EDGES Measurements

Hamdi Mani, Judd Bowman

***Abstract*—the impedance of the dipole antenna used for the EDGES experiment was measured in 2 locations: the roof of one of ASU buildings and at the deployment site. It was found that the antenna has better than 10dB return loss relative to 50 ohm reference impedance or, equivalently, 0.32 reflection coefficient on its operating bandwidth: 100-200 MHz. The impedance was found to vary significantly in the band.**

***Index Terms*— Dipole Antenna, antenna output impedance, low frequency radio astronomy.**

I. Introduction

The EDGES antenna is a four-point dipole designed by A. Rogers and J. Bowman. The antenna is dual polarization but only one polarization is used. The output of the antenna is differential and a balun was connected to transform the balanced output to single ended. This allowed connection to a single ended low noise amplifier.

II. Antenna impedance measurement at ASU

The EDGES antenna was measured on the roof of the physics building at ASU without ground screen. The location is not optimum because of reflections from different walls and objects, this measurement was done to check the setup and instrument and prepare for the trip to MRO where better impedance measurements were done. The S11 measurement was done using the R&S ZVL3 vector network analyzer calibrated at the end of a long coax cable.

Fig1. Impedance measurement setup on the roof of ASU's PSF building, the antenna was positioned as far as possible from the walls. Data was recorded when all persons are in a sitting position to minimize reflections.

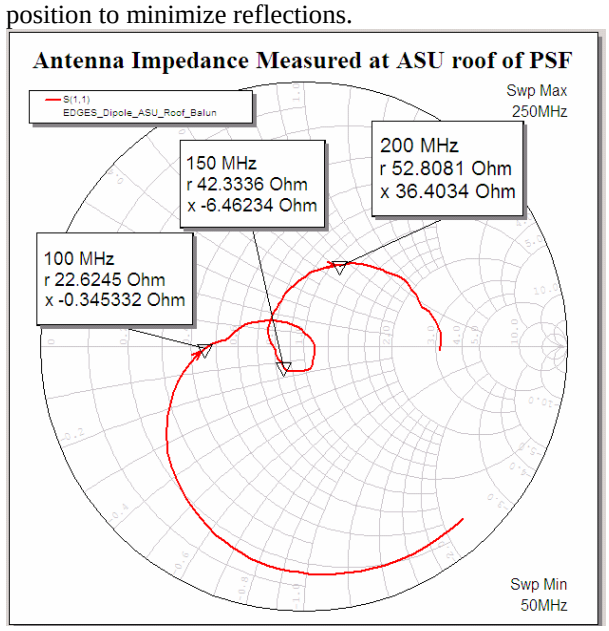

Fig2. Complex impedance in a Smith chart

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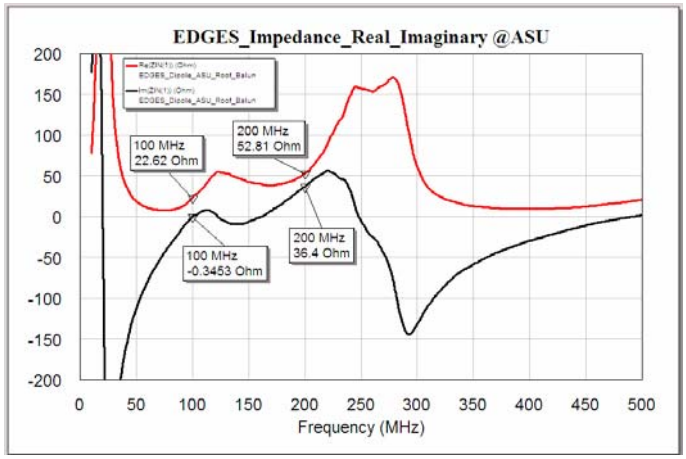

Fig3. Real and Imaginary part of the impedance.

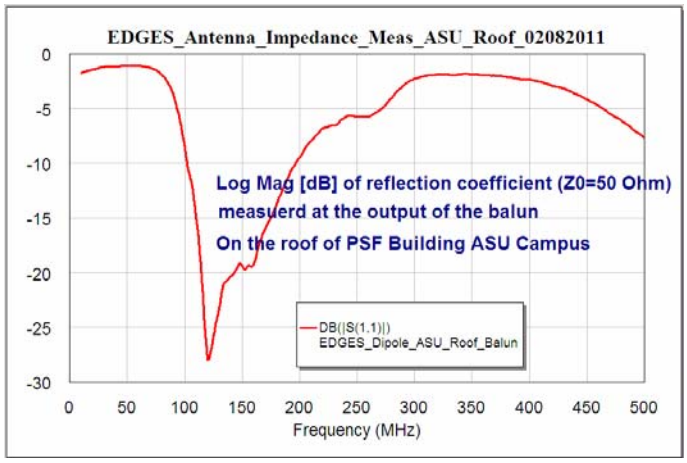

Fig3. The return loss (s11 [dB]) of the antenna relative to 50 ohm.

The return loss of the antenna was measured before by one of the authors at MIT, Fig4. shows the data for different dipole spacings.

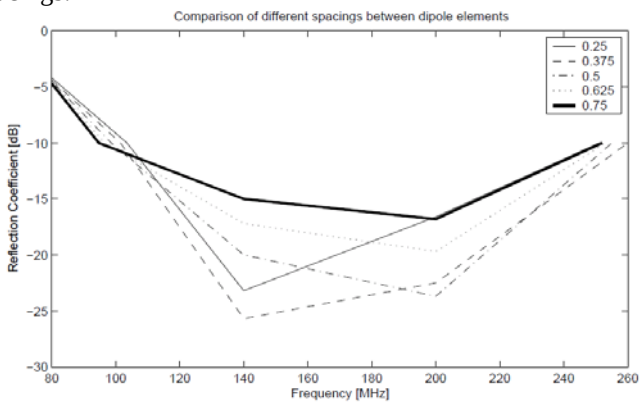

Fig4. Return loss (S11 [dB]) of the antenna measure by J. Bowman at MIT, this data is comparable with the data taken at ASU.

III. MEASUREMENT OF THE EDGES BALUN

The baluns used for EDGES were measured on a 3 port network analyzer after replacing the 2 input terminals (used to connect to the antenna) by SMA connectors. The input and output match of few baluns were measured as well as amplitude and phase balance.

A careful calibration was performed on the R&S ZVA24 VNA using an electronic calibration unit and phase/amplitude stable RF cables.

Fig5 shows the measurement setup

Fig5. From Left to right: Balun with terminals, balun with SMA connectors and balun connected to the 3 port of a 4-port VNA during measurement.

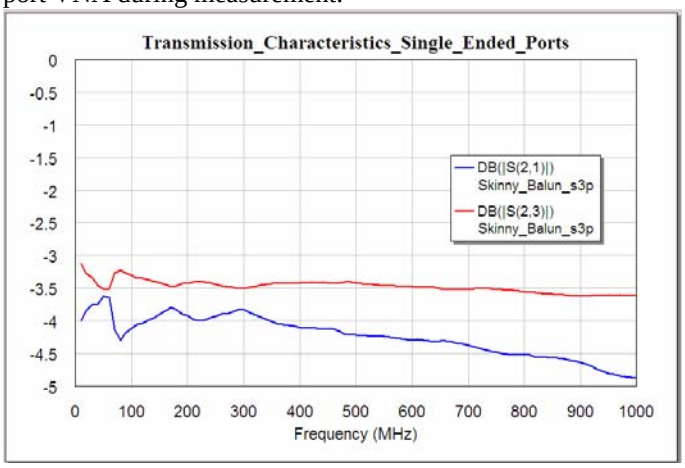

Fig6. Tranmission from Port1 to Port2 (Blue trace) and from Port 3 to Port 2 (red trace).

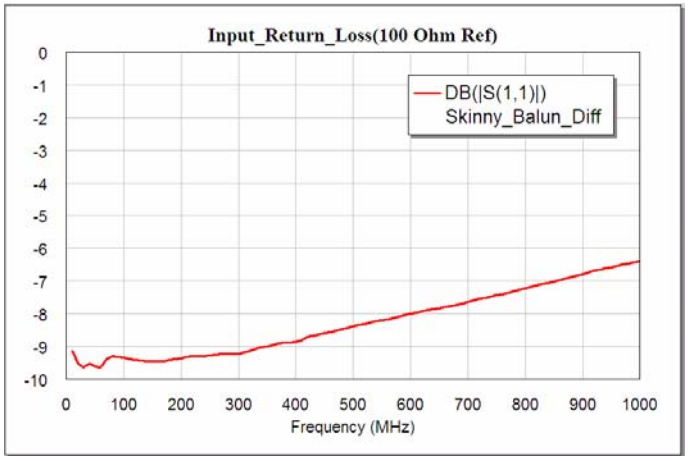

Fig7. Input return loss relative to 100 ohm reference impedance.

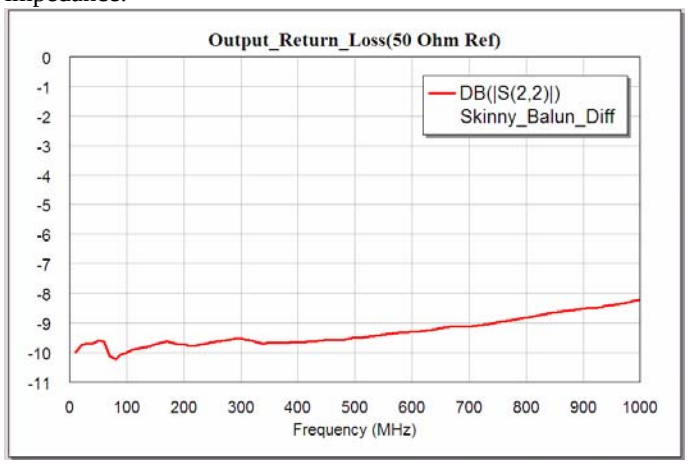

Fig8. Output return loss relative to 50 ohm reference impedance.

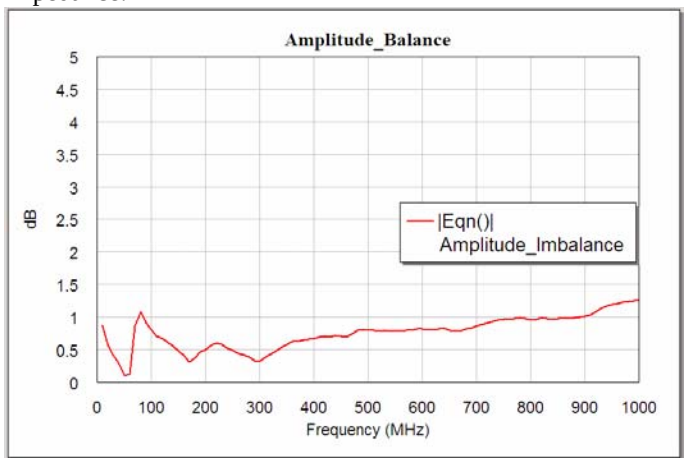

Fig9. Amplitude balance of the balun

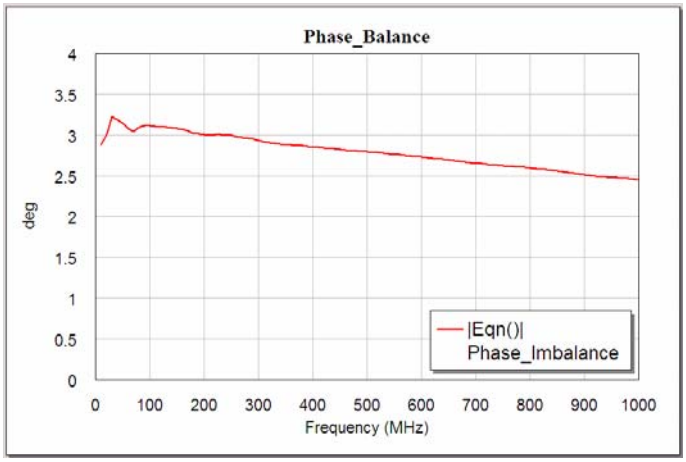

Fig10. Phase balance of the balun.

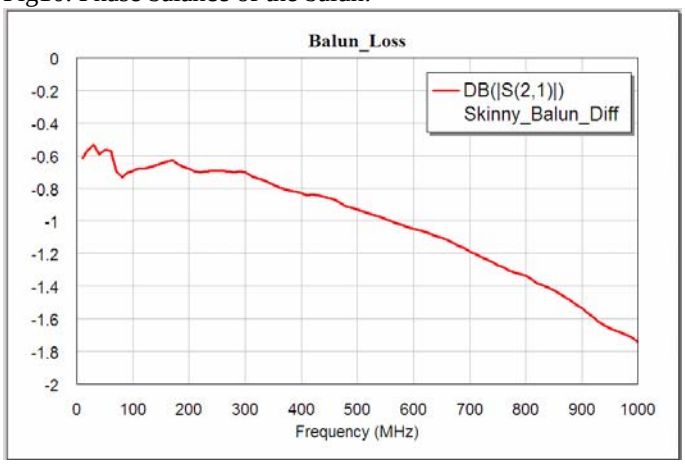

Fig11. Loss of the balun as measured by the 3 port VNA.

Fig12. Balun with compensating ferrite choke.From Left to right: Balun with terminals, balun with SMA connectors and balun connected to the 3 port of a 4-port VNA during measurement.

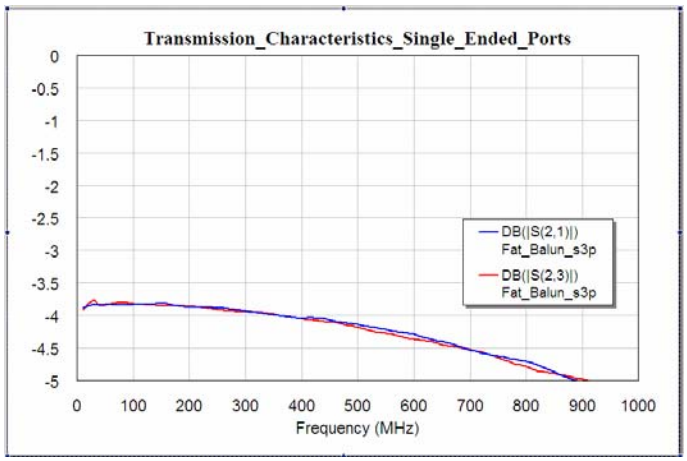

Fig13. Transmission from Port1 to Port2 (Blue trace) and from Port 3 to Port 2 (red trace).

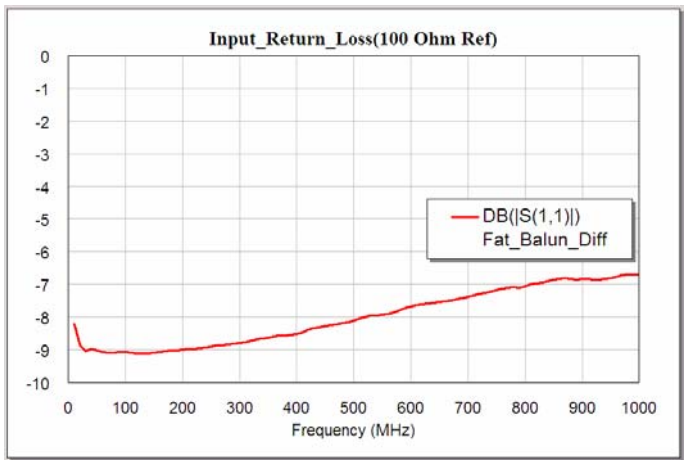

Fig14. Input return loss relative to 100 ohm reference impedance.

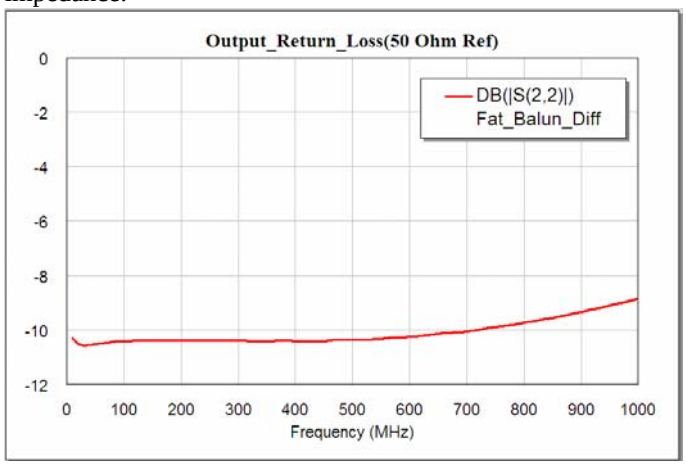

Fig15. Output return loss relative to 50 ohm reference impedance.

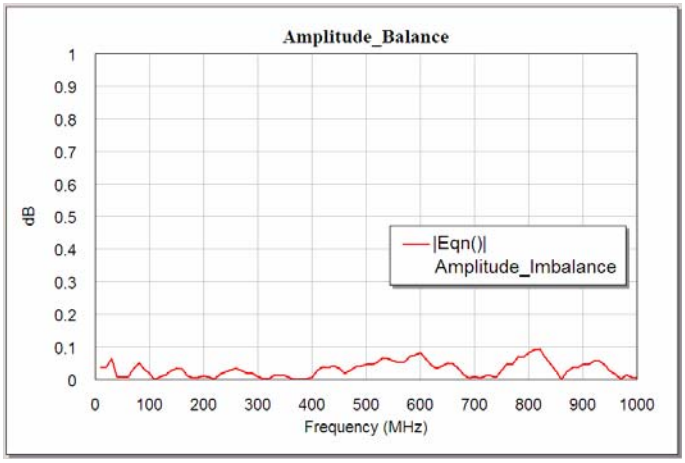

Fig16. Amplitude balance of the balun

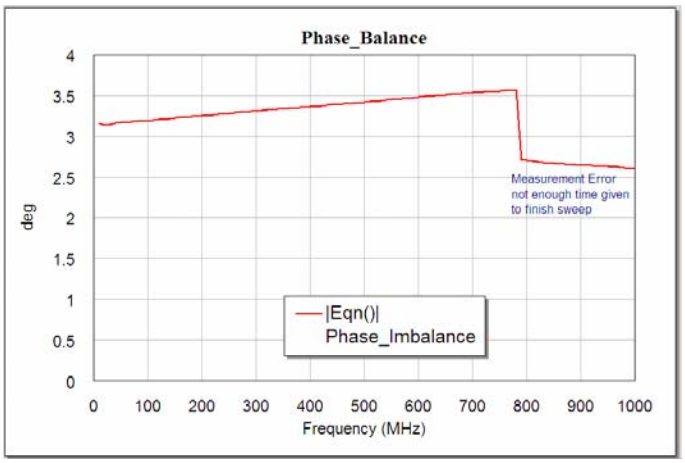

Fig17. Phase balance of the balun

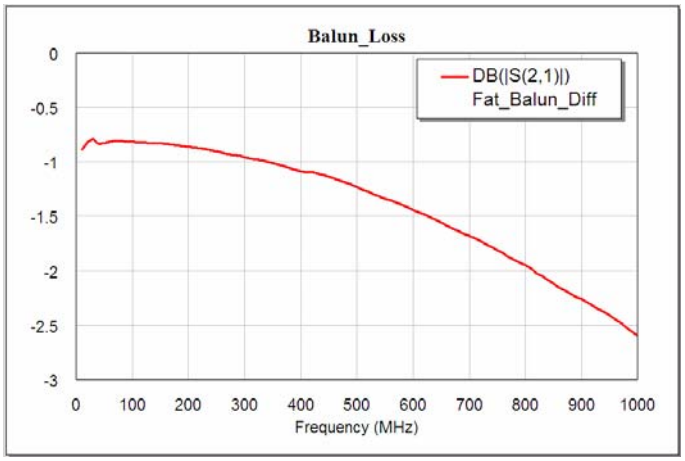

Fig18. Loss of the balun.

The Mini-circuit Balun Part # ZFSCJ-2-1-S was measured to compare.
Fig19 shows the measurement setup.
Fig20 to Fig 19 shows the collected data.

Fig19. the mini circuits connected to the 3 ports of the 4-port VNA.

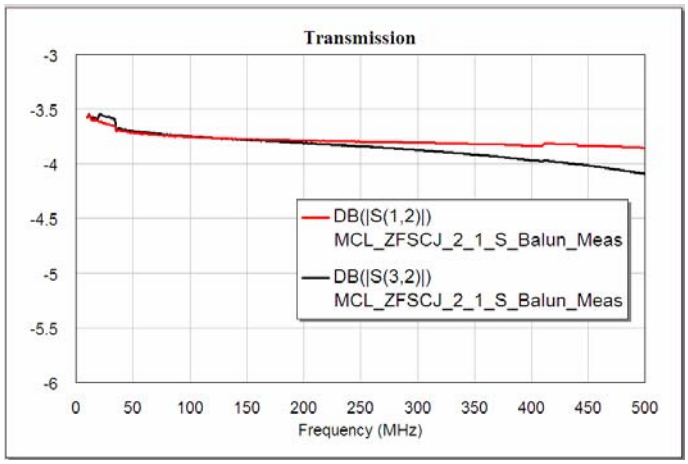

Fig20. Transmission from Port1 to Port2 (Blue trace) and from Port 3 to Port 2 (red trace).

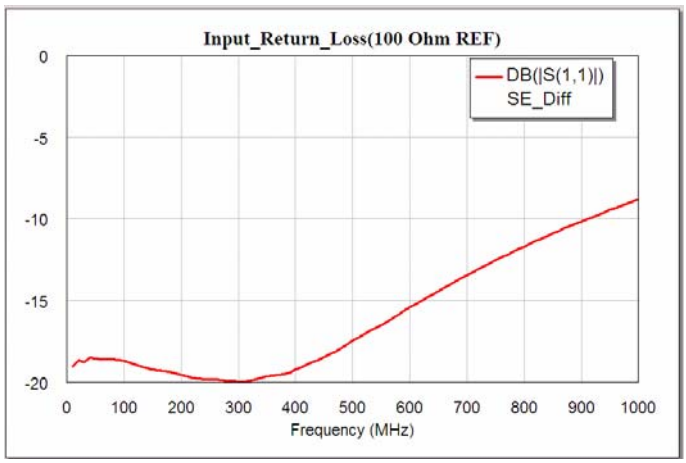

Fig21. Input return loss relative to 100 ohm reference impedance.

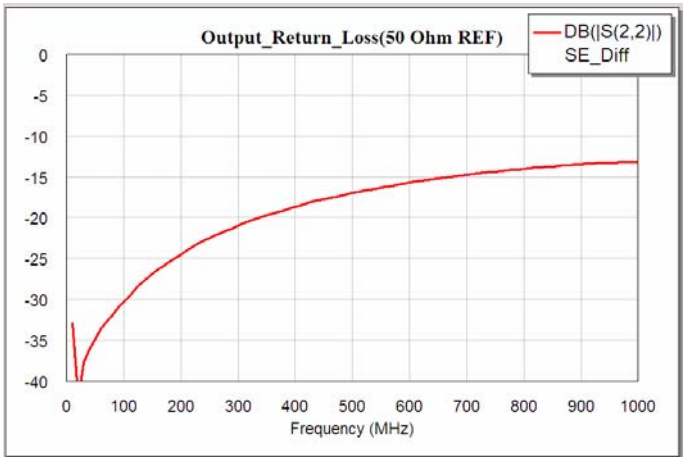

Fig22. Input return loss relative to 100 ohm reference impedance.

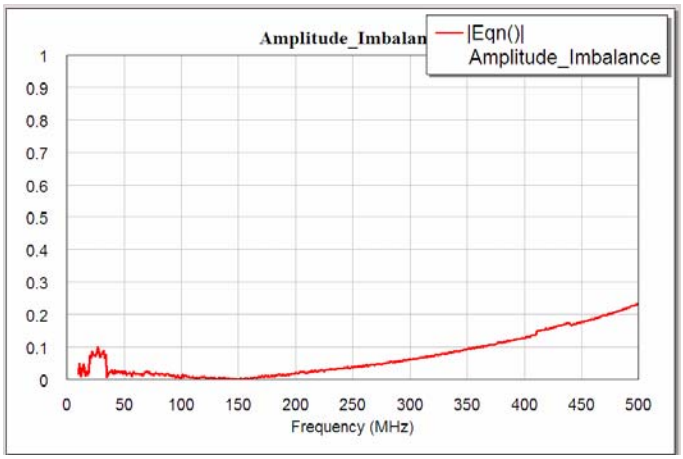

Fig23. Amplitude balance of the balun

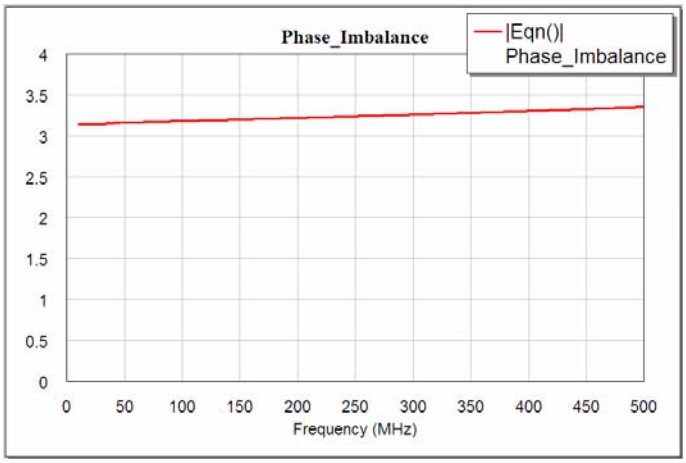

Fig24. Phase balance of the balun

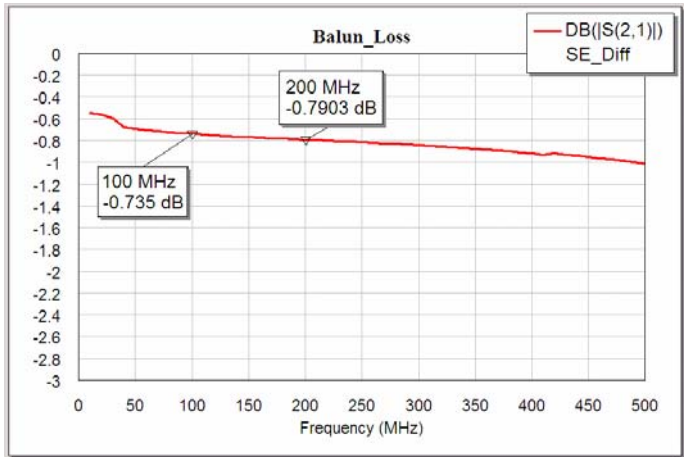

Fig25. Loss of the MCL balun.

The losses of the three baluns is shown on one plot for comparison:

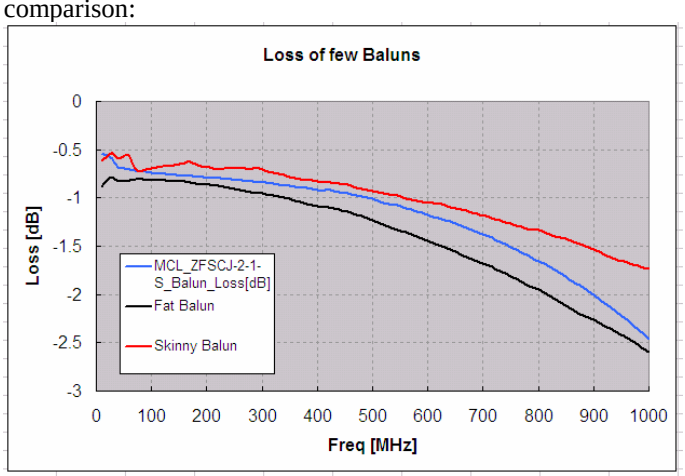

Fig26: the three measured baluns have comparable loss.

IV. IMPEDANCE MEASUREMENT OF EDGES ANTENNA AT THE MURCHISSON RADIO OBSERVATORY

The impedance of the antenna was measured when the system was deployed at the MRO. A portable vector network analyzer was used to take 10 measurements of the impedance of the antenna, the VNA was remotely controlled to avoid having people close to the antenna and minimize reflections.

Fig27. EDGES system during antenna impedance measurement.

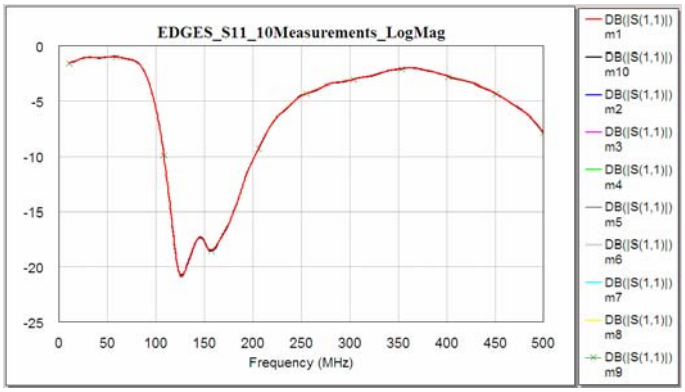

Fig28. 10 impedance measurements were taken

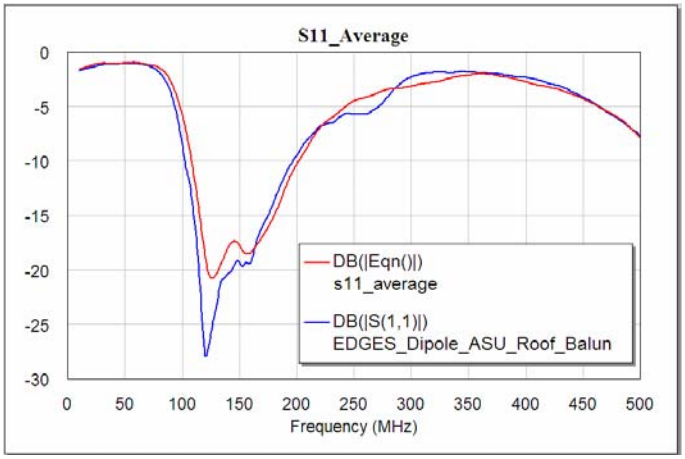

Fig29. The 10 impedance measurements were averaged and shown with the impedance measured on Campus.

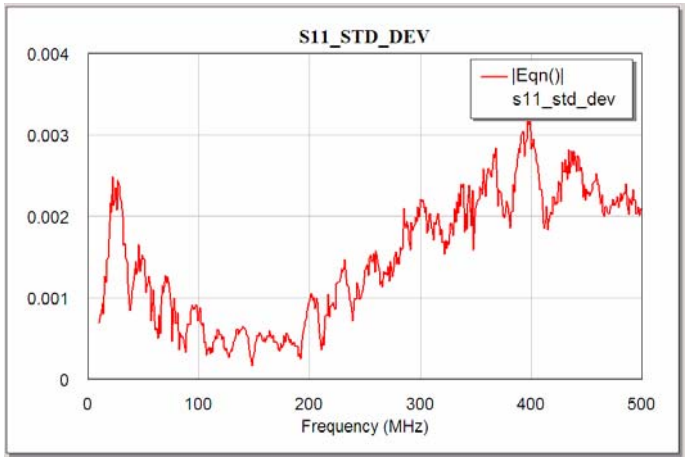

Fig30. The std dev (or RMS) of the 10 s11 measurements. This tells us the error on the measurement.

V. EDGES FRONT END LNA MEASUREMENTS

The EDGES system has a very low noise front end amplifier preceded by a switch that connects the input of the amplifier to the antenna or to a calibration noise source.

The s-parameters of the LNA were measured on the lab. Fig31. shows the gain, input and output power matches of the amplifier.

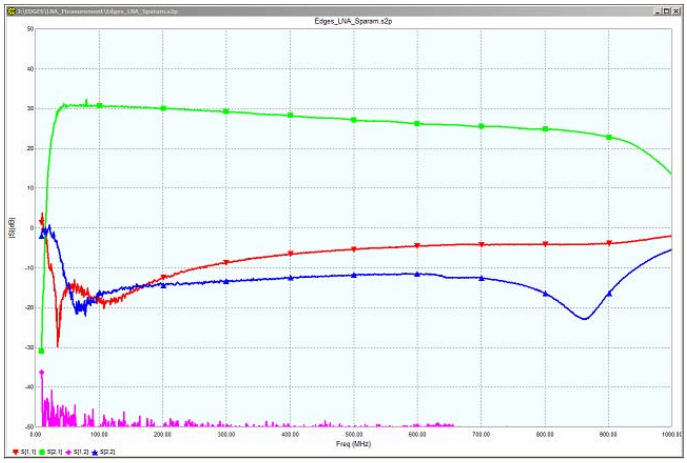

Fig31. s parameters of the EDGES LNA measured on the Lab. Green curve: S21, Red Curve: S11, Blue Curve:S22, Magenta Curve: S12.

The s11 of the LNA was measured on the field when the system was deployed.

Fig32 shows 3 s11 measurements taken on the field when the output of the amplifier was connected to the rest of the system.

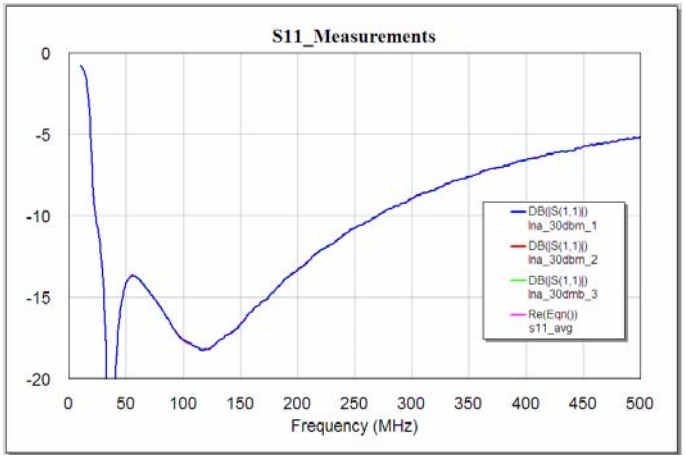

Fig32. LNA s11 measurements on the field.

Fig33 shows the error on the measurement.

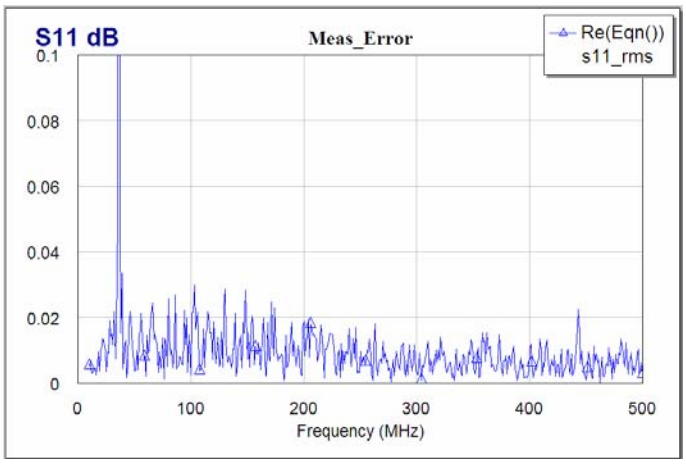

Fig33. error on the measurement of the magnitude of the s11 of the EDGES LNA as measured on the field.

The noise of the LNA was measured on the Lab using a spectrum analyzer and a calibrated noise source (HP346C).

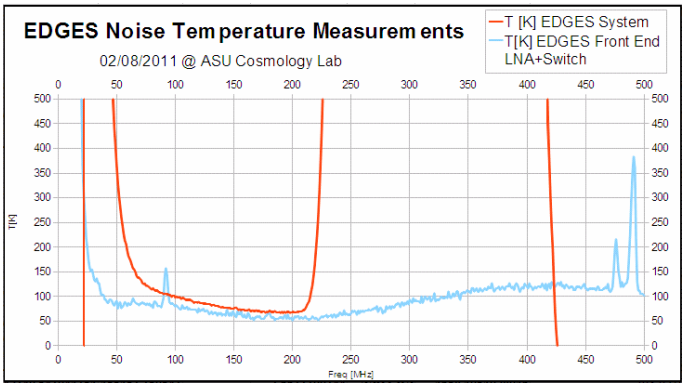

Fig34. Noise temperature of the EDGES LNA including the input switch in 2 configurations: LNA alone and LNA connected to the rest of the system.

VI. EDGES FRONT END CALIBRATION NOISE SOURCE.

The noise output of the calibration source that is used to calibrate the system was measured using a commercial noise source.

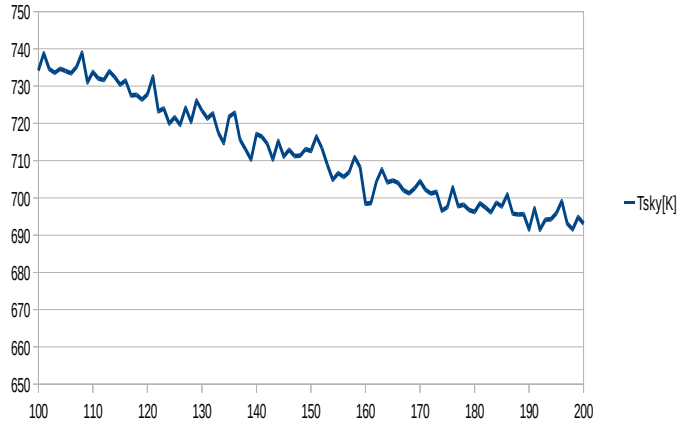

Fig35. EDGES Tcal on the 100-200MHz in a blown up scale showing the ripple in the measurement.

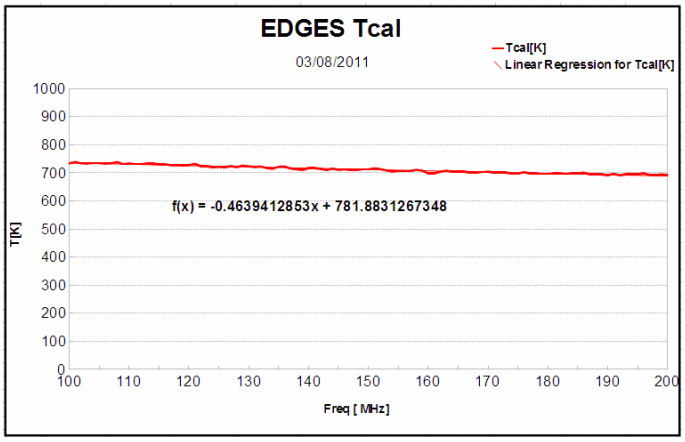

Fig36. Noise cal signal on the 100-200 MHz band. The measured data was fitted with a line.

VII. EDGES TOTAL SYSTEM GAIN

The total gain the EDGES receiver was measured on the lab. This is the gain of the LNA and the receiver and includes the long coaxial cable connecting the system to the back end computer.

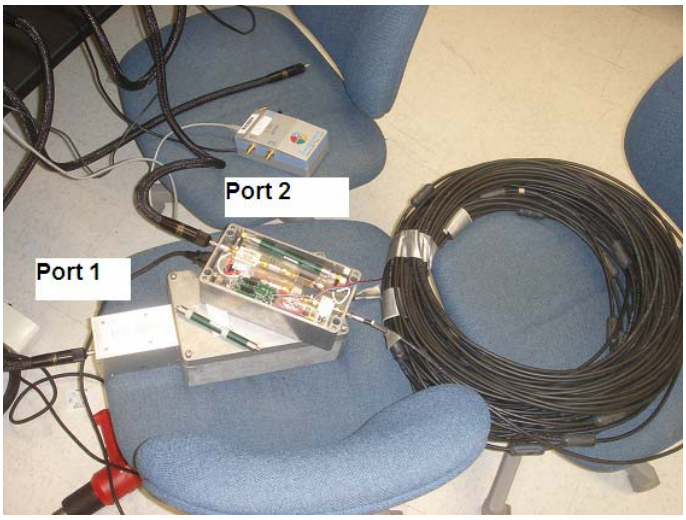

Fig37. setup used to measured the total gain of the EDGES system. Port1 is connected to the input of the front end LNA and port2 is connected to the output of the long coax xable.

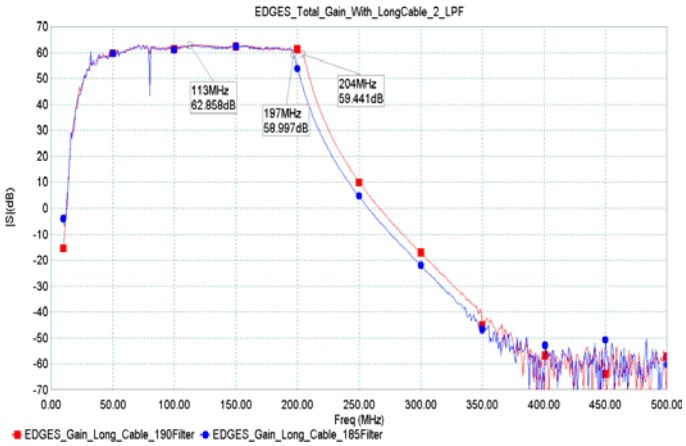

Fig38. Total gain of the EDGES system showing more than 60dB of gain on the middle of the band. 2 measurements were done with 2 different filters.

VIII. PARAGRAPH 3

IX. CONCLUSION & DISCUSSION

X. ACCOMPANYING FILES

AKNOLWEDGEMENT

REFERENCES

[1]
[2]
[3]

APPENDIX : BALUN DATA