423 (R = 23.7)		2 5 0.86 (0.21", UD) 0.8	SpecCand SN AGN Star SN? AGN? Star? Bogus Bogus or submit
46663 (1534877)	**17cras** 2017-04-26 show SN yasuda	149.46692 , 2.34929		2 4 0.48 (1.66", spec) 1	SpecCand SN AGN Star SN? AGN? Star? Bogus

website for transient candidate (Subaru/HSC)

previous

17bkem

Transient ID: 24453 Variable_id: 716097

Number of detections: 16 (NY's selection, paramsand)

Number of CNN real: 16 (cnncand)

machine learning

Tags Click a tag for removal

SN tominaga(2017-12-31) moriya(2018-01-07) Moriya tominaga(2017-11-07) Tominaga tominaga(2017-11-01)

Insert tags

SpecCand | SN | AGN | Star | Unclear | Bogus | or | submit

SN? | AGN? | Star?

Ra, Dec (Decimal)	Ra, Dec		tract	patch	x,y
150.99039 , 2.86079	10:03:57.69, +02:51:38.8		9813	0,7	2107.22 , 31491.53 2107.22 , 3591.53

Host Ra, Dec (Decimal)	Extend	Spec-z	Type_COSMOS	Distance	Photo-z (Mizuki)	Distance (Mizuki)	Host id
150.99086 , 2.86091	1		galaxy COSMOS catalog	1.72864	$0.52000^{+0.52000}_{-0.52000}$	0.01458	43163558036409810

Image links	hscMap	CDSS	Finding chart		
fits files	9814 7,8	9813 0,8	9813 1,8	Ref	Sub
2017-01-21	9814 7 7	9813 0,7	9813 1,7		
HSC-Z	9814 7,6	9813 0,6	9813 1,6		

Images

real, bogus, forced

2017-03-29 (57841.30) HSC-G

2017-03-25 (57837.27) HSC-R2

2017-03-22 (57834.43) HSC-Z CNN

2017-03-22 (57834.32) HSC-G

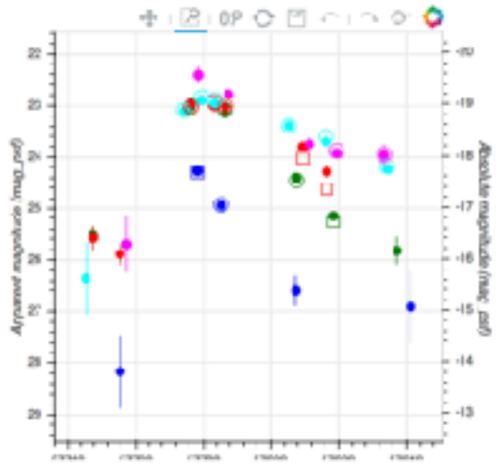
2017-03-21 (57833.35) HSC-Y

2017-03-07 (57819.47) HSC-Y CNN

time sequence
(ref, search, sub)

Light curve mag_psf change redshift set

Filters: HSC-G HSC-R HSC-I HSC-Z HSC-Y select



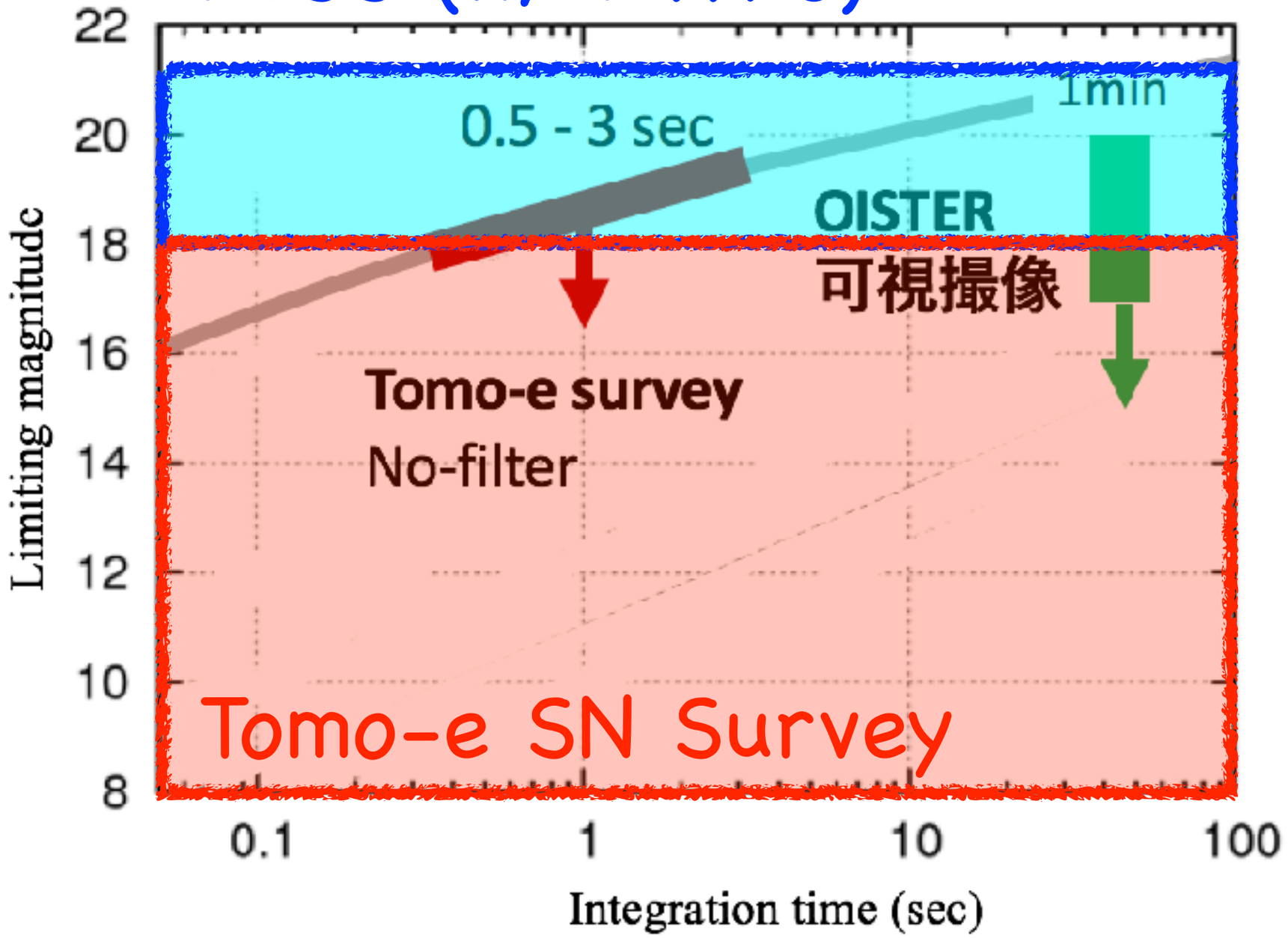
light curve (mag)

Comments

submit

No comments posted yet.

KISS (w/ KWFC)

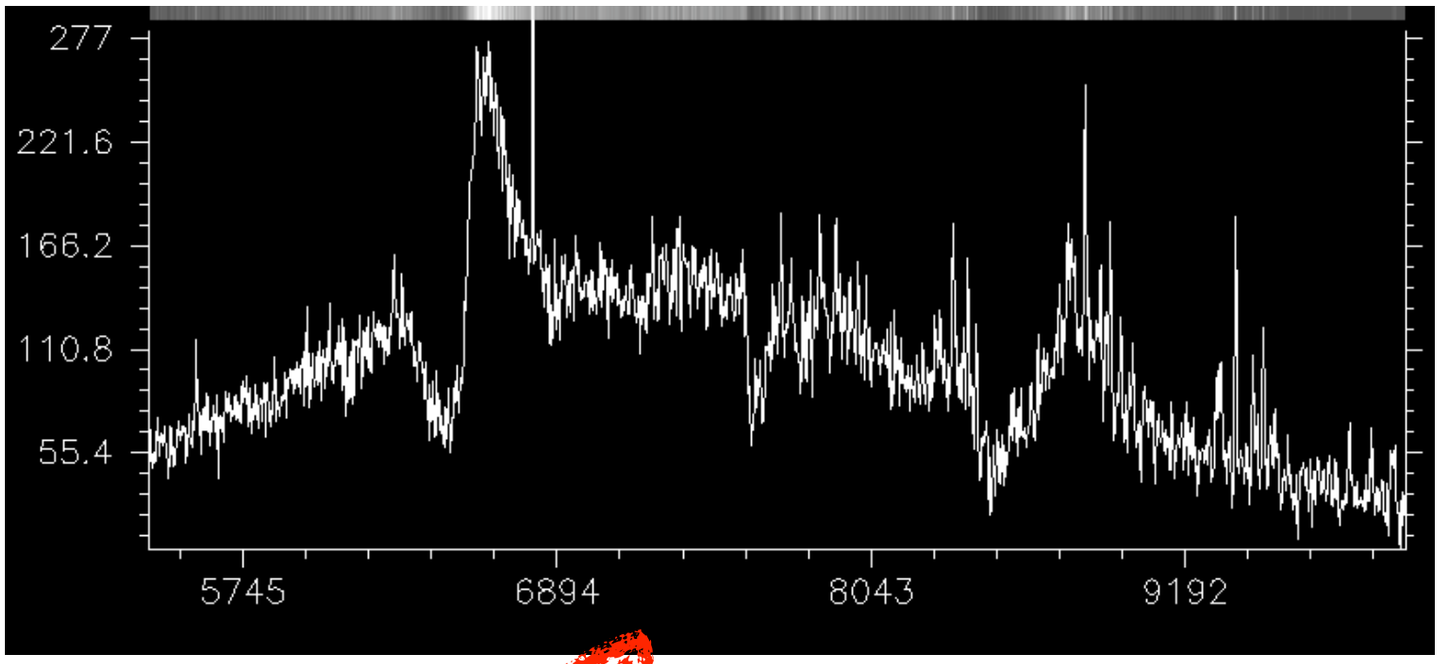


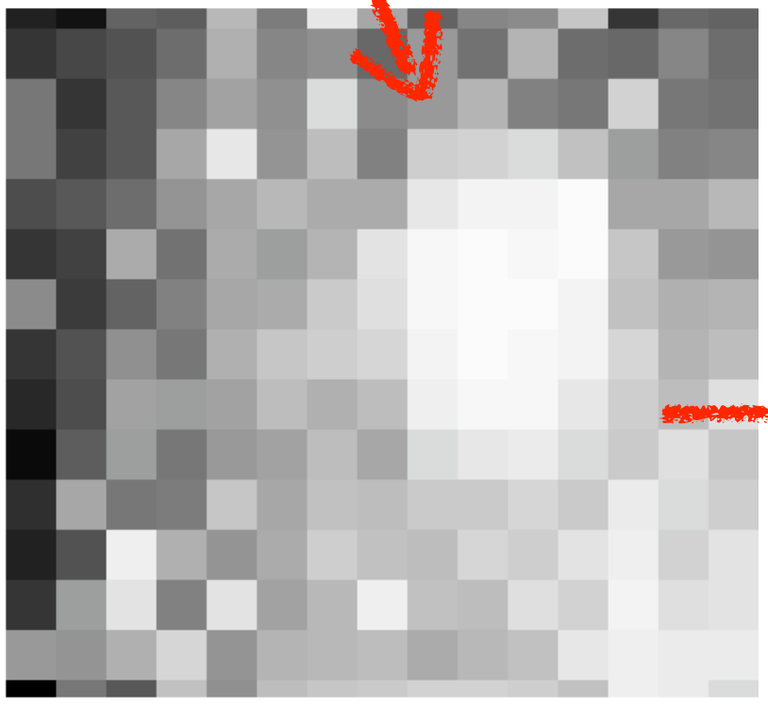
5σ検出限界

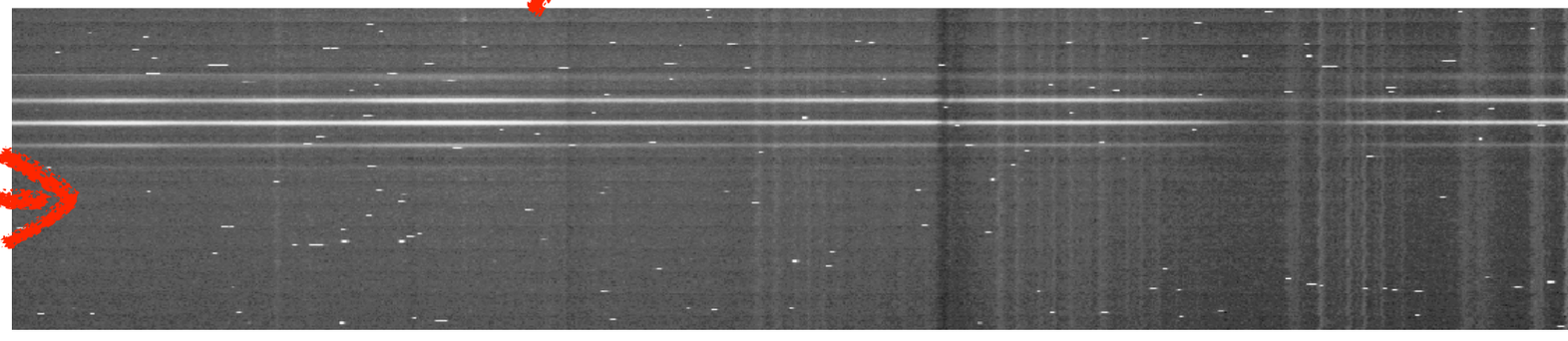
©Sako

"flash" spectroscopy w/ Kyoto 3.8-m/KOOLS-IFU

- IFU is an ideal instrument for SN quick follow-up
  - no accurate slit alignment necessary

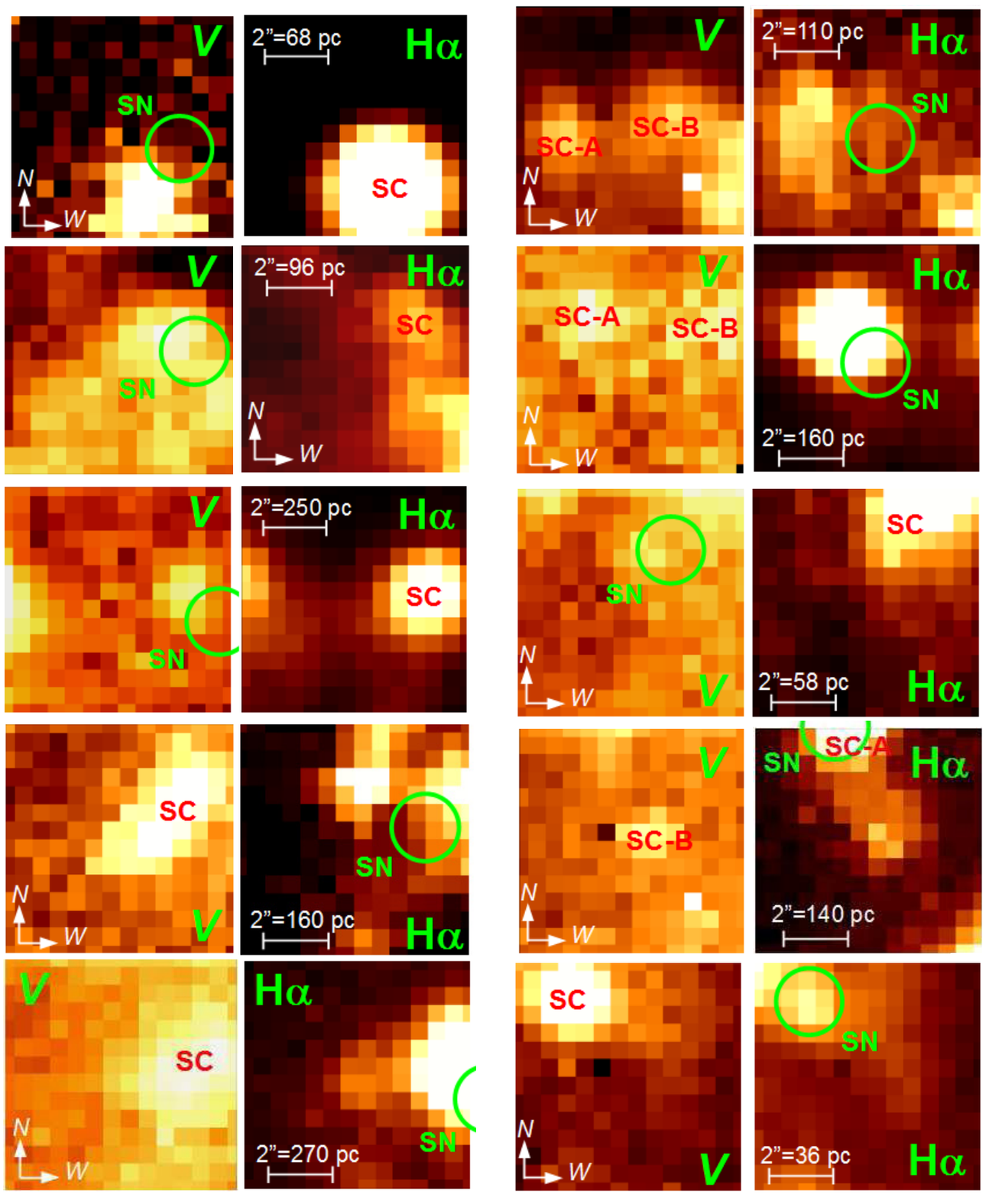






©Peter Nugent (SNFactory/UH88/SNIFS)

"flash" spectroscopy w/ Kyoto 3.8-m/KOOLS-IFU



star clusters (possible hosts)
spectroscopy at the same time

UH88/SNIFS observations
e.g., Kuncarayakti+2013
(SNe IIP, II-L)

"flash" spectroscopy w/ Kyoto 3.8-m/KOOLS-IFU

- IFU is an ideal instrument for SN quick follow-up
  - no accurate slit alignment necessary
- Tomo-e Gozen (Q1) SN Survey starts from April 2018.
  - Kyoto 3.8m tel. operation starts from summer 2018.
- ToO / queue observations
  - Both queue systems are developed by Maehara-kun(?).

- sensitivity: 19.0 mag (S/N=10)
  - 30-minute exposure, R~600-800
- **10-30 minutes exposure** is enough for Tomo-e Gozen SNe.
- total maximum(?) observing time (KOOLS-IFU)
  - identification: 1000 SNe x 1 epoch ==> ~40 nights
    - photo-z/distance prior to reduce the number
  - detailed study: + 100 SNe x 10 epochs ==> ~80 nights
  - ==> a few tens good candidates ==> ~30 nights

Summary

- supernovae in early phases
  - shock breakouts
  - key to progenitors
- What we want to do is ...
  - discoveries of supernovae in early phases w/ Tomo-e Gozen
  - flash spectroscopy w/ Kyoto/KOOLS-IFU
- Tomo-e Gozen all-sky survey
  - 3 sec exposure, 2-hour cadence, 18 mag, 10,000 deg2
  - Q1 (5 deg2) survey from 2018 April
  - ~1,000 SNe/yr w/ "Q4" (full Tomo-e)
    - several "young" SNe