

THE KAT-7 INCREMENTAL SKY SURVEY (KISS)

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FOLEY ET AL ..

&

ON BEHALF OF COMM & SPT Team

Cape Town,
South Africa

CONTENT:

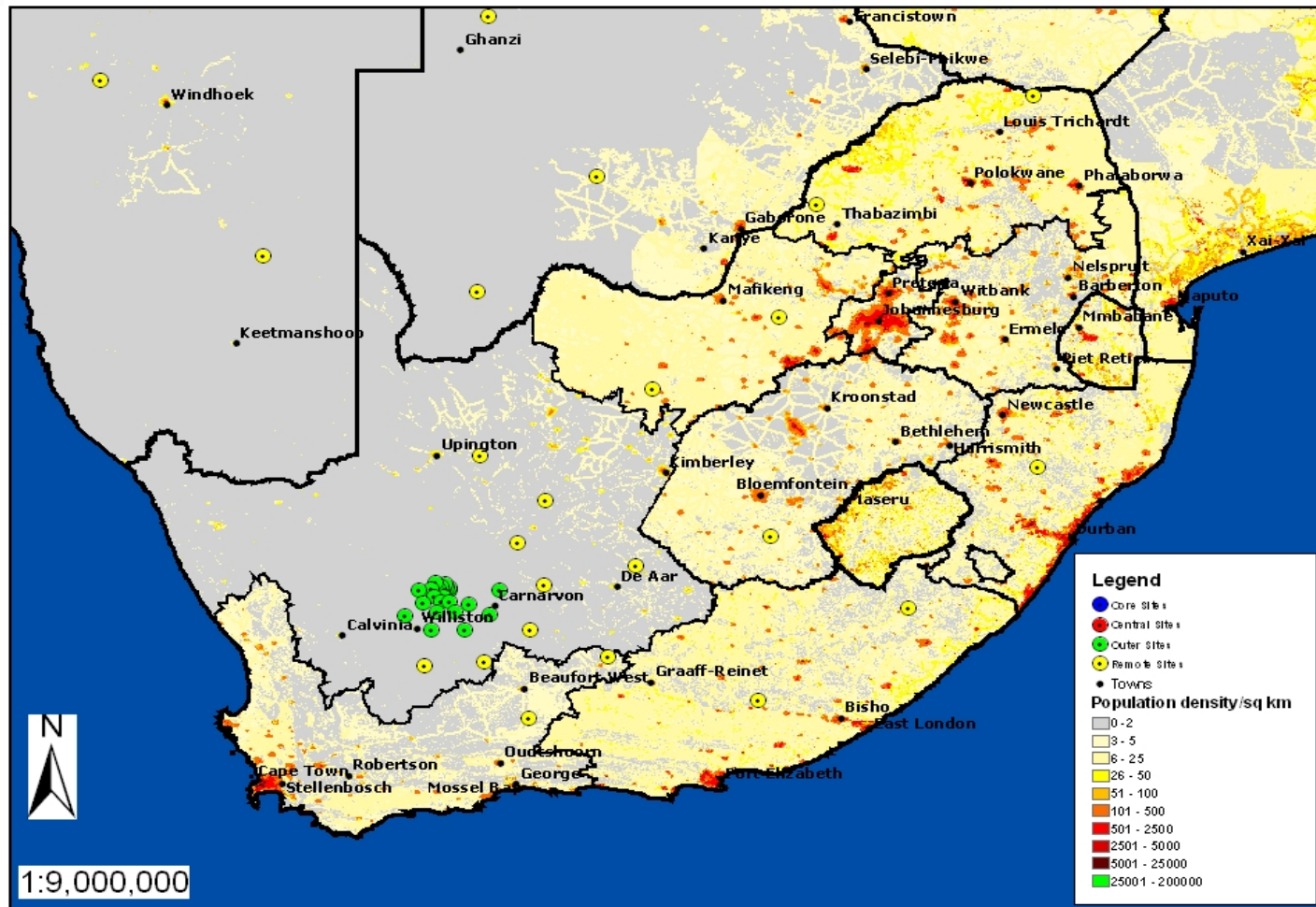
KAT-7

- Overview
- Science Verification
- KISS

MeerKAT

- Update (Justin)
- Commissioning Plan
- Early science

KAROO ASTRONOMY RESERVE:



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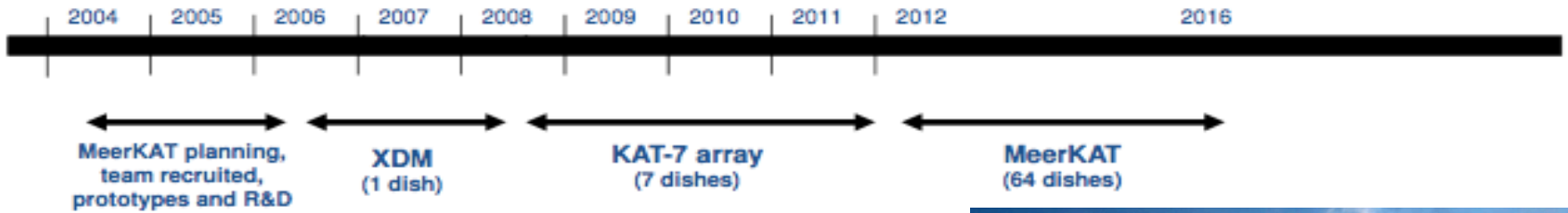
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TIMELINE



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KAROO ARRAY TELESCOPE (KAT-7)



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KAT-7 SPECIFICATIONS:

Parameter	Value
Number of antennas	7
Dish diameter	12 m
Min baseline	26 m
Max baseline	185 m
Frequency range	1200 - 1950 MHz
Max instantaneous bandwidth	256 MHz
Polarisation	Linear H & V
T_{sys}	26 K
Aperture efficiency	0.65
System Equivalent Flux Density	1000 Jy
Latitude	-30:43:17.34
Longitude	21:24:38.46
Elevation	1038 m
Digital back-end	ROACH boards

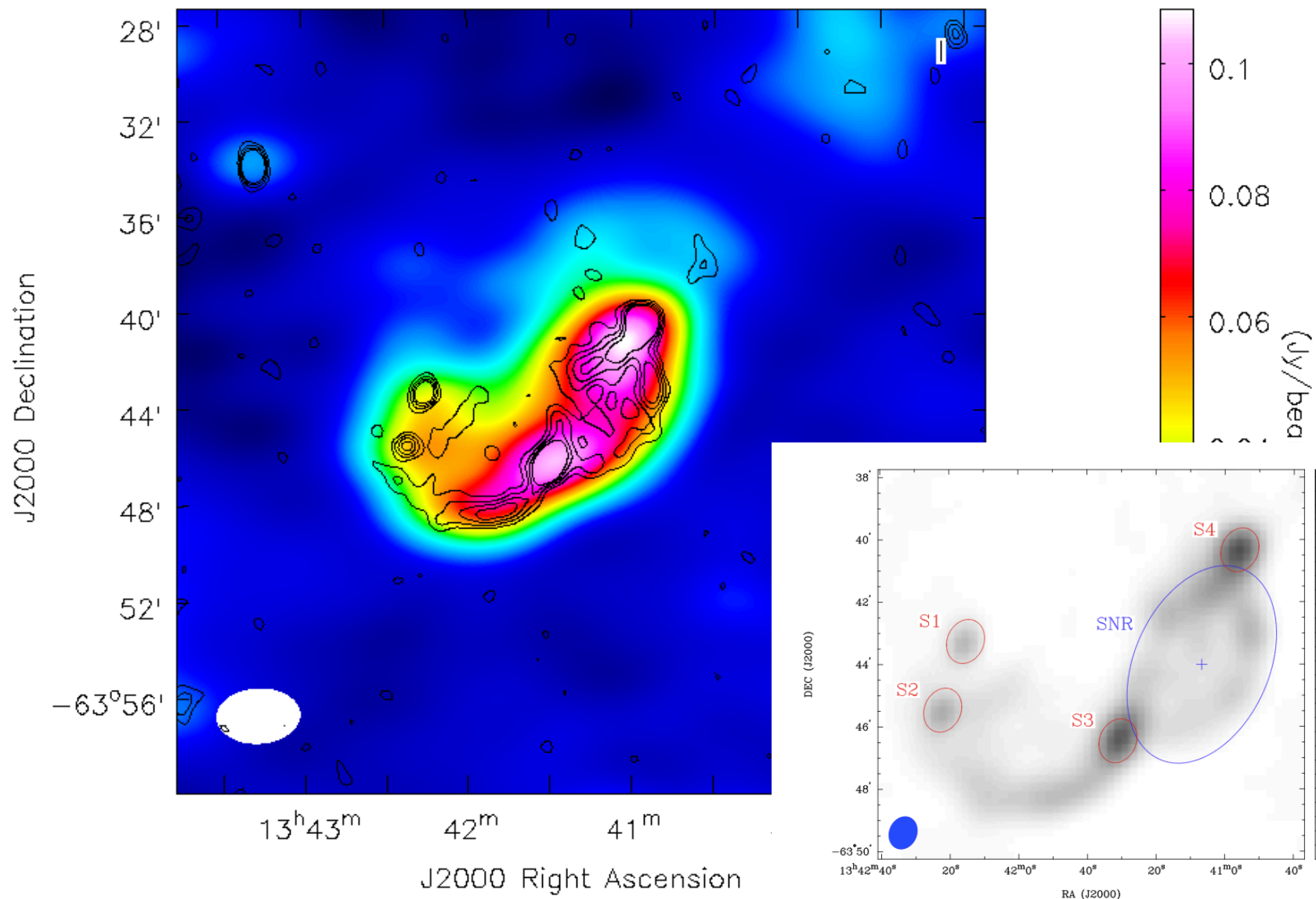
mode	total BW (MHz)	number of channels	channel BW (kHz)
c16n2M4k	1.5625	4096	0.381
c16n7M4k	6.25	4096	1.526
c16n25M4k	25	4096	6.104
c16n400M4k	256	1024	390.625

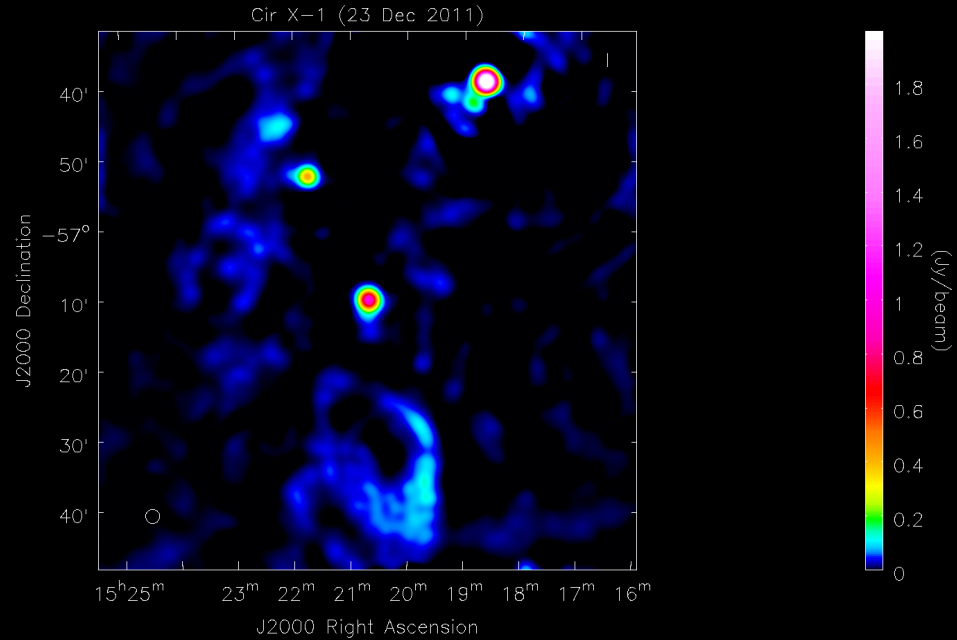
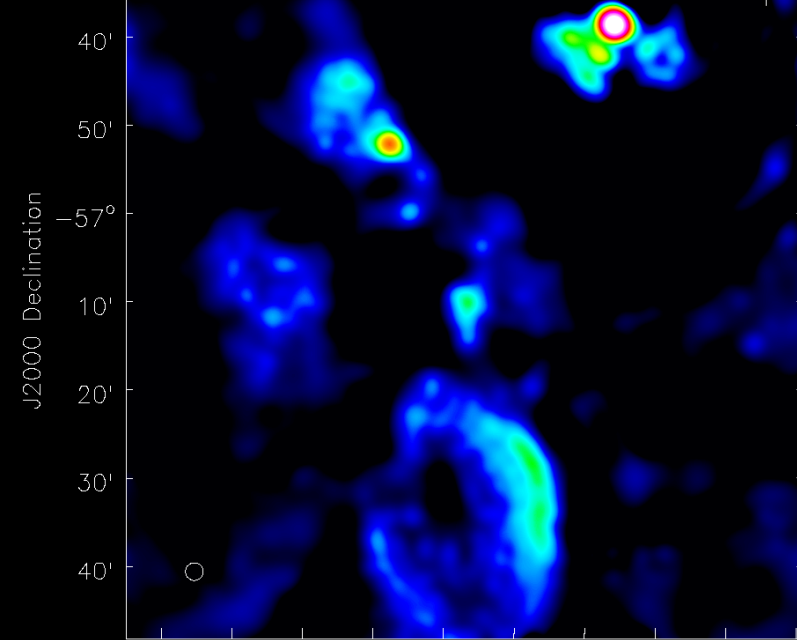
- Largest detectable size (arcmin): 30 (22)
- Resolution (arcmin): 4.19(3.06)
- Sensitivity (mJy/beam): 0.05
- Confusion limit (1σ) (mJy/beam): 0.25
- Int. time to hit point source confusion (hrs): 0.23 hrs

KAT-7 CONTINUUM SCIENCE

- Super Nova Remnant
- Transient - Cir X-1
- Galaxy clusters
- Calibrator Monitoring
- Blazar Variability
- Giant Radio Galaxy (GRG)
- Target of Opportunity (ToO)
- Survey
 - KAT-7 Incremental Sky Survey (KISS)
- TAC

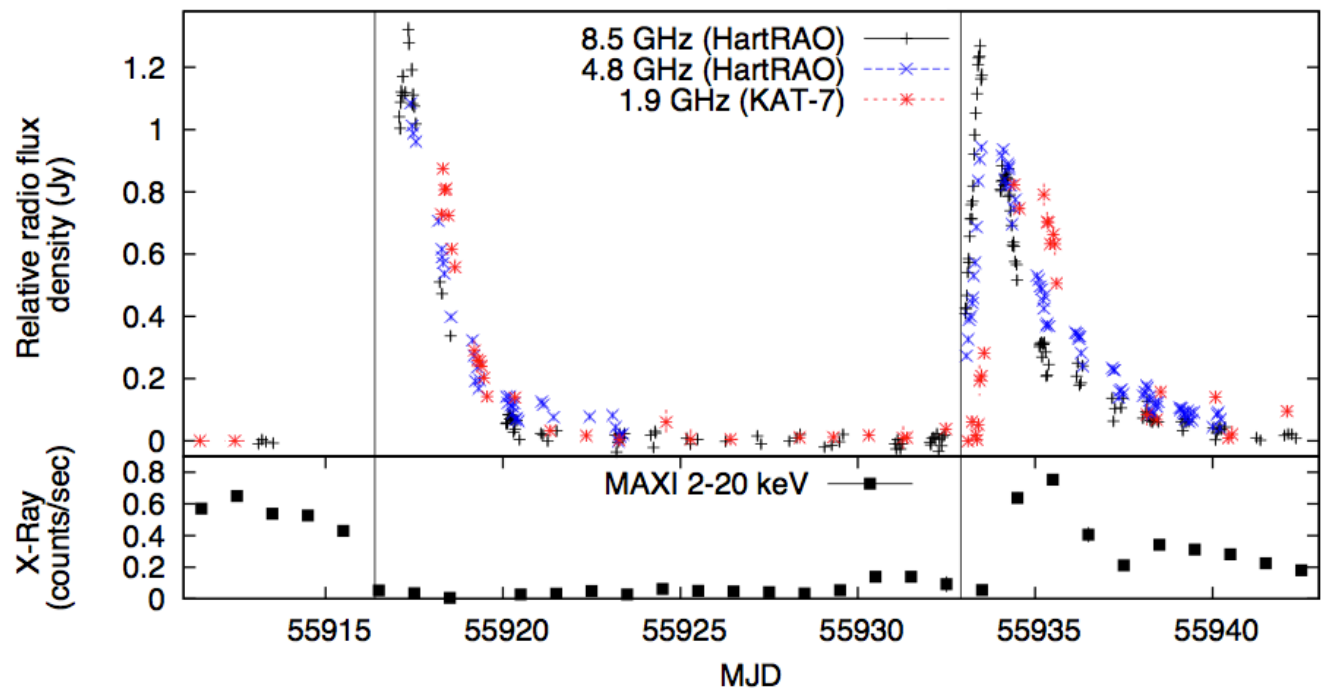
SNR_G308.3 -1.4





Cir X-1 revealed the presence of X-ray jets normally found in black hole systems

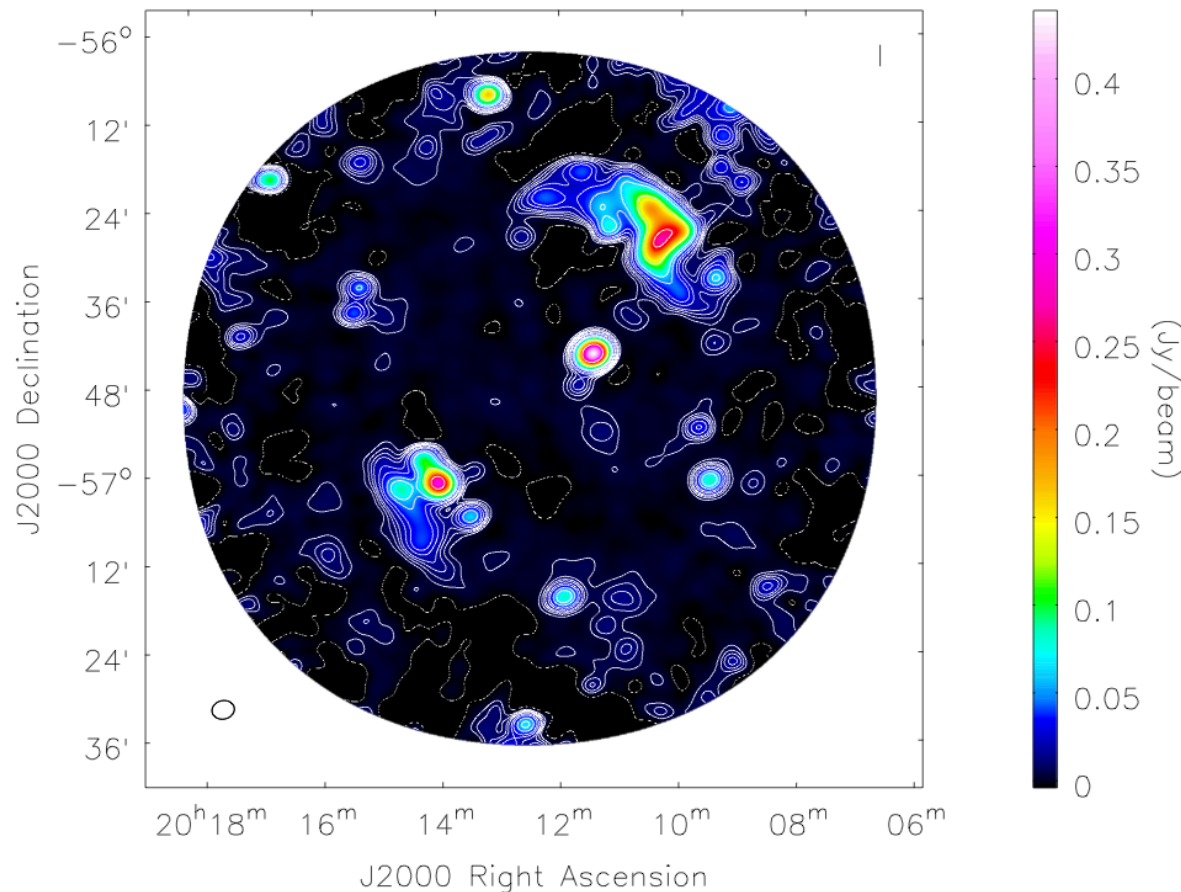
Armstrong et al.
(2013MNRAS.
433.1951A)



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DIFFUSE EMISSION: GALAXY CLUSTERS



Full-polarization KAT-7 at 1.33 and 1.82 GHz

Presence of both radio relics as well as the brightest cluster galaxy

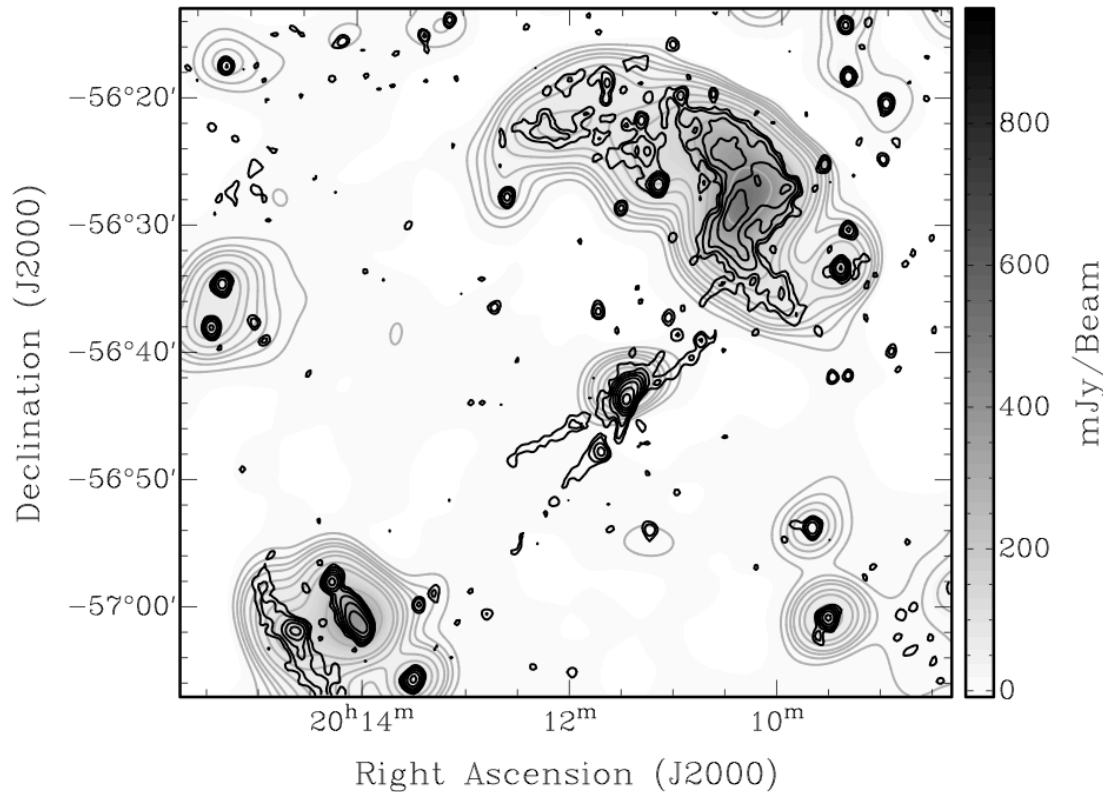
Presence of localized excess, which tentatively identify as a radio mini-halo.

This mini-halo candidate has an integrated flux density of $67.2 \pm 4.9 \text{ mJy beam}^{-1}$ at 1.37 GHz, corresponding to a radio power of $P_{1.4 \text{ GHz}} = 4.28 \pm 0.31 \times 10^{23} \text{ W Hz}^{-1}$,

Consistent with mini-halo power scaling.

Riseley et al., MNRAS 447, 1895–1910 (2015)

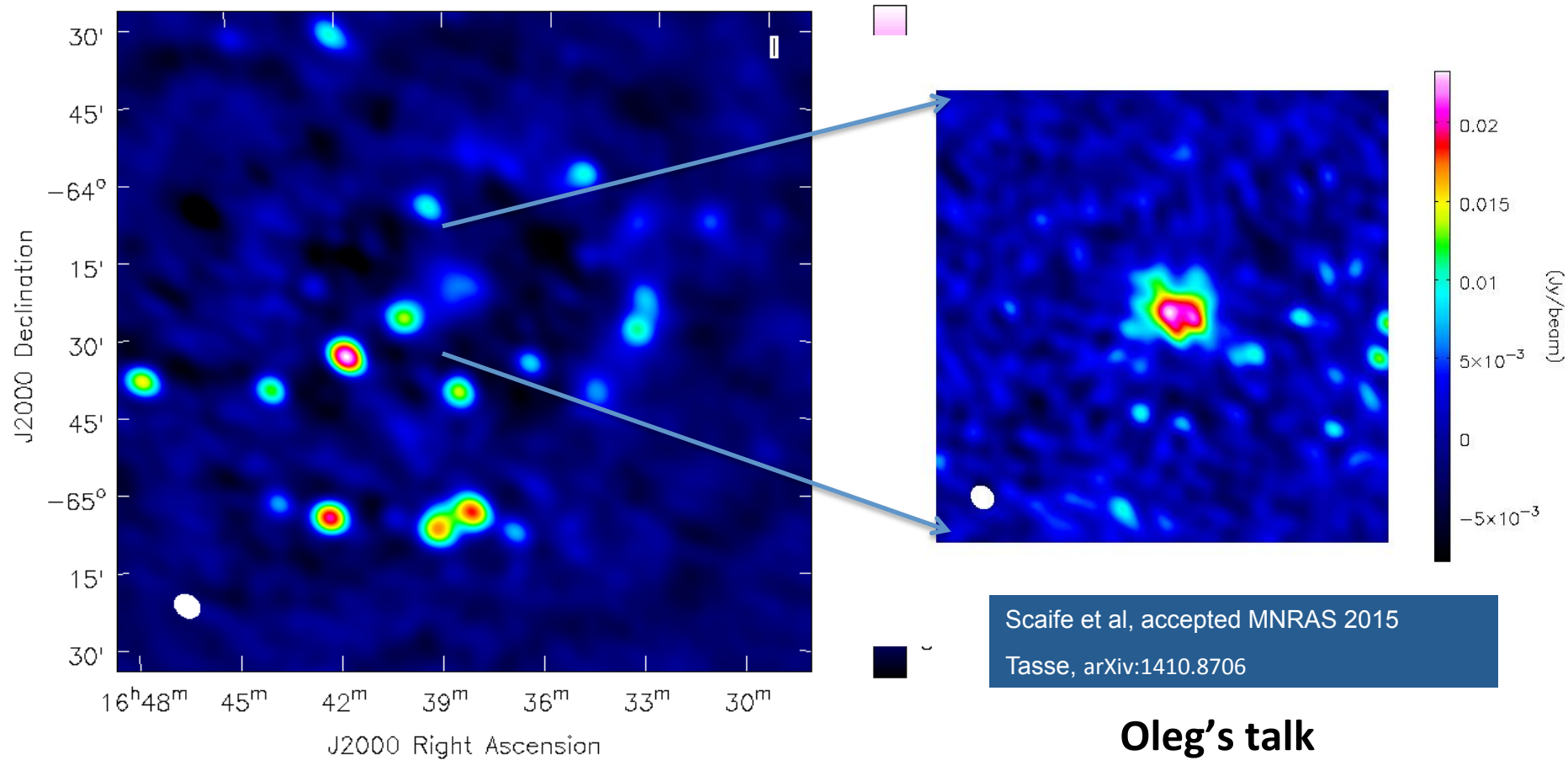
MINI-HALO CANDIDATE

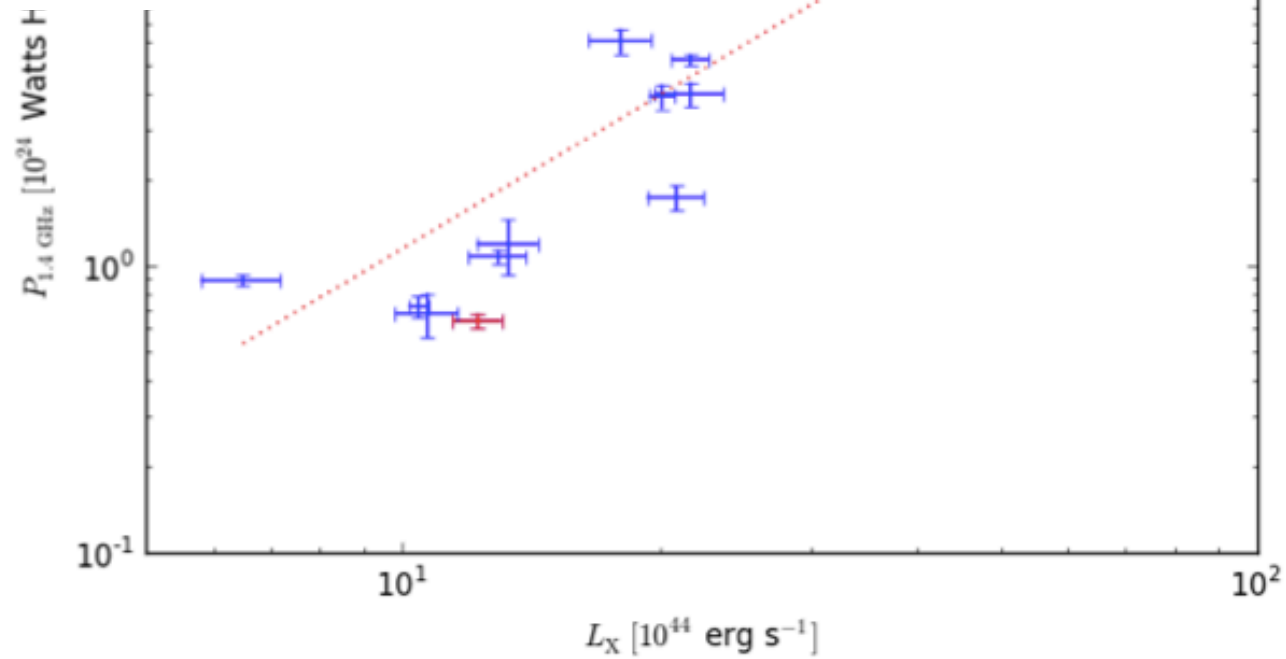
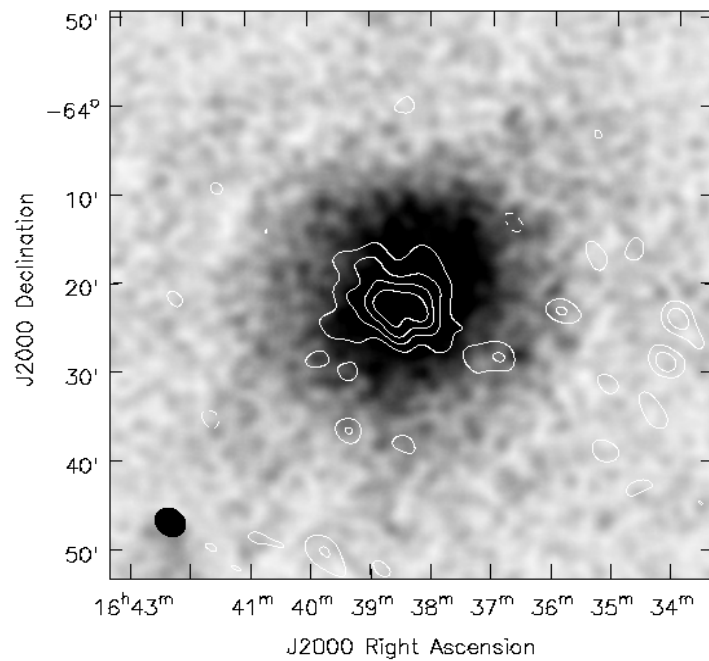


	ν_{obs} (MHz)	1372	1826
W relic	$S_{\text{int}}(\text{I})$ (Jy)	2.47 ± 0.17	1.92 ± 0.14
	$S_{\text{int}}(\text{P})$ (Jy)	0.16 ± 0.01	0.22 ± 0.01
	P/I (per cent)	6.63 ± 0.57	11.45 ± 1.07
E relic	$S_{\text{int}}(\text{I})$ (Jy)	0.35 ± 0.02	0.34 ± 0.02
	$S_{\text{int}}(\text{P})$ (Jy)	0.06 ± 0.01	0.05 ± 0.01
	P/I (per cent)	15.60 ± 2.60	15.60 ± 2.20
	θ (arcsec)	251	180
	$\sigma_{\text{rms}}(\text{I})$ (mJy beam $^{-1}$)	2.18	1.30

MHc has an integrated flux density of 77.6 ± 5.2 mJy at 1.37 GHz, corresponding to $P_{1.4 \text{ GHz}} = 5.20 \pm 0.35 \times 10^{23} \text{ W Hz}^{-1}$

NEW HALO: TRIANGULUM AUSTRALIS

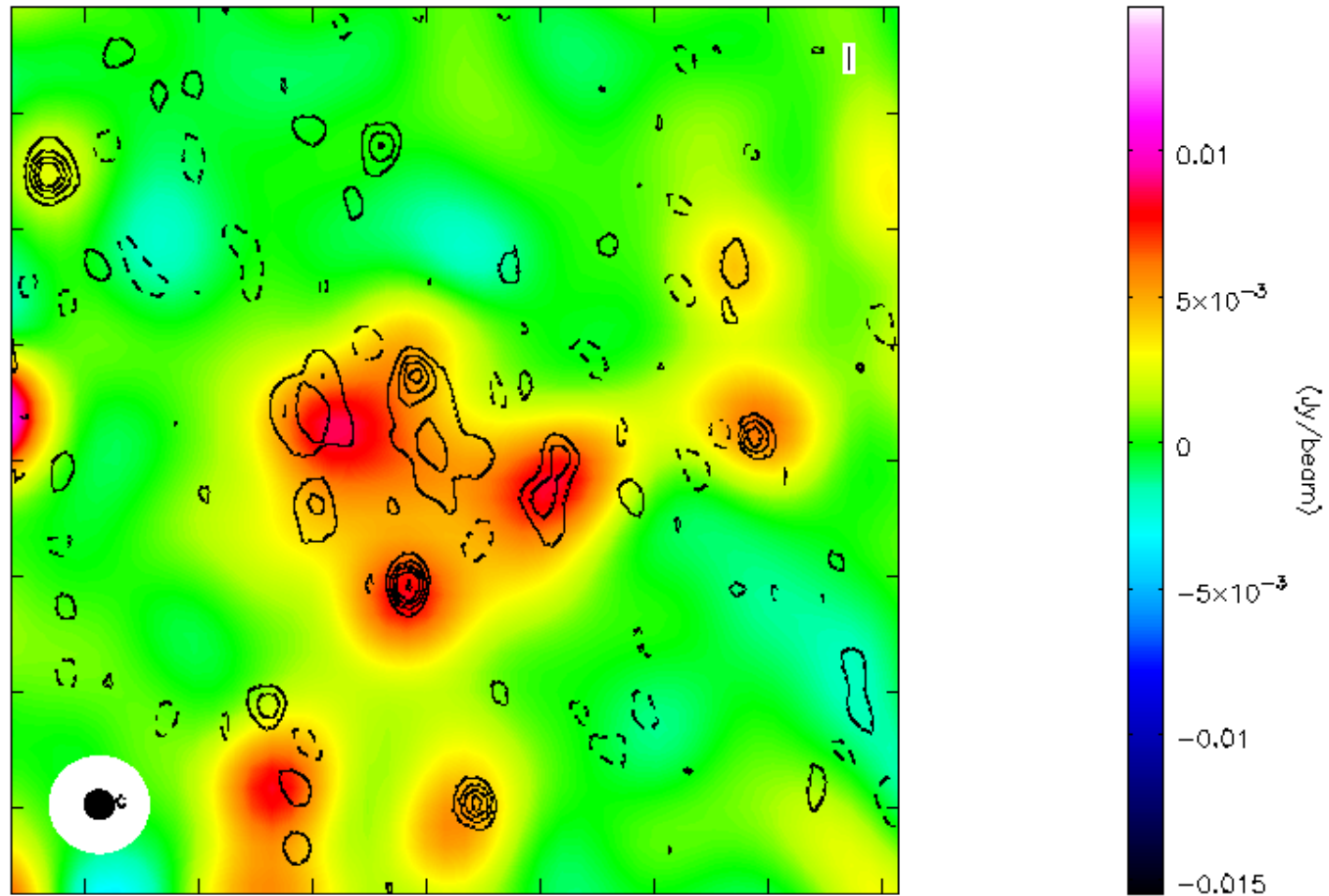




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NEW HALO!



In preparation

CALIBRATOR VARIABILITY

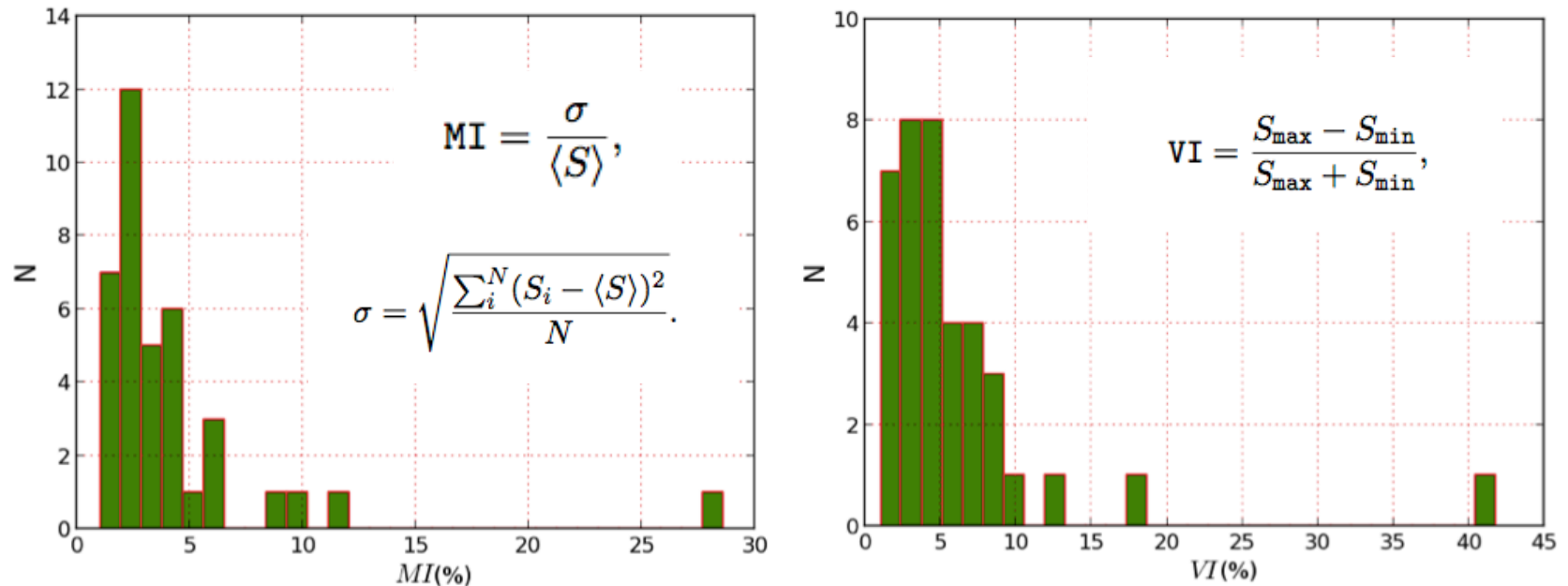
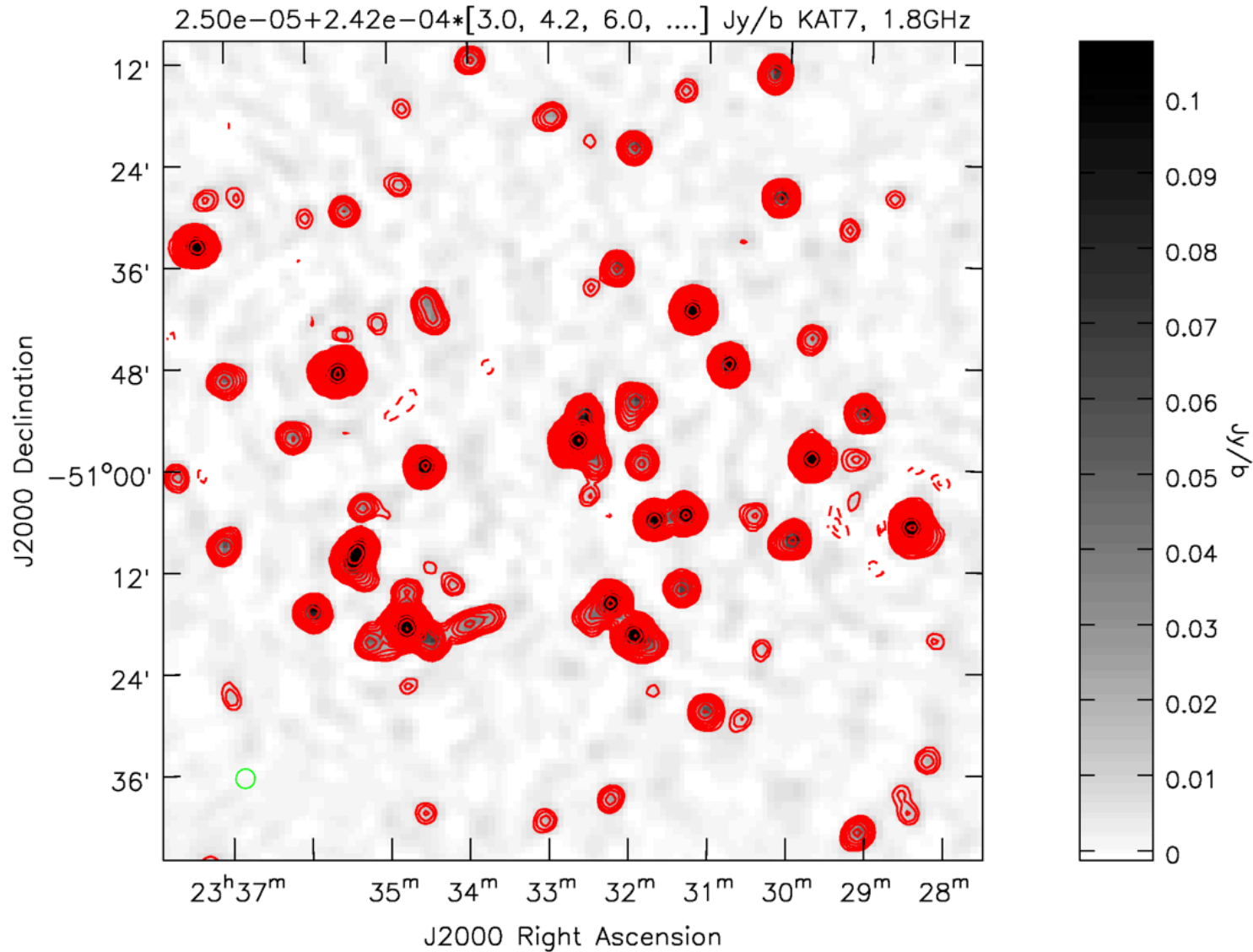


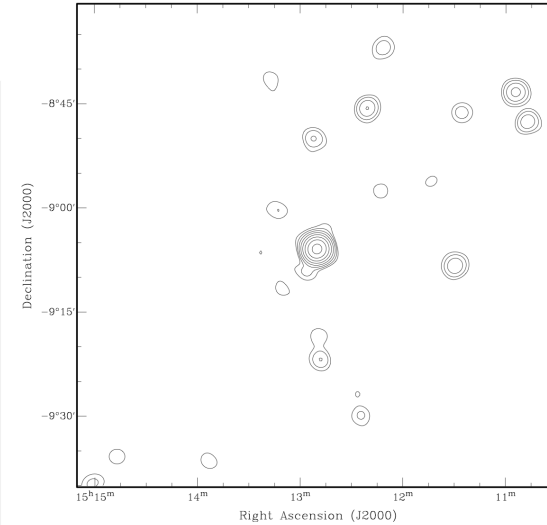
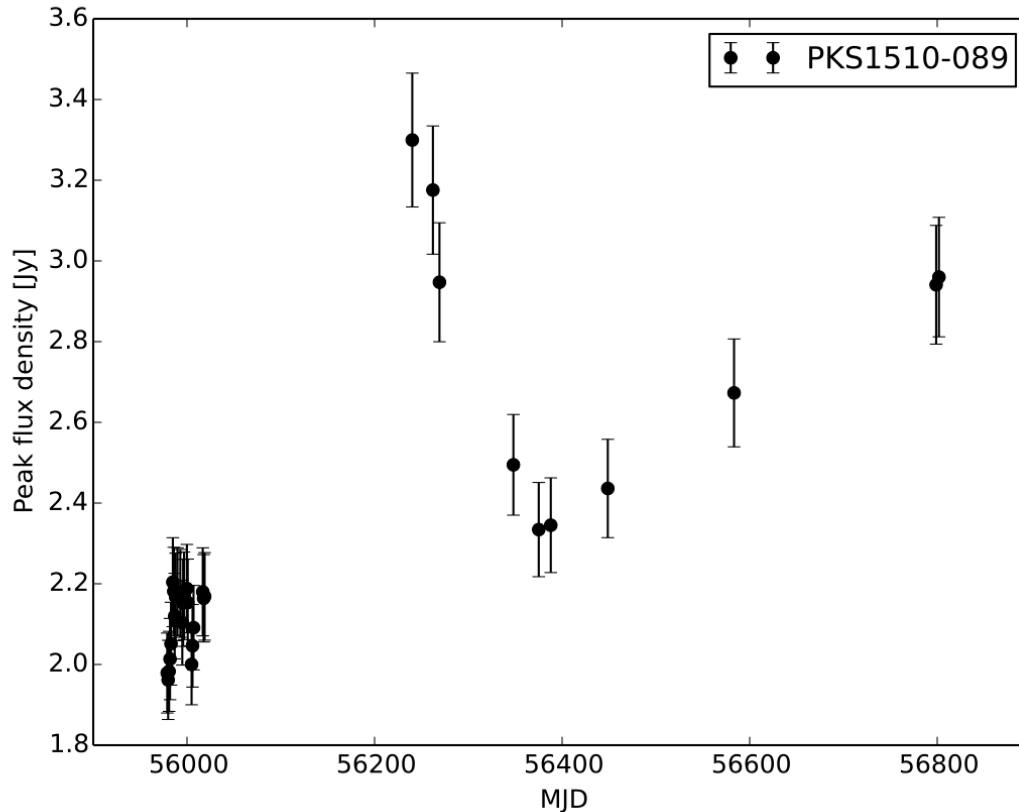
FIGURE 4.2: The histogram describing the modulation index (MI) [left panel] and variability index (VI) [right panel] of the sources. Majority of the sources (93 – 95%) have MI and VI values $\leq 10\%$.

Kassaye, MSc Thesis (2015)

SOURCE VARIABILITY



BLAZAR VARIABILITY (PKS1510-089)

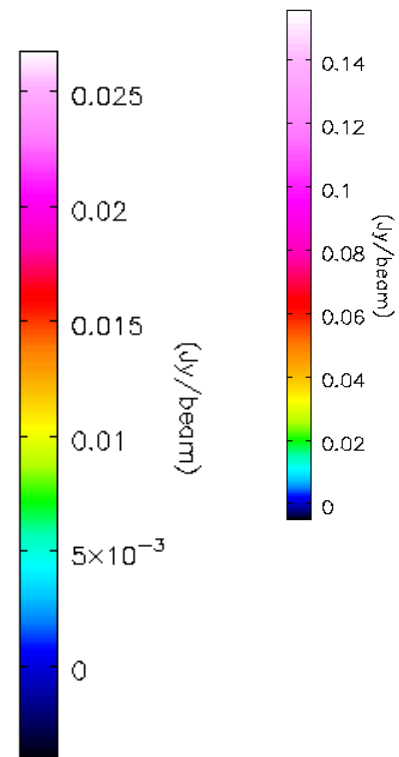
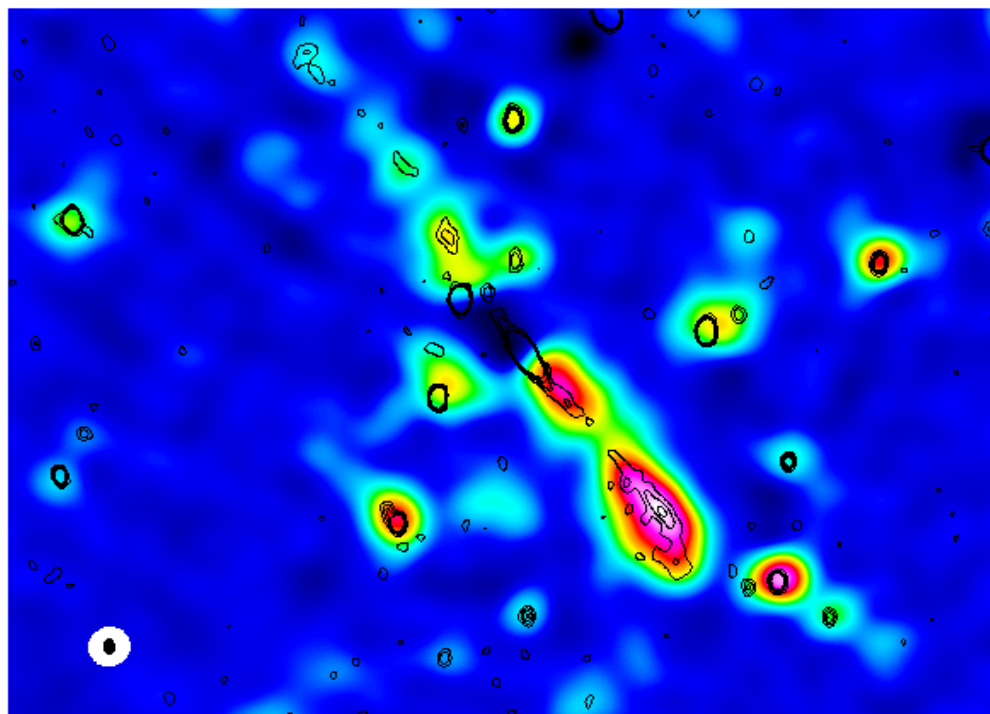
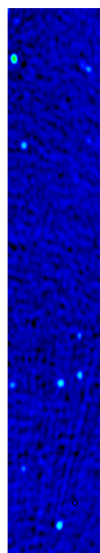


PKS1510-089, observed on 22nd Feb 2012 and reduced using the pipeline. The contours are at [-2, 2, 4, 8, 16, 32, 64, 128, 256] × 5.8 mJy beam⁻¹. The image rms is around 1.9 mJy beam⁻¹.

Source	χ^2	V_{rms} %	MI %	$Y_{[3C286]}$ %	$Y_{[PKS1934]}$ %
3C286	0.023	-4.979	0.746	-	-1.746
PKS 1934-638	0.009	-4.946	0.467	1.746	-
PKS J1510-0543	0.124	-4.000	1.713	4.625	4.944
PKS J1517-2422	0.542	-4.700	3.694	10.854	10.994
PKS 1510-089	7.434	14.713	15.559	46.624	46.657

Oozeer et al, IoP proceedings, 2014

GIANT RADIO GALAXY (GRG)



$z = 0.0211$, Linear size ~ 1.4 Mpc



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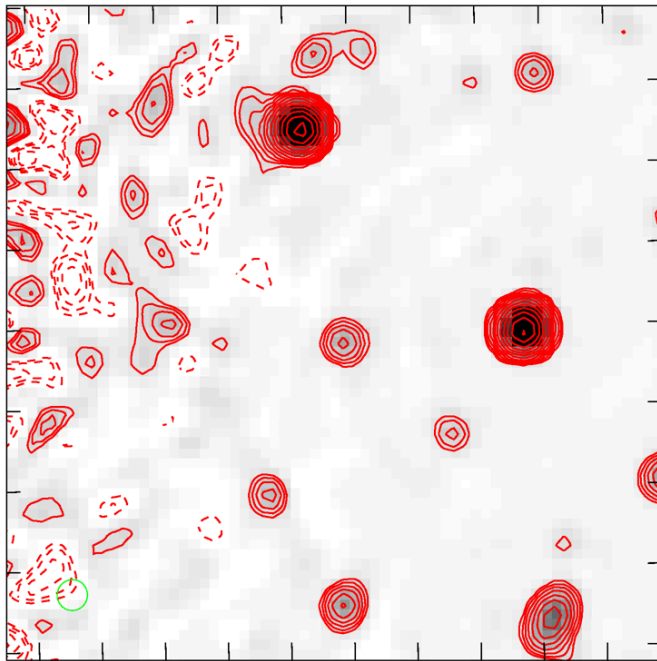


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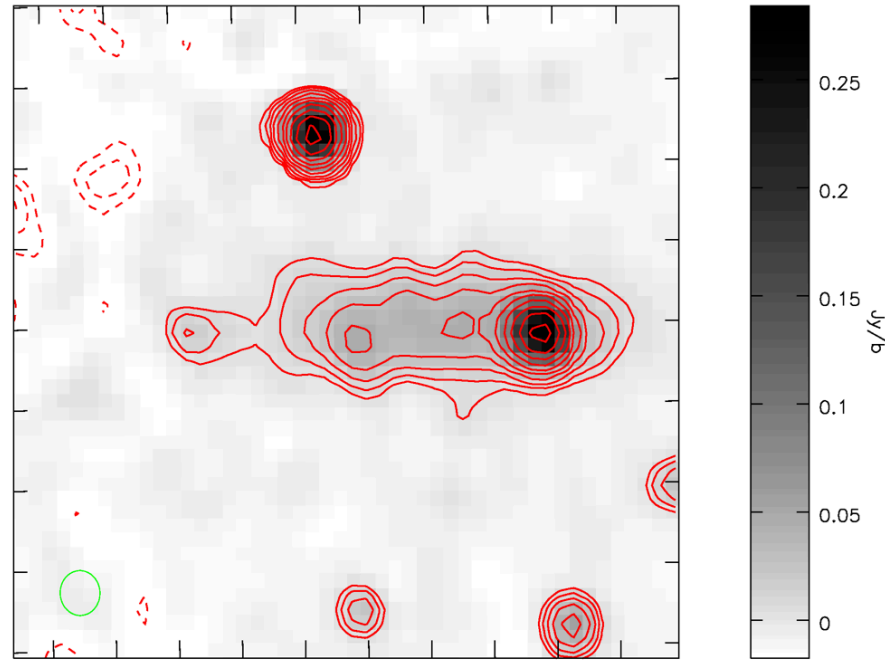
KISS SCIENCE:

$3.99\text{e-}04 + 2.02\text{e-}03 * [2.2, 3.1, 4.4, \dots]$ Jy/b KAT7, 1.8GHz



The 1.8 GHz image is made from 45 datasets taken over 2.5 years

$1.62\text{e-}03 + 4.92\text{e-}03 * [2.2, 3.1, 4.4, \dots]$ Jy/b KAT7, 1.328GHz



The 1.3 GHz image is made from 13 datasets taken over 2 months

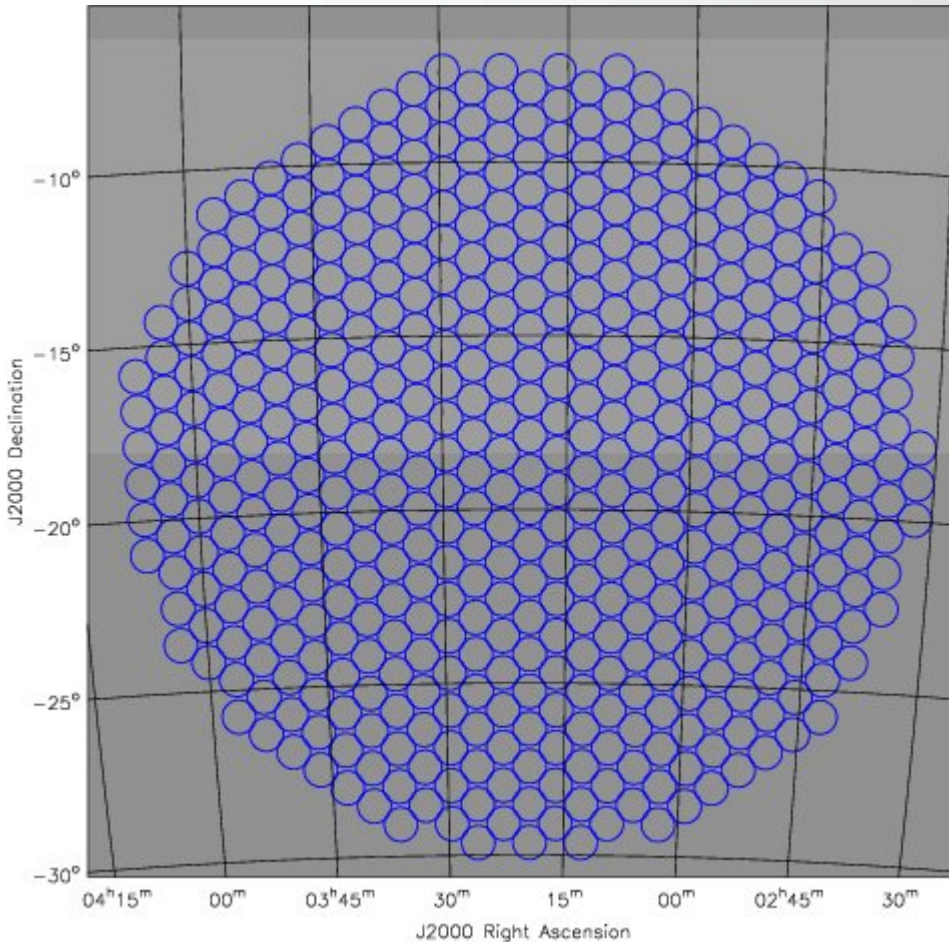
KAT-7 INCREMENTAL SKY SURVEY (KISS):

- **Survey Proposal:**
 - **PIs : Sirothia S K, Oleg Smirnov, Oozeer N, Foley T, Goedhart S, Mauch T.**
- **Aim:**
 - We propose observation 300 sq deg (min 100 sq deg) of sky:
 - (a) WMAP extreme cold spot, CDFS and
 - (b) Hydra cluster at 1.3 GHz and 1.8 GHz.
 - The major aim of the survey is to demonstrate the incremental/consistent improvements to the existing images and models from the survey with new observations.
 - In combination with other surveys, the imaging data will find use in spectral (curvature) studies of sources and diffuse emission studies.

KISS: OBJECTIVES

- The data would be used to:
 - demonstrate the capability for the incremental sky surveys
 - build a database for instant calibration and imaging for any new observations
 - update the incremental sky models using the new observations in the region
 - gradually increasing this to cover all observable sky
 - with other surveys, the imaging data will find use in spectral (curvature) studies of sources and diffuse emission studies.

KISS: POINTING (500)

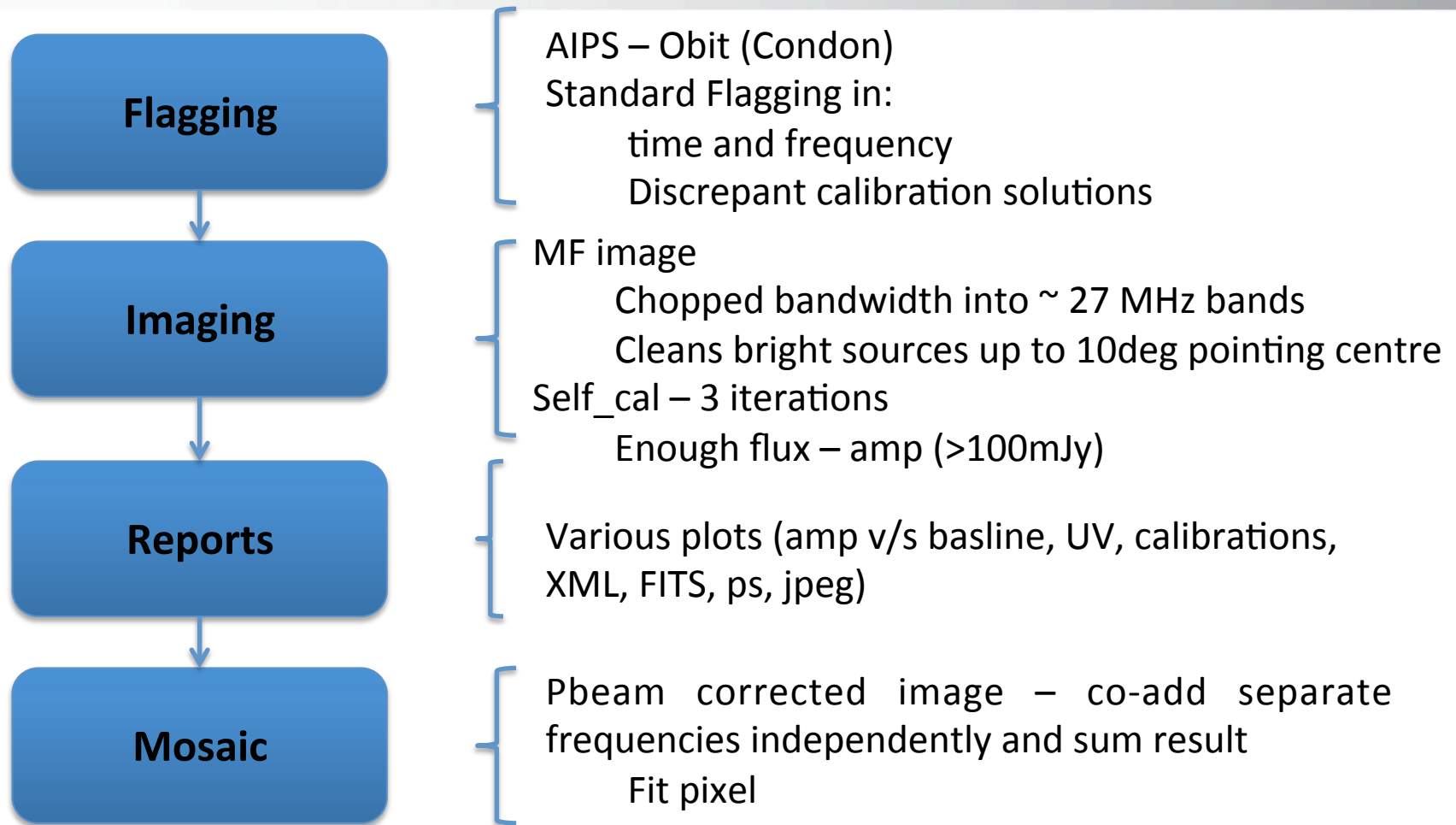


A portion of combined KAT7 image from 42 independent observation of a field centered at W2332-5056 at 1.8 GHz, demonstrating combining of multiple observation of same field and showing the model and noise improvement.

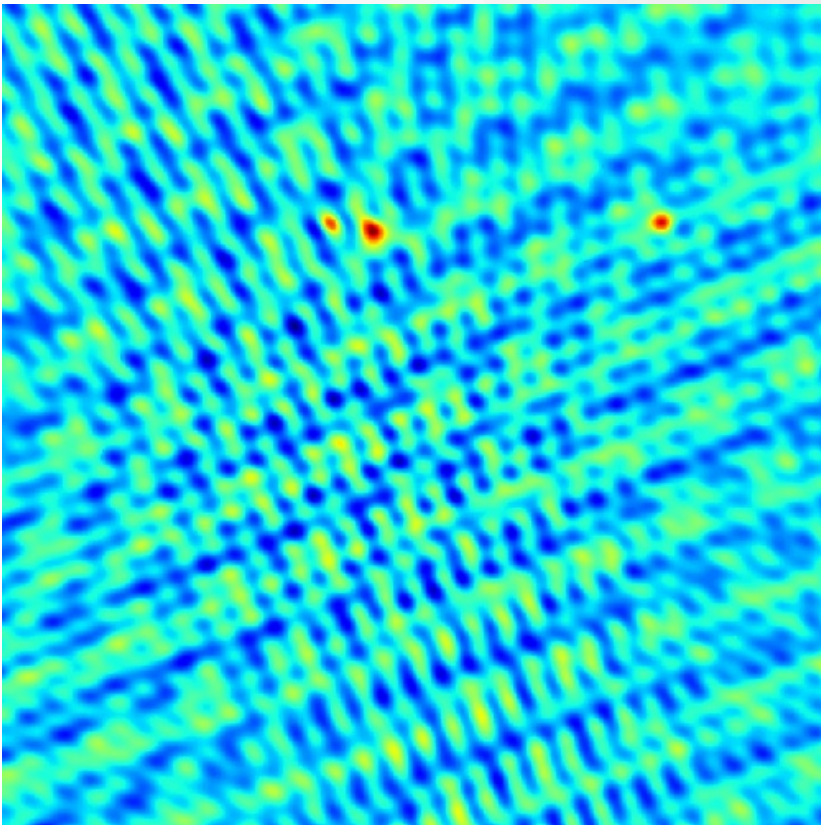
The same field is now deeply observed at 1.3 GHz also.

Updated pointings

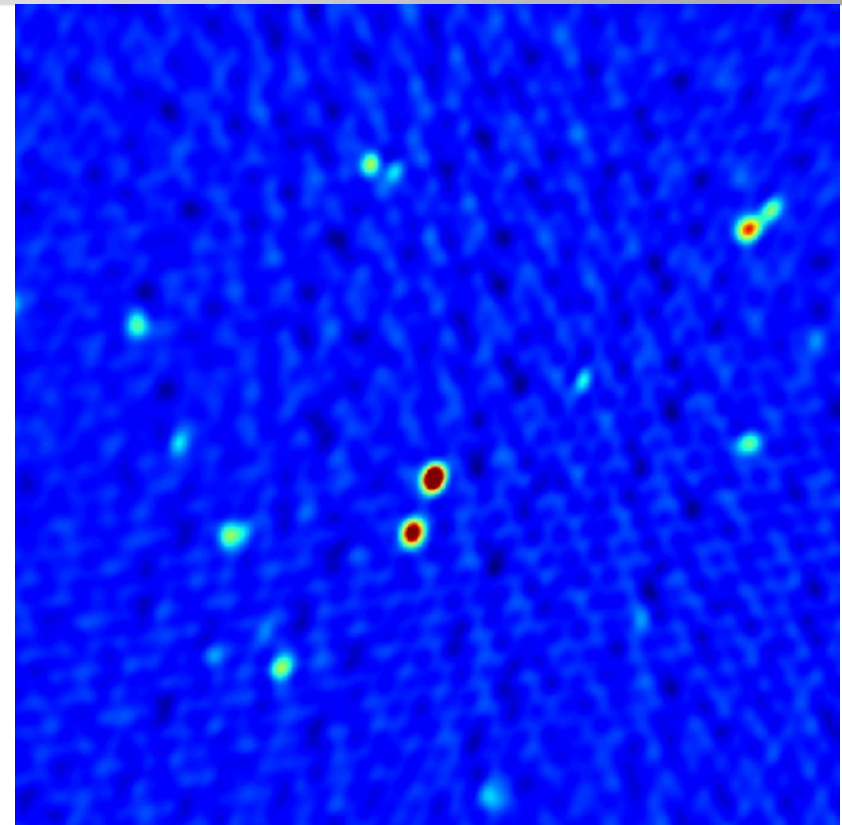
AUTOMATIC PIPELINE



KISS: SAMPLE AUTOMATIC IMAGES



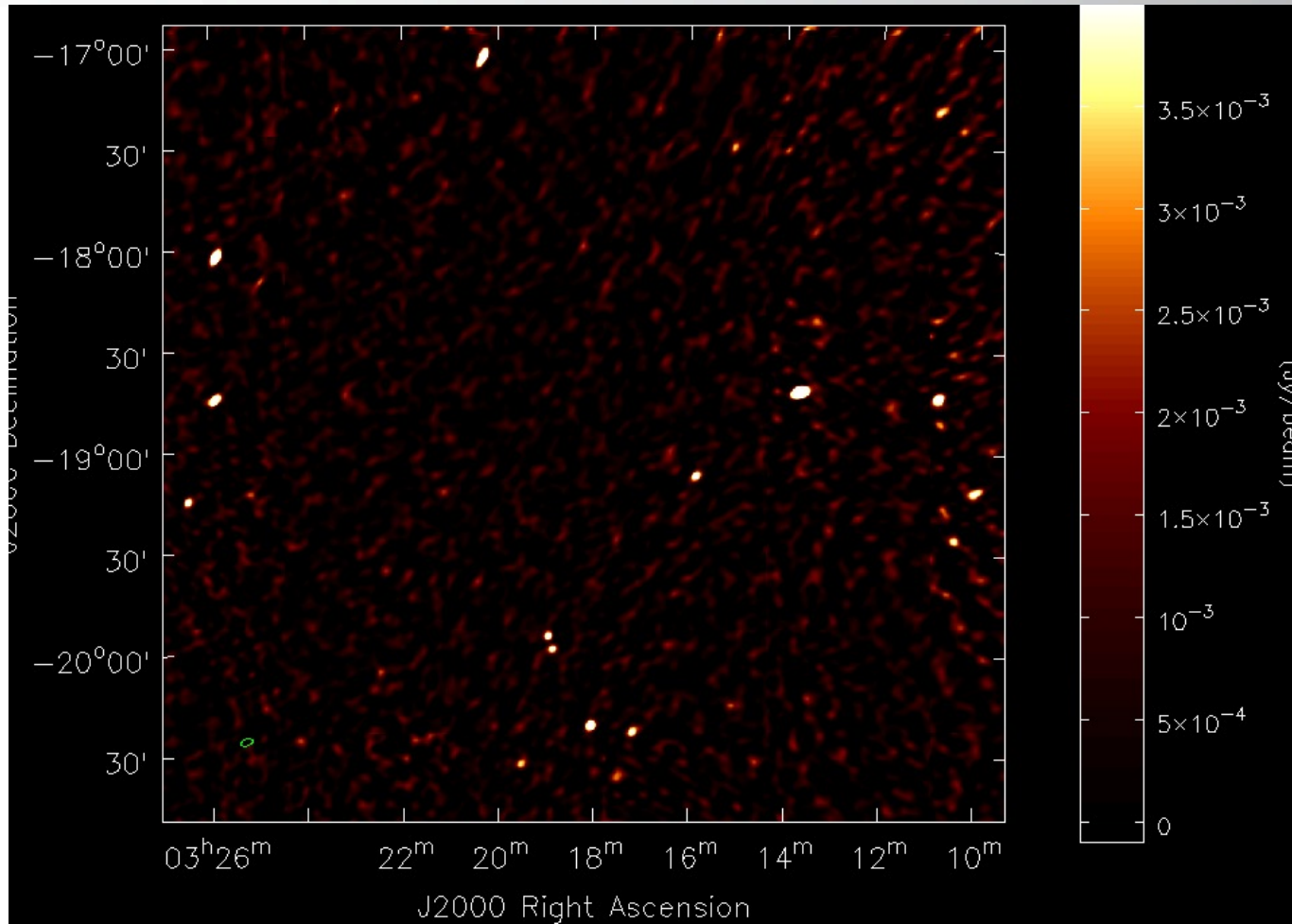
Bad



Good



KISS: MOSAIC



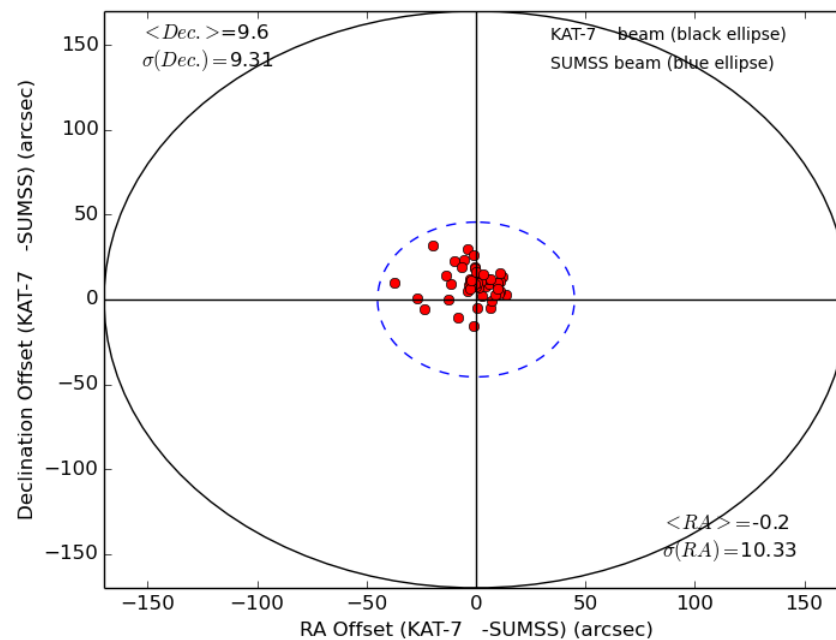
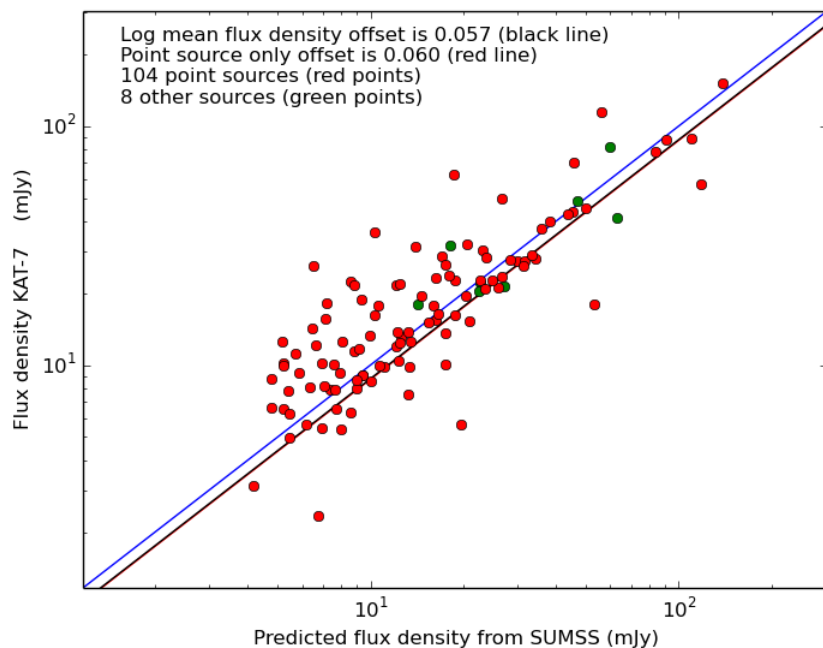
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KATCATALOGUE CROSS MATCHING:



MEERKAT KEY SPECIFICATIONS:

Aperture Lower Frequency Upper Frequency Total physical aperture	400 MHz 15 GHz 9161 m ²	64 x 13.5-m (diameter) offset parabolic antennas Graceful degradation below 400 MHz Dishes will work up to 22 GHz (0.6mm RMS) 64 x 13.5m Dishes
Array Configuration radius <~400 m ~400 m < radius < ~1000 m ~1000 m < radius < 4000 m	~50% (30 ant.) ~20% (13 ant.) ~30% (19 ant.)	
Antenna RF System L-band Feed/LNA UHF-band Feed/LNA X-band Feed/LNA Additional feed designed for	0.9 – 1.67 GHz 0.58 – 1.015 GHz 8.0 – 14.5 GHz S-band?	Available end 2016 Design done/not fitted 2016 Not fitted 2016 4 feeds in total
Digital Outputs Number of Sample streams bits per sample	2 10	Sampled 1712 MSa/s for L band (dual- polarization) 8 effective bits
Signal Transport System L & UHF bands X band	43.85 Gbit s ⁻¹ 96 Gbit s ⁻¹	Optical fibre to signal processor up to 12km Digitised data rate per antenna To be Confirmed



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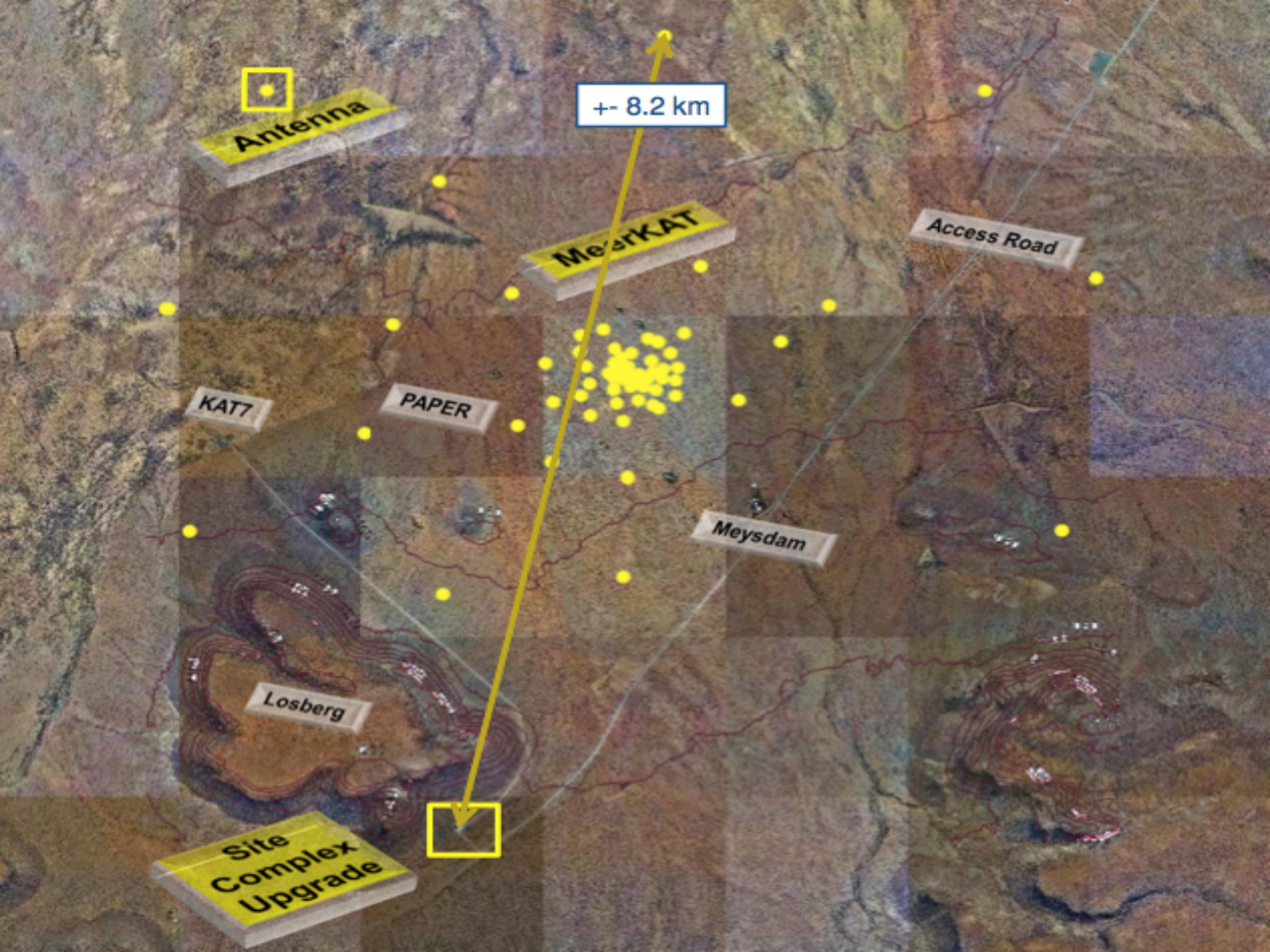


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MEERKAT KEY SPECIFICATIONS:

Receivers and Optics		
Antenna/Feed Efficiency (L & X bands)	70%	Average over frequency
Antenna/Feed Efficiency (UHF bands)	65%	
Average Tsys: L-band Feed/LNA	20 K	
Average Tsys: UHF-band Feed/LNA	28 K	
Average Tsys: X-band Feed/LNA	25 K	
Ae/Tsys (all antennas)		
UHF-band	213 m ² /K	Average: 0.58 – 1.0 GHz
L-band	321**	Average: 0.9 – 1.7 GHz
X-band	321	Average: 8 – 14.5 GHz
Field-of-View @ λ30 cm (1 GHz)		
Imaging Dynamic Range	1.69 deg ²	1000-hr single-field integration
Spectral Dynamic Range	8.6 x 10 ⁵ (59 dB) ≥ 40 dB	



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Name	Bandwidth/[MHz]	Number of channels	Channel width/[kHz]	Correlator integration/[s]
Wideband Course (wc)	856 : 770 usable	4096	209	0.5
Wideband Fine (wf)	856 : 770 usable	32768	26 (5km/s)	0.5
Narrowband Fine (nf)	5 x (856/64=13.4)	4096	3.3	0.5
Narrowband Double (nd)	5 x (856/128=6.7)	4096	1.6	0.5
Pulsar timing	856 : 770 usable	4096	209	4.79μs
VLBI	2 ^N *500*32	32	2 ^N *500	0.5
Incoherent beam total power	856	4096	209	0.001
Antenna voltage buffer	N/A	N/A	N/A	N/A
TA (x4) voltage	856 : 770 usable	4096	209	4.79μs
TA (x4) correlation products	856 : 770 usable	4096	209	4.79μs
Fly's eye transient search	856 : 770 usable	4096	209	0.5

MEERKAT HIGH LEVEL MILESTONES

- Array Release 1 (6 receptors) Engineering Verification completed by 5 April 2016
 - 16 receptors and correlator available
- Array Release 1 Science Commissioning completed 31 May 2016
 - once 6 done, the additional antennas gets added on a rolling basis (i.e. *array commissioning significantly simplified*)
- 16 Antenna Array Science capable by 30 June 2016 (Commissioning done and science capability, but science on PI projects not scheduled to start by then)

MEERKAT HIGH LEVEL MILESTONES...

- Array Release 2 (32 receptors) Engineering Verification completed Dec 2016 (additional single receptors Engineering Verification completed)
- Array Release 2 (32 receptors) Science commissioning completed 31 March 2017
 - . Early Science (PI projects) starts
 - . Wideband (WB) Imaging
 - . Pulsar Timing
 - . additional science modes to follow

MEERKAT HIGH LEVEL MILESTONES...

- Array Release 3 (64 antennas) Engineering Verification completed March 2017
- Array Release 3 (64 antennas) Science Commissioning completed June 2017
 - WB Imaging
 - Pulsar Timing
 - additional science modes to follow

DATA PRODUCTS WITH MEERKAT

- **Level 0:**
 - Raw visibilities with first pass T/F averaging, flagging
 - Big data volume
 - MLSP only use if pipeline needs tweaking
 - **NOT** stored indefinitely ... very important!
- **Level 1:**
 - Calibrated visibilities, with full flagging and calibration applied by the pipeline and ready for imaging
 - Calibrated visibilities stored for a short period TBD (~2 weeks)
 - Calibration and flagging tables archived so that Level 1 visibilities can be recalculated from archived Level 0 at any time

MEERKAT – SCIENCE:

Allocated hours

PI project	Focus	L band hours	Contact
LADUMA	Deep HI	5000	Lindsay
Radio Pulsar Timing	Pulsar Timing	7860	Tony
MHONGOOSE	30 Galaxies	6000	Sean
MeerKAT Absorption Line Survey	HI Absorption	4000	Sharmila
<u>TRAPUM</u>	Fast Transients	3080	Jasper
A MeerKAT HI Survey of the Fornax Cluster	FORNAX HI	2450	Laura
MIGHTEE	Deep Continuum	1950	Nadeem
ThunderKAT	Slow Transients	3000	Richard
ThunderKAT Commensal	Slow Transients	all	Richard

CONCLUSION:

- KAT-7 engineering prototype
 - Producing science
 - Archival data – potential publications
 - Other surveys on-going (Galactic Centre, ...)
- MeerKAT is coming at full throttle
 - Get involved and understand the system

THANK YOU

nadeem@ska.ac.za

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HOMOGRAPHY ANALYSIS:

