



Memo 66

Relative Sensitivities of the SKA and Other Current or Near-Future Instruments

Dayton Jones
19/10/05

This memo considers the expected sensitivity of the SKA compared with that of all existing large radio astronomy instruments, both arrays and single antennas. I have also included instruments currently under construction (EVLA, ATA, ALMA). The main purpose of these comparisons is to illustrate the magnitude of the increase in sensitivity represented by the SKA. Spectral line sensitivities, continuum sensitivities, and survey speeds are compared over the frequency range from 0.3 to 30 GHz. The low end of the SKA frequency range (0.1 GHz) is not included only because there are so few instruments to compare it with. This will change once performance figures are available for LOFAR.

The instruments included in the table of sensitivity comparisons are listed below, along with their physical collecting areas:

Arecibo	39000 m ²
EVLA	13254
GBT	7850
Effelsberg	7850
WSRT	6872
ATA 350	10299
MERLIN	7000
GMRT	47713
ALMA	9048

The values for aperture efficiency, system temperature, and bandwidth in the tables below have been taken from published specifications or web sites of the various instruments and interpolated as needed. In cases where I could not find appropriate information, I have made plausible guesses.

Assumptions:

Line sensitivity = $A_{\text{eff}}/T_{\text{sys}}$

Continuum sensitivity = $(A_{\text{eff}}/T_{\text{sys}}) (\text{BW})^{1/2}$

Survey speed = $\text{FoV} (A_{\text{eff}}/T_{\text{sys}})^2 \text{BW}$

FoV for SKA = $(1.4 \text{ GHz} / \square)^2$ square degrees

(FoV = total instantaneous field of view)

(N.B. - The SKA requirement for a 200 deg²

FoV between 0.5 and 1.0 GHz is also included)

For the SKA, $A_{\text{eff}}/T_{\text{sys}}$ values were taken (or interpolated) directly from the science specifications, so variations in aperture efficiency and system temperature over frequency are included. For the other instruments I have estimated the frequency dependencies (no doubt imperfectly), and used maximum bandwidths obtained from the instrument web sites where possible. Where sky temperature is an important component of T_{sys} it has been taken from the US-SKA Technical Memo “Antenna Noise Temperature Calculation” by G. Cortez Medellin. The results are tabulated on the following pages.

Relative sensitivities vs. frequency:

		<u>0.3 GHz</u>	<u>1.0 GHz</u>	<u>3.0 GHz</u>	<u>10 GHz</u>	<u>30 GHz</u>
SKA	(Aperture efficiency and T_{sys} are included in specified A/T for SKA)					
	BW/pol	0.15 GHz	0.5 GHz	1.5 GHz	5.0 GHz	8.0 GHz
Line sensitivity		10000.	20000.	20000.	18000.	5000.
Continuum sens.		3873.	14142.	24495.	40249.	14142.
Survey speed		3.3×10^8	3.9×10^8 (3.9×10^{10} for a 200 deg ² FoV)	1.3×10^8	3.2×10^7	4.4×10^5
Arecibo	Aperture eff.	0.7	0.7	0.7	0.5	
	System temp.	60 K	40 K	40 K	40 K	
	BW/pol	0.15 GHz	0.5 GHz	1.0 GHz	1.0 GHz	
Line sensitivity		455.	683.	683.	488.	-----
Continuum sens.		177.	483.	683.	488.	-----
Survey speed		2.4×10^3	1.6×10^3 (1.1×10^4 for ALFA)	366.	17.	-----
EVLA	Aperture eff.	0.7	0.7	0.7	0.7	0.5
	System temp.	50 K	20 K	20 K	20 K	30 K
	BW/pol	0.15 GHz	0.5 GHz	1.5 GHz	5.0 GHz	8.0 GHz
Line sensitivity		186.	464.	464.	464.	221.
Continuum sens.		72.	328.	568.	1038.	625.
Survey speed		7.2×10^4	5.3×10^4	1.8×10^4	5.3×10^3	214.
GBT	Aperture eff.	0.7	0.7	0.7	0.7	0.65
	System temp.	50 K	20 K	20 K	20 K	30 K
	BW/pol	0.15 GHz	0.5 GHz	1.5 GHz	5.0 GHz	6.4 GHz
Line sensitivity		110.	275.	275.	236.	170.
Continuum sens.		43.	194.	619.	528.	430.
Survey speed		580.	1.1×10^3	356	79.	6.

		<u>0.3 GHz</u>	<u>1.0 GHz</u>	<u>3.0 GHz</u>	<u>10 GHz</u>	<u>30 GHz</u>
Effelsberg	Aperture eff.		0.63	0.63	0.46	0.3
	System temp.		30 K	40 K	50 K	70 K
	BW/pol		0.12 GHz	0.5 GHz	0.3 GHz	2.0 GHz
Line sensitivity	-----	165.	124.	72.	34.	
Continuum sens.	-----	57.	88.	39.	48.	
Survey speed	-----	92.	24.	0.4	0.07	
WSRT	Aperture eff.	0.59	0.54	0.5	0.3	
	System temp.	120 K	30 K	60 K	120 K	
	BW/pol	0.08 GHz	0.16 GHz	0.16 GHz	0.16 GHz	
Line sensitivity	34.	124.	57.	17.	-----	
Continuum sens.	10.	50.	23.	7.	-----	
Survey speed	464.	1.1 x 10 ³	113.	0.2	-----	
ATA 350	Aperture eff.		0.7	0.7	0.7	
	System temp.		40 K	40 K	40 K	
	BW/pol		0.1 GHz	0.1 GHz	0.1 GHz	
Line sensitivity	-----	179.	179.	179.	-----	
Continuum sens.	-----	57.	57.	57.	-----	
Survey speed	-----	2.5 x 10 ⁴	2.8 x 10 ³	251.	-----	
MERLIN	Aperture eff.	0.7	0.7	0.7	0.7 (no MkIA)	
	System temp.	50 K	30 K	30 K	30 K	
	BW/pol	0.15 GHz	0.5 GHz	1.5 GHz	2.0 GHz	
Line sensitivity	98.	163.	163.	60.	-----	
Continuum sens.	38.	115.	200.	85.	-----	
Survey speed	790.	649.	216.	20.	-----	

		<u>0.3 GHz</u>	<u>1.0 GHz</u>	<u>3.0 GHz</u>	<u>10 GHz</u>	<u>30 GHz</u>
GMRT	Aperture eff.	0.7	0.7			
	System temp.	100 K	100 K			
	BW/pol	0.03 GHz	0.03 GHz			
	Line sensitivity	334.	334.	-----	-----	-----
	Continuum sens.	58.	58.	-----	-----	-----
	Survey speed	5.2×10^3	466.	-----	-----	-----
ALMA	Aperture eff.					0.7
	System temp.					100 K
	BW/pol					8 GHz
	Line sensitivity	-----	-----	-----	-----	63.
	Continuum sens.	-----	-----	-----	-----	179.
	Survey speed	-----	-----	-----	-----	70.

Summary of results in log-log format:



