High-Redshift SNe with Subaru and *Hubble*

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Why High Redshift?

Scolnic+ 18: FoM 63.2

We Still Have Weak Constraints on Time-Varying DE
Two Efficient Techniques for HST

See Change: Search In $z > 1.1$ galaxy clusters

SUbaru SNe with Hubble Infrared: Find $z > 1.1$
SNe with Hyper Suprime-Cam

HSC DR2 on legacySurvey.org
See Change: Search In \( z > 1.1 \) galaxy clusters

- Quantified efficiency: fully blind SN searching with \(~\) few simulated SNe injected into every visit!
- First undersampled IR random forest classifier for transients
- Automated near-real-time forward modeling discovery photometry for all candidates
- Semi-automated single-epoch (discovery) typing and targeted followup forecasts
- WFC3 \( F814W, F105W, F140W \), and frequently \( F160W \)
See Change: Search in $z > 1.1$ galaxy clusters

25 cosmology SNe Ia!
Preliminary, blinded, old HD, etc.
Coming soon!

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Diagram showing the relationship between distance modulus and redshift, with references to various studies and datasets.
Moving on to HSC (thanks to Clare Saunders for discussion of HSC data)

Largest Field of View on an 8m Telescope

1.7 degree^2

Tens of SNe Ia in one image!
How to Efficiently Discover High-Redshift SNe?

All HST ACS WFC z-band ever taken on any field (since 2001): ~1500 hours.
Comparable sensitivity per unit time.

ACS F850LP

HSC z-Band

⇒ Half a night with HSC rivals all ACS z orbits!
SUbaru Supernovae with Hubble Infrared (SUSHI)

- Piggyback on Subaru Strategic Program (COSMOS, SXDS)
- Typical 5-sigma AB depths per point comparable to an *HST* visit! 
  
  \[
g \sim 26.7, \quad r \sim 26.5, \quad i \sim 26.2, \quad \text{and} \quad z \sim 25.7
\]

One SN of 23 probable high-z SNe Ia so far…

3x better measured than without *Hubble*. 4x more robust to calibration uncertainties.
For both surveys: Undersampled Forward-Modeling IR Photometry

One independent model for each filter
Use spatially variable PSFs from Anderson+ 16
Simulated-SN tests confirm that spatial variation of the PSF is a significant effect.
For both surveys: Recalibrating WFC3 IR to CALSPEC

Count-rate nonlinearity calibration from Riess+ 19.

Uses redder Deustua observations to span same color range as SNe.

The real PSF is color-dependent, but possible evidence for bandpass modifications, too.
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Short timescale IR detector effects? Charge trapping/release, nonlinear IPC, …

Set constraints by working with up-the-ramp samples.
SUSHI: status

- HSC survey was efficient past the redshift range of the SUSHI SNe (1.1 to 1.4); selection effects seem to be subdominant.
- 23-25 likely SNe Ia in hand (out of 26).
- WFC3 IR photometry and absolute calibration likely good to ~1%
- Most host-galaxies have been spectroscopically observed.