Precision Analog Receiver System for EoR

R. Somashekar
Raman Research Institute, Bangalore
Team: Jishnu Nambissan T, Ravi Subrahmanyan, Udaya Shankar N and Saurabh Singh

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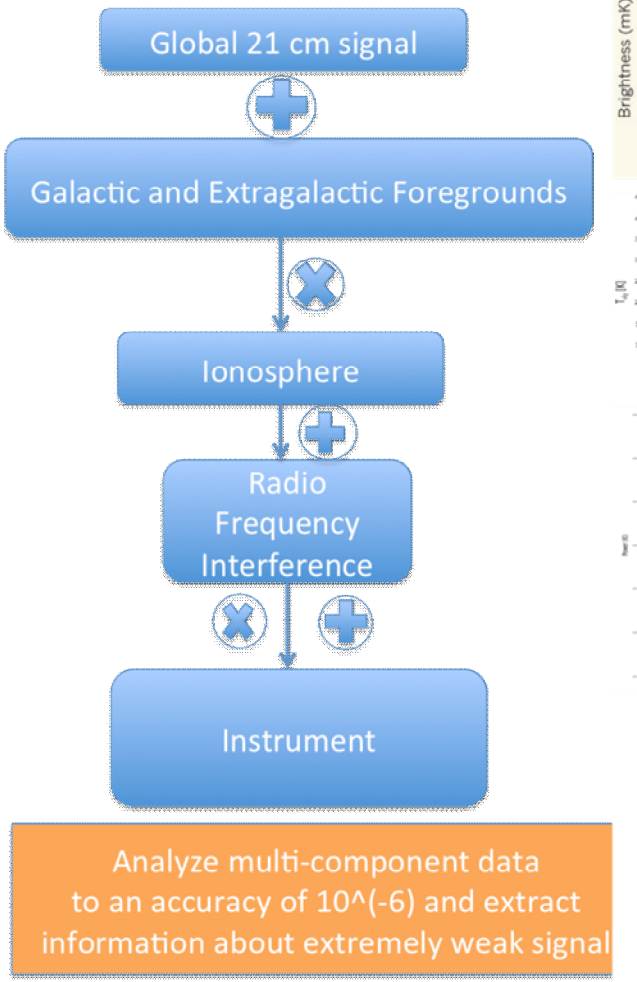
Overview :

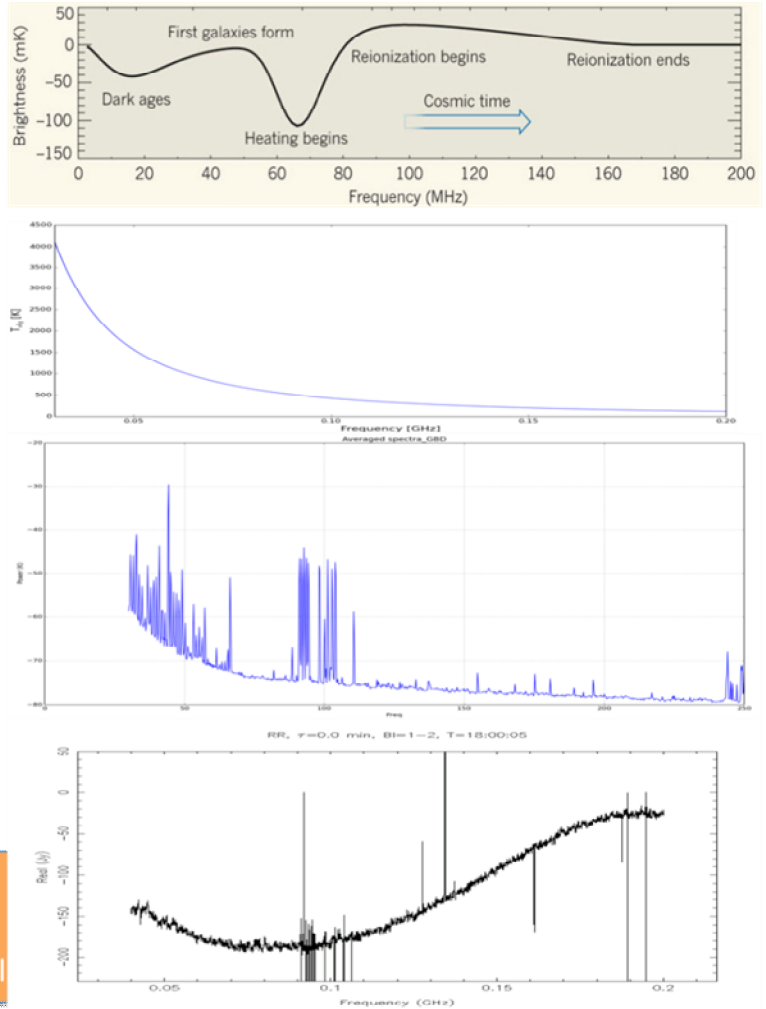
- Introduction to SARAS
- Challenges in the detection
- Design Philosophy
- SARAS System overview
- Receiver architecture
- Site considerations
- Analog Receiver block
- Preliminary test results
- Conclusion

Introduction to SARAS:

- In the cosmic evolution of the universe, **Cosmic Dawn** (CD) and **Epoch of Reionization** (EoR) are significant times when first light from the first luminous objects emerged and began transforming and ionizing the primordial gas
- CD/EoR phase of the Universe is believed to have occurred between **~100 million** and a **billion years** after the Big Bang
- At the Raman Research Institute, we are working on **SARAS** (**S**haped **A**ntenna measurement of the background **RA**dio **S**pectrum), an instrument **primarily designed to detect** the signature in the **global 21-cm signal** from CD/EoR
- The system is built to operate in the band from 40-200MHz and optimized for observing the spectral feature between 40-100 MHz

Challenges in the detection





21-cm signal
< 100s of mK

Foregrounds
100-10,000 K

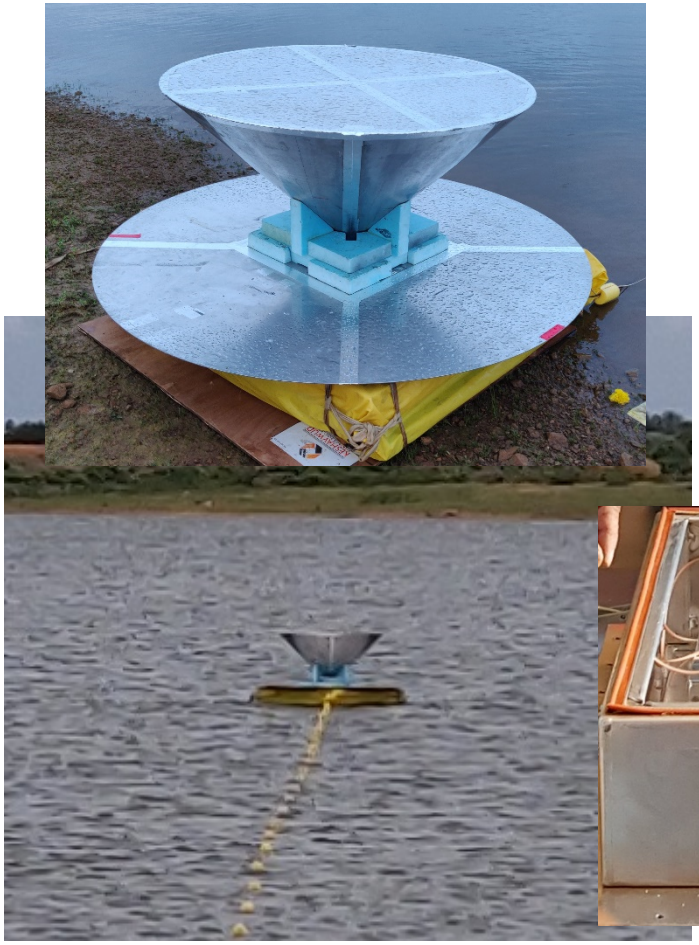
RFI
A few K to 10,000 K and more

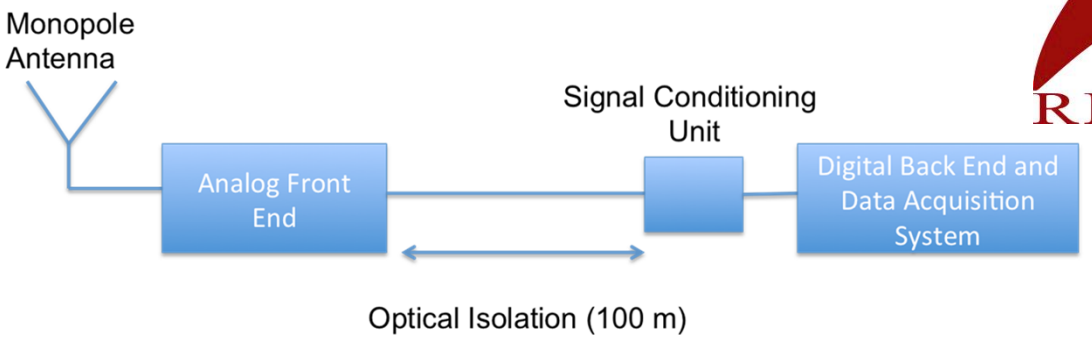
Receiver Noise
50-100 K

Design philosophy

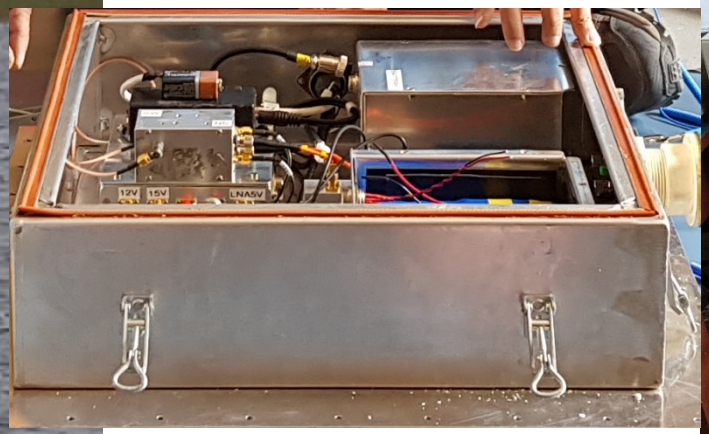
- Foregrounds have smooth spectrum while the 21-cm signal is predicted to have various spectral features
- Thus the design of the instrument is focused towards avoiding any spectral features from the system that may mimic the signal.
- Developing more robust algorithms, including applying maximally smooth functions, to separate foregrounds and systematics from the 21-cm signal
- It is a constrained polynomial approach in which coefficients are optimized such that there is no zero crossing in any second and higher order derivatives (i.e. there is no inflection point in the fit)
- Such functions fit only to the smooth part of the curve and preserve the spectral structures

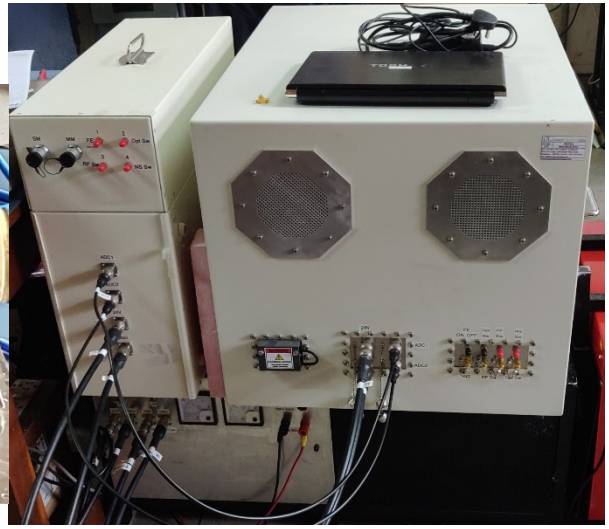
SARAS 3 -- System overview





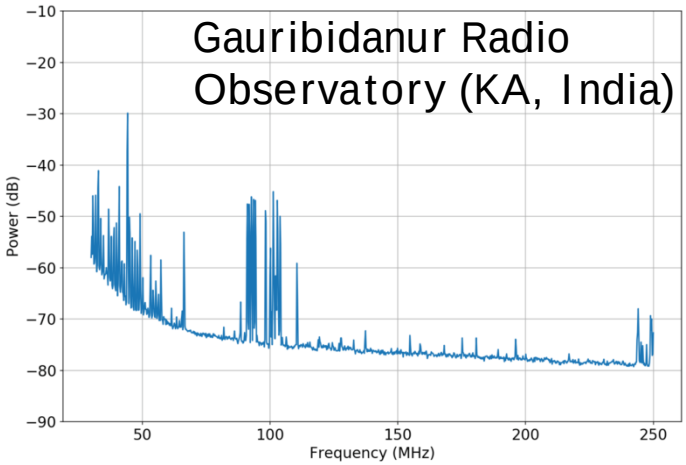
Frequency Range -- 40MHz to 200MHZ

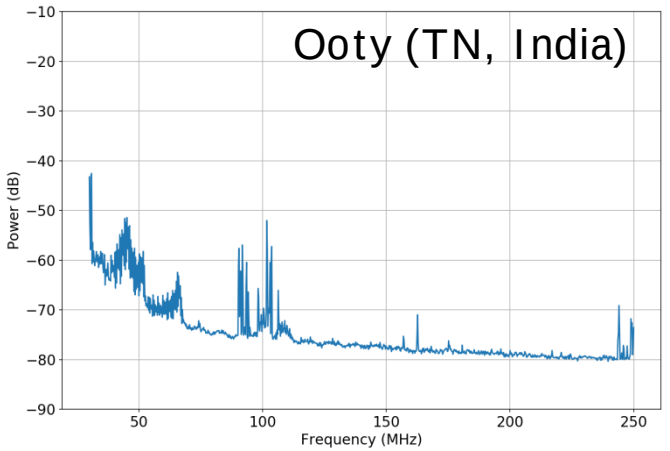


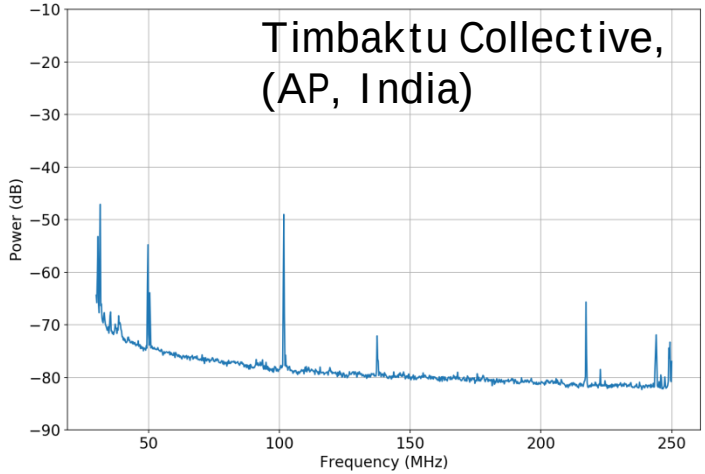


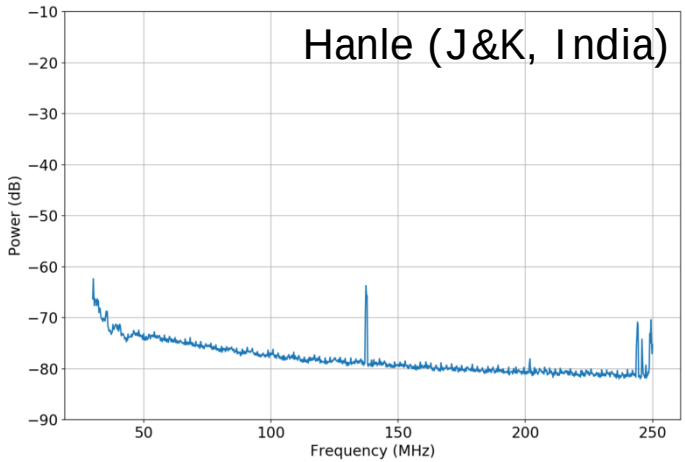
SARAS: **S**haped **A**ntenna measurement of the background **RA**dio **S**pectrum

Locating an observing site



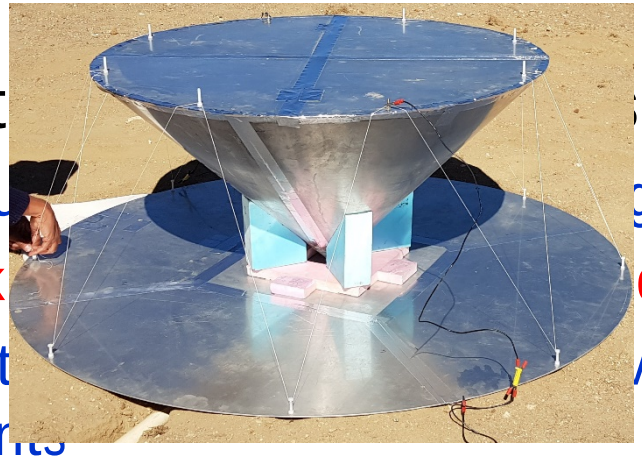






Site challenges :

- Site and Environmental conditions :
  - RFI consideration of selected site – systematics restricts NOT TO USE filters in the Analog frontend chain.
  - No metallic component above the reflector surface or close by.
  - Experiment location :
    - Timbakktu gh as 50 DegC during day!
    - Leh Ladak dry weather Static charge.
    - Floating st ve any metallic components
    - Enclosure, units and connectors need to be IP67
    - Ease of assembly and deploying in the field



SARAS Analog Front end

Front end Receiver criteria

Internal linear DC Power support at least a week before recharging.

No clocks or switching states.

Careful incorporation of ESD protection – ensuring no systematics.

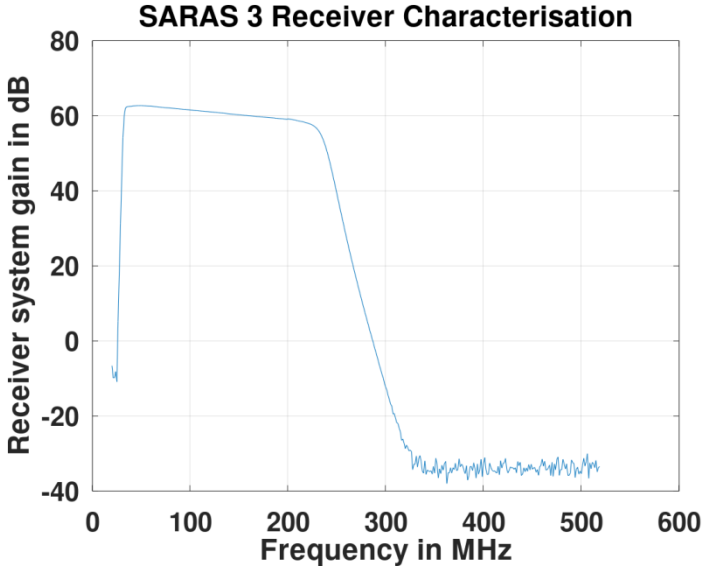
Maximum miniaturization ensuring spectral smoothness.

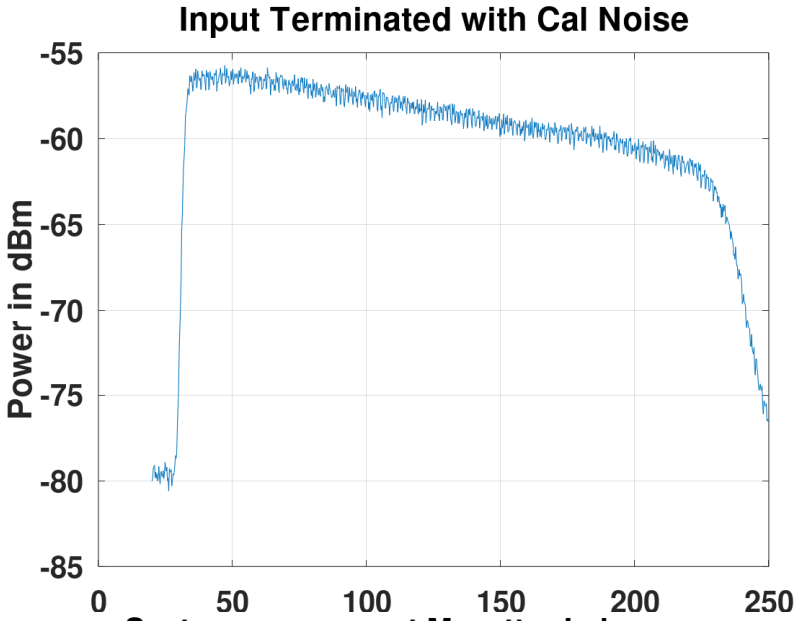
DC power distribution on coaxial cable with adequate filtering.

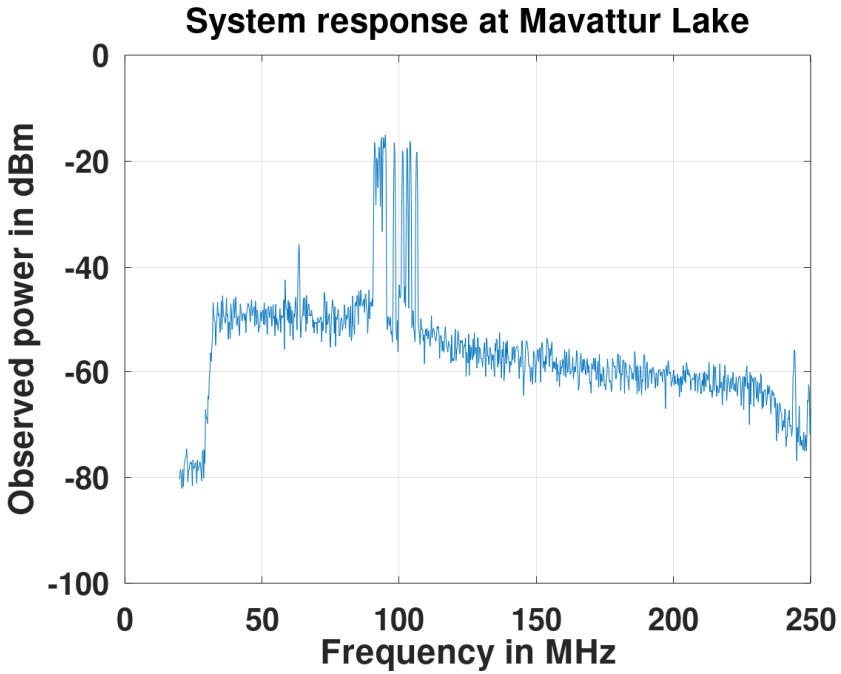
RFoF – IP67 APC connectors to minimize reflections

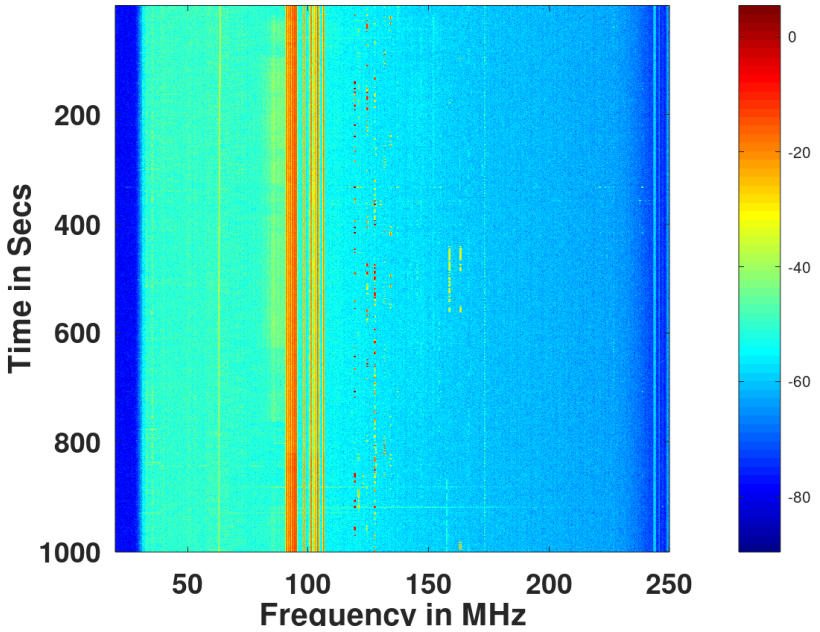
Non Clock based logical monitoring

Preliminary trials at Lab & Mavattur Lake:









SARAS 3 receiver system terminated with open /short, Load and Antenna simulator tested in the lab for long hours and data acquired. The data analyzed had no systematics to a level of a few milli kelvin.

Exploring RFI free Oasis for observations.....

Other receiver systems with collaborations, so far....

1. *C-band receiver for Satellite Astrometry – VLBI techniques.*
2. *Multiband Receiver for Pulsar tomography – Green Bank*
3. *Proof of Concept 4 antenna 50MHz system for GMRT*
4. *P-Band receiver chain for enhanced bandwidth observations with the Ooty Radio Telescope*
5. *L and S Band receiver for satellite Navigational experiments*

Thank You

SARAS team

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