Sundial: Updated Simulations for the Roman Space Telescope's High-Latitude Time Domain Survey

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Motivation

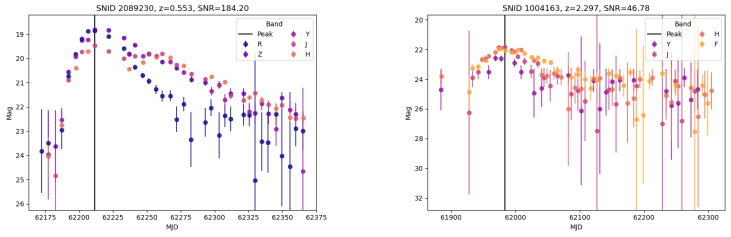
Sundial is a simulated catalog of observations from the High-Latitude Time Domain Survey (HLTDS). It is the successor to the Hourglass [1] simulation, and uses the most up-to-date observing strategy, with observations beginning with the Pilot in April 2027. Sundial will be useful for validating spectroscopy for OpenUniverse [2] simulations, training spectral classification tools, calibration, calculating volumetric supernova rates, and validation of HLTDS results once released. Simulations are generated using the supernova simulation software SNANA [3] with the Pippin [4] wrapper, and we also perform SALT3 [5] light curve fitting.

Photometric Selection Cuts

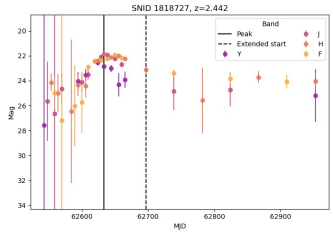
"**Cosmology-grade**" Type Ia supernovae (SNeIa) must have: i) cumulative SNR ≥ 35; ii) at least one observation within 5 days of the peak; iii) at least one observation before the peak; iv) at least 2 observations after the peak; v) one observation at least 20 days after the peak.

Light Curves

Below: two sample light curves from the Core component of HLTDS, one at a high redshift (z>2) and one at a lower redshift (z~0.5).



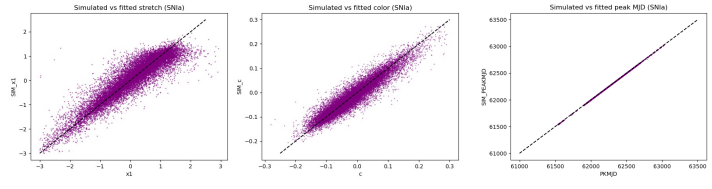
Below: one sample light curve demonstrating the necessity of the Extended component of HLTDS, as this supernova (SN) would have failed selection cuts without it, because it requires an observation over 20 days after peak.



These light curves are well-sampled, and demonstrate that the Core observing strategy produces light curves suitable for precision cosmology analysis across a range of redshifts.

SALT3 Fitting

Recovered SALT3 [5] parameters agree well with simulated values for stretch (left), color (center), and peak MJD (right). After applying our photometric selection cuts and requiring a strong SALT3 fit, **14,808** SNeIa remain.



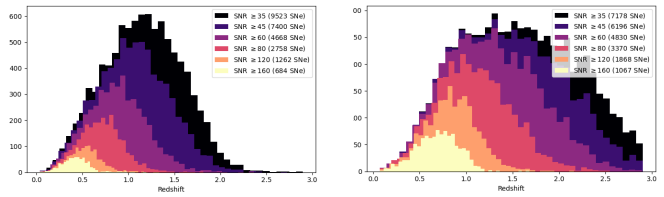
Observing Strategy

- Two tiers: Wide (shorter exposures, F062, F087, F106, F129, and F158) and Deep (longer exposures, F087, F106, F129, F158, and F184)
- **Pilot**: 8 epochs starting April 22, 2027.
- **Core**: 5 day cadence of observations for 2 years, starting June 5, 2028
- **Extended**: 3 epochs between Pilot + Core, 5 epochs after Core.

Results

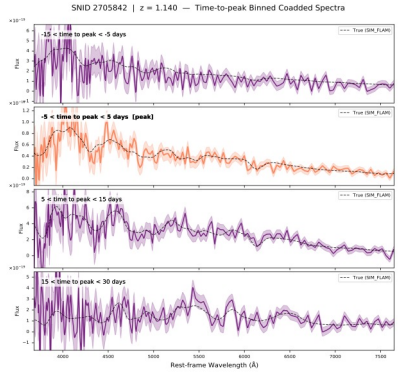
Right: count of all transients in Sundial, by date of first detection. Note, counts are before cosmology grade selection cuts. Below: redshift distributions in both the Wide (left) and Deep (right) observing tiers, grouped by cumulative SNR. **The Deep tier uncovers objects at higher redshifts to better SNR, but the Wide tier uncovers more overall objects.**

Transient	Pilot	Extended	Core	Total
SNIa	2423	4815	23945	31183
CCSN	2787	7442	36250	46479
SNIa-91bg	119	181	1349	1649
SNIax	122	247	1373	1742
AGN	173	1	1	175
ILOT	0	0	13	13
KN	0	0	2	2
PISN	4	6	11	21
SLSN	7	24	107	138
TDE	3	5	29	37



Prism Spectra

An example spectral time series with spectra coadded based on observation date. The model SNIa spectrum is overplotted in black. While the spectra do have noise, the broad features of the model SNIa are well-preserved. Of SNeIa that pass our photometric selection cuts, **5,483** have spectra.



Conclusions

Sundial is the most recent, up-to-date simulated catalog for all transients HLTDS will find, from core-collapse supernovae to Type Ia supernovae and beyond. These simulations predict that HLTDS will discover tens of thousands of cosmology-grade SNeIa, over 5,000 of which also have spectra. Sundial enables analysis of survey performance, transient characterization, and cosmology forecasts.

References

[1] B. M. Rose *et al* 2025 *ApJ* **988** 65
[2] *Monthly Notices of the Royal Astronomical Society*, Volume 544, Issue 4, December 2025, Pages 3799–3823
[3] Richard Kessler *et al* 2009 *PASP* **121** 1028
[4] Hinton *et al* 2020 *Journal of Open Source Software*, 5(47), 2122
[5] W. D. Kenworthy *et al* 2021 *ApJ* **923** 265