Status of SuperB Project

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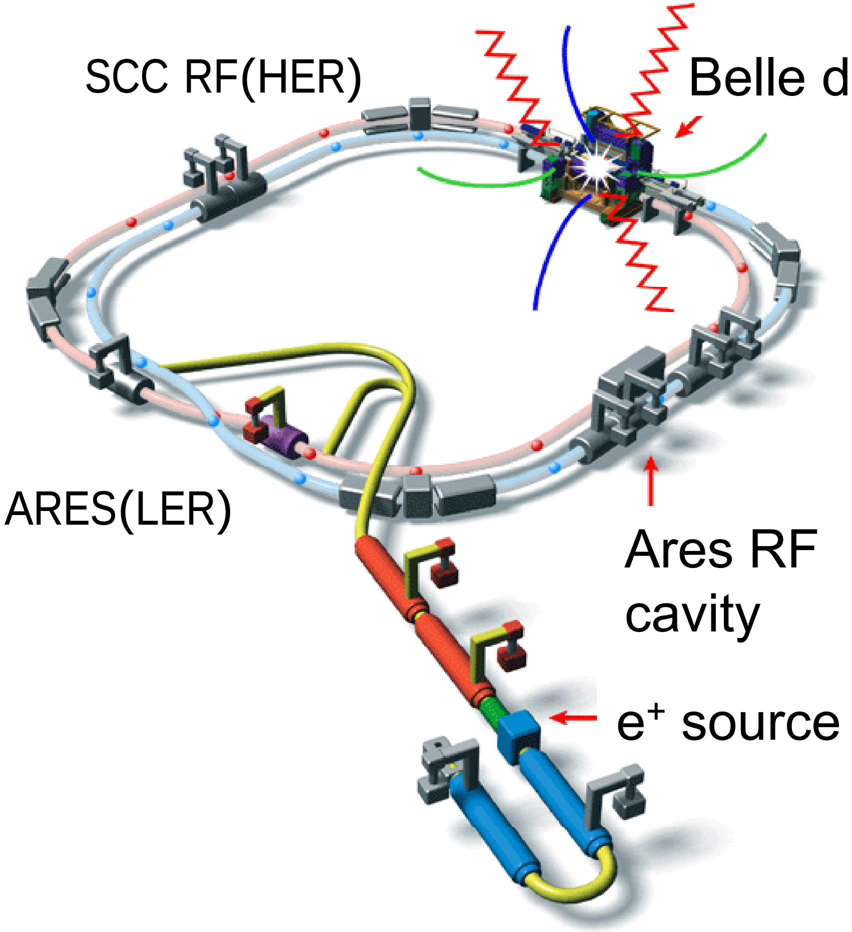
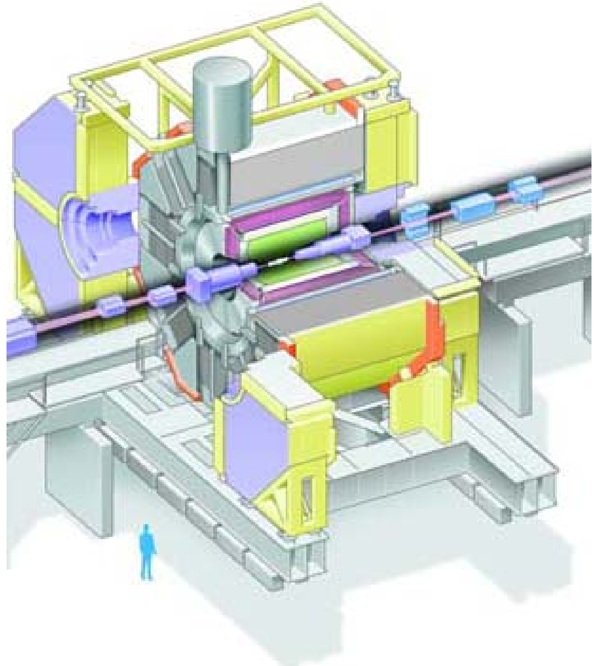
Flavour in the era of LHC- Final Meeting
CERN March 28, 2007

SUCCESS of BFACTORIES

~~8 x 3.5 GeV~~
22 mrad crossing angle

13 countries,
57 institutes,
~400 collaborators



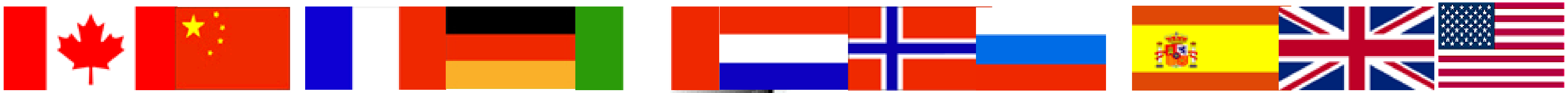


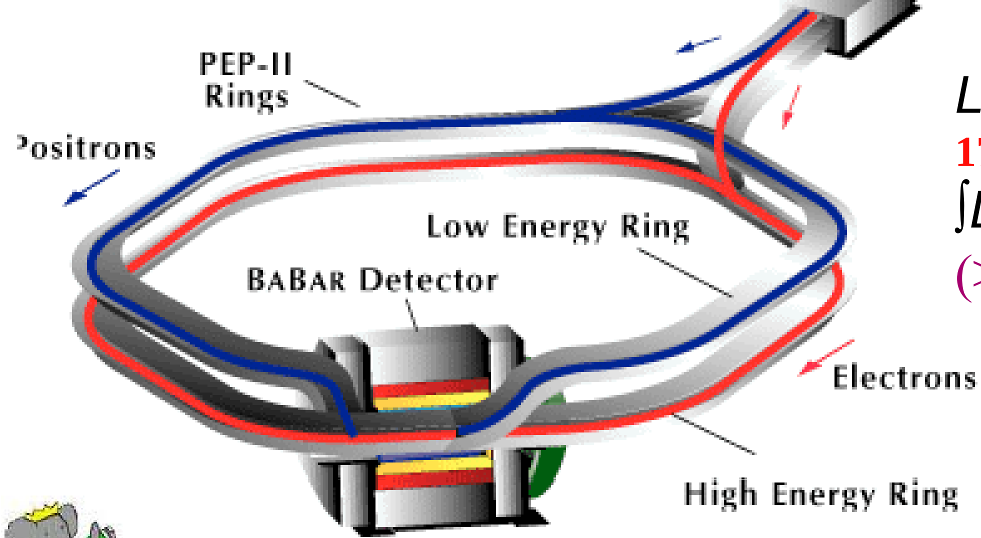
8GeV (e^-) × 3.5GeV (e^+)
peak luminosity:
1.7118 x 1034 cm-2

1662 mA (LER) , 1340 mA (HER) 1389 bunches

since 1999 **710.254 /fb**

SUCCESS of BFACTORIES 11 Countries, 80 Institutions, 623 Physicists





L_{max} =**12.069** × **1033** cm−2sec−1

1722 bunches 2900 mA LER 1875 mA HER

$\int L dt$ = 407.69 fb^{-1}@{Y(4S)+off(~10%)}

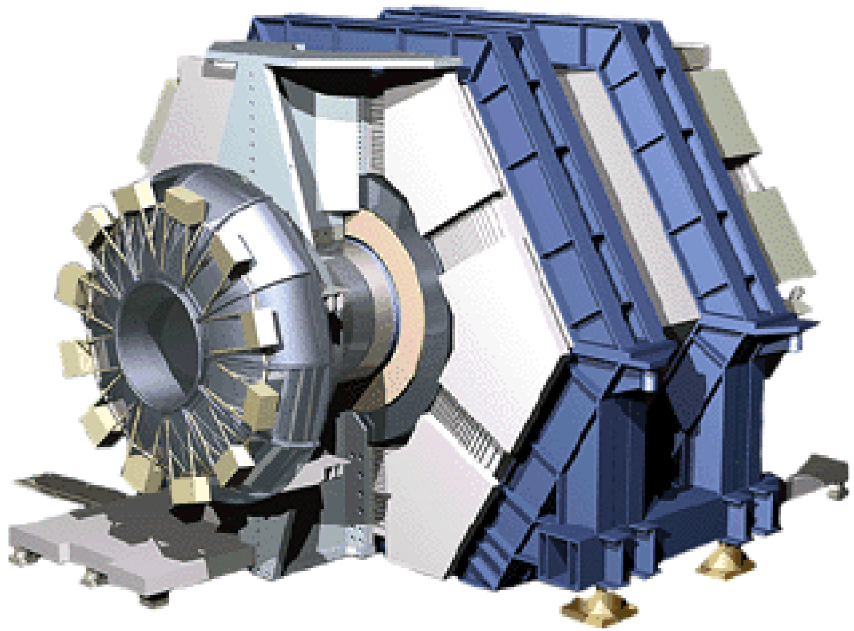
(>3.7x10^8 B events)

Charged tracking/vertexing
- 5-layer DSSD Si μstrip
- 40 layers (He-isobutane)

Hadron identification
- tracker: dE/dx
- DIRC imaging Cerenkov

Electron/photon
- CsI calorimeter

Muon/K_L
- Instrumented flux return

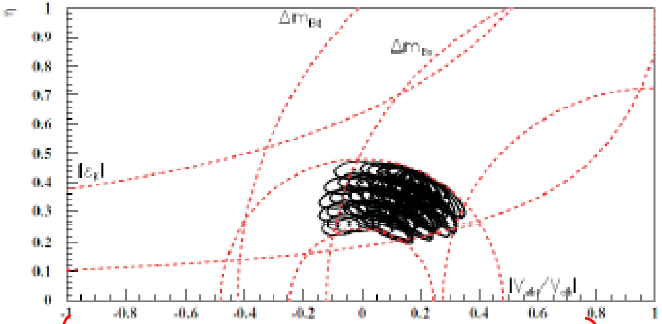


OUTLINE

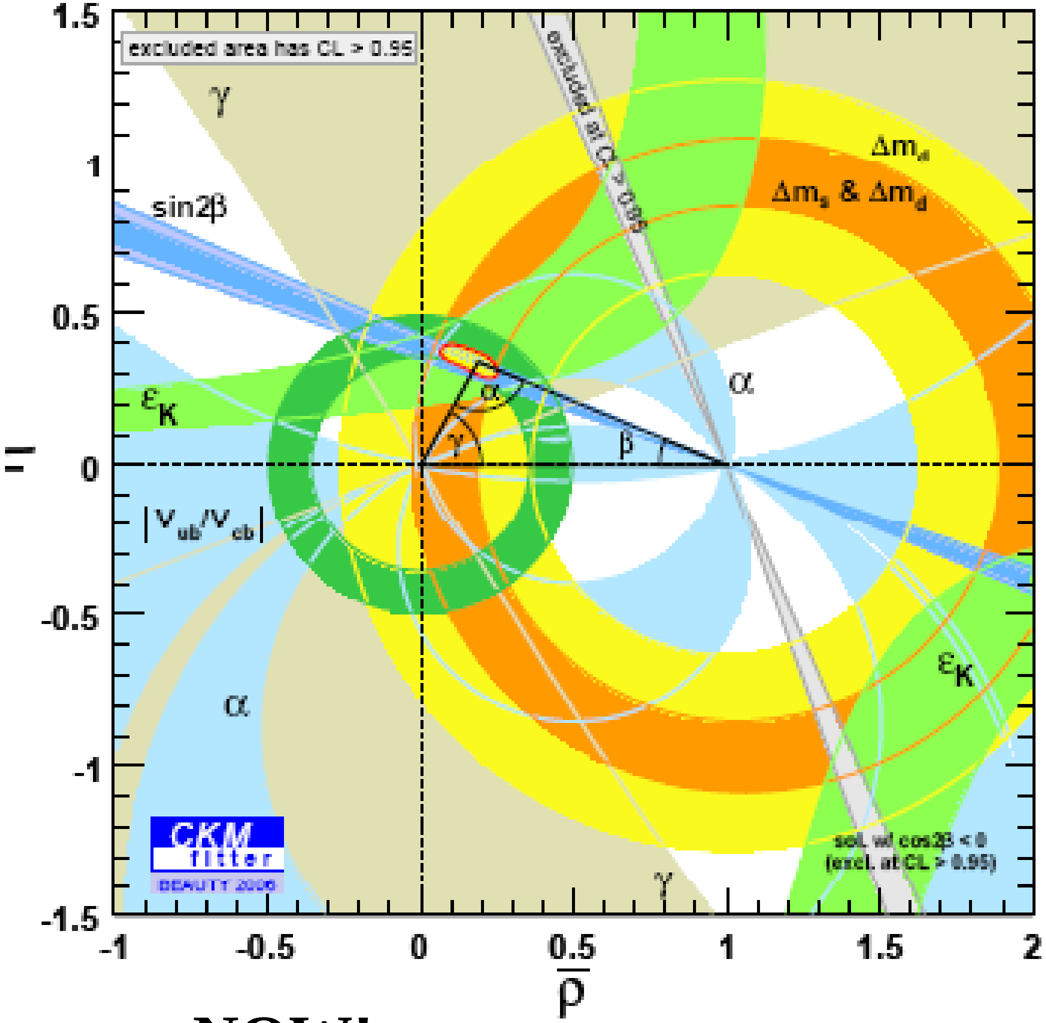
- From BFactories to Super BFactories :
  ideas and evolution.
- The status of the SuperB project as Super Flavour Factory
- Next steps

CKM Unitarity Triangle

Before Bfactories



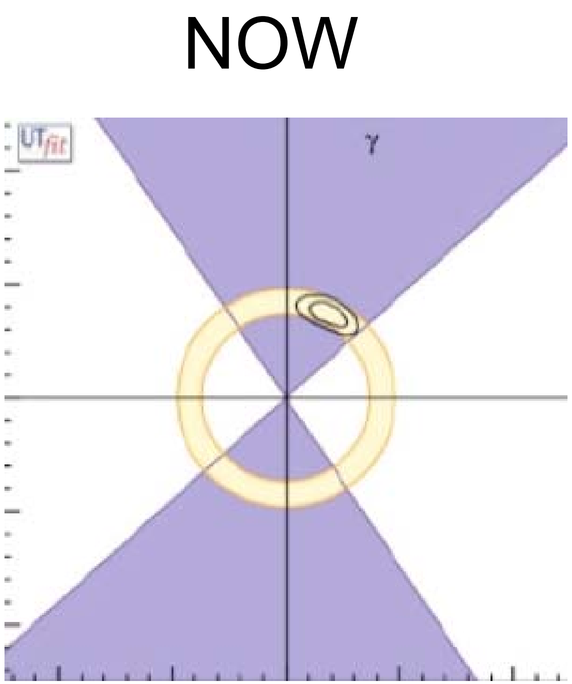
One example of CKM information coming only by sides measurements

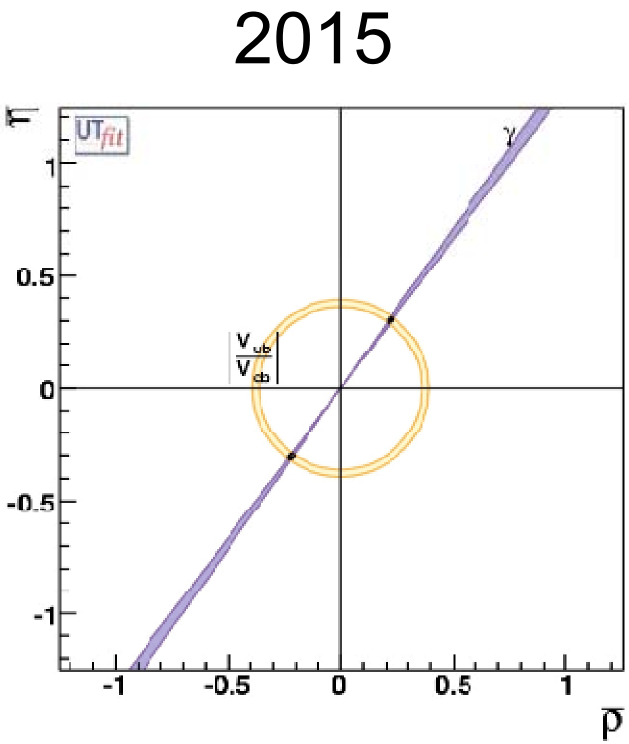


NOW!

CKM: Tree Level processes

Triangle vertex
Determined by N.P.
free processes





With 50 ab-1

γ *is measured at 1° level*

- Theorists promise to reduce theoretical uncertainties on sides: (V.Lubicz, SuperB IV Villa Mondragone nov.2006)
  - V_{ub} : 2% (excl.) 2% (incl.)
  - V_{cb} : 1% (excl.) 0.5% (incl.)

CPV in rare decays (PENGUINS)

Precision expected at high lumi from unpolarized e+ e-

Channel	*Goal*	3 ab^{-1}	10 ab^{-1}	50 ab^{-1}
$S(B^0 \to \Phi K_s)$	~5%	16%	8.7%	3.9%
$S(B^0 \to \eta' K_s)$	~5%	5.7%	3%	1%
$S(B^0 \to \pi^0 K_s)$		8.2%	5%	4%
$S(B^0 \to \pi^0 K_s \gamma)$	SM ~2%	11%	6%	4%
$A_{CP}(b \to s \gamma)$	SM ~5%	1.0%	0.5%	0.5%
$A_{CP}(B \to K^* \gamma)$	SM ~5%	0.6%	0.3%	0.3%

τ (GOLDEN MEDAL)/ Charm (BRONZE)

SuperB will be a Superτ and SuperC
I will not present sensitivity for LFV or Universality
(see M.Roney talk).
A new star from Babar and Belle:

$$D^0 - \overline{D^0} \quad mixing$$

x= (0.85+0.32-0.31)% y= (0.71+0.20-0.22)%
(HFAG- D.Asner)

cosδ = 0.40+0.23-0.31 x=0,y=0 is excluded at 5 σ

I will skip also $B^{\pm} \rightarrow \tau^{\pm} \nu$
and motivation for runs at Y(5S):B_s

- NO oscillations
- Only partially integrated time dependent asymmetries

$$\frac{\Gamma_{t_{tag} \geq t_{CP}} - \Gamma_{t_{tag} < t_{CP}}}{\Gamma_{t_{tag} \geq t_{CP}} + \Gamma_{t_{tag} < t_{CP}}}$$

$\Delta\Gamma_{s,}$ possible
$A_{sl(s)}$ YES
B_s -> $\mu\mu$ YES
B_s -> $\gamma\gamma$ YES

Start of an adventure

Since 2002 inside the Belle and Babar communities studies have been started to evaluate possible upgrades of KEKB and PEPII to increase luminosities well above $10^{34} cm^{-2} s^{-1}$.

It was clear in 2004 that if the goal is to look for evidence of new physics beyond S.M. in the era of LHC and before ILC would be needed more than 10 ab^{-1} / year it corresponds to $\sim 10^{10}$ b,c and τ pairs per year.

Only in this way this new facility could have chance of discovering New Physics and being complementary with LHC experiments .

Super B factories can do tau physics, explore channel with neutrinos including $B \rightarrow$ (invisible).

Three factors to determine luminosity:

Stored current:

1.36/1.75 A (KEKB)

→ 4.1/9.4 A (SuperKEKB)

Beam-beam parameter:

0.059 (KEKB)

→ >0.24 (SuperKEKB)

Lorentz factor

$$L = \frac{\gamma_{\pm}}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\frac{I_{\pm}\xi_{\pm y}}{\beta_y^*}\left(\frac{R_L}{R_y}\right)$$

Classical electron radius

Beam size ratio

Geometrical reduction factors due to crossing angle and hour-glass effect

Luminosity:

0.16×10^{35} cm^{-2}s^{-1} (KEKB)

8×10^{35} cm^{-2}s^{-1} (SuperKEKB)

Vertical β at the IP:

6.5/5.9 mm (KEKB)

→ 3.0/3.0 mm (SuperKEKB)

Summary from Oide's talk at 2005 2nd Hawaii SuperBF Workshop

- Present design of SuperKEKB **(SAME CONSIDERATIONS FOR PEPII)** hits fundamental limits in the beam-beam effect and the bunch length (HOM & CSR) Higher current is the only way to increase the luminosity .

- Many technical and cost issues are expected with a new RF system

We need a completely different collider scheme.....

HIGH CURRENT and HIGH BACKGROUND IS AN ISSUE FOR DETECTOR DESIGN
WALL POWER NEEDED (even >>100MW)

(2005) Super PEPII study/ similar to Super KEKB

Luminosity	2-3x10[34]	1.5x10[35]	2.5x10[35]	7x10[35]	Units
e^+	3.1	3.1	3.5	8.0	GeV
e^-	9.0	9.0	8.0	3.5	GeV
I^+	4.5	8.7	11.0	6.8	A
I^-	2.0	3.0	4.8	15.5	A
β(y*)	7	3.6	3.0	1.5	mm
β(x*)	30	30	25	15	cm
Bunch length	7.5	4	3.4	1.7	mm
# bunches	1700	1700	3450	6900	
Crossing angle	0	0	±11	±15	mrad
Tune shifts (x/y)	8/8	11/11	11/11	11/11	x100
rf frequency	476	476	476	952	MHz
Site power	40	75	85	100	MW

Now 3.A

And 2.A

Fancy idea of PANTA

- Basic Idea comes from the ATF2-FF experiment

In the proposed experiment it seems possible to acheive spot sizes at the focal point of about 2μm*20nm at very low energy (1 GeV), out from the damping ring

- Rescaling at about 10GeV/CM we should get sizes of about 1μm*10nm =>
- Is it worth to explore the potential of a Collider based on a scheme similar to the Linear Collider one

Hawaii workshop on Super-B factory March-2005 (P.Raimondi)

BUT!

After several attempt still HIGH DISRUPTION Effective horizontal size during collision about 10 times smaller, vertical size 10 times larger

High Lumi solutions with HIGH WALL POWER >100 MW

The breakthrough

Nevertheless we decided to go on and explore possibility of a super machine of 10^{36} cm^{-2} s^{-1} or more giving an integrated lumi > 15 ab^{-1} / year trying to fund high lumi on small beam size, low emittance and final focus similar to ILC.

A strongly determined SuperB community was formed and the INFN set up an International Study Group to prepare a CDR with: Physics Case, Machine and Detector conceptual design.

The SuperB effort is coordinated by a Steering Committee with members from France,Italy,Germany, Russia,Spain,UK and US.

We had 4 SuperB workshops in one year from Nov 2005 to Nov 2006 and several national meetings in different countries

Several hundreds of physicists : theorists, experimentalists and machine people took part to general workshops

PHYSICS CASE for Super Flavour Factory

The physics case for a Super Flavour Factory emerged solid if : The sample of data available in a few years of running would be bigger than 50 ab $^{-1}$ and approaching 100 ab $^{-1}$ (10^{11} B Bbar, tau and charm pairs) .

L between 10^{36} and 10^{37} cm^{-2} s^{-1}

WALL POWER<<50MW as in KEKB and PEPII

Background in the detector as in PEPII

Possibility of running at lower CM Energy (4.0 GeV) still with $L > 10^{35}$ for special runs on Charm (making use of the coherent production of D's from ψ'.)

Possibility of one polarized beam for Tviolation studies in τ.

We in fact are planning both beams polarized.

The running period is overlapped to LHC. (Results from Super Flavour Factory and LHC are largely complementary).

REFERENCE DOCUMENTS see for example:

Report from Roadmap committee (Slac.BABAR Analysis Doc#828 26July2004)

The Discovery Potential of a Super B Factory (Slac-R-709)

Letter of Intent for KEK Super B Factory (KEK Report 2004-4)

Physics at Super B Factory (hep-ex/0406071)

Many documents available at the URL : www.pi.infn.it/SuperB

BUT WHERE ARE WE NOW?

High luminosity requires:

- **short bunches**
- **small vertical emittance**
- **large horizontal size and emittance to mimimize beam-beam**

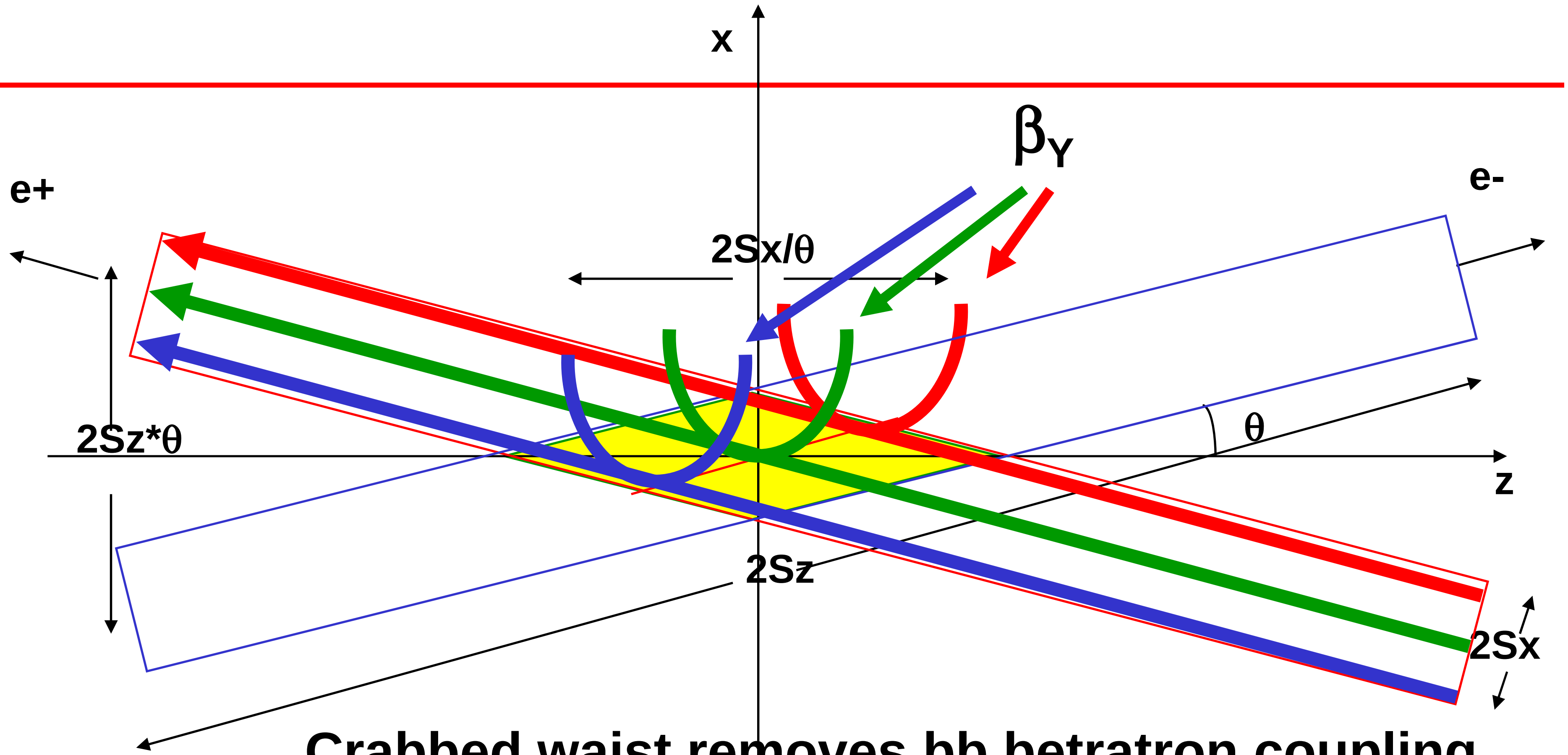
For a ring:

- **easy to achieve small horizontal emittance and horizontal size**
- **Vertical emittance goes down with the horizontal**
- **Hard to make short bunches**

Crossing angle swaps X with Z, so the high luminosity requirements are naturally met:

Luminosity goes with $1/\varepsilon_x$ and is weakly dependent by σ_z

CROSSING ANGLE WITH CRAB WAIST



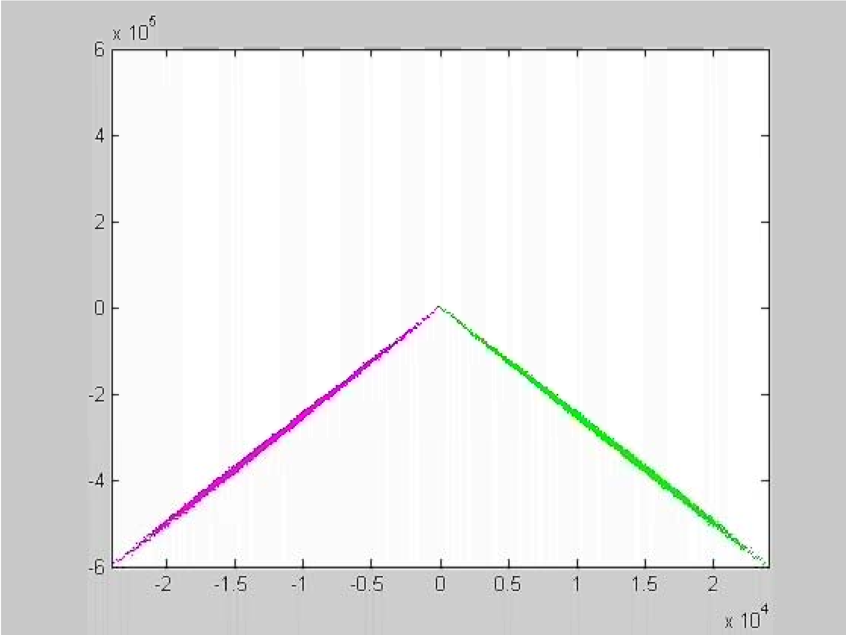
Crabbed waist removes bb betratron coupling Introduced by the crossing angle

Vertical waist has to be a function of x:

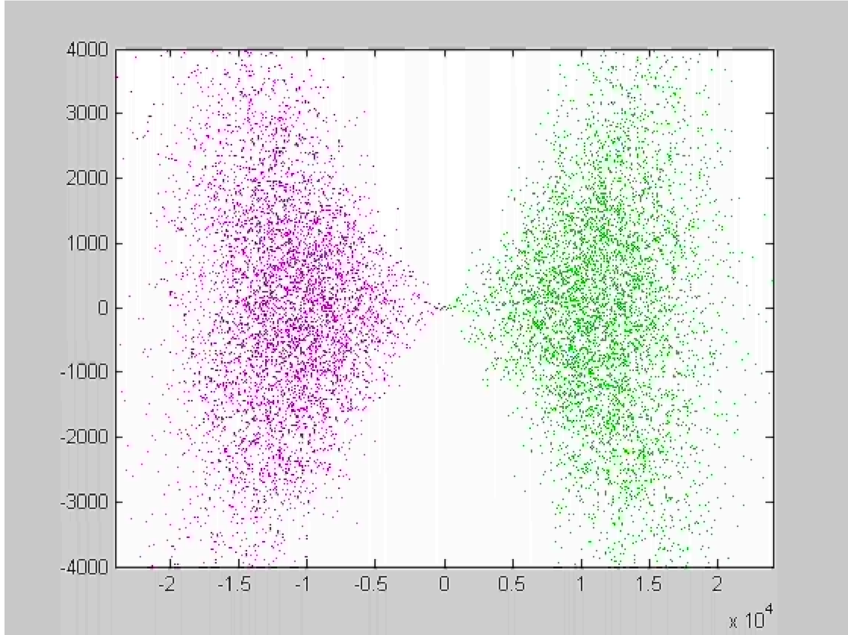
Z=0 for particles at $-\sigma_x$ ($-\sigma_x/2\theta$ at low current)

Z= σ_x/θ for particles at $+\sigma_x$ ($\sigma_x/2\theta$ at low current)

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



Horizontal Plane



Vertical Plane

Collisions with uncompressed beams

Crossing angle = 2*25mrad

Relative Emittance growth per collision about $1.5*10^{-3}$

$\varepsilon_{yout}/\varepsilon_{yin}=1.0015$

BB simulations with ILC code etc...

Various satisfactory simulations have been made with the contribution of many people from various laboratories and with different codes:

LNF,BINP,KEK,LAL,CERN

Collisions with uncompressed beams

Crossing angle = 2*15 mrad

Relative Emittance growth per collision: $\varepsilon_{yout}/\varepsilon_{yin}$=1. 5x$10^{-3}$

SuperB new approach based on ILC FF and DR

*Crossing angle = 2*17 mrad*

ILC DR & FF

DR damping time as PEPII-KEKB

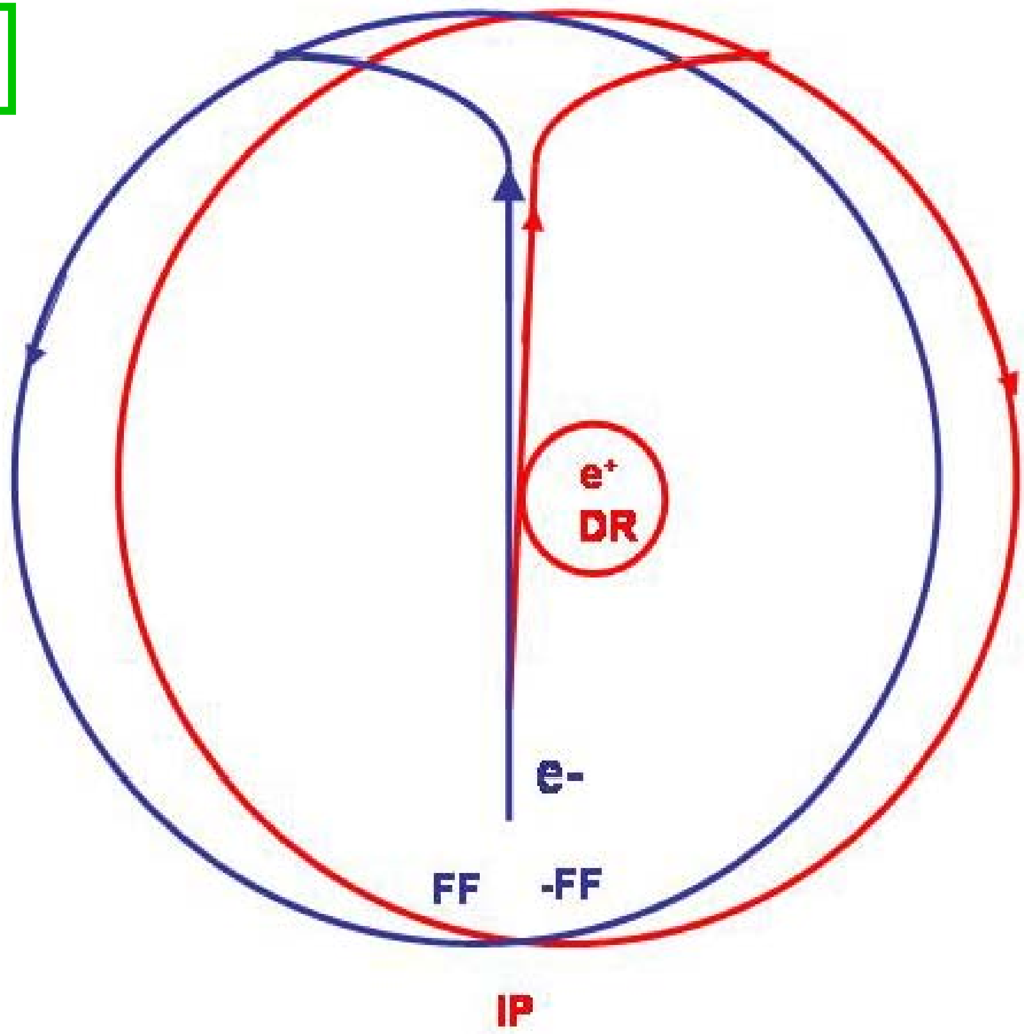
1.5 times DR bunch charges

Same ILC-IP betas

Crossing angle and "crab waist" to minimize bb blowup

Design based on recycling all PEP hardware, Bends, Quads and Sexts, and RF system.

Low ΔE and wall power.



SuperB Contributors (Basic concepts):
BINP: KEKB: LNF: Pisa:SLAC

Machine parameters

	Nominal	Parameters	Upgrade	Parameters	Ultimate	Parameters
PARAMETER	LER	HER	LER	HER	LER	HER
Particle type	e+	e-	e+	e-	e+	e-
Energy (GeV)	4	7	4	7	4	7
Luminosity x 10^{36}	1		2.4		3.4	
Circumference (m)	2250	2250	2250	2250	2250	2250
Revolution frequency (MHz)	0.13	0.13	0.13	0.13	0.13	0.13
Eff. long. polarization (%)	0	80	0	80	0	80
RF frequency (MHz)	476	476	476	476	476	476
Harmonic number	3570	3570	3570	3570	3570	3570
Momentum spread	8.4E-04	9.0E-04	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Momentum compaction	1.8E-04	3.0E-04	1.8E-04	3.0E-04	1.8E-04	3.0E-04
Rf Voltage (MV)	6	18	6	18	7.5	18
Energy loss/turn (MeV)	1.9	3.3	2.3	4.1	2.3	4.1
Number of bunches	1733	1733	3466	3466	3466	3466
Particles per bunch x10^{10}	6.16	3.52	5.34	2.94	6.16	3.52
Beam current (A)	2.28	1.30	3.95	2.17	4.55	2.60
Beta y* (mm)	0.30	0.30	0.20	0.20	0.20	0.20
Beta x* (mm)	20	20	20	20	20	20
Emit y (pmr)	4	4	2	2	2	2
Emit x (nmr)	1.6	1.6	0.8	0.8	0.8	0.8
Sigma y* (microns)	0.035	0.035	0.020	0.020	0.020	0.020
Sigma x* (microns)	5.657	5.657	4.000	4.000	4.000	4.000
Bunch length (mm)	6	6	6	6	6	6
Full Crossing angle (mrad)	34	34	34	34	34	34
Wigglers (#)	4	2	4	4	4	4
Damping time (trans/long)(ms)	32/16	32/16	25/12.5	25/12.5	25/12.5	25/12.5
Luminosity lifetime (min)	10.4	5.9	7.4	4.1	6.1	3.5
Touschek lifetime (min)	5.5	38	2.9	19	2.3	15
Effective beam lifetime (min)	3.6	5.1	2.1	3.4	1.7	2.8
Injection rate pps (100%)	4.9E+11	2.0E+11	1.5E+12	5.0E+11	2.1E+12	7.2E+11
Tune shifts (x/y) (from formula)	0.004/0.17	0.004/0.17	0.007/0.16	0.007/0.16	0.009/0.2	0.009/0.2
RF Power (MW)	17		35		44	

We have a Machine Baseline

A baseline of machine design for 1.0 10^{36} is now available!

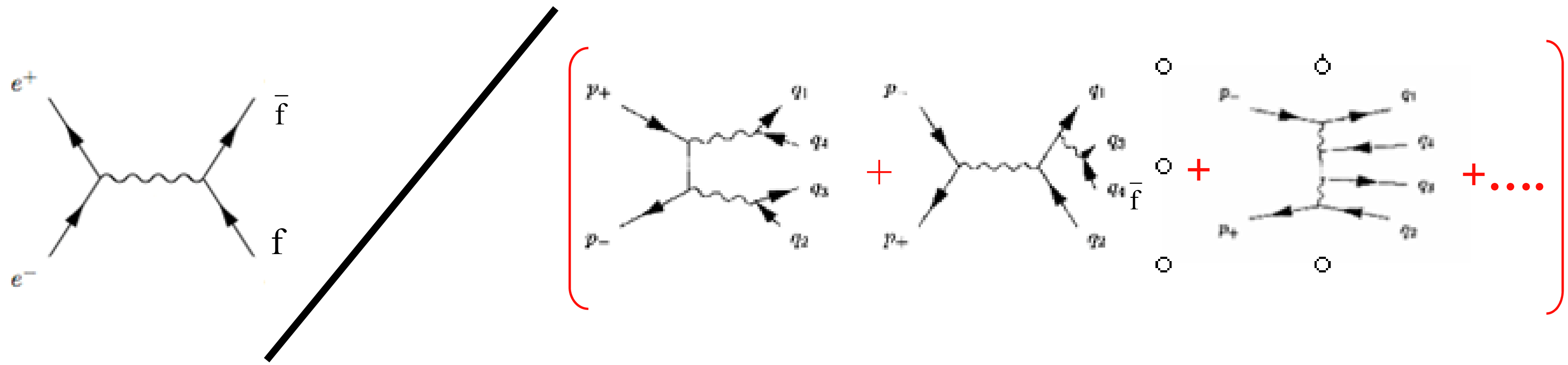
It could operate at 4.0 GeV c.o.m Energy at luminosity 10^{35}

A preliminary estimate of fully inclusiveWall Power is now available

(17MW+18MW)=35MW! As in PEPII

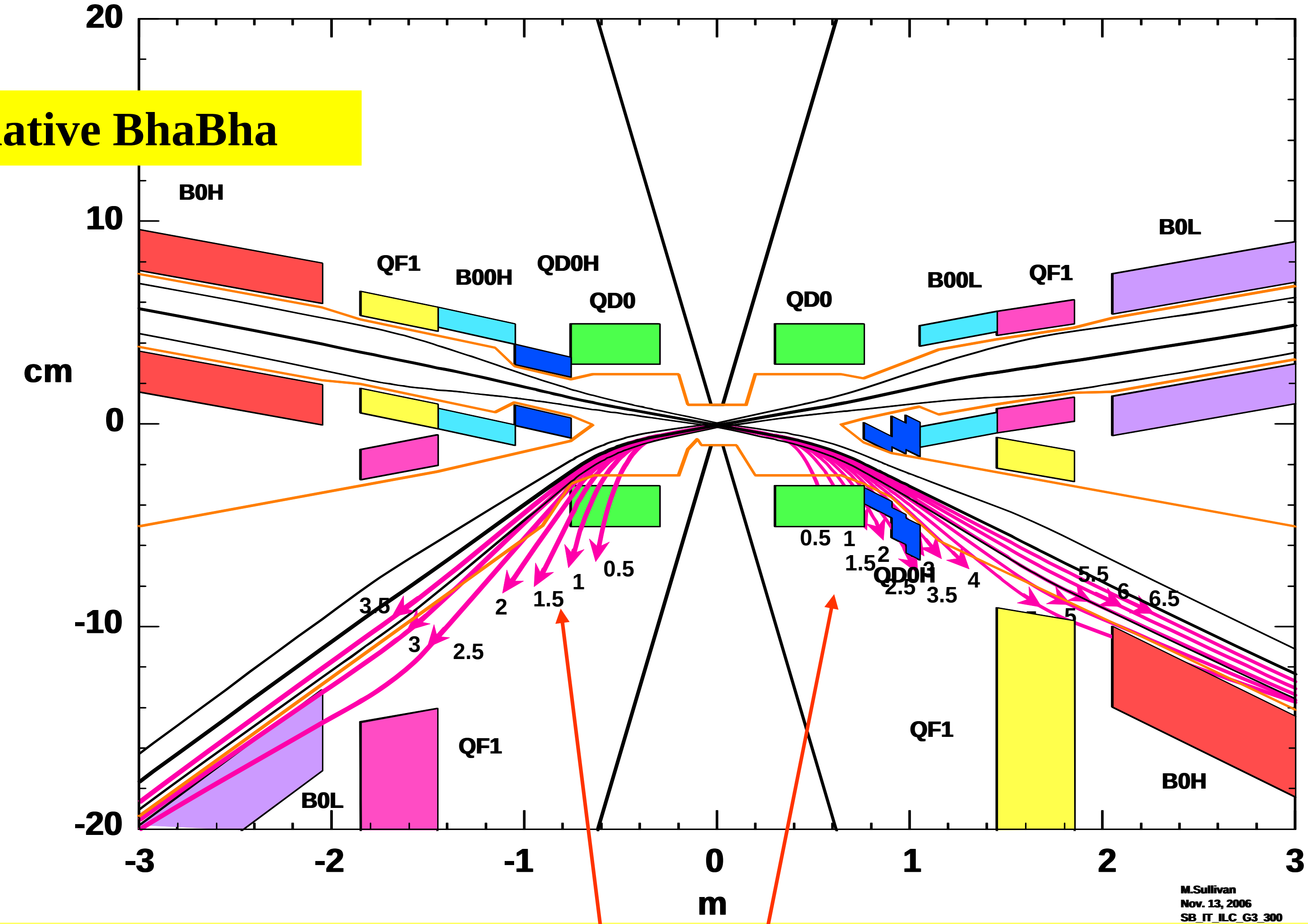
Current as is now in PEPII (can manage Background !)

Polarized beams for tau physics and to enhance the events from annihilation processes (b,c,tau pairs) w.r.t. pair production (polarisation of positrons and electrons as considered produce almost a factor 1.5 more of signal events wrt unpolarized, while the Bhabha production is the same)



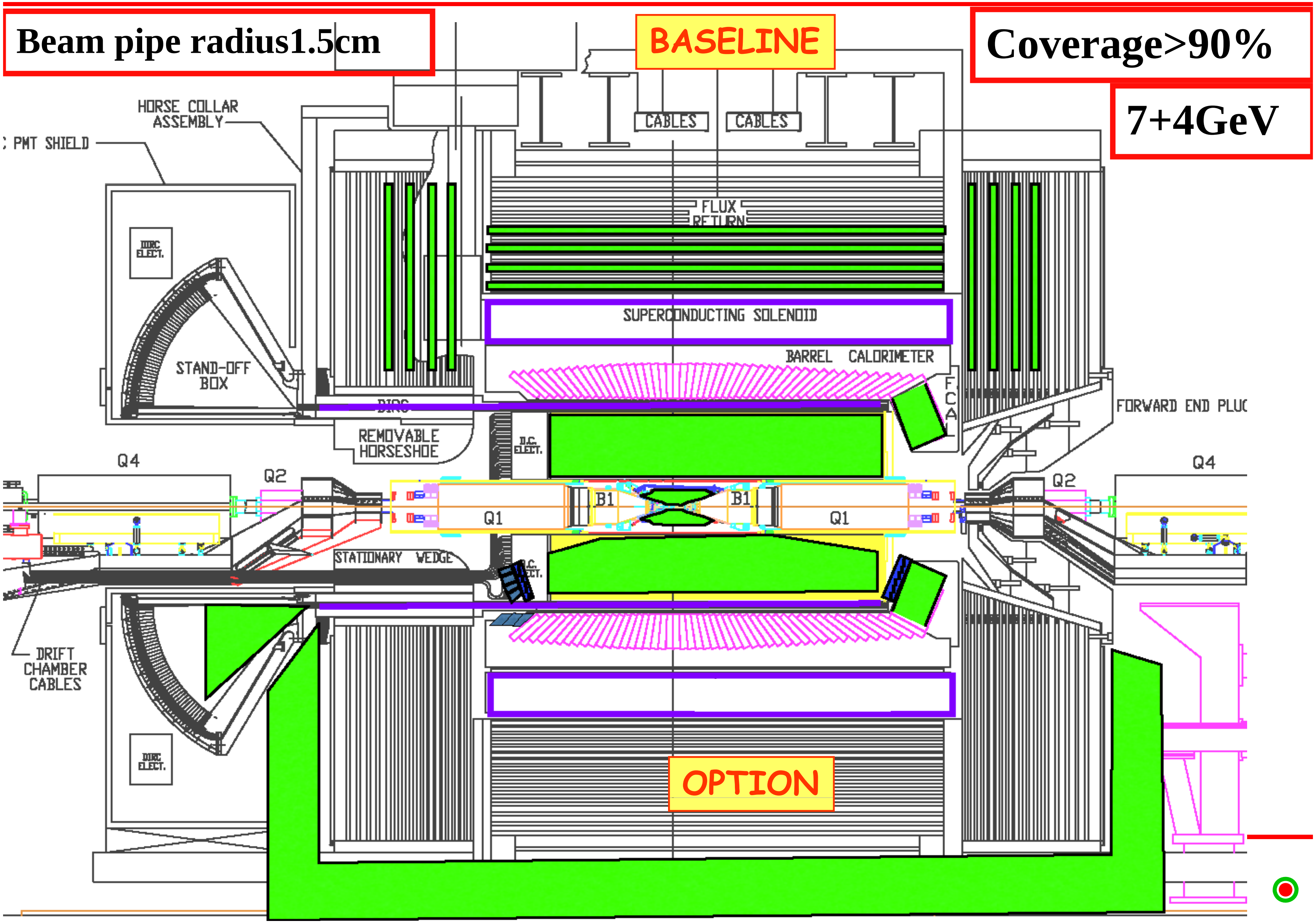
We have an IR design coping with main BKG source

Radiative BhaBha



Need serious amount of shielding to prevent the produced shower from reaching the detector.

Extrapolation from BABAR, it could have been from Belle



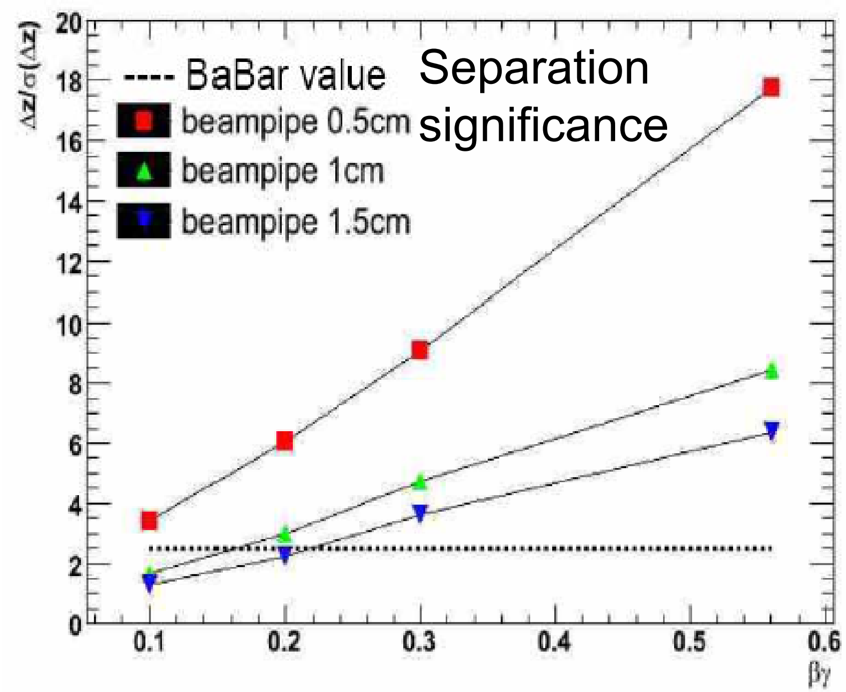
Beam Pipe Radius and Detector Issues

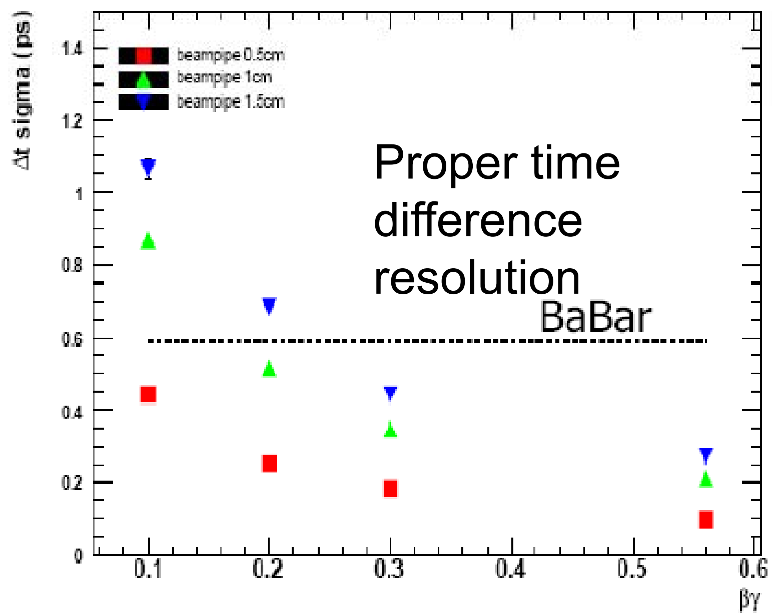
- Small beam pipe radius possible because of small beam size
  - Studied impact of boost on vertex separation ($B \rightarrow \pi\pi$)
  - Rest of tracking is Babar
  - Beam pipe needs to be cooled.Study is in progress to keep total thickness low in the order of % of χ_{rad}

7+4GeV

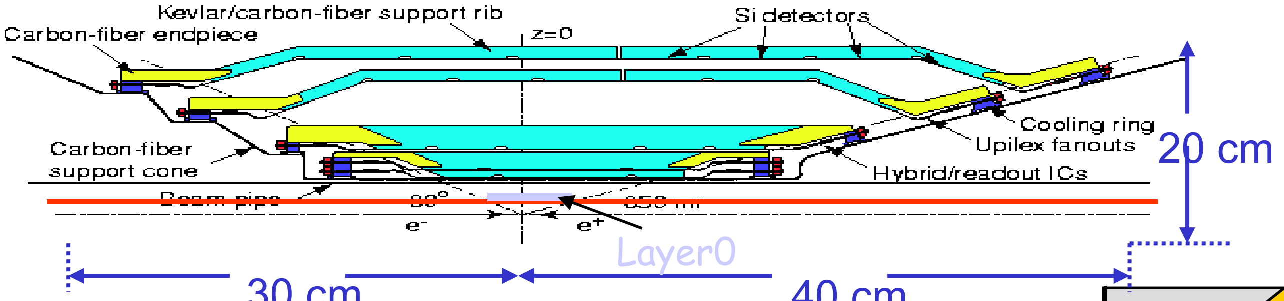
Boost $\beta\gamma$=.28

Instead of 0.56

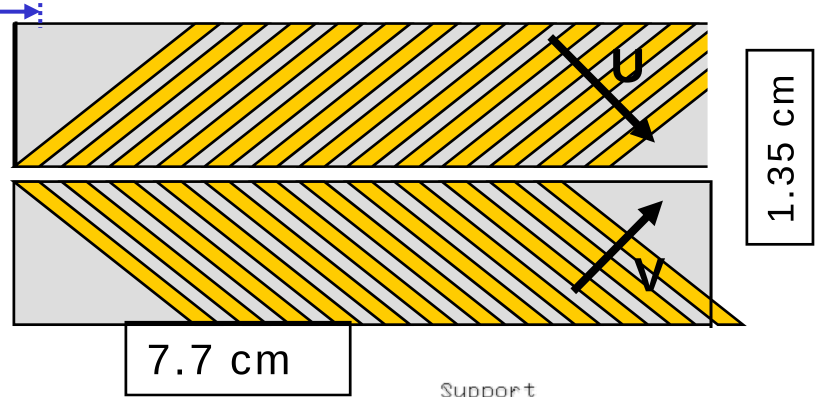


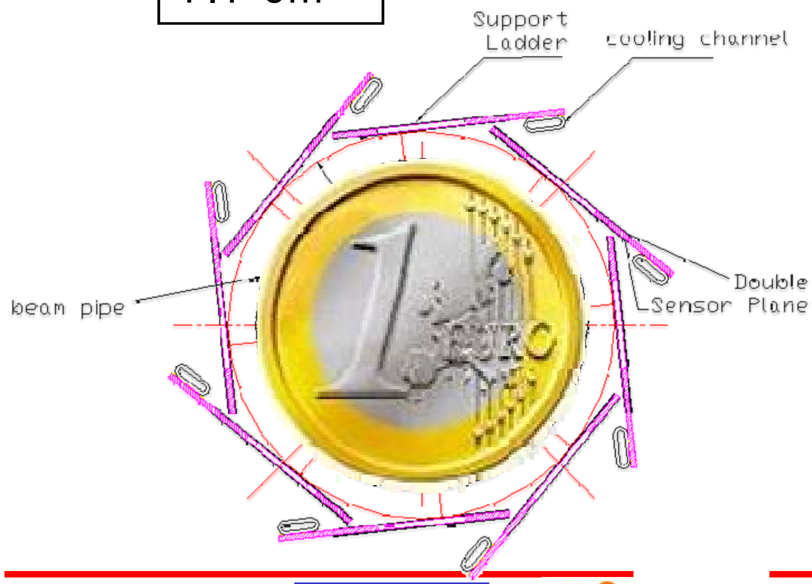


SVT Layer 0



- Depends critically on background level
  - Striplet solution (baseline)
    - Basically already available technology but more sensitive to background. OK for 1MHz/cm^2
    - Some margin to improve background sensitivity
  - Monolithic Active Pixel Solution solution (option)
    - R&D is still ongoing but giving a big safety margin in terms of performance and occupancy
    - Cooling and mechanical issues need to be addressed



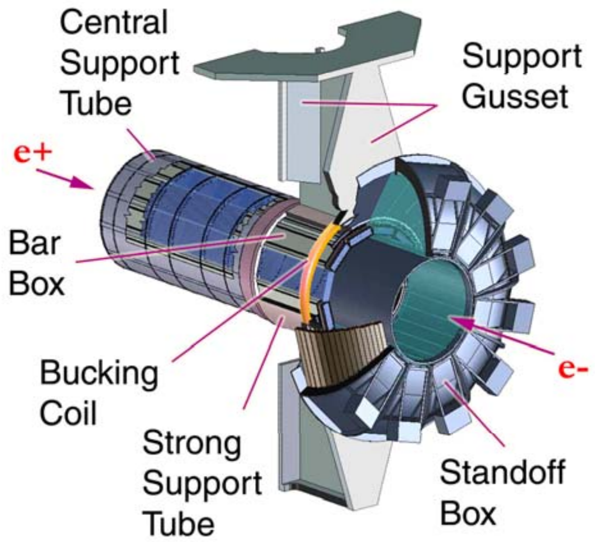


DCH

- Basic technology adequate.
- Cannot reuse BaBar DCH because of aging
- Baseline:
  - Same gas, same cell shape
  - Carbon fiber endplates instead of Al to reduce thickness
  - → Need to do complete background estimate
- Options/Issues to be studied:
  - Miniaturization and relocation of readout electronics
    - Critical for backward calorimetric coverage
  - Conical endplate
  - Further optimization of cell size/gas

Particle ID

- Barrel DIRC baseline
  - Quartz bars are OK and can be reused
    - Almost irreplaceable
  - PMTs are aging and need to be replaced
  - Keep mechanical support
- Barrel Options
  - Faster PMTs
  - Focusing readout
  - Different radiator
  - Extra tracking device outside DIRC



Forward/Backward PID options:
Aerogel-based focusing RICH or TOF
Serious interference with other systems as material in front of the EMC. it requires space then miniaturization and displacement of DCH electronics

TOF seems the only viable option

Forward EMC crystals

- Barrel CsI(Tl) crystals
  - Still OK and can be reused (the most expensive detector in BaBar)
  - Baseline is to transport barrel as one device
- Both pure CsI and LSO could be used in the forward EMC
- LSO more expensive, but more light, more compact, and more radiation hard
  - Now LSO is available industrially
  - Cost difference still significant, but not overwhelming.
- Use LSO as baseline
  - Gives better performance
  - Leaves PID option open
- CsI option still open
  - in case of cost/availability issues

Crystal	CsI(Tl)	CsI	LSO
τ decay(ns)	680, 3340	16	47
χ_0(cm)	1.86	1.86	1.14
$R_{moliere}$ (cm)	3.8	3.8	2.3
$\lambda_{nuclear}$ (cm)	37	37	
LY (γ/MeV)	56000, 64:36%	2500	27000
λpeak (nm)	550	315	420
Rad Hard (Mrad)	.01	.01-.1	100
ρ (g/cm3)	4.51	4.51	7.40
n_0	1.79	1.95	1.82

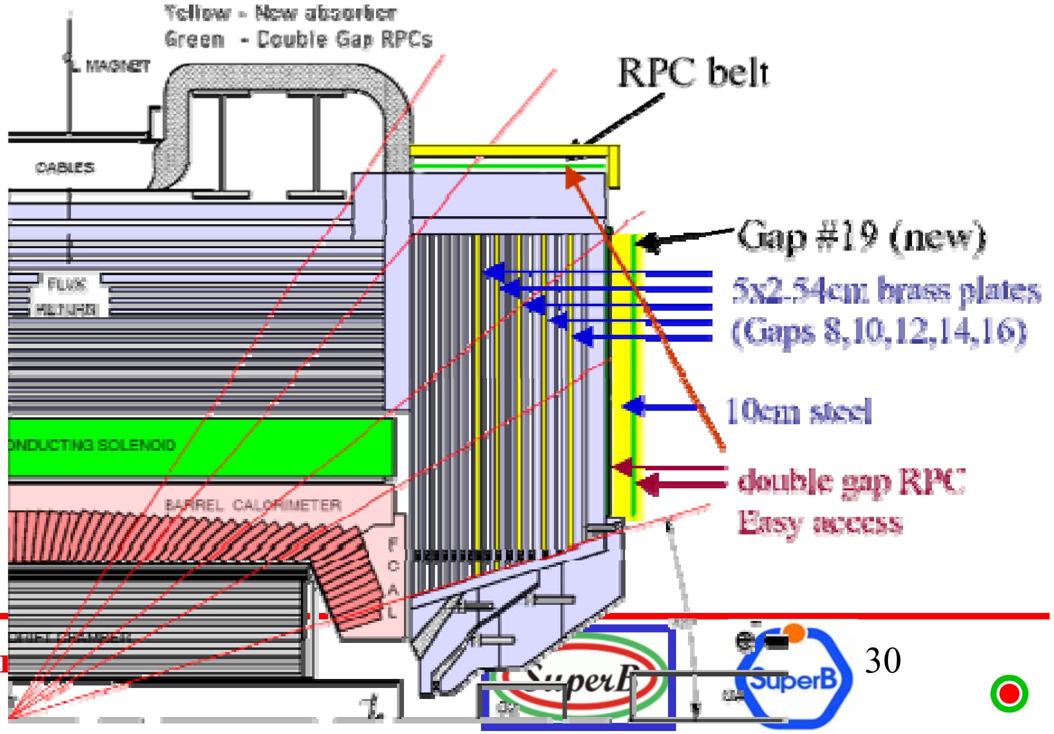
Backward calorimeter

- Keep as an option
  - Backward endcap
  - Barrel extension
- Could be less performant
- Benchmark physics gain

IFR and steel

- BaBar configuration has too little iron for μ ID
  - $> 6.5\ \lambda_I$ required; 4-5 available in barrel
- Fine segmentation overdid K_L efficiency optimization
  - Focus on μ ID : fewer layers and more iron
  - → Is it possible to use the IFR in K_L veto mode ?

- Baseline:
  - Fill gaps in Babar IFR with more iron
  - Leave 7-8 detection layers
  - Need to verify structural issues
  - LST in barrel
  - Avalanche RPC in EC for rate



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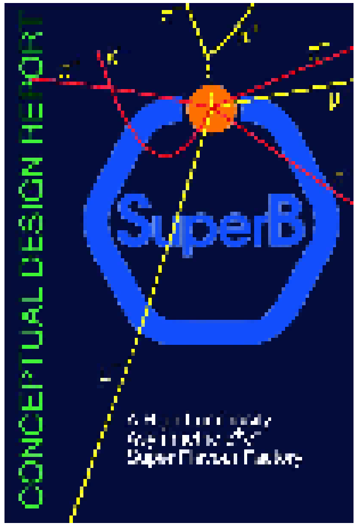
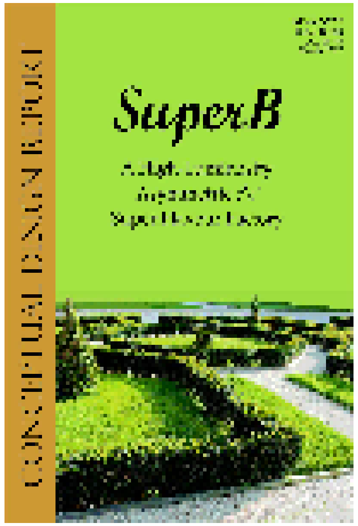
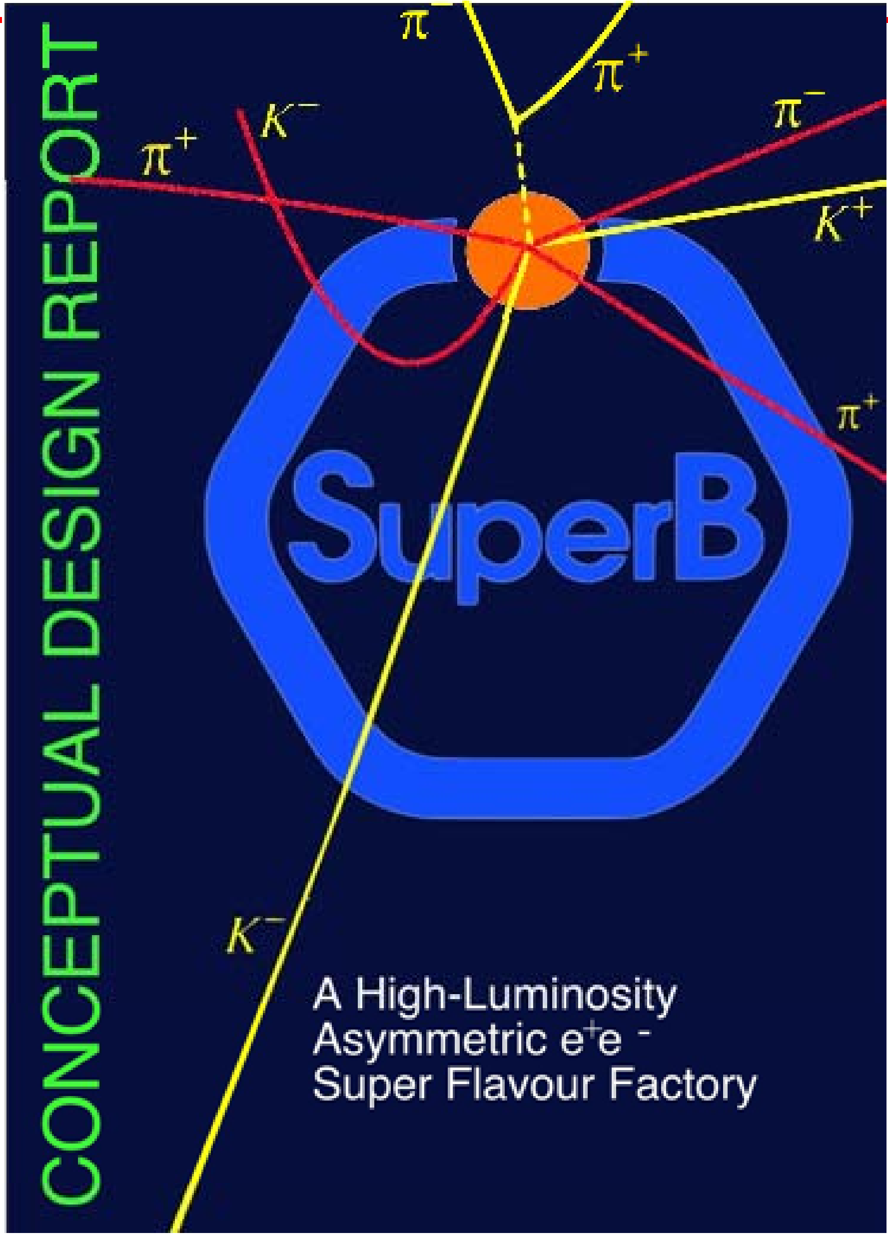
3 options





CDR



The CDR of SuperB is ready!

Available as public Draft in at:

http//www.pi.infn.it/SuperB

And the distribution of the printed version by INFN and SLAC will start in a few days.

- The International Review Committee for SuperB appointed by the INFN will start activity by receiving copy of our CDR.
- The Report is expected in the fall 2007.

CRAB WAIST test in Daphne at end Summer-Fall 2007 (milestone!)
Optimization of the SuperB design (Nov, 2007)
ASK FOR FUNDING to create a international cooperation to build SuperB as "**Regional Machine**" as in the report of the European Strategy Group.

As a start we intend to apply to EU in the FP7 **(by May 2,2007)** for the design study and the tests related to SuperB.
Partners EU and non EU laboratories and agencies:INFN,ORSAY,Cockroft-Daresbury,CERN, Budker-Novosibirsk, KEK,SLAC,

Next dates

May 7 meeting in LNF and Roma Tor Vergata to present officially CDR to Press and local authorities.

May 9-11 SuperB workshop in Paris

Last day devoted to a joint meeting SuperB-SuperKEKB communities.

POSSIBLE!

If approved it will probably be built in Italy not far from Frascati.

SuperB will become an international entity close to the National Laboratory of Frascati , but not part of it.

It will be run internationally in a true cooperation spirit among partners.

Tor Vergata : A POSSIBLE SITE