Optimum band definition from the survey point of view

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Evolution of MeerKAT L band

Request for proposals (October 2009):

0.90–1.75 GHz (1.94:1) → 0.58–2.5 GHz "frequency range"

Technical review (July 2010):

1.00–1.75 GHz (1.75:1) L band

0.58–1.015 GHz (1.75:1) UHF band

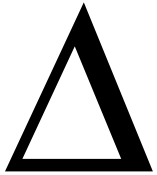
Final decision (January 2012):

0.90–1.67 GHz (1.86:1) L band

0.58–1.015 GHz (1.75:1) UHF band

what happened?

May 2011 change request



Downward shift of MeerKAT L band...

+ requested by LADUMA and Absorption Line Survey

+ other MeerKAT large survey teams neutral to positive

+ project scientist (R. Booth) formulated four options for scientific, technical, and cost review

+ option “extend 2” endorsed by international Science Advisory Group and project management

Four possible options

Option	"as is"	"shift down"	"extend 1"	"extend 2"
Band	1.00–1.75	0.90–1.575	0.90–1.726	0.90–1.67
Ratio	1.75:1	1.75:1	1.92:1	1.86:1
VLBI	OK	not OK	?	?
1.59–1.72				
Rcvr?	OK	$, time	$, time	$, time
Dgtzr?	OK	OK	$, time	OK

Science gains (for LADUMA+MALS)

(1) Shift MeerKAT Phase 1 redshift ranges to $0 < z_{HI} < 0.58$ and (for main lines) $0 < z_{OH} < 0.85$. For HI, that's 1.1 Gyr more lookback time.

(2) Increase Phase 1 volume probed for HI by factor 2.2–2.7, leading to ~20% more 4σ HI detections and ~100% more sources with optical redshifts for stacking.

(3) Gain scientific distinctiveness in Phase 1 vs. surveys elsewhere limited to $z_{HI} < 0.45$.

(4) Observe unique redshift shell ($0.41 < z_{HI} < 0.58$) with both L-band and UHF-band receivers in Phase 2.

Science costs (for other people)

(1) Some threat to use of full 1.59–1.72 GHz VLBI band.

(2) Loss of 1720 MHz OH satellite line at $z_{OH} < 0.03$.

Feedback from OH pundits among LADUMA Cols: much of key extragalactic OH science at $z < 0.2$ has already been done by Arecibo, and Galactic OH science does not uniquely depend on MeerKAT's sensitivity. (Note: this assessment also applies to 1612 MHz satellite and 1665, 1667 MHz main lines.)

Turning to SKA1-mid...

Baseline design features 5 bands (pp 15, 48):

Band 1	**0.35–1.05**	**3:1**
Band 2	**0.95–1.76**	**1.85:1**
Band 3	**1.65–3.05**	**1.85:1**
(Band 4	**2.80–5.18**	**1.85:1)**
(Band 5	**4.60–13.8**	**3:1)**

...consider this revision

Baseline design features 5 bands (pp 15, 48):

Band 1	0.35–1.05	3:1	0.35–1.05
Band 2	0.95–1.76	1.85:1	0.77–1.43
Band 3	1.65–3.05	1.85:1	1.40–2.59
(Band 4	2.80–5.18	1.85:1)	2.54–4.70
(Band 5	4.60–13.8	3:1)	4.60–13.8

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Galactic HI+OH; VLBI

...consider this revision

Baseline design features 5 bands (pp 15, 48):

Band 1	0.35–1.05	3:1	0.35–1.05	some redundancy for Galactic plane pulsar searches
Band 2	0.95–1.76	1.85:1	0.77–1.43	
Band 3	1.65–3.05	1.85:1	1.40–2.59	
(Band 4	2.80–5.18	1.85:1)	2.54–4.70	
(Band 5	4.60–13.8	3:1)	4.60–13.8	

Implications for HI+OH surveys

Band 1 = 0.35–1.05 GHz:

+ ranges: $0.35 < z_{HI} < 3.06$ and $0.59 < z_{OH} < 3.76$

Band 2 = 0.77–1.43 GHz:

+ ranges: $0 < z_{HI} < 0.84$ and $0.16 < z_{OH} < 1.16$
+ interesting $z_{OH} > 0.2$ range still covered fully
+ increases HI lookback time by 2 Gyr, cosmic volume by factor 5.3 per pointing (including “vuvuzela” flare but not RFI)
+ gets rid of RFI from Iridium (1.62–1.66 GHz) and GNSS (1.56–1.61 GHz), although adds RFI from rest of GSM-900 (0.94–0.96 GHz)

Overlap redshift shell

Overlap = 0.77–1.05 GHz:

+ ranges: $0.35 < z_{HI} < 0.84$ and $0.59 < z_{OH} < 1.16$

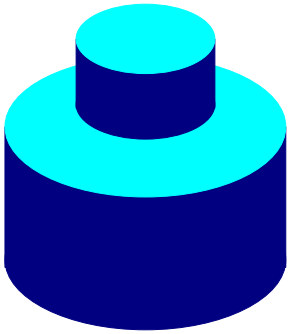
+ 3.1 Gyr cosmic time; 3.6×10^6 Mpc^3 per pointing

+ would be observed 100% of the time in fields being surveyed by both Bands 1 and 2

+ Δz_{HI} = excellent redshift range for doing unique, spatially resolved HI science at depths only SKA1-mid can reach

+ Δz_{OH} probes epoch when cosmic merger rate is ramping up but not yet at its peak

Plausible survey strategies



I. Bake your own wedding cake.

+ Use band 2 to make wide/shallow map, within which band 1 is used for narrower/deeper patches.
+ Large, overlapping volumes will help beat cosmic variance at all redshifts.

II. Go to town on a single pointing.

+ Resolved HI science at $z_{HI} < 0.35$ with band 2: fairly straightforward.
+ Integrate with band 1 long enough to enable resolved HI science out to $0.35 < z_{HI} < 0.84$ – also enabling *unresolved* HI science at $0.84 < z_{HI} < 3.06$.

Will low-*z* OH science suffer?

Galactic/low-*z* OH observations can still be done with SKA1-mid Band 3 and (for main lines) SKA1-survey Band 2 PAFs, with 0.65–1.67 GHz.

Band boundaries can be defined to maximize unbroken z_{OH} coverage (as in baseline plan) or unbroken z_{HI} coverage (as in proposed revision). DRM science priorities rather than tradition should determine which.