SKA Configurations Design

Rob Millenaar

Overview

- Introduction
  - The Task Force
  - Purpose
  - Methods
- Configuration Design
  - Topics for study
  - Practical constraints

Introduction

The Task Force

The work is done in WP3, by the Configurations Task Force (CTF), which is one of the task forces of the Site Characterisation Working Group (SCWG).

Core team:

- Rosie Bolton
- Anna Scaife
- Mattieu de Villiers
- Rob Millenaar
- Plus many advisors

Purpose

- PrepSKA assignment #1 (WP3.5): ‘Study ideal configurations for the SKA and determine single configuration that optimises for total return from KSP’s. Match ideal configuration to geographical realities...’
- PrepSKA assignment #2 (WP3.7): ‘Investigate infrastructure deployment cost…’
- Bottom line: Configurations will have to be designed, fit for costing, the results of which will be fed into the site selection process.

Methods

The CTF has chosen following approach:

- Consider the KSP, Memo 100, DRM and work already done for the site bids of 2005
- Use science requirements primarily to drive the designs
- Apply constraints via the 'masks'
- Feed back results to science community, SWG, SCWG, SSEC
- Keep track of factors that ultimately determine the practical feasi bility of those designs.

Configuration Design

Configuration Design

The designs are done for:

- Initially all technology types in combination (i.e. in terms of collecting area)
- In practice starting with a dish layout; later fine-tune the configurations of all three with the final distribution of collecting area over the three technology types.
- Design for Phase 2, with Phase 1 being a subset.
  The best options for the Phase 1 configurations will be examined.

Configurations Design

There is a set of very demanding specifications, for example:

- Imaging dynamic range
  - Clean psf with low rms sidelobe level
  - Multi frequency synthesis analysis required
- Scale free logarithmic distribution of collecting area
  - Smooth distribution
  - Capable of snapshot imaging
- Very high dish packing in the centre
  - Issues with shadowing
  - Accessibility

Configurations Design

Summary of the distribution of receptors across the SKA, phase 2.

Collecting area													
region	radius km	dishes				dense AA (high)				sparse AA (low)			
		%		# dishes		%		# stations		%		# stations	
		cum.	zone	cum.	zone	cum.	zone	cum.	zone	cum.	zone	cum.	zone
core	0.5	20	20	600	600	30	30	75	75	66	66	165	165
	2.5	50	30	1500	900	66	36	165	90				
interm.	180	80	30	2400	900	100	34	250	85	100	34	250	85
remote	3000+	100	20	3000	600								
	Total		100		**3000**		100		**250**		100		**250**

Configurations Design

Practical consequences:

- Accommodate three technology types
  - Dishes, sparse and dense aperture arrays
  - Three separate core areas
- Merging from cores into (common) spiral arms
  - Spiral arms provide the required range of baseline lengths and orientations, without the severe cost penalty of a random distribution
  - Nominally 5 arms, symmetric to ~180km from centre
  - Asymmetric up to 3000+km from centre
  - The transition from random cores to the spiral arms needs special attention

A list of topics

Examples of items studied (non-exhaustive)

Configurations Design

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Specific studies:

- Practical figures of merit (PSFRMS, uv-gap), implementation in tools
- Random vs spiral layout
- Effects of holes for other cores in layout
- Effects of antenna clumping into stations
- Fine-tuning overall distribution of collecting area
- Shape of spiral arms
- Number and symmetry of spiral arms
- Effects of asymmetry: azimuthal asymmetry and skewed layouts
- Effects of number and distribution of remote sites
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Clumping into stations

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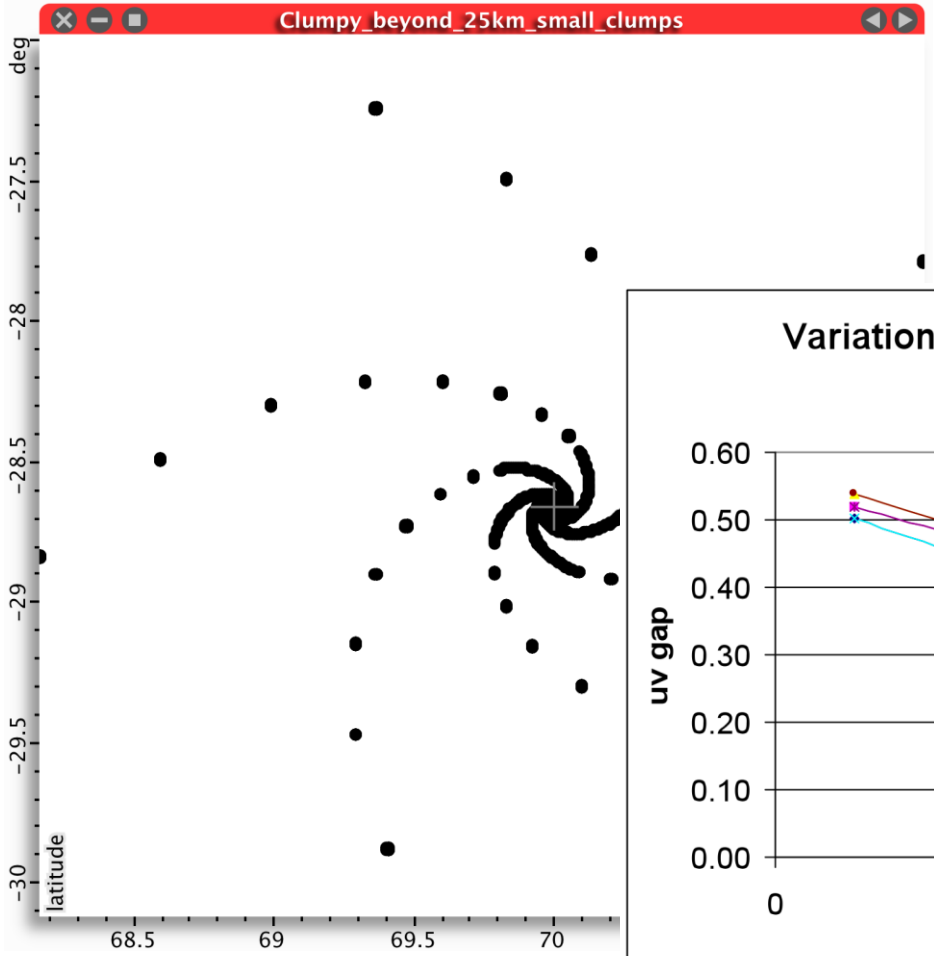
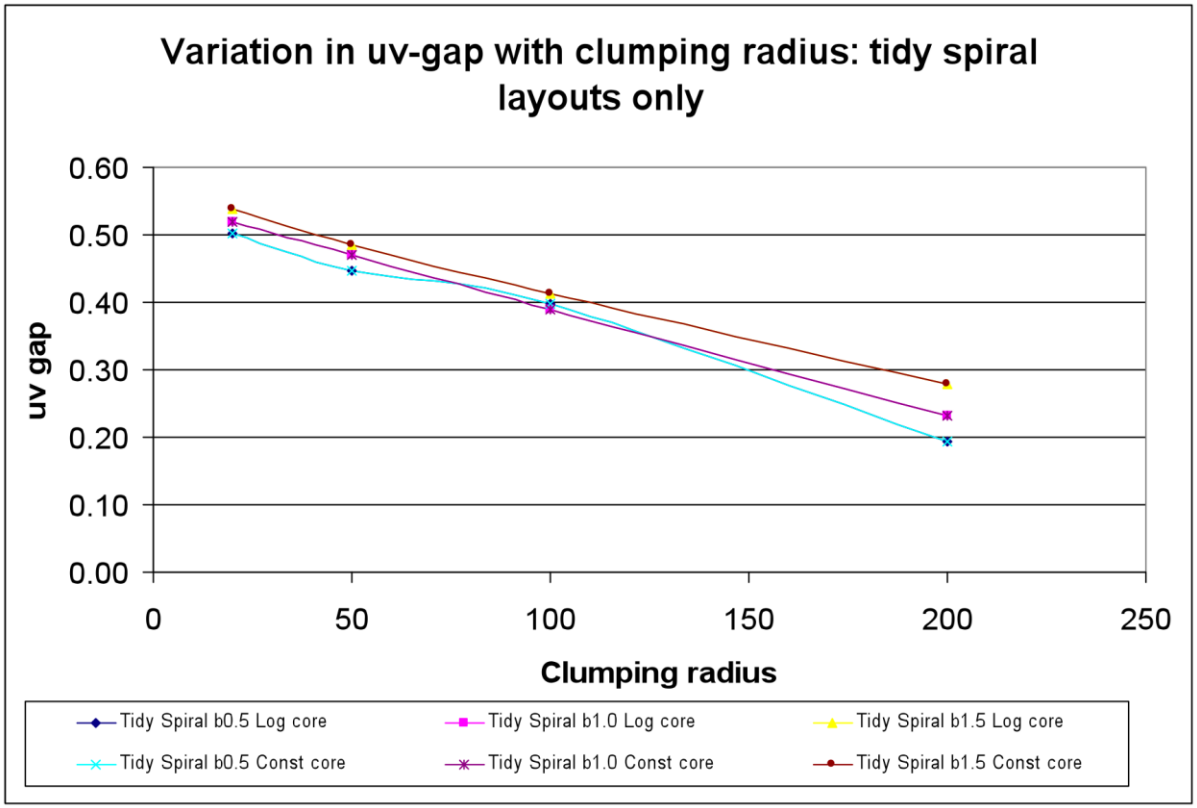
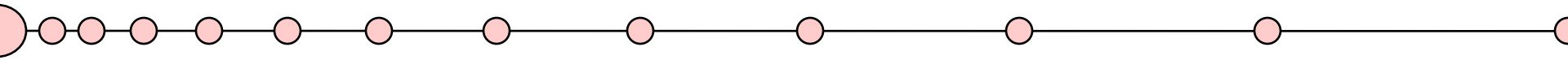




Strings of Dishes

Consequence of preventing dishes to cluster:

- Out to some radius we have Dishes on a string
- And beyond: Clustered antennas in stations.
- The physical size of the stations with individually correlated antennas is being simulated.
- Beyond some distance: Beamformed stations.
- Complicated considerations:
  - Imaging quality, vs
  - Cost – more infrastructure, correlator processing, power distribution



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Number of Spiral Arms

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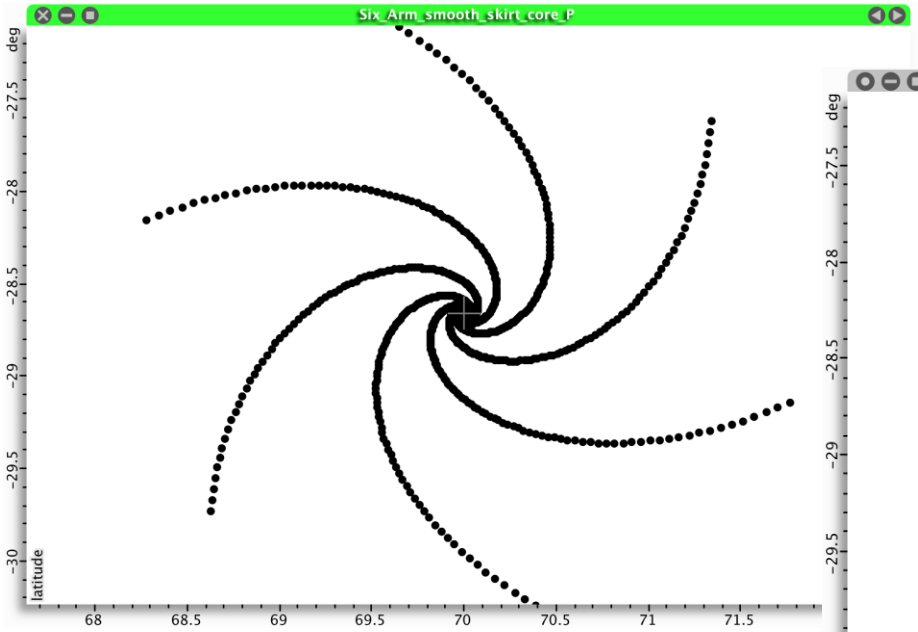
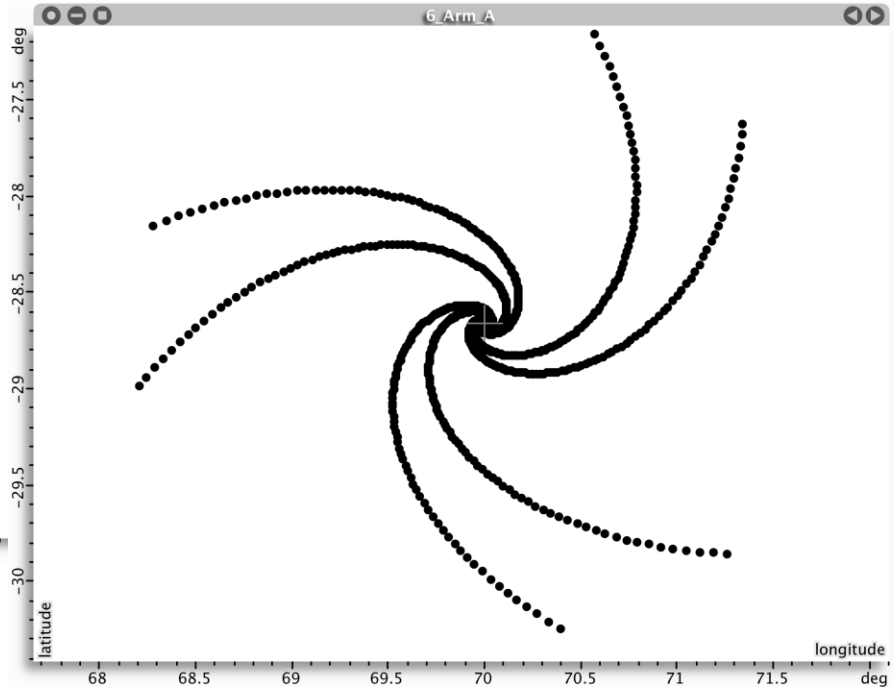
- Even number uniformly-spaced arms are pointless
- So, odd number is better, but…
- Even better is even-numbered array with broken conjugate symmetry





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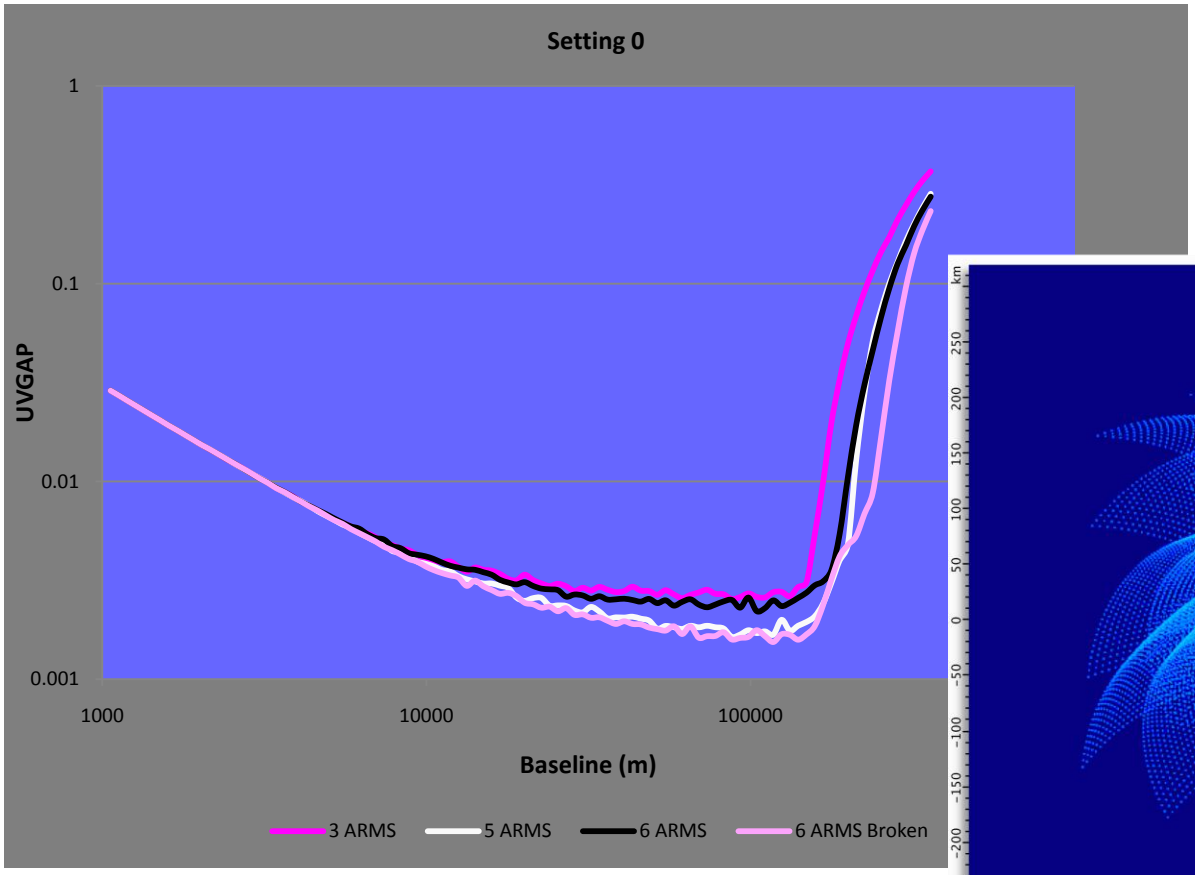

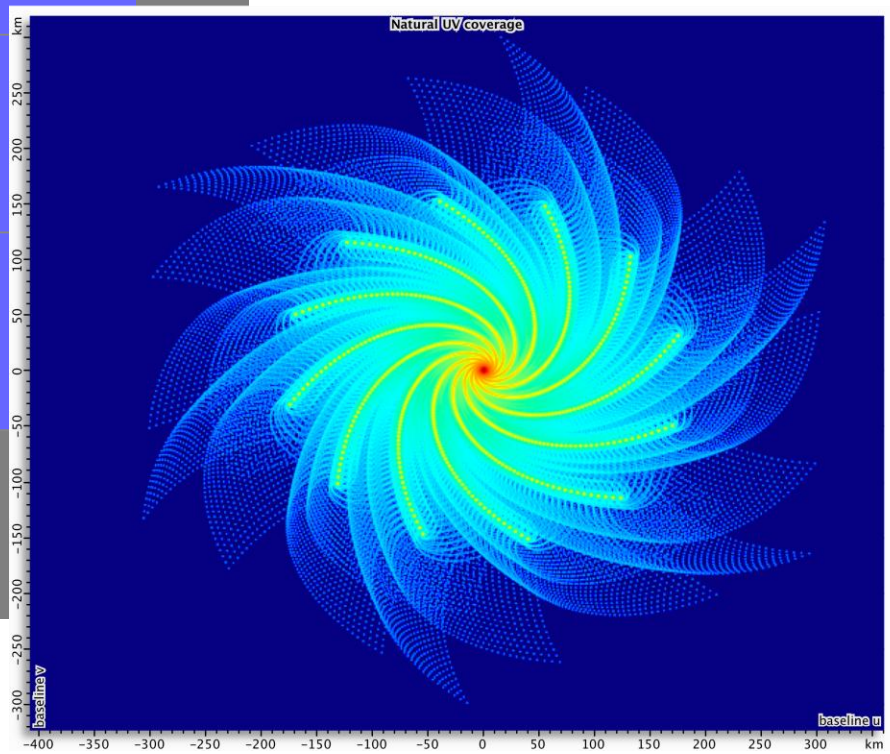

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Asymmetry in azimuth

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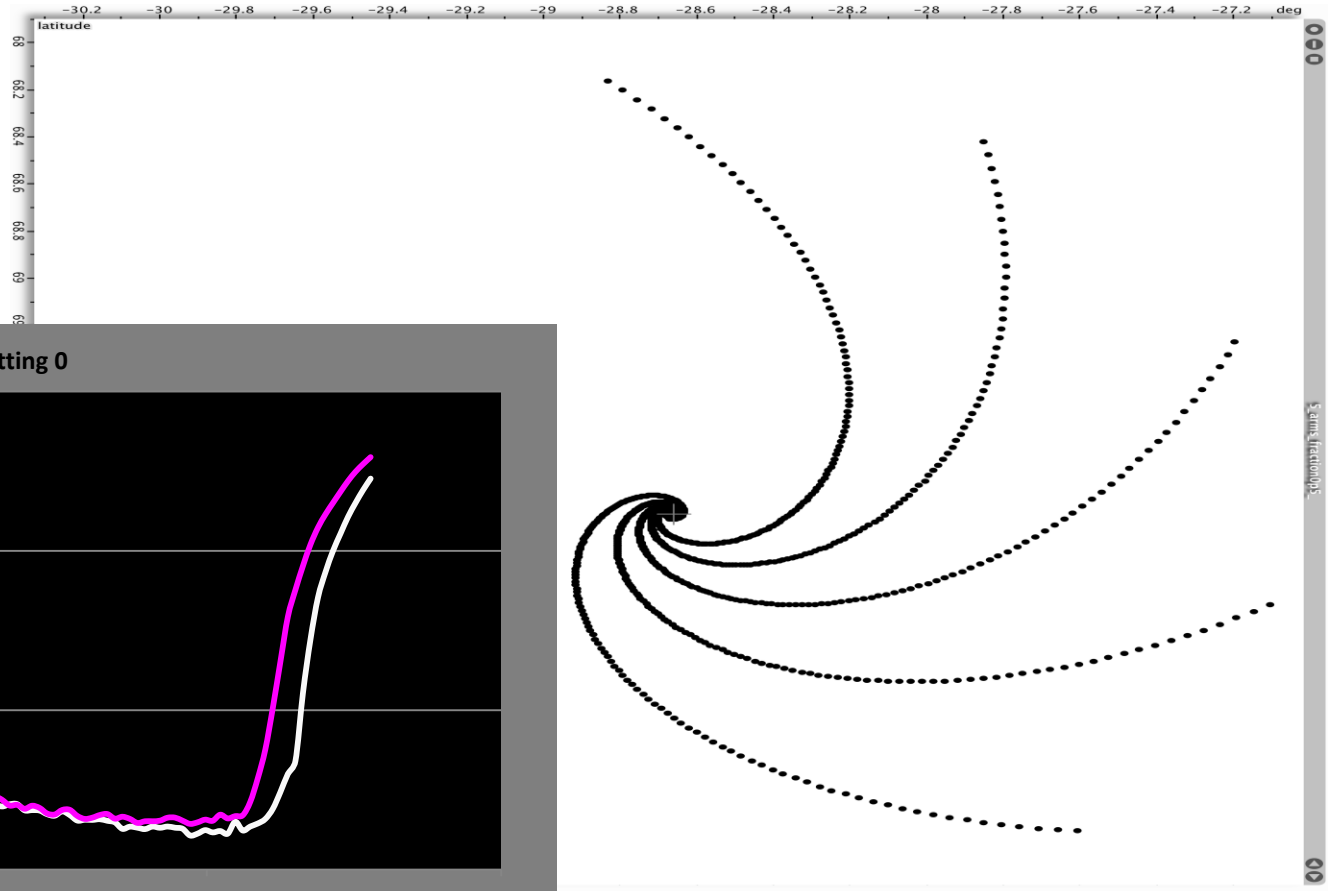

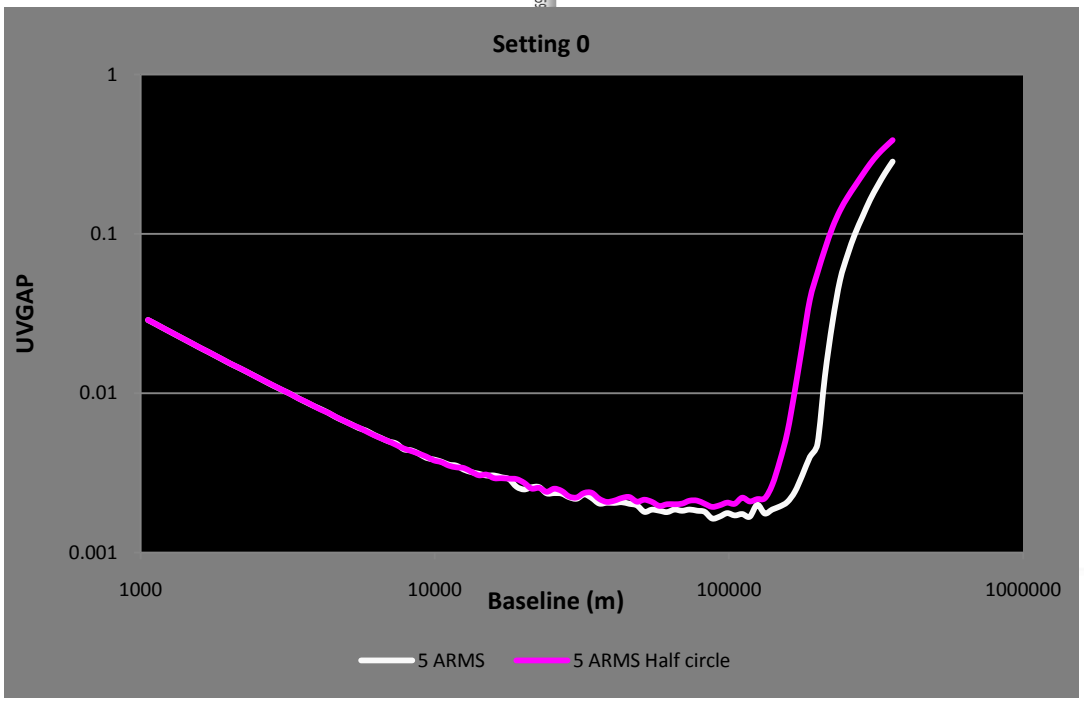

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Populating dish core

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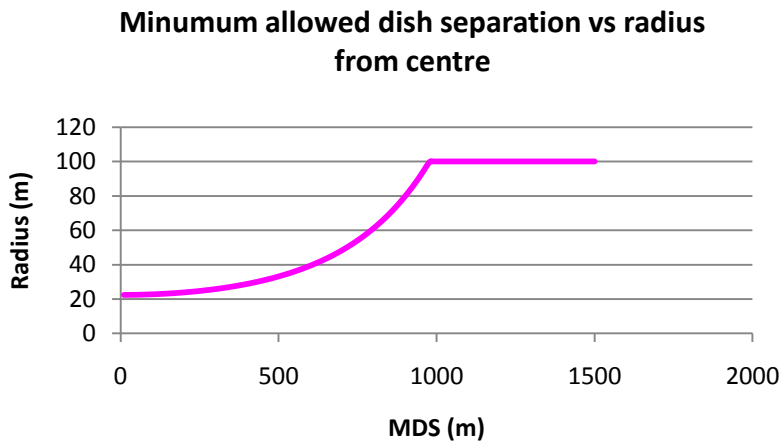
- Memo 100 says: 600 dishes in 500m radius in core
- Analysis done on a Gaussian distribution for densest part with minimum distance of 1.5D, merging in log distribution for the rest of the array.



Shadowing

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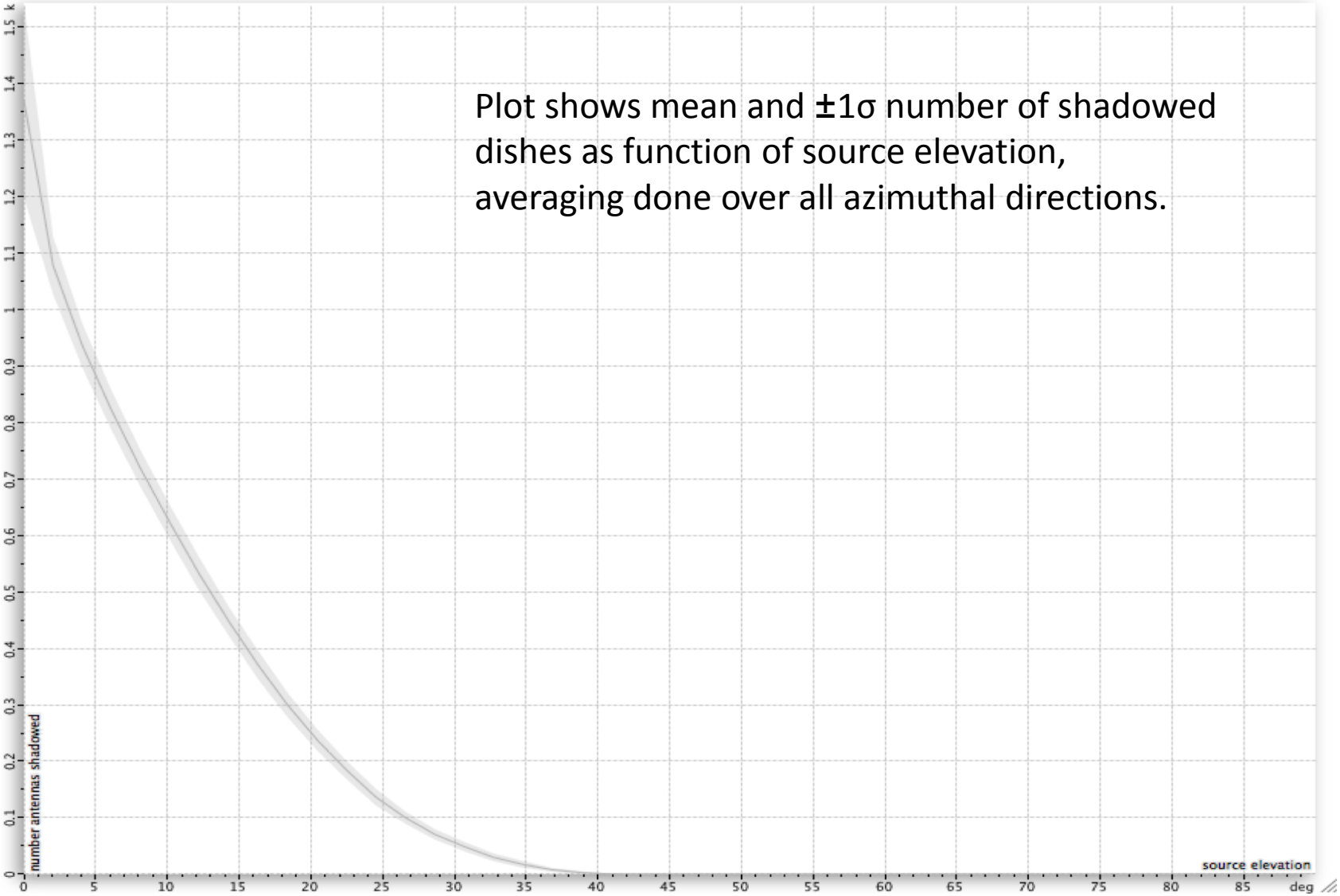

Plot shows mean and ±1σ number of shadowed dishes as function of source elevation, averaging done over all azimuthal directions.

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Redundant baselines

- Applies to the core
- Can be done by placing antennas on a grid in x, y and z (→u,v,w)
- To investigate:
  - Grid size, including in z
  - Number of redundant baselines
  - Effects on gaps in uv distribution
  - Precision of redundancy

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Masks

The mechanism to restrain placement of antennas or stations is via Masks:

- Geographical
  - Terrain (slopes, rugged terrain, horizon limit, water course, floodplains)
  - Environmental, cultural exclusion (reserves, heritage, etc)
- EMI
  - Centre's of human activity (towns, settlements, farms, mines)
  - Roads, rail
- RFI
  - Transmitters (broadcasting, mobile comms), beyond RQZ

Masks

Status (March 2010):

- Draft Mask specification, of which the EMI specifications are fixed.
- Finding agreement on the geographical aspects:
  - definitions of categories
  - methods for deriving information
  - actual specifications
  - GIS data sources to be used
- Working on RFI mask specifications, that apply for remote areas mostly
  - Detrimental levels of RFI, considering number of sampler bits and receiver saturation (IP3)

More on Configurations

Sessions at SKA2010:

Wed. 09:45 - Science WG and CTF

Wed. 11:30 – Configurations Task Force