HOM heating at the IP and in QD0

Update 2012

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MDI Meeting
SLAC, April 12, 2012

Outline

- *ILC beam parameters*
- *ILC interaction region geometry*
- *Beam fields*
- *Wake potentials and loss power*
- *Trapped and propagating modes*
- *Frequency spectrum*
- *Resistive wake fields*
- *Total power loss*

ILC beam parameters

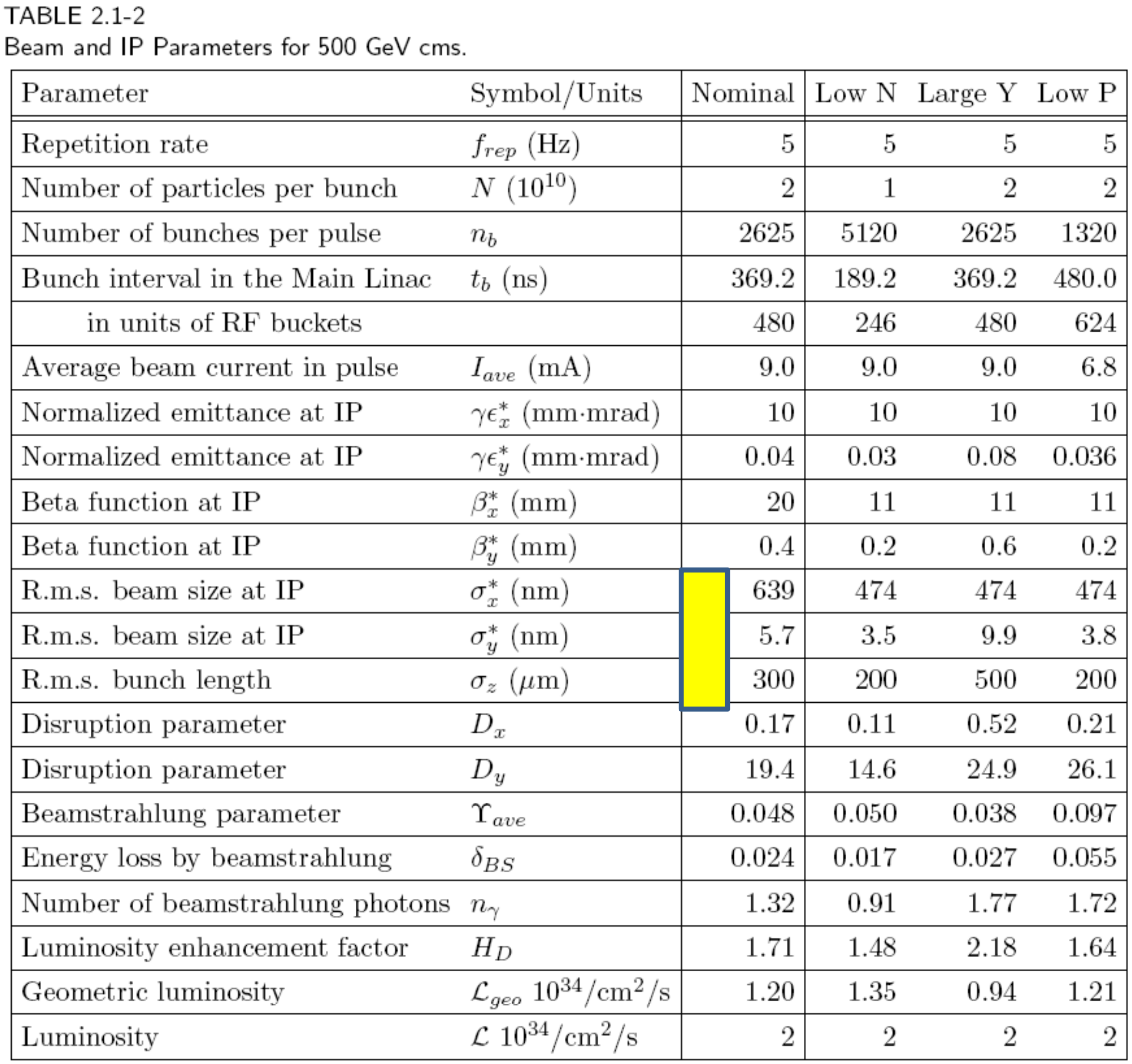


TABLE 2.1-2
Beam and IP Parameters for 500 GeV cms.

Parameter	Symbol/Units	Nominal	Low N	Large Y	Low P
Repetition rate	f_{rep} (Hz)	5	5	5	5
Number of particles per bunch	N (10^{10})	2	1	2	2
Number of bunches per pulse	n_b	2625	5120	2625	1320
Bunch interval in the Main Linac	t_b (ns)	369.2	189.2	369.2	480.0
in units of RF buckets		480	246	480	624
Average beam current in pulse	I_{ave} (mA)	9.0	9.0	9.0	6.8
Normalized emittance at IP	$\gamma\epsilon_x^*$ (mm·mrad)	10	10	10	10
Normalized emittance at IP	$\gamma\epsilon_y^*$ (mm·mrad)	0.04	0.03	0.08	0.036
Beta function at IP	β_x^* (mm)	20	11	11	11
Beta function at IP	β_y^* (mm)	0.4	0.2	0.6	0.2
R.m.s. beam size at IP	σ_x^* (nm)	639	474	474	474
R.m.s. beam size at IP	σ_y^* (nm)	5.7	3.5	9.9	3.8
R.m.s. bunch length	σ_z (μm)	300	200	500	200
Disruption parameter	D_x	0.17	0.11	0.52	0.21
Disruption parameter	D_y	19.4	14.6	24.9	26.1
Beamstrahlung parameter	Υ_{ave}	0.048	0.050	0.038	0.097
Energy loss by beamstrahlung	δ_{BS}	0.024	0.017	0.027	0.055
Number of beamstrahlung photons	n_γ	1.32	0.91	1.77	1.72
Luminosity enhancement factor	H_D	1.71	1.48	2.18	1.64
Geometric luminosity	$\mathcal{L}_{geo}$ $10^{34}/\mathrm{cm}^2/\mathrm{s}$	1.20	1.35	0.94	1.21
Luminosity	$\mathcal{L}$ $10^{34}/\mathrm{cm}^2/\mathrm{s}$	2	2	2	2

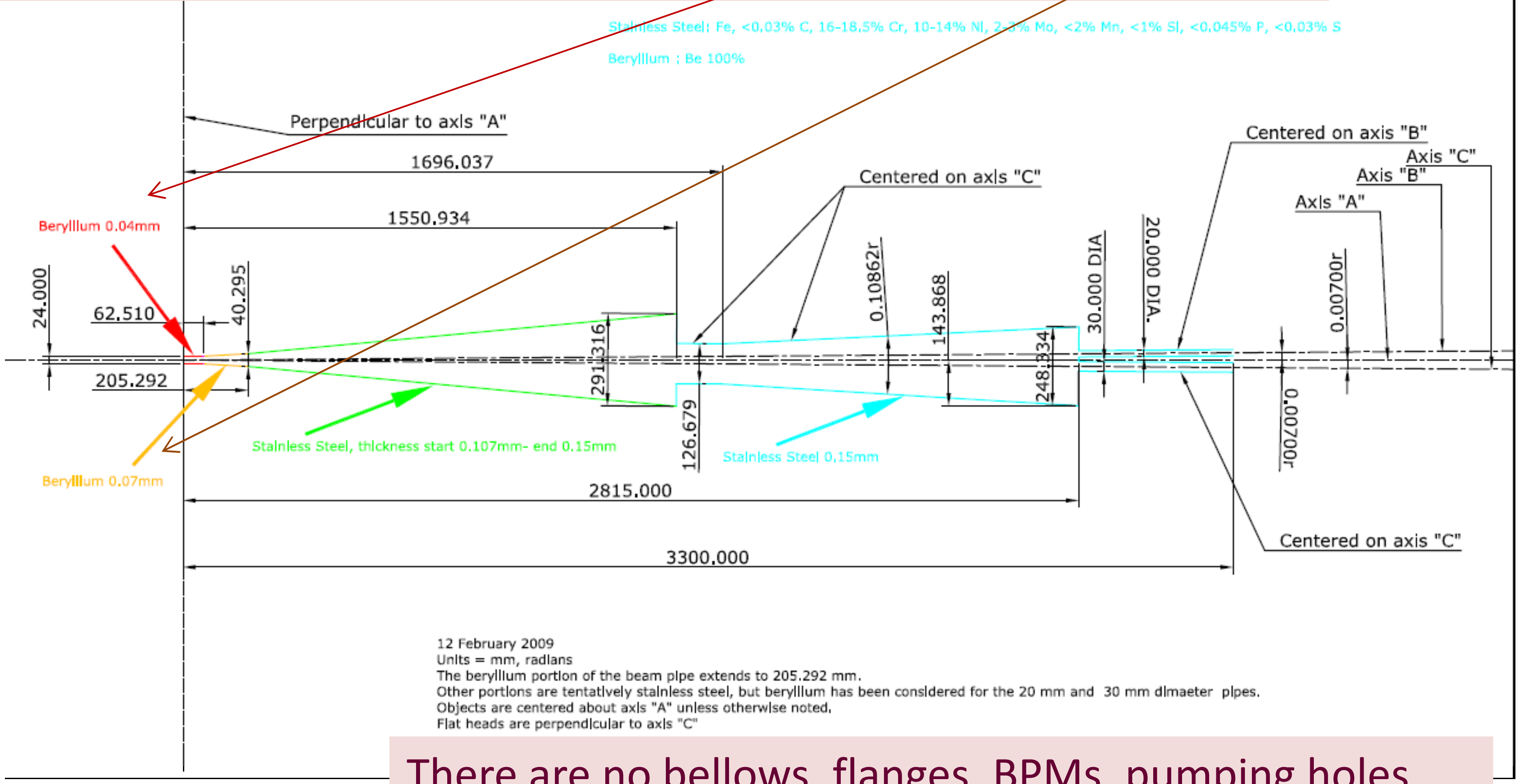
INTERNATIONAL LINEAR COLLIDER
REFERENCE DESIGN REPORT
AUGUST, 2007

- Bunch charge = 3.2 nC
- Bunch length = 0.2-0.3 mm

- Bunch spacing = 369.2 ns
- Beam current in a pulse 9 mA
- Duty ratio=200

ILC IR geometry from Marco Oriunno

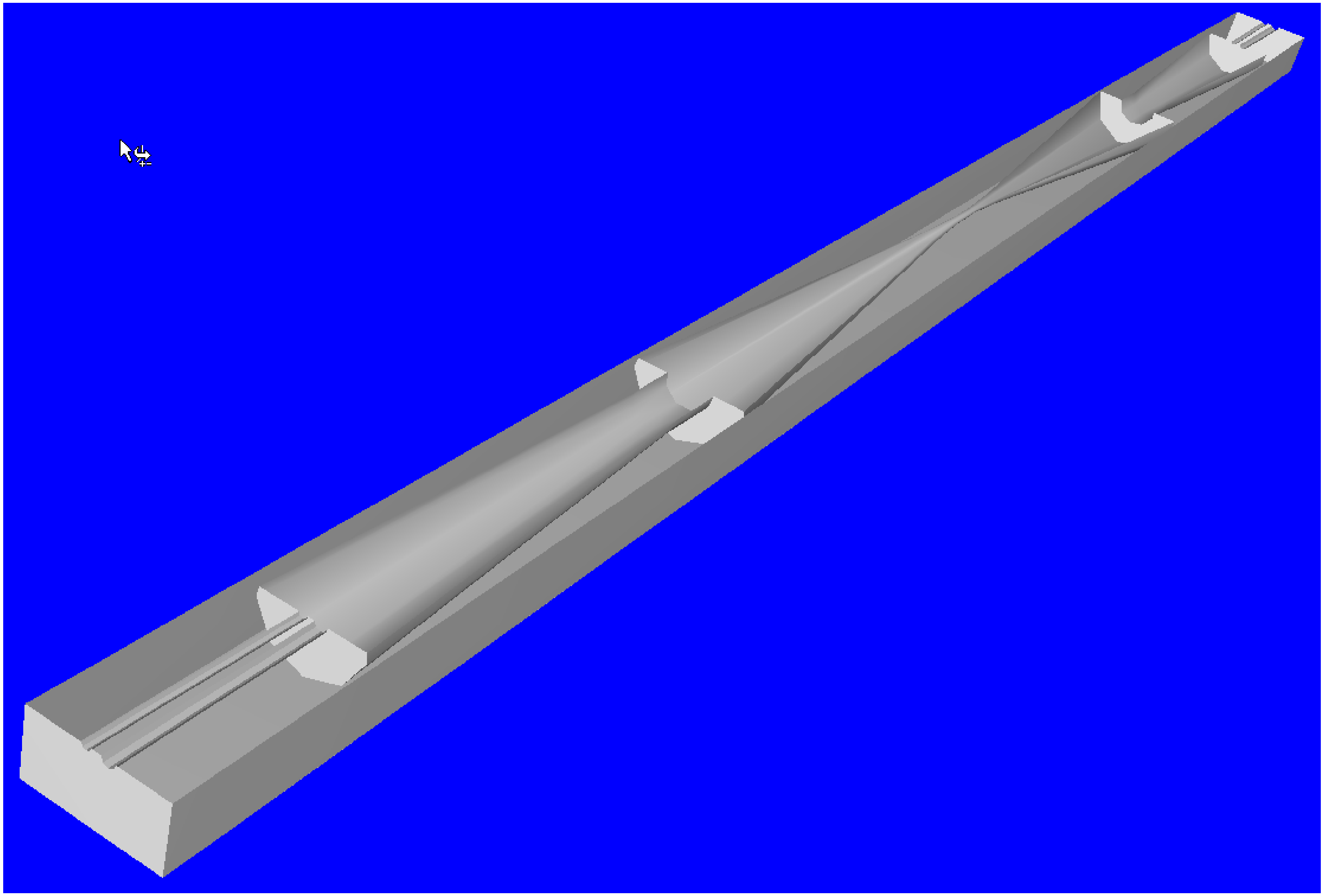
Comments from Takhashi Maruyama:
The thickness of the cylindrical beam pipe is 400 microns,
and of the conical section is 700 microns.



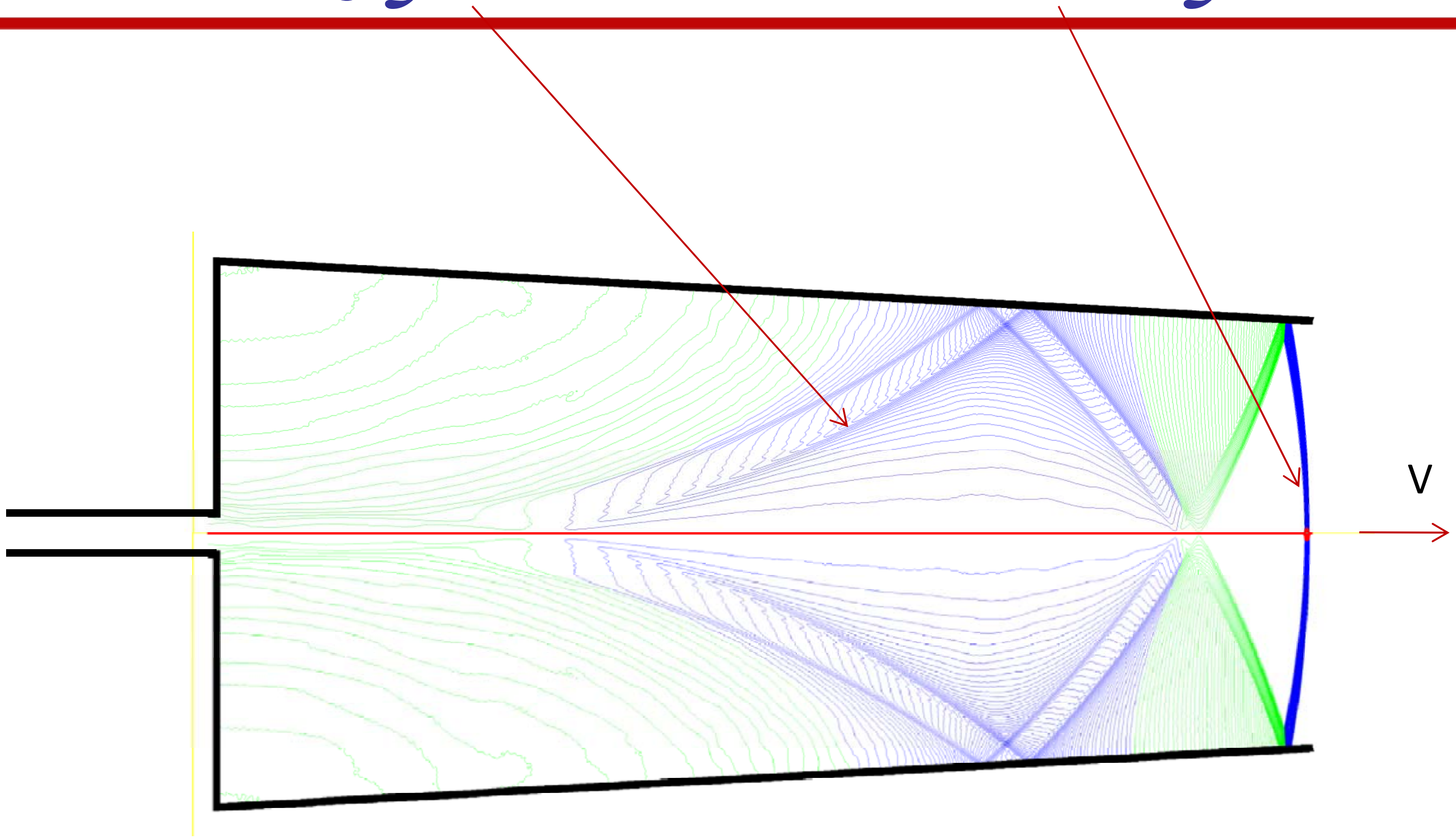
12 February 2009
Units = mm, radians
The beryllium portion of the beam pipe extends to 205.292 mm.
Other portions are tentatively stainless steel, but beryllium has been considered for the 20 mm and 30 mm dimaeter pipes.
Objects are centered about axis "A" unless otherwise noted.
Flat heads are perpendicular to axis "C"

There are no bellows, flanges, BPMs, pumping holes, …

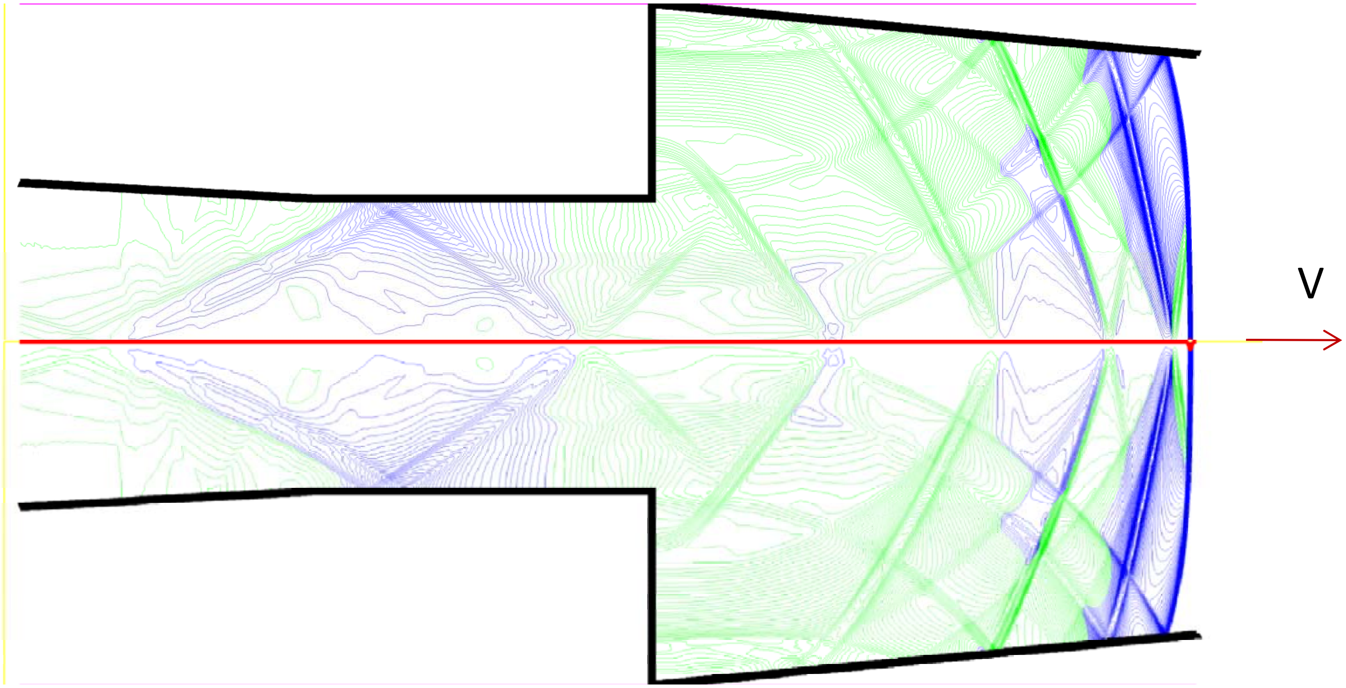
3-D stl model from Marco Oriunno



Wake fields and a bunch field



After a second chamber step



Bunch field

Electric field at the beam pipe wall

$$E = \frac{cZ_0}{(2\pi)^{3/2}} * \frac{eN_b}{a\sigma} \qquad E_{\left[\frac{kV}{cm}\right]} = 1.15 * \frac{N}{10^{10}} * \frac{1}{a_{cm}\sigma_{cm}}$$

$$a_{cm} = 1cm \qquad N = 2 \cdot 10^{10}$$

$$\sigma_{cm} = 0.03cm \qquad E = 75\frac{kV}{cm}$$

$$\sigma_{cm} = 0.02cm \qquad E = 115\frac{kV}{cm}$$

High electric field at the wall.

Beam spectrum

Bunch spectrum goes to higher frequency with shorter bunches

$$A(\omega) \sim e^{-\left(\frac{\omega}{c}\sigma\right)^2}$$

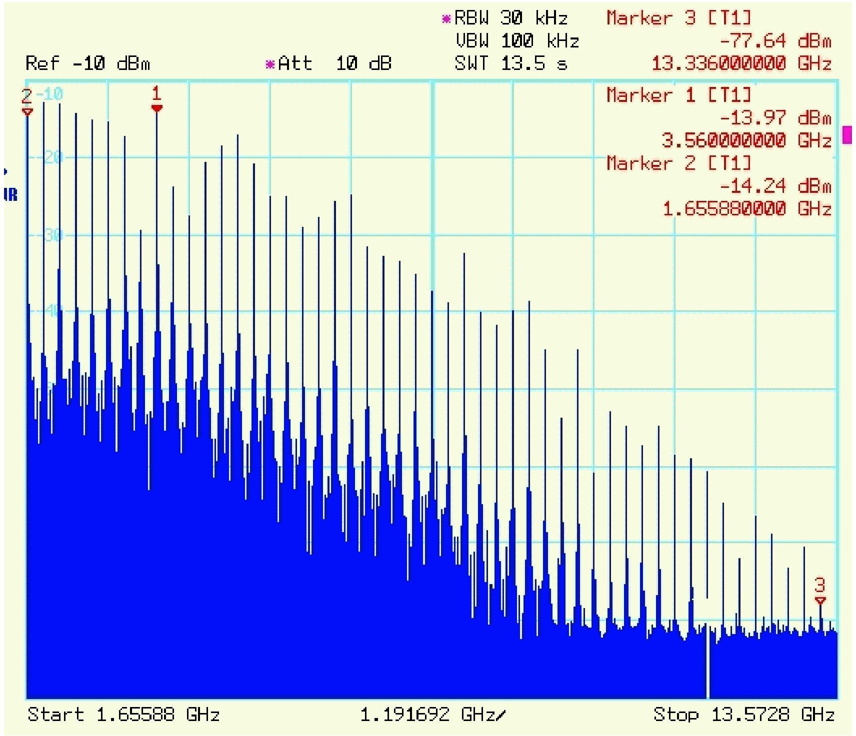
$$f_{\max} = \frac{c}{2\pi\sigma} = 160 - 240\ \text{GHz}$$

Bunch spacing resonances

$$f_n = \frac{n}{\tau_b} \qquad n = 1, 2, 3, \ldots$$

$$\frac{1}{\tau_b} = \frac{f_{RF}}{480} = 2.7\ \text{MHz}$$

Example from PEP-II



```
                              *RBW 30 kHz    Marker 3 [T1]
                               VBW 100 kHz        -77.64 dBm
Ref -10 dBm         *Att  10 dB SWT 13.5 s    13.336000000 GHz
                                             Marker 1 [T1]
                                                  -13.97 dBm
                                              3.560000000 GHz
                                             Marker 2 [T1]
                                                  -14.24 dBm
                                              1.655880000 GHz

Start 1.65588 GHz         1.191692 GHz/          Stop 13.5728 GHz
```

Wake potentials and Green's function

Wake potential describes the integrated effect of the wake fields

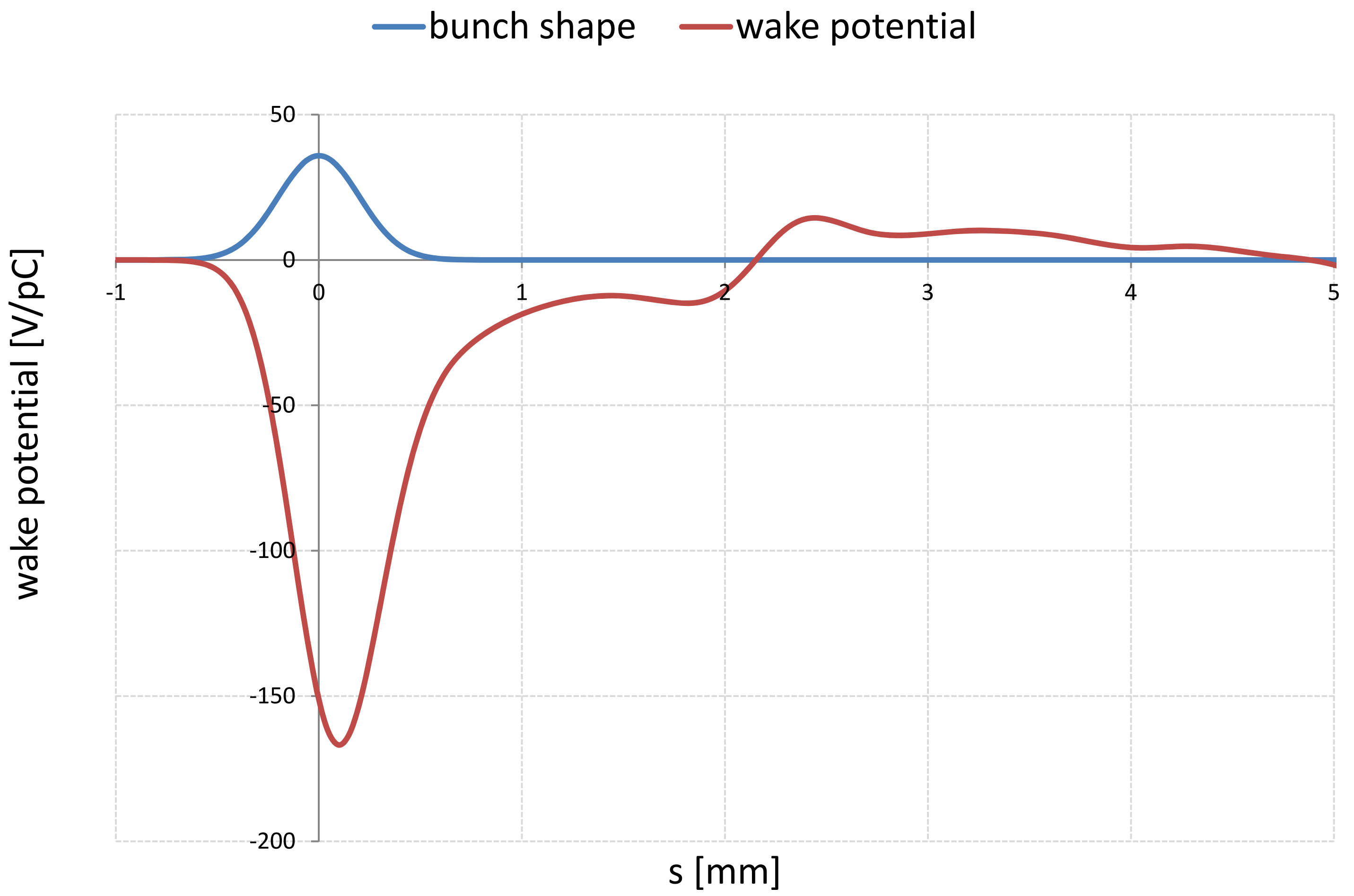
$$W(\tau) = \int_{-\infty}^{\infty} E_z(t, z)_{z=c(t-\tau)}\, dt$$

and can be calculated in the time domain by solving Maxwell's equations.

Wake potential of a point charge is a Green's function to calculate fields of any bunch distribution

$$W(\tau) = \int_{-\infty}^{\tau} \rho(\tau')G(\tau-\tau')d\tau' = \int_{0}^{\infty} \rho(\tau-\tau')G(\tau')d\tau'$$

Short range wake potential (0.2 mm bunch)



Calculated with a code "NOVO"

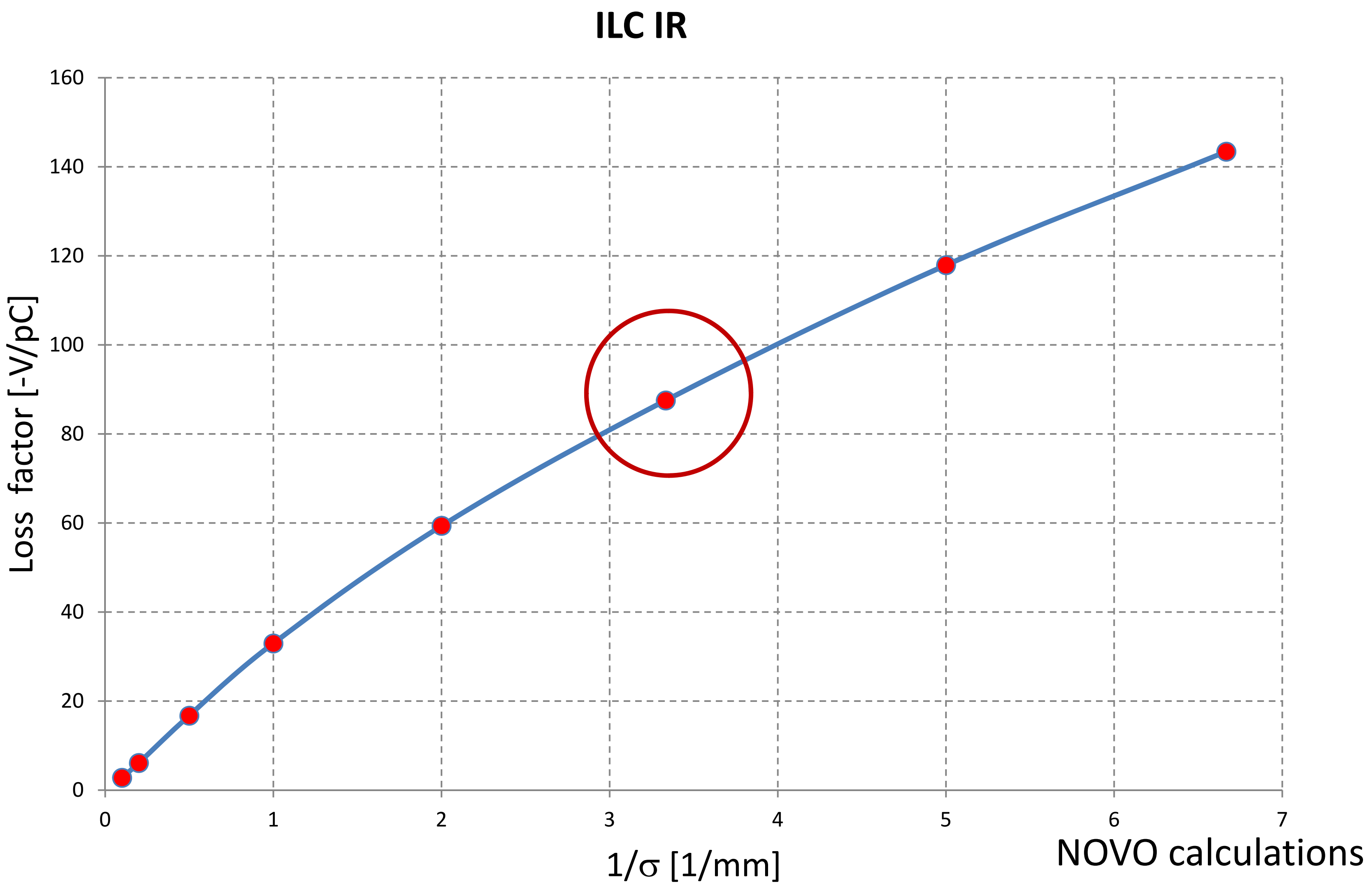
Bunch Loss Factor

- Beam energy loss is calculated by

$$k = \frac{1}{Q} \int_{-\infty}^{\infty} W(\tau)\rho(\tau)d\tau \qquad Q = \int_{-\infty}^{\infty} \rho(\tau)d\tau$$

- Single bunch loss factor is normalized to a bunch charge and usually measured in V/pC.

Loss factor of IR vs bunch length



NOVO calculations

Loss frequency integral

- We introduce loss frequency integral of a single bunch

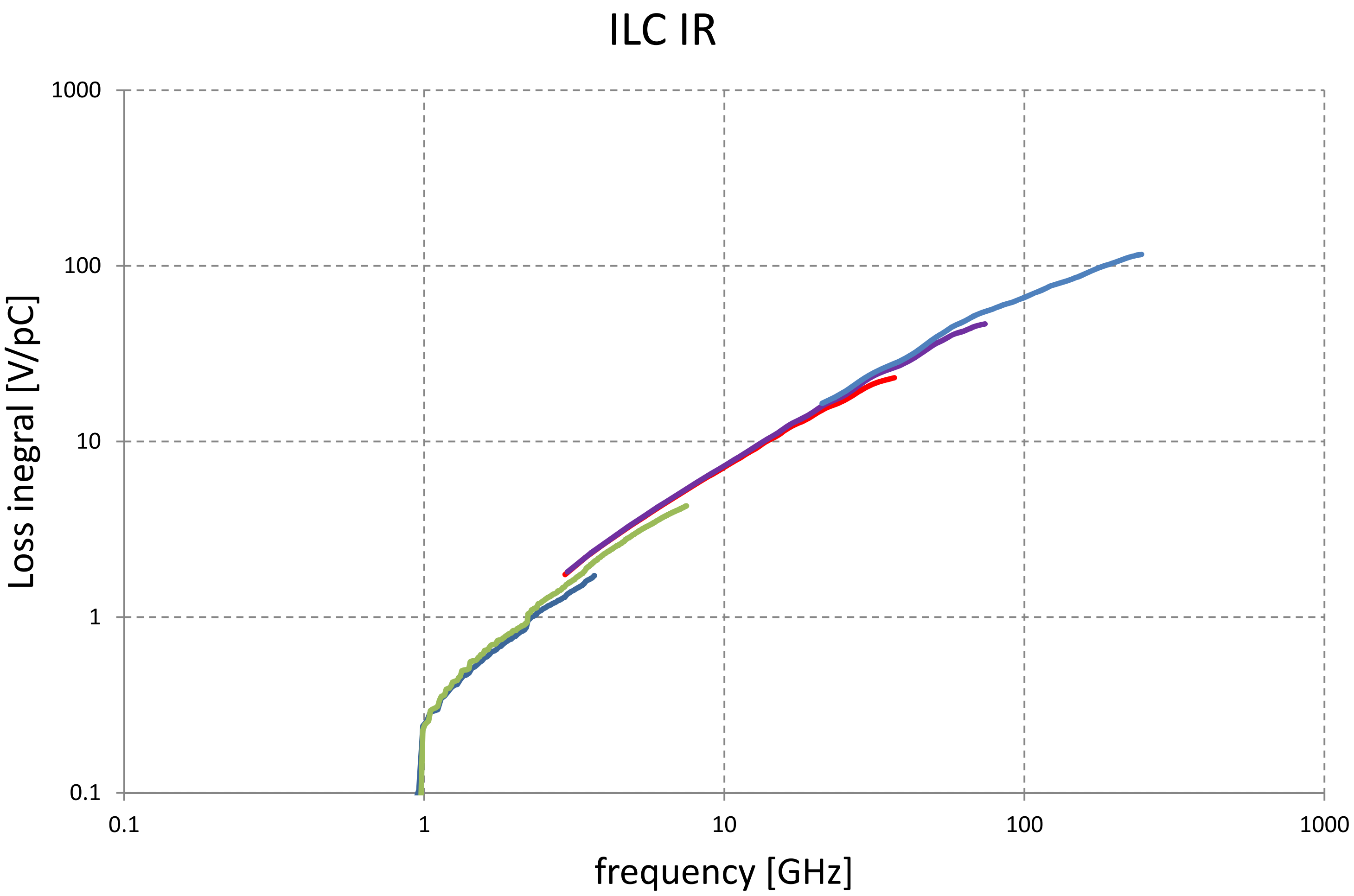
$$K_s(\omega) = \mathrm{Re}\{\frac{1}{\pi}\int_0^{\omega} W_s(\omega)\rho(-\omega)d\omega\} =$$

$$= \frac{1}{\pi}\int_0^{\omega} \left|\rho_s(\omega)\right|^2 \mathrm{Re}\{Z(\omega)\}d\omega$$

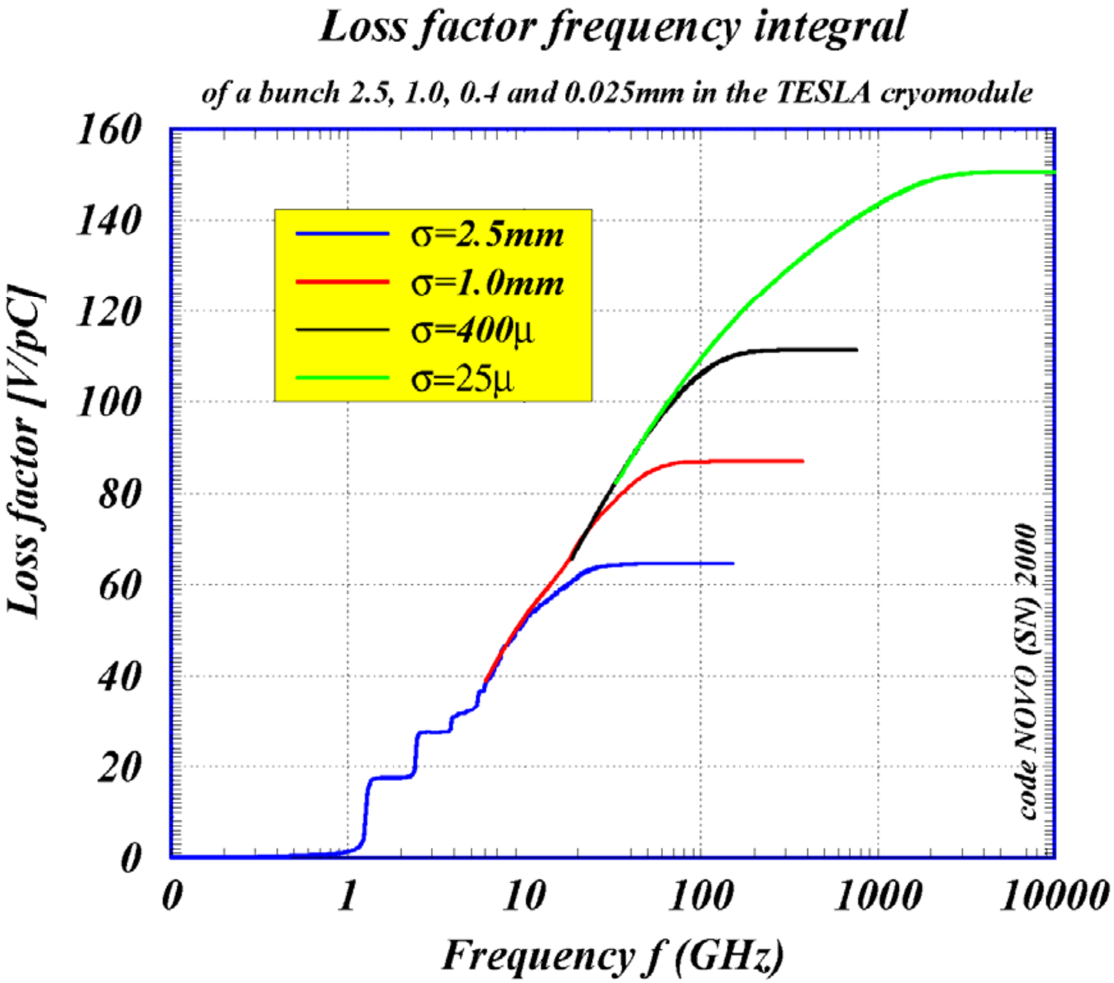
- Full integration gives the loss factor:

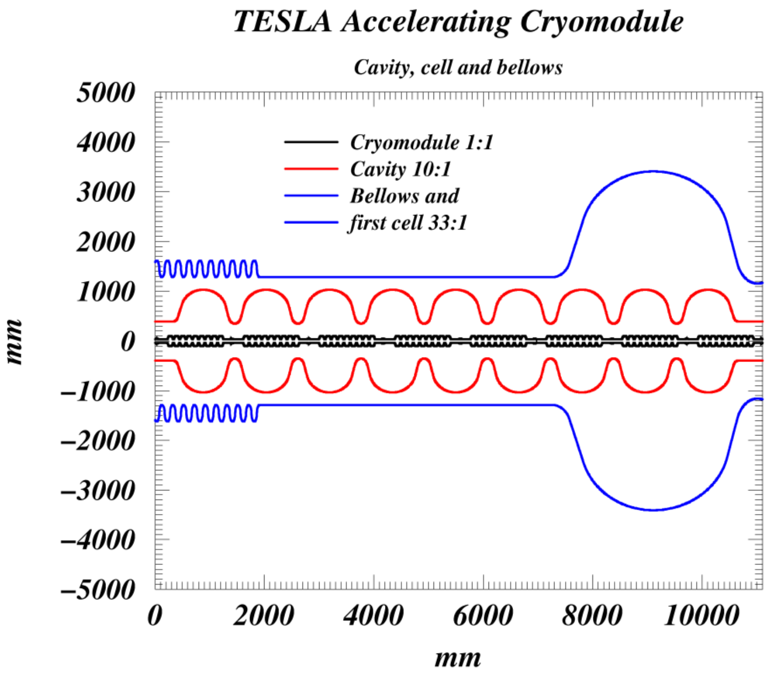
$$K_s(\omega \to \infty) = k_s$$

Loss frequency integral of IR



Comparison with loss frequency integral of the ILC (TESLA) cryo-module





IR produce almost same amount of wake fields as one cryomodule

Power loss of a train of bunches

- IR is a large “cavity”.
- Some of the fields excited in the IR can be trapped and absorbed there. Other part can leave IR, travel along the beam pipes and absorbed.
- Trapped modes may have high Q-value and keep the fields from the previous bunches.
- Modes with higher frequencies can leave the region.

Longitudinal impedance

- A Fourier transform of a Green's function gives a longitudinal coupling impedance

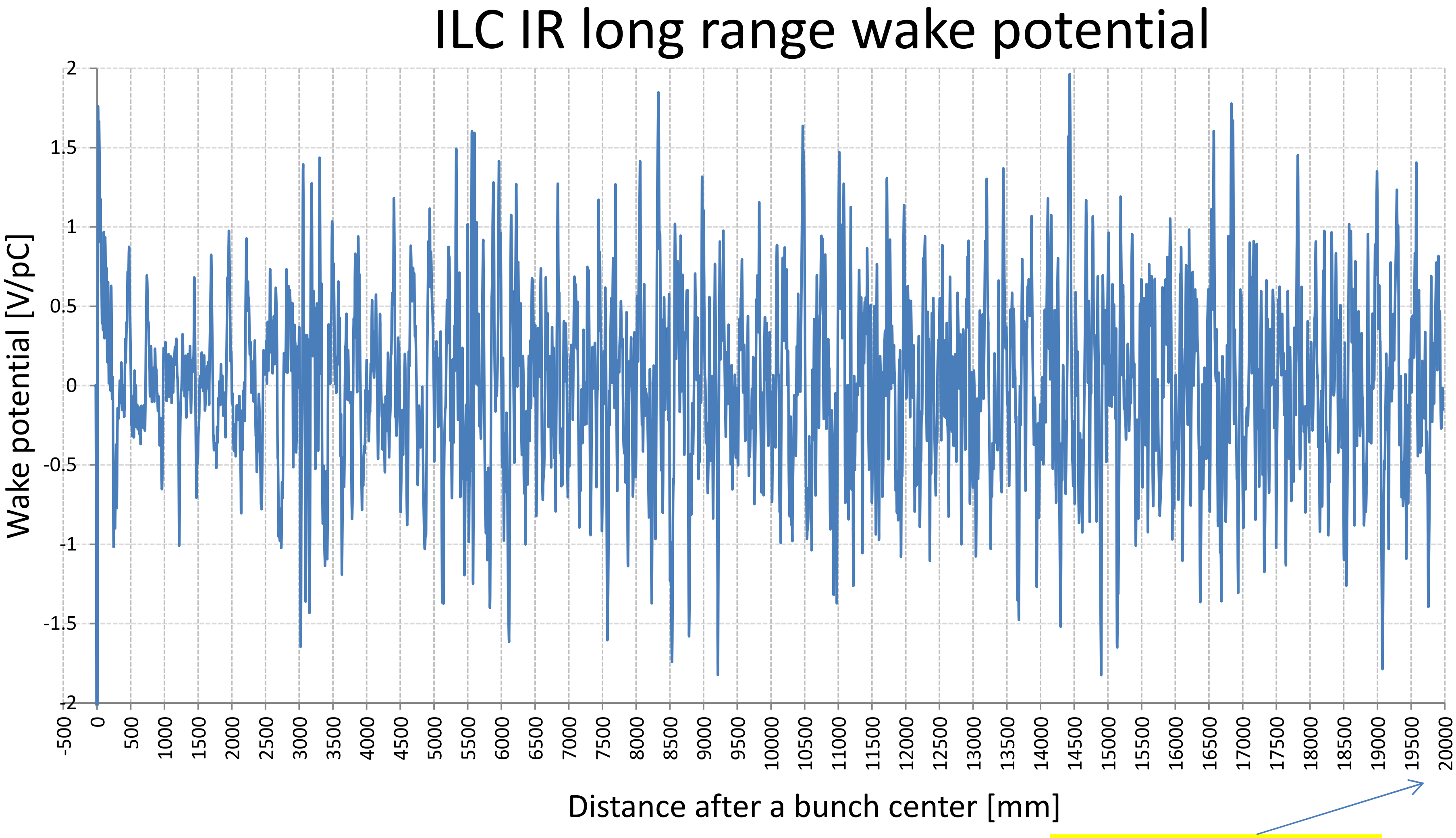
$$Z(\omega) = \int_{-\infty}^{\infty} G(\tau)\exp(-i\omega\tau)d\tau$$

- We can use wake potential to calculate longitudinal impedance

$$W(\omega) = \int_{-\infty}^{\infty} W(\tau)\exp(-i\omega\tau)d\tau =$$

$$= \rho(\omega)\times\int_{0}^{\infty} G(\tau')\exp(i\omega\tau')d\tau' = \rho(\omega)\times Z(-\omega)$$

Long-range wake potential



20 m after a bunch

Cut-off frequency

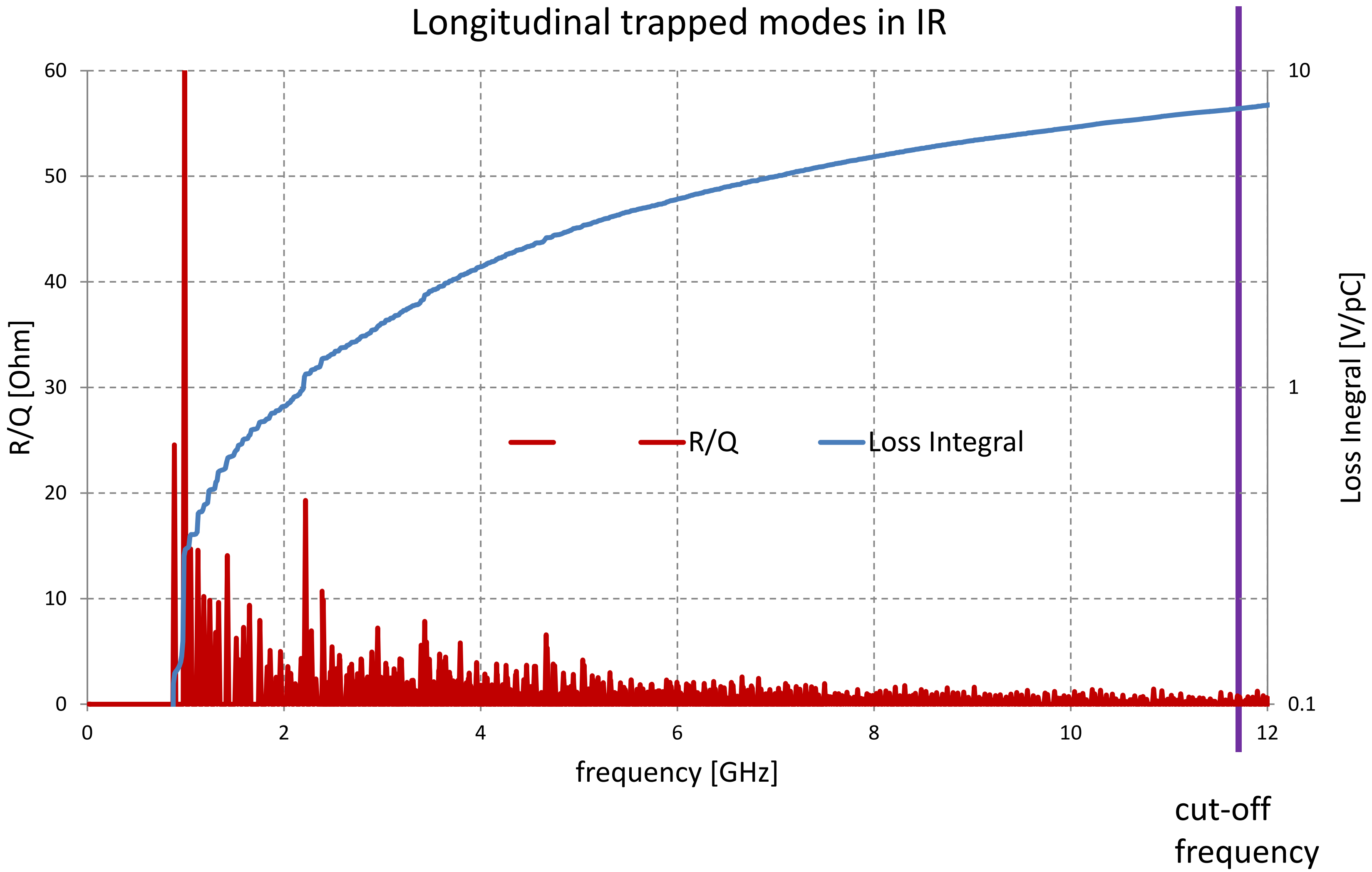
- Cut-off frequency is the maximum frequency of captured modes in a cavity.
- It is determined by the size of a beam pipe.
- For E01 mode

$$f^{cut-off}_{[GHz]} = \frac{c}{a} \times \frac{\nu_{01}}{2\pi} = \frac{0.11474}{a_{[m]}}$$

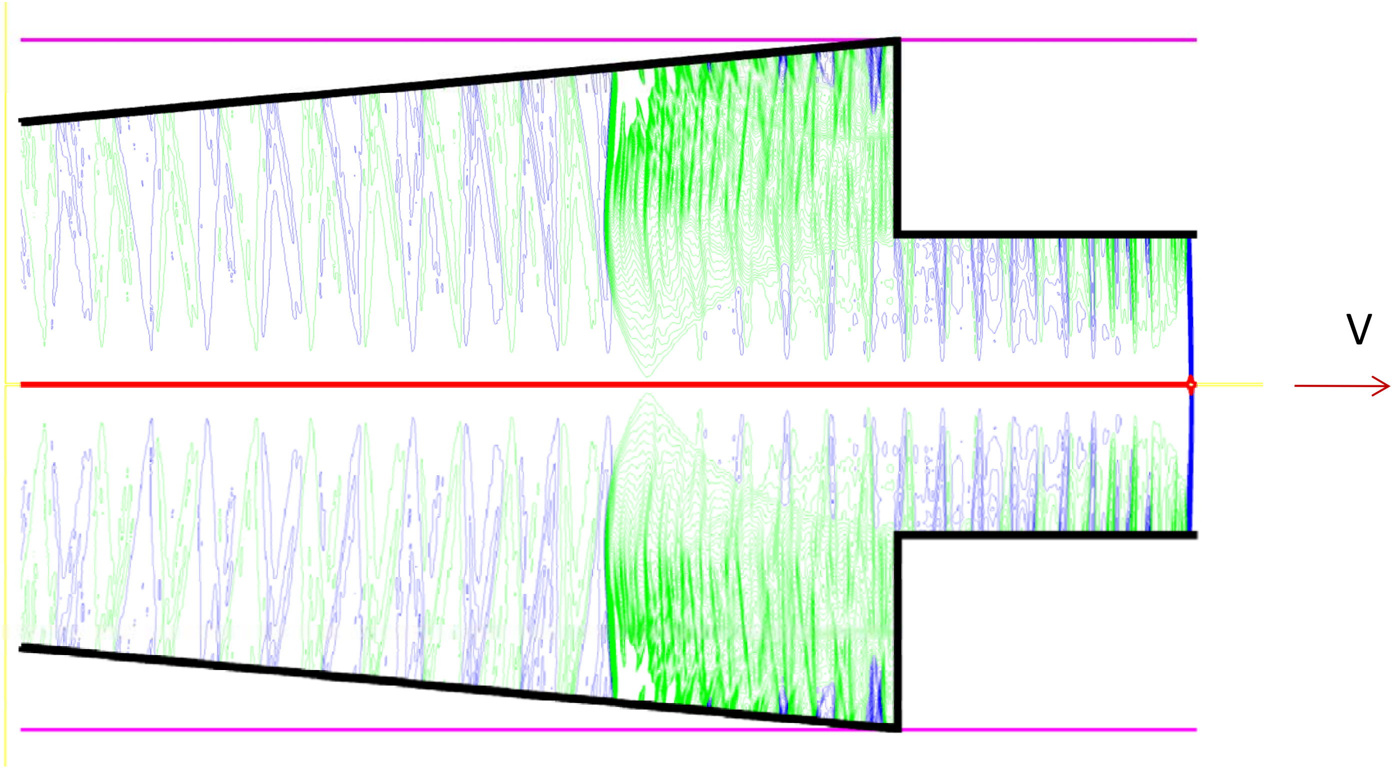
ILC IR: a=10mm=0.01m

f=11.47 GHz

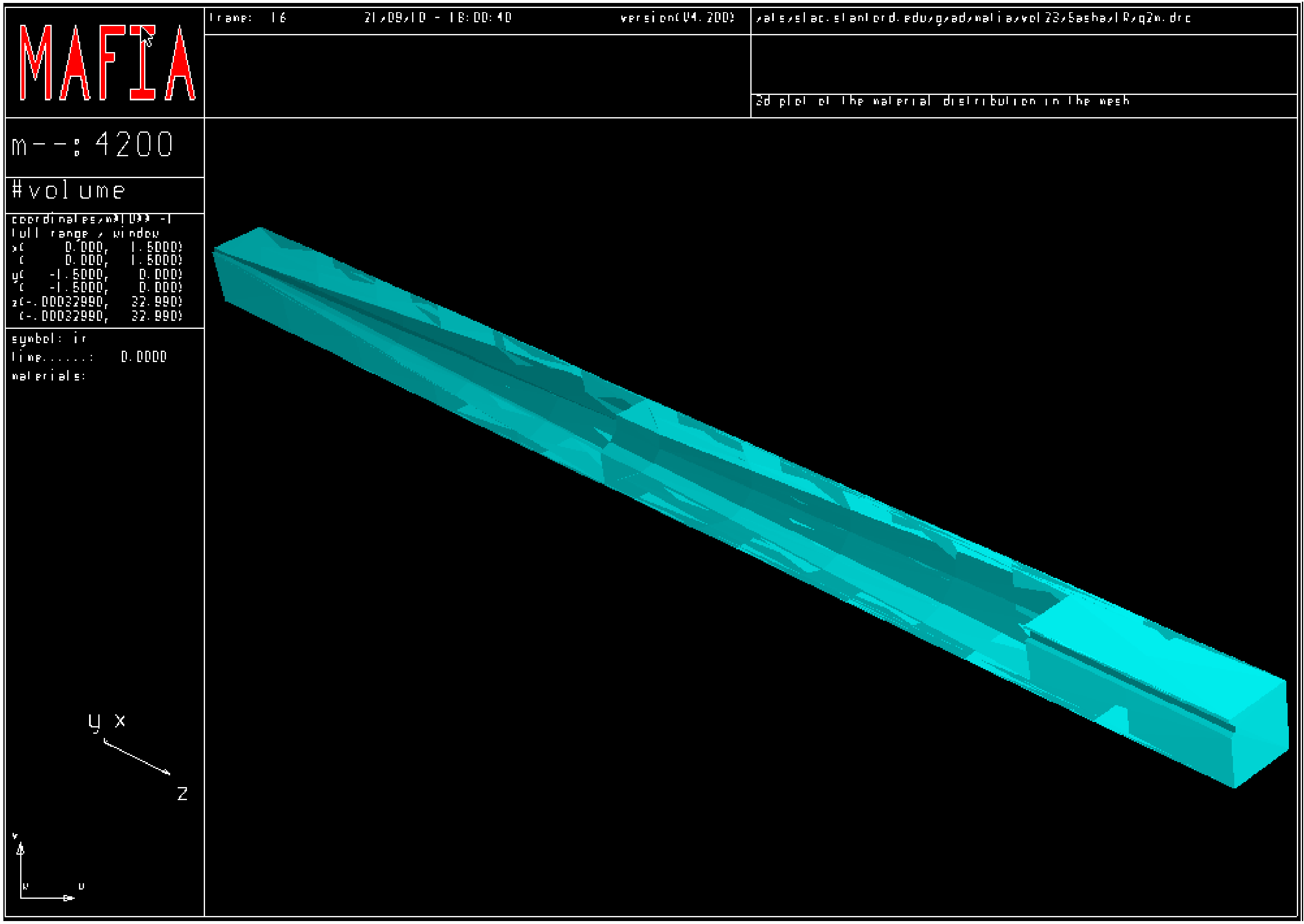
Trapped modes of IR



Wake fields in the corner

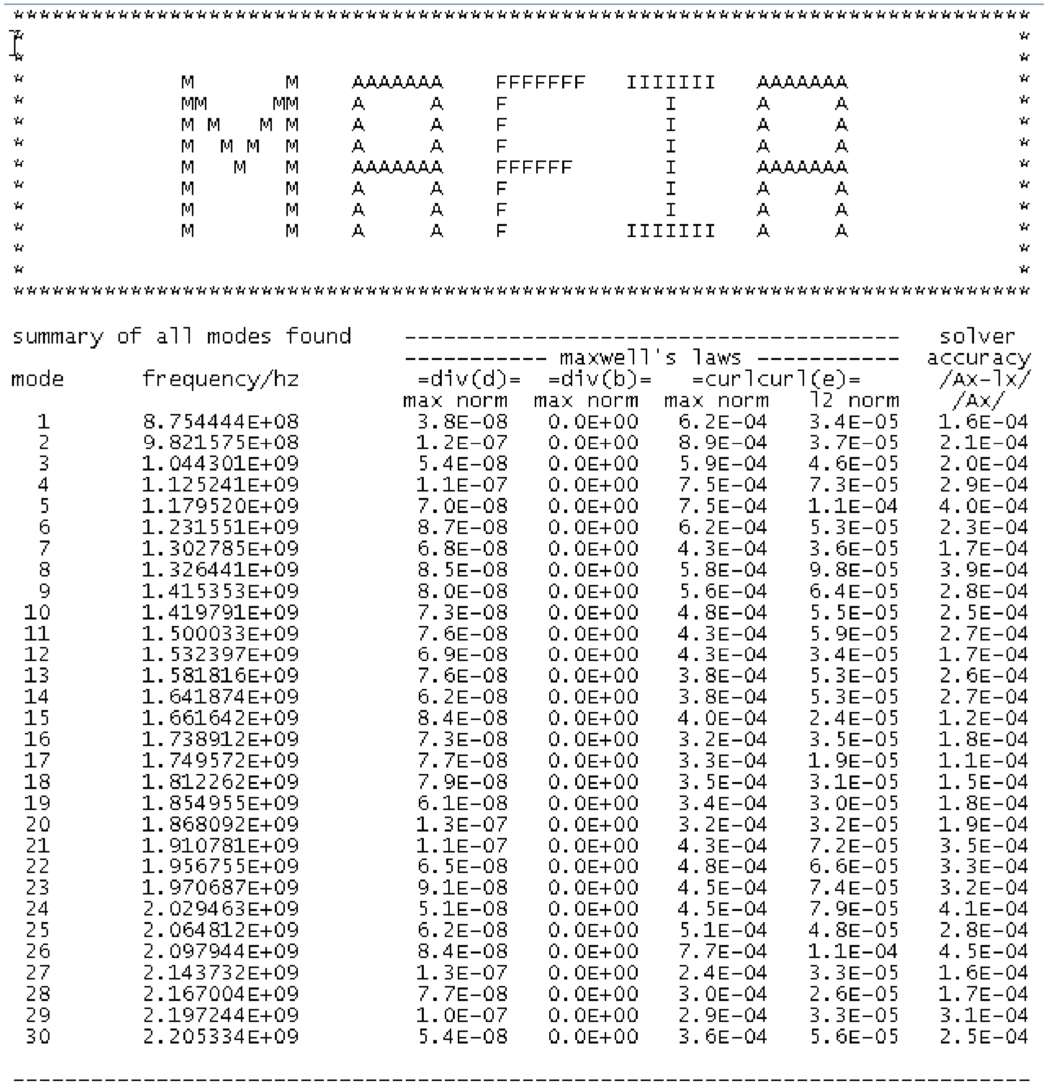


½ * ½ * ½ model for MAFIA simulations



```
MAFIA
frame:   16        21/09/10 - 18:00:40        version(V4.200)
/afs/slac.stanford.edu/g/ad/mafia/vol23/Sasha/IR/q2m.drc
3d plot of the material distribution in the mesh
m--: 4200
#volume
coordinates/m*[10** -1]
full range / window
x(      0.000,    1.5000)
 (      0.000,    1.5000)
y(    -1.5000,     0.000)
 (    -1.5000,     0.000)
z(-.00032990,    32.990)
 (-.00032990,    32.990)
symbol: ir
time......:     0.0000
materials:
```

MAFIA simulations

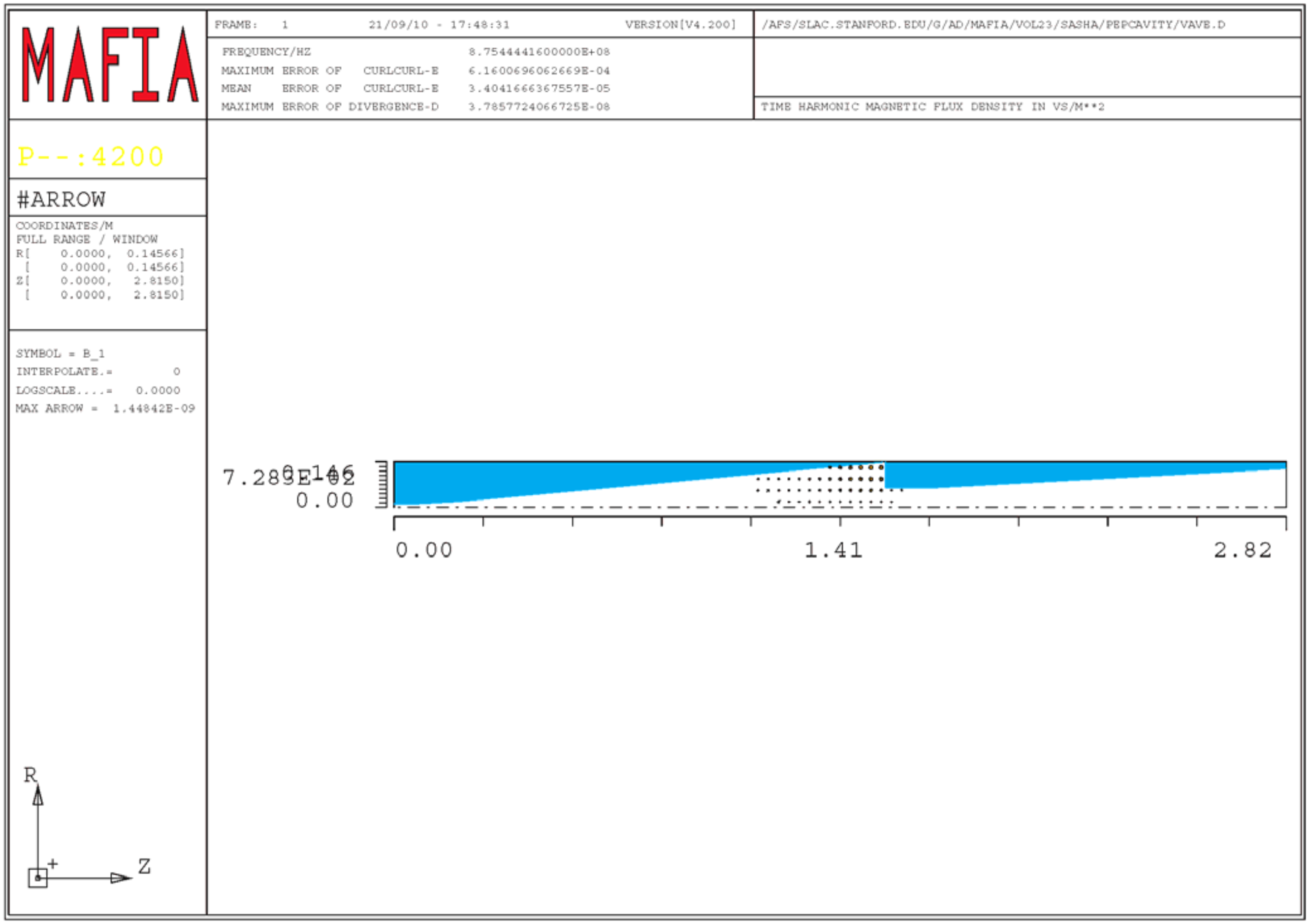


```
******************************************************************************
*                                                                            *
*                                                                            *
*            M       M    AAAAAAA    FFFFFFF   IIIIIII   AAAAAAA             *
*            MM     MM    A     A    F            I      A     A             *
*            M M   M M    A     A    F            I      A     A             *
*            M  M M  M    A     A    F            I      A     A             *
*            M   M   M    AAAAAAA    FFFFFF       I      AAAAAAA             *
*            M       M    A     A    F            I      A     A             *
*            M       M    A     A    F            I      A     A             *
*            M       M    A     A    F         IIIIIII   A     A             *
*                                                                            *
*                                                                            *
******************************************************************************

summary of all modes found       --------------------------------------   solver
                                 ----------- maxwell's laws -----------  accuracy
mode       frequency/hz           =div(d)=  =div(b)=   =curlcurl(e)=      /Ax-lx/
                                 max norm  max norm  max norm   l2 norm    /Ax/
  1        8.754444E+08           3.8E-08   0.0E+00   6.2E-04   3.4E-05   1.6E-04
  2        9.821575E+08           1.2E-07   0.0E+00   8.9E-04   3.7E-05   2.1E-04
  3        1.044301E+09           5.4E-08   0.0E+00   5.9E-04   4.6E-05   2.0E-04
  4        1.125241E+09           1.1E-07   0.0E+00   7.5E-04   7.3E-05   2.9E-04
  5        1.179520E+09           7.0E-08   0.0E+00   7.5E-04   1.1E-04   4.0E-04
  6        1.231551E+09           8.7E-08   0.0E+00   6.2E-04   5.3E-05   2.3E-04
  7        1.302785E+09           6.8E-08   0.0E+00   4.3E-04   3.6E-05   1.7E-04
  8        1.326441E+09           8.5E-08   0.0E+00   5.8E-04   9.8E-05   3.9E-04
  9        1.415353E+09           8.0E-08   0.0E+00   5.6E-04   6.4E-05   2.8E-04
 10        1.419791E+09           7.3E-08   0.0E+00   4.8E-04   5.5E-05   2.5E-04
 11        1.500033E+09           7.6E-08   0.0E+00   4.3E-04   5.9E-05   2.7E-04
 12        1.532397E+09           6.9E-08   0.0E+00   4.3E-04   3.4E-05   1.7E-04
 13        1.581816E+09           7.6E-08   0.0E+00   3.8E-04   5.3E-05   2.6E-04
 14        1.641874E+09           6.2E-08   0.0E+00   3.8E-04   5.3E-05   2.7E-04
 15        1.661642E+09           8.4E-08   0.0E+00   4.0E-04   2.4E-05   1.2E-04
 16        1.738912E+09           7.3E-08   0.0E+00   3.2E-04   3.5E-05   1.8E-04
 17        1.749572E+09           7.7E-08   0.0E+00   3.3E-04   1.9E-05   1.1E-04
 18        1.812262E+09           7.9E-08   0.0E+00   3.5E-04   3.1E-05   1.5E-04
 19        1.854955E+09           6.1E-08   0.0E+00   3.4E-04   3.0E-05   1.8E-04
 20        1.868092E+09           1.3E-07   0.0E+00   3.2E-04   3.2E-05   1.9E-04
 21        1.910781E+09           1.1E-07   0.0E+00   4.3E-04   7.2E-05   3.5E-04
 22        1.956755E+09           6.5E-08   0.0E+00   4.8E-04   6.6E-05   3.3E-04
 23        1.970687E+09           9.1E-08   0.0E+00   4.5E-04   7.4E-05   3.2E-04
 24        2.029463E+09           5.1E-08   0.0E+00   4.5E-04   7.9E-05   4.1E-04
 25        2.064812E+09           6.2E-08   0.0E+00   5.1E-04   4.8E-05   2.8E-04
 26        2.097944E+09           8.4E-08   0.0E+00   7.7E-04   1.1E-04   4.5E-04
 27        2.143732E+09           1.3E-07   0.0E+00   2.4E-04   3.3E-05   1.6E-04
 28        2.167004E+09           7.7E-08   0.0E+00   3.0E-04   2.6E-05   1.7E-04
 29        2.197244E+09           1.0E-07   0.0E+00   2.9E-04   3.3E-05   3.1E-04
 30        2.205334E+09           5.4E-08   0.0E+00   3.6E-04   5.6E-05   2.5E-04

------------------------------------------------------------------------------
```

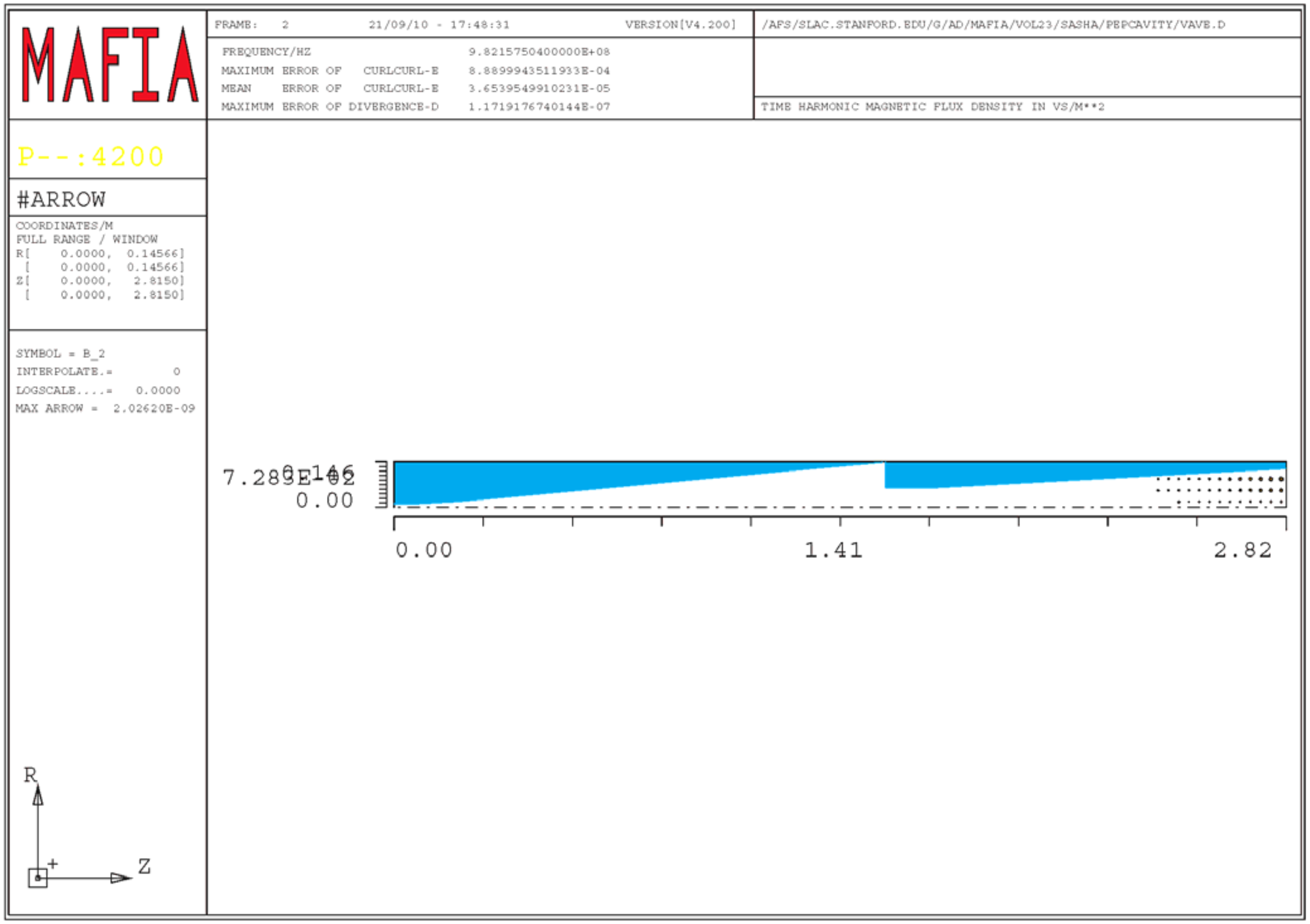
Second mode



```
MAFIA
FRAME:   1          21/09/10 - 17:48:31            VERSION[V4.200]
/AFS/SLAC.STANFORD.EDU/G/AD/MAFIA/VOL23/SASHA/PEPCAVITY/VAVE.D
FREQUENCY/HZ                            8.7544441600000E+08
MAXIMUM  ERROR OF    CURLCURL-E         6.1600696062669E-04
MEAN     ERROR OF    CURLCURL-E         3.4041666367557E-05
MAXIMUM  ERROR OF DIVERGENCE-D          3.7857724066725E-08
TIME HARMONIC MAGNETIC FLUX DENSITY IN VS/M**2
P--:4200
#ARROW
COORDINATES/M
FULL RANGE / WINDOW
R[     0.0000,  0.14566]
 [     0.0000,  0.14566]
Z[     0.0000,   2.8150]
 [     0.0000,   2.8150]

SYMBOL = B_1
INTERPOLATE.=          0
LOGSCALE....=     0.0000
MAX ARROW =   1.44842E-09
```

Other mode



```
FRAME:    2          21/09/10 - 17:48:31              VERSION[V4.200]
/AFS/SLAC.STANFORD.EDU/G/AD/MAFIA/VOL23/SASHA/PEPCAVITY/VAVE.D

FREQUENCY/HZ                          9.8215750400000E+08
MAXIMUM  ERROR OF    CURLCURL-E       8.8899943511933E-04
MEAN     ERROR OF    CURLCURL-E       3.6539549910231E-05
MAXIMUM  ERROR OF DIVERGENCE-D        1.1719176740144E-07

TIME HARMONIC MAGNETIC FLUX DENSITY IN VS/M**2

COORDINATES/M
FULL RANGE / WINDOW
R[     0.0000,  0.14566]
 [     0.0000,  0.14566]
Z[     0.0000,   2.8150]
 [     0.0000,   2.8150]

SYMBOL = B_2
INTERPOLATE.=          0
LOGSCALE....=     0.0000
MAX ARROW =   2.02620E-09
```

Interaction with one mode

Mode voltage decay $V(t) = V(o)\, e^{-\frac{t}{\tau_{l,n}}}$

Loaded time decay
or filling time $\tau_{l,n} = \dfrac{2Q_l}{\omega_n} = \dfrac{2Q_l}{2\pi f_n} = \dfrac{Q_l}{\pi f_n}$

Loaded Q-value
which includes coupling Q_l

Bunch spacing τ_b

Mode **survives** to
the next bunch if $\dfrac{\tau_b}{\tau_{l,n}} << 1$

and loaded Q $Q_l >> \dfrac{\omega_n \tau_b}{2} = \pi f_n \tau_b$

Coherent and incoherent excitation

	Incoherent	Coherent at resonance
condition	$Q_l \ll \pi f_n \tau_b$	$Q_l \gg \pi f_n \tau_b$
Loss power	$P_n = I^2 \frac{\omega_n}{2} \frac{R}{Q} \tau_b$	$P_n = I^2 \frac{R}{Q} Q_l$
Loss factor $k_n = \frac{\omega_n}{2} \frac{R}{Q}$	$P_n = I^2 k_n \tau_b$	$P_n = 2I^2 k_n \tau_{l,n}$

If the bunch spacing is equal to mode decay time the coherent power is only two times larger than incoherent power

Total loss power (all trapped modes)

Total power $$P_{incoh.} = I^2 \tau_b \sum_n k_n \qquad P_{coh.} = 2I^2 \sum_n k_n \tau_{l,n}$$

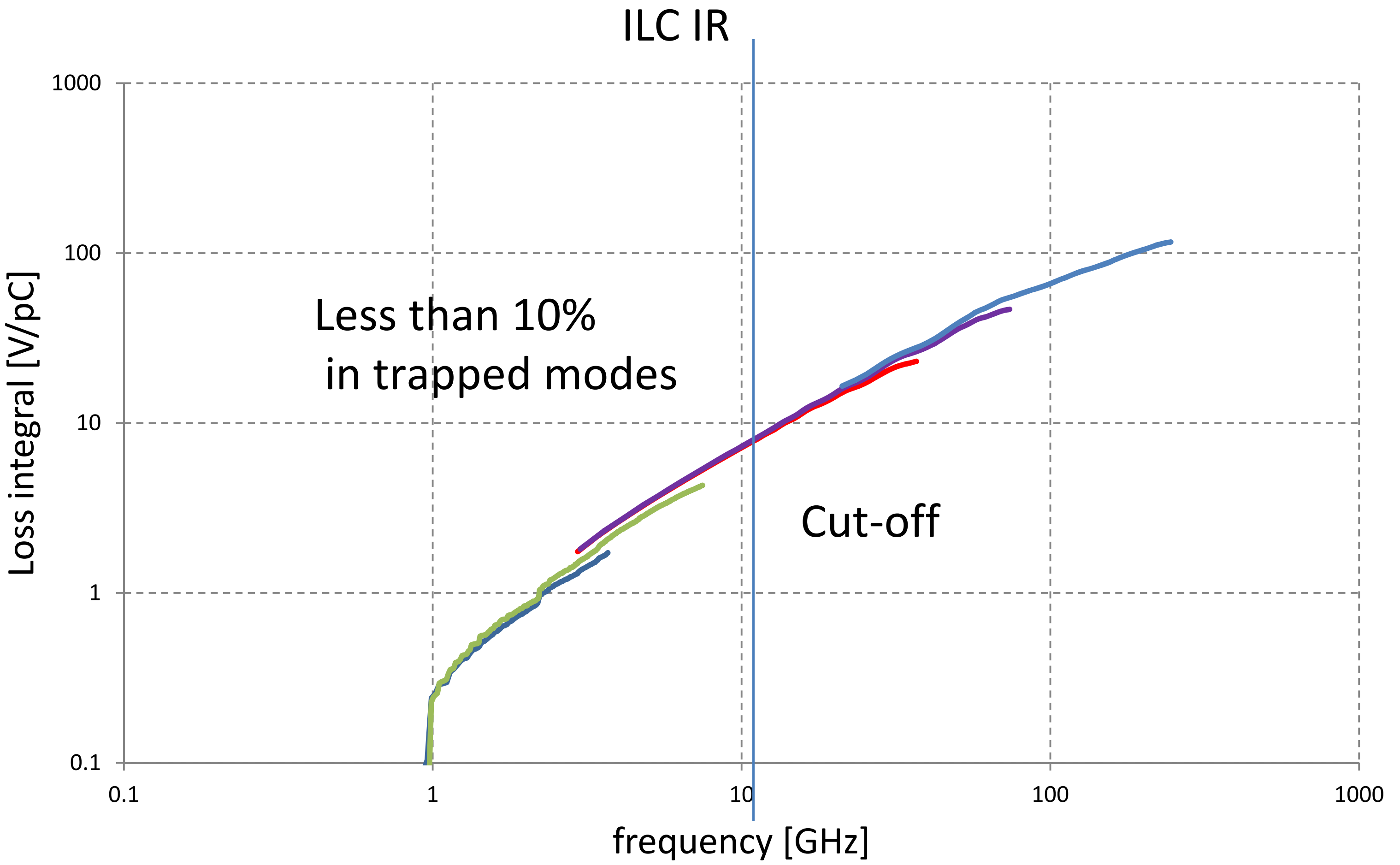
Trapped mode frequency range	0.85 – 11.5 GHz
Bunch spacing	369.2 ns
Loaded Q $Q_l = \pi f_n \tau_b$	990 - 13300

$$\sum_n k_n = 7.3 \text{ V/pC}$$

$$P_{incoh.} = 440 \text{ W} \qquad P_{coh.} = 880 \text{ W}$$

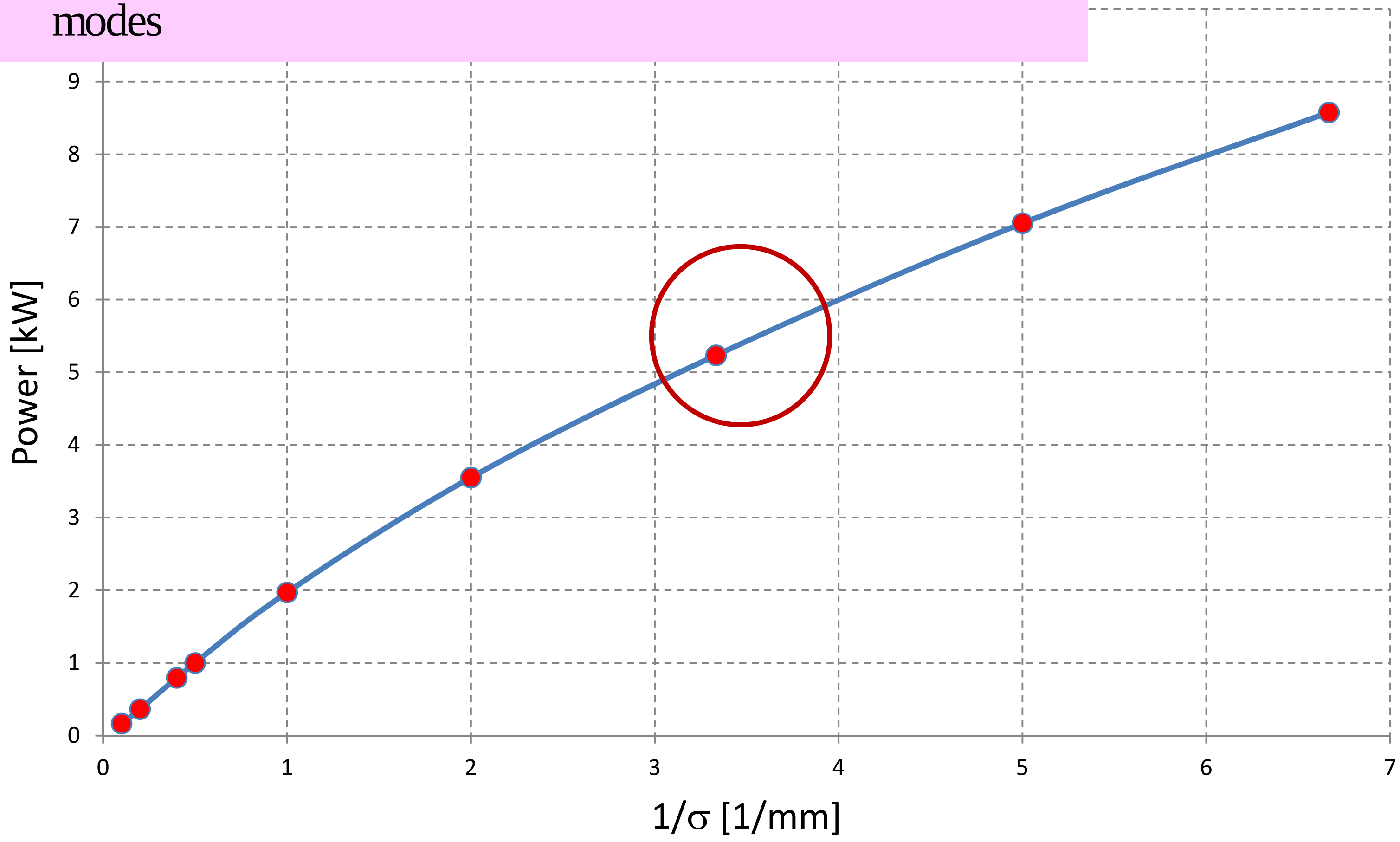
Average power is 200 times smaller

Loss integral and cut-off frequency



Power loss in a pulse (two beams)

$$P = P_{\substack{\text{trapped}\\ \text{modes}}} + 2I_{beam}^2 \times T_b \times (k_s - K(\omega_{cut-off}))$$

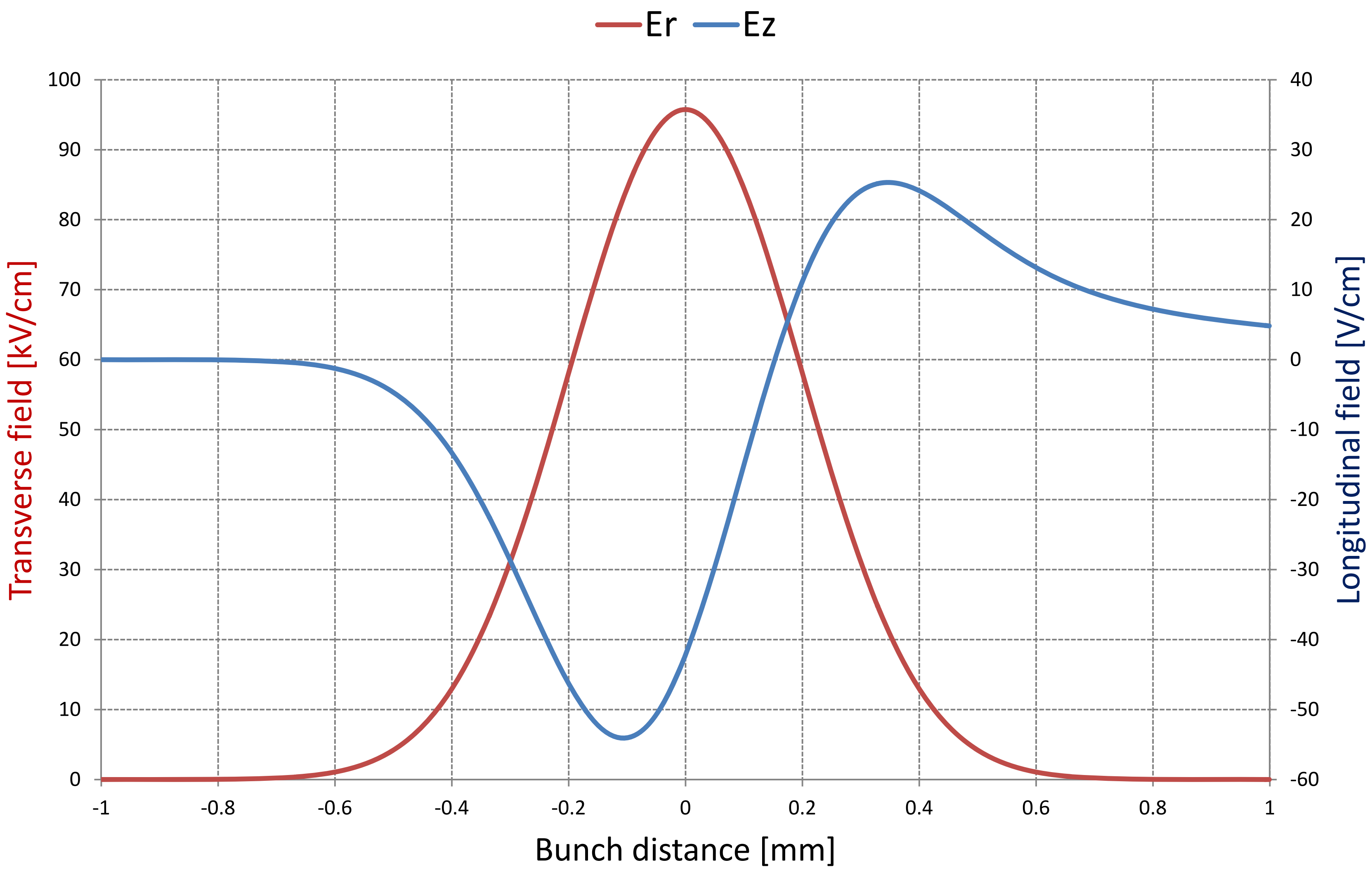


Resistive-wall wake fields

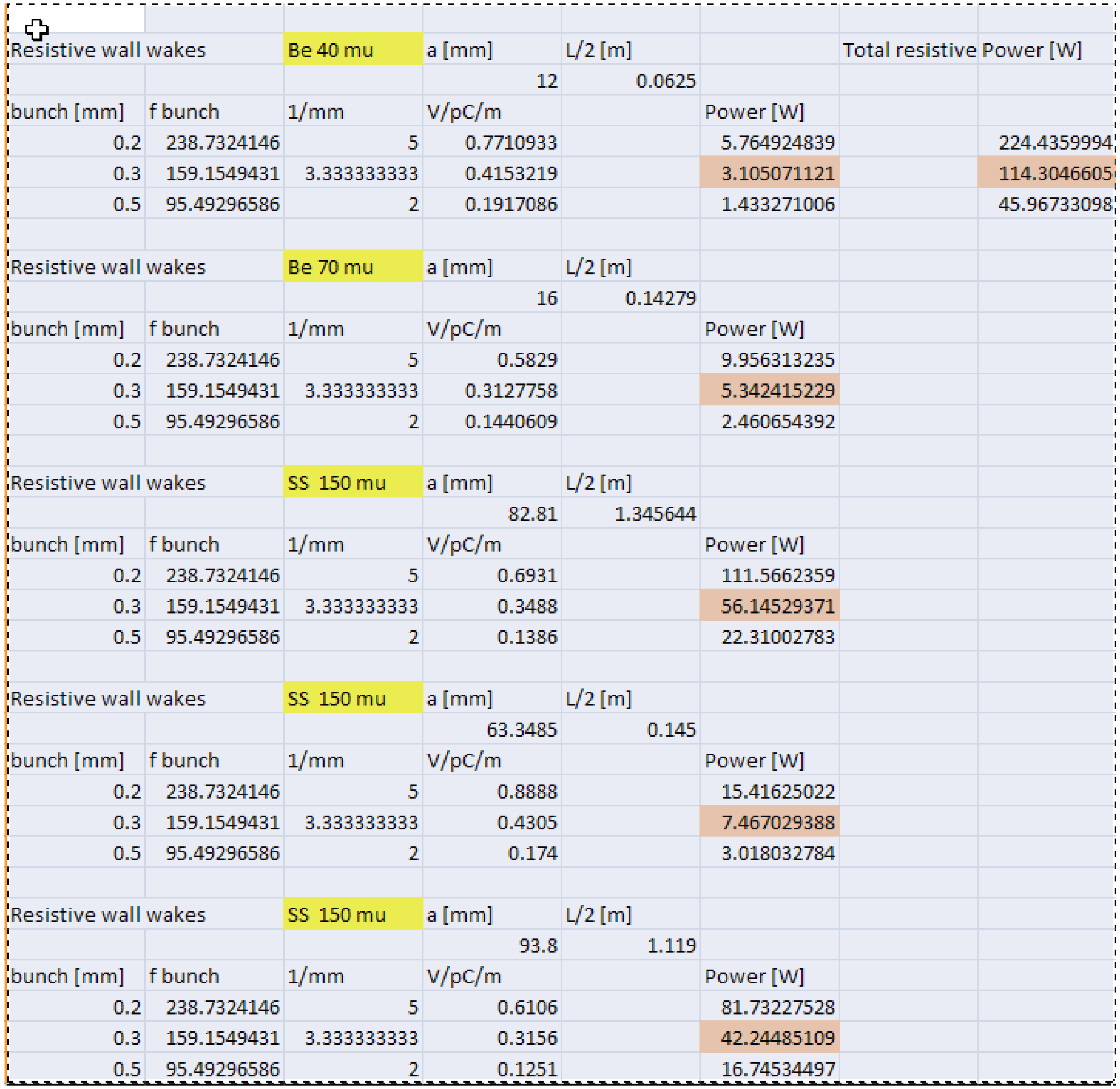
(Losses of image currents)

conductivity	/Ohm/mm
Al	35000
Cu	58000
SS	1400
Au	48800
Be	25000
Ni	14600
NEG	55-1000

Fields in Be chamber. Bunch 0.2 mm



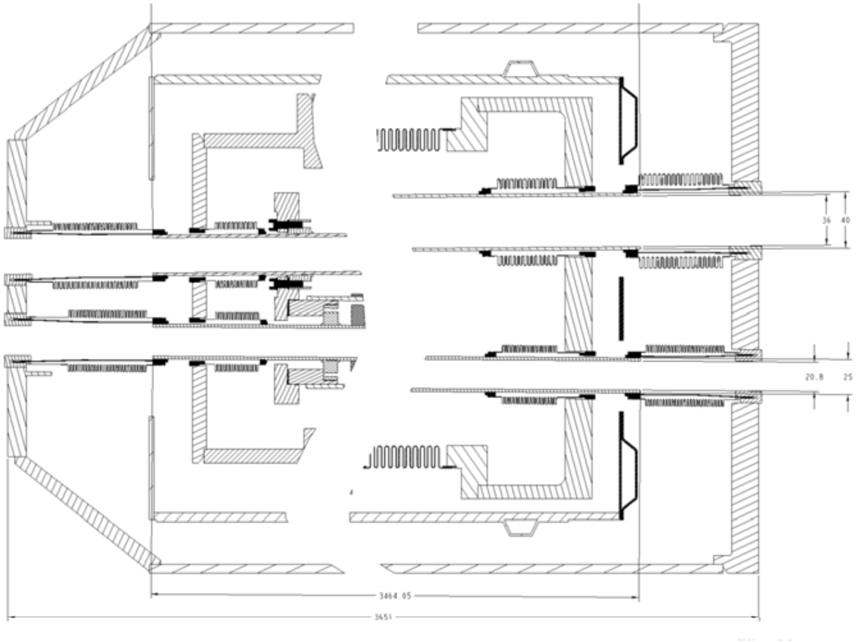
Power loss due to resistive wall. Not so much.



Resistive wall wakes		Be 40 mu	a [mm]	L/2 [m]		Total resistive	Power [W]
			12	0.0625			
bunch [mm]	f bunch	1/mm	V/pC/m		Power [W]		
0.2	238.7324146	5	0.7710933		5.764924839		224.4359994
0.3	159.1549431	3.333333333	0.4153219		3.105071121		114.3046605
0.5	95.49296586	2	0.1917086		1.433271006		45.96733098
Resistive wall wakes		Be 70 mu	a [mm]	L/2 [m]			
			16	0.14279			
bunch [mm]	f bunch	1/mm	V/pC/m		Power [W]		
0.2	238.7324146	5	0.5829		9.956313235		
0.3	159.1549431	3.333333333	0.3127758		5.342415229		
0.5	95.49296586	2	0.1440609		2.460654392		
Resistive wall wakes		SS 150 mu	a [mm]	L/2 [m]			
			82.81	1.345644			
bunch [mm]	f bunch	1/mm	V/pC/m		Power [W]		
0.2	238.7324146	5	0.6931		111.5662359		
0.3	159.1549431	3.333333333	0.3488		56.14529371		
0.5	95.49296586	2	0.1386		22.31002783		
Resistive wall wakes		SS 150 mu	a [mm]	L/2 [m]			
			63.3485	0.145			
bunch [mm]	f bunch	1/mm	V/pC/m		Power [W]		
0.2	238.7324146	5	0.8888		15.41625022		
0.3	159.1549431	3.333333333	0.4305		7.467029388		
0.5	95.49296586	2	0.174		3.018032784		
Resistive wall wakes		SS 150 mu	a [mm]	L/2 [m]			
			93.8	1.119			
bunch [mm]	f bunch	1/mm	V/pC/m		Power [W]		
0.2	238.7324146	5	0.6106		81.73227528		
0.3	159.1549431	3.333333333	0.3156		42.24485109		
0.5	95.49296586	2	0.1251		16.74534497		

X 5 (NEG) =600 W

QD0



Input pipe:
Diameter=20.8mm
Length= 3651mm

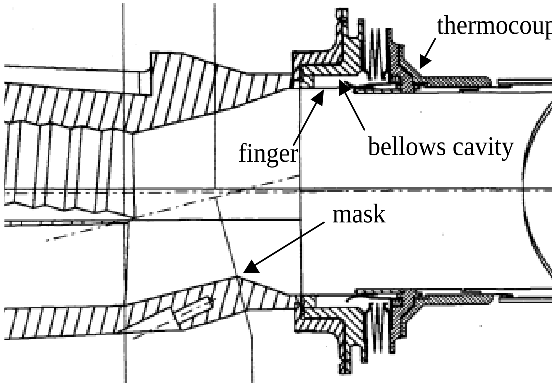
Output pipe
Diameter=36 mm
Length=3651mm

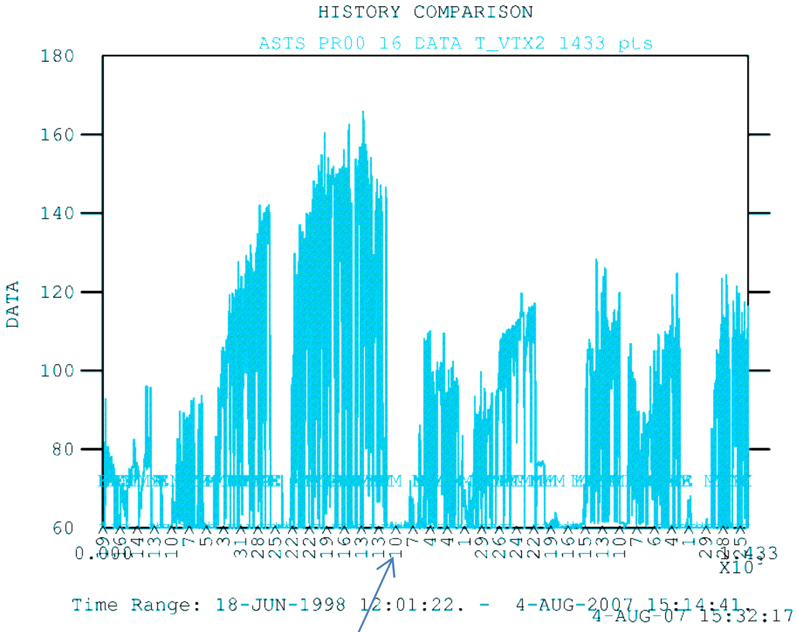
Resistive loss:

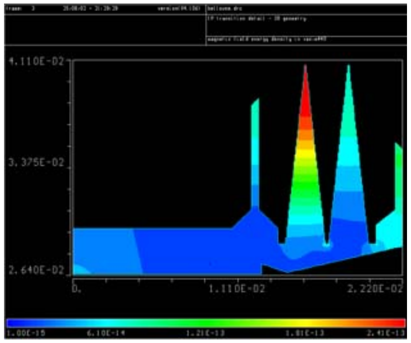
Preliminary calculations for a tube of a diameter of 20.8 mm and length of 3.651 m gives 200 W pulsed losses or 1 W averaged power.

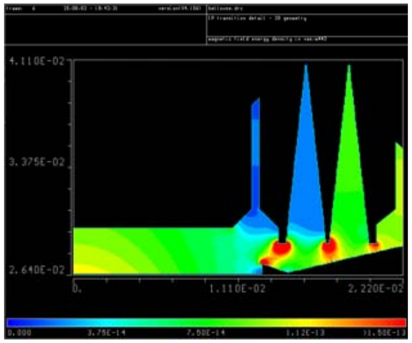
A tube of 36 mm dissipate 0.6 W averaged power.

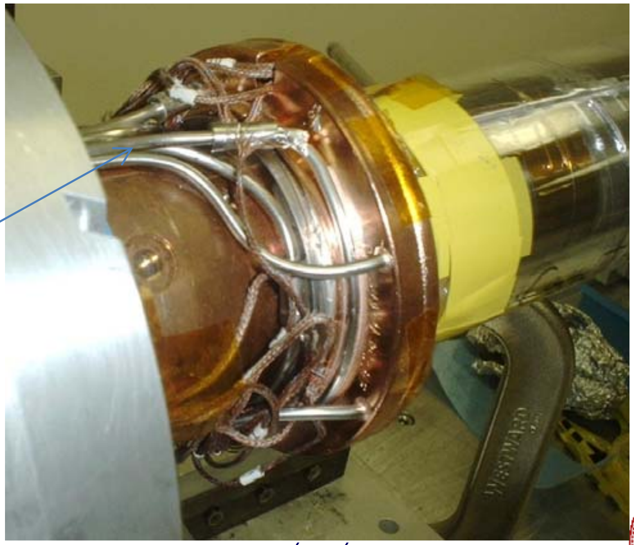
History: PEP-II vertex bellows











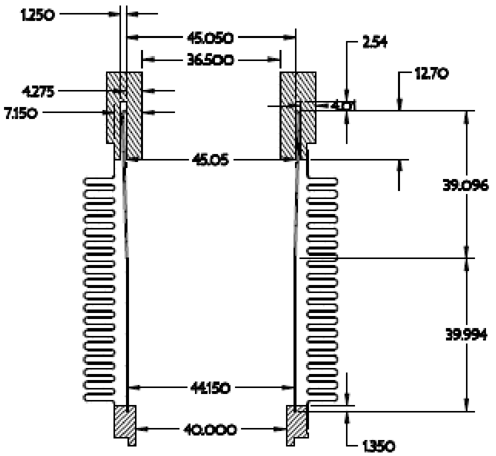
Mike Sullivan
installed air cooling

Bellows of different size

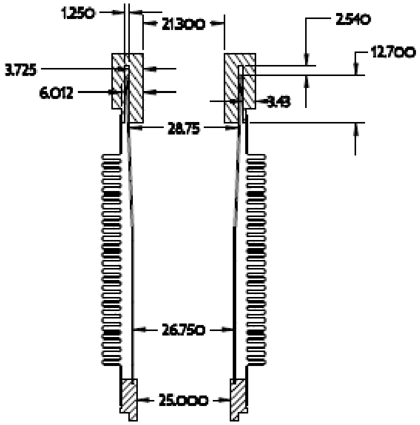
Sasha;

Here is what we have right now on the RF shield assemblies. All materials are stainless steel, but the contact portion of the fingers will be silver plated.

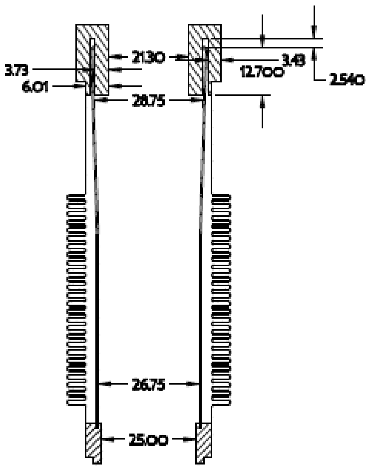
Andy Marone



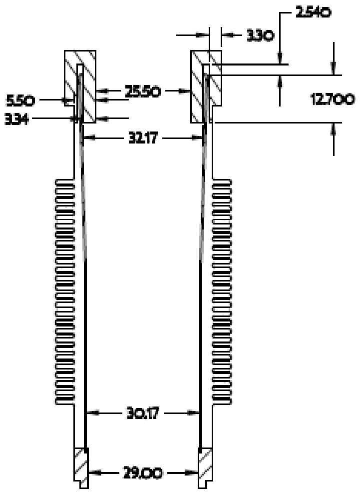
LE EXTRACTION
SECTION A-A
SCALE 1.500



LE INJECTION
SECTION A-A
SCALE 1.500

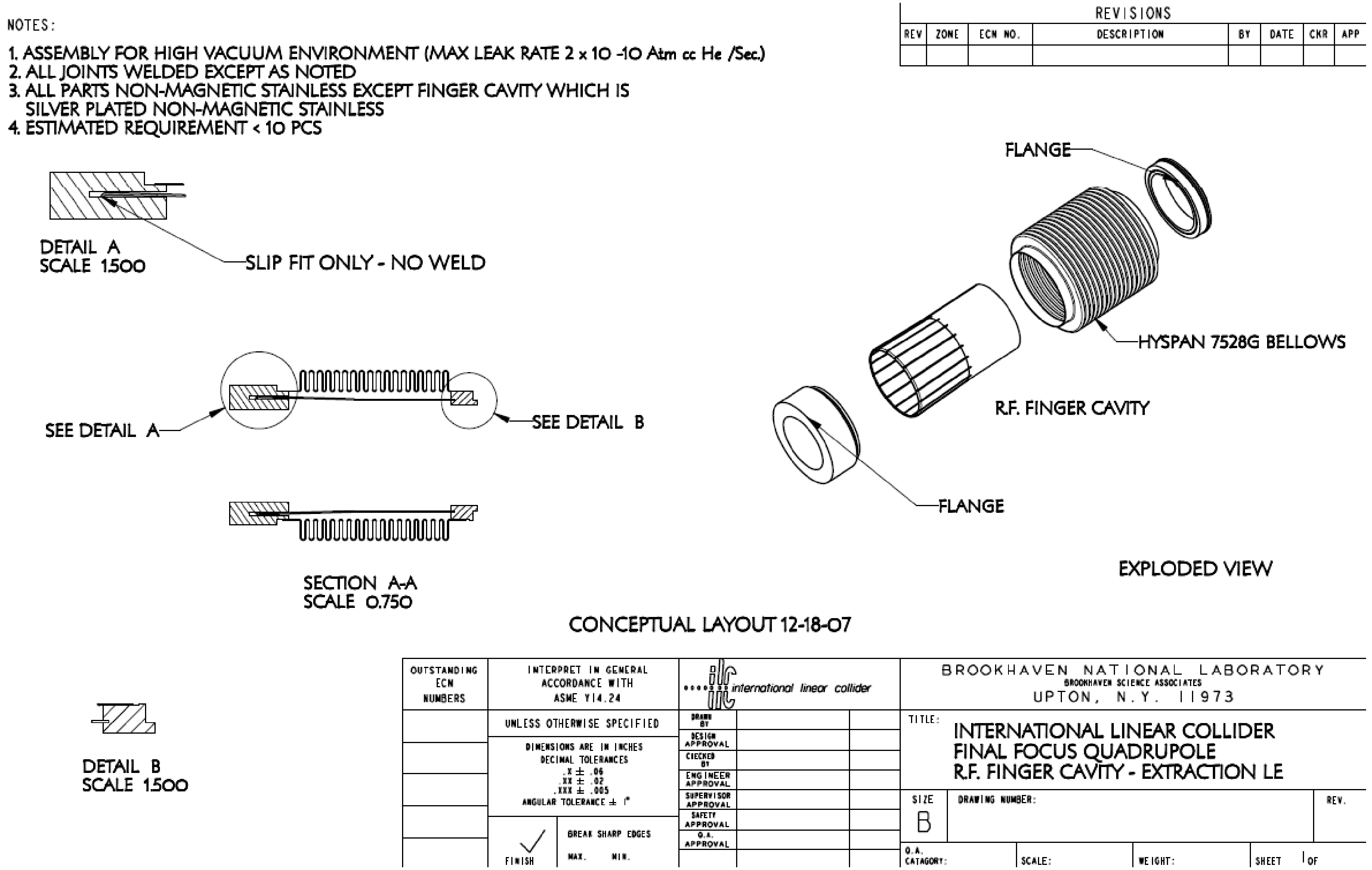


IP INJECTION
SECTION A-A
SCALE 1.500



IP EXTRACTION
SECTION A-A
SCALE 1.500

QD0 bellows. Conceptual layout.



NOTES:

1. ASSEMBLY FOR HIGH VACUUM ENVIRONMENT (MAX LEAK RATE 2 x 10 -10 Atm cc He /Sec.)
2. ALL JOINTS WELDED EXCEPT AS NOTED
3. ALL PARTS NON-MAGNETIC STAINLESS EXCEPT FINGER CAVITY WHICH IS SILVER PLATED NON-MAGNETIC STAINLESS
4. ESTIMATED REQUIREMENT < 10 PCS

REVISIONS

REV	ZONE	ECN NO.	DESCRIPTION	BY	DATE	CKR	APP

CONCEPTUAL LAYOUT 12-18-07

OUTSTANDING ECN NUMBERS

INTERPRET IN GENERAL ACCORDANCE WITH ASME Y14.24

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES
DECIMAL TOLERANCES
.X ± .06
.XX ± .02
.XXX ± .005
ANGULAR TOLERANCE ± 1°

FINISH ✓

BREAK SHARP EDGES
MAX. MIN.

international linear collider

DRAWN BY:
DESIGN APPROVAL:
CHECKED BY:
ENGINEER APPROVAL:
SUPERVISOR APPROVAL:
SAFETY APPROVAL:
Q.A. APPROVAL:

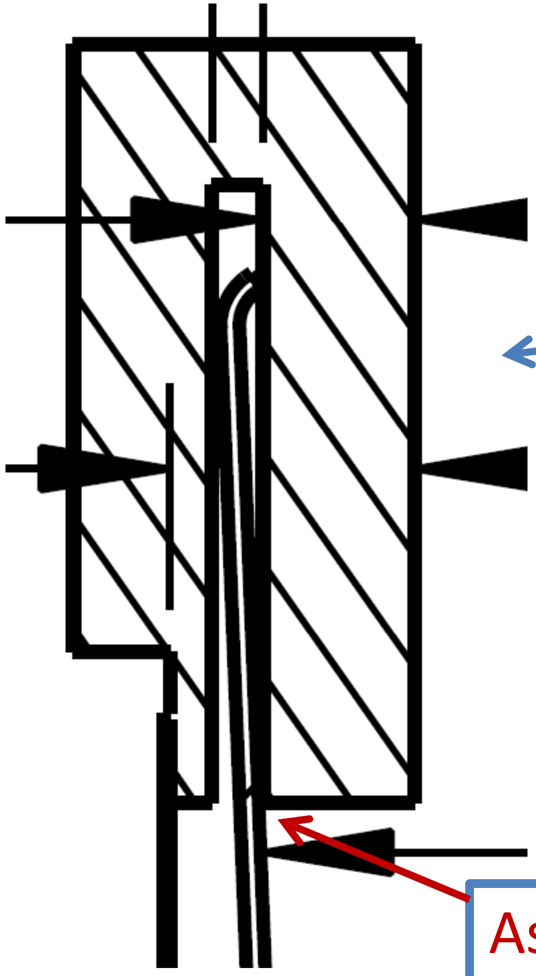
BROOKHAVEN NATIONAL LABORATORY
BROOKHAVEN SCIENCE ASSOCIATES
UPTON, N.Y. 11973

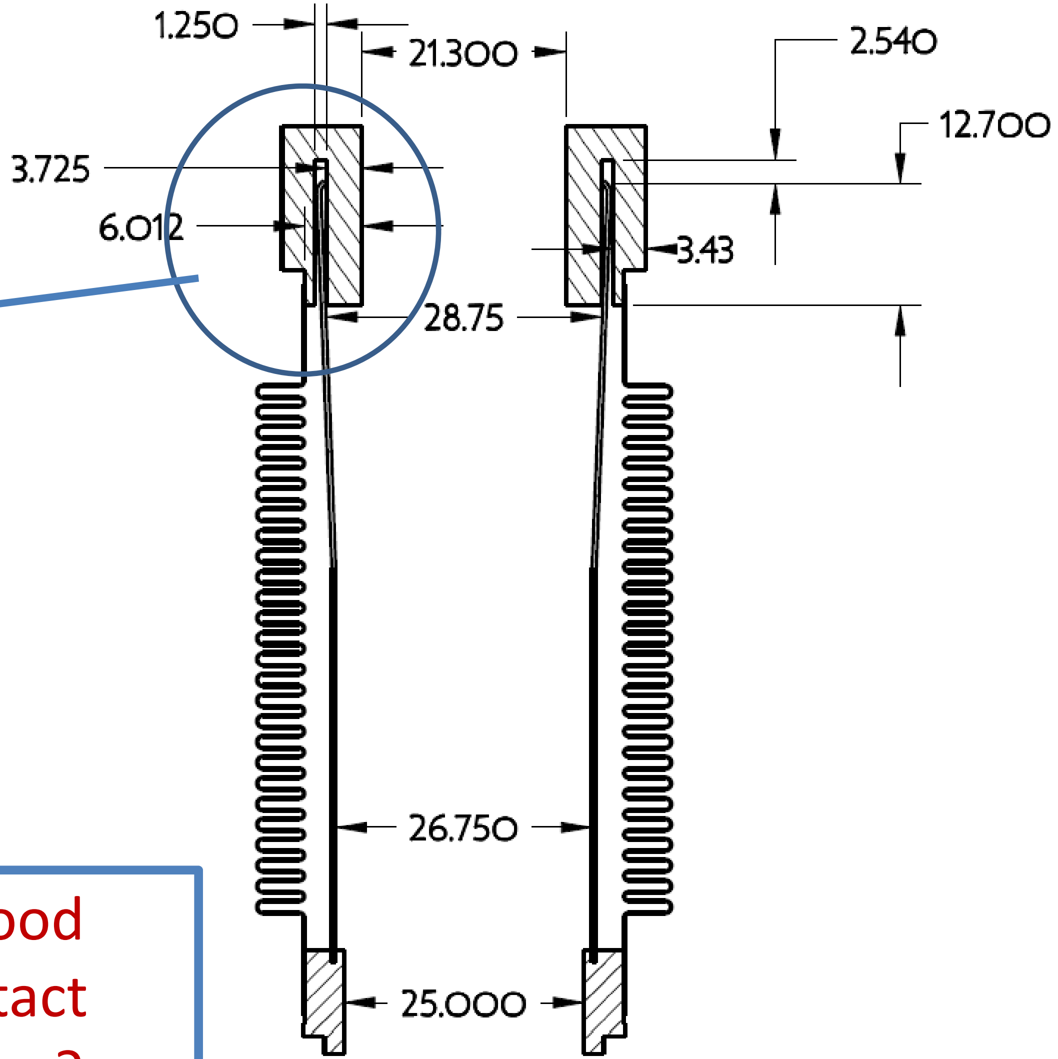
TITLE: INTERNATIONAL LINEAR COLLIDER
FINAL FOCUS QUADRUPOLE
R.F. FINGER CAVITY - EXTRACTION LE

SIZE: B
DRAWING NUMBER:
REV.:

Q.A. CATAGORY:
SCALE:
WEIGHT:
SHEET 1 OF

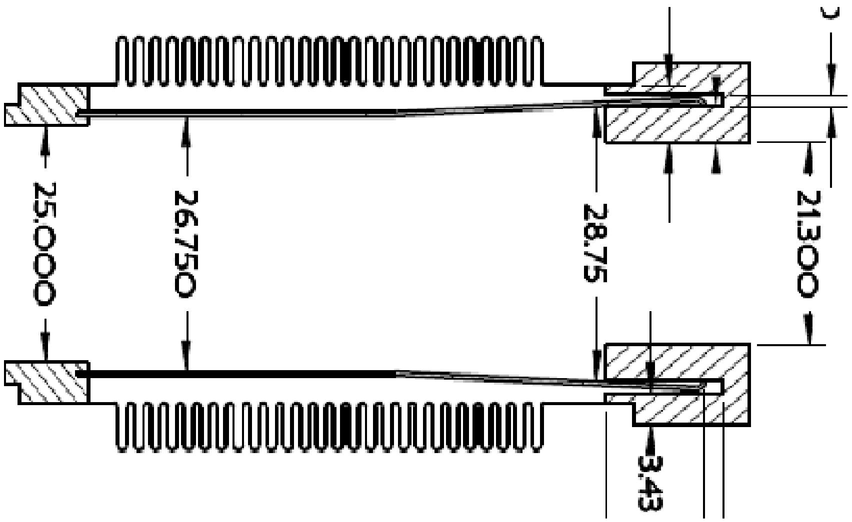
Bellows. Details.

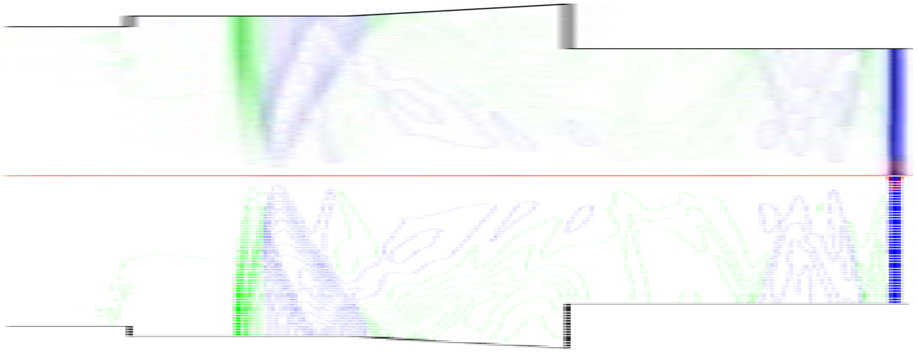


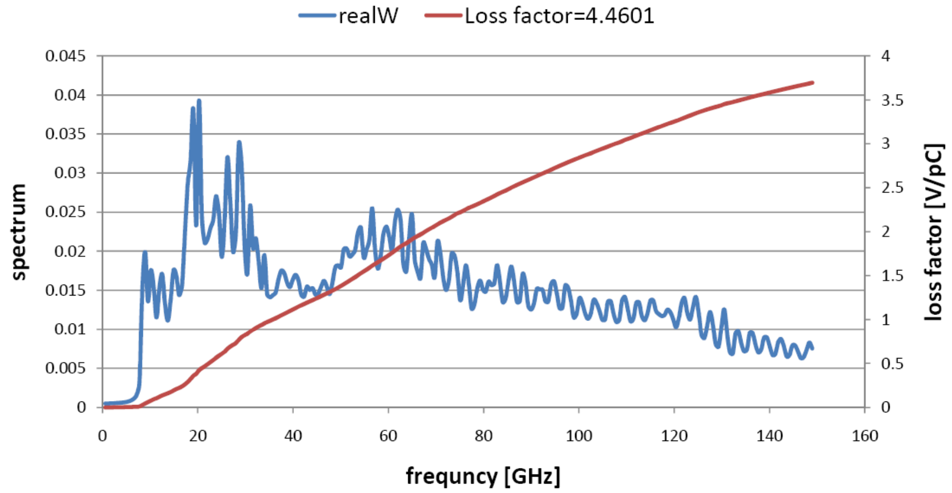


Assuming good electric contact here. Is it true?

Fields and spectrum

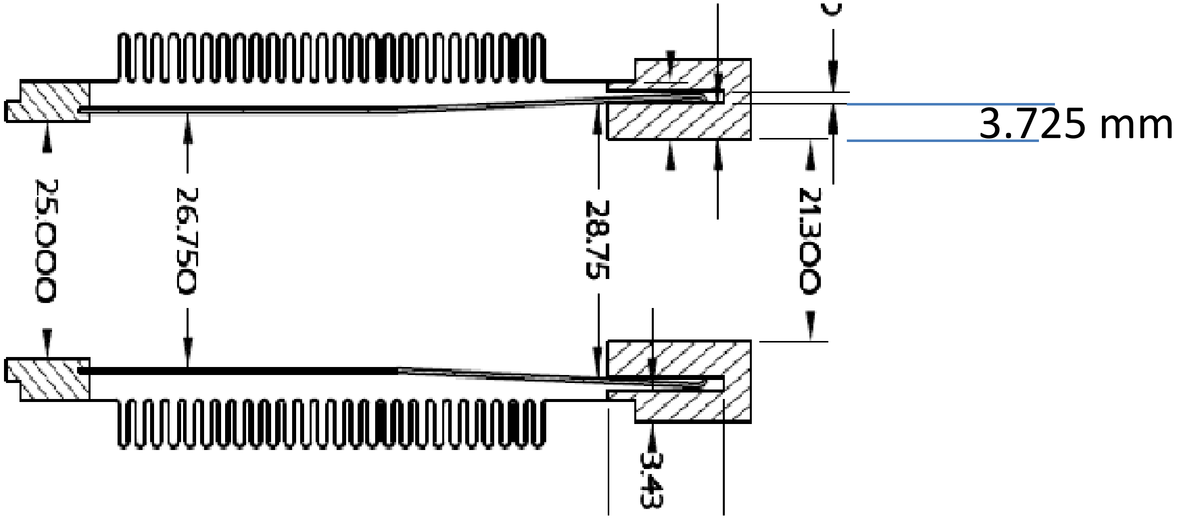


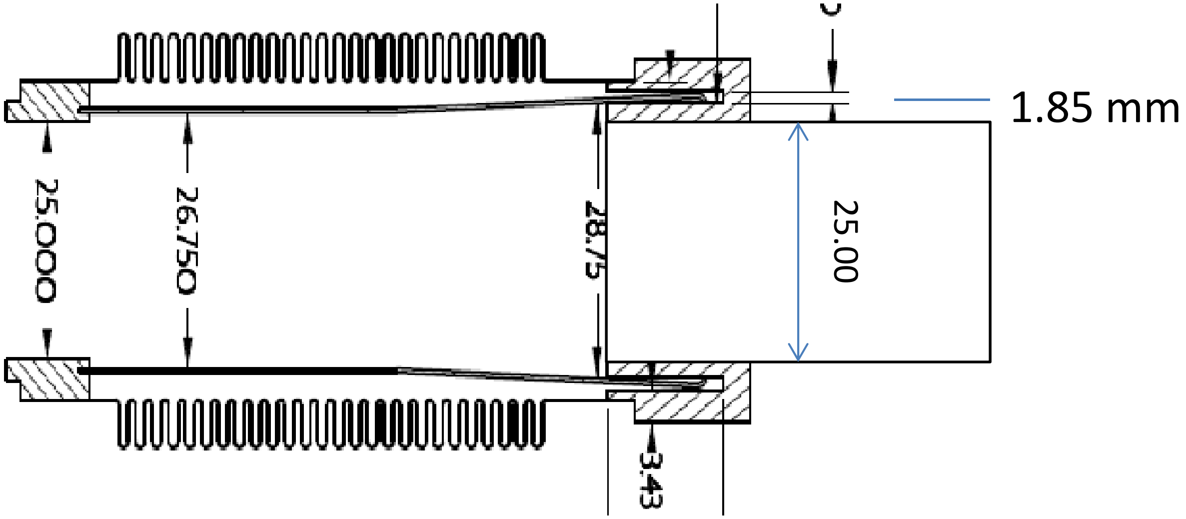




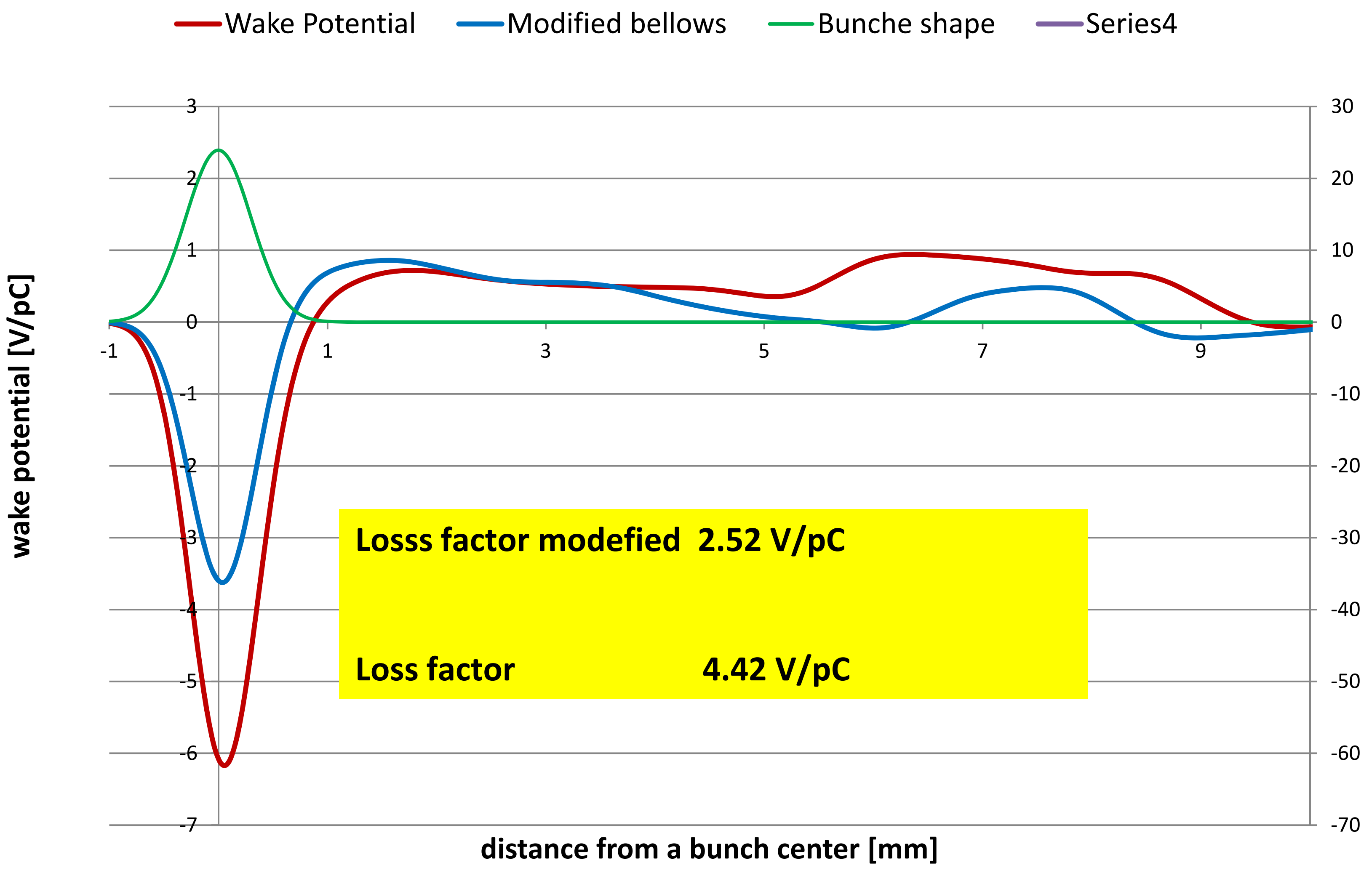
A bellows produces an additional power of 0.6 W (averaged).

Can we reduce the loss factor?





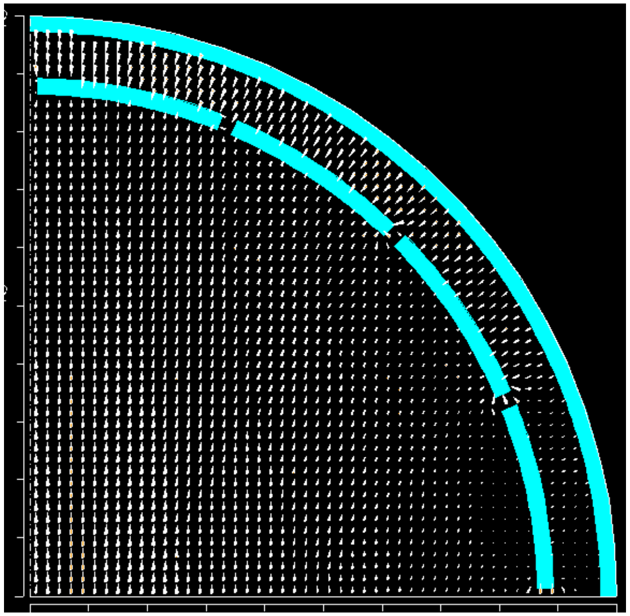
Wake potentials for two cases. 75% reduction



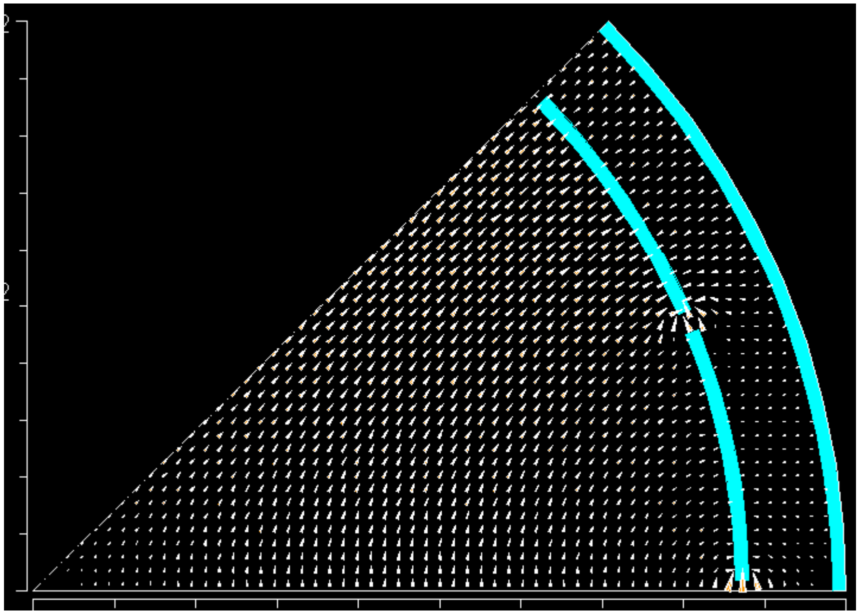
Losss factor modefied 2.52 V/pC

Loss factor 4.42 V/pC

Coupling. Field distribution

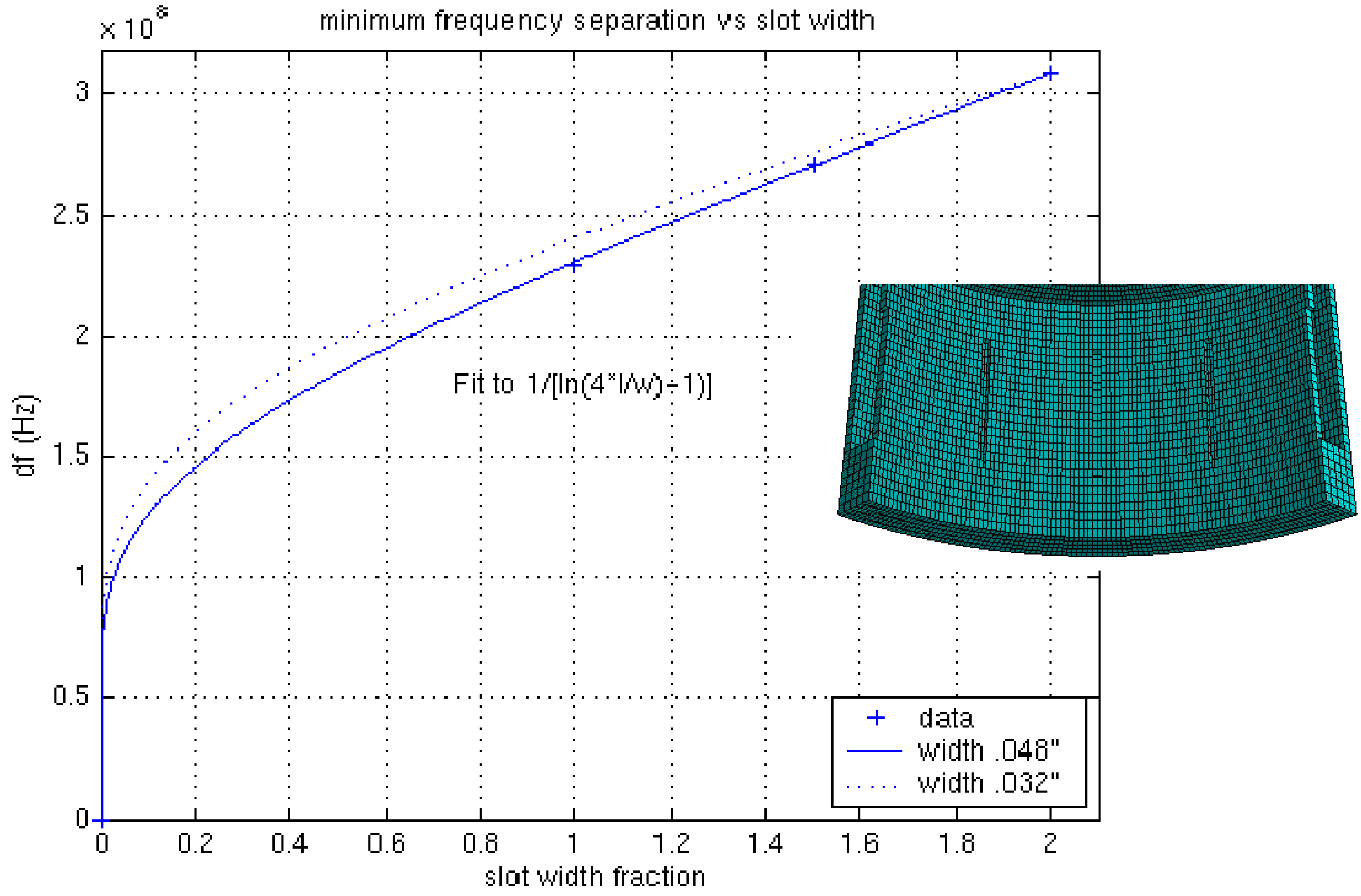


Dipole electric field



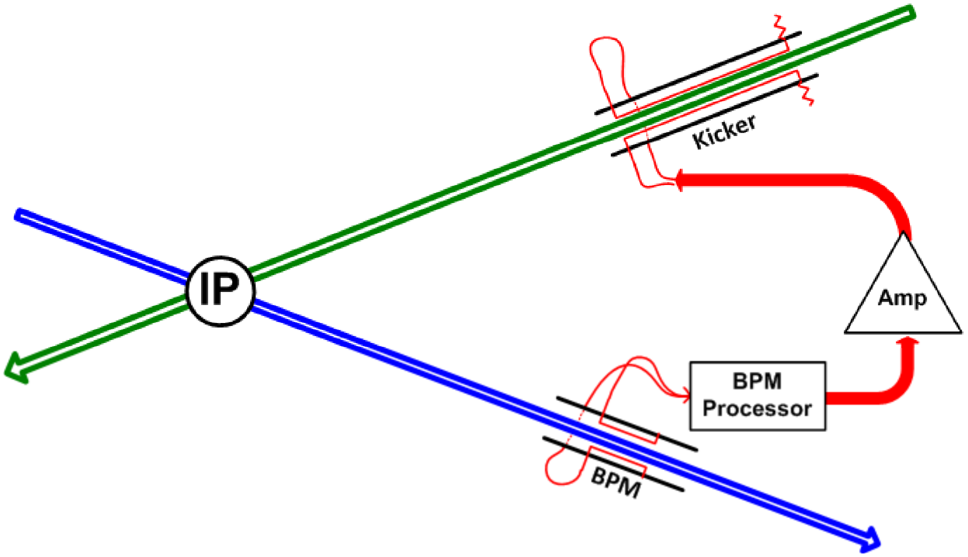
Quadrupole electric field

Coupling through the fingers



Following analysis

- May be by increasing the radius we will solve the bellow's problem, however
- To study modes inside a bellows cavity we need to know the exact geometry.
- The coupling through the shielded fingers depends mainly upon the number of fingers and the length of fingers.
- The modes, which can go through the fingers, may be excited by a beam at some vacuum chamber irregularities like it was in PEP-II vertex bellows.



- Block diagram of feedback system. The deflection of the outgoing beam (blue) leaving the IP is measured in the BPM. Signal flow is in red. The kicker steers the incoming beam (green) into collision at the IP.

SLAC strip-line BPMs

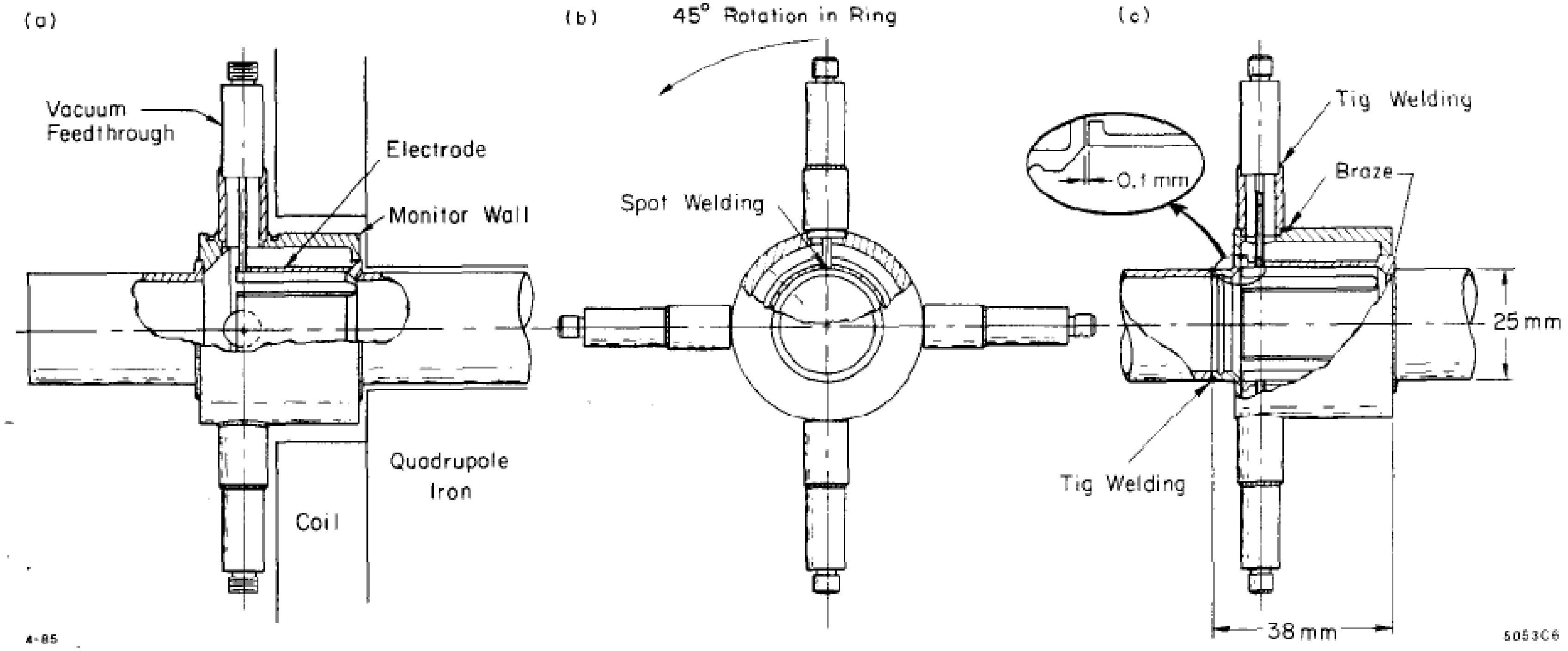
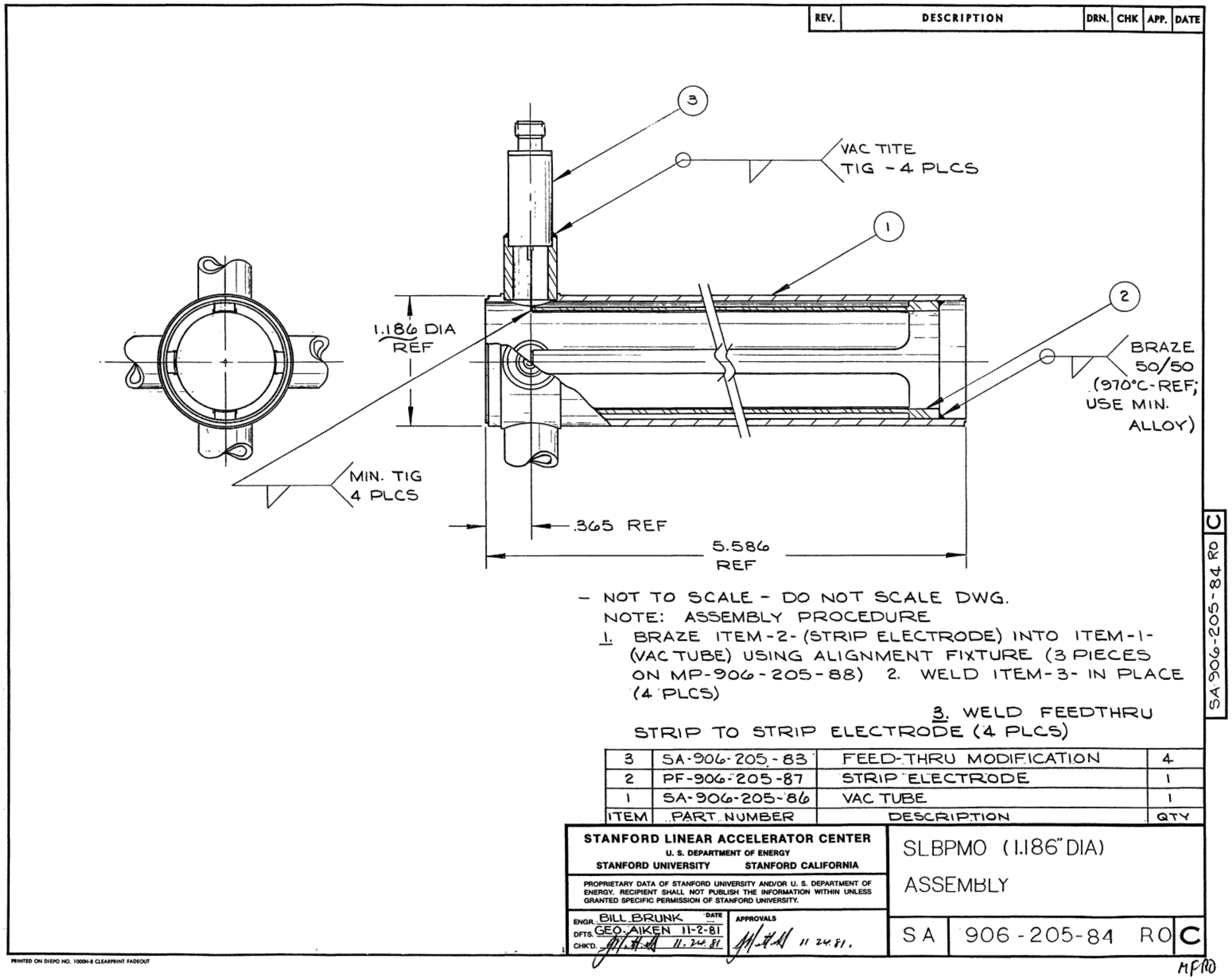


Fig. 5. Beam position monitor configurations: a) for beam transfer lines, b) general end view, and c) for the ring.

SLAC drawings



– NOT TO SCALE – DO NOT SCALE DWG.

NOTE: ASSEMBLY PROCEDURE

1. BRAZE ITEM-2-(STRIP ELECTRODE) INTO ITEM-1-(VAC TUBE) USING ALIGNMENT FIXTURE (3 PIECES ON MP-906-205-88) 2. WELD ITEM-3- IN PLACE (4 PLCS)

3. WELD FEEDTHRU STRIP TO STRIP ELECTRODE (4 PLCS)

ITEM	PART NUMBER	DESCRIPTION	QTY
3	SA-906-205-83	FEED-THRU MODIFICATION	4
2	PF-906-205-87	STRIP ELECTRODE	1
1	SA-906-205-86	VAC TUBE	1

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U. S. DEPARTMENT OF ENERGY
STANFORD UNIVERSITY STANFORD CALIFORNIA

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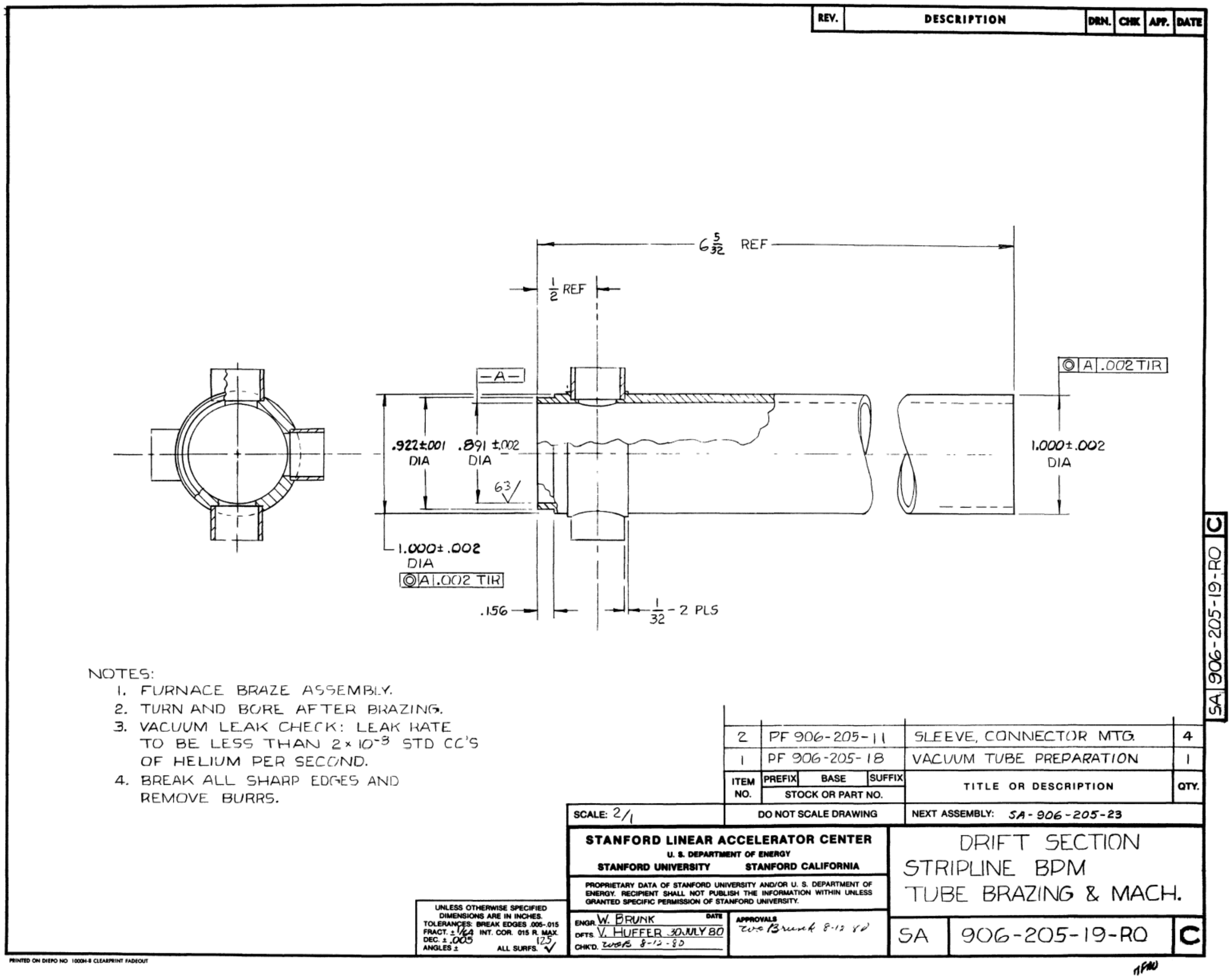
ENGR. BILL BRUNK DATE
DFTS. GEO. AIKEN 11-2-81
CHK'D. 11. 24. 81
APPROVALS 11 24. 81.

SLBPMO (1.186" DIA)
ASSEMBLY

SA 906-205-84 RO C

SLAC drawings



NOTES:

1. FURNACE BRAZE ASSEMBLY.
2. TURN AND BORE AFTER BRAZING.
3. VACUUM LEAK CHECK: LEAK RATE TO BE LESS THAN 2×10^{-8} STD CC'S OF HELIUM PER SECOND.
4. BREAK ALL SHARP EDGES AND REMOVE BURRS.

ITEM NO.	STOCK OR PART NO. (PREFIX / BASE / SUFFIX)	TITLE OR DESCRIPTION	QTY.
2	PF 906-205-11	SLEEVE, CONNECTOR MTG.	4
1	PF 906-205-18	VACUUM TUBE PREPARATION	1

SCALE: 2/1
DO NOT SCALE DRAWING
NEXT ASSEMBLY: SA-906-205-23

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DRIFT SECTION
STRIPLINE BPM
TUBE BRAZING & MACH.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
TOLERANCES: BREAK EDGES .005-.015
FRACT. ± 1/64 INT. COR. .015 R. MAX.
DEC. ± .005
ANGLES ± ALL SURFS. 125 ✓

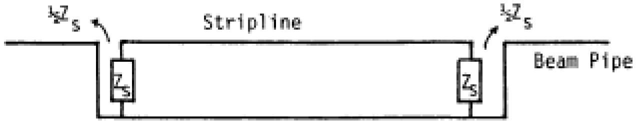
ENGR. W. BRUNK
DFTS. V. HUFFER 30 JULY 80
CHK'D. WWB 8-12-80
APPROVALS
W Brunk 8-12-80

SA 906-205-19-RO C

PRINTED ON DIEPO NO 1000H-8 CLEARPRINT FADEOUT

IMPEDANCES OF STRIP-LINE BEAM-POSITION MONITORS

KING-YUEN NG



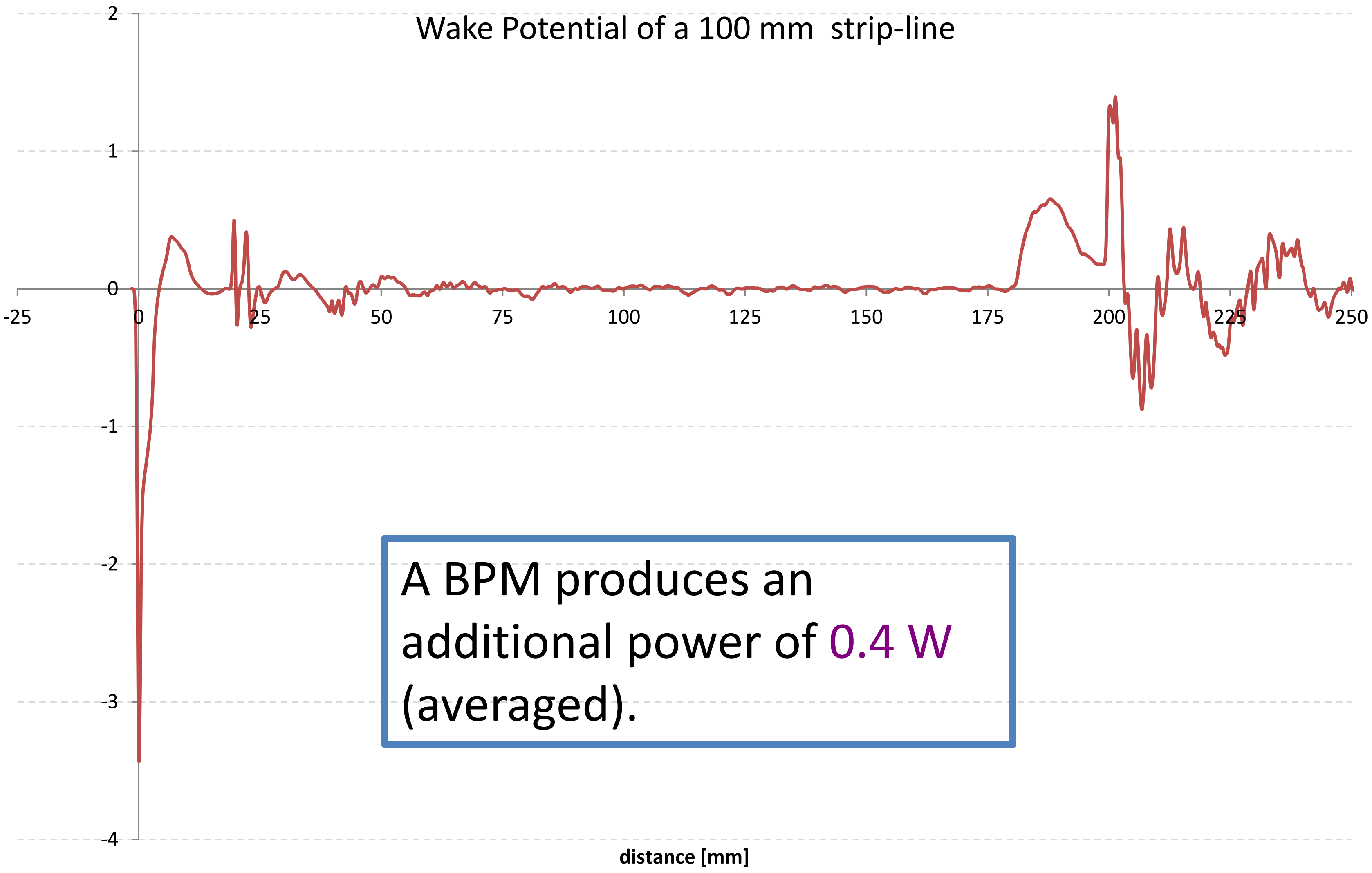
$$V_u(t) = \frac{Z_s}{2}\left(\frac{\phi_0}{2\pi}\right)\left[I(t) - I\left(t - \frac{l}{\beta_p c} - \frac{l}{\beta_s c}\right)\right],$$

$$V_d(t) = \frac{Z_s}{2}\left(\frac{\phi_0}{2\pi}\right)\left[I\left(t - \frac{l}{\beta_s c}\right) - I\left(t - \frac{l}{\beta_p c}\right)\right].$$

$$(Z_\parallel)_{\mathrm{BPM}} = Z_s\left(\frac{\phi_0}{2\pi}\right)^2\left(\sin^2\frac{\omega l}{c} + j\sin\frac{\omega l}{c}\cos\frac{\omega l}{c}\right).$$

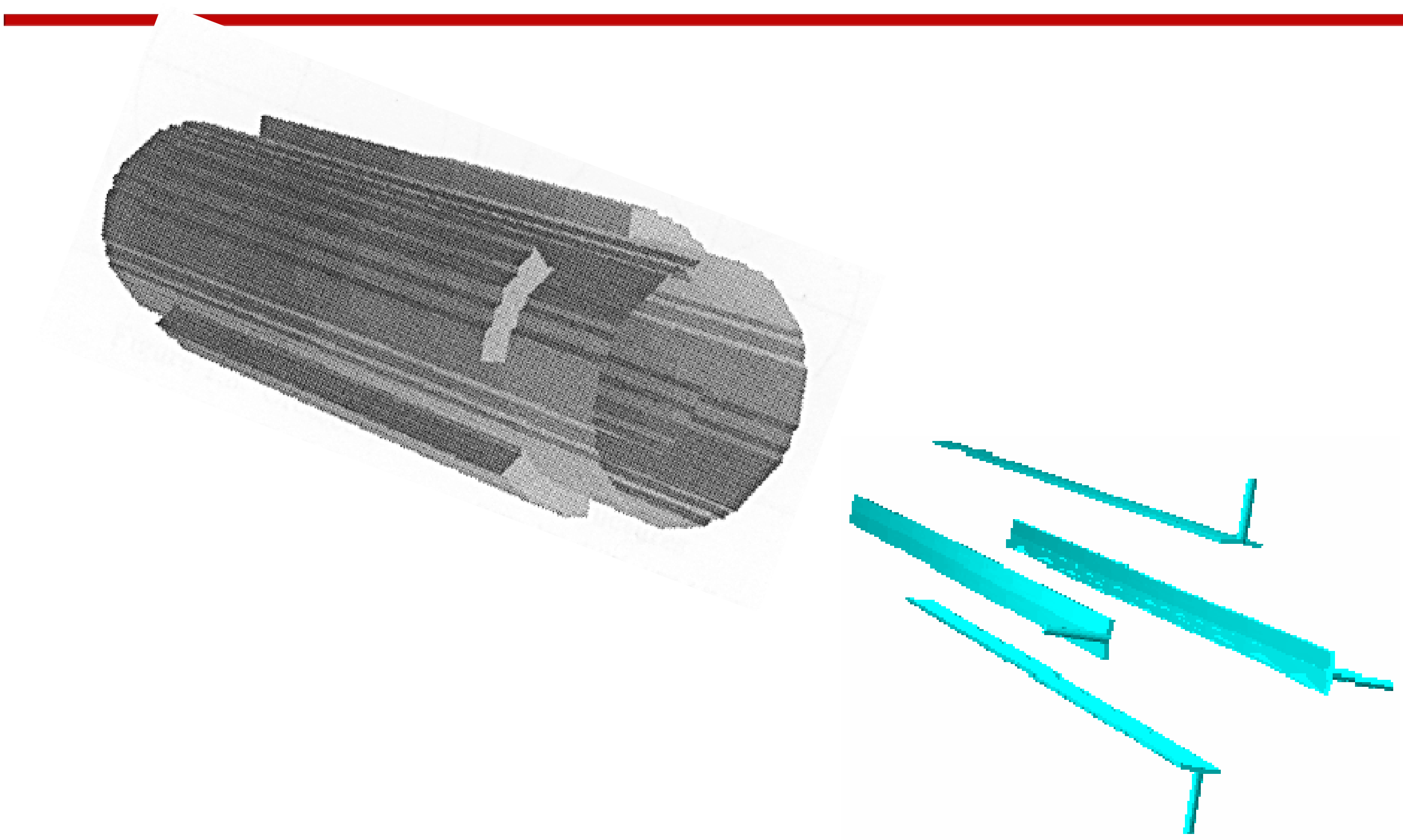
$$(Z_\perp)_{\mathrm{BPM}} = \frac{c}{b^2}\left(\frac{4}{\phi_0}\right)^2\left(\sin^2\frac{\phi_0}{2}\right)\left[\frac{(Z_\parallel)_{\mathrm{BPM}}}{\omega}\right]$$

Strip-line BPM Loss factor=2.6133[V/pC]

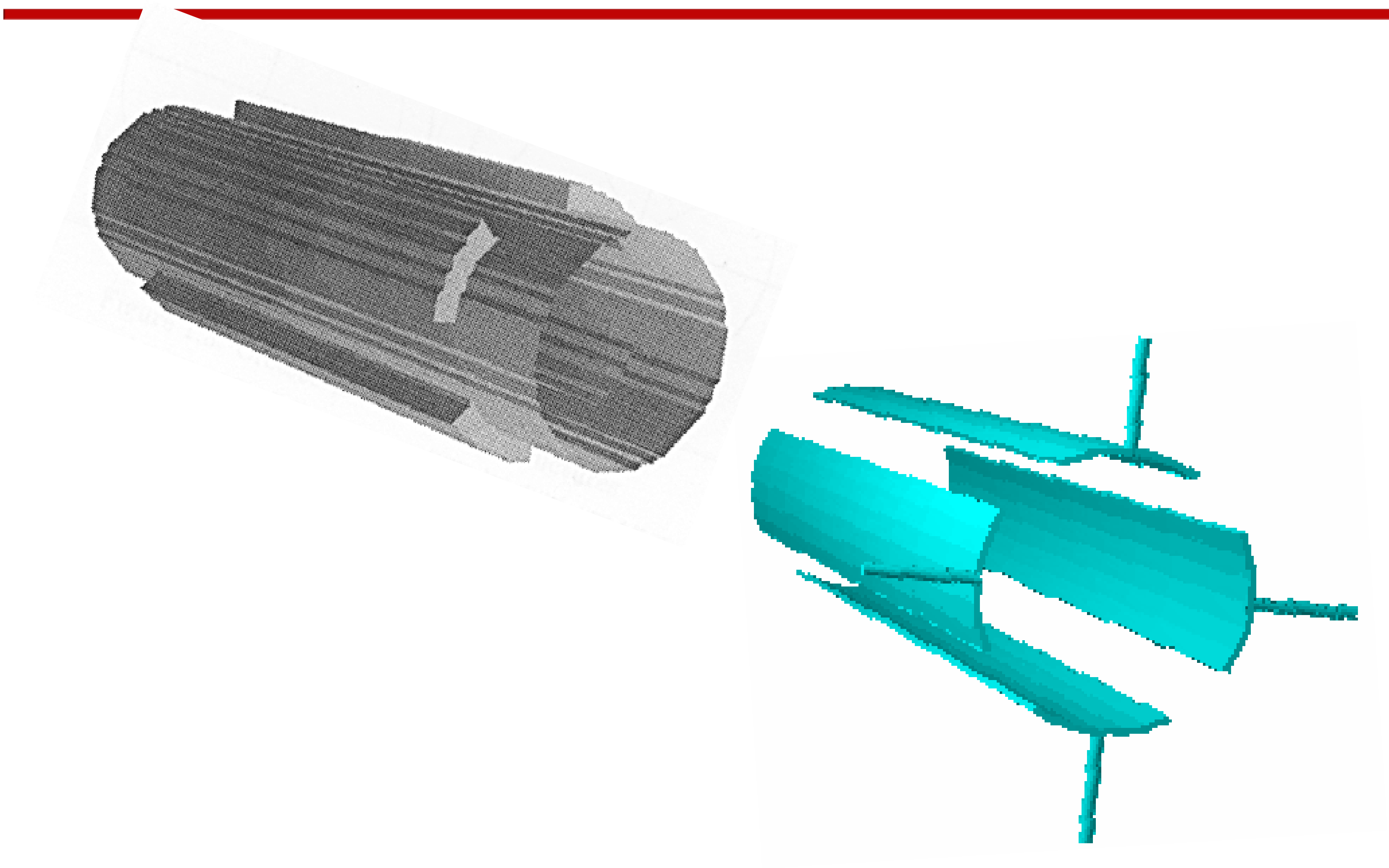


A BPM produces an additional power of 0.4 W (averaged).

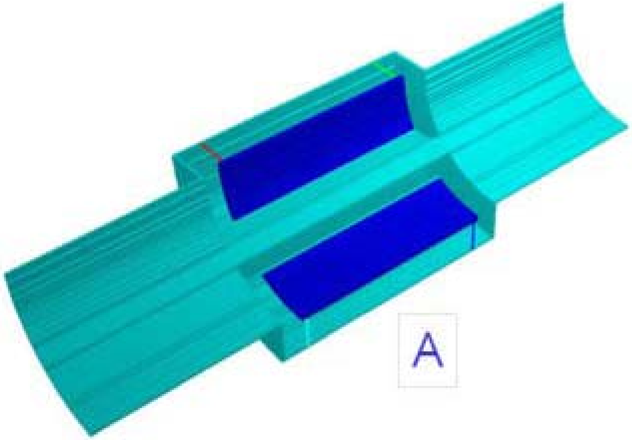
Strip-line kicker

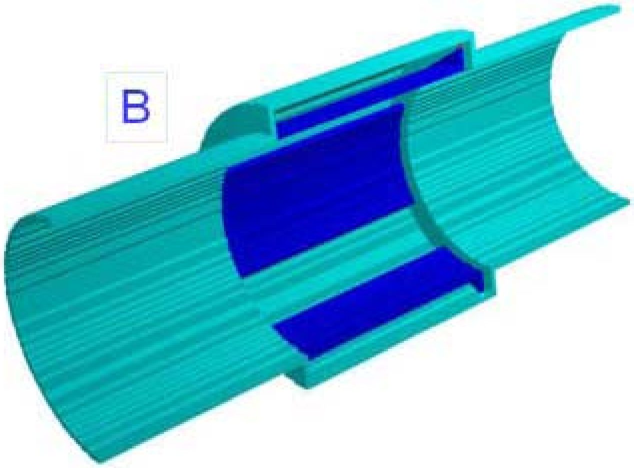


Strip-line kicker



MAFIA models





Summary

- The amount of beam energy loss in IR is almost equal to the energy loss in one accelerating cryo-module.
- Additional energy spread accumulated in the IR is very small.
- Spectrum of the wake fields is limited to 300 GHz
- Average power of the wake fields excited in IR is around 30 W for nominal parameters (6 kW pulsed)
- In the QD0 region the additional losses are of 4W (averaged) . BPMs and kickers must be added.