Roman CCS White Paper

Considerations for Selecting Fields for the Roman High-latitude Time Domain Core Community Survey

Roman Core Community Survey: High Latitude Time Domain Survey

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Abstract:
In this white paper, we review five top considerations for selecting locations of the fields of the Roman High-latitude Time Domain Survey. Based on these considerations, we recommend Akari Deep Field South (ADFS)/Euclid Deep Field South (EDFS) in the Southern Hemisphere has it avoids bright stars, has minimal Milky Way dust, is in Roman Continuous viewing zone, overlaps with multiple past and future surveys, and minimal zodiacal background variation. In the North, Extended Groth Strip (EGS) is good except for its zodiacal variation and Supernova/Acceleration Probe North (SNAP-N) and European Large Area Infrared Space Observatory Survey-North 1 (ELAIS N-1) are good except for their synergistic archival data.

1 Introduction

The choice of field location for the Roman's High Latitude Time Domain Survey is one of the most critical ones for planning the survey, and a decision that well precedes the onset of the survey allows the community to prepare for synergies across the electromagnetic spectrum. Here, we review the key considerations of field selections, and make recommendations based on the constraints. Other white papers will discuss the number and size of the survey fields, here we will focus solely on the trades in field locations. The focus of this particular white paper is led by optimization of a cosmological survey with Type Ia Supernovae (SNe Ia), but we note many other astrophysical studies are impacted by the choice of this field.

We quantify five key selection criteria when choosing the location of the deep fields.

1. Avoid bright stars
2. High Galactic latitude to minimize dust extinction and MW stars
3. High ecliptic latitude to minimize zodiacal light, and to reach the Roman Space Telescope continuous-viewing zone to avoid observational seasons and meet Roman science requirement SN 2.3.4
4. Overlap with past, current, and planned wide-area surveys
5. Seasonal variation of zodiacal background

1.1 Avoiding bright stars

This consideration is often overlooked, but recently necessitated a change in the position of Euclid's Deep Field [1]. The magnitude of a bright-star cutoff must be studied; for Euclid, this was around 6th magnitude in the I band. Due to the higher sensitivity of Roman, it may be advantageous to place a cutoff closer to the 7th magnitude. However, it is unclear how feasible it may be to avoid fainter stars than 6th simply due to the number of them across the sky. A figure from the Euclid study is shown as figure 1.

1.2 Minimizing Milky Way dust extinction

While Milky Way (MW) extinction must be considered for maximizing the depth of the observations, it is also a key systematic for studies of SN Ia cosmology. MW extinction uncertainty is fundamentally different from host-galaxy extinction because, while the latter imprints on the rest frame, MW extinction imprints on the observer frame. This translates into different amounts of correction in the rest frame, i.e., as a function of redshift, and thus can have covariance with the cosmological parameters. At lower values of MW extinction the absolute spatial variance in the extinction is also smaller which helps to reduce effect.

The A_V values of various fields are given in Table 1. We recommend a maximum A_V per field of 0.04 to limit the impact of this systematic uncertainty. For low MW dust, we prefer Supernova/Acceleration Probe North (SNAP-N), European Large Area Infrared Space Observatory Survey-North 1 (ELAIS N-1), Extended Groth Strip (EGS), Akari Deep Field South (ADFS)/Euclid Deep Field South (EDFS)[2], Supernova/Acceleration Probe (SNAP-S), and the JWST North Ecliptic Pole Time Domain Field (JWST NEP TDF).

[1] https://sci.esa.int/web/euclid/-/61403-three-dark-fields-for-euclid-deep-survey
[2] https://www.cosmos.esa.int/web/euclid/euclid-survey

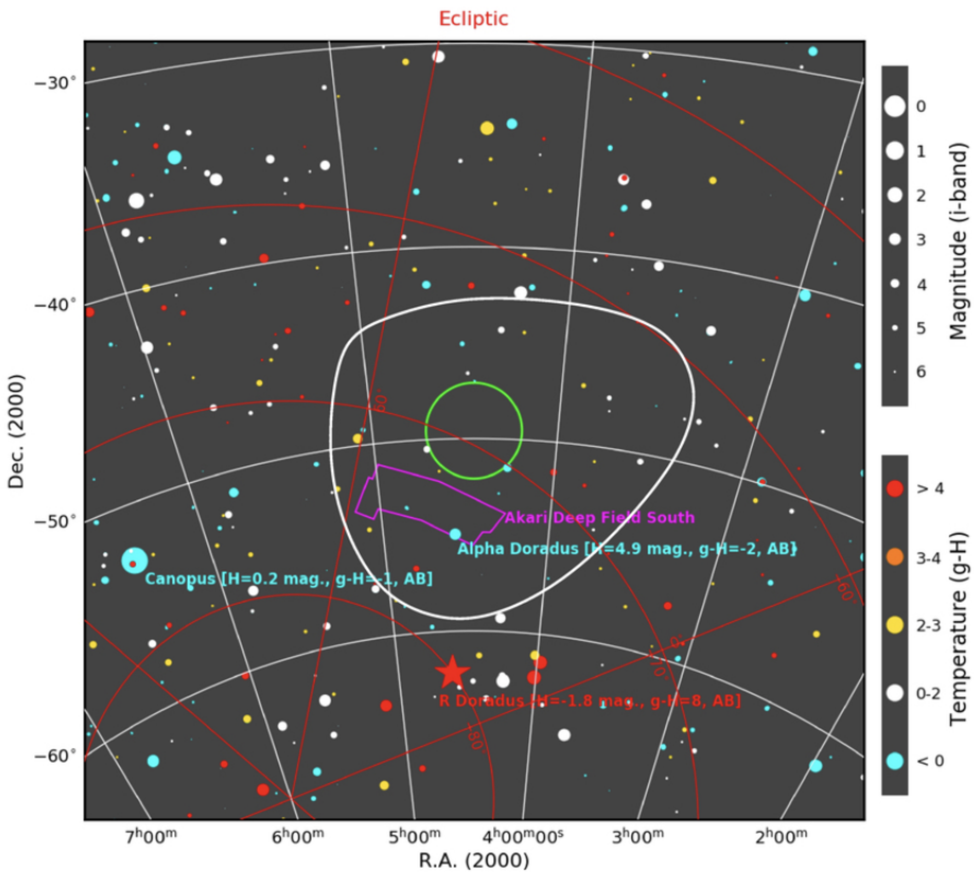

Figure 1: Created for the Euclid Survey while studying deep field locations (credit to Jean-Charles Cuillandre). The positioning of the Euclid Deep Field South (green) and Akari Deep Field South (purple) relative to bright stars in the area.

1.3 Continuous Viewing Zone

Seasonal gaps in coverage are sub-optimal, especially for high redshift transients, a unique capability of Roman. The typical light curve length at rest frame for a SN Ia is ~ 45 days. At a redshift of $z = 1.5$, this would be almost 4 months. Therefore, edge effects on the sample due to seasonality can be quite serious.

The obvious recommendation is for the fields to be in the Continuous Viewing Zone (CVZ, $>54^{\circ}$ above/below the ecliptic). The Declination limits for the CVS vary by RA. The CVZ limit ranges from $\pm 77^{\circ}$ and $\pm 31^{\circ}$. Figure 2 in an all sky plot showing the CVZ, the Galactic plane, Milky Way dust, and candidate fields.

1.4 Synergies with other surveys & instruments

Overlap with other surveys is important for a number of reasons. This includes observations in different parts of the electromagnetic spectrum (e.g., UV/optical), spectroscopic follow-up of transients and acquisition of host-galaxy redshifts. For different fields, there are a lot of different avenues for synergies with past and current surveys. For a detailed list of synergies specifically between the largest surveys of the next decade—Roman, Rubin Observatory's LSST, and Euclid—see Rose et al. 2021.

There are many fields with rich archival data as well as future Rubin, Euclid and DESI data, such

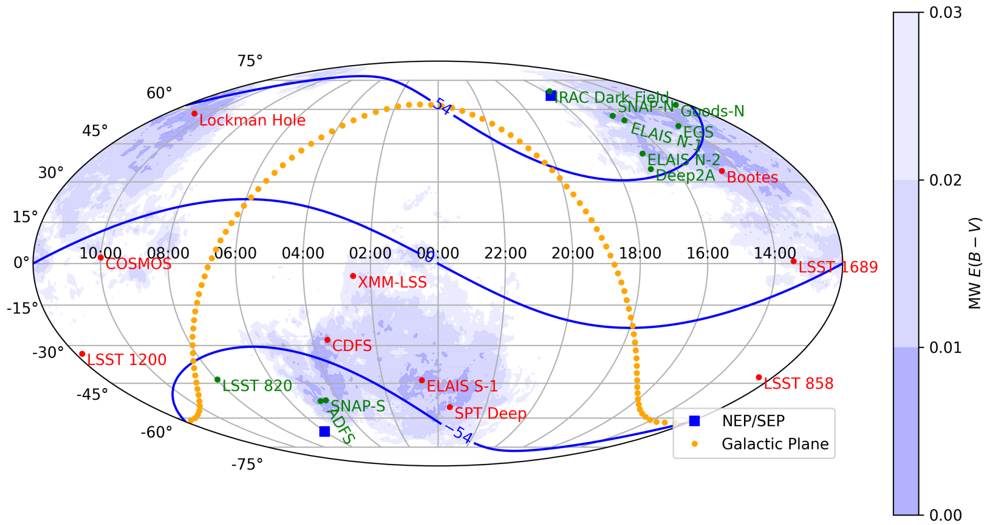

Figure 2: An all-sky plot of possible Roman time-domain fields. Green labels are in the current Roman CVZ ($\pm 54^{\circ}$ off the ecliptic) and red labels are outside the CVZ. Low Milky Way dust extinction is shown as blue shading. Overall, the top field choices include Extended Groth Strip (EGS), and Akari Deep Field South/Euclid Deep Field South (ADFS). We note that if the field of regard is improved by $\sim$8°, some particularly attractive fields such as the Chandra Deep Field-South (CDFS) would become accessible.

as Chandra Deep Field-South (CDFS), that are not in the CVZ. CDFS is the closest, just 8° outside. Though ADFS/EDFS will also be observed with Rubin and Euclid and also has archival data.

Roman has in-kind time on Subaru PFS, the largest multi object spectrograph of the 2030s. Since Subaru is in the Hawaii, it can not observe Roman's Southern CVZ. With extremely high airmass, Subaru can observe down to a declination of $\sim -30^{\circ}$, the declination of CDFS. DESI can also obtain redshifts down to $m_{AB} \sim 25$ in the northern sky.

Another field to consider with rich pre-existing archival data is the JWST NEP TDF (Jansen & Windhorst, 2018). Overlap of the HLTDS deep tier with the JWST NEP TDF could be beneficial given the extant data from X-ray (Chandra; $\lesssim$1 keV) to radio (LOFAR; 150 MHz) along with significant investment of time from HST, JWST, and many ground-based observatories. This field of roughly 14' diameter was selected to be free of foreground stars brighter than $\sim$15.5 mag, low MW extinction ($A_V \sim 0.03$), and in the northern CVZ.

Of the northern fields with minimal Milky Way dust—SNAP-N, ELAIS N-1, JWST NEP TDF, and EGS—JWST NEP TDF and EGS have the broadest archival data set.

The Roman High-latitude Time Domain survey should also consider synergies with the Roman High-latitude Wide Area Survey. The Wide Area Survey requires a deep spectroscopic field. If this field overlapped with the Time Domain field, then the same galaxy redshifts can be used for multiple core Roman science cases.

1.5 Seasonal variation of zodiacal background

High ecliptic latitude reduces zodiacal background as well was keeps a field in the Roman CVZ. When looking at the zodiacal background and variability throughout the year, using an ecliptic latitude of $<$15° from the ecliptic poles is a good proxy for minimizing seasonal variation. When performing a full calculation (by using `ZodiPy`, San et al. 2022), EGS has about twice the seasonal variation compared

Table 1: Possible CVZ fields for the
Roman High-latitude Time Domain Survey

Name	RA (deg)	Dec (deg)	A_V (mag)
North Hemisphere			
SNAP-N	246.25	$+57.0$	0.020
ELAIS N-1	242.75	$+55.0$	0.021
EGS	214.25	$+52.5$	0.022
JWST NEP TDF	260.70	$+65.8$	0.030
Goods-N	189.19	$+62.2$	0.032
ELAIS N-2	251.70	$+41.0$	0.040
Deep2A	253.00	$+34.9$	0.048
IRAC Dark Field	265.00	$+69.0$	0.120
Southern Hemisphere			
ADFS/EDFS	71.00	-52.3	0.021
SNAP-S	67.50	-52.0	0.022
LSST 820	119.56	-43.4	0.940

A_V values are for Schlafly & Finkbeiner (2011) via
https://irsa.ipac.caltech.edu/applications/DUST/.

to SNAP-N, ELAIS N-1, and ADFS/EDFS.

2 Conclusion

After going through five main selection criteria, we present possible fields, section 1.2. Of these possible fields, ADFS/EDFS in the Southern Hemisphere has minimal Milky Way dust, is in the CVZ, overlaps with multiple past and future surveys, and minimal zodiacal variation. In the North, EGS is good except for its zodiacal variation and SNAP-N and ELAIS N-1 are good except for their synergistic archival data.

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