WALLABY MEMO 26: Post-RASSP tiling schemes

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BACKGROUND

The recent Review of ASKAP Survey Science Projects (RASSP) recommended an allocation of 8,832 hrs to WALLABY over the period 2023-2028. This is less than the 12,480 hrs requested for covering the entire southern hemisphere (which is again less than original goal of covering the entire sky south of Declination $-30°$; Koribalski et al. 2020). The de-scope option, which was to cover the sky south of $-14°$ was accepted as a possible fall-back by the RASSP committee, with the final decision left to the team. In addition to confirming, or otherwise, which parts of the sky should be observed, there is the question of the order in which the observations should be scheduled to facilitate rapid science output by team members.

FACTORS

Factors which should be taken into account in choice of tiling strategy include:

- Scientific usefulness to team members
- Legacy value
- Commensality with other SSPs
- Overlap with other multi-wavelength large-area surveys
- Contiguity

It is also likely that, after the 5-yr initial observing period, and possibly after a telescope upgrade, that legacy surveys such as WALLABY could continue to be allocated observing time due to their scientific productivity and usefulness in providing targets for the future SKA telescope.

CONSTRAINTS

The MRO is at latitude 26°S, so observations at northerly declinations are possible (e.g. RACS goes up to Dec $+45°$). However, for WALLABY which requires a total integration time of 16 hrs per tile, it becomes difficult to go further north than Dec $+30°$ due to scheduling and processing constraints.

In considering tiling strategies, it is important to keep in mind other scheduling and processing constraints. For example, it will not initially be possible to obtain survey-quality data near strong continuum sources. Comparison of nominal tile centres with the RACS-low catalogue suggests that, below the equator, almost exactly half the tiles have a 2 Jy, or stronger, source within 2.7° of the nominal tile centre.

Equatorial uv-coverage is also not as good as most other parts of the sky. Pilot survey experience shows that it is sufficient for spectral-line imaging, but removing strong continuum sources is harder, so a higher bright-source threshold may be required.

PLANNING

The WALLABY team consultation process leading to the 2021 RASSP proposal was greatly in favour of a contiguous southern hemisphere survey in the case that the requested observing time was fully allocated. However, for the de-scope option, there was more discussion, with arguments variously being made for equatorial coverage for better overlap with

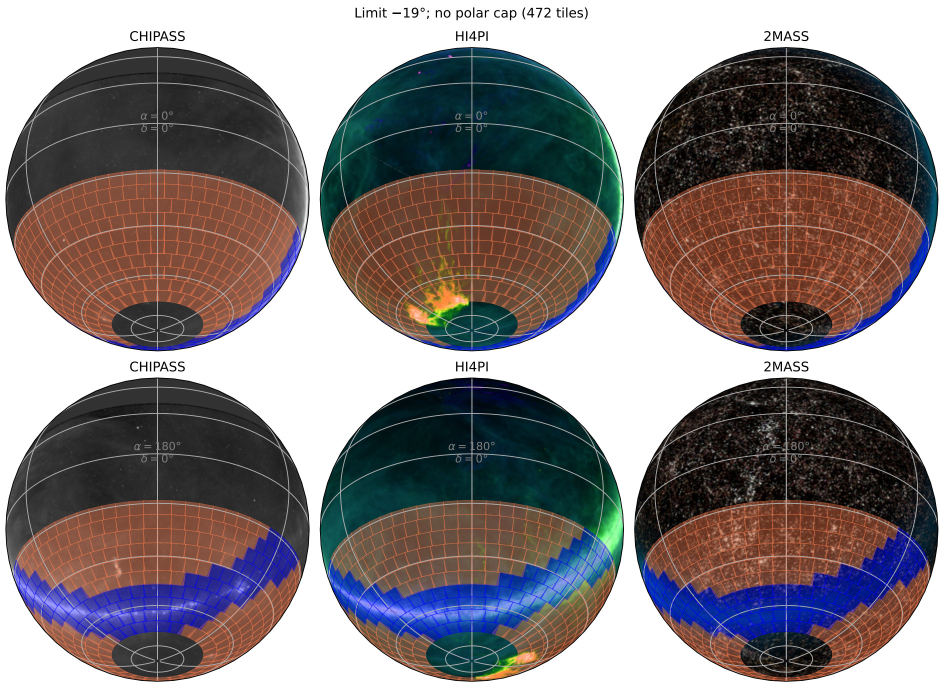

Figure 1. Core WALLABY survey option A overlaid on images from CHIPASS 1.4 GHz continuum (left-hand column), HI4PI Galactic HI (middle column), and the 2MASS extended galaxy survey (right hand column). Tiles near the Galactic plane are shaded in blue (GASKAP synergy). The top and bottom rows are orthographic projections with meridians at RA 0° and 180°, respectively.

current and future optical surveys, for regions of special scientific significance (e.g. local large-scale structures), and for complementarity with FAST.

CORE SURVEY

Recent discussions involving the management and executive teams have favoured the establishment of a 'core' survey that occupies the majority (around 80%, or 11,000 deg^2) of the allocated observing time and that covers a contiguous region of sky. Two example core survey options are:

- Option A ($-72.3° < \delta < -18.9°$; 472 tiles): aligned with the RASSP fallback option, but ignores the southern cap, which has a different tiling scheme and less-efficient overlapping.
- Option B ($-40.3° < \delta < -2.7°$; 502 tiles): better synergy with multiwavelength surveys including EMU.

The above two example core surveys are illustrated in Figures 1 and 2 superimposed on continuum, HI and galaxy overlays.

ADDITIONAL REGIONS

The availability of up to 20% of survey tiles on top of a core survey gives the team flexibility to target 'special' regions missed in the core survey. For example, these could include: the Magellanic Stream; nearby extended groups such as Sculptor; the Virgo cluster; the plane of the Local Supercluster; extensions of the Hydra-Centaurus supercluster; and synergy fields. Of course, the extra tiles can also just be used to extend the contiguous coverage. For option A above, there are 80 additional tile placements available (each tile is approximately $5.4° \times 5.4°$); for option B, there are 50. A non-exhaustive list of specific examples of tile placement is given below, with associated tile plots shown in the Appendix.

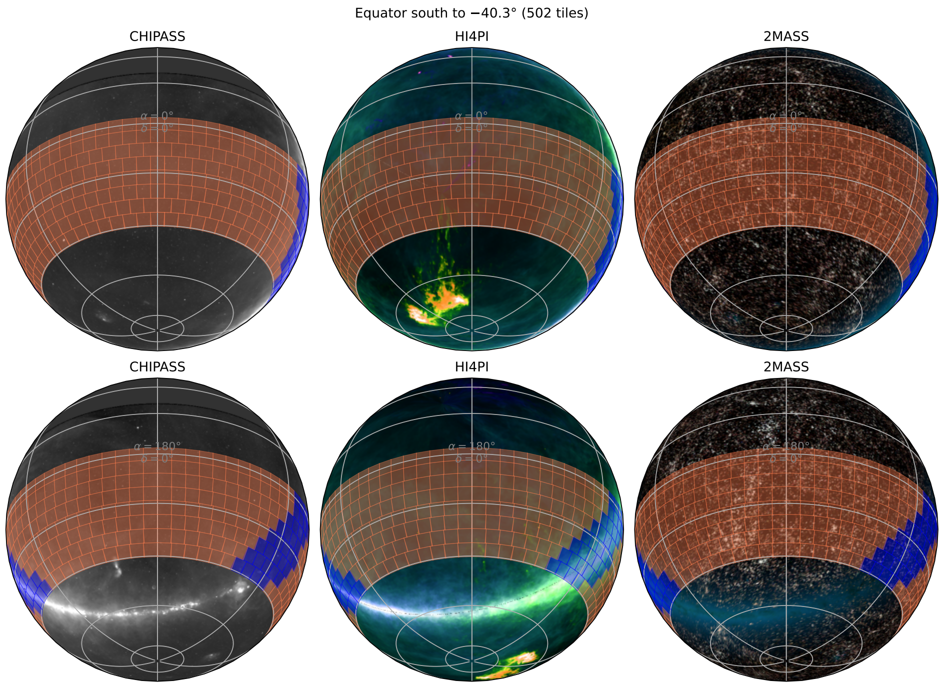

Figure 2. Core WALLABY survey option B. Overlays and projections as for Figure 1.

1. Polar cap (43 tiles): the south polar cap is covered by a different tiling scheme. It covers the southern portion of the Magellanic Clouds and the source of the Leading Arm.

2. Virgo cluster (30 tiles): the Virgo cluster is the nearest cluster to us and is an excellent example of a dynamically young cluster with substructure and galaxies infalling from connected filaments.

3. Extended declination strips: extended RA strips are possible to the north of core Option A ($-18.9° < \delta < -13.5°$; 65 tiles) or to the south of core Option B ($-45.7° < \delta < -40.3°$; 51 tiles). The former ensures connectivity with the FAST CRAFTS HI survey (Zhang et al. 2021) and increases synergies with northern surveys. The latter extends further into the dynamically interesting Hydra-Centaurus supercluster. There are not enough 'spare' tiles to extend core Option B to the north ($2.7° < \delta < 8.1°$; 67 tiles) as this requires 17 more tiles than available. However, part coverage would further increase overlap with SDSS, DESI etc, and include the Virgo cluster southern extension.

4. Subaru: the Hyper Suprime-Cam SSP *grizy* Survey (62 tiles): this includes a wide component (1310 deg^2) covering equatorial fields intended to explore the nature of dark matter and dark energy via weak lensing observables (Aihara et al. 2018). It overlaps with other wide-deep surveys such as GAMA and Stripe 82.

5. Random sampling: for a given number of fields, some cosmology programs (e.g. bulk flow measurement) prefer the widest sky-sampling possible. Other projects prefer to interpolate across small-scale structure (e.g. Hubble constant), or prefer a wide spatial range of galaxy separations (e.g. correlation functions, power spectra). The example sampling shown covers the Dec range from $-19°$ to $-30°$.

6. Centaurus A group (48 tiles): alongside the Sculptor group, which lies mostly within both core options, the Cen A group is a nearby rich group of galaxies associated with the Cen A radio galaxy.

7. Great Attractor (60 tiles): centred near the Galactic Plane, the GA is close to the local dipole of galaxy motion and is a region rich with galaxies in the redshift range 0.01-0.02. The more distant Shapley concentration lies slightly north and largely within both of the core options.

8. Pavo-Indus (59 tiles): a southern extension of the Local Supercluster, but no longer following the Supergalactic equator.

9. Vela supercluster (15 tiles): slightly more distant ($z \sim 0.06$) than Shapley, it is another largely obscured galaxy concentration which may be dynamically important.

ACTION

The WALLABY Science Working Groups and WALLABY team are invited to submit their preferences for core survey options (A, B or other choices) and favoured additional regions (options 1-9, or other suggestions). Suggestions should be accompanied by a scientific motivation and will receive maximum attention if received before June 9.

REFERENCES

Aihara, H., Arimoto, N., Armstrong, R., et al. 2018, PASJ, 70, S4, doi: 10.1093/pasj/psx066

Koribalski, B. S., Staveley-Smith, L., Westmeier, T., et al. 2020, Ap&SS, 365, 118, doi: 10.1007/s10509-020-03831-4

Zhang, K., Wu, J., Li, D., et al. 2021, MNRAS, 500, 1741, doi: 10.1093/mnras/staa3275

APPENDIX: SKY PLOTS FOR ADDITIONAL FIELDS

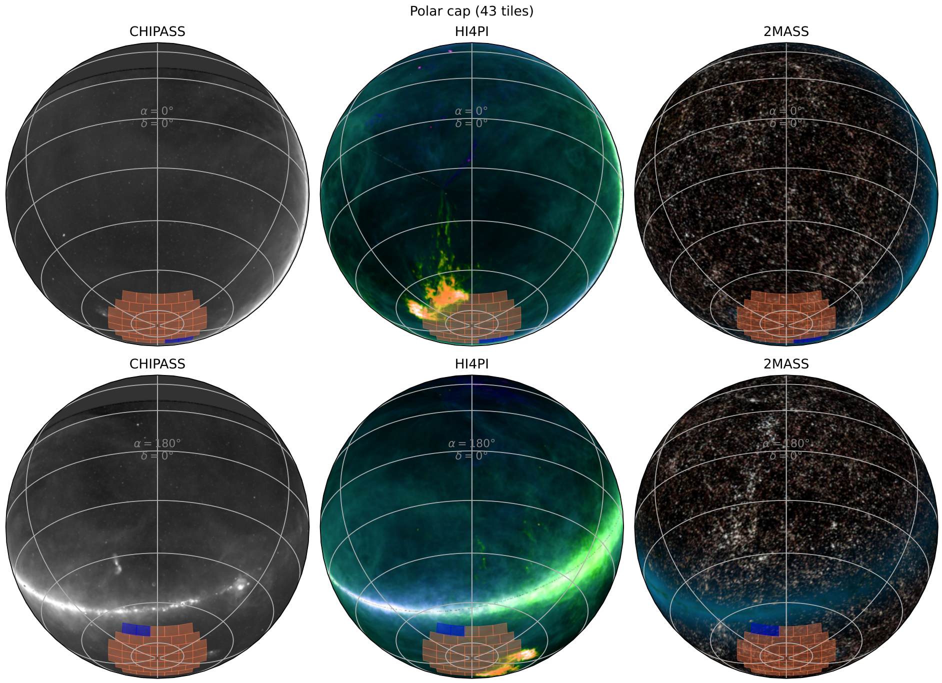

Figure 3. Example additional region - Polar cap (43 tiles). Overlays and projections as for Figure 1.

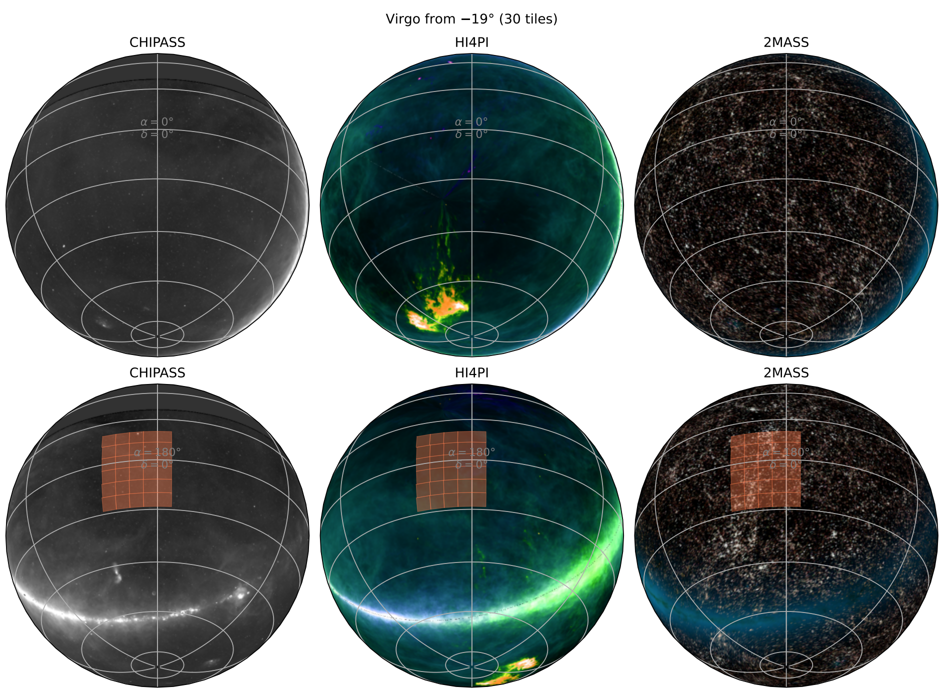

Figure 4. Example additional region - Virgo cluster (30 tiles). Overlays and projections as for Figure 1.

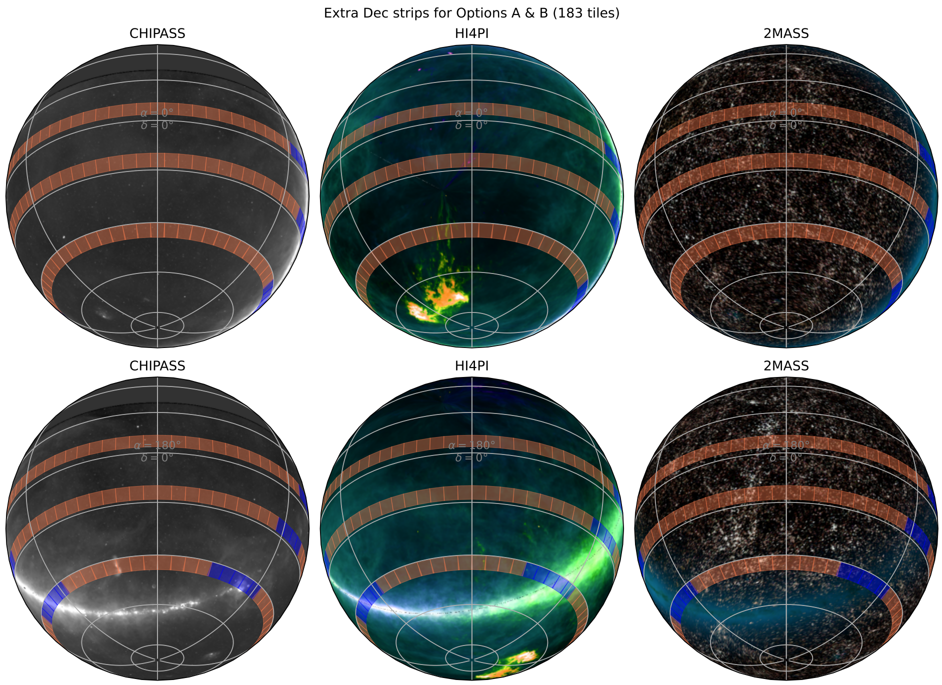

Figure 5. Example additional region - Extra Dec strips (67+65+51 tiles, for northern, middle and southern Dec strips, respectively). Overlays and projections as for Figure 1.

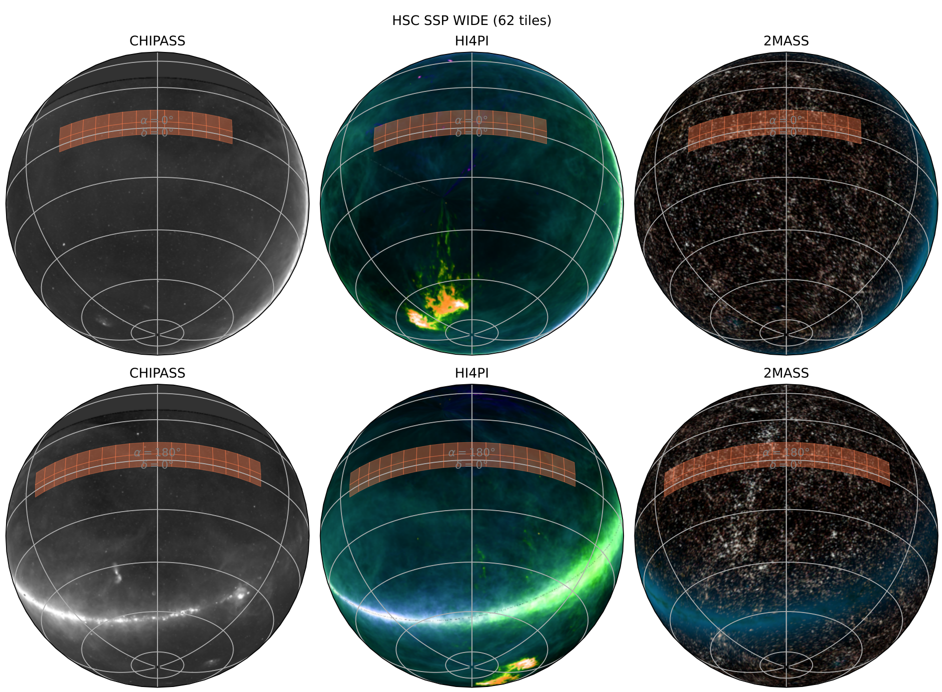

Figure 6. Example additional region - HSC SSP wide (62 tiles). Overlays and projections as for Figure 1.

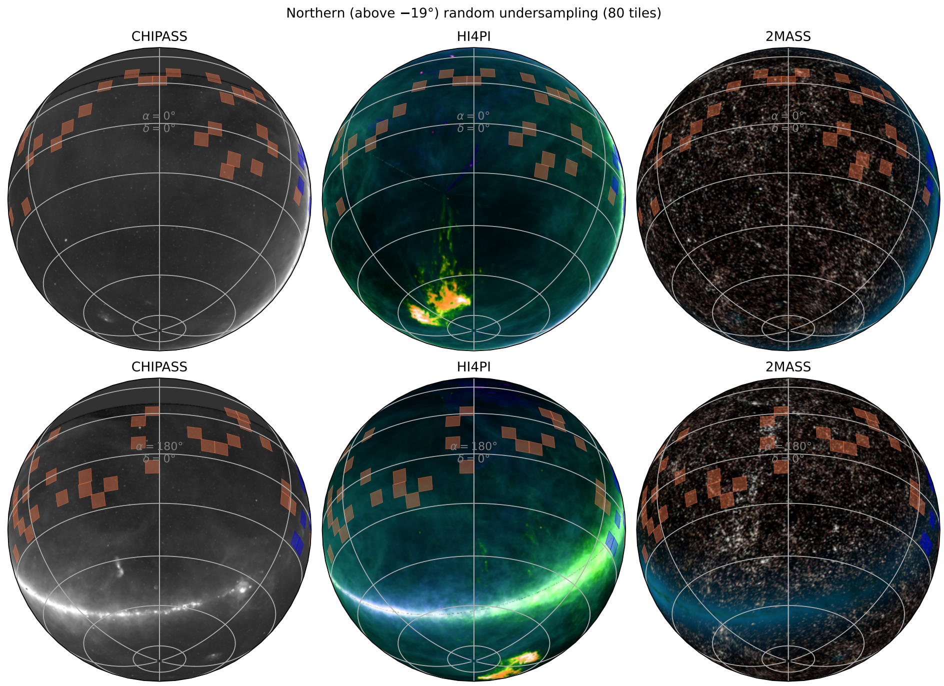

Figure 7. Example additional region - random sampling (80 tiles in this example). Overlays and projections as for Figure 1.

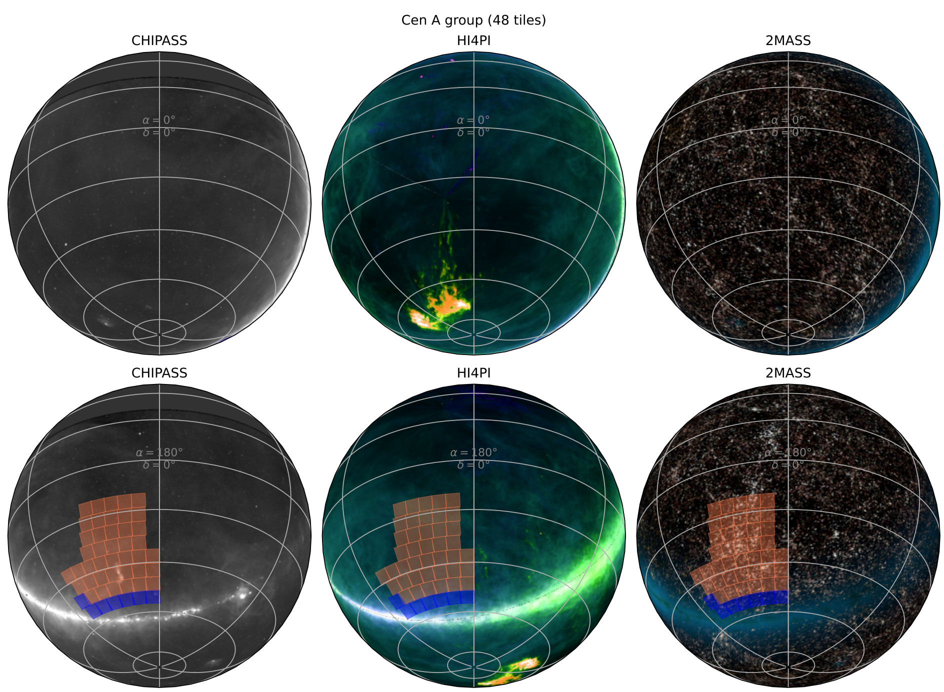

Figure 8. Example additional region - Cen A group (48 tiles). Overlays and projections as for Figure 1.

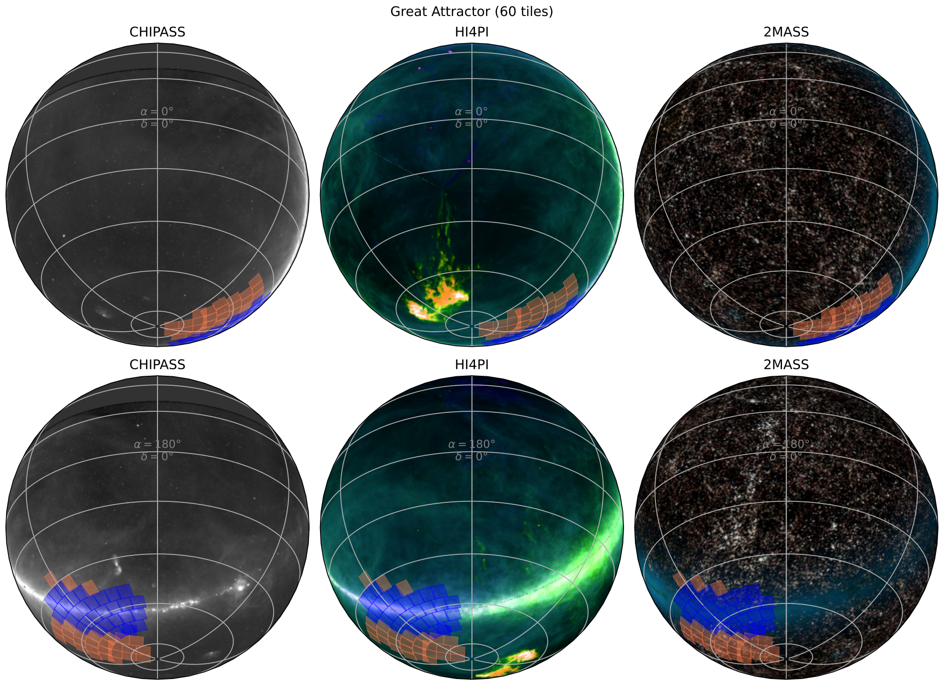

Figure 9. Example additional region - Great Attractor (60 tiles). Overlays and projections as for Figure 1.

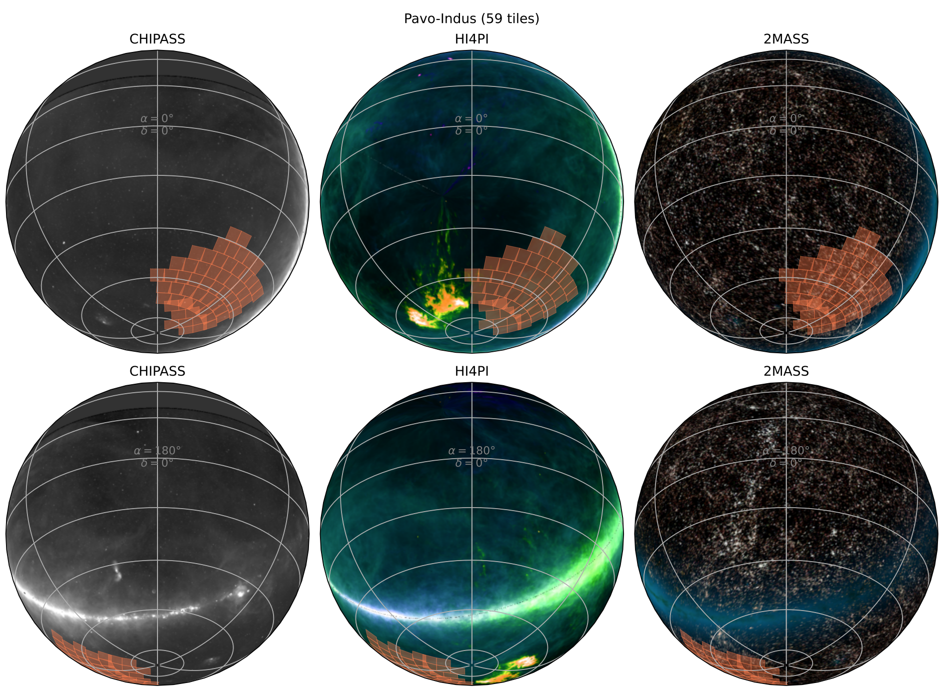

Figure 10. Example additional region - Pavo-Indus group (59 tiles). Overlays and projections as for Figure 1.

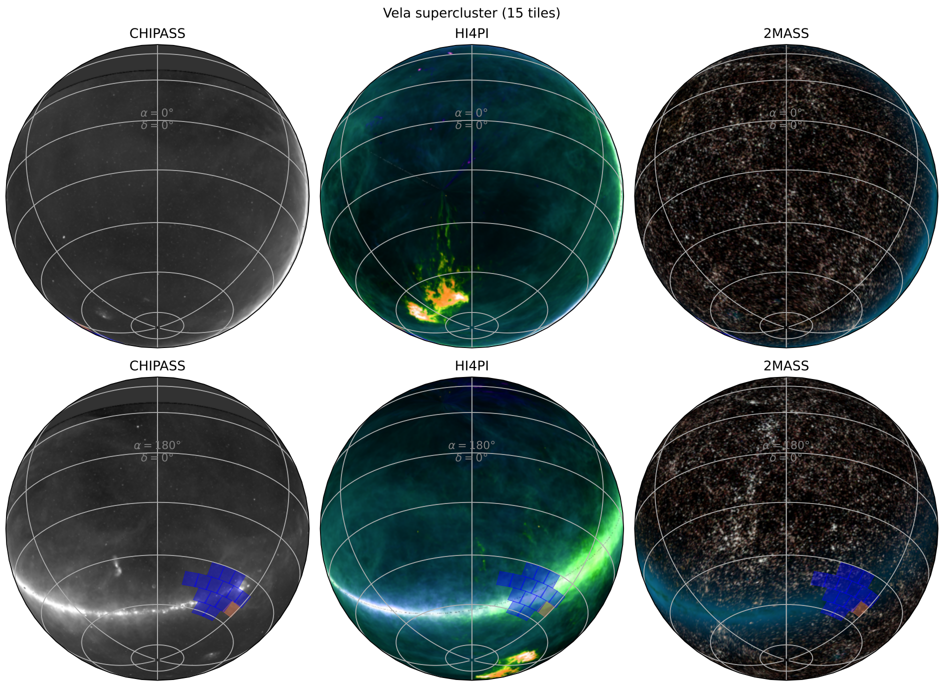

Figure 11. Example additional region - Vela supercluster (15 tiles). Overlays and projections as for Figure 1.