THE MITRA FRONT-END

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AIMS of my Bsc(Hons) Physics research project

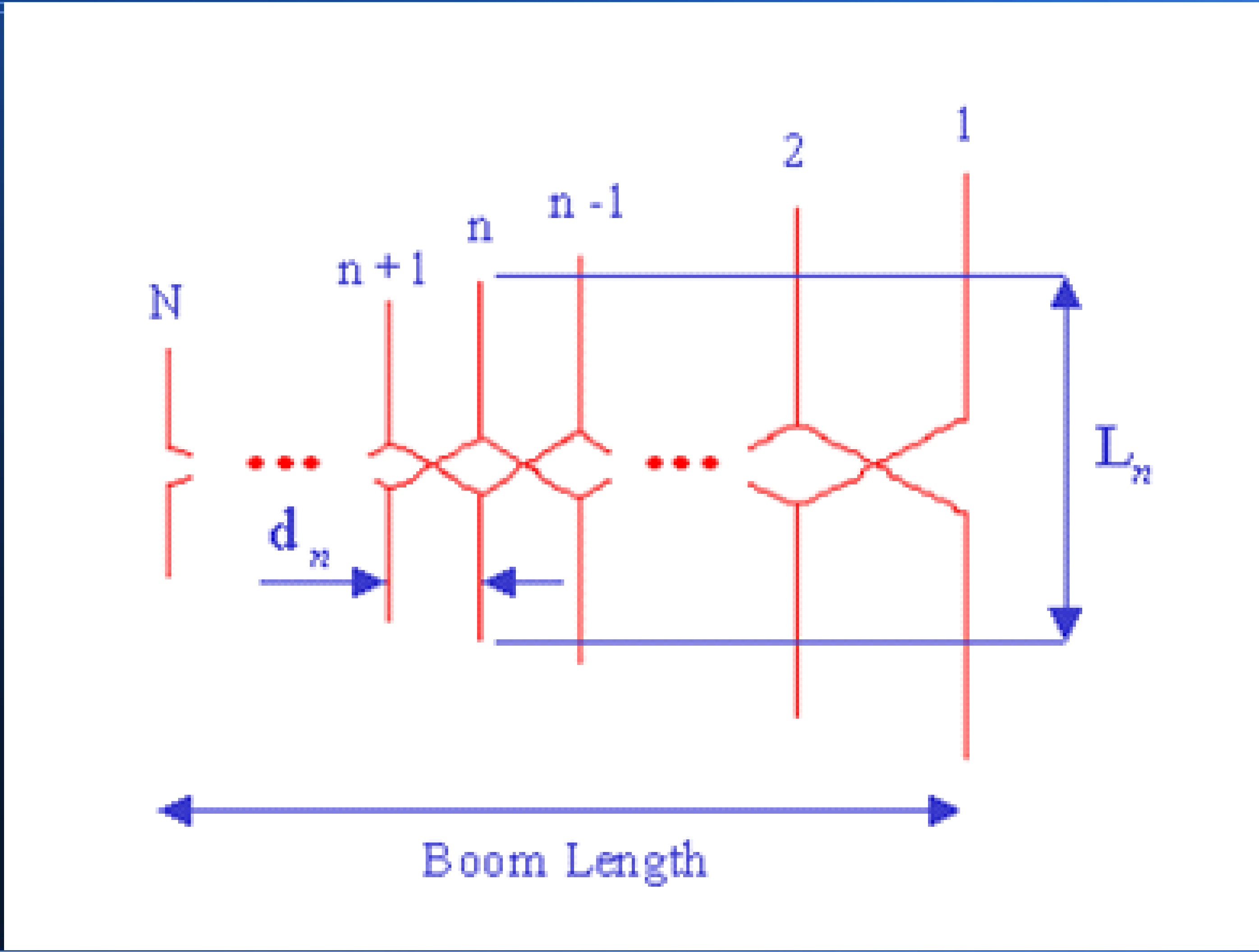
Design a front-end system for the MITRA in the frequency range 200MHz to 800MHz

Construct sixteen dual polarised log periodic dipole antennas forming an array of eight antenna in North-South direction placed in East and eight antennas in North-south direction placed in West.

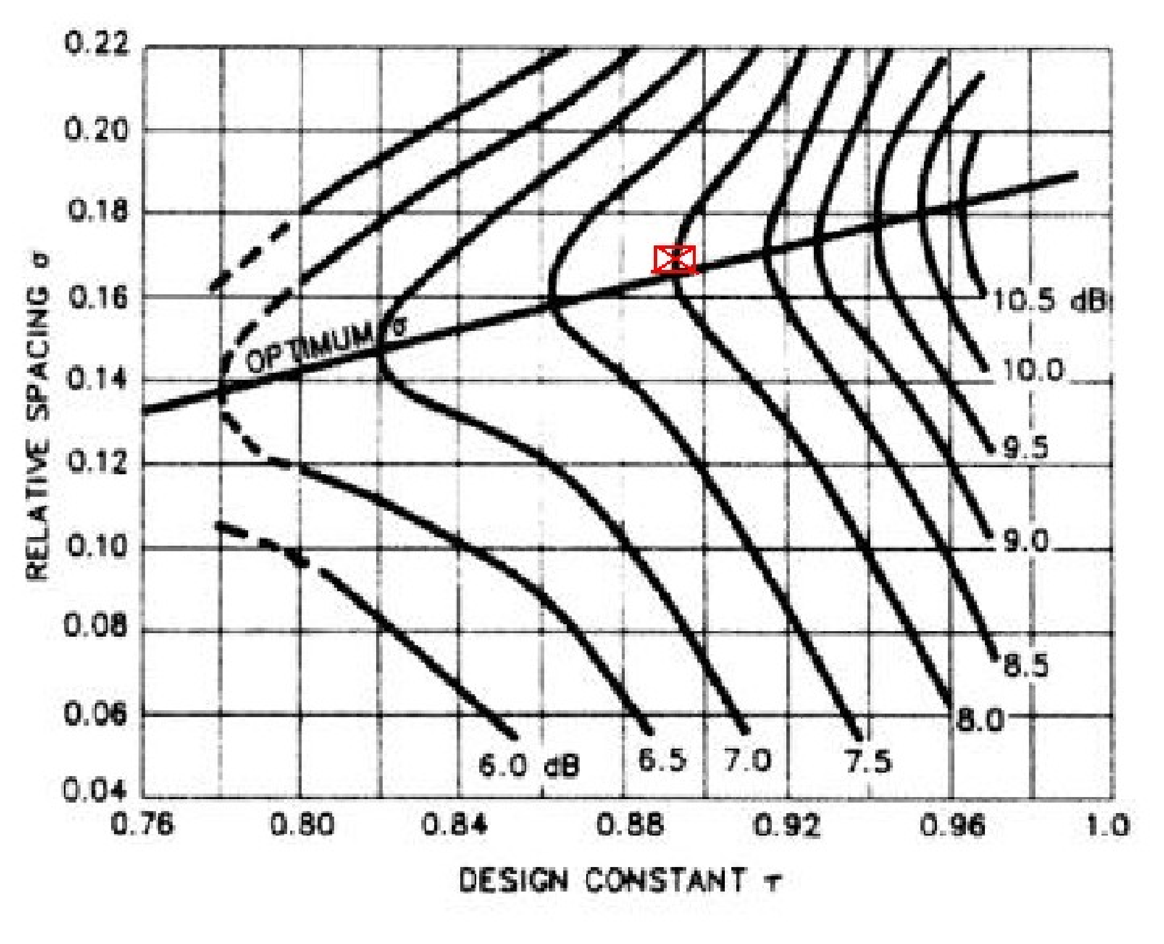
Outline of the talk

- Dual Polarised Log periodic Antenna
- Simulation
- Earlier work (Prayag 2011)
- Antenna design & construction
- Front end electronics
- Array design & construction
- Observations
- MRT3 in CALLISTO network
- Future work

LPA definition



LPA: choice of τ & σ

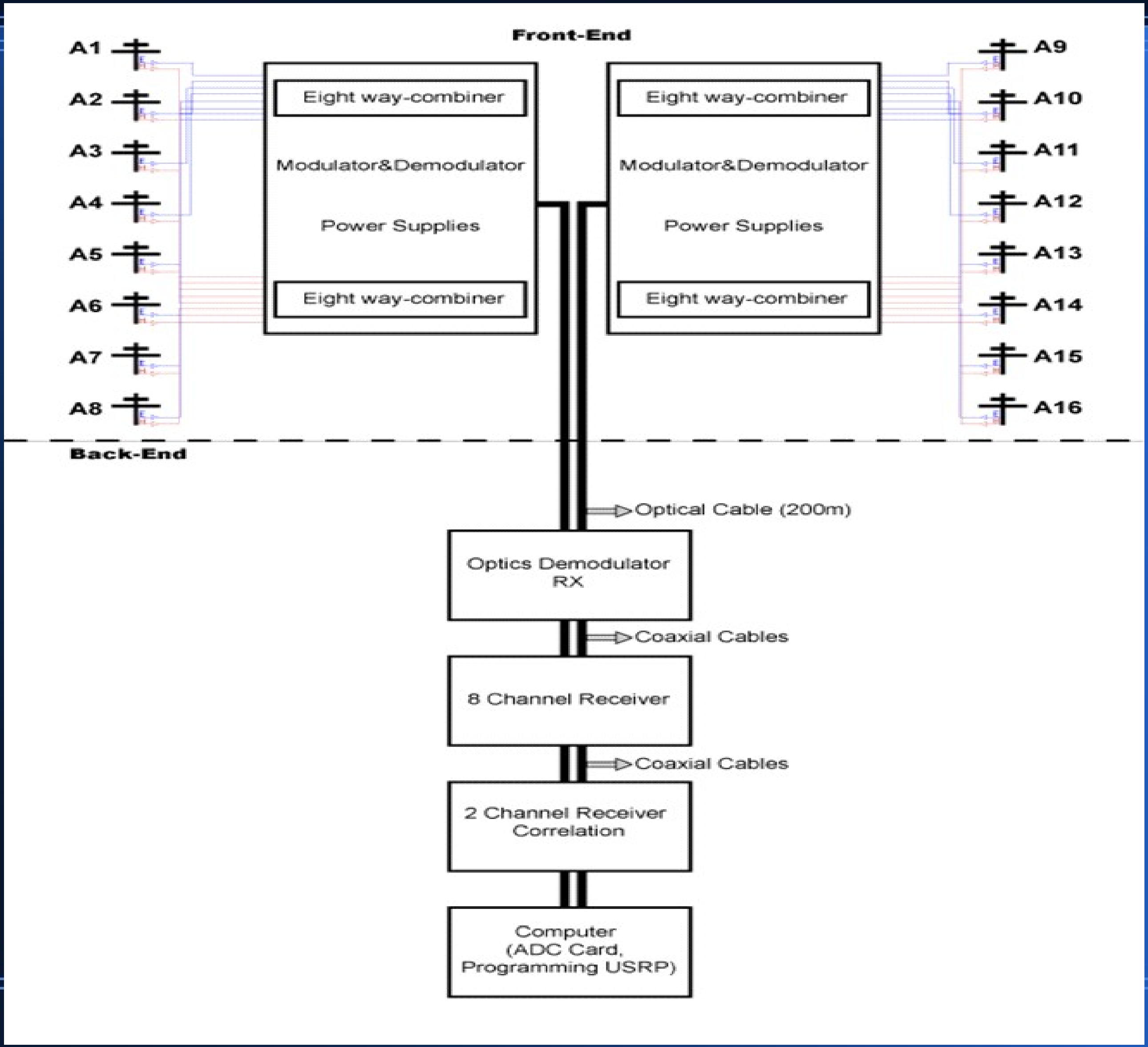


LPA: Version 1

Bras d'Eau 11.04.2011

Durban 27.07.2011

A schematic of the whole front-end and back-end system



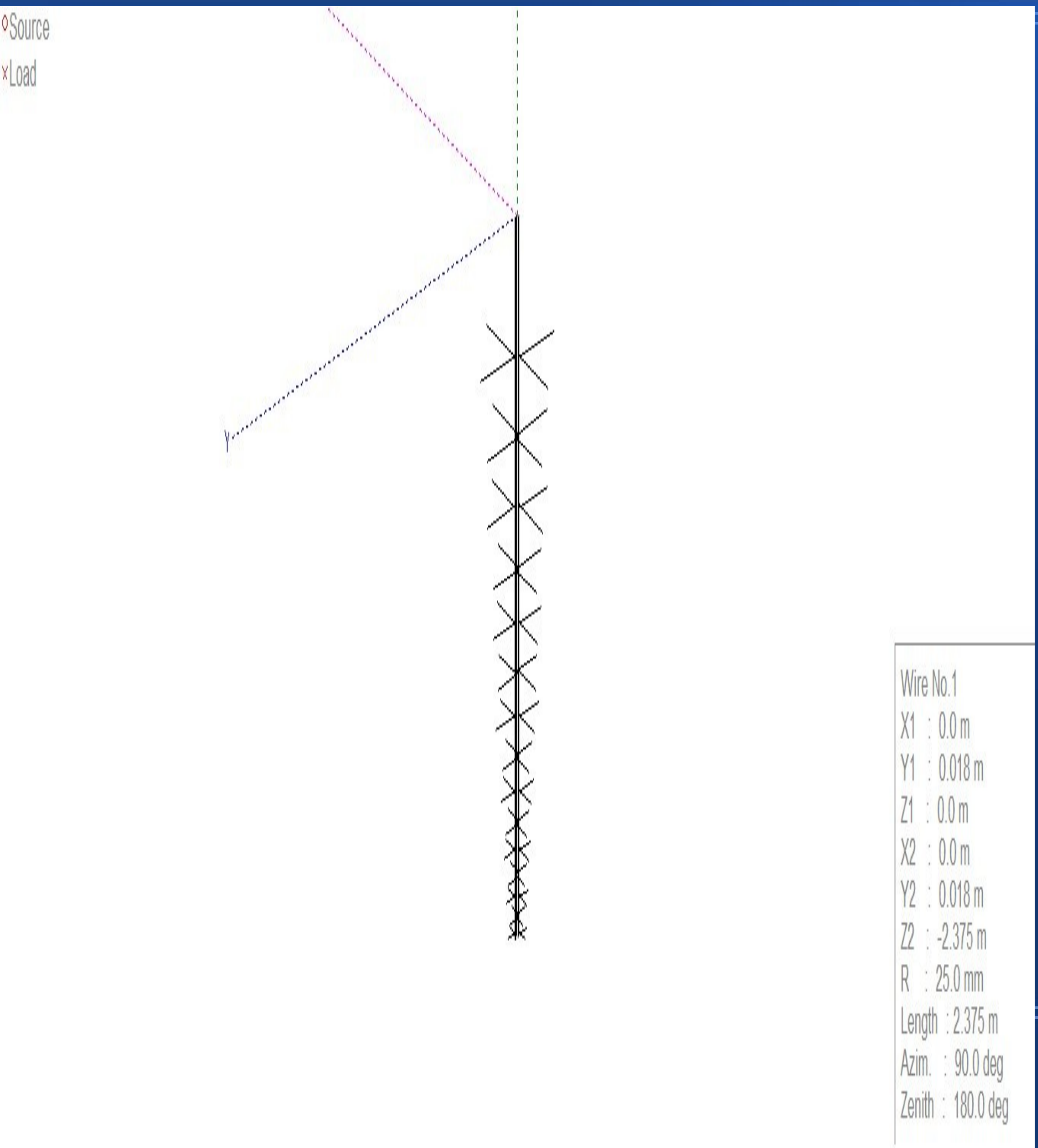
Construction of the LPDA

Certain parameters were known:

- The length of the transmission line which is 2.375 m long.
- The length of the dipole elements and spacing between them.

Length of elements (mm)	Resonant Frequency (GHz)
100 (shortest element)	3.000
111	2.702
121	2.479
133	2.256
146	2.055
160	1.875
182	1.648
195	1.538
217	1.382
240	1.250
265	1.132
295	1.017
330	0.909
363	0.826
460 (longest element)	0.652

The LPDA MODEL



From these parameters:

- $\tau = 0.905$
- $\sigma = 0.292$
- $\cot \alpha = 4\sigma/(1- \tau)$

$\alpha = 4.6°$

Schematic of the spacers

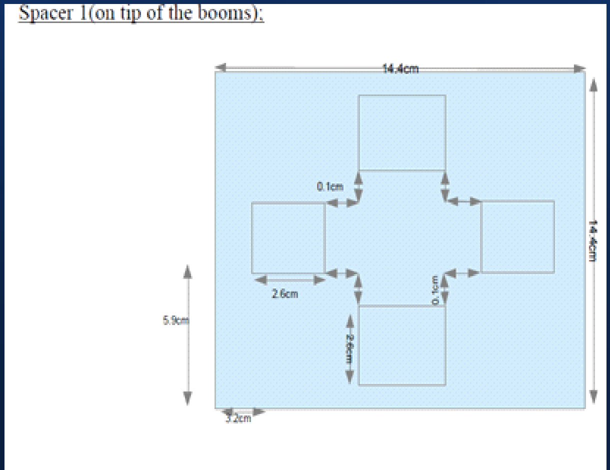
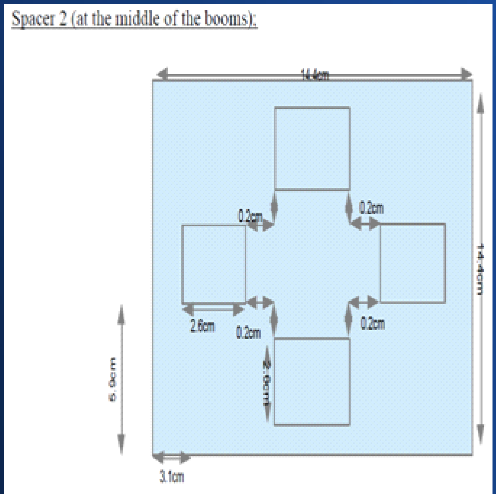
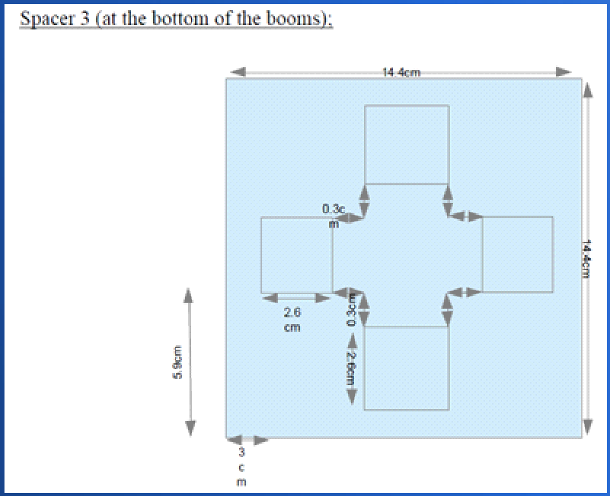
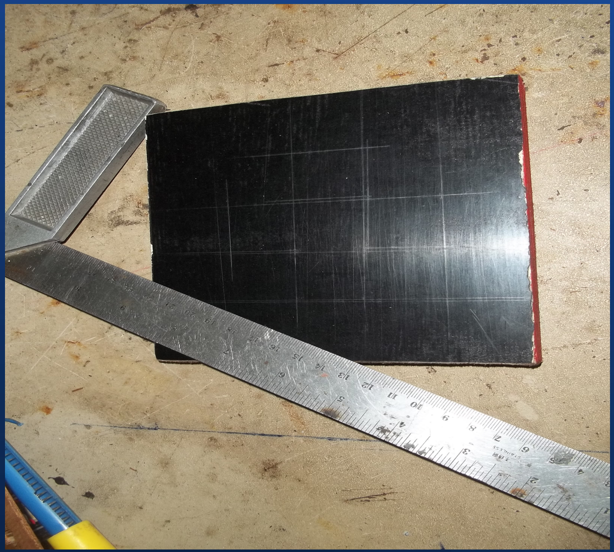


Figure 4.4: Spacer 1





MAKING OF THE SPACER



Cutting of booms

Boom marking

Spacings (mm)	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}	D_{16}
	15	57	64	72	81	91	102	115	129	145	163	183	206	231	260	460

Boom piercing

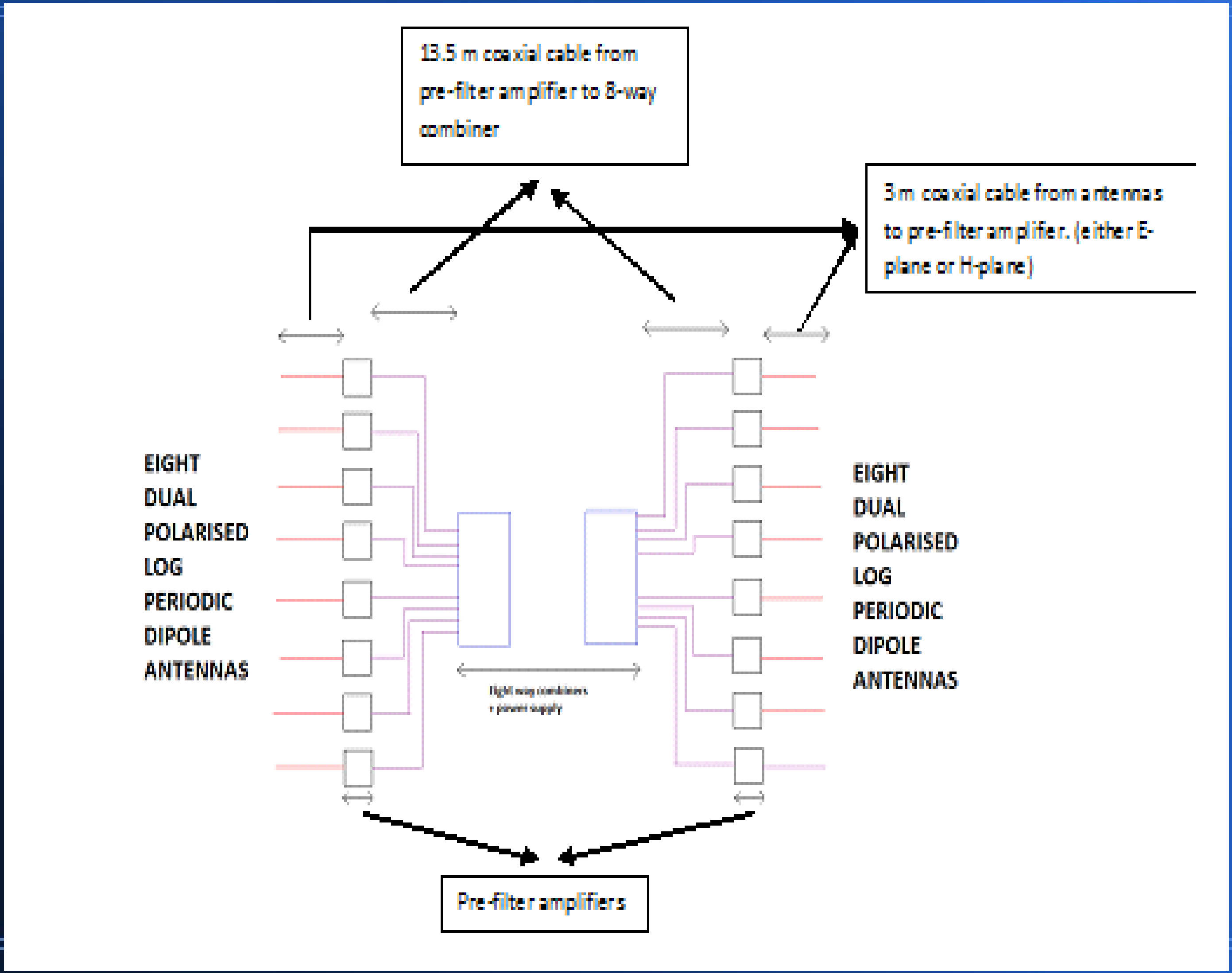
Cutting of elements

Grinding of elements

Assembling the booms and the elements to the booms

Welding

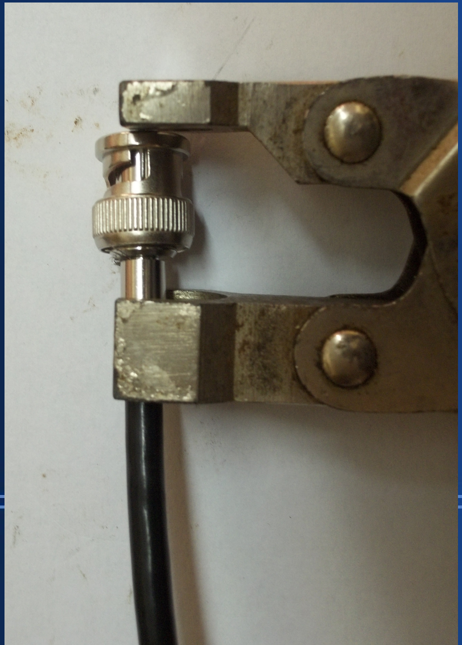
The front-end electronics



Coaxial cable measurements
Connection of three part BNC connectors with RG58 coaxial cable

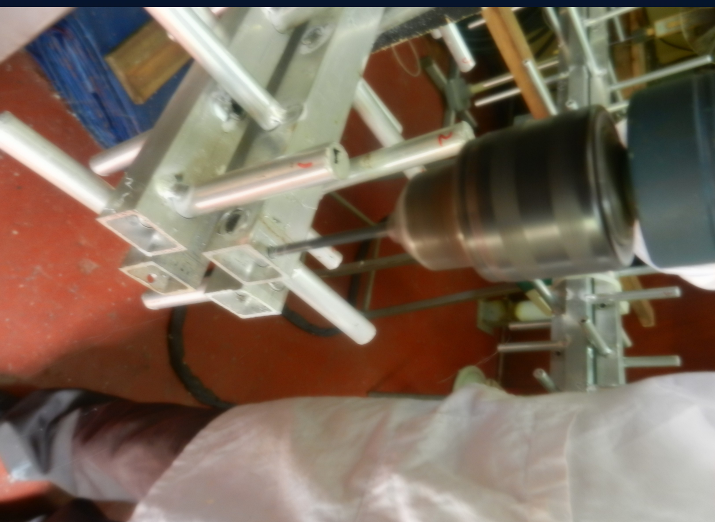


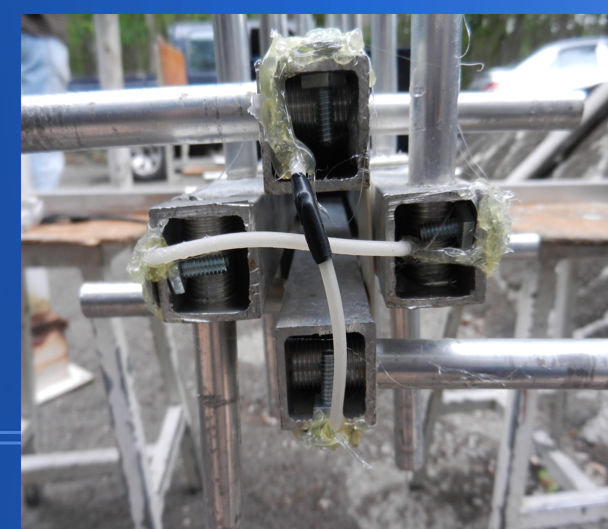





Wiring the booms

SCIENTIA SALUS PATRIAE

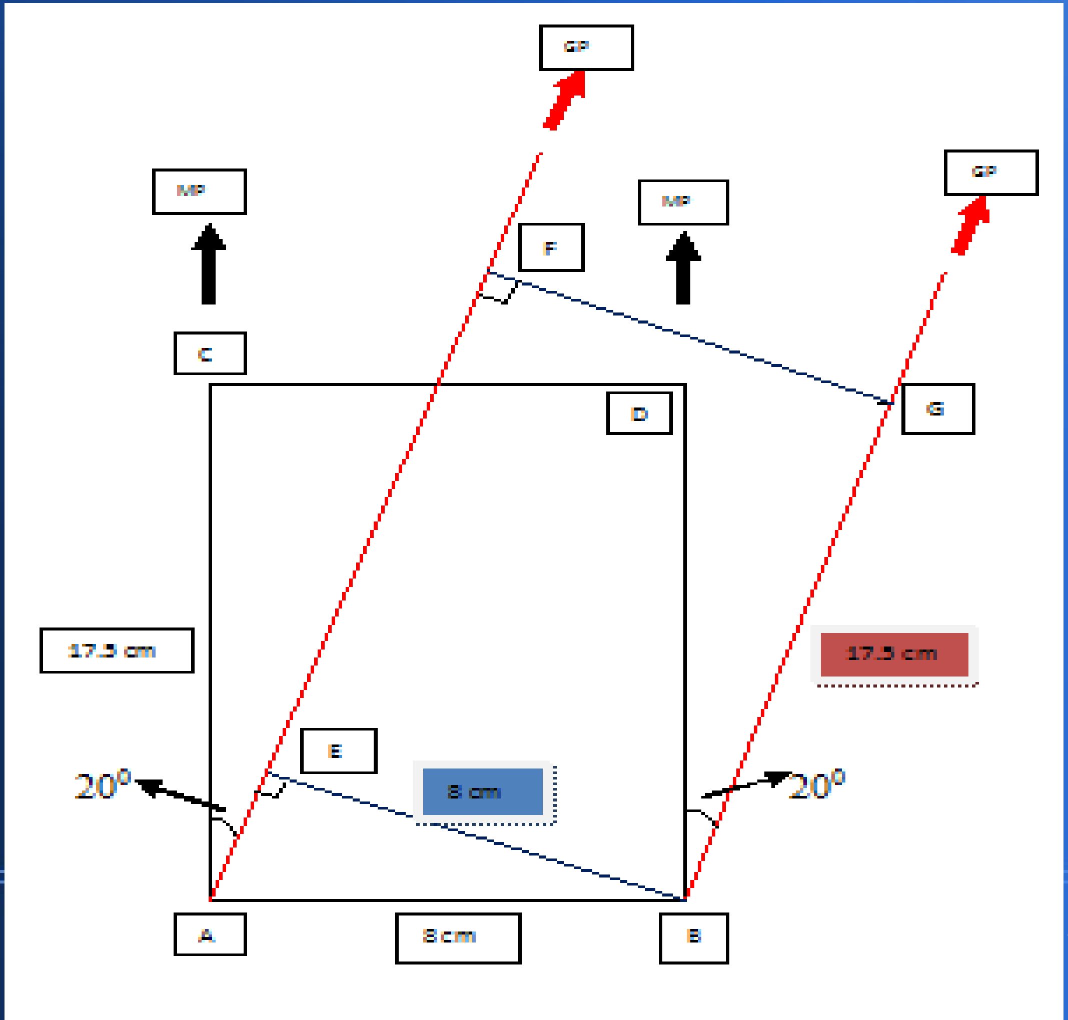




Connections of pre-filter amplifiers

Ground preparation and land marking for the array

Clearing of forested piece of land
Finding magnetic pole and geocentric pole.



- Leveling and mounting of the array at the MRT

Ground preparation and land marking for the array

The same array configuration of the array would be built at the DUT on the university roof.

Array synthesis

- Array in the North-South direction

$$\Psi = (2\pi d/\lambda) \sin \alpha$$

$$A0 = E0 + E0\exp(-i\Psi) + E0\exp(-2i\Psi) + E0\exp(-3i\Psi) + E0\exp(-4i\Psi) + \ldots E0\exp(-7i\Psi)$$

$$A0 = E0\,(1-\exp(-7i\Psi))/\,(1-\exp(-i\Psi))$$

$$= [E0 \sin(7\Psi/2) / \sin(\Psi/2)] \,.\, \exp(-7i\Psi/2),$$

$A0 = E0 \sin(7\Psi/2) / \sin(\Psi/2)$ Amplitude of the East and west array (ARRAY FACTOR)

- Array in the East-West direction

$$\delta = (2\pi D/\lambda) \sin \Theta$$

$$\text{Total array East-West} = A0 + A0\exp(-i\delta)$$

$$= A0\,(1+\exp(-i\delta))$$

$$= A0 \exp(-i\delta/2)\,(\exp(i\delta/2) + \exp(-i\delta/2))$$

$$= 2\,Ao \,.\, \exp(-i\delta/2) \,.\, \cos(\delta/2)$$

$$= 2\,Ao \,.\, \cos(\delta/2)$$

- Total amplitude of whole array configuration;

$$A = \text{Array factor} \times \text{Total array East-West}$$

$$= Ao \times 2\,Ao \,.\, \cos(\delta/2)$$

$$= 2\,Ao^2 \,.\, \cos(\delta/2)$$

$$= 2 \,.\, [Eo \sin(7\Psi/2) / \sin(\Psi/2)]^2 \,.\, \cos(\delta/2)$$

$$= 2Eo^2 \,.\, [\sin^2(7\Psi/2) / \sin^2(\Psi/2)] \,.\, [\cos(\delta/2)]$$

Thus,

Intensity (I) = Amplitude^2 (A^2)

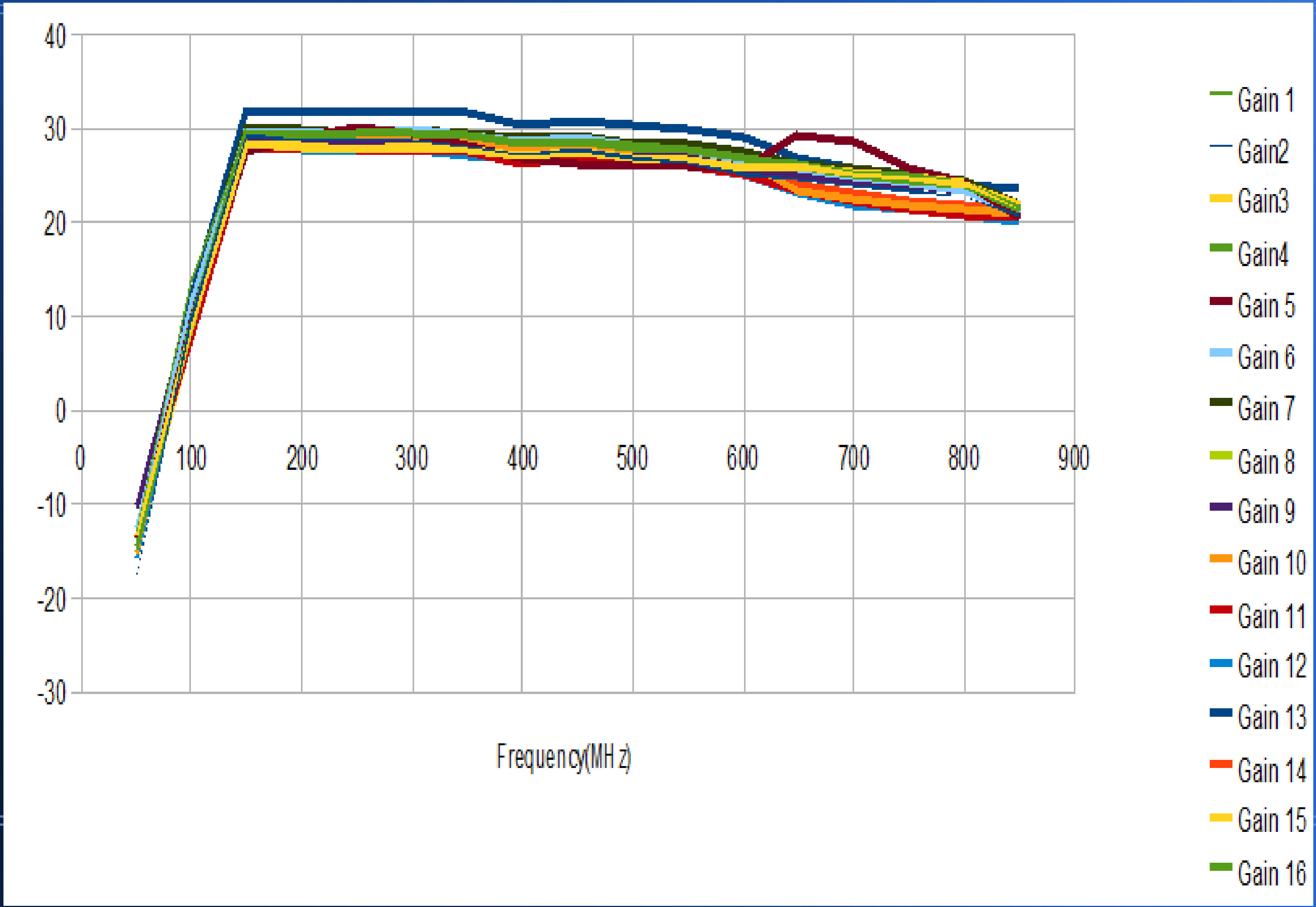
$$I = 4\,E0^4 \,.\, [\sin^4(7\Psi/2) / \sin^4(\Psi/2)] \,.\, [\cos^2(\delta/2)]$$

Tests and results

- Testing connections of BNC with coaxial cables

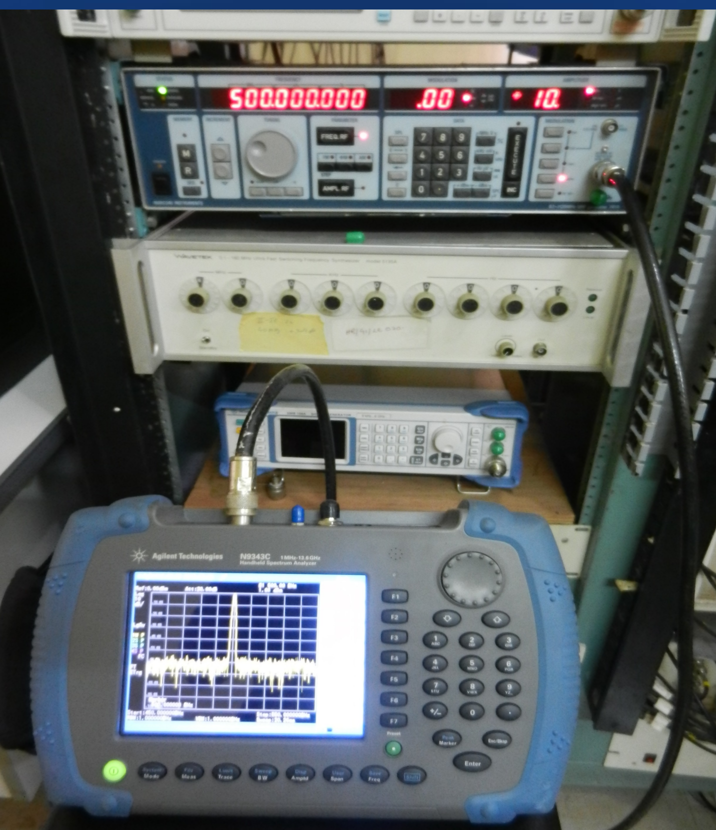
- Testing of pre-filter amplifiers

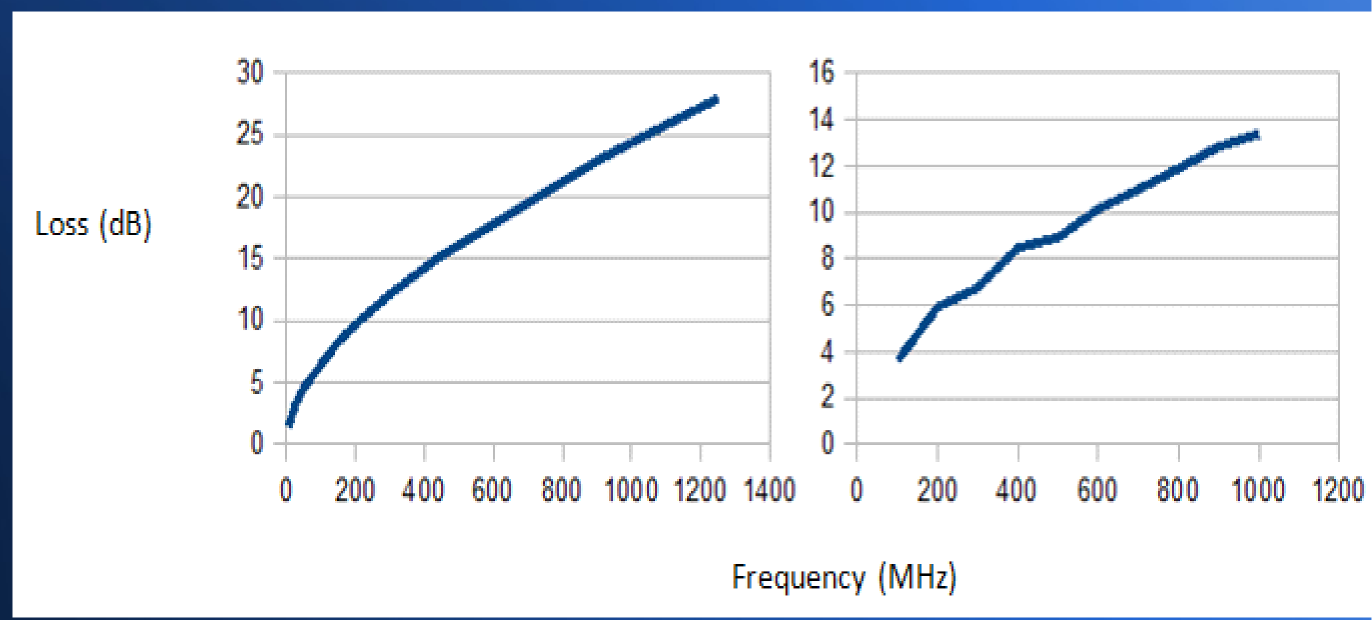
Graph of gain(dB) against frequency(MHz)



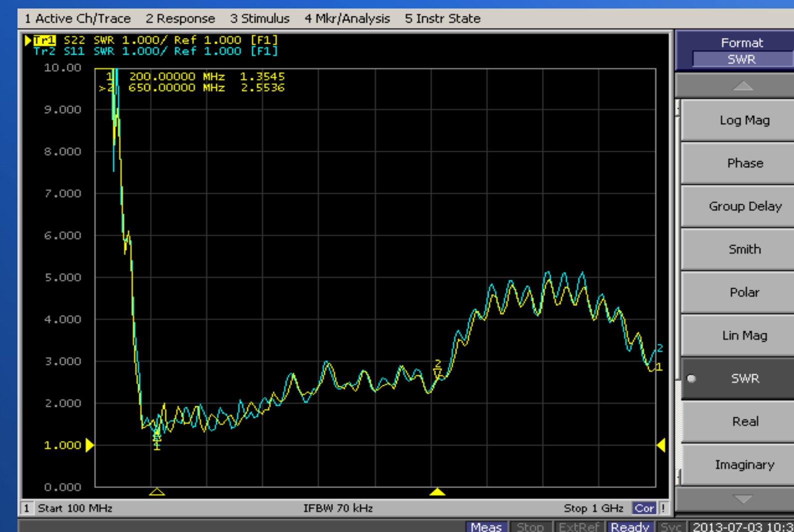
Tests and results

- Testing loss in 50 m coaxial cable of type RG 213U

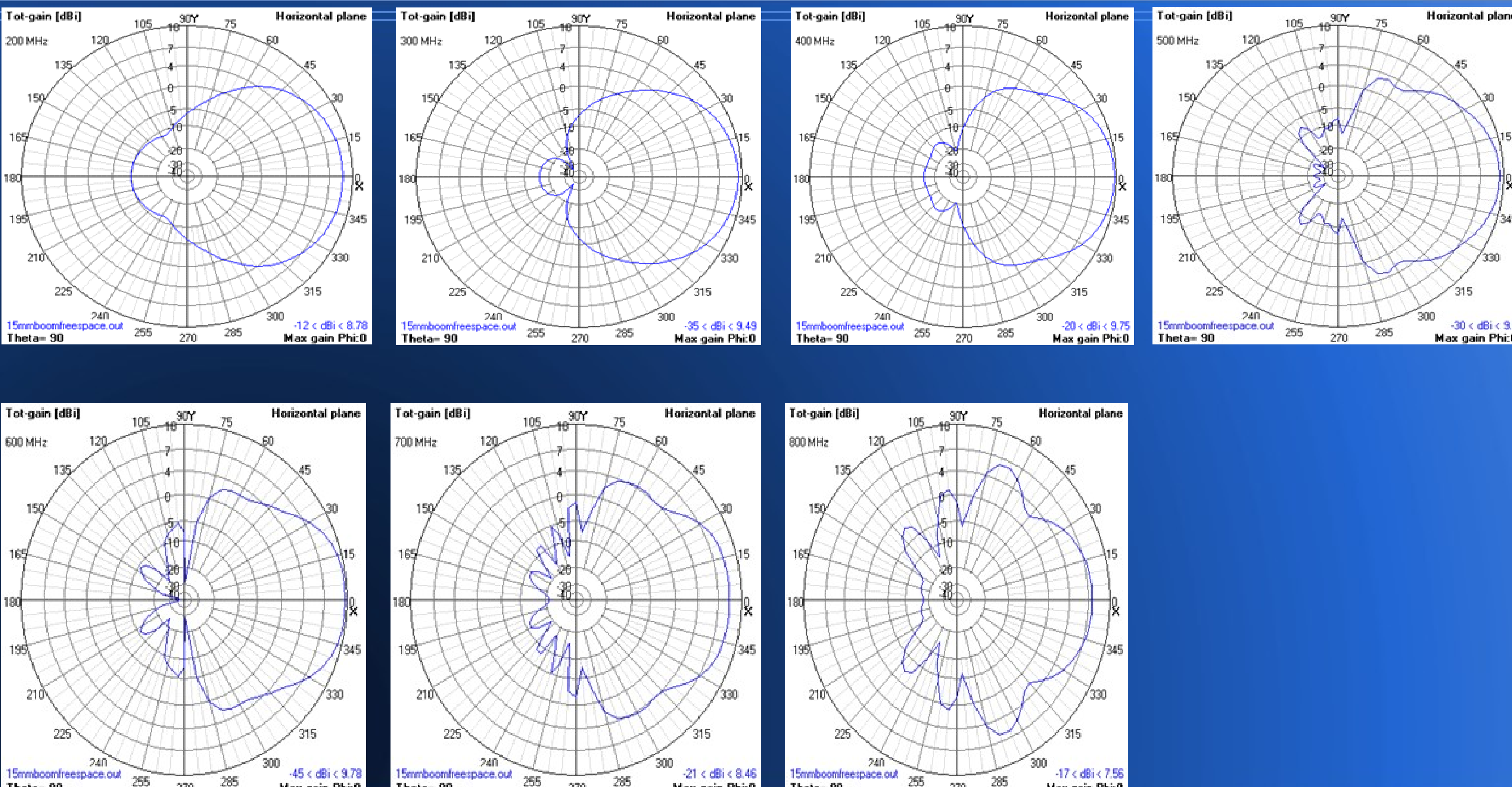




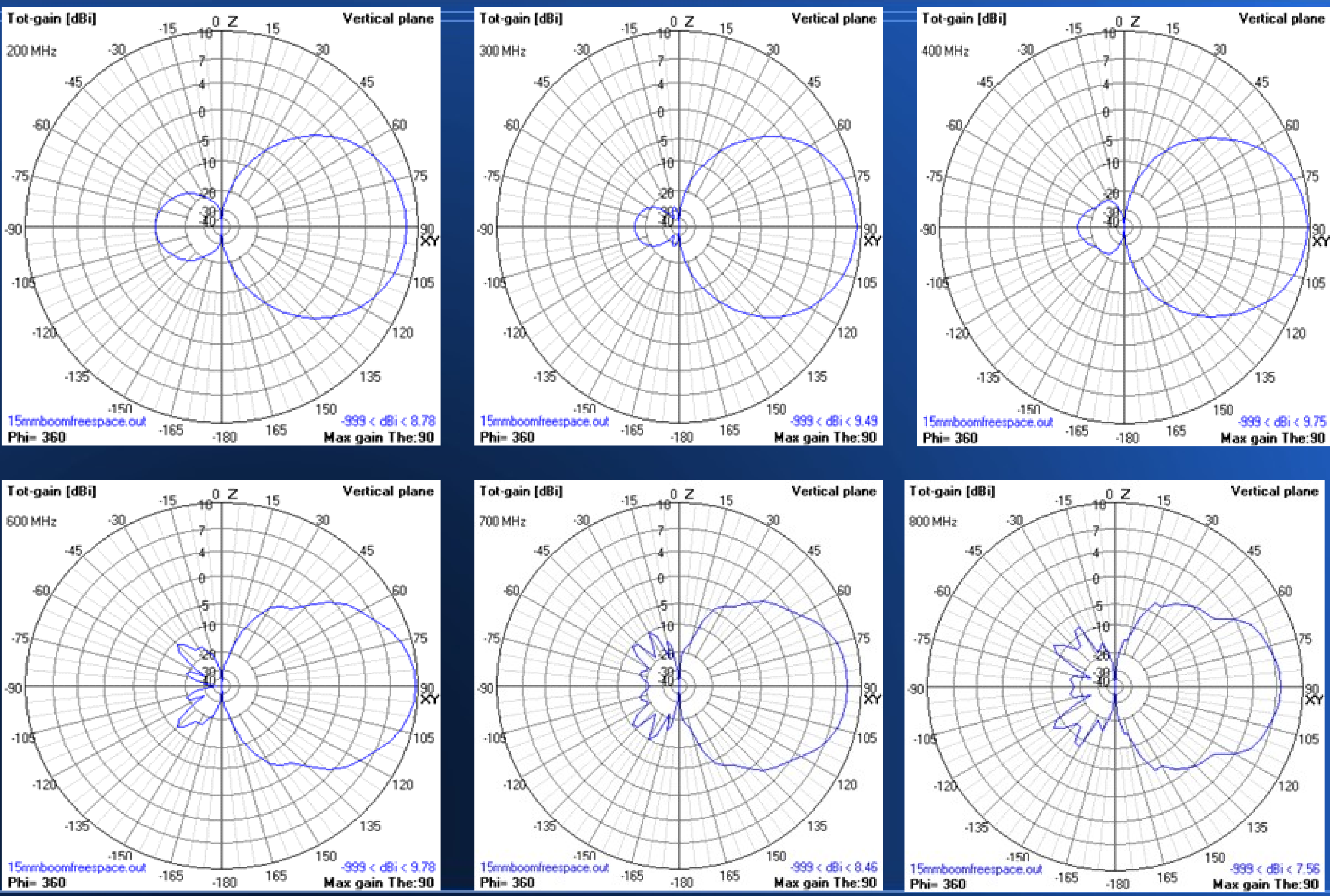
VSWR test of the LPDA



Simulated plots of the LPDA in E-plane at 200MHz-800MHz by DUT



Simulated plots of the LPDA in H-plane at 200MHz-800MHz by DUT



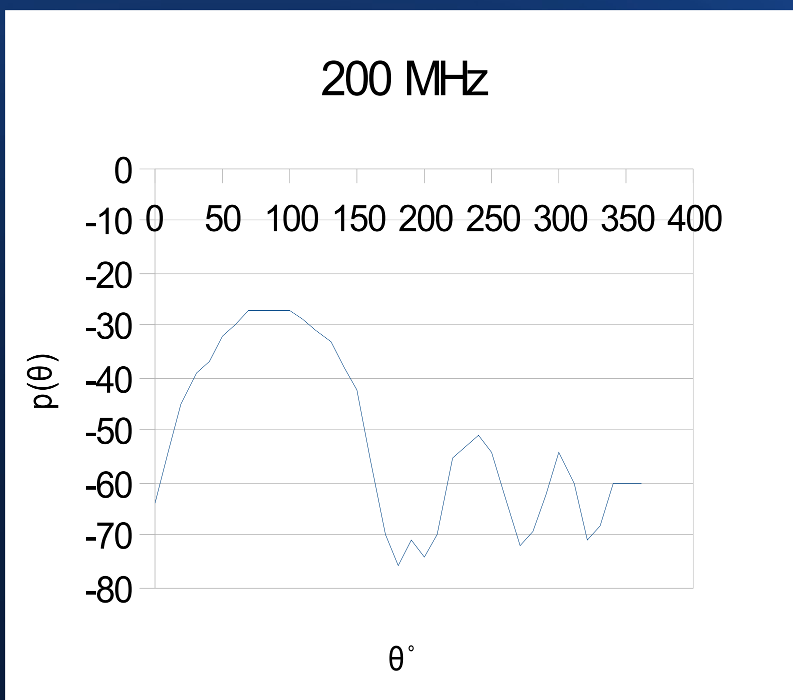
• Determining the Half Power Beam Width (HPBW) of Log Periodic Dipole Antenna

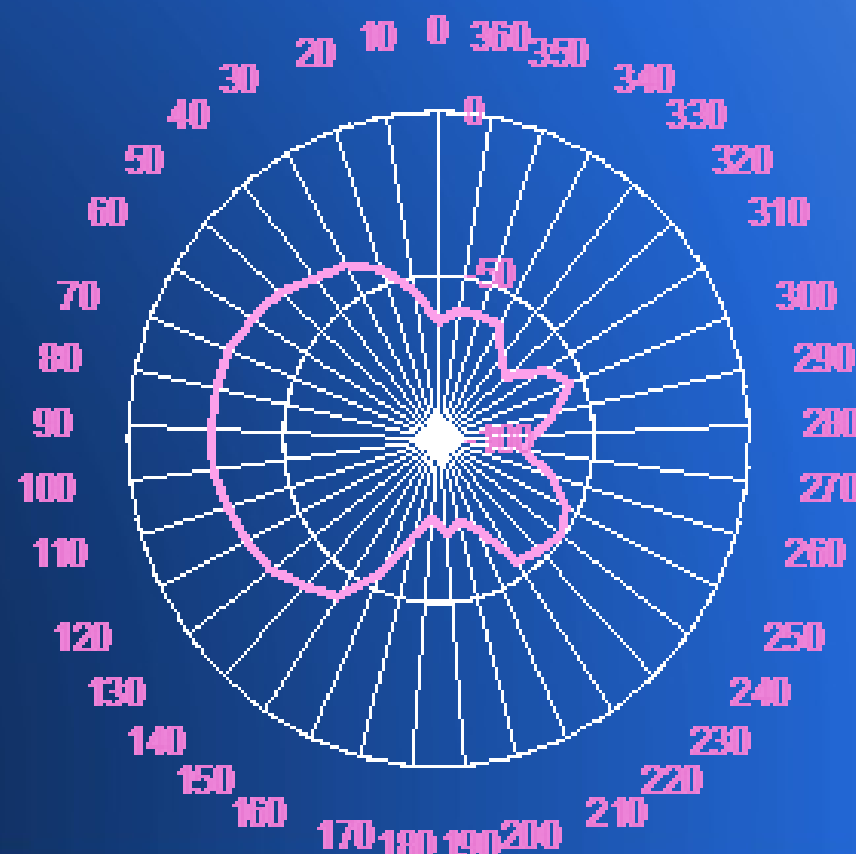
I.Near-field test

Normally we have four different combinations for the HPBW test as the antenna is dually polarised (EeEr, HeHr, EeHr, HeEr)

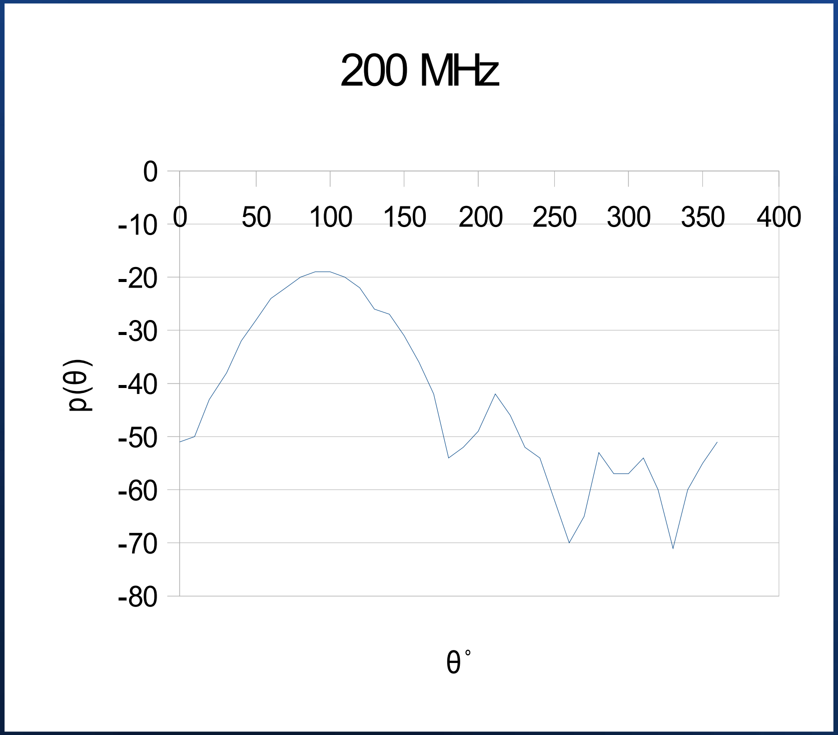
Tests and results

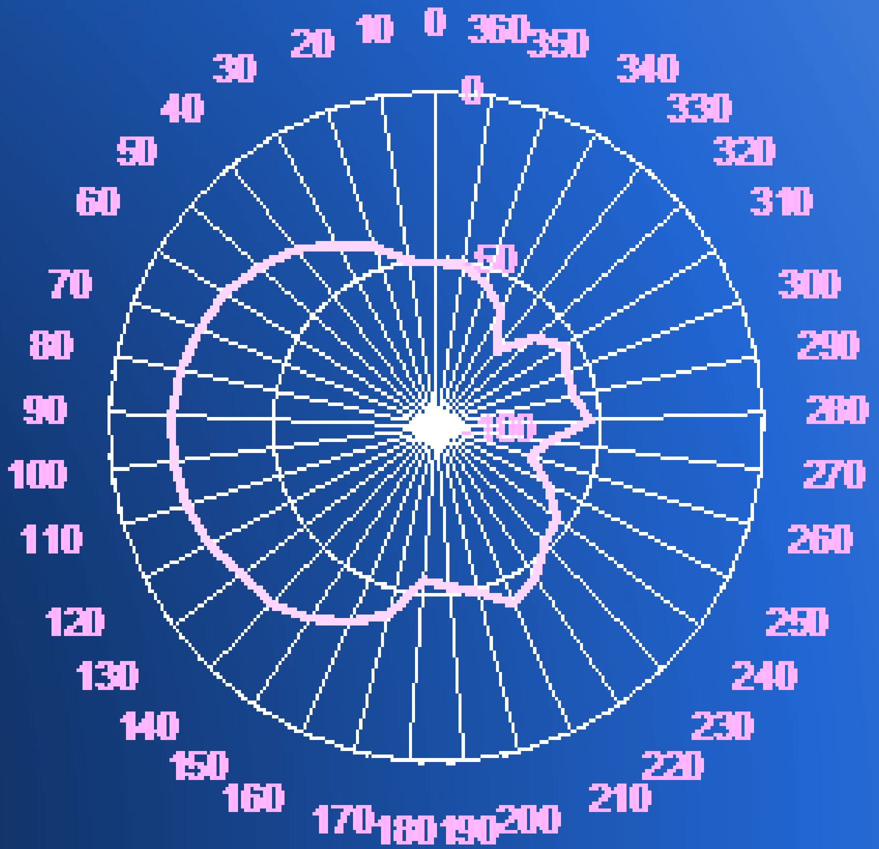
- Radiation pattern in near-field region at 200MHz.





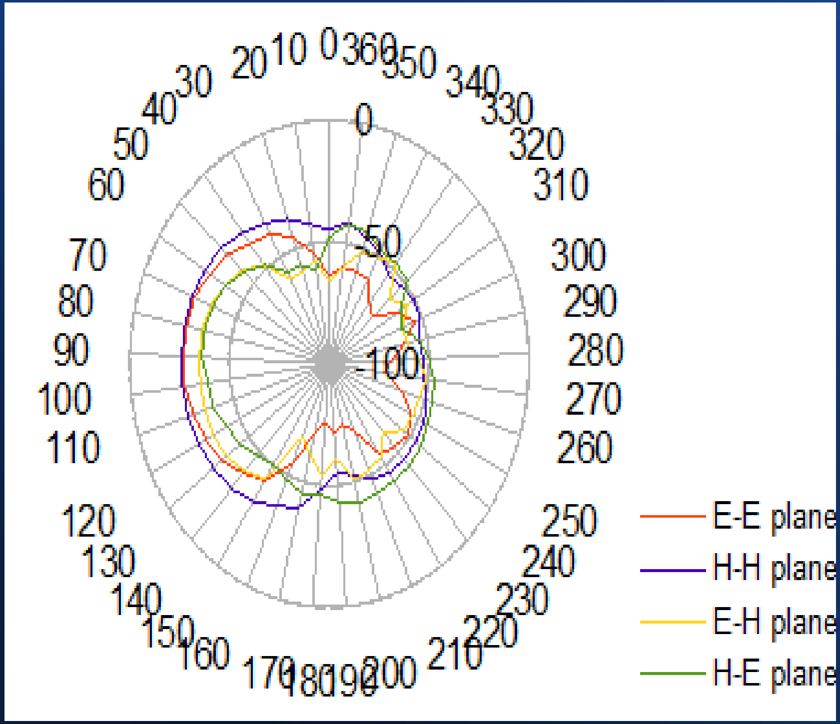
Radiation pattern in Near-field region at 200 MHz after ninety degree rotation of both emitter and reciever.

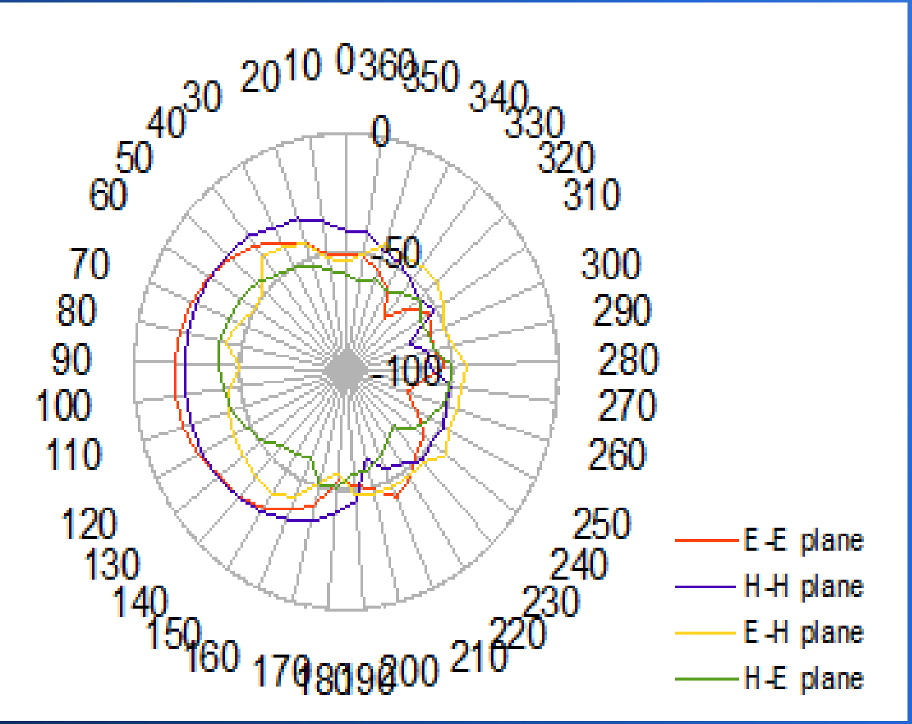




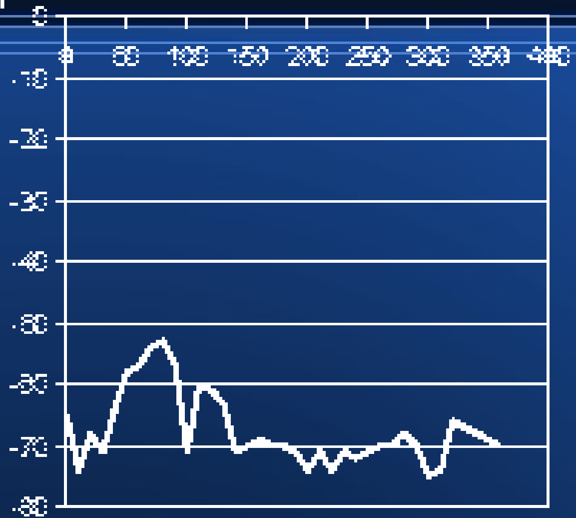
Tests and results

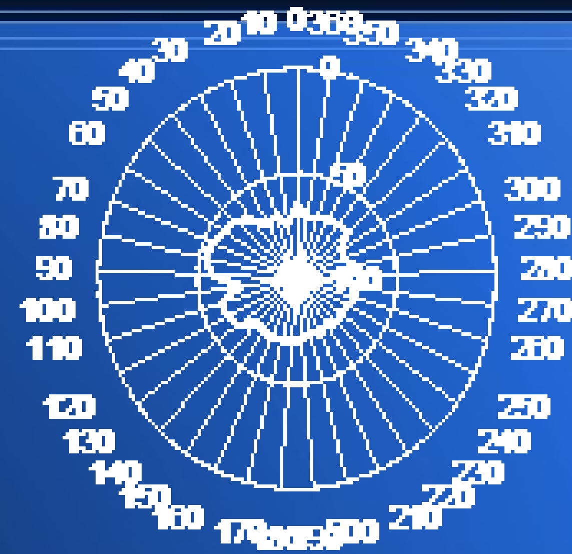
- Combined plots in Near-field region for all plane combinations.



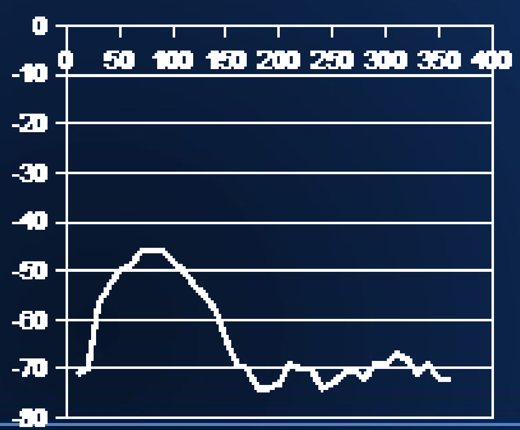


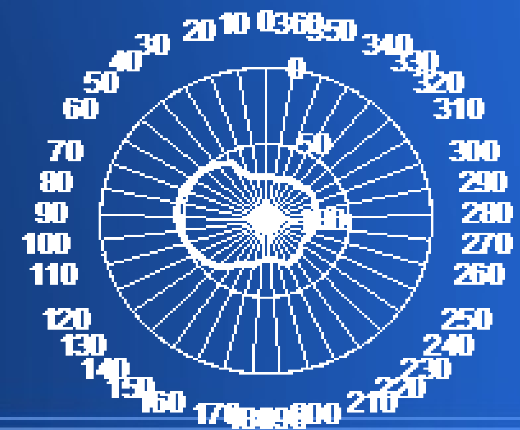
- Radiation pattern in far-field region at 200 MHz without using a pre-filter amplifier



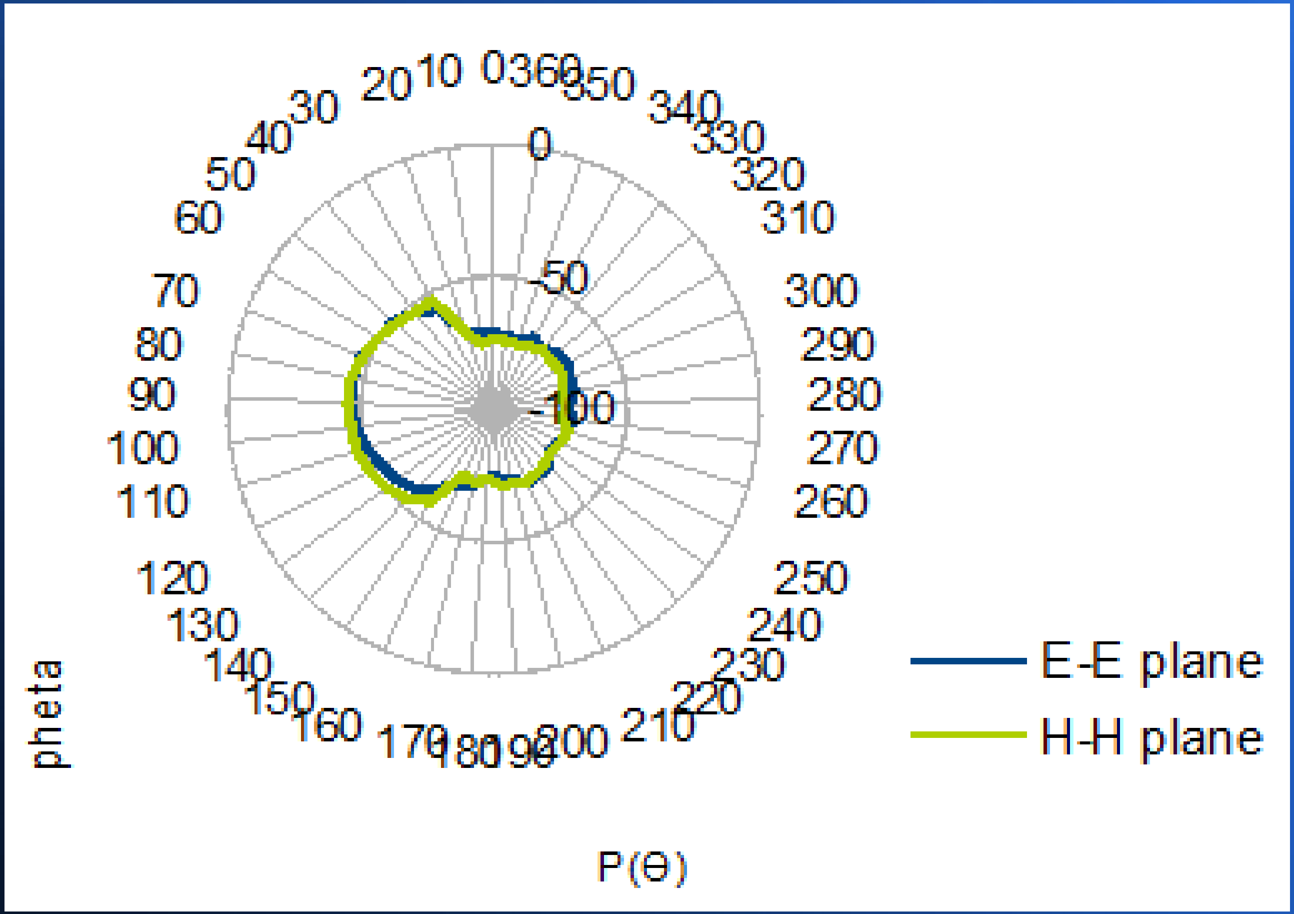


Radiation pattern in far-field region using a pre-filter amplifier.

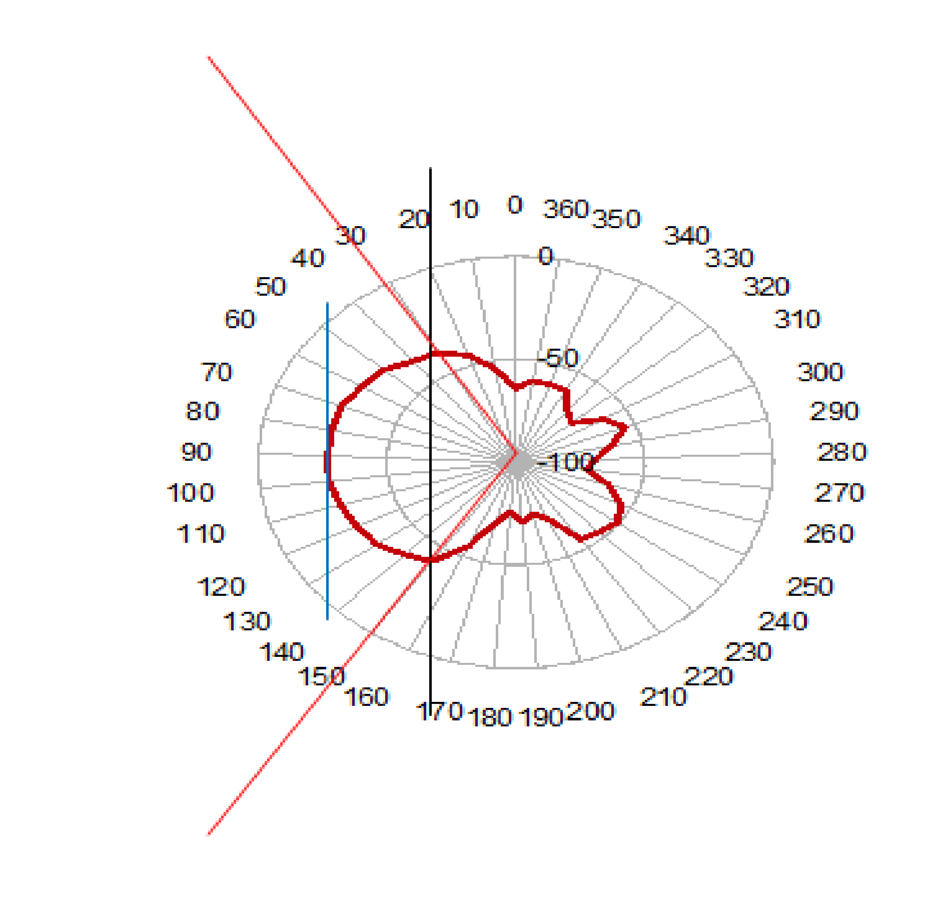




Combined polar plots in E-E plane and H-H plane of far-field region.



- The measured HPBW of the antenna is approximately 120^{0}



Tests and results

Testing of antenna response of all sixteen antennas in both E-plane and H-plane.

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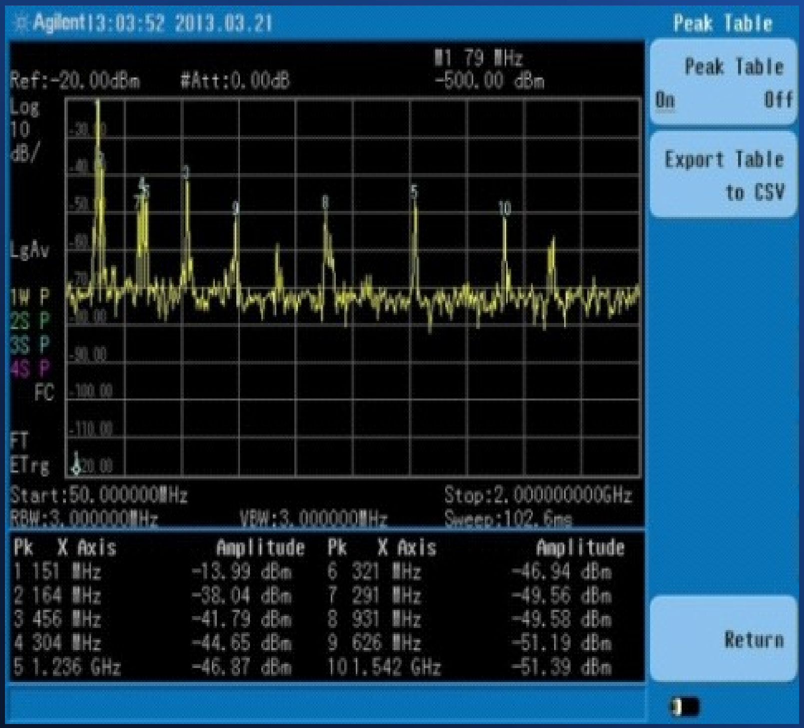
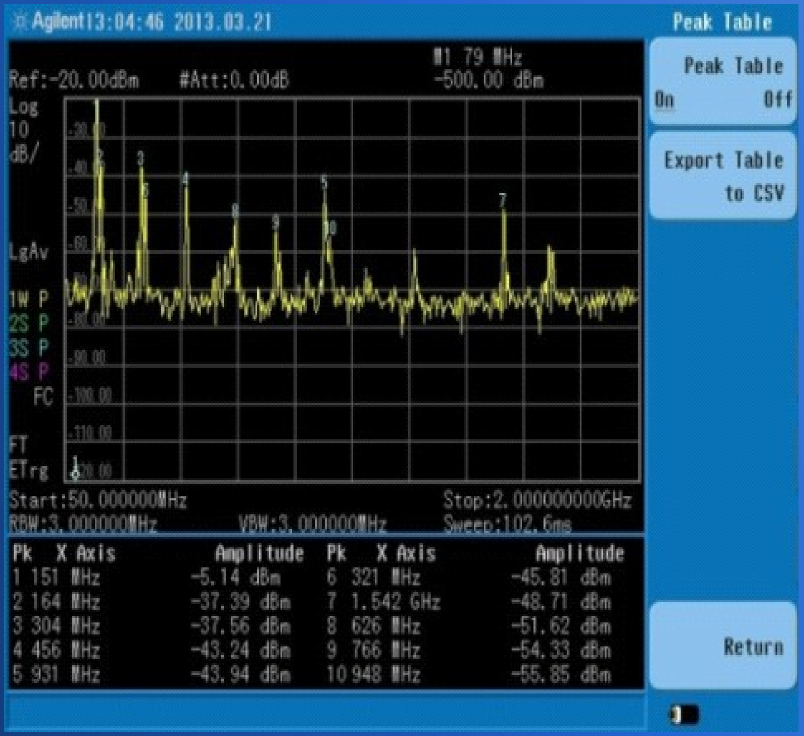
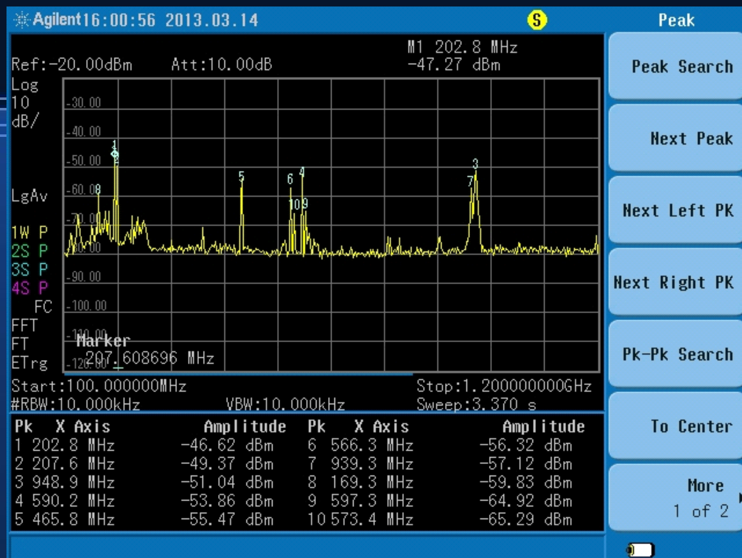
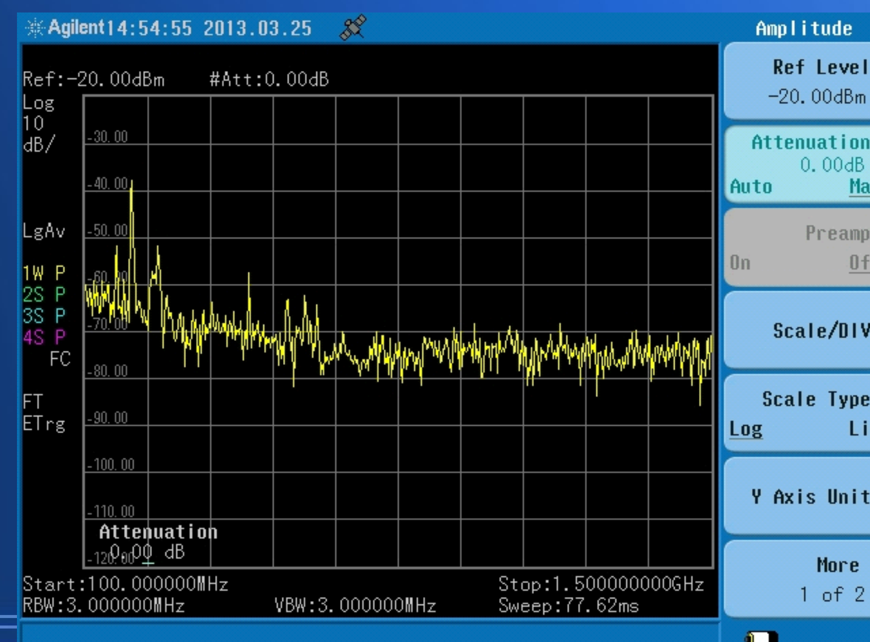




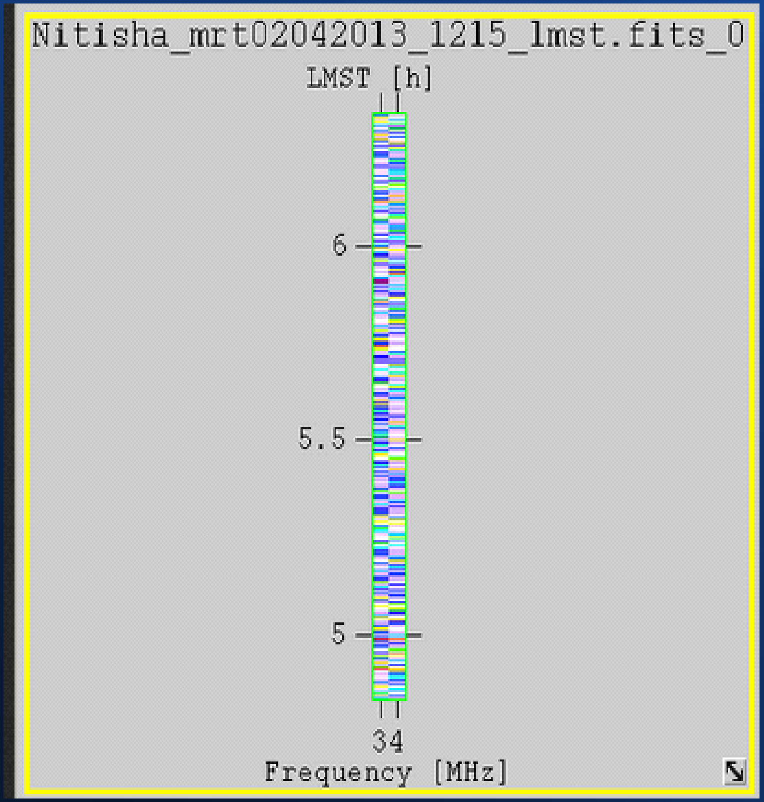
- Antenna response of East array.



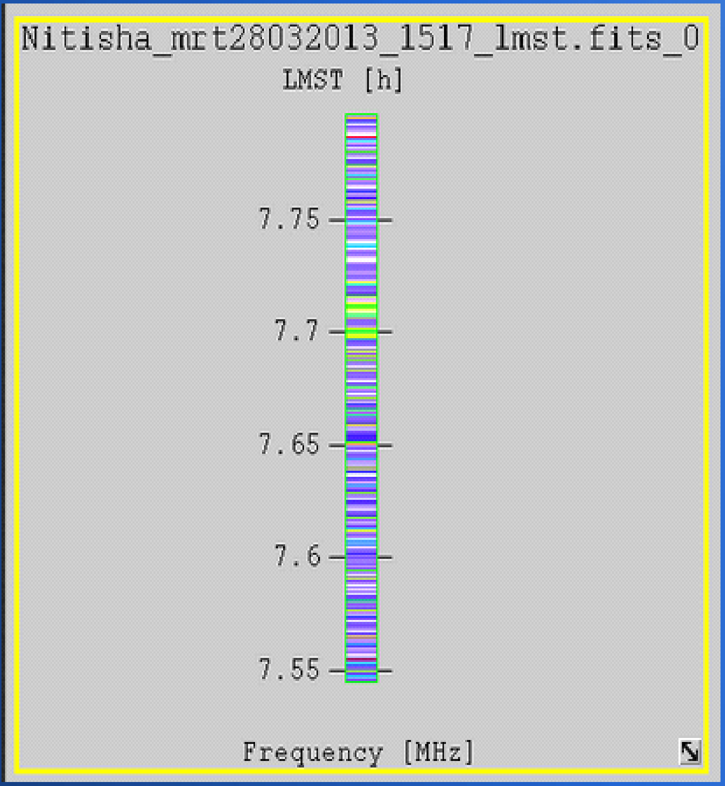
Antenna response of East array using a 200m optical cable.



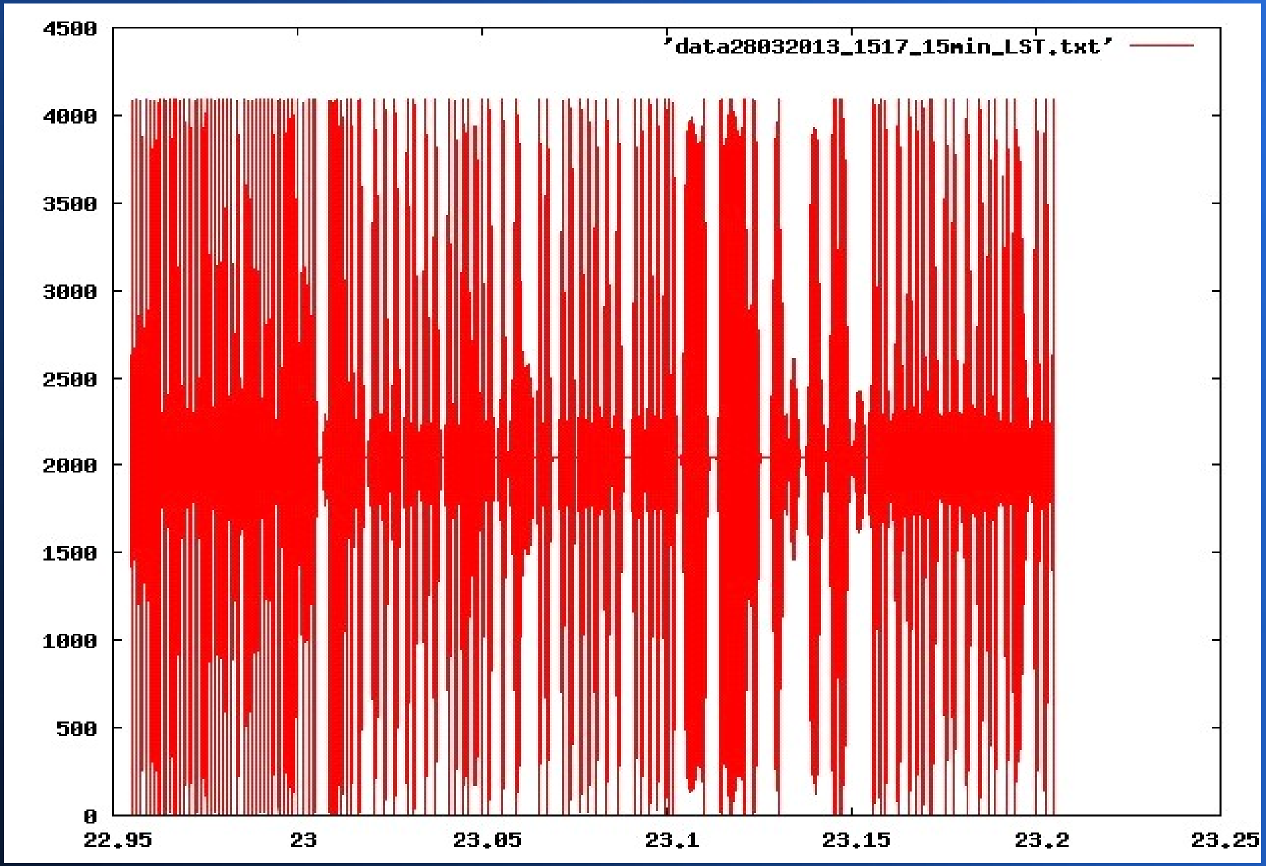
Observations using optical cable



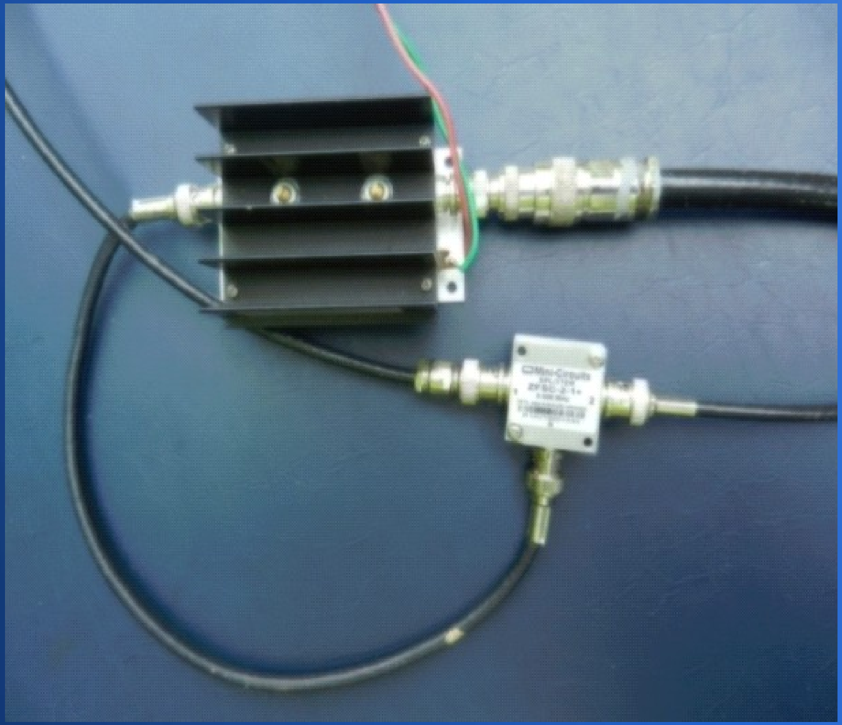
Observations using coaxial cable



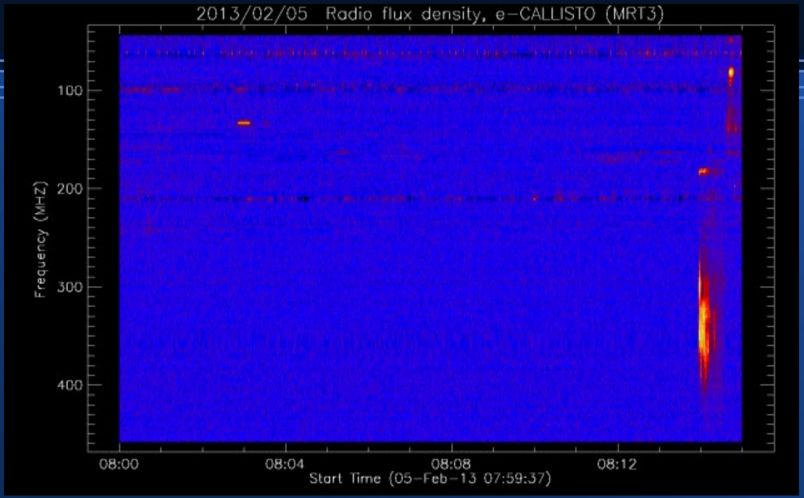
Pictor A fringes at 144 MHz

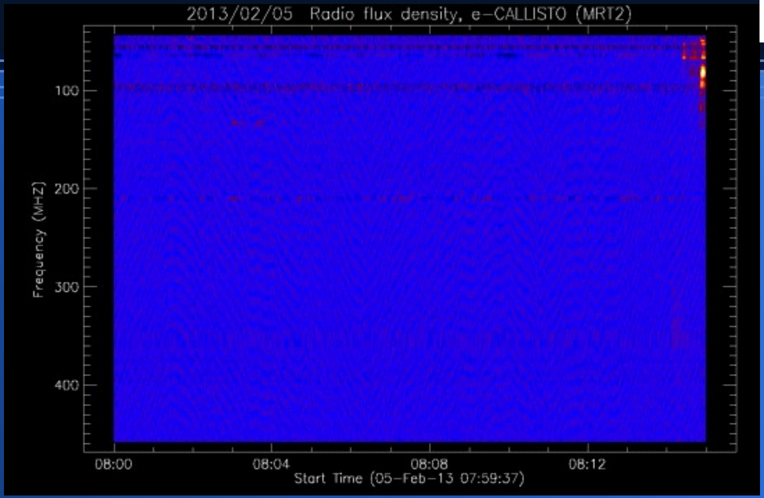


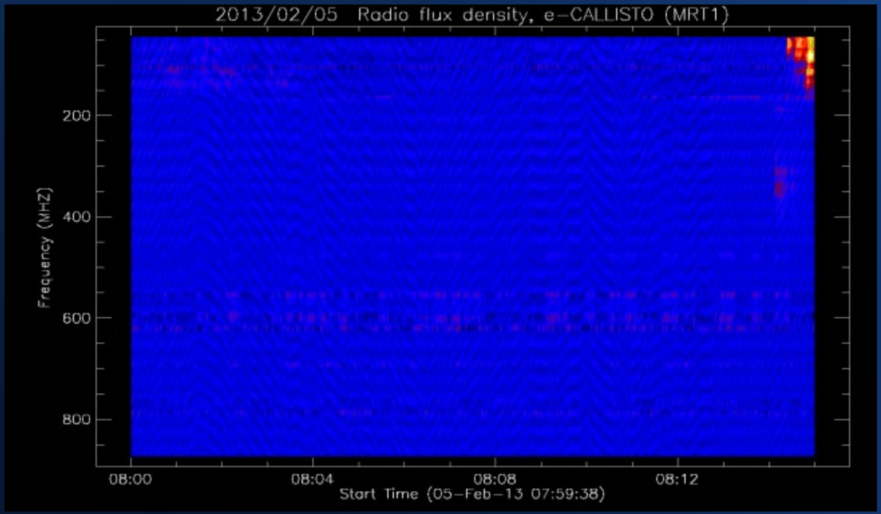
The e-CALLISTO test

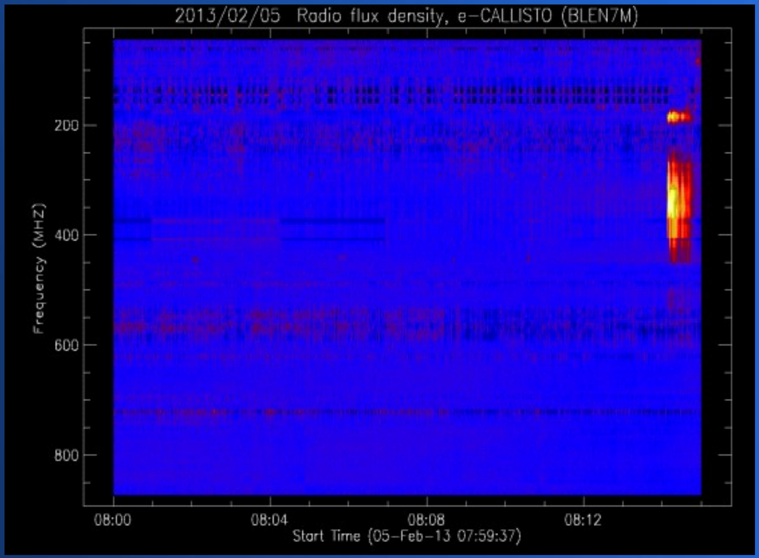


5th February solar flare

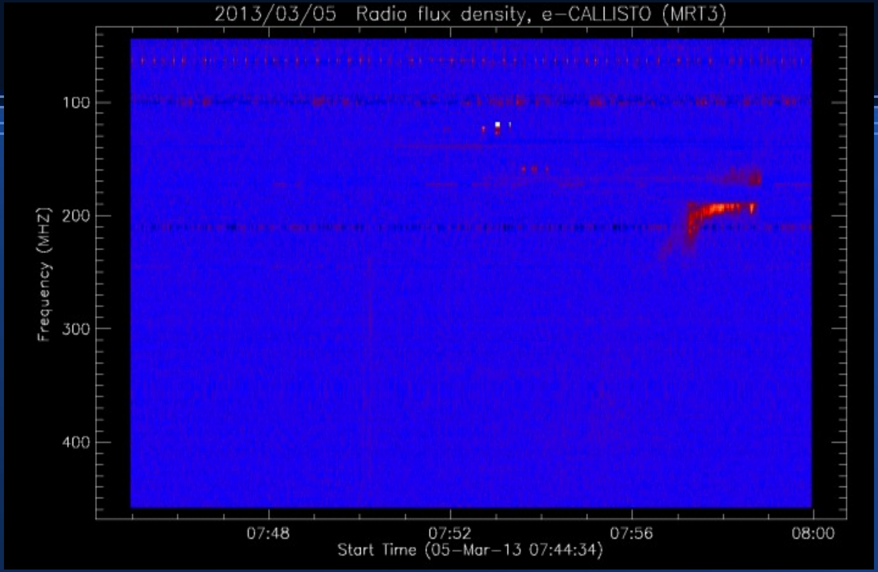


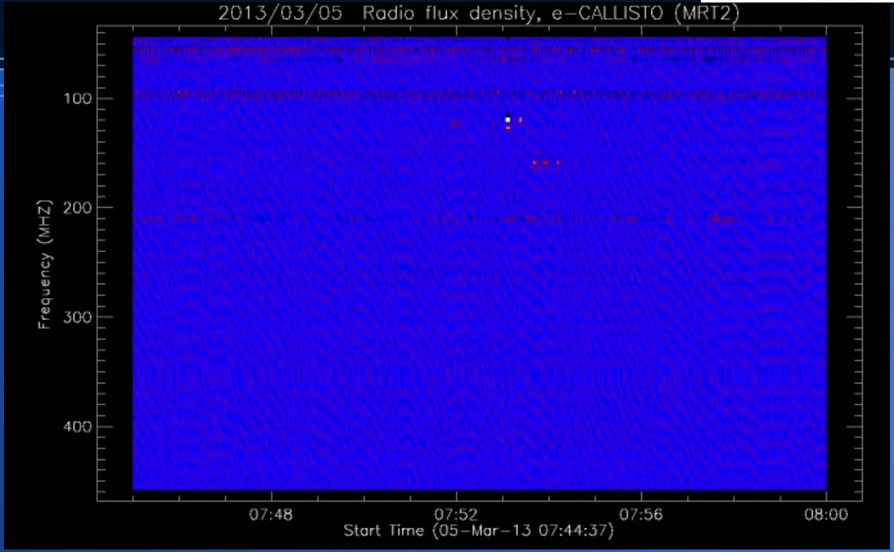


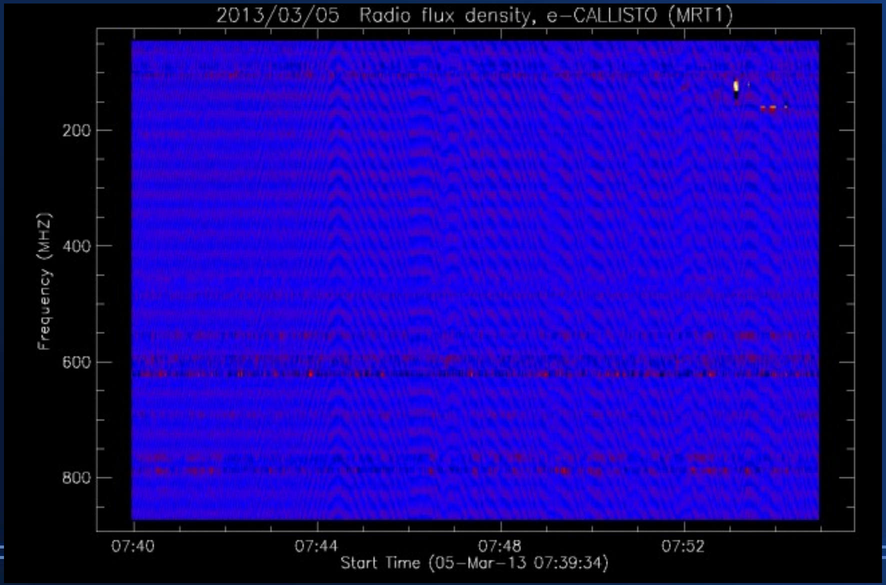


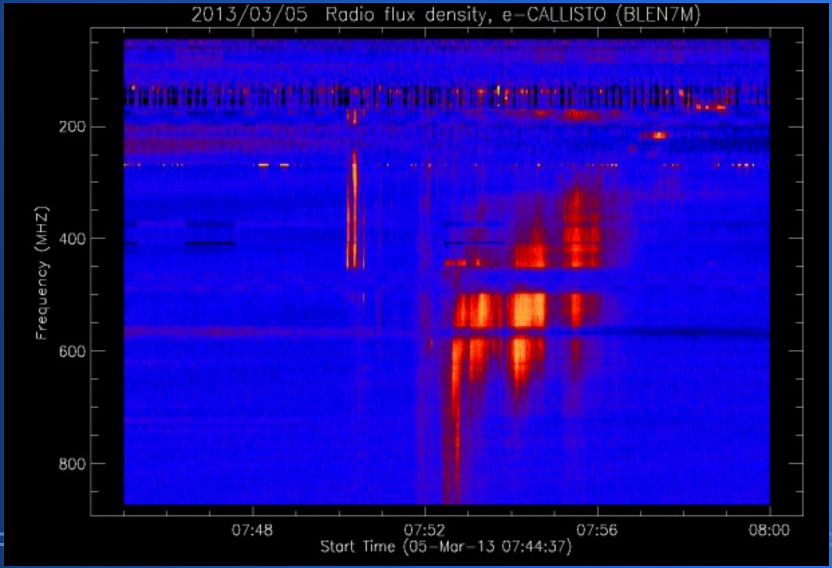


5th March solar flare

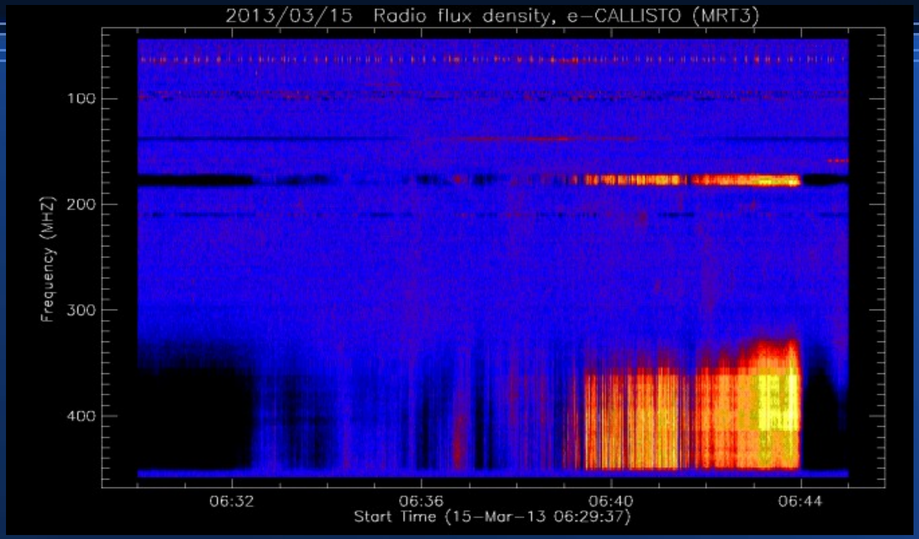


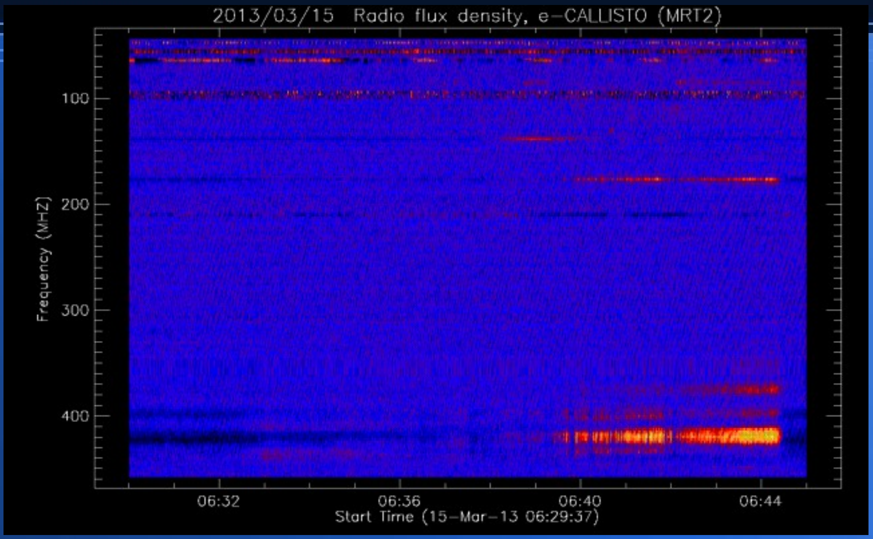


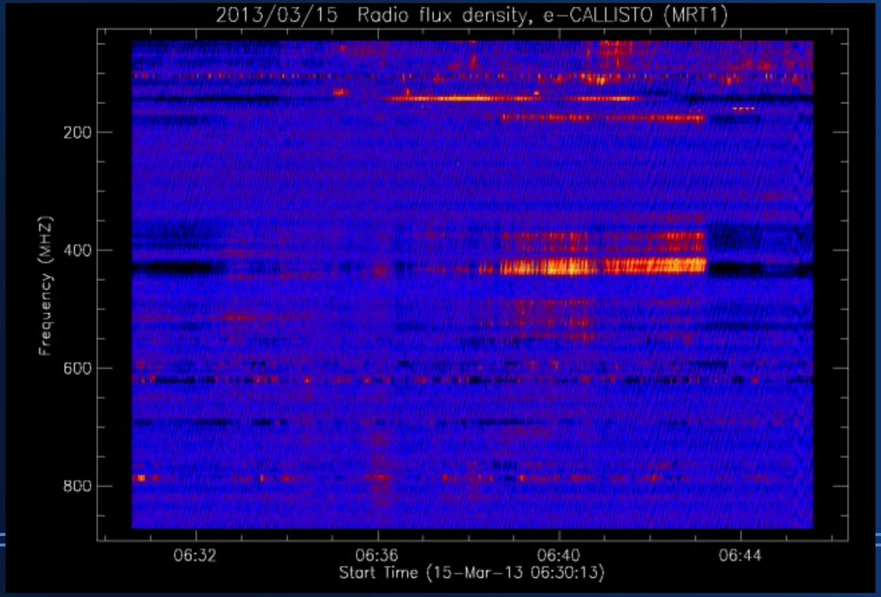


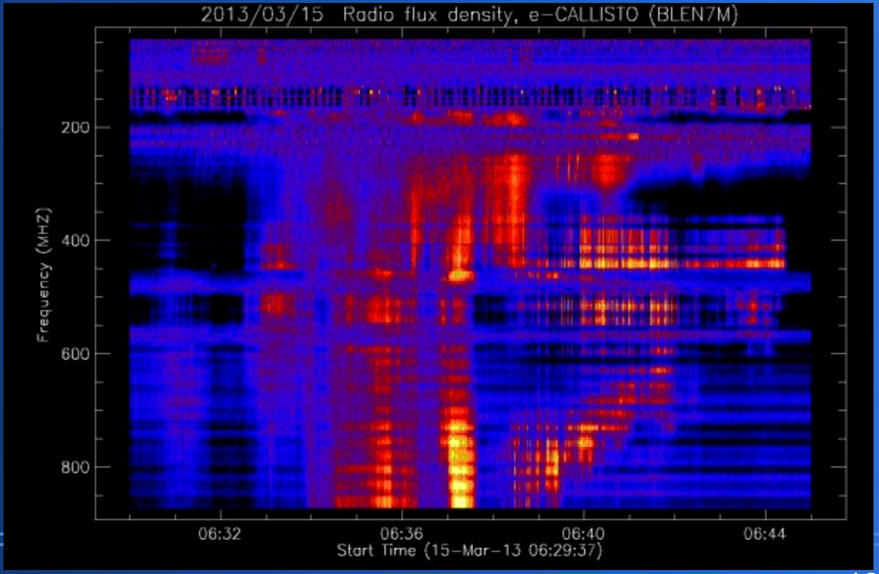


15th March solar flare









Conclusions

- Some of the bands to which most antennas could respond were: 151 MHz, 201-204 MHz, 554 MHz, 948.3 MHz, 1.236 GHz and 1.542 GHz.
- The front-end system satisfies the frequency range of MITRA.
- The antenna (MRT 3) has become a part of the International Network of Solar Radio spectrometers.

Future works

- Observations would be done for different configurations of the array.
- The array would consist of more such antennas for observations

I sincerely thank you for your kind attention.