Type Ia Supernova Cosmology with the Dark Energy Survey

Kyle Barbary (Argonne National Laboratory)
For the DES SN working group

SN 2012fr in NGC 1365

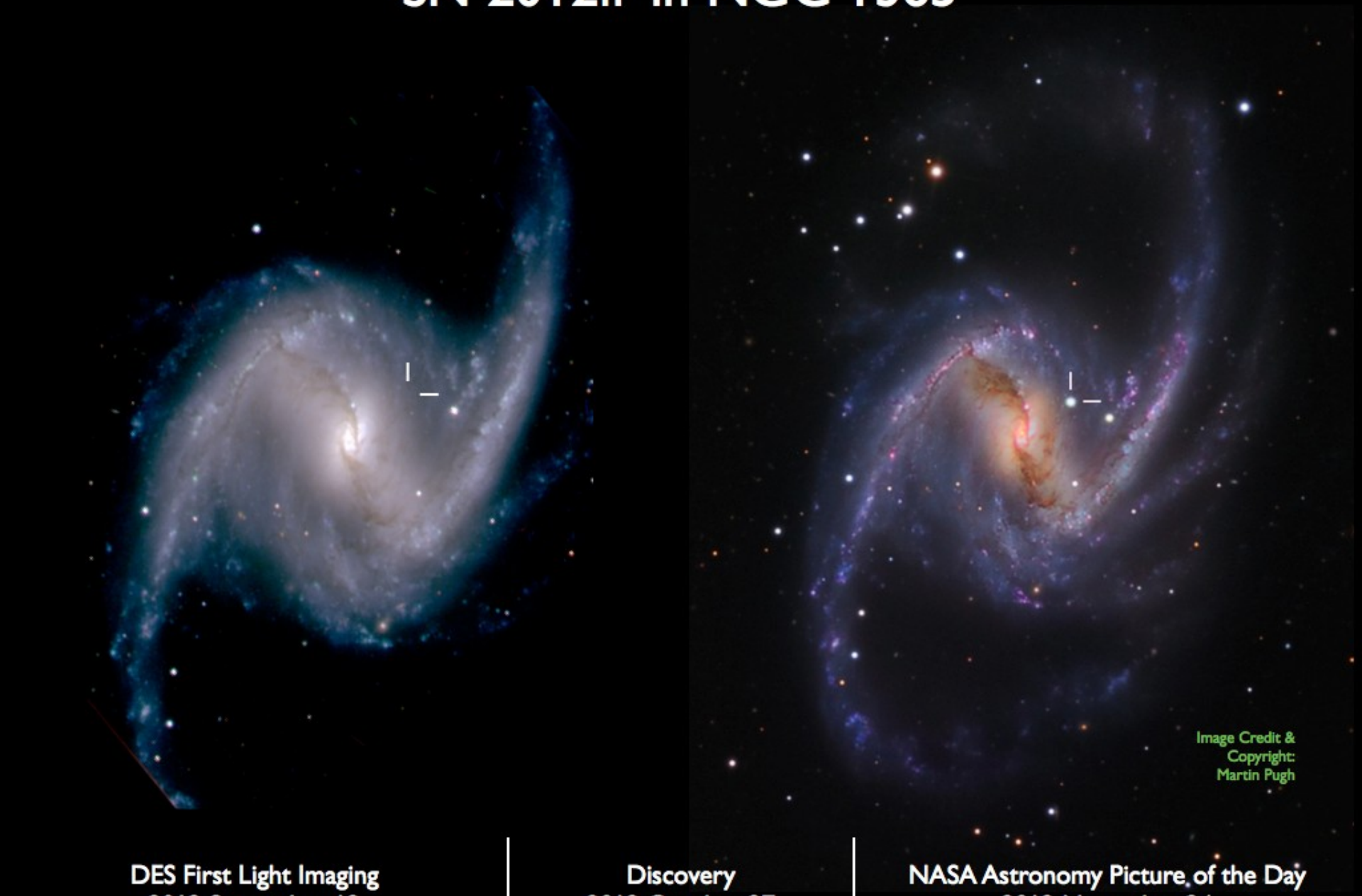

Image Credit & Copyright: Martin Pugh

DES First Light Imaging
2012 September 12

Discovery
2012 October 27

NASA Astronomy Picture of the Day
2012 November 24

DES Supernova Members

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- Rahul Biswas
- Eve Kovacs

Fermilab

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- David Finley
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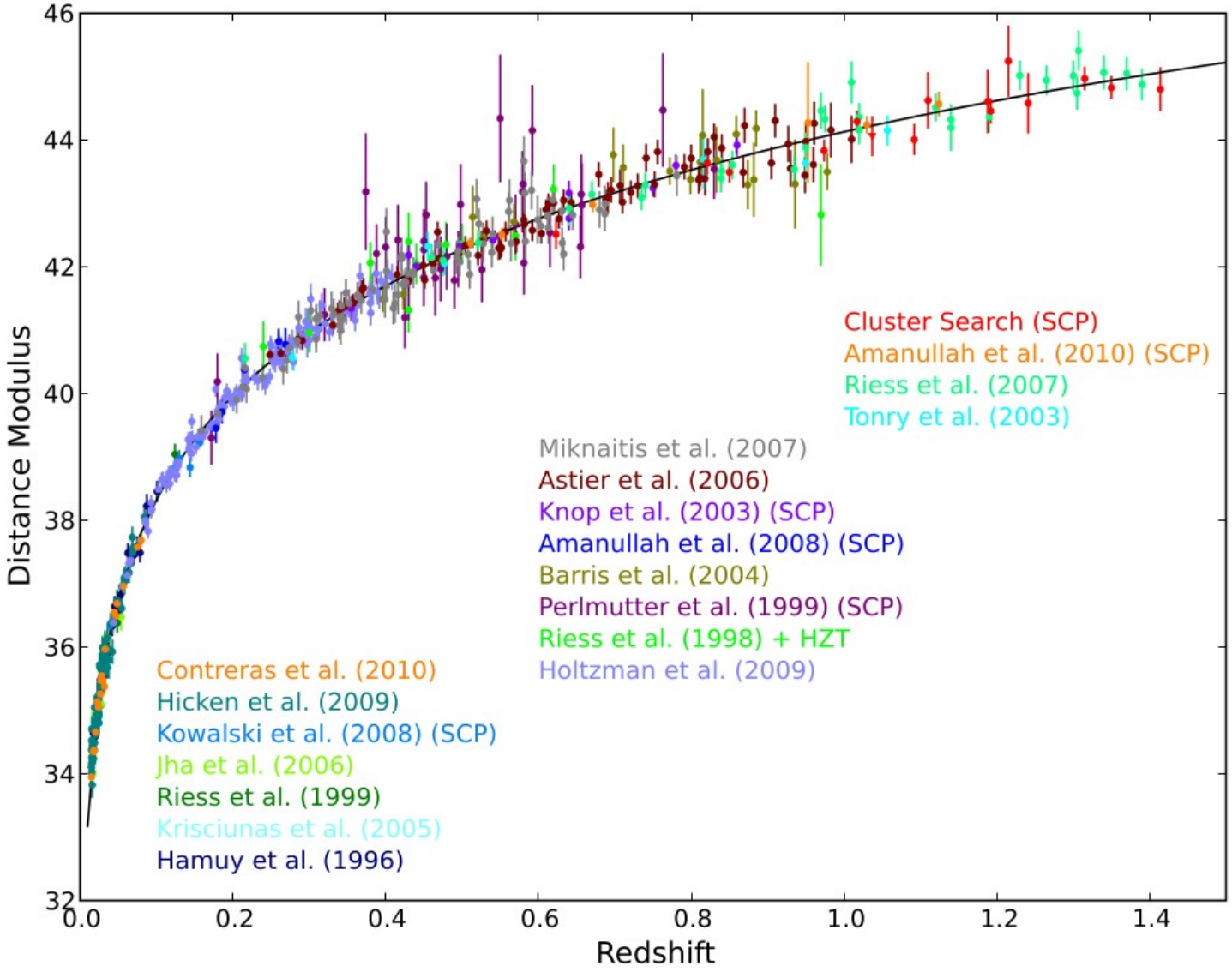
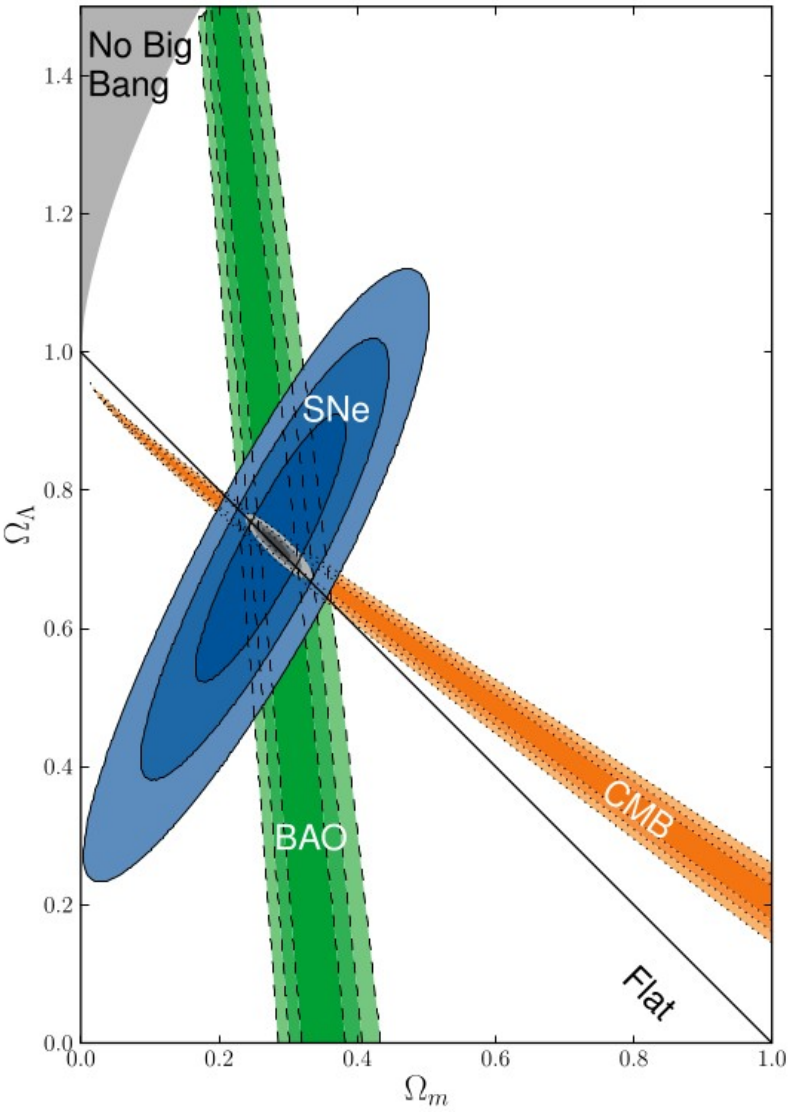
Outline

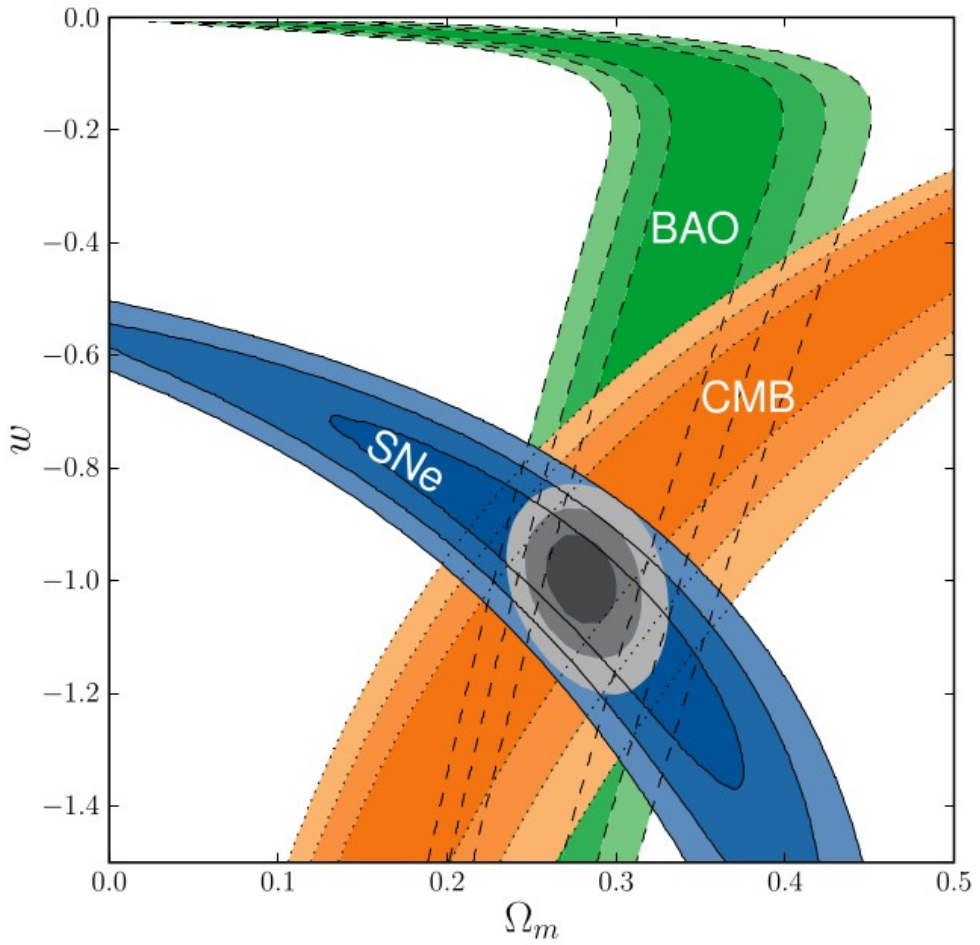
- DES Supernova program at a glance
- Science Verification Data
  (Dec 2012 – Jan 2013)
- Looking Forward ...
  - Photometric Calibration
  - Spectroscopic follow-up strategy & photometric typing

Lightning SN Ia cosmology review



Lightning SN Ia cosmology review



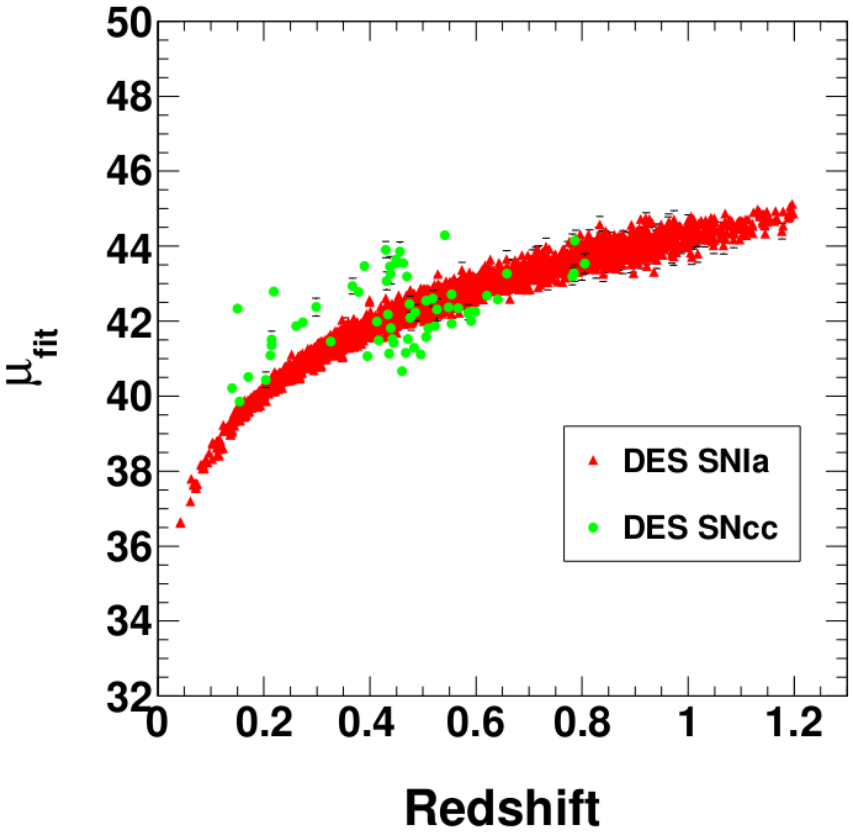


DES Supernova Survey at a glance

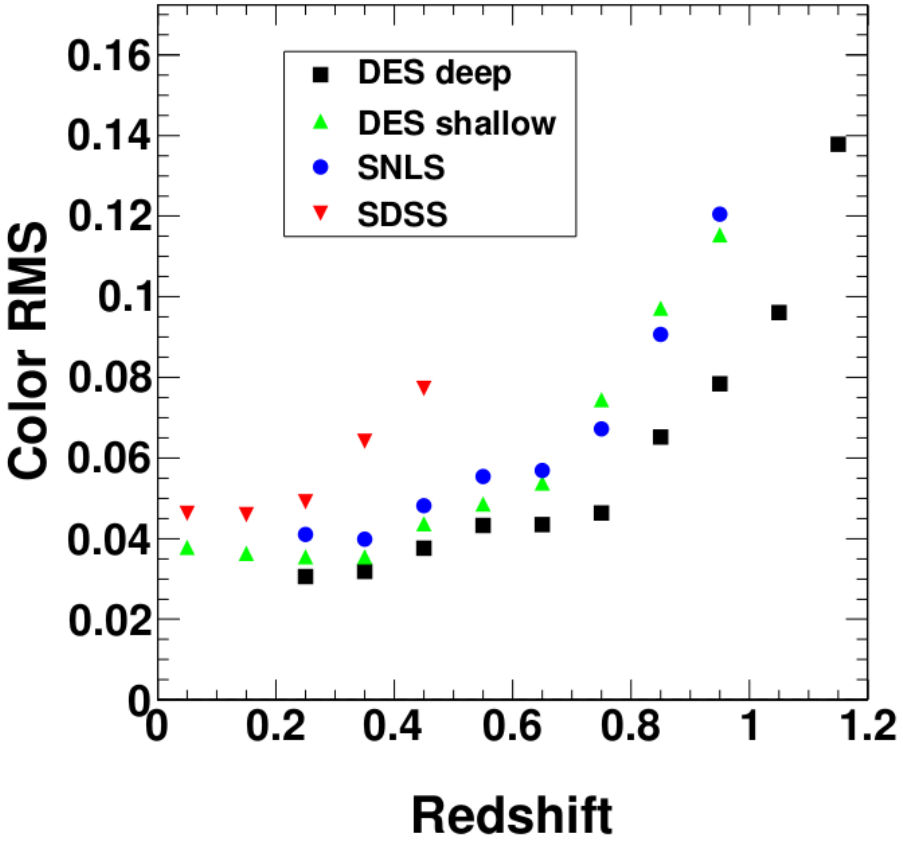
	Dark Energy Survey	Current Major Survey (SNLS: Megacam @ CFHT)
Number of Type Ia SNe	~3500 (Photometric typing)	~500 (spectroscopic typing)
Redshift range	up to z ~ 1.2 (deep z band)	up to z ~ 1.0
Fields	10 pointings @ 3 deg^2 (8 “shallow”, 2 “deep”)	4 pointings @ 1 deg^2 (all “deep”)
Cadence	~5 day cadence over 5 months	(similar)
Spectroscopic Follow-up	**Subset** of candidates observed by 4-10m class telescopes	**All** SN Ia candidates confirmed at 4-10m class telescopes

Key advances

- Statistics: split SNe into subsets to better understand astrophysical systematics



- Deep z-band: better systematic control at high-z

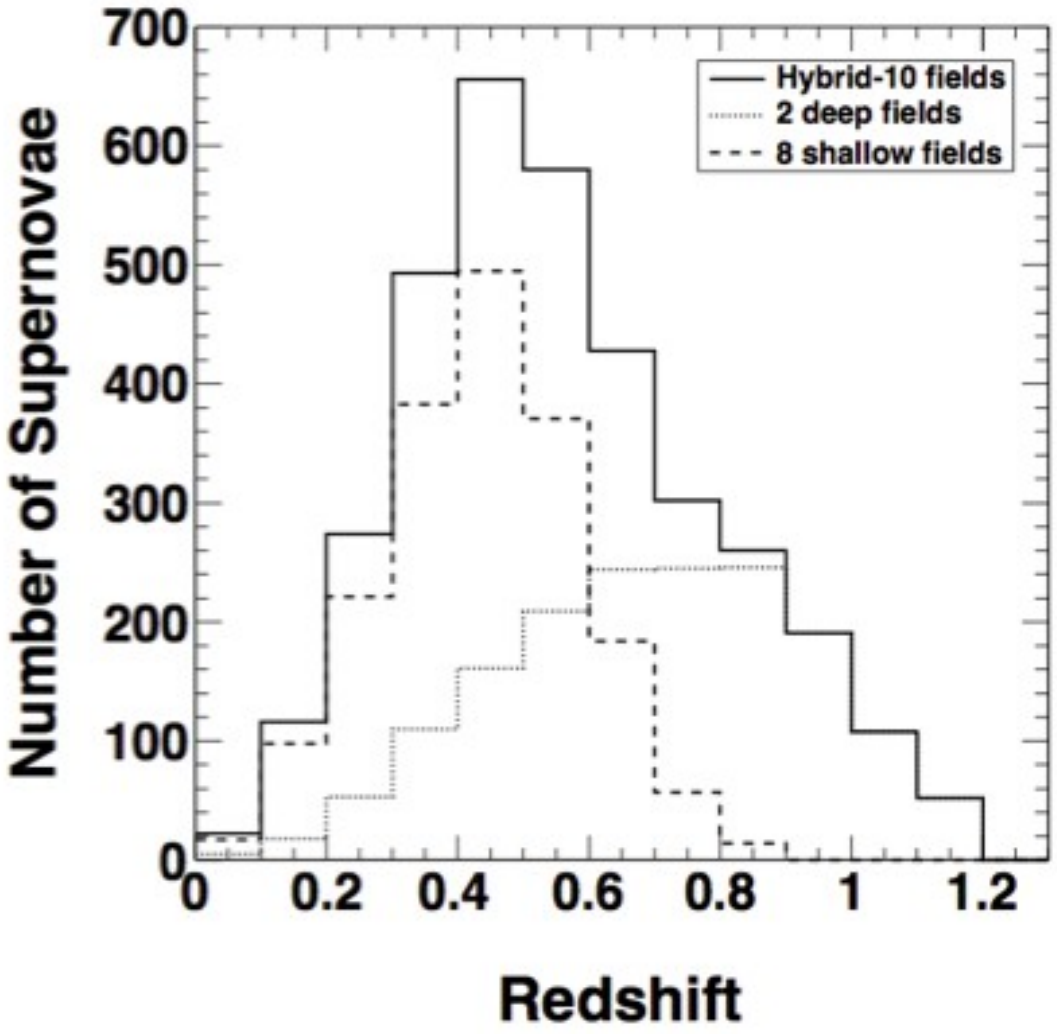


Shallow & Deep Fields

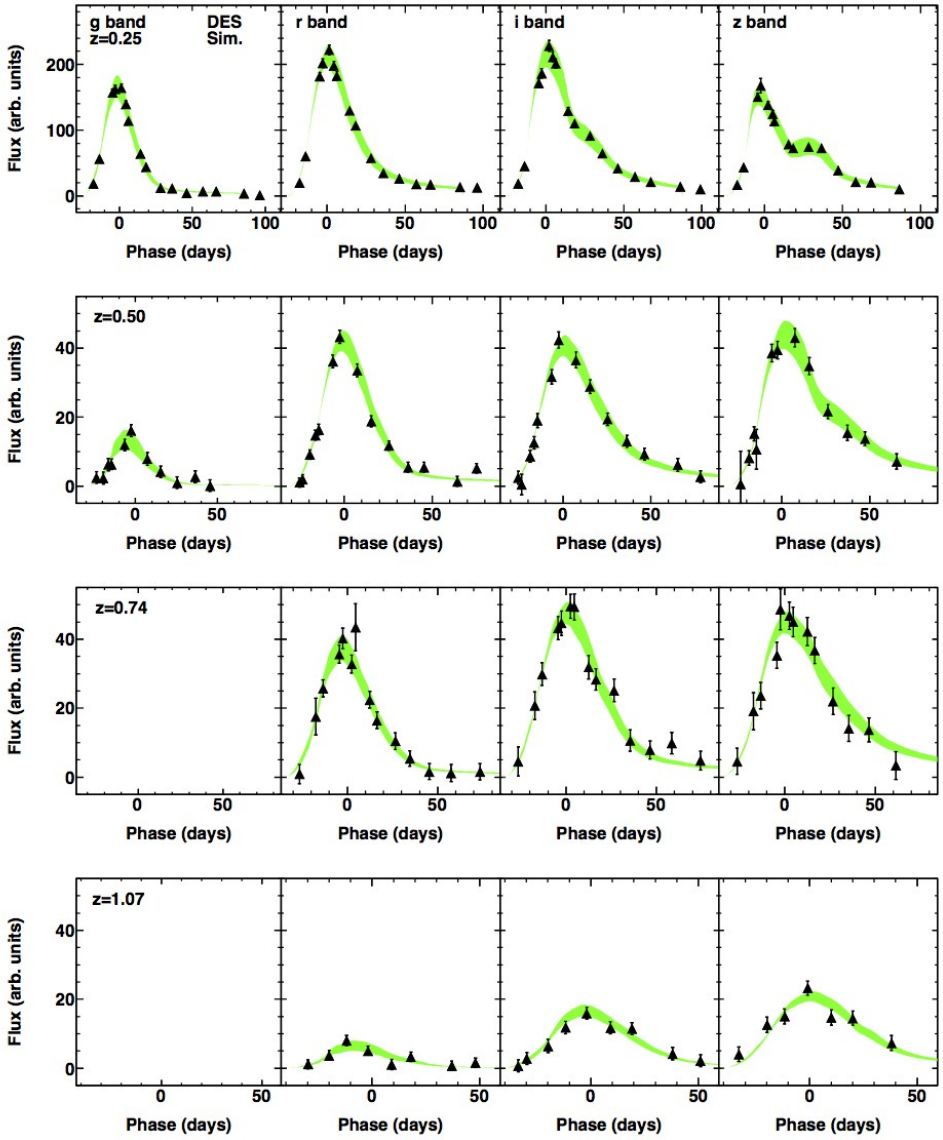
Filter	Exp time (Shallow)	Exp time (Deep)
g	3 min	10 min
r	2.5 min	20 min
i	3.3 min	30 min
z	6.6 min	60 min
	~15 min	**~2 hrs**

Filter	Limiting Mag (Shallow)	Limiting Mag (Deep)
g	24.9	25.6
r	24.3	25.4
i	23.9	25.1
z	23.7	24.8

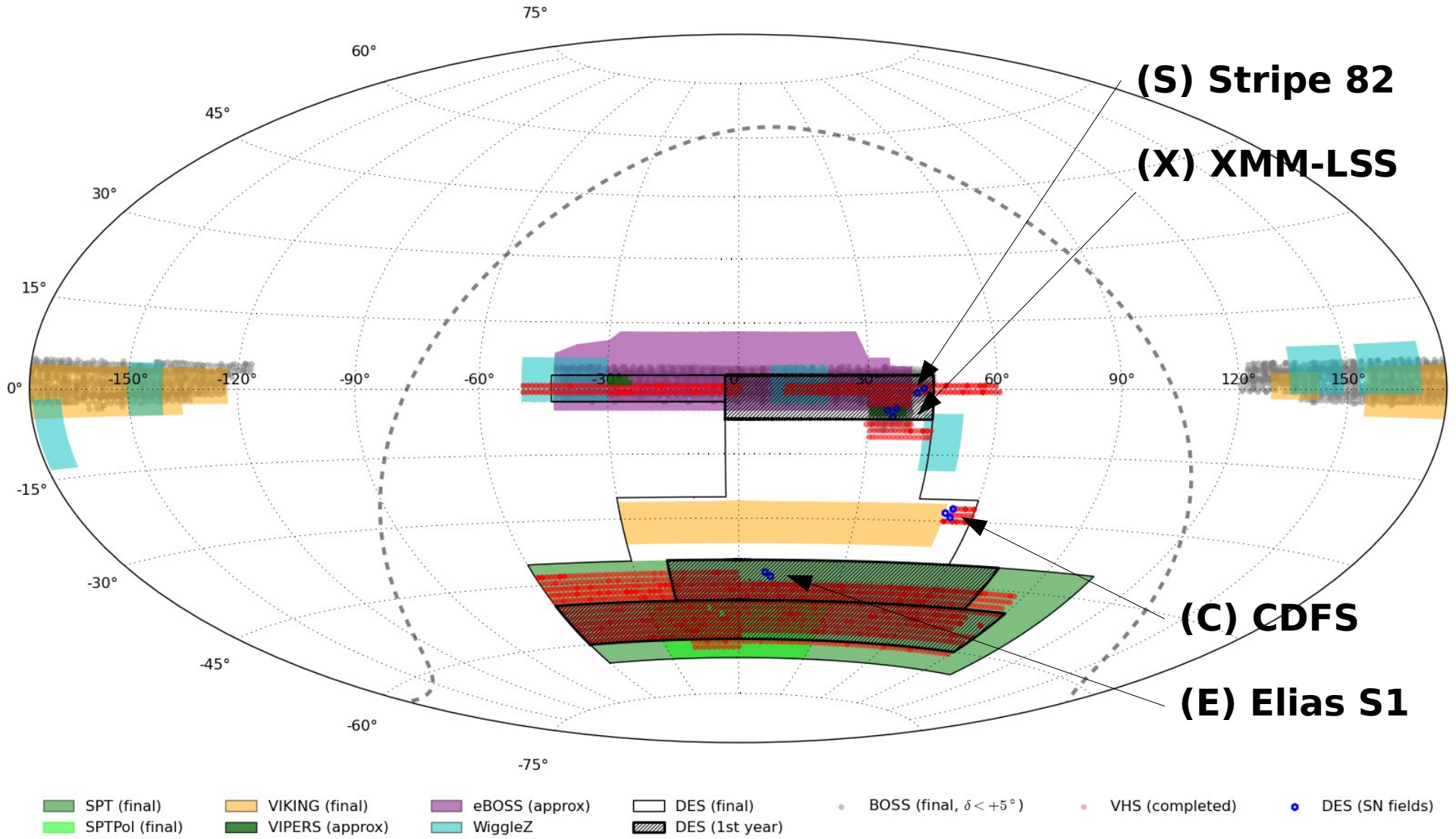
DES 5-year SN Ia redshift distribution



DES Simulated Light curves



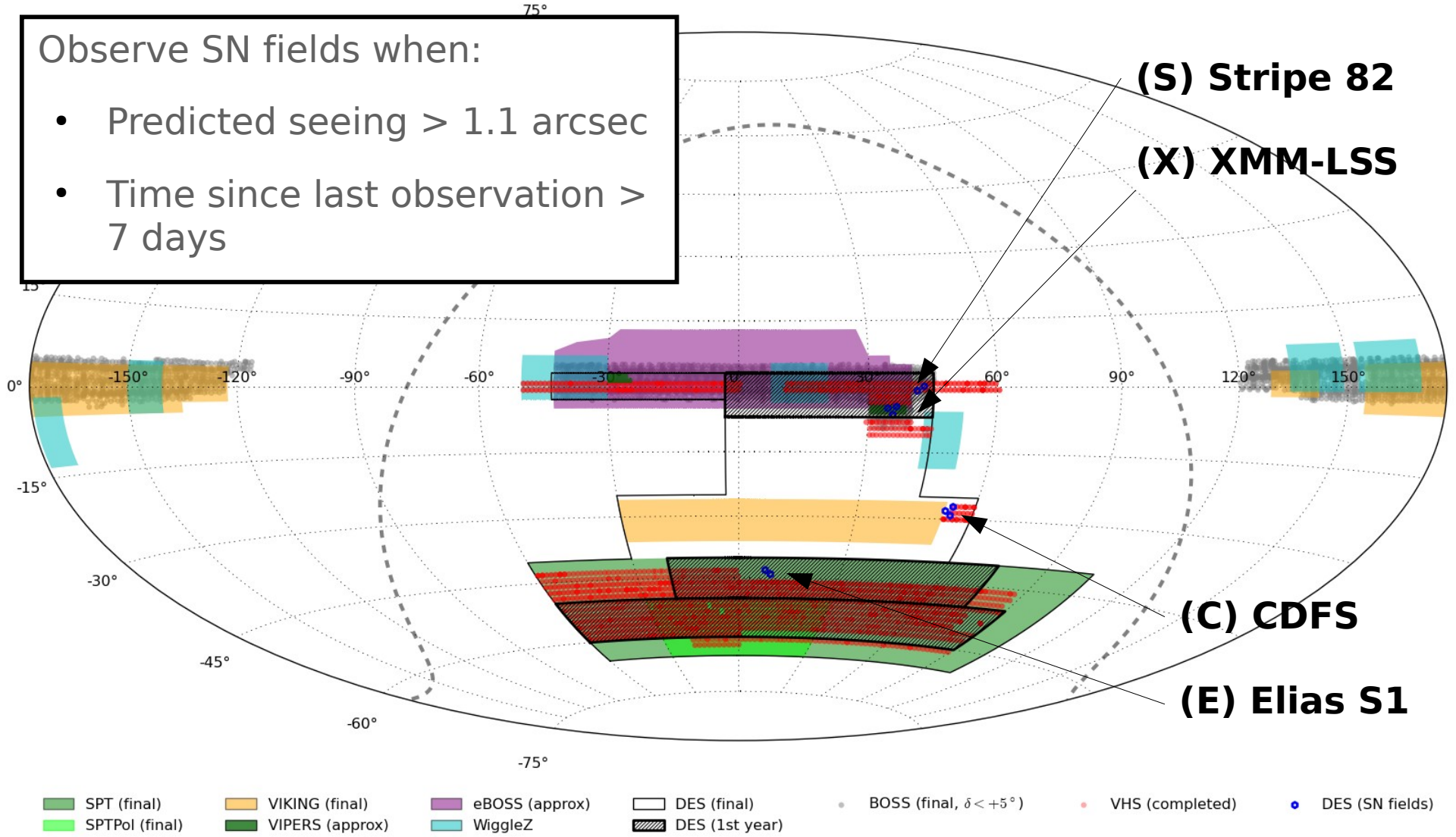
DES SN fields



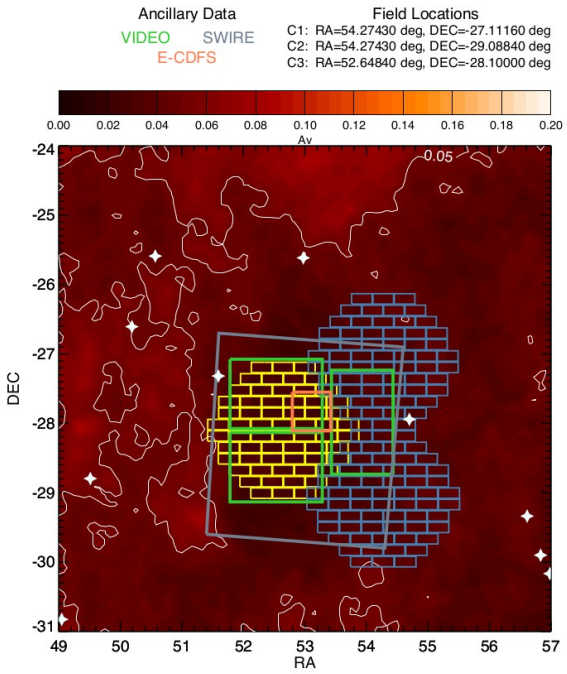
DES SN fields

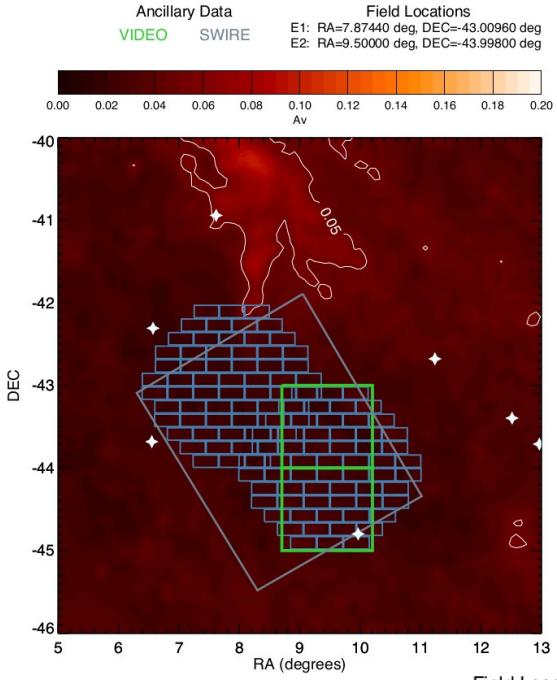
Observe SN fields when:

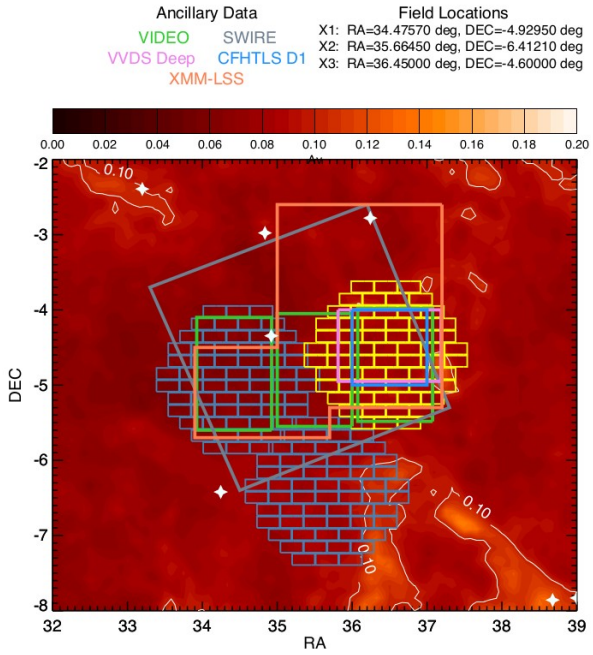
- Predicted seeing > 1.1 arcsec
- Time since last observation > 7 days

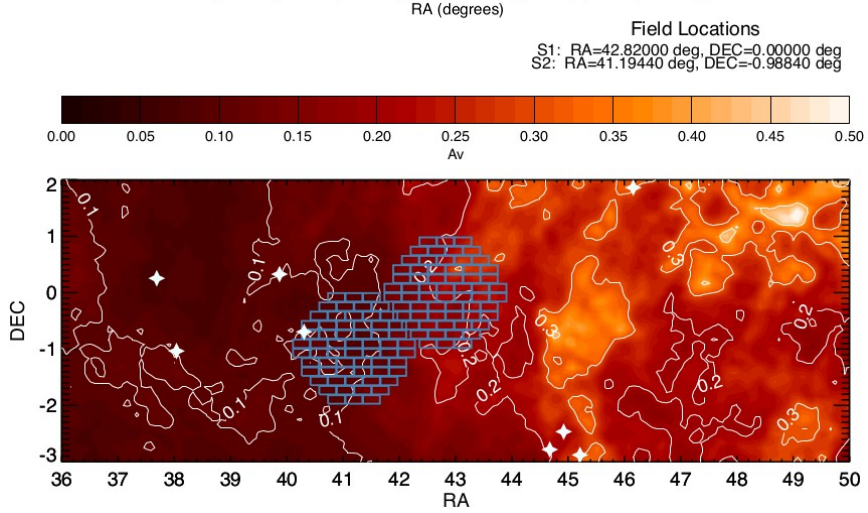


DES SN fields: ancillary data









Outline

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- Science Verification Data
  (Dec 2012 – Jan 2013)
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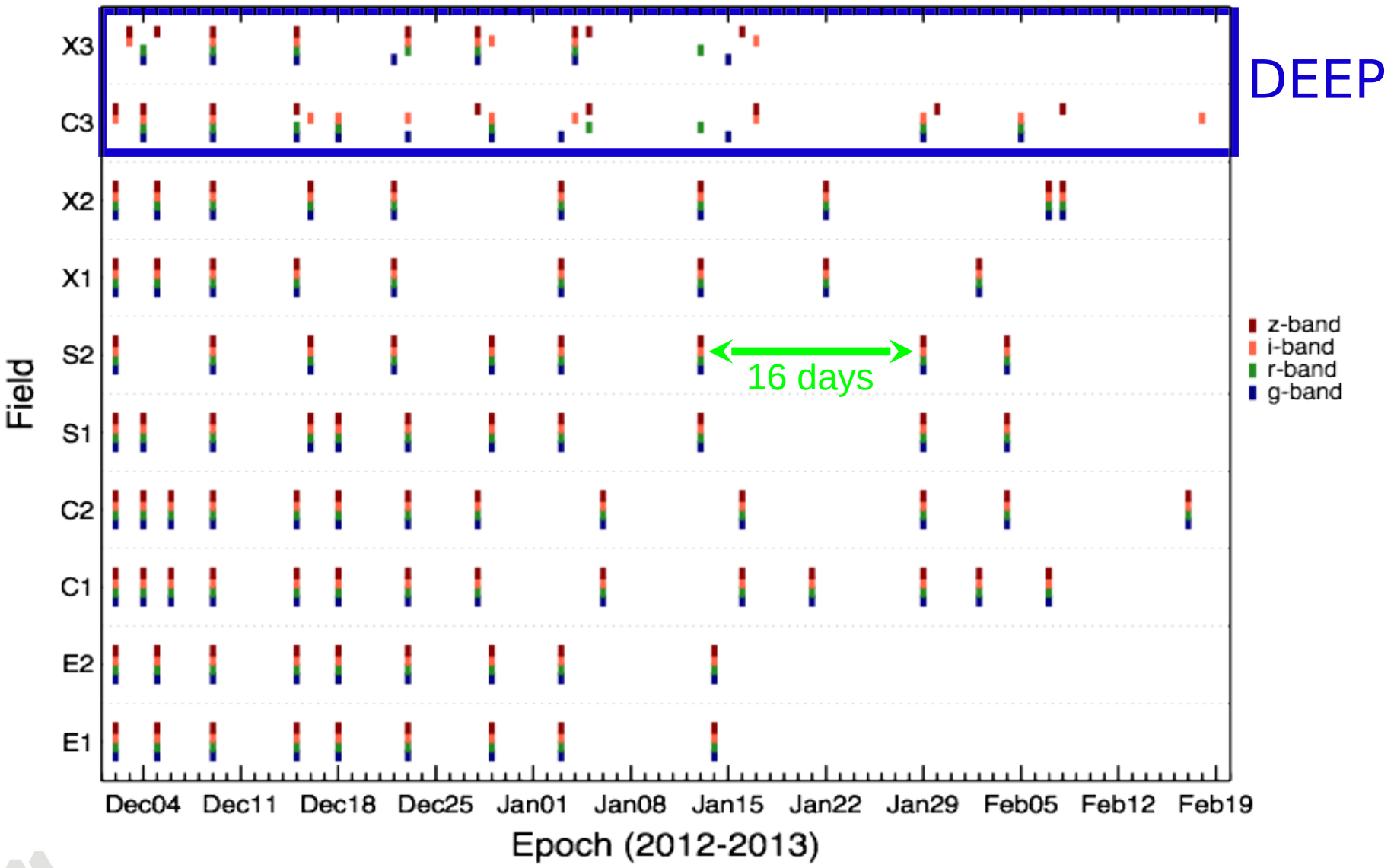
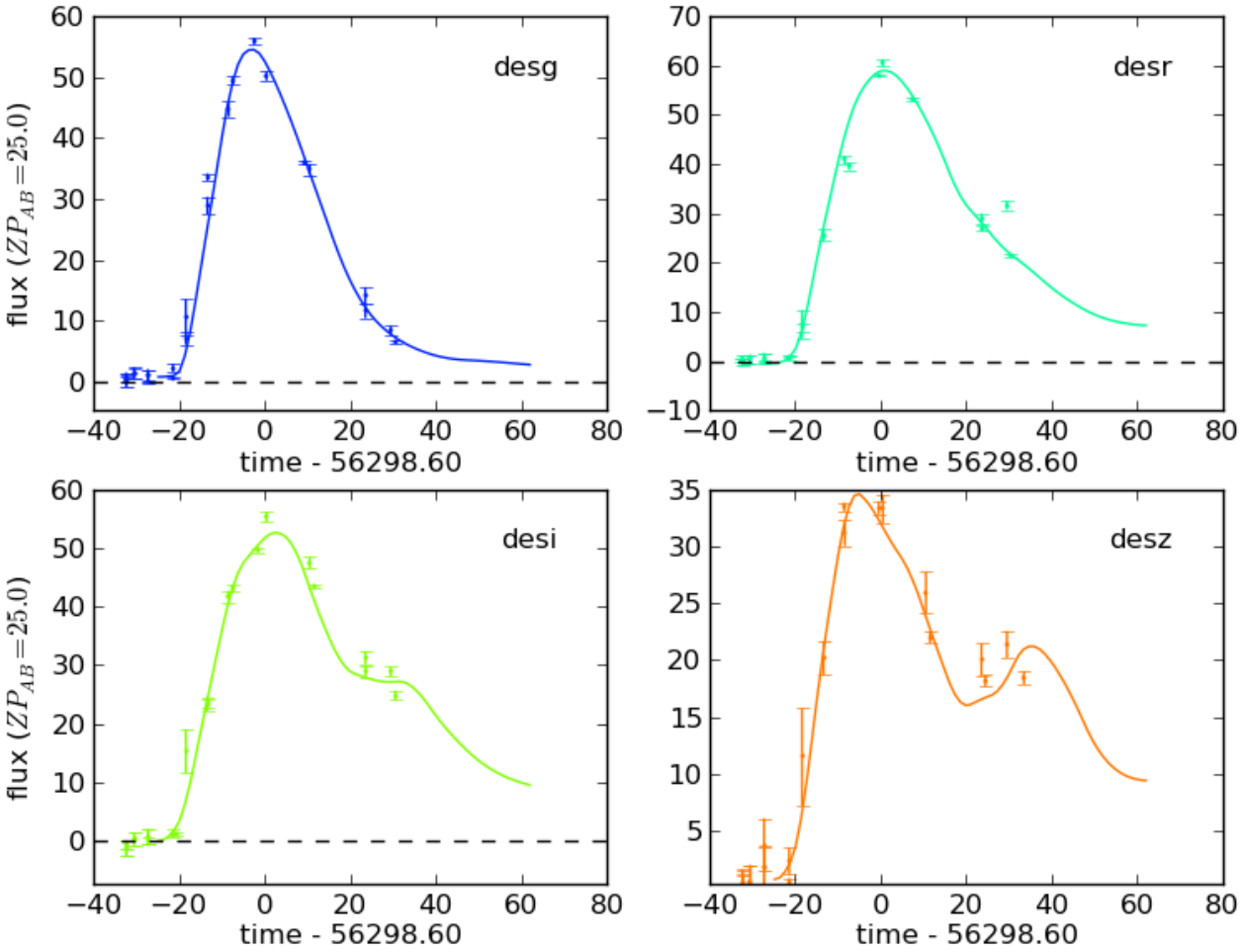
  - Spectroscopic follow-up strategy & photometric typing

Science Verification: SN Candence



Science Verification: Supernovae



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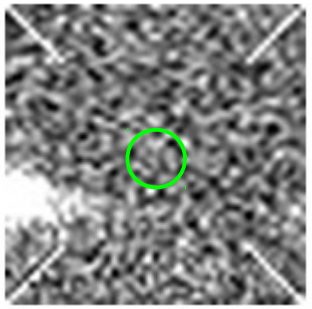
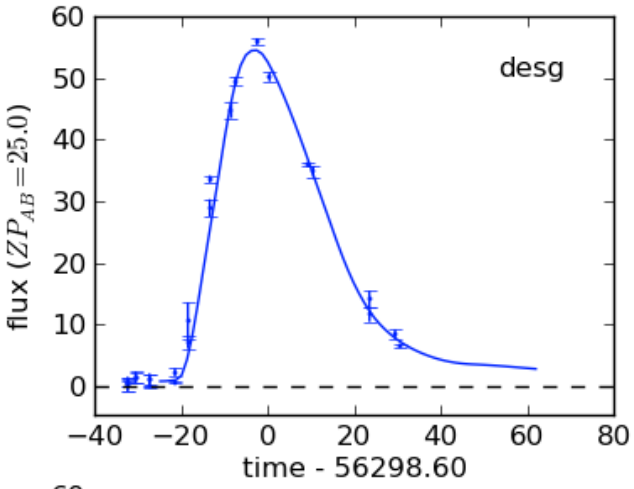
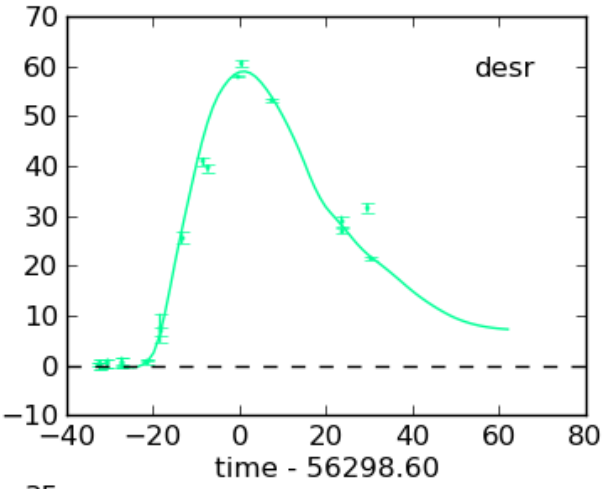
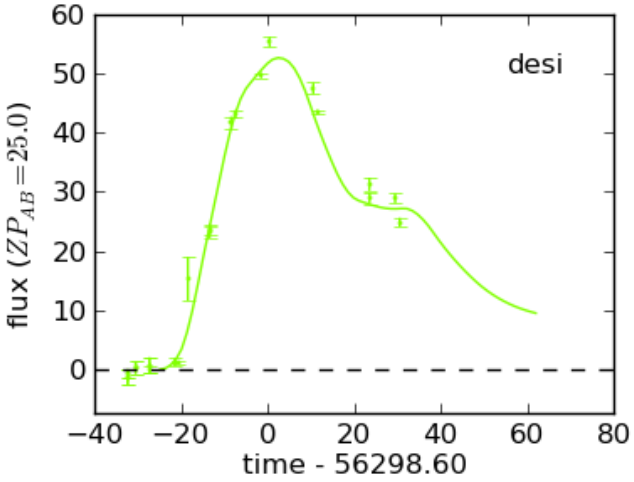
DES12C3a
(642239)

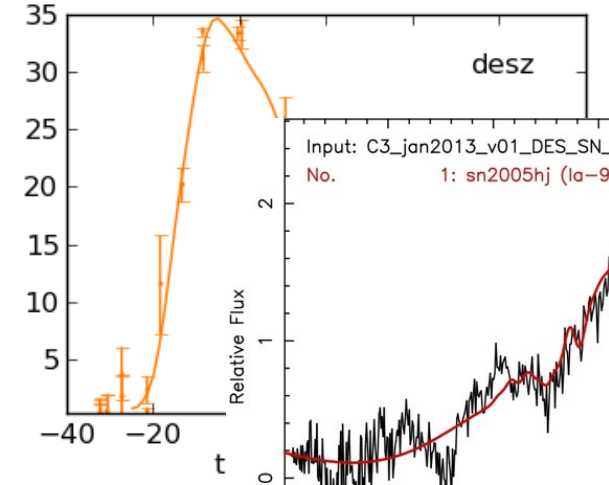


Science Verification: Supernovae



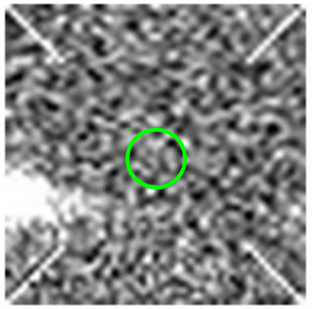


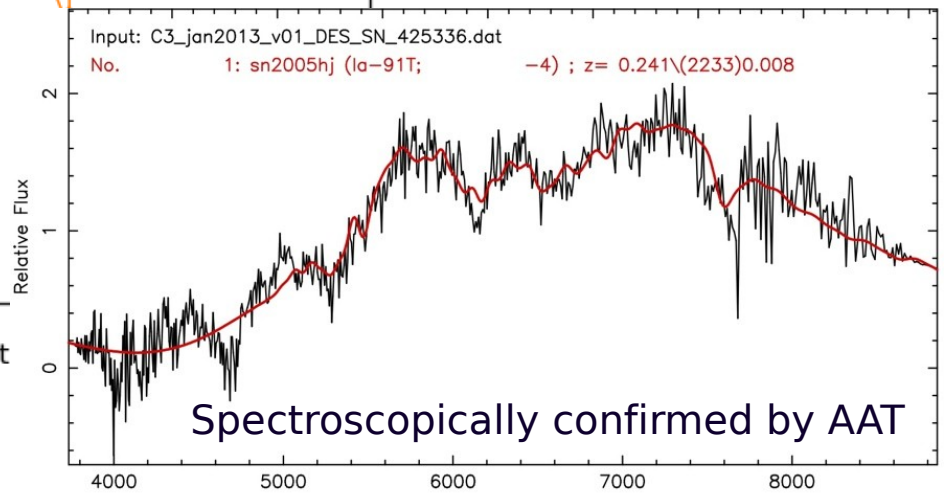




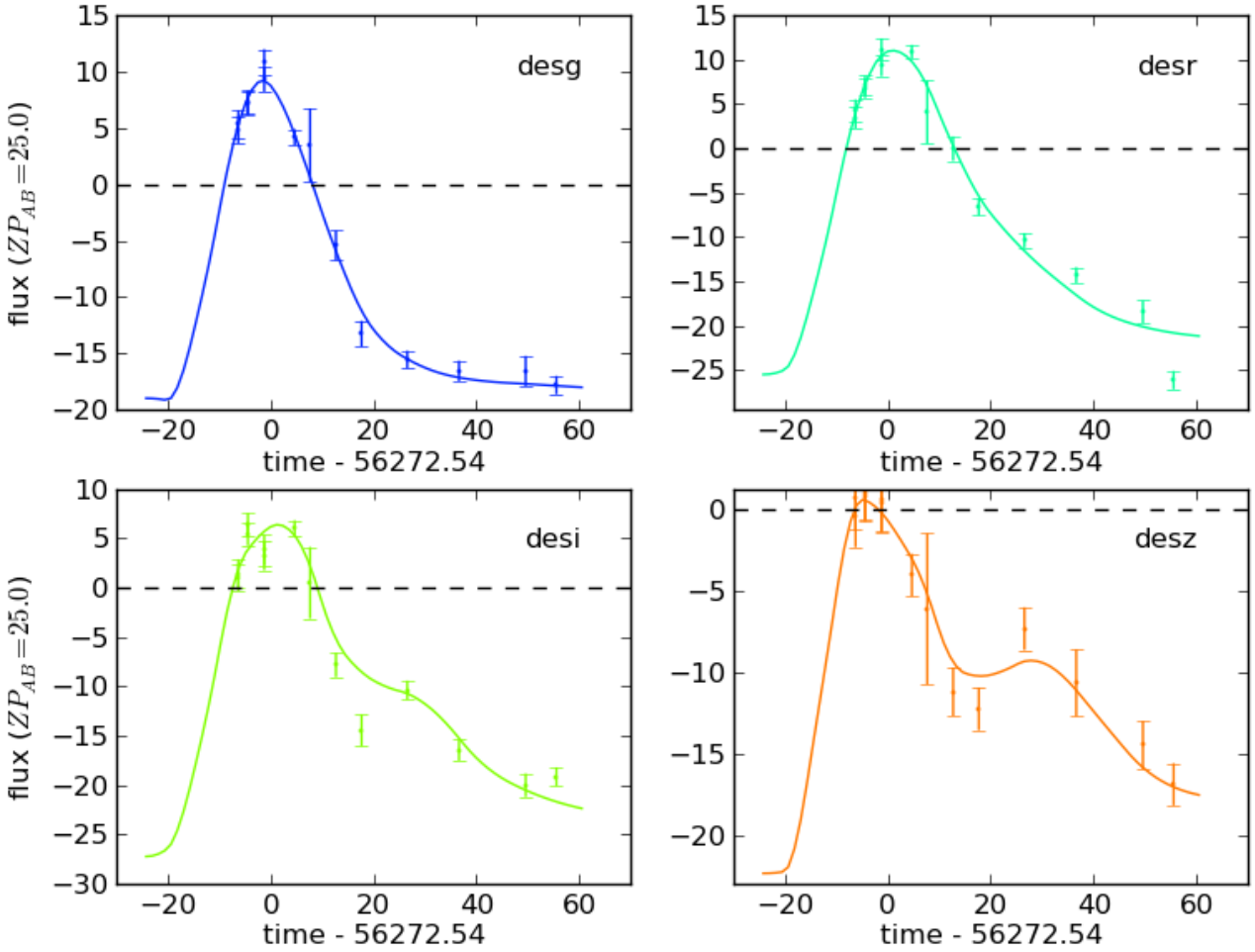
$z = 0.241$

DES12C3a (642239)





Science Verification: Supernovae



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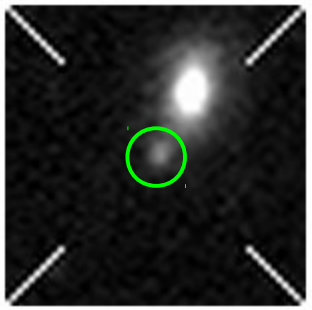
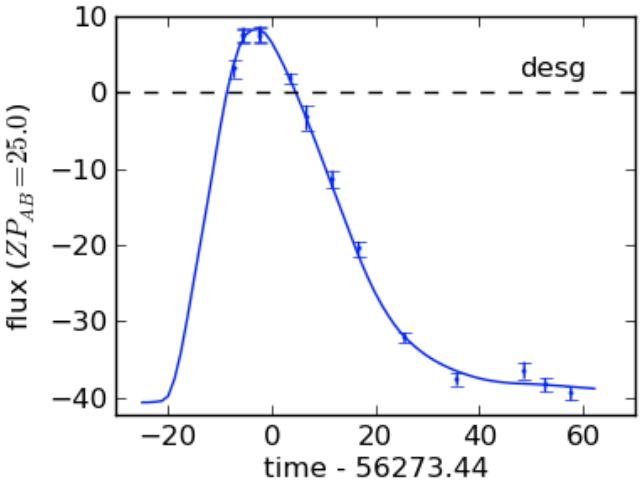
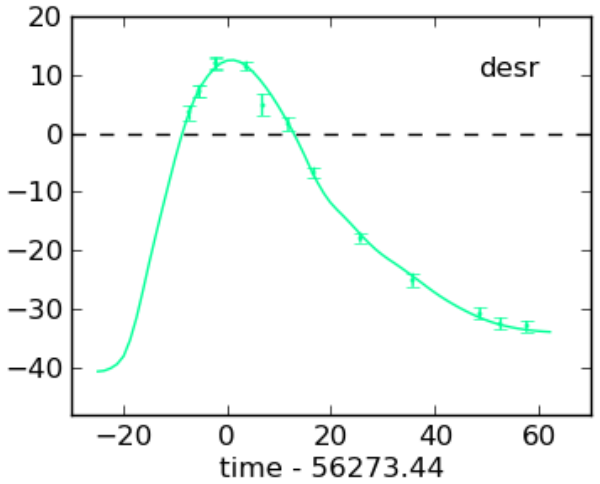
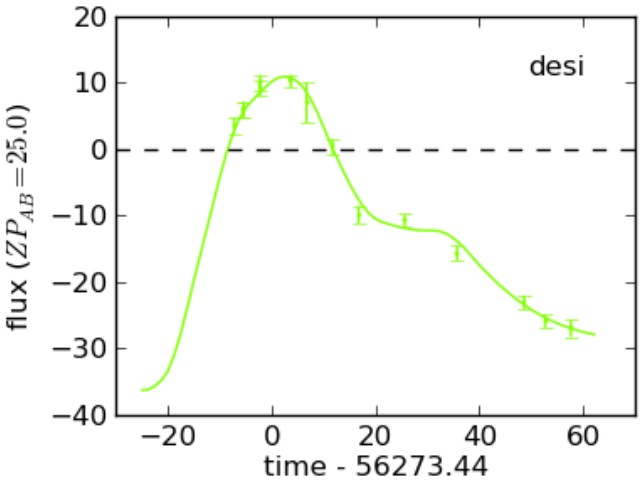
(619935)

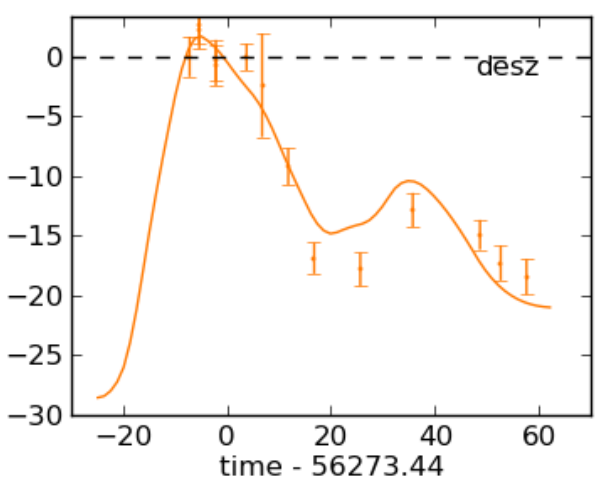


Science Verification: Supernovae









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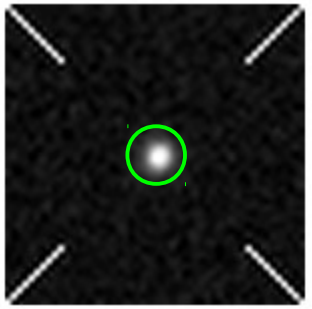
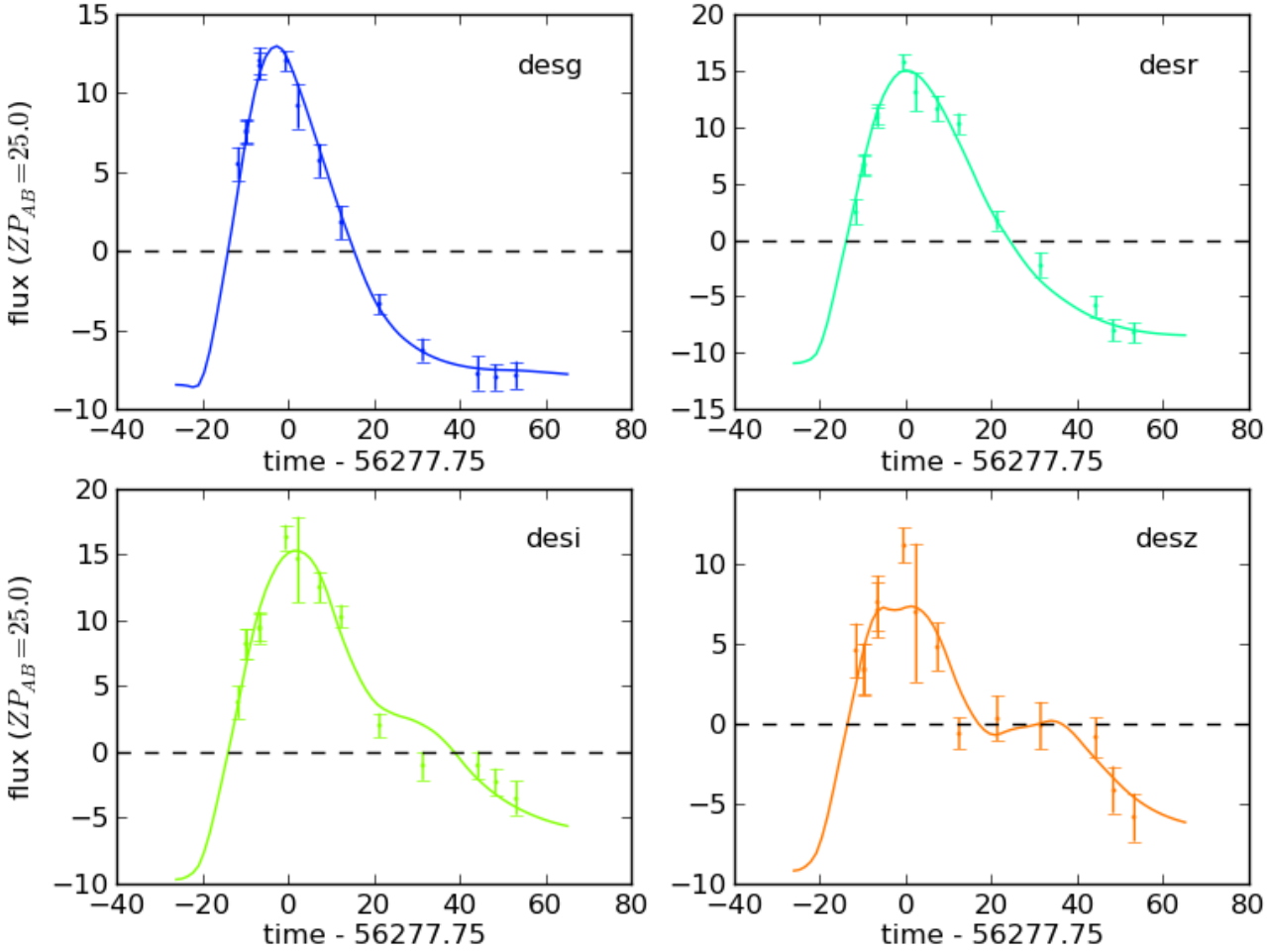
DES12C1b

(636359)



Science Verification: Supernovae



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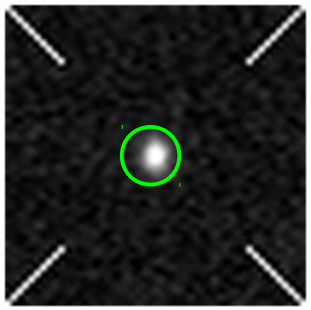
DES12C1a

(636909)



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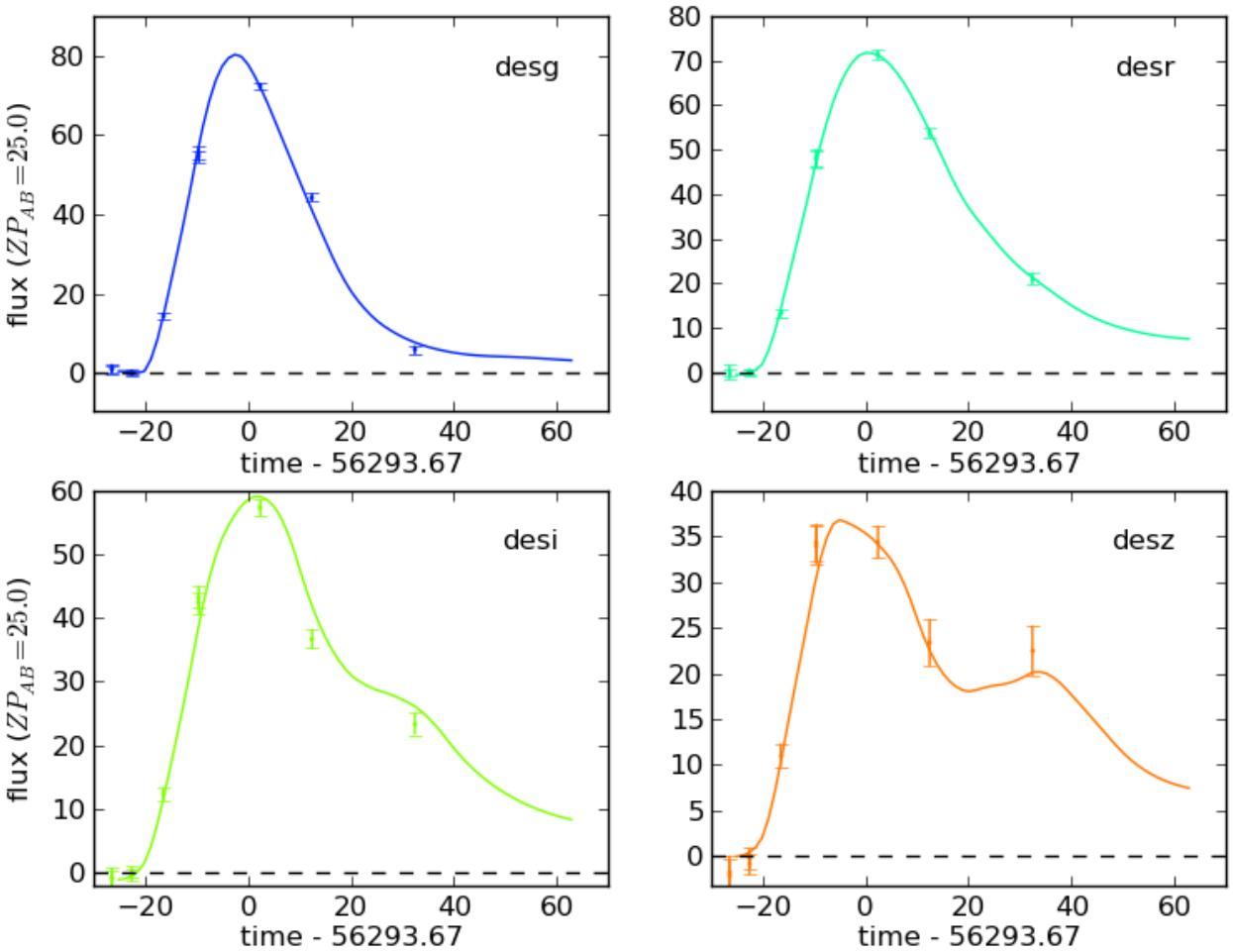
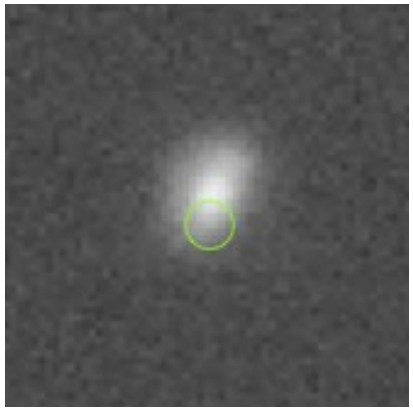
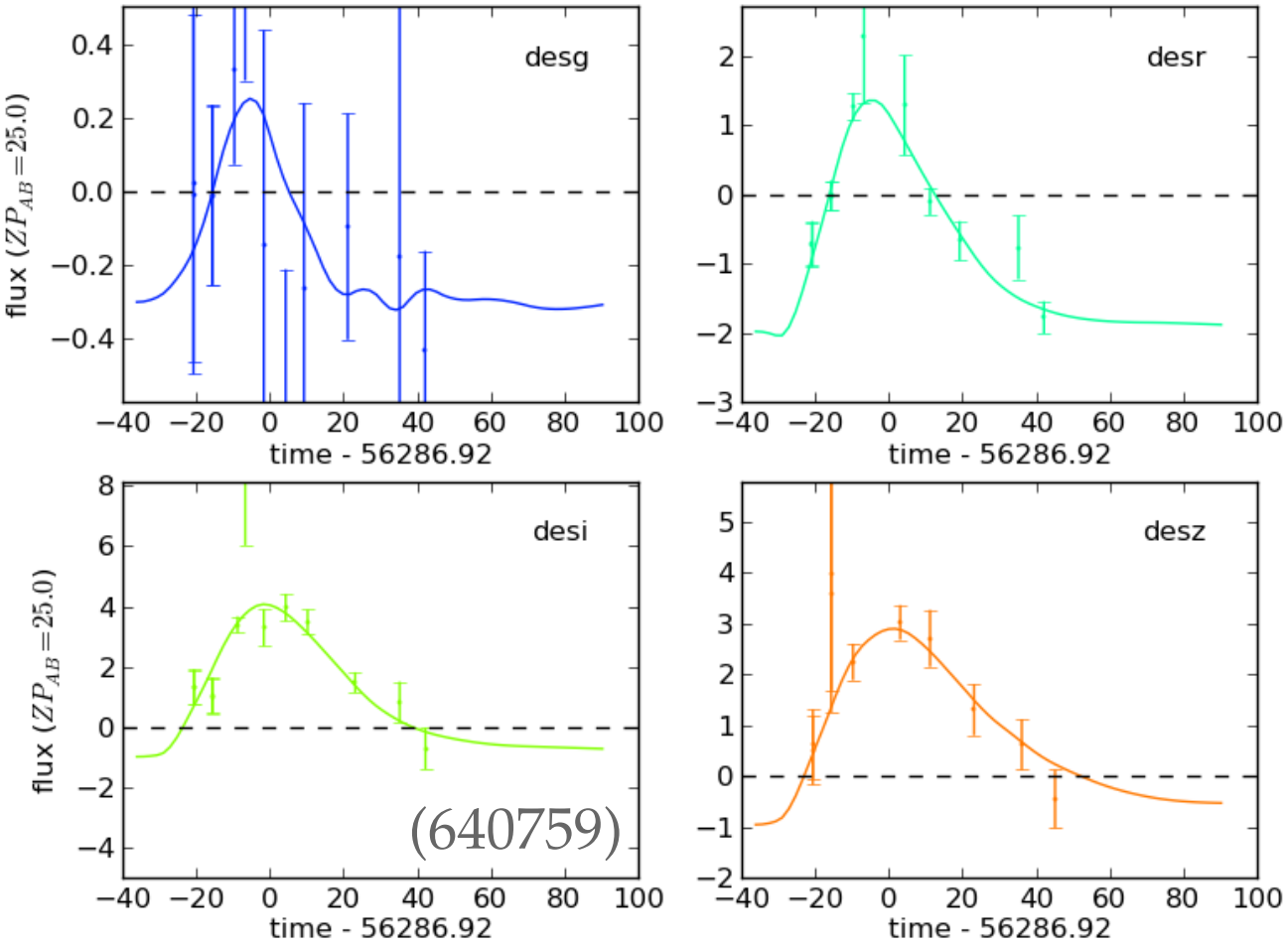


$z = 0.26 \pm 0.01$ (photo-z from SN lightcurve)

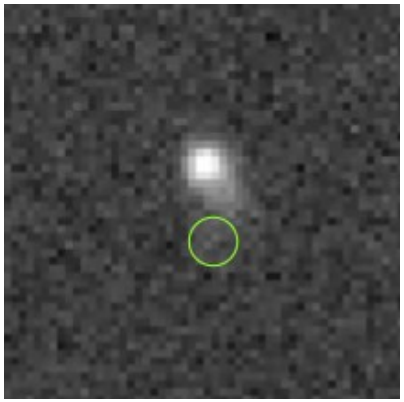
(635230)



Science Verification: Supernovae

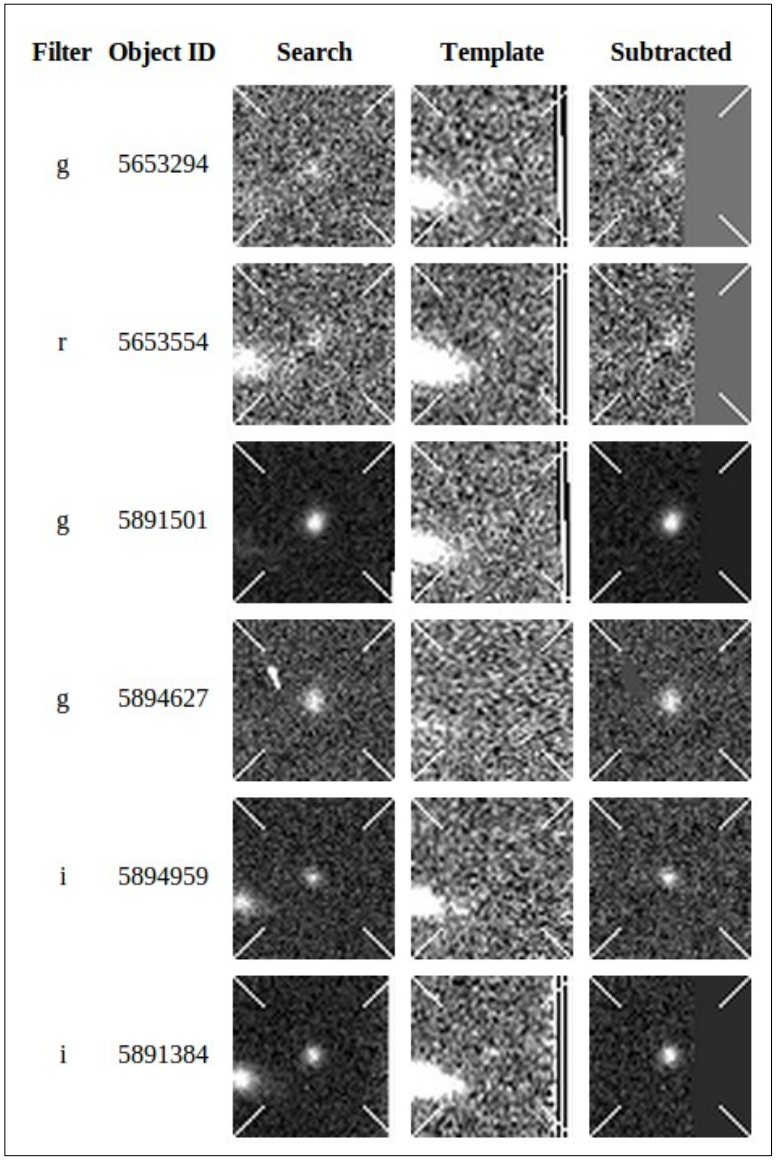


$z = 0.806$
from host spec-z
(VVDS)

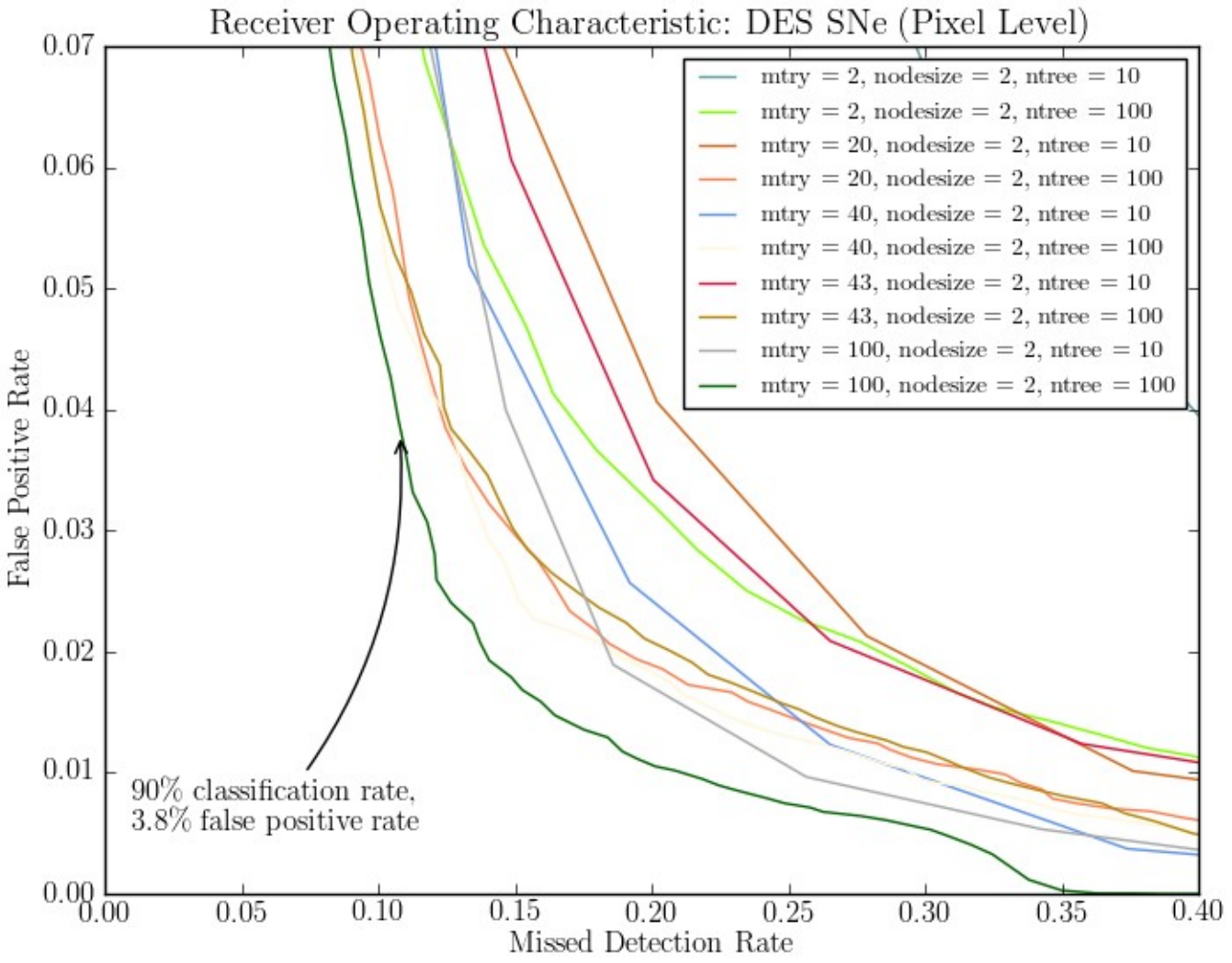


Improving Candidate Selection

	Total Candidates	Human flagged as interesting
During SV	585,664	3,184
reprocessing	408,304	7,219



Random forest candidate selection



SV data: summary

- Refined subtraction pipeline now in place
- Machine Learning will be in place reducing scanning load
- Deep reference images from SV
- Data looks good; lots of SNe; analyses in progress (even with preliminary photometry)

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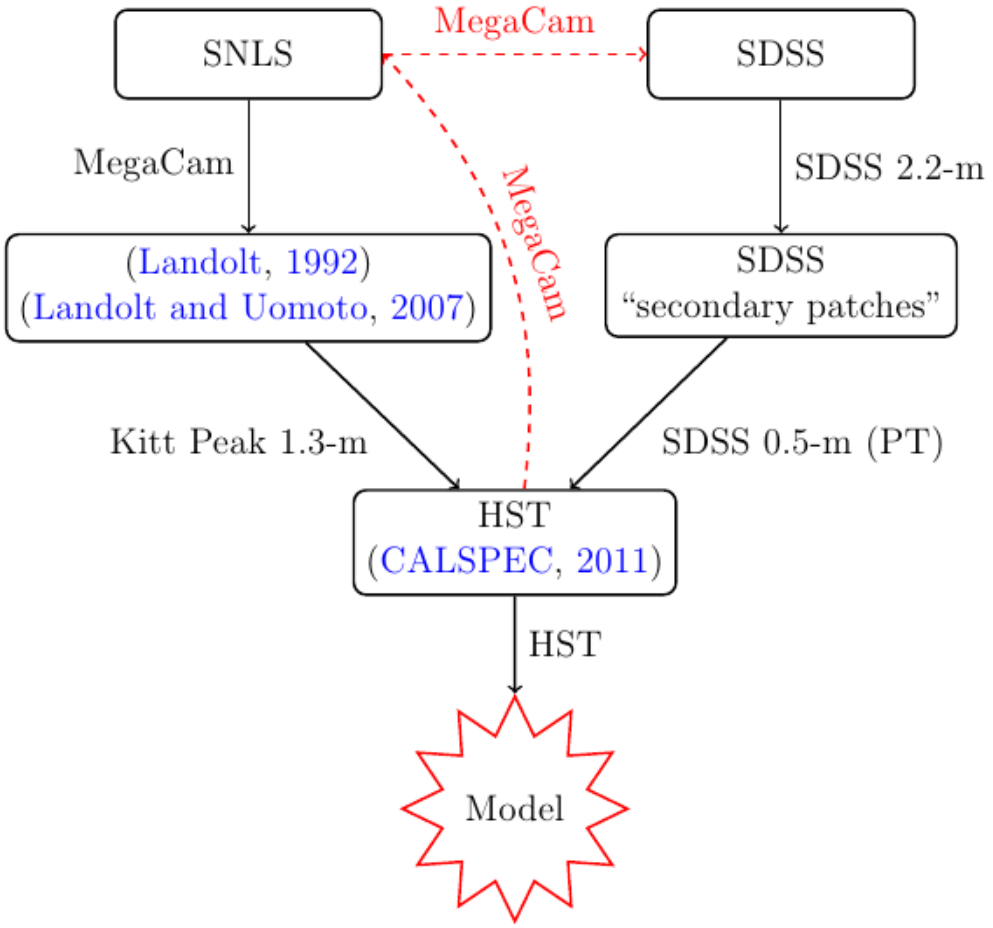
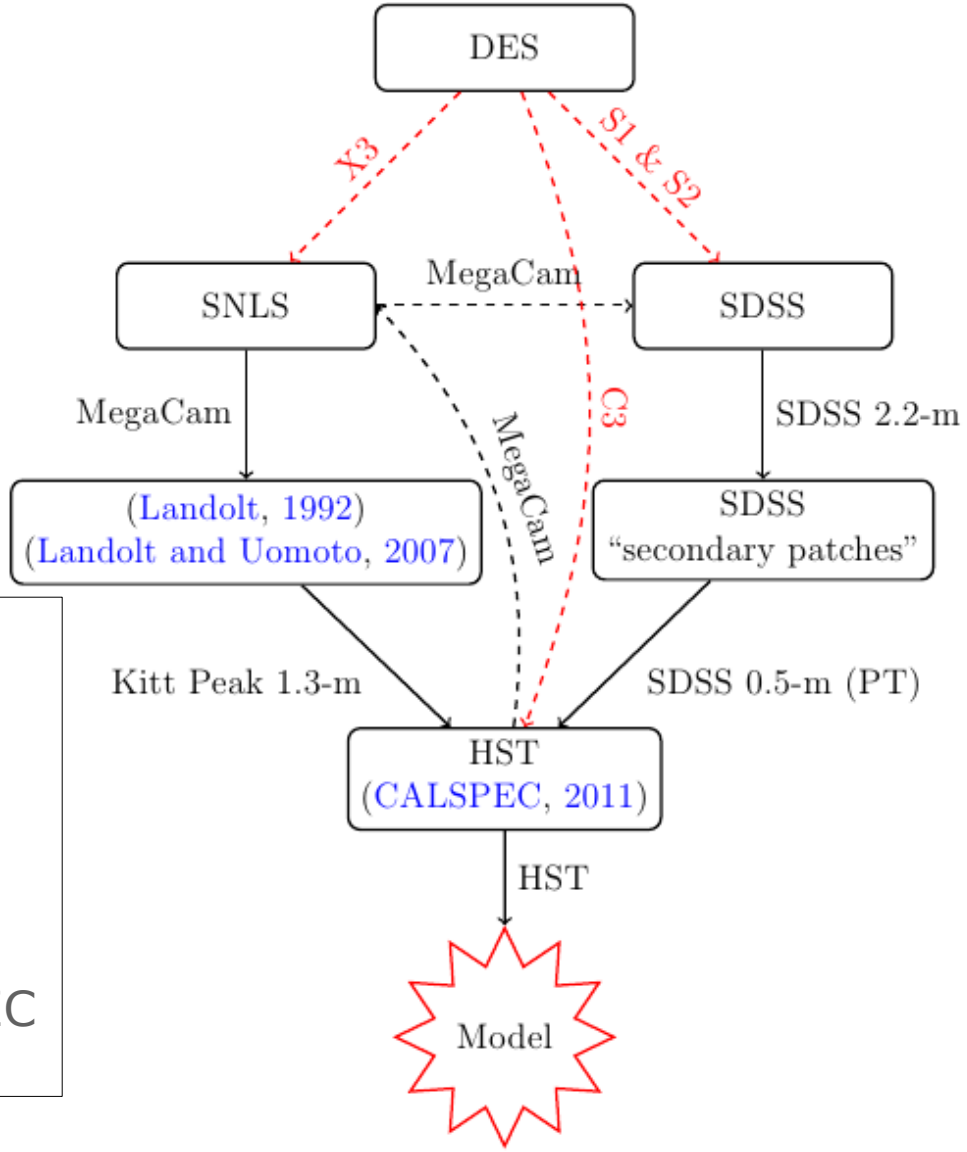
Photometric Calibration

- Leverage overall DES calibration plans
  - DECal plans and other atmospheric monitoring systems
  - Spectroscopic observations of white dwarfs
- **Direct Calibration Chain**



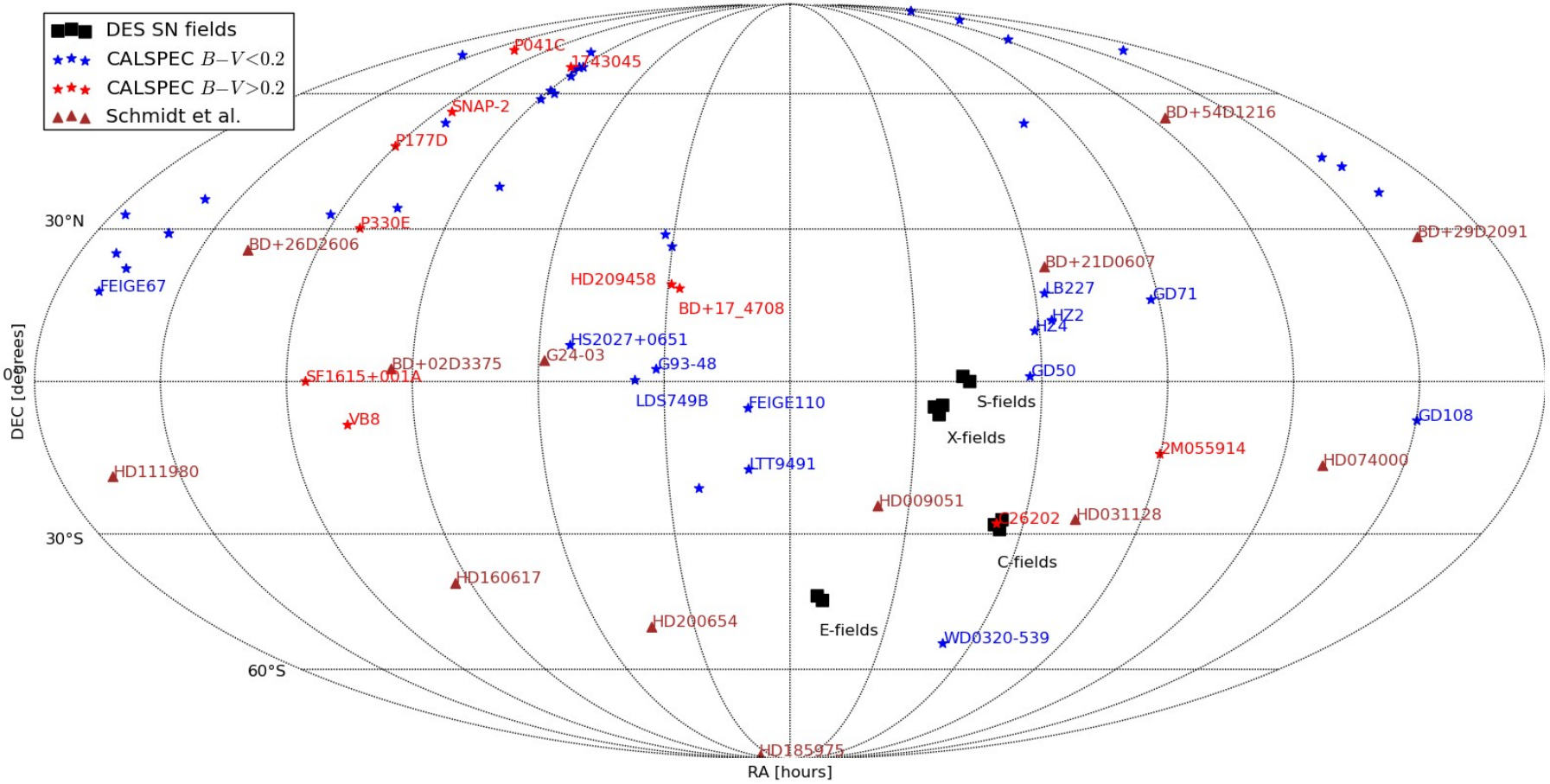
Photometric Calibration

- As direct as possible
- Redundant chains
- Anchor calibration to chain established for SNLS & SDSS



- Additional observations of CALSPEC standards
  - Observe standards at same airmass as SN fields
  - field stars in each field directly calibrated to CALSPEC

HST CALSPEC standards



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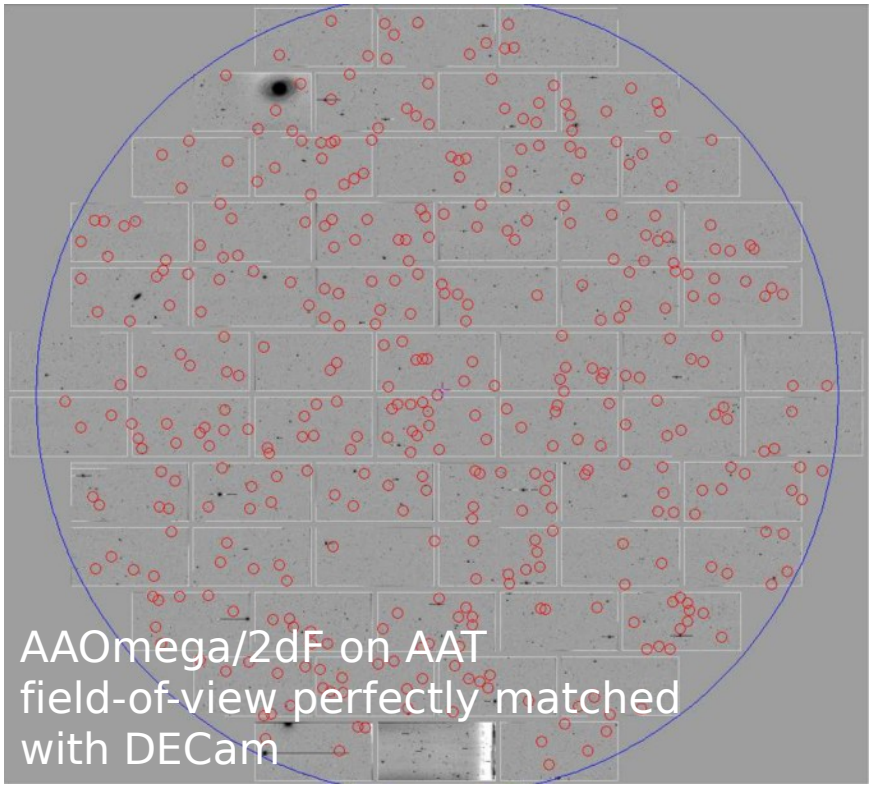
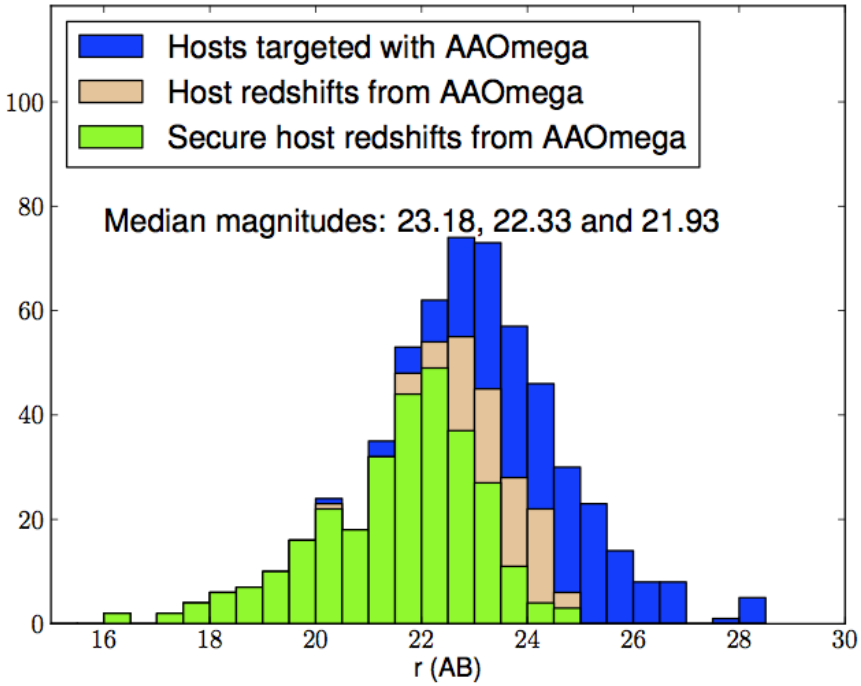
Spectroscopic follow-up

SN Classification: Photometric classification with a “random” spectroscopic training sample

- 8-meter telescopes: training sample and host-less SNe
- 4-meter telescopes: host spectra for redshifts

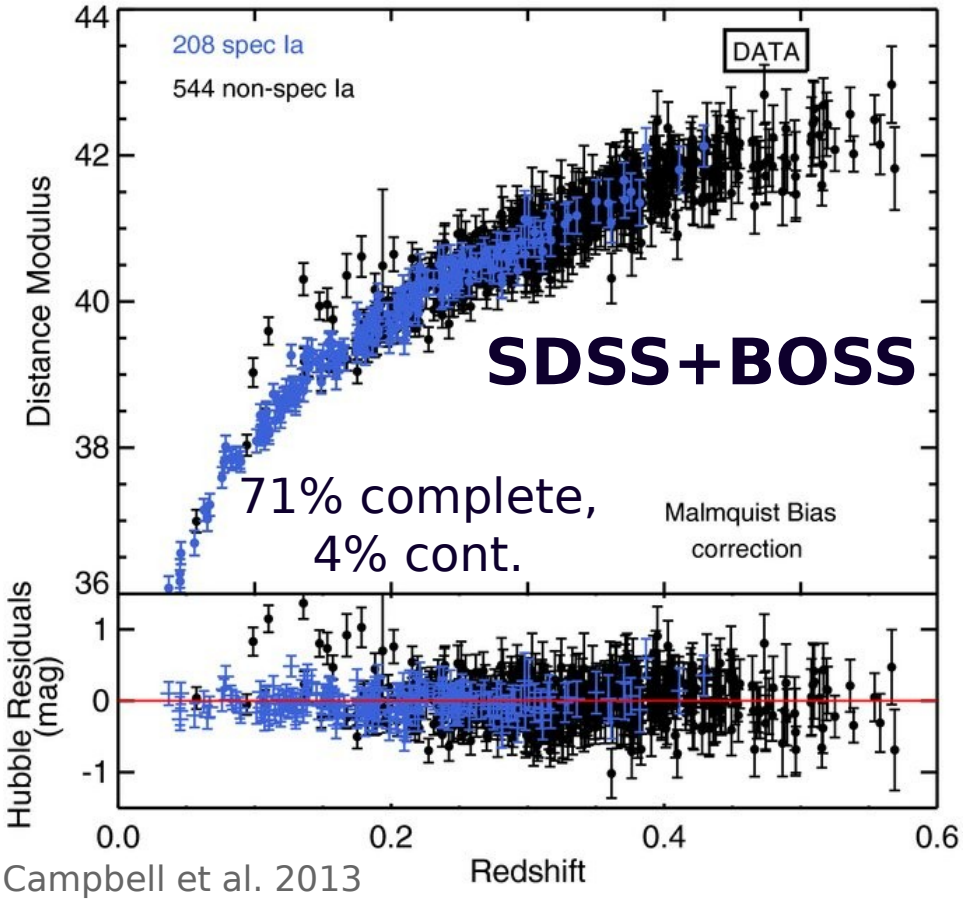




Lidman et al. 2012

OzDES: 100 nights/5 years

Photometric Typing



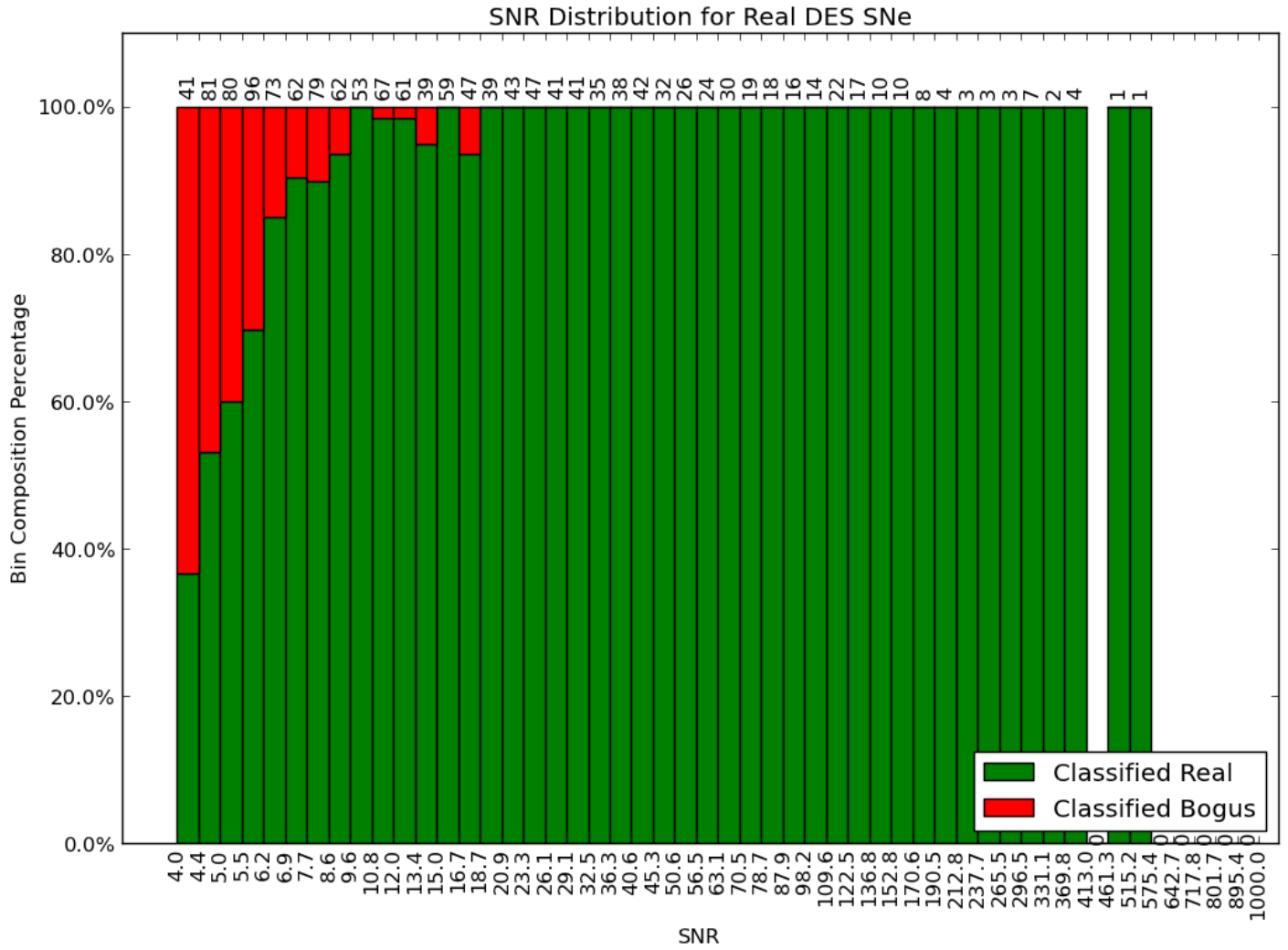
Campbell et al. 2013
ApJ, 763, 2

- Photometric typing is our biggest new challenge
- magnitude-limited survey gives you ~75% Type Ia SNe
- Typing systematics:
  a matter of understanding the distribution of core-collapse SNe that look “kinda like” Type Ia
- Type Ia's are not a perfectly uniform sample anyway – need to understand distributions very well
- An opportunity looking forward to LSST

Summary

- DES Supernova program at a glance
  Nice advance over current SN sample; main high-z SN survey over next 5 years
- Science Verification Data
  (Dec 2012 – Jan 2013)
  Data look good; ready to start survey in two weeks(!)
- Looking Forward ...
  - Photometric Calibration
    Robust, multi-faceted plan for calibration
  - Spectroscopic follow-up strategy & photometric typing
    Nearly complete spectroscopic redshifts;
    optimistic about photometric typing

Random Forest



Cosmology constraints