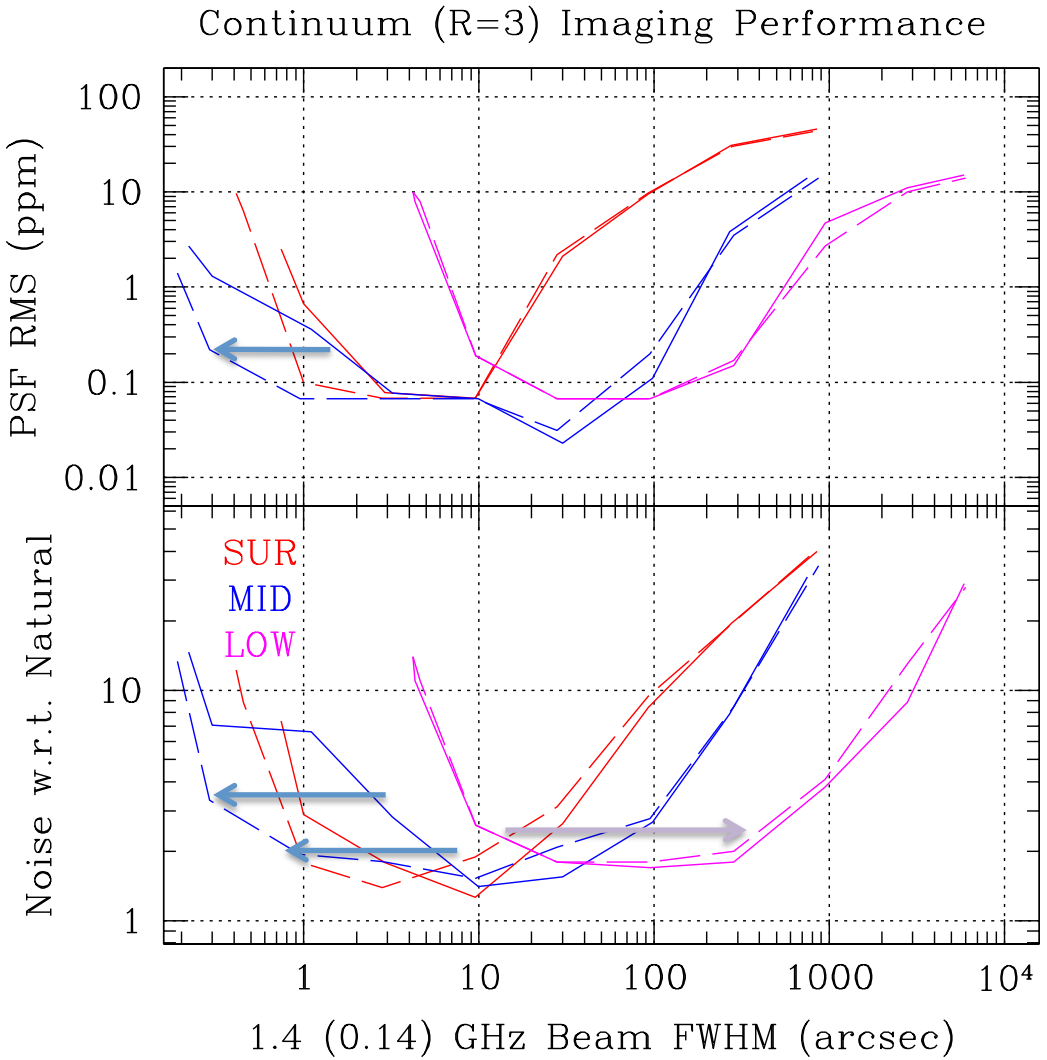
Continuum Surveys

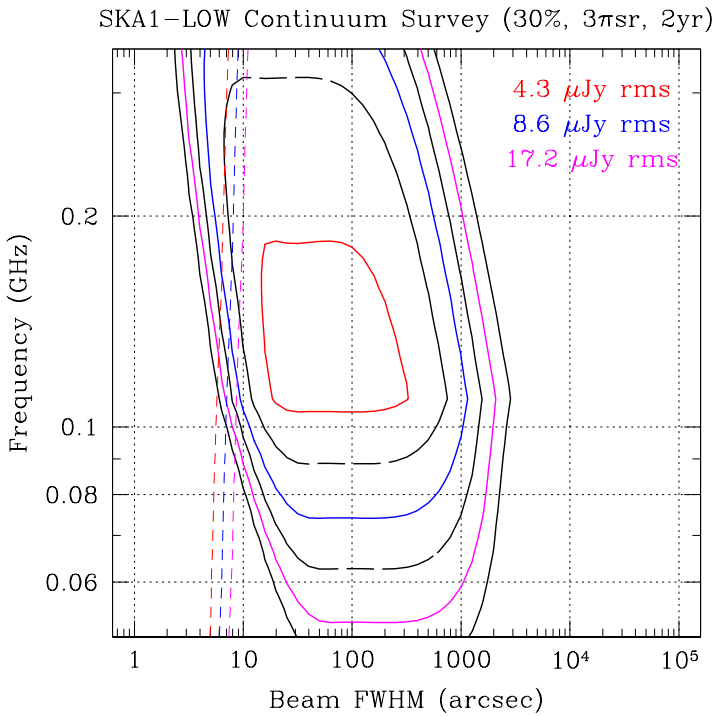
Topics	Rms (μJy)	Area (deg2)	Resolution (“)	Freq. (GHz)	Science	Notes
wide	0.5 – few	Few 100s 5k - 20k All-sky for legacy	0.5 - 5	low/mid/ high	Local Galaxy/ AGN statistical studies Cluster/ diffuse emission studies Cosmology Magnetism	high freq. For for thermal emission in SFGs + young stars
deep	≤0.05	Few 10s (≥100 for clusters)	≤0.1-0.5	mid/high	Galaxy/AGN resolved physics	≤0.1” for SF/AGN separation & R par on nuclear scale

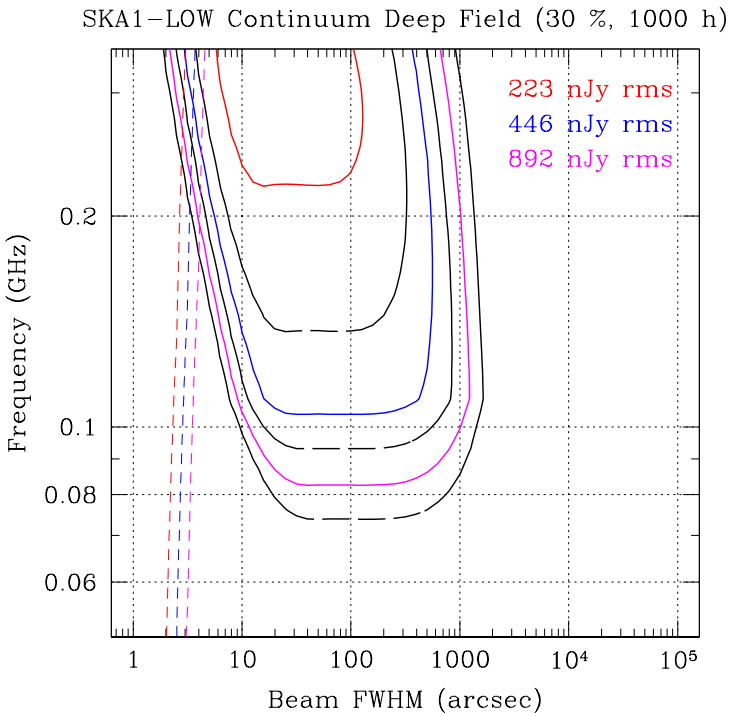
Where SKA is unique or gives significant advantages:
Ex: Galaxy/AGN → routinely do resolved physics up to high redshifts ?
Magnetism/relativistic science (total intensity synchrotron emission, polarization studies)
Cosmology/weak lensing?

Continuum Performance



Continuum Survey Performance: SKA_LOW





Confusion limited very quickly: ~10 μJy rms surveys only feasible at ν> 150 MHz
~1 μJy rms surveys only feasible at ν> 200 MHz

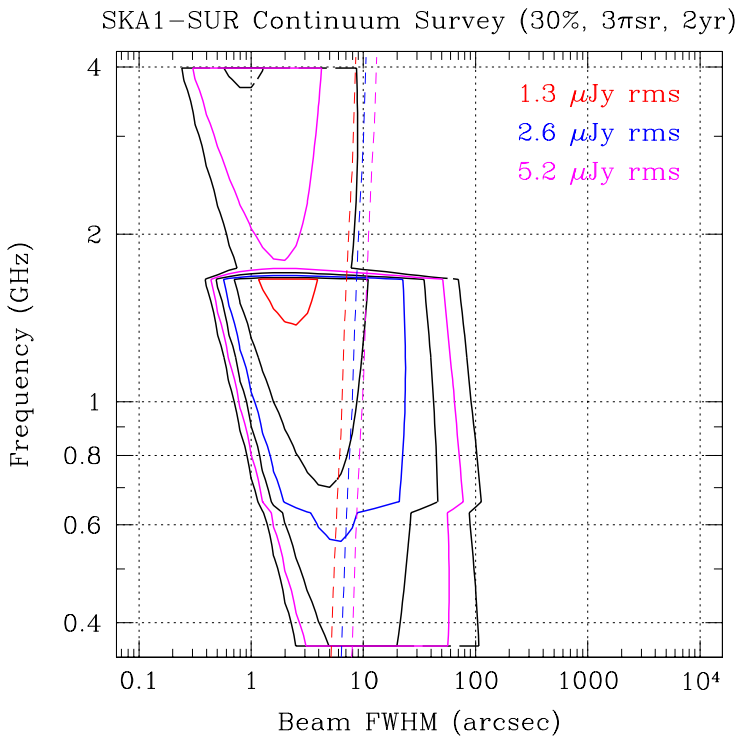
➔few arcsec resolution wide surveys at LOFAR deep fields limit

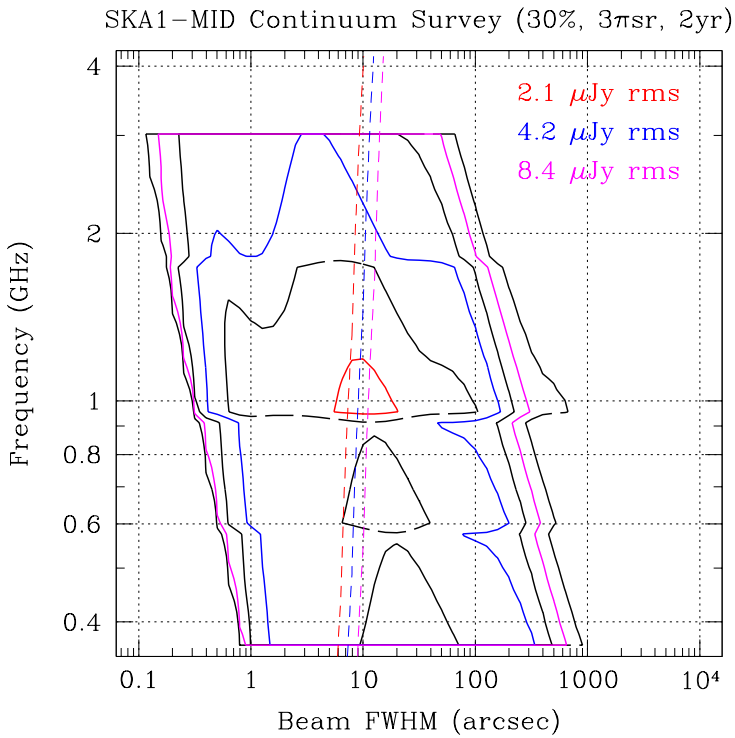
➔1 μJy rms deep field (2-3" res) limited to pointings of 4 sq. degr. (>200 Mhz)

1-10 μJy limit at >150 MHz (few arcsec res. limit) → is it useful?

What do we miss in terms of science (see Huub's talk)?

Continuum All Sky Surveys: SUR vs. MID





SUR factor 2 better survey speed (factor 4 would be very interesting)

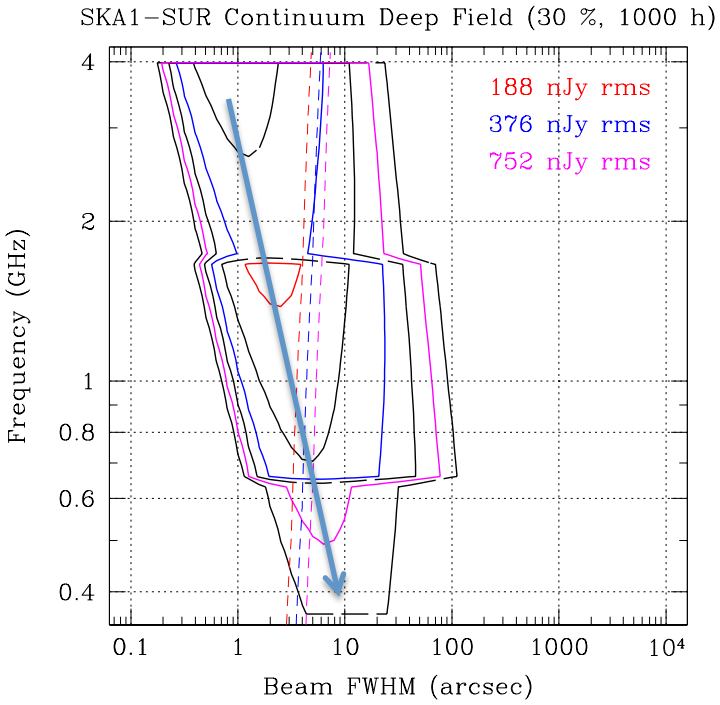
All sky/wide surveys in given observing time at few arcsec resolution (1-2”):

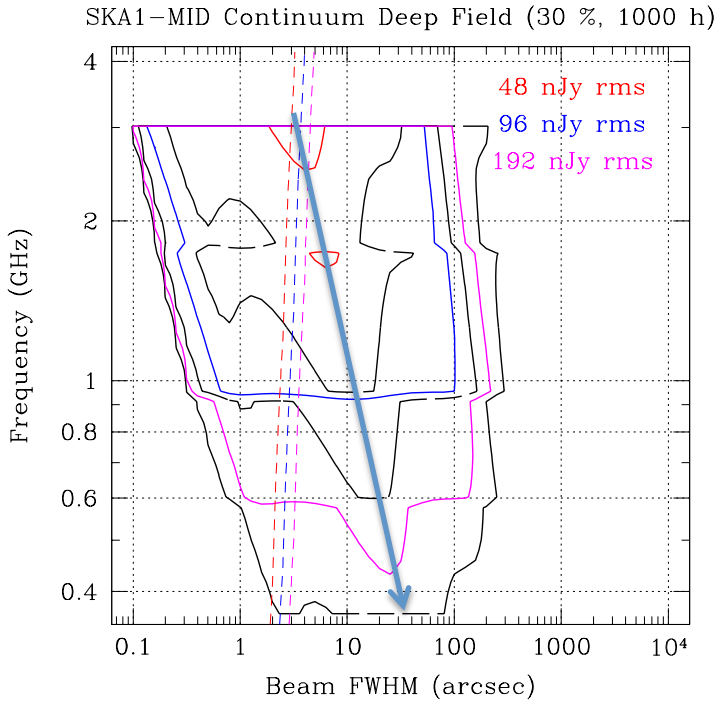
• SUR factor ~2 deeper than MID or same depth but lower frequency (better commensality with HI)

•MID competitive for very high res. (0.5”) 5-10 μJy rms wide surveys at>2 GHz (if Gaussian beams)

Q: Do we need a few μJy sub-arcsec. wide survey? Lensing? Resolve EMU AGN/SF?

Continuum Deep Fields: SUR vs. MID





SUR has a better match between sensitivity and resolution performance

MID has significantly better sensitivity but array is not very efficient for <1" res:

➔ most efficient at highest ν (smallest FoV)

~50 nJy rms surveys at 2" res at ν>2 GHz (0.3 sq. deg.) (30 sq. degr. → >1.2 yr)

~ 50 nJy rms survey at 0.2" res at at ν>2 GHz over 30 sq. deg.) → 2.5 yr

Q: Do we want to increase efficiency at higher res/lower freq.? Synergy with HI

Points to be discussed

- Most important science drivers for continuum surveys (wide and deep)
- SKA1 perfomance (LOW/MID/SUR) in terms of
  - ✓ resolution (low/mid freq.)
  - ✓ dirty beam shape (low/mid freq.)
  - ✓ Surface brightness sensitivity
  - ✓ frequency coverage (very low/very high)
  - ✓ broadband BW
  - ✓ Imaging DR
  - ✓ instrumental polarization
  - ✓ Control of Systematics (flux calibration errors, etc.)
  - ✓ Faster survey speed for SUR and higher res. for MID?
  - ✓ …

- what for SKA1 and what for SKA2?
- Other issues?

Other caveats

Thermal noise + high Imaging DR
➔ both important for deep continuum surveys

➔Gaussian dirty beam (see Jim's talk)
optimize array for natural PSF
[Power-law radial distribution ➔ scale-free arrays]
SKA1_MID 3x higher noise for uniform weigthing

Other inputs/caveats (from Jim)

- confusion not an issue at arcsec res.
  [confusion noise ~ 9 nJy at ~1.5” res]
- arcsec res. for detection experiments of low SB SFGs
  at microJy level
  [for res ~ 0.22” → noise ~14 nJy @ 1.7 GHz]
- | log v1/v2 | > 1 to get accurate spectral index at low S/N
  → matched LOW/MID surveys
- Gaussian dirty beam → optimize array for natural PSF
  [Power-law radial distribution → scale-free arrays]
  SKA1_MID 3x higher noise for uniform weigthing
- Imaging DR very important

Science Requirements - Summary

Topics	Rms (μJy)	Area (deg2)	Resolution (“)	Freq. (GHz)	Notes	Critical parameter
Star Formation 10^{11} L_{sun} z~8	0.004 (20 nJy 5σ)	Few 10s? + wide	~0.1 to resolve disks (z>1)	high (10 GHz)	Thermal em. at high z	Resolution/ frequency
AGN Radio mode RL/RQ	50 nJy 1 μJy	Few 10s + wide	0.5	mid mid	0.5” enough? SF/AGN separation R par on nuclear scale	Resolution?
Clusters	1 μJy 50 nJy	All sky 100	5	mid mid	Pointed obs more efficient?	SKA LOW useless due to confusion
Stars	~1 μJy	Wide area	~0.1 for ids in crowded stellar fields?	>5	To get young objs [low ν -> coherent em]	Frequency/ resolution
Cosmology	1(0.5)	20k(5k)	<2 for ids 0.5 for lensing	mid		resolution
Magnetism	few μJy <100 nJy	All sky few 10s	~1? ~1?	Broadband Broadband	SUR+LOW MID	Res. for LOW