Dynamic range of the SKA images: source between pixels

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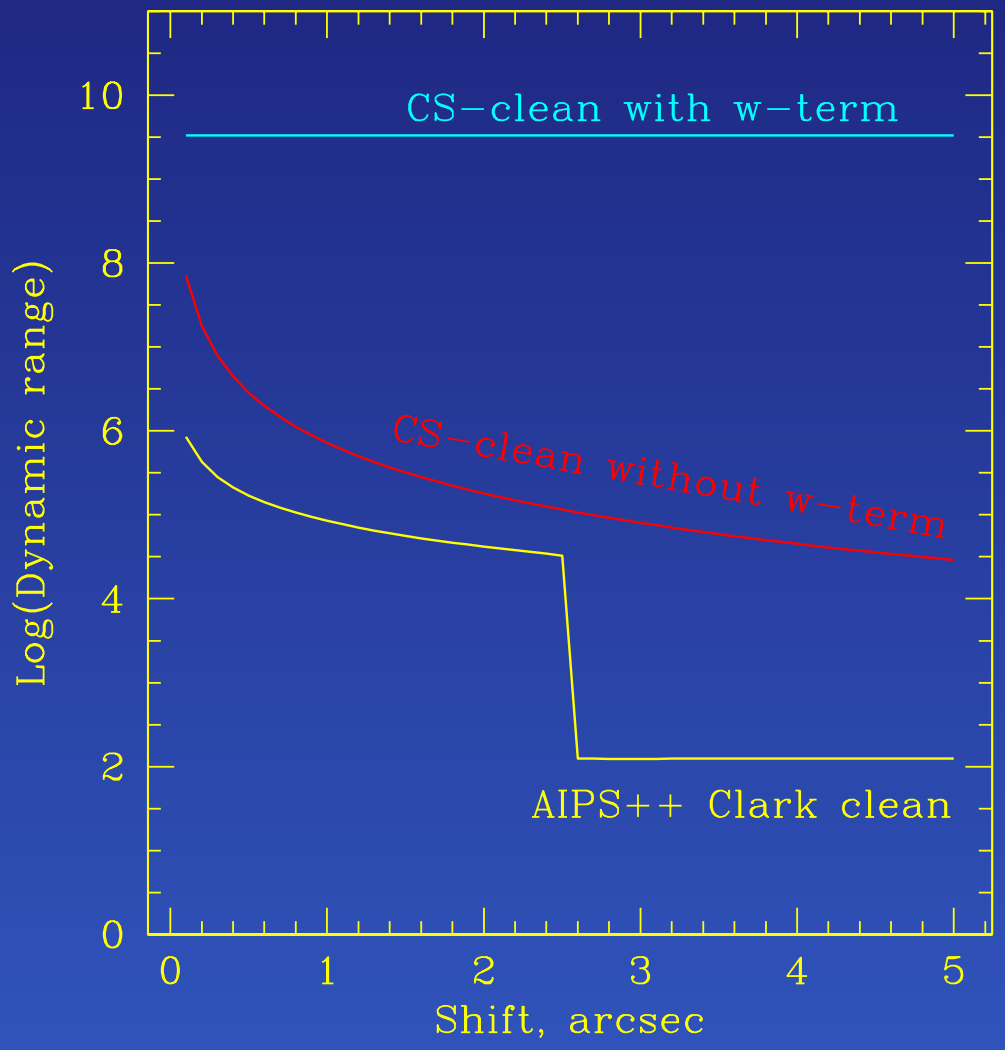
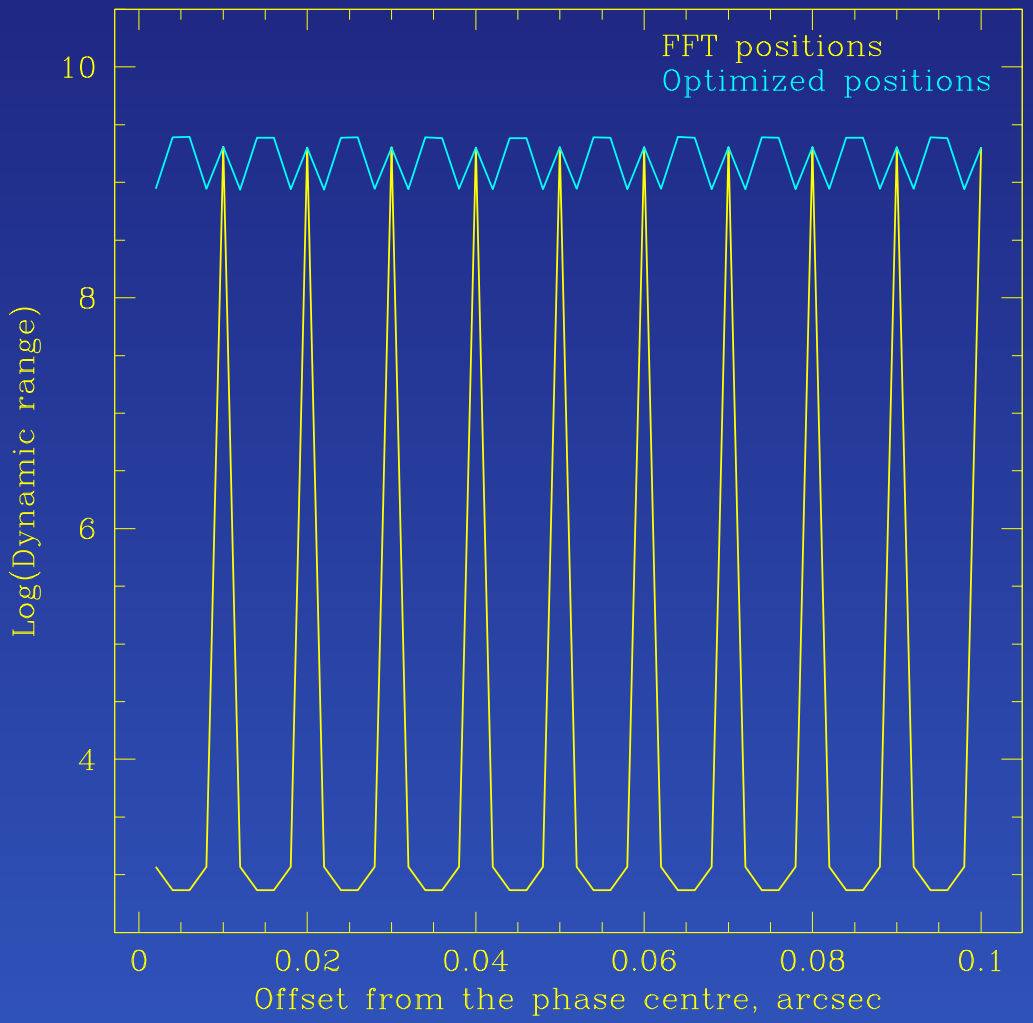
Abstract. We present the result of simulations aimed at understanding the limit of dynamic range of SKA images achievable with the Cotton-Schwab clean. All simulations have been done for simple sky brightness models comprising one or a few point sources. A spiral station layout (SKA concept description, June 2002) and a snapshot observation have been assumed. We studied the dynamic range loss when the sources were not located on grid points. A modification of the Cotton-Schwab clean, where a better peak position is found by optimization of the Discrete Fourier Transform near the maximum of the current residual image, showed an excellent performance.

Results reported in Geraldton



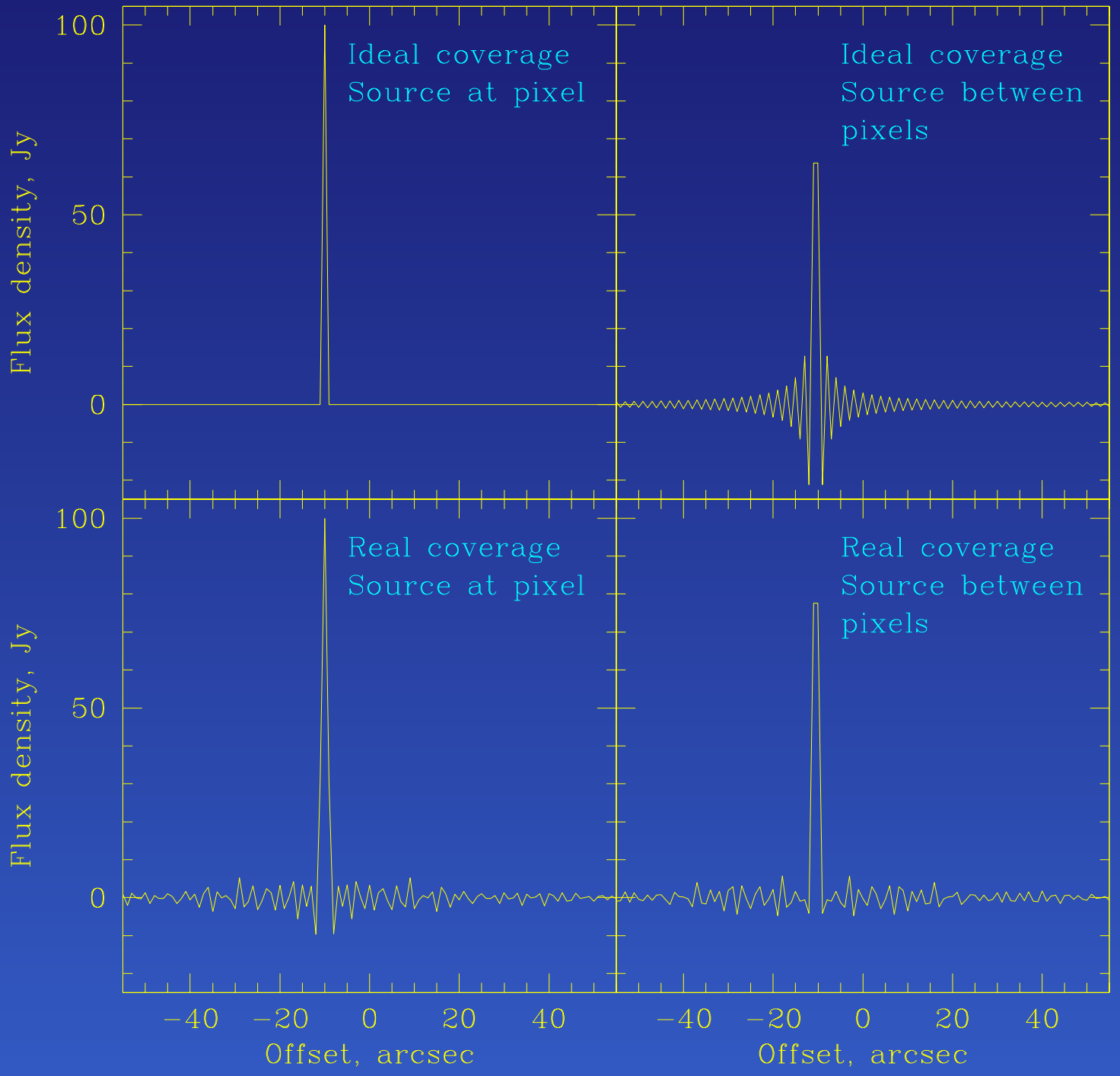
- Model is a point source offset from the phase centre
- The dynamic range decreases mostly due to w-term
- The step produced by the Clark Clean represents the inner quarter of the image
- The Cotton-Schwab clean can provide a flat dependence

Source between pixel

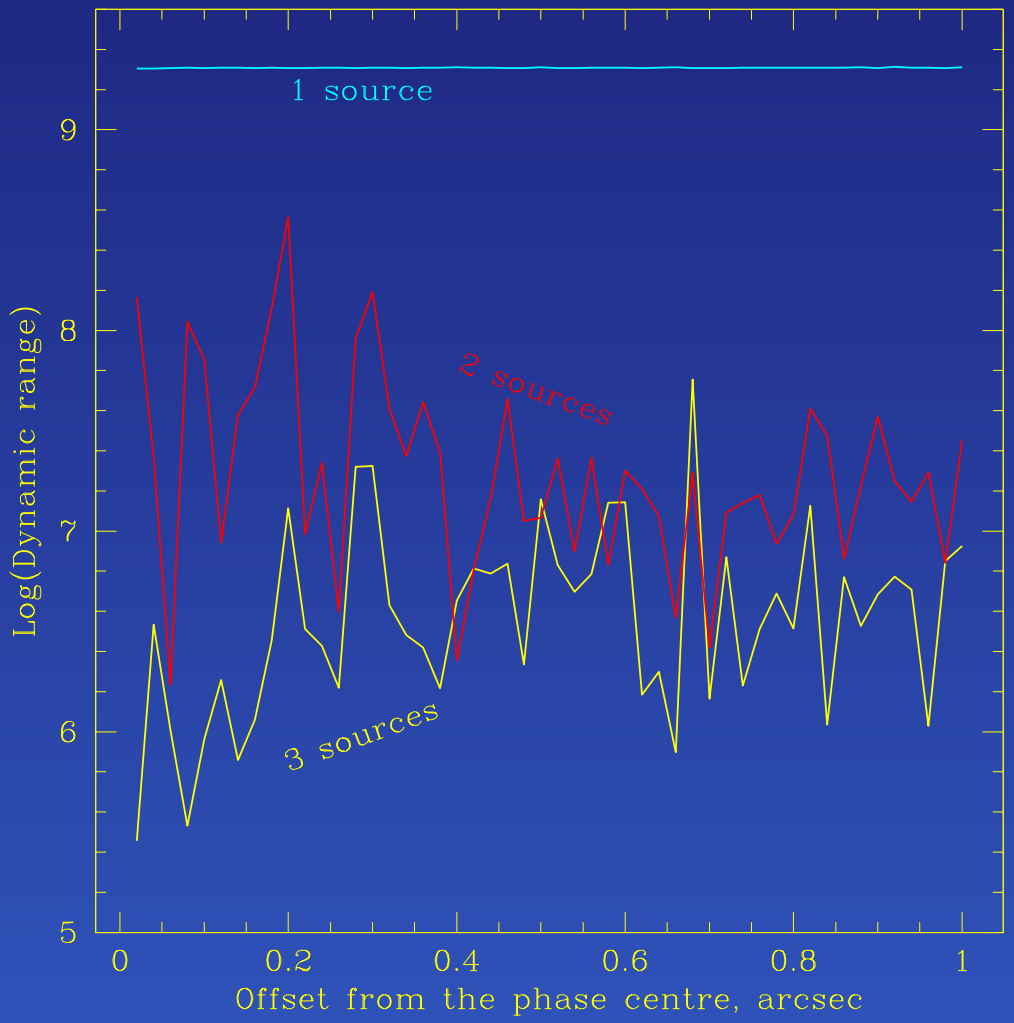


- The dynamic range is low when the source is between pixels
- We need many harmonics to reproduce the signal which is not periodic at a given sampling interval
- The problem can be solved if we introduce the optimization of the peak position found by FFT

1-D

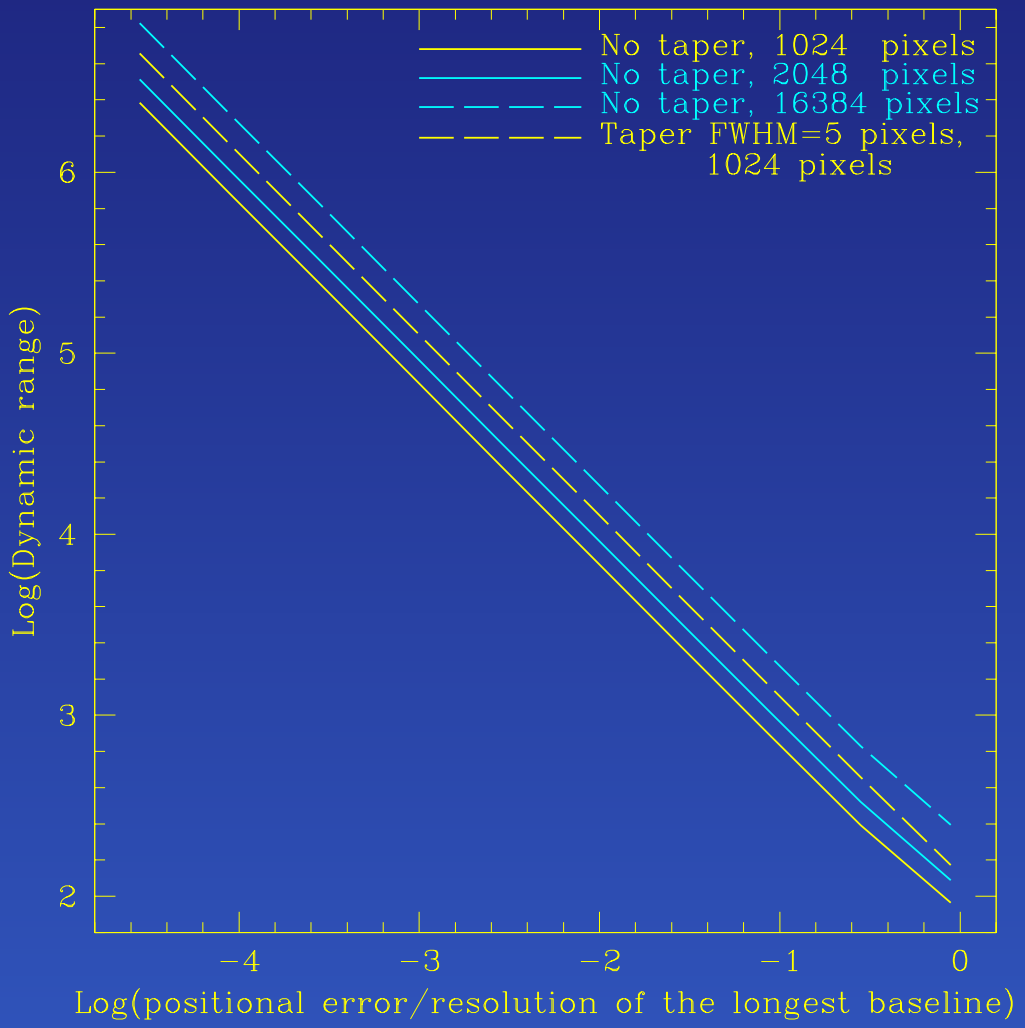

Ideal coverage
Source at pixel
Ideal coverage
Source between pixels
Real coverage
Source at pixel
Real coverage
Source between pixels
Flux density, Jy
Flux density, Jy
100
50
0
100
50
0
−40
−20
0
20
40
−40
−20
0
20
40
Offset, arcsec
Offset, arcsec

Source between pixel



- One source: offset in declination
- Two sources: both are offset in declination, one at 3”, another at a given quantity
- Three sources: one has 3” offset in right ascension, two others are offset in the opposite directions in declination at a given quantity

Error in the component position



- Due to positional error residual emission does not vanish
- Different cell (and image) sizes and tapering do not considerably improve the situation
- Variance of the gradient of the PSF should be minimized instead of PSF itself

Conclusions

- The Cotton-Schwab clean with the model taking into account the w-term can produce the dynamic range $> 10^6$ if the source is centered at the image pixel
- If the optimization of the clean component position is added it can give such a high dynamic range even if the source is located between image pixels
- With the weights taken into consideration such algorithm works well for a few point sources in the field
- Algorithm allowing both signs of the flux of clean components is superior over that with only positive signs
- The accuracy of the clean component position should be better than 10^{-4} of the resolution of the largest baseline if one wants to reach a dynamic range as high as 10^6.
- The variance of the gradient of the PSF should be optimized