New Ideas for Super B Factories for Flavour Physics

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Linear Collider ideas for a Super B factory

- “An electron-positron linear collider as a B-anti B Meson factory” (Amaldi & Coignet 1986)
- Idea resurrected at Hawaii Super B workshop (Pantaleo Raimondi, April 2005)
- “Super B: a linear high luminosity B factory” (J.Albert et al, hep-physics/0512235)

Benefits from all the Linear Collider R&D that has been going on in the last 20 years.

Looks feasible to get luminosity of 1-2 x 10^{36} at Y(4S)

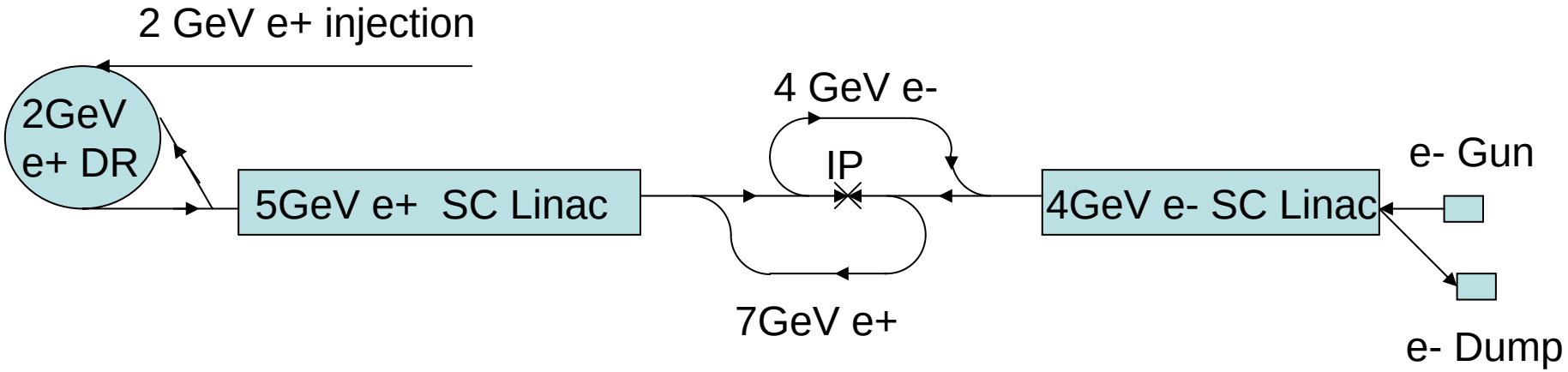
Series of recent workshops

- Hawaii (April 2005)
  - www.phys.hawaii.edu/superb
- Frascati (November 2005, March 2006 and November 2006)
  - www.lnf.infn.it/conference/superbf05
- CERN Flavour in the LHC era (November 2005, February 2006, May 2006 …)
  - mlm.home.cern.ch/mlm/FlavLHC.html
- SLAC (June 2006)
  - www-conf.slac.stanford.edu/superb/Default.html
- KEK (September 2006)

The Basic Ideas

- Use the ILC damping ring design for the e+/e- storage rings
- Use the ILC final focus design to collide very small beams at high luminosity
- Do all this asymmetrically (7x4GeV) on the Y(4S) resonance
- Options include:
  - Bunch compression
  - Linacs for acceleration after the damping rings
  - Crossing angles
  - Crab cavities
  - Travelling waist

First Linear Super B scheme with single pass collisions (Frascati, November 2005)



- Use Superconducting Linacs to recover energy
- Use low energy damping rings to reduce synchrotron radiation
  - Maybe no e^- damping ring
- Use bunch compression and final focus a la ILC
- Polarized beams possible

Damp bunches for ~10ms
Extract and collide after ~1000 turns and then recycle.

Very low backgrounds in detector!

Energy & asymmetry tunable

~1GW Power consumption!

Scaling laws to optimize the single pass IP parameters

- Disruption: $D \approx \frac{N\sigma_z}{(\sigma_x \sigma_y)}$

  Decrease σ_z + decrease N
  Increase spotsize

- Luminosity $L \approx \frac{N^2}{(\sigma_x \sigma_y)}$

  Increase N
  Decrease spotsize

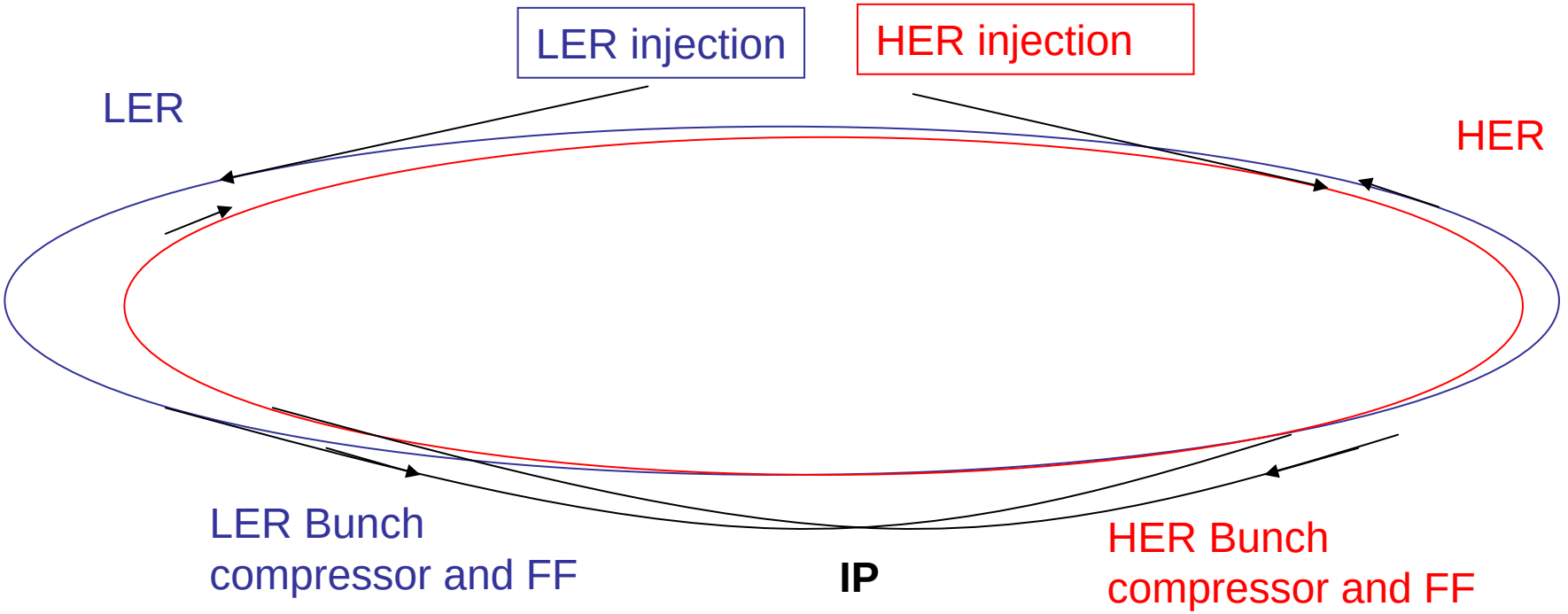
- δE@Y(4S): $\delta_E \approx \frac{N^2}{(\sigma_x^2 \sigma_z)}$

  Increase σ_z + decrease N
  Increase spotsize

Contradicting requests!

Nominal design has 6000 Bunches each with N~10^{11} particles

Linear-B scheme

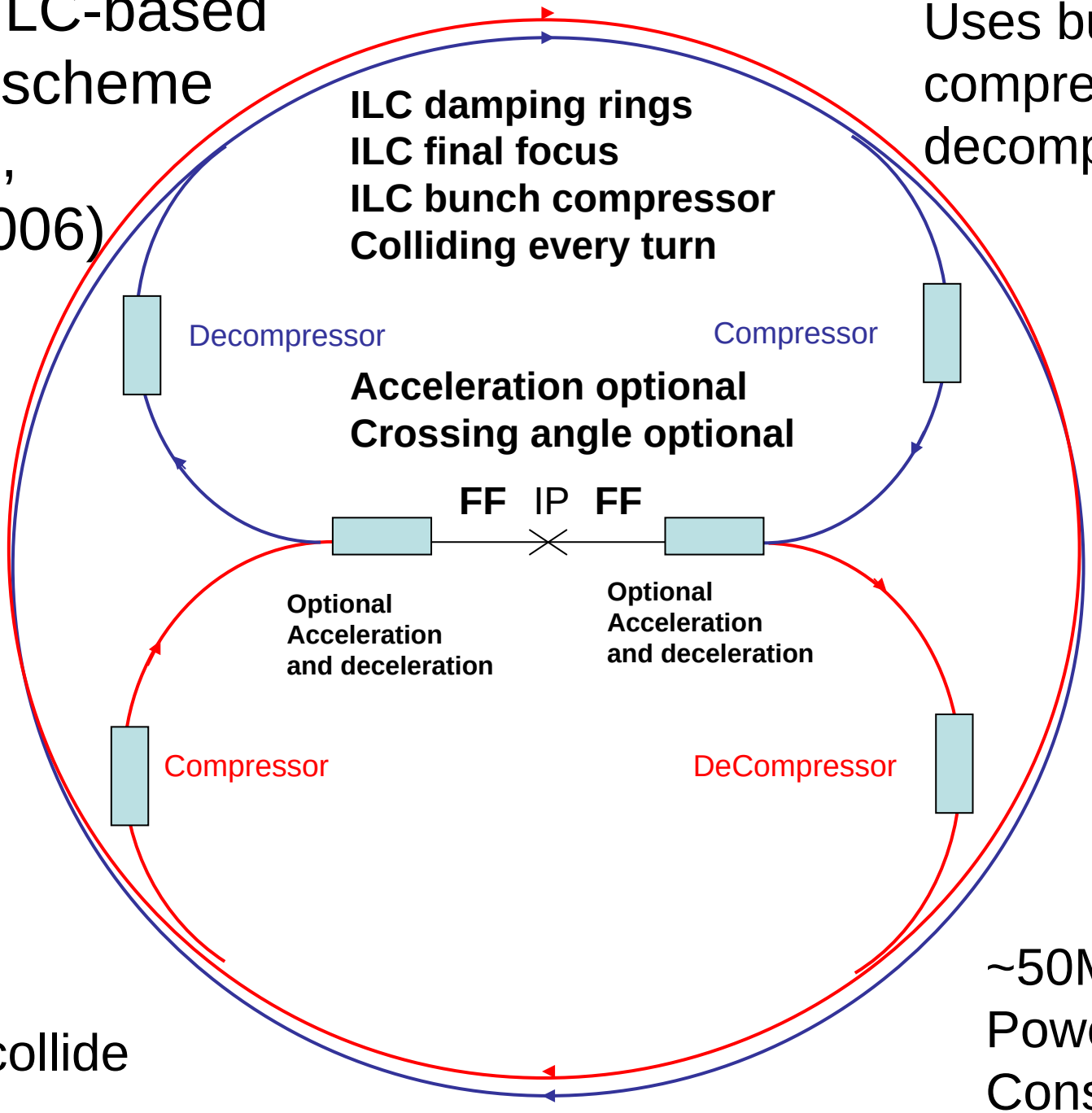


Overall ring length 6Km
Collision frequency about
120Hz*10000bunch_trains=1.200MHz

Bunch train stays in the rings for 8.3msec, then is extracted, compressed and focused.

Second ILC-based Super B scheme (Frascati, March 2006)

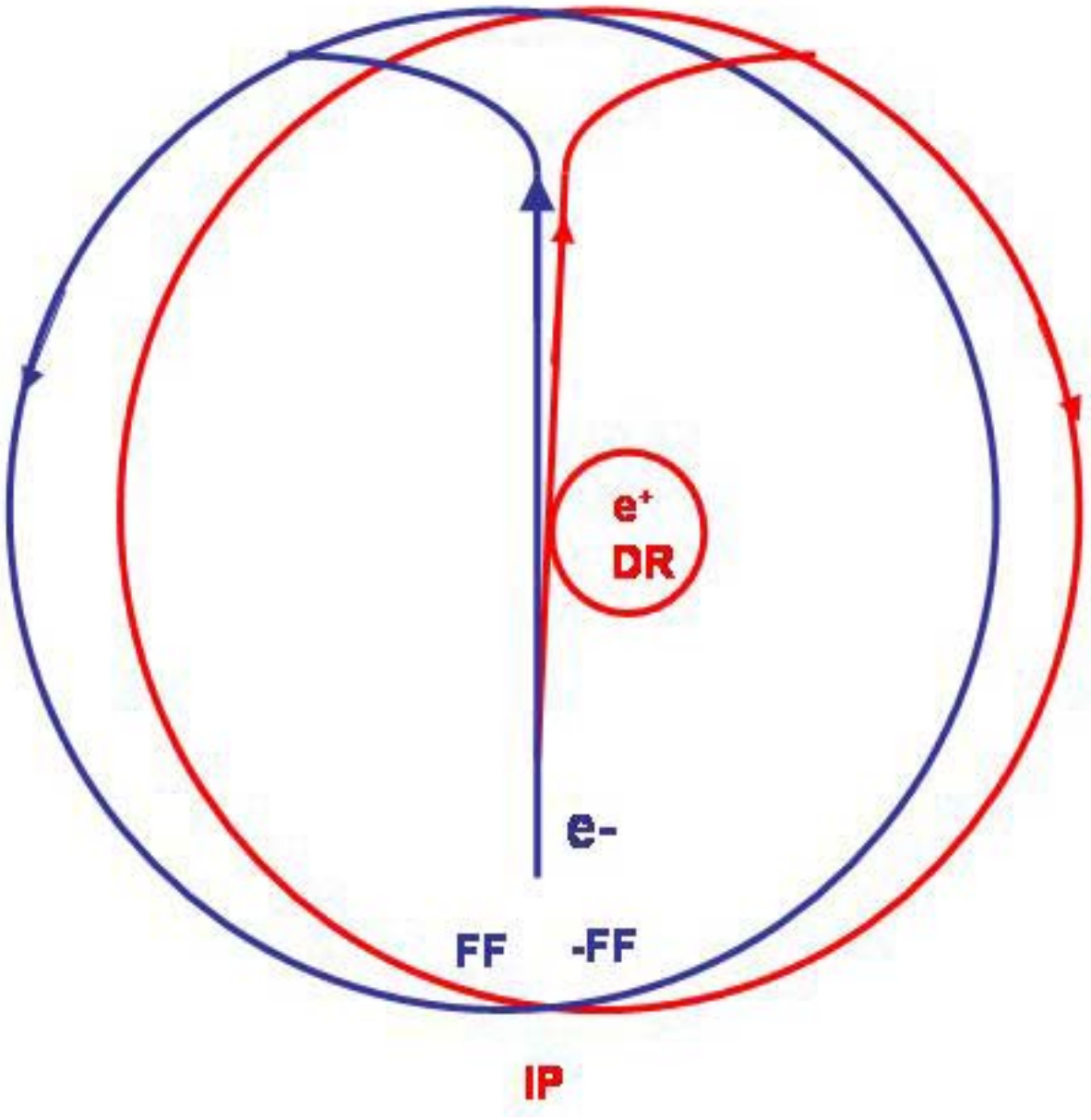
Uses bunch compression/ decompression



Bunches collide every turn

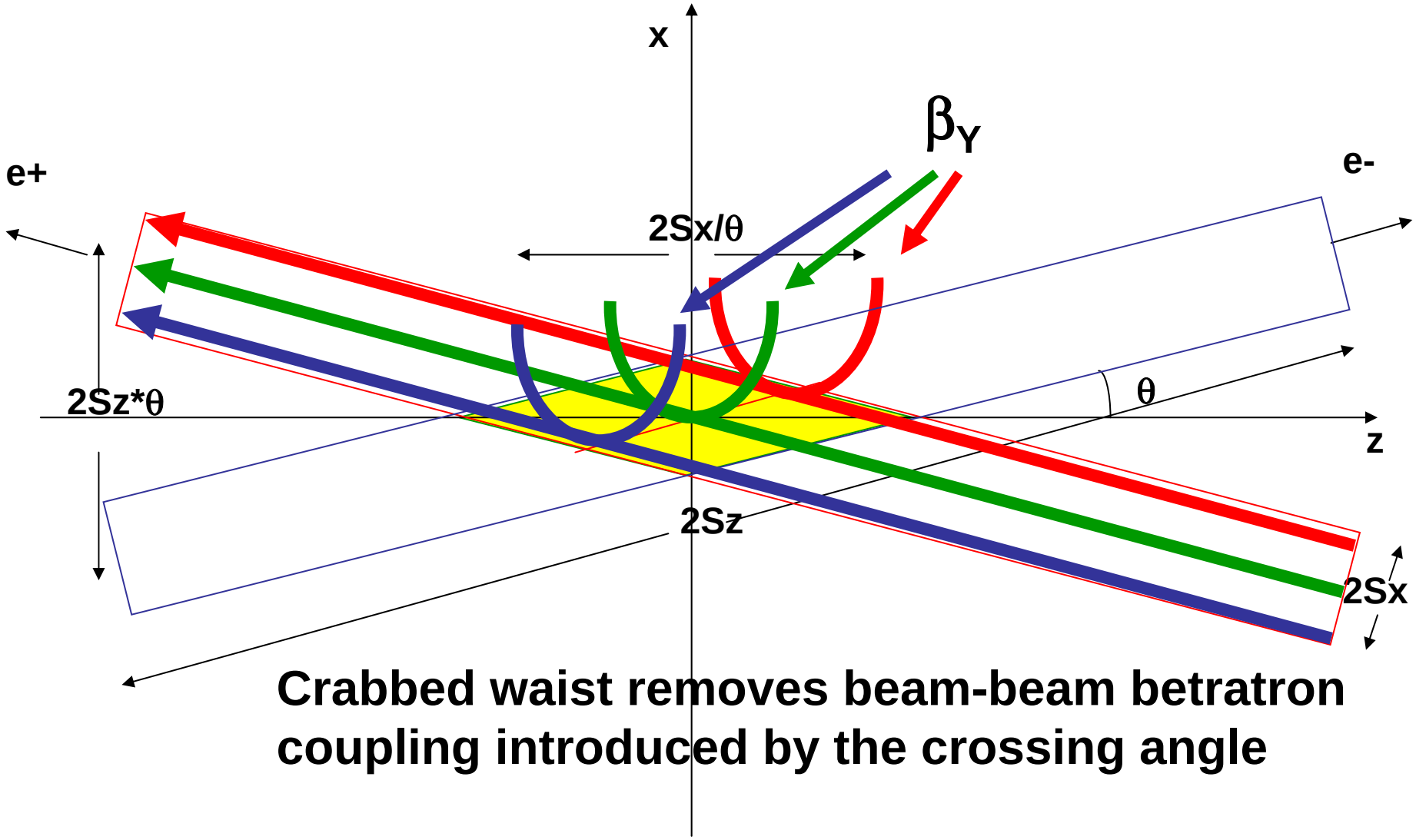
~50MW Power Consumption

Super B with Large Crossing Angle



- **Crossing angle of 2x25 mrad**
- **Only a small longitudinal part of each bunch collides with a small part of the opposing bunch**
- **Small beam-beam disruption**
- **No need for strong damping**

~32MW Power Consumption



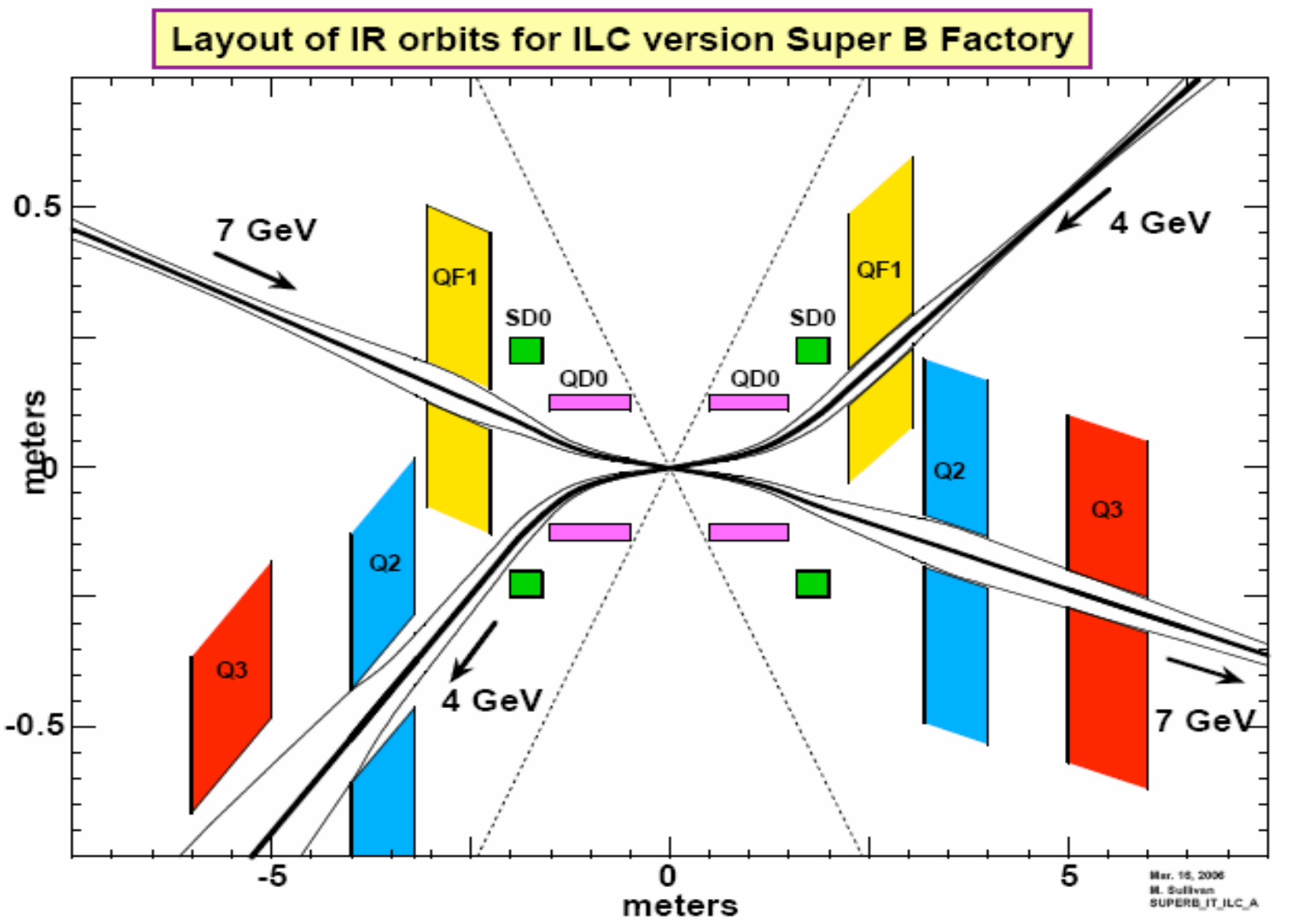
Crabbed waist removes beam-beam betratron coupling introduced by the crossing angle

Vertical waist has to be a function of x:

Z=0 for particles at $-\sigma_x$

Z= σ_x/θ for particles at + σ_x

Realized with a sextupole in phase with the IP in X and at $\pi/2$ in Y



Superconducting Final Focus Quads are shared

There is a 25mrad Crossing Angle

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	0.76	5
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	9

John Seeman, FPCP 2006

Detector requirements

- Beam currents are similar to those in PEP-II
- Luminosity related backgrounds are a worry (Bhabhas)
- Possible to reduce beam pipe radius to 10-15mm and improve vertexing
- Change forward/backward regions to improve acceptance (Particle ID, Calorimetry)

Most of the existing BaBar and Belle detectors could be reused!

Status of SuperB Studies

- Damping Ring design a la ILC is well advanced (Biagini, Wolski)
- Travelling final focus scheme is likely to be tested in 2007 (Raimondi)
- Beam-beam simulations are in progress in several places (Koop, Ohmi…)
- Interaction region design (Sullivan)
- Detector issues (Forti, Hitlin, Roodman…)

SuperB-ILC synergy

- Collaboration on design issues (particularily for the damping rings)
- Possible use of SuperB as a development facility for ILC damping rings
- Decrease in ILC commissioning time
- Increase in Super B and ILC performance during operations through machine development and exchange of information

Not clear if SuperB comes before ILC or at about the same time ...

Comments on Site and Cost

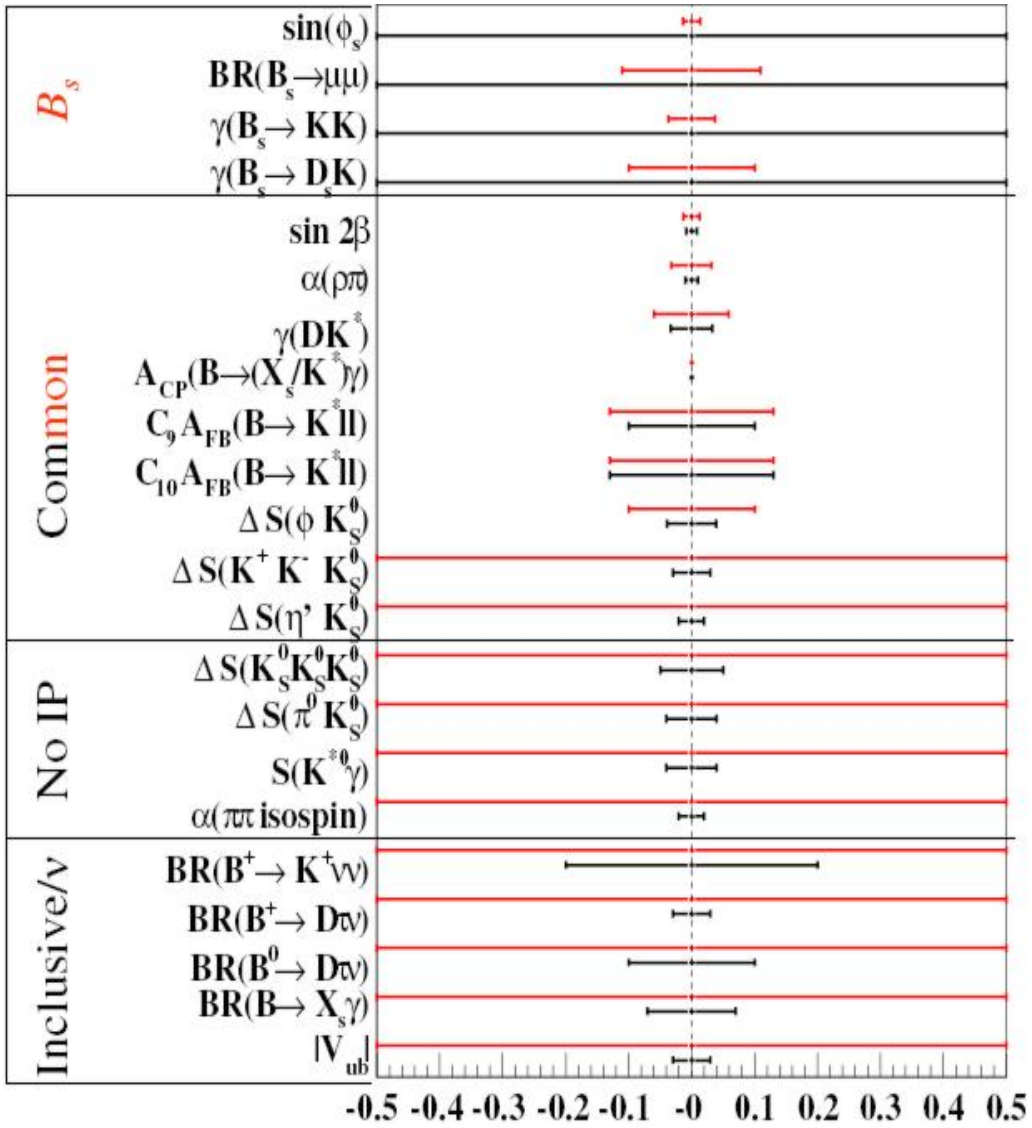
- Needs a ring of 2.2 to 6km circumference
  - Frascati is interested, but would need to dig a new tunnel which is expensive
  - There are several existing tunnels of the right size: KEK, PEP, HERA, Tevatron …some of which may be unused soon…
- For the very small beams at the final focus site stability is likely to be an issue (as it is for the ILC)
- A very preliminary cost estimate for the crossing angle version is $500M (+$200M if a new tunnel is required)

Backup Slides

LHCb 2/fb vs Super B 50/ab

(Jim Libby - LHCb)

- LHCb does CP violation in B_s decays
- Both can do the angles α,β,γ and the rare decay b–>sll
- SuperB does V_{ub} and rare decays with ν,τ and photons



Complementary to each other!

SuperKEKB vs ILCSuperB

- Luminosity 4-8x10^{35} (Oide, CERN)
- Currents 4.1/9.4A
- Higher backgrounds
- Power 73MW
- Technology mostly well understood
- Could be built today

- Luminosity 1-2x10^{36} (Raimondi, CERN)
- Currents 1.6A
- Lower backgrounds
- Power 34MW
- Technology being developed for ILC
- Could be built in a few years time