Cylinder + 12-m Dish Hybrid

John Bunton
CSIRO

Why Hybrids?

- At low frequencies antenna technologies that do not use concentrators are used.
  - elemental receptor already have large effective area
    - » eg a simple dipole at 30 MHz has an area of about 10 m^2
  - LNAs, downconverters and A/D converters have low cost at these frequencies.

Effective area per receptor (m2)

Cylinder, lens and dish diameter 10 m.

	Dipole	Cylinder	Lens or Dish
0.1 GHz	1	30	100
0.3 GHz	0.1	10	100
1 GHz	0.01	3	100
3 GHz	0.001	1	100
10 GHz	0.0001	0.3	100

x100

x100

Cylinder

Dish

Why use concentrators at high frequency?

- As the frequency increases, the cost of electronics increases.
  - For example at a frequency of 30 GHz all current radiotelescopes use cooled receivers making the cost of the electronics per receptor orders of magnitude dearer than at 30 MHz.
- This together with the fact that the effective area of an elemental receptor has gone down by a factor of one million dictates that a two dimensional concentrator such as a parabolic dish be used.

Hybrid Proposal

- Consider hybrid solutions to the SKA where the frequencies below about 5 GHz would largely be handled by cylindrical reflectors.
- Higher frequencies would use
  - LNSD proposal using 12-m hydroformed parabolic dishes, or
  - LAR with a 200m adaptive reflector
- Consider the LNSD 12-dishes in the following discussion

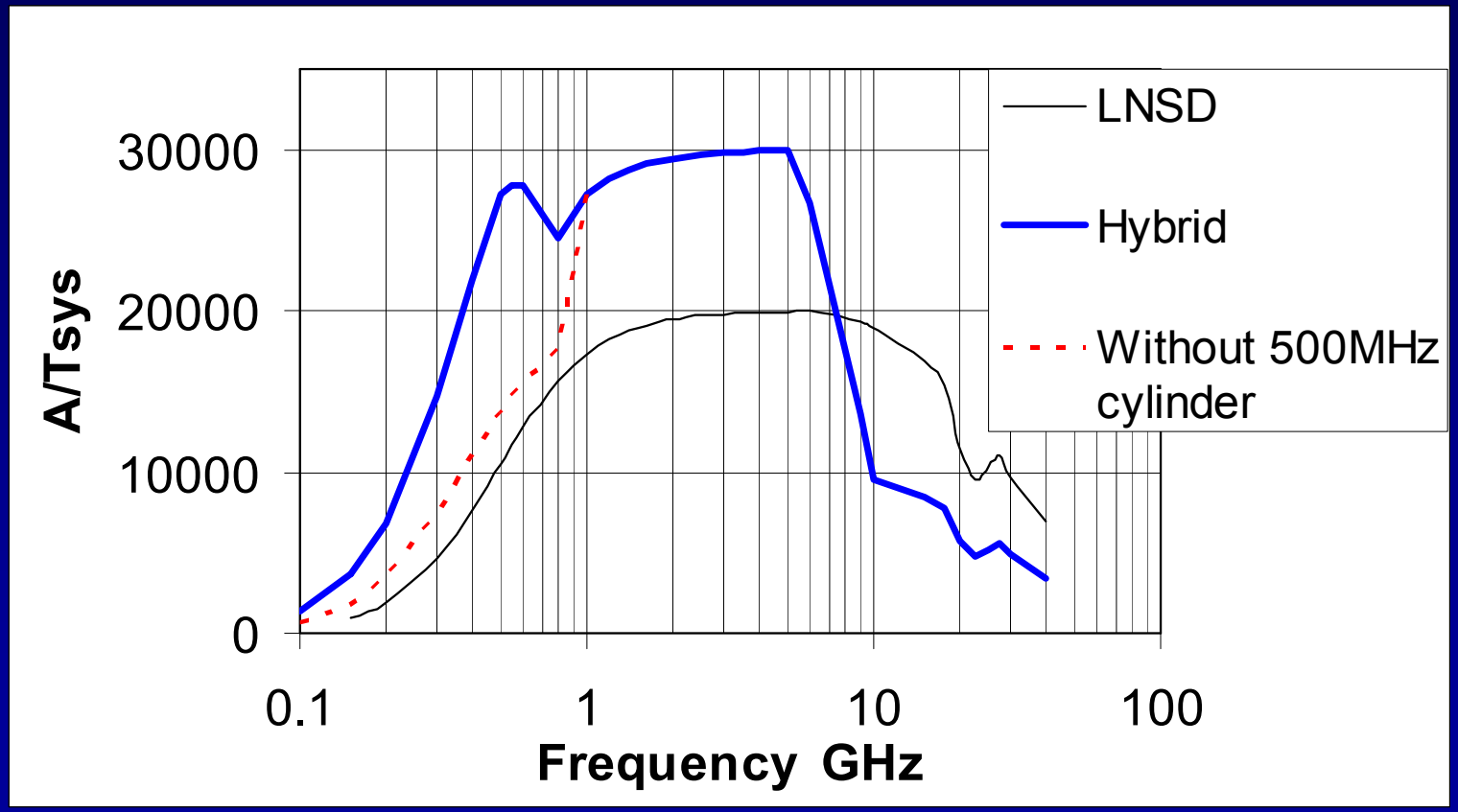
Antenna cost – 15m cylinder

	Cost at 5 GHz (US$/m^2)	Cost at 0.5 GHz (US$/m^2)
Reflector	228	105
Linefeed hardware	13	6
LNA and RF beamformer	38	4
Downconversion and A/D	24	3
Line feed to beamformer	32	5
Total cost per m^2 Cost for 10^6 m^2	335 $335M	123 $123M
Cost of LNSD-12m dishes	$860M	

The Hybrid Mix

- Constrain solutions to same total cost as the LNSD 12m proposal
- Build half of the 12-m antennas ($430M) and both sets of 15-m cylinders ($335M+$123M).
  - Total cost is similar to the full-sensitivity 12-m antenna SKA.
  - The hybrid solution has traded high frequency sensitivity for low frequency sensitivity
  - Low frequency limit extended down from 200 MHz to 100 MHz.
  - Above 10 GHz the sensitivity is halved.
  - Does not include the saving in 12-m cost by going to a symmetric design ($50M)

Sensitivity for cylinder + 12-m hybrid



Other differences

- Bandwidth 2.4GHz at 5GHz
  - SKA spec is 1.5GHz
- Low frequency limit is now 100MHz
  - 12-m dishes are limited to 150MHz (at x3 lower sensitivity)
- Cylinder FOV at 1.4GHz is 24 square degrees
  - 12-m dishes are 1 square degree
- These factors give an x100 improvement for 3 key science drivers!
  - Pulsars
  - HI surveys for evolution and dark energy

Conclusion

- This hybrid solution uses low and mid frequency cylindrical antenna arrays together with 12-m hydroformed antennas with a sensitivity of 10,000 m2/K.
- This increases the sensitivity below 5 GHz by a factor of 1.5 to 3.7.
- At high frequencies all proposed science can still be done, but with reduced sensitivity
- This is has to be balanced against the science cases which can take advantage of the increased low frequency sensitivity.