SKA1-Mid Simulations

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March 7, 2014

1 Introduction

The SKA at mid frequencies (SKA-Mid) will be built in two distinct phases, SKA-Mid phase one (SKA1-Mid) and phase two (SKA2-Mid) in South Africa, and SKA-SUR in phase 1 in Australia. The key science goals for SKA1-Mid include the study of the history and role of neutral hydrogen in the Universe from the dark ages to the present-day, the use of pulsars as probes of fundamental physics [1] and continuum and HI surveys to pin down the cosmological model.

In this document, we attempt to gauge the scale-dependent sensitivity of the mid-frequency array described in the *SKA1 System Baseline Design* (BD) document [1]. The performance of this configuration is then compared to four alternative configurations. We also explore different weighting and tapering schemes as a way of increasing performance.

The rest of this document is laid out as follows: in subsection 1.2 we discuss the science requirements for SKA1-Mid, then in subsection 1.3 we describe layouts that we will be considering. In section 2 we describe our simulation techniques and the metrics we generated from the experiment. Finally, the results, discussions and concluding remarks are in sections section 3 and section 4.

1.1 SKA1-Mid Baseline Design

The mid-frequency array described in the BD is a 254 dish array with about 36% of the dishes within a radius of 400m (core), 40% of the dishes are between 400m and 4km (outer-core) with the remaining 24% in 3 three spiral arm-like structures starting from abot 2km and stretching out to a radius around 70km. Figures 1 and 2 show the BL layout and baseline distribution histogram (log_{10} space). With about 200 fifteen metre dishes (bar the 64 13.5 metre MeerKAT dishes) within a radius of 4km, this array promises high sensitivity, with noise values around 63μJy beam^{-1} hr$^{1/2}$ [1]. However, with three distinct dish-density regions, the resulting full sensitivity (natural weighting) PSF has two pedestals corresponding to the abrupt changes in dish densities from the core to the outer-core and from the outer-core to the spiral arms (see Appendix A). With such a configuration, a uv-weighting that tends towards uniform is required to obtain high resolution and uv-tapering might be also be required to get a well behaved PSF. Leading to lower sensitivity due to the down-weighting of baselines[1]. It is therefore important to quantify the scale-dependent sensitivity of this configuration, i.e., what is the sensitivity at different angular scales and how this sensitivity is affected by different uv-weighting and tapering schemes.

1.2 SKA1-Mid science requirements

The general scientific requirements for SKA1[2] (SRD) published by the SPO in March 2014 suggest that (at least for SKA1-Mid), an array with a maximum baseline of around 100km is required. Therefore, we seek a layout with the shortest possible maximum baseline that does at least as well as the "second generation" baseline design in the resolution range 0.4-1 arcsec over 650, 800 and 1100MHz while not significantly compromising the performance at the larger angular scales. Moreover, having a layout which performs just as well as (or better) than the baseline layout but which covers significantly less space translates to less trenching, which may present the opportunity to re-invest the funds somewhere else, therefore we consider the conservative addition of 12 dishes. However, we note that improvements on the scales of interest are still possible without these 12 additional dishes. In the next section we present 4 alternate layouts, these layouts have maximum baselines of 90,100,120 and 133 km. The scale dependent sensitivity of these layouts is compared to the baseline layout in section 2.

[1] uniform uv-weighting down-weights the uv-points corresponding to shorter baselines, and hence gives better resolution, while a uv-taper down-weights the edges of the uv-coverage (longer baselines) to decrease sidelobe levels

1.3 Background on Layouts

The following SKA1-Mid layouts are under consideration here:

REF2 Second-generation layout (254 dishes) produced by Robert Braun (September 2013)[2]. This layout has a maximum baseline of 173km.

Wi-jAkBl This is the REF2 layout with the core (within a radial distance of 300m from the centre REF2) "puffed up" by 10%, with i additional dishes and j dishes from the outer core (between 400m and 4km from the centre of REF2) added to the spiral arms. The spacing in the arms is then optimized to get more sensitivity on the longer (> 50km) baselines(See baseline distribution histograms in Figure 2). Each spiral arm stretches out to k kilometres and the maximum baseline length is about l kilometres.

The details of the layouts are tabulated in Table 1, and Figure 1 shows the layouts and Figure 2 shows the baseline distribution histogram for the different layouts. Figure 3 shows the uv-coverage for the different layouts at 1.1GHz at declinations -50,-30,-10 degrees for 8hr tracks. At this point no optimisation has been done on the antenna distributions and we emphasise that further improvements can be and should be made.

REF2 [254 dishes]	SKA dishes	MeerKAT dishes	Both	%
Core	63	30	93	36
Outer-core	67	34	101	40
Spiral-arms	60	0	60	24
W9-12A54B90 [266 dishes]				
Core	70	30	93	36
Outer-core	58	34	92	34
Spiral-arms	81	0	81	30
W9-12A60B100 [266 dishes]				
Core	70	30	93	36
Outer-core	58	34	92	34
Spiral-arms	81	0	81	30
W9-12A72B120 [266 dishes]				
Core	70	30	93	36
Outer-core	58	34	92	34
Spiral-arms	81	0	81	30
W9-12A80B133 [266 dishes]				
Core	70	30	93	36
Outer-core	58	34	92	34
Spiral-arms	81	0	81	30

Table 1: Breakdown of the layouts under consideration.

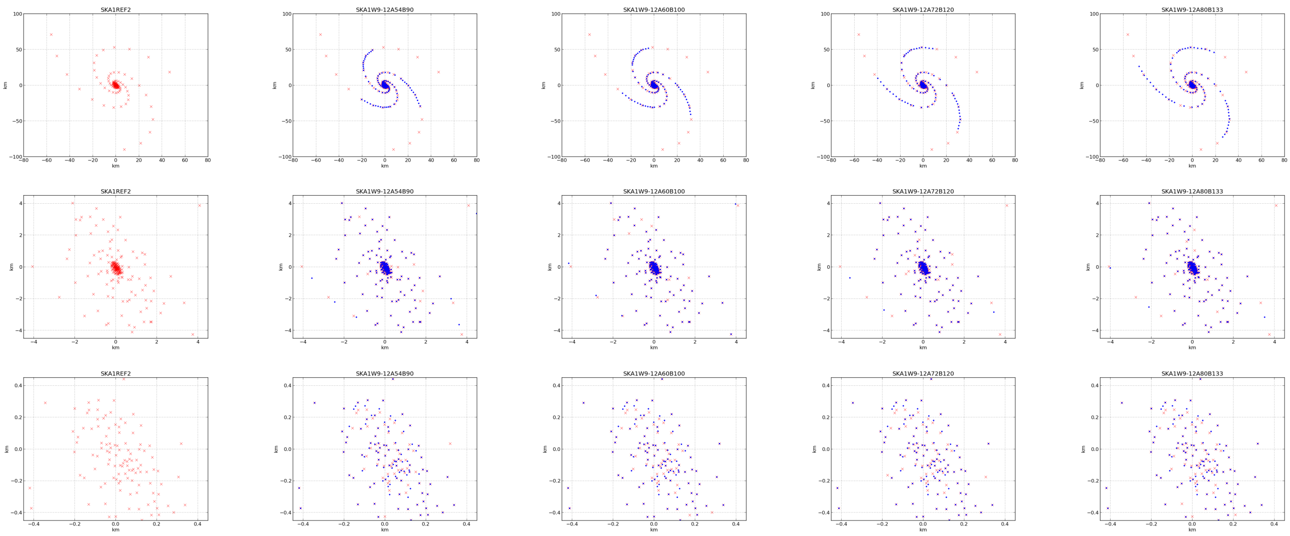

Figure 1: Antenna layouts, REF2 ploted as a reference (red crosses)

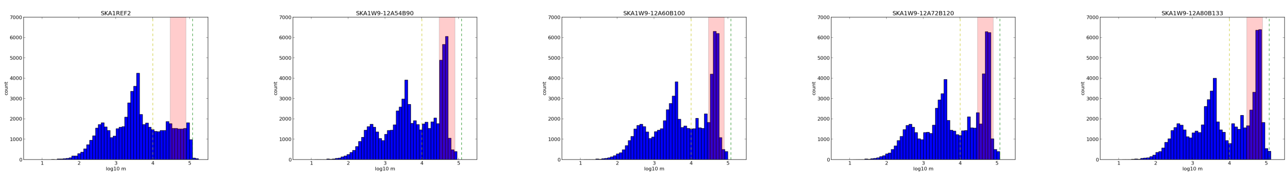

Figure 2: Baseline distribution with the uv-distance in log_{10} km . Yellow and green dashed lines mark 10 and 120 kilometres respectively, and the pink strip represents baselines from 30-80km.

[2]We assume this to be the baseline layout.

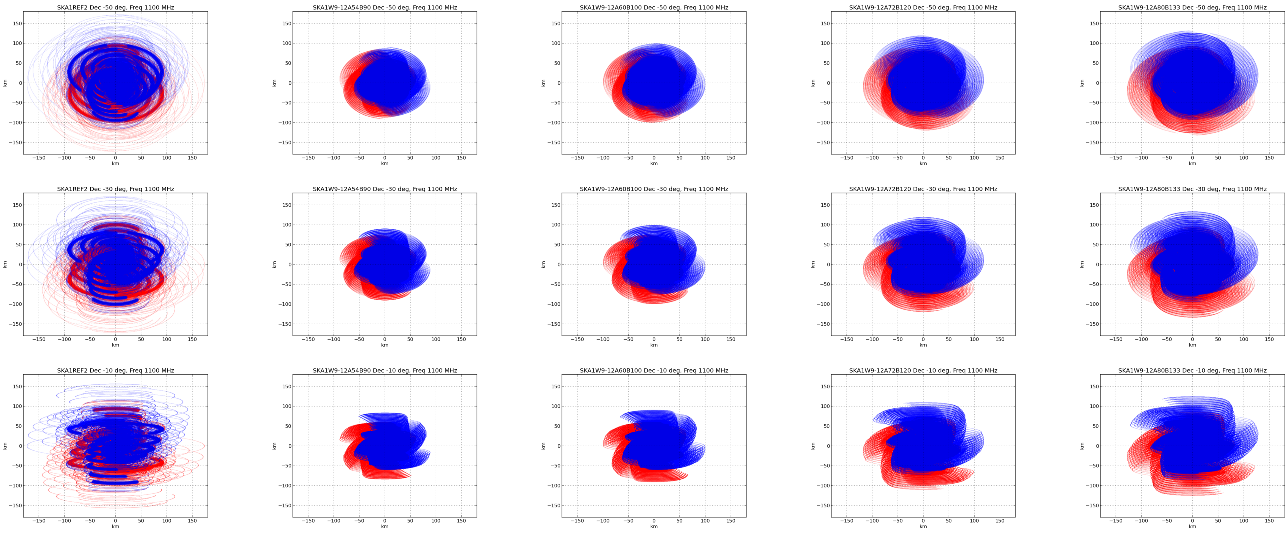

Figure 3: UV-Coverage for 8-hr tracks at 1.1 GHz (50MHz bandwidth) at declinations -50,-30,-10 for the different layouts. Blue indicates uv-points, red indicates conjugate uv-points.

2 The Experiment

Our aim is to investigate the scale-dependent sensitivity of the layouts described in the previous section. We use the `makems` tool make simulated measurement sets of a an 8hr track with a 60s integration time on declinations {-50, -30, -10} degrees at frequencies of {650, 800, 1100}MHz with a single 50MHz channel. The expected rms noise per real and imaginary part for each visibility is calculated as

$$\sigma_{\text{vis}} = \frac{\text{SEFD}}{\sqrt{2\Delta t \Delta\nu}}. \tag{1}$$

We use the baseline designs SEFD value of 400 corresponding to the 15 m dishes. We then fill the MS with random Gaussian noise using the computed value of the noise for a given integration and bandwidth. We then use the (CASA-derived) `lwimager` tool to make maps of the PSF, and dirty maps of the noise using various weighting schemes. Note that for uniform and robust weighting, a crucial parameter is the size of the uv-bin over which weights are uniformized. By default this is determined from the full image size, but `lwimager` allows one to uniformize the weights over bins corresponding to a user-defined FoV instead. For these simulations uv-bins corresponding to a FoV of 10 arcmin were used. The following metrics were generated:
Note: These metrics are generated at different angular scales, this is done by applying an inner-taper[3] to taper out baselines that do not fall with a given resolution range, i.e., only considering uv-points that correspond to a given resolution.

- PSF FWHM size (mean of the FWHM dimensions). This was measured by making high-resolution images of the PSF (0.05 arcsec resolution), and fitting a Gaussian to the PSF. Note that for the highly non-Gaussian PSFs corresponding to natural and (some) robust weighting schemes, the fit is very poor, so the size parameter becomes somewhat ill-defined (Table 2). A catalog of PSF cross-sections is provided in the Appendix A
- PSF symmetry (PSF size parameters are obtained as explained above). As a measure of PSF symmetry, we define $\text{PSF}_{sym} = 1 - \text{FWHM}_{min}/\text{FWHM}_{maj}$, then $\text{PSF}_{sym} = 0$ is perfect symmetry, and the symmetry degenerates as $\text{PSF}_{sym} \to 1$ (Table 3).
- Rms pixel noise at different angular scales for 50 and 166MHz wide bands (Tables 4 and 5).
- SNR for a 10μJy source at 1100MHz with a spectral index of -0.7 after 8hrs for a 166MHz band (Table 6).
- Average SNR over frequencies 650, 800 and 1100MHz (166MHz band) after 8 hours, for a 10μJy source at 1100MHz with an spectral index of -0.7 (Table 7). $\overline{SNR10} = \sqrt{SNR10^2_{650} + SNR10^2_{800} + SNR10^2_{1100}}$.
- Hours required to reach a mean SNR of 10 (Table 8).

3 Results

[3]The weights for the taper are generated using a Butterworth function.

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.65	1.33	2.33	3.35	803.08	0.60	1.33	2.35	3.34	792.32	0.59	1.33	2.35	3.35	763.61
SKA1W9-12A54B90	0.85	1.29	2.32	3.34	794.44	0.81	1.24	2.35	3.33	790.43	0.69	1.28	2.34	3.33	767.45
SKA1W9-12A60B100	0.84	1.25	2.32	3.33	796.90	0.77	1.23	2.36	3.34	789.93	0.64	1.30	2.34	3.34	767.82
SKA1W9-12A72B120	0.78	1.22	2.35	3.35	798.73	0.70	1.28	2.35	3.32	790.38	0.57	1.32	2.32	3.33	763.27
SKA1W9-12A80B133	0.74	1.25	2.34	3.32	797.36	0.65	1.30	2.36	3.28	790.65	0.54	1.32	2.30	3.33	767.22

(a) DEC=-10, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.73	1.22	2.25	3.26	745.23	0.62	1.21	2.24	3.25	791.85	0.53	1.19	2.24	3.26	761.50
SKA1W9-12A54B90	0.96	1.22	2.23	3.25	732.34	0.78	1.16	2.23	3.25	790.56	0.59	1.15	2.24	3.25	766.98
SKA1W9-12A60B100	0.88	1.19	2.23	3.25	735.91	0.72	1.16	2.24	3.25	789.78	0.57	1.16	2.24	3.25	767.31
SKA1W9-12A72B120	0.77	1.16	2.24	3.25	736.00	0.64	1.15	2.24	3.25	790.19	0.53	1.17	2.23	3.25	761.79
SKA1W9-12A80B133	0.71	1.16	2.24	3.25	734.91	0.61	1.15	2.23	3.25	790.41	0.51	1.17	2.23	3.26	766.24

(b) DEC=-10, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	1.03	1.33	2.27	3.27	745.23	0.98	1.31	2.27	3.26	791.85	0.94	1.29	2.26	3.26	761.50
SKA1W9-12A54B90	1.15	1.31	2.25	3.26	732.34	1.02	1.26	2.25	3.26	790.56	0.91	1.25	2.26	3.26	766.98
SKA1W9-12A60B100	1.09	1.28	2.25	3.26	735.91	0.98	1.25	2.26	3.26	789.78	0.89	1.26	2.26	3.26	767.31
SKA1W9-12A72B120	1.01	1.26	2.26	3.26	736.00	0.93	1.25	2.26	3.26	790.19	0.87	1.26	2.25	3.26	761.79
SKA1W9-12A80B133	0.98	1.25	2.26	3.25	734.91	0.91	1.25	2.26	3.25	790.41	0.87	1.27	2.25	3.27	766.24

(c) DEC=-10, robust-2 weighting with a 1 arcsec Gaussian taper

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.65	1.34	2.35	3.37	797.29	0.60	1.33	2.35	3.34	790.58	0.59	1.33	2.35	3.35	759.20
SKA1W9-12A54B90	0.87	1.27	2.35	3.35	788.73	0.81	1.22	2.35	3.33	791.56	0.68	1.30	2.34	3.34	761.56
SKA1W9-12A60B100	0.85	1.24	2.34	3.33	790.37	0.77	1.22	2.36	3.35	790.15	0.63	1.31	2.34	3.33	762.26
SKA1W9-12A72B120	0.78	1.22	2.37	3.35	792.88	0.69	1.29	2.34	3.31	790.22	0.56	1.33	2.32	3.34	752.20
SKA1W9-12A80B133	0.74	1.27	2.34	3.33	791.02	0.64	1.31	2.36	3.28	790.01	0.53	1.33	2.30	3.34	762.18

(d) DEC=-30, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.71	1.21	2.24	3.26	737.52	0.60	1.19	2.24	3.24	789.76	0.51	1.18	2.24	3.25	757.10
SKA1W9-12A54B90	0.93	1.19	2.23	3.25	729.39	0.76	1.15	2.24	3.25	791.60	0.58	1.14	2.23	3.25	760.62
SKA1W9-12A60B100	0.86	1.17	2.23	3.25	729.56	0.70	1.14	2.24	3.25	789.93	0.55	1.15	2.23	3.25	761.36
SKA1W9-12A72B120	0.75	1.15	2.24	3.25	732.45	0.63	1.14	2.23	3.24	789.92	0.52	1.16	2.22	3.25	750.82
SKA1W9-12A80B133	0.70	1.14	2.23	3.24	729.42	0.60	1.15	2.24	3.24	789.70	0.50	1.16	2.23	3.26	761.07

(e) DEC=-30, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	1.02	1.31	2.26	3.26	737.52	0.97	1.29	2.27	3.25	789.76	0.93	1.28	2.26	3.26	757.10
SKA1W9-12A54B90	1.13	1.29	2.25	3.26	729.39	1.00	1.25	2.26	3.26	791.60	0.90	1.25	2.25	3.26	760.62
SKA1W9-12A60B100	1.07	1.26	2.25	3.26	729.56	0.97	1.25	2.26	3.26	789.93	0.89	1.25	2.26	3.25	761.36
SKA1W9-12A72B120	1.00	1.25	2.26	3.26	732.45	0.92	1.24	2.25	3.25	789.92	0.87	1.26	2.25	3.26	750.82
SKA1W9-12A80B133	0.96	1.25	2.26	3.25	729.42	0.90	1.25	2.26	3.25	789.70	0.87	1.26	2.25	3.27	761.07

(f) DEC=-30, robust-2 weighting with a 1 arcsec Gaussian taper

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.65	1.34	2.34	3.35	799.83	0.60	1.33	2.36	3.34	789.57	0.58	1.33	2.34	3.36	763.91
SKA1W9-12A54B90	0.87	1.27	2.34	3.33	793.72	0.81	1.22	2.35	3.33	786.93	0.68	1.31	2.34	3.34	761.27
SKA1W9-12A60B100	0.85	1.24	2.33	3.33	796.94	0.77	1.22	2.36	3.34	787.46	0.64	1.32	2.34	3.34	761.29
SKA1W9-12A72B120	0.79	1.22	2.35	3.34	796.68	0.70	1.28	2.35	3.32	786.41	0.56	1.33	2.32	3.34	756.61
SKA1W9-12A80B133	0.74	1.26	2.33	3.32	796.20	0.65	1.31	2.36	3.27	786.28	0.53	1.33	2.29	3.34	762.58

(g) DEC=-50, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.71	1.21	2.24	3.26	743.31	0.60	1.19	2.24	3.25	788.86	0.51	1.17	2.24	3.25	762.04
SKA1W9-12A54B90	0.94	1.19	2.23	3.25	735.05	0.77	1.15	2.23	3.25	786.91	0.58	1.14	2.23	3.25	760.90
SKA1W9-12A60B100	0.87	1.16	2.23	3.25	738.92	0.71	1.15	2.23	3.25	787.29	0.56	1.15	2.24	3.25	760.87
SKA1W9-12A72B120	0.76	1.15	2.24	3.25	741.45	0.63	1.14	2.23	3.24	786.27	0.52	1.16	2.23	3.25	756.20
SKA1W9-12A80B133	0.70	1.14	2.23	3.24	737.83	0.60	1.15	2.23	3.24	786.08	0.50	1.16	2.23	3.26	762.15

(h) DEC=-50, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	1.02	1.31	2.26	3.27	743.31	0.97	1.29	2.26	3.26	788.86	0.92	1.27	2.26	3.26	762.04
SKA1W9-12A54B90	1.14	1.28	2.25	3.26	735.05	1.01	1.25	2.26	3.26	786.91	0.90	1.24	2.25	3.26	760.90
SKA1W9-12A60B100	1.08	1.26	2.25	3.26	738.92	0.97	1.25	2.26	3.26	787.29	0.89	1.25	2.26	3.26	760.87
SKA1W9-12A72B120	1.00	1.25	2.26	3.26	741.45	0.92	1.24	2.25	3.25	786.27	0.87	1.26	2.25	3.25	756.20
SKA1W9-12A80B133	0.97	1.24	2.26	3.25	737.83	0.90	1.25	2.25	3.25	786.08	0.87	1.26	2.25	3.27	762.15

(i) DEC=-50, robust-2 weighting with a 1 arcsec Gaussian taper

Table 2: FWHM PSF sizes (in arcseconds) for the different layouts at different scales. These values are generated at 650, 800 and 1100MHz, for angular scales {0.4-1, 1-2, 2-3, 3-4, 600-3600} arcsec labeled as *resbin* {1, 2, 3, 4, 5} respectively. This is doner for natural, robust-2 weighting and robust-2 weighting with a 1 arcsec Gaussian taper, at declinations -10, -30 and -50 degrees. For each column, the intensity of the color increases with the value.

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.05	0.02	0.04	0.07	0.00	0.06	0.06	0.02	0.06	0.03	0.06	0.02	0.07	0.03	0.05
SKA1W9-12A54B90	0.04	0.05	0.05	0.05	0.01	0.06	0.05	0.01	0.06	0.02	0.06	0.03	0.05	0.02	0.02
SKA1W9-12A60B100	0.05	0.05	0.03	0.04	0.01	0.05	0.07	0.00	0.07	0.03	0.06	0.03	0.08	0.01	0.02
SKA1W9-12A72B120	0.05	0.03	0.05	0.06	0.00	0.06	0.06	0.01	0.06	0.03	0.05	0.00	0.06	0.01	0.01
SKA1W9-12A80B133	0.06	0.00	0.04	0.04	0.01	0.05	0.06	0.01	0.06	0.02	0.06	0.01	0.07	0.02	0.03

(a) DEC=-10, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.07	0.01	0.00	0.01	0.01	0.07	0.02	0.01	0.00	0.03	0.06	0.00	0.00	0.00	0.05
SKA1W9-12A54B90	0.07	0.04	0.01	0.00	0.00	0.07	0.02	0.01	0.00	0.02	0.07	0.00	0.00	0.00	0.02
SKA1W9-12A60B100	0.07	0.04	0.01	0.00	0.01	0.07	0.01	0.01	0.00	0.03	0.06	0.00	0.00	0.00	0.02
SKA1W9-12A72B120	0.06	0.02	0.00	0.00	0.01	0.07	0.00	0.01	0.00	0.03	0.04	0.01	0.00	0.00	0.01
SKA1W9-12A80B133	0.06	0.01	0.00	0.00	0.00	0.06	0.00	0.01	0.01	0.02	0.04	0.00	0.01	0.00	0.03

(b) DEC=-10, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.05	0.02	0.00	0.01	0.01	0.04	0.02	0.01	0.00	0.03	0.03	0.00	0.00	0.00	0.05
SKA1W9-12A54B90	0.05	0.03	0.01	0.00	0.00	0.04	0.01	0.01	0.00	0.02	0.02	0.00	0.00	0.00	0.02
SKA1W9-12A60B100	0.05	0.03	0.01	0.00	0.01	0.04	0.01	0.01	0.00	0.03	0.02	0.00	0.00	0.00	0.02
SKA1W9-12A72B120	0.04	0.01	0.00	0.00	0.01	0.03	0.00	0.01	0.00	0.03	0.01	0.01	0.00	0.00	0.01
SKA1W9-12A80B133	0.03	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.03

(c) DEC=-10, robust-2 weighting with a 1 arcsec Gaussian taper

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.13	0.07	0.08	0.06	0.02	0.09	0.08	0.06	0.08	0.03	0.06	0.08	0.06	0.05	0.07
SKA1W9-12A54B90	0.20	0.09	0.03	0.07	0.03	0.17	0.03	0.08	0.06	0.01	0.12	0.02	0.07	0.06	0.03
SKA1W9-12A60B100	0.19	0.06	0.06	0.08	0.03	0.15	0.00	0.07	0.07	0.03	0.12	0.05	0.07	0.04	0.04
SKA1W9-12A72B120	0.16	0.01	0.05	0.06	0.02	0.13	0.00	0.07	0.06	0.03	0.11	0.06	0.05	0.04	0.04
SKA1W9-12A80B133	0.14	0.02	0.06	0.08	0.03	0.12	0.03	0.07	0.01	0.02	0.08	0.07	0.06	0.04	0.04

(d) DEC=-30, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.12	0.04	0.02	0.01	0.05	0.11	0.03	0.00	0.01	0.03	0.07	0.02	0.00	0.01	0.07
SKA1W9-12A54B90	0.10	0.03	0.00	0.00	0.02	0.10	0.02	0.00	0.01	0.01	0.08	0.01	0.01	0.00	0.04
SKA1W9-12A60B100	0.10	0.03	0.01	0.01	0.04	0.10	0.02	0.00	0.00	0.03	0.07	0.01	0.01	0.01	0.04
SKA1W9-12A72B120	0.10	0.01	0.01	0.00	0.03	0.10	0.01	0.01	0.01	0.03	0.06	0.00	0.01	0.00	0.04
SKA1W9-12A80B133	0.11	0.01	0.01	0.00	0.04	0.09	0.00	0.00	0.00	0.02	0.06	0.01	0.01	0.00	0.05

(e) DEC=-30, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.07	0.04	0.02	0.01	0.05	0.05	0.03	0.00	0.01	0.03	0.03	0.02	0.00	0.01	0.07
SKA1W9-12A54B90	0.06	0.02	0.00	0.00	0.02	0.04	0.01	0.00	0.01	0.01	0.02	0.01	0.01	0.00	0.04
SKA1W9-12A60B100	0.05	0.02	0.01	0.01	0.04	0.04	0.01	0.00	0.00	0.03	0.02	0.00	0.01	0.01	0.04
SKA1W9-12A72B120	0.05	0.01	0.01	0.00	0.03	0.03	0.01	0.01	0.01	0.03	0.01	0.00	0.01	0.00	0.04
SKA1W9-12A80B133	0.05	0.01	0.01	0.00	0.04	0.03	0.00	0.00	0.00	0.02	0.01	0.01	0.01	0.00	0.05

(f) DEC=-30, robust-2 weighting with a 1 arcsec Gaussian taper

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.11	0.04	0.06	0.02	0.02	0.10	0.07	0.07	0.08	0.03	0.06	0.05	0.06	0.03	0.08
SKA1W9-12A54B90	0.16	0.08	0.04	0.04	0.01	0.13	0.04	0.05	0.07	0.04	0.10	0.03	0.07	0.02	0.06
SKA1W9-12A60B100	0.16	0.04	0.05	0.04	0.01	0.12	0.02	0.07	0.08	0.06	0.10	0.02	0.07	0.02	0.06
SKA1W9-12A72B120	0.14	0.01	0.04	0.03	0.01	0.10	0.00	0.05	0.07	0.06	0.09	0.04	0.06	0.02	0.03
SKA1W9-12A80B133	0.12	0.04	0.05	0.04	0.01	0.10	0.03	0.06	0.03	0.05	0.07	0.04	0.05	0.03	0.07

(g) DEC=-50, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.08	0.03	0.01	0.00	0.02	0.08	0.01	0.00	0.01	0.03	0.04	0.01	0.00	0.00	0.08
SKA1W9-12A54B90	0.07	0.01	0.01	0.01	0.00	0.07	0.01	0.00	0.00	0.04	0.06	0.01	0.01	0.01	0.06
SKA1W9-12A60B100	0.08	0.02	0.00	0.00	0.01	0.08	0.01	0.00	0.00	0.06	0.05	0.01	0.00	0.00	0.06
SKA1W9-12A72B120	0.08	0.02	0.00	0.01	0.02	0.07	0.01	0.00	0.00	0.06	0.04	0.00	0.01	0.01	0.03
SKA1W9-12A80B133	0.08	0.01	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.05	0.04	0.01	0.00	0.00	0.07

(h) DEC=-50, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	0.04	0.02	0.01	0.00	0.02	0.03	0.01	0.00	0.01	0.03	0.02	0.01	0.00	0.00	0.08
SKA1W9-12A54B90	0.04	0.01	0.00	0.01	0.00	0.03	0.01	0.00	0.00	0.04	0.01	0.01	0.00	0.01	0.06
SKA1W9-12A60B100	0.04	0.01	0.00	0.00	0.01	0.03	0.01	0.00	0.00	0.06	0.01	0.00	0.00	0.00	0.06
SKA1W9-12A72B120	0.03	0.01	0.00	0.01	0.02	0.02	0.00	0.00	0.00	0.06	0.01	0.00	0.01	0.01	0.03
SKA1W9-12A80B133	0.03	0.01	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.05	0.00	0.01	0.00	0.00	0.07

(i) DEC=-50, robust-2 weighting with a 1 arcsec Gaussian taper

Table 3: PSF symmetry (see section 2) for the different layouts at different scales. These values are generate at 650, 800 and 1100MHz, for angular scales {0.4-1, 1-2, 2-3, 3-4, 600-3600} arcsec labeled as *resbin* {1, 2, 3, 4, 5} respectively. This is done for natural, robust-2 weighting and robust-2 weighting with a 1 arcsec Gaussian taper, at declinations -10, -30, and -50 degrees. For each column, the intensity of the color increases with the value.

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	2.80	3.00	3.90	4.70	9.60	2.60	2.90	3.90	4.80	12.00	2.50	3.00	4.00	4.70	17.00
SKA1W9-12A54B90	3.50	1.80	3.40	4.30	10.00	2.30	2.00	3.70	4.50	13.00	1.80	2.50	3.80	4.40	18.00
SKA1W9-12A60B100	2.80	1.90	3.60	4.40	10.00	2.00	2.20	3.70	4.60	13.00	1.70	2.70	3.80	4.60	18.00
SKA1W9-12A72B120	2.10	2.10	3.70	4.40	10.00	1.80	2.50	3.80	4.80	12.00	1.70	2.80	4.00	5.30	18.00
SKA1W9-12A80B133	1.90	2.30	3.80	4.60	10.00	1.80	2.70	3.90	5.10	13.00	1.70	2.80	4.10	5.40	18.00

(a) DEC=-10, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	3.20	3.90	5.10	5.50	9.40	3.20	4.10	5.00	5.30	12.00	3.20	4.20	4.60	4.80	17.00
SKA1W9-12A54B90	3.30	2.80	3.70	4.80	9.80	3.20	2.50	4.10	4.70	13.00	3.10	2.70	4.00	4.40	18.00
SKA1W9-12A60B100	3.10	2.50	4.10	4.80	9.80	3.00	2.60	4.30	4.80	13.00	2.90	3.10	4.20	4.60	18.00
SKA1W9-12A72B120	2.80	2.60	4.60	5.20	9.80	2.70	2.90	4.60	5.20	12.00	2.60	3.70	4.40	5.40	18.00
SKA1W9-12A80B133	2.60	2.70	4.70	5.30	9.80	2.60	3.20	4.70	5.50	13.00	2.40	3.90	4.70	5.80	18.00

(b) DEC=-10, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	3.10	3.70	5.00	5.50	9.40	3.00	3.80	4.90	5.30	12.00	3.10	3.90	4.50	4.80	17.00
SKA1W9-12A54B90	2.50	2.50	3.60	4.80	9.80	2.30	2.40	4.10	4.70	13.00	2.10	2.70	3.90	4.40	18.00
SKA1W9-12A60B100	2.40	2.40	4.00	4.80	9.80	2.20	2.50	4.20	4.80	13.00	2.20	3.00	4.10	4.60	18.00
SKA1W9-12A72B120	2.30	2.60	4.50	5.20	9.80	2.30	2.90	4.50	5.20	12.00	2.50	3.40	4.30	5.40	18.00
SKA1W9-12A80B133	2.20	2.70	4.70	5.30	9.80	2.40	3.20	4.60	5.50	13.00	2.60	3.60	4.60	5.80	18.00

(c) DEC=-10, robust-2 weighting with a 1 arcsec Gaussian taper

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	2.80	3.00	3.90	4.80	10.00	2.50	3.00	4.10	4.70	13.00	2.60	2.90	4.10	4.80	18.00
SKA1W9-12A54B90	3.30	1.80	3.60	4.40	11.00	2.20	2.00	3.70	4.50	14.00	1.80	2.60	3.70	4.40	20.00
SKA1W9-12A60B100	2.60	1.90	3.70	4.40	11.00	1.90	2.20	3.70	4.50	14.00	1.70	2.80	3.80	4.70	20.00
SKA1W9-12A72B120	2.00	2.20	3.70	4.50	11.00	1.80	2.70	3.80	4.80	13.00	1.60	2.80	4.00	5.30	19.00
SKA1W9-12A80B133	1.80	2.50	3.70	4.50	11.00	1.70	2.70	3.80	5.30	14.00	1.70	2.90	4.20	5.50	19.00

(d) DEC=-30, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	3.00	3.70	4.70	5.00	9.70	2.90	3.90	4.50	4.80	13.00	3.10	3.90	4.20	4.50	19.00
SKA1W9-12A54B90	3.10	2.40	3.80	4.40	10.00	3.10	2.20	3.90	4.40	14.00	2.90	2.70	3.80	4.10	20.00
SKA1W9-12A60B100	2.90	2.20	4.00	4.60	11.00	2.80	2.30	4.00	4.40	14.00	2.70	3.10	3.80	4.30	20.00
SKA1W9-12A72B120	2.60	2.40	4.30	4.60	11.00	2.60	2.90	4.10	4.90	13.00	2.40	3.40	4.10	5.10	19.00
SKA1W9-12A80B133	2.50	2.60	4.40	4.80	11.00	2.40	3.20	4.30	5.10	14.00	2.30	3.60	4.30	5.60	19.00

(e) DEC=-30, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	2.80	3.50	4.60	4.90	9.70	2.80	3.60	4.50	4.80	13.00	2.90	3.50	4.20	4.40	19.00
SKA1W9-12A54B90	2.20	2.20	3.70	4.40	10.00	2.10	2.20	3.80	4.30	14.00	2.00	2.60	3.70	4.10	20.00
SKA1W9-12A60B100	2.10	2.20	4.00	4.60	11.00	2.00	2.40	3.90	4.40	14.00	2.00	2.90	3.80	4.30	20.00
SKA1W9-12A72B120	2.10	2.40	4.20	4.60	11.00	2.10	2.80	4.10	4.80	13.00	2.30	3.20	4.10	5.10	19.00
SKA1W9-12A80B133	2.10	2.60	4.30	4.80	11.00	2.20	3.00	4.20	5.10	14.00	2.40	3.30	4.30	5.60	19.00

(f) DEC=-30, robust-2 weighting with a 1 arcsec Gaussian taper

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	2.80	3.00	3.90	4.80	10.00	2.60	2.90	4.10	4.80	13.00	2.50	3.00	4.00	4.70	18.00
SKA1W9-12A54B90	3.40	1.80	3.50	4.40	11.00	2.30	2.00	3.70	4.50	13.00	1.80	2.70	3.70	4.40	19.00
SKA1W9-12A60B100	2.70	1.90	3.60	4.40	11.00	2.00	2.20	3.70	4.50	13.00	1.70	2.80	3.80	4.70	19.00
SKA1W9-12A72B120	2.00	2.20	3.60	4.60	11.00	1.70	2.60	3.80	4.70	13.00	1.60	2.80	4.00	5.40	19.00
SKA1W9-12A80B133	1.90	2.40	3.70	4.50	11.00	1.70	2.70	3.80	5.20	13.00	1.70	2.90	4.20	5.40	19.00

(g) DEC=-50, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	3.00	3.60	4.50	4.80	9.90	2.90	3.70	4.30	4.70	13.00	3.00	3.80	4.10	4.30	18.00
SKA1W9-12A54B90	3.00	2.40	3.60	4.30	10.00	3.00	2.10	3.70	4.10	13.00	2.90	2.60	3.60	4.00	19.00
SKA1W9-12A60B100	2.90	2.20	3.90	4.50	10.00	2.80	2.30	3.80	4.30	13.00	2.70	3.00	3.70	4.20	19.00
SKA1W9-12A72B120	2.60	2.30	4.00	4.50	10.00	2.50	2.80	3.90	4.60	13.00	2.40	3.40	4.00	5.00	19.00
SKA1W9-12A80B133	2.40	2.60	4.20	4.70	10.00	2.40	3.10	4.10	5.00	13.00	2.20	3.50	4.10	5.50	19.00

(h) DEC=-50, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	2.80	3.40	4.50	4.70	9.90	2.80	3.50	4.30	4.70	13.00	2.80	3.40	4.00	4.30	18.00
SKA1W9-12A54B90	2.20	2.20	3.60	4.20	10.00	2.00	2.10	3.60	4.10	13.00	1.90	2.50	3.50	4.00	19.00
SKA1W9-12A60B100	2.10	2.10	3.80	4.40	10.00	2.00	2.30	3.80	4.20	13.00	2.00	2.80	3.60	4.20	19.00
SKA1W9-12A72B120	2.00	2.40	3.90	4.50	10.00	2.00	2.70	3.90	4.60	13.00	2.20	3.10	3.90	5.00	19.00
SKA1W9-12A80B133	2.10	2.60	4.10	4.70	10.00	2.20	3.00	4.00	5.00	13.00	2.40	3.20	4.10	5.50	19.00

(i) DEC=-50, robust-2 weighting with a 1 arcsec Gaussian taper

Table 4: Noise (in μJy) for a 50MHz band after an 8hr synthesis with a 60s integration for the differenr layouts at different scales. These values are generated at 650, 800 and 1100 MHz, at angular scales {0.4-1, 1-2, 2-3, 3-4, 600-3600} arcsec labeled as *resbin* {1, 2, 3, 4, 5} respectively. This is done for natural, robust-2 weighting and robust-2 weighting with a 1 arcsec Gaussian taper, at declinations -10, -30 and -50 degrees. For each column, the intensity of the color increases with the value.

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	1.60	1.70	2.20	2.60	5.30	1.40	1.60	2.10	2.60	6.60	1.40	1.60	2.20	2.60	9.50
SKA1W9-12A54B90	1.90	0.98	1.90	2.40	5.50	1.30	1.10	2.00	2.40	7.10	0.99	1.40	2.10	2.40	10.00
SKA1W9-12A60B100	1.50	1.00	2.00	2.40	5.60	1.10	1.20	2.00	2.50	6.90	0.94	1.50	2.10	2.50	10.00
SKA1W9-12A72B120	1.20	1.20	2.00	2.40	5.50	0.99	1.40	2.10	2.60	6.80	0.91	1.50	2.20	2.90	10.00
SKA1W9-12A80B133	1.10	1.30	2.10	2.50	5.50	0.98	1.50	2.10	2.80	6.90	0.91	1.60	2.30	2.90	10.00

(a) DEC=-10, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	1.80	2.10	2.80	3.00	5.20	1.70	2.20	2.70	2.90	6.60	1.80	2.30	2.50	2.60	9.50
SKA1W9-12A54B90	1.80	1.50	2.00	2.60	5.40	1.80	1.40	2.30	2.60	7.10	1.70	1.50	2.20	2.40	10.00
SKA1W9-12A60B100	1.70	1.40	2.20	2.60	5.40	1.70	1.40	2.40	2.70	6.90	1.60	1.70	2.30	2.50	10.00
SKA1W9-12A72B120	1.50	1.40	2.50	2.90	5.40	1.50	1.60	2.50	2.90	6.80	1.40	2.00	2.40	3.00	10.00
SKA1W9-12A80B133	1.40	1.50	2.60	2.90	5.40	1.40	1.80	2.60	3.00	6.90	1.30	2.10	2.60	3.20	10.00

(b) DEC=-10, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	1.70	2.00	2.70	3.00	5.20	1.70	2.10	2.70	2.90	6.60	1.70	2.10	2.50	2.60	9.50
SKA1W9-12A54B90	1.40	1.40	2.00	2.60	5.40	1.30	1.30	2.30	2.60	7.10	1.20	1.50	2.20	2.40	10.00
SKA1W9-12A60B100	1.30	1.30	2.20	2.60	5.40	1.20	1.40	2.30	2.60	6.90	1.20	1.60	2.30	2.50	10.00
SKA1W9-12A72B120	1.20	1.40	2.50	2.80	5.40	1.20	1.60	2.50	2.90	6.80	1.30	1.90	2.40	3.00	10.00
SKA1W9-12A80B133	1.20	1.50	2.60	2.90	5.40	1.30	1.70	2.50	3.00	6.90	1.40	2.00	2.50	3.20	10.00

(c) DEC=-10, robust-2 weighting with a 1 arcsec Gaussian taper

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	1.50	1.60	2.20	2.60	5.50	1.40	1.60	2.20	2.60	7.10	1.40	1.60	2.20	2.60	10.00
SKA1W9-12A54B90	1.80	0.97	2.00	2.40	5.90	1.20	1.10	2.00	2.50	7.50	0.97	1.40	2.00	2.40	11.00
SKA1W9-12A60B100	1.40	1.00	2.00	2.40	5.90	1.10	1.20	2.10	2.50	7.50	0.92	1.50	2.10	2.60	11.00
SKA1W9-12A72B120	1.10	1.20	2.00	2.50	5.90	0.96	1.50	2.10	2.60	7.40	0.90	1.60	2.20	2.90	10.00
SKA1W9-12A80B133	1.00	1.30	2.00	2.50	5.90	0.94	1.50	2.10	2.90	7.50	0.93	1.60	2.30	3.00	11.00

(d) DEC=-30, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	1.70	2.00	2.60	2.70	5.30	1.60	2.10	2.50	2.70	7.10	1.70	2.10	2.30	2.50	10.00
SKA1W9-12A54B90	1.70	1.30	2.10	2.40	5.70	1.70	1.20	2.10	2.40	7.50	1.60	1.50	2.10	2.30	11.00
SKA1W9-12A60B100	1.60	1.20	2.20	2.50	5.80	1.60	1.30	2.20	2.40	7.50	1.50	1.70	2.10	2.40	11.00
SKA1W9-12A72B120	1.40	1.30	2.30	2.50	5.80	1.40	1.60	2.30	2.70	7.40	1.30	1.90	2.20	2.80	10.00
SKA1W9-12A80B133	1.30	1.40	2.40	2.70	5.80	1.30	1.70	2.40	2.80	7.50	1.20	2.00	2.40	3.10	11.00

(e) DEC=-30, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	1.60	1.90	2.50	2.70	5.30	1.50	2.00	2.40	2.60	7.10	1.60	1.90	2.30	2.40	10.00
SKA1W9-12A54B90	1.20	1.20	2.10	2.40	5.70	1.10	1.20	2.10	2.40	7.50	1.10	1.40	2.00	2.20	11.00
SKA1W9-12A60B100	1.10	1.20	2.20	2.50	5.80	1.10	1.30	2.10	2.40	7.50	1.10	1.60	2.10	2.40	11.00
SKA1W9-12A72B120	1.10	1.30	2.30	2.50	5.80	1.20	1.50	2.20	2.70	7.40	1.30	1.70	2.20	2.80	10.00
SKA1W9-12A80B133	1.20	1.40	2.40	2.60	5.80	1.20	1.70	2.30	2.80	7.50	1.30	1.80	2.40	3.10	11.00

(f) DEC=-30, robust-2 weighting with a 1 arcsec Gaussian taper

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	1.60	1.60	2.10	2.60	5.50	1.40	1.60	2.20	2.60	7.00	1.40	1.70	2.20	2.60	10.00
SKA1W9-12A54B90	1.80	0.98	1.90	2.40	5.90	1.20	1.10	2.00	2.50	7.30	0.98	1.50	2.10	2.40	11.00
SKA1W9-12A60B100	1.50	1.00	2.00	2.40	5.90	1.10	1.20	2.00	2.50	7.40	0.94	1.50	2.10	2.60	11.00
SKA1W9-12A72B120	1.10	1.20	2.00	2.50	5.80	0.96	1.40	2.10	2.60	7.30	0.90	1.50	2.20	2.90	10.00
SKA1W9-12A80B133	1.00	1.30	2.10	2.50	5.90	0.94	1.50	2.10	2.90	7.30	0.92	1.60	2.30	3.00	10.00

(g) DEC=-50, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	1.60	2.00	2.50	2.60	5.50	1.60	2.10	2.40	2.60	7.00	1.70	2.10	2.20	2.40	10.00
SKA1W9-12A54B90	1.70	1.30	2.00	2.30	5.70	1.70	1.20	2.00	2.30	7.30	1.60	1.40	2.00	2.20	11.00
SKA1W9-12A60B100	1.60	1.20	2.10	2.40	5.70	1.60	1.20	2.10	2.30	7.40	1.50	1.70	2.00	2.30	11.00
SKA1W9-12A72B120	1.40	1.30	2.20	2.50	5.60	1.40	1.50	2.20	2.50	7.30	1.30	1.80	2.20	2.70	10.00
SKA1W9-12A80B133	1.30	1.40	2.30	2.60	5.70	1.30	1.70	2.20	2.70	7.30	1.20	1.90	2.30	3.00	10.00

(h) DEC=-50, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	1.50	1.90	2.40	2.60	5.50	1.50	1.90	2.30	2.60	7.00	1.50	1.90	2.20	2.40	10.00
SKA1W9-12A54B90	1.20	1.20	2.00	2.30	5.70	1.10	1.20	2.00	2.30	7.30	1.10	1.40	1.90	2.20	11.00
SKA1W9-12A60B100	1.10	1.20	2.10	2.40	5.70	1.10	1.30	2.10	2.30	7.40	1.10	1.60	2.00	2.30	11.00
SKA1W9-12A72B120	1.10	1.30	2.20	2.50	5.60	1.10	1.50	2.10	2.50	7.30	1.20	1.70	2.10	2.70	10.00
SKA1W9-12A80B133	1.10	1.40	2.30	2.60	5.70	1.20	1.60	2.20	2.70	7.30	1.30	1.80	2.30	3.00	10.00

(i) DEC=-50, robust-2 weighting with a 1 arcsec Gaussian taper

Table 5: Noise (in μJy) for a 166MHz band after an 8hr synthesis with a 60s integration for the different layouts at different scales. These values are generated at 650, 800 and 1100 MHz, at angular scales {0.4-1, 1-2, 2-3, 3-4, 600-3600} arcsec labeled as *resbin* {1, 2, 3, 4, 5} respectively. This is done for natural, robust-2 weighting and robust-2 weighting with a 1 arcsec Gaussian taper, at declinations -10, -30 and -50 degrees. For each column, the intensity of the color increases with the value.

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	9.26	8.76	6.68	5.63	2.73	8.79	7.79	5.84	4.77	1.89	7.26	6.08	4.55	3.87	1.06
SKA1W9-12A54B90	7.54	14.75	7.73	6.15	2.61	9.78	11.51	6.13	5.12	1.77	10.12	7.26	4.85	4.11	0.99
SKA1W9-12A60B100	9.55	14.12	7.31	6.04	2.60	11.25	10.55	6.11	4.98	1.80	10.67	6.82	4.82	3.93	0.99
SKA1W9-12A72B120	12.44	12.53	7.14	5.92	2.61	12.60	9.01	5.97	4.76	1.83	10.99	6.56	4.59	3.46	0.99
SKA1W9-12A80B133	13.65	11.36	7.01	5.78	2.61	12.80	8.56	5.89	4.43	1.80	11.03	6.40	4.41	3.40	1.00

(a) DEC=-10, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	8.11	6.72	5.21	4.77	2.79	7.18	5.61	4.55	4.31	1.89	5.62	4.30	3.96	3.80	1.05
SKA1W9-12A54B90	8.07	9.47	7.18	5.51	2.68	7.02	9.08	5.49	4.87	1.77	5.92	6.65	4.58	4.14	0.99
SKA1W9-12A60B100	8.59	10.35	6.50	5.46	2.69	7.53	8.82	5.29	4.71	1.80	6.29	5.83	4.35	3.98	0.99
SKA1W9-12A72B120	9.53	10.15	5.77	5.05	2.69	8.40	7.79	4.99	4.36	1.83	7.11	4.97	4.17	3.37	1.00
SKA1W9-12A80B133	10.06	9.66	5.55	4.97	2.69	8.90	7.04	4.86	4.14	1.80	7.50	4.70	3.89	3.12	1.00

(b) DEC=-10, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	8.59	7.11	5.27	4.79	2.79	7.47	5.99	4.61	4.33	1.89	5.83	4.70	4.02	3.83	1.05
SKA1W9-12A54B90	10.49	10.53	7.22	5.53	2.68	9.77	9.42	5.55	4.89	1.77	8.59	6.84	4.65	4.16	0.99
SKA1W9-12A60B100	11.16	10.86	6.56	5.48	2.69	10.15	8.97	5.36	4.72	1.80	8.18	6.13	4.42	4.00	0.99
SKA1W9-12A72B120	11.70	10.14	5.84	5.07	2.69	10.08	7.84	5.06	4.37	1.83	7.41	5.34	4.22	3.38	1.00
SKA1W9-12A80B133	11.83	9.58	5.63	4.99	2.69	9.65	7.19	4.93	4.14	1.80	7.06	5.06	3.92	3.14	1.00

(c) DEC=-10, robust-2 weighting with a 1 arcsec Gaussian taper

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	9.39	8.90	6.72	5.49	2.63	9.00	7.70	5.60	4.82	1.77	7.11	6.18	4.45	3.83	0.99
SKA1W9-12A54B90	8.00	14.87	7.40	6.03	2.45	10.16	11.11	6.19	5.05	1.67	10.34	6.94	4.88	4.13	0.93
SKA1W9-12A60B100	10.16	14.04	7.21	5.94	2.43	11.71	10.20	6.10	5.04	1.67	10.88	6.61	4.81	3.88	0.93
SKA1W9-12A72B120	13.24	12.11	7.11	5.86	2.47	12.98	8.58	6.02	4.72	1.69	11.11	6.45	4.53	3.44	0.96
SKA1W9-12A80B133	14.24	10.73	7.08	5.82	2.45	13.26	8.32	5.97	4.30	1.66	10.74	6.38	4.35	3.34	0.94

(d) DEC=-30, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	8.73	7.17	5.61	5.31	2.71	7.75	5.91	5.03	4.71	1.77	5.92	4.66	4.30	4.07	0.98
SKA1W9-12A54B90	8.47	10.85	6.94	5.98	2.53	7.46	10.36	5.87	5.21	1.67	6.22	6.68	4.83	4.42	0.93
SKA1W9-12A60B100	9.16	11.83	6.54	5.73	2.48	8.03	9.74	5.74	5.14	1.67	6.72	5.93	4.75	4.20	0.93
SKA1W9-12A72B120	10.15	10.95	6.17	5.67	2.51	8.87	7.97	5.53	4.68	1.69	7.55	5.29	4.44	3.55	0.96
SKA1W9-12A80B133	10.72	10.05	6.05	5.45	2.50	9.52	7.16	5.31	4.44	1.66	8.08	5.08	4.22	3.25	0.94

(e) DEC=-30, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	9.32	7.62	5.70	5.33	2.71	8.06	6.38	5.11	4.73	1.77	6.36	5.15	4.38	4.10	0.98
SKA1W9-12A54B90	11.73	11.91	7.03	6.00	2.53	10.92	10.38	5.96	5.24	1.67	9.16	6.91	4.90	4.45	0.93
SKA1W9-12A60B100	12.75	12.18	6.63	5.76	2.48	11.31	9.62	5.82	5.16	1.67	8.90	6.31	4.83	4.22	0.93
SKA1W9-12A72B120	12.76	10.81	6.26	5.69	2.51	10.62	8.08	5.60	4.70	1.69	7.86	5.73	4.50	3.57	0.96
SKA1W9-12A80B133	12.44	9.97	6.14	5.46	2.50	10.34	7.50	5.39	4.45	1.66	7.53	5.53	4.25	3.27	0.94

(f) DEC=-30, robust-2 weighting with a 1 arcsec Gaussian taper

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	9.28	8.81	6.81	5.51	2.61	8.85	7.81	5.62	4.75	1.79	7.15	6.00	4.53	3.89	1.00
SKA1W9-12A54B90	7.83	14.68	7.46	5.98	2.46	10.10	11.28	6.15	5.10	1.70	10.22	6.84	4.87	4.12	0.95
SKA1W9-12A60B100	9.87	13.98	7.24	5.92	2.47	11.50	10.27	6.17	5.05	1.69	10.65	6.54	4.83	3.90	0.95
SKA1W9-12A72B120	13.06	12.19	7.23	5.79	2.49	13.02	8.74	5.98	4.80	1.71	11.10	6.49	4.57	3.39	0.95
SKA1W9-12A80B133	14.23	10.76	7.03	5.82	2.47	13.26	8.30	6.00	4.34	1.71	10.82	6.35	4.34	3.35	0.95

(g) DEC=-50, natural weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	8.85	7.22	5.81	5.52	2.65	7.75	6.07	5.24	4.85	1.79	6.04	4.77	4.48	4.20	1.00
SKA1W9-12A54B90	8.70	10.96	7.27	6.19	2.54	7.50	10.72	6.17	5.53	1.70	6.22	6.92	5.06	4.58	0.95
SKA1W9-12A60B100	9.23	12.08	6.77	5.90	2.55	8.03	10.08	5.95	5.35	1.69	6.72	6.00	4.92	4.31	0.95
SKA1W9-12A72B120	10.23	11.26	6.58	5.84	2.57	9.06	8.26	5.80	4.95	1.71	7.68	5.43	4.61	3.64	0.95
SKA1W9-12A80B133	10.82	10.26	6.29	5.57	2.56	9.58	7.25	5.57	4.58	1.72	8.15	5.20	4.40	3.30	0.95

(h) DEC=-50, robust-2 weighting

	650MHz					800MHz					1100MHz				
resbin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SKA1REF2	9.37	7.72	5.90	5.55	2.65	8.15	6.60	5.32	4.87	1.79	6.48	5.31	4.56	4.23	1.00
SKA1W9-12A54B90	12.09	12.22	7.36	6.22	2.54	11.27	10.72	6.26	5.55	1.70	9.49	7.18	5.15	4.61	0.95
SKA1W9-12A60B100	12.60	12.44	6.86	5.93	2.55	11.49	9.94	6.04	5.37	1.69	9.04	6.42	5.00	4.33	0.95
SKA1W9-12A72B120	12.98	11.13	6.68	5.86	2.57	11.21	8.41	5.88	4.96	1.71	8.10	5.94	4.67	3.66	0.95
SKA1W9-12A80B133	12.64	10.17	6.39	5.59	2.56	10.46	7.64	5.65	4.58	1.72	7.66	5.71	4.43	3.32	0.95

(i) DEC=-50, robust-2 weighting with a 1 arcsec Gaussian taper

Table 6: SNR after 8 hours relative to a 10μJy source at 1100Hz (166 MHz band) with a spectral index of -0.7 for the different layouts. These values are generated at 650, 800 and 1100 MHz, at angular scales {0.4-1, 1-2, 2-3, 3-4, 600-3600} arcsec labeled as *resbin* {1, 2, 3, 4, 5} respectively. This is done for natural, robust-2 weighting and robust-2 weighting with a 1 arcsec Gaussian taper, at declinations -10, -30 and -50 degrees. For each column, the intensity of the color increases with the value.

resbin	1	2	3	4	5
SKA1REF2	14.68	13.21	9.97	8.34	3.49
SKA1W9-12A54B90	15.97	20.07	10.99	8.99	3.30
SKA1W9-12A60B100	18.21	18.90	10.68	8.75	3.31
SKA1W9-12A72B120	20.84	16.77	10.38	8.35	3.34
SKA1W9-12A80B133	21.72	15.60	10.16	8.04	3.33

(a) DEC=-10, natural weighting

resbin	1	2	3	4	5
SKA1REF2	12.21	9.76	7.96	7.47	3.53
SKA1W9-12A54B90	12.22	14.71	10.13	8.44	3.36
SKA1W9-12A60B100	13.04	14.80	9.44	8.23	3.39
SKA1W9-12A72B120	14.56	13.72	8.69	7.47	3.40
SKA1W9-12A80B133	15.38	12.85	8.34	7.18	3.39

(b) DEC=-10, robust-2 weighting

resbin	1	2	3	4	5
SKA1REF2	12.79	10.42	8.08	7.50	3.53
SKA1W9-12A54B90	16.71	15.70	10.22	8.48	3.36
SKA1W9-12A60B100	17.16	15.36	9.55	8.26	3.39
SKA1W9-12A72B120	17.12	13.88	8.80	7.50	3.40
SKA1W9-12A80B133	16.82	13.00	8.45	7.20	3.39

(c) DEC=-10, robust-2 weighting with a 1 arcsec Gaussian taper

resbin	1	2	3	4	5
SKA1REF2	14.82	13.29	9.82	8.26	3.32
SKA1W9-12A54B90	16.55	19.82	10.81	8.89	3.10
SKA1W9-12A60B100	18.94	18.57	10.60	8.70	3.09
SKA1W9-12A72B120	21.61	16.18	10.35	8.27	3.14
SKA1W9-12A80B133	22.22	15.00	10.23	7.97	3.11

(d) DEC=-30, natural weighting

resbin	1	2	3	4	5
SKA1REF2	13.09	10.39	8.68	8.19	3.38
SKA1W9-12A54B90	12.89	16.42	10.29	9.08	3.16
SKA1W9-12A60B100	13.91	16.43	9.92	8.77	3.13
SKA1W9-12A72B120	15.46	14.54	9.40	8.16	3.17
SKA1W9-12A80B133	16.45	13.35	9.09	7.74	3.15

(e) DEC=-30, robust-2 weighting

resbin	1	2	3	4	5
SKA1REF2	13.87	11.19	8.82	8.22	3.38
SKA1W9-12A54B90	18.46	17.25	10.43	9.13	3.16
SKA1W9-12A60B100	19.22	16.75	10.06	8.81	3.13
SKA1W9-12A72B120	18.37	14.66	9.53	8.19	3.17
SKA1W9-12A80B133	17.84	13.64	9.21	7.76	3.15

(f) DEC=-30, robust-2 weighting with a 1 arcsec Gaussian taper

resbin	1	2	3	4	5
SKA1REF2	14.68	13.22	9.92	8.25	3.32
SKA1W9-12A54B90	16.36	19.74	10.83	8.87	3.14
SKA1W9-12A60B100	18.52	18.54	10.67	8.70	3.14
SKA1W9-12A72B120	21.52	16.35	10.44	8.25	3.17
SKA1W9-12A80B133	22.26	15.00	10.21	7.99	3.15

(g) DEC=-50, natural weighting

resbin	1	2	3	4	5
SKA1REF2	13.23	10.57	9.01	8.47	3.35
SKA1W9-12A54B90	13.06	16.82	10.80	9.48	3.20
SKA1W9-12A60B100	13.96	16.84	10.27	9.06	3.20
SKA1W9-12A72B120	15.67	14.98	9.91	8.47	3.23
SKA1W9-12A80B133	16.59	13.60	9.48	7.93	3.22

(h) DEC=-50, robust-2 weighting

resbin	1	2	3	4	5
SKA1REF2	14.01	11.46	9.17	8.51	3.35
SKA1W9-12A54B90	19.06	17.77	10.95	9.52	3.20
SKA1W9-12A60B100	19.30	17.16	10.42	9.10	3.20
SKA1W9-12A72B120	18.97	15.17	10.05	8.51	3.23
SKA1W9-12A80B133	18.11	13.94	9.61	7.95	3.22

(i) DEC=-50, robust-2 weighting with a 1 arcsec Gaussian taper

Table 7: SNR after 8 hours relative to a 10μJy source at 1100Hz (166 MHz band) with a spectral index of -0.7 averaged over 650,800 and 1100MHz, for the different layouts at different scales. These values are generated for angular scales $\{$0.4-1, 1-2, 2-3, 3-4, 600-3600$\}$ arcsec labeled as *resbin* $\{$1, 2, 3, 4, 5$\}$ respectively. This is done for natural, robust-2 weighting and robust-2 weighting with a 1 arcsec Gaussian taper, at declinations -10, -30 and -50 degrees. For each column, the intensity of the color increases with the value.

resbin	1	2	3	4	5
SKA1REF2	3.71	4.59	8.05	11.51	65.86
SKA1W9-12A54B90	3.14	1.99	6.62	9.90	73.43
SKA1W9-12A60B100	2.41	2.24	7.01	10.44	73.03
SKA1W9-12A72B120	1.84	2.84	7.43	11.49	71.91
SKA1W9-12A80B133	1.70	3.29	7.75	12.39	72.29

(a) DEC=-10, natural weighting

resbin	1	2	3	4	5
SKA1REF2	5.37	8.40	12.61	14.35	64.11
SKA1W9-12A54B90	5.36	3.70	7.79	11.24	70.72
SKA1W9-12A60B100	4.70	3.65	8.97	11.81	69.78
SKA1W9-12A72B120	3.77	4.25	10.59	14.33	69.11
SKA1W9-12A80B133	3.38	4.85	11.50	15.50	69.51

(b) DEC=-10, robust-2 weighting

resbin	1	2	3	4	5
SKA1REF2	4.89	7.37	12.26	14.21	64.11
SKA1W9-12A54B90	2.86	3.25	7.65	11.13	70.72
SKA1W9-12A60B100	2.72	3.39	8.76	11.72	69.78
SKA1W9-12A72B120	2.73	4.15	10.33	14.22	69.11
SKA1W9-12A80B133	2.83	4.73	11.21	15.41	69.51

(c) DEC=-10, robust-2 weighting with a 1 arcsec Gaussian taper

resbin	1	2	3	4	5
SKA1REF2	3.64	4.53	8.30	11.74	72.62
SKA1W9-12A54B90	2.92	2.04	6.84	10.13	83.09
SKA1W9-12A60B100	2.23	2.32	7.12	10.56	83.64
SKA1W9-12A72B120	1.71	3.06	7.46	11.69	80.96
SKA1W9-12A80B133	1.62	3.56	7.64	12.60	82.83

(d) DEC=-30, natural weighting

resbin	1	2	3	4	5
SKA1REF2	4.67	7.41	10.62	11.94	70.03
SKA1W9-12A54B90	4.81	2.97	7.55	9.70	79.88
SKA1W9-12A60B100	4.13	2.96	8.13	10.41	81.88
SKA1W9-12A72B120	3.35	3.78	9.06	12.00	79.41
SKA1W9-12A80B133	2.96	4.49	9.68	13.34	80.61

(e) DEC=-30, robust-2 weighting

resbin	1	2	3	4	5
SKA1REF2	4.16	6.39	10.28	11.83	70.03
SKA1W9-12A54B90	2.35	2.69	7.35	9.61	79.88
SKA1W9-12A60B100	2.16	2.85	7.91	10.32	81.88
SKA1W9-12A72B120	2.37	3.72	8.81	11.92	79.41
SKA1W9-12A80B133	2.51	4.30	9.43	13.27	80.61

(f) DEC=-30, robust-2 weighting with a 1 arcsec Gaussian taper

resbin	1	2	3	4	5
SKA1REF2	3.71	4.58	8.13	11.74	72.69
SKA1W9-12A54B90	2.99	2.05	6.82	10.16	81.22
SKA1W9-12A60B100	2.33	2.33	7.03	10.57	81.28
SKA1W9-12A72B120	1.73	2.99	7.34	11.75	79.77
SKA1W9-12A80B133	1.61	3.55	7.67	12.52	80.49

(g) DEC=-50, natural weighting

resbin	1	2	3	4	5
SKA1REF2	4.57	7.16	9.85	11.16	71.37
SKA1W9-12A54B90	4.69	2.83	6.86	8.91	78.12
SKA1W9-12A60B100	4.11	2.82	7.59	9.75	77.96
SKA1W9-12A72B120	3.26	3.56	8.14	11.14	76.50
SKA1W9-12A80B133	2.91	4.33	8.90	12.73	77.06

(h) DEC=-50, robust-2 weighting

resbin	1	2	3	4	5
SKA1REF2	4.08	6.09	9.52	11.05	71.37
SKA1W9-12A54B90	2.20	2.53	6.67	8.82	78.12
SKA1W9-12A60B100	2.15	2.72	7.37	9.67	77.96
SKA1W9-12A72B120	2.22	3.48	7.92	11.06	76.50
SKA1W9-12A80B133	2.44	4.12	8.67	12.65	77.06

(i) DEC=-50, robust-2 weighting with a 1 arcsec Gaussian taper

Table 8: The hours required to reach a mean SNR of 10 (average over 650,800 and 1100MHz), assuming a 10μJy source at 1100MHz with a spectral index of -0.7 for the different layouts at different scales. These values are generated for angular scales {0.4-1, 1-2, 2-3, 3-4, 600-3600} arcsec labeled as *resbin* {1, 2, 3, 4, 5} respectively. This is done forr natural, robust-2 weighting and robust-2 weighting with a 1 arcsec Gaussian taper, at declinations -10, -30 and -50 degrees. For each column, the intensity of the color increases with the value.

4 Conclusions

The metrics we have used suggest that the science goals (at least those listed in the SRD) can be met by a layout which covers significantly less space compared to the baseline layout. Some of these "smaller" layouts perform better than the baseline layout at smaller scales, up to a 50% improvement in terms of the noise properties, while not compromising the larger scales. This obviously presents an opportunity to reduce trenching and data transport costs. Moreover, bringing in the dishes further out translates to a greater sensitivity on the relevant (to the science goals of SKA1-Mid) smaller scales, as can be seen in Tables 4-8. Even more encouraging is the fact that this doesn't compromise the size or the symmetry of the PSF as seen in Tables 2 and 3.

References

[1] http://www.skatelescope.org/wp-content/uploads/2013/05/SKA-TEL-SKO-DD-001-1_BaselineDesign1.pdf

[2] https://www.skatelescope.org/wp-content/uploads/2014/03/SKA-TEL_SCI-SKO-SRQ-001-1_Level_0_Requirements-1.pdf

A PSF cross-sections

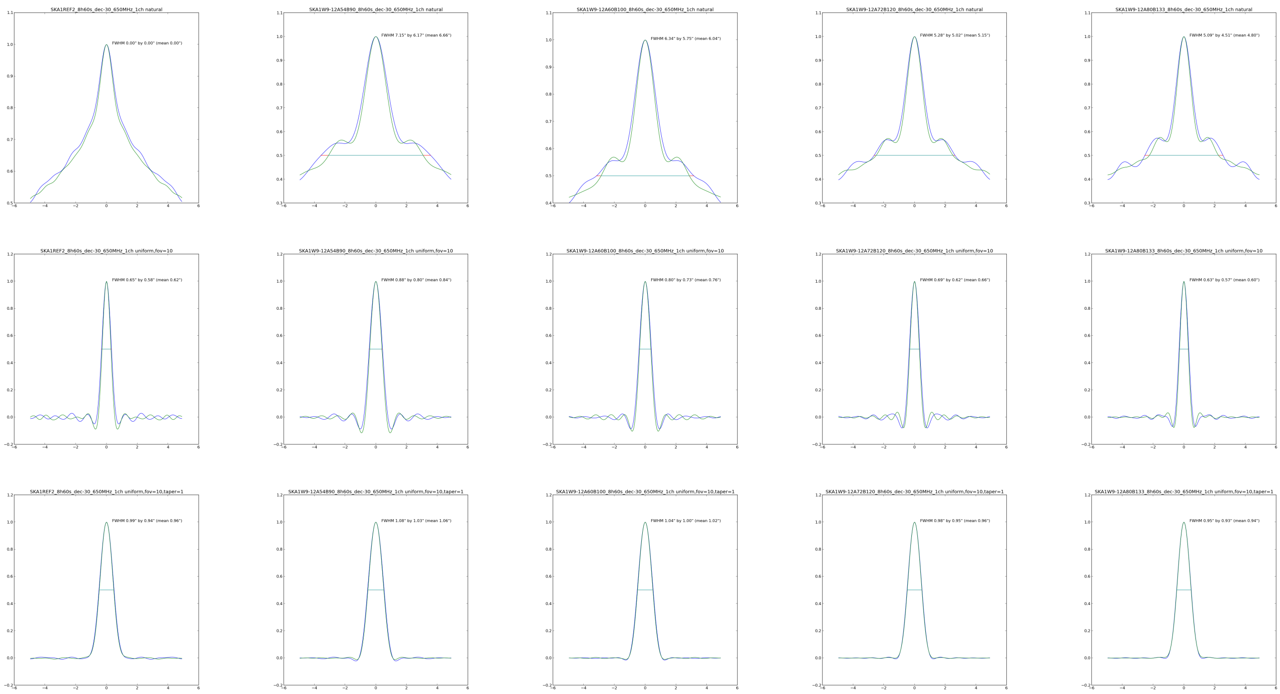

Figure 4: PSF cross-sections at Dec=-30 deg, Freq=650MHz. Row 1 and 2 are for natural and uniform weighting respectively, and row 3 is for uniform weighting with a 1 arcsec Gaussian taper. The blue and and green curves are cross-sections along l and m respectively, and the horizontal line marks the FWHM of the Gaussian fit. FWHM parameters are included in the plot.

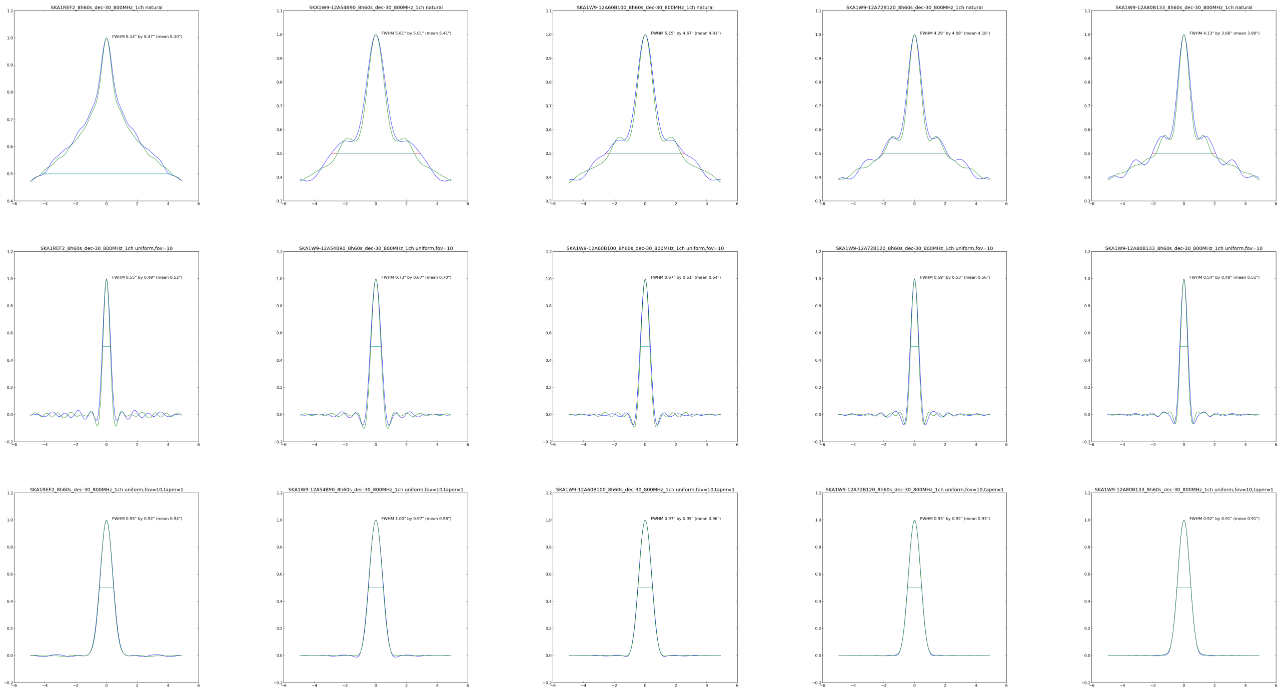

Figure 5: PSF cross-sections at Dec=-30 deg, Freq=800MHz. Row 1 and 2 are for natural and uniform weighting respectively, and row 3 is for uniform weighting with a 1 arcsec Gaussian taper. The blue and and green curves are cross-sections along l and m respectively, and the horizontal line marks the FWHM of the Gaussian fit. FWHM parameters are included in the plot.

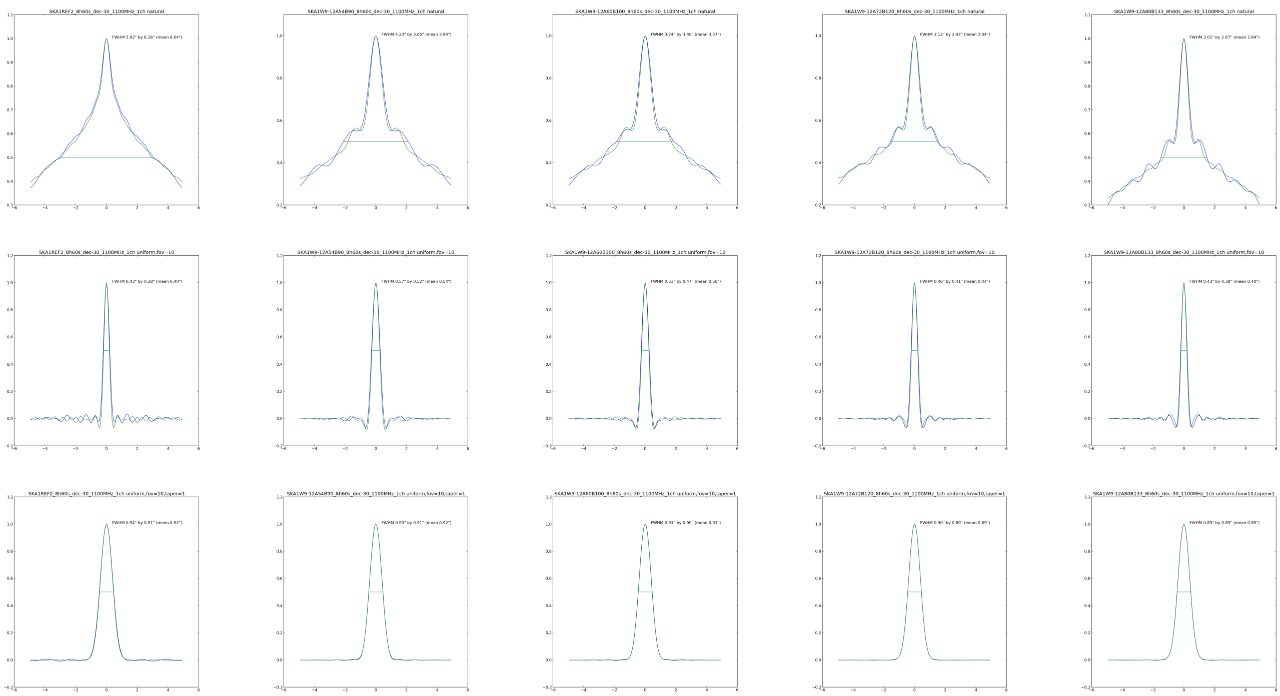

Figure 6: PSF cross-sections at Dec=-30 deg, Freq=1100MHz. Row 1 and 2 are for natural and uniform weighting respectively, and row 3 is for uniform weighting with a 1 arcsec Gaussian taper. The blue and and green curves are cross-sections along l and m respectively, and the horizontal line marks the FWHM of the Gaussian fit. FWHM parameters are included in the plot.