MeerKAT Overview

Jasper Horrell, 3GC-II Workshop 2011, Albufeira, Portugal

SKA SKA Project

Major components:

- SKA site bid – South Africa and Australia shortlisted – decision by Feb

- MeerKAT – SKA precursor and world class facility

- Youth Into Science – skills development and training programme

- African VLBI Network

MeerKAT focus today…

MeerKAT

Karoo Array Telescope -> KAT

(20 dishes initially)

+

More funding from government

=

More KAT (64 dishes) -> MeerKAT

("Meer" is Afrikaans for more)

SK A
SKA AFRICA
SQUARE KILOMETRE ARRAY

MeerKAT Specifications

- 64x13.5m offset Gregorian dishes. 1mm rms surface. 15 arcsec pointing accuracy (with approx 5 arcsec tracking consistency)

- Frequency range 0.59 – 14.5 GHz

- 65k freq channels (spread over 4 sub-bands)

- L-band sensitivity: Ae/Tsys = >220 m^2/K

Prime Focus

Offset Gregorian
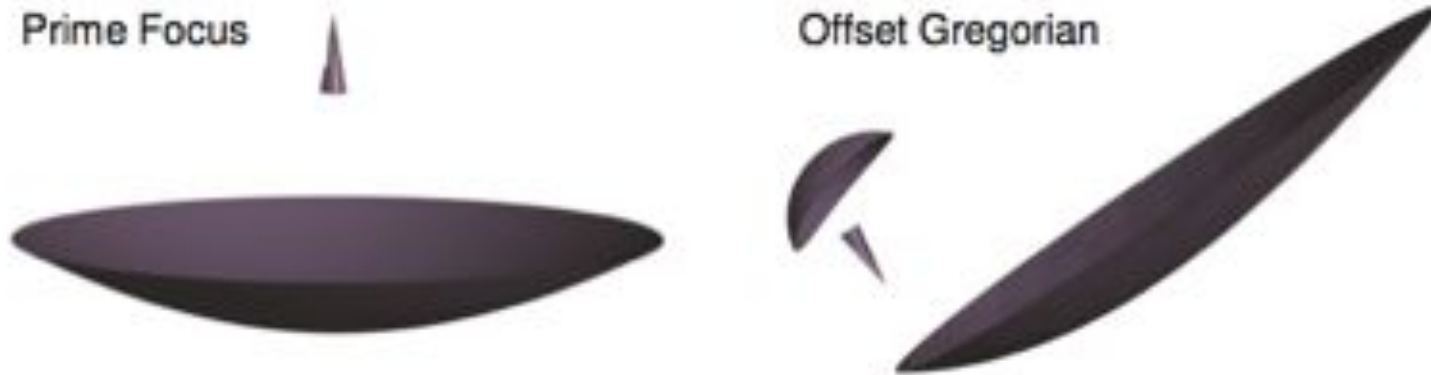
Offset Dish – prelim design
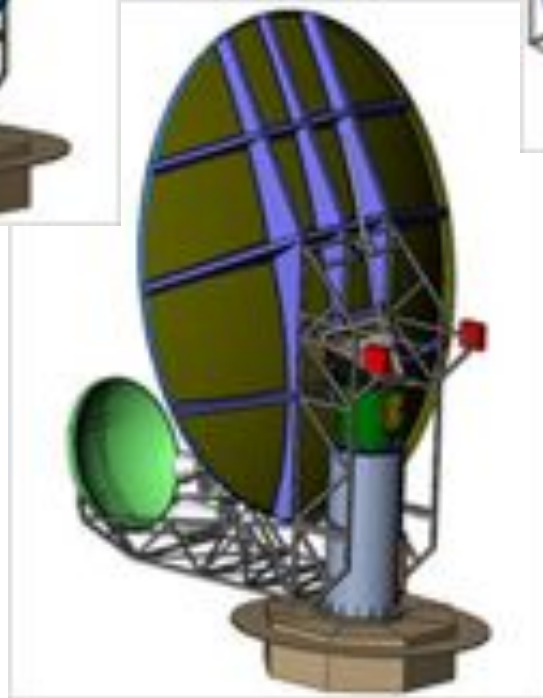
MeerKAT Phases/Specs

	Phase 1	Phase 2
Est. completion	2016	2018
Frequency bands (GHz)	1.0 - 1.7	0.59 – 1.1 8 -14.5
RF bandwidth (MHz)	850	6500
Sampling frequency (Gsps)	5	30
Processed bandwidth (MHz)	850	6500
Max baseline (km)	8	8

MeerKAT Movie

MeerKAT Large Survey Projects

Announced 2010 (covers 75% observing time, 25% still PI driven):

- Priority 1:

    - Deep HI Field (5000 hours)

    - Radio Pulsar Timing (7860 hours)

- Priority 2:

    - MESMER: MeerKAT Search for Molecules in the EOR (6500 hours)

    - MeerKAT Absorption Line Survey (4000 hours)

    - MHONGOOSE: Deep Observations of Targeted Nearby Galaxies (6000 hours)

    - TRAPUM: Transients and Pulsars with MeerKAT (3080 hours)

    - MeerKAT HI Survey of Fornax (2450 hours)

    - MeerGAL: MeerKAT High Frequency Galactic Plane Survey (3300 hours)

    - MIGHTEE: Deep Continuum Survey (approx 1950 hours)

    - ThunderKAT: Hunt for Dynamic and Explosive Radio Transients with MeerKAT (3000 hours)

MeerKAT Project Status

- 3 centres: JHB (some "business" functions, infrastructure and site bid); Cape Town (engineering and science); Karoo (site)

- About 100 people employed directly on the project currently (growing)

- Plus several major industry partners (EMSS represented here)

- MeerKAT (and SKA) site operational after major infrastructure development

- Site on grid power (with diesel backup) with fibre connection to Cape Town.

- KAT-7 engineering (and science) test-bed deployed on site. Full program of commissioning operations.

- Continued strong political support

Good momentum!

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Success Factors

Major factors at play:

- An excellent, well-protected, accessible and workable RFI-quiet site

- Continued strong top-level political and funding support

- A large pool of talented and innovative people from which to draw

- Strong international collaborations

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MeerKAT Political Support
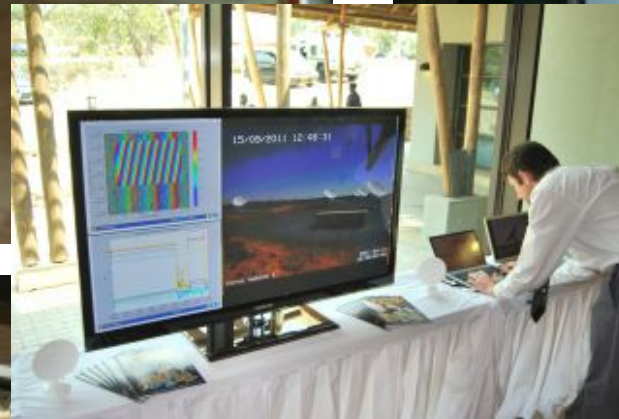
Weekly Flights - not quite ☺

Weekly Flights - actual
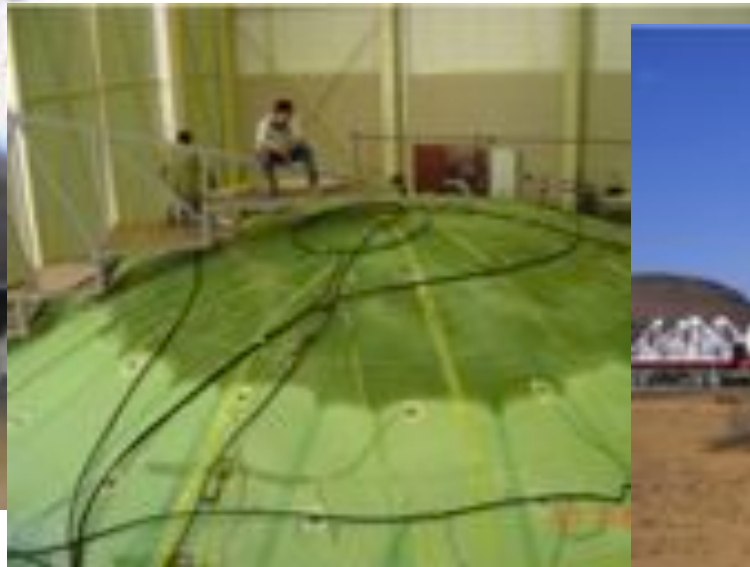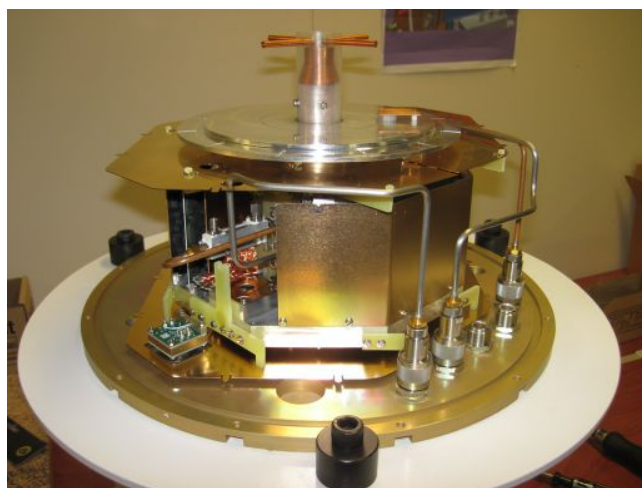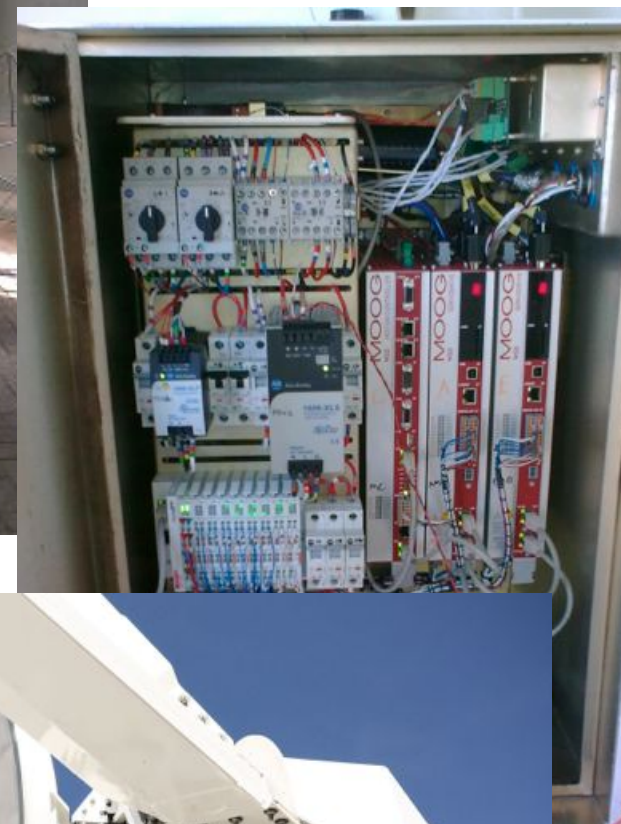
Cape Town Office

Infrastructure

KAT-7

engineering prototype

test MeerKAT ideas

develop technology and skills

1200 - 1950 MHz sky frequency

some science work

7 prime focus dishes

demonstrate operational site

400 MHz sampled bandwith (256 MHz usable)
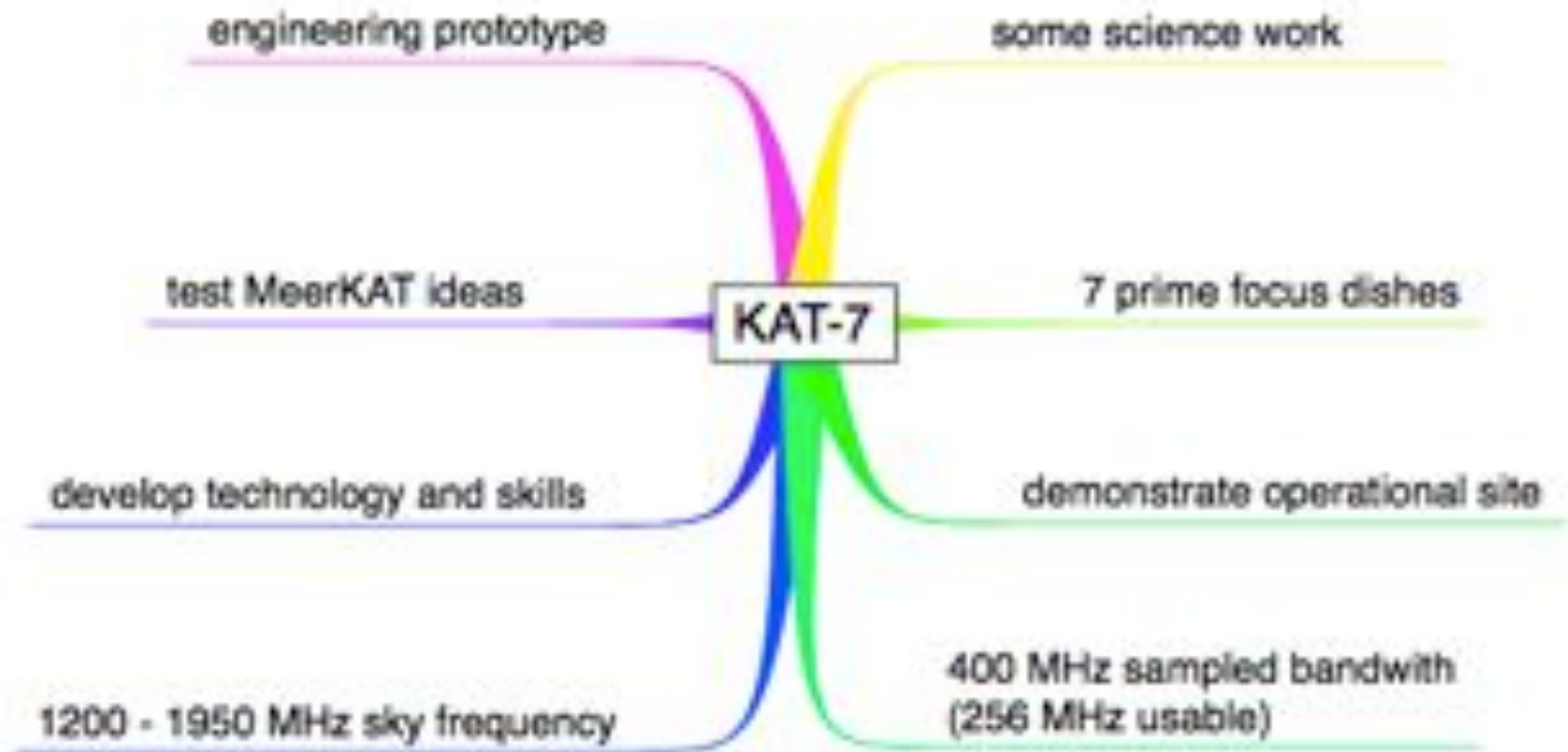
KAT-7

KAT-7 Movie

KAT-7 Composite Dishes

KAT-7 Dishes

Feeds, Receivers & Electronics

Feeds, Receivers & Electronics

Cold Feeds

Cold Feed Installation

Digital Signal Processing

2008:
ROACH1 (Virtex5)
320 GMAC limit
40 Gbps interconnect

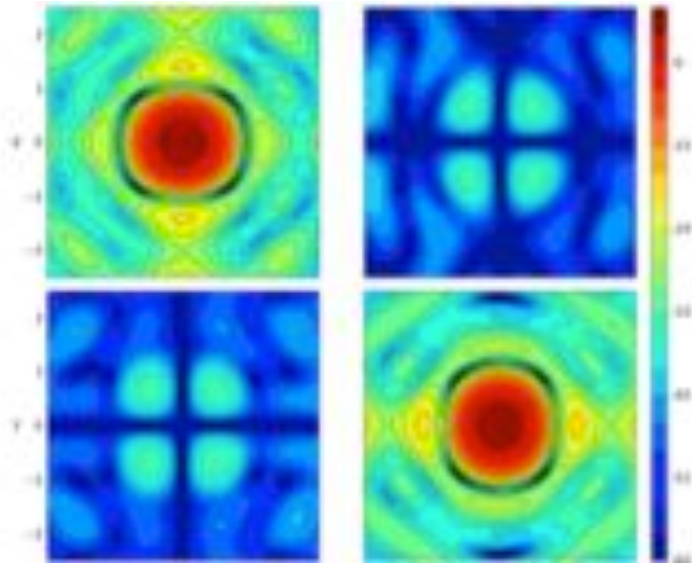**2010:**
ROACH2 (Virtex6)
1.4 TMAC limit
80 Gbps interconnect

2012:
ROACH3 ('Virtex7')
3 TMAC ?
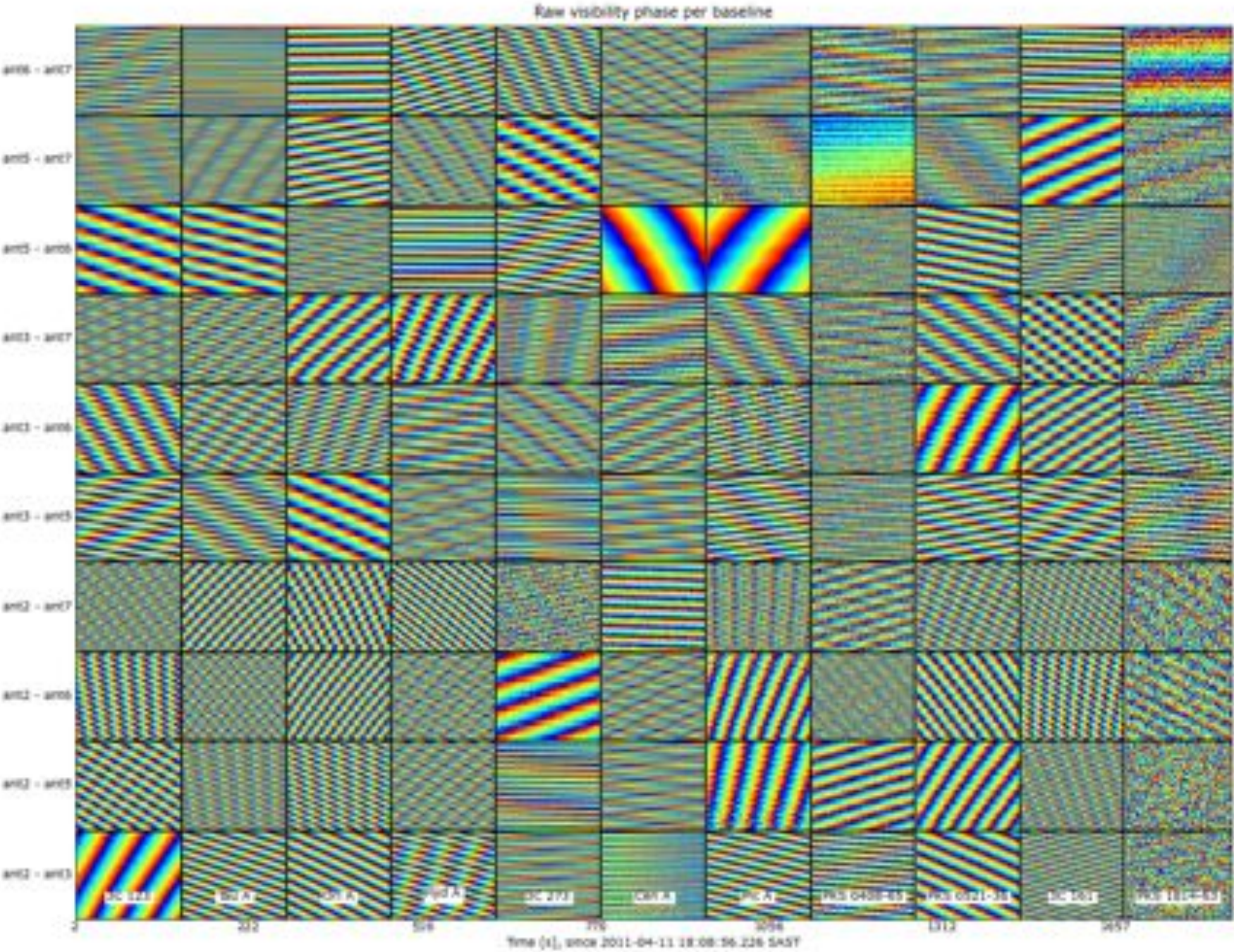160 Gbps ?

2014:
ROACH4 ('Virtex8')
6 TMAC ??
320 Gbps ??

KAT-7 Correlator (16-element)

KAT-7 Software
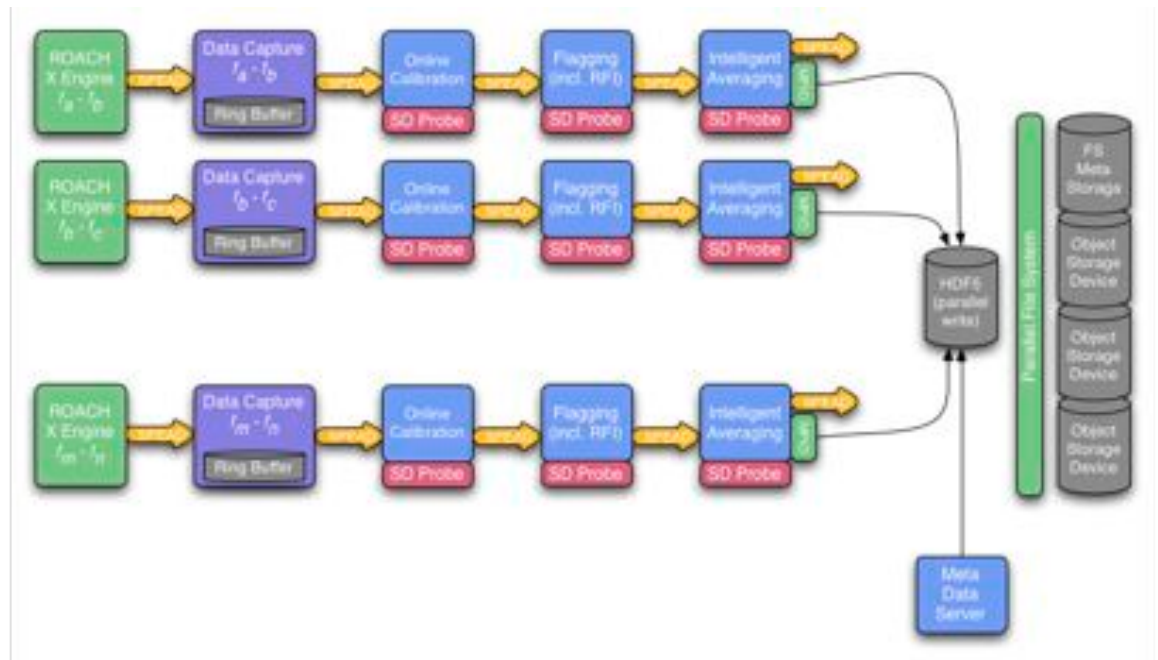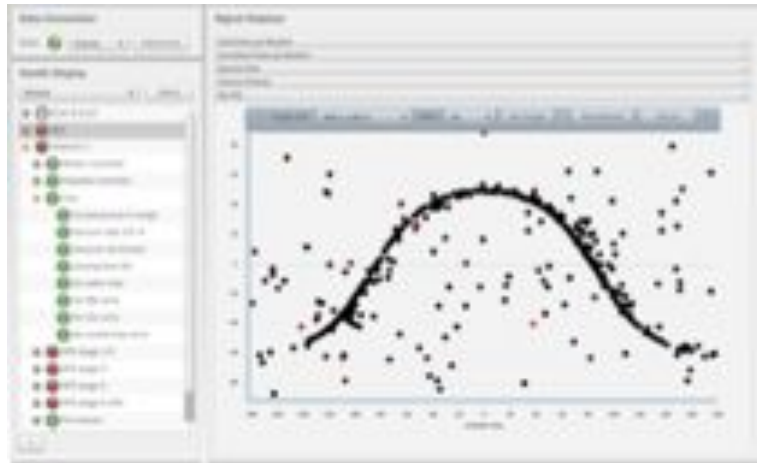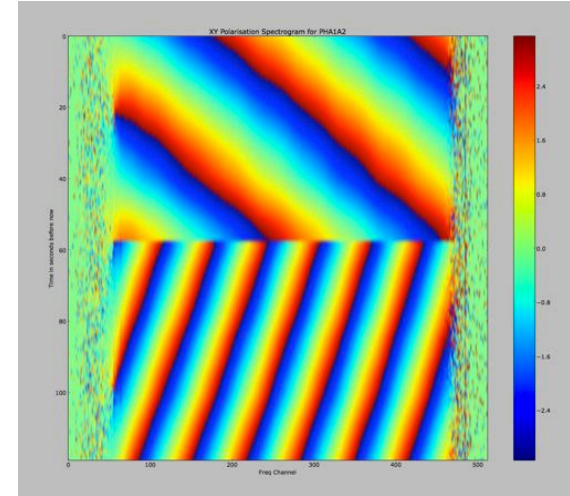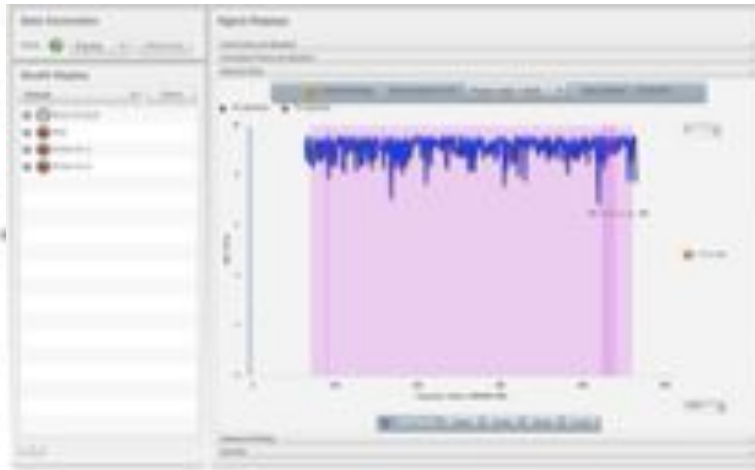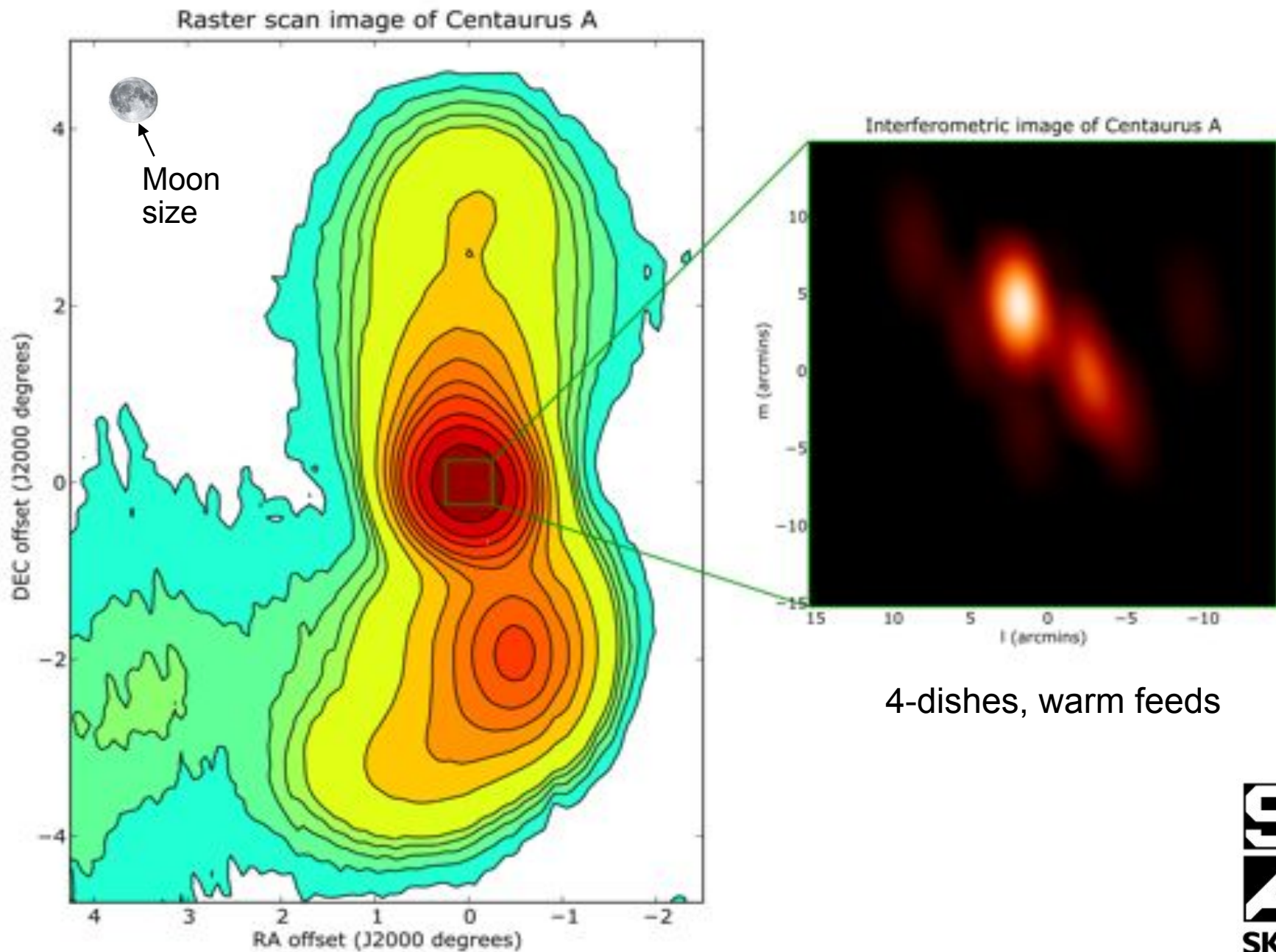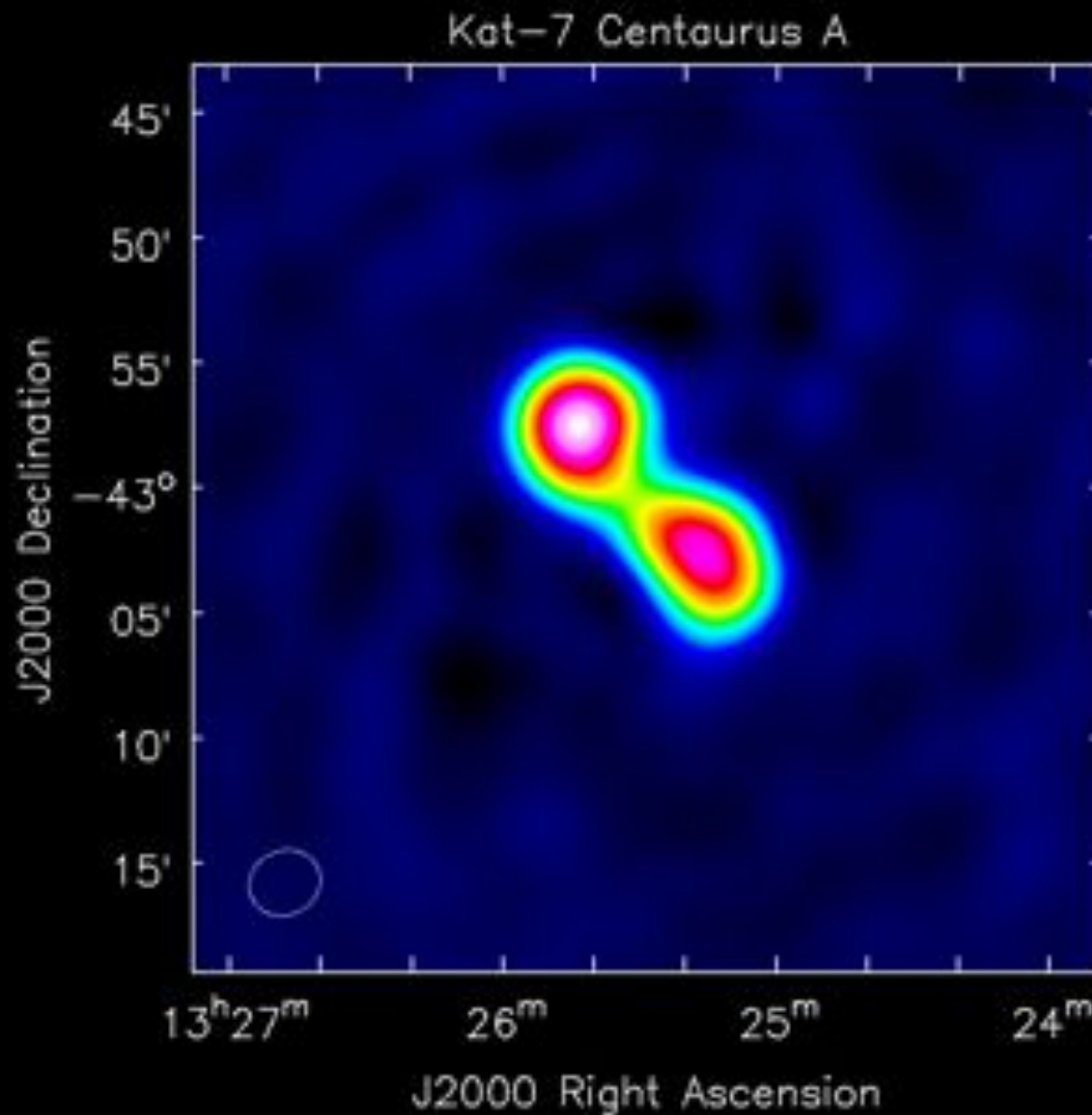
Baseline Calibration Fringes – KAT-7 Correlator

Raw visibility phase per baseline

Time [s], since 2011-04-11 18:08:56.226 SAST

KAT-7 Cen A (2010)

Raster scan image of Centaurus A

Moon size

Interferometric image of Centaurus A

4-dishes, warm feeds

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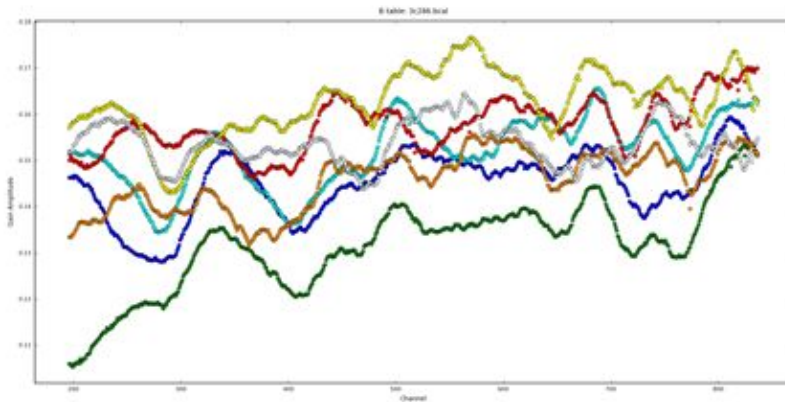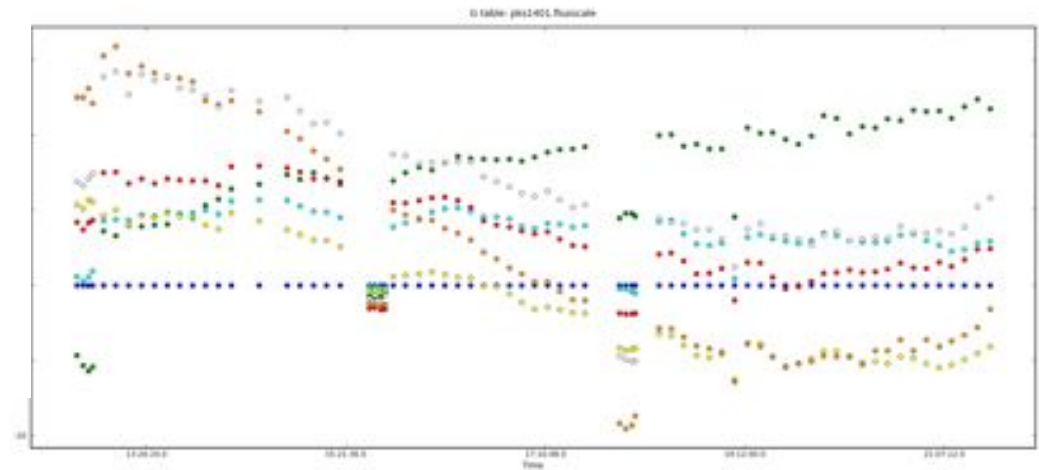SQUARE KILOMETRE ARRAY

KAT-7 Cen A (2011)
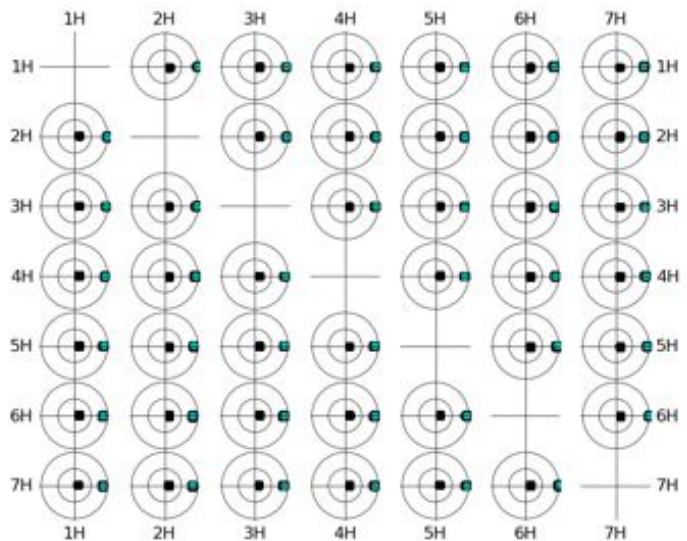

Kat-7 Centaurus A

7 cold feeds

KAT-7 Cen A (2011)

Bandpass ampl

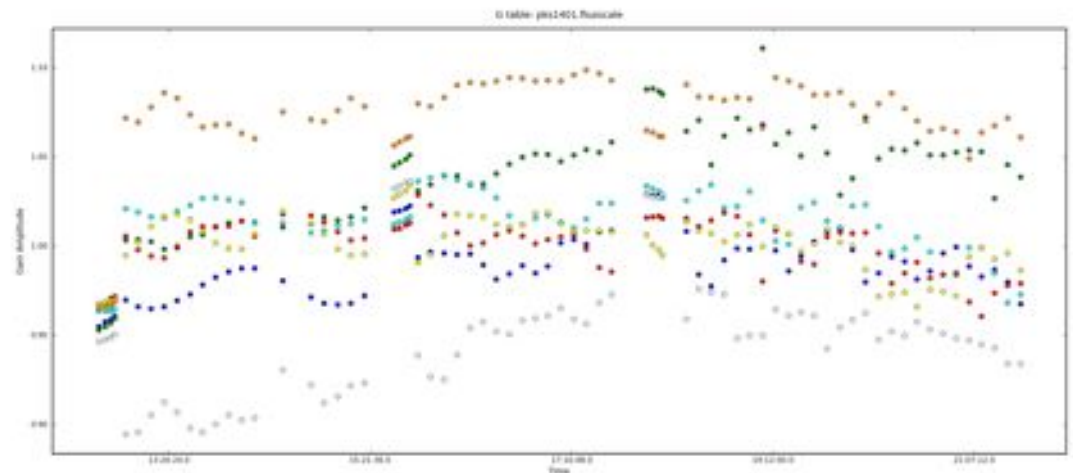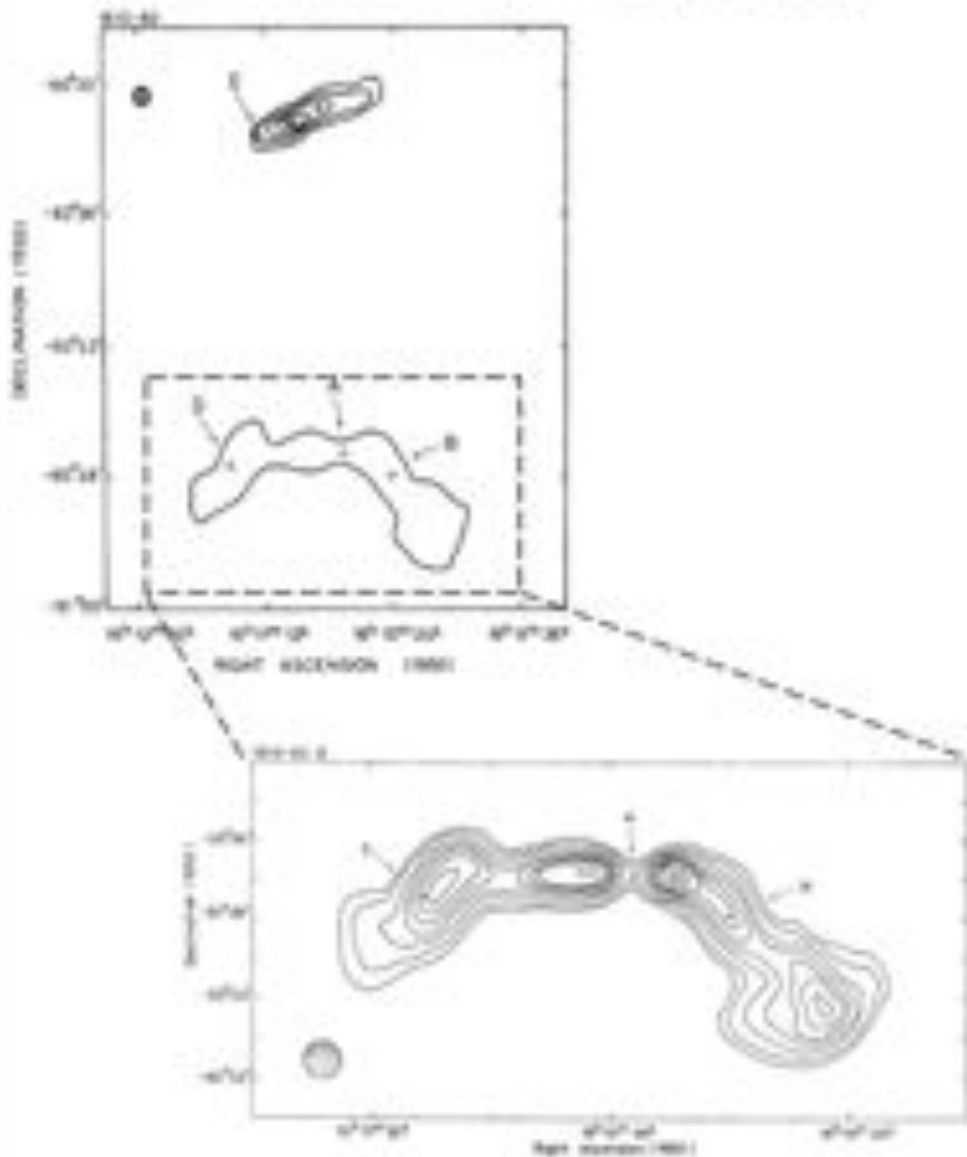Gain cal phase
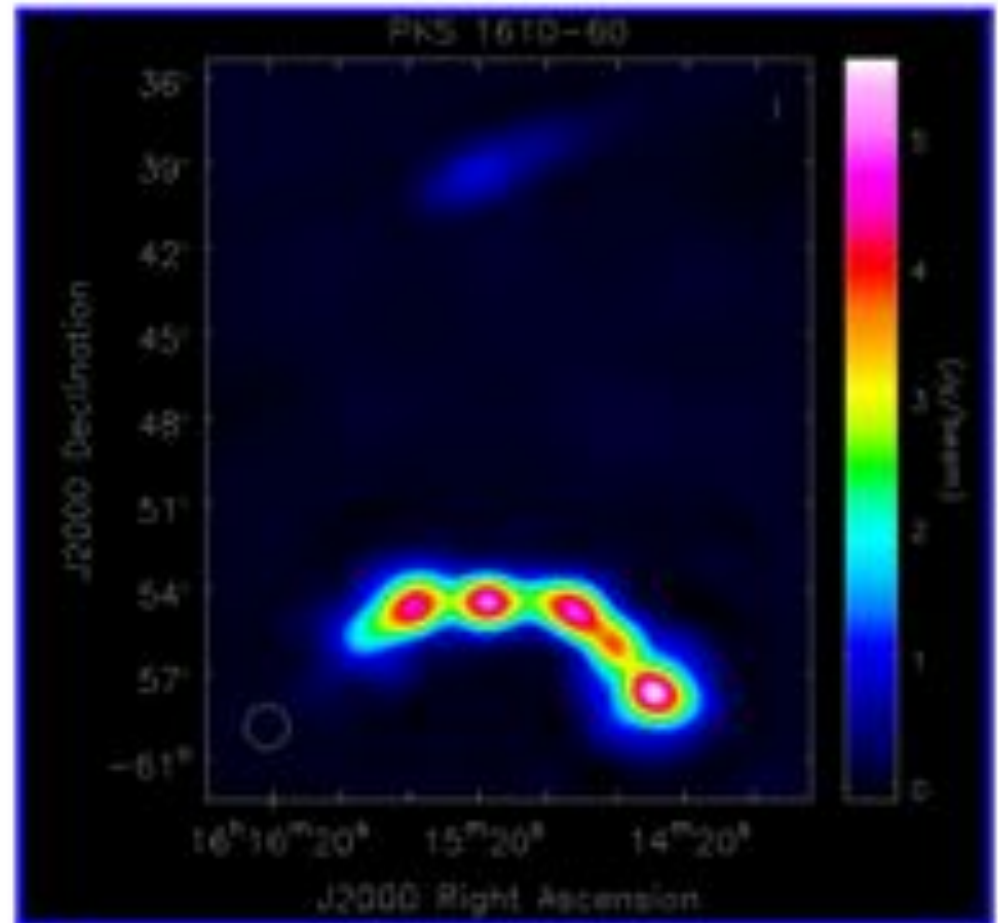
Bandpass cal and stopped

Gain cal ampl

1610-60.5 & 1610-60.8 at 1415 MHz.
Galaxies A, B, D & E are identified.
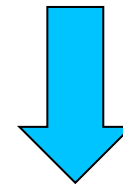(Christiansen, et al. 1977, MNRAS, 181, 183)

1610-60.5 & 1610-60.8 observed with KAT-7, Aug 2011

MeerKAT Array Layout

- Work by Brad Frank & Erwin de Blok

- 64-dish layout close to final (80-dish superset also exists). Some small tweaks may still occur.

- Designed with fairly compact core, but also with good sensitivity over range of resolutions (flat over 10-50 arcsecs)

|	MeerKAT 80 (Ver. 3.6)	MeerKAT 64 (Ver. 3.6)
Min baseline	29 m	29 m
N(dishes) within 500 m	48	39
N(dishes) within 1 km	58	45
N(dishes) within 2 km	67	53
N(dishes) within 4 km	78	62
Max baseline	7.7 km	7.7 km

MeerKAT Array Layout
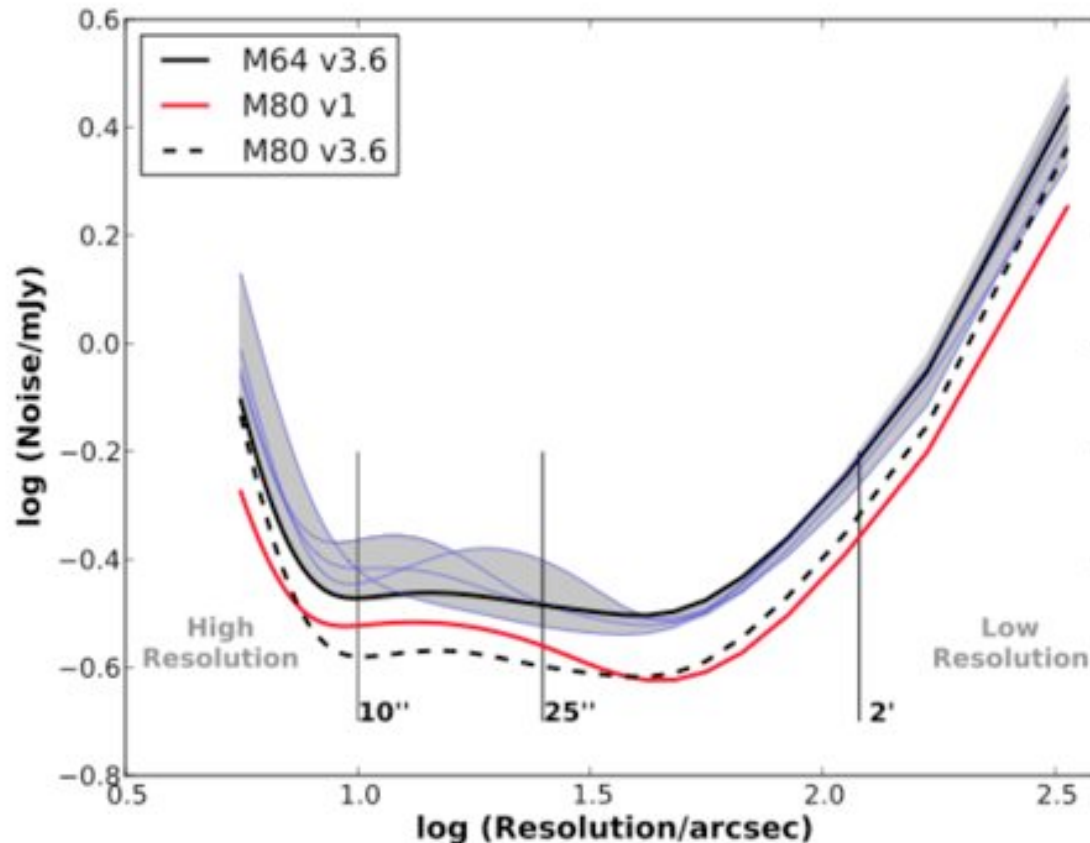
Sensitivity versus resolution for original 80-dish (ver1), 80-dish (ver 3.6) and 64-dish (ver 3.6) for constant size (12m) dish.
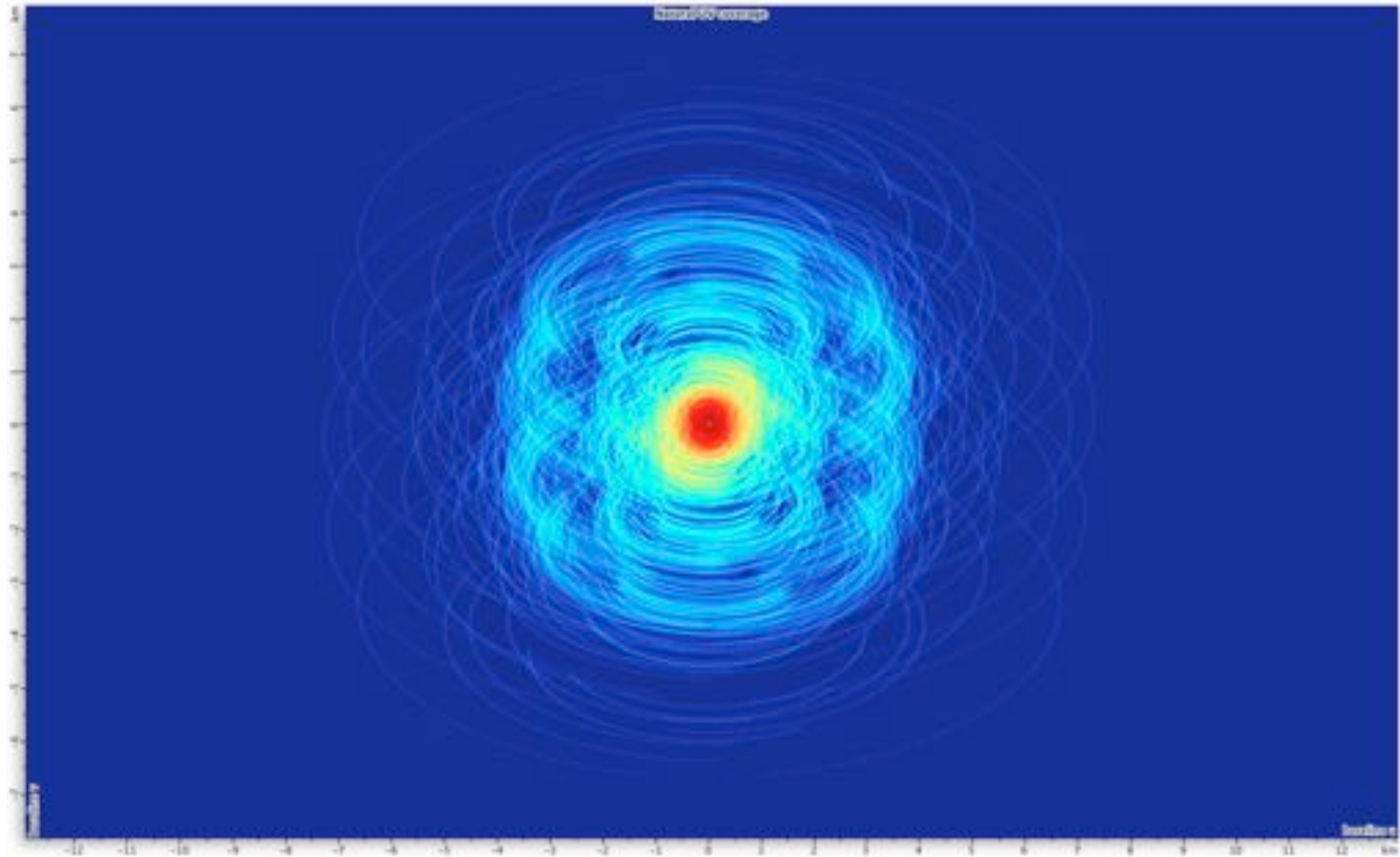Also shown (light blue) are some less good 64-dish configs.

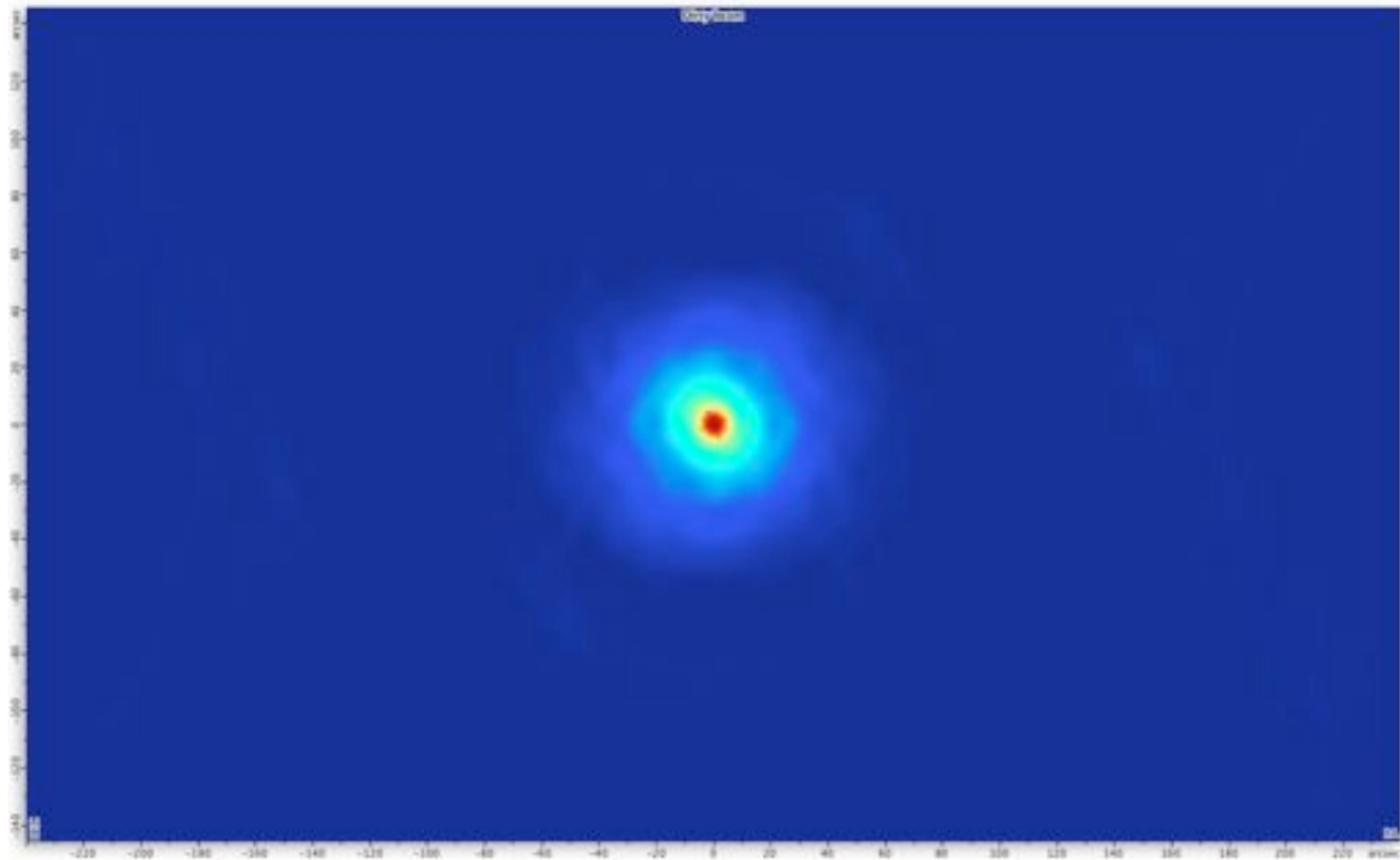# MeerKAT Array Layout

MeerKAT Array Layout
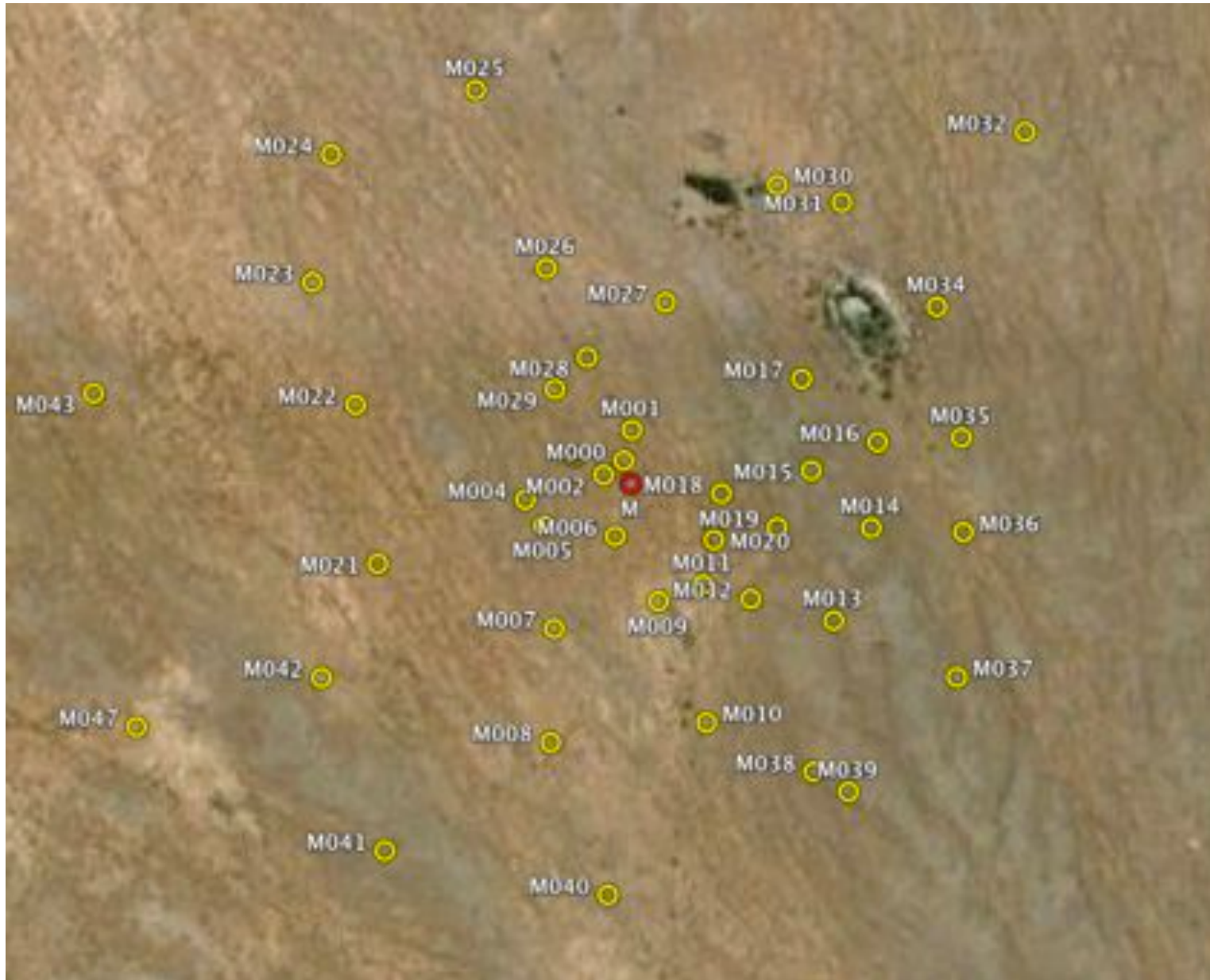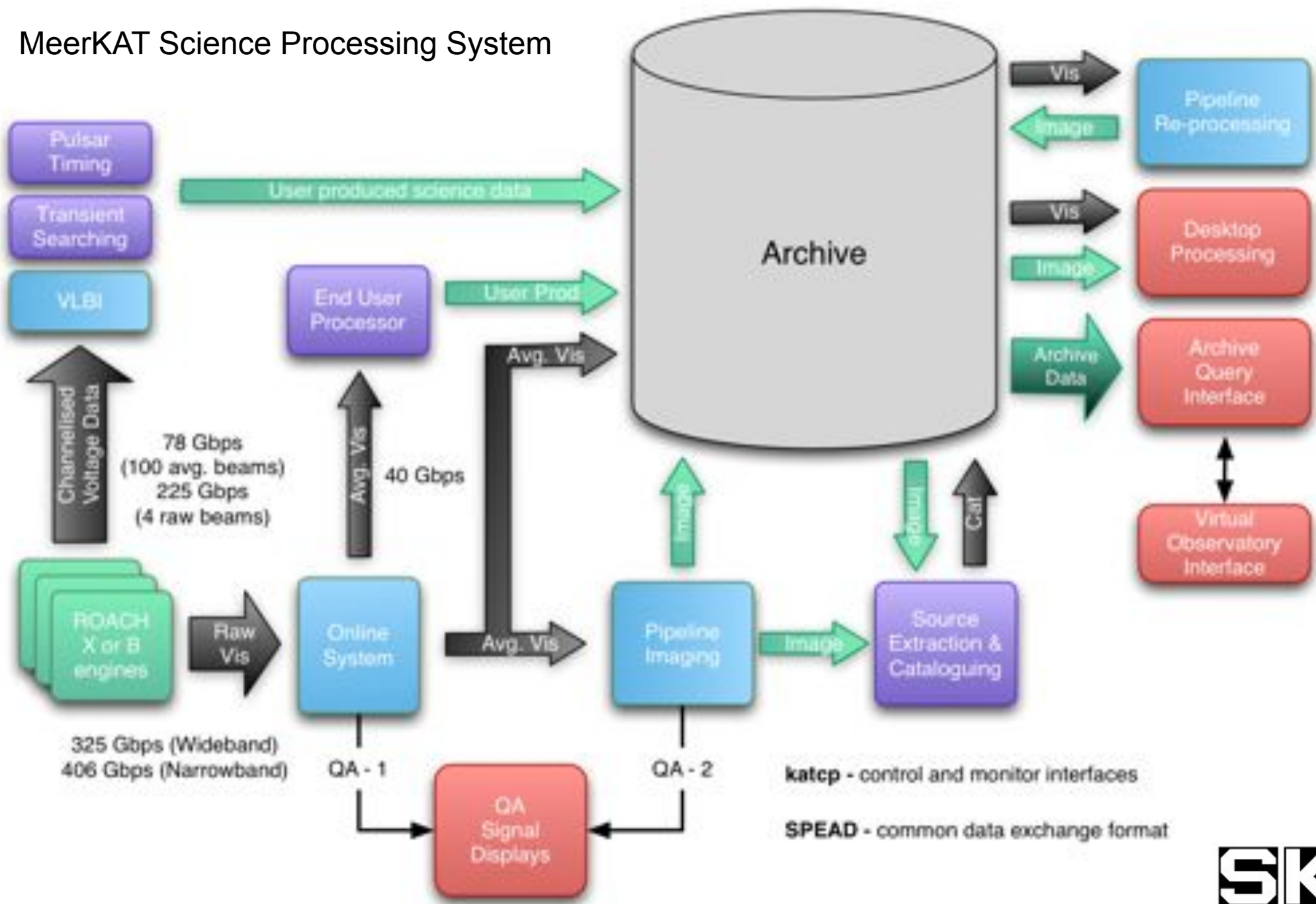
MeerKAT U-V Coverage

64-dish uv coverage for 8 hour observation, zenith centered

MeerKAT PSF

64-dish point spread function for 8 hour observation, zenith centered

MeerKAT Science Processing System

MeerKAT to provide:

- Calibrated visibilities

- Certain standard pipelines (spectral line image cubes, continuum images)

- Storage for visibility data (project disk quotas?)

- A 10 PB archive on site plus 3 PB in CT, plus likely European mirror

- Archive access and facilities to reprocess from archive

- Flexible architecture for "black belt" users

- Support for some re-use of existing mature packages where possible – mostly at extemities of system (support CASA, MeqTrees)

MeerKAT Pipelines

- Non-trivial…

- One pipeline to rule them all? – almost certainly not

- A few pipelines to cover the common cases? – perhaps.

- Science quality pipeline output? – with time and experience… perhaps.

photo: Mike Slagter

photo: darthdowney

photo: surfglassy

KAT-7: What do we have now?

- Data capture framework to HDF5 file and MS writing capability

- Simple archive for commissioning purposes

- SCAPE commissioning package -> becoming interferometric

- First imaging software

- Simulation and data reduction tests in Meqtrees

- Prototype online system based on ROACH sampling, followed by GPUs pre-processing and disk storage. Allows for raw data recording for commissioning, VLBI, software correlation, SETI

- ASTRON and NRAO collaborations

- Some great early results on the KAT-7 system

- A lot of work to be done over the next few years.

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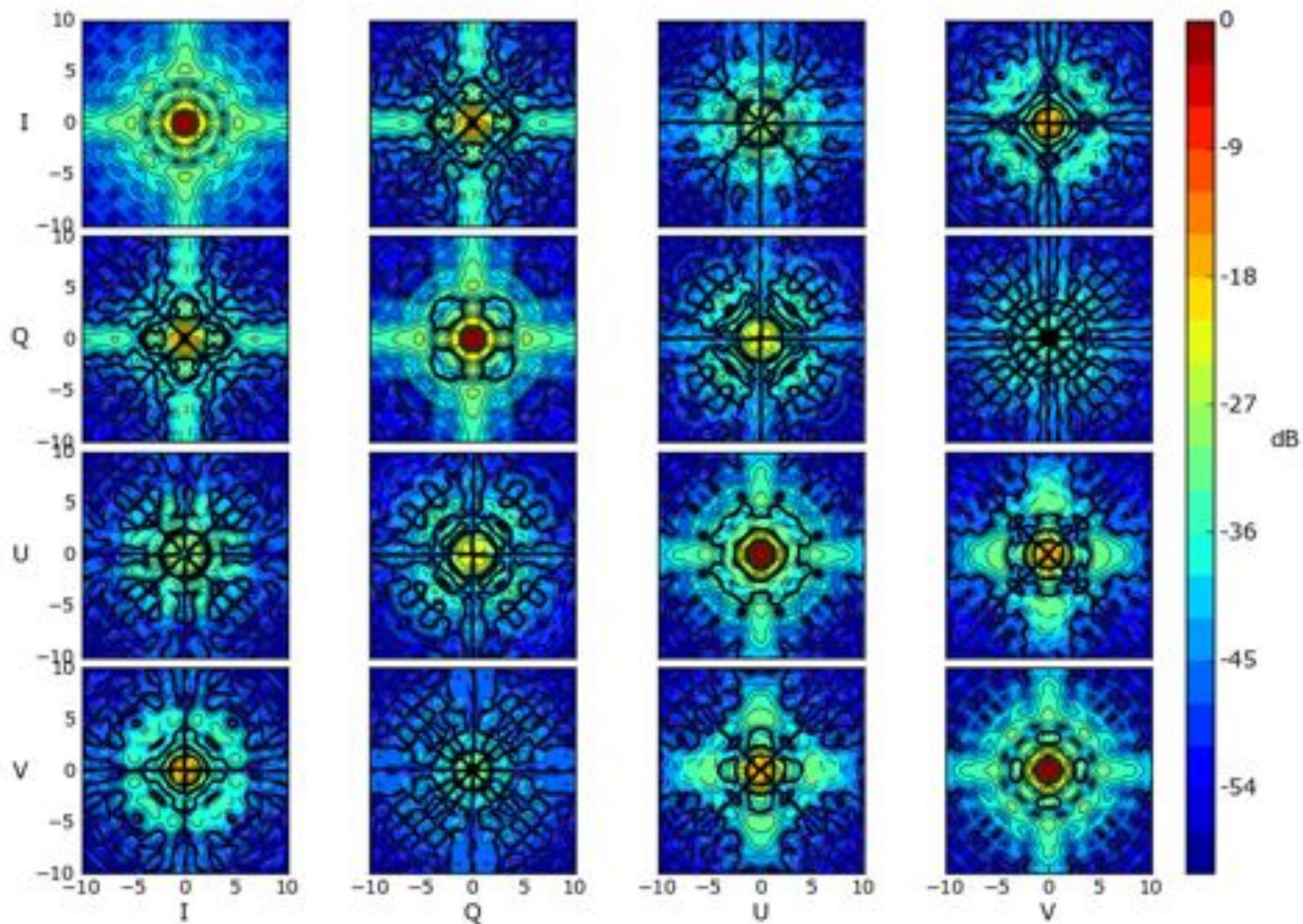SQUARE KILOMETRE ARRAY

Next few months

- Tests of streaming framework (online system) prototype on KAT-7

- More mature imaging on KAT-7 (CASA and MeqTrees). Detail is important.

- Parallelization investigations (CASA)

- Ongoing HDF5 scalability testing

- Start of some pulsar and transient tools on KAT-7 (in collaboration)

- More formal engagement with large survey project teams

- More detail design for MeerKAT (archive, data model etc)

SKA South Africa
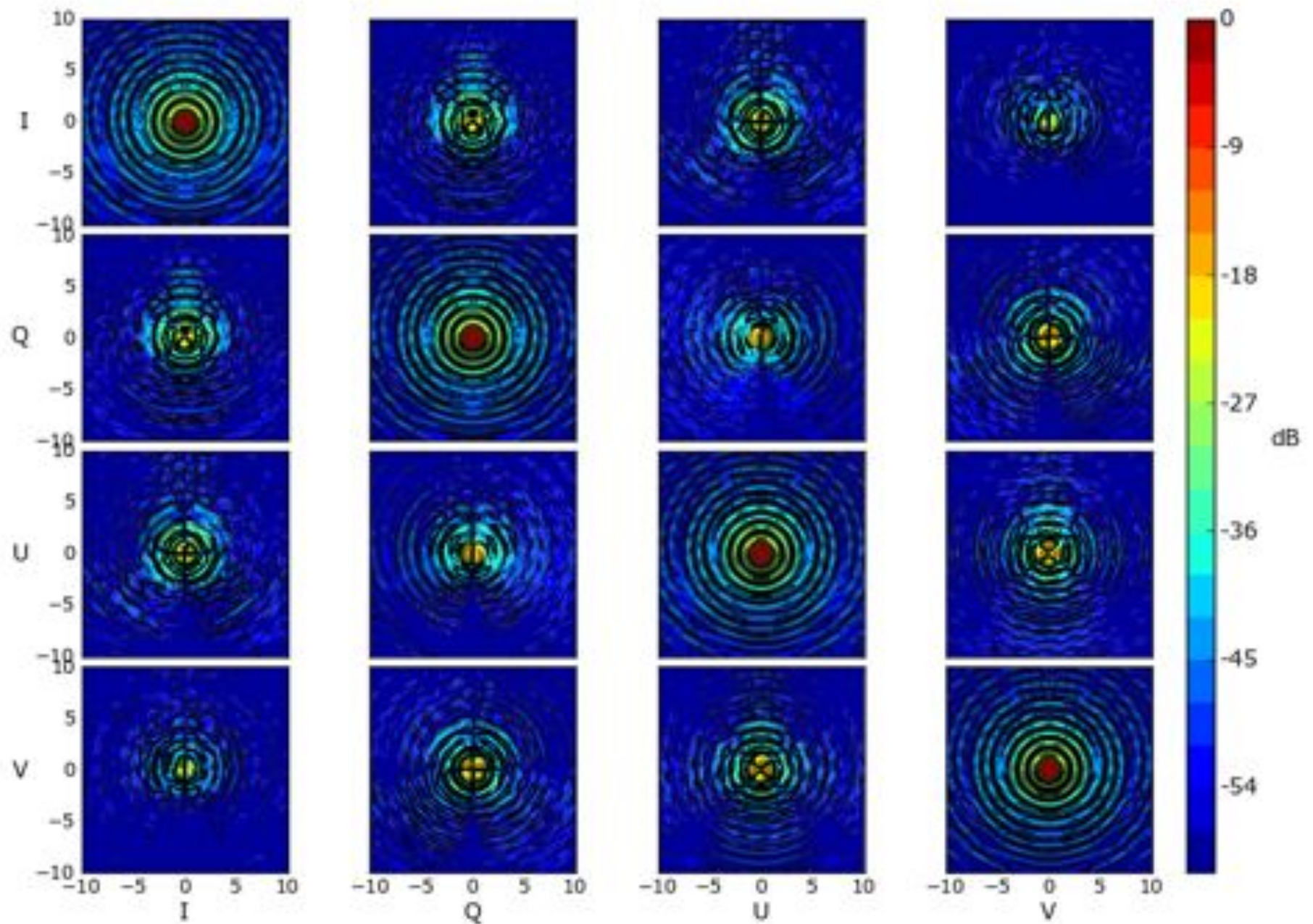SQUARE KILOMETRE ARRAY

Beam Patterns

- EMSS Antennas has modelled KAT-7 (prime focus) and MeerKAT (offset Gregorian) beam patterns using FEKO.

- Plots courtesy of Ludwig Schwardt

- Should be interesting to anyone working with primary beam effects…

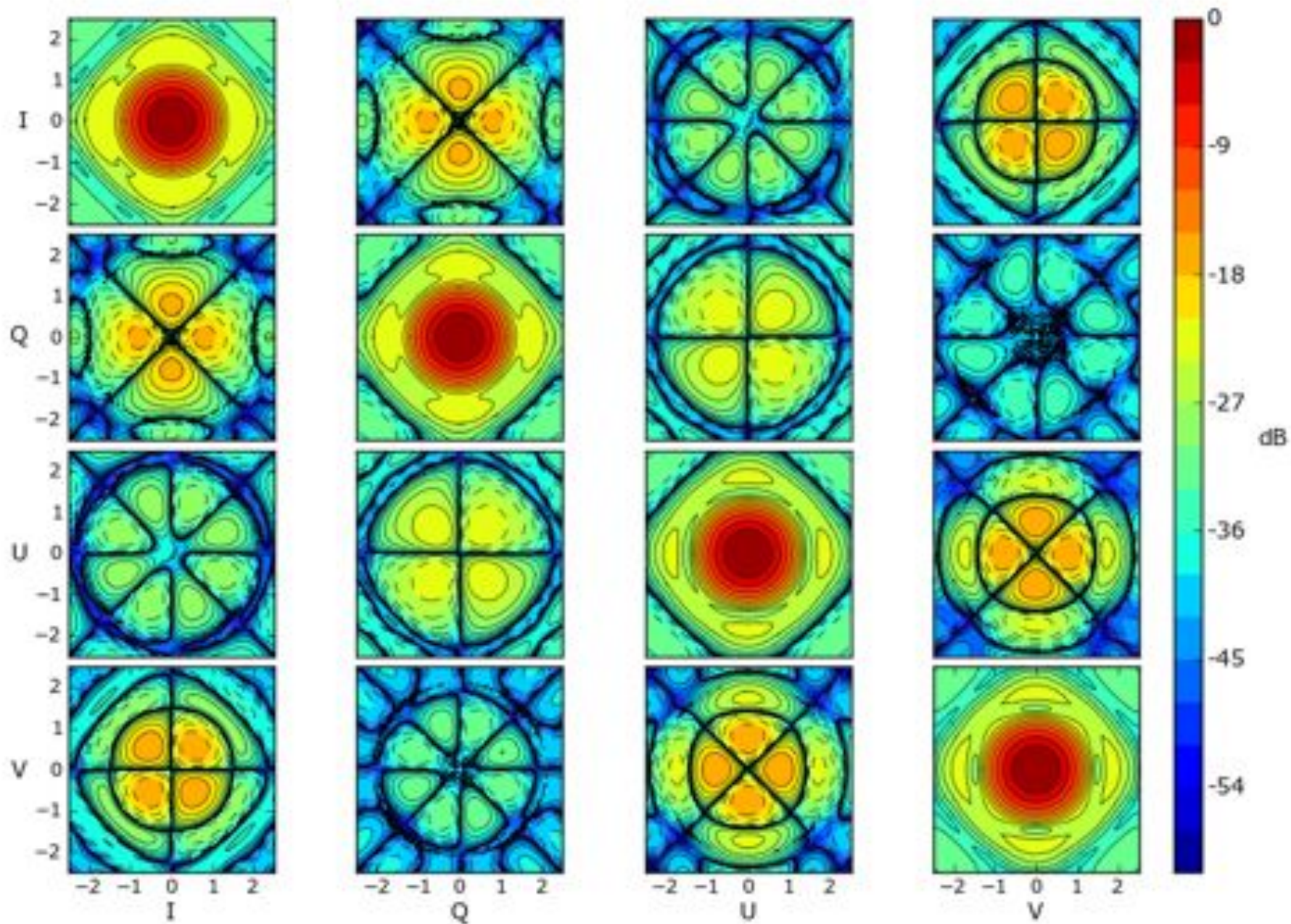Prime focus: Beam Mueller matrix on 20° field at 1600.0 MHz
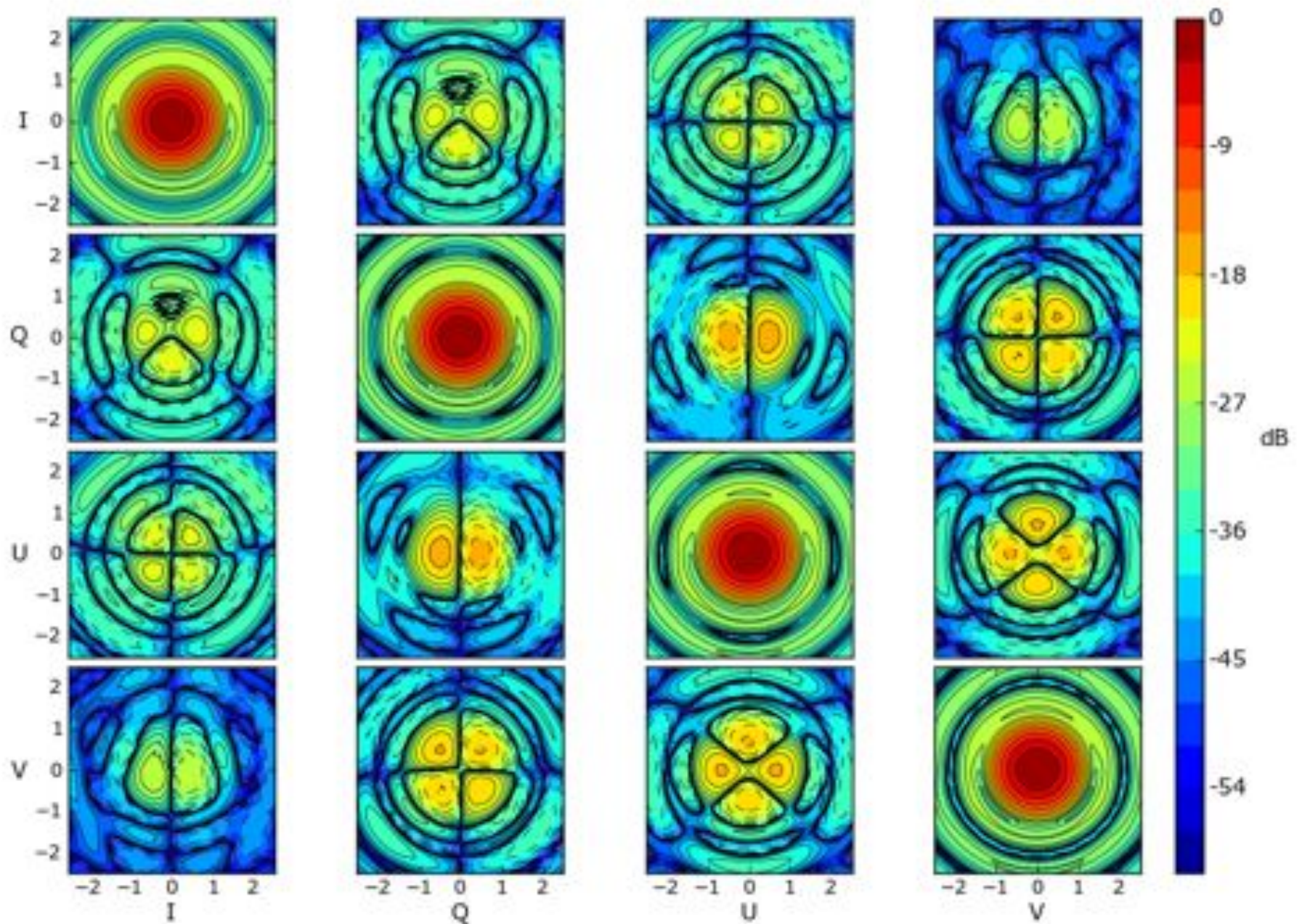
Offset:

Beam Mueller matrix on 20° field at 1600.0 MHz

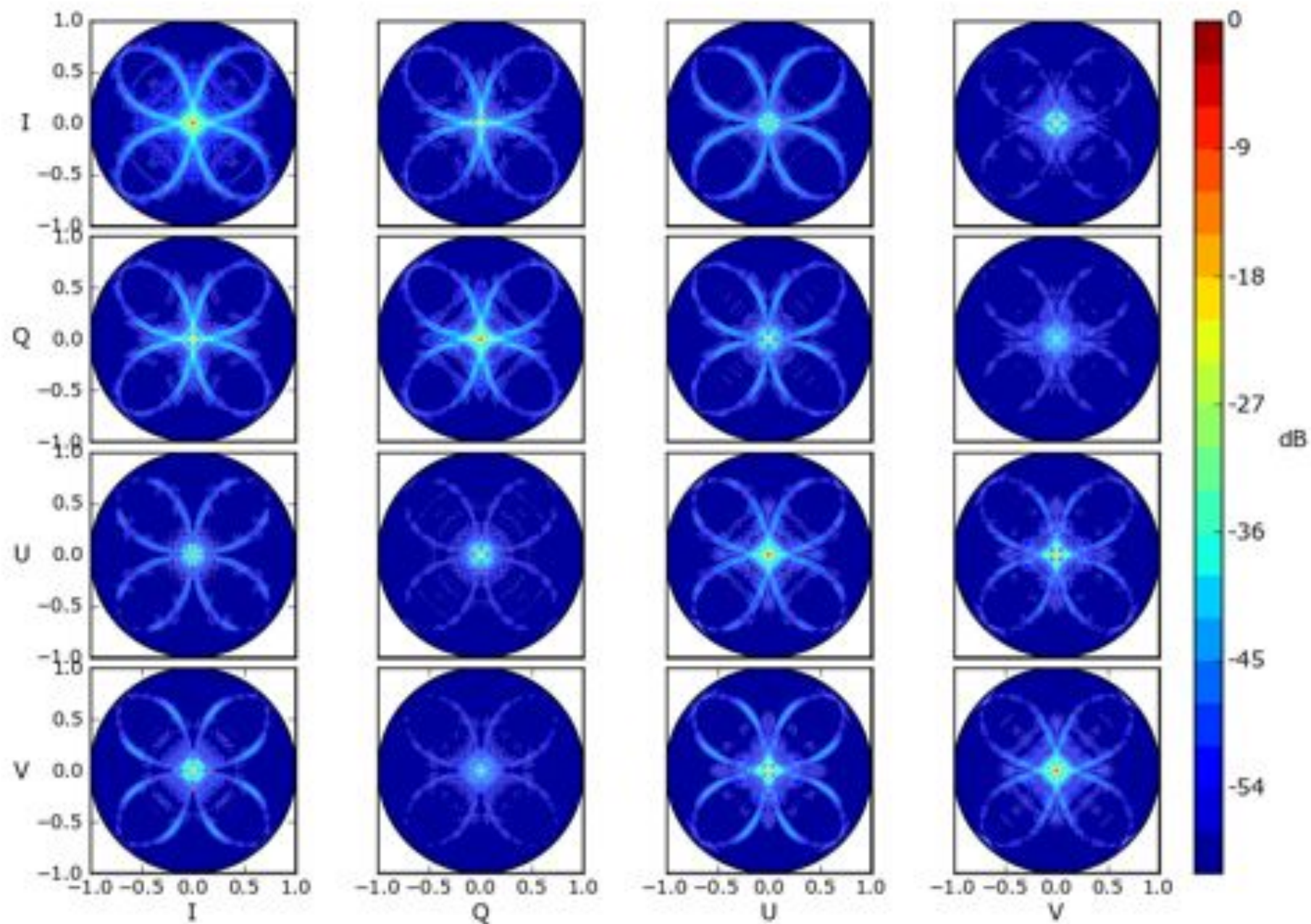Beam Mueller matrix on 5° field at 1600.0 MHz

Offset:

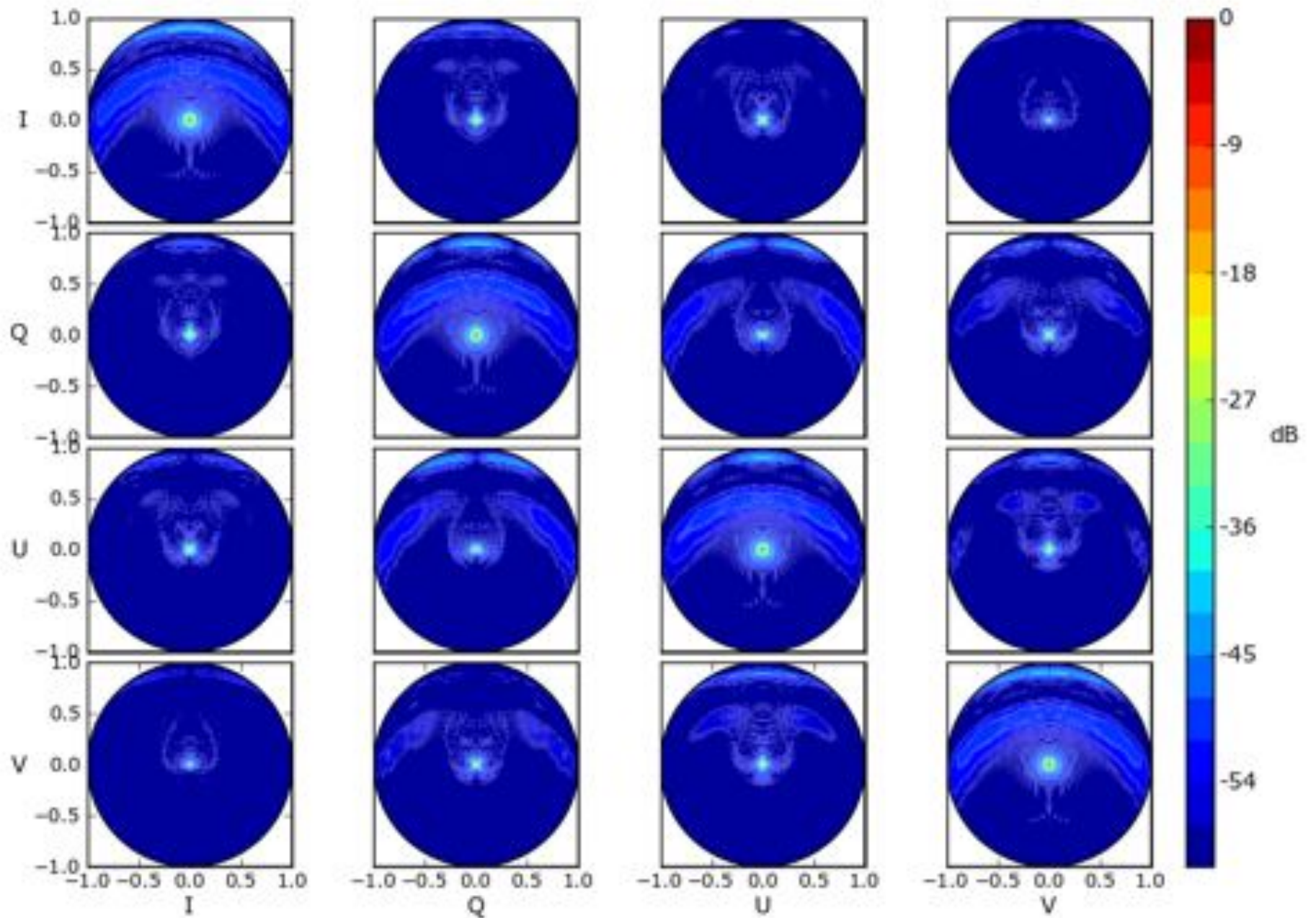Beam Mueller matrix on 5° field at 1600.0 MHz

Prime focus: Beam Mueller matrix on 180° field at 1600.0 MHz

Offset:

Beam Mueller matrix on 180° field at 1600.0 MHz

Questions?

jasper @ ska.ac.za

http://www.ska.ac.za