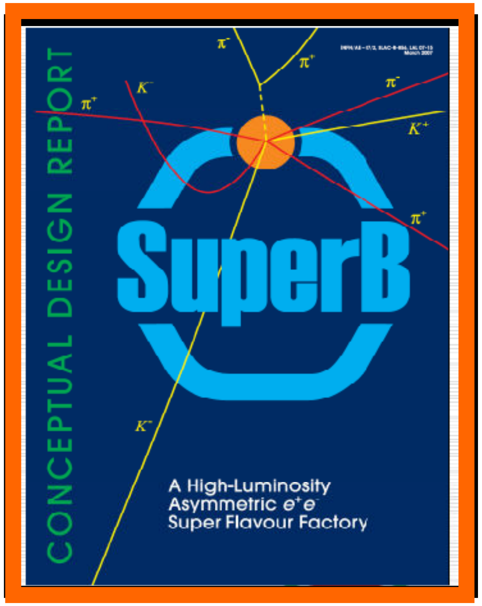
The SuperB Project


CONCEPTUAL DESIGN REPORT

SuperB

A High-Luminosity
Asymmetric e^+e^-
Super Flavour Factory

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In this seminar I'll discuss a project named SuperB factory. « Super » because the luminosity will be100 times the one of the present B-factory with the aim of discovering and/or studying NP

Two of such projects exist

1. « KEKB in Japan »
2. « SuperB in Italy »

I'll discuss the program to construct a SuperB factory (with new accelerating scheme concepts) in Italy, near by Frascati

Why we are discussing it now ?

The TDR phase of the project has been approuved (6MEuros/year)
We aim for an project approuval (during this phase) by the beginning of the next year for a data taking in ~2015.

Physics Program

Why ?

35’

The Machine

How ?

15’

The Detector

Left for discussion

Physics Program

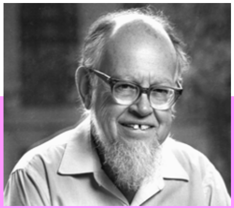
SuperB is a discovery machine in LHC era

Flavour Physics in the *Standard Model* (SM) in the quark sector:

10 free parameters

6 quarks masses

4 CKM parameters



parametrization : λ ,$\mathbf{A}$, $\bar{\rho}$, $\bar{\eta}$

η responsible for CP violation in SM

In the Standard Model, charged weak interactions among quarks are codified in a 3 X 3 unitarity matrix :

the  **Matrix**.

C K M

The existence of this matrix conveys the fact that the quarks which participate to weak processes are linear combination of mass eigenstates

The fermion sector is poorly constrained by SM + Higgs Mechanism

mass hierarchy and CKM parameters

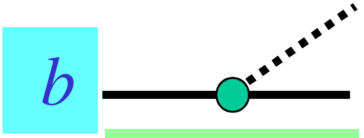
The **CKM** Matrix

Wolfenstein parametrization

4 parameters : λ ,**A**, ρ, η

$$\begin{array}{c|ccc} & d & s & b \\ \hline u & 1-\lambda^2/2 & \lambda & A\lambda^3(\rho-i\eta) \\ c & -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ t & A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{array}$$

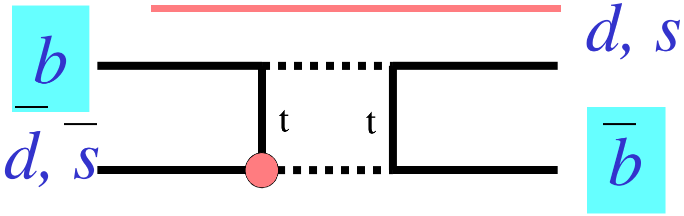
V_{tb}



V_{ub}, V_{cb}

B decays

B Oscillations



The *b-Physics* plays a very important role in the determination of those parameters

The Unitarity Triangle

The CKM is unitary

$$V V^\dagger = V^\dagger V = 1$$

The non-diagonal elements of the matrix products correspond to 6 triangle equations

$$V^*_{ud}V_{us} + V^*_{cd}V_{cs} + V^*_{td}V_{ts} = 0 \qquad \lambda\ \lambda\ \lambda^5$$

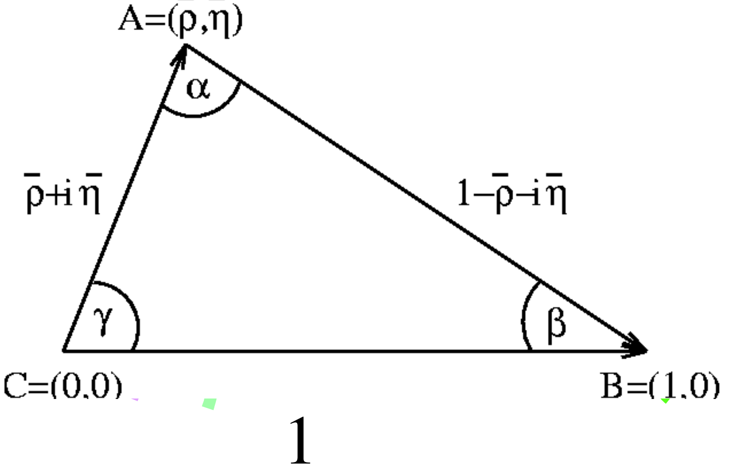
$$V^*_{ub}V_{ud} + V^*_{cb}V_{cd} + V^*_{tb}V_{td} = 0 \qquad \lambda^3\ \lambda^3\ \lambda^3$$

$$V^*_{us}V_{ub} + V^*_{cs}V_{cb} + V^*_{ts}V_{tb} = 0 \qquad \lambda^4\ \lambda^2\ \lambda^2$$

$$V^*_{ud}V_{td} + V^*_{us}V_{ts} + V^*_{ub}V_{tb} = 0 \qquad \lambda^3\ \lambda^3\ \lambda^3$$

$$V^*_{td}V_{cd} + V^*_{ts}V_{cs} + V^*_{tb}V_{cb} = 0 \qquad \lambda^4\ \lambda^2\ \lambda^2$$

$$V^*_{ud}V_{cd} + V^*_{us}V_{cs} + V^*_{ub}V_{cb} = 0 \qquad \lambda\ \lambda\ \lambda^5$$



$$\overline{AB} = \frac{V_{td}V^*_{tb}}{V_{cd}V^*_{cb}} = \sqrt{(1-\bar\rho)^2+\bar\eta^2} = \frac{1}{\lambda}\left|\frac{V_{td}}{V_{cb}}\right| \sim \frac{1}{\lambda}\left|\frac{V_{td}}{V_{ts}}\right|$$

$$\overline{AC} = \frac{V_{ud}V^*_{ub}}{V_{cd}V^*_{cb}} = \sqrt{\bar\rho^2+\bar\eta^2} = \left(1-\frac{\lambda^2}{2}\right)\frac{1}{\lambda}\left|\frac{V_{ub}}{V_{cb}}\right|$$

$$\beta = \arg\left(\frac{V_{td}V^*_{tb}}{V_{cd}V^*_{cb}}\right) = \operatorname{atan}\left(\frac{\bar\eta}{(1-\bar\rho)}\right)$$

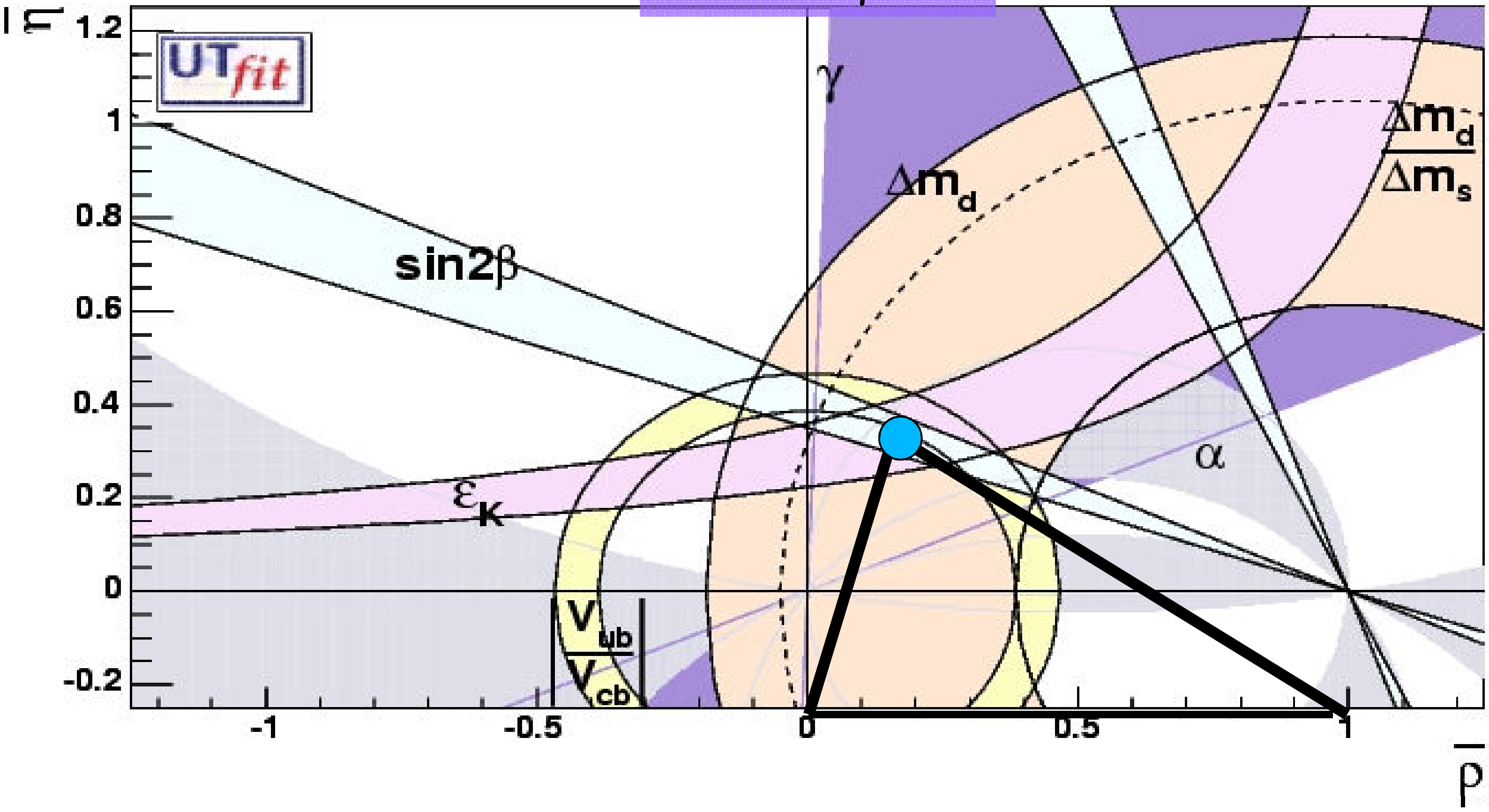
$$\gamma = \arg\left(\frac{V_{ud}V^*_{ub}}{V_{cd}V^*_{cb}}\right) = \operatorname{atan}\left(\frac{\bar\eta}{\bar\rho}\right)$$

Also for angles B physics is crucial

$$\alpha + \beta + \gamma = \pi$$

An example on how to fit the UT parameters and fit new physics

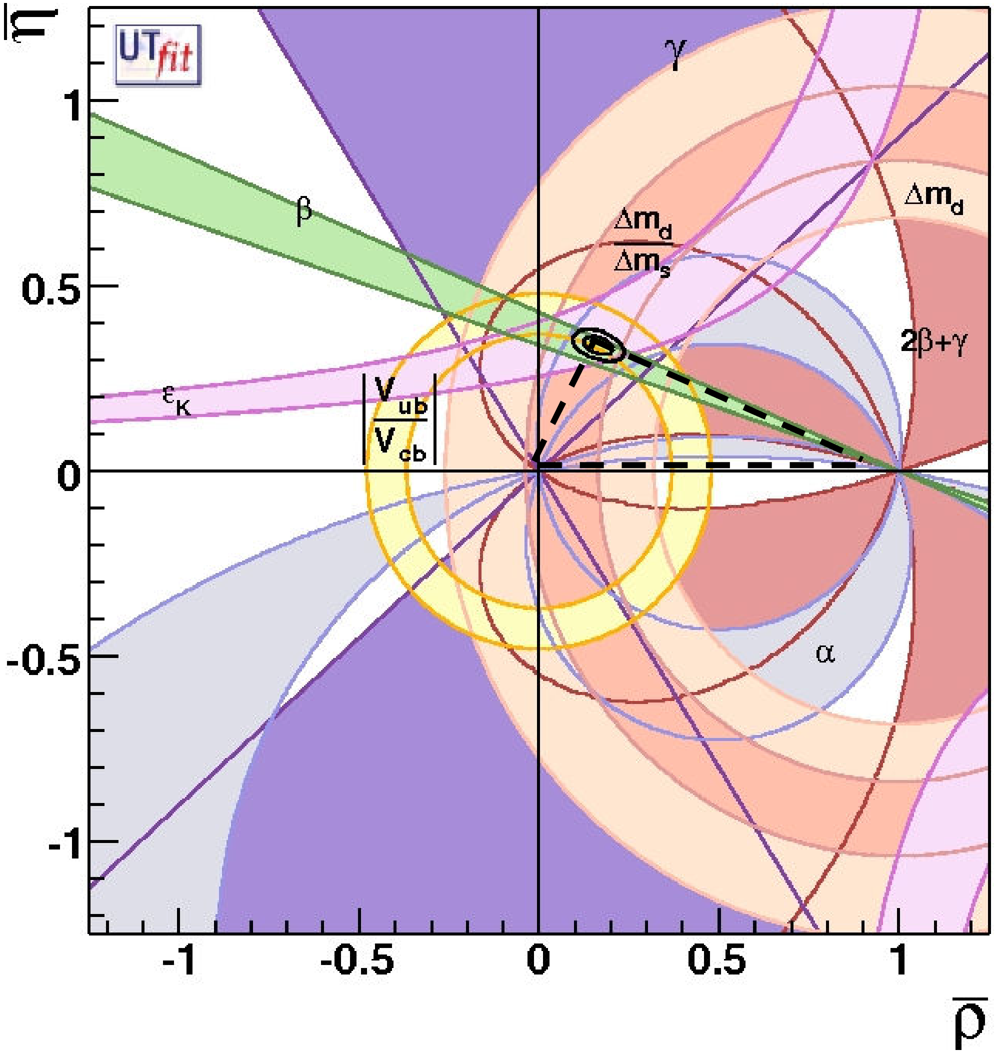
B→DK : γ



Crucial Test of the SM in the quarks sector

Coherent picture of CP Violation in SM

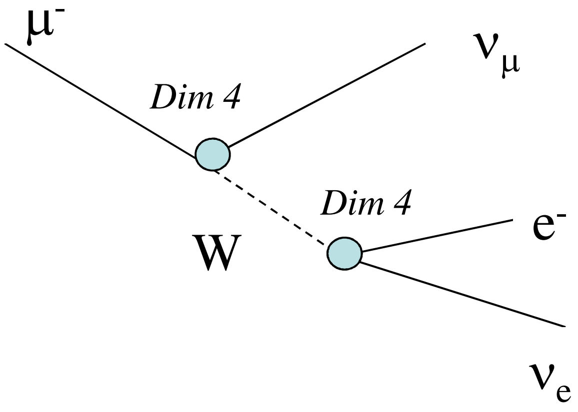
B factory legacy



Why to go on ?

$$L_{CC} = \frac{g}{\sqrt{2}}\left(J_\mu^- W_-^\mu + J_\mu^+ W_+^\mu\right)$$

SM

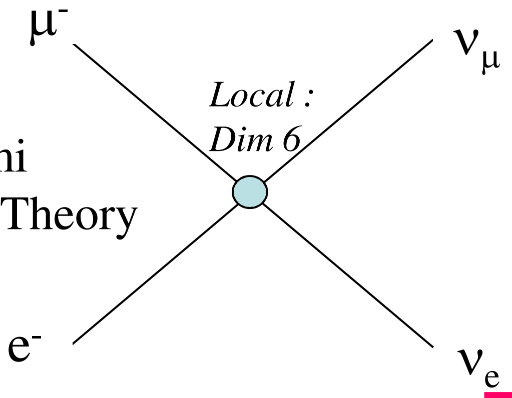


$$M = \left(\frac{g}{\sqrt{2}}\bar{u}_{\nu_\mu}\gamma^\mu \frac{1}{2}(1-\gamma_5)u_\mu\right)\frac{1}{M_W^2-q^2}\left(\frac{g}{\sqrt{2}}\bar{u}_e\gamma_\mu \frac{1}{2}(1-\gamma_5)u_{\nu_e}\right)$$

if $q^2<<M_W^2$ (case of beta decay)

$$M \approx \frac{g^2}{8M_W^2}\left(\bar{u}_{\nu_\mu}\gamma^\mu(1-\gamma_5)u_\mu\right)\left(\bar{u}_e\gamma_\mu(1-\gamma_5)u_{\nu_e}\right)$$

Fermi
Effective Theory



$$M \approx \frac{G_F}{\sqrt{2}}\left(\bar{u}_{\nu_\mu}\gamma^\mu(1-\gamma_5)u_\mu\right)\left(\bar{u}_e\gamma_\mu(1-\gamma_5)u_{\nu_e}\right)$$

Experimentally from muon decay $G_F = 1.16\times 10^{-5}\,GeV^{-2}$

$$\boxed{\frac{G_F}{\sqrt{2}} = \frac{g^2}{8M_W^2}}$$

The effective coupling constant GF is expressed as the SM « fundamental » coupling constant g divided by the mass of the propagator M_W squared (consequence of Dim=6 operators [4legs])

In this specific case we know

→ from SM $e = g\sin(\theta_W)$

→ Experimentally M_W~80 GeV

The weak interaction is not weak because of $g<<e$ but because of the large value for the W mass

Effective Flavour Theory to New Flavour Physics : A game of scale and coupling

$$\mathscr{L}_{\mathrm{eff}} = \mathscr{L}_{\mathrm{SM}} + \sum_{k=1} \Big(\sum_i C_i^k \, Q_i^{(k+4)} \Big) / \Lambda^k$$

New operators which are of dimension >4, in principle the theory is not Renormalizable…as Fermi theory was not..!
[You can show that in B physics the new operators have dimension 6]

NP flavour effects are governed by two players

→ the value of the new phyiscs scale Λ
→ the effective flavour-violating coupling C's

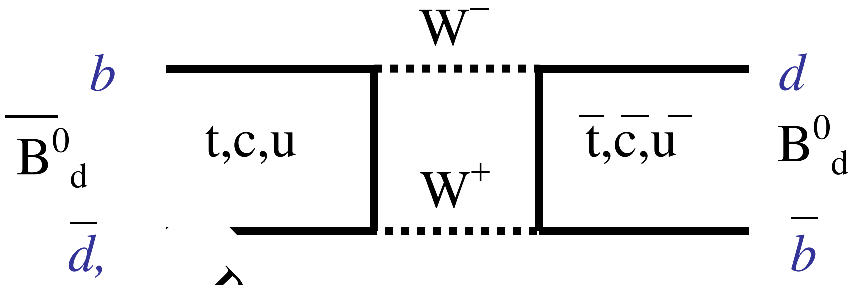
In explicit models

Λ ~ mass of virtual particle (Fermi theory : M_W)
C ~loop coupling × flavour coupling (SM/MFV α_w × CKM)

Example for B oscillations (FCNC-$\Delta B=2$)

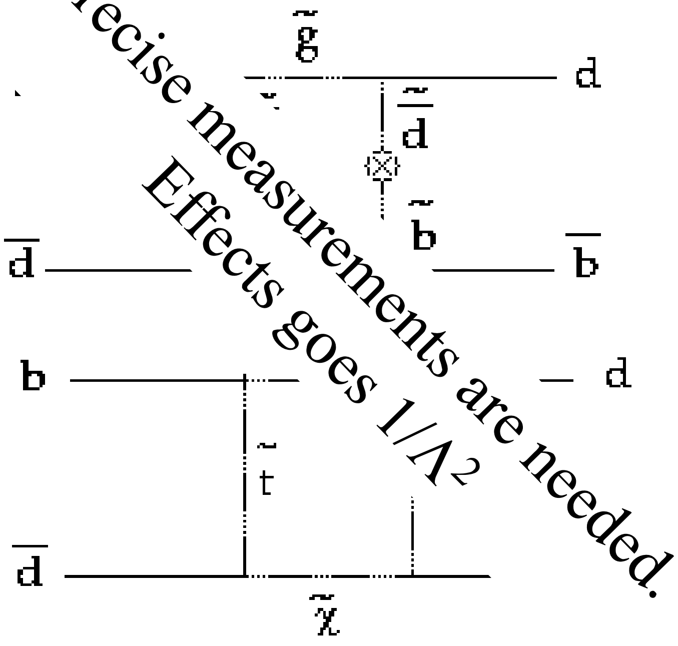
FCNC porcesses are ideal place to look for NP effects because they are suppressed in SM

SM



$$\frac{\left|V_{tb}^{*}V_{tq}\right|}{M_W^2}$$

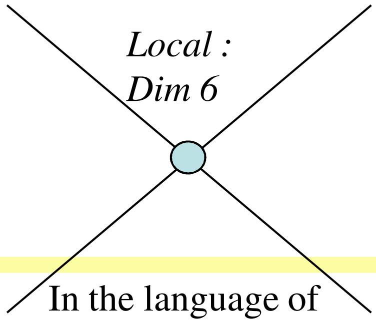
BSM



Precise measurements are needed

Effects goes $1/\Lambda^2$

$$\frac{\left|\delta_{bq}\right|}{\Lambda_{eff}^2}$$

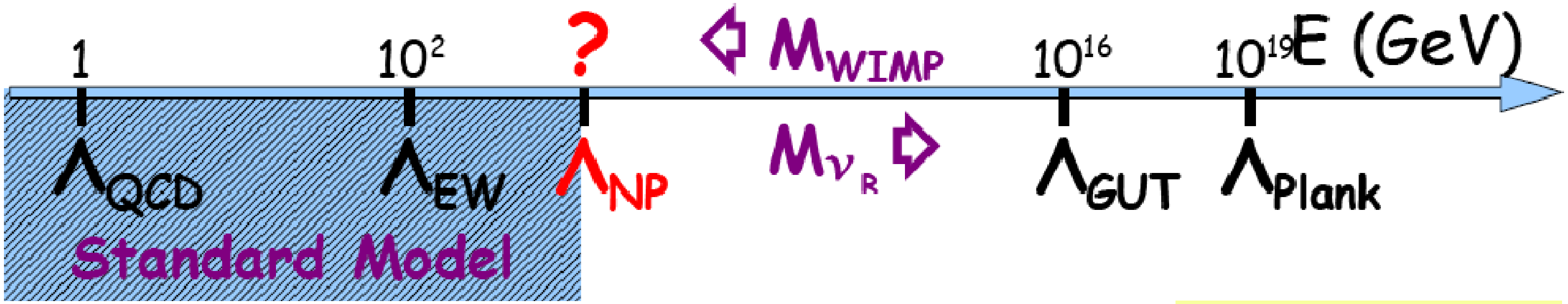


In the language of
The EFT, the operators
have dimension 6
→ $1/\Lambda^2$

The measurements (in this case Δm_d)
are modified wrt the predictions of the SM by the presence of BSM particles.

modifications are important if couplings are larger and/or NP masses are lighter

At which scale should we have to look for NP
$\Lambda \sim 0.5, 1\ldots10^{16}$ TeV ?
In other words is NP expected just under the corner..?

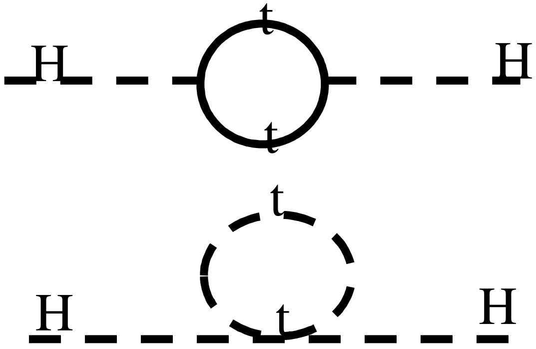


LHC will search on this range

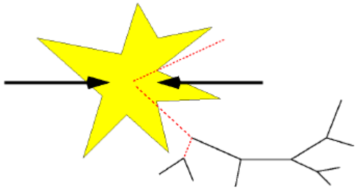
The quantum stabilization of the Electroweak Scale suggests that $\Lambda\sim$ 1TeV

$$m_H^2 \to m_{bare}^2 + \boxed{\delta m_H^2}$$

$$\delta m_H^2 = -\frac{3G_F}{\sqrt{2}\pi^2} m_t^2 \Lambda_{NP}^2 \boxed{\sim -(0.3\Lambda_{NP})^2}$$

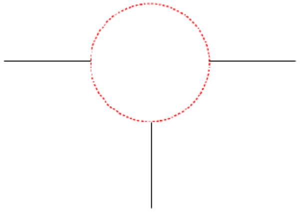


Those are arguments of fine tuning…if the NP scale is at 2-3..10 TeV
…naturalness is not at loss yet…



“Relativistic path”

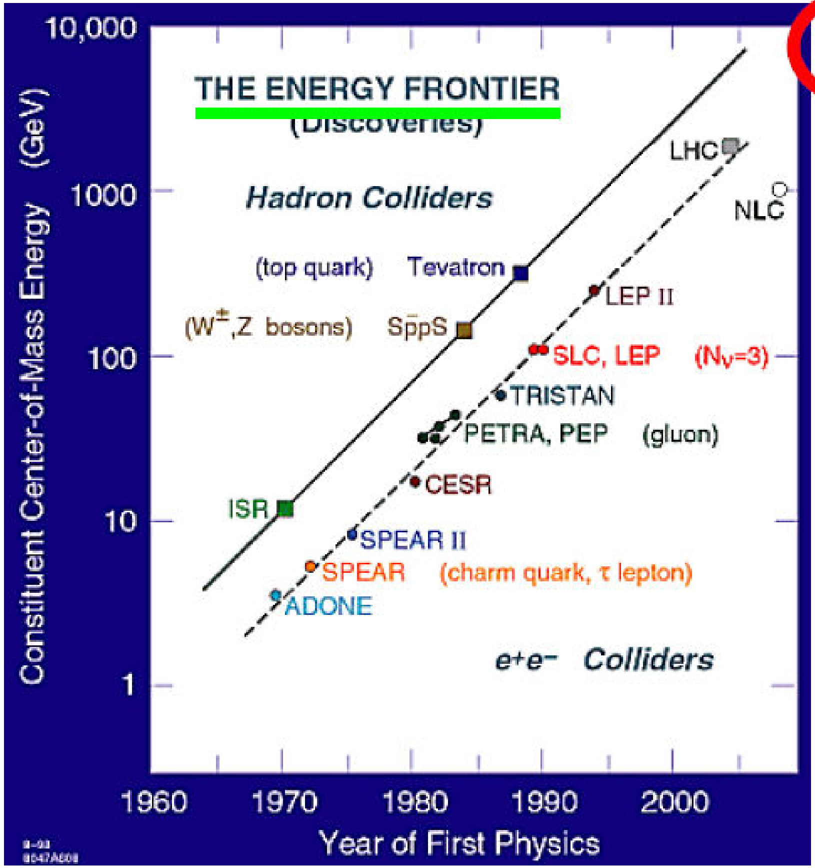
Crucial : Center-of-mass energy

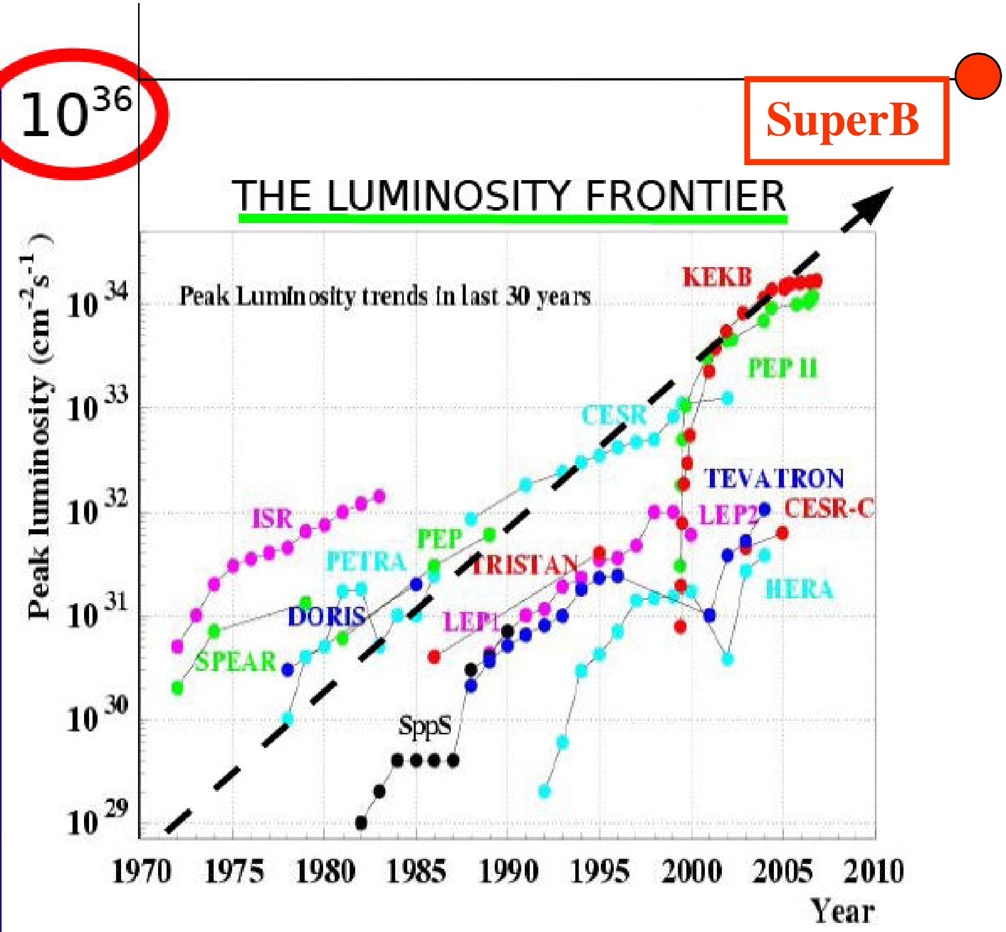


“Quantum path”

Crucial : Luminosity

Look for discrepancy wrt SM on many different measurements





The experiments working on flavour phyiscs
have to perform flavour measurements such that

$$\frac{\left|\delta_{bq}\right|}{\Lambda^{2}_{eff}}$$

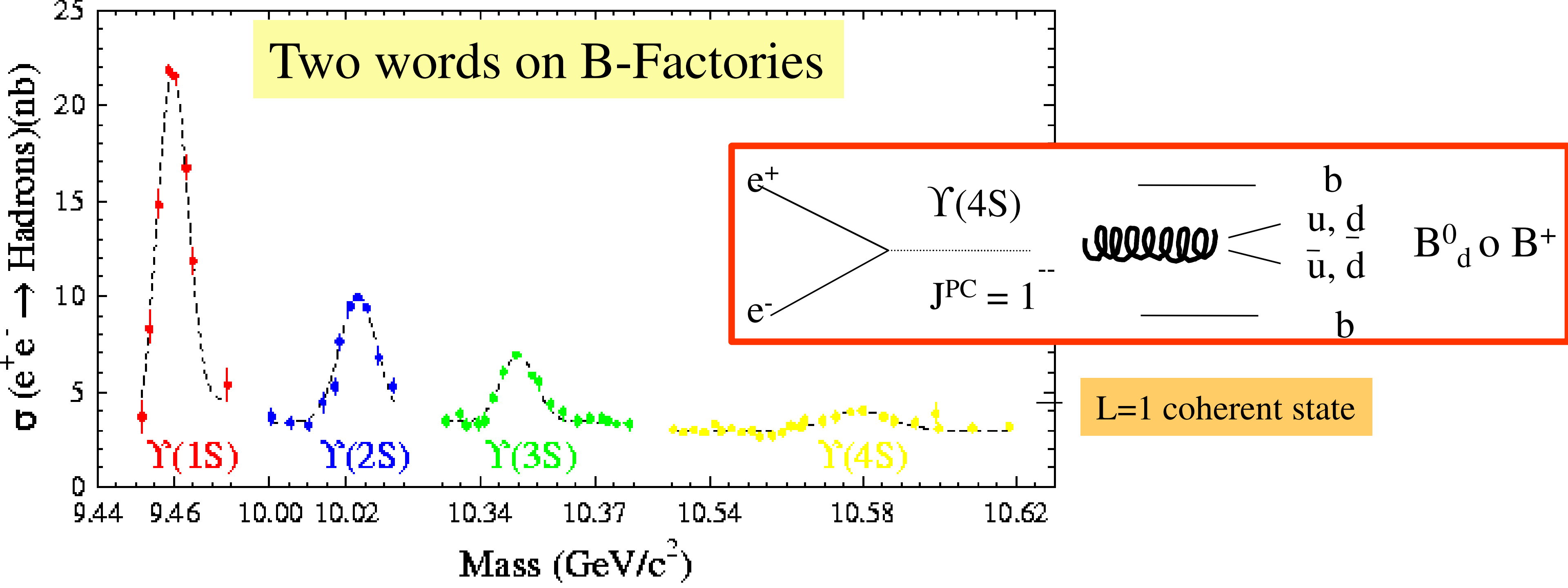
→ if NP particles are discovered at LHC we able to study the flavour structure of the NP

→ we can explore NP scale beyond the LHC reach

B-factory at present : Babar at PEP Belle at KEK	2000-2009
LHCb now and tomorrow	2009-2015
SuperB factories ..the day after tomorrow	2015-2020

I'll discuss this

Two words on B-Factories



L=1 coherent state

- Example $L = 10^{34}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1}$ 1 year (~1.5×10^{7} seconds)
- $L_{\mathrm{int}} = 1.5 \times 10^{41}\ \mathrm{cm}^{-2} = 150\ \mathrm{fb}^{-1}$
- $N = \sigma\ L_{\mathrm{int}}$
- production cross section of the l'Υ(4s) : ~1.1 nb

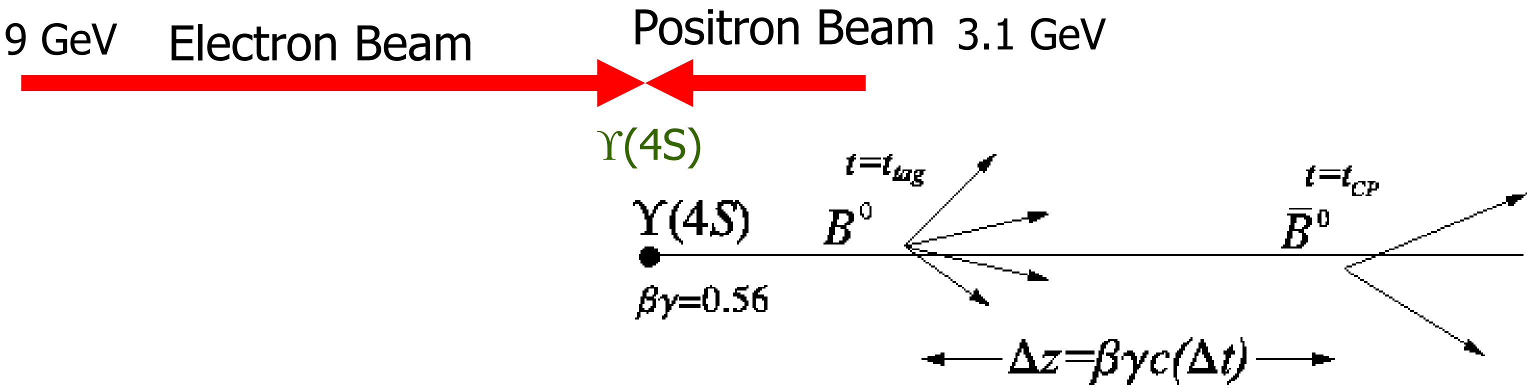
⇒ ~ 1.5×10^{8} Υ(4s) produced by year

Babar has collected $450\mathrm{fb}^{-1}$ and Belle $\sim 800\mathrm{fb}^{-1}$

The *Y*(4S) Boost - Asymmetric B-factories

The purpose of asymmetric beam energies is to boost the $B^0\overline{B}^0$ system relative to the lab frame.

$$
\begin{aligned}
p_{\mathrm{cm}} = p_{\Upsilon(4S)} &= (E_{e^-} + E_{e^+}, (E_{e^-} - E_{e^+})\hat{\mathbf{z}}) \\
E_{\mathrm{cm}} = \sqrt{4E_{e^-}E_{e^+}} &= M(\Upsilon(4S)) \\
\beta &= \frac{E_{e^-} - E_{e^+}}{E_{e^-} + E_{e^+}} \qquad \beta\gamma = \frac{E_{e^-} - E_{e^+}}{2E_{e^-}E_{e^+}} \\
\Rightarrow < \Delta z > &= \beta\gamma c\tau_B \approx 260\ \mu\mathrm{m}
\end{aligned}
$$

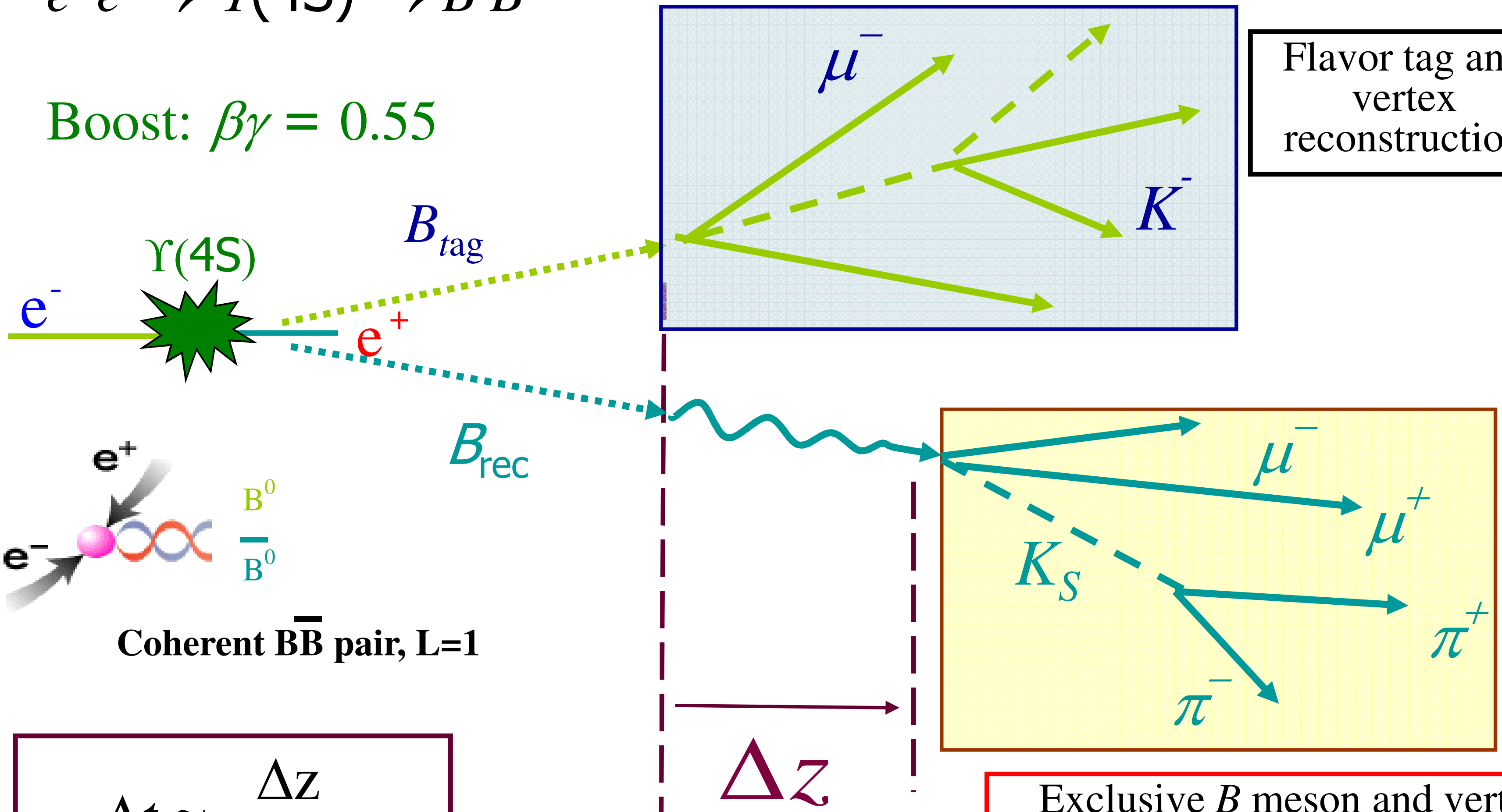


By measuring Δ*z*, we can follow time dependent effects in B decays.

At the $\Upsilon(4S)$ resonance

$$e^+e^- \rightarrow \Upsilon(4S) \rightarrow B\,\bar{B}$$

Boost: $\beta\gamma = 0.55$



Flavor tag and vertex reconstruction

Coherent $B\bar{B}$ pair, L=1

Exclusive *B* meson and vertex reconstruction

$$\Delta t \approx \frac{\Delta z}{\langle \beta\gamma \rangle c}$$

Start the Clock

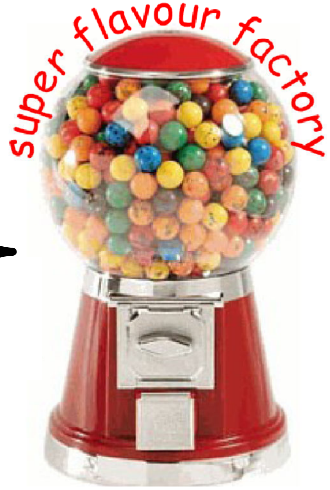
$L= 10^{34}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1} \rightarrow 150\ \mathrm{fb}^{-1} \rightarrow 1.5 \times 10^{8}\ \Upsilon(4s)$ produced by year

$L= 10^{36}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1} \rightarrow 15\ \mathrm{ab}^{-1} \rightarrow 1.5 \times 10^{10}\ \Upsilon(4s)$ produced by year

B factories have shown that a variety of measurements can be performed in the clean environment. → Asymmetric B factory

The systematic errors are very rarely irreducible and can almost on all cases be controlled with control samples. (up to..50-100ab^{-1}) → High luminosity

Many and interesting measurements can be done at different energies (charm/τ threshold, U(5S), other Upsilons..) → Flavour factories



SuperB factory potential discovery evaluated with 75ab^{-1}

B physics @ Y(4S)

Variety of measurements for any observable

Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab^{-1})
$\sin(2\beta)$ ($J/\psi\, K^0$)	0.018	0.005 (†)
$\cos(2\beta)$ ($J/\psi\, K^{*0}$)	0.30	0.05
$\sin(2\beta)$ (Dh^0)	0.10	0.02
$\cos(2\beta)$ (Dh^0)	0.20	0.04
$S(J/\psi\, \pi^0)$	0.10	0.02
$S(D^+D^-)$	0.20	0.03
α ($B \to \pi\pi$)	$\sim 16°$	3°
α ($B \to \rho\rho$)	$\sim 7°$	1–2° (∗)
α ($B \to \rho\pi$)	$\sim 12°$	2°
α (combined)	$\sim 6°$	1–2° (∗)
γ ($B \to DK$, $D \to CP$ eigenstates)	$\sim 15°$	2.5°
γ ($B \to DK$, $D \to$ suppressed states)	$\sim 12°$	2.0°
γ ($B \to DK$, $D \to$ multibody states)	$\sim 9°$	1.5°
γ ($B \to DK$, combined)	$\sim 6°$	1–2°
$2\beta + \gamma$ ($D^{(*)\pm}\pi^\mp$, $D^\pm K^0_S\pi^\mp$)	20°	5°
$S(\phi K^0)$	0.13	0.02 (∗)
$S(\eta' K^0)$	0.05	0.01 (∗)
$S(K^0_S K^0_S K^0_S)$	0.15	0.02 (∗)
$S(K^0_S \pi^0)$	0.15	0.02 (∗)
$S(\omega K^0_S)$	0.17	0.03 (∗)
$S(f_0 K^0_S)$	0.12	0.02 (∗)
$\lvert V_{cb}\rvert$ (exclusive)	4% (∗)	1.0% (∗)
$\lvert V_{cb}\rvert$ (inclusive)	1% (∗)	0.5% (∗)
$\lvert V_{ub}\rvert$ (exclusive)	8% (∗)	3.0% (∗)
$\lvert V_{ub}\rvert$ (inclusive)	8% (∗)	2.0% (∗)

Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab
$\mathcal{B}(B \to \tau\nu)$	20%	4% (†)
$\mathcal{B}(B \to \mu\nu)$	visible	5%
$\mathcal{B}(B \to D\tau\nu)$	10%	2%
$\mathcal{B}(B \to \rho\gamma)$	15%	3% (†)
$\mathcal{B}(B \to \omega\gamma)$	30%	5%
$A_{CP}(B \to K^*\gamma)$	0.007 (†)	0.004 († ∗)
$A_{CP}(B \to \rho\gamma)$	~ 0.20	0.05
$A_{CP}(b \to s\gamma)$	0.012 (†)	0.004 (†)
$A_{CP}(b \to (s+d)\gamma)$	0.03	0.006 (†)
$S(K^0_S\pi^0\gamma)$	0.15	0.02 (∗)
$S(\rho^0\gamma)$	possible	0.10
$A_{CP}(B \to K^*\ell\ell)$	7%	1%
$A^{FB}(B \to K^*\ell\ell)s_0$	25%	9%
$A^{FB}(B \to X_s\ell\ell)s_0$	35%	5%
$\mathcal{B}(B \to K\nu\bar{\nu})$	visible	20%
$\mathcal{B}(B \to \pi\nu\bar{\nu})$	–	possible

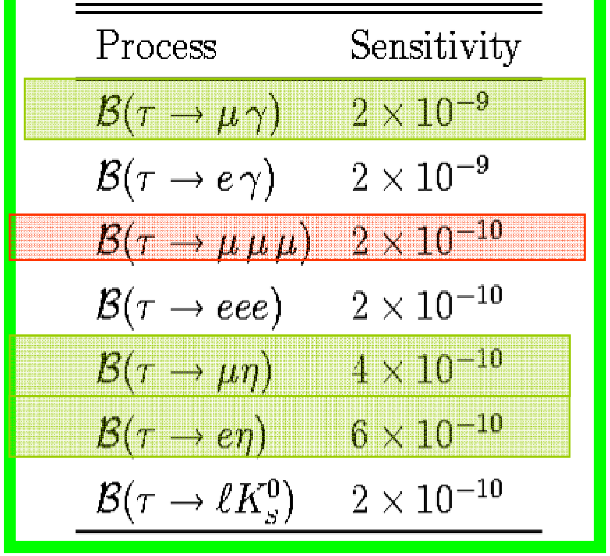
🟥 Possible also at LHCb

🟥 Similar precision at LHCb

Example of « SuperB specifics »

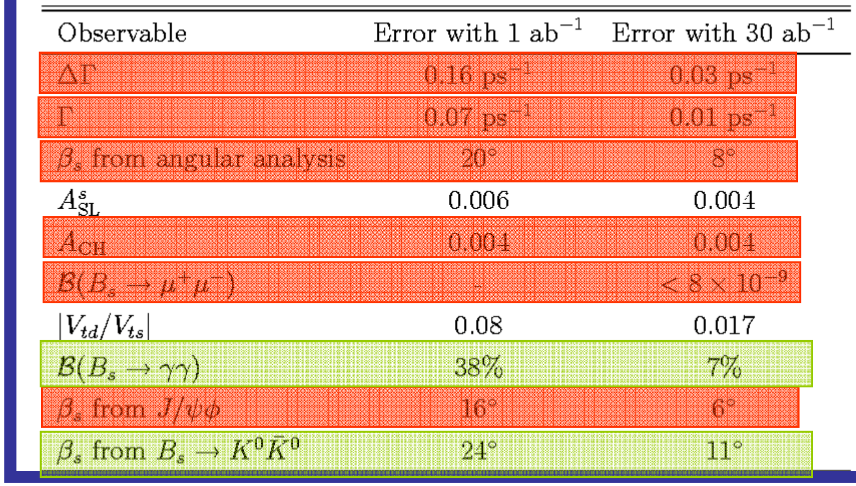
- inclusive in addition to exclusive analyses
- channels with π^0, γ's, ν, many Ks…

τ physics (polarized beams)



Process	Sensitivity
$\mathcal{B}(\tau \to \mu\gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to e\gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to \mu\mu\mu)$	2×10^{-10}
$\mathcal{B}(\tau \to eee)$	2×10^{-10}
$\mathcal{B}(\tau \to \mu\eta)$	4×10^{-10}
$\mathcal{B}(\tau \to e\eta)$	6×10^{-10}
$\mathcal{B}(\tau \to \ell K^0_s)$	2×10^{-10}

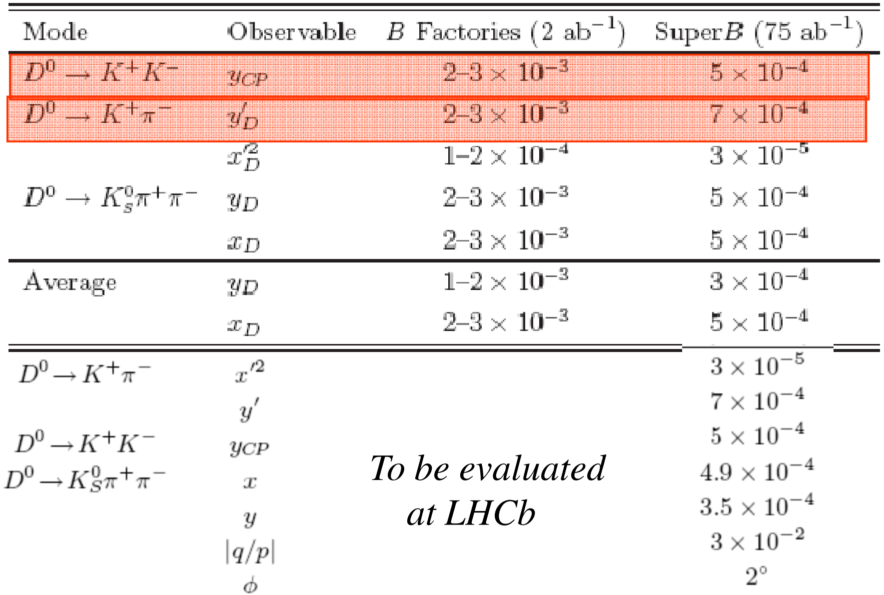
B_s at Y(5S)



Observable	Error with 1 ab^{-1}	Error with 30 ab^{-1}
$\Delta\Gamma$	$0.16\ \text{ps}^{-1}$	$0.03\ \text{ps}^{-1}$
Γ	$0.07\ \text{ps}^{-1}$	$0.01\ \text{ps}^{-1}$
β_s from angular analysis	20°	8°
A^s_{SL}	0.006	0.004
A_{CH}	0.004	0.004
$\mathcal{B}(B_s \to \mu^+\mu^-)$	-	$< 8 \times 10^{-9}$
$\lvert V_{td}/V_{ts}\rvert$	0.08	0.017
$\mathcal{B}(B_s \to \gamma\gamma)$	38%	7%
β_s from $J/\psi\phi$	16°	6°
β_s from $B_s \to K^0\bar{K}^0$	24°	11°

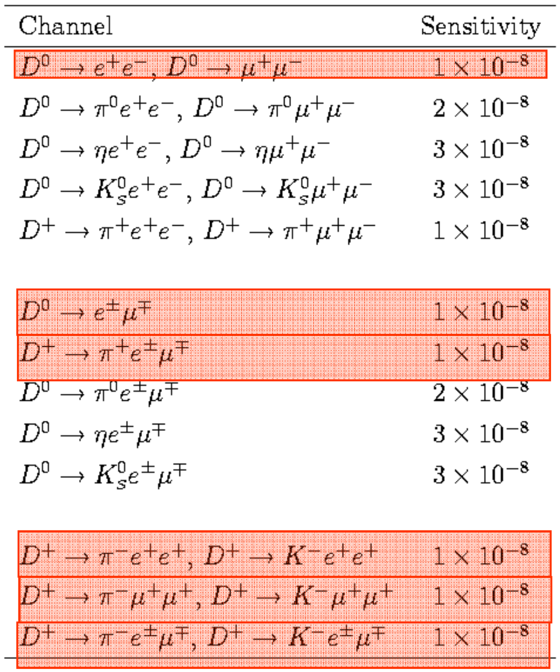
Bs : Definitively better at LHCb

Charm at Y(4S) and threshold



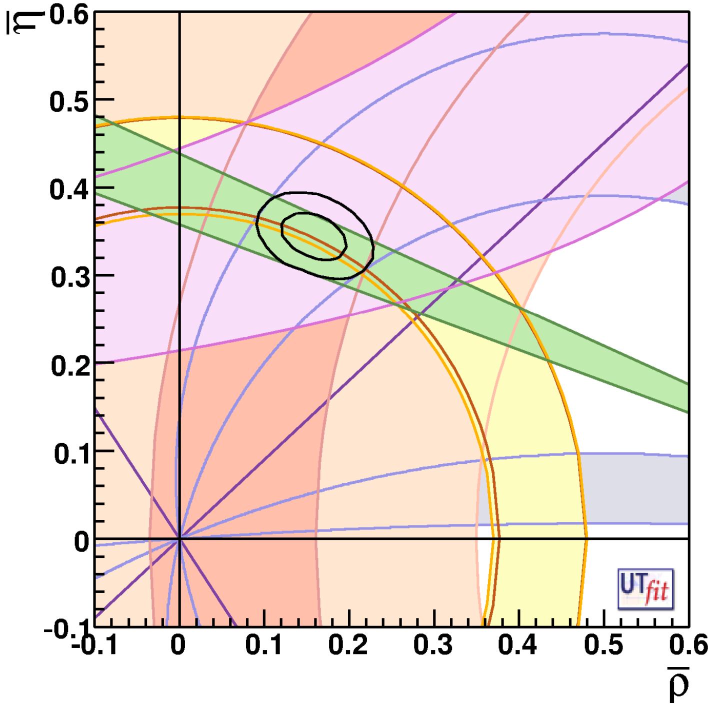
Mode	Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab^{-1})
$D^0 \to K^+K^-$	y_{CP}	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
$D^0 \to K^+\pi^-$	y'_D	$2\text{–}3 \times 10^{-3}$	7×10^{-4}
	x'^2_D	$1\text{–}2 \times 10^{-4}$	3×10^{-5}
$D^0 \to K^0_s\pi^+\pi^-$	y_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
	x_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
Average	y_D	$1\text{–}2 \times 10^{-3}$	3×10^{-4}
	x_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
$D^0 \to K^+\pi^-$	x'^2		3×10^{-5}
	y'		7×10^{-4}
$D^0 \to K^+K^-$	y_{CP}		5×10^{-4}
$D^0 \to K^0_S\pi^+\pi^-$	x		4.9×10^{-4}
	y		3.5×10^{-4}
	$\lvert q/p\rvert$		3×10^{-2}
	ϕ		2°

To be evaluated at LHCb

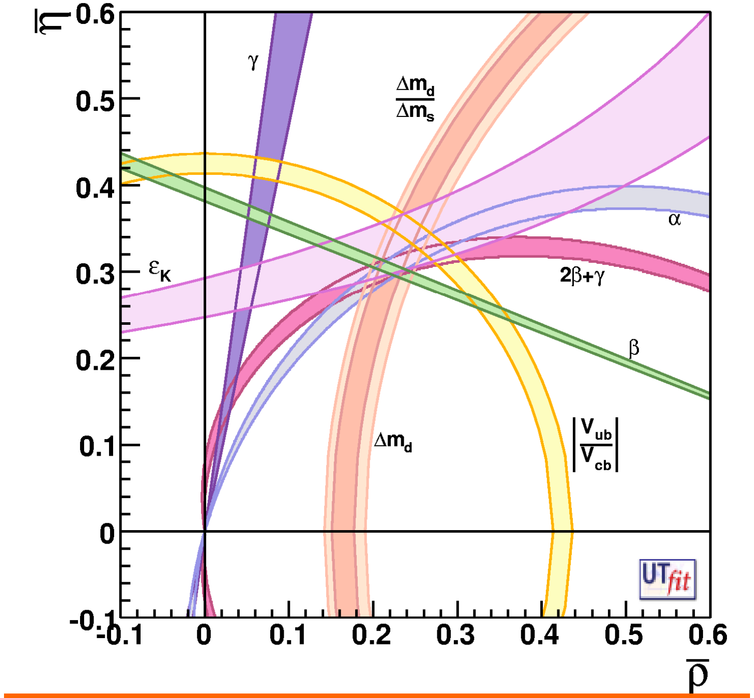


Channel	Sensitivity
$D^0 \to e^+e^-$, $D^0 \to \mu^+\mu^-$	1×10^{-8}
$D^0 \to \pi^0e^+e^-$, $D^0 \to \pi^0\mu^+\mu^-$	2×10^{-8}
$D^0 \to \eta e^+e^-$, $D^0 \to \eta\mu^+\mu^-$	3×10^{-8}
$D^0 \to K^0_se^+e^-$, $D^0 \to K^0_s\mu^+\mu^-$	3×10^{-8}
$D^+ \to \pi^+e^+e^-$, $D^+ \to \pi^+\mu^+\mu^-$	1×10^{-8}
$D^0 \to e^\pm\mu^\mp$	1×10^{-8}
$D^+ \to \pi^+e^\pm\mu^\mp$	1×10^{-8}
$D^0 \to \pi^0e^\pm\mu^\mp$	2×10^{-8}
$D^0 \to \eta e^\pm\mu^\mp$	3×10^{-8}
$D^0 \to K^0_se^\pm\mu^\mp$	3×10^{-8}
$D^+ \to \pi^-e^+e^+$, $D^+ \to K^-e^+e^+$	1×10^{-8}
$D^+ \to \pi^-\mu^+\mu^+$, $D^+ \to K^-\mu^+\mu^+$	1×10^{-8}
$D^+ \to \pi^-e^\pm\mu^\mp$, $D^+ \to K^-e^\pm\mu^\mp$	1×10^{-8}

Today



SuperB+Lattice improvements



Improving CKM is crucial to look for NP

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

$\rho = \quad \pm 0.0028$
$\eta = \quad \pm 0.0024$

10^{34} luminosity to have measurable effects <u>(anyhow)</u> if NP particle with masses at the <u>EW scale</u>

10^{36} luminosity to have measurable effects <u>(anyhow)</u> if NP particle with masses at the <u>TeV scale</u>

Let’s consider (reductively) the GOLDEN MATRIX for B physics

	H^+ high $\tan\beta$	Minimal FV	Non-Minimal FV (1-3)	Non-Minimal FV (2-3)	NP Z-penguins	Right-Handed currents
$\mathcal{B}(B \to X_s \gamma)$		X		O		O
$A_{CP}(B \to X_s \gamma)$				X		O
$\mathcal{B}(B \to \tau \nu)$	X- CKM					
$\mathcal{B}(B \to X_s l^+ l^-)$				O	O	O
$\mathcal{B}(B \to K \nu \overline{\nu})$				O	X	X
$S(K_S \pi^0 \gamma)$						X
β			X- CKM			

X The GOLDEN channel for the given scenario

○ Not the GOLDEN channel for the given scenario, but can show experimentally measurable deviations from SM.

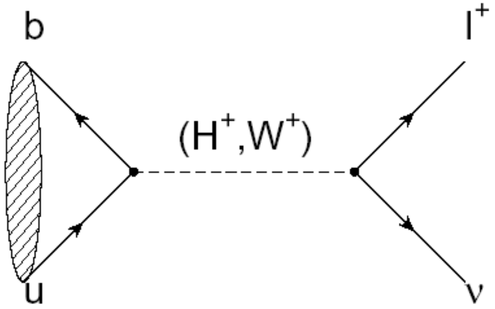
« SuperB specifics »

- inclusive analyses
- channels with π^0, γ, ν, many Ks…

In the following some examples of ↓ →

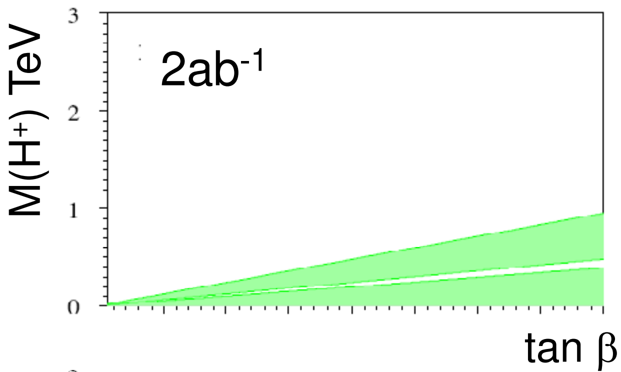
leptonic decay B→lν

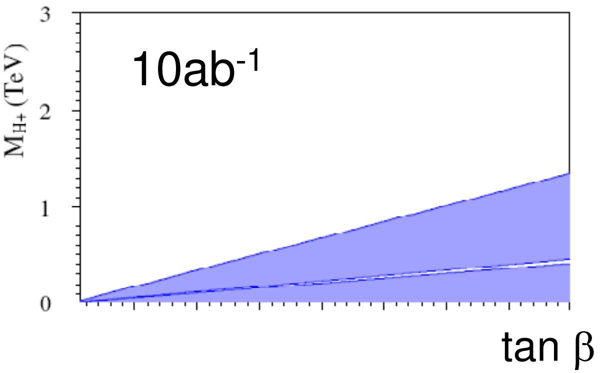
$$BR(B\to\tau\nu)=BR_{SM}(B\to\tau\nu)\left(1-\frac{m_B^2}{M_H^2}\tan^2\beta\right)^2$$

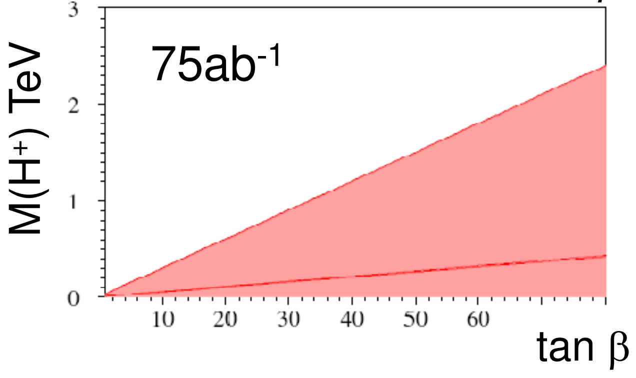


$BR(B\to\tau\nu) = (1.73 \pm 0.34)10^{-4}$ (exp. Belle+BaBar)

Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab
$\mathcal{B}(B\to\tau\nu)$	20%	4% (†)
$\mathcal{B}(B\to\mu\nu)$	visible	5%
$\mathcal{B}(B\to D\tau\nu)$	10%	2%







SuperB $-75ab^{-1}$

M_H~1.2-2.5 TeV
for tanβ~30-60

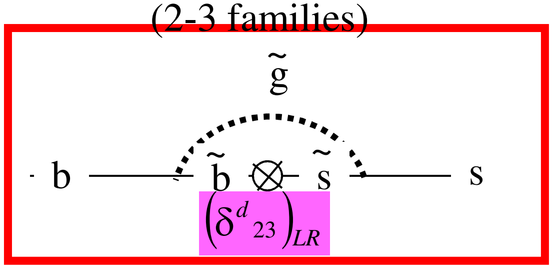
MSSM+generic soft SUSY breaking terms

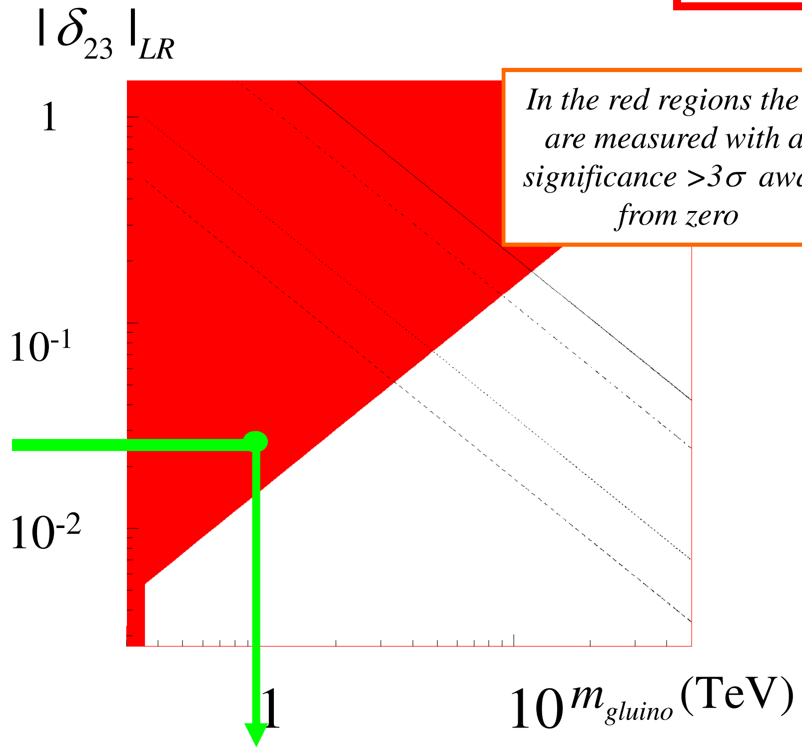
Flavour-changing NP effects in the squark propagator

→ NP scale SUSY mass $\tilde{m} \sim m_{\tilde{g}}$

→ flavour-violating coupling $(\delta^q_{ij})_{AB} \equiv \frac{(M^2_{ij})^q_{AB}}{\tilde{m}^2}$

New Physics contribution (2-3 families)



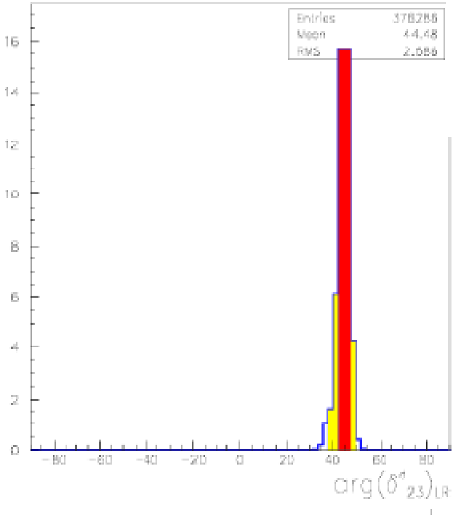


In the red regions the δ are measured with a significance $>3\sigma$ away from zero

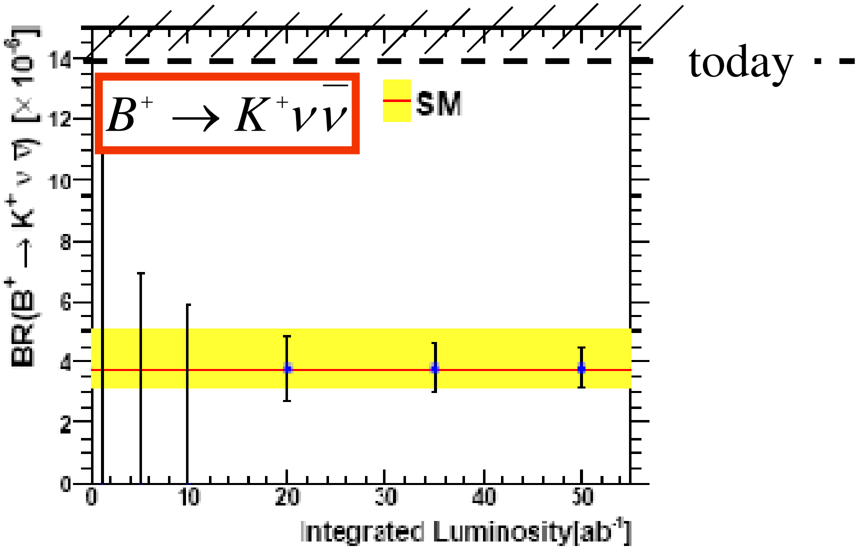
$|\delta_{23}|_{LR} = (0.026 \pm 0.005)$

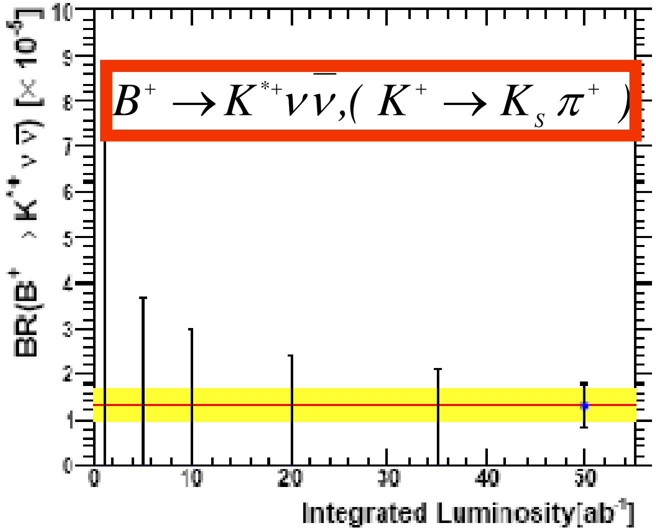
$\mathrm{Arg}(\delta_{23})_{LR} = (44.5 \pm 2.6)^\circ$

1 TeV



Br(B → K ν ν) – Z penguins and Right-Handed currents



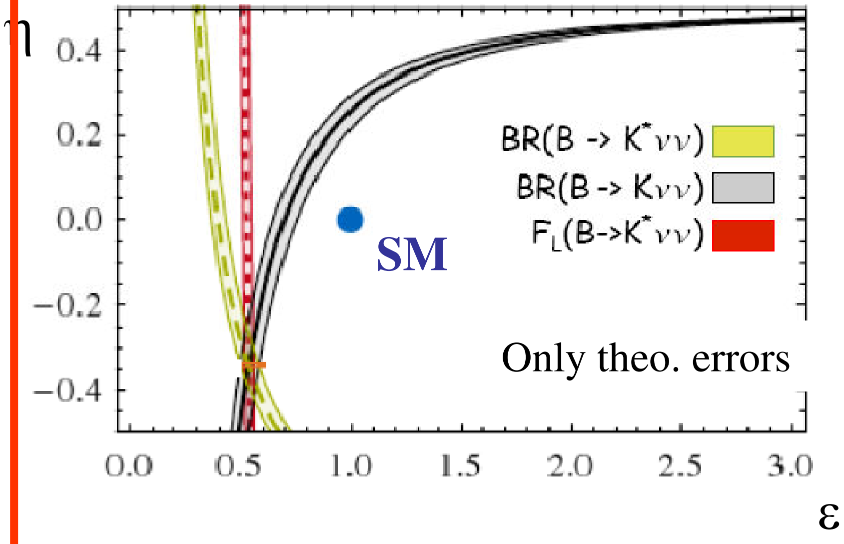


~[20-40] ab^{-1} are needed for observation
>>50ab^{-1} for precise measurement

Altmannshofer et al, arXiv:0902.0160

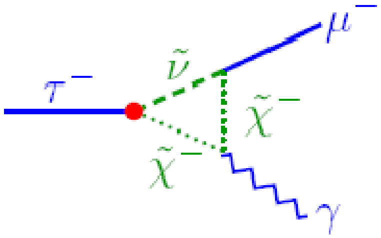
$$\epsilon = \frac{\sqrt{|C_L^\nu|^2 + |C_R^\nu|^2}}{|(C_L^\nu)^{\rm SM}|}$$

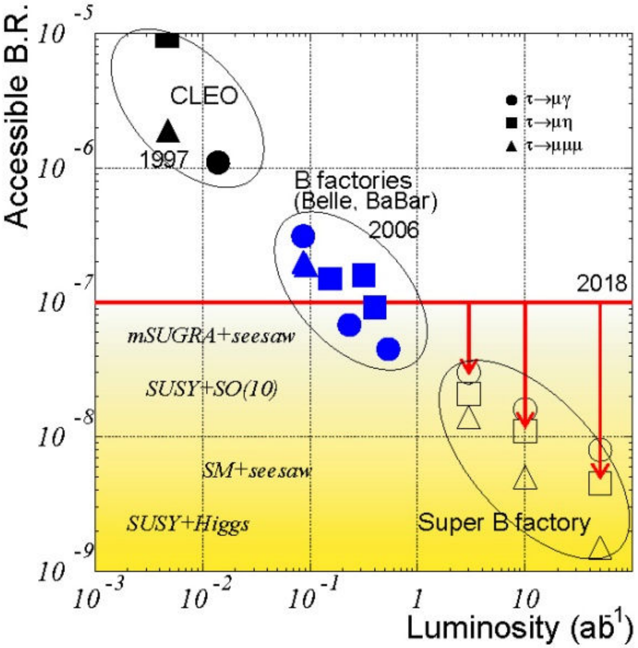
$$\eta = \frac{-{\rm Re}\,(C_L^\nu C_R^{\nu *})}{|C_L^\nu|^2 + |C_R^\nu|^2}$$



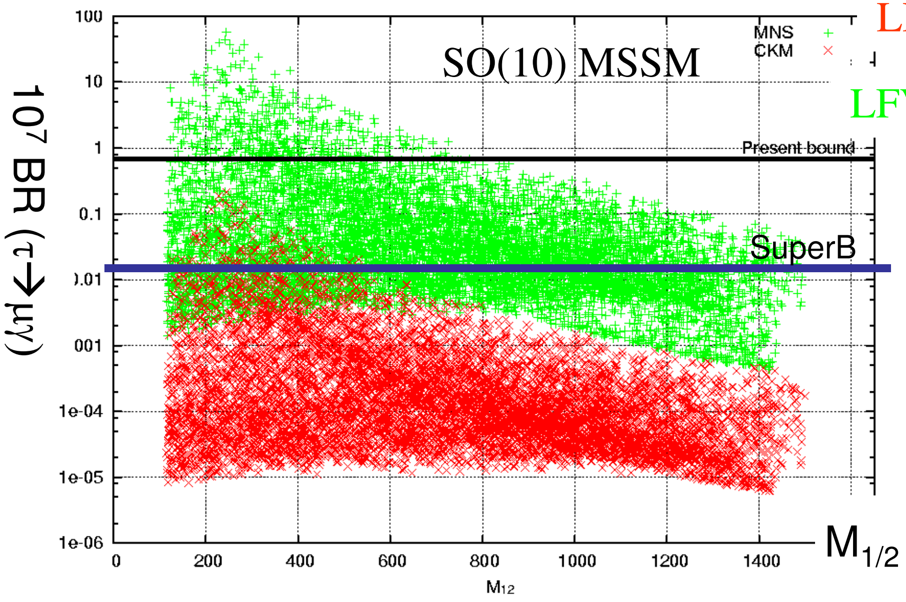
If these quantities are measured @ <~10% deviations from the SM can be observed

Lepton Flavour Violation τ→ μ γ. We can gain a very important order of magnitude 10^{-8} → 10^{-9}
Complementarity with μ → e γ





Process	Sensitivity
$\mathcal{B}(\tau \to \mu\gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to e\gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to \mu\mu\mu)$	2×10^{-10}
$\mathcal{B}(\tau \to eee)$	2×10^{-10}
$\mathcal{B}(\tau \to \mu\eta)$	4×10^{-10}
$\mathcal{B}(\tau \to e\eta)$	6×10^{-10}
$\mathcal{B}(\tau \to \ell K_s^0)$	2×10^{-10}



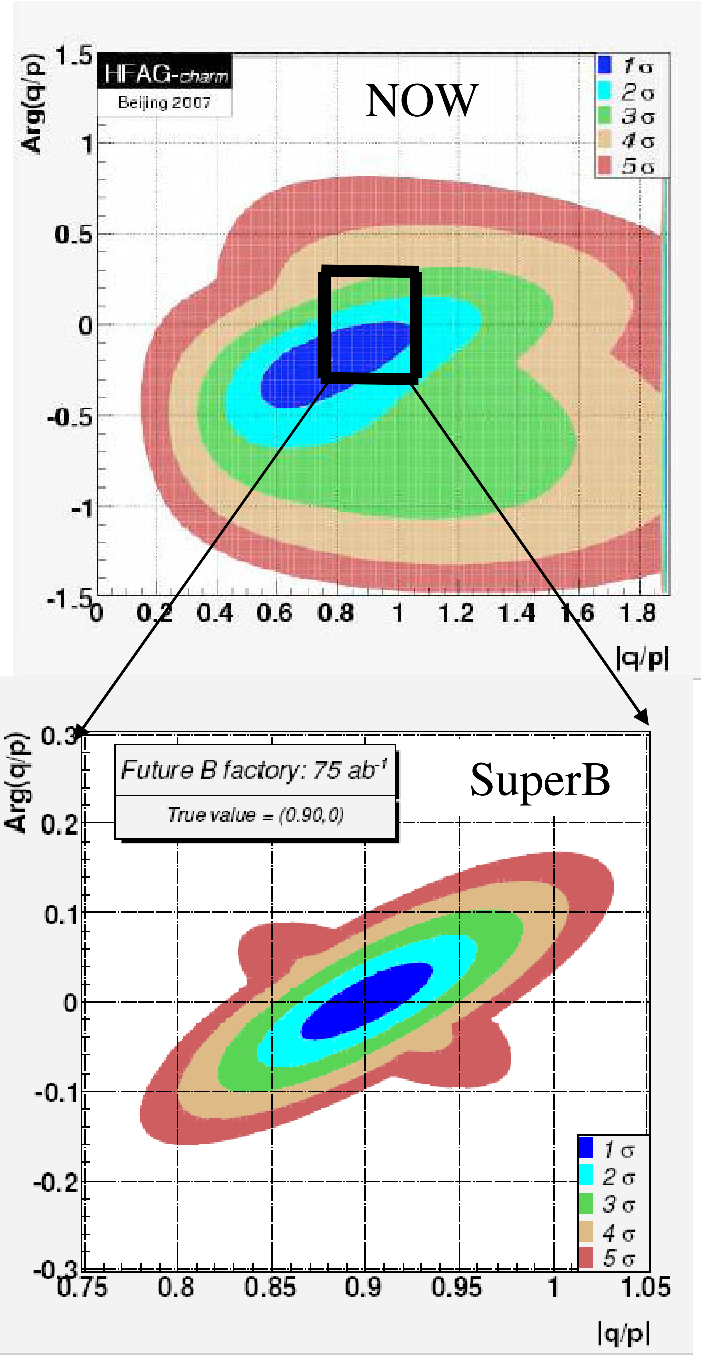
LFV from CKM

LFV from PMNS

MEG sensitivity μ→eγ ~10^{-13}

CP Violation in charm

Mode	Observable	$\Upsilon(4S)$ $(75\ \text{ab}^{-1})$	$\psi(3770)$ $(300\ \text{fb}^{-1})$
$D^0 \to K^+\pi^-$	x'^2	3×10^{-5}	
	y'	7×10^{-4}	
$D^0 \to K^+K^-$	y_{CP}	5×10^{-4}	
$D^0 \to K^0_S\pi^+\pi^-$	x	4.9×10^{-4}	
	y	3.5×10^{-4}	
	$\lvert q/p \rvert$	3×10^{-2}	
	ϕ	2°	
$\psi(3770) \to D^0\overline{D}^0$	x^2		$(1-2) \times 10^{-5}$
	y		$(1-2) \times 10^{-3}$
	$\cos\delta$		$(0.01-0.02)$



New excitement on spectroscopy

See V. Balagura seminar

More data are needed :

→to complete the picture

→ to better studying the recently discovered particle (quantum numbers, branching fractions…)

	$J/\psi\pi^+\pi$	$D^{(*)}D^{(*)}$	$J/\psi\omega$	$J/\psi\pi^+\pi^0$	$\psi(2S)\pi$	$J/\psi K,\pi$	$\Psi(2S)\pi\pi$	$J/\psi\phi,\eta$	$J/\psi\gamma$
Notes	Mass range for B	Low stat	Only B dec	Mass range! No ISR	No ISR No π^0	No Search	No B-dec	Only B dec	Mass window
X(3872)	Seen	Seen	Not seen	Not seen	Not seen	No search	N/A	Not seen	Seen
Y(3940)	No search	X(3940) ?	Seen	No search	Not seen	No search	No search	No Fit	No fit
Y(4260)	Seen	No fit	No fit	No search	No search	No search	Not seen	No fit	N/A
Y(4350)	Not seen	No fit	No fit	No search	No search	No search	Seen	No fit	N/A
Z(4430)	No search	No search	No fit	No search	Seen	No search	No search	No Fit	No search
Y(4660)	Not seen	No fit	No fit	No search	No search	No search	Seen	No Fit	N/A

$L = 10^{36} cm^{-2} sec^{-1}$ → $15 ab^{-1}$ per year

We need at least 75 ab^{-1} → $L = 10^{36} cm^{-2} sec^{-1}$ is the baseline option

That's is the factory we need !

Unprecented precision

SuperB can perform many measurements at <1% level of precision

Precision on CKM parameters will be improved by more than a factor 10

… and do not forget… **SuperB** could also a **Super-Super τ-charm factory**, If we *run at threshold*.

Unique opportunity of LFV measurements, better if *beam polarized*.

SuperB Discovery Potential and Complementary to LHC

NP will be studied (measuring the couplings) if discovered at LHC

if NP is not (or "partially") seen at TeV, SuperB is the way of exploring NP scales of several TeV (in some scenario several (>10)TeV..)

The Machine

How it is possible to gain a factor 100 in the luminosity ..?

10^{34} $cm^{2}sec^{-1}$ → 10^{36} $cm^{2}sec^{-1}$

$$L \propto D \frac{f_r N^2}{(\sigma_x \sigma_y)} \frac{1}{\sqrt{1+\Phi^2}}$$

$$\Phi = \frac{\sigma_z}{\sigma_x} tg(\frac{\vartheta}{2})$$

$$D \approx \frac{N\sigma_z}{(\sigma_x \sigma_y)}$$

To have large luminosity

Two ways :

→ Inscrease the currents (N~current)

→ Decrease the beam size

1) Single passage : D (disruption) high [profit of beam-beam effects (pinch)] small σ_x,σ_y

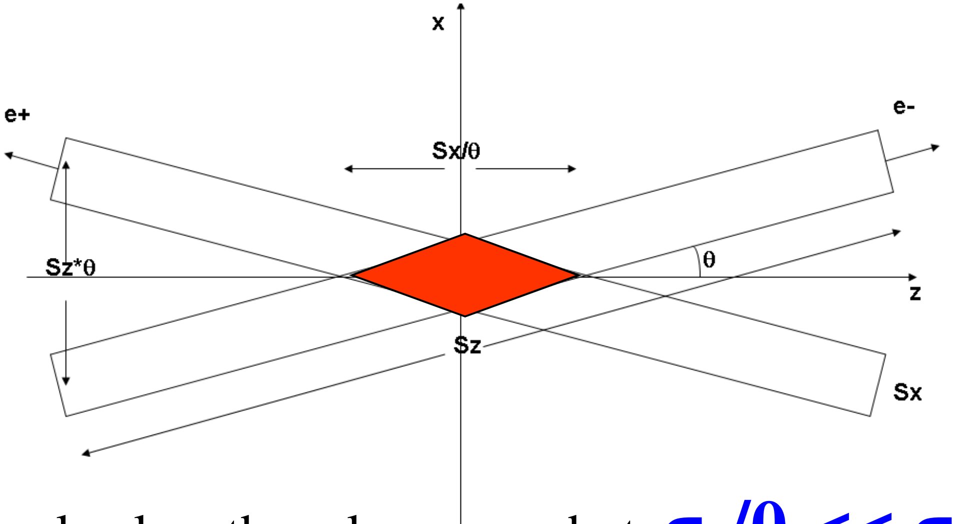
2) The beam has to be re-utilized in an accumulation ring → to maxime f_r →D “small”

3)To keep D small and small σ_x,σ_y we also need small σ_z

N.B. It is very difficult to reduce the size of the beam in z direction (say σ_z<0.5mm)

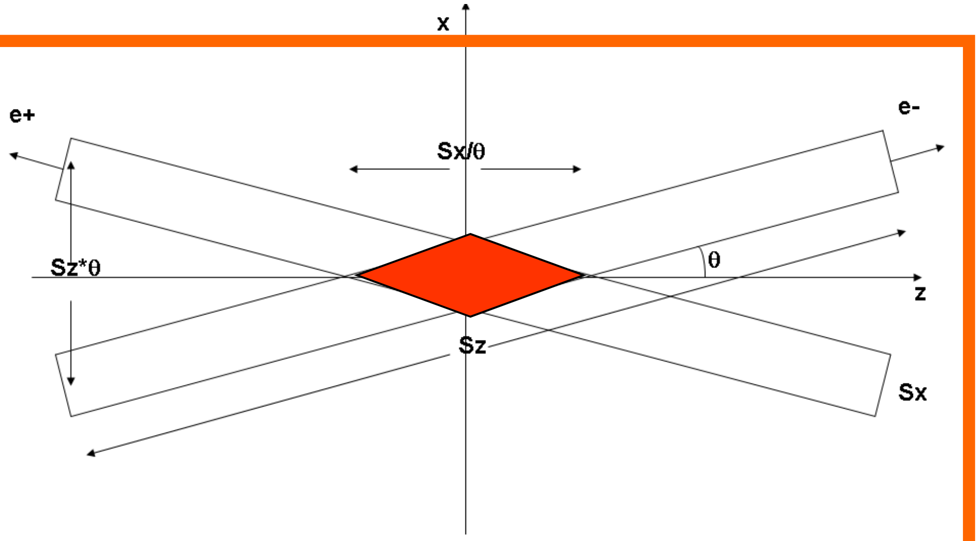
Solution :

Crossing angle interaction

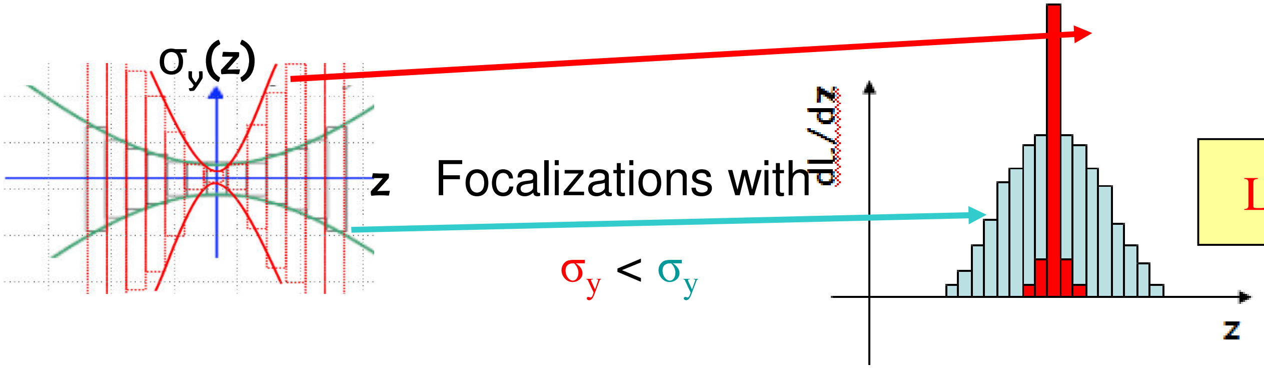


Crossing angle between e^+ and e^- : bunch overlap length no longer σ_z, but $\boldsymbol{\sigma_x/\theta << \sigma_z}$

"Hourglass effect"



Reducing σ_z we also meet another very important condition



Focalizations with

$\sigma_y < \sigma_y$

$\text{Lumi}_y < \text{Lumi}_y$

The stronger the focalization, the quicker the de-focalzation !

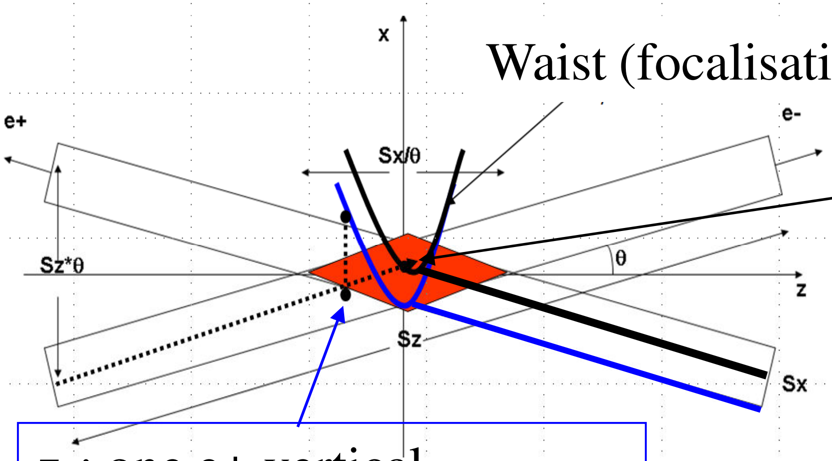
If σ_y too small w.r.t σ_z : particle density drops so fast, away from the IP, that Luminosity is in fact reduced.

An important consequence : **get high luminosity without inscreasing the current avoid to have a drammatic backgrounds in the detector**

And now we need to… Crab the Waist

Crossing angle between e^+ and e^- : bunch overlap length no longer σ_z, but $\sigma_x/\theta << \sigma_z$!

<u>But</u>: Charge density, thus the forces, felt by e^+/e^- in the crossing region depends on x, y & z simultaneously !



Waist (focalisation) on y

z_2: another e+ vertical focalisation

→ another density → another Force

z_1: one e+ vertical focalisation → a charge density → a force

Force depends

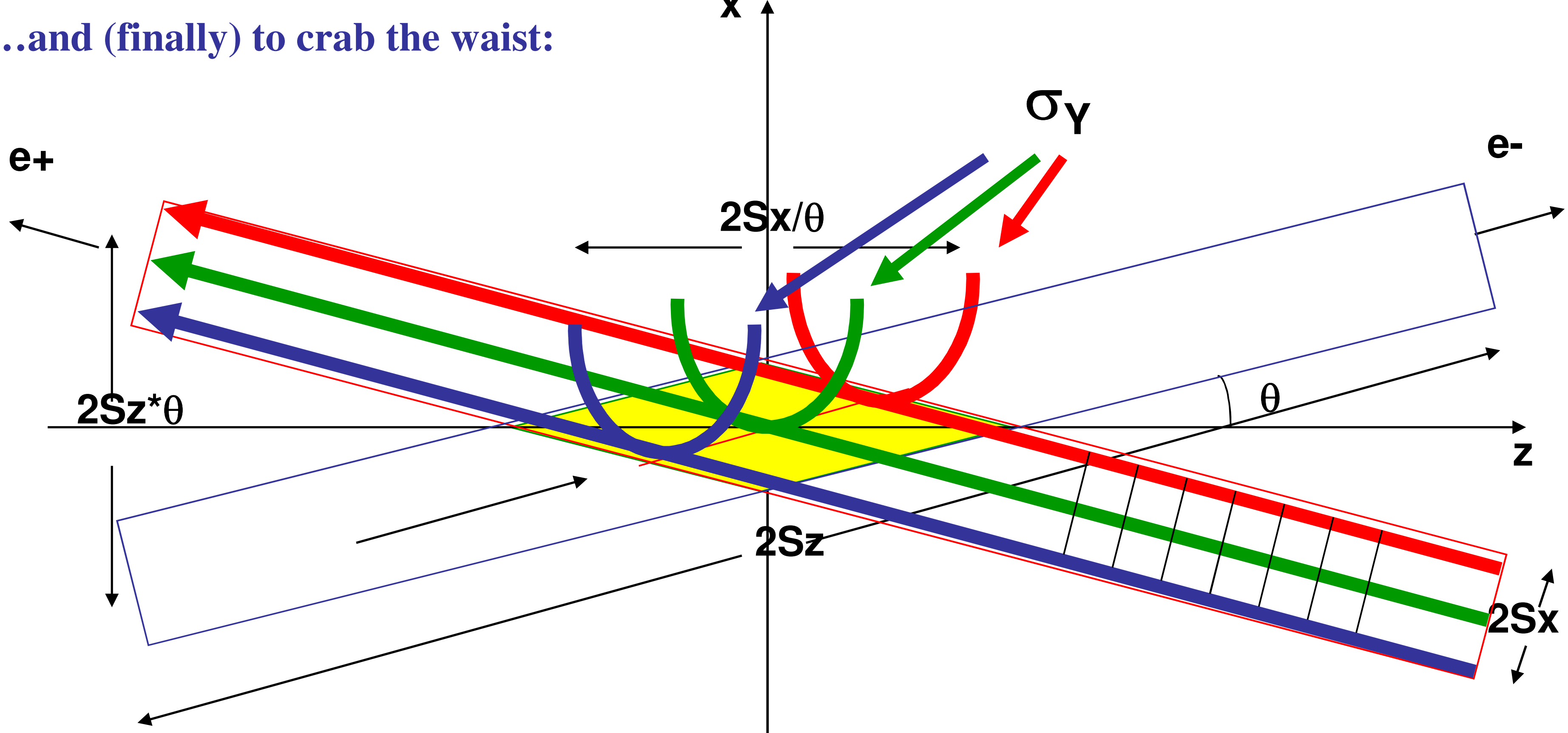
on x **& z** or y **& z**

-Coupling between the x, y and z components of the e+/e- trajectories

→**<u>oscillations around the collider</u>**

In the machine language : **Additional** betatron-betatron / synchro-betatron **resonances**

…and (finally) to crab the waist:



Vertical waist has to be a function of x:

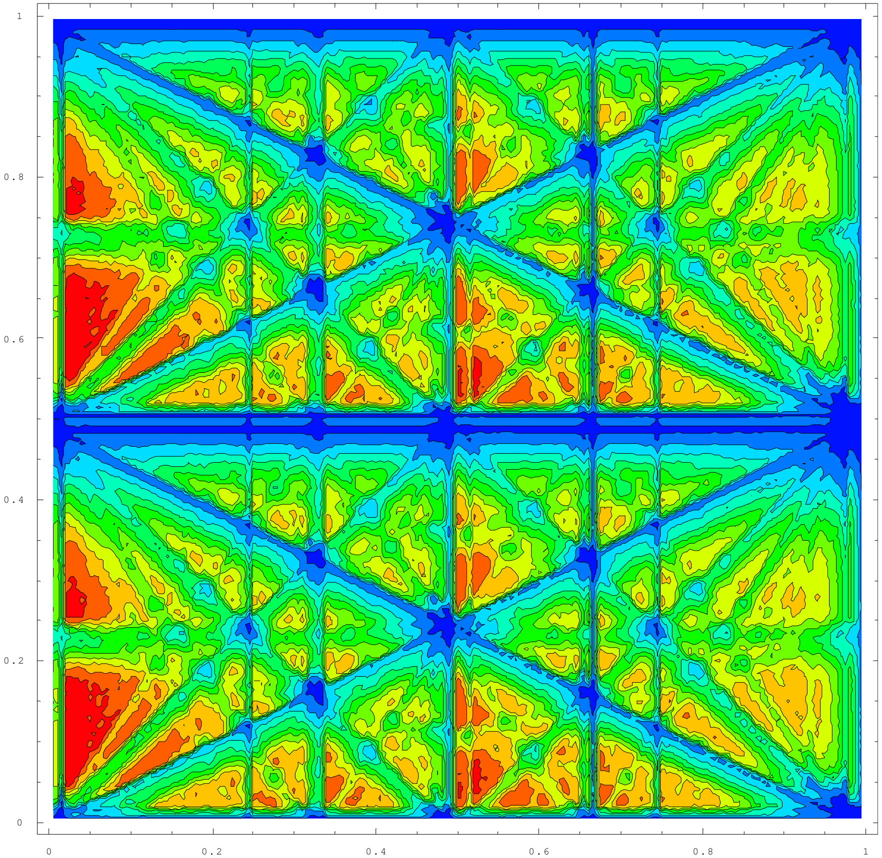
Crabbed waist realized with a sextupole

(in phase with the IP in X and at π/2 in Y slight luminosity increase)

Conceptually simple : restore the B-B effects to those we have quadrupoles focalizing in 2D
(compensate the effects of the crossing angle)

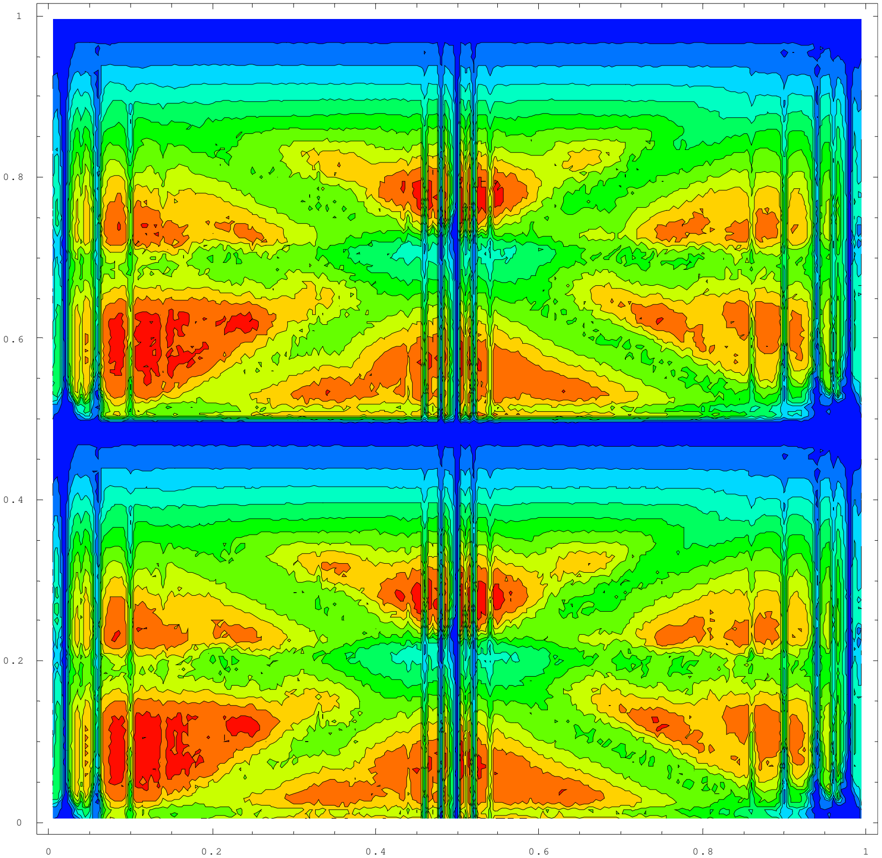
Example of resonance suppression

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

After some iterations , here are the parameter of the machine :

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	

- Possibility of energy scaling to work at the τ/charm center of mass with an estimated luminosity loss of an order of magnitude.

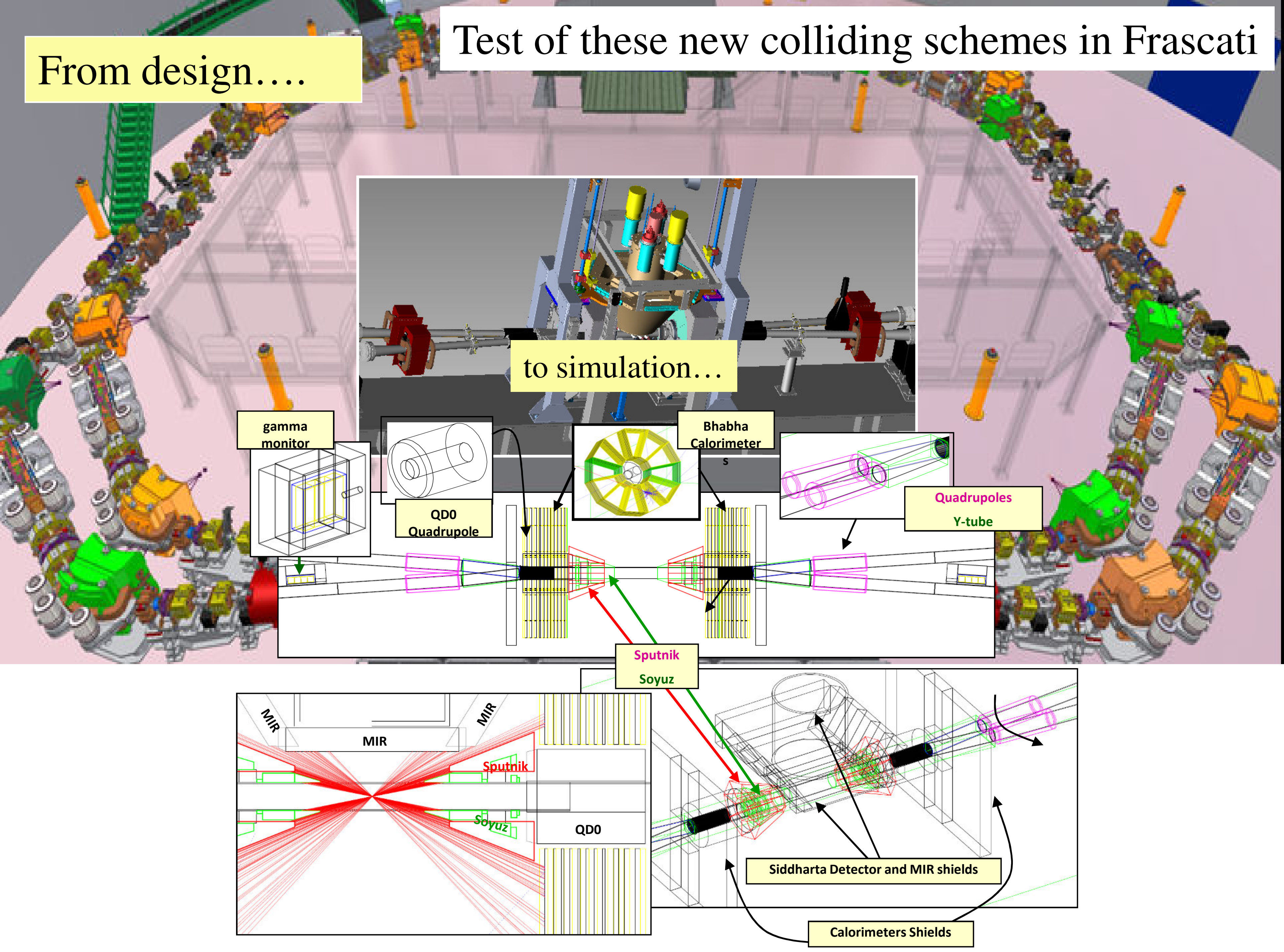
$10^{36}cm^{-2}\ sec^{-1}$ → $10ab^{-1}$ per year

$3{,}4\times10^{36}cm^{-2}\ sec^{-1}$ → $\sim 35ab^{-1}$ per year

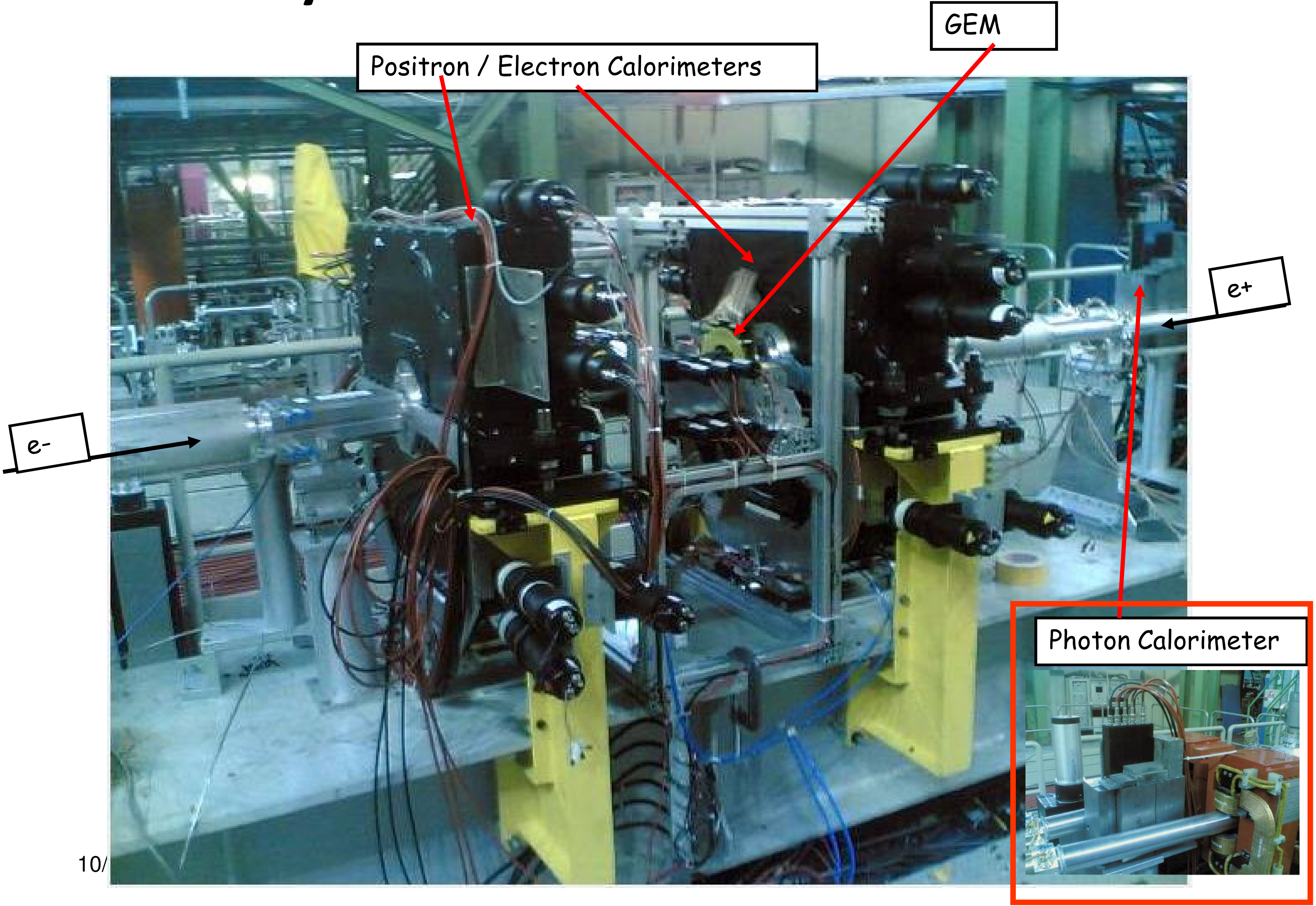
Test of these new colliding schemes in Frascati

From design….

to simulation…



To Reality…



Positron / Electron Calorimeters

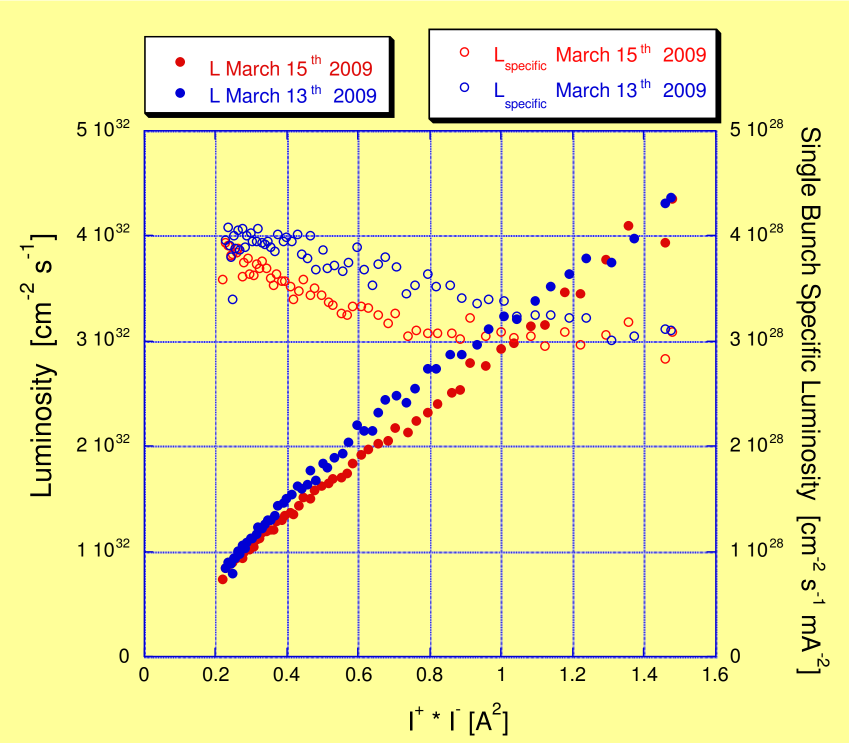
GEM

e-

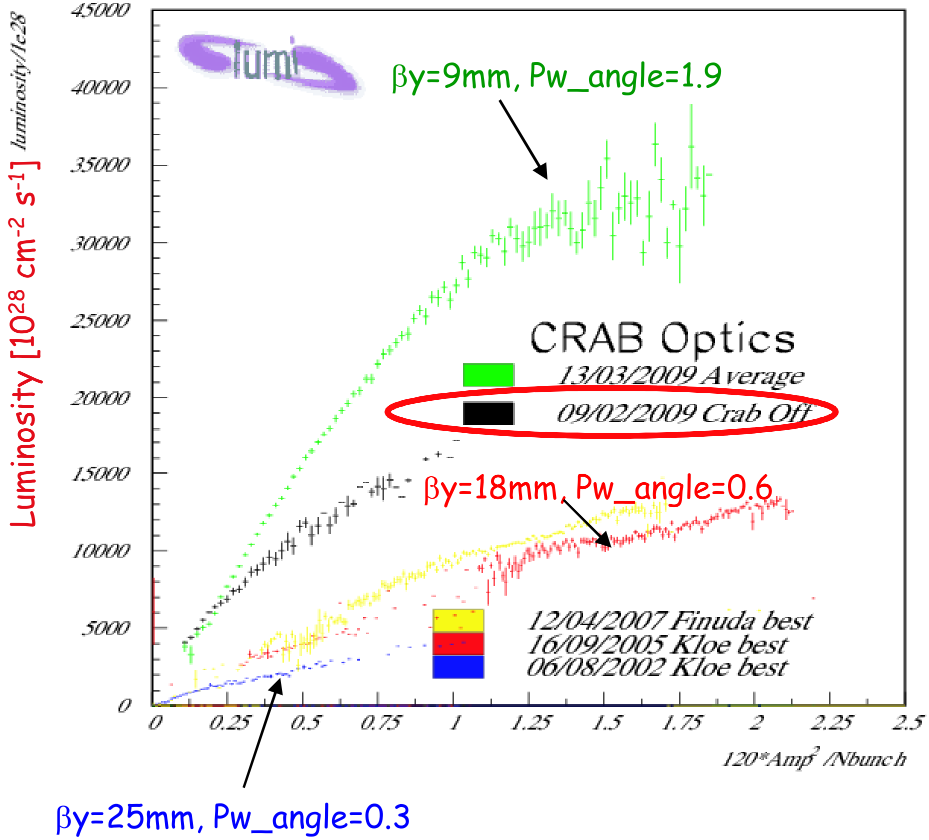
e+

Photon Calorimeter

DAFNE Luminosity results



Data averaged on a full day



βy=9mm, Pw_angle=1.9

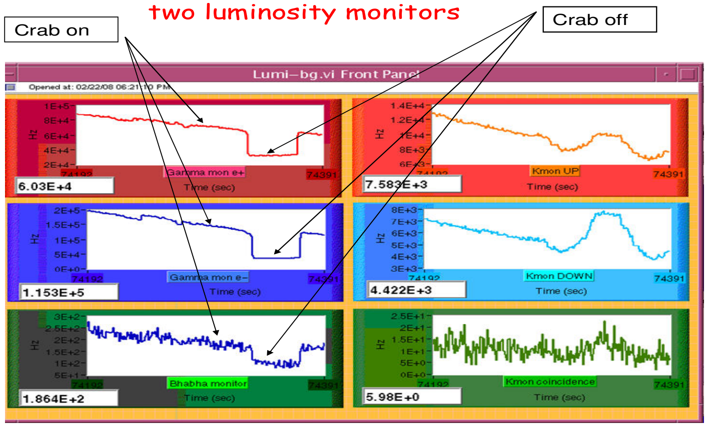
βy=18mm, Pw_angle=0.6

βy=25mm, Pw_angle=0.3

two luminosity monitors

Crab on

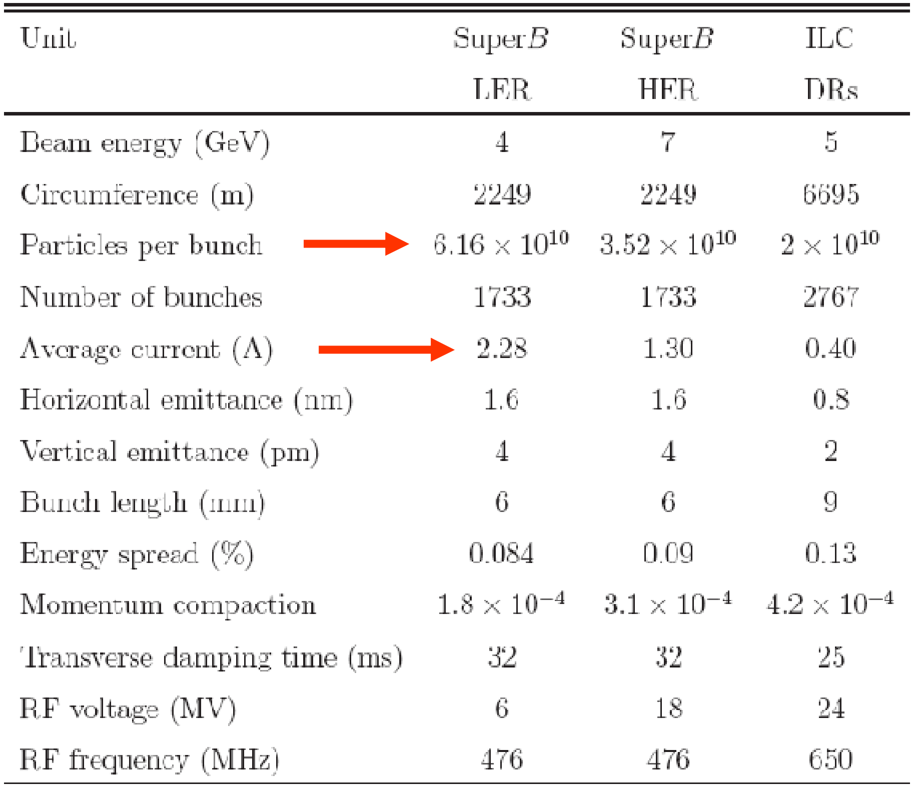
Crab off



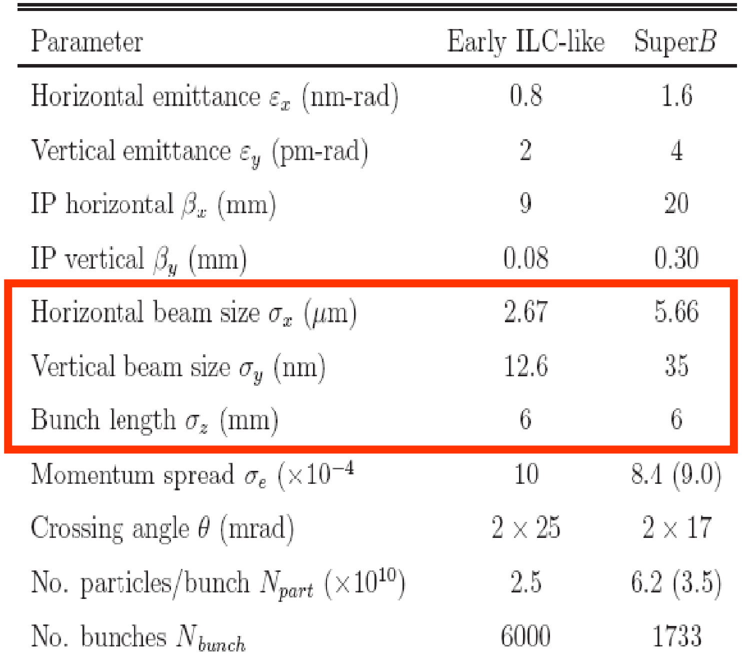
Results match the simulation expectations

How to extrapolate the Dafne results to SuperB ?

Synergy with ILC



Unit	Super*B* LER	Super*B* HER	ILC DRs
Beam energy (GeV)	4	7	5
Circumference (m)	2249	2249	6695
Particles per bunch →	6.16×10^{10}	3.52×10^{10}	2×10^{10}
Number of bunches	1733	1733	2767
Average current (A) →	2.28	1.30	0.40
Horizontal emittance (nm)	1.6	1.6	0.8
Vertical emittance (pm)	4	4	2
Bunch length (mm)	6	6	9
Energy spread (%)	0.084	0.09	0.13
Momentum compaction	1.8×10^{-4}	3.1×10^{-4}	4.2×10^{-4}
Transverse damping time (ms)	32	32	25
RF voltage (MV)	6	18	24
RF frequency (MHz)	476	476	650



Parameter	Early ILC-like	Super*B*
Horizontal emittance ε_x (nm-rad)	0.8	1.6
Vertical emittance ε_y (pm-rad)	2	4
IP horizontal β_x (mm)	9	20
IP vertical β_y (mm)	0.08	0.30
Horizontal beam size σ_x (μm)	2.67	5.66
Vertical beam size σ_y (nm)	12.6	35
Bunch length σ_z (mm)	6	6
Momentum spread σ_e ($\times 10^{-4}$	10	8.4 (9.0)
Crossing angle θ (mrad)	2×25	2×17
No. particles/bunch N_{part} ($\times 10^{10}$)	2.5	6.2 (3.5)
No. bunches N_{bunch}	6000	1733

RINGS

IP

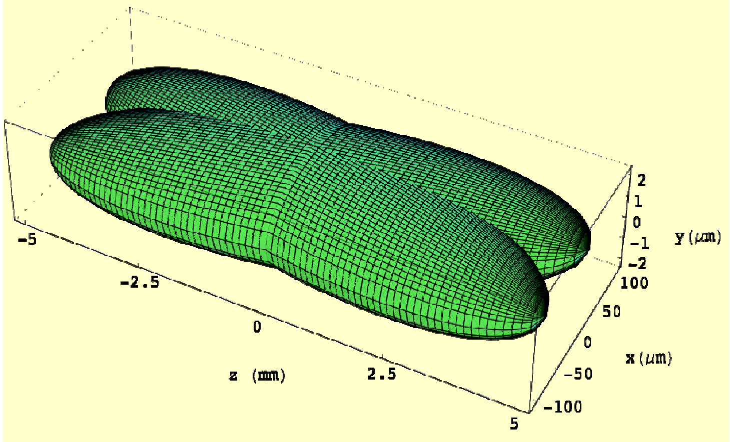
Comparison of SuperB to Super-KEKB (their option until a 1 month ago..)

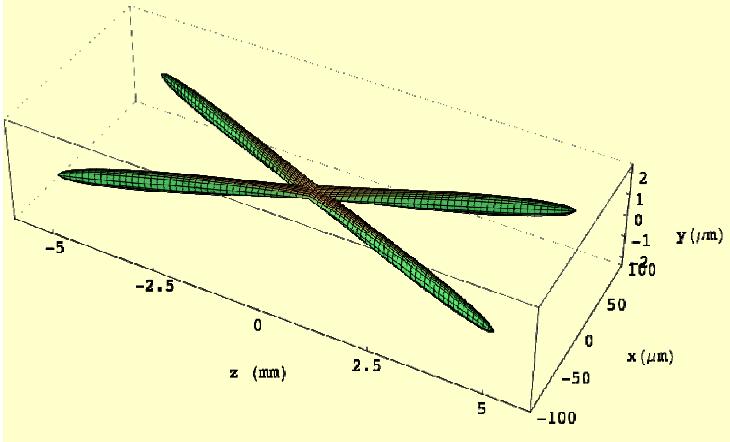
Parameter	**Units**	***SuperB***	**Super-KEKB**
Energy	**GeV**	**4x7**	**3.5x8**
Luminosity	**10^{36}/ cm^2/s**	**1.0 to 2.0**	**0.5 to 0.8**
Beam currents	**A**	**1.9x1.9**	**9.4x4.1**
β_y*	**mm**	**0.22**	**3.**
β_x*	**cm**	**3.5x2.0**	**20.**
Crossing angle (full)	**mrad**	**48.**	**30. to 0.**
RF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

luminosity 10^{36} 5×10^{35}

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

IP beam distributions for KEKB





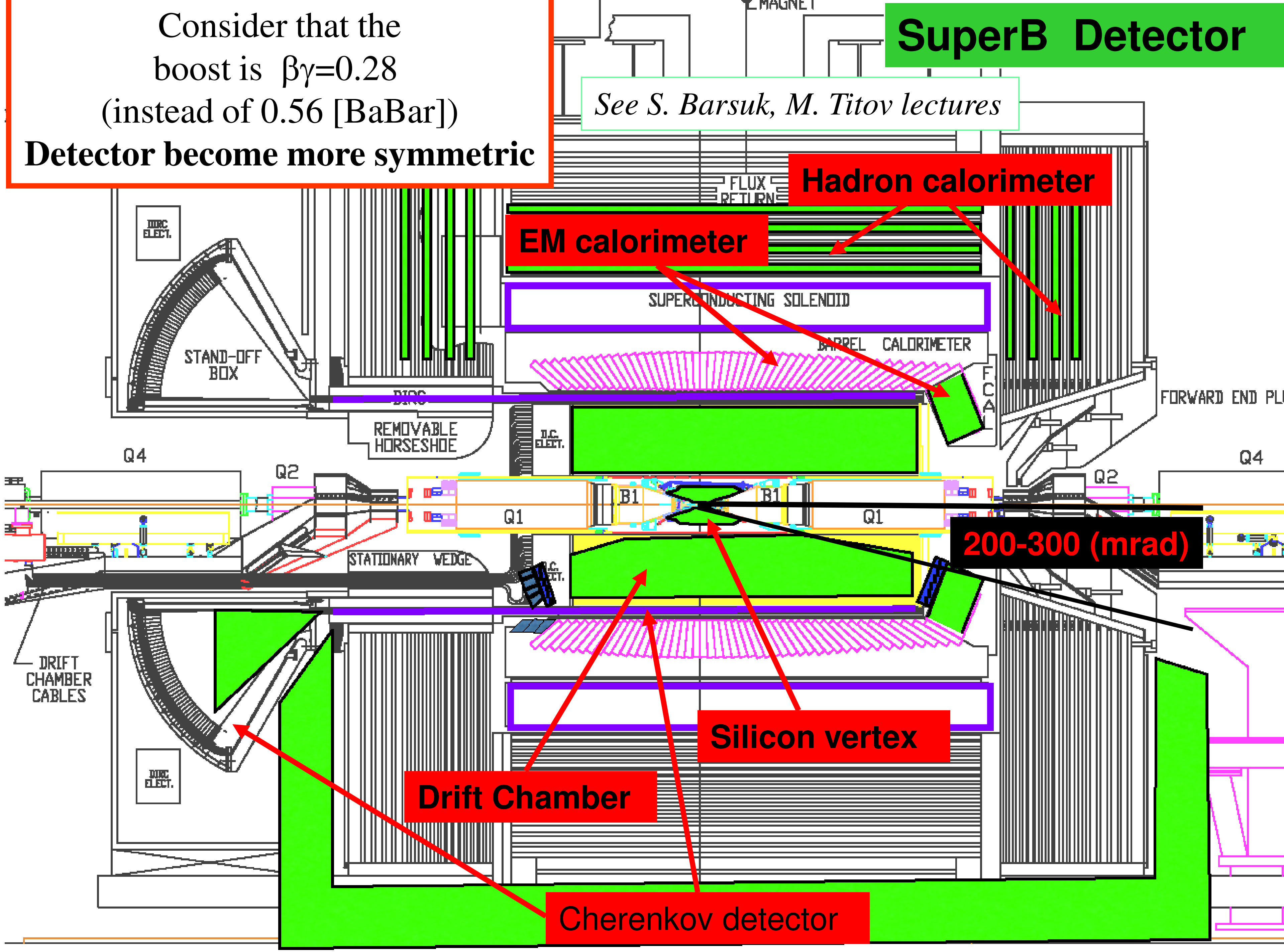
IP beam distributions for *SuperB*

The Detector

SuperB Detector

Consider that the
boost is βγ=0.28
(instead of 0.56 [BaBar])
Detector become more symmetric

See S. Barsuk, M. Titov lectures



Hadron calorimeter

EM calorimeter

200-300 (mrad)

Silicon vertex

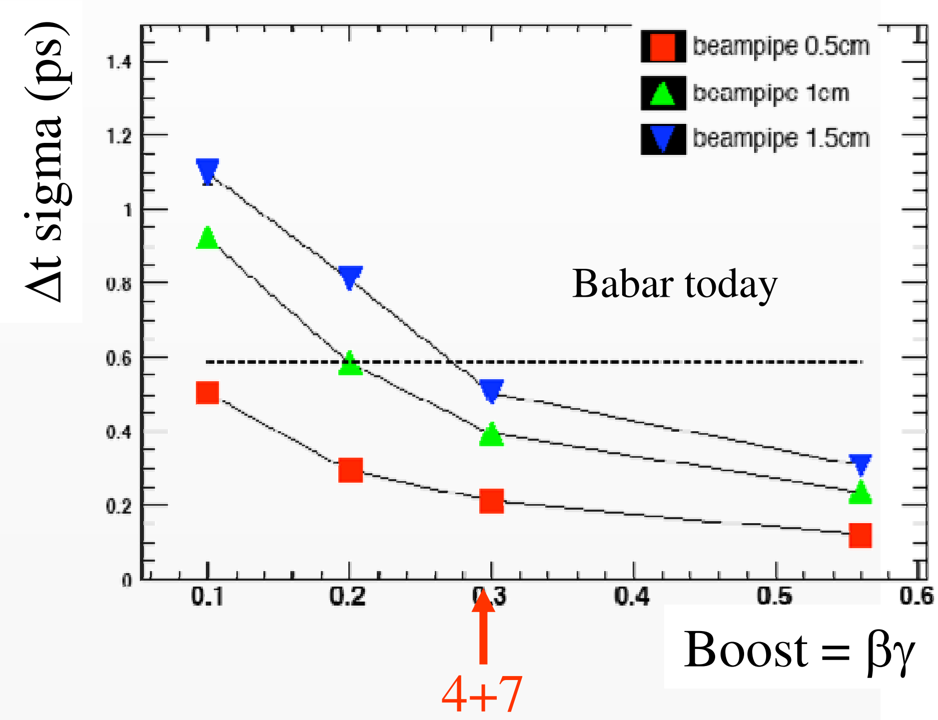
Drift Chamber

Cherenkov detector

- **Baseline interaction region defined**
  - 300 mrad line separating detector from accelerator, backward and forward
  - No support tube
    - although magnet support still needs to be fleshed out
  - 1 cm inner radius of the beam pipe

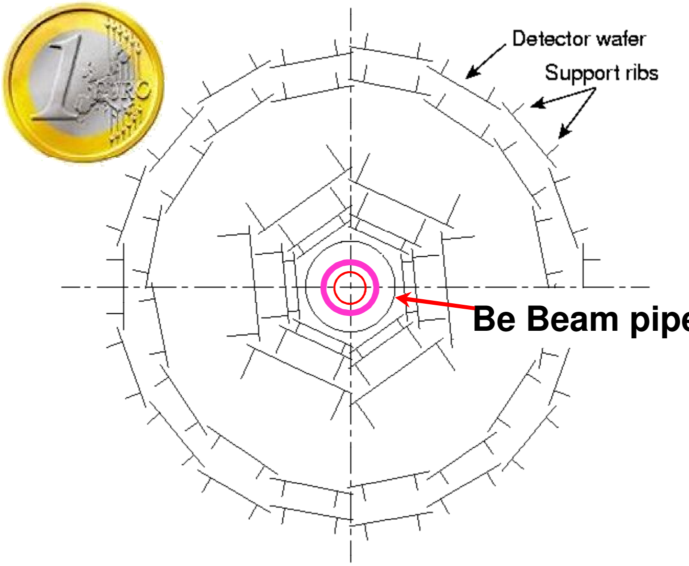
Forw (mrad)	**Back (mrad)**	**Coverage**
350	500	91.2%
350	350	93.1%
300	300	94.9%
200	200	97.7%
100	100	99.4%

- **Energy asymmetry**
  - 4x7 ok **if** we can use a 1cm beam pipe and get enough vertex resolution.



In the following just few example of sub-detectors

SVT (Silicon Detector)



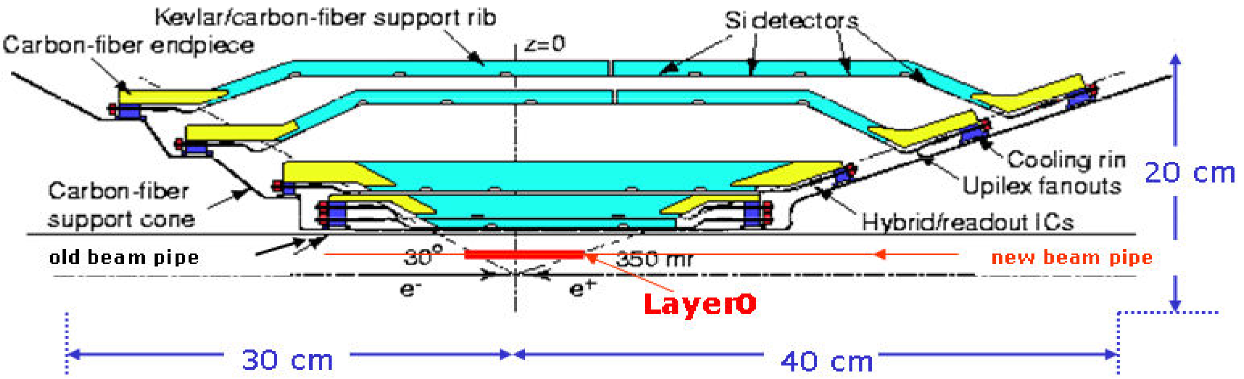
Physics studies shows that we have the following constraints:

R beampipe ~ 1-1.2 cm
Beampipe ~ 0.5% X_0
Layer_0 radius ~ 1.2-1.5 cm

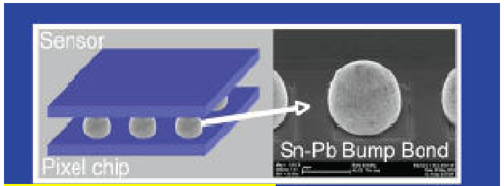
Layer 0 very close
To the beam pine ADDED

BaBar SVT

Layer	Radius
0	1.2-1.5 cm
1	3.3 cm
2	4.0 cm
3	5.9 cm
4	9.1 to 12.7 cm
5	11.4 to 14.6 cm



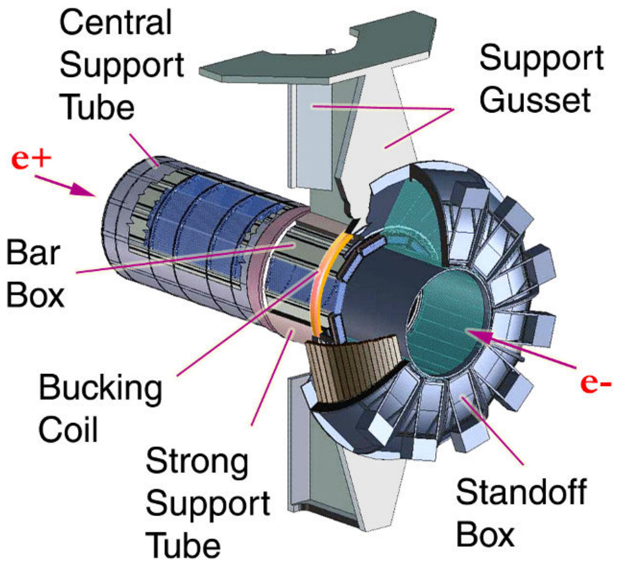
Layer0 pixel options under study

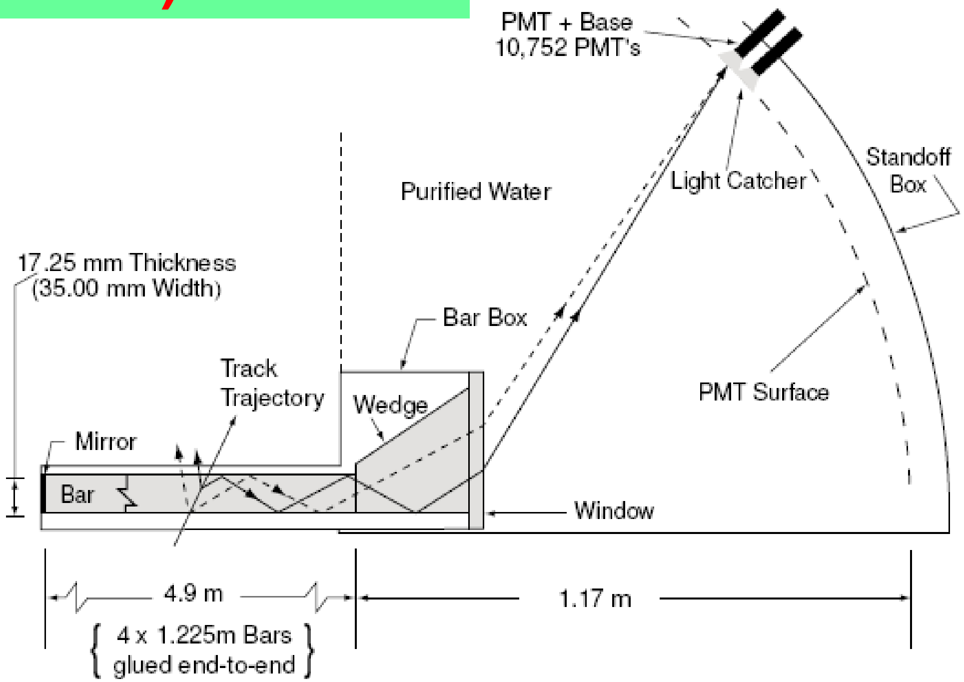


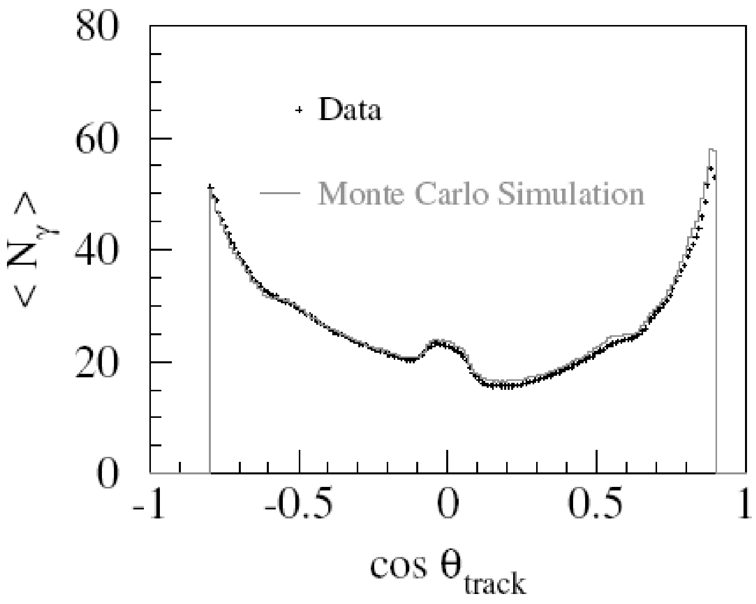
Hybrid Pixels

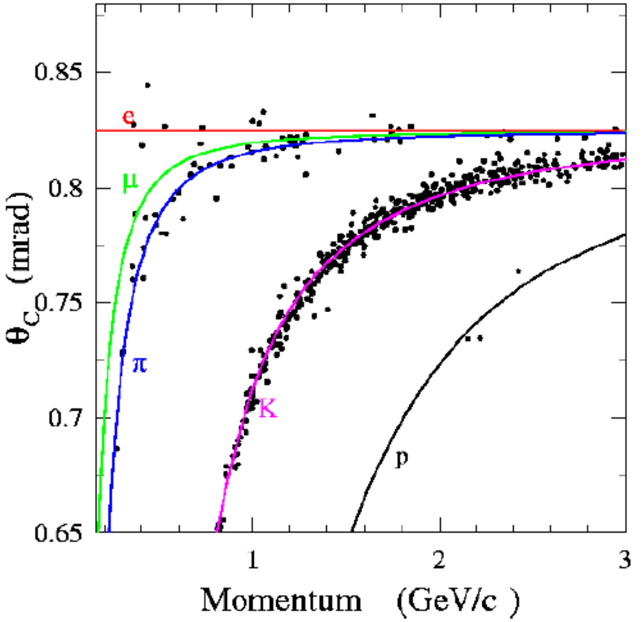
Particle ID (Cherenkov detector) - barrel

Shown by S. Barsuk









PID in the forward region

Very little space between the Drift Chamber and the Electomagnetic Calorimeter.

The principle of time of flight (TOF)

Two particles m1, m2, with same momentum flying a distance L, have a Δt time flight difference given by

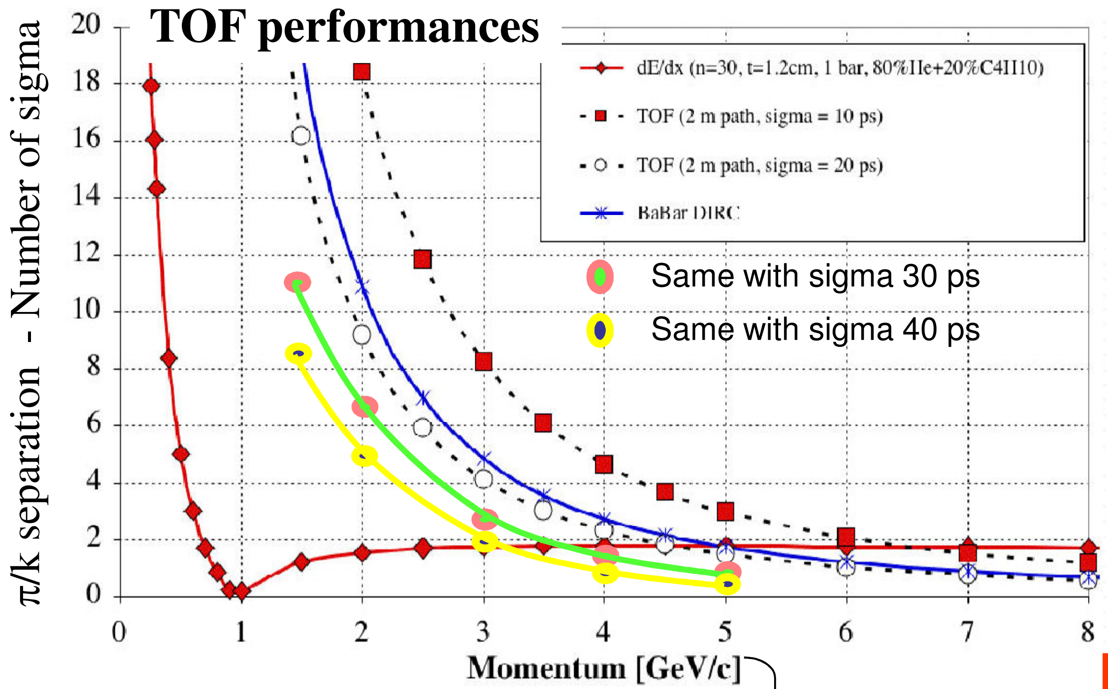
Master formula 1

$$\boxed{\Delta t \approx \frac{Lc}{2p^2}\left(m_1^2 - m_2^2\right)}$$

Dependence on $1/p^2$

Same example π/K separation for p=1GeV/c and L=2m → Δt=~760ps
p=3GeV/c " → Δt=~80ps

So if we want 4σ separation of π/K up to 3 GeV/c
we need a time resolution $\sigma(t)$~20ps



σ_{sci} = contribution of the light flash

σ_l = variation of the travel time due to
i) different point impact
ii) emission angle of the photons

detector

σ_{TTS} = photoelectron transit time spread (TTS)

PM

N_{eff} = number of primary photoelectrons

PM+detector

σ_{elec} = spread time due to the electronics

electronics

Need : $\sigma(t)$ ~20ps

$$\sigma(t) = \sqrt{\frac{\sigma_{sci.}^2 + \sigma_l^2 + \sigma_{TTS}^2}{N_{eff.}} + \sigma_{elect.}^2}$$

$$\sigma_{TTS} \sim (30-40)\,ps$$

$$\sigma_{el} < 10\,ps$$

$$\Downarrow$$

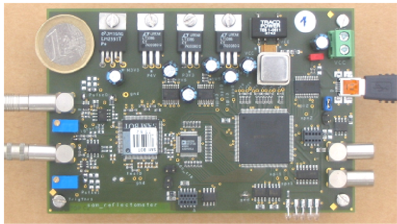
$\sigma(t)$ ~ 20ps

→ Test bench for photodiodes (MCP-PMT, SiPM)

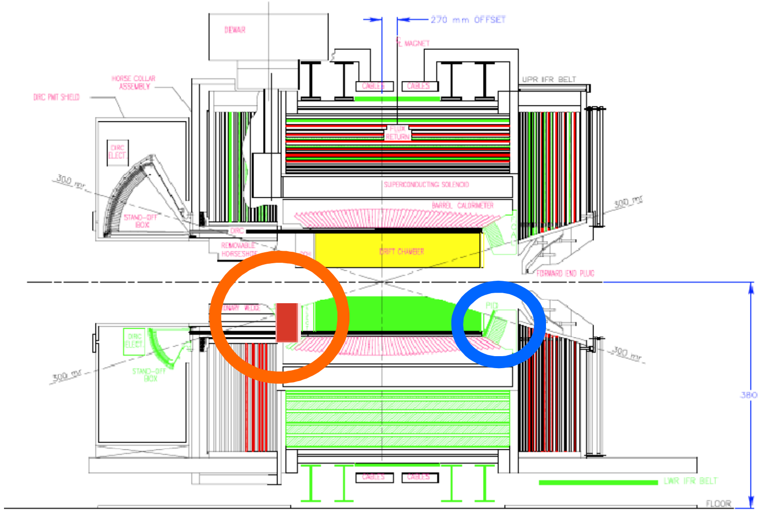
→ Test the system PMs+electronics

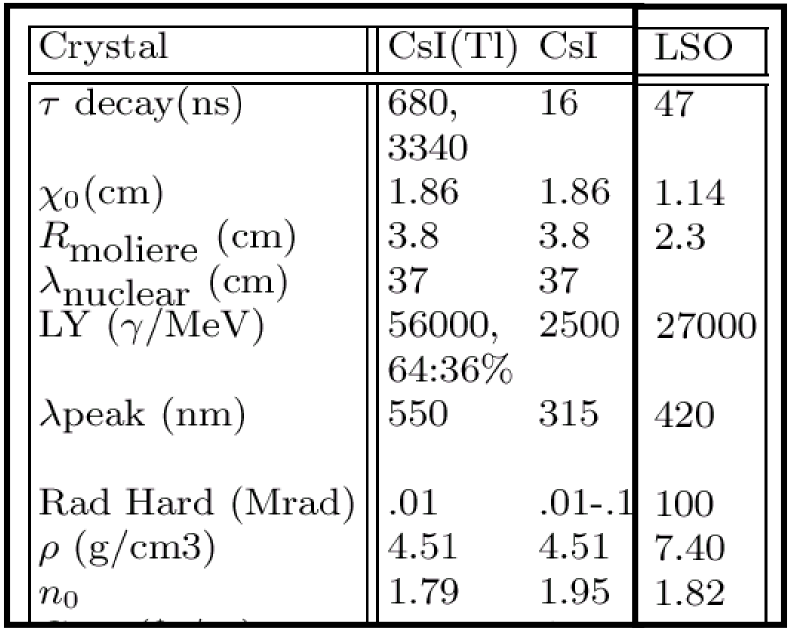
→ In future
detector + PMs + electronics

Similar project submitted for ANR

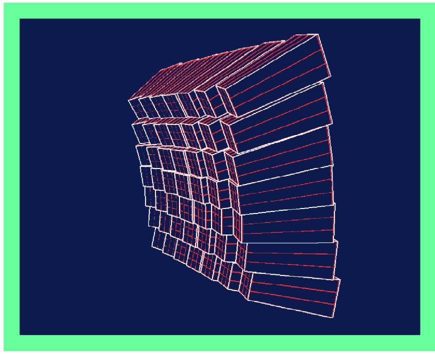


EMC – forward





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
λ_{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



We need

→A crystal with a smaller Molière radius

→A crystal that is more radiation hard

→A crystal with a faster decay time
(occupancy at lower angle)

See
S. Barsuk
lecture

Why not, you ask, use PbWO4?

→ Because we need a crystal that produces more light than a lead brick

We have an excellent candidate
in LSO/LYSO,

Conclusions

PHYSICS

SuperB (L>10^{36}) is a discovery machine at the TeV scale

→ *Measurable effects (anyhow) if NP particles with masses at the TeV scale*

→ *Give also the opportunity of exploring NP scales of the several TeV*

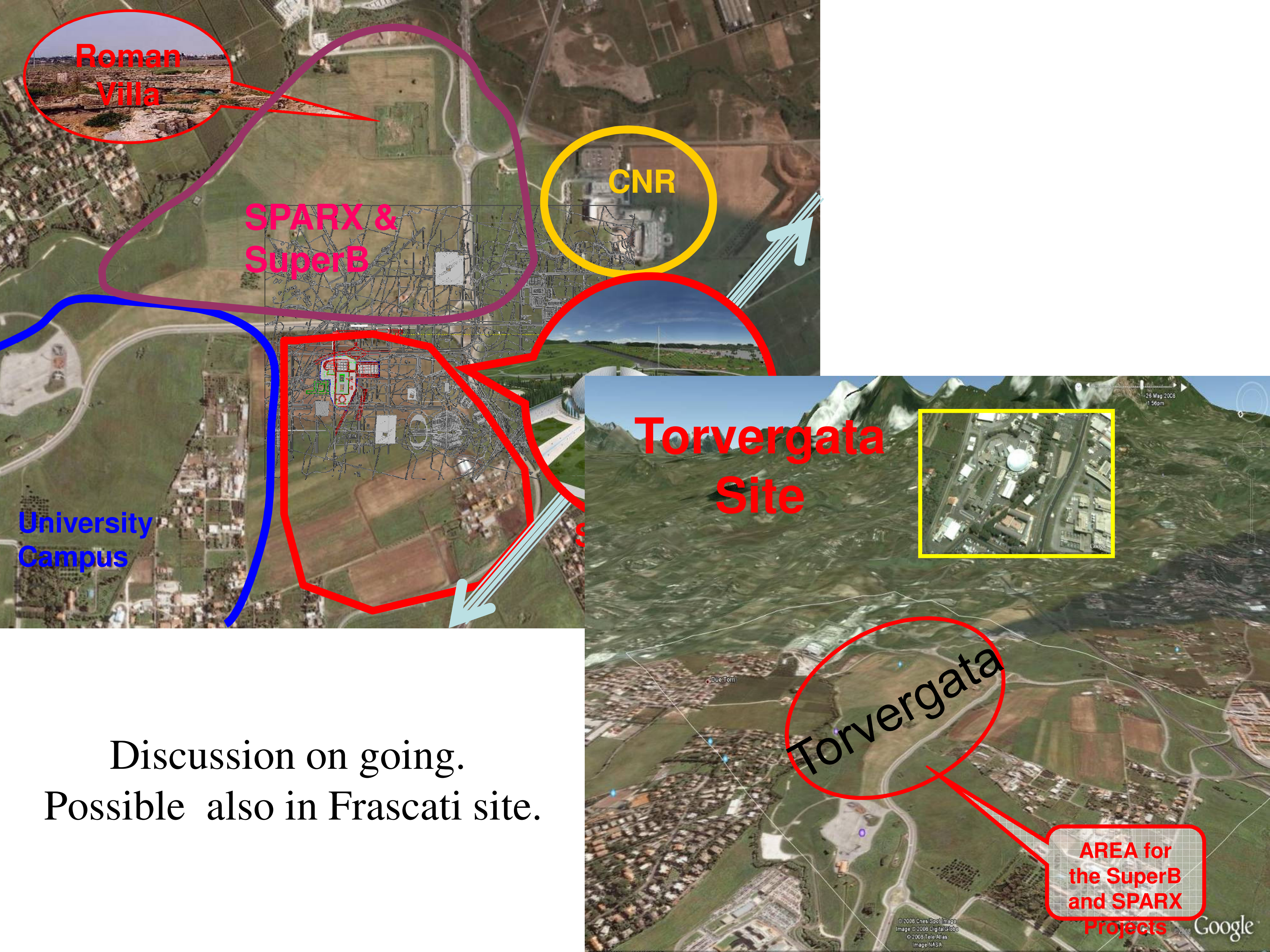
MACHINE

Machine is challenging and based on new accelerating schemes : "crab waist" : luminosity > 10^{36} possible !

Success of Frascati tests has proven that they work !

DETCTOR

Detector largely inspired from Babar one will be largely improved



Discussion on going.
Possible also in Frascati site.

→ The TDR phase has started and financed (18MEuros)

Proto-Collaboration formed

→The approuval of the project could already happen during this phase (from now to mid-2010)

If you want to join SuperB-project you are welcome !

Backup Material

Try to reuse parts of Babar as much as possible

- Quartz bars of the DIRC
- Barrel EMC CsI(Tl) crystal and mechanical structure
- Superconducting coil and flux return yoke.

R&D and engineering required

- Small beam pipe technology
- Thin silicon pixel detector for first layer
- Drift chamber CF mechanical structure, gas and cell size
- Photon detection for DIRC quartz bars
- Forward PID system (TOF or focusing RICH)
- Forward calorimeter crystals (LSO)
- Minos-style scintillator for Instrumented flux return
- Electronics and trigger
- Computing – large data amount

- “Politics”
- Milestones
- What Next

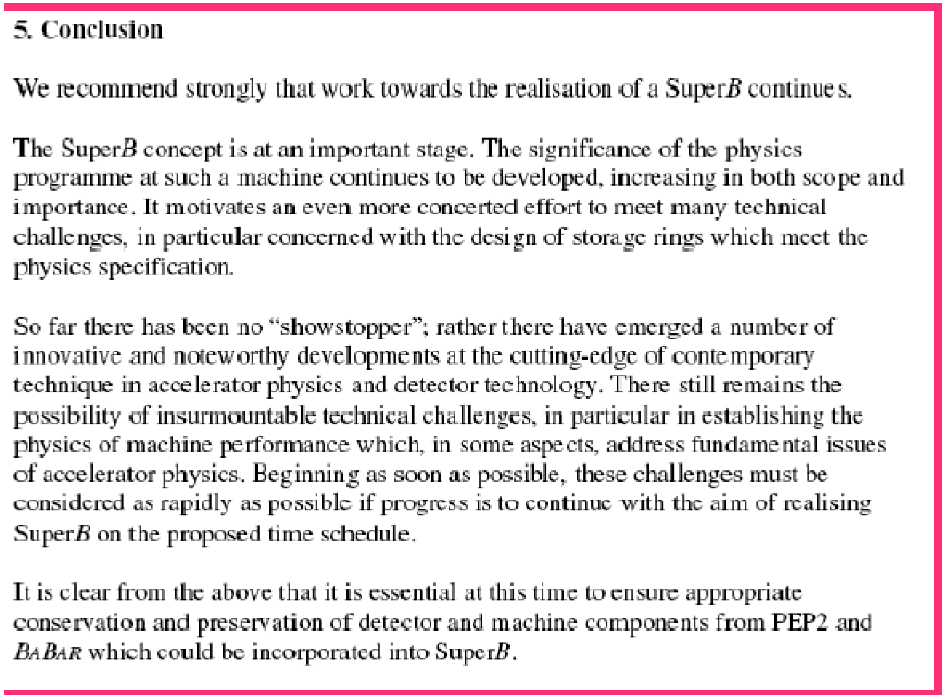
Super B project status

- The Italian process
- The European process
- The US process
- Interferences with KEK roadmap?

First Report
of the International Review Committee (IRC)
for the SuperB^1 Project

Hiroaki Aihara, John Dainton, Rolf Heuer, Young Kee Kim, Jacques Lefrançois,
Antonio Masiero, Steve Myers, Tatsuya Nakada^2, Daniel Schulte, Abe Seiden

Roma, May 21st 2008



5. Conclusion

We recommend strongly that work towards the realisation of a Super*B* continues.

The Super*B* concept is at an important stage. The significance of the physics programme at such a machine continues to be developed, increasing in both scope and importance. It motivates an even more concerted effort to meet many technical challenges, in particular concerned with the design of storage rings which meet the physics specification.

So far there has been no “showstopper”; rather there have emerged a number of innovative and noteworthy developments at the cutting-edge of contemporary technique in accelerator physics and detector technology. There still remains the possibility of insurmountable technical challenges, in particular in establishing the physics of machine performance which, in some aspects, address fundamental issues of accelerator physics. Beginning as soon as possible, these challenges must be considered as rapidly as possible if progress is to continue with the aim of realising Super*B* on the proposed time schedule.

It is clear from the above that it is essential at this time to ensure appropriate conservation and preservation of detector and machine components from PEP2 and *BABAR* which could be incorporated into Super*B*.

The project positively received by the IRC

- unique sensitivity to flavour in new physics
  - indirect energy reach < ~ 10 TeV ?
- new flavour physics beyond few TeV
  - SuperB = (indirect) energy frontier → discovery machine
- continue evaluation to establish physics specification

Latest News 19th Dec 2008,

from Marcello Giorgi

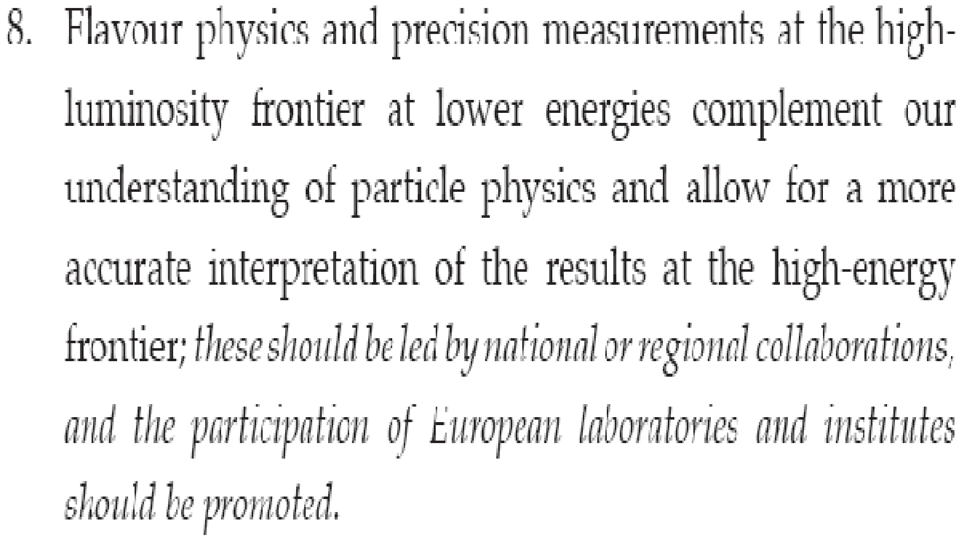
"…It is a great pleasure to annonce you that INFN Board of Directors has endorsed the SuperB as a special project. The consensus was unanimously expressed after a long and exhausting discussion. The implications are that thereb is no obstacle to proceed with the TDR and to move to the construction of the strong organization that we need.

The project will receive the financial support ain a very generous way by the Lazio Regional governement. Roberto Petronzio after the vote of the Board was authorized by the Lazio government to officially announce this contribution that could fully cover the cost of the project preparation,

In addition INFN will give extra money through the Gruppo I. Nando Ferroni, chair of Gruppo I, confirmed in front of the Board. INFN will ask us periodical reports to the Board of Directors, to monitor the process.

Roberto Petronzio has also communicated that the funding process for construction with the National Italian Governement has started and in good shape

The European process



8. Flavour physics and precision measurements at the high-luminosity frontier at lower energies complement our understanding of particle physics and allow for a more accurate interpretation of the results at the high-energy frontier; *these should be led by national or regional collaborations, and the participation of European laboratories and institutes should be promoted.*

- European strategy recognition process
  - SuperB project presented to he CERN Council in September 2008. recognition possible in March 2009
  - ECFA subgroup report in Nov 2008

20 November 2008

Report on the INFN Super Flavour Factory Project

Working Group set up by the restricted meeting of ECFA

Y. Karyotakis (LAPP, France), F. Linde (Nikhef, the Netherlands),
B. Spaan (Uni. Dortmund, Germany)
Chaired by T. Nakada (EPFL, Switzerland)

Introduction

INFN requested European Committee for Future Accelerator (ECFA) to form an opinion on their Super Flavour Factory project during its restricted meeting (RECFA) in Lisbon on 29th of March 2008. Following a proposal by the ECFA chair, K. Meier, RECFA asked one of its members, T. Nakada, to form and chair an internal working group who should prepare a report, which should then be endorsed by ECFA. The working group consists of the four authors of this report. The report consists of a physics section describing the current status of flavour physics and the significance of a future Super Flavour Factory, a short description of the INFN project as understood by the working group, consideration of the global situation, and finally a summary.

ECFA report summary - 1

- We consider that **flavour physics should be seen as an important part of the European research programme of elementary particle physics**, complementary to physics provided by the energy frontier experiments. For the coming ~5 years, LHCb will do this job in the b and c quark sectors. To follow-up this progress, **collecting 50 ab–**1 **or more at** Υ(**4S) energy with e+e– storage rings by the end of the next decade would be a significant milestone, if this can be realised at a moderate cost**.

- The INFN Super Flavour Factory project team proposes a novel scheme to obtain luminosity of ≥1036 cm–2s–1, two orders of magnitude more than what has been achieved up to now, without increasing the beam currents. This is a distinct advantagefor some of the machine operation aspects and background to the experiment, as well as for the running cost of the machine. This idea of obtaining a high luminosity with tiny beam spots at the collision point based on very small emittance beams and crab waist collisions could revolutionize the design of the future colliders. **Therefore, westrongly support the R&D effort to see if such a machine can really be built.**

ECFA report summary –Part 2

- The current tests at DAFNE are promising and we would like to congratulate the team for this impressive achievement. **However, a substantial amount of work is still required for producing a Technical Design Report**, which will be a base for establishing an international consortium for the realisation of the project. **A strong core team of experienced accelerator physicists and engineers based at one location should be established already for the TDR work**. Without it, contributions from the various interested laboratories cannot be effectively utilized. **A strong team of experienced machine physicists will be needed also for the operation**. This machine has to achieve its design luminosity in order to be truly competitive.

- Given the complexity of the project, we feel that **a clear plan containing realistic technical milestones and resource requirements together with a strategy how to obtain them is needed as a necessary condition for an approval of the project**.

- Such a plan should aim at **obtaining an integrated luminosity of significantly more than 50 ab–**1 **by not much later than the end of the next decade**. Given the very ambitious time scale, a clear decision taking process must be established soon.

Eureopean steps in three steps :

- Initial Presentation to Council(Done in Sept 2008): Council takes note
- SPC advises council : Council takes note and comments: March/June 2009
- Formal recognition once the project is approved

CERN/SPC/914
CERN-Council-S/030
Original: English
27 November 2008

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

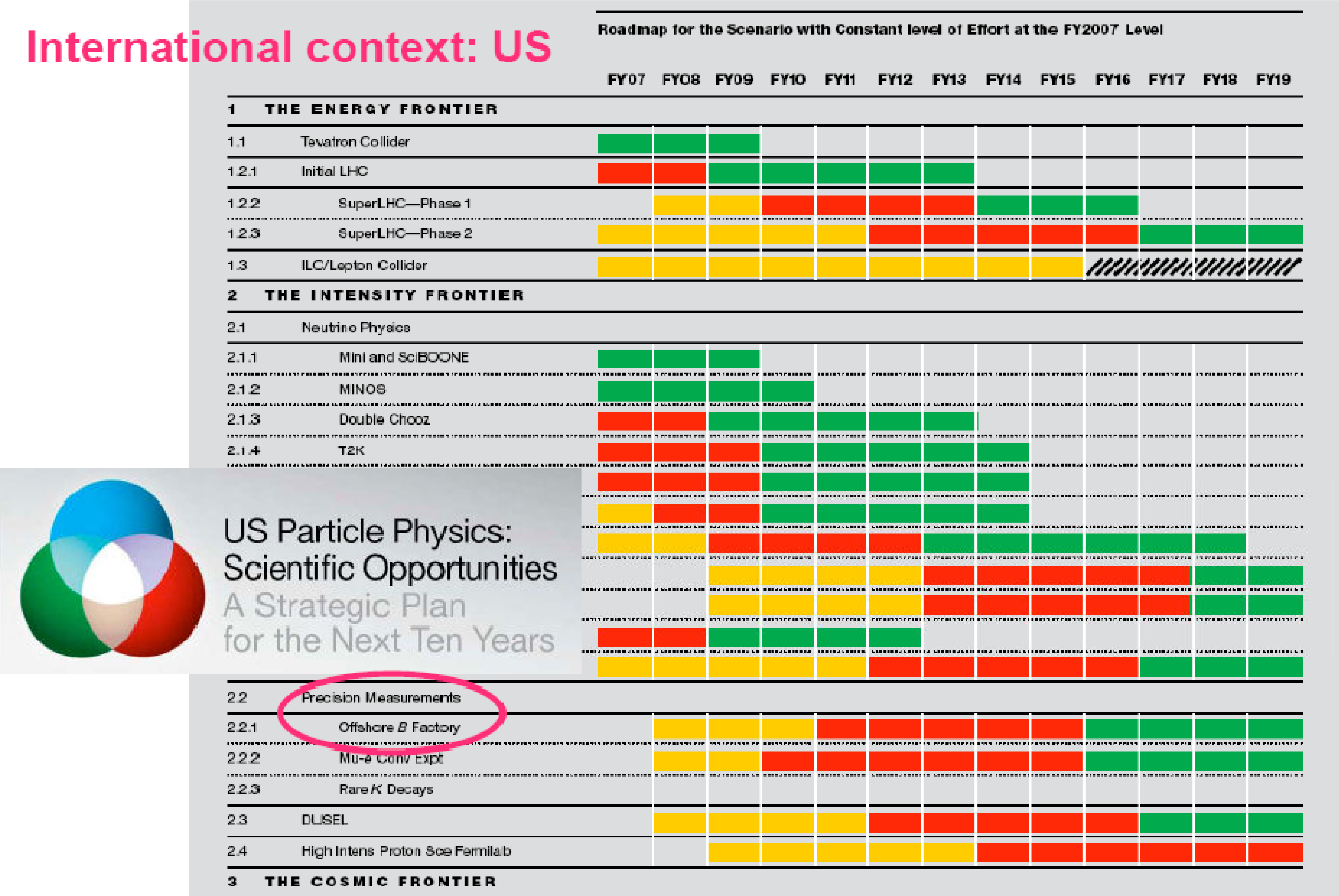
Action to be taken		Voting Procedure
For Information	SCIENTIFIC POLICY COMMITTEE 259th Meeting 8 & 9 December 2008	-
For Approval	EUROPEAN STRATEGY SESSION OF COUNCIL RESTRICTED 5th Session 11 December 2008	Simple Majority of Member States represented and voting

RECOGNITION AND FOLLOW-UP OF PROJECTS RELEVANT TO THE EUROPEAN STRATEGY FOR PARTICLE PHYSICS

The Council is invited to take note of this document, which sets out the implementation details for the remit of the European Strategy Session of Council, described in paragraph 3.1 of document CERN/2732/Rev. In particular, the Council is invited to approve the procedure set out in section 3 relating to the recognition and follow-up of projects relevant to the European Strategy for Particle Physics by the European Strategy Sessions of Council.

One offshore Super B factory project official part of the US P5 report in « scenario B »

International context: US



Roadmap for the Scenario with Constant level of Effort at the FY2007 Level

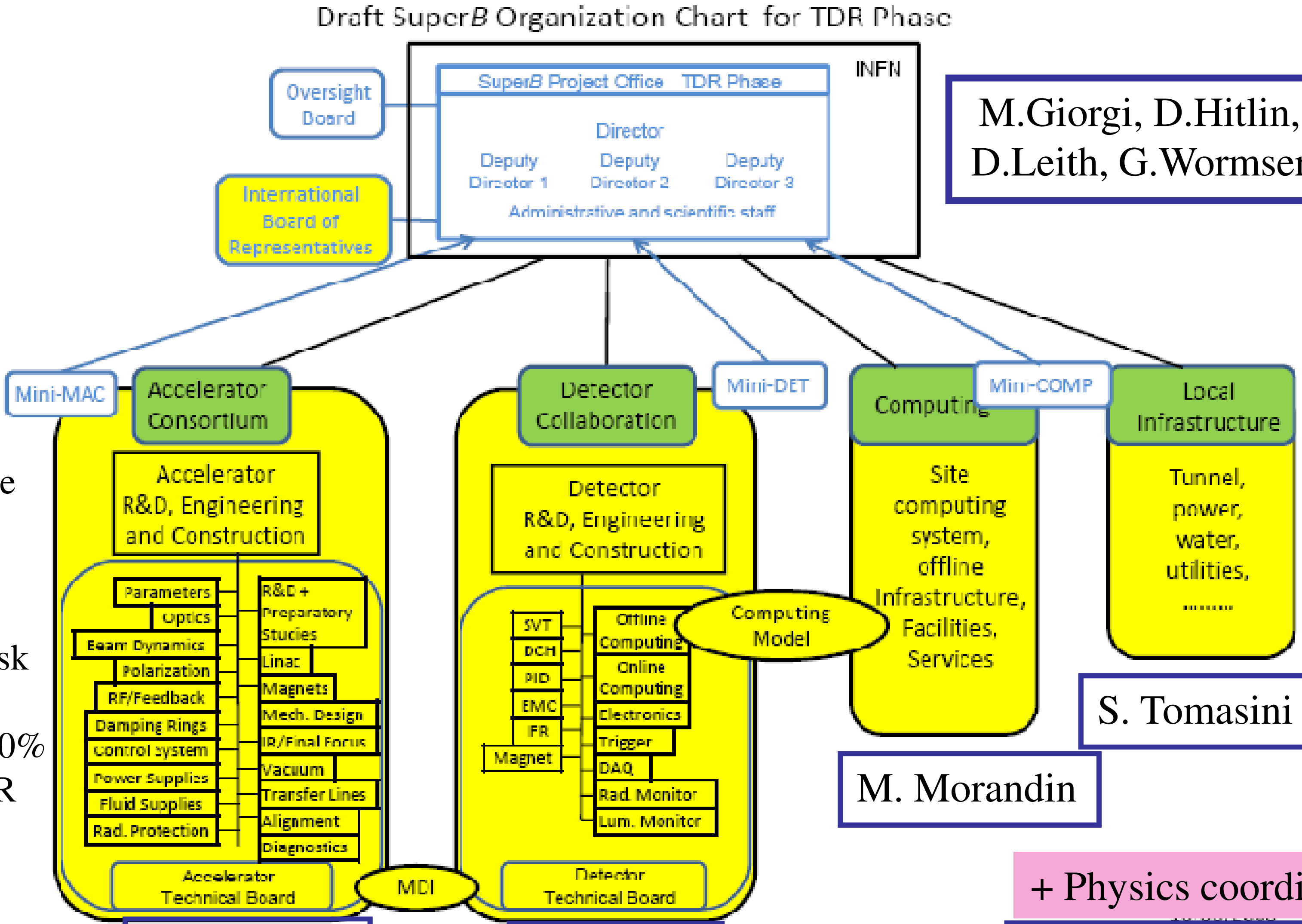
		FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19
1	**THE ENERGY FRONTIER**													
1.1	Tevatron Collider	🟩	🟩	🟩										
1.2.1	Initial LHC	🟥	🟥	🟩	🟩	🟩	🟩	🟩						
1.2.2	SuperLHC—Phase 1		🟨	🟨	🟥	🟥	🟥	🟥	🟩	🟩	🟩			
1.2.3	SuperLHC—Phase 2	🟨	🟨	🟨	🟨	🟨	🟥	🟥	🟥	🟥	🟥	🟩	🟩	🟩
1.3	ILC/Lepton Collider	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	▨	▨	▨	▨
2	**THE INTENSITY FRONTIER**													
2.1	Neutrino Physics													
2.1.1	Mini and SciBOONE	🟩	🟩	🟩										
2.1.2	MINOS	🟩	🟩	🟩	🟩									
2.1.3	Double Chooz	🟥	🟥	🟩	🟩	🟩	🟩	🟩						
2.1.4	T2K	🟥	🟥	🟥	🟩	🟩	🟩	🟩	🟩					
		🟥	🟥	🟥	🟩	🟩	🟩	🟩	🟩					
		🟨	🟥	🟥	🟩	🟩	🟩	🟩	🟩					
		🟨	🟨	🟥	🟥	🟥	🟥	🟩	🟩	🟩	🟩	🟩	🟩	
				🟨	🟨	🟨	🟨	🟥	🟥	🟥	🟥	🟥	🟩	🟩
				🟨	🟨	🟨	🟨	🟥	🟥	🟥	🟥	🟥	🟩	🟩
		🟥	🟥	🟩	🟩	🟩	🟩							
		🟨	🟨	🟨	🟨	🟨	🟥	🟥	🟥	🟥	🟥	🟩	🟩	🟩
2.2	Precision Measurements													
2.2.1	Offshore *B* Factory		🟨	🟨	🟨	🟥	🟥	🟥	🟥	🟥	🟩	🟩	🟩	🟩
2.2.2	Mu-e Conv Expt		🟨	🟨	🟥	🟥	🟥	🟥	🟥	🟥	🟩	🟩	🟩	🟩
2.2.3	Rare *K* Decays													
2.3	DUSEL		🟨	🟨	🟨	🟨	🟥	🟥	🟥	🟥	🟥	🟩	🟩	🟩
2.4	High Intens Proton Sce Fermilab			🟨	🟨	🟨	🟨	🟨	🟥	🟥	🟥	🟥	🟥	🟥
3	**THE COSMIC FRONTIER**													

US Particle Physics:
Scientific Opportunities
A Strategic Plan
for the Next Ten Years

Interactions with Japan

- KEKB upgrade part of KEK roadmap
- Nobel prize effect?
- Interference with SuperB project negative or positive?
- The « one joint program , two phases » model ?
  - Today there are two KEK machine physicists doing machine simulation in Frascati

TDR organisation



Draft Super*B* Organization Chart for TDR Phase

INFN

Super*B* Project Office TDR Phase

Director

Deputy Director 1

Deputy Director 2

Deputy Director 3

Administrative and scientific staff

Oversight Board

International Board of Representatives

Mini-MAC

Accelerator Consortium

Accelerator R&D, Engineering and Construction

- Parameters
- Optics
- Beam Dynamics
- Polarization
- RF/Feedback
- Damping Rings
- Control System
- Power Supplies
- Fluid Supplies
- Rad. Protection
- R&D + Preparatory Studies
- Linac
- Magnets
- Mech. Design
- IR/Final Focus
- Vacuum
- Transfer Lines
- Alignment
- Diagnostics

Accelerator Technical Board

MDI

Detector Collaboration

Mini-DET

Detector R&D, Engineering and Construction

- SVT
- DCH
- PID
- EMC
- IFR
- Magnet
- Offline Computing
- Online Computing
- Electronics
- Trigger
- DAQ
- Rad. Monitor
- Lum. Monitor

Detector Technical Board

Computing Model

Computing

Mini-COMP

Site computing system, offline Infrastructure, Facilities, Services

Local Infrastructure

Tunnel, power, water, utilities, ………

M.Giorgi, D.Hitlin,
D.Leith, G.Wormser

4 labs for the moment
-Frascati
-LAL
-Novossibirsk
-SLAC
covering 60% of the TDR needs

P, Raimondi
J. Seeman

F. Forti
B. Ratcliff

M. Morandin

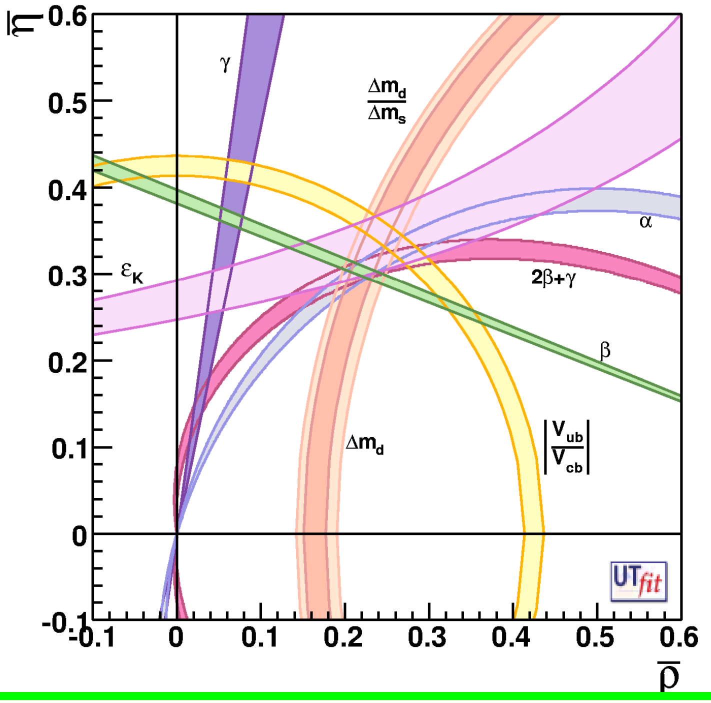
S. Tomasini

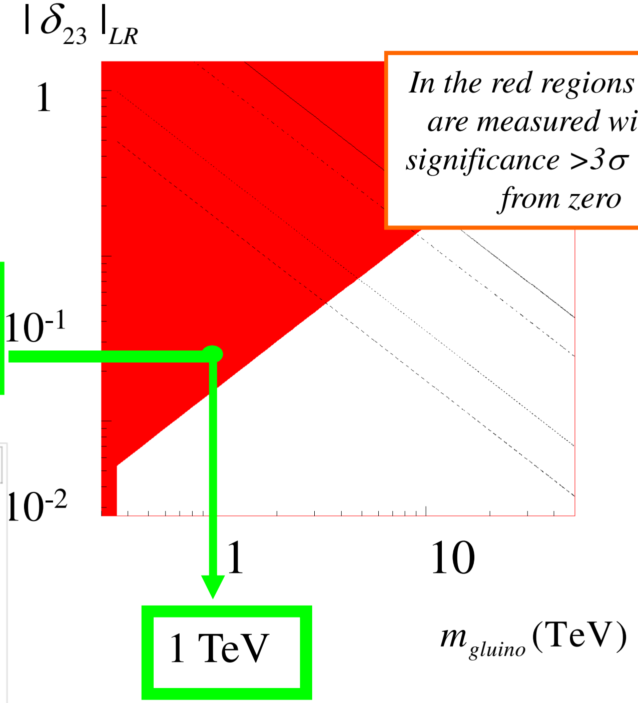
+ Physics coordination

D. Brown M. Ciuchini,
P. Harrison, A. Stocchi

Physics Case
..en pillule…

SuperB+Lattice improvements

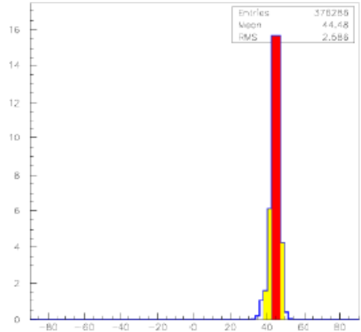


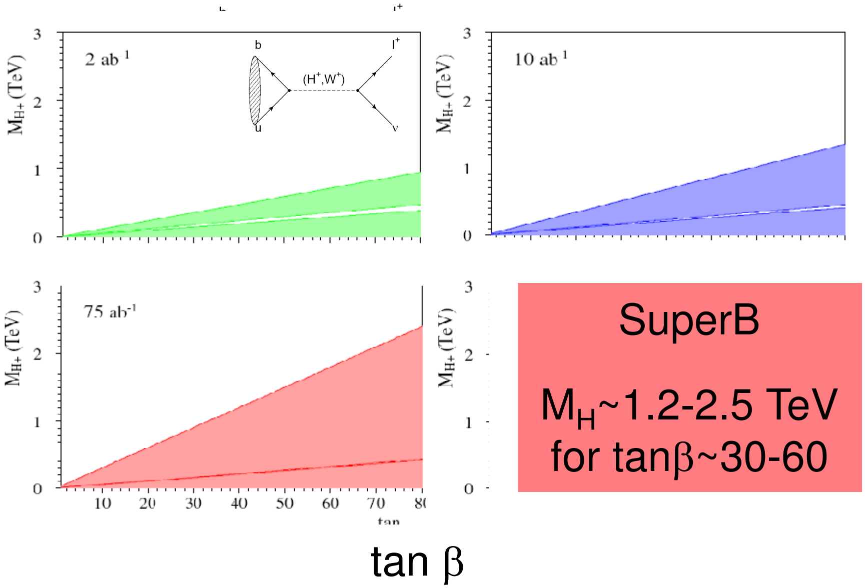


In the red regions the δ are measured with a significance $>3\sigma$ away from zero

$|\delta_{23}|_{LR}$ = (0.026 ± 0.005)

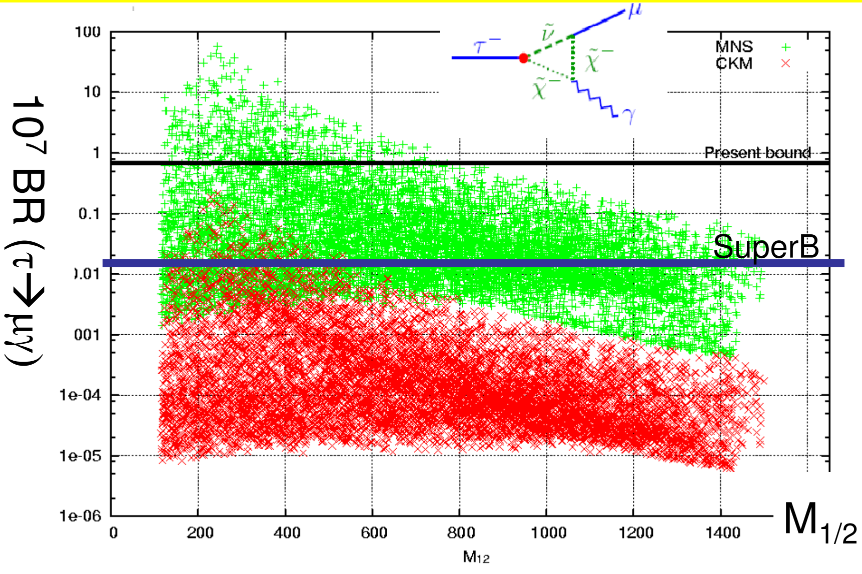
$\mathrm{Arg}(\delta_{23})_{LR}$=(44.5± 2.6)°

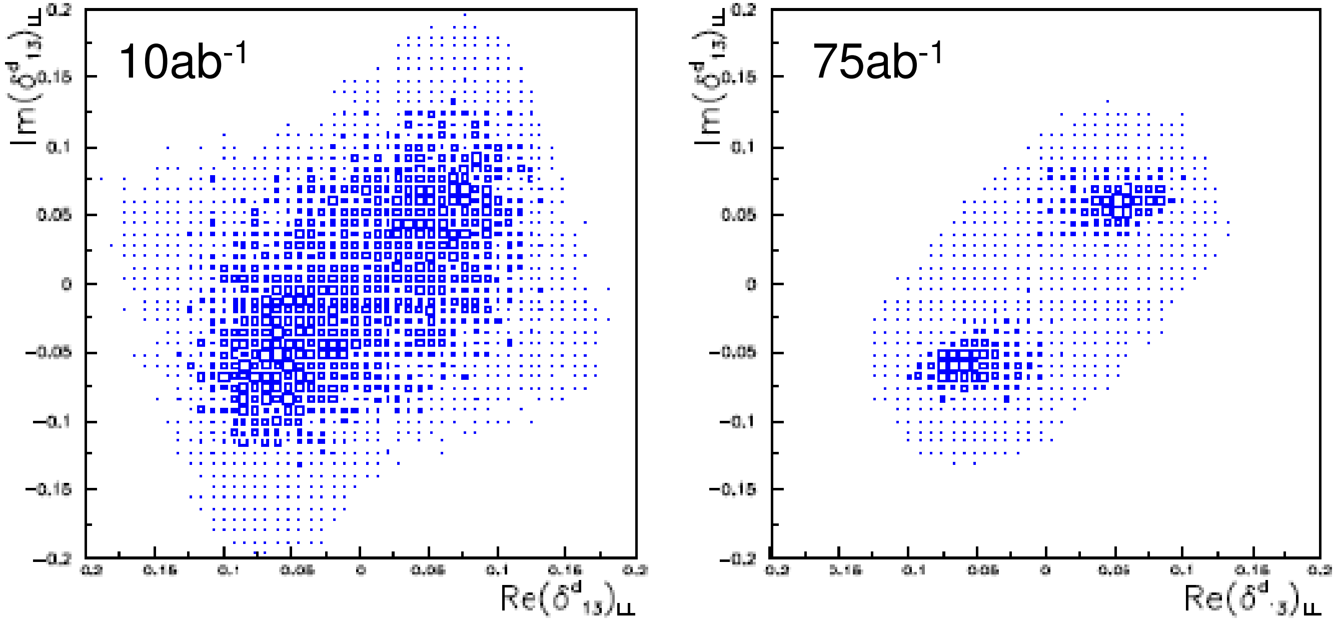




SuperB

M_H~1.2-2.5 TeV for tanβ~30-60





Determination of Susy mass insertion parameter $(\delta_{13})_{LL}$

with 10 ab^{-1} and 75 ab^{-1}

Importance of having very large sample >75ab^{-1}

GOLDEN MODES

	H^+ high $\tan\beta$	Minimal FV	Non-Minimal FV (1-3)	Non-Minimal FV (2-3)	NP Z-penguins	Right-Handed currents
$\mathcal{B}(B \to X_s\gamma)$		X		●		●
$A_{CP}(B \to X_s\gamma)$				X		●
$\mathcal{B}(B \to \tau\nu)$	X- CKM					
$\mathcal{B}(B \to X_s l^+ l^-)$				●	●	●
$\mathcal{B}(B \to K\nu\overline{\nu})$				●	X	X
$S(K_S\pi^0\gamma)$						X
β			X- CKM			

X The GOLDEN channel for the given scenario

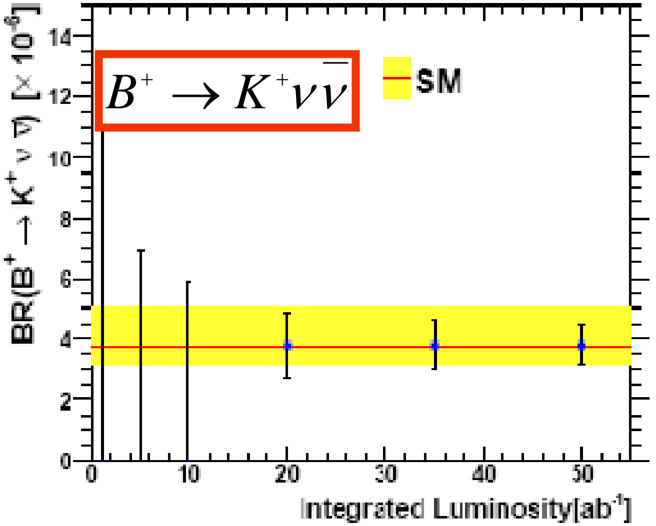
● Not the GOLDEN channel for the given scenario but can show experimentally measurable deviations from SM.

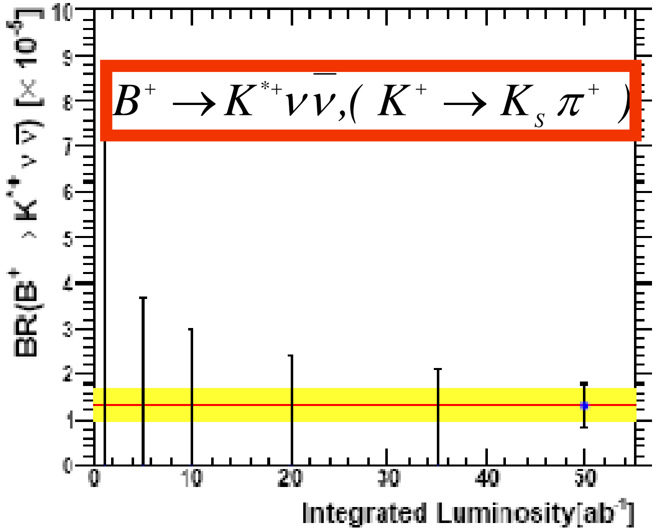
Branching fraction Br(B → K ν ν)

Today

The best UL < 14 10^{-6}

SM BF= 4 10^{-6}

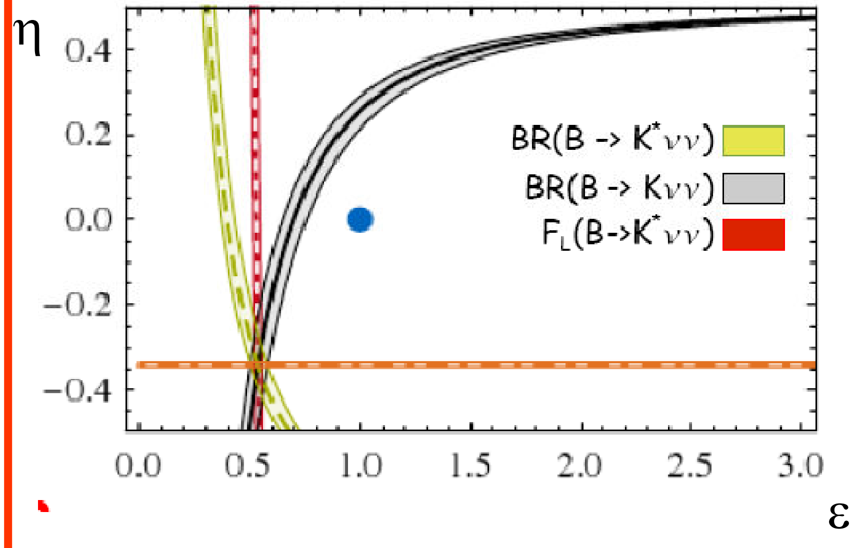




Altmannshofer et al, arXiv:0902.0160

$$\epsilon = \frac{\sqrt{|C_L^\nu|^2 + |C_R^\nu|^2}}{|(C_L^\nu)^{\mathrm{SM}}|}$$

$$\eta = \frac{-\mathrm{Re}\,(C_L^\nu C_R^{\nu *})}{|C_L^\nu|^2 + |C_R^\nu|^2}$$



~20ab^{-1} are needed for observation

>50ab^{-1} for precise measurement

Charm Physics

Charm physics using the charm produced at Υ(4S)

Charm physics at threshold 0.3 ab^{-1}

Consider that running 2 month at threshold we will collect 500 times the stat. of CLEO-C

Strong dynamics and CKM measurements

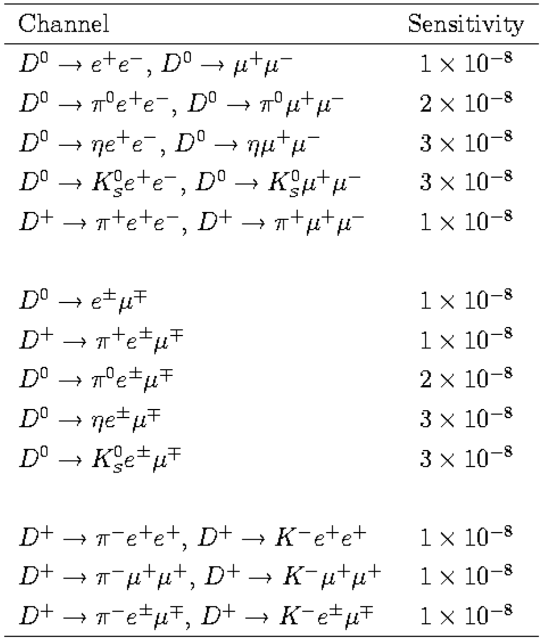
@threshold(4GeV)

D decay form factor and decay constant @ 1%
Dalitz structure useful for γ measurement

ξ~1%,
exclusive V_{ub} ~ few %
syst. error on γ from Dalitz Model <1°

Rare decays FCNC down to 10^{-8}

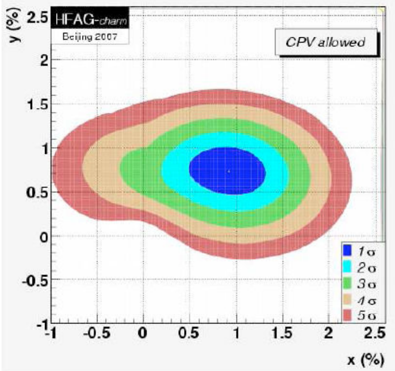
@threshold(4GeV)

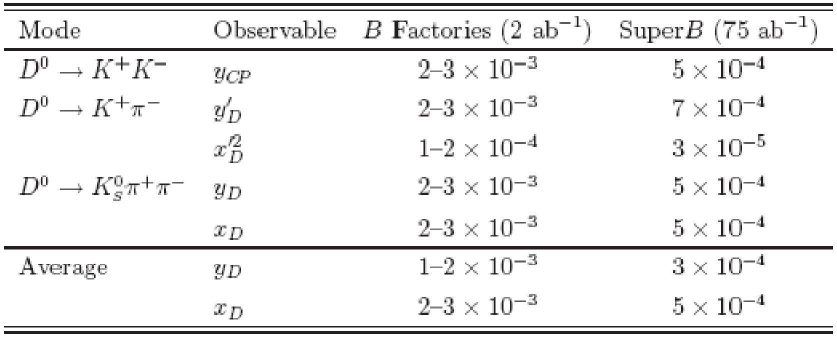


Channel	Sensitivity
$D^0 \to e^+e^-$, $D^0 \to \mu^+\mu^-$	1×10^{-8}
$D^0 \to \pi^0 e^+e^-$, $D^0 \to \pi^0\mu^+\mu^-$	2×10^{-8}
$D^0 \to \eta e^+e^-$, $D^0 \to \eta\mu^+\mu^-$	3×10^{-8}
$D^0 \to K^0_S e^+e^-$, $D^0 \to K^0_S\mu^+\mu^-$	3×10^{-8}
$D^+ \to \pi^+ e^+e^-$, $D^+ \to \pi^+\mu^+\mu^-$	1×10^{-8}
$D^0 \to e^\pm\mu^\mp$	1×10^{-8}
$D^+ \to \pi^+ e^\pm\mu^\mp$	1×10^{-8}
$D^0 \to \pi^0 e^\pm\mu^\mp$	2×10^{-8}
$D^0 \to \eta e^\pm\mu^\mp$	3×10^{-8}
$D^0 \to K^0_S e^\pm\mu^\mp$	3×10^{-8}
$D^+ \to \pi^- e^+e^+$, $D^+ \to K^- e^+e^+$	1×10^{-8}
$D^+ \to \pi^-\mu^+\mu^+$, $D^+ \to K^-\mu^+\mu^+$	1×10^{-8}
$D^+ \to \pi^- e^\pm\mu^\mp$, $D^+ \to K^- e^\pm\mu^\mp$	1×10^{-8}

D mixing

Better studied using the high statistics collected at Υ(4S)





Mode	Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab^{-1})
$D^0 \to K^+K^-$	y_{CP}	2–3×10^{-3}	5×10^{-4}
$D^0 \to K^+\pi^-$	y'_D	2–3×10^{-3}	7×10^{-4}
	x'^2_D	1–2×10^{-4}	3×10^{-5}
$D^0 \to K^0_S\pi^+\pi^-$	y_D	2–3×10^{-3}	5×10^{-4}
	x_D	2–3×10^{-3}	5×10^{-4}
Average	y_D	1–2×10^{-3}	3×10^{-4}
	x_D	2–3×10^{-3}	5×10^{-4}

CP Violation in mixing could now addressed

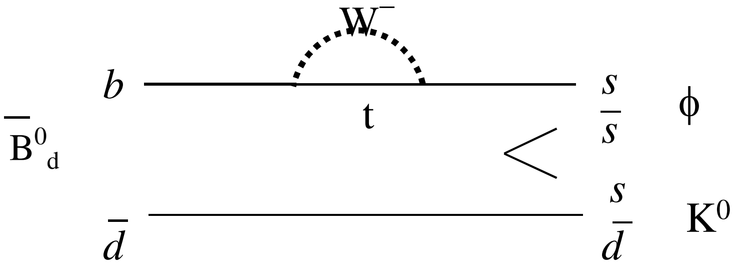
Theory keeps up...

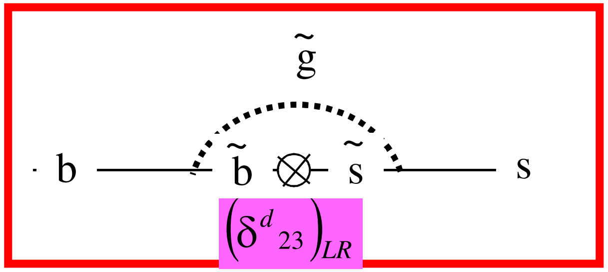
- lattice QCD can reach the O(1%) precision goal in time
- some progress for inclusive techniques for SL B decays
- non-leptonic B decays are more problematic

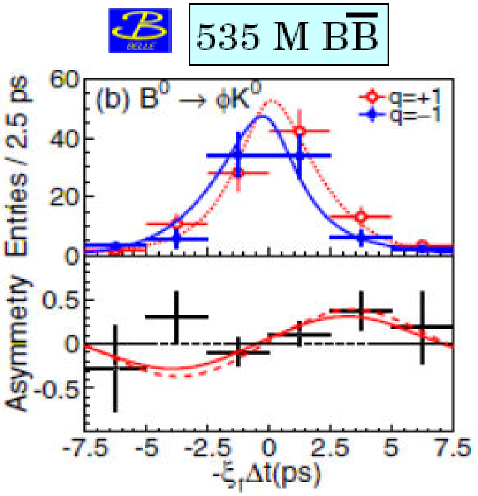
Measurement	Hadronic Parameter	Present Error	6 TFlops	60 TFlops	1-10 PFlops (Year 2015)
$K \to \pi l \nu$	$f_+^{K\pi}(0)$	0.9 %	0.7 %	0.4 %	< 0.1 %
ε_K	$\hat{B}_K$	11 %	5 %	3 %	1 %
$B \to l \nu$	f_B	14 %	3.5-4.5 %	2.5-4.0 %	1.0-1.5 %
Δm_d	$f_{Bs}\sqrt{B_{B_s}}$	13 %	4-5 %	3-4 %	1-1.5 %
$\Delta m_d / \Delta m_s$	ξ	5 %	3 %	1.5-2 %	0.5-0.8 %
$B \to D/D^* l \nu$	$\mathcal{F}_{B \to D/D^*}$	4 %	2 %	1.2 %	0.5 %
$B \to \pi/\rho \, l \nu$	$f_+^{B\pi}, \ldots$	11 %	5.5-6.5 %	4-5 %	2-3 %
$B \to K^*/\rho(\gamma, l^+ l^-)$	$T_1^{B \to K^*/\rho}$	13 %	——	——	3-4 %

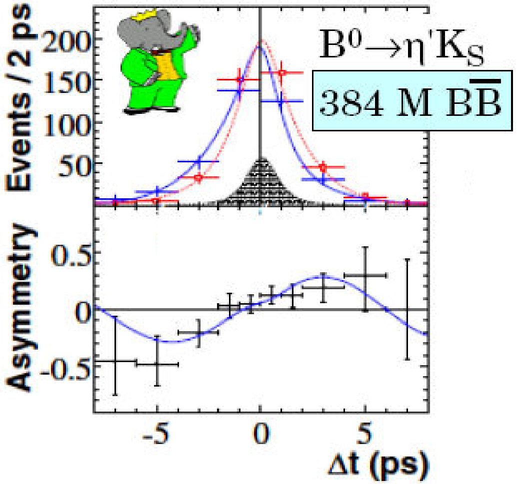
V. Lubicz, 4th SuperB Workshop and SuperB CDR

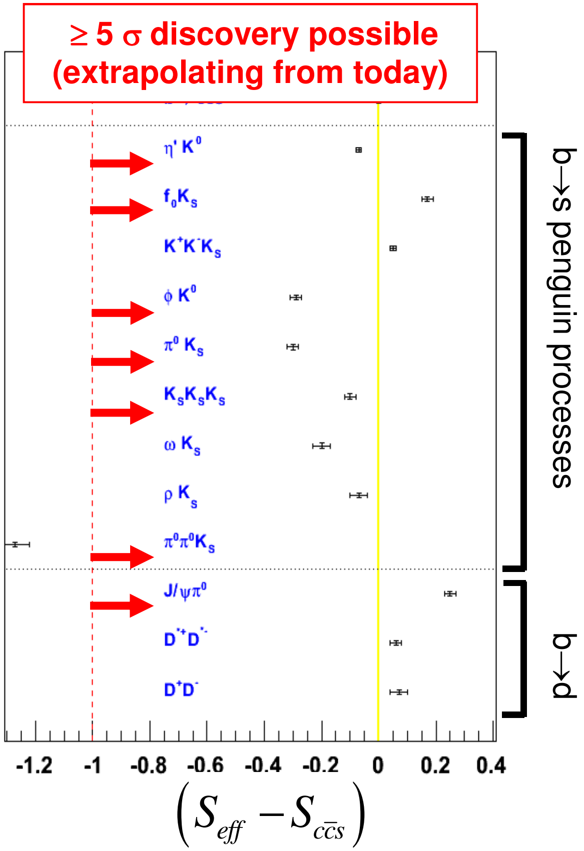
Another example of sensitivity to NP : **sin2β from "s Penguins"…**









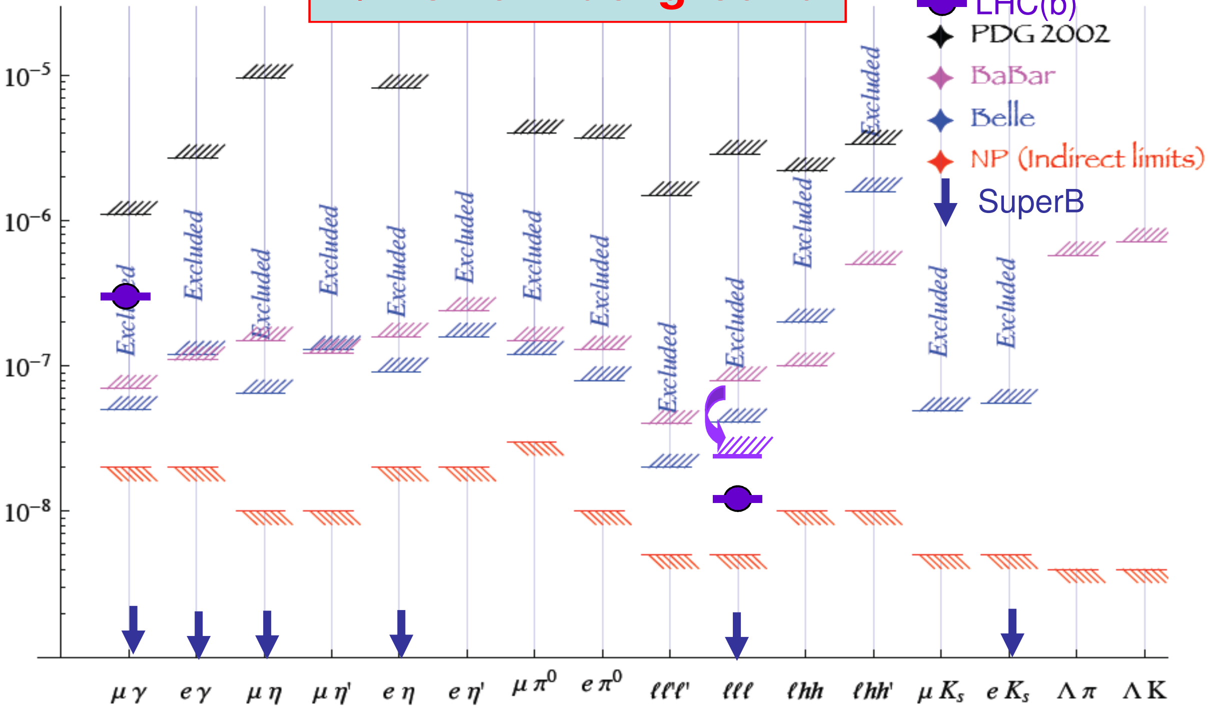

≥ 5 σ discovery possible (extrapolating from today)

Many channels can be measured with ΔS~(0.01-0.04)

Observable	B Factories (2 ab^{-1})	**SuperB**
$S(\phi K^0)$	0.13	0.02 (∗)
$S(\eta' K^0)$	0.05	0.01 (∗)
$S(K^0_S K^0_S K^0_S)$	0.15	0.02 (∗)
$S(K^0_S \pi^0)$	0.15	0.02 (∗)
$S(\omega K^0_S)$	0.17	0.03 (∗)
$S(f_0 K^0_S)$	0.12	0.02 (∗)

(*) theoretical limited

e^- beam polarization
⇒ Lower Background



SuperB Sensitivity ($75ab^{-1}$)

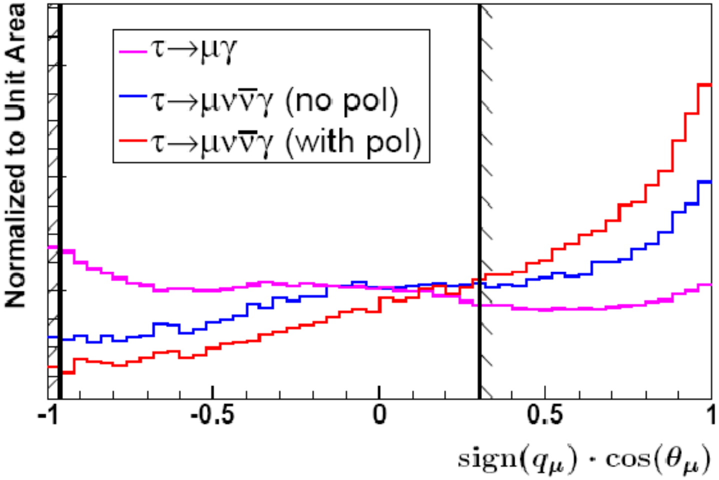
Process	Sensitivity
$\mathcal{B}(\tau \to \mu\,\gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to e\,\gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to \mu\,\mu\,\mu)$	2×10^{-10}
$\mathcal{B}(\tau \to eee)$	2×10^{-10}
$\mathcal{B}(\tau \to \mu\eta)$	4×10^{-10}
$\mathcal{B}(\tau \to e\eta)$	6×10^{-10}
$\mathcal{B}(\tau \to \ell K^0_S)$	2×10^{-10}

- LHC is ***not*** competitive (Re: both GPDs and LHCb).
- SuperB sensitivity ~10 – 50× better than NP allowed branching fractions.

Polarized beams

Polarized beam is
(SuperB specific)

LFV analyses :
novel additional handle on backgrounds



τ anomalous moment **(g-2)**

The anomalous tau momentum influence both the **angular distribution** and the **τ polarization**.
Measure the Re(F2) and Im(F2) of the (g-2) from factor

$$\Delta a_\mu = a_\mu^{\rm exp} - a_\mu^{\rm SM} \approx (3\pm1)\times10^{-9}$$

$$\Delta a_\tau/\Delta a_\mu \sim m_\tau^2/m_\mu^2 \xrightarrow{\text{NP effects}} \Delta a_\tau \sim 10^{-6}$$

	Snowmass points predictions						Super*B*
	1a	1b	2	3	4	5	exp. resolution
$\Delta a_\mu \times 10^{-9}$	3.1	3.2	1.6	1.4	4.8	1.1	
$\Delta a_\tau \times 10^{-6}$	0.9	0.9	0.5	0.4	1.4	0.3	< 1

without beam polarization, expected worse by factor ≈ 10, and worse systematics

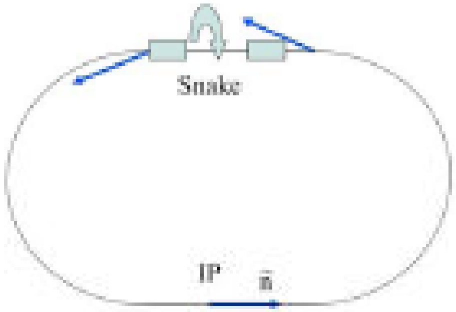
Polarisation is
- -an important issue for LFV
- -opens the possibility of measuring (g-2)
- -….

Under study

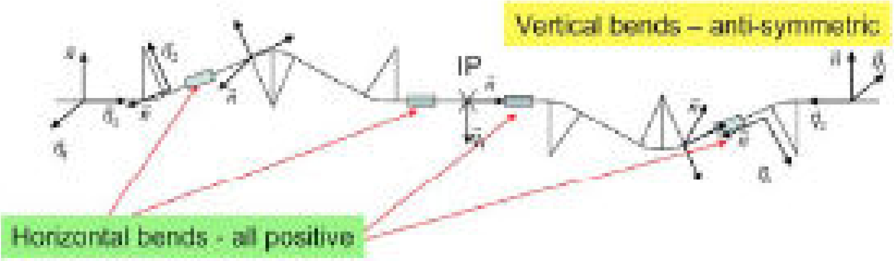
Polarisation

- In a storage ring, particle spins naturally precess around the vertical fields of the arc dipoles, at a rate determined by the particle energy.
  - This means that vertical polarisation is naturally preserved, but longitudinal polarisation can be lost without preventive measures.

- For SuperB, there are two options to maintain longitudinal polarisation in the beam at the IP:
  1. Use solenoids opposite the IP, to rotate the spin by π around the longitudinal axis.
  2. Use solenoids or vertical bends to rotate between vertical and longitudinal spin before and after the IP.



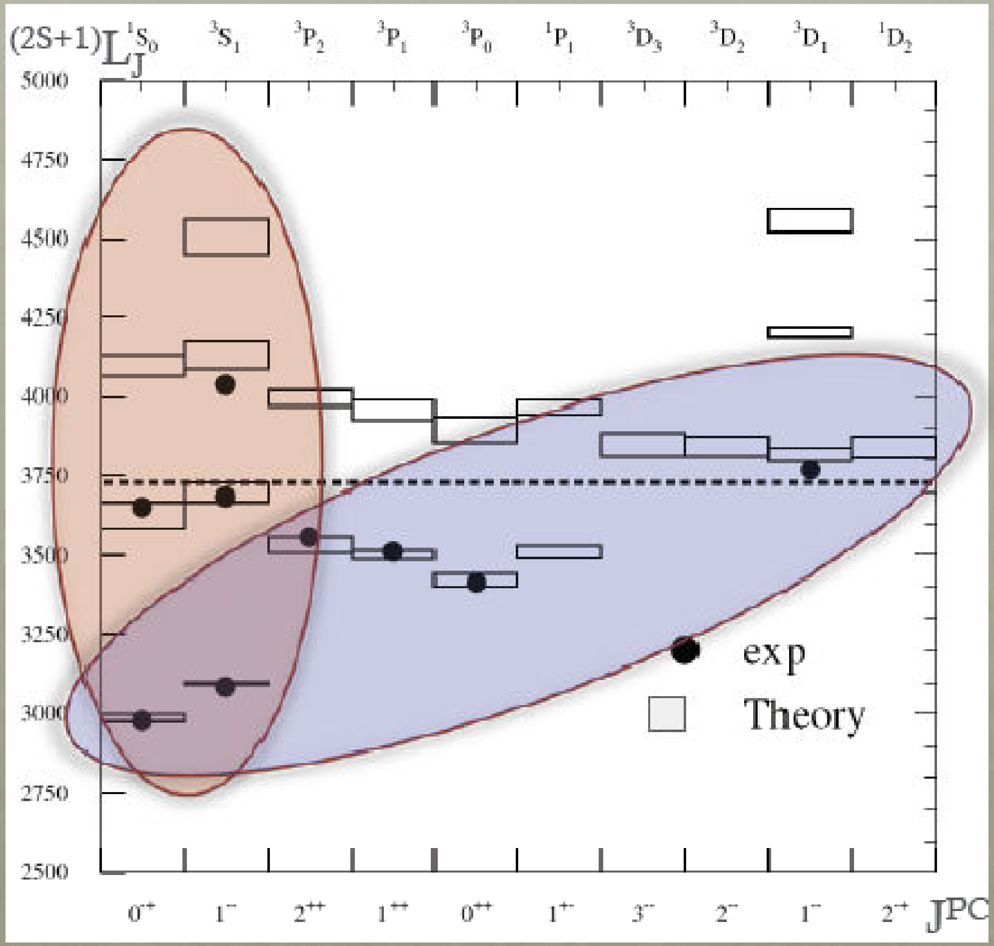
- Option 2 will probably work best for the multi-GeV SuperB rings, but more studies are needed.



- With a source providing ~ 90% polarisation, it is expected that an average polarisation of 80% can be achieved for the e^- beam. e^+ polarisation would be an upgrade…

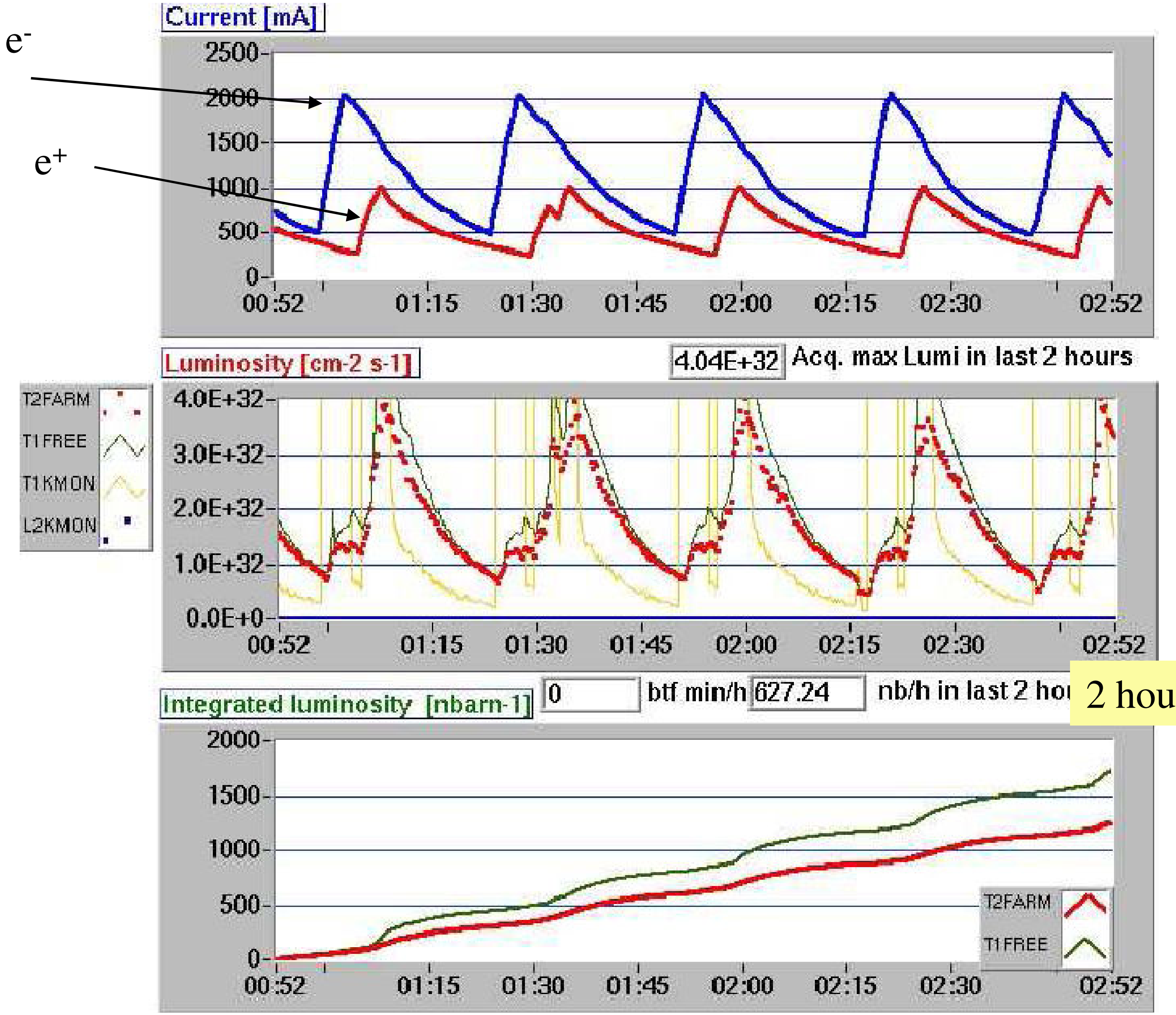
PANDA VS SUPERB (II)

B-Factories better suited to low L and 1--



$p\bar{p}$ annihilations better suited to lower states (narrower)

Still need to compare yields on same footing!



4.04E+32 Acq. max Lumi in last 2 hours

0 btf min/h 627.24 nb/h in last 2 hou

2 hours at ~ 4.0 10^{32}

In a condense table

	PEPII	KEKB	SuperB
current	2.5 A	1.7 A	2.3 A
betay	10 mm	6 mm	0.3 mm
betax	400 mm	300 mm	20 mm
Emitx (sigmax)	23 nm	~ 20 nm	1,6 nm
y/x coupling	0,5-1	0.25 %	0,25 %
Bunch length	10 mm	6 mm	6 mm
τ	16/32 msec	16/32 msec	16/32 msec
ζy	0.07	0.1	0.17
L	$1.2\ 10^{34}$	$1.7\ 10^{34}$	$1\ 10^{36}$

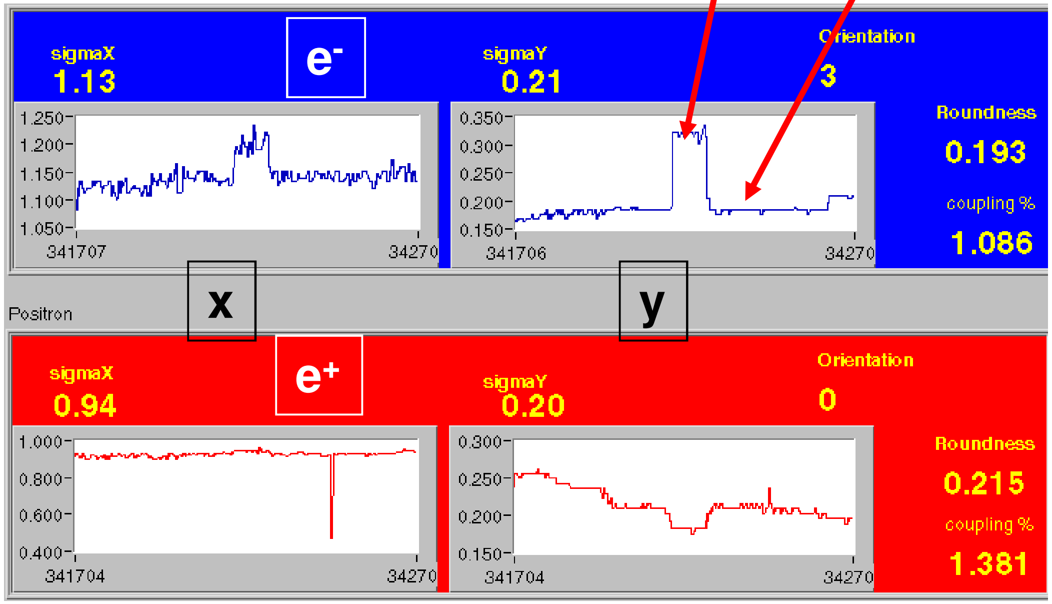
Effect of crab sextupoles on luminosity

A huge work on machine optimization has been done and is still in progress in term of feedbacks systems tuning, background minimization and tuning of the machine luminosity

Transverse beam dimensions at the Synchrotron Light Monitor

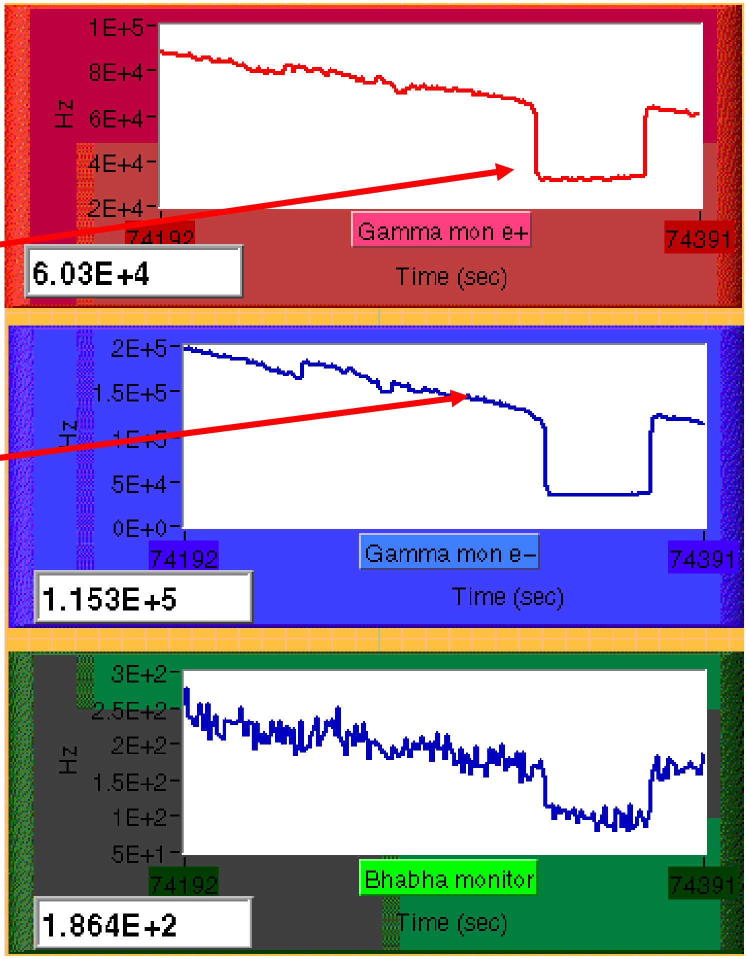
Crab OFF

Crab ON


e-
sigmaX 1.13
sigmaY 0.21
Orientation 3
Roundness 0.193
coupling % 1.086

Positron
e+
sigmaX 0.94
sigmaY 0.20
Orientation 0
Roundness 0.215
coupling % 1.381

LUMINOMETERS


Gamma mon e+ 6.03E+4
Gamma mon e– 1.153E+5
Bhabha monitor 1.864E+2

Blow-up in beam sizes and decrease in Bhabha rates observed when crab sextupols for one ring OFF (other ring ON)

DAFNE latest results

Recent Achievements

L_{peak} = 4.05 cm^{-2}s^{-1}

lastLumDisplaySidd.vi Front Panel

Opened at: 12/05/08 09:47:07 PM

081205 2164

SIDDHARTA Luminosity

e- mA: 1431

e+ mA: 1106

4.05E+32

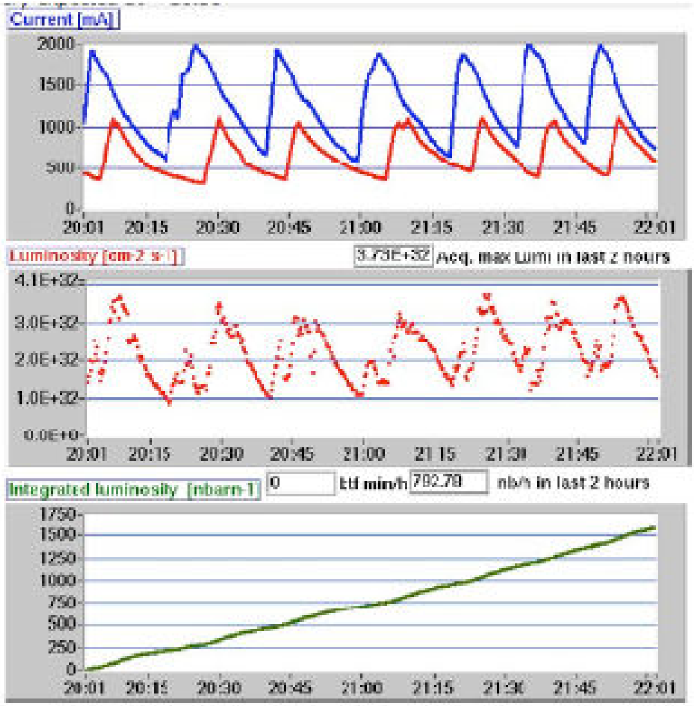
i2lam

file: /u2/data/lumi/20081205.dat

RUNNING

Dec. 5th 2008

$L_{\int 1\ hour}$ = .79 pb^{-1}



The experiment is still on going

DCH (Drift Chamber)

- Basic technology adequate.
- Cannot reuse BaBar DCH because of aging
- Baseline:
  - Same He-C_4H_{10}, same cell shape
  - Carbon fiber endplates instead of Al to reduce thickness
  - → Need to do complete background estimate
- Possible Options/Issues
  - Miniaturization and relocation of readout electronics
    - Critical for backward calorimetric coverage
  - Conical endplate
  - Further optimization of cell size/gas

EMC (Electromagnetic Calorimeter)

- Barrel CsI(Tl) crystals
  - Still OK and can be reused (the most expensive detector in BaBar)
  - Baseline is to transport barrel as one device

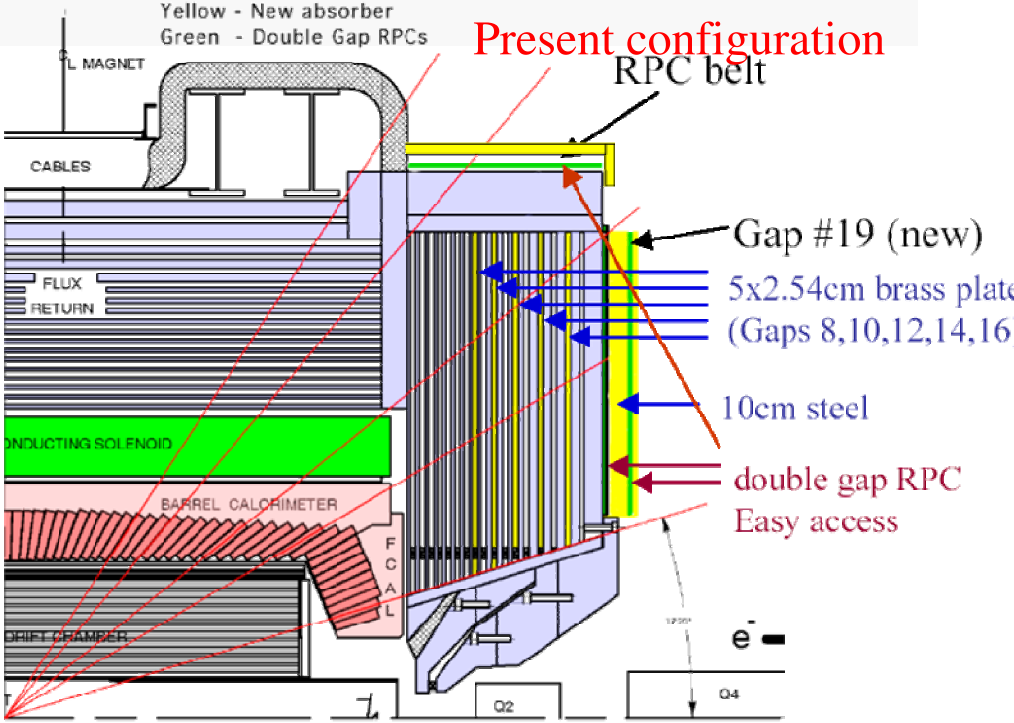
- Forward Endcap EMC
  - BaBar crystal are damaged by radiation and need to be replaced
  - Occupancy at low angle makes CsI(Tl) too slow
  - Use LSO as baseline
    - + gives better performance
    - + leaves PID option open

- Backward EMC option
  - Because of material in front will have a degraded performance
    - Maybe just a VETO device for rare channels such as $B \rightarrow \tau\nu$.
  - Physics impact needs to be quantitatively further assessed
  - DIRC bars are necessarily in the middle
  - DCH electronics relocation is critical for the perfomance
  - **A scintillating tile design provides adequate flexibility ~10K SiPM channels**

IFR and steel

- BaBar configuration has too little iron for μ ID
  - > 6.5 λ_I required; 4-5 available in barrel
- Fine segmentation overdid K_L efficiency optimization
  - Focus on m 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
  - Extruded scintillators are a safe option
  - Avalanche RPC if evidence of lower rate



6x2.54cm brass plates (Gaps 5,7,9,11,13,15)

Present configuration

RPC belt

Gap #19 (new)

5x2.54cm brass plate

(Gaps 8,10,12,14,16

10cm steel

double gap RPC

Easy access

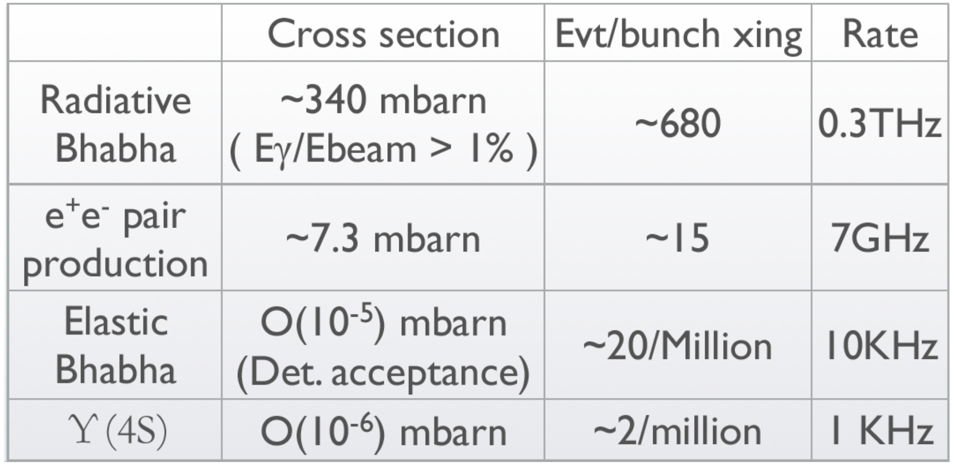
Trigger/DAQ/Electronics

- Detailed evaluation in progress
- Should prepare for a trigger rate of 50-100KHz
  - Unless a hardware L1 Bhabha rejector is developed
- Some electronics could be reusable
  - Some front-end cards, power supplies
- The bulk of the electronics is obsolete and unmaintainable
  - Should be remade with state-of-the-art technology
- Clearly a major cost driver
  - Costing using recent experiments experience (LHC)

The break-through in the machine design is making our life a bit easier.

Still important sources of background:

- Luminosity sources
  - beam-beam
  - radiative Bhabha
- Linear with currents
  - lost particles and s.r.



	Cross section	Evt/bunch xing	Rate
Radiative Bhabha	~340 mbarn (Eγ/Ebeam > 1%)	~680	0.3THz
e^+e^- pair production	~7.3 mbarn	~15	7GHz
Elastic Bhabha	$O(10^{-5})$ mbarn (Det. acceptance)	~20/Million	10KHz
Υ(4S)	$O(10^{-6})$ mbarn	~2/million	1 KHz

Other sources of background

- Touschek background
- Thermal outgassing due to HOM losses;
  Not an issue with these currents
- Injection background

Working Group Report
on
INFN Super Flavour Factory Project

RECFA meeting, Athens, 11 October 2008

RECFA Internal Working Group
Y. Karyotakis, F. Linde, T. Nakada*) and B. Spaan,
*) Chair

Physics III

- A step beyond the "LHCb" era for an e^+e^- machine requires >50 time more statistics than now to be enough to establish any effects of beyond the Standard Model, which exhibit no sign now or in coming couple of years (in particular for "inclusive" $\Delta B=1$ $b\to s$ and $b\to d$ process?).
- LFV, e.g. $\tau\to e\gamma$ would be a big hit. (interesting to see what $\mu\to e\gamma$ will say in coming years)

- The main goal of PEB-II and KEKB was a quantitative test of the KM mechanism of CP violation from the $B_d\to J/\psi K_S$ decays.
  ⇒ CKM parameters were known enough to make a good prediction for the required luminosity.
- For a SuperB project, we do not have such a "success guaranteed" minimum luminosity, since we don't know the New Physics parameters.
  ⇒But this is the case for the most of the high energy frontier accelerators too.

INFN Super Flavour Factory I

ILC synergy

- Very high luminosity >10^{36}cm^{2}s^{-1} obtained by colliding tiny beams. (similar to a LC)
  ⇒needs small emittance (similar to a LC damping ring), large crossing angle and crab waist

  But works as a circular collider (Novel idea developed by INFN)

  ☺☺ Its required current not higher than the present machines (RF power 17 MW)
  - affordable operation cost
  - easier operation
  - small background

- Test being done with DAFNE
  very successful, but still at low currents
- More simulation work needed to fully understand the result
- Machine parameters need some robustness.
- No real design for the complete system.

⇒ to be addressed by the TDR within 1 to 2 years in collaboration with the interested Asian, European and US laboratories.

Conclusions

- Flavour physics is an important part of the European particle physics programme. Rich physics programme.
- An e^+e^- collider at $\Upsilon(4S)$ energy region would be a significant milestone if
  - much more than 50 ab^{-1} by the end of ~2020
  - moderate cost
- INFN Project addresses these points by
  - Very high luminosity $>10^{36}$ with a unique machine concept
  - Reutilizing PEP-II rings and injector, and BaBar
- Machine R&D should be strongly supported for the TDR to show that the concept can be indeed realised.
  (R&D is also useful for the future machines)
- For an approval, there should be
  - a clear plan containing realistic technical milestones
  - required resources and strategy how to obtain them

  with a goal to achieve much more than 50 ab^{-1} data by ~2020 to make a meaningful impact. Much later than this, physics landscape could be drastically different.

Very ambitious plan and need to move fast.