Max-Planck-Institut
für Radioastronomie

The Giant Metrewave Radio Telescope

GMRT

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GMRT user

Outline

-The instrument – features and scientific goals

- Issues in the observations data reduction

- Practicalities – how to apply for GMRT time, how to prepare an observing schedule

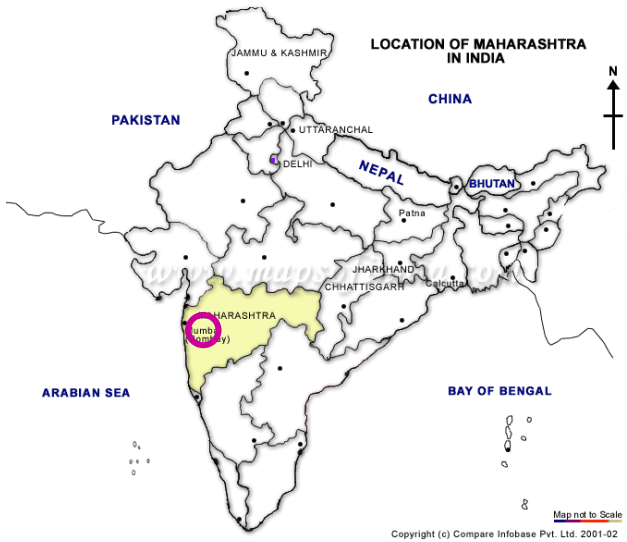
- Some results

GMRT

- Radio interferometer designed to explore the low frequency range of the radio spectrum (now between 150 MHz and 1.4 GHz)

- Project of the Tata Institute of Fundamental Research (TIFR), National Centre for Radio Astrophysics (NCRA)

- Located in Maharastra (India), near Pune



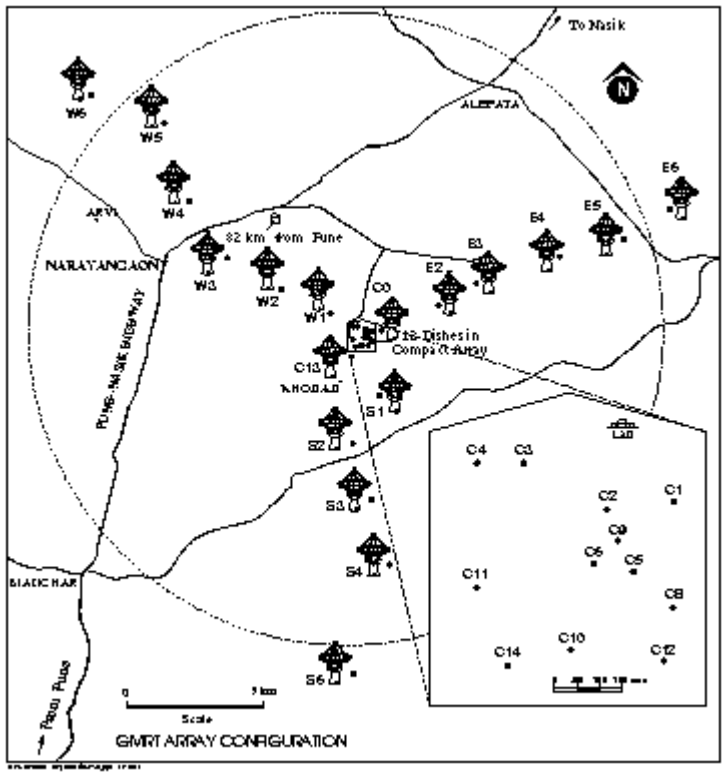
The Array

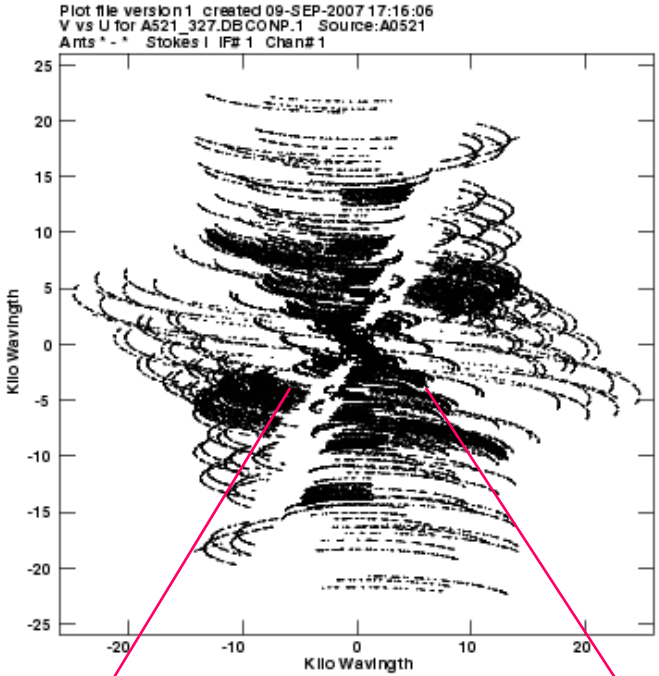
- Consists of 30 parabolic antennas, with diameter of 45 m

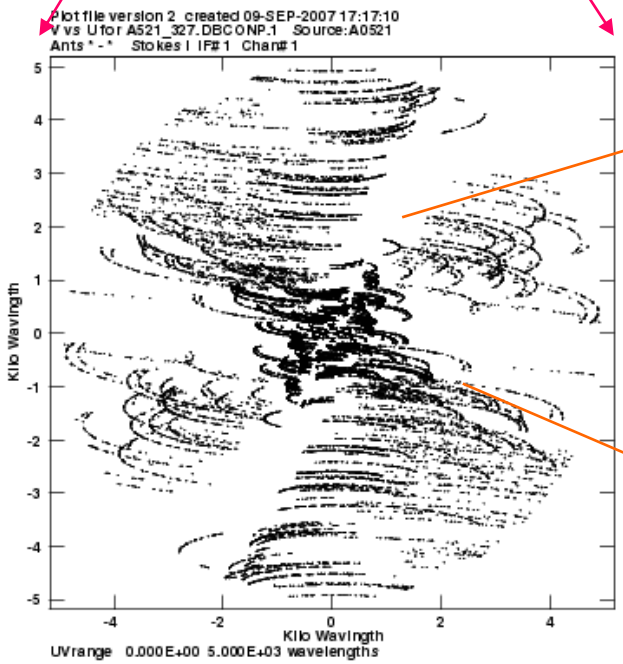
- Covers the range 150 MHz – 1.4 GHz with 5 bands:

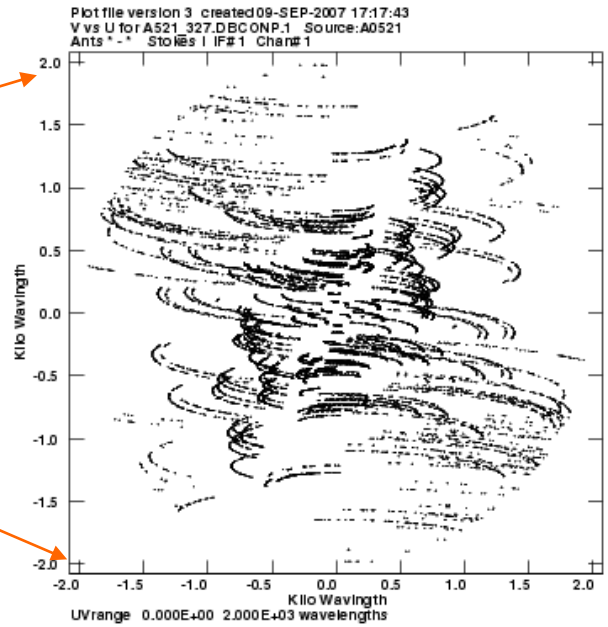
  150 -156 MHz 232-244 MHz 315-335 MHz 590-630 MHz 1000-1450 MHz

- One single configuration with fixed antennas: a compact array with 14 dishes in a central 1 km^2 and the remaining antennas in a sort of Y configuration, with longest baseline of the order of 25 km









GMRT u-v coverage at 325 MHz

$\delta = -10^{\circ}$

7 hr on source

Specifications

Parabolic Reflector Diameter	45m
Focal Length	18.54 m
Physical aperture	1590 m^2
Sensitivity of single dish	0.3 K / Jy
Feed Support	Quadrupod
Mounting	Altitude-azimuth
Elevation Limits	Software Limit 17 — 90 degrees
	Hardware Limit 15 — 110 degrees
Azimuth Limits	Software Limit —265 to +265 degree
	Hardware Limit —270 to +270 degre
Slew rate	Azimuth 30 degree/minute
	Elevation 20 degree/minute
Design wind speeds	Operation upto 40 km/h

Table 1: Measured System Parameters of GMRT

	Frequency (MHz)				
	151	235	325	610	1420
Primary Beam (arc min)	186±6	114±5	81 ± 4	43 ± 3	$24 \pm 2 * (1400/f)$
Receiver Temperature (T_R)	144	55	50	60	40
Typical T_{sky} (off galactic plane)	308	99	40	10	4
Total System Temperature (K) ($T_R + T_{sky} + T_{ground}$)	482	177	108	92	76
Antenna Temp (K/Jy/Antenna)	0.33	0.33	0.32	0.32	0.22
Synthesised Beam (arcsec)					
Whole Array	20	13	9	5	2
Central Square	420	270	200	100	40
Largest Detectable Source(arcmin)	68	44	32	17	7
Usable Frequency Range (MHz)					
Reliable	150 - 156	232 to 244	315 to 335	590 to 630	1000 to 1450
With some Luck	150 to 158	230 to 250	305 to 360	570 to 650	950 to 1450
Fudge Factor(actual to estimated)					
Short Observations	10	5	2	2	2
Long Observations*	5	2	2	1	1
Best rms sensitivies achieved so far as known to us (mJy)	1.5	0.6	0.3	0.02	0.03
Typical Dynamic Ranges	>1000	>1000	>1500	>1500	>2000

* For spectral observations fudge factor is close to 1

New 40-80 MHz feed developed and tested, soon available for all antennas of the array *(S. Amiri)*

Low Frequency Feed in boxing ring configuration and co-located with 327 MHz GMRT existing feed with extended reflector. On the ground and attached to the GMRT dish turret.

Scientific goals of GMRT

- Low frequency part of the non thermal radio spectrum
- Sensitive to extended low brightness radio emission
- Large range of angular resolutions within just one observation
- Large field of view

Epoch of galaxy formation (high-z neutral hydrogen)

Pulsars and neutron stars

Stellar objects, Galactic plane (Sun, SNR, transients)

Deep surveys

Extended emission (normal galaxies, lobes of radio galaxies, galaxy clusters …)

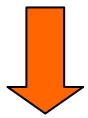
…

Some features of GMRT

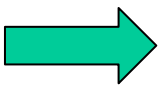
2 bands (USB and LSB) recorded at each frequency, with RR and LL recorded in each band – Full Stokes parameters newly available

Bandwidth of 16 MHz (each band) down to 325 MHz; 8 MHz below

Ionosphere and RFI become an issue at low frequencies (below 610 MHz)



Spectral line correlation essential at these frequencies both for RFI removal and to reduce bandwidth smearing over the field of view



Bandwidth divided into 128 channels (new feature 256 channels), width from 3 to 125 kHz/ch

Issues in the observations and data reduction

Preparing the observation

Selection of phase calibrator is an issue for $\nu \leq 610$ MHz- always check the NVSS and VLSS images

A-priori calibration

Now possible to combine USB and LSB before the data reduction starts

RFI removal and bandpass calibration

Self calibration always necessary

Imaging

Dealing with strong sources off the phase centre

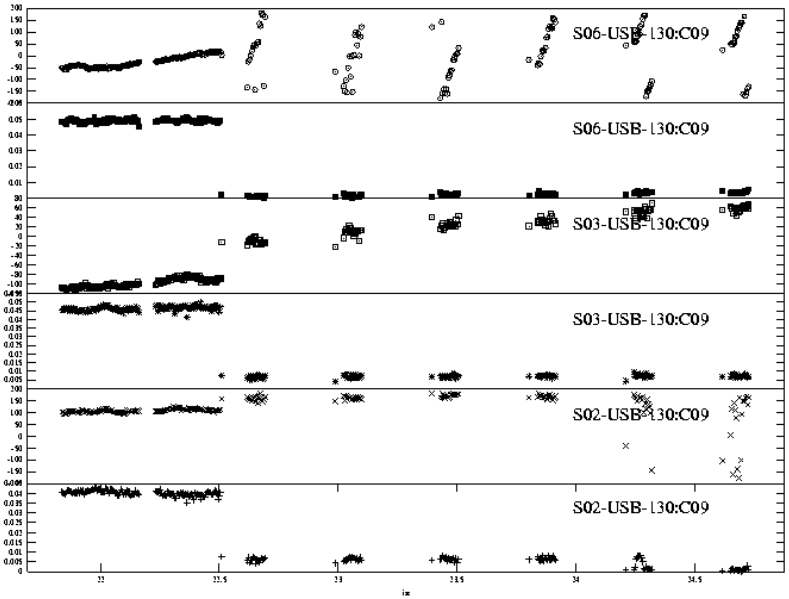
Large field of view (i.e. ~3° at 327 MHz) requires 3D imaging

Raw data into fits format with gvfits (available only at GMRT)

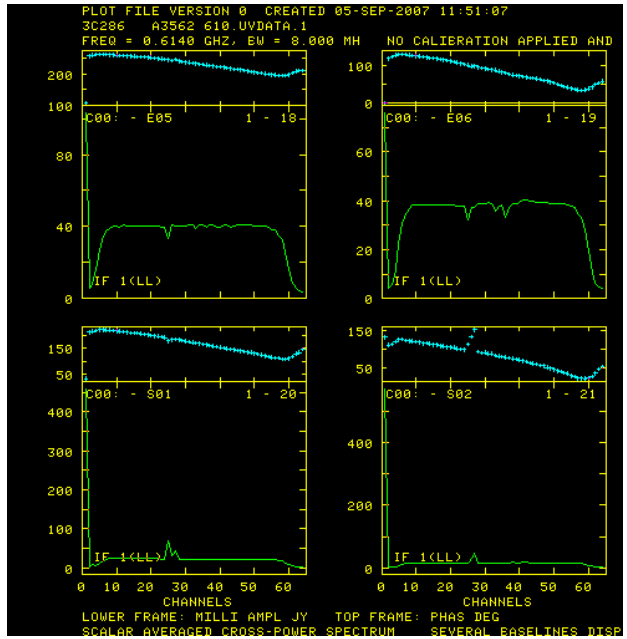
Full data reduction with AIPS

Checks during the observations

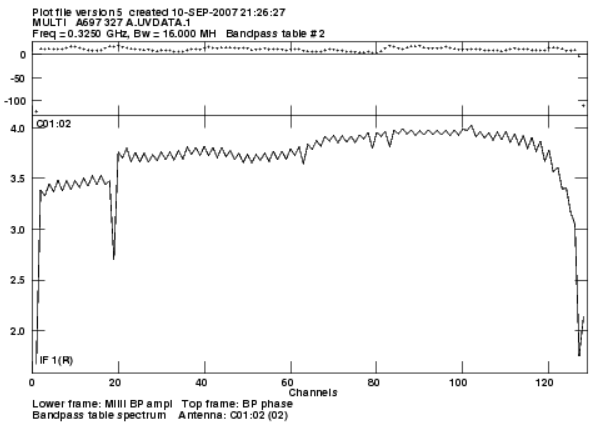
Keep an eye on the calibrator

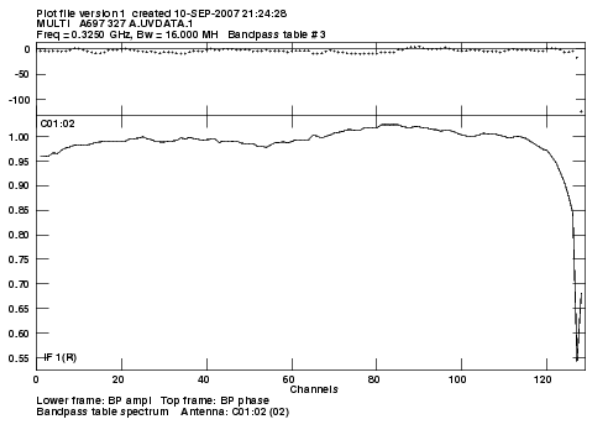


Band at 610 MHz



at 327 MHz

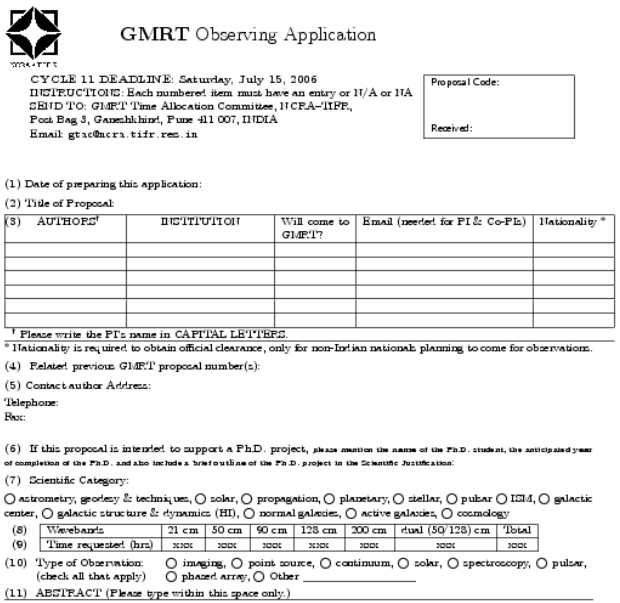




How to apply for GMRT time

2 deadlines/year, January and July

Email submission (cover+scientific justification)



GMRT Observing Application

CYCLE 11 DEADLINE: Saturday, July 15, 2006
INSTRUCTIONS: Each numbered item must have an entry or N/A or NA
SEND TO: GMRT Time Allocation Committee, NCRA-TIFR,
Post Bag 3, Ganeshkhind, Pune 411 007, INDIA
Email: gtac@ncra.tifr.res.in

Proposal Code:

Received:

(1) Date of preparing this application:

(2) Title of Proposal:

(3) AUTHORS†	INSTITUTION	Will come to GMRT?	Email (needed for PI & Co-PIs)	Nationality *

† Please write the PI's name in CAPITAL LETTERS.

* Nationality is required to obtain official clearance, only for non-Indian nationals planning to come for observations.

(4) Related previous GMRT proposal number(s):

(5) Contact author Address:

Telephone:

Fax:

(6) If this proposal is intended to support a Ph.D. project, please mention the name of the Ph.D. student, the anticipated year of completion of the Ph.D. and also include a brief outline of the Ph.D. project in the Scientific Justification:

(7) Scientific Category:

○ astrometry, geodesy & techniques, ○ solar, ○ propagation, ○ planetary, ○ stellar, ○ pulsar ○ ISM, ○ galactic center, ○ galactic structure & dynamics (HI), ○ normal galaxies, ○ active galaxies, ○ cosmology

(8)	Wavebands	21 cm	50 cm	90 cm	128 cm	200 cm	dual (50/128) cm	Total
(9)	Time requested (hrs)	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx

(10) Type of Observation: (check all that apply) ○ imaging, ○ point source, ○ continuum, ○ solar, ○ spectroscopy, ○ pulsar, ○ phased array, ○ Other _____

(11) ABSTRACT (Please type within this space only.)

(12) Will PI/ Co-PI be present for observations? ○ Yes ○ No Data reduction at? ○ Home ○ Other xxxxxxx

(13) Help required: ○ None ○ Consultation ○ Priori (extensive help)

(14) Spectroscopy Only:

	line 1	line 2	line 3	line 4
Transition (HI, OH, etc)				
Rest Frequency (MHz)				
Velocity (km/s)				
Observing frequency (MHz)				
Frequency Resolution (kHz/channel)				
Rms noise (mJy/bm, nat. weight., 1 hr)				
Rms noise (K, nat. weight., 1 hr)				

(15) Number of sources xxxx (If more than 10 please attach a list together with LST range(s). If more than 30 sources give only selection criteria and LST range(s).)

(16) Name	Epoch: 1950○ 2000 ○ RA Dec hh mm ± xxxx	GMRT array†	Band (/cm)	Band-width (MHz)	Flux Density line (mJy‡)	Flux Density cont. (mJy)	Max. ang. size (')	Requ-ired rms (mJy/ beam)	Time§ requ-ested (hrs)	LST range (hrs)

† Please indicate your preference for the GMRT Array configuration as per the following possibilities:
F All antennas available.
Hxx Only xx antennas required (eg. VLBI, pulsar test/ monitoring)
C00 Central square antennas only
C01 Central Square antennas + 1st antenna in each arm } Phased Array
A00 Arm antennas only
A01 Arm antennas only with upto 4 antennas from the Central Square

‡ Peak flux density.

§ including overheads.

Notes to the table (if any):

(17) Dates preferably avoided:

(18) Special requirements of hardware, software, or operating procedures, etc:

- 1 side band (16 MHz) ○ or, 2 sidebands (32 MHz) ○
- Is integration time less than 8 seconds required for extended periods? ○
- Specify expected disk space requirement for the project (if more than 10 GBytes):
- Non-standard Frequency ○
- Short spacing critical ○
- Correlator - Full Polar * ○
- Correlator - High resolution (256 channels) * ○
- Phased array required ○
- If pulsar, specify pulsar backend required:

* on experimental basis

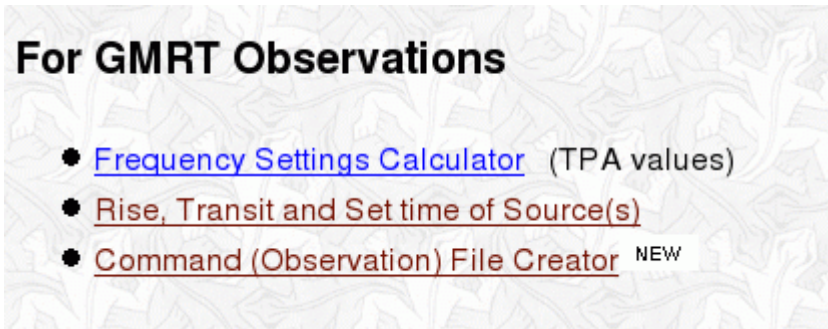
(19) IMPORTANT: If your proposal(s) for GMRT observations have been scheduled in the past,

How to prepare the observing schedule

Calibrators (primary, secondary, bpass)

Visibility of target sources

Frequency & setup



- **Project Title** : Galaxy
- **User's Name** : J K Ram
- **User's Email** : xyz@abc.res.in
- **Date of Obs.** : 01 01 2006
- **Start Time (LST)** : 00 00
- **Integration Time (sec)** : 16
- **Correlator Mode** : IndianPolar
- **Radio Frequency Band** : 325 -- (305 - 345)
- **Observation Type** : Continum
- **Spectral line Frequency (MHz) at the center of the band** (line obs only)
- **Band Width (MHz),** (line obs only) : 16

Source List

Source(s) Co-ordinates :-

Source_Name	RA	Dec	Epoch
3C147	05h38m43.50s	+49d49'42.7"	1950.0
0837-198	08h37m11.18s	-19d51'56.8"	2000.0.
NGC1851	05h14m06.30s	-39d02'50.0"	2000.0

Command File

- **Flux Cal at beginning** : 3C48
- **Target Source(s) & Phase cal(s) Loop** :

Scan-Time(min)	Target-Name
10	1254+116
30	NGC5435

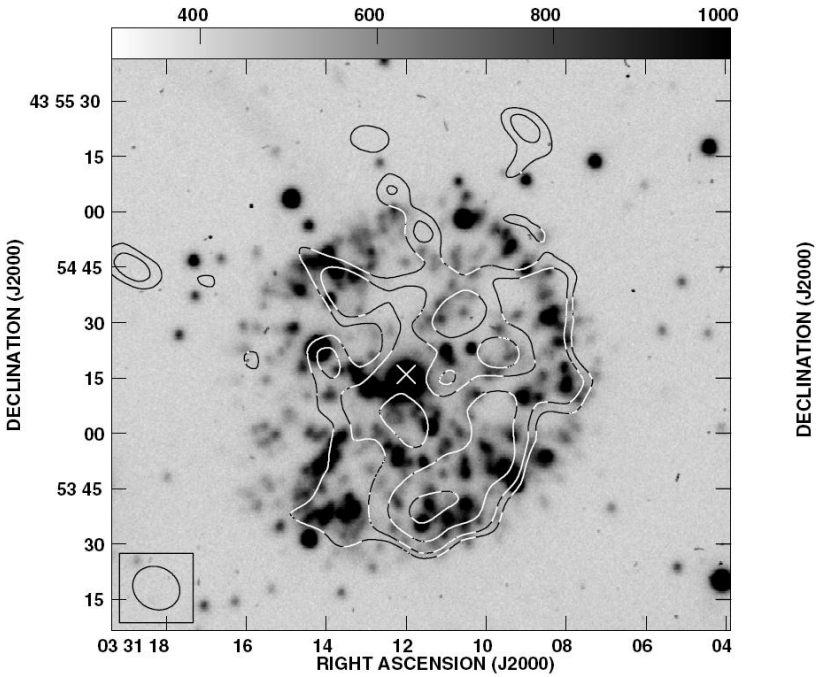
- **Flux Cal at End** : 3C48

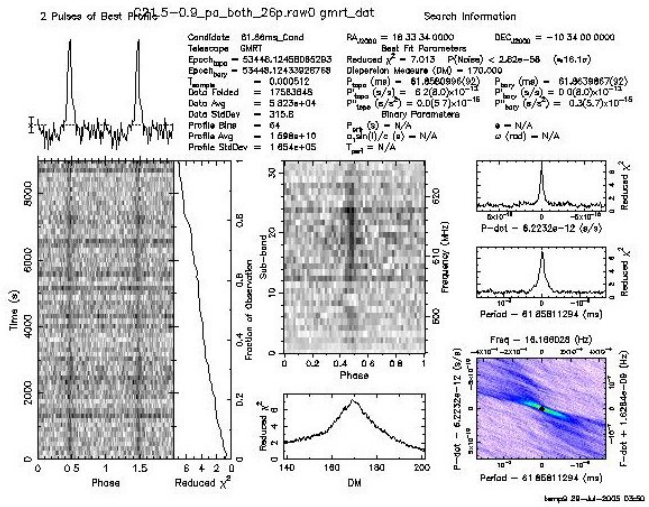
Submit Default

Released on Experimental Basis.

Command file sent to telescope operators

FROM THE GMRT WEB SITE





Nova GK Persei

610 MHz radio emission overlaid on the optical emission lines

Discovery of a 60 msec pulsar *in the SNR G21.5-0.9*

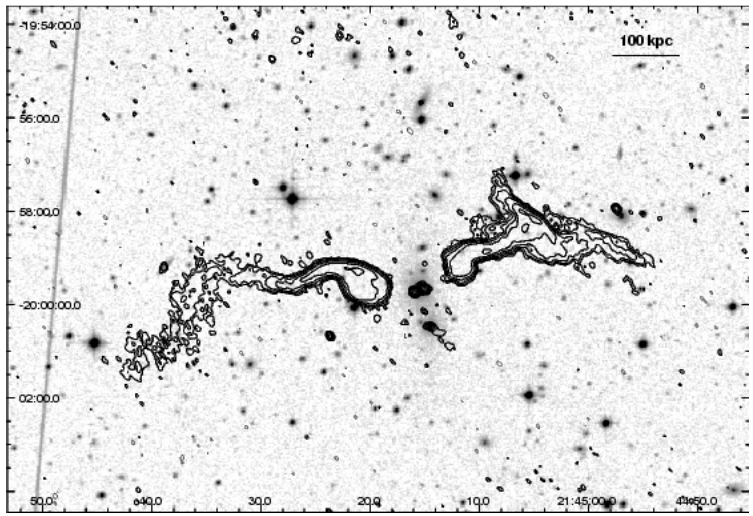
Studies of radio galaxies

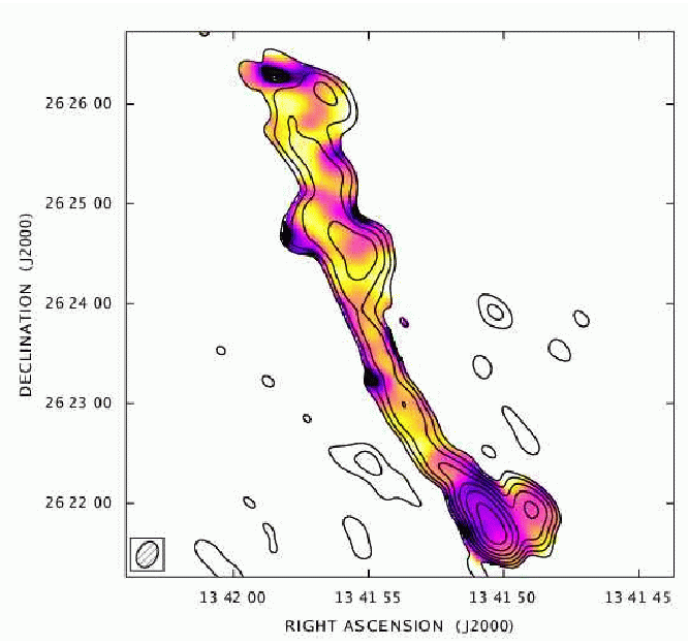
(from Giacintucci et al., A&A, in press)

Central radio galaxy in the poor galaxy cluster A2372

610 MHz: rms ~ 40 μJy/b

θ ~ 6"x6"

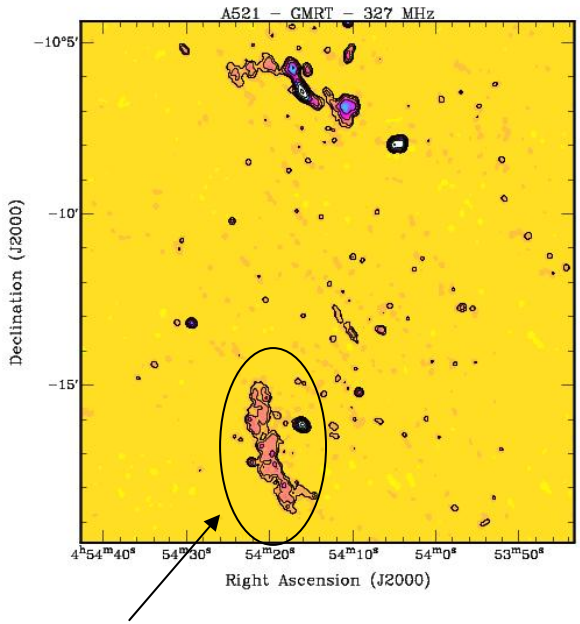




Head tail galaxy at the centre of the poor galaxy cluster A1775

Spectral index image 235-610 MHz with 235 MHz overlaid

Diffuse emission from galaxy clusters



327 MHz relic radio emission in the rich merging galaxy cluster A521

rms ~ 90 μJy/b, θ ~ 9"x9"

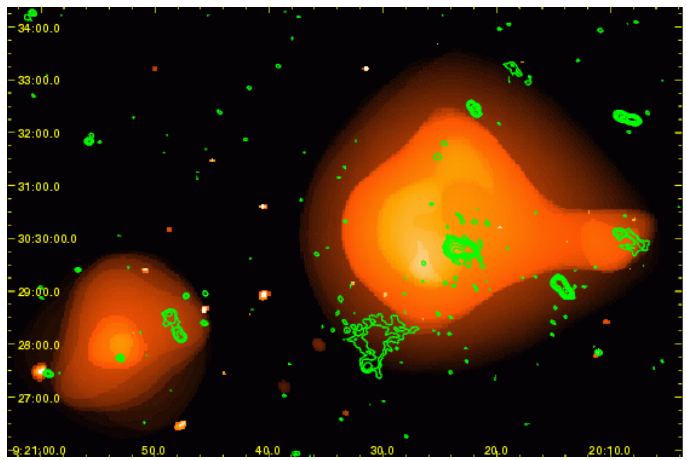
(Macario, Master Thesis, 2007)

610 MHz emission overlaid on Chandra

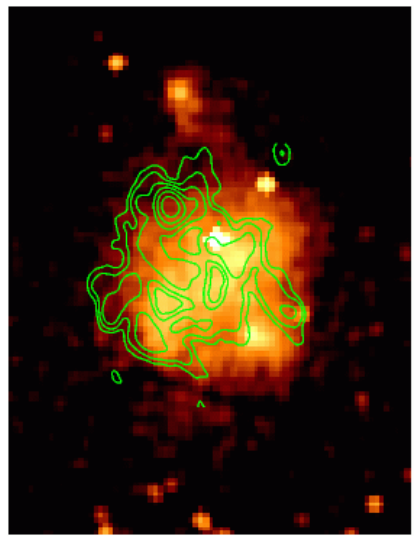
rms ~60 μJy/b, θ ~ 6"x6"

(Venturi et al. 2007)

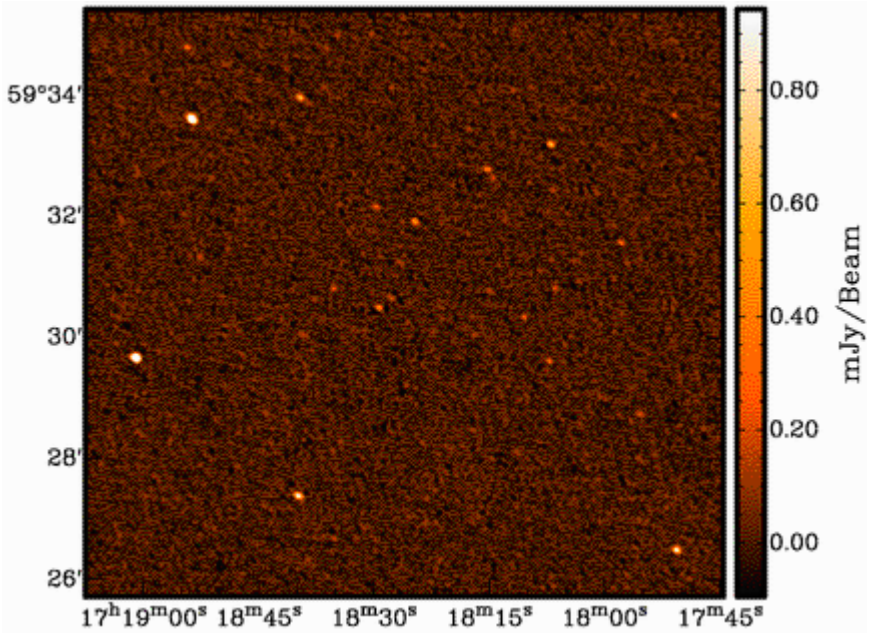
A781



RXCJ2003-2323

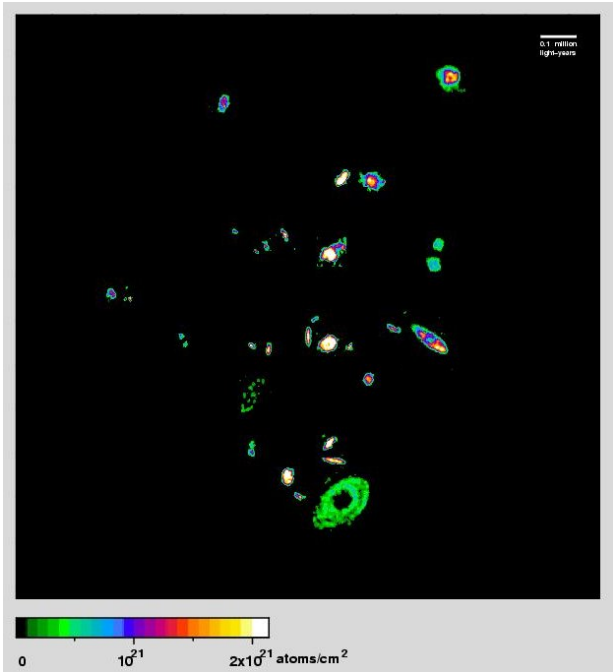


FROM THE GMRT WEB SITE



610 MHz image of the Spitzer First Look Survey – rms 30 μJy/b,

4 deg²



Eridanus Group of Galaxies

HI emission from more than 60 galaxies;
HI deficiency for those galaxies in regions of higher density