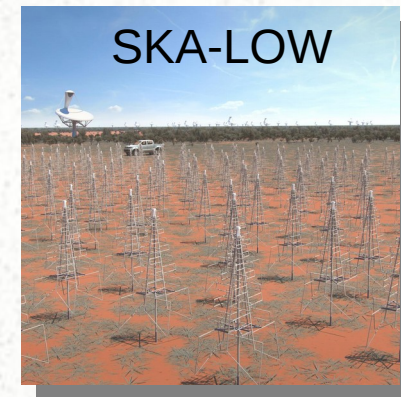


Broadband imaging of radio halos and relics with the uGMRT: a science case for SKA



Ruta Kale

*National Centre for Radio Astrophysics,
Tata Institute of Fundamental Research,
Pune, India*

AND SKA-India Continuum Science Working Group



Outline



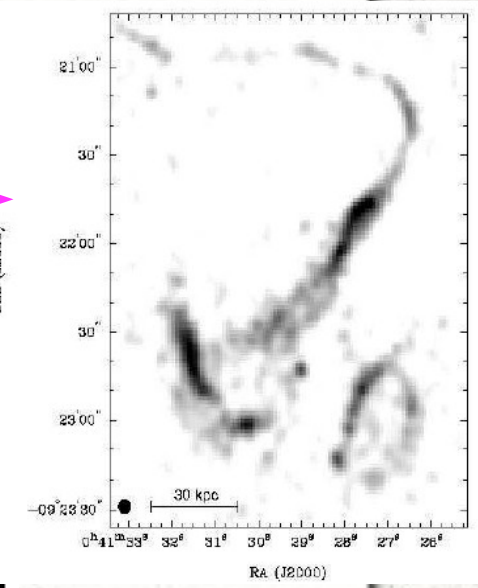
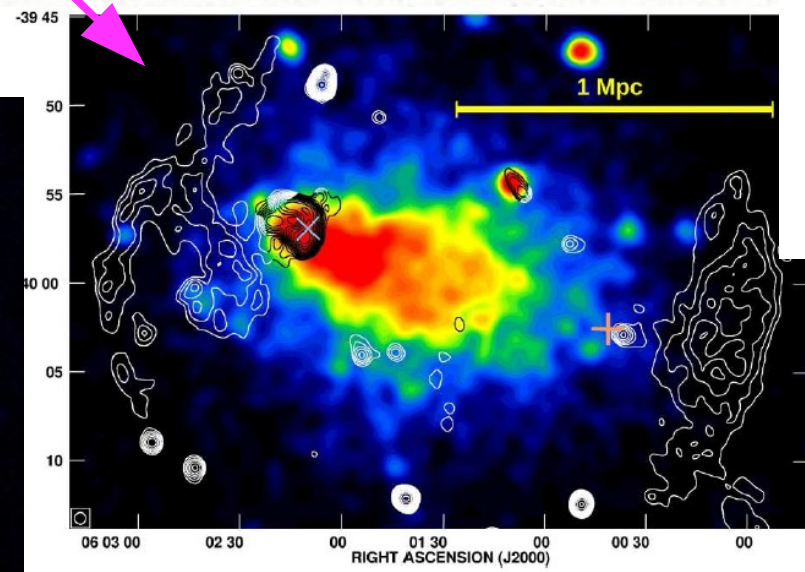
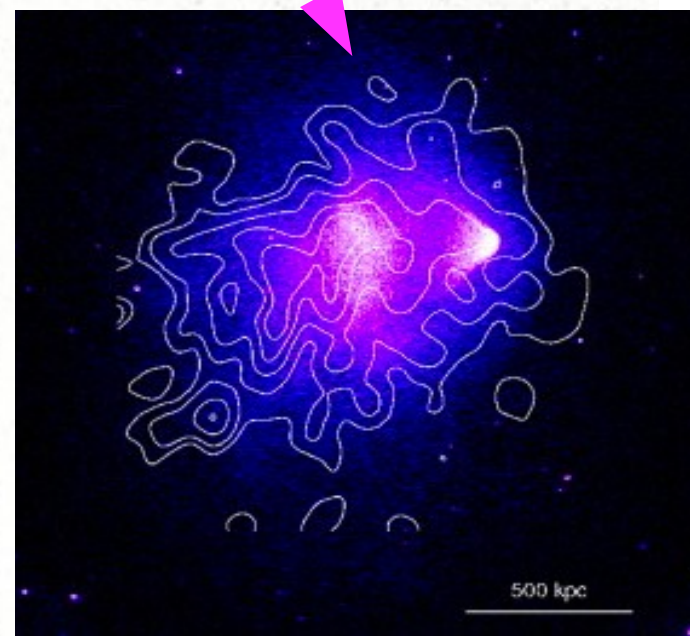
- Radio halos, relics and phoenixes
- Broadband spectra to constrain theoretical models
- uGMRT and SKA implications to spectral index mapping and radio halo detections
- First images of Abell 4038 and Abell 2256 with the uGMRT
- Perspectives for SKA

Cluster radio sources ($\sim 100s$ kpc)

Diffuse synchrotron sources: NOT associated with individual galaxies
 100s kpc to Mpc scales

Radio halos, relics and phoenixes

Review: Brunetti & Jones 2014



Slee et al. 2001

Abell 3376, Kale et al. 2012, Bagchi et al 2006

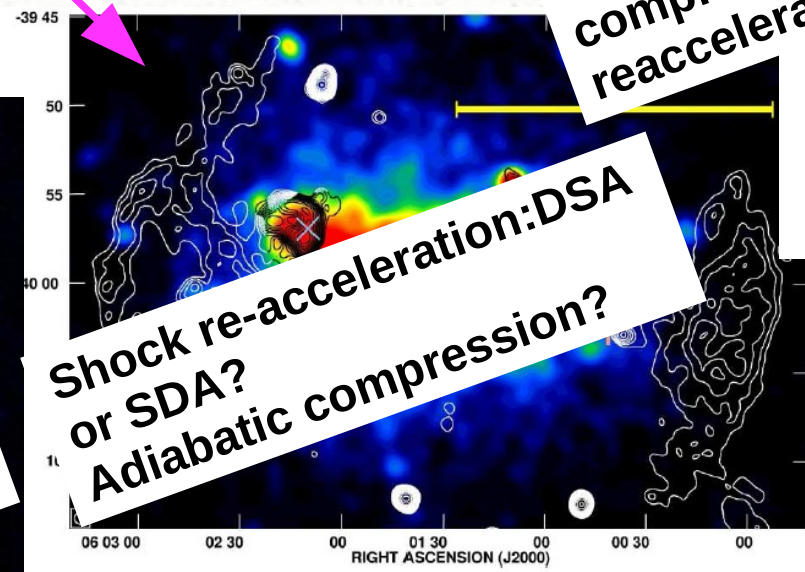
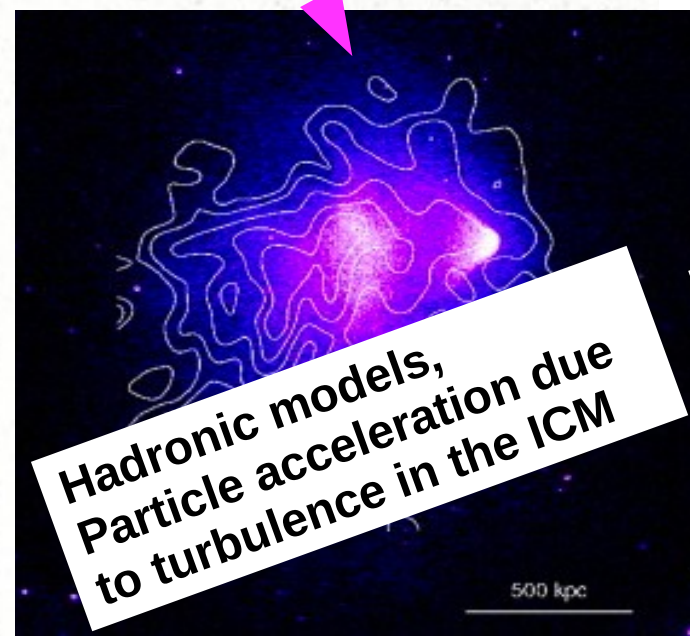
Bullet cluster, Liang et al 2000, Markevitch et al 2005

Cluster radio sources ($\sim 100s$ kpc)

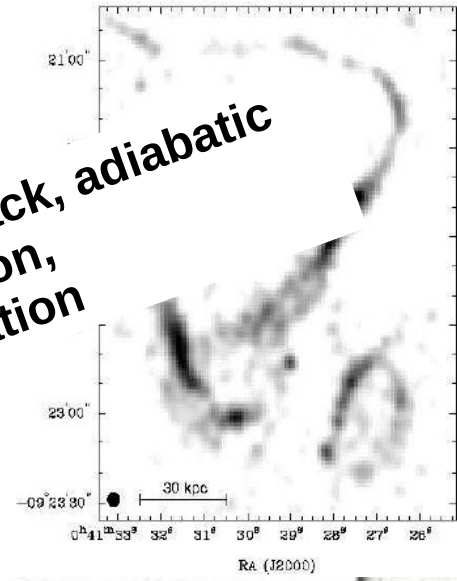
Diffuse synchrotron sources: NOT associated with individual galaxies
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Radio halos, relics and phoenixes

Review: Brunetti & Jones 2014



AGN feedback, adiabatic compression, reacceleration



Slee et al. 2001

Abell 3376, Kale et al. 2012, Bagchi et al 2006

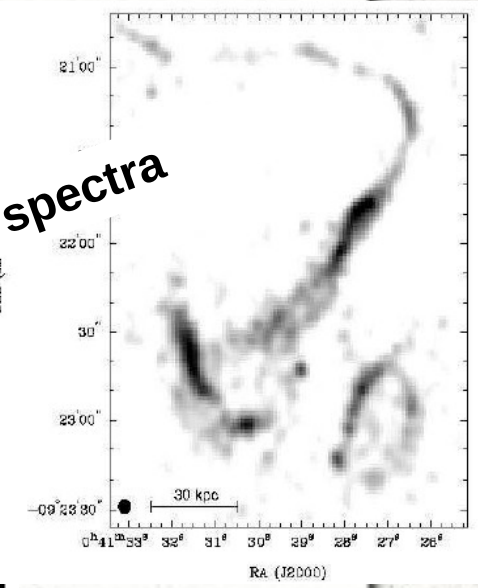
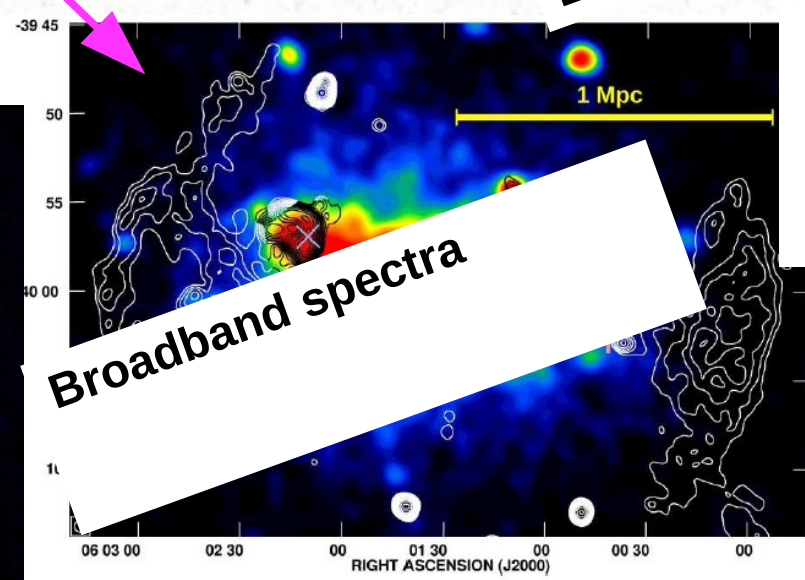
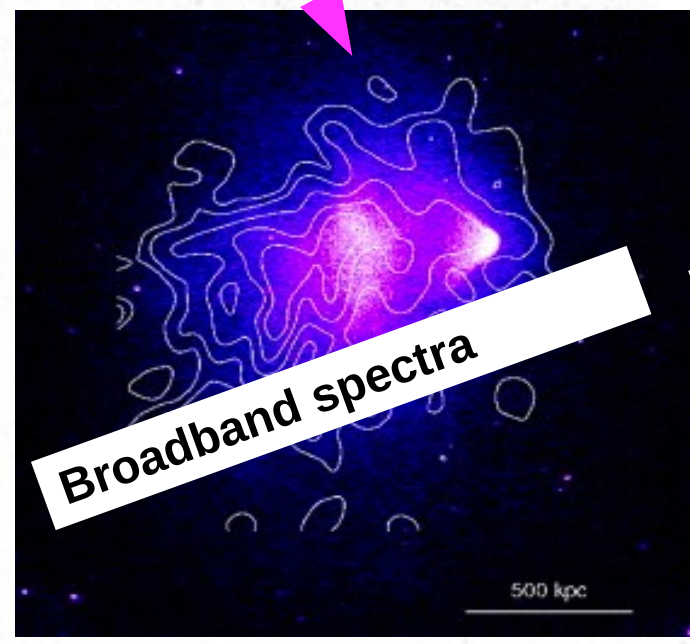
Bullet cluster, Liang et al 2000, Markevitch et al 2005

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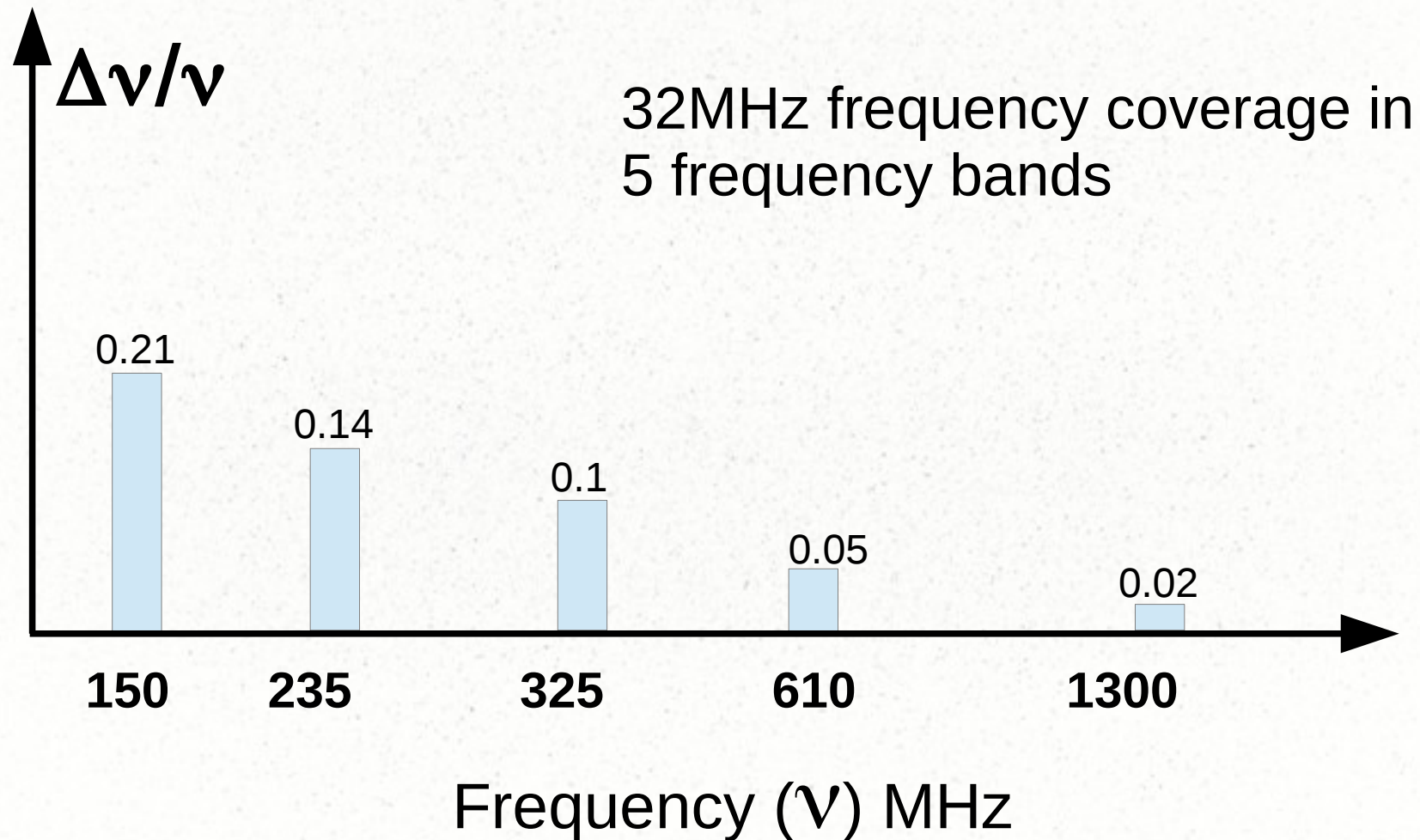


Slee et al. 2001

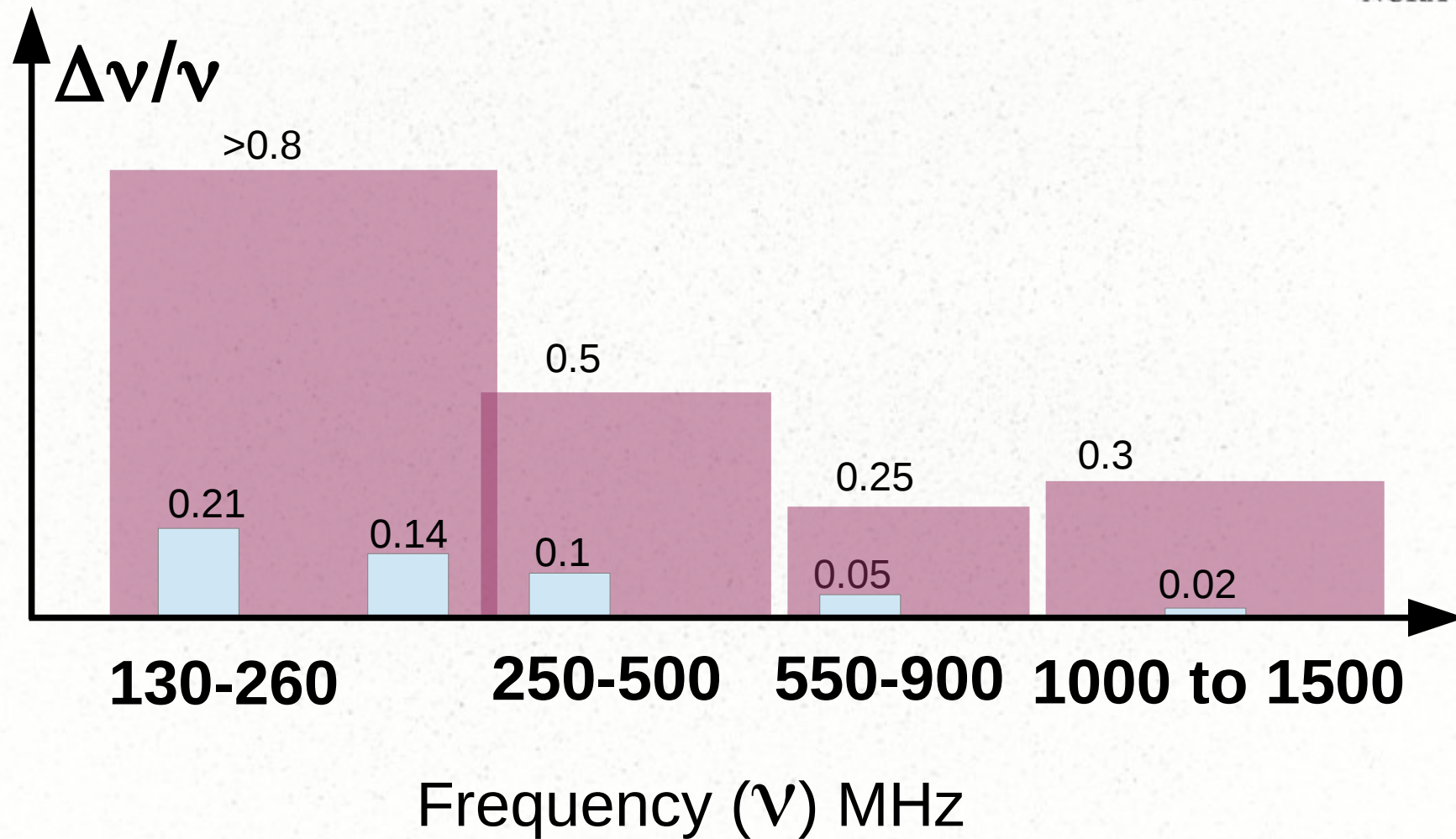
Abell 3376, Kale et al. 2012, Bagchi et al 2006

Bullet cluster, Liang et al 2000, Markevitch et al 2005

Current GMRT



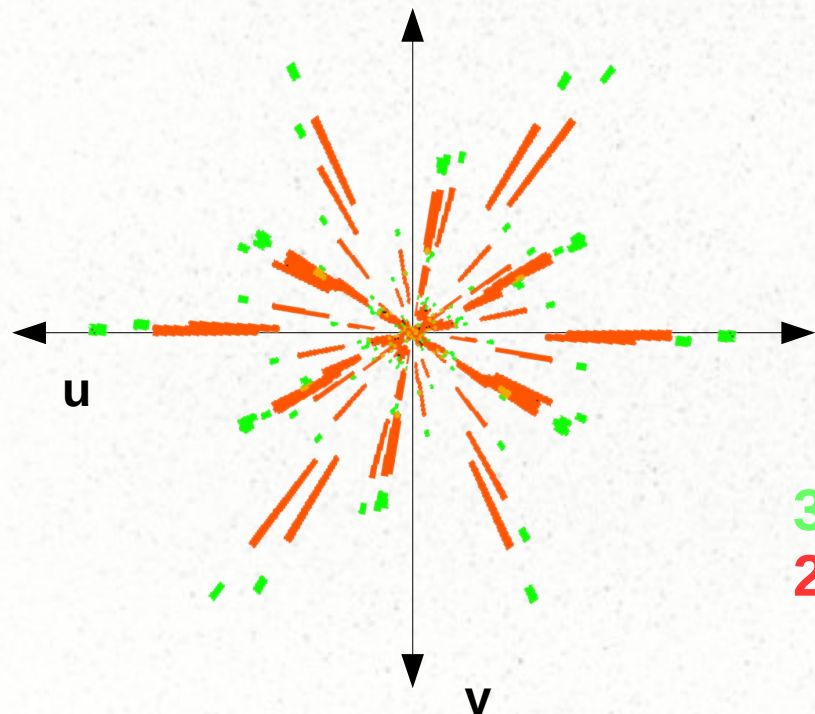
Upgraded GMRT Vs GMRT



uv-coverage: the long and short of it



- Broad bandwidths imply better uv-coverage



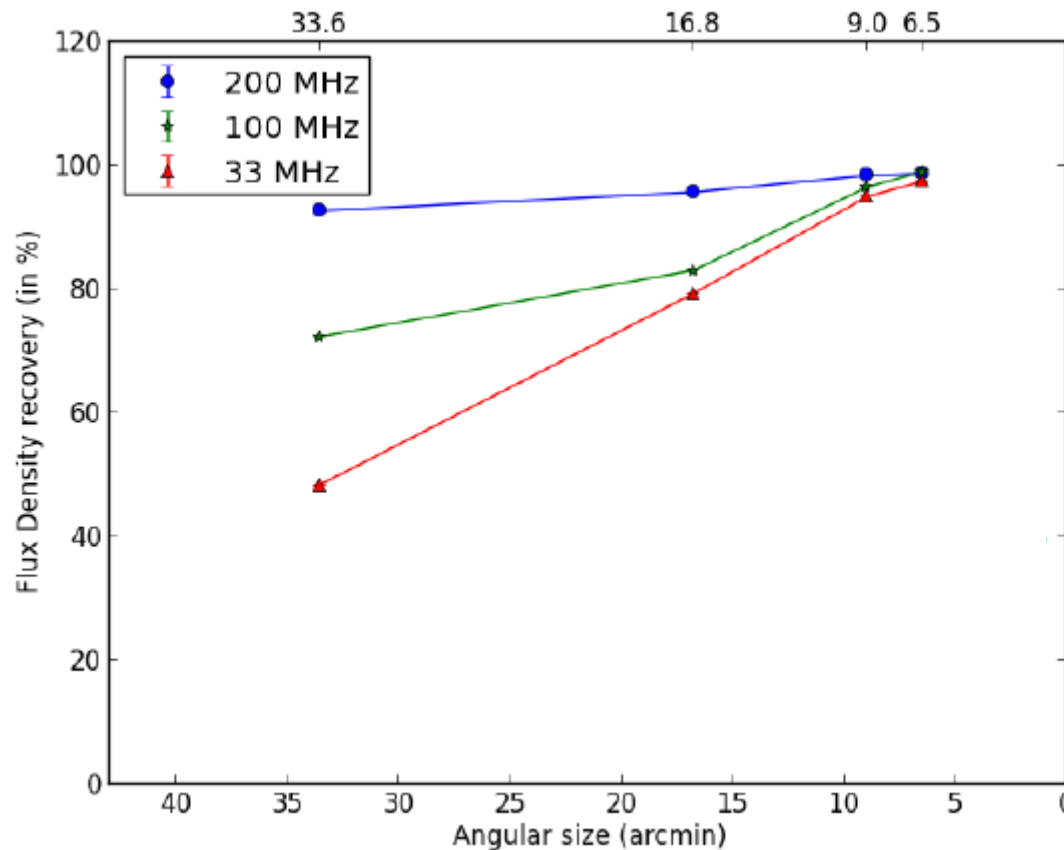
10 minutes uv-coverage
of GMRT and uGMRT

33 MHz GMRT 610 MHz
200 MHz uGMRT 300-500 MHz

Simulations of recovery of extended sources



Largest angular scale sampled ~ wavelength / minimum baseline length
See also Wilner & Welch 1994 for discussion of this issue



GMRT and uGMRT

SPARCS 2016 talk by Deepak.

Future: SKA1-MID simulation

uv-coverage: spectral index mapping



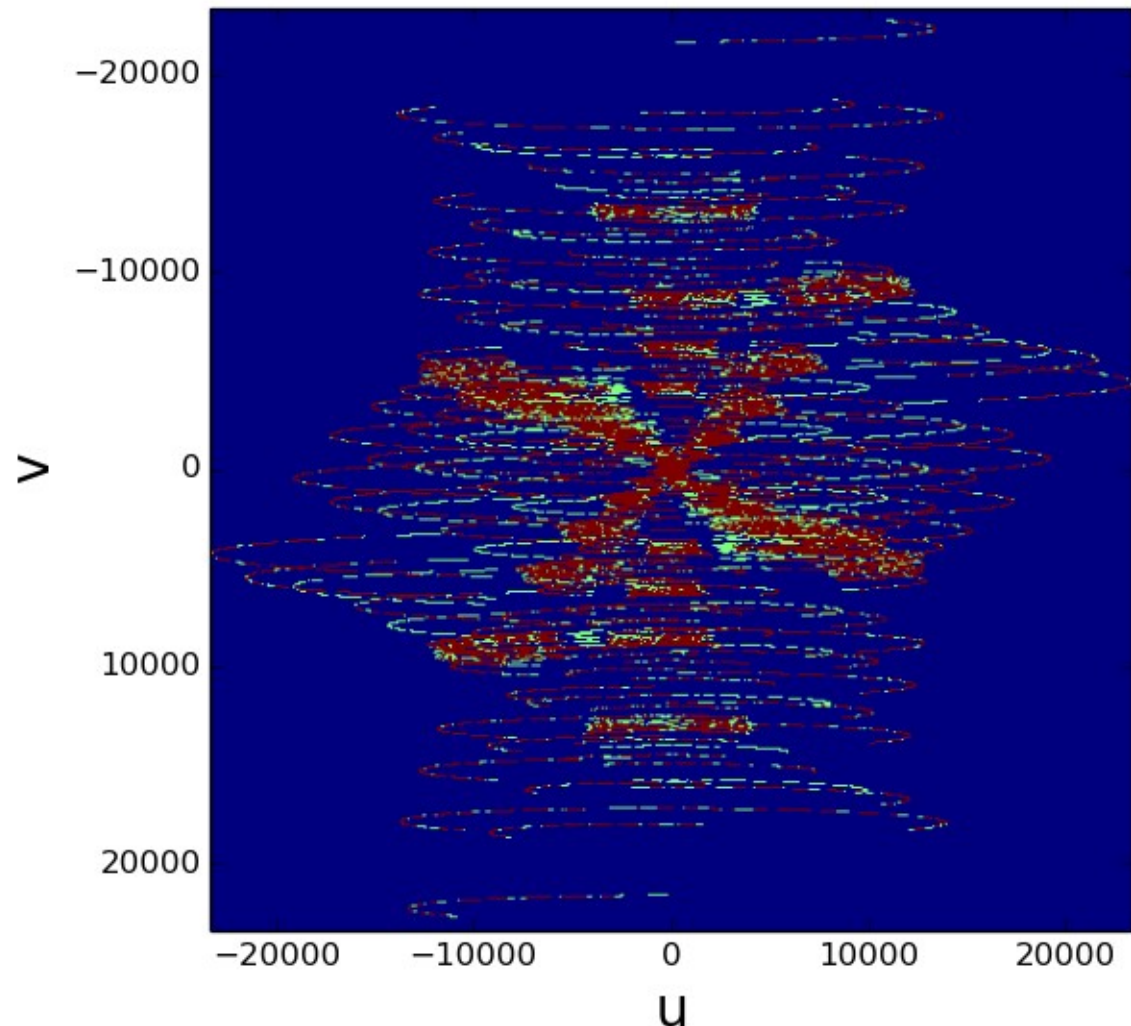
- Comparison of GMRT 610 and 235 MHz uv-coverages

■ No data ■ Overlapping ■ No overlap

Filling fraction
 $= F_{FL} = 11\%$

Overlap fraction
 $= F_{OL} = 72\%$

Wide bandwidth
means implies
factors ~100%
overlap and >50%
filling factors



uGMRT observations of Abell 2256



16 antennas (RR, LL)

402 MHz image

Bandwidth ~ 200 MHz

Time ~ 8 hours

About 45 % data

flagged.

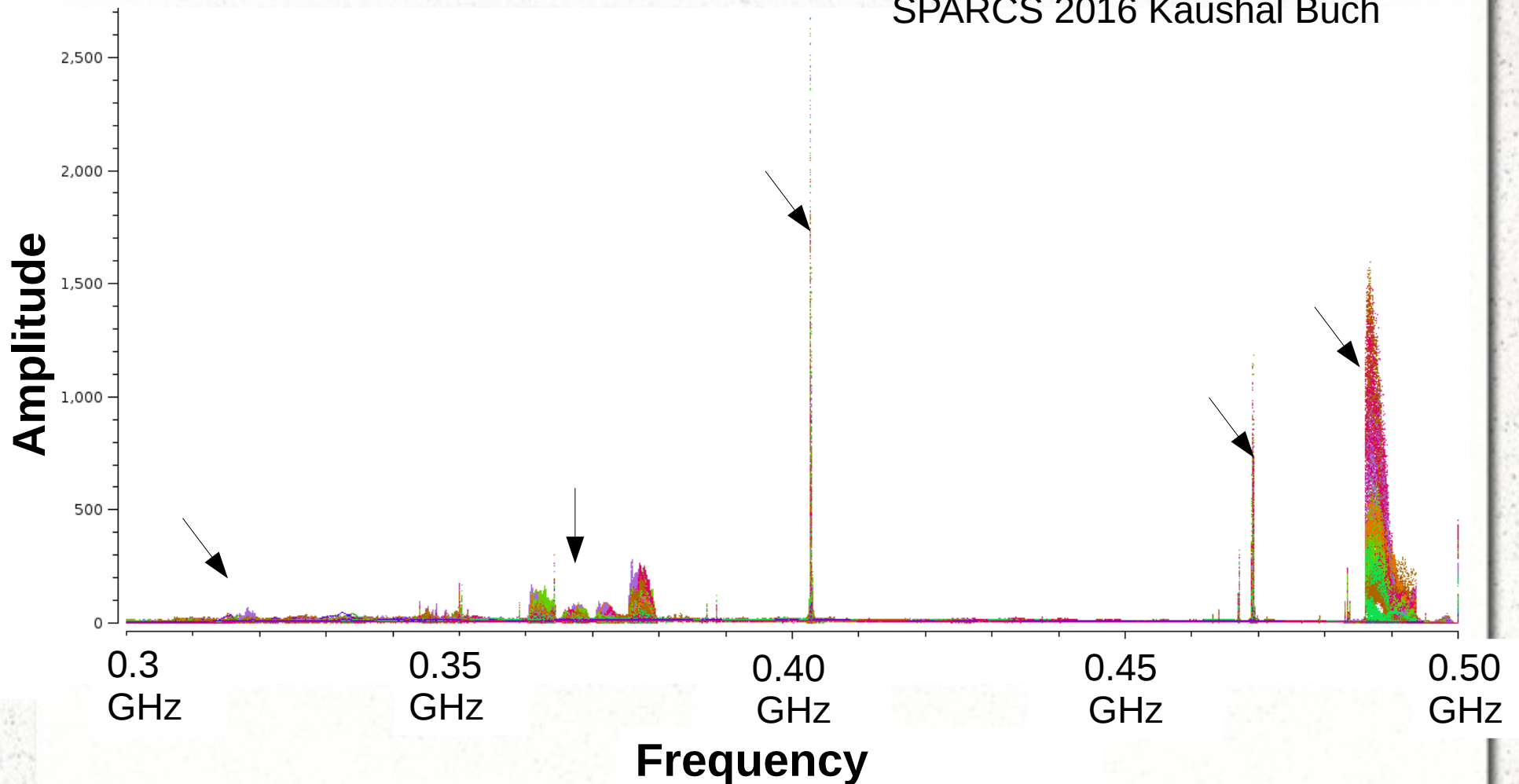
Rms ~ 400 microJy/b

Beam = 17.6" x 8.2"

uGMRT RFI situation

Radio frequency interference: online excision

SPARCS 2016 Kaushal Buch



a2256_split_avg8ch_t1.image.tt0-raster

80°

Abell 2256

uGMRT, 402 MHz

79°

78°

77°

17^h30^m 20^m 10^m 00^m 16^h50^m 40^m

J2000 Right Ascension

16 antennas (RR, LL)

402 MHz image

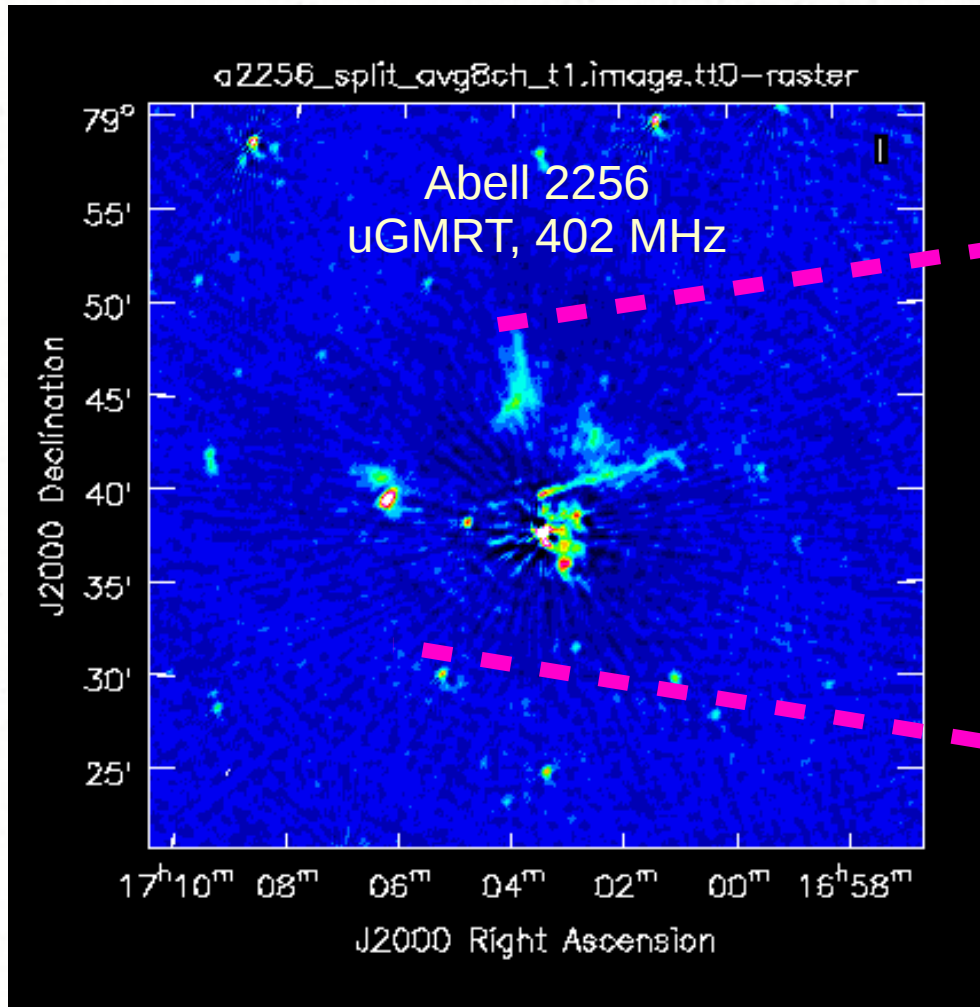
Bandwidth ~ 200 MHz

Time ~ 8 hours

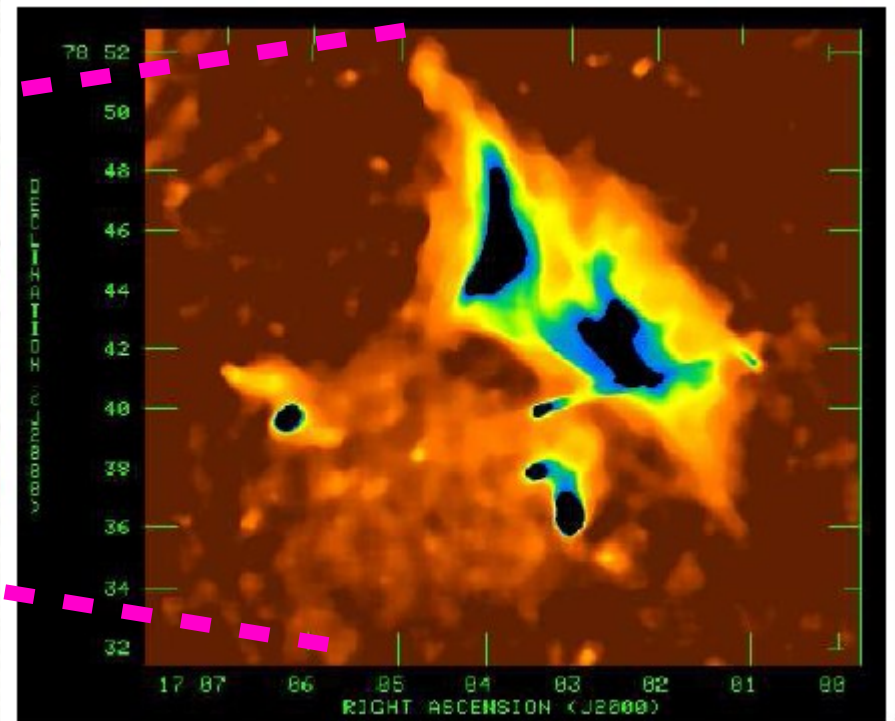
About 45 % data
flagged.

Rms ~ 400 microJy/b

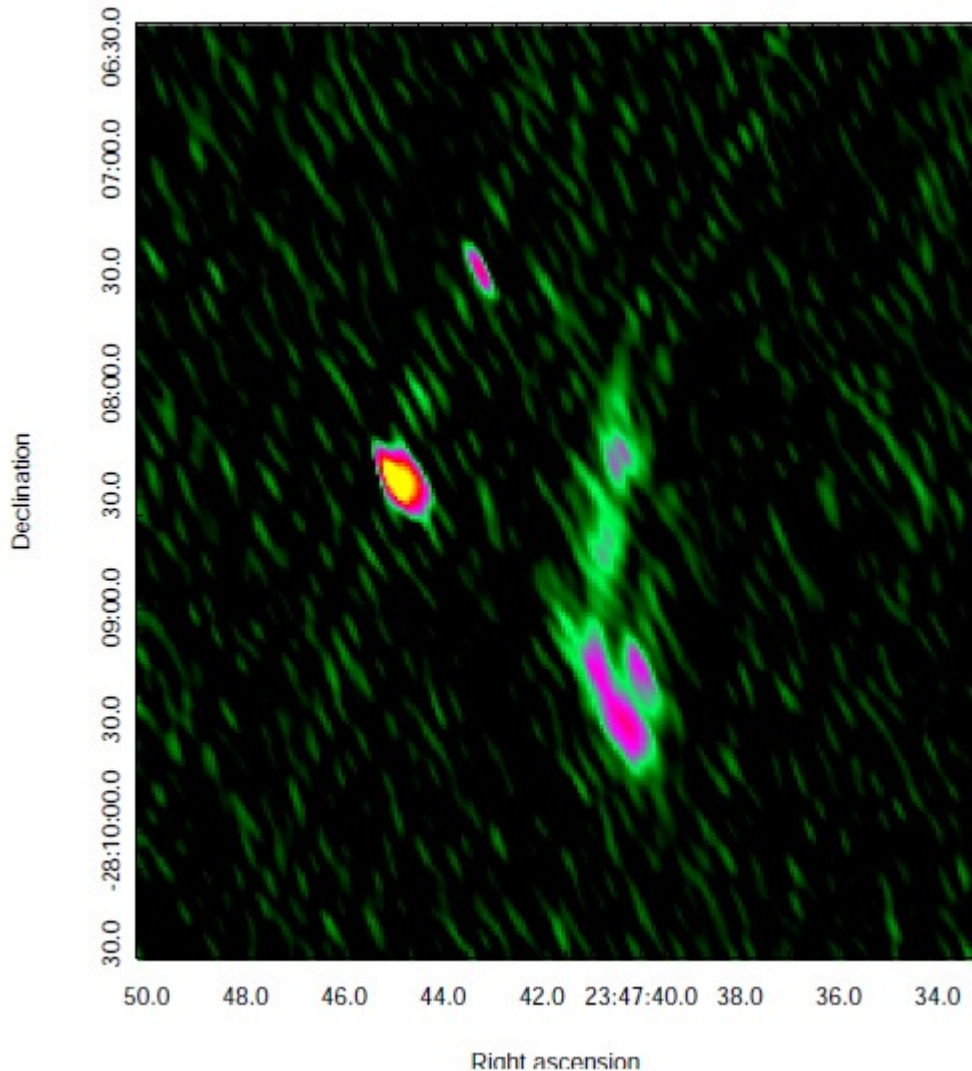
Beam = 17.6" x 8.2"



JVLA 1-2 GHz
Owen et al 2014



uGMRT observations of Abell 4038



16 antennas (RR, LL)

1000-1400 MHz, 3 hours

Each pol processed

separately due to

limitation of CASA

Rms = 60 micro Jy / beam

GMRT 1280 MHz

observations:

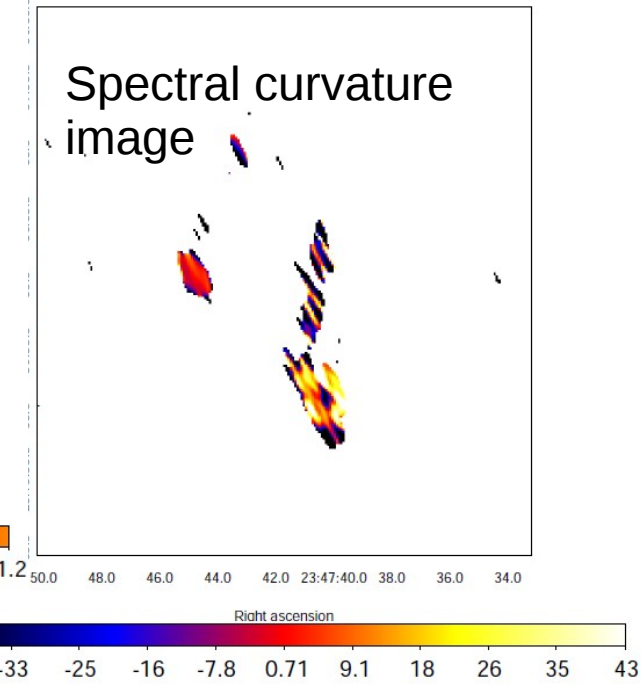
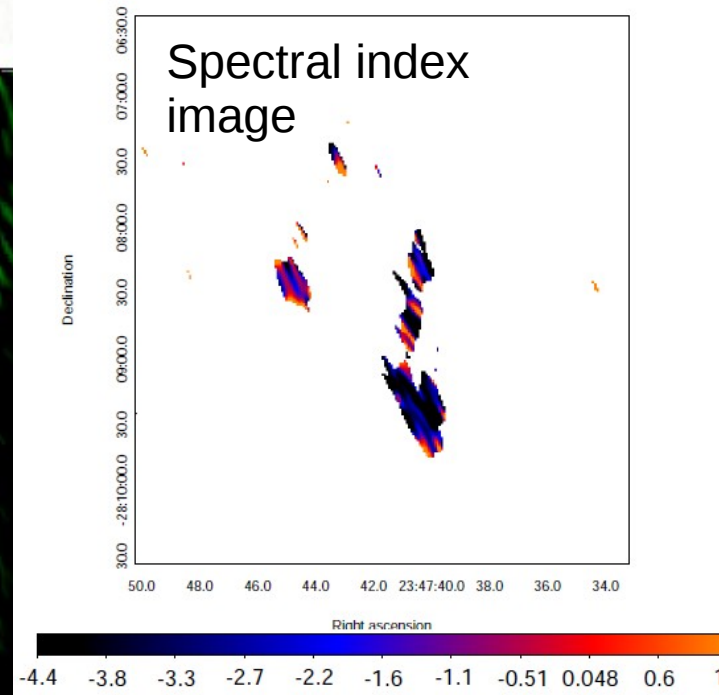
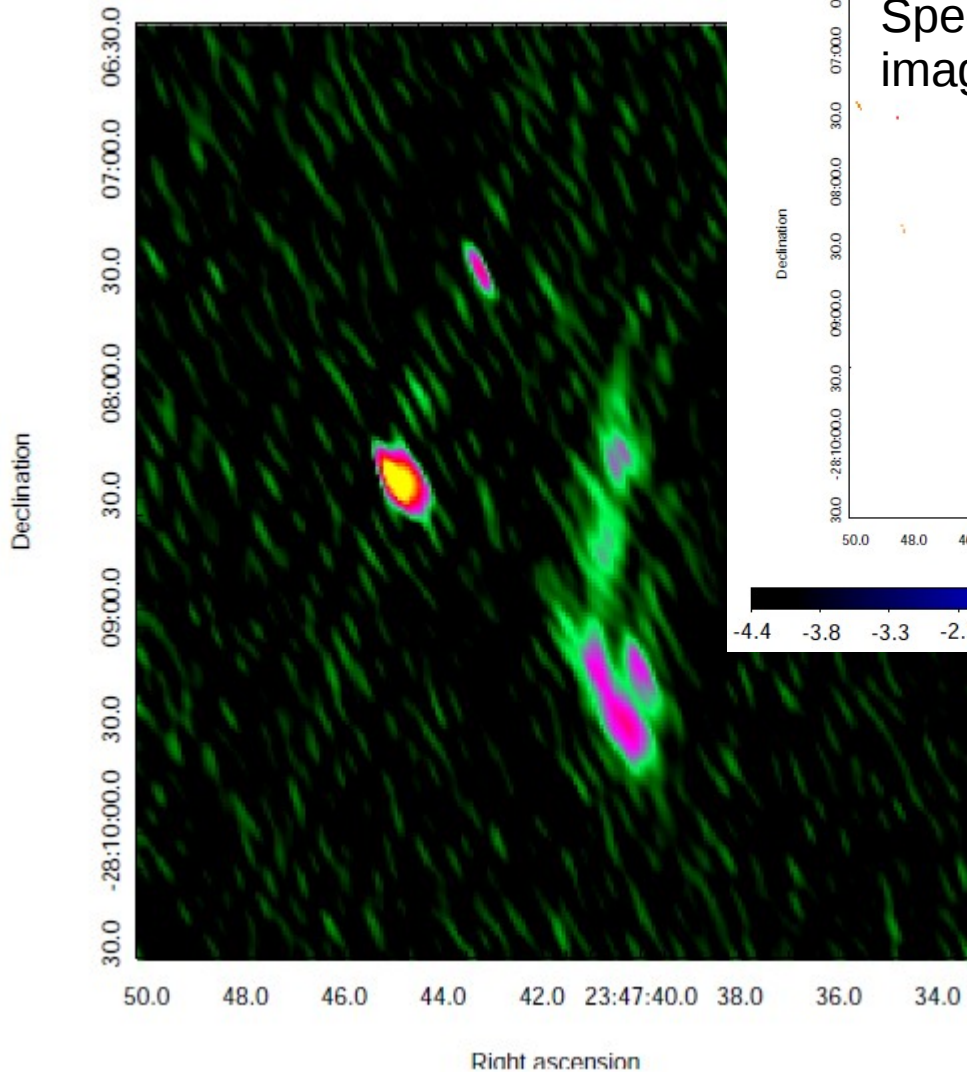
Rms ~ 90 micro Jy/beam

Kale &
Dwarakanath
2012

uGMRT observations of Abell 4038



Image



Spectral curvature:
Due to curvature in particle energy distribution?
Duffy and Blundell 2012

arXiv:1610.08182

Astrophysics > Cosmology and Nongalactic Astrophysics

Clusters of galaxies and the cosmic web with SKA

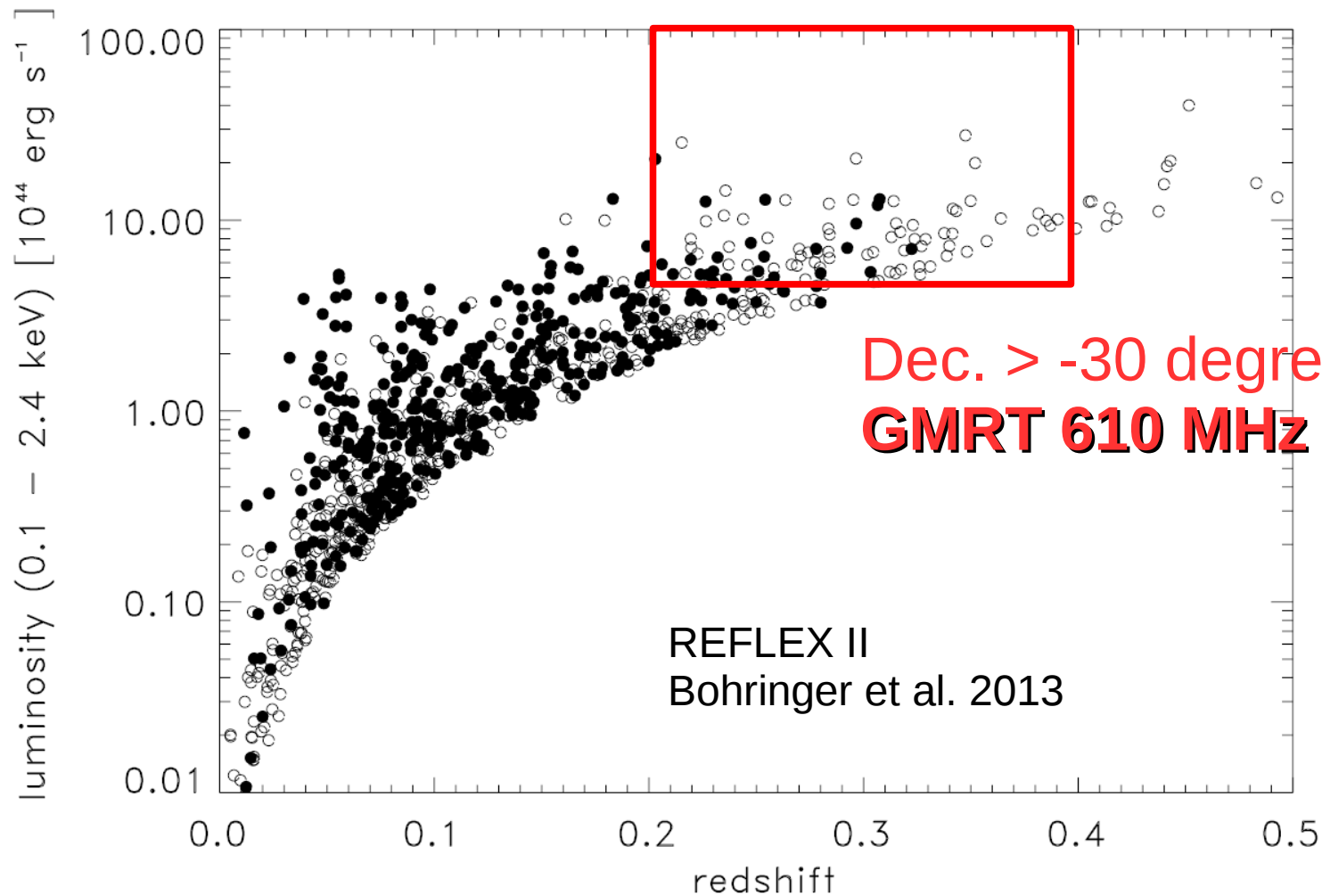
[Ruta Kale](#) (1), [K. S. Dwarakanath](#) (2), [Dharam Vir Lal](#) (1), [Joydeep Bagchi](#) (3), [Surajit Paul](#) (4), [Siddharth Malu](#) (5), [Abhirup Datta](#) (5), [Viral Parekh](#) (2), [Prateek Sharma](#) (6), [Mamta Pandey-Pommier](#) (7) ((1) National Centre for Radio Astrophysics, T.I.F.R., Pune, (2) Raman Research Institute, Bangalore, (3) I.U.C.A.A., Pune, (4) Department of Physics, S.P. Pune University, (5) I.I.T., Indore, (6) I.I.Sc., Bangalore, (7) Univ Lyon, Univ Lyon 1, Ens de Lyon, CNRS, Centre de Recherche Astrophysique de Lyon)

(Submitted on 26 Oct 2016)

To appear in Journal of Astrophysics and Astronomy (JOAA) special issue on "Science with the SKA: an Indian perspective"

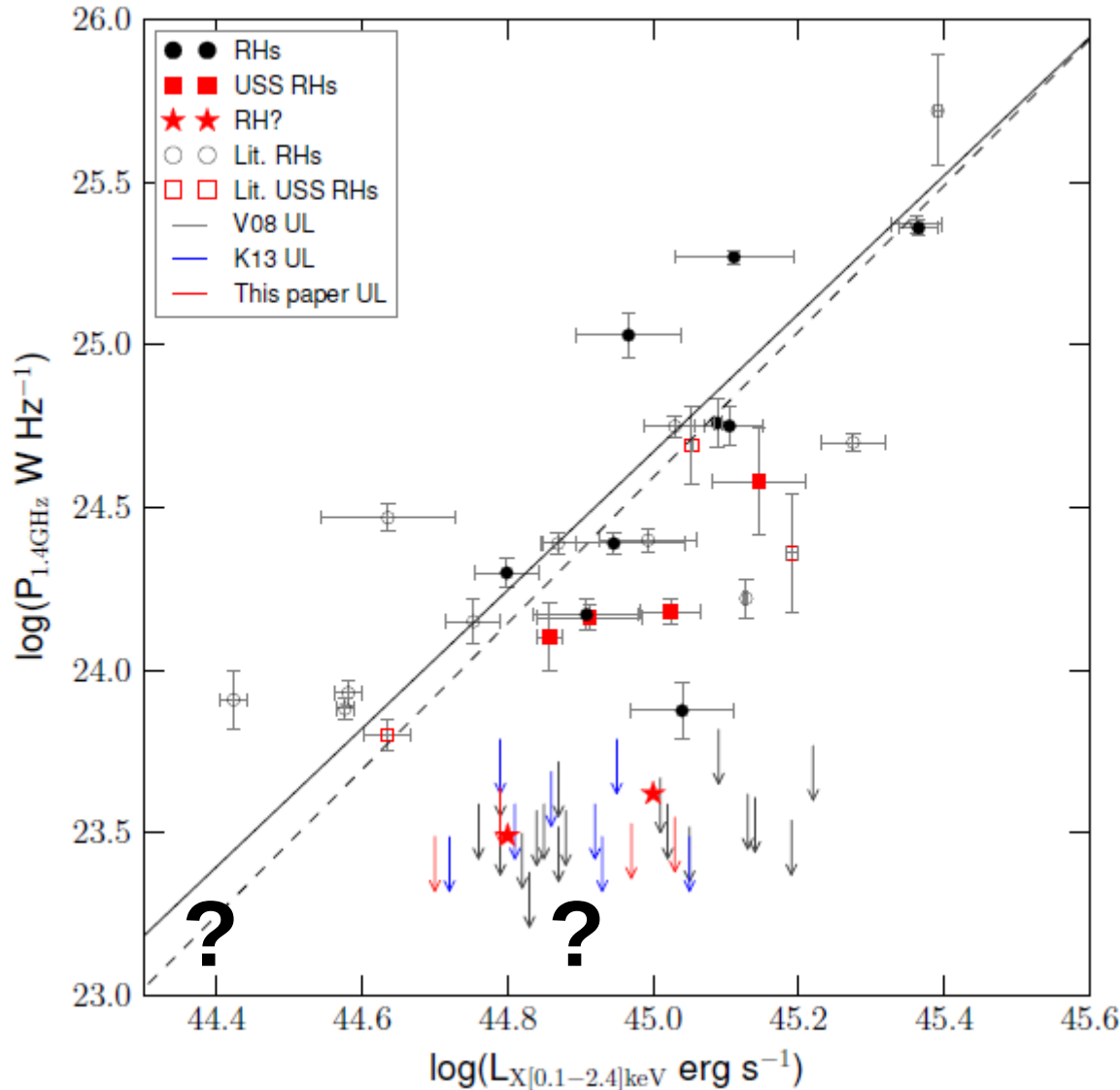
Clusters surveys

Extended GMRT Radio Halo Survey (GRHS + EGRHS)



GRHS : Venturi et al 2007, 2008; EGRHS: Kale et al 2013, 2015a

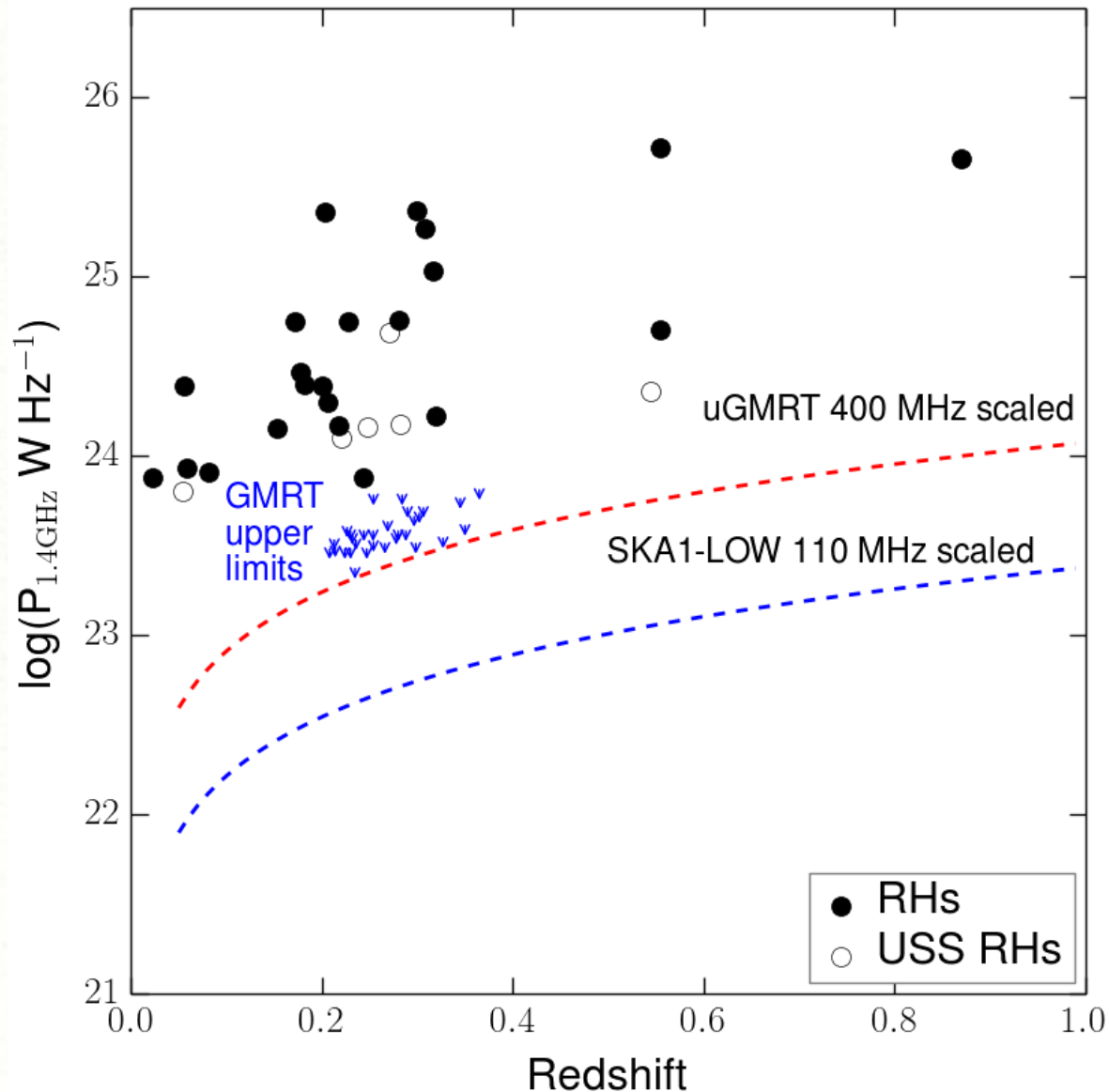
Extended GMRT Radio Halo Survey



GRHS : Venturi et al 2007,
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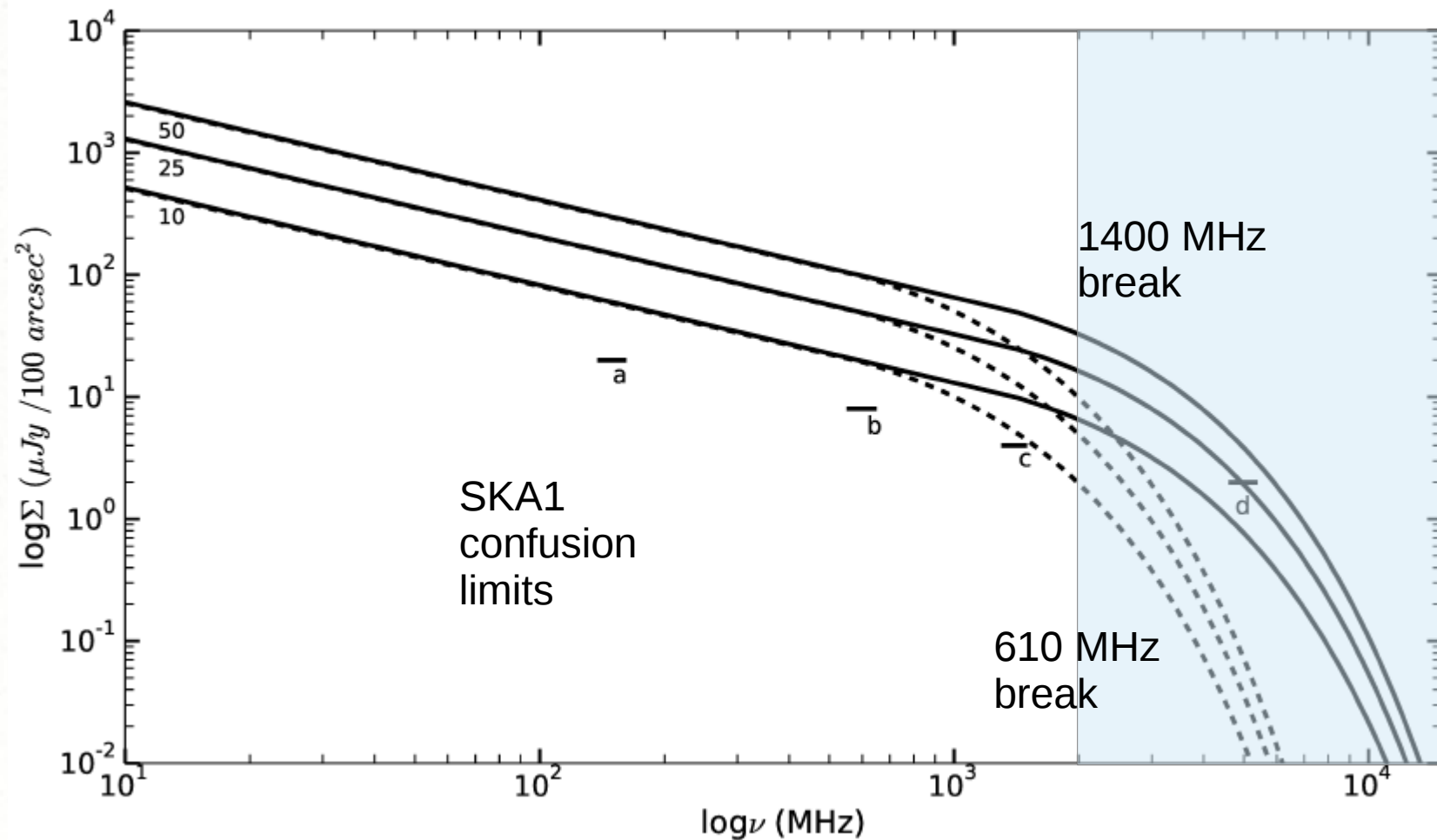
Non-detections:
Upper limits using model
radio halo injections

Predictions for uGMRT and SKA1-LOW



EGRHS : Venturi et al
2007, 2008; Kale et al 2013,
2015a;
Cassano et al. 2013, 2015

Surface brightness detection with SKA1



Cluster science cases for SKA1



- Discovery of a couple of thousand radio halos (also relics) from all sky surveys with the SKA1-LOW and SKA1-MID (L band)
(SKA CWG, radio halo predictions in Cassano et al. 2015)
- Broadband imaging of diffuse cluster radio sources using SKA1-LOW and MID
(including Band 5, shortest baseline ~ 25 m, can image Mpc size radio halos at $z > 0.2$)

arXiv:1610.08182

