Report on ILC and SuperB work at LNF

S. Guiducci

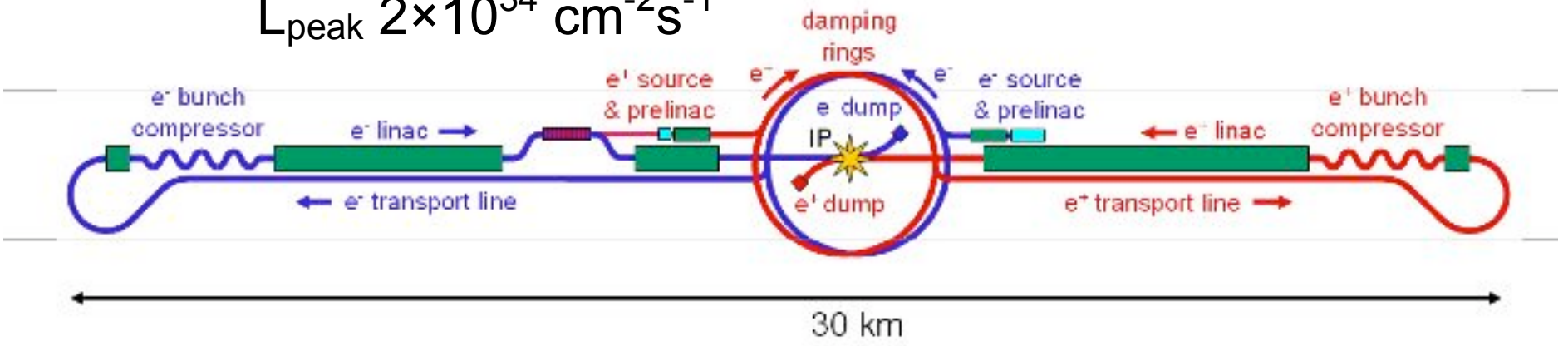
3rd EuCARD Steering Committee Meeting

LNF 4-5 November 2009

ILC Reference Design

E_{CM} 500 GeV
L_{peak} 2×10^{34} $cm^{-2}s^{-1}$

February 2007



- **11 km SC linacs operating at 31.5 MV/m for 500 GeV**
- **Centralized injector**
  - 5 Gev damping rings for e^+ and e^- in a shared tunnel
  - Undulator-based positron source
- **Single IR with 14 mrad crossing angle**
- **Dual tunnel configuration for safety and availability**

Documented in Reference Design Report (RDR)

ILC R&D / Design Plan

Major Technical Design Phase Goals:

- **ILC design evolved for cost / performance optimization**
- **Complete crucial demonstration and risk-mitigating R&D**
- **Updated VALUE estimate and schedule**
- **Project Implementation Plan**

INFN-LNF ILC Activity

- Participation to GDE activity since the beginning: Snowmass Workshop, Aug. 2005
- Responsabilities in the GDE (Damping Ring)
- Important INFN contribution to the Reference Design Report
- European Projects: EUROTeV (FP6)
- **LNF activity is focused on damping rings**

Damping Ring RDR Requirements

- Store 2700 - 5400 bunches per linac pulse
- Reduce the emittances by orders of magnitude (5 for e^+ vertical emittance)
- extremely low emittance values
  - ε_x **= 0.6 nm**
  - ε_y **= 2 pm (minimum ever achieved)**
- Short damping time τ_x = 21 ms
- Wigglers needed: total length ~ 200 m, peak field 1.6 T

Damping Ring Main Challenges

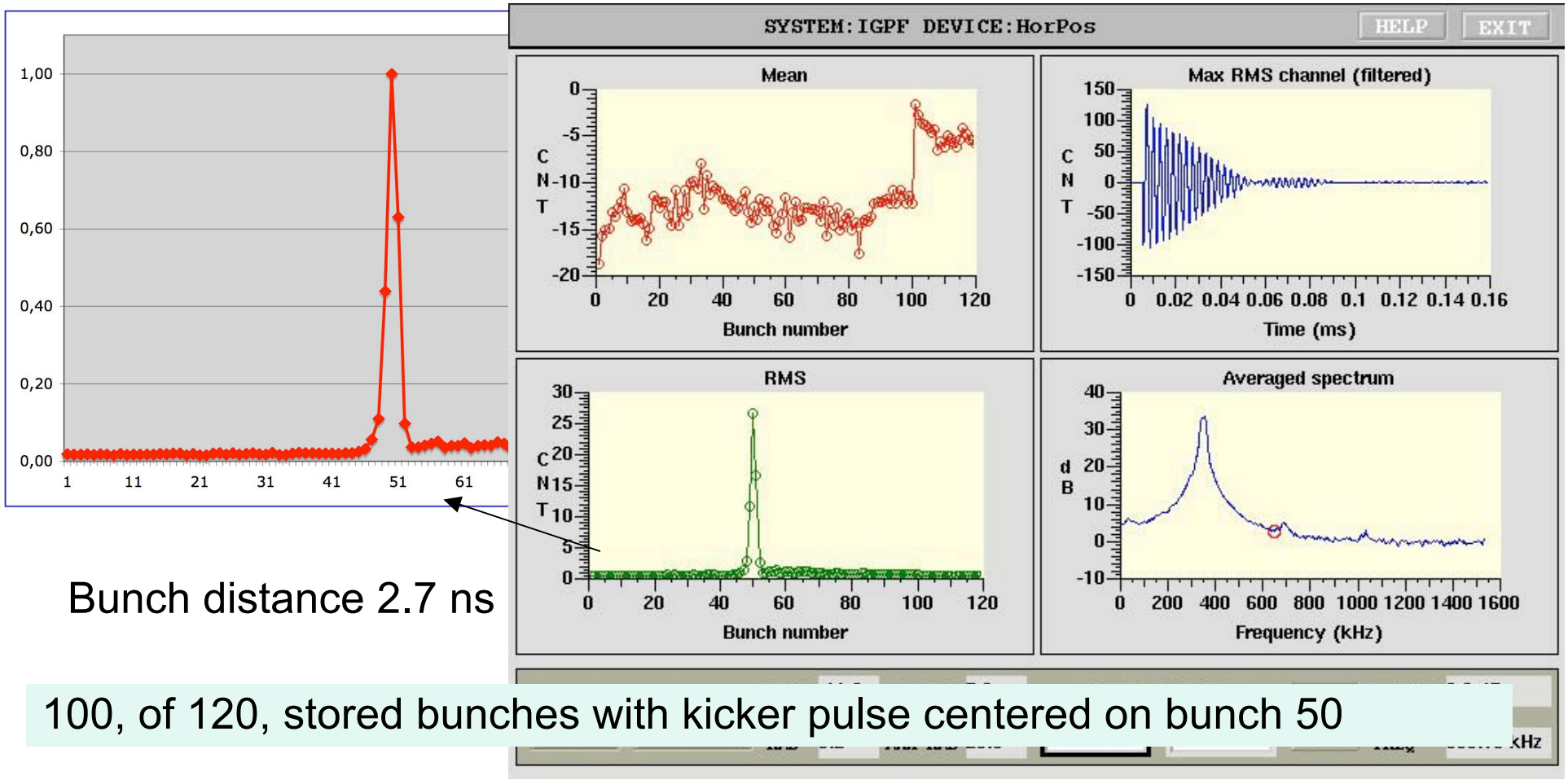
- Ultra low emittance
- Control of electron cloud effect in positron DR
- Control of the fast ion instability in the electron DR
- Developing a very fast rise and fall time kicker for single bunch injection and extraction in the ring.

LNF fast kickers activity

- Injection and extraction kickers are one of the most critical issues since the bunch distance and ring circumference are related to kicker pulse duration
- R&D programs are in progress in laboratories worldwide both on fast pulsers and on stripline electrodes
- Requirements:
  - **total pulse duration: < 6.2 ns for 3 ns bunch distance;**
  - **good uniformity;**
  - **low impedance;**
  - **up to 6 MHz repetition rate**

e^+ beam oscillation with fast kick

Measured by diagnostics of the horizontal digital feedback system.

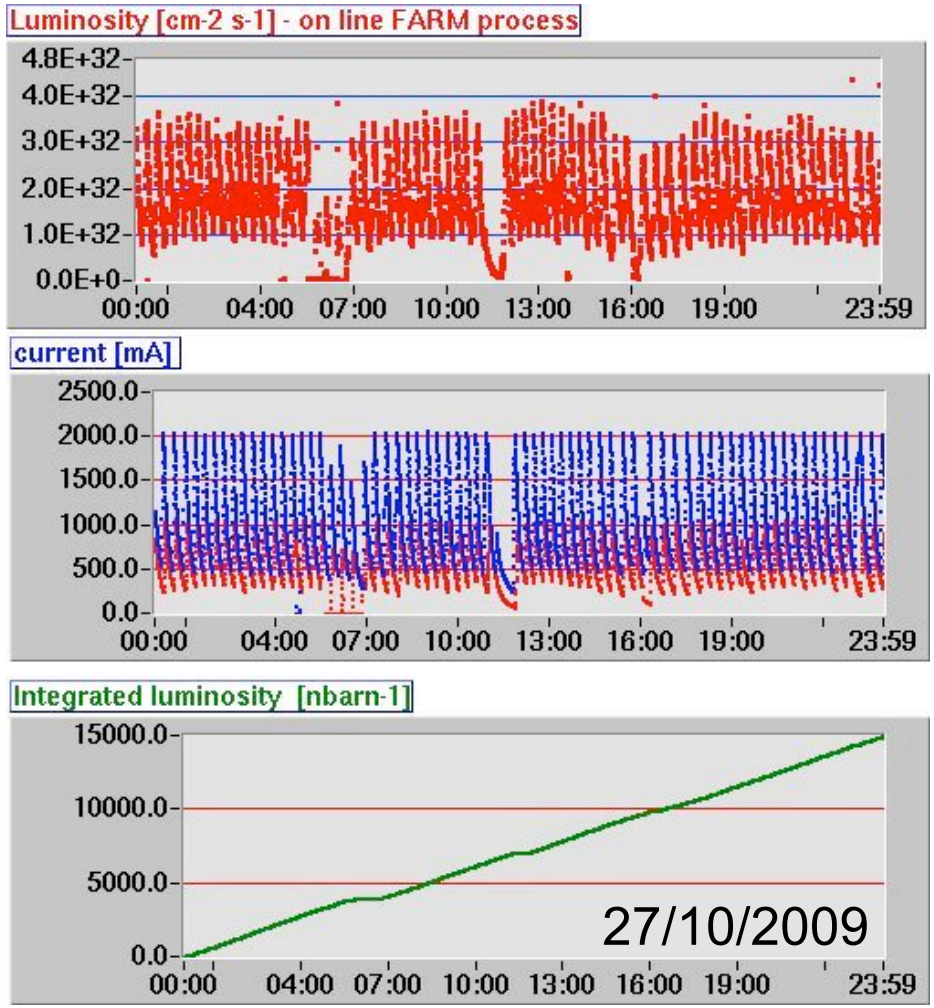


Bunch distance 2.7 ns

100, of 120, stored bunches with kicker pulse centered on bunch 50

Fast Kickers installed in DAFNE rings
Pulse duration < 12 ns

Fast pulsers reliability



L_{peak} 4.0e32 $cm^{-2}s^{-1}$

Integrated luminosity 15 pb^{-1}/day

Record integrated luminosity

Hybrid kickers (2 fast pulsers) are operating on e^- ring since September 17th

3 e^- injections/hour

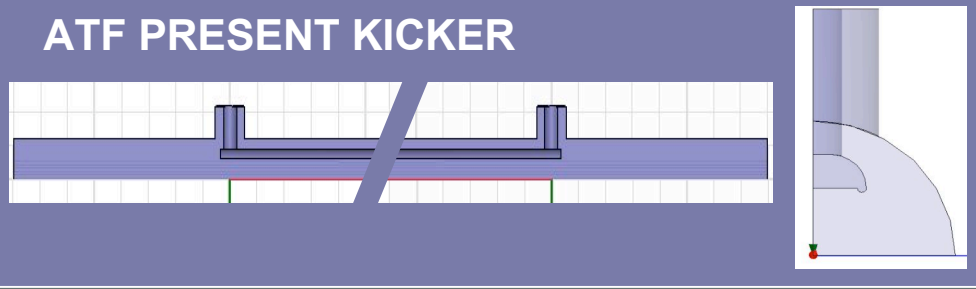
~1000 shots/inj

Total ~ $7 \cdot 10^4$ shots/day

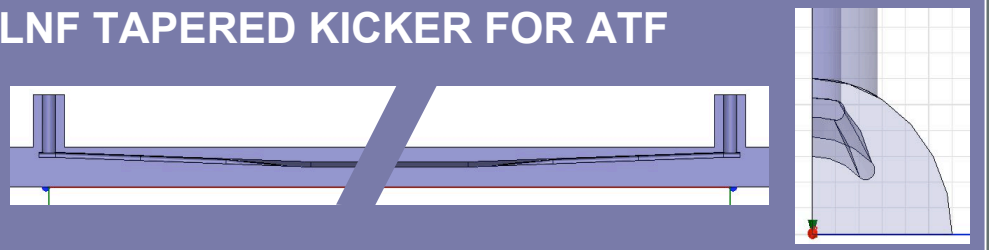
Timing has been setup within 1ns and remains stable

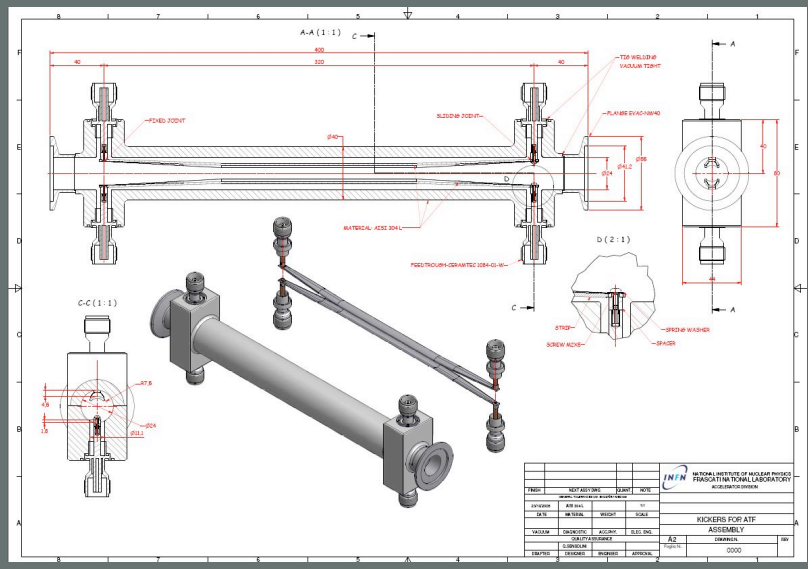
A KICKER with ILC specifications for ATF

ATF PRESENT KICKER



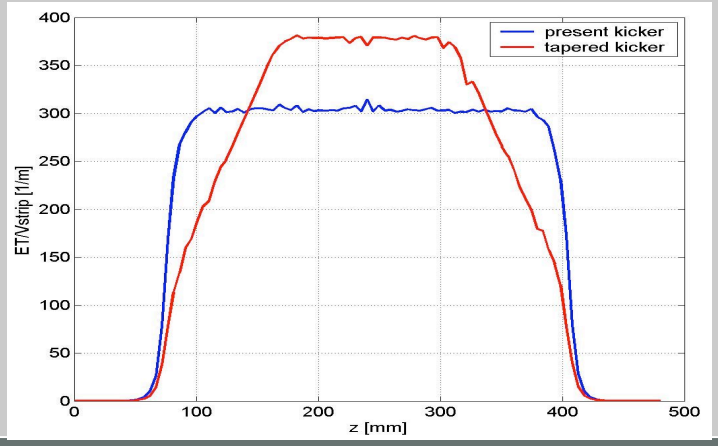
LNF TAPERED KICKER FOR ATF





Both the structures have been simulated with HFSS

Ready for sending to KEK



Deflecting field along the longitudinal structure axis

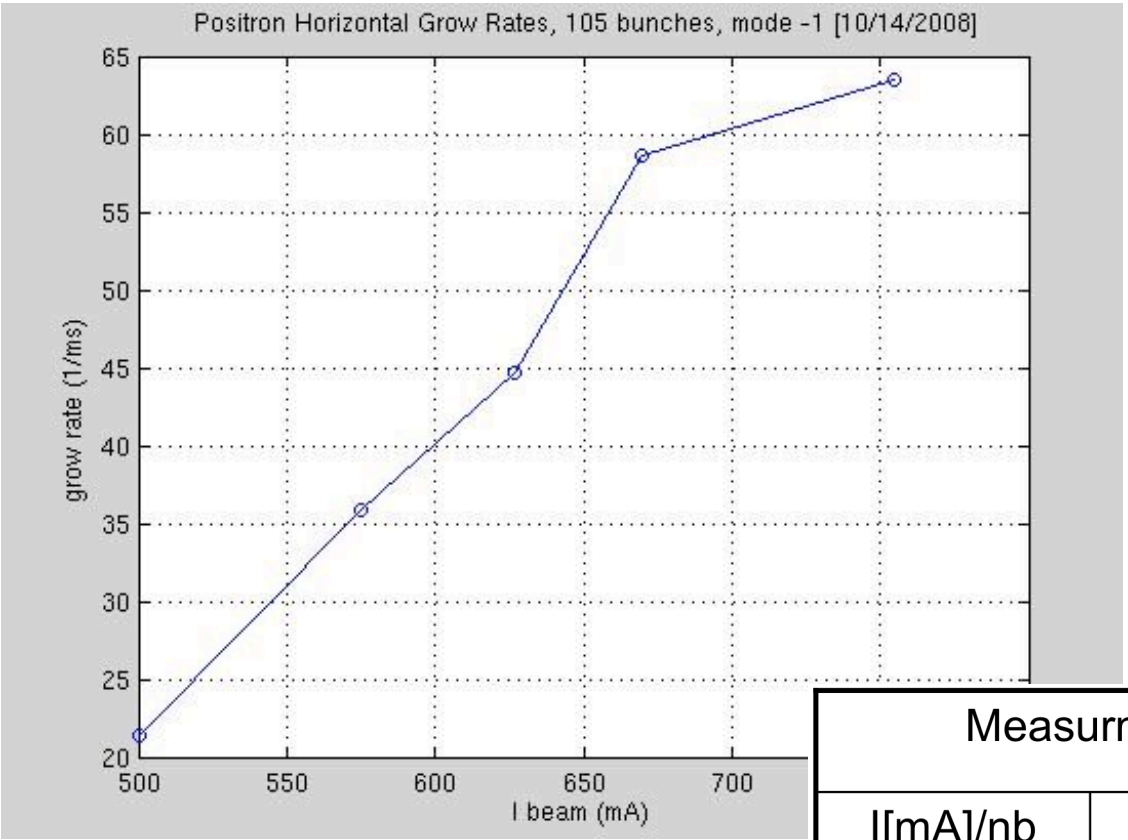
Blue: straight section stripline
Red: tapered stripline

D. Alesini

Electron-cloud Studies at DAΦNE

- Positron current limited at 800 mA by the horizontal instability, stronger than in May
- Measurements versus different optics parameters
- Comparison versus e-cloud simulations
- Simulations are consistent with observations
- A pragmatic solution: **add a second e^+ Transverse Horizontal Feedback**
- **A positron current of 1.1 A has been stored**

Multibunch instability caused by electron cloud at DAFNE
Simulations consistent with main observations.



e^+ beam horizontal grow rates
105 bunches

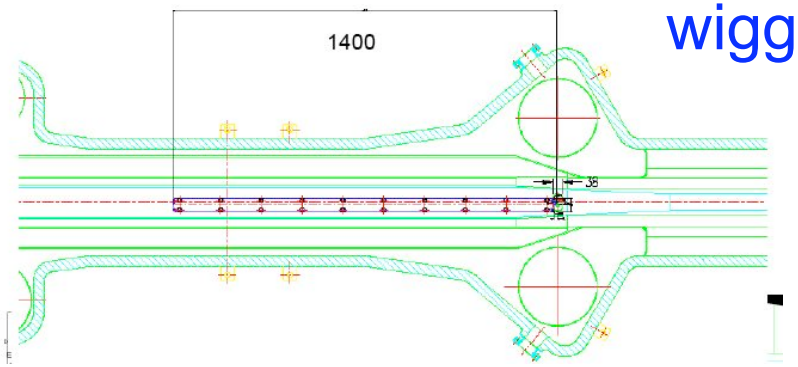
Grow rates are very fast and are linear versus beam current

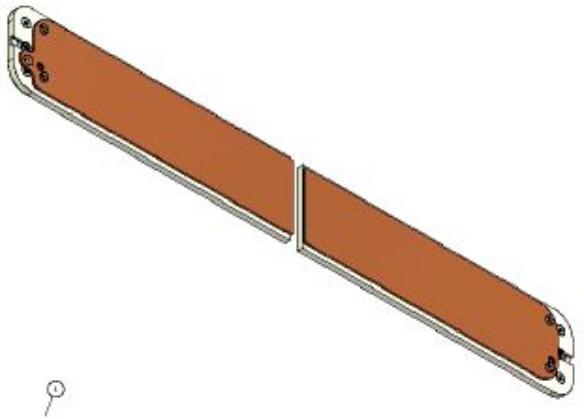
the e+ current was limited at 800mA

Measurment		Simulation	
I[mA]/nb	τ/T_0	I[mA]/nb	τ/T_0
1000/105	73	1200/120	100
750/105	56	900/120	95
500/105	100	600/120	130

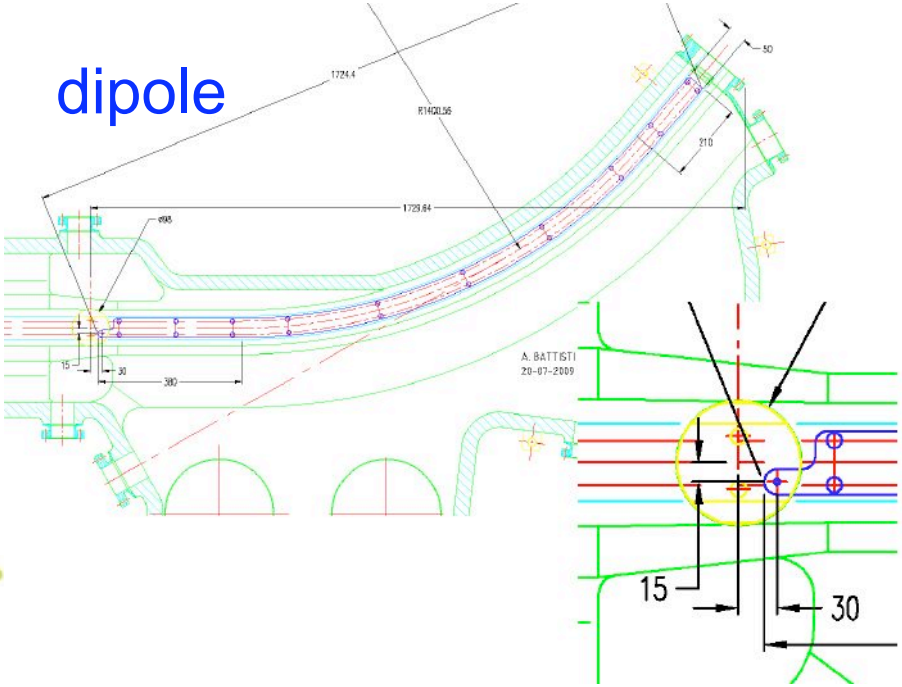
Clearing Electrodes to reduce the electron cloud will be installed in the DAFNE dipoles and wigglers

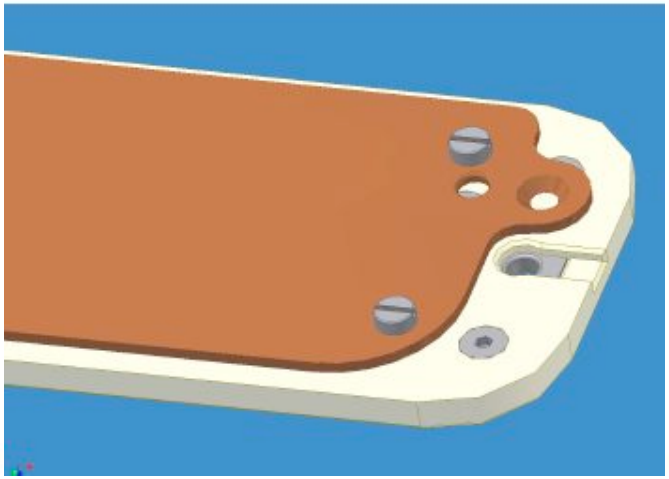
wiggler



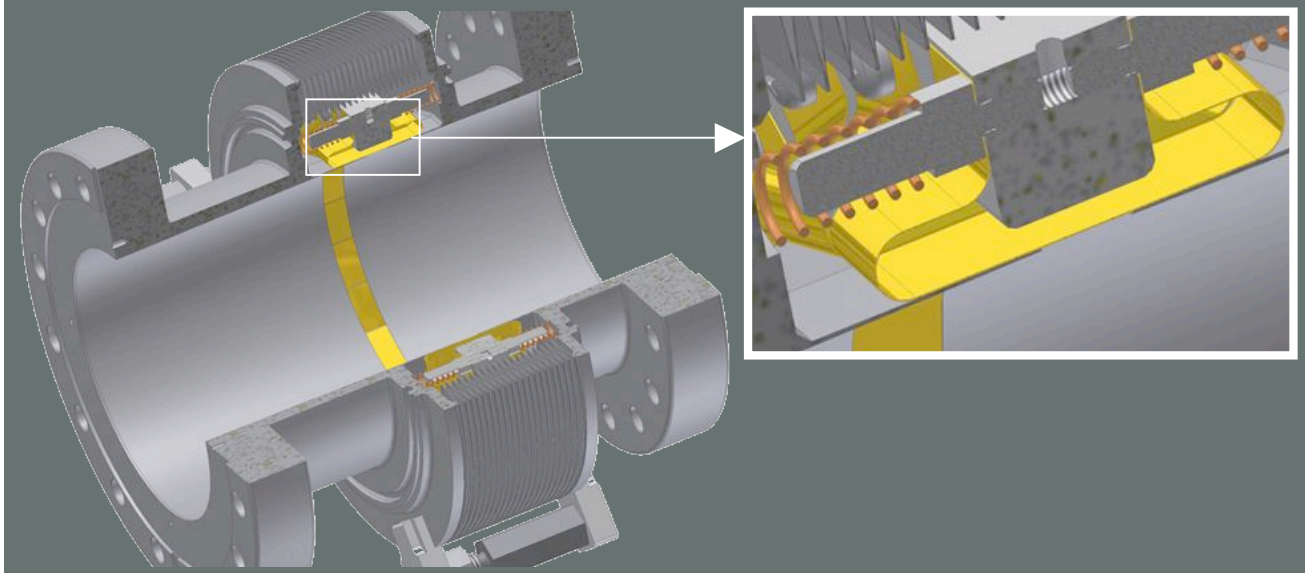


dipole



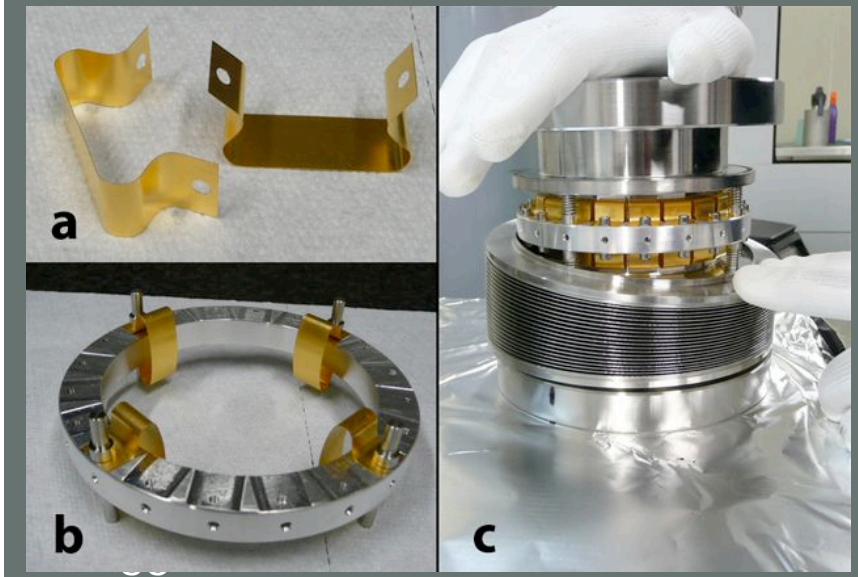


DRAWING OF THE NEW LOW IMPEDANCE DAFNE BELLOWS



The shield is composed of:

- 2 cylindrical pipes, welded at the bellows ends, give continuity to the beam pipes except for the gap between them.
- 20 Ω shaped, gold-coated, Be-Cu strips, shielding this gap.
- A floating thick aluminium ring where the 20 strips are bolted.

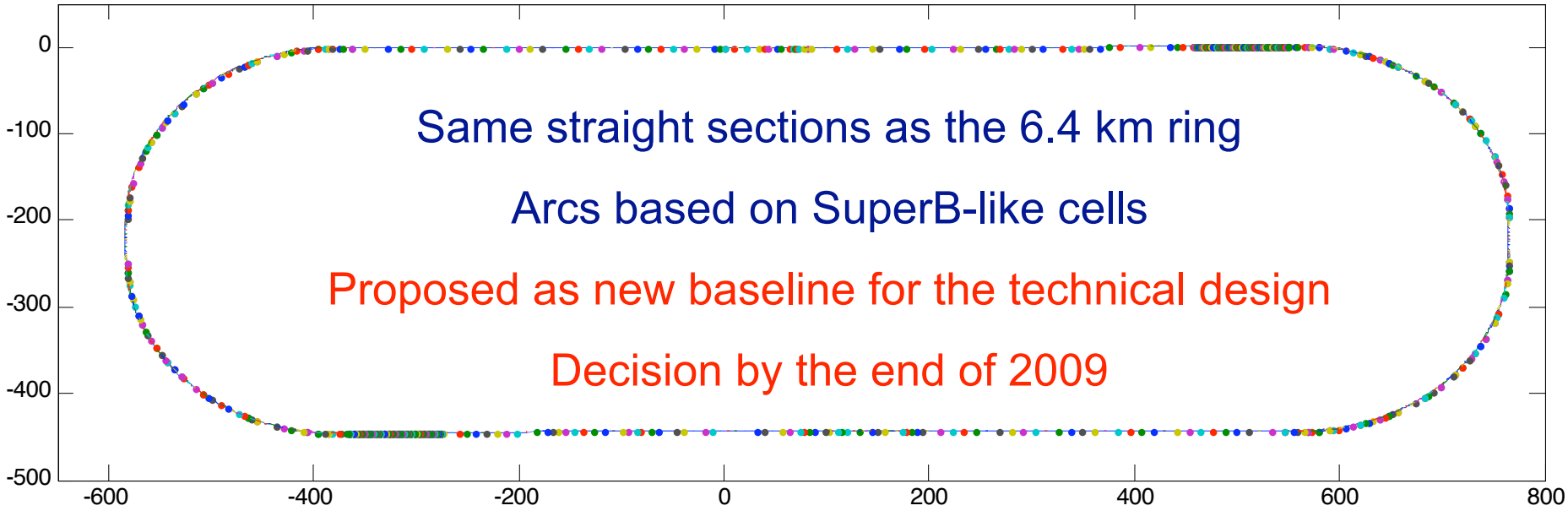


gold coated strip (a),
supporting Al ring (b),
bellows assembly (c).

Will be adopted for the ILC damping ring

New 3Km layout

ILC Damping Ring

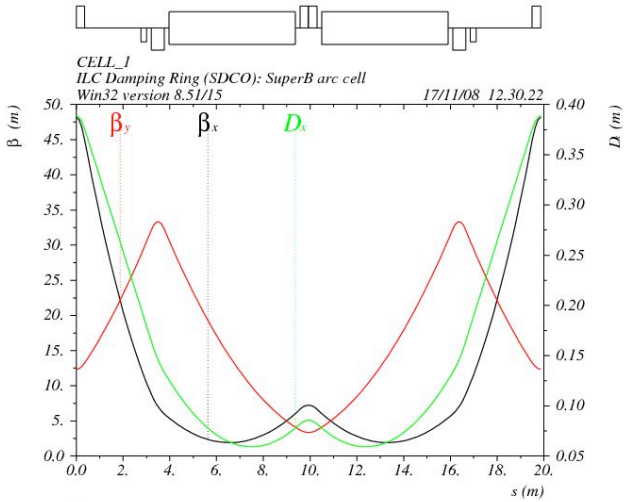


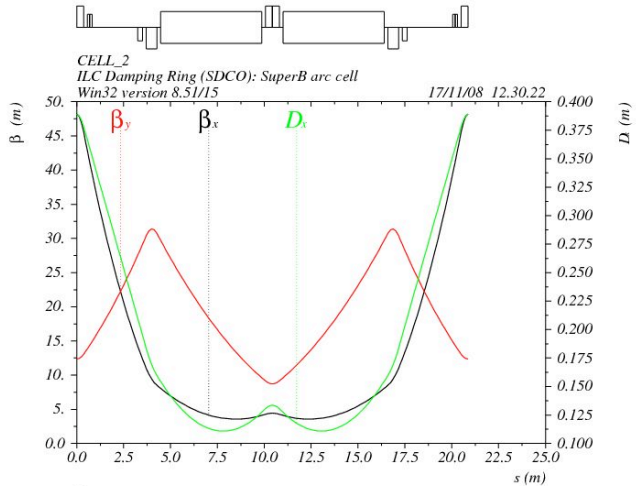
Same straight sections as the 6.4 km ring

Arcs based on SuperB-like cells

Proposed as new baseline for the technical design

Decision by the end of 2009





SuperB-like cells

M. Biagini

The SuperB accelerator

- *SuperB-Factory* is an asymmetric collider that can exploit new promising design approaches:
  - large Piwinski angle scheme will allow for peak luminosity ≥ 10^{36} cm^{-2} s^{-1} well beyond the current state-of-the-art, *without a significant increase in beam currents or shorter bunch lengths*
  - "*crab waist*" sextupoles used for suppression of dangerous resonances
  - low currents with reduced detector and background problems, with affordable operating costs
  - polarized electron beam can produce polarized τ leptons, opening an entirely new realm of exploration in lepton flavor physics

A new idea for L increase (LPA & CW)

P.Raimondi, 2° SuperB Workshop, March 2006

P.Raimondi, D.Shatilov, M.Zobov, physics/0702033

Principle: beams more focused at IP + "large" crossing angle (LPA) + 2 sextupoles/ring to "twist" the beam waist at the IP (CW)

- Ultra-low emittance
- Very small β^* at IP
- Large crossing angle
- "Crab Waist" transformation
- Small collision area
- Lower β^* is possible
- NO parasitic crossings
- NO x-y-betatron resonances

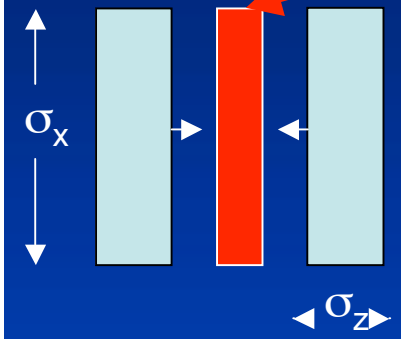
Proved to work at upgraded DAΦNE Φ-Factory 2008-2009

Large crossing angle, small x-size

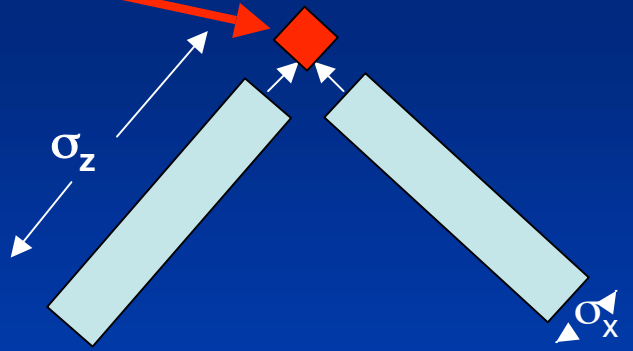
1) Head-on,
Short bunches

Overlap region

2) Large crossing angle,
long bunches



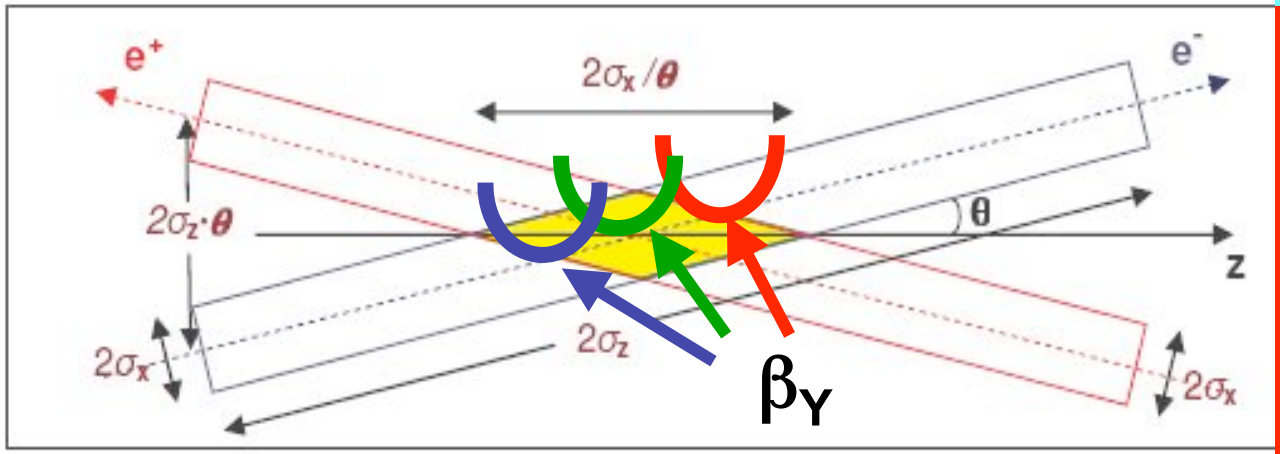
(1) and (2) have same Luminosity, but (2) has longer bunches and smaller σ_x



Vertical waist has to be a function of x:
Z = 0 for particles at $-\sigma_x$ ($-\sigma_x/2\theta$ at low current)
Z = σ_x/θ for particles at + σ_x ($\sigma_x/2\theta$ at low current)

Large Piwinski angle:

$\Phi = tg(\theta)\sigma_z/\sigma_x$

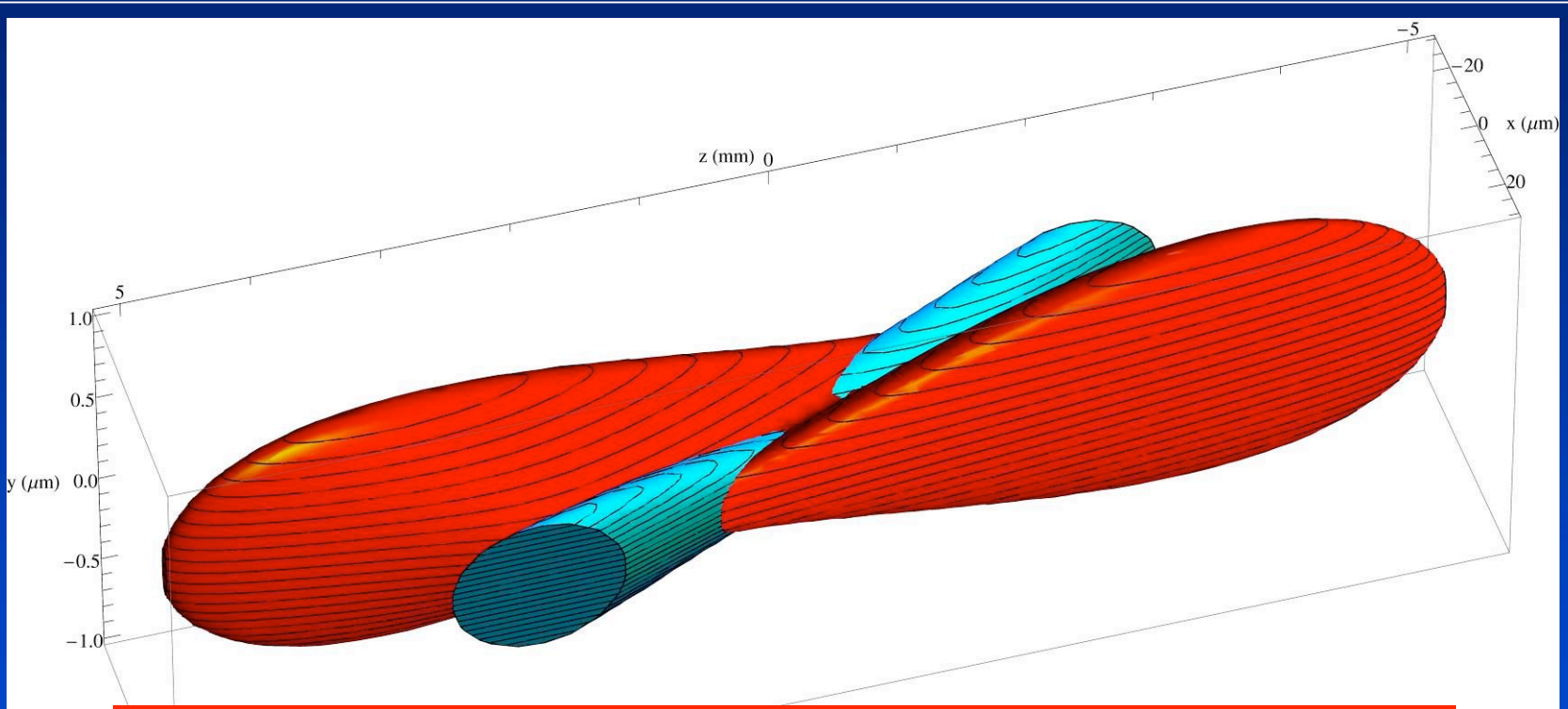


y waist can be moved along z with a sextupole on both sides of IP at proper phase

"Crab Waist"

How it works

Crab sextupoles OFF: Waist line is orthogonal to the axis of other beam



All particles in both beams collide in the minimum β_y region, with a net luminosity gain

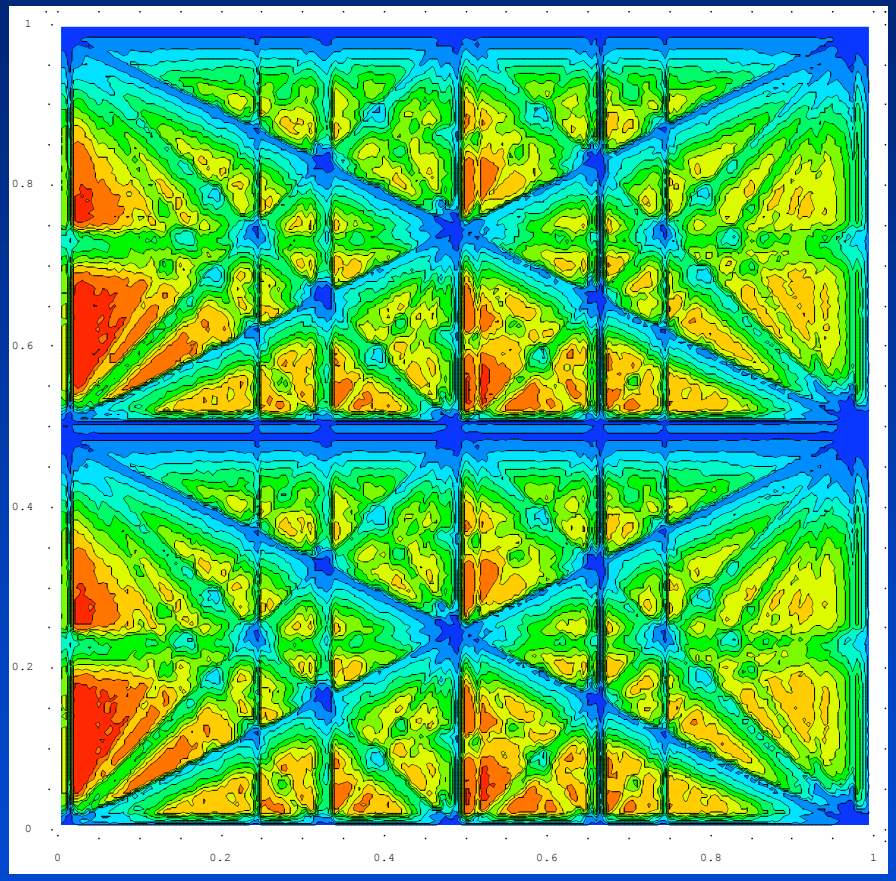
Crab sextupoles ON: Waist moves parallel to the axis of other beam: maximum particle density in the overlap between bunches

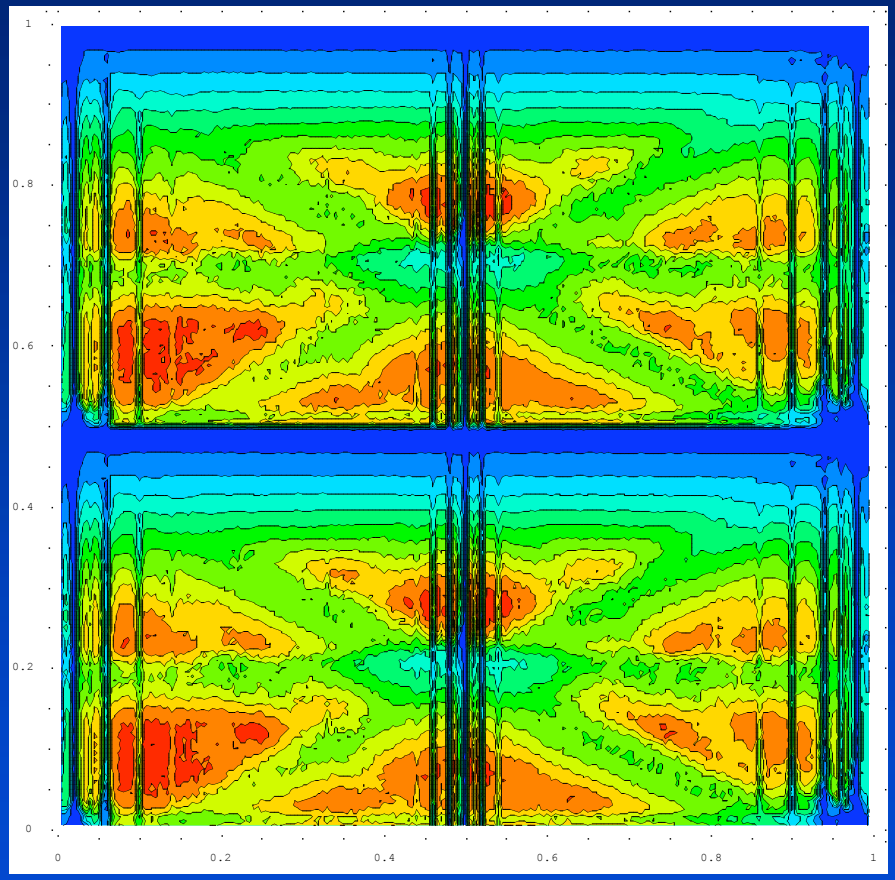
Plots by E. Paoloni

Example of x-y resonance suppression in LPA&CW scheme

D.Shatilov's (BINP)

Much higher luminosity!





Typical case (KEKB, DAΦNE):

1. low Piwinski angle $\Phi < 1$
2. β_y comparable with σ_z

Crab Waist On:

1. large Piwinski angle $\Phi >> 1$
2. β_y comparable with σ_x/θ

SuperB builds on the successes of past accelerators

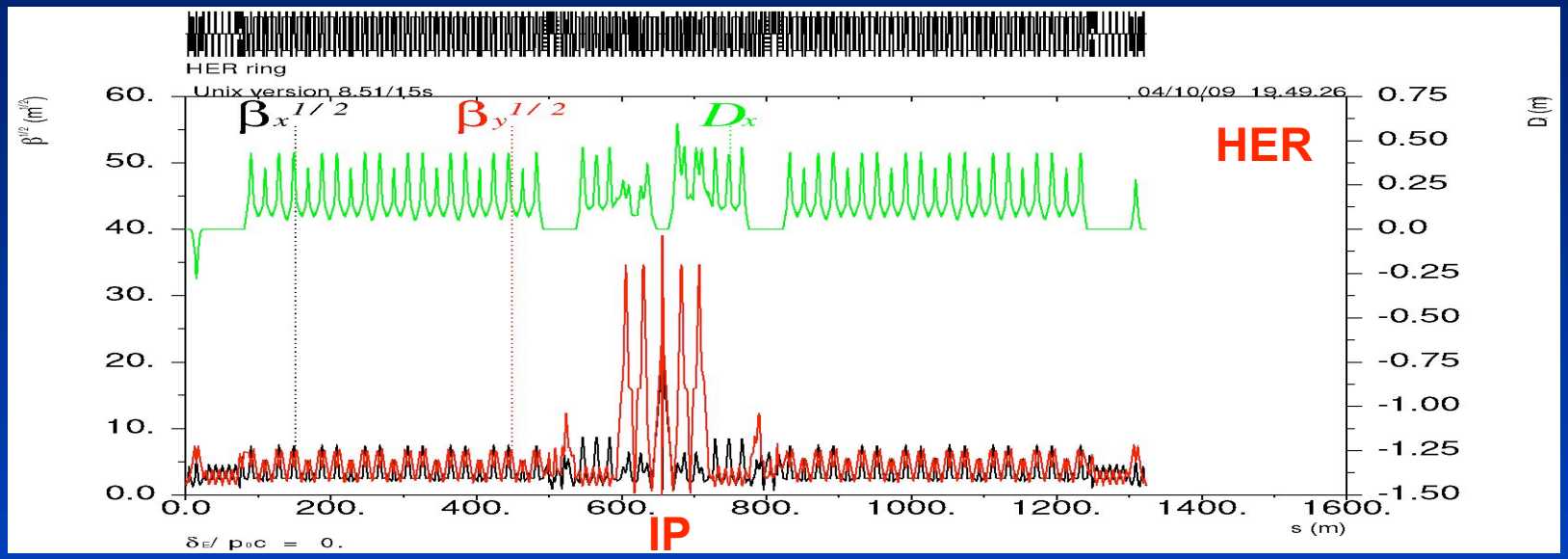
- PEP-II LER stored beam current: 3.2 A in 1722 bunches (4 nsec) @ 3.1 GeV and 23 nm, with little Electron Cloud Instability effect on Luminosity
- Low emittance lattices designed for ILC damping rings, PETRA-3, NSLC-II, and PEP-X (few nm horizontal x few pm vertical)
- Very low emittance achieved in ATF, Diamond, SLS
- Successful crab waist luminosity tests at DAΦNE
- Spin manipulation tests in Novosibirsk
- Efficient spin generation with a high current gun and spin transport to the Final Focus at the SLC
- Successful 2 beams, asymmetric Interaction Regions built by KEKB and PEP-II
- Successful continuous injection with the detector taking data (KEKB and PEP-II)

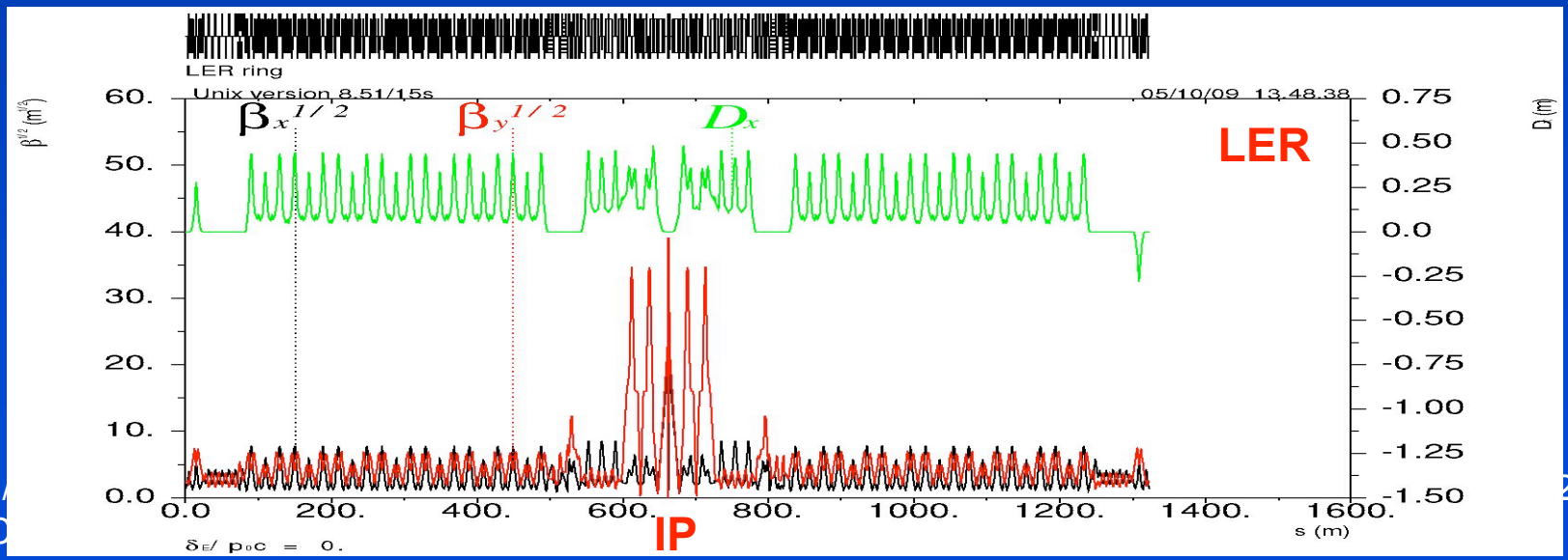
SuperB main features

- Goal: maximize luminosity while keeping wall power low

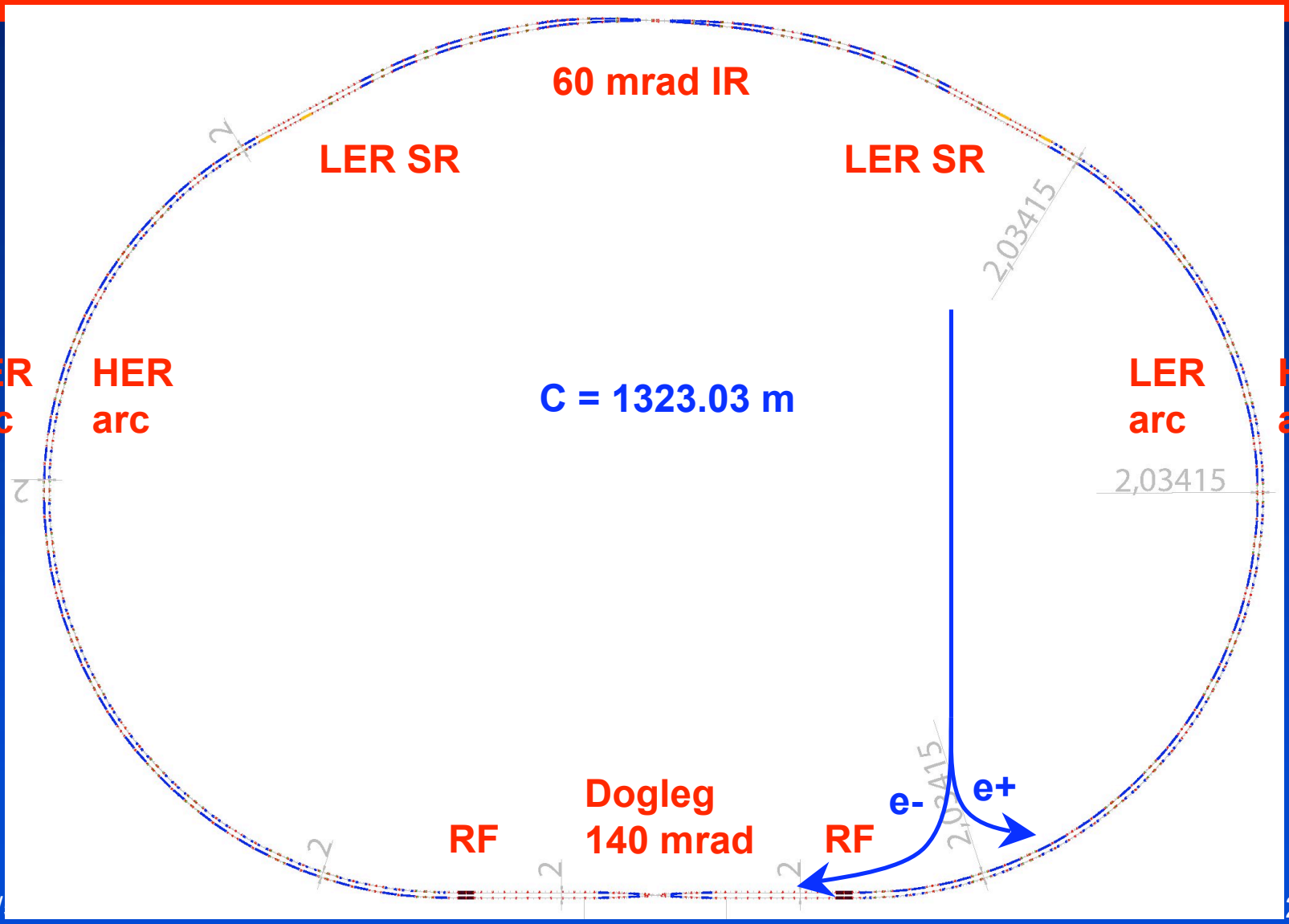
- 2 rings (~4 GeV and ~7 GeV) with flexible design
- Ultra low emittance optics: 7x4 pm vertical emittance
- Beam currents: comparable to present Factories
- LPA & CW scheme used to maximize luminosity and minimize beam size blow-up
- No “emittance” wigglers used (save power)
- Design based on recycling PEP-II hardware (save costs)
- Longitudinal polarization for electrons in the LER (unique feature)
- Possibility to push the cm energy down to the τ-charm threshold with a luminosity of 10^{35} cm^{-2} s^{-1}

Rings Optical Functions



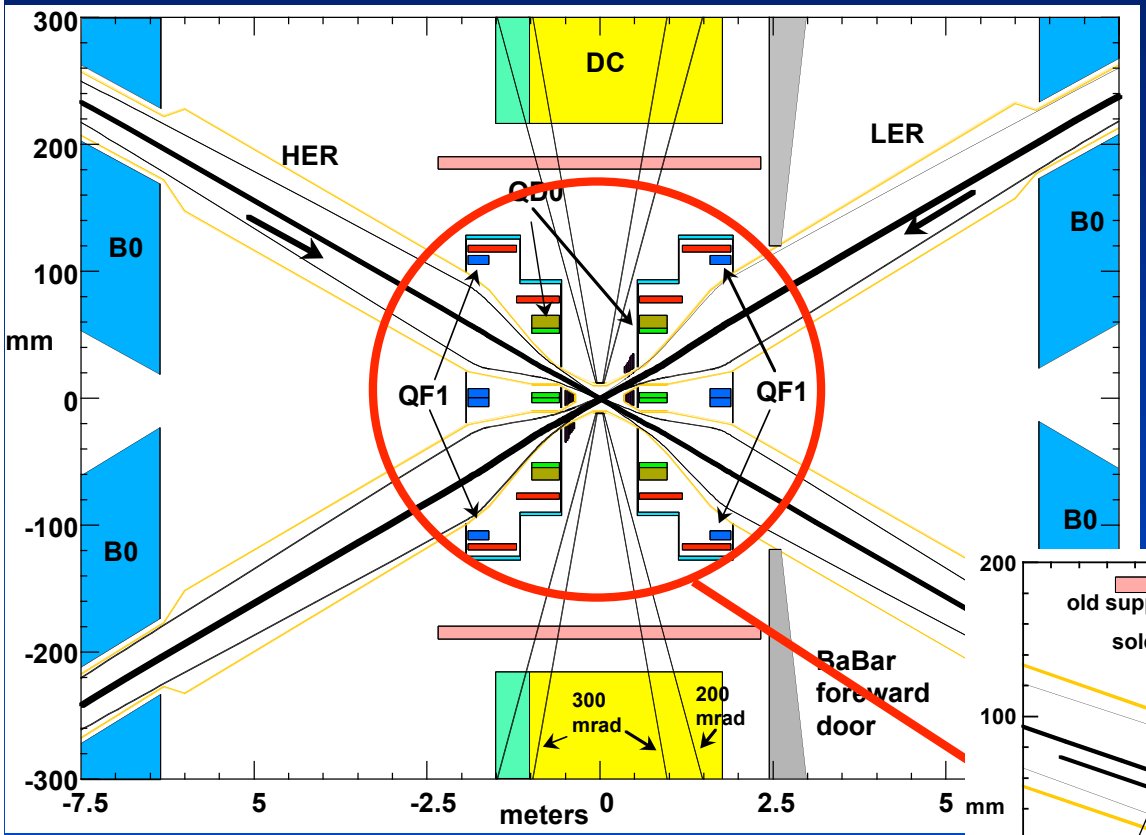


Rings layout

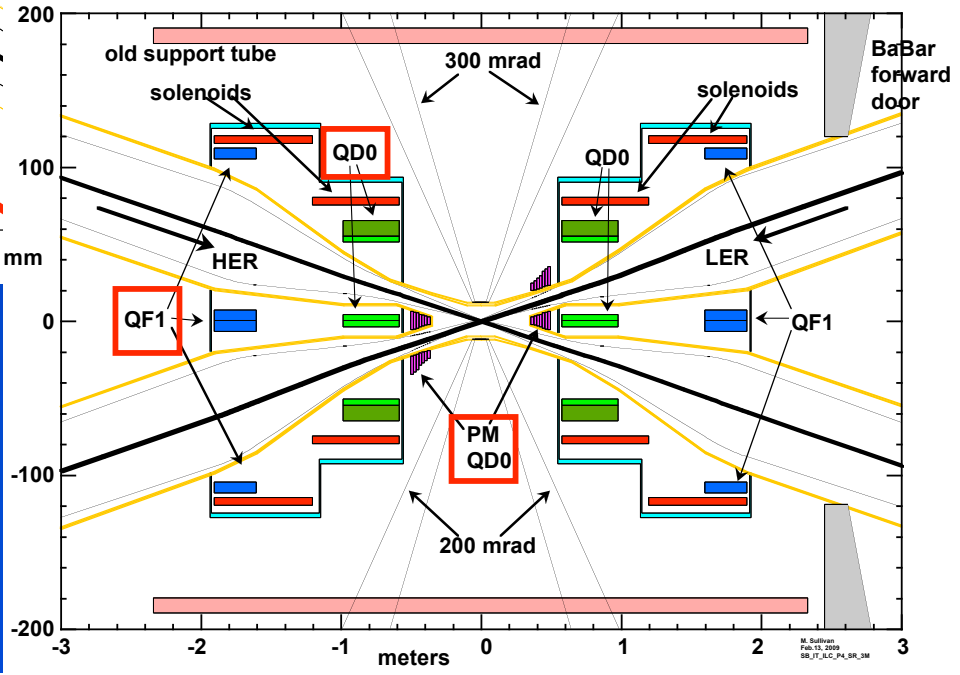


IR design

M. Sullivan (SLAC)



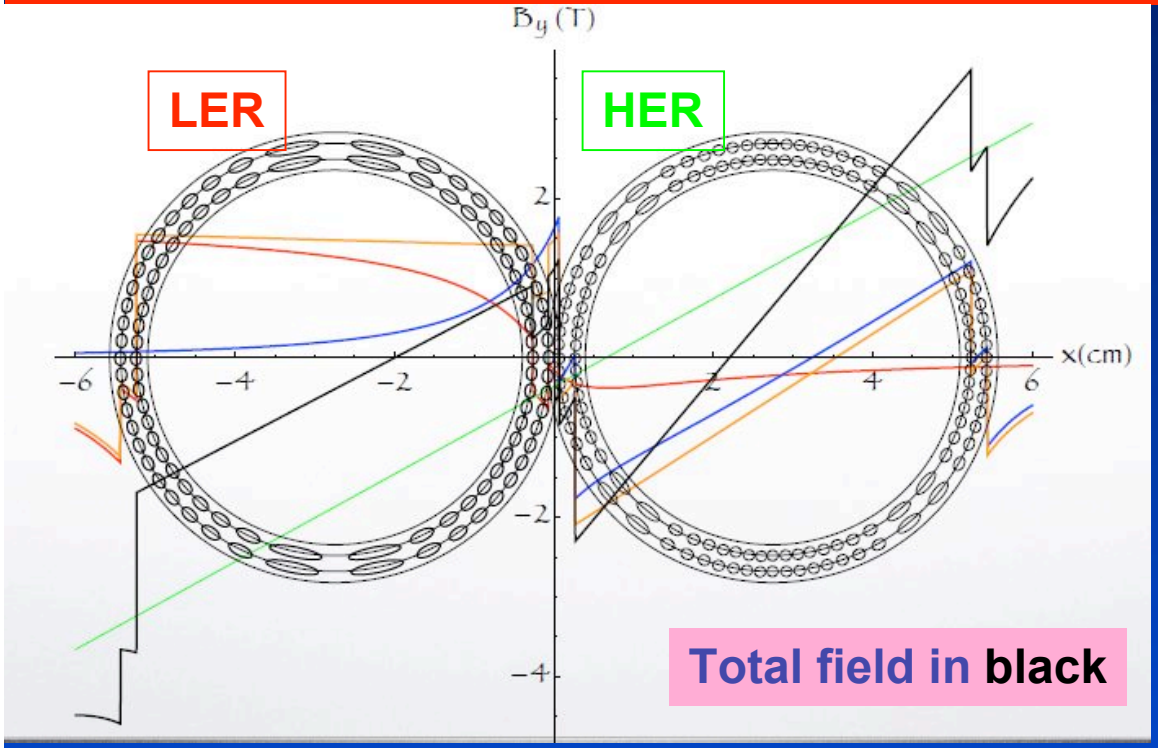
With a larger crossing angle (60 mrad total) beams are far enough apart at 0.35 m from the IP to have enough space to install a PM, in front of QD0, for LER which needs more focusing

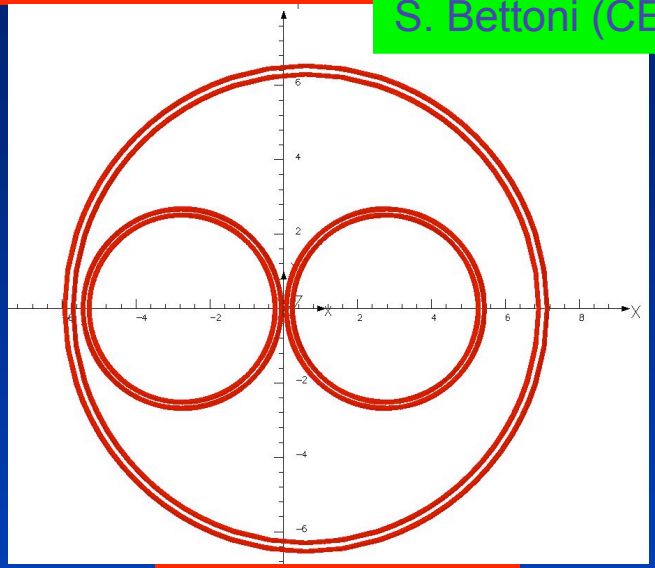


- QD0 design of new conception
- QD0 & QF1 are SC and share same cryostat
- Compensating solenoids are included

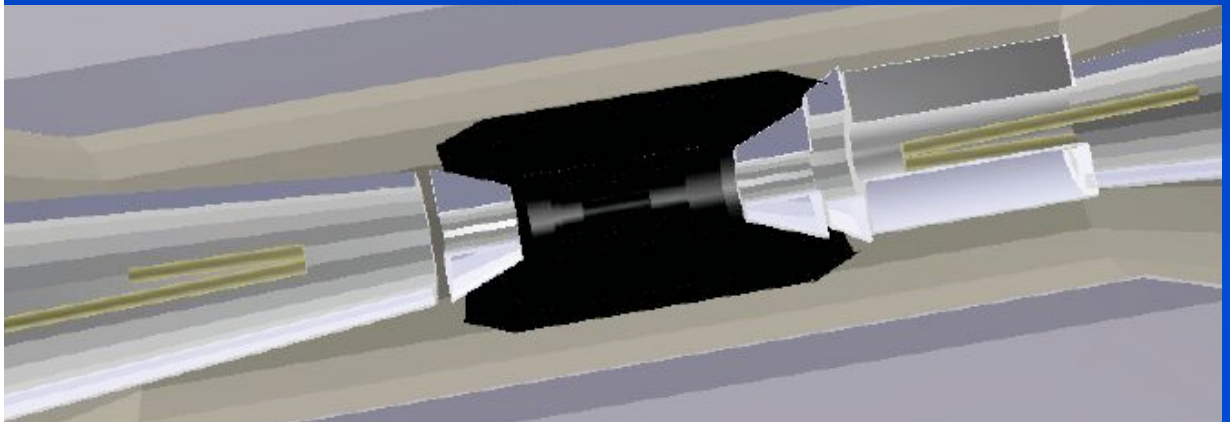
R&D on SC Quadrupoles at the IP

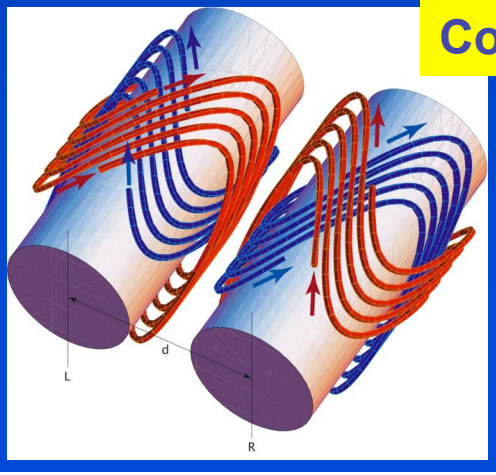
E. Paoloni (Pisa),
S. Bettoni (CERN)



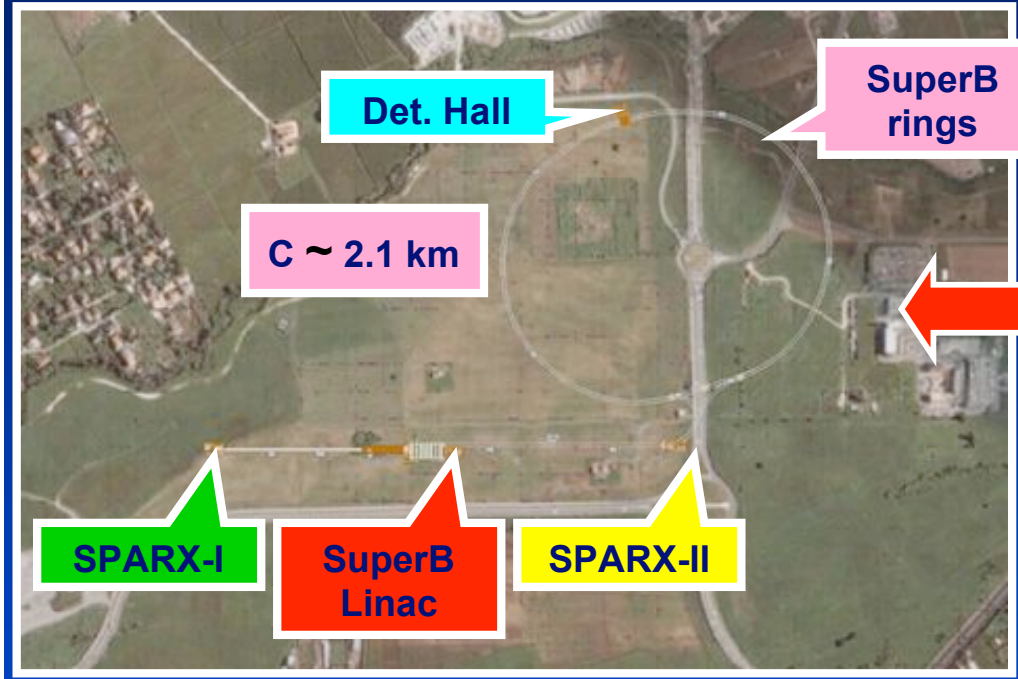


Latest design: Q & qq





SuperB site choices



University of Tor Vergata Campus:
- green field

Frascati National Laboratories:
- existing infrastructures