

Non- Invasive Bunch Length Monitor, Fast Kicker, Bunch Shaper, and Photogun.

Electrodynamic, DOE SBIR DE-SC0009509 SBIR Phase II, no cost extension.

PI: Brock F. Roberts

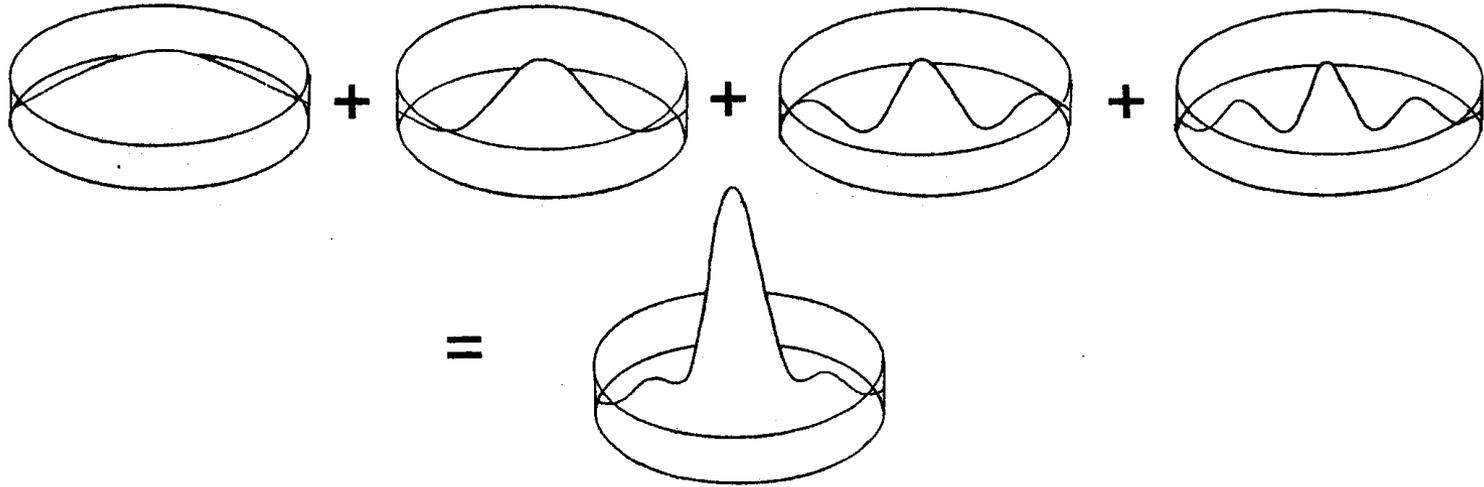
DOE Phase II SBIR Topic: 41G, Nuclear Physics Accelerator Technology, Accelerator Control and Diagnostics.

Collaborator: Thomas Jefferson National Accelerator Facility (TJNAF). Continuous Beam Electron Accelerator Facility, (CBAF). Center for Injectors and Sources (CIS)

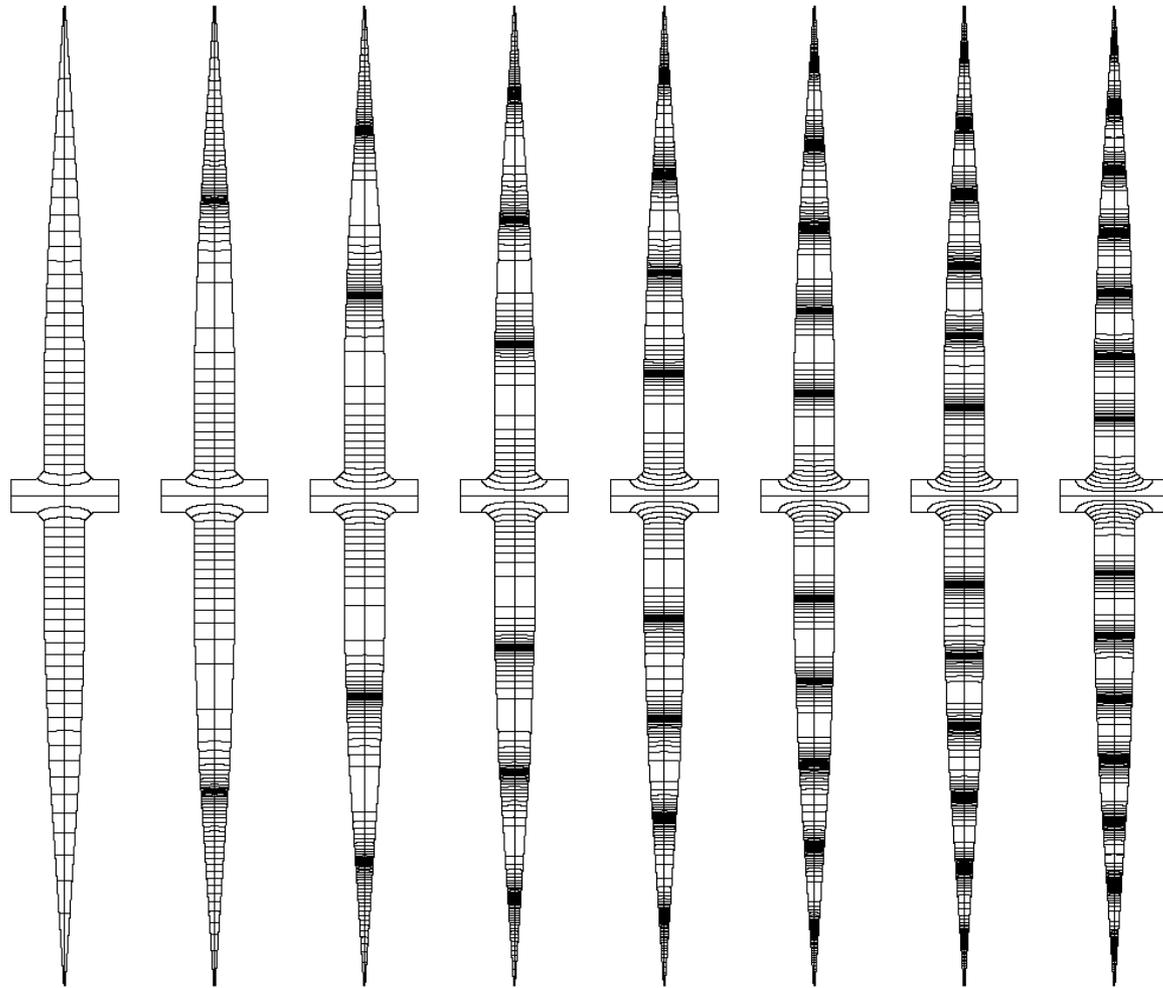
Contractor: University of New Mexico, Electrical Engineering Dept. Applied Electromagnetics group.

Electrodynamic : 4909 Paseo Del Norte suite D, Albuquerque, NM 87113 (505)-225-9279

Can several harmonic TM_{0N0} modes be simultaneously superimposed?



Yes, the cavities shape tunes the TM_{0NO} modes to be Harmonic



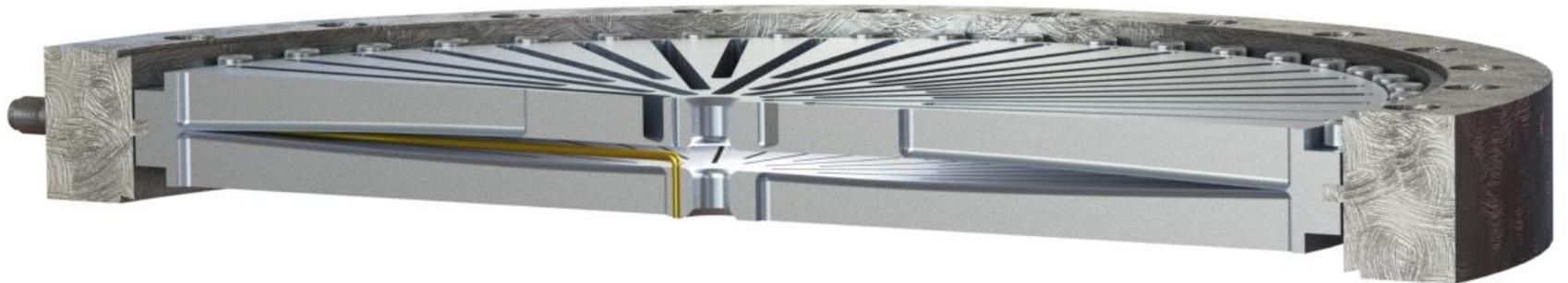
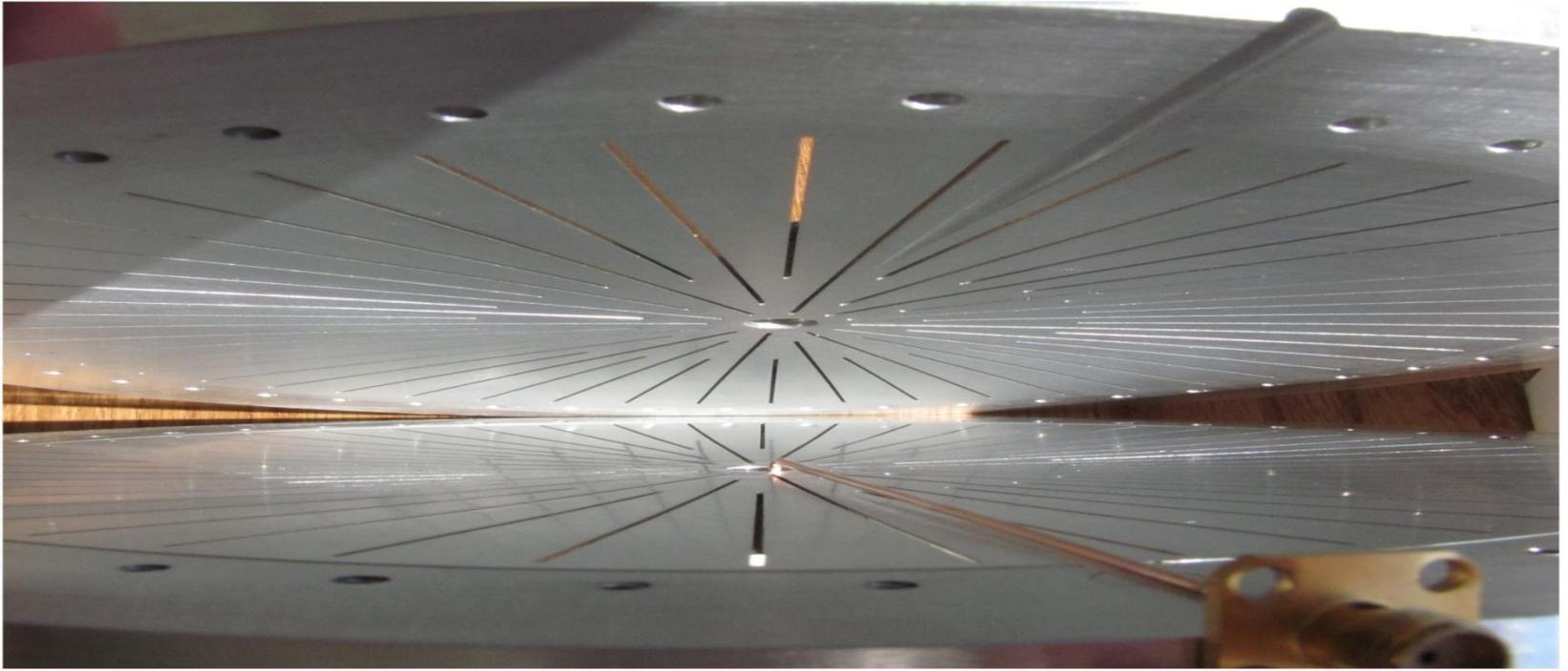
There are many harmonic geometries!

Efficiency



Bandwidth

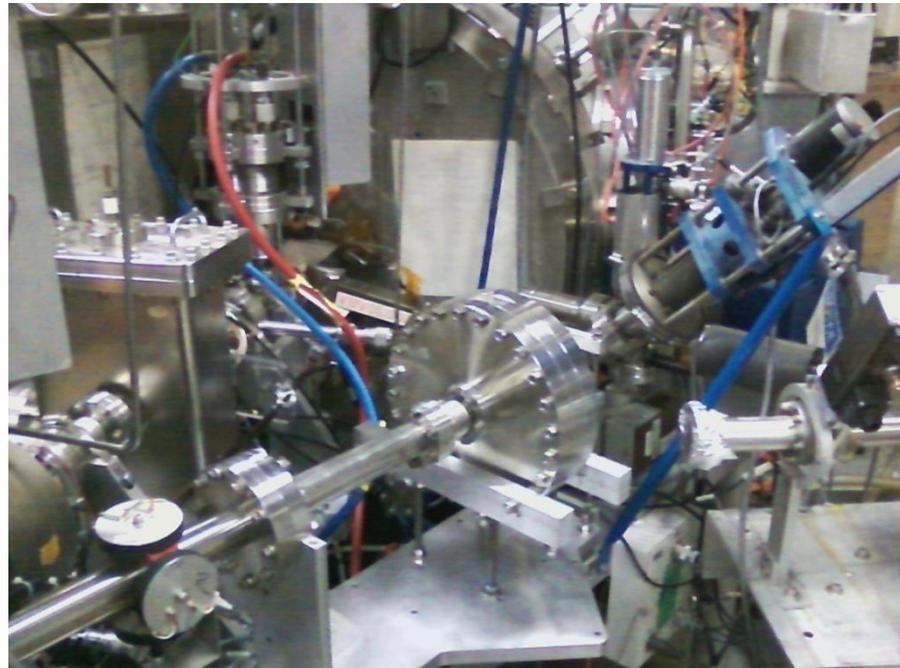
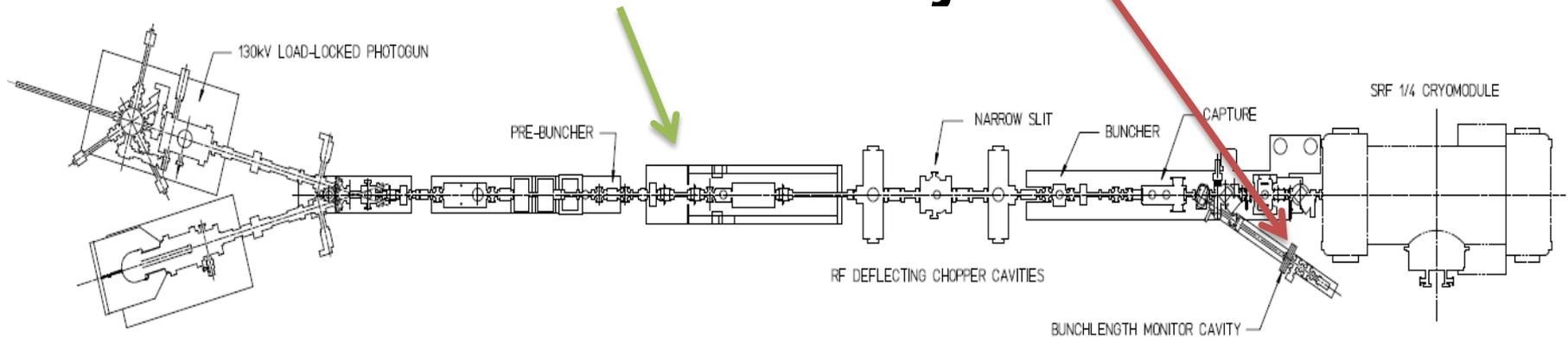
Wideband Antenna





Beam Monitor

Beam Monitor Evaluation in CEBAF's injector

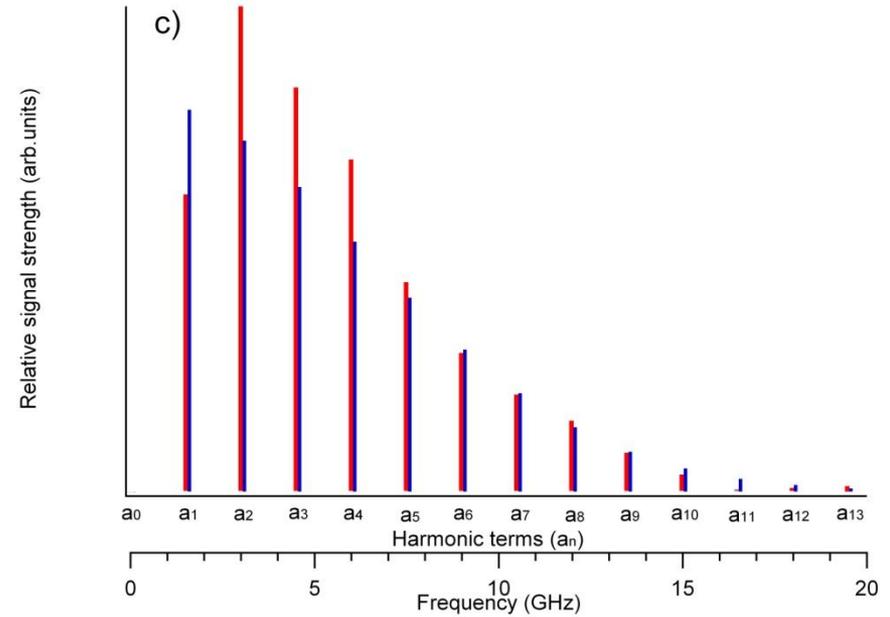
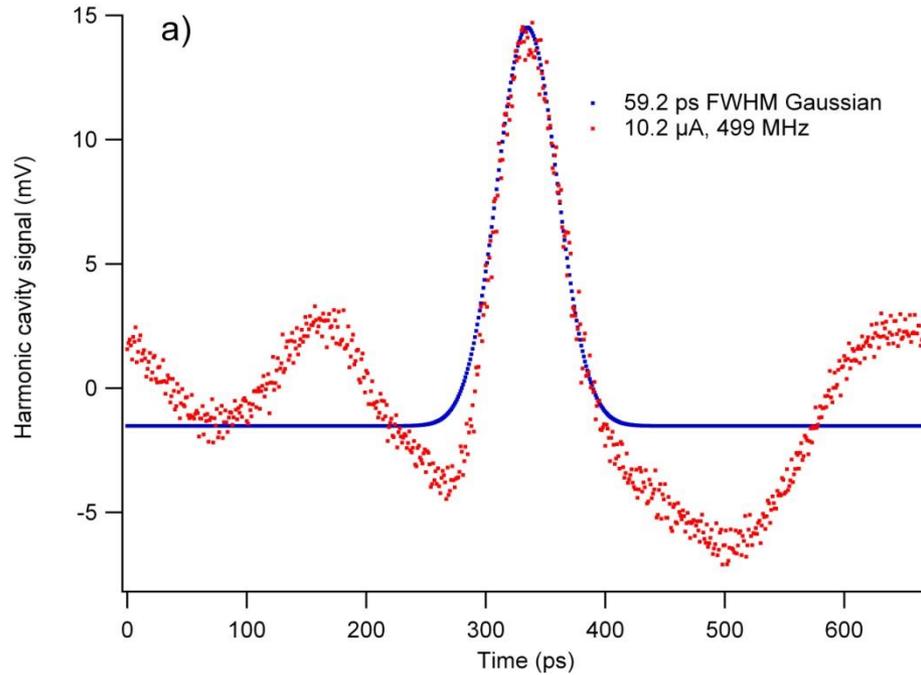


The detected waveform is the superposition of the cavity modes excited by the beam. The beam can be described in the same format; the compact trigonometric form of their Fourier series

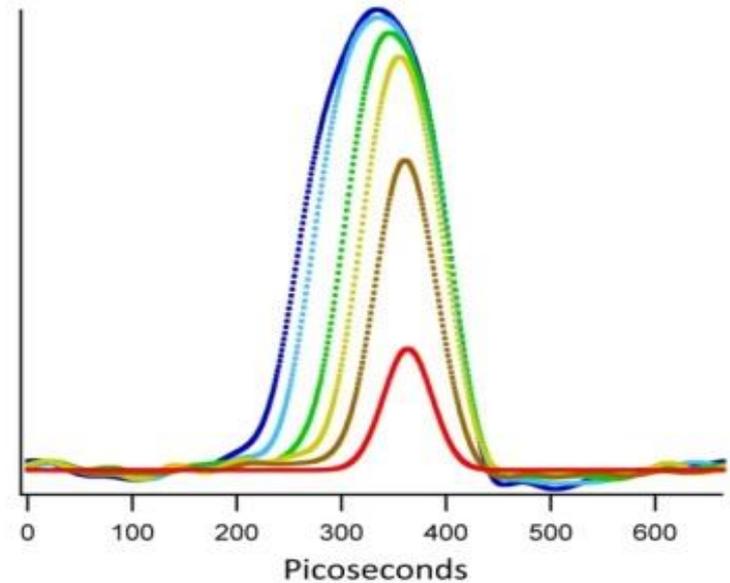
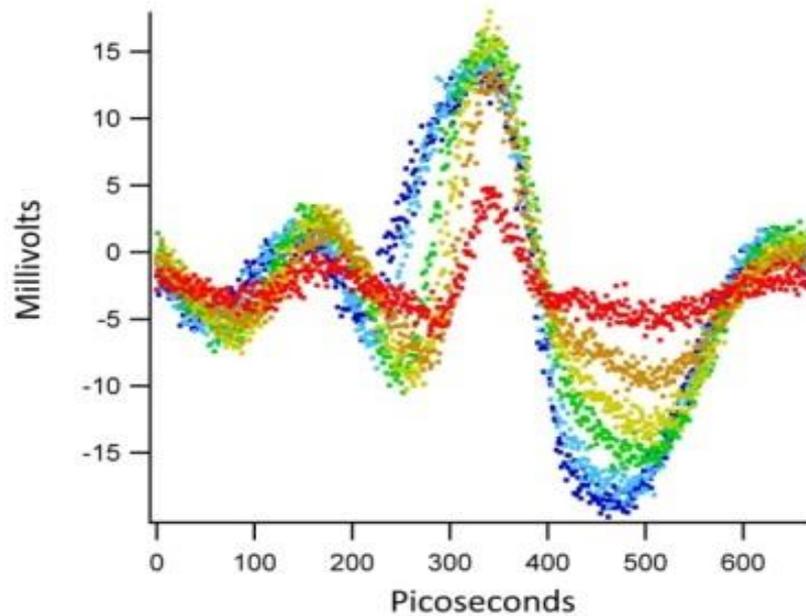
$$F(v_{detected}(t)) = a_{TM_{010}} \cos(\omega_0 t + \theta_{010}) + \\ a_{TM_{020}} \cos(2\omega_0 t + \theta_{020}) \dots \\ + a_{TM_{0n0}} \cos(n\omega_0 t + \theta_{0n0}).$$

$$F(i_{beam}(t)) = a_1 \cos(\omega_0 t + \theta_1) + a_2 \cos(2\omega_0 t + \theta_2) \dots \\ + a_n \cos(n\omega_0 t + \theta_n).$$

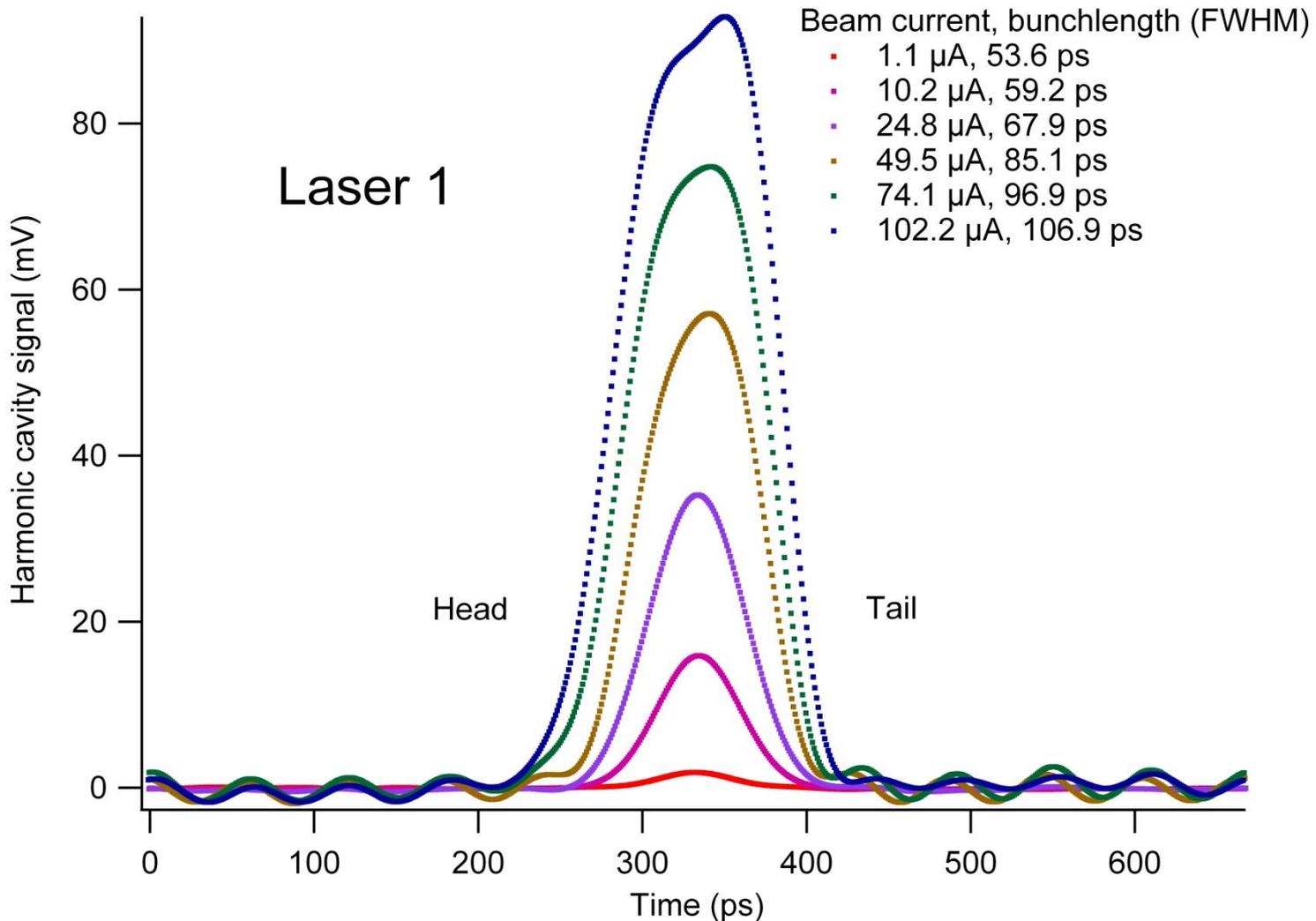
Harmonic Cavity Transfer Function



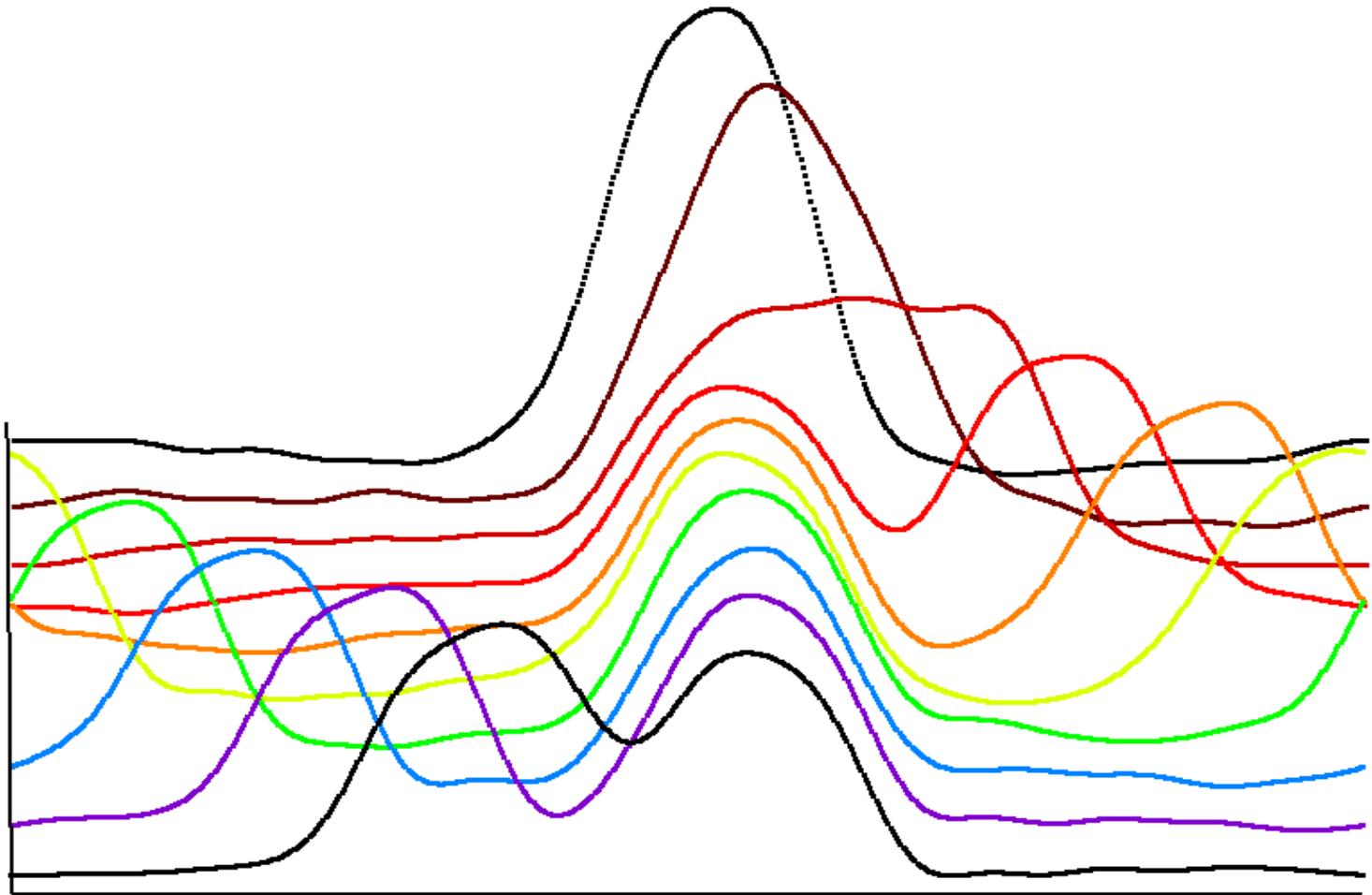
The ratio of these two series is the harmonic cavities transfer function. Once determined, the cavities transfer function can be used to un-distort subsequent data independent of new bunch shapes.



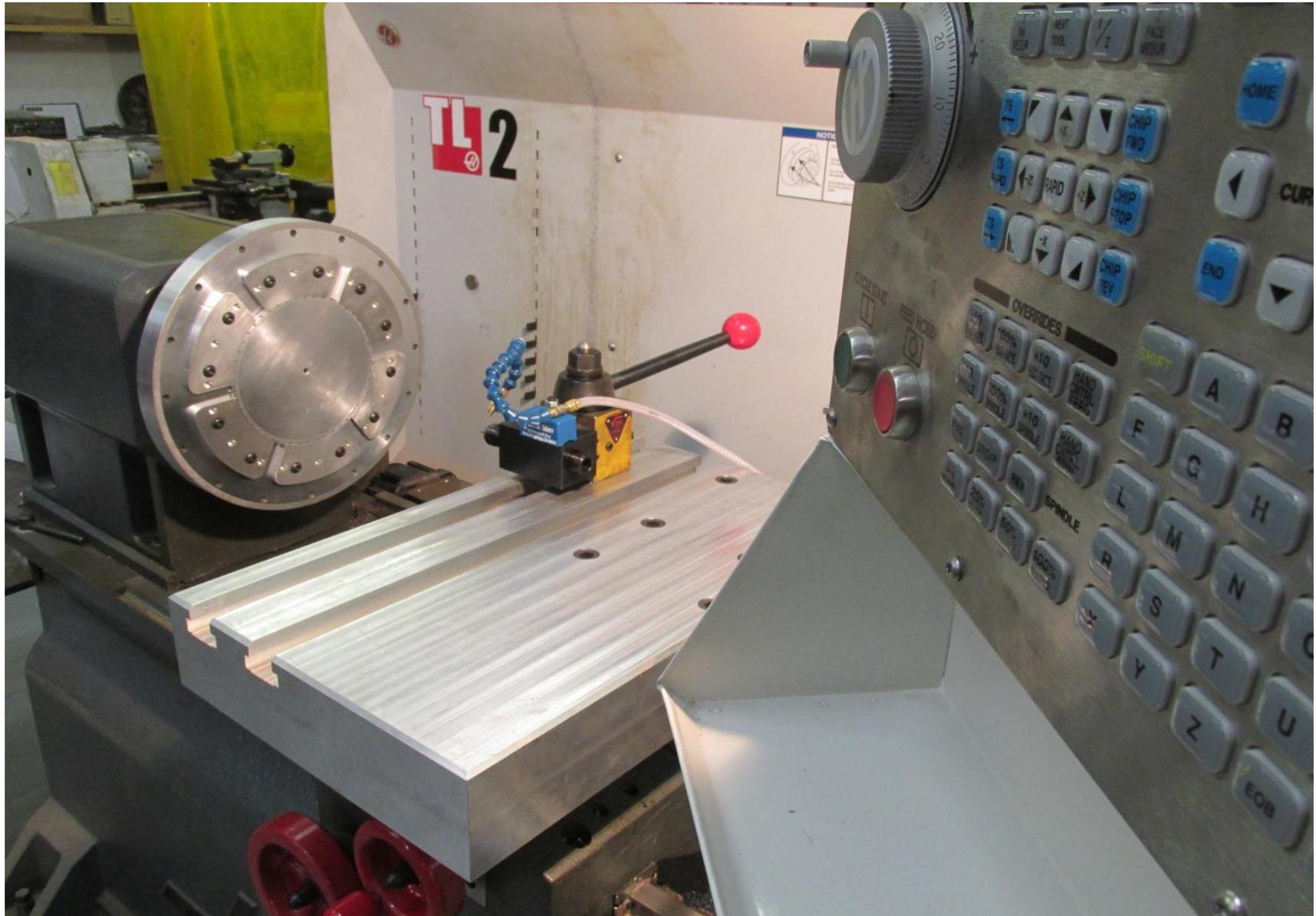
Bunch Width Measurement

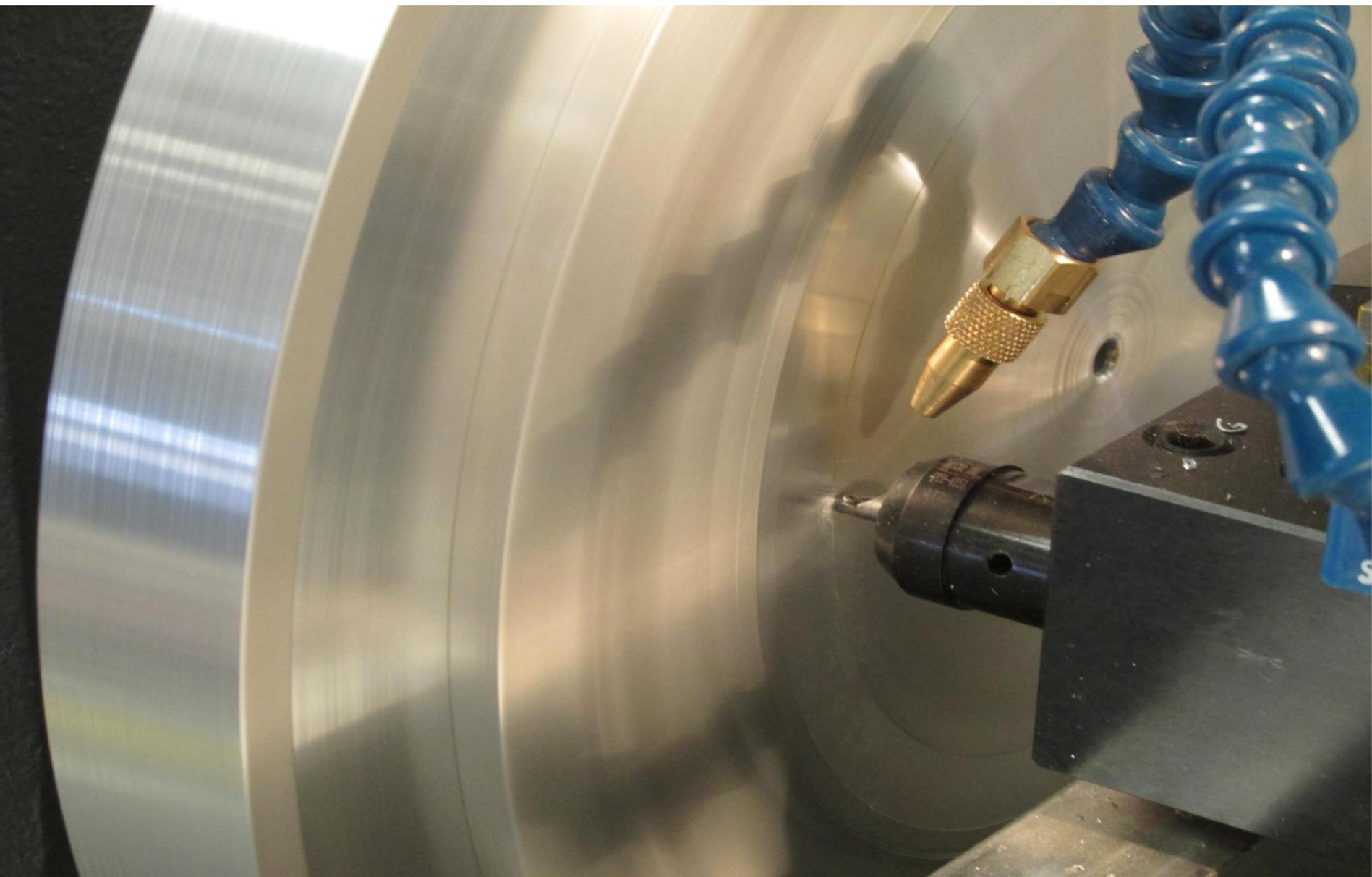


Measurement of Two Interleaved 499 MHz beams.

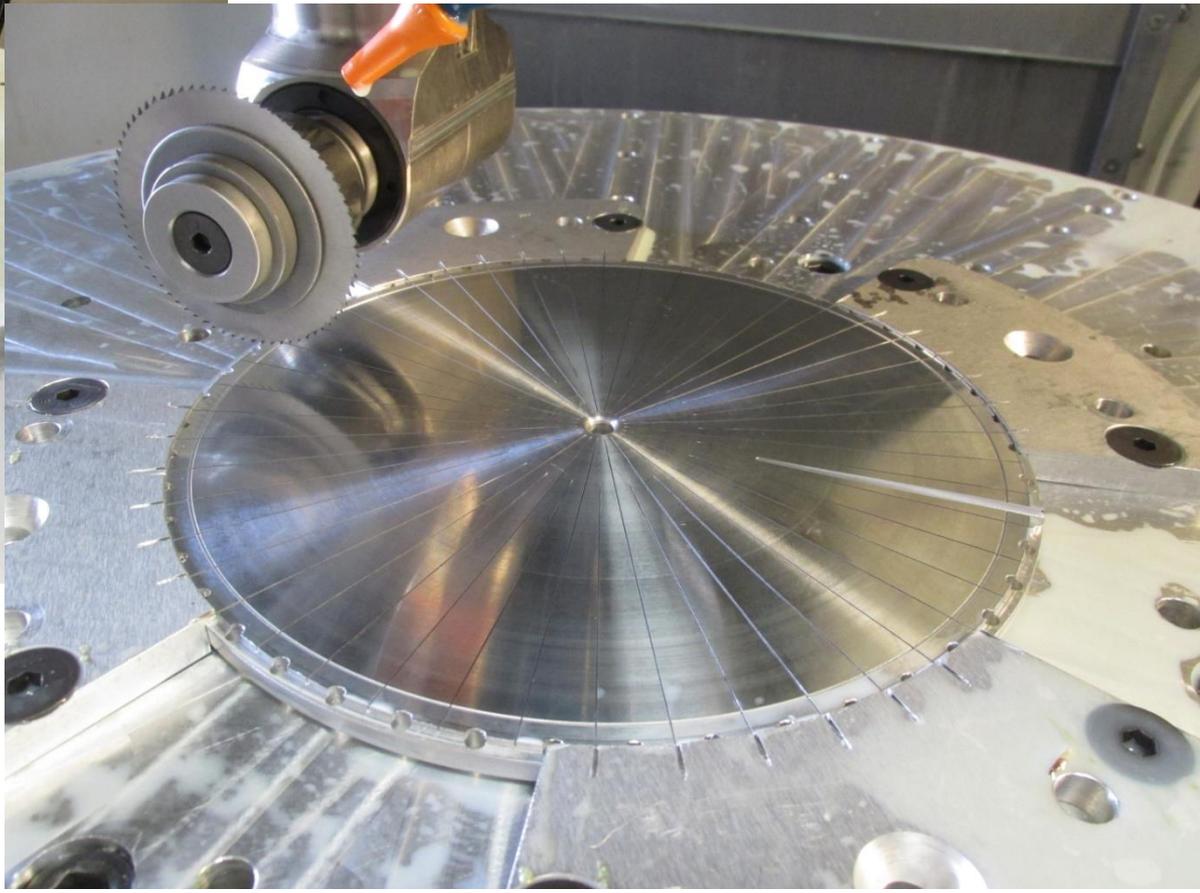
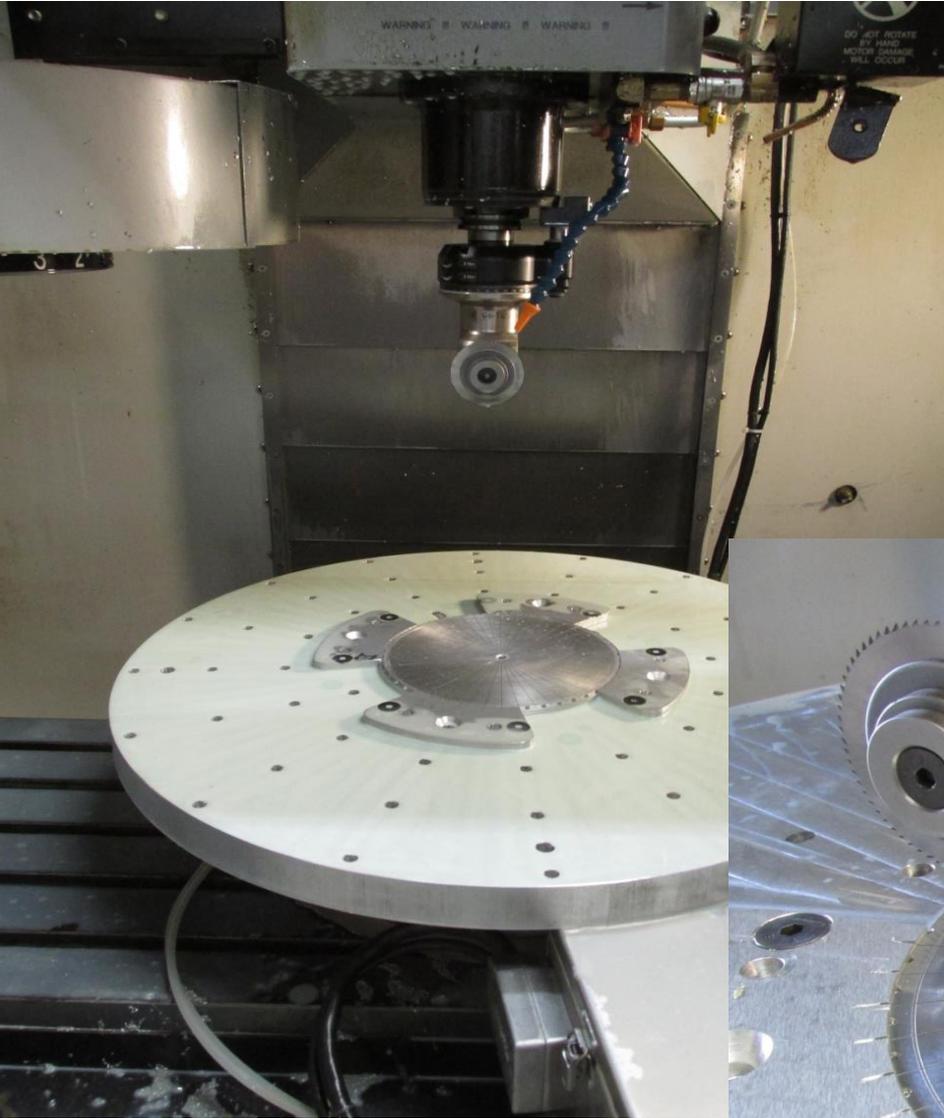


CNC Lathe and Vacuum Chuck



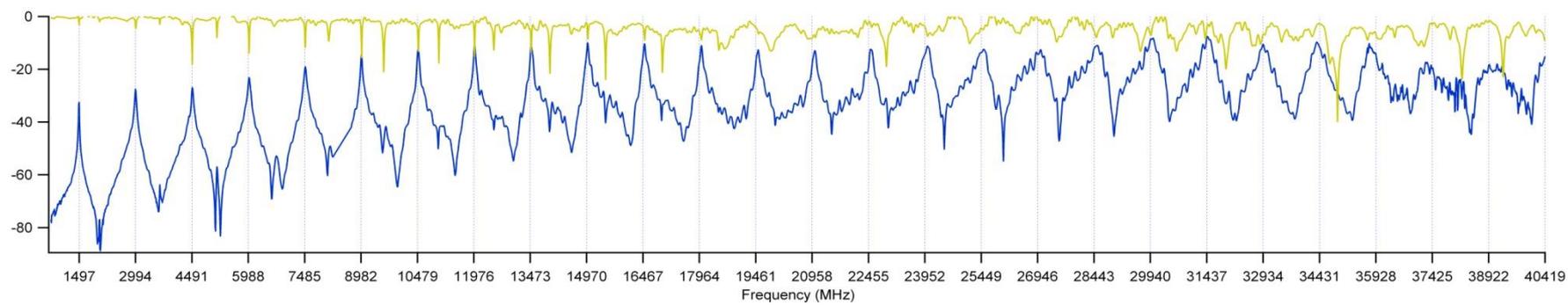


Slitting Saw on CNC Mill with 26" rotary



Brazing in Argon Gas

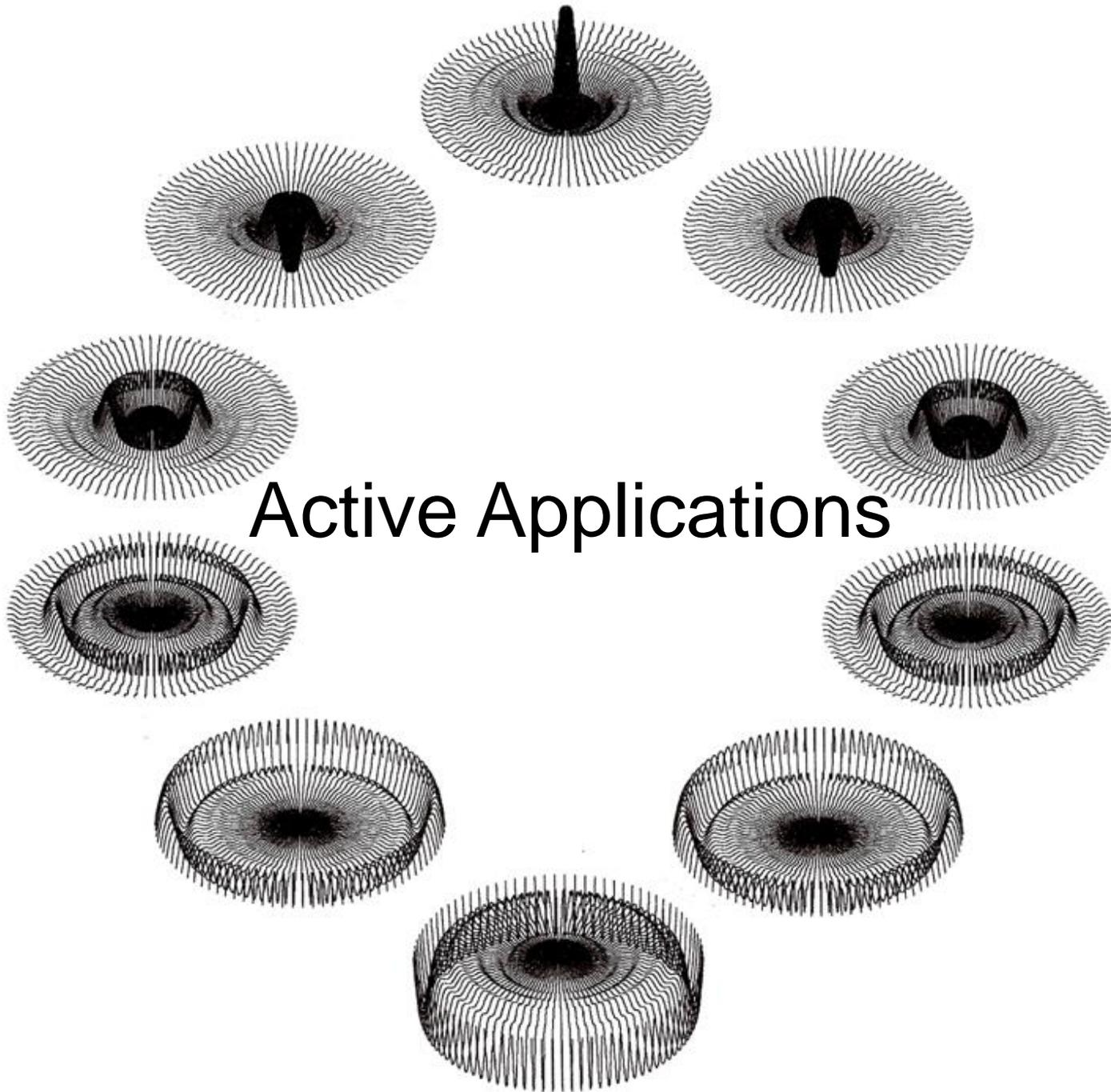




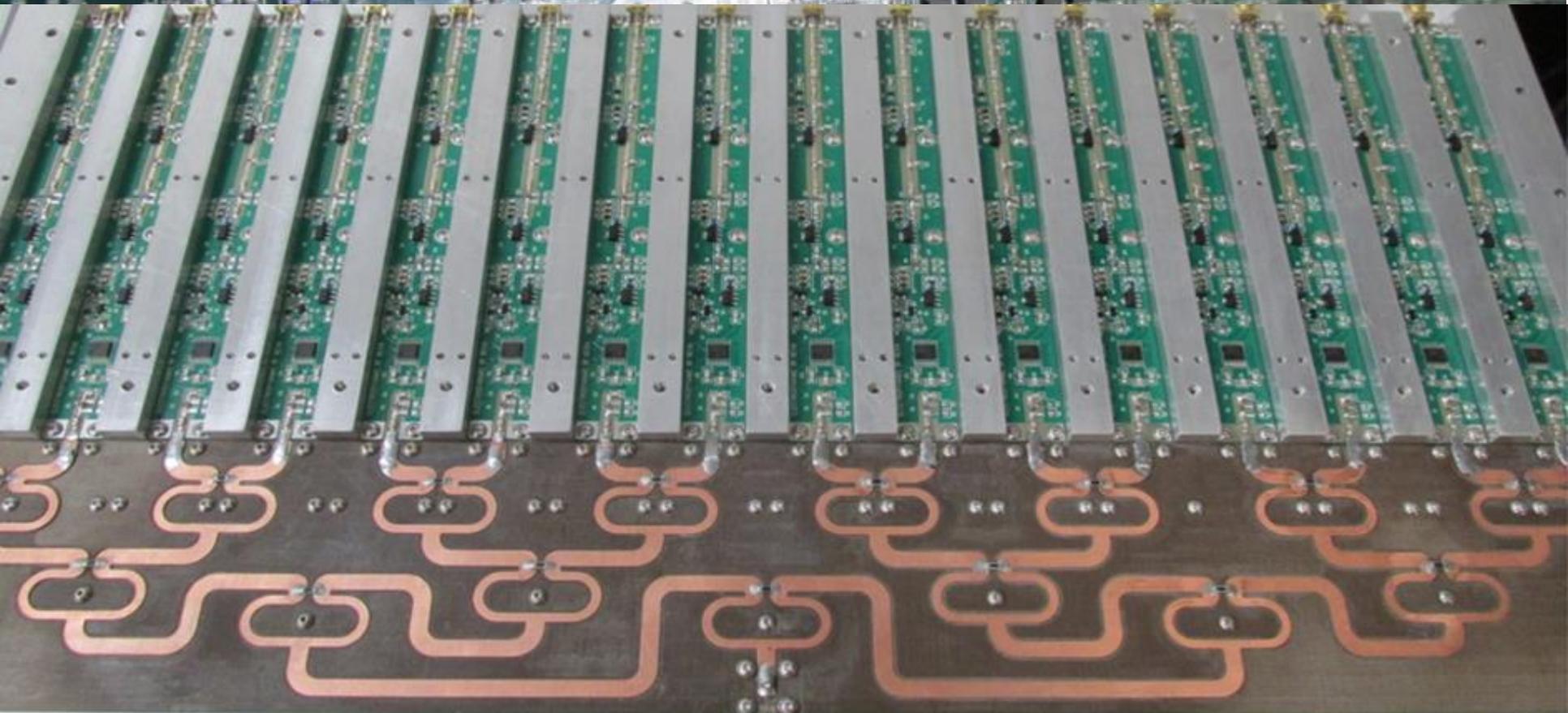
Phase II Beam Monitors



Active Applications



Harmonic Arbitrary Waveform Generator (HAWG)



HAWG Graphical User Interface

File Edit Format View Help

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[GENERAL]
Description=Standard settings for ElectroDynamics
master_offset=0
num_controllers=16

[controller_1]
amplitude=50
phase=291
name=Fundamental
divisor=1
dac1_offset=0
dac2_offset=0
paactive=1

[controller_2]
amplitude=100
phase=189
name=2nd Harmonic
divisor=2
dac1_offset=0
dac2_offset=0
paactive=1

[controller_3]
amplitude=100
phase=27
name=3rd Harmonic
divisor=3
dac1_offset=0
dac2_offset=0
paactive=1

[controller_4]
amplitude=100
phase=339.5
name=4th Harmonic
divisor=4
dac1_offset=0
dac2_offset=0
paactive=1

[controller_5]
amplitude=36
phase=164
name=5th Harmonic
```

File Help

Standard Settings for ElectroDynamics

Control Channel	Phase	Amplitude	Active
1 Fundamental	20.56	76.90	True
2 2nd Harmonic	194.49	91.92	True
3 3rd Harmonic	30.02	100.00	True
4 4th Harmonic	339.50	100.00	True
5 5th Harmonic	164.00	36.00	True
6 6th Harmonic	326.40	75.00	True
7 7th Harmonic	261.00	79.00	True
8 8th Harmonic	353.70	55.00	True
9 9th Harmonic	51.44	88.24	True
10 10th Harmonic		123.91 73.50	False
11 11th Harmonic		64.27 92.14	False
12 12th Harmonic		0.00 100.00	False
13 13th Harmonic		0.00 100.00	False
14 14th Harmonic		0.00 100.00	False
15 15th Harmonic		0.00 100.00	False
16 16th Harmonic		0.00 100.00	False

UNKNOWN CMD5007FFFFE
SET CHANNEL SUCCESS

P001
RFSTATE=ON

2nd Harmonic

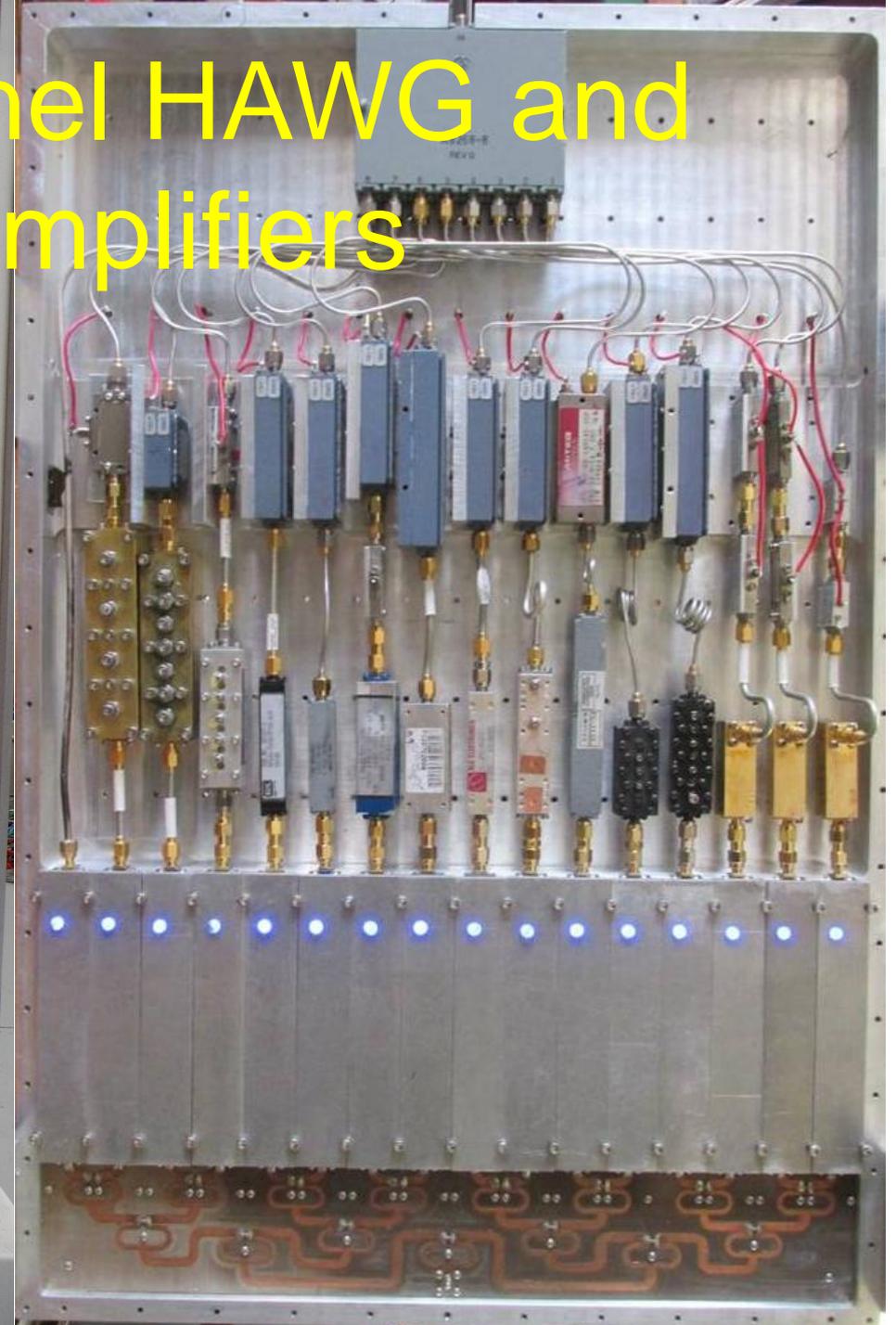
Phase 194.490 Ampl 92 Active

X: -88.99998 0E1 Y: -23.00008 628

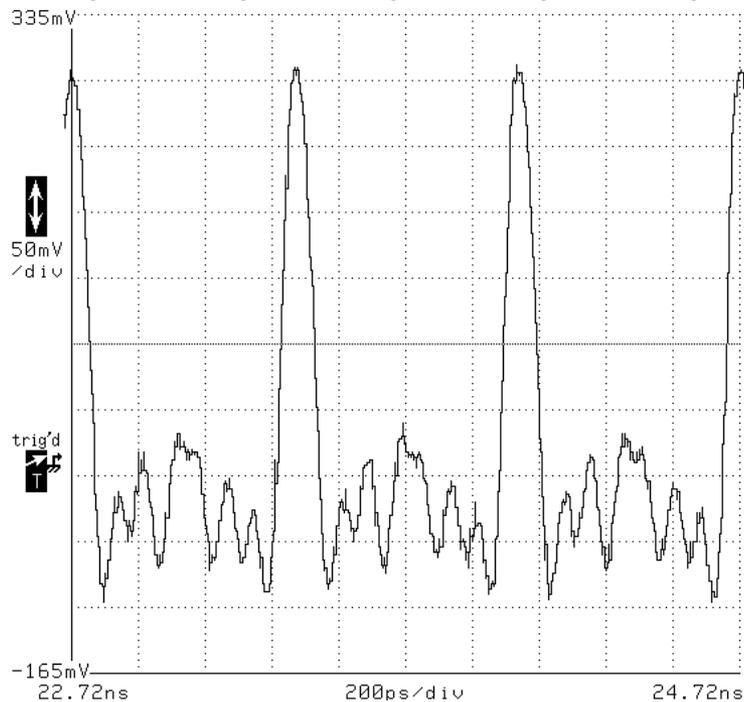
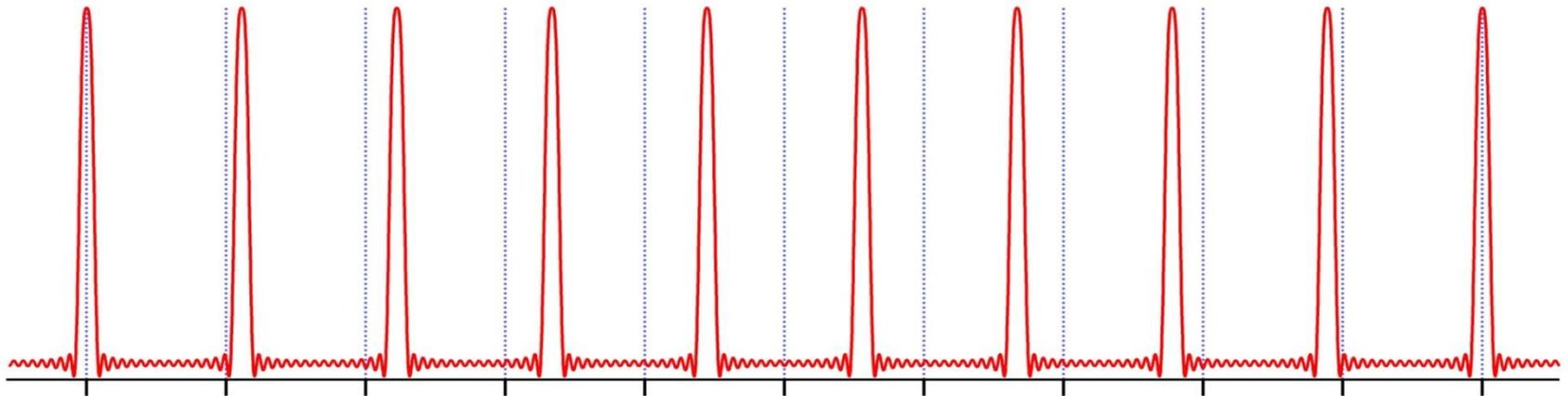
Master Phase Offset 0.000

Reset Phases Reset Amplitudes

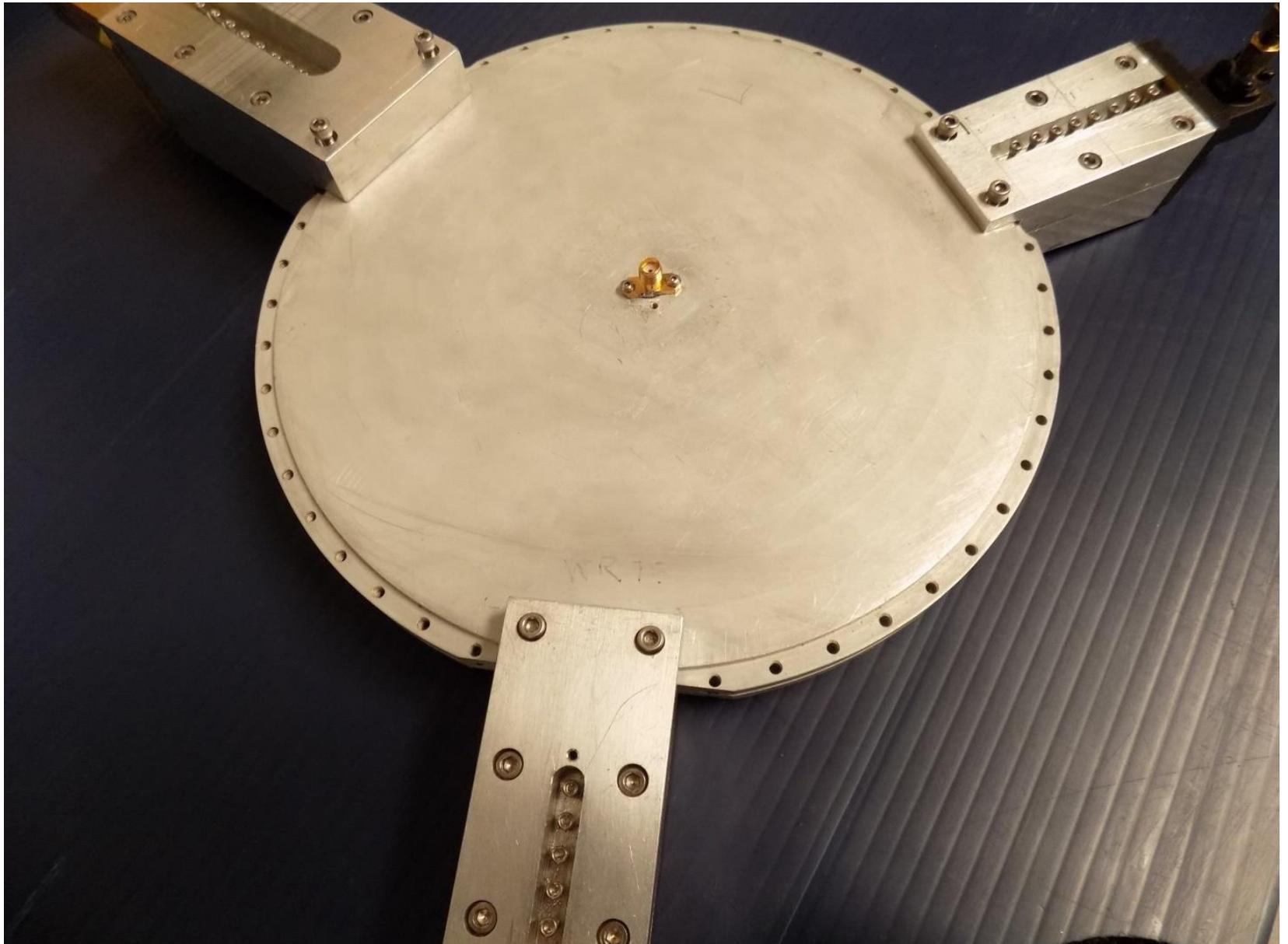
Sixteen Channel HAWG and Power Amplifiers



Fractionally Interleaved Kicking



High Power Waveguide Coupling.



CNC Lathe/Mill hybrid can now machine harmonic cavities up to 8 ft. in diameter.



Thank you for supporting the SBIR Program

- Better harmonic cavities with greater bandwidth will equip CEBAF with high resolution beam monitors.
- Upcoming kicking and bunch shaping experiments will evaluate fractionally interleaved kicking, and a bunch shaping photogun.
- Electrodynamics has won the International Beam Instrumentation Conference's (IBIC) 2016 Faraday Cup award.