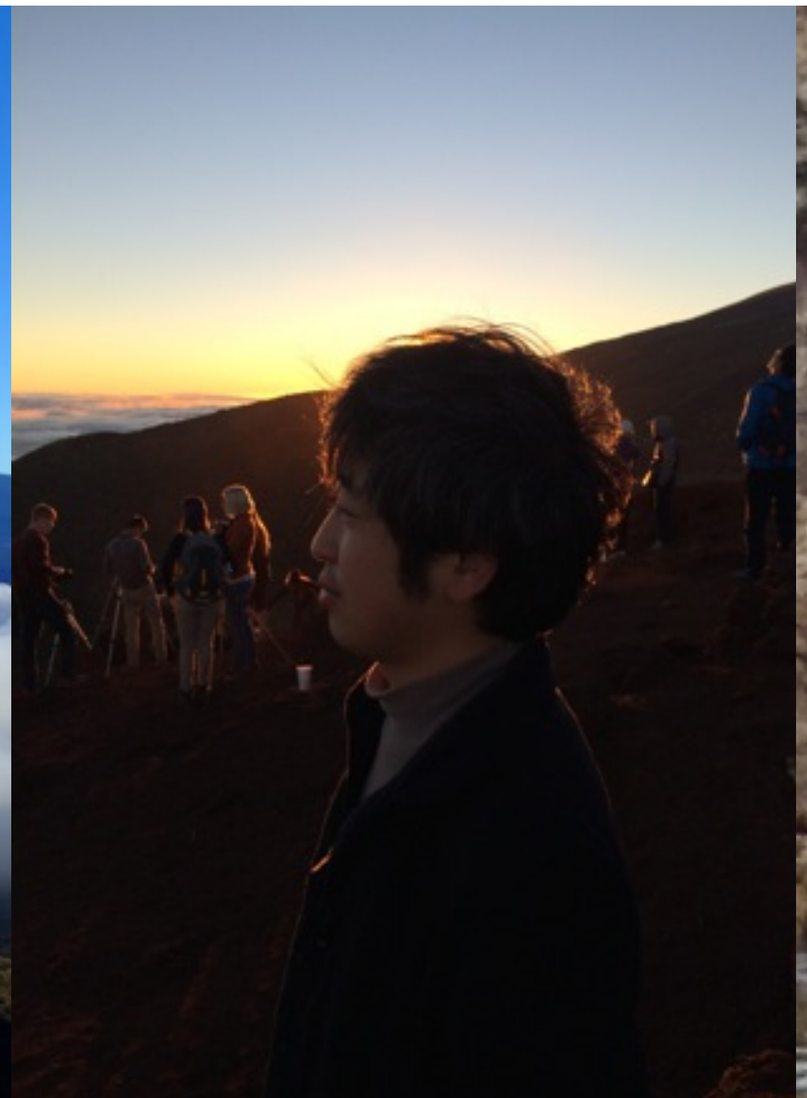
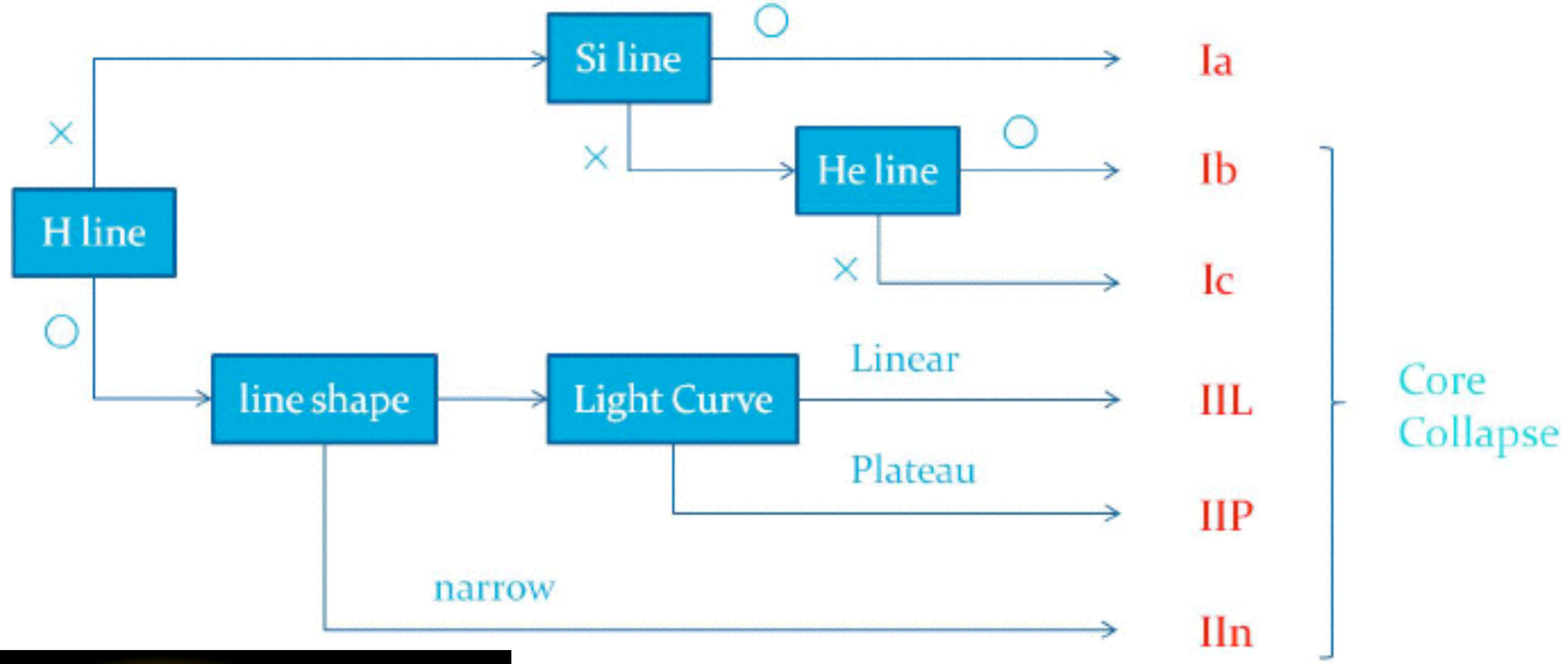
Kiso Supernova Survey (KISS)

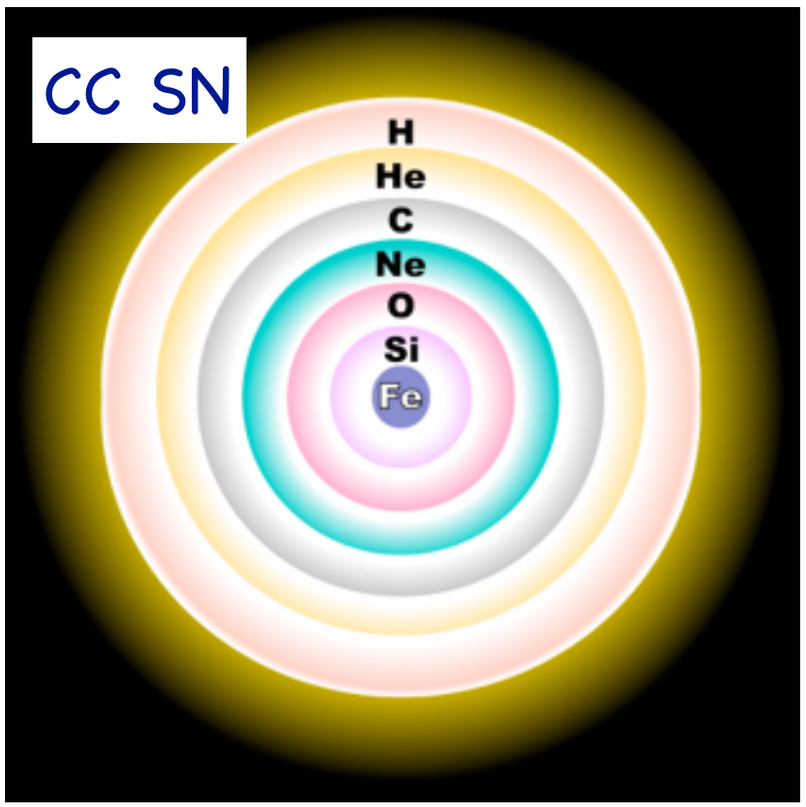
諸隈 智貴 (東京大学), 冨永 望 (甲南大学),
田中 雅臣 (国立天文台), KISS project member

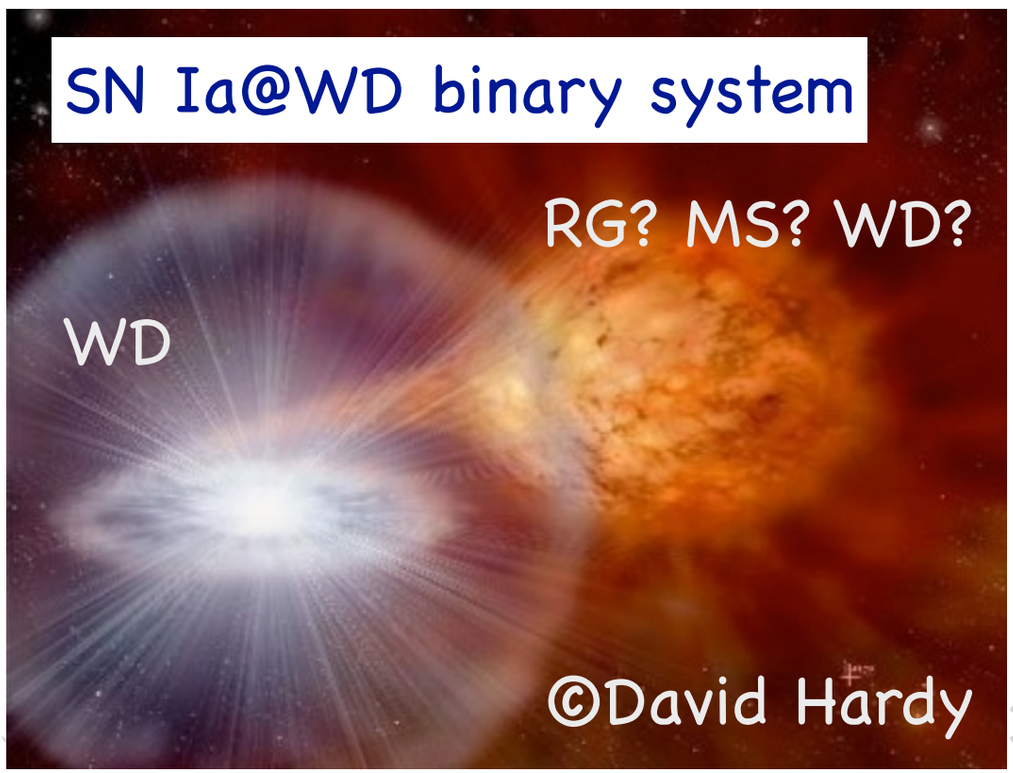


超新星 = 星の最期の大爆発

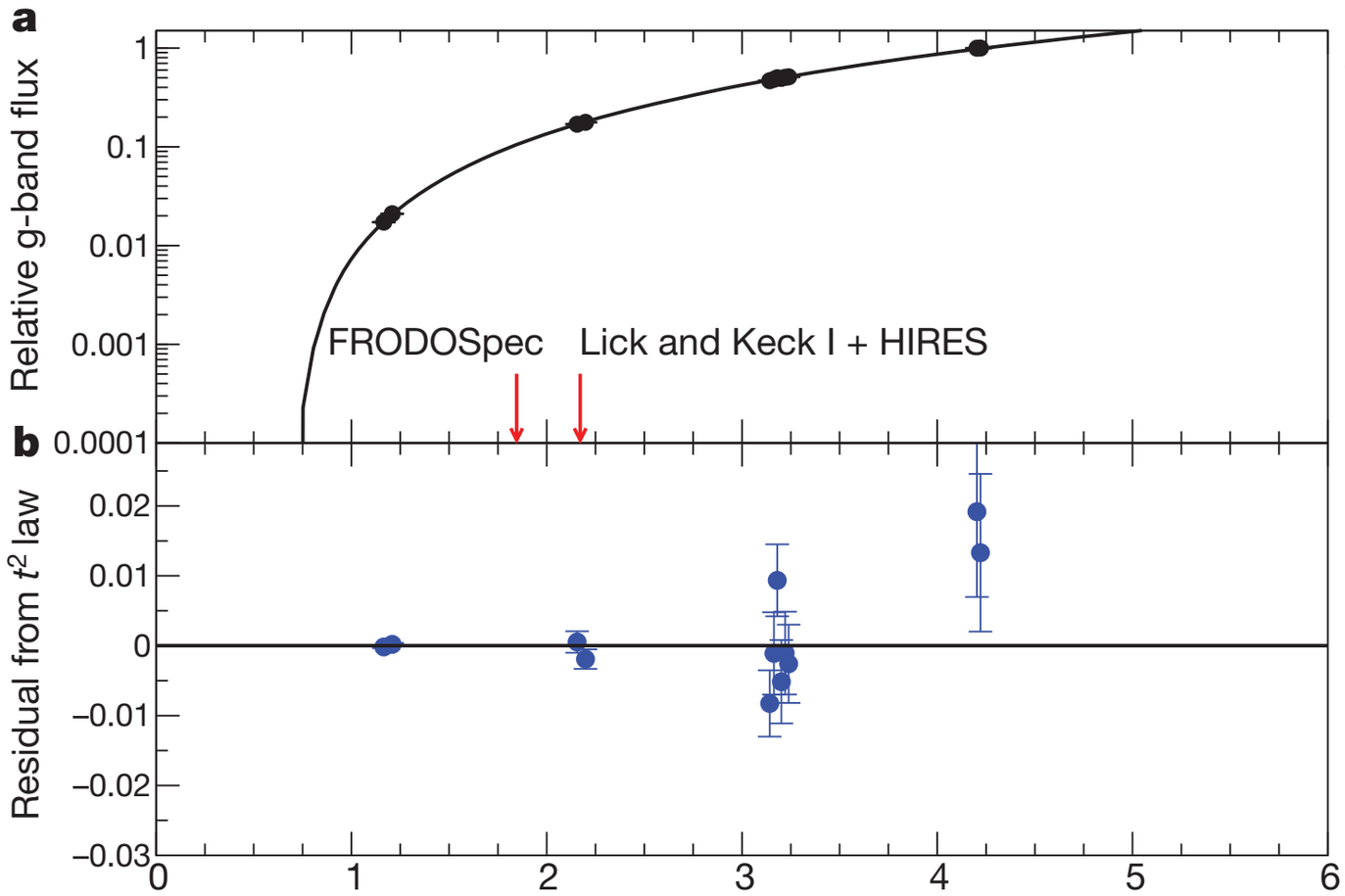
分類

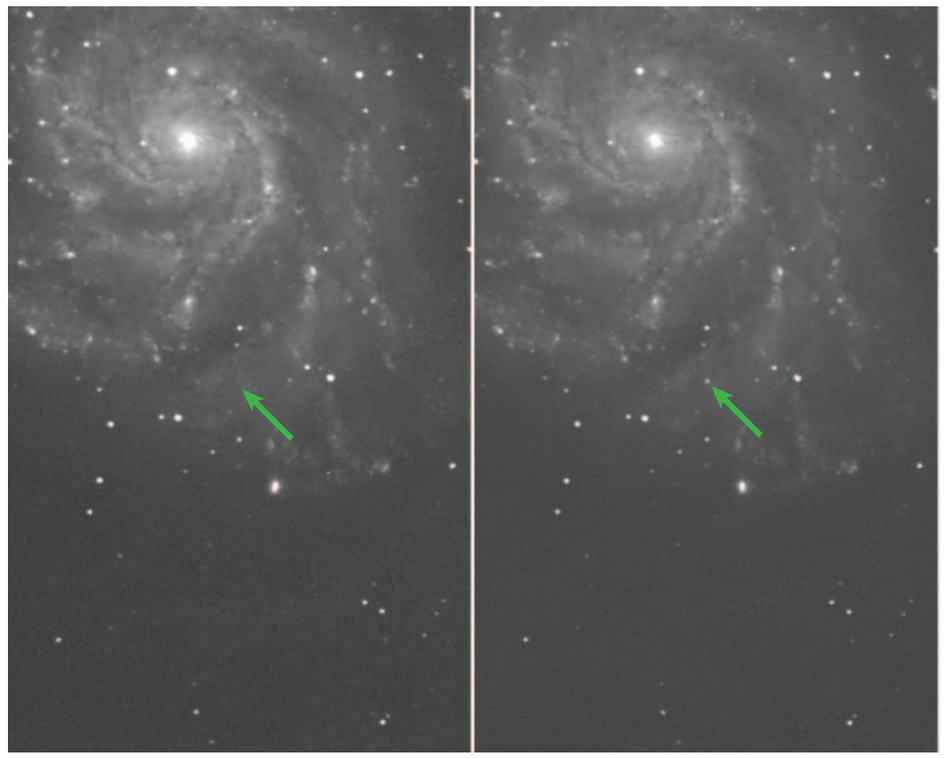






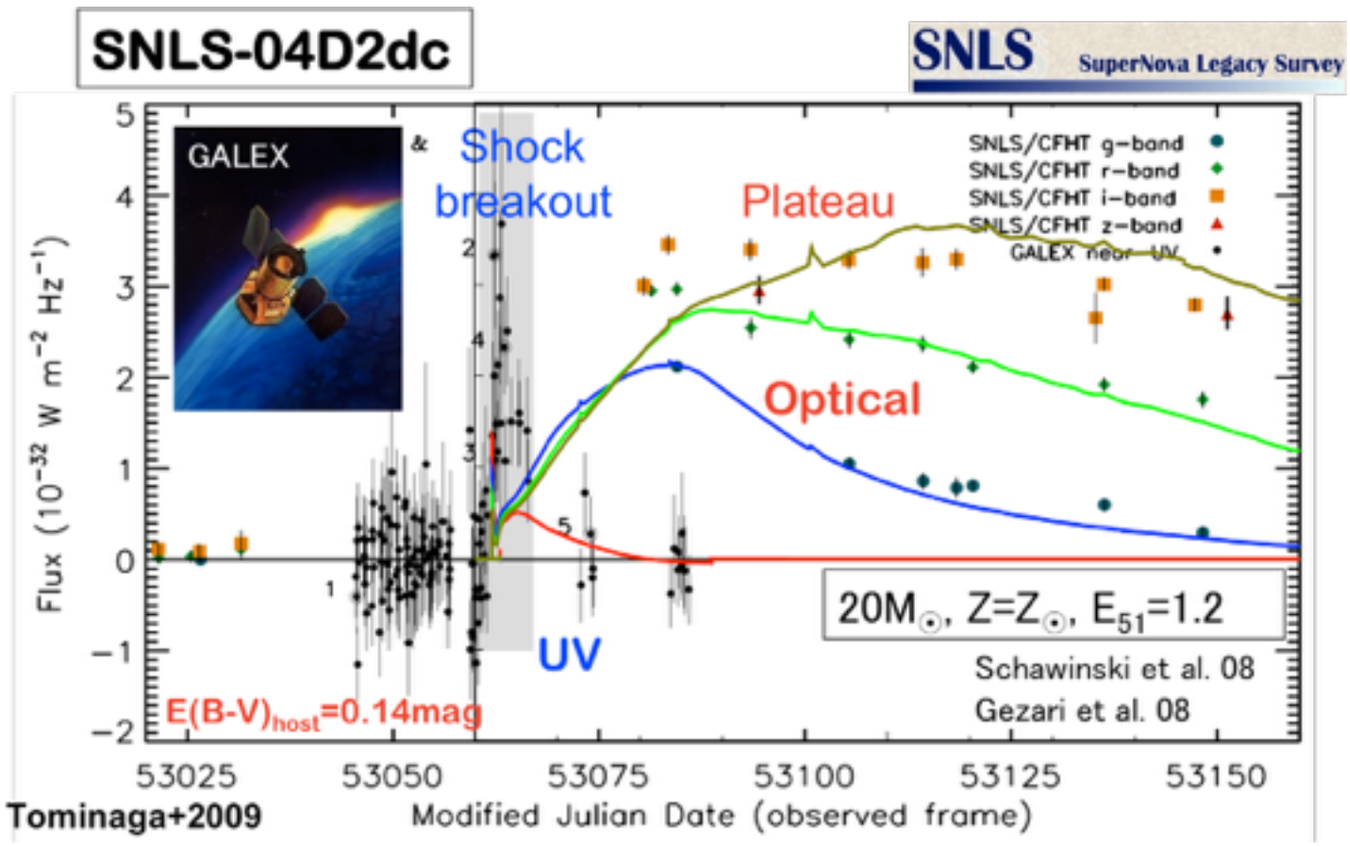
SN 2011fe (Ia, Nugent+2011)

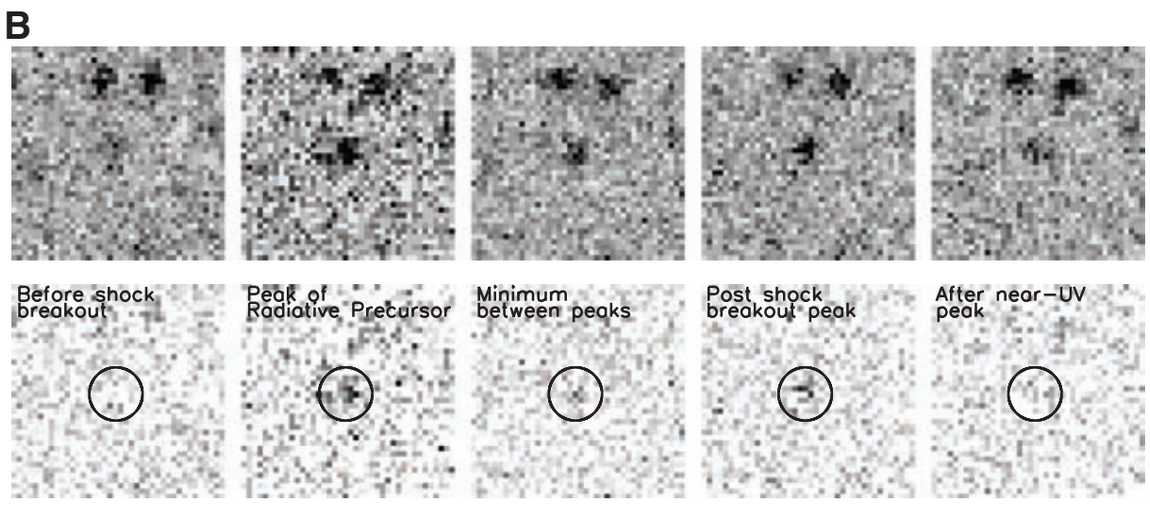




できる限り早期の発見を

Time (d since MJD 55796.0)





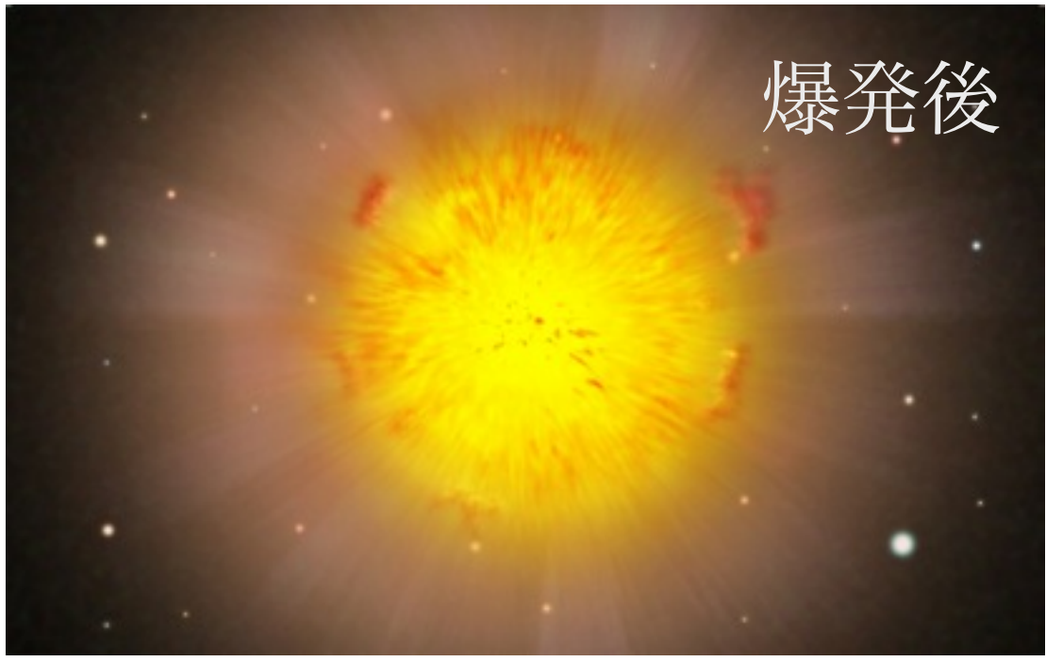
Schawinski+2008

Tominaga+2009

KISSプロジェクトの目的

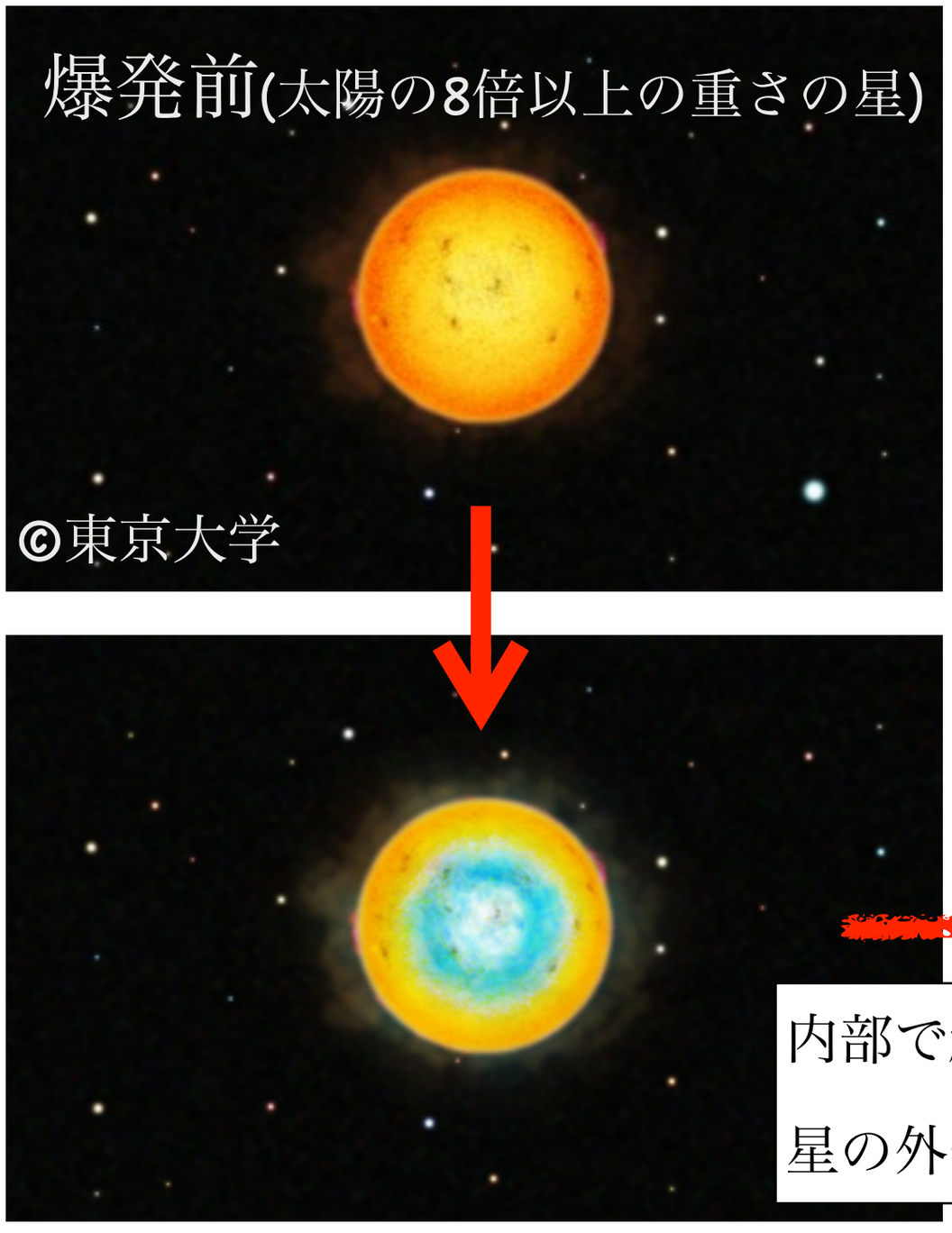
shock breakout = 超新星の爆発の"ほぼ瞬間"をとらえる

数日

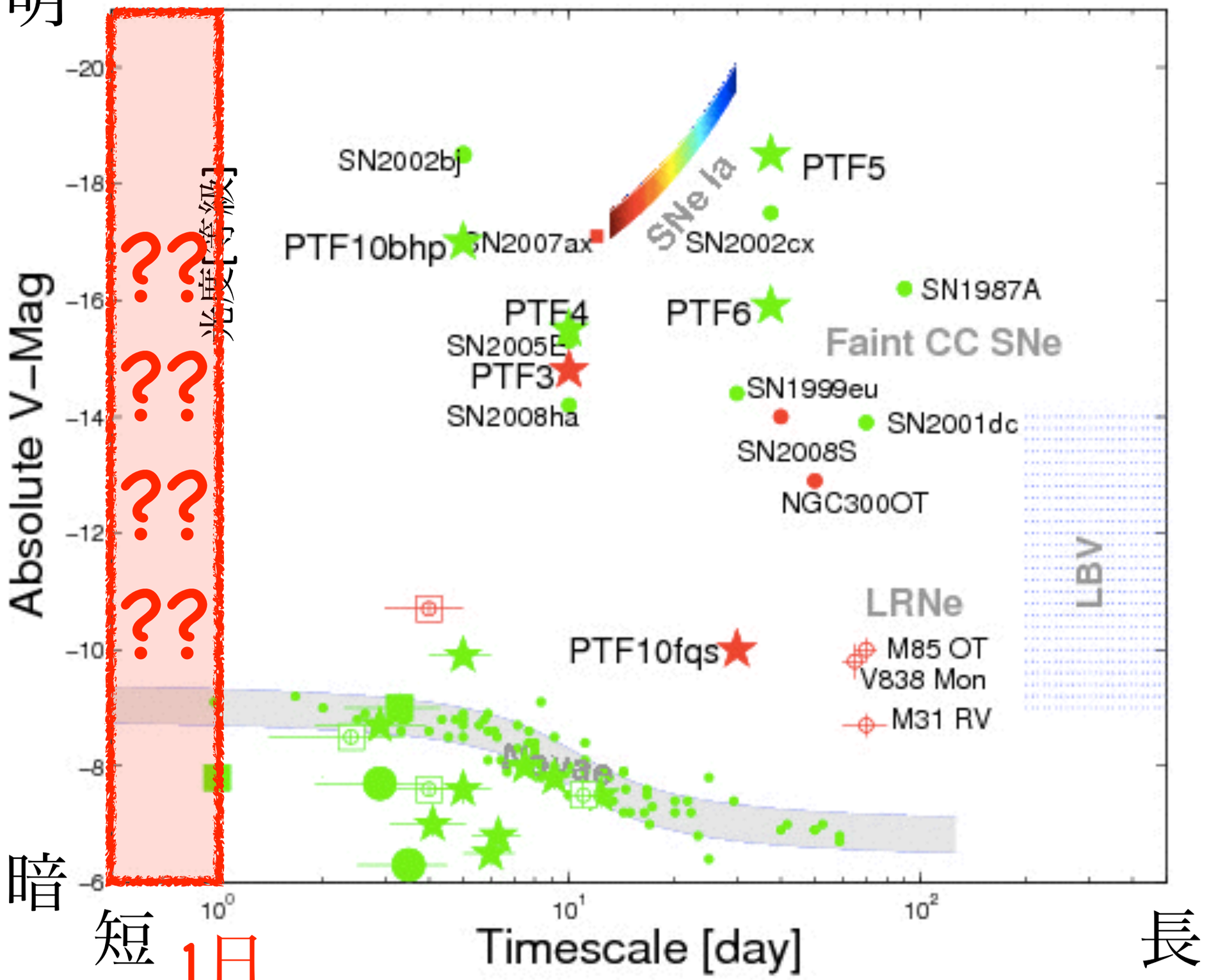


KISSプロジェクトの目的

shock breakout = 超新星の爆発の"ほぼ瞬間"をとらえる



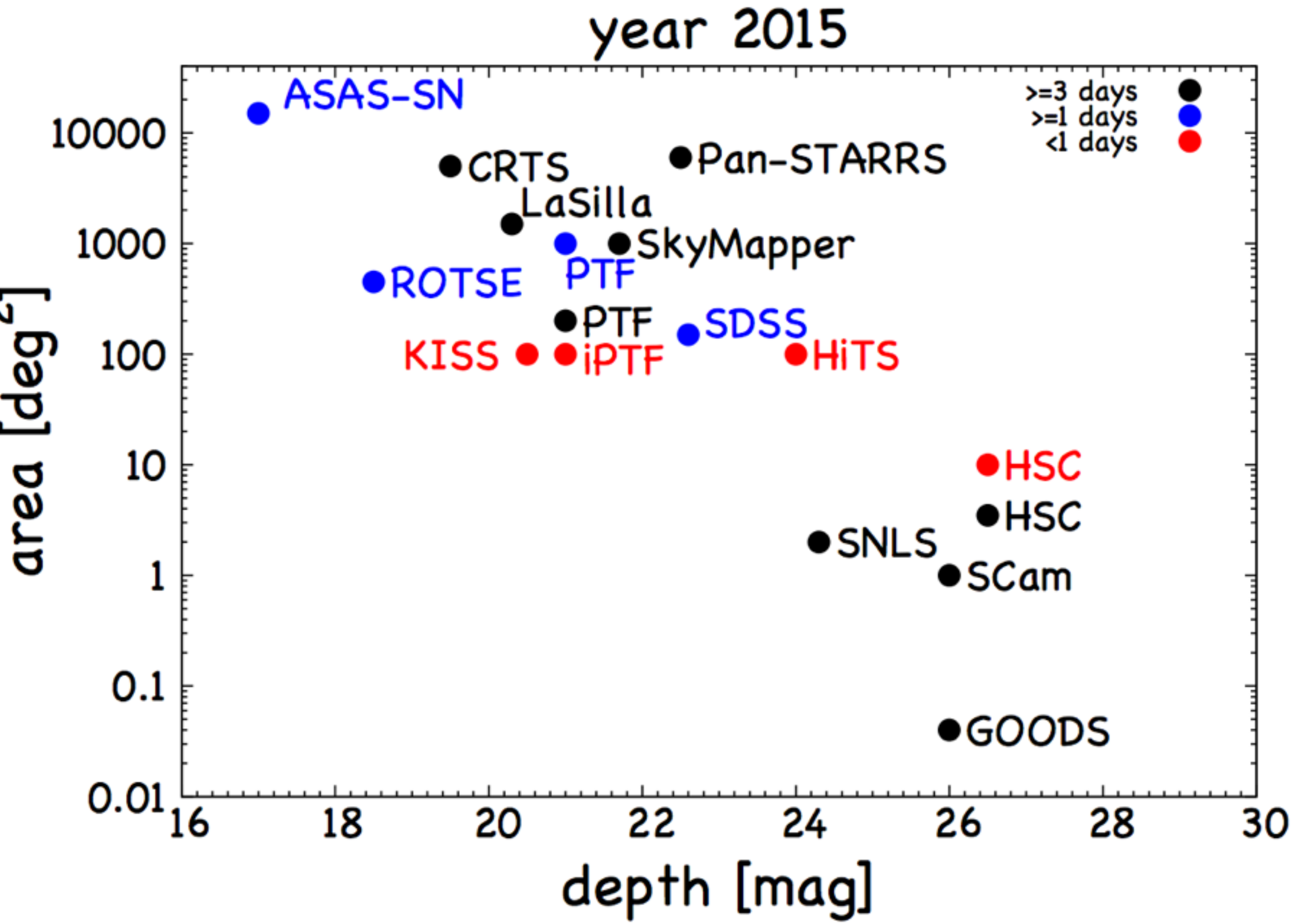
明



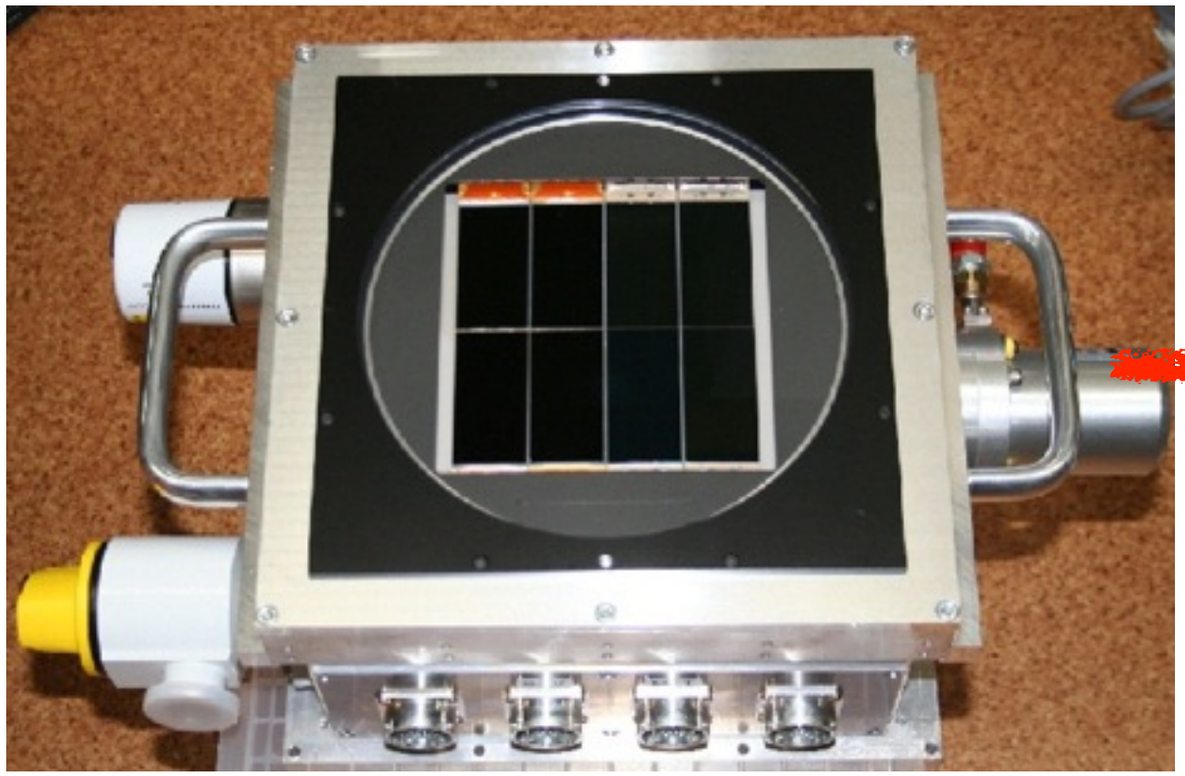
暗　　長

短　1日

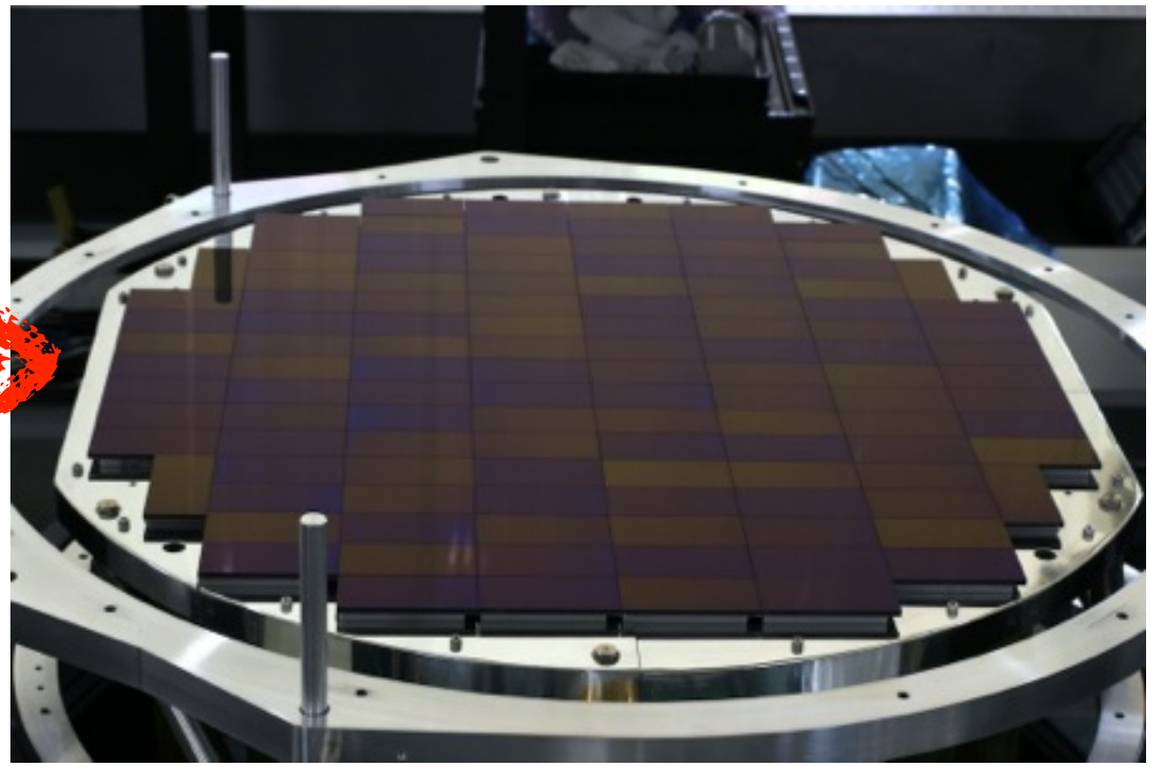
Kasliwal+2011


year 2015
area [deg^2]
depth [mag]
>=3 days
>=1 days
<1 days
ASAS-SN
CRTS
Pan-STARRS
LaSilla
SkyMapper
ROTSE
PTF
PTF
SDSS
KISS
iPTF
HiTS
HSC
HSC
SNLS
SCam
GOODS
10000
1000
100
10
1
0.1
0.01
16
18
20
22
24
26
28
30

Searches for Shock Breakouts



Kiso/KWFC



Subaru/Hyper Suprime-Cam

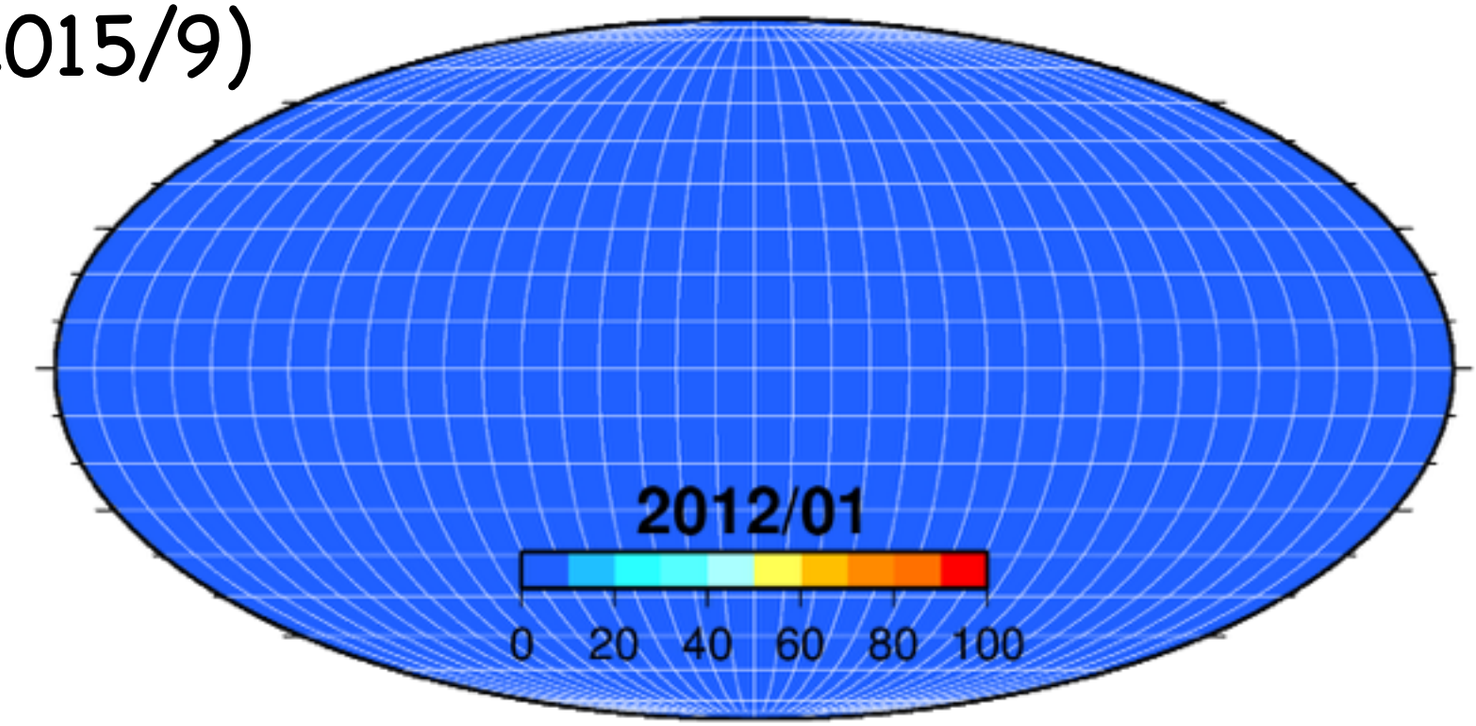
KWFC観測(KISS)でshock breakoutの物理を検証・確立

最遠方の重力崩壊型超新星の観測手段

冨永くん's talk

KISS Survey Strategy (TM+2014)

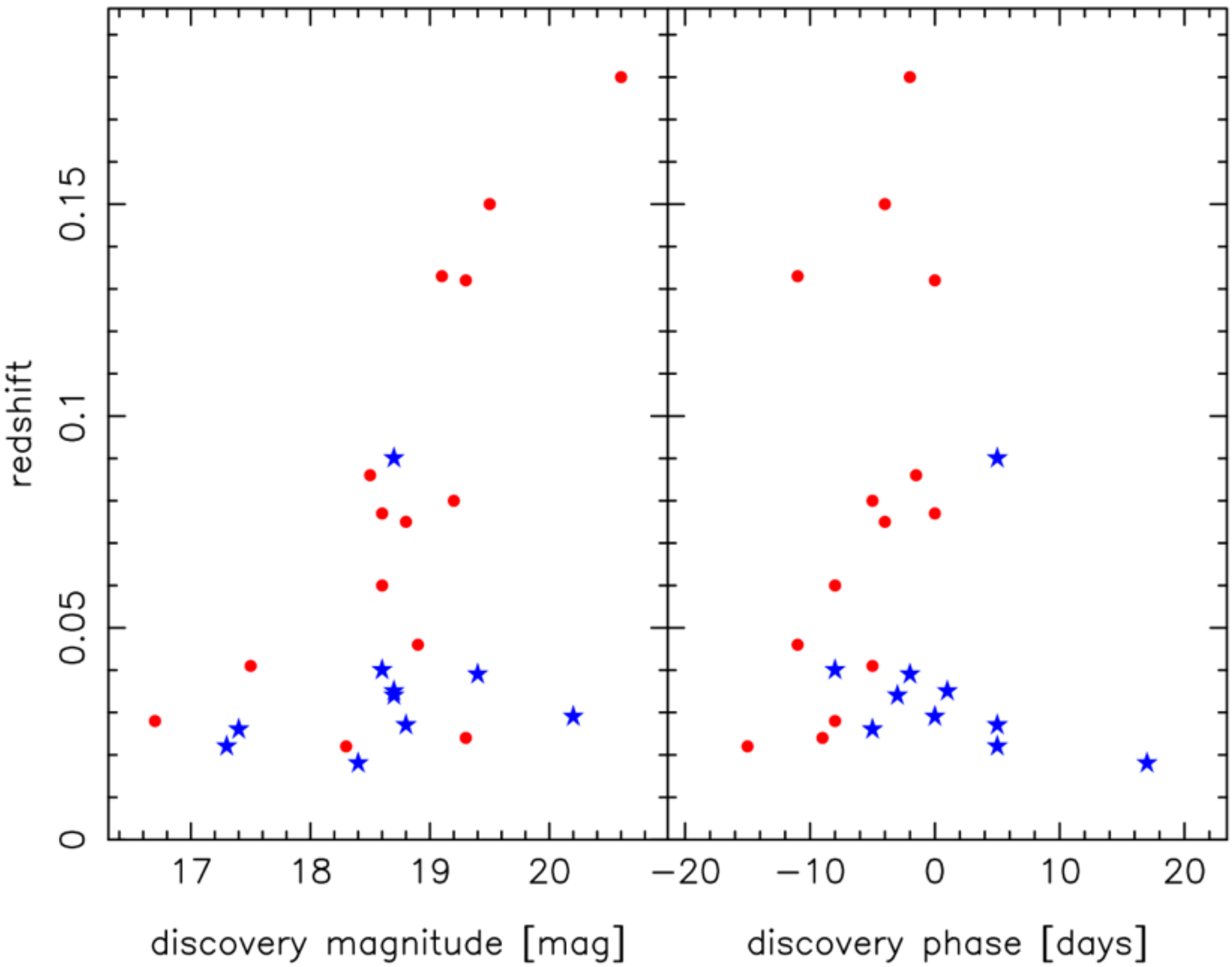
- 木曽シュミット望遠鏡 + KWFC (4 deg^2)
- g-band (4700 A)
- 3-minute exposure (20-21 mag)
- 1時間 cadence
- 50-100 deg^2 / night
- ~100 nights / year
- 2012/4 - 2015/3 (==> 2015/9)



KISS SN Summary

	2012	2013	2014	2015	計
CBET SN (KISS)	3	5	13	1	22
ATel SN (KISS)	0	0	0	2+1	2+1
dwarf nova (KISS)	0	0	1	0	1
SN by other groups	9	12	5	6	32
AGN	0	1	2	0	3
unknown transient w/ spec.	0	8	3	0	11
unknown transient w/o spec.	6	11	22	7	46
total	18	37	46	17	118

redshift vs discovery magnitude/phase (updated)



CBET / ATel name	tel	inst
SN 2012cm	Kanata	HOWPol
SN 2012cq	TNG	DOLORES
SN 2012ct	TNG	DOLORES
SN 2013I	NOT	ALFOSC
SN 2013J	NOT	ALFOSC
SN 2013Y	NOT	ALFOSC
SN 2013al	TNG	DOLORES
SN 2013ba	NOT	ALFOSC
SN 2014Q	TNG	DOLORES
SN 2014S	TNG	DOLORES
SN 2014T	TNG	DOLORES
SN 2014U	Magellan	FIRE
SN 2014an	OAO	KOOLS
SN 2014bd	du Pont	WFCCD
SN 2014bk	NOT	ALFOSC
SN 2014bo	OAO	KOOLS
SN 2014cf	Magellan	IMACS
SN 2014dh	NOT	ALFOSC
dwarf nova in Gemini	Kanata	HOWPol
SN 2014dy	OAO	KOOLS
SN 2014ec	Nayuta	LISS
SN 2014ed	Nayuta	LISS
SN 2015E	Kanata, Nayuta	HOWPol, LISS
KISS15m	NOT	ALFOSC
KISS15n	Liverpool, NOT, Magellan	SPRAT, ALFOSC, IMACS
KISS15q	Nayuta	LISS

SN Follow-Up Observations (CBET, ATel)

25 SNe
1 dwarf nova

KISS(7)
domestic(3)
TNG(6)
NOT(8)
その他海外(4)

KISS highlights

- Survey Strategy (TM+2014, PASJ) published
- peculiar RL-NLS1, KISS14k (Tanaka+2014, ApJL) published

Publ. Astron. Soc. Japan (2014) 66 (6), 114 (1–16)
doi: 10.1093/pasj/psu105
Advance Access Publication Date: 2014 December 4

Kiso Supernova Survey (KISS): Survey strategy

Tomoki Morokuma,[1,*] Nozomu Tominaga,[2,3] Masaomi Tanaka,[4] Kensho Mori,[5] Emiko Matsumoto,[2] Yuki Kikuchi,[1] Takumi Shibata,[2] Shigeyuki Sako,[1] Tsutomu Aoki,[6] Mamoru Doi,[1,7] Naoto Kobayashi,[1] Hiroyuki Maehara,[6] Noriyuki Matsunaga,[8] Hiroyuki Mito,[6] Takashi Miyata,[1] Yoshikazu Nakada,[1] Takao Soyano,[6] Ken'ichi Tarusawa,[6] Satoshi Miyazaki,[4] Fumiaki Nakata,[9] Norio Okada,[4] Yuki Sarugaku,[10] Michael W. Richmond,[11] Hiroshi Akitaya,[12] Greg Aldering,[13] Ko Arimatsu,[8,10] Carlos Contreras,[14,15] Takashi Horiuchi,[16] Eric Y. Hsiao,[14,15] Ryosuke Itoh,[5] Ikuru Iwata,[9] Koji S. Kawabata,[12] Nobuyuki Kawai,[17] Yutaro Kitagawa,[1] Mitsuru Kokubo,[1] Daisuke Kuroda,[18] Paolo Mazzali,[19,20,21] Toru Misawa,[22] Yuki Moritani,[12] Nidia Morrell,[14] Rina Okamoto,[16] Nikolay Pavlyuk,[23] Mark M. Phillips,[14] Elena Pian,[24,25] Devendra Sahu,[26] Yoshihiko Saito,[17] Kei Sano,[8,10] Maximilian D. Stritzinger,[15] Yutaro Tachibana,[17] Francesco Taddia,[27] Katsutoshi Takaki,[5] Ken Tateuchi,[1] Akihiko Tomita,[28] Dmitry Tsvetkov,[23] Takahiro Ui,[5] Nobuharu Ukita,[18] Yuji Urata,[29] Emma S. Walker,[30] and Taketoshi Yoshii[17]

[1]Institute of Astronomy, Graduate School of Science, The University of Tokyo, 2-21-1 Osawa, Mitaka, Tokyo 181-0015, Japan
[2]Department of Physics, Faculty of Science and Engineering, Konan University, 8-9-1 Okamoto, Kobe, Hyogo 658-8501, Japan
[3]Kavli Institute for the Physics and Mathematics of the Universe (WPI), The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8583, Japan
[4]National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
[5]Department of Physical Science, Hiroshima University, 1-3-1 Kagamiyama, Higashi-Hiroshima, Hiroshima 739-8526, Japan
[6]Kiso Observatory, Institute of Astronomy, Graduate School of Science, The University of Tokyo 10762-30, Mitake, Kiso-machi, Kiso-gun, Nagano 397-0101, Japan
[7]Research Center for the Early Universe, Graduate School of Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-003, Japan

The Astrophysical Journal Letters, 793:L26 (6pp), 2014 October 1
doi:10.1088/2041-8205/793/2/L26

DISCOVERY OF DRAMATIC OPTICAL VARIABILITY IN SDSS J1100+4421: A PECULIAR RADIO-LOUD NARROW-LINE SEYFERT 1 GALAXY?

Masaomi Tanaka[1], Tomoki Morokuma[2], Ryosuke Itoh[3], Hiroshi Akitaya[4], Nozomu Tominaga[5,6], Yoshihiko Saito[7], Łukasz Stawarz[8,9], Yasuyuki T. Tanaka[4], Poshak Gandhi[10], Gamal Ali[11], Tsutomu Aoki[12], Carlos Contreras[13], Mamoru Doi[2], Ahmad Essam[11], Gamal Hamed[11], Eric Y. Hsiao[13], Ikuru Iwata[14], Koji S. Kawabata[4], Nobuyuki Kawai[7], Yuki Kikuchi[2], Naoto Kobayashi[2], Daisuke Kuroda[15], Hiroyuki Maehara[11], Emiko Matsumoto[5], Paolo A. Mazzali[16,17,18], Takeo Minezaki[2], Hiroyuki Mito[11], Takashi Miyata[2], Satoshi Miyazaki[1], Kensho Mori[3], Yuki Moritani[4], Kana Morokuma-Matsui[19], Nidia Morrell[13], Tohru Nagao[20], Yoshikazu Nakada[2], Fumiaki Nakata[14], Chinami Noma[21], Ken Ohsuga[1], Norio Okada[1], Mark M. Phillips[13], Elena Pian[22,23], Michael W. Richmond[24], Devendra Sahu[25], Shigeyuki Sako[2], Yuki Sarugaku[8], Takumi Shibata[3], Takao Soyano[11], Maximilian D. Stritzinger[26], Yutaro Tachibana[7], Francesco Taddia[27], Katsutoshi Takaki[3], Ali Takey[11], Ken'ichi Tarusawa[12], Takahiro Ui[3], Nobuharu Ukita[15], Yuji Urata[28], Emma S. Walker[29], and Taketoshi Yoshii[7]

[1] National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588, Japan; masaomi.tanaka@nao.ac.jp
[2] Institute of Astronomy, School of Science, University of Tokyo, Mitaka, Tokyo 181-0015, Japan
[3] Department of Physical Sciences, Hiroshima University, Higashi-Hiroshima, Hiroshima 739-8526, Japan
[4] Hiroshima Astrophysical Science Center, Hiroshima University, Higashi-Hiroshima, Hiroshima 739-8526, Japan
[5] Department of Physics, Faculty of Science and Engineering, Konan University, Kobe, Hyogo 658-8501, Japan
[6] Kavli Institute for the Physics and Mathematics of the Universe (WPI), The University of Tokyo, Kashiwa, Chiba 277-8583, Japan
[7] Department of Physics, Tokyo Institute of Technology, Meguro-ku, Tokyo 152-8551, Japan
[8] Institute of Space and Astronautical Science, JAXA, Sagamihara, Kanagawa 252-5210, Japan
[9] Astronomical Observatory, Jagiellonian University, ul. Orla 171, 30-244 Krakow, Poland
[10] Department of Physics, Durham University, Durham DH1-3LE, UK
[11] National Research Institute of Astronomy and Geophysics, Helwan, Cairo, Egypt
[12] Kiso Observatory, Institute of Astronomy, School of Science, The University of Tokyo, Kiso, Nagano 397-0101, Japan
[13] Carnegie Observatories, Las Campanas Observatory, Colina El Pino, Casilla 601, Chile
[14] Subaru Telescope, National Astronomical Observatory of Japan, Hilo, HI 96720, USA
[15] Okayama Astrophysical Observatory, National Astronomical Observatory of Japan, Asakuchi, Okayama 719-0232, Japan
[16] Astrophysics Research Institute, Liverpool John Moores University, IC2, Liverpool Science Park, 146 Brownlow Hill, Liverpool L3 5RF, UK
[17] Istituto Nazionale di Astrofisica-OAPd, vicolo dell'Osservatorio 5, I-35122 Padova, Italy
[18] Max-Planck-Institut für Astrophysik, Karl-Schwarzschild-Strasse 1, D-85748 Garching, Germany
[19] Nobeyama Radio Observatory, Nobeyama, Minamimaki, Minamisaku, Nagano 384-1305, Japan
[20] Research Center for Space and Cosmic Evolution, Ehime University, Bunkyo-cho, Matsuyama 790-8577, Japan
[21] Astronomical Institute, Tohoku University, Aramaki, Aoba-ku, Sendai 980-8578, Japan
[22] Scuola Normale Superiore di Pisa, Piazza dei Cavalieri 7, I-56126 Pisa, Italy
[23] INAF-Istituto di Astrofisica Spaziale e Fisica Cosmica, Via P. Gobetti 101, I-40129 Bologna, Italy
[24] Department of Physics, Rochester Institute of Technology, 85 Lomb Memorial Drive, Rochester, NY 14623-5603, USA
[25] Indian Institute of Astrophysics, Koramangala, Bangalore 560 034, India
[26] Department of Physics and Astronomy, Aarhus University, Ny Munkegade, DK-8000 Aarhus C, Denmark
[27] The Oskar Klein Centre, Department of Astronomy, Stockholm University, AlbaNova, SE-10691 Stockholm, Sweden
[28] Institute of Astronomy, National Central University, Chung-Li 32054, Taiwan
[29] Department of Physics, Yale University, New Haven, CT 06520-8120, USA
Received 2014 July 9; accepted 2014 September 1; published 2014 September 11

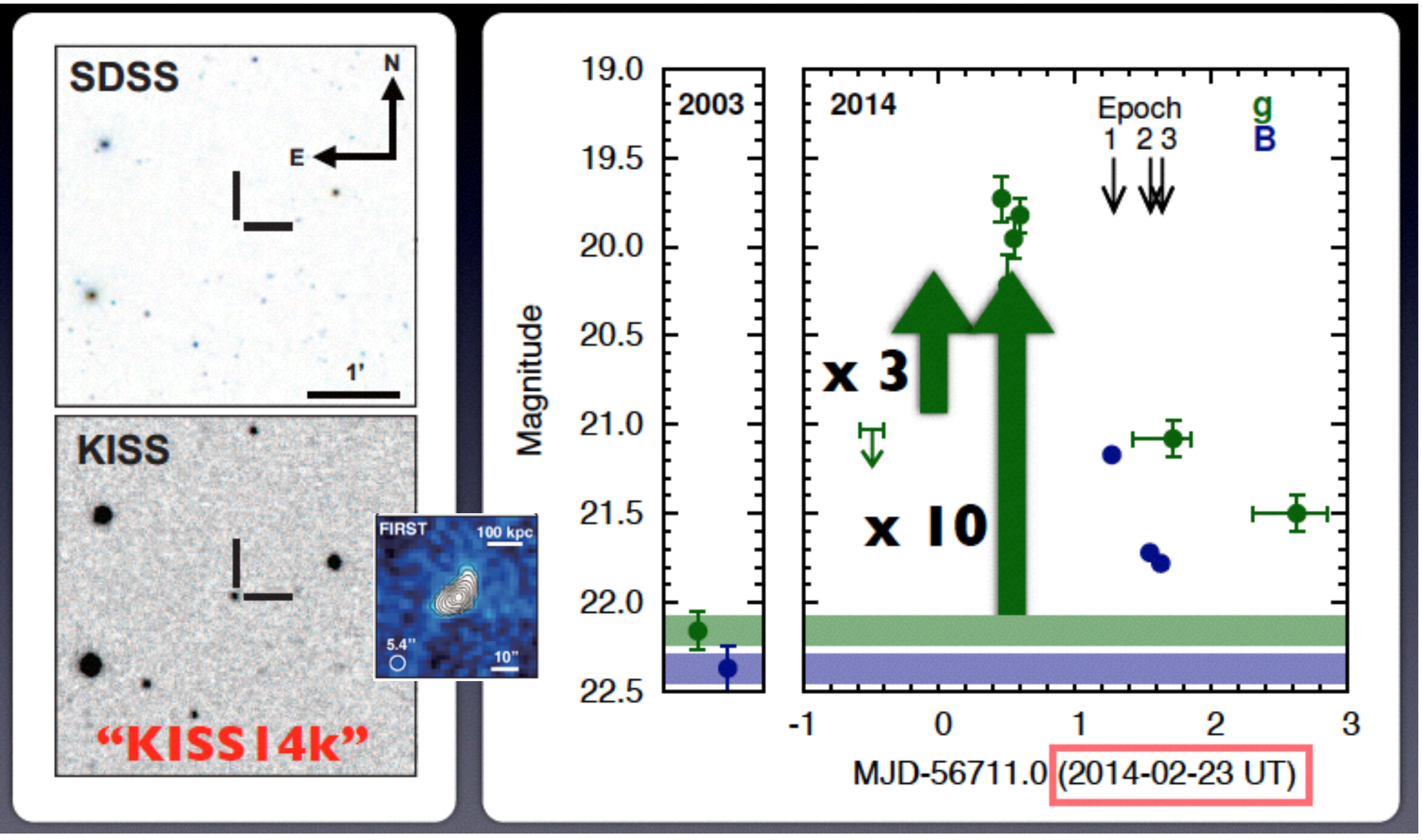
ABSTRACT

We present our discovery of dramatic variability in SDSS J1100+4421 by the high-cadence transient survey Kiso Supernova Survey. The source brightened in the optical by at least a factor of three within about half a day. Spectroscopic observations suggest that this object is likely a narrow-line Seyfert 1 galaxy (NLS1) at $z = 0.840$, however, with unusually strong narrow emission lines. The estimated black hole mass of $\sim 10^7 M_\odot$ implies bolometric nuclear luminosity close to the Eddington limit. SDSS J1100+4421 is also extremely radio-

KISS highlights

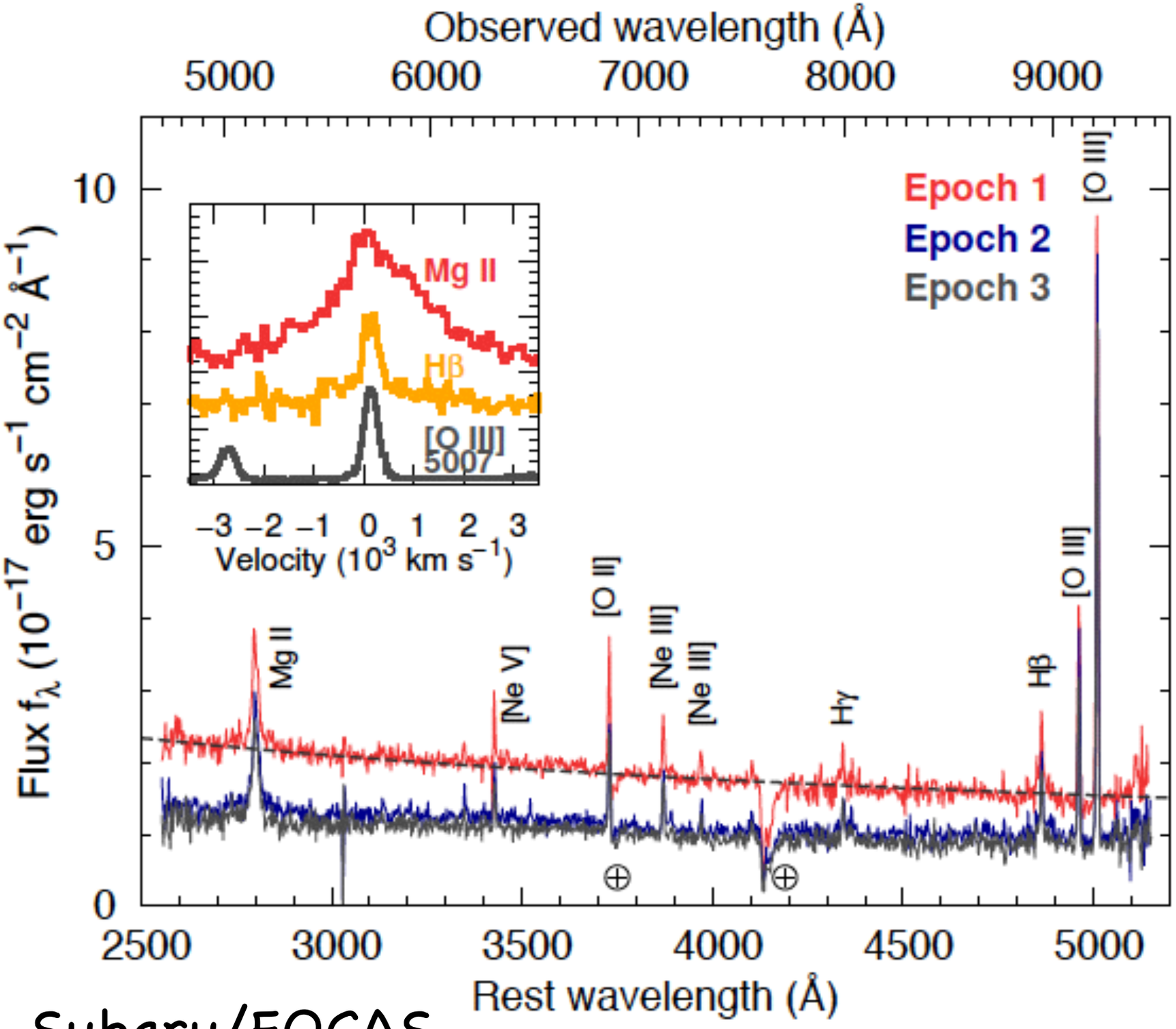
- Survey Strategy (TM+2014, PASJ) published
- peculiar RL-NLS1, KISS14k (Tanaka+2014, ApJL) published
- KISS14k OISTER 1-month observations (TM+2015a) in prep.
- Type Ibn SN, KISS14z/SN 2014bk (TM+2015b) in prep.
- KISS14k EVN+VERA observations (Gabanyi+?)
- Early detections of Type Ia SNe (Jiang+2015) in prep.
- short time-scale transient rate (Tanaka+?)
- [SN shock breakout ?]

KISS14k: radio-loud narrow-line Seyfert 1



Tanaka+2014

KISS14k: radio-loud narrow-line Seyfert 1



- 1-2x10^7 Msun
- strong [OIII]
- extended NLR?

Subaru/FOCAS

Tanaka+2014

KISS14k: OISTER 1-month (2014/10-11) Monitoring

- z=0.84 radio-loud narrow-line Seyfert 1 (Tanaka+2014)
- 2 components ==> jet w/ 2 different electron energy distribution or jet+accretion disk

Morokuma+2015, in prep.

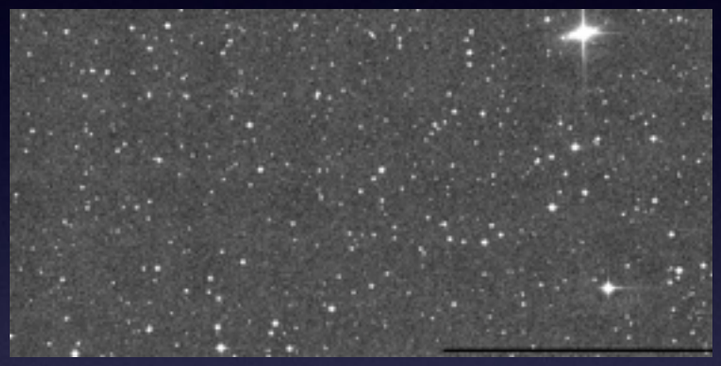
KISS14z: Ibn型超新星@z=0.0697

- Ib + "n": 濃いCSM
- これまでの報告例: ~10天体
- 最大光度前の発見は2例目?

Early detections of Type Ia SNe (Jiang+, in prep.)

Kiso observatory

KISS pipeline



standard reduction

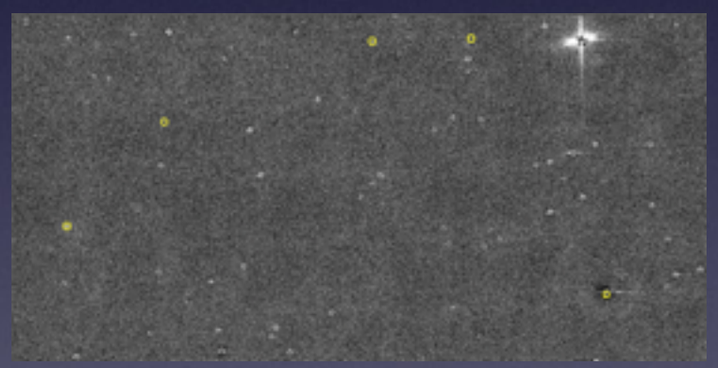


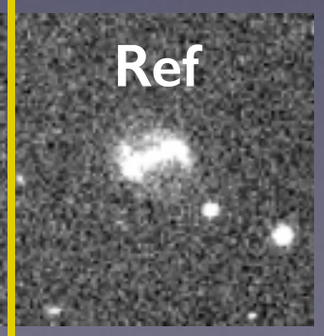
image subtraction

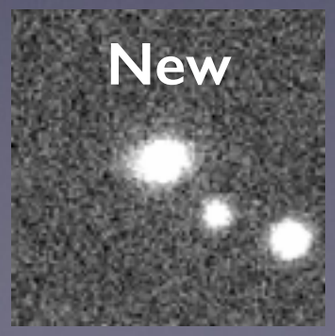
source detection

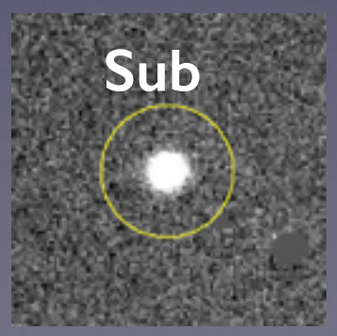
< 10 min

~ 50GB/day

cut-out images



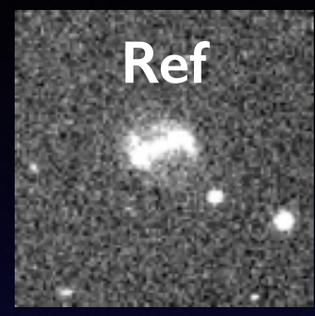


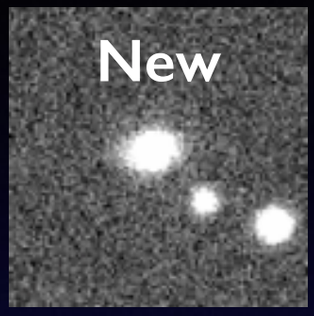


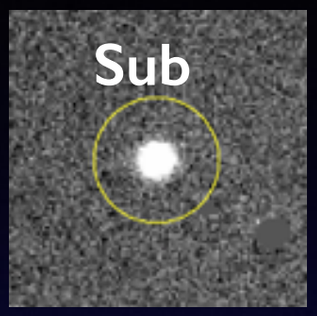
KISS database

Tokyo

cut-out images







KISS database

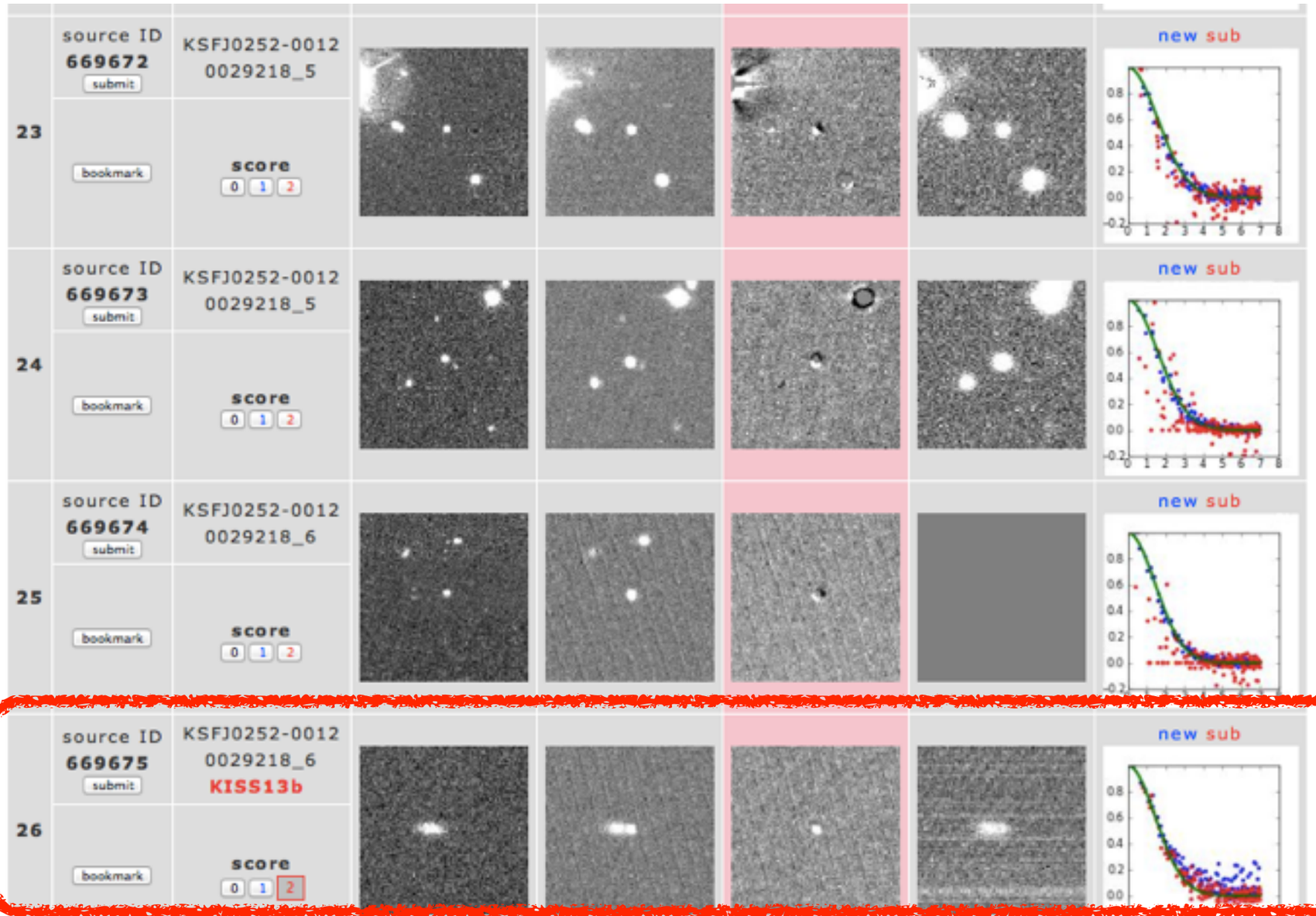
KISS interface

facebook Realtime check

Amateur astronomers@amywhere

Japanese Amateur Astronomers' Help

- ~20人のアマチュアの方々の参加
- 大量の偽物の変動天体から本物(1000個に1個)を選び出す



Japanese Amateur Astronomers' Help

- ~20人のアマチュアの方々の参加
- 大量の偽物の変動天体から本物(1000個に1個)を選び出す
- 27天体のCBET/ATel報告中、17の報告に貢献
- 共著者として報告文章に名前を記載

Title: Supernova 2014cf
Authors: Morokuma, T.; Tominaga, E. Matsumoto; N.; Tanaka, M.; Mameta, K.; Fukuda, S.; Tomita, K.; Morrell, N.; Phillips, M.; Hsiao, E. Y.
Publication: Central Bureau Electronic Telegrams, 3944, 1 (2014). Edited by Green, D. W. E.
Publication Date: 08/2014
Origin: CBAT
Objects: 2014cf
Bibliographic Code: 2014CBET.3944....1M

Abstract

CBET 3944 available at Central Bureau for Astronomical Telegrams.

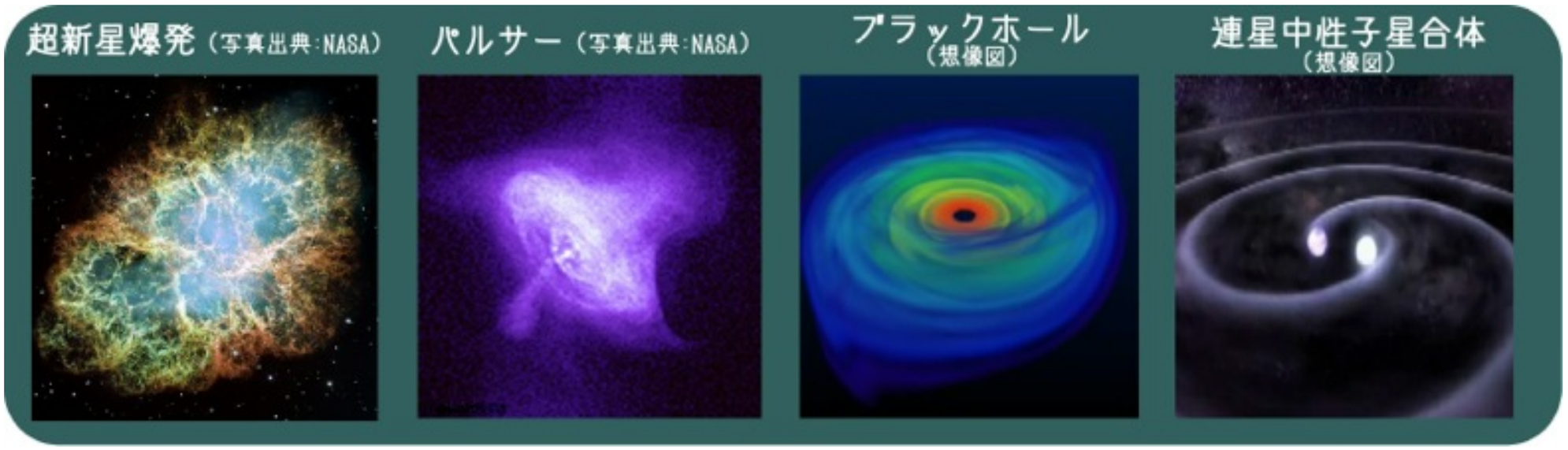
今後・・・

KISSプロジェクト+αの今後

- 2015年9月の観測(9/11-22)をもって一旦終了とします
- これまでの3年間のデータの整理、論文化へ(年内メド)
- 重力波天文学がいよいよ始まります
  - 重力波検出のアラートを受けてToO追観測
  - その他突発現象(MAXI衛星からのアラート)のToO追観測
- Tomo-e Gozen (4 deg^2 ==> 20 deg^2)の時代(2017年?)に?

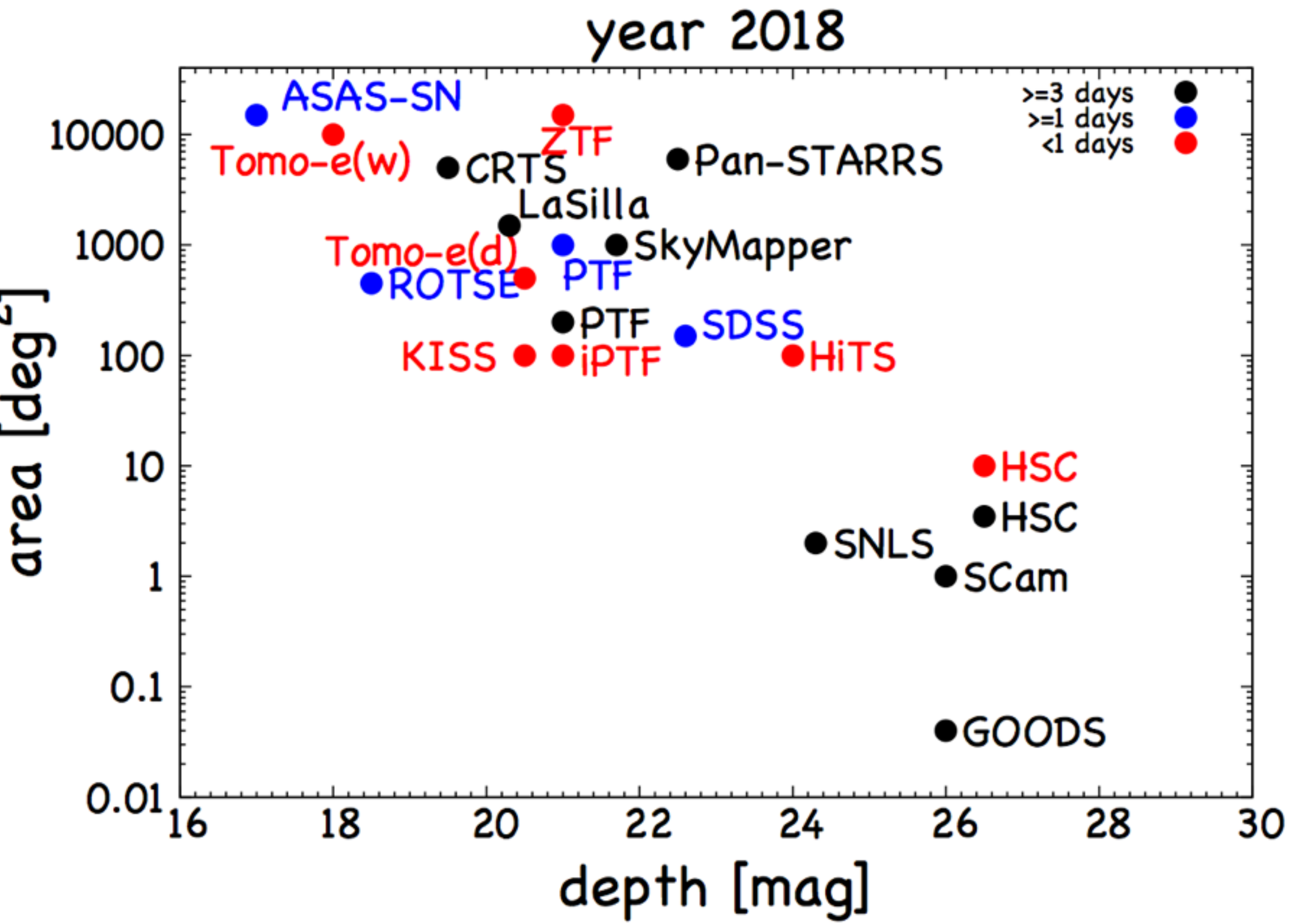
重力波天文学の幕開け

- 重力波検出器
  - advanced LIGO (米国に2台), LIGO-India (2022年?)
  - advanced Virgo (イタリア)
  - KAGRA (日本/神岡)
- 200 Mpc以内の中性子星合体からの重力波検出が可能に
  - 検出数: 年間1-10天体のオーダー
- 重力波到来方向の不定性: ~100 deg^2
  - 広視野カメラでのフォローアップ観測が不可欠



Tomo-e Gozen時代の超新星サーベイ

- より高い効率での広視野観測
  - 広視野化: 4 deg^2 ==> 20 deg^2
  - 短い読み出し時間: ~0 sec
- サーベイ戦略(~18 mag)
  - 全天 x [1時間 cadence]
  - 3000 deg^2 x [15分 cadence]
- 大量 & 多様な超新星の早期発見
  - ~10 shock breakouts / 2 years
  - ~60 superluminous supernovae / 2 years
  - very nearby supernovae
- フォローアップ観測@日本&東アジア
  - 広島かなた(1.5m), 西はりま(2m), 京都(3.8m)


year 2018
>=3 days
>=1 days
<1 days
ASAS-SN
Tomo-e(w)
ZTF
CRTS
Pan-STARRS
LaSilla
Tomo-e(d)
SkyMapper
ROTSE
PTF
PTF
SDSS
KISS
iPTF
HiTS
HSC
HSC
SNLS
SCam
GOODS
10000
1000
100
10
1
0.1
0.01
area [deg2]
16
18
20
22
24
26
28
30
depth [mag]

Tomo-e Gozen時代の超新星サーベイ

- より高い効率での広視野観測
  - 広視野化: 4 deg^2 ==> 20 deg^2
  - 短い読み出し時間: ~0 sec
- サーベイ戦略(~18 mag)
  - 全天 x [1時間 cadence]
  - 3000 deg^2 x [15分 cadence]
- 大量 & 多様な超新星の早期発見
  - ~10 shock breakouts / 2 years
  - ~60 superluminous supernovae / 2 years
  - very nearby supernovae
- フォローアップ観測@日本&東アジア
  - 広島かなた(1.5m), 西はりま(2m), 京都(3.8m)

KISS Summary

- 2012/04より開始、2015/09で一旦終了 ==> これまでのデータの吟味
- 1時間cadenceでの超高頻度超新星探査
- 見かけ等級 g~20 mag, 距離 d~<200Mpc
  - ~1 shock breakout/3年
- KISSでより詳細な物理的理解、すばる/HSCで遠方星形成史etc.
- これまで27 SNe/dwarf novaの同定+報告
- データ即時解析、国内外follow-up collaboration体制の整備
- by-product: 珍しいタイプの超新星(Ibn型), Ia型超新星早期検出, AGN(radio-loud NLS1)
- 重力波電磁波対応天体同定へ向けた準備
- Tomo-e Gozenでの全天超新星サーベイ
- 2 papers & more in prep.
  - Morokuma+2014: survey paper
  - Tanaka+2014: peculiar narrow-line Seyfert 1