For SKA antennas, the efficiency is 80-90% from ~1-15 GHz. It drops off at the low-frequency end because the sub-reflector becomes electrically small, and at the high end when reflector surface errors become larger than ~λ/30. Noise at the extreme ends of the frequency range arises mainly from sky background (see Figure 6). Between 1 and 20 GHz, noise arises from the front-end amplifiers and increases with frequency.

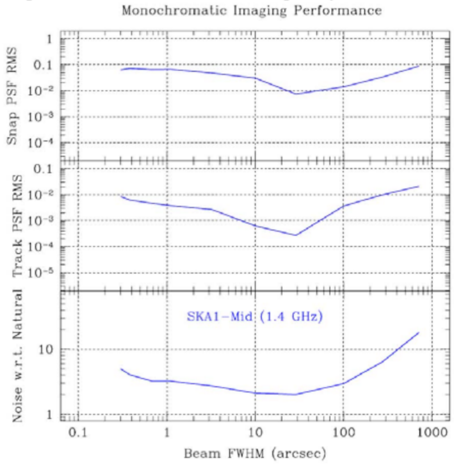

Figure 7: Beam performance at 1.4 GHz for a single frequency, equivalent to a typical spectral line observation. Bottom: The ratio of noise on an image to the minimum attainable (with natural weighting) as a function of beamsize. Middle: The ratio of rms sidelobe level to the peak of the beam for an 8-hr track. Top: The ratio of rms sidelobe level to the peak of the beam for a zenith snapshot observation.

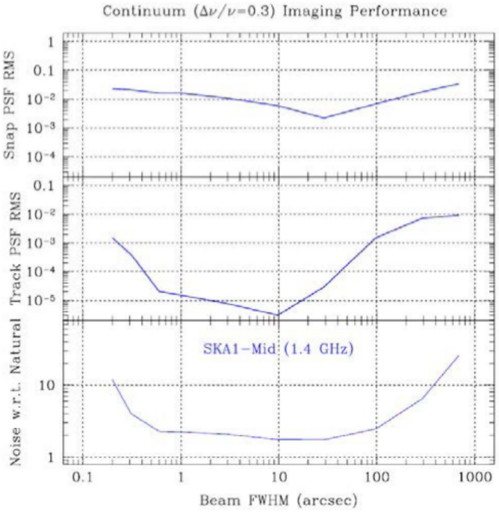

Figure 8: Similar to Figure 7, except that the bandwidth ratio is similar to that expected for a typical continuum observation.

Figure 7 and Figure 8 are plots of three measures of beam quality. The quality of the synthesised beam can be characterised by its rms sidelobe level for a given sensitivity (A_e/T_{sys}). The metric used here is the side-lobe level in the central 10x10 beam areas around the synthesised beam (PSF). The primary drivers are the distribution of collecting area (array configuration) and the duration of tracking. Almost as important is the fractional bandwidth being sampled, which for continuum observations can be very large, but cannot be considered for spectral line observations. In addition, the visibility weights used in forming the beam, which can be applied post-observation, are also important. However, there is always a trade-off between signal-to-noise ratio and beam-shape. Unweighted *u*-*v* samples (so-called natural weighting) produce the highest signal-to-noise, but a rather poorly shaped beam. The visibility data weighting method employed for the illustration is so-called "uniform" weighting, followed by a Gaussian visibility taper to yield the specified PSF diameter.

5. Systematic Errors

Many of the most challenging science programs will require very long integration times – a target of 1000 hr has been set. The essential test of this is whether fluctuations on images and in the spectral domain are reduced in amplitude as $\sqrt{\tau}$, where τ is the integration time (i.e., limited only by 'natural' sources of noise, not instrumental errors). For spectral-line and continuum imaging applications, this applies at the full resolution over the full field-of-view across the full range of frequencies. Similarly challenging requirements exist in the time domain.

In general the aperture synthesis technique is robust because correlation tends to suppress independent errors arising from different array elements. Also phase and amplitude 'closure' rules enhance robustness. Nevertheless errors that that add coherently over time tend to be those that are inherent in the design. Accordingly a significant part of the design effort is devoted to identifying sources of error and to providing 'budgets' to distribute allocations across the system. Antenna optics, pointing, path length, and 'design for calibration and modeling' and examples of this work.

6. Acknowledgements

The huge number of engineers, scientists and others working on the design of the SKA telescopes are acknowledged here. This paper is possibly the smallest possible description of one telescope, and cannot possibly do justice to all those contributions.