Linear Collider Workshop 2009

Emittance reduction by SC wigglers in the ATF-DR

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October 2nd, 2009

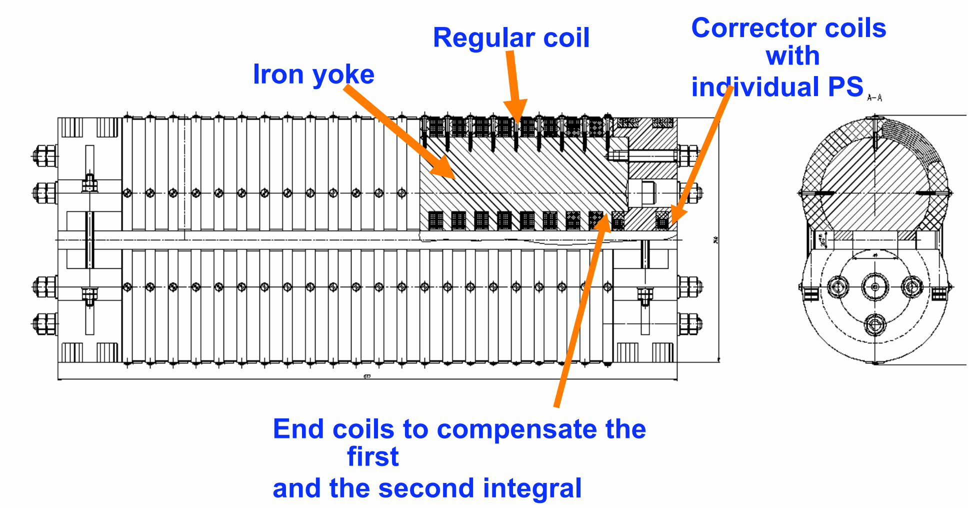
Motivation

- One of the main ATF2 goals is the creation of very low emittance beams
- High-field damping wigglers can be used for further emittance and also damping time reduction in the damping ring
- Super-conducting wigglers are considered in the design of the CLIC damping rings
- Short prototypes are being constructed and magnetically measured
- Final magnet should be tested with beam

NbTi Wiggler Design

P. Vobly, et al., 2008

- Present design uses NbTi wet wire in separate poles clamped together (2.5T, 5cm period)
- Wire wound and impregnated with resin in March
- Short prototype (0.8m) assembled including corrector coil and quench protection system by end of April
- Field measurements started at in June showing poor performance due to mechanical stability problems
- Presently wiggler delivered at CERN for additional beam measurements and further design optimization

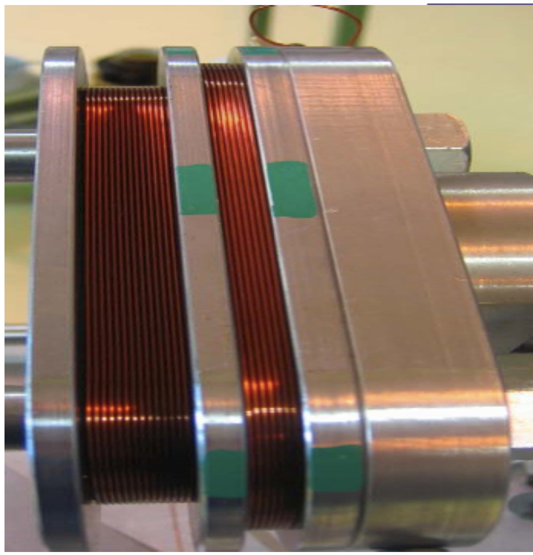


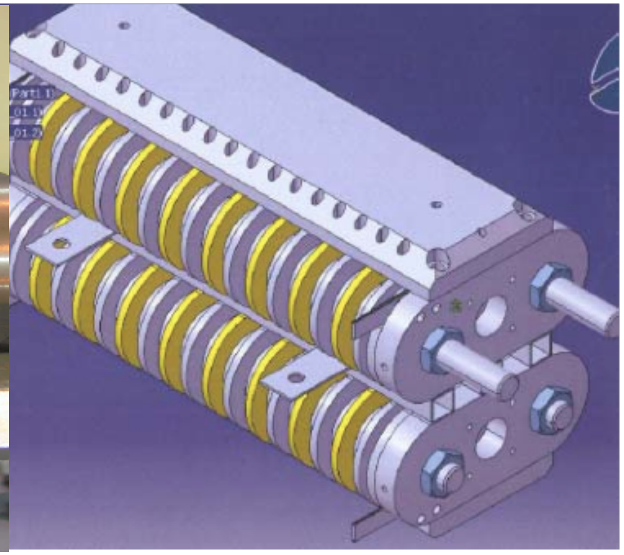
Nb_3Sn Wiggler Design

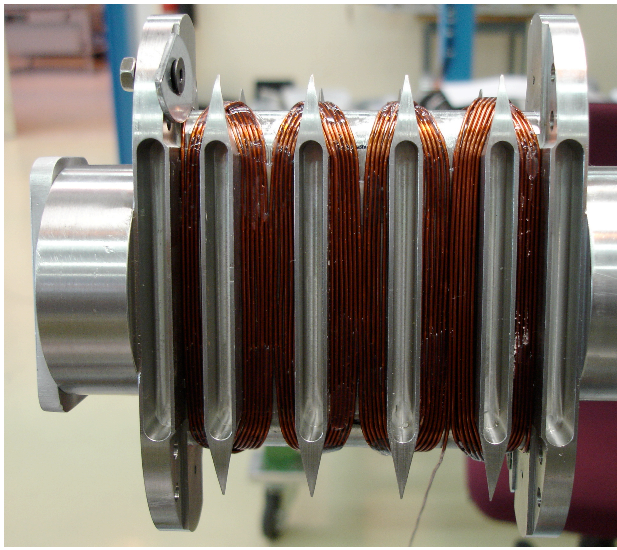
R. Maccaferri and S. Bettoni, 2009

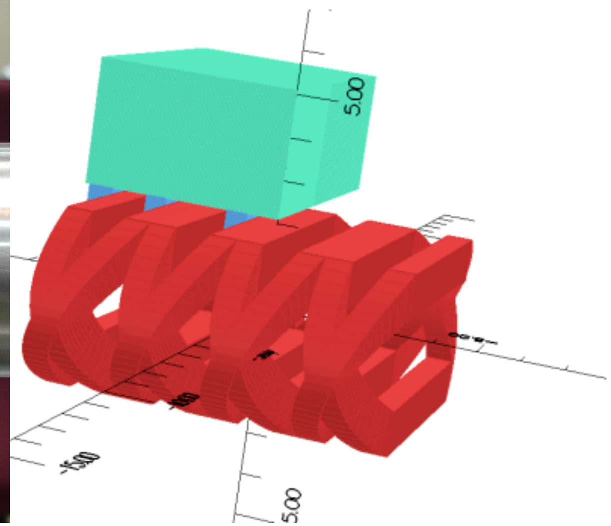
- Two models (2.8T, 40mm period)
  - Vertical racetrack (VR)
  - Double helix (WH), can reach 3.2T with Holmium pole tips
- Nb3Sn can sustain higher heat load (10W/m) than NbTi (1W/m)
- Between 2009-2010, 2 short prototypes will be built, tested at CERN and measured at Un. Of Karlsruhe/ANKA
- Higher wiggler field for lower gap

Type	Bmax	Period	Gap
Nb_3Sn	2.8 T	40 mm	16 mm
NbTi	2.0 T	40 mm	16 mm
Nb_3Sn	2.8 T	30 mm	10 mm
NbTi	2.2 T	30 mm	10 mm









ATF2 parameters

- Wiggler effect is calculated for typical ATF2 parameters, excluding the effect of coupling and IBS
- The emittance can be evaluated as

$$\varepsilon_x = \frac{C_q \gamma^3}{J_x} \frac{I_{50} + I_{5w}}{I_{20} + I_{2w}}$$

and the horizontal damping time

$$\tau_x = \frac{960.13}{B\,\gamma^2} \frac{C}{J_{x0} + F_w}$$

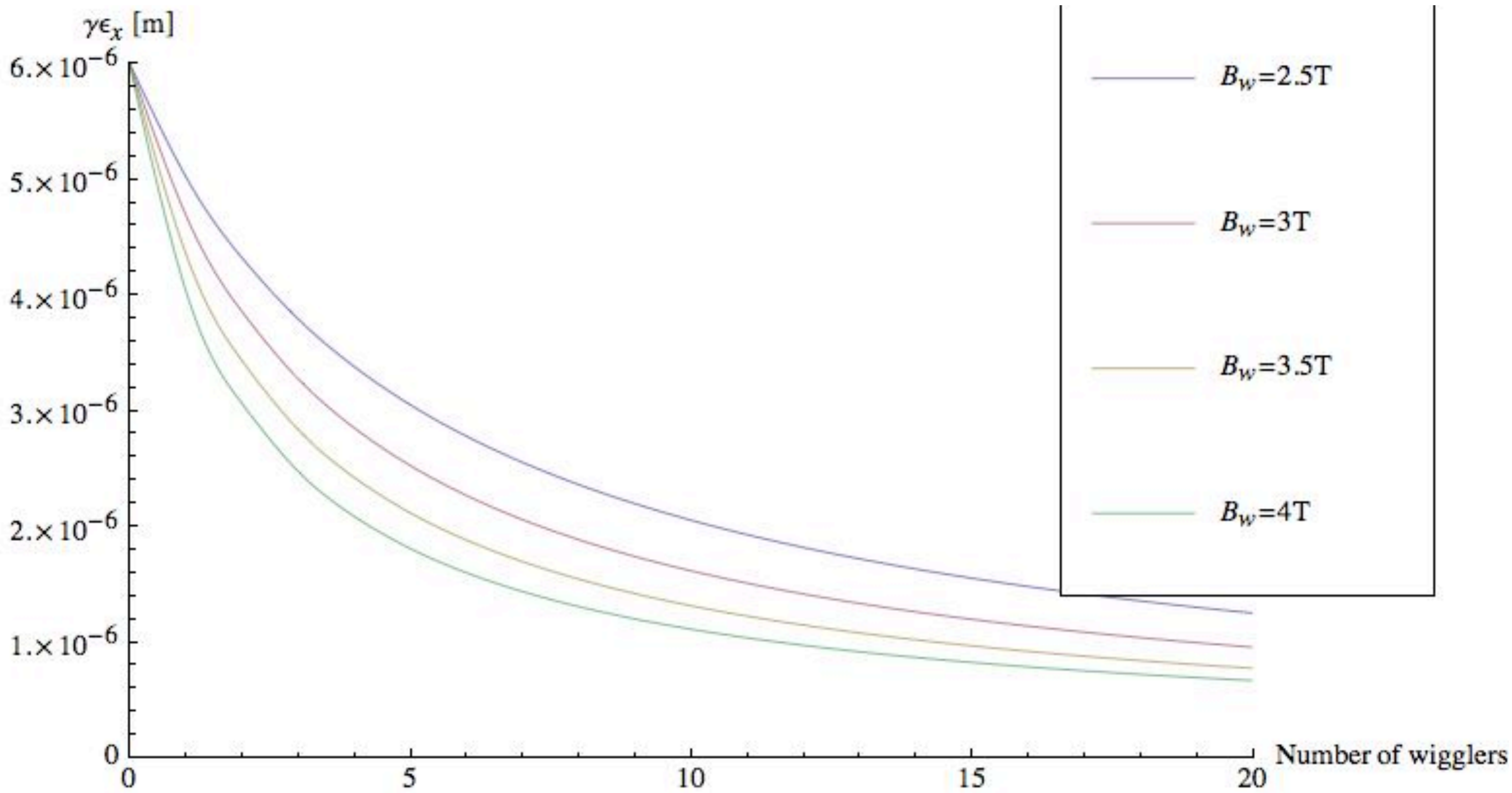
with $$I_{5w} \approx \frac{\lambda_w^2 \beta_w L_w}{384 \rho_w^5}, \quad I_{2w} = \frac{L_w}{2\rho_w^2}, \quad J_x = \frac{J_{x0} + F_w}{1 + F_w}$$

and $$F_w = \frac{B_w^2 L_w}{4\pi\, 0.017\, \gamma\, B}, \quad \rho_w = \frac{0.017\,\gamma}{B_w}$$

Energy [GeV]	1.3
Circumference [m]	138
Hor. damping partition number	1.84
Number of arc cells	36
Bend field [T]	0.69
Wiggler length [m]	2
Beta function on wiggler [m]	2
Hor. Norm. Emittance [μm.rad]	6

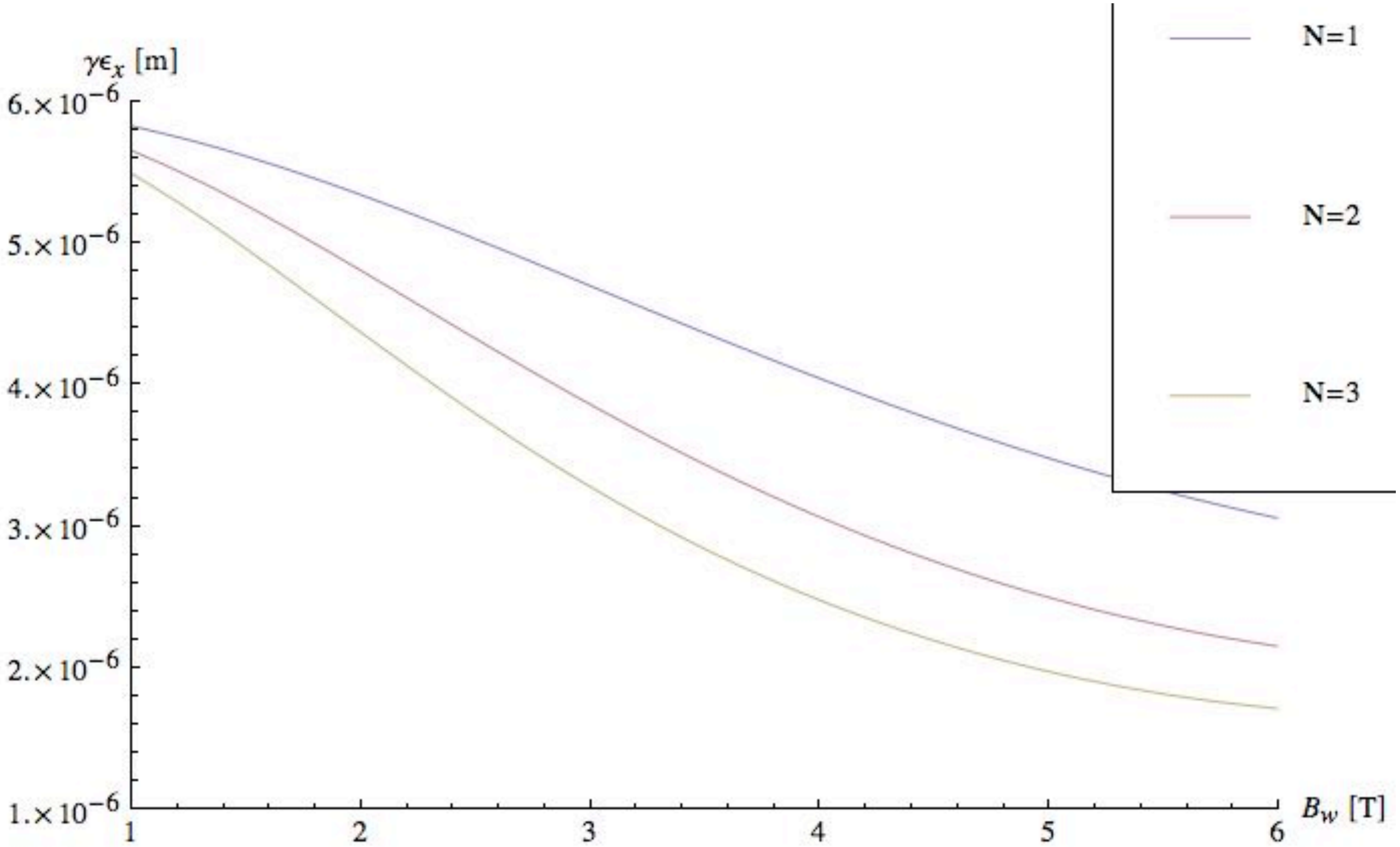
Wiggler effect in emittance

- Important emittance reduction for a few wigglers, saturating as number of wigglers grows
- Strong dependence on the the wiggler peak field
- Weaker dependence on the period length



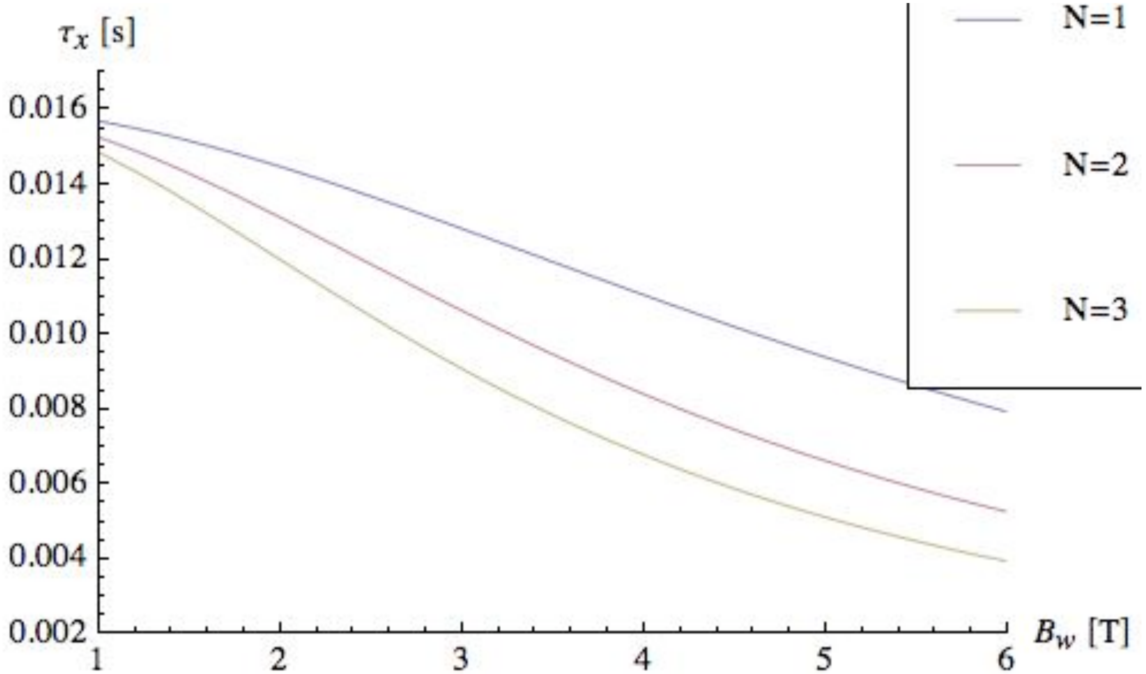
Wiggler effect in emittance

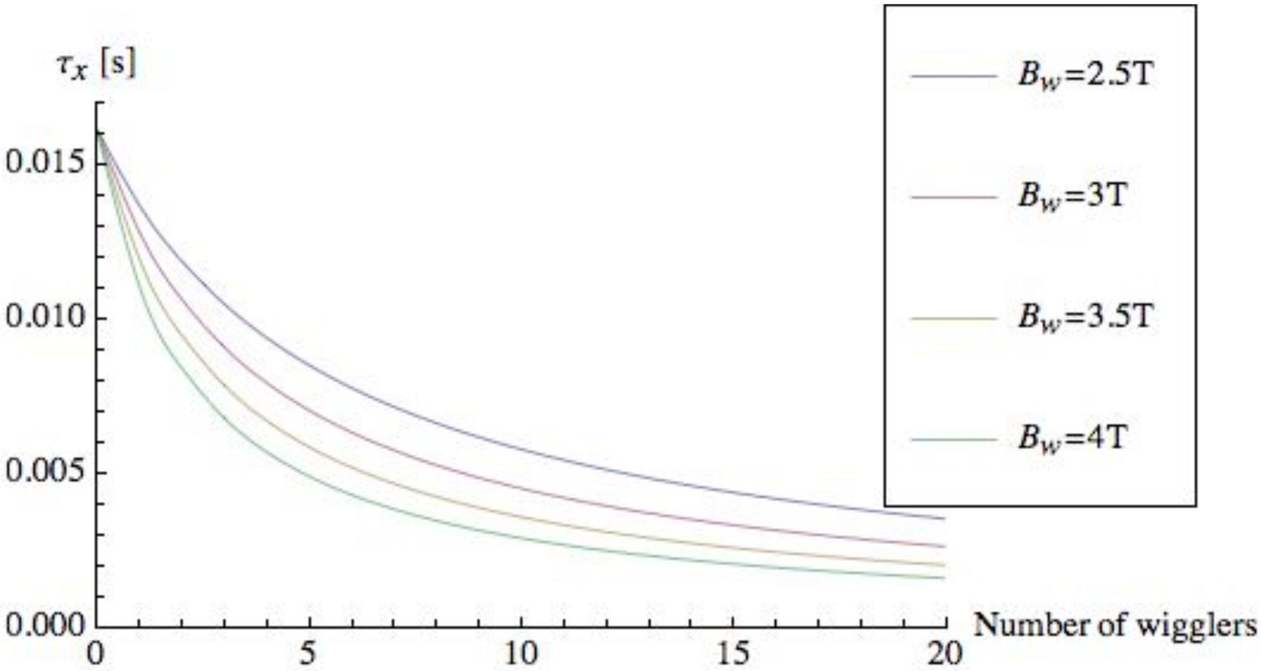
- With a 4T wiggler field and 1 wiggler, more than 30% emittance reduction
- Emittance reduction of around 30% for two 3T wigglers
- Higher field can be achieved for smaller gaps but incompatible with ATF2 operation (geometrical acceptance)



Effect in damping time

- Similar dependence of damping times to number of wigglers and peak field





Next steps

- Important emittance reduction with the inclusion of SC wigglers
- Reduction should be re-estimated when including the effect of IBS and coupling
- Effect of wigglers to dynamic aperture
  - Pending specifications for the CLIC damping rings and measurements
- Evaluation of technical aspects, i.e. available space, radiation absorption, associated cryogenic system