Calculation of IR chamber wakefields

Sep. 04, 07

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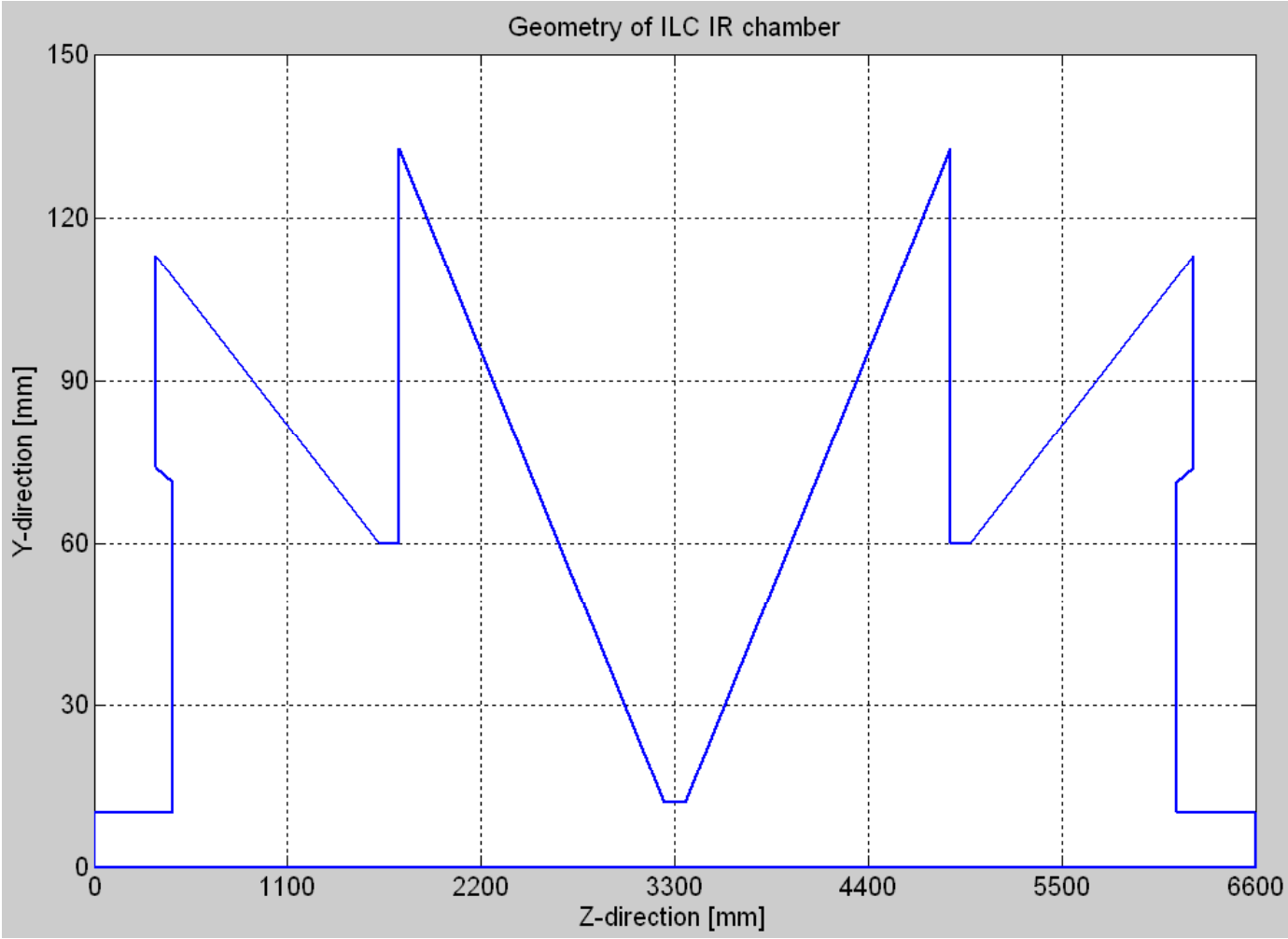
ILC BDS Meeting, 15 May 2007.
http://ilcagenda.linearcollider.org/getFile.py/access?contribId=0&resId=1&materialId=slides&confId=1598



Analytical:
axisymmetric

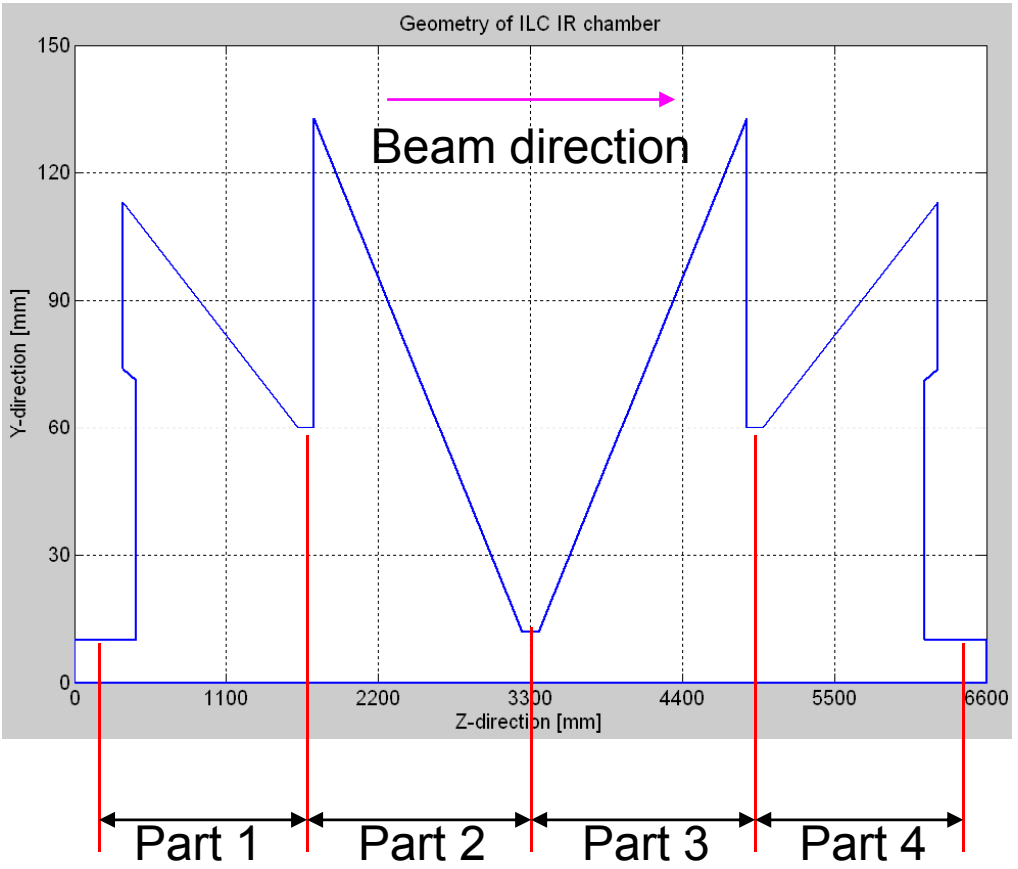
ABCI:
2-D axisymmetric
dummy boundaries

MAFIA:
2D axisymmetric
open boundaries

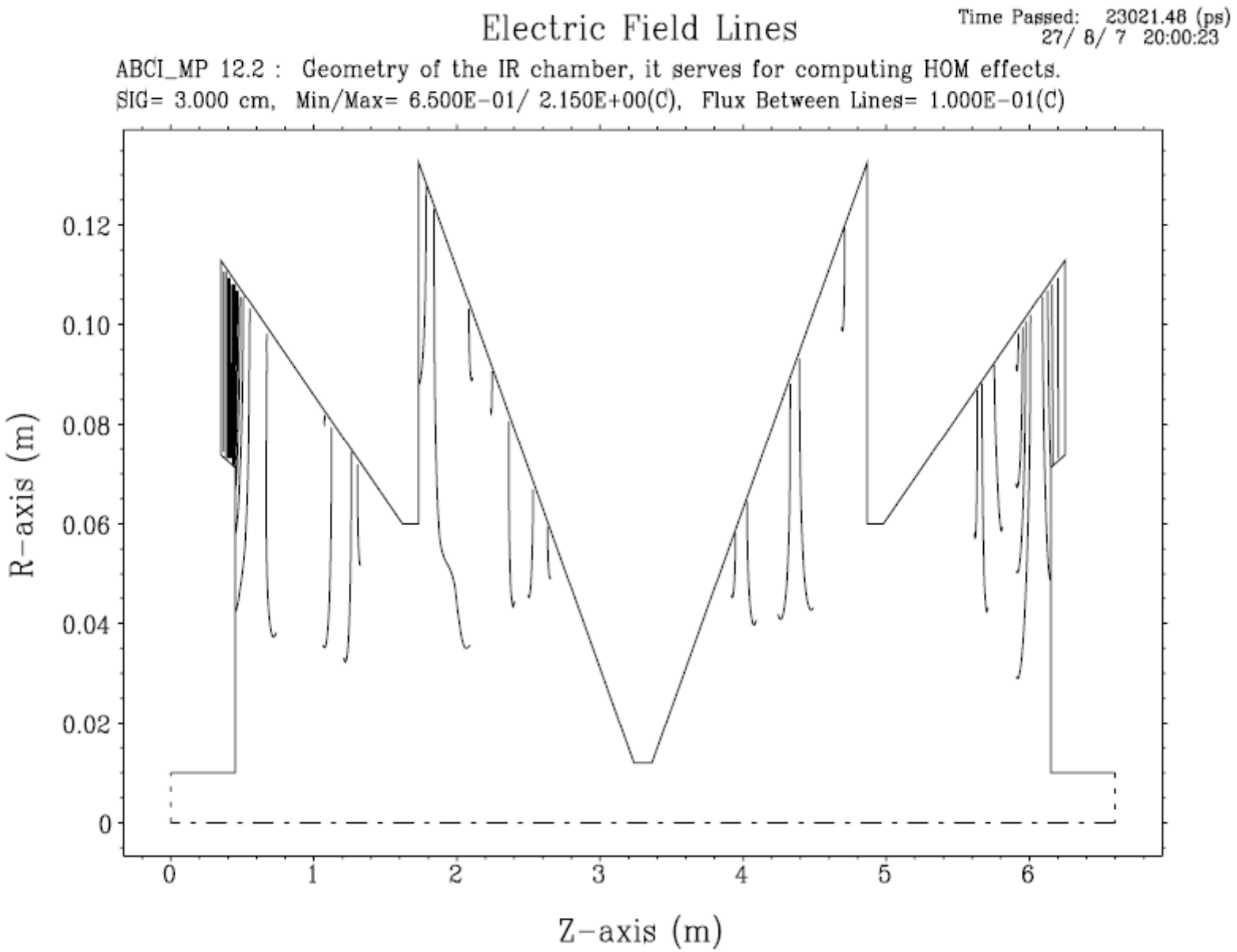
GDFIDL:
3-D axisymmetric
electric boundaries

Analytical estimation

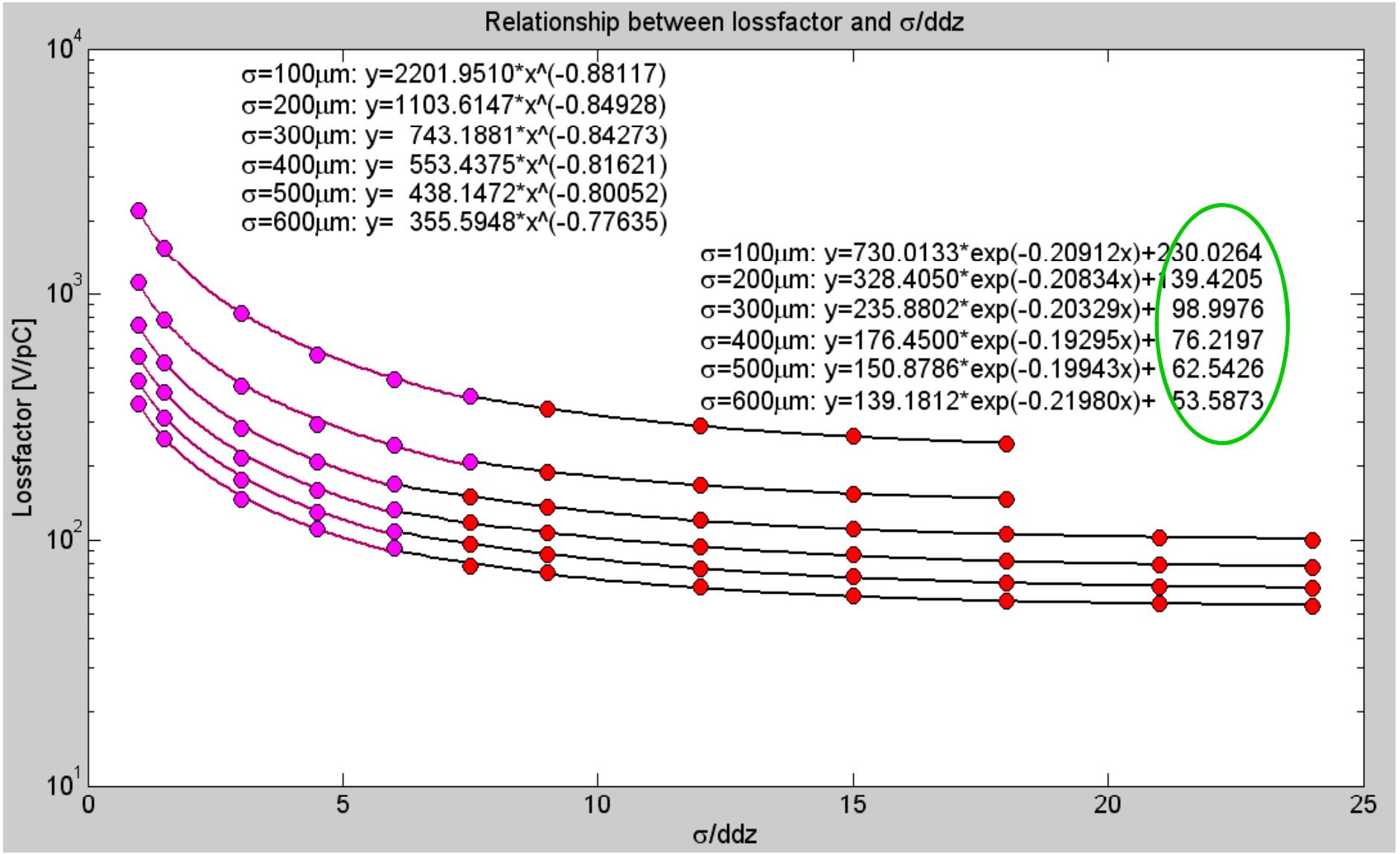
1) Part 1 and Part 3 can be looked as two shallow cavities ($r_{out}>r_{in}$). (Handbook of Accelerator Physics and Engineering, p231)
2) Part 2 and Part 4 can use the relation between diffraction impedance formulae and optical approximation impedance formulae to estimate. (PRST, 10, 054401, 2007)

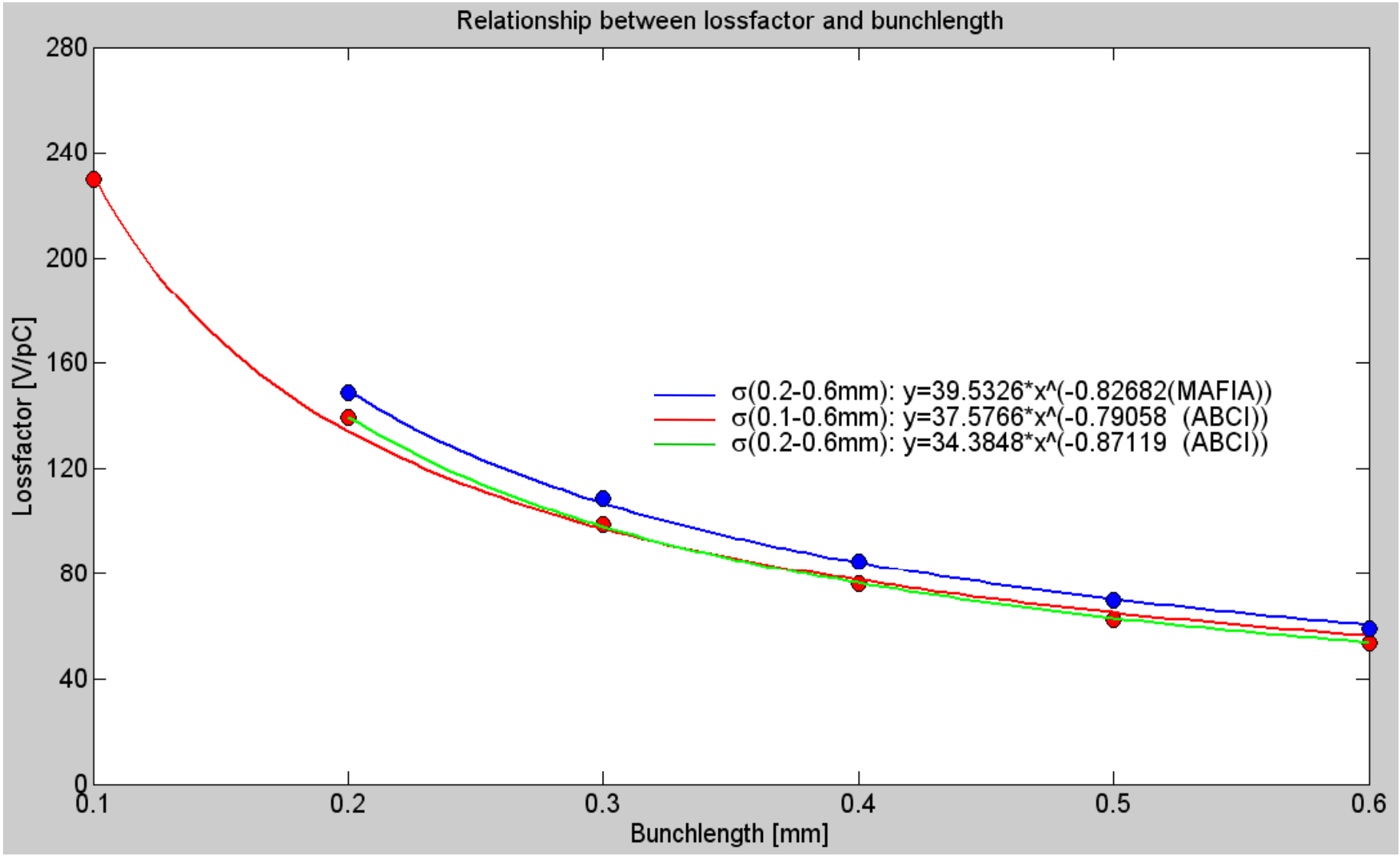


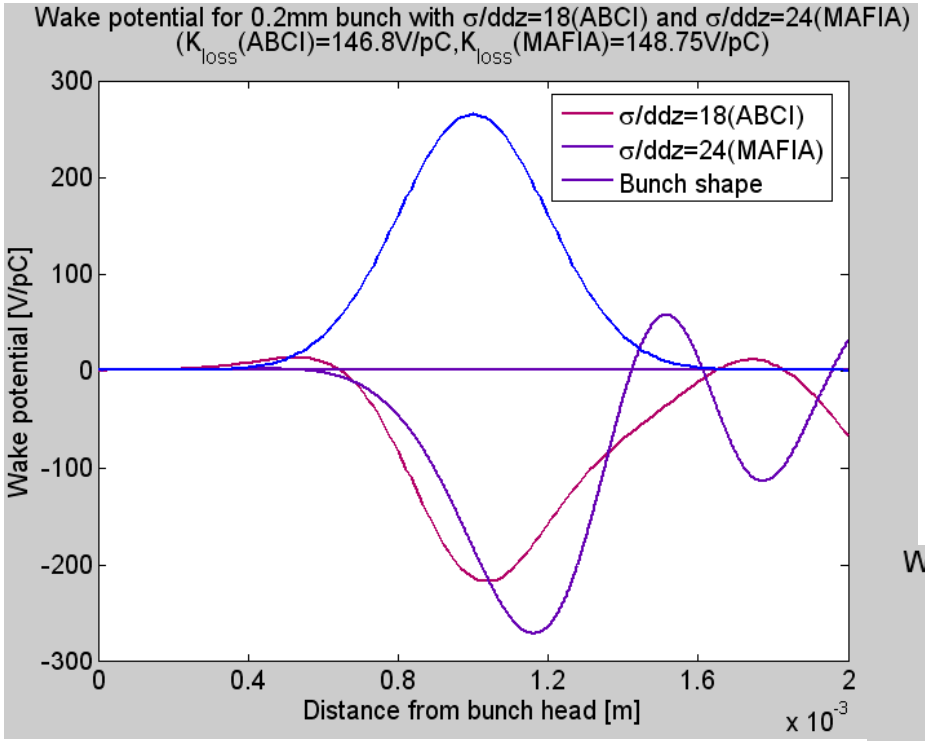
1) The total impedance is estimated to be $4Z_0/\pi$, while loss factor is $2Z_0c/(\pi^{3/2}\sigma)$.
2) For σ=0.6mm, 0.5mm, 0.4mm, 0.3mm, 0.2mm and 0.1mm, the loss factors will be 67.76V/pC, 81.31V/pC, 101.63V/pV, 135.51V/pC, 203.27V/pC and 406.54V/pC.

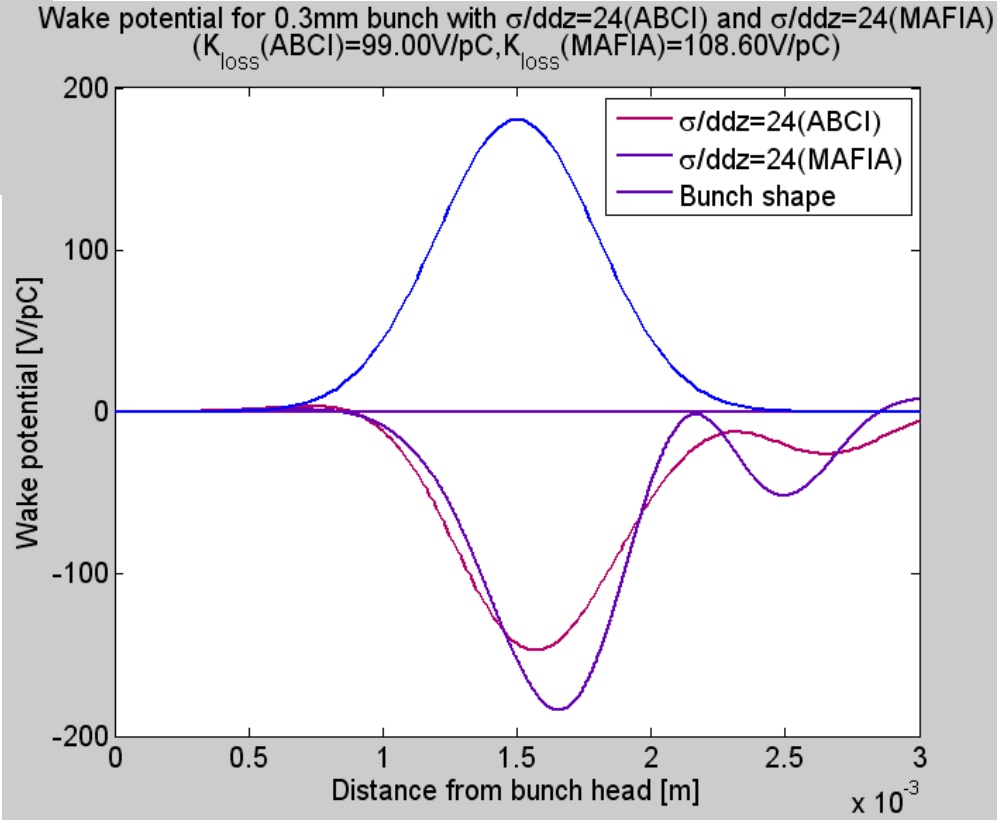

Electric Field Lines
Time Passed: 23021.48 (ps)
27/ 8/ 7 20:00:23
ABCI_MP 12.2 : Geometry of the IR chamber, it serves for computing HOM effects.
SIG= 3.000 cm, Min/Max= 6.500E-01/ 2.150E+00(C), Flux Between Lines= 1.000E-01(C)
R-axis (m)
0.12
0.10
0.08
0.06
0.04
0.02
0
0
1
2
3
4
5
6
Z-axis (m)

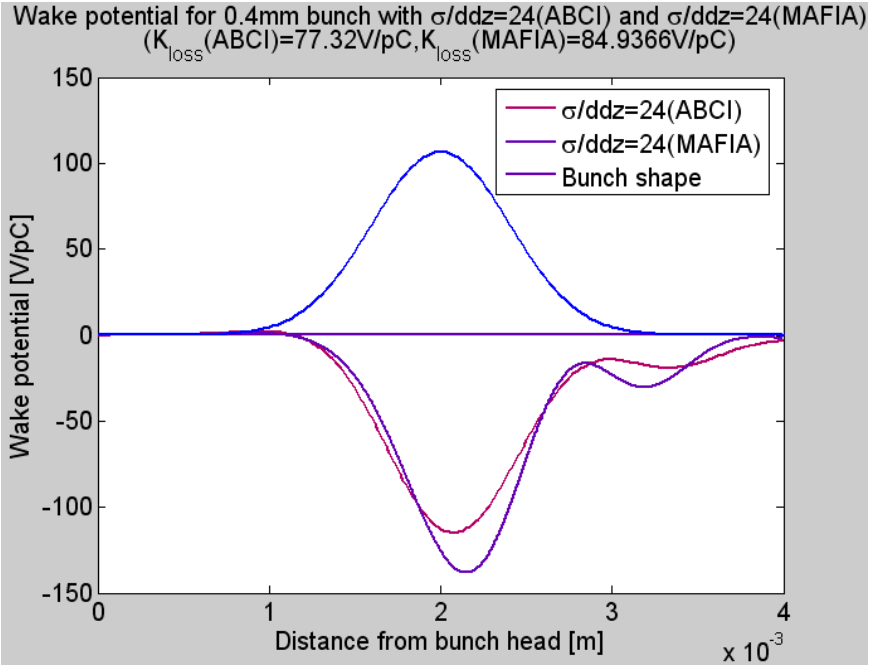
ABCI simulation result

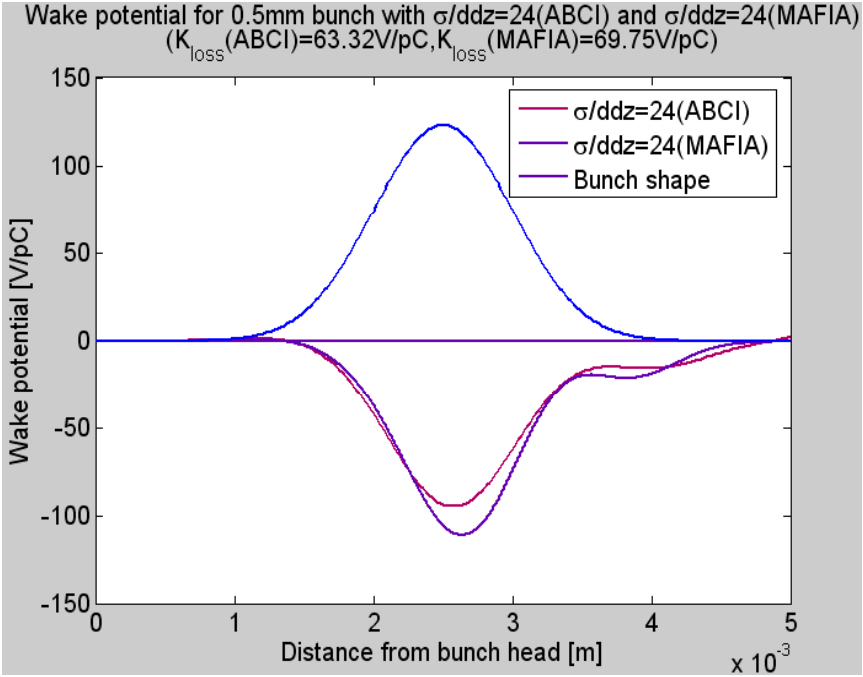


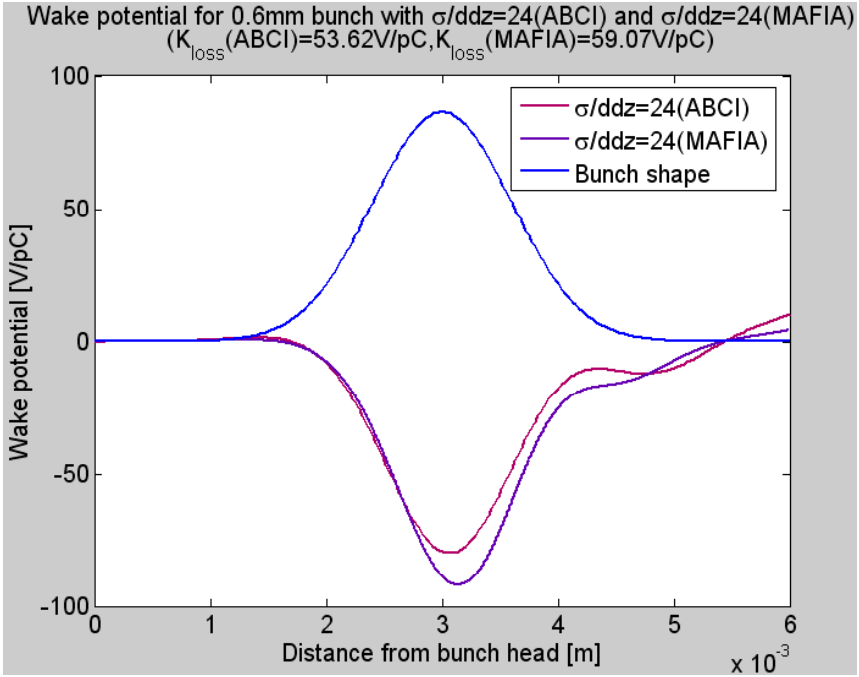

Relationship between lossfactor and bunchlength
Lossfactor [V/pC]
Bunchlength [mm]
0
40
80
120
160
200
240
280
0.1
0.2
0.3
0.4
0.5
0.6
σ(0.2-0.6mm): y=39.5326*x^(-0.82682(MAFIA))
σ(0.1-0.6mm): y=37.5766*x^(-0.79058 (ABCI))
σ(0.2-0.6mm): y=34.3848*x^(-0.87119 (ABCI))

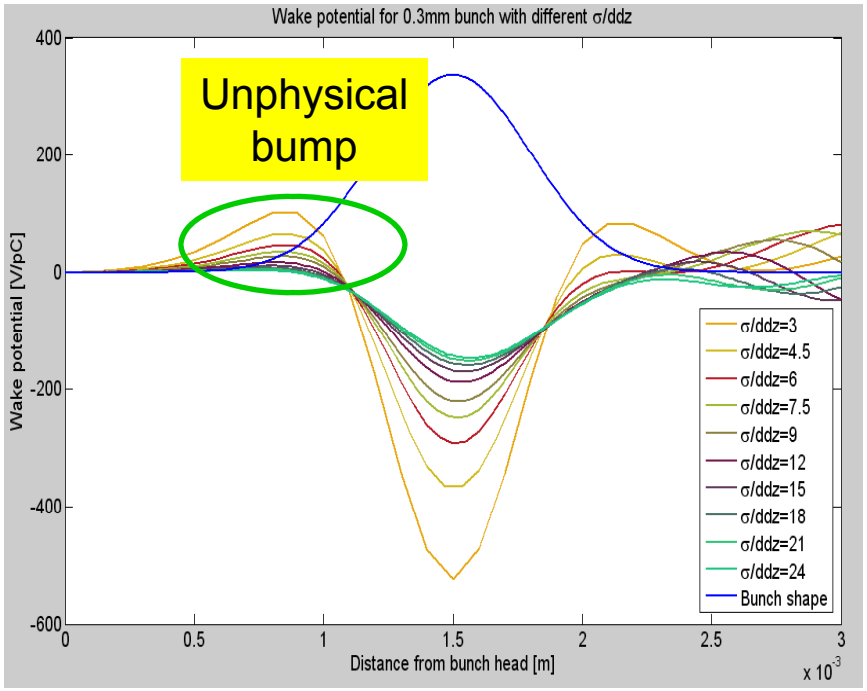

Wake potential for 0.2mm bunch with σ/ddz=18(ABCI) and σ/ddz=24(MAFIA)
(K_loss(ABCI)=146.8V/pC,K_loss(MAFIA)=148.75V/pC)
σ/ddz=18(ABCI)
σ/ddz=24(MAFIA)
Bunch shape
Wake potential [V/pC]
Distance from bunch head [m]
x 10^-3
300
200
100
0
-100
-200
-300
0
0.4
0.8
1.2
1.6
2

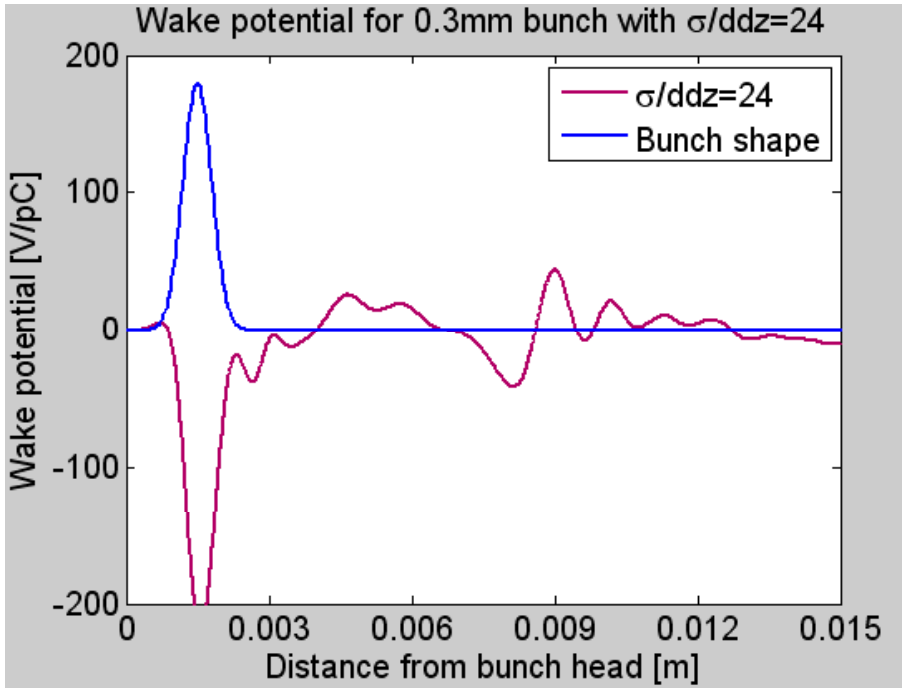

Wake potential for 0.3mm bunch with σ/ddz=24(ABCI) and σ/ddz=24(MAFIA)
(K_loss(ABCI)=99.00V/pC,K_loss(MAFIA)=108.60V/pC)
σ/ddz=24(ABCI)
σ/ddz=24(MAFIA)
Bunch shape
Wake potential [V/pC]
Distance from bunch head [m]
x 10^-3
200
100
0
-100
-200
0
0.5
1
1.5
2
2.5
3

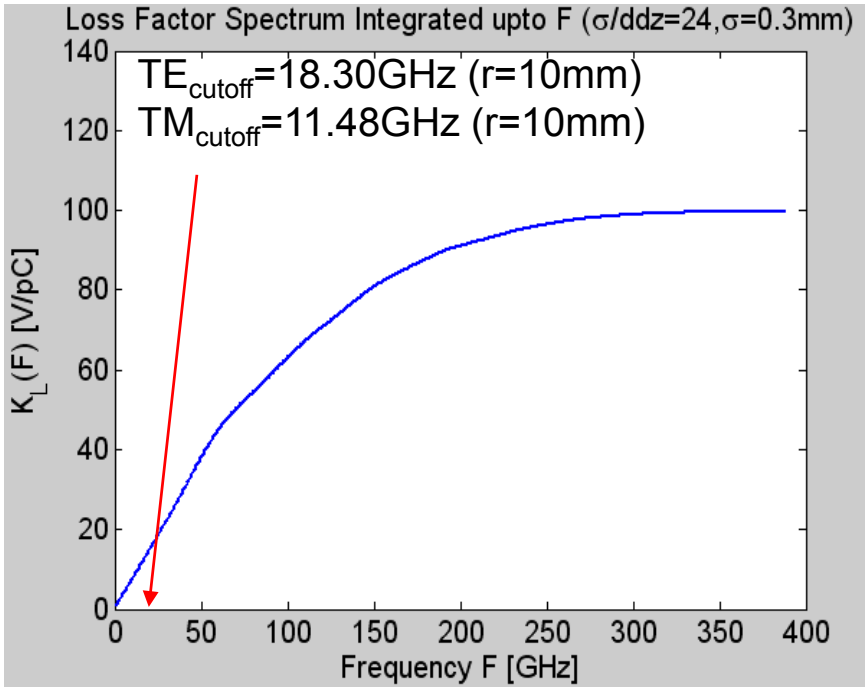

Wake potential for 0.4mm bunch with σ/ddz=24(ABCI) and σ/ddz=24(MAFIA)
(K_loss(ABCI)=77.32V/pC,K_loss(MAFIA)=84.9366V/pC)
σ/ddz=24(ABCI)
σ/ddz=24(MAFIA)
Bunch shape
Wake potential [V/pC]
Distance from bunch head [m]
x 10^-3

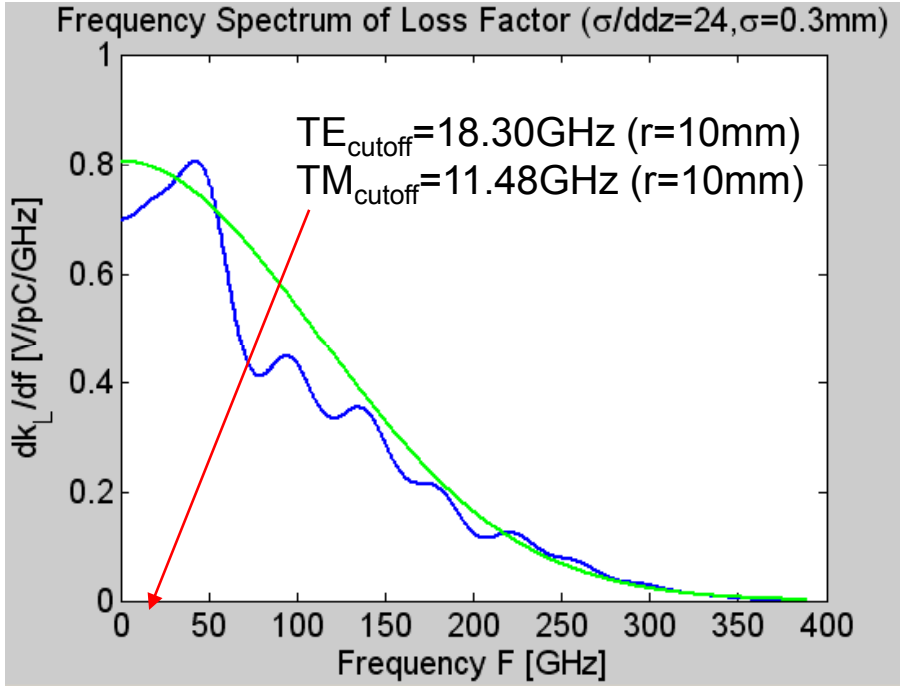

Wake potential for 0.5mm bunch with σ/ddz=24(ABCI) and σ/ddz=24(MAFIA)
(K_loss(ABCI)=63.32V/pC,K_loss(MAFIA)=69.75V/pC)
σ/ddz=24(ABCI)
σ/ddz=24(MAFIA)
Bunch shape
Wake potential [V/pC]
Distance from bunch head [m]
x 10^-3


Wake potential for 0.6mm bunch with σ/ddz=24(ABCI) and σ/ddz=24(MAFIA)
(K_loss(ABCI)=53.62V/pC,K_loss(MAFIA)=59.07V/pC)
σ/ddz=24(ABCI)
σ/ddz=24(MAFIA)
Bunch shape
Wake potential [V/pC]
Distance from bunch head [m]
x 10^-3


Wake potential for 0.3mm bunch with different σ/ddz
Unphysical bump
Wake potential [V/pC]
Distance from bunch head [m]
x 10^-3
σ/ddz=3
σ/ddz=4.5
σ/ddz=6
σ/ddz=7.5
σ/ddz=9
σ/ddz=12
σ/ddz=15
σ/ddz=18
σ/ddz=21
σ/ddz=24
Bunch shape


Wake potential for 0.3mm bunch with σ/ddz=24
σ/ddz=24
Bunch shape
Wake potential [V/pC]
Distance from bunch head [m]


Loss Factor Spectrum Integrated upto F (σ/ddz=24,σ=0.3mm)
TE_cutoff=18.30GHz (r=10mm)
TM_cutoff=11.48GHz (r=10mm)
K_L (F) [V/pC]
Frequency F [GHz]


Frequency Spectrum of Loss Factor (σ/ddz=24,σ=0.3mm)
TE_cutoff=18.30GHz (r=10mm)
TM_cutoff=11.48GHz (r=10mm)
dk_L /df [V/pC/GHz]
Frequency F [GHz]

Summary of analytical estimation, ABCI & MAFIA simulation

Incoherent Power

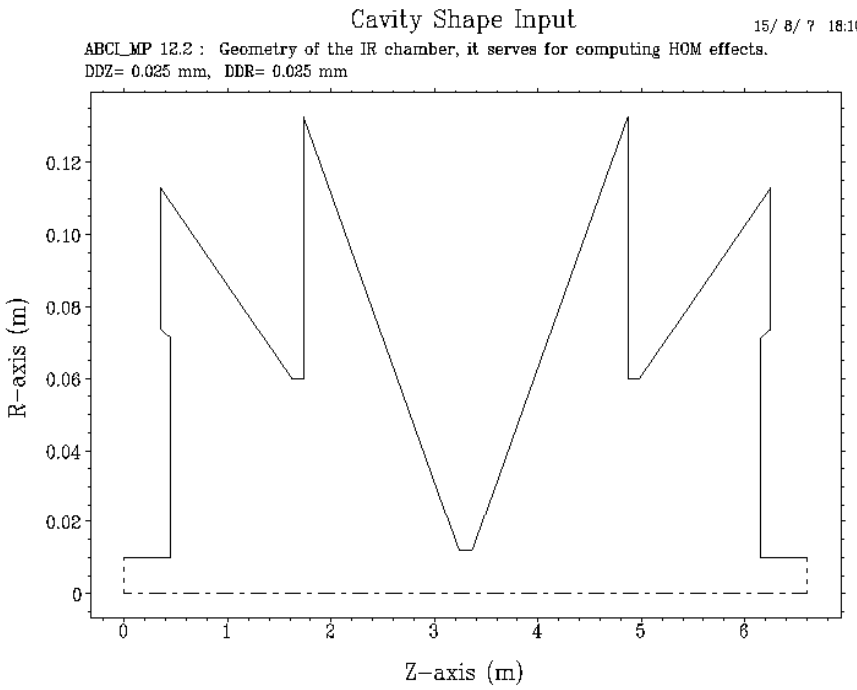
$$P = k\tau_b \left\{ (I_{e^+})^2 + (I_{e^-})^2 \right\}$$

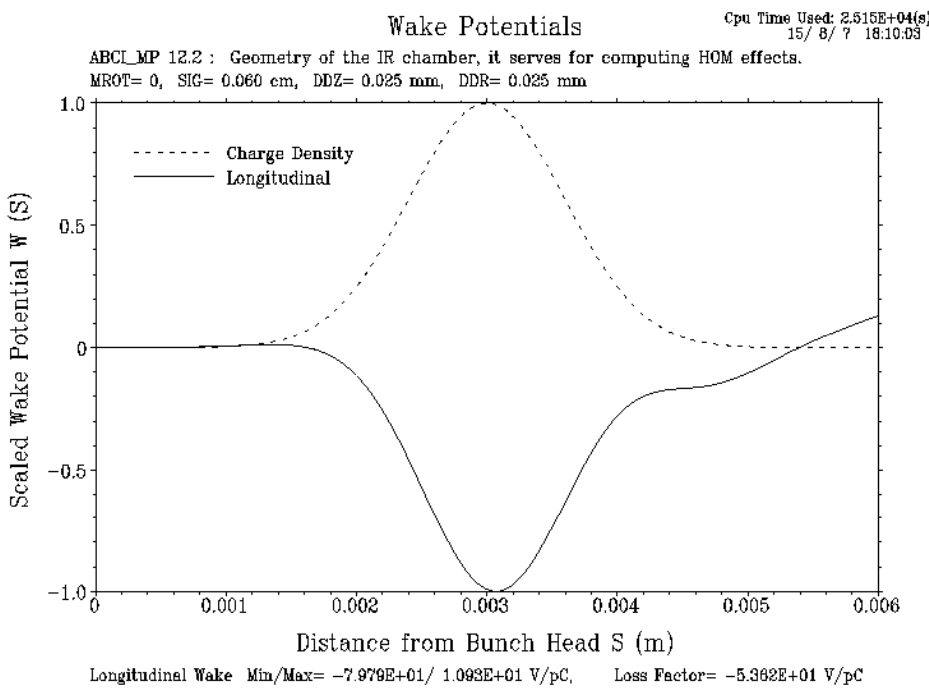
Bunch length	Loss factor (Analytical)	Loss factor (MAFIA)	Loss factor (ABCI)	*Power loss (pulse)	*Power loss (average)	*Power left in the chamber
0.6mm	67.76	59.07	53.59	2.97kW	7.20W	~20%
0.5mm	81.31	69.75	62.54	3.47kW	8.40W	~16%
0.4mm	101.63	84.94	76.22	4.23kW	10.24W	~12%
0.3mm	135.51	108.60	99.00	5.48kW	13.29W	~9%
**0.2mm	203.27	148.75	139.42	7.72kW	18.73W	~6%
**0.1mm	406.54	~19 days' cal.	230.03	12.55kW	30.43W	~3%

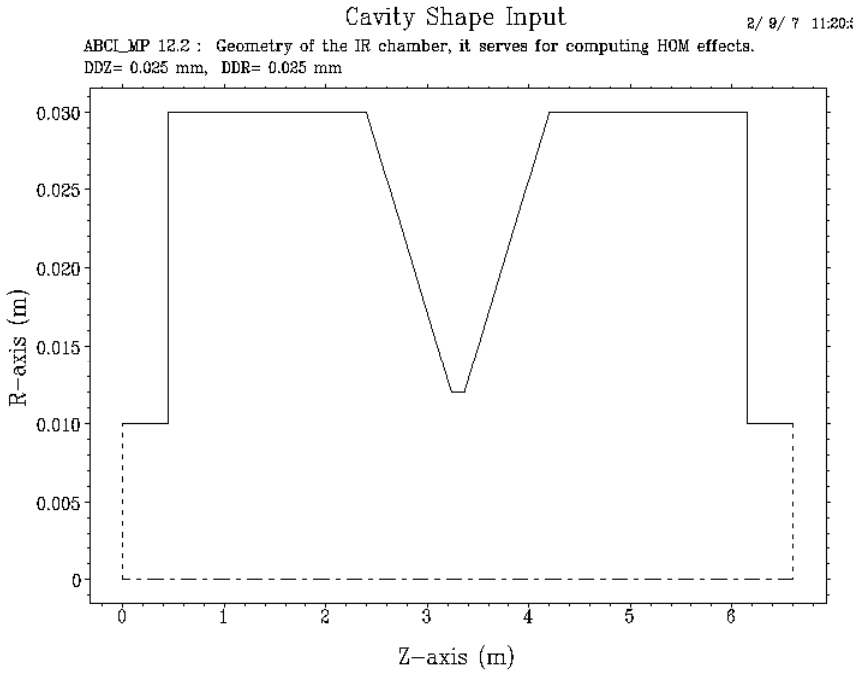
*For nominal ILC beam parameters with bunch interval of 369ns and bunch population of 2*10^10, calculated from ABCI result.
**Simulation result's accuracy is limited due the limited mesh number.

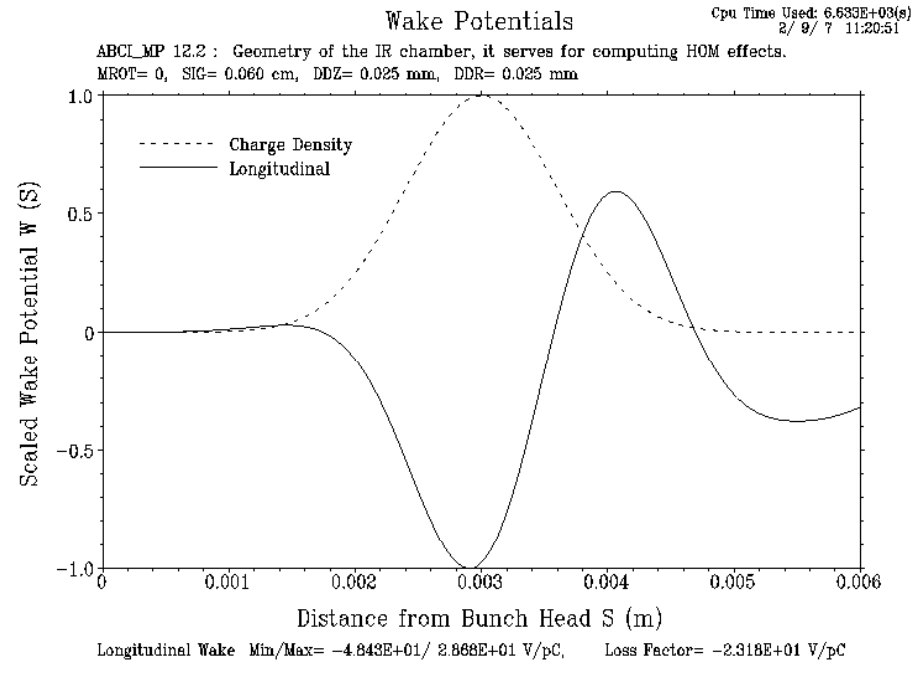
Next plan

- 3-D simulation (including both axisymmetric and nonaxisymmetric cases) with parallel version GDFIDL (in progress, hard).
- Power attenuation analysis along the beam pipe with MAFIA (in progress).
- Trapped modes analysis in the chamber with Analyst, MAFIA or GDFIDL (to be started).
- Analysis including the other components, such as bellows, BPMs, etc.
- Power absorber studies, etc.


Cavity Shape Input
15/ 8/ 7 18:10:03
ABCI_MP 12.2 : Geometry of the IR chamber, it serves for computing HOM effects.
DDZ= 0.025 mm, DDR= 0.025 mm
R-axis (m)
Z-axis (m)


Wake Potentials
Cpu Time Used: 2.515E+04(s)
15/ 8/ 7 18:10:03
ABCI_MP 12.2 : Geometry of the IR chamber, it serves for computing HOM effects.
MROT= 0, SIG= 0.060 cm, DDZ= 0.025 mm, DDR= 0.025 mm
Charge Density
Longitudinal
Scaled Wake Potential W (S)
Distance from Bunch Head S (m)
Longitudinal Wake Min/Max= -7.979E+01/ 1.093E+01 V/pC, Loss Factor= -5.362E+01 V/pC

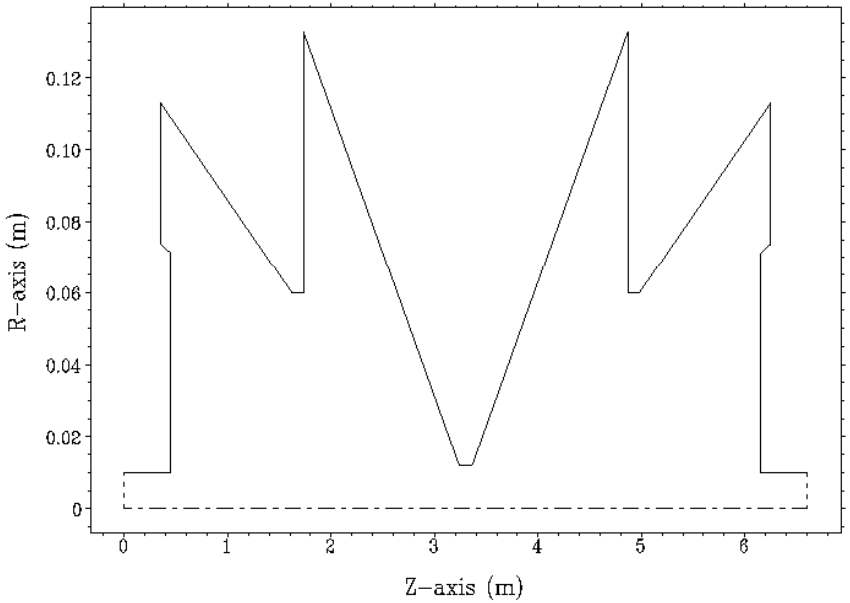

Cavity Shape Input
2/ 9/ 7 11:20:51
ABCI_MP 12.2 : Geometry of the IR chamber, it serves for computing HOM effects.
DDZ= 0.025 mm, DDR= 0.025 mm
R-axis (m)
Z-axis (m)


Wake Potentials
Cpu Time Used: 6.633E+03(s)
2/ 9/ 7 11:20:51
ABCI_MP 12.2 : Geometry of the IR chamber, it serves for computing HOM effects.
MROT= 0, SIG= 0.060 cm, DDZ= 0.025 mm, DDR= 0.025 mm
Charge Density
Longitudinal
Scaled Wake Potential W (S)
Distance from Bunch Head S (m)
Longitudinal Wake Min/Max= -4.843E+01/ 2.868E+01 V/pC, Loss Factor= -2.318E+01 V/pC

Cavity Shape Input

15/ 8/ 7 18:10:03

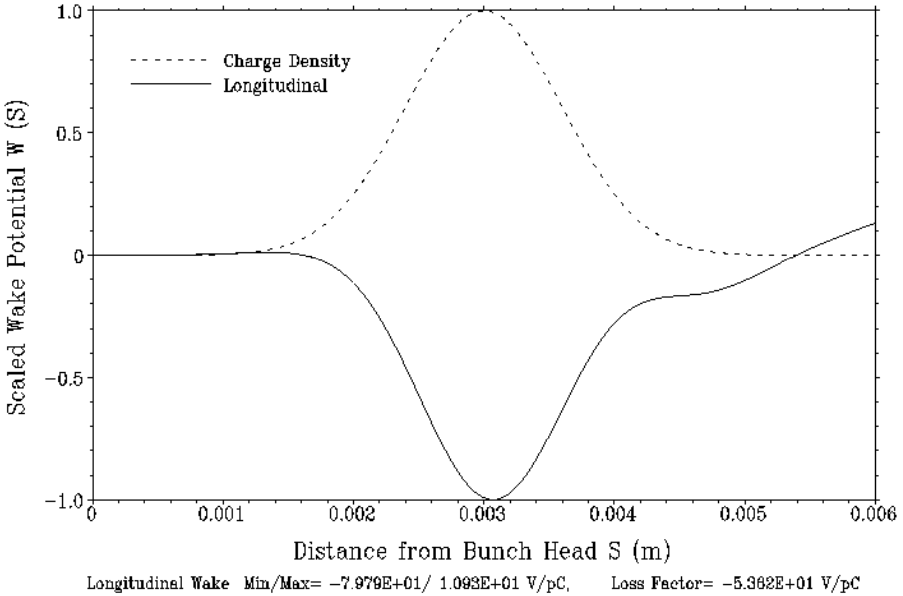
ABCI_MP 12.2 : Geometry of the IR chamber, it serves for computing HOM effects.
DDZ= 0.025 mm, DDR= 0.025 mm



Wake Potentials

Cpu Time Used: 2.515E+04(s)
15/ 8/ 7 18:10:03

ABCI_MP 12.2 : Geometry of the IR chamber, it serves for computing HOM effects.
MROT= 0, SIG= 0.060 cm, DDZ= 0.025 mm, DDR= 0.025 mm

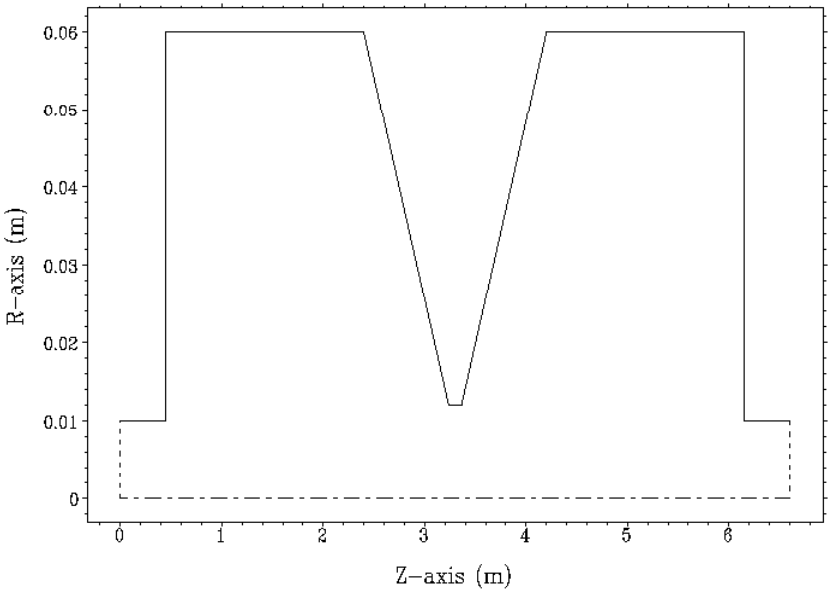


Longitudinal Wake Min/Max= -7.979E+01/ 1.093E+01 V/pC, Loss Factor= -5.362E+01 V/pC

Cavity Shape Input

1/ 9/ 7 23:10:28

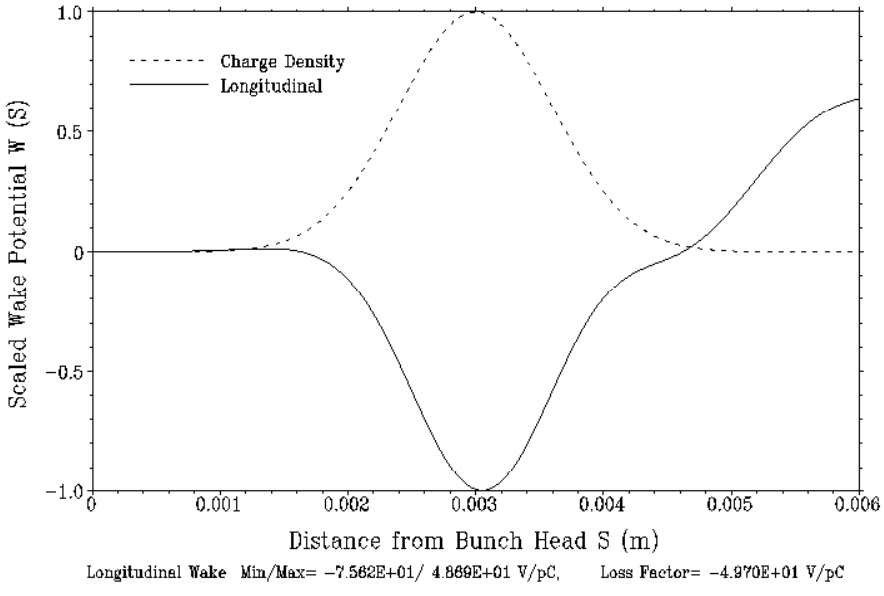
ABCI_MP 12.2 : Geometry of the IR chamber, it serves for computing HOM effects.
DDZ= 0.025 mm, DDR= 0.025 mm



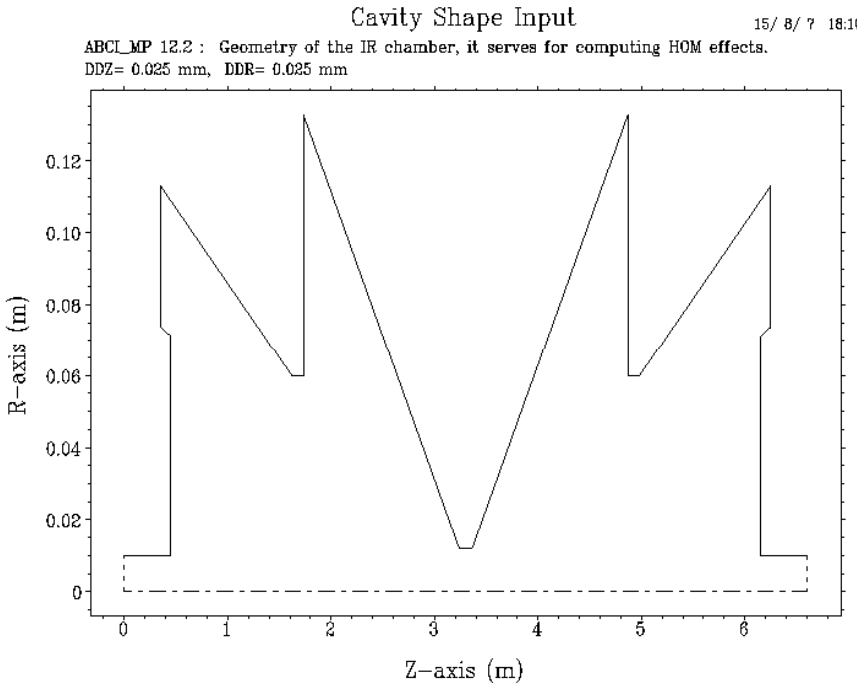
Wake Potentials

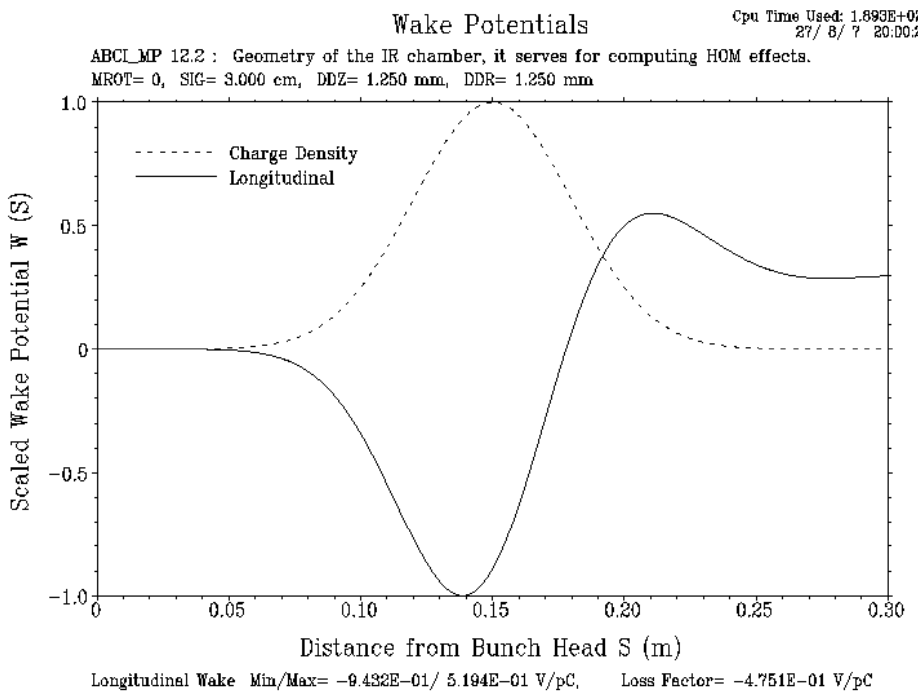
Cpu Time Used: 1.392E+04(s)
1/ 9/ 7 23:10:28

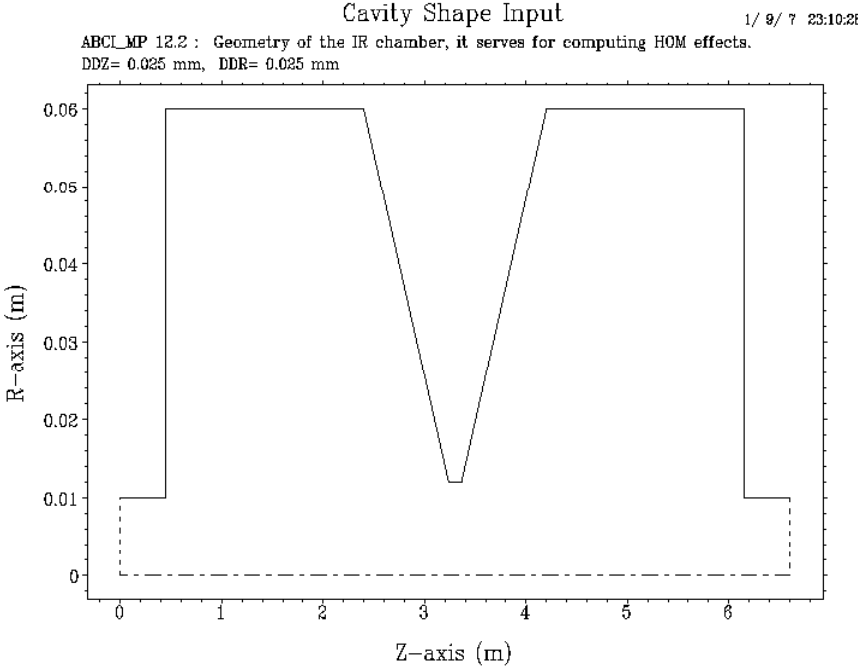
ABCI_MP 12.2 : Geometry of the IR chamber, it serves for computing HOM effects.
MROT= 0, SIG= 0.060 cm, DDZ= 0.025 mm, DDR= 0.025 mm

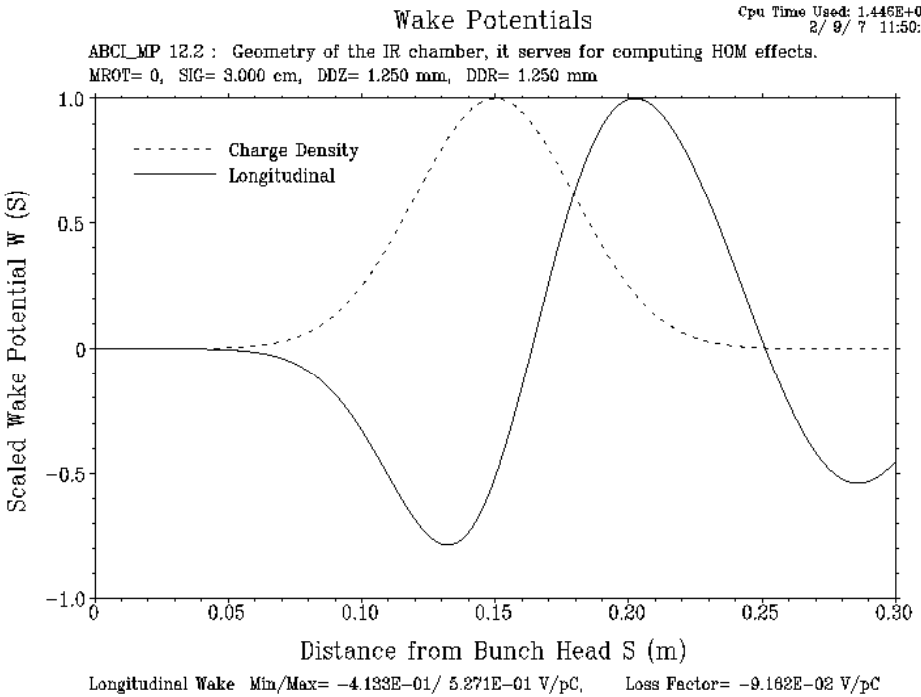


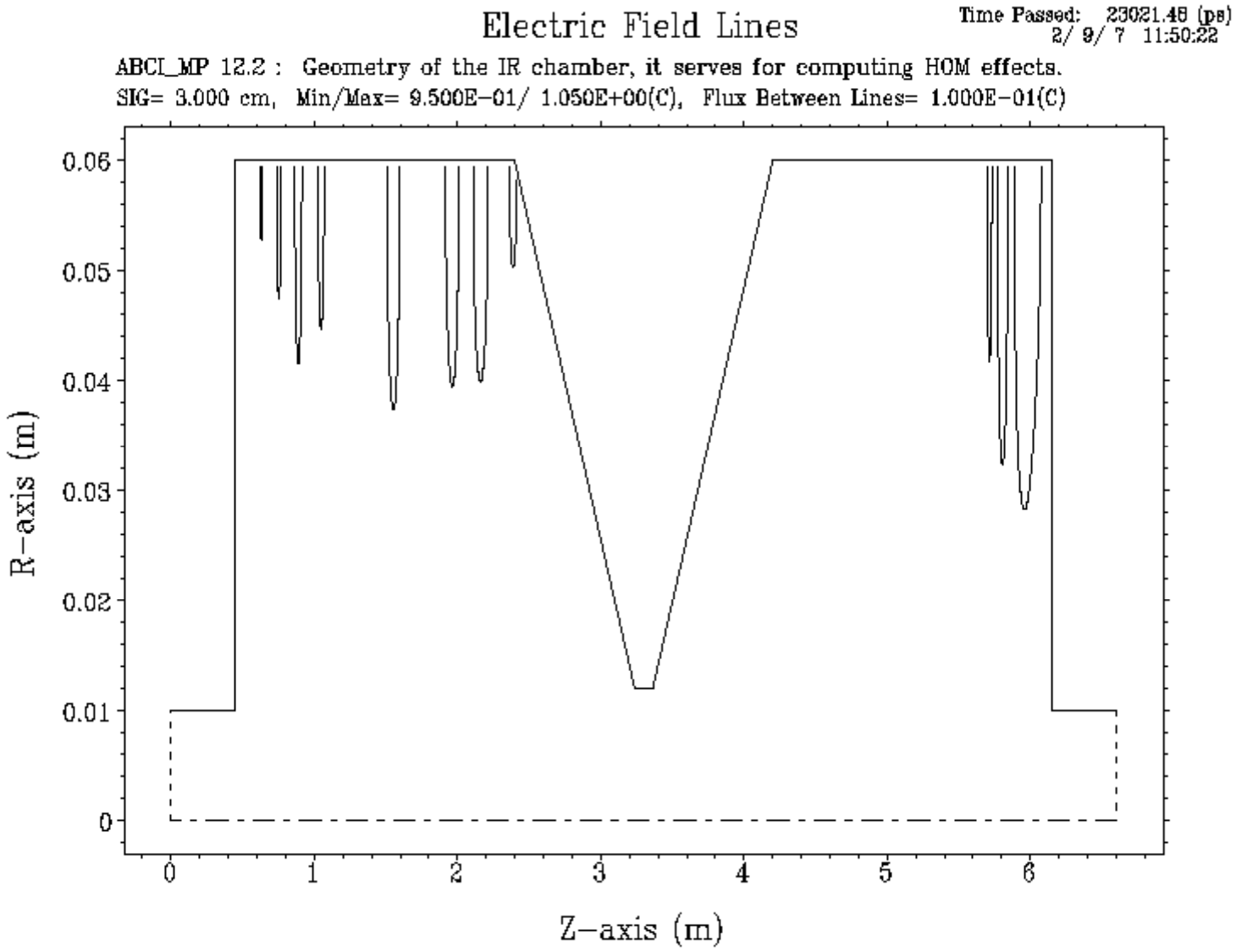
Longitudinal Wake Min/Max= -7.562E+01/ 4.869E+01 V/pC, Loss Factor= -4.970E+01 V/pC


Cavity Shape Input
15/ 8/ 7 18:10:03
ABCI_MP 12.2 : Geometry of the IR chamber, it serves for computing HOM effects.
DDZ= 0.025 mm, DDR= 0.025 mm
R-axis (m)
Z-axis (m)


Wake Potentials
Cpu Time Used: 1.893E+02(s)
27/ 8/ 7 20:00:23
ABCI_MP 12.2 : Geometry of the IR chamber, it serves for computing HOM effects.
MROT= 0, SIG= 3.000 cm, DDZ= 1.250 mm, DDR= 1.250 mm
Charge Density
Longitudinal
Scaled Wake Potential W (S)
Distance from Bunch Head S (m)
Longitudinal Wake Min/Max= -9.432E-01/ 5.194E-01 V/pC, Loss Factor= -4.751E-01 V/pC


Cavity Shape Input
1/ 9/ 7 23:10:28
ABCI_MP 12.2 : Geometry of the IR chamber, it serves for computing HOM effects.
DDZ= 0.025 mm, DDR= 0.025 mm
R-axis (m)
Z-axis (m)


Wake Potentials
Cpu Time Used: 1.446E+02(s)
2/ 9/ 7 11:50:22
ABCI_MP 12.2 : Geometry of the IR chamber, it serves for computing HOM effects.
MROT= 0, SIG= 3.000 cm, DDZ= 1.250 mm, DDR= 1.250 mm
Charge Density
Longitudinal
Scaled Wake Potential W (S)
Distance from Bunch Head S (m)
Longitudinal Wake Min/Max= -4.133E-01/ 5.271E-01 V/pC, Loss Factor= -9.162E-02 V/pC


Electric Field Lines
Time Passed: 23021.48 (ps)
2/ 9/ 7 11:50:22
ABCI_MP 12.2 : Geometry of the IR chamber, it serves for computing HOM effects.
SIG= 3.000 cm, Min/Max= 9.500E-01/ 1.050E+00(C), Flux Between Lines= 1.000E-01(C)
R-axis (m)
0.06
0.05
0.04
0.03
0.02
0.01
0
0
1
2
3
4
5
6
Z-axis (m)