Supernova Opportunities

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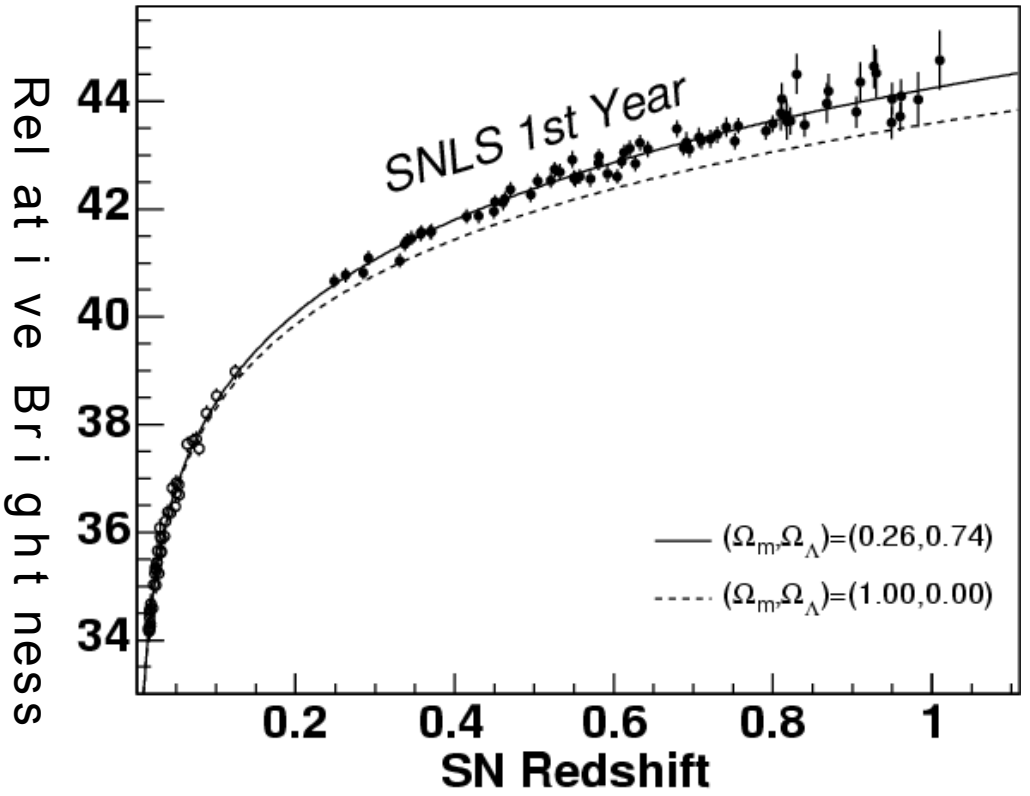
Supernova Cosmology Primer

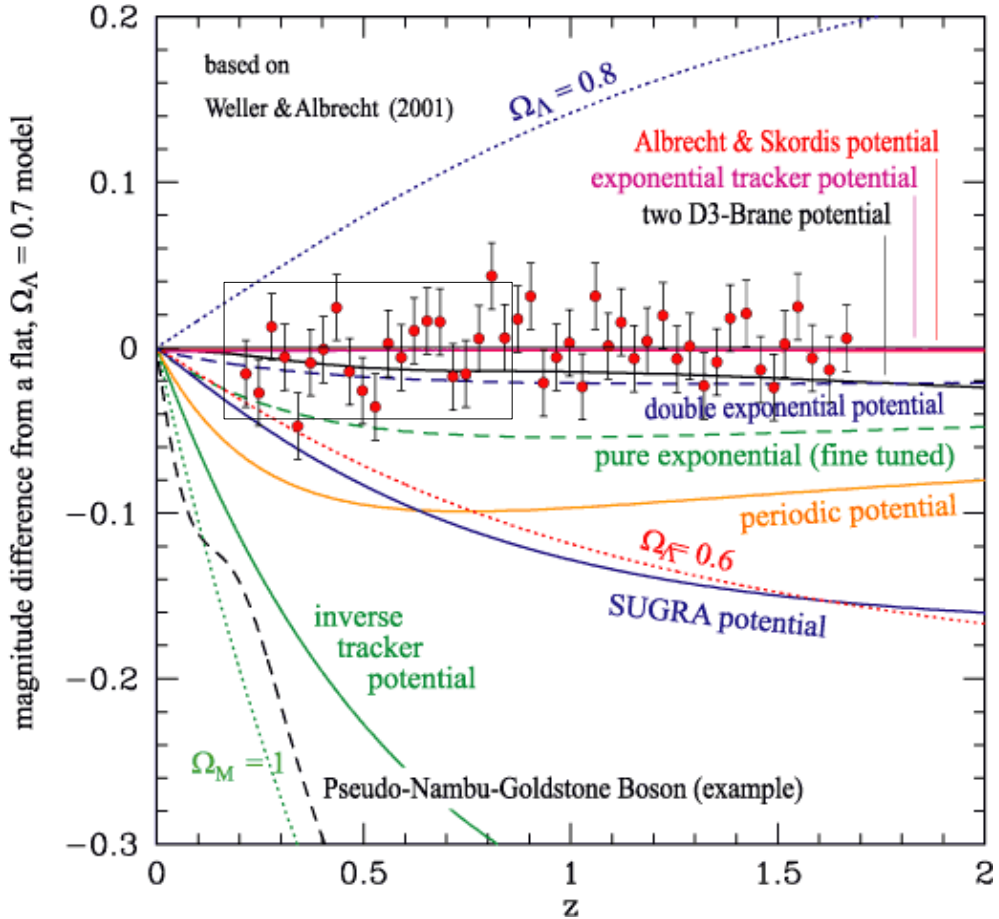
- Type Ia supernovae (SNe Ia) have uniform luminosity at peak brightness
- Relative brightnesses measure relative distances
- The SN Ia Hubble diagram (redshift vs. brightness) maps the expansion history of the Universe

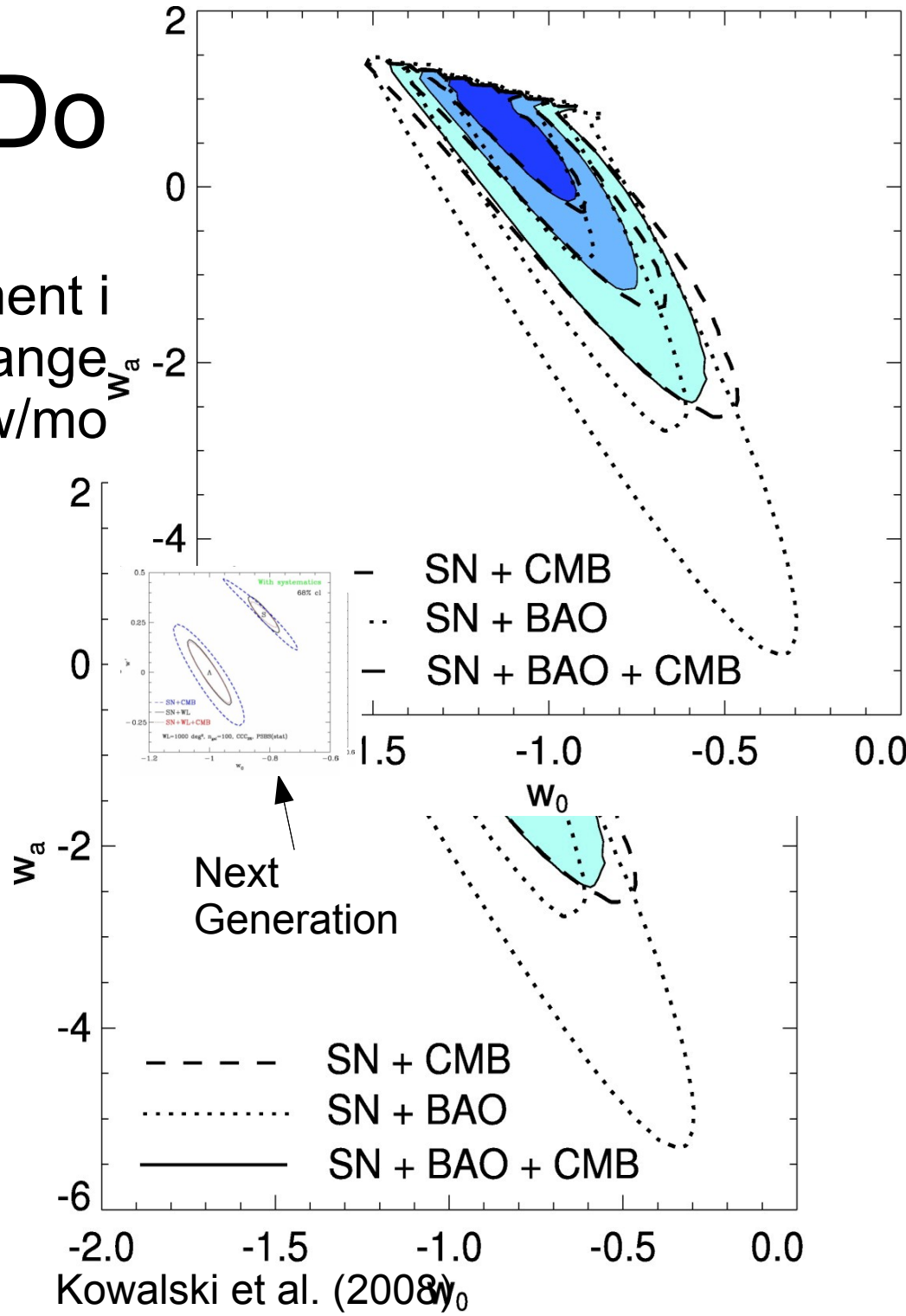


Astier et al. (2006)

Why Bother Do

- Possibility for drastic improvement i energy by increasing redshift range systematics control – need new/mo





Limiting Sources of Uncertainty

- In today's data it is not numbers of SNe
- Important sources of limiting uncertainty
  - Flux calibration onto a physical (MKS) scale
  - Obscuration from host-galaxy dust
  - Intrinsic supernova heterogeneity
- Many ideas on how to reduce uncertainties – need to be applied in new experiments
- New statistically complete sets are important
  - Old supernovae don't count
  - Systematics not on a sqrt(N) tail

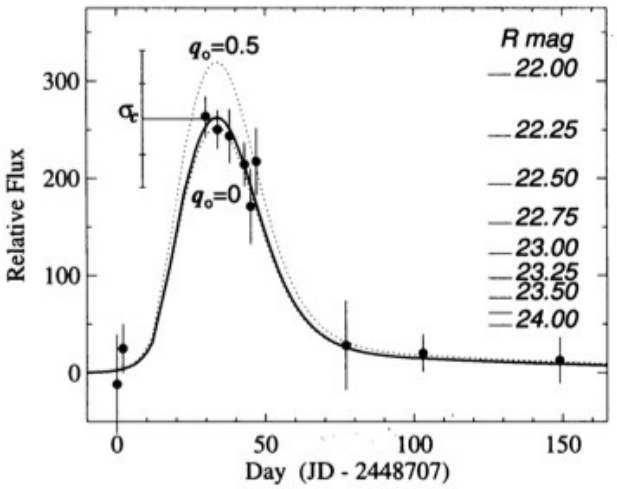
Systematic Control: Observe More For Each Supernova

- SNe Ia are slightly heterogeneous
  - As used today, may not be an unbiased distance indicator
  - Correlations between heterogeneous features and absolute magnitude may make SNe an even better distance indicator
- So expand observation suite of SNe Ia to monitor heterogeneity
  - Improve signal-to-noise, temporal sampling, duration, multiple bands, NIR, spectroscopy, polarimetry, host-galaxy, ...

Supernova Observing Primer

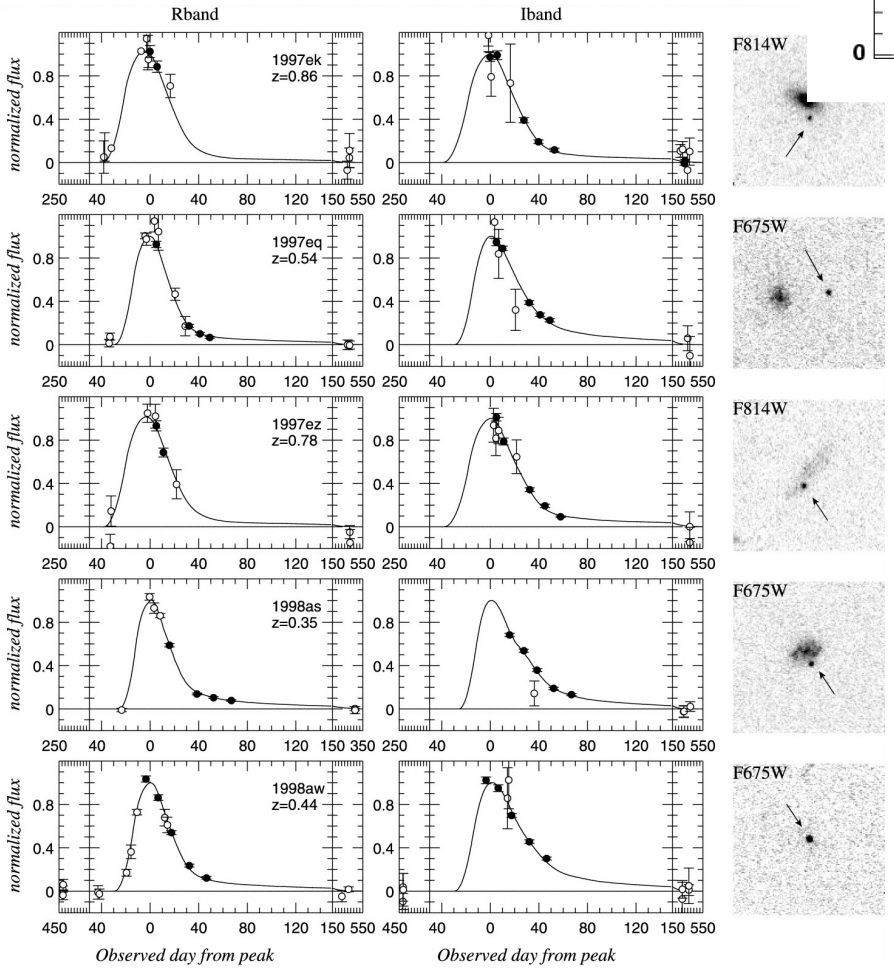
- Discover, classify, get time-evolving flux and colors, redshift for each supernova
- “Rolling Survey”
  - Wide-field imager
    - Image same field every few days in SN optical-NIR band(s): automatic generation of SN light curves
  - Real-time processing to discover transients
  - Triggered photometric and spectroscopic follow-up for data not provided by the search

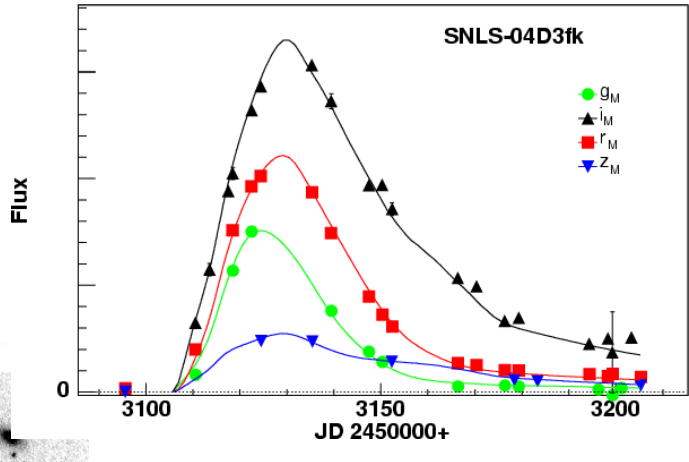
Data From the Past



Perlmutter et al. (1995)

Knop et al. (2003)

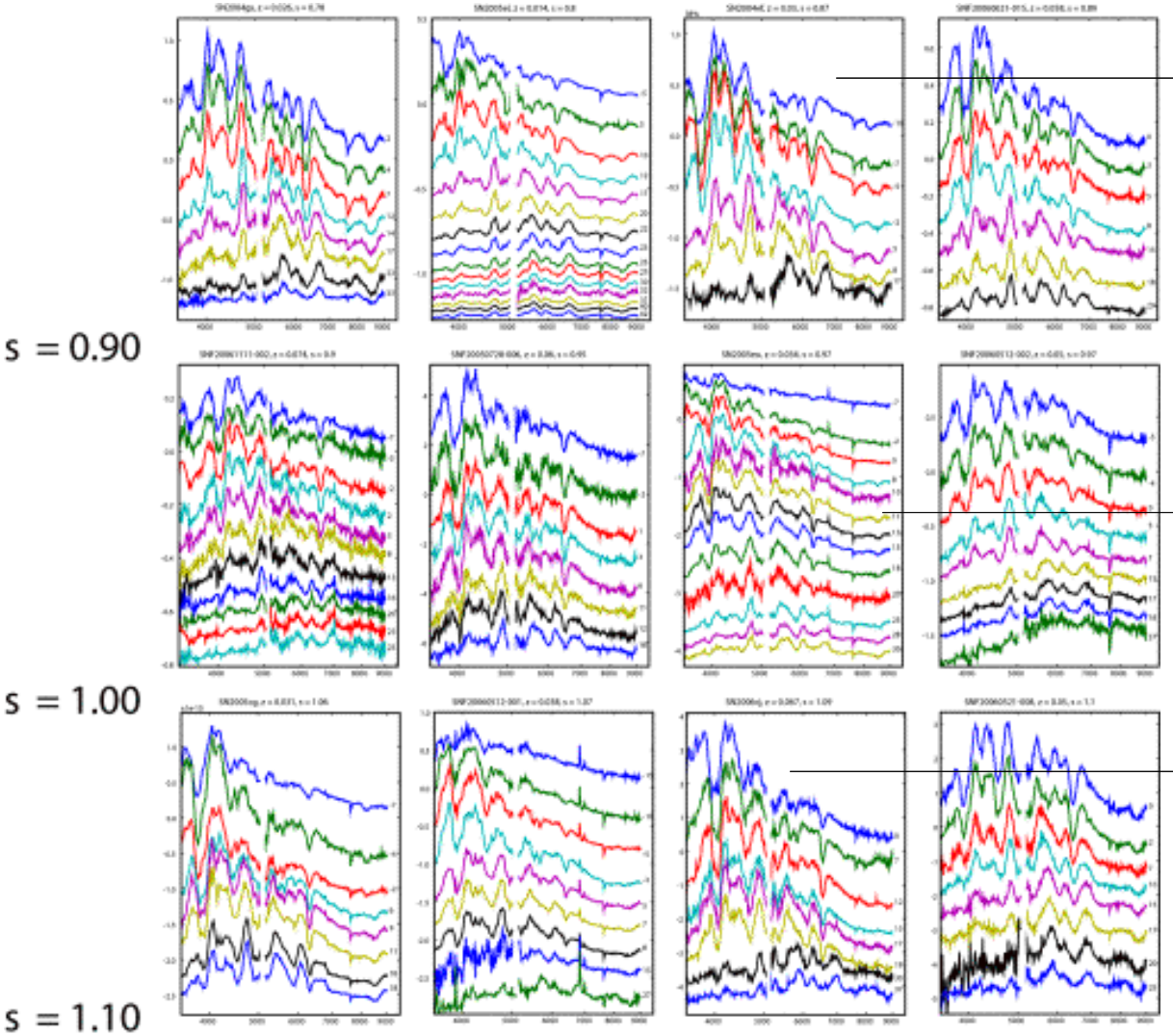


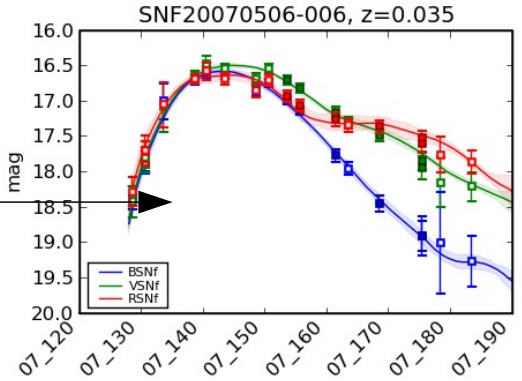


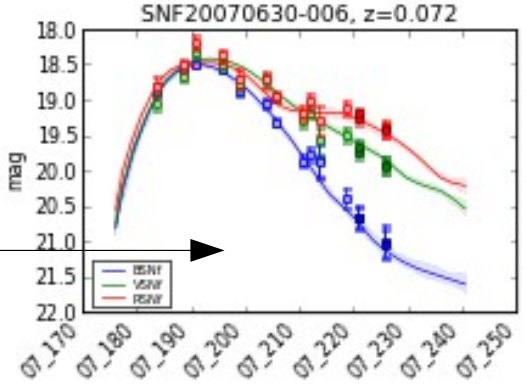
Astier et al. (2006)

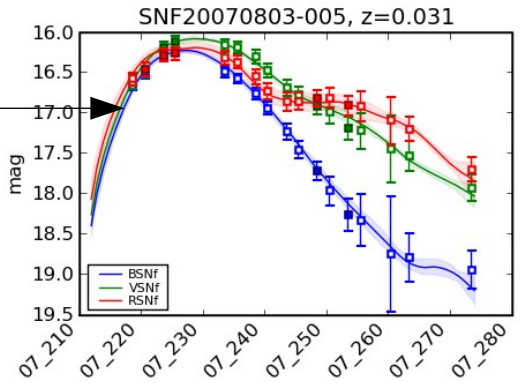
Modern Set

- SNFactory (Aldering et al.)
- SNIFS integral field unit at the UH 88”









Heterogeneity (2 Examples)

- With “modern” data set we can see supernova diversity
- Seen in spectra and light curves
- Are SNe worse or better distance indicators than we thought?

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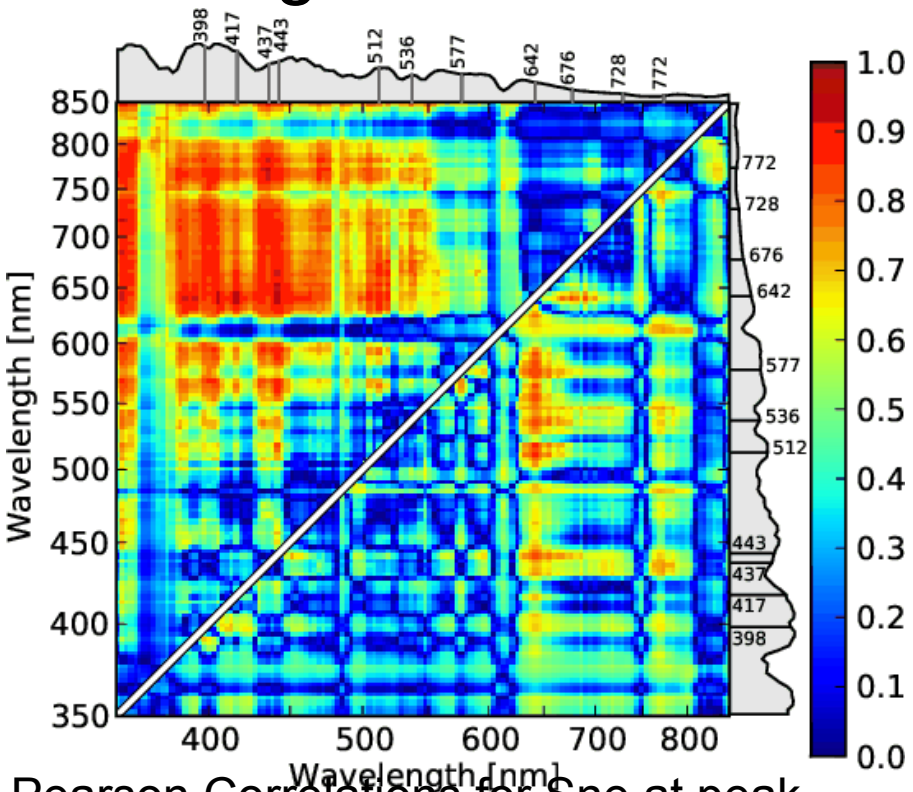
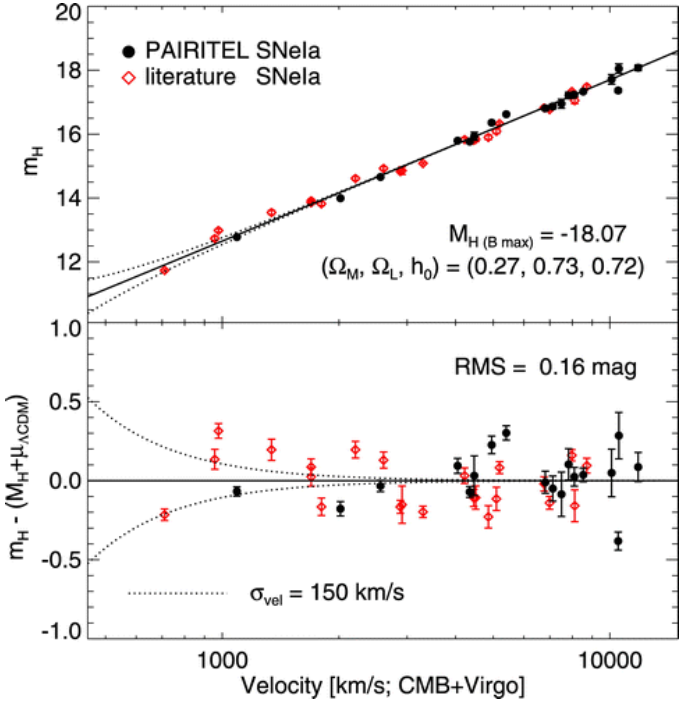


Pearson Correlations for Sne at peak brightness (Bailey et al. 2009)

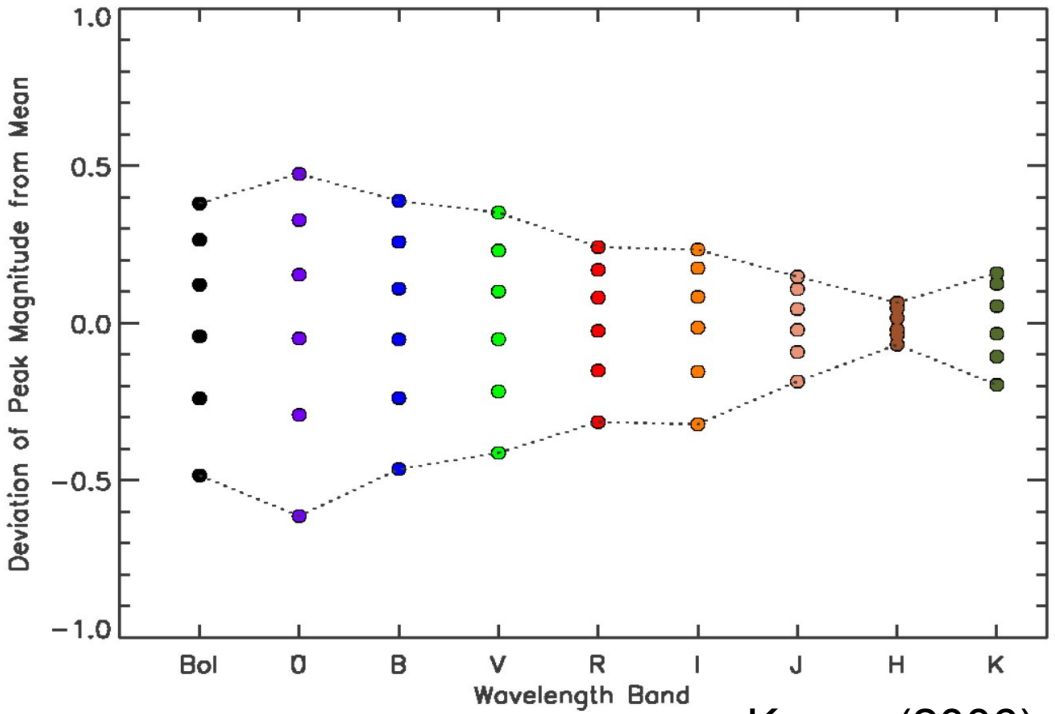
Two families of SN risetimes (Strovink 2007)

SNe in the NIR

- Traditionally SN cosmology uses restframe optical
- Restframe NIR is fertile ground to explore
  - SNe intrinsically more homogeneous TBC
  - Less dust absorption



Wood-Vasey et al. (2008)



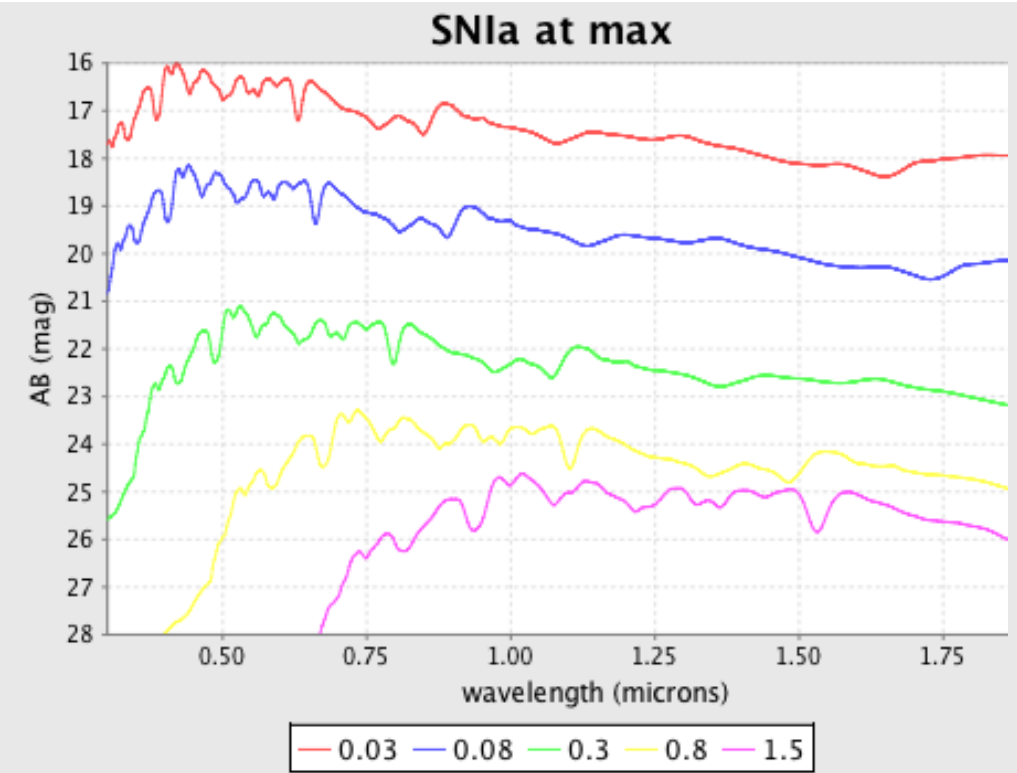
Kasen (2006)

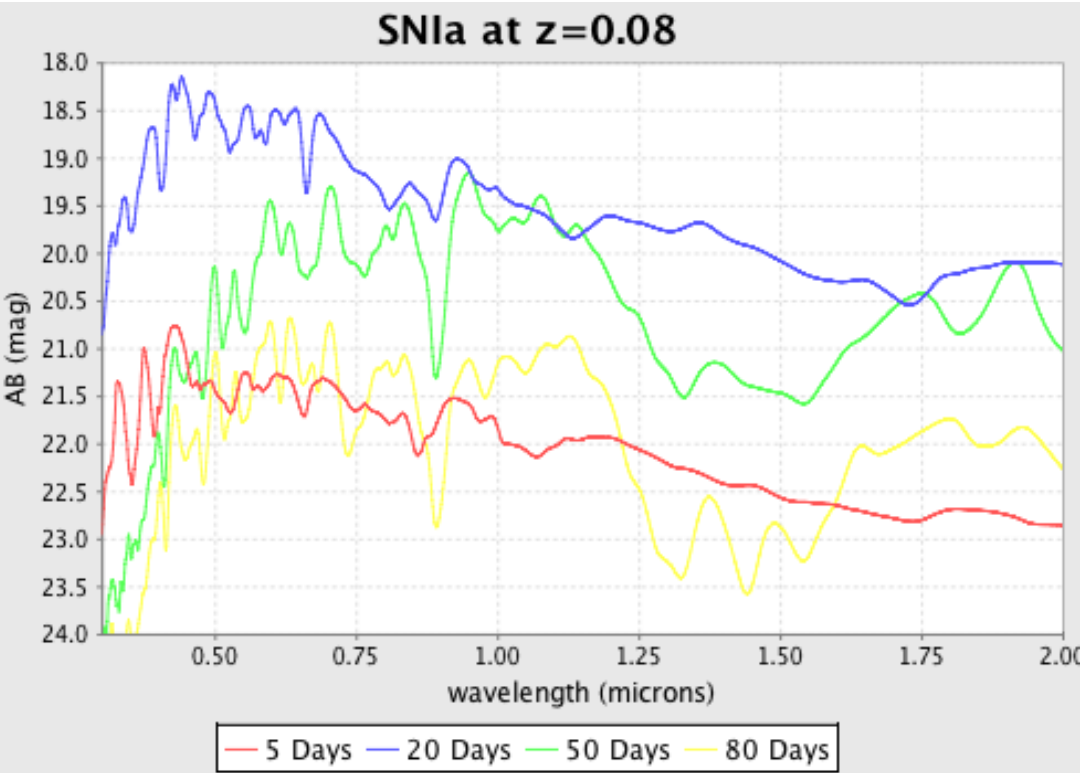
Wish List for Cosmology Dataset

- Coordinated observation over $0.03<z<2$ range
- >150 SNe per 0.1 redshift bin for cosmology
- >>150 Sne per 0.1 redshift bin for heterogeneity studies
- Cadence of a few days in SN frame
- Data extending from before to ~2 months after explosion in SN frame
- 0.35 – 2.5 um in SN frame
- Light curves with S/N>25 at peak brightness
- Spectra with S/N>25 per 2000 km/s resolution element

Supernova Flux – Redshift and Phase

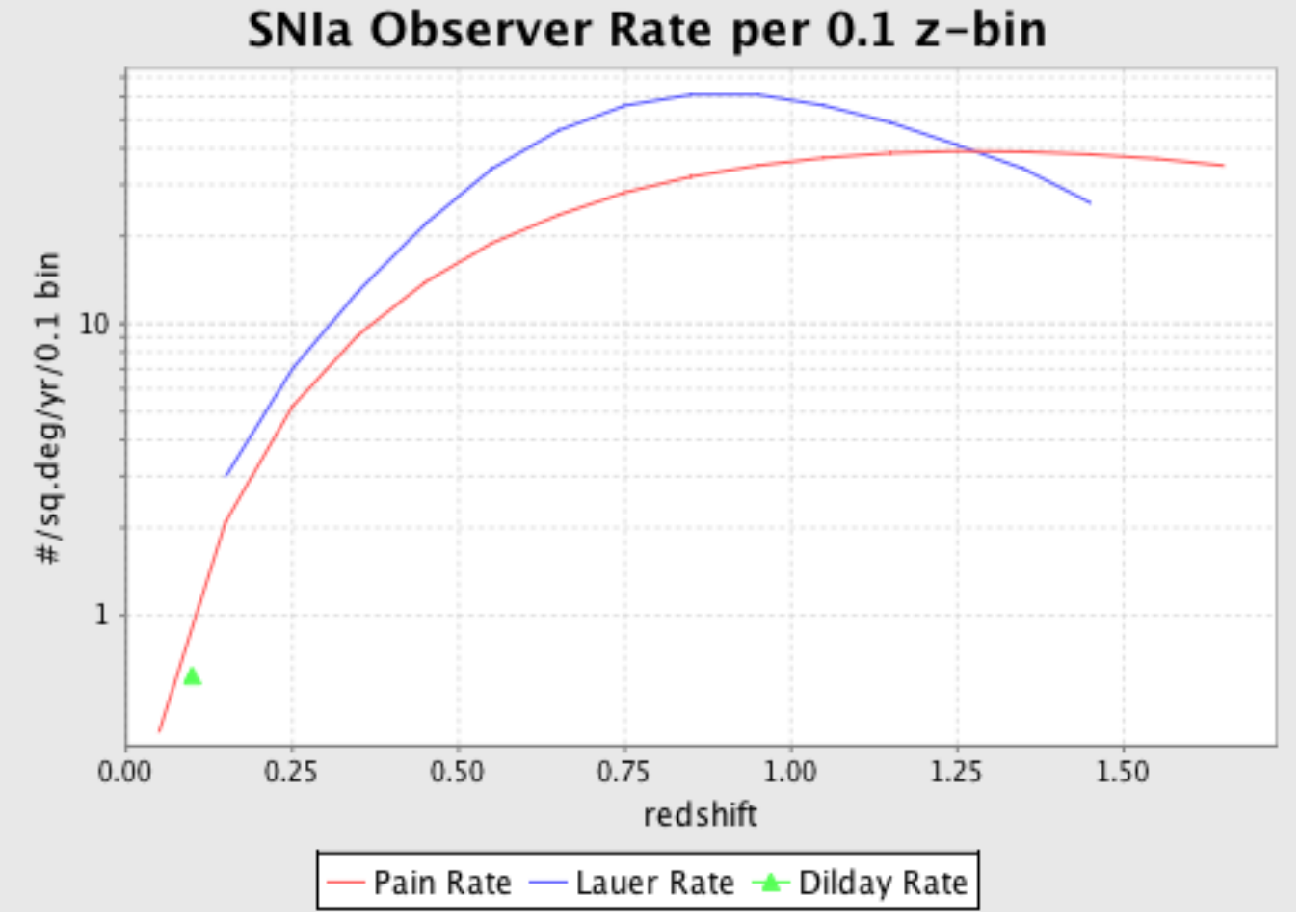
- Most flux emitted at optical wavelengths
- Shifted redwards at high redshifts and after peak brightness





SN Rates

- Large fields of view allow simultaneous observation of many supernovae

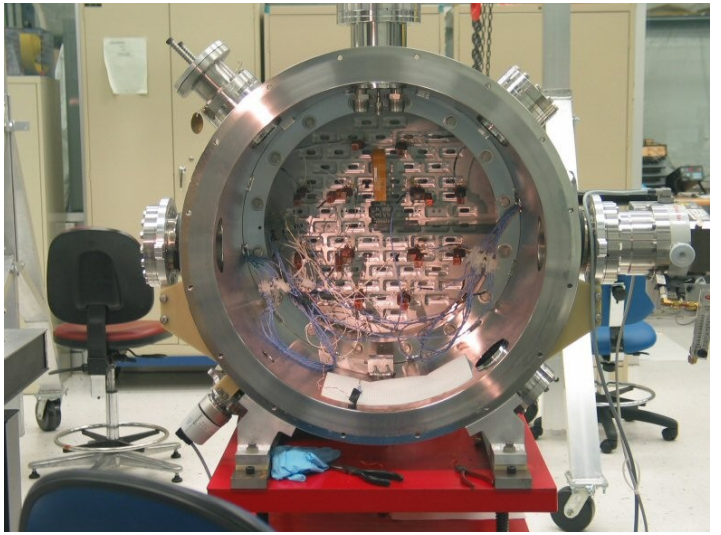


Required Resources

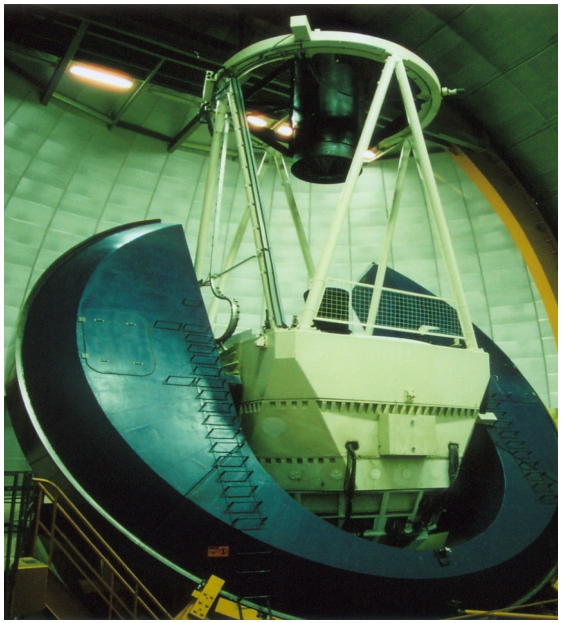
- Given the SN fluxes and rates, the following resources are used at temperate and space observatories

	Targeted Redshift			
	<0.1	~0.3	~0.6	>1.2
FOV (sd) (multiplex)	>5	~2	~1	>0.3
Aperture (m)(imaging)	<1	~2.5	4	~1.5 (space)
Aperture (m)(spec)	1.5	~4	~10	~2 (space)

Dark Energy Survey



- Start 2011
- ~3000 SNe from 0.25<z<1.0
- 4-m Blanco Telescope at CTIO
- 1260 hours over 5 years
- 3 sq deg CCD camera
- ~15 square degrees survey area
- Seeking collaboration to enhance the program
  - Coordinated with VIDEO/VISTA survey for J light curves of selected fields – can't get deep enough for H
  - Time for spectroscopic confirmation

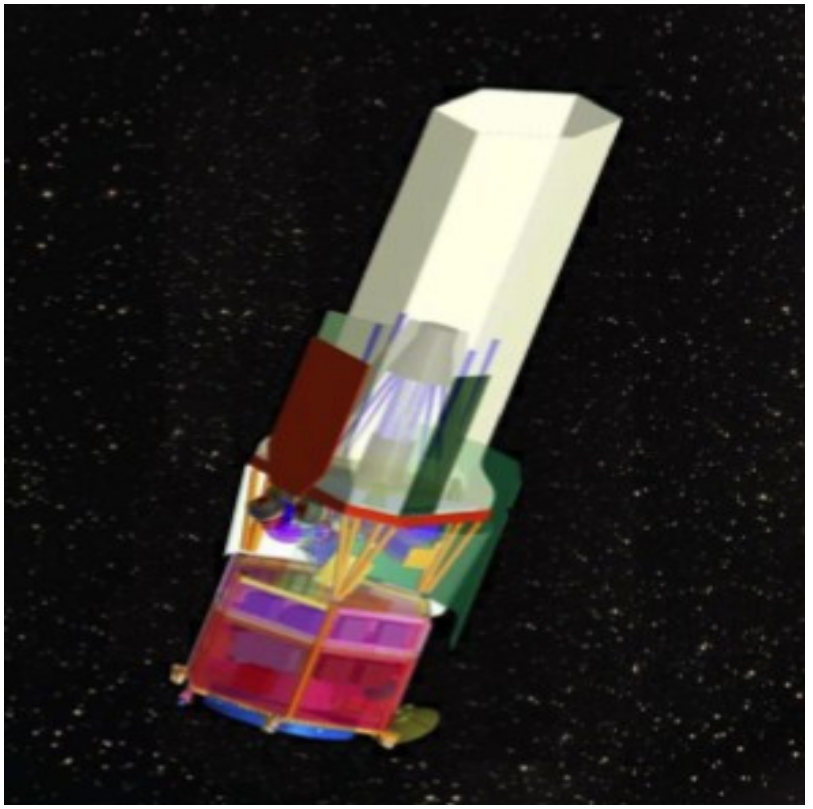


0.3<z<1

- Other planned ground-based programs
  - PS1, PanStarrs, LSST
  - Similar to DES with larger telescope aperture and/or field of view
  - SASIR – 6-m telescope, YJHK, San Pedro Matir
- Like DES, need more than just the search telescopes
  - Coordinated red-NIR widefield imaging survey
  - Spectroscopic typing of discoveries
    - Spectrophotometry preferred but not required
- Room for an independent NIR search?

JDEM/IDECS

- Timescale ??
- Space observatory
- 1.5-m telescope
- ~0.3 sd imaging camera
- R~75-150 slitless grism or IFU spectroscopy - TBD
- 0.35 – 2 micron coverage



0.3<z<1.7 (Space)

- With its “small” field of view and “large” aperture, JDEM is not optimal for low-z SNe
- Cosmology objectives require a complementary ground-based survey
  - Low-z sample
    - Anchor the Hubble diagram
    - Quantify JDEM systematic uncertainties
  - Observed with
    - Similar or better signal-to-noise as JDEM
    - Similar or broader/finer SN-frame wavelength range/resolution as JDEM (0.35 to ~0.8 um)

0.3<z<1.7 (Space)

- Status of the spectrograph is unknown - spectroscopic follow-up from the ground?

Low-z Supernova Work-Together

- Photometric Surveys – now and soon
  - Palomar Transient Factory TF, La Silla-Quest, SkyMapper
  - ~1.25-m telescopes, 6-16 sd fields of view
  - z<0.2
- Spectroscopic Followup
  - SNIFS at a TBD telescope
  - Major proposal submitted for the NTT
  - Carnegie resources (NIR)
  - Exploring new instruments and other observatories
    - A new IFU for northern and southern hemisphere coverage?

Desired Resources

- Low-z
  - Extremely wide-field small aperture <1-m telescope(s) for discovery (maybe photometric followup)
  - Integral field spectrometers for the followup
- Moderate-z
  - Wide-field multiplexed spectroscopy at >4-m telescopes
- All-z
  - JHK wide-field imaging
  - Optical-IR spectroscopy

Antarctica as a Site for Desired Resources

- Sky brighter by 2x in B, 20% in V
  - Not a problem? At B and V most SN observations are source-noise limited
- Free seeing >~0.22”
  - Do more with less mirror
- Low thermal emission
  - K-band
- Long days
  - Limits continuous viewing of evolving supernovae, worse with increasing redshift

Other SN topics to think about

- Core-collapse supernovae
- Strong lensing and time-delays of SNe Ia
- UV brakeout
- Characterization of diversity in dust absorption

谢谢