Radio Astronomy in India :
spectrum requirements of a passive service

GMRT with star trails : photograph courtesy of S. Meshram & D. Oberoi (NCRA)

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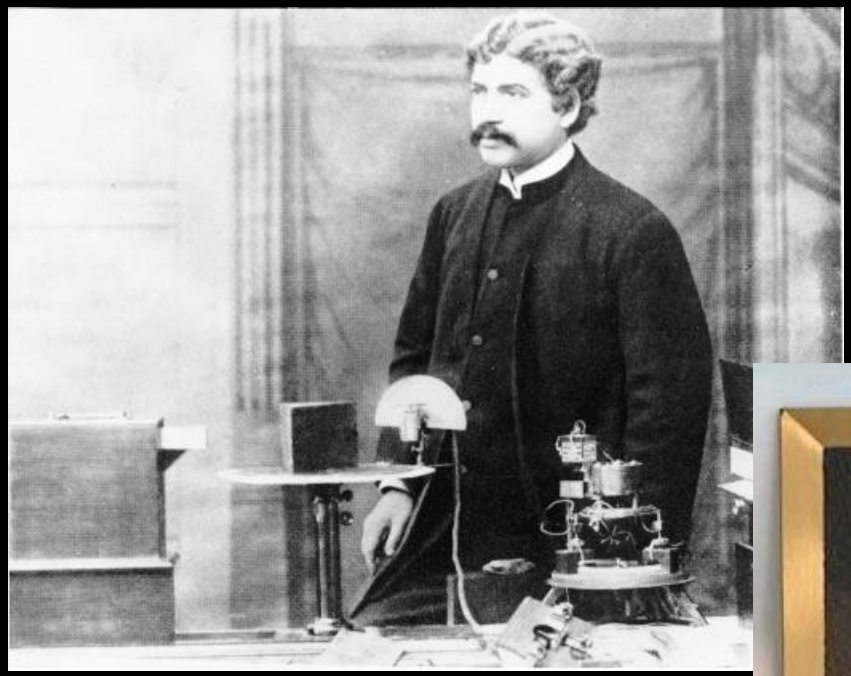
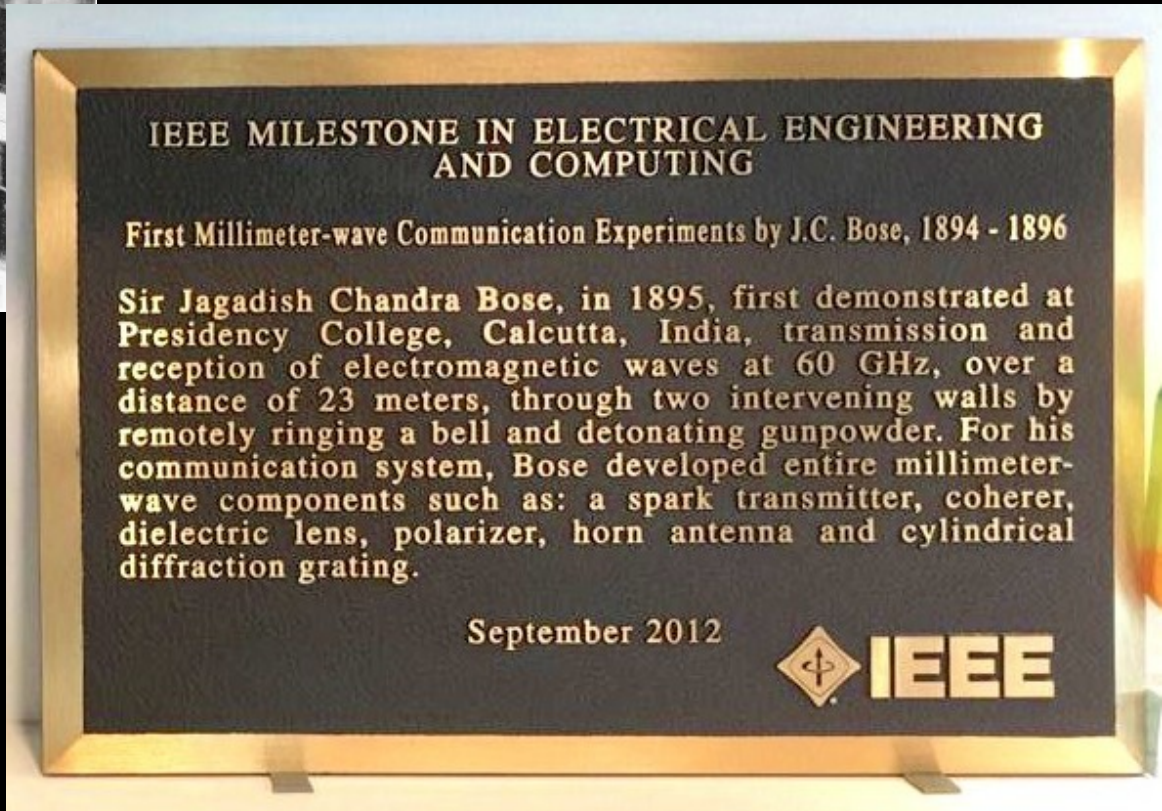
Recognition of pioneering work of J.C. Bose : first IEEE Milestone in India



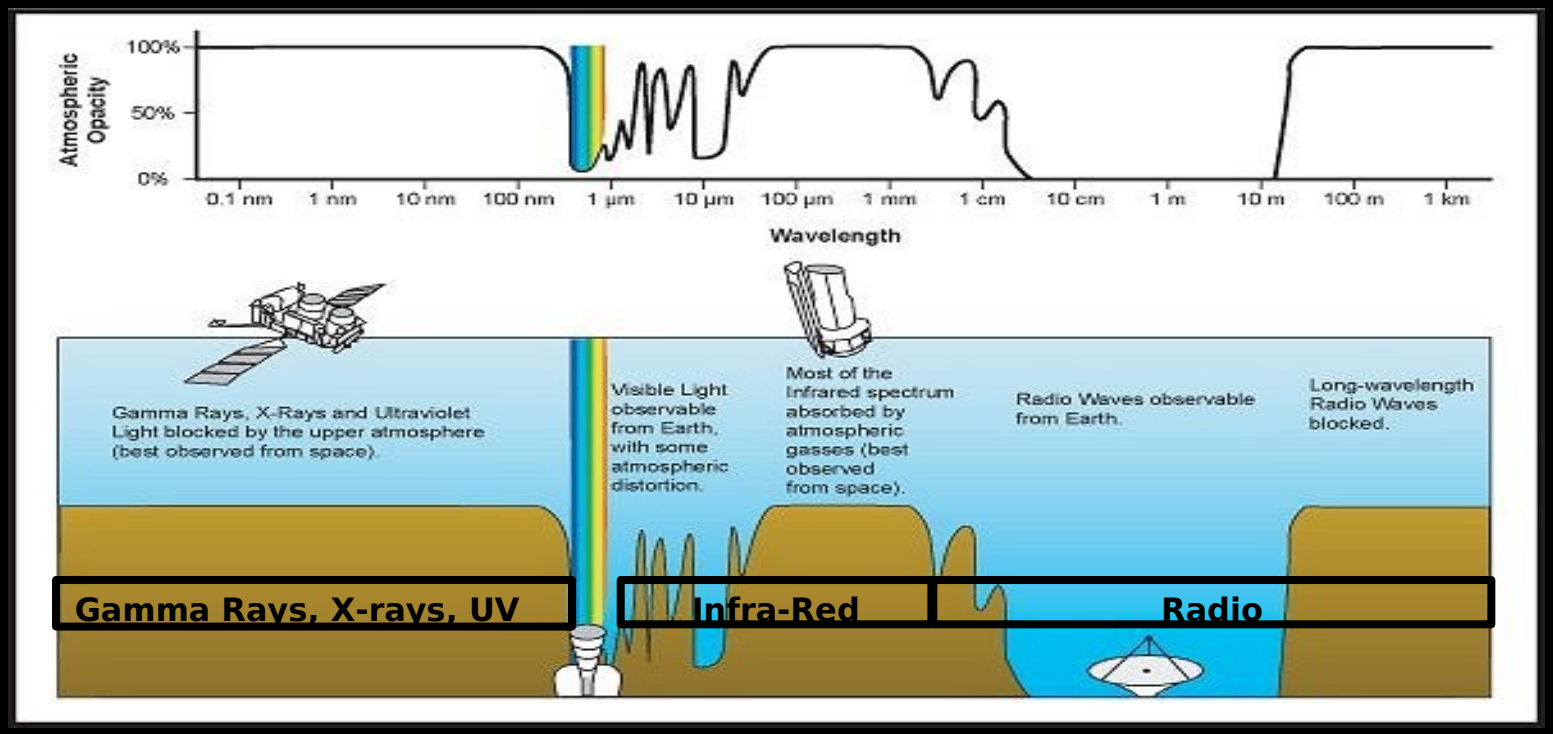
- **IEEE recognised the 1894 pioneering work of J.C. Bose in 2012, with the award of the first IEEE Milestone in India !**



- 2nd IEEE Milestone in India is for Noble prize winning work of C.V. Raman !

What is Radio Astronomy ?

- Started in 1940s, more than 50 yrs after work of Archarya J. C. Bose
- Study of diverse objects and phenomena in the Universe, via radio signals received from them
- For this, we use radio telescopes : what are these ?



Radio Telescopes : Basics

It is like your satellite dish, but there is a challenge :

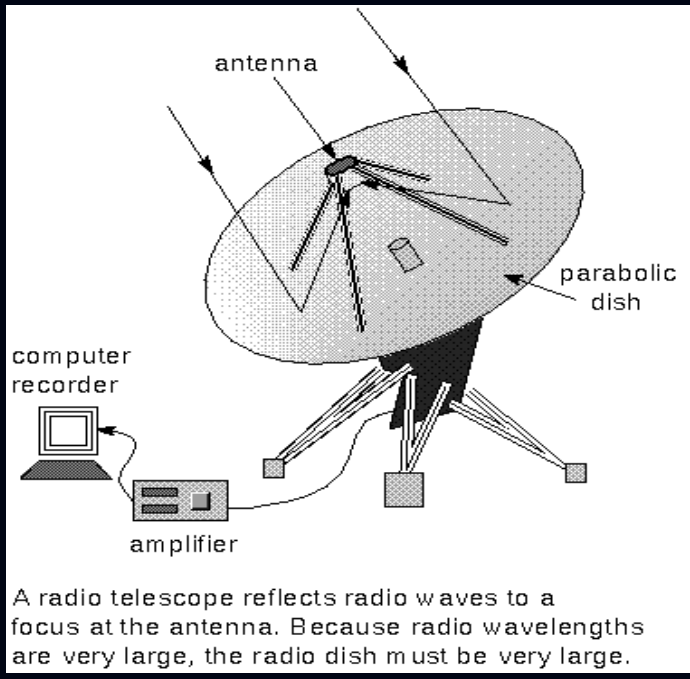
- Celestial radio signals are VERY weak (& there is corruption due to noise !) ; unit of flux used is :

  $1\ Jy = 10^{-26}$ W / m^2 / Hz

- Input radio power into a typical telescope is ~ -100 dBm !

  (would take 1000 years of continuous operation to collect 1 milliJoule of energy !!)

- For high sensitivity (to see faint sources out to the distant reaches of the Universe) we use :
  - Large antennas (10-100 metres in diameter)
  - Arrays of antennas, spread out over large distances (tens to hundreds of kilometres)
  - High quality, low noise electronics in the receivers
  - Large bandwidth of observation (hundreds of MHz)
  - Long duration of observation (hours to days)



A radio telescope reflects radio waves to a focus at the antenna. Because radio wavelengths are very large, the radio dish must be very large.

Radio Astronomy Telescopes

One 45-m antenna of GMRT array

The 100-m Greenbank Telescope

The 300-m Arecibo Telescope

The VLA array telescope

The ALMA array Telescope

Radio Astronomy in India

- Several important radio astronomy installations:
  - Giant Metrwave Radio Telescope (GMRT) near Pune is a major low frequency radio facility (~ 100 to 1500 MHz) – largest in the world in this range
  - Ooty Radio Telescope (ORT) near Ootacamund is a large radio observatory working around 326 MHz
  - Gauribidanur Radio Observatory (GBO) near Bangalore is a low frequency facility from 30 to 150 MHz
  - Radio telescopes coming up in other locations : e.g. IIT-Indore
  - Plans for higher frequency facilities (upto 10 GHz) under implementation at some locations

GMRT – a typical modern radio observatory

- The Giant Metrewave Radio Telescope (GMRT) is a major low frequency radio facility (~ 100 to 1500 MHz) – largest in the world in this range
- Located in western part of India, about 80 km from Pune; spread out over a 30 km region. (we welcome visitors !)
- Built and operated (since 2002) by the National Centre for Radio Astrophysics (NCRA) of the Tata Institute of Fundamental Research (TIFR) – many new and interesting results in ~ 20 yrs of operation.
- Few years ago (in 2019) completed a major upgrade : increases the sensitivity significantly and makes it a more versatile facility – will maintain frontline position of GMRT for next few years !

What do we learn about the Universe ?

Large number of fascinating objects and phenomena, covering :

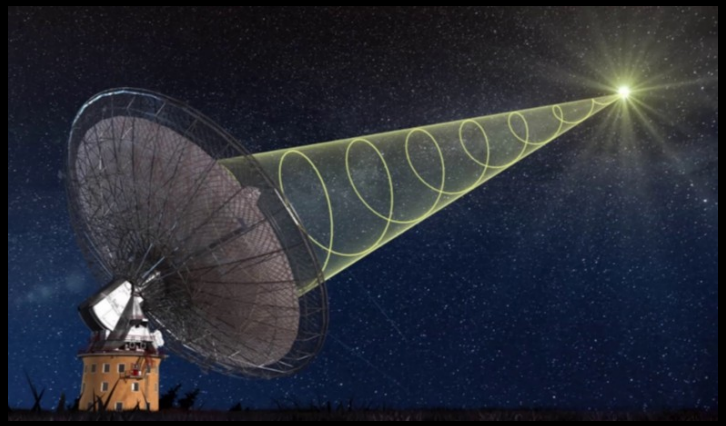
- Sun and our solar system,
- extra-solar planets,
- exotic objects in our Galaxy, e.g. pulsars
- all kinds of galaxies in the far reaches of the Universe,
- how the Universe “began”,
- how the Universe has evolved over billions of years

- and much more…

A radio galaxy and it’s surroundings in full glory

Exotic Phenomena : Are We Alone ?!?

- Ever since man understood about evolutio of life on Earth within the Solar System, one burning question has been : are we alone, or is there life elsewhere ??
- One of the best ways of Searching for Extra-Terrestrial Intelligence (SETI) is to look for radio signal from aliens !!
- Large radio telescopes are ideally suited for this !
- However, the problem is several orders of magnitude worse than the proverbial needle in a haystack – it is a major challenge !
- Radio telescopes dedicated to SETI e.g. Allen Telescope Array (corporate funding!)



Looking for radio signals from aliens

Allen Telescope Array

GMRT : Innovations & Achievements Recognised !

The IEEE Milestone

- On November 24, 2020, the IEEE announced the award of the status of a “IEEE Milestone” facility to the GMRT
- This is only the 3rd such Milestone in India – the other two milestones celebrate the achievements of J.C. Bose (1895) and C. V. Raman (1928)
- This is a major international recognition for GMRT & NCRA, and a fitting tribute to all those who have worked over the last 30 yrs or so to make the GMRT what it is today; and a special tribute to Prof Swarup

Handover of the Milestone Plaque : 30th March 2021

Needs of radio astronomy in India as a passive service

Sources of interference for radio astronomy

- Signals from any man made source are several orders of magnitude stronger than the power levels at which radio astronomy facilities operate ==> strong intereference!
- Radio Frequency Interference (RFI) sources can be

  (a) unintentional : HT power equipment, industrial equipment, agricultural equipment, household devices, computers, any sparking device (petrol engine)

  (b) intentional : Radio, TV, mobile comm, satellites, ATC, radars etc.
- We share the spectrum with these sources and need to minimise the interference
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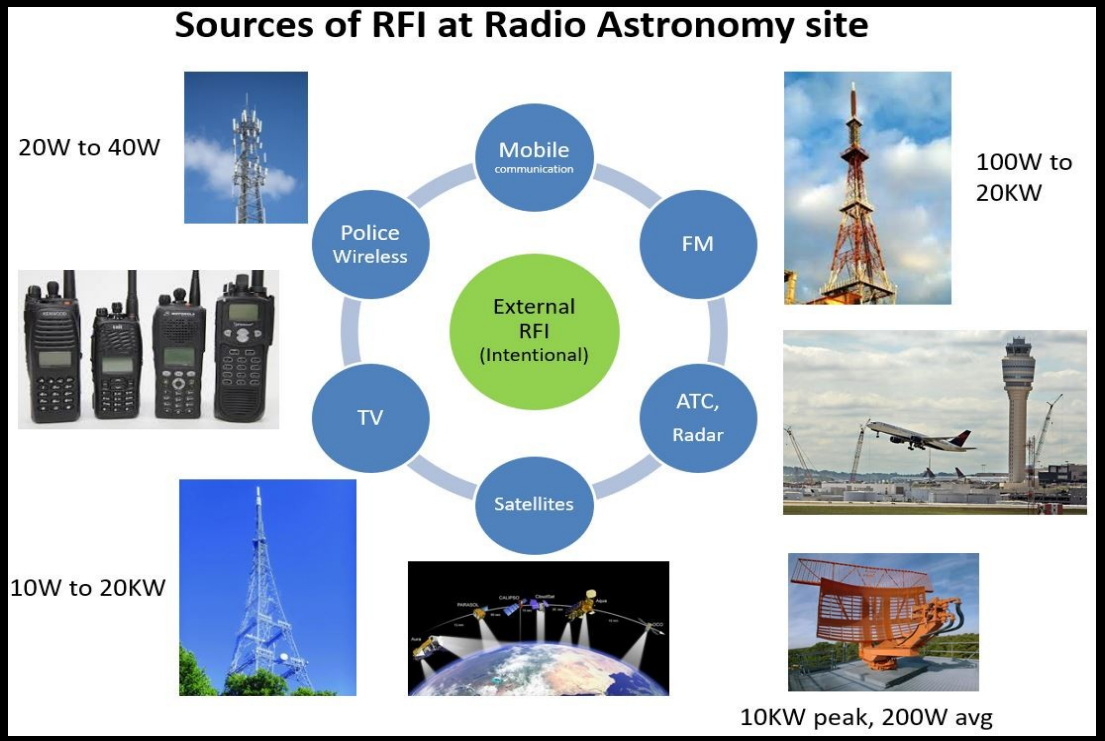
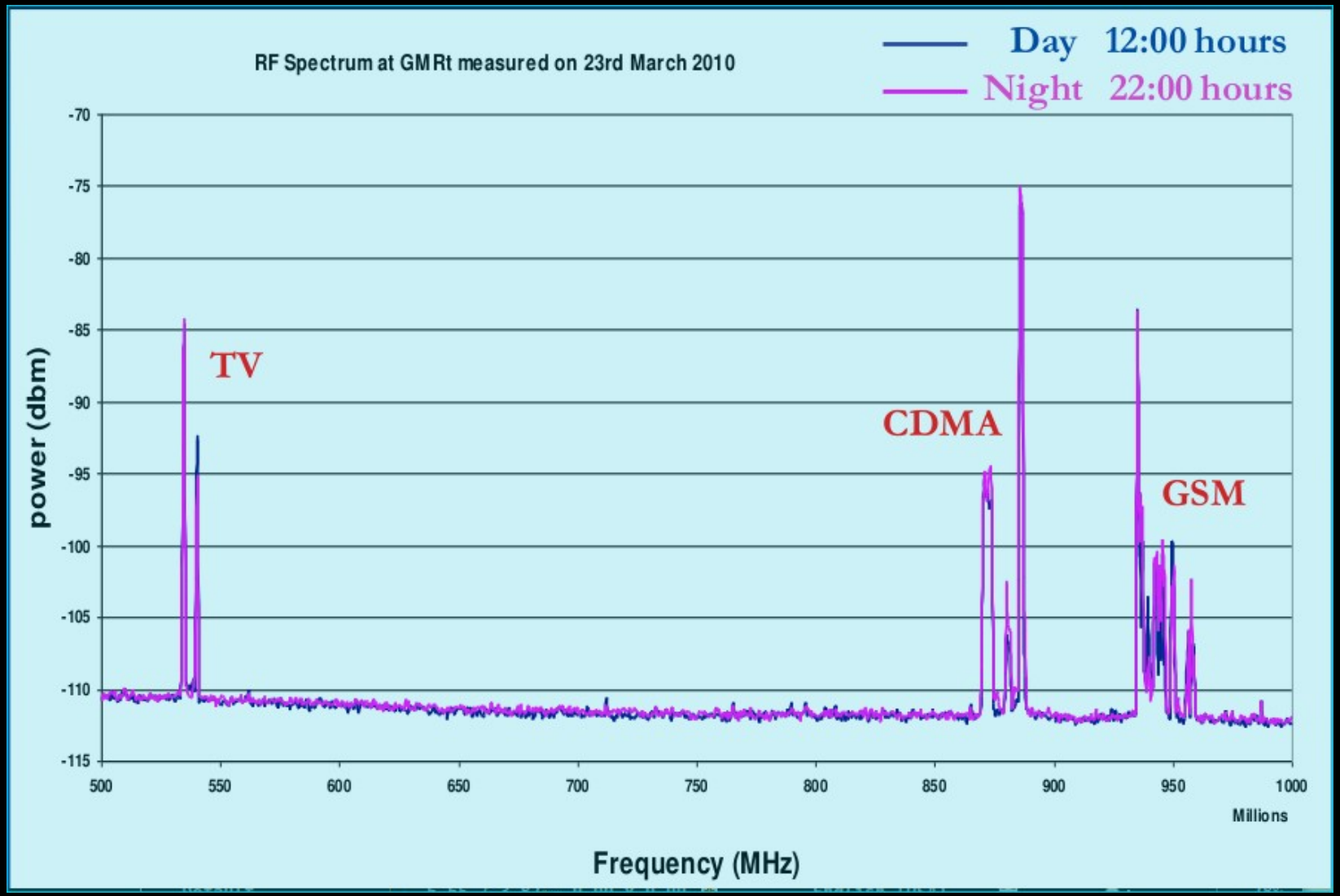


GMRT : Operating Frequency Bands & RFI

Frequency	Radio Astronomy Band	System Bandwidth	Source of Interference observed near Radio Astronomy band.
150 MHz	150 – 153.6 MHz	130 – 230 MHz	Air Traffic control, Fixed Mobile, TV Transmission,
235 MHz	230 – 235 MHz	213 – 253 MHz	Digital Audio Broadcast (DAB), Aeronautical Radio Navigation, Leakage from Cable TV signals.
327 MHz	322 – 328.6 MHz	307 – 347 MHz	Fixed Mobile, Aeronautical Radio Navigation
610 MHz	604 – 616 MHz	580 – 640 MHz	TV Transmission
1060 – 1420 MHz	1400 – 1427 MHz	950 – 1450 MHz	Fixed Mobile Broadcasting, Satellite

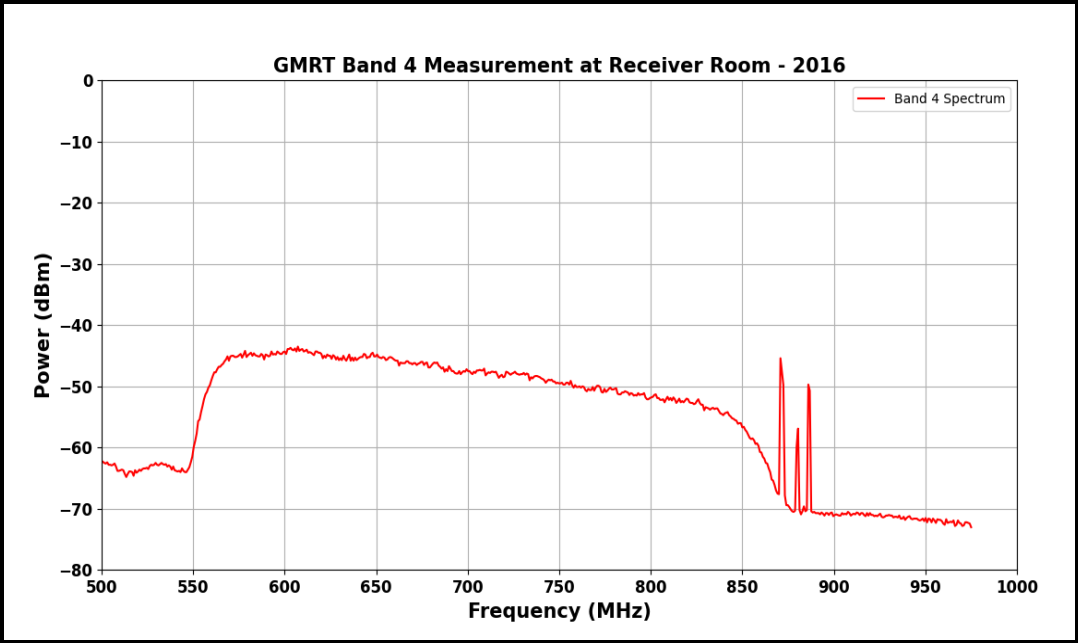
Example radio spectrum at GMRT

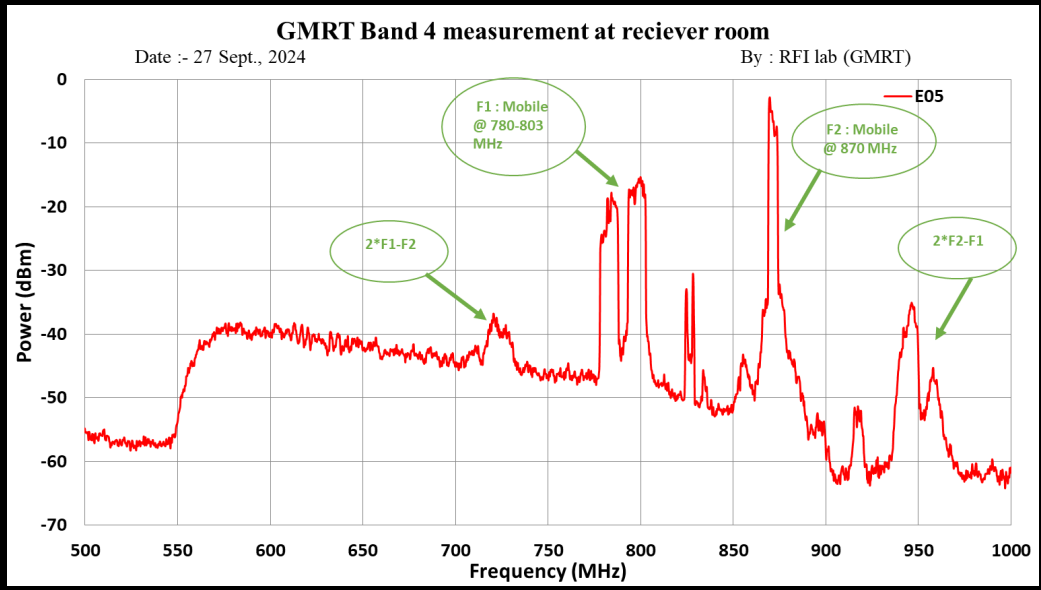


Corruption of GMRT signals due to RFI

- Significant degradation of radio astronomy signal takes place due to RFI

- Several mitigation schemes are needed :
  (a) better electronics
  (b) signal processing tricks
  (c) improved shielding
  (d) coordination with other users of the spectrum !





Closing Comments

- Radio Astronomy is a completely passive service
- India has a strong position in this field of fundamental research, with some of the best facilities in the world like the GMRT
- Signals received are EXTREMELY weak
- Hence, we need to use as much bandwidth as possible
- The need of protection from man-made transmissions from other active users is quite stringent
- We need cooperation from the entire community of users of the radio spectrum in the country to allow us to continue to probe the secrets of the Universe and bring them to you !

Thank you for your attention !