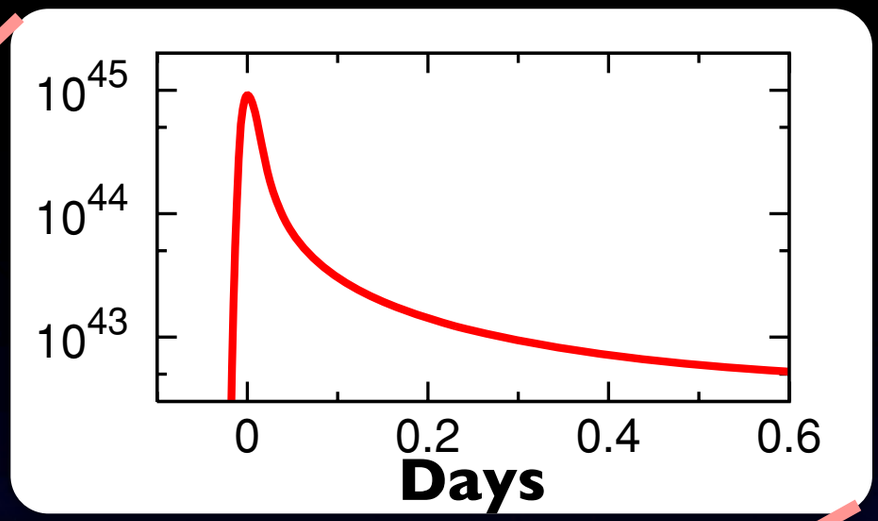
Prompt follow-up observations of transients
- Toward SN shock breakout detection -

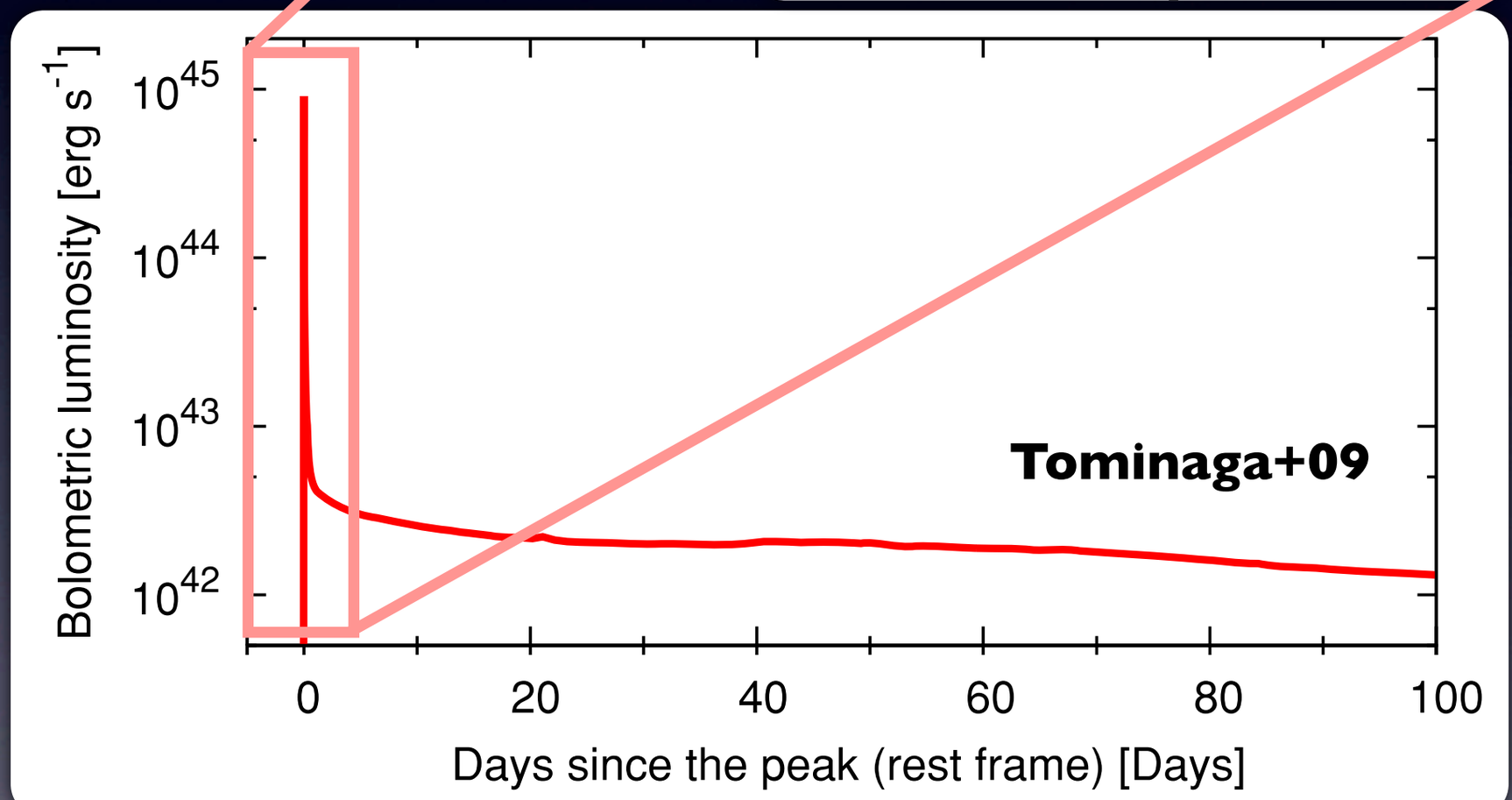
超新星爆発ショックブレイクアウトの検出に向けた
突発天体の即時フォローアップ観測

Masaomi Tanaka (NAOJ)

on behalf of **KISS** collaboration
Tomoki Morokuma (U. Tokyo), Nozomu Tominaga (Konan),
Nobuharu Ukita (NAOJ), Emiko Matsumoto (Konan),
Katsutoshi Takaki (Hiroshima), Masayuki Yamanaka (Konan),
and many collaborators

The first moment of SN explosion





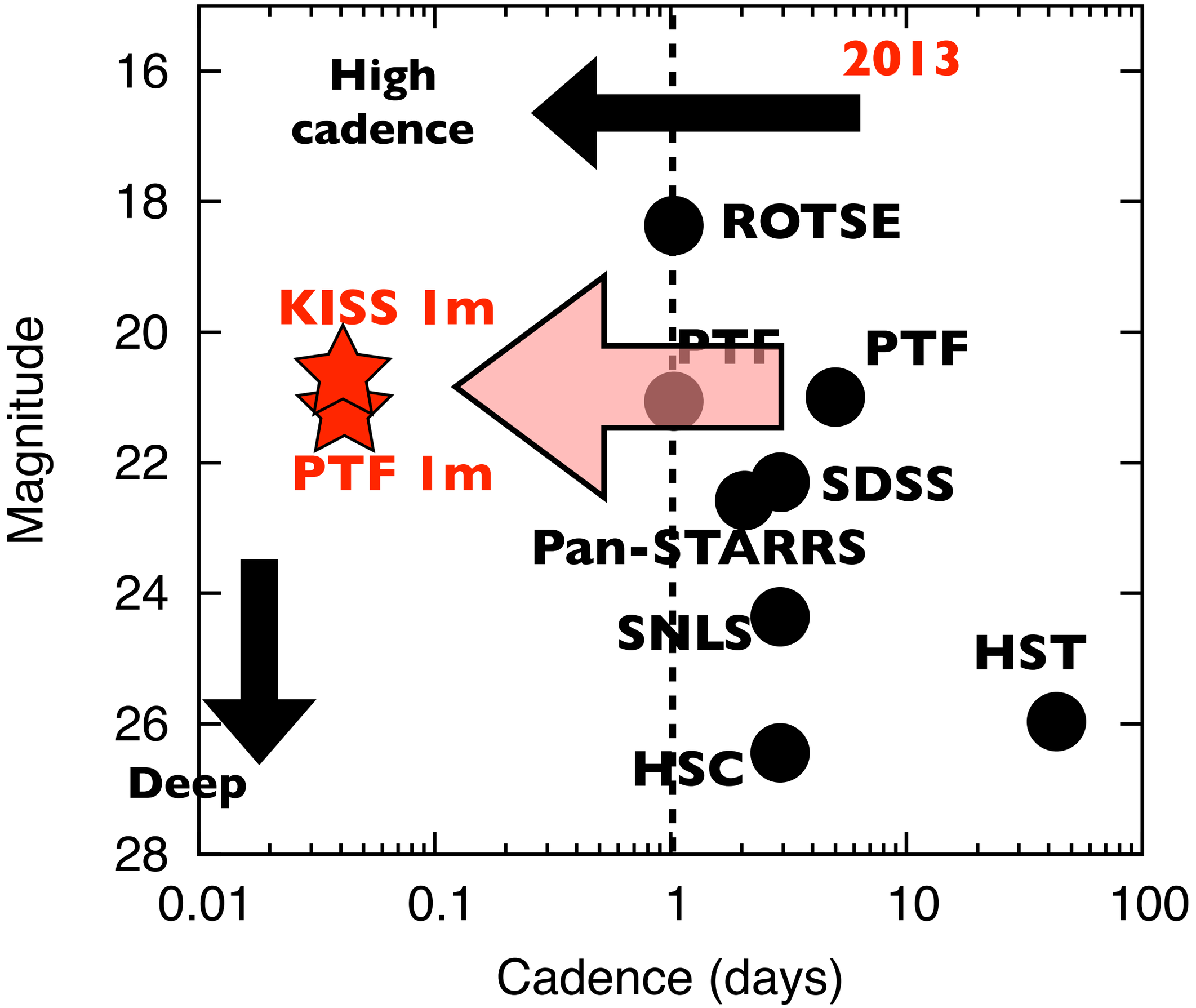
- Probe of progenitor's stellar radius
- Probe of high-z Universe

KISS: Kiso Supernova Survey
(2012 Apr - 2015 Mar)

- **Extremely high cadence**
  - 1-hr cadence <= 2-3 days
  - 4 deg^2 FOV (KWFC)
  - ~ 20-21 mag in g-band (3 min exposure)
  - ~50-100 deg^2 /day (SDSS fields, high SFR)
  - ~100 nights /yr
  - Automatic data reduction

Kiso 1.05m Schmidt telescope

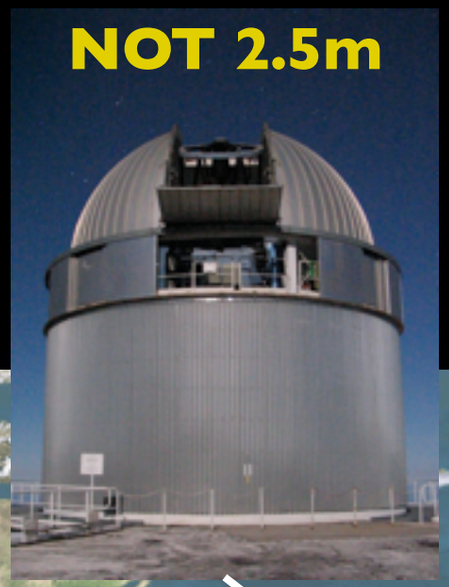
Expected number of detection ~1 / yr


2013
High cadence
ROTSE
KISS Im
PTF
PTF
PTF Im
SDSS
Pan-STARRS
SNLS
HST
HSC
Deep
16
18
20
22
24
26
28
Magnitude
0.01
0.1
1
10
100
Cadence (days)

~80 SN candidates (as of 2014 May)

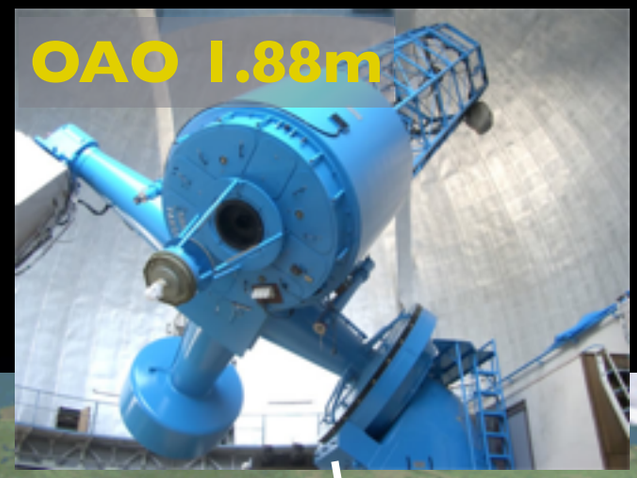
KISS12a
KISS12f
KISS12k
KISS13a
KISS12b
KISS12g
KISS12l
KISS13b
KISS12c
KISS12h
KISS12m
KISS13d
KISS12d
KISS12i
KISS12n
KISS13j
KISS12e
KISS12j
KISS12q
KISS13l

TNG 3.6m



NOT 2.5m

Hiroshima 1.5m

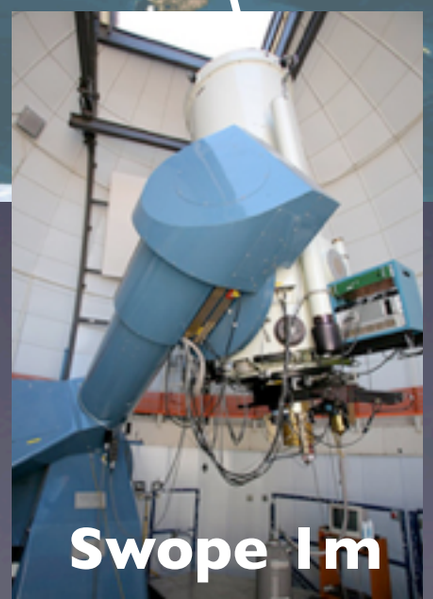


OAO 1.88m

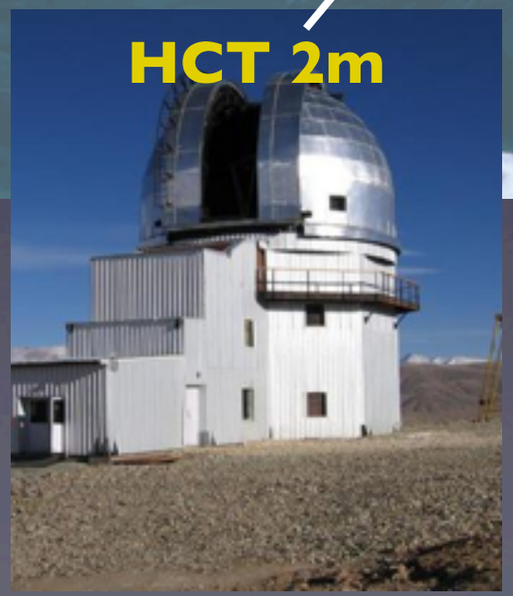
Spectroscopy in the same night!

NOTE: Non-ToO observation!
(we ALWAYS have SNe)
Weather is the major factor of success

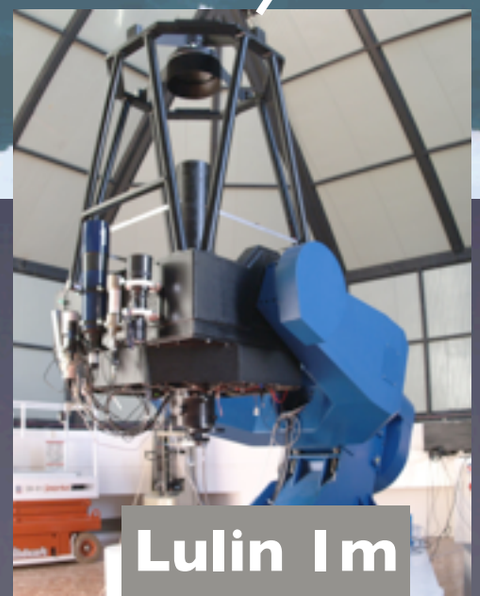
WIYN 0.9m



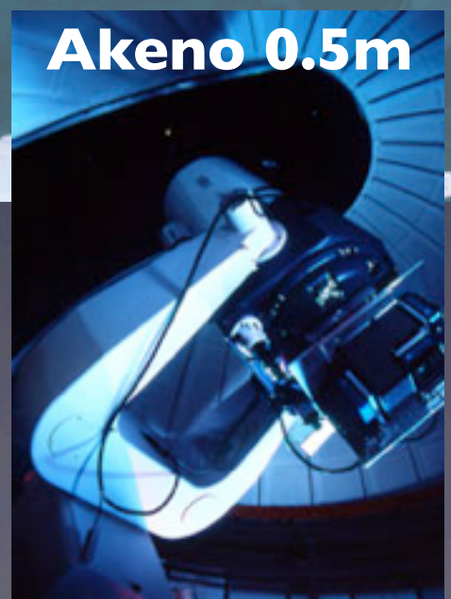
Swope 1m



HCT 2m



Lulin 1m



Akeno 0.5m

Status

13B: 4 nights (1-2 night/month)

2013/9 (2 nights)

	5	6	7	8	9	10	11	12
Kiso								
OAO	-						-	-

Pointing trouble (Kiso)

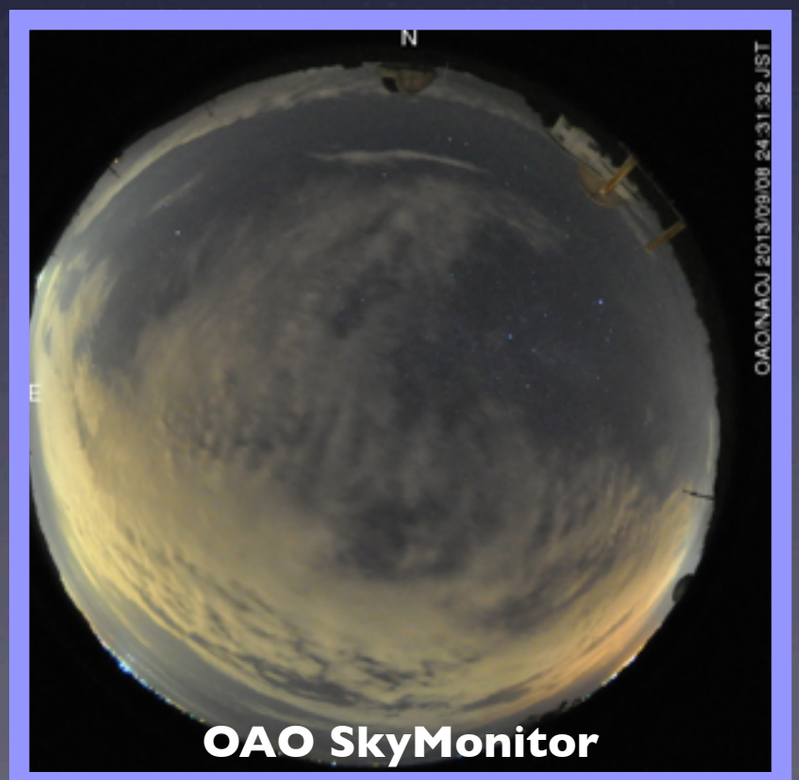
Spectroscopy of 19-20 mag SN candidates (not from KISS)

=> 2 IAU/CBET circulars

Good

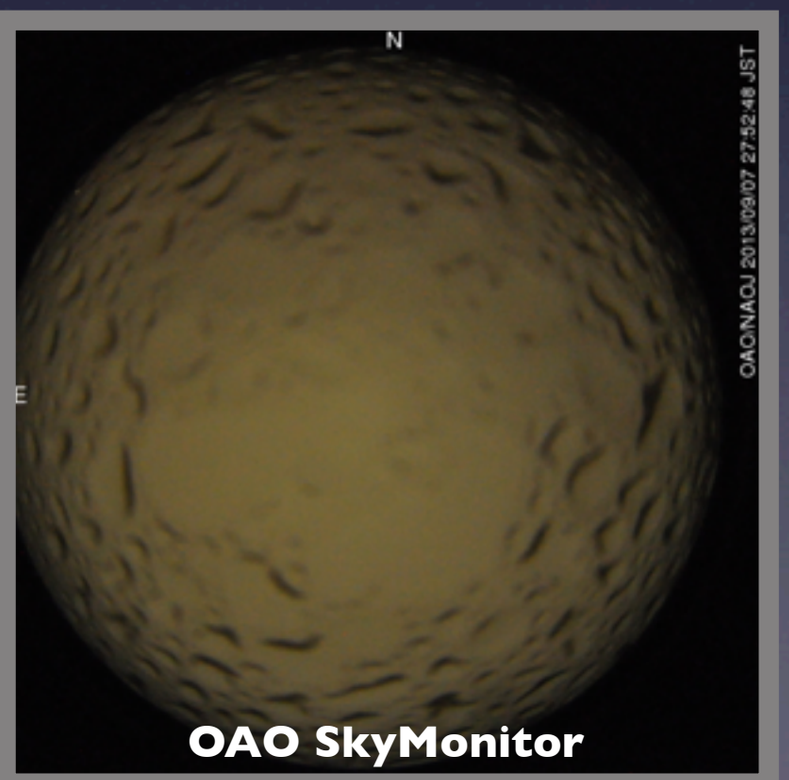
OAO SkyMonitor

Moderate



OAO SkyMonitor

Bad



OAO SkyMonitor

Status

13B: 4 nights (1-2 night/month)

2013/9 (2 nights)

	5	6	7	8	9	10	11	12
Kiso								
OAO	-						-	-

Pointing trouble (Kiso)

Spectroscopy of 19-20 mag SN candidates
(not from KISS)
=> 2 IAU/CBET circulars

2013/10 (1 night)

	30	1	2	3	4	5	6	7
Kiso								
OAO	-	-		-		-		-

2013/11 (1 night)

	30	31	1	2	3	4	5	6
Kiso								
OAO	-	-						-

Spectroscopy
on the discovery day
(but unable to identify)

Status

14A: 13 nights (1-4 nights/month)

Good Moderate Bad

2014/1-2 (1 night)

	26	27	28	29	30	31	1	2
Kiso								
OAO	-	-	-	-			-	-

Unable to identify due to low S/N

2014/2-3 (3 nights)

	25	26	27	28	1	2	3	4
Kiso								
OAO	-	-						-

Spectroscopy on the discovery day (but unable to identify)

2014/3-4 (2 nights)

	28	29	30	31	1	2	3	4
Kiso								
OAO								-

1st identification of KISS SN (2 days after the discovery)

2014/4 (4 nights)

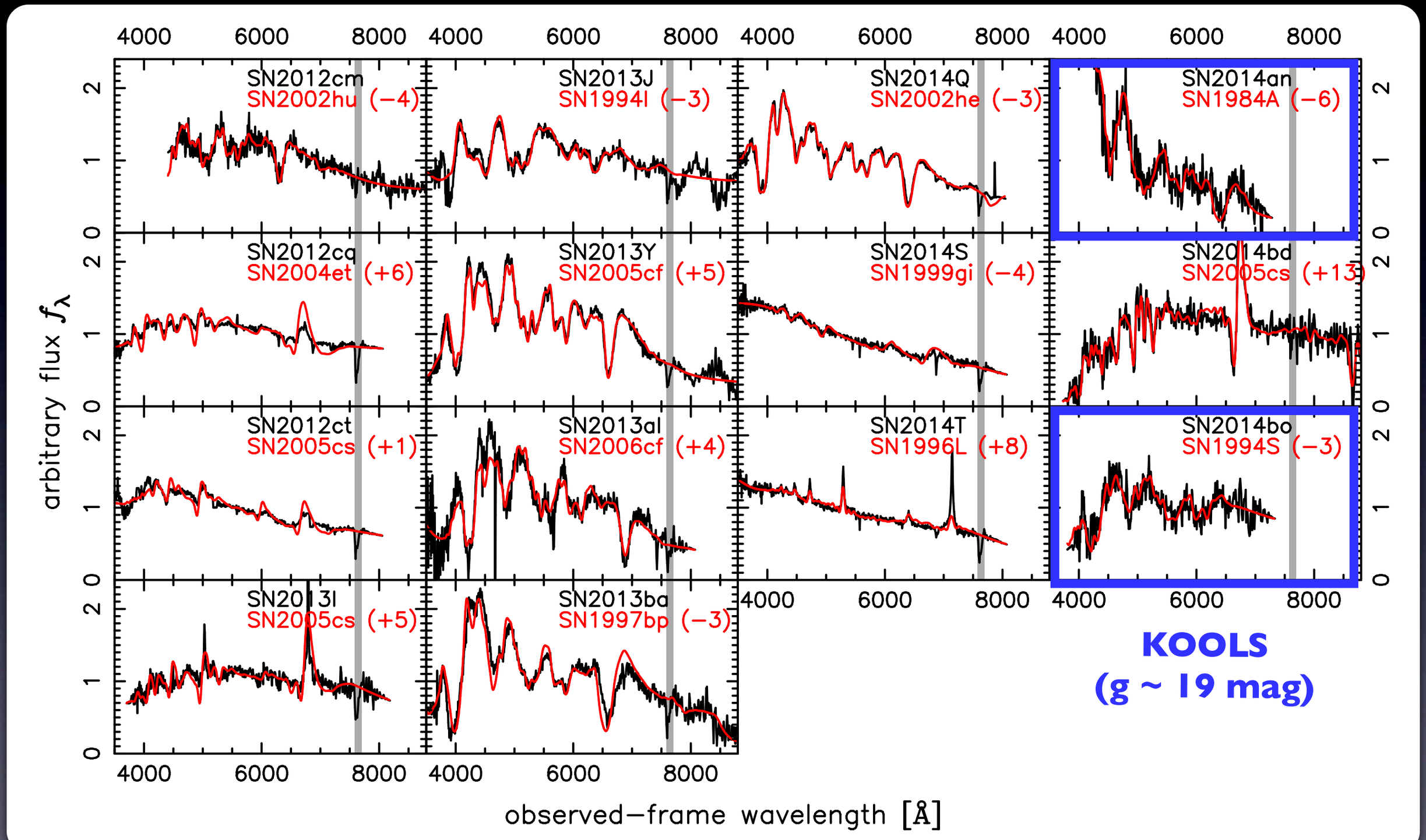
	24	25	26	27	28	29	30	1
Kiso								
OAO	-	-					-	-

2014/5 (3 nights)

	24	25	26	27	28	29	30	31
Kiso								
OAO	-	-				-	-	-

2nd identification of KISS SN (8 days after the discovery)

15 IAU supernovae



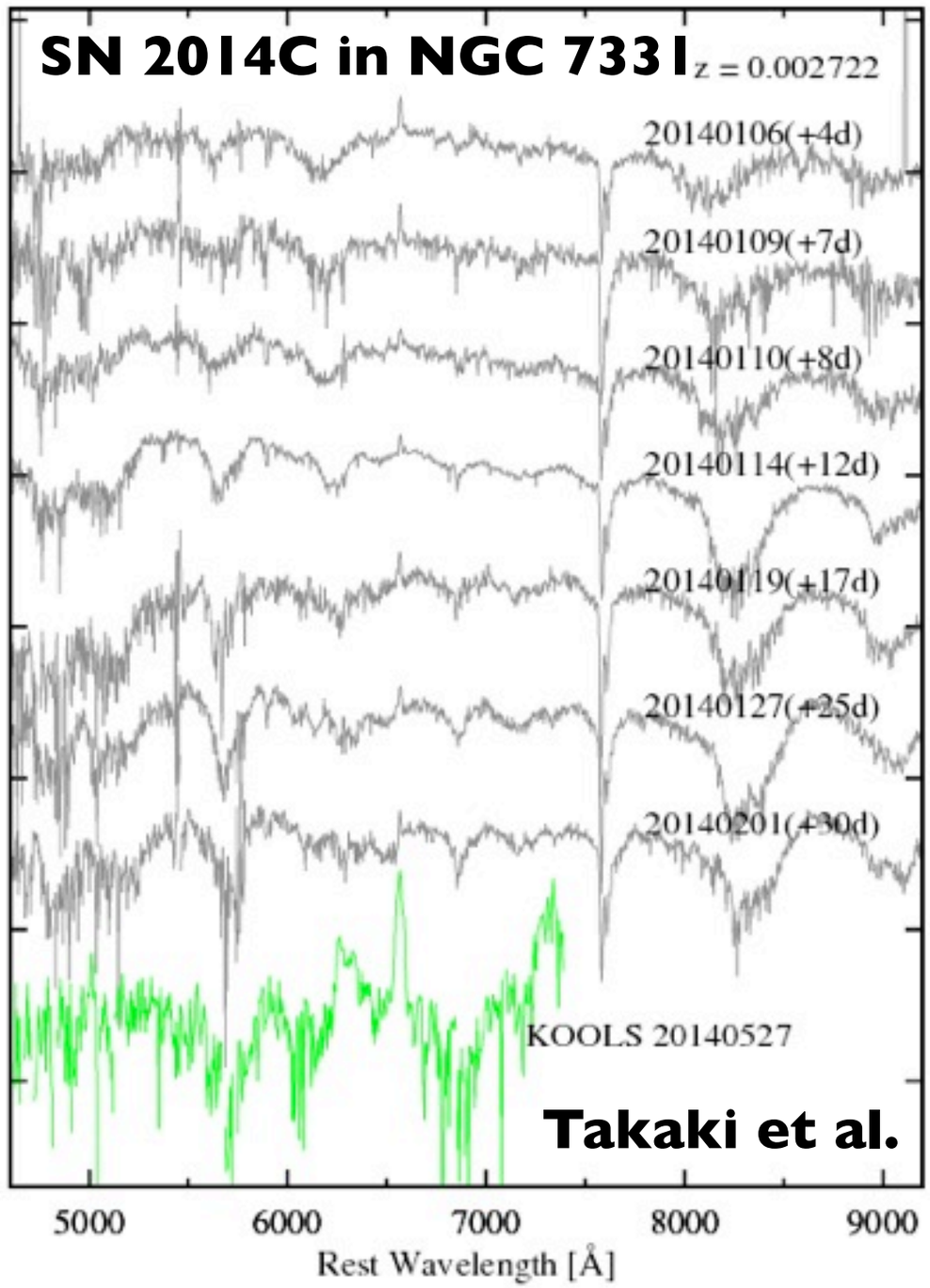
Morokuma, Tominaga, MT+14, submitted to PASJ
(KISS survey strategy and initial results)

~80 SN candidates (as of 2014 May)

KISS12a
KISS12f
KISS12k
KISS13a
KISS12b
KISS12g
KISS12l
KISS13b
KISS12c
KISS13d
KISS12i
KISS12n
KISS13j
KISS12e
KISS12j
KISS12q
KISS13l

No shock breakout yet

Science under moderate weather condition
- Tomography of SN ejecta -



4 days

8 days

17 days

30 days

150 days

300 days

Kanata
~ 16 mag

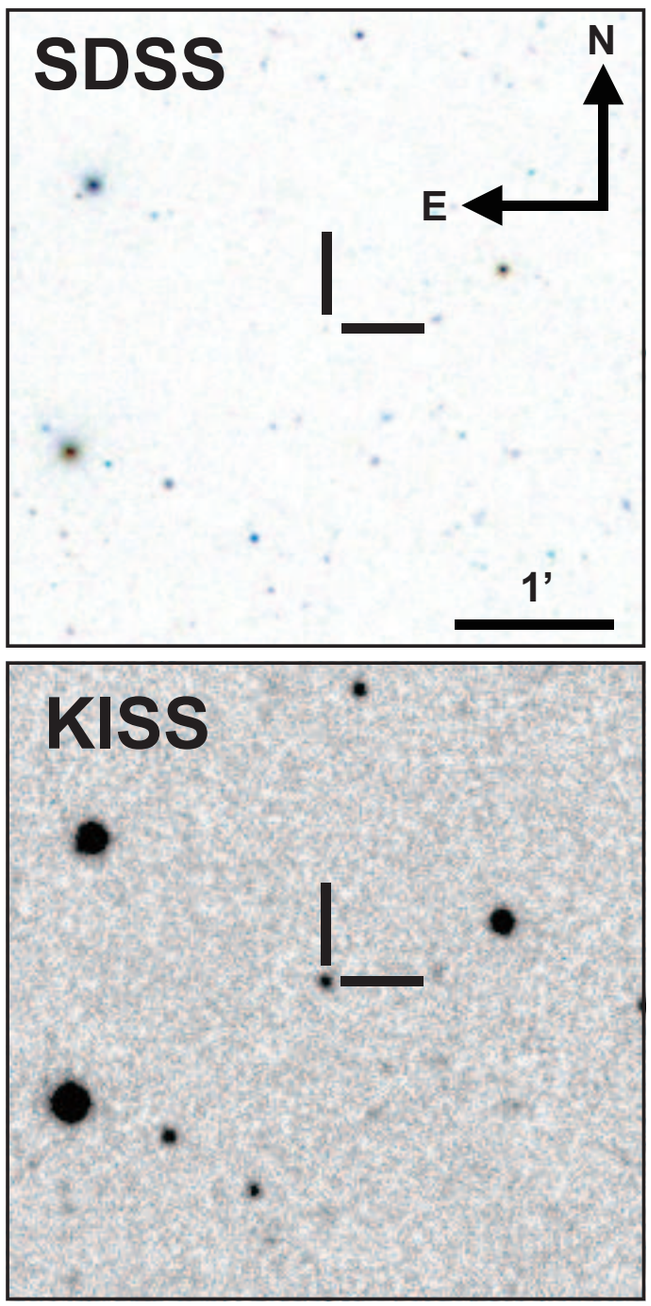
KOOLS
~18 mag

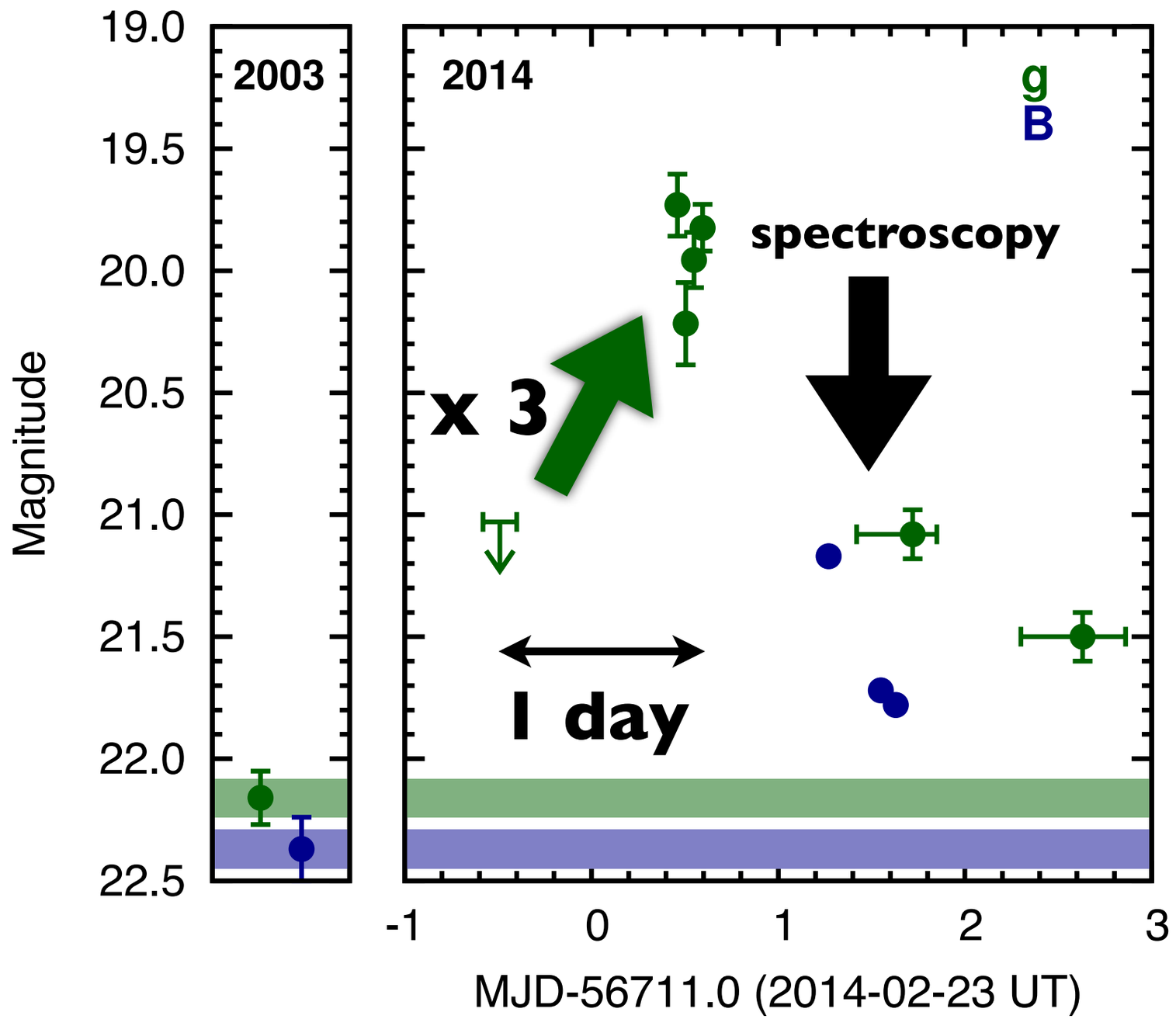
Subaru
~ 23 mag

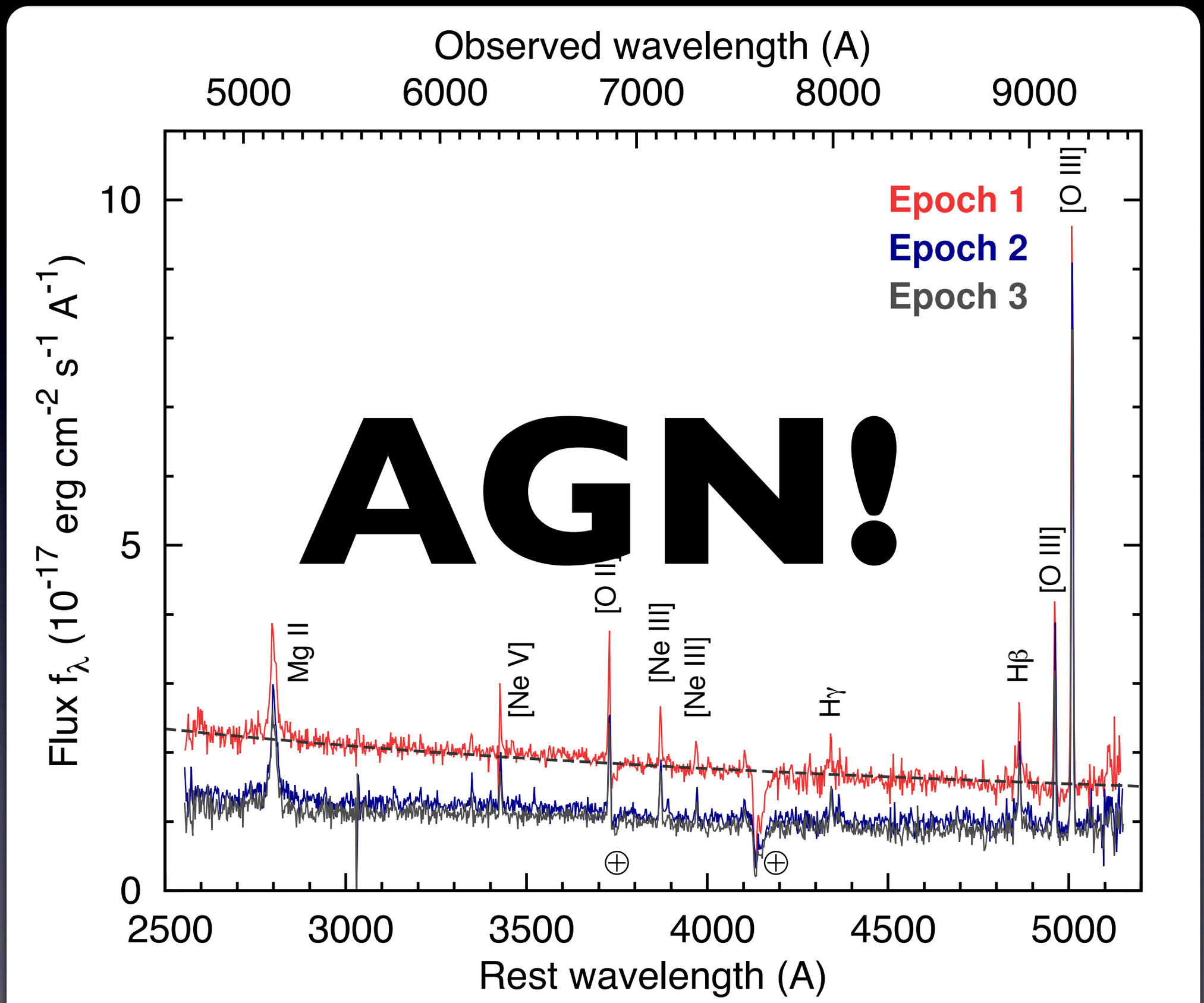
Outer ejecta (opt. thick)

Inner ejecta (opt. thin)

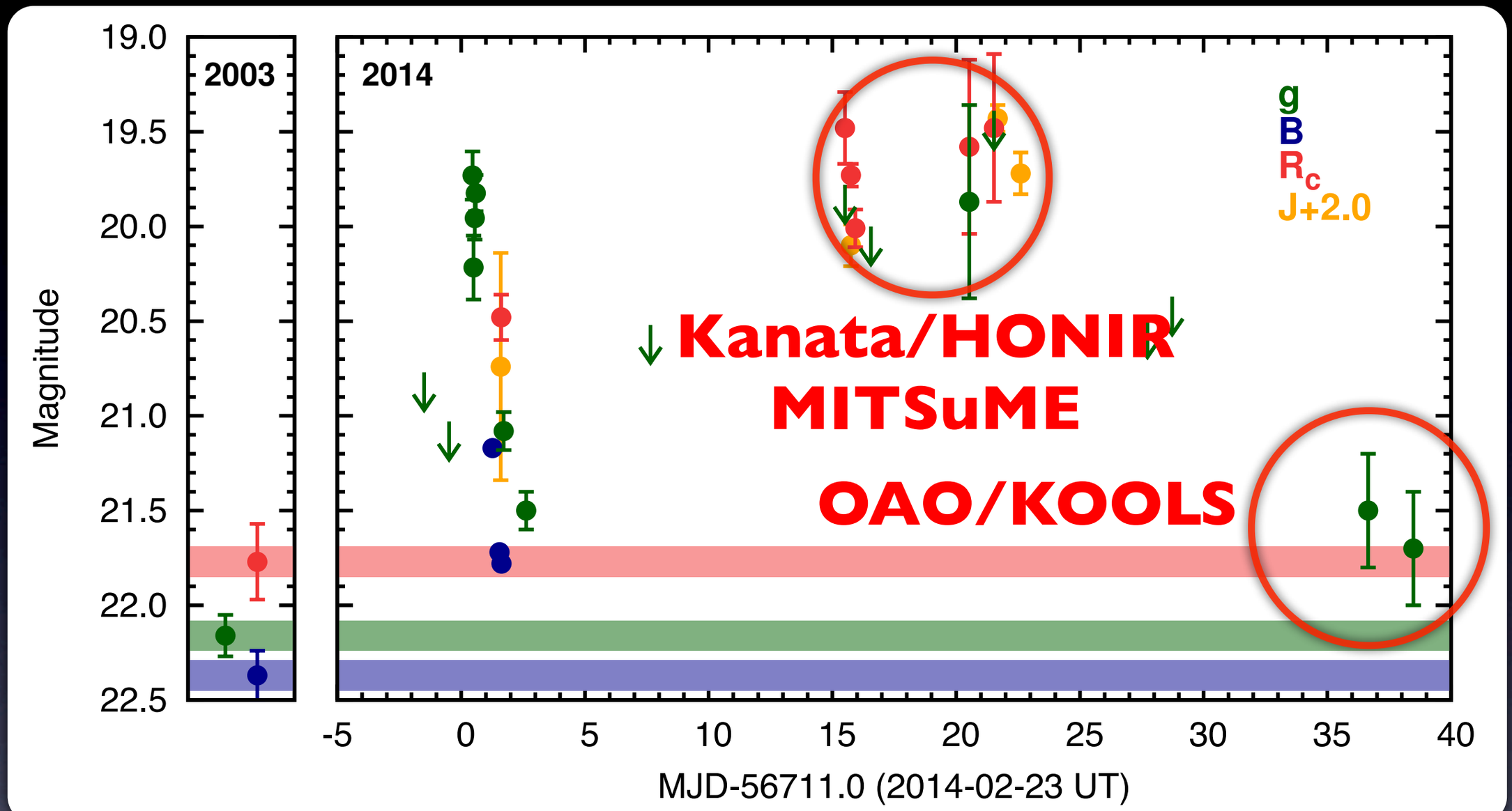
Project led by Katsutoshi Takaki (Hiroshima)


SDSS
N
E
1'
KISS


2003
2014
g
B
spectroscopy
x 3
1 day
Magnitude
19.0
19.5
20.0
20.5
21.0
21.5
22.0
22.5
-1
0
1
2
3
MJD-56711.0 (2014-02-23 UT)


Observed wavelength (A)
5000
6000
7000
8000
9000
10
5
0
Flux f_λ (10^{-17} erg cm^{-2} s^{-1} A^{-1})
Epoch 1
Epoch 2
Epoch 3
AGN!
[O III]
[O III]
[O II]
Mg II
[Ne V]
[Ne III]
[Ne III]
Hγ
Hβ
2500
3000
3500
4000
4500
5000
Rest wavelength (A)

Follow-up observations: optical/radio/X-ray



Extremely radio-loud AGNs with

- $M_{BH} \sim 10^5$-10^8 Msun
- $L \sim L_{Edd}$

=> Relativistic jets in "growing" SMBH

MT, Morokuma, Itoh, Akitaya, Tominaga, Saito et al. 2014, submitted to ApJ

Summary

- **KOOLS spectroscopy for KISS (4+13 nights in 13B/14A)**
  - Observations on the same night
  - Identification of 2 KISS SNe (19-20 mag)
  - No SN shock breakout yet
- **Ongoing work/Future plan**
  - Survey until 2015 Mar
  - 16.5 nights for 14B
  - Coordinated observations with Kanata/Subaru

*** Morokuma+14, submitted to PASJ (KISS initial results)**
*** MT+14, submitted to ApJ (flare in an unusual AGN)**