@Subaru UM Jan.2007

Status reports of intensive programs

I. Cosmology with High-Redhisft Type Ia Supernovae

S02B-I04 02B 10 nights

II. Dark Energy Measurements using SNIa in Elliptical Galaxies

S05B-137 05B 5 nights 06A 5 nights

S06B-085 06B 2 nights 07A 2 nights

Mamoru Doi (PI)
University of Tokyo

Co-investigators

S02B-I04

Mamoru Doi[1], Naoki Yasuda[2], Nobunari Kashikawa[2] , Kentaro Motohara[1], Tomoki Morokuma[1], H.Furusawa[2], K.Aoki[2], Y.Ohyama[2], K.Nomoto[1], Saul Perlmutter[3], Isobel Hook[4], Reynald Pain[5], Christpher Lidman[6], Ariel Goobar[7]

SXDS Team Suprime-Cam Group Supernova Cosmology Project Team

[1]Univ. of Tokyo, [2]NAOJ, [3]LBNL, [4]Oxford Univ., [5]LPNHE,[6]ESO,[7]Univ. of Stochholm

S05B-137, S06B-085

Mamoru Doi[1], Naoki Yasuda[2], Tomonori Totani[3], Nobunari Kashikawa[2] , Kentaro Motohara[1], Tomoki Morokuma[1], Naohiro Takanashi[1], Koichi Tokita[1], Takashi Ihara[1], H.Furusawa[2], K.Aoki[2], Y.Ohyama[2], Saul Perlmutter[4], Greg Aldering[4], Christpher Lidman[5], Ariel Goobar[6]

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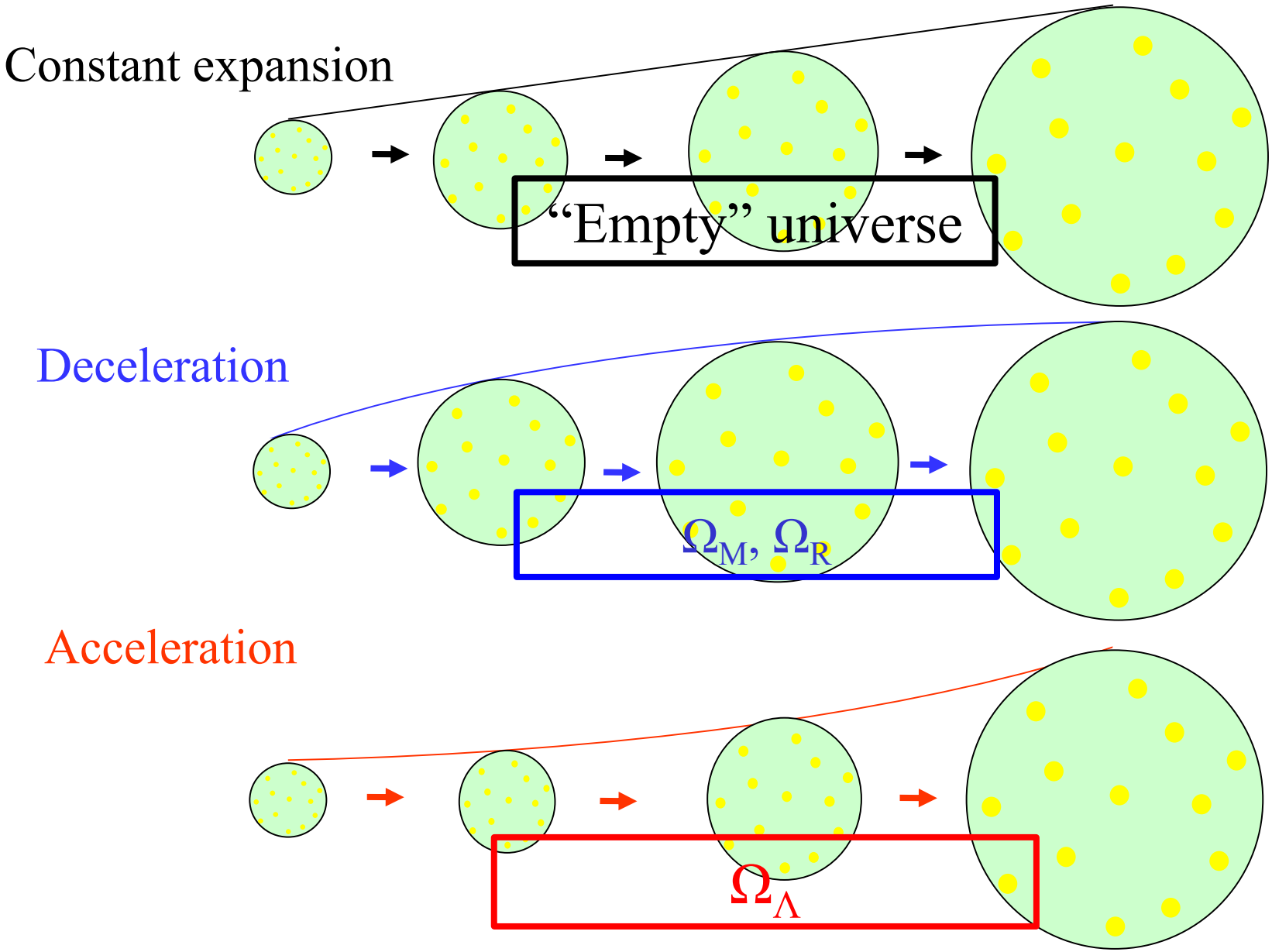
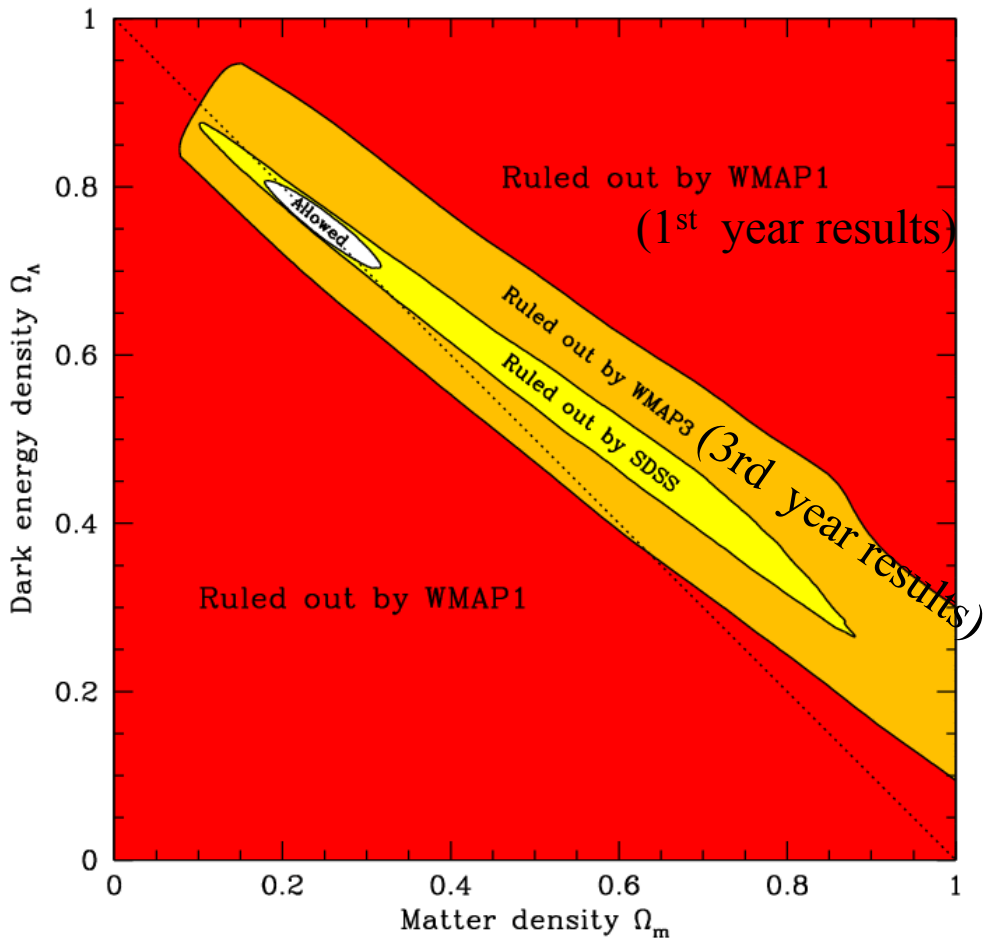
I Measuring Expansion of the Universe with SNIa



Results from "Standard Lod" measurements
CMB and SDSS galaxy survey

Tegmark et al. 2006



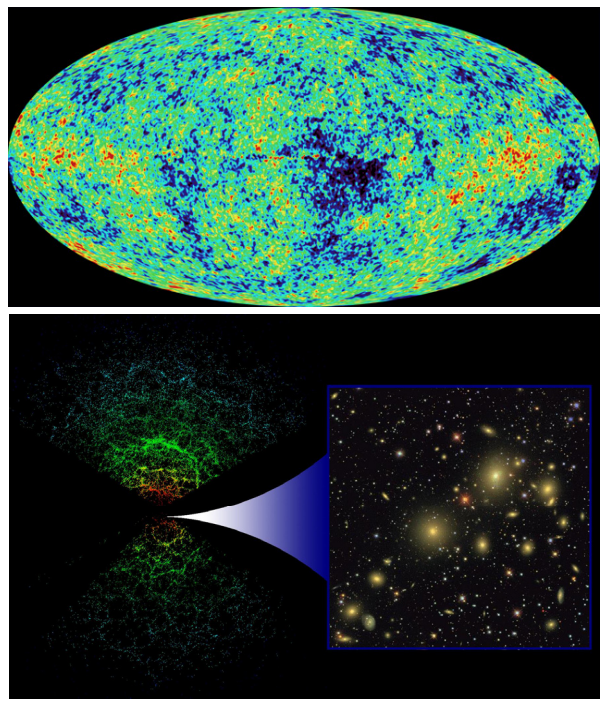
Ω_Λ

Ω_M

Dark Energy 75%

Matter 25%

Flat Universe



Ω_Λ (Dark Energy)

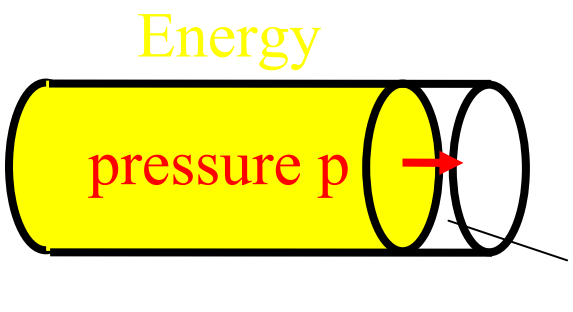
A big mystery even for Physics

density $\rho \propto a^{-3(1+w)}$

Matter w=0
Radiation w=1/3

cosmological constant: $w = -1$

$w = p/\rho = -1$: energy with "negative pressure"



$-\Delta E = \Delta V \cdot p$

Deceleration Parameter

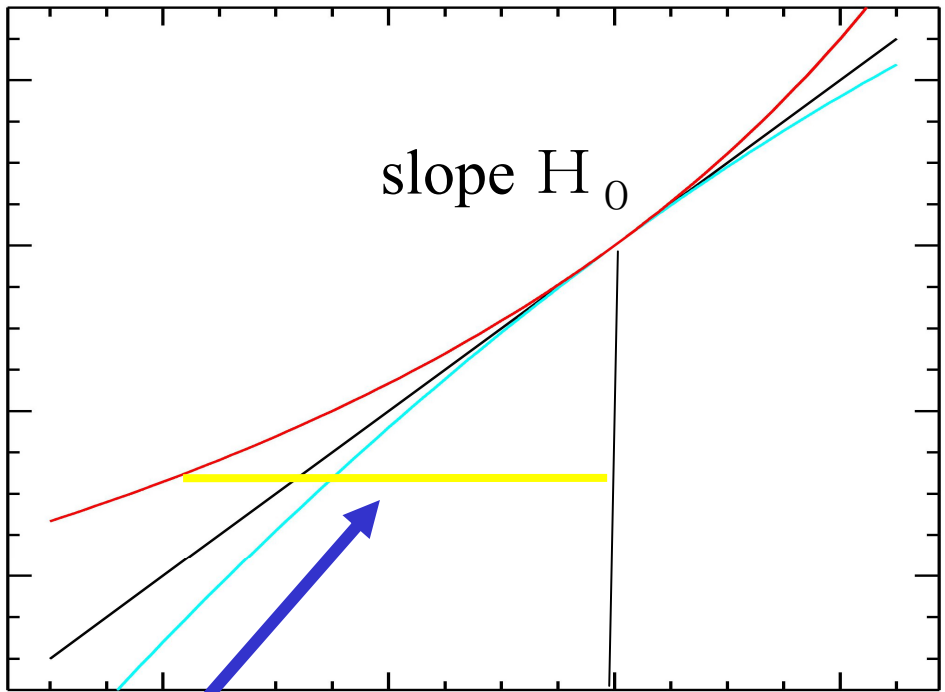
$$q_0 \equiv -\ddot{a}(t_0)a(t_0)/\dot{a}^2(t_0) = \tfrac{1}{2}(\Omega_M - 2\Omega_\Lambda + 2\Omega_R)$$

$\rho_\Lambda \sim 7\times10^{-30}$ g/cm3 → very small to measure at laboratory

Measurements with SN
Redshift and Distance

$a \propto (1+z)^{-1}$

spectroscopy



(time) = (distance)/c → Flux

photometry

Type Ia Supernova

- Standard Candle（Luminosity~constant）

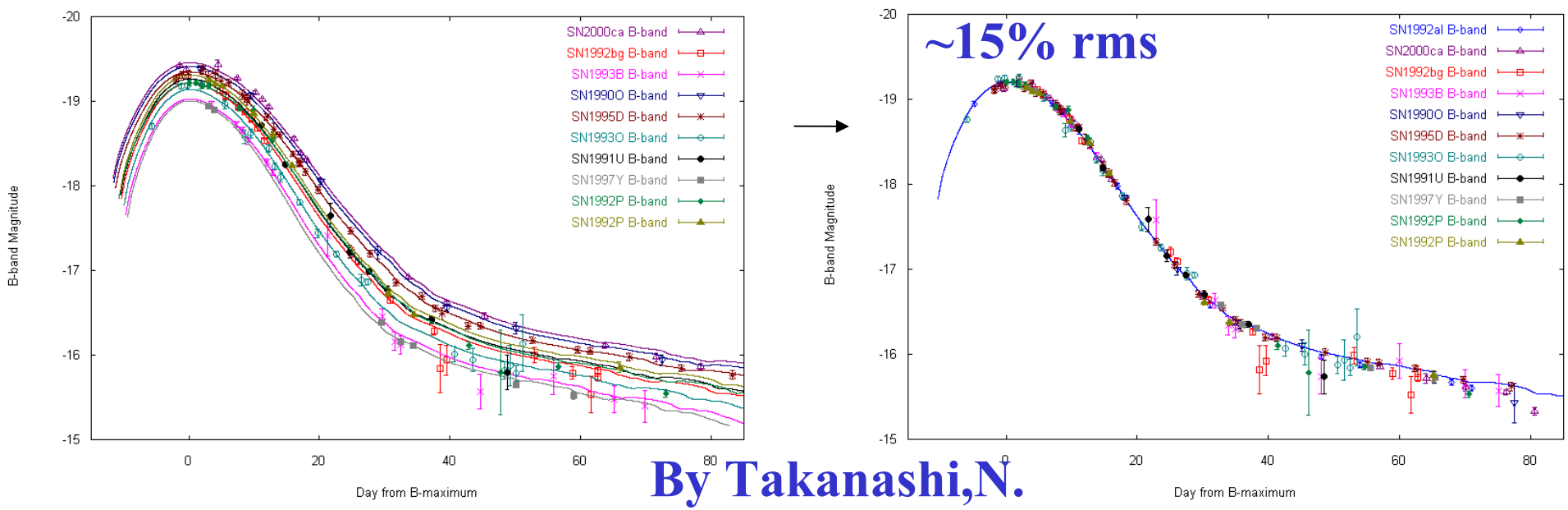
  →WD（@binary system）reached

  Chandrasekar limit（~1.4solar mass）

  ⇔ Core collapse SNe Type II, Ib, Ic

- Large Luminosity (~whole galaxy)

  → measurable at cosmological distance

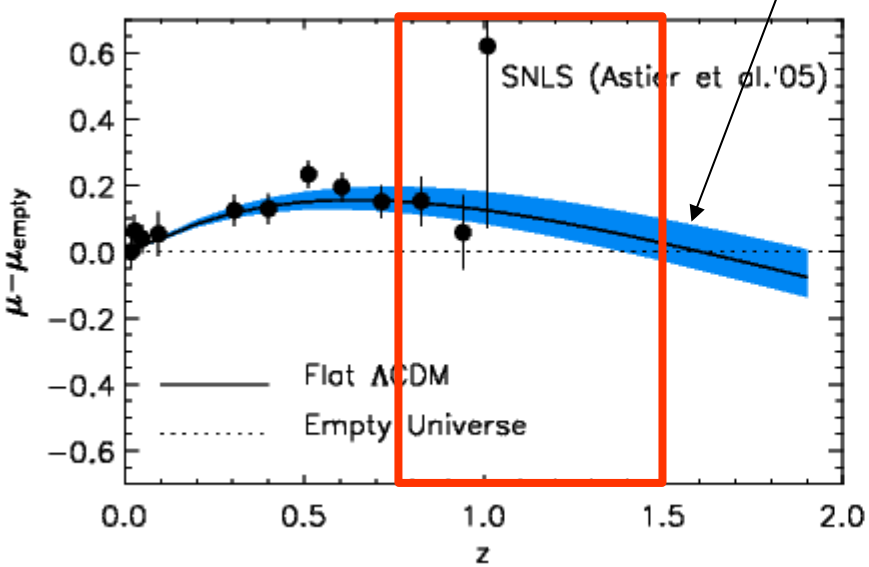


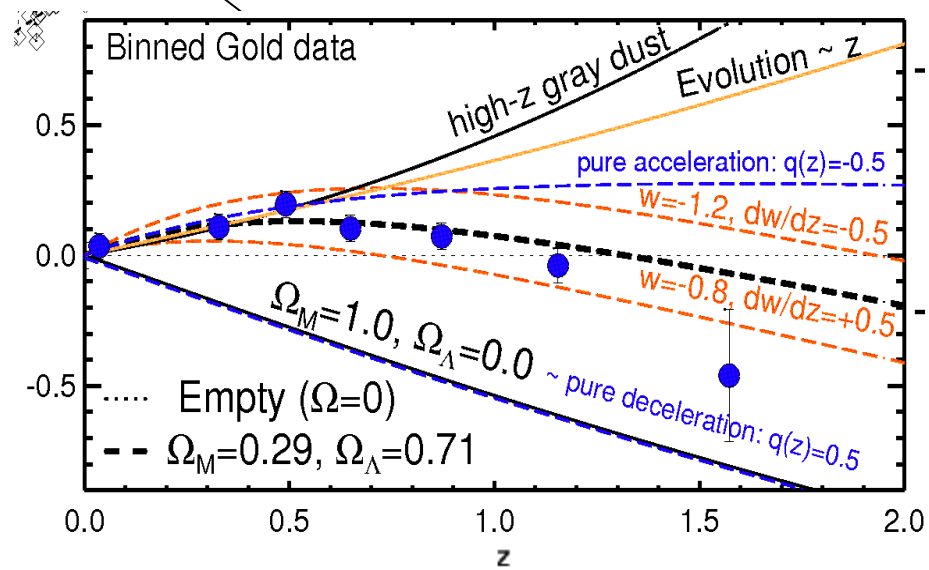
By Takanashi,N.

Recent Results from SNe

(Spergel et al. 2006)

$\Omega_\Lambda \sim 0.7$ $\Omega_M \sim 0.3$





CFHT MEGACAM &
8-10m telescopes for spectroscopy
Astier et al. 2005

HST&previous data
Riess et al. 2006

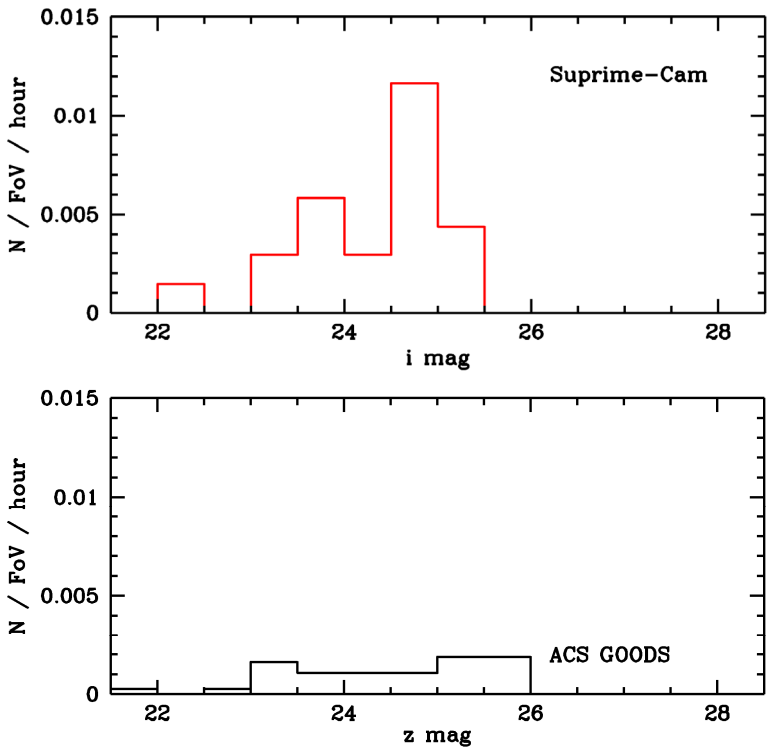
II. S02B-I04 (10 nights in 2002B)

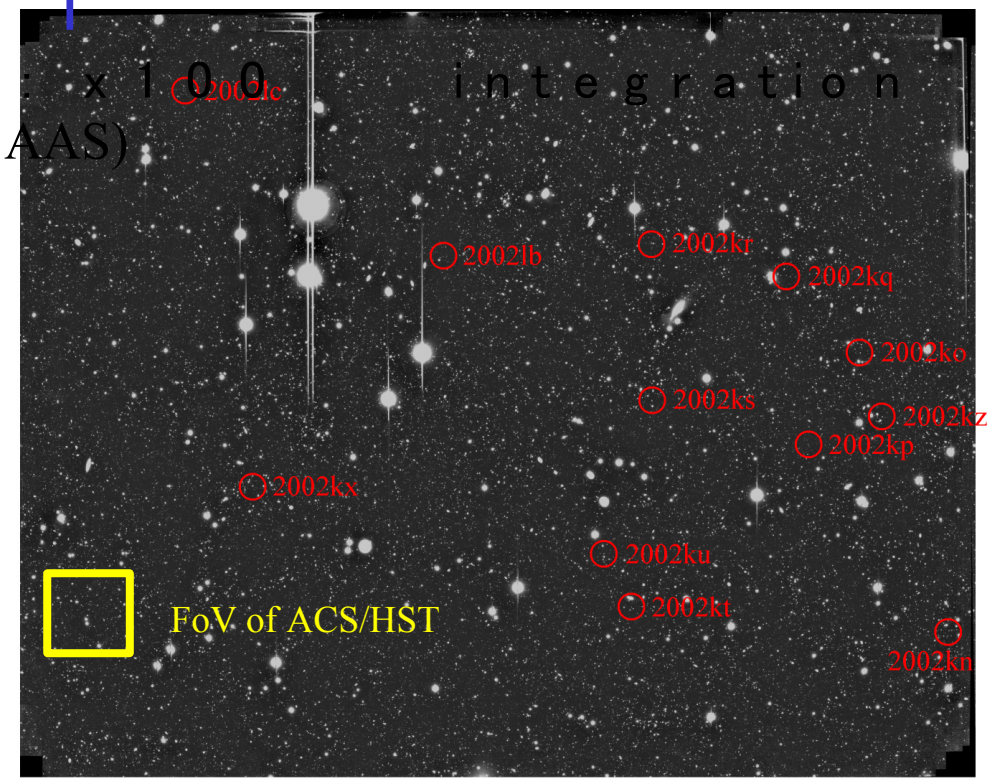
Suprime-Cam: The most powerful imager to find distant SNe

~20 times more effective than ACS@HST

x100 integration

, AAS)





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電話 03-3545-0131

超新星18個発見

宇宙の運命 これで分かる?

膨張を続けるか 収縮に転じるか 観測可能に

ハワイ・すばる望遠鏡

ハワイにある国立天文台のすばる望遠鏡が、数十億光年先にある超新星18個を発見した。土居守・東京大助教授（観測的宇宙論）らのグループが29日に発表した。宇宙が膨張する様子の分析に適した距離にあり、これらの超新星を今後、何度か観測すれば、「宇宙が加速膨張しているか」という宇宙の運命をめぐる議論が決着できると期待されている。

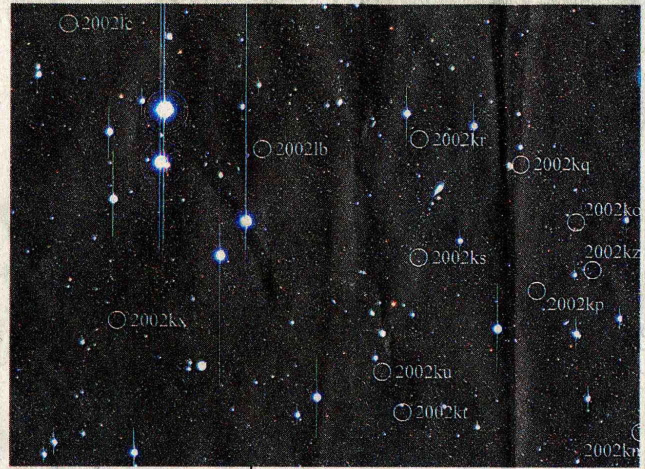
超新星は、星が最後に起こす大爆発。今回の18個は、いずれもくじら座の周辺でみつけた。推定距離は40億～70億光年。うち12個は1枚の画像に写っていた。口径8メートル級の大望遠鏡のなかでも最大の視野を生かした形で、これほど多数の超新星を一度に発見したのは世界で初めてという。

膨張を続ける宇宙の将来は、膨張の仕方で決まる。その速度が減速している場合、膨張が止まって収縮に転じ、やがて宇宙がつぶれてしまう可能性もある。宇宙年齢を137億歳とした米航空宇宙局（NASA）の今年2月の発表は加速説を支持したが、試算は間接的な推計にとどまっていた。

膨張速度の変化をより直接的に求めるには、数十億光年以上遠方で、距離も明確な超新星の明るさの変化を調べればいい。しかし、こうした超新星は暗くて観測が難しく、これまで数個しか見つかっていなかった。

今回の超新星を今後、何度か観測することで、宇宙が現在の半分の大きさだったころの膨張の様子をみることができるとみられる。

土居助教授は「同じ超新星を今秋以降にも観測する予定で、それによって宇宙の膨張について明確な結論が得られるだろう」と話している。



画像1枚に12個

1枚の画像で発見した12個の超新星。数字付きの丸で囲んだ部分にある。数字は、超新星につけられた識別番号。この画像の範囲は、満月がほぼすっぽりと入る大きさに相当する＝田中壱さんとSXDSチーム提供

芹沢助教

偽証罪で ス

【クリーブランド（米オハイオ州）＝村山知博】日本人の研究者2人が米国の研究施設から試料を盗んだとされる「遺

伝子スパイ
リーブラン
は28日、偽
ていた芹沢
ンザス大助

人は分か
誰にも理解
孟司さんの
×
「金魚の
フン然。大
うのに野党

Schedules changed

original plan: FOCAS 4 nights , CISCO 6 nights,
Suprime-Cam 13 nights from SXDS, 2 nights from SN (←ToO)

bad weather for Suprime-Cam search
FOCAS 2 nights → Suprime-Cam 2 nights

telescope actuator trouble
FOCAS 1 night → CISCO 1 night

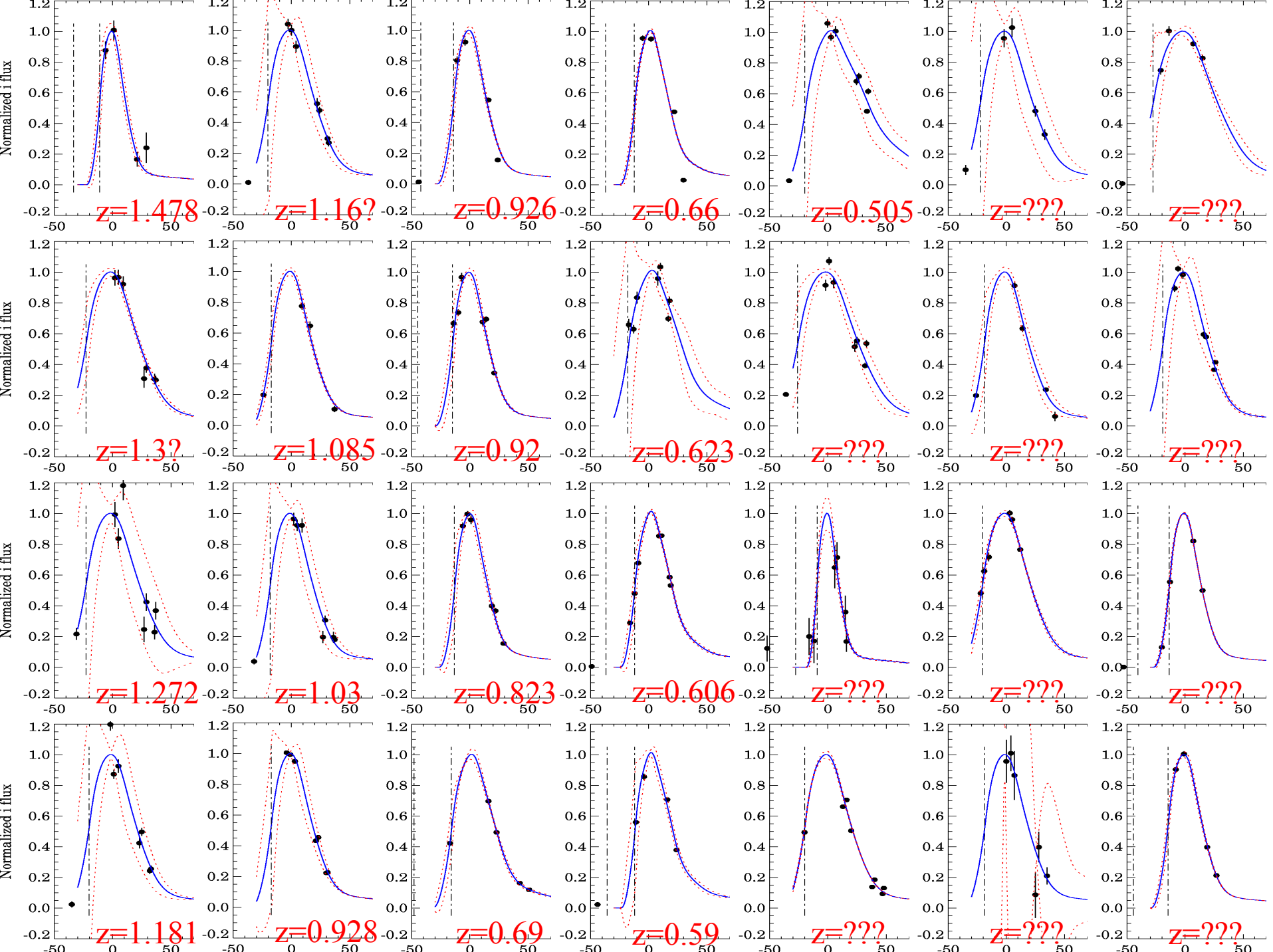
CISCO troubles, Strong Astigmatism, etc.
CISCO 4 nights → Suprime-Cam 2 nights

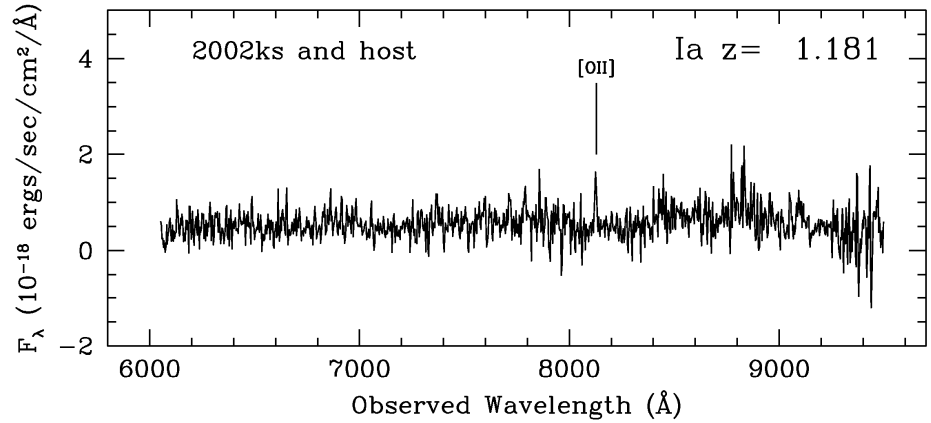
filter trouble with Suprime-Cam …

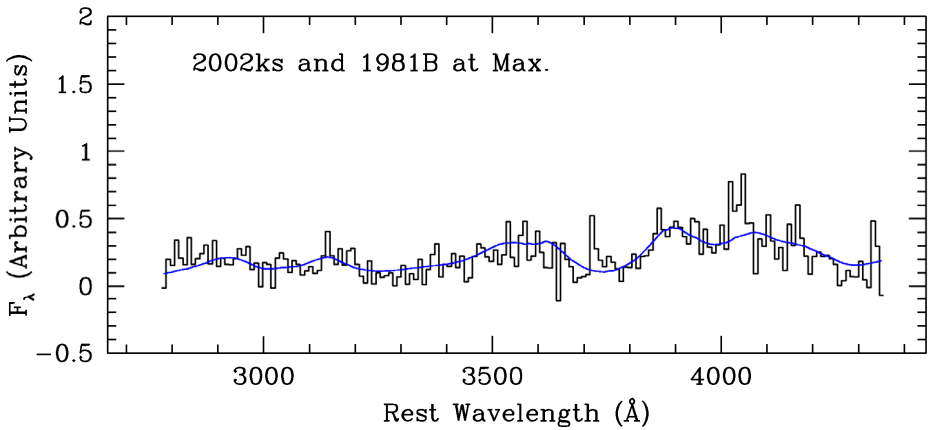
real schedule: FOCAS 1 night, CISCO 3? nights,
Suprime-Cam 13 nights from SXDS, 6 nights from SN

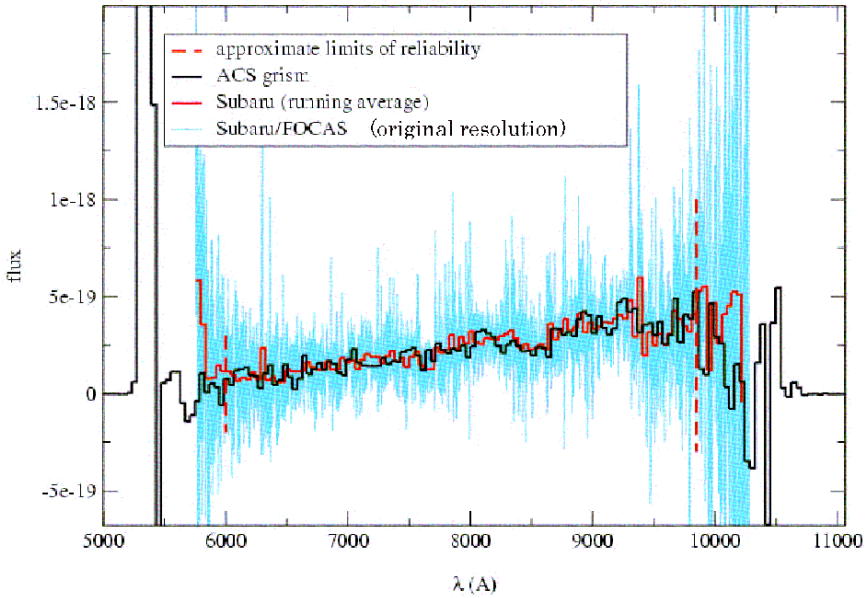
→ optimized for light curve observations with Suprime-Cam

⇔ high quality measurements at z~1.2


Normalized i flux
z=1.478
z=1.16?
z=0.926
z=0.66
z=0.505
z=???
z=???
z=1.3?
z=1.085
z=0.92
z=0.623
z=???
z=???
z=???
z=1.272
z=1.03
z=0.823
z=0.606
z=???
z=???
z=???
z=1.181
z=0.928
z=0.69
z=0.59
z=???
z=???
z=???







SN+host at z=1.28

red FOCAS （7200sec）

black HST/ACS（12000sec）

consistent

Ia at z=1.18

(with VLT, Lidman et al. 2004)

2002 Fall preliminary summary (spectroscopic sample)

name	IAUC	redshift	type	spectroscopy	HST	J-band
SuF02-081	-	1.45-1.48?*		VLT	△	
SuF02-012	SN2002lc	1.3-1.5		Keck/VLT/Subaru/HST	○	NICMOS
SuF02-083	-	1.272?		VLT		
SuF02-065	SN2002ks	1.181*	Ia	VLT	○?	NICMOS
SuF02-007	-	1.14?		VLT/Subaru		
SuF02-060	SN2002kr	1.063*	Ia	VLT/Gemini	○	NICMOS
SuF02-061	-	1.08?		Keck/Subaru		
SuF02-017	SN2002kn	1.03	Ia?	Keck/Gemini/VLT	△	ISAAC/CISCO
SuF02-071	SN2002kp	0.928*		Keck	△	ISAAC
SuF02-037	SN2002kv	0.926*		Keck		
SuF02-000	SN2002ku	0.92*		Keck		
SuF02-002	SN2002kq	0.823*		VLT		
SuF02-021	-	0.69		Keck		
SuF02-055	SN2002ky	0.66		Keck		
SuF02-082	SN2002kx	0.623*		Keck		
SuF02-025	SN2002km	0.606*	Ia	VLT		
SuF02-077	SN2002kw	0.59		Keck		
SuF02-001	SN2002ko	0.57	Ia	Keck		
SuF02-019	SN2002kt	0.505*		Keck		
SuF02-028	SN2002kz	0.347?		VLT		
SuF02-059	-	0.269		Keck		

*: host galaxy

Ne found with Suprime-Cam

	Candidates	Spectr.	Confirmed SN Ia	HST followup
2001 Spring	22	8	3	1
2002 Spring	55	13	5	4
2002 Fall	44	27	5	3
Total	121	48	13	8

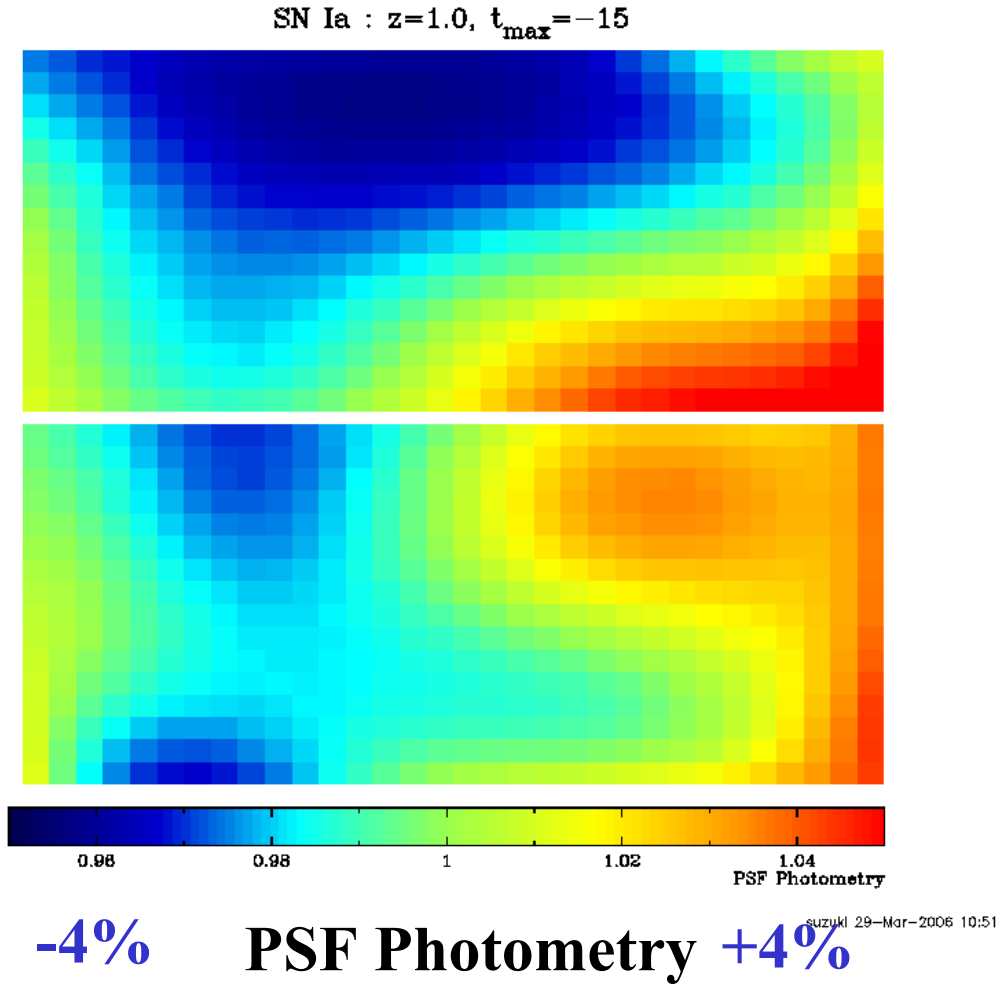
Supernova Cosmology Project
follow-up observations with Keck, VLT, Gemini, HST

Final analysis
On going

However, unexpectedly,

HST ACS PSF (x, y, color, time) was not stable

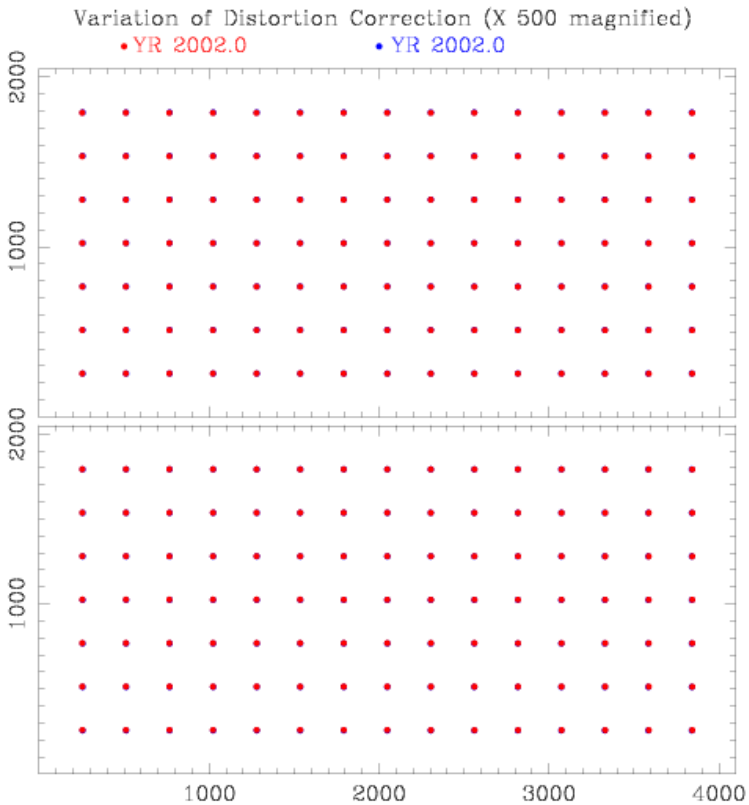
- Changes with
- CCD (x, y)
- SN Phase
- Day / Night
- Distortion(t)
- + CTE

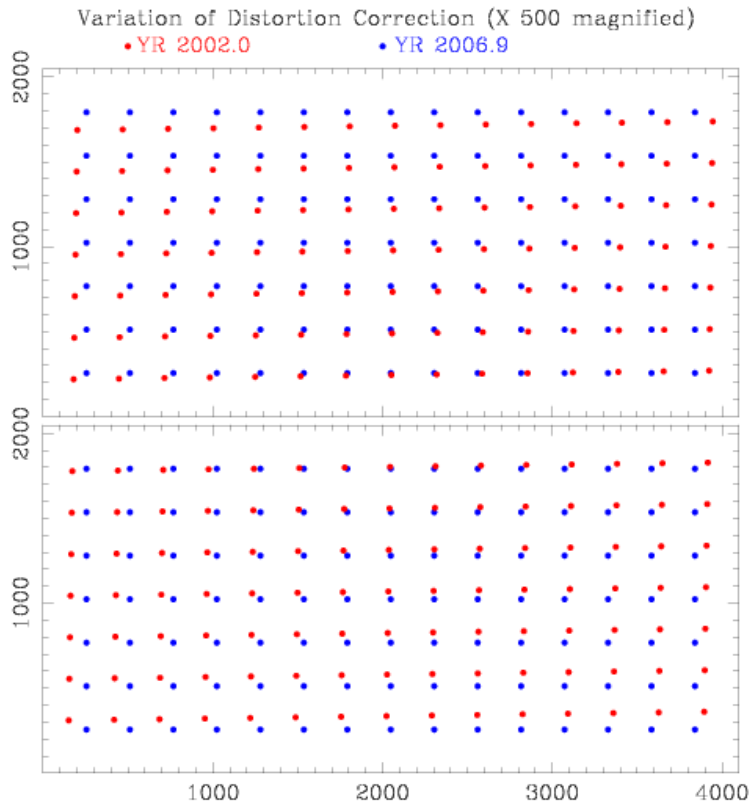


-4% **PSF Photometry** **+4%**

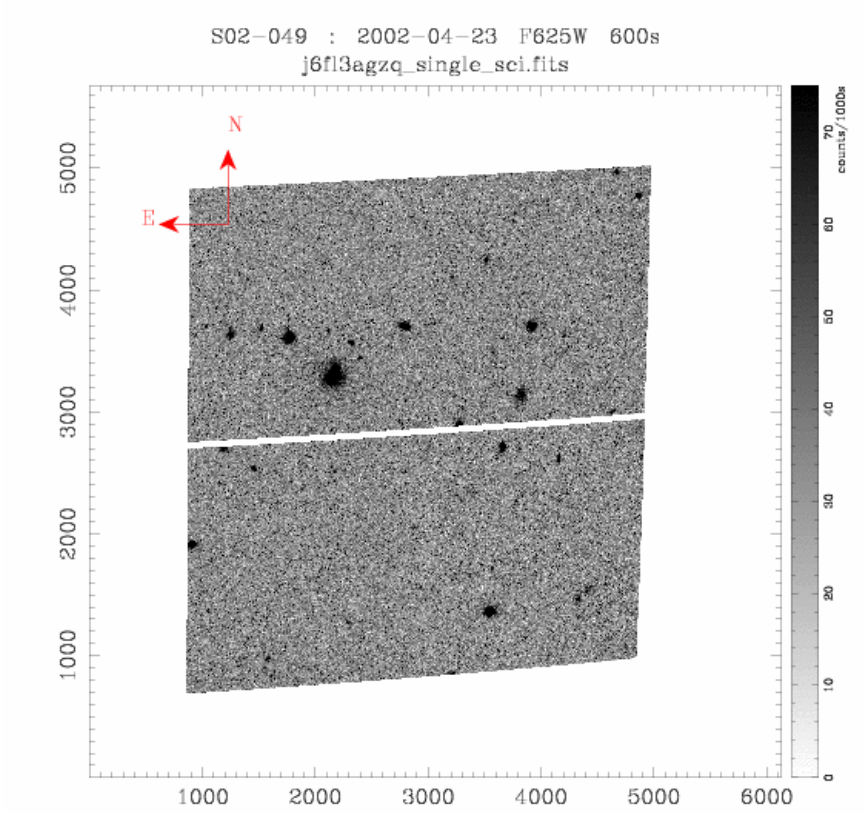
By Naotaka Suzuki (LBNL)

HST ACS
Time Dependent Distortion

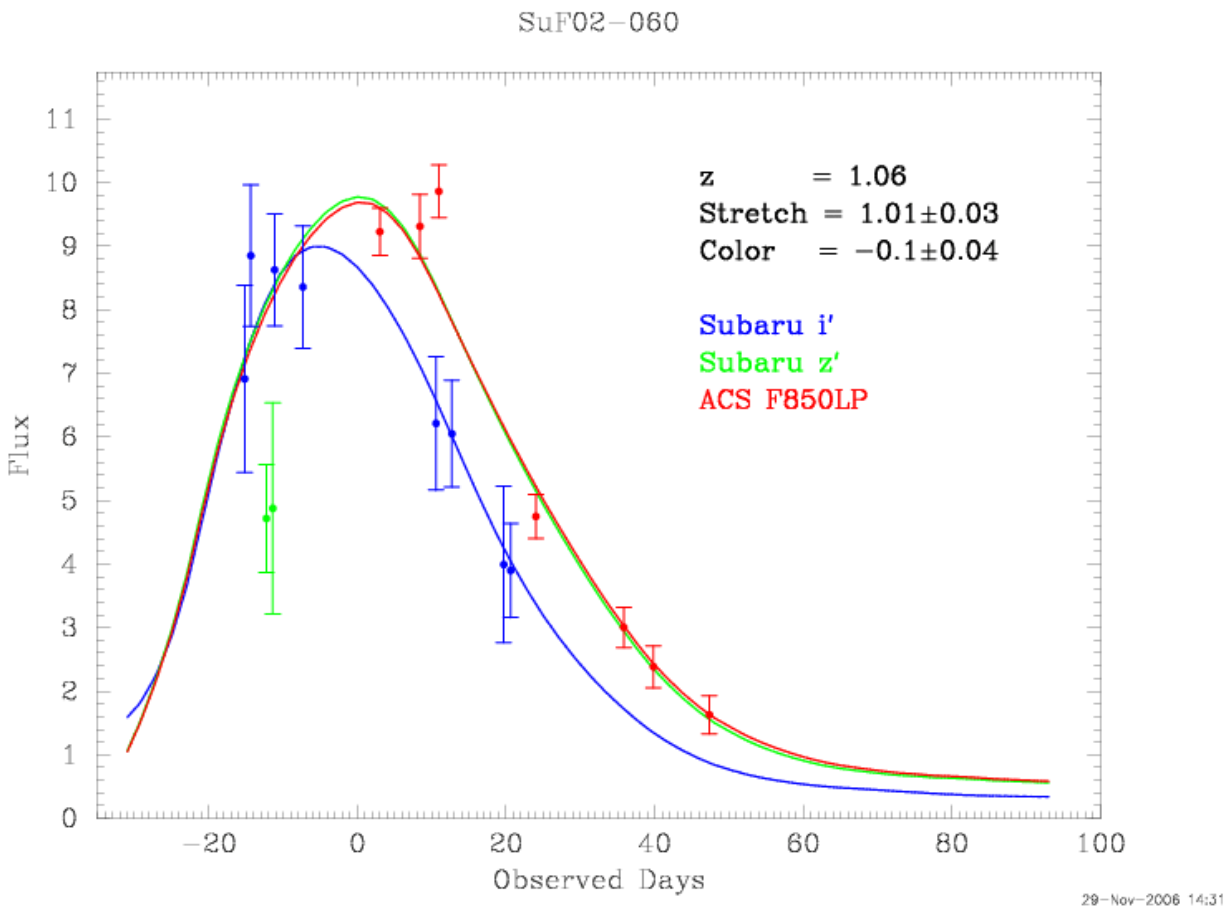




HST ACS: 2 Gyro Rotated Field



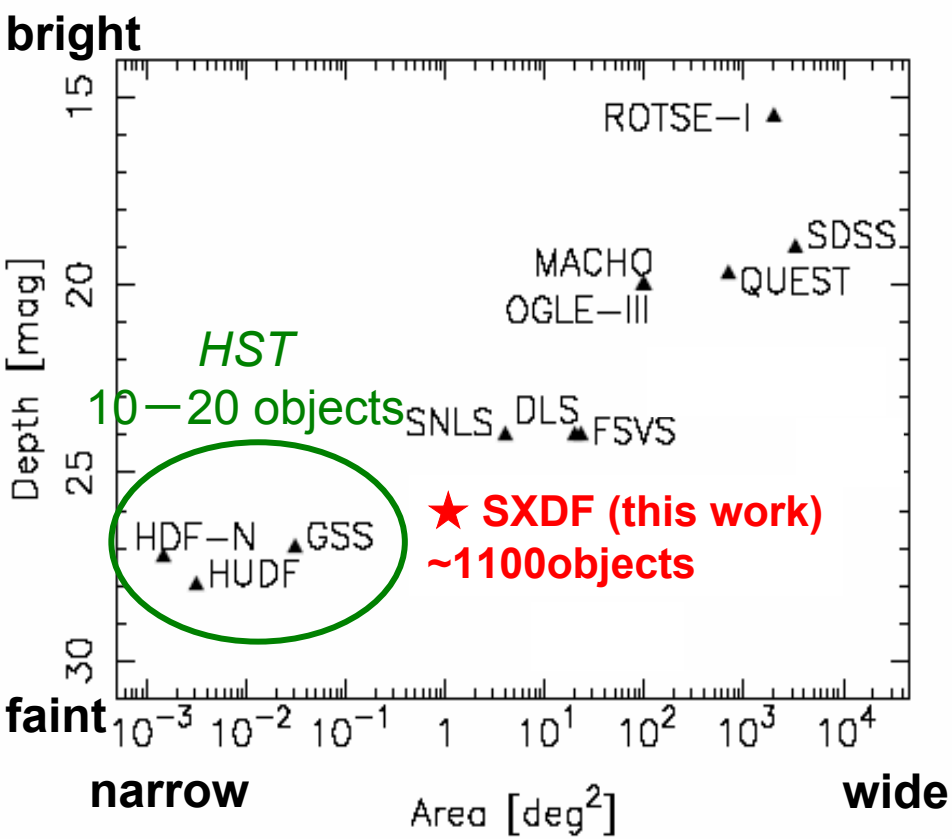
SN Ia Light Curves still to be worked out



A Survey for Faint Optical Variables

By Morokuma et al. (2007)

→ poster



First statistical results

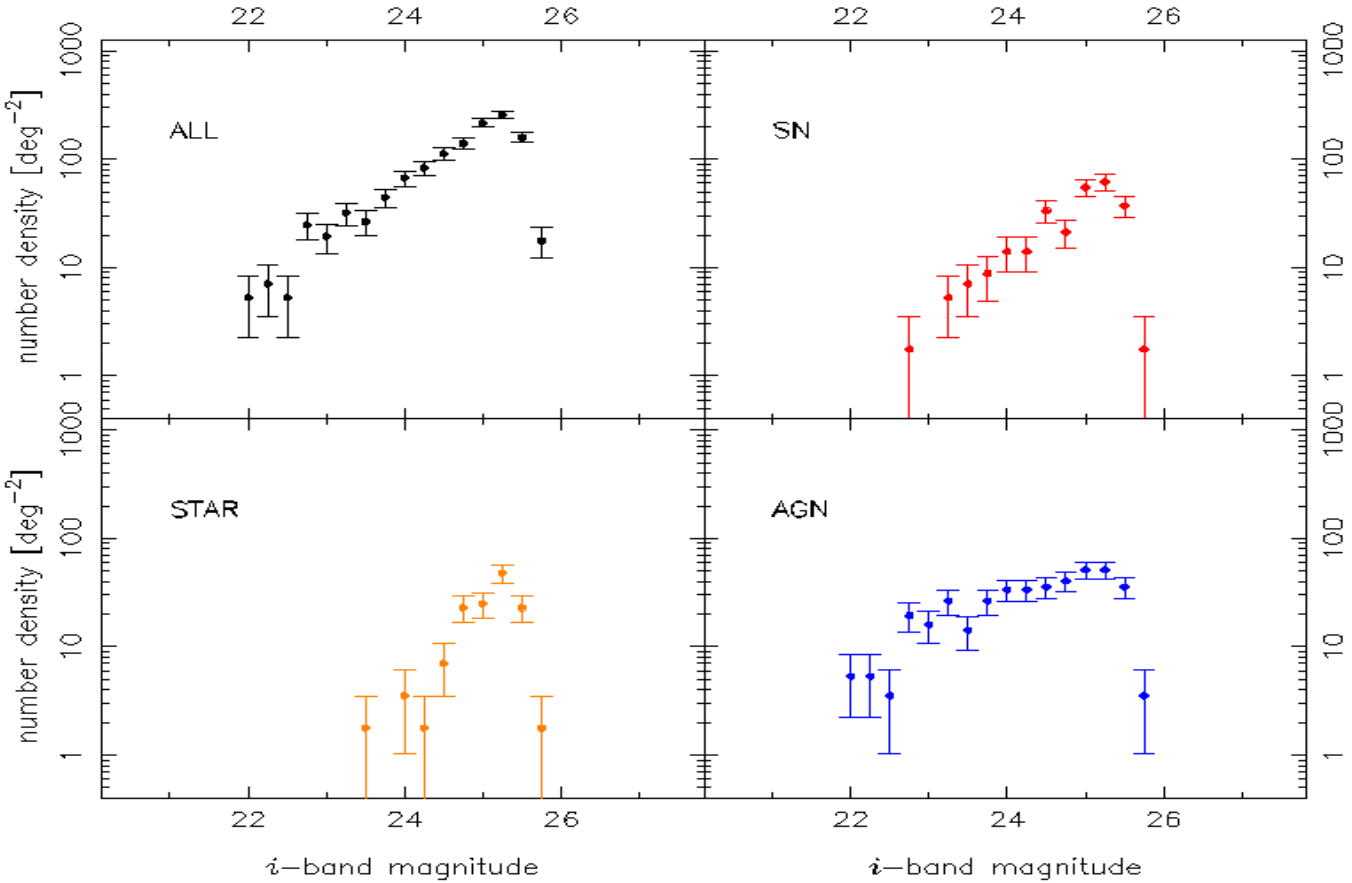
SXDF deep photometry

Optical variability

X-ray data from Newton

MIR data from Spitzer

Variable objects found in multi-epoch imaging of Suprime-Cam



poster

Variable component only

Morokuma et al. 2006

→ **First statistical results of optical faint variables**

- **Low-luminosity AGN population not found with deep X-ray survey**
- Possible most distant RR-Lyrae in our Galaxy
- SN rate studies

Publications, plans

IAUC7649 Doi et al. 2001 (7SNe), IAUC7971 Yasuda et al. (6SNe),
IAUC8119 Doi et al. 2003 (13SNe)
AAS Yasuda et al. 2004
Lidman et al. 2005 (VLT spectroscopy)

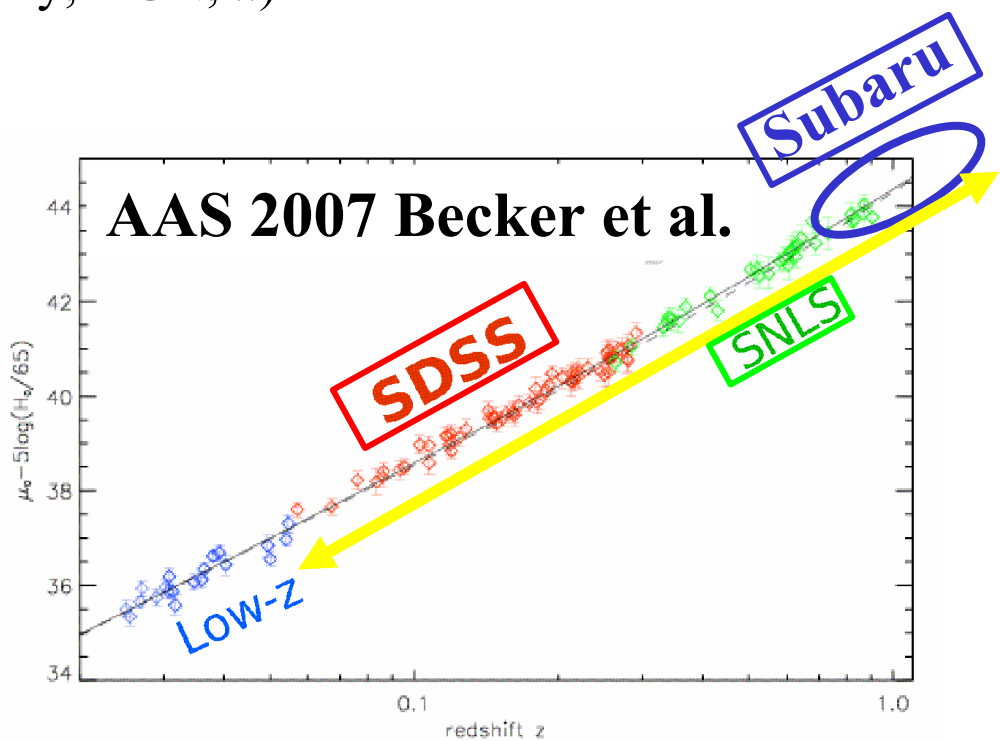
Zero point photometry with USNO 1m

Yasuda et al. 2007 (Suprime-Cam)
Suzuki,N.? et al. 2007 (HST)
Morokuma et al. 2007a,b,.. (variability, AGN, ..)
Oda et al. 2007? (SN rate)

After final HST photometry

(Also contributed SXDS)

Future further usage
SN cosmology
only using SDSS band data
Suprime-Cam, SNLS, SDSS



III. SNIa on elliptical host galaxies

High-z Cluster surveys by SCP (2005-2006)

HST imaging (S.Perlmutter et al)	219 orbits
Subaru spectroscopy (M.Doi et al.)	14 nights
VLT spectroscopy (C.Lidman et al.)	16 hours+DDT
Keck spectroscopy (S.Perlmutter et al.)	6 nights+

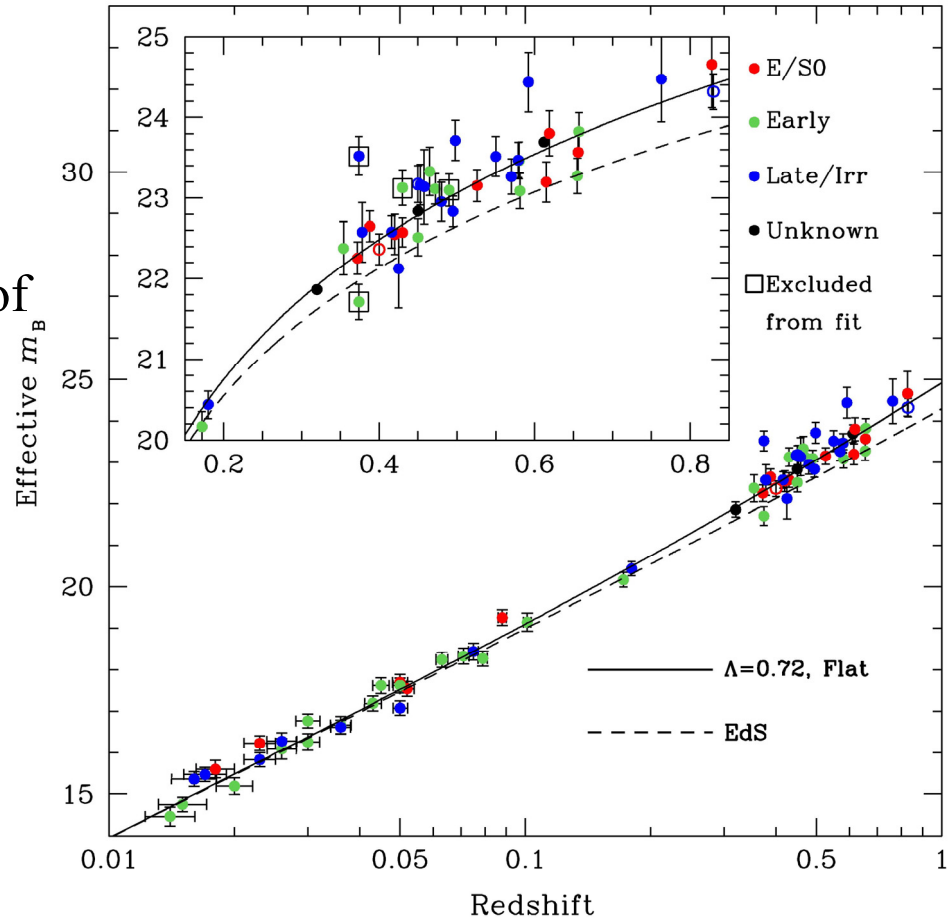
with cluster search/study teams
- RCS (Gladders, Yee et al.)
- RDCS (Rosati et al.)
- IRAC (Eisenhardt et al.)
- XMM (Mullis et al.)

RDCS 1252.9 @ z=1.23 (ISAAC and ACS)

Host extinction

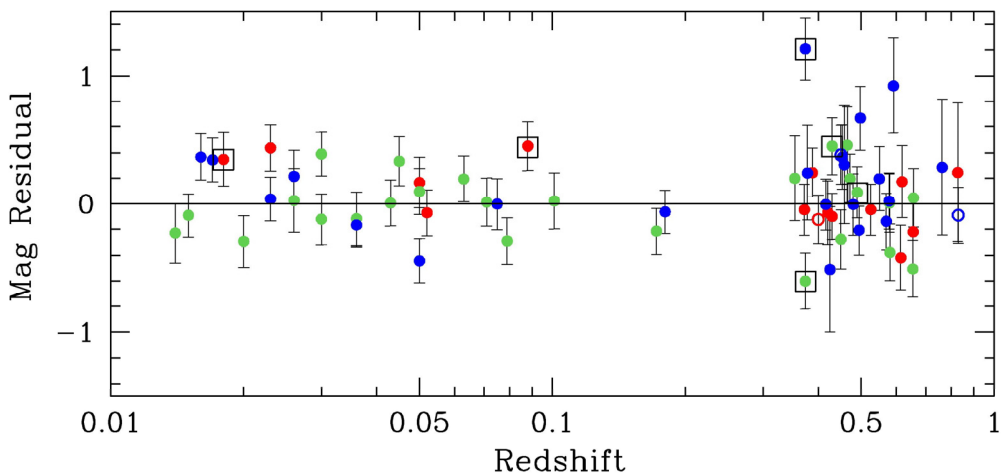
Sullivan et al. 2003

Host galaxy morphology of SNe with HST

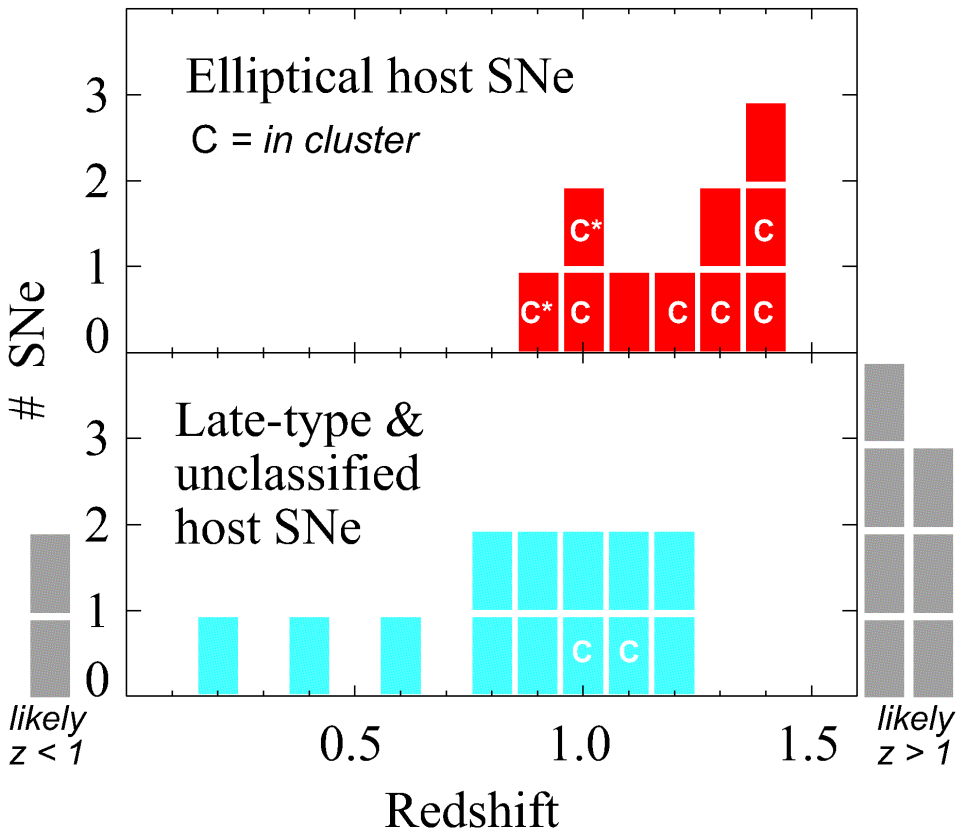


blue : late type
red : E/S0

E/S0
σ =0.16 mag
⇔
All sample
σ ~0.5 mag



SNe found

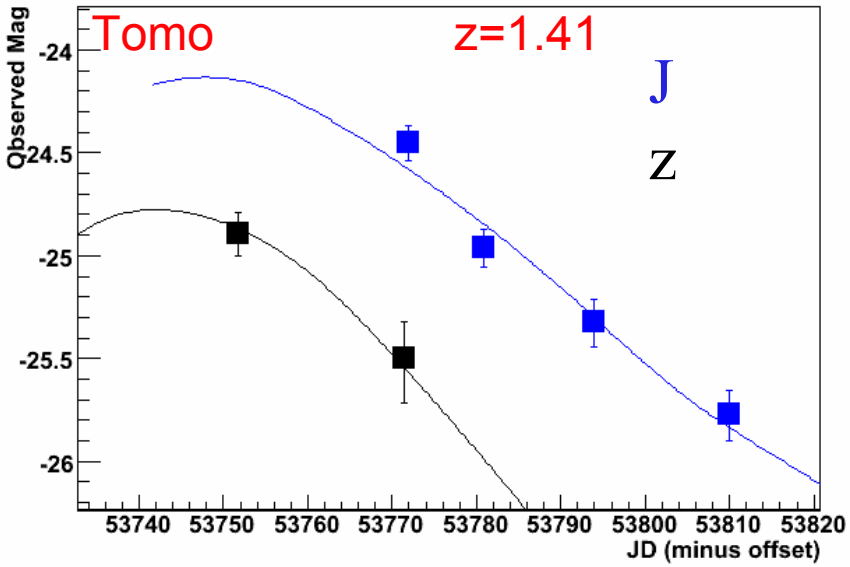


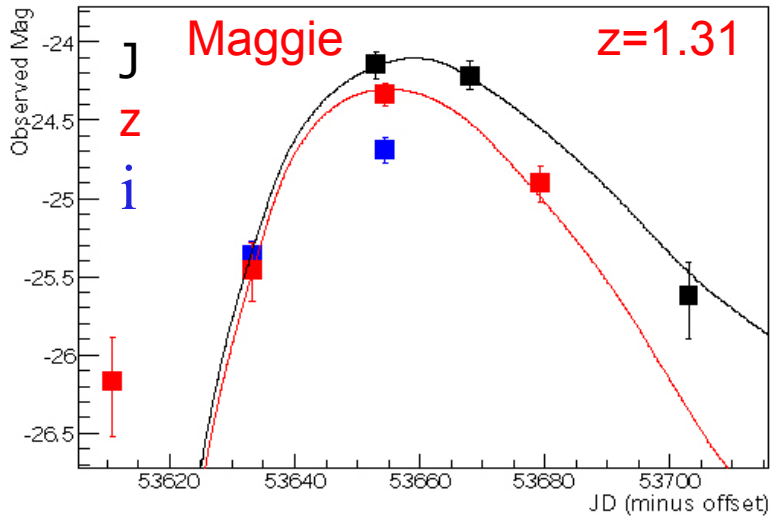
Redshift successfully determined so far

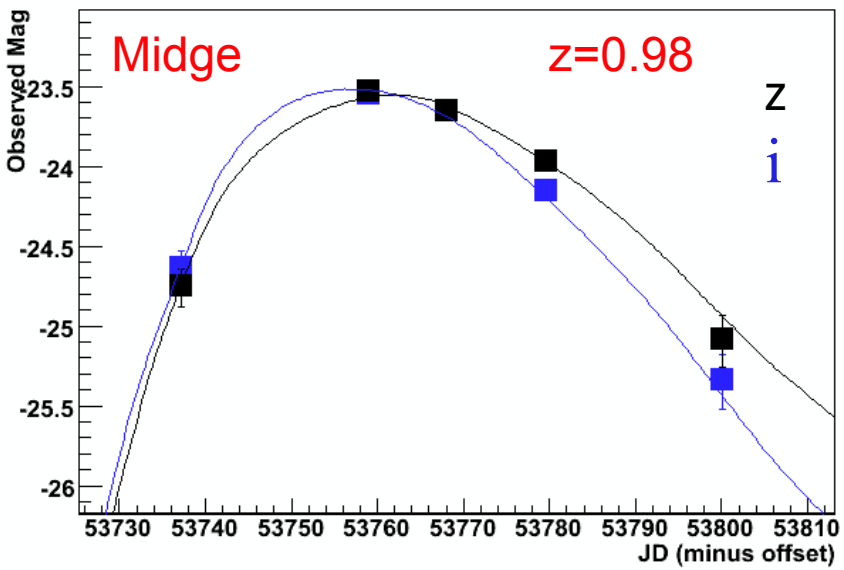
total 23 SNe

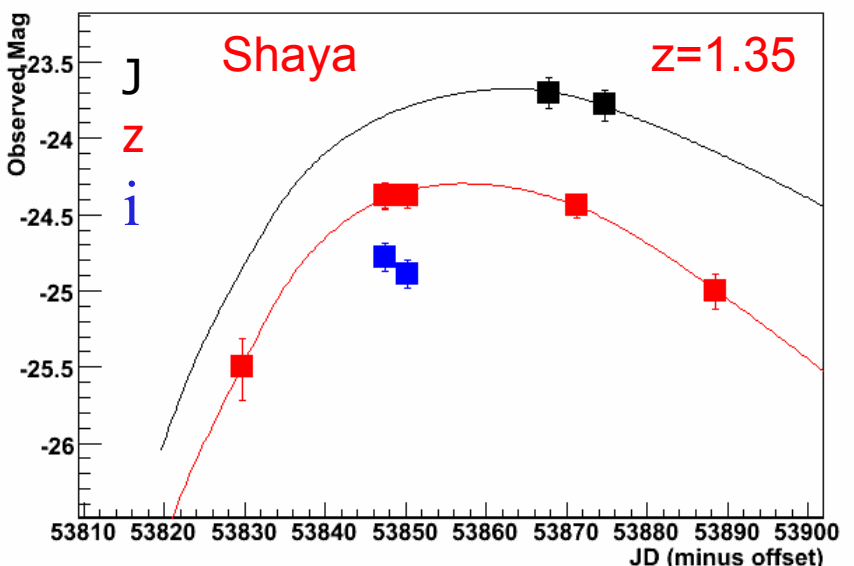
Subaru 19 SNe

Preliminary SN Light curves

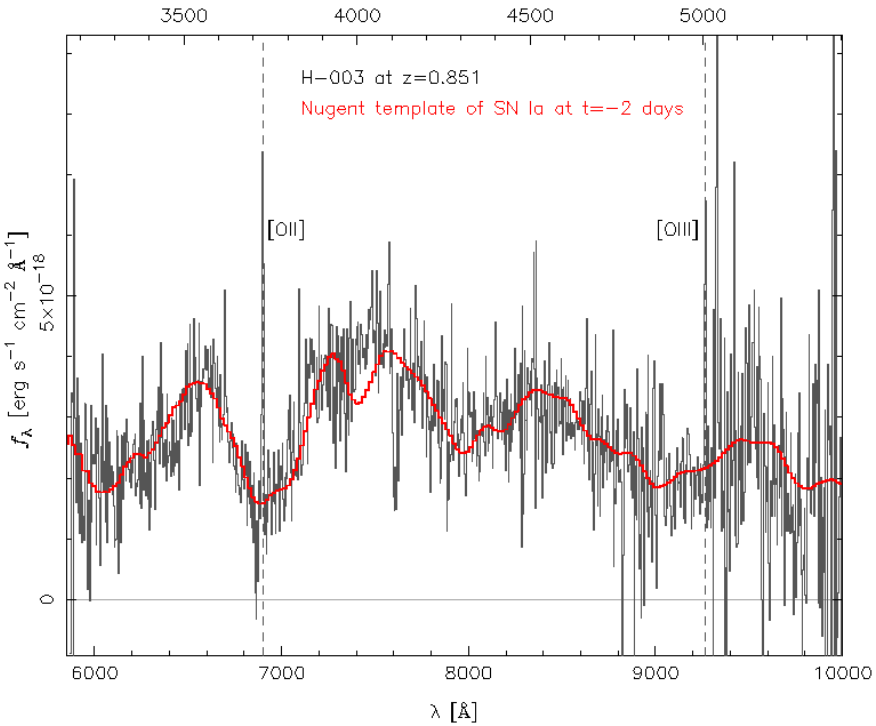


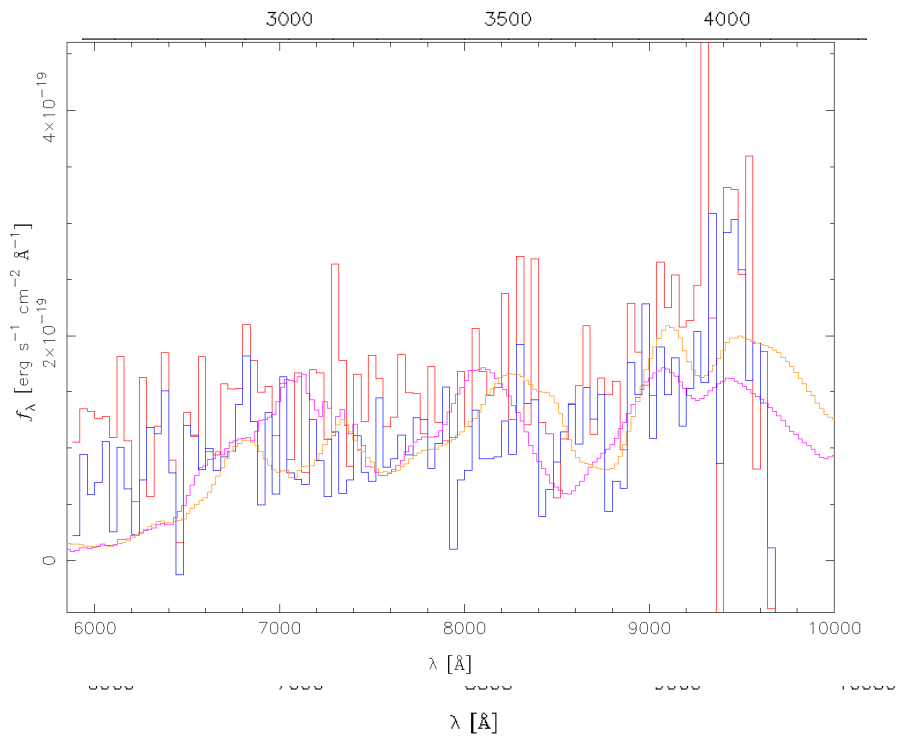






Example spectra with FOCAS





z=0.851

z=1.3

Spectroscopy of SN
with good Light Curves
total 18 Sne
Subaru 12 SNe

LGAO for distant SNe

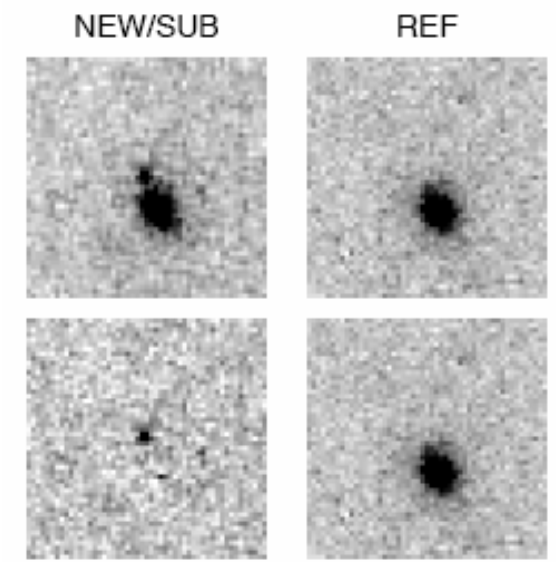
KeckII+NIRC2+LGAO

Rest-Frame R-band Lightcurve of a $z \sim 1.3$ Supernova Obtained with Keck Laser Adaptive Optics

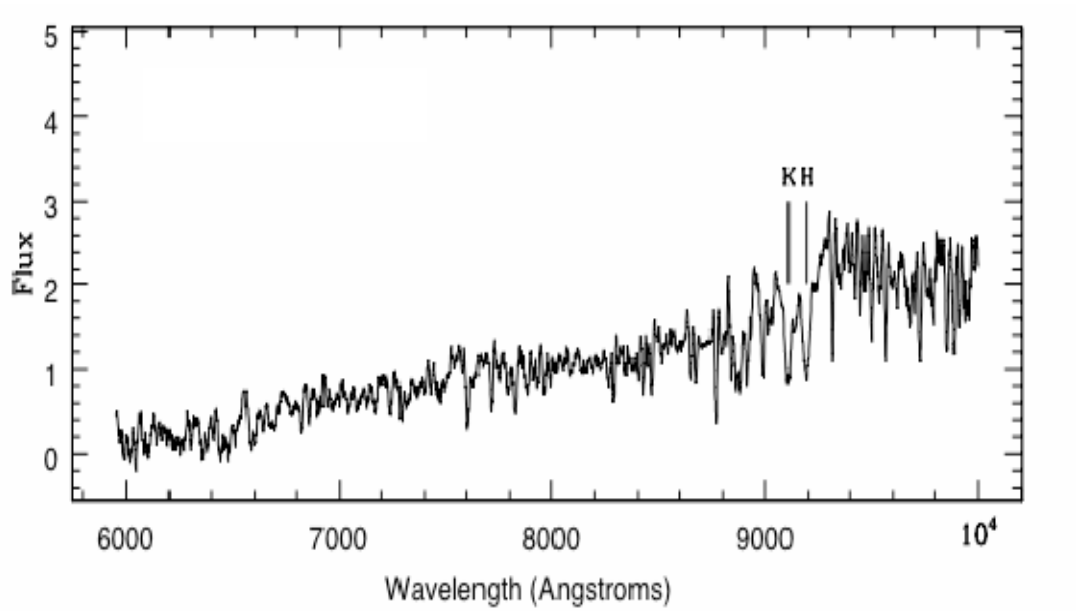
J. Melbourne [1], K.S. Dawson [5], D.C. Koo [1], C. Max [1,2], J. E. Larkin [3], S. A. Wright [3], E. Steinbring [4], M. Barczys [3] G. Aldering [5], K. Barbary [5,11], M. Doi [6], V. Fadeyev [5], G. Goldhaber [5,11], T. Hattori [7], Y. Ihara [6], N. Kashikawa [8], K. Konishi [9], M. Kowalski [5], N. Kuznetsova [5], C. Lidman [10], T. Morokuma [6], S. Perlmutter [5,11], D. Rubin [5,11], D.J. Schlegel [5], A. L. Spadafora [5], N. Takanashi [6], N. Yasuda [9]

Submitted,2006/09

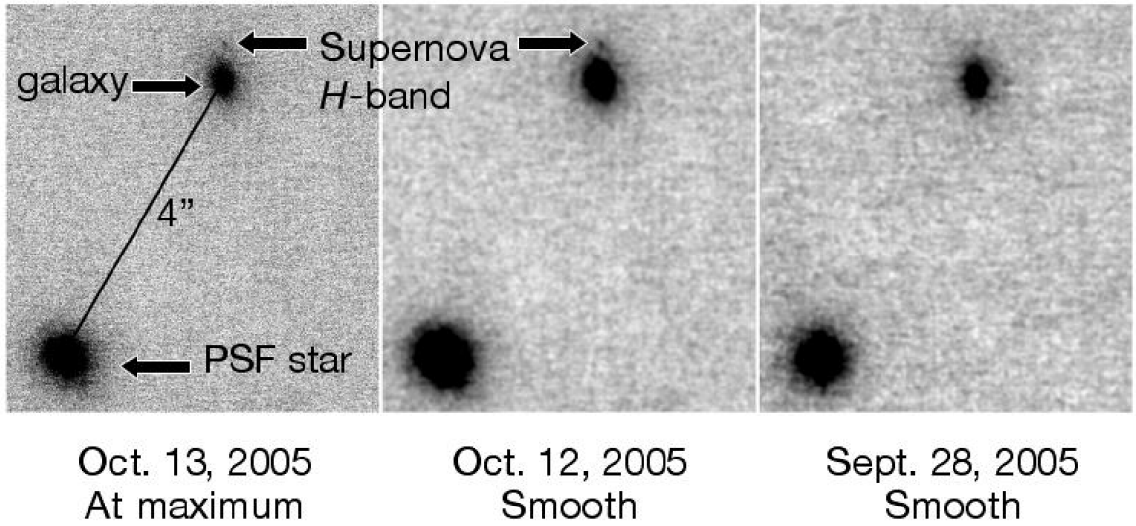
Found with HST/ACS

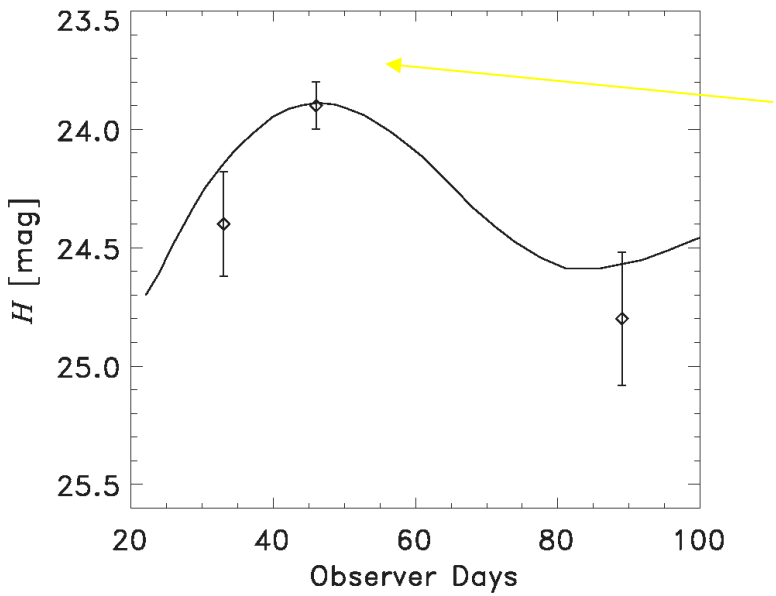


Spectroscopy with Subaru/FOCAS



Keck+LGAO+NIRC2





H=23.9±0.14mag

Exposure time 3600sec

PSF(FWHM) 0.053 arcsec

Pretty good accuracy

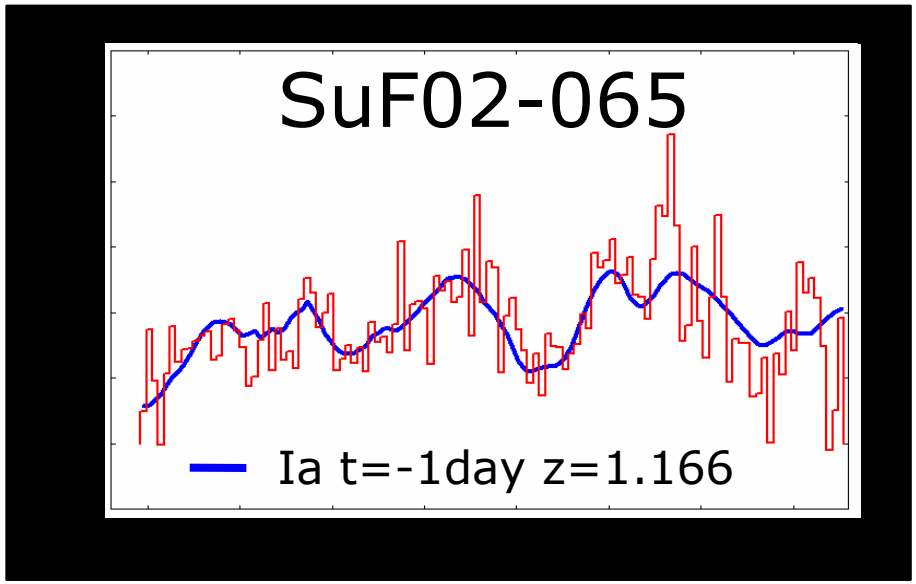
Young power

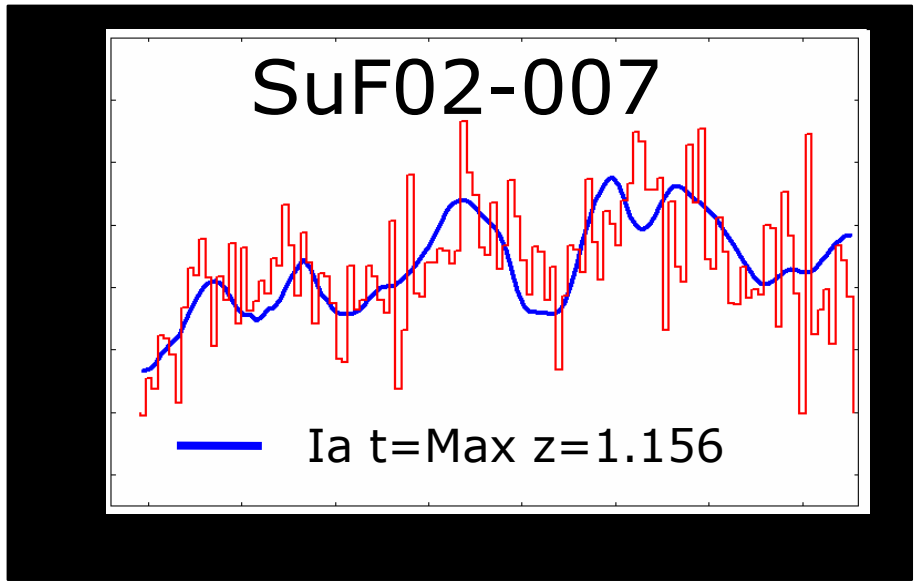
See Posters

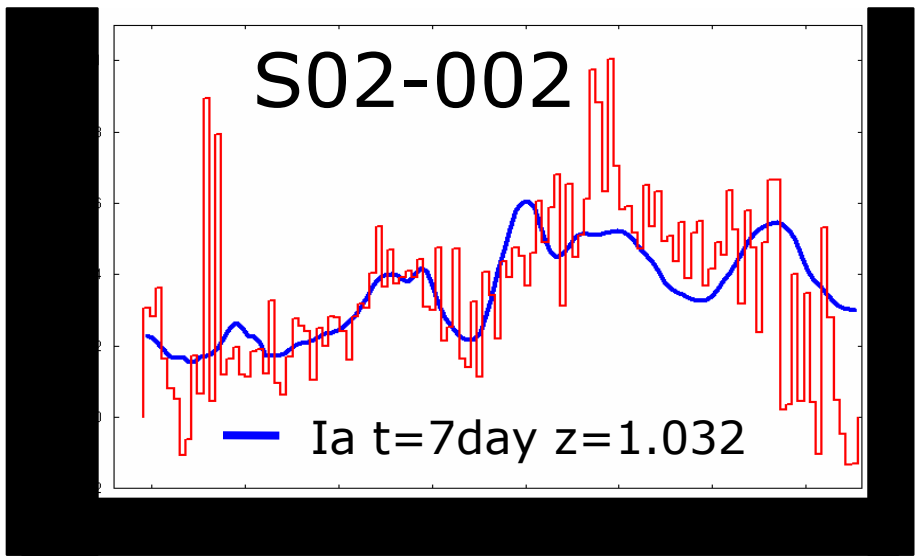
Tomoki Morokuma (UTokyo, D3) SN faint spectroscopy, variability
Naohiro Takanashi (UTokyo, D2) fitting SN light curve
Takeshi Oda (KyotoU, D2) comparing SN rate with models
Kohichi Tokita (UTokyo, D1) fitting SN spectra
Yutaka Ihara (UTokyo, M2) studying SN progenitor
Kohki Konishi (UTokyo, M2) studying SNIa spectral evolution
….

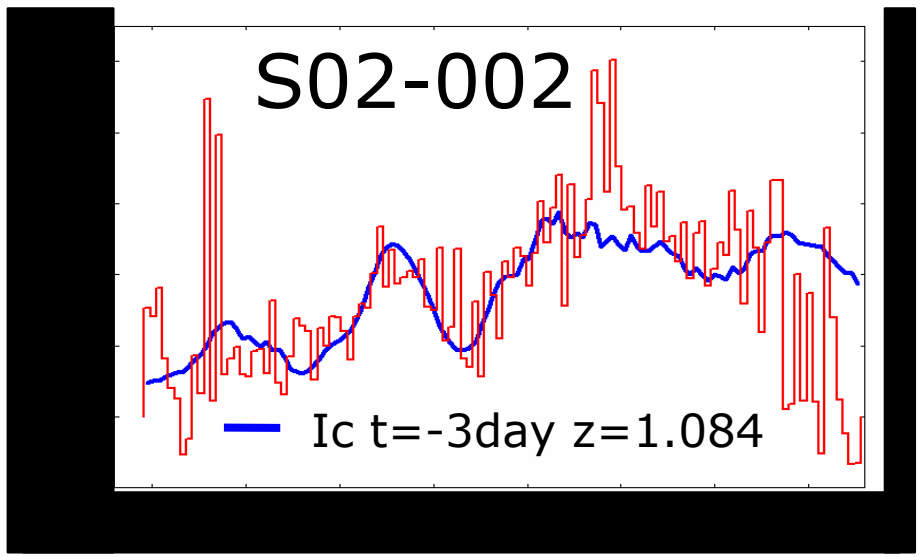
(with SDSS SN follow-up programs etc.)

Least χ^2fitting of Spectra (by K.Tokita)









X axis : observed wavelength (A) Y axis : Flux (erg/sec/cm^2/A)