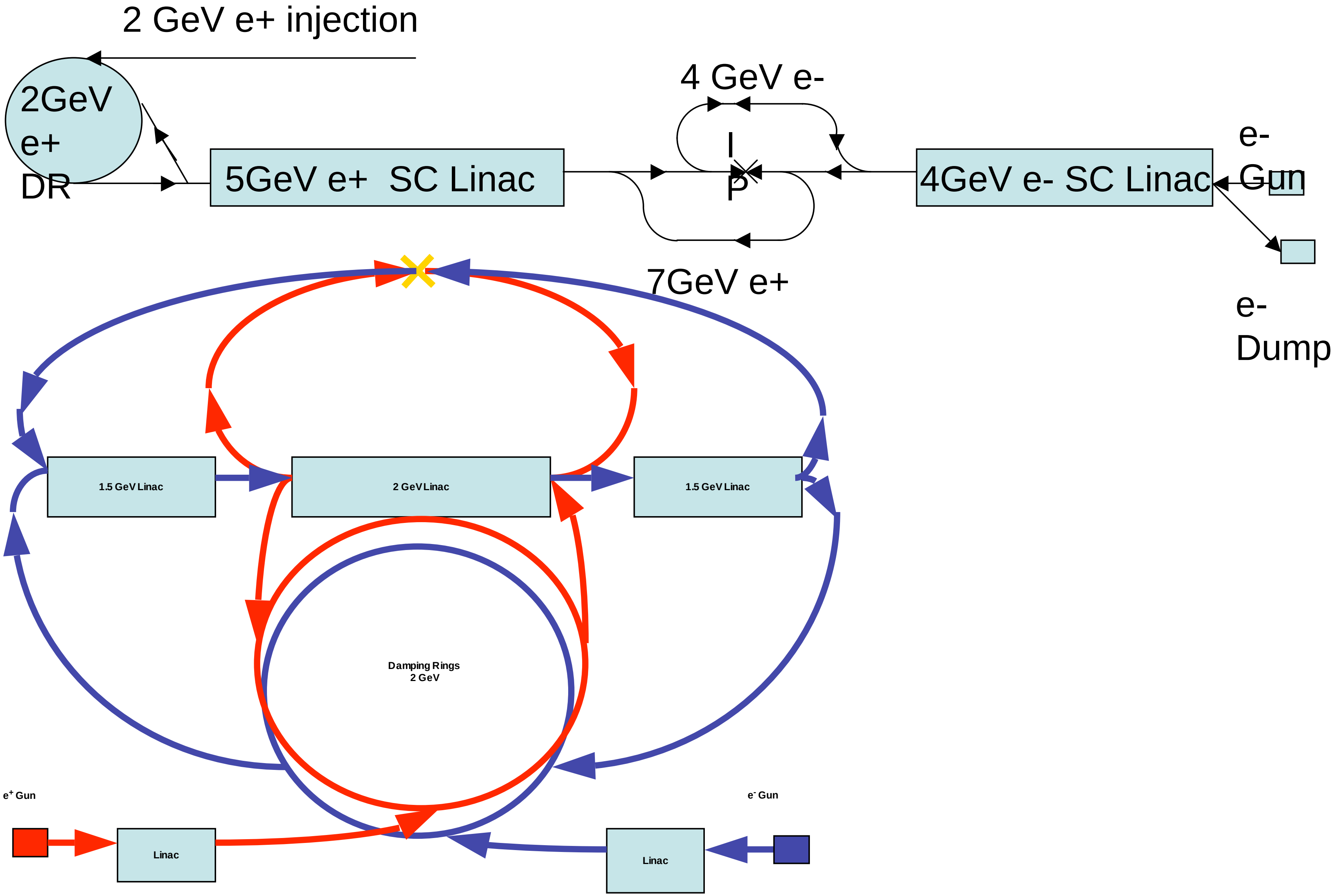
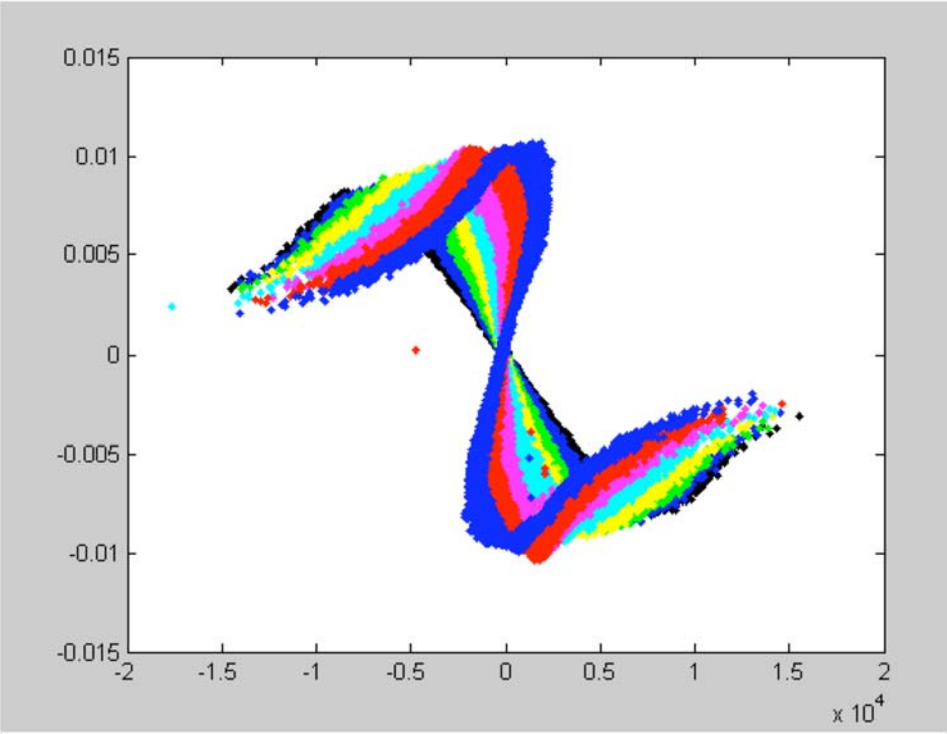
Summary of WGs

P. Raimondi

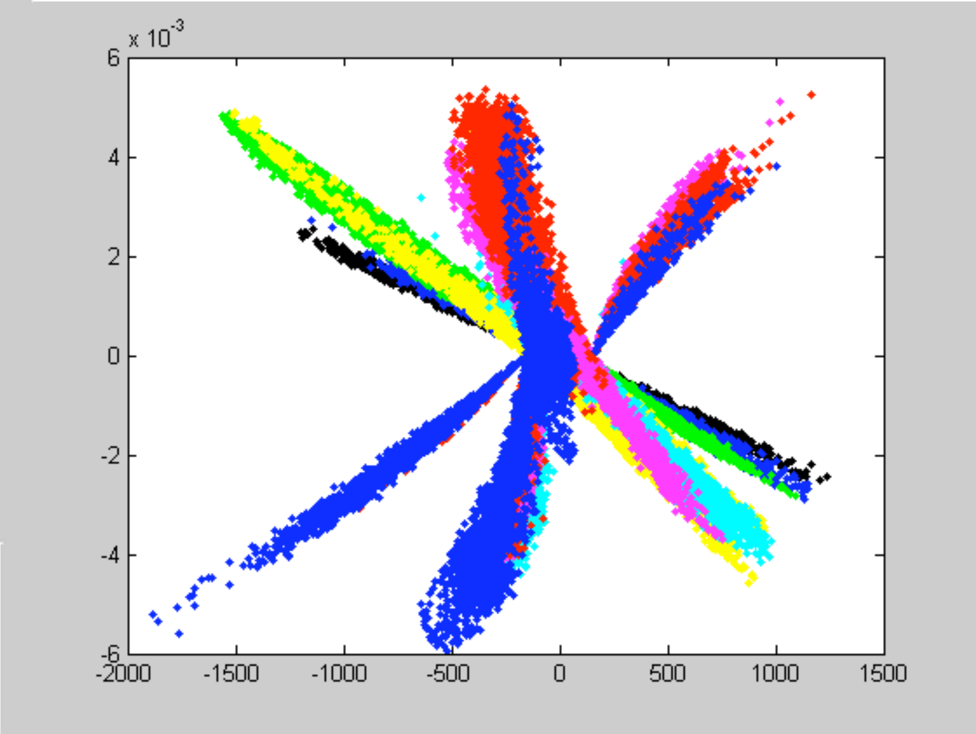
Frascati, March 17, 2006

Linear Super B schemes with acceleration and energy recovery





Horizontal phase after the collision



Vertical phase after the collision

IP Parameters set considered at the workshop caused large increase of the emittance due to the collision:

$e_{x\_out}/e_{x\_in}=12$ $e_{y\_out}/e_{y\_in}=300$

M. Biagini studies

Progress in design optimization after the 1° SuperB workshop

Between December-2005 and March-2006 a lot of studies have been made in order to understand what are the sources of the blow-ups in the collision and how to minimize then.

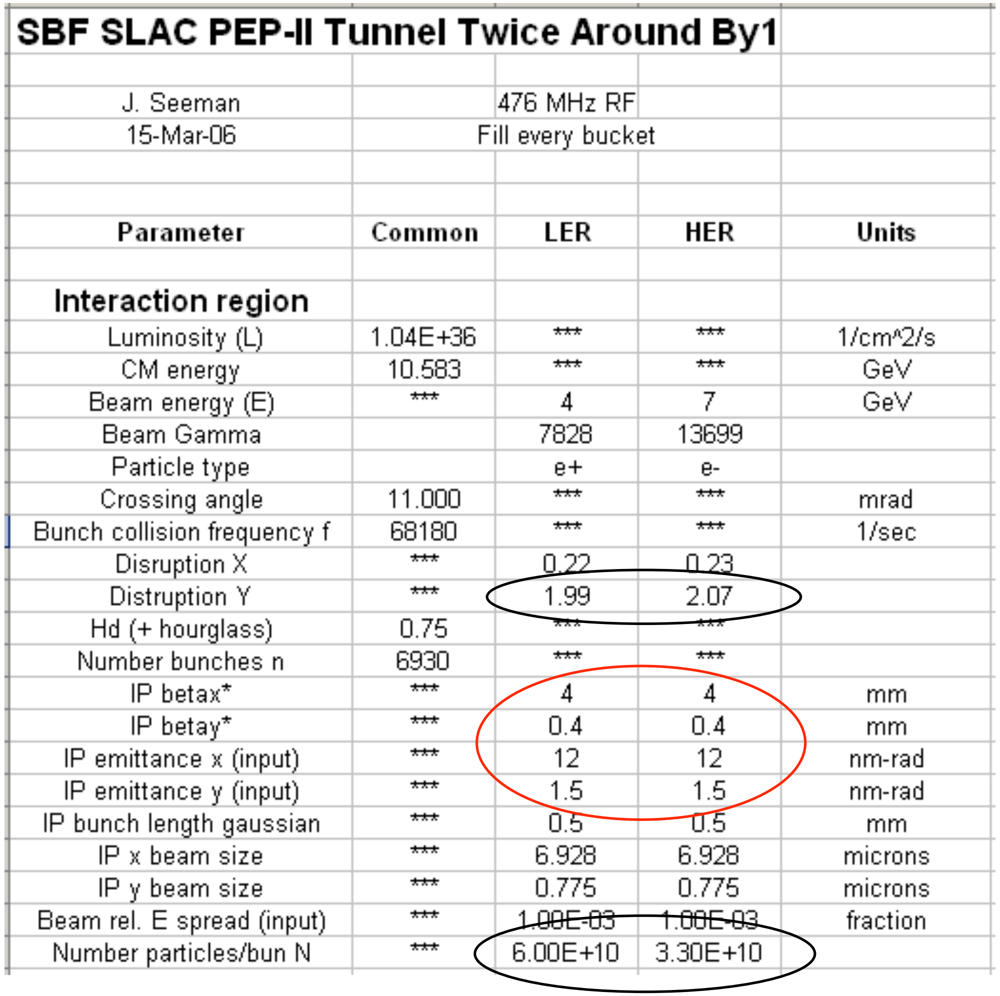
Power requirements could be greatly reduced if collision is less disruptive

Search for a trade off between luminosity delivered in one collision and power spent for each collision

Search for the simplest and more economic solution

	Round	Flat (1)	Flat (2)	Flat (3)
Sigx* mm	0.9	30 (1 betatron)	30 (1 betatron)	2.67
Etax mm	0.0	+-1.5	+-1.5	0.0
Sigy nm	900	12.6	12.6	12.6
Betx mm	0.55	2.5	2.5	17.8
Bety mm	0.55	0.080	0.080	0.080
Sigz_IP mm	0.8	0.100	0.100	4.0
Sige_IP	1.0e-3	2.0e-2	2.0e-2	1.0e-3
Sige_Lum	0.7e-3	1.0e-3	1.0e-3	0.7e-3
Emix nm	1.5	0.4	0.4	0.4
Emiy nm	1.5	0.002	0.002	0.002
Emiz mm	0.8	2.0	2.0	4.0
Cross_angle mrad	Optional	Optional	2*25	2*25
Sigz_DR mm	0.8	4.0	4.0	4.0
Sige_DR	1.0e-3	0.5e-3	0.5e-3	1.0e-3
Np 10e10	7.0	7.0	1.0	2.0
Nbunches	10000	10000	5000	5000
DR_length km	6.0	6.0	3.0	3.0
Damping_time msec	10	10	10	10
Nturns_betwe_coll	50	50	1	1
Collision freq MHz	10.0	10.0	500	500
$L_{singleturn}$ 1e36	1.3	1.3	1.2	0.8
$L_{multiturn}$ 1e36	0.9	0.9	1.0	1.2

Super-B-Factory in a 4400 m Tunnel 0.4 mm



SBF SLAC PEP-II Tunnel Twice Around By1

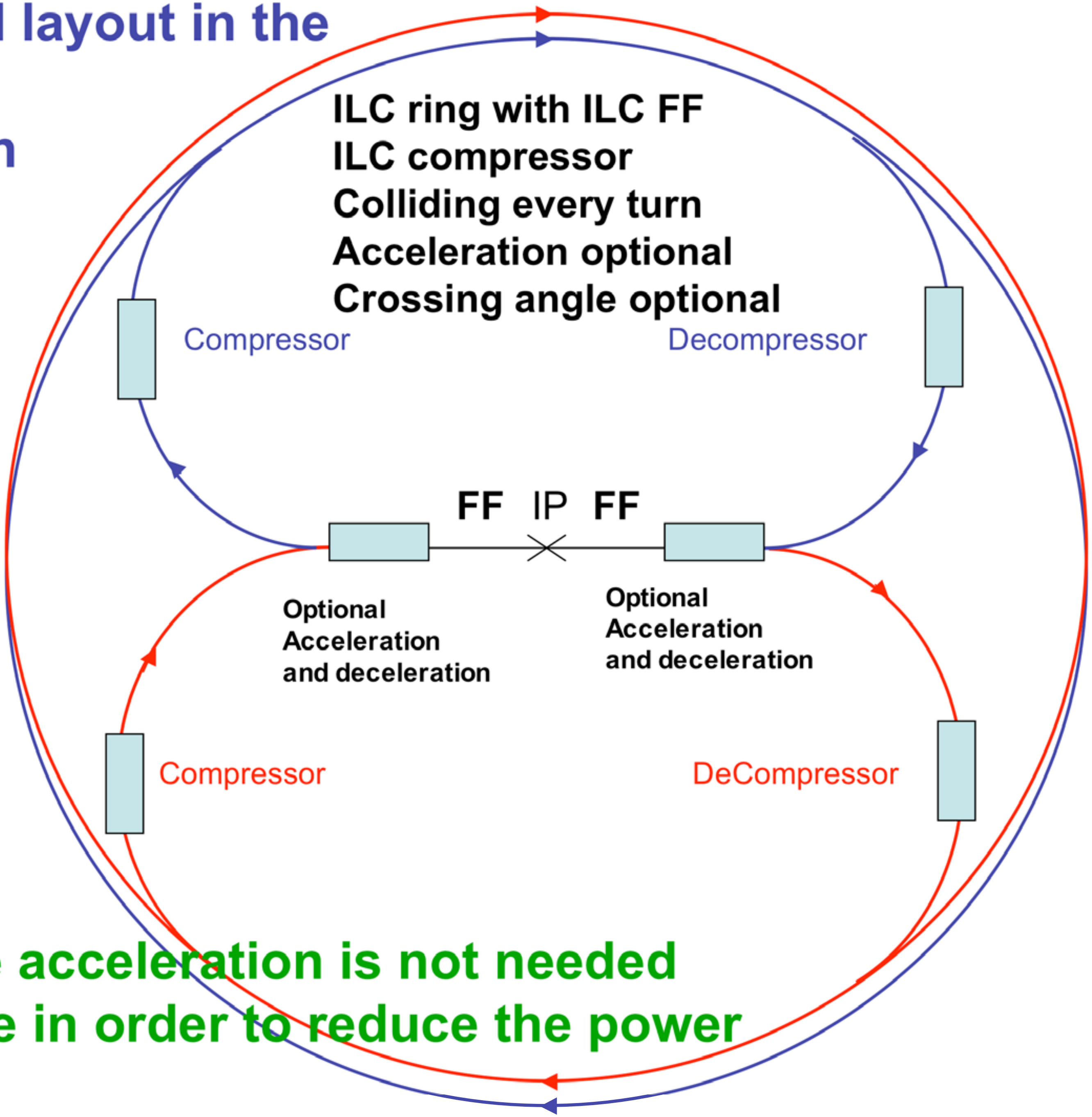
J. Seeman — 476 MHz RF
15-Mar-06 — Fill every bucket

Parameter	Common	LER	HER	Units
Interaction region				
Luminosity (L)	1.04E+36	***	***	1/cm^2/s
CM energy	10.583	***	***	GeV
Beam energy (E)	***	4	7	GeV
Beam Gamma		7828	13699	
Particle type		e+	e-	
Crossing angle	11.000	***	***	mrad
Bunch collision frequency f	68180	***	***	1/sec
Disruption X	***	0.22	0.23	
Distruption Y	***	1.99	2.07	
Hd (+ hourglass)	0.75	***	***	
Number bunches n	6930	***	***	
IP betax*	***	4	4	mm
IP betay*	***	0.4	0.4	mm
IP emittance x (input)	***	12	12	nm-rad
IP emittance y (input)	***	1.5	1.5	nm-rad
IP bunch length gaussian	***	0.5	0.5	mm
IP x beam size	***	6.928	6.928	microns
IP y beam size	***	0.775	0.775	microns
Beam rel. E spread (input)	***	1.00E-03	1.00E-03	fraction
Number particles/bun N	***	6.00E+10	3.30E+10	

Conclusions

- Colliding every turn helps with the collision rate.
- The ILC final focus will allow very small $b_y^* = 0.4$ mm.
- The beam emittances are not very small (12 nm x 1.5 nm).
- Bunch compressors are needed to shorten the bunch.
- Having two “loops” per ring in a tunnel allows adequate damping in one ring, room for bunch compression and final focus in the other, and twice as many bunches.
- Standard beam-beam parameters can keep the needed damping time long and the AC power low.
- We must study further the bunch compression and Final Focus beam issues.

Simplified layout in the Small Disruption Regime



ILC ring with ILC FF
ILC compressor
Colliding every turn
Acceleration optional
Crossing angle optional

Now the acceleration is not needed anymore in order to reduce the power

In summary, the small disruption regime requires:

small sigmaz (=> large sigmae from compressor)

big sigmax

small sigmay (for luminosity) and betay

BB-compensation by traveling focus

all the requirements do fit togheter with the monocromator

it simultaneneously enlarge sigmax and decrease the luminosity energy spread

moreover since the natural horizontal emittance is small, the emittance ratio of about 0.5% ensure the small sigmay

Scaling the parametrs to an every-turn colliding machine

- Equilibrium Emittance Vertical blowup about 60%
- Blowup as function of beam currents almost linear
- Blowup as function of damping time goes like Tau$^{1/3}$
- Reducing the bunch charge by a factor 6 (10^{10}), equilibrium blowup decreases to 10%
- Reducing the damping by a factor 50 (collision every turn) equilibrium blowup increases by a factor 4 ($50^{1/3}$)
- Final Blowup in this case is about 40%
- Geometric Luminosity decreases by a factor 36 due to less charge and increases by a factor 50 for increased collision rate
- With the same parameters but colliding in the ring (bunch compressor and FF in the ring), we get:

  $L=10^{36}$ with $Npart=10^{10}$ and

  $L=4*10^{36}$ with $N=2*10^{10}$

Scaling the parameters for an every-turn colliding machine, with Uncompressed Bunches

Colliding every turn very promising but requires a bunch compressors and a decompressor in the ring (about 400MeV S-band)

In principle not needed to compress the beams if we collide with a crossing angle such as:

$s_z*x_{cross}=24mm$ (same projected horizontal size)

$s_x/x_{cross}=100mm$ (same effective longitudinal interaction region)

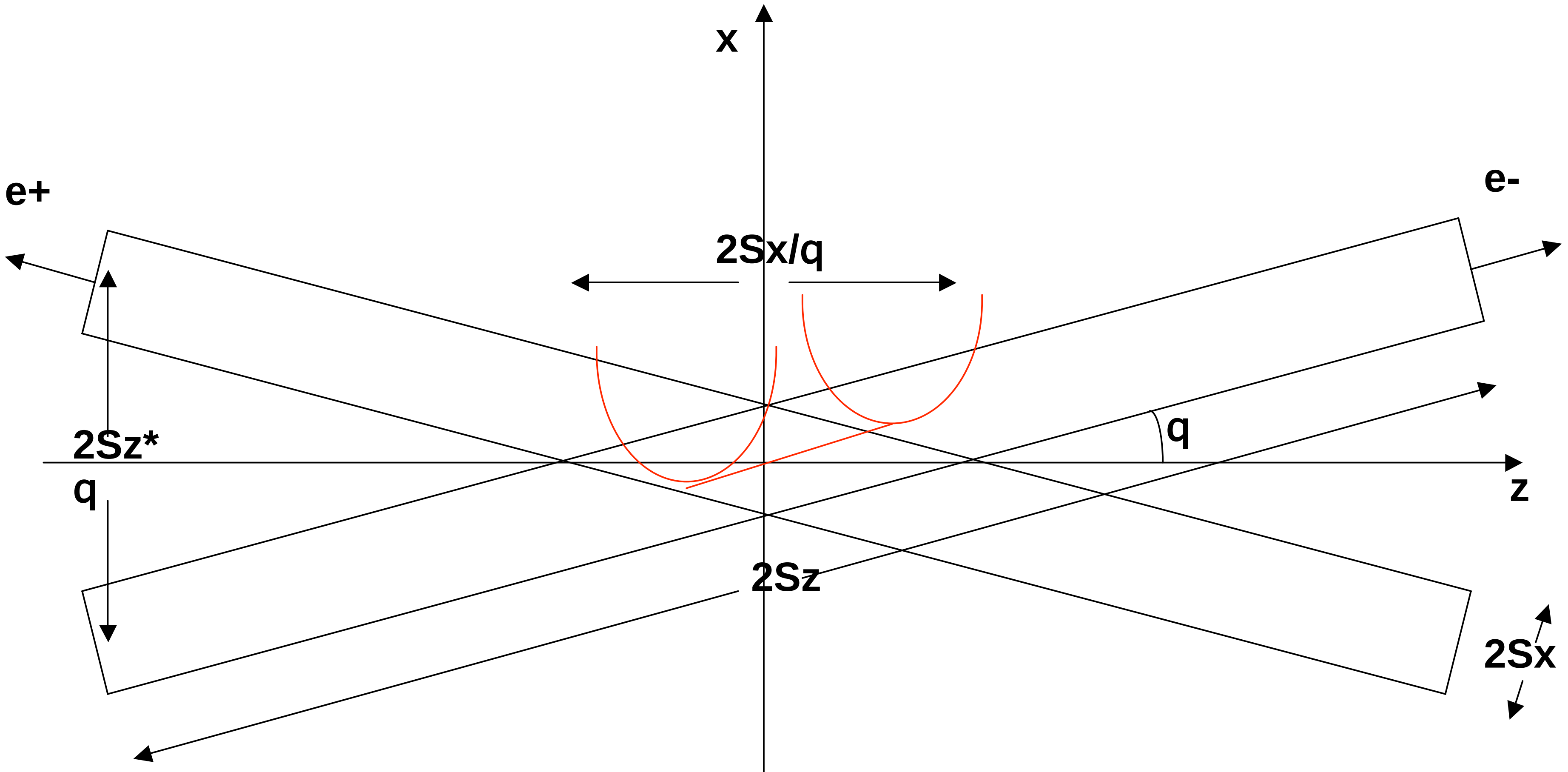
$s_y=12.6nm$, $b_y=80um$ like in the compressed case

These parameters gives the same geometric luminosity like the compressed case:

If $s_z=4mm$ we need:

x_cross=6mrad, $s_z=0.6um$

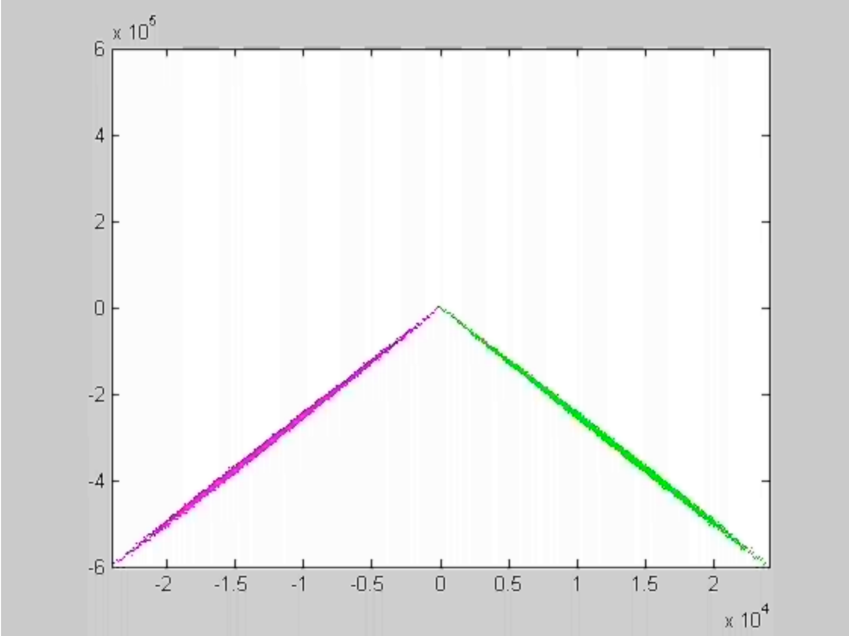
However now beam-beam worsened because the beams see each other also at non-minimum betay locations



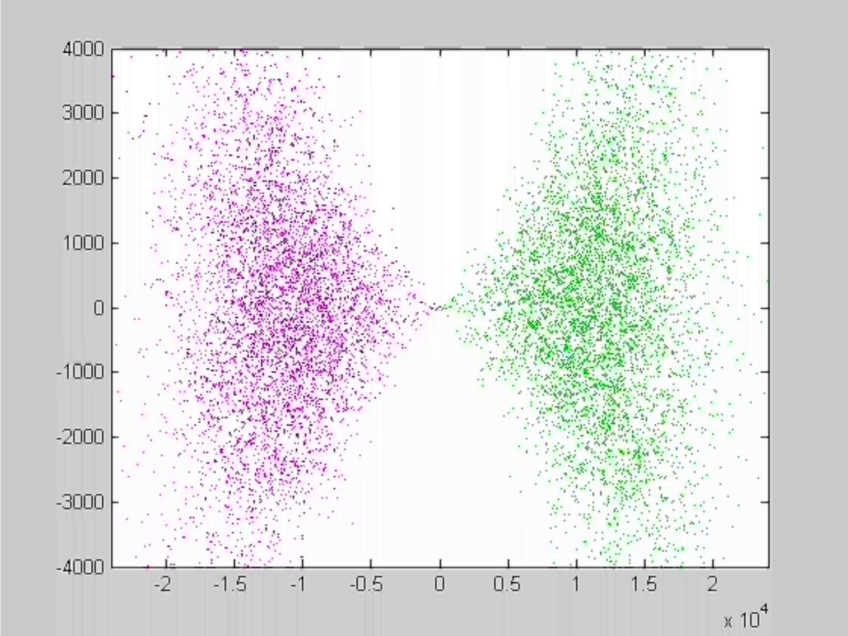
Vertical waist has to be a function of x:

Z=0 for particles at –s_x (- $s_x/2$ at low current)

Z= s_x/q for particles at + s_x ($s_x/2$ at low current)



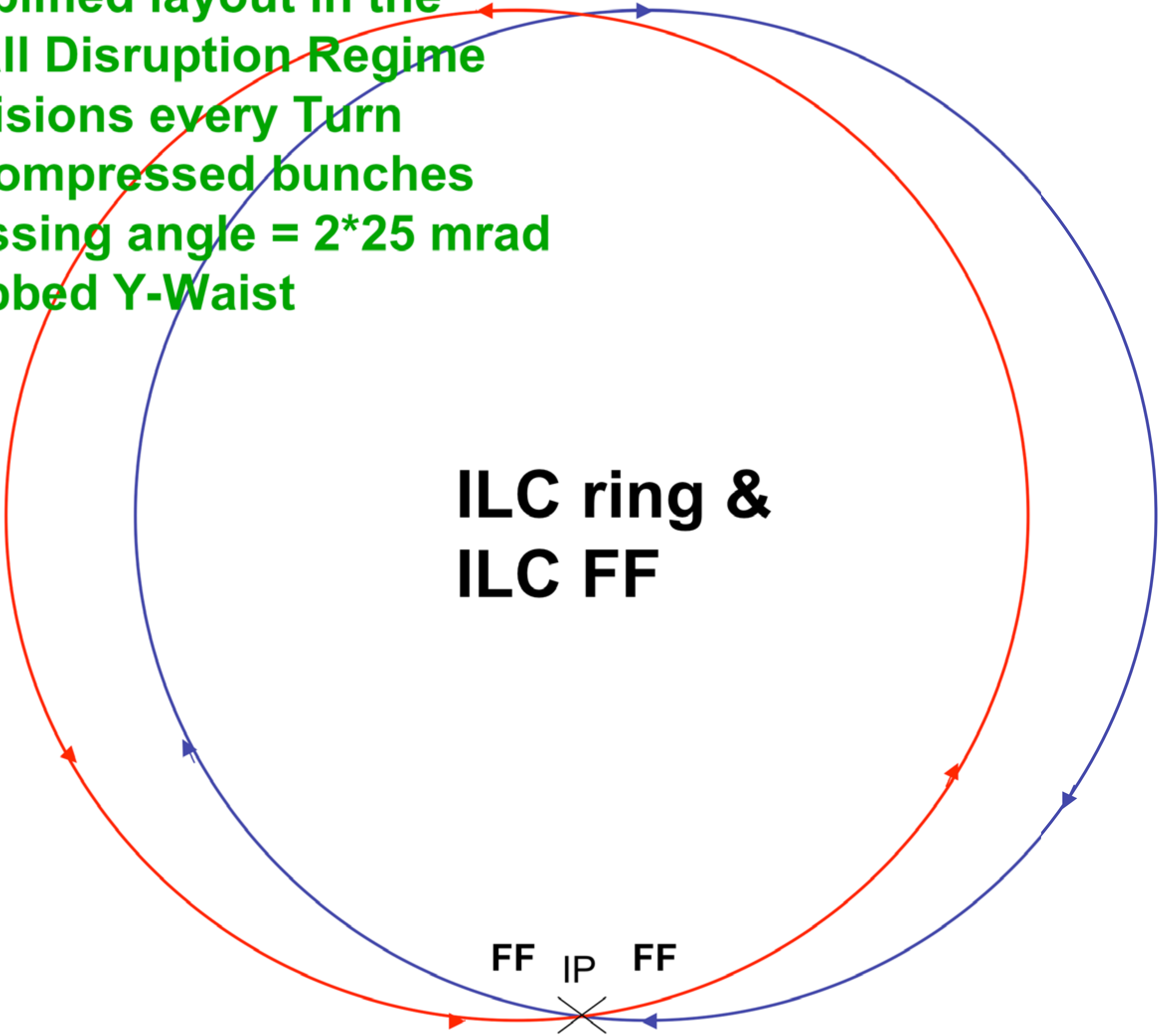
Horizontal Plane



Vertical Plane

Collisions with uncompressed beams
Crossing angle = 2*25mrad
Relative Emittance growth per collision about $1.5*10^{-3}$
(Eafter_collision/Ebefore_collision=1.0015)

Simplified layout in the
Small Disruption Regime
Collisions every Turn
Uncompressed bunches
Crossing angle = 2*25 mrad
Crabbed Y-Waist



Conclusions (3)

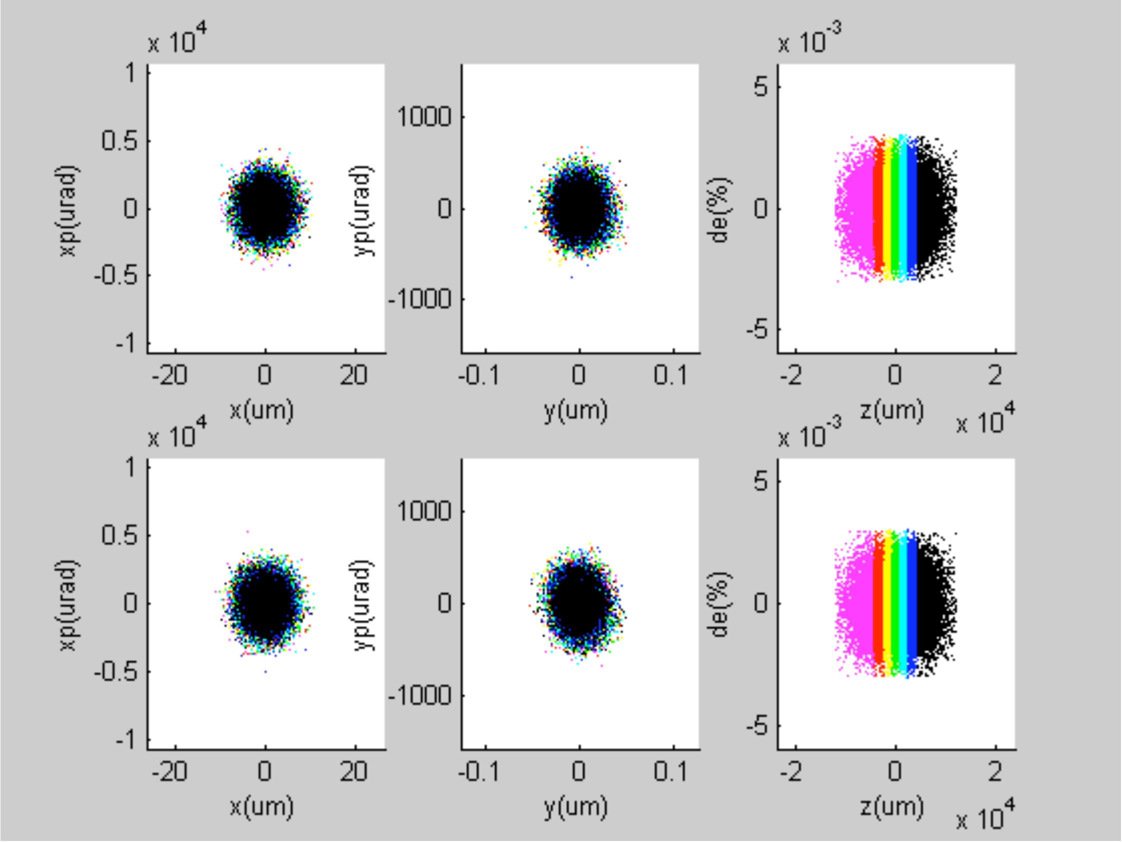
Solution with ILC DR + ILC FF seems extremely promising.

- Requires virtually no R&D
- Uses all the work done for ILC
- Ring and FF layouts virtually done, 3km circunference rings
- 100% Synergy with ILC
- IR extremely simplified
- Beam stay clear about 20sigmas supposing 1cm radius beam pipe
- Beam Currents around 1.5Amps
- Background should be better than PEP and KEKB
- Possibly to operate at the tau with L=10^35
- To be studied the possibility to run down to the phi
- Total cost about half of the ILC e+ DRs (2 e+ 6km rings in ILC)
- Power around 40MW, still to be further optimized (goal 25MW)
- Possible to reuse PEP RF system, power supplies, Vacuum pumps, etc., further reducing the overall cost
- Needs the standard injector system, probably a C-band 7GeV linac like in KEKB upgrade (already designed) (around 100ME)

4 Beams conclusions

- 4 beams are more unstable than the 2 beams scheme, highly disrupted, with larger emittance blow up and lower luminosity
- Not exhaustive analysis → not excluded we can find better working parameter set in the future
- Shorter beams seem to work better
- Larger horizontal beam size is better
- Higher energy definitely works better
- Possible for ILC !!!!

Asymmetric energies (4x7 GeV) with transparency condition (I)



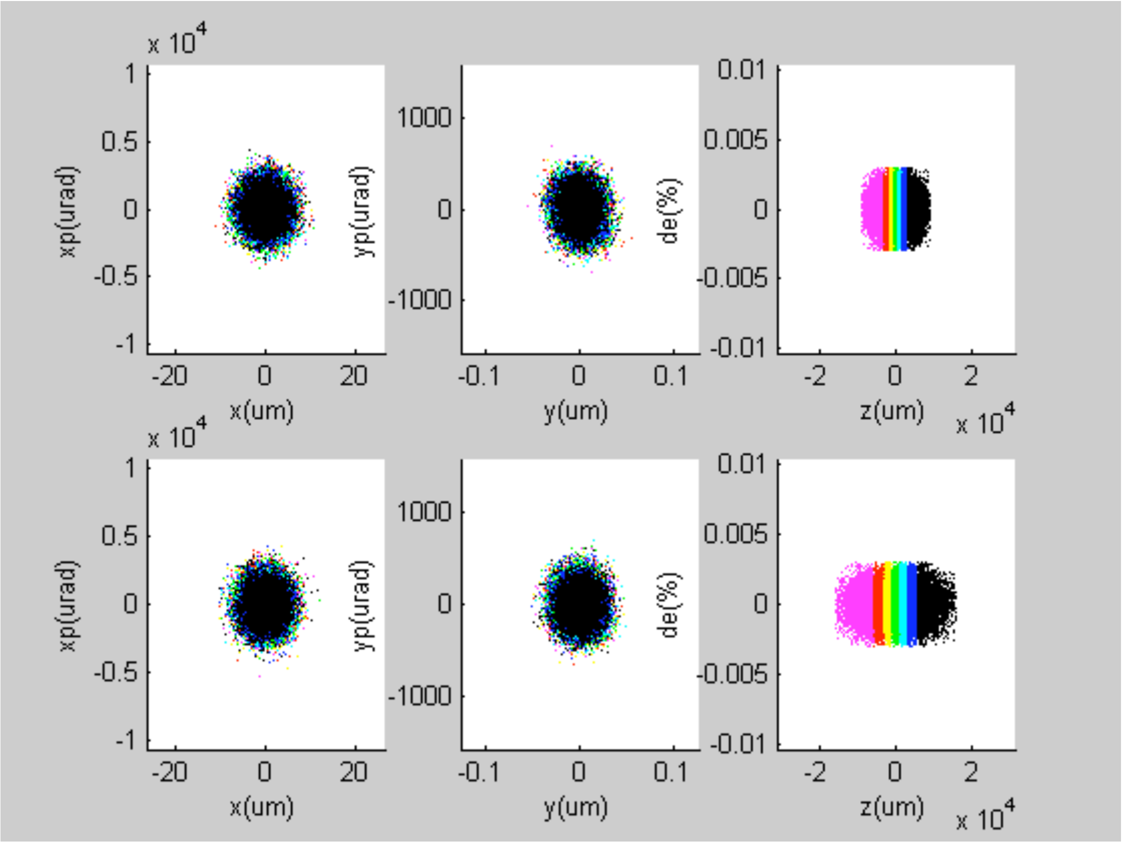
Np(4 GeV) = 2.65×10^{10}

Np(7 GeV) = 1.51×10^{10}

I(4 GeV) = 2.1 A

I(7 GeV) = 1.2 A

Asymmetric energies (4x7 GeV) with asymmetric bunch lengths



Np(4 GeV) = 2×10^{10}

Np(7 GeV) = 2×10^{10}

I(4 GeV) = 1.6 A

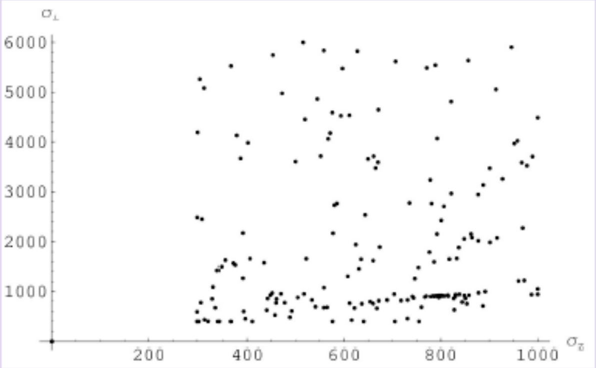
I(7 GeV) = 1.6 A

s_z I(4 GeV) = 3.02 mm

s_z I(7 GeV) = 5.29 mm

Sampling and optimization

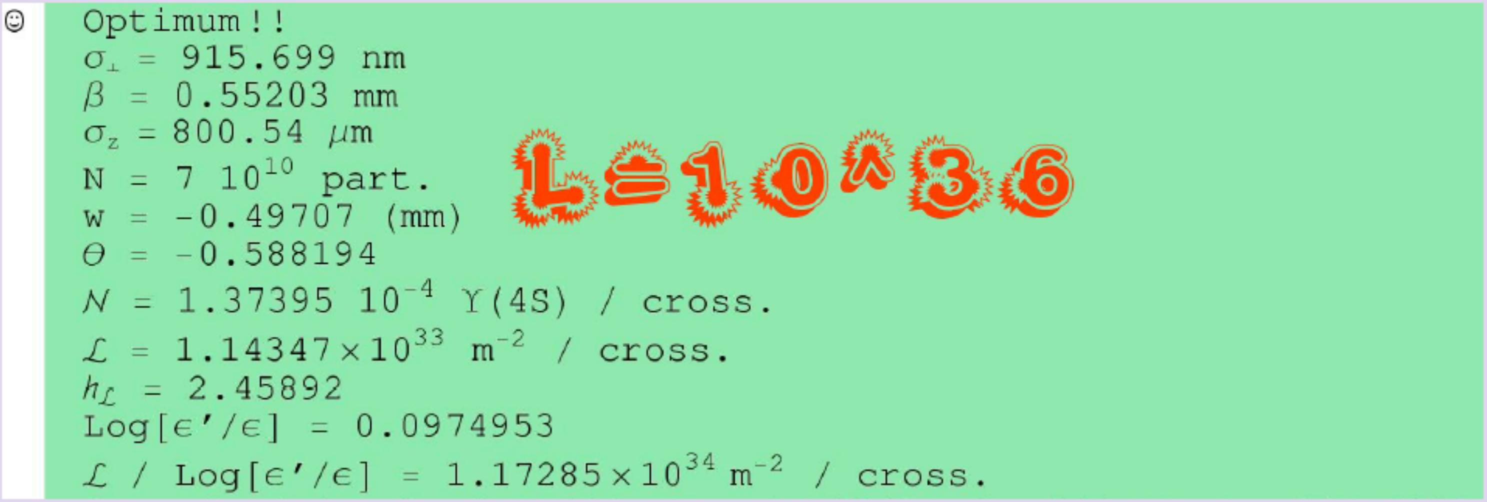
“Random” sampling



Floated parameters

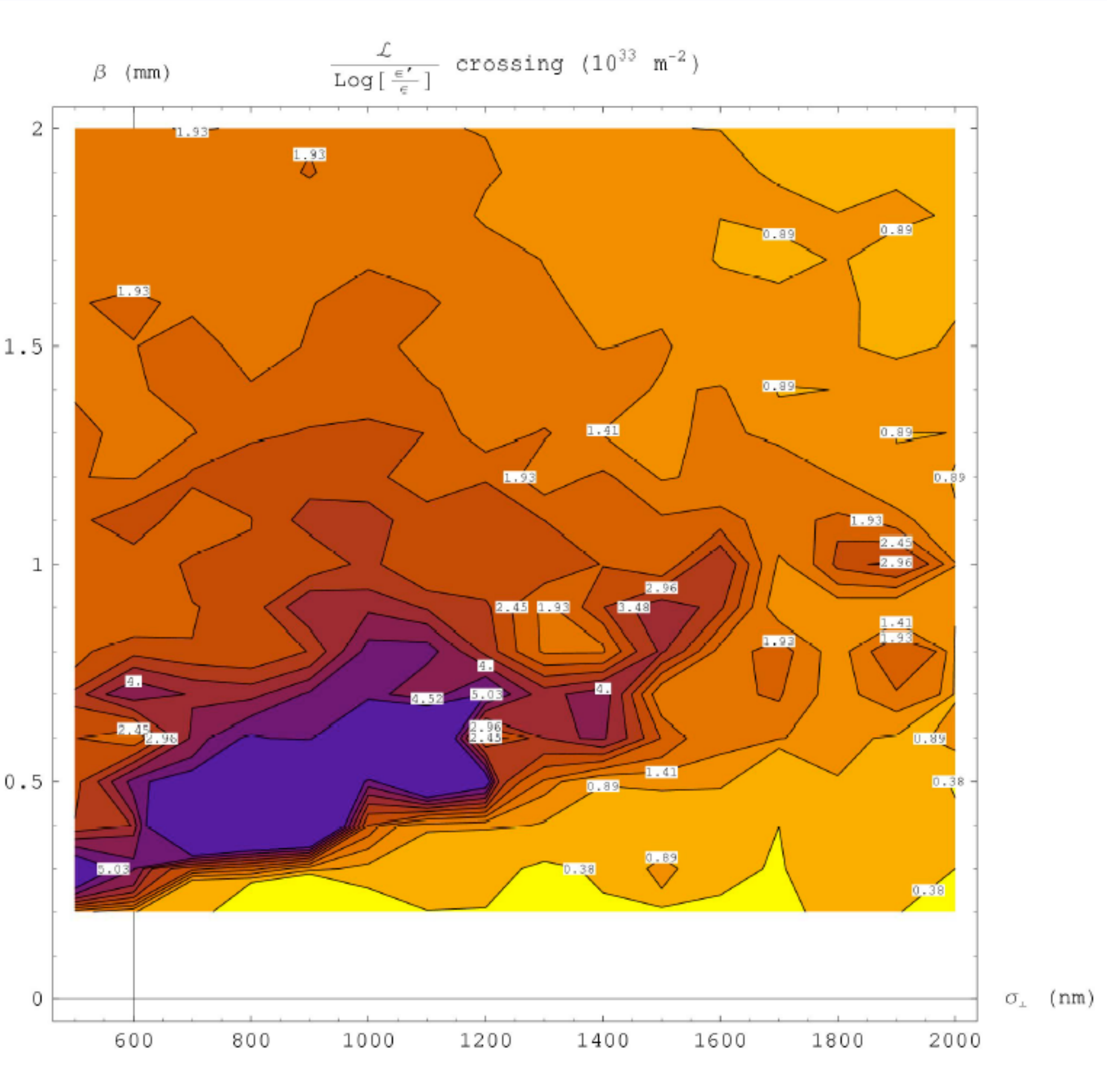
- $\sigma_x = \sigma_y$
- $\beta_x = \beta_y$
- σ_z
- Waist shift and traveling focus correlations

Optimum



```
Optimum!!
σ⊥ = 915.699 nm
β = 0.55203 mm
σz = 800.54 μm
N = 7 10^10 part.
w = -0.49707 (mm)
Θ = -0.588194
𝒩 = 1.37395 10^-4 ϒ(4S) / cross.
ℒ = 1.14347×10^33 m^-2 / cross.
hℒ = 2.45892
Log[ε'/ε] = 0.0974953
ℒ / Log[ε'/ε] = 1.17285×10^34 m^-2 / cross.
```

Scans around optimum point: $\mathcal{L}/\mathcal{B}$

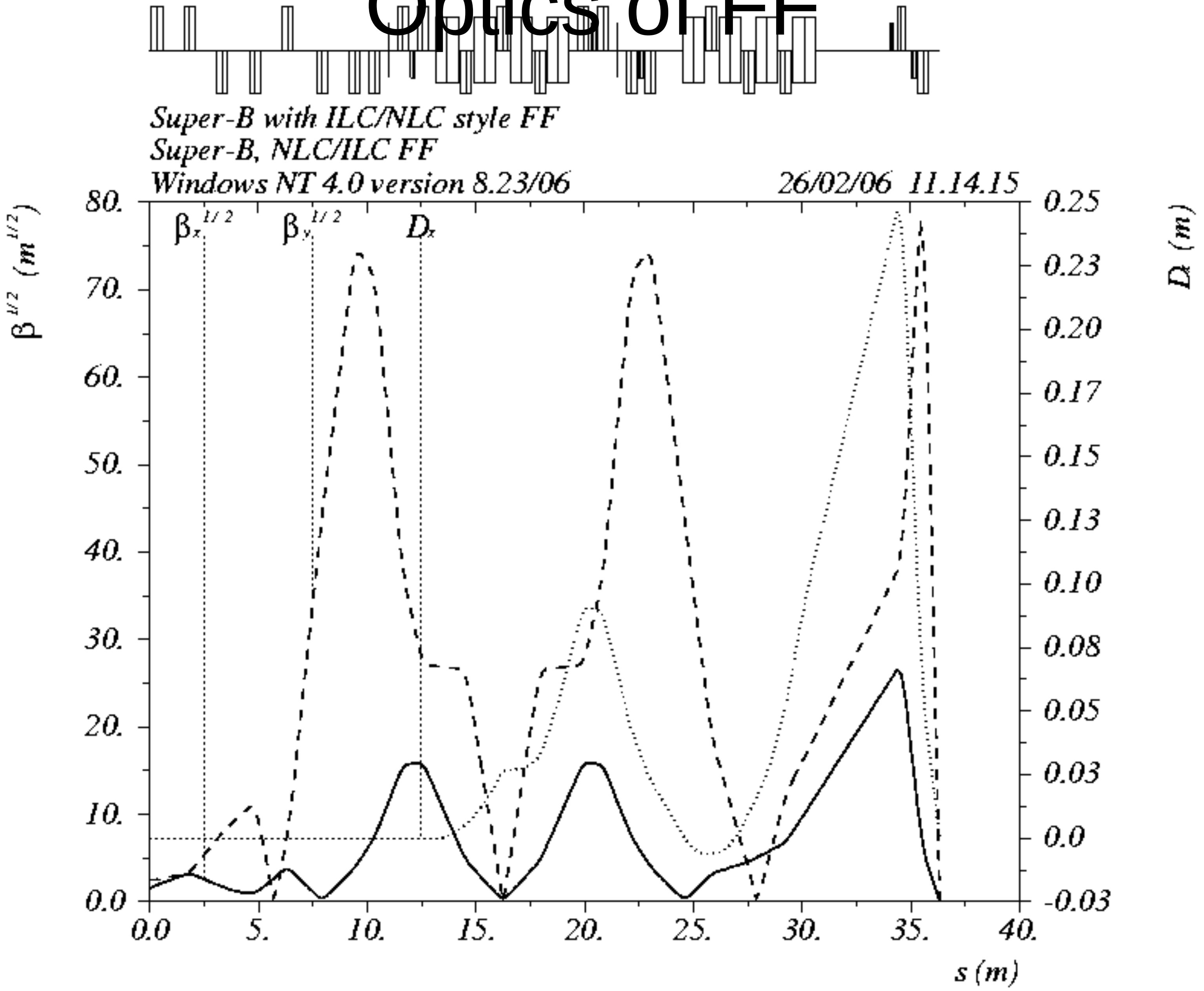


Scan over the $\beta_x \sigma_x$ plane of the figure of merit:

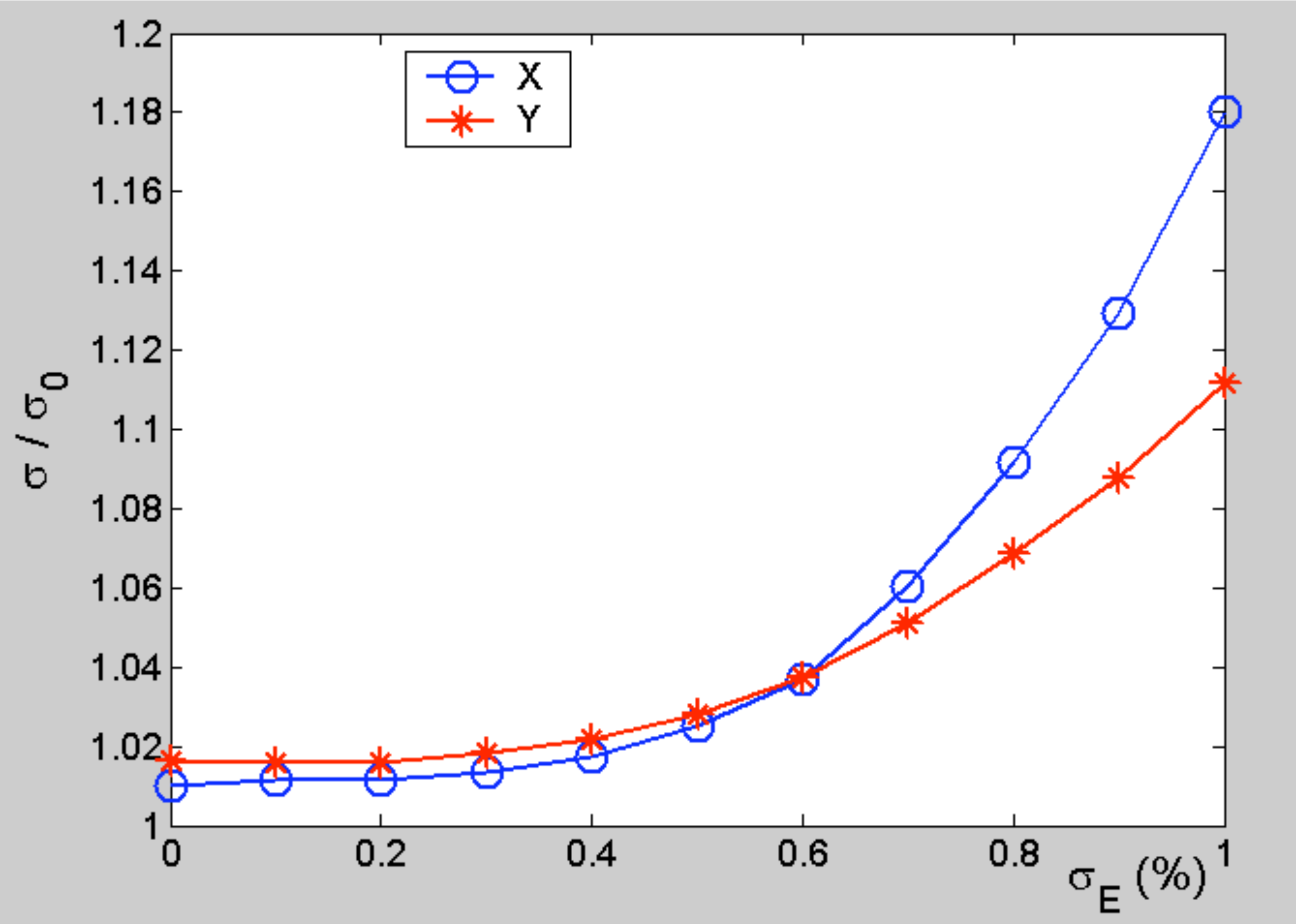
$$\frac{\mathcal{L}}{\log \frac{\epsilon'}{\epsilon}}$$

The optimum seats in the blue lake

Optics of FF

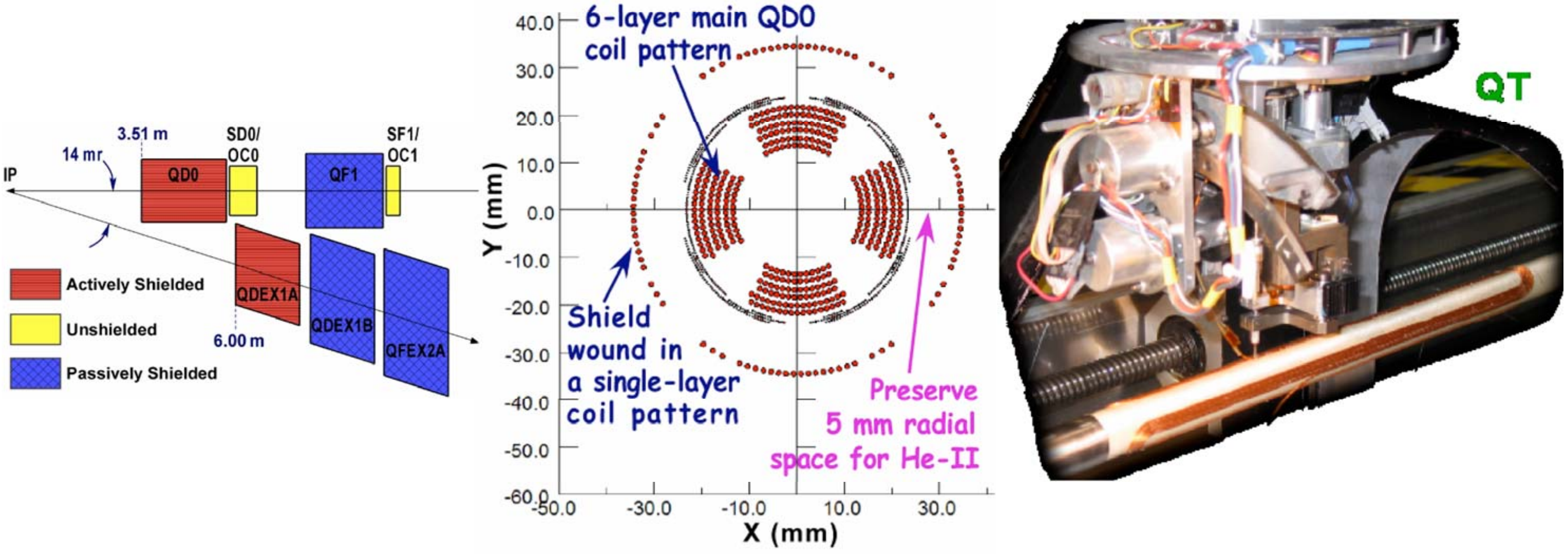

Super-B with ILC/NLC style FF
Super-B, NLC/ILC FF
Windows NT 4.0 version 8.23/06
26/02/06 11.14.15
β^1/2 (m^1/2)
Dx (m)
βx^1/2
βy^1/2
Dx
80.
70.
60.
50.
40.
30.
20.
10.
0.0
0.25
0.23
0.20
0.17
0.15
0.13
0.10
0.08
0.05
0.03
0.0
-0.03
0.0
5.
10.
15.
20.
25.
30.
35.
40.
s (m)

Tracked bandwidth



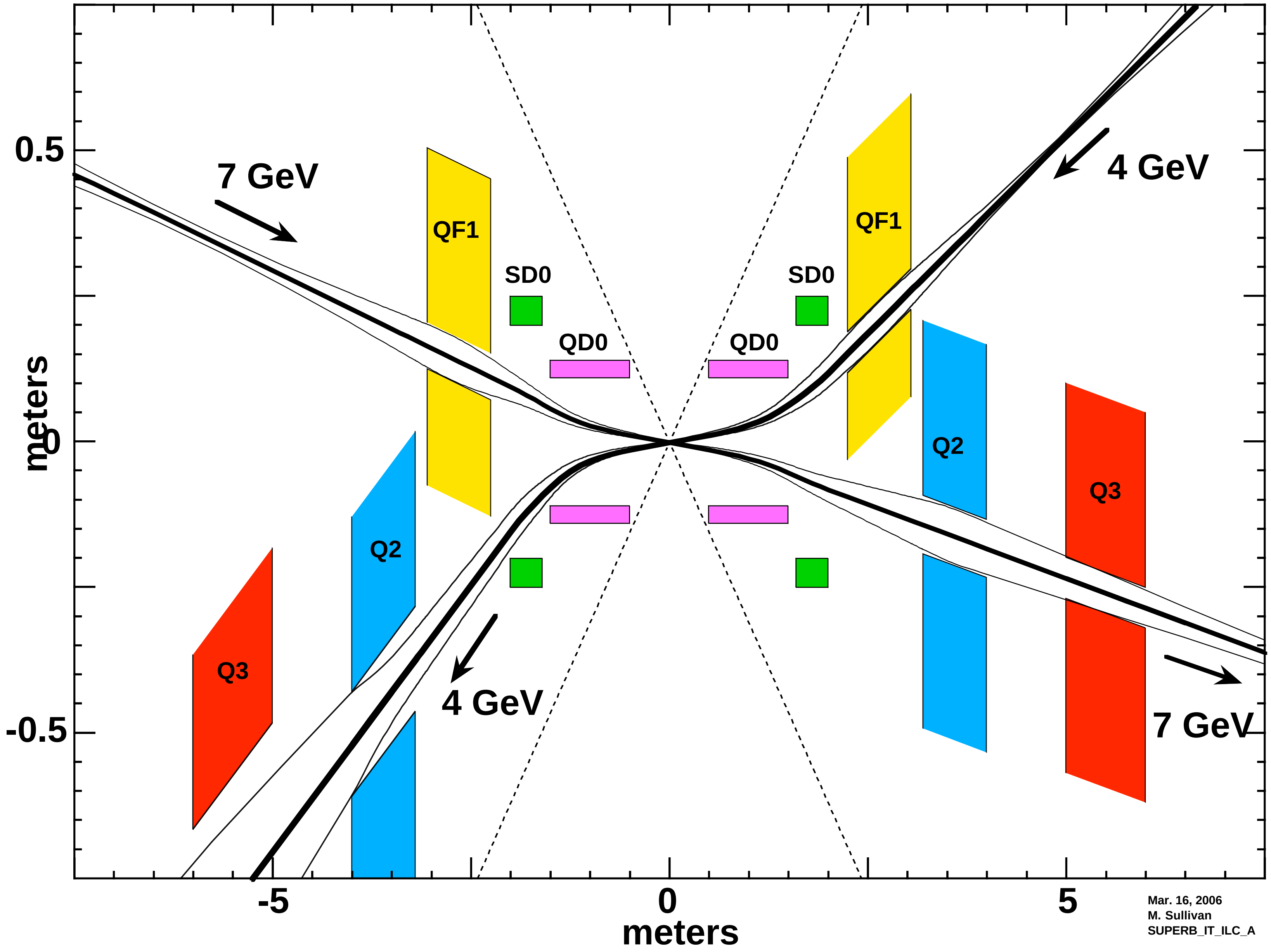
IR layout

- With L*=0.5m has to use common QD0? Needs to be looked…
- If the L* would be ~0.8m, one can use separate beamlines with BNL direct wind compact quads, similar as for ILC 20/14mrad IR:



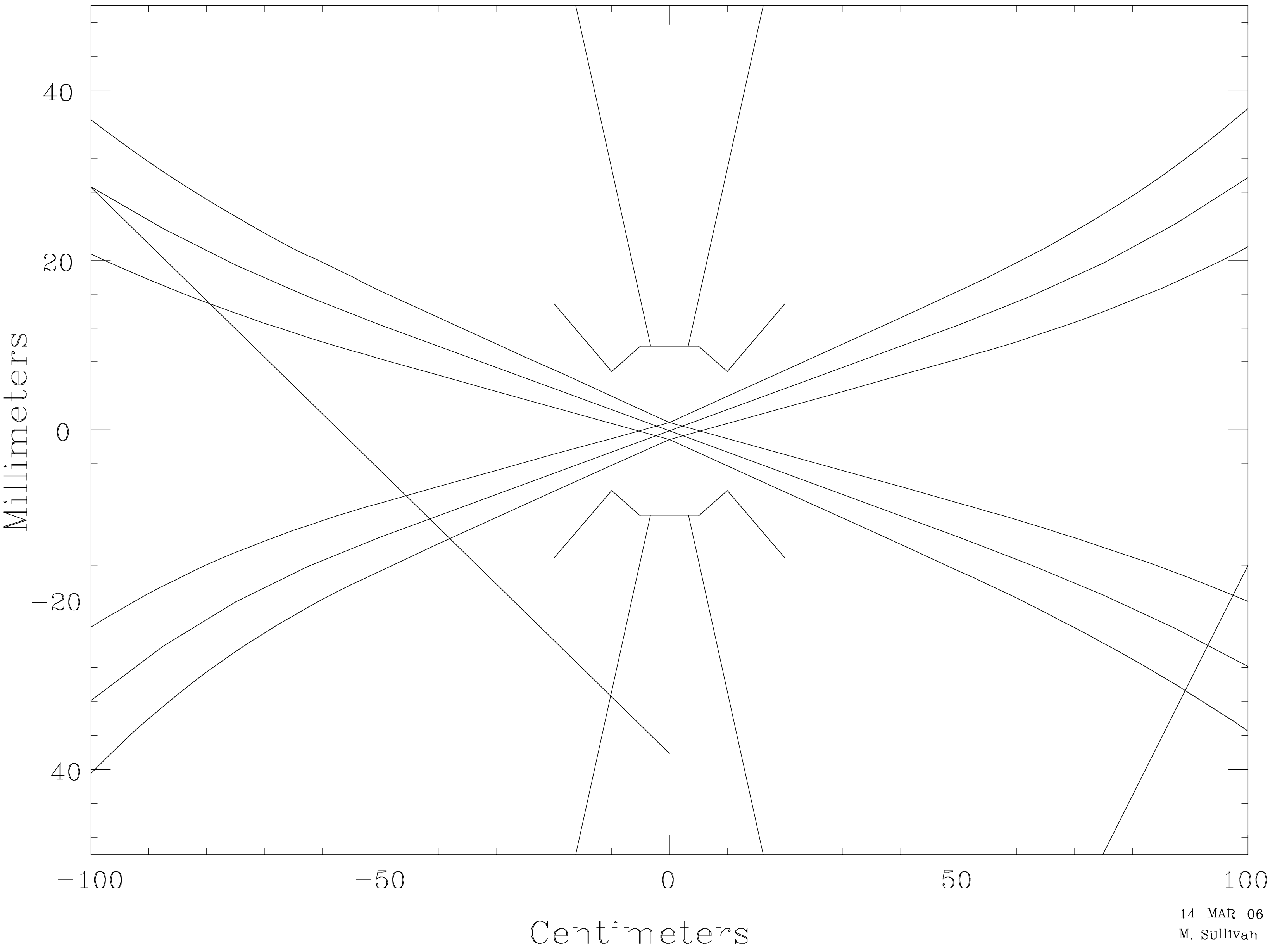
ILC IR layout, self-shielding QD0 proposed by Brett Parker, and production of quad test for ILC at BNL. This self shielding QT was recently successfully tested.

Layout of IR orbits for ILC version Super B Factory



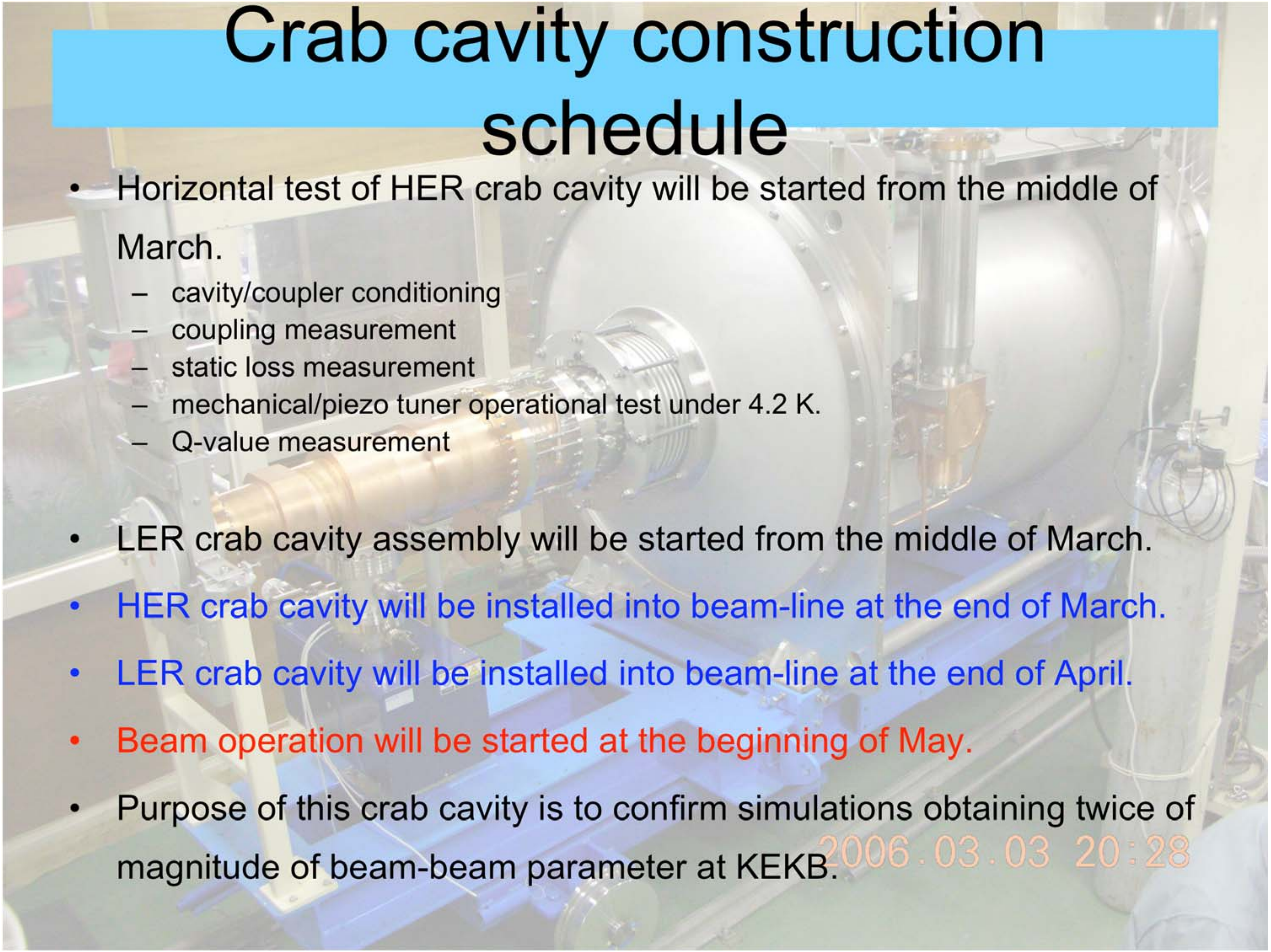
Mar. 16, 2006
M. Sullivan
SUPERB_IT_ILC_A

SuperB ILC Ver. A



14−MAR−06
M. Sullivan

Crab cavity construction schedule



- Horizontal test of HER crab cavity will be started from the middle of March.
  - cavity/coupler conditioning
  - coupling measurement
  - static loss measurement
  - mechanical/piezo tuner operational test under 4.2 K.
  - Q-value measurement
- LER crab cavity assembly will be started from the middle of March.
- HER crab cavity will be installed into beam-line at the end of March.
- LER crab cavity will be installed into beam-line at the end of April.
- Beam operation will be started at the beginning of May.
- Purpose of this crab cavity is to confirm simulations obtaining twice of magnitude of beam-beam parameter at KEKB.

Strategy of SuperKEKB

- Accomplishment of higher luminosity
  - Brute-force
    - Higher beam currents
      - Large number of RF cavities and stations to obtain RF power
      - Frequency detuning due to beam loading
      - Cure of HOM power
      - Handling of SR power
      - Cure of electron cloud instability and ion instability
      - Bunch-by-bunch feedback system (transverse and longitudinal)
      - Powerful injector
    - Smaller beta function at IP
      - New QCS+special magnets at IR
      - Need short bunch length (Cure of CSR should be necessary.)
  - New idea
    - Higher beam-beam parameter
      - Head-on collision which is realized by crab cavities.

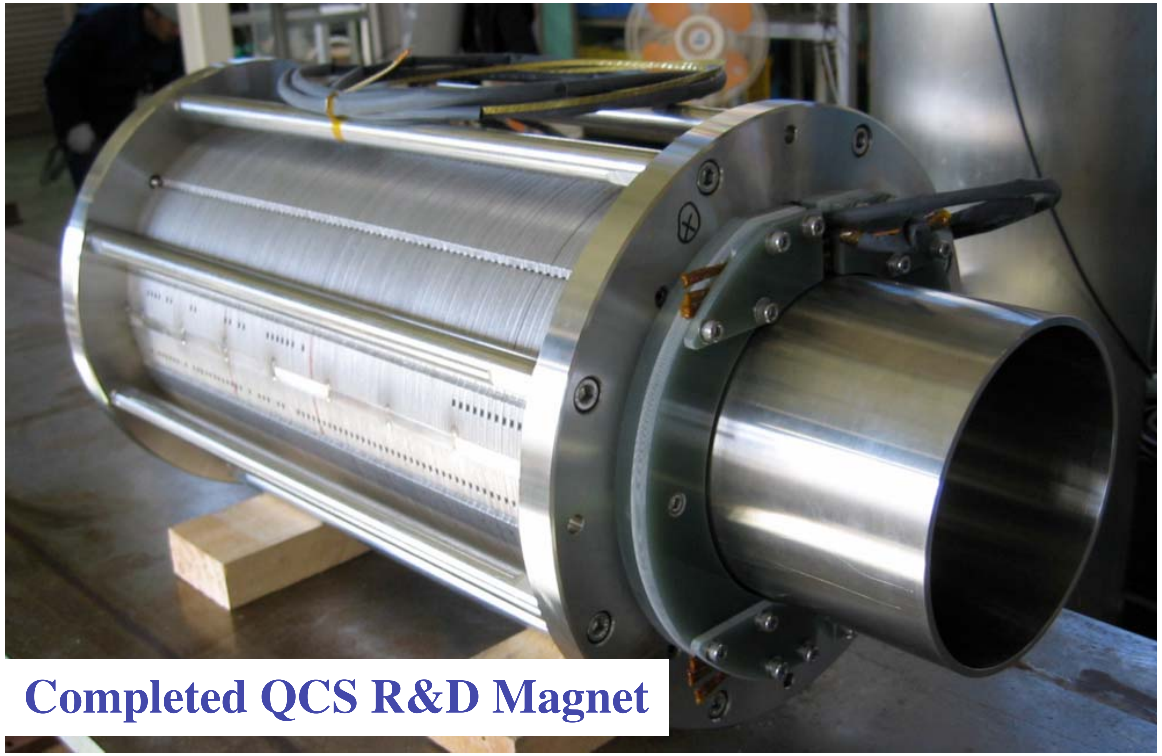
Lattice parameters w/o and w/ beam-beam effect

SuperKEKB		bare lattice	with beam-beam	unit
Beam current (LER/HER)	I	9.4/4.1	9.4/4.1	A
Beam energy (LER/HER)	E	3.5/8.0	3.5/8.0	GeV
Emittance	e_x	24	130	nm
Horizontal beta at IP	b_x^*	20	1.9	cm
Vertical beta at IP	b_y^*	3	2.4	mm
Horizontal beam size	s_x^*	69	50	mm
Vertical beam size	s_y^*	0.73	1.0	mm
Beam size ratio	$r = s_y^*/s_x^*$	1.1	2.0	%
Crossing angle (30 mrad crab crossing)	q_x	0	0	mrad
Luminosity reduction	R_L	0.86	0.82	
x_x reduction	R_{xx}	0.99	0.98	
x_y reduction	R_{xy}	1.11	1.16	
Reduction ratio	R_L/R_{xy}	0.78	0.70	
Horizontal beam-beam (estimated with S-S simulation)	x_x	0.152	0.030	
Vertical beam-beam (estimated with S-S simulation)	x_y	0.215	0.187	
Luminosity	L	4.0 x 10^{35}		$cm^{-2}s^{-1}$

Dynamic effect

Construction of QCS realtype magnet for R&D

12 double pancake coils for the one magnet



Completed QCS R&D Magnet

Preparation for the vertical test

ILCDR Nominal Parameters

Number of Bunches/train	2820
Bunch charge	2 10^{10}
Train repetition rate	5 Hz
Injected bunch separation	330 ns
Maximum injected norm. betatron amplitude (e+)	0.09 m-rad
Injected full width energy spread (e+)	1%
injected norm. emittance (e-)	45 µm
Injected full width energy spread (e-)	0.1%
Extracted norm. horizontal emittance	8 µm
Extracted norm. vertical emittance	20 nm
Extracted bunch length	6 mm
Extracted energy spread	1.4 10^{-3}

Issues for the circumference choice

- Acceptance
  - achieving a large acceptance is easier in a circular 6 km ring than in a dogbone ring.
- Collective effects
  - Electron-cloud effects make a single 6 km ring unattractive, unless significant progress can be made with mitigation techniques.
  - Space-charge effects will be less problematic in a 6 km than in a 17 km ring
  - The electron ring can consist of a single 6 km ring, assuming that the fill pattern allows a sufficient gap for clearing ions.
- Kickers
  - The injection/extraction kickers are more difficult in a shorter ring. R&D programs are proceeding fast and, it is expected that will demonstrate a solution for a 6 km circumference.

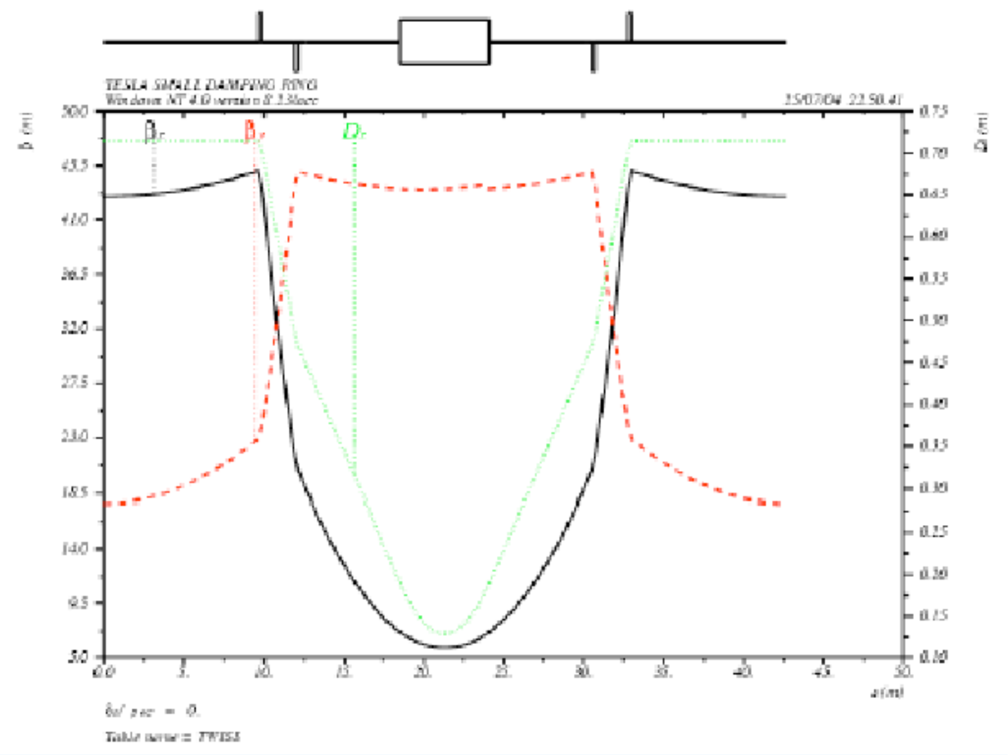
Lattice Description

- The ring is designed with 10-fold symmetry and incorporates 10 long straight sections.
- 8 of the straight sections contain wigglers and RF cavities, the other 2 can accommodate tune adjustment sections, and injection/extraction lines.

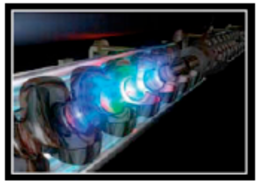
•arc cells

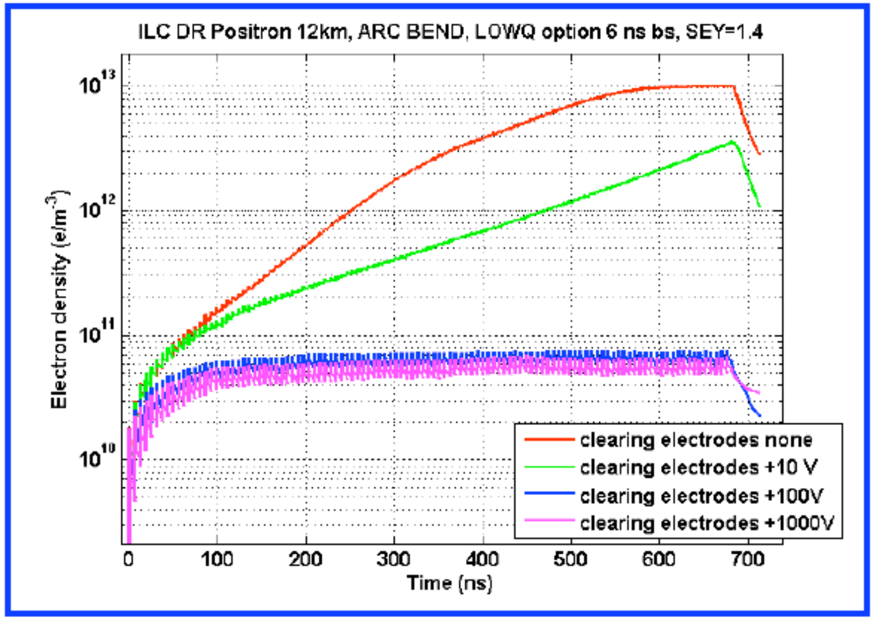
-TME cells 40 m long

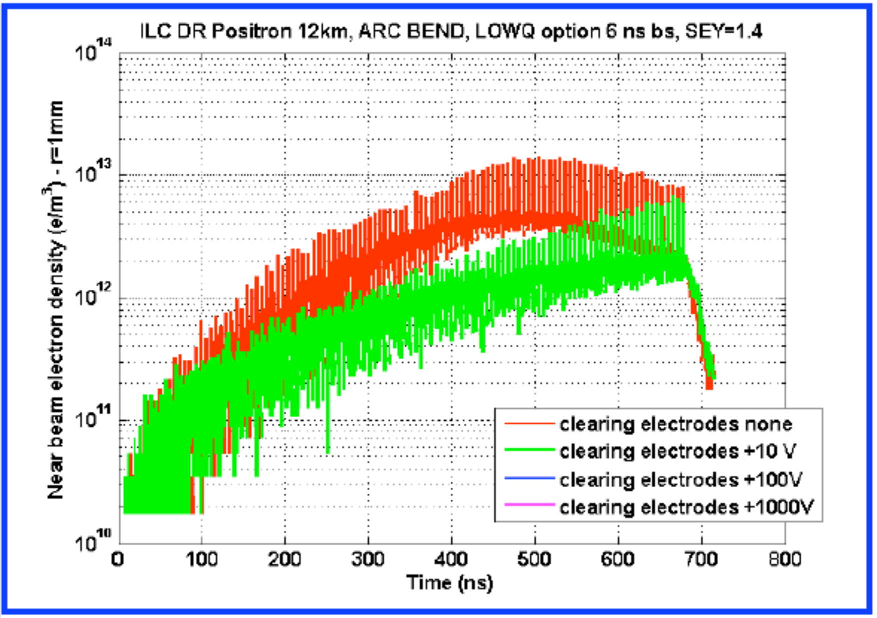
-72 dipoles 5.6 m long with rather low , 0.2 T, bending field.



Curved clearing electrodes







using POSINST

M. Pivi – P. Raimondi, SLAC, Mar 2006

Luminosity and electromagnetic fields

- We need high current beams of very short bunches to achieve super high luminosity
- These beams carry high intensity electromagnetic fields.

Electric field at the beam pipe wall

$$E = \frac{cZ_0}{(2\pi)^{3/2}} * \frac{eN_b}{a\sigma} \qquad E_{\left[\frac{kV}{cm}\right]} = 23. * \frac{N_b}{10^{11}} * \frac{1}{a_{cm}\sigma_{cm}}$$

If these fields are near a sharp metal corner they may exceed the breakdown threshold

Bunch field spectrum

- Field spectrum goes to higher frequency with shorter bunches exponentially

$$A(\omega) \sim e^{-\left(\frac{\omega}{c}\sigma\right)^2}$$

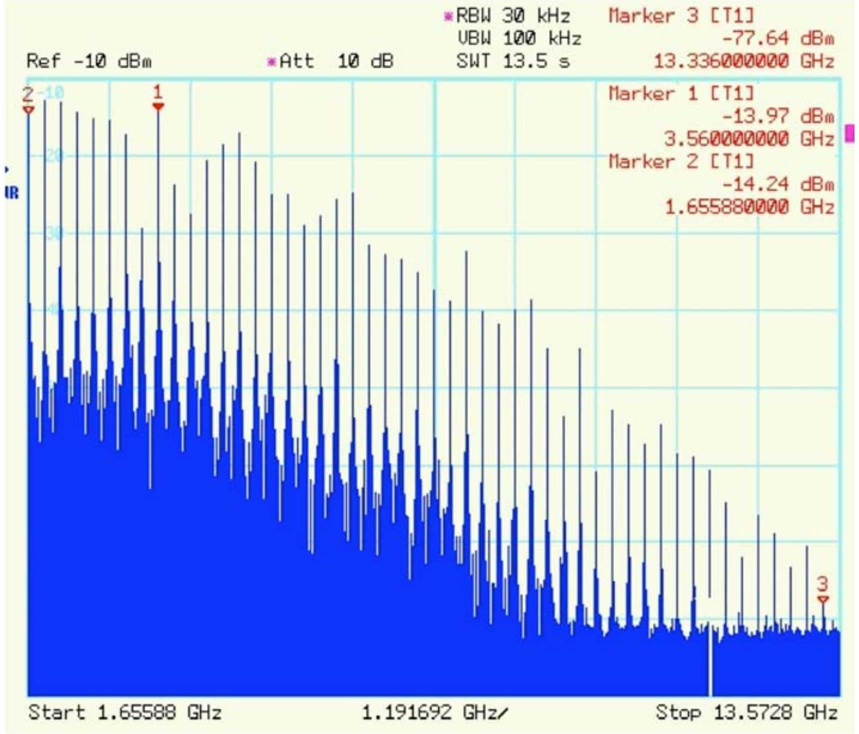
Bunch spacing resonances

$$f_n = \frac{n}{\tau_b} \qquad n = 1, 2, 3, \ldots$$

Bunch spacing

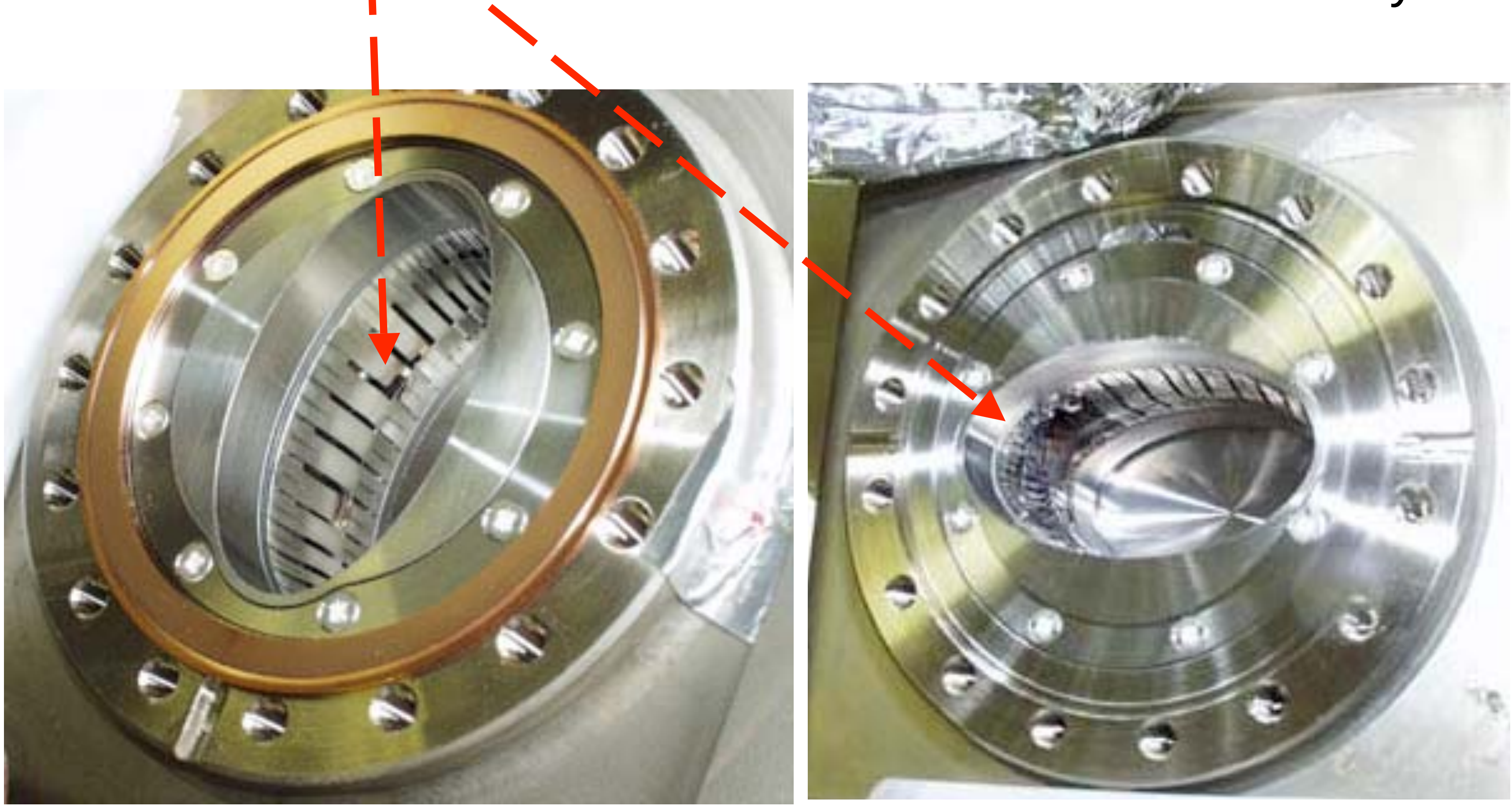
$$\tau_b = \frac{m}{f_{RF}} \qquad m = 1, 2, 3, \ldots$$

Beam spectrum (12 mm bunch)



Wake field Evidence from PEP-II

- Shielded fingers of some vacuum valves were destroyed by breakdowns of intensive HOMs excited in the valve cavity.



Comparison of 2.5, 1, and 0.5 cm pipes at IP.

pipe Radius [m]	0.025	0.01	0.005
Material	Cu	Cu	Cu
resistivity [Ohm m]	1.69E-08	1.69E-08	1.69E-08
S0 [m]	3.83E-05	2.08E-05	1.31E-05
bunch length [m]	0.003	0.003	0.003
Loss factor	0.004	0.010	0.021
Bunch spacing [nsec]	2.1	2.1	2.1
beam current [A]	23	23	23
power [kW/m]	**9.684**	**24.209**	**48.418**

This is only resistive-wall power!

Summary

- Vacuum chamber must be very smooth.
- HOM absorbers must be installed in every region that has unavoidable discontinuity of vacuum chamber
- Increase the bunch length in damping rings

The RTML area systems leaders are Eun-San Kim and Peter (PT) Tenenbaum. They are happy to hear from you!

Table of Contents

Brief Description

The RTML starts just downstream of the damping ring extraction system (at the point where the design dispersion and dispersion' are both zeroed, after the second kicker system and the bend which compensates the DR septum), and continues until the upstream face of the first main linac cryomodule (nominally at 15 GeV). The RTML includes the following subsystems, in order of S position:

- A set of 4 orthonormal skew quads which are used to eliminate coupling from the DR extraction septum and also residual coupling from the spin rotator solenoids (which nominally are internally corrected, but these things are never perfect)
- A profile monitor or set of profile monitors which are used to tune the emittance and coupling of the beam extracted from the DR
- A betatron collimation system which eliminates transverse beam halo: collimation is 2 phases x 2 planes x 1 iteration
- A beam jitter measurement system for trajectory feedforward correction
- A turnaround which delays the beam with respect to a line-of-sight cable to permit trajectory feedforward correction
- A spin rotator which allows the polarization vector to be oriented to any direction desired by the experimenters
- A 4-D multi-wire emittance measurement station which includes the steering dipoles for trajectory feedforward correction.
- A first stage bunch compressor which compresses the RMS bunch length to about 1 mm, and includes a pulsed extraction system so that the beam need not be sent on to the next system during tuneup of the bunch compressor
- A second stage bunch compressor which compresses the RMS bunch length to 150 to 300 um
- A 2 x 2D emittance measurement station and pulsed extraction system.

Fundamental Parameters

- The first fundamental parameter is the damping time, determining energy loss/turn U_0:

$$\tau_{d,x} = \frac{2}{J_x}\frac{E}{U_0}\tau_{rev} = \frac{2}{J_x}\frac{\rho}{88.5E^3}\tau_{rev}$$

- For 10 ms damping and 2200 m length:
  - LER (4GeV): U_0=5.6 MeV, HER (7 GeV): 9.9 MeV
  - bending radii: 21.5 m (1.1T) 4 m (3.3T) (assuming no wigglers or other "tricks")
- S.r. power:
  - 15+8.5=23.5 MW for 1.5 A in each ring
  - > "Wal-plug power" ≈ 47 MW for the rf

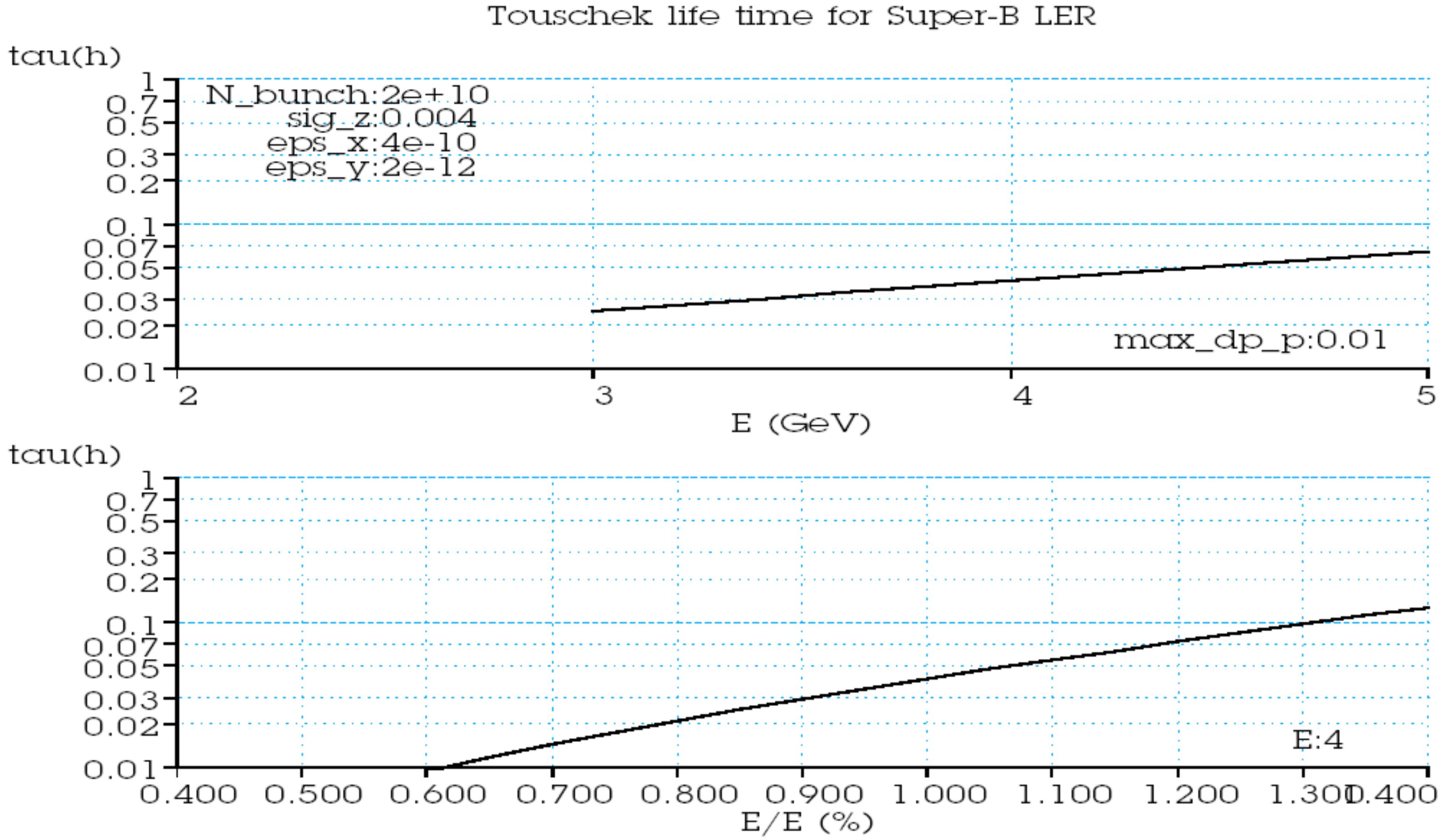
Lattice Comparison

	at 3.1 GeV	at 4 GeV			
Parameter	**PEP-II LER**	**PPA (Cai)**	**OTW (Kuroda)**	**mWiggler**	**Unit**
circumference	2.2	2.8	3.2	2.2	km
X tune	36	48	45	72	
Y tune	35	48	24	24	
momentum comp.	0.00124	0.00028	0.00036	0.00003	
X damping time	≈65	39	24	7	ms
X emittance	24	0.28	0.26	1 (0.5)•	nmr
dP/P	6.40E-04	1.00E-03	1.10E-03	1.20E-03	
Main dipole field	10	1	1.55	16.7	kG
Arc focusing cells	96	164	120	96	regular cells
Cell type	FODO	FODO	TME	TME	
Vrf for 4 mm bunches	22	17	25	6*	MV
nus for above	0.07	0.025	0.035	0.0024	

***: 3.5 mm bunch length**

•: parameters for 1 nmr cell, 0.5 nmr cell slightly different

Touschek Lifetime



Emittance blow-up from IBS may be of concern as well

Instability Thresholds (comp PEP-II)

- μwave instability (Z/n ≈ 3Ω)

$$I_b = \frac{2\pi|\eta|(E/e)(\beta\sigma_b)^2}{\left|\frac{Z_{||}}{n}\right|_{eff}}$$

  - Ok for PPA, OTW, factor 60 worse than PEP for mWig
- TMCI threshold

$$I_b = \frac{4(E/e)\nu_s}{\langle \mathrm{Im}(Z_\perp)\beta_\perp \rangle R}\frac{4\sqrt{\pi}}{3}\sigma_l$$

  - $Z_\perp \approx 0.5\mathrm{M\Omega/m}$: factor of 10 worse than PEP, probably ok since I_b less by 4.

Version 1. Damping Ring Filling Pattern (INFN Roadmap Report, 20 Dec 2005)

Injection/extraction of train of 10000 bunches

- E=2 GeV – damping ring energy
- Π=6500 m – ring circumference
- n=10000 – number of bunches/ring
- $f_{inj/extr}$=120 Hz –inj/extraction rate
- $f_{collisions}$=1.2 MHz – average collision rate
- $T_{cooling}$=8.3 ms – cooling time

Principle of Stroboscopic Injection/Extraction Scheme

- Repetition frequency of kicker pulses slightly differs from the multiple of revolution frequency
- As a result bunch passes a kicker’s location with a slip relative to a pulse moment
- Each bunch after injection makes, say, 384 turns in a damping ring before being extracted
- Kicker pulse duration time is shorter compared to the bunch spacing

Space charge tune shift

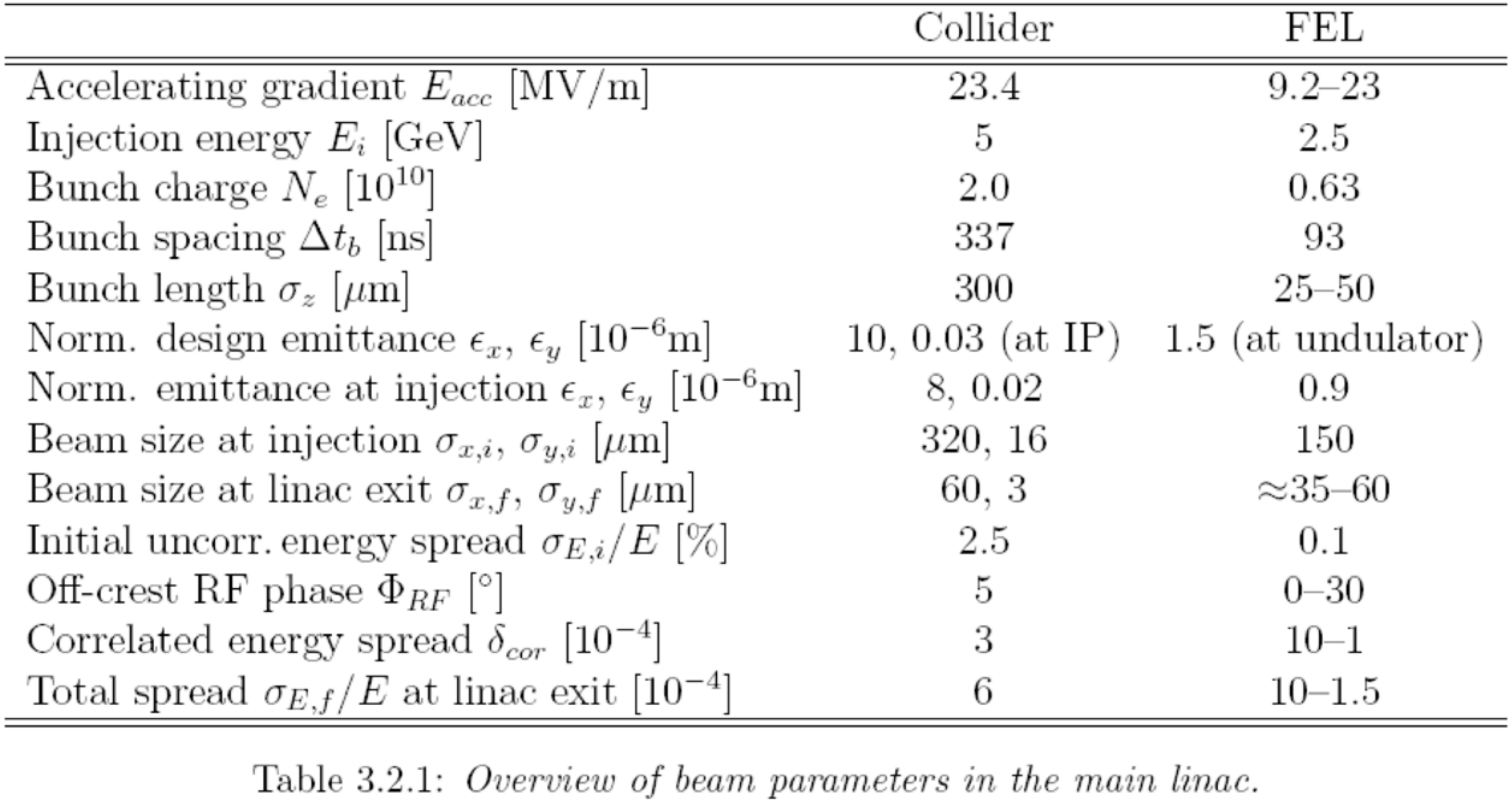
Incoherent tune shift

$$\Delta Q_{sc} = \frac{L r_e N}{\gamma^2 (2\pi)^{3/2} \sqrt{\varepsilon_x \varepsilon_{x_i}}\, \sigma_{x_i}} x_i$$

	SuperB	**TESLA**	**NLC**
Circumference	3181.5	17000	300
Sigma Z	0.003	0.006	0.0038
N	1.05E+11	2.00E+10	7.50E+09
energy [GeV]	2	5	1.98
gamma	3.91E+03	9.78E+03	3.87E+03
norm emit X	5.48E-06	9.00E-06	3.00E-06
norm emit Y	1.25E-08	2.00E-08	3.00E-08
Radus of electron	2.81784E-15	2.81784E-15	2.81784E-15
2PI	6.2832	6.2832	6.2832
SC Tune shift Y	**4.969**	**0.250**	**0.024**

Better to go to higher energy in damping ring

Linac 4 GeV is a TESLA-type linac, with higher repetition rate

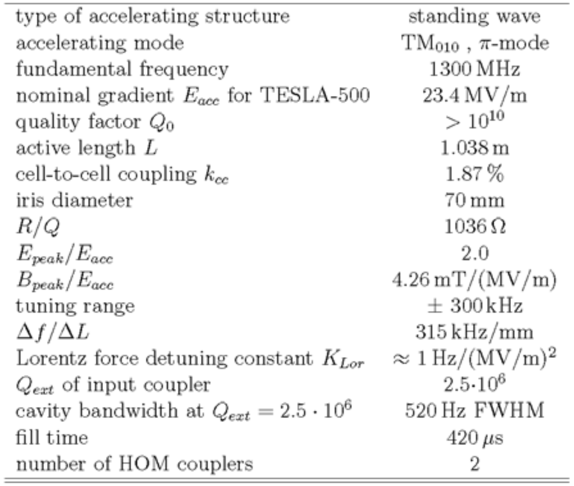


	Collider	FEL
Accelerating gradient E_{acc} [MV/m]	23.4	9.2–23
Injection energy E_i [GeV]	5	2.5
Bunch charge N_e [10^{10}]	2.0	0.63
Bunch spacing Δt_b [ns]	337	93
Bunch length σ_z [μm]	300	25–50
Norm. design emittance ϵ_x, ϵ_y [10^{-6}m]	10, 0.03 (at IP)	1.5 (at undulator)
Norm. emittance at injection ϵ_x, ϵ_y [10^{-6}m]	8, 0.02	0.9
Beam size at injection $\sigma_{x,i}$, $\sigma_{y,i}$ [μm]	320, 16	150
Beam size at linac exit $\sigma_{x,f}$, $\sigma_{y,f}$ [μm]	60, 3	≈35–60
Initial uncorr. energy spread $\sigma_{E,i}/E$ [%]	2.5	0.1
Off-crest RF phase Φ_{RF} [°]	5	0–30
Correlated energy spread δ_{cor} [10^{-4}]	3	10–1
Total spread $\sigma_{E,f}/E$ at linac exit [10^{-4}]	6	10–1.5

Table 3.2.1: *Overview of beam parameters in the main linac.*

TESLA Linear Collider

Wake fields in Tesla cavities



type of accelerating structure	standing wave
accelerating mode	TM_{010} , π-mode
fundamental frequency	1300 MHz
nominal gradient E_{acc} for TESLA-500	23.4 MV/m
quality factor Q_0	$> 10^{10}$
active length L	1.038 m
cell-to-cell coupling k_{cc}	1.87 %
iris diameter	70 mm
R/Q	1036 Ω
E_{peak}/E_{acc}	2.0
B_{peak}/E_{acc}	4.26 mT/(MV/m)
tuning range	± 300 kHz
$\Delta f/\Delta L$	315 kHz/mm
Lorentz force detuning constant K_{Lor}	≈ 1 Hz/(MV/m)^2
Q_{ext} of input coupler	$2.5{\cdot}10^6$
cavity bandwidth at $Q_{ext} = 2.5 \cdot 10^6$	520 Hz FWHM
fill time	420 μs
number of HOM couplers	2

Table 2.1.1: *Parameters of the 9-cell cavity (note that we adopt here the definition of shunt impedance by the relation $R = V^2/P$, where P is the dissipated power and V the peak voltage in the equivalent parallel LCR circuit).*

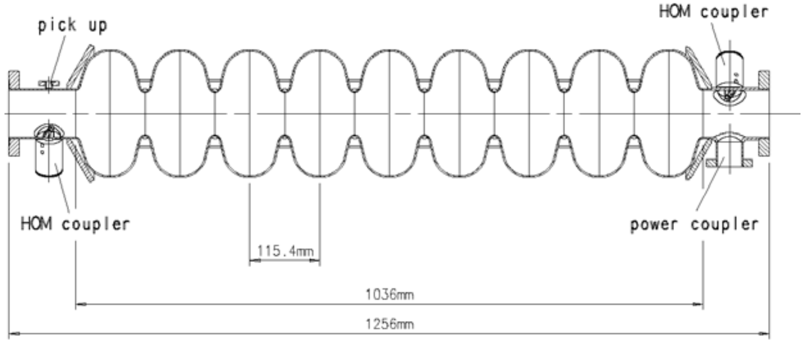
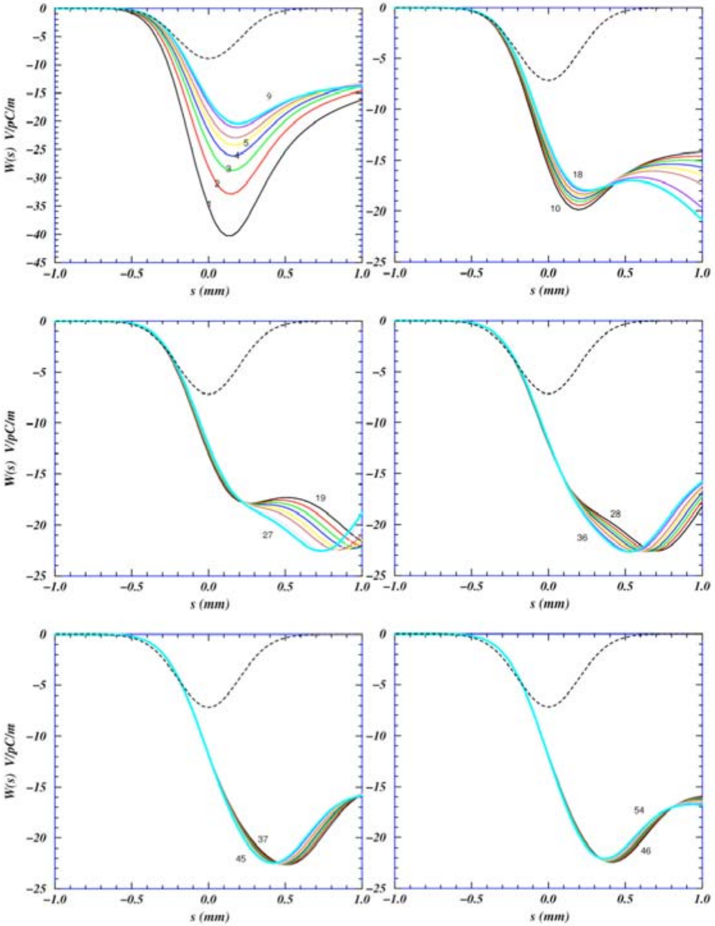


Figure 2.1.3: *Side view of the 9-cell cavity with the main power coupler port and two higher-order mode couplers.*

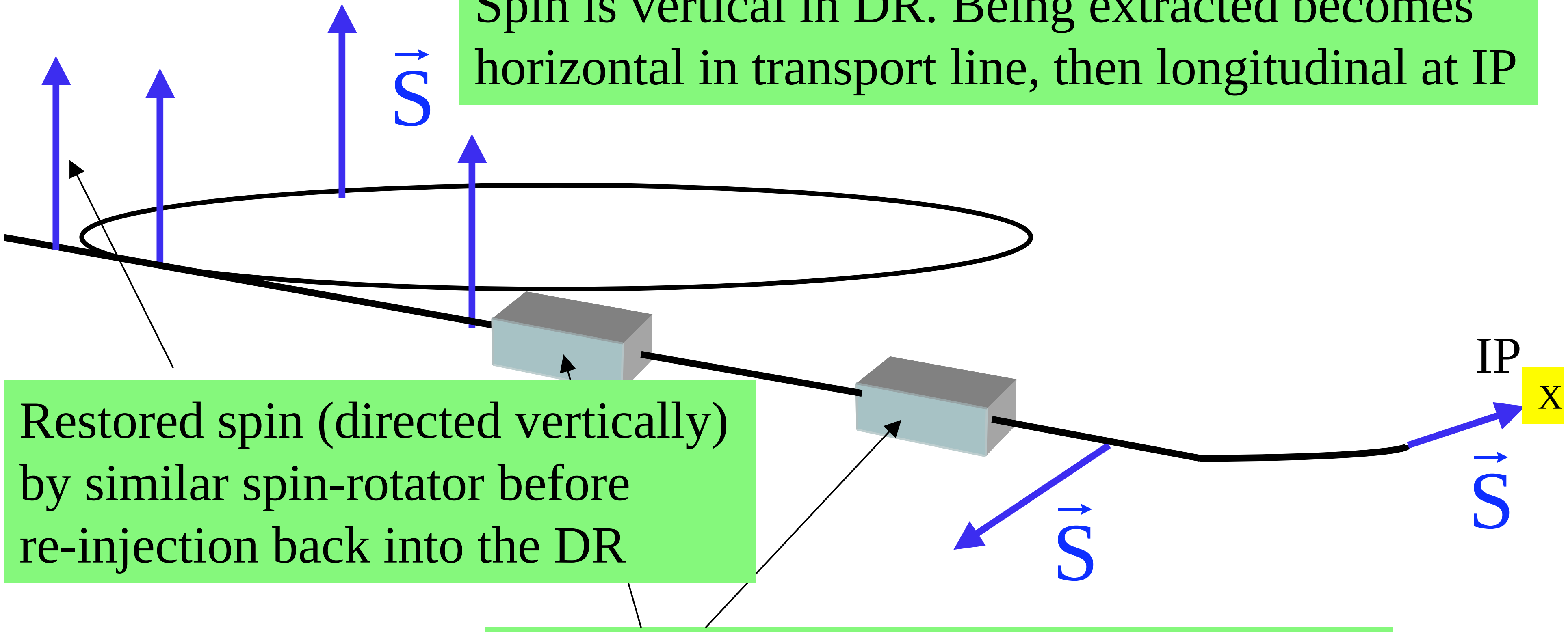


0.2 mm bunch Wake potential in the last cell

Polarization Scenario

- Selfpolarization via Sokolov-Ternov mechanism in damping rings. For e^+ this is the only way.
- Rotate spin alternatively by $+90^0$ or $–90^0$ around z-axis in the transport channel with subsequent beam and spin rotation in the horizontal plane to get finally the longitudinal polarization at IP.
- Option: accelerate longitudinally polarized electrons from a gun (we need $\sim 10^6$ polarized electrons/bunch).

Polarization Scenario (Cont’d)



Spin is vertical in DR. Being extracted becomes horizontal in transport line, then longitudinal at IP

Restored spin (directed vertically) by similar spin-rotator before re-injection back into the DR

45^0+ 45^0 Spin Rotator (two solenoids and few quads in between)

Polarization Degree

$$\zeta = \frac{8}{5\sqrt{3}} \frac{<B^3>}{<|B|^3>} = \frac{8}{5\sqrt{3}} \frac{B_+{}^2 - B_-{}^2}{B_+{}^2 + B_-{}^2}$$

$$\frac{8}{5\sqrt{3}} \qquad 0.924$$

For $B_+ = 1.542\ \mathrm{T},\ B_- = -0.514\ \mathrm{T},\quad \frac{B_+{}^2 - B_-{}^2}{B_+{}^2 + B_-{}^2} = 0.8$

$$\zeta \qquad 0.74$$

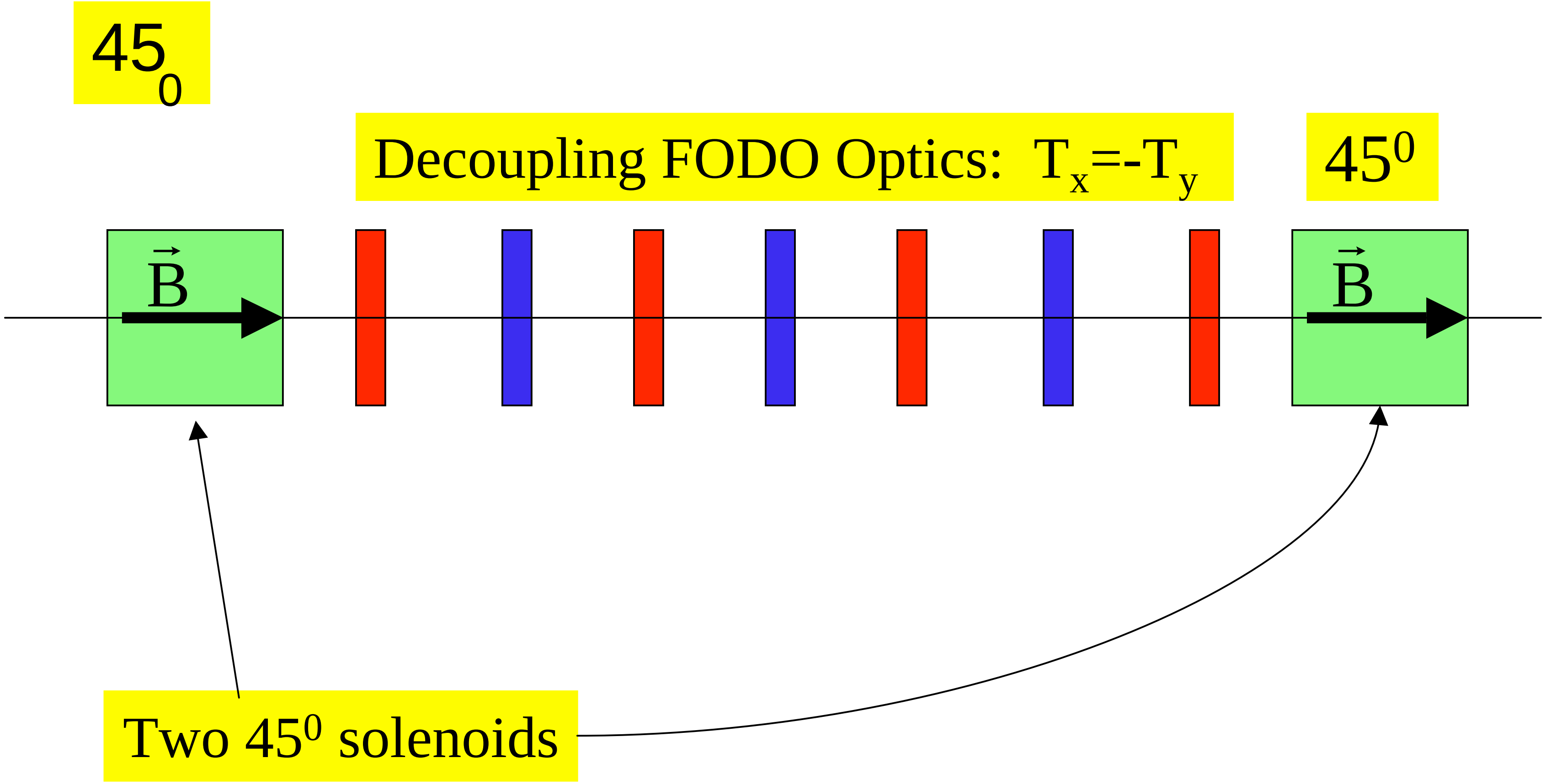
Polarization Time

$$\tau_p^{-1} = \frac{5\sqrt{3}}{8} \lambda_e r_e c \gamma^5 < \frac{1}{|r|^3} >$$

$$\text{For} \quad E = 2\,\text{GeV}, \; B_+ = 1.542\,\text{T}, \; B_- = 0.514\,\text{T}, \; l_w / \Pi = 20\%$$

$$\tau_p = 4500\ \text{s}$$

90^0 Spin Rotator for Transport Channel



45_0

Decoupling FODO Optics: T_x=-T_y

45^0

Two 45^0 solenoids

Decoupling Insertion between two Solenoids

$$M_{Sol} = \begin{pmatrix} A & 0 \\ 0 & A \end{pmatrix} \cdot \begin{pmatrix} I \cdot \cos(\varphi) & I \cdot \sin(\varphi) \\ -I \cdot \sin(\varphi) & I \cdot \cos(\varphi) \end{pmatrix}$$

$$M_{Sol} \cdot \begin{pmatrix} T_x & 0 \\ 0 & T_y \end{pmatrix} \cdot M_{Sol} = ???$$

For $T_x = -T_y \rightarrow$

$$\begin{pmatrix} I \cdot \cos(\varphi) & I \cdot \sin(\varphi) \\ -I \cdot \sin(\varphi) & I \cdot \cos(\varphi) \end{pmatrix} \cdot \begin{pmatrix} T & 0 \\ 0 & -T \end{pmatrix} \cdot \begin{pmatrix} I \cdot \cos(\varphi) & I \cdot \sin(\varphi) \\ -I \cdot \sin(\varphi) & I \cdot \cos(\varphi) \end{pmatrix} =$$

$$= \begin{pmatrix} T & 0 \\ 0 & -T \end{pmatrix} \quad \rightarrow \quad M_{Sol} \cdot \begin{pmatrix} T & 0 \\ 0 & -T \end{pmatrix} \cdot M_{Sol} = \begin{pmatrix} ATA & 0 \\ 0 & -ATA \end{pmatrix}$$

Action items (to be extended)

- Freeze one or two parameter sets
- Define a layout
- Assign working groups for the different subsystems
  BB simulations: Ohnishi,paoloni,biagini etc
  confirmations results and optimizations
  DR: Wolsky,Guiducci,Wienands,Cai etc
  FF/IR: Seryi, Sullivan,Roodman etc
  RF, Linac,Impedance,Chamber designs:
  Novokhatski
  BC: Tenenbaum, Guiducci,Biagini
  Injection System: Variola,Albert,Sheppard
  Polarization, koop, variola,Sheppard
  Collimation: Roodman,Sullivan,Wienands
- Define the synergy with ILC, R&D, lattice designs, etc…
- Evaluate the possibility to reuse Pep hardware.
- Make a cost and power consuption estimate and optimization
- Make a time schedule
- Define the international collaborations