MWA ANTENNA MEASUREMENTS AT THE MURCHISON RADIO OBSERVATORY

Hamdi Mani, Judd Bowman

***Abstract*—Individual elements of one MWA tile were measured on site and on the deployment configuration. The impedance of few dipole antennas was measured using the VNA and was found to vary from element of the tile to another. The crosstalk between different tile elements was also measured.**

***Index Terms*— phased array antennas, low frequency dipole antennas.**

I. Introduction

The MWA-32T is made of 32 tiles, each one of them is a 4 X 4 dipoles . The dipoles are dual polarization and are separated by distance 1.07m and are mounted on a mesh ground screen that improves the pattern and reduces spill over noise pickup

II. ANTENNA IMPEDANCE MEASUREMENTS

Each element of the tile is dipole antenna with 2 polarizations and differential output. A 2port VNA was used to measure single ended sparameters. An SMA to terminal transition was made to connect to the dipole and allows connection to the VNA ports.
The R&S ZVL3 portable VNA was used to do the measurement, the settings of the VNA:

- Frequency Range: 10MHz -500 MHz
- Frequency Points: 491
- Excitation signal power:0 dBm
- Averaging: 10

Since the impedance measurement is a reflection measurement, care was taken to minimize reflections from the setup, equipment and operators. The network analyzer was connected to a laptop computer with wireless connection to another computer far away from the tile. The VNA was remotely controlled from a long distance and reflections are reduced.

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Tile #08 was chosen since there is easier access to it. Fig0. is a layout of one tile.

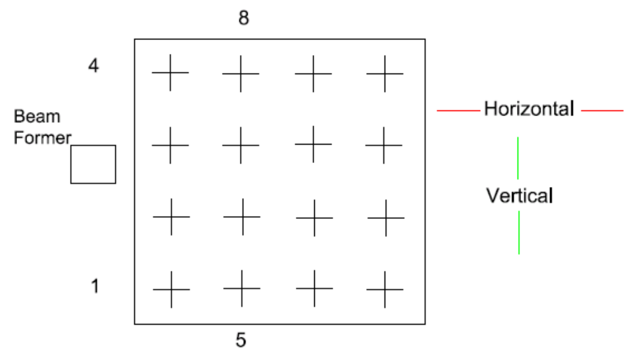

Fig0. 4 X 4 element tile.

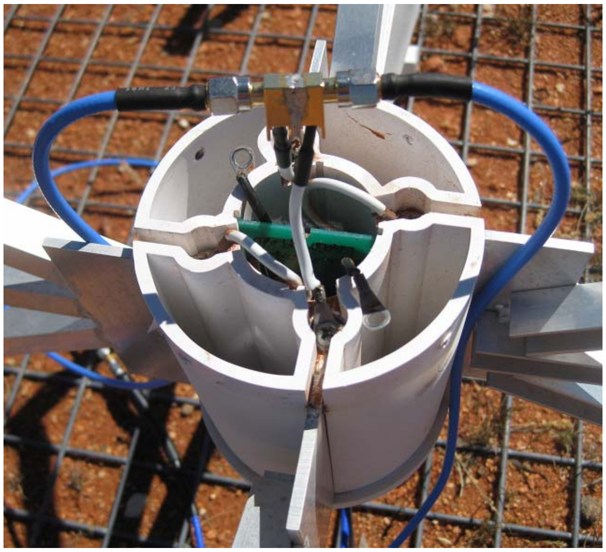

Fig1. The connection to one of the polarization of the antenna. The LNA was disconnected but the LNA board was left in place. The white wire terminals (twin leads) have the same length and wire gauge than the actual twin leads used to connect to the LNA. The grounds of the 2 SMAs are soldered together and connected to the VNA cables(blue cables). The VNA was calibrated at the end of the blue cables. The measurement reference plane is the SMA connector.

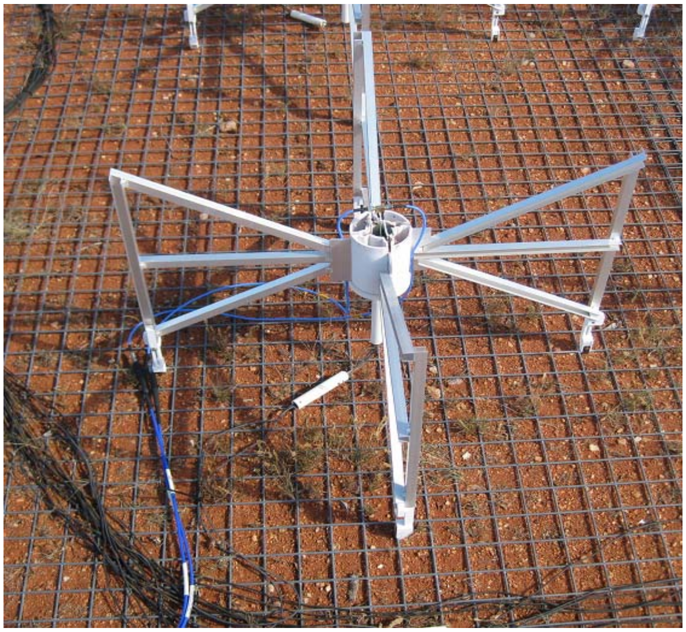

Fig2. The VNA cables were wrapped in a way to minimize reflections and long cables were used to bring the VNA as far as possible from the dipole being measured.

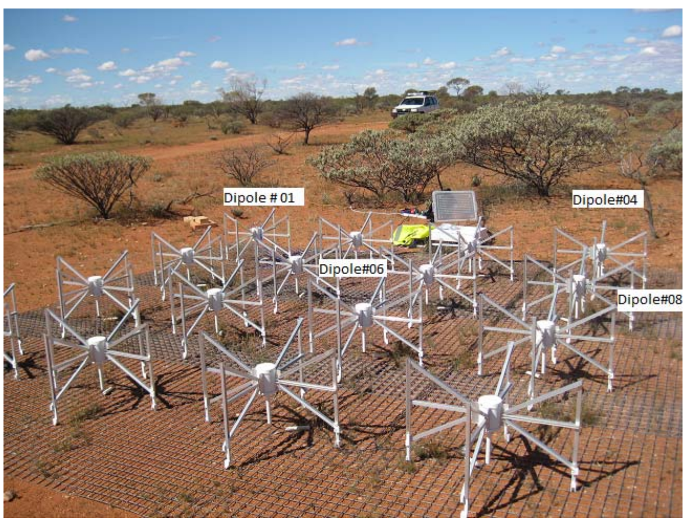

Fig3. Measurement setup showing the VNA, laptop computer used to communicate remotely with the VNA.

3 antenna elements were measured: dipole#01, #02 and #06. Fig4. shows the output differential reflection coefficitient magnitude relative to 100 Ohm of the 2 polarizations of dipole#01.
Similarly, the polarizations of dipoles #02 and #06 were measured and data is shown on Fig5 and Fig6.

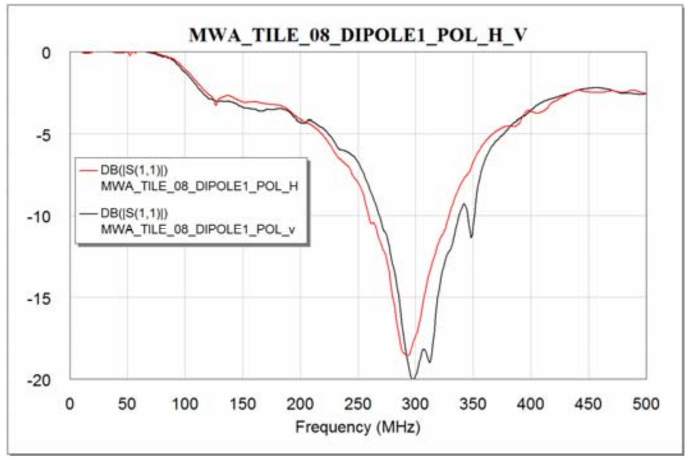

Fig4. Return loss of dipole#01 Polarizations H and V. The return loss was computed from single ended s parameters. The return loss is relative to 100 Ohm characteristic impedance.

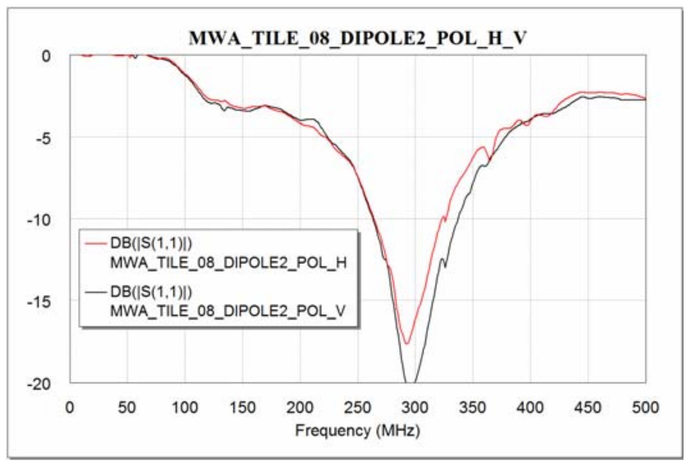

Fig5. Return loss relative to 100 ohm impedance of dipole #02.

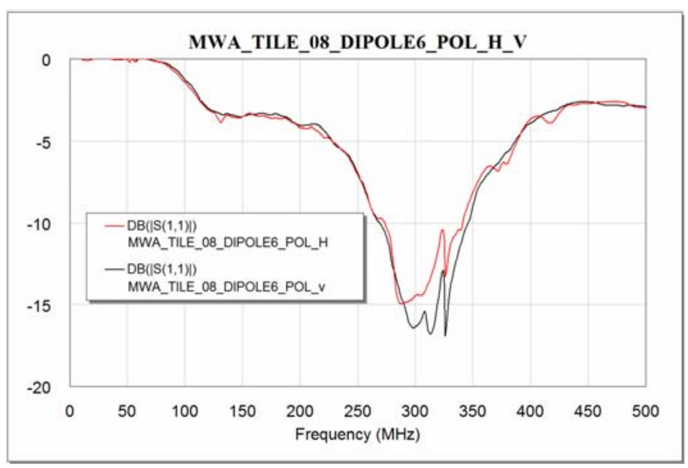

Fig6. Return loss relative to 100 ohm impedance of dipole #06.

The magnitude of the reflection coefficient for the H and V polarizations of the three measured dipoles is shown on Fig7 and Fig8.

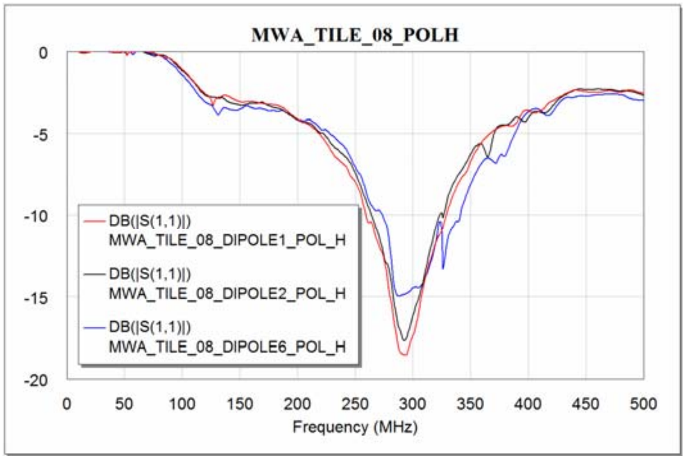

Fig7.H pol of 3 measured dipoles.

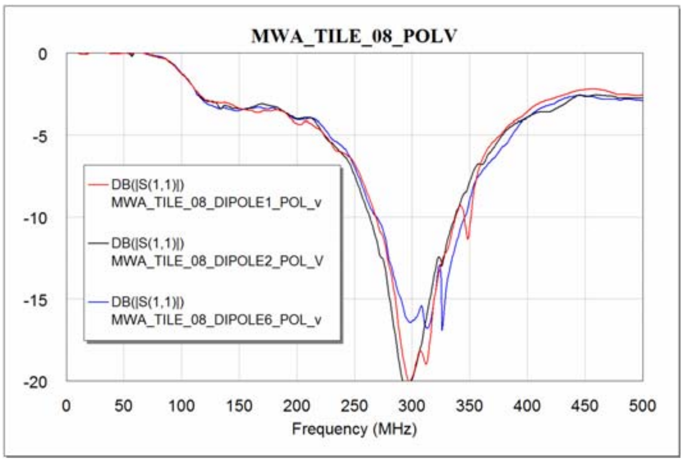

Fig8. V pol of the 3 measured dipoles.

The complex impedance of the pol H and pol V of the three measured antennas is shown on smith chart plots on Fig9 and Fig10

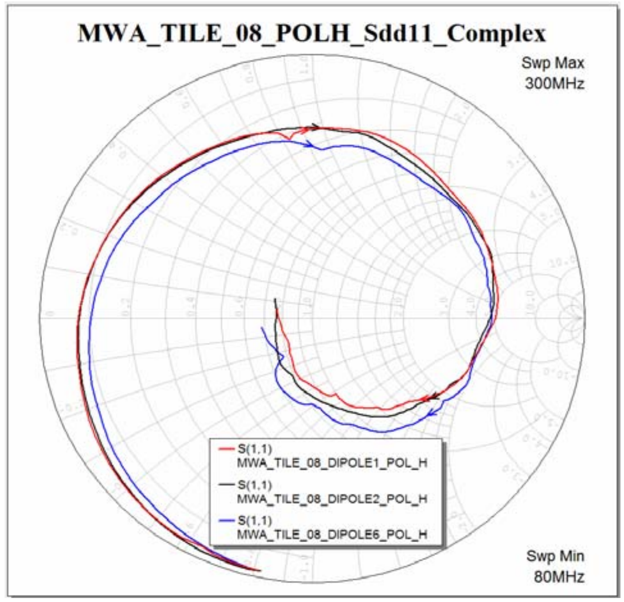

Fig9. Complex impedance of POLH of dipoles #01 , #02 and #06.

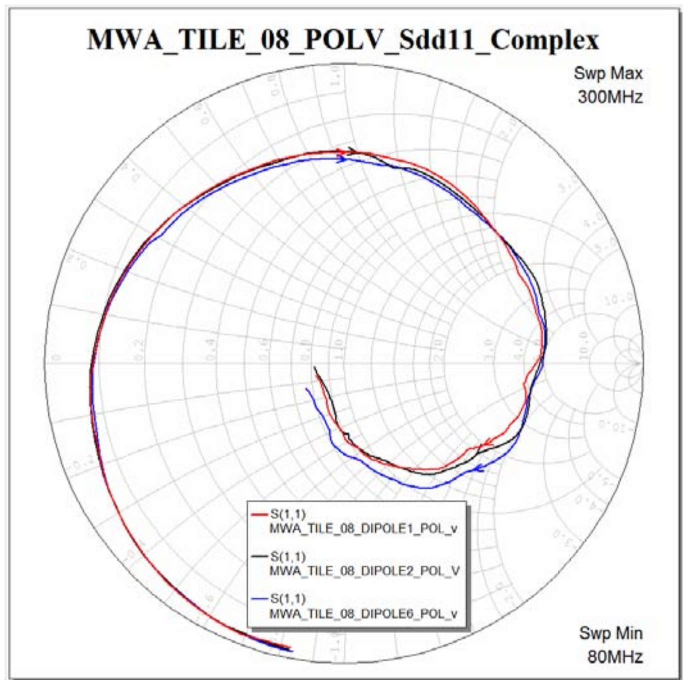

Fig10. Complex impedance of POLH of dipoles #01 , #02 and #06.

During the measurement, we noticed that the impedance of the antenna changes drastically when the antenna terminals (twin leads) were moved and when their shapes changed.

The V polarization of dipole #02 was measured with 5 different terminal configurations; their shape was changed and data was taken to quantify the sensitivity of the antenna impedance to terminals.
Fig 11. shows the change in the complex impedance as the

wire terminals were moved and the spacing between them was varied.

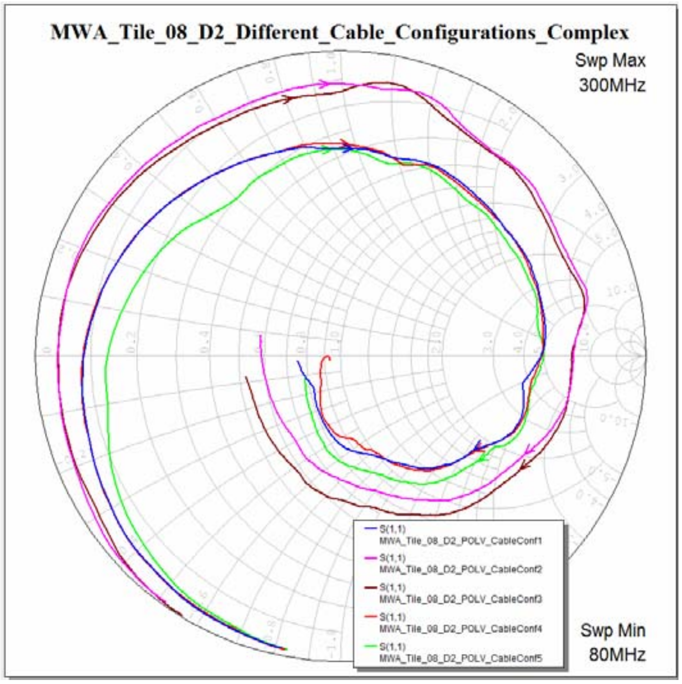

Fig11. Complex impedance of the antenna when the wire terminals shapes were changed 5 times.

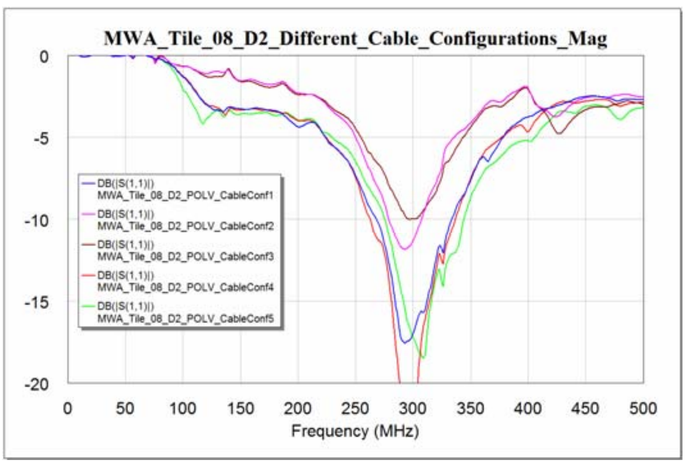

Fig12. return loss variation of the antenna when the shape of the antenna wire terminals were changed. 5 wire terminal configurations were used.

III. MEASUREMEN OF THE COUPLING FACTOR BETWEEN THE 2 POLARIZATIONS OF ONE ANTENNA (DIPOLE#01 OF TILE #08)

2 Baluns and a 2Port VNA were used to measure the coupling between the 2 polarizations of the same dipole. The balun transform the differential output antenna into single ended output which is connected to one of the ports of the VNA for reflection and transmission measurement.

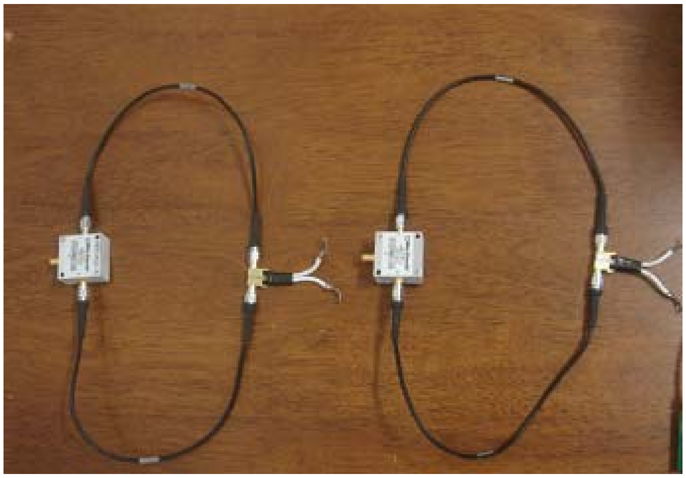

Fig13. Balun and antenna terminals used to measure the isolation between the polarizations of a single antenna as well as the isolation between the antennas within one tile.

Fig14. Connection to the antenna during polarizations coupling measurement.

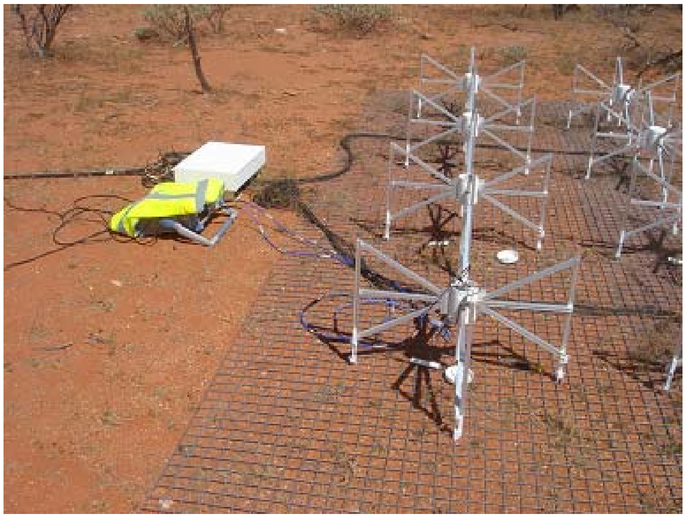

Fig15. Measurement setup showing the antenna, cabling and the VNA.

The loss of the balun was measured and found to be very small and was neglected on this measurement. For this reason, the reference plane for the coupling measurement is the end of the antenna terminals connected to the dipole.
The 2 polarizations measured are equivalent to a 2port network.

The coupling factor between the POL A and B of one antenna was defined as the ratio of the power available from the terminals of POL B to the power delivered to POL A. This definition takes into account power match at the input and output. The antenna is not well matched to the measurement system and most of the power is reflected.
The power available at POL B is the same at the power delivered to the load (in this case port2 of the VNA) in case the antenna is matched.
The power delivered to POLA is equal to the power available from the source (port 1 of the VNA).
The coupling factor definition becomes equivalent to the maximum available power gain (MAG) of the network. The MAG of a 2 port network:

$$GMax = \left| \frac{S_{21}}{S_{12}} \right|$$

Microwave office design software was used to compute the MAG from the measured s parameters.
More detailed derivations are shown on the APPENDIX attached to this report.
Fig16. shows the coupling factor between the 2 polarizations in 2 configurations of the wire terminals to see how much the shape of the terminals affect the coupling.

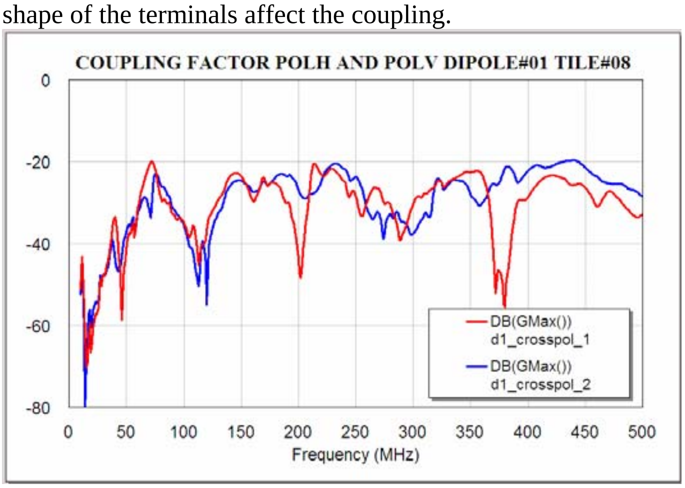

Fig16. coupling factor between POLH and POLV of dipole element #01 of tile #08 neglecting the loss of the balun. 2 measurements were done, wire terminals shape has been changed to see how sensitive the coupling is to the antenna terminal configuration.

The coupling (or isolation) between the polarizations is lower than 20dB up to 500MHz, this does not include any crosstalk between the LNAs.

IV. MEASUREMENT OF THE COUPLING FACTOR BETWEEN ANTENNAS IN ONE TILE (TILE #08)

The same coupling measurement was performed on polarizations of different antennas within the same tile. Again, the coupling factor or the isolation between the tile element was computed as the maximum available power gain of the 2 port network formed y the 2 measured polarizations.

The setup is shown on Fig 17.

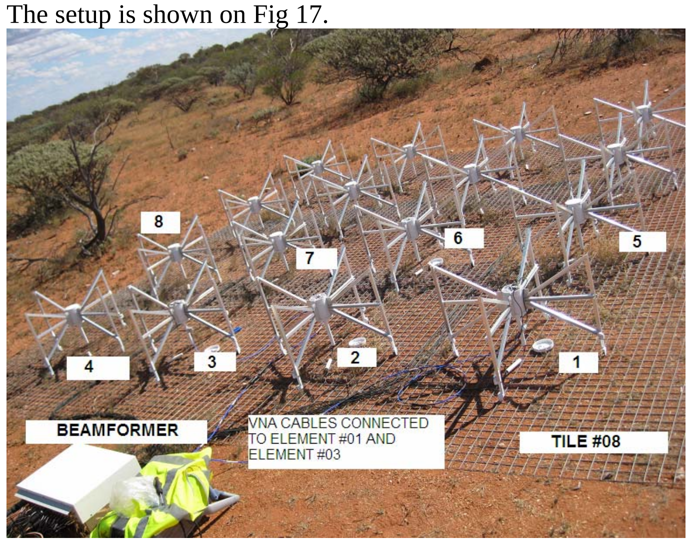

Fig17. setup used to measure the coupling or isolation between the elements of 1 tile.

Fig18. Shows the isolation between POLH of dipole#01 and POLH of Dipole#02 together with the reflection coefficients measured through the balun.

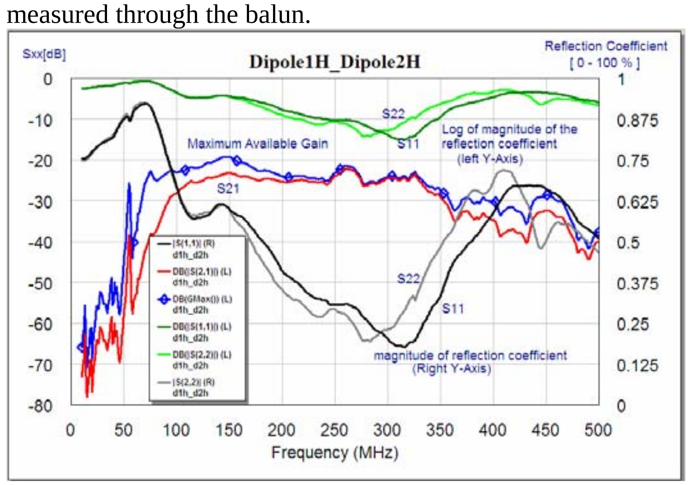

Fig18. blue curve is the isolation between POLH of Dipole1 and POLH of neighboring dipole2.

The same measurement was repeated for combination polarizations on different dipoles to have an idea about the upper limit to the coupling between the elements of the tile. Fig19. shows a data for a few combinations of tile elements.

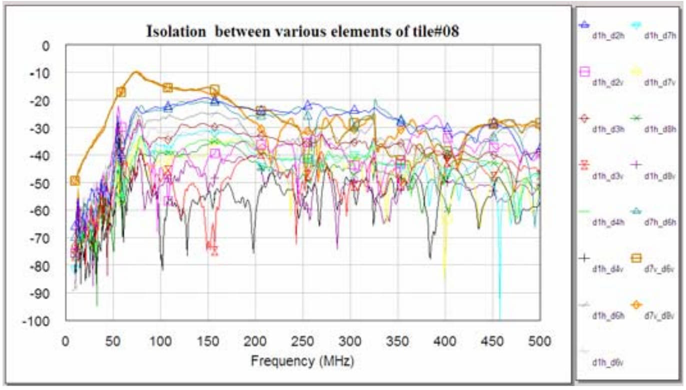

Fig19. Isolation between a number of elements of tile#08.

The isolation between the elements is better than -20dB (100 times power attenuation) except dipole 7V-6V and 7V-8V.

The isolation between dipole 6 and 7 is show on fig20 for POLH and POLV.

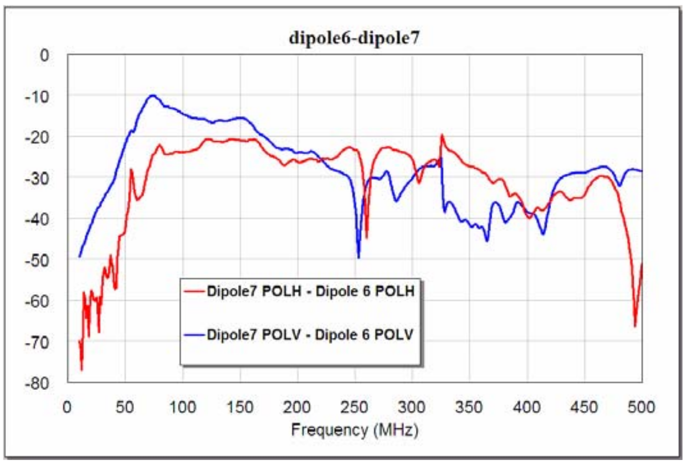

Fig20. The isolation between POLH dipole 6 and 7 is better than 20dB but for some reason the isolation between POLV of the same dipoles is worse and reach 10dB. This can be a measurement error. The measurement should be repeated.

V. PARAGRAPH 3

VI. CONCLUSION & DISCUSSION

VII. ACCOMPANYING FILES

AKNOLWEDGEMENT

REFERENCES

[1]
[2]