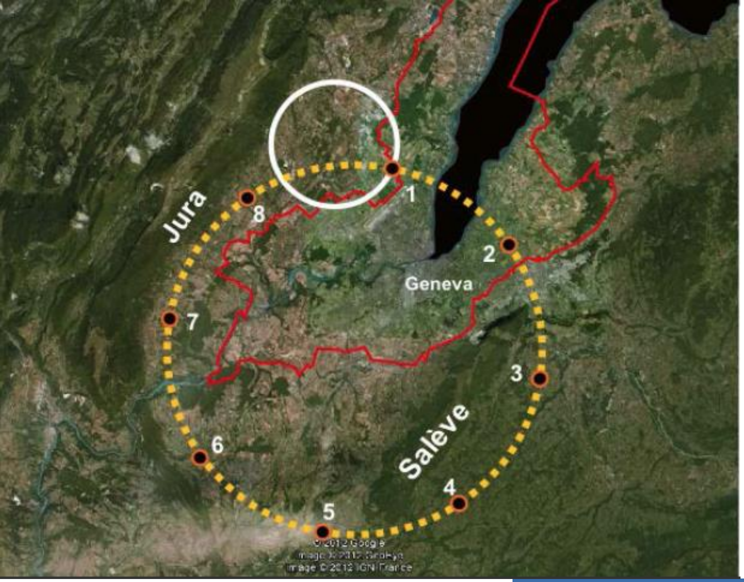
TLEP ... the very first steps

LEP3 and TLEP

Zimmermann, F (CERN, Geneva, Switzerland)

07 December 2012

	LEP3	TLEP
circumference	26.7 km	80 km
max beam energy	120 GeV	175 GeV
max no. of IPs	4	4
luminosity at 350 GeV c.m.	-	0.7×10^{34} cm^{-2}s^{-1}
luminosity at 240 GeV c.m.	10^{34} cm^{-2}s^{-1}	5×10^{34} cm^{-2}s^{-1}
luminosity at 160 GeV c.m.	5×10^{34} cm^{-2}s^{-1}	2.5×10^{35} cm^{-2}s^{-1}
luminosity at 90 GeV c.m.	2×10^{35} cm^{-2}s^{-1}	10^{36} cm^{-2}s^{-1}



TLEP

... the very first steps

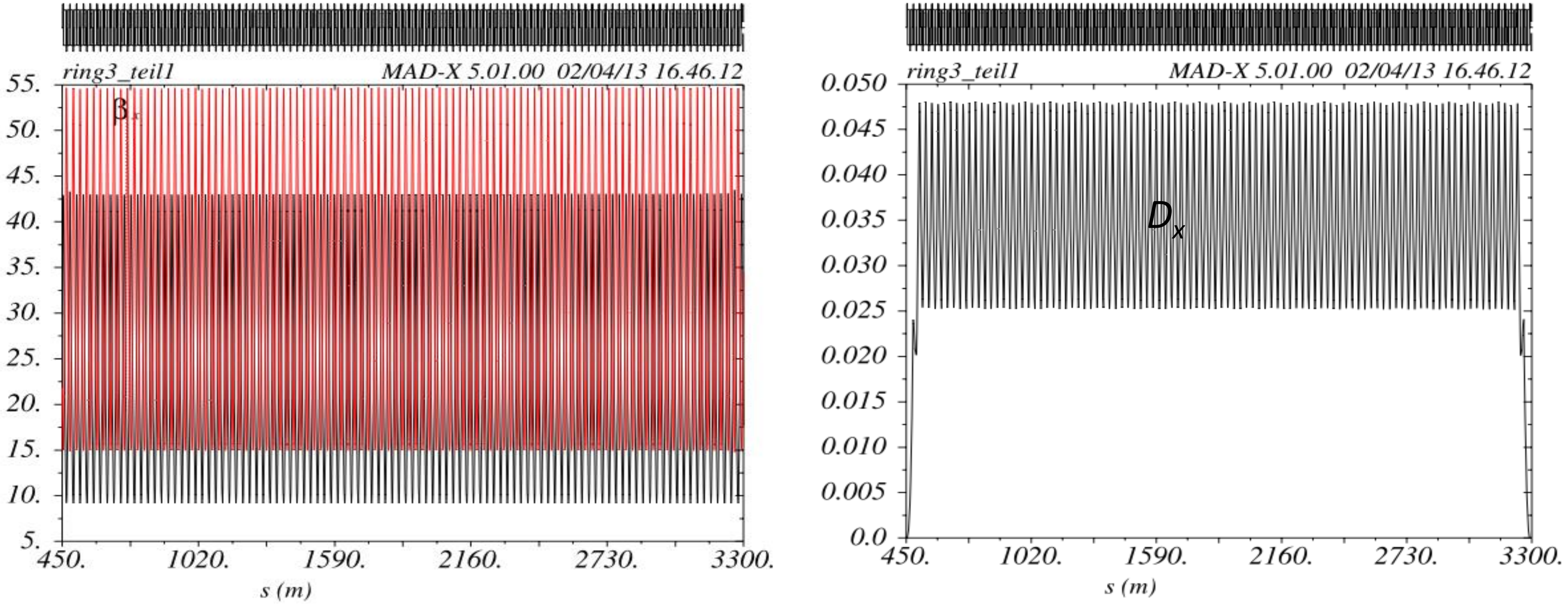
	LEP2	LHeC	LEP3	TLEP-Z	TLEP-H	TLEP-t
beam energy E_b [GeV]	104.5	60	120	45.5	120	175
circumference [km]	26.7	26.7	26.7	80	80	80
beam current [mA]	4	100	7.2	1180	24.3	5.4
#bunches/beam	4	2808	4	2625	80	12
#e-/beam [10^{12}]	2.3	56	4.0	2000	40.5	9.0
horizontal emittance [nm]	48	5	25	30.8	9.4	20
vertical emittance [nm]	0.25	2.5	0.10	0.15	0.05	0.1
bending radius [km]	3.1	2.6	2.6	9.0	9.0	9.0
partition number J_ε	1.1	1.5	1.5	1.0	1.0	1.0
momentum comp. α_c [10^{-5}]	18.5	8.1	8.1	9.0	1.0	1.0
SR power/beam [MW]	11	44	50	50	50	50
β^*_x [m]	1.5	0.18	0.2	0.2	0.2	0.2
β^*_y [cm]	5	10	0.1	0.1	0.1	0.1
σ^*_x [μm]	270	30	71	78	43	63
σ^*_y [μm]	3.5	16	0.32	0.39	0.22	0.32
hourglass F_{hg}	0.98	0.99	0.59	0.71	0.75	0.65
ΔE^{SR}_{loss}/turn [GeV]	3.41	0.44	6.99	0.04	2.1	9.3

SuperKEKB: $\varepsilon_y/\varepsilon_x$=0.25%

TLEP ... Lattice Design

based on considerations & experience from LEP (W.Herr) / LEP3 (Y. Cai)

Arc: 96 standard FoDo cells & 2 half bend cells at beginning and end
length of arc: 2.8km
length of straight section: 0.45 km



TLEP ... Lattice Design

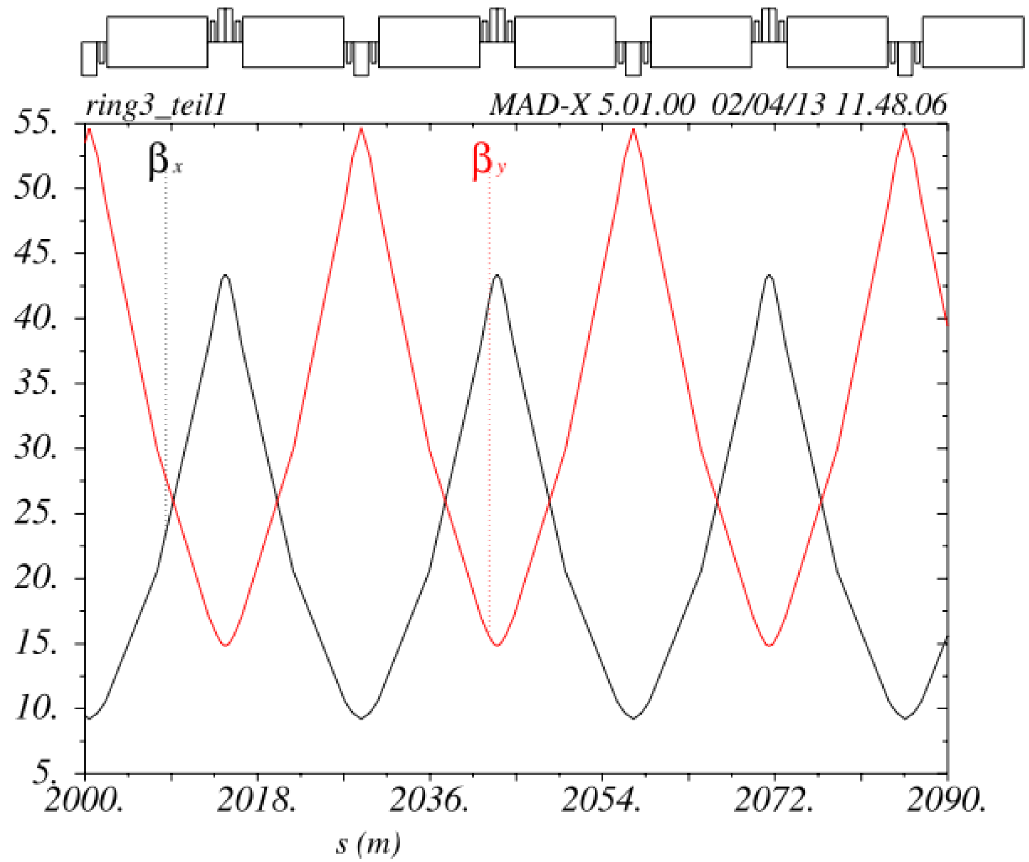
Arc: the single FoDo cell

until now ... 2 dipoles / 2 quadrupoles
to be optimised according to hardware engineering

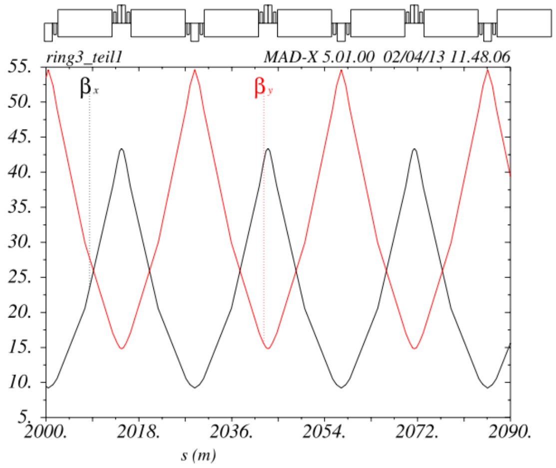
short cell length: ≈ 30 m

advantage: small betas
small dispersion
small emittance

but: realistic hardware design ?



TLEP ... Lattice Design



Arc: the single FoDo cell

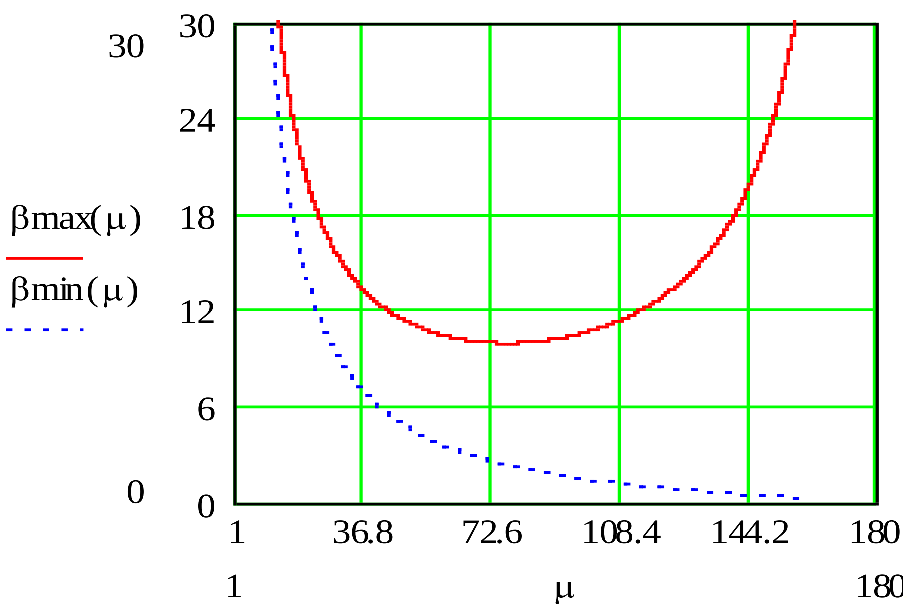
phase advance: 90^0 / 60^0

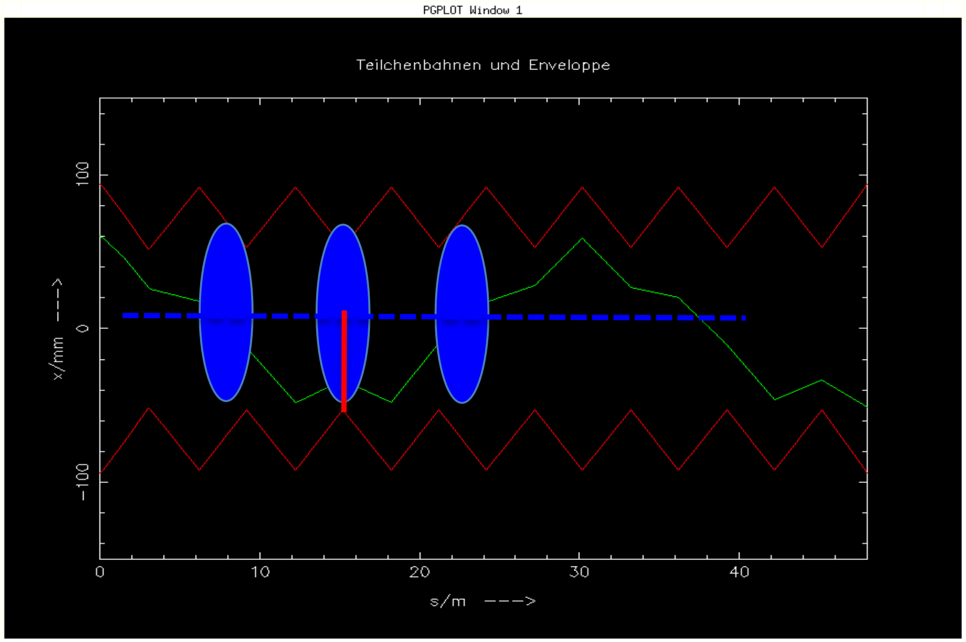
to be discussed ...

***90^0 horizontally**: small dispersion & emittance*

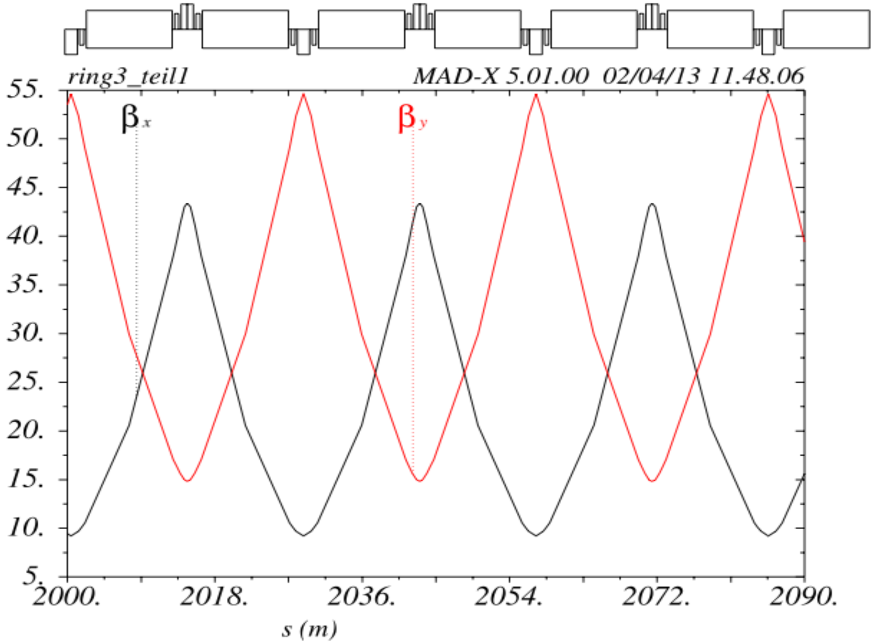
***60^0 vertically**: small beam size (β_y)*

and better orbit correction tolerance (LEP experience)





TLEP ... Lattice Design



Hardware:

2 dipoles per FoDo

l(B0) = 10.5 m
l (QF) = l(QD) = 1.5m

$B_0 \approx 0.074$ T
$G \approx 85$ T/m

Complete Arc:
4700 dipoles and quadrupoles

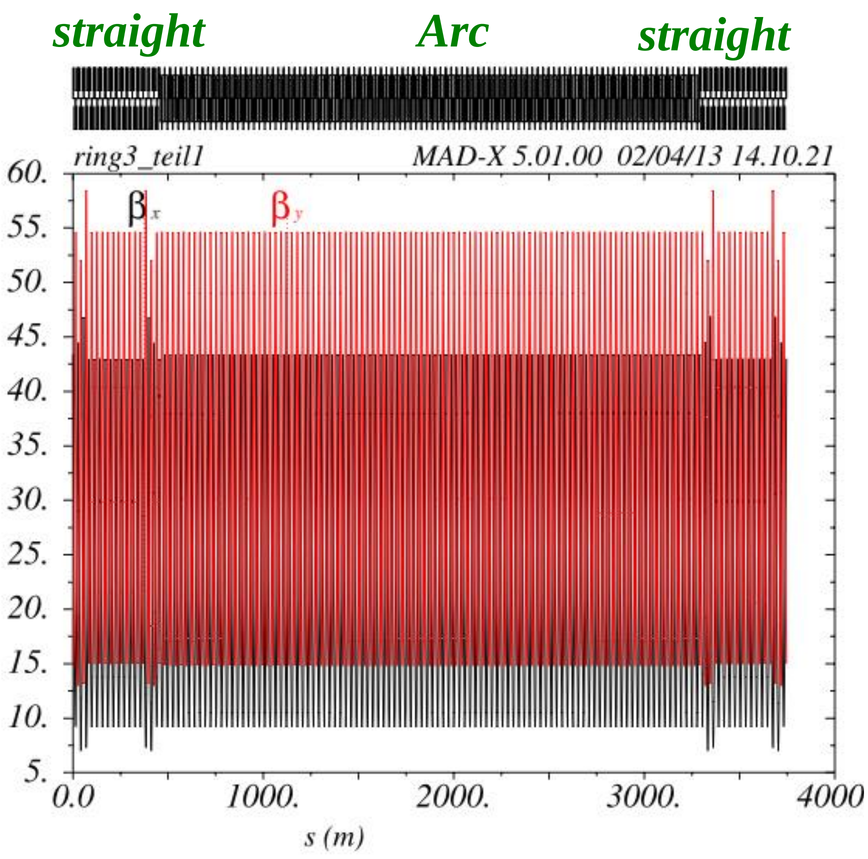
TLEP ... Lattice Design

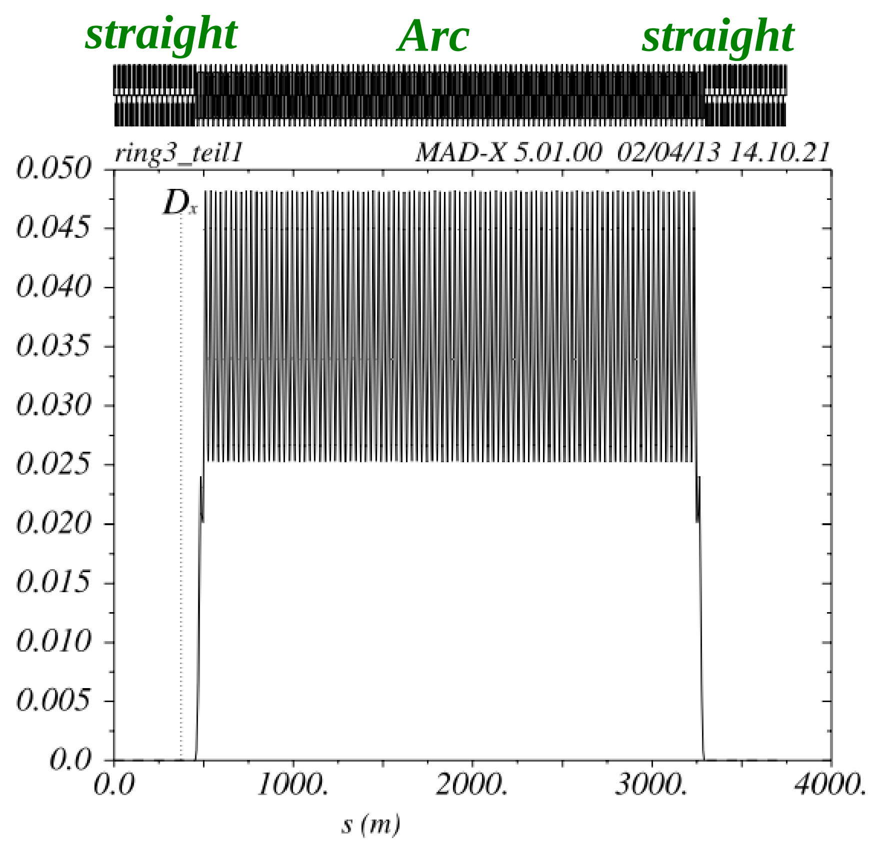
The straight sections:

6 matching quadrupoles,

8 “empty” FoDo cells, dispersion free

6 matching quadrupoles



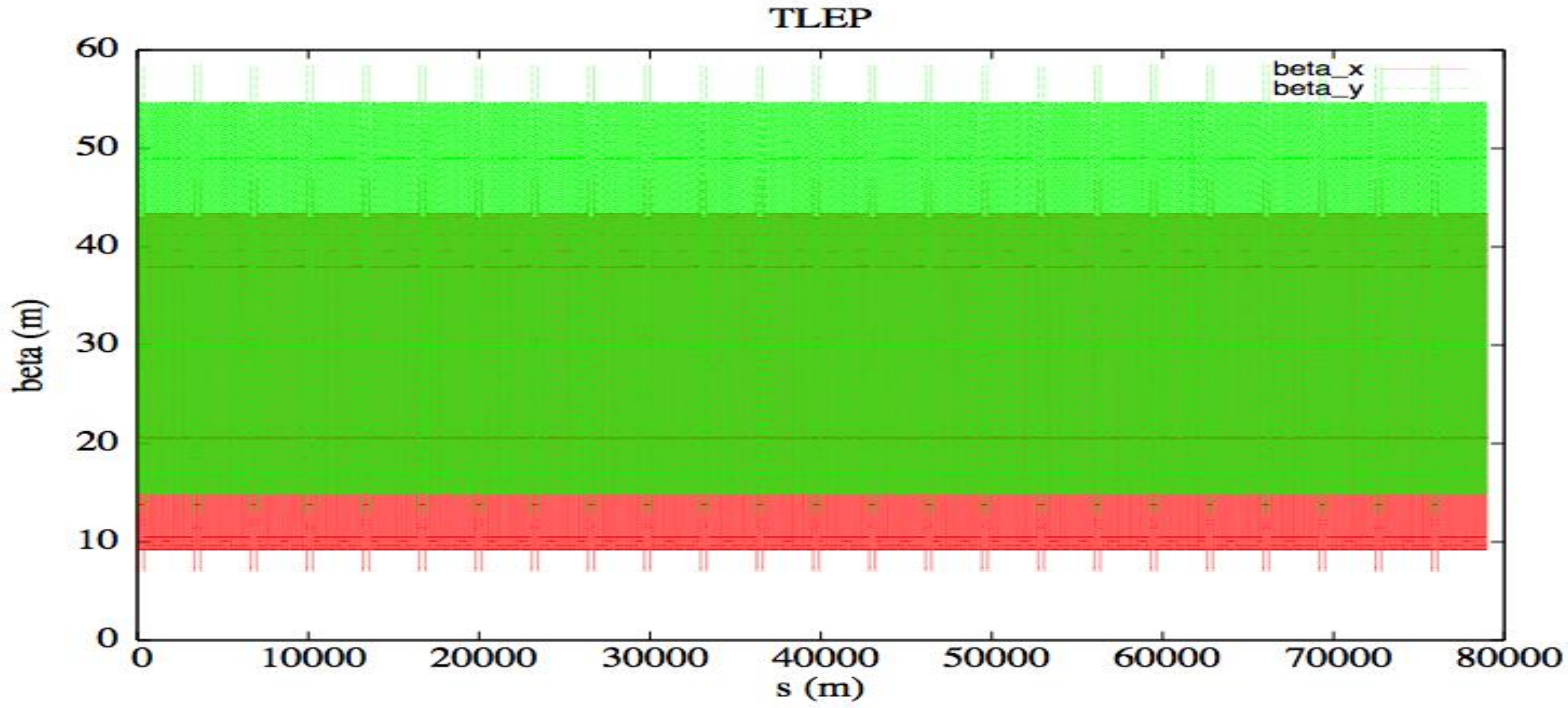


TLEP ... Lattice Design

The Ring: a kind of three times LEP

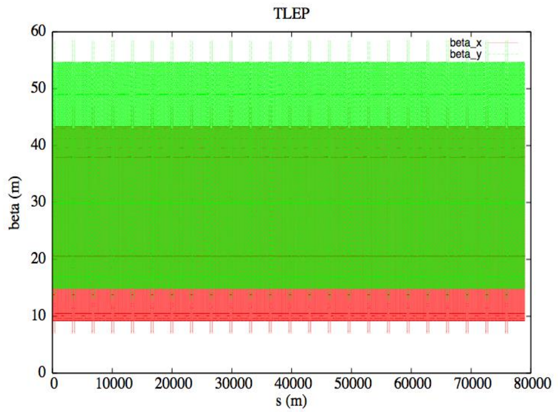
24 Arcs, 24 straight sections

?? one or two mini-beta-insertions ??



TLEP ... Lattice Design

The Ring: a kind of three times LEP



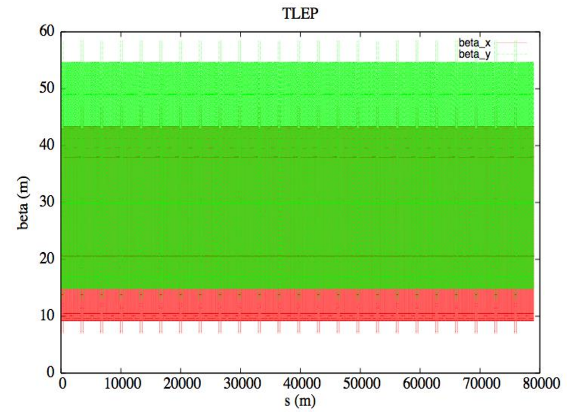
Main Parameters:

$\beta_x = 45m$
$\beta_y = 55m$
$L = 78996m$

```
emit;

enter EMIT module

 Global parameters for electrons, radiate = T:

 C                 78996.65702 m          f0                0.00379500183 MHz
 T0                263.5044842 musecs     alfa             2.719928991e-06
 eta             2.719920464e-06          gamma(tr)            606.3469774
 Bcurrent         0.00547236431 A/bunch   Kbunch                    1
 Npart                   9e+12 /bunch     Energy                          175 GeV
 gamma             342466.4839            beta                            1
guess:             0                  0                   0
     U0          10459.447070 [MeV/turn]
```

TLEP ... Lattice Design

The Ring: a kind of three times LEP



Main Parameters:

momentum compaction

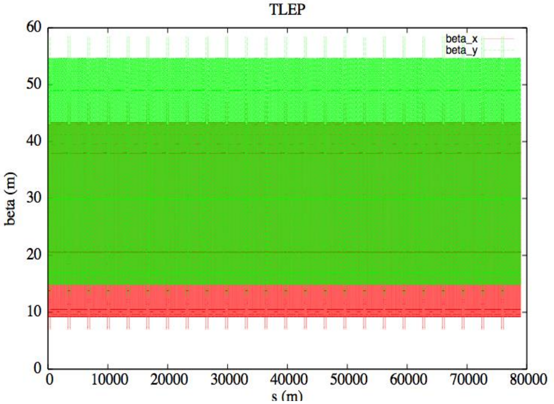
MADX: α_{cp} =2.7*10^{-6}

energy loss per turn:

MADX: α_{cp} =10.4 GeV

TLEP ... Lattice Design

The Ring: a kind of three times LEP



Main Parameters:

Damping & Beam Emittance

Damping partition numbers	0.99997901	0.99999668	2.00001740
Damping constants [1/s]	0.11340796E+03	0.11340997E+03	0.22682266E+03
Damping times [s]	0.88177229E-02	0.88175670E-02	0.44087305E-02
Emittances [pi micro m]	0.33951783E-03	0.47789413E-31	0.29751606E+00

$\varepsilon = 3.4 \cdot 10^{-10}$ rad m ***... quite a bit smaller than required.***

-> *optimise optics for higher ε*

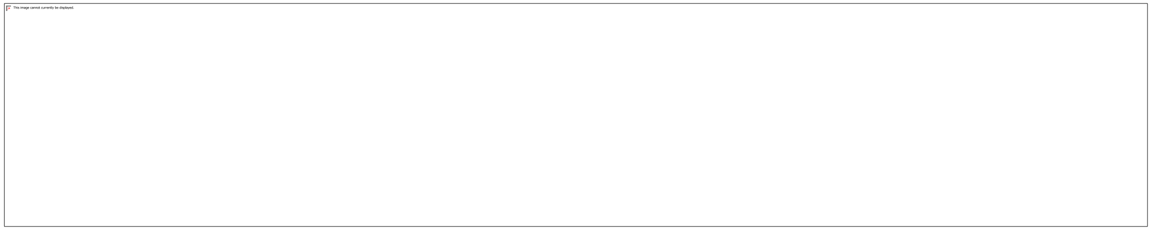
-> *install wigglers for ε control*

Synchrotron Radiation Power

$N_p = 9 \cdot 10^{12}$

$\Delta U_0 = 10.4$ MeV

$T_0 = 263\ \mu s$



TLEP ... questions to be discussed

crab waist / mini beta / local Q' control ??

Restriction on the energy and luminosity of e^+e^- storage rings due to beamstrahlung

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Novosibirsk State University, 630090, Novosibirsk, Russia
(Dated: 29 March 2012)

The role of beamstrahlung in high-energy e^+e^- storage-ring colliders (SRCs) is examined. Particle loss due to the emission of single energetic beamstrahlung photons is shown to impose a fundamental limit on SRC luminosities at energies $2E_0 \gtrsim 140$ GeV for head-on collisions and $2E_0 \gtrsim 40$ GeV for crab-waist collisions. With beamstrahlung taken into account, we explore the viability of SRCs in the $2E_0 = 240$–500 GeV range, which is of interest in the precision study of the Higgs boson. At $2E_0 = 240$ GeV, SRCs are found to be marginally competitive with linear colliders; however, at $2E_0 = 400$–500 GeV, the attainable SRC luminosity would be a factor 15–25 smaller than desired.

PACS numbers: 29.20

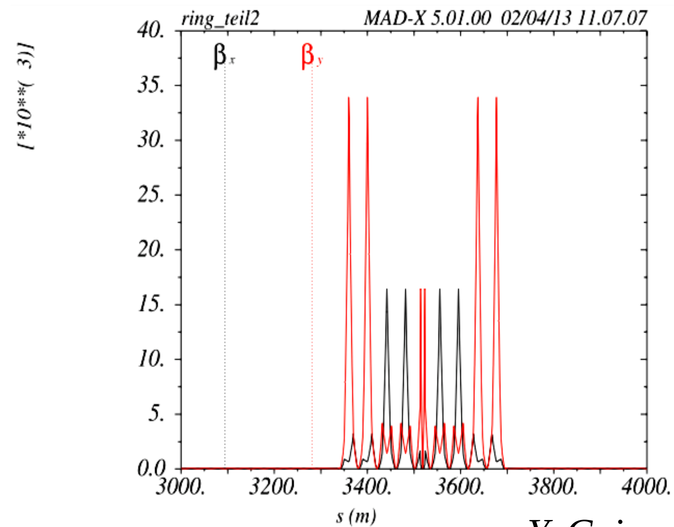
In conclusion, we have demonstrated that beamstrahlung suppresses the luminosities of high-energy e+e− storage rings as $1/E^{4/3}$ at beam energies E > ∼ 70GeV for head-on collisions and E >∼ 20GeV for crab-waist collisions. Very importantly, beamstrahlung makes the luminosities attain-able in head-on and crab-waist collisions approximately equal above these threshold energies. At 2*E = 240 500GeV, beamstrahlung lowers the luminosity of crab-waist rings by a factor of 15-40.

TLEP ... the next steps

mini beta / ~~local Q' control~~ ? / ~~crab waist~~ ??

* mini beta insertion: ... "LEP-like version" preferred

how many ... first guess: two
no crab waist / no ILC like mini β



Y. Cai

* optimisation of cell structure:
phase advance / hard ware

* damping wigglers: emittance control

* chromaticity compensation

* layout interaction region / beam separation / synchrotron radiation at IR

* cell structure modification for different energies