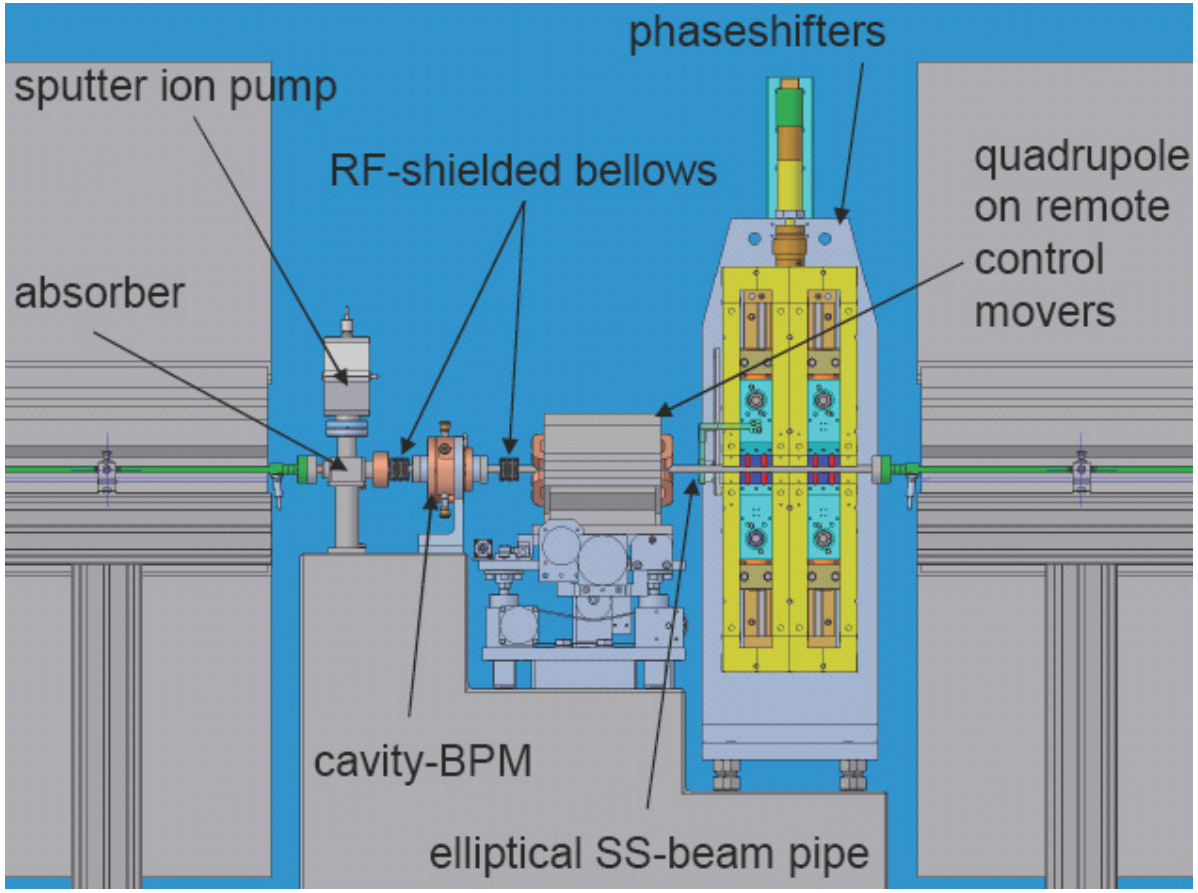
Wakefields in XFEL undulator intersections

Igor Zagorodnov

Beam Dynamics Group Meeting

26.02.07

T .Wohlenberg WP19 Warm Vacuum Staus Report
XFEL Project Meeting 13.12.2006



UNDULATOR- CELL(6.1m) = UNDULATOR (5m) + INTERSECTION (1.1m)

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Chamber dimensions :	length :	5122mm	
	width:	70mm	
	heigh:	9.6mm	
	elliptical aperture:	horizontal: 15mm	vertical: 8.8mm

extruded aluminium chamber

Aluminium

$$\sigma = 3.66 \cdot 10^{7} [\Omega^{-1} \mathrm{m}^{-1}]$$

$$\tau = 7.1 \cdot 10^{-15} [\mathrm{sec}]$$

$$\Delta_{rough} = 600 [\mathrm{nm}]$$

$$\Delta_{oxid} = 5 [\mathrm{nm}]$$

Elliptical chamber length = 5122 mm

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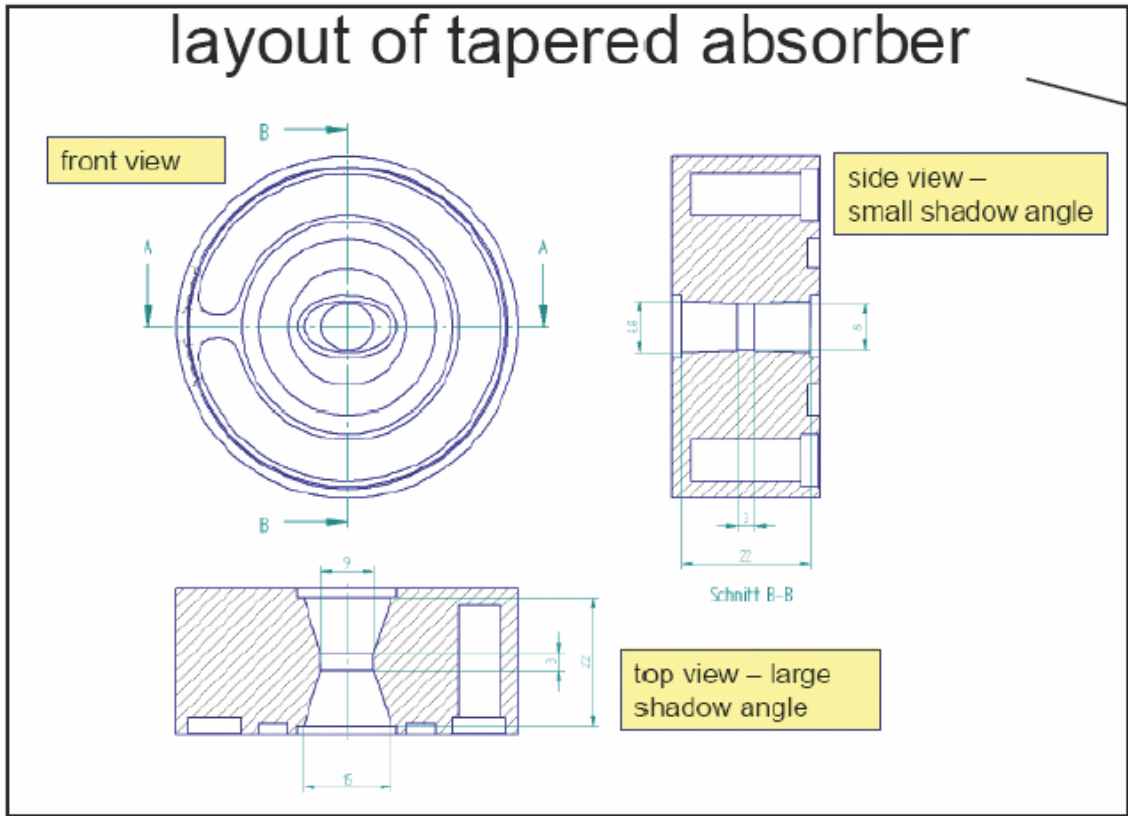


Absorber :
length 3mm
Tapers 2*9.5 mm
width 9mm
heigh 8mm

Copper

$$\sigma = 5.8 \cdot 10^{7} [\Omega^{-1} \mathrm{m}^{-1}]$$

$$\tau = 2.46 \cdot 10^{-14} [\mathrm{sec}]$$

$$\Delta_{rough} = 0 [\mathrm{nm}]$$

$$\Delta_{oxid} = 0 [\mathrm{nm}]$$

Absorber length = 22 mm

Cavity BPM design, Dirk Lipka

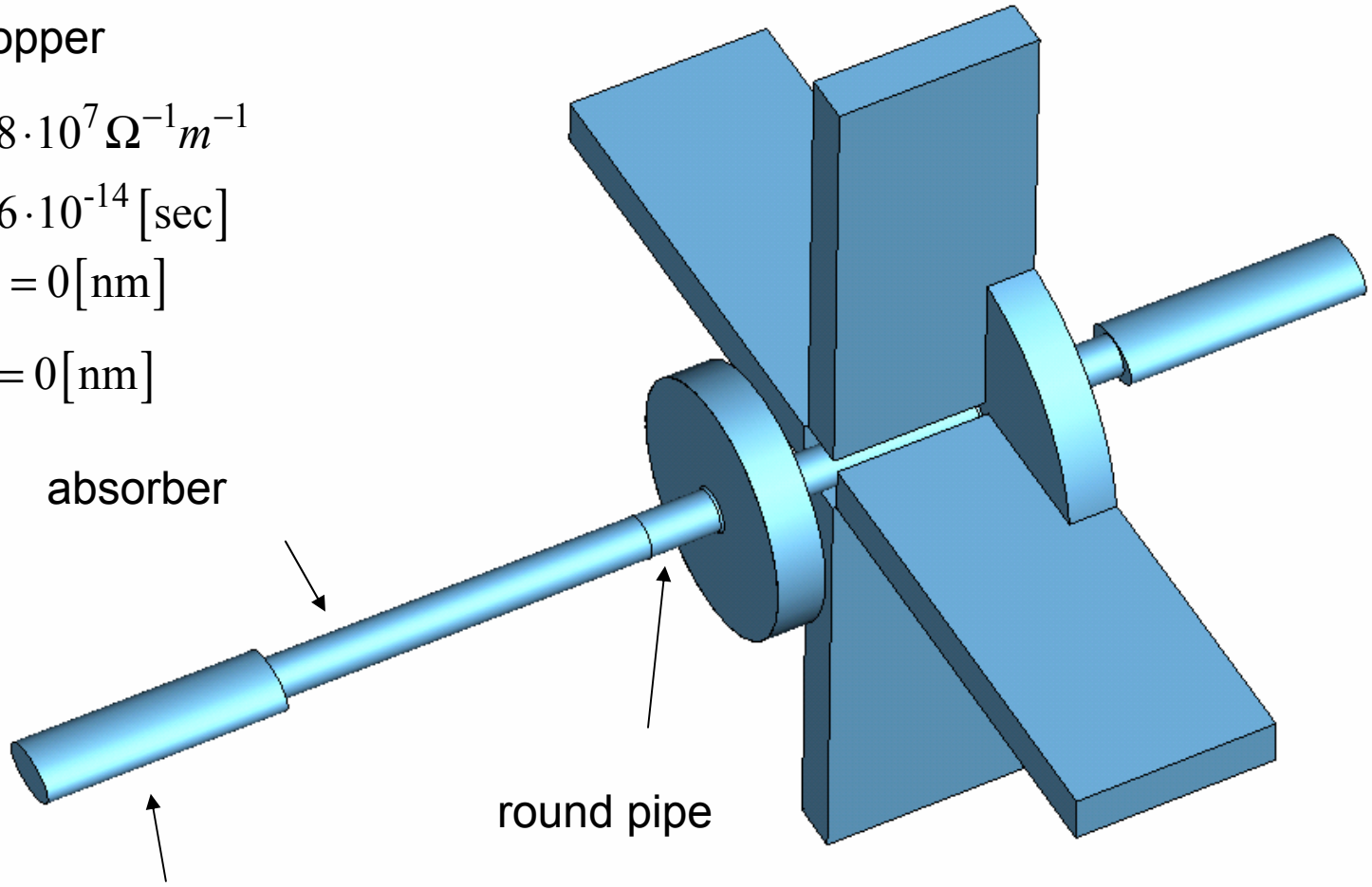
Copper

$\sigma = 5.8 \cdot 10^{7}\,\Omega^{-1} m^{-1}$

$\tau = 2.46 \cdot 10^{-14}\,[\mathrm{sec}]$

$\Delta_{rough} = 0\,[\mathrm{nm}]$

$\Delta_{oxid} = 0\,[\mathrm{nm}]$



Round pipe length = 690mm

Cavity BPM = 2 Pillbox cavities with gap 10mm and distance 45 mm between them

Elements

Elliptical chamber = 5122 mm

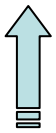
Absorber = 22 mm

Round pipe = 690 mm

Cavity BPM = 2 Pillbox cavities with gap 10mm and distance 45 mm between them

Pumping slots = 2*25=50 mm

5122+22+690+50=
=5884 mm



Pumpschlitzgeo. im Pumpkreuz:	Breite 1mm, Länge 20-25mm Anzahl 12 Stück/Kreuz Pumpschlitz in Strahllängsrichtung
Schiebestück:	>Sitzt direkt hinter dem synchrotron Licht Absorber. >Sprung am Schiebestück ca.0,5mm im Durchmesser
Pumpschlitzgeo. am Schiebestück:	Breite 1mm,Länge 20-25mm Anzahl 8 Stück/Schiebestück

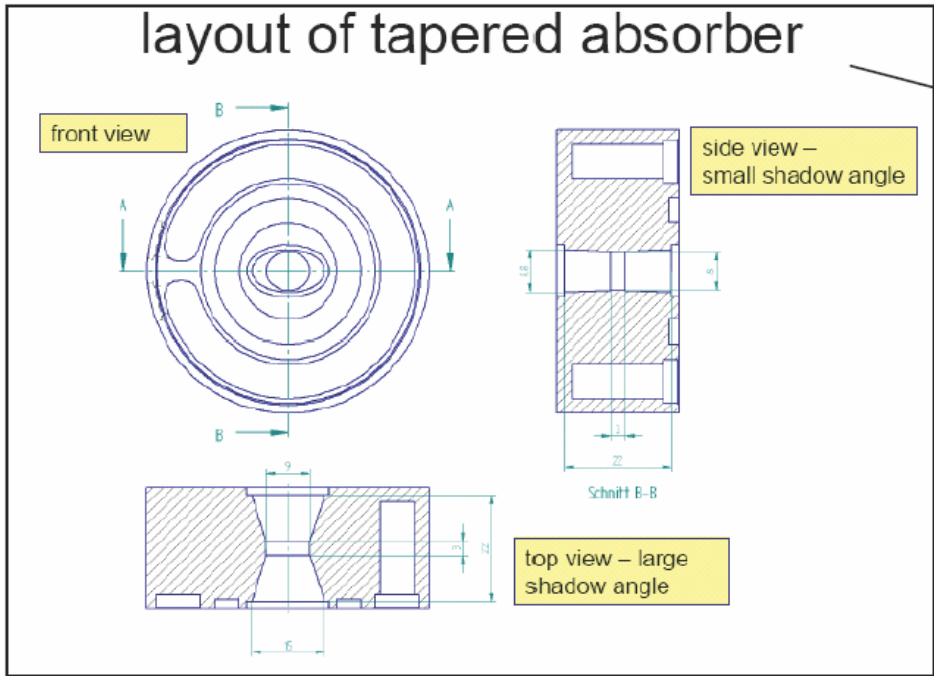
Not considered
(see TESLA FEL 2005-10)

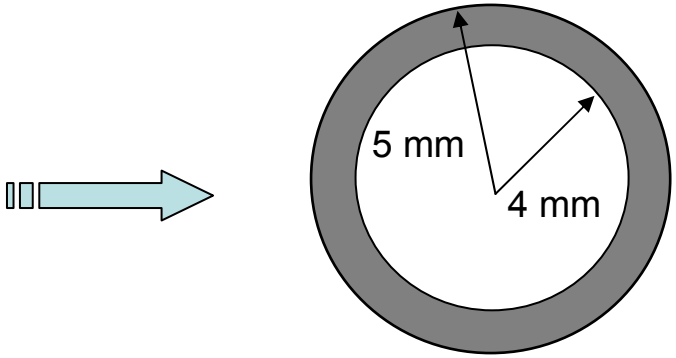
216 mm

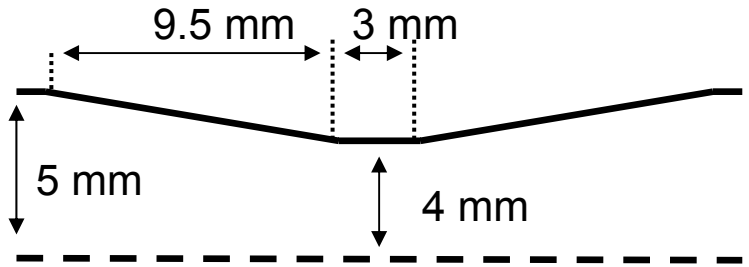
(5000+1100)-5884=266

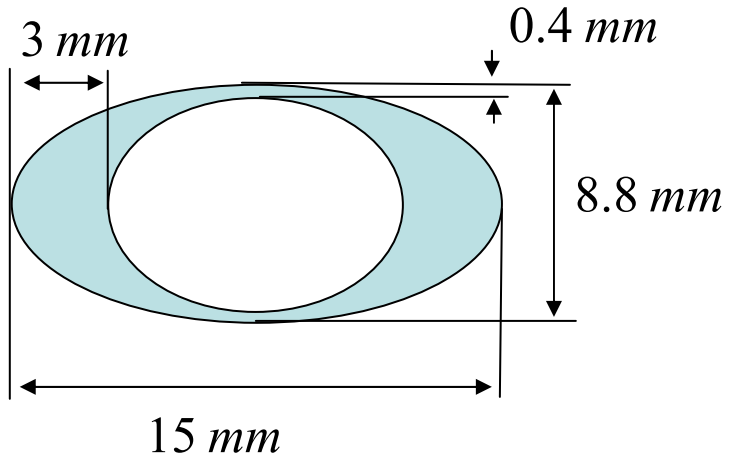
Flange gaps?
Belows?
???

Absorber

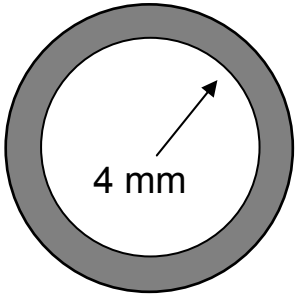

layout of tapered absorber
front view
side view –
small shadow angle
top view – large
shadow angle


5 mm
4 mm

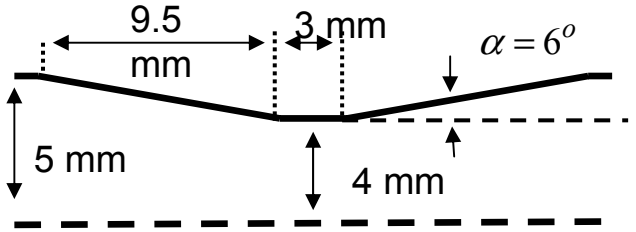

9.5 mm
3 mm
5 mm
4 mm

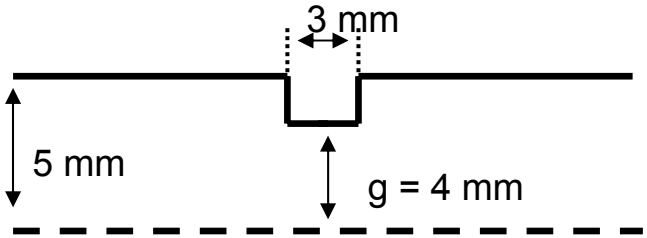

3 mm
0.4 mm
8.8 mm
15 mm

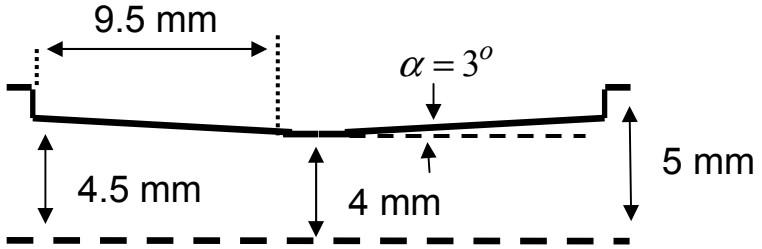
Absorber. Effect of Tapering

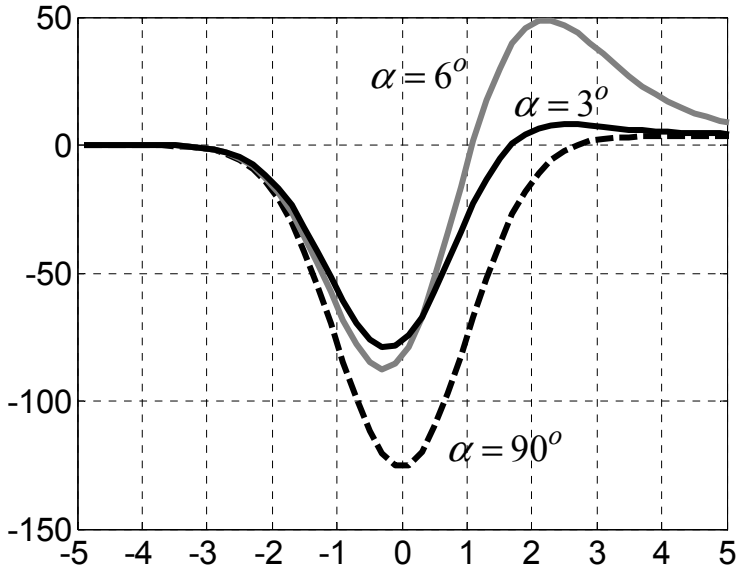


$$\alpha \sim \frac{\sigma}{g} \approx 0.4^o$$



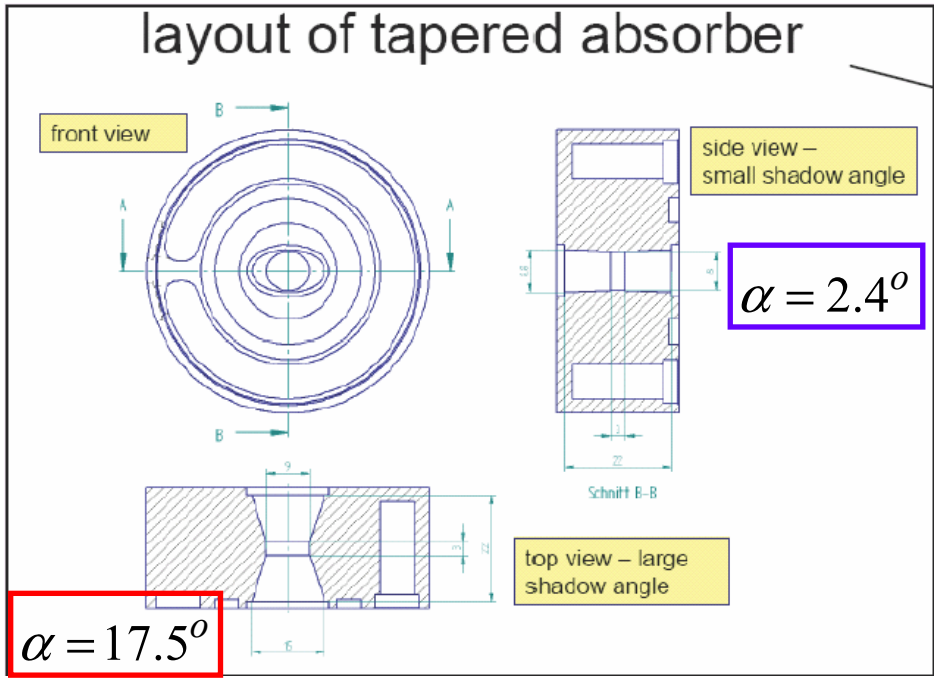


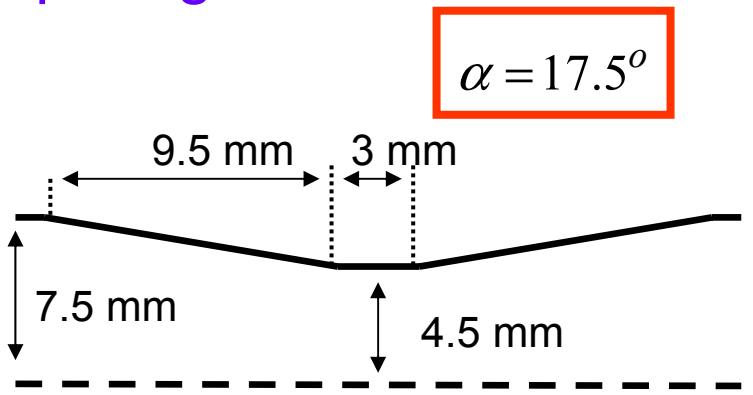




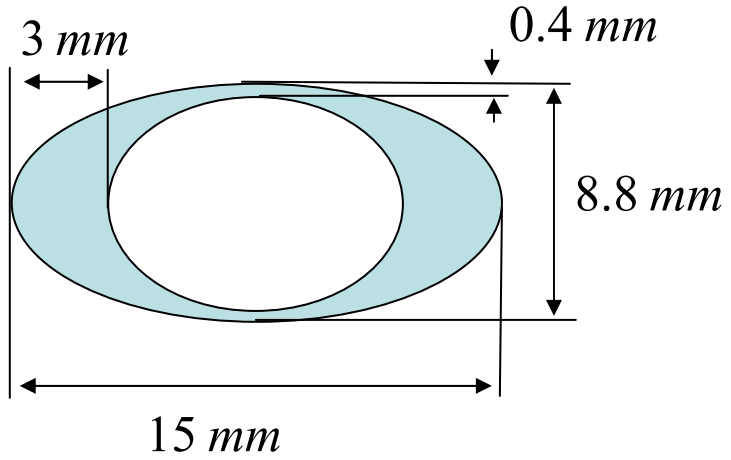
	Loss, V/pC	Spread, V/pC
step	**89**	**35**
taper	48	39
taper +step	**52**	**26**

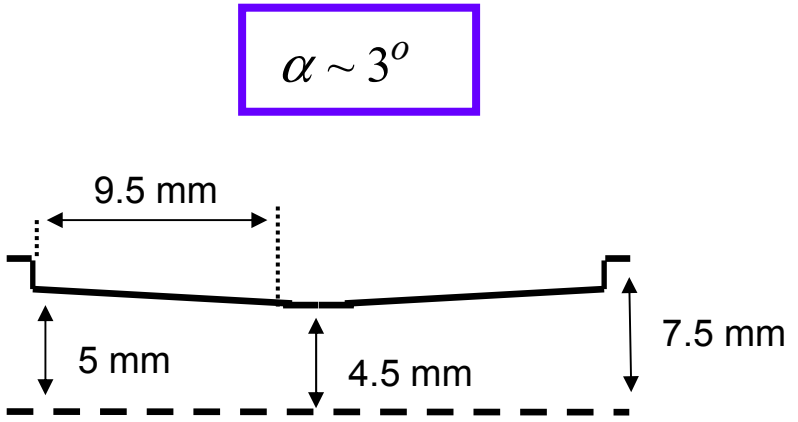
Absorber. Effect of Tapering





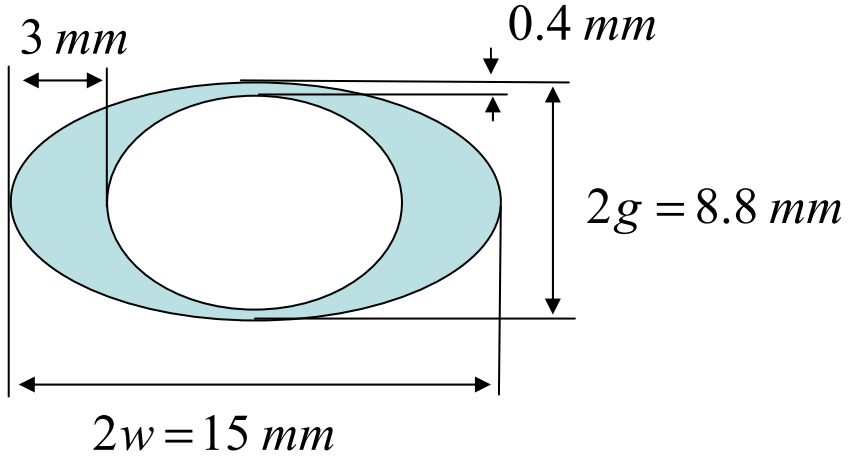
This taper has no effect.





The taper angle should be about 3 grad.

Absorber. Long Elliptical Step Collimator



Loss=86 V/pC

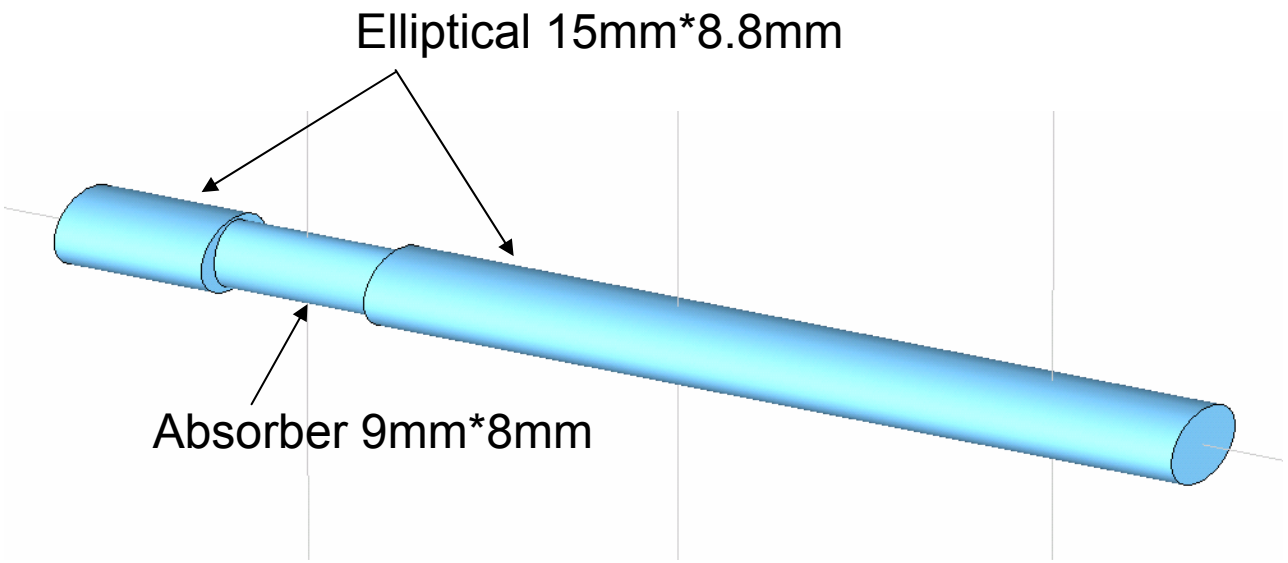
$$G(x,y,x_0,y_0) = G^0(x,y,x_0,y_0) - G^0(0,g,x_0,y_0)$$

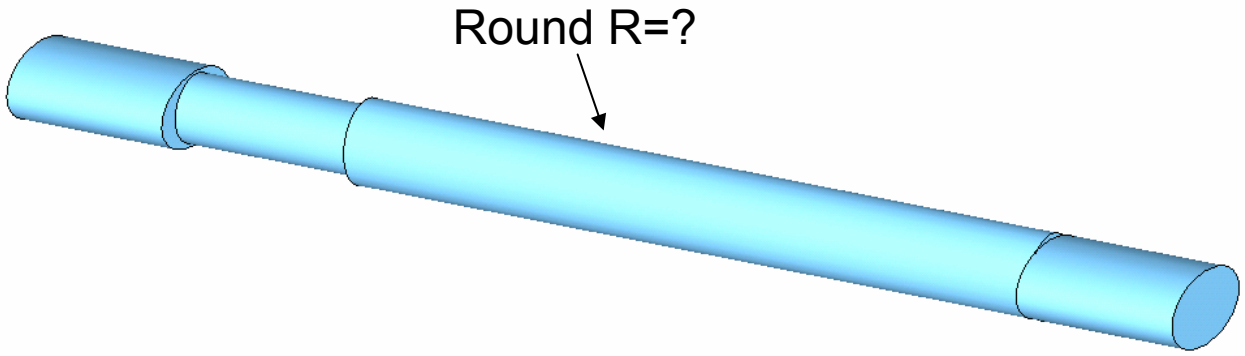
$$G^0(x,y,x_0,y_0) = -4\sum_{n=1}^{\infty}\frac{e^{-nu_0}}{n}\left[\frac{\mathrm{Re}\,T_n\left(\frac{x+iy}{d}\right)\mathrm{Re}\,T_n\left(\frac{x_0+iy_0}{d}\right)}{\cosh(nu_0)} + \frac{\mathrm{Im}\,T_n\left(\frac{x+iy}{d}\right)\mathrm{Im}\,T_n\left(\frac{x_0+iy_0}{d}\right)}{\sinh(nu_0)}\right] - \ln\left[(x-x_0)^2+(y-y_0)^2\right]$$

G.Stupakov, K.L.F.Bane, I.Zagorodnov
„Optical approximation in the theory of geometric impedance“, in preparation

The semi-analytical approach developed in the paper allows to calculate high-frequency impedance of any short transition.

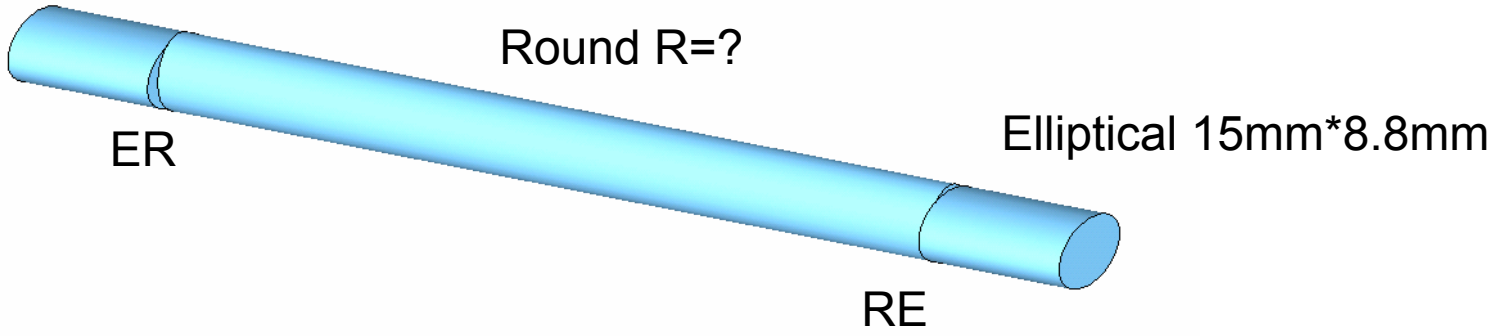
Absorber+Round Pipe

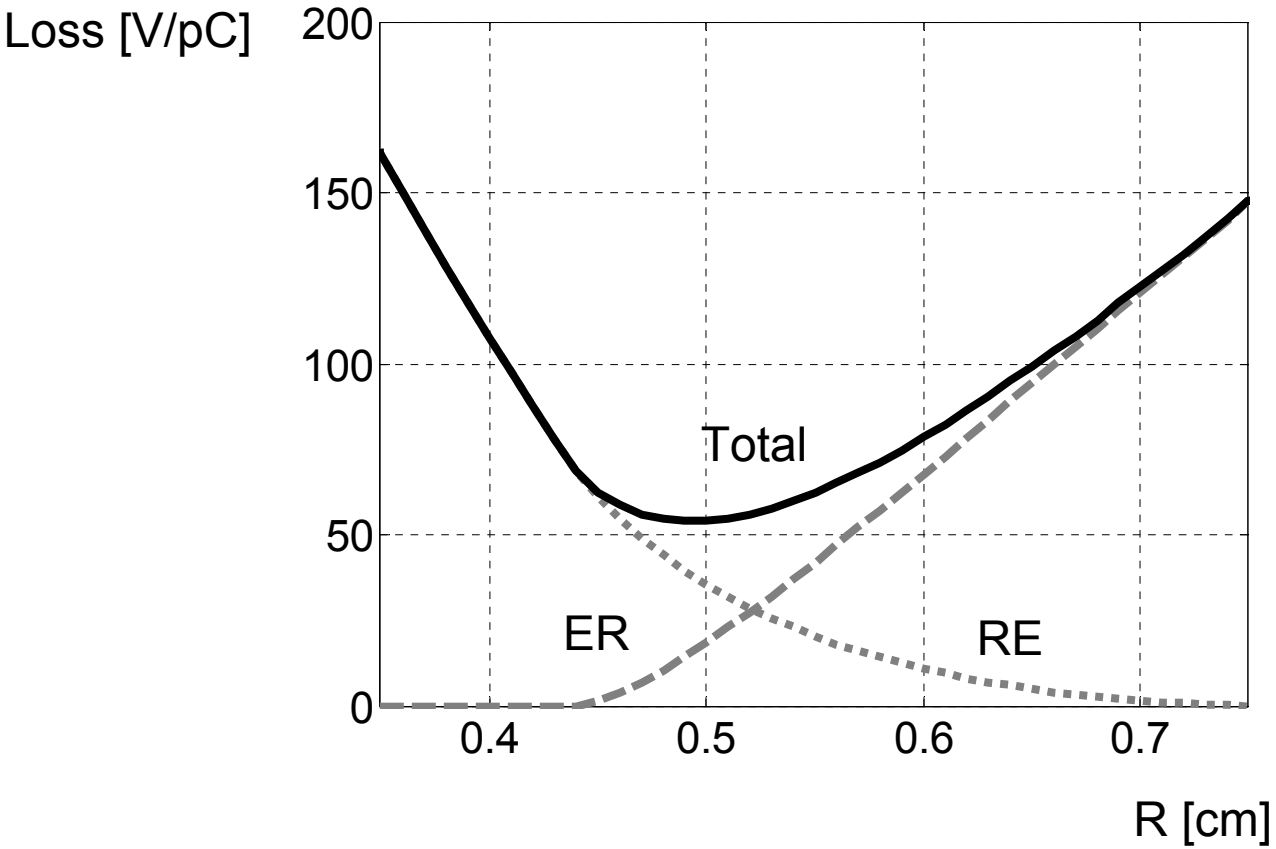




Elliptical+Round Pipe

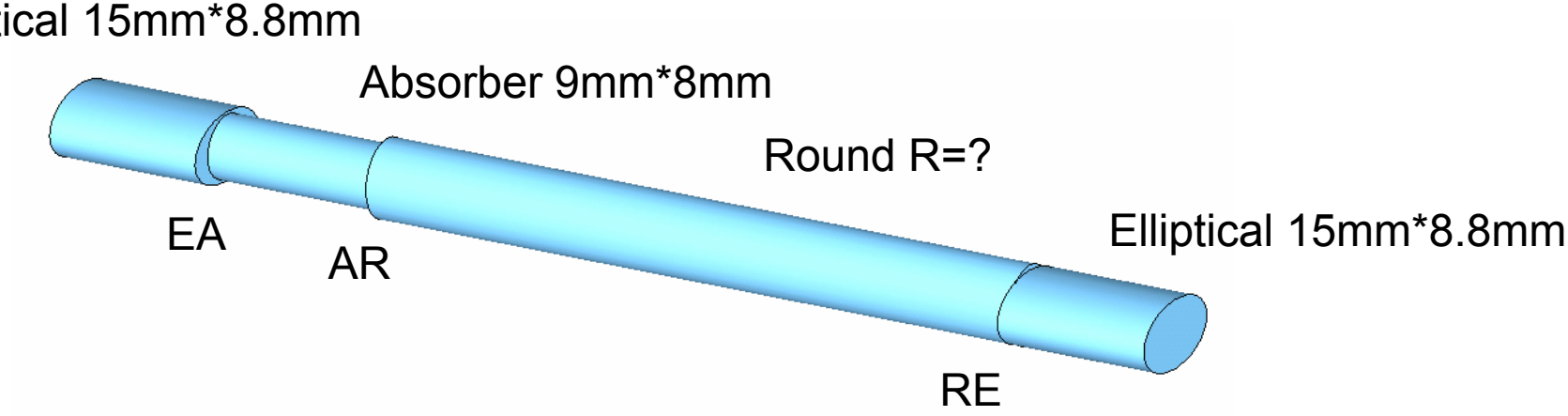
Elliptical 15mm*8.8mm

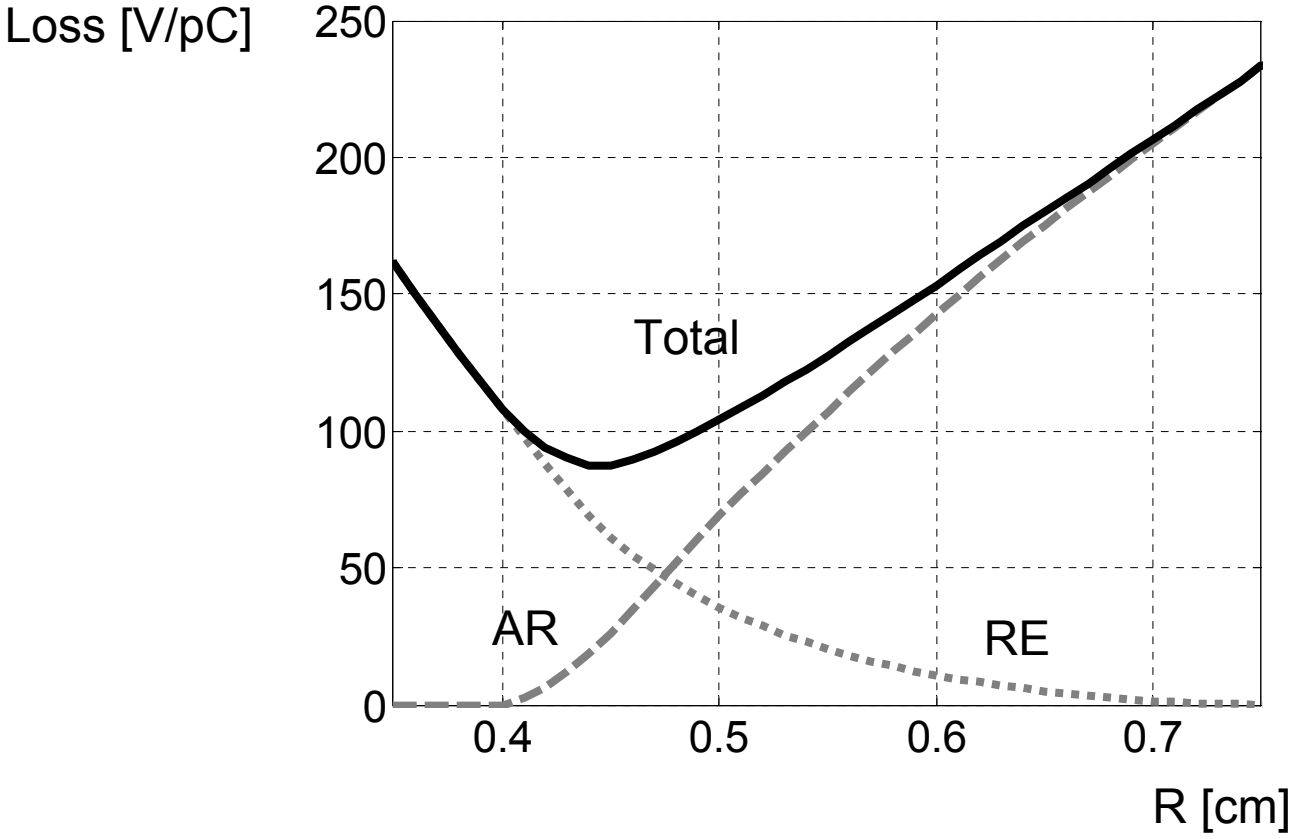




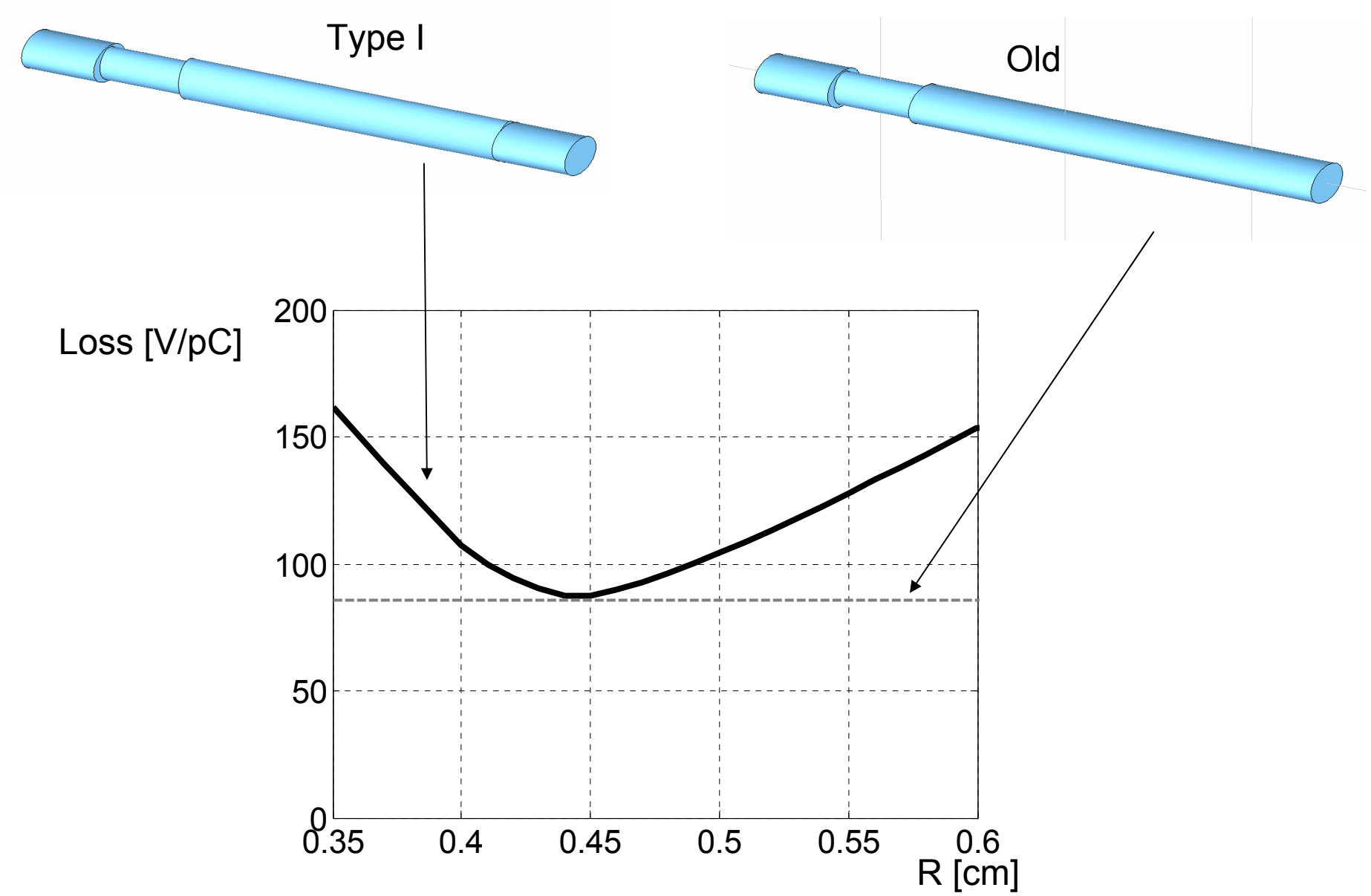
Let us forget about absorber and suggest that we want to have a round pipe.
Why do not take a round absorber with R=5mm?

Absorber+Round Pipe+Elliptical Pipe

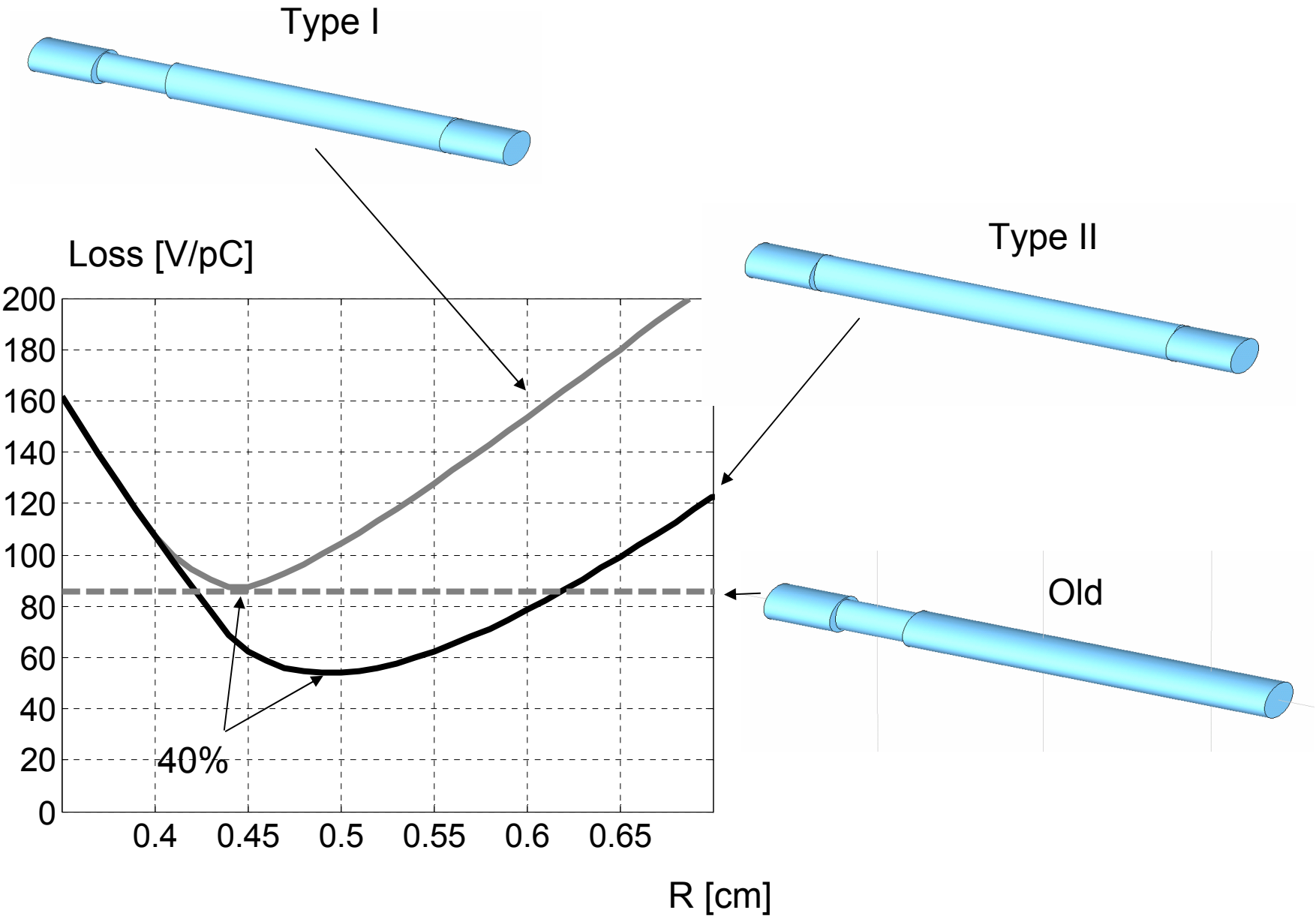




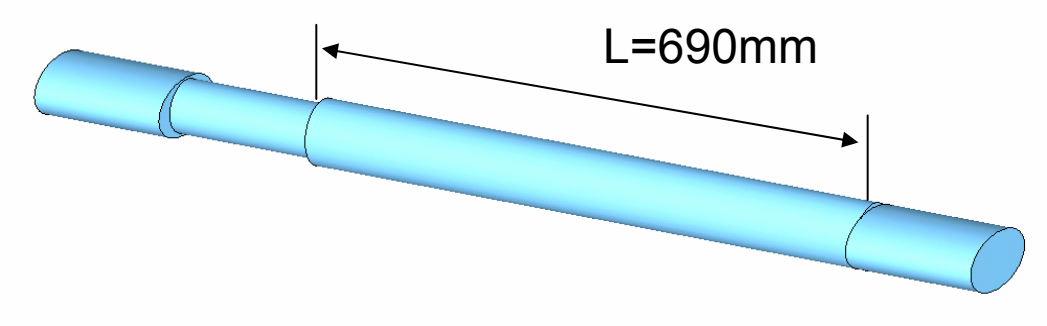
Geometric Wakes

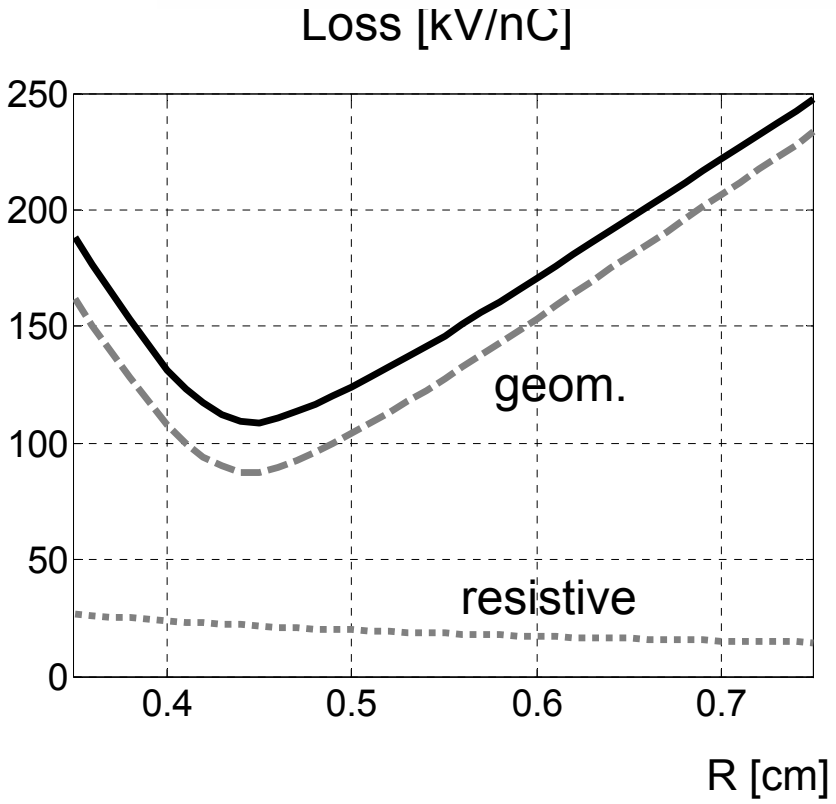


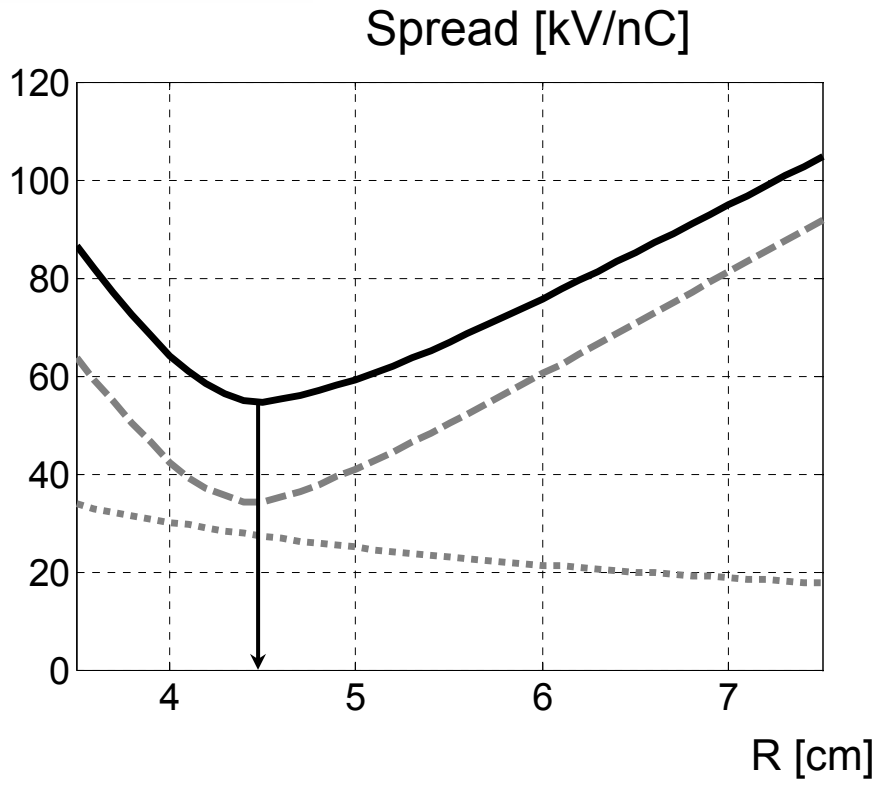
Geometric Wakes



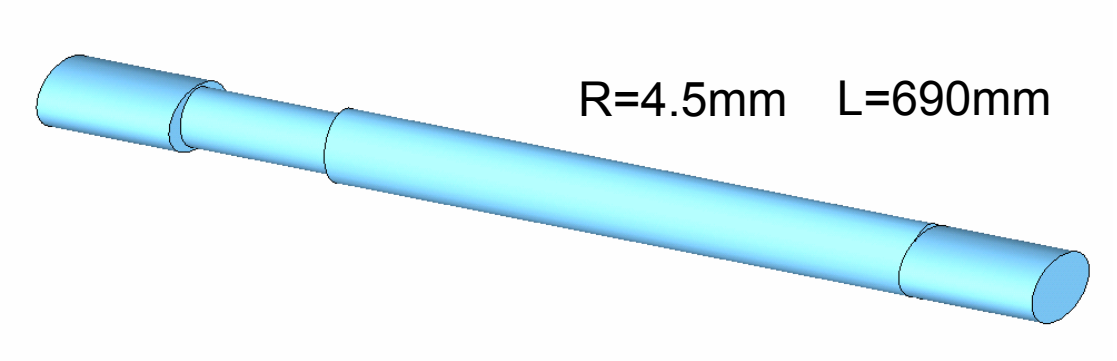
Geometric+Resistive Wakes

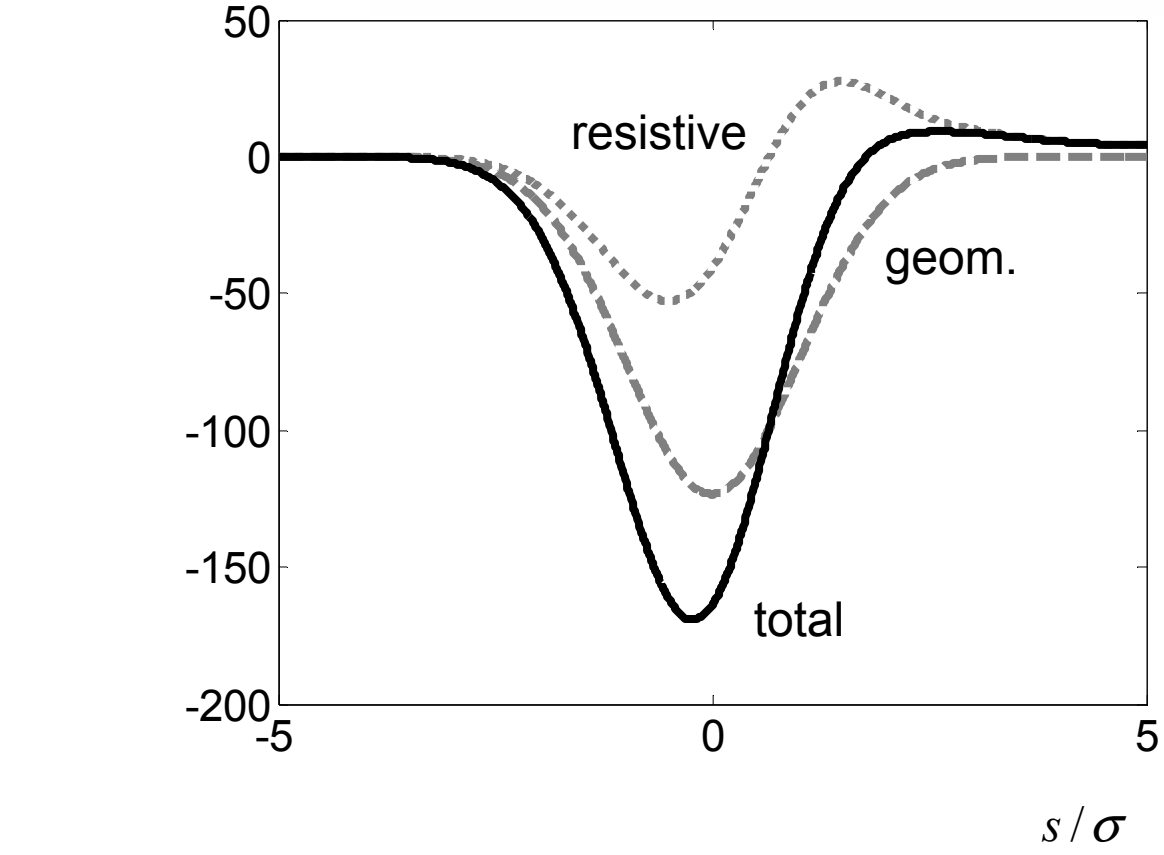






Geometric+Resistive Wakes



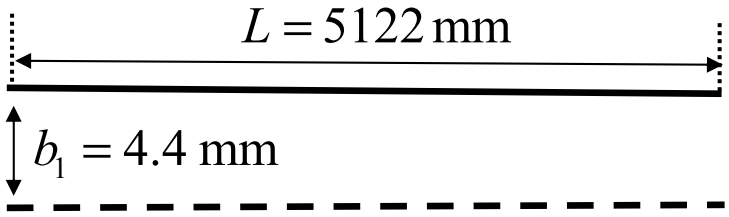


	Loss, V/pC	Spread, V/pC
res.	**22**	**27**
geom.	**87**	**34**
total	**109**	**55**

Main Pipe (resistive+oxid layer+roughness)

(T.Wohlenberg)

Materialauswahl:	zu erwartende Oxidschicht:
Aluminium:	5nm
Kupfer:	nach 10min ca. 1nm bis 5nm
Gold	Annahme 0nm



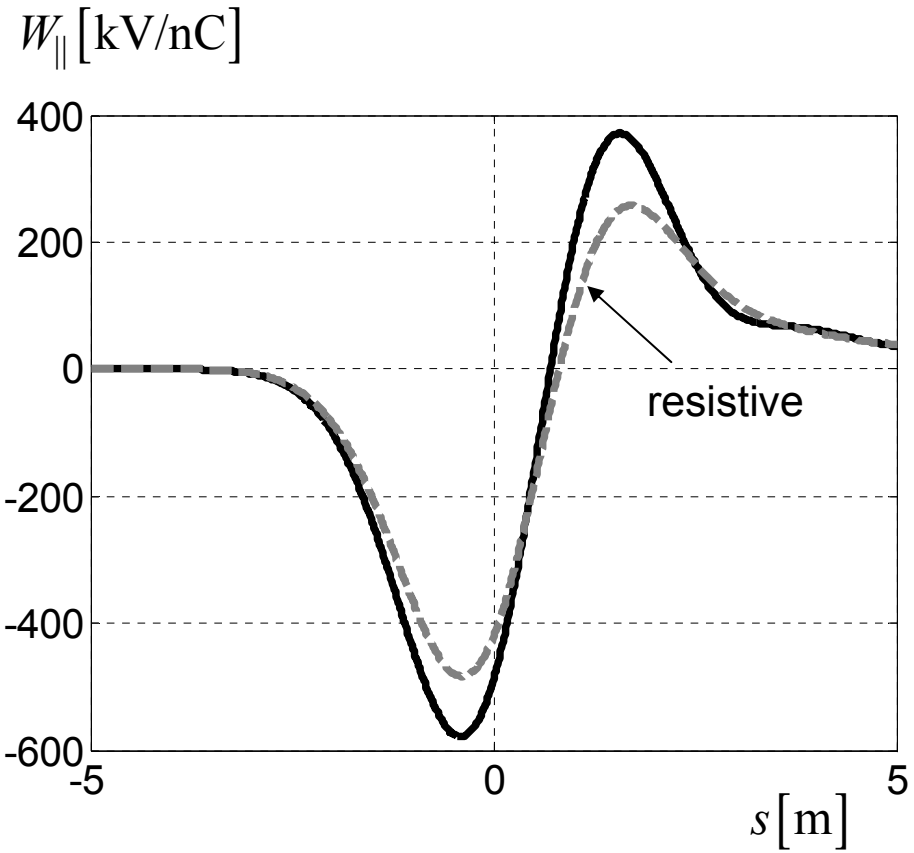
Aluminium

$$\sigma = 3.66 \cdot 10^{7}\,[\Omega^{-1}\mathrm{m}^{-1}]$$

$$\tau = 7.1 \cdot 10^{-15}\,[\mathrm{sec}]$$

$$\Delta_{rough} = 600\,[\mathrm{nm}]$$

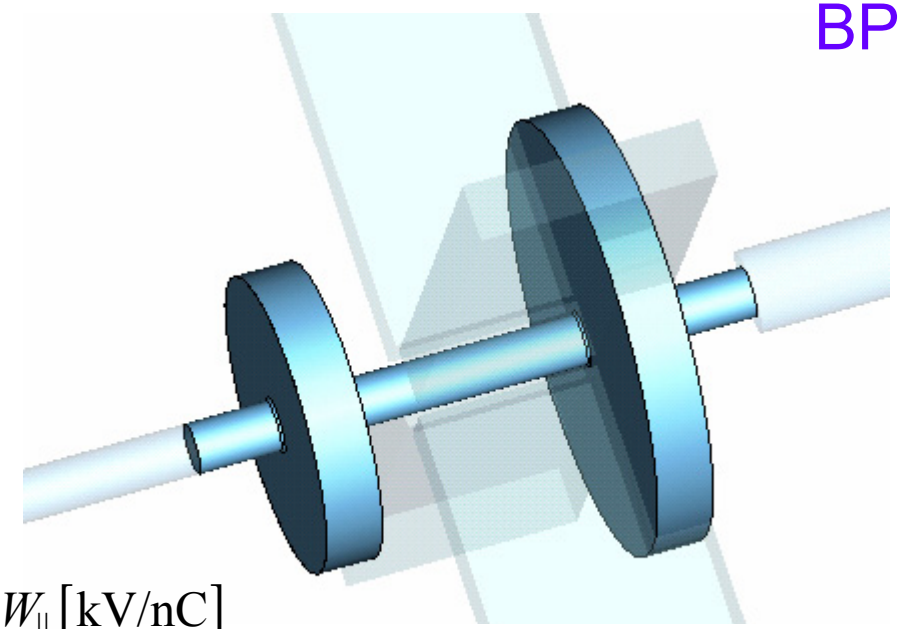
$$\Delta_{oxid} = 5\,[\mathrm{nm}]$$

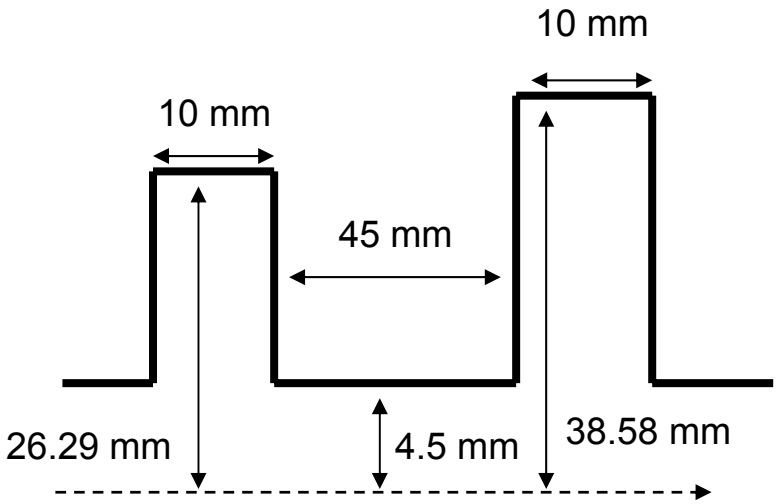


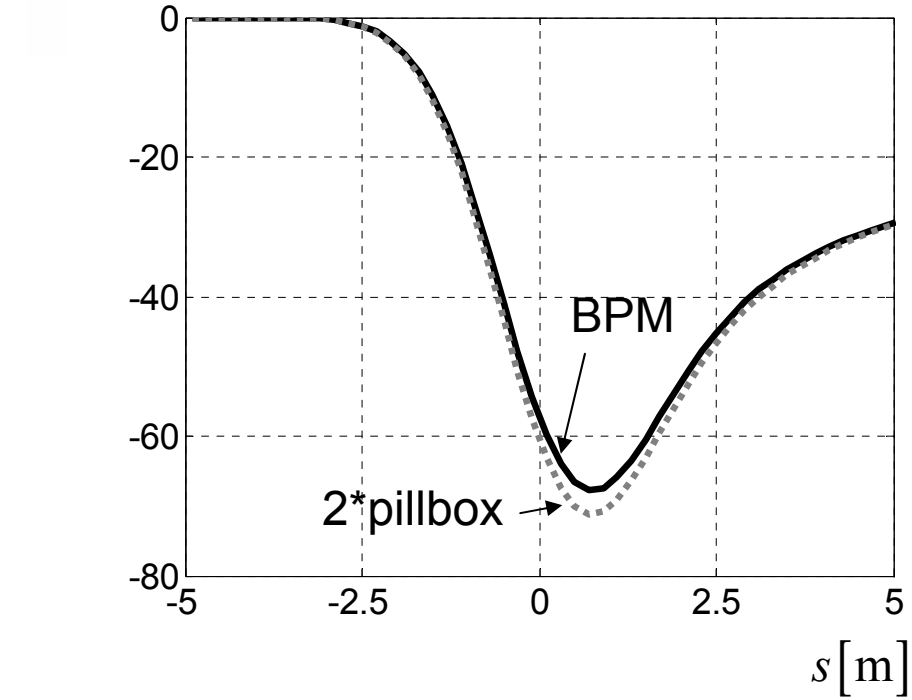
kV/nC

	resistive	total
Loss	225	241
Spread	238	310

BPM







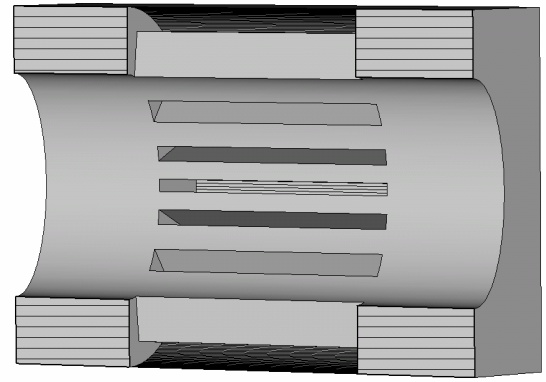
kV/nC

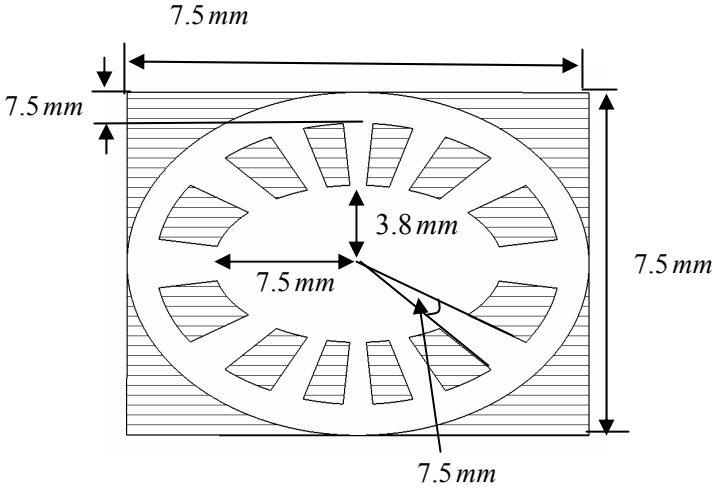
	only first pillbox	total
Loss	25	48
Spread	10	19

Pumping Slots

Pumpschlitzgeo. im Pumpkreuz:	Breite 1mm, Länge 20-25mm Anzahl 12 Stück/Kreuz Pumpschlitz in Strahllängsrichtung
Pumpschlitzgeo. am Schiebestück:	Breite 1mm,Länge 20-25mm Anzahl 8 Stück/Schiebestück

2 items?





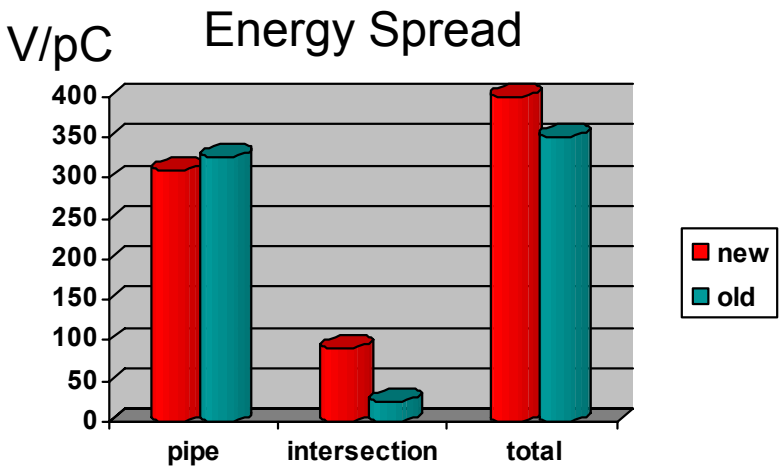
Old geometry!

kV/nC

Loss	9*2=18
Spread	4*2=8

Impedance Budget

	Undulator pipe	Pump (2 items)	BPM (2 pillboxes)	Round pipe in intersection with absorber	
	15mm* 8.8mm (5122 mm)	Old geometry	2*10mm	pipe R=4.5 absorber 8mm*9mm (690+22=712mm)	pipe R=5mm absorber R=5mm (712mm)
Loss, kV/nC	**241**	**18**	**48**	**109**	74
Spread, kV/nC	**310**	**8**	**25**	**55**	41



Old budget from TESLA-FEL 2005-10 (elliptical pipe 15*7.6 mm)

		Loss, V/pC	Spread, V/pC
Total geom.	pro section	**70**	**25**
resistive (Al)	6.1m	**303**	**325**

Conclusion

- In new budget the energy spread is larger by 14 %.
- Intersection causes about 25 % of the energy spread.
- Round pipe with R=4.5 mm does not increase longitudinal wake.
- To suppress the geometric wake the tapers should be less than 3 grad.
- Why do not take a round absorber with R=5mm?
- A description of 216 mm? (bellows, flange gaps, etc)