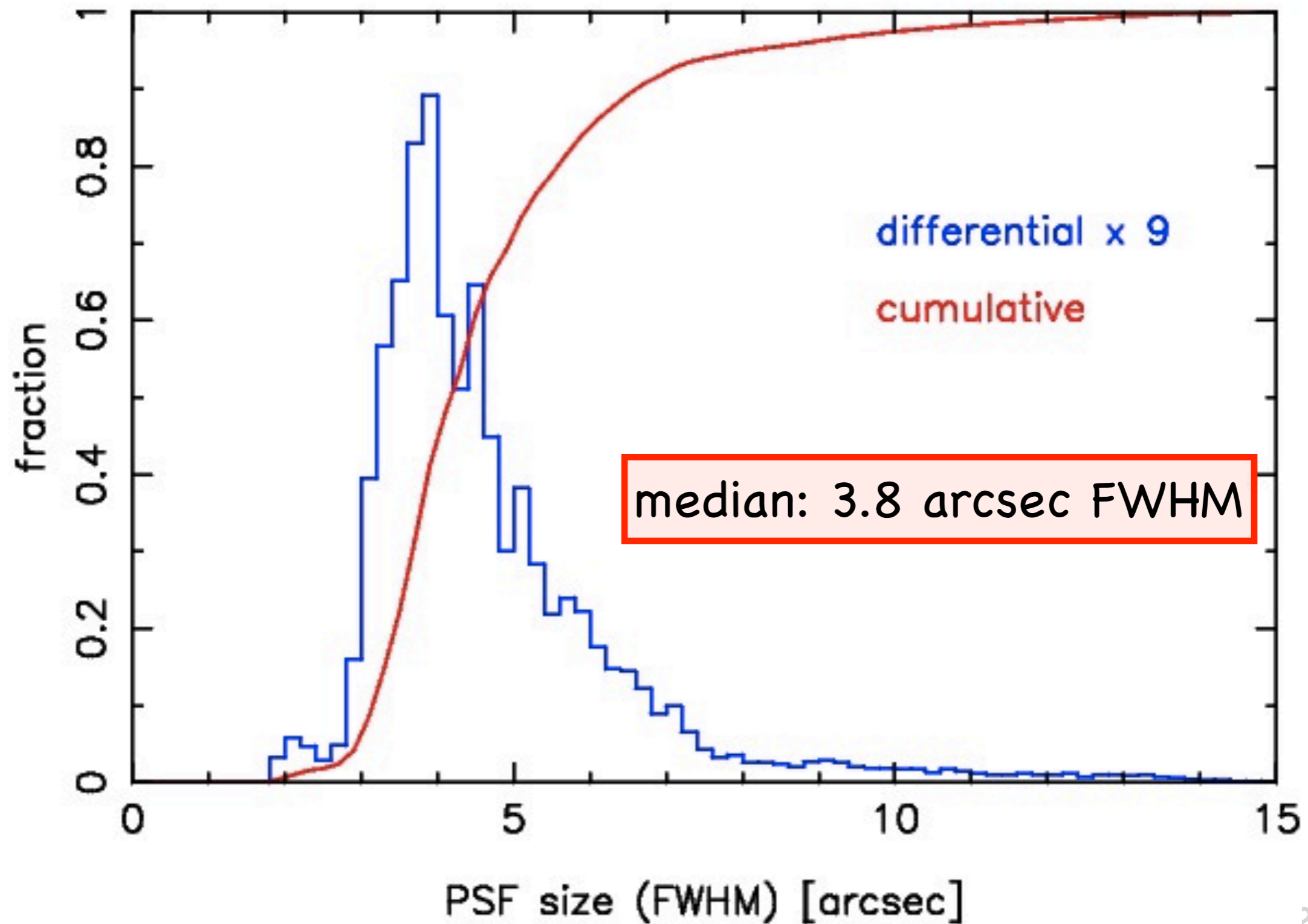




# Kiso Supernova Survey (KISS)

諸隈 智貴 (東京大学)

# Seeing statistics in g-band





## Kiso Supernova Survey (KISS): Survey Strategy

Tomoki MOROKUMA<sup>1</sup>, Nozomu TOMINAGA<sup>2,2b</sup>, Masaomi TANAKA<sup>3</sup>, Kensho MORI<sup>4</sup>, Emiko MATSUMOTO<sup>2</sup>, Yuki KIKUCHI<sup>1</sup>, Takumi SHIBATA<sup>2</sup>, Shigeyuki SAKO<sup>1</sup>, Tsutomu AOKI<sup>5</sup>, Mamoru DOI<sup>1,6</sup>, Naoto KOBAYASHI<sup>1</sup>, Hiroyuki MAEHARA<sup>5</sup>, Noriyuki MATSUNAGA<sup>7</sup>, Hiroyuki MITO<sup>5</sup>, Takashi MIYATA<sup>1</sup>, Yoshikazu NAKADA<sup>1</sup>, Takao SOYANO<sup>5</sup>, Ken'ichi TARUSAWA<sup>5</sup>, Satoshi MIYAZAKI<sup>5</sup>, Fumiaki NAKATA<sup>8</sup>, Norio OKADA<sup>9</sup>, Yuki SARUGAKU<sup>9</sup>, Michael W. RICHMOND<sup>10</sup>, Hiroshi AKITAYA<sup>11</sup>, Greg ALDERING<sup>12</sup>, Ko ARIMATSU<sup>9,7</sup>, Carlos CONTRERAS<sup>13,14</sup>, Takashi HORIUCHI<sup>10</sup>, Eric Y., HSIAO<sup>13,14</sup>, Ryosuke ITOH<sup>4</sup>, Ikuru IWATA<sup>5</sup>, Koji, S. KAWABATA<sup>11</sup>, Nobuyuki KAWAI<sup>10</sup>, Yutaro KITAGAWA<sup>1</sup>, Mitsuru KOKUBO<sup>1</sup>, Daisuke KURODA<sup>17</sup>, Paolo MAZZALI<sup>18,19,20</sup>, Toru MISAWA<sup>21</sup>, Yuki MORITANI<sup>11</sup>, Nidia MORRELL<sup>13</sup>, Rina OKAMOTO<sup>15</sup>, Nikolay PAVLYUK<sup>22</sup>, Mark M. PHILLIPS<sup>13</sup>, Elena PIAN<sup>23,24</sup>, Devendra SAHU<sup>20</sup>, Yoshihiko SAITO<sup>16</sup>, Kei SANO<sup>9,7</sup>, Maximilian D. STRITZINGER<sup>14</sup>, Yutaro TACHIBANA<sup>16</sup>, Francesco TADDIA<sup>20</sup>, Katsutoshi TAKAKI<sup>4</sup>, Ken TATEUCHI<sup>1</sup>, Akihiko TOMITA<sup>27</sup>, Dmitry TSVETKOV<sup>22</sup>, Takahiro Ue<sup>4</sup>, Nobuharu UKITA<sup>17</sup>, Yuji URATA<sup>28</sup>, Emma S. WALKER<sup>29</sup>, Taketoshi YOSHII<sup>16</sup>

<sup>1</sup>Institute of Astronomy, Graduate School of Science, The University of Tokyo, 2-21-1, Osawa, Mitaka, Tokyo 181-0015, Japan

<sup>2</sup>Department of Physics, Faculty of Science and Engineering, Konan University, 8-9-1 Okamoto, Kobe, Hyogo 658-8501, Japan

<sup>2b</sup>Kavli Institute for the Physics and Mathematics of the Universe (WPI), The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8583, Japan

<sup>3</sup>National Astronomical Observatory of Japan, 2-21-1, Osawa, Mitaka, Tokyo 181-8588, Japan

<sup>4</sup>Department of Physical Science, Hiroshima University, Higashi-Hiroshima, Hiroshima 739-8526, Japan

<sup>5</sup>Kiso Observatory, Institute of Astronomy, School of Science, The University of Tokyo 10762-30, Mitake, Kiso-machi, Kiso-gun, Nagano 397-0101, Japan

<sup>6</sup>Research Center for the Early Universe, Graduate School of Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033

<sup>7</sup>Department of Astronomy, The University of Tokyo, Hongo 7-3-1, Bunkyo-ku, Tokyo 113-0033, Japan

<sup>8</sup>Subaru Telescope, 650 North A'ohoku Place, Hilo, HI 96720, USA

<sup>9</sup>Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3-1-1 Yoshinodai, Chuo-ku, Sagami-hara, Kanagawa 252-5210, Japan

<sup>10</sup>Department of Physics, Rochester Institute of Technology, Building 76-1274, 85 Lomb Memorial Drive, Rochester, NY 14623-5603, USA

<sup>11</sup>Hiroshima Astrophysical Science Center, Hiroshima University, Higashi-Hiroshima, Hiroshima 739-8526, Japan

<sup>12</sup>Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, CA 94720, USA

<sup>13</sup>Carnegie Observatories, Las Campanas Observatory, Colina El Pino, Casilla 601, Chile

<sup>14</sup>Department of Physics and Astronomy, Aarhus University, Ny Munkegade, DK-8000 Aarhus C, Denmark

<sup>15</sup>Department of Physics, Faculty of Science, Shinshu University, 3-1-1 Asahi, Matsumoto, Nagano 390-8621, Japan

<sup>16</sup>Department of Physics, Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro-ku, Tokyo 152-8551, Japan

<sup>17</sup>Okayama Astrophysical Observatory, National Astronomical Observatory of Japan, 3037-5 Honjo, Kamogata, Asakuchi, Okayama 719-0232, Japan

<sup>18</sup>Astrophysics Research Institute, Liverpool John Moores University, IC2, Liverpool Science Park, 146 Brownlow Hill, Liverpool L3 5RF, UK

<sup>19</sup>Max-Planck Institut für Astrophysik, Karl-Schwarzschildstr. 1, D-85748 Garching, Germany

<sup>20</sup>INAF-Osservatorio Astronomico di Padova, Vicolo dell'Osservatorio 5, I-35122 Padova, Italy

<sup>21</sup>School of General Education, Shinshu University, 3-1-1 Asahi, Matsumoto, Nagano 390-8621, Japan

<sup>22</sup>Lomonosov Moscow State University, Sternberg Astronomical Institute, 13 Universitetskij prospekt, Moscow 119234, Russia

<sup>23</sup>Scuola Normale Superiore di Pisa, Piazza dei Cavalieri 7, I-56126 Pisa, Italy

<sup>24</sup>INAF-Istituto di Astrofisica Spaziale e Fisica Cosmica, Via P. Gobetti 101, I-40129 Bologna, Italy

<sup>25</sup>Indian Institute of Astrophysics, Koramangala, Bangalore 560 034, India

<sup>26</sup>The Oskar Klein Centre, Department of Astronomy, Stockholm University, AlbaNova, SE-10691 Stockholm, Sweden

<sup>27</sup>Faculty of Education, Wakayama University, Sakaedani 930, Wakayama 640-8510, Japan

<sup>28</sup>Institute of Astronomy, National Central University, Chung-Li 32054, Taiwan

<sup>29</sup>Department of Physics, Yale University, PO Box 208120, New Haven, CT 06520-8120, USA

tmorokuma@ioa.s.u-tokyo.ac.jp

Morokuma+2014  
submitted to PASJ  
on 2014/07/10

59名

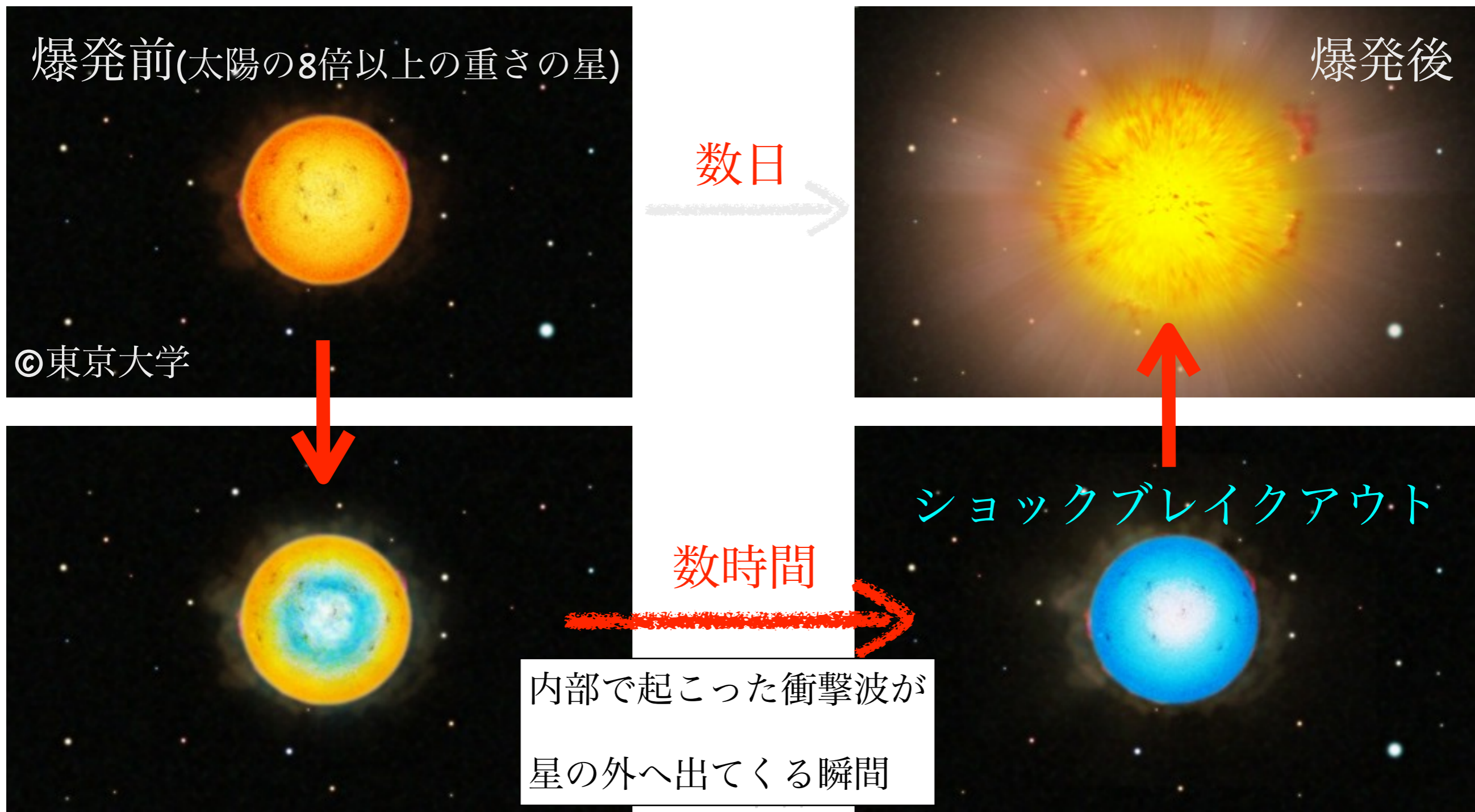
- コアメンバー
- KWFC開発者
- フォローアップ観測



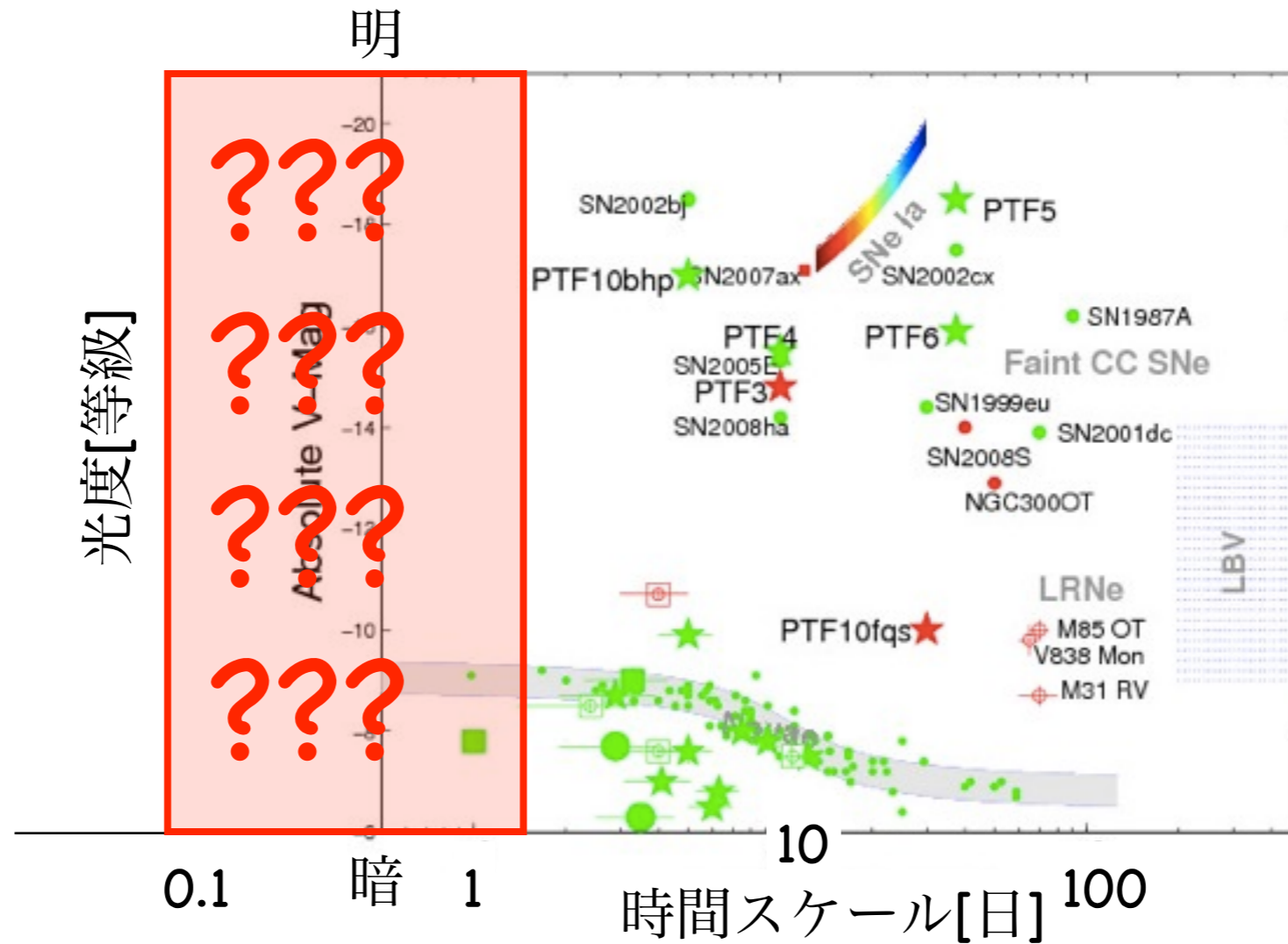
# KISSの目的

◎ **shock breakout** = 超新星の爆発の“ほぼ瞬間”をとらえる

△ 約50億年後の消滅してしまう頃の地球に生きているかもしれない子孫のため



# Kiso Supernova Survey (KISS)



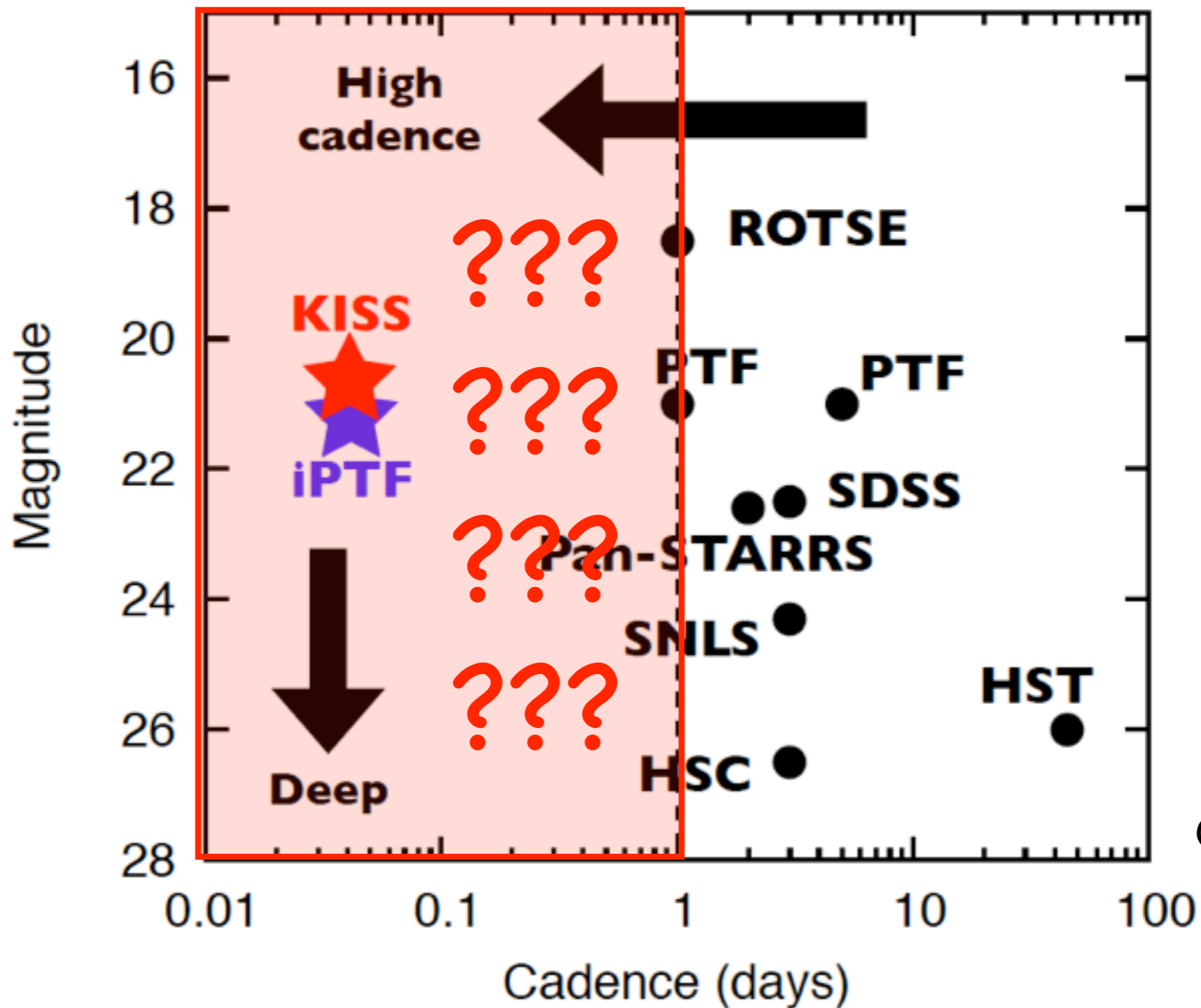
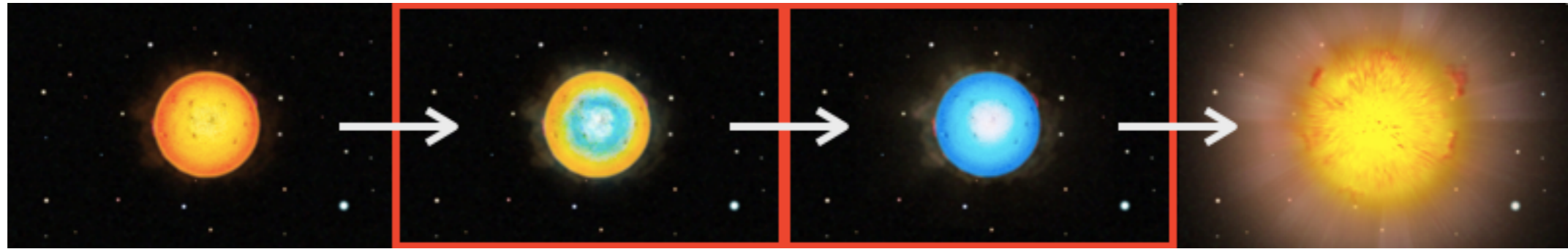
Kasliwal+2011 (Palomar Transient Factoryの成果)

## 超新星ショックブレイクアウト(Shock Breakout)

重力崩壊後、中心部で衝撃波 --> 衝撃波が星表面を通過する際に、非常に明るく輝く



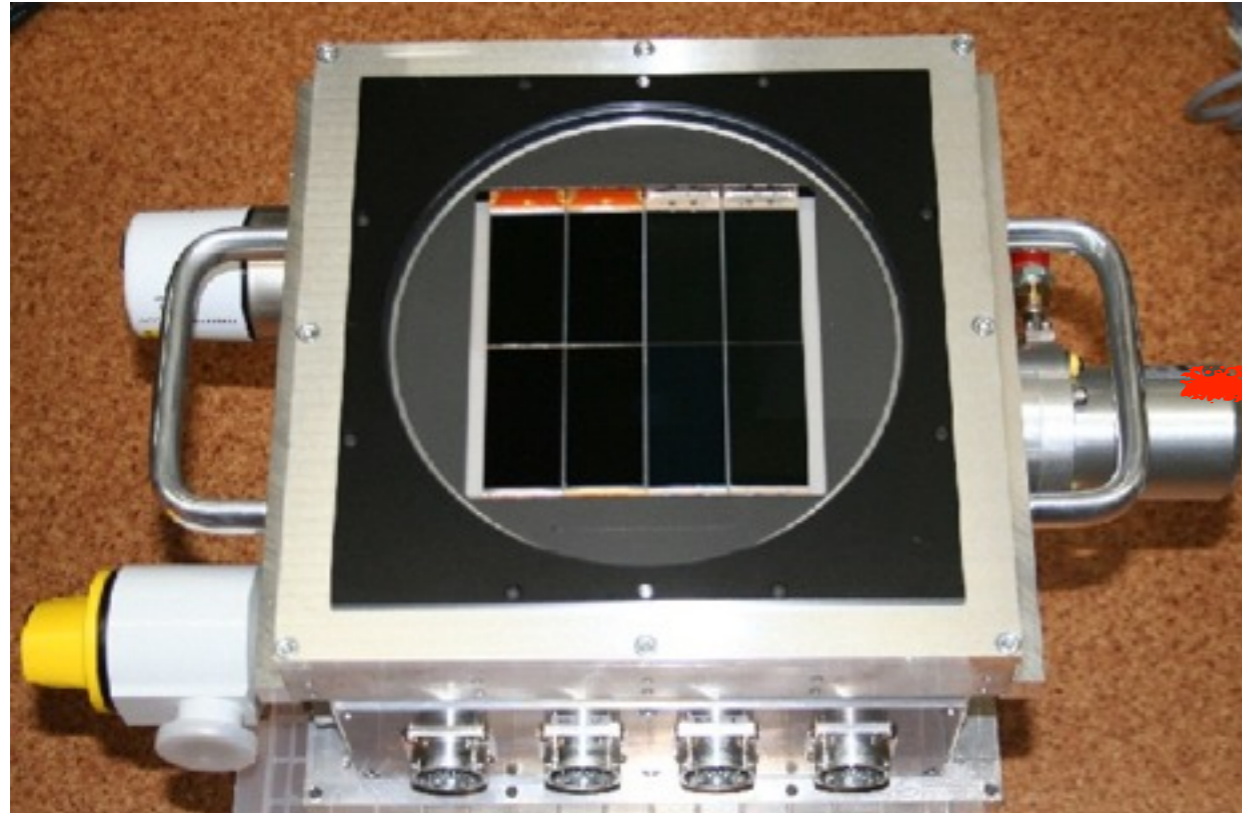
# Kiso Supernova Survey (KISS)



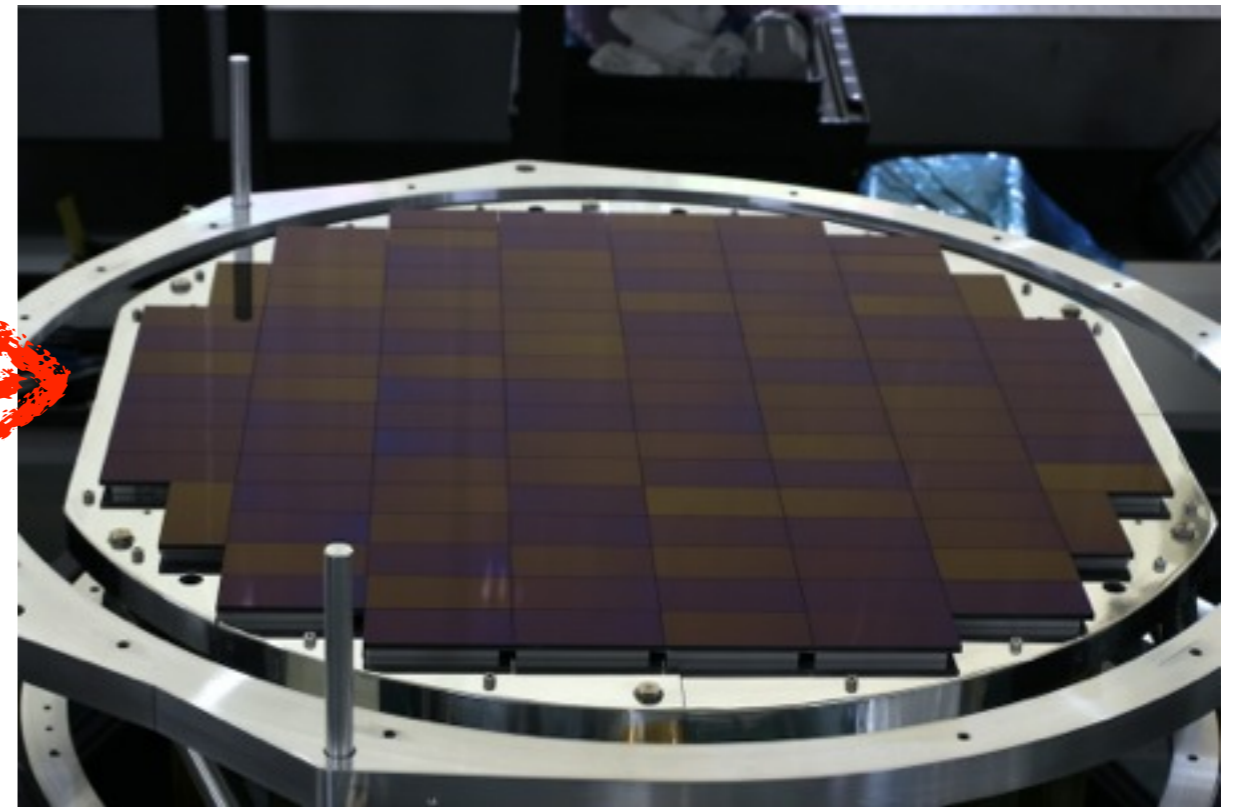
©Masaomi Tanaka



# 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

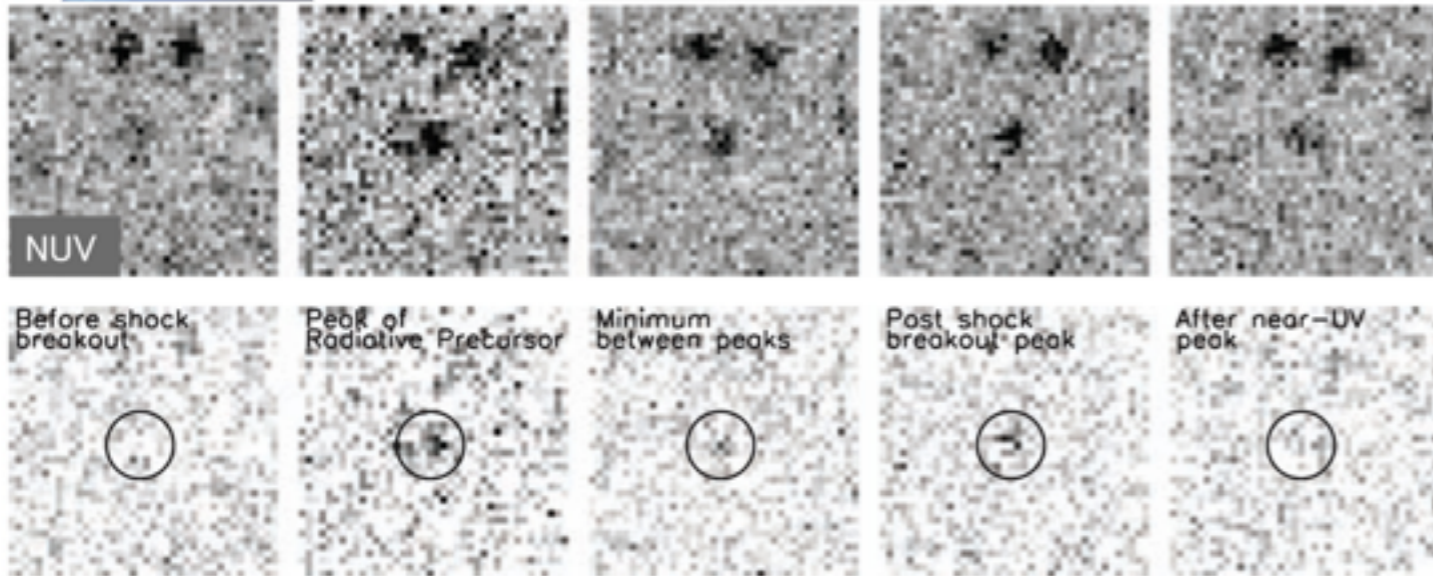
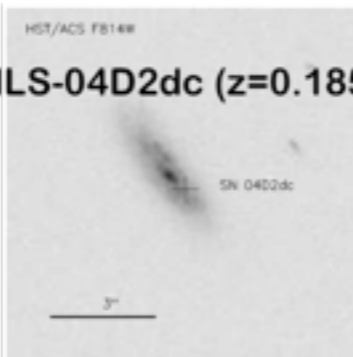
# 検出例@UV

SNLS SuperNova Legacy Survey

SNLS-04D2dc (z=0.1854)

Schawinski et al. 08  
Gezari et al. 08

GALEX



Multigroup radiation hydrodynamics code  
**STELLA** (Blinnikov + 98)  
でLCを再現

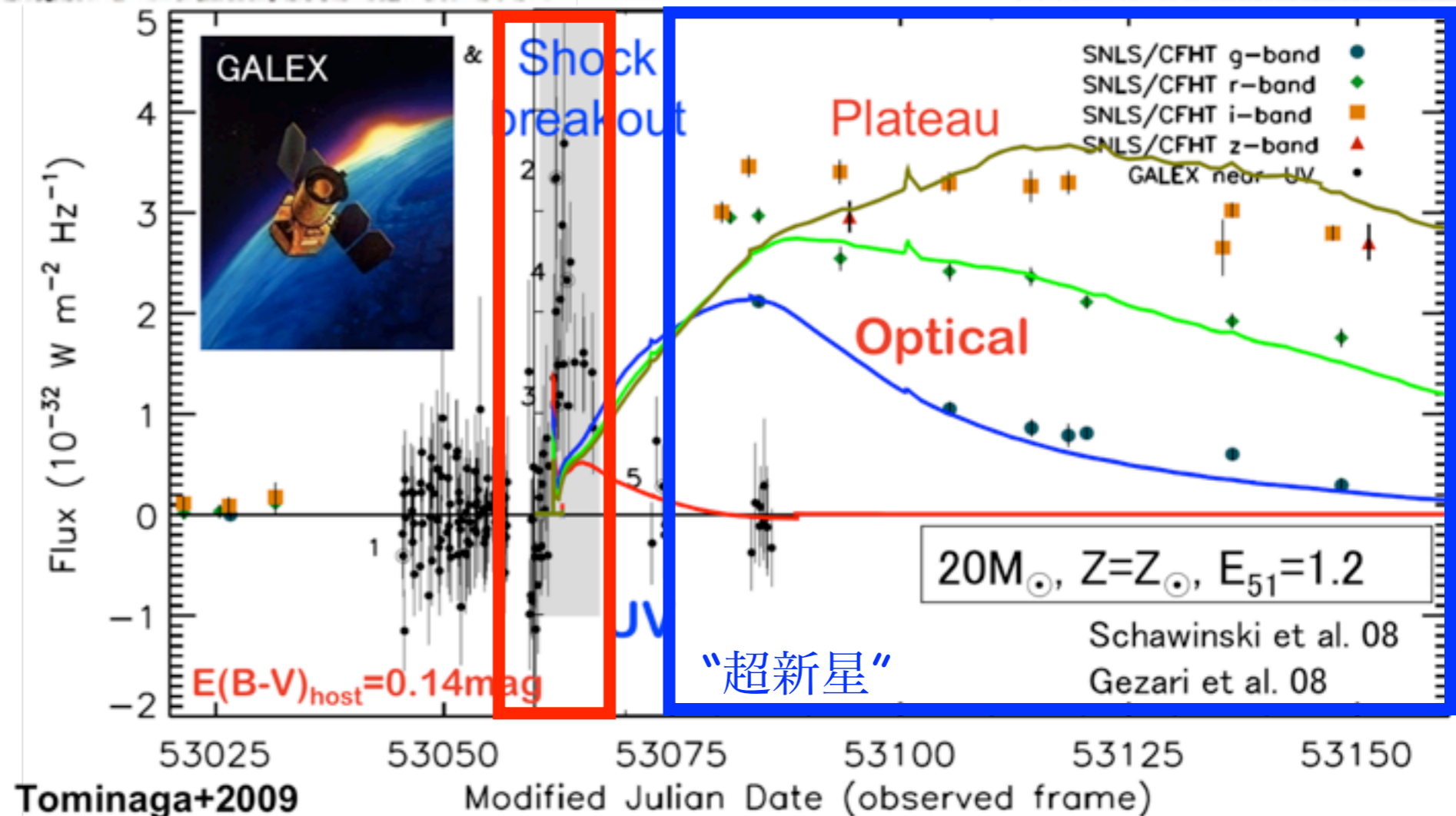
25日



SNLS SuperNova Legacy Survey

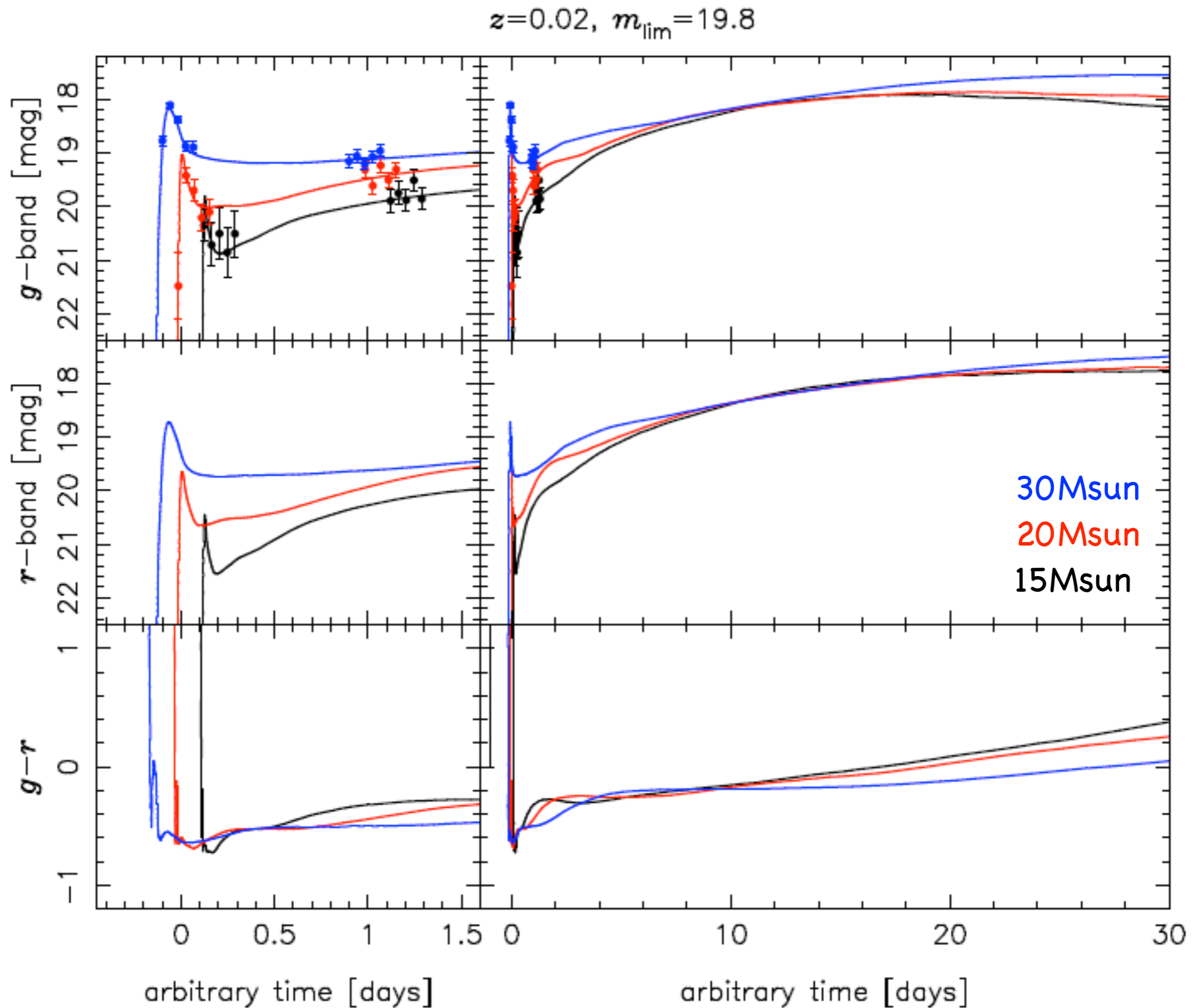
SNLS-04D2dc@z=0.19

GALEXによる偶然の観測



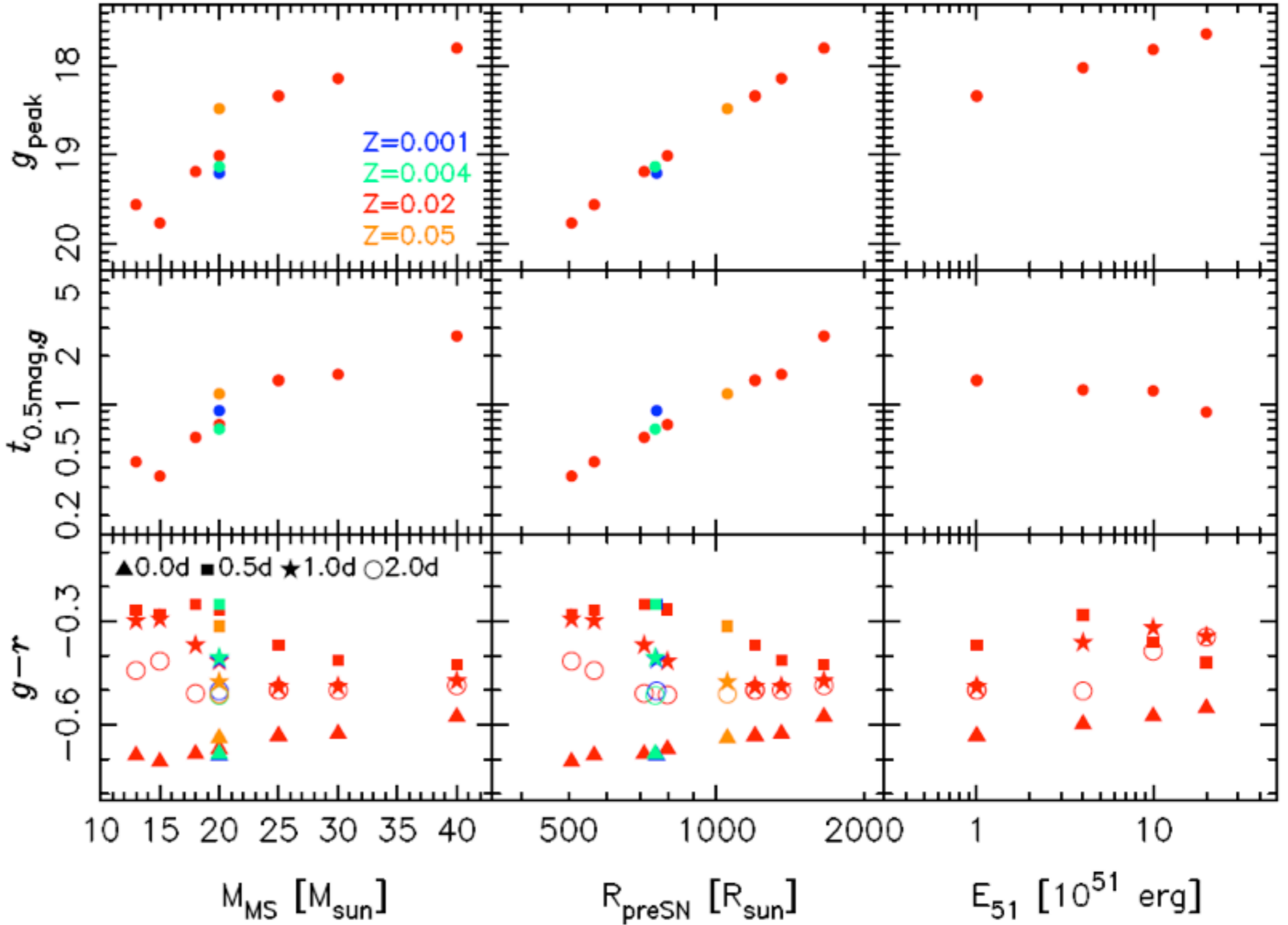


# Expected Light Curves



$z=0.02$

peak光度

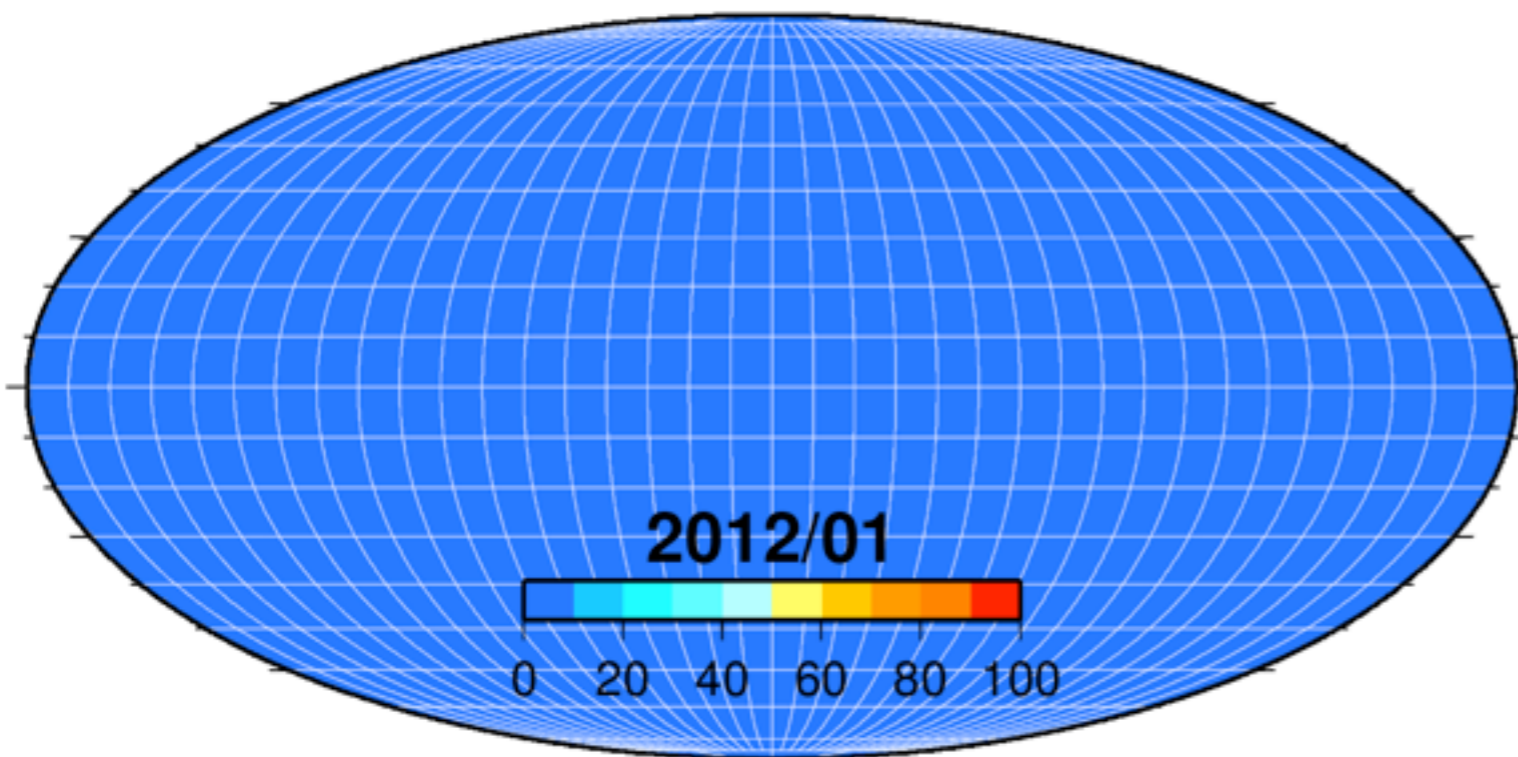


減光の  
タイムスケール

カラー

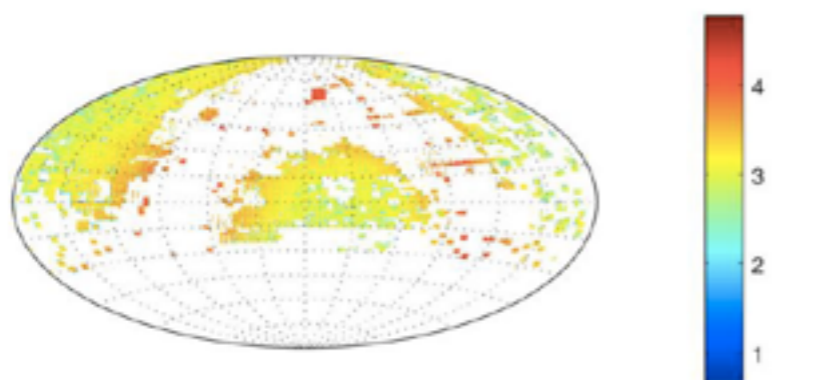


# Uniqueness & Sky Coverage



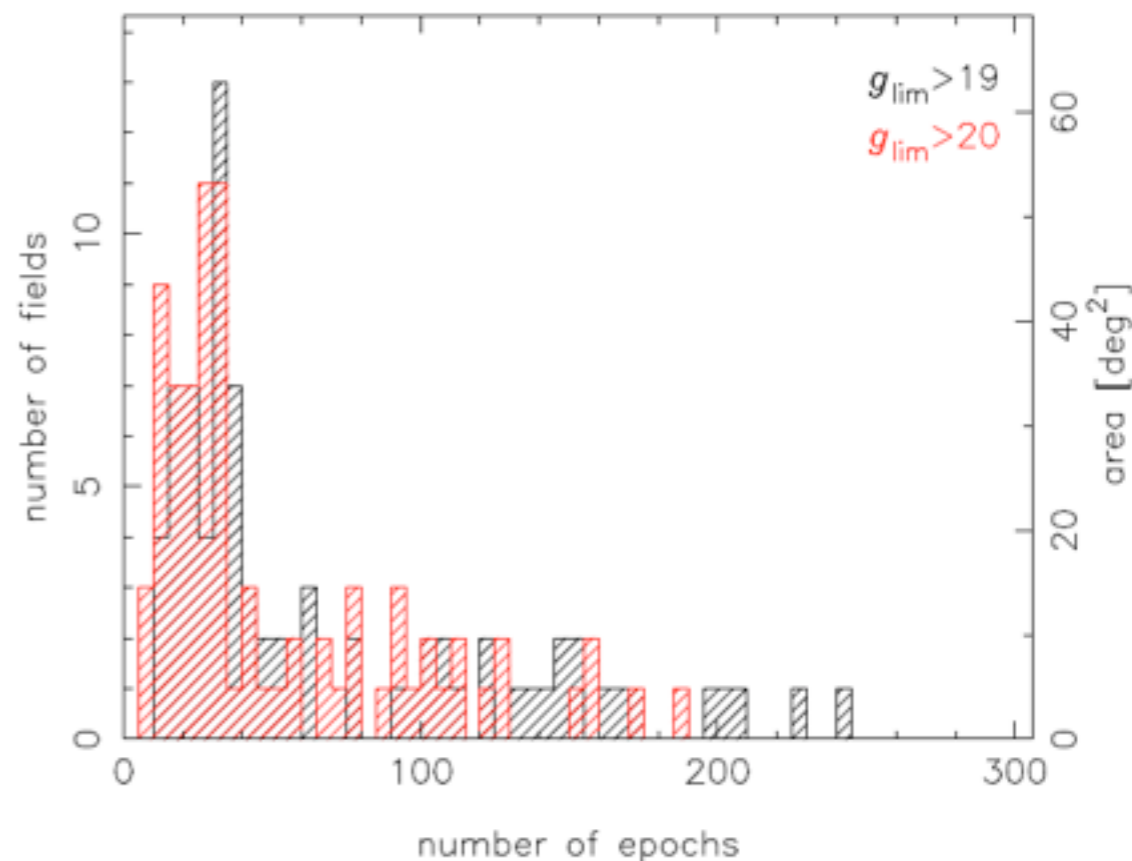
- 1 hour cadence
- 5 visits per night
- single band (g)
- > 100 deg<sup>2</sup> per night

©Masaomi Tanaka



PTF sky coverage (Ofek+2012)

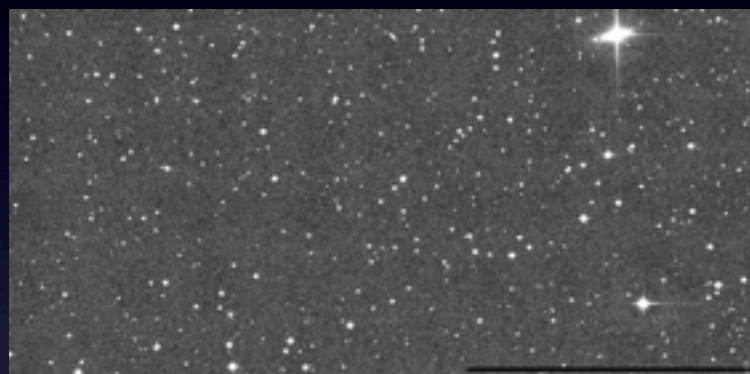
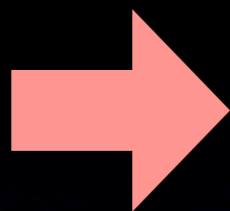
FIG. 3.—Coverage of the PTF photometric catalog 1.0 shown in an equal-area Aitoff projection in equatorial coordinates. RA = 0°, Dec = 0° is in the center of the map. The coding shows the number of stars per deg<sup>2</sup> as calculated in a grid of 0.5 × 0.5 deg<sup>2</sup> cells on the sky. See the electronic edition of the *PASP* for a color version of this figure.



# Kiso observatory



## KISS pipeline



standard reduction

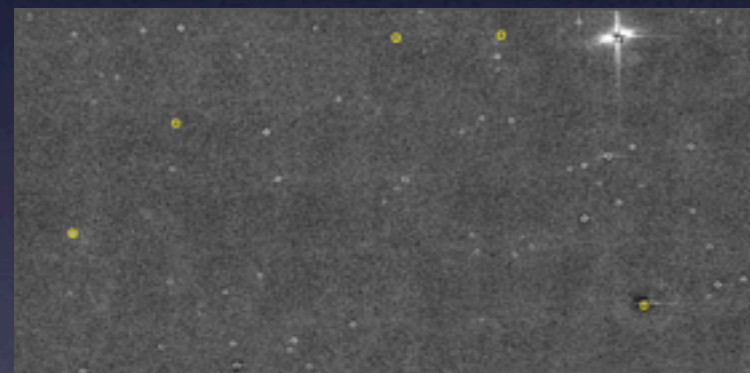


image subtraction

source detection

**< 10 min**

**~ 50GB/day**

## cut-out images

Ref

New

Sub

## KISS database

source  
info

# Tokyo

## cut-out images

Ref

New

Sub

## KISS

source  
info

## KISS interface

<http://www>

facebook

Realtime check

Amateur astronomers@amywhere

©Masaomi Tanaka



# KISS Follow-Up Observations



- 広島大学かなた望遠鏡(1.5m), 東工大MITSuME(0.5m), 岡山188cm, ...

光赤外線・大学間連携



- Rochester Institute of Technology (KPNO 0.9m)



- Indian Institute of Astrophysics (HCT 2m)



- Carnegie Supernova Project (CSP; NOT 2.5m, Du Pont 2.5m, Magellan 6.5m)

- Telescopio Nazionale Galileo (TNG/DOLORES; 3.5m)

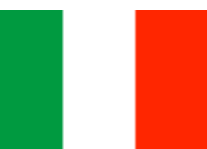


- SNFactory (UH88/SNIFS; 2.2m)

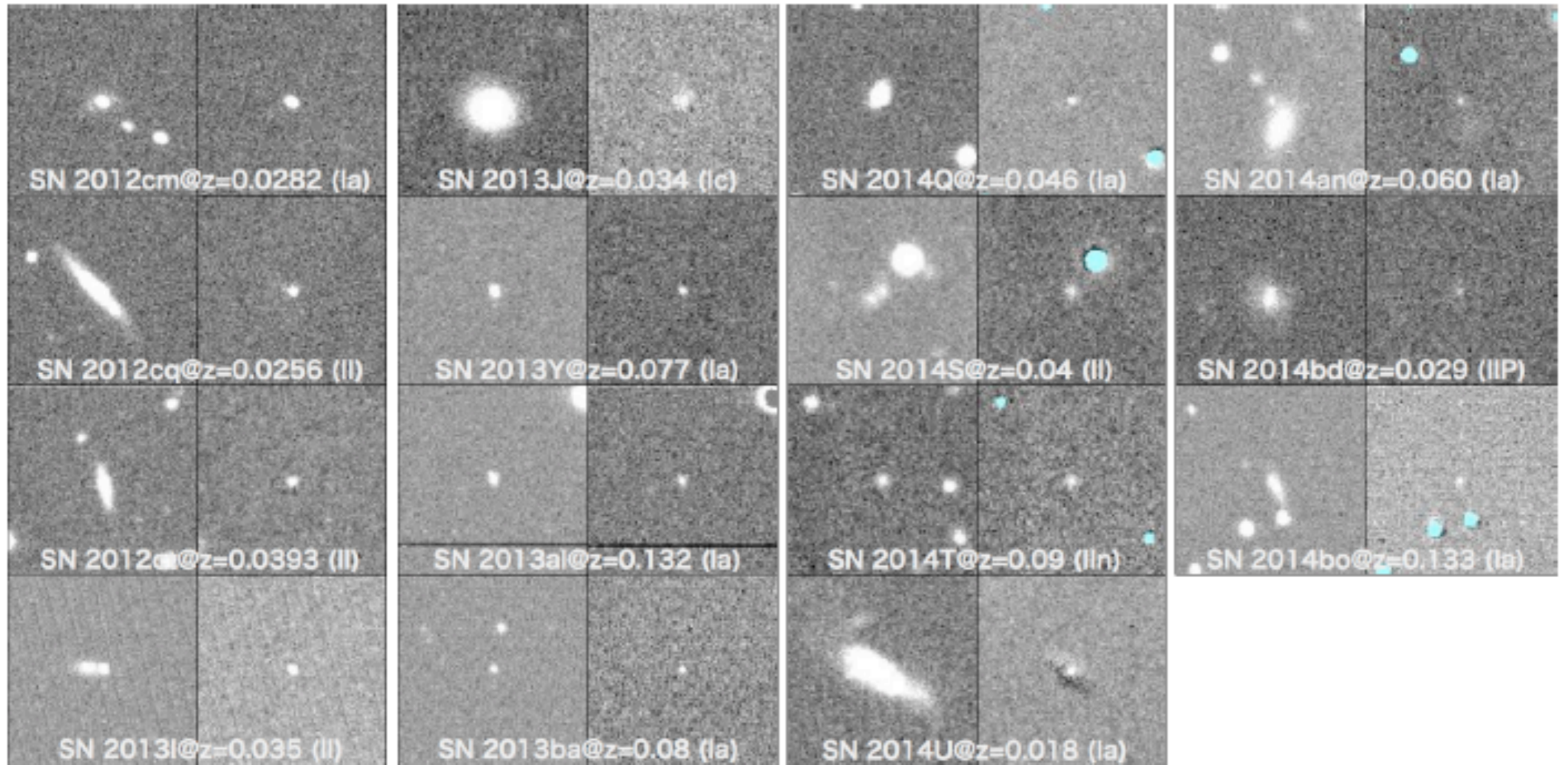


- Russian Institutes (0.9m)

- Subaru (8.2m)

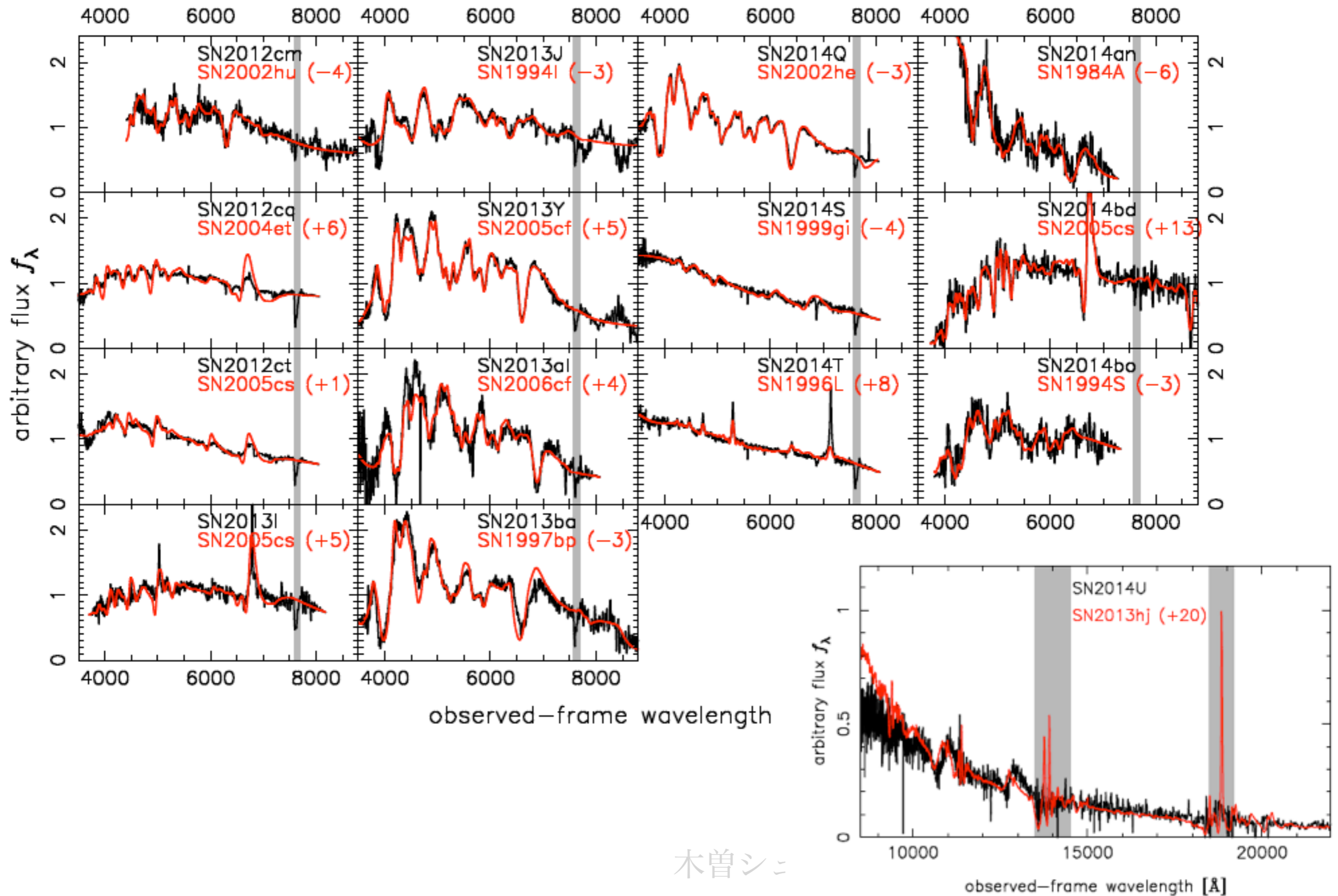


# 15+1 Spectroscopically Confirmed SNe by KISS

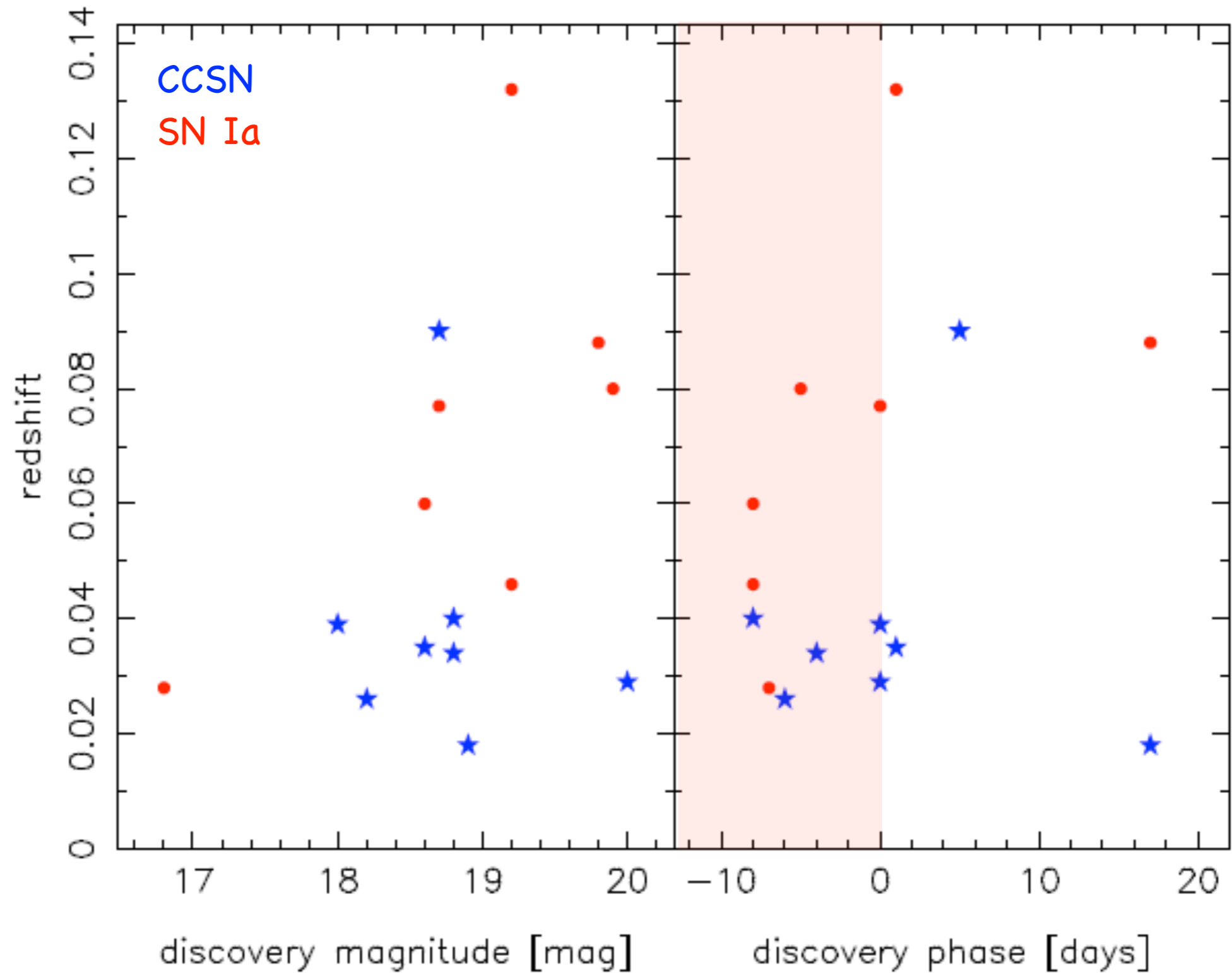




# Spectra



# redshift vs discovery magnitude





# by-products

✓ Radio-Loud Narrow-Line Seyfert 1 (KISS14k; SDSSJ1100+4421)

田中さん's talk (Tanaka+2014, submitted)

✓ Ibn型超新星 (KISS14z)

大学間連携での撮像観測, KISS collaborationでの分光観測

✓ 低光度AGNの変動-->松本さん's talk

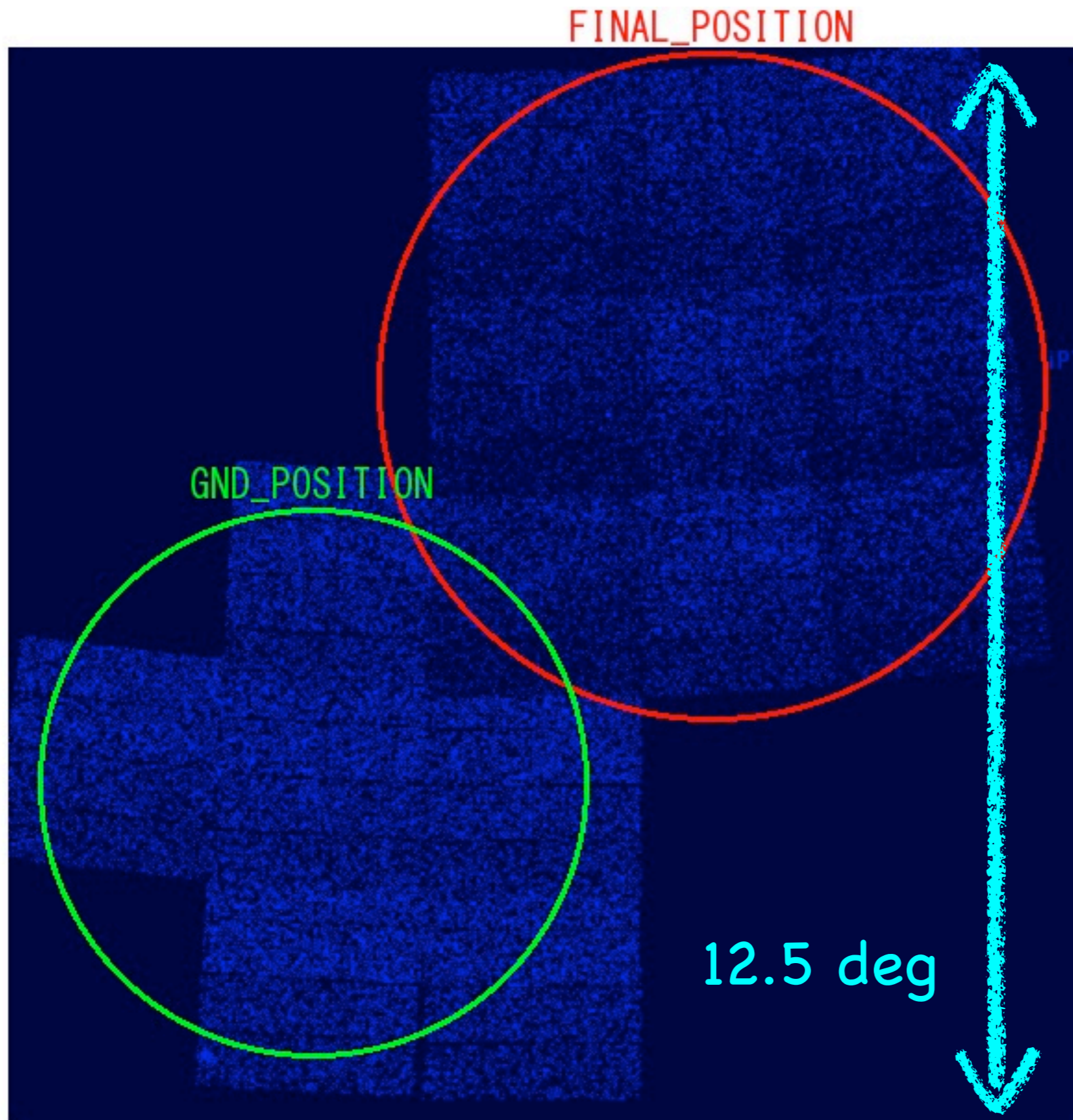
岡山188cm/KOOLS, UH88/WFGS2での分光観測

✓ NEO (Near-Earth Object)の軌道決定

✓ 重力波電磁波源(~10 deg error circle)フォローアップ観測

Fermi Gamma-ray Burst Monitor (GBM)での練習

# 重力波電磁波対応天体フォローアップ観測



error circle:  $\sim 10$  deg

Fermi Gamma-ray Burst Monitor (GBM)と同程度

KISS解析パイプラインを応用  
CMOSでも



# KISS Summary

- Kiso Supernova Survey (KISS): 2012/04より開始
- 1時間間隔(cadence)での超高頻度超新星探査
- 見かけ等級  $g \sim 20$  mag, 距離  $d \sim < 200$  Mpc  
~1 shock breakout/3yrs
- 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16 SNeの同定+報告
- データ即時解析、国内外follow-up collaboration体制の整備
- 珍しい超新星(Ibn型), AGN(radio-loud NLS1)などのby-product
- 重力波電磁波対応天体同定へ向けた準備
- Morokuma+2014/Tanaka+2014 submitted to PASJ/ApJL