# *BFactories Presente e Futuro*

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# OUTLINE

- From BFactories :
  ideas and experiments
- Some Results CPV (Direct & Indirect), Rare B Decays,Tau-Charm Physics
- Next steps : Super Flavor Factory

# Physics GOALS for Bfactories

1)Search for CP violation in B meson decays, largely predicted by the Standard Model

2)Test extensively at this low energy scale the Standard Model by measuring precisely enough quantities to impose constraints on the Standard Model parameters

~~CP~~ in b sector has been established by BaBar and Belle (2001)

**TRY to open windows on new Physics beyond Standard Model**

More precise CKM measurements, Rare B decays, Charm study, Tau rare decays .

# 3 ways to CP violation

CPV in decay:

$$\mathrm{A}_{CP,f/\bar{f}} \equiv \frac{\Gamma(\bar{i} \to \bar{f}) - \Gamma(i \to f)}{\Gamma(\bar{i} \to \bar{f}) + \Gamma(i \to f)}$$

CPV in mixing:

$$\mathrm{A}_{SL}(t) \equiv \frac{d\Gamma/dt\,(\bar{P}^0_{phys} \to l^+X) - d\Gamma/dt\,(P^0_{phys} \to l^-X)}{d\Gamma/dt\,(\bar{P}^0_{phys} \to l^+X) + d\Gamma/dt\,(P^0_{phys} \to l^-X)} = \frac{1-|q/p|^4}{1+|q/p|^4}$$

$|q/p| \neq 1$

**T Viol.!!**

**As in $K_L$ exp of Cronin et al. 1964**

CPV in the interference decay-mixing:

$\Im\mathrm{m}(\lambda_f) \neq 0$

$$\lambda_f \equiv \frac{q}{p}\frac{\bar{A}_f}{A_f}$$

For example: decays to CP eigenstates $f_{CP}$

$$\mathrm{A}_{f_{CP}}(t) \equiv \frac{d\Gamma/dt\,(\bar{P}^0_{phys} \to f_{CP}) - d\Gamma/dt\,(P^0_{phys} \to f_{CP})}{d\Gamma/dt\,(\bar{P}^0_{phys} \to f_{CP}) + d\Gamma/dt\,(P^0_{phys} \to f_{CP})}$$

$$A_1 = |A_1| \qquad \xrightarrow{\text{CP}} \qquad \bar{A}_1 = |A_1|$$

$$i \to f \qquad\qquad \bar{i} \to \bar{f}$$

$$A_2 = |A_2|\, e^{i\delta}\, e^{i\phi} \qquad\qquad \bar{A}_2 = |A_2|\, e^{i\delta}\, e^{-i\phi}$$

$\delta \to \delta$ (CP-conserving)

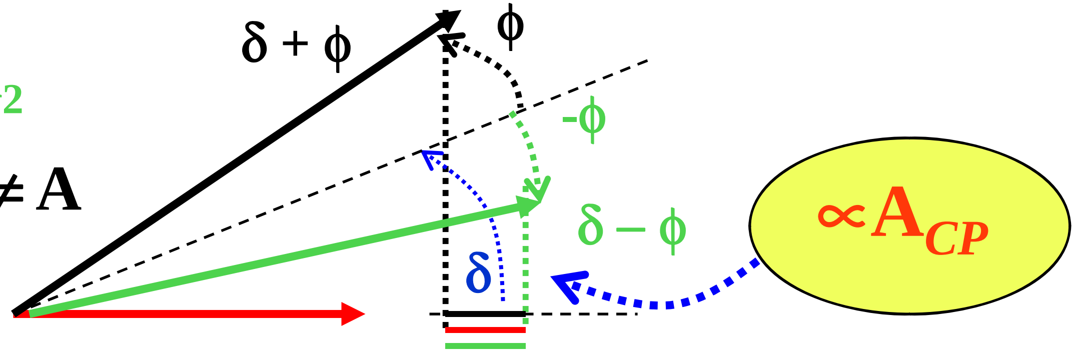
$\phi \to -\phi$ (CP-violating)

$$A_{CP,f/\bar{f}} \equiv \frac{\Gamma(\bar{i} \to \bar{f}) - \Gamma(i \to f)}{\Gamma(\bar{i} \to \bar{f}) + \Gamma(i \to f)} \propto \sin\Phi \sin\delta$$

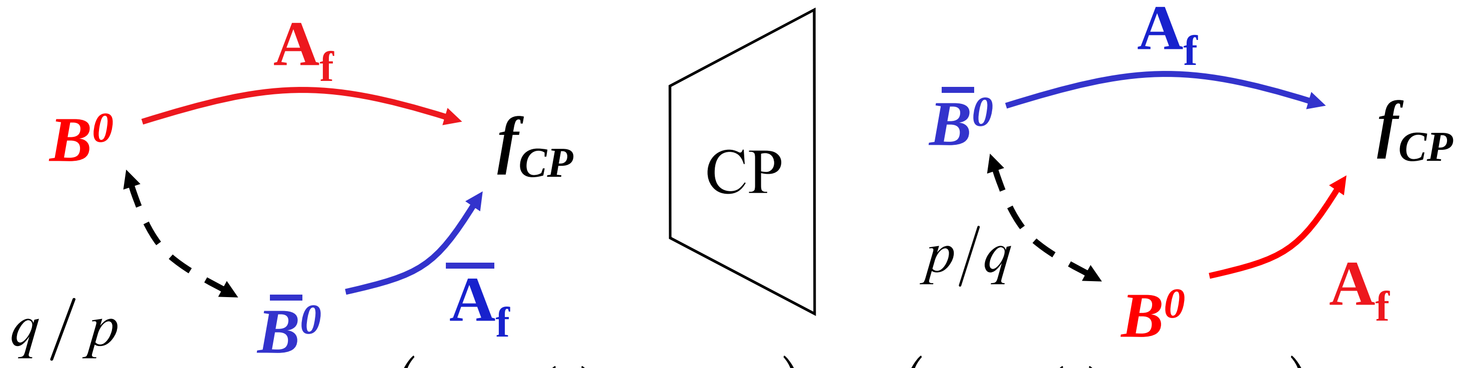
Time-integrated "direct" CP asymmetry requires two amplitudes and $\delta \neq 0$:

$$A = A_1 + A_2$$

$$\bar{A} = A_1 + \bar{A}_2 \neq A$$



# Observables time-dependent CP asymmetry




$$\Rightarrow \quad \Gamma\left(B^0_{phys}(t) \to f_{CP}\right) \neq \Gamma\left(\bar{B}^0_{phys}(t) \to f_{CP}\right)$$

Interference between mixing and decay to a CP eigenstate.
Flavor-tagged time-dependent decay rates are different!
they are governed by the "CP parameter":

$$\lambda_{f_{CP}} = \eta_{f_{CP}} \frac{q}{p} \frac{\bar{A}_{f_{CP}}}{A_{f_{CP}}}$$

*CP* eigenvalue

$\approx e^{-i2\beta}$ from mixing

Amplitude ratio

$$C_{f_{CP}} = \frac{1-|\lambda_{f_{CP}}|^2}{1+|\lambda_{f_{CP}}|^2}$$

$$S_{f_{CP}} = \frac{-2\,\mathrm{Im}\,\lambda_{f_{CP}}}{1+|\lambda_{f_{CP}}|^2}$$

For single decay amplitude

$= 0$

$= -\mathrm{Im}\,\lambda_{f_{CP}}$

**Asymmetry**

$$A_{f_{CP}}(\Delta t) = C_{f_{CP}} \cos(\Delta m_d \Delta t) - S_{f_{CP}} \sin(\Delta m_d \Delta t)$$

# ~~CP~~ in Standard Model

$$V = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} = \begin{pmatrix} 1-\frac{1}{2}\lambda^2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\frac{1}{2}\lambda^2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + O(\lambda^4)$$

CP Violating phase

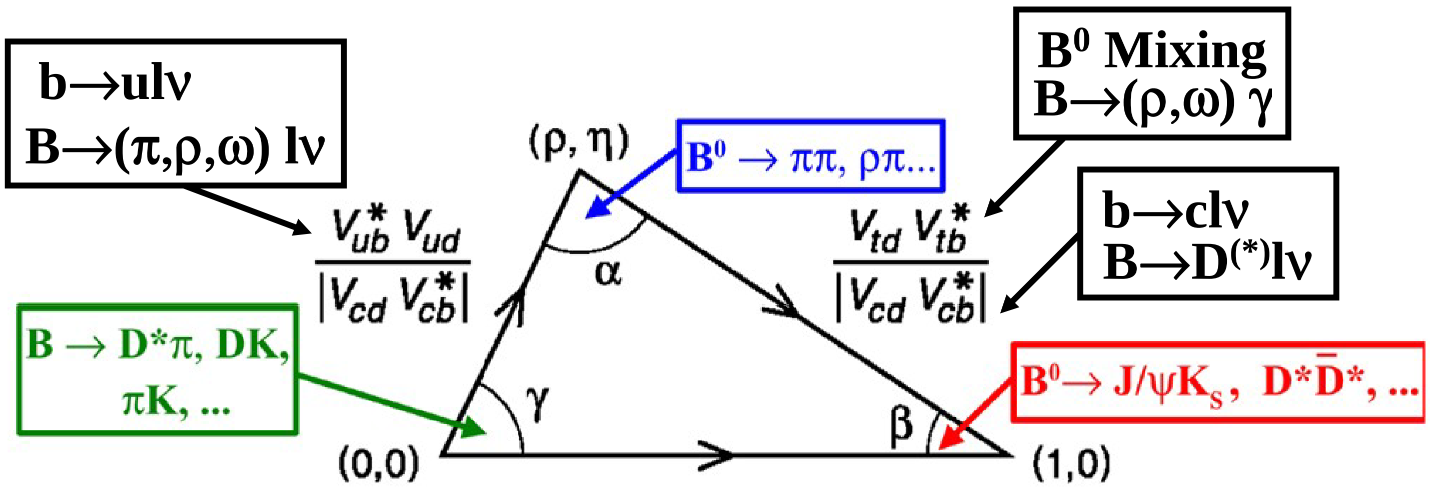
*CKM quark mixing matrix*

*Unitarity condition*

d·s* = 0 (K system)

s·b* = 0 ($B_s$ system)

d·b* = 0 ($B_d$ system)



# Precise tests of CKM

Angle $\beta/\Phi_1$ and $\alpha/\Phi_2$ can be measured through time dependent asymmetries.

## Tools:

Particle ID to tag meson decaying in CP eigenstate (B or antiB)

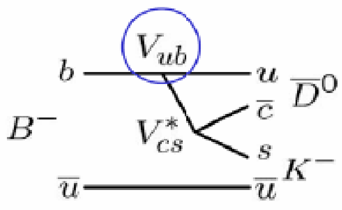
Precise measurement of decay time (Double Side Silicon Strip detectors). (Firstly used in Lep experiments)

Boost the c.o.m of B-antiB system (from Y4s) to allow mesons travel O(several 100mm) before decay. (This method was fistly used for the measurement of charm lifetime in fixed target experiments)

# Time dependent measurement of CPV Asymmetry

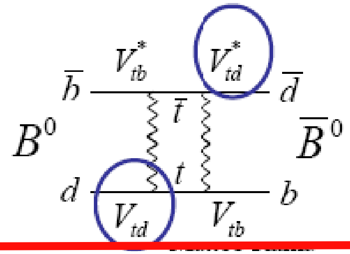
$$\gamma = \arg\left[-\frac{V_{ub}^* V_{ud}}{V_{cb}^* V_{cd}}\right]$$

Phase of $V_{ub}$
(b→u transition)



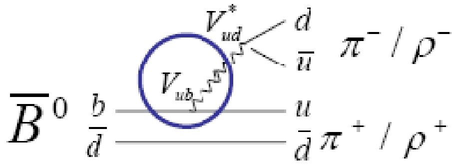

$$\beta = \arg\left[-\frac{V_{cb}^* V_{cd}}{V_{tb}^* V_{td}}\right]$$

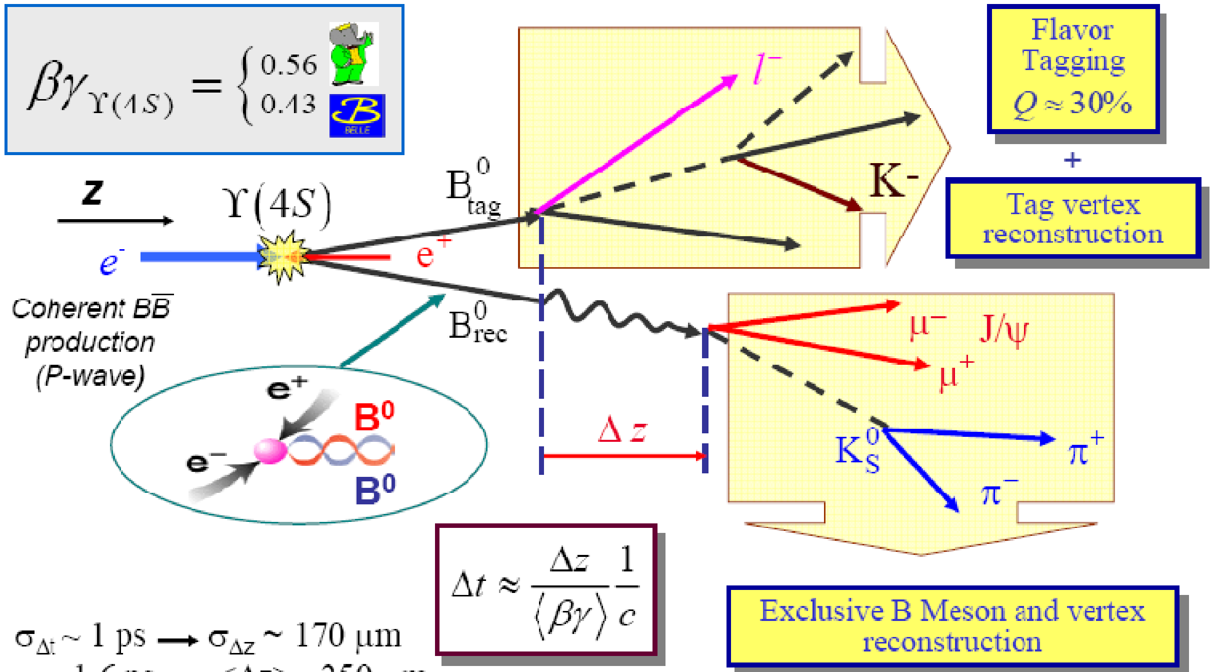
Phase of $V_{td}$
($B^0$-$B^0$ mixing)




$$\alpha \equiv \pi - (\gamma + \beta) \equiv \arg\left[-\frac{V_{tb}^* V_{td}}{V_{ub}^* V_{ud}}\right]$$

Phase of $V_{td}$ and $V_{ub}$ ($B^0$-$B^0$ mixing + b→u transition)



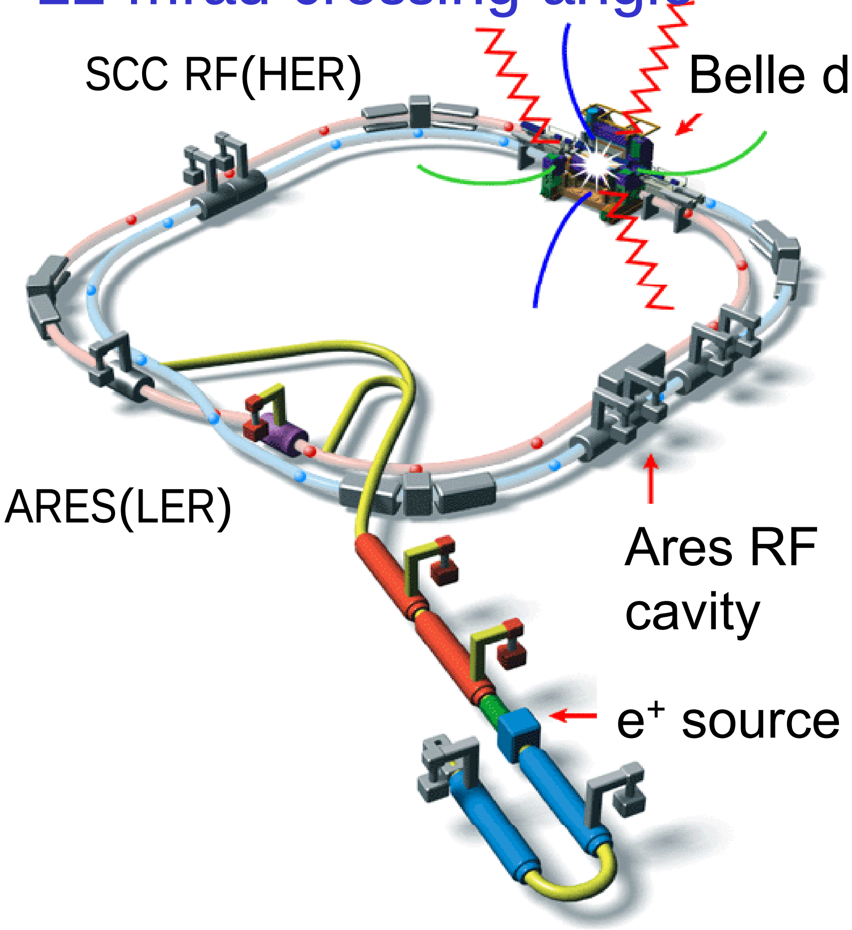



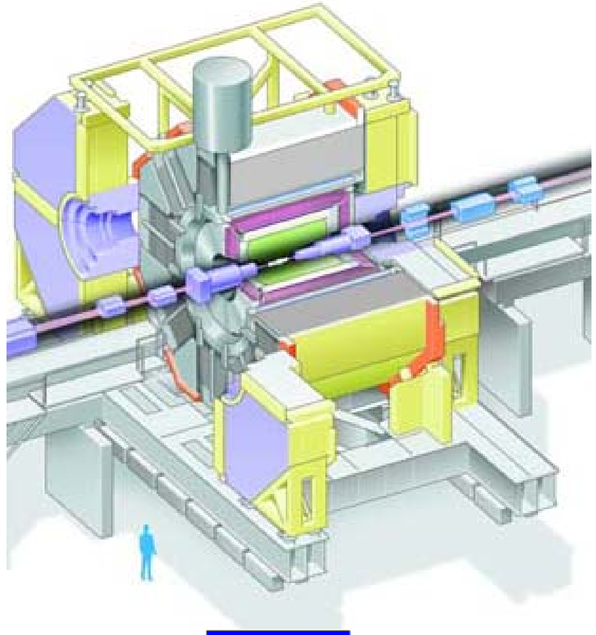

$\sigma_{\Delta t} \sim 1$ ps ⟶ $\sigma_{\Delta z} \sim 170$ μm
$\tau_B \sim 1.6$ ps ⟶ $\langle \Delta z \rangle \sim 250$ μm

# SUCCESS of BFACTORIES

8 x 3.5 GeV
22 mrad crossing angle

13 countries,
57 institutes,
~400 collaborators



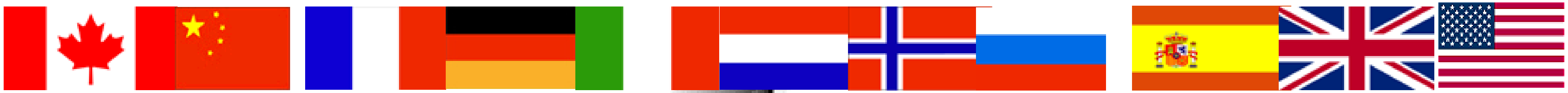



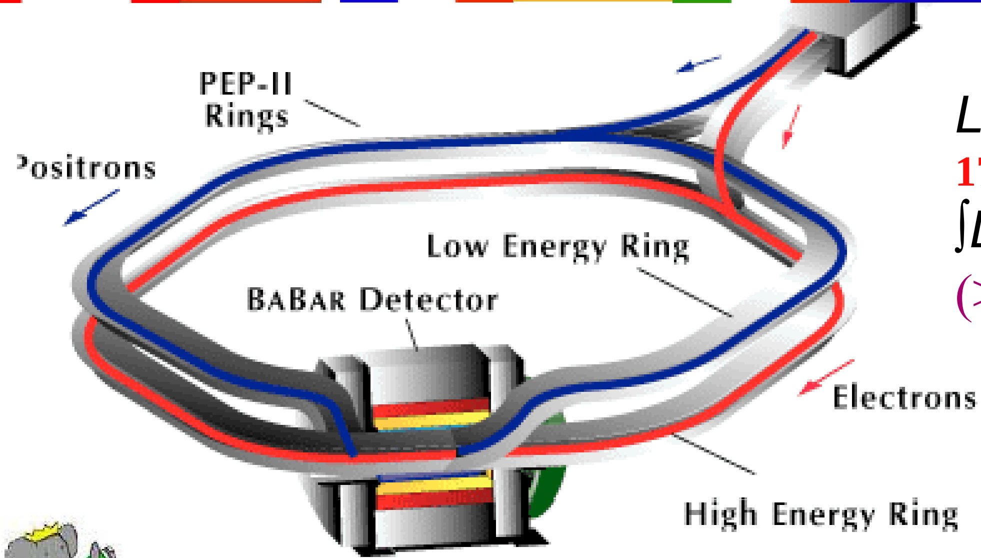
$8GeV\ (e^-) \times 3.5GeV\ (e^+)$
peak luminosity:
1.7118 x 1034 cm-2

since 1999 **710.254 /fb**

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

## 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$^{-1}$@{Υ(4S)+off(~10%)}

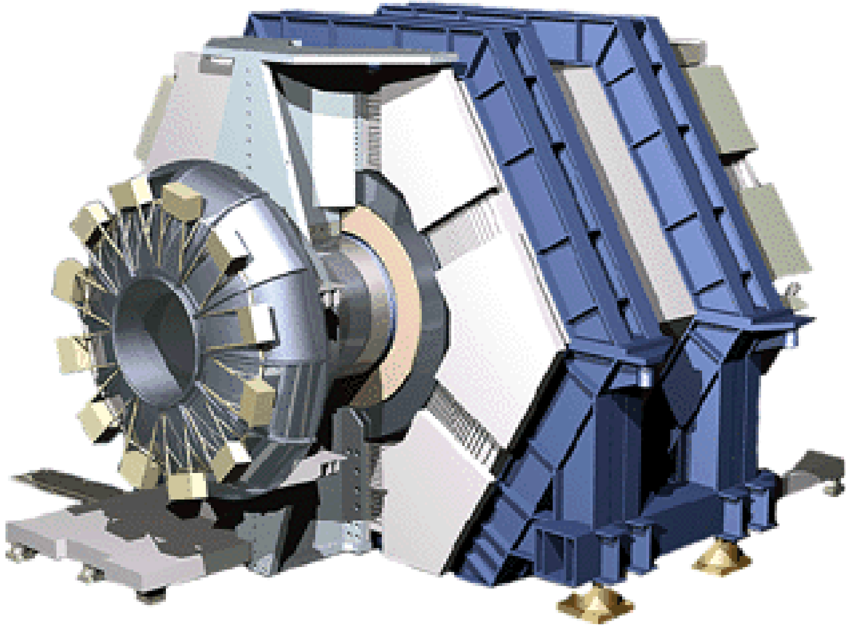
(>3.7x10$^{8}$ B events)

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

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

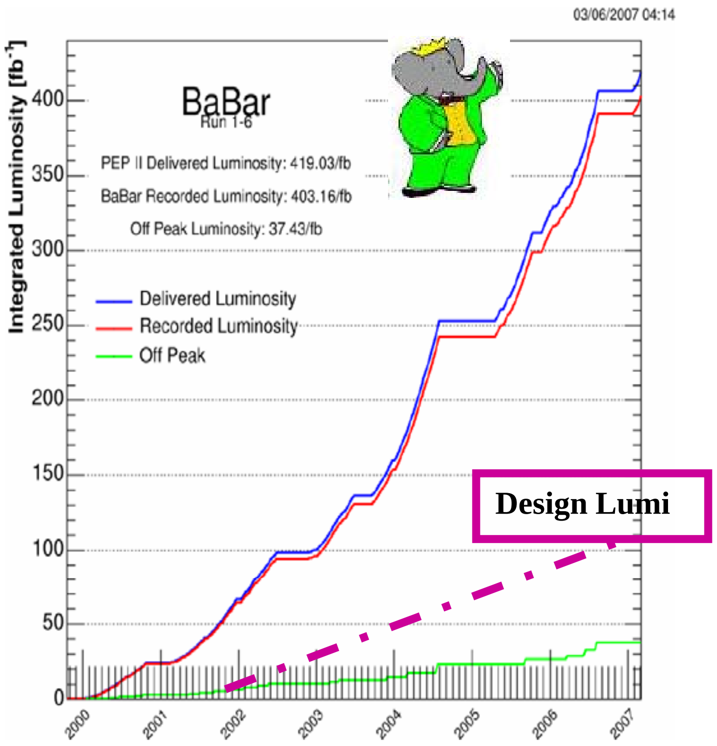
Electron/photon
- CsI calorimeter

Muon/$K_L$
- Instrumented flux return

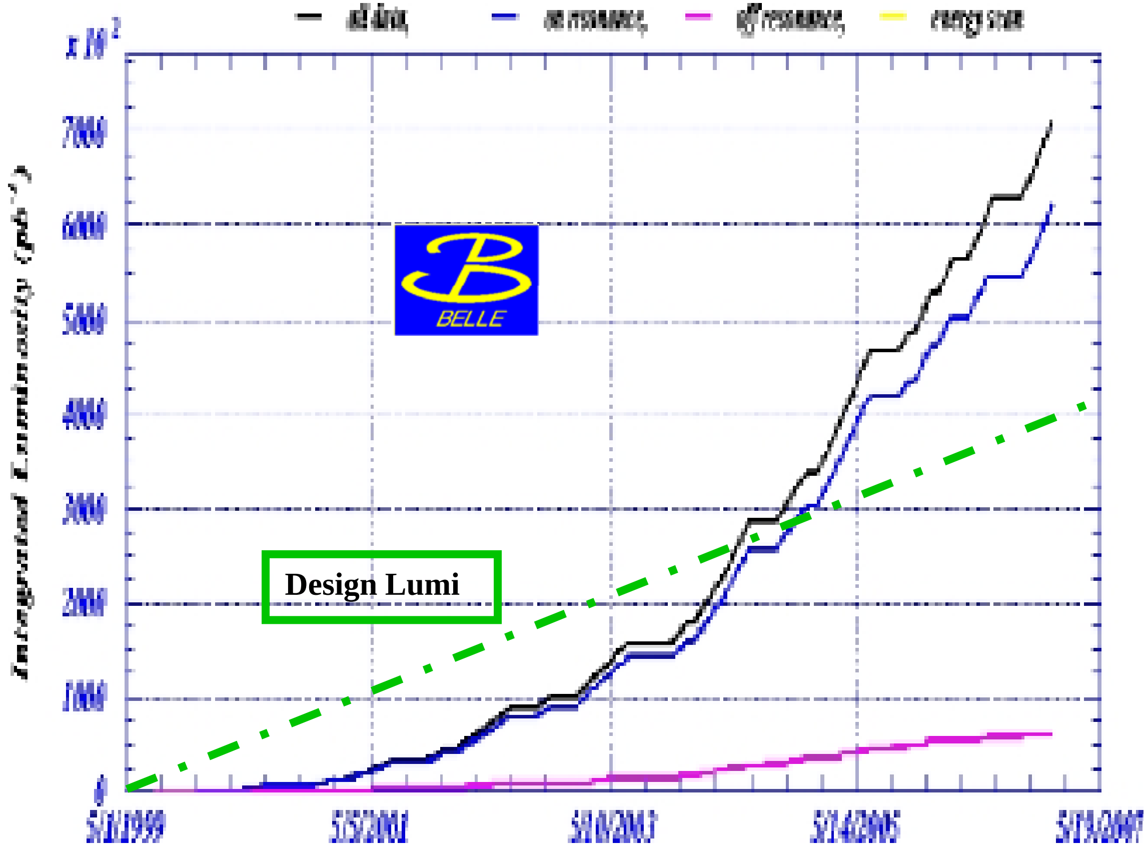


# Great Success of Accelerator Physics

Total > 1.1ab−1



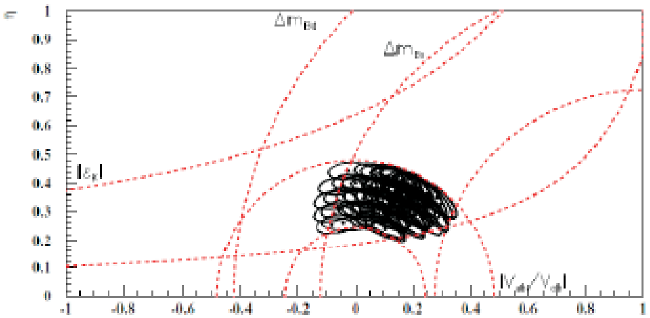

PEP-II (BaBar)
400fb-1



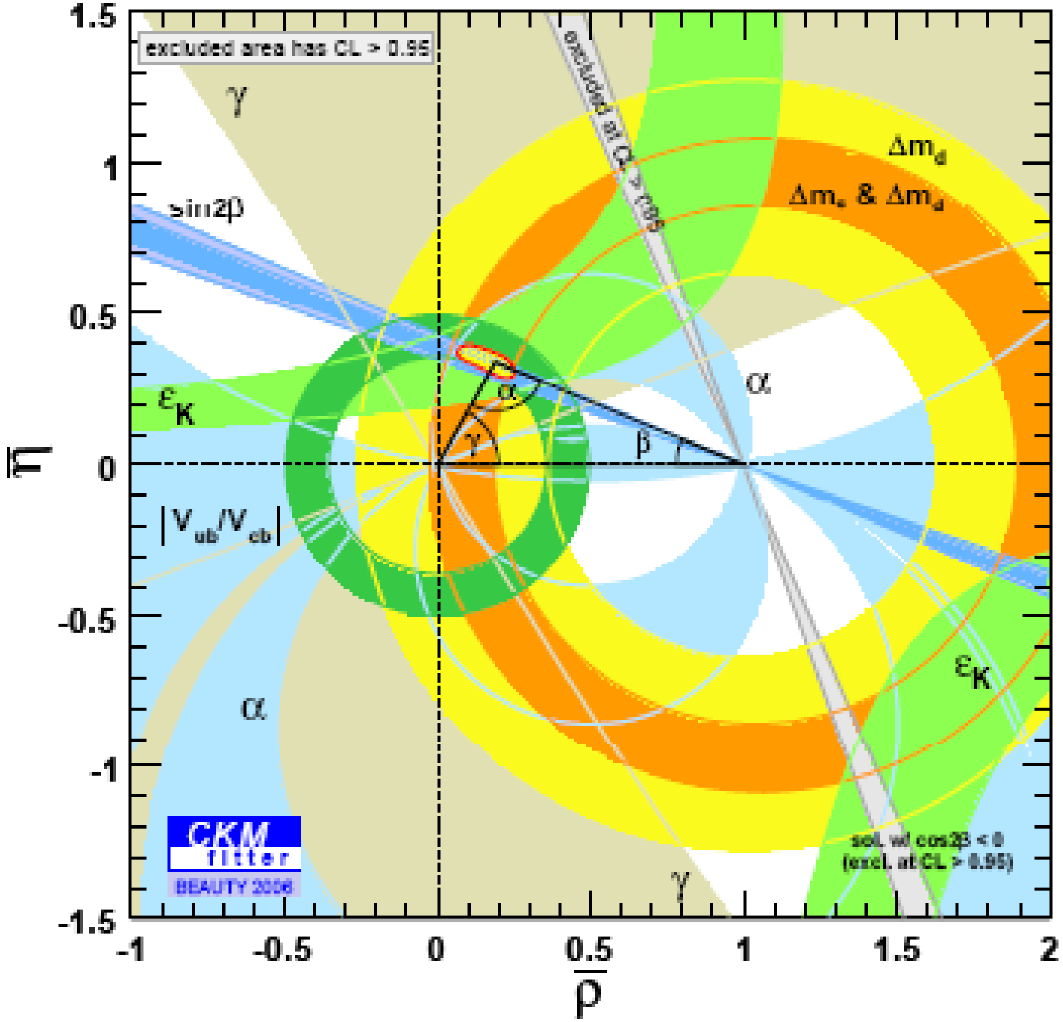

KEKB (Belle)
710fb-1

# CKM Unitarity Triangle

## Before Bfactories

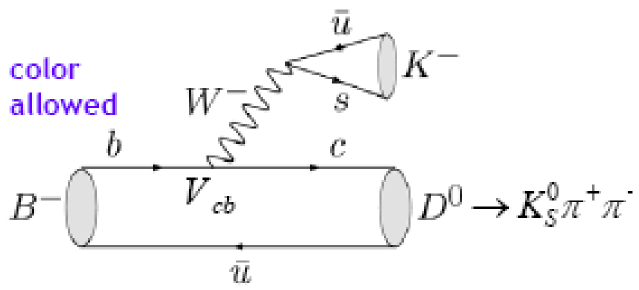



One example of CKM information coming only by sides measurements

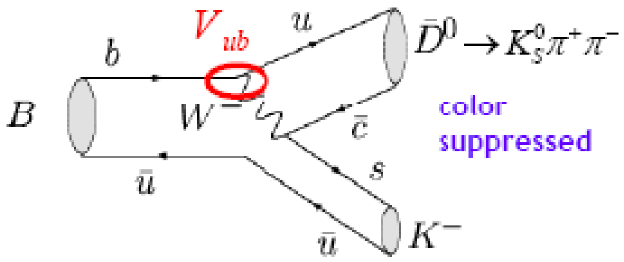


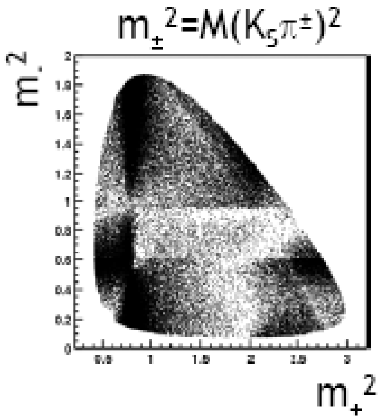

**NOW!**

# γ angle



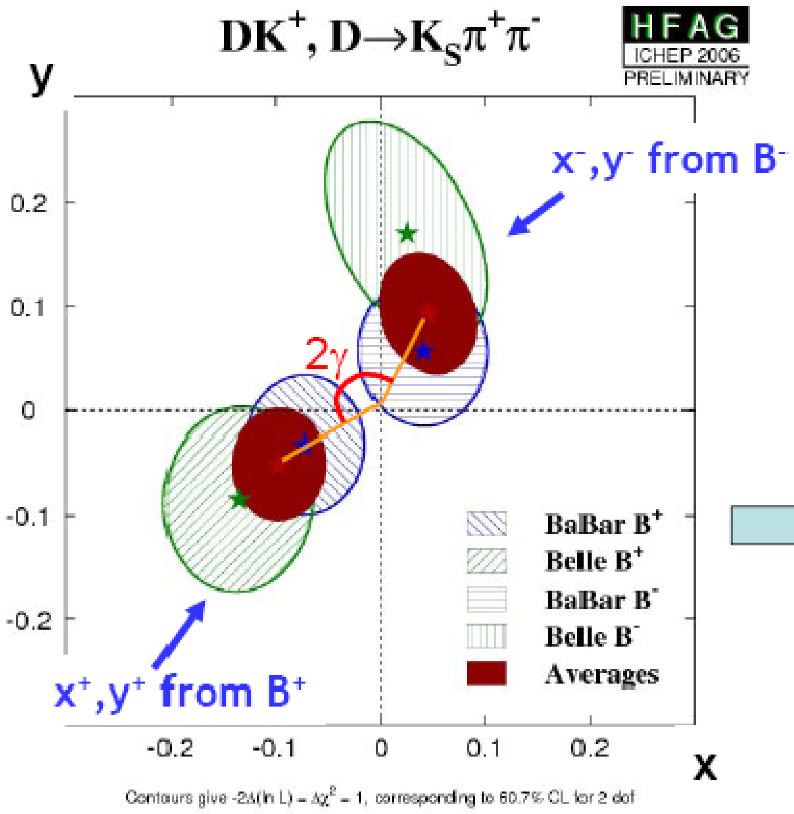

+




$$CP \quad \begin{aligned} \Gamma(B^-) &\propto |f_-|^2 + r_b^2 |f_+|^2 + 2x_- \,\mathrm{Re}\left(f_- f_+^*\right) + 2y_- \,\mathrm{Im}\left(f_- f_+^*\right) \\ \Gamma(B^+) &\propto |f_+|^2 + r_b^2 |f_-|^2 + 2x_+ \,\mathrm{Re}\left(f_+ f_-^*\right) + 2y_+ \,\mathrm{Im}\left(f_+ f_-^*\right) \end{aligned}$$

- $f_\mp \equiv f(m_\mp^2, m_\pm^2)$ are measured from large $D^0$ control sample
- $x_\mp = r_b \cos(\delta \mp \gamma)$, $y_\mp = r_b \sin(\delta \mp \gamma)$ are measured from fit to the D Dalitz plot of $B^\pm$




BaBar:

- BaBar measurement of (x,y) more precise but favors a smaller $r_b$ (the $B^+$ and $B^-$ points are closer to 0 )
- $\sigma(\gamma) \sim 1/r_b$ → Belle $\sigma(\gamma)$ is smaller

BaBar ($D^{(*)0}K$)

$$\boxed{\gamma = (92 \pm 41 \pm 10 \pm 13)^\circ}$$
(stat) (syst) (Dalitz)

Belle ($D^{(*)0}K^{(*)}$)

$$\boxed{\gamma = (53\,^{+15}_{-18} \pm 3 \pm 9)^\circ}$$
(stat) (syst) (Dalitz)

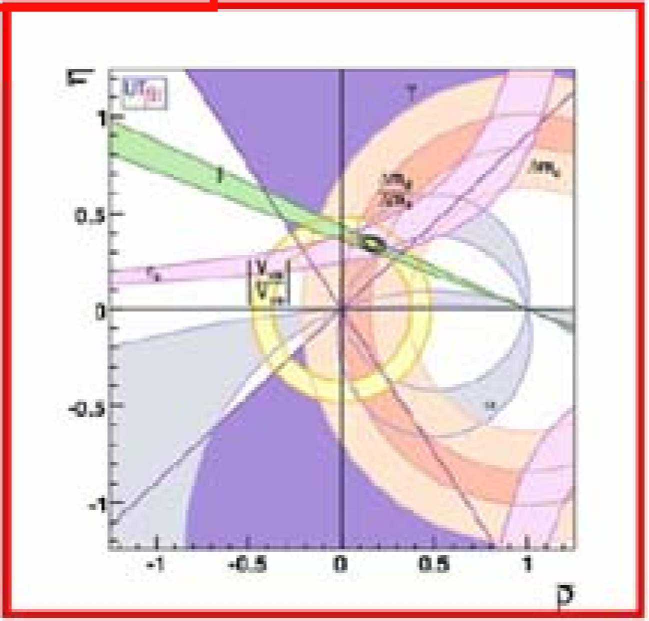
# UTfit as now and in …2015 with SuperB

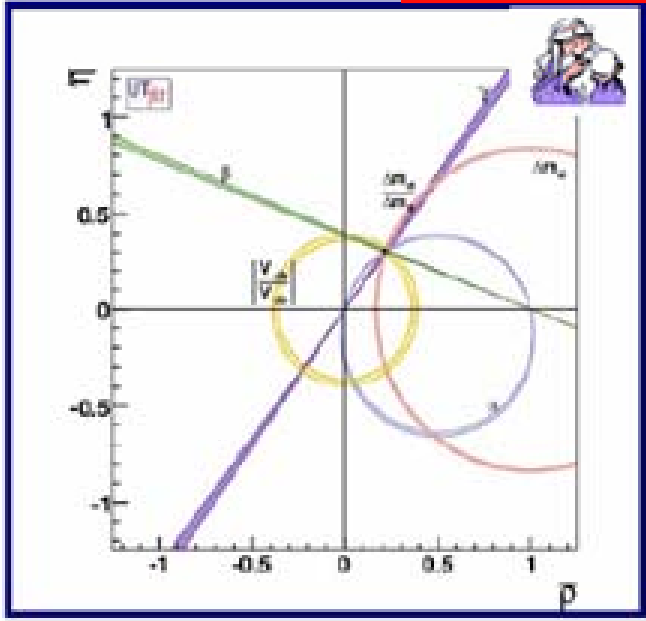
Triangle vertex
Determined by N.P.
free processes

**1 ab$^{-1}$**

**50 ab$^{-1}$**

With 50 ab-1 $\gamma$ *is measured at 1° level*




$\bar\rho = 0.163 \pm 0.028$

$\bar\eta = 0.344 \pm 0.016$

$\bar\rho = 0.2226 \pm 0.0028$

$\bar\eta = 0.3052 \pm 0.0024$

Theoretical uncertainties on sides could be reduced: (V.Lubicz, SuperB IV Villa Mondragone nov.2006)
Vub : 2% (excl.) 2% (incl.)Vcb : 1% (excl.) 0.5% (incl.)

# All together

$\sigma(\sin(2\beta/\phi_1))$ = 0.02 (BaBar + Belle)

- precision measurement still dominated by statistical error
- B-factories will approach the systematic and theoretical limit but won't reach it

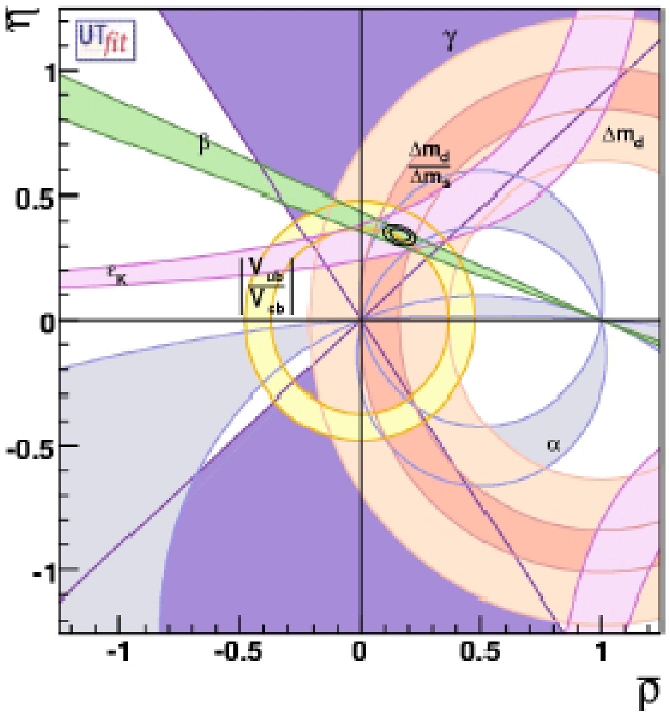
$\sigma(\alpha/\phi_2)$~10°

- two solutions in $[0,180]^0$ allowed, (one compatible with SM expectation). More data will help suppressing one.

$\sigma(\gamma/\phi_3)$~20°-35° depending on stat. treatment

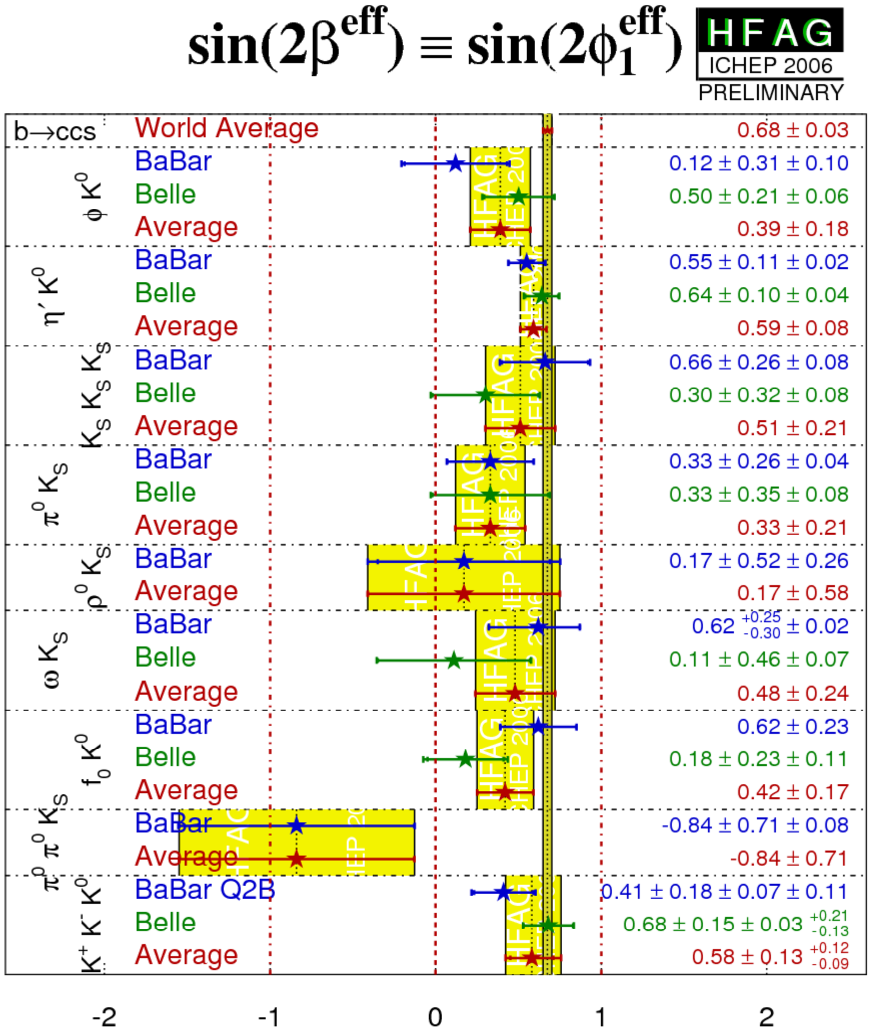
- considered out of reach for B-factories till a few years ago
- hard to predict the uncertainty at the end of 1st B-factory era till σ(rb)/rb is large (~30% at present)

ρ-η constrain, everything



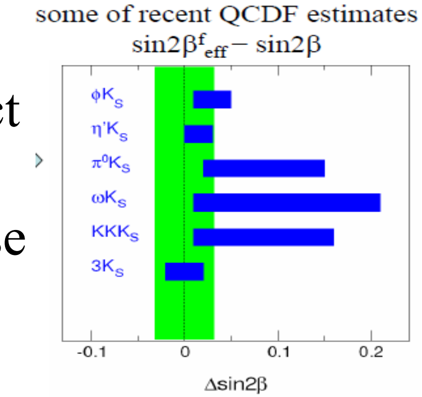

$\rho = 0.163 \pm 0.028$
$\eta = 0.344 \pm 0.016$

# ICHEP06: β from $b \to s$ Penguins




Smaller than $b \to c\bar{c}s$ in all of 9 modes

Theory tends to predict positive shifts (originating from phase in Vts)




Naïve average of all $b \to s$ modes

$\sin 2\beta^{eff} = 0.52 \pm 0.05$

2.6 σ deviation between penguin and tree

($b \to s$) ($b \to c$)

***More statistics crucial for mode-by-mode studies!***

# CPV in rare decays (PENGUINS)

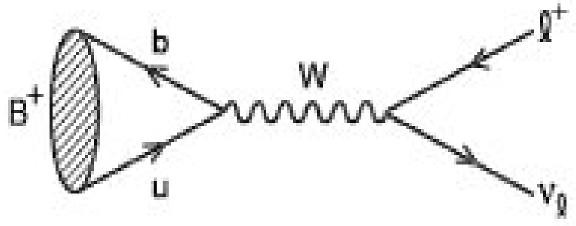
**Precision expected at high lumi from unpolarized e+ e-**

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

# $B^{\pm} \to \tau^{\pm} \nu$

ICHEP06 Browder (Belle)
Sekula (BaBar)

<u>Important</u> as W (suppressed by $V_{ub}$) can be replaced by charged Higgs, etc




$$\mathcal{B}(B^+ \to \ell^+ \nu_\ell) = \frac{G_F^2 m_B m_\ell^2}{8\pi}\left(1 - \frac{m_\ell^2}{m_B^2}\right) f_B^2 |V_{ub}|^2 \tau_B$$

SM prediction
$(1.59 \pm 0.40) \times 10^{-4}$
(depends on $f_B$ and $V_{ub}$)

<u>Difficult</u> due to neutrinos in the final state

BELLE: tag with fully reconstructed B mesons (180 channels)

(revised). 3.5 σ significance

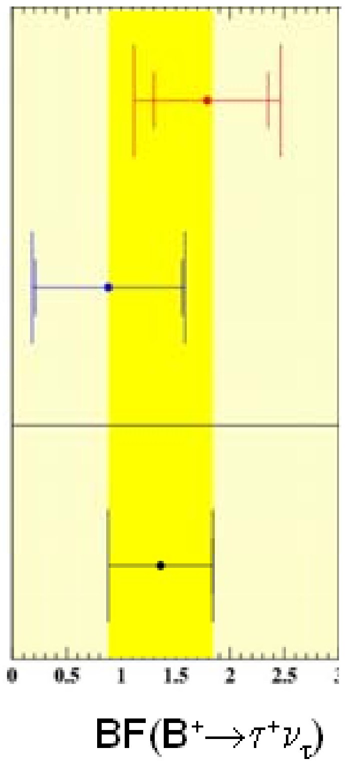
$$\mathrm{BF}(B^+ \to \tau^+ \nu_\tau) = (1.79^{+0.56+0.39}_{-0.49-0.46})\times$$

BABAR: Tag with B→D(*)lν

$$\mathrm{BF}(B^+ \to \tau^+ \nu_\tau) = (0.88^{+0.68}_{-0.67} \pm 0.11) \times 10^{-4}$$

BF<1.80@90%CL

Averaged $(1.36 \pm 0.48)$x10-4

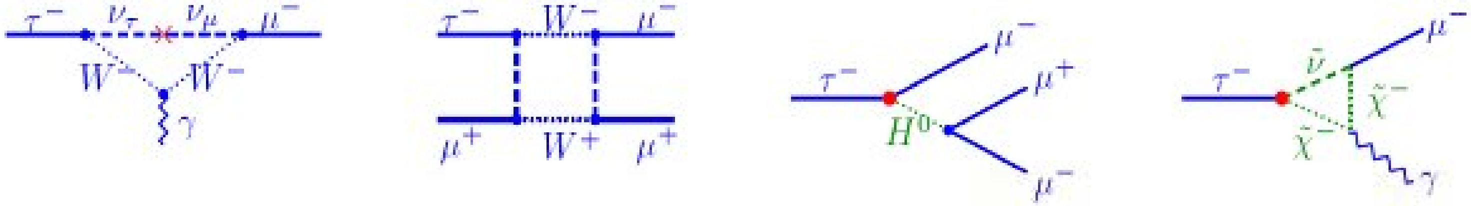


# Search for New Physics (Lepton Flavour Violation)

The B factories are also τ factories

$\sigma(\tau^+\tau^-) = 0.89$ nb at $\sqrt{s} = M(\Upsilon)$

Total sample of ~1.5 billion taus



**90% CL limits**

$Br(\tau^- \to e^-\gamma) < 12 \times 10^{-8}$

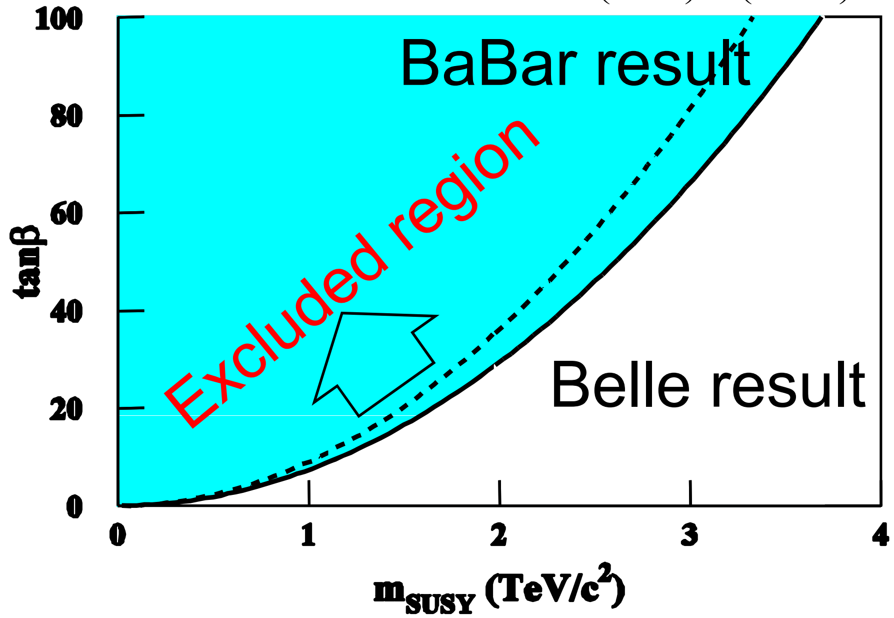
$Br(\tau^- \to \mu^-\gamma) < 4.1 \times 10^{-8}$

BELLE

$Br(\tau^- \to e^-\gamma) < 11 \times 10^{-8}$

$Br(\tau^- \to \mu^-\gamma) < 6.7 \times 10^{-8}$

$$Br(\tau \to \mu\gamma) = 3.0\times10^{-6} \times \left(\frac{\tan\beta}{60}\right)^2 \times \left(\frac{M_{SUSY}}{1\text{TeV}}\right)^{-4}$$




R.Barlow ICHEP06

# A new star from Babar and Belle

:

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

**G.Piredda will talk about!**

**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**

**In a Super Flavor Factory the Tau and Charm T/CPV studies motivate the beam polarization and special runs at low Energy (4GeV)**

**Motivation for runs at Y(5S): are coming from studies of $B_s$**

- 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
$B_s \to \mu\mu$ YES
$B_s \to \gamma\gamma$ 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 $\tau$ 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 $B \to$ (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:

$0.16 \times 10^{35}$ cm$^{-2}$s$^{-1}$ (KEKB)

$8 \times 10^{35}$ 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 | $2\text{-}3 \times 10^{34}$ | $1.5 \times 10^{35}$ | $2.5 \times 10^{35}$ | $7 \times 10^{35}$ | 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 |
| $\beta(y^*)$ | 7 | 3.6 | 3.0 | 1.5 | mm |
| $\beta(x^*)$ | 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**

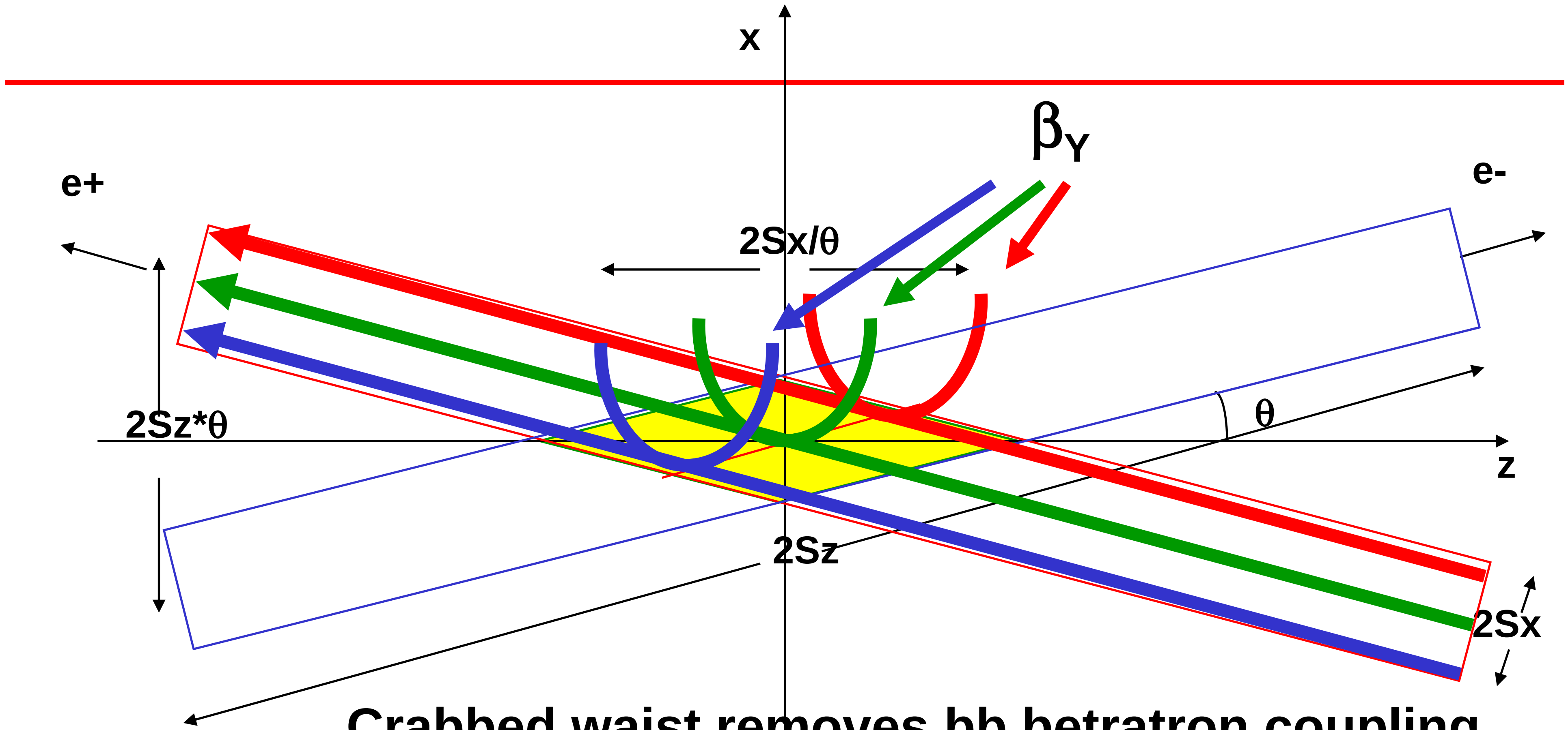
**For a ring:**

- **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 $\sigma_z$**

**CROSSING ANGLE WITH CRAB WAIST**



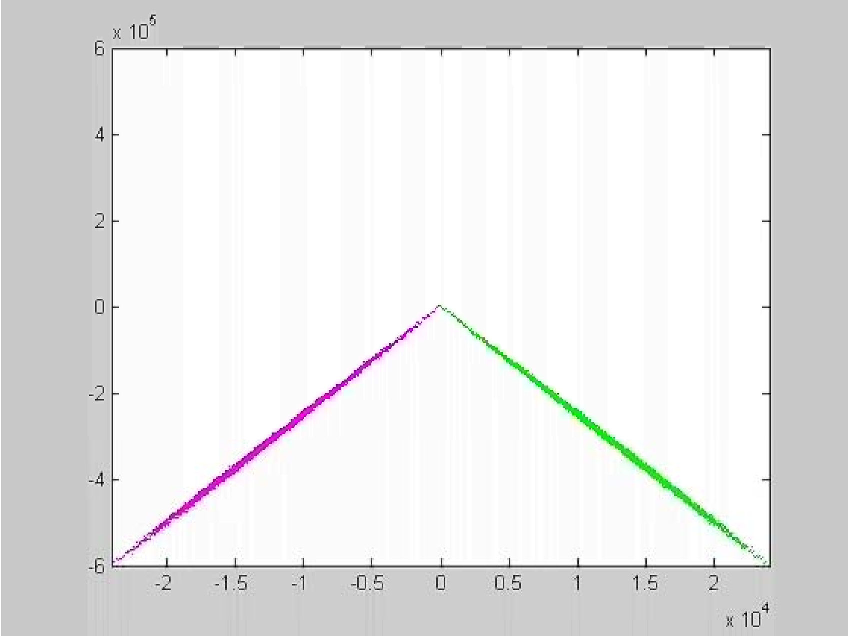

**Crabbed waist removes bb betratron coupling Introduced by the crossing angle**

Vertical waist has to be a function of x:

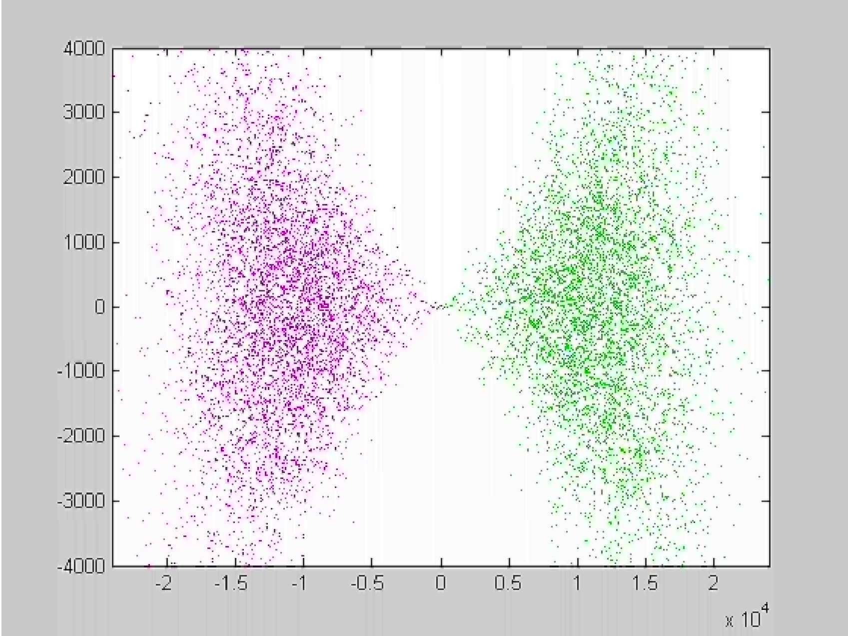
Z=0 for particles at $-\sigma_x$ ($-\sigma_x/2\theta$ at low current)

Z= $\sigma_x/\theta$ 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. 5x10$^{-3}$**

# *SuperB new approach based on ILC FF and DR*

*Crossing angle = 2*17 mrad*

**ILC DR & FF**

**DR damping time as PEPII-KEKB**

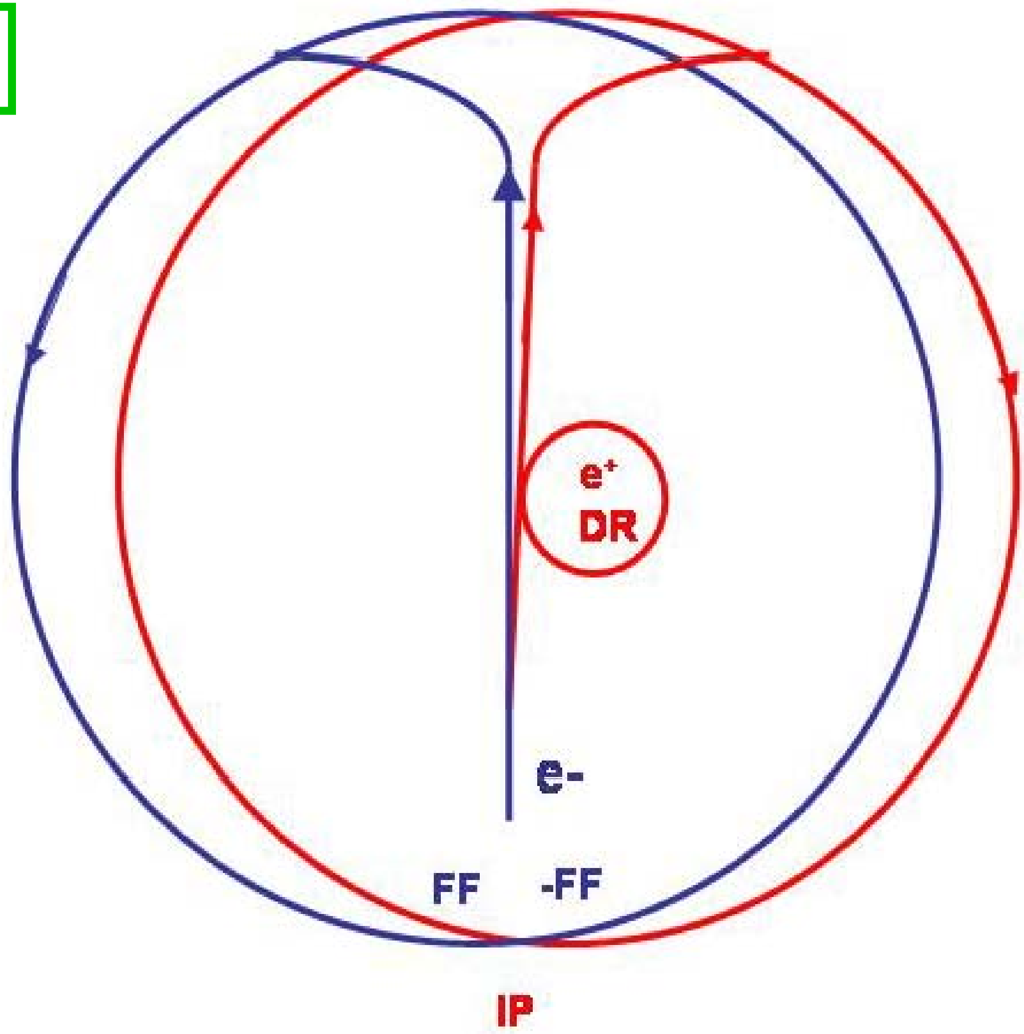
**1.5 times DR bunch charges**

**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 x$10^{10}$ | 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!

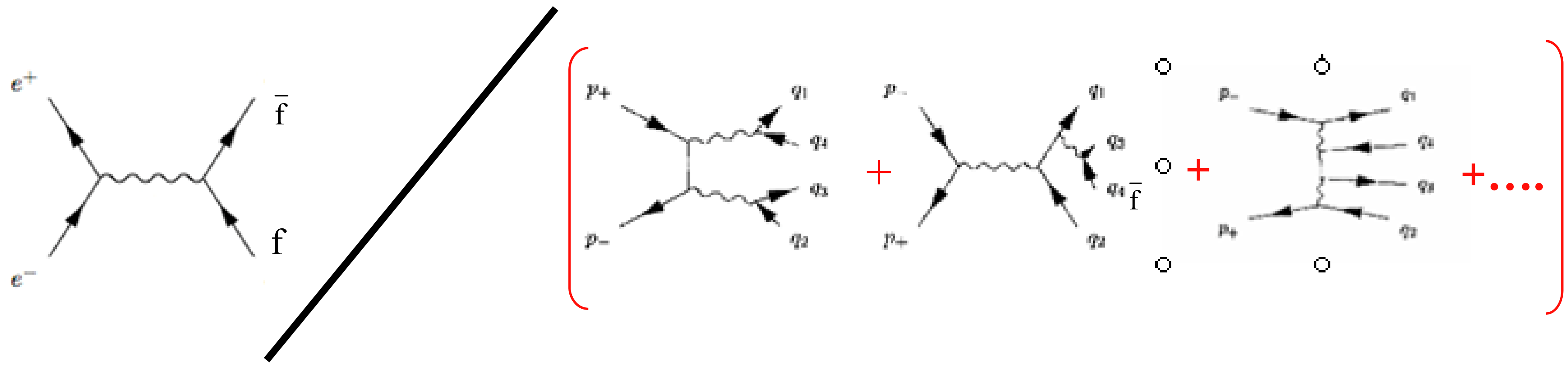
It could operate at 4.0 GeV c.o.m Energy at luminosity $10^{35}$

A preliminary estimate of fully inclusiveWall Power is now available

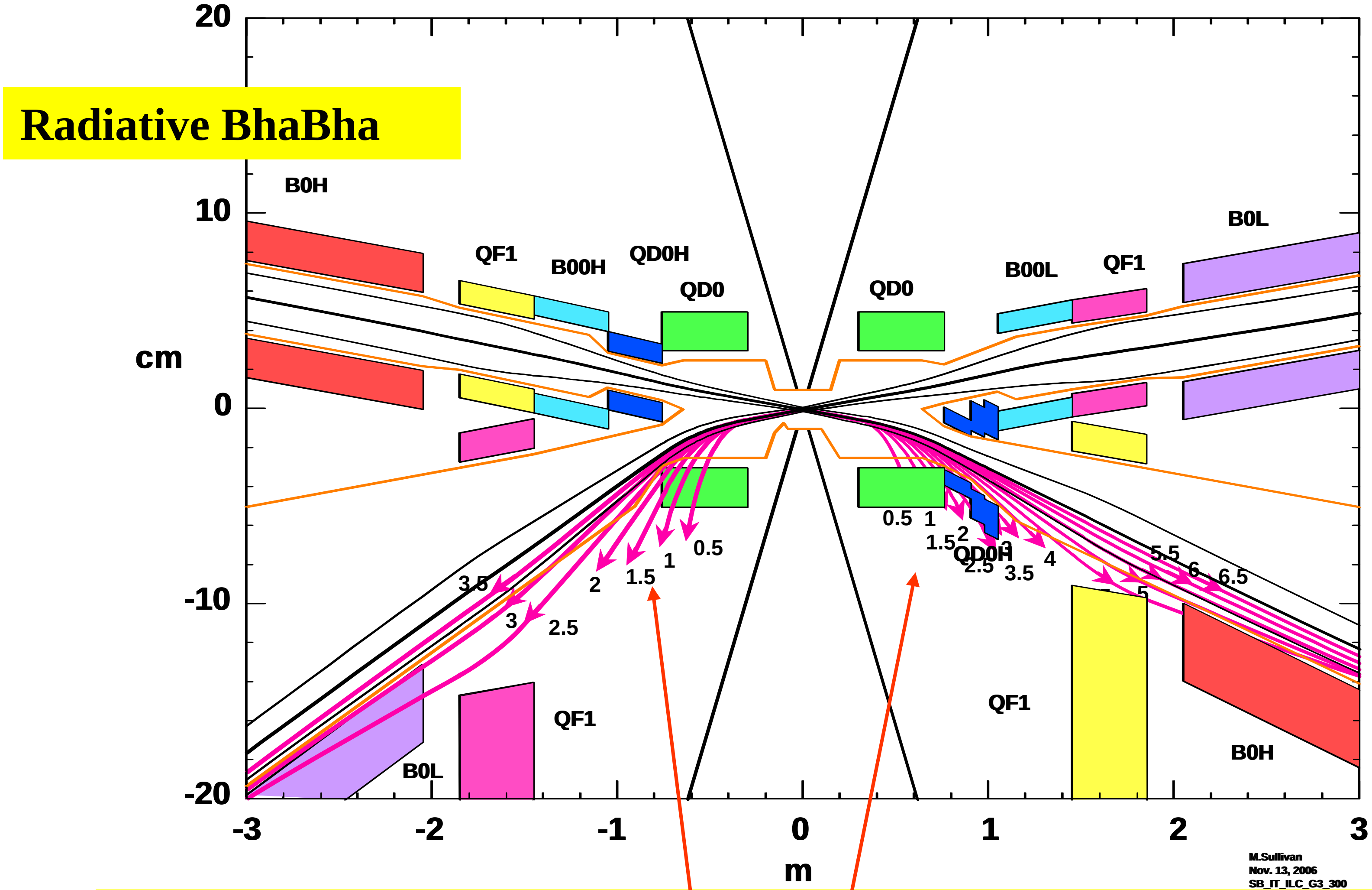
(17MW+18MW)=35MW! As in PEPII

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

One polarized beam(e-) is considered for tau physics . The possibility of adding polarized positron is uder study. It can  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



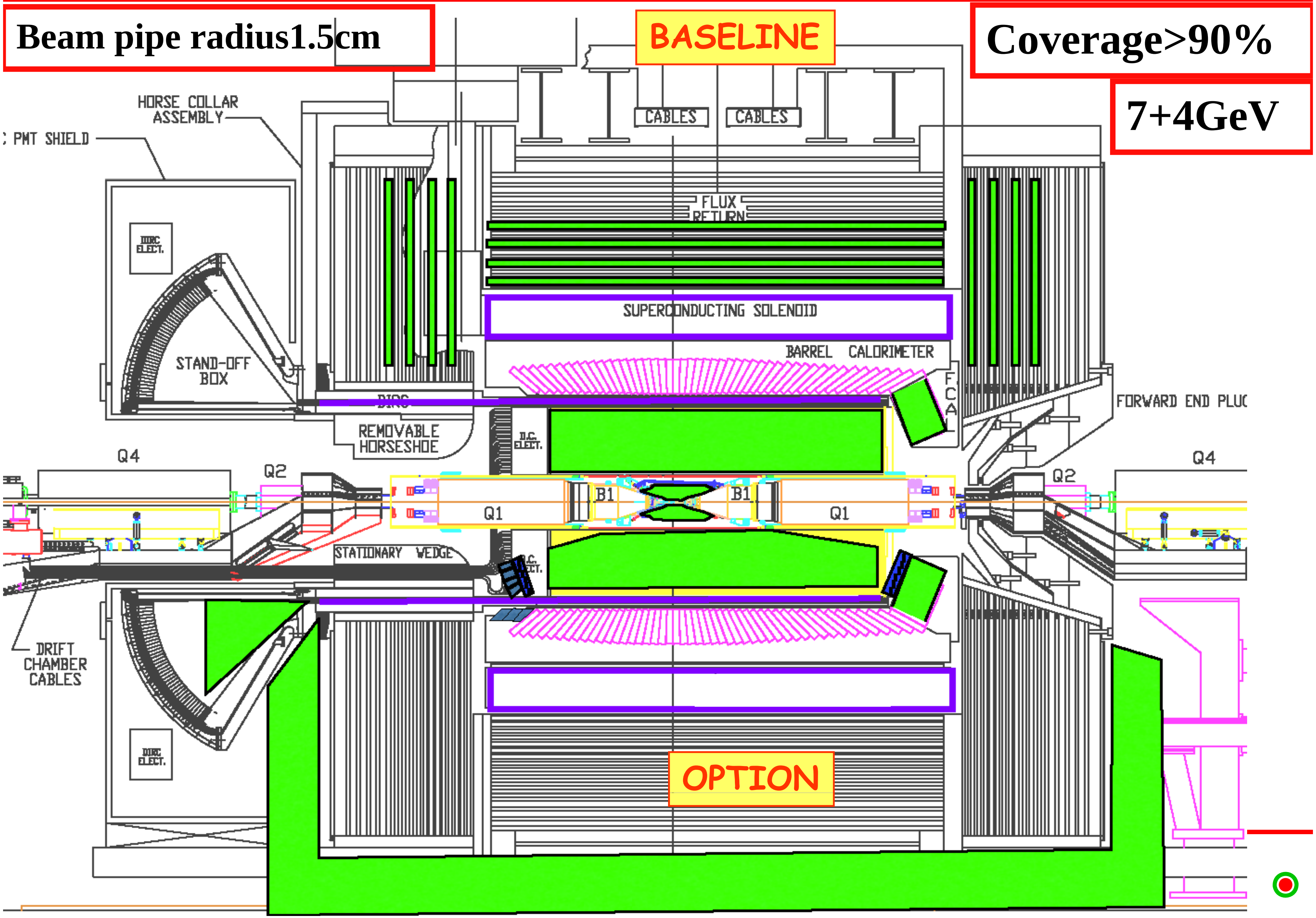

Need serious amount of shielding to prevent the produced shower from reaching the detector.

# Extrapolation from BABAR, it could have been from Belle

**Beam pipe radius1.5cm**

**Coverage>90%**

**7+4GeV**



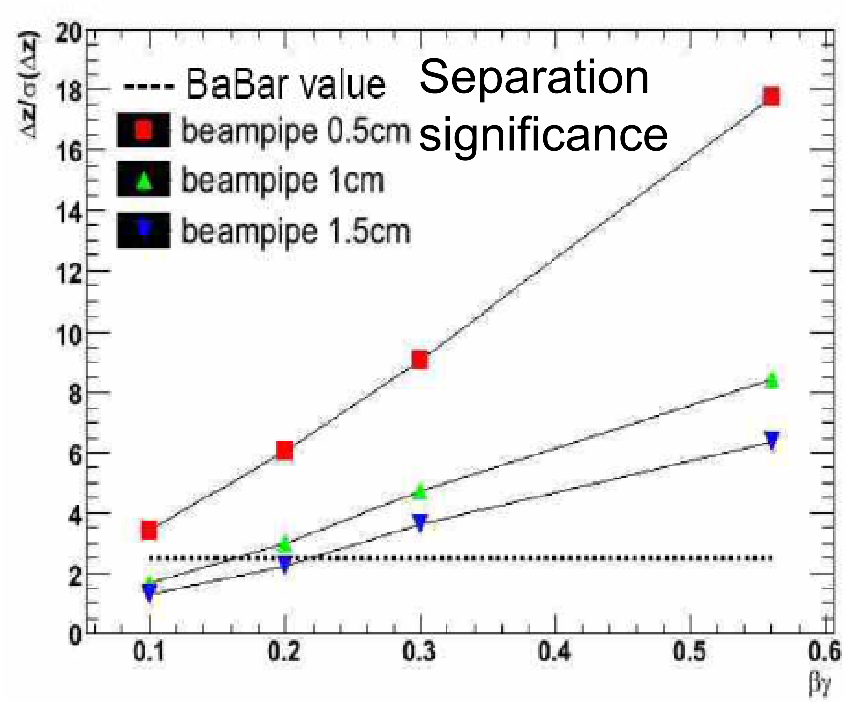
# Beam Pipe Radius and Detector Issues

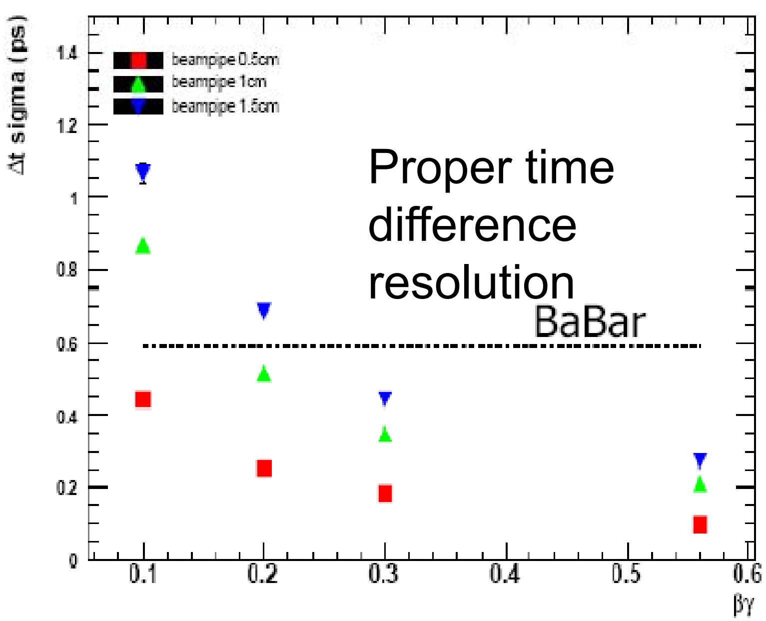
- Small beam pipe radius possible because of small beam size
  - Studied impact of boost on vertex separation ($B \rightarrow \pi\pi$)
  - Rest of tracking is Babar
  - Beam pipe needs to be cooled.Study is in progress to keep total thickness low in the order of % of $\chi_{rad}$

7+4GeV

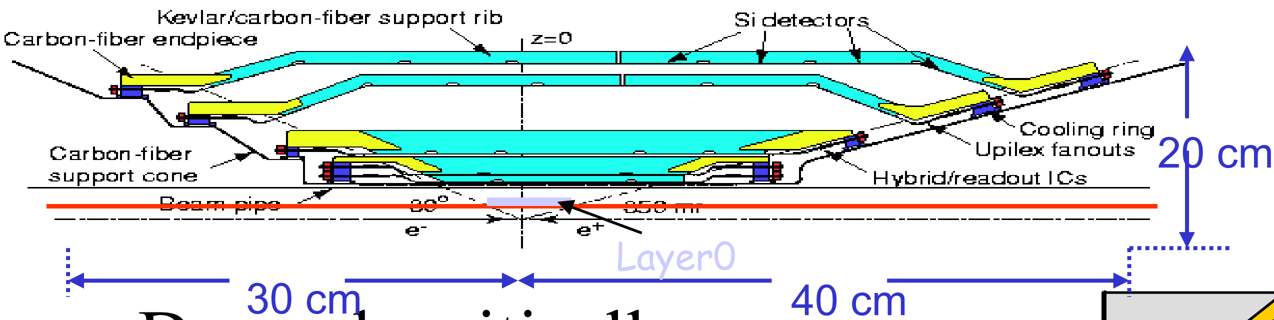
Boost $\beta\gamma$=.28

Instead of 0.56

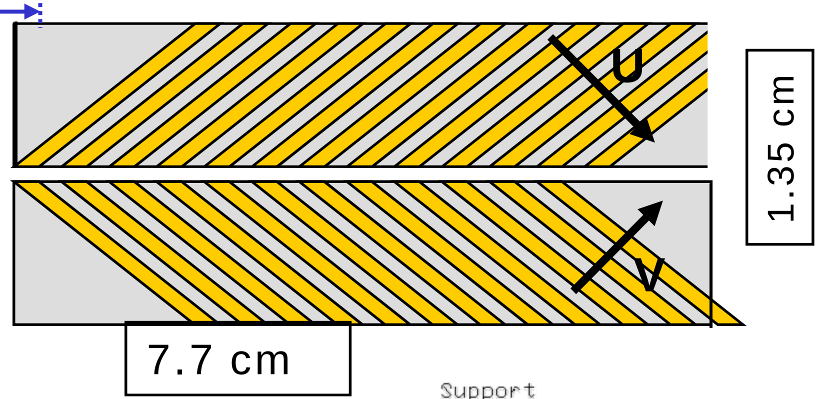


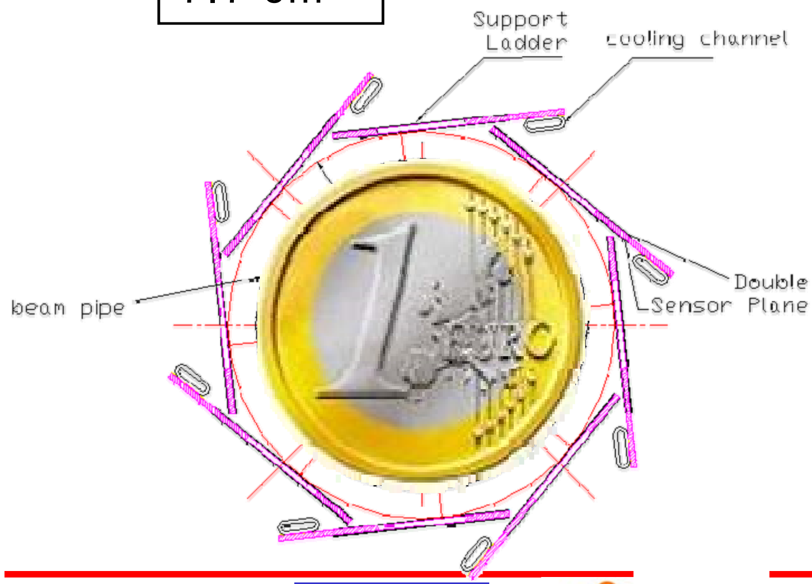



# SVT Layer 0




- 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



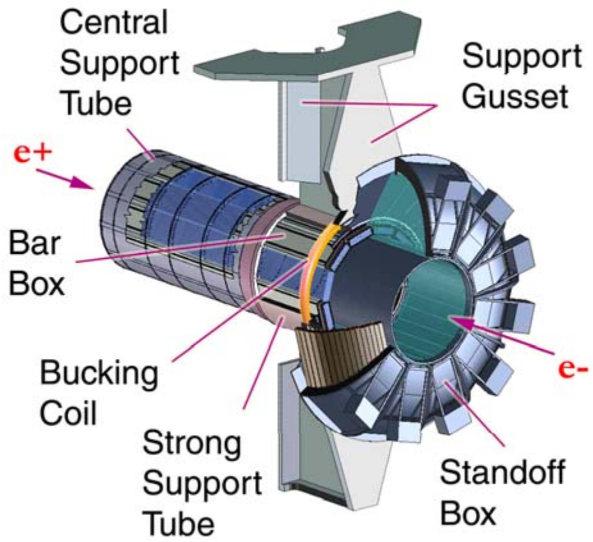



# DCH

- 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 |
|---|---|---|---|
| $\tau$ decay(ns) | 680, 3340 | 16 | 47 |
| $\chi_0$(cm) | 1.86 | 1.86 | 1.14 |
| $R_{moliere}$ (cm) | 3.8 | 3.8 | 2.3 |
| $\lambda_{nuclear}$ (cm) | 37 | 37 | |
| LY ($\gamma$/MeV) | 56000, 64:36% | 2500 | 27000 |
| $\lambda$peak (nm) | 550 | 315 | 420 |
| Rad Hard (Mrad) | .01 | .01-.1 | 100 |
| $\rho$ (g/cm3) | 4.51 | 4.51 | 7.40 |
| $n_0$ | 1.79 | 1.95 | 1.82 |

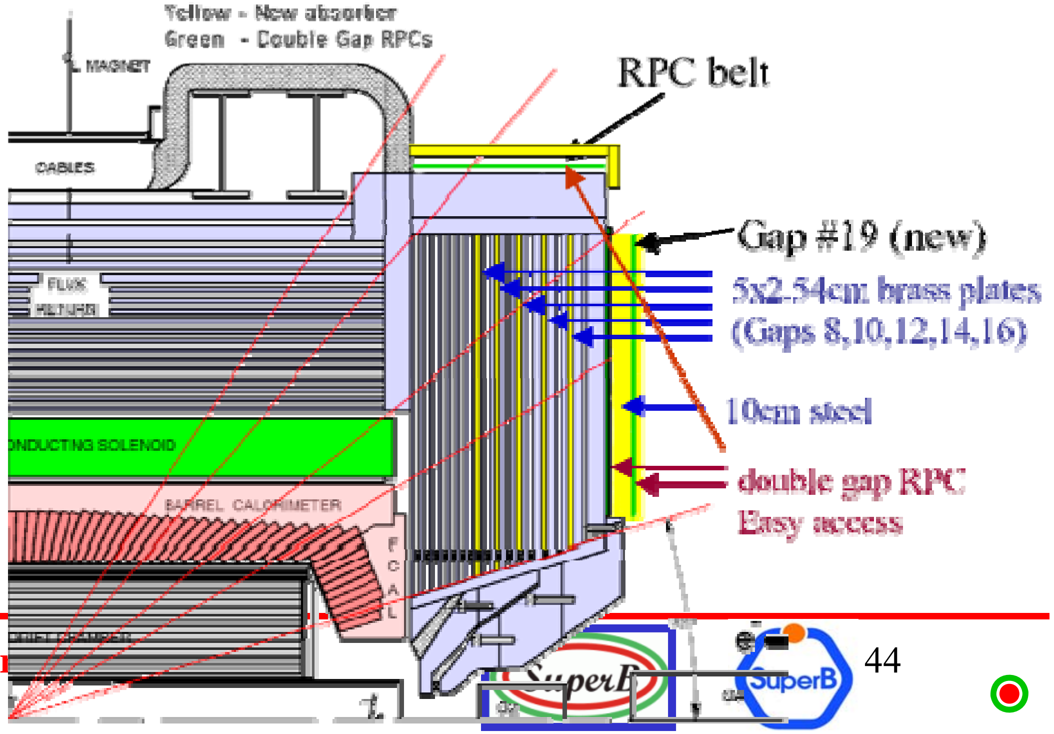
## Backward calorimeter

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

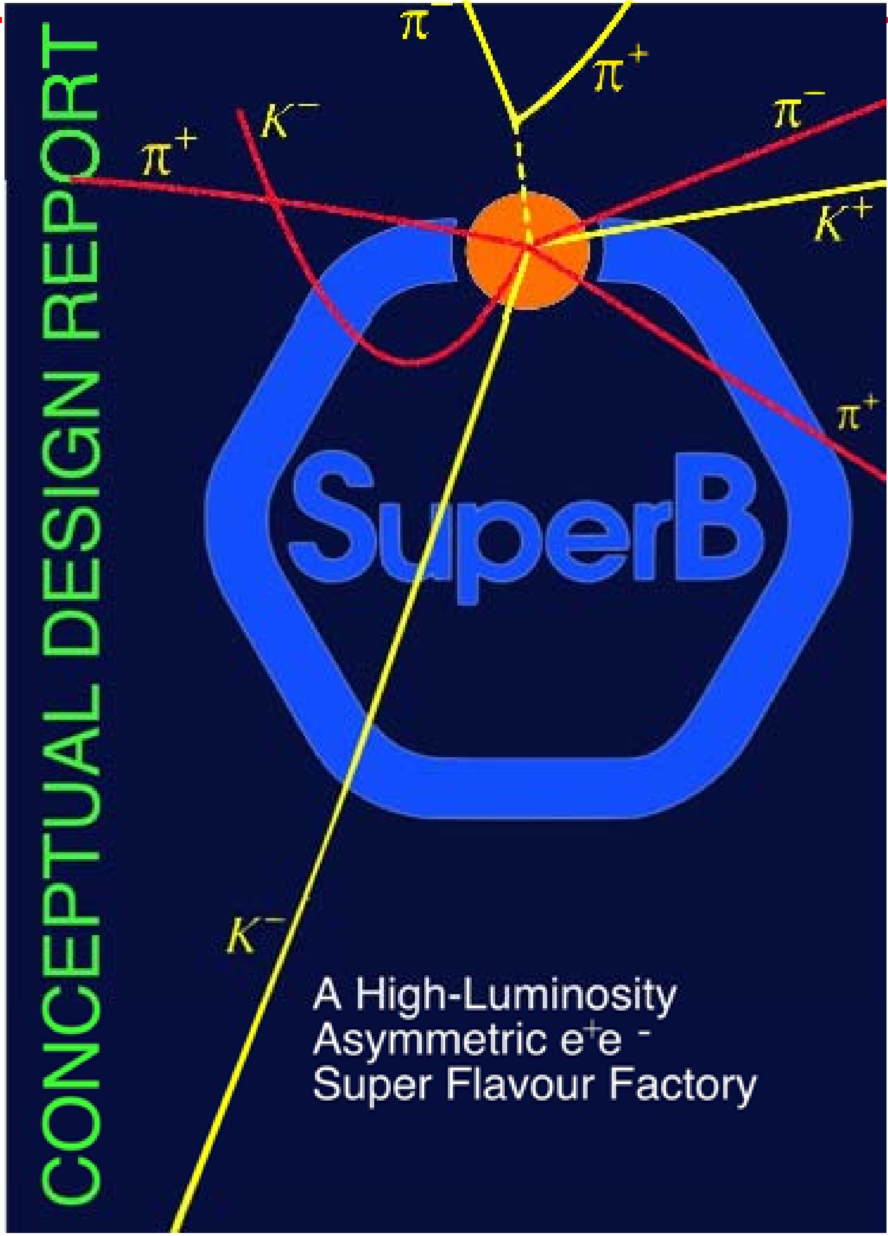
# IFR and steel

- 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



# 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 4 meeting in LNF and Roma Tor Vergata to present officially CDR to th scientific community and to Press and central and local authorities.

May 9-11 SuperB workshop in Paris

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

# Approval(?) in 2008(?)

**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