LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

SuperB project status & Dafne tests

A.Variola on behalf of *SuperB* Team

Posipol 09

Lyon, France, June 2009

SuperB Collaboration Team

CDR

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TDR

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F. Touze, A. Variola (CNRS, France)
A. Chance, O. Napoly (CEA Saclay, France)
F. Bosi, E. Paoloni (Pisa University, Italy)

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The SuperB accelerator for flavour physics

- *SuperB* exploits new design approaches:
  - large Piwinski angle (LPA) scheme allowing for peak luminosity $\geq 10^{36}$ **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 affordable operating costs and fewer detector backgrounds
  - polarized electron (positrons?) beam producing polarized τ leptons, opening an entirely new realm of exploration in lepton flavor physics
- A CDR was published in 2007, a TDR ready by end 2010
- *SuperB* project scrutinized by International Review Committee (chair J. Dainton, 9 members), accelerator by a MiniMachine Advisory Committee (chair J. Dorfan, 10 members)

Both have endorsed the project for Physics program and accelerator feasibility

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A new idea for collisions (LPA & CW)

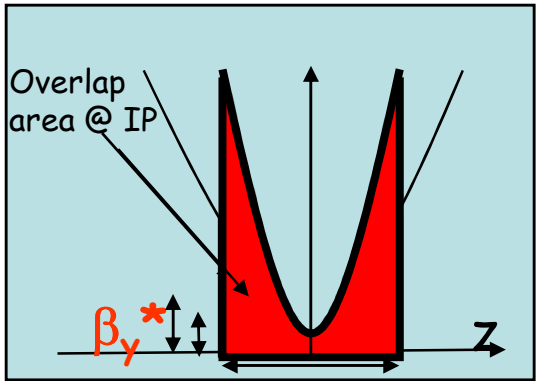
P.Raimondi, 2° SuperB Workshop, March 2006

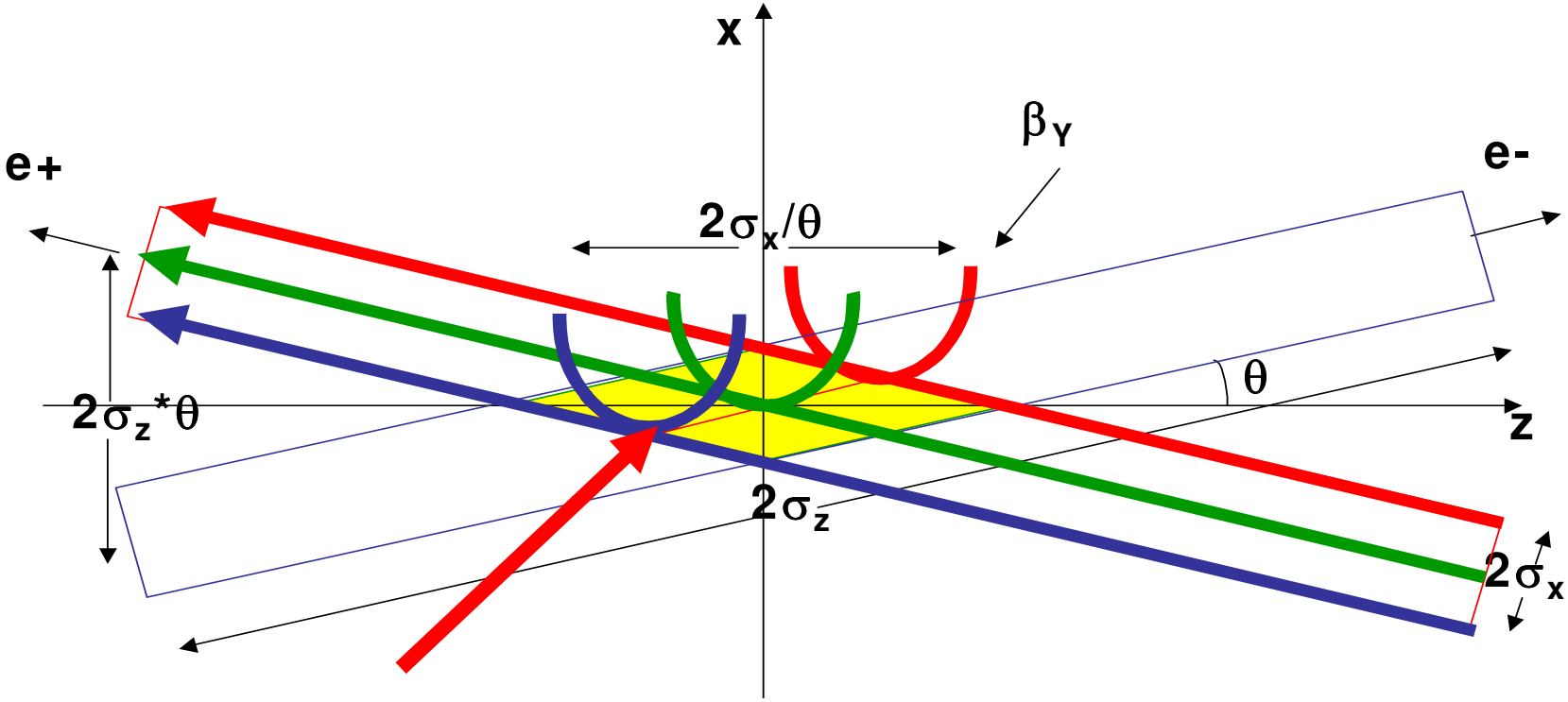
Principle: thigher focus on beams at IP + "large" crossing angle (LPA) + a couple of sextupoles/ring to "twist" the beam waist at the IP (CW)

- Large crossing angle
- "Crab Waist" transformation

- Small collision area
- Ultra-low emittance
- Very small β^* at IP
- Lower β^* is possible
- NO parasitic crossings
- NO x-y-betatron resonances

- $\beta^*_y \sim \sigma_z$ to avoid hourglass effect
- Long-range beam-beam interactions causing τ^+ τ^- reduction limiting I^+_{MAX} I^-_{MAX} and consequently L_{peak} and $L_\int$
- Avoid transverse size enlargements due to the beam-beam interaction (Disruption)





Small collision area: σ_x/θ

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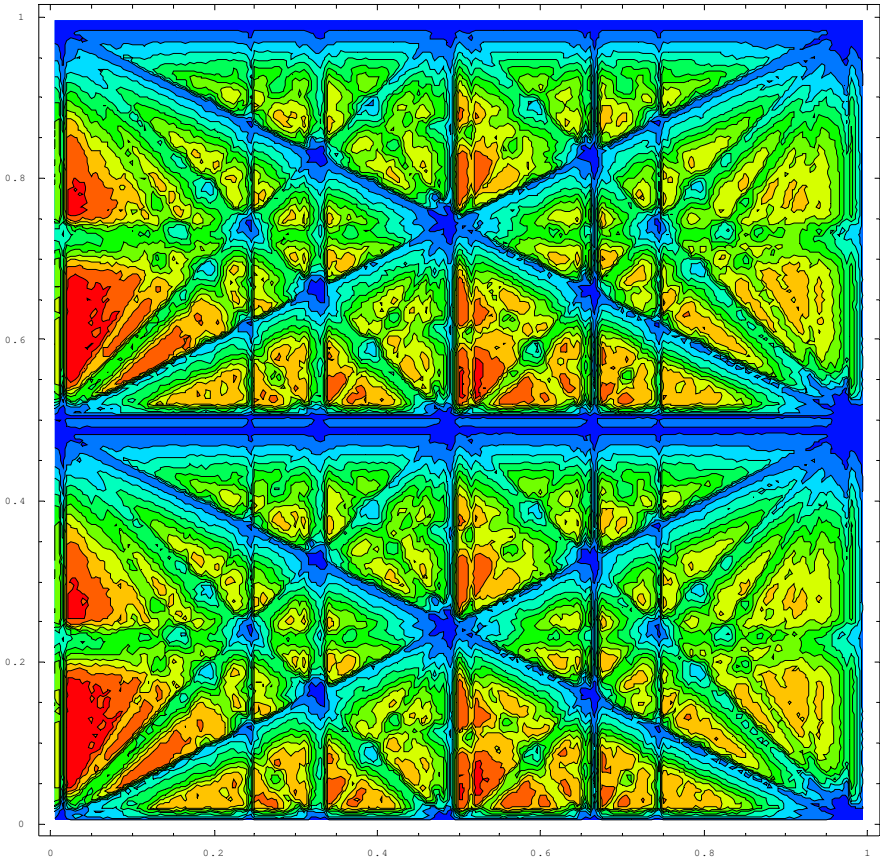
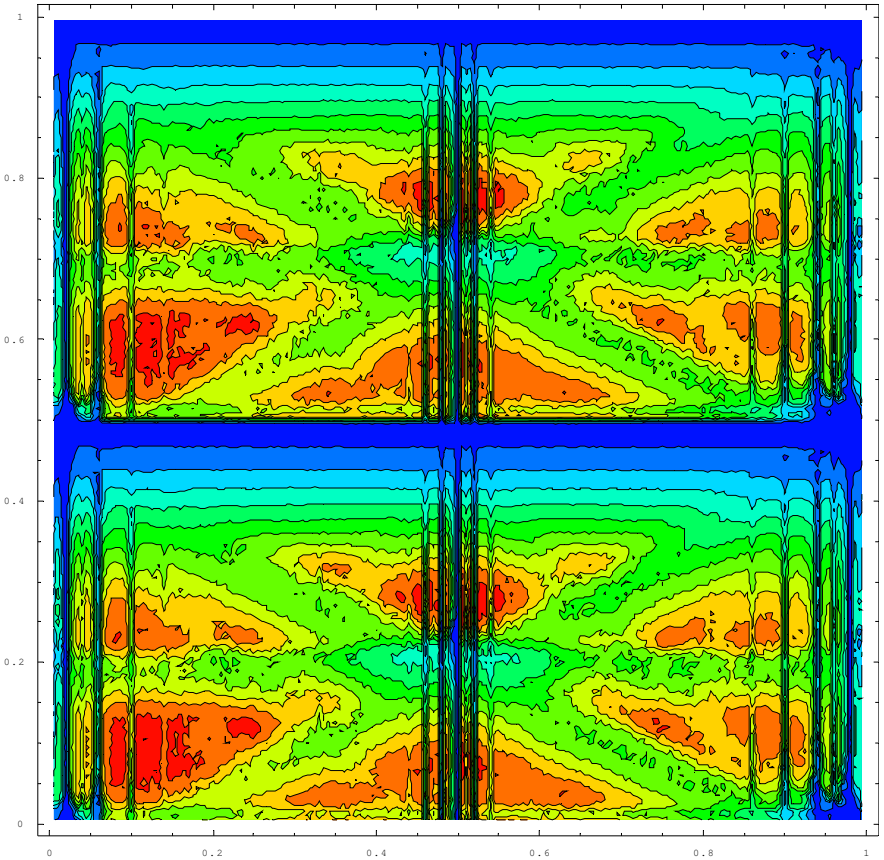
x-y resonance suppression in LPA&CW

D.Shatilov's (BINP), ICFA08 Workshop

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

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- The new scheme has been tested in DAFNE

DAFNE tests

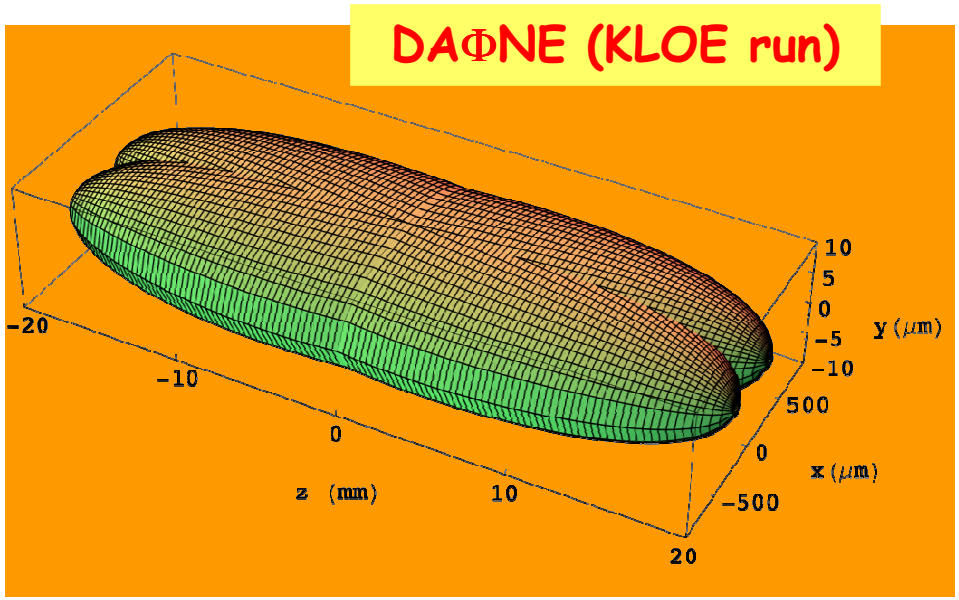
for Physics Programs

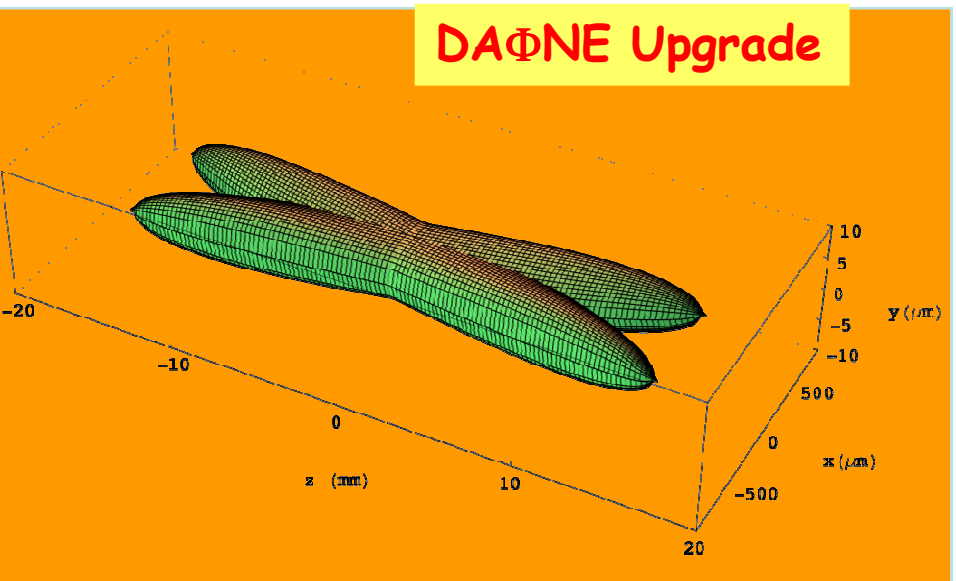
1. Fits DAΦNE schedule (shut down for SIDDHARTA installation in mid 2007)
2. Satisfies new physics programs (SIDDHARTA, KLOE2, FINUDA...)
3. Requires moderate modifications
4. Relatively low cost (1 mln Euro)

for Beam Dynamics

1. No detector solenoidal field
2. No splitter magnets
3. No compensating solenoids
4. No parasitic crossings
5. Lower beam impedance (simple IR, new bellows, new injection kickers)

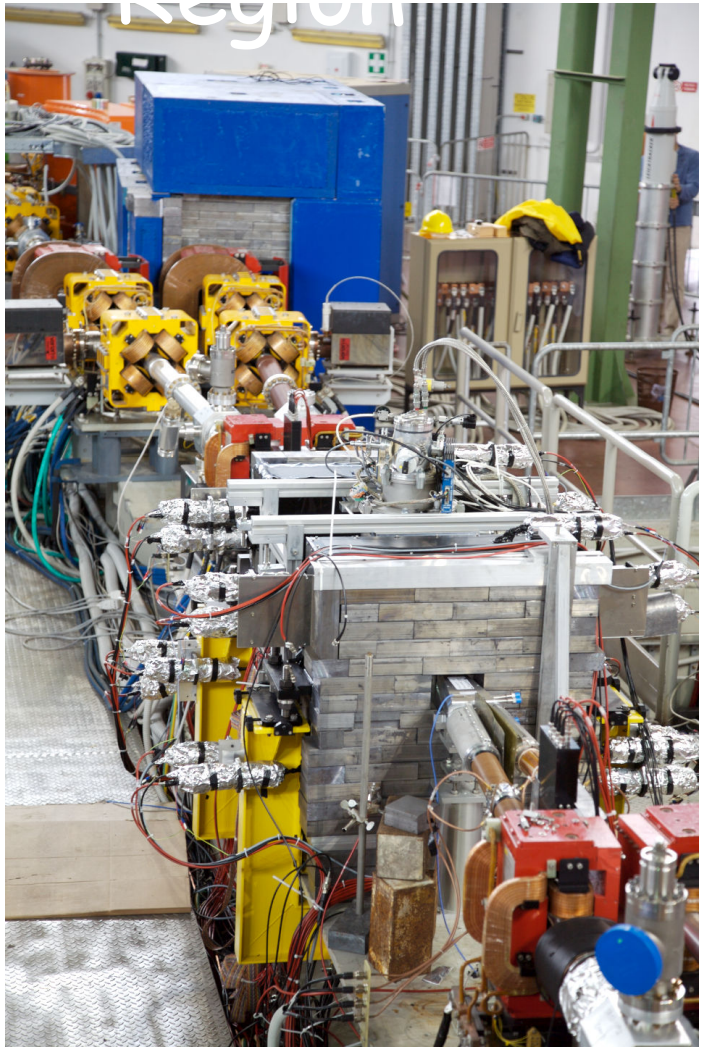
BEAM PROFILES @IP AND NEW PARAMETERS

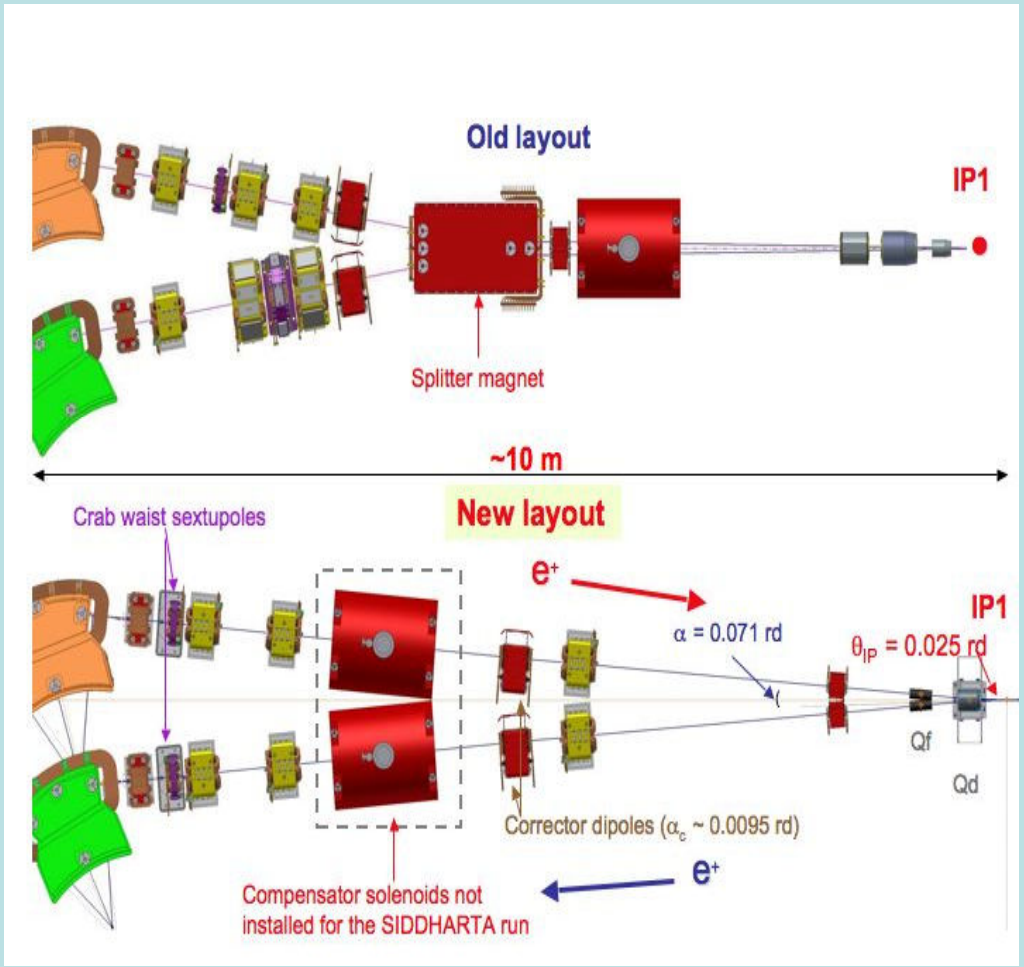


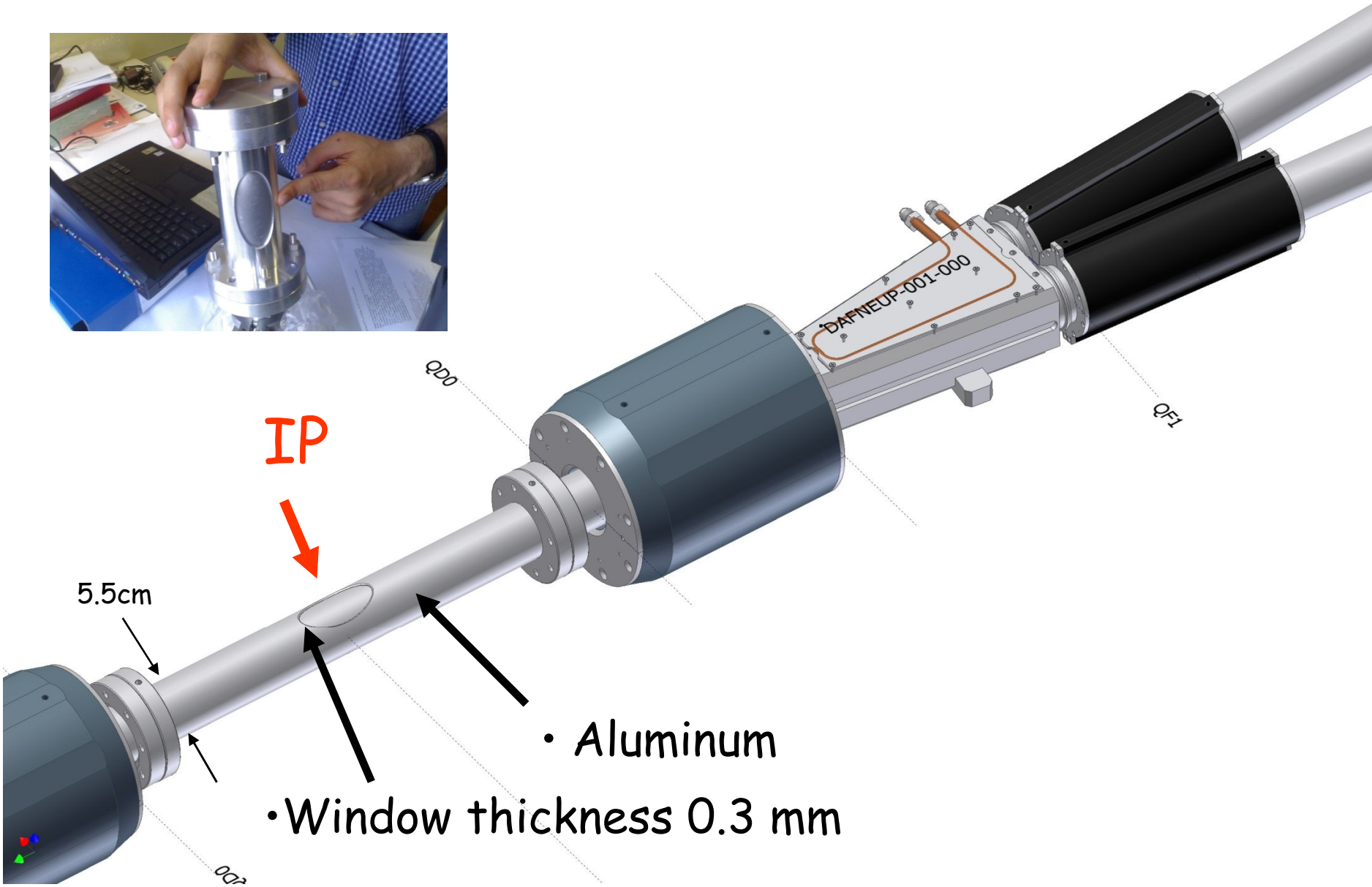


	DAΦNE (KLOE run)	DAΦNE Upgrade
I_{bunch} (mA)	13	13
N_{bunch}	110	110
β_y* (cm)	1.8	0.85
β_x* (cm)	160	26
σ_y* (μm)	5.4 low curr	3.1
σ_x* (μm)	700	260
σ_z (mm)	25	20
Horizontal tune shift	0.04	0.008
Vertical tune shift	0.04	0.055
θ_{cross} (mrad) (half)	12.5	25
$\Phi_{Piwinski}$	0.45	2.0
L ($cm^{-2}s^{-1}$)	1.5×10^{32}	5×10^{32}

3 times more luminosity obtained just with 3 times smaller vertical beam

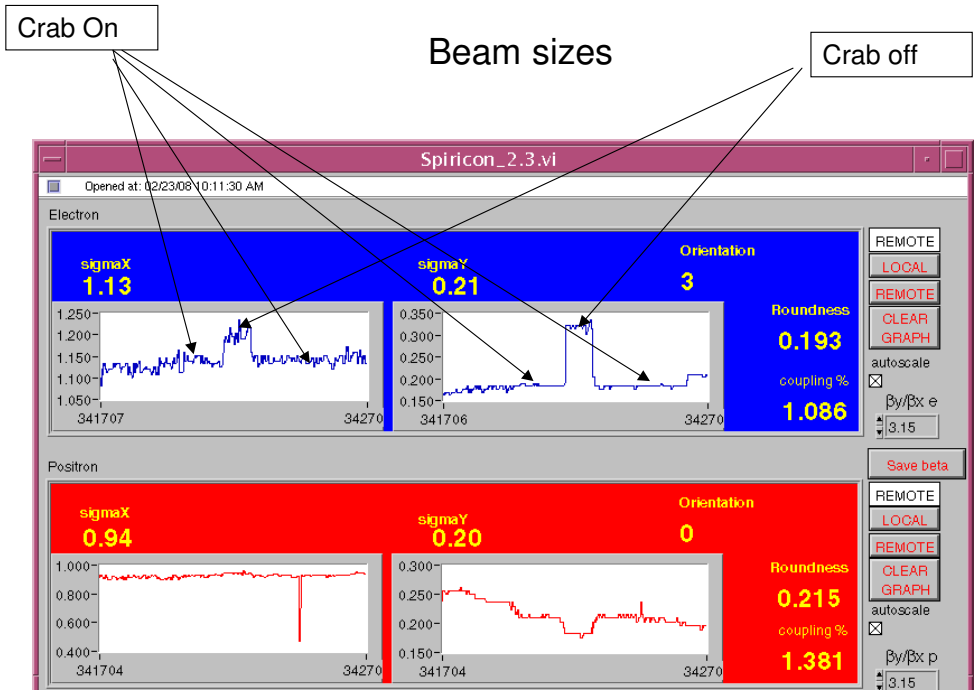


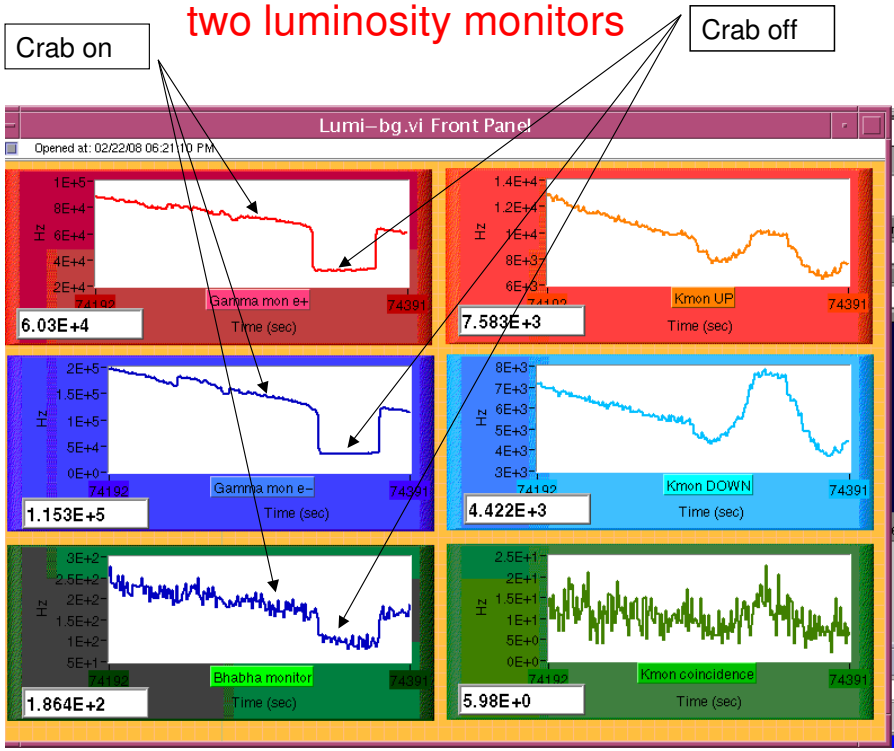

Old layout
IP1
Splitter magnet
~10 m
New layout
Crab waist sextupoles
e+
α = 0.071 rd
IP1
θIP = 0.025 rd
Qf
Qd
Corrector dipoles (αc ~ 0.0095 rd)
e+
Compensator solenoids not
installed for the SIDDHARTA run


DAFNEUP-001-000
QD0
QF1
IP
5.5cm
• Aluminum
•Window thickness 0.3 mm

Crab Waist Works:

First Experimental Evidence





Crab Sextupoles on since the first test

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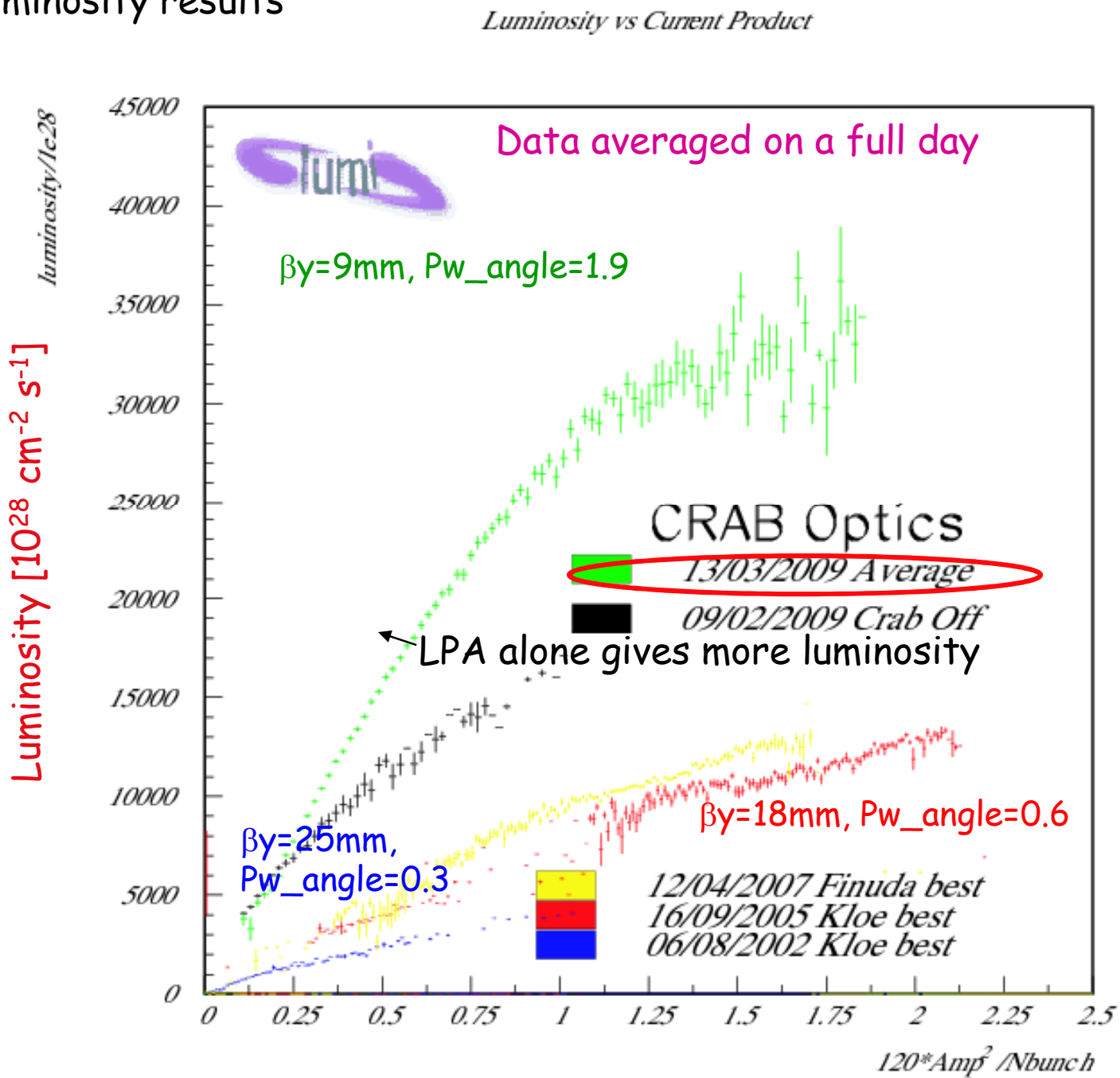
Luminosity results



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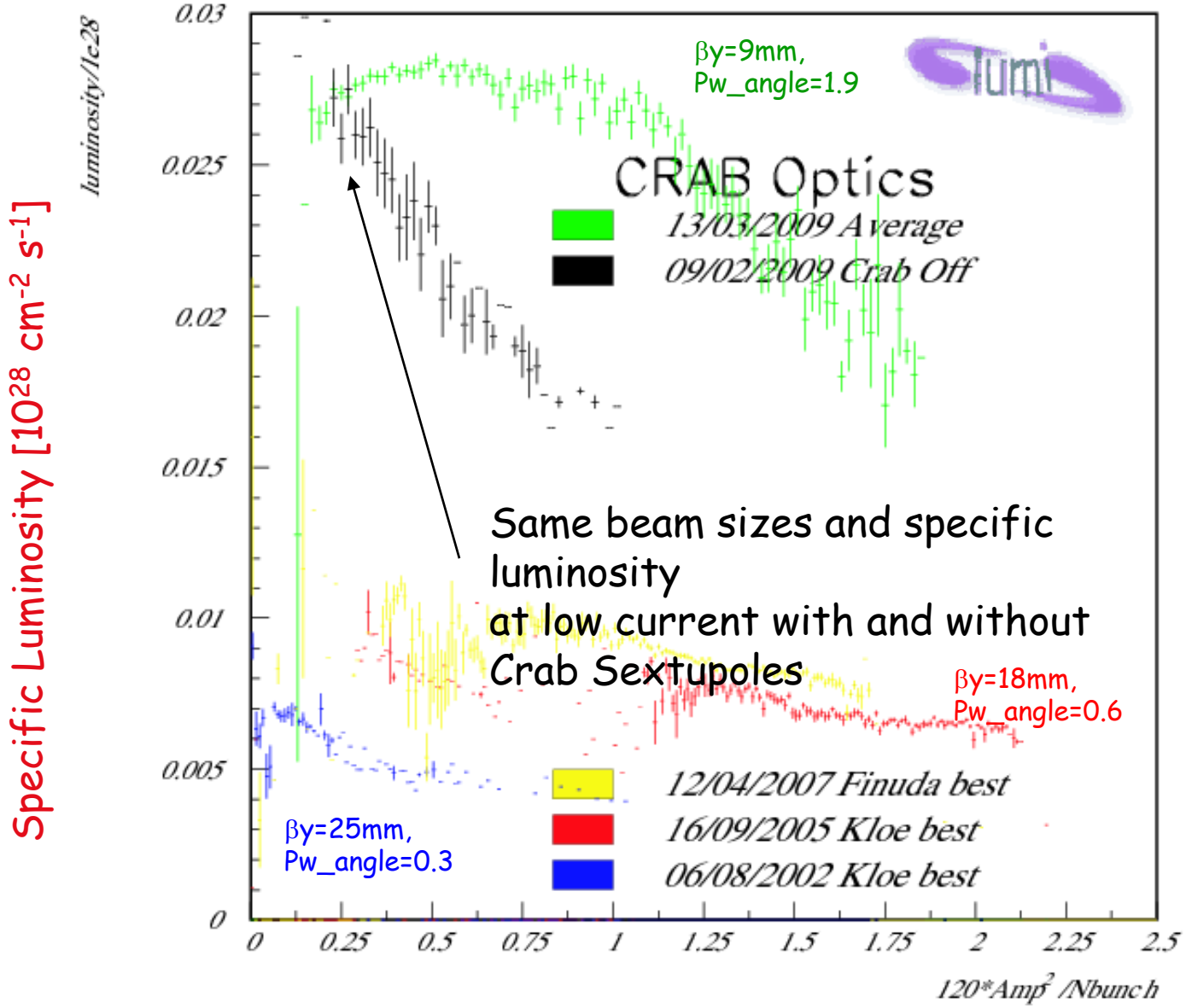

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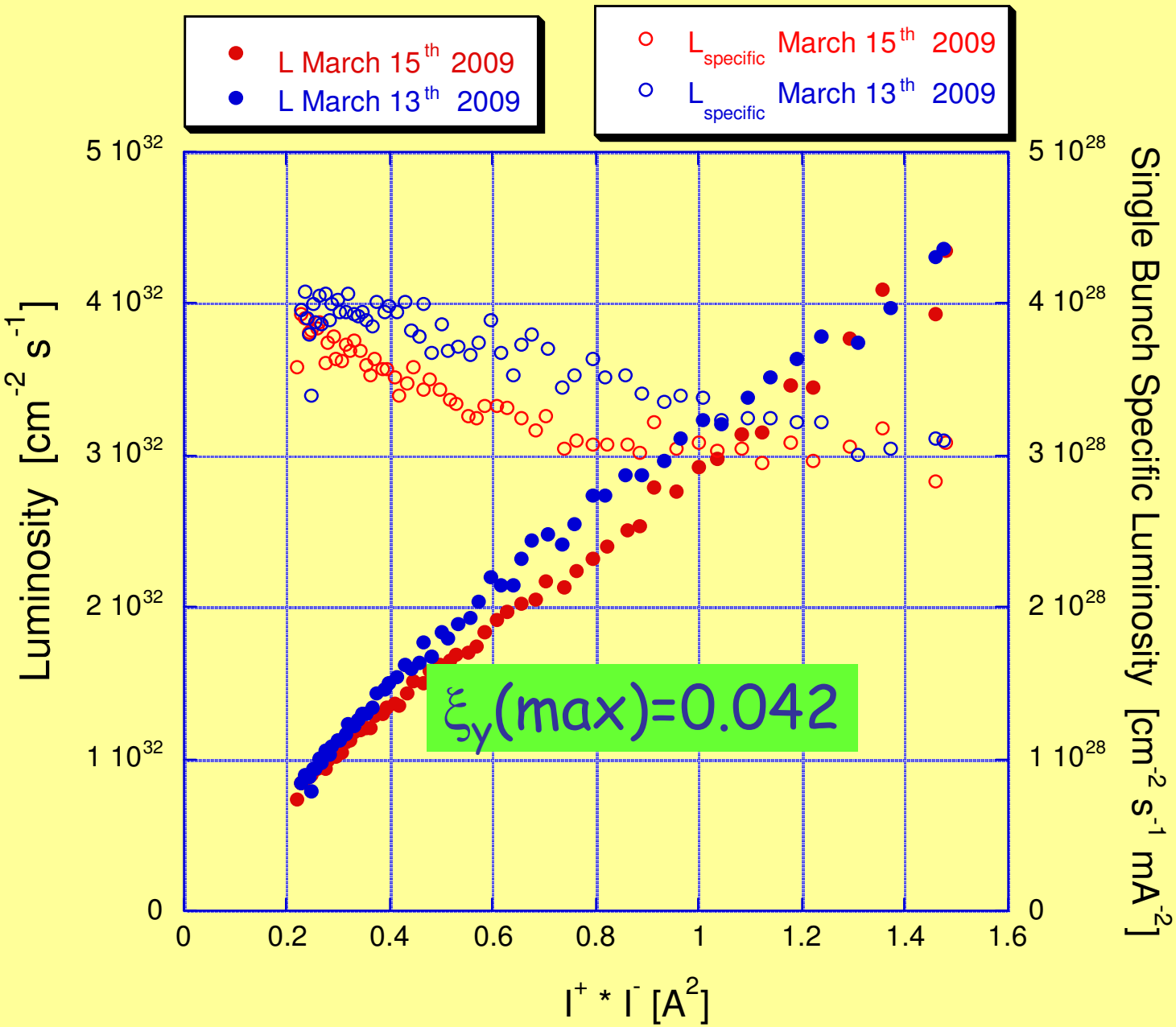
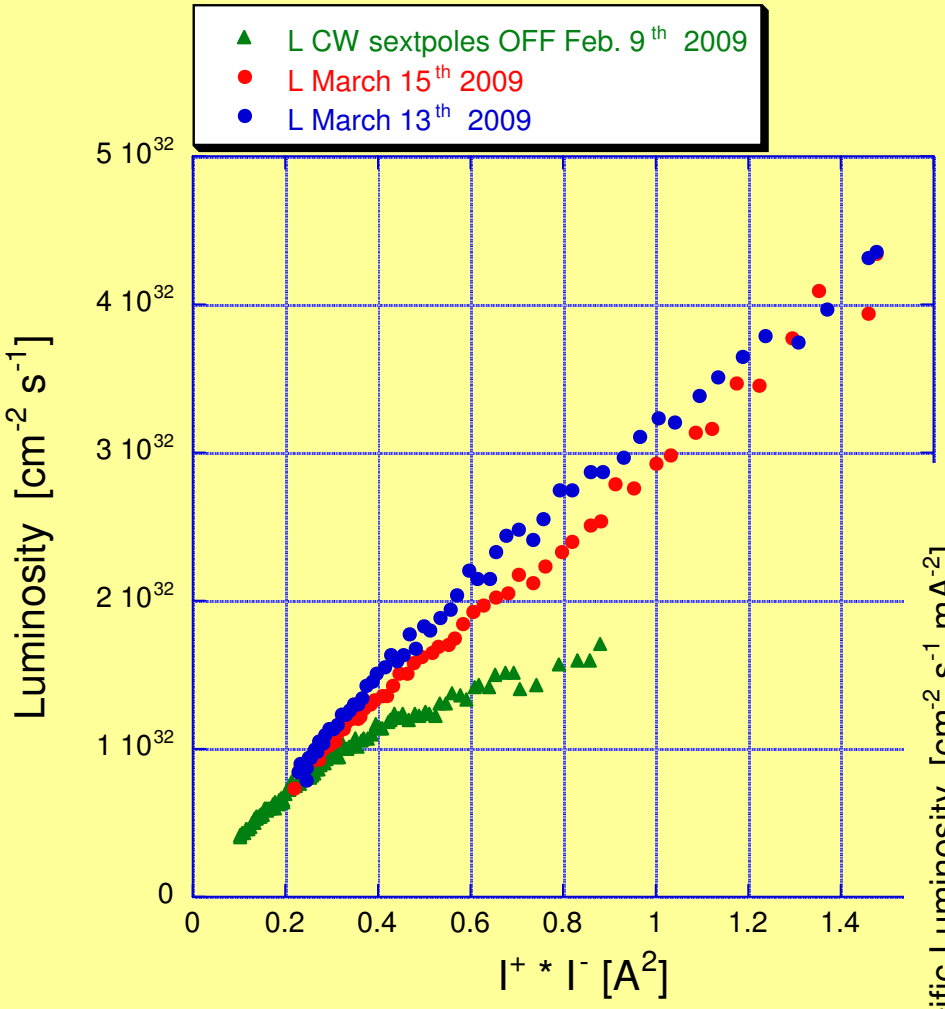
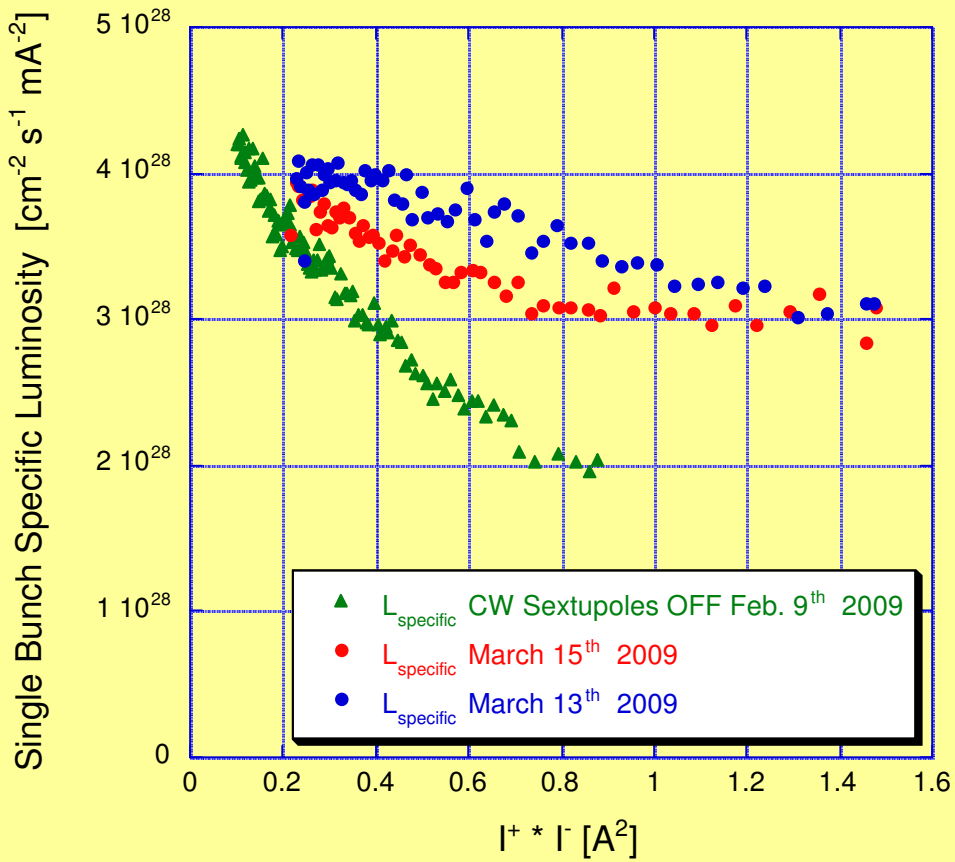
Best two fills Luminosity vs Current Product



Crab on/off Specific Luminosity vs Current Product

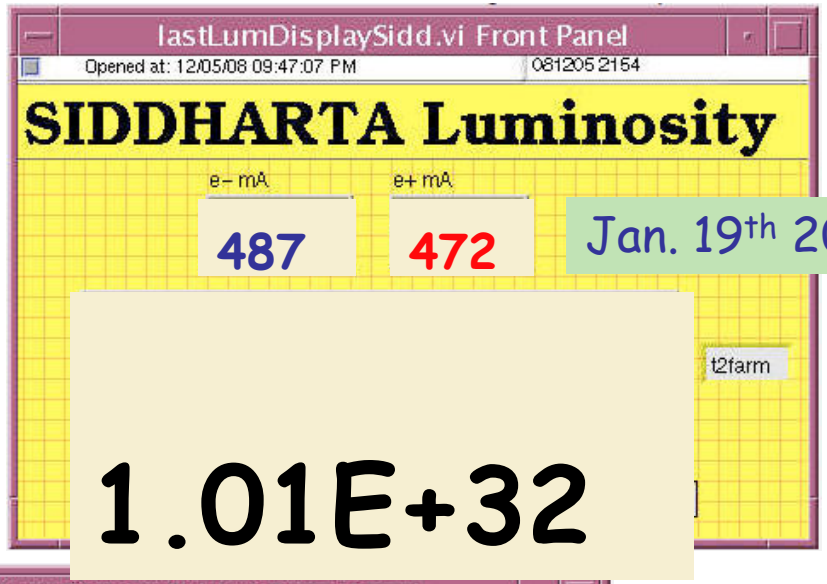




Crab on/off Luminosity vs Current Product

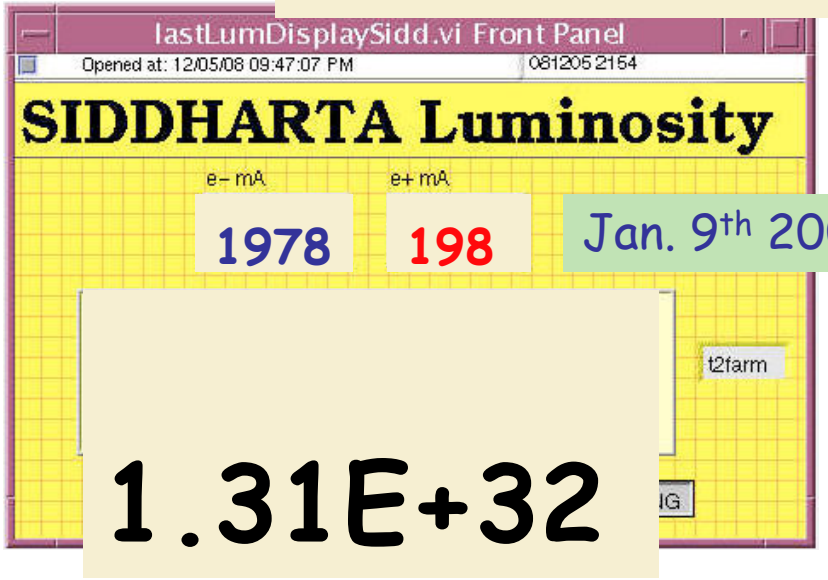
Luminosity in weak-weak and strong-weak regime

Low currents
$\xi_y \sim 0.020$



Jan. 19th 2009

Asymmetric currents
$\xi_y \sim 0.0626$



Jan. 9th 2009

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And so……

36th MEETING OF THE LNF SCIENTIFIC COMMITTEE

FINDINGS AND RECOMMENDATIONS

1 THE DAΦNE PROGRAM: STATUS AND RECOMMENDATIONS

1.1 DAΦNE UPGRADE: PERFORMANCE AND OUTLOOK

fact that the principle of crab-waist compensation has been shown to work; this must be recognised as a major advance in the long history of fighting the beam-beam effect in e^+e^- colliders. It is also an important step towards validation of the SuperB design concepts.

Finally, the effect of the crab-waist compensation is striking. As we were able to observe directly in the control room, excitation of the sextupoles on either or both beams reduces the corresponding beam sizes in collision, as predicted.

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- The scheme has been demonstrated and it is ready for a new high luminosity machine.

SuperB main features

- Goal: maximize luminosity while keeping wall power low

- 2 rings (4x7 GeV) design: flexible
- 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 e^- in the HER (unique feature)

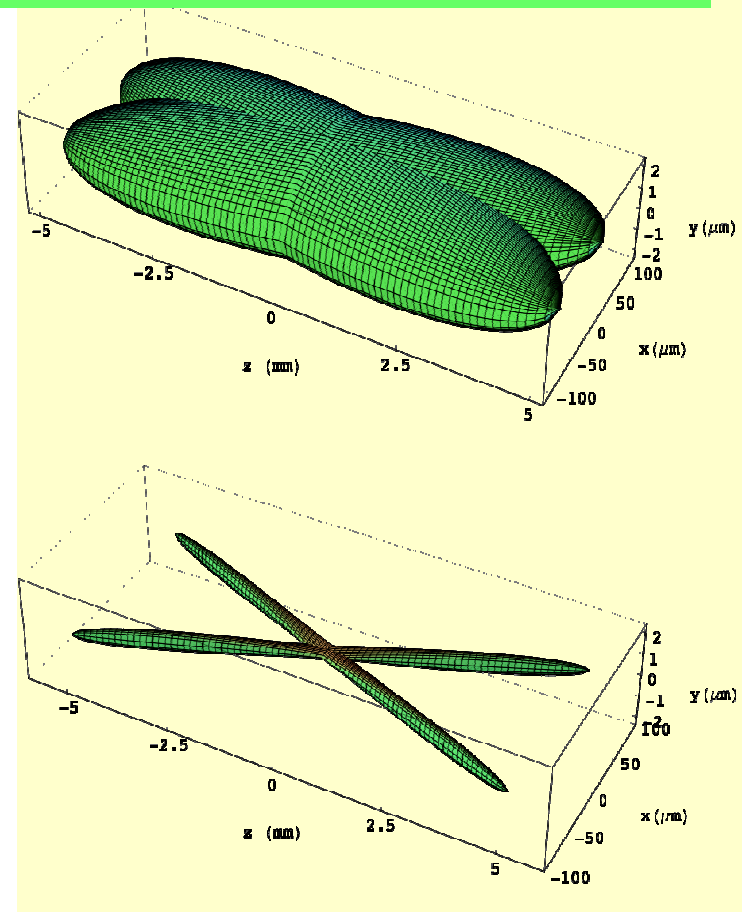
SuperB parameters flexibility

LER/HER	Unit	June 2008	Jan. 2009	March 2009	LNF site
E+/E-	GeV	4/7	4/7	4/7	4/7
L	$cm^{-2}\ s^{-1}$	$1x10^{36}$	$1x10^{36}$	$1x10^{36}$	$1x10^{36}$
I^+/I^-	Amp	1.85 /1.85	2.00/2.00	2.80/2.80	2.70/2.70
N_{part}	$x10^{10}$	5.55 /5.55	6/6	4.37/4.37	4.53/4.53
N_{bun}		1250	1250	2400	1740
I_{bunch}	mA	1.48	1.6	1.17	1.6
$\theta/2$	mrad	25	30	30	30
β_x^*	mm	35/20	35/20	35/20	35/20
β_y^*	mm	0.22 /0.39	0.21 /0.37	0.21 /0.37	0.21 /0.37
ε_x	nm	2.8/1.6	2.8/1.6	2.8/1.6	2.8/1.6
ε_y	pm	7/4	7/4	7/4	7/4
σ_x	μm	9.9/5.7	9.9/5.7	9.9/5.7	9.9/5.7
σ_y	nm	39/39	38/38	38/38	38/38
σ_z	mm	5/5	5/5	5/5	5/5
ξ_x	X tune shift	0.007/0.002	0.005/0.0017	0.004/0.0013	0.004/0.0013
ξ_y	Y tune shift	0.14 /0.14	0.125/0.126	0.091/0.092	0.094/0.095
RF stations	LER/HER	5/6	5/6	5/8	6/9
RF wall plug power	MW	16.2	18	25.5	30.
Circumference	m	1800	1800	1800	1400

Comparison of SuperB to Super-KEKB

Parameter	Units	*SuperB*	Super-KEKB
Energy	GeV	4x7	3.5x8
Luminosity	10^{36}/ cm^2/s	1.0 to 2.0	0.5 to 0.8
Beam currents	A	1.9x1.9	9.4x4.1
β_y^*	mm	0.22	3.
β_x^*	cm	3.5x2.0	20.
Crossing angle (full)	mrad	48.	30. to 0.
RF power (AC line)	MW	20 to 25	80 to 90
Tune shifts	(x/y)	0.0004/0.2	0.27/0.3

IP beam distributions for KEKB



100 times more luminosity obtained just with 100 times smaller vertical beam

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IP beam distributions for *SuperB*

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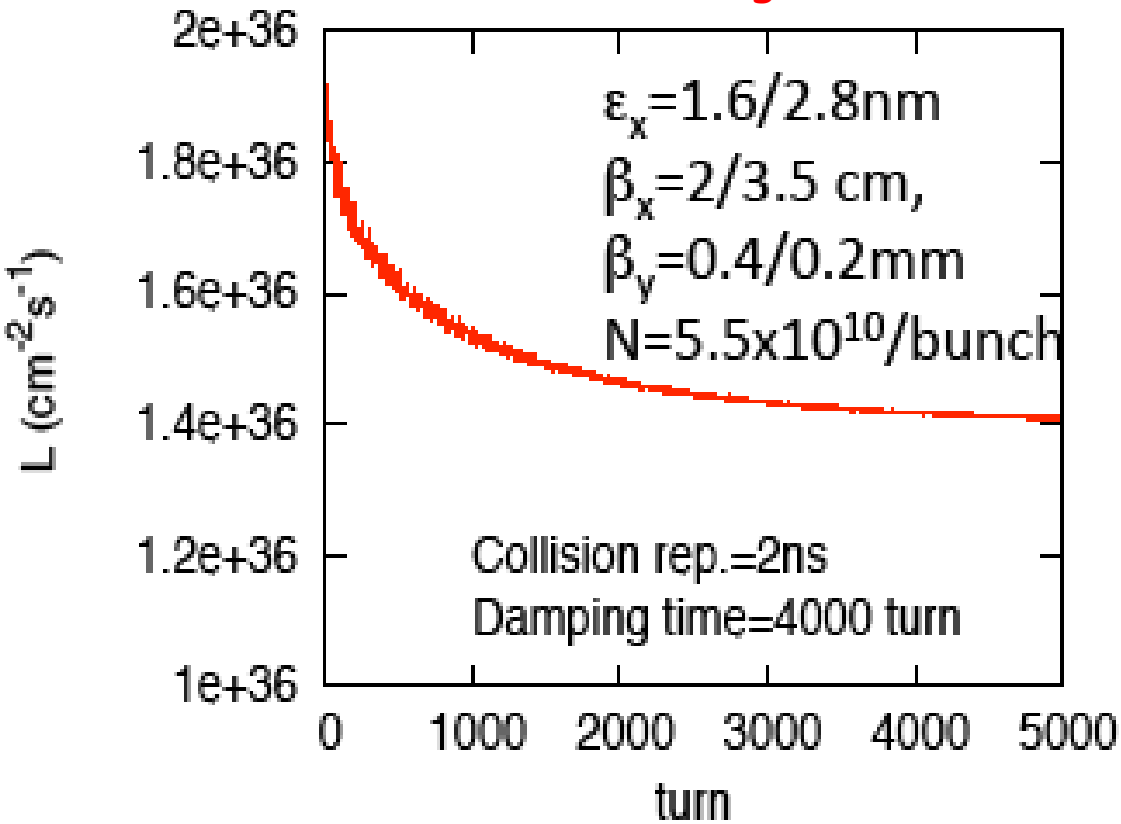
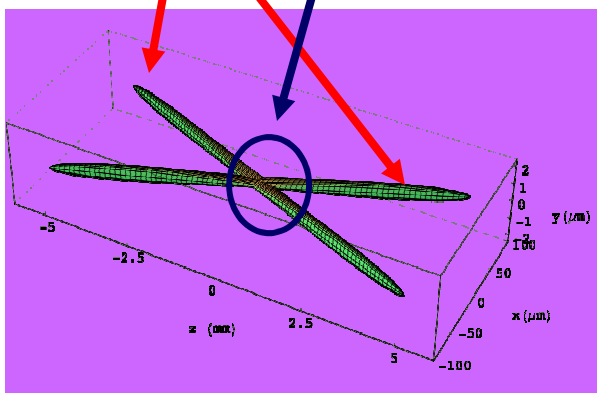
- Extension of the DAFNE tests to the SuperB machine:
- TEST on the beam-beam effect codes
- 1) weak-strong ok
- 2) strong-strong ok

Strong-strong beam-beam simulations

June '08 lattice, higher tune shift



- Strong-strong modified code (much faster):
  - PIC for beams overlap area
  - gaussian for beam tails



Luminosity of 10^{36} can be reached

K. Ohmi

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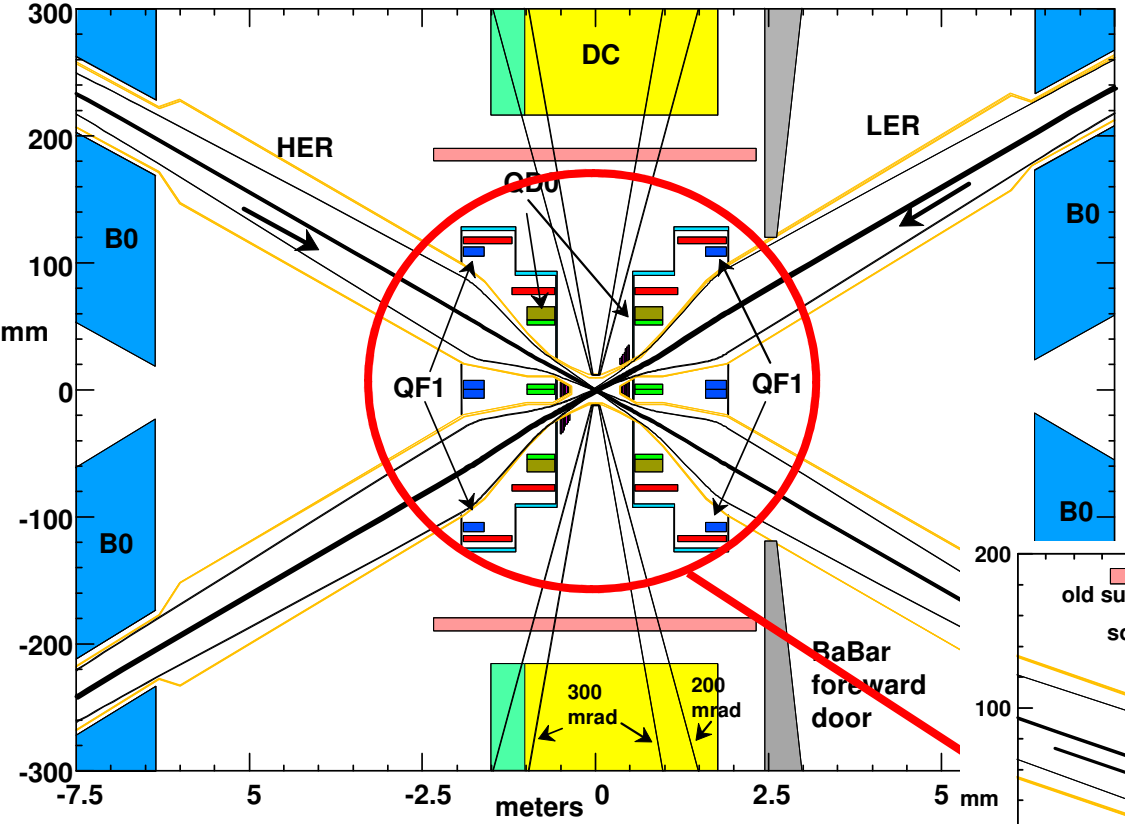
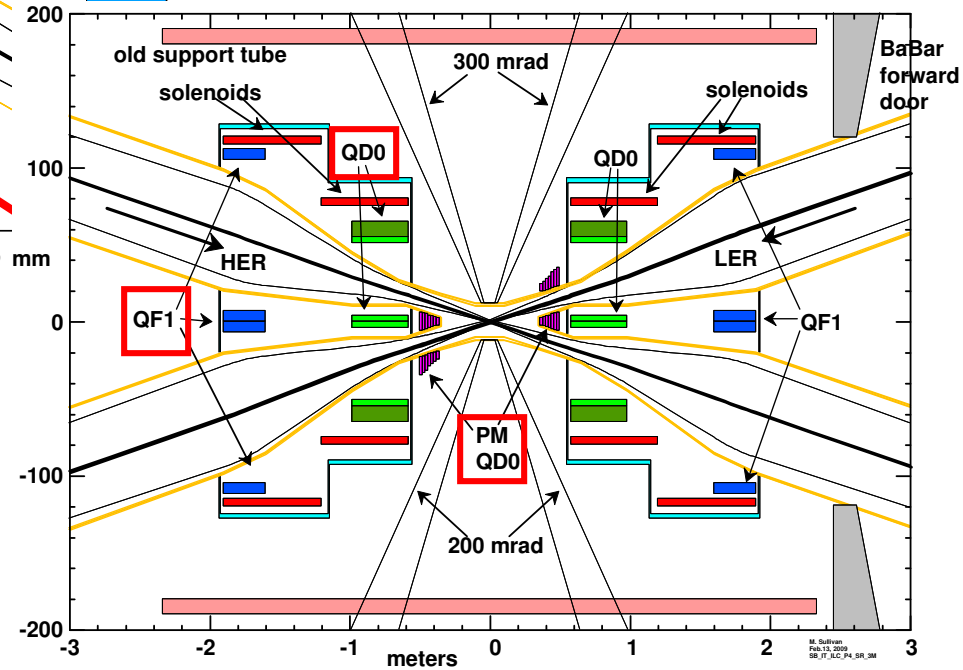
New IR design

M. Sullivan



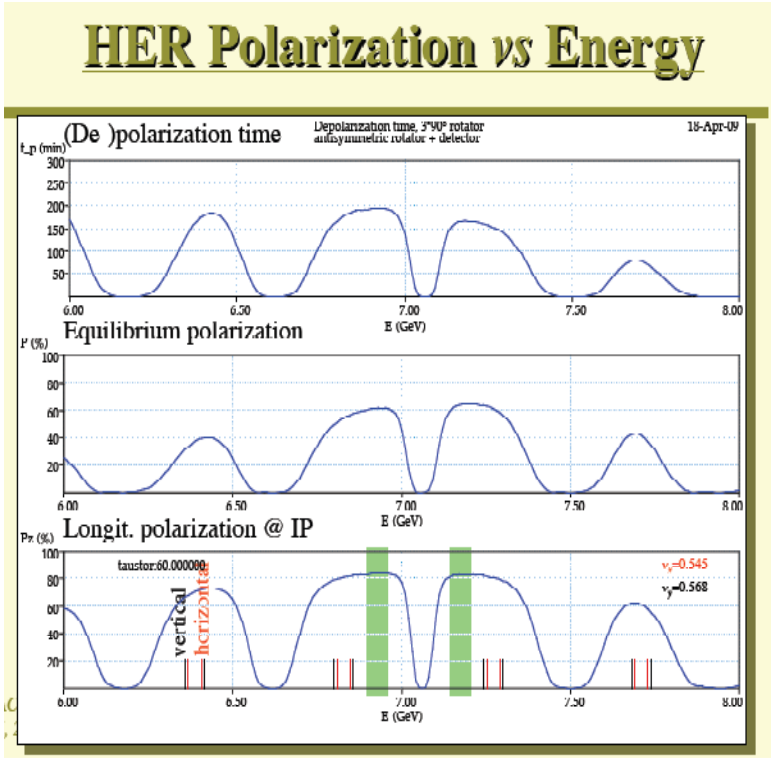


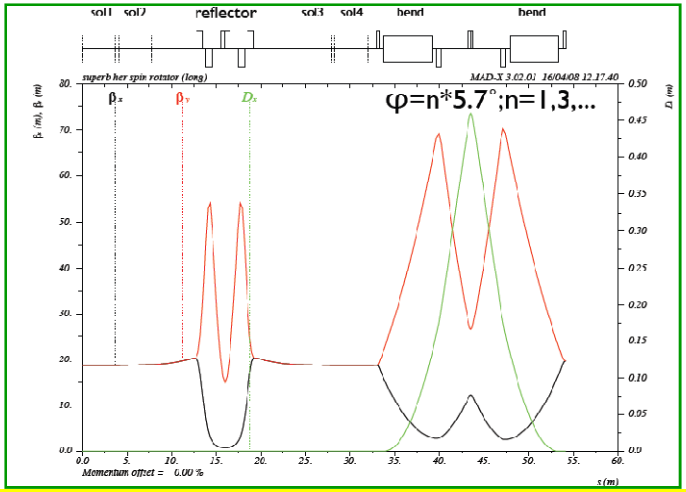
- New QD0 design
- QD0 & QF1 are SC and share same cryostat
- Compensating solenoids were included

Polarization in HER

U. Wienands

- Polarization of one beam is included
  - either energy beam could be polarized
  - LER less expensive, HER easier (HER was chosen)
- Longitudinal polarization times and short beam lifetimes indicate a need to inject vertically polarized electrons
  - plan is to use SLC polarized e^- gun
- There are several possible IP spin rotators:
  - solenoids look better (vertical bends give unwanted vertical emittance growth)





Spin rotator with solenoids and bends

Expected longitudinal polarization at IP ~ 85%(inj) x 95%(ring) = 80%(effective)

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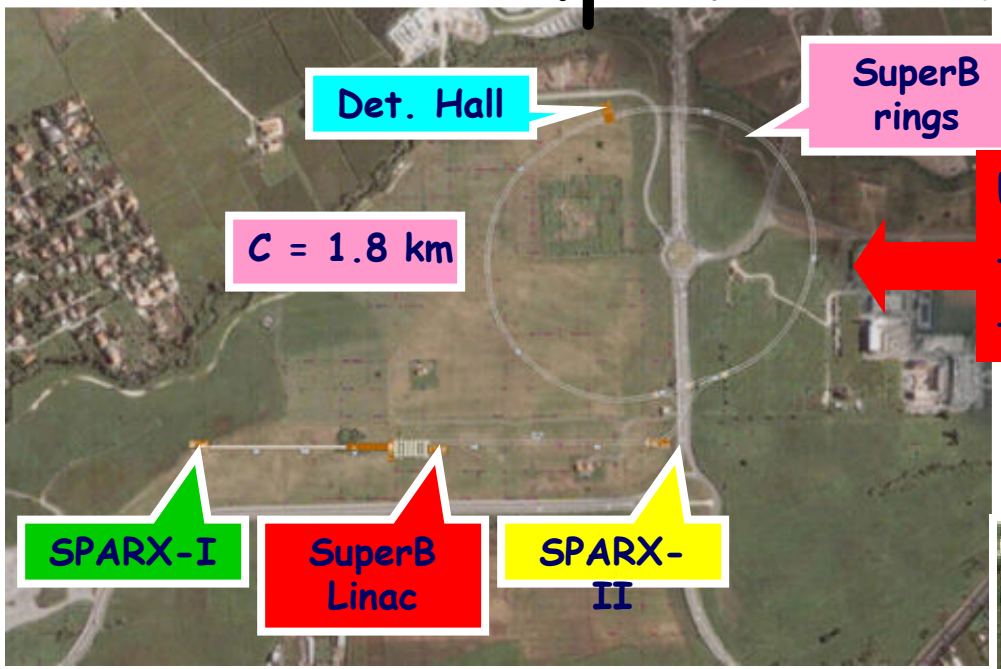
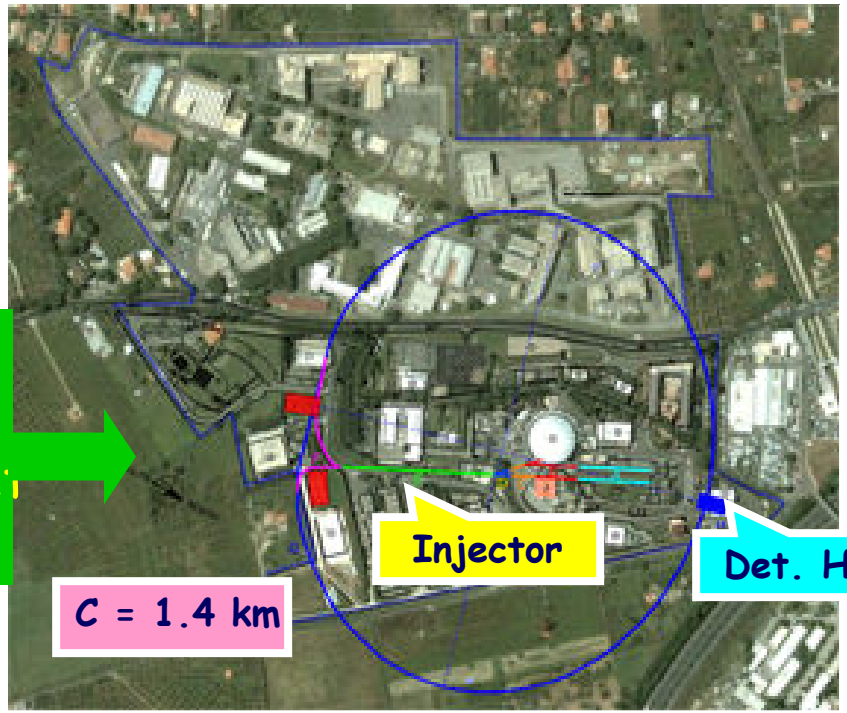
S. Tomassini

SuperB site choices



University of Tor Vergata Campus:
- green field
- synergy with SPARX-FEL project

Frascati National Laboratories:
- infrastructures
- synergy with SPARX-FEL project still possible



Conclusions

- *DAΦNE tests have shown that the LPA&CW scheme works !*
- *Simulations weak strong and strong strong fits the DAFNE experiement => extension to SuperB*

- *SuperB* parameters are being optimized around 1 x 10^{36} cm^{-2} s^{-1}
- Mini-MAC has endorsed the machine design: "*Mini-MAC now feels secure in enthusiastically encouraging the SuperB design team to proceed to the TDR phase, with confidence that the design parameters are achievable" (April 2009)*
- Planning for a Technical Design Report for the end of 2010 has started
- Italian Gov => 15 MEuros for TDR phase
- Polarised machine
- Strong correlation with LC
- EXTREMELY EXCITING PROJECT: it condensate all

the challenges in accelerator physics and all the new ideas…..

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- Thanks to all the “slides providers”

Backup slides

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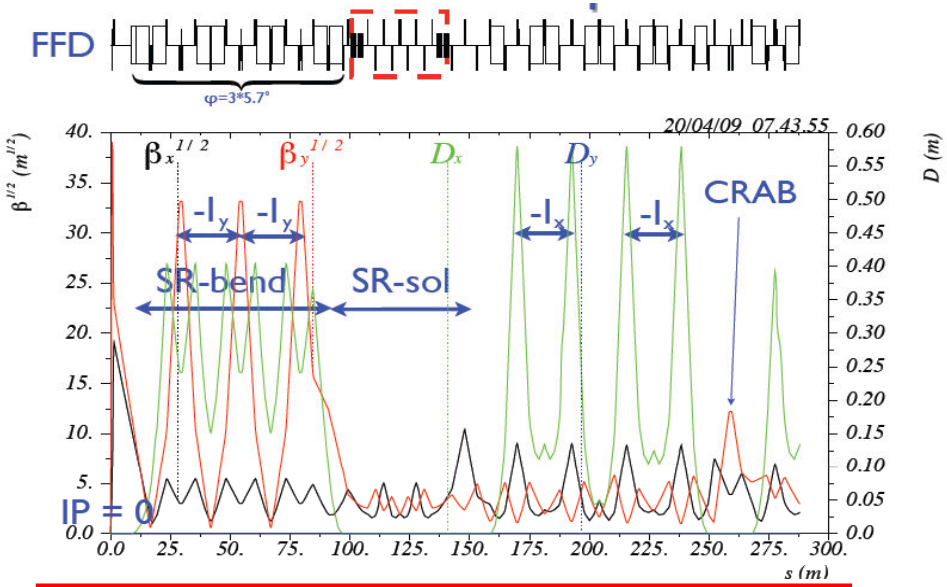
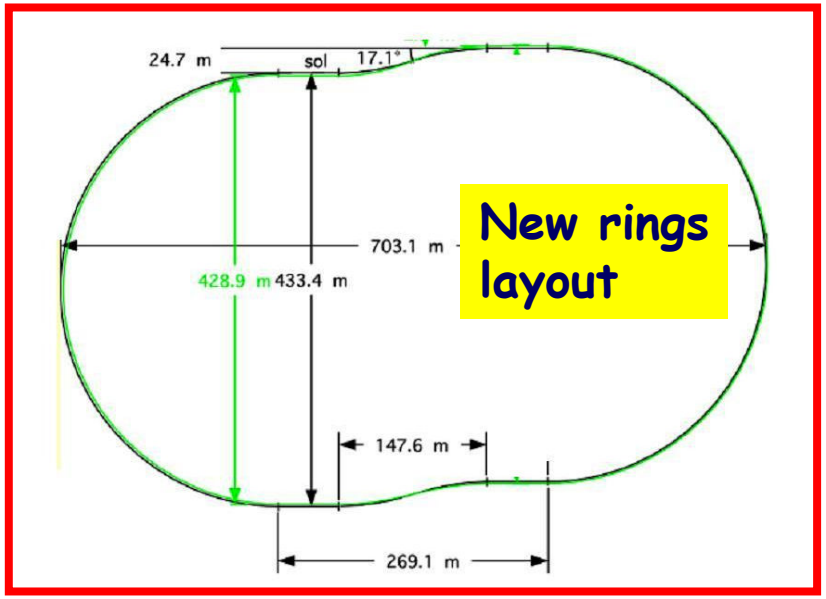
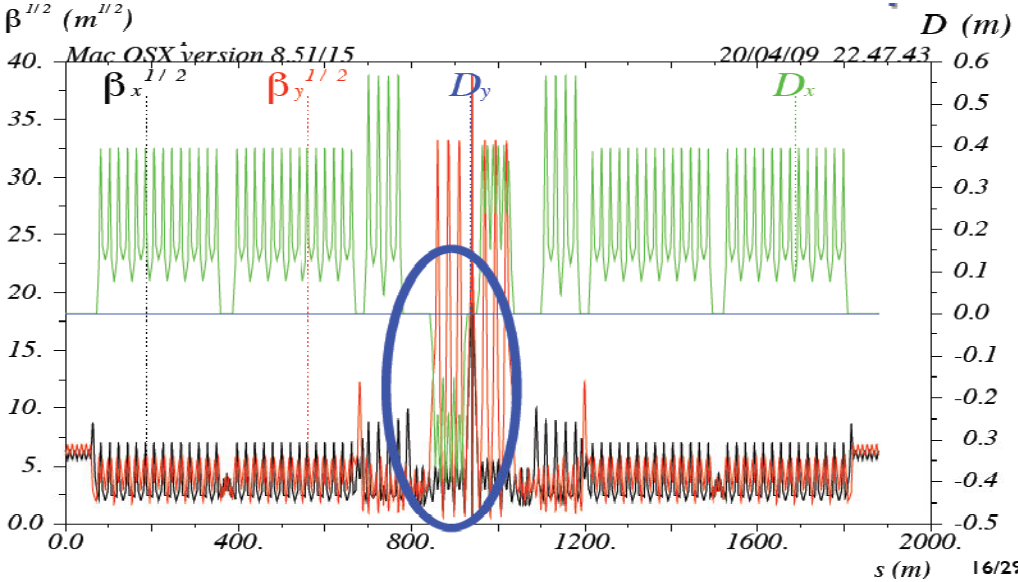
HER with spin rotator

W. Wittmer



- Introduced spin rotators on both sides of IP in HER to provide longitudinal polarized electrons at IP and maintain the chromatic characteristic of the original design necessary for the crab waist scheme, band width and dynamic aperture
- Bends have opposite sign w.r.t. IP for spin transparency condition





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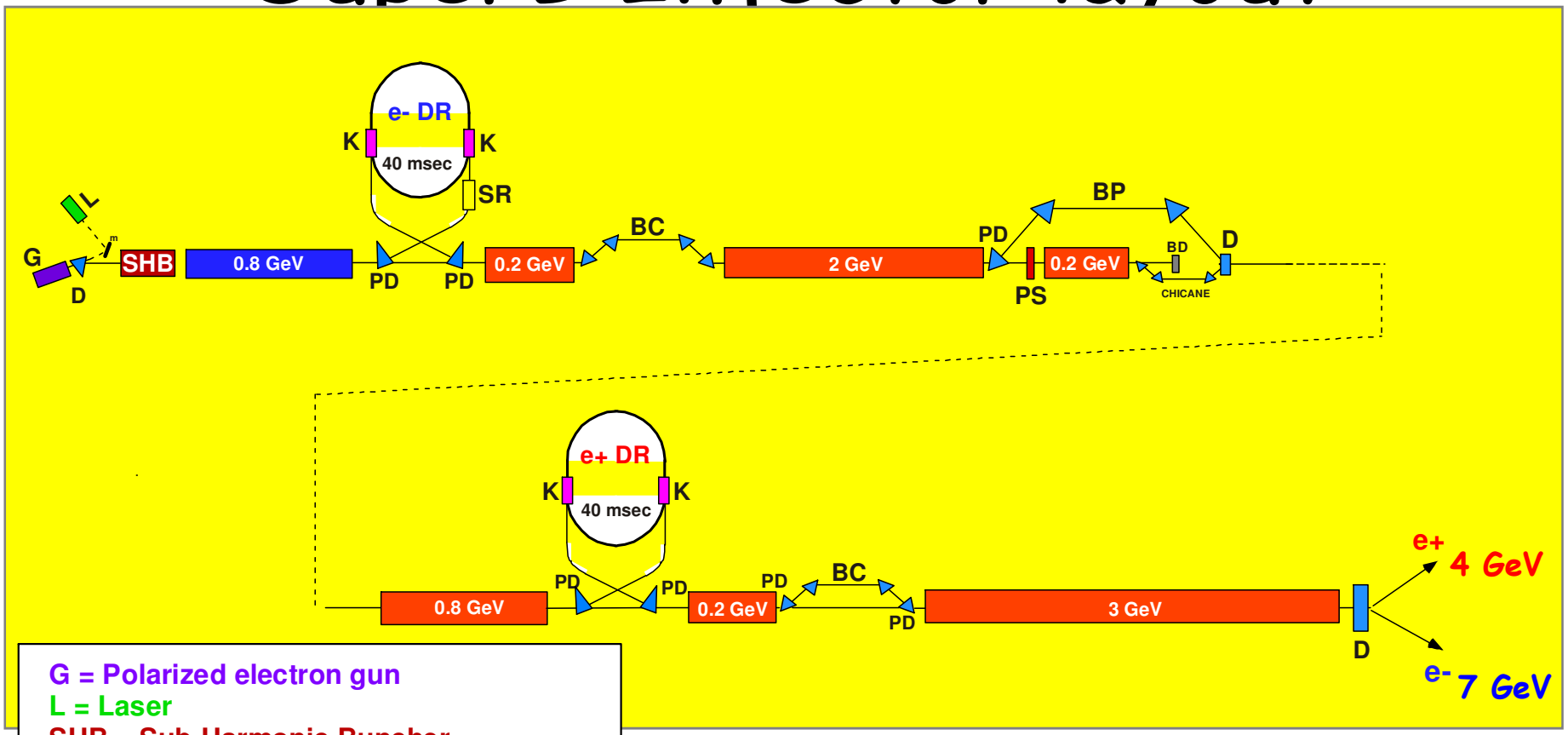
R. Boni

SuperB Injector layout

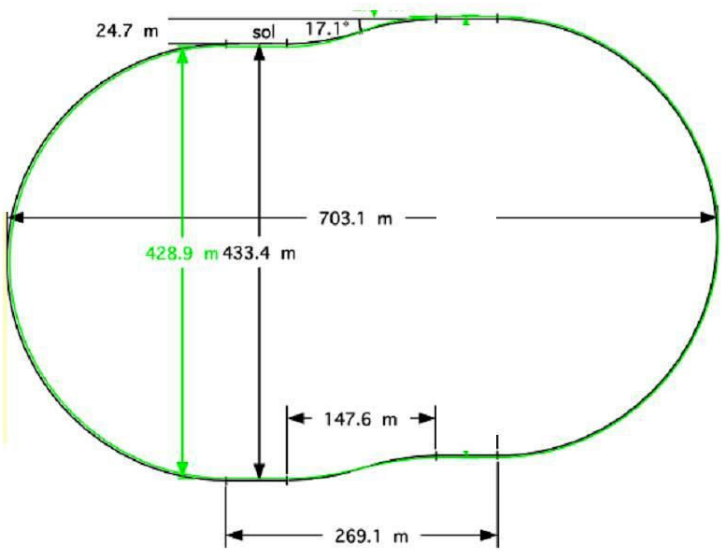


G = Polarized electron gun
L = Laser
SHB = Sub-Harmonic Buncher
PD = Pulsed Dipole
D = DC Dipole
K = Injection/Exctraction Kicker
SR = Spin Rotator
BC = Bunch Compressor
PS = Positron Source
BP = By-Pass Line
BD = e- Beam Dumper

$F_{LINAC} = 2856$ MHz

Alessandro Variola
Posipol 2009, Lyon-France

Layout: PEP-II magnets reuse



Available

Needed

L_{mag} (m)	0.45	5.4
PEP HER	-	194
PEP LER	194	-
SBF HER	-	130
SBF LER	224	18
SBF Total	224	148
Needed	30	0

Quads

L_{mag} (m)	0.56	0.73	0.43	0.7	0.4
PEP HER	202	82	-	-	-
PEP LER	-	-	353	-	-
SBF HER	165	108	-	2	2
SBF LER	88	108	165	2	2
SBF Total	253	216	165	4	4
Needed	51*	134	0	4	4

Sexts

L_{mag} (m)	0.25	0.5
PEP HER/LER	188	-
SBF Total	372	4
Needed	184	4

All PEP-II magnets can be used, dimensions and fields are in range

RF requirements are met by the present PEP-II RF system