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The upgraded GMRT : Current Status and Future Prospects

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The Giant Metrewave Radio Telescope (GMRT), located near Pune in India, is a major international facility at low radio frequencies, operational since 2002. Consisting of 30 fully steerable antennas of 45 metre diameter each, it can be used as an aperture-synthesis array for imaging, as well as a phased array to study compact radio sources such as pulsars. The original GMRT was designed to operate in 5 radio bands located between 150 and 1450 MHz, with a maximum bandwidth of 32 MHz. The legacy GMRT system will be described in brief.

The GMRT has recently completed a major upgrade that is targeted to improve its sensitivity by a factor of upto three and make it a much more versatile instrument [1]. The goal has been to provide (a) near seamless frequency coverage from about 50 to 1500 MHz; (b) improved receiver systems with higher G/Tsys; (c) a maximum instantaneous bandwidth of 400 MHz; (d) a revamped servo system; (e) a sophisticated monitor and control system; and (f) matching improvements in infrastructure and computing. This upgrade will keep the GMRT at the forefront as one of the most sensitive facility in the world in the 50 to 1500 MHz range, till the SKA phase-1 comes along.

The above upgrade plans involved a complete redesign of the entire receiver chain of the GMRT : octave wide feeds with matching low noise amplifiers and special filters to block out strong RFI signals; a scheme of transmission of the new wideband and existing narrowband signals over the existing optical fibre communication system from the antennas to the central building; and a versatile digital back-end correlator and pulsar receiver using the latest FPGA and GPU technologies, to process the 400 MHz bandwidth signals. This was accompanied by use of brushless motors and matching drive system to replace the old servo system; next generation hardware and software for the new monitor and control system; enhanced data storage for the archival system; new data analysis pipelines for the broadband data; and improved computing facilities. These systems and their installation to produce a fully working upgraded GMRT, while keeping the legacy GMRT available to users, will be described in detail. Furthermore, significant effort has been put in to tackle the challenge of RFI in many different ways, in order to make the wideband uGMRT more robust and reliable for use as a low frequency observatory.

Even as the various sub-systems of the upgraded GMRT (uGMRT) were being completed and installed, the upgraded observatory was made available to users in a phased manner from April 2016 onwards. The full uGMRT, complete with all the receiver bands and final version of the back-end was formally inaugurated in March 2019, and released to the global community from April 2019 onwards. Since then, several exciting new results have been reported with the uGMRT, and new frontiers of exploration are being opened, ranging over a diverse set of topics, such as : the highest redshift detection of neutral hydrogen in emission, detailed new studies of galaxy clusters, low frequency follow-up of various kinds of transients (GRBs, FRBs, GW events etc), high quality pulsar timing studies including the Indian Pulsar Timing Array, opening up of the new field of magnetic stars etc. A sample of the new discoveries with the uGMRT and its future potential will be presented.

To summarise, this paper will present an overview of how the upgrade was implemented, describe some of the challenges faced (including a detailed treatment of novel RFI mitigation techniques), detail the performance being achieved with the uGMRT, present the most exciting of the early results, and spell out the plans for future enhancements.

References

[1} Y. Gupta et al., "The upgraded GMRT: opening new windows on the radio Universe", Current Science, 113, 4, August 2017, pp. 707-714, doi: 10.18520/cs/v113/i04/707-714.