Geometrical Wakes in XFEL Undulator

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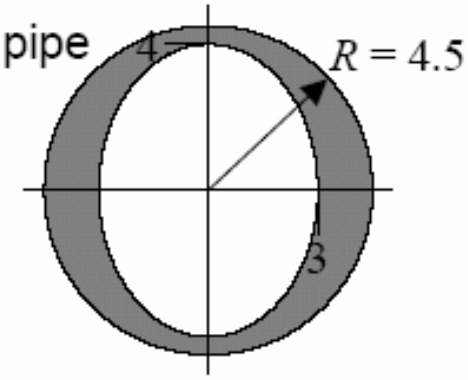
Beam Dynamics Group Meeting

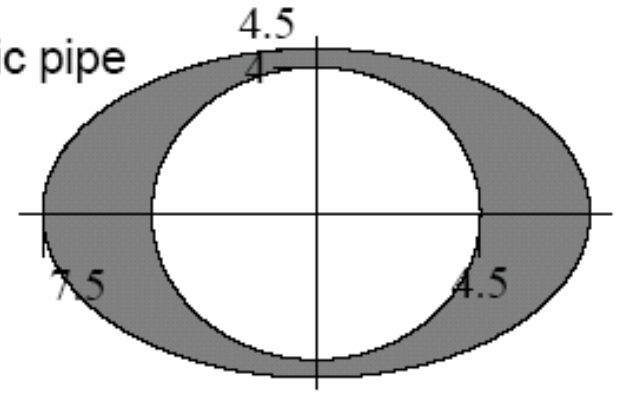
26.05.05

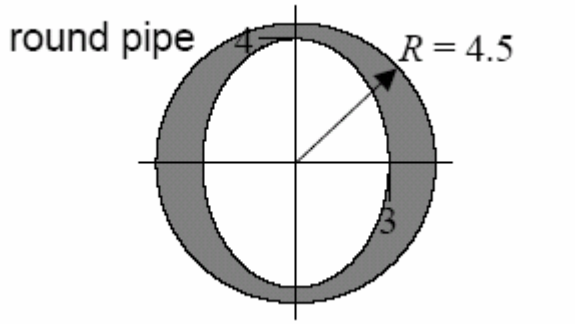
screens

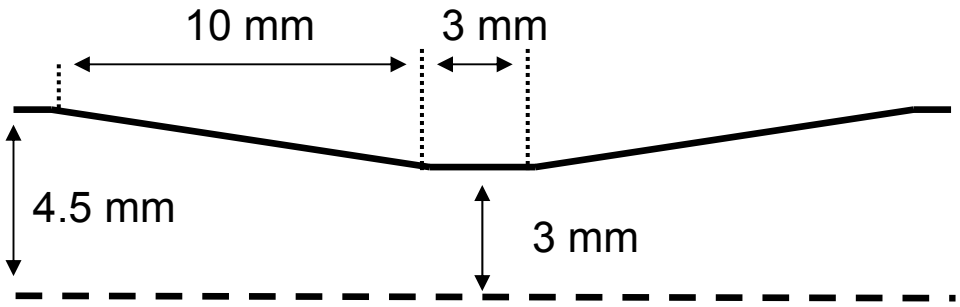
round pipe

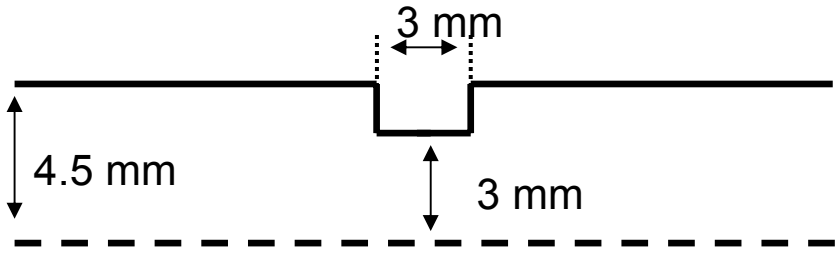


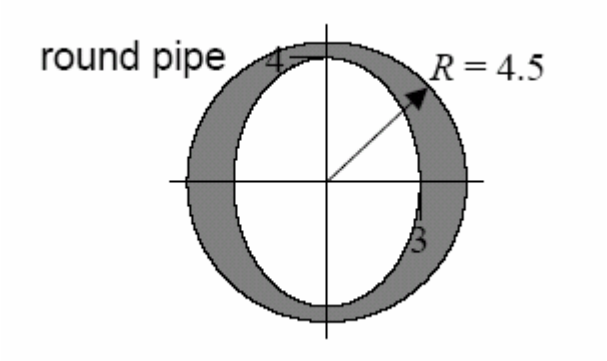
elliptic pipe

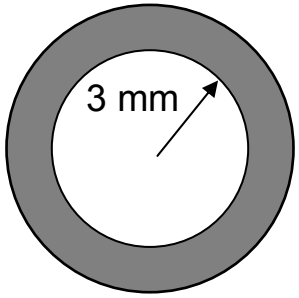



round pipe
4
R = 4.5
3


10 mm
3 mm
4.5 mm
3 mm







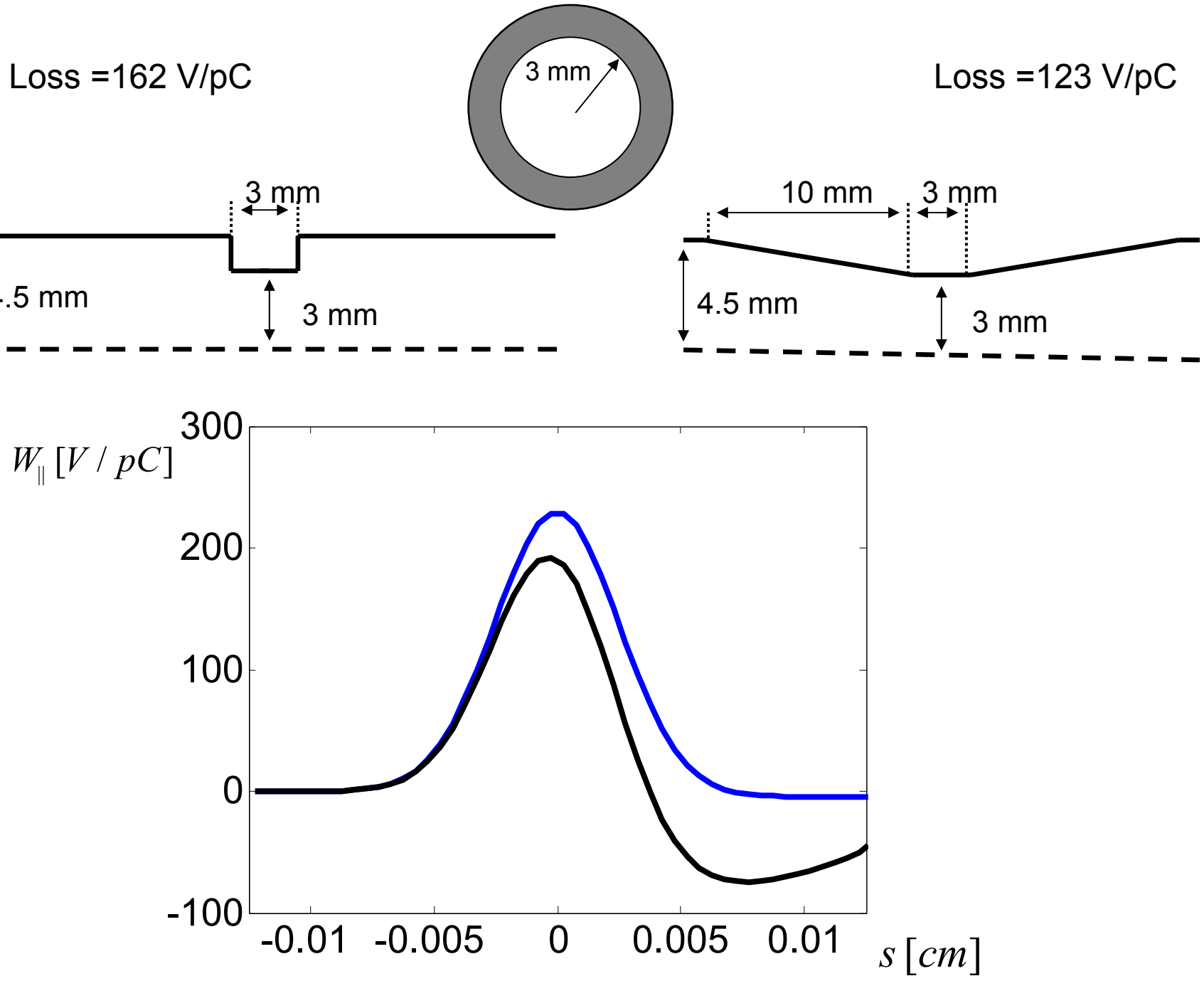
$$Z:\ (\text{collimated energy})$$

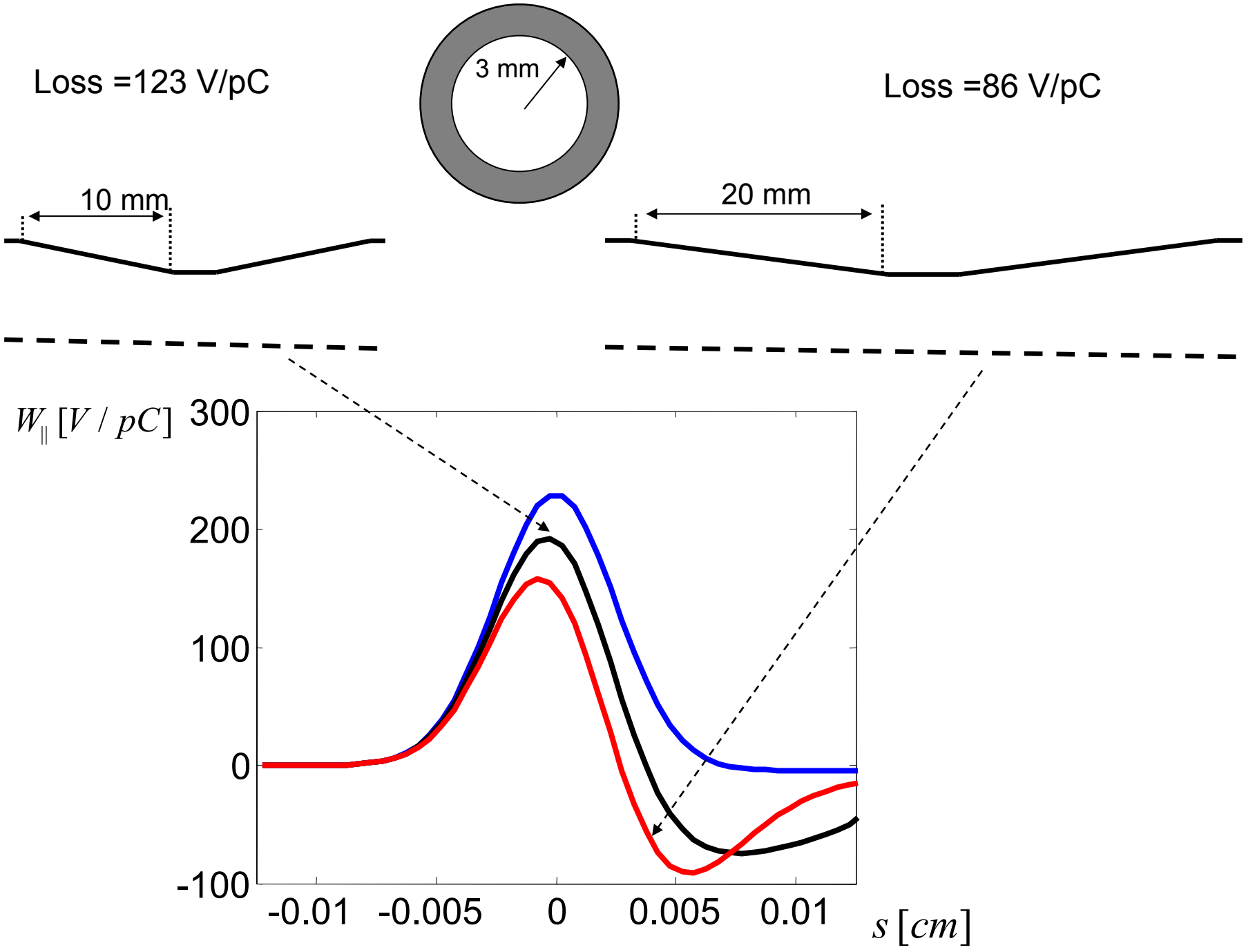
$$Z = \frac{4}{c} 0.2719\,[a.u.]$$

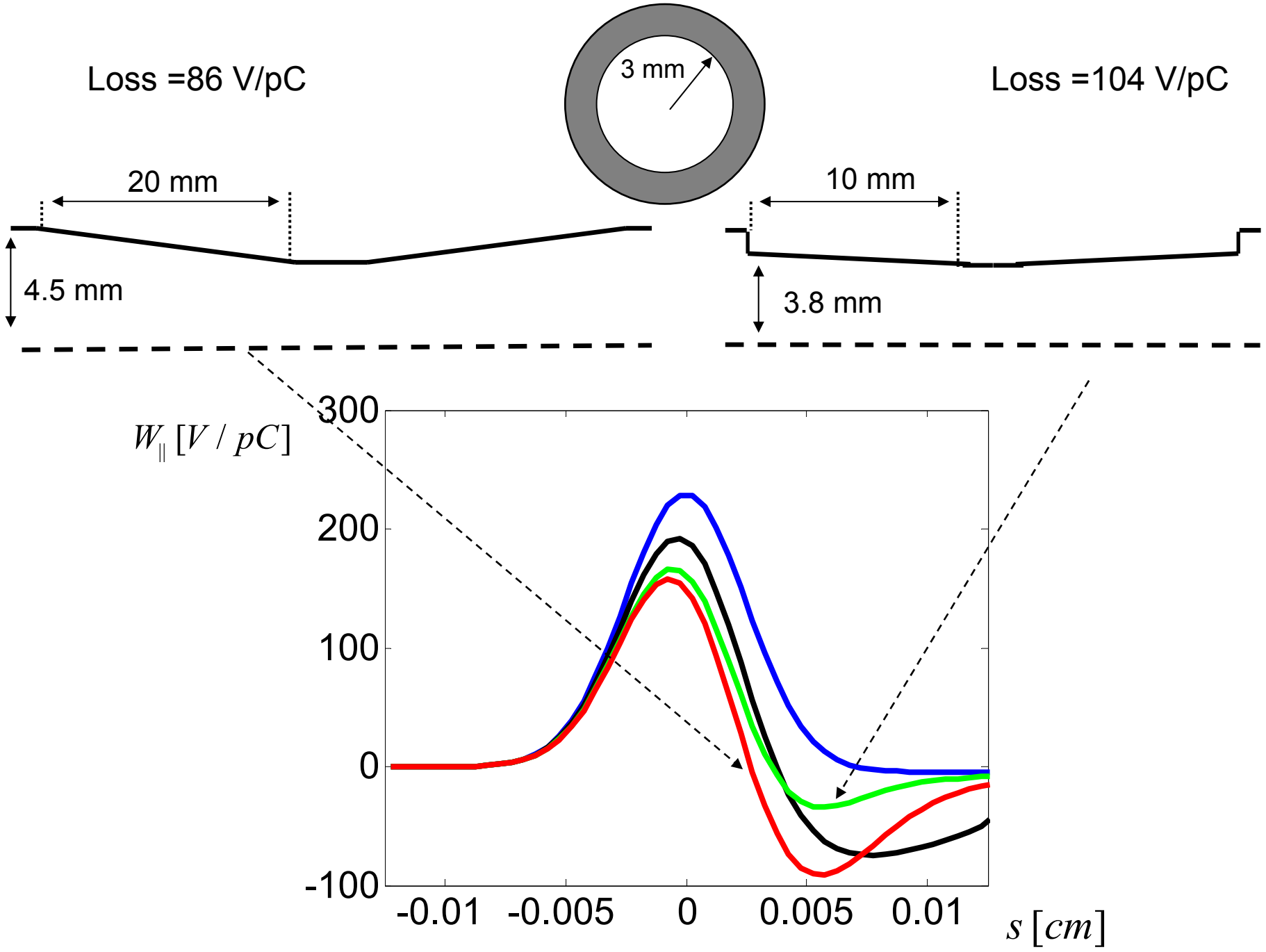
Loss =110 V/pC

$$Z = \frac{4}{c} 0.4055\,[a.u.]$$

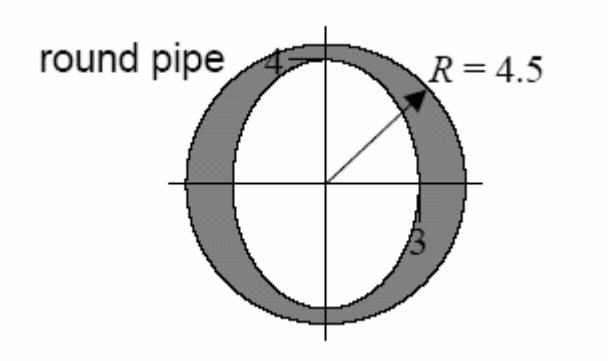
Loss =164 V/pC

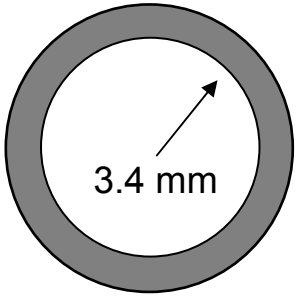

Loss =162 V/pC
3 mm
Loss =123 V/pC
3 mm
10 mm
3 mm
4.5 mm
3 mm
4.5 mm
3 mm
$W_{\parallel}\,[V/pC]$
300
200
100
0
-100
-0.01
-0.005
0
0.005
0.01
$s\,[cm]$


Loss =123 V/pC
3 mm
Loss =86 V/pC
10 mm
20 mm
$W_{\parallel}\,[V/pC]$
300
200
100
0
-100
-0.01
-0.005
0
0.005
0.01
$s\,[cm]$


Loss =86 V/pC
3 mm
Loss =104 V/pC
20 mm
10 mm
4.5 mm
3.8 mm
$W_{\parallel}\,[V\,/\,pC]$
300
200
100
0
-100
-0.01
-0.005
0
0.005
0.01
$s\,[cm]$

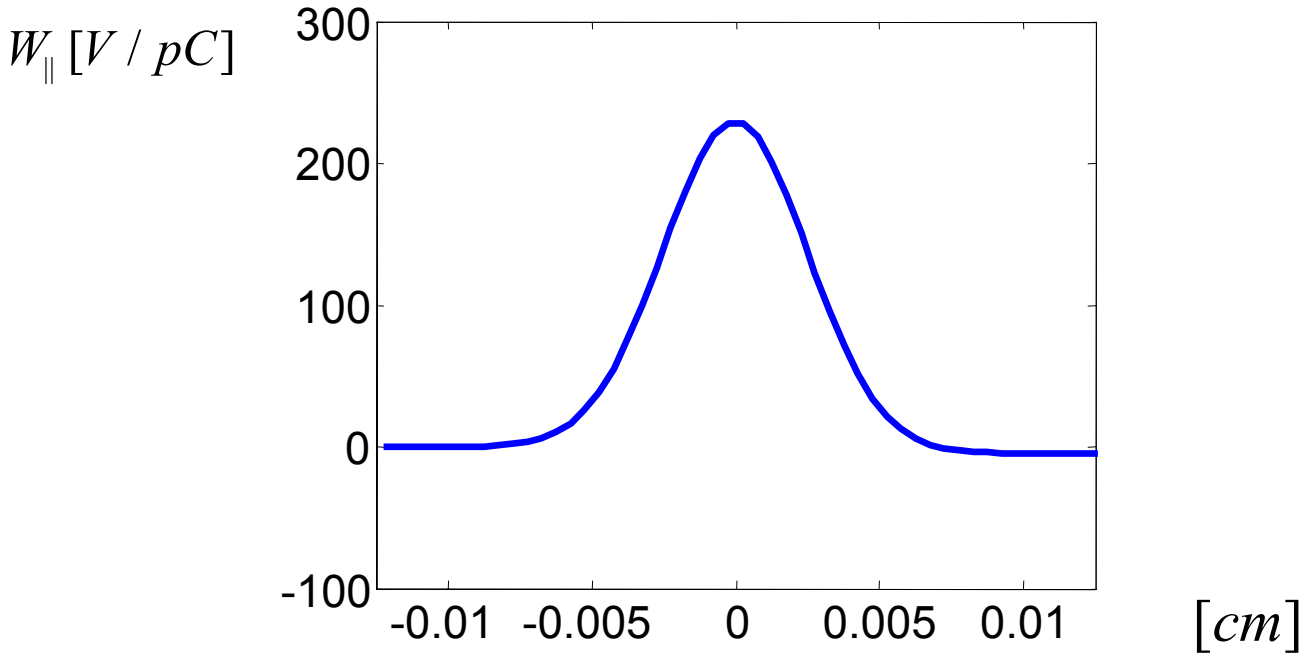
3D => „equivalent“ 2D

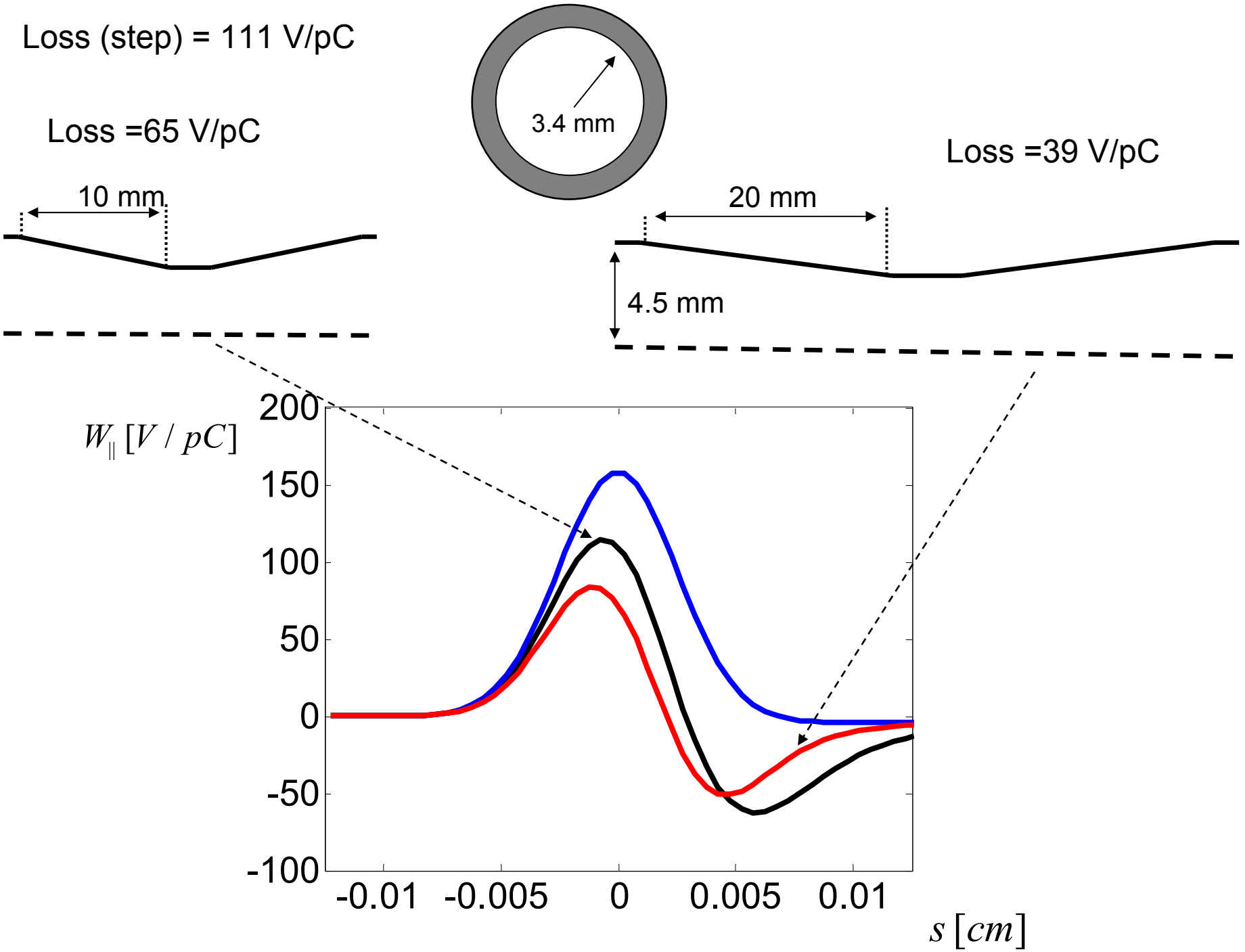




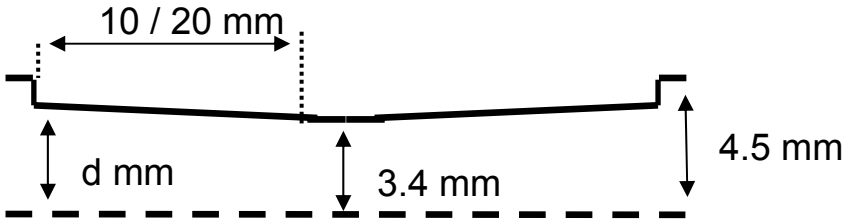
Loss =110 V/pC

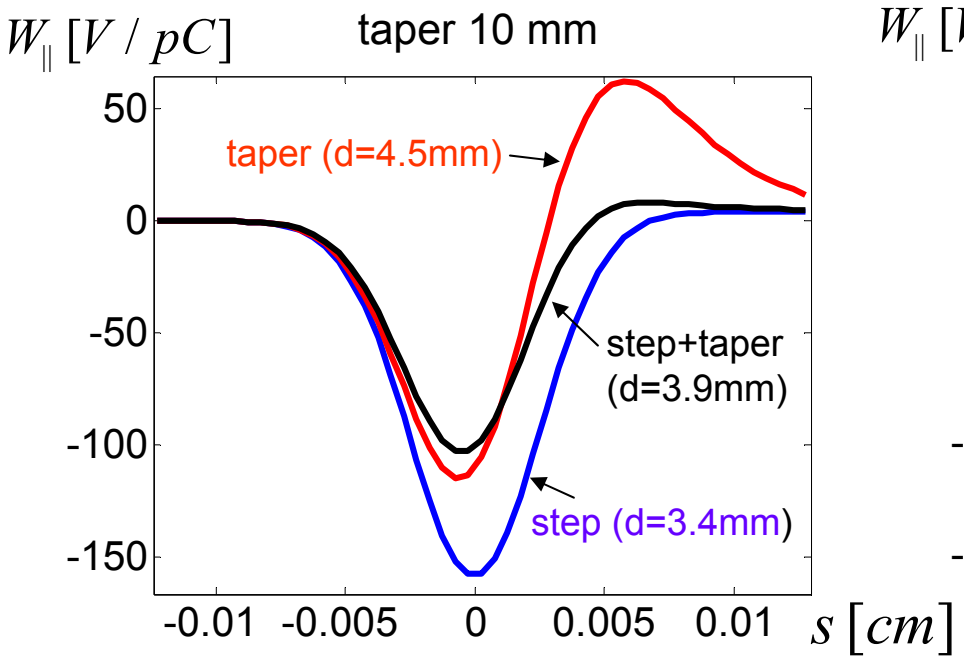
Loss = 111 V/pC

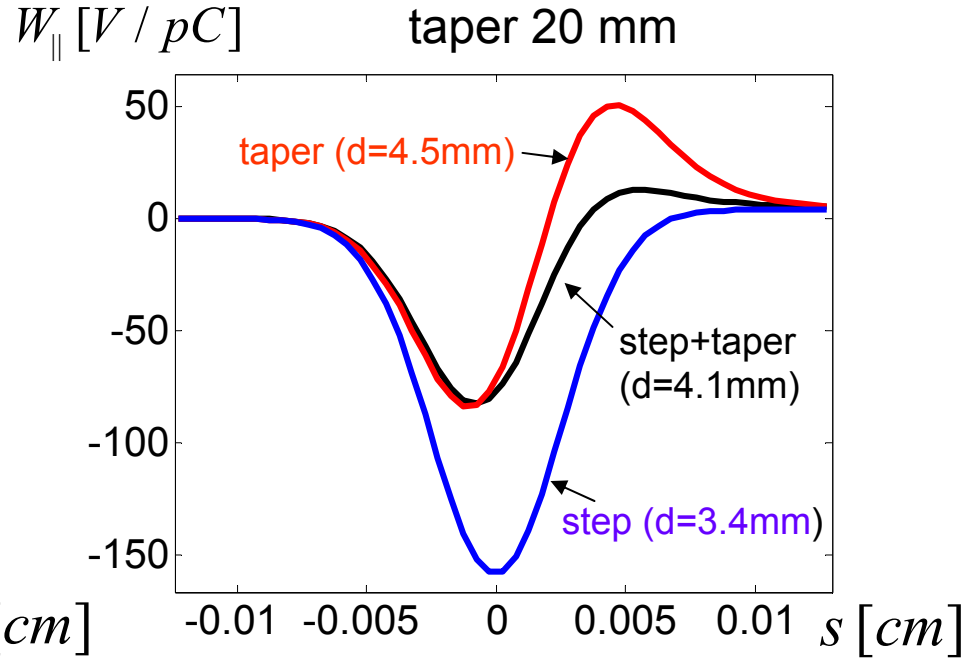



Loss (step) = 111 V/pC
Loss =65 V/pC
10 mm
3.4 mm
Loss =39 V/pC
20 mm
4.5 mm
$W_{\parallel}\,[V\,/\,pC]$
200
150
100
50
0
-50
-100
-0.01
-0.005
0
0.005
0.01
$s\,[cm]$

$\sigma = 25\,mkm$





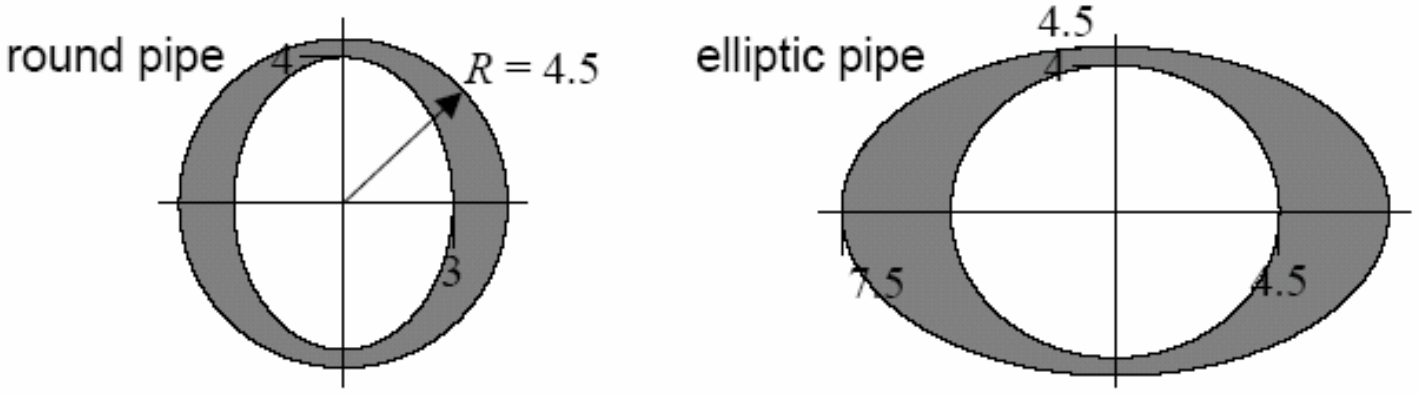


	Loss, V/pC	Spread, V/pC	Peak, V/pC
step	110	43	-156
taper 10mm	65	49	-114
taper 10mm + step	67	32	-102

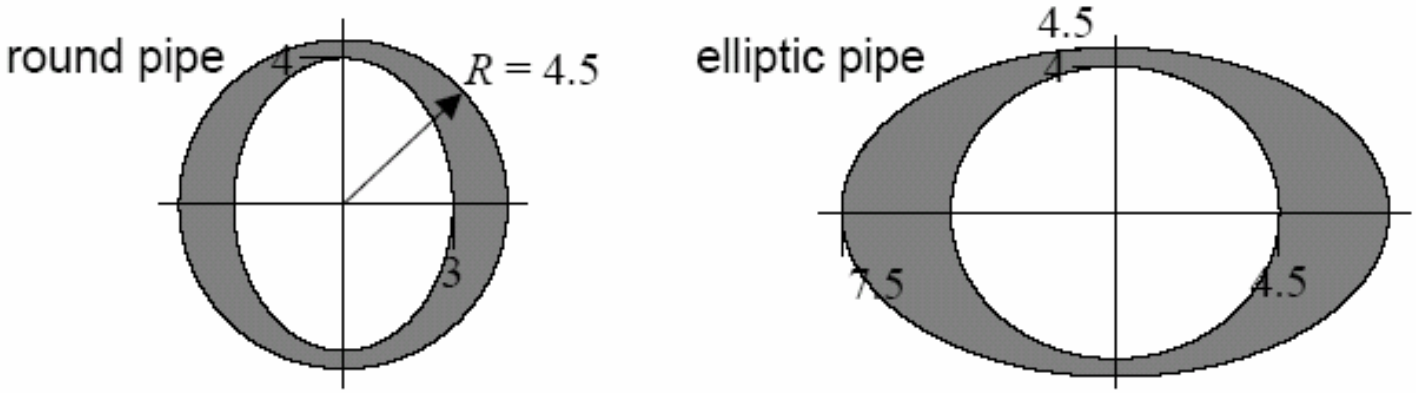
	Loss, V/pC	Spread, V/pC	Peak, V/pC
step	**110**	**43**	**-156**
taper 20mm	38	42	-83
taper 20mm +step	**50 (45%)**	**29 (67%)**	**-82 (53%)**

3D?

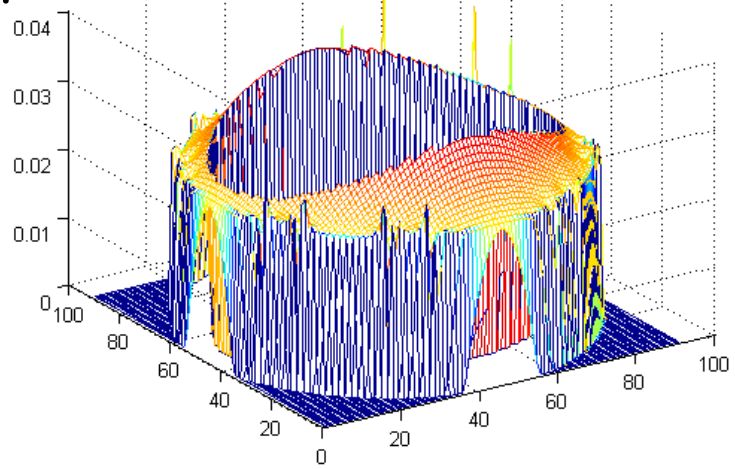
screens



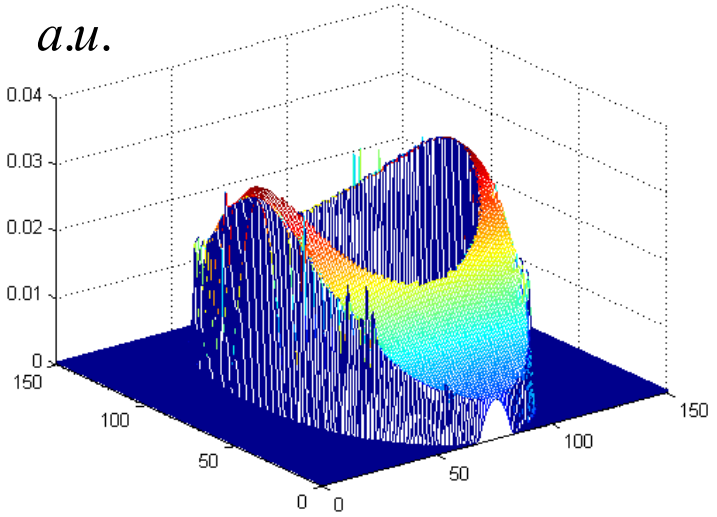
screens



$\frac{|E|}{a.u.}$



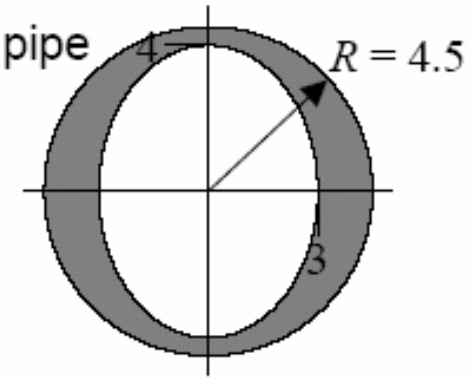
$\frac{|E|}{a.u.}$



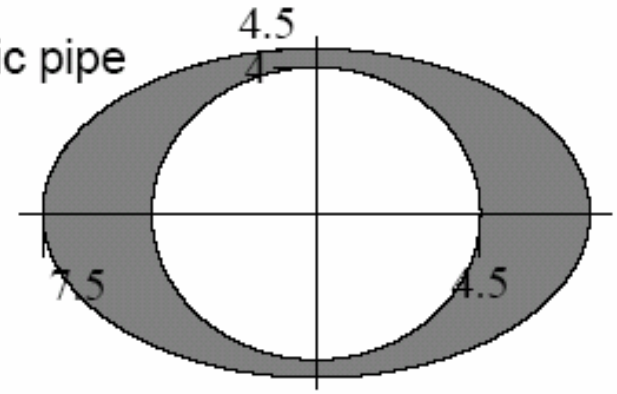
2D static solver in Matlab. Geometry from MWS. =>
collimated energy for any shape and arbitrary transverse charge distribution

screens

round pipe



elliptic pipe

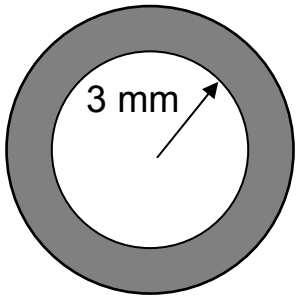


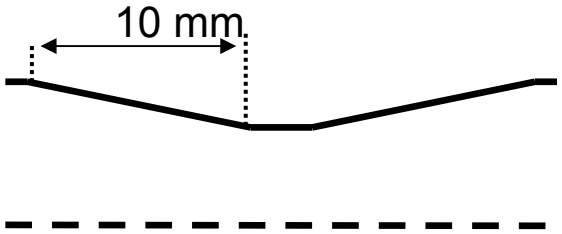
h, mm	Energy, a.u.	Loss, V/pC
analytical	0.2719	**110.31**
0.1	0.2726	110.58

h, mm	Energy, a.u.	Loss, V/pC
0.25		
0.1	0.2234	**90.6**
0.05		
0.025		

The results for the step geometry coincide with M.Dohlus‘ results.

3D - tapering?

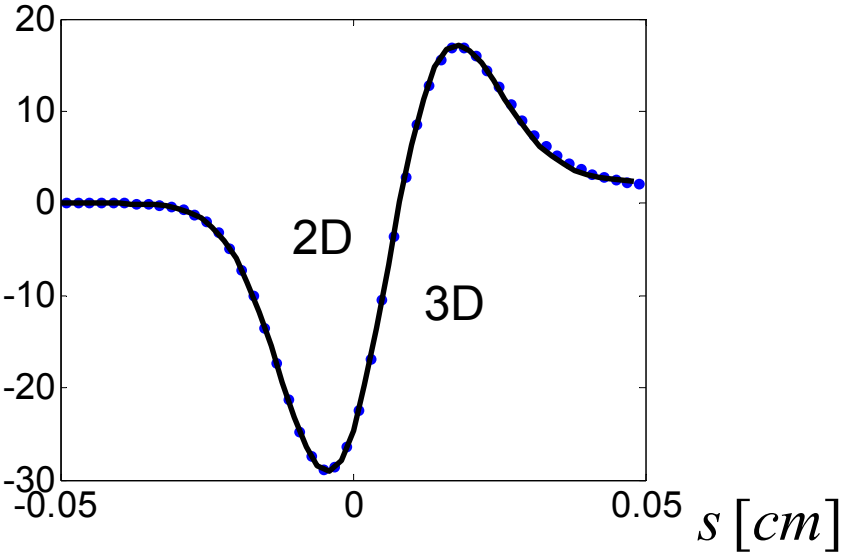




$\sigma = 100 mkm$

$\sigma = 25\, mkm$

$W_{\parallel}\,[V/pC]$

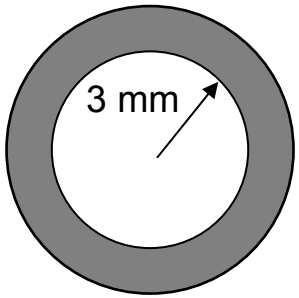


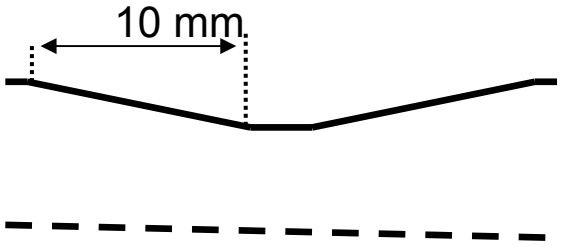
$$h = \frac{\sigma}{5}?$$

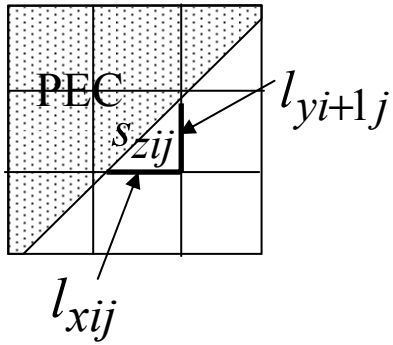
Very fine mesh (1800*1800*4600) Memory limitations.

Coarser mesh transversally?

2D with coarse mesh

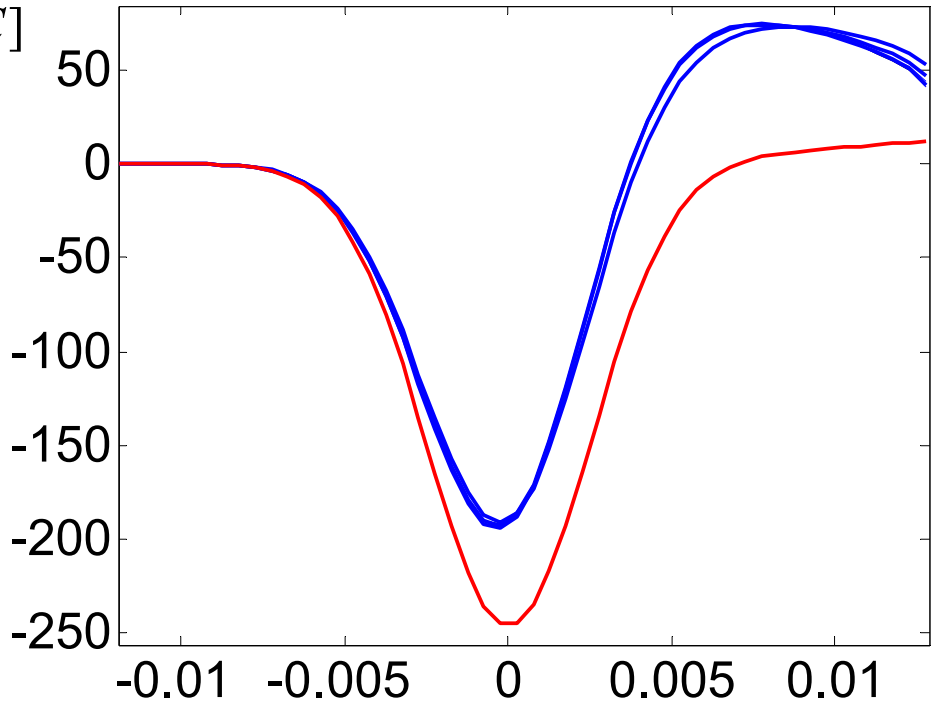






$\sigma = 25\,mkm$

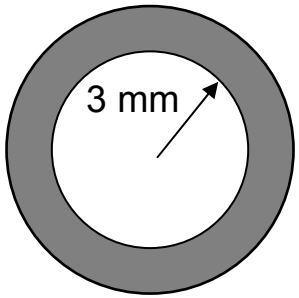
$W_{\|}\,[V/pC]$

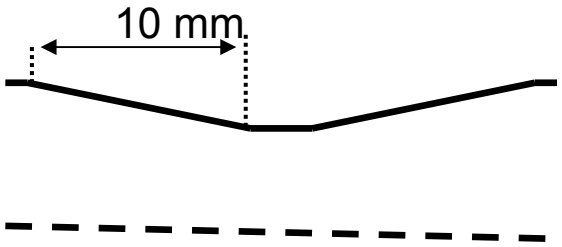


$1\times1,\ 1\times2,\ldots,1\times32$ $(conformal)$

1×32 $(staircase)$

3D - tapering with coarse mesh?



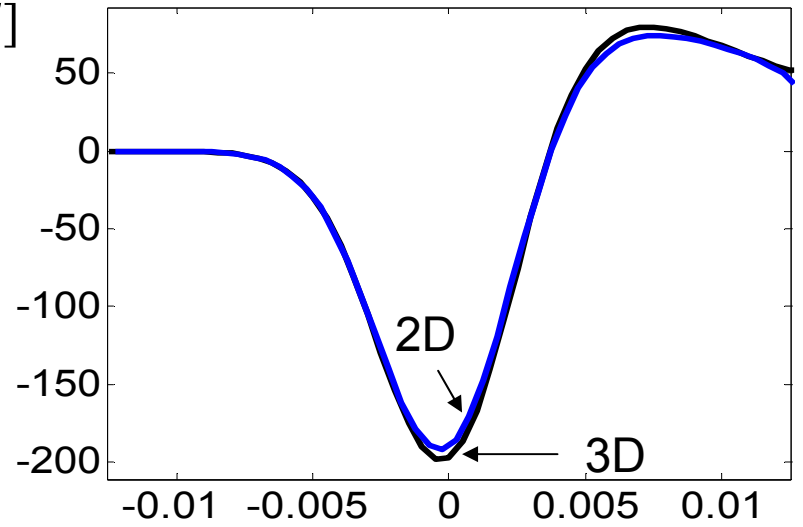


	Loss
2D	124
3D	128

$\sigma = 25\,mkm$

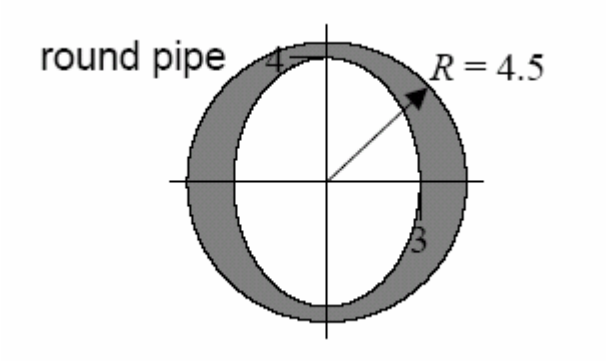
$W_{\parallel}\,[V/pC]$

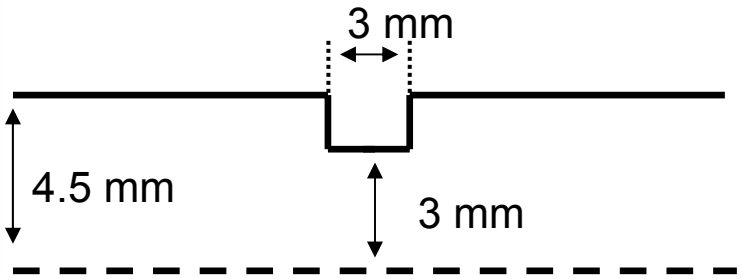
$1\times10(conformal)$



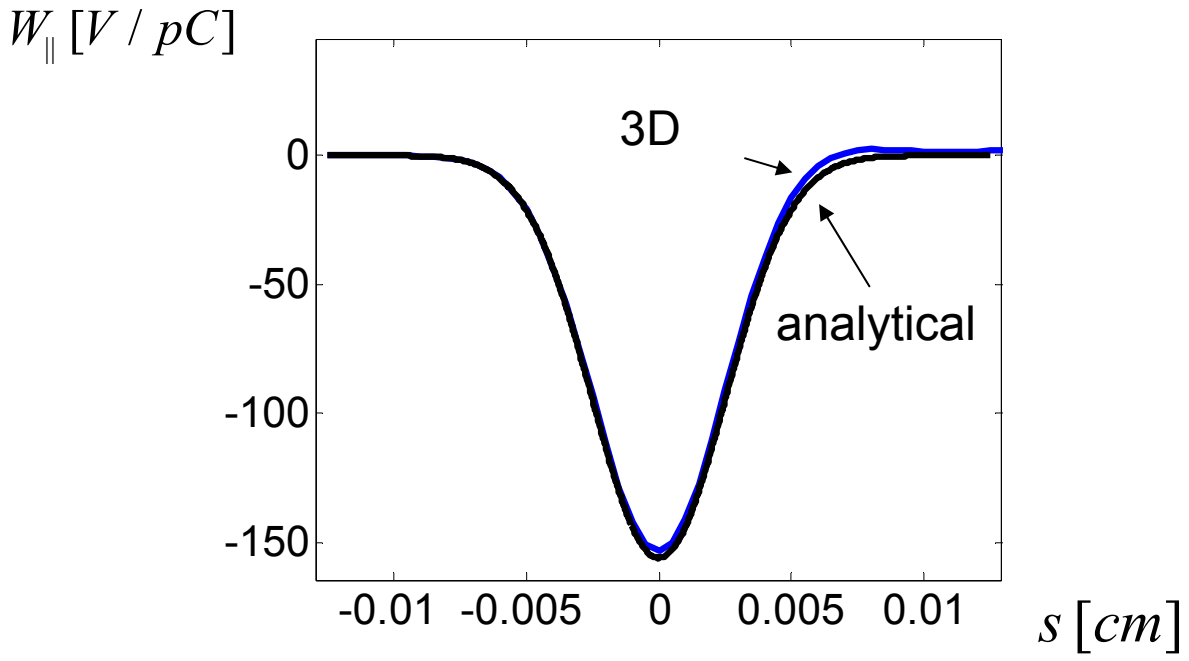
We can model tapering in 3D

3D - shape?

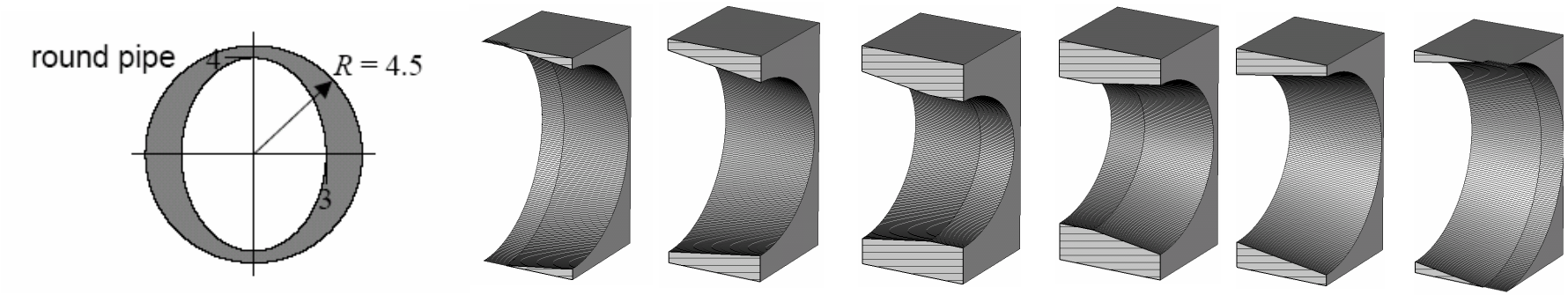


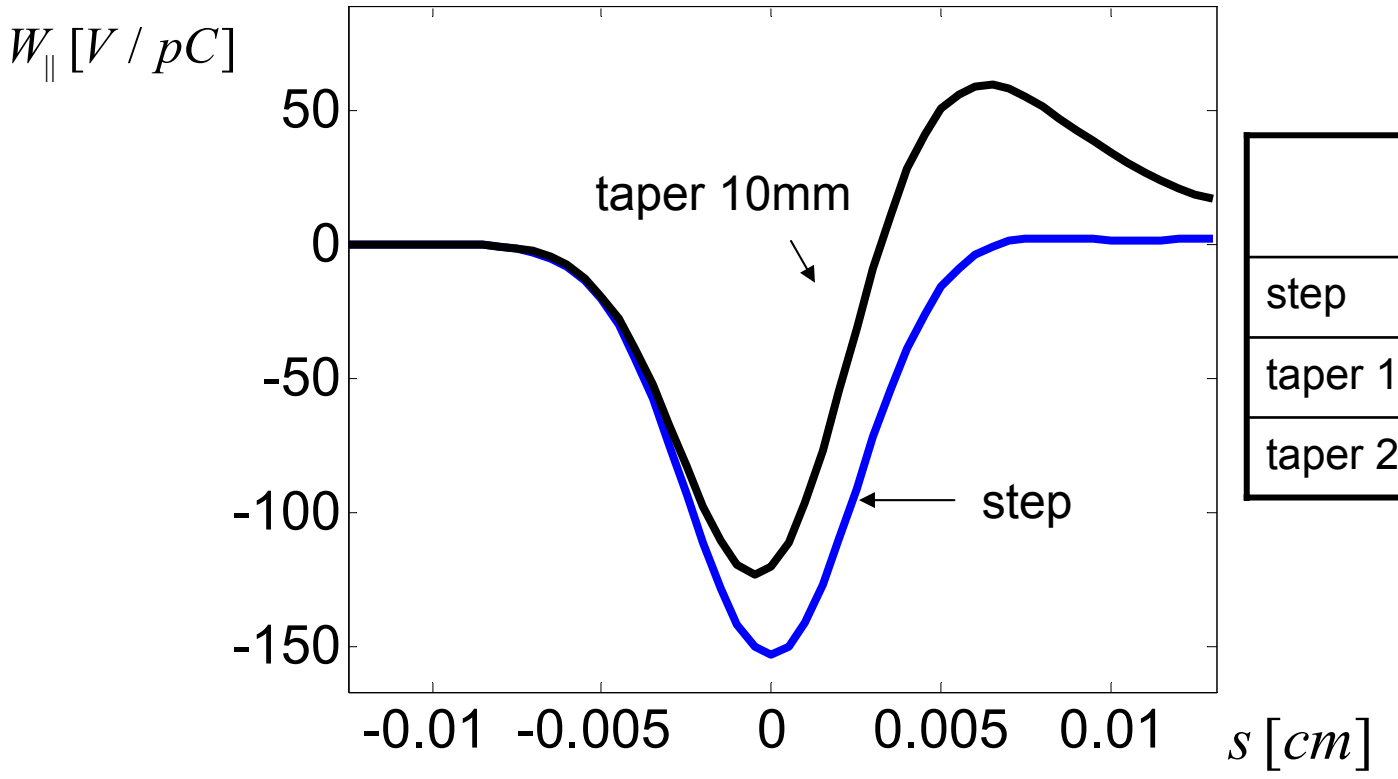


	Loss
analytical	110
3D	108



We can model elliptical shape in 3D

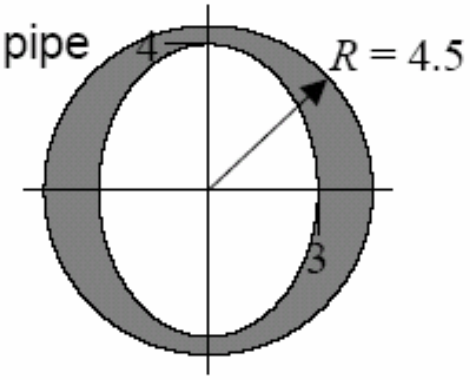




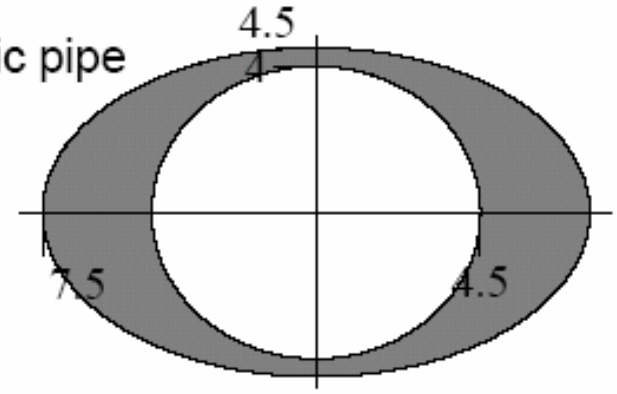
	Loss, V/pC
step	110 (111)
taper 10mm	75 (65)
taper 20mm	50? (39)

screens

round pipe



elliptic pipe



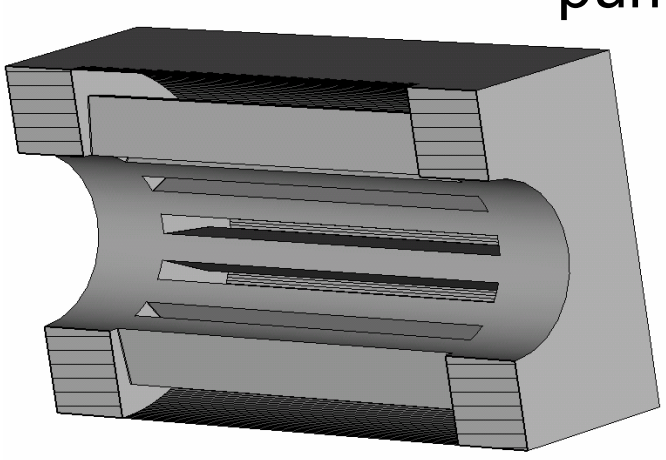
	Loss, V/pC	Spread, V/pC	Peak, V/pC
step	110	43	-156
taper 10mm	74	48	-123
taper 20mm	50?	43?	-90?

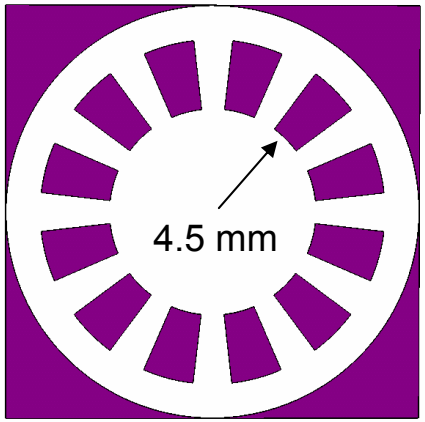
	Loss, V/pC	Spread, V/pC	Peak, V/pC
step	91	36	-128
taper 10mm			
taper 20mm			

In round pipe we are able to study all 3D elements

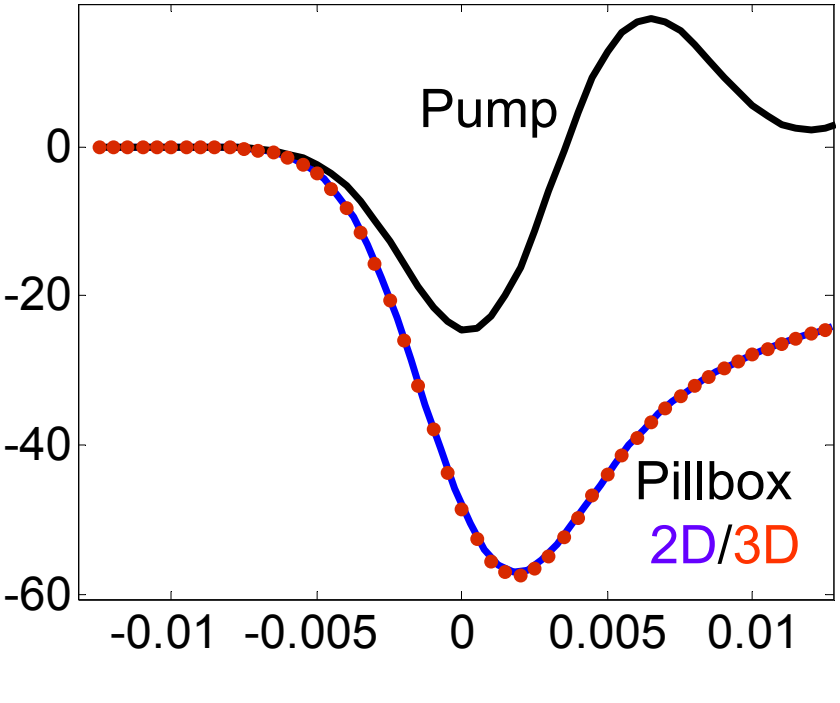
Indirect integration procedure is required!

pumping slots





$W_{\parallel}\,[V/pC]$

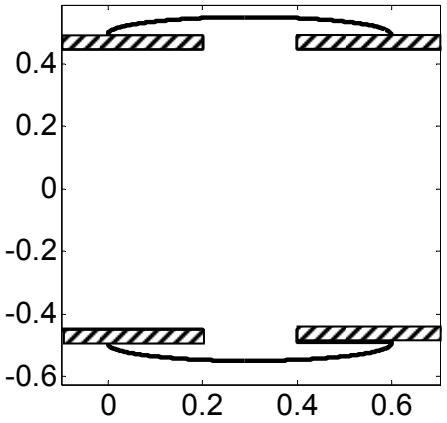


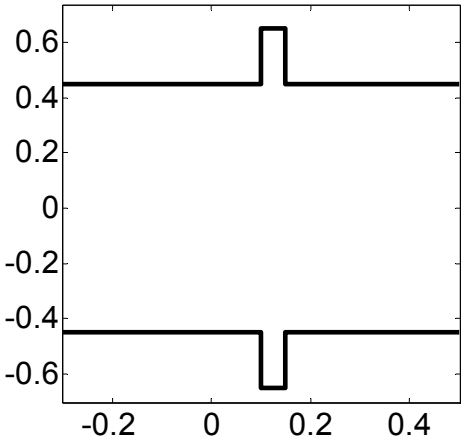
$s\,[cm]$

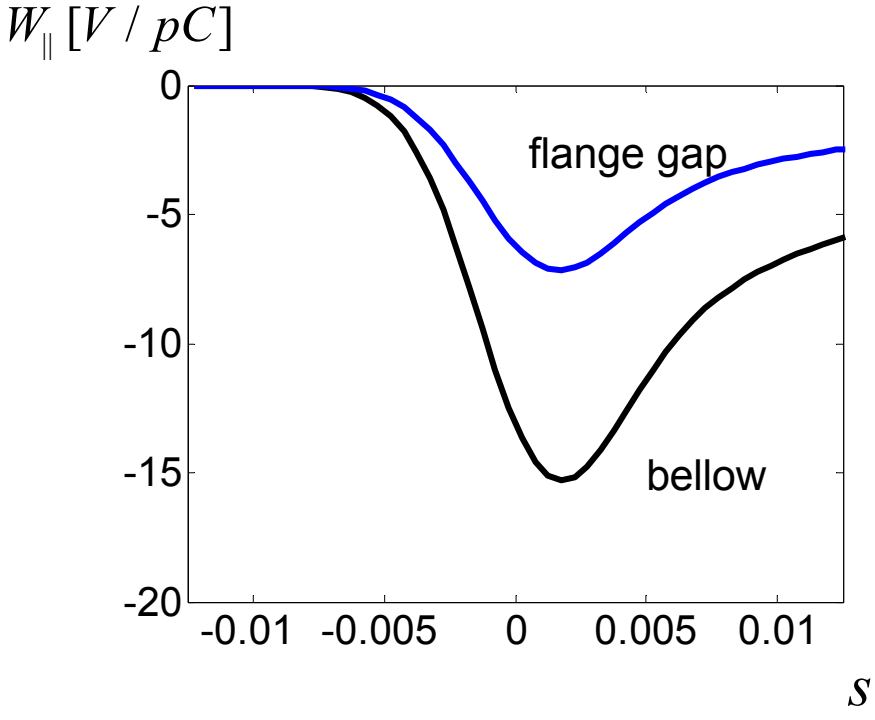
$\sigma = 25\,mkm$

	Loss, V/pC	Spread, V/pC	Peak, V/pC
pump	15	10	-24
pillbox	40	16	-57

below, flange gap



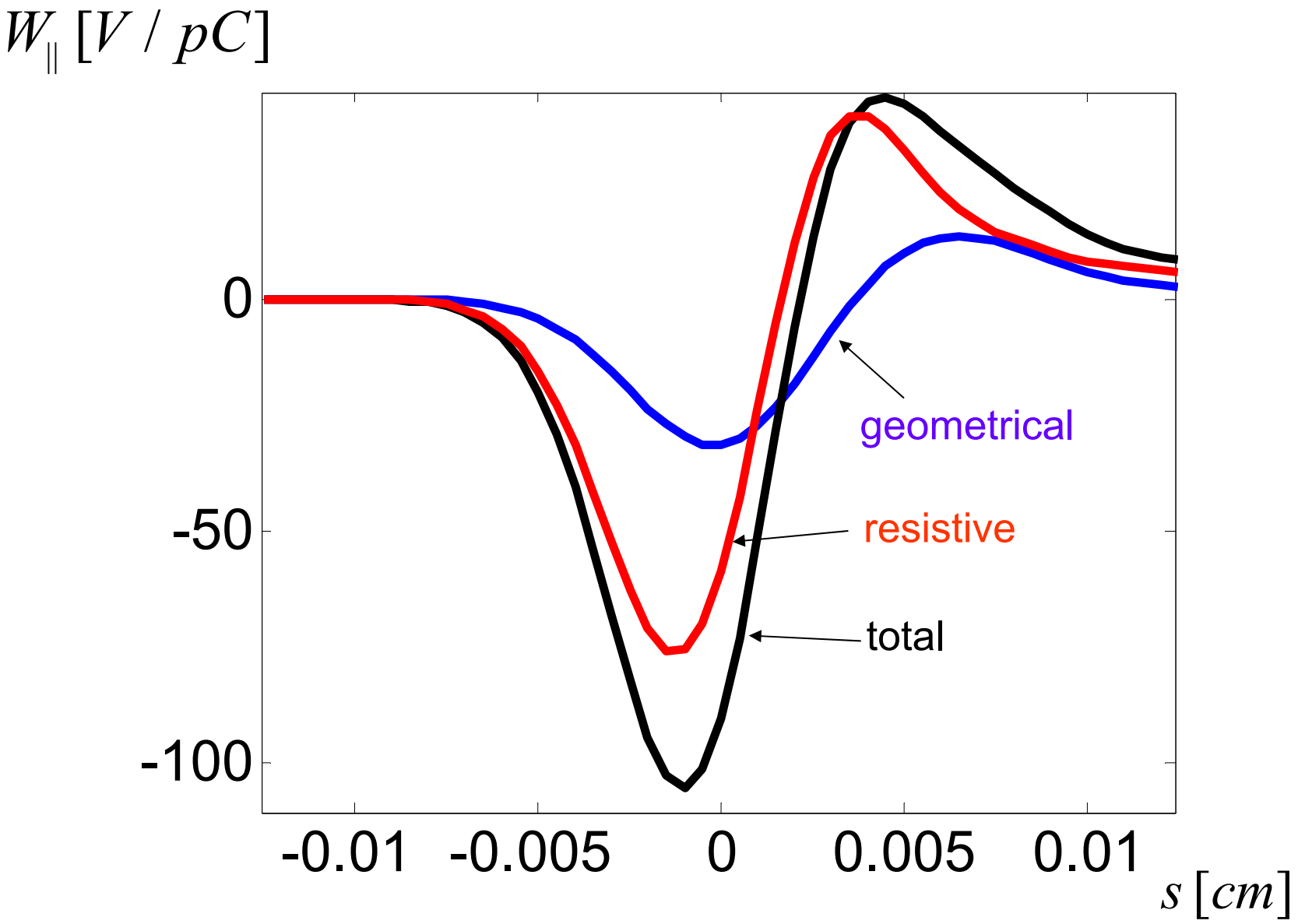




	Loss, V/pC	Spread, V/pC	Peak, V/pC
bellow	11	4.4	-15
flange gap	5.1	2.0	-7.2

Geometrical wakes for the case of round pipe

	pro section (6 m)	Loss, V/pC	**Spread, V/pC**	Peak, V/pC
absorber (taper 10mm)	1	74	48	-123
pump („pumpkreuz“, „schiebestück“)	2	15	10	-24
bellow	1	11	4.4	-15
flange gap	1	5.1	2.0	-7.2
Total geom.		**120**	**70**	**-190**
resistive (cu) (M.Dohlus)		**186**	**237**	


$W_{\parallel}\,[V\,/\,pC]$
0
-50
-100
-0.01
-0.005
0
0.005
0.01
$s\,[cm]$
geometrical
resistive
total

Conclusion

- We are able to do 3d calculations for the required bunch length (sigma=25mkm)
- The wakes for the round pipe are estimated: **the geometrical wake is comparable to the resistive one**
- The elliptical pipe requires additional efforts: an indirect procedure for wake integration should be developed

Next

- XFEL simulations with wake fields
- Wakes for the elliptical pipe + indirect method in 3D
- Wakes for expected bunch shape + XFEL simulations