Subaru transient survey

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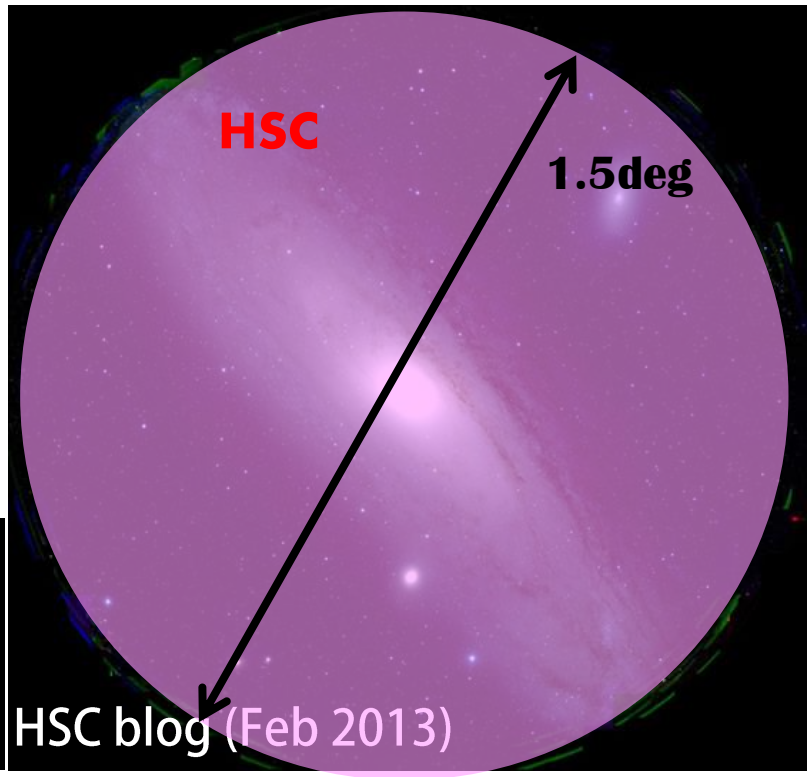
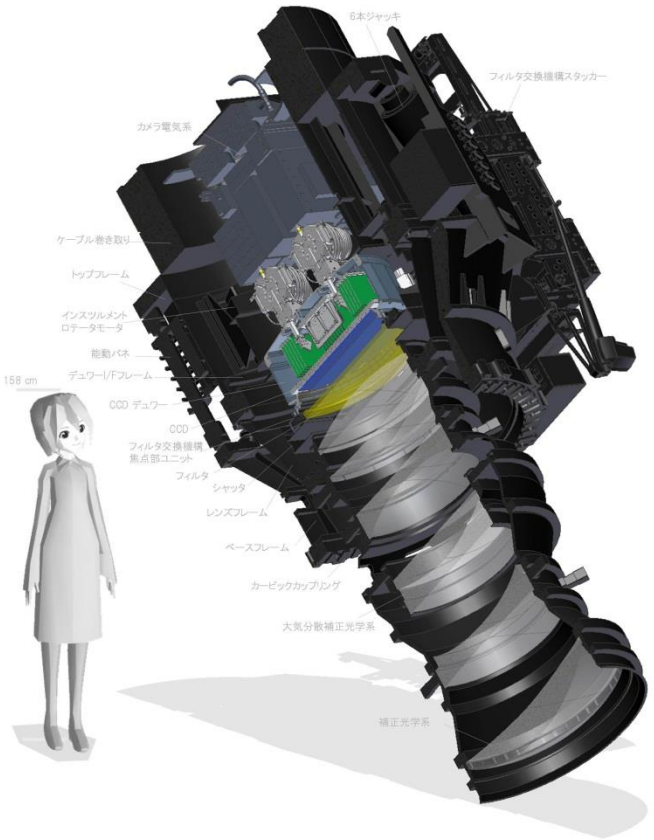
(Konan University)

Subaru/Hyper Suprime Cam

- Hyper Suprime-Cam (HSC)
  - Diameter: 8.2m, FoV: 1.77deg^2, ~900M pixels





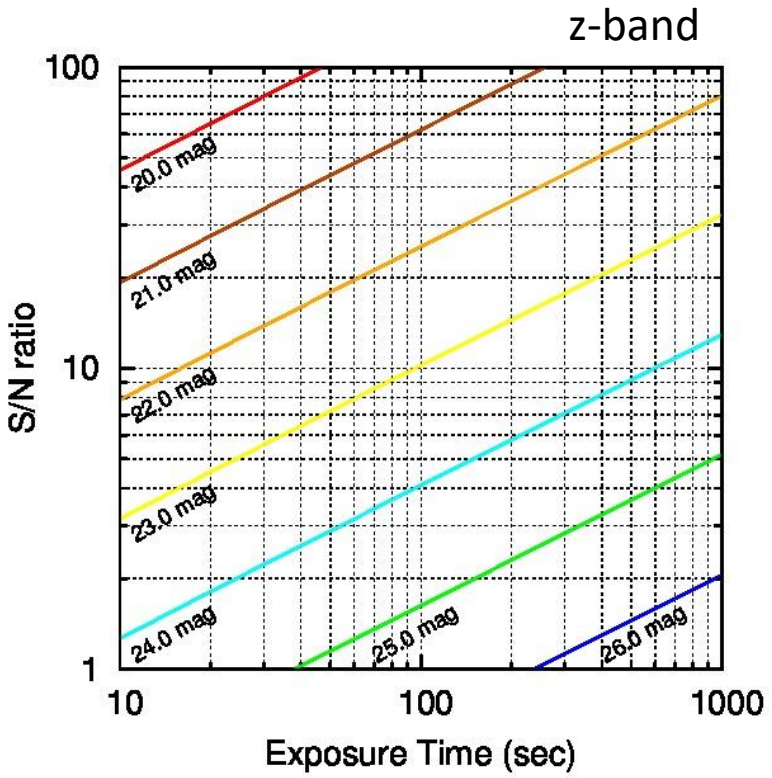
HSC instrument parameters

- Number of science CCDs:

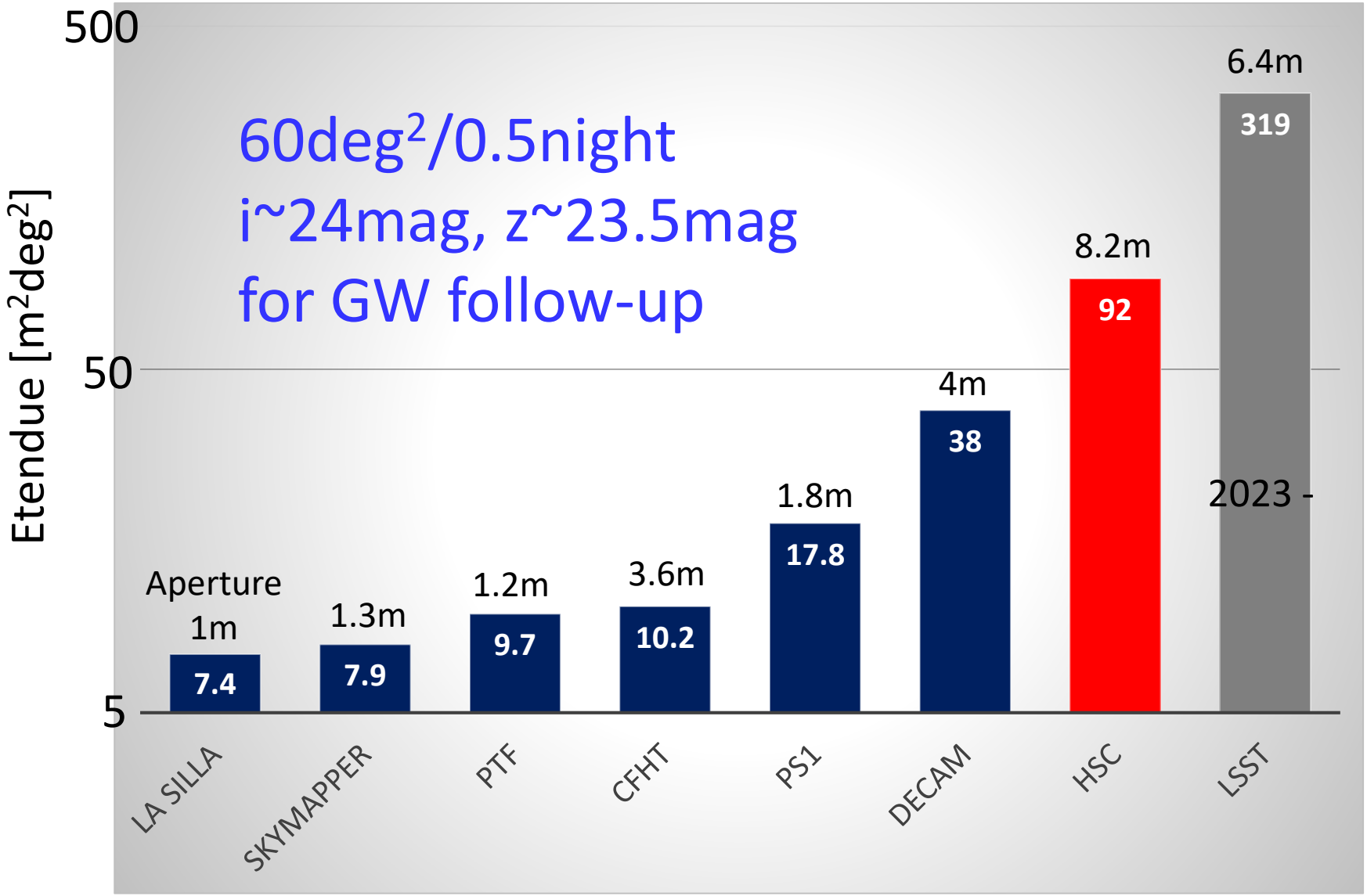
  104 chips (4 unavailable chips)
- Overhead time: ~35 sec per exposure
- Number of filters: 6
- Filter exchange: ~30 min

5σ lim. mag.
w/ 1min exp.

g	25.5
r	23.9
i	24.2
z	23.6
Y	22.8



Etendue of optical telescopes



Available only on gray/dark nights

Schedule for January 2018

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	Jan 01 ○	Jan 02	Jan 03	Jan 04	Jan 05	Jan 06
	Obs FOCAS Obs FOCAS	S17B-002 Kodama MOIRCS		S17B-002 Kodama MOIRCS	S17B-130 Kotani CHARIS+SCExAO	UH-07B Hodapp CHARIS+SCExAO S17B-130 Kotani CHARIS+SCExAO
Jan 07	Jan 08 ◑	Jan 09	Jan 10	Jan 11	Jan 12	Jan 13
UH-07B Hodapp CHARIS+SCExAO Taiken Kikaku (1hr)/Obs HDS	SSP HSC Eng/Queue HSC	SSP HSC S17B-055I Suzuki HSC	Queue HSC	Queue HSC	Queue HSC S17B-055I Suzuki HSC	SSP HSC
Jan 14	Jan 15	Jan 16 ●	Jan 17	Jan 18	Jan 19	Jan 20
UH-18B Tholen HSC	UH-18B Tholen HSC	S17B-116 [ToO] Y. Tanaka HSC SSP HSC	S16B-001I Inoue HSC	S16B-001I Inoue HSC	S16B-001I Inoue HSC	SSP HSC
Jan 21	Jan 22	Jan 23 ◐	Jan 24	Jan 25	Jan 26	Jan 27
S17B-044 Yoshida HSC Queue HSC	Keck Prochaska HSC S17B-055I Suzuki HSC	Eng/Queue HSC SSP HSC	UH-28A Goebel CHARIS+SCExAO S16A-119I Aoki HDS	S17B-093 Currie CHARIS+SCExAO S16A-119I Aoki HDS	S16A-119I Aoki HDS	S16A-119I Aoki HDS Obs IRCS+AO188(LGS)
Jan 28	Jan 29	Jan 30 ○	Jan 31			
Keck Melis COMICS	S17B-092 Takagi IRCS+AO188(LGS)					

Need to submit proposals

- Deadline: early Sep/Mar for A/B semesters

Semester		Proposals			Nights		
		Submitted	Accepted	Ratio	Requested	Awarded	Ratio
S17A	2017/02 - 2017/07	166	42	25%	418.3	82	20%
S17B	2017/08 - 2018/01	135	37	27%	294	69.5	24%
S18A	2018/02 - 2018/07	155	45	29%	347.3	94	27%
S18B	2018/08 - 2019/01	156	50	32%	415.7	84.5	20%
S19A	2019/02 - 2019/07	133	46	35%	354.9	89.5	25%

- HSC is more competitive than the average.

There are 3 kinds of proposals.

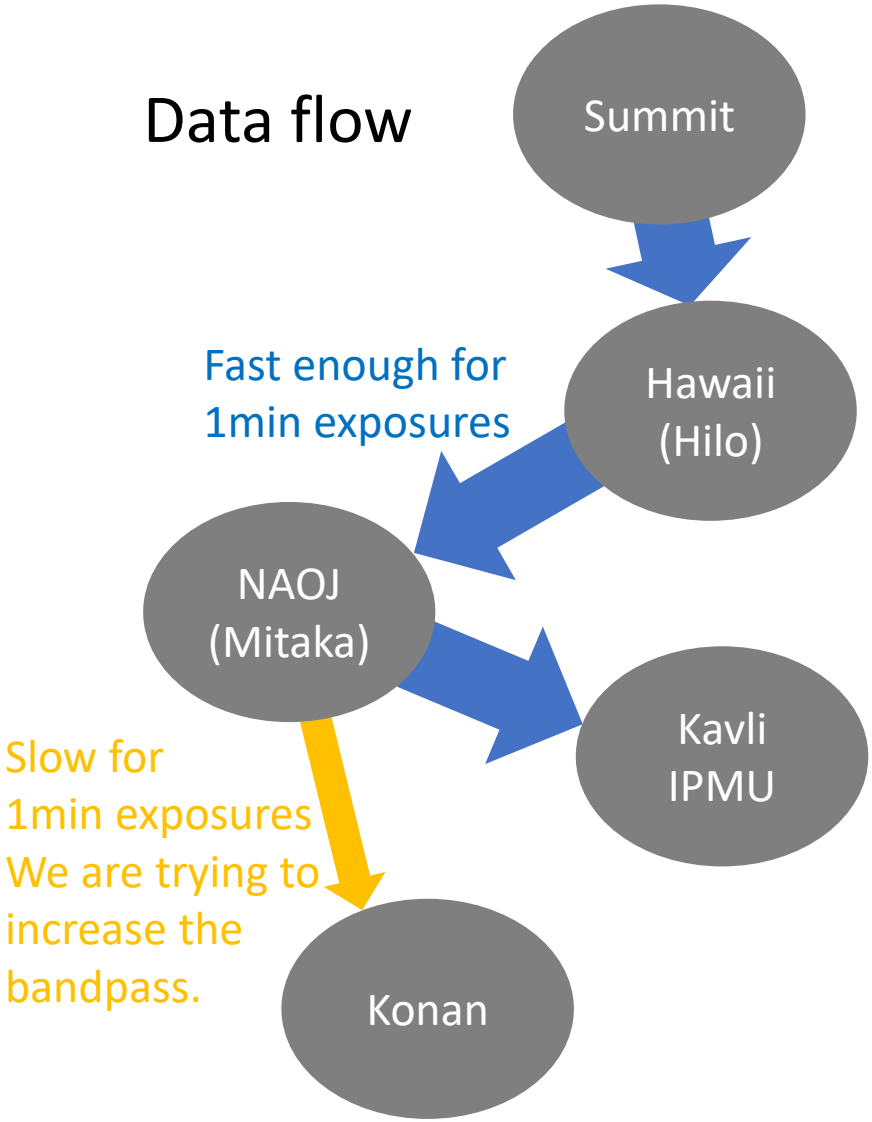
- Openuse: <= 5 nights, 1 semester
- Intensive: <= 40 nights, <= 6 semesters
- SSP: <= 300 nights, <= 10 semesters

Data analysis for transient surveys

Transient finding system

- Naoki Yasuda and NT are working on it.
- Hawaii observatory
  - CPU: 176 cores
  - Storage: 20TB
- Kavli IPMU
  - CPU: 1200 cores
  - Storage: 3.5PB
- Konan University
  - CPU: 488 (+320) cores
  - Storage: 500TB

Data flow



Subaru strategic program (SSP)

COSMOS (Nov 2016 – Apr 2017): several days cadence

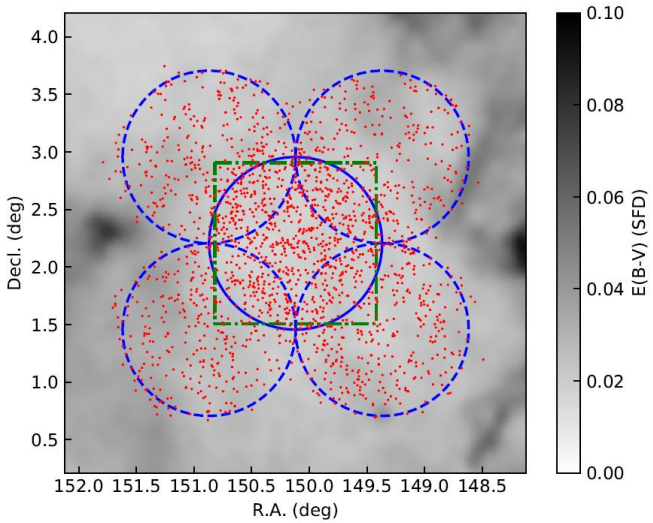
Two layers:

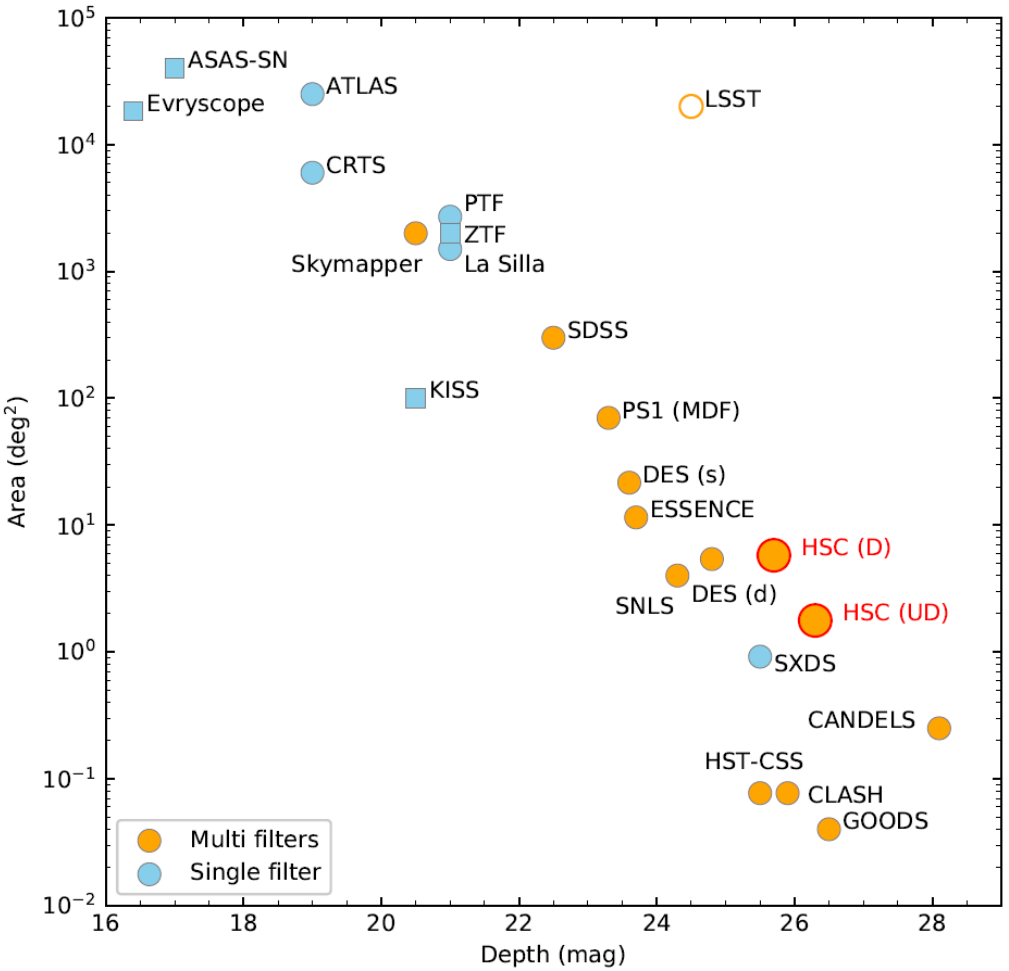
- Deep: Ω=5.8deg^2

  m_{lim}~25.7, 4 months

- Ultradeep: Ω=1.8deg^2

  m_{lim}~26.3, 6 months



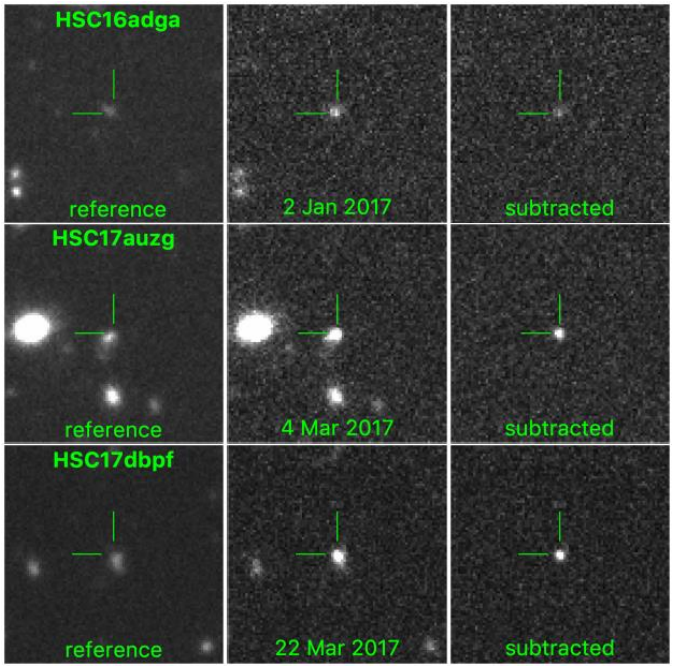


Yasuda + submitted

Pick-up results -SLSNe-

Subaru HIgh-Z sUpernova CAmpaign (SHIZUCA)

Moriya+18 (arXiv:1801.08240)
Curtin+18 (arXiv:1801.08241)



SHIZUCA discovered SLSNe at z=1.9-2.4.

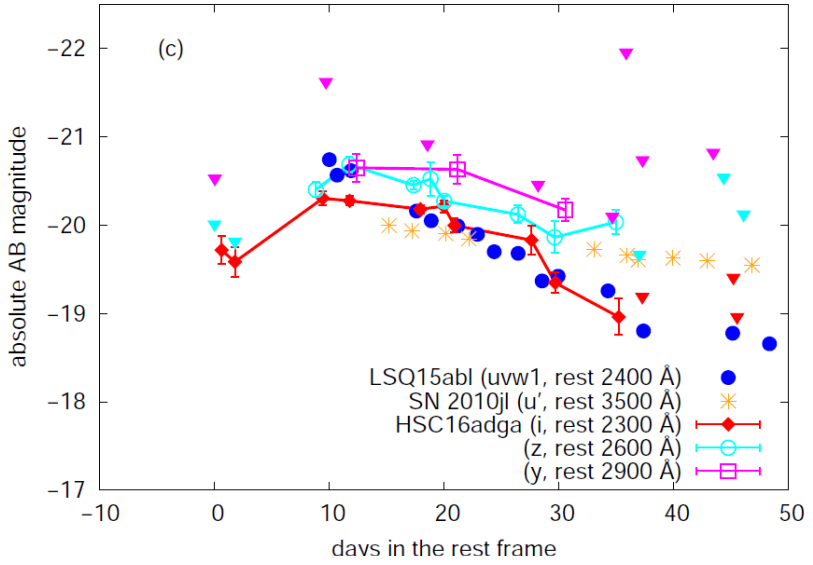


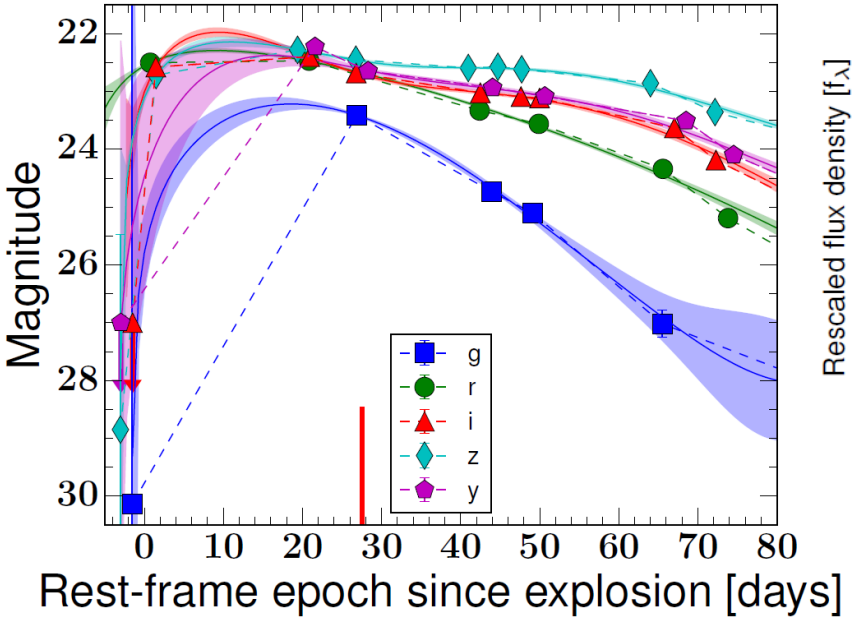
Table 1. List of SNe and SN candidates.

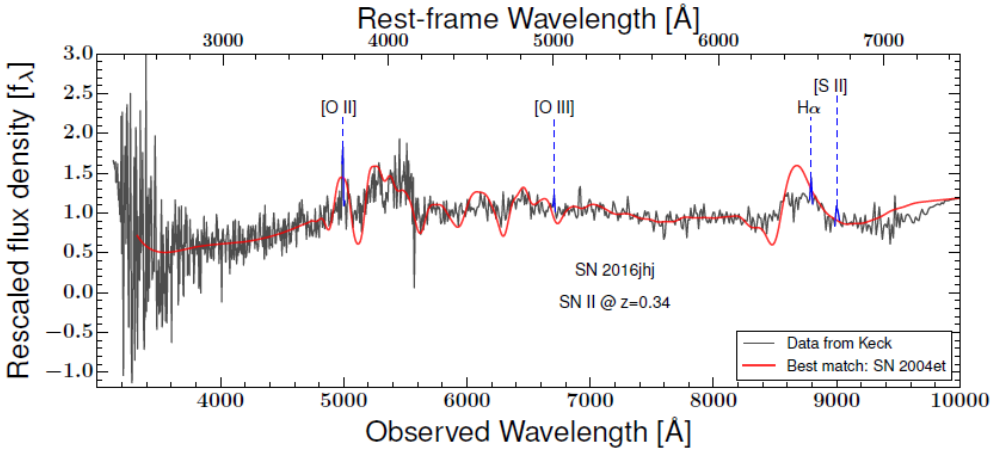
HSC name	IAU name	redshift	host galaxy magnitudes in the HSC filters g	r	i	z	y	Section
HSC16adga	SN 2016jhm	2.399 ± 0.004[a]	24.55 ± 0.03	24.42 ± 0.04	24.48 ± 0.06	24.29 ± 0.07	24.20 ± 0.13	3.1
HSC17auzg	SN 2016jhn	1.965 ± 0.004[a]	23.88 ± 0.02	23.77 ± 0.02	23.54 ± 0.02	23.41 ± 0.03	23.58 ± 0.06	3.2
HSC17dbpf	SN 2017fei	1.851 ± 0.004[a]	24.11 ± 0.02	23.91 ± 0.02	23.67 ± 0.03	23.63 ± 0.04	23.60 ± 0.08	3.3
HSC16apuo	AT 2016jho	$2.8225^{+0.4727}_{-0.7032}$[b]	27.00 ± 0.75	25.31 ± 0.19	25.50 ± 0.35	24.92 ± 0.29	26.10 ± 0.29	4.1
HSC17dsid	AT 2017fej	$4.1974^{+0.0908}_{-0.126}$[b]	27.74 ± 0.34	25.07 ± 0.04	24.83 ± 0.04	24.68 ± 0.05	25.23 ± 0.18	4.2

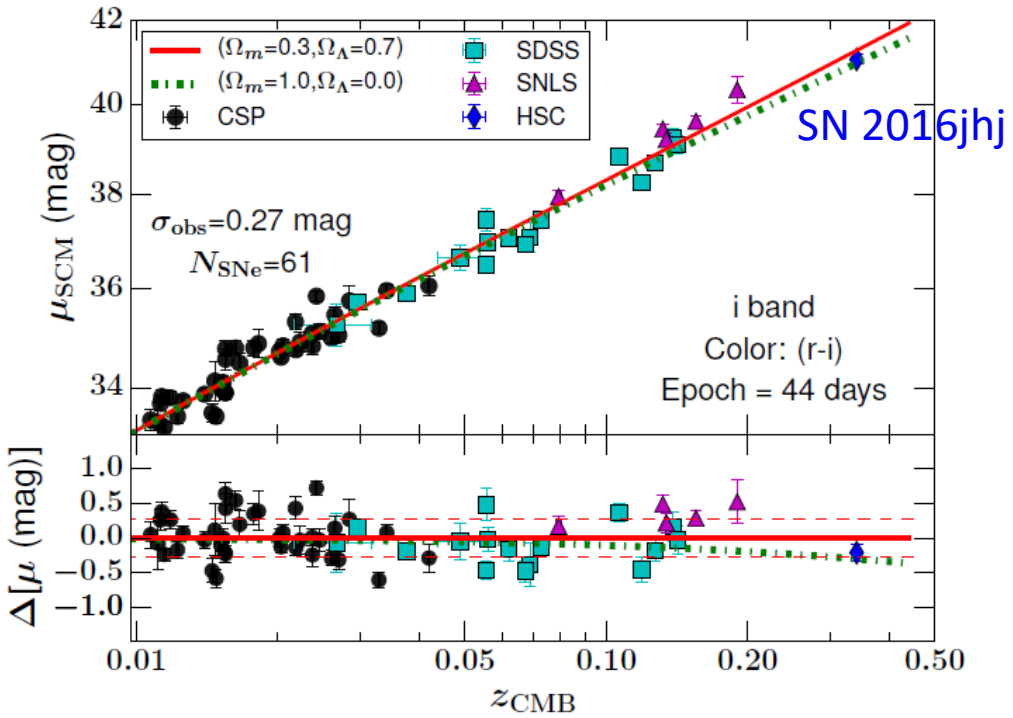
[a] Spectroscopically confirmed (Curtin et al. 2018).

[b] COSMOS2015 photometric redshift (Laigle et al. 2016).

Pick-up results -IIP cosmology-







SN 2016jhj at z=0.34 extended
the Type II supernova Hubble diagram.

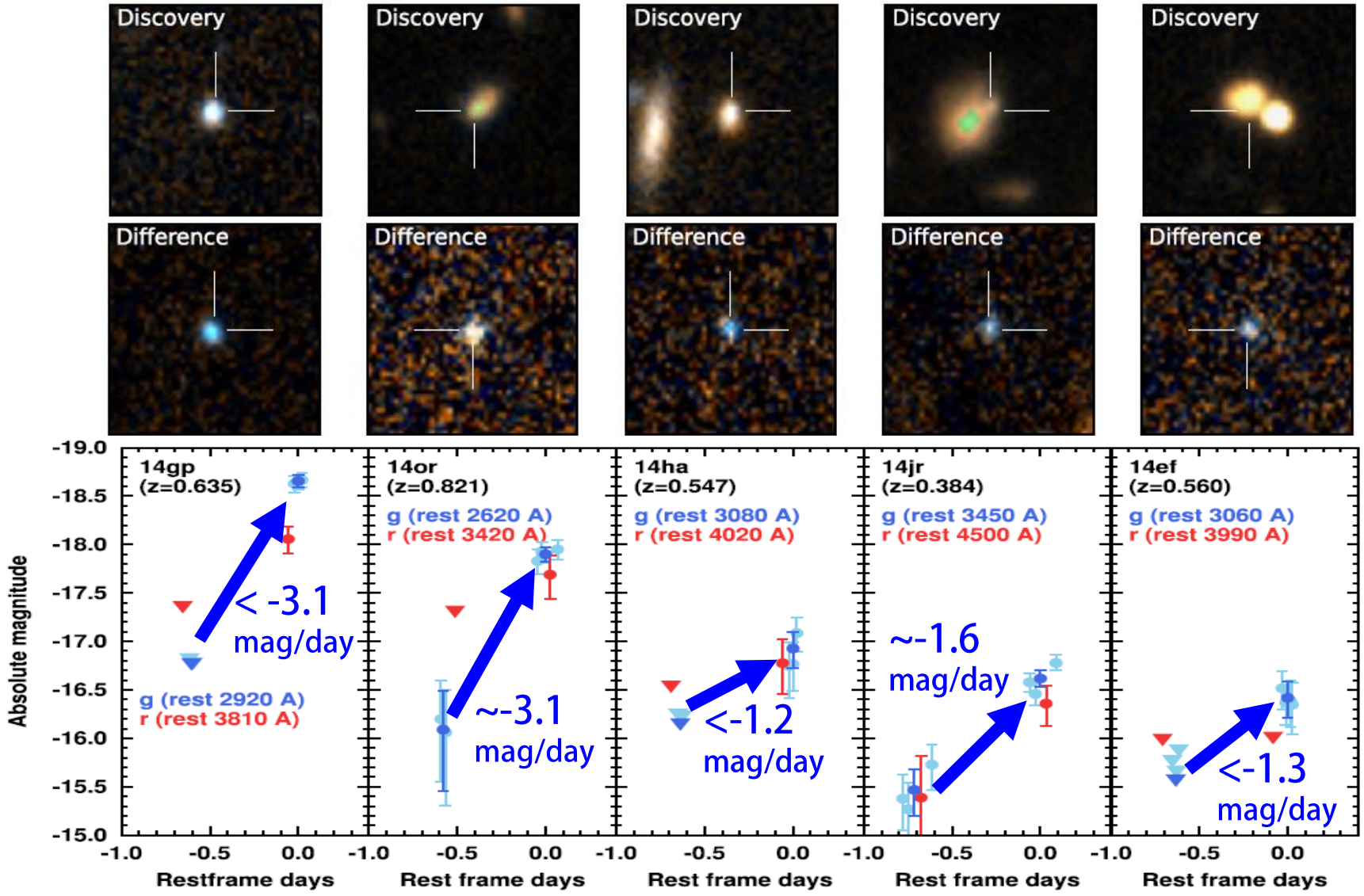
de Jaeger+18 (arXiv:1709.01513)

Openuse program

- Subaru HSC survey optimized for optical transients
  - PI: Nozomu Tominaga
  - Jul 2014 (2 nights): g,r 10min exp., 7 fields, ~1hr cadence
    follow-up at ~1month later
  - Nov 2014 (2 nights): g,r 36min exp., 2 fields, ~1hr cadence
    no follow-up
  - May 2015 (1 night): g,r 6min exp., 13 fields, ~1.5hr cadence
    follow-up cancelled
  - Aug 2015 (1 night): poor weather
  - Mar 2016 (2 x 0.5 nights): poor weather
  - Jun 2018 (4 x 0.5 nights): cancelled
- Multi-band Subaru Survey for Early-phase SNe Ia
  - PI: Jian Jiang
  - Apr 2016 (1.5 nights): g,r 1.5-2min exp., 35 fields, ~1-2hr cadence

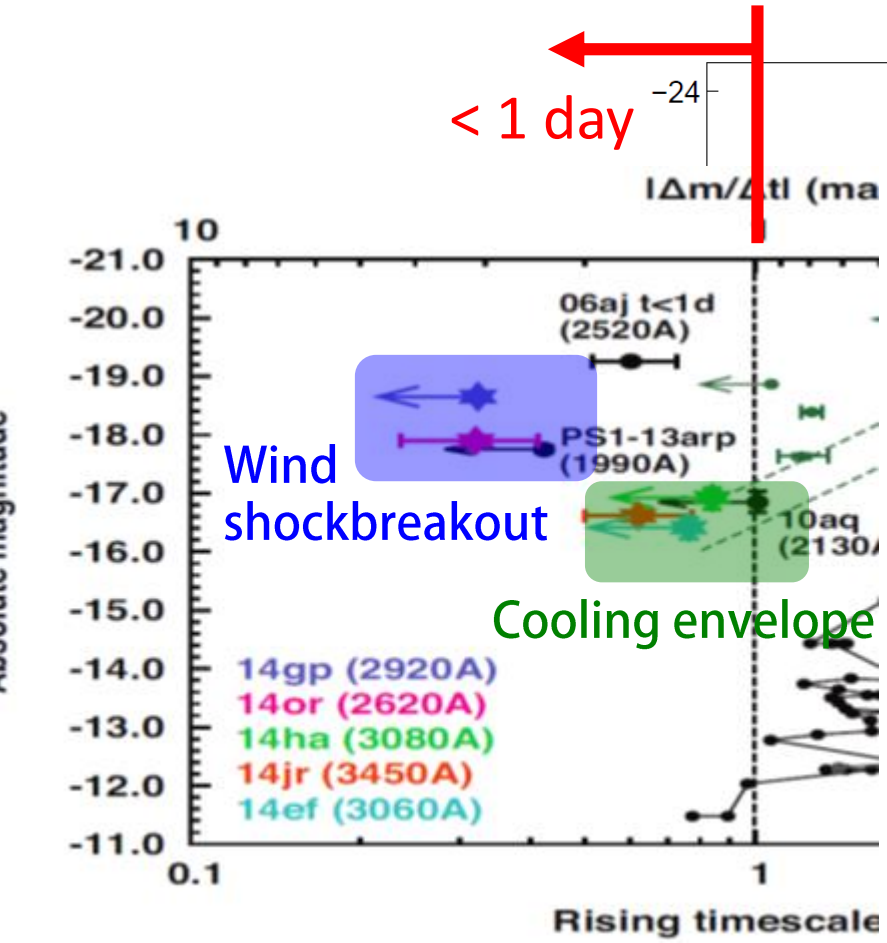
Pick-up results -rapid rising transients-

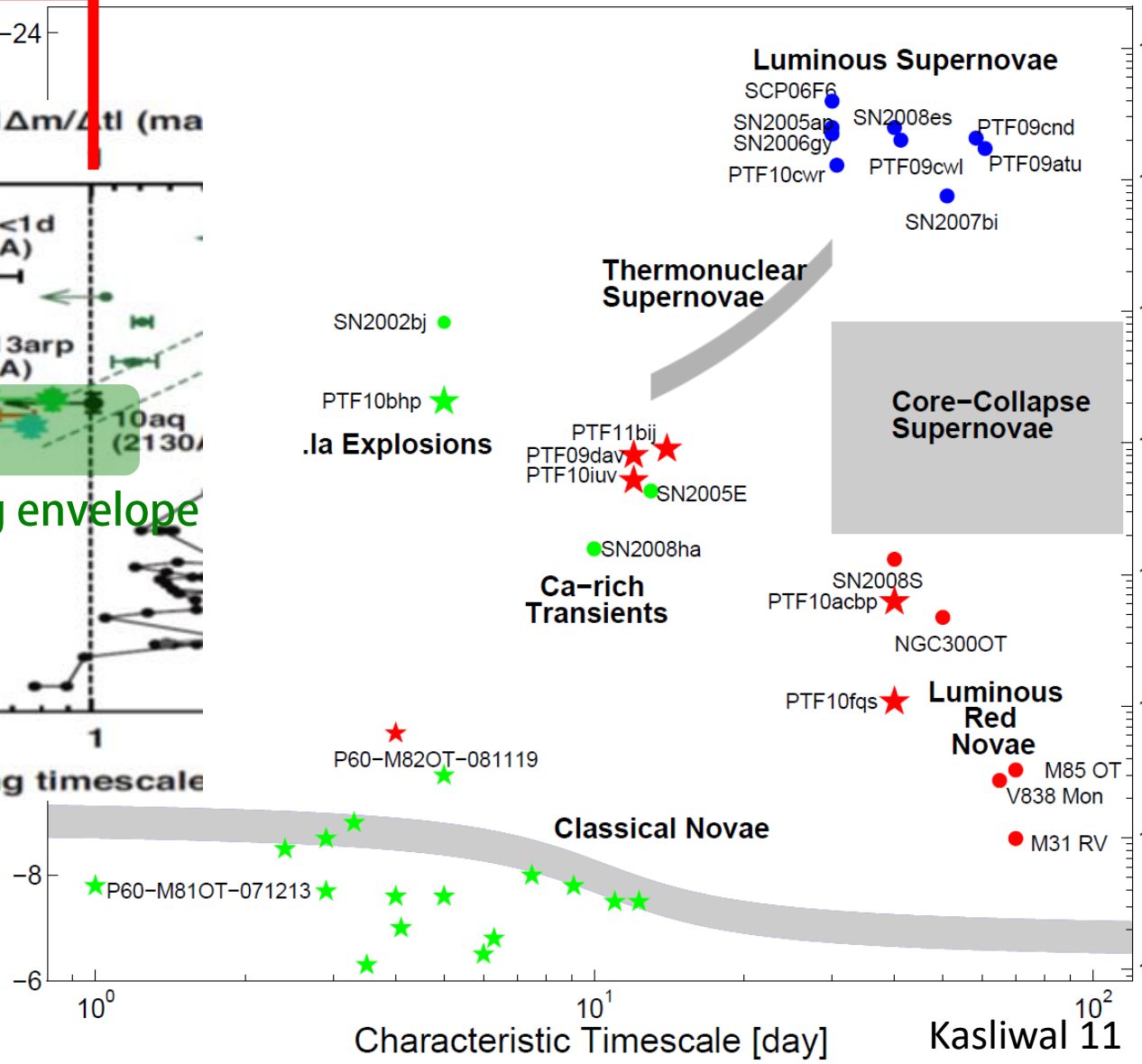
5 rapid-rising transients were discovered in 2 nights.



Tanaka, NT+ 16 (arXiv:1601.03261)

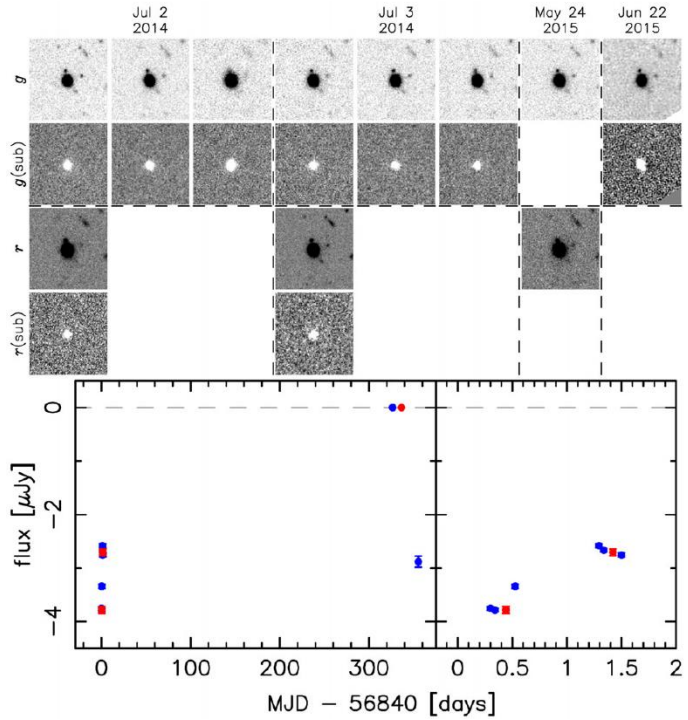
Pick-up results -rapid rising transients-





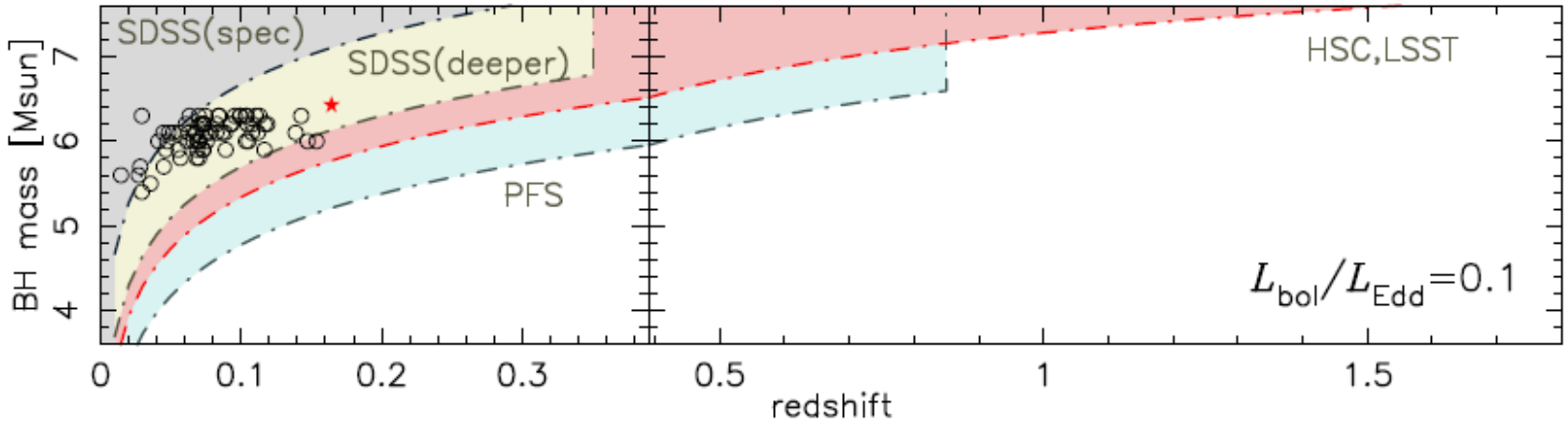
The event rate of rapid-rising transients is >~9% of the core-collapse supernova rate.

Pick-up results -low-mass AGN-



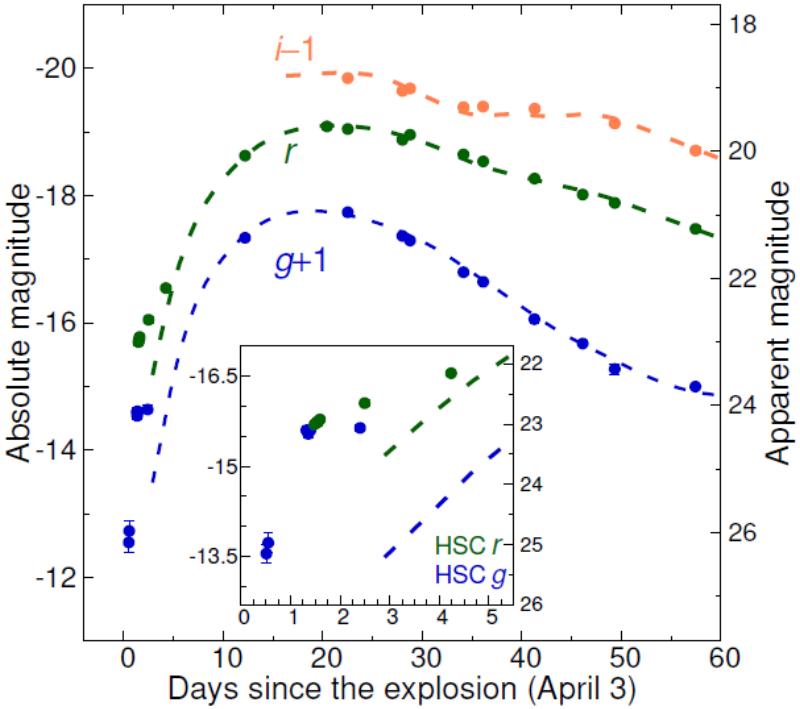
The high-cadence observation enables to select low-mass active black holes (BHs) at galaxy centers. Spectroscopic follow-up observation identify an active 2.7×10^6Msun BH at z = 0.164.

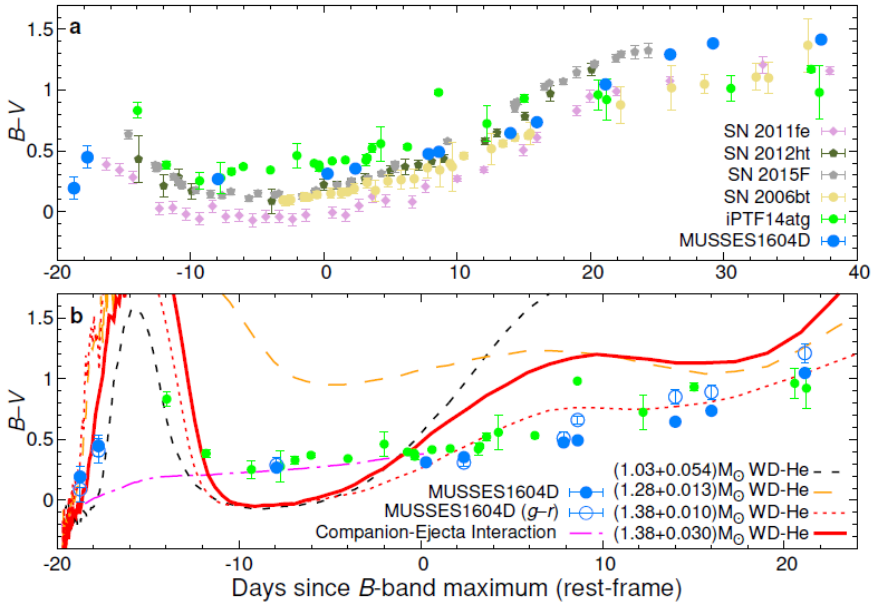
Fig. 5. Detectable BH mass as a function of redshift.
An Eddington ratio of 0.1 is assumed. A variability amplitude of 10% is also assumed.

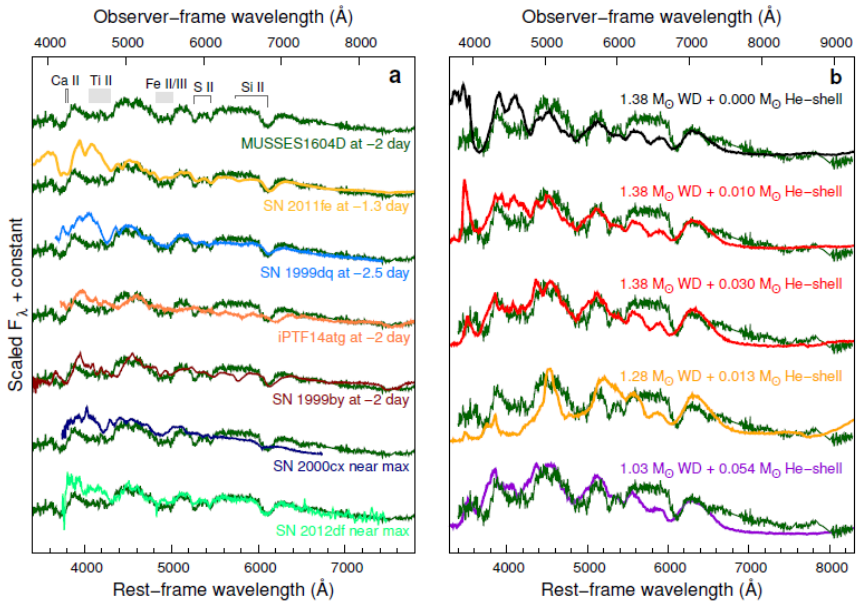


Morokuma+16 (arXiv:1603.02302)

Pick-up results -A hybrid SN Ia-







A red optical flash at ~0.5 days after explosion can be explained with a SN explosion triggered by a detonation of a thin helium shell.

Jiang + 17 (arXiv:1710.01824)

Future plan

- HSC-SSP: transient survey in SXDS
  - Aug 2019 – Jan 2020
  - 3 fields in deep (4 month), 1 field in UD (6 month)
  - high-cadence in g-band (18 fields nights)
- Openuse
  - 1hr cadence survey
  - May 1-4, 2019: 4 x 0.5 nights (+GMOS follow-up 2 nights)
  - 30 sec exp. in g (<25.1mag), 60 fields (106deg^2)
    or 1min exp. in g (<25.5mag), 45 fields (80deg^2)
- More future
  - HSC-intensive or HSC-SSP-2 for a transient survey?