Survey Overlap and Joint Pixel Processing of the Time-Domain Surveys

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January 11th 2021

Proposed Roman Time-Domain Survey

- Both Science Investigation Teams (SITs) are jointly writing up our findings, including survey proposals (latest: Rose+ arXiv 2111.03081)

- 5 day cadence over two years (144 epochs)

- Two imaging tiers: Wide + Deep, two (smaller) prism tiers for SN spectroscopy

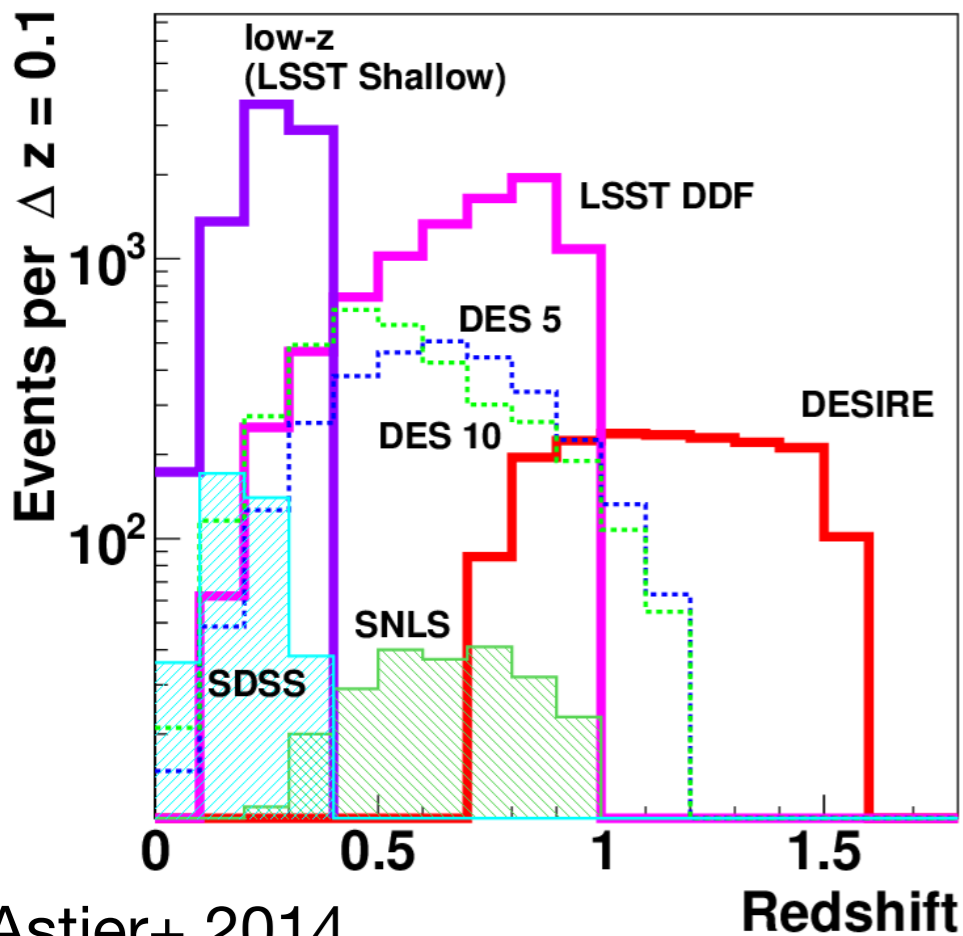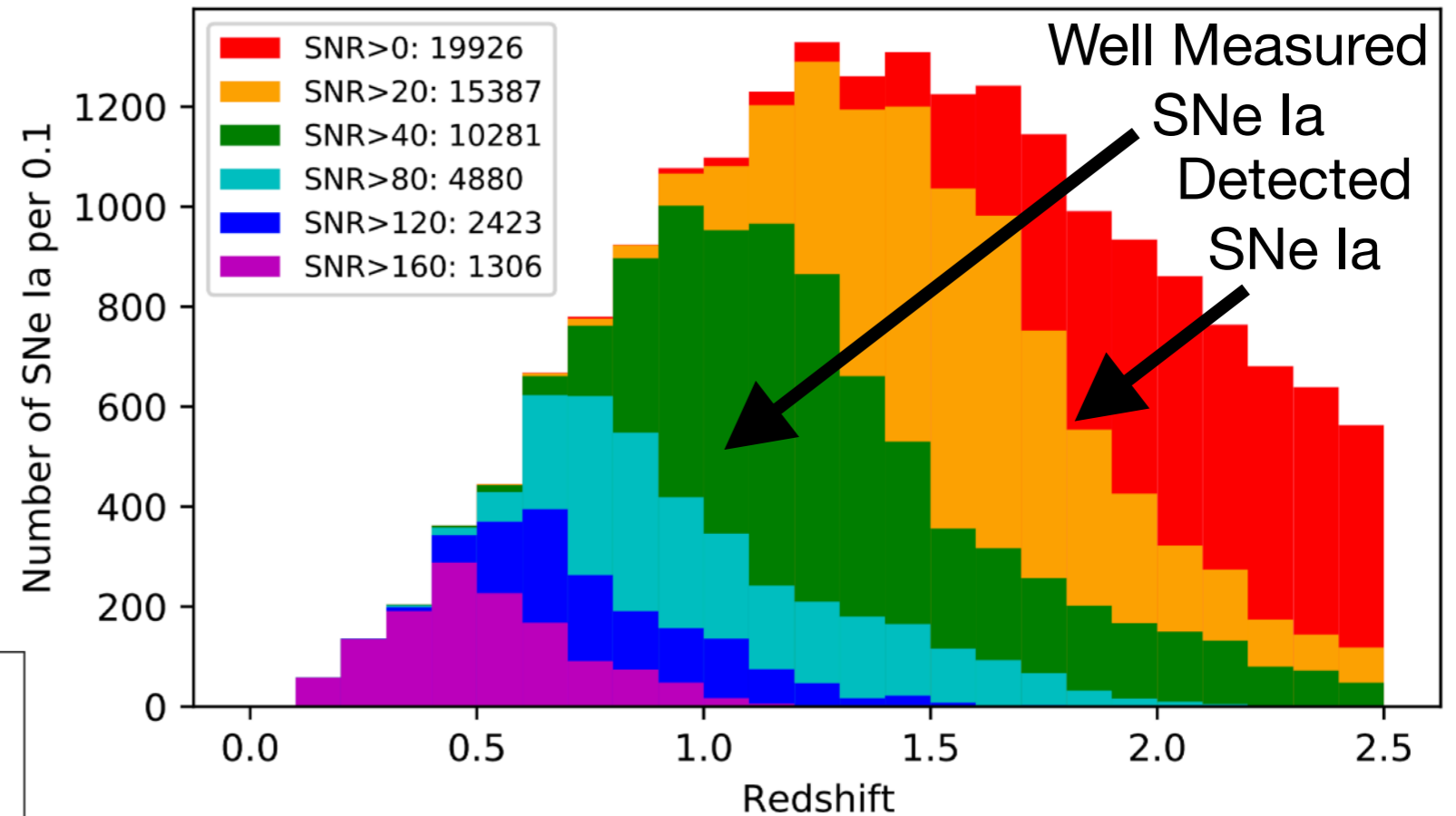|	F062	F087	F106	F129	F158	F184	Prism
Medium Tier 15.96 deg^2	160s 26.4 AB 29.1 AB	100s 25.6 AB 28.3 AB	100s 25.5 AB 28.2 AB	100s 25.4 AB 28.1 AB			900s 3.36 deg^2
Deep Tier 5.32 deg^2			300s 26.7 AB 29.4 AB	300s 26.6 AB 29.3 AB	300s 26.5 AB 29.2 AB	900s 26.7 AB 29.4 AB	3600s 1.12 deg^2

Proposed Roman Time-Domain Survey

- Two concentric imaging tiers: Medium + Deep, two (smaller) prism tiers for SN spectroscopy

- The survey will probably split into northern and southern fields. At least the southern fields should overlap Euclid + Rubin Observatory.
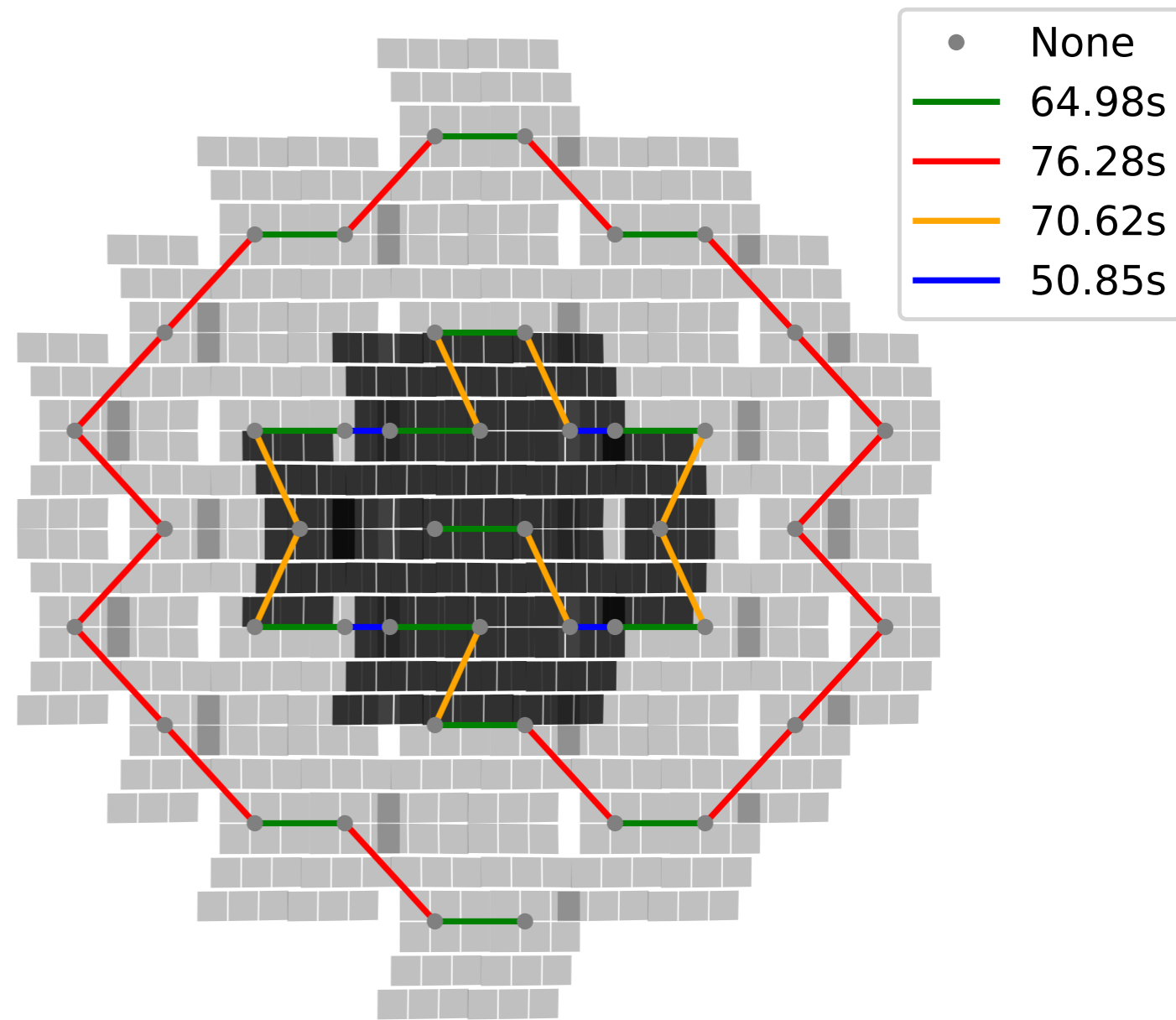
SN Ia Redshift Distributions

Roman: ~10,000 high-quality SN Ia distances extending beyond redshift 2

Legend:
- SNR>0: 19926
- SNR>20: 15387
- SNR>40: 10281
- SNR>80: 4880
- SNR>120: 2423
- SNR>160: 1306

Well Measured SNe Ia

Detected SNe Ia

Astier+ 2014

Rubin Observatory: many more SNe, covering a lower redshift range/wider area that Roman is inefficient for observing, and observer-frame optical data.

Cosmology Forecasts
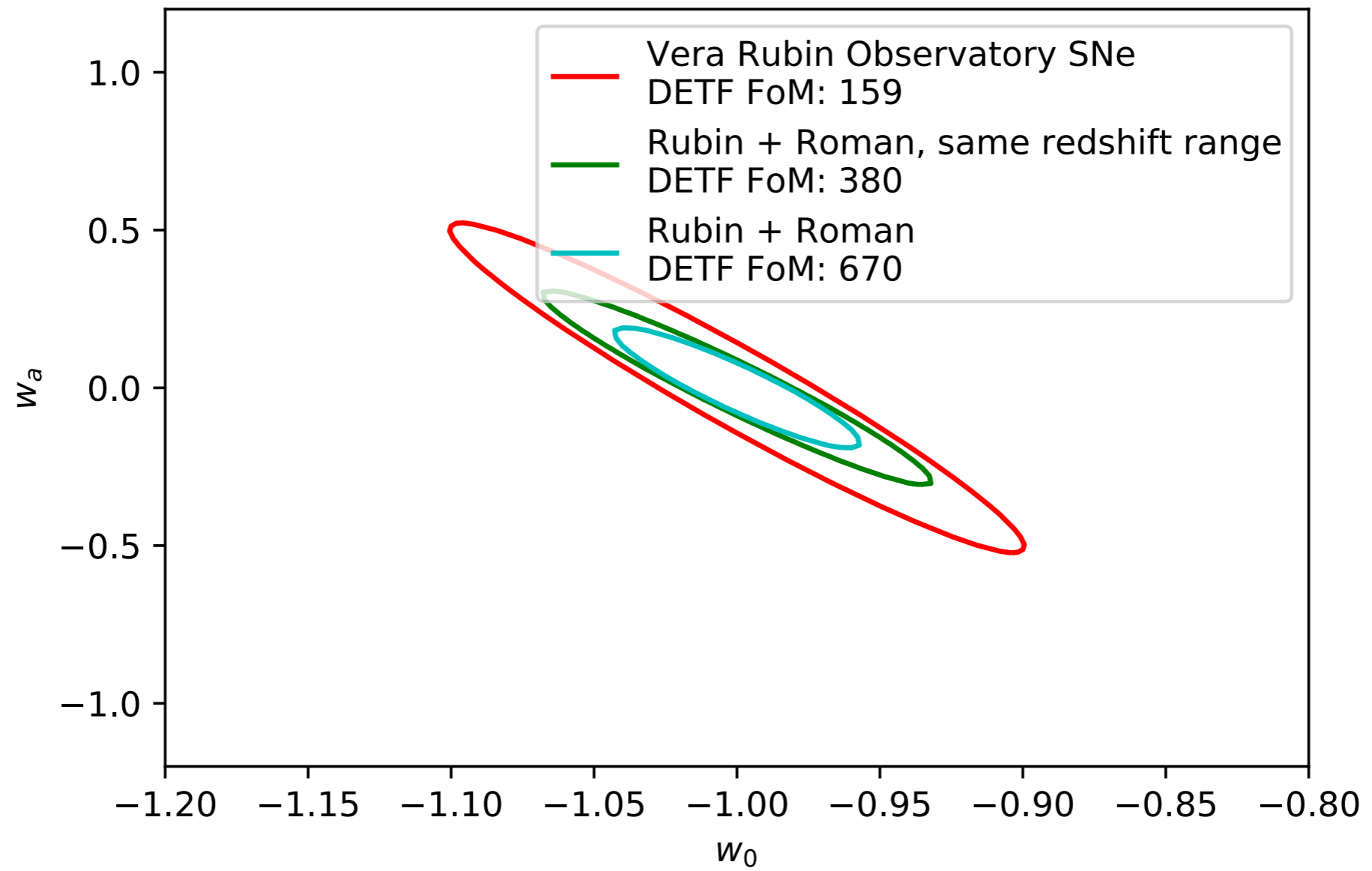
DETF Figure of Merit evaluated with a Fisher-matrix code similar to Astier+ 2011 (see also Hounsell+ 2018), flat universe, CMB S4, and 1000 nearby SNe assumed.

- Significant cosmological gains from overlapping ground-based optical and space-based IR in real time. At least for SNe Ia, no need to be exactly simultaneous.

General Improvements in Combining Surveys

- With ~ 1,000 supernova host galaxies per square degree, multiplexed spectroscopy (e.g., Yuan+ 2015) is a huge help! Euclid grism, Subaru Prime Focus Spectrograph, 4MOST, and the *Roman* grism and prism are all important redshift sources and together can deliver redshifts for most host galaxies and a significant fraction of the SNe (ongoing SN SIT work).

- Optical + NIR + spectroscopy gains in measuring SN distances and training photometric classifiers.

- Possible calibration improvements, e.g., HgCdTe detectors have no charge-transfer inefficiency, CCDs have no count-rate nonlinearity.

- Target of Opportunity observations for a subset of events (e.g., strongly lensed SNe)

Which Fields to Pick?
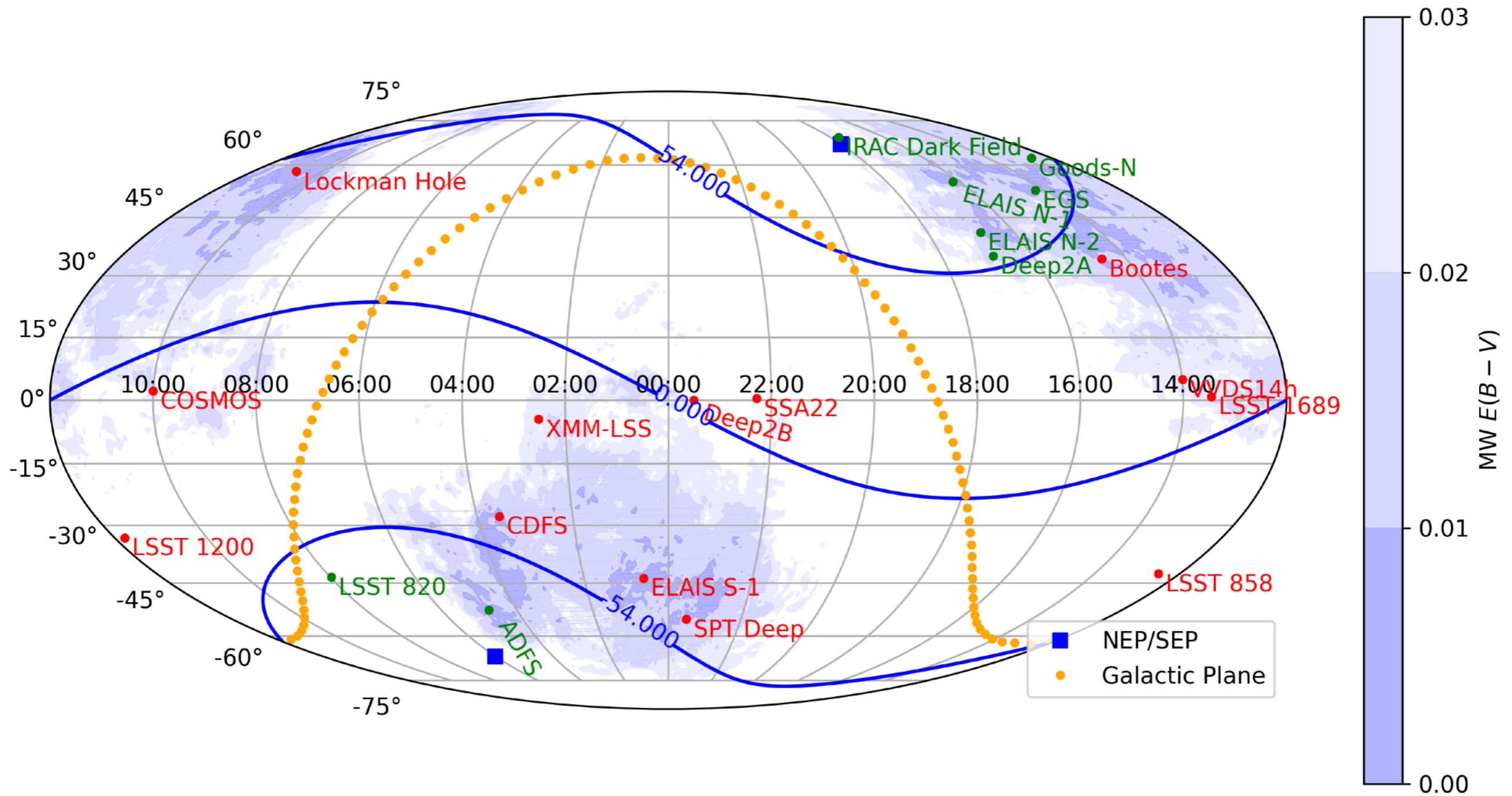
- Should overlap for the southern field.

- It would be great if the Roman continuous viewing zone included CDFS, at least when facing away from the Sun (for northern-hemisphere ground-based overlap)!

Importance of Joint-Pixel Processing: SN Light Curves
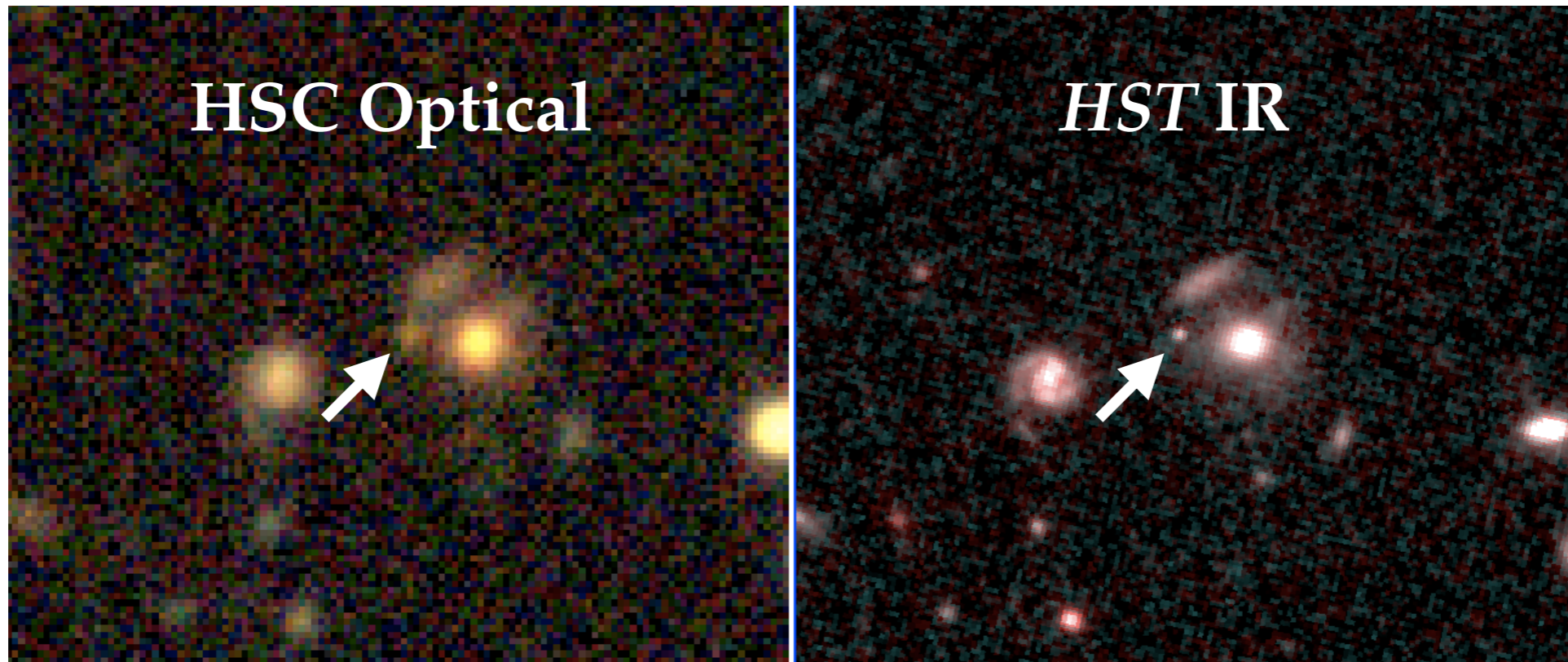
- Above $z\sim1$, there is very little flux in the observer-frame optical, but this rest-frame region may be useful for constraining host-galaxy extinctions, SN metallicities, or SN photometric redshifts (and other transient science).

- Astrometry from higher-resolution Roman data enables precise photometry of this ground-based optical data.

- Desired data products: 1) relative astrometric solutions between each ground or space visit precise to ~0".02 so that the SN fluxes can be placed on the same scale to mmags 2) ability to apply SN centroid priors (taking SED dependence into account) in the scene-modeling photometry of Rubin SNe.

Importance of Joint-Pixel Processing: SN Host Galaxies
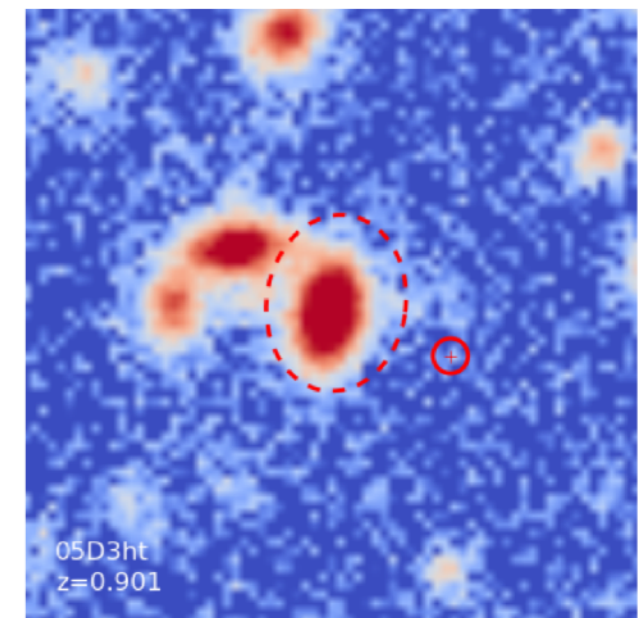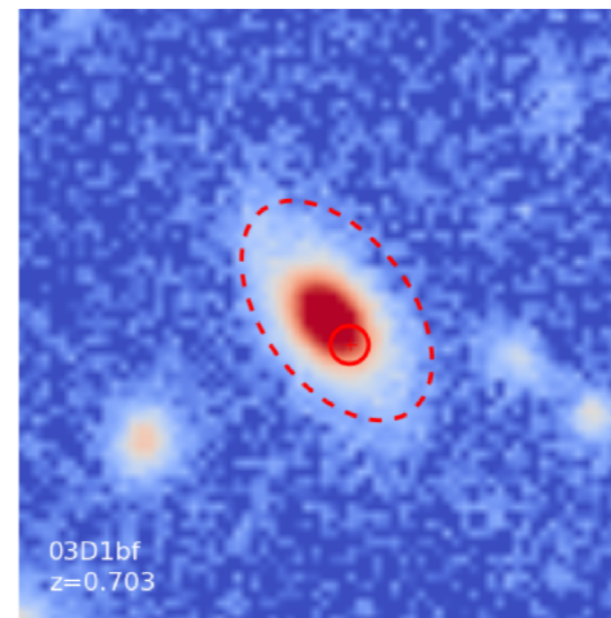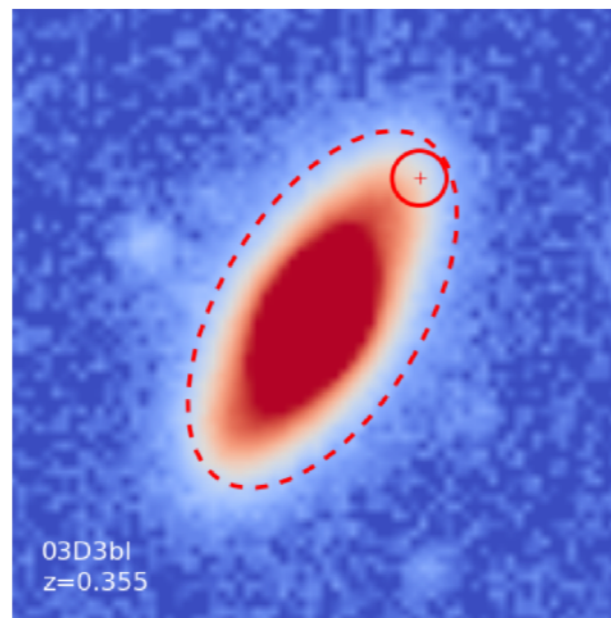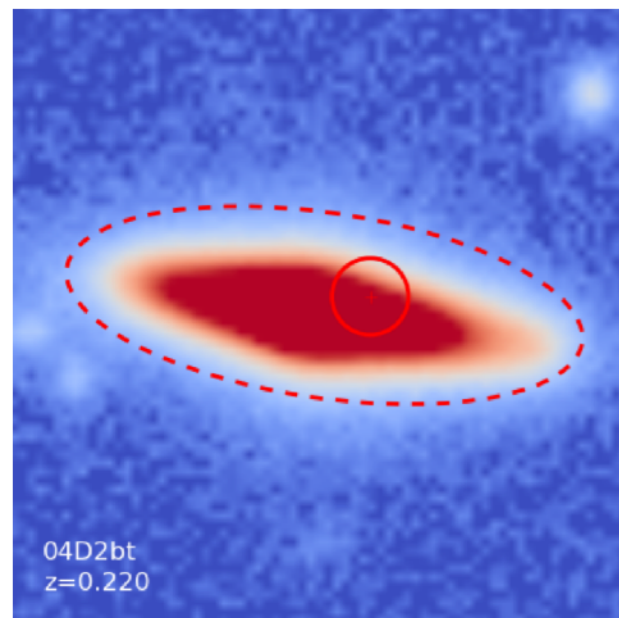
- Local galaxy properties (in the range 1—3 kpc) seem to be more informative for SNe than global properties (e.g., Roman+ 1706.07697), and blue optical bands are important at high redshift.

- Desired data products (ideally both without stacking of ground-based data): 1) a ground+space rest-frame UV—NIR spatially resolved model of host galaxy (this can be a static model) 2) model blends from nearby galaxies for more accurate global properties.

Conclusions

- There are significant cosmological gains in combining surveys, especially ground-based optical imaging and spectroscopy with space-based IR imaging.

- While some of the gains could be realized at the catalog level, really using into the per-epoch pixels will get us broader rest-frame wavelength coverage, higher spatial resolution galaxy information; both are important for constraining systematic uncertainties.

- Luckily, although we need high-temporal resolution, only a small part of the sky around each transient needs such attention.