Measurement of expansion of the Universe using high-z type Ia supernovae

公募研究 18H04345

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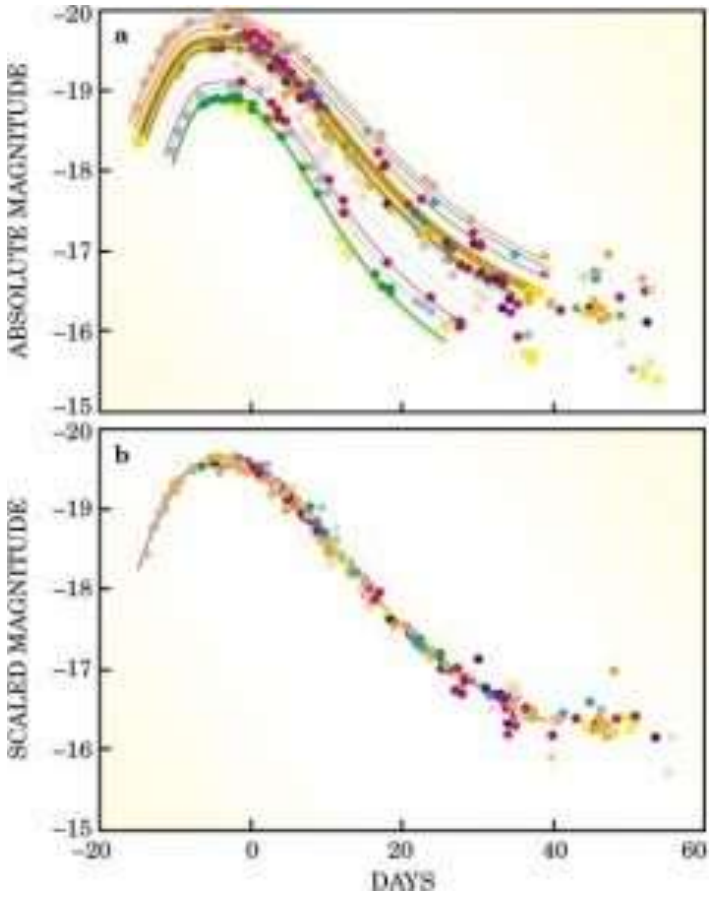
and
HSC SSP Transient team + SCP

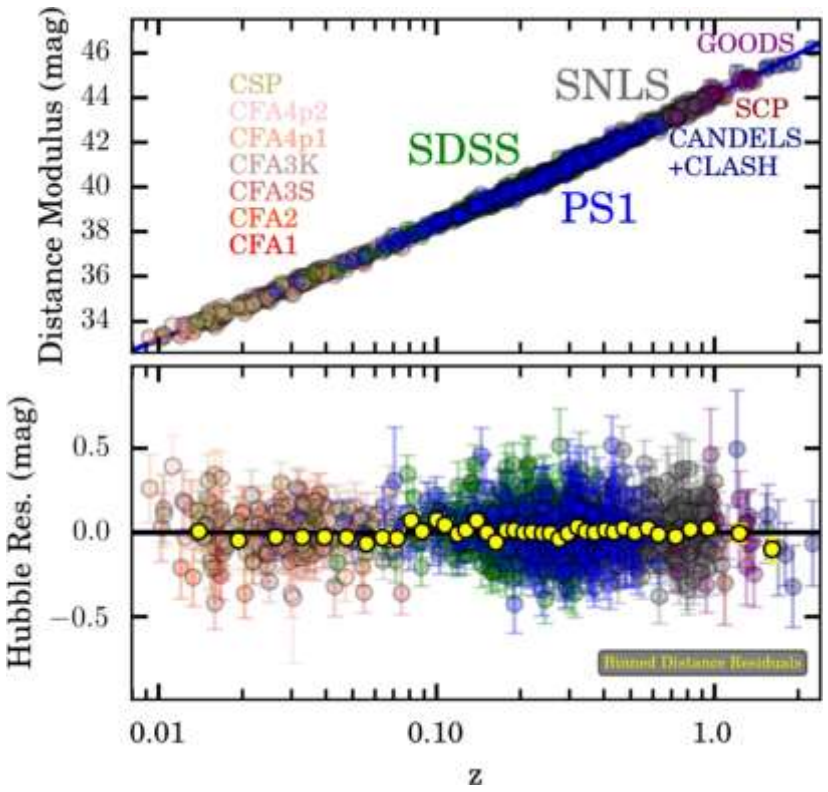
Type Ia Supernova

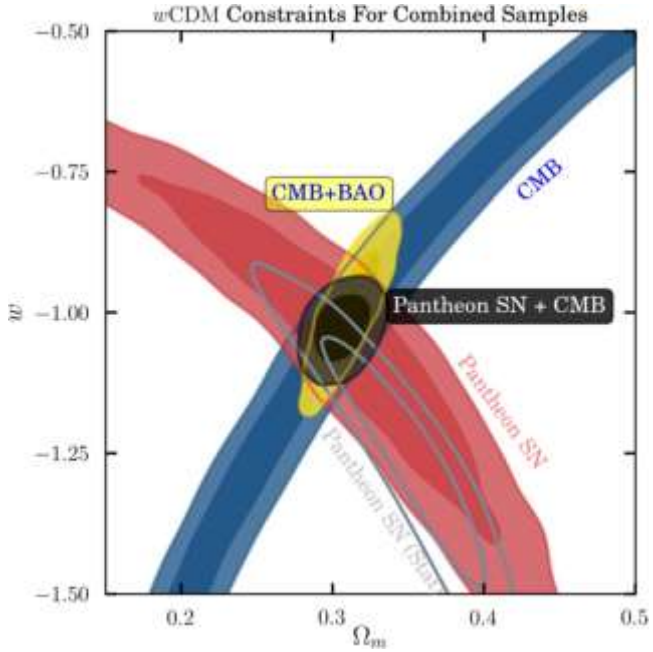
- Thermonuclear explosion of white dwarfs
- Chandrasekhar mass limit of $1.44M_{\odot}$
- Standardizable candle with a light curve shape parameter
- Bright enough (M_B~-19) to reach cosmological distance (z~1)



SN Ia cosmology

Scolnic et al. 2018 (ApJ, 859, 101)

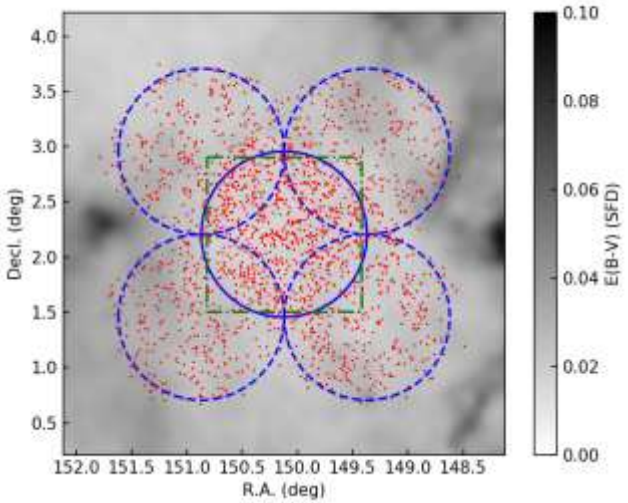


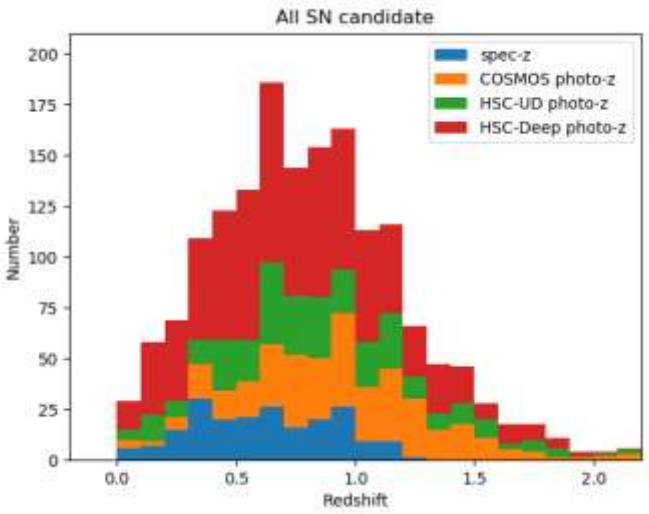


Only a few tens of SNe Ia at z > 1 detected by HST
HSC can play an important role at this redshift range
To constrain time variability of dark energy

HSC SSP Transient Survey

- HSC SSP Ultra-Deep/Deep field COSMOS
- November 2016 – April 2017 (over 6 months)
- 1,824 SN candidates
- 433 SN Ia candidates
  - 163 at z > 1
- Spec-z (host galaxies) only for 38
  - 5 at z > 1





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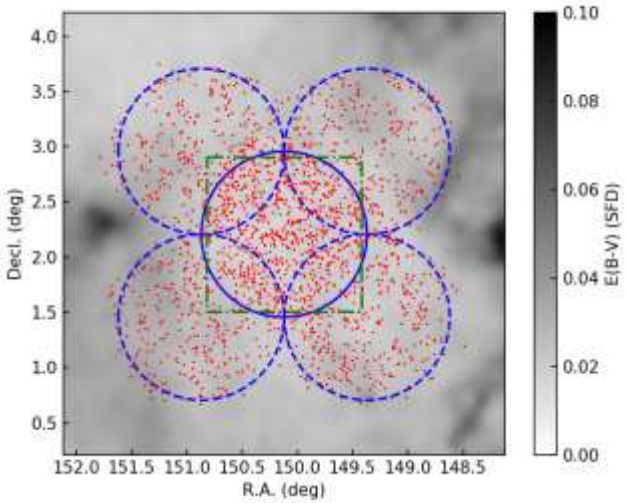

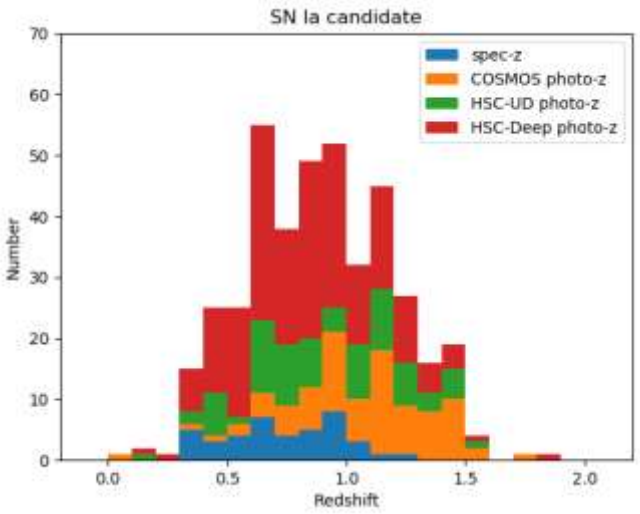

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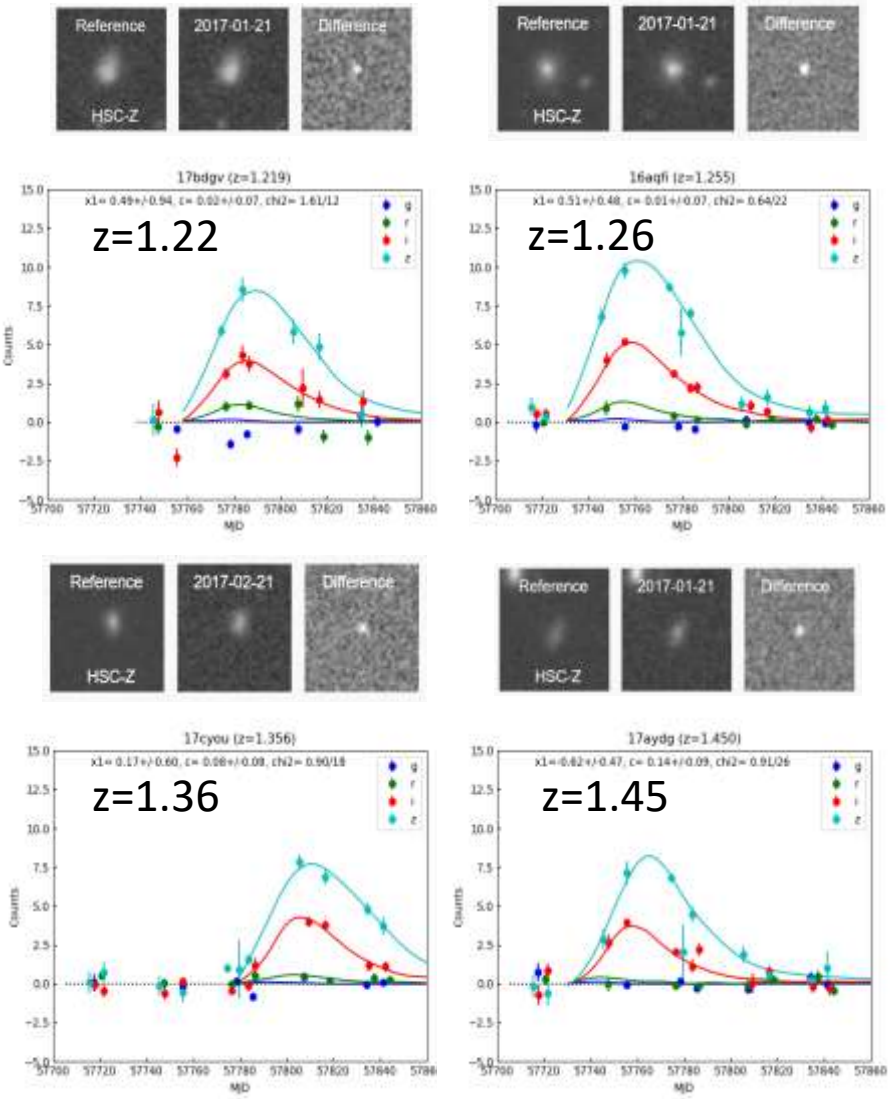


Tasks toward SN Ia cosmology

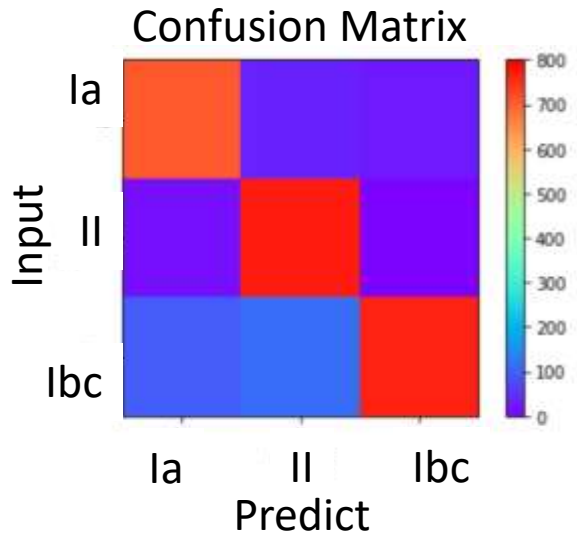
- SN Ia sample definition
- Properties of host galaxies including host redshift
- Detailed photometry
- Photometric calibration
- (Revised SN Ia light curve template)
- HST photometry

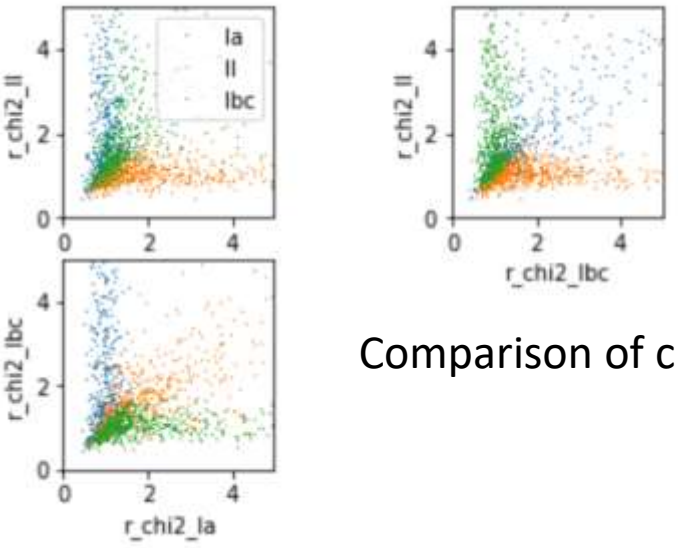
- SN Ia cosmology

Photometric SN classification

- Only several spectroscopy of live SNe
- Need to classify SN only with photometric data
- Template fitting of Ia, II, Ibc + Machine Learning
- Input to Machine:
  - chi2 for each templates
  - M_B for each templates
  - shape and color parameters for Ia template
- Predict SN type (Ia, II, Ibc)

- Testing with simulated light curve
- Working reasonably well
- Doing more than the comparison of chi2 of each templates





Comparison of chi2

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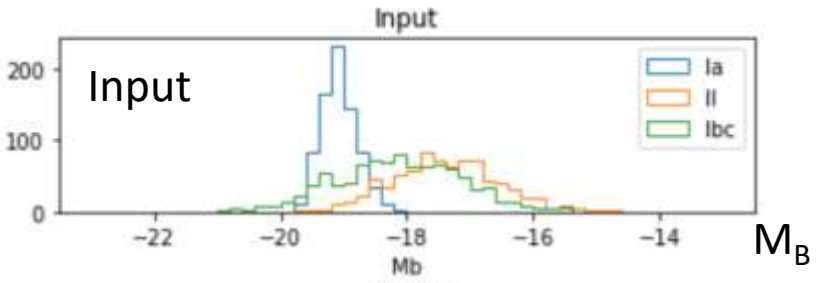
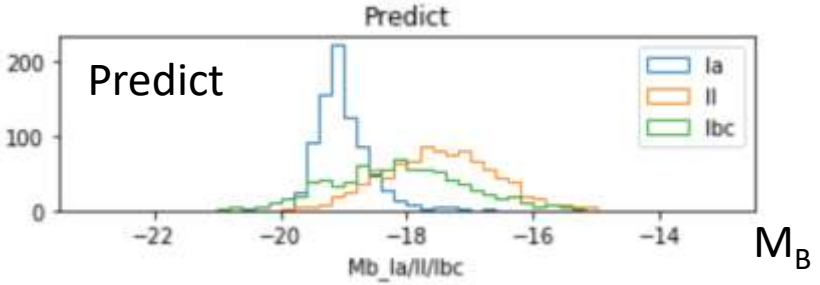
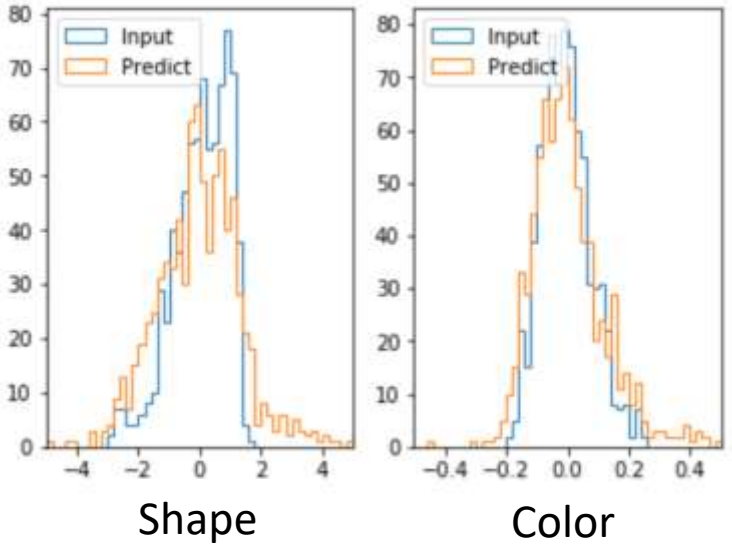
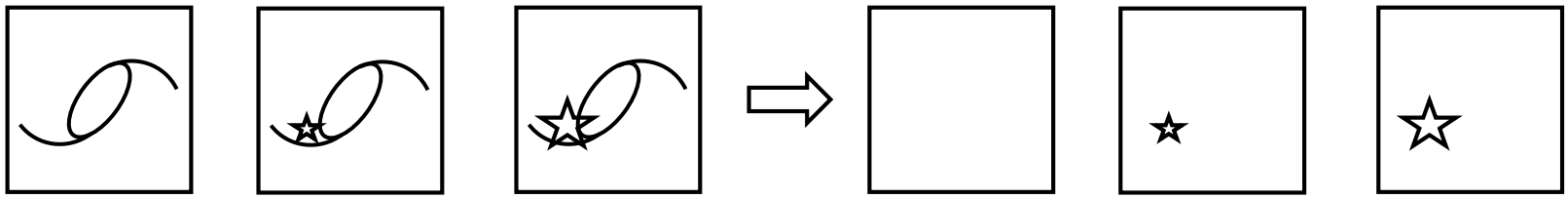






Scene modeling photometry

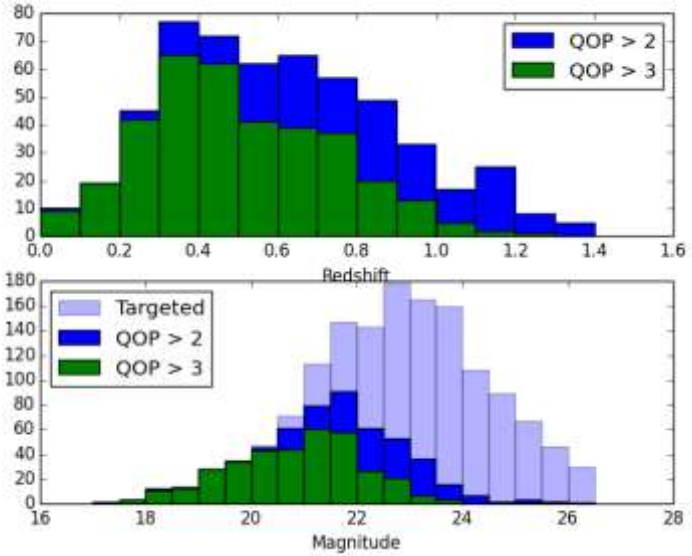
- Current photometry



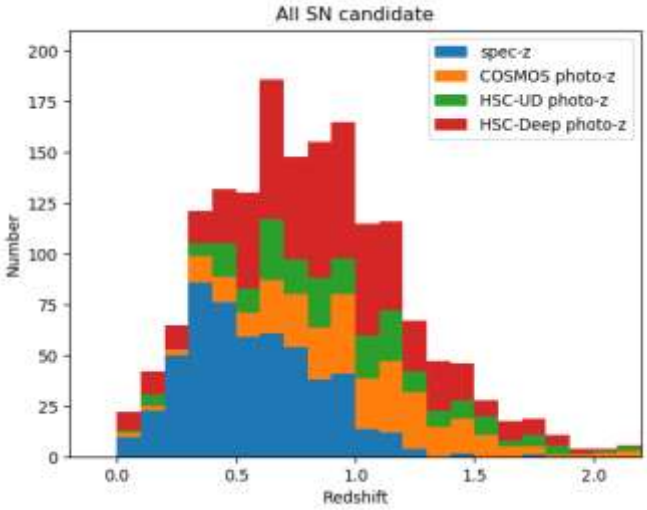
  - Subtract reference image and photometry on difference image
- Scene modeling photometry
  - Simultaneously fit constant background (pixel values) and variable SN brightness using known PSF model
  - No need for re-sampling and convolution
- Developed for SDSS/SNLS

Measurement of host redshift

- Anglo-Australian Telescope + AAOmega/2dF (~400 fibers / 2degree^2)
  - 2018 Feb 8-11
  - 2019 Jan 4-9
  - Fully reduced
  - ~500 new redshifts
  - Very effective at z < 0.8



- VLT + Subaru, Keck, Gemini to be reduced
  - targeted ~30 candidates at high-z (z > 1)
  - There are still ~100 candidates to be observed at z > 1
  - Use photo-z or wait for PFS?



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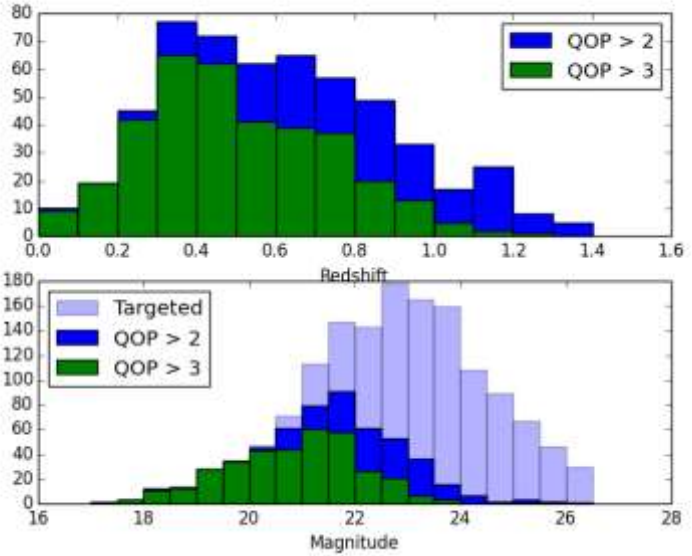
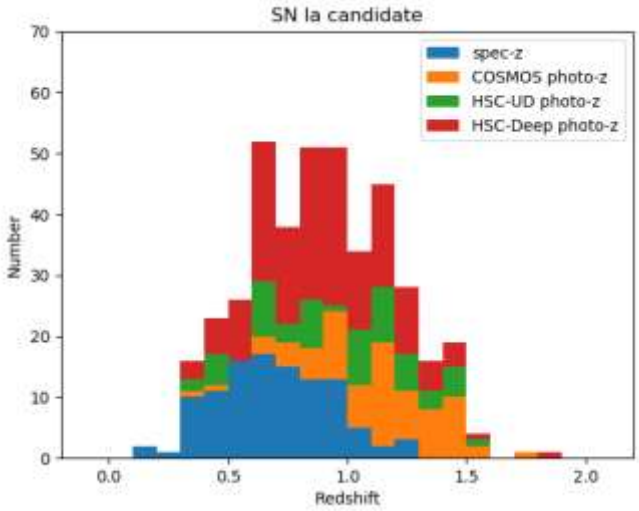
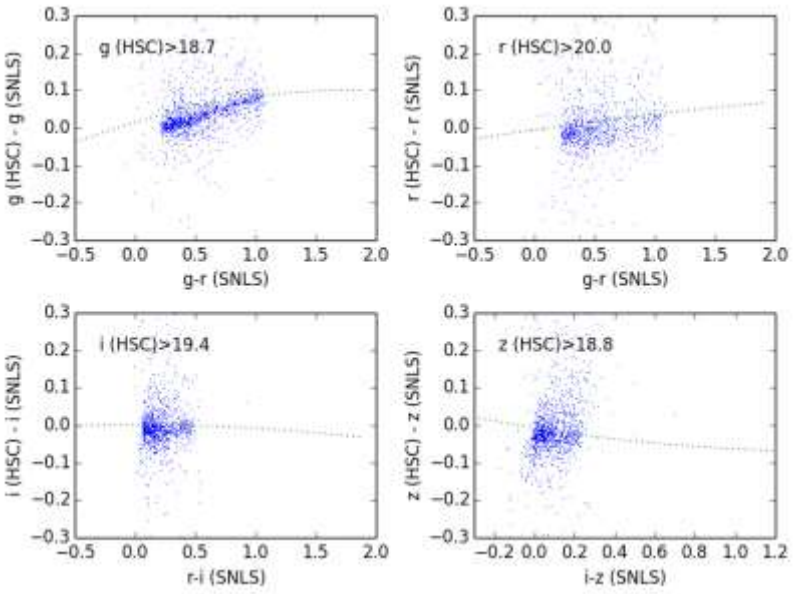




Photometric calibration

- One of major source of systematics
- COSMOS region is covered by SuperNova Legacy Survey (SNLS) by Canada France Hawaii Telescope
- SNLS tertiary catalog is well calibrated

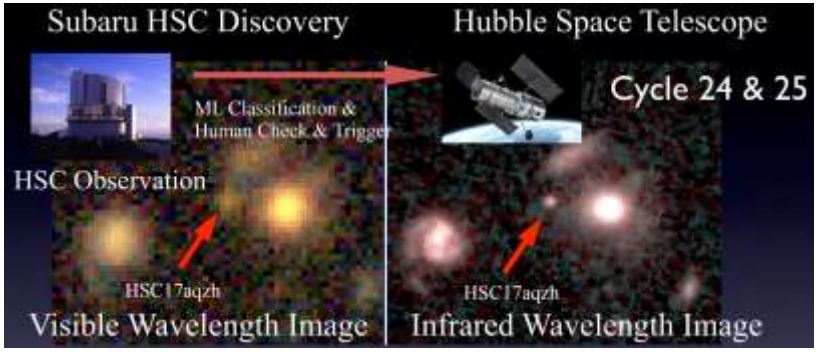
- Calibration of HSC with SNLS at <1% level could be possible
  - Need to understand offsets
  - Need to go fainter for SNLS

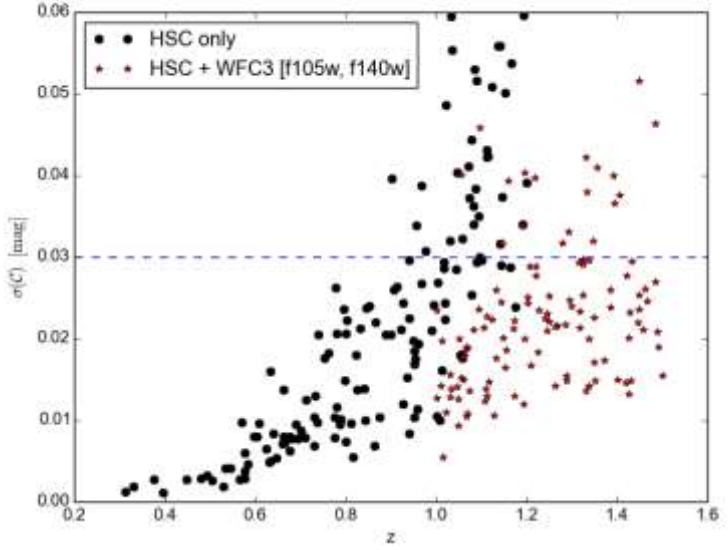


Blue dots : common stars
Green line : synthetic relation

HST photometry

- HST proposal by N. Suzuki has been accepted
- 26 SN Ia candidates observed by HST/WFC3 (F105W/F140W)
- Get accurate rest-frame optical color
- Reference images are being taken
- Need to get final photometry for observed candidates





Summary

- HSC SSP Transient Survey identified large number of SN Ia candidates usable for cosmology
  - HSC is more powerful than HST
- Tasks for SN Ia cosmology are on-going
  - Photometric classification
  - Detailed photometry
  - Measuring host-galaxy redshifts
  - Photometric calibration
- Next Transient Survey will start from September on another HSC SSP Ultra-Deep/Deep field (SXDS)