A DR in the TEVATRON tunnel using HERA-e components?

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ILC DR basic requirements:

- ϵ_x^N=8 μm
- repetition rate: 5 Hz $\rightarrow \tau_x < 200$ ms

Equilibrium emittance and damping time:

$$\epsilon_x = C_q \gamma^2 \frac{\mathcal{I}_5}{J_x \mathcal{I}_2} \qquad C_q = 3.832 \times 10^{-13} \text{ m}$$

$$J_x = 1 - \frac{\mathcal{I}_4}{\mathcal{I}_2} \simeq 1$$

$$\tau_x = \frac{2\pi R}{C_x E^3} \frac{1}{\mathcal{I}_2 - \mathcal{I}_4} \qquad C_x = 2113.1 \text{ m}^2\text{GeV}^{-3}\text{s}^{-1}$$

with

$$\mathcal{I}_2 \equiv \oint ds \frac{1}{\rho^2}$$

$$\mathcal{I}_4 \equiv 2 \oint ds \frac{D_x K}{\rho}$$

$$\mathcal{I}_5 \equiv \oint ds \frac{\beta_x D_x'^2 + 2\alpha_x D_x D_x' + \gamma_x D_x^2}{|\rho|^3}$$

The recipe is to minimize $\mathcal{I}_5$ and maximize $\mathcal{I}_2$.

Low emittance rings have been developed as *synchrotron radiation* sources using **DBA** (or basic Chasman-Green) and **TBA** cells

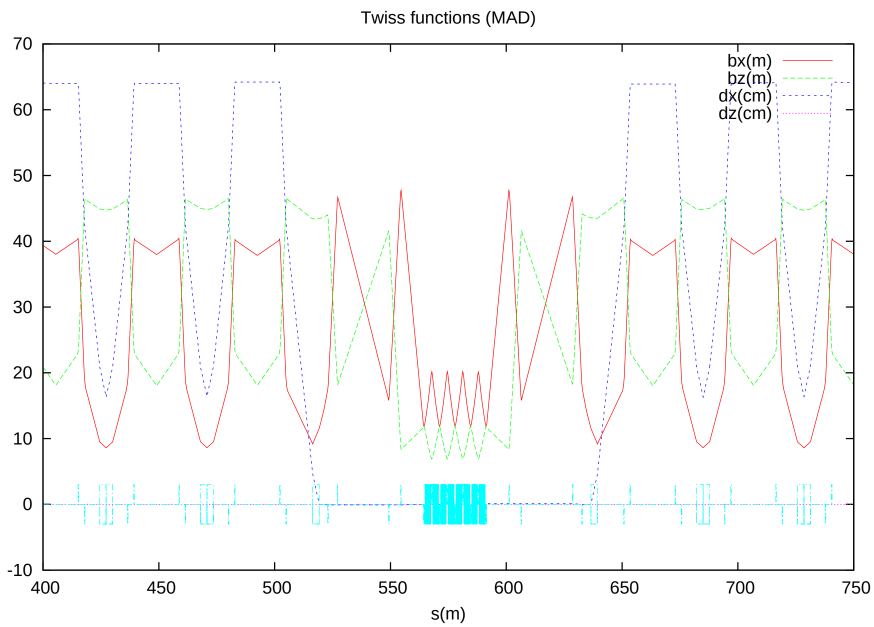
$$\epsilon_x = \frac{K}{12\sqrt{15}} C_q \frac{\gamma^2}{J_x} \theta_{bend}^3$$

K being a quality factor depending on the structure:

$$K_{min} = 3 \quad \text{for DBA}$$

$$K_{min} = 2.3 \quad \text{for TBA}$$

TME (K_{min}=1) have been proposed for 3th generation light sources, for the CLIC DR and the ILC DR (OCS).



OCS TME lattice

L=6 Km Q_x=50.84 Q_z=40.80 $\xi_x^{natural}$= -65.0 $\xi_z^{natural}$=-54.3

The minimum emittance in a pure **FODO** is achieved when $\Delta\mu_c$=135^o

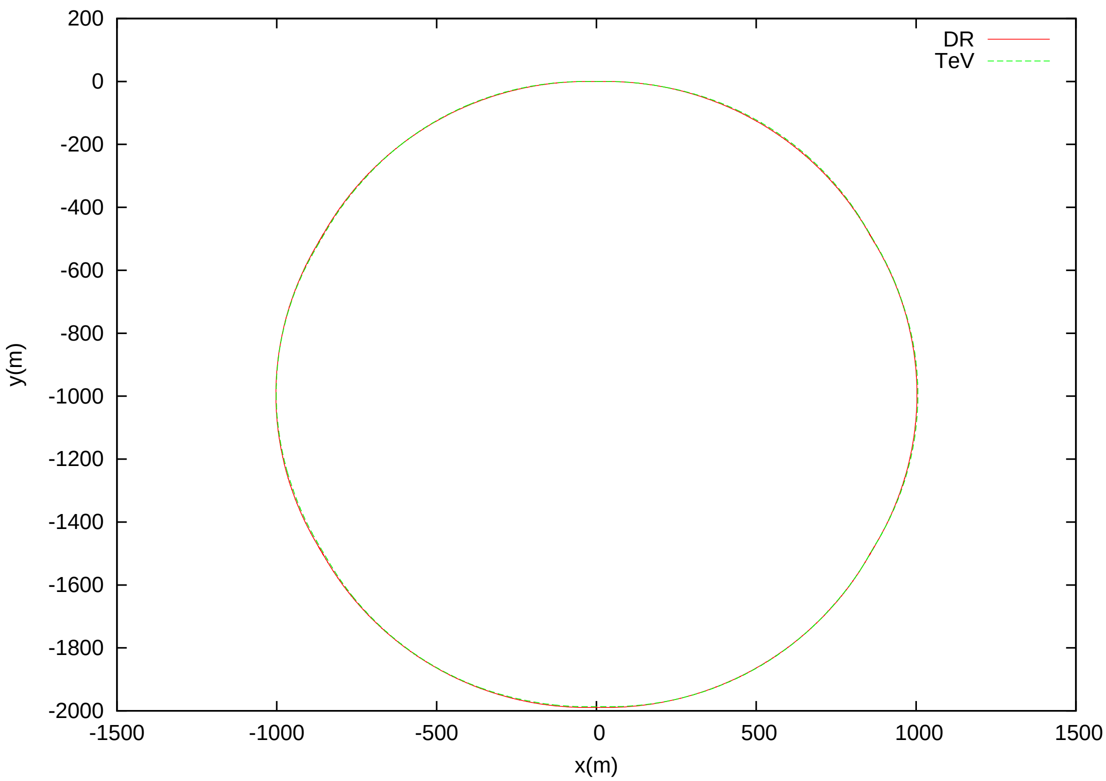
$$\epsilon_x = 1.2 C_q \frac{\gamma^2}{J_x} \theta_{bend}^3 \frac{L_{FODO}}{2\ell_{bend}}$$

(thin lens approximation) which is at least 25 (or 38 wrt the TME) times larger, but...

The double ring $p/e^{\pm}$ collider **Hera** in Hamburg is going to stop operation next year. Could we take advantage (of some) of the $e^{\pm}$ ring components?

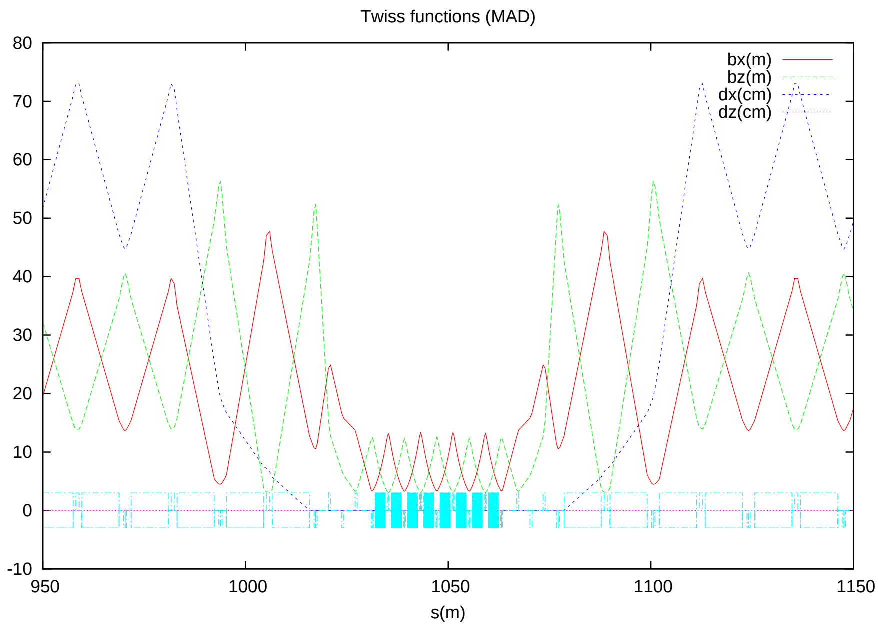
- 6335.8 m, 4 arcs, 4 straight sections
- 144 + 56 (tunable) FODO cells, cell length: 23.5 m
- Bending magnets: ℓ=9.2 m, ϕ=0.015103 rad, ρ=611 m

By using **252** (!) of such cells and increasing the bending radius to 737 m, the Tevatron geometry is roughly matched with 6 identical arcs and 6 straight sections each 60 m long.



$$dR_{max} \simeq 2.5 \text{ m}$$

A possible lattice with dispersion-free regions for damping wigglers



$60^o/60^o$ FODO cells

Q_x=51.22 Q_z=53.27 $\xi_x^{natural}$= -59.2 $\xi_z^{natural}$=-65.4

The FODO phase advance could be increased to decrease the emittance but at the expense of the chromaticity.

The large bending radius is

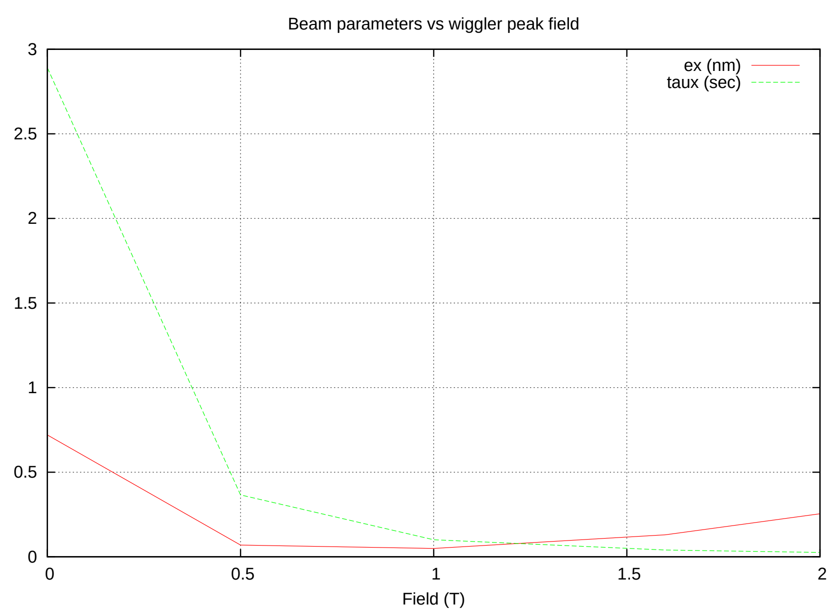
- convenient for the emittance,
- but not for the damping time.

Beam parameters at 5 GeV, w/o wigglers

	ILC design	TevDR	OCS
ϵ_x (nm)	0.8 (*)	0.72	2.7
τ_x (sec)	<0.2 (?)	2.9	0.303

(*) ϵ_x^N=8 μm $\rightarrow \epsilon_x = \epsilon_x^N/\gamma = 0.8$ nm at 5 GeV.

Damping wigglers are needed in order to reduce the damping time.



TevDR

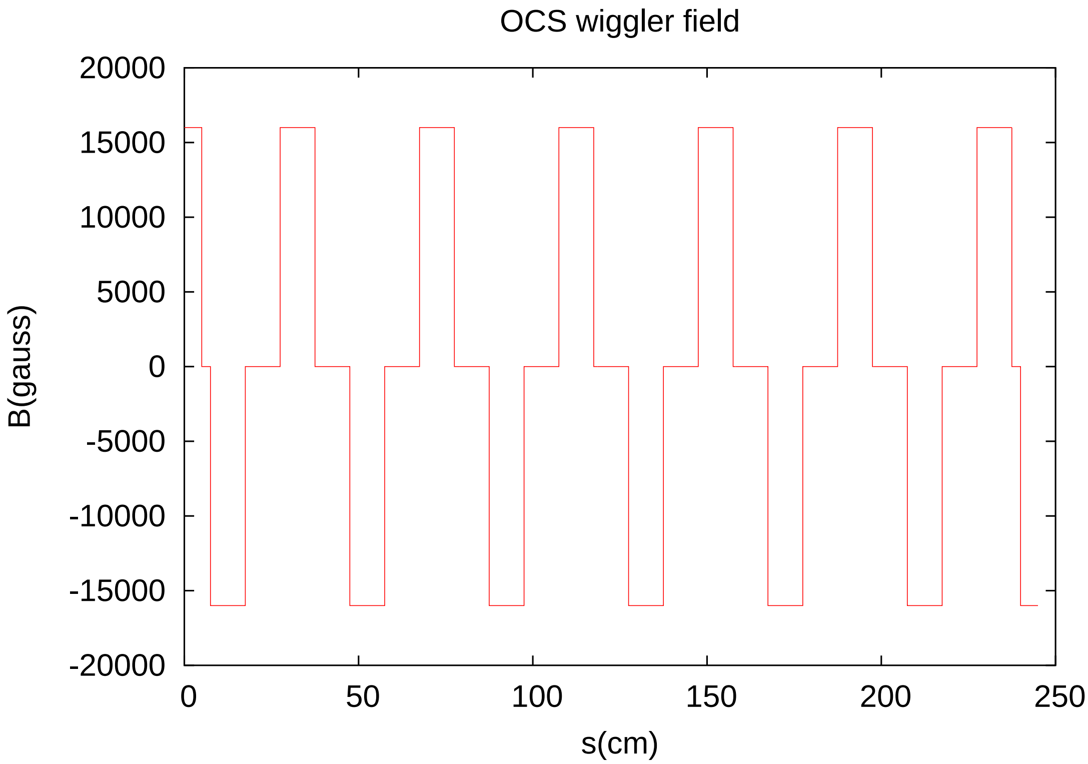
Beam parameters at 5 GeV with 8 2.5 m long wigglers/straight section

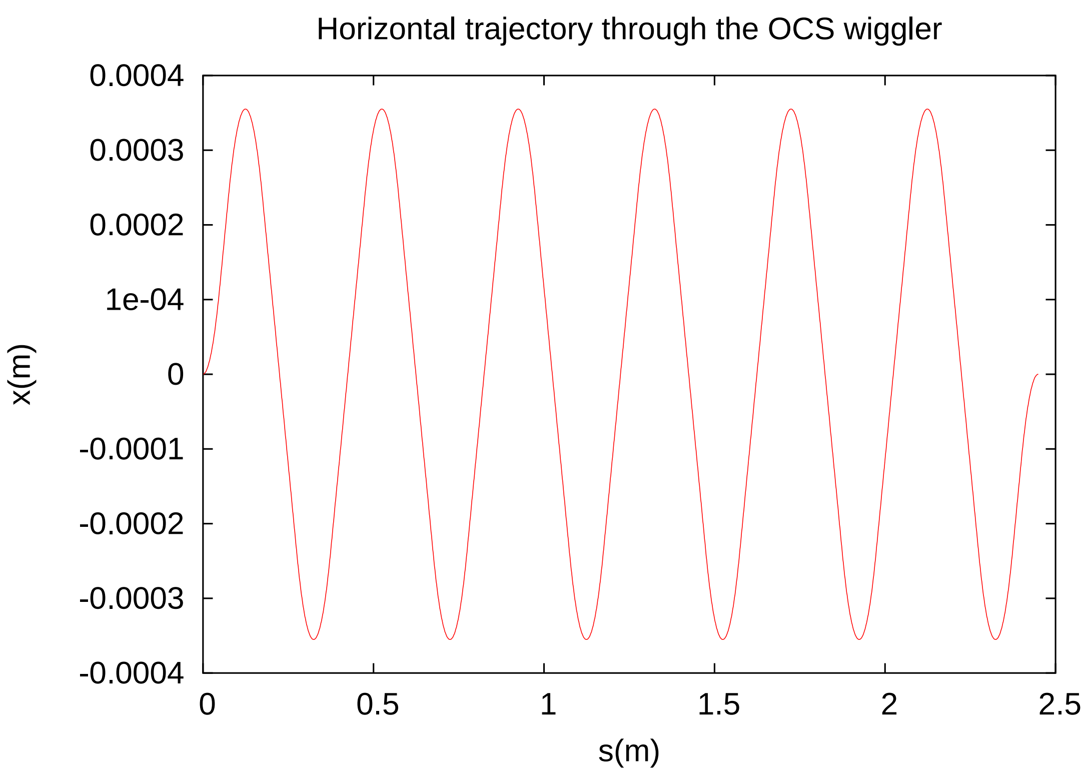
B_w (T)	ρ_w (m)	ϵ_x (nm)	τ_x (sec)
1.0	16.9	0.05	0.10
1.6	10.6	0.13	0.04

OCS

Beam parameters at 5 GeV with 80 2.5 m long wigglers

B_w (T)	ρ_w (m)	ϵ_x (nm)	τ_x (sec)
1.6	10.6	0.58	0.022


OCS wiggler field
B(gauss)
20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
0
50
100
150
200
250
s(cm)


Horizontal trajectory through the OCS wiggler
x(m)
0.0004
0.0003
0.0002
1e-04
0
-0.0001
-0.0002
-0.0003
-0.0004
0
0.5
1
1.5
2
2.5
s(m)

Conclusions

The lattice here presented does not pretend to be *the* final solution, but only a very first trial. A closer look to the actual Tevatron tunnel geometry is needed:

- 252 FODO cells are not available: could we reduce their numbers by slightly increasing the space within the FODO magnets and increasing the bending angle?

A 6 km ring for a 5 GeV beam

- ...is very generous: a smaller ring could offer the same emittance and lower damping time
- but for other reasons seems to be a good compromise for the DR of the ILC

A FODO lattice

- is not the best for minimising the emittance but, if the DR is going to be anyway long, it could make the job
- ...in particular for a test facility at low price!

To be addressed:

- Is the field quality of the Hera-e magnets good enough at 5 GeV?
- Could we learn something running Hera-e at lower energy before the machine is shut down?