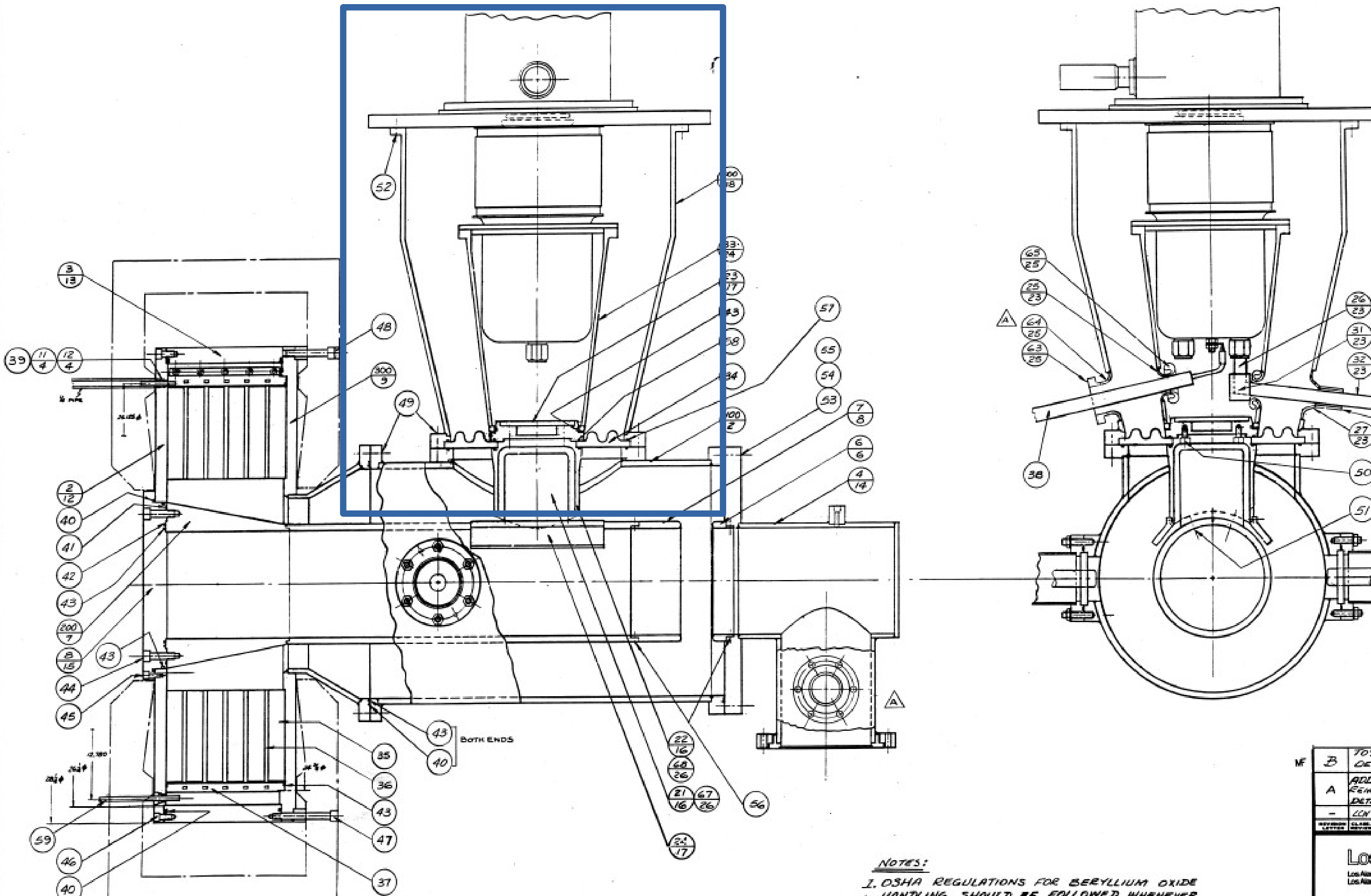
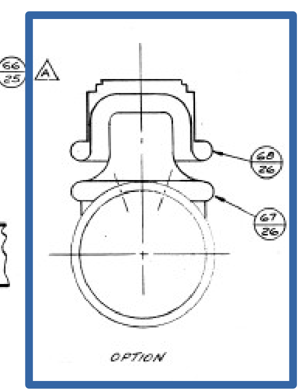
Coupler

C.Y. Tan
11 June 2015





PART NUMBER ITEM #	NUMBER REQD	PARTS LIST DESCRIPTION
34	1	rf WINDOW (REXOLITE) - 95Y225183 D-1
35	6	FERRITE RING 95Y225179 D-1
36	5	BeO RING 95Y225180 D-1
37	1	WATER COOLING RING 95Y225182 D-1
38	1	rf CABLE RG-17A/U
39	14	NEOPRENE O-RING #010
40	AS NEEDED	" " " LINEAR STOCK, 3/16 ϕ
41	1	" " " #270
42	1	" " " #262
43	AS NEEDED	.150 ϕ SPRING CONTACT RING - BERYLLIUM COPPER, SILVER PLATED
44	6	.375-16 UNC SOC. HD CAP SCW, 1.5 LG., SST
45	8	.250-20 UNC " " " " .875 LG., SST
46	12	.375-16 UNC " " " " .750 LG., SST
47	12	" " " " " " " 3.50 LG., SST
48	12	" " " " " " " 2.50 LG., SST
49	16	" " " " " " " 1.25 LG. SST.
50	8	.250-20 UNC " " " " .75 LG SST.
51	2	.313-18 UNC " " " " .50 LG SST.
52	12	.250-20 UNC " " " " 1.00 LG. SST.
53	8	.375-16 UNC " " " " 2.50 LG SST.
54	8	.375-16 UNC NUTS, SST
55	16	.375 AN WASHERS, SST
56	12	#6-32 UNC FLAT HD SCW, .375 LG. SST
57	2	NEOPRENE O-RING #275
58	2	" " " #250
59	2	.250 O.D. × .035 WALL TUBING 12 LG, SST

NOTES:

1. OSHA REGULATIONS FOR BERYLLIUM OXIDE HANDLING SHOULD BE FOLLOWED WHENEVER ANY MACHINING PROCESS OR RELATED OPERATIONS ON BeO PARTS MAY RESULT IN DUST, FUMES, OR CHIPS. CALL LANL GROUP HSE-5 FOR INSTRUCTIONS.
2. DISPOSAL OF THE BeO PARTS (DETAILS 36) MUST BE DONE PER OSHA REGULATIONS. AGAIN CALL GROUP HSE-5 FOR INSTRUCTIONS.

MF

REVISION LETTER	CLASS. REVIEW	REVISIONS	DATE	CHANGED BY	CHECKED BY	APPROVED BY
B		TOTAL SHTS WAS 25 - ADDED DETAILS 67 & 68 & OPTION VIEW	8/7/85	LCW		
A		ADDED VACUUM PORT ON DETAIL 4 REMOVED DETAILS 28, 29, & 30 - ADDED DETAILS 63, 64, 65, 66 - TOTAL SHTS WAS 24	3/25/85	LCW		
–	LCW	ORIGINAL ISSUE	–	–	–	–

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

CLASSIFICATION OF DRAWING: UNCL
PART: UNCL TITLE BLOCK: UNCL

TITLE
PERPENDICULAR BIASED
RF CAVITY COLD MODEL

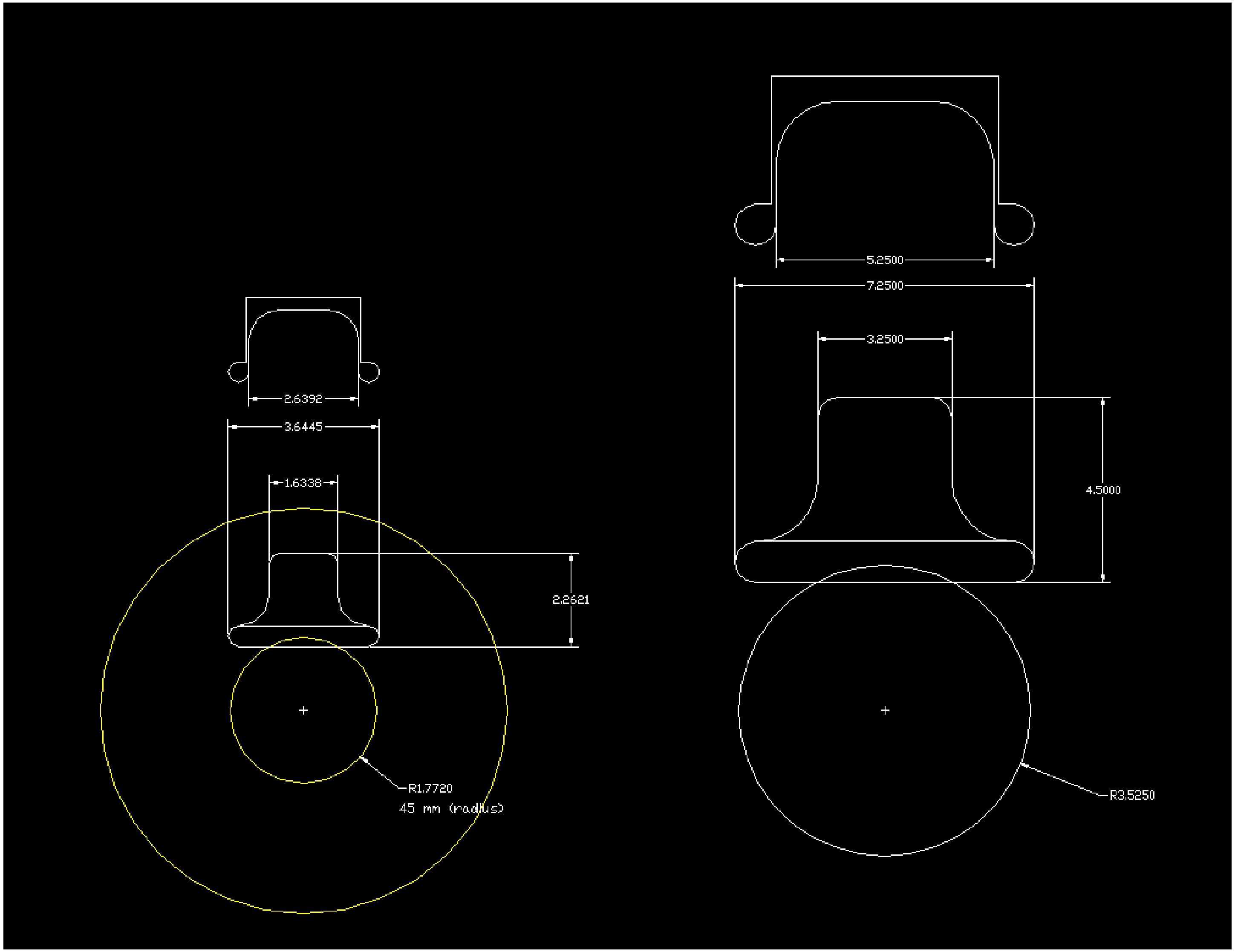
LAMPF II

	SIGNATURE	DATE	GROUP
ORIGINATED			
DRAWN	WILKERSON	3/11/85	WX-4
CHECKED			
PROJ. ENGR.	WILKERSON		
APPROVED			
RELEASED			

TOLERANCE - (UNLESS OTHERWISE NOTED)
X - ± ____ 0.XX - ± ____ ANGULAR - ± ____
0.X - ± ____ 0.XXX - ± ____ FINISH - ____

SCALE	TOTAL SHEETS	DRAWING NO.	SHEET SIZE NO.
DO NOT SCALE	26	95Y225181	D-1

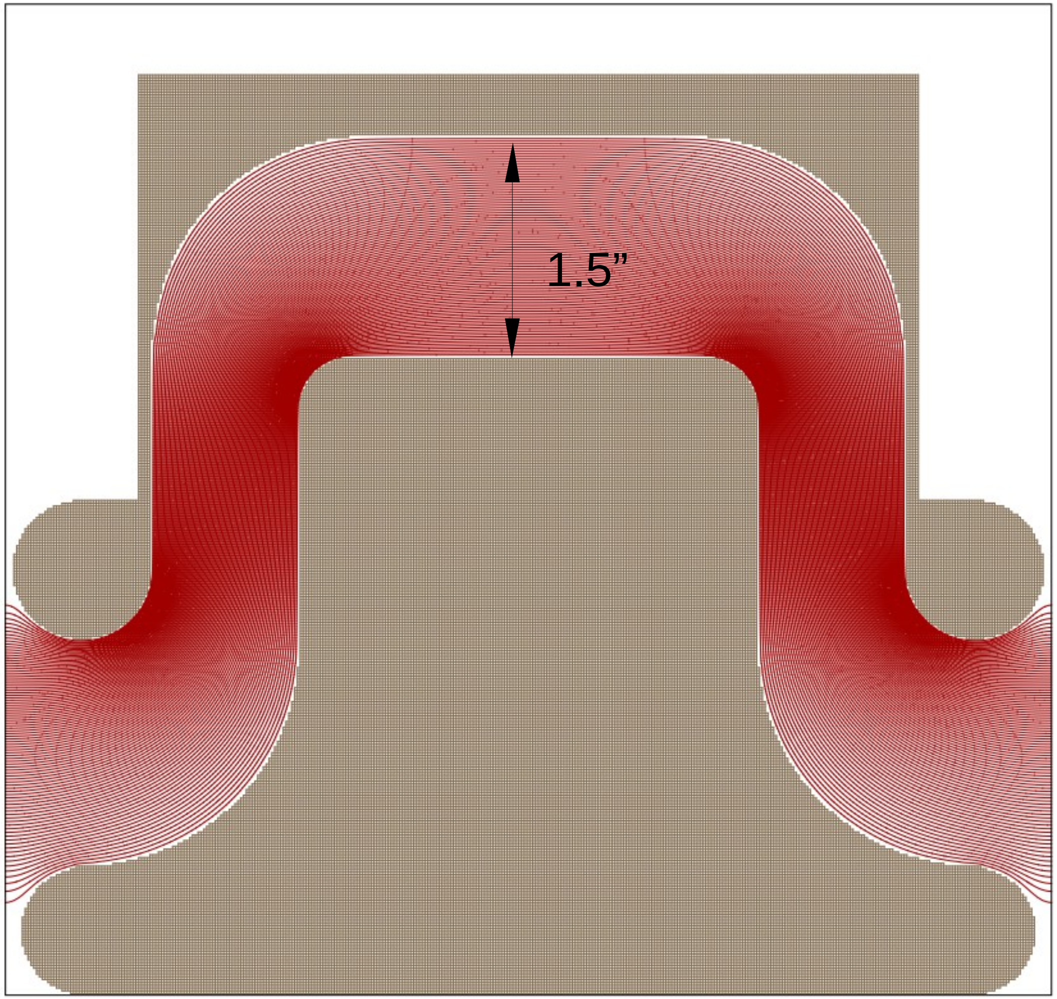
LANL Coupler



Rescaled for our cavity

LANL design

Simion calculation

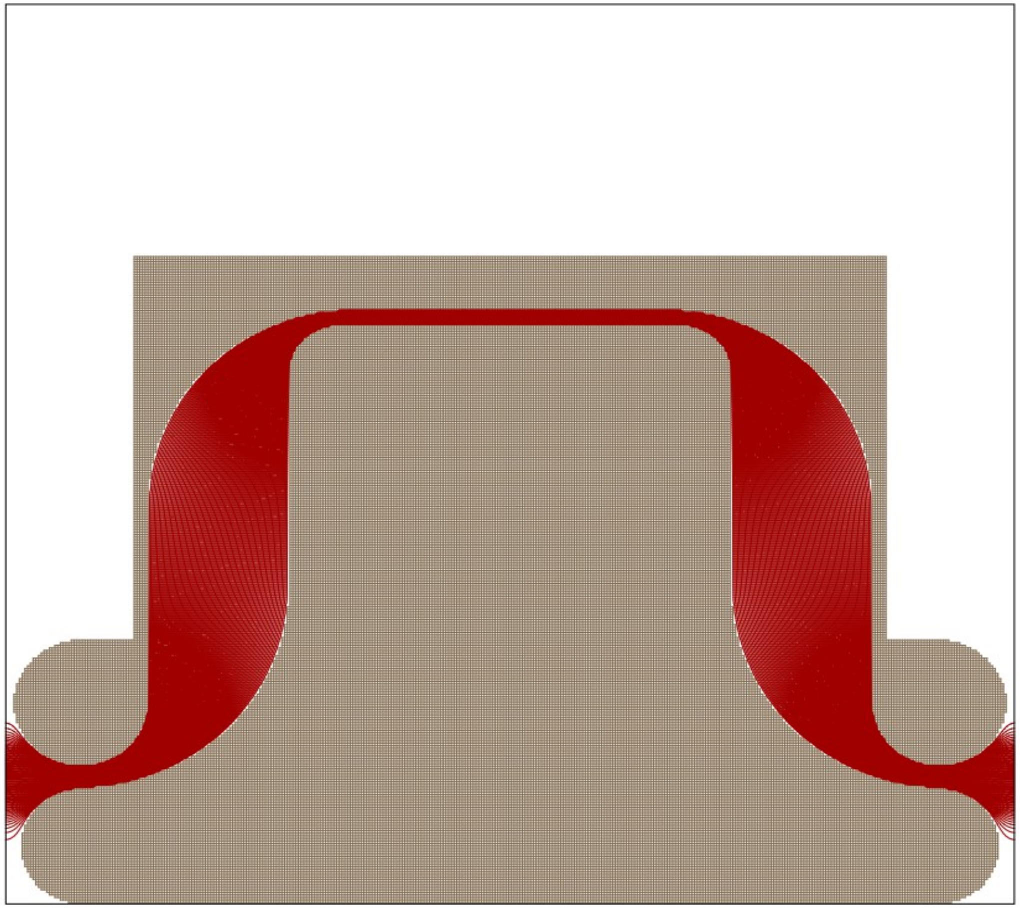


Simion calculation says LANL capacitance is 8 pF. But ssl-preprint-067.pdf claims their cap is 13 pF, so it is about 50% off. Needs to be checked with a better program. <u>I am going to assume that SIMION is correct for now.</u>

Using the reduced size for our cavity, the scale reduction is α=0.5
And $C \sim A/d$, rescaling everything by α,
$A \rightarrow \alpha^2 A$ and $d \rightarrow \alpha d$, thus $C \rightarrow \alpha C$.

Thus the capacitance of the reduced size coupling capacitor is 4 pF. This is too small for us.

Move cap closer



I checked two cases:

- 0.2” gap: 28 pF
- 0.1” gap: 42 pF

These are probably underestimates.

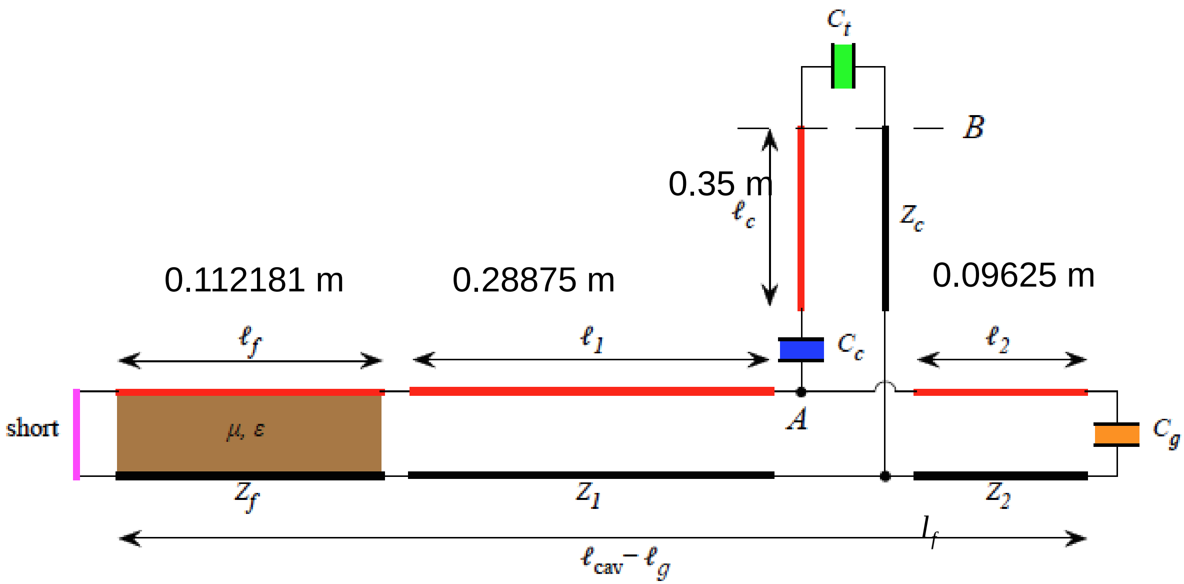
Again, for our smaller sized cap, it will be:

- 0.1” gap: 14 pF
- 0.05” gap: 21 pF

Therefore, the gap for us is probably going to be between 0.1” and 0.2” to get 10 pF, if we leave the gaps on the sides as is.

0.1” – 0.2” is probably too small a gap to hold off 100 kV.

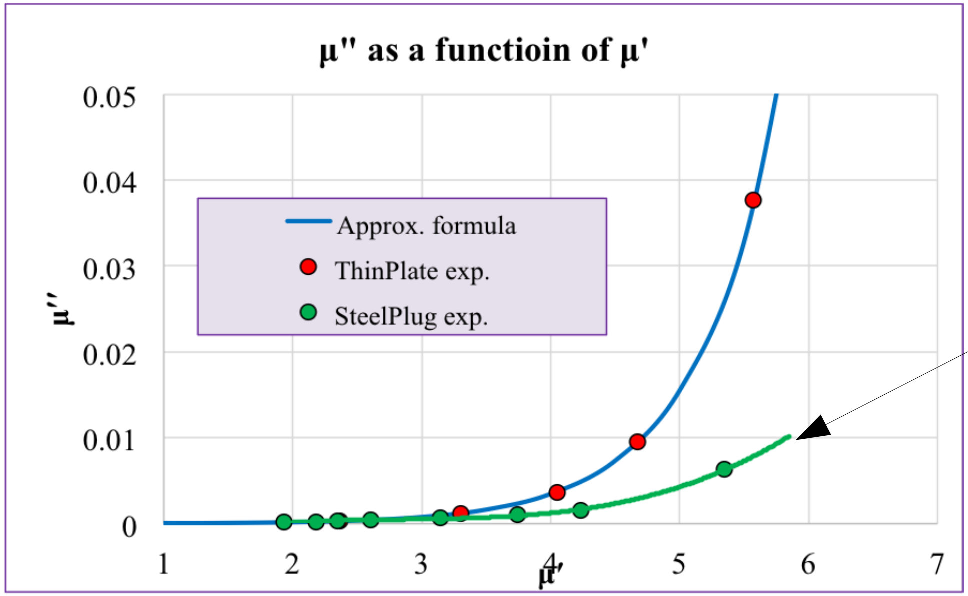
Summary of dimensions used in calculations

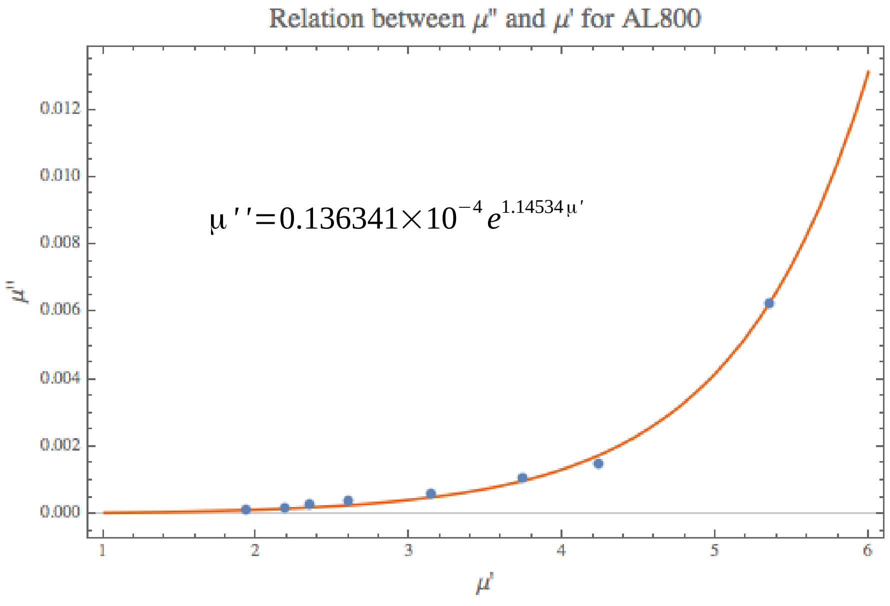


Parameter	value	comments
C_c	10 pF	Coupling capacitance
C_t	60 pF	Tube capacitance
C_g	3.4 pF	Gap capacitance
rfi	0.105 m	Inner radius of ferrite
rfo	0.170 m	Outer radius of ferrite

Parameter	value	comments
Z_1, Z_2	61.299 Ω	Non-ferrite characteristic impedance
Z_c	20.9269 Ω	Characteristic impedance of coupler

The new measurement of μ'' vs μ' used in calculation

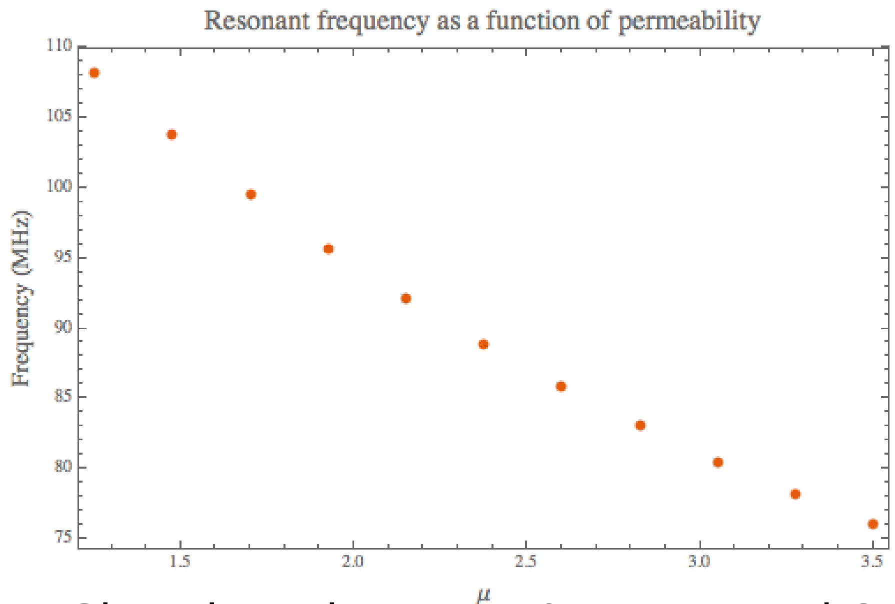


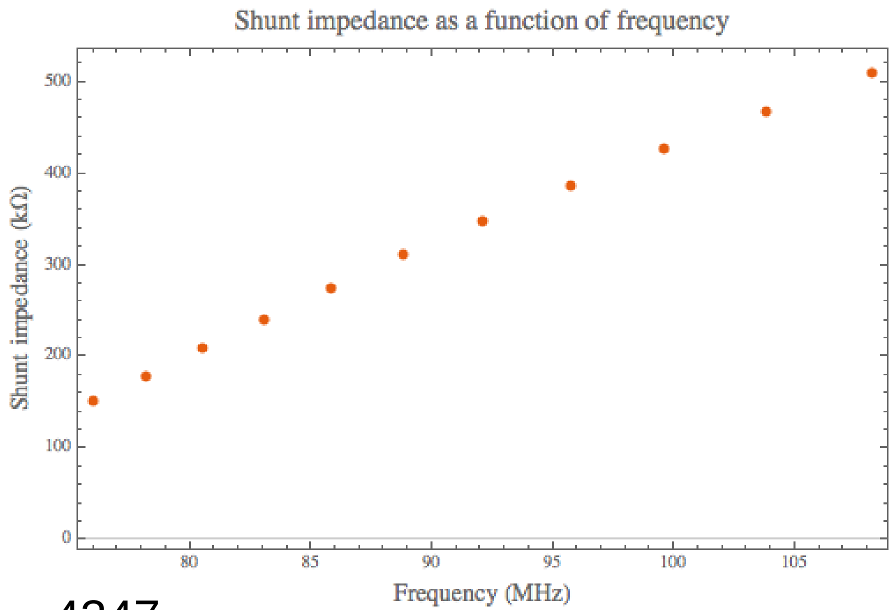


The data is from 21 May 2015 talk.

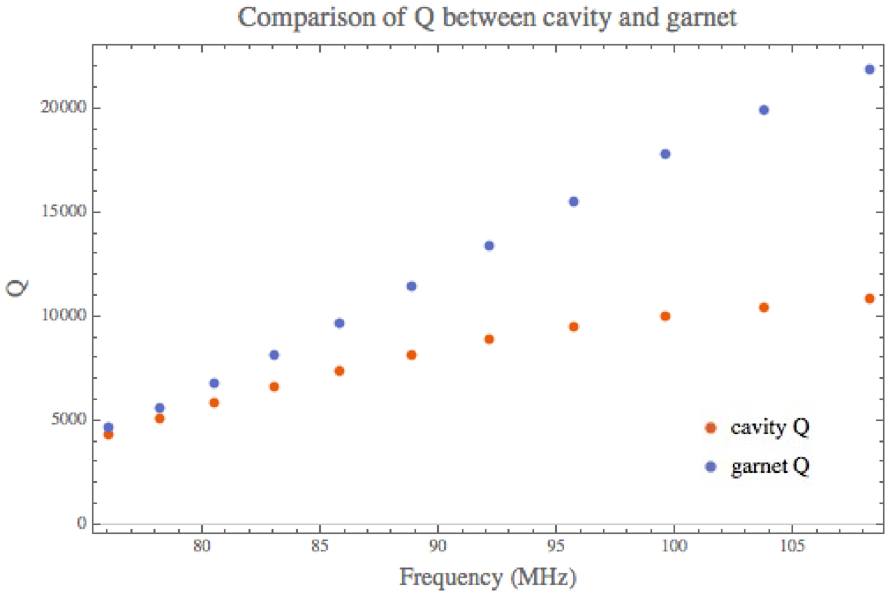
Steel Plug experiment data is used in Mathematica calculation.

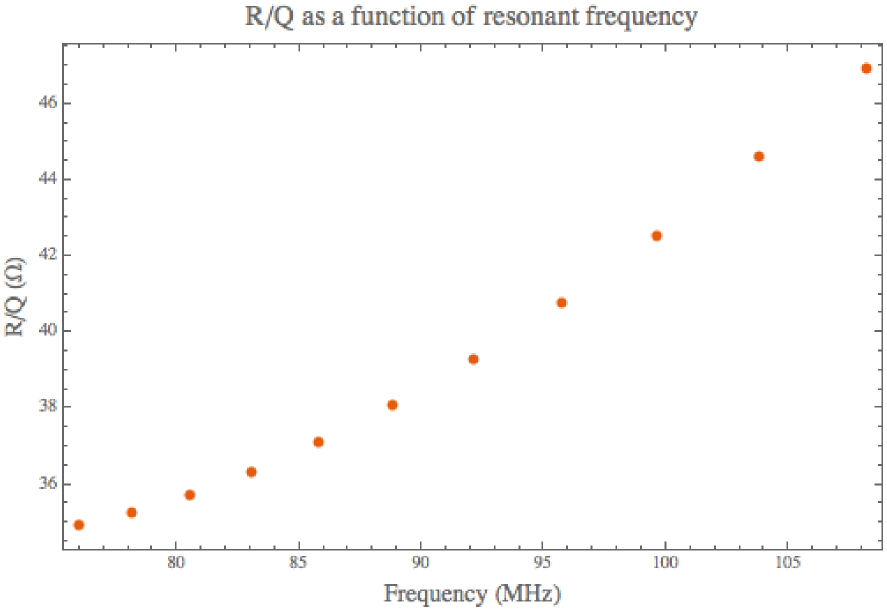
The following are results from Mathematica



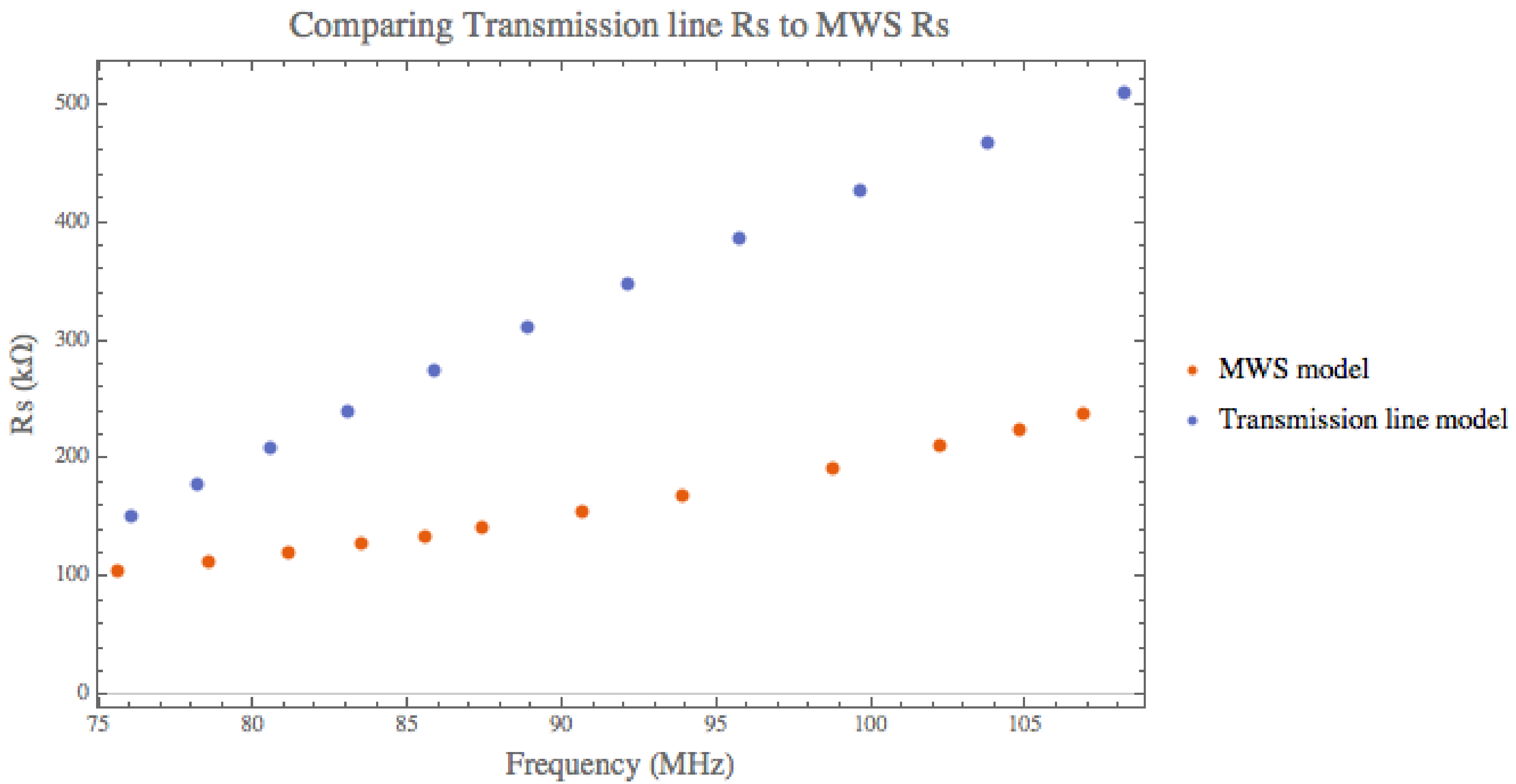


Shunt impedance at 76 MHz = 151 kΩ, Q = 4347
R/Q at 76 MHz = 35 Ω





Rs comparison



Note: I divided Gennady's results by 2 because RF group's definition is always from rms, i.e.

$P_{rms} = V_{rms}^2/R_s$

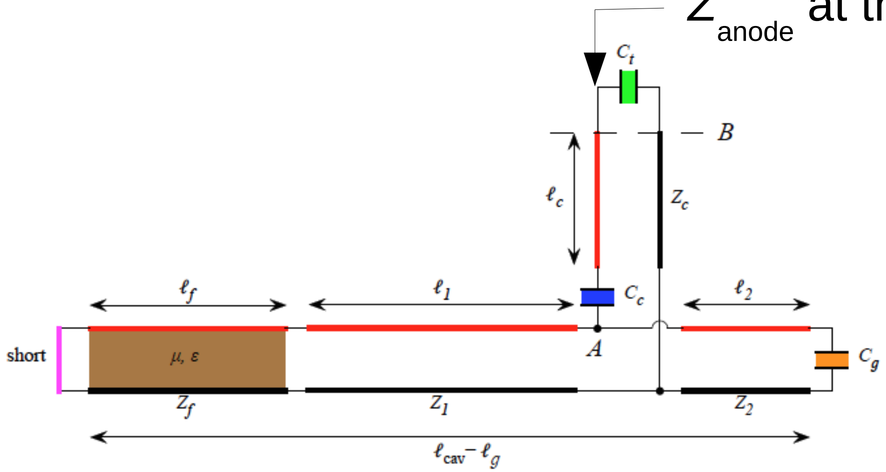
$\Rightarrow R_s = V_{rms}^2/P_{rms} = V_{peak}^2/2P_{rms} = Veff^2/2P_{thermal} = R_{gennady}/2$

Interesting points

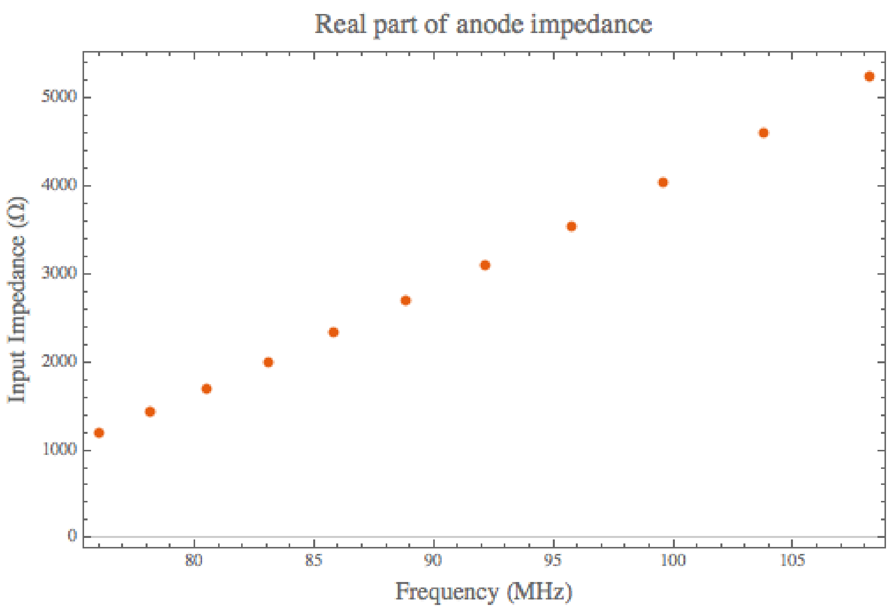
- Transmission line (TL) model predicts Rs has a much higher Q at higher frequencies. Similar Rs at 76 MHz ~100 kΩ
  - For high frequencies, does this mean that losses are much higher from non-uniform B-field in MWS than uniform B-field in TL model?
- I'm not sure this makes sense:
  - MWS has lower losses at low frequency compared to TL model and yet its Rs is smaller than TL? Note: Rs is “poportional” to Q. Recall $R/Q = \omega_0 L$.

Anode impedance

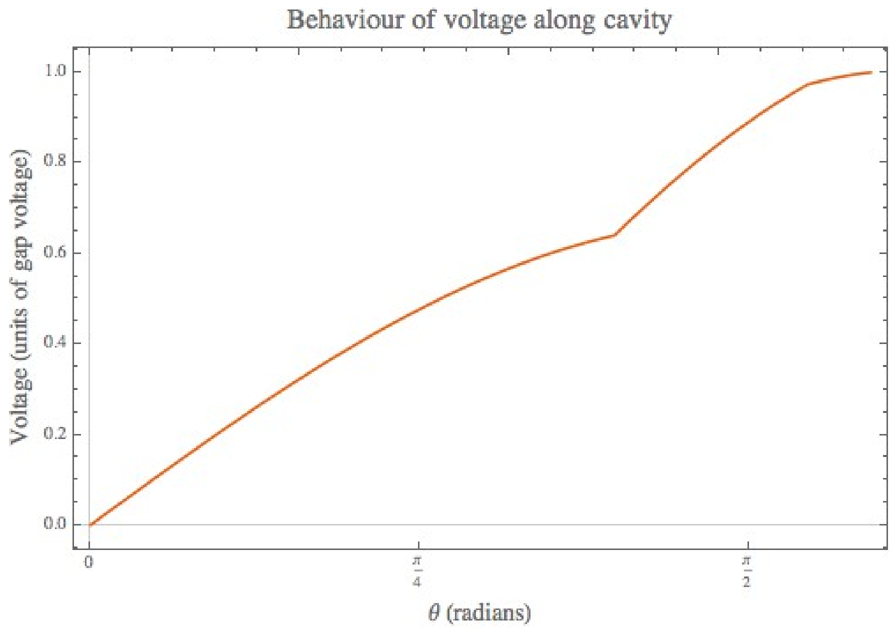
Z_{anode} at this point



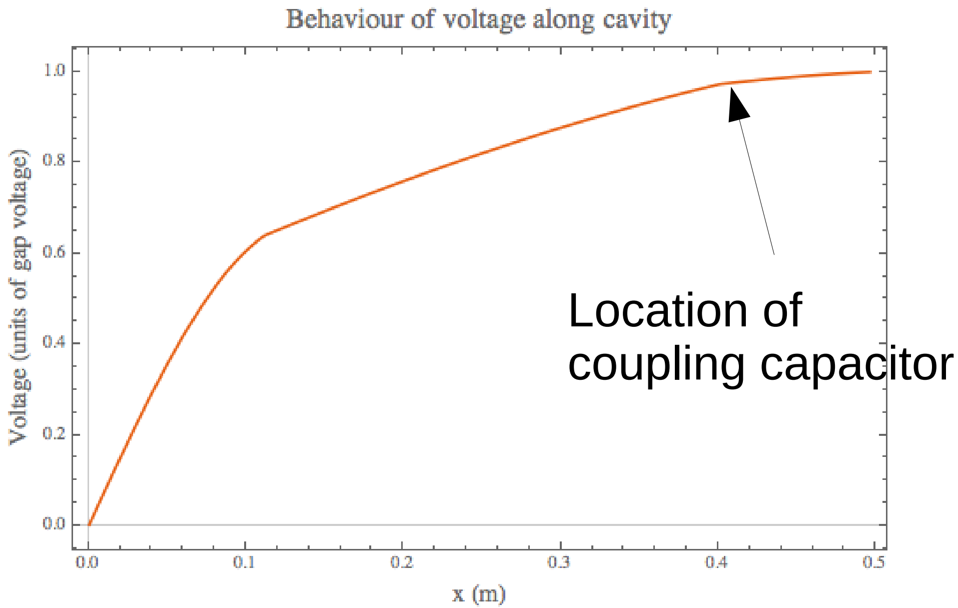
At 76 MHz = R_{anode} = 1.2 kΩ



Voltage along the cavity

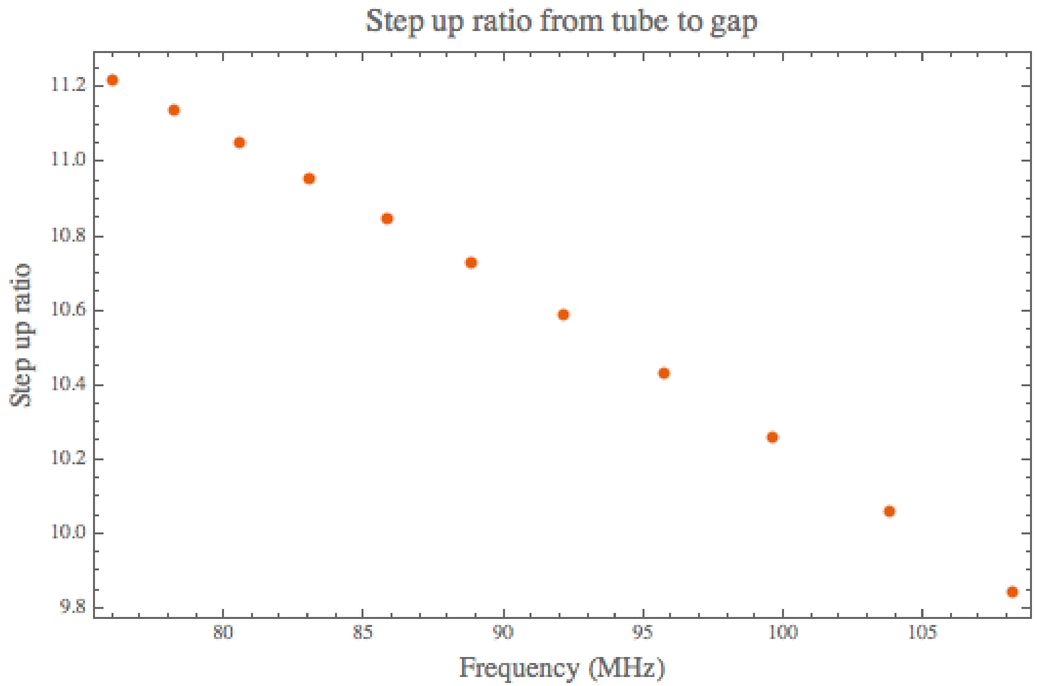


In terms of phase



In terms of position

Step up ratio



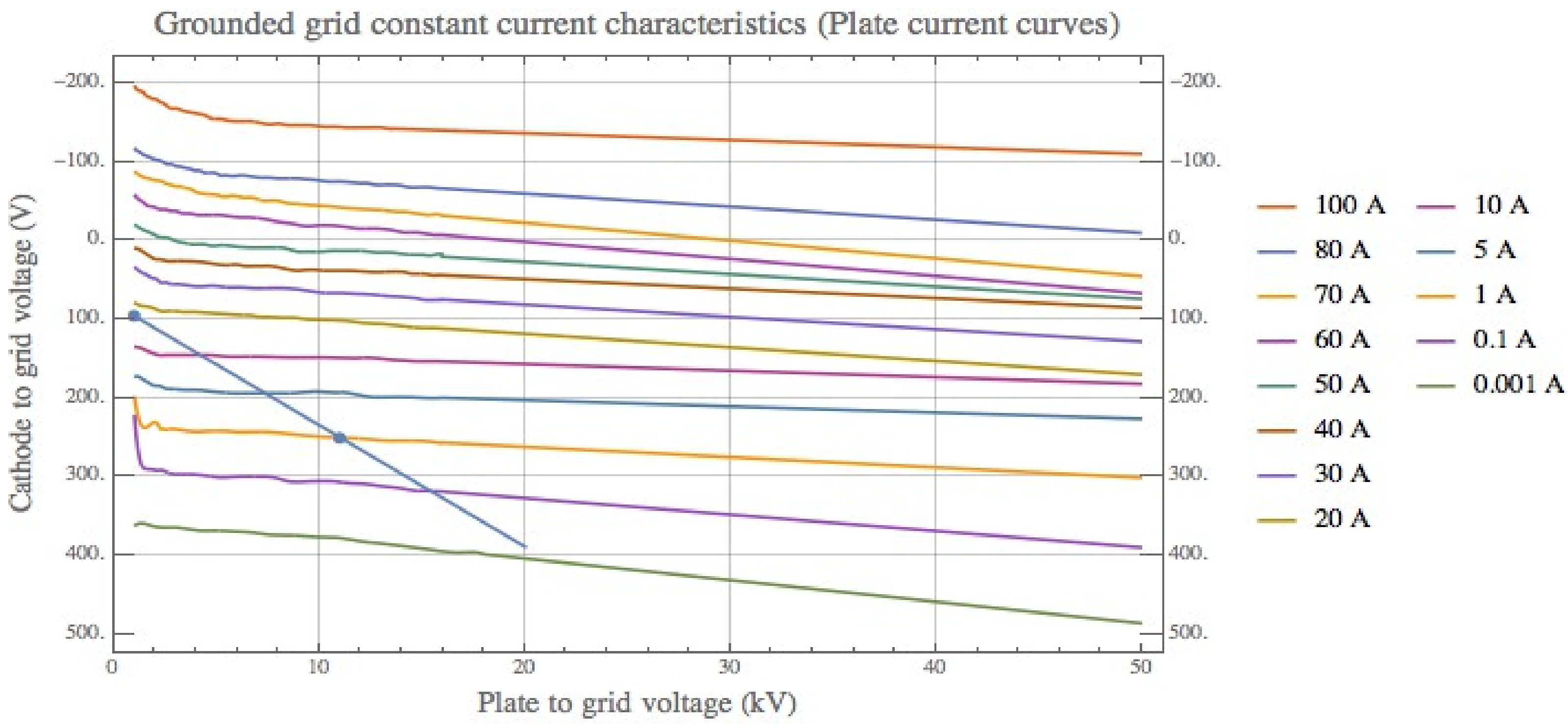
This is highly dependent on the coupling capacitance that we have chosen. Can be changed later.

Assume step up is 10 for now.

SSC etc. using step up of 8.

This choice affects the load line and thus the DC power losses.

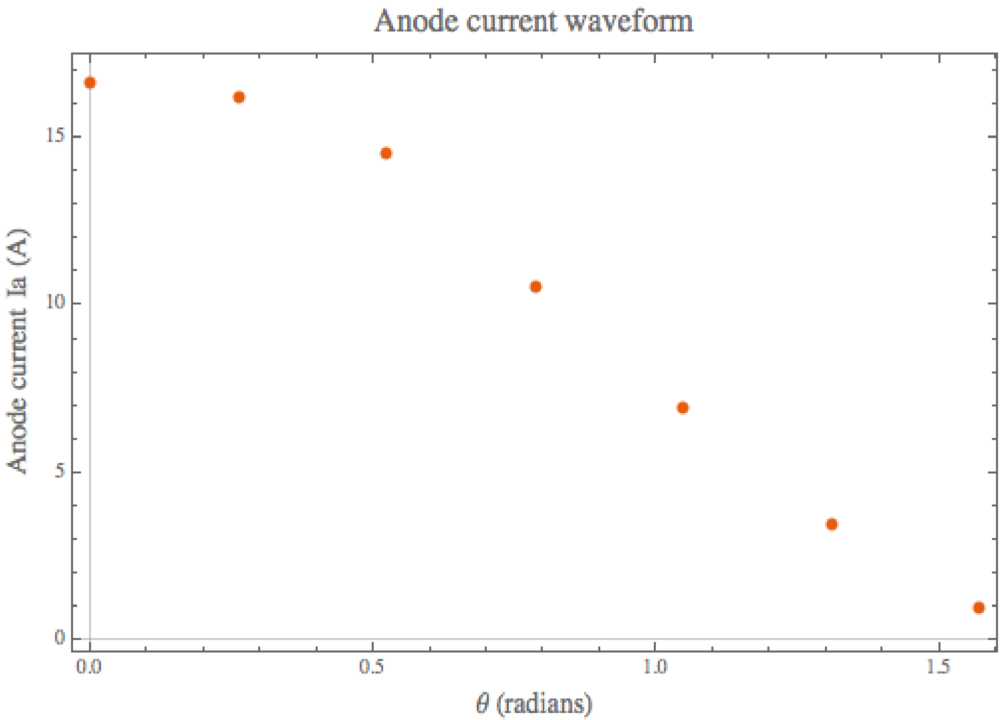
Y567 Grounded Grid Load line



The two points that were chosen are:
Right hand point (Vanode = 11 kV – assuming stepup of 10, 1 kV screen voltage, and Vcathode = 250 V cathode to grid bias)
Left hand point (Vanode = 1.025 kV – screen to grid bias,
I peak = 4 * I0 = 15.97 A)

I0 = takes into account the inefficiency of class B operation, Vgap = 100 kV and Rshunt = 151.8 kΩ.

Fourier components



Idc = 4.88 A, and thus DC input power Vanode = 11 kV => Pdc = 54 kW.

I@76 MHz = 7.73A gives Prf = 38 kW

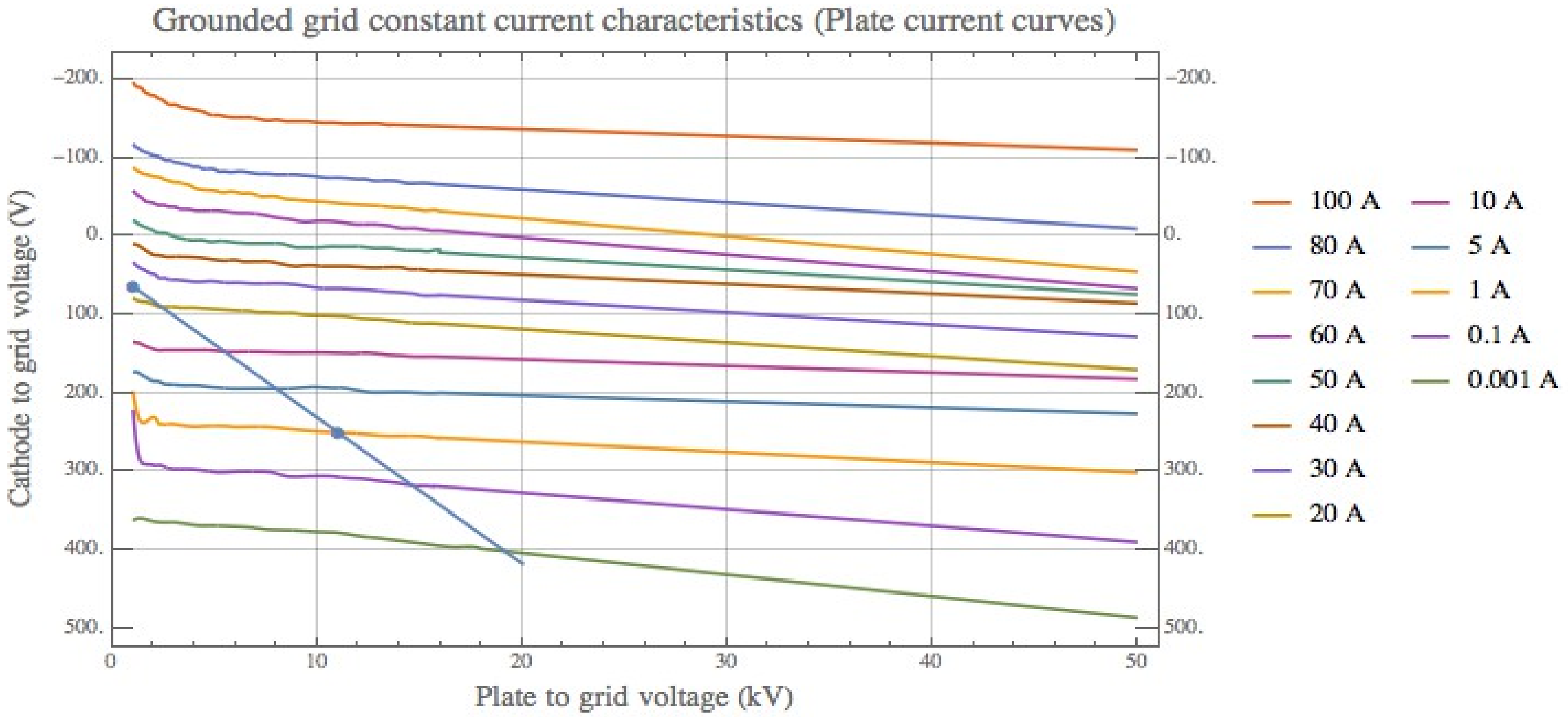
Efficiency = 0.72

The load resistance (which I assume is the anode resistance) = 1.3 kΩ

This number is consistent with the anode resistance calculated earlier = 1.2 kΩ

Latest numbers of anode resistance of 1.2 kΩ works very well for the Y567 where we want the number to be about 1.5 kΩ.

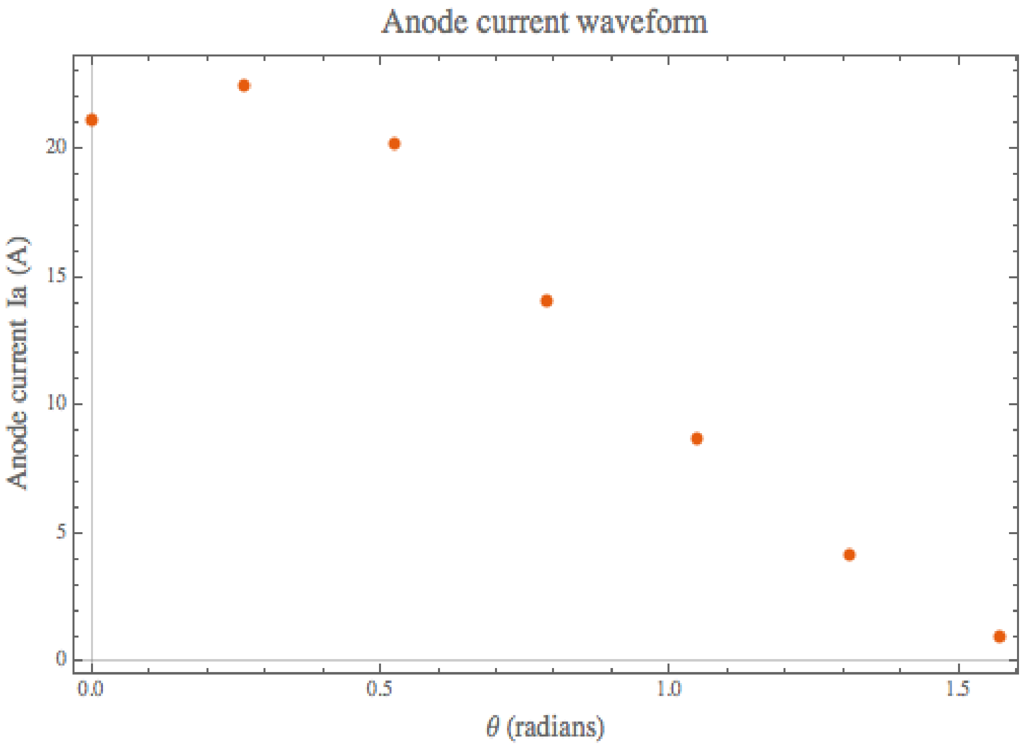
Y567 Grounded Grid Load line (Gennady's Rs=105.9 kΩ)



The two points that were chosen are:
Right hand point (Vanode = 11 kV – assuming stepup of 10, 1 kV screen voltage, and Vcathode = 250 V cathode to grid bias)
Left hand point (Vanode = 1.025 kV – screen to grid bias,
I peak = 4 * I0 = 22.89 A)

I0 = takes into account the inefficiency of class B operation, Vgap = 100 kV and Rshunt = 105.9 kΩ.

Fourier components (MWS numbers)



Idc = 6.5 A, and thus DC input power Vanode = 11 kV => Pdc = 71.4 kW.

I@76 MHz = 10.4A gives Prf = 52 kW

Efficiency = 0.73

The load resistance (which I assume is the anode resistance) = 0.96 kΩ

Don't know anode resistance yet from MWS. Need to put in coupler to get value.

0.96 kΩ works for the Y567.

Todo/Summary

- Is 10 pF a realistic choice for the coupling capacitor?
  - Impacts design of the coupling capacitor. Simple rescaling of LANL design gives 4 pF. (← This number needs to be checked with some other program)
  - Looks like coupling capacitor will need to hold off about 100 kV. I think this is doable. SSC cavity gap voltage is 127 kV. (PAC1993_0753.PDF)