SSG Response to NRAO Internal Science Review

7.1.1 **All Sky:** *The majority of the reviewers were supportive of All Sky as being a resource for the community, producing state-of-the-art radio reference images in the coming era of all sky surveys such as LSST and Euclid.*

No response appears to be required.

7.1.2 **Wide vs. All Sky:** *The relative roles of Wide vs. All Sky need to be clearer. There needs to be a more quantitative justification of the additional depth over the specified field (see point 3 below), in light of the much larger time allocation for Wide. A number of reviewers point out there may be other options to obtain much (or perhaps even more), of the science in less time:*

Given these comments/criticisms, we have now combined the time devoted to Wide into a deeper All-Sky tier that will produce 3 epochs of all-sky images, each down tot 120μJy/bm. This allows for (and greatly improves upon) all of the time-domaine science that was possible by the previous Wide tier, with the added advantage of a factor of 3 times larger area. The final depth of the All-Sky tier will be 69 μJy/bm, not significantly different than the originally proposed 50 μJy/bm Wide tier.

7.1.4 **Justification of depth:** *There was wide agreement among reviewers that the proposal needs a much more quantitative analysis of the required depths of the different parts of the survey to achieve the stated science goals:*

The depth of Wide was likely poorly justified. Given that we have now combined All-Sky and Wide together, the depth of the All-Sky tier is driven by the minimum time it would take to survey the entire VLA-visible sky in 3 epochs to enable time-domaine science, which is considered to be a key science driver of the All-Sky survey component. To stay within data rate limits, this requires an OTF scan-speed of 120 μJy/bm/hr/deg^2, and thus a final depth of 69 μJy/bm. As pointed out by the reviewers, the depth of Deep is well defined – it is the combination of area and sensitivity that sets the minimum requirements for a statistically significant weak lensing detection in the radio (i.e., the forecasted detection for a weak lensing signal is 4.9 σ for the full 10 deg^2 and 3.6σ for 5.5 deg^2 – excluding ECDFS). This in turn leads to a depth/area that is able to address cosmological problems in the radio, as well as study the evolution of galaxies from the peak of cosmic star formation free from the effects of cosmic variance that currently hamper every other deep radio survey (see 7.1.4 below for additional details).

With respect to the goal of weak lensing in the radio, at this depth/area we are estimating that we will only be able to just detect the signal – any significant reduction in depth or area would result in not being able to see the signal. Furthermore, existing PI surveys do not reach the required depth over large enough areas to make a detection, as illustrated in the right hand panel of Figure 7 in the VLASS Proposal: these numbers equate to only just detecting the signal with VLASS-Deep, and that existing data over smaller survey areas will yield a non-detection (i.e., $< 3\sigma$ significance). Consequently, while VLASS-Deep plans to leverage the existing COSMOS data, therefore helping to cut the requested time, the existing COSMOS data alone (i.e., $2\,\text{deg}^2$ down to $2\,\mu$Jy) will not yield a detection.

7.1.4 **PI science:** *There was general concern as to crossing the line between PI science (some of which is ongoing) vs. a community survey. This was particularly relevant when considering the Galactic and DEEP parts of the survey. The SSG needs to demonstrate clearly how the science results represent a major improvement over current, or planned, PI large programs. The proposal should also be more explicit as to the breadth of the community served by each component.*

We will not address the concern with the previous Galactic component of the survey, as this too is now part of the All-Sky tier. As for the concern that VLASS Deep treads on PI science, we believe that this criticism is unwarranted. Unlike typical large (i.e., few 100 hr) PI-driven VLA science programs, VLASS Deep is able to take a transformational step for studies of galaxy evolution by moving beyond the point of simply counting galaxies and measuring the average luminosity function. To properly understand galaxy evolution requires a clear understanding of the role played by environment and AGN activity. This requirement forces the need to cover a wide enough area that is sensitive to galaxies in all environments over the epoch of peak activity (i.e., $0.5 < z < 3$). With $10\,\text{deg}^2$, VLASS Deep is able to achieve this by having enough volume to study 10's of clusters with masses $> 10^{14}\,M_{\odot}$. In doing so, astronomers will be able to start addressing the question of quenching and downsizing with a measure of star formation rate that is free from dust obscuration, and also does not suffer from the resolution problems of existing *Herschel* surveys – *VLASS Deep is actually as sensitive to obscured star formation as the deepest Herschel far-infrared survey data, but covers a factor of ≈100× more area with ≈10× higher spatial resolution (see Figure 12 in VLASS Proposal).* Smaller area surveys, such as the existing area in COSMOS, simply cannot address these science goals.

To date, the combined area of all extragalactic deep fields at $\lesssim 2\mu$Jy at S-band (or equivalent) constitutes $< 3\,\text{deg}^2$. Given that star formation is environmentally dependent, any investigation of the evolution of star-forming galaxies requires that we be able to probe them over the full range of cosmic environments (e.g., from rich clusters to voids). And, by having multiple fields covering such large areas (i.e., ECDFS, EN1, COSMOS), such a survey will be able to overcome/test any remaining cosmic variance effects. VLASS Deep, like the LSST Deep Drilling Fields, SERVS, and VIDEO surveys, lies in parameter space that sits between the ultra deep *HST* surveys and the wide, DES-like surveys. Sampling this portion of survey parameter space is extremely important as it allows us to fully probe the epoch in the Universe which is most active, taking into account the rarer AGN, powerful starbursts, along with the moderate luminosity AGN and star-forming galaxies and environment. The extremely wide-area surveys do not have the depth to do this, while ultra-deep surveys simply do not sample the requisite volume and are limited by cosmic variance.

Furthermore, a goal of VLASS Deep is to relate the radio sources to the underlying dark matter distribution through halo occupation modeling. This requires having enough continuous area to reach the halo-halo clustering term (not just how satellites cluster around central dominant galaxies - usually called the single halo term). Therefore, one needs to enter the linear regime, while retaining the requisite depth to also model the single halo term. This turnover from the single halo to the two-halo term occurs at around $2'$. However, to obtain the pair statistics at this scale with the expected number density of radio sources requires a linear scale of around 2° (e.g., Lindsay et al., 2014b), which is achieved by two of our chosen fields (i.e., ECDFS & EN1). Again, such goals are not achievable through PI science. *Further proof can be seen by that fact that first generation SKA1 reference radio-continuum surveys, which are in the process of being reviewed, are currently being benchmarked against the Deep imaging component of VLASS (Prandoni & Seymour, 2014).*

As already discussed above, we have chosen $10\,\mathrm{deg}^2$ as the full survey area of Deep, as this is the only way to: enable the chance for a statistically significant detection of weak lensing in the radio (see Figure 4 in the VLASS Proposal); reduce the Poisson uncertainty for deriving statistically meaningful luminosity functions for star-forming galaxies (see Figure 2 in VLASS Proposal); as well as to reduce sample variance due to large-scale structure (see Figure 3 in VLASS Proposal), which is critical for developing our understanding of the link between star formation, galaxy mass and environment. Finally, it is worth stressing that the Deep tier provides the only means for non-radio experts working on either galaxy evolution and cosmology to readily incorporate meaningful radio data into their investigations. It would be impossible for such a survey to be executed and reduced/imaged via a PI program(s) – the needs (time/effort/computing power/disk space) far exceed what can be expected by a typical member of the astronomical community.

7.1.5 **Unnecessary text:** *There were a couple of statements in the proposal that were gratuitous, and off-putting to the reviewers. These could be removed with no loss of content or impact.*

These were not gratuitous comments in our view, but important comments that reviewers should take into account. In fact, it was recommended to us by early red team reviewers of the proposal that we be very upfront and directly and carefully address the question of the science that would not be done on the VLA due to VLASS. We took those comments from the red team reviewers very seriously, and that is why we included these sentences and this information.

i **Low ranked science:** *The argument that the surveys will only displace low-ranked science irked a number of the referees:*

This hopefully is a true and accurate statement, and needs to be considered when people consider whether or not large surveys should be conducted on oversubscribed telescopes. These are the kinds of considerations that major observatories like *HST* and *Spitzer* regularly think about and take into consideration when decided on large projects versus smaller PI products.

ii **Citation statistics:** *Likewise, the use of citation statistics was called-out as misleading, possibly wrong, and generally unnecessary.*

Citation statistics are a recognized mechanism for assessing the importance of projects and scientific discoveries. While, of course, citation statistics are less than perfect measures, nevertheless they are one accepted and regularly utilized metric that the NSF, NASA, NIH, as well as tenure review and promotion committees, etc. regularly employ. We have carefully described how the statistics we use were acquired (and for the citation statistics for the prior VLA surreys they are easily recreated through ADS). In addition to the information here we also did separate assessments by hand of whether the citations to FIRST and NVSS utilized the data and survey results or were referencing methodology. The vast majority of the references (over 90%) were to the data. Additionally, though there were worries expressed that PI NRAO proposal reference information might be incomplete (i.e., underestimates) the same is clearly true for the FIRST and

NVSS citation references as well, where again an independent analysis shows that 25% of papers which mention NVSS for example in the text do not reference the NVSS in the references. Thus, while imperfect, citation and publication references are an accepted and regularly utilized measure of relevance and we believe it is important to take them into account when predicting the likely importance of VLASS to future science.

7.2.1 **Deep – Distant galaxies:** *The most significant concern for DEEP and galaxies was the duplication of science relative to the current on-going PI programs. The proposal would be much stronger if they included:*

- *A summary table of the on-going or planned deep fields.*
- *A clear delineation of how the proposed observations improve substantially upon the ongoing surveys (note: simply more is not good enough).*

We believe that, while Deep touches a number of outstanding questions that PI science programs are trying to answer, the statement that the science goals put forth by Deep can in anyway be achieved through PI sciences is false. See the response to 7.1.4 above for a detailed response to this criticism.

As for the statement that existing PI programs are able to overcome cosmic variance, this is incorrect. Figure 1 illustrates the sample variance for various surveys including: UKIDSS UDS ($0.8\,\mathrm{deg}^2$), COSMOS ($2\,\mathrm{deg}^2$), and VIDEO ($12\,\mathrm{deg}^2$). This is shown for $10^{11}\,M_\odot$ galaxies. Consequently, to overcome sample variance for massive galaxies (which host the AGN and the powerful starbursts) one requires at minimum $10\,\mathrm{deg}^2$ (i.e., which is achieved by VLASS-Deep) to minimize sample variance to $<<$ 10%, making this term subdominant relative to Poisson noise.

7.2.2 **Deep – Cosmology:** *It was difficult to tell from the proposal how the expected VLASS results compare to other efforts under the DETF umbrella. Is this just a technique demonstration project?*

- *A quantitative comparison of the expected cosmological constraints from VLASS weak lensing and large scale structure measurements, relative to techniques being pursued elsewhere. Will the VLASS represent a major new tool in cosmology?*
- *If this is just a technique demonstration project, they need to justify more clearly why 10 deg^2 and 3000 hours is needed.*

For a quantitative comparison with state-of-the-art (optical) weak lensing surveys, we look at the forecasted detection significance numbers for CFHTLenS, KiDS and DES (Brown et al. 2014). The proposed VLASS Deep ($10\,\mathrm{deg}^2$) is aimed at delivering a $5\,\sigma$ detection in the radio. Current optical weak lensing surveys, such as CFHTLenS ($154\,\mathrm{deg}^2$), KiDS ($1500\,\mathrm{deg}^2$), and DES ($5000\,\mathrm{deg}^2$), are expected to deliver detections with a significance of 15, 30, and $43\,\sigma$, respectively. We believe that there is little point in propagating the power spectrum forecasts into forecasts for e.g. DETF FoM – that would be quite a lot of work and it would not actually tell us much more than what these numbers already suggest. DES will constrain dark energy parameters with nearly an order of magnitude better precision than VLASS Deep. Of course, such precision comparisons tell us absolutely nothing about is the impact of *systematics*, which is the key strength of radio weak lensing. Systematic errors in lensing measurements dominate the uncertainty, and must be carefully accounted for to ensure that

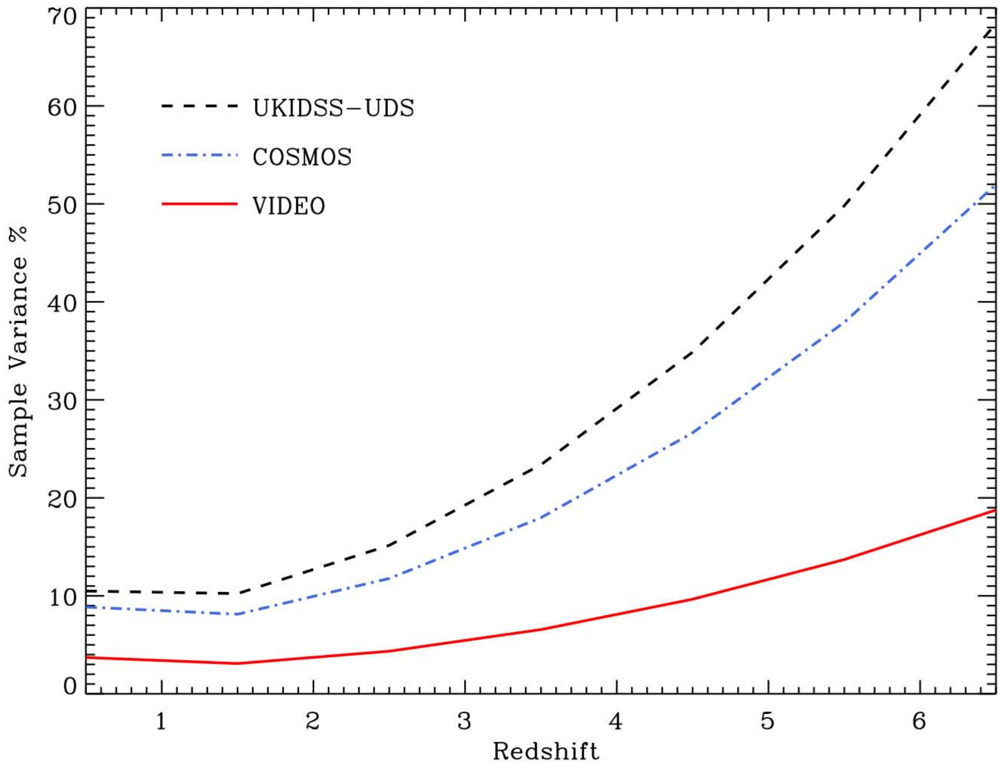

Figure 1: Percentage cosmic/sample variance for massive galaxies (i.e., $> 10^{11}\,M_{\odot}$) in three key near-infrared surveys. Based on the prescription of Moster et al. (2011, ApJ, 731, 113).

cosmological constraints from lensing are unbiased and as precise as possible. This is indeed the reason why weak lensing is a key science driver of the SKA, and why the weak lensing aspect of VLASS-Deep is not only a pathfinder, but potentially *a groundbreaking project to provide the first definitive measurement of weak lensing in the radio years before SKA Phase 1 construction has finished.* In the process we hope to demonstrate the unique advantages of radio wavelengths for Dark Energy science, i.e., having well known deterministic PSF (beam), the extension to high redshift that radio offers over optical surveys, working directly in the *uv*-plane, and the use of polarization to suppress astrophysical systematic effects.

7.2.3 **Galactic structure:** *a few referees pointed out that Planetary Nebulae will be heavily resolved at $0.''76$ resolution of order 100 beams over the source, even at 8 kpc distance! In fact, the sources may be undetectable in A array, given the roughly factor 10 to 20 spatial dynamic range of an A array snapshot (ie. shortest vs. longest baselines). The proposers need to demonstrate that they can indeed detect PNe, and detect them at a level useful for Galactic structure studies.*

The most significant change to the entire VLASS proposal as it relates to the VLASS-Galactic component is that it has been dropped from the final VLASS definition submitted for external review. In doing so, A-configuration observations for the Galactic plane/bulge region have been removed. Thus, many of the criticisms are less applicable than before. Here we address the remaining reviewer concerns.

For concerns specifically associated with the detection of thermal sources, such as PNe, we

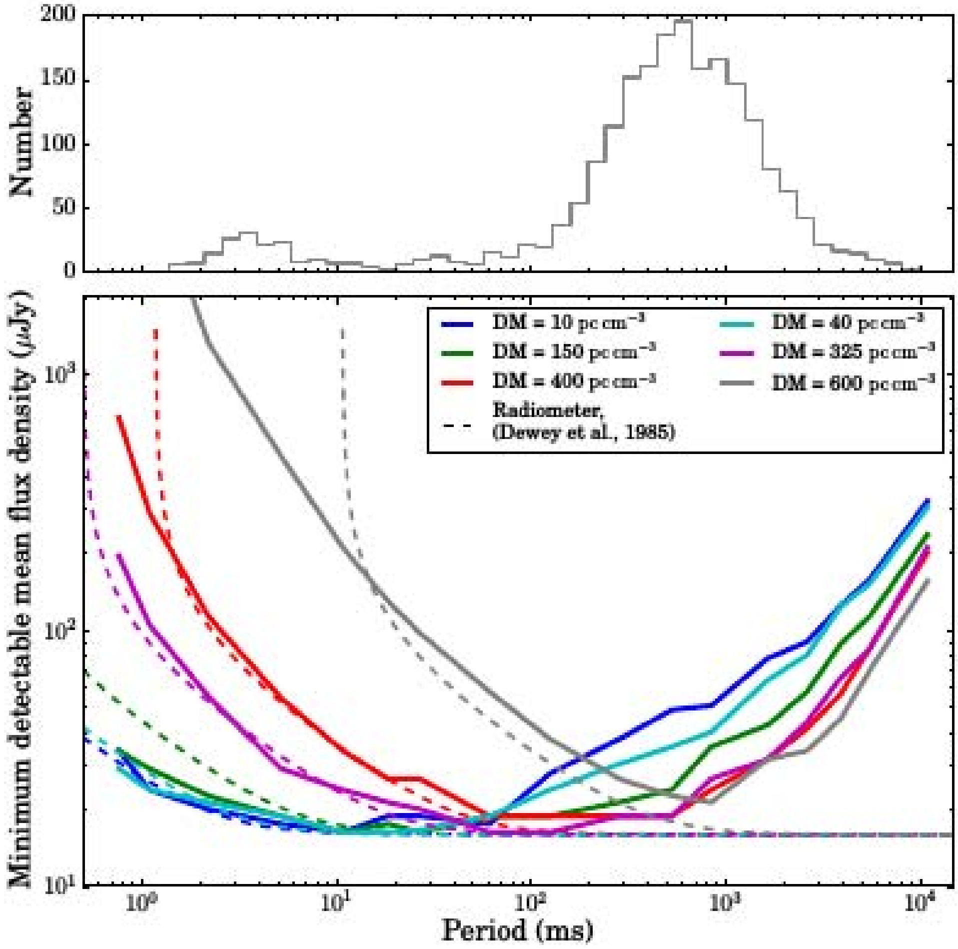

Figure 2: [Taken from Lazarus et al. (the PALFA Survey collaboration; 2015, in preparation)] *Bottom* – Minimum detectable phase-average flux density curves for the PALFA survey as determined using synthetic pulsar signals with FWHM=2.6%. The reduction in sensitivity at long periods is due to the red noise in the data. Clear discrepancies are seen when comparing the measured curves with those derived using the radiometer equation (Dewey et al. 1985). Sensitivity to long-period pulsars is overestimated, and sensitivity to MSPs is underestimated. However, using a more complete formulation of the radiometer equation better models the sensitivity in the short period regime (Cordex & Chernoff 1997). *Top* – Period distribution of all Galactic radio pulsars with periodicities listed in the ATNF catalog.

have now added a reference to Aaquist & Kwok to illustrate that nearby PNe are a few to several arcseconds in size. This angular scale is well matched to the VLASS/All-Sky angular resolution of 2.″5. Furthermore, more distant PNe (or Galactic sources in general) should be even smaller, minimizing the risk that the VLASS would resolve out the sources.

Given that most HII regions and PNe are not simple spherical shells, but show more compact sub-structure, an angular resolution of a few arcseconds is desirable. Produced by the free-free emission from ionized gas, expected brightness temperatures might be a few hundreds of degrees to of order 10^3 K. Thus, arcsecond angular resolution and a brightness temperature sensitivity of order 10 K or better (as is clearly achieved by the VLASS All-Sky tier, having $\sigma_{T_B} \approx 1.5$ K) will be sufficient to detect large numbers of distant thermal sources.

7.2.4 **Galactic sources:** *there were significant questions concerning source identifications. For* *instance, the proposers need to demonstrate that the MSP search has some major advantage over other techniques currently being used.*

To better address how VLASS will be able to contribute significantly to MSP searches, we have now added additional text in the proposal describing that VLASS is the first step in a "winnowing" procedure, by which source structure, spectral index, polarization, multi-wavelength counterparts, etc., are used to reduce the number of pulsar candidates to a small number of high quality ones for intense periodicity searches.

Specifically, the VLASS All-Sky tier is expected to produce a source density of $290\,\mathrm{deg}^2$. We expect between 25–50% of these sources to be resolved at the flux density and angular resolution of VLASS (Coleman & Condon, 1985; Muxlow et al., 2005) and immediately rejected as candidate radio pulsars. With a combination of multi-wavelength counterpart comparisons, polarization, future high angular resolution observations, and other criteria, we expect it to be feasible to reduce the source density to of order $30\,\mathrm{deg}^2$. At this level, there is less than one candidate pulsar per single dish beam (e.g., GBT), and a targeted periodicity search is preferable (i.e., takes less time) to a blind survey.

It is worth emphasizing that the proposed procedure is not only applicable to MSPs, but to canonical pulsars, highly scattered objects, ultra-compact binaries, etc.. For instance, a pulsar-black hole system might very contain a "canonical" pulsar ($P \sim 1\,\mathrm{s}$). However, the extent to which acceleration searches can be performed could limit standard periodicity searches. Ideally, one might think that the telescope sensitivity provides some basic minimum flux density to which a source could be detected. That is certainly the case for the typical continuum survey for steady sources (e.g., extragalactic sources). However, because of effects such as limited frequency channelization and dispersion smearing, that is not the case for pulsar searches.

In the bottom panel of Figure 2 [for more detail, see Lazarus et al. (the PALFA Survey collaboration; 2015, in preparation)], the different colored curves illustrate the effects for pulsars with different dispersion measures (DMs, i.e., distances). Pulsar ALFA is an ongoing pulsar survey at Arecibo, and is the most sensitive of its kind to date yielding some exceptionally faint and high-dispersion objects. One can easily see that the curves are *far* from flat, i.e., constant sensitivity at all periods. Instead, the shorter period pulsars are increasingly affected by these effects. For the shortest period pulsars ($\sim$few ms periods), the effective reduction in sensitivity can be 10x or more. While the effects are most significant at short periods, note that they may still be important at modest periods. A distant (i.e., high DM) PSR-BH binary system in which the PSR has a period of order $1\,\mathrm{s}$ might still suffer an effective reduction in sensitivity by a factor of a few for some ranges in the DM.

7.2.5 **Faraday Tomography:** *a few referees performed detailed calculations that show that the sensitivity in the RM synthesis, even for Wide, will be inadequate to perform a proper RM-grid experiment. While the aspiration of true Faraday tomography is laudable, the proposers need to go beyond aspiration, and address this sensitivity concern how will the VLASS will make a major step forward in this field?*

Summary response: The key advantages of the VLASS All-Sky polarization work are in probing Faraday complexity along and across the line of sight. This will complement and be further leveraged by upcoming SKA precursor surveys at L-band. For background source experiments we will simultaneously improve the polarized source density (at S:N$>$ 10) by a factor of 6 above the 1 per square degree currently available, with an RM accuracy that is comfortably below the strength of the expected foreground signals. Separately, the Deep Tier

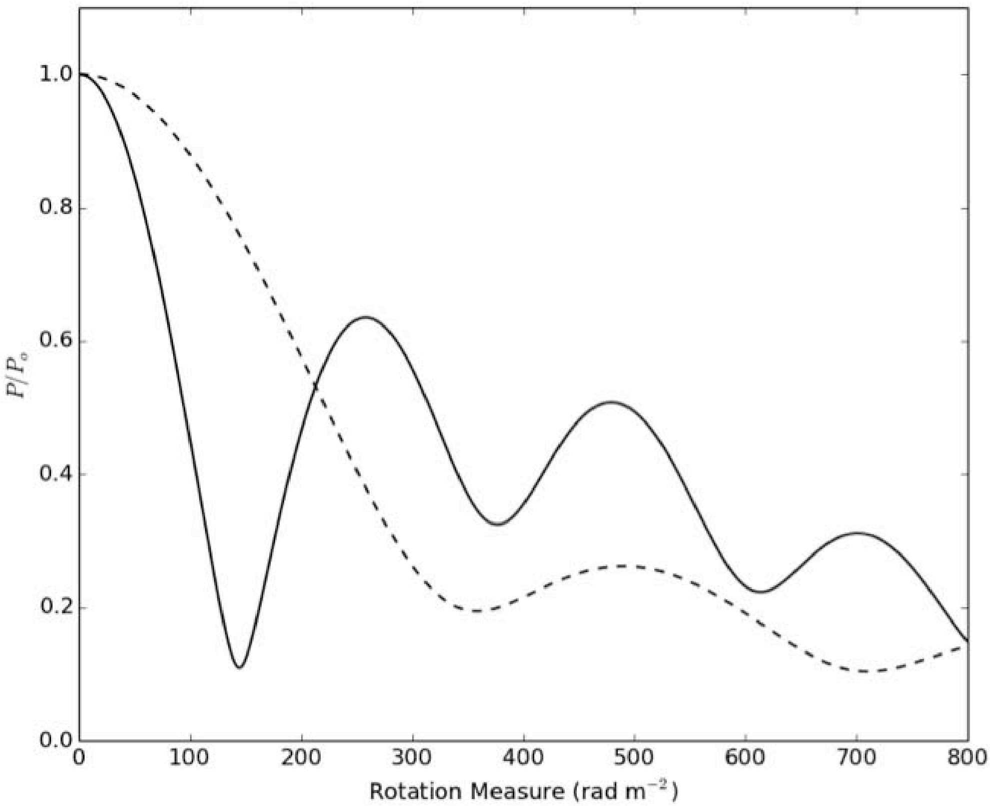

Figure 3: Faraday depth response function. The available non-RFI contaminated frequencies at S-band provides a FWHM response of ~200 rad m^{-2}.

will produce the first statistically significant sample of polarized galactic disks beyond the local universe.

Detailed Response:

1. The primary polarization advantage of the All-Sky S-band observations is to probe the Faraday complexity over the wide 2–4 GHz range. This will produce the first polarization survey with reasonable depth, sky coverage and resolution. Such complexity is best documented by the recent work of Farnes et al. (2014, ApJS 212, 15, Fig. 3) on sources pre-selected to be polarized at 1.4 GHz. Large, unbiased, and uniformly observed samples with VLASS are needed to turn this into a useful diagnostic tool for the Faraday medium in active galactic nuclei (AGN). Additionally, there are no existing all-sky polarization surveys with resolutions better than the NVSS 45″, so the VLASS will enable study of Faraday variations across large samples of spatially resolved sources for the first time, even if we detect no more sources than the NVSS; this is important for both studies of the medium local to the source and the intervening Faraday screen.
2. An important additional benefit of the proposed All-Sky program is in providing background polarized sources for targeted samples such as MgII absorbers and clusters of galaxies (we did not describe or fully investigate the additional uses for an all-sky RM grid). These two background experiments rely on a) increasing the number of sources now available and b) having sufficient resolution in RM space to detect a signal.

a) As noted by one of the reviewers, the Rudnick & Owen (2014) results at 1.″6 resolution predict approximately 6 sources per deg^2 at 0.7 mJy (S:N=10). We agree, and note that the decreased signal at 3 GHz due to the spectral index would nominally be expected to reduce the source density. However, the median fractional polarization at S-band is 1.3× higher than at L-band, even for the very low resolution (i.e., 9′) SPASS beam, [Lamee, Rudnick, Farnes & Caretti (2015, in preparation)], so we still expect 6 sources per square degree at S:N>10. This is a factor of 6 above the existing surface density of polarized sources from the NVSS (the current best all-sky survey), enabling background studies that are not currently feasible.

b) Resolution in RM space is also critical. The MgII absorbers (steep spectrum) were shown by Farnes et al. (2014, astro-ph:1406.2526) to have a mean difference of ∼20 $\mathrm{rad\,m^{-2}}$ from non-absorbers. Cluster experiments using sources in the cluster itself (not background sources) claim $\sim 10^2$ $\mathrm{rad\,m^{-2}}$ signals. In order to measure such signals using VLASS, the RM resolution must be comparable, at worst, and preferably better. The attached plot shows that using the combination of 2000–2128 MHz and 2384–3600 MHz (the RFI free bands as noted by the reviewer), we will achieve an accuracy of ∼10 $\mathrm{rad\,m^{-2}}$ at the survey limit (S:N=10), comfortably within the above requirements. The high sidelobes from this wavelength coverage are not a concern for background experiments, which will be dominated by a single Faraday depth for each source. [The dashed line shows the upper sub-band alone.]

The best current all-sky grid for background RM values is the NVSS grid (Taylor et al. 2009), which provided an RM accuracy of about 10 $\mathrm{rad\,m^{-2}}$ and a sky density of 1 source per deg^2. For the VLASS, with 69 μJy per beam rms, a polarized flux density of 0.7 mJy will provide a S:N=10 and an RM precision of 10 $\mathrm{rad\,m^{-2}}$. Stacking analysis of the NVSS (Stil et al. 2014), and extrapolation of the Rudnick and Owen (2014) GOODS-N direct polarization detections, indicate a source density at this polarized flux density of $> 6-10$ sources per deg^2, an order of magnitude improvement over the NVSS.

In addition to the specific background experiments above, where an error of 10 $\mathrm{rad\,m^{-2}}$ is sufficient, we can also consider experiments where higher precision would be useful. The rms scatter due solely to internal Faraday rotation measures of extragalactic sources is currently estimated at 5–7 $\mathrm{rad\,m^{-2}}$. Thus, an RM precision of 5 rad/m2 will result in a data set whose noise variance is dominated by the properties of the background objects rather than measurement error. This will be achieved for polarized flux densities above about 1.5 mJy with several objects per square degree, in comparison with a polarized flux of ∼10 mJy for the NVSS (split into its two bands), with a source density of ∼0.3 per deg^{-2}. The VLASS Faraday grid will thus allow studies of the extragalactic Faraday universe that were not possible with the NVSS RM grid.

7.2.6 **Transients and cadence:** *Numerous reviewers questioned the cadence of Wide and its ultimate usefulness for hidden explosions. The proposers need to explain how they will categorize different transient events in light of the 15 month cadence of Wide, and why 4 epochs are required.*

As already discussed in the response to 7.1.2 above, Wide has now been combined into the All-Sky tier, creating a 3 epoch, all-sky survey with a 32 month cadence. As described below, the choice of S-band and cadence enables all of the proposed transient science goals.

First, S-band is undoubtedly a better choice than L-band for transient science. In particular, VLASS looks to make the first census of extragalactic explosive transients bypassing issues caused by relativistic beaming and dust obscuration in other bands. Typically radio emission from such events is due to the synchrotron emission from the expanding fireball produced by a supernova or merger event interacting with the surrounding circumstellar medium. As this fireball expands the luminosity and spectral energy distribution of the emission evolves: typically the radio spectrum initially becomes optically thick at high radio frequencies (typically $\gtrsim$100 GHz) with the emission becoming less luminous and peaking at lower radio frequencies as the fireball expands. By the time such events become optically thick at low radio frequencies ($\lesssim$10 GHz), the timescale on which the emission evolves is typically months to years. Thus, we are effectively watching a sky full of explosions playing out on year-long time scales and an appropriate strategy to detect and characterize these events must be employed.

With this in mind, the choice of S-band allows us to benefit strongly in two fashions. The radio emission peaks earlier at S-band and with higher peak luminosity than at L-band. The former effect is particularly important - the explosive extragalactic sky evolves on *very* long timescales at 1.4 GHz. This will hamper efforts by upcoming surveys like MeerKAT and ASKAP. For example, the primary transient experiment with ASKAP (VAST) will survey a 10,000 $\deg^2$ area each day for 2.5 years. However, this entire survey duration is less than the typical rise time for radio supernovae at 1.4 GHz and thus is poorly optimized for detecting extragalactic transients. While they will have dense sampling of the light curve of events as they do occur, this is not a very powerful tool for distinguishing between different classes of explosive transient, particularly as ASKAP is essentially a monochromatic survey with very little information available on the broad spectral energy distribution of each event.

By contrast, events evolve much faster at S-band such that the 3 individual discovery epochs of VLASS are separated by a duration greater than the evolution timescale of all known classes of extragalactic explosive events. Thus, each snapshot is fully refreshed view of the transient radio sky maximizing the detection rate of events for the VLASS. Moreover, while VLASS is a monochromatic survey, the VLA is a versatile instrument and can deliver broadband SEDs through rapid triggered follow-up of each transient event that will provide a much more powerful diagnostic of the spectral energy distribution and its evolution than can be achieved by SKA pathfinders. Together, with reference optical data of the host galaxies, this will easily enable classification of various classes of extragalactic radio transient.

Finally, we note that VLASS is equally sensitive to transients on short timescales as long timescales. The detection rate for a class of transient measured between two epochs reaches a cumulative maximum when the separation between those epochs exceeds the typical time for that class of transient to reach peak luminosity. Thus, the detection rate for transients on all timescales is maximized by the VLASS strategy. However, once again, rapid triggered follow-up with the VLA is needed to measure the spectral energy distribution of the event, and the timescale over which it evolves.