WALLABY Memo 27

Census of current and upcoming multi-wavelength surveys relevant for the science exploitation of WALLABY data

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Disclaimer

This is not a static document, but a continuously evolving one. It is not intendend to be a complete census of all the extragalactic surveys available/planned, but to focus on the most relevant ones for WALLABY. No detailed investigation of small regions of sky (e.g., Virgo) is presented here.

Available now - mid 2022

Imaging Surveys

Optical (u,g,r,i,z) imaging at a depth at least equal to that of the SDSS survey (point source S/N=5 ∼22.2 mag) is available for a very large fraction of the extragalactic sky observable by ASKAP. Figure 1 provides information on sky coverage and sensitivity for the DECam Local Volume Exploration Survey (DELVE) survey which, at the moment, offers one of the best compromises in terms of coverage and depth. The DESI Legacy Imaging Surveys, shown in Fig. 2, is at least 1 mag deeper than DELVE but, at the moment, has a smaller footprint. Please note the lack of coverage within +/-10 degrees from the Galactic Plane. Until LSST comes on-line, below Declination −30 degrees there will not be any option. Above Declination −30 Pann-STARRS will provide SDSS-like depth. In the near infrared, the VISTA Hemisphere Survey (VHS) reaches a sensitivity of 21.1 in J band, significantly better than 2MASS. While this survey is used for the target selection of 4HS (see below), for searches of optical counterparts and general analysis of WALLABY sources, the SWG5 chairs believe that DELVE and DESI provide a richer dataset to play with.

The most relevant imaging survey providing significantly deeper imaging data for reasonably large areas of sky is the HSC-SSP survey. As shown in Fig. 2, this covers parts of the equatorial regions and reach a point source sensitivity of 26.1 in r-band. This will be, for the next 2-3 years, the best imaging survey to put significant constraints on the existence of almost dark galaxies or tidal streams associated with HI detections.

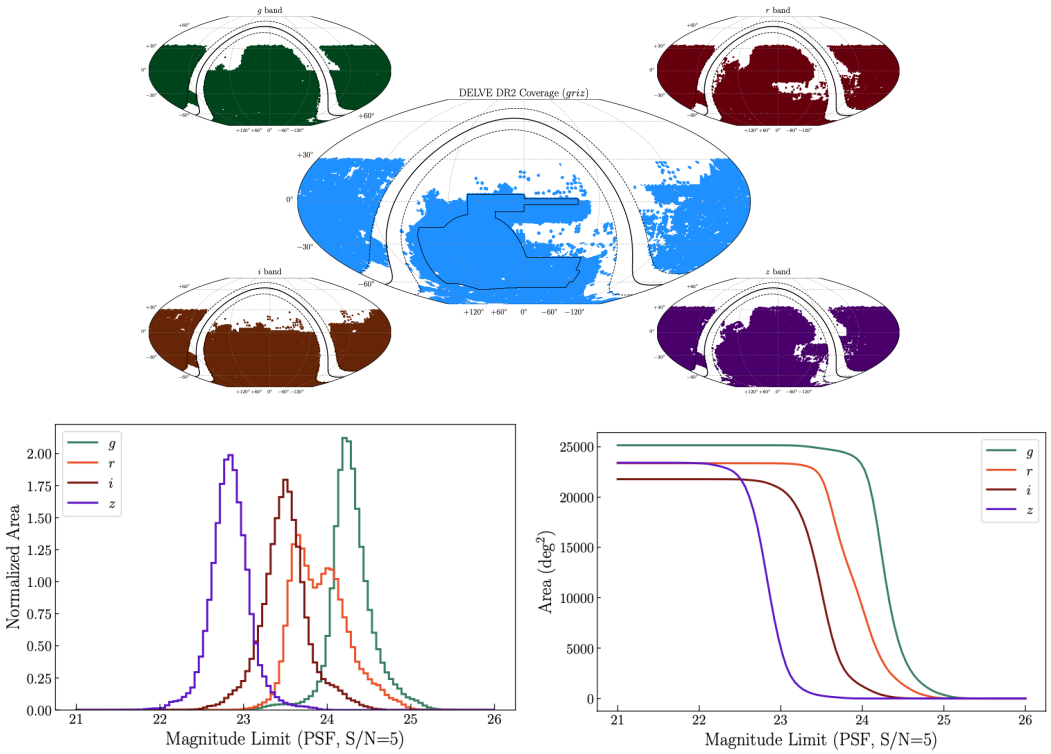

Figure 1: *Top*: sky footprint for the DELVE DR2 imaging survey. *Bottom*: Distribution of the point-source magnitude limit (left) and comulative area distribution (right).

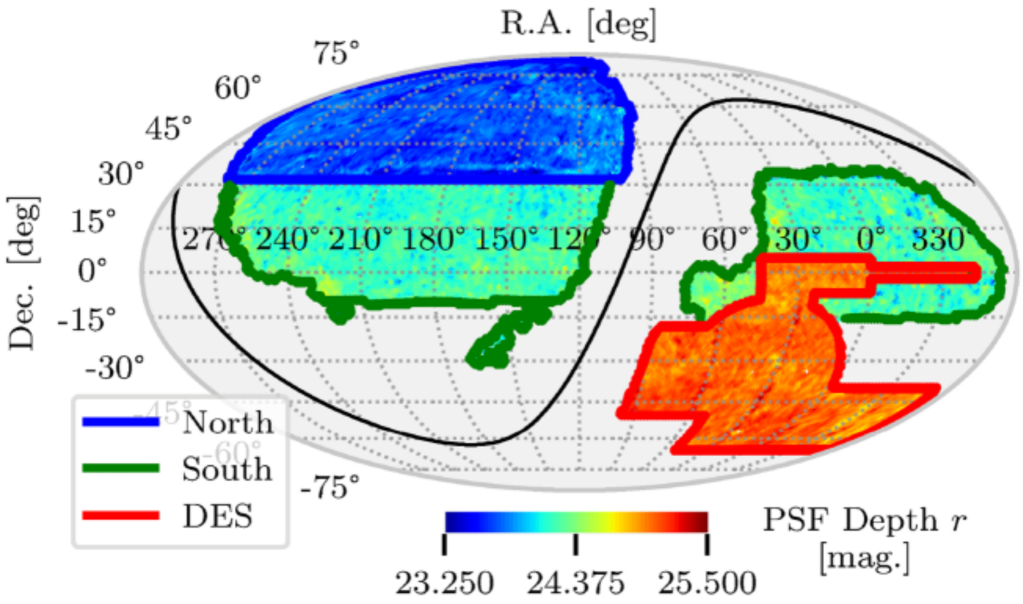

Figure 2: Survey footprint and depth for the DESI Legacy Imaging Surveys

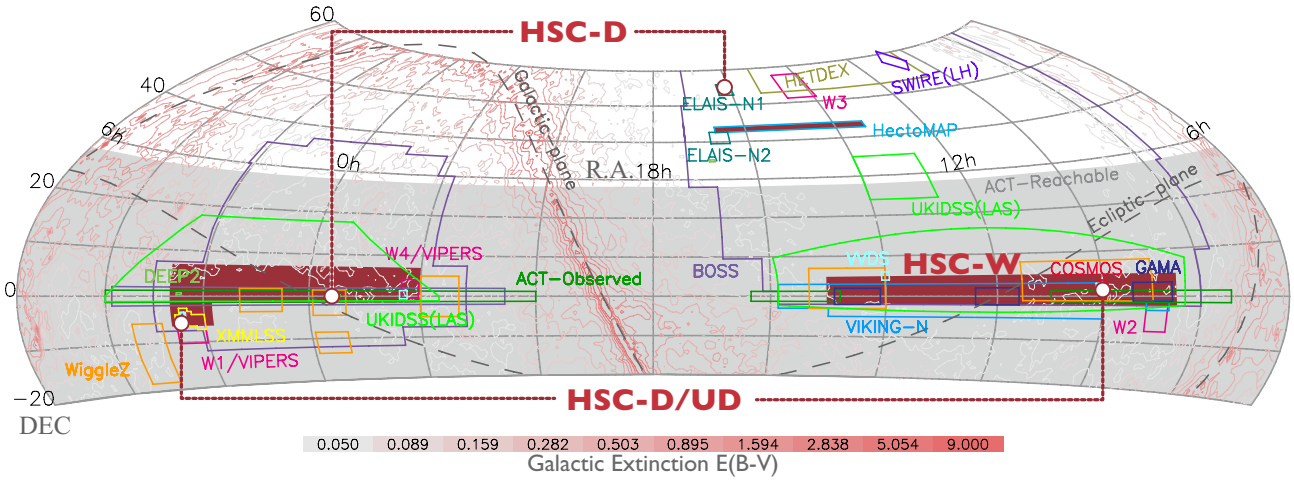

Figure 3: Sky footprint for the HSC-SSP survey.

Lastly, outside the optical regime, the WISE All-sky and GALEX surveys provide very useful mid-infrared and UV photometry. WISE is all-sky, so not significant constraints here. GALEX coverage is patchier, but the sky coverage is semi-random and it should not be used to prefer one region compared to another. As discussed below in the "Value-added products" section, it is the availability of UV+MIR SFRs that may impact more directly on the WALLABY survey footprint.

Redshift Surveys

Figure 4 presents a summary of the main large-area spectroscopic surveys currently available. For the northern hemisphere, the best one currently available is still the SDSS redshift survey (yellow), targeting galaxies with r <17.77 mag and having a median redshift z ∼0.07. In the southern hemisphere, the 6dF redshfit survey (green) is nearly complete for galaxies with $K < 12.65$ and has a median redshift z ∼0.05. Lastly, the GAMA survey (blue) provides significantly higher completeness (either r <19.8 or i <19.2) and a median redshift z ∼0.2. See the section below on "Value-added products" for a discussion on how this impacts the availability of environmental metrics.

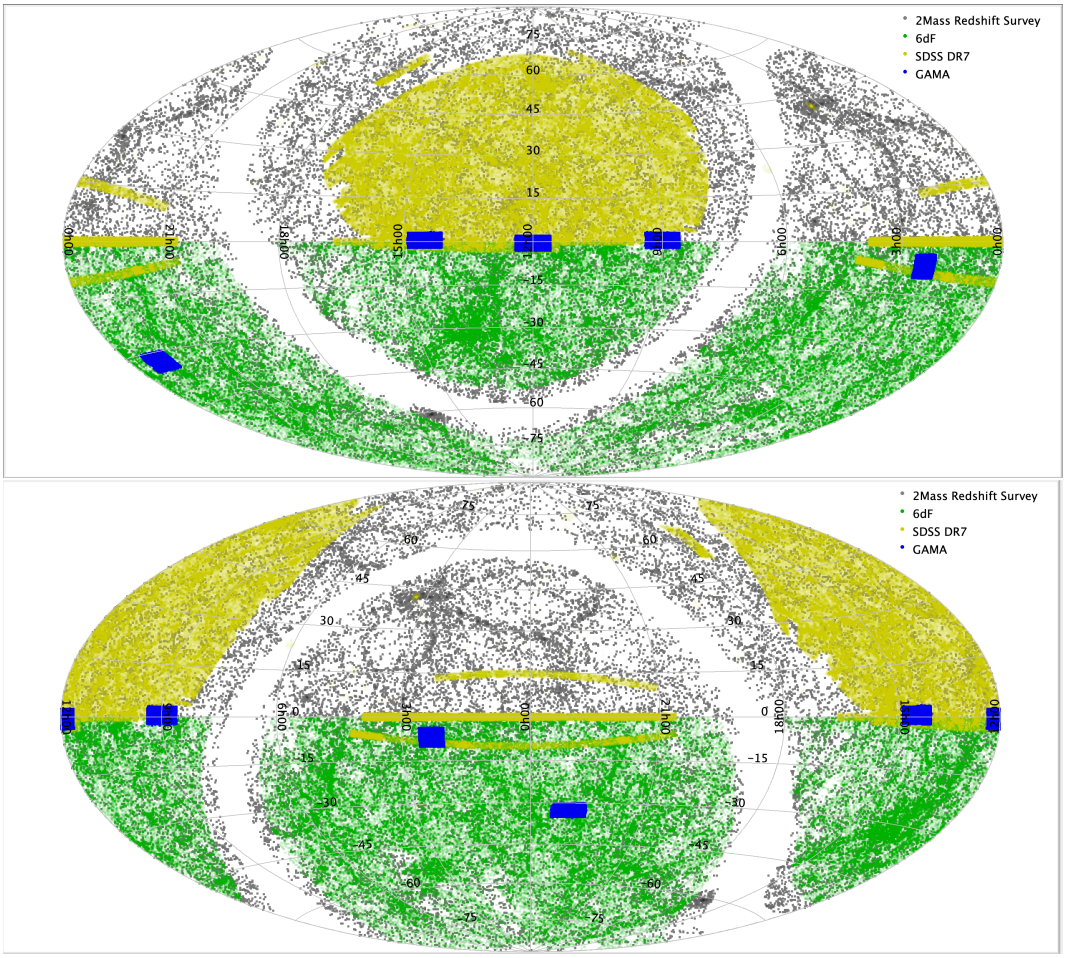

Figure 4: The distribution of SDSS (yellow), 6dF (green), 2MASS (grey) and GAMA (blue) redshift surveys. The top and bottom plots simply show two different projections, with the top centred at 12h and the bottom centred at 0hrs in right ascension.

Integral field Spectroscopic (IFS) surveys

The only two large IFS surveys are SAMI and MaNGA which, combined, include roughly 13000 galaxies at $z < 0.12$. Figure 5 shows the sky distribution for the galaxies targeted by the two surveys, SAMI in magenta and MaNGA in teal. It is clear that any meaningful overlap would require coverage of the equatorial regions.

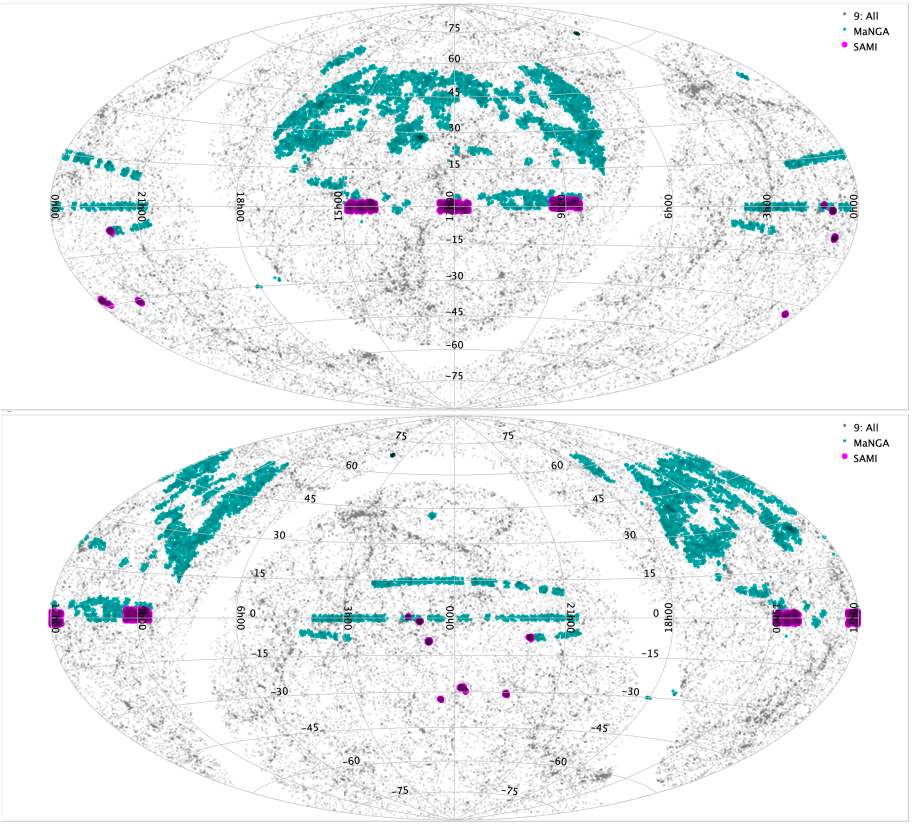

Figure 5: The distribution of SAMI (magenta), MaNGA (teal) galaxies. Galaxies in the 2MASS redshift survey are shown in (grey) for reference. The top and bottom plots simply show two different projections, with the top centred at 12h and the bottom centred at 0hrs in right ascension

Value-added products

Most of the best quality value-added data: stellar masses, star formation rates, sizes, structural properties, environmental metrics, are readily available only for the footprint of the SDSS spectroscopic survey. Fig. 6 gives an idea of the footprint by showing the galaxies included in the GALEX SDSS WISE catalog, which is one of the best available catalog when it comes to stellar mass and SFR estimates. This, of course, includes the GAMA regions (see also Fig. 4) for which even better quality info are available (in particular environmental information, as the survey has a higher spectroscopic completeness).

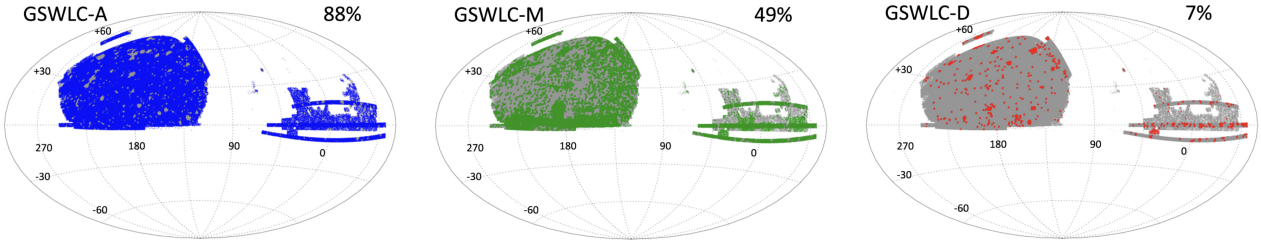

Figure 6: Sky distribution of galaxies included in the GALEX SDSS WISE catalog. The different colours indicate different depth available for the GALEX data, going from shallow (AIS quality data) in green, to deep in red.

Below the Equator, there is very limited availability of value-added products. Even when it comes to structural parameters and sizes, the 2MASS survey is still the only/best one available. Similarly, when it comes

to environmental metrics, the only available option is the Tully et al. 2015 Group catalog, which is limited to very local galaxies ($z < 0.03$). WISE can provide good quality stellar masses, and WISE+GALEX (when available) can definitely allow good quality SFRs estimates. However, no published catalog is available, and to obtain SFRs it will require (in some cases) to re-do the photometry for both WISE and UV data (as indeed done for the WALLABY pilor and pre-pilot papers).

On-going

Spectroscopy

The only notable survey currently on-going is the Dark Energy Survey Instrument (DESI) spectroscopic survey, which is obtaining redshift at a depth similar or better than GAMA ($r < 19.5$ for the bright catalog, with a faint-filler catalog reaching r=20) for most of the northern sky and reaching, for some regions, a Declination of ∼-15 degrees (see Fig. 7). The first data release should arrive by the end of the year, with the survey completed by 2026. This means that, to get spectroscopic coverage better than 6dF for lage areas of sky below -15 degrees in Declination and outside the GAMA regions (e.g., G23), we will need to wait for 4MOST surveys (see below).

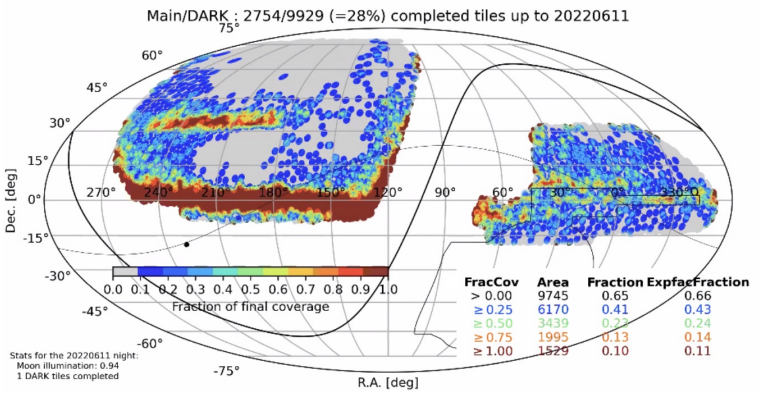

Figure 7: Current progress status for the DESI spectroscopic survey. Credit: Cullan Howlett.

Planned

Imaging: VRO/LSST imaging survey. Expected to deliver the best optical imaging survey (6 bands: u, g,r,i,z,y) of the Southern sky. Expected footprint and survey depth in r-band is shown in Fig. 8. The project is expected to start in 2024, so it is reasonable to assume that data will not become available before 2025.

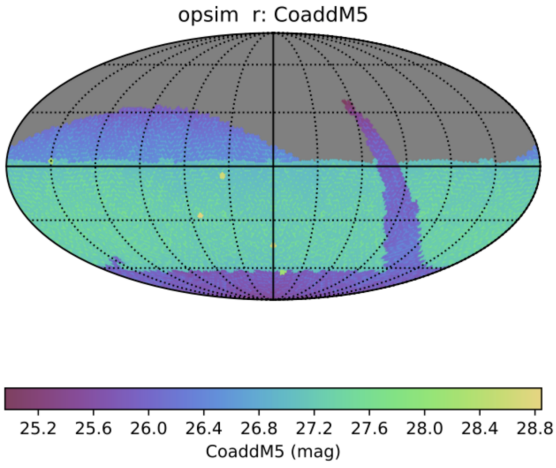

Figure 8: Expected sky coverage and r-band depth for the VRO/LSST imaging survey.

Spectroscopy: 4MOST surveys 4HS and WAVES will deliver excellent spectroscopic redshift for entire southern sky. Namely, 4HS will target all galaxies in the southern hemisphere with J magnitude <18. WAVES-wide will target galaxies with magnitude z <21 mag and spectroscopic redshift lower than 0.2 in two regions, each one 750 deg^2 wide, one in the Equatorial region overlapping the G12 and G15 GAMA fields, and the other one at −30 Declination overlapping with the G23 field (see Fig. 9). More details can be found here `https://tinyurl.com/bdjx3ysm`. As for LSST, 4MOST surveys are expected to start in 2024, so most of these data won't be available before 2025, at the earliest.

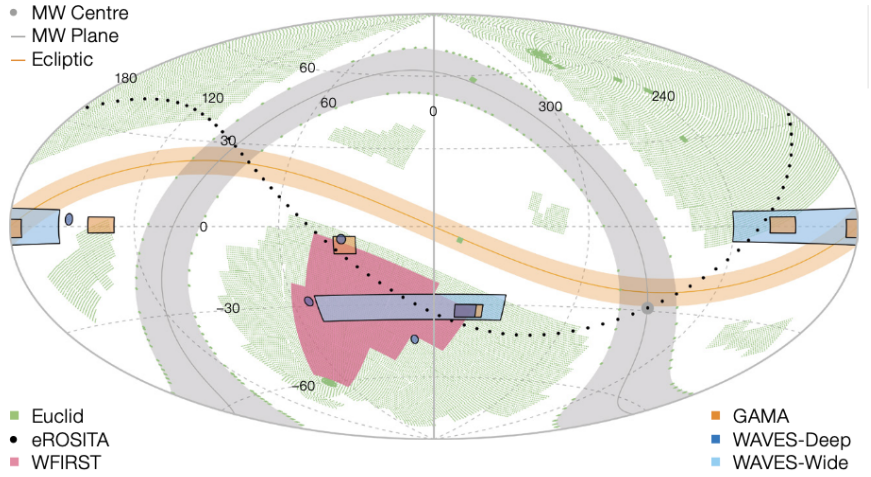

Figure 9: Expected footprint for the WAVES-wide survey (light-blue).

IFS surveys: The only relevant IFS survey currently planned is the HECTOR survey. The survey will start by Jan 2023 and will target between 4000 and 15000 galaxies (depending on the lifetime of the AAT). The targets are extracted from the WAVES regions (both north and south), plus 10-ish clusters across the southern sky.