

Microwave Measurement of eCloud using Resonant Cavity Technique in the Main Injector (MI)

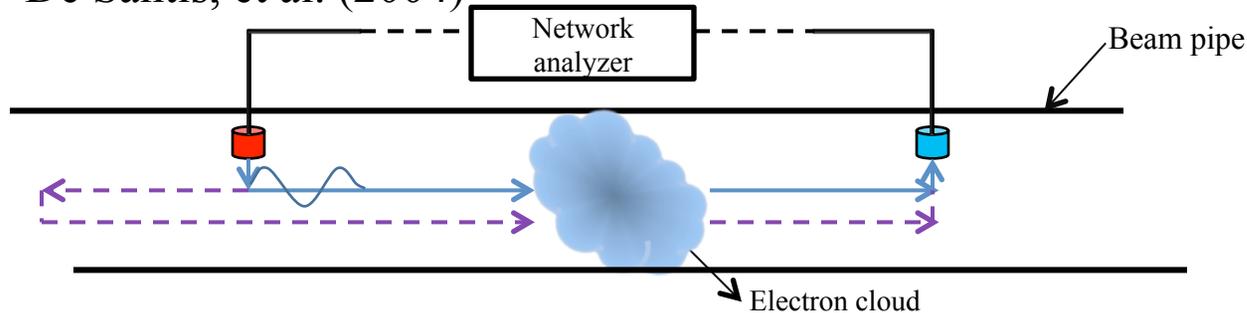
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- Mentor : Charles Thangaraj

Objectives of the project

- Measurement of electron cloud density (ECD) in a small section of MI using microwave technique
- Use of ears to:
 1. enhance the signal of the phase shift
 2. Create a cavity-like space
 3. protect the antennas from beam loss
- Presence of two dipole magnets between the transmitter and receiver antennas that also enhance the signal of the phase shift

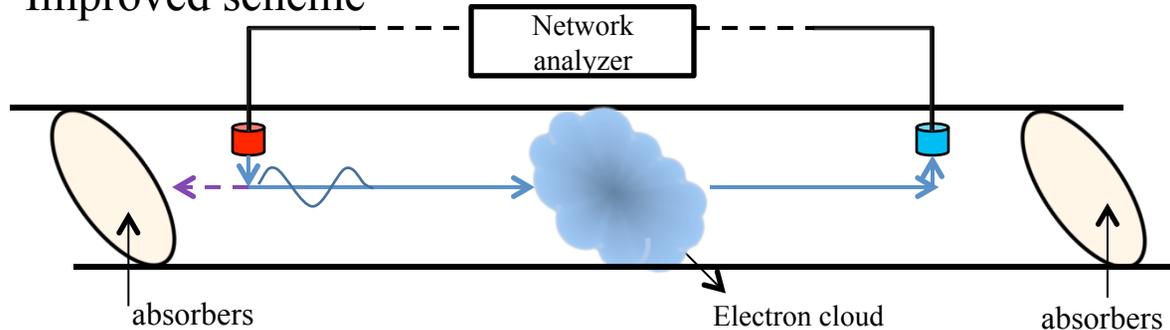
Experimental methods

- De Santis, et al. (2004)



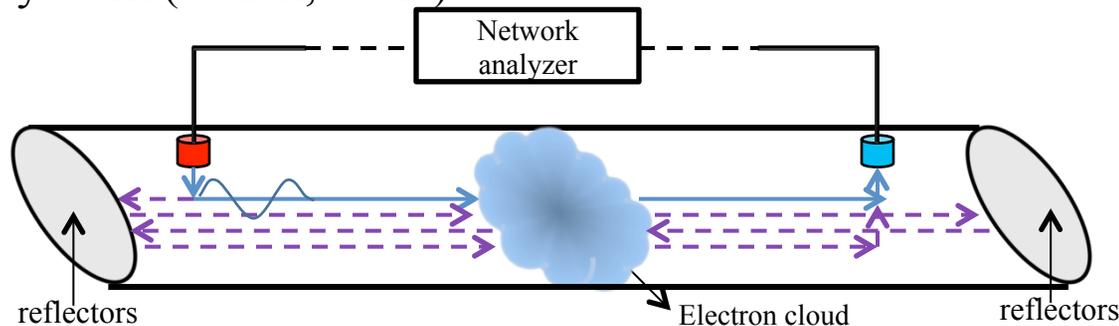
- **Big unlocalized** phase shift signal due to unwanted reflections.

- Improved scheme



- **Small localized** phase shift.

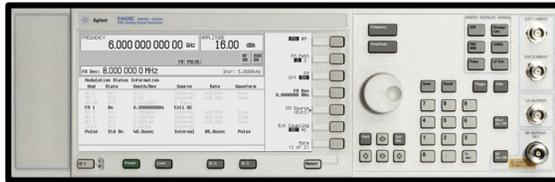
- My work (C. Tan, et al.)



- **Big localized** phase shift due to localized reflections.

Equipment specifications

Signal Generator

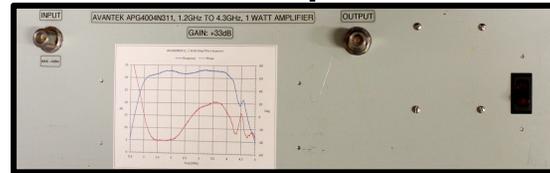


Agilent
E4428C

Max Amplitude:
20 dBm

Bandwidth:
250 kHz to 6.0 GHz

Power Amplifier

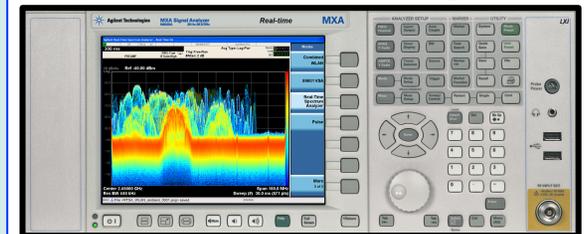


Avantek
APG4004N311

1 W amplifier
+33 dB gain

Bandwidth:
1.2 GHz to 4.3 GHz

Spectrum Analyzer



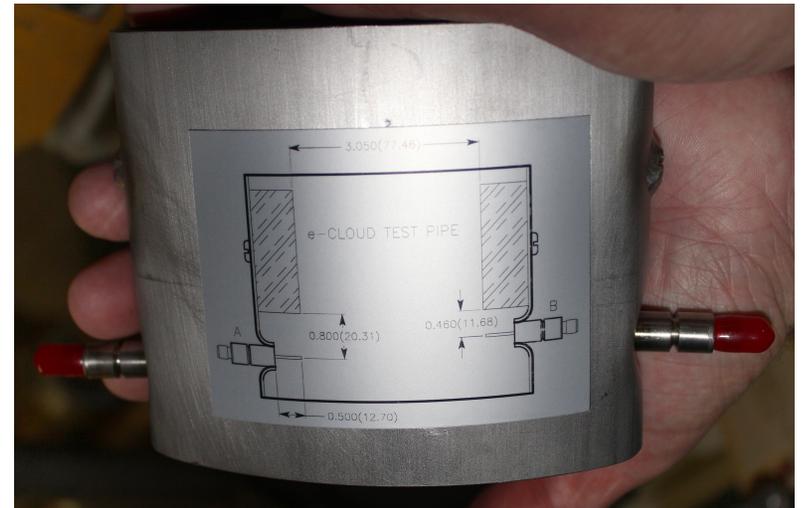
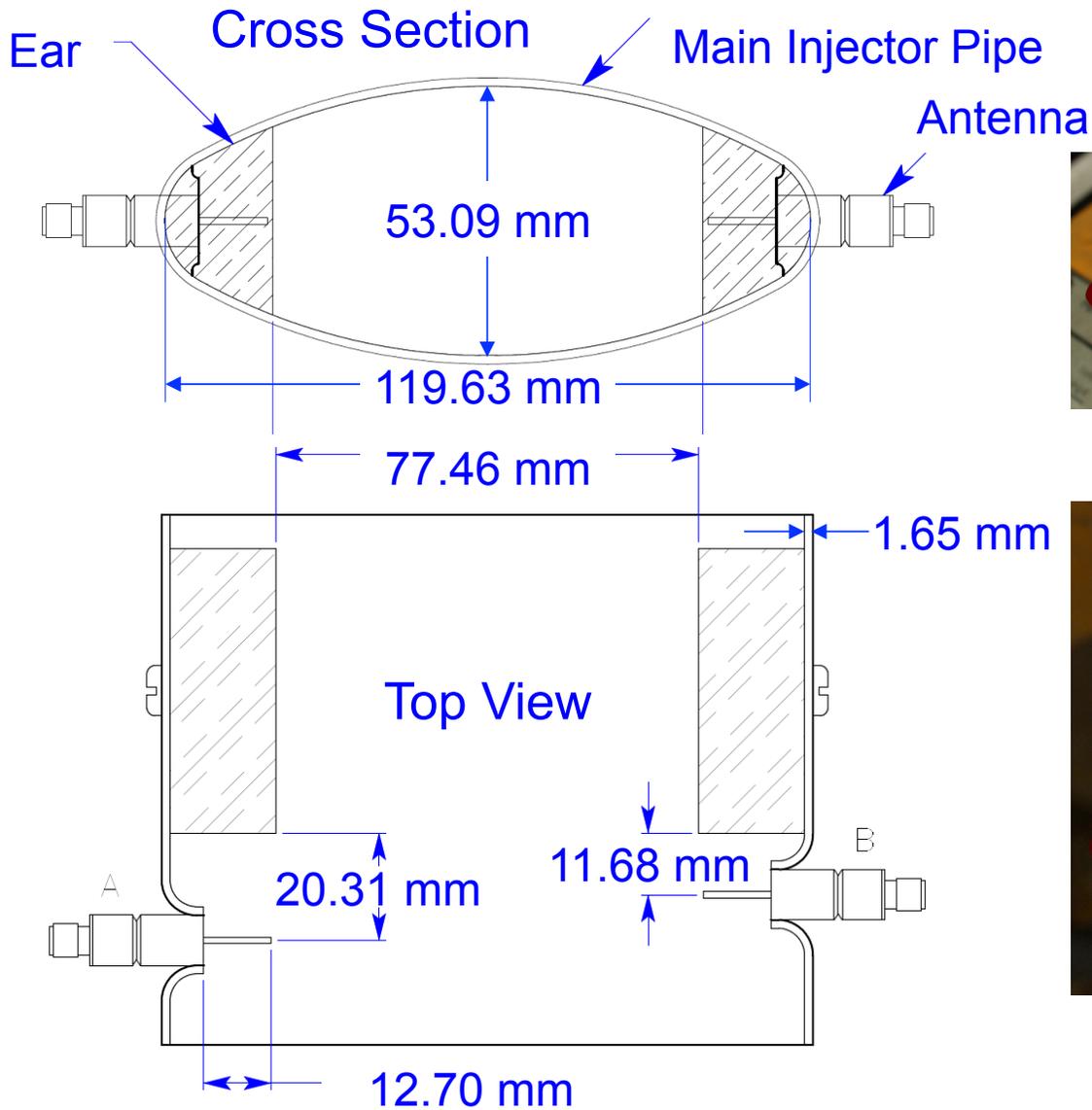
Agilent
N9020A

Bandwidth:
20 Hz to 13.6 GHz

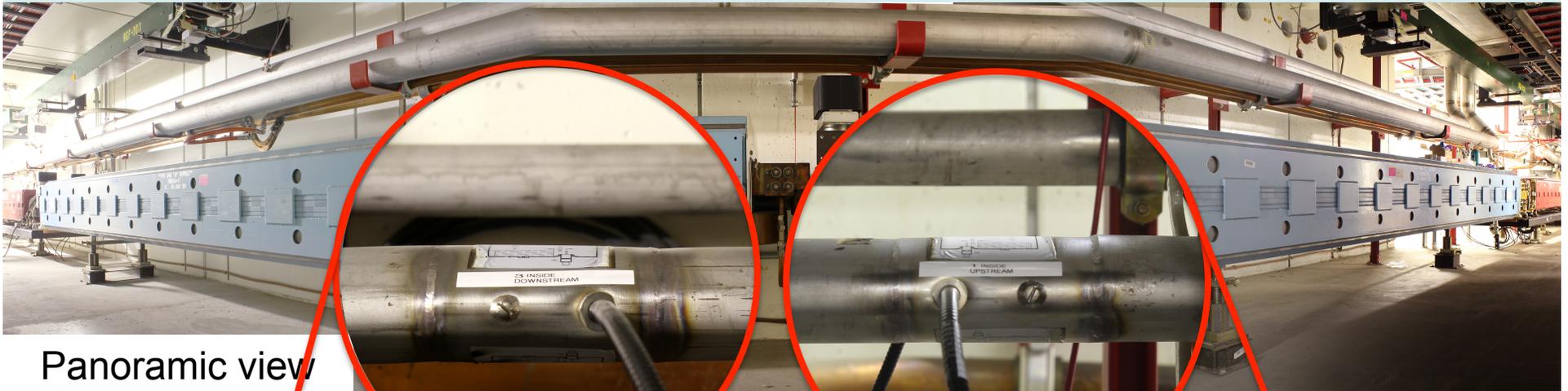
Assembly of the equipment at MI-20



Mechanical Drawings and photos of the detector



Section of the pipe used in the measurements



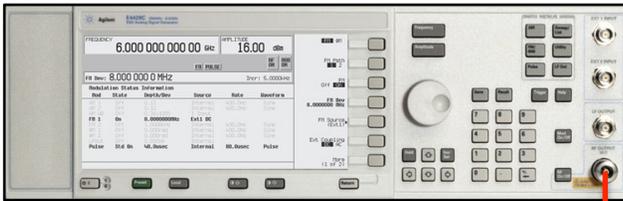
Panoramic view



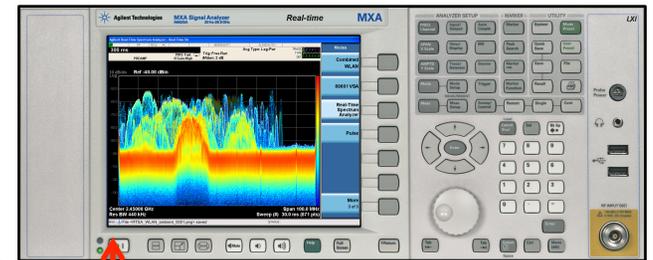
Shortened view

Schematic of the experimental setup

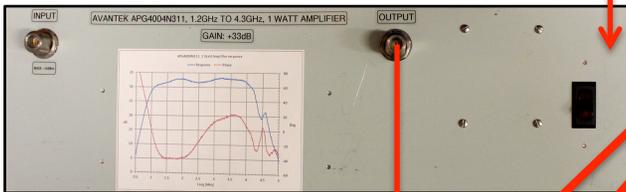
Signal Generator



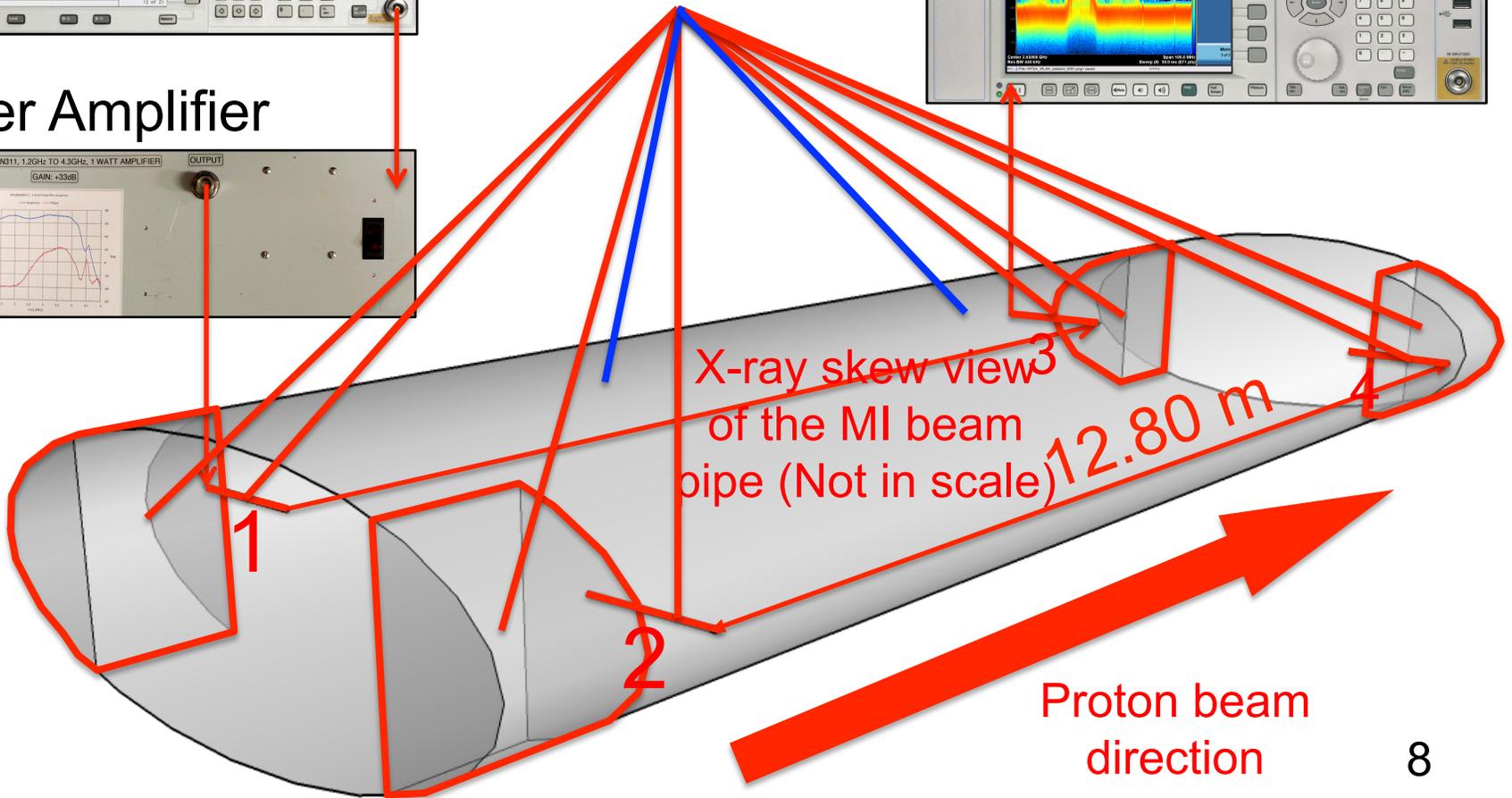
Spectrum Analyzer



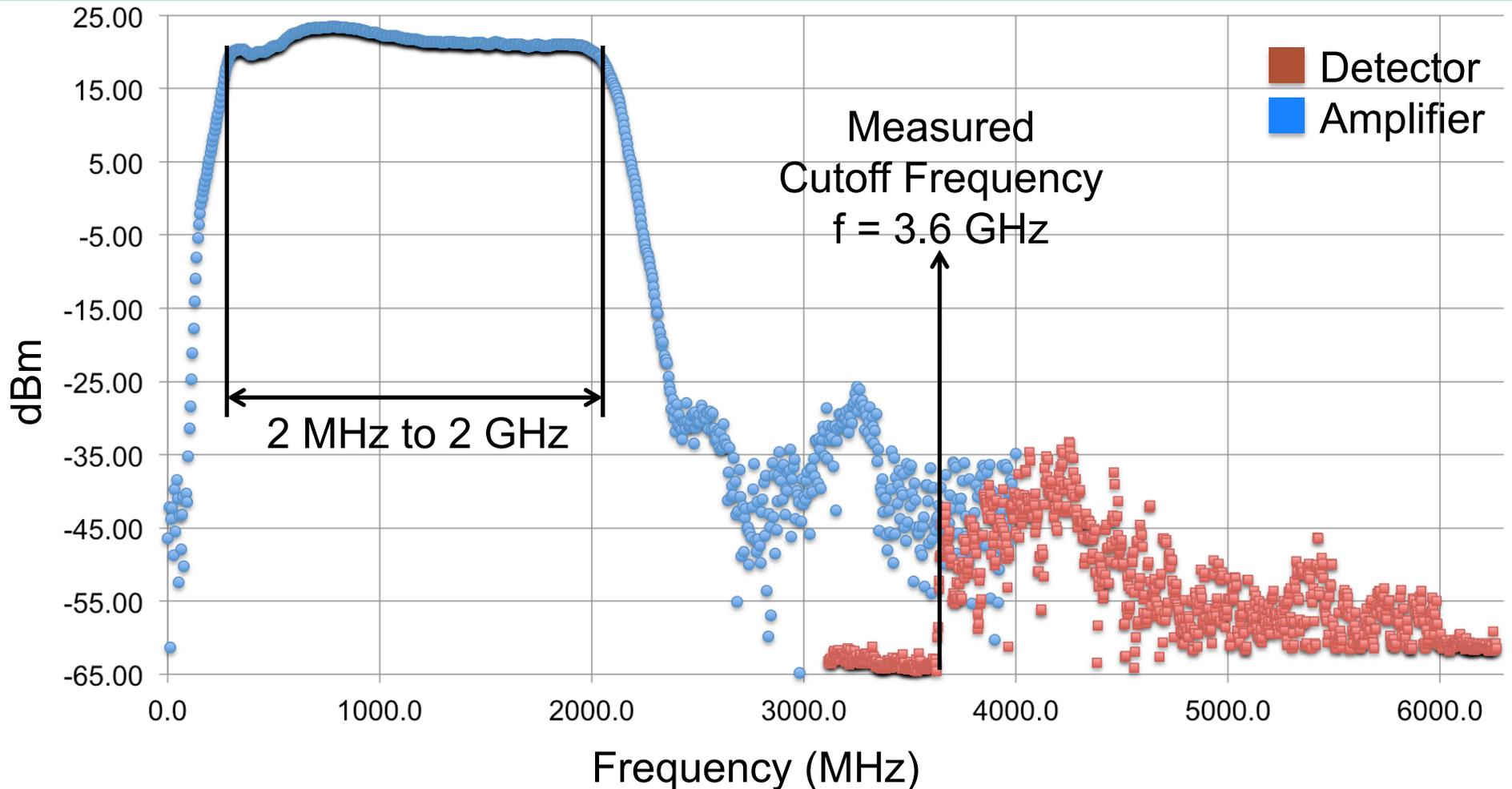
Power Amplifier



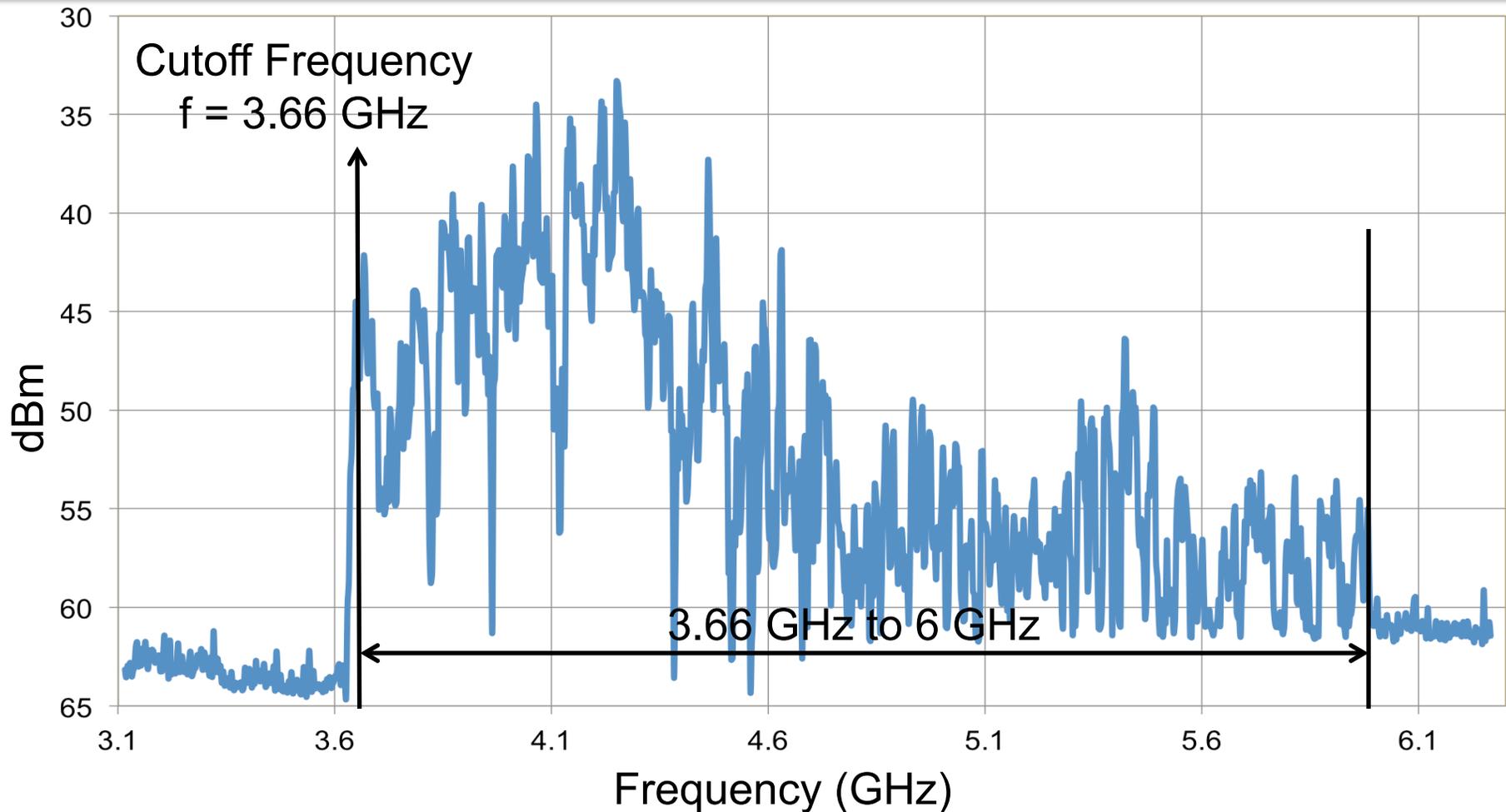
Two FEM 2401
Dipoles



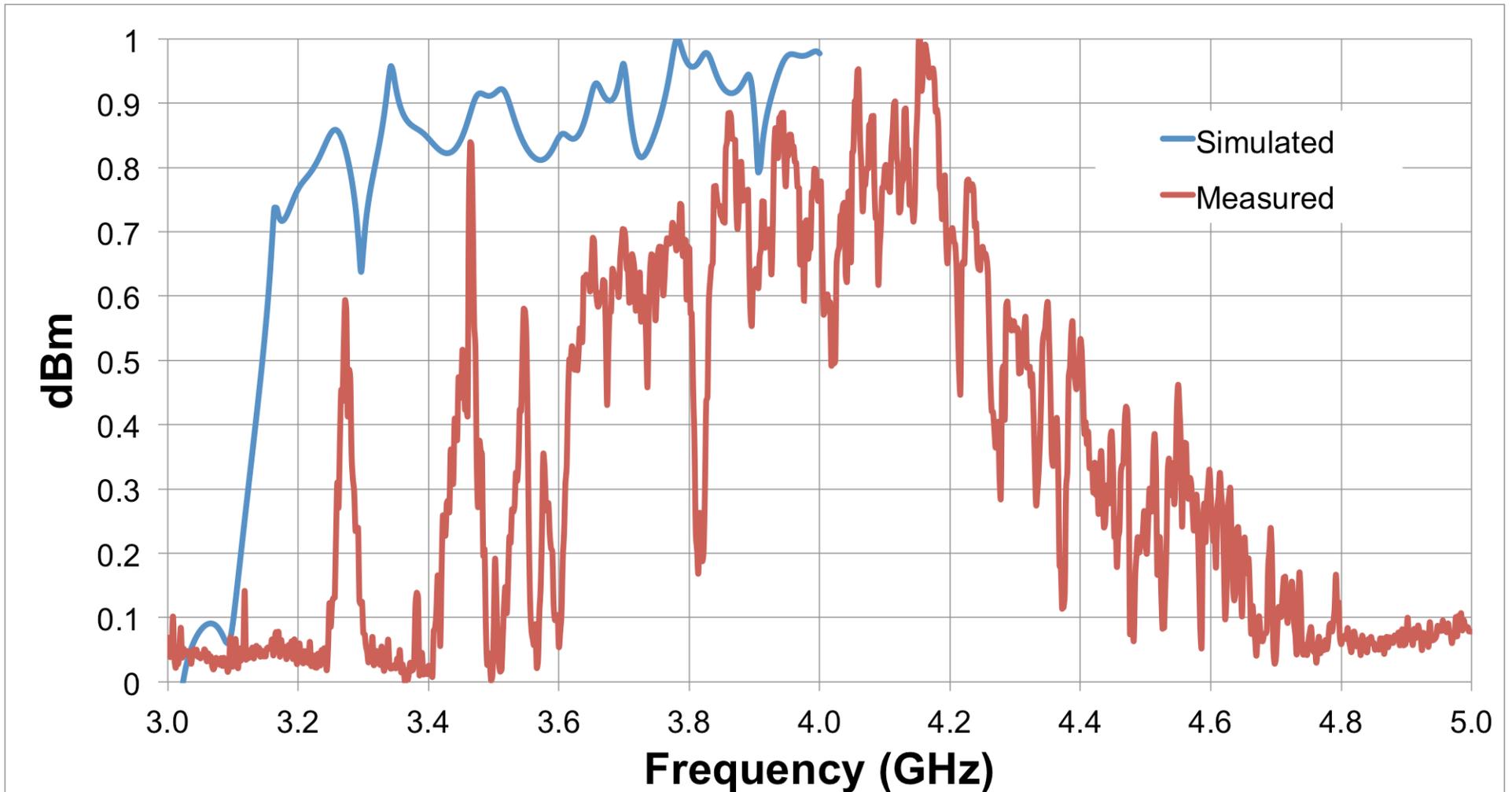
Power amplifier I bandwidth and signal from detector (no amplifier)



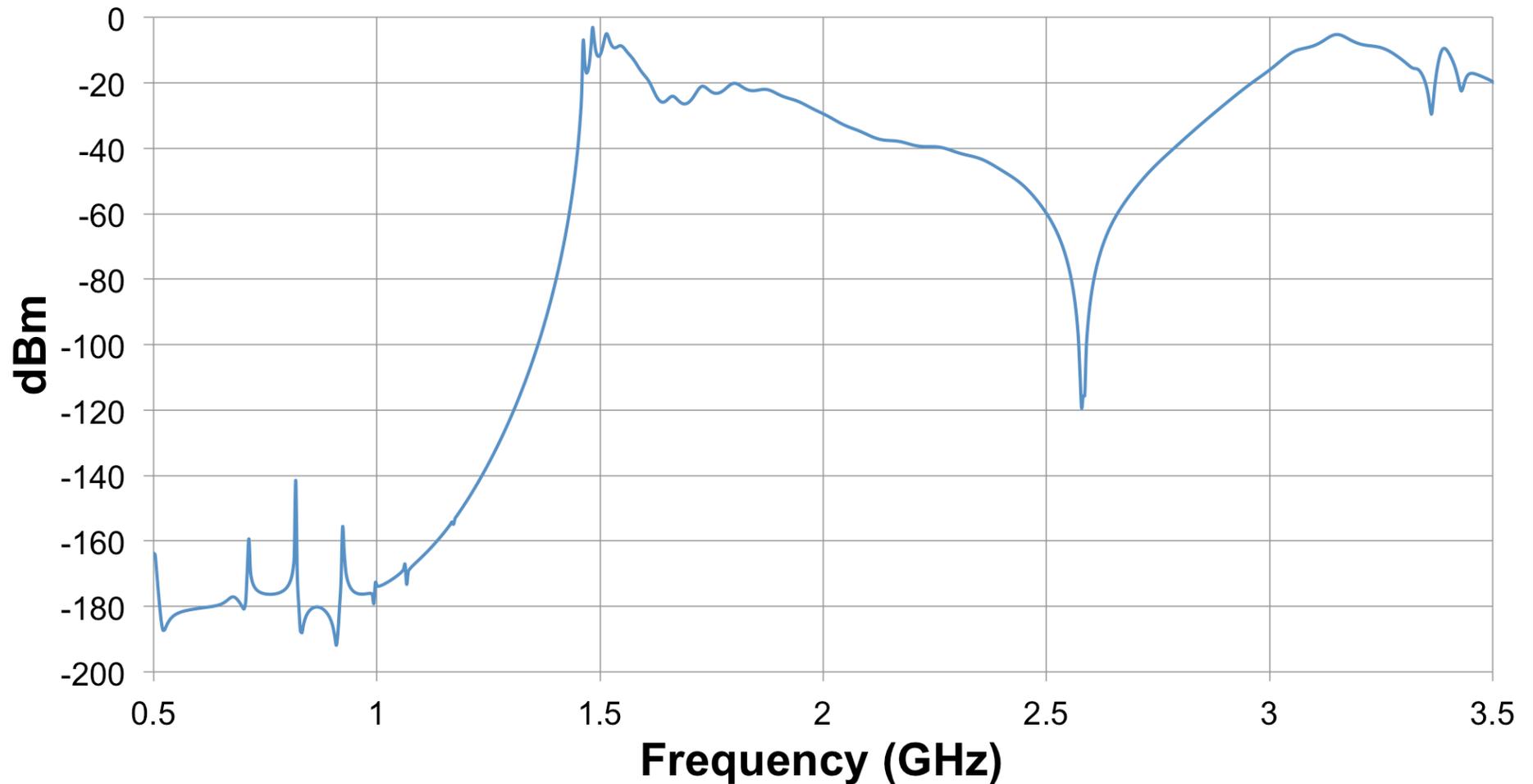
S_{21} – antennas 1 to 3 – no beam and no amplifier



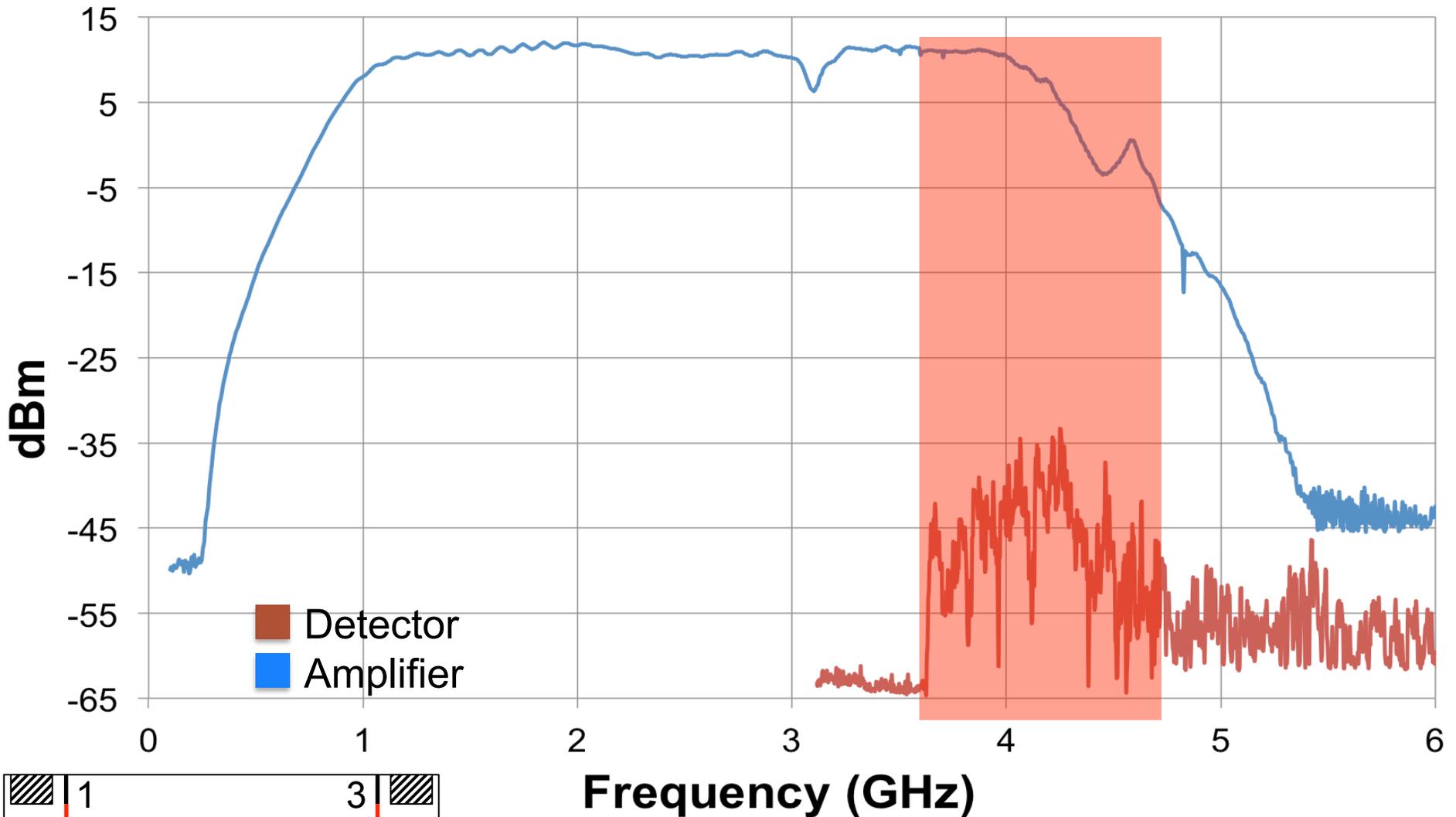
Simulation using CST Microwave Studio (MI experimental setup)



Simulation using CST Microwave Studio (Dipole Antenna)

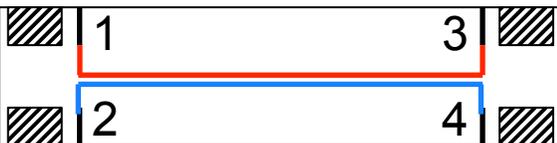
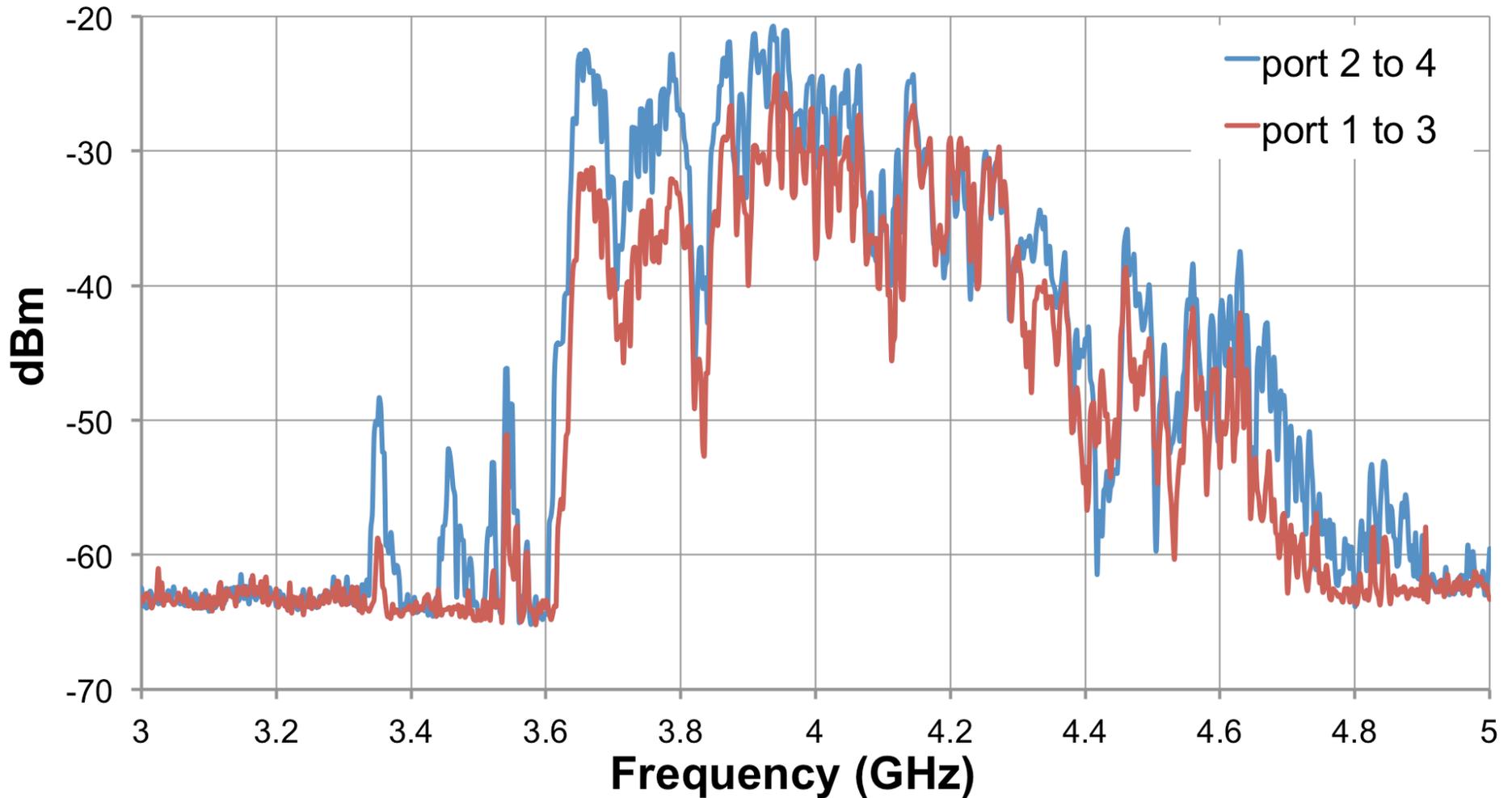


Power amplifier II bandwidth & signal from detector (no amplifier)

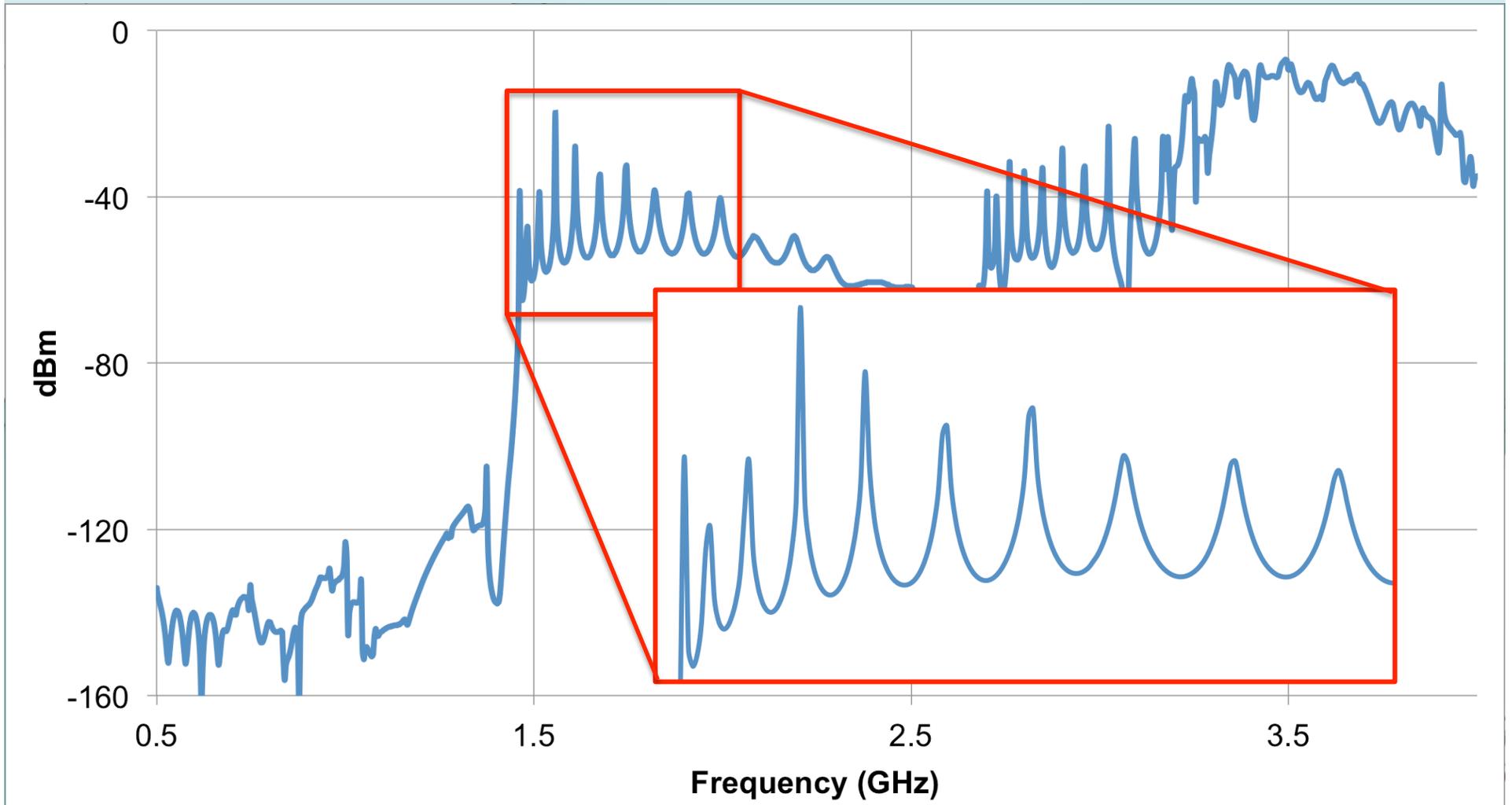


1	3
2	4

S_{21} measurements - no beam and using power amplifier II



Simulation using CST Microwave Studio (Magnetic Loop)



Acknowledgements

Alphabetically:

- Carol Angarola
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- Bob Zwaska
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- My fellow interns

Thanks for listening...



...Questions?

References

- [1] H. Wang et al., “Microwave reflection technique for electron cloud density measurement”. Lee Teng Summer Internship, Fermilab, 2011.
- [2] M. Backfish, “Electron Cloud in Steel Beam Pipe vs Titanium Nitride Coated and Amorphous Carbon Coated Beam Pipes in Fermilab’s Main Injector”. Masters Thesis, Fermilab, 2013.
- [3] S. Desantis et al., “Measurement of Electron Clouds in Large Accelerators by Microwave Dispersion”. Physical Review Letters, 100, 2008.
- [4] K. Sonnad et al., “Simulation and Analysis of Microwave transmission through an electron cloud a comparison of results”. Proceedings of PAC’07, 2007.
- [5] P. A. Kyaw et al., “Improving boundary conditions for microwave reflection to measure electron cloud density”. Lee Teng Summer Internship, Fermilab, 2012.
- [6] Y.-M. Shin et al., “Electron cloud density analysis using microwave cavity resonance”. IOP Publishing, 2013.
- [7] M. Backfish., “Measurement of ECD using RFAs”. private communication, 2013.