Resonant Polarimetry and Magnetometry

Electrodynamic, DOE SBIR DE-SC0017120 SBIR Phase II, year 2.

PI: Brock F. Roberts, PhD

DOE Phase II SBIR Topic: 25e, Nuclear Physics Accelerator Technology, Polarized Beam Sources and Polarimeters.

Collaborators: Laboratory of Elementary-Particle Physics (LEPP) at Cornell University and the Thomas Jefferson National Laboratory's (JLAB) Center for Injectors and Sources (CIS).

Subcontractor: Thomas Jefferson National Laboratory's (JLAB) Center for Injectors and Sources (CIS).

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Electrodynamic

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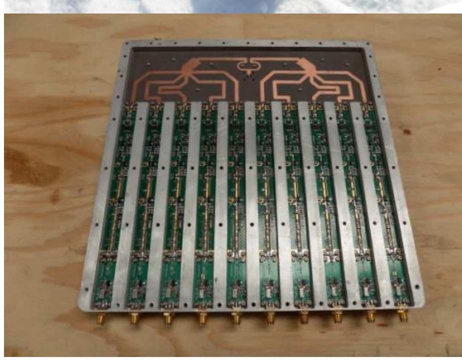
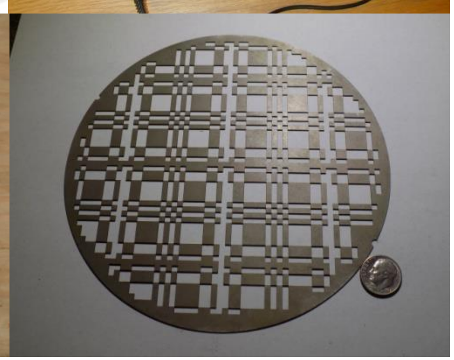
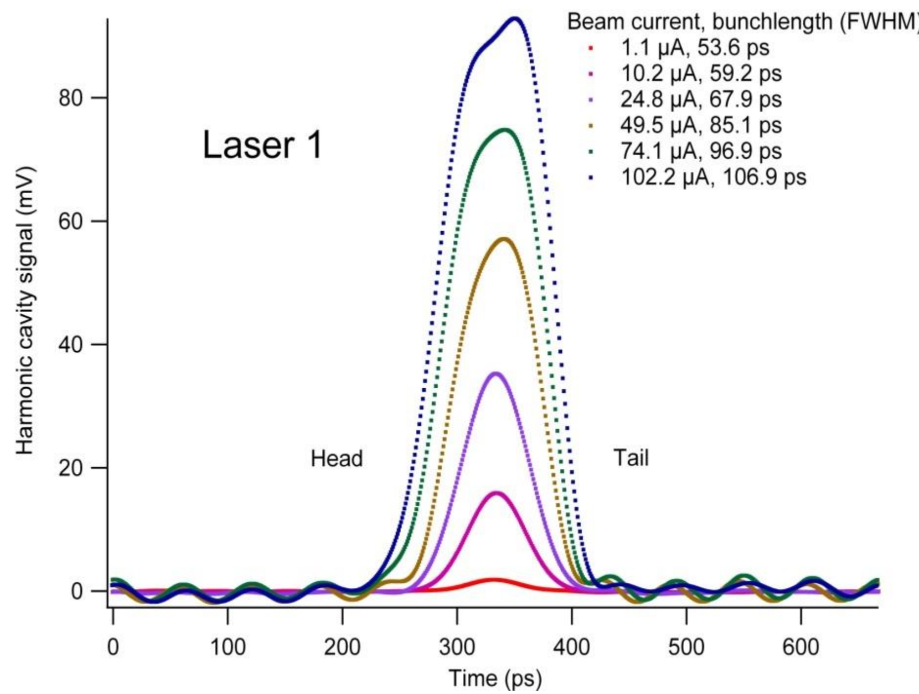
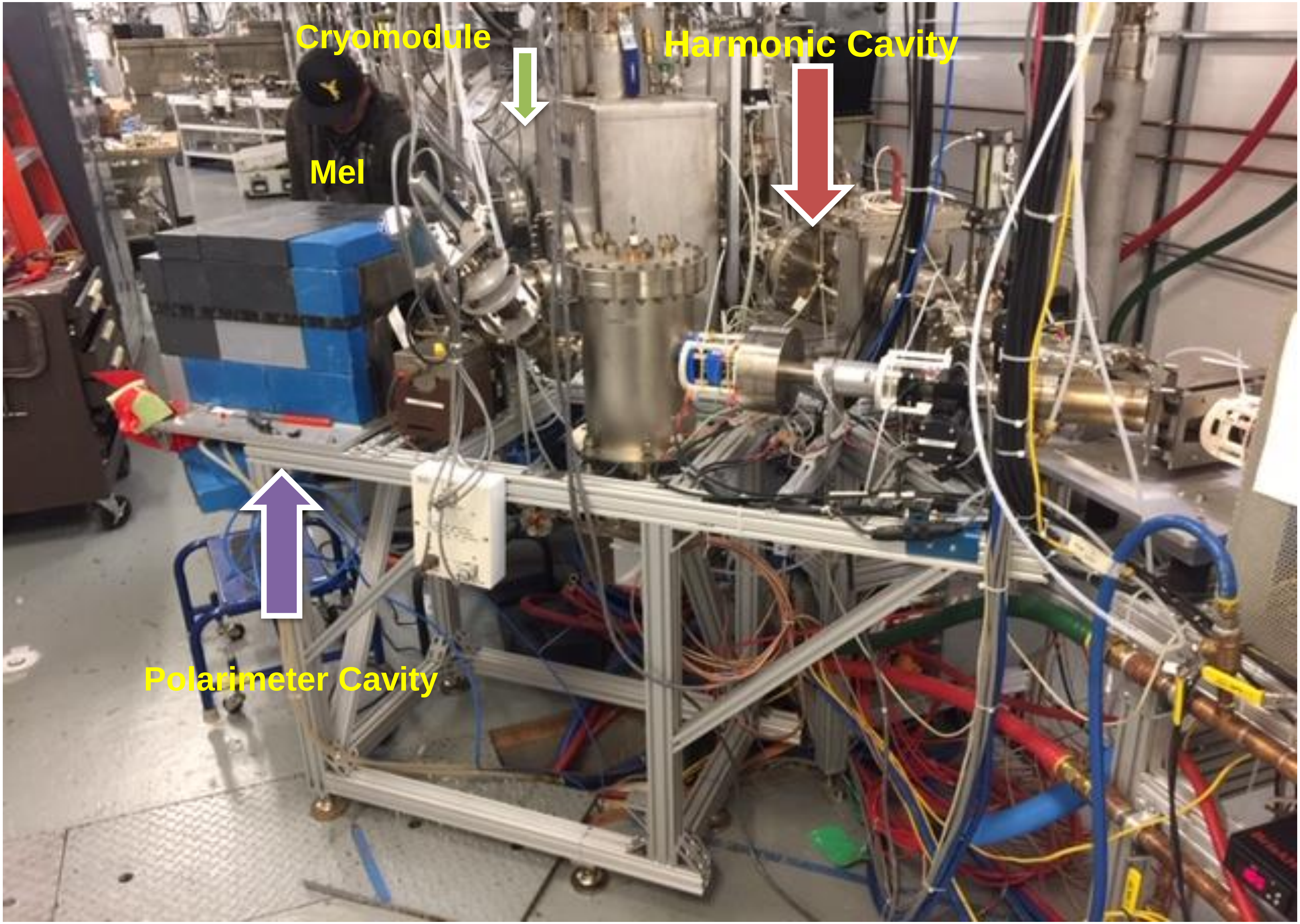
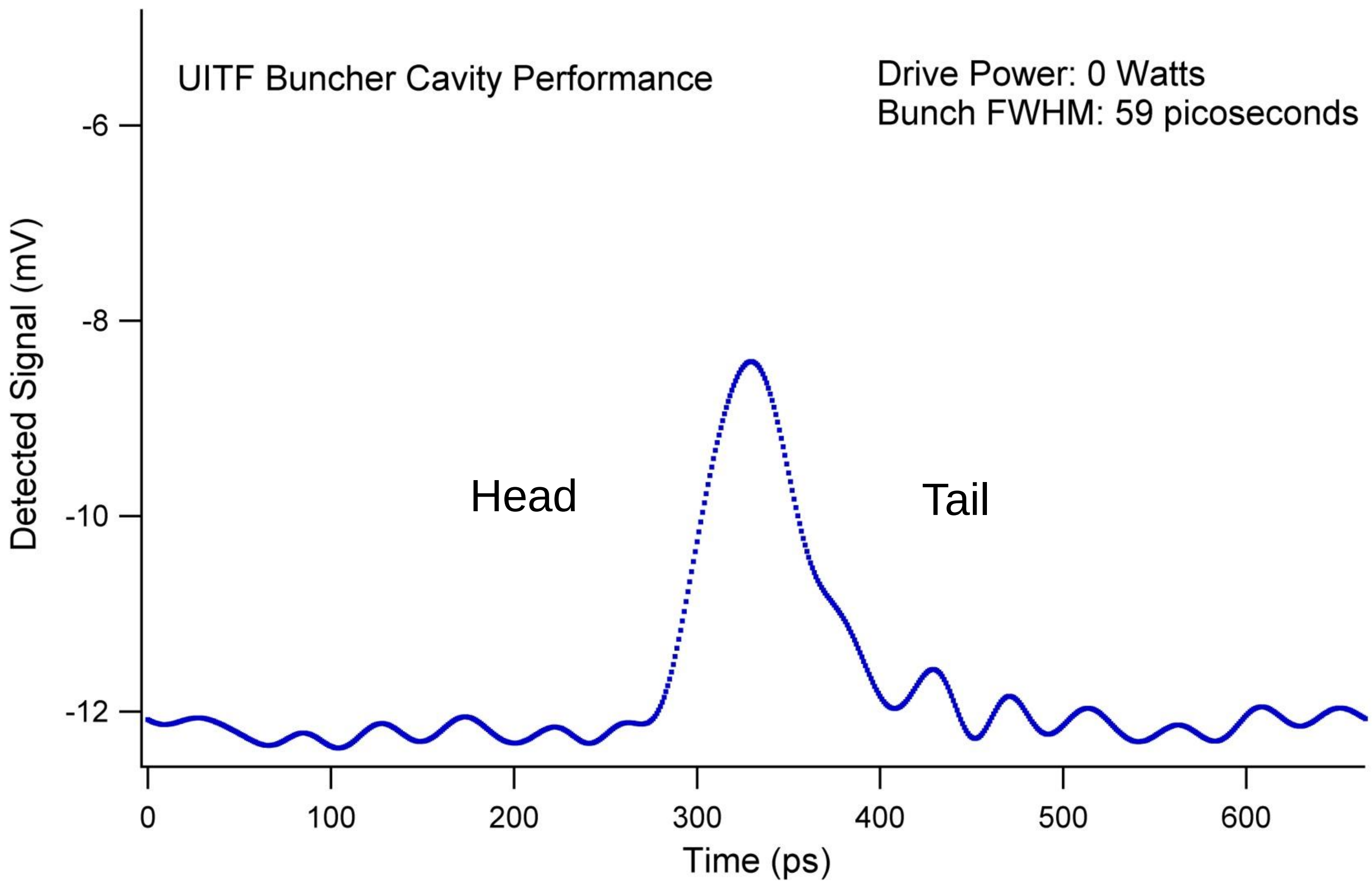
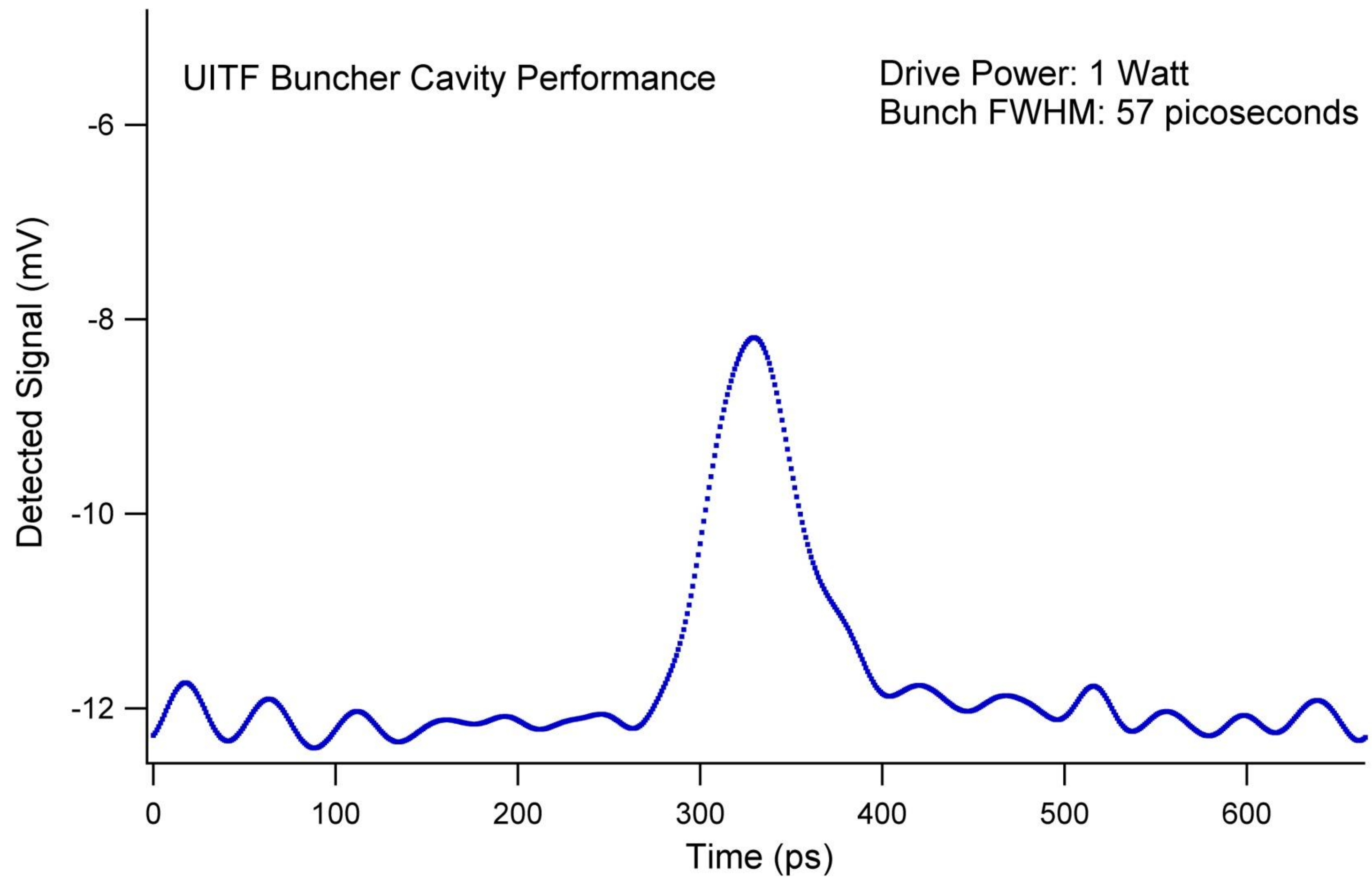
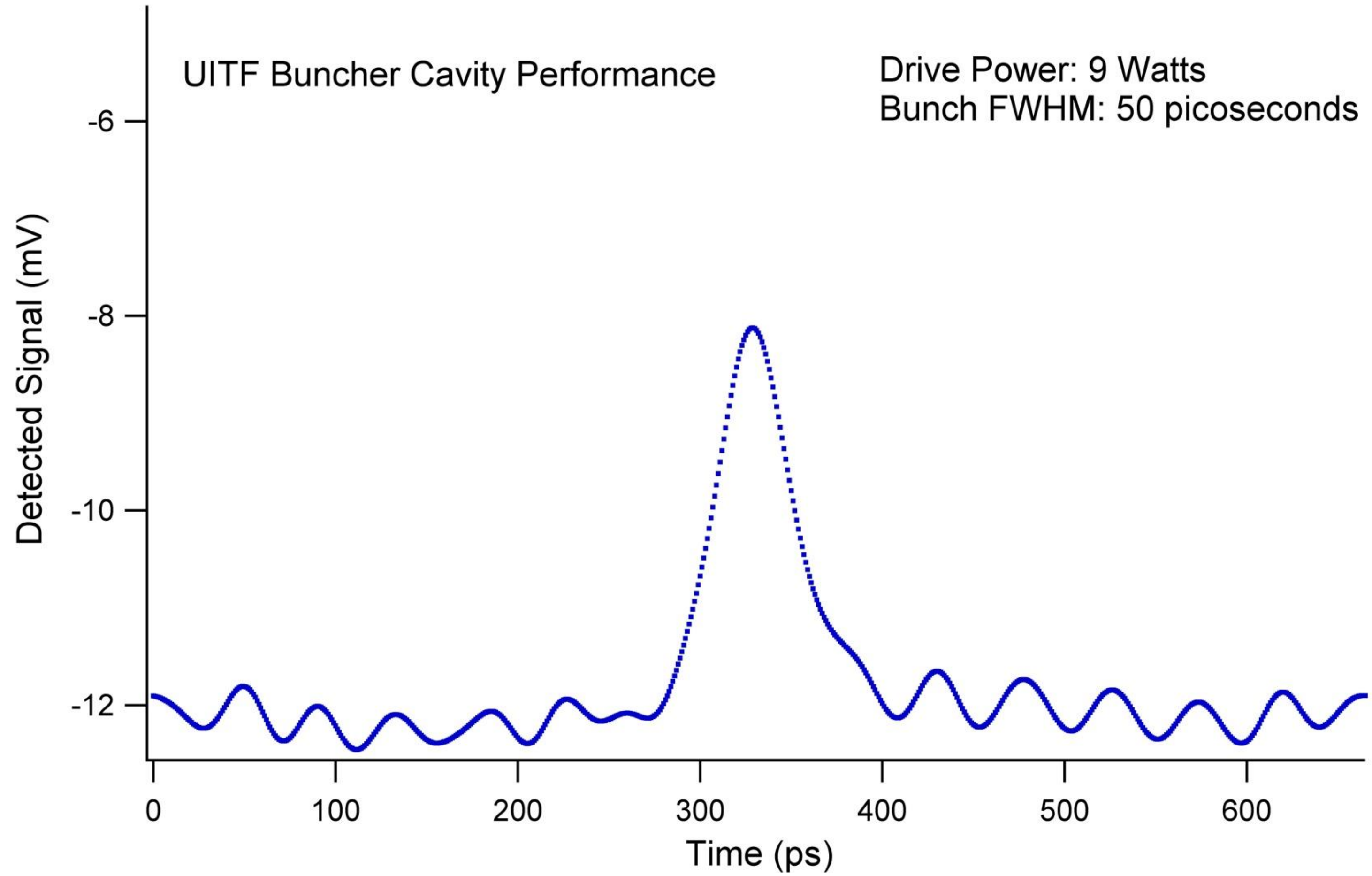





Cryomodule
Harmonic Cavity
Mel
Polarimeter Cavity

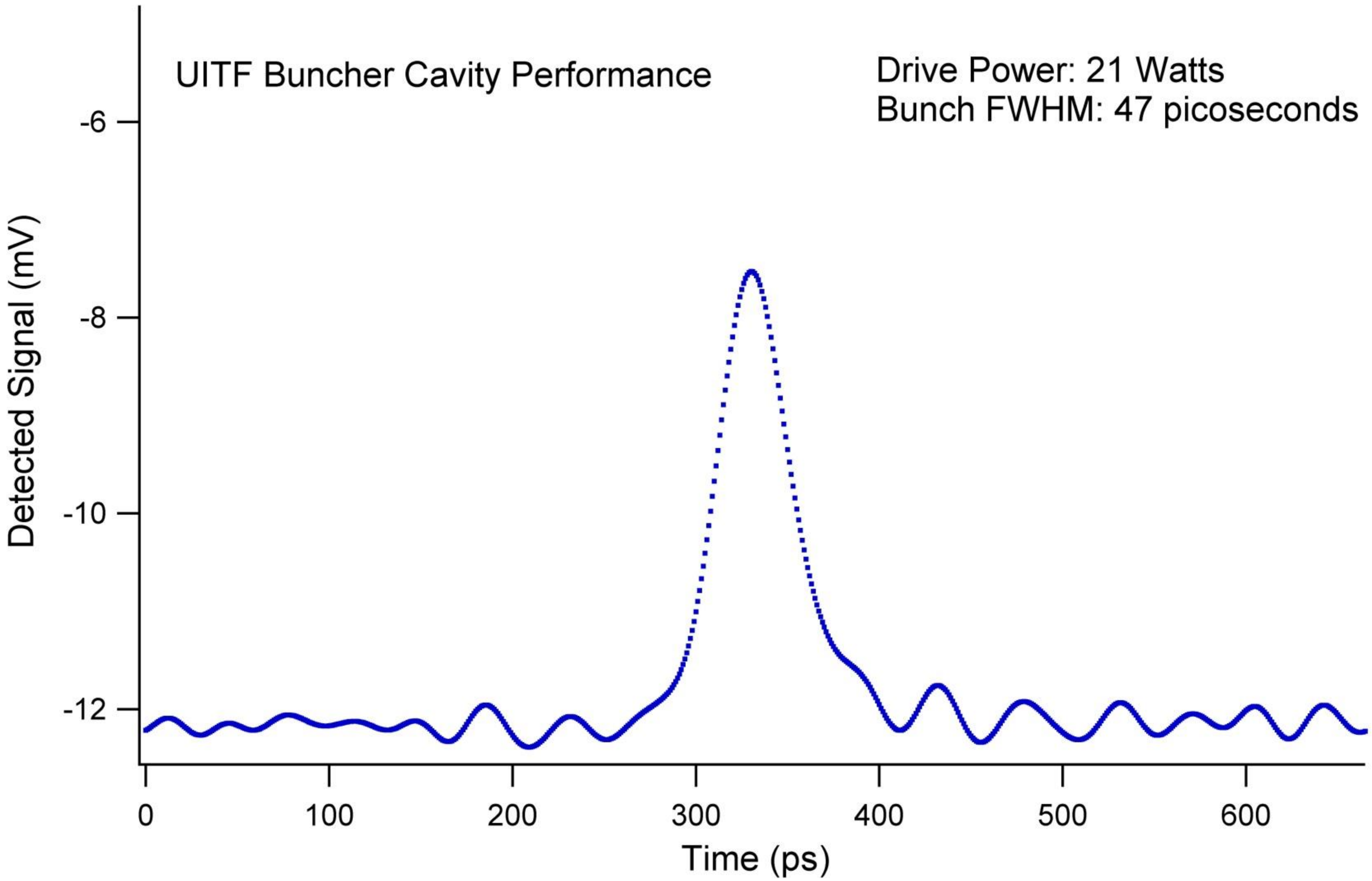

UITF Buncher Cavity Performance
Drive Power: 0 Watts
Bunch FWHM: 59 picoseconds
Head
Tail
Detected Signal (mV)
-6
-8
-10
-12
0
100
200
300
400
500
600
Time (ps)

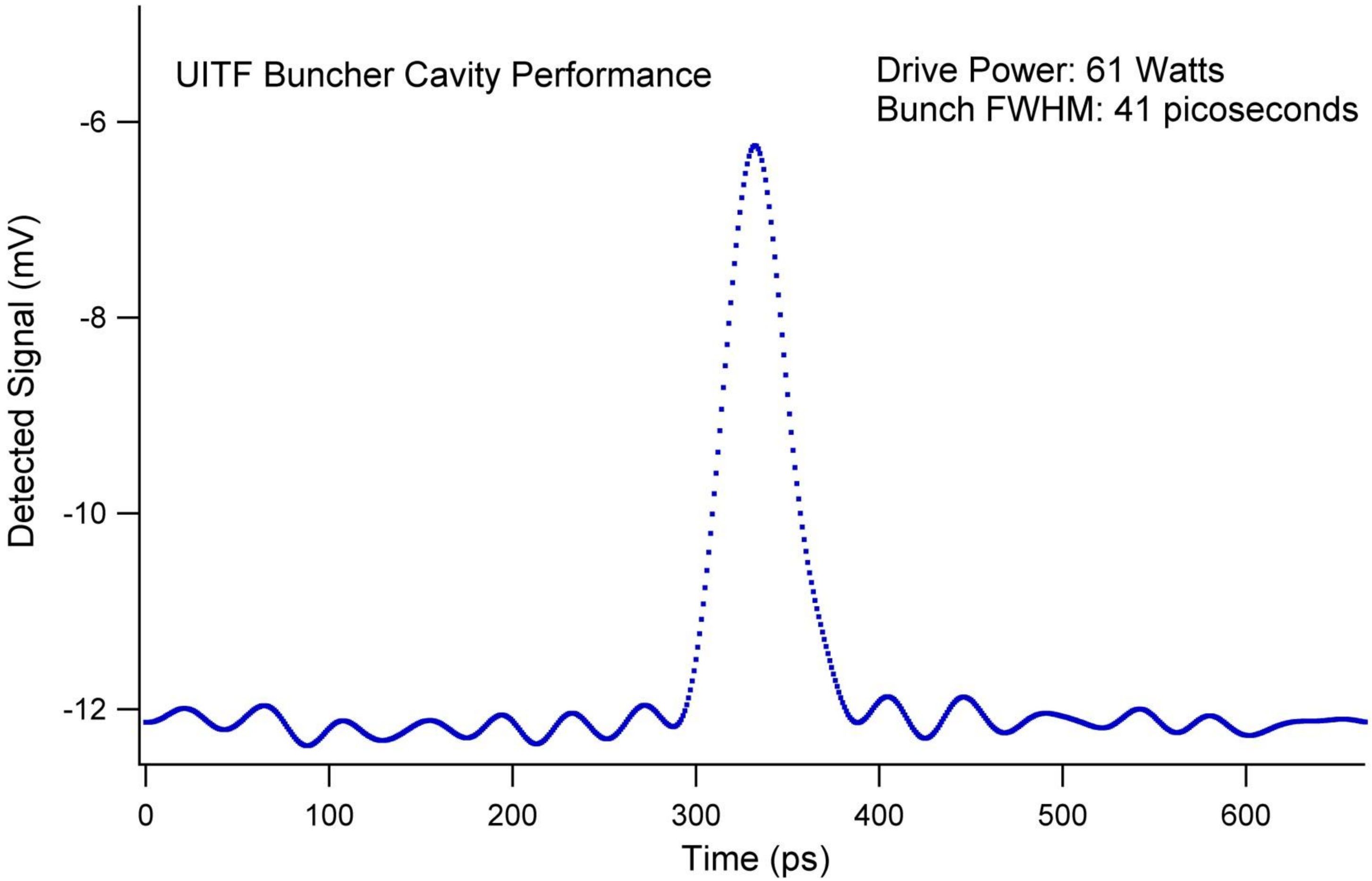


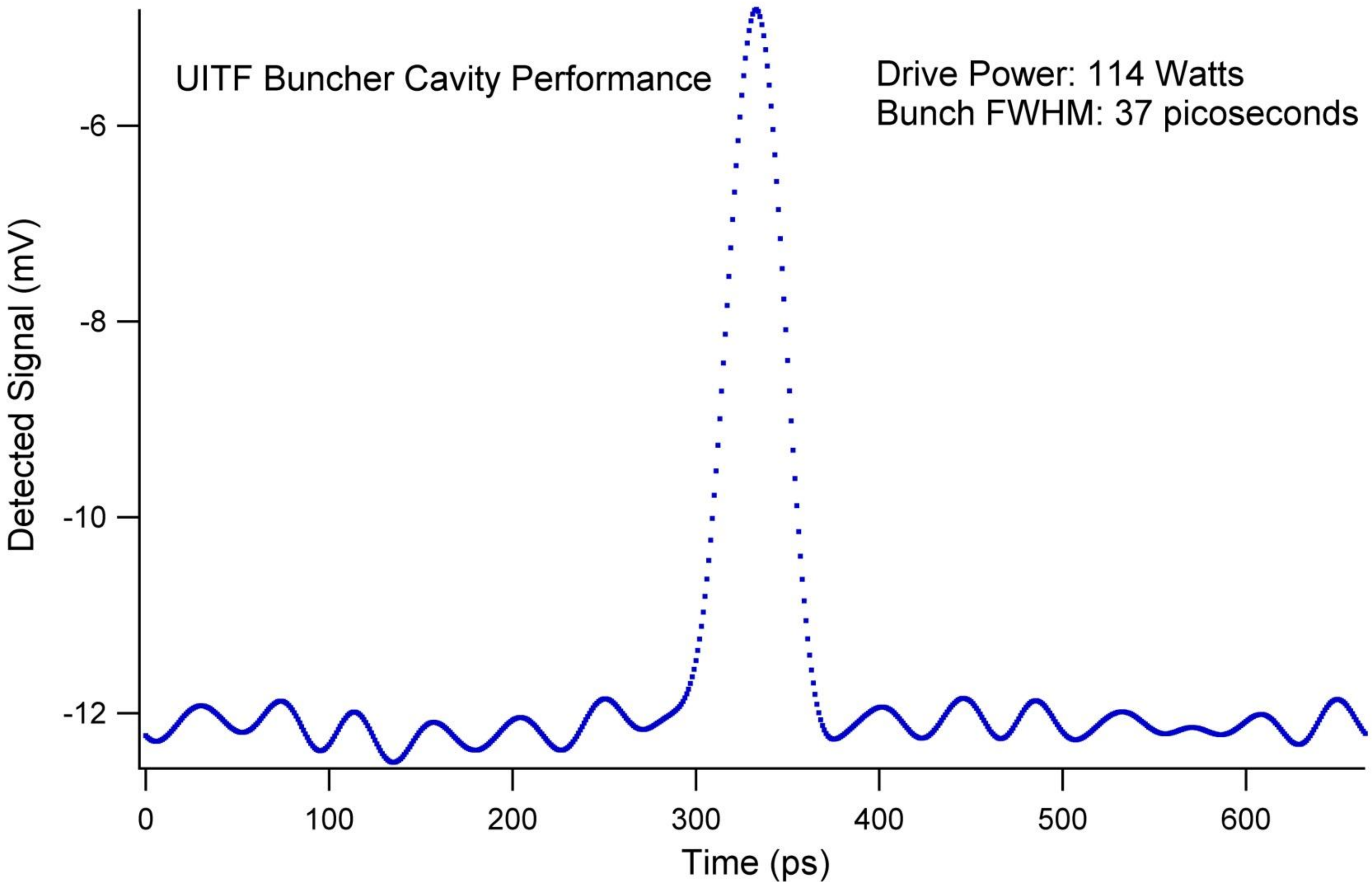
UITF Buncher Cavity Performance
Drive Power: 1 Watt
Bunch FWHM: 57 picoseconds
Detected Signal (mV)
-6
-8
-10
-12
0
100
200
300
400
500
600
Time (ps)

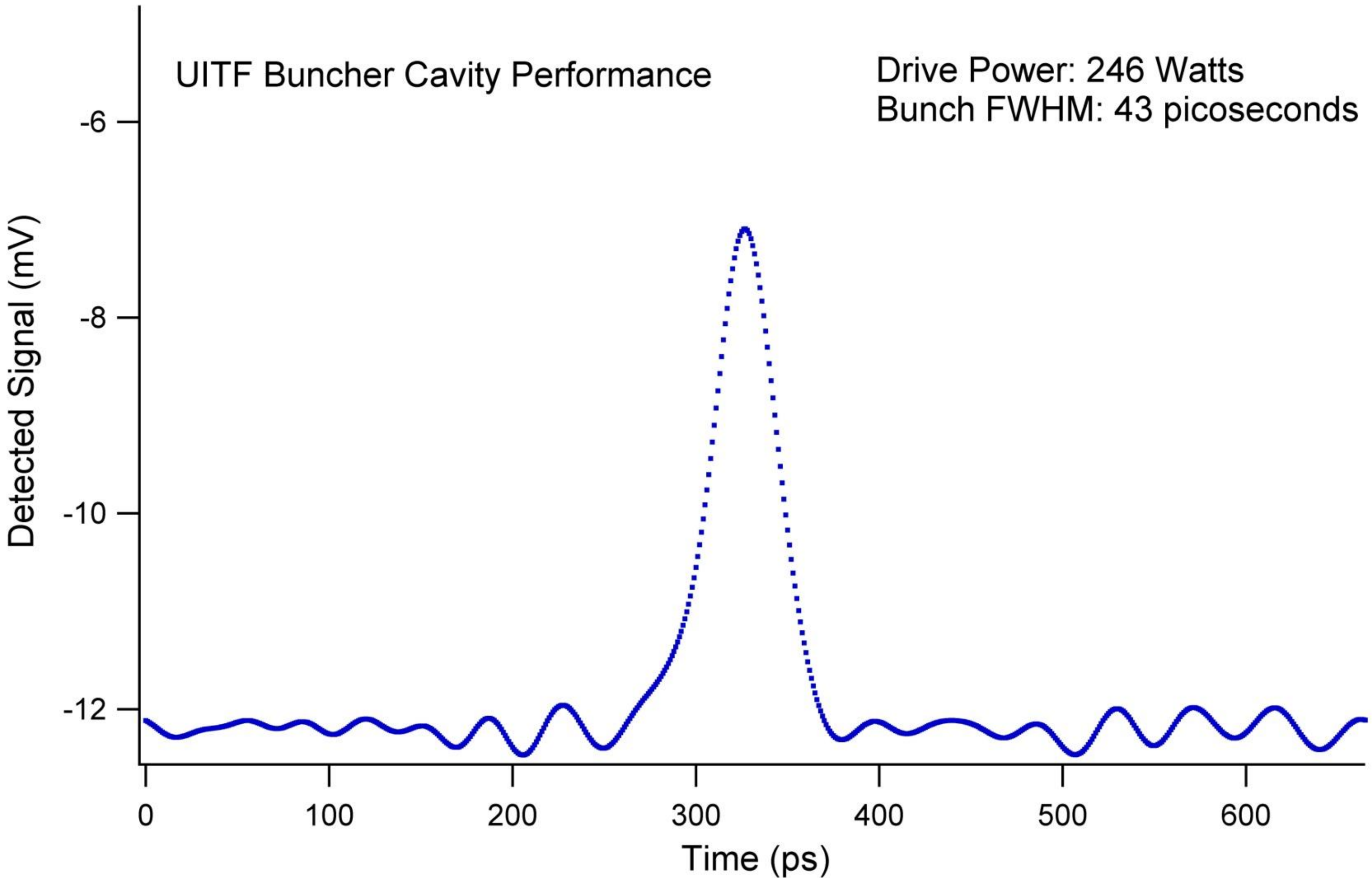


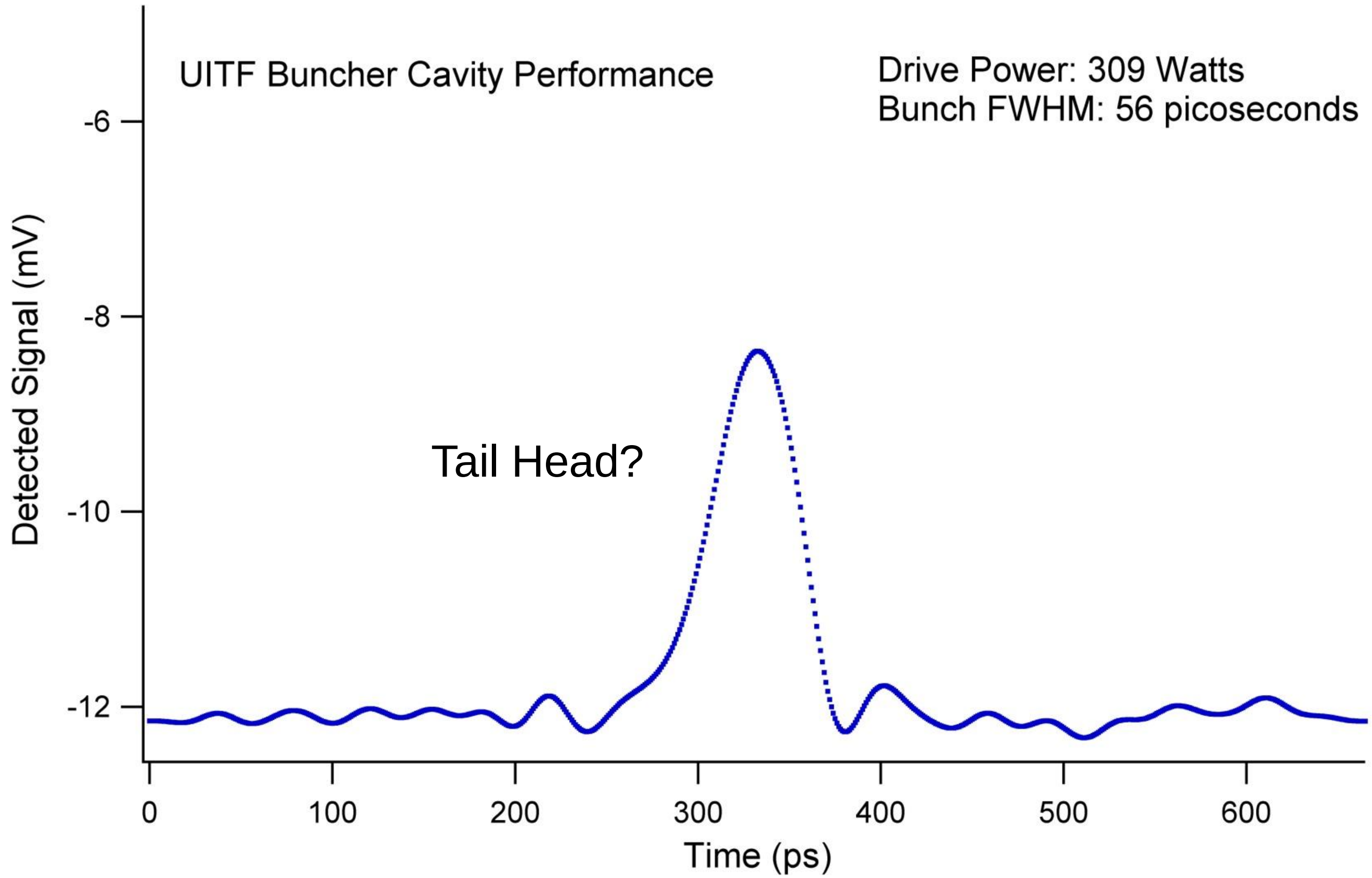
UITF Buncher Cavity Performance
Drive Power: 9 Watts
Bunch FWHM: 50 picoseconds
Detected Signal (mV)
-6
-8
-10
-12
0
100
200
300
400
500
600
Time (ps)


UITF Buncher Cavity Performance
Drive Power: 21 Watts
Bunch FWHM: 47 picoseconds
Detected Signal (mV)
-6
-8
-10
-12
0
100
200
300
400
500
600
Time (ps)


UITF Buncher Cavity Performance
Drive Power: 61 Watts
Bunch FWHM: 41 picoseconds
Detected Signal (mV)
-6
-8
-10
-12
0
100
200
300
400
500
600
Time (ps)


UITF Buncher Cavity Performance
Drive Power: 114 Watts
Bunch FWHM: 37 picoseconds
Detected Signal (mV)
-6
-8
-10
-12
0
100
200
300
400
500
600
Time (ps)


UITF Buncher Cavity Performance
Drive Power: 246 Watts
Bunch FWHM: 43 picoseconds
Detected Signal (mV)
-6
-8
-10
-12
0
100
200
300
400
500
600
Time (ps)

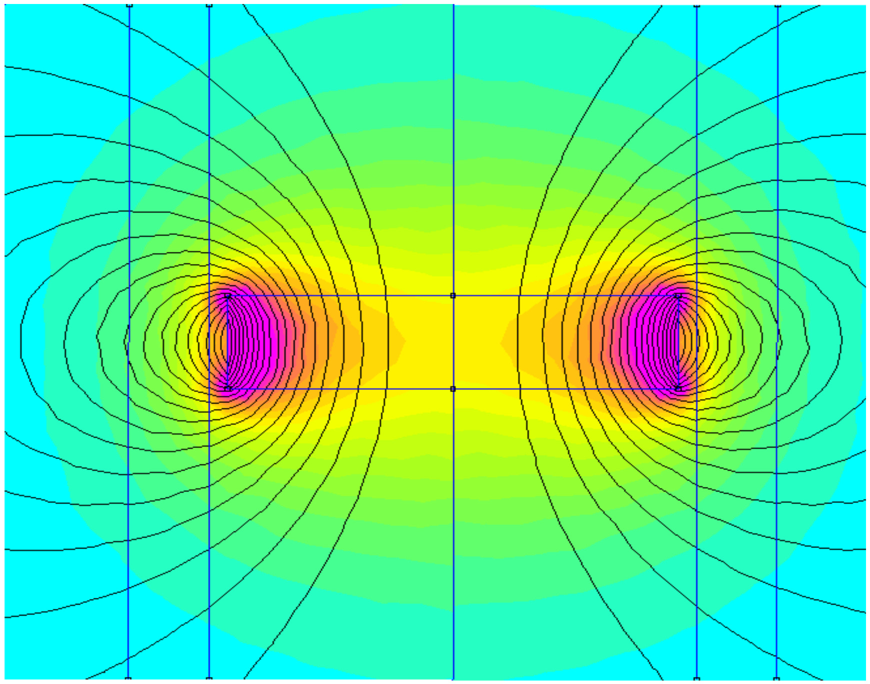


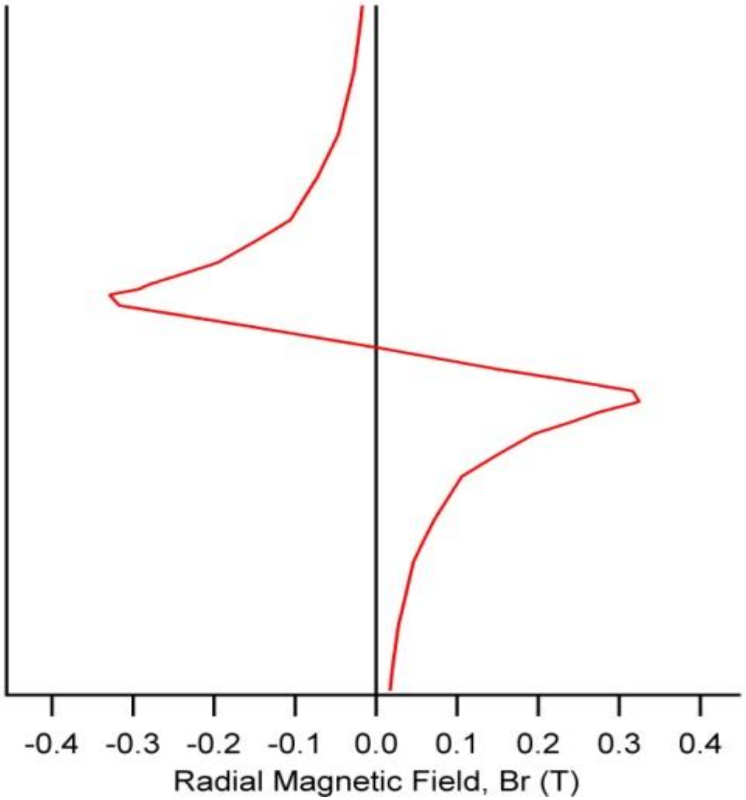
UITF Buncher Cavity Performance
Drive Power: 309 Watts
Bunch FWHM: 56 picoseconds
Tail Head?
Detected Signal (mV)
-6
-8
-10
-12
0
100
200
300
400
500
600
Time (ps)

Resonant Polarimetry and Magnetometry

- To non-invasively measure bunch magnetization or spin magnetization, energy must be exclusively extracted from its component of the of the passing beam’s magnetic field.
- Longitudinally spin polarized and longitudianlly magnetized bunches have a magnetic field orientation that is orthogonal to the beams current’s magnetic field and is similar to a dipole magnet traveling North/South or S/N down a beam tube.
- Magnetized beams have the same magnetic field orientation as longitudinally spin polarized beams.

The Classic Magnet in Tube Drop Experiment

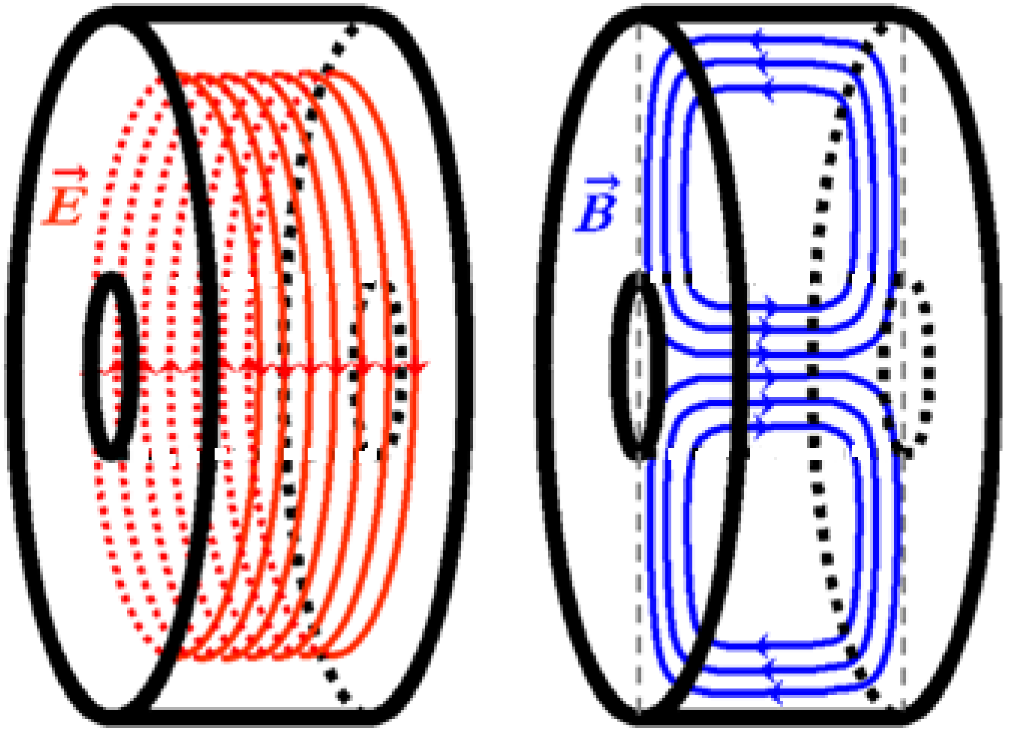




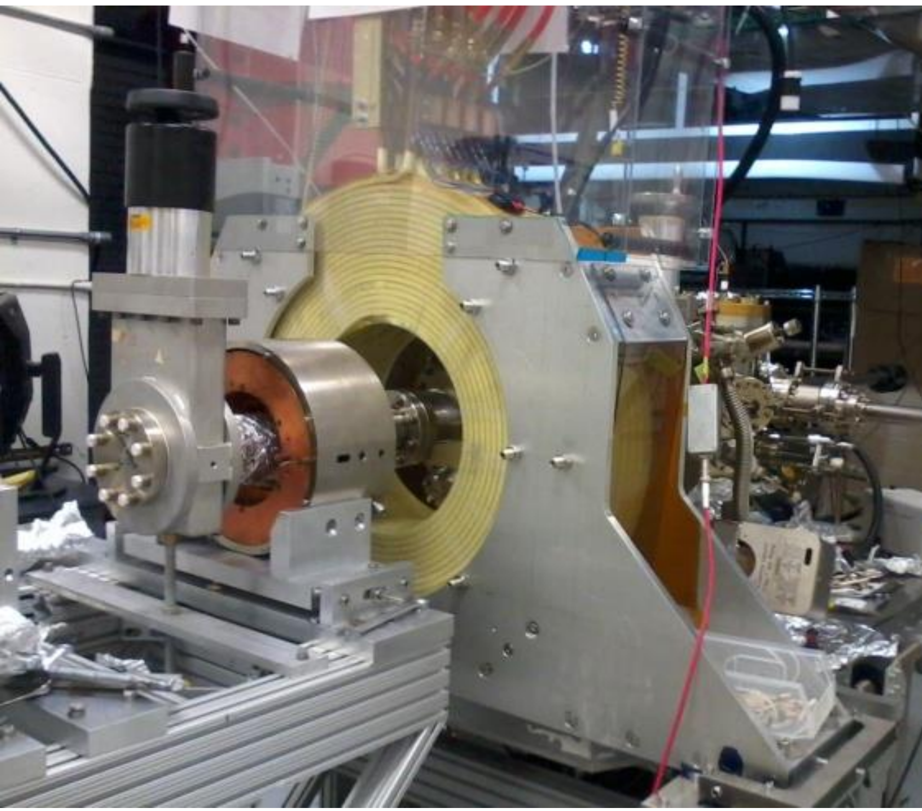
$$F = mg = I_{ind}(B_r \; 2\pi r_{tube}),$$

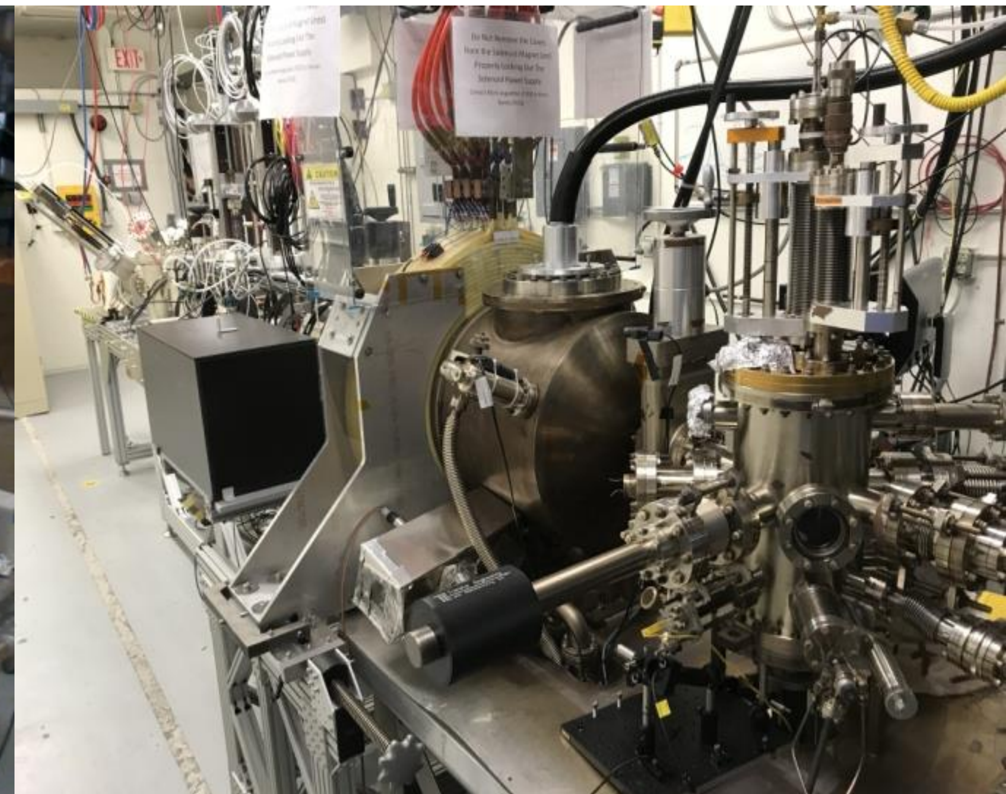
$$V_{ind} = v(B_r \; 2\pi r_{tube})$$

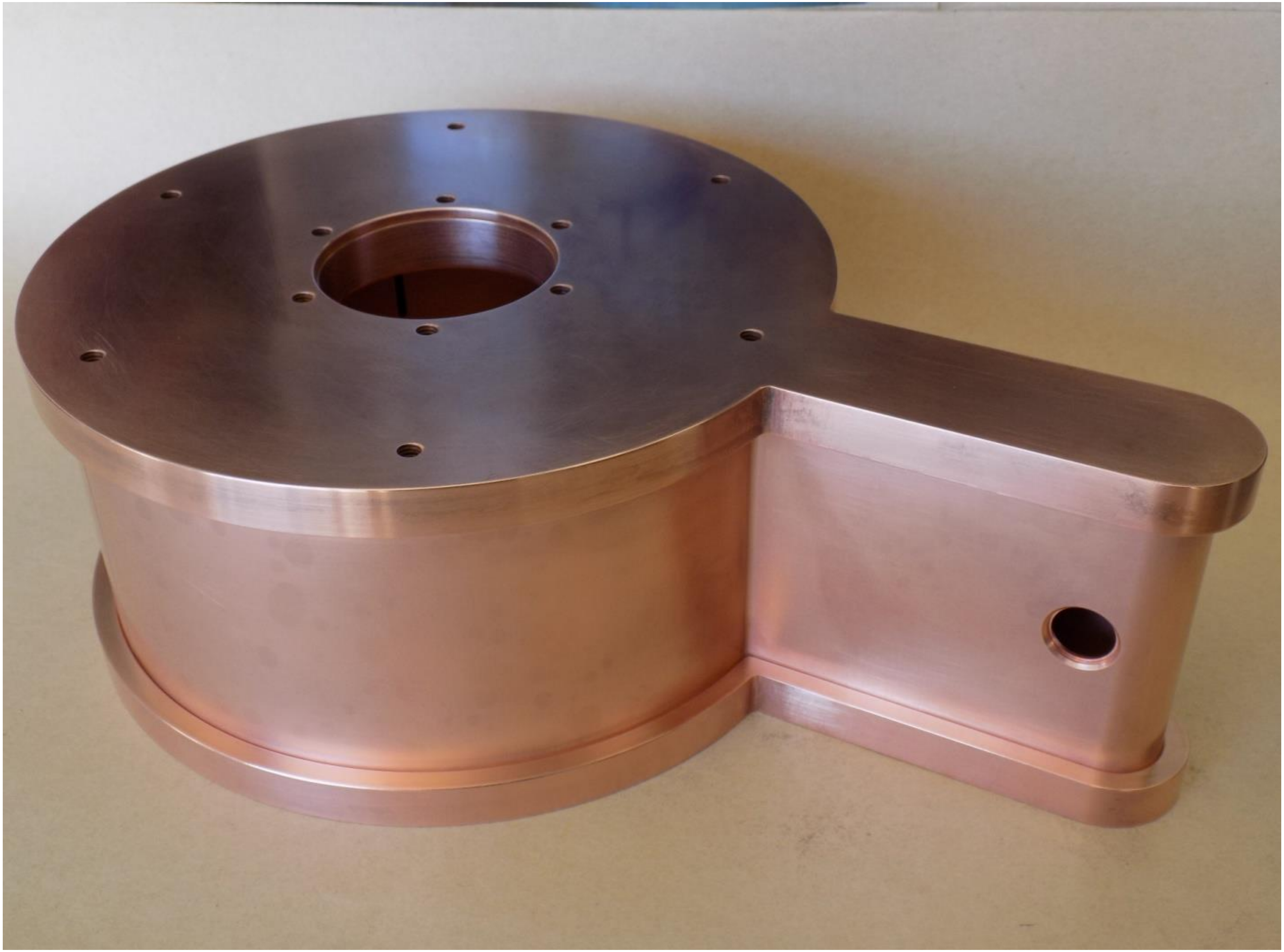
TE_{011} Resonant Mode

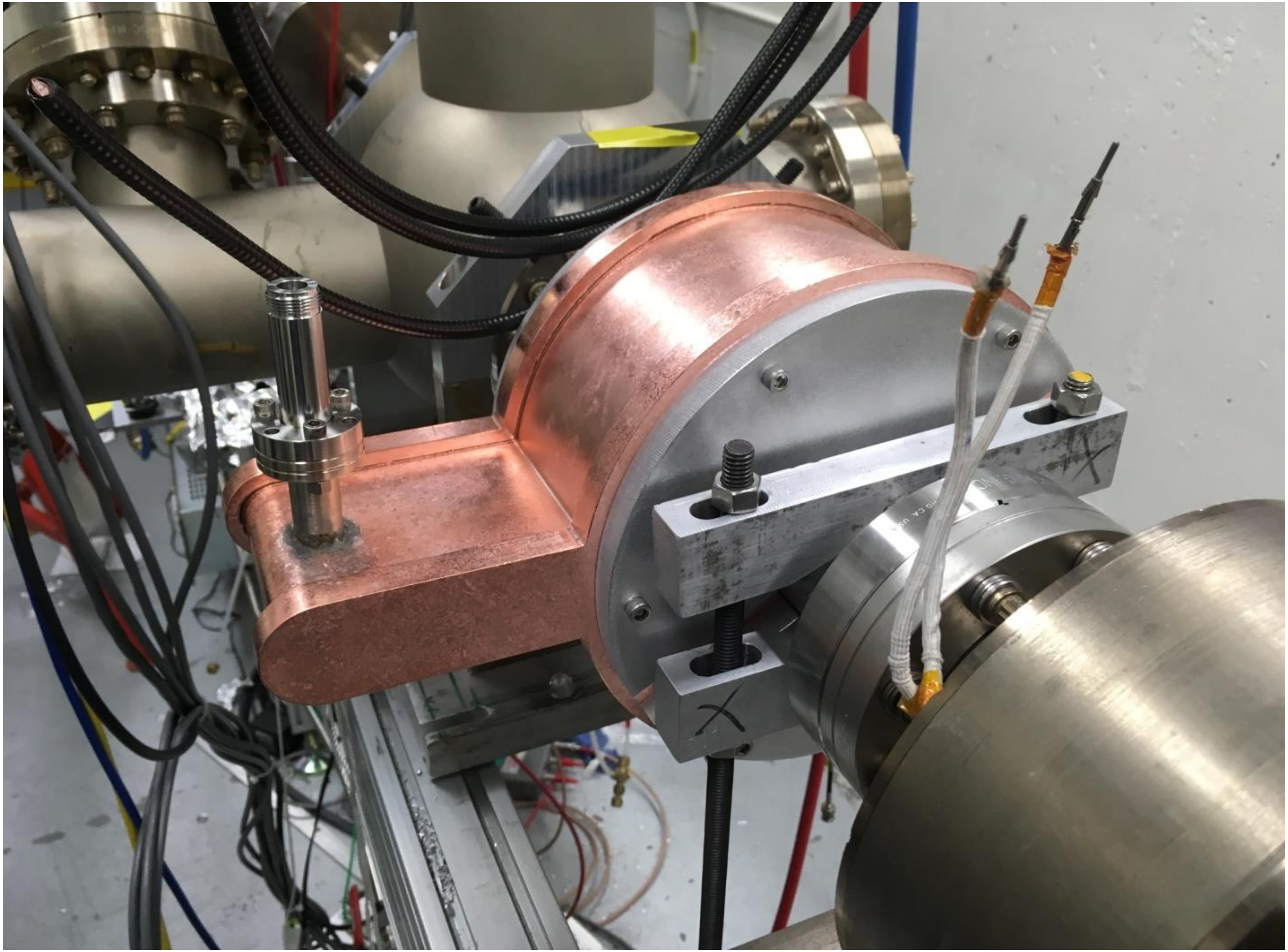


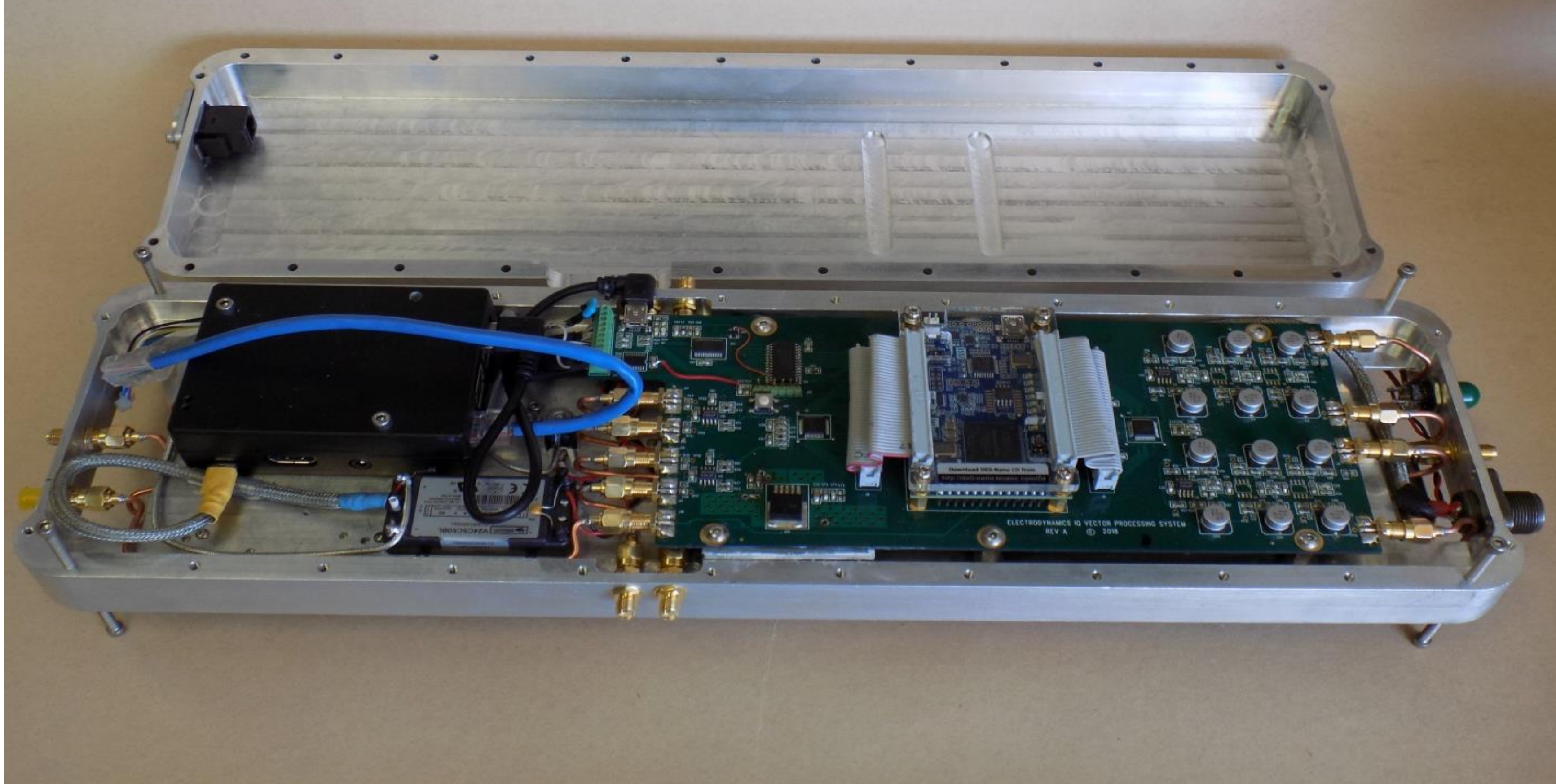
Resonant Magnetometry on the GTS at Jlab










ELECTRODYNAMICS IQ VECTOR PROCESSING SYSTEM
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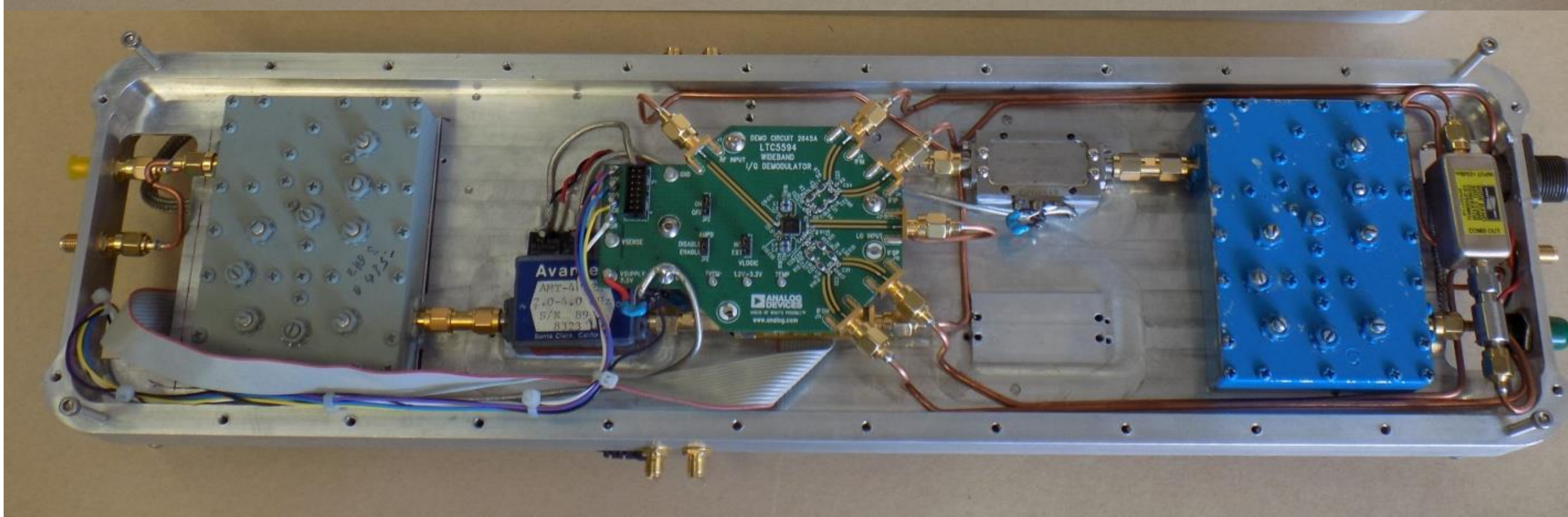
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ENABLE
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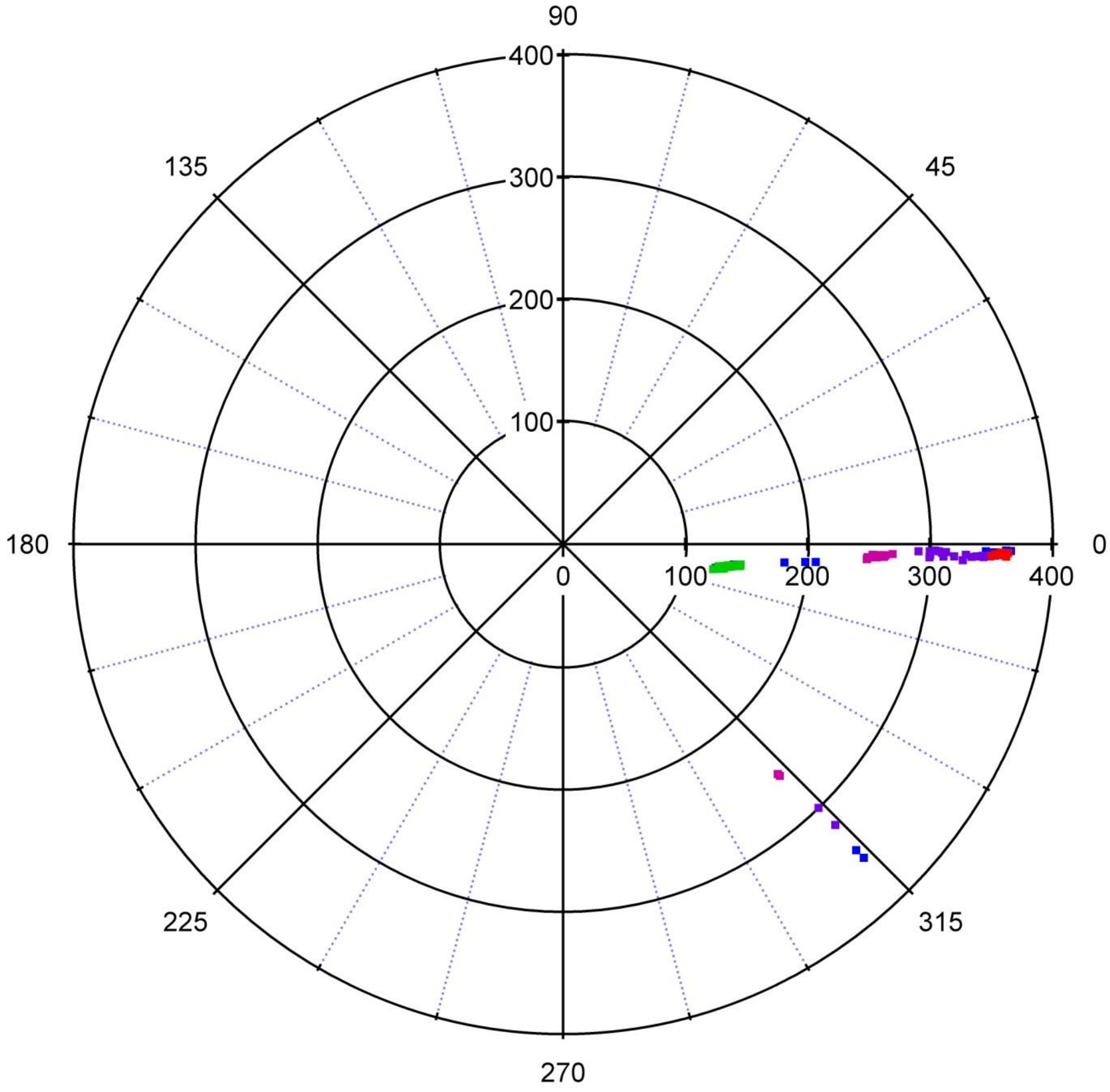
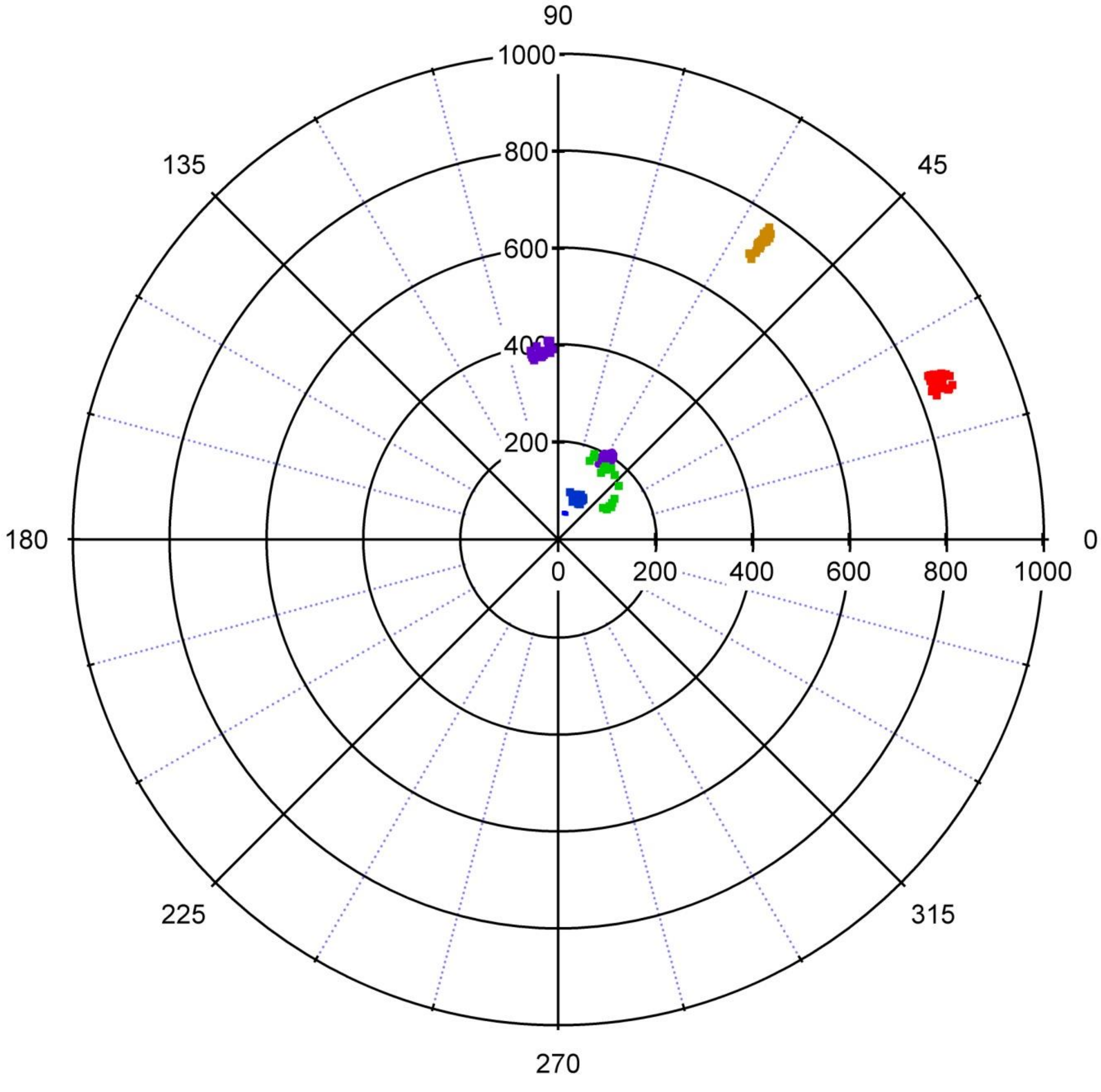
Measurement of an Unmagnetized Beam



Measurement of a Magnetized Beam



Magnetometry Observations:

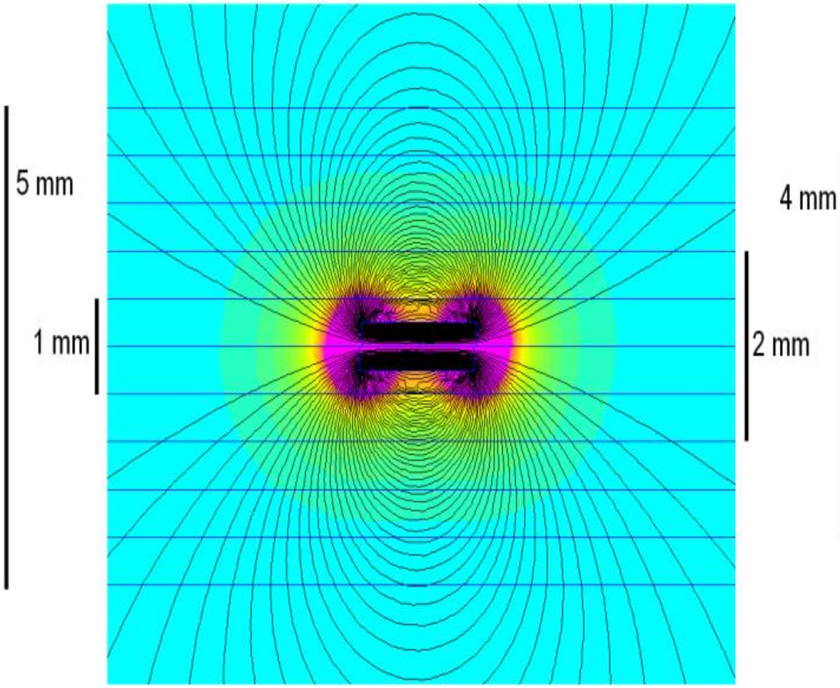
A non-magnetized beam centered in the bore of a TE011 mode resonant cavity produces no signal.

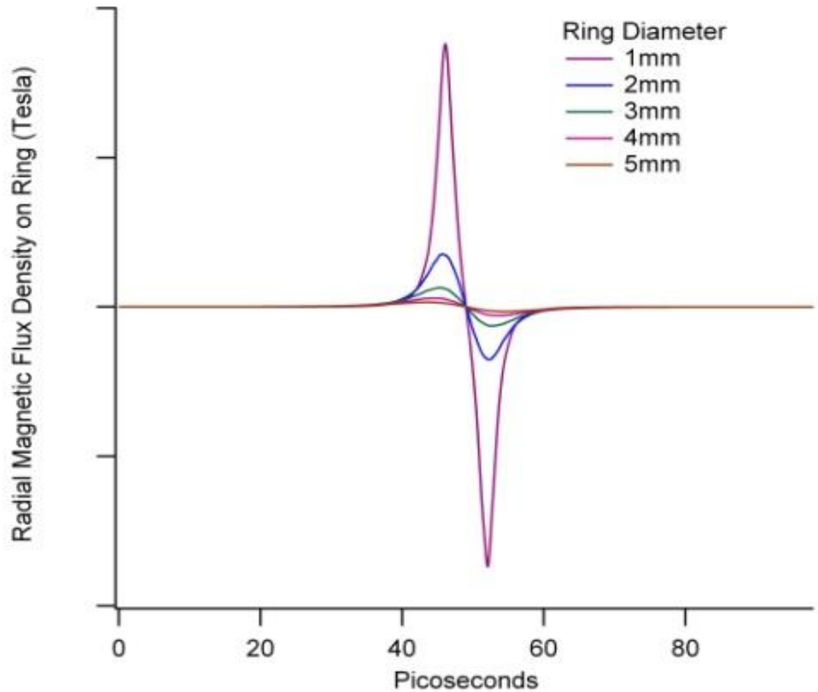
A magnetized and centered beam produces a signal many orders of magnitude above the noise floor.

An off-axis unmagnitized beam creates a strong signal with a constant phase.

An off-axis magnetized beam creates a strong signal with phase shift that changes with beam position.

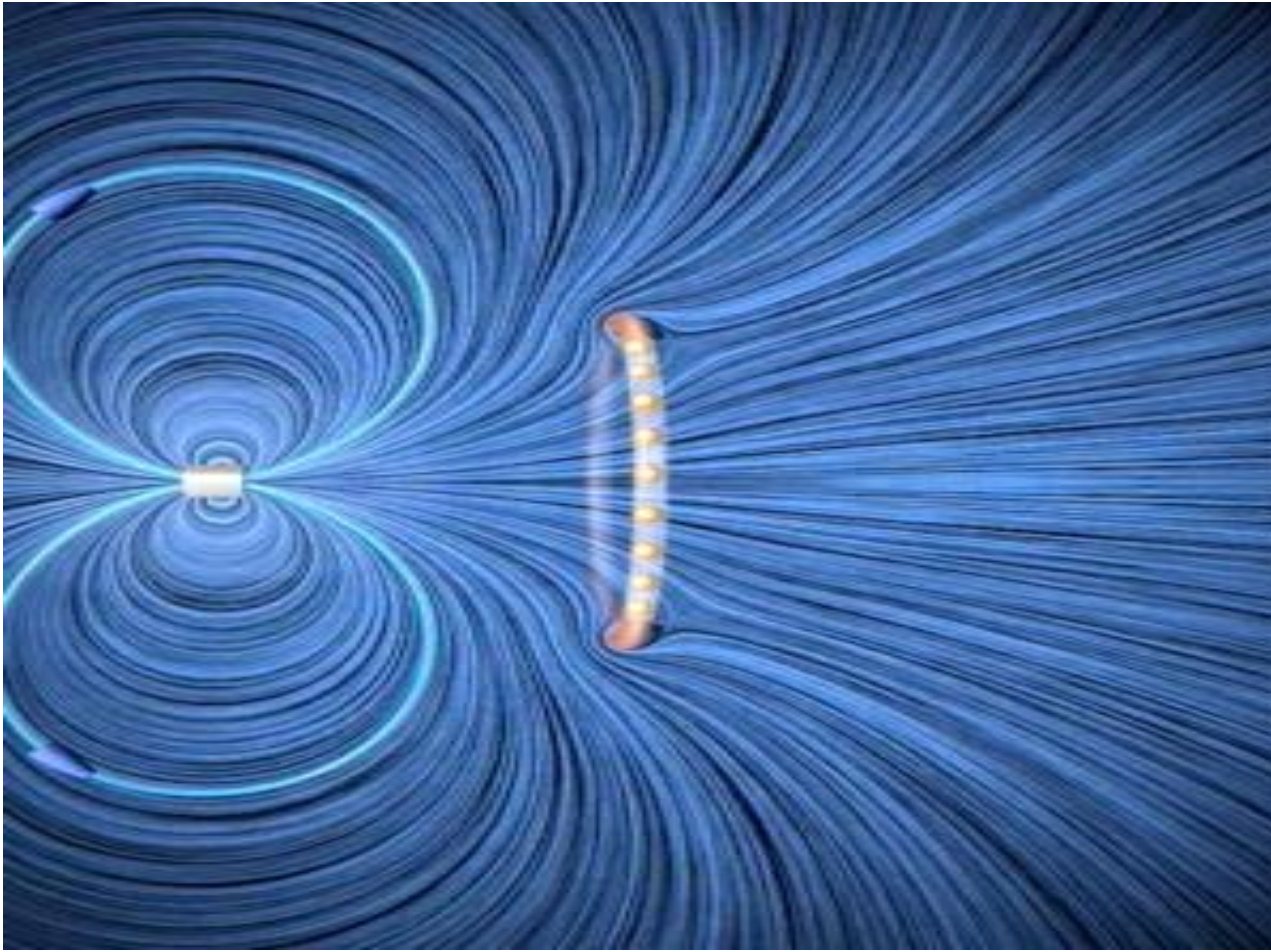
It is believed that the phase shift is due to the nature of the cavities induction and can be used to distinguish electric from magnetic excitation of an off axis beam.

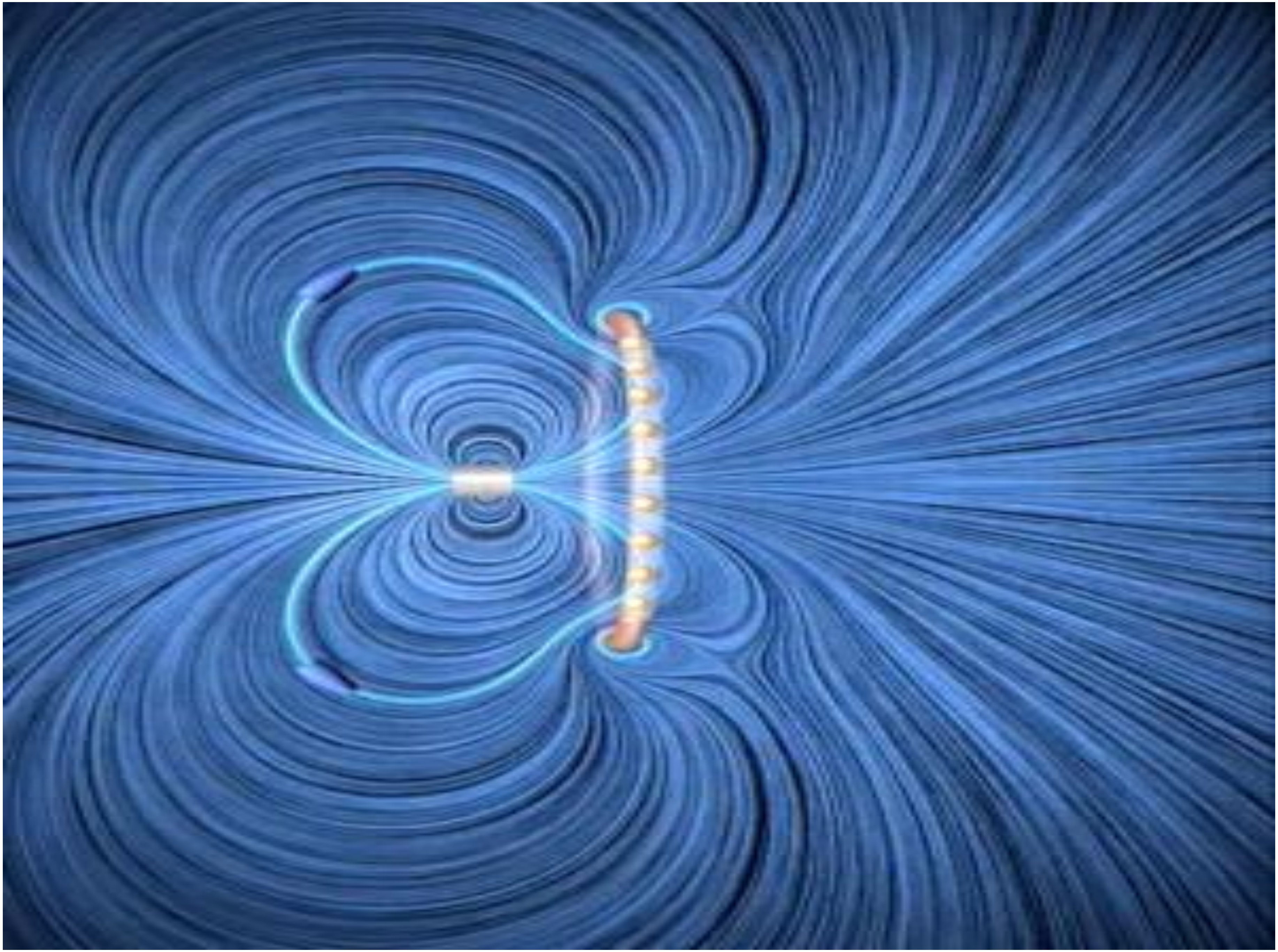


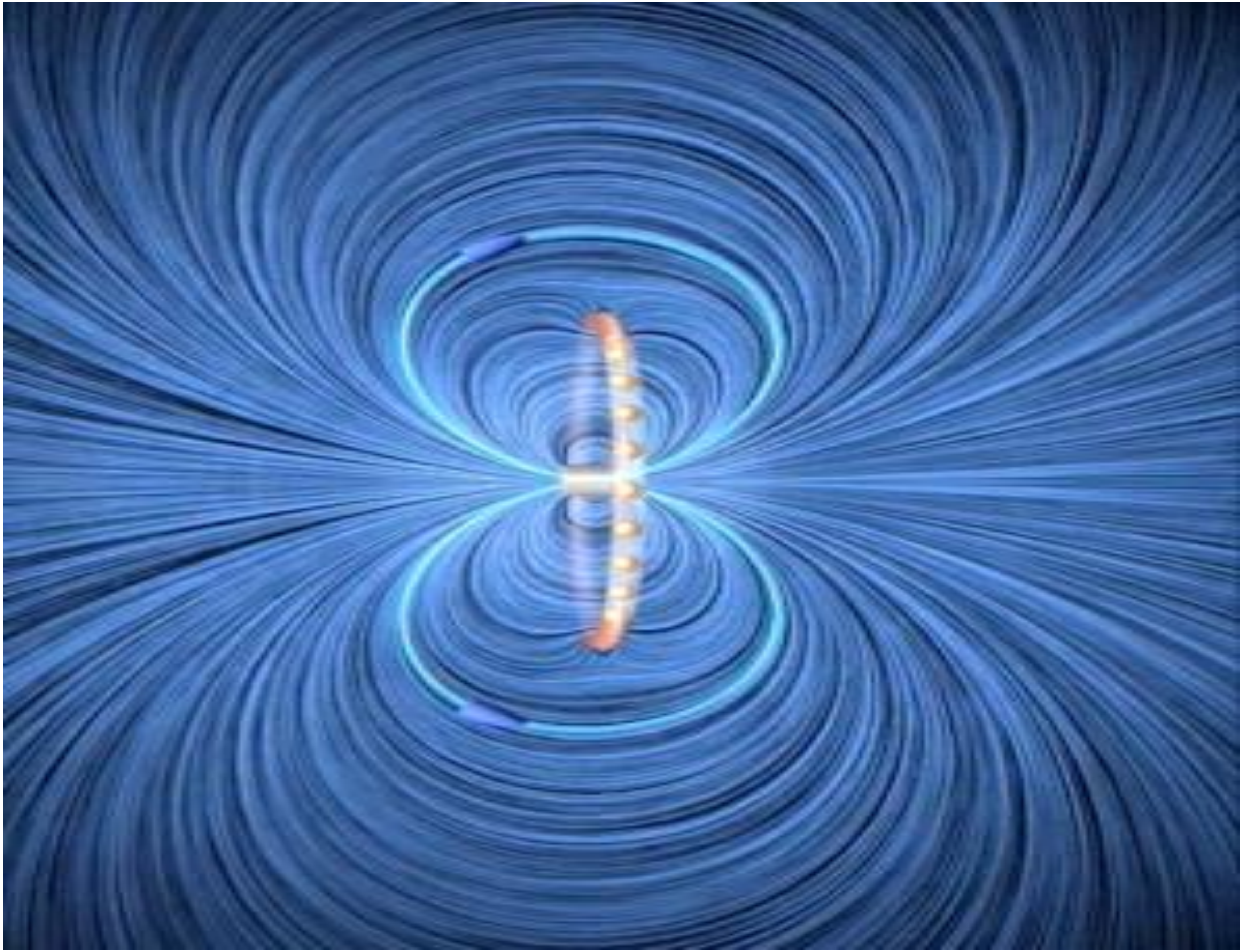


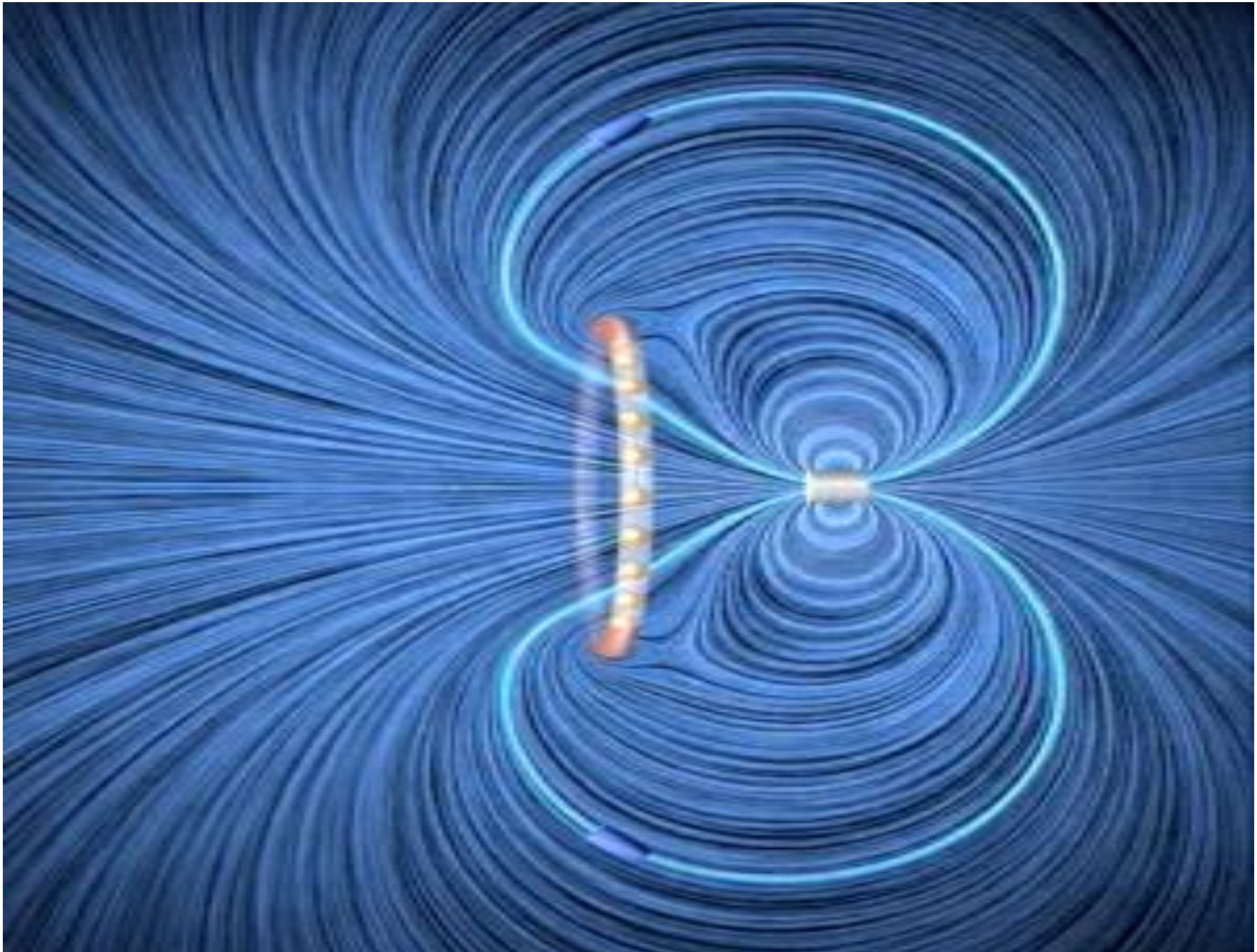
$$F = I_{ind}(B_r\ 2\pi r_{tube}),$$

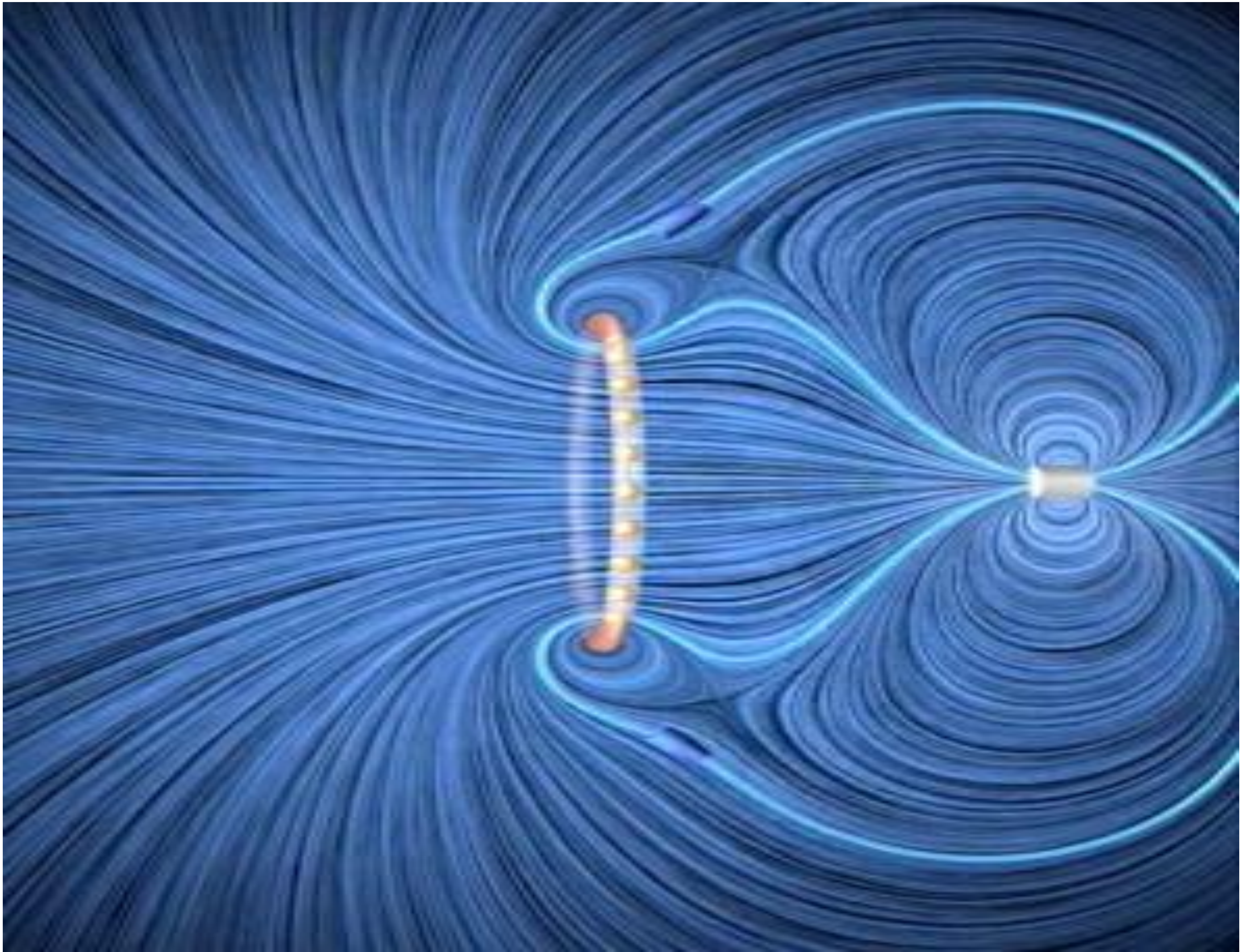
$$V_{ind} = v(B_r\ 2\pi r_{tube})$$



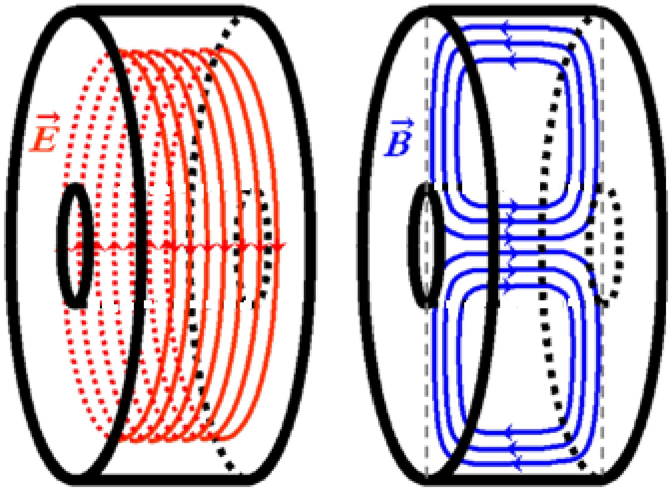


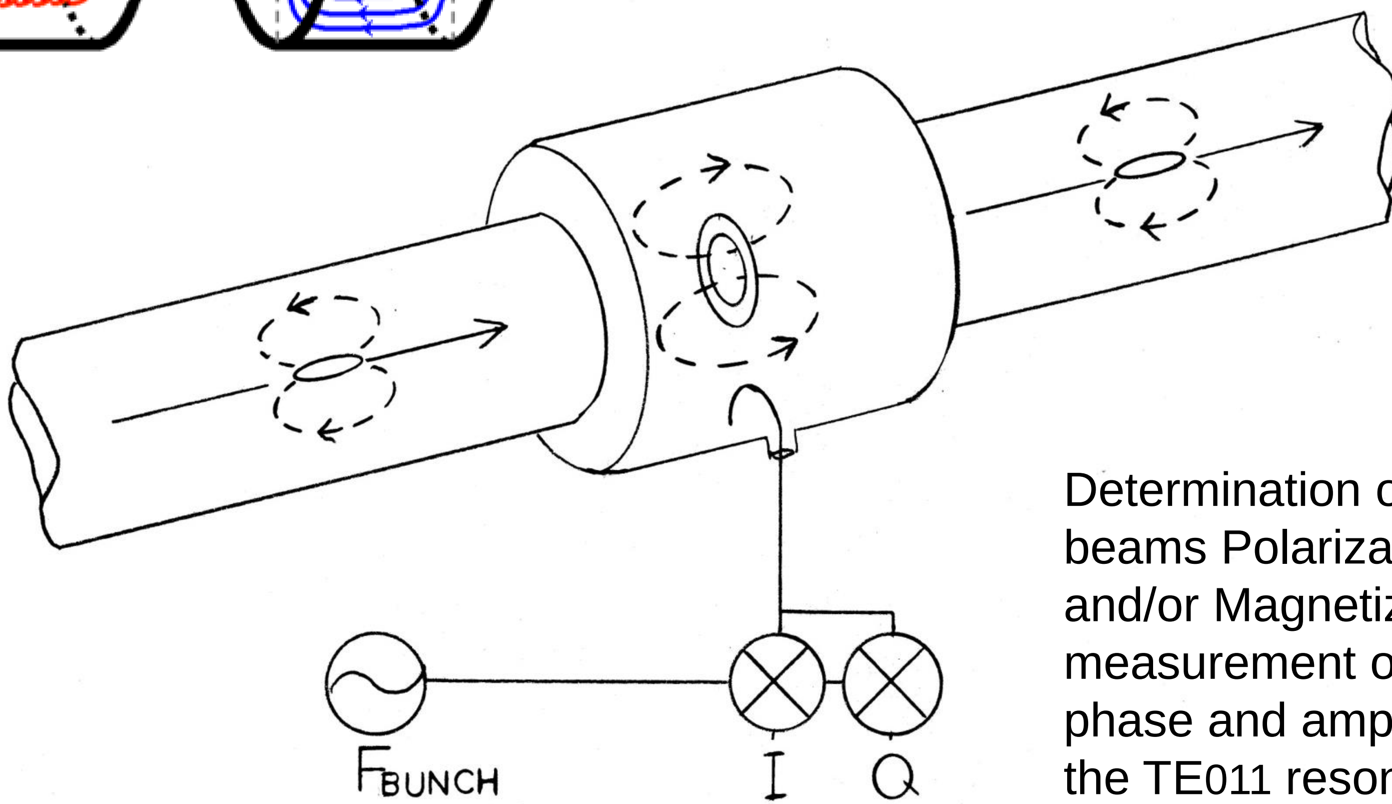




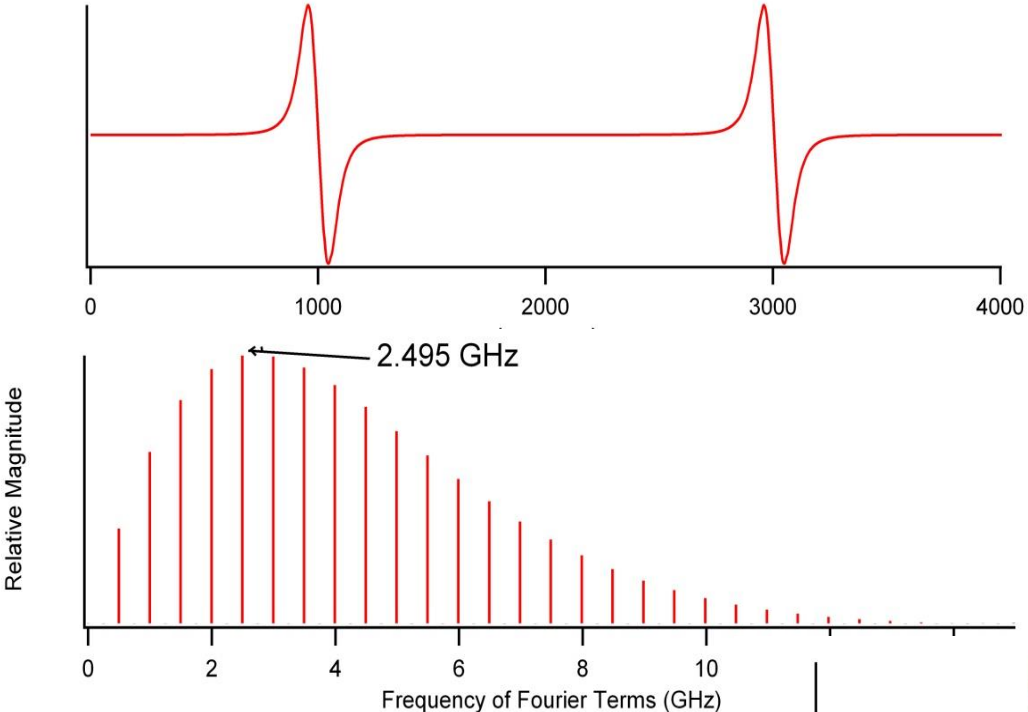


TE011 Cavity Resonance



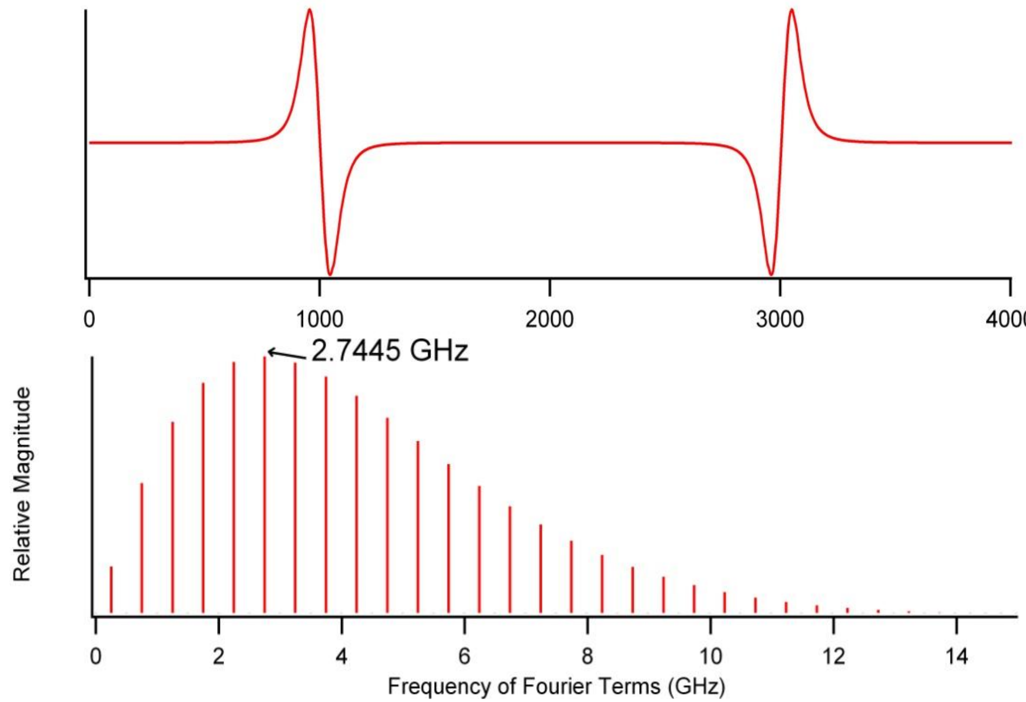


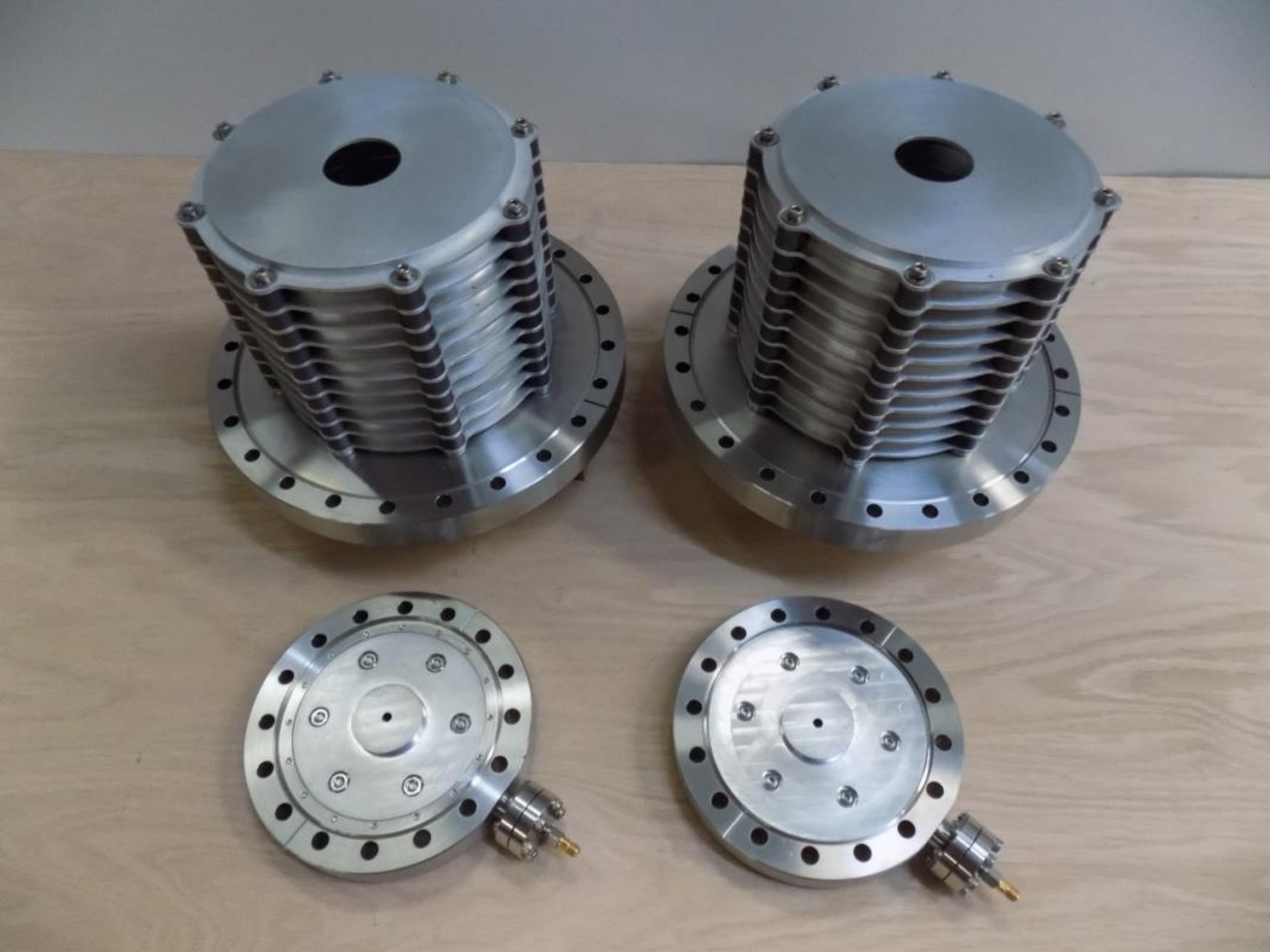
Determination of the beams Polarization and/or Magnetization by measurement of the phase and amplitude of the TE011 resonance induced.

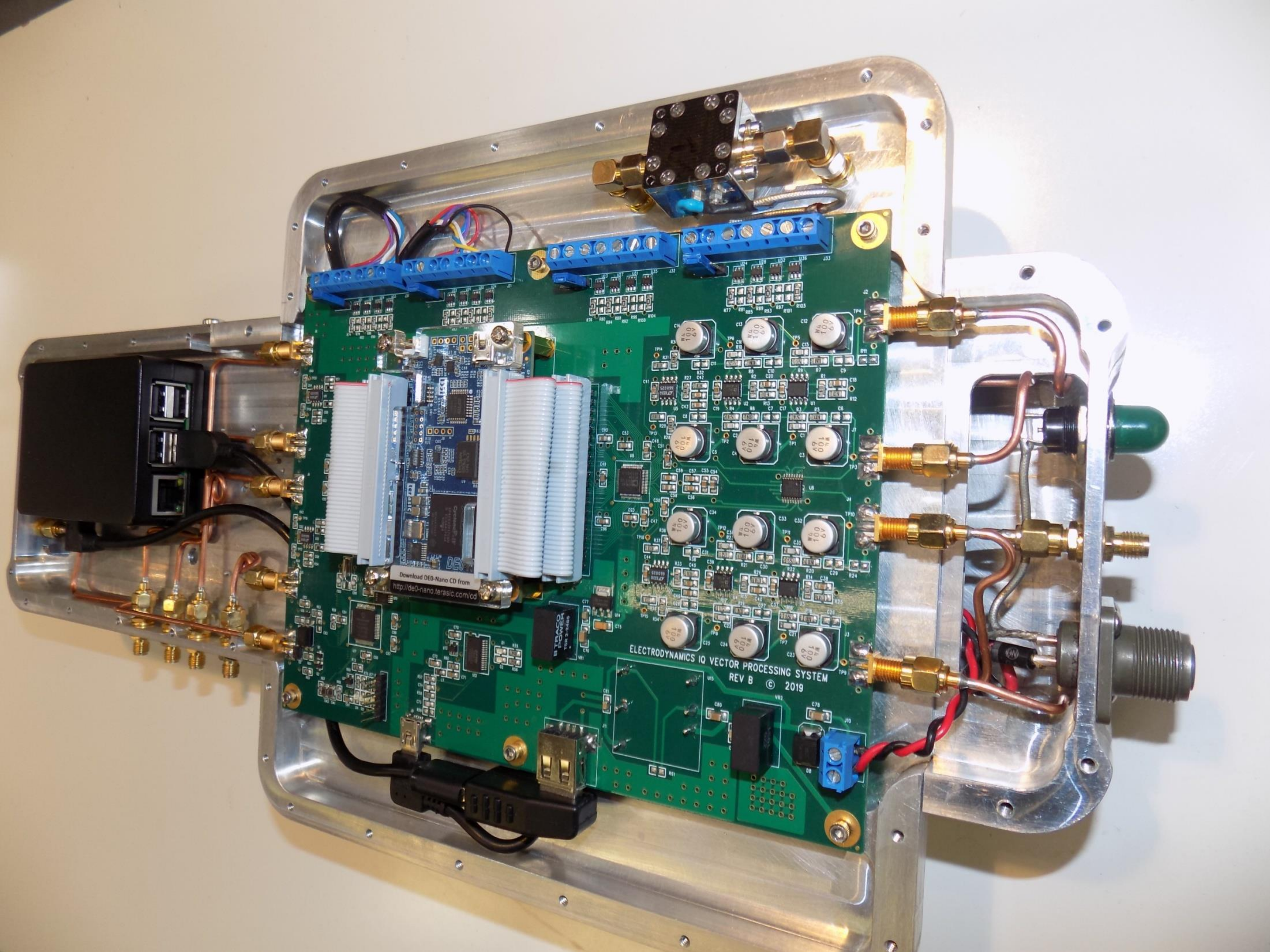


N/S, N/S Beam

N/S, S/N Beam



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TRACO POWER

Thank you for supporting the SBIR Program

- A 14.97 GHz polarimetry system has been installed on the UITF.
- Magnetometry will soon resume on the GTS.
- Soon we will install a ring coupled polarimeter system on the UIFT.
- Got ions? We would like to measure their bunch profile, magnetization, and hopefully their longitudinal polarization.

web.mit.edu/8.02t/www/802TEAL3D/visualizations/faraday/FallingMagnetResistive/FallingMagnetResistive.htm] pp 7-11
https://wiki.jlab.org/ciswiki/index.php/Resonant Polarimeter