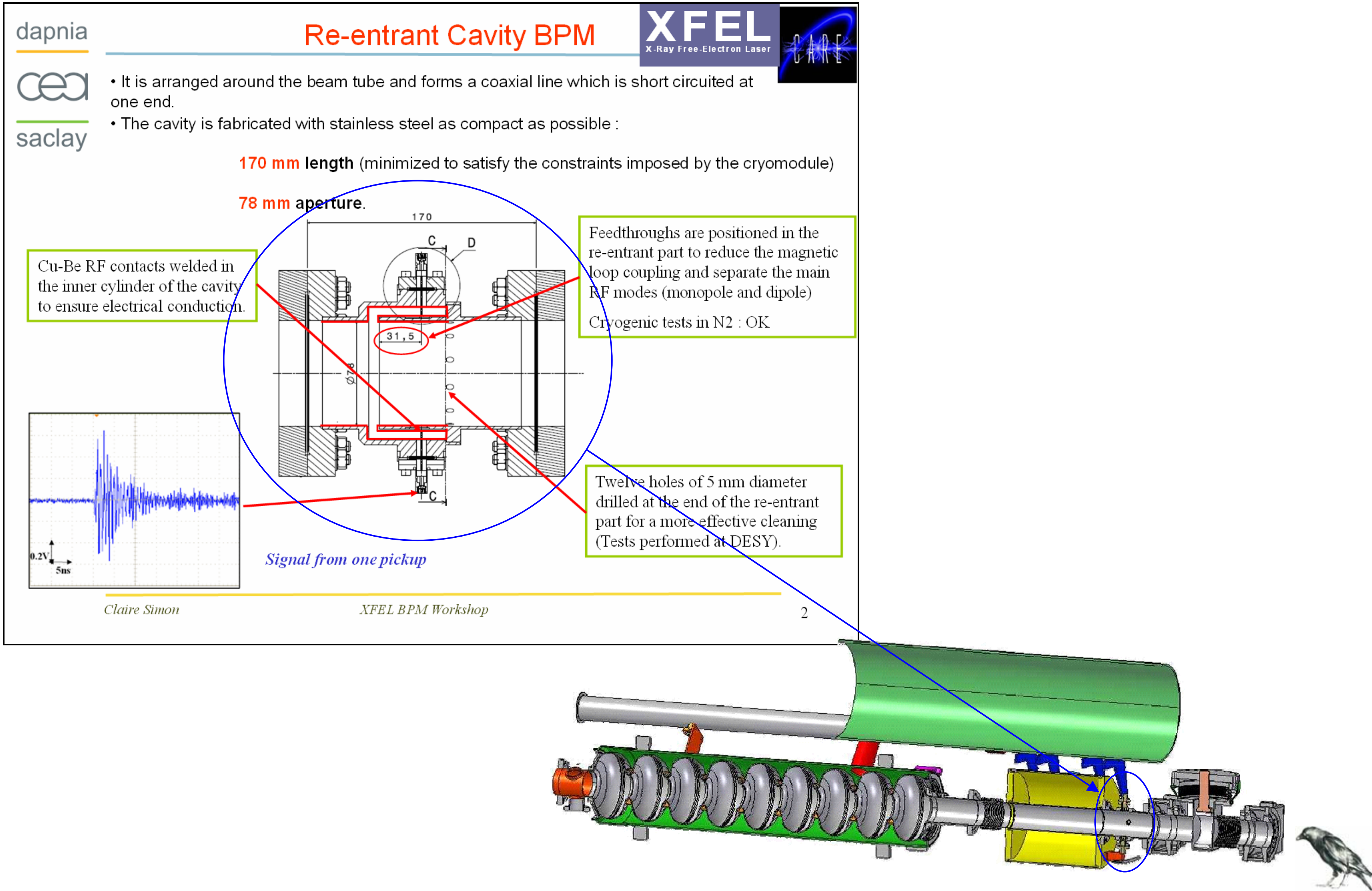
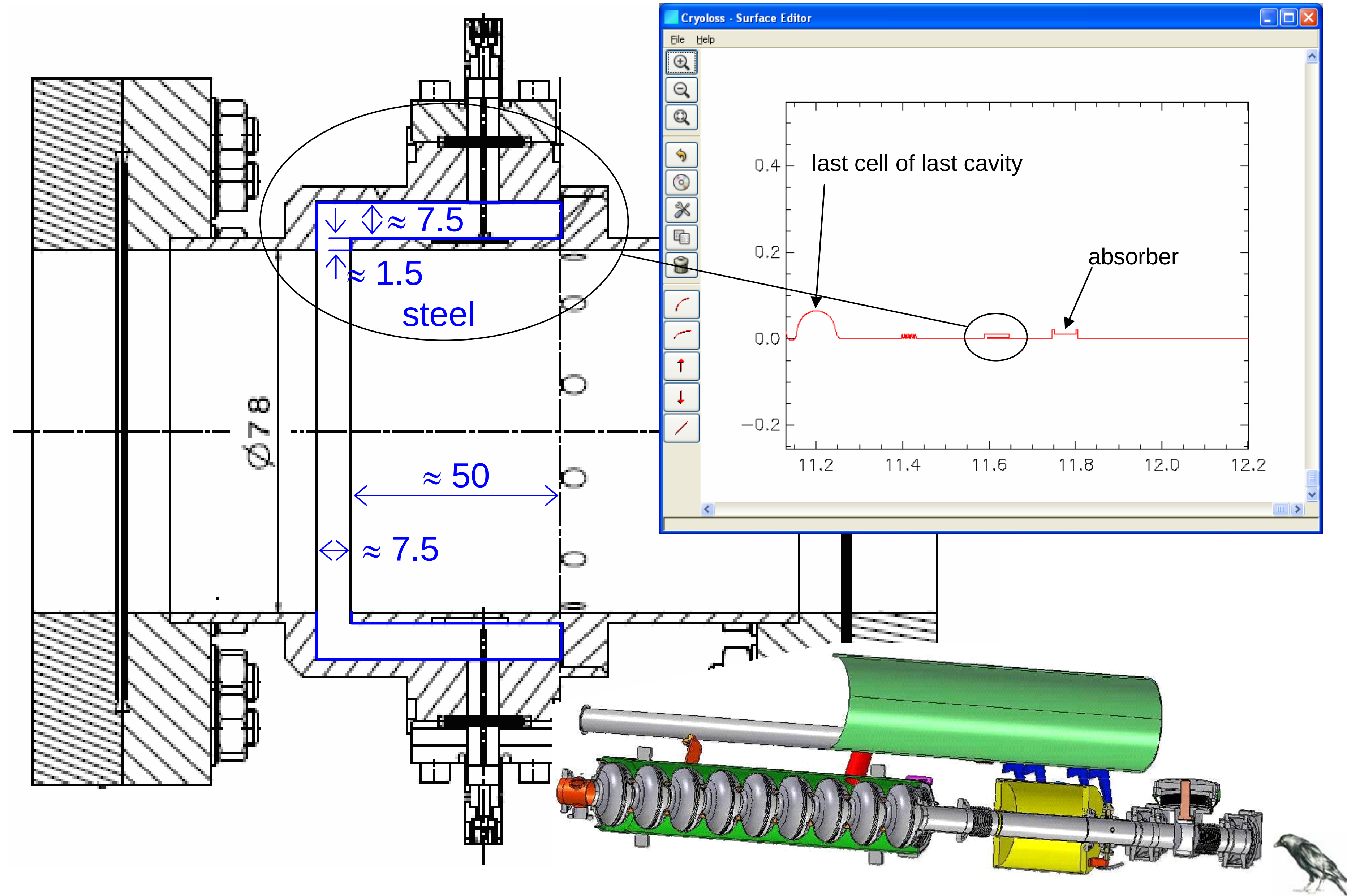
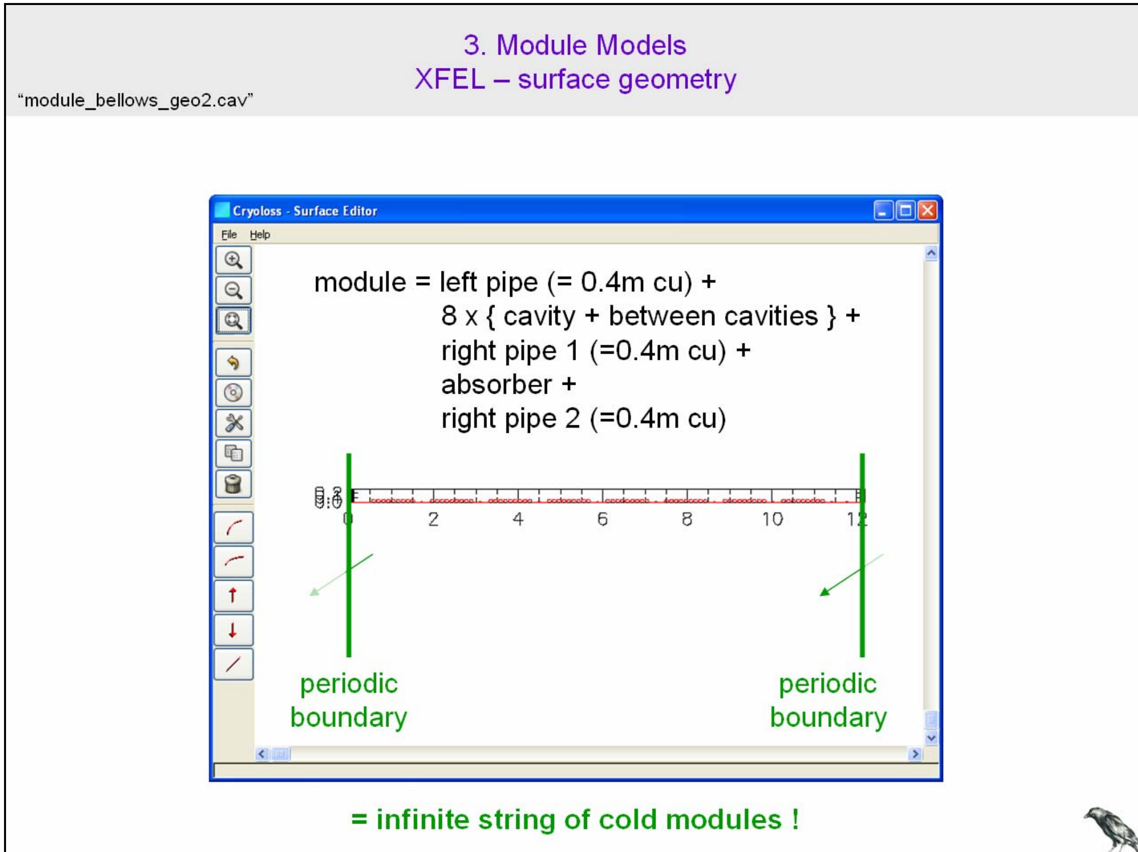
Absorption of Wake Fields from Accelerating Cavities in Re-Entrant Cavity BPM

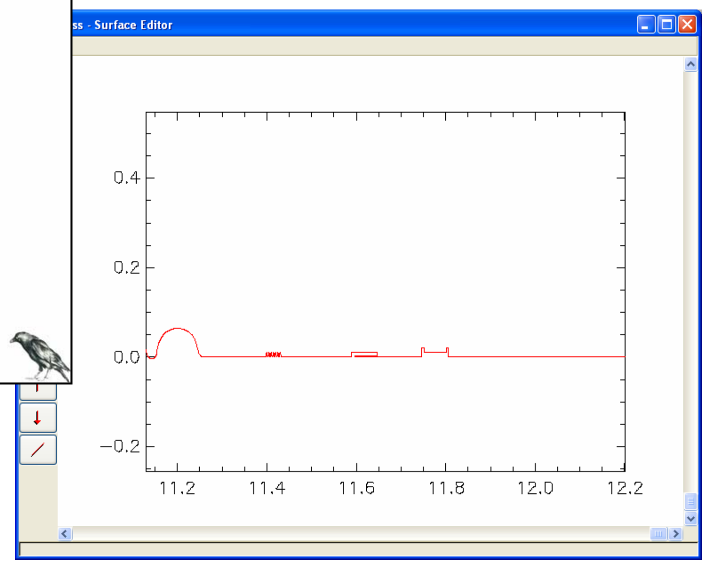


geometry used for cryoloss



geometry used for cryoloss



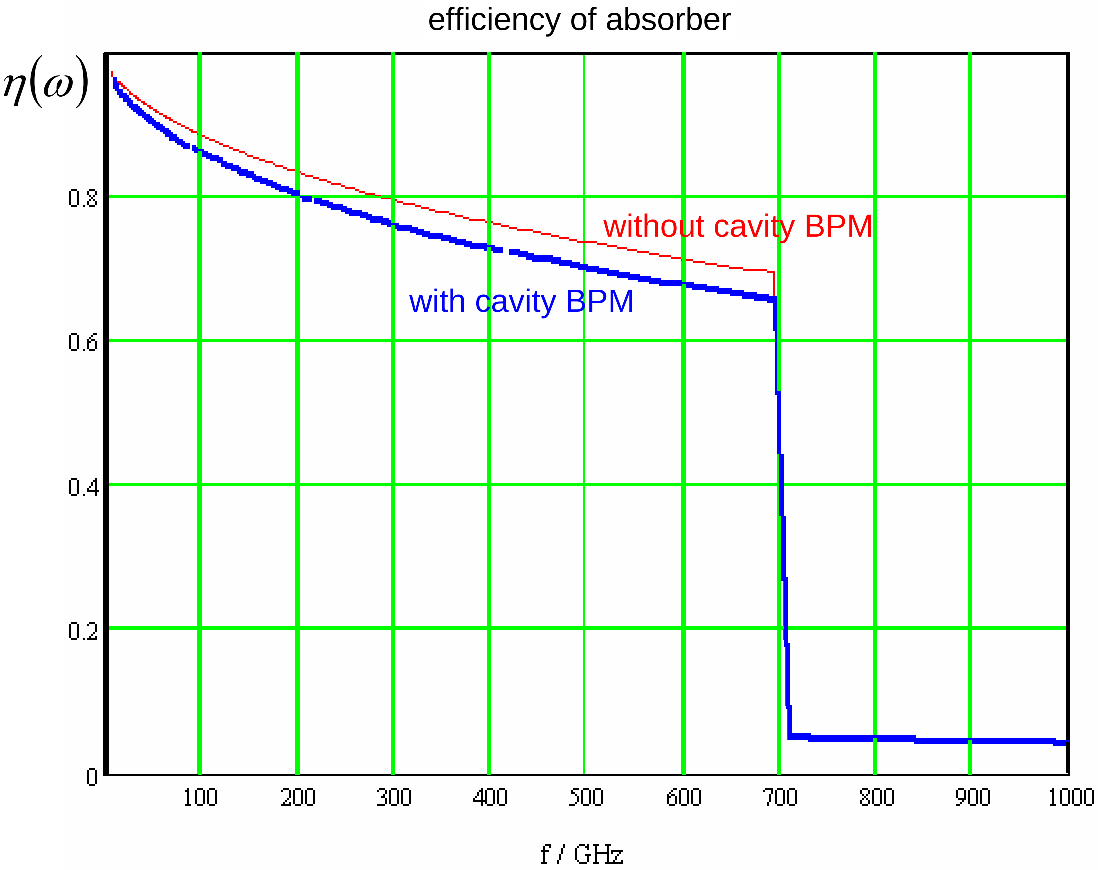


periodic string of modules

see geometry description in:
http://www.desy.de/xfel-beam/data/talks/talks/dohlus_-_cryo_calc_20071112.pdf

absorber 1
perfect cu

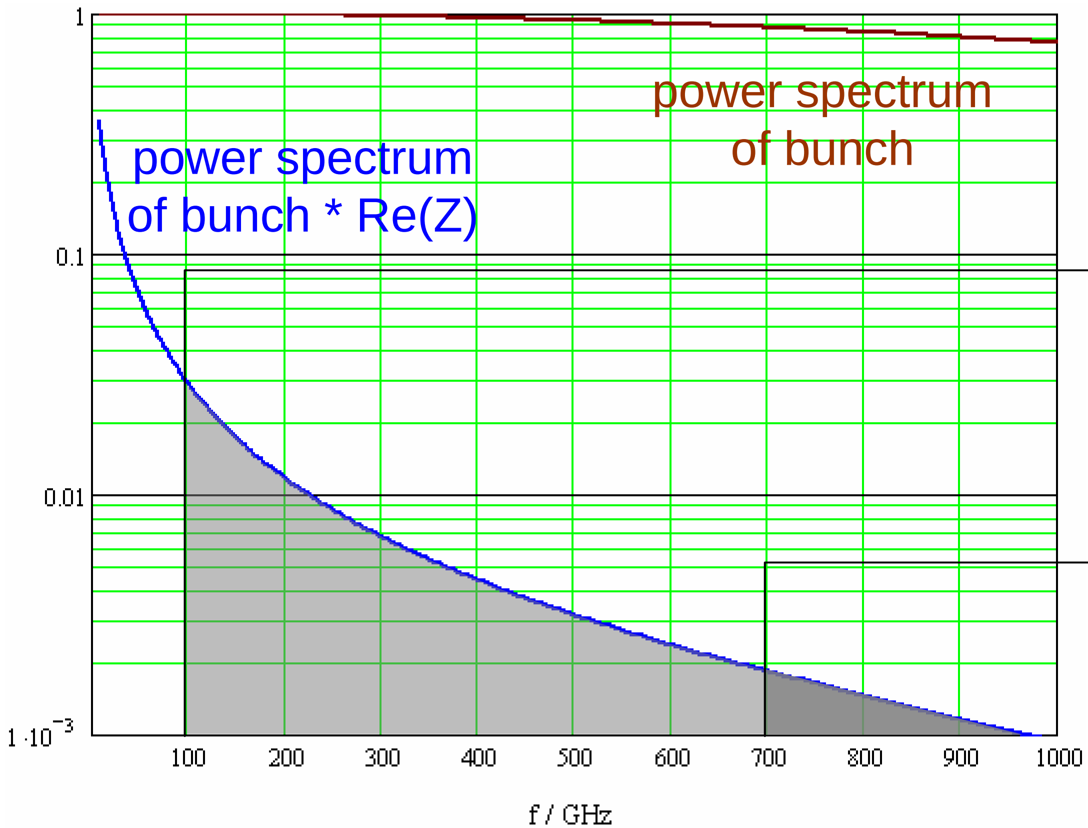
cryoloss results
XFEL



absorber 1
perfect cu

total absorber efficiency

bunch length = 25 µm



$$\frac{\int_{100\mathrm{GHz}\cdot 2\pi}^{\infty} P^{(\sigma)}\,\mathrm{Re}\{Z\}\,d\omega}{\int_{0}^{\infty} P^{(\sigma)}\,\mathrm{Re}\{Z\}\,d\omega} \approx 0.258$$

$$\frac{\int_{700\mathrm{GHz}\cdot 2\pi}^{\infty} P^{(\sigma)}\,\mathrm{Re}\{Z\}\,d\omega}{\int_{0}^{\infty} P^{(\sigma)}\,\mathrm{Re}\{Z\}\,d\omega} \approx 0.046$$

total absorber efficiency without cavity BPM: = 83.1 %

total absorber efficiency with cavity BPM: = 80.9 %

with $\eta_{\mathrm{abs}}(\omega) = 0$ for $\omega > 700\mathrm{GHz}\cdot 2\pi$

summary

2.2% additional losses in in re-entrant cavity BPM

	10x3000 bunches / sec	30x3000 bunches / sec
single bunch losses =	4.6 W	13.8 W
losses per cavity BPM =	0.1 W	0.3 W
best-case-2K-cryo-load = (per module with C-BPM)	0.9 W	2.6 W

single passage losses due to re-entrant cavity BPM

10x3000 bunches / sec	30x3000 bunches / sec
0.04 W	0.12 W

a large part of these losses goes to the HOM absorber estimated 2004, 3250 bunches, 10Hz

$$P_{single\_passage\_750GHz} := \frac{k_{750GHz}(\sigma_{bu}) \cdot {q_b}^2}{T_{bs}} \cdot L_{active} \cdot \eta_{bu\_duty}$$

$$P_{single\_passage\_750GHz} = 0.214$$

d) Power to HOM Absorber (estimated efficiency = 0.75)

$i_{hom\_abs} := 1$ (1: yes there is an absorber, 0: no)

$\eta_{hom\_abs} := 0.75 \cdot i_{hom\_abs}$ (no design so far: efficiency is speculative)

$$P_{to\_hom\_absorber} := \eta_{hom\_abs} \cdot (P_{single\_passage\_5GHz} - P_{single\_passage\_750GHz})$$

$$P_{hom\_nc\_walls} := (1 - \eta_{hom\_abs}) \cdot (P_{single\_passage\_5GHz} - P_{single\_passage\_750GHz})$$

$$P_{to\_hom\_absorber} = 2.806$$

$$P_{hom\_nc\_walls} = 0.935$$

e) Thermal Isolation of HOM Absorber

(no design so far: numbers are just an example)

$$P_{2K\_hom\_abs} := (0.150 + 0 \cdot P_{to\_hom\_absorber}) \cdot i_{hom\_abs}$$

$$P_{4K\_hom\_abs} := (1.5 + 0 \cdot P_{to\_hom\_absorber}) \cdot i_{hom\_abs}$$

$$P_{70K\_hom\_abs} := (0 + 0 \cdot P_{to\_hom\_absorber}) \cdot i_{hom\_abs}$$

6.4. Single Passage HOM-Losses other Components

$$P_{2K\_single\_other} := 0$$

$$P_{4K\_single\_other} := 0$$

$$P_{70K\_single\_other} := 0$$

only losses below 750 GHz, including 10% safty margin (for resonant losses etc.)

new cryoloss calculation:
abs 1, high-rrr-copper: η=83.4%
abs 2, high-rrr-copper: η=81.7%
complete frequency range, but 4.6% losses to 2K above 700 GHz
abs 1, high-rrr-copper: η=83.4%
abs 2, high-rrr-copper: η=81.7%

therefore efficiency to ~750 GHz:
abs 1, … : 83.4%/(1-0.046) ≈ 87%
abs 2, … : 81.7%/(1-0.046) ≈ 85%

for high-rrr-copper there is still the 10% safty margin

abs 1 (eps=15, tanδ=0.2)
abs 2 (eps=40, tanδ=0.7)

estimated 2004, 3250 bunches, 10Hz

7. Summary

7.1. Losses at 2K

$P_{Q0\_module} = 6.004$	$P_{2K} := P_{Q0\_module}$
$P_{all\_couplers\_2k} = 0.38$	$P_{2K} := P_{2K} + P_{all\_couplers\_2k}$
$P_{2K\_res\_hom} = 0$	$P_{2K} := P_{2K} + P_{2K\_res\_hom}$
$P_{2K\_res\_other} = 0$	$P_{2K} := P_{2K} + P_{2K\_res\_other}$
$P_{single\_passage\_750GHz} = 0.214$	$P_{2K} := P_{2K} + P_{single\_passage\_750GHz}$
(1) $P_{hom\_nc\_walls} = 0.935$	$P_{2K} := P_{2K} + P_{hom\_nc\_walls}$
(2) $P_{2K\_hom\_abs} = 0.15$	$P_{2K} := P_{2K} + P_{2K\_hom\_abs}$
	$P_{2K} = 7.683$

7.2. Losses at 4K

$P_{all\_couplers\_4k} = 3.361$	$P_{4K} := P_{all\_couplers\_4k}$
$P_{4K\_res\_hom} = 0$	$P_{4K} := P_{4K} + P_{4K\_res\_hom}$
$P_{4K\_res\_other} = 0$	$P_{4K} := P_{4K} + P_{4K\_res\_other}$
$P_{4K\_hom\_abs} = 1.5$	$P_{4K} := P_{4K} + P_{4K\_hom\_abs}$
	$P_{4K} = 4.861$

7.3. Losses at 70K

$P_{all\_couplers\_70k} = 32.722$	$P_{70K} := P_{all\_couplers\_70k}$
$P_{70K\_res\_hom} = 0$	$P_{70K} := P_{70K} + P_{70K\_res\_hom}$
$P_{70K\_res\_other} = 0$	$P_{70K} := P_{70K} + P_{70K\_res\_other}$
$P_{70K\_hom\_abs} = 0$	$P_{70K} := P_{70K} + P_{70K\_hom\_abs}$
	$P_{70K} = 32.722$

(1) geschaetzter Wirkungsgrad 75%

(2) statische Verluste, thermische Isolation des HOM absorber
2008: 135mW für Bellows +
4x25mW für Stützen
= (0.15+0.085)W

zusaetzliche 2K Verluste:
re-entrent cavity BPM: 0.1W @ 10Hz
0.3W @ 10Hz
pro Module mit diesem Monitor Typ