Accelerator Work Summary

U. Wienands

SLAC PEP-II

My thanks for speakers to provide me with copies of their talks…

Lots of progress shown, unable to do justice to all in 30 min…

Seeman

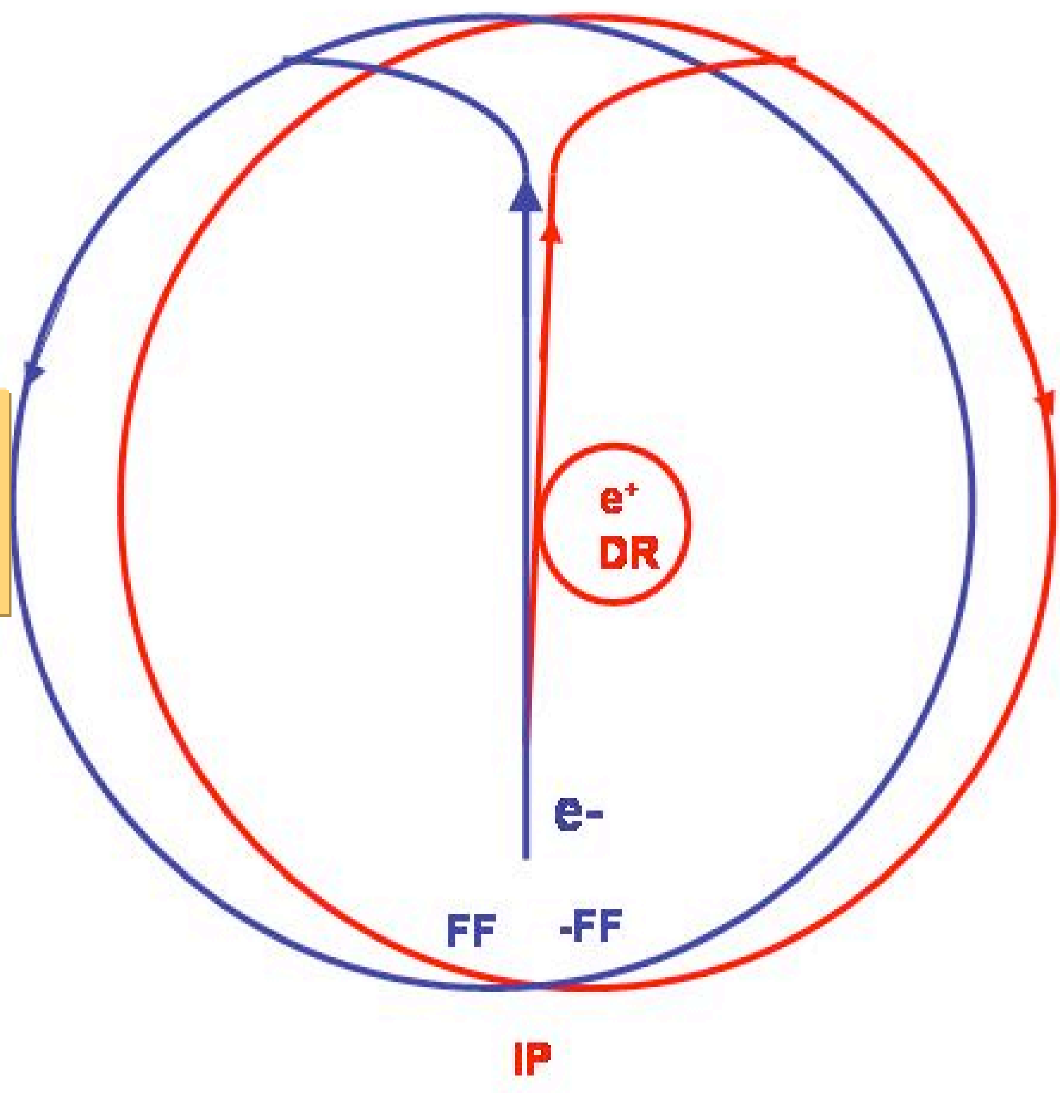
Parameters of Super-B Designs

Collider		ξ_y	N	β_y*	s	E	F	Lumin
Units			10^{10}	mm	m	GeV	(~Hd)	10^{35}
PEP-II	Normal	0.068	8	11	1.26	3.1	0.84	0.10
KEKB	Normal	0.065	5.8	6	2.1	3.5	0.76	0.16
Super-PEP-II	High I low βy	0.12	10	1.7	0.32	3.5	0.81	7
Super-KEKB	High I low βy	0.28	12	3	0.59	3.5	0.85	8
Linear SuperB	Single pass	29.	10	0.5	250	4	1.07	10
SuperB	Bunch shorten	0.14	6	0.4	0.63	4	0.75	10
SuperB	X'ing angle	0.045	2	0.08	0.5	5	0.8	10

Present workshop dealt with the last scenario

Simplified SuperB layout
Crossing angle = 2*25 mrad

Raimondi



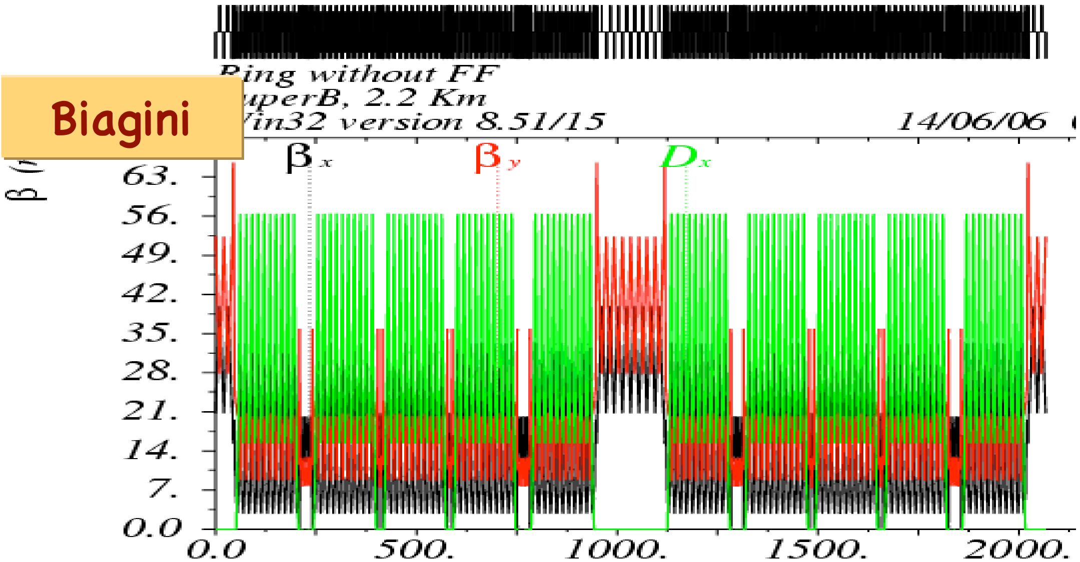
ILC ring & ILC FF

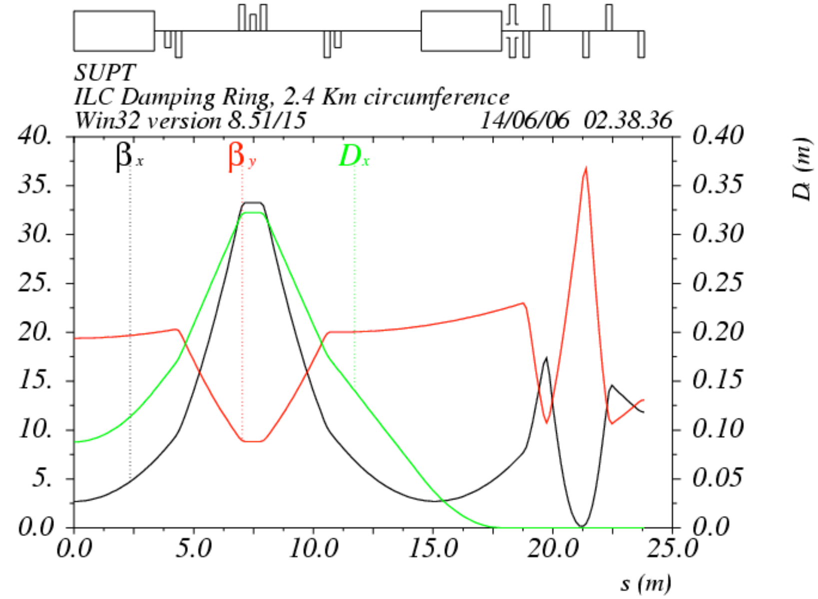
Damping Rings' Status

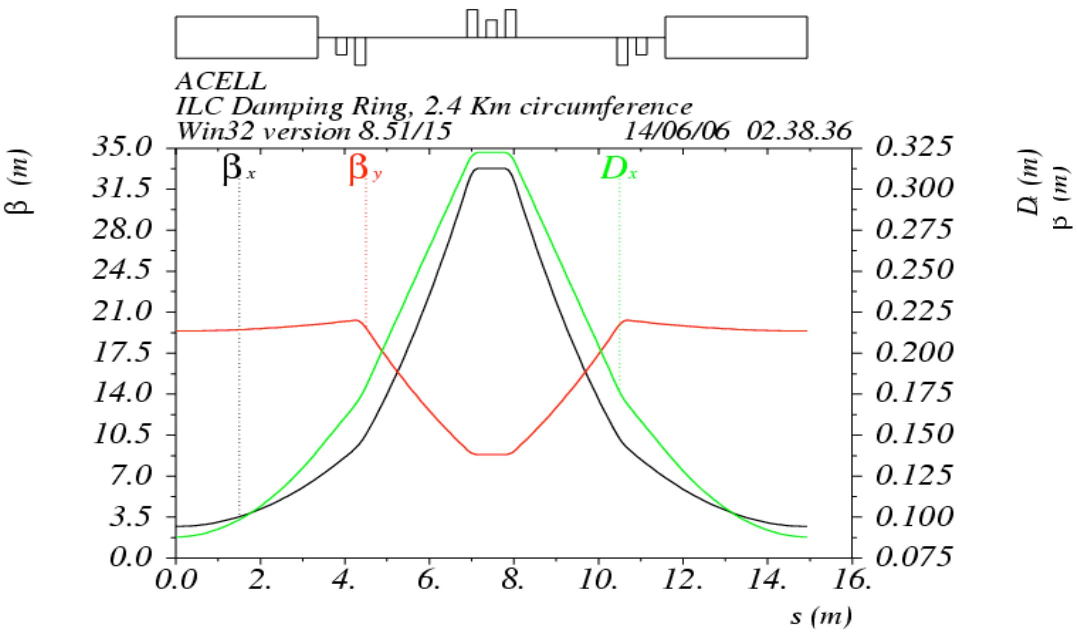
- 2 Designs: 2.2 km, 3.2 km
  - based on ILC OCS lattice, with ILC-Style IR
  - Tracking studies have begun
- ILC Design with 6.6 km also based on OCS: good acceptance
  - Existence proof of a lattice with good acceptance
  - IR not matched into this one yet
- Beware of wiggler nonlinearities!

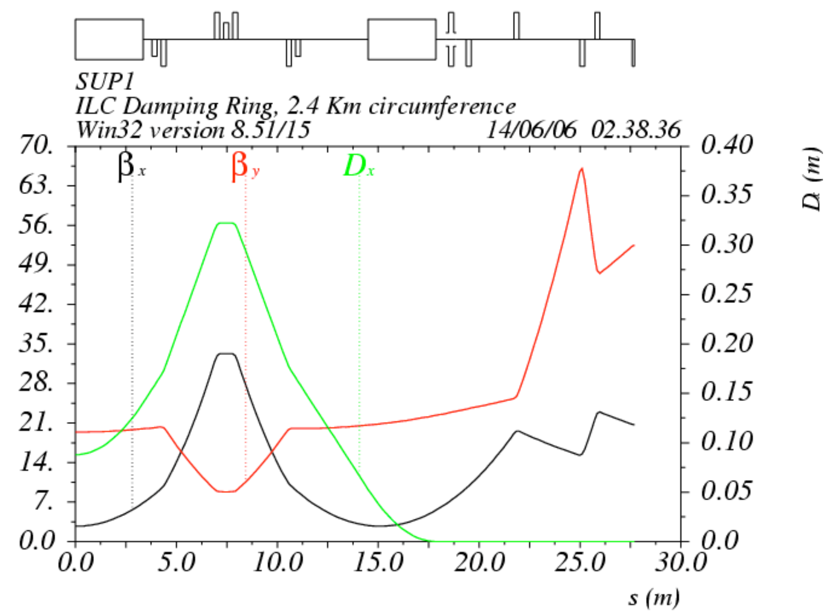
7 GeV ring, 2.2 Km

Biagini



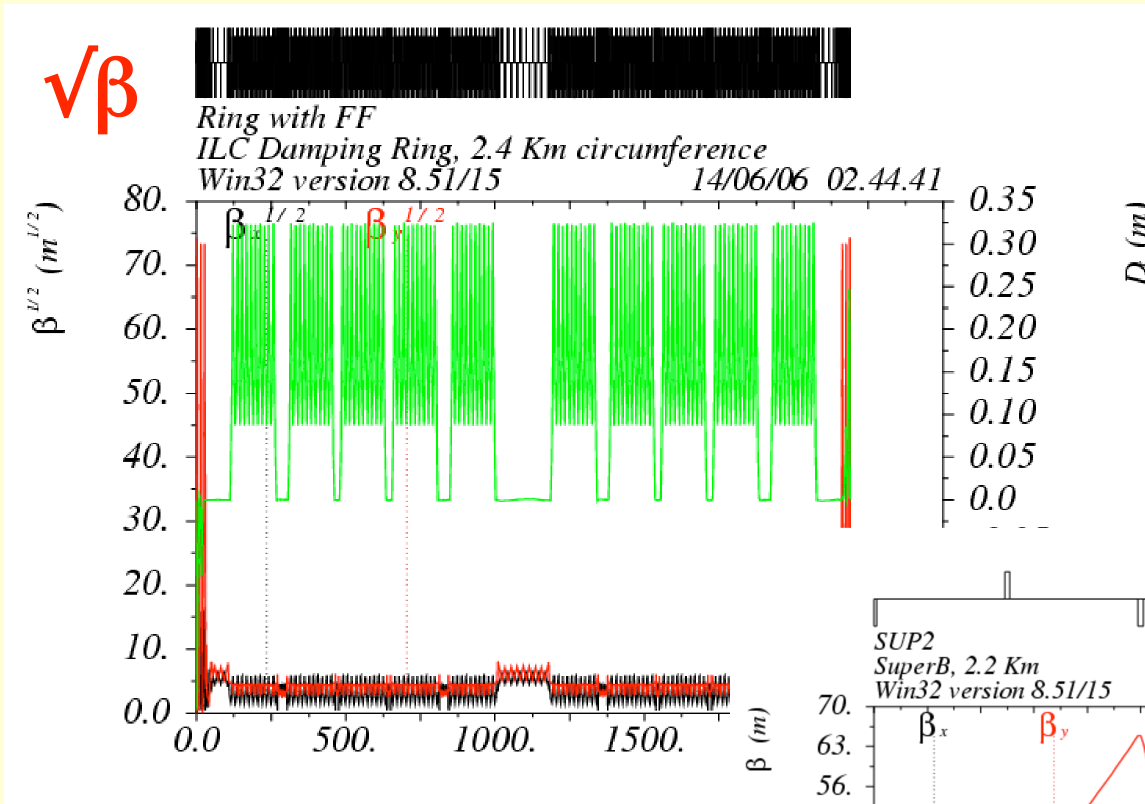




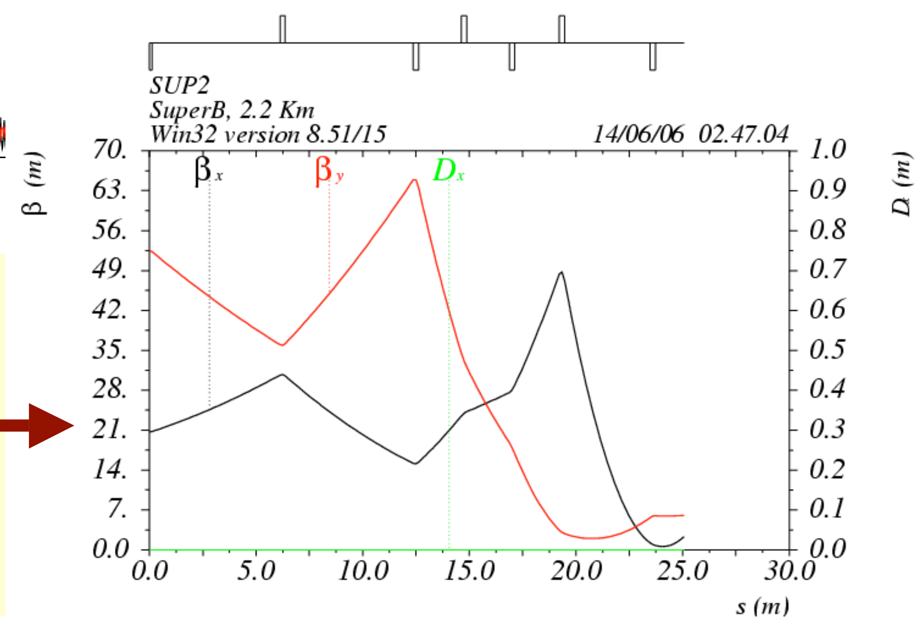


2.2 Km ring with FF

Biagini



Matching section to FF



Comparison of Ring Parameters

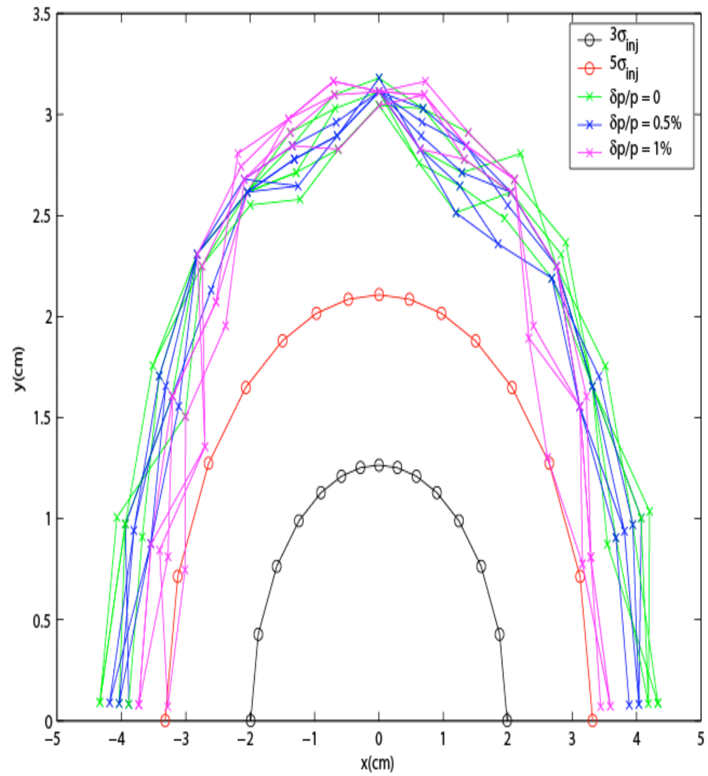
Biagini

	4 GeV			7 GeV		
C (m)	6114.	3251.	2230.	6114.	3251.	2230.
B_w (T)	1.6	1.4	1.4	1.6	1.4	1.4
L_{bend}(m)	5.6	5.6	6.72	11.2	10.6	6.72
N. bends	96	96	100	96	96	100
B_{bend} (T)	0.078	0.155	0.125	0.136	0.144	0.218
Uo (MeV/turn)	5.7	4.4	3.5	10.7	6.4	7.
N. wigg. cells	8	8	8	6	4	4
τ_x (ms)	28.8	19.8	17.	26.	24.	14.5
τ_s (ms)	14.4	10.	8.6	13	12.	7.25
ε_x (nm)	0.5	0.38	0.37	0.5	0.565	0.64
σ_E	1.1×10^{-3}	1.1×10^{-3}	10^{-3}	1.3×10^{-3}	1.32×10^{-3}	1.35×10^{-3}
I_{beam} (A)	2.5	2.5	2.5	1.4	1.4	1.4
P_{beam}(MW)	14.	11.	8.8	15.	9.	9.8
P_{wall} (MW) (50% eff)	43.5	30	28	-	-	-

Dynamic Aperture of Baseline Lattice with Magnetic Errors

Cai

- Tracking of SuperB Ring designs in progress. This is the latest 6 km ILC DR Design (wiggler, no IR)
- Multipole errors specified according to PEP-II and SPEAR3 magnets are included
- Single-mode model is used for all wigglers
- Tracking with LEGO in 1024 turns
- Injected beam: $\varepsilon_x=\varepsilon_y=\mu$m–rad



DR Hardware

- Vacuum system: likely within envelope of present technology (PEP-II LER)
- Rf: warm or cold possible, no fundamental issue
  - large number of rf stations (e.g. 22 stn/klystrons)
  - instability thresholds likely within present technology

Collective, Intensity Effects

Pivi, Cai, Heifets, Novo-khatski

- ECI: Clearing electrodes and/or surface treatments
  - R&D program in PEP-II/ILC collaboration
    - Different chambers, measurement of SEY after irradiation
- Fast Ion Instability
  - Growth rates potentially O(1 turn)
  - But not a limit in any extant machine
    - (however, HER may see something like this at high pressure!)
- HOM Effects
  - At 6 mm bunch length maybe 1 MW of power into HOMs
  - Vtx chamber particularly vulnerable

Growth Rate of Resistive-Wall Instability

Cai

ILC DR Designs

Table 3.31: Growth rates of resistive-wall instability, with 16 mm radius vacuum chamber in the wiggler.

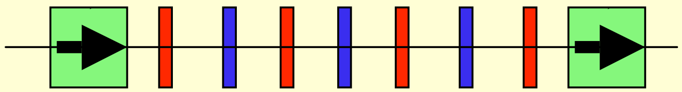
Lattice	Growth rate, Γ [ms^{-1}]	Growth time, f_0/Γ [turns]
PPA	0.940	113
OTW	0.567	164
OCS	2.75	17.8
BRU	0.860	55.1
MCH	0.376	50.0
DAS	0.355	49.6
TESLA	0.277	63.6

The tune shift $\Delta\nu_y \approx \Gamma/\omega_0$ caused by the resistive-wall impedance is equal to the growth rate divided by the angular revolution frequency. Generally speaking, it can vary along the bunch train and distort the optics for bunches in the tail of the train. However, for the damping rings the effect is small, see Table 3.32.

Polarization

Koop

- Single Siberian Snake most elegant way to create longitudinal polarization at IP.
- But depolarization time at 4 GeV ≈30 s
- at 3 GeV: ≈250 s, > beam lifetime, ≈ ok
- Alternative: 90° spin rotators around IP
  - specific locations prescribed
  - only works for 1 energy
  - likely a coupling nightmare (or use very long compensated rotator)

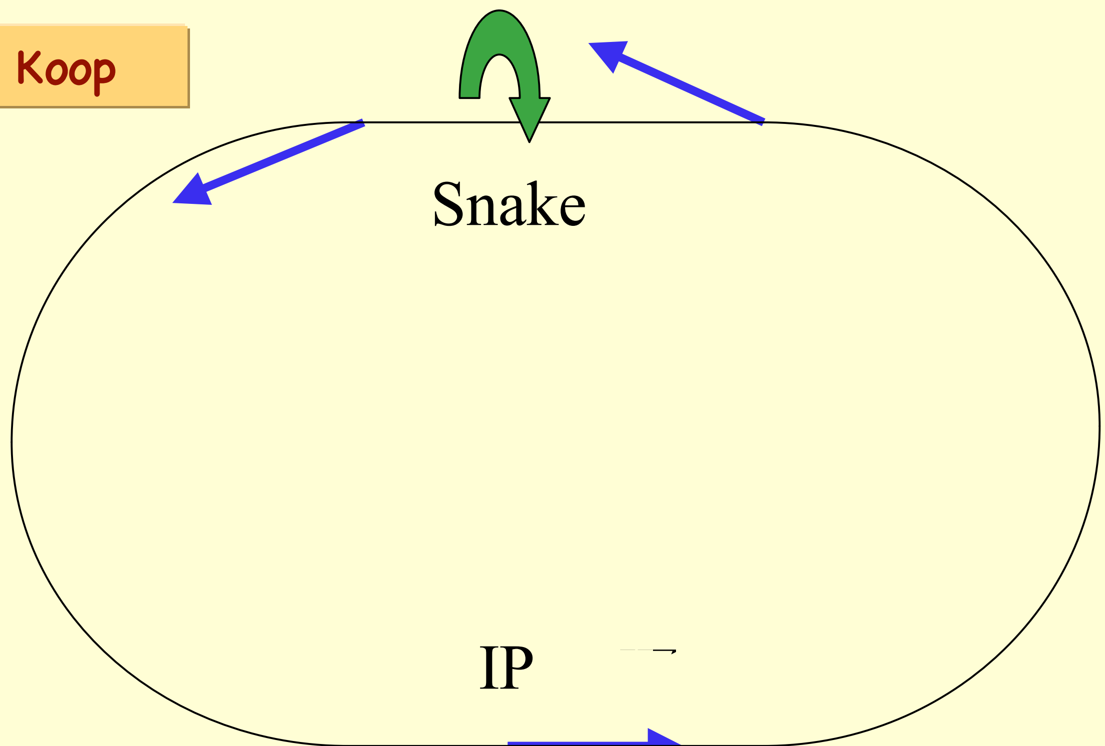


- IR optics should be spin transparent to maintain polarization.

Closed spin orbit with the snake

Derbenev, Kondratenko, Skrinsky, 1977

Koop



Snake rotates the spin by 180^0 around z-axis

In arcs spin lie everywhere in the horizontal plane

At IP spin is directed longitudinally

With a partial snake at a magic energy spin is directed longitudinally at IP and also at the snake's location

Some IP Parameters

Sullivan

HER LER

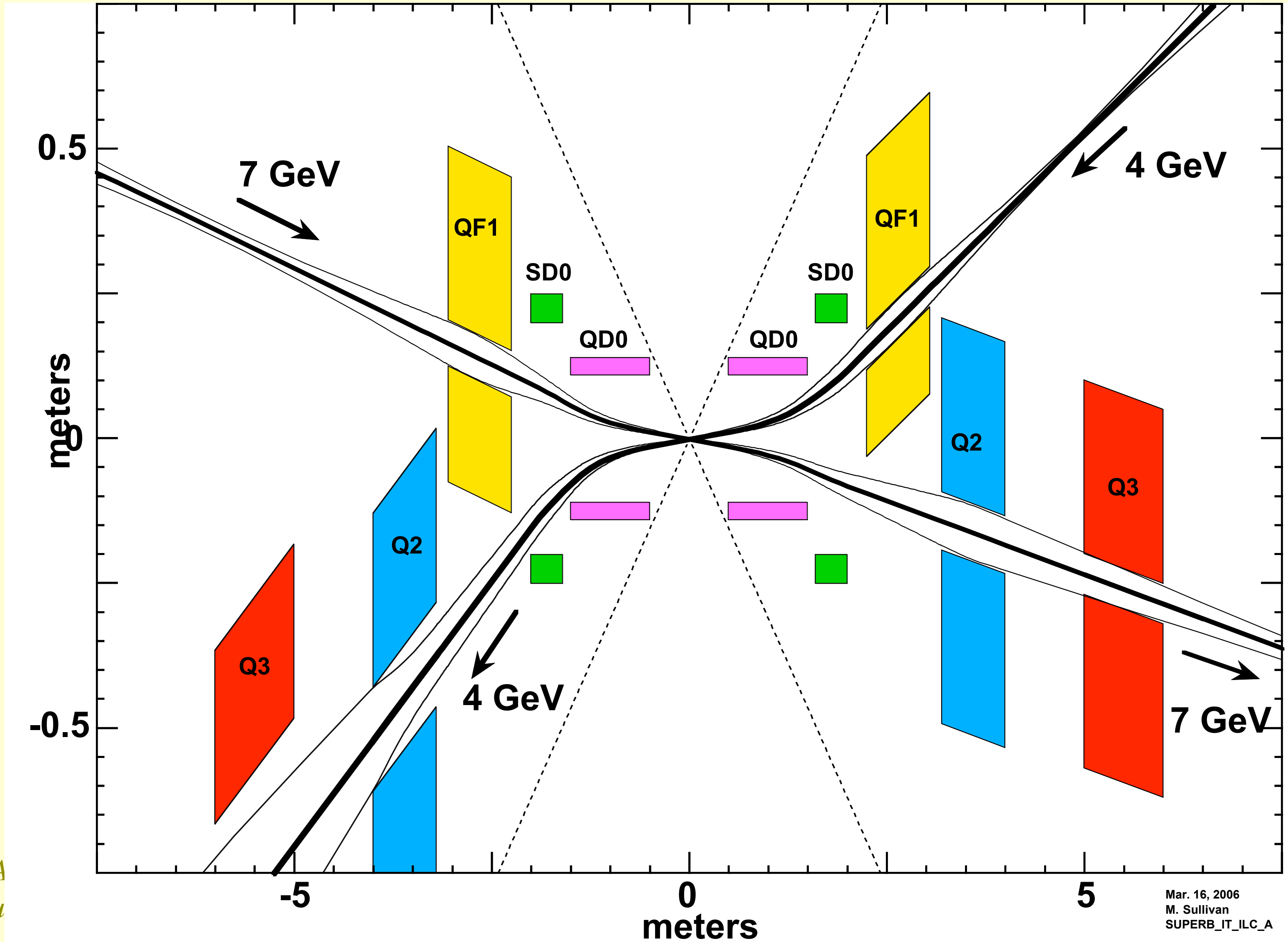
- Beta x (mm) 2.5 2.5
- Beta y (mm) 0.08 0.08
- Emittance x (nm-rad) 0.4 0.4
- Emittance y (nm-rad) 0.002 0.002
- Sigma x (μm) 2.67 2.67
- Sigma y (μm) 0.0126 0.0126
- Bunch spacing (m) 0.6
- Crossing angle (mrad) ±25
- Luminosity 0.8×10^{36}

Some Issues

- Shared vs common QD
  - depends on (or determines) crossing angle
  - flexibility vs space constraints
- Vtx Chamber radius
  - 1 cm pipe hard to mask, HOM and s.r. power issue
- Avoidance of radiative Bhabha background
  - avoid too strong bends close after the IP
- Optics design not final
  - final solution will likely get longer
  - weak vs full-strength anti-solenoids
  - spin matching??

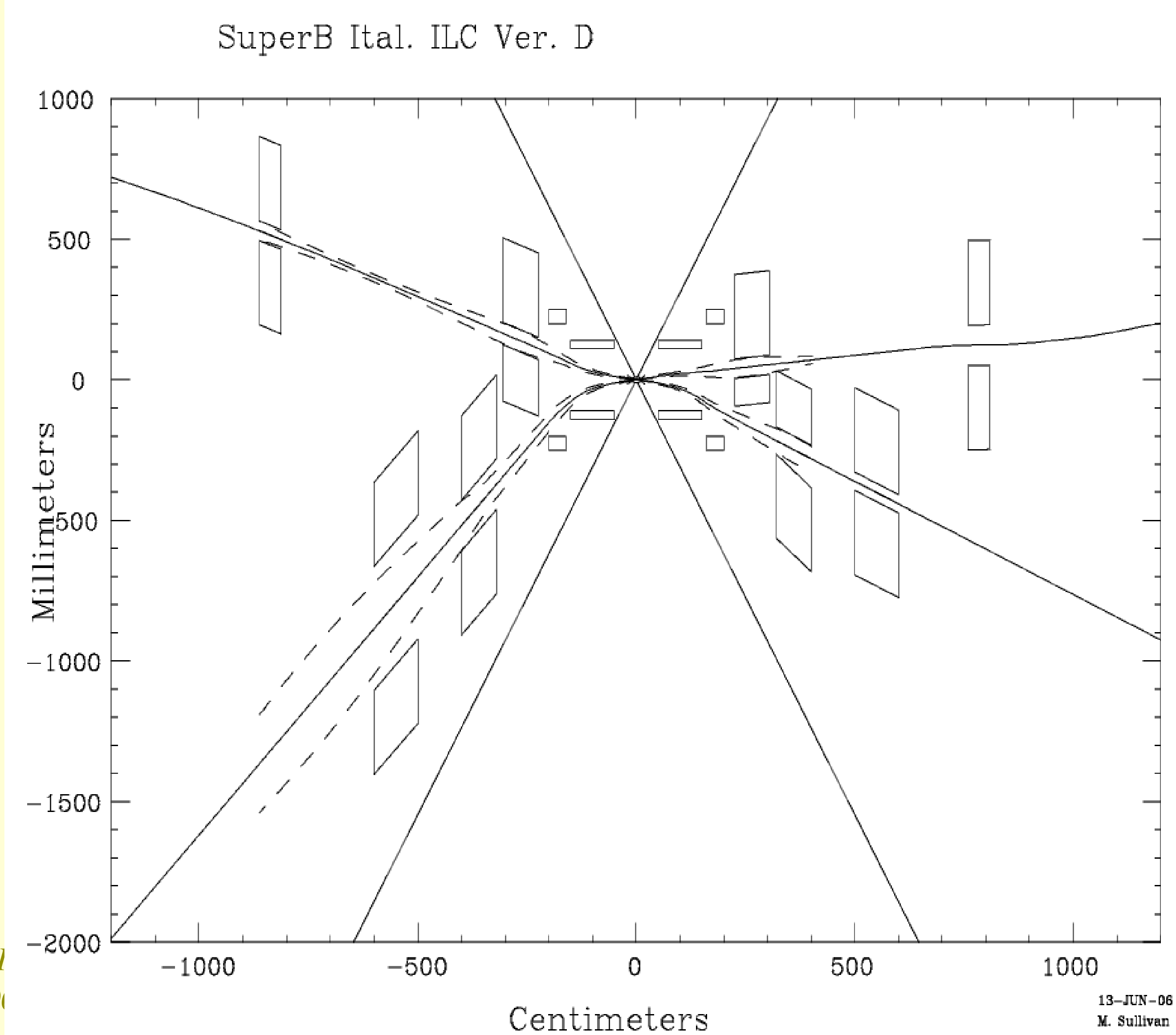
IR design from March Workshop

Sullivan



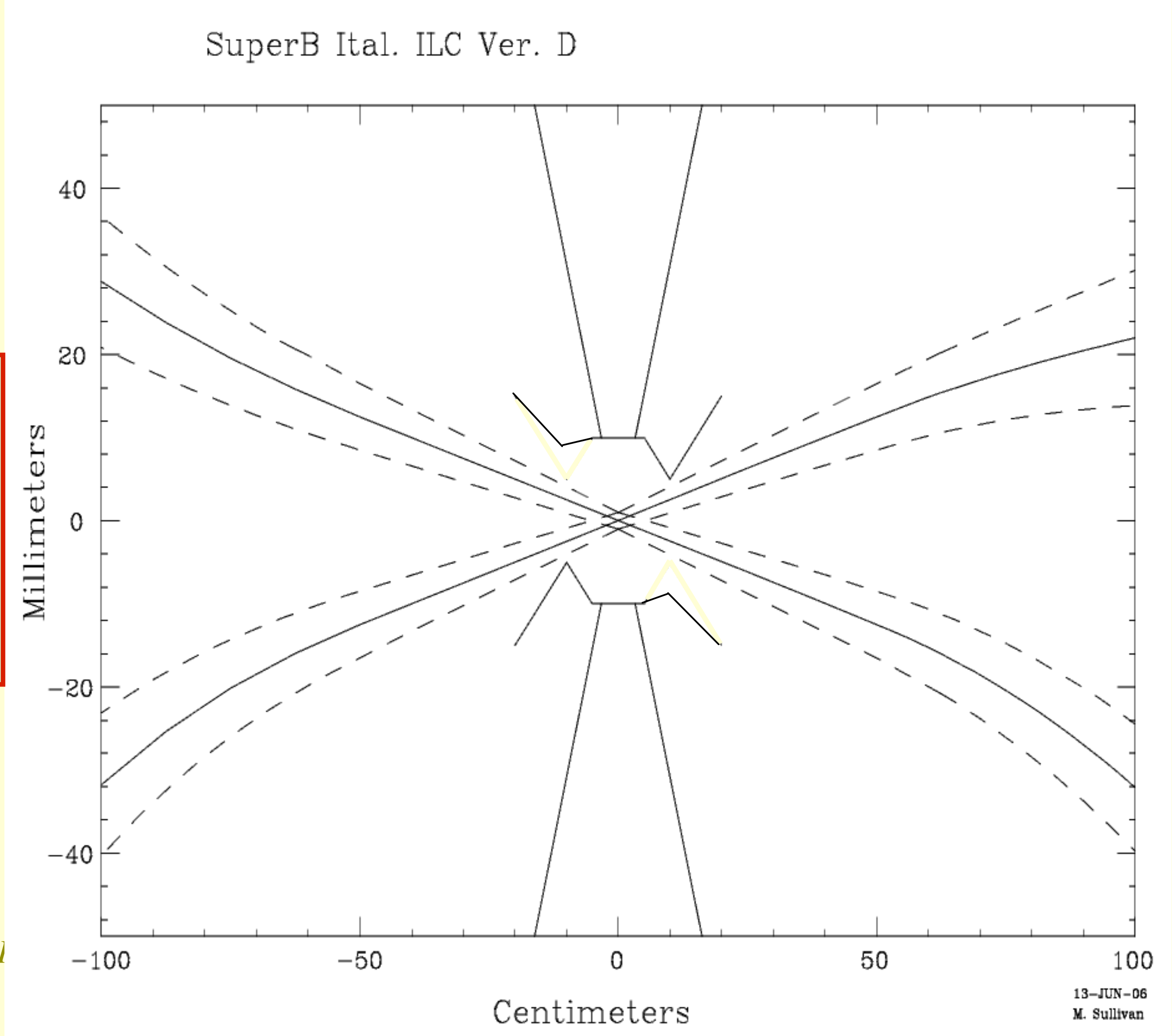
Fourth IR Concept

Sullivan



June 2006, Rev. 4

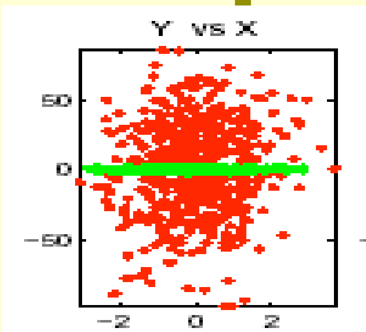
Sullivan



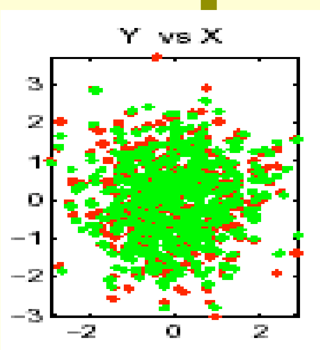
Masking is more open. This improves HOM power issues.

Seryi

Anti-solenoid for IR



without compensation $\sigma_y / \sigma_y(0)=32$

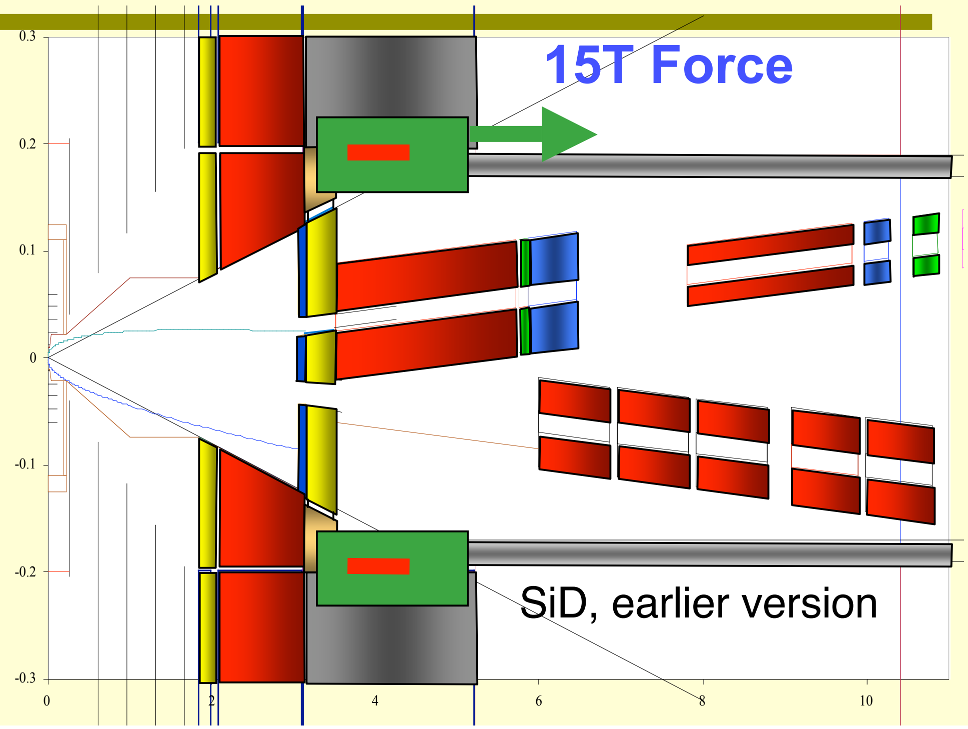


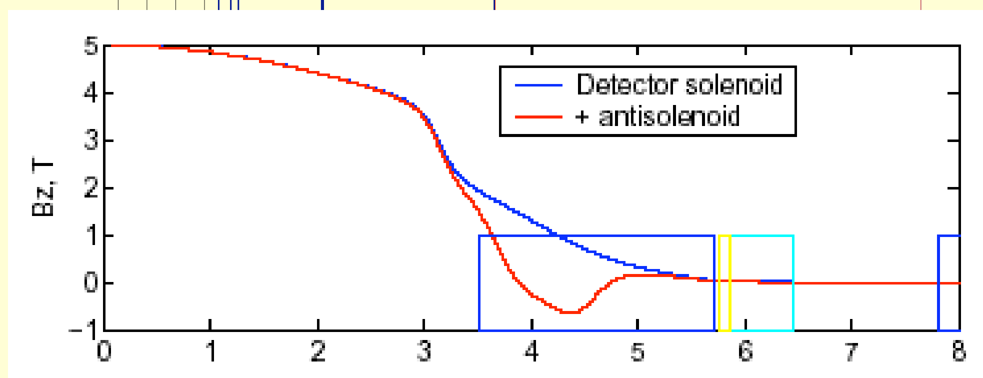
with compensation by antisolenoid $\sigma_y / \sigma_y(0)<1.01$

When solenoid overlaps QD0, anomalous coupling increases the IP beam size 30 – 190 times depending on solenoid field shape (green=no solenoid, red=solenoid)

Even though traditional use of skew quads could reduce the effect, the LOCAL COMPENSATION of the fringe field (with a little skew tuning) is the best way to ensure excellent correction over wide range of beam energies

Local correction requires anti-solenoid with special shape. The antisolenoid is weak since its integrated strength is much smaller than that of detector solenoid





YURI NOSOCHKOV AND ANDREI SERYI

Phys. Rev. ST Accel. Beams 8, 021001 (2005)

FF Work Summary

Seryi

- Need to lengthen the optics to decrease aberrations in FF and improve dynamic aperture of the ring
  - there are other optics ideas (e.g. sextupole for crab) that need to be implemented
- If FD is common, optics can be optimized to improve focusing of the outgoing beam with
- Separate FD give a lot of advantages and L* of ~0.8m or less may be possible
- Weak antisolenoids are beneficial for local compensation of coupling

Beam-Beam Simulations

- Significant progress in simulating the crab waist scheme
  - so far it appears to hold up
  - extant machines & SuperB/SuperKEKB
- Codes are being extended & modified to better simulate this scenario
- Progress in analytic understanding of the beam-beam interaction
  - "Universal Luminosity Formula" shows independence on crossing angle under certain conditions.

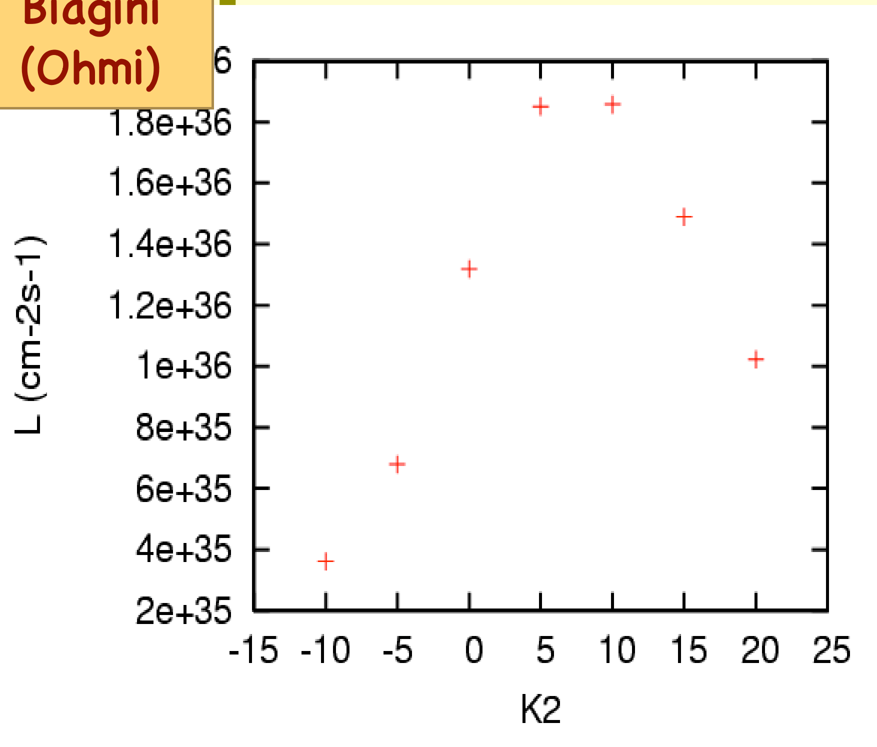
Crab-waist simulations

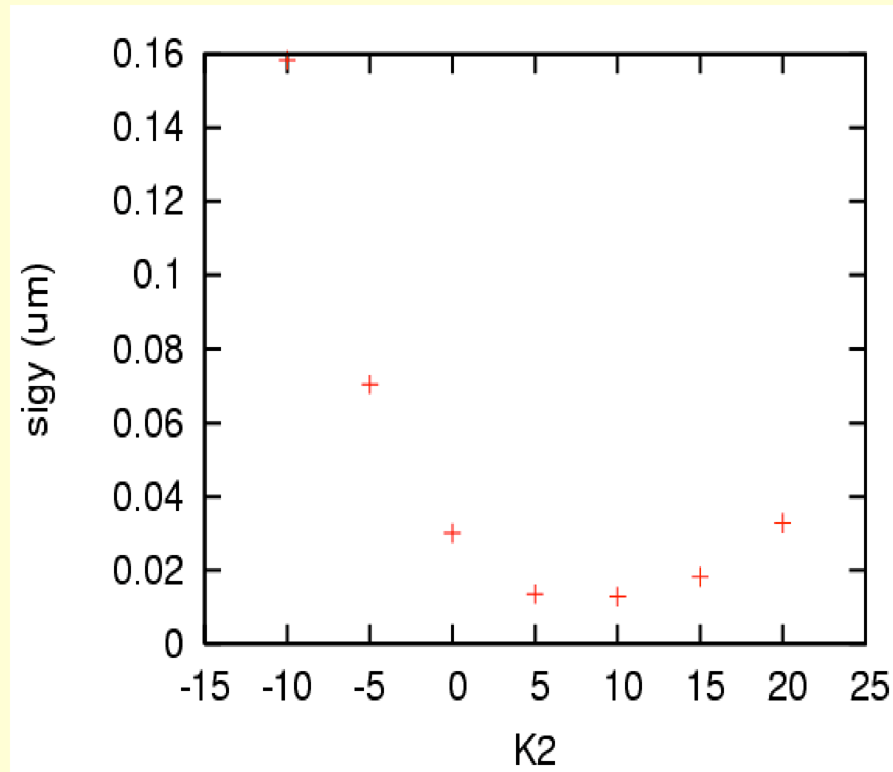
Biagini

- **The new idea is being checked by several beam-beam codes:**
  - Guinea-Pig: strong-strong , ILC centered
  - BBC (Hirata): weak-strong
  - Lifetrack (Shatilov): weak-strong with tails growths calculation
  - Ohmi: weak-strong (strong-strong to be modified for long bunches and large angles)

Ohmi's weak-strong code

Biagini (Ohmi)





Luminosity

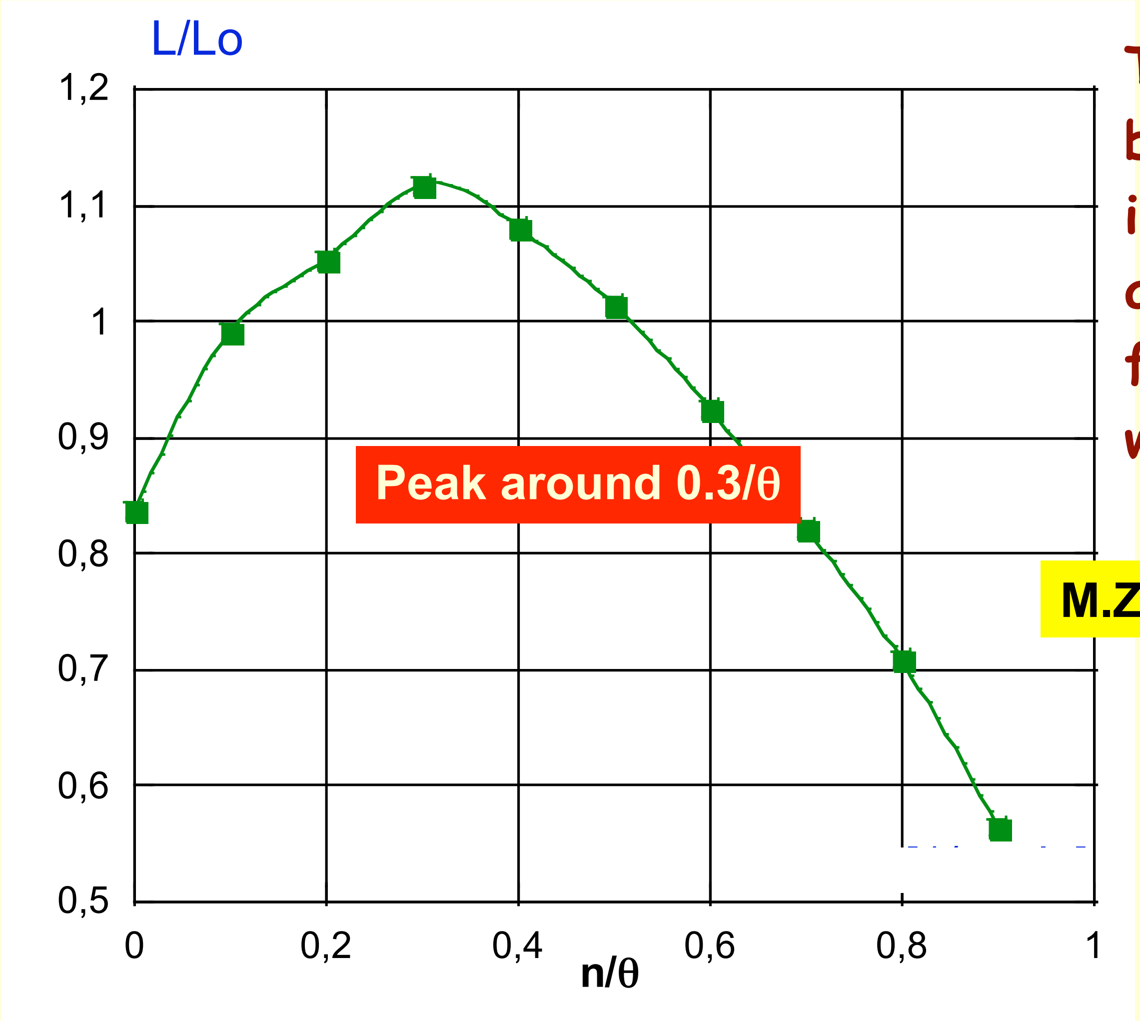
Vertical blow-up

K2 is the strength of the sextupolar nonlinearity introduced to have crab waist

(Geometric) Luminosity

Biagini

Scan *vs* crab waist n/θ



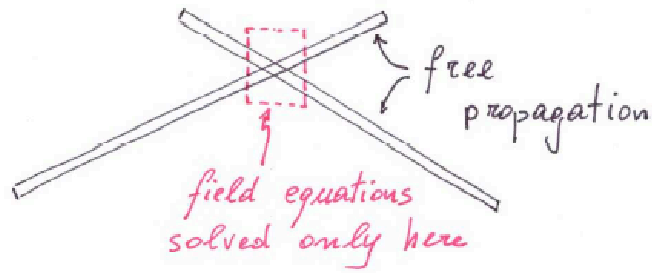
Takes into account both bb interactions and geometric factor due to crab waist

M.Zobov, LNF

Speeding up the GuineaPig

Paolini

I : VERY CRUDE APPROX.



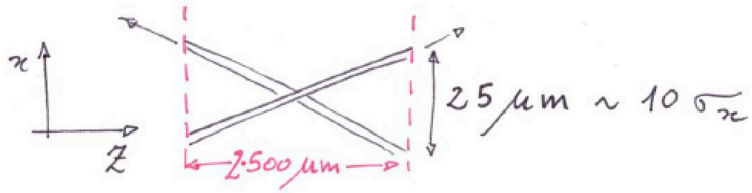
• Solve the Poisson equations only for the few colliding slices.

$N_{slice} \simeq 10^3$

$N_{colliding} \simeq 10$

• gain a factor 100 in CPU time

• simulating the field in $|z| < 500\ \mu m$



• Not yet optimal: guinea pig evaluates $\vec{E}$ in the whole box...

DR Test Facilities (proposed)

Seeman

- DESY-HERA: e-ring to migrate to a full ILC DR, move to site later.
  - 6 km ring, ILC DR parameters,
- CESR ILC DR test: use wigglers to bring emittance down
  - < 3 nmr ex, 15 pmr ey @ 2 GeV, 400 mA 6…8 ns
- PEP Study: HER makes 5 nmr at 3 GeV, could do e+ and high beam current.
  - 5nmr, 1.7 mm bunch length

Approximate SBF Site Power (3 km ring)

Seeman

- Campus +detector = 5 MW
- Linac and e+ at 30 Hz = 10 MW
- Magnets (~1.5 x PEP-II) = 10 MW
- RF (4 x 7 GeV) (2.5 A x 1.4 A) = 22.4 x 2=45 MW
- Total = ~70 MW

Cost Algorithm

Seeman

- Method:
  - Scale known costs of extant projects
    - Parameters, Inflation
  - Compare to other estimates for similar projects
    - SuperKEKB, previous SuperPEP estimate
- "Green Field" site: ≈M$716
  - Cost of infrastructure (tunnels, bldgs, …), injector ≈1/4 of the above.
- *Note*: Strictly scaling & WAG. No engineering or design knowledge applied here!

To Do List

Raimondi

Goal: have a preliminar done before the next workshop

1) DR based on PEP Hardware
2) DR based on Tor Vergata Site (possibly (1)-compatible)
   Biagini, Wolski, Cai, Wienands

3) Parameters Studies and Optimization
   Ohmi, Paoloni, Zobov, Shatilov

4) FF optimization
   Seryi,Raimondi

5) IR optimization
   Sullivan,Seryi + Detector people

6) Cost scaling, estimates and optimization
7) Power requirements
8) Ring Layout
   Seeman

9) Spin handling
   Koop
10) Injector design

More Issues

UW & Group

- Settle the energy ratio & vtx radius (working decision)!
- Show the 2.2 km ring can be built & meets the requirements => the larger ones would be simpler.
- Optimize & make more realistic the FF & the IR design
- Need an existence proof by tracking that a DR with IR can have sufficient acceptance.
- A full, 3d, strong-strong simulation of the machine.
- Instability thresholds should be estimated using the present DR parameters.
- Evaluate Rf needs using the ILC s/c rf-cavity parameters
- Spell out the injection/injector parameters.
  Detector blank-out due to continuous injection?
- Do we need a spin-matched IR design??
- Feedback issues, how to maintain the beam emittance