

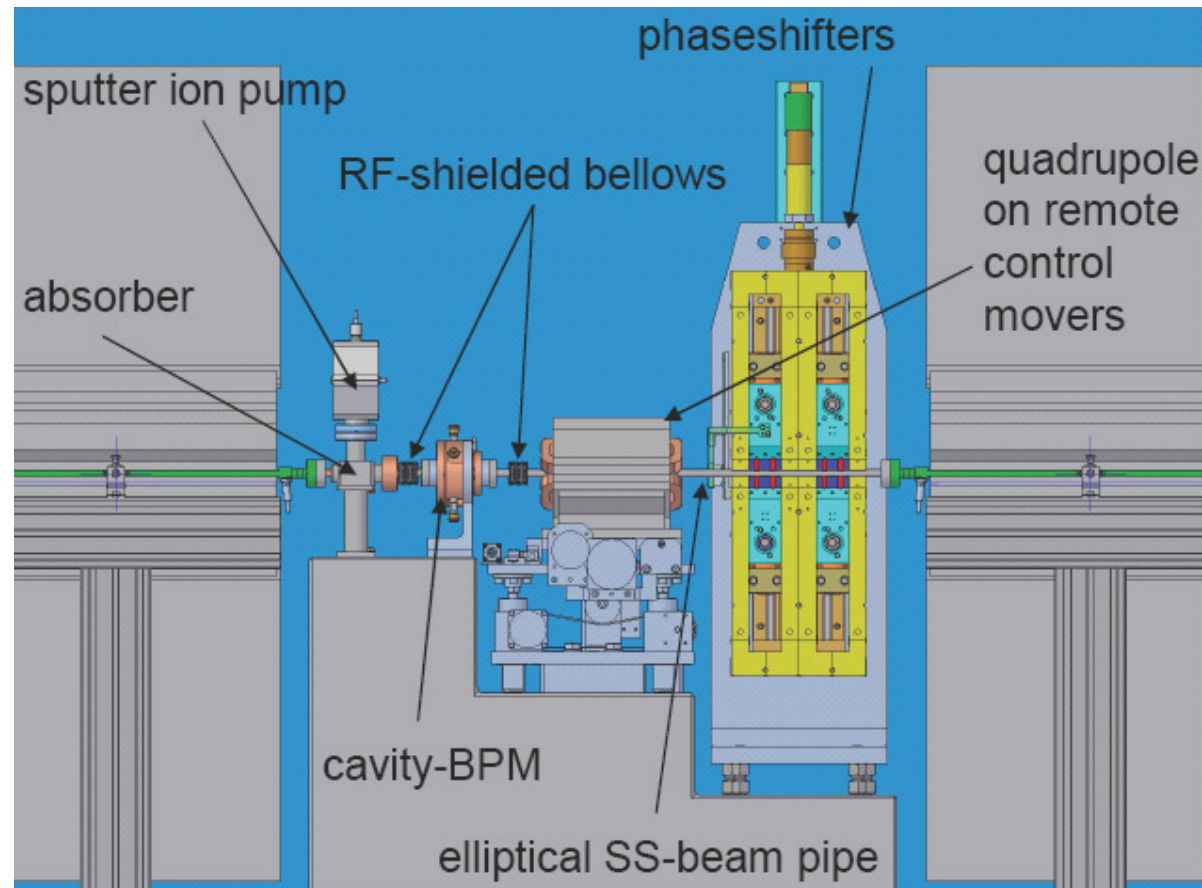


Wakefields in XFEL undulator intersections

Igor Zagorodnov

Beam Dynamics Group Meeting

26.02.07



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

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

extruded aluminium chamber

Aluminium

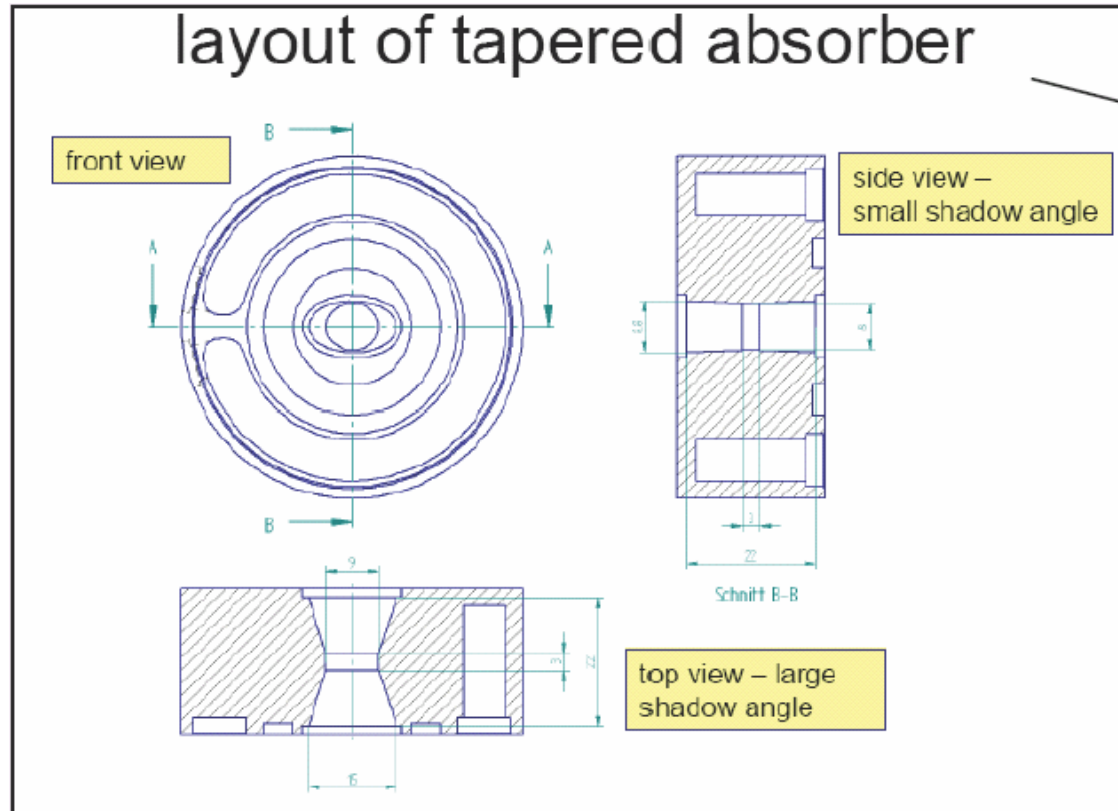
$$\sigma = 3.66 \cdot 10^7 [\Omega^{-1} \text{m}^{-1}]$$

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

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

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

Elliptical chamber length = 5122 mm



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

Copper

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

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

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

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

Absorber length = 22 mm

Cavity BPM design, Dirk Lipka

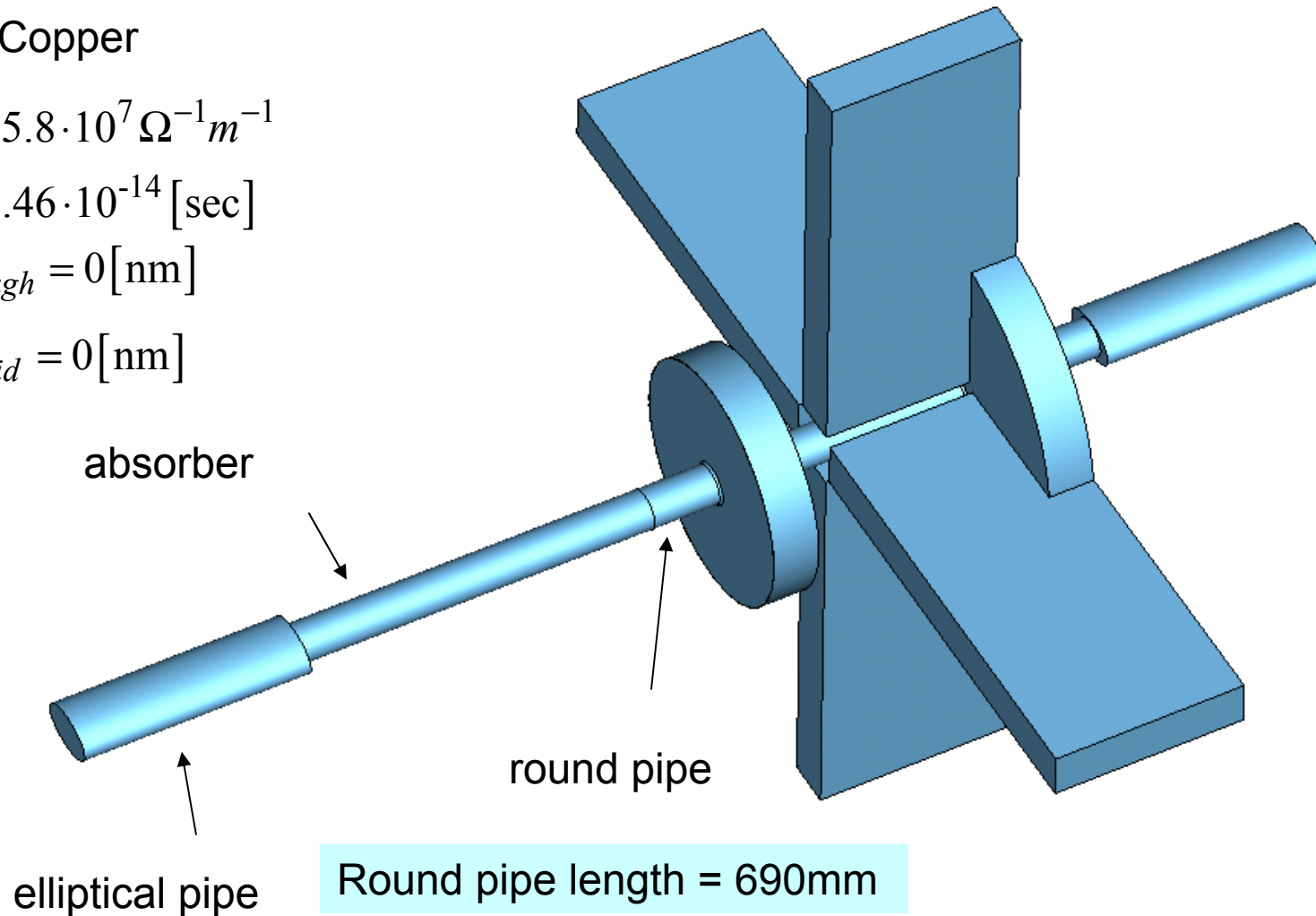
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Elements

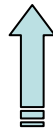
Elliptical chamber = 5122 mm

Absorber = 22 mm

Round pipe = 690 mm

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

Pumping slots = $2 \cdot 25 = 50$ mm



Pumpschlitzgeo.
im Pumpkreuz:

Breite 1mm, Länge 20-25mm
Anzahl 12 Stück/Kreuz
Pumpschlitz in Strahlängsrichtung

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

$$5122+22+690+50=5884 \text{ mm}$$

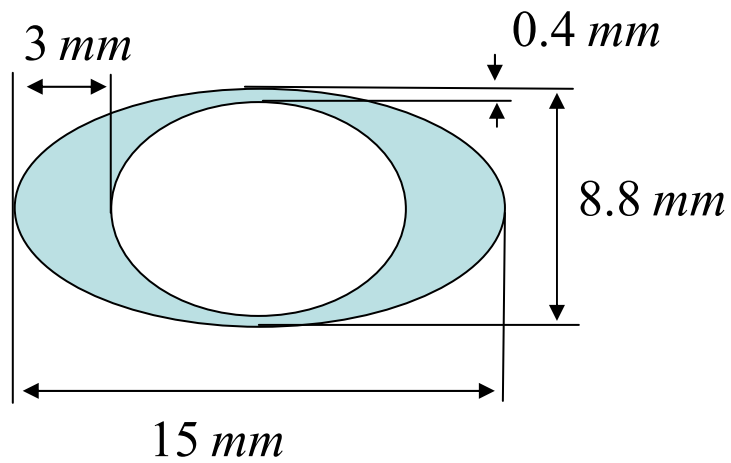
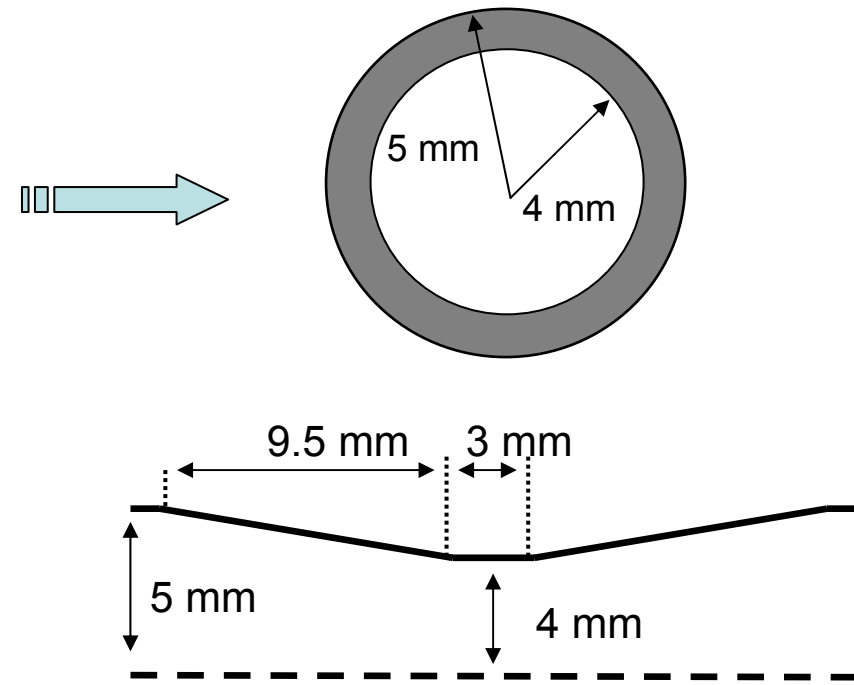
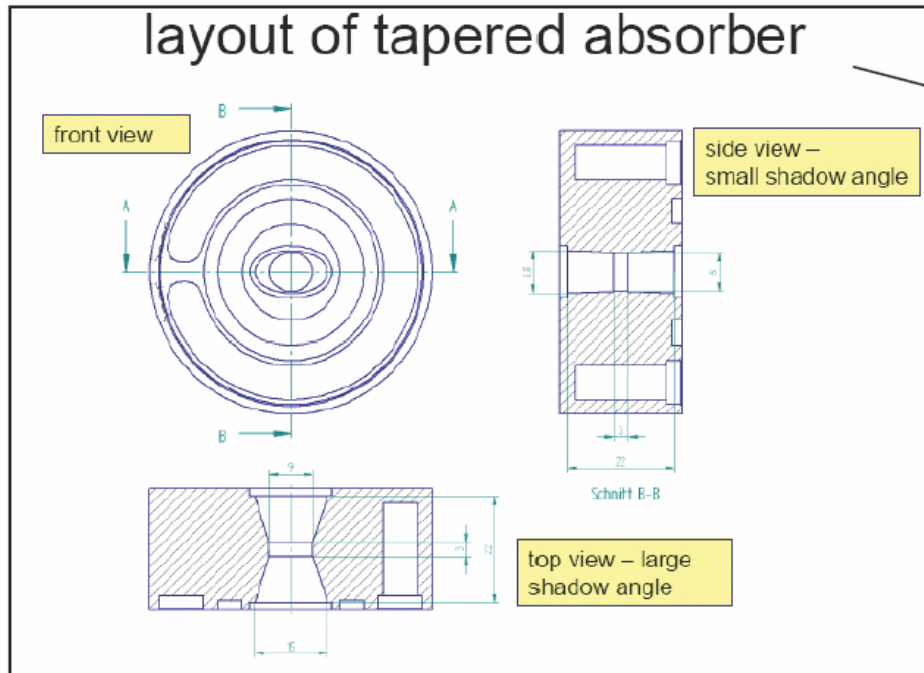
Not considered
(see TESLA FEL 2005-10)

216 mm

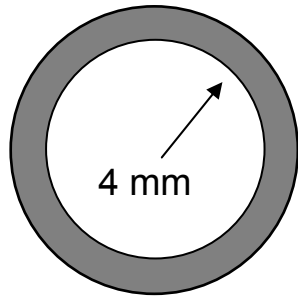
$$(5000+1100)-5884=266$$

Flange gaps?
Belows?
???

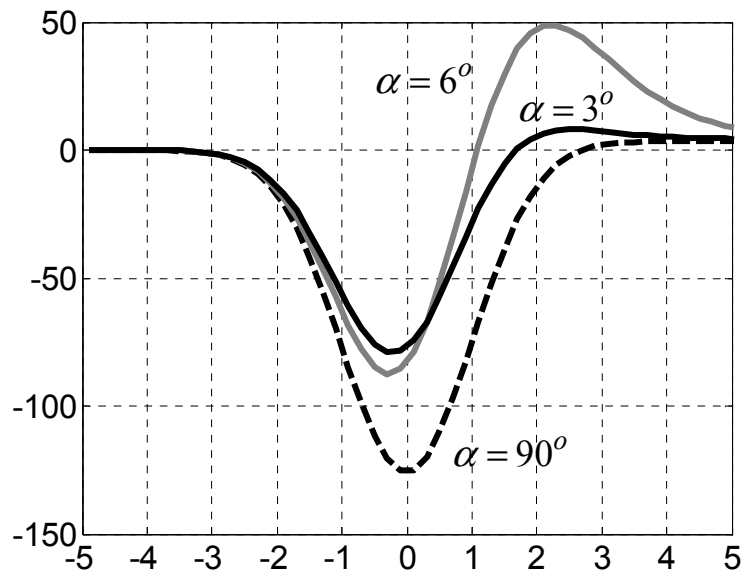
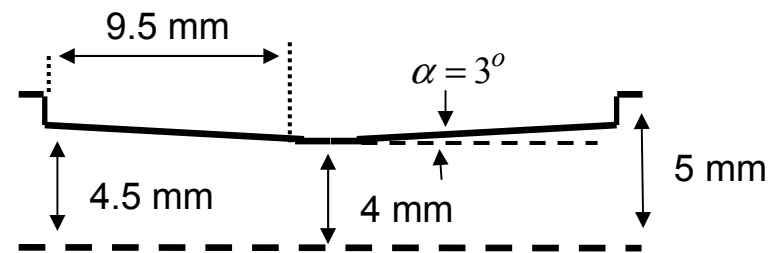
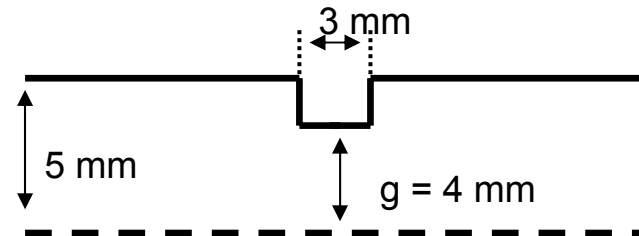
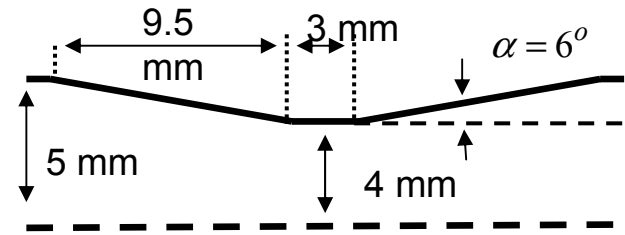
Absorber



Absorber. Effect of Tapering

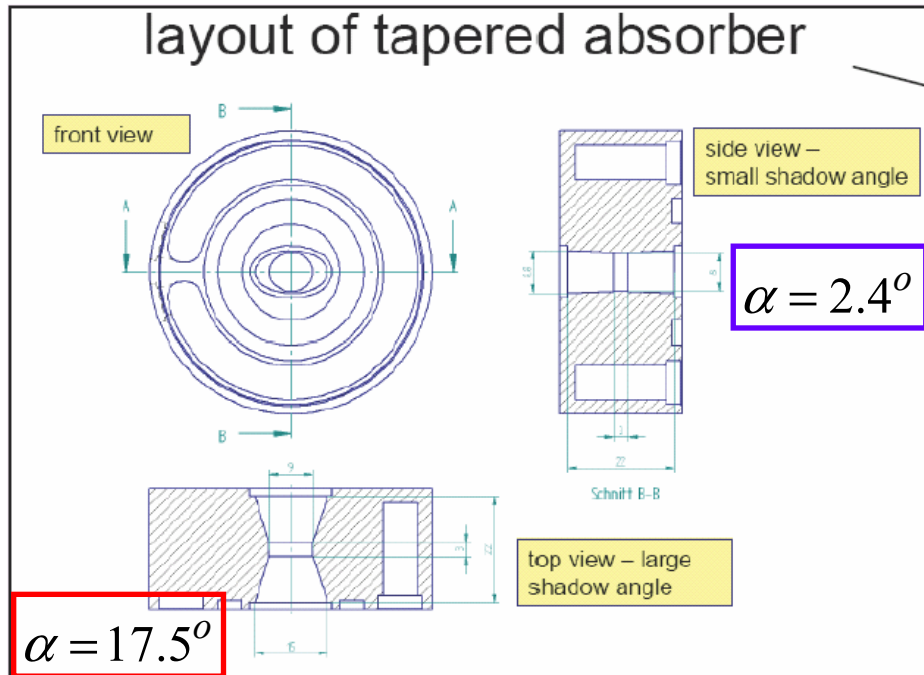


$$\alpha \sim \frac{\sigma}{g} \approx 0.4^\circ$$

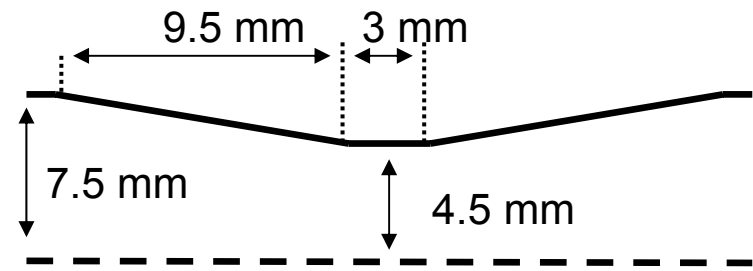


	Loss, V/pC	Spread, V/pC
step	89	35
taper	48	39
taper +step	52	26

Absorber. Effect of Tapering

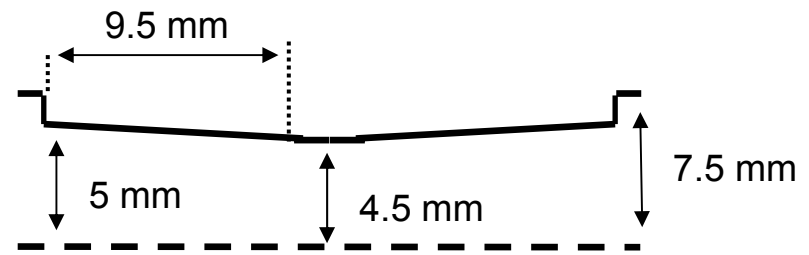
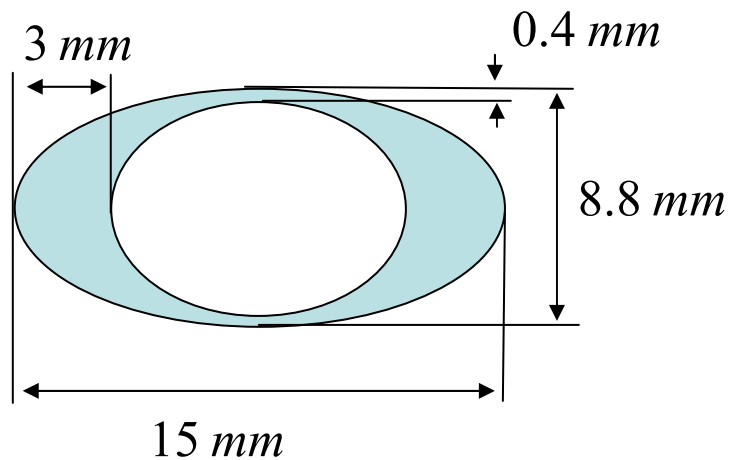


$\alpha = 17.5^\circ$



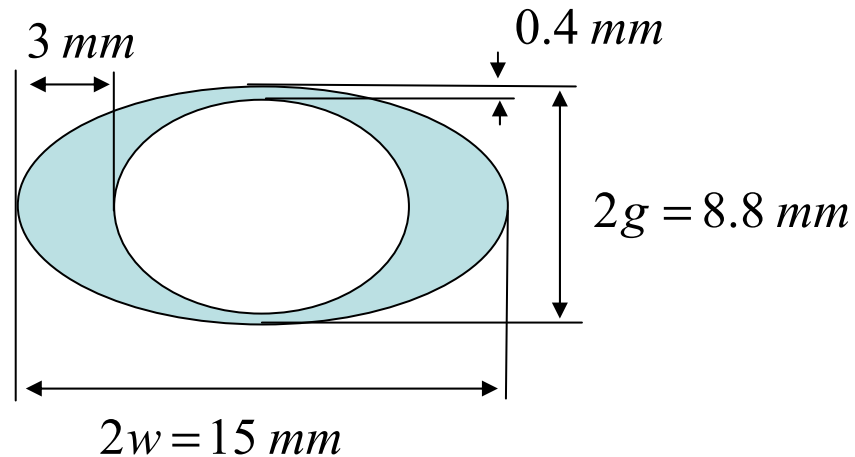
This taper has no effect.

$\alpha \sim 3^\circ$



The taper angle should be about 3 grad.

Absorber. Long Elliptical Step Collimator



Loss=86 V/pC

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

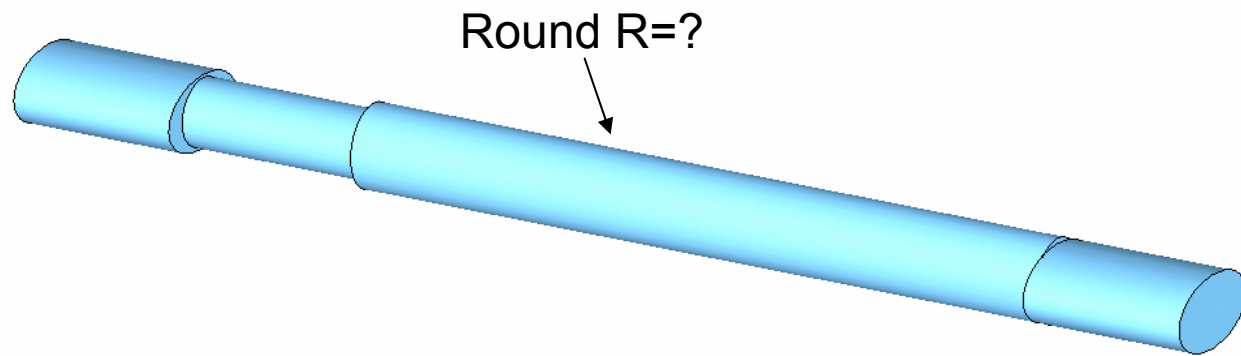
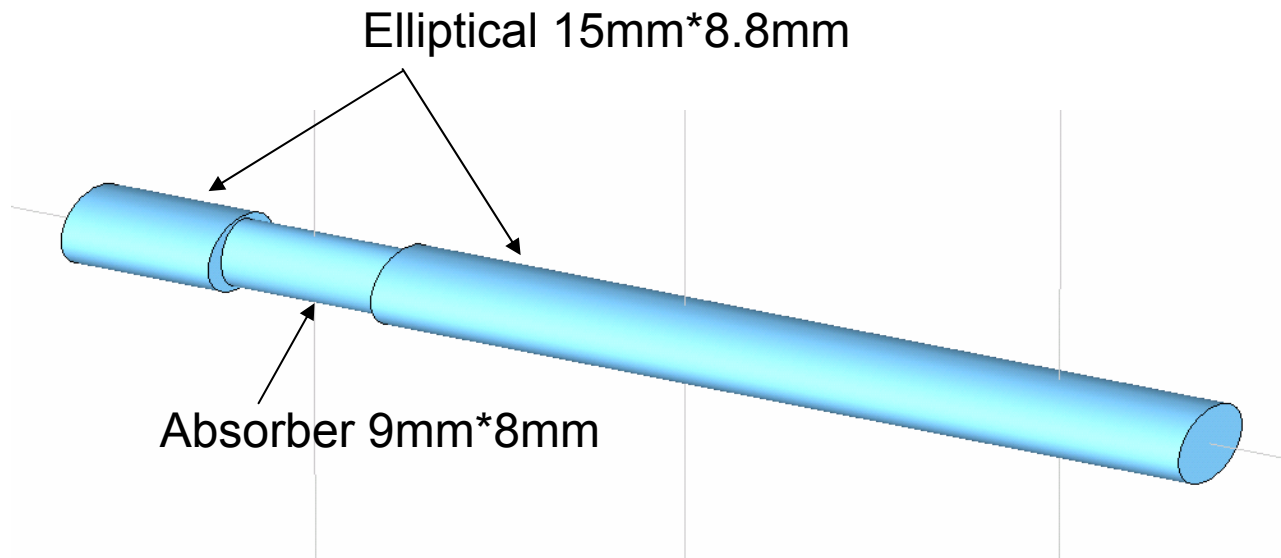
$$G^0(x, y, x_0, y_0) = -4 \sum_{n=1}^{\infty} \frac{e^{-nu_0}}{n} \left[\frac{\operatorname{Re} T_n \left(\frac{x+iy}{d} \right) \operatorname{Re} T_n \left(\frac{x_0+iy_0}{d} \right)}{\cosh(nu_0)} + \frac{\operatorname{Im} T_n \left(\frac{x+iy}{d} \right) \operatorname{Im} T_n \left(\frac{x_0+iy_0}{d}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

G.Stupakov, K.L.F.Bane, I.Zagorodnov

„Optical approximation in the theory of geometric impedance“, in preparation

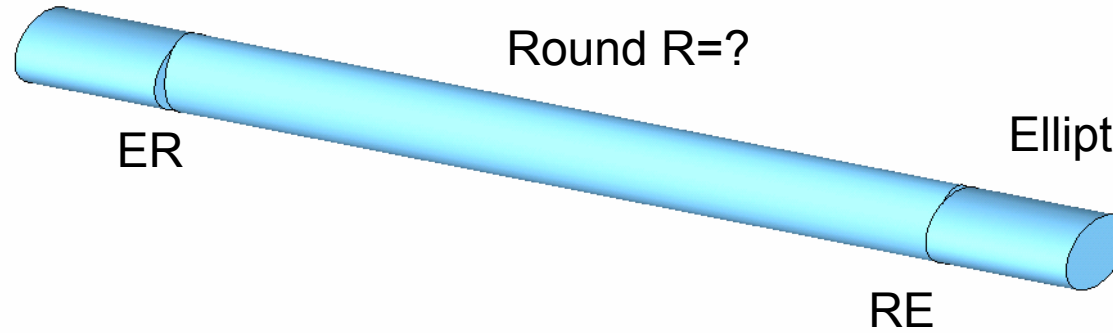
The semi-analytical approach developed in the paper allows to calculate high-frequency impedance of any short transition.

Absorber+Round Pipe



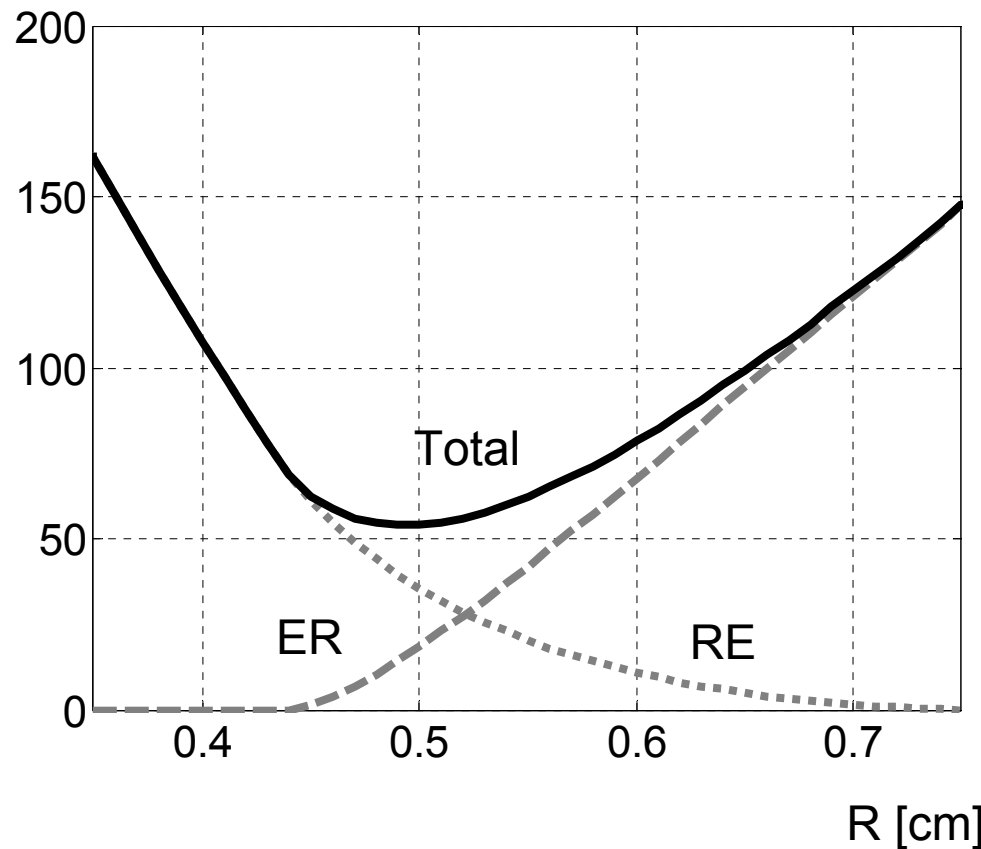
Elliptical+Round Pipe

Elliptical 15mm*8.8mm



Elliptical 15mm*8.8mm

Loss [V/pC]



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?

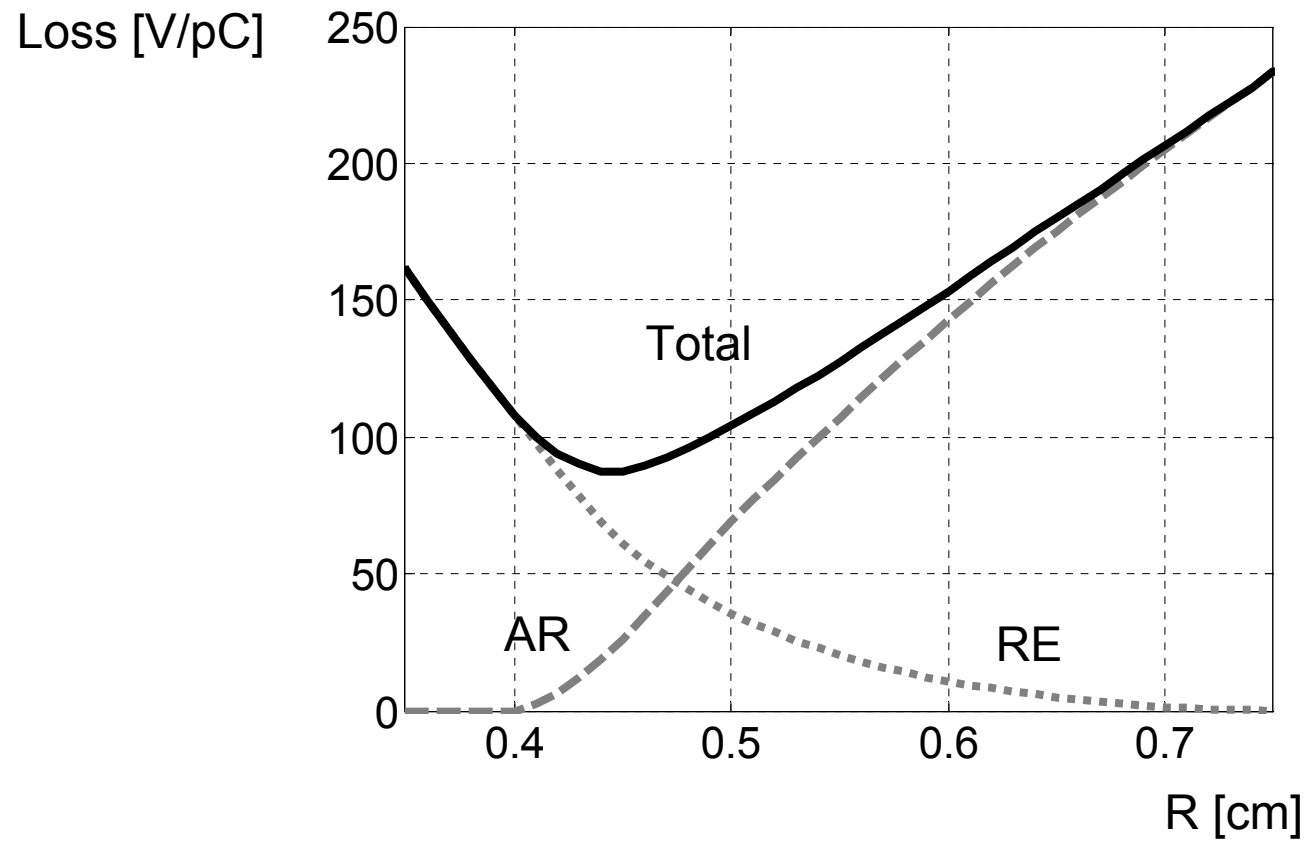
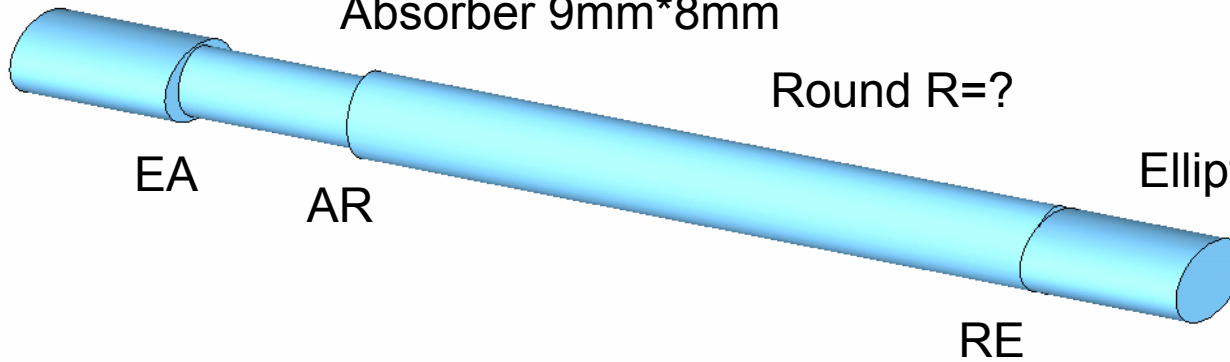
Absorber+Round Pipe+Elliptical Pipe

Elliptical 15mm*8.8mm

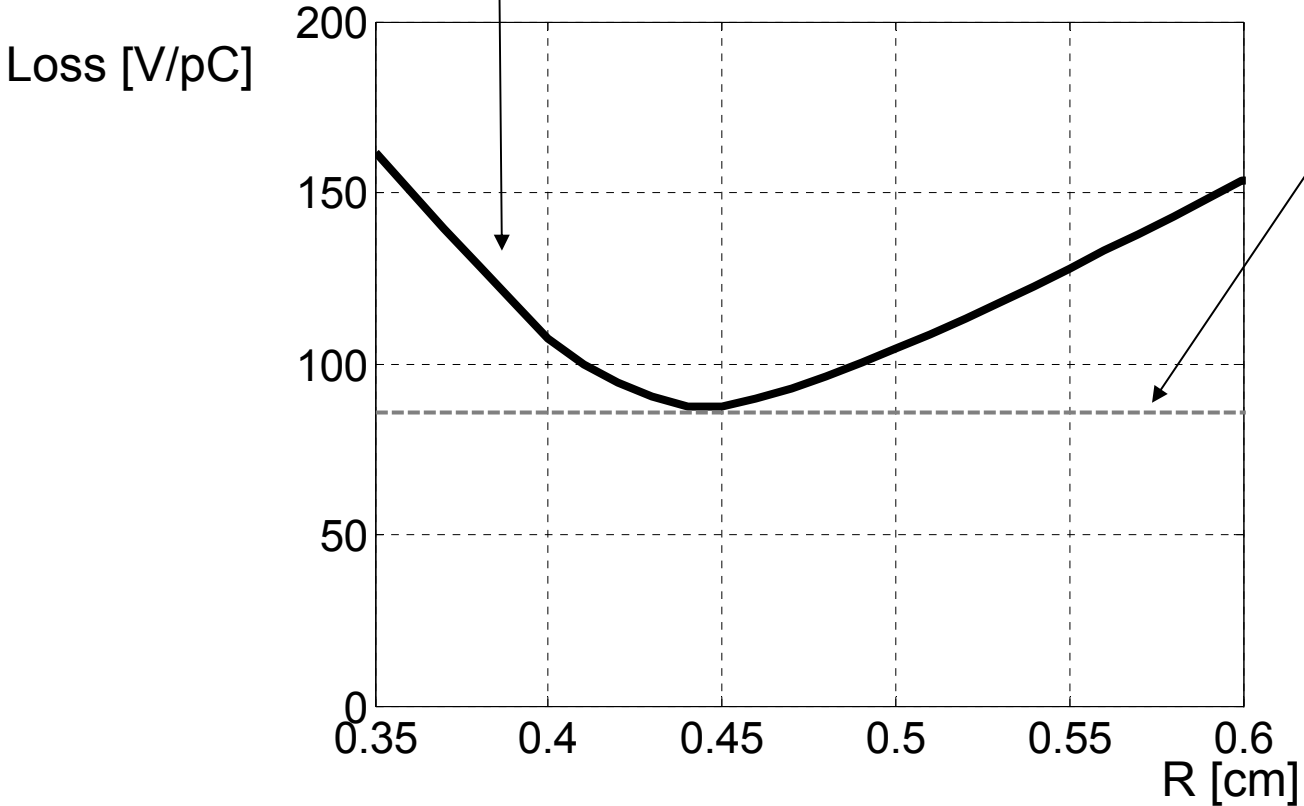
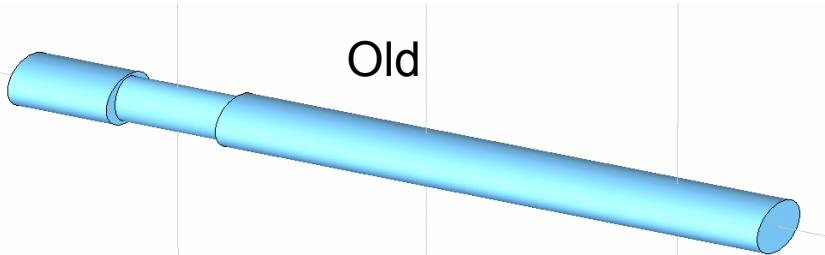
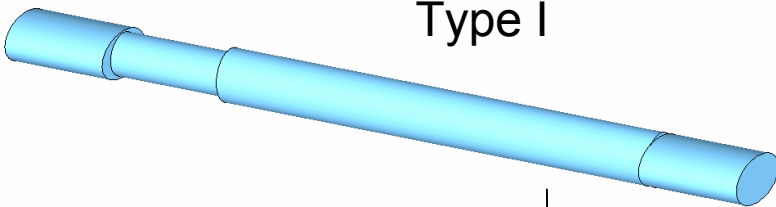
Absorber 9mm*8mm

Round R=?

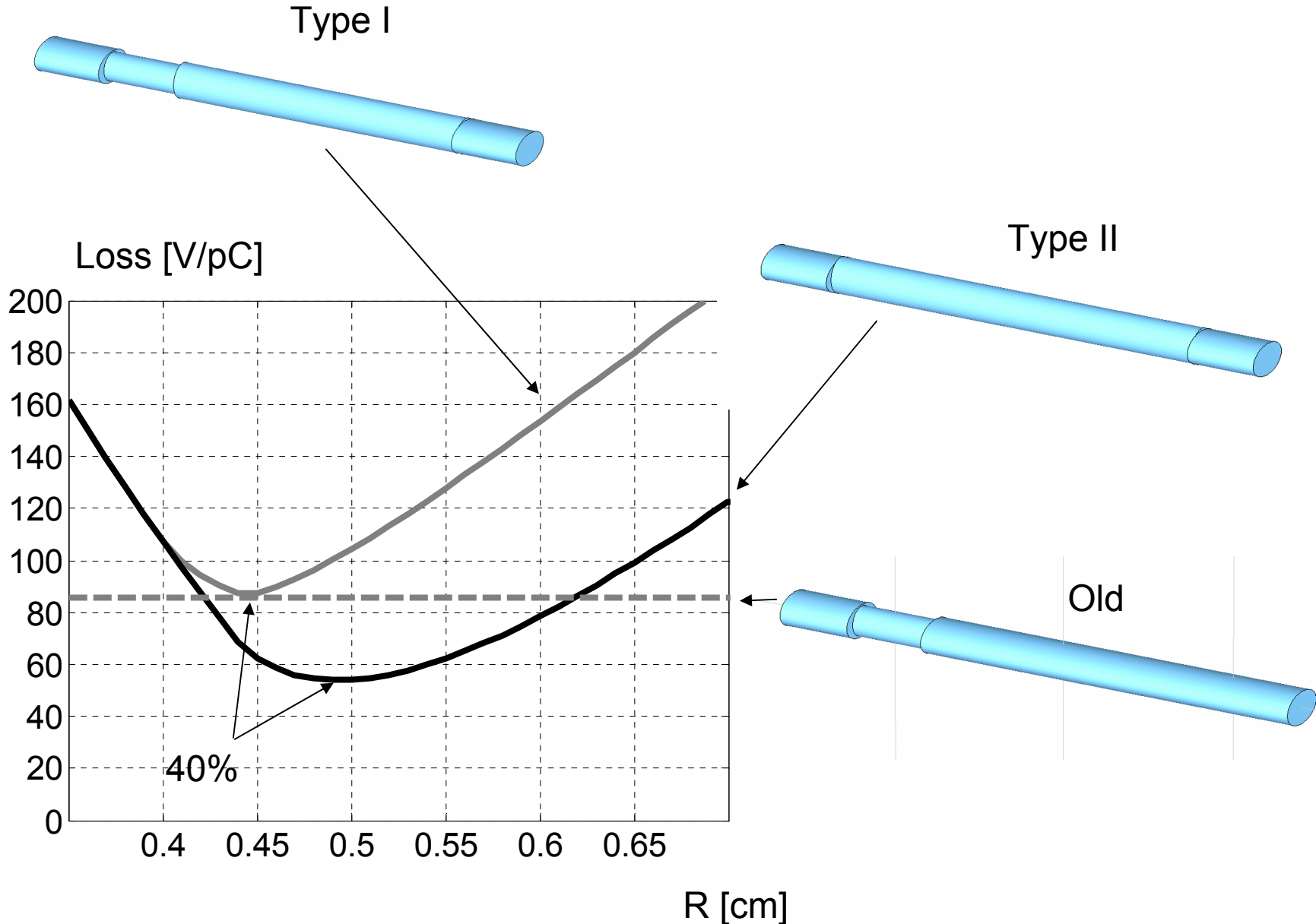
Elliptical 15mm*8.8mm



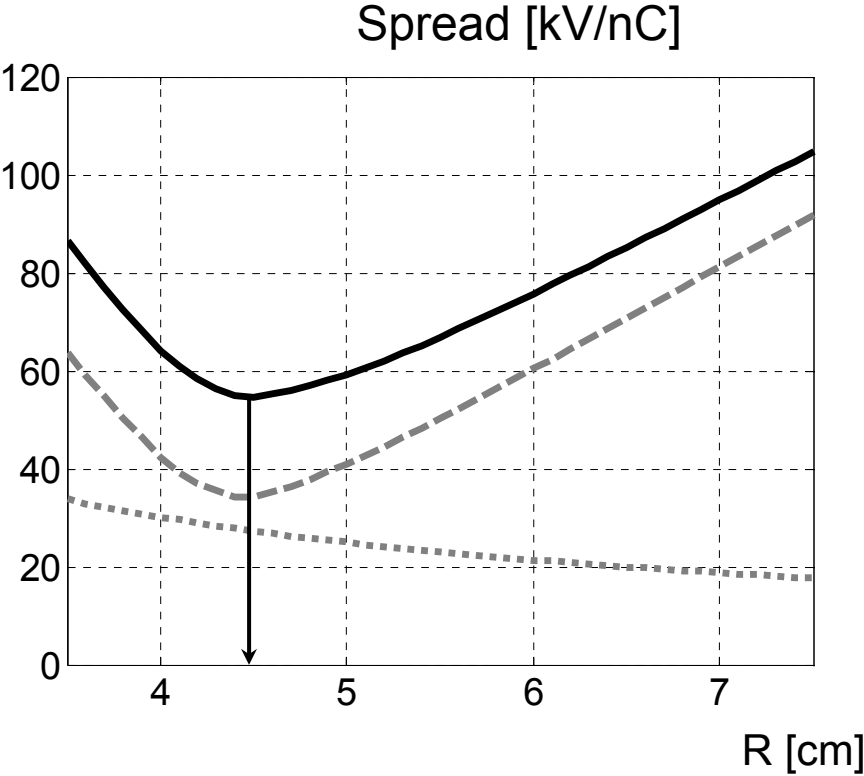
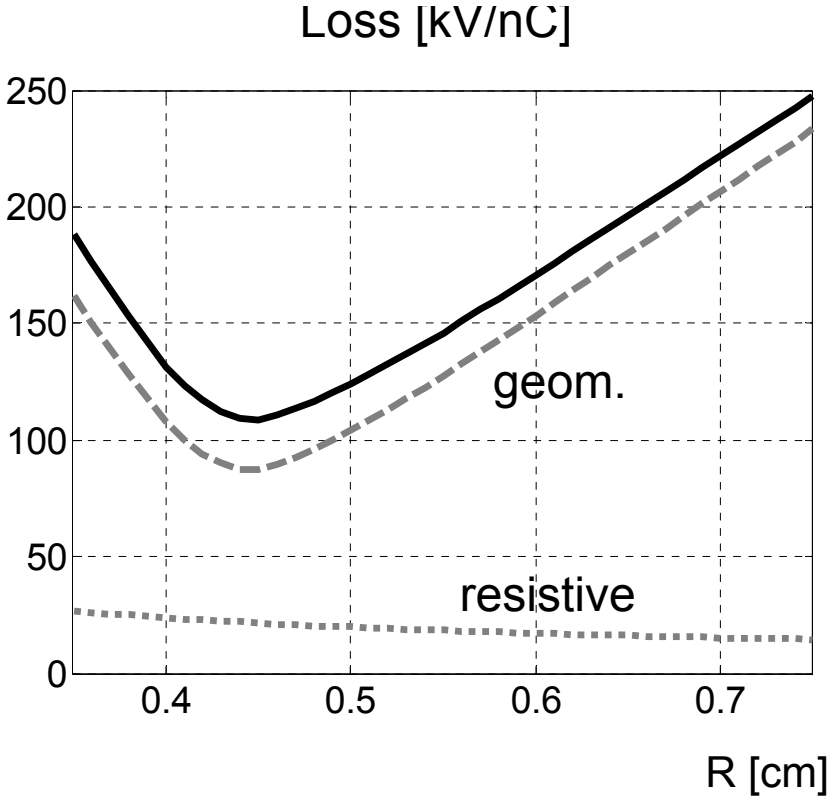
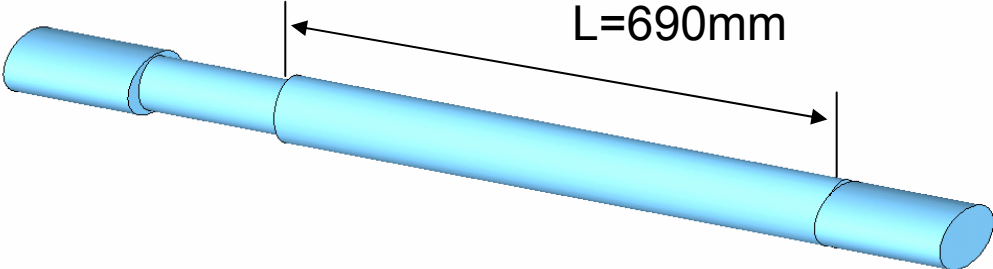
Geometric Wakes



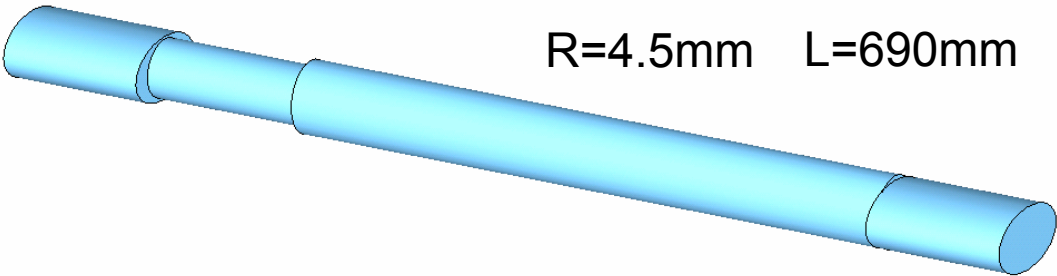
Geometric Wakes



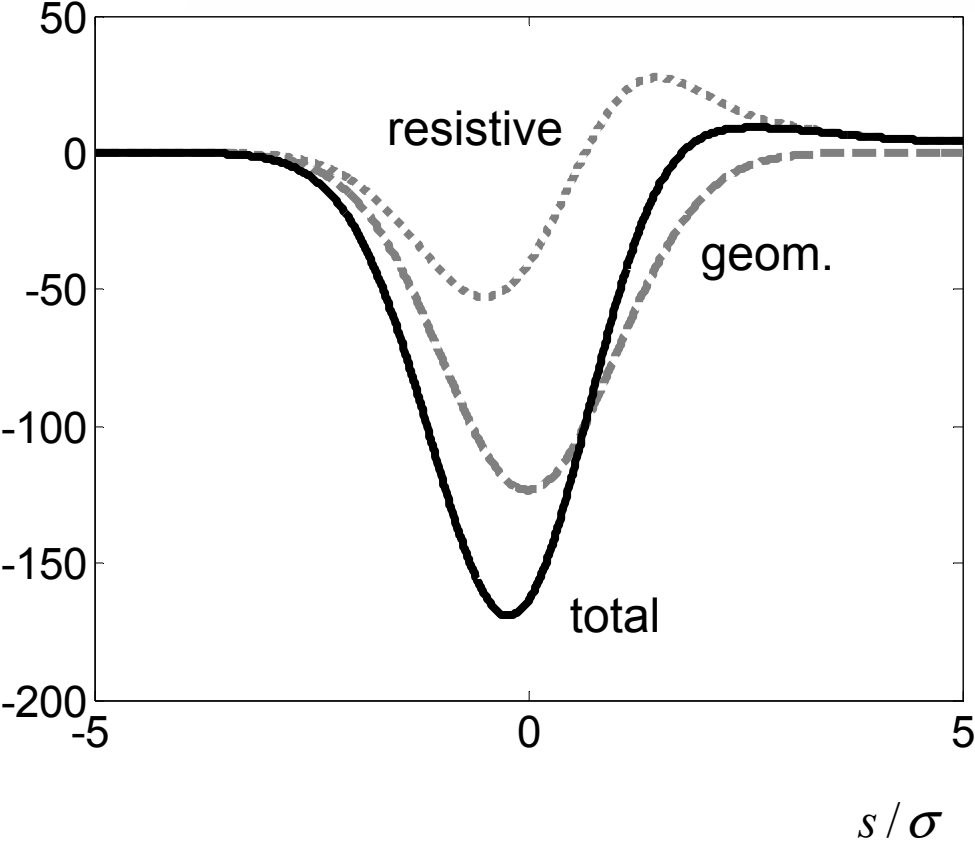
Geometric+Resistive Wakes



Geometric+Resistive Wakes



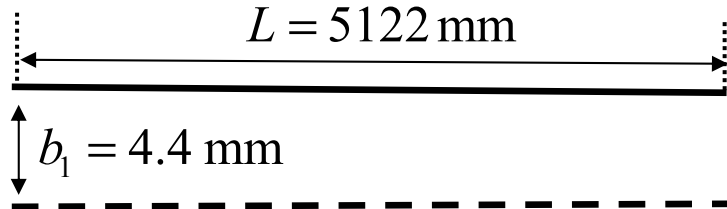
$W_{||} [V / pC]$



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

(T.Wohlenberg)

Main Pipe (resistive+oxid layer+roughness)



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

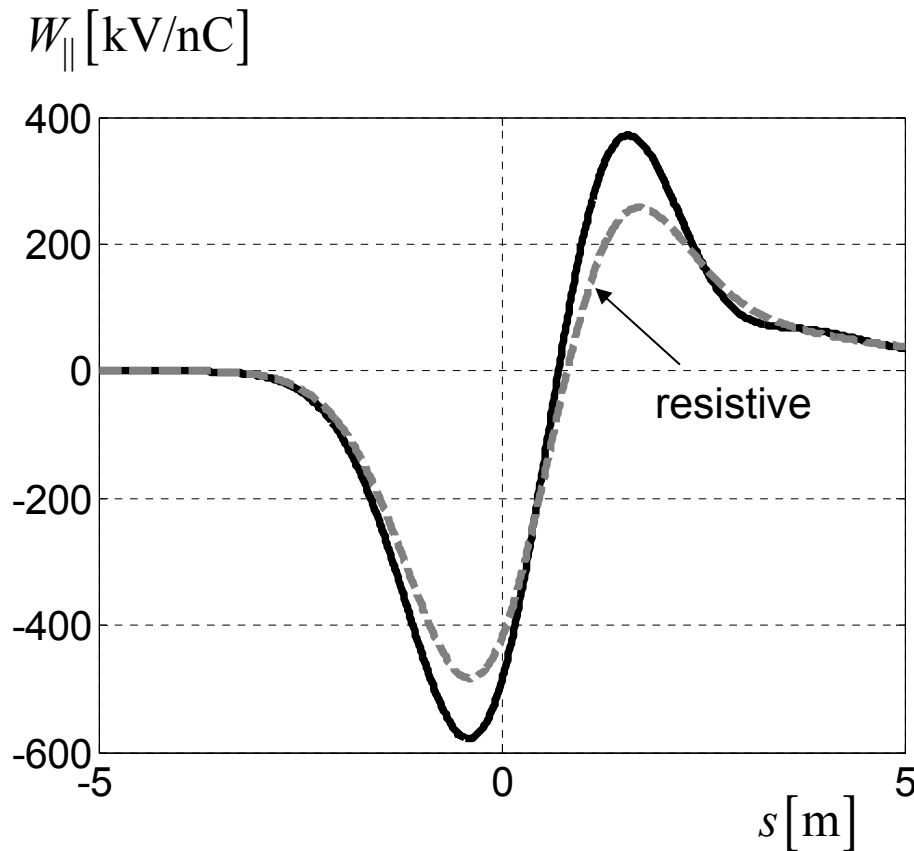
Aluminium

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

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

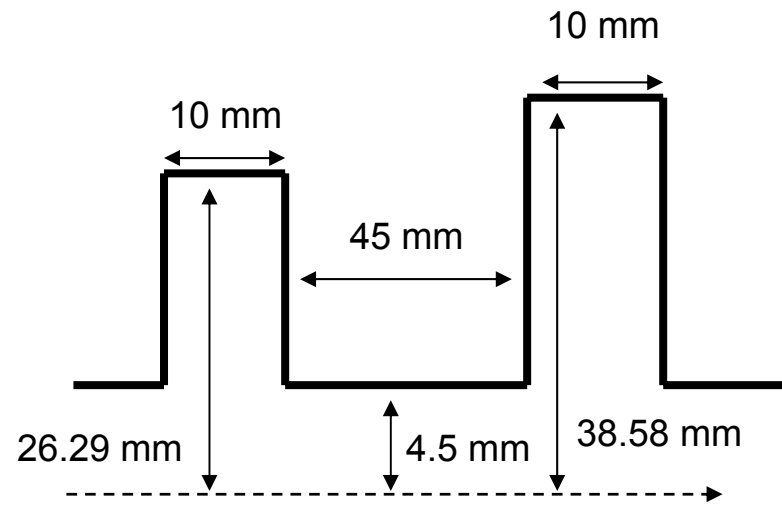
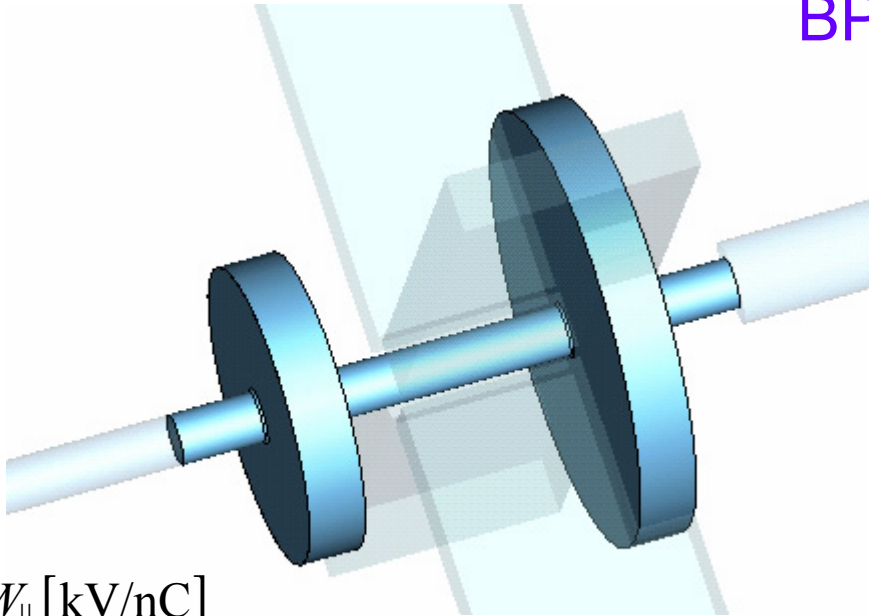
$$\Delta_{oxid} = 5 [\text{nm}]$$



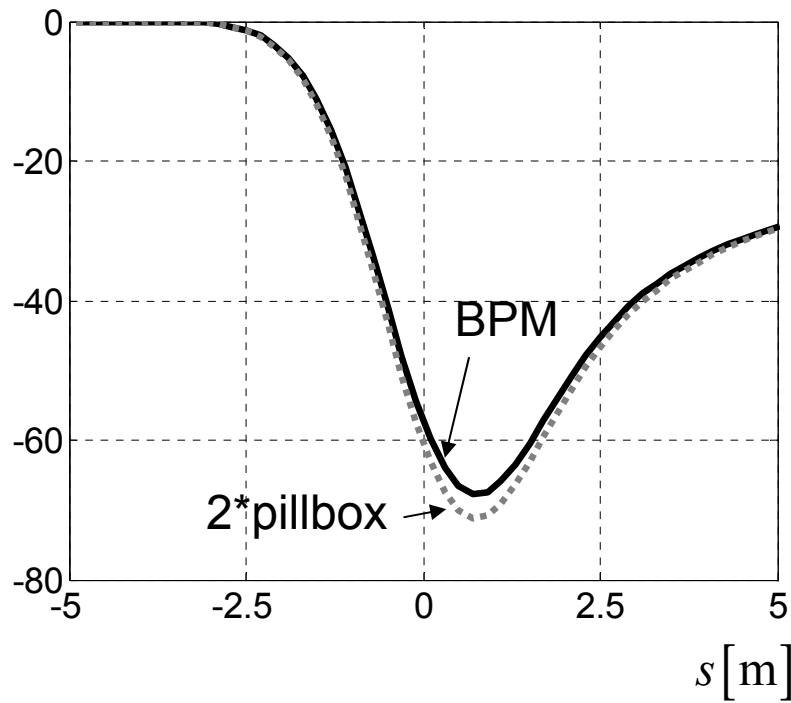
kV/nC

	resistive	total
Loss	225	241
Spread	238	310

BPM



$W_{||}$ [kV/nC]



kV/nC

	only first pillbox	total
Loss	25	48
Spread	10	19

Pumping Slots

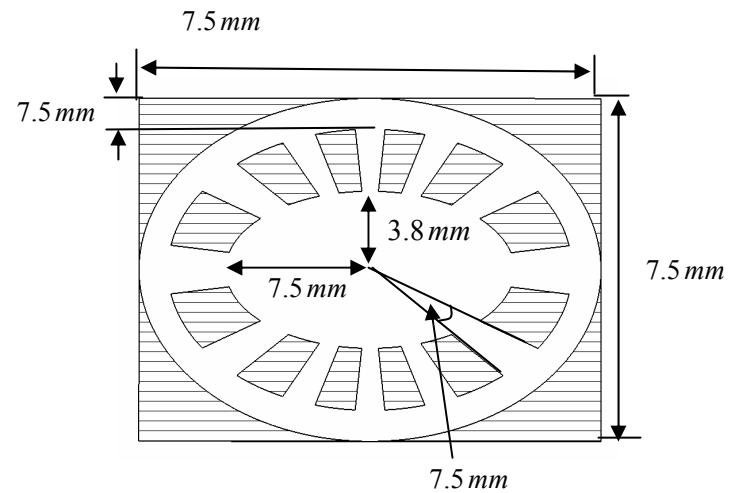
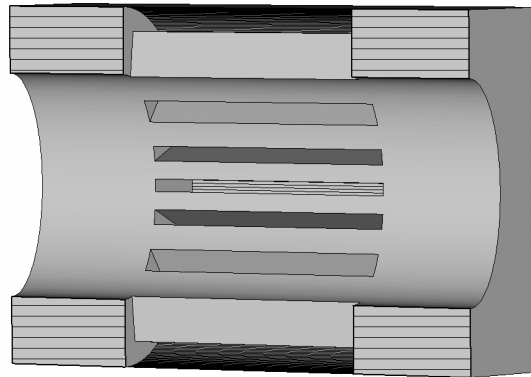
Pumpschlitzgeo.
im Pumpkreuz:

Breite 1mm, Länge 20-25mm
Anzahl 12 Stück/Kreuz
Pumpschlitz in Strahlängsrichtung

Pumpschlitzgeo.
am Schiebestück:

Breite 1mm, Länge 20-25mm
Anzahl 8 Stück/Schiebestück

2 items?



Old geometry!

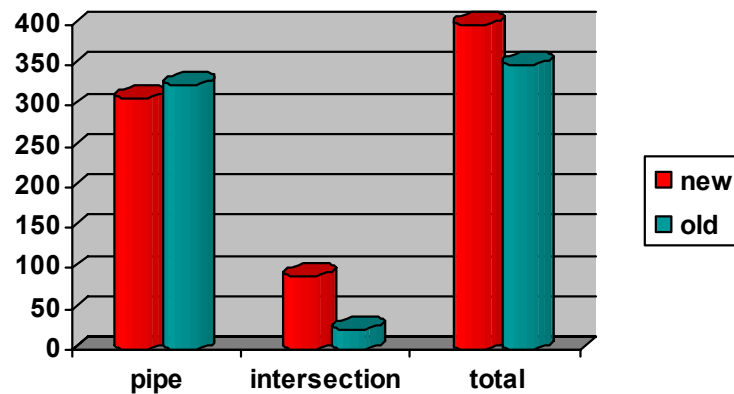
kV/nC

Loss	$9 \cdot 2 = 18$
Spread	$4 \cdot 2 = 8$

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

V/pC Energy Spread



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)

V/pC Energy Spread

