Comparison of SKA Survey Speeds

John D. Bunton, *CSIRO TIP*

Introduction

Survey speeds for the SKA concepts vary considerably. Here two simple figures of merit are proposed that allow concepts to be compared. The figures of merit are related to the sky and frequency space covered in unit time. The values for the SKA concepts are derived and compared.

Figures of Merit

SKA survey bandwidth can be large e.g. HI for redshifts up to 4. Thus it is proposed to develop a figure of merit suitable for large area surveys over a wide frequency range. The speed is proportional to the field of view (FOV) and the square of the sensitivity (A/Tsys). Here the sensitivity (S) normalised to 20,00 m^2/K is used. If concept bandwidth (BW) is less than survey bandwidth the speed is also proportional to BW. This gives a frequency bandwidth figure of merit:

fbFOM = FOV x BW x S^2

With wide band concepts the FOV at either end of the band can be very different. The overlap of fields at low frequencies leads to increased sensitivity. Narrow band concepts will take longer but some increase in speed is possible by eliminating the FOV overlap. For very low fractional bandwidth the time reduction factor is: $TR(x)=1-x+1/3x^2$ where x is the ratio of survey bandwidth to maximum frequency. The resulting survey has constant sensitivity and normalising to the SKA specification bandwidth of 0.5 +f/5 give a constant sensitivity figure of merit:

csFOM = FOV x BW x S^2 x TR(BW/fmax)/TR(0.5/fmax+0.2)

Results

Results for concepts that can image at 1.4, 6 and 20 GHz are given in tables opposite. The FOVs and BWs are taken from the relevant concept descriptions or updates. In the tables both 12 m concepts (LNSD and the preloaded reflectors) are grouped together. They have the same FOV and the BW for the LNSD concept has been used for both.

The Aperture array (at 1.4 GHz) and the Luneburg lens (in the current update) have an A/Tsys = 10,000 m^2/K. This halves the sensitivity per image and requires four times the observing time to compensate. However, changes to the concepts could give full sensitivity. In particular, the original concept description of the Luneburg Lens specified full sensitivity. For the two concepts two values are given: one for full sensitivity and one for half sensitivity.

Discussion

The 12m, LAR and the full sensitivity Luneburg lens, when operating at narrow bandwidth and constant sensitivity, have similar speeds at 1.4GHz. The aperture array is a little slower, mainly due to the restricted bandwidth (70 beams each with 200MHz, 44 beams per deg^2). In all cases KARST is a slow instrument due to the single focus feeds specified. The fastest concept is the cylinder which is able to use most of the linefeed's field of view (FOV) by trading bandwidth for FOV (factor of 6). A further advantage is its large filled aperture, which makes the correlator 15 times more efficient than the 12m concepts. At higher frequencies the full use of 12m and LAR bandwidths increases their relative FOM. However the cylinders is still about ten times faster.

Table 1: Survey figures of merit — 1.4GHz SKA

Concept	Imaging FOV, deg^2	Bandwidth MHz	fbFOM FOV .BW	csFOM CS survey
Cylinder	48	800	38,400	37,800
12 m	1.5	1250	1,875	1,560
LAR	1	1250	1,250	1,000
Luneburg lens	1.5 12	375 46	560 550	775 975
Luneburg lens A/Tsys =10,000	1.5 12	375 46	140 136	194 234
Aperture array	1.6	200	320	550
Aperture array A/Tsys =10,000	1.6	200	80	126
KARST	1.5e-3	570	0.85	1

Table 2: Survey figures of merit — 6 GHz SKA

Concept	Imaging FOV, deg^2	Bandwidth MHz	fbFOM FOV .BW	csFOM CS survey
Cylinder	1.3	1600	2080	2120
12 m	0.082	3200	262	198
LAR	0.054	4000	216	140
Luneburg lens	0.08 0.65	375 46	30 30	38 40
Luneburg lens A/Tsys =10,000	0.08 0.65	375 46	7.5 7.5	9.5 10
KARST	8e-5	1000	0.08	0.09

Table 3: Survey figures of merit — 20 GHz SKA

Concept	Imaging FOV, deg^2	Bandwidth MHz	fbFOM FOV .BW	csFOM CS survey
Cylinder	0.12	1600	192	223
12 m	0.0075	3200	24	26
LAR	0.005	4000	20	21
Luneburg lens	0.0074 0.059	375 46	2.7 2.7	3.3 3.4
Luneburg lens A/Tsys =10,000	0.0074 0.059	375 46	0.7 0.7	.85 .85