SuperB Flavour Factory, why on ILC technology ?

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Flavour in the era of LHC
CERN 15-17 May 2006

Success of BFactories

Original mission

1)Search for CP violation in B meson decays as predicted in Standard Model

2)Measure precisely at this low energy scale 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

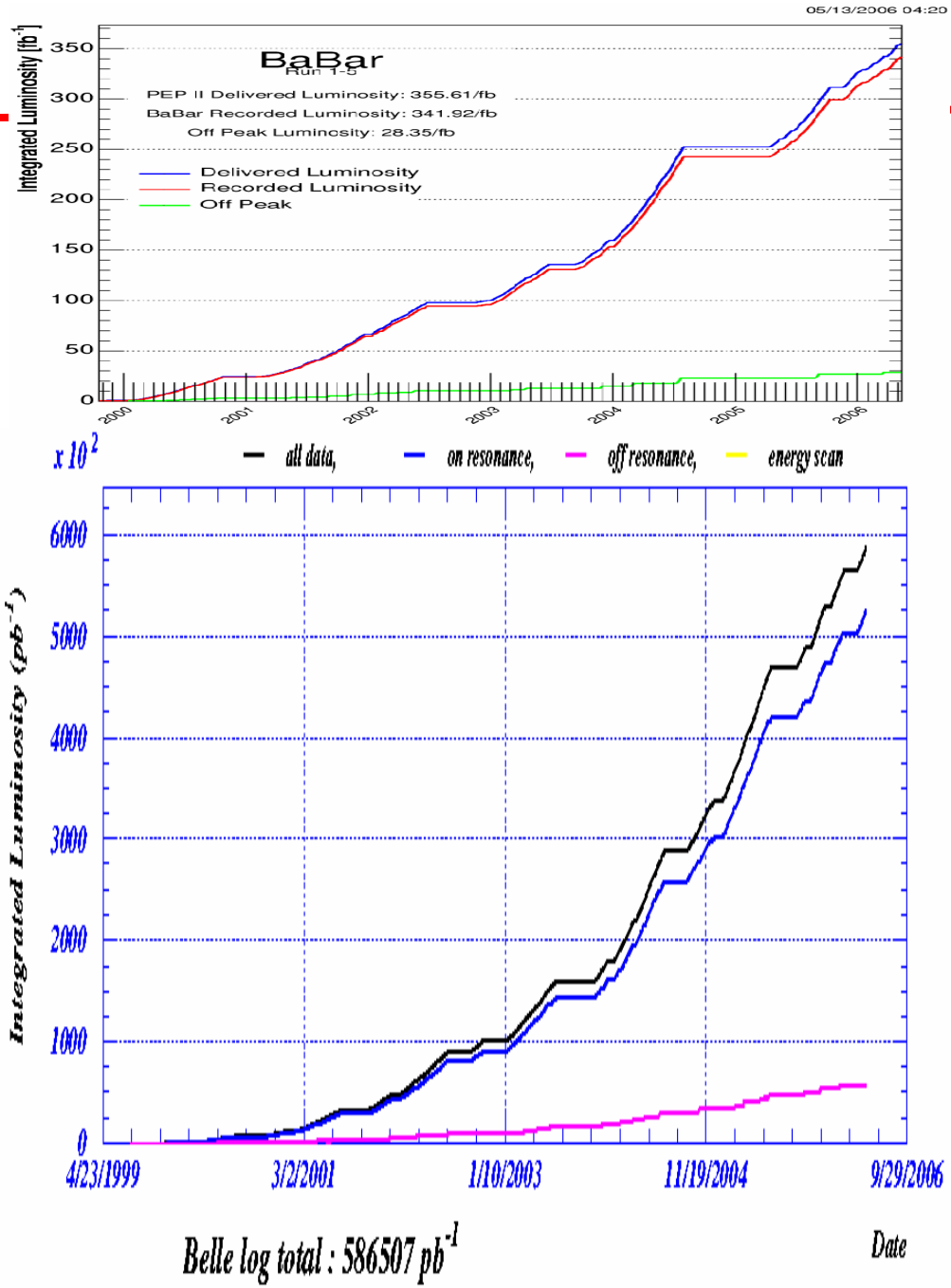
More precise CKM measurements, Rare B decays, Charm study, Tau rare decays .

Integrated LUMINOSITIES

The present total integrated Luminosity of the two Bfactories is above 0.9/ab.

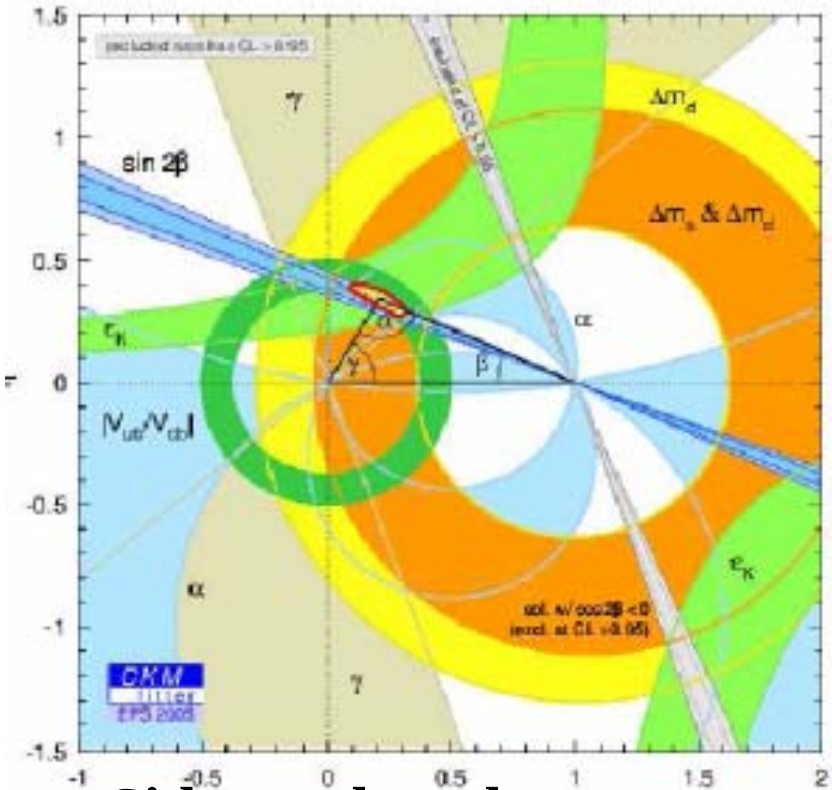
10^9 BB pair have been produced

The same number of $\tau+\ \tau-$ and c cbar

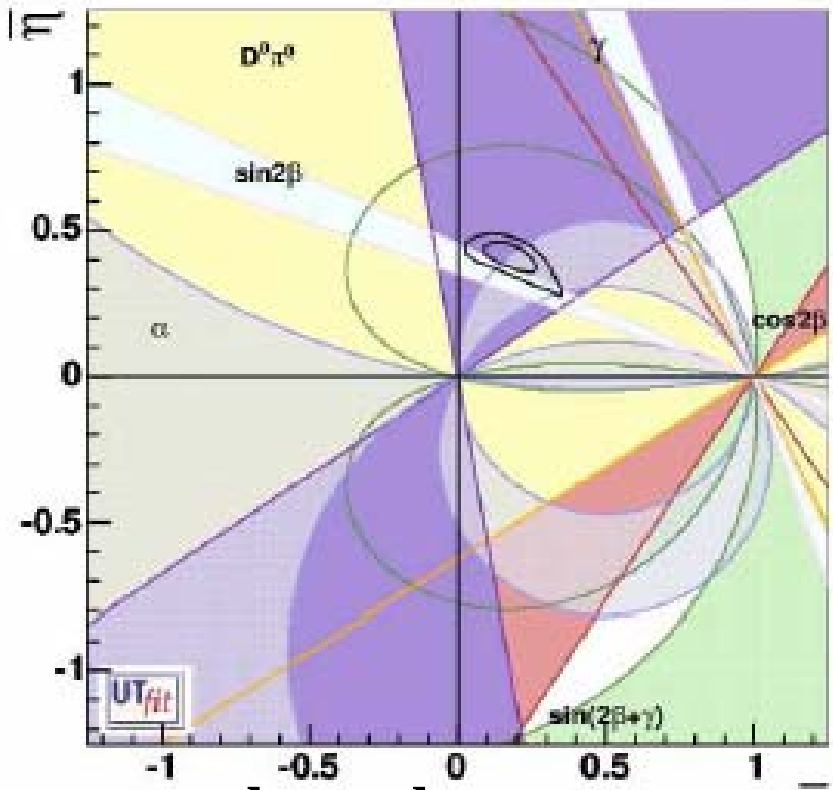


Great success of BaBar and Belle

But great success of CKM



Sides and angles



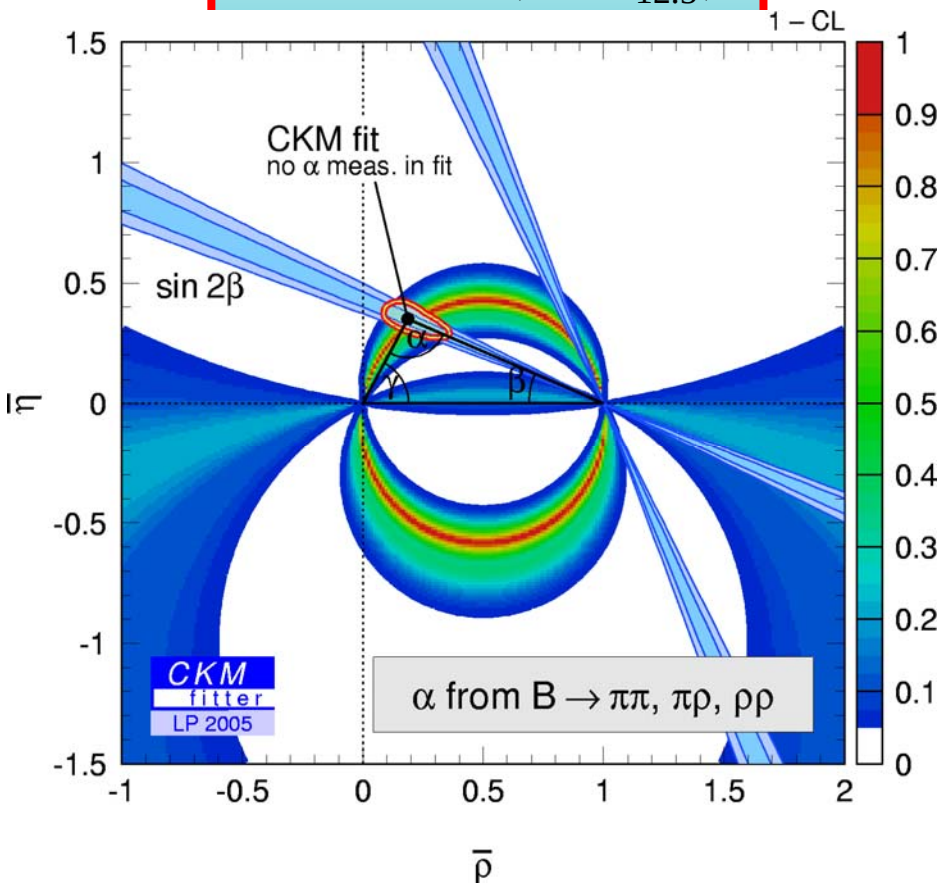
only angles

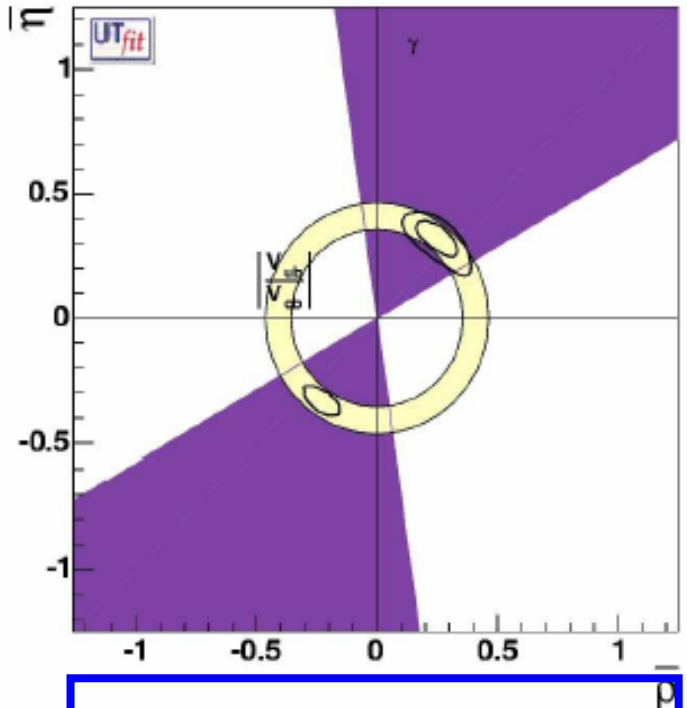
Hints of NP from UT ?

$\alpha[\text{all}] = (99^{+12}_{-9})^\circ$

USE: ε, Δm_d, sin 2β, γ, α, cos 2β

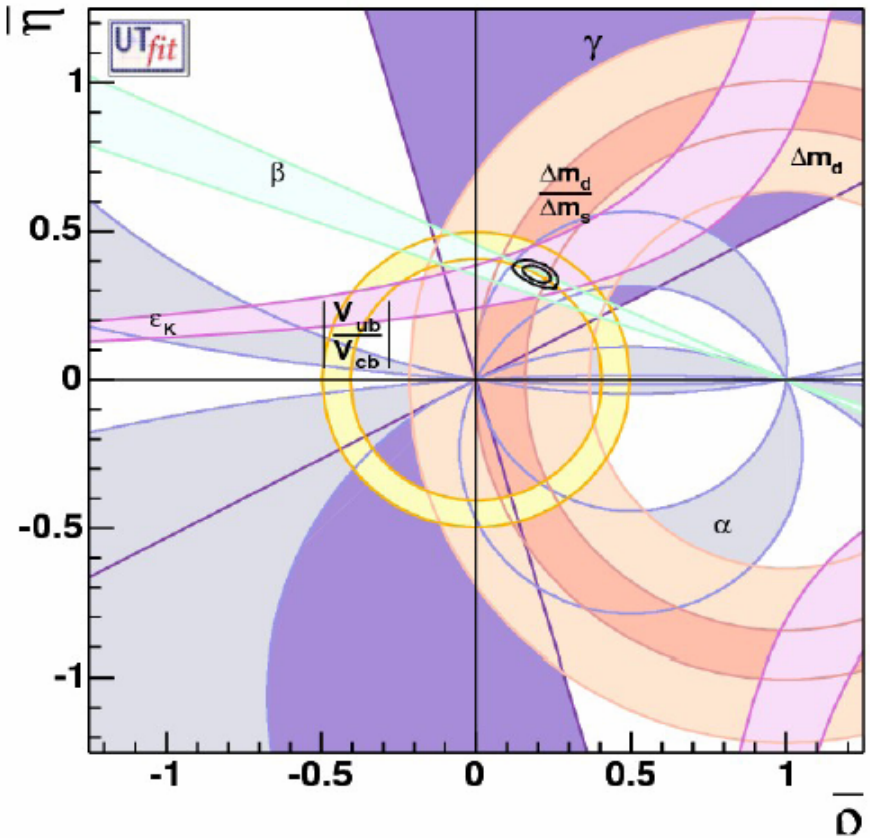
$\alpha[\text{CKM}] = (93.1^{+9.6}_{-12.5})^\circ$



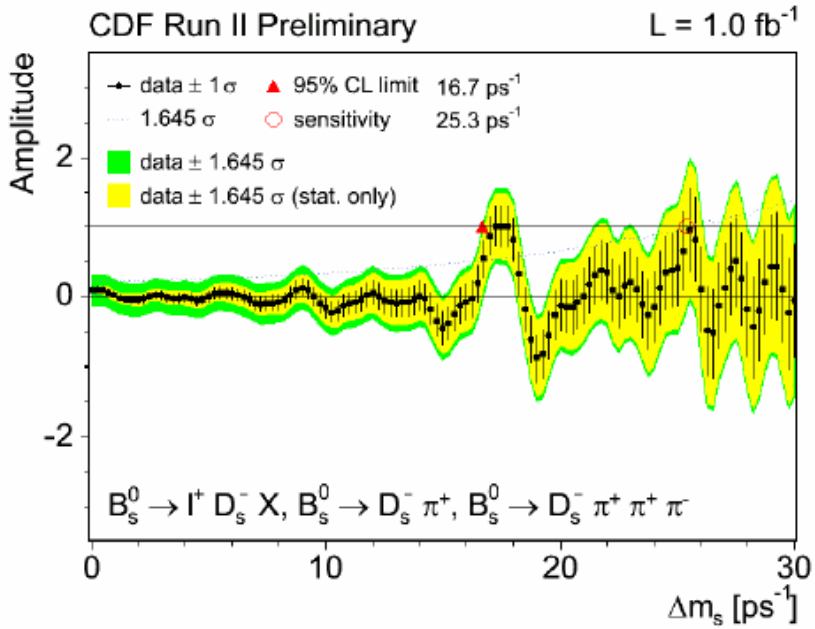


From the general **Fit** : SM at 93% C. L.
NP at 7% C. L.

L.Silvestrini LP05



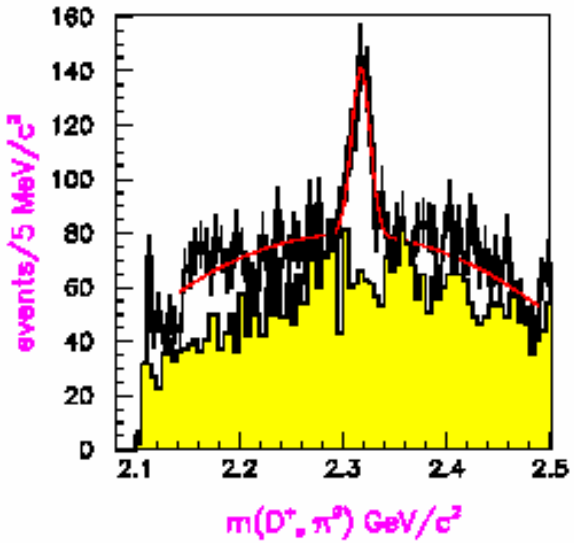
M.Pierini



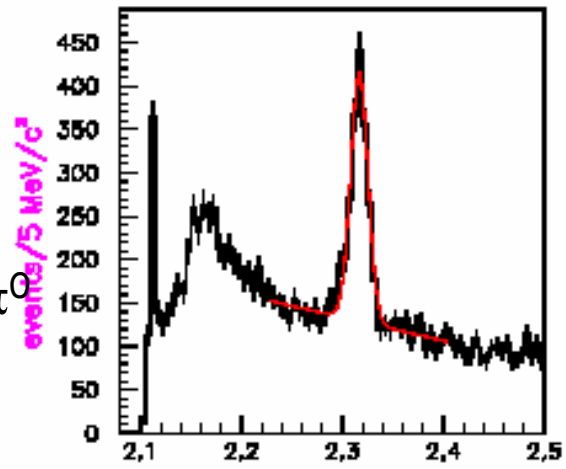
$\bar{\rho} = 0.193 \pm 0.029$
[0.133, 0.248] @ 95% Prob.

$\bar{\eta} = 0.355 \pm 0.019$
[0.318, 0.393] @ 95% Prob.

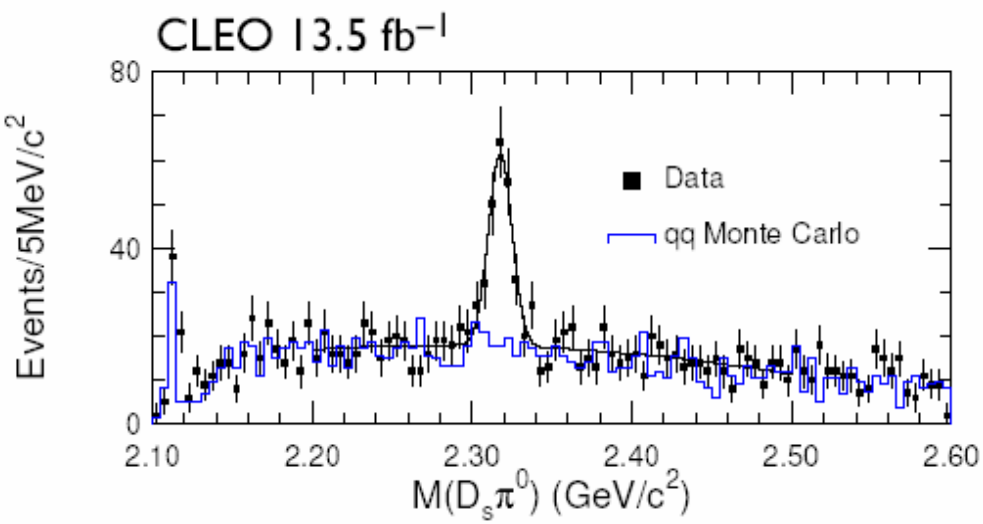
Not only CPV : $D_s(2317) \rightarrow D^+s(1970)\ \pi^0$:

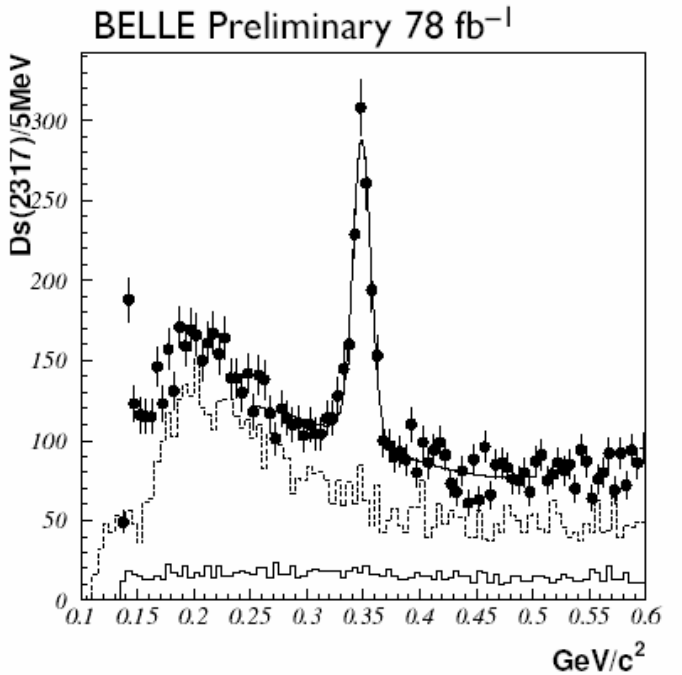


$D^+_s \rightarrow K^+K^-\ \pi^+$



$D^+_s \rightarrow K^+K^-\ \pi^+\ \pi^0$





Also Spectroscopy

BABAR has first observed $D_s(2317)$ and BELLE the $X(3872)$ and $Y(3940)$.

More recent: $Y(4260)$ in $\pi^+\pi^- J/\psi$ Mass Spectrum

(ISR production: $e^+e^- \rightarrow (\gamma)J/\psi\pi^+\pi^-$)

Rare states have been accessible to Babar and Belle thanks to the very high statistics collected with a luminosity of about 10^{34} cm $^{-2}$ s $^{-1}$.

More and more states would be accessible with a luminosity >> 10^{36} cm $^{-2}$ s $^{-1}$

With higher statistics

The success of BFactories was due to:

HIGH statistics

Very clean environment

Good performance for time dependent analysis (Lorentz boost, thin beam pipe, good vertexing, good tagging)

What about extrapolating precision on UT parameters to higher statistics.

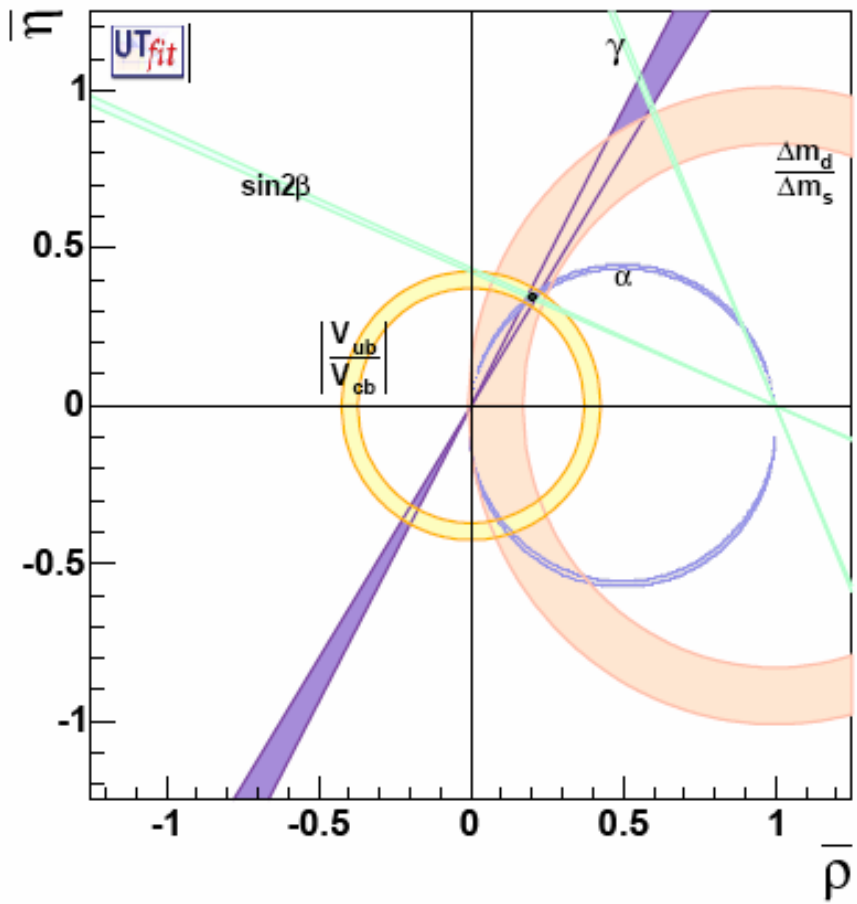
Unitarity Triangle – Sides& Angles

Unitarity Triangle - Sides		e^+e^- Precision		
Measurement	**Goal**	**3/ab**	**10/ab**	**50/ab**
V_{ub} (inclusive)	syst =5-6%	2%	1.3%	
V_{ub} (exclusive) (π,ρ)	syst=3%	5.5%	3.2%	
f_b B($B\to\mu\nu$)	SM: B~5x10^{-7}			
F_bB($B\to\tau\nu$)	SM: B~5x10^{-5}	3.3 σ	6 σ	13σ f_b to ~10%
V_{td}/V_{ts} ($\rho\gamma/K*\gamma$)	Theory 12%	~3%	~1%	

Unitarity Triangle - Angles	e^+e^- Precision		
Measurement	**3/ab**	**10/ab**	**50/ab**
$\alpha(\pi\pi)$ ($S_{\pi\pi}$, $B\to\pi\pi$ BR's+ isospin)	6.7°	3.9°	2.1°
$\alpha(\rho\pi)$ (Isospin, Dalitz) (syst $\geq$3°)	3, 2.3°	1.6, 1.3°	1, 0.6°
$\alpha(\rho\rho)$ (penguin, isospin, stat+syst)	2.9°	1.5°	0.72°
$\beta(J/\psi K_S)$ (all modes)	0.3°	0.17°	0.09°
$\gamma(B\to D^{(*)}K)$ (ADS)		2-3°	
γ(all)		1.2-2°	

Theory: α~1° β~ 0.2° γ<<1°

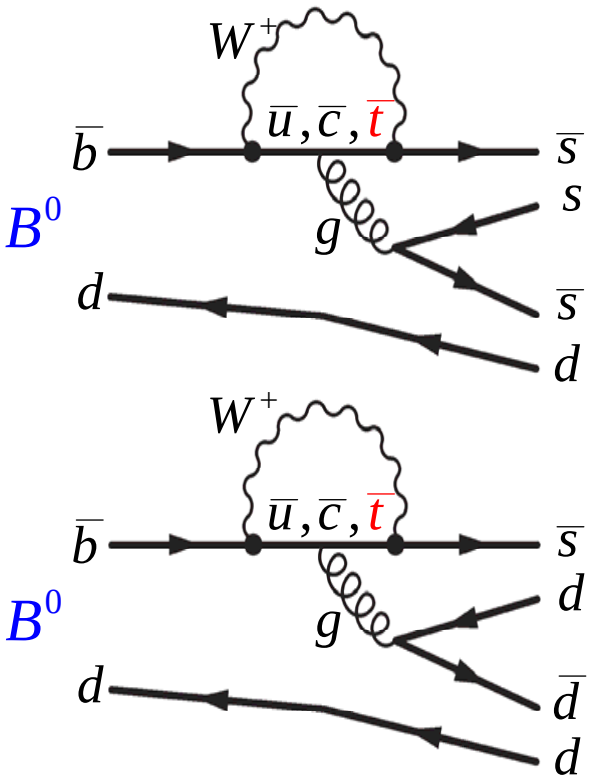
UNIVERSAL UT fit with 50 ab^{-1}



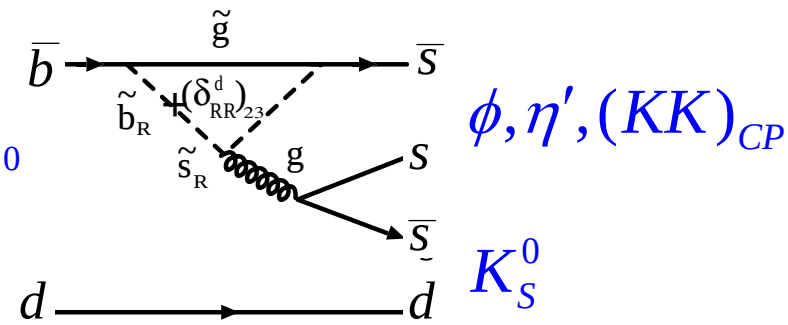
Universal fit makes only use of quantities independent of NP contributions within MFV

sin2β and loops a road to NP?

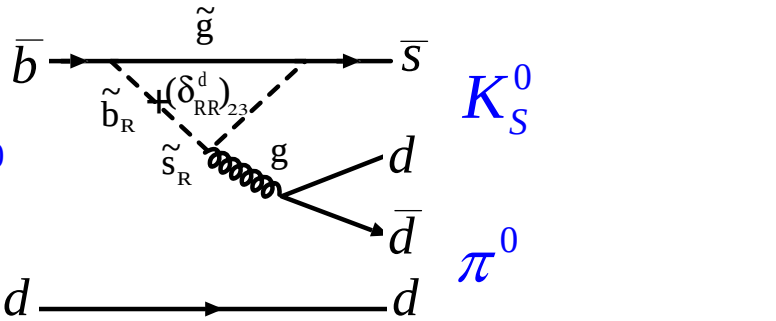
In SM interference between B mixing, K mixing and Penguin $b\to s\bar{s}s$ or $b\to s\bar{d}d$ gives the same $e^{-2i\beta}$ as in tree process $b\to c\bar{c}s$. However loops can also be sensitive to New Physics!



$O(\lambda^2)$
~ 5%
Purely dimensional estimate
$O(\lambda^2/\bar{\lambda})$
~ 20%

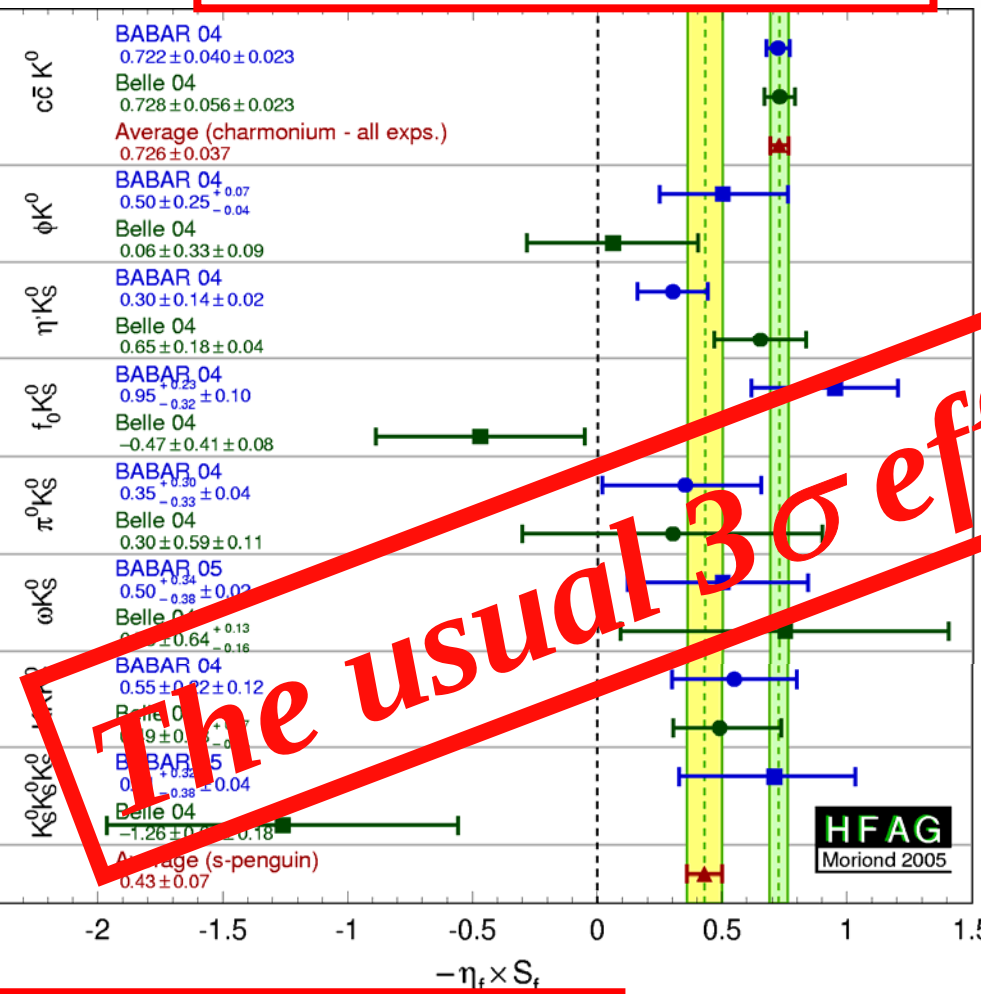


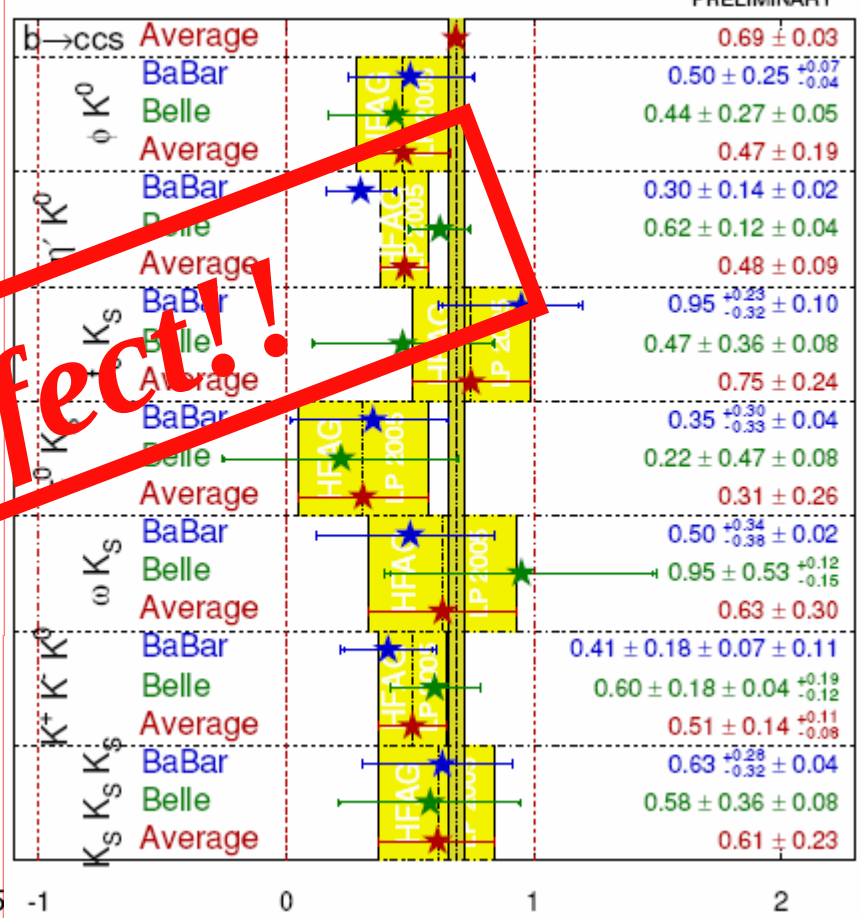
New phases from SUSY?



Before summer 2005

Lp05





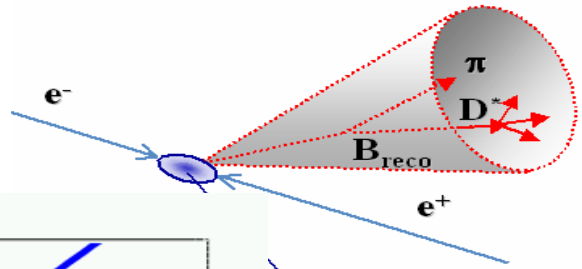
The usual 3σ effect!!

Deviation from SM:
No theory error: 3.7 σ
Naïve theory errors: 2.9 σ

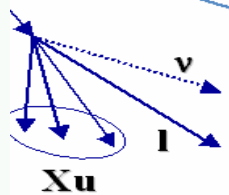
- All except $\eta' K^0$ are within $\sim 1\sigma$
- All except $f_0 K^0_S$ have $\Delta S < 0$

Peculiarity of e+e- Factory : Recoil Method as pure B beam

F.Forti



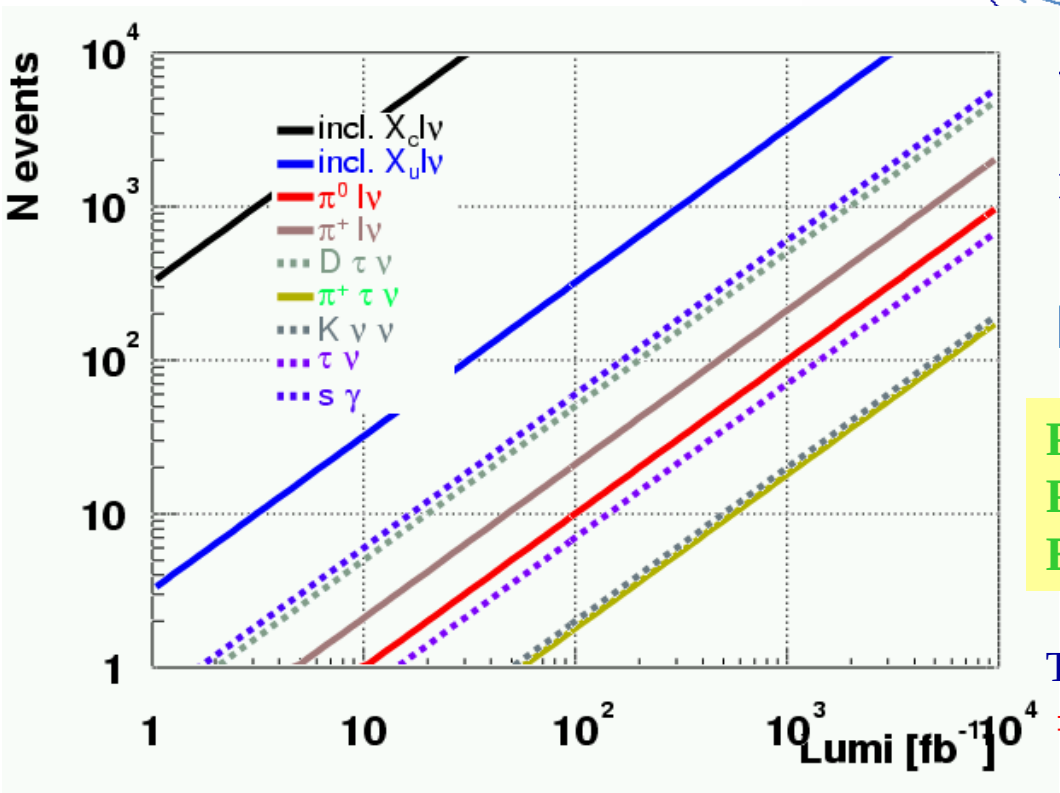
- Fully reconstruct one of the two Bs in hadronic modes...
- ...and do it with "high" efficiency



- The remaining of the event is the other B

You have a single B beam!!

Daniele del Re UCSD



Recoil cinematics well known
Recoil flavor and charge is determined
Event closure needed with neutrinos

The final efficiency is ~0.4% (per bb_{bar} pair)
$\Rightarrow$ ~4000 B/fb^{-1} (at 30% purity)
$\Rightarrow$ 1500 B^0/fb^{-1}
$\Rightarrow$ 2500 B^+/fb^{-1}
> 10^7 recoil Bs in 10ab^{-1}

Physics case for very high lumi

On the physics case a lot of documents are available they are the result of three years of Physics workshops in Slac ,in KEK and Joint meetings in Hawaii .

Three years of Physics Workshops have produced heavy documents . See for example:

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)

At the URL :

www.pi.infn.it/SuperB

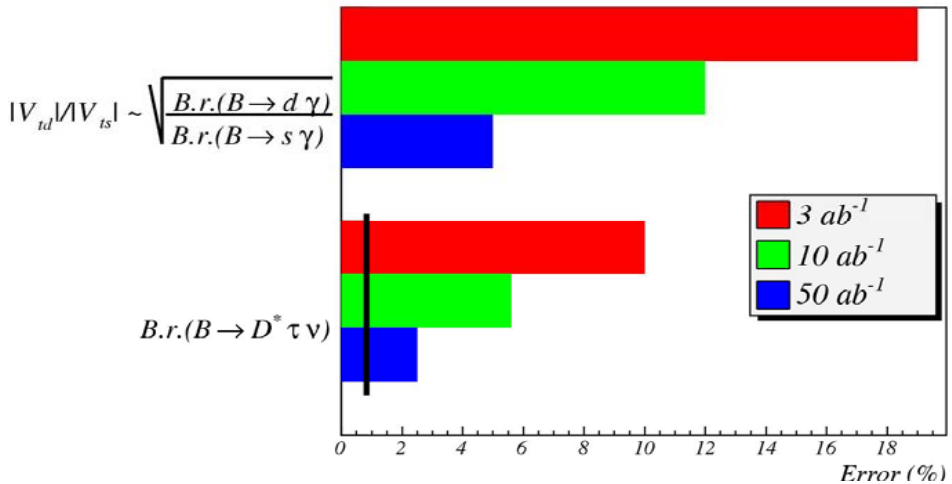
you can find documents and links to documents

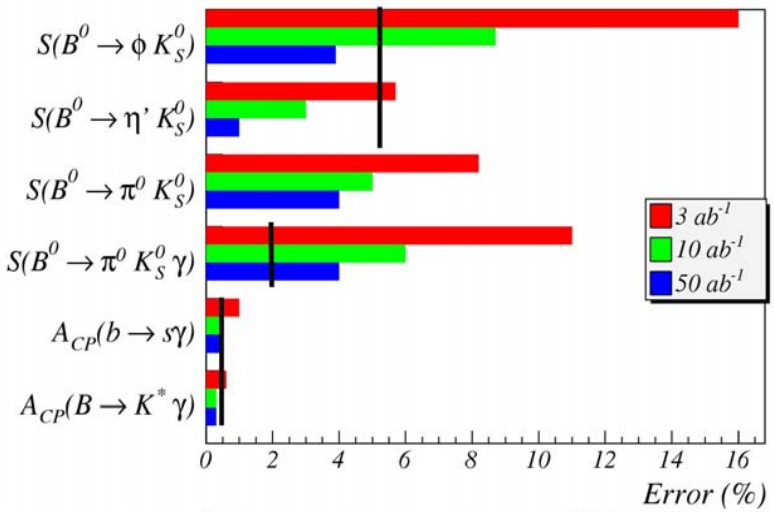
The physics case for a Super Flavour Factory is solid if :

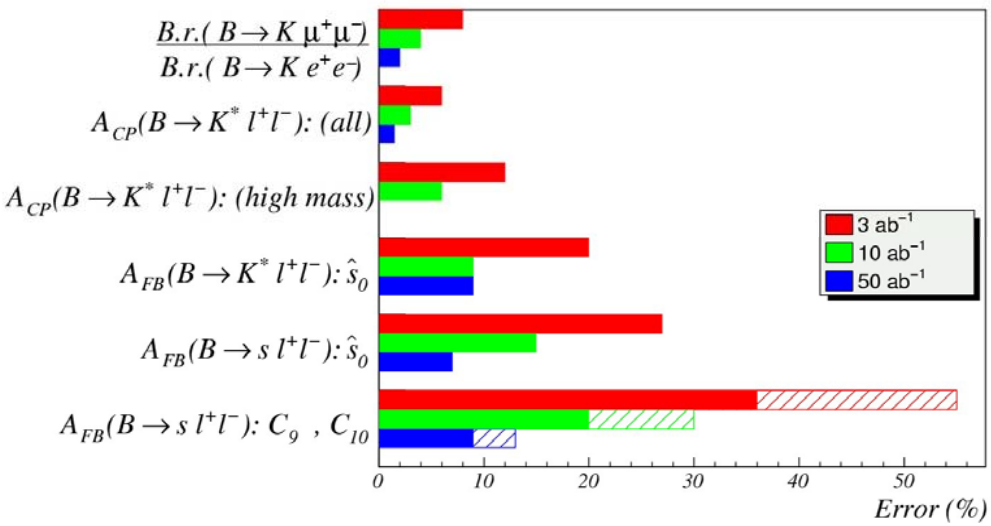
The sample of data available in a few years of running can reach 100 ab $^{-1}$ (10 ^{11} BBbar, tau and charm pairs)

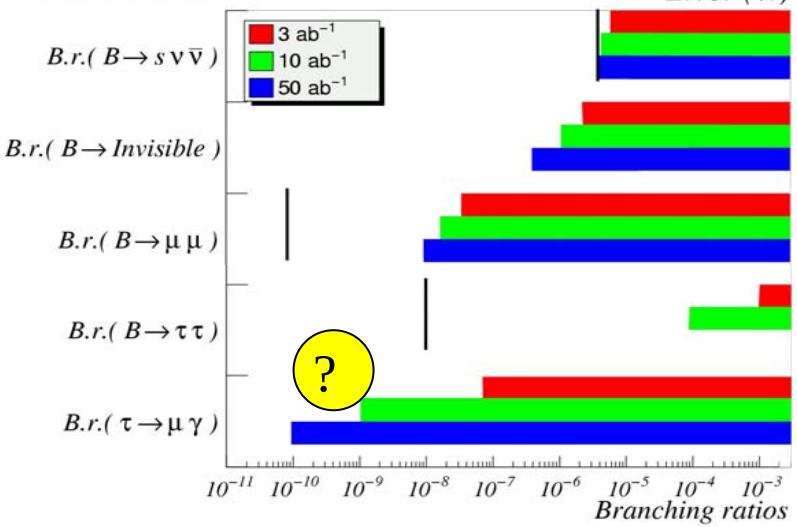
The running period is overlapped to LHC. (Results from Super Flavour and LHC are largely complementary).

As asked by the president of INFN an international study group has been formed to study the case, to evaluate the solution with time, costs, synergies, footprint of the machine……


$|V_{td}|/|V_{ts}| \sim \sqrt{\frac{B.r.(B \to d\,\gamma)}{B.r.(B \to s\,\gamma)}}$
$B.r.(B \to D^{*}\,\tau\,\nu)$
3 ab^{-1}
10 ab^{-1}
50 ab^{-1}
0 2 4 6 8 10 12 14 16 18
Error (%)


$S(B^0 \to \phi\, K^0_S)$
$S(B^0 \to \eta'\, K^0_S)$
$S(B^0 \to \pi^0\, K^0_S)$
$S(B^0 \to \pi^0\, K^0_S\,\gamma)$
$A_{CP}(b \to s\gamma)$
$A_{CP}(B \to K^{*}\,\gamma)$
3 ab^{-1}
10 ab^{-1}
50 ab^{-1}
0 2 4 6 8 10 12 14 16
Error (%)


$\frac{B.r.(B \to K\,\mu^{+}\mu^{-})}{B.r.(B \to K\,e^{+}e^{-})}$
$A_{CP}(B \to K^{*}\,l^{+}l^{-})$: (all)
$A_{CP}(B \to K^{*}\,l^{+}l^{-})$: (high mass)
$A_{FB}(B \to K^{*}\,l^{+}l^{-}): \hat{s}_0$
$A_{FB}(B \to s\,l^{+}l^{-}): \hat{s}_0$
$A_{FB}(B \to s\,l^{+}l^{-})$: C_9 , C_{10}
3 ab^{-1}
10 ab^{-1}
50 ab^{-1}
0 10 20 30 40 50
Error (%)


$B.r.(B \to s\,\nu\,\bar{\nu})$
$B.r.(B \to Invisible)$
$B.r.(B \to \mu\,\mu)$
$B.r.(B \to \tau\,\tau)$
$B.r.(\tau \to \mu\,\gamma)$
3 ab^{-1}
10 ab^{-1}
50 ab^{-1}
?
10^{-11} 10^{-10} 10^{-9} 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3}
Branching ratios

Some parameters for comparison with hadron expriments

	P.Lumi ($10^{33}cm^{-2}s^{-1}$)	σ_{bb} (10^{-33})	BB (10^7/y)	σ_{bb}/σ_{qq}
Bfactories	10	1.1	16	0.3
SuperB	2÷5x1000	1.1	3÷7.5 1000	0.3
pp at LHC		500000		0.005

In LHC-b the peak luminosity is 0.2 ($10^{33}cm^{-2}s^{-1}$) and in one year (2/fb) 100000 (10^7/y) B are expected

τ and charm pairs as many as BB in e+e- factories

What kind of Super B Factory?

- Peak Lumi >>10^{36} cm $^{-2}$ s^{-1} to allow 50/ab in one or two years of running.
- Running period : overlap with LHC and possibly before ILC
- Asymmetric (at least 7+4 GeV)

Options under evaluation:

Possibility to operate symmetric even at lower energy for τ and charm physics and with at least one polarised beam.

Still with at least 10^{35} cm $^{-2}$ s^{-1} .

More

- **Low background. Lower than in Babar**
- Wall power less than 50 MW(goal 25MW)
- Low beam energy spread for best background rejection as inPEPII or KEKB.
- Upgradable to higher performance
- Possibiliy of reusing existing machine components
- High level of Synergy with other machine projects as ILC.
- “ To be studied the possibility to run down to Φ ”

Traditional machines

Prescription for high lumi is :

- Increase current higher than 10 Amps (?)
- Then increase Background in the detectors
- Increase wall power

Above 5 10^{35} cm $^{-2}$ s^{-1} seems very hard the design of detector with present or near future technology

Wall power jumps soon above hundreds of MW.

Heretic Solution

A new scheme:

the "Linear" SuperB

(It is not a linear machine)

- Basic Idea comes from the ATF2-FF experiment (R&D for ILC)

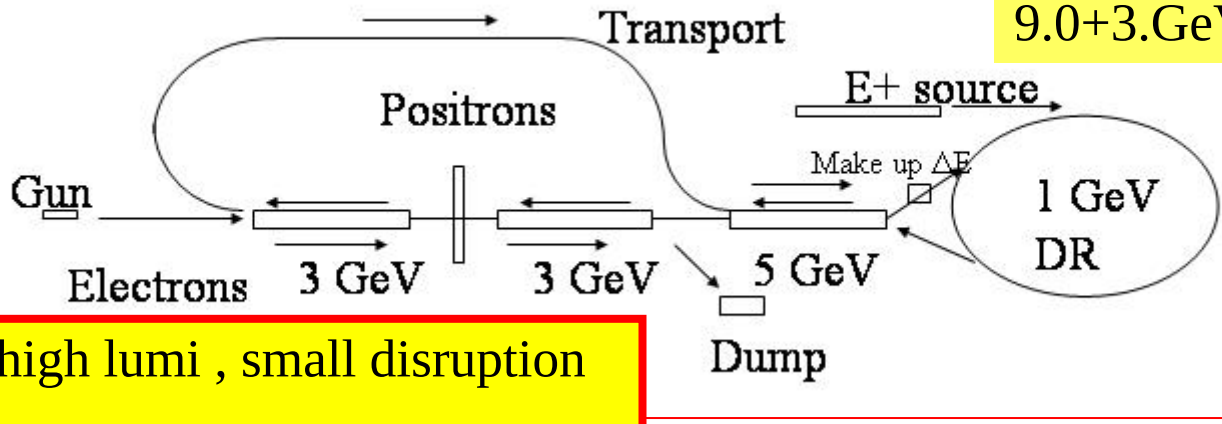
  In the proposed experiment it seems possible to acheive spot sizes at the focal point of about 2μm*20nm at very low energy (1 GeV), out from the damping ring
- Rescaling at about 10GeV/CM we should get sizes of about 1μm*10nm =>
- Is it worth to explore the potentiality of a Collider based on a scheme similar to the Linear Collider.

(P.Raimondi at Hawaii 05 meeting on Super B)

Basic idea first shot

- Instead of being a limitation, Beam-Beam interaction might actually help to increase the luminosity,but more power in DR.
- Need to find a suitable parameters set: stable collisions, reasonable outgoing emittances and energy spread
- Average current through the detector 10-100 times smaller than in the rings (10-100 mA)
- Experiment looks reasonable(narrow beam pipe-no Bkgd)
- Damping Rings, even with a parameter set very similar to the ILC ones, have still to handle a lot more current and more radiation from increased damping
- Energy spread in collision is also an issue
- WALL POWER 1100 MW!!!!!!!!

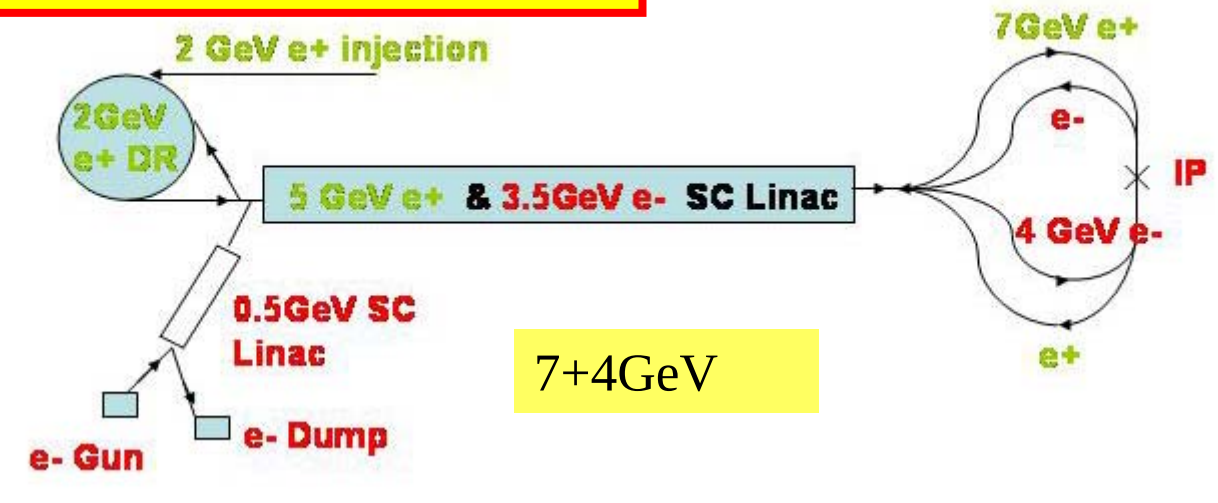
Several Layouts…



9.0+3.GeV

But need of high lumi , small disruption

➡ Single turn collision, xing angle and……



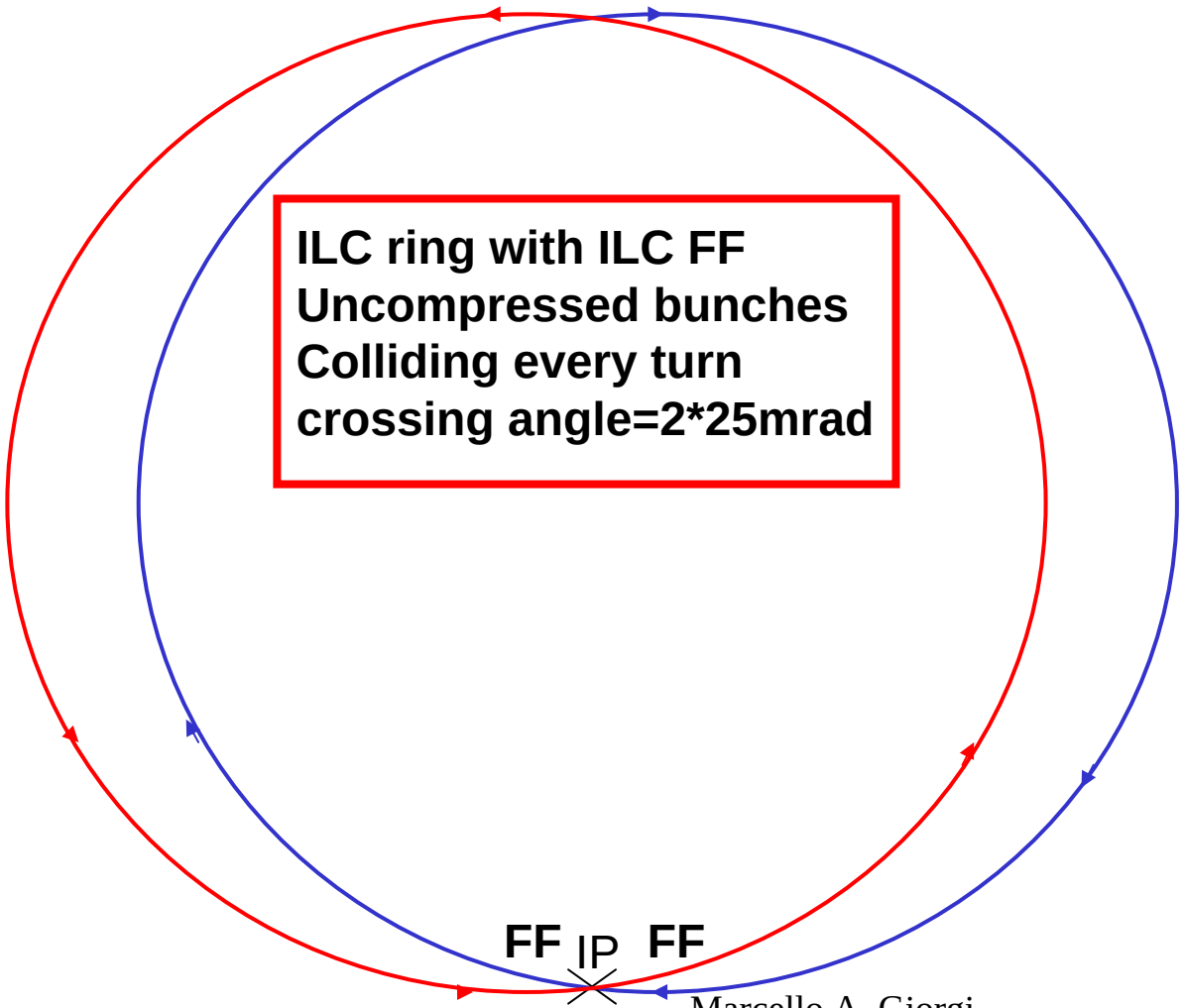
7+4GeV

Solution

See P.Raimondi talk

Synergy with ILC + CRAB WAIST

(3 Km/ 6Km)



BKGD expected lower than in BaBar at PEPII.

1.0 cm Beam pipe possible inside SVT

Total Wall Power (66% transfer eff.): 34 MW !!

	LER 4 GeV	HER 7 GeV
C (m)	3006.	3006.
B_w (T)	1.6	1.6
L_{bend}(m)	5.6	11.2
B_{bend} (T)	0.078	0.136
Uo (MeV/turn)	4.6	7.8
N. wigg. cells	8	4
τ_x (ms)	17.5	18.
τ_s (ms)	8.8	9.
ε_x (nm)	0.54	0.54
σ_E	1.1×10^{-3}	1.45×10^{-3}
I_{beam} (A)	2.5	1.4
P_{beam}(MW)	11.5	10.9

Also 6000 m.

N_{bunch}=5000 /10000

cm σ_E=0.9x10^{-3}

0.5x10-3

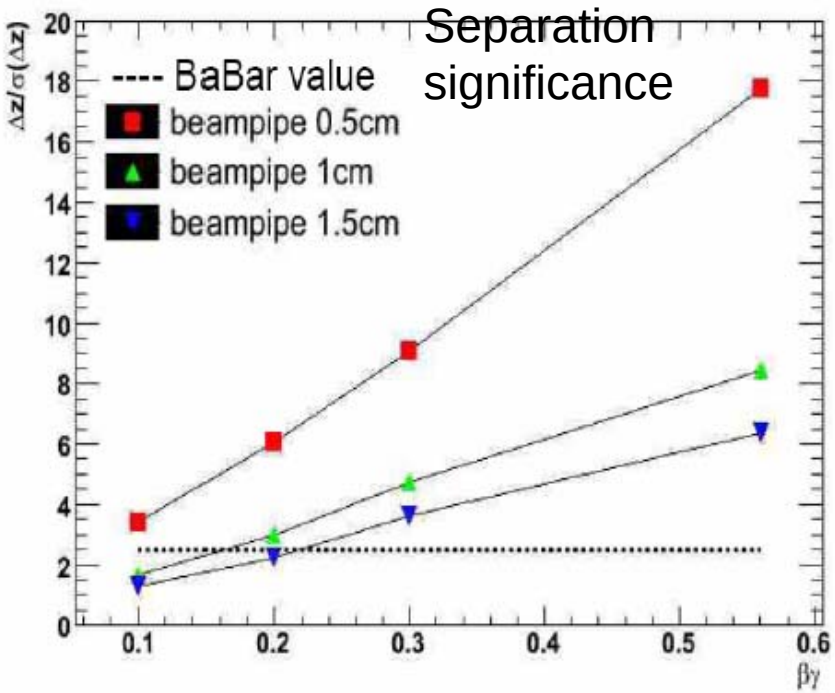
Beam Pipe Radius

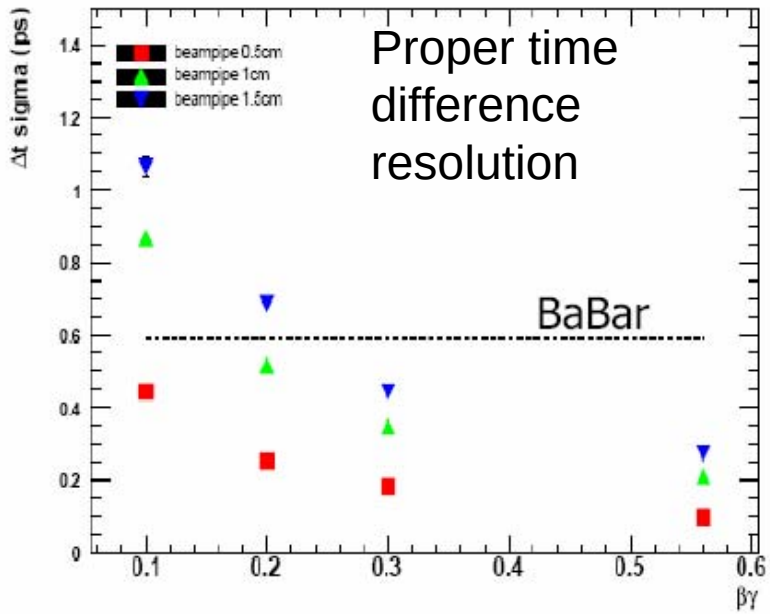
- Small beam pipe radius possible because of small beam size
  - Studied impact of boost on vertex separation (B→ππ)
  - Beampipe hypothesis (no cooling)
    - 5um Au shield to protect from soft photons
    - 0.5cm → 200um Be and 5um hit resolution (0.21% X0)
    - 0.5cm → 300um Be and 10um hit resolution (0.24% X0)
    - 0.5cm → 500um Be and 10um hit resolution (0.29% X0)
  - 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





Detector comments

Background should be lower than in Babar. Occupancy would be OK in Vertex Detector even with a smaller radius beam pipe. (from 3cm of Babar down to 1.cm). Simulations are currently run for interaction region and Bgkd.

Apparatus would be more hermetic than Babar and Belle (7+4 GeV).

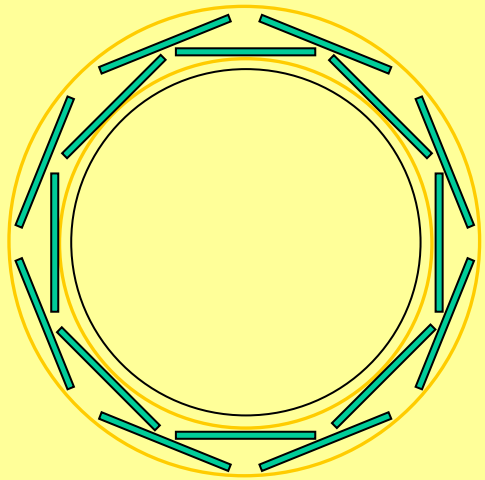
Detectors don't require a major R&D

PID would be needed also in forward/backward direction.

By reducing Lorentz boost higher resolution vertex is needed (MAPS?)

R&D on EMC (Babar Caltech..)

R&D on PID (Babar: Slac) (Belle :KeK ,Lubijana



x5 scale with 10mm radius BP, 6mm pixel chip

R&D on Maps within Belle (Hawaii group)and Babar (Pisa+Slac)

Two monolithic active pixel layers glued on beam pipe

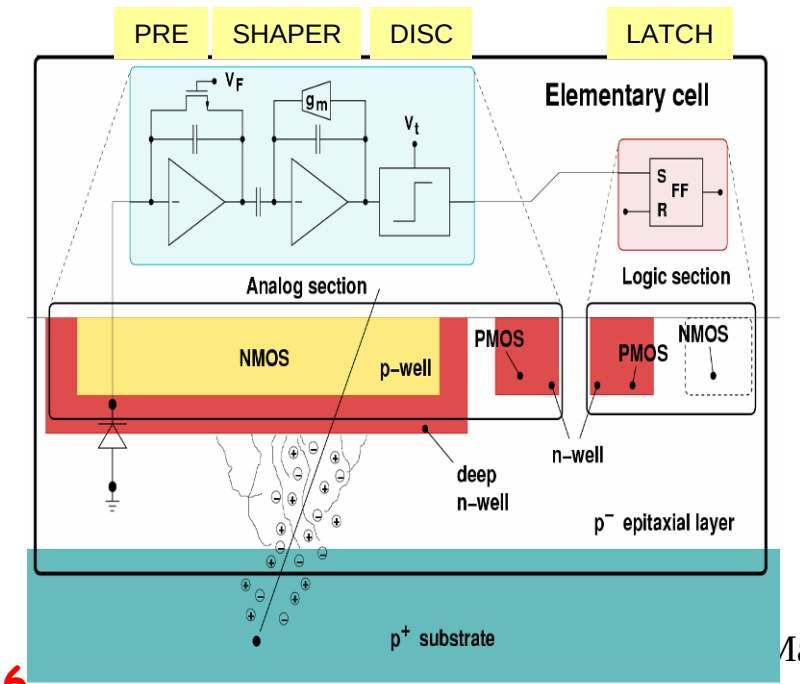
Since active region is only ~10μm, silicon can be thinned down to ~50μm.Good resolution O(5μm).

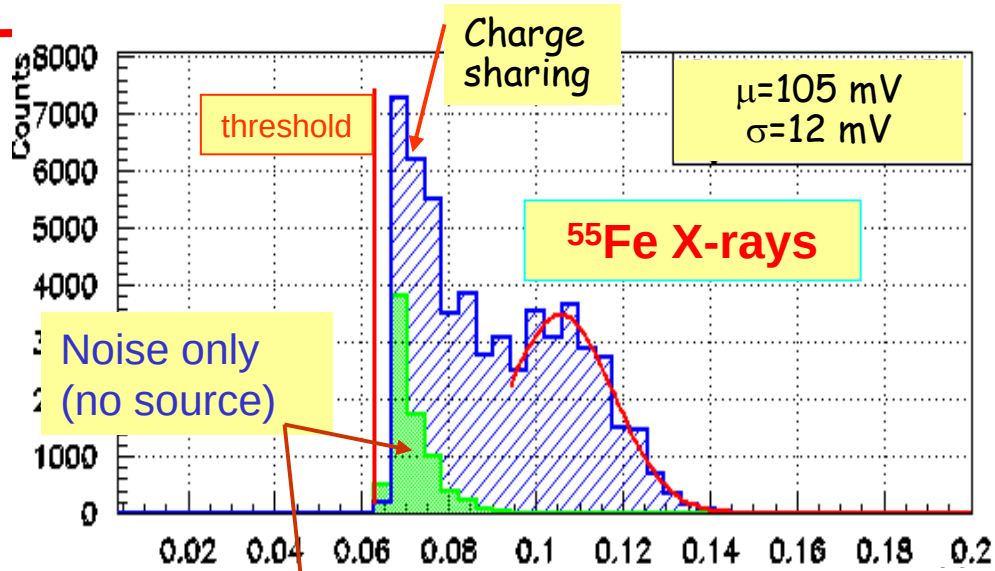
Improves pattern recognition robustness and safety against background

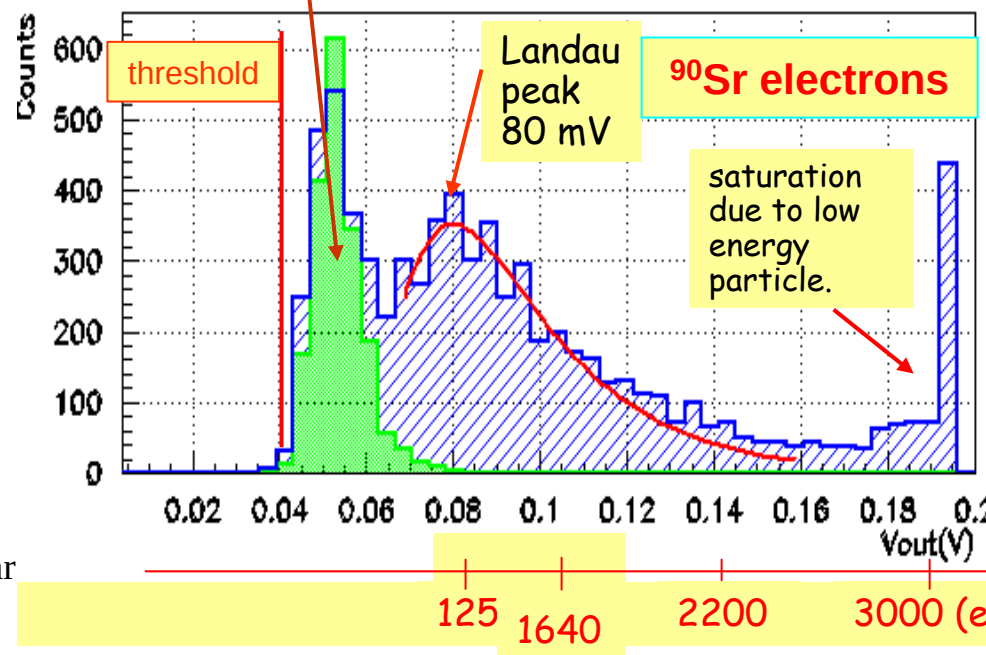
MAPS R&D

~~ST 0.13um triple well technology~~
Single pixels tested with source
Full signal processing chain

- SLIM chip (Babar collabor.)







International study group

An international Study Group was set up coordinated by a steering committee with the aim of preparing a document (CDR) by the end of 2006. We had 2 workshops in Frascati:

November2005

March 2006

Next 2 workshops :

- 14-17june 06 in SLAC
- october 06 in Rome (Parallel :Theory, Expt., Machine)

An Steering committee is coordinating the group activity

M.A.G. coordinator

Members: 1 Canada,2 France, 2 Germany, 2 Italy, 2 Russia, 2Spain, 2 UK, 4 US.

Activity is documented in

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

Short term goals

- Better definition of a single machine design
- Study of the interaction region and Background
- Evaluation of needs for special runs symmetric, at c.m. energies even lower than 10 GeV.
- Evaluation of benefits with one polarized beam

An ad hoc task force lead by D.Hitlin is in charge of studying need for special runs for tau-charm.

Preliminary report in june.

Conclusions

- A SuperB Flavor Factory based on Linear Collider components seems feasible to deliver in a year >20/ab (> 2 10^{10} BBbar, $\tau+\tau-$, c-cbar pairs)
- Full Synergy with ILC project is visible
- (same damping ring, same final focus from ILC R&D)
- Crab waist could be beneficial for ILC project

Possible test in 2007 of crab waist in Daphne at LNF.

A positive result could give an increase in peak lumi of a factor 3 above design.

Conclusion 2

Only one Super B Factory will be built if one.

Site decision should be open

Lumi as high as possible

(> 10^{36} better 10^{43} !!)

We have set up an International Group

Collaboration between SuperB and SuperKEKB is needed and welcome!