Cycle 0 Capabilities - Minimum

- 16 x 12m antenna array
- 18 - 250m baselines, 2 configurations
- Single field imaging
- Bands 3, 6, 7 & 9 (no bands 4, 5 or 8)
- Set of ~21 spectral modes (see later)
- No subarrays, no special modes
- Amplitude Calibration good to 5% for bands 3 and 6 but less accurate at high frequencies – e.g. 15% at band 9 (?). This would be relative to best known objects, e.g. planets.

Cycle 0 Capabilities - Stretch

To be decided by ~ mid-March 2011

Priority order as given by ASAC in last report

1. Baselines longer than 250m, 3 configurations (or perhaps some other scheme to give us longer baselines late in the first cycle).
2. Polarization: Full Stokes parameters on compact sources: *Q*, *U* and *V* accurate to 1% (?) of *I*.
3. Pointed Mosaics – up to 25 points (?)
4. Zero-spacing (single-dish rasters maps) – to cover same area as mosaics – Spectral Line only.

We have already concluded that item 4 cannot be offered as the software is not sufficiently well tested.

Spectral modes expected to be available for ALMA Cycle 0

1. Time Division Modes (TDM).
   These are intended for all observations of continuum sources and for objects with wide, smooth spectral lines, e.g. distant galaxies. Short integration times, e.g. 0.1 seconds, are possible.

TDM modes		Point Spacing[1] (MHz) →		
Band-	MHz	7.8	15.6	31.3
width[2]	1800	1[3]	**2**[3]	4[3]

"ASAC" modes in red

Notes :

1) This is the spacing of the data points in the spectrum. The actual spectral resolution depends on what smoothing function is applied to reduce "ringing": the FWHM ranges between 1.21 and about 2 times the point spacing.
2) This is the bandwidth for <u>one</u> baseband. There are normally <u>four</u> available.
3) The numbers "N_pol" in these cells show the number of polarization products provided: 1 – single pol, **2** – both polarizations, 4 – Full Stokes. In general case **2** will be preferred, but for polarization measurements case 4 must be used. Band 7 may require the use of case 4 due to a front-end set-up issue.

Spectral modes expected to be available for Cycle 0 (continued)

2. Frequency Division Modes (FDM). These will be used for most spectral line observations. Resolution and bandwidth can be chosen in steps of a factor of 2 as shown in the table. The integration times can be ~1 second, typically substantially longer.

FDM modes		Spacing of spectral points[1] (kHz)→							
Band-	MHz	7.6	15.3	30.5	61	122	244	488	977
width[2]	1800						1^3	**2^3**	4^3
↓	938					1	**2**	4	
	469				1	**2**	4		
	234			1	**2**	4			
	117		1	**2**	4				
	58.6	1	**2**	4					

Notes as for previous slide. In addition note that:

4) For FDM the digitization efficiency is ~85% whereas for TDM it is ~88%.
5) The 4 basebands need to have the same mode, i.e. bandwidth / resolution.

More on Limitations

- The requirement 5) that all the basebands are set to the same bandwidth is a software limitation which is in fact likely to be lifted by the start of Cycle 0 observing. We will however not be able to demonstrate the use of different bandwidths on each baseband before ~August 2011 and this will therefore not be included in the call.
- Multi-region modes (where one makes up say 469 MHz of bandwidth with 8 disjoint sub-bands) will not be supported. This is expected to be ready for Cycle 1.
- The even more sophisticated modes ("multi-resolution modes") where different parts of the same quadrant are used with different set-ups are also excluded. These, together with items like twice-Nyquist sampling and 4-bit modes will probably not be available until Cycle 2.

Continuum Sensitivity when observing lines

- The following calculation shows that for most observing the fact that we cannot use different configurations for the different quadrants is not a major limitation.
- Consider observations at 230 GHz using a channel spacing of 122 kHz, which gives a spectral resolution of 0.32 km/s (FWHM after Hanning smoothing). Using dual polarization, we have 469 MHz bandwidth per baseband so we end up with 1876 MHz of continuum bandwidth.
- Compare this with 5870 MHz: the maximum we could have had if this limitation were not there. The increase in the noise on the continuum data is only a factor of 1.77.
- The three-sigma continuum sensitivity with this factor included is then about 0.2 mJy per beam in one hour.
- In this situation the sensitivity for the line and continuum scale together as $1/\sqrt{\text{bandwidth}}$, so for same case but with a spectral resolution of 0.08 km/s the continuum sensitivity would be 0.4 mJy.

Early Science Configurations

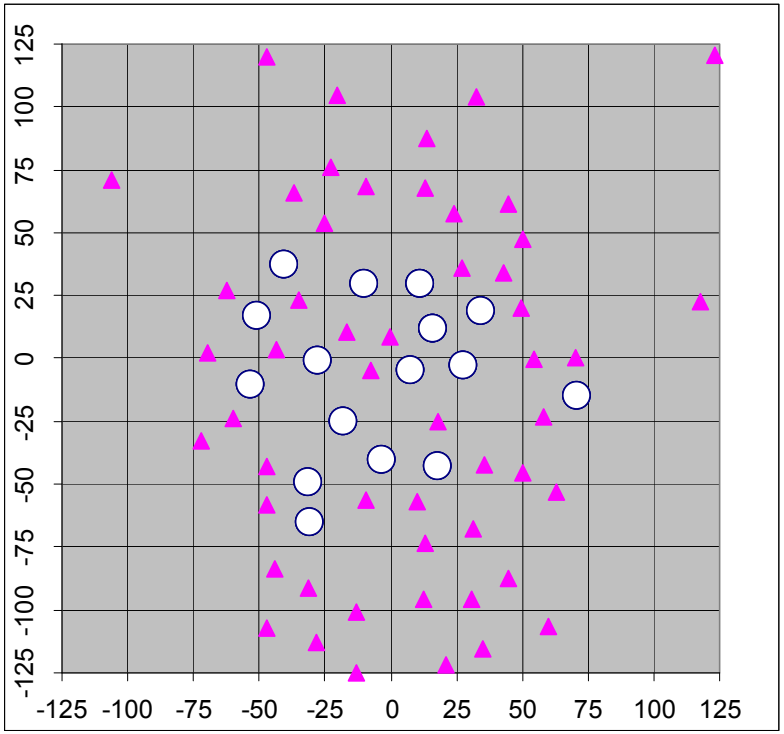
Reporting on effort of a Tiger Team
led by Eric Villard and Crystal Brogan
with key input from Frédéric Boone

Goals for Cycle 0

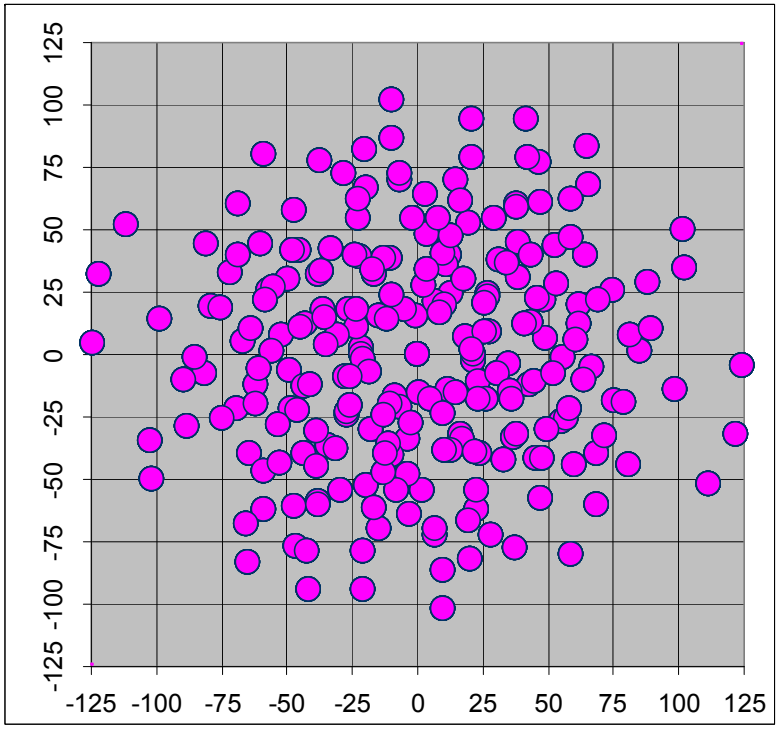
Assume most projects are to do imaging and so with 16 antennas we need good hour angle coverage. Generally +/- 3hrs taken here.

1. Small: emphasize brightness sensitivity, extended objects. Shadowing is the major issue – trade-off against shortest baselines.
2. Medium: essentially largest size that will fit on the pads that will be available at start of Cycle 0.
3. Large (stretch item): high resolution, requires new power distribution system. Due by September but plan this for after the shut-down.

Small Array



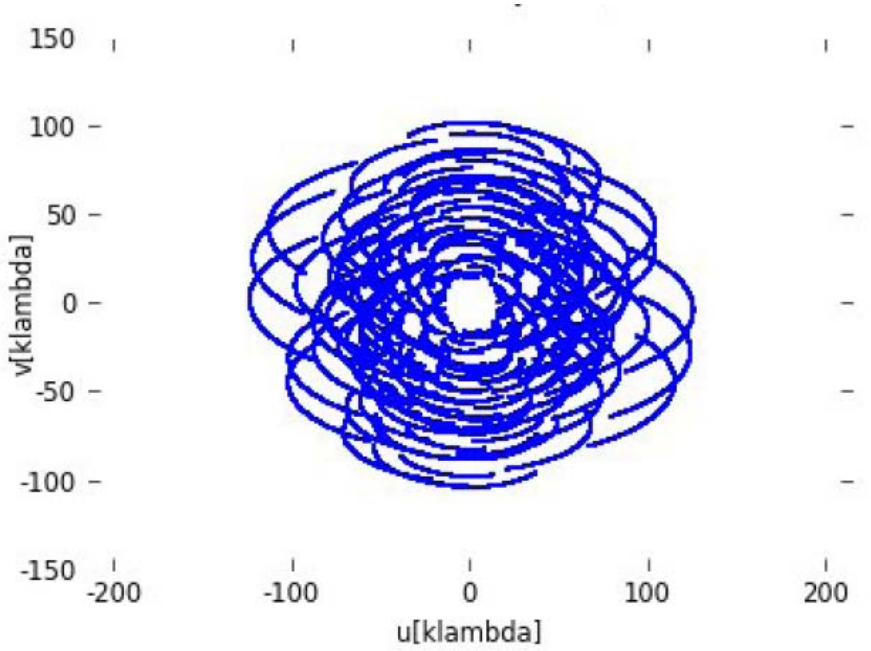
Pads positions

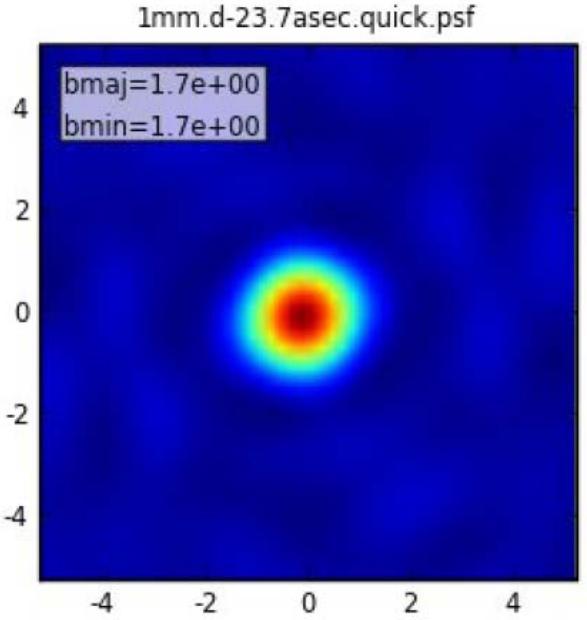


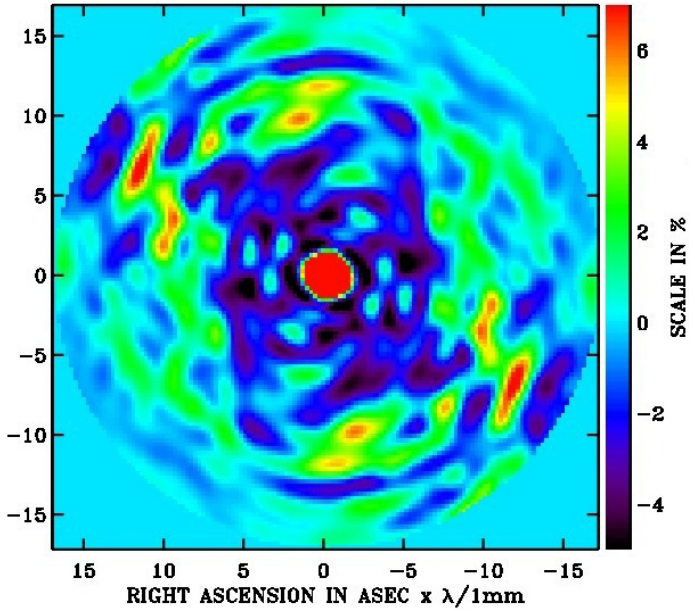
UV (snapshot at zenith

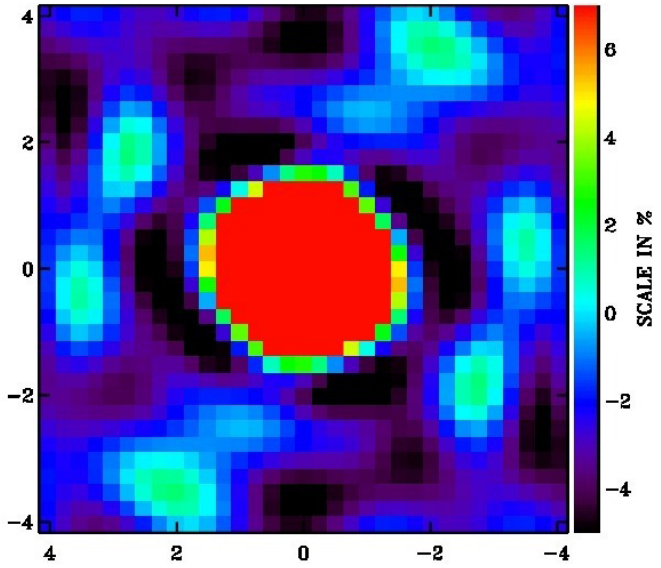
- Optimized for Gaussian distribution of samples in UV plane with FWHM 105 meters and 125 m maximum baseline.
- No blocking for δ -53 to +7 for 6 hour tracks (+/- 3 in HA).

- Source at Dec -23 +/- 3 hrs Patterns for 1mm



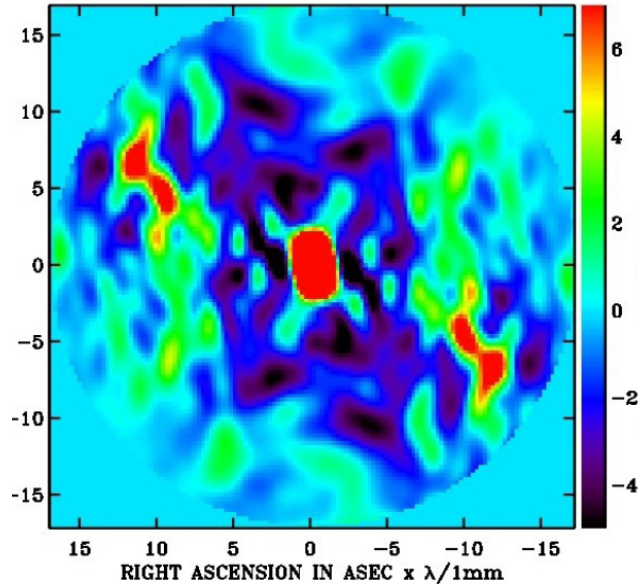






SOURCE DEC. = 27.0 deg
NATURAL WEIGHTING
BMAJ= 2.6 arcsec BMIN= 1.6 arcsec

Dec +27



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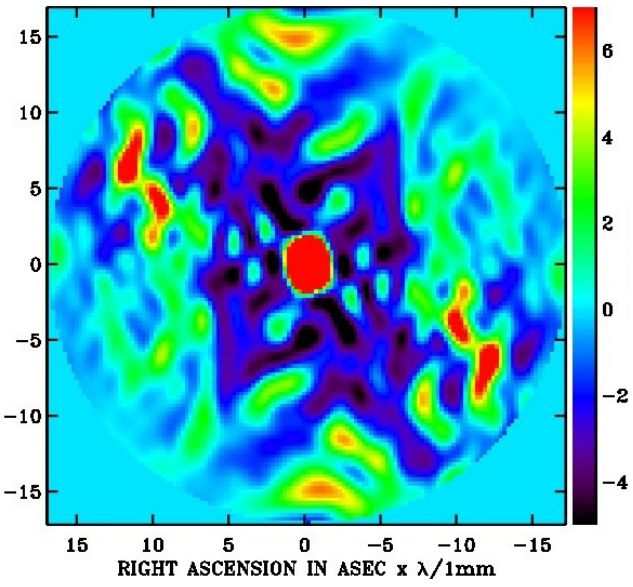
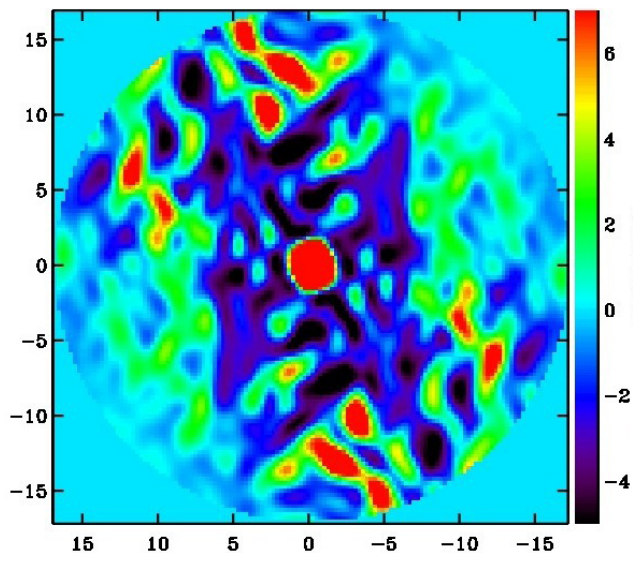
NATURAL WEIGHTING
BMAJ= 2.1 arcsec BMIN= 1.6 arcsec

Dec +17



SOURCE DEC. = 7.0 deg
NATURAL WEIGHTING
BMAJ= 1.9 arcsec BMIN= 1.6 arcsec

Dec +07



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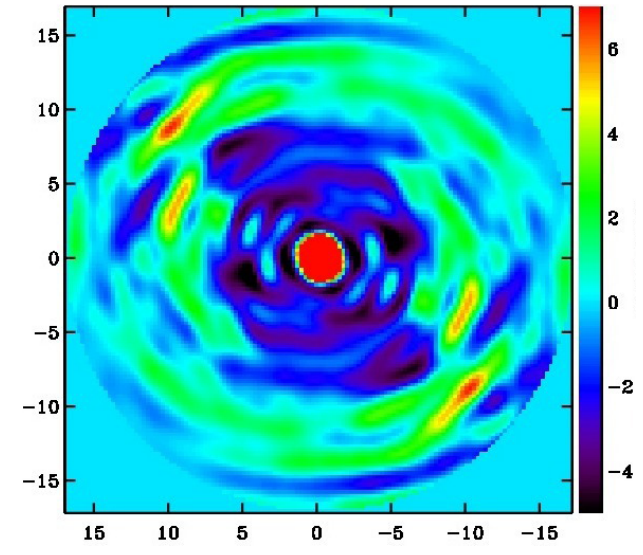
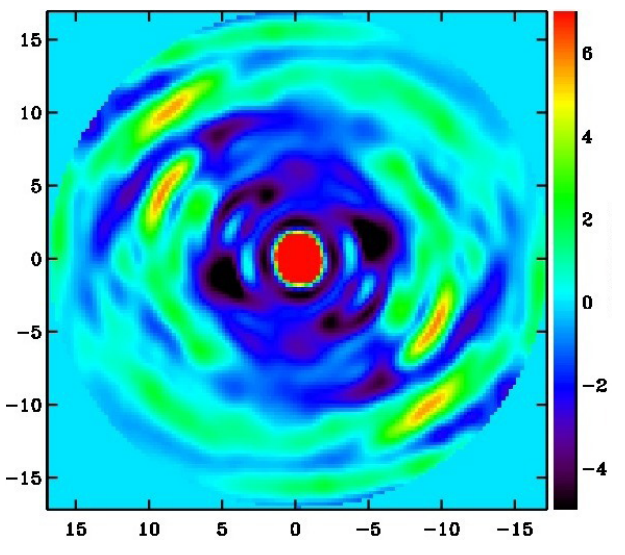
NATURAL WEIGHTING
BMAJ= 1.8 arcsec BMIN= 1.6 arcsec

Dec -53



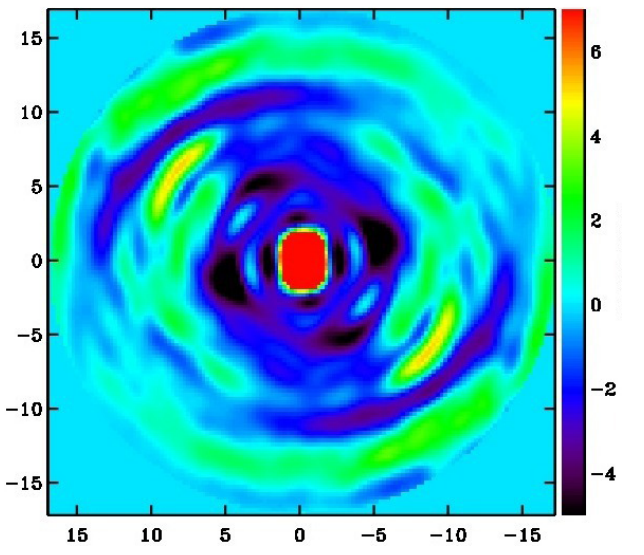
SOURCE DEC. = −63.0 deg
NATURAL WEIGHTING
BMAJ= 2.0 arcsec BMIN= 1.7 arcsec

Dec -63



SOURCE DEC. = −73.0 deg
NATURAL WEIGHTING
BMAJ= 2.3 arcsec BMIN= 1.7 arcsec

Dec -73



Small Array – cases checked

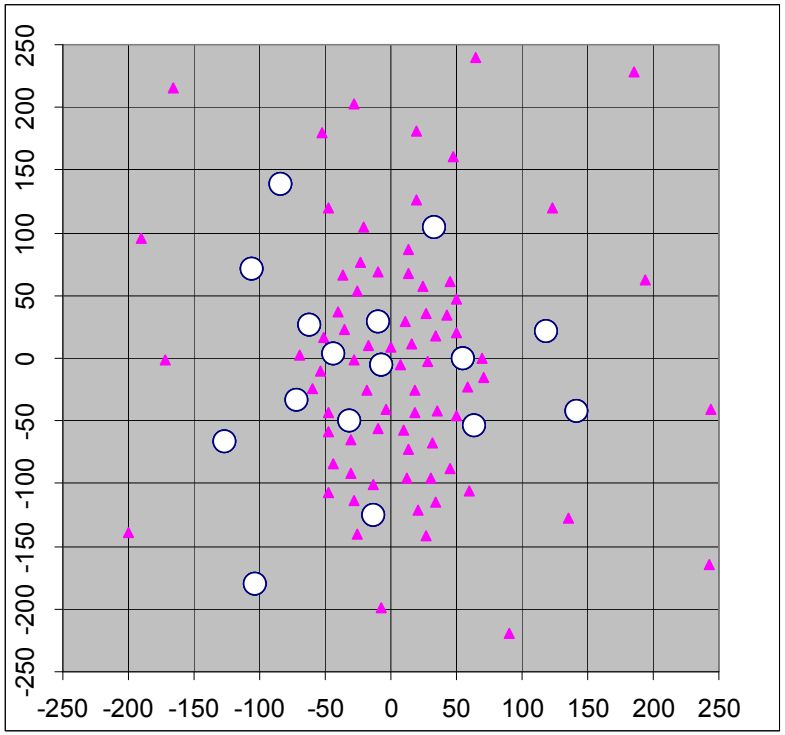
Table 1: Compact Array Characterizations

Characteristic	CSV	Cpct-1	Cpct-2	Cpct-3	Cpct-3REH	Cpct-4	Cpct-5	Cpct-6
Beam	2.1x2.1	1.8x1.7	1.7x1.7	1.7x1.7	1.7x1.7	1.7x1.5	1.9x1.6	1.7x1.5
Max sidelobes	22%	9%	11%	6%	7.5%	12%	10%	8%
Close sidelobes	8%	1%	3%	3%	3%	1.50%	6%	2%
Least $\pm$3hr sp(kλ)	17.2	13.5	12.7	13.5	15.2	12.5	12.3	13.5
Flux recovery	5.3”	6.8”	7.2”	6.8”	5”.9	7.3”	7.4”	6.8”
Shadowing +10		6.50%	9.80%	5.10%	0%	13.70%	16.20%	4.90%
Max $\pm$HA		4.5h	4.0h	4.50h	4.5h	3.5h	3.2h	4.6h
Max sidelobes	%	6.7%	%	5.5%	7.5%	%	9.1%	6.3%
Close sidelobes	%	<1%	%	$\sim$3%	3%	%	6%	<2%
Least $\pm$HA sp(kλ)	...	11.6	11.6	11.6	11.6	11.6	11.6	11.6
Flux recovery-HA	...	7.8”	7.8”	7.9”	5”.9	7.9”	7.86”	7.95”

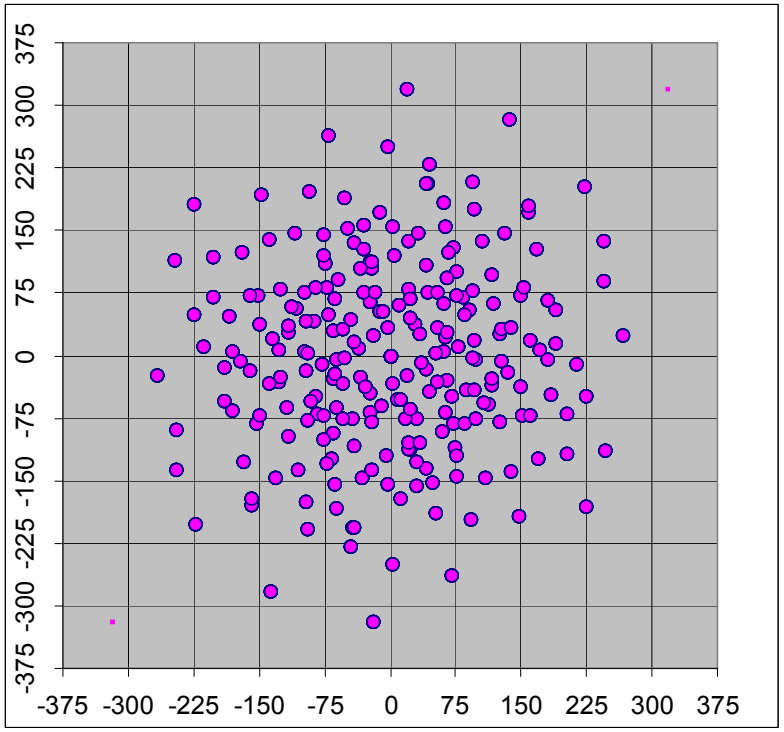
Comparison is with the current “CSV” 8-element array.

Differences are not very large. I think we improve a bit but, given that we can only choose which pads to use (and not move them!), it is not likely we cannot get extremely good dirty beams.

Medium Array

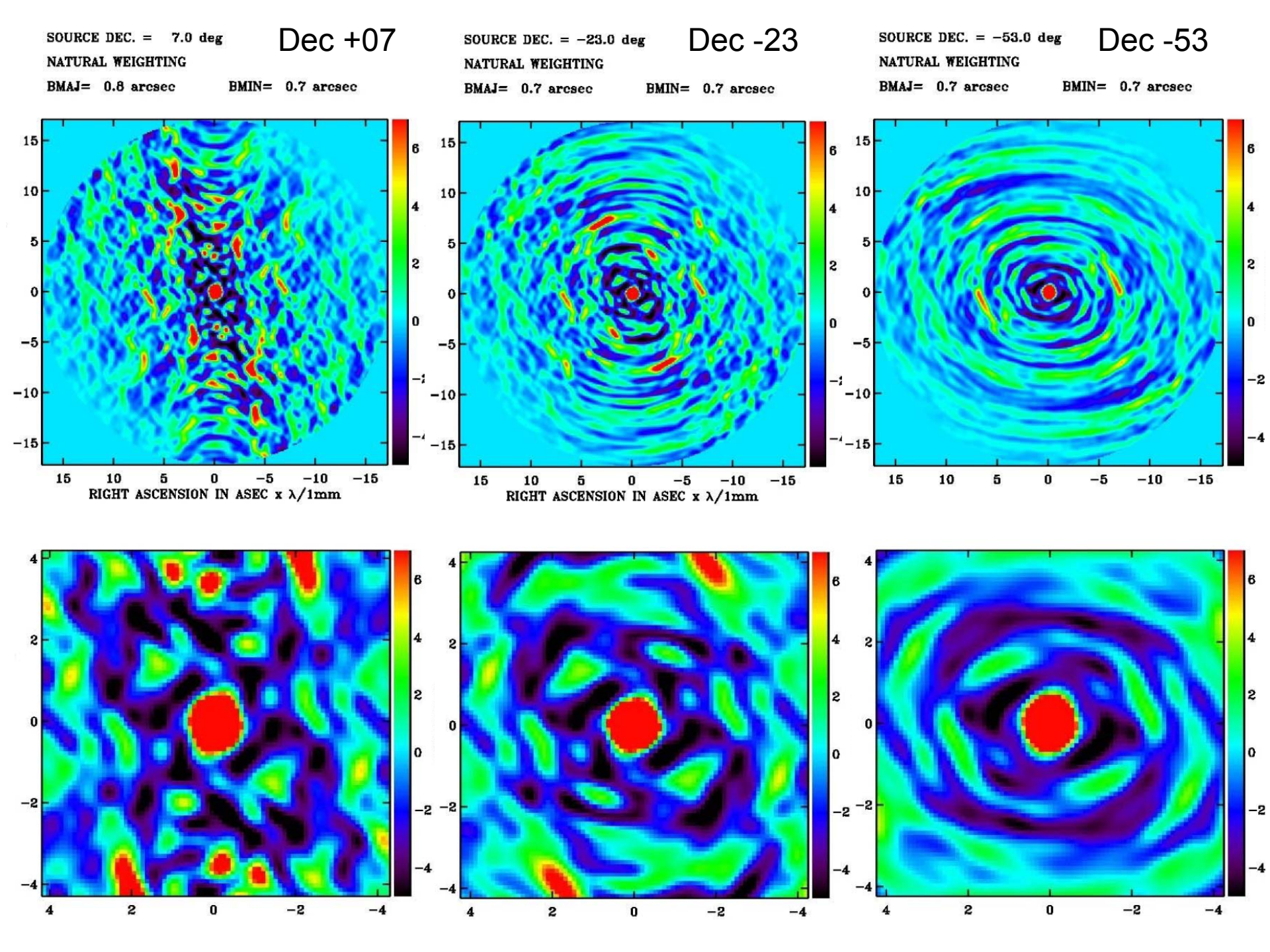


Pads positions

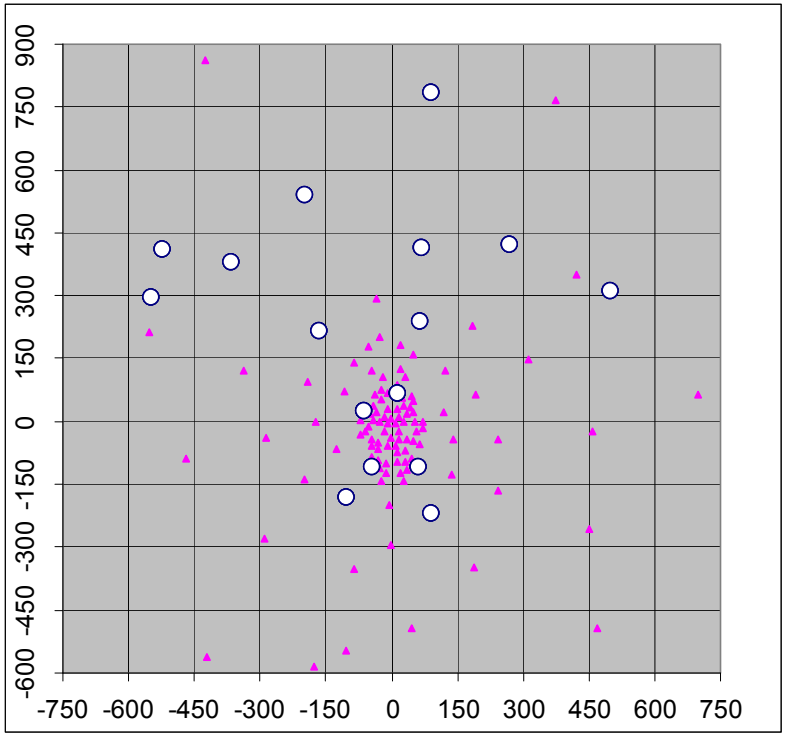


UV (snapshot at zenith)

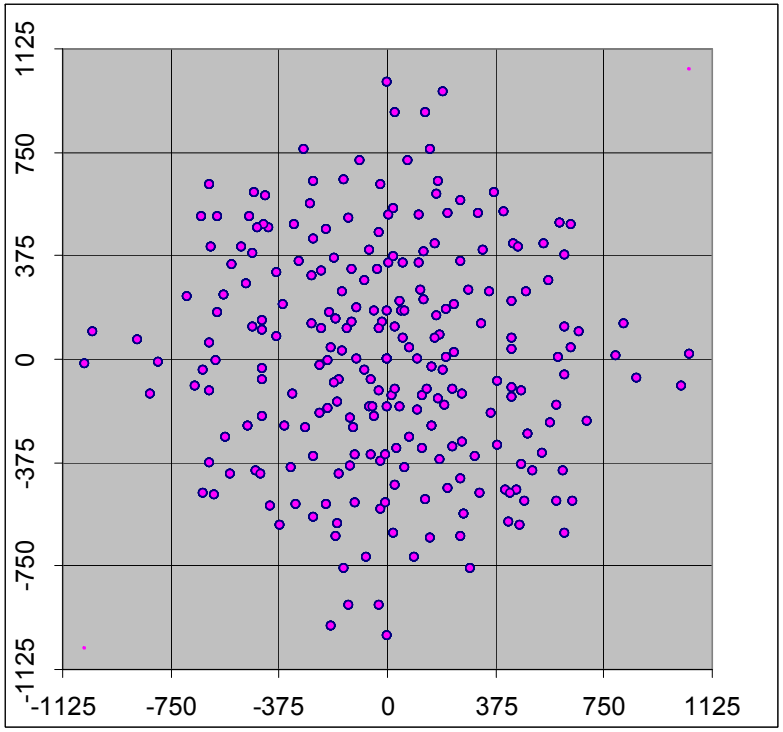
- Target FWHM 280 meters. Maximum baseline 320 meters.
- Shortest baselines of 30 to 40 meters - no blocking issues.


SOURCE DEC. = 7.0 deg
NATURAL WEIGHTING
BMAJ= 0.8 arcsec
BMIN= 0.7 arcsec
Dec +07
SOURCE DEC. = −23.0 deg
NATURAL WEIGHTING
BMAJ= 0.7 arcsec
BMIN= 0.7 arcsec
Dec -23
SOURCE DEC. = −53.0 deg
NATURAL WEIGHTING
BMAJ= 0.7 arcsec
BMIN= 0.7 arcsec
Dec -53
RIGHT ASCENSION IN ASEC x λ/1mm
RIGHT ASCENSION IN ASEC x λ/1mm

Large Array



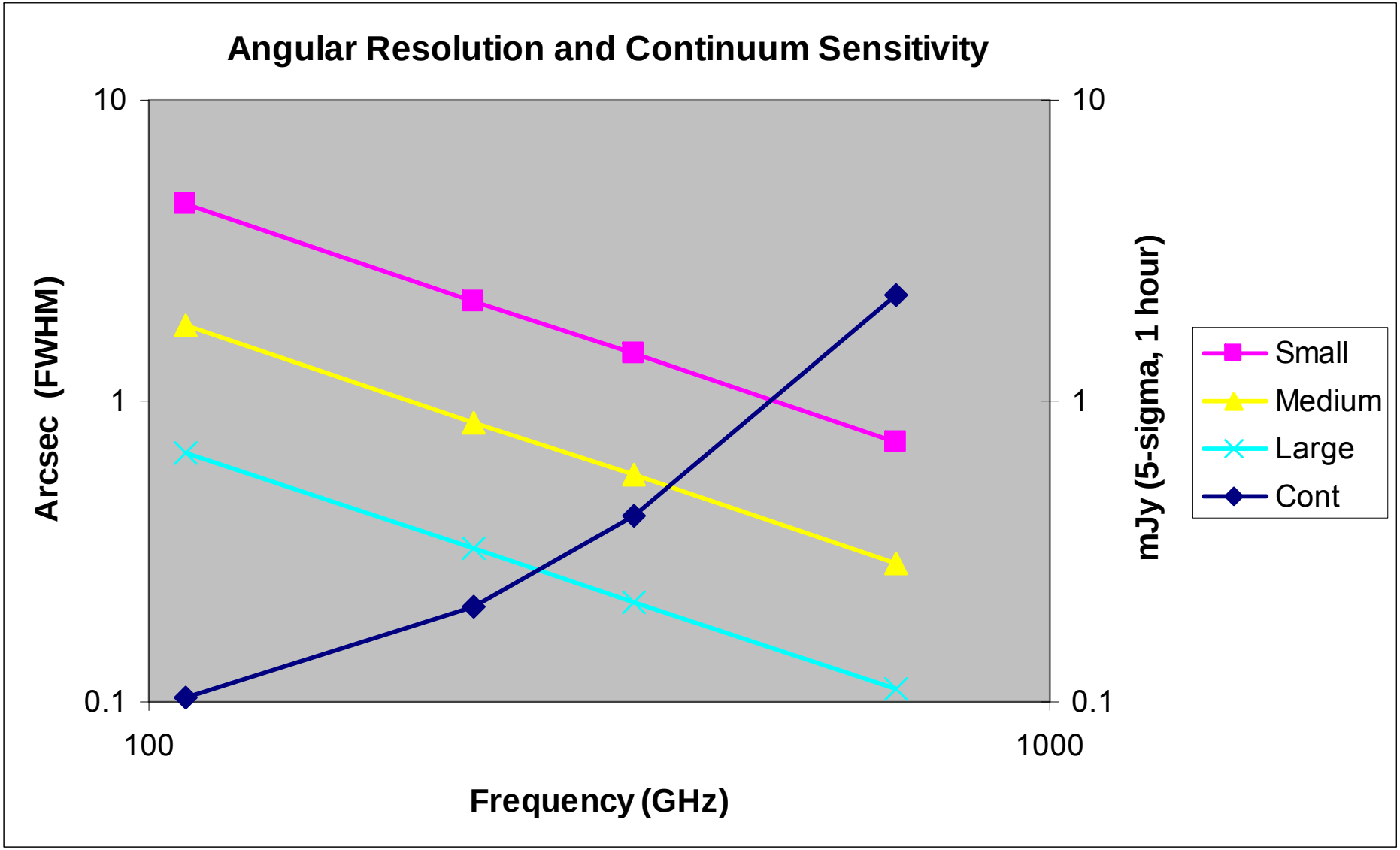
Pads positions



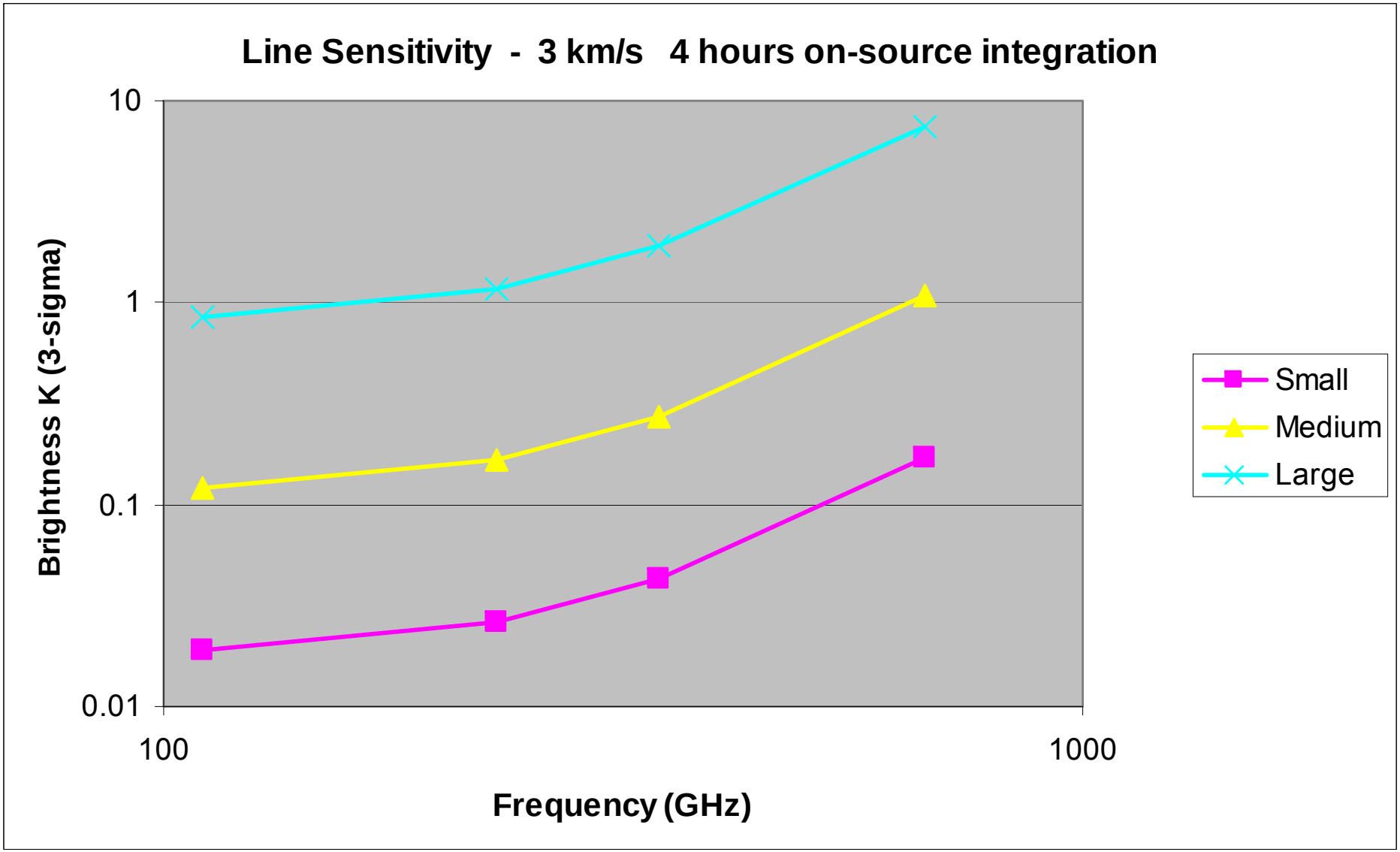
UV (snapshot at zenith)

- Still working on this. Proposed target FWHM is 750 meters. Beamwidth will be ~0.25 arcsec at 1mm.

Basic Performance



Spectral Line Imaging



Question to ASAC

- Is the proposed step of about 2.65 in angular resolution, and therefore about 7 in brightness temperature sensitivity, OK or is it too large, or perhaps too small?

  (Previous plan was for factors of 2.)
- Anything else missed here?

- I believe that the main issue is simply the provision of sufficient hardware (power, foundations) and the logistics of the moves.

Antenna Numbers

- With some margins we should expect to have 20 antennas at the AOS by November and 25 by late Feb 2012.
- If we assume one of these is a 7 meter in November and three by Feb[1] then these become 19 and 22.
- This means that by Feb we can have a core of 16 antennas with 6 to fill in, provide redundancy, etc.

[1]Note that this is already problematic from the point of view of demonstrating the ACA in time for the call for proposals for cycle 1.

Straw-man Sequence

- Start with “small” array. (First moves in late March if antenna stations are ready)
- Additional antennas go onto “medium” pads.
- There are some common pads too
- So in late November (?) move about 8 antennas from small to medium pads to complete the medium array.
- I think ~5 days should be enough to do moves and check out the system, in good conditions.
- Late December move remaining inner pads to longer baselines for CSV testing
- During Feb shutdown complete the “Large” array using antennas from the medium but keep any “spare” antennas on shorter baselines.
- Choice of whether to stay with Large to June or change back to smaller ones.

Mosaicing

- Obviously we have not achieved what we wanted but both that taking of data with reasonably low overhead and getting it into CASA have been demonstrated.
- We (Alison and I) regard the remaining steps as relatively low risk.
- May still be able to get some good results in the next week or so.

Polarization

- Obviously this is the hard one.
- For the advertised 1% precision we are actually rather close even for modest sources sizes and spectral lines.
- It is not comfortable that we have a new and not-understood effect here, which we certainly won't solve in the next week, and also that we have only band 3 data.
- My suggestion is that we offer this but with some extra level of "best efforts / own risk" notice.