Wiggler optimization and radiation absorption scheme in light sources and damping rings

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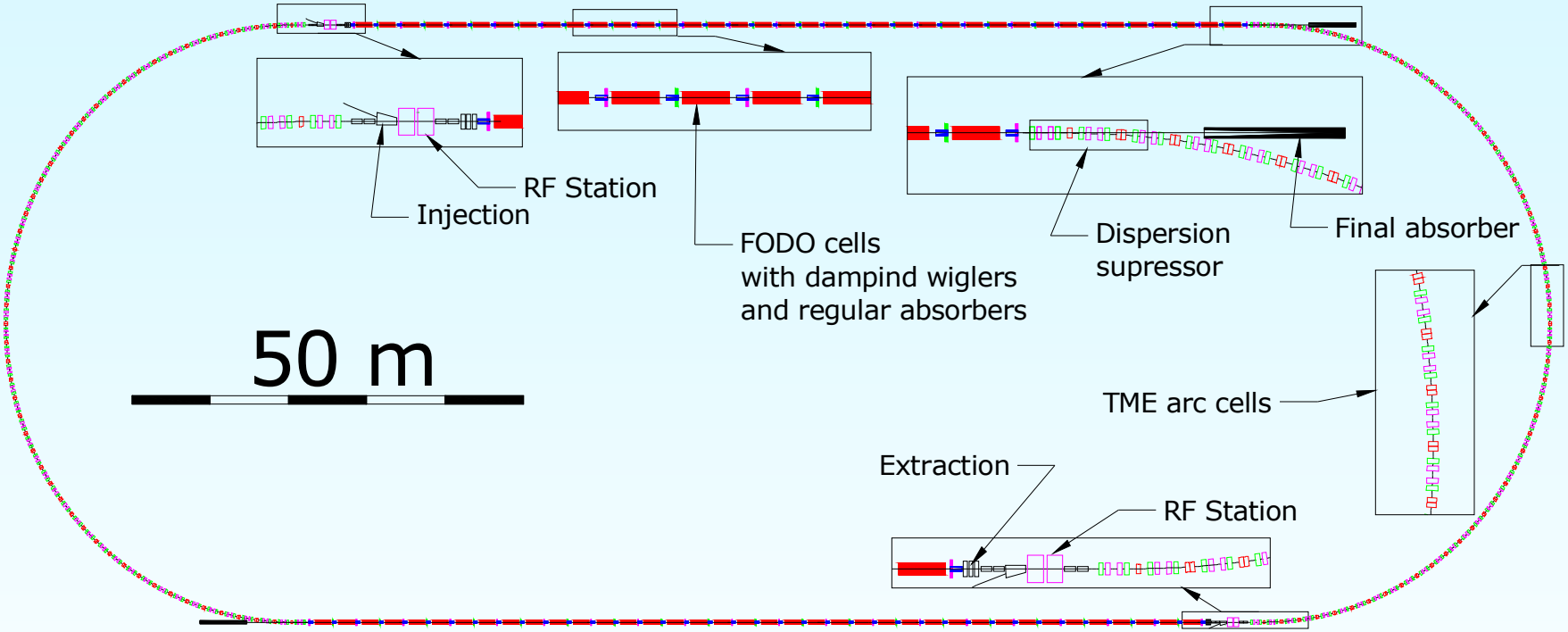
Main issues

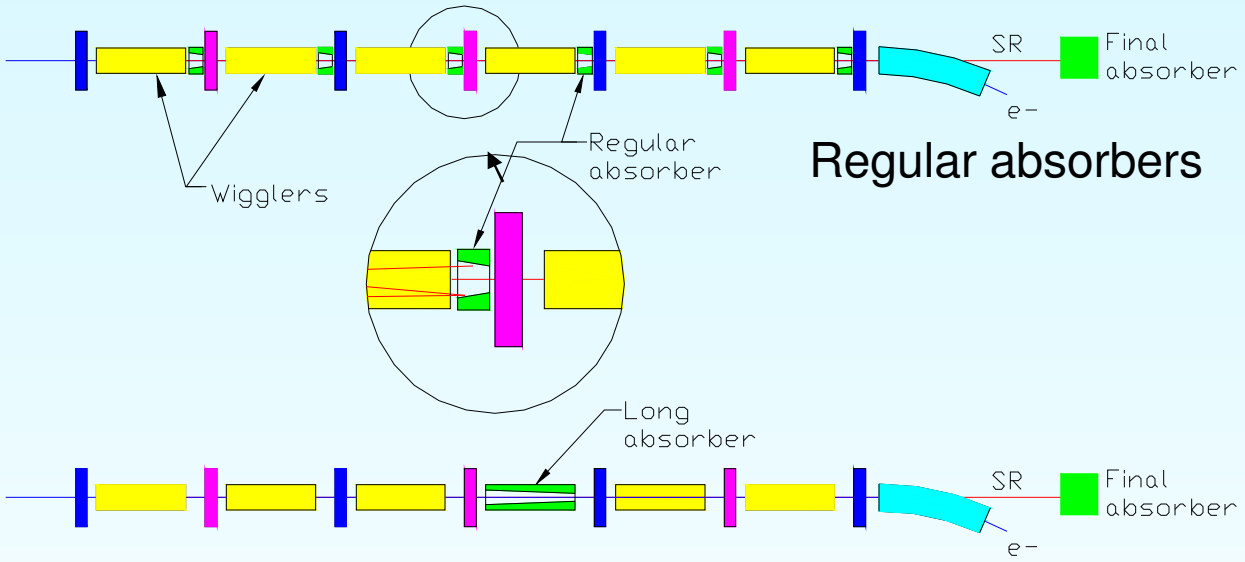
- *SR absorption problems overview*
- *SR loads simulation approaches for multiwiggler sections*
- *SR absorption systems, specific features*
  - *PETRA-III*
  - *CLIC-DR*
  - *ILC-DR*
- *Summary*

Problem overview

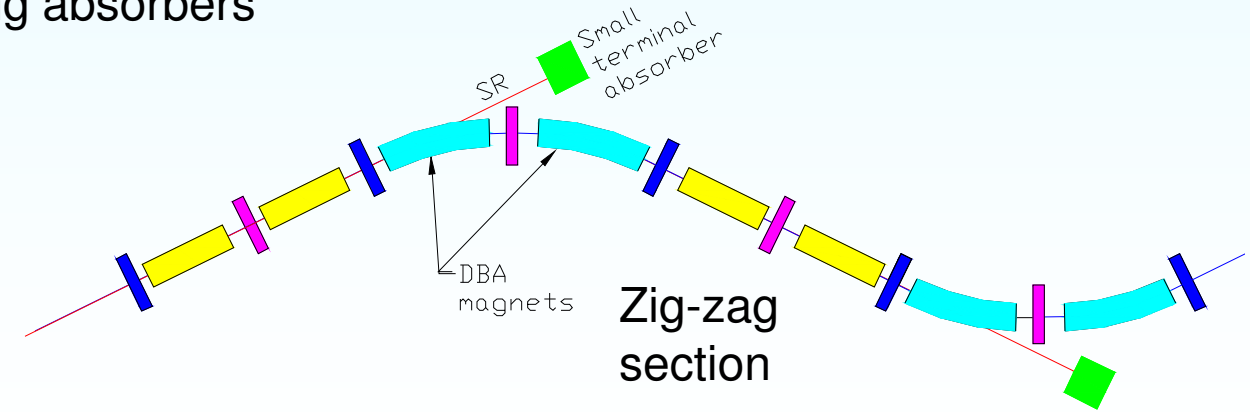


	PETRA-III	*CLIC-DR*	*ILC-DR*
Beam energy, GeV	*6*	*2.86*	*5*
Average current, mA	*200*	*170*	*400*
Number of wiggler (in one section)	*10*	*38*	*88*
SR wiggler power, kW	*42.1*	*11 – 12*	*39.7*
Total SR power in one section, kW	*421.1*	*420 – 460*	*3494*

Possible solutions



Long absorbers



Code for calculation of SR power loads for SR absorbers

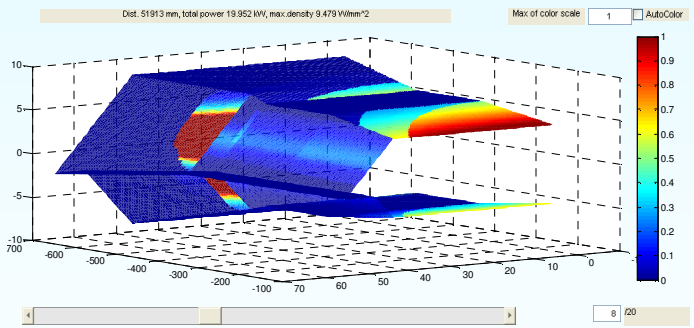
$$\frac{dP}{d\Omega} = \frac{d^2P}{d\theta\, d\psi} = P_T \frac{21\gamma^2}{16\pi K} G(K)\, f_K(\gamma\theta, \gamma\psi)$$

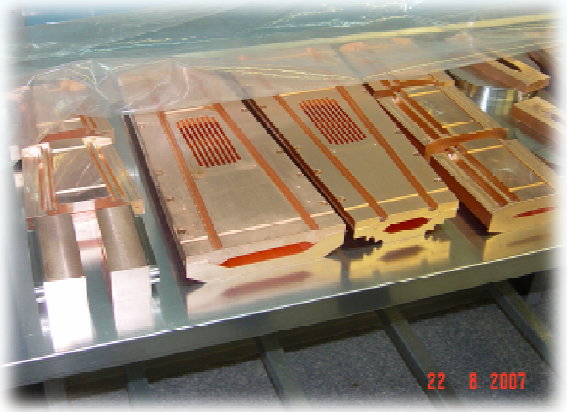
$$P_T[\mathrm{kW}] = 0.633 \cdot E_e^2[\mathrm{GeV}] \cdot B^2[\mathrm{T}] \cdot L[\mathrm{m}] \cdot I[\mathrm{A}]$$

$$f_K(\gamma\theta, \gamma\psi) = \sqrt{1 - \left(\gamma\theta / K\right)^2} \left\{ \frac{1}{\left(1 + (\gamma\psi)^2\right)^{5/2}} + \frac{5(\gamma\psi)^2}{7\left(1 + (\gamma\psi)^2\right)^{7/2}} \right\}$$

$$G(K) = K \frac{K^6 + \frac{24}{7}K^4 + 4K^2 + \frac{16}{7}}{\left(1 + K^2\right)^{7/2}}$$

K.-J. Kim, Nucl. Instr. And Meth A246(1986)

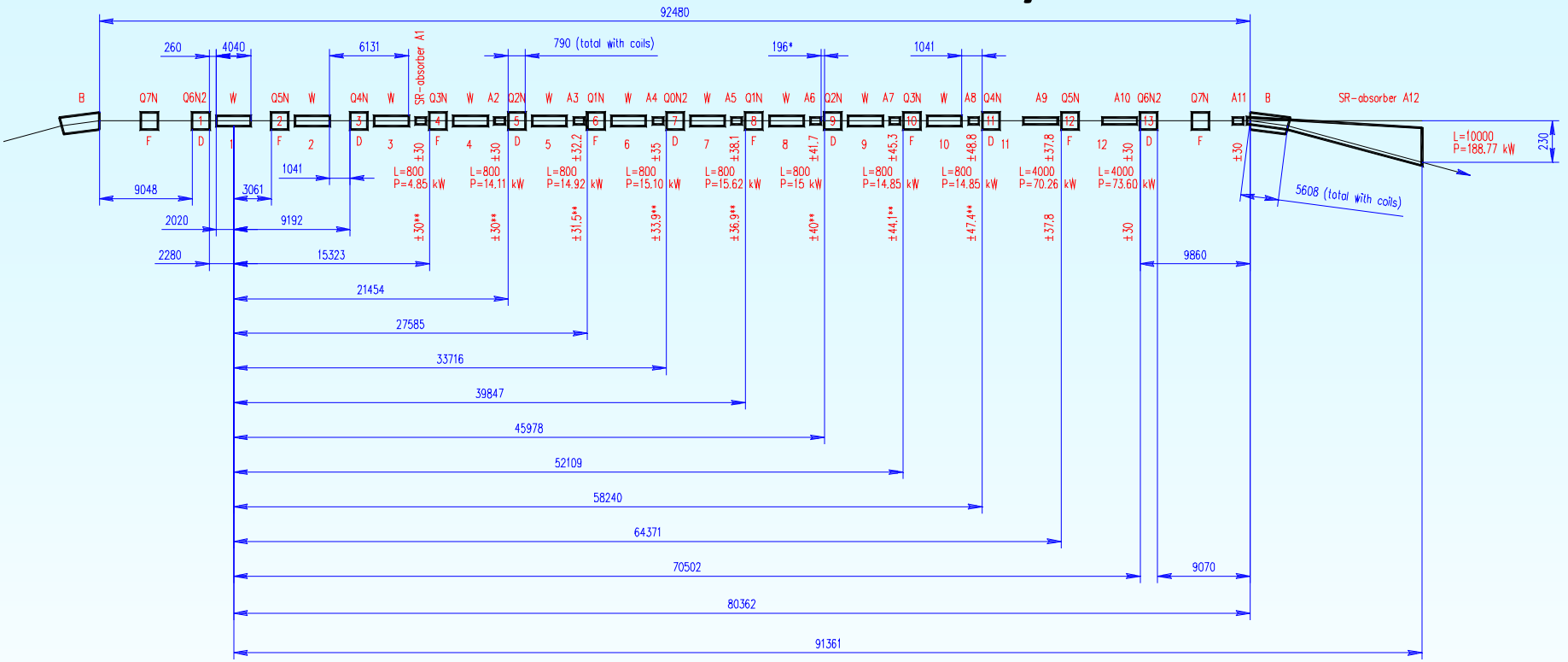




For design and optimization of Petra-III damping section a special codes were developed for SR power load simulations. The codes performs a following actions:

- *Ray tracing technique for accounting of absorber shadows*
- *Parametric optimization of absorber shape*
- *COD and elements misalignments accounting*
- *3D modeling of complicated absorber shape*
- *Adaptive triangular meshing of internal absorber surface for precise integration of power density*

PETRA-III absorber system



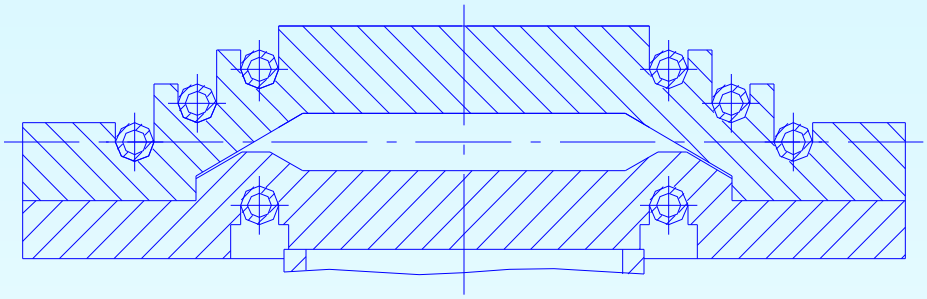
Main mashie parameters

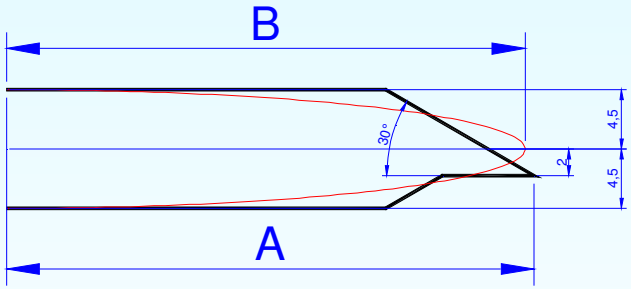
Beam energy, GeV	*6*
Average current, mA	*200*
Number of wiggler (in one section)	*10*
SR wiggler power, kW	*42.1*
Total SR power in one section, kW	*421.1*

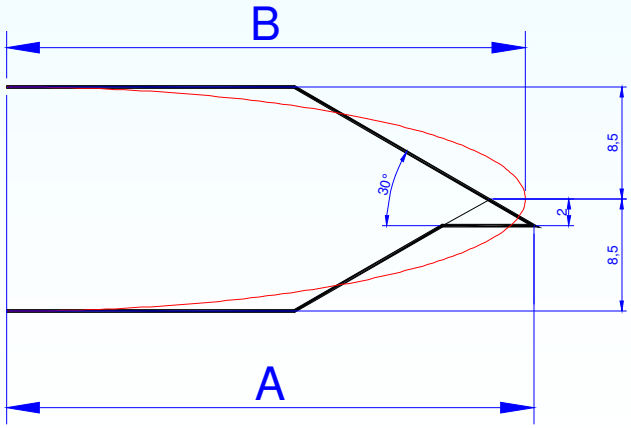
Permanent magnet wiggler parameters

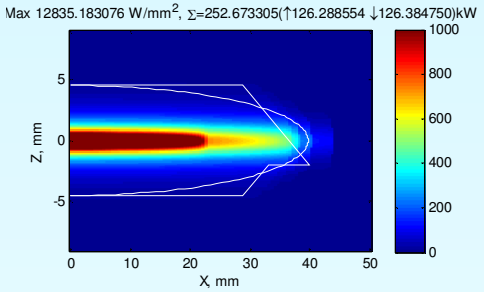
Peak field, T	*1.56*
Period, cm	*20*
K	*29.51*
Number of wiggler (in one section	*10*
Wiggler length, m	*4*
Magnetic gap, mm	*24*
Vertical aperture, mm	*17*

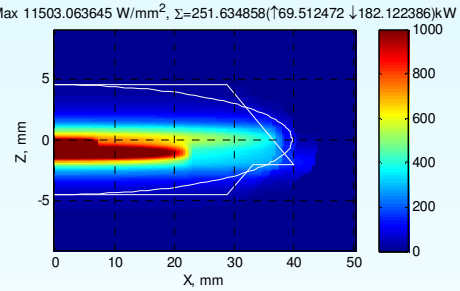
Regular absorber design for PETRA-III DWS

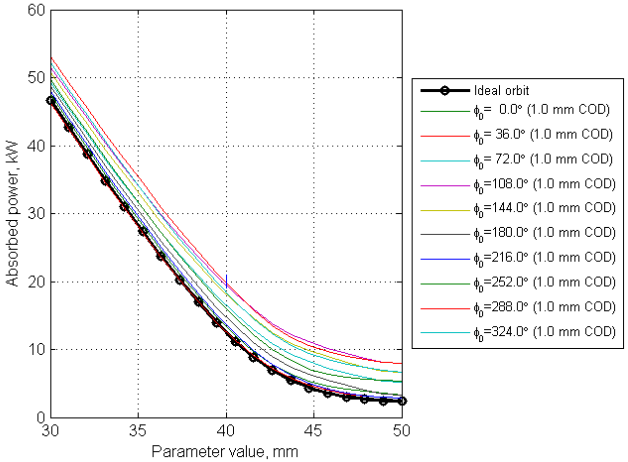




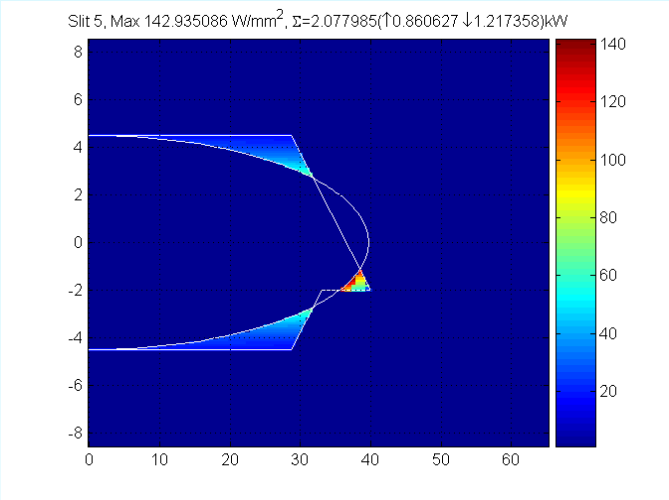


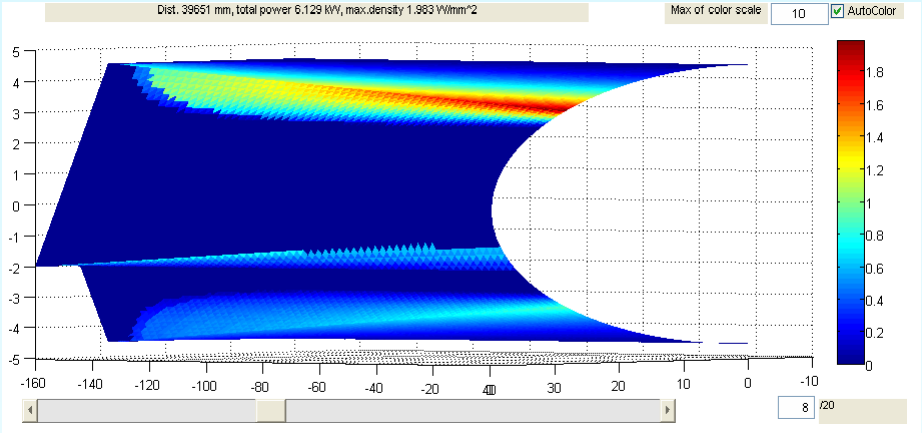


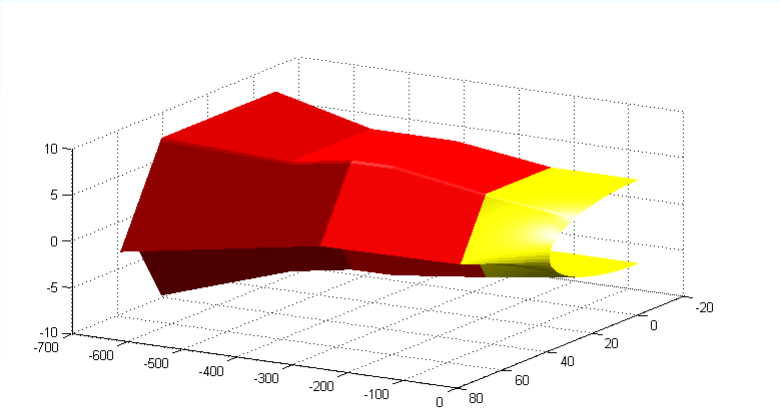


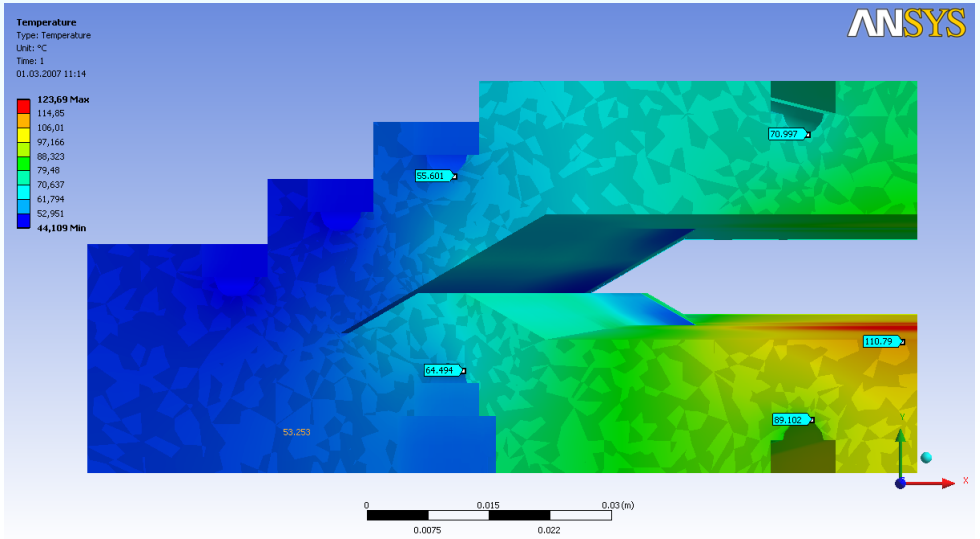


Regular absorber design for PETRA-III DWS

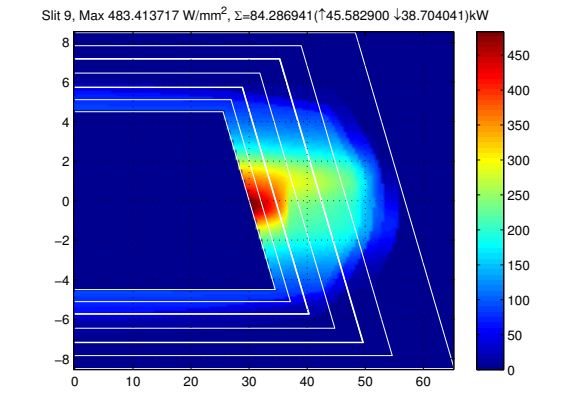


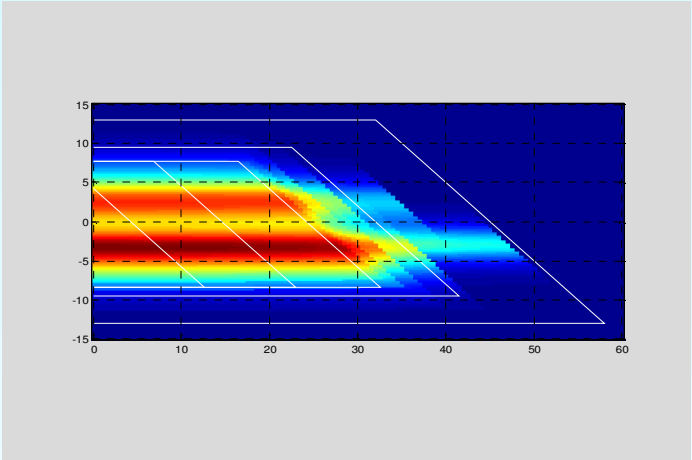


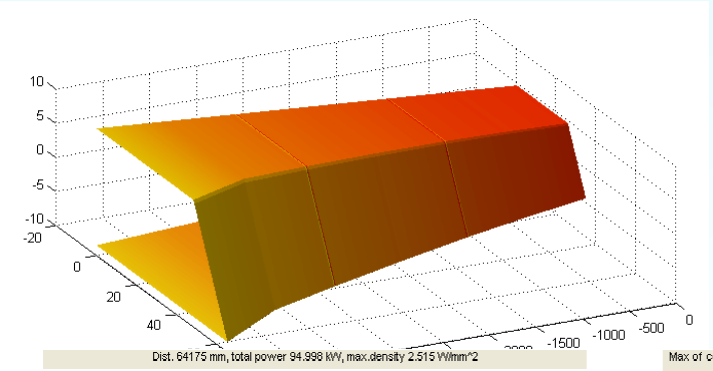


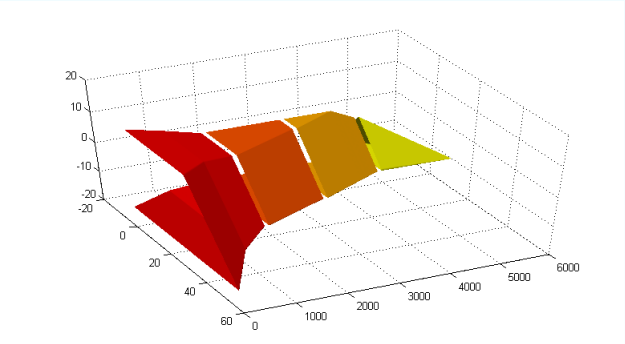


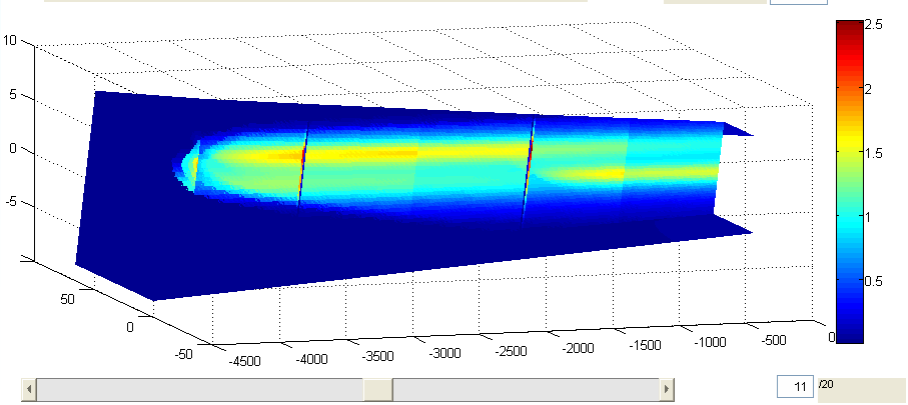
Long and final absorbers sectioning



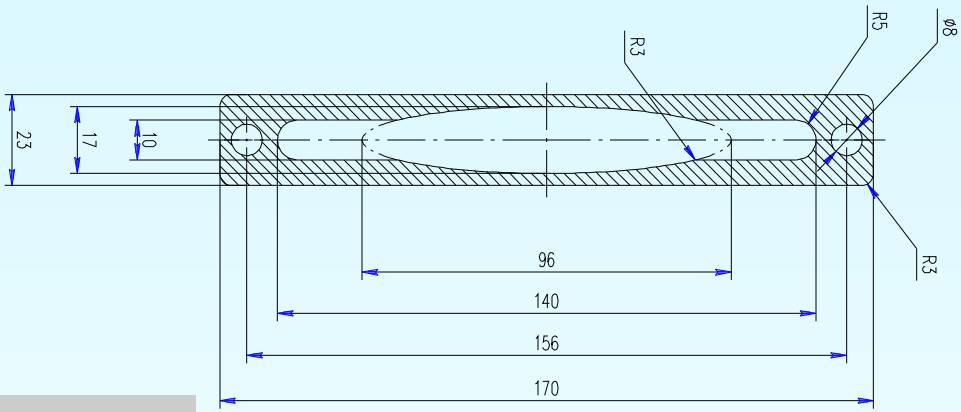


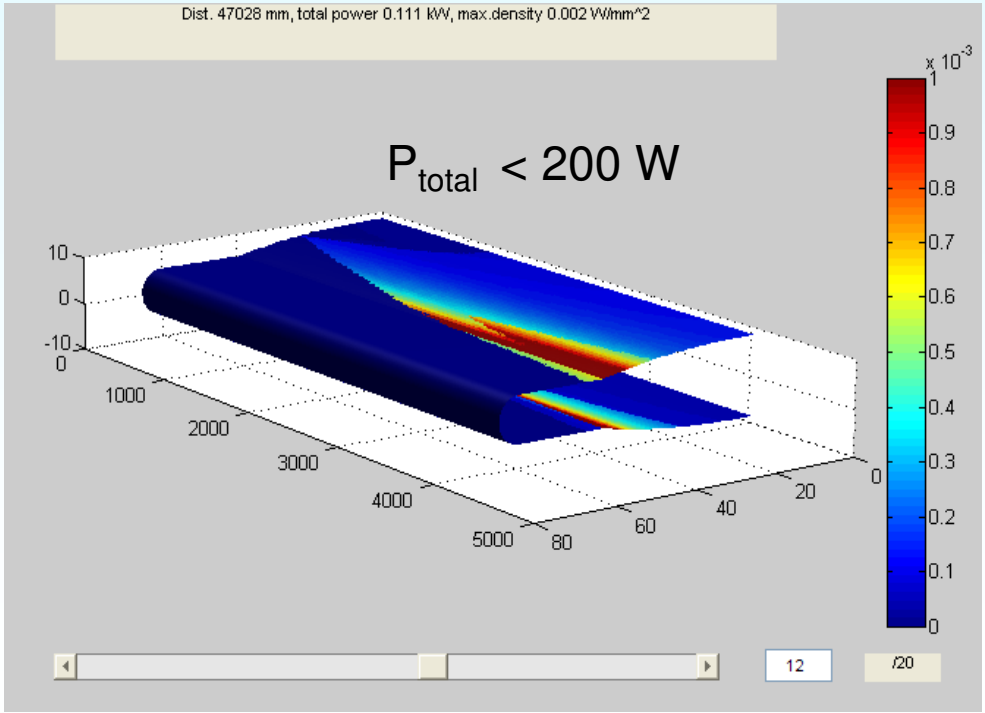




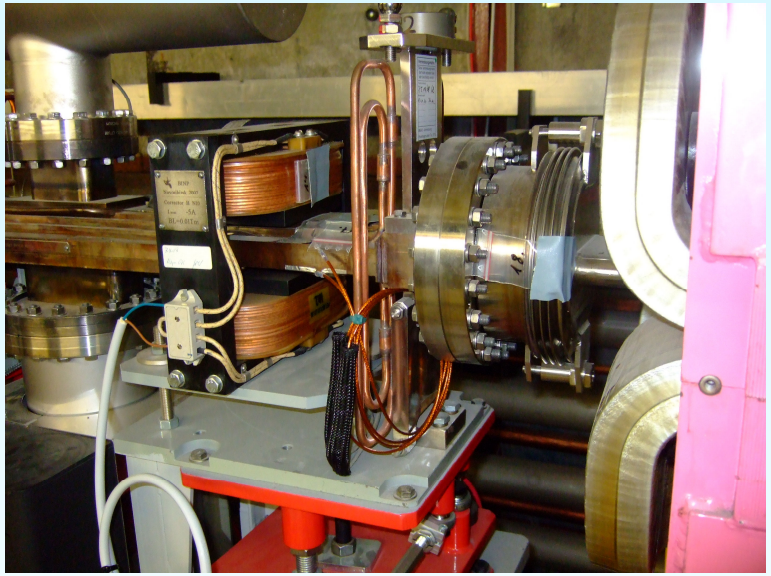


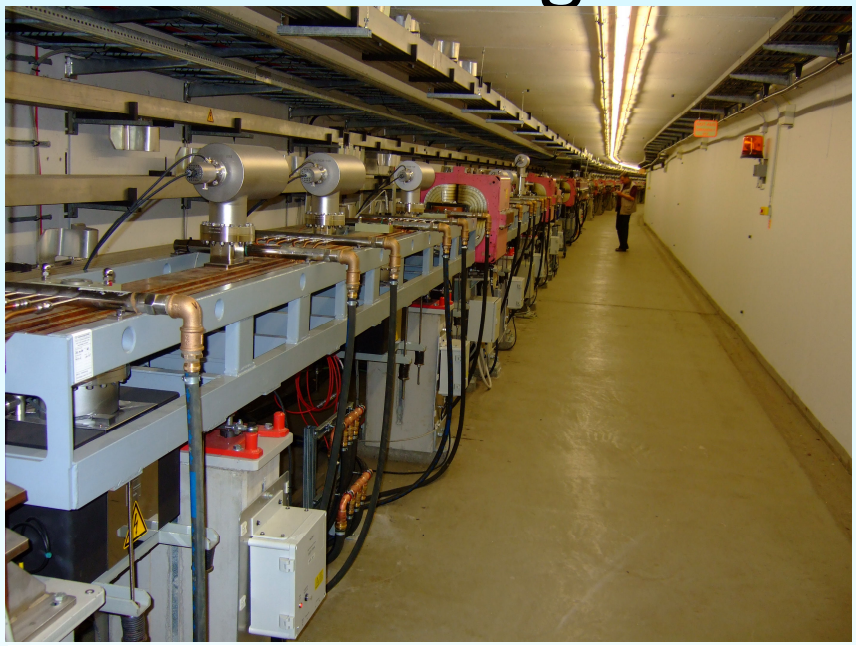
Wiggler VC design and power load

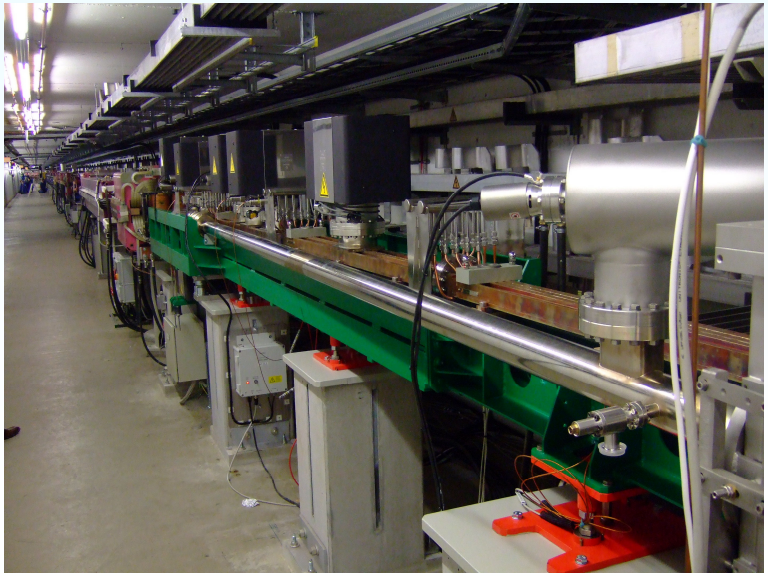


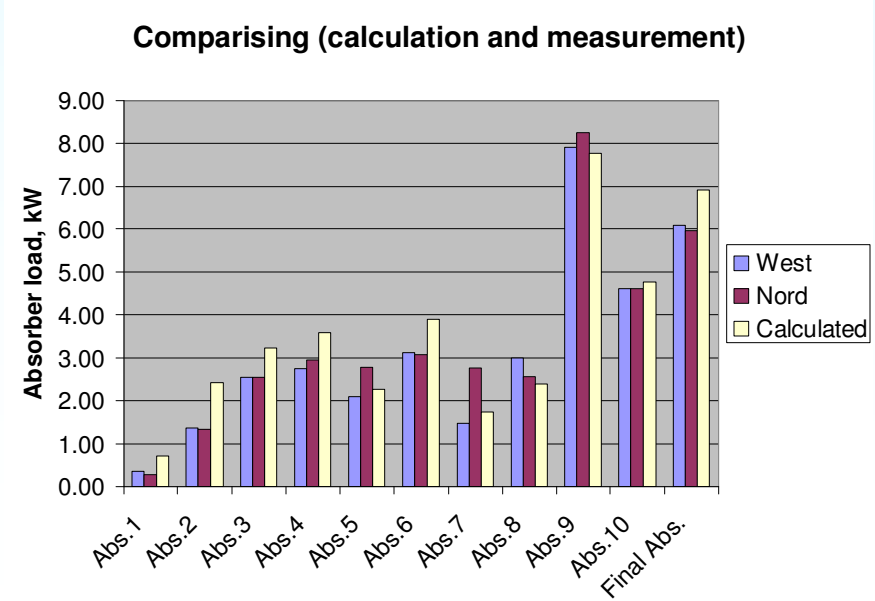


Petra-III DWS commissioning

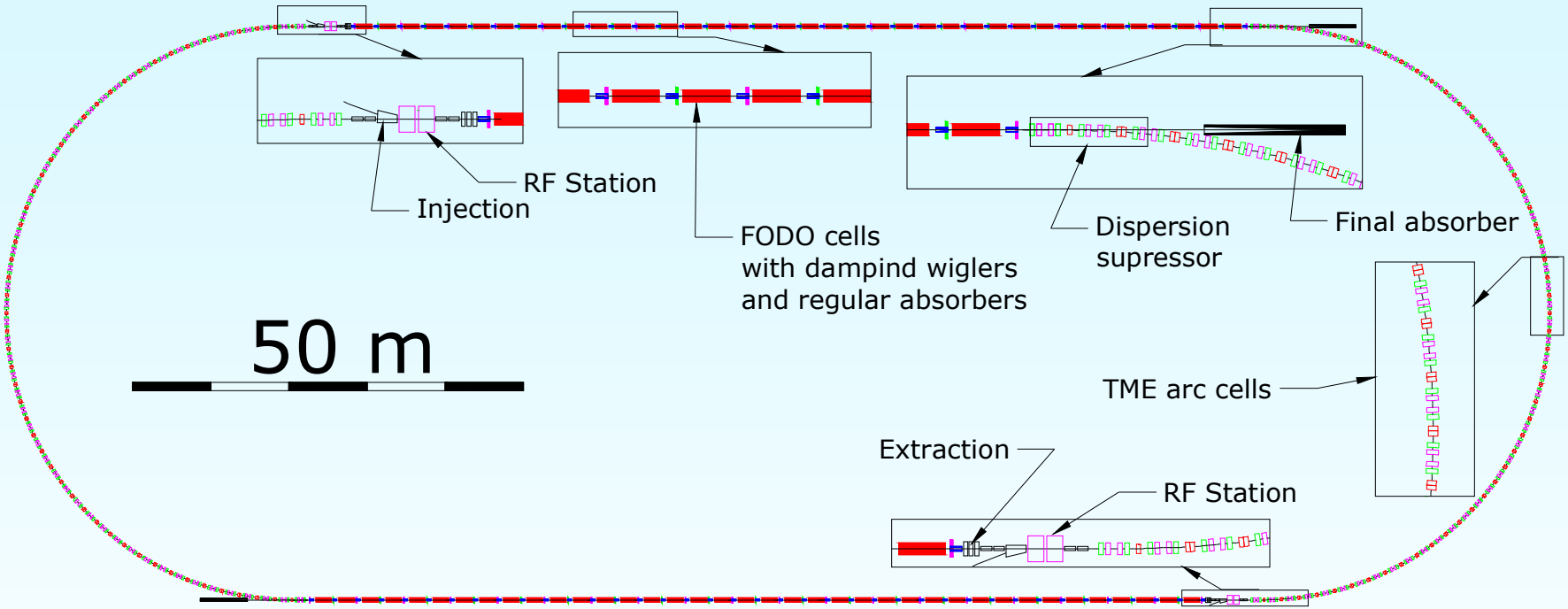








CLIC-DR absorber system



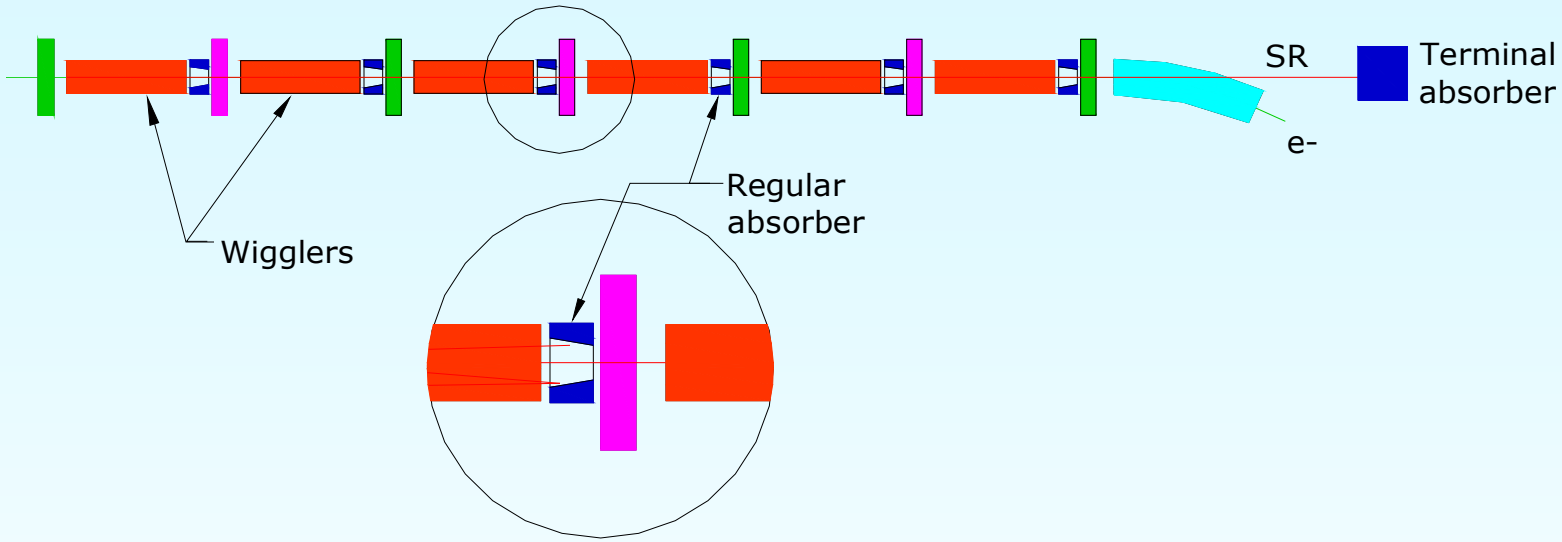
Superconductive wiggler parameters

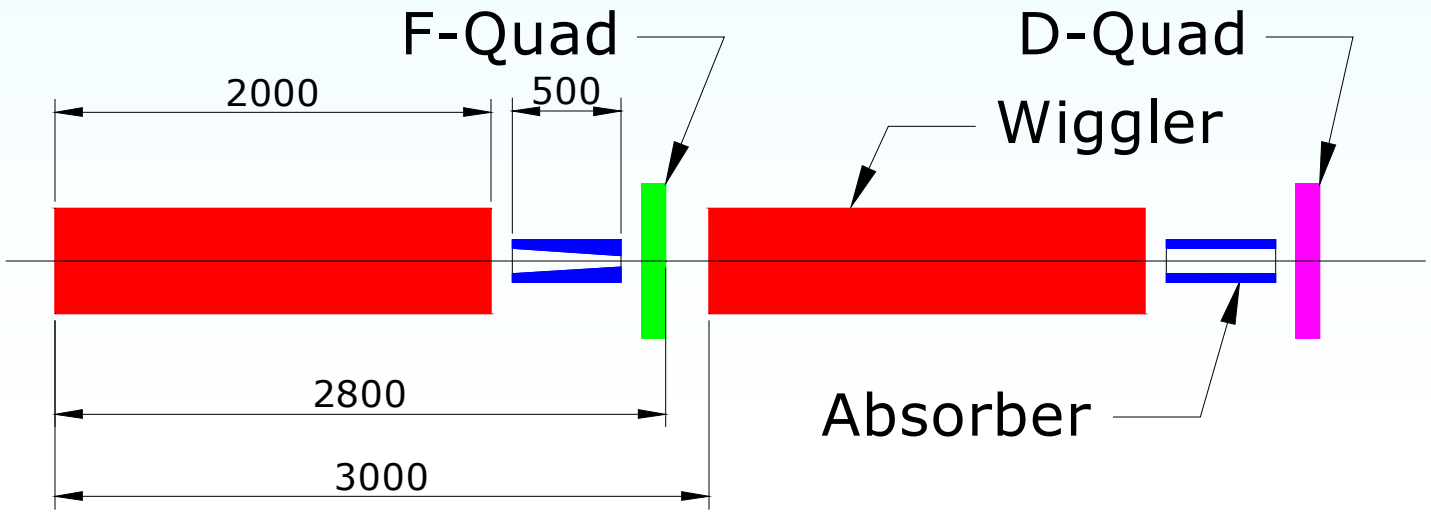
Main mashie parameters

Beam energy, GeV	*2.86*
Average current, mA	*170*
Number of wiggler (in one section)	*38*
SR wiggler power, kW	*11 – 12*
Total SR power in one section, kW	*420 – 460*

Coil material	*Nb_3Sn*	*NbTi*
Peak field, T	*2.8*	*2.5*
Period, cm	*4*	*5*
K	*11.7*	*10.5*
Wiggler length, m	*2*	*2*
Magnetic gap, mm	*12*	*15*
Vertical aperture, mm	*?*	*12*

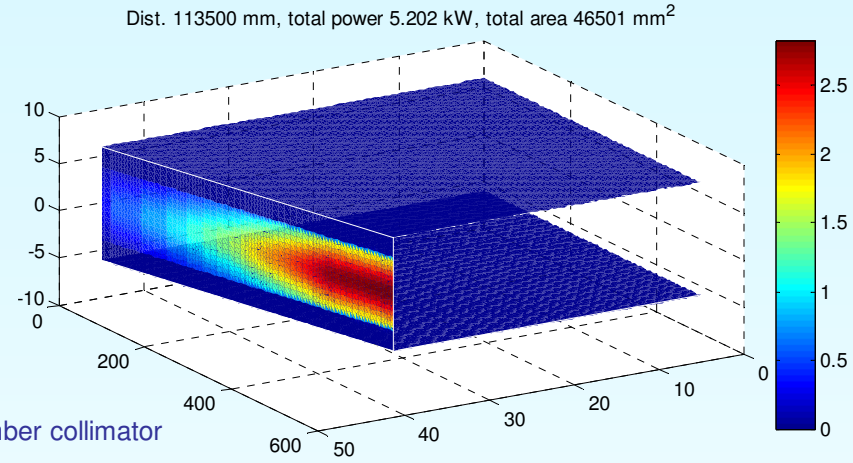
SR power evacuation strategy





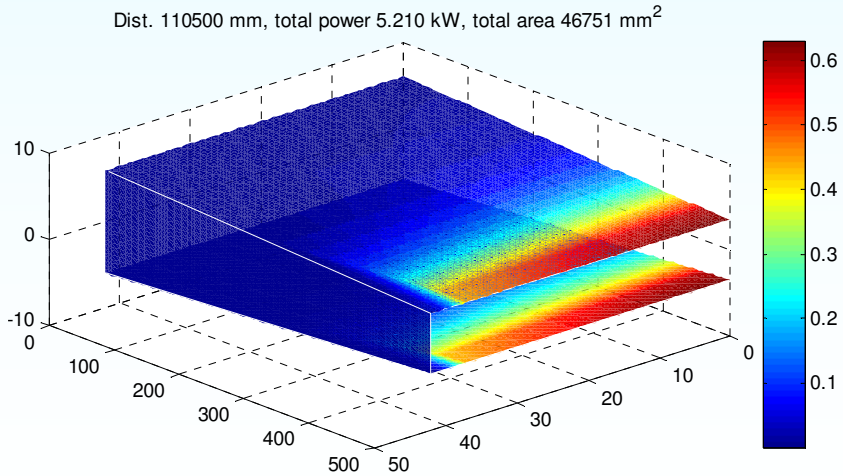
Choice for horizontal aperture for even number absorbers

BINP wiggler version



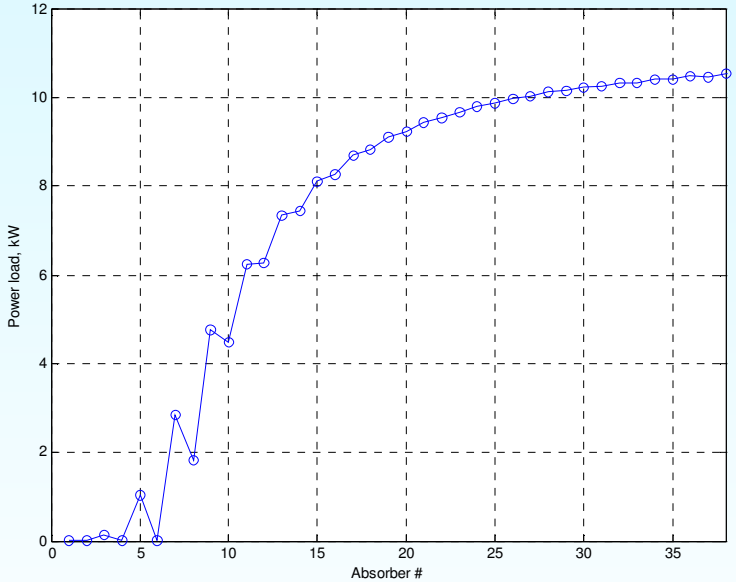
Even number collimator

72x12 mm, P=10.4 kW



Odd number collimator

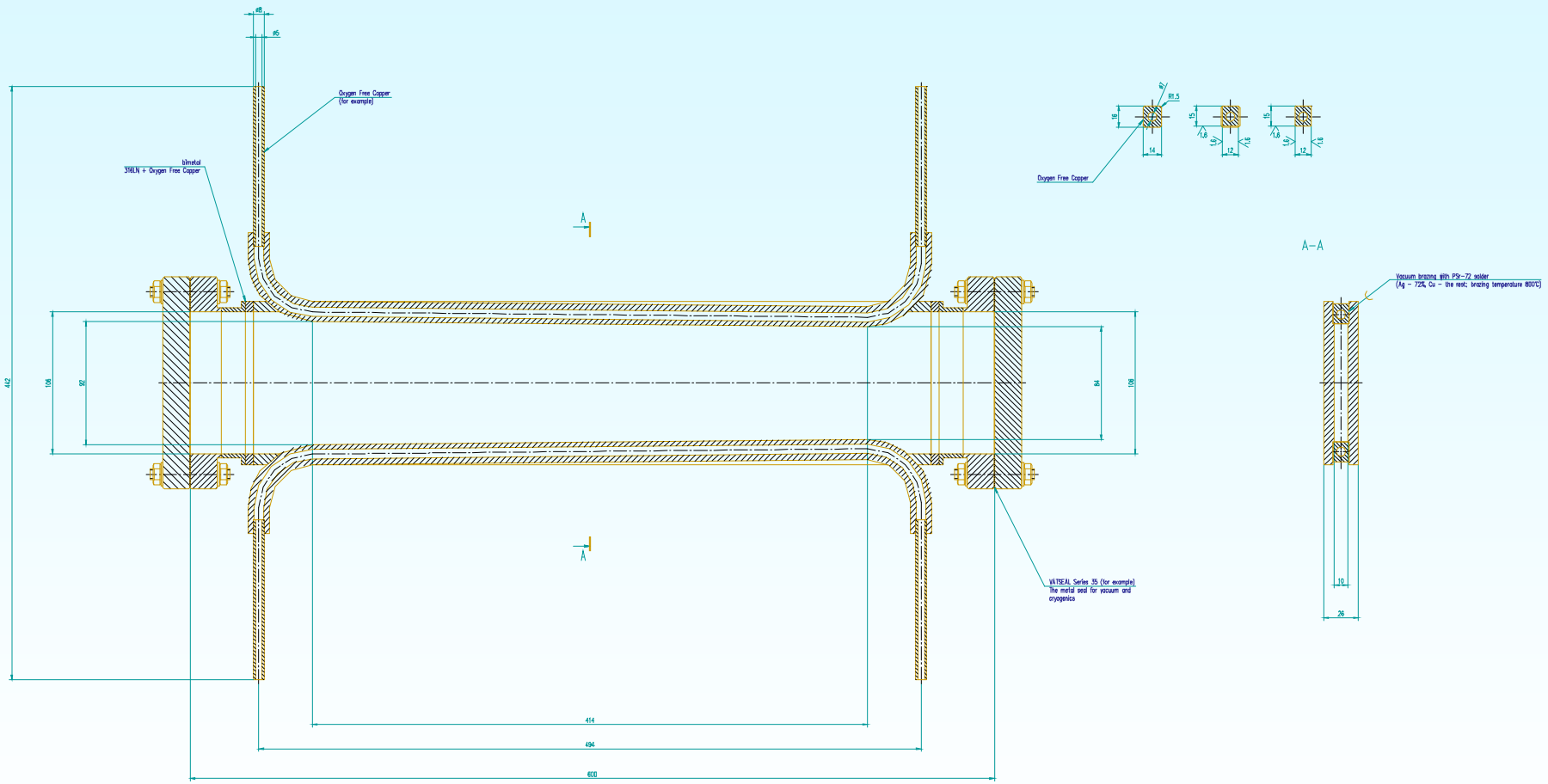
84x7 mm, P=10.4 kW



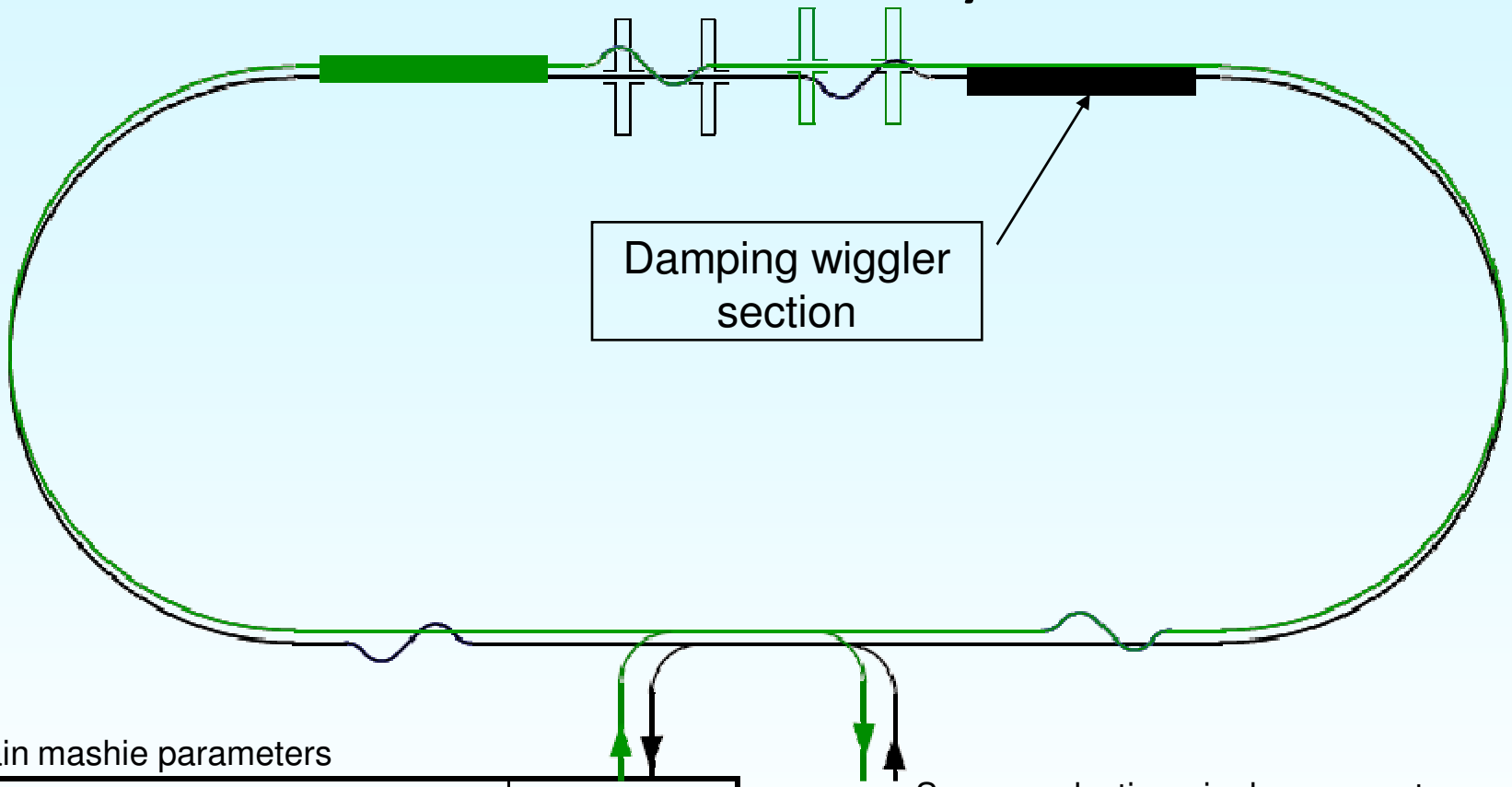
Total load to the LN wiggler liner is about 36 W

Even number wiggler VC load distribution, P=9.4 W

Horizontal collimator design



ILC-DR absorber system



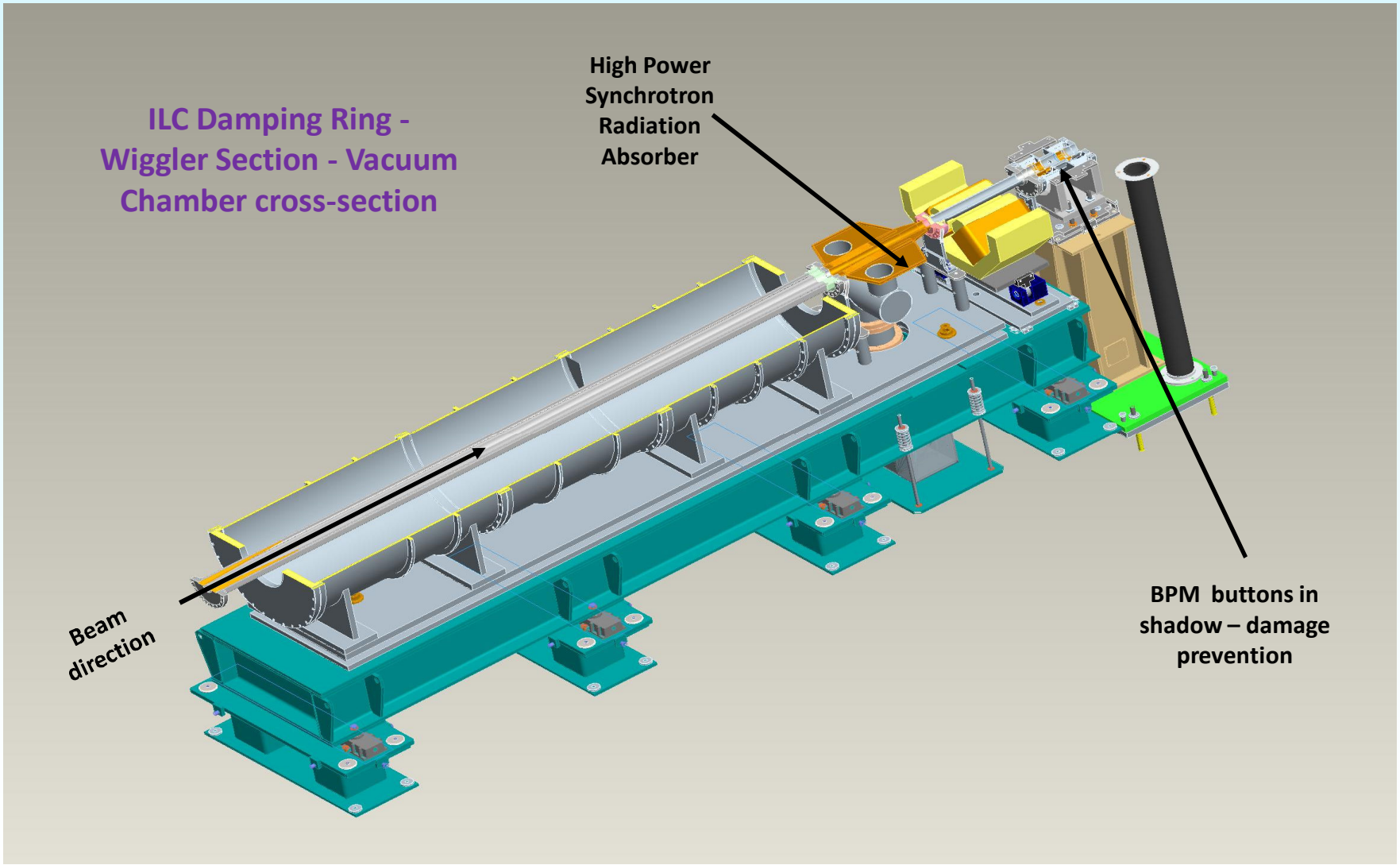
Main mashie parameters

Beam energy, GeV	*5*
Average current, mA	*400*
Number of wiggler (in one section)	*88*
SR wiggler power, kW	*39.7*
Total SR power in one section, kW	*3494*

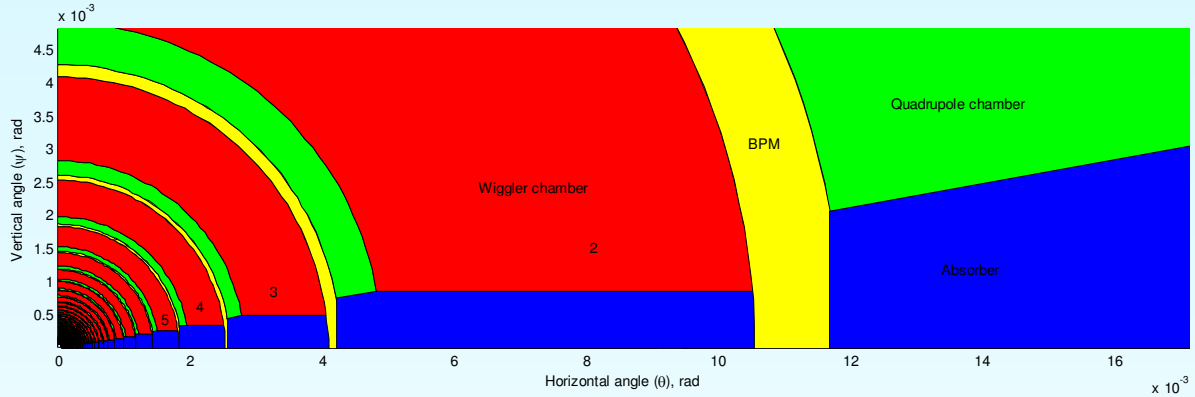
Superconductive wiggler parameters

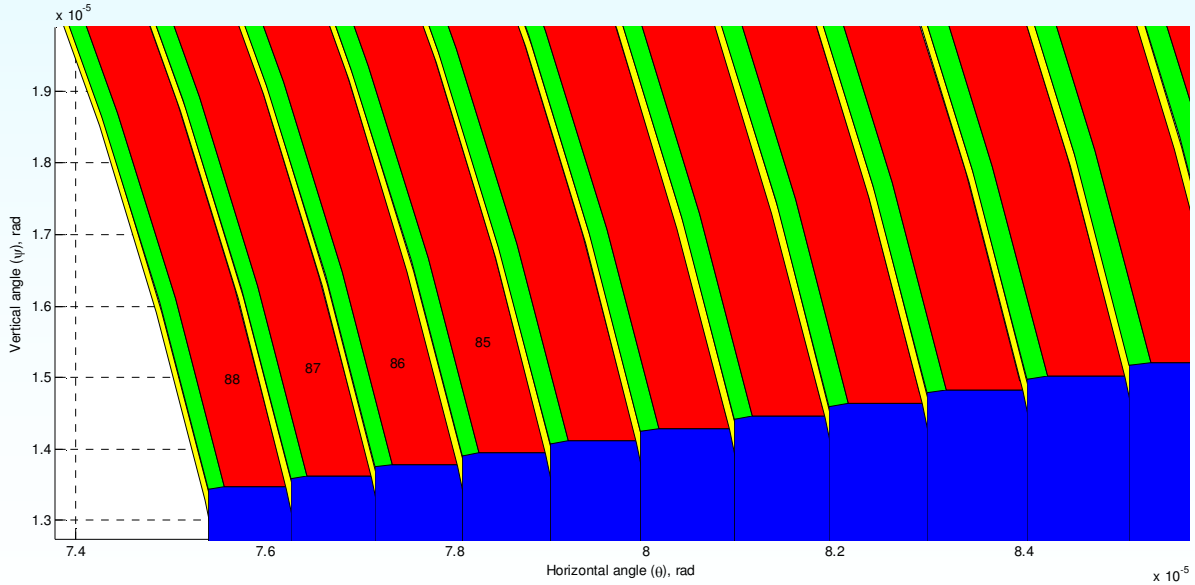
Peak field, T	*1.6*
Period, cm	*40*
K	*59*
Wiggler length, m	*2.45*
Vertical aperture, mm	*60*

ILC-DR vacuums chamber



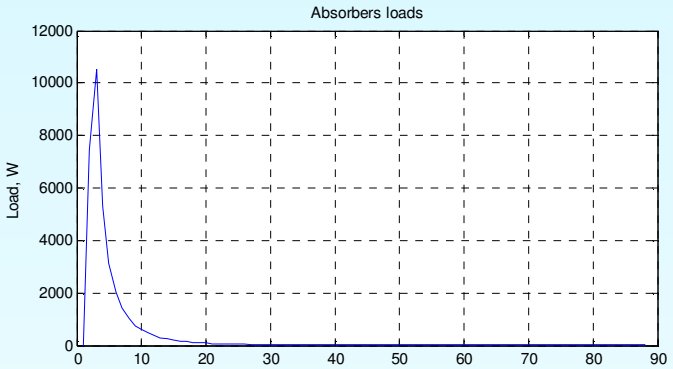
ILC-DR vacuums chamber
Internal view from first wiggler center

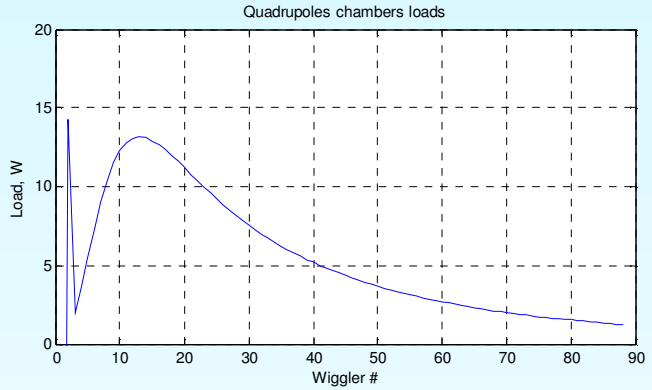


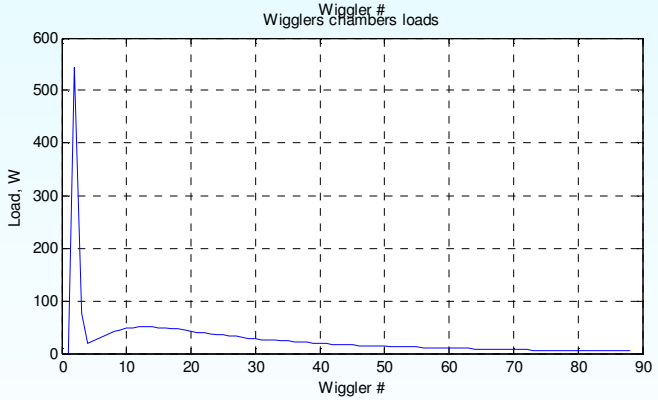


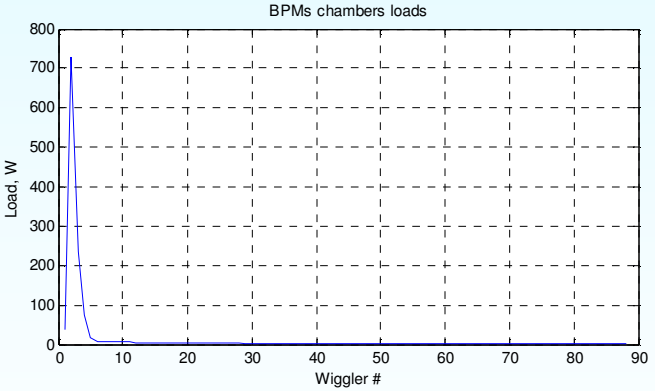
$$\frac{dP}{d\Omega} = \frac{d^2P}{d\theta\, d\psi} = P_T \frac{21\gamma^2}{16\pi K} G(K)\, f_K(\gamma\theta, \gamma\psi)$$

$$f_K(\gamma\theta, \gamma\psi) = \sqrt{1-\left(\gamma\theta/K\right)^2}\left\{\frac{1}{\left(1+(\gamma\psi)^2\right)^{5/2}} + \frac{5(\gamma\psi)^2}{7\left(1+(\gamma\psi)^2\right)^{7/2}}\right\}$$









Last cell elements	Power load, kW
Wiggler chamber	2.39
Absorber	35.5
Quadrupole chamber	0.422
BPM chamber	1.28

Summary

- *The problem of safe and reliable absorption and evacuation of the SR power is a one key problem in damping wiggler section design procedure.*

- *For design and optimization of Petra-III damping section a special codes were developed for SR power load simulations.*

- *This code was use for preliminary design of the absorber systems of CLIC and ILC damping rings and can be used for final design and optimizations*

Thank you for attention