RF Measurements of the APS Operational Thermionic Cathode Gun

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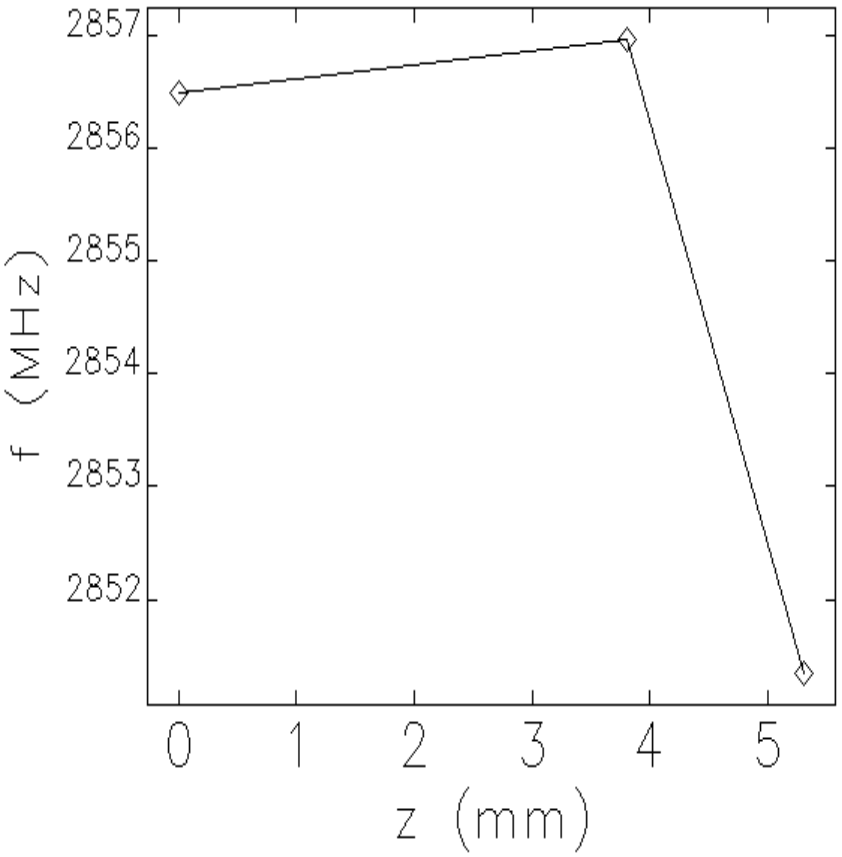
Accelerator Systems Division
Photo-Injector Physics Meeting
June 18, 2013

Background: RF Measurements done at the ITS



Nicholas Sereno <sereno@aps.anl.gov>
Feb 6, 2013

"Well, the shimming results don't make sense. Attached is a plot showing the accelerating mode resonant frequency vs relative distance the cathode surface is inside the gun.

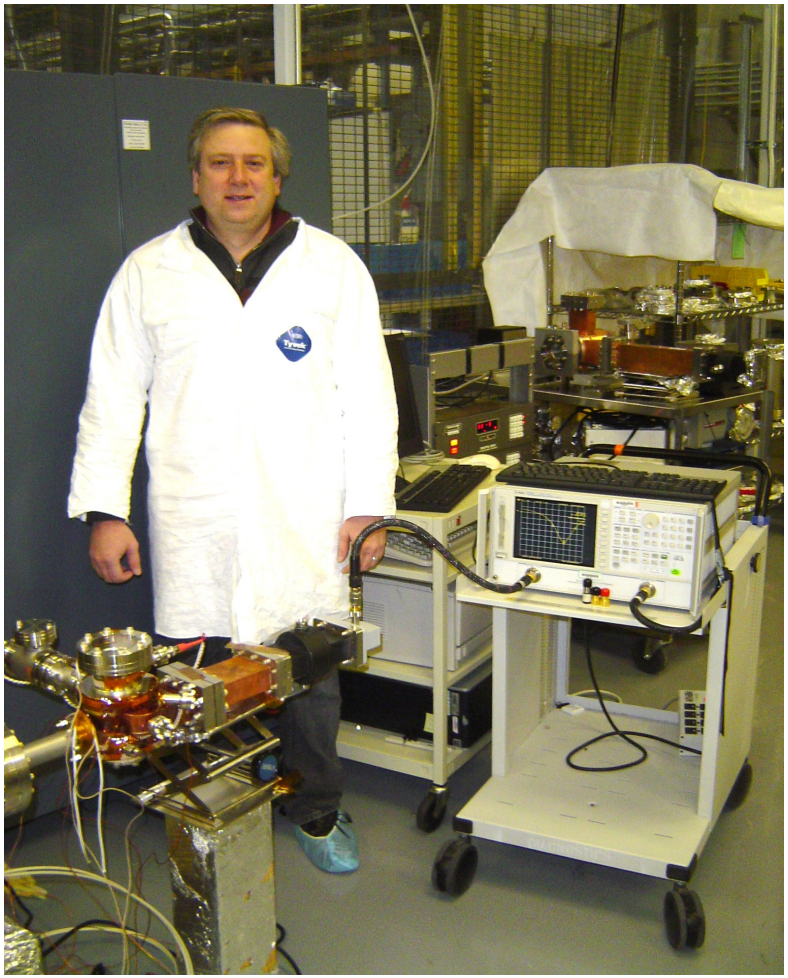
The position z=0 mm is the position with the 0.209" shim installed.
The z=5.3 mm position is with the 0.209" (=5.3 mm) shim removed.
The middle point at 3.9 mm is the recent result this morning with the 0.150" shim. This point should have been lower than the point at z=0."

N. Sereno, S. Pasky and M. Douell,
https://icmsdocs.aps.anl.gov/docs/groups/aps/documents/data/aps_1435794.pdf

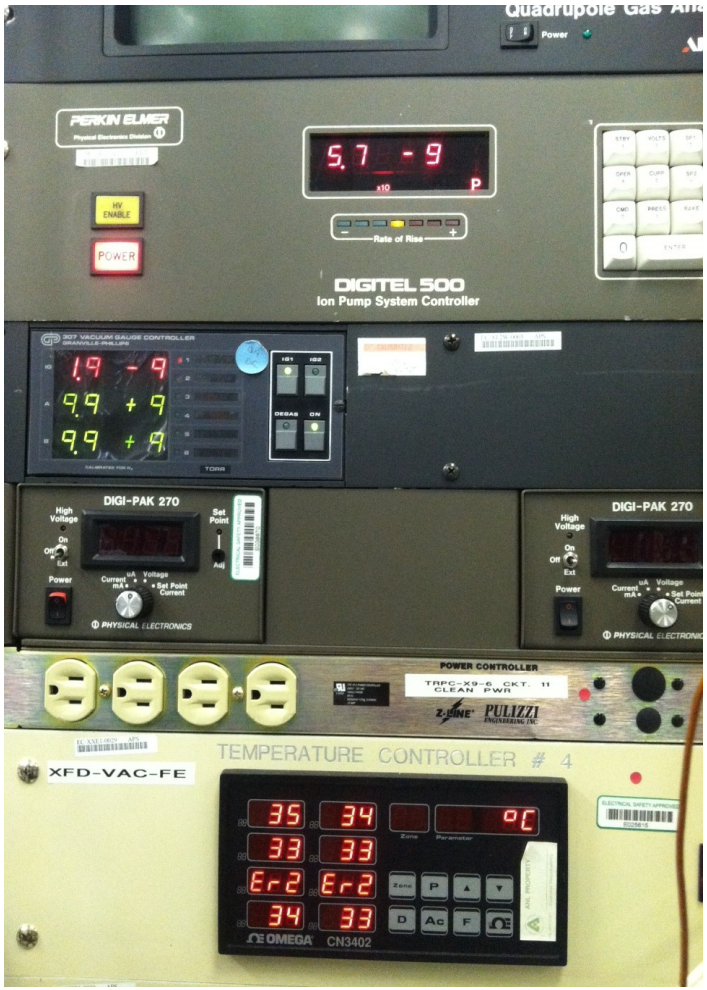
3G2 (3rd Generation, Gun #2, "Larry") Moved to the Vacuum Lab.

- One heater tape is wrapped around the gun body. Six therm-couplers are taped around to measure the gun temperature and one of them is used to control gun body temperature at [35, 40, 45]°C.
- Cathode heater power is adjusted to [0, 5, 10, 15] W.
- A set of cathode shims of [0. 071, 0.110,0.141,0.150,0.209] inches are used to control the cathode longitudinal position inside the RF gun.
- A precision torque wrench was used to tighten the screws that hold the cathode assembly to the gun back plate. Torque values used are [0.1, 0.2, 0.4]Lb*inch.

Larry (&Nick) at the Vacuum Lab.



Gun wrapped with heater tape, hooked with the network analyzer.
Photo by Glenn Decker)



Top two: Ion pump and ion gauge display;
Bottom: Thermo-coupler readings.

Network Analyzer Measurements

- At each setting, the following parameters are taken:
  - Vacuum (ion pump and ion gauge readings);
  - Gun body temperature (six thermo-couplers);
  - Cathode heater current and voltage (power is then calcualted);
- At each setting, three sets of network analyzer curves are collected:
  - The three resonance modes frequencies;
  - High-resolution measurement of the π-mode resonance frequency and external quality factor;
  - The coupling factor.

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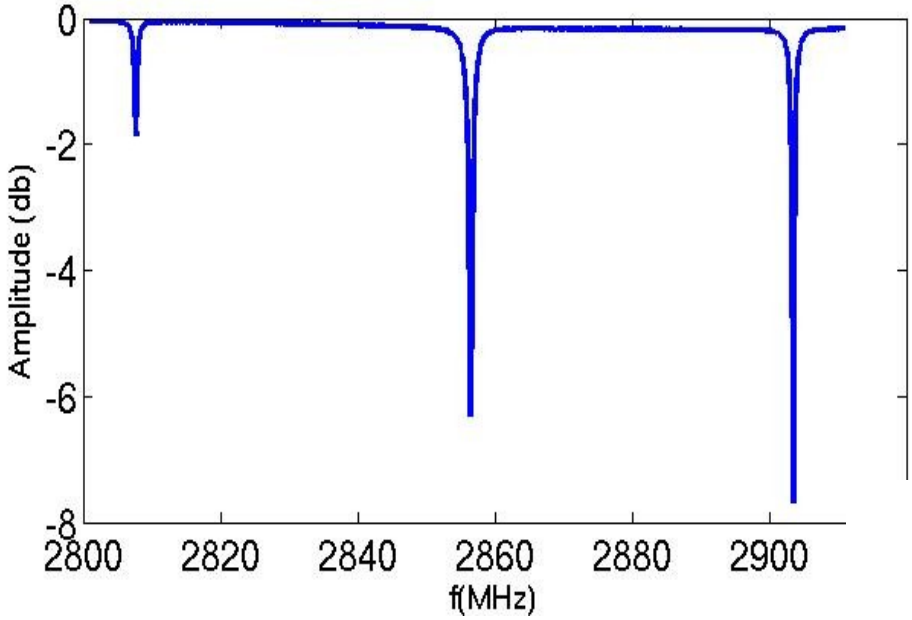
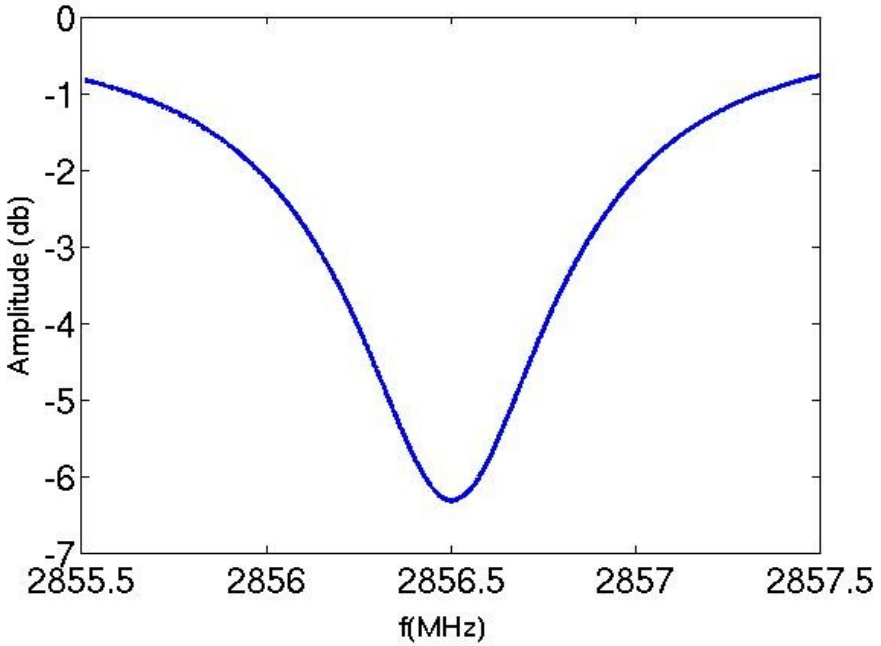
Example Network Analyzer Data (35C, 0W, 0.150”)

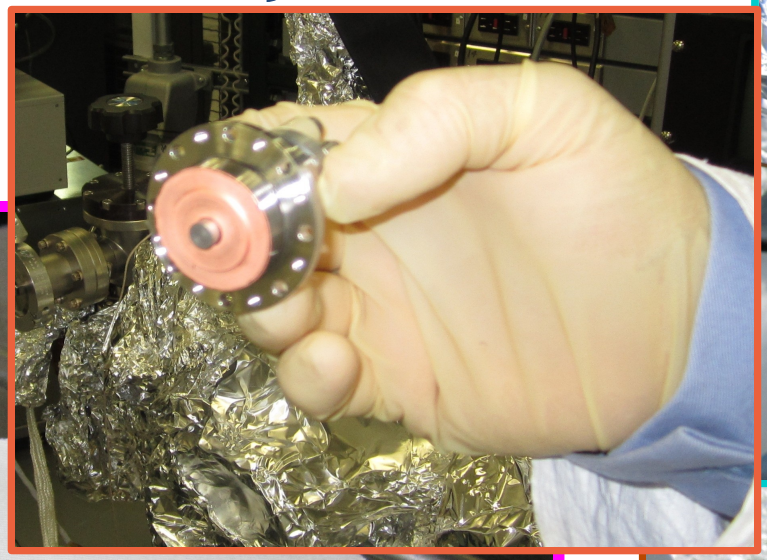


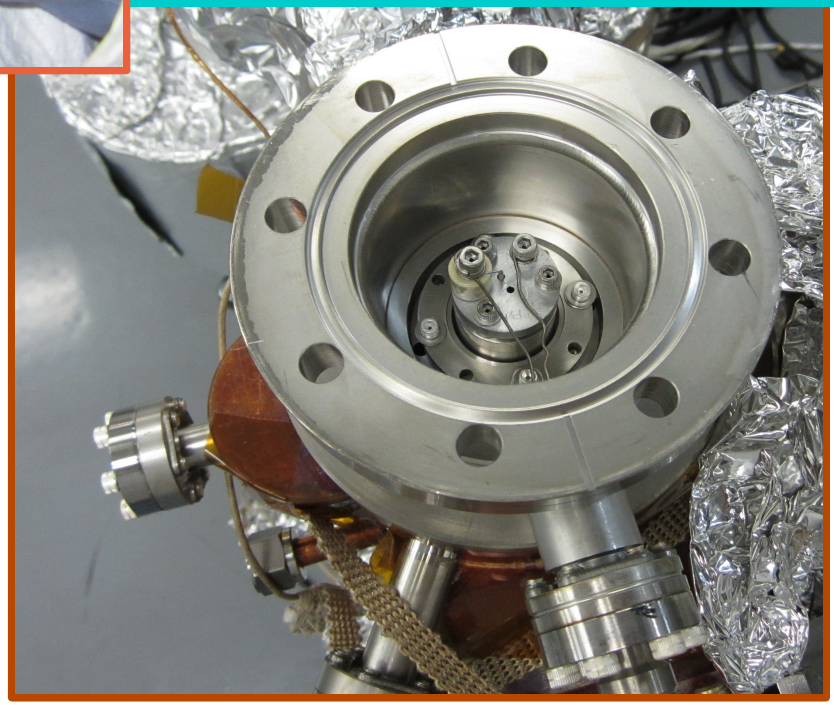
The three resonance modes

Pi-mode



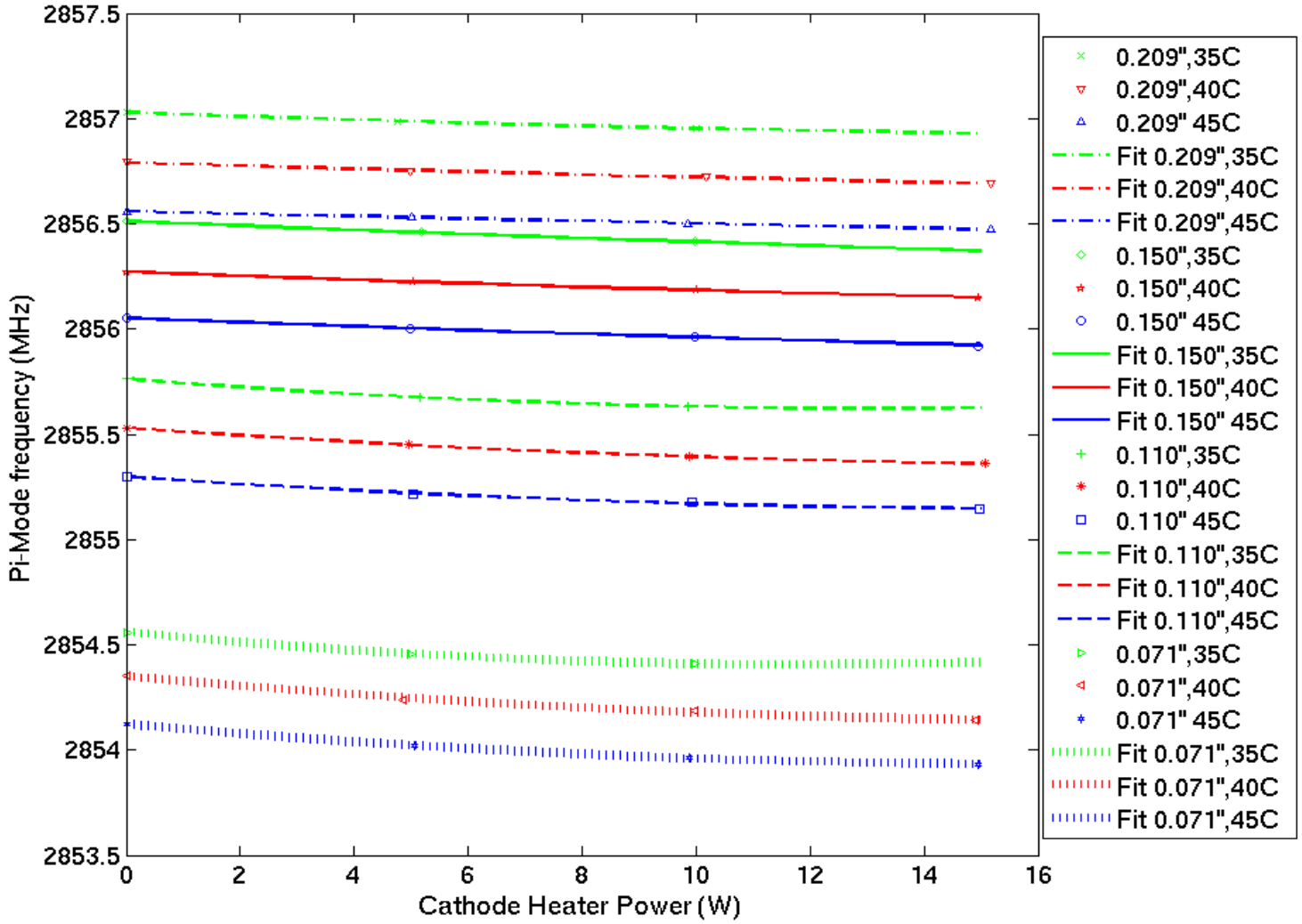
Cathode Assembly and Shims





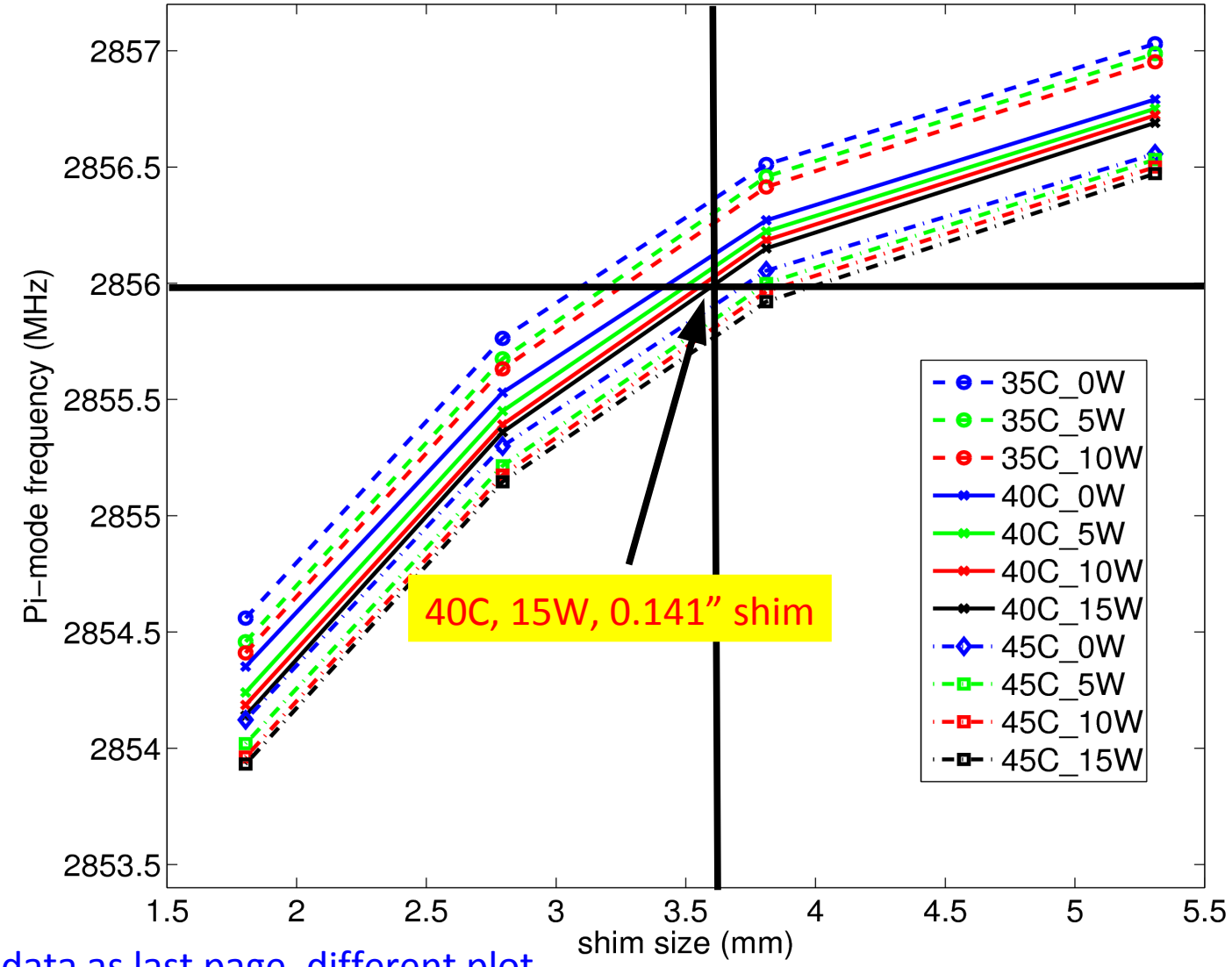
Photos taken by Jeff D.

Shim [0.150,0.110,0.209,0.071]”(2/28-4/12)



Results of the network analyzer measurement of pi-mode frequency at different cathode heater power, gun body temperature and shim size.

Shim [0.150,0.110,0.209,0.071]” (2/28-4/12)



Same data as last page, different plot.

Torque Wrench Test with 0.150” Shim (4/17-5/7)

- From the measurements using [0.150,0.110,0.209,0.071]” shims, the 0.150” brings the π-mode resonance frequency closest to 2856 MHz.
- Using a torque wrench to tighten the cathode assembly

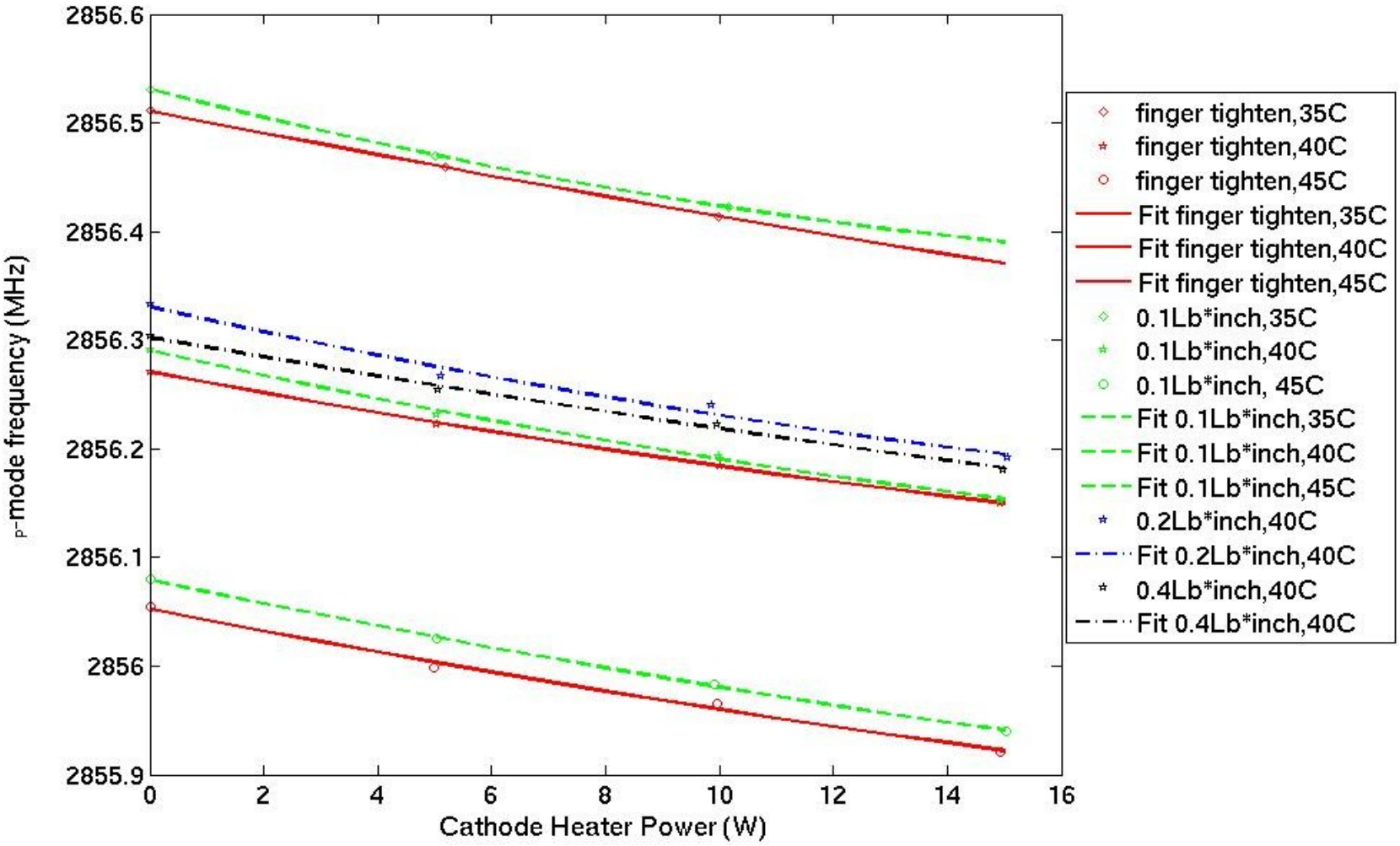
  → a quantitative pressure on the gun back plate

  → precise shaping of the cathode holder area (25um per 0.2 Lb*in torque*)

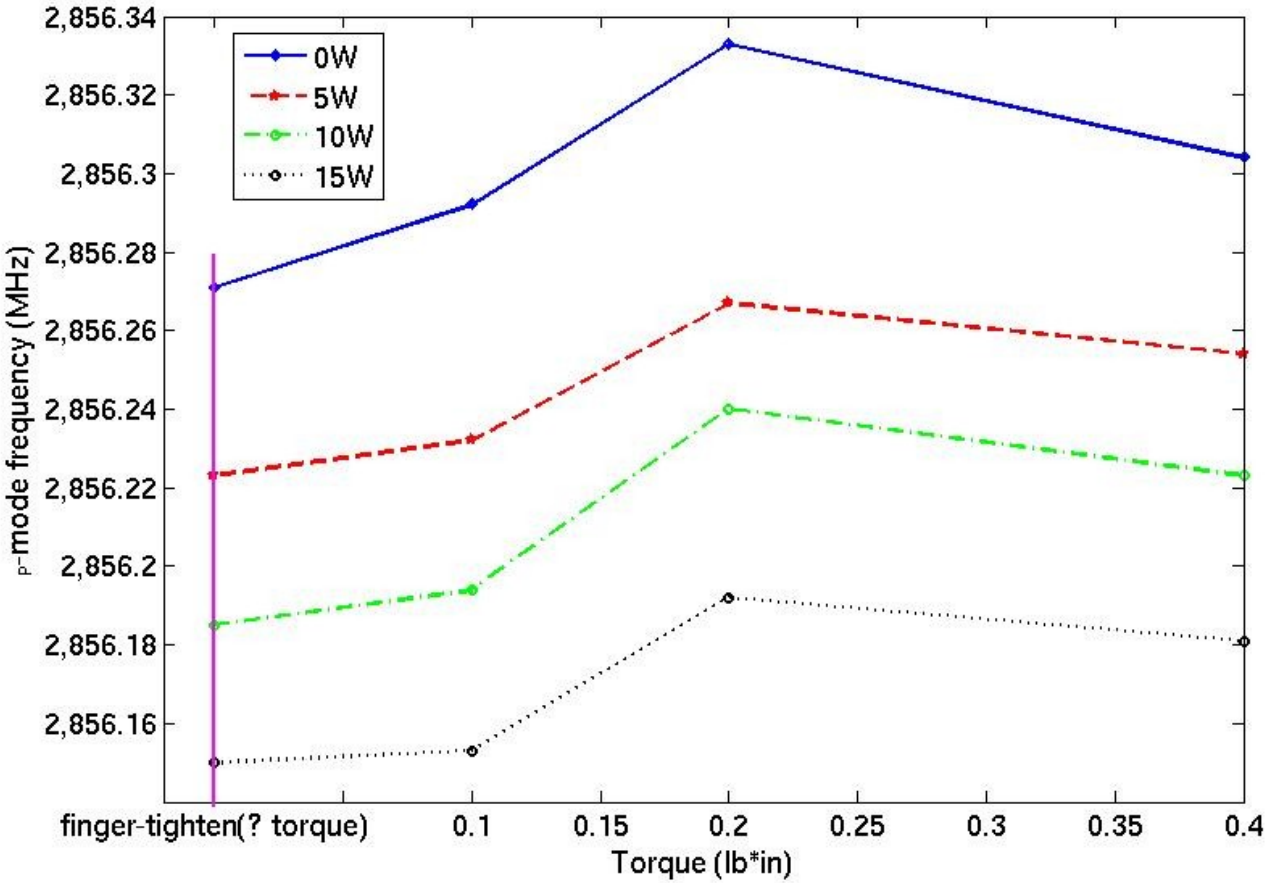
  → repeatable resonance frequency.

*Per Bill Jansma

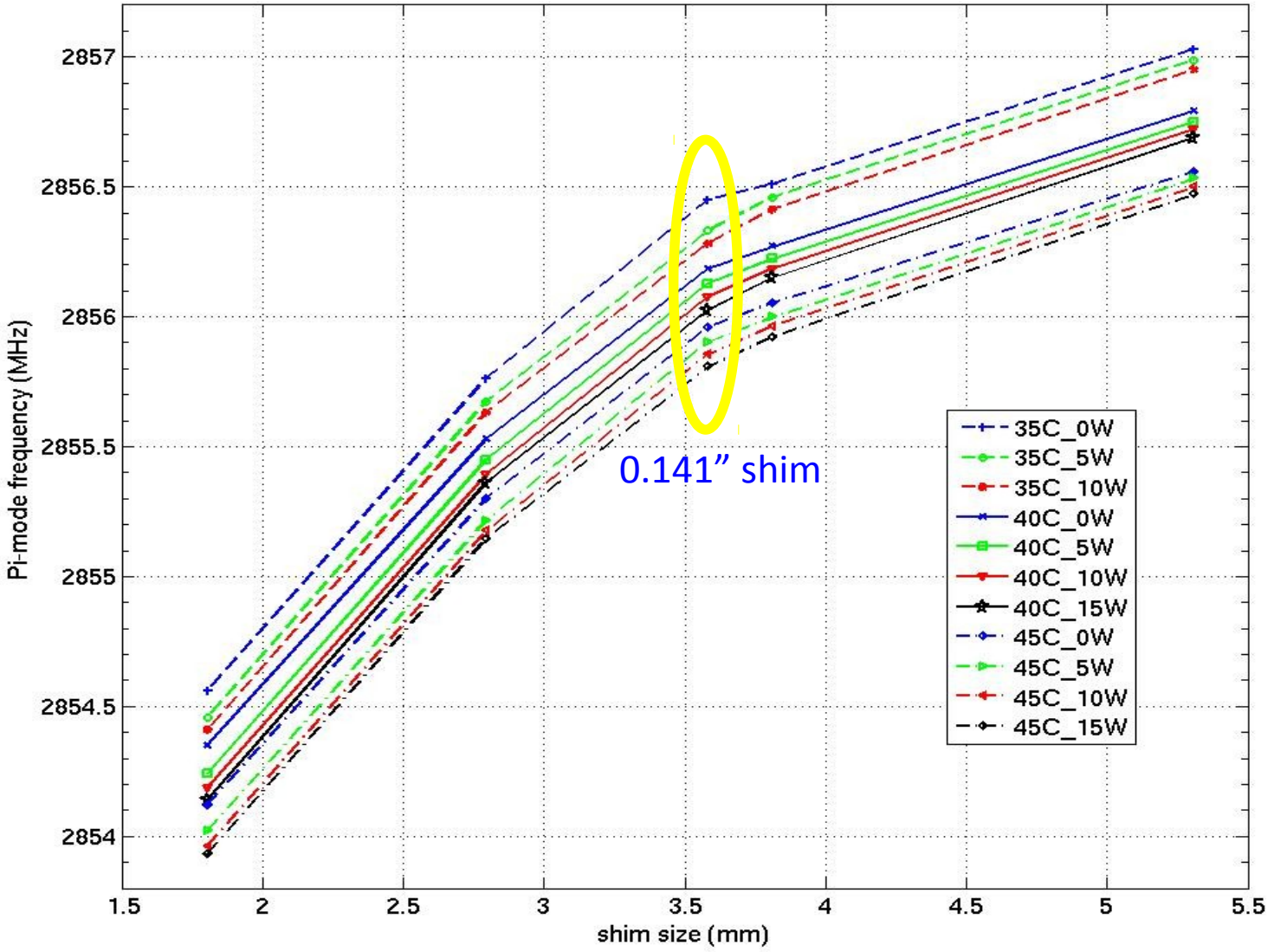
Measurements of Torque [0.1,0.2,0.4] lb*in (with 0.150” Shims)-I



Measurements of Torque [0.1,0.2,0.4] lb*in (with 0.150” Shims)-II

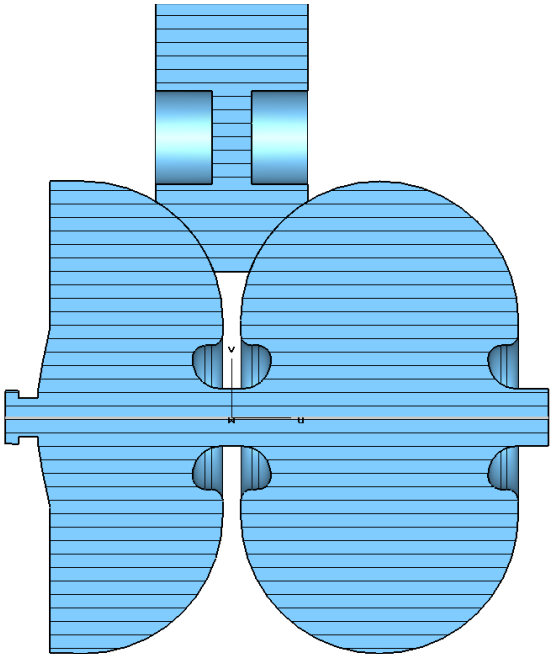


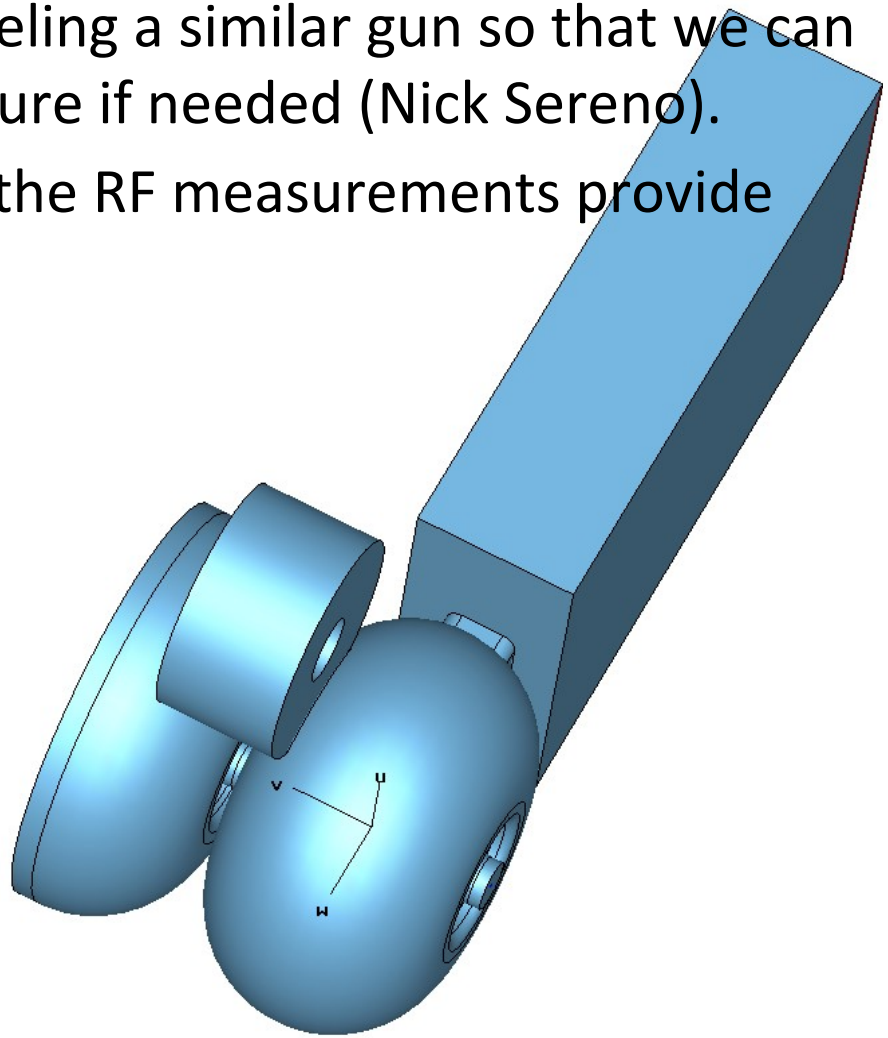
New Shims Machined 0.141”



RF Gun Modeling (Xiang Sun)

- There is a lack of information on the gun geometry.
- Xiang Sun is working on modeling a similar gun so that we can fabricate new guns in the future if needed (Nick Sereno).
- The outside dimensions and the RF measurements provide insights for the RF modeling.





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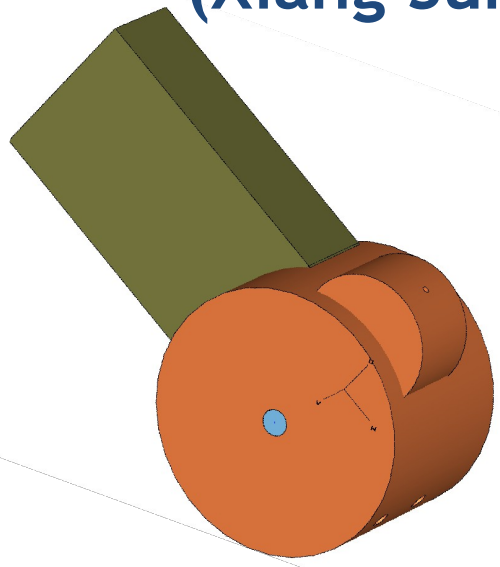

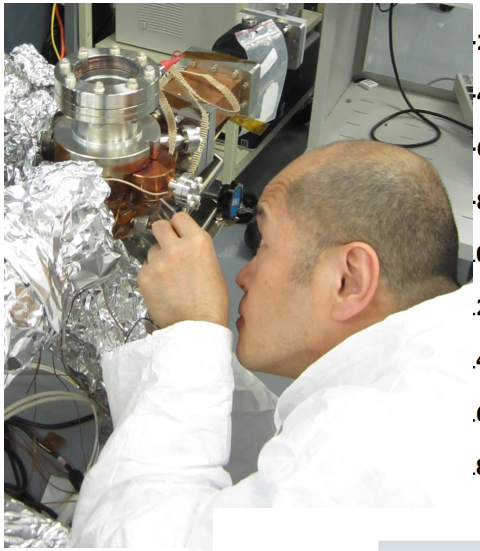

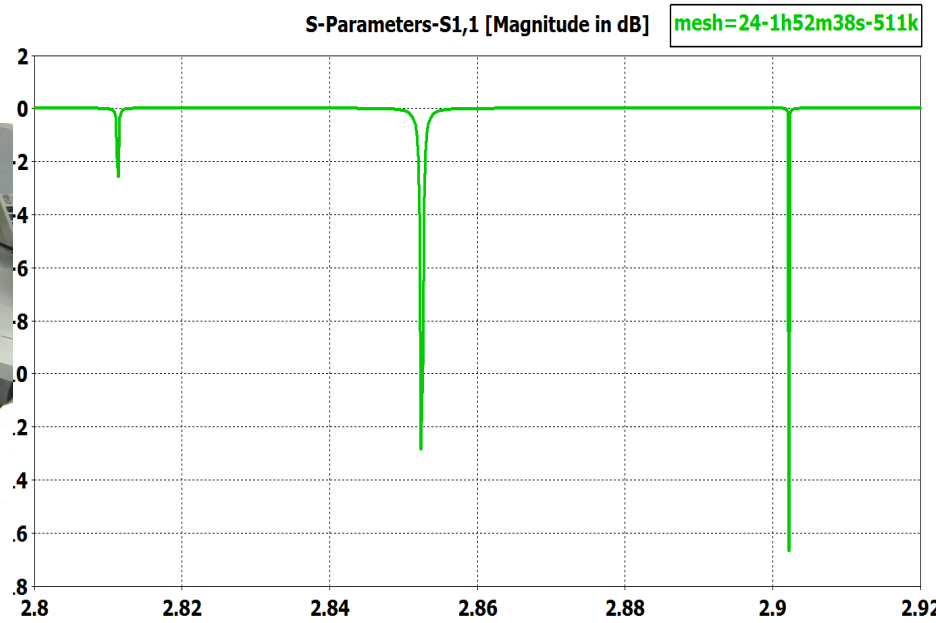

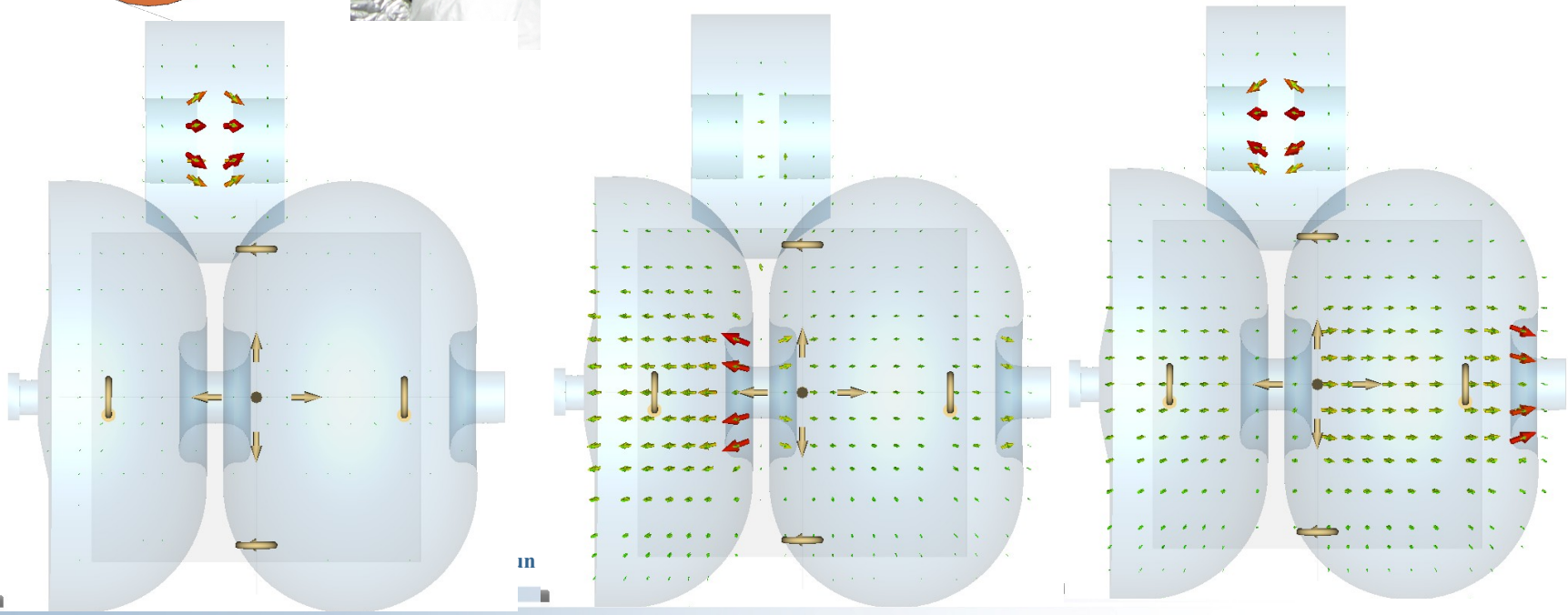

Summary

- Systematic RF measurements of the 3G2 gun are performed and a new set of shim of proper size are made.
- Pi-mode frequency is tuned to 2856.024MHz using the new 0.141” shim, with the gun body temperature at 40°C (middle of the cooling water temperature range at the LINAC) and cathode heater power at 15W.
- Future test with the gun running on temperature control via cooling water (rather than heater tape as in these measurements) will be done to confirm our results.
- The measurement/shim adjustment will be repeated on the BBC gun for Chunxi’s LDRD cathode program.
- Gun RF modeling for an ultimate design independent of the gun vendor is underway.

Acknowledgments

We thank Wayne Michalek and John Hoyt for their help in setting up the gun for measurements at the vacuum lab. Thanks to Bill Jansma for his discussions on the torque and gun back plate distortion.

I would like to thank Nick for getting me involved in these measurements, and for setting up the network analyzer and showing me how to use it.