Flavor Physics: SuperB the Super Flavor Factory

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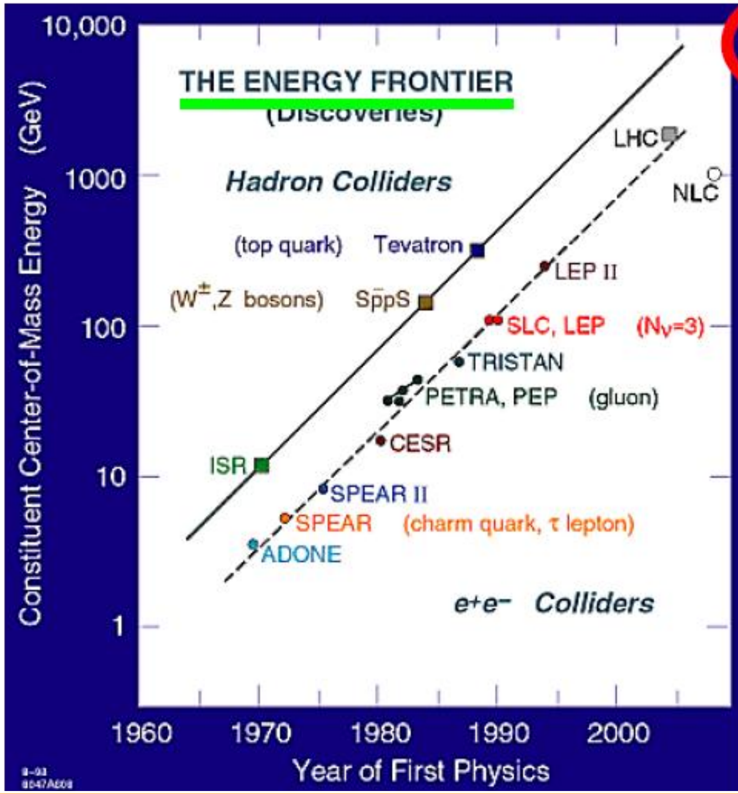
The Flavor Route

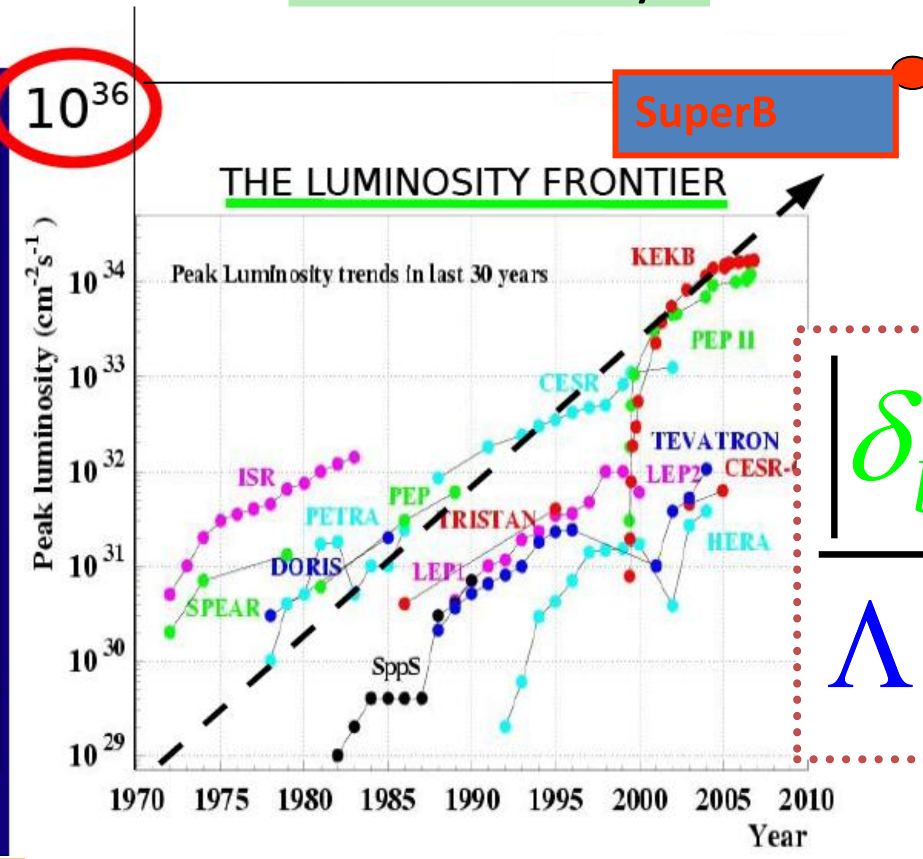
“Relativistic path”

Crucial : Center-of-mass energy

“Quantum path”

Crucial : Luminosity





$$\frac{|\delta_{bq}|}{\Lambda_{eff}}$$

The quantum stabilization of the Electroweak Scale suggest that NP is @ ~ 1 TeV
LHC will search on this range

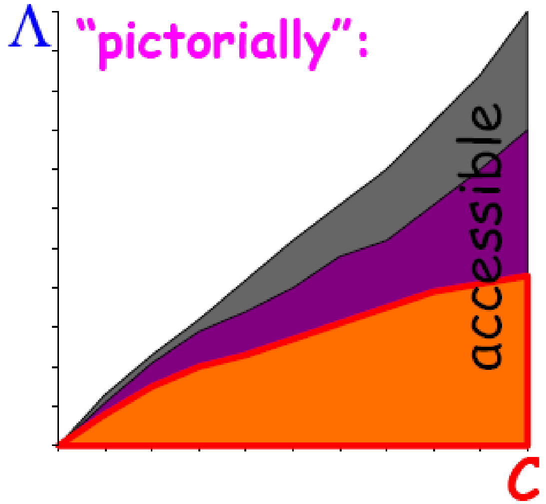
- if NP particles are discovered at LHC we are able to study the flavour structure of the NP
- we can explore NP scale beyond the LHC reach

10^{34} ↔ EW scale ~100GeV

10^{36} ↔ TeV scale

High Luminosity flavor factory potential for New Physics complementary to Energy Frontier

- Flavor precision measurements sensitive to New Physics (NP)
  - Measure interference effect in known processes
  - Measure decays: rare or forbidden in Standard Model
- NP effects governed by
  - New Physics Scale NP(Λ)
  - Effective coupling C
    - Different Intensities (from interactions)
    - Different Patterns (for instance from simmetries)



With 7-10x10^{10} pair bb, cc, ττ (75-100 ab^{-1}) it is possible

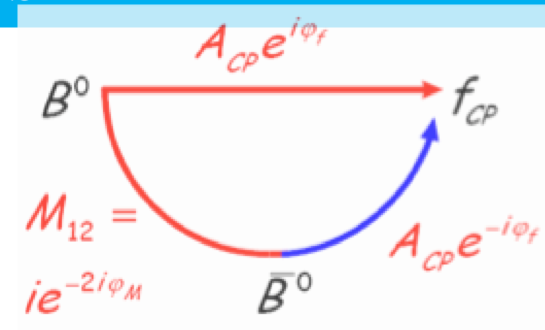
NP(Λ) found at LHC
- Determine couplings FV e CPV of NP
- Look for heavier states
- Study the flavor structure of NP

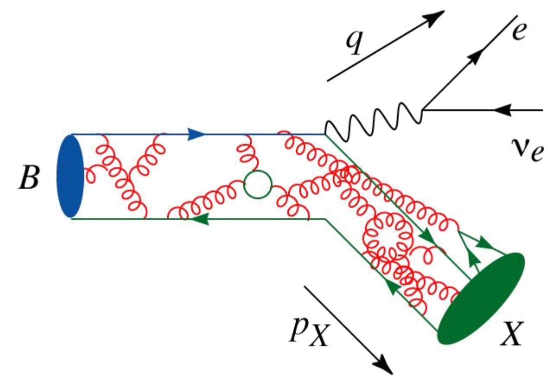
NP(Λ) not found at LHC
- Look for indirect signals of NP
- Link them to explaining NP models
- Constrain regions in parameter space with NP(Λ) sensitivity up several tens of TeV.

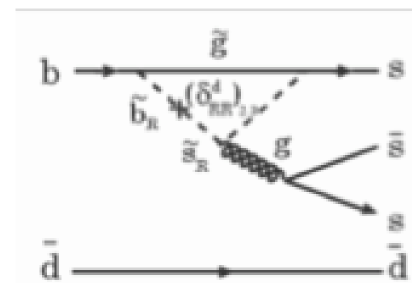
Some phenomena as LFV in t decay show clear signals of NP

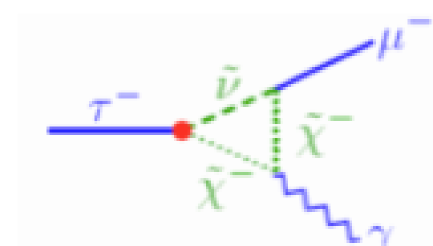
Why flavour physics

1. Explore the origin of CP violation
   - Key element for understanding the matter content of our present universe
   - Established in the B meson in 2001
   - Direct CPV established in B mesons in 2004
2. Precisely measure parameters of the standard model
   - For example the elements of the CKM quark mixing matrix
   - Disentangle the complicated interplay between weak processes and strong interaction effects
3. Search for the effects of physics beyond the standard model in loop diagrams
   - Potentially large effects on rates of rare decays, time dependent asymmetries, lepton flavour violation, …
   - Sensitive even to large New Physics scale, as well as to phases and size of NP coupling constants



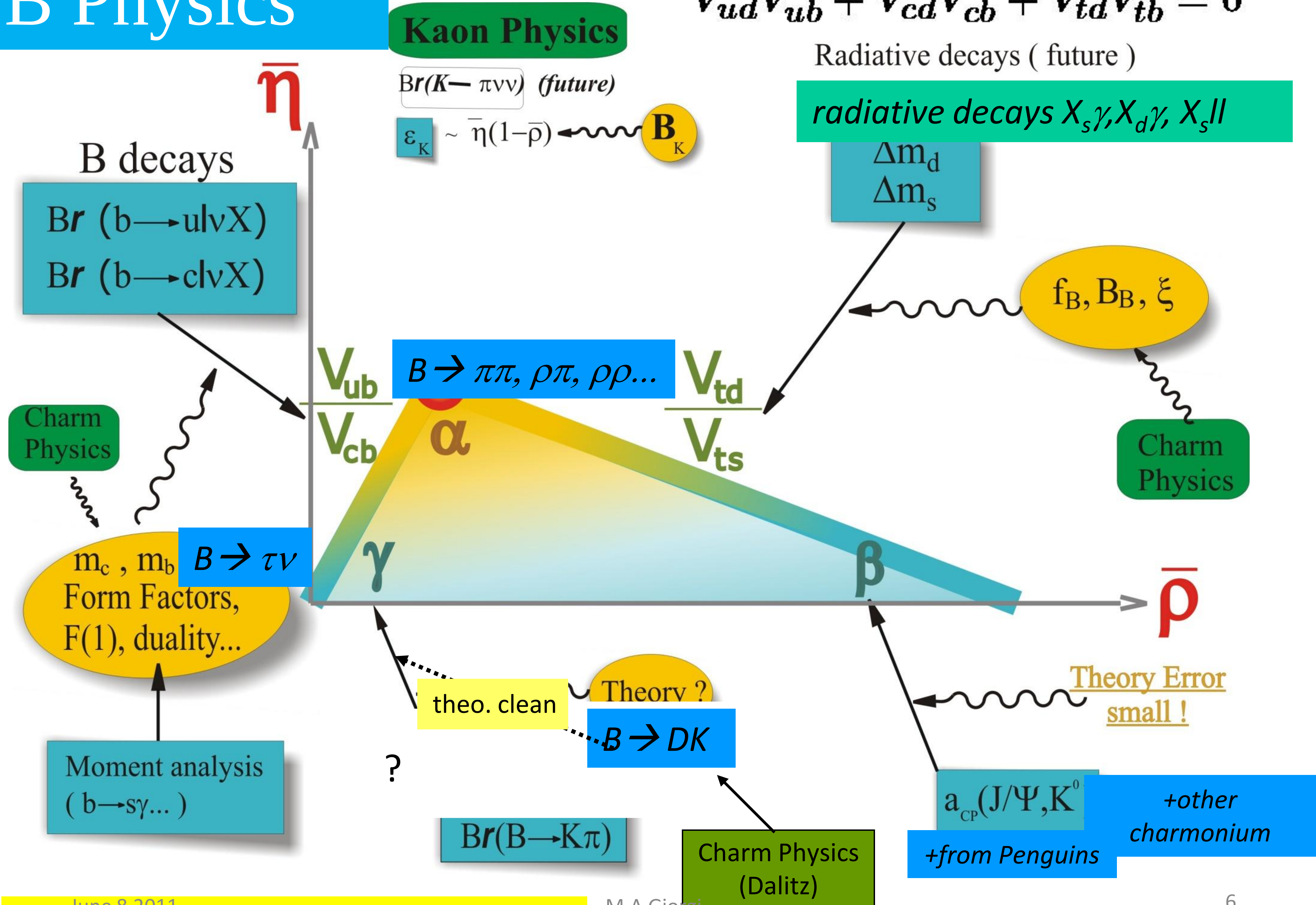






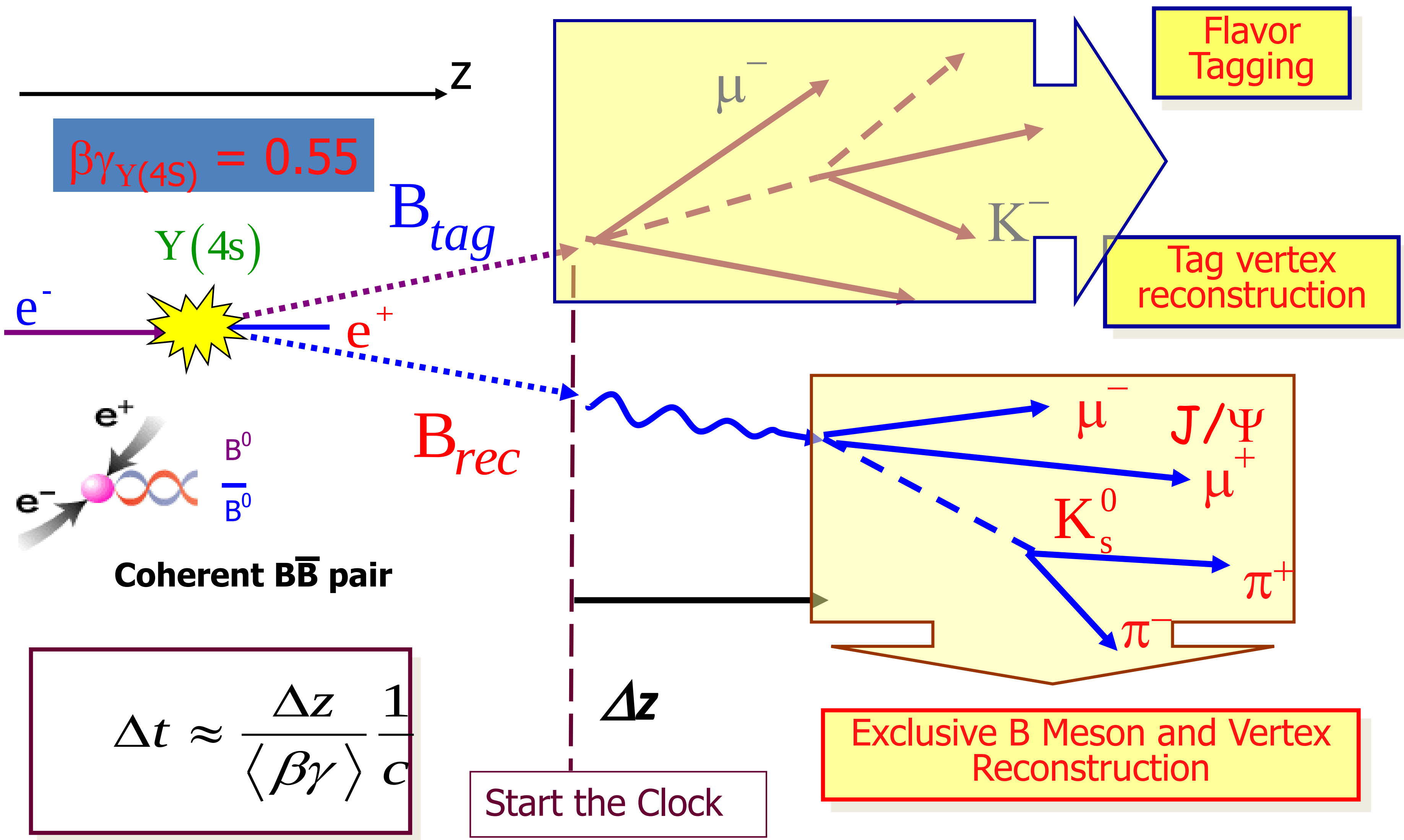
B Physics

$$V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$$



From A.Stocchi talk in Benasque (Sp)-Jan.2011

Experimental ingredients: BaBar optimized for time dependent CP asymmetries

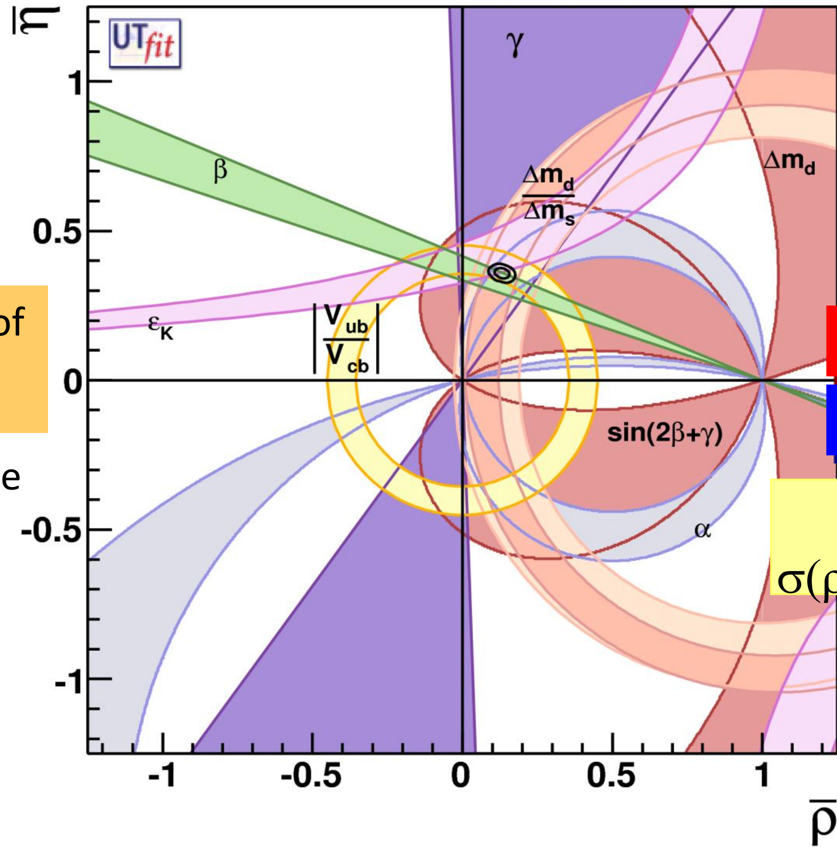


$$\Delta t \approx \frac{\Delta z}{\langle \beta\gamma \rangle}\frac{1}{c}$$

Fit on Unitarity Triangle

Coherent picture of FCNC and CPV processes in SM

Consistence on an over constrained fit of the CKM parameters



$\rho = 0.132 \pm 0.020$

$\eta = 0.358 \pm 0.012$

With a precision of $\sigma(\rho)$ ~15% and $\sigma(\eta)$ ~4% !

Discovery : absence of New Particles up to the

~2 Electroweak Scale !

CKM matrix is the dominant source of flavour mixing and CP violation

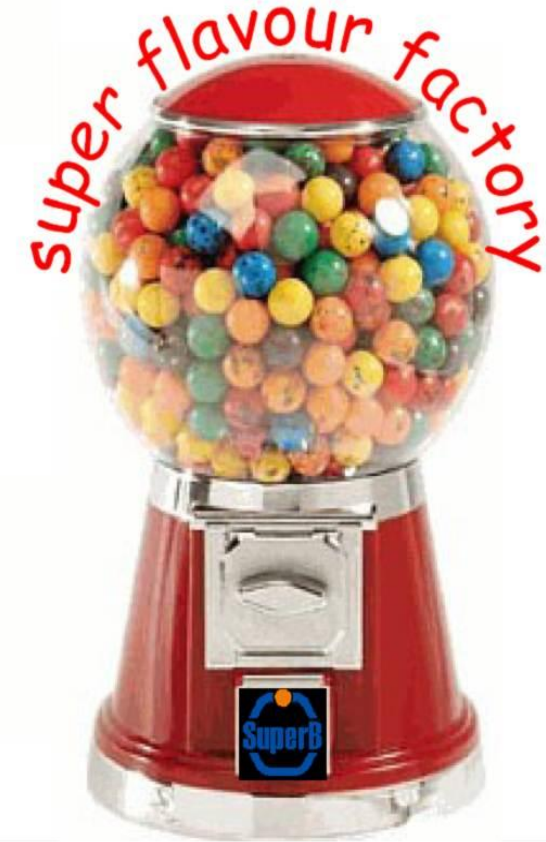
Goals of SuperB

SuperB is a Super Flavor Factory

High statistics production of

$b\bar{b}$, $b\bar{b}$, $\tau^+\tau^-$ pairs.

Follow the high intensity route to New Physics , look at signals through high precision measurements in Flavor/



© by Ciuchini

Physics programme in a nutshell

- Versatile flavour physics experiment
  - Probe new physics observables in wide range of decays.
    - Pattern of deviation from Standard Model can be used to identify structure of new physics.
    - Clean experimental environment means clean signals in many modes.
    - Polarized e^- beam benefit for τ LFV searches.
  - Best capability for precision CKM constraints of any existing/proposed experiment.
    - Measure angles and sides of the Unitarity triangle
    - Measure other CKM matrix elements at threshold and using τ data.

$B_{u,d}$ physics: Rare Processes and Precision Measurements

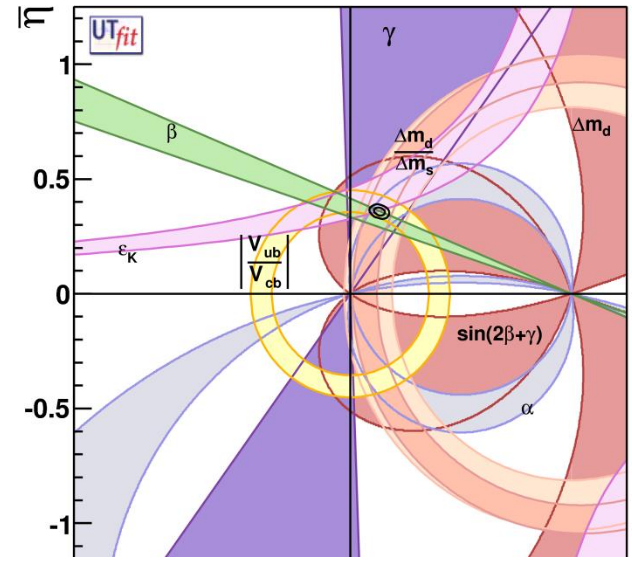
- Goal: Reveal presence of New Physics (NP) using two-pronged attack:
  - Search for **Rare Processes**: NP contributions can be as large as Standard Model ones
    - Large sensitivity to NP
    - Ability to distinguish among NP models
  - Make **Precision Measurements** of many quantities: over constrain the Standard Model predictions
    - NP will often lead to discrepancies in global analyses of measured processes
- SuperB will build on experience of current B-factories.

CKM constraints

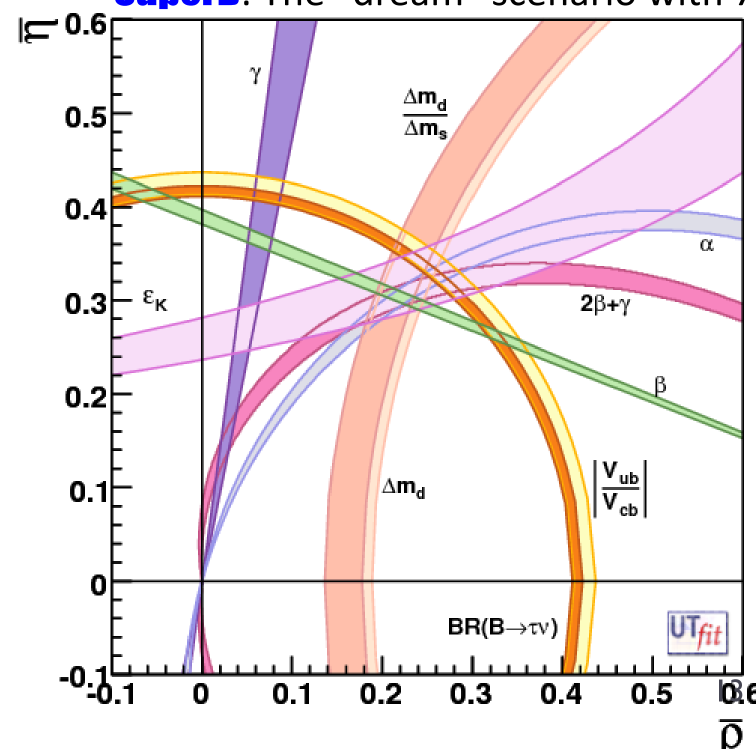
SuperB measures the sides and angles of the Unitarity Triangle (UT)

- Many measurements constrain the sides and angles of the UT: the SM predicts that all measurements “intersect” at apex of the triangle
- When NP is present, the measurements do not yield a unique apex, but you need the high precision of a Super Flavour Factory.

Today:



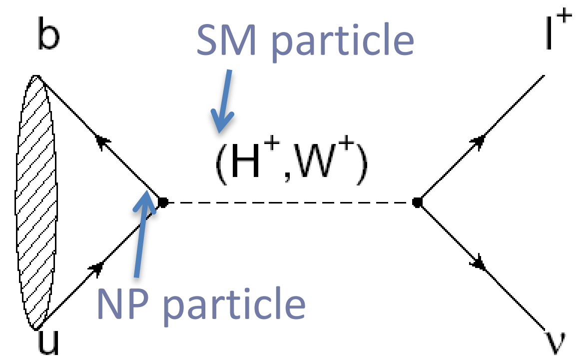
SuperB: The "dream" scenario with $75ab^{-1}$

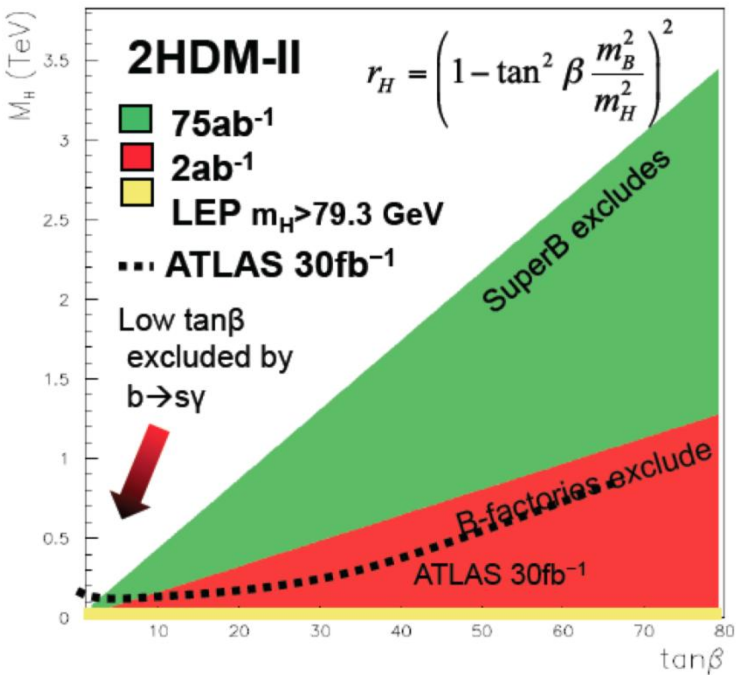


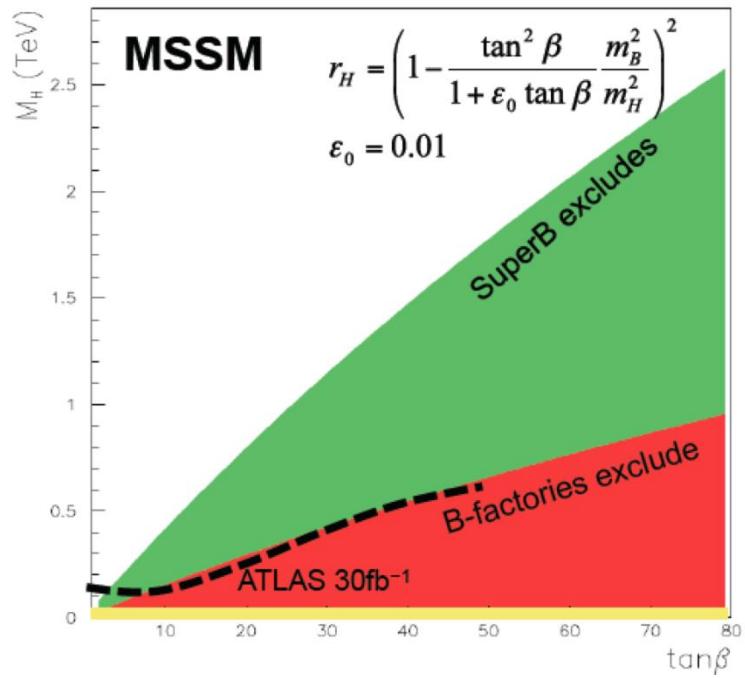
$B_{u,d}$ physics: Rare Decays

- Example: $B^{\pm} \rightarrow \tau^{\pm}\nu$
  - Rate modified by presence of H^+

$$r_H = \frac{\mathcal{B}_{SM+NP}}{\mathcal{B}_{SM}}$$







b→d transition

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

b→d transition

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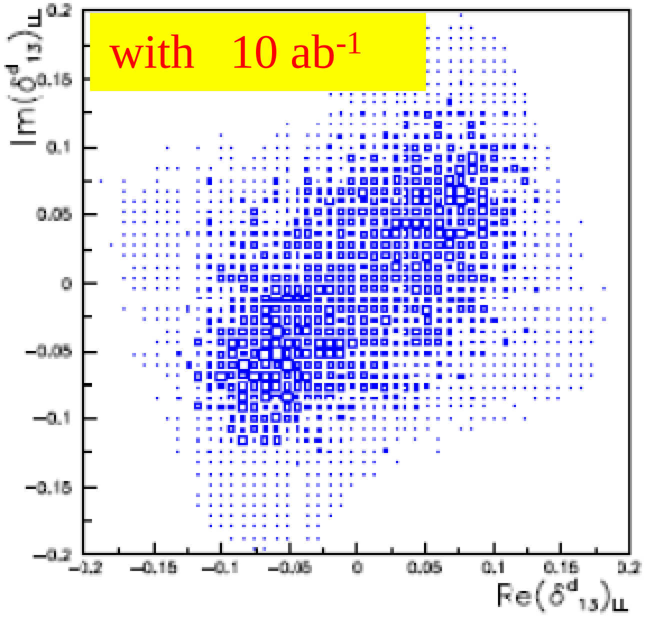
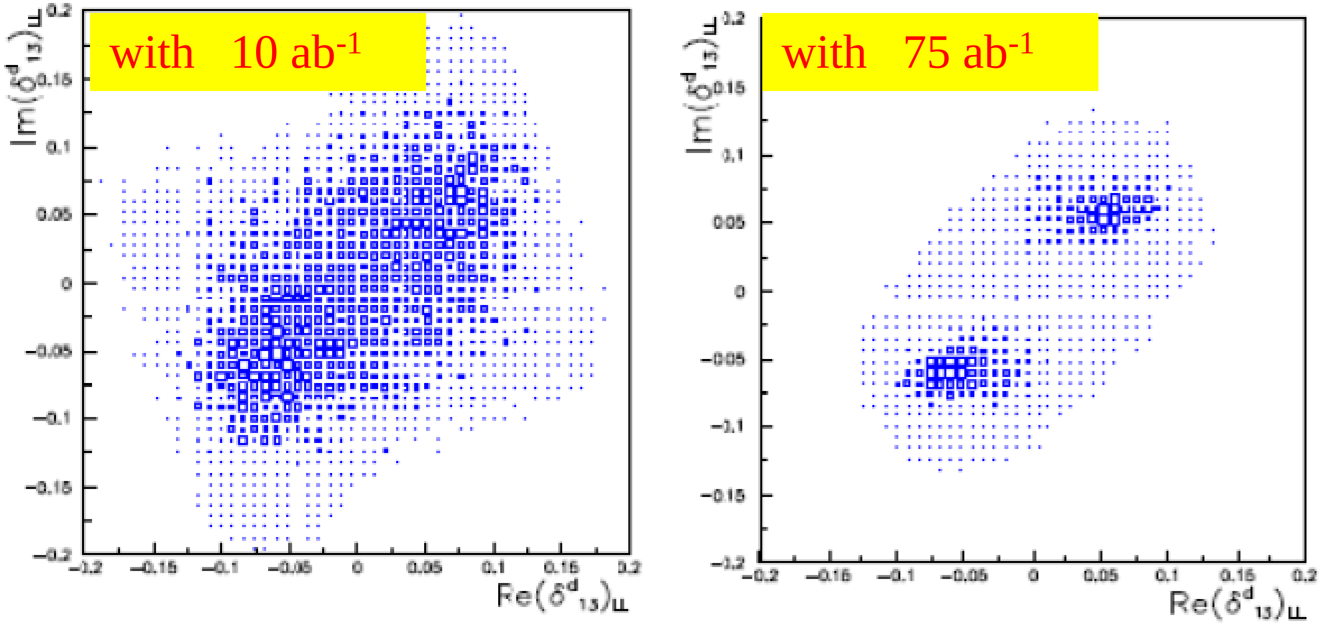


b→d transition

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



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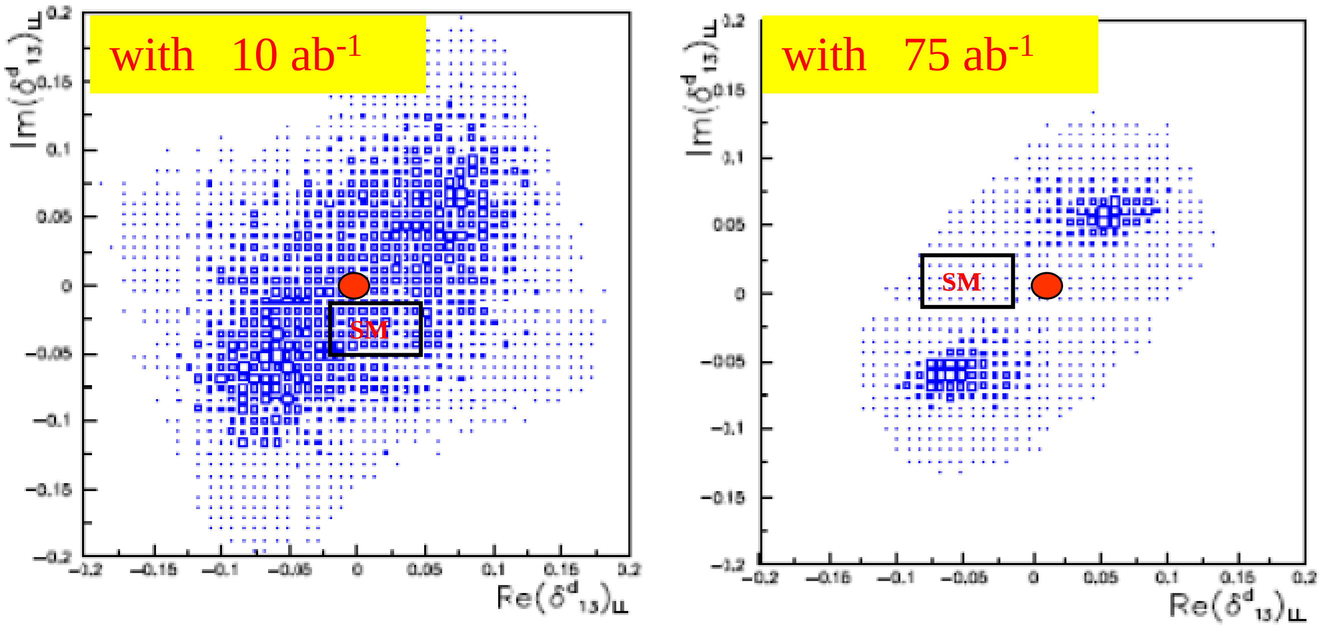

b→d transition

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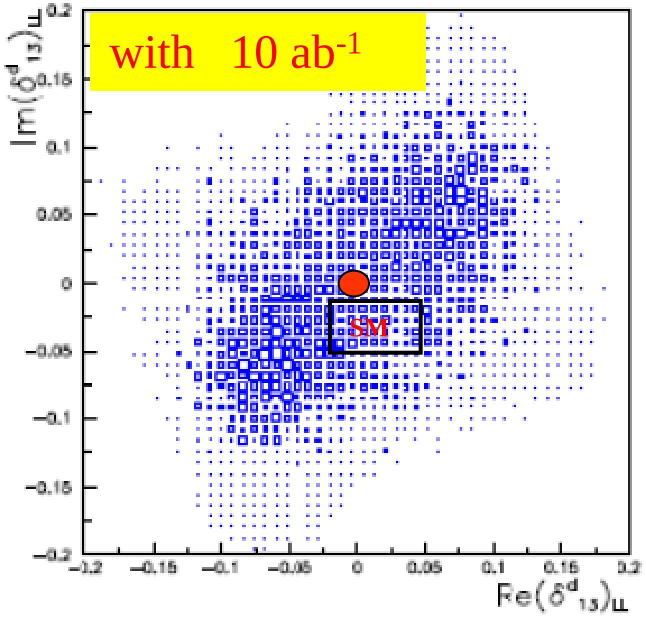
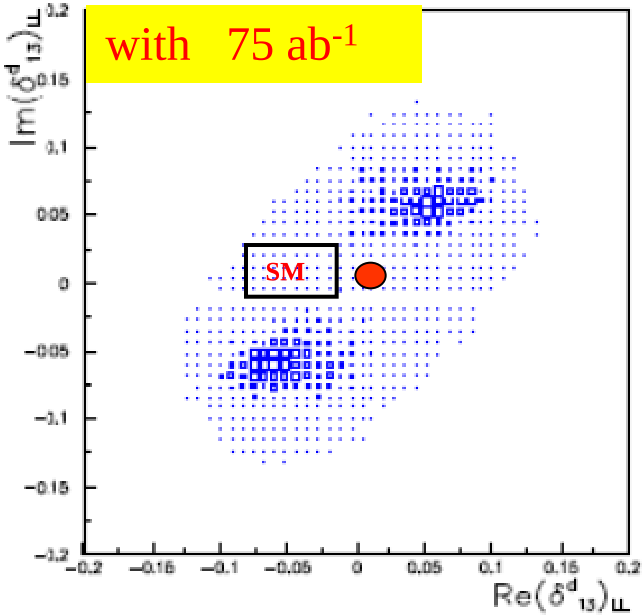
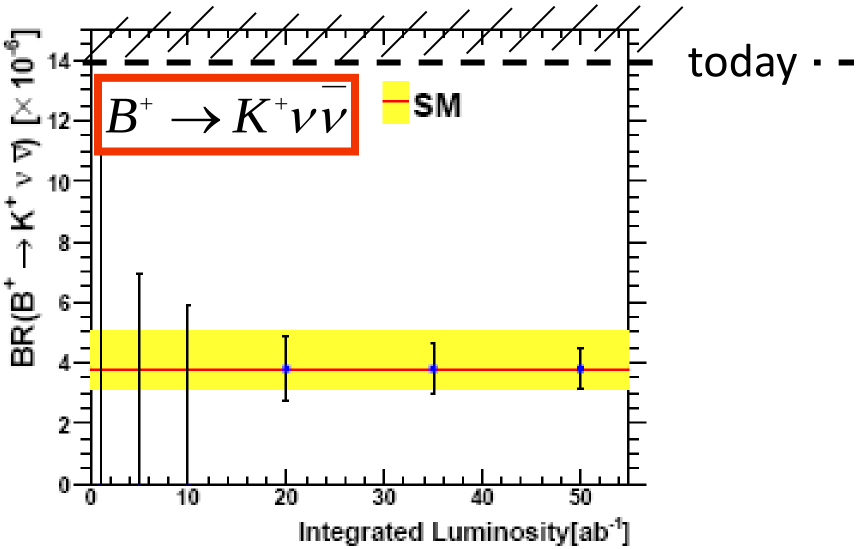
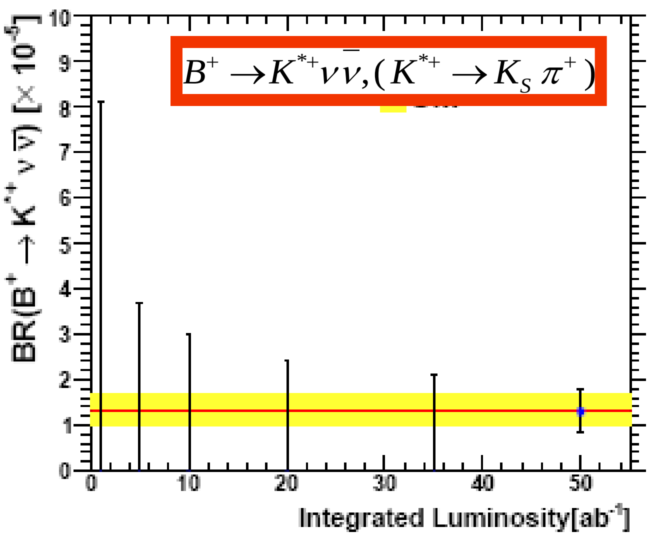




Importance of having very large sample >75ab^{-1}

Br($B_d \to K \nu \nu$) – Z penguins and right hand current



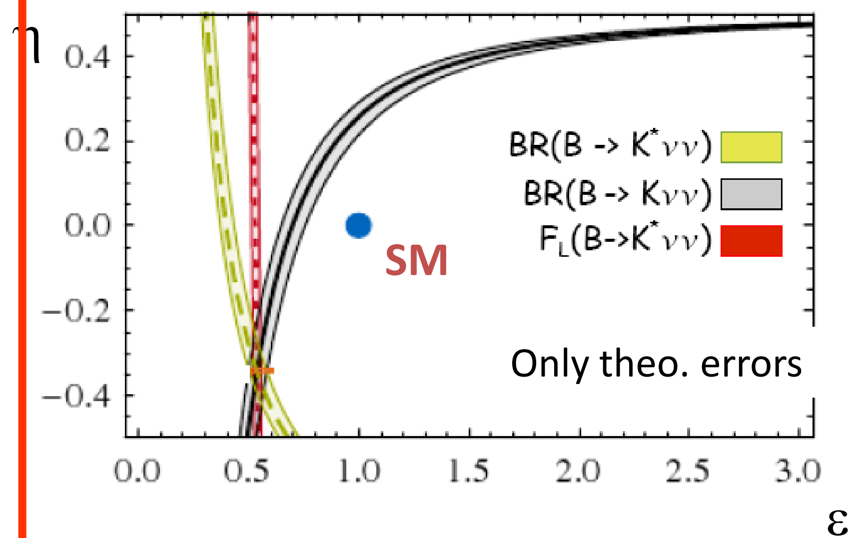


~[20-40] ab^{-1} are needed for observation
>>50ab^{-1} for precise measurement

Altmannshofer et al, arXiv:0902.0160

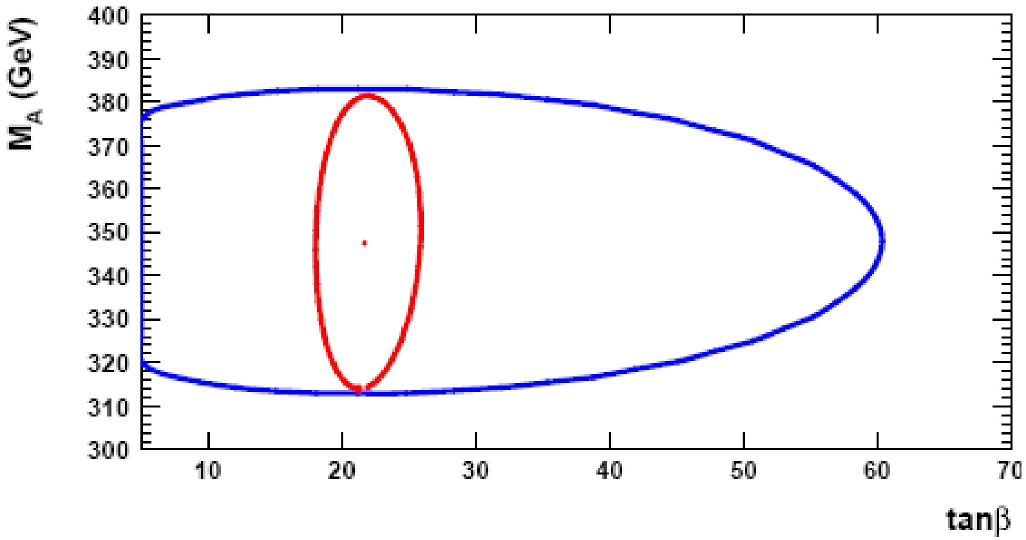
$$\epsilon = \frac{\sqrt{|C_L^\nu|^2 + |C_R^\nu|^2}}{|(C_L^\nu)^{\rm SM}|}$$

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



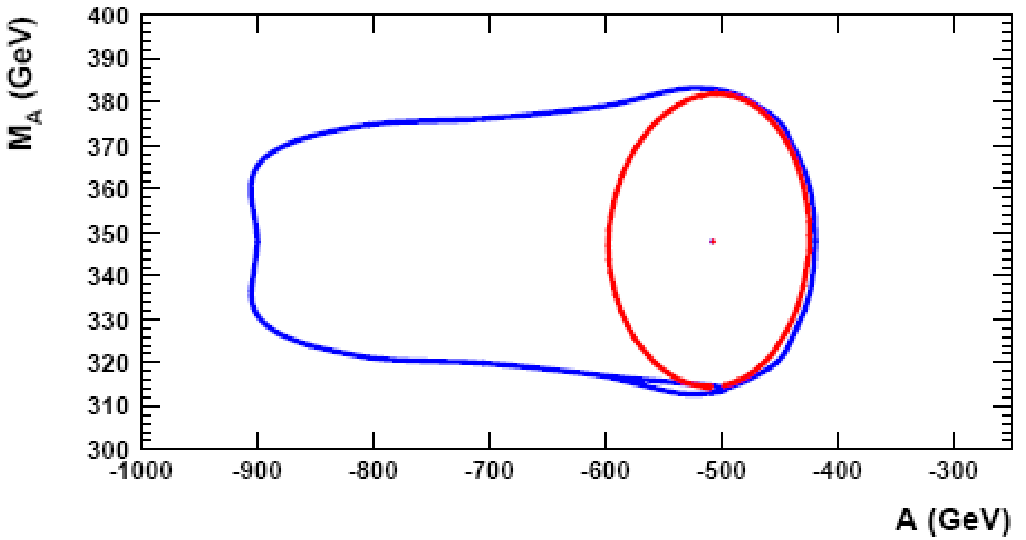
If these quantities are measured @ <~10% deviations from the SM can be observed

COMPLEMENTARY: LHC and Flavour with 75 ab^{-1}



IF LHC DISCOVERS SUPERSYMMETRY

EXAMPLE FROM VALENCIA PROCEEDINGS



Red are LHC+EW constraints + SuperB

Blue is LHC alone

Charm @ SuperB

- *Run at ϒ(4S):* $\mathcal{L} = 10^{36}\ \mathrm{cm}^{-2}\ \mathrm{sec}^{-1};\ \int \mathcal{L}\,dt = 75\ \mathrm{ab}^{-1}$ at the $\Upsilon(4S)$
  βγ=0.238

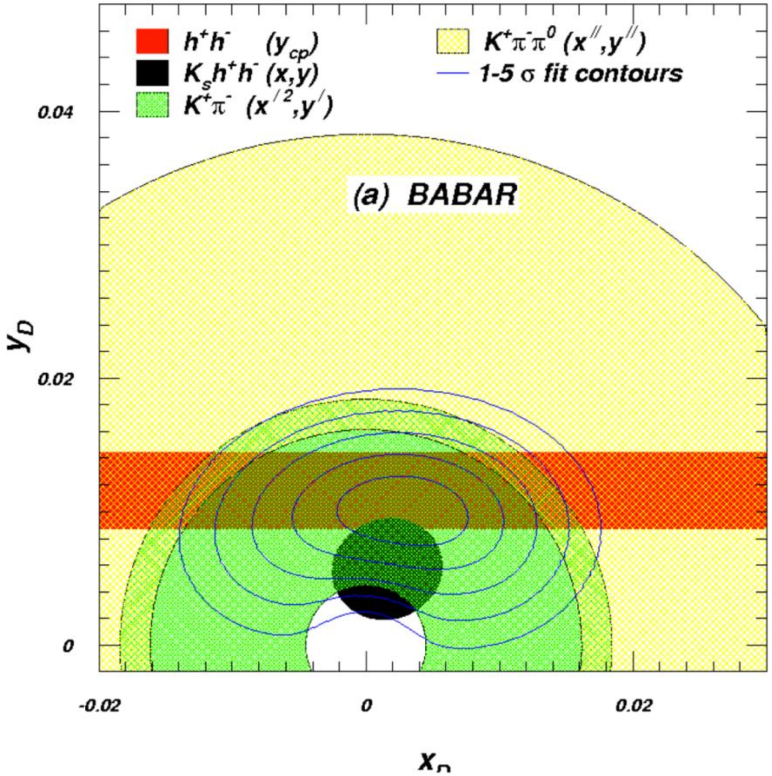
✓ Large improvement in D^0 mixing and CPV: factor 12 improvement in statistical error wrt BaBar (0.5 ab^{-1});
✓ time-dependent measurements will benefit also of an improved (2x) D^0 proper-time resolution. [≈1KHz of $c\bar{c}$]

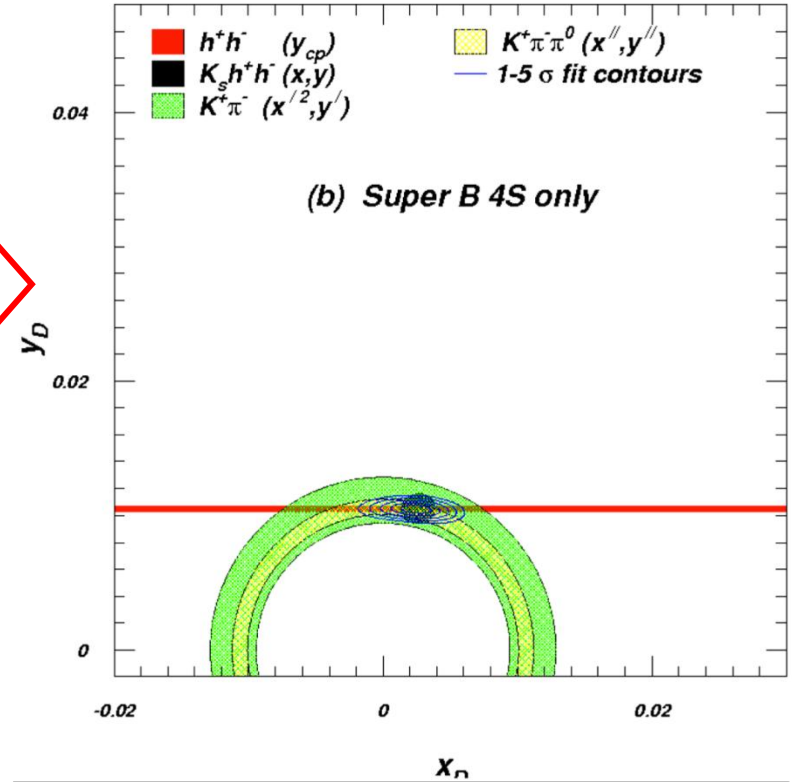
Unique feature of SuperB

- *Run at ψ(3770):* $\mathcal{L} = 10^{35}\ \mathrm{cm}^{-2}\ \mathrm{sec}^{-1};\ \int \mathcal{L}\,dt = 500\ \mathrm{fb}^{-1}$ at the $\Psi(3770)$
  βγ up to 0.9

✓ $D\bar{D}$ coherent production with 100x BESIII data and CM boost up to βγ=0.9;
✓ almost zero background environment;
✓ possibility of time-dependent measurements exploiting quantum coherence.

Sensitivity projections with 75 ab^{-1} at $\Upsilon(4S)$





Fit	$x \times 10^3$	$y \times 10^3$	$\delta^\circ_{K^+\pi^-}$	$\delta^\circ_{K^+\pi^-\pi^0}$
(a)	$3.01^{+3.12}_{-3.39}$	$10.10^{+1.69}_{-1.72}$	$41.3^{+22.0}_{-24.0}$	43.8 ± 26.4
Stat.	(2.76)	(1.36)	(18.8)	(22.4)

Fit	$x \times 10^3$	$y \times 10^3$	$\delta^\circ_{K^+\pi^-}$	$\delta^\circ_{K^+\pi^-\pi^0}$
(b)	$xxx^{+0.72}_{-0.75}$	$xxx \pm 0.19$	$xxx^{+3.7}_{-3.4}$	$xxx^{+4.6}_{-4.5}$
Stat.	(0.18)	(0.11)	(1.3)	(2.9)

Uncertainties shrink:

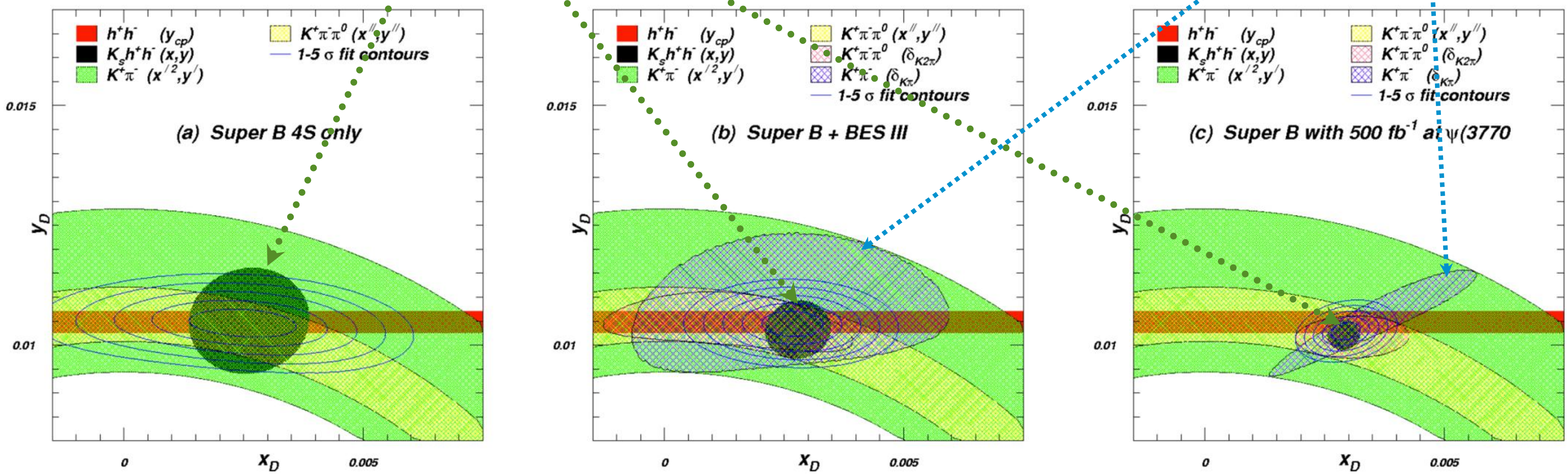
$x_D \rightarrow x_D/4$; $y_D \rightarrow y_D/10$

Precision in x_D is limited by Dalitz plot model.

- Two improvements in mixing precision come from threshold data:

CAVEAT: NO TIME-DEPENDENT STUDIES INCLUDED YET

- Dalitz plot model uncertainty shrinks
- Information on overall strong phase is added



Fit	$x \times 10^3$	$y \times 10^3$	$\delta^\circ_{K^+\pi^-}$	$\delta^\circ_{K^+\pi^-\pi^0}$
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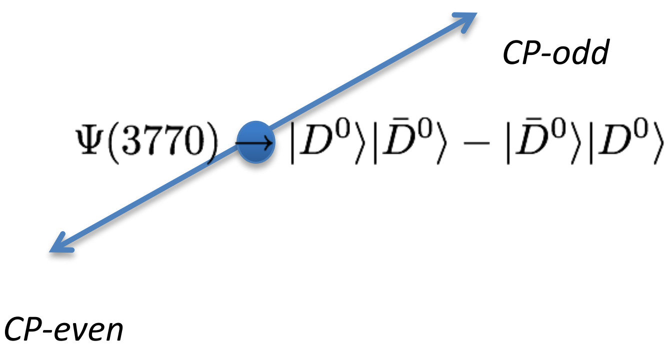
Stat.	(0.18)	(0.11)	(1.3)	(2.9)

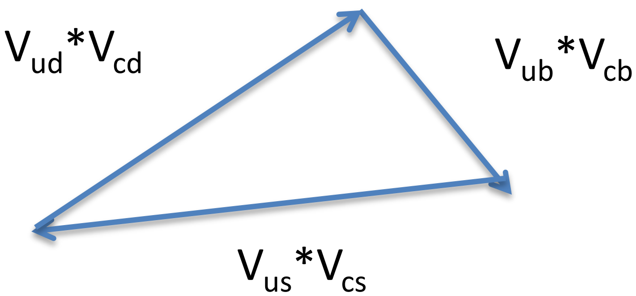
Fit	$x \times 10^3$	$y \times 10^3$	$\delta^\circ_{K^+\pi^-}$	$\delta^\circ_{K^+\pi^-\pi^0}$
(c)	$xxx \pm 0.42$	$xxx \pm 0.17$	$xxx \pm 2.2$	$xxx^{+3.3}_{-3.4}$
Stat.	(0.18)	(0.11)	(1.3)	(2.7)

Fit	$x \times 10^3$	$y \times 10^3$	$\delta^\circ_{K^+\pi^-}$	$\delta^\circ_{K^+\pi^-\pi^0}$
(d)	$xxx \pm 0.20$	$xxx \pm 0.12$	$xxx \pm 1.0$	$xxx \pm 1.1$
Stat.	(0.17)	(0.10)	(0.9)	(1.1)

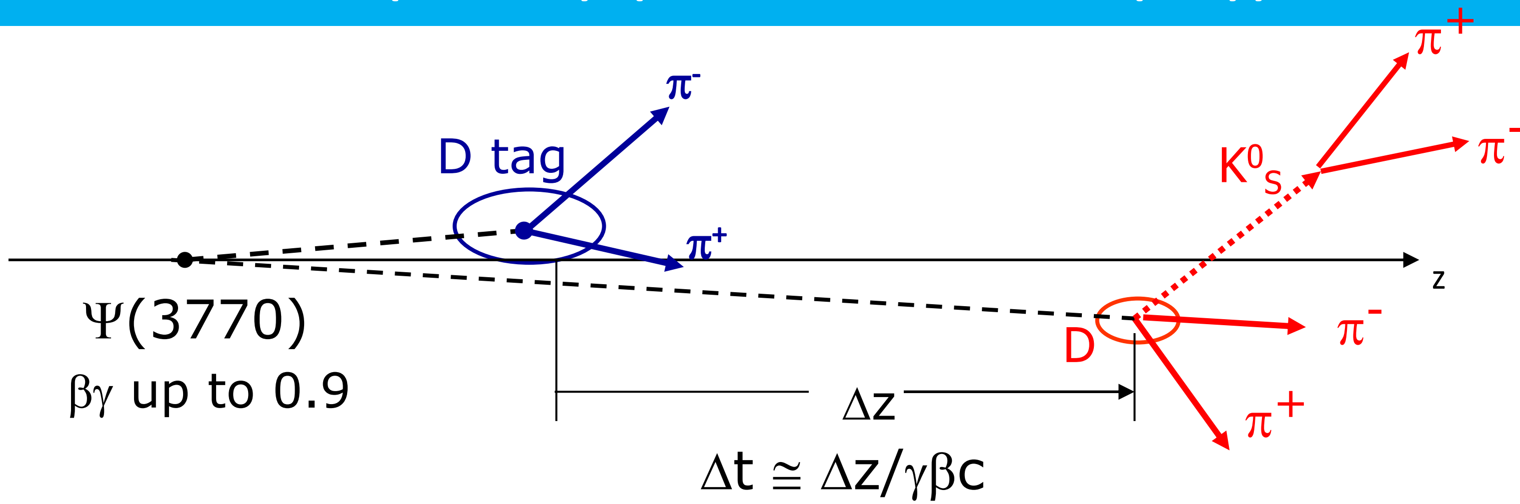
Charm at $D\bar{D}$ threshold

- Almost zero background analyses: search for rare/forbidden decays, precise measurement of relative D^0-$\bar{D}^0$ strong phases, search for CPV in wrong sign (WS) semileptonic (SL) D^0 decay modes.
- Unique possibilities of time-dependent measurements at $D\bar{D}$ threshold currently under study:
  - coherent production allows time-dependent measurements also withCP-tagged events;
  - CP, T, CPT conservation tests similar to those in K^0-$\bar{K}^0$ and B^0-$\bar{B}^0$ systems;
  - measure of the unitarity triangle in the Charm sector.





Time dependent measurements at the $\Psi(3770)$ (same as for $\Upsilon(4s)$)



1. Reconstruct the decay vertex of the two D mesons

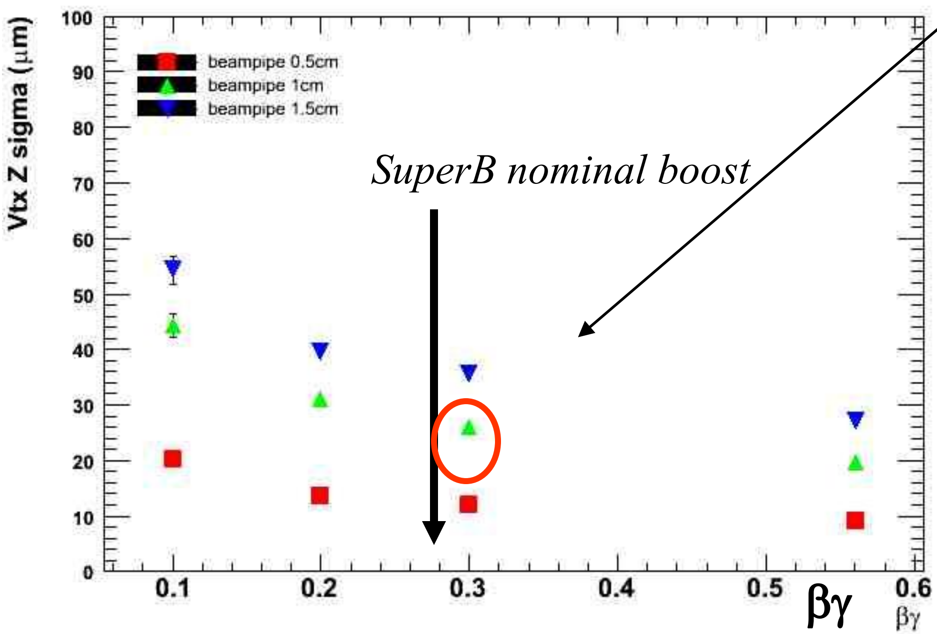
2. Compute the proper time difference Δt

$$\sigma(\Delta t) \propto \frac{\sigma(\Delta z)}{\beta\gamma c}$$

minimum boost needed to achieve the required Δt resolution

Time dependent measurements at DD threshold: only possible at SuperB

- Proper time resolution dominated by decay vertex resolution.
  - Production vertex precisely determined thanks to nm beamspot dimensions



With Super*B* lumi at 4 GeV = 10^{35} cm^{-2}s^{-1} expected ~10^9 $D\bar{D}$ per month

$\beta\gamma ct = 0.28 \times 120\ \mu m \sim 30 \mu m$

Average flight distance similar to vertex resolution $\rightarrow \sigma_t \sim \tau$

Experimental considerations of running at $D\bar{D}$ threshold with boost

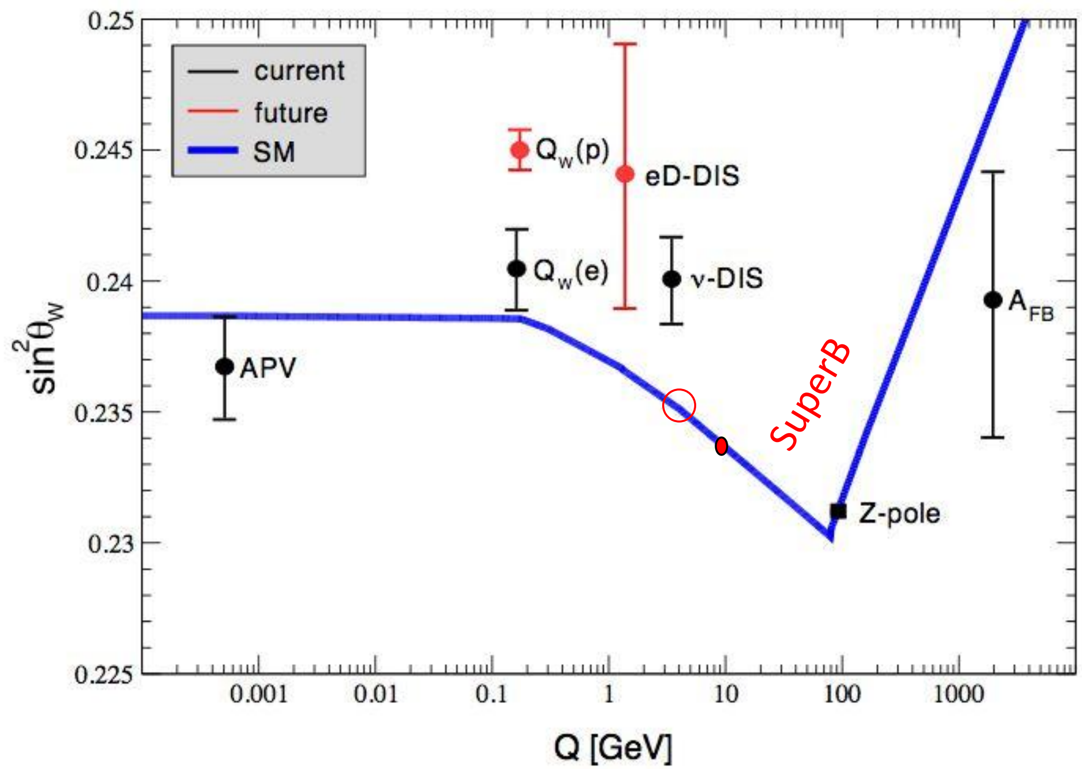
- Pro:
  - Very clean environment, backgroud extremely low;
  - Quantum coherence: mixing and CP, T, CPT analyses;
  - Access to D^0-$\overline{D^0}$ relative phases and possibilities of time-dependent Dalitz plot analyses with a model independent approach;
  - Systematic errors reduction due to background and Dalitz model uncertainties;

- Cons:
  - Time-dependent measurement require larger CM boost compared to the B^0-$\overline{B^0}$ case to achieve adequate time resolution;
  - reconstruction efficiency decreases with large CM boost. Need to optimize the boost value.

Measurements with Polarization

Precision Electroweak

- $\sin^2\theta_W$ can be measured with polarised e^-



Measure LR asymmetry in

$$
\begin{aligned}
e^+e^- &\rightarrow c\bar{c} \\
e^+e^- &\rightarrow \mu^+\mu^- \\
e^+e^- &\rightarrow \tau^+\tau^-
\end{aligned}
$$

at the ϒ(4S) to same precision as LEP/SLC at the Z-pole.

Can also perform crosscheck at ψ(3770).

Is this measurement also possible with Charm?

1. @ Υ(4S) . But hadronization correction.
2. Operate at a ccbar vector resonance above open charm threshold Ψ(3770), use the same analysis method as for b.

Polarization at low energies with high luminosity is needed

That is included in the SuperB design

g-2 Reach (Valencia Report 2008)

Δa_μ is not in good agreement with SM

Measuring differential cross section of tau production would lead to measurement of the real part of tau form factor.

SPS	1a	1b	2	3	4	5
$\Delta a_\mu \times 10^{-9}$	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

$$\frac{d\sigma}{d\cos(\theta)} = a \cdot \cos(\theta)^2 + b$$

$$a \propto \beta^2 |F_1|^2$$

$$b \propto (2-\beta^2) \cdot |F_1|^2 + 4\mathrm{Re}[F_2]$$

We began considering 1-3 prong whose experimental selection is cleaner

Need to tag the sample:

Lepton tag: higher purity & higher diluition (at least 3 neutrinos)

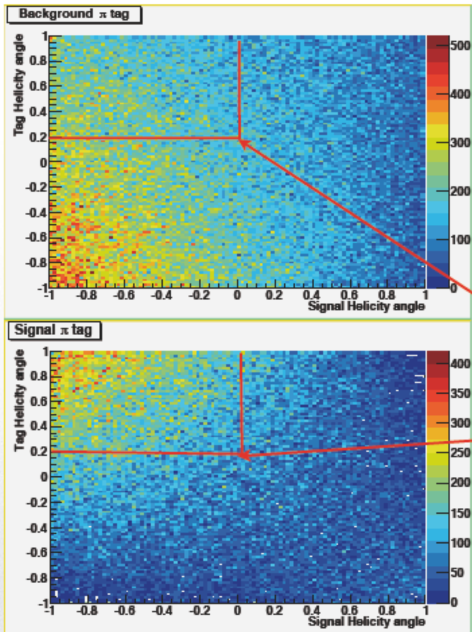
Hadronic tag: lower purity & lower diluition (2 neutrinos)

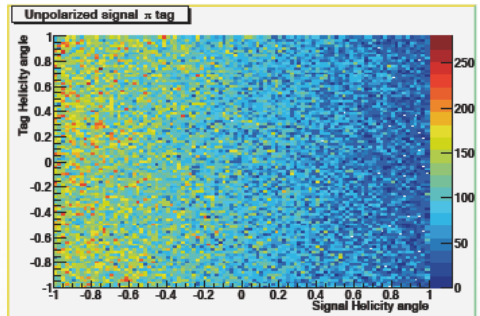
Systematics come mainly from tracking

Should be able to measure the real part (0.75-1.7)x10^{-6}

EXPERIMENT ⇓	Cross Section $Re\{F_2\}$	Normal Asymmetry $Im\{F_2\}$
Babar+Belle $2ab^{-1}$	4.6×10^{-6}	2.1×10^{-5}
Super B/Flavor Factory (1 yr. running) $15ab^{-1}$	1.7×10^{-6}	7.8×10^{-6}
Super B/Flavor Factory (5 yrs. running) $75ab^{-1}$	7.5×10^{-7}	3.5×10^{-6}

Polarized beam and tag on leptons and on hadrons (t→ p n /t→ r n) reduces irreducible background!

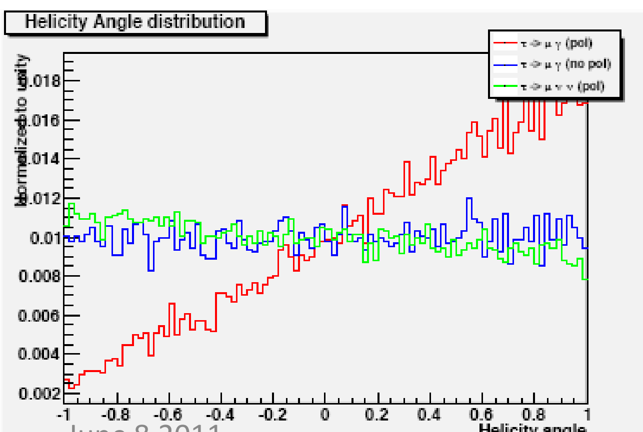




75 ab^{-1}

Applying a rectangular cut
eff. on signal ~40-45%
bkg retained ~ 10-15%

Sensitivity improves at least by a factor 2. Equivalent to a factor 4 increase in luminosity.



$B(\tau \to \mu\gamma)\ 2 \times 10 - 9$

$B(\tau \to e\,\gamma)\ 2 \times 10 - 9$

$B(\tau \to \mu\gamma)\ 1 \times 10 - 9$

$B(\tau \to e\,\gamma)\ 1 \times 10 - 9$

Polarisation is
- -an important issue for LFV
- -opens the possibility of measuring (g-2)
- -opens measurement of EW parameters

Summary of Flavor Physics Program

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…

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}

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	*To be evaluated at LHCb*	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°

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}
$D^0 \to K^0_S e^+e^-$, $D^0 \to K^0_S\mu^+\mu^-$	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}
$D^0 \to \pi^0e^\pm\mu^\mp$	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}

B_s at Y(5S)

Observable	Error with 1 ab^{-1}	Error with 30 ab^{-1}
$\Delta\Gamma$	0.16 ps^{-1}	0.03 ps^{-1}
Γ	0.07 ps^{-1}	0.01 ps^{-1}
β_s from angular analysis	20°	8°
$A^s_{\rm SL}$	0.006	0.004
$A_{\rm CH}$	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

Many unique quality measurements

Experiment: No Result | Moderate Precision | Precise | Very Precise

Theory: Moderately clean | Clean Need lattice | Clean

Observable/mode	Current (now)	LHCb (2017)	SuperB (2021)	LHCb upgrade ')	theory
τ Decays					
$\tau \to \mu\gamma$	yellow	yellow	green	yellow	green
$\tau \to e\gamma$	yellow	yellow	green	yellow	green
$B_{u,d}$ Decays					
$B \to \tau\nu, \mu\nu$	yellow	red	blue	red	blue
$B \to K^{(*)+}\nu\overline{\nu}$	red	red	green	red	green
S in $B \to K_S^0\pi^0\gamma$	yellow	red	green	red	yellow
S in other penguin modes	yellow	yellow	green	blue	yellow
$A_{CP}(B \to X_s\gamma)$	blue	yellow	green	yellow	green
$BR(B \to X_s\gamma)$	blue	yellow	green	yellow	yellow
$BR(B \to X_s\ell\ell)$	yellow	red	green	red	green
$BR(B \to K^{(*)}\ell\ell)$	yellow	blue	green	green	yellow
B_s Decays					
$B_s \to \mu\mu$	red	blue	red	green	green
β_s from $B_s \to J/\psi\phi$	red	blue	red	green	green
$B_s \to \gamma\gamma$	red	red	blue	red	green
a_{sl}	red	red	green	red	green
D Decays					
mixing parameters	yellow	blue	green	green	green
CPV	red	blue	green	green	green
Precision EW					
$\sin^2\theta_W$ at $\Upsilon(4S)$	red	red	green	red	green
$\sin^2\theta_W$ at Z-pole	red	blue	red	green	yellow

Benefit from polarised e⁻ beam

very precise with improved detector

Statistically limited: Ang. analysis with >75ab^{-1}

Right handed currents

SuperB measures many more modes

systematic error is main challenge

control systematic error with data

SuperB measures e mode well, LHCb does μ

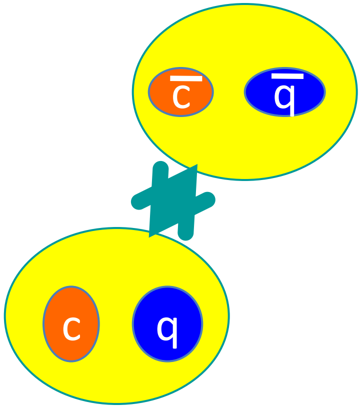
Clean NP search

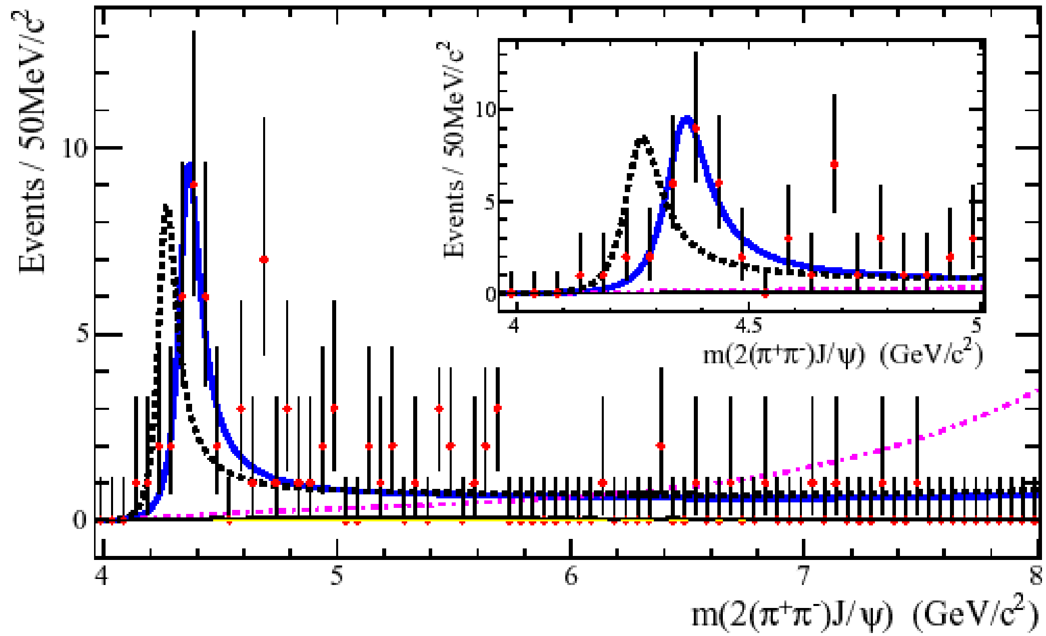
Theoretically clean

b fragmentation limits interpretation

Exotic hadronic spectroscopy

Hints of a new type of particles with more than 3 quarks

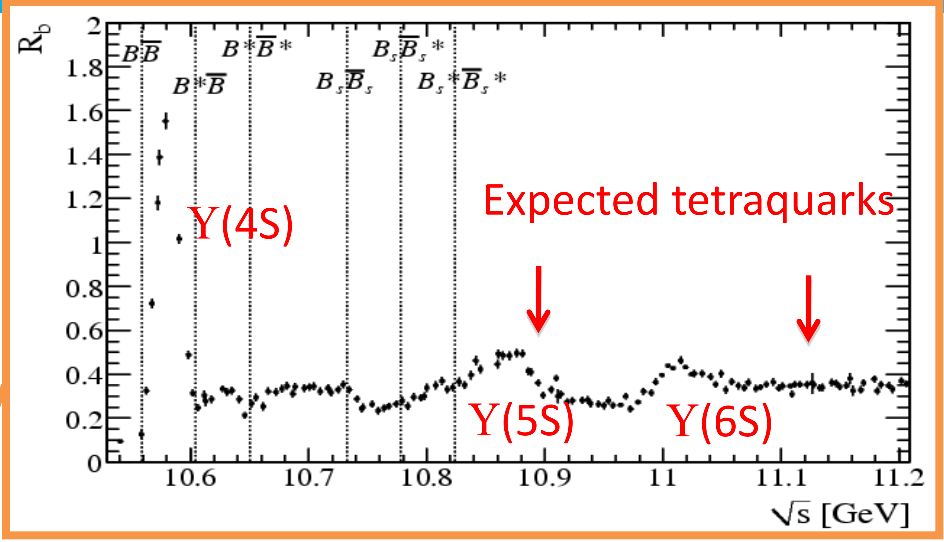


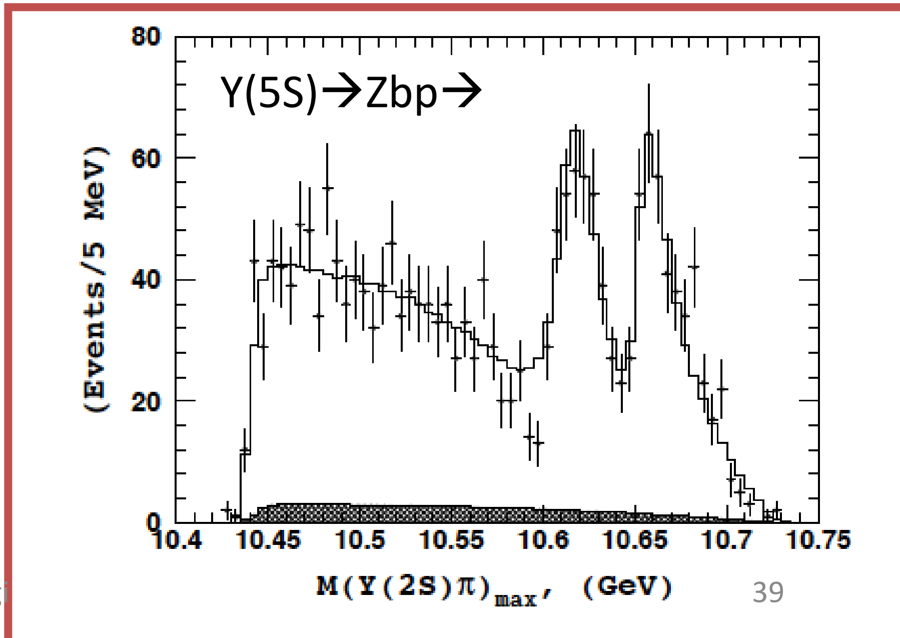


B-Factories produced a lot of results but ...

Exotic hadrons @ SuperB

- **Much larger statistics** @Y(4S) needed
- High luminosity energy scan needed:
  - produce resonances directly (E~4-4.5 GeV)
  - Exploit recent evidence of exotic states produced at Y(5S)





Physics Coordination

Physics Coordinators : A.Bevan,M.Ciuchini,M.Rama, J.Walsh
Bd: A. Stocchi,
Bs : A. Drutskoy
Charm: B.Meadows, N.Neri
Tau : A.Lusiani, M. Roney
Spectroscopy& Exotics : R.Faccini, A.Polosa
Interplay : M.Ciuchini,L.Silvestrini
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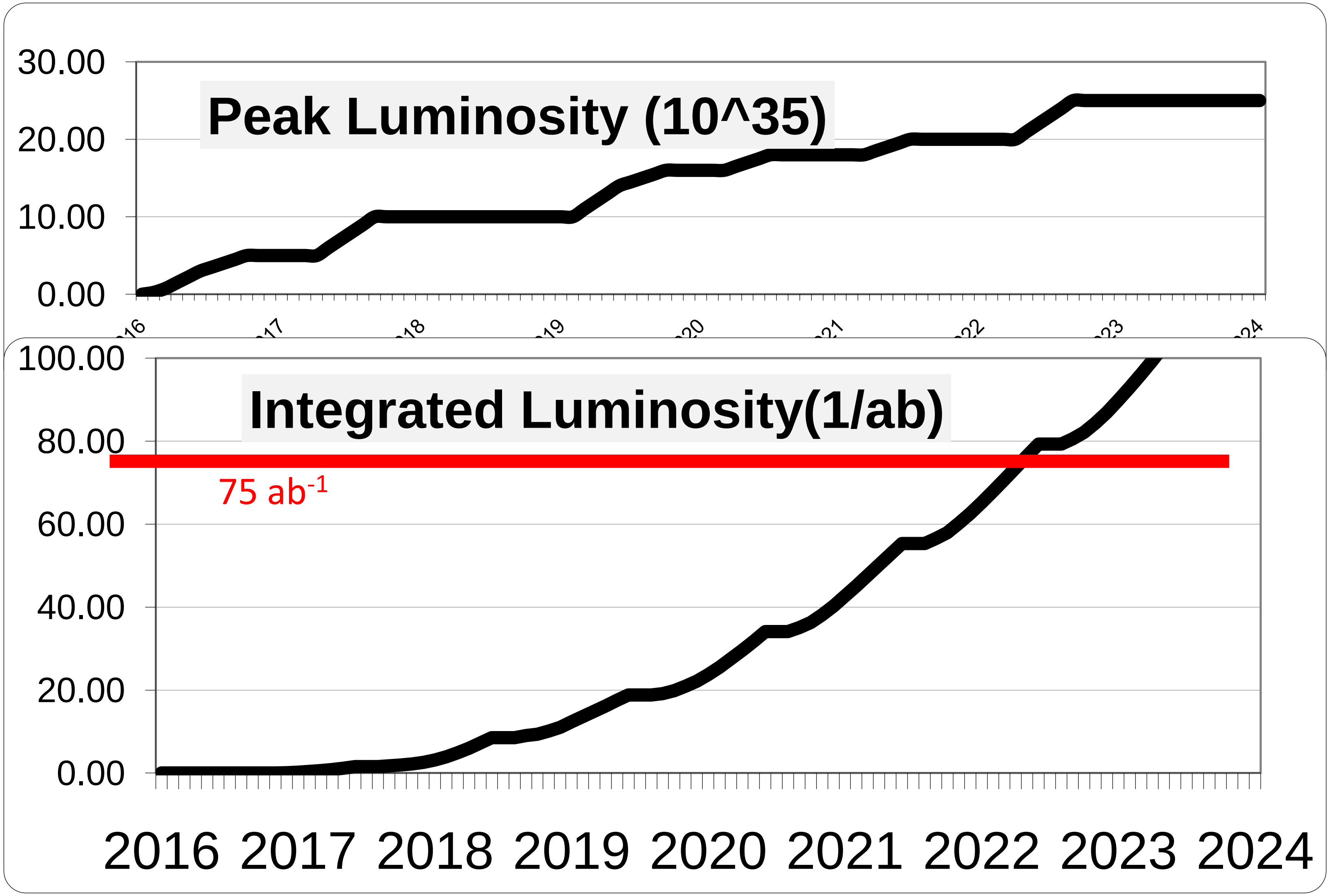
REQUIREMENTS FROM PHYSICS

Parameter	Requirement	Comment
Luminosity (top-up mode)	10^{36} cm^{-2}s^{-1} @ $\Upsilon(4S)$	Baseline/Flexibility with headroom at 4. 10^{36} cm^{-2}s^{-1}
Integrated luminosity	75 ab^{-1}	Based on a “New Snowmass Year” of 1.5 x 10^7 seconds (PEP-II & KEKB experience-based)
CM energy range	τ threshold to $\Upsilon(5S)$	For Charm special runs (still asymmetric……)
Minimum boost	$\beta\gamma$ ≈0.237 ~(4.18x6.7GeV)	1 cm beam pipe radius. First measured point at 1.5 cm
e^- Polarization Boost up to 0.9 in runs at low energy under evaluation for charm physics	≥80%	Enables τ *CP* and *T* violation studies, measurement of τ *g*-2 and improves sensitivity to lepton flavor-violating decays. Detailed simulation, needed to ascertain a more precise requirement, are in progress.

Future Super B Factories

	SuperB	Super KEKB
Peak Luminosity	$>10^{36}$	0.8×10^{36}
Integrated Luminosity	75 ab^{-1}	50 ab^{-1}
Site	Green Field	KEKB Laboratory
Collisions	mid 2016	2015
Polarization	80% electron beam	No
Low energy running	10^{35} @ charm threshold	No
Approval status	Approved	Approved

SuperB Luminosity model

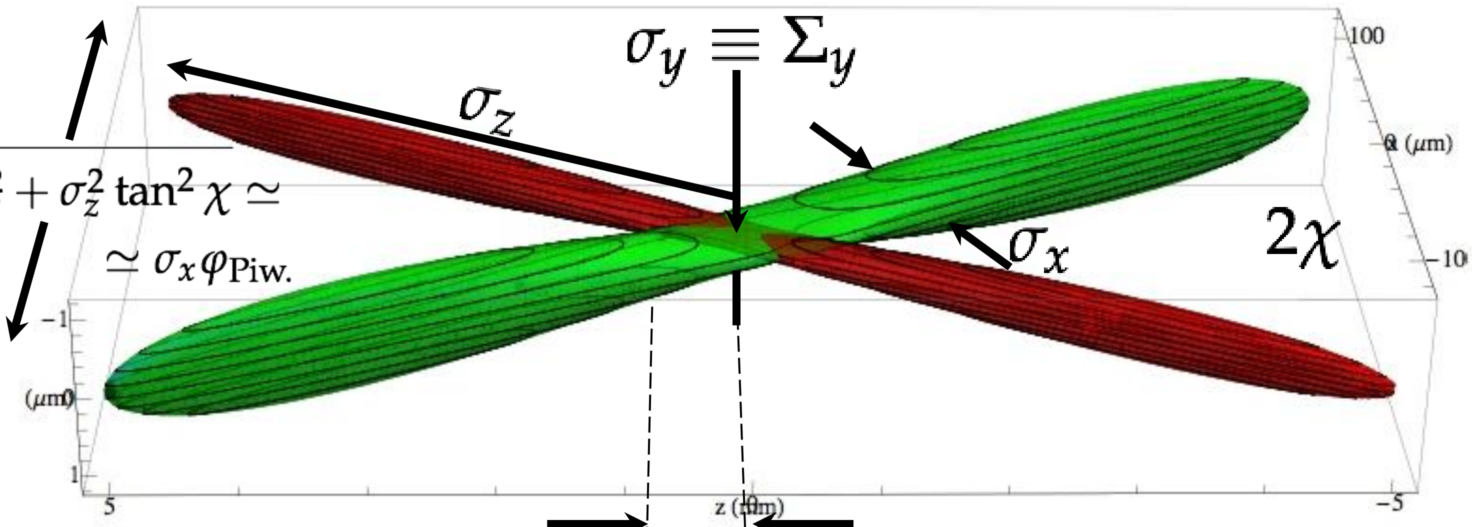


Large Piwinsky angle

$$\varphi_{\text{Piwinsky}} \equiv \frac{\sigma_z \tan\chi}{\sigma_x} > 20$$

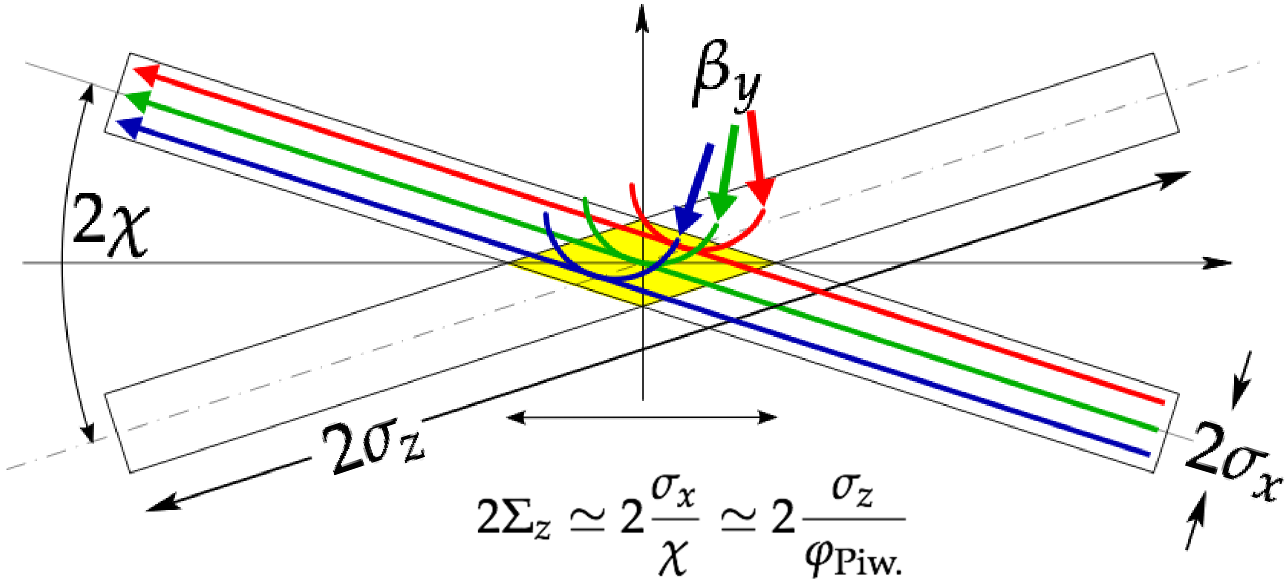
- Bunches are "long" (σ_z ~ 5 mm),
  "natural" aspect ratio σ_y / σ_x ~ 0.5%
- The collision region is short (Σ_z ~ 400 μm),
  very small aspect ratio Σ_y / Σ_x ~ 0.01 %

$$\Sigma_x = \sqrt{\sigma_x^2 + \sigma_z^2 \tan^2\chi} \simeq$$
$$\simeq \sigma_x \varphi_{\text{Piw.}}$$



$$\Sigma_z \simeq \frac{\sigma_x}{\chi} \simeq \frac{\sigma_z}{\varphi_{\text{Piw.}}}$$

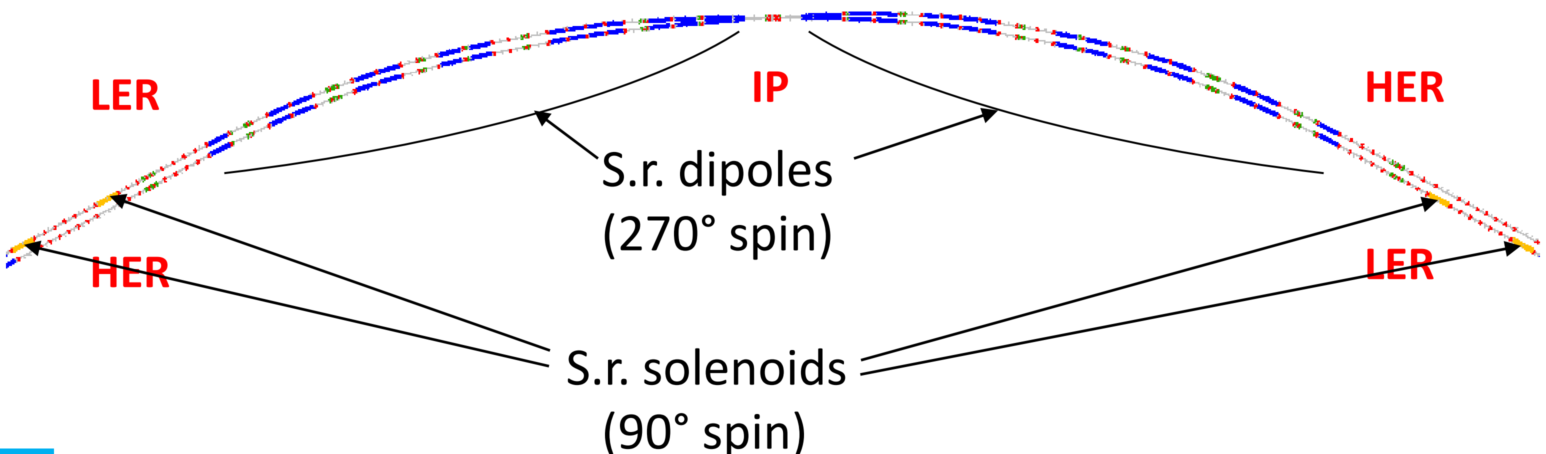
Crab Waist



- Crab waist: modulation of the y-waist position, particles collides a same β_y realized with a sextupole upstream the IP.
- Minimization of nonlinear terms in the beam-beam interaction: reduced emittance growth, suppression of betatron and sincro-betatron coupling
- Maximization of the bunch-bunch overlap: luminosity gain

Polarization in SuperB: Spin Rotation

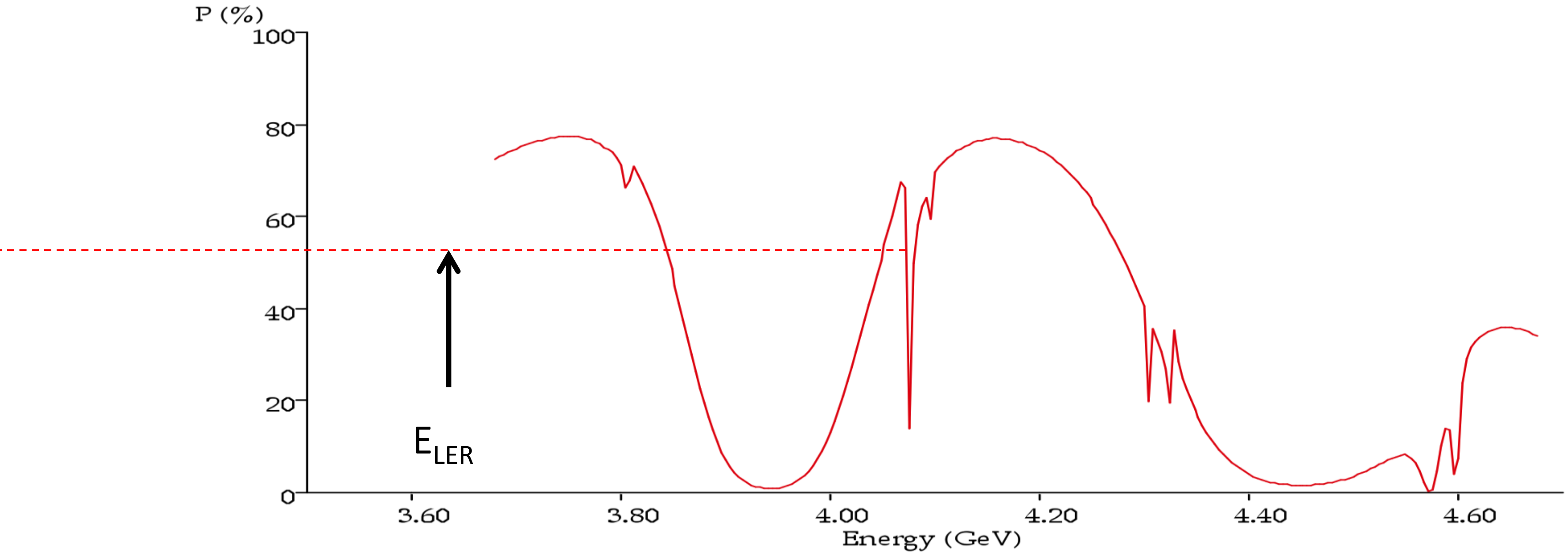
- 90° spin rotation about *x* axis
  - 90° about *z* followed by 90° about *y*
- "flat" geometry => no vertical emittance growth
- Solenoid scales with energy => LER more economical
- Solenoids are split & decoupling optics added.



P.Raimondi

Polarization resonances

- polarization resonances do constraint the beam Energy choice
- Plot shows the resonances in the energy range of LER
- Beam polarization computed assuming
  - 90% beam polarization at injection
  - 3.5 minutes of beam lifetime (bb limited)
- From this plot is clear that the best energy for LER should be 4.18 GeV → HER must be 6.7 GeV



RF & Power

Novokhatski

Super-B RF plug power. Base Line.

Sasha Novokhatski "RF and HOMs absorbers"

HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER+
Total	Zero I		Max	Number			Total	Total	Total	forward	reflected	LER
RF	Bunch	Bunch	voltage	of	S.R.	HOMs	cavity	reflected	forward	to one	from	Total
voltage	length	spacing	per cavity	cavities	power	power	loss	power	power	cavity	one	forward
MV	mm	ns	MV	klystrons	MW	MW	MW	MW	MW	MW	MW	MW
	4.69											
7.01	4.78	4.20	0.58	12.00	3.99	0.27	0.54	0.36	5.16	0.43	0.03	8.19
	5.00			6.00								
												HER+
LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER
Total	Zero I		Max	Number			Total	Total	Total	forward	reflected	Plug
RF	Bunch	Bunch	voltage	of	S.R.	HOMs	cavity	reflected	forward	to one	from	Power
voltage	length	spacing	per cavity	cavities	power	power	loss	power	power	cavity	one	eff.~50%
MV	mm	nsec	MV	klystrons	MW	MW	MW	MW	MW	MW	MW	MW
	4.29											
5.25	4.71	4.20	0.66	8.00	2.12	0.41	0.45	0.05	3.03	0.38	0.01	16.38
	5.00			4.00								

Power absorption

Sasha Novokhatski "RF and HOMs absorbers"

- All power in the rings (5.2 MW + 3 MW) should be absorbed by the water cooling system directly without causing any unpleasant beam problem like emittance growth or instability due to high intensity of the generated wake fields, vacuum pressure rise or electron multipactoring.
- Same amount of power (8.2 MW) will be dissipated in the klystron beam collectors.

Transverse wake fields

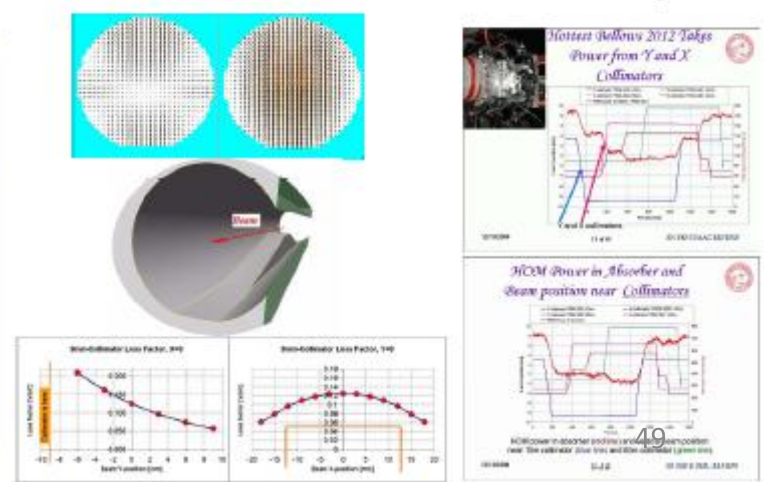
Sasha Novokhatski "RF and HOMs absorbers"

- Transverse wake fields are generated in the asymmetrical parts of the beam pipe.
- Transverse wake fields can penetrate through the small hole in the vacuum chamber or longitudinal slots of shielded bellows, vacuum valves and RF shields.
- Transverse wake fields may propagate long distances.

Need collimators

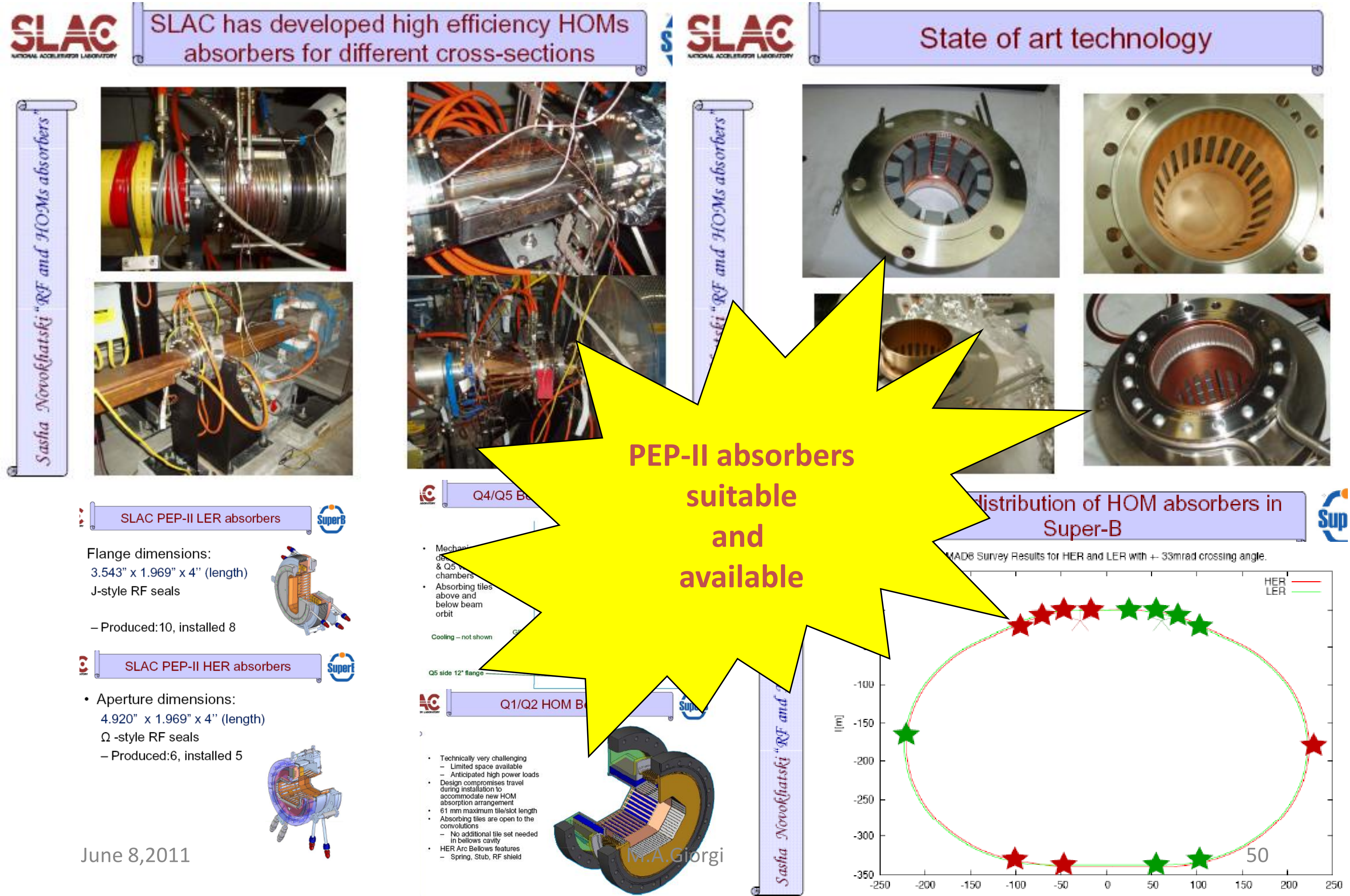
PEP-II collimator is optimized but still produces a lot of transverse fields

Sasha Novokhatski "RF and HOMs absorbers"



HOMs Absorbers

S. Novokhatski

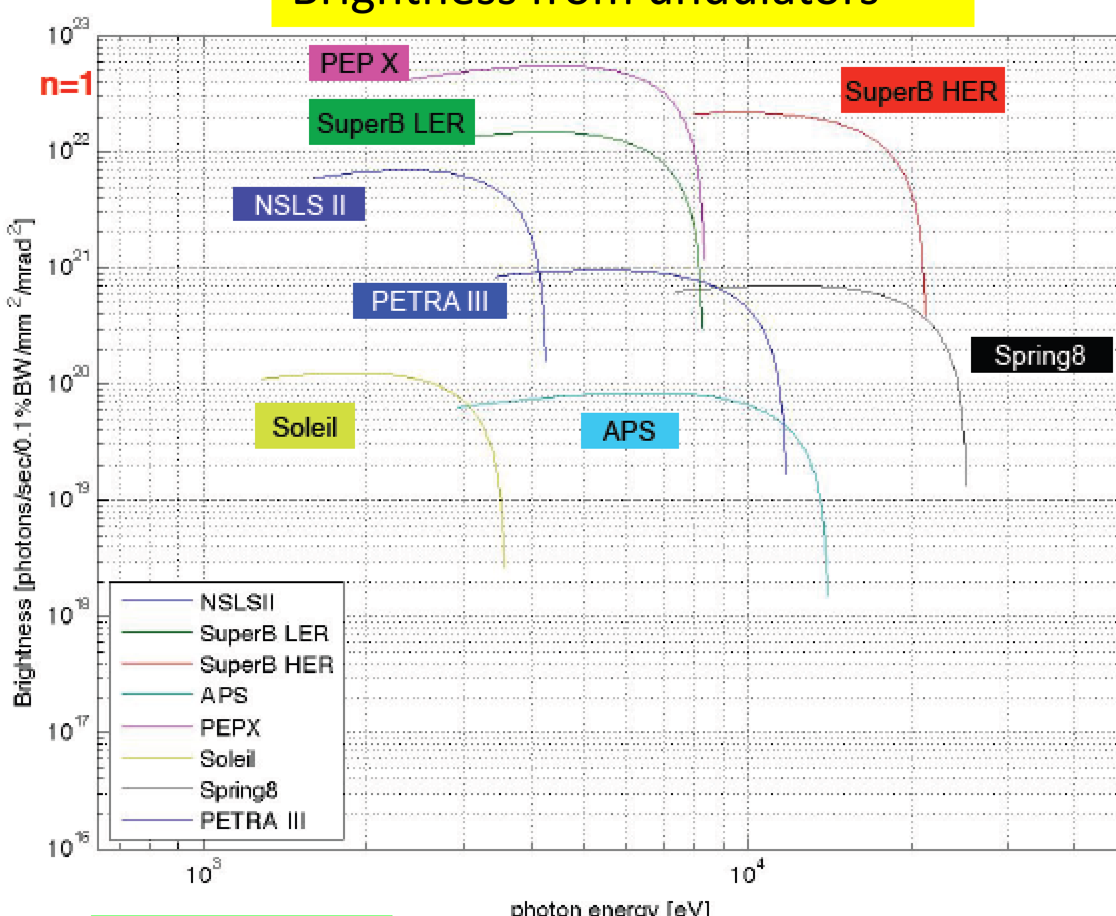


Synchrotron light options @ SuperB

- Comparison of brightness and flux from undulators for different energies dedicated SL sources & SuperB HER and LER
- Light properties from undulators better than most SL

Parameters *	SuperB HER	SuperB LER	NSLS II
	IVU20	IVU20	IVU20
E [GeV]	6.7	4.18	3
I [mA]	1892	2447	500
σx [mm]	60.0 E-3	66.5 E-3	33.3 E-3
σy [mm]	2.4 E-3	2.6 E-3	2.9 E-3
σx' [mrad]	33.3 E-3	37.0 E-3	16.5 E-3
σy' [mrad]	2.1 E-3	2.7 E-3	2.7 E-3
N [1]	148	148	148
λu [mm]	20	20	20
Kmax [1]	1.83	1.83	1.83
Kmin [1]	0.1	0.1	0.1

Brightness from undulators

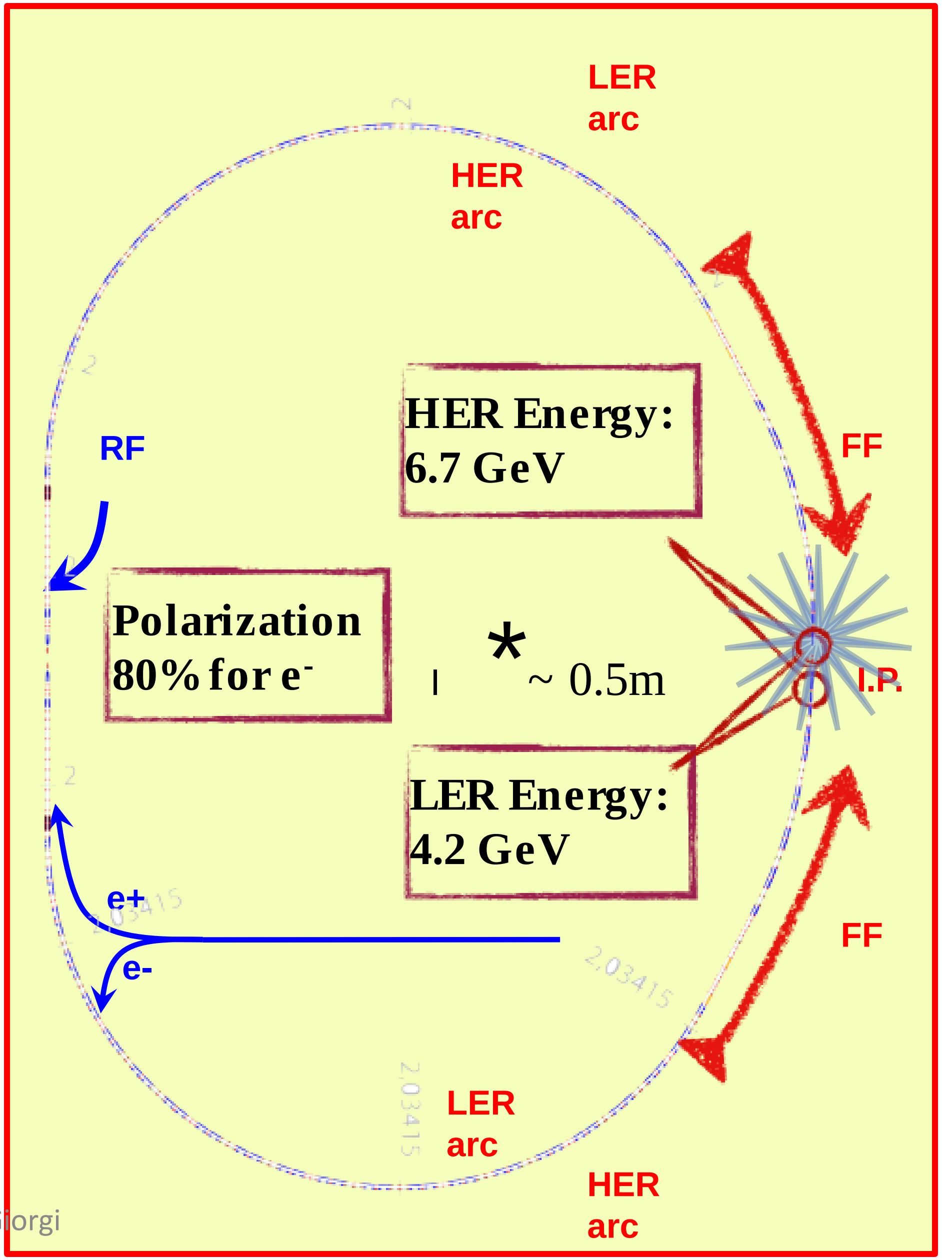


W. Wittmer

Collider Parameters are "stable"

		Base Line		Low Emittance		High Current		Tau-charm	
Parameter	Units	HER (e+)	LER (e-)	HER (e+)	LER (e-)	HER (e+)	LER (e-)	HER (e+)	LER (e-)
LUMINOSITY	$cm^{-2}\ s^{-1}$	1.00E+36		1.00E+36		1.00E+36		1.00E+35	
Energy	GeV	6.7	4.18	6.7	4.18	6.7	4.18	2.58	1.61
Circumference	m	1258.4		1258.4		1258.4		1258.4	
X-Angle (full)	mrad	66		66		66		66	
β_x @ IP	cm	2.6	3.2	2.6	3.2	5.06	6.22	6.76	8.32
β_y @ IP	cm	0.0253	0.0205	0.0179	0.0145	0.0292	0.0237	0.0658	0.0533
Coupling (full current)	%	0.25	0.25	0.25	0.25	0.5	0.5	0.25	0.25
Emittance x (with IBS)	nm	2.00	2.46	1.00	1.23	2.00	2.46	5.20	6.4
Emittance y	pm	5	6.15	2.5	3.075	10	12.3	13	16
Bunch length (full current)	mm	5	5	5	5	4.4	4.4	5	5
Beam current	mA	1892	2447	1460	1888	3094	4000	1365	1766
Buckets distance	#	2		2		1		1	
Ion gap	%	2		2		2		2	
RF frequency	MHz	476.		476.		476.		476.	
Revolution frequency	MHz	0.238		0.238		0.238		0.238	
Harmonic number	#	1998		1998		1998		1998	
Number of bunches	#	978		978		1956		1956	
N. Particle/bunch (10^{10})	#	5.08	6.56	3.92	5.06	4.15	5.36	1.83	2.37
σ_x effective	μm	165.22	165.30	165.22	165.30	145.60	145.78	166.12	166.67
σ_y @ IP	μm	0.036	0.036	0.021	0.021	0.054	0.0254	0.092	0.092
Piwinski angle	rad	22.88	18.60	32.36	26.30	14.43	11.74	8.80	7.15
Σ_x effective	μm	233.35		233.35		205.34		233.35	
Σ_y	μm	0.050		0.030		0.076		0.131	
Hourglass reduction factor		0.950		0.950		0.950		0.950	
Tune shift x		0.0021	0.0033	0.0017	0.0025	0.0044	0.0067	0.0052	0.0080
Tune shift y		0.097	0.097	0.0891	0.0892	0.0684	0.0687	0.0909	0.0910
Longitudinal damping time	msec	13.4	20.3	13.4	20.3	13.4	20.3	26.8	40.6
Energy Loss/turn	MeV	2.11	0.865	2.11	0.865	2.11	0.865	0.4	0.17
Momentum compaction (10^{-4})		4.36	4.05	4.36	4.05	4.36	4.05	4.36	4.05
Energy spread (10^{-4}) (full current)	dE/E	6.43	7.34	6.43	7.34	6.43	7.34	6.43	7.34
CM energy spread (10^{-4})	dE/E	5.0		5.0		5.0		5.0	
Total lifetime	min	4.23	4.48	3.05	3	7.08	7.73	11.4	6.8
Total RF Wall Plug Power	MW	16.38		12.37		28.83		2.81	

SuperB Collider Progress Report



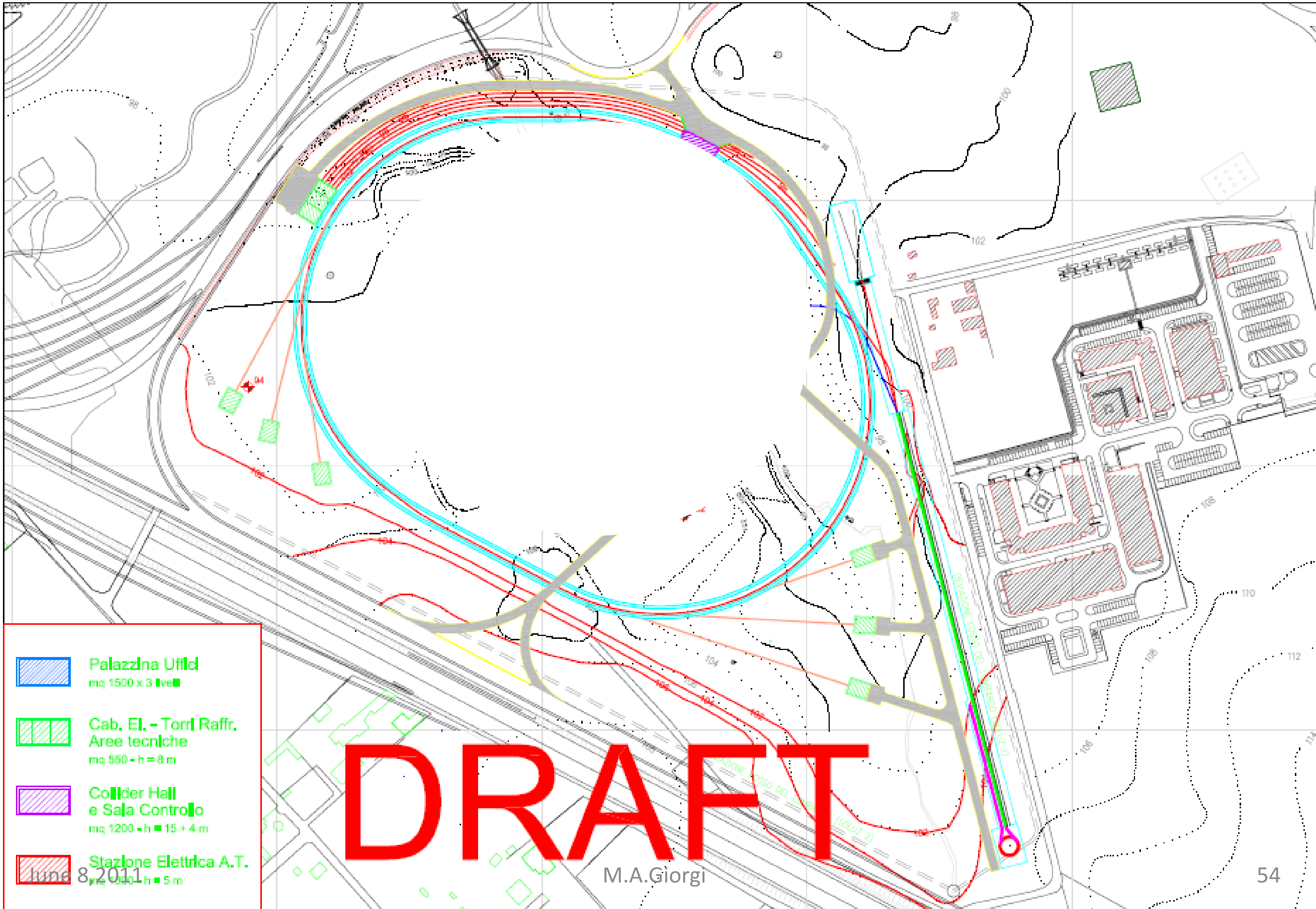
New PDG table for SuperB

HIGH-ENERGY COLLIDER PARAMETERS: e^+e^- Colliders (III)

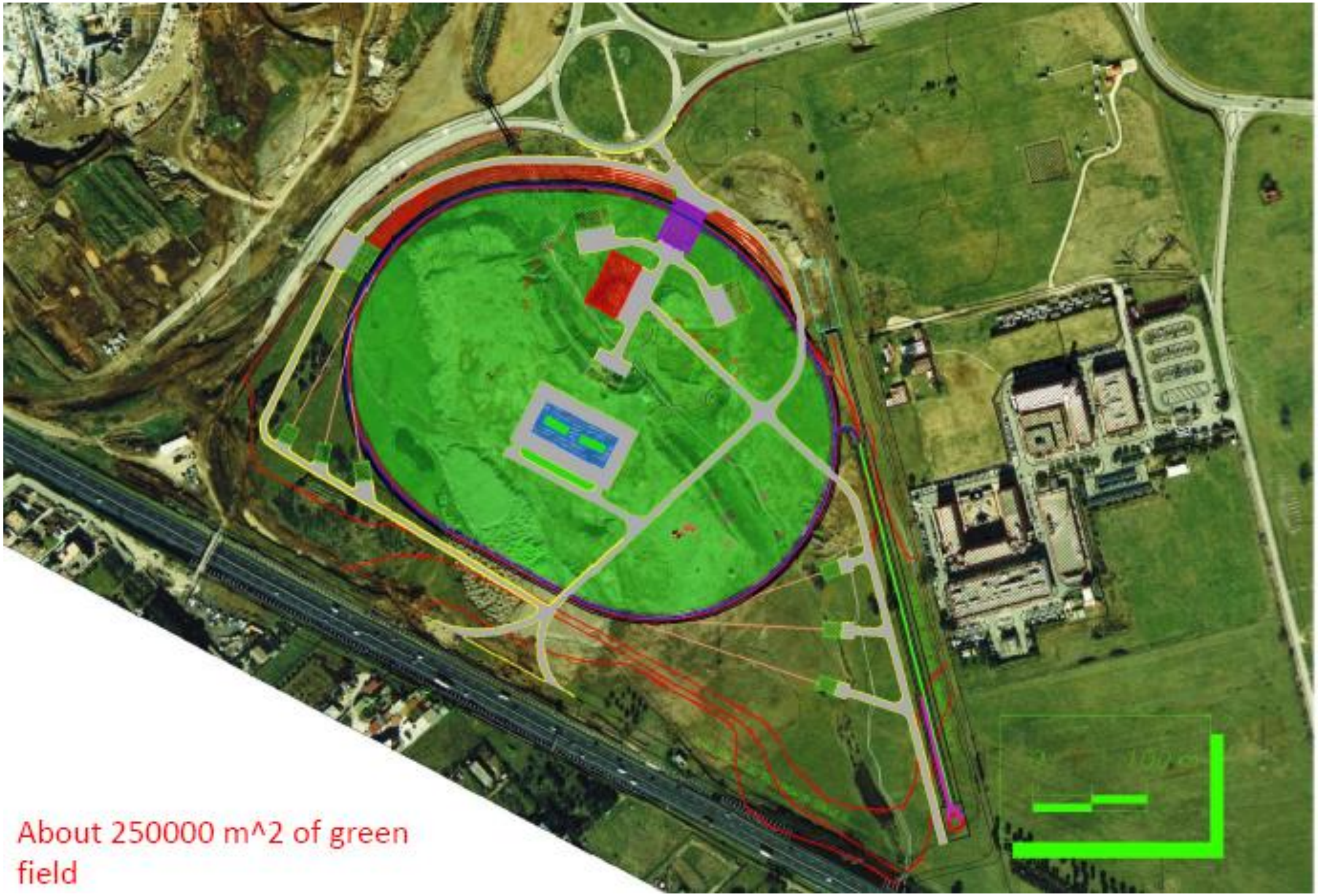
Updated in early 2010 with numbers received from representatives of the colliders (contact J. Beringer, LBNL). For existing (future) colliders the latest achieved (design) values are given. Quantities are, where appropriate, r.m.s.; H and V indicate horizontal and vertical directions; s.c. stands for superconducting.

	KEKB (KEK)	PEP-II (SLAC)	SuperB (Italy)	SuperKEKB (KEK)
Physics start date	1999	1999	TBD	2014 ?
Physics end date	—	2008	—	—
Maximum beam energy (GeV)	e^-: 8.33 (8.0 nominal) e^+: 3.64 (3.5 nominal)	e^-: 7–12 (9.0 nominal) e^+: 2.5–4 (3.1 nominal) (nominal $E_{\rm cm}$ = 10.5 GeV)	e^-: 4.2 e^+: 6.7	e^-: 7 e^+: 4
Luminosity (10^{30} cm^{-2}s^{-1})	21083	12069 (design: 3000)	1.0×10^6	8×10^5
Time between collisions (μs)	0.00590 or 0.00786	0.0042	0.0042	0.004
Full crossing angle (μ rad)	$\pm 11000^\dagger$	0	± 33000	± 41500
Energy spread (units 10^{-3})	0.7	e^-/e^+: 0.61/0.77	e^-/e^+: 0.73/0.64	e^-/e^+: 0.58/0.84
Bunch length (cm)	0.65	e^-/e^+: 1.1/1.0	0.5	e^-/e^+: 0.5/0.6
Beam radius (μm)	H: 124 (e^-), 117 (e^+) V: 0.94	H: 157 V: 4.7	H: 8 V: 0.04	e^-: 11 (H), 0.062 (V) e^+: 10 (H), 0.048 (V)
Free space at interaction point (m)	+0.75/−0.58 (+300/−500) mrad cone	±0.2, ±300 mrad cone	±0.35	e^- : +1.20/ − 1.28, e^+ : +0.78/ − 0.73 (+300/−500) mrad cone
Luminosity lifetime (hr)	continuous	continuous	continuous	continuous
Turn-around time (min)	continuous	continuous	continuous	continuous
Injection energy (GeV)	e^-/e^+ : 8/3.5	2.5–12	e^-/e^+ : 4.2/6.7	e^-/e^+ : 7/4
Transverse emittance (π rad-nm)	e^-: 24 (57*) (H), 0.61 (V) e^+: 18 (55*) (H), 0.56 (V)	e^-: 48 (H), 1.5 (V) e^+: 24 (H), 1.5 (V)	e^-: 2.5 (H), 0.006 (V) e^+: 2.0 (H), 0.005 (V)	5 (H), 3 (V)
β^*, amplitude function at interaction point (m)	e^-: 1.2 (0.27*) (H), 0.0059 (V) e^+: 1.2 (0.23*) (H), 0.0059 (V)	e^-: 0.50 (H), 0.012 (V) e^+: 0.50 (H), 0.012 (V)	e^-: 0.032 (H), 0.00021 (V) e^+: 0.026 (H), 0.00025 (V)	e^-: 0.025 (H), 3×10^{-4} (V) e^+: 0.032 (H), 2.7×10^{-4} (V)
Beam-beam tune shift per crossing (units 10^{-4})	e^-: 1020 (H), 900 (V) e^+: 1270 (H), 1290 (V)	e^-: 703 (H), 498 (V) e^+: 510 (H), 727 (V)	20 (H), 950 (V)	e^-: 12 (H), 807 (V) e^+: 28 (H), 893 (V)
RF frequency (MHz)	508.887	476	476	508.887
Particles per bunch (units 10^{10})	e^-/e^+: 4.7/6.4	e^-/e^+: 5.2/8.0	e^-/e^+: 5.1/6.5	e^-/e^+: 6.53/9.04
Bunches per ring per species	1585	1732	978	2500
Average beam current per species (mA)	e^-/e^+: 1188/1637	e^-/e^+: 1960/3026	e^-/e^+: 1900/2400	e^-/e^+: 2600/3600
Beam polarization (%)	—	—	> 80	—
Circumference or length (km)	3.016	2.2	1.258	3.016
Interaction regions	1	1	1	1
Magnetic length of dipole (m)	e^-/e^+ : 5.86/0.915	e^-/e^+: 5.4/0.45	e^-/e^+: 0.9/5.4	e^-/e^+ : 5.9/4.0
Length of standard cell (m)	e^-/e^+ : 75.7/76.1	15.2	40	e^-/e^+ : 75.7/76.1
Phase advance per cell (deg)	450	e^-/e^+: 60/90	360 (V), 1080 (H)	450
Dipoles in ring	e^-/e^+ : 116/112	e^-/e^+: 192/192	e^-/e^+: 186/102	e^-/e^+ : 116/112
Quadrupoles in ring	e^-/e^+ : 452/452	e^-/e^+: 290/326	e^-/e^+: 290/300	e^-/e^+ : 466/460
Peak magnetic field (T)	e^-/e^+ : 0.25/0.72	e^-/e^+: 0.18/0.75	e^-/e^+: 0.52/0.25	e^-/e^+ : 0.22/0.19

Possible layout @ Tor Vergata



Site (Tor Vergata)



FF vibrations budget

K. Bertsche

- An overall vibration control design is being developed for the FF magnets. The added measurements of the Frascati site are very encouraging and the fact that the beams tend to move together with QD0 motion has significantly loosened the tolerance requirements on cryostat motion

Element	RMS motion	Xfer Fn	IP displacement	
			no feedback	with feedback
Cryostat linear	< 1 μm	< 0.035	< 35 nm	< 3.5 nm
Cryostat rotation	< 2 μrad	0.014 m/rad	< 30 nm	< 3 nm
Arc quads	< 1 μm	0.03	< 30 nm	< 3 nm
Total (two rings)			< 78 nm	< 7.8 nm

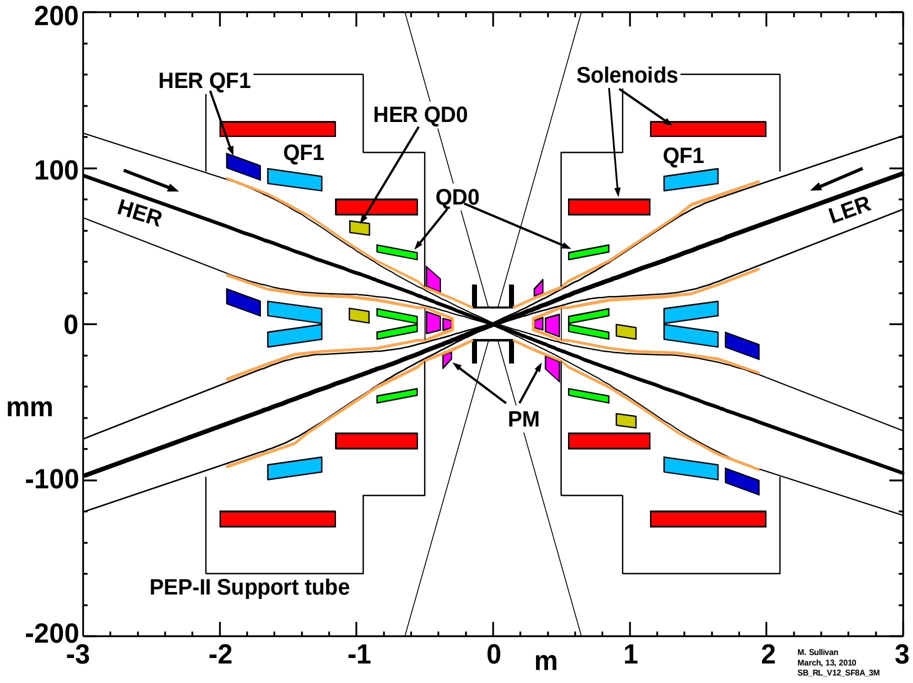
- Assumes beam feedback achieves > 10x reduction of motion at IP
  - If motion is kept 10x smaller, may not need beam feedback
- Budget applies to integrated RMS motion > 1 Hz
- This budget will keep relative motion < 8 nm, and lumi loss < 1%

Vibrations

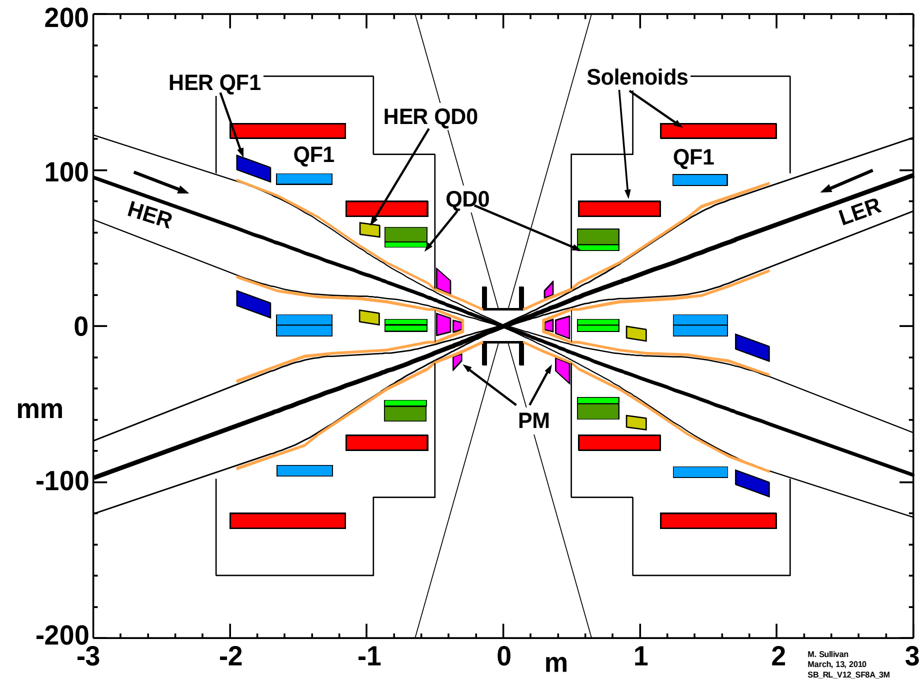
The results of the measurement campaign in Tor Vergata by the Lapp-Annecy Group at the end of April2011 indicates that vibration is not a problem for SuperB even in rush hours.

(Well below 1.0 μm amplitude)

Final Quad (QD0) Design: 2 possible choices

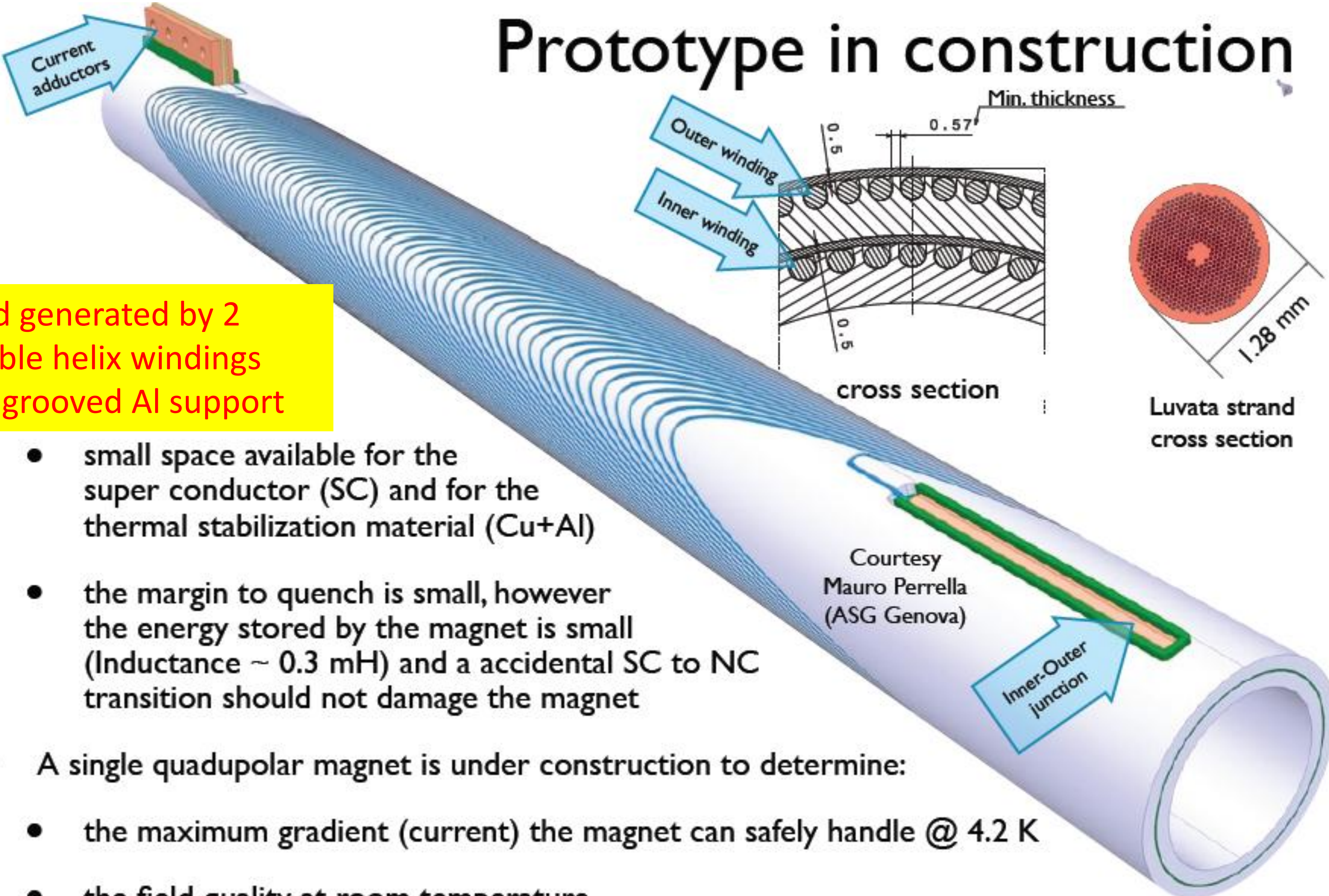


Vanadium Permendur
"Russian" Design



Air core SC QD0, QF1
"Italian" Design

Prototype in construction



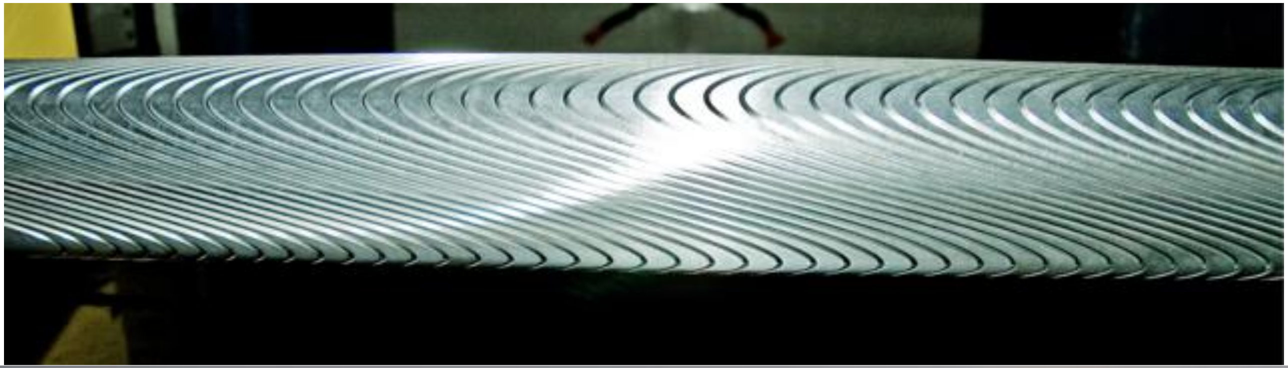
Field generated by 2 double helix windings in a grooved Al support

- small space available for the super conductor (SC) and for the thermal stabilization material (Cu+Al)
- the margin to quench is small, however the energy stored by the magnet is small (Inductance ~ 0.3 mH) and a accidental SC to NC transition should not damage the magnet

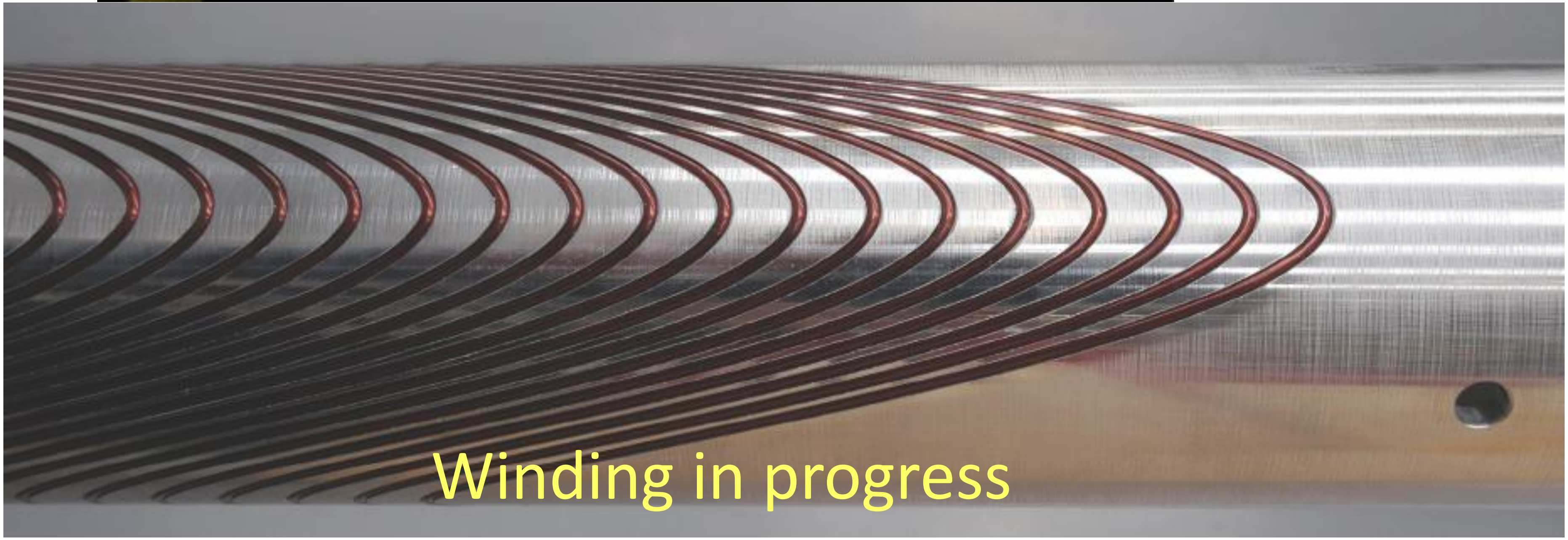
- A single quadupolar magnet is under construction to determine:
  - the maximum gradient (current) the magnet can safely handle @ 4.2 K
  - the field quality at room temperature
- 200 m of SC wire kindly gifted by Luvata: Φ=1.28 mm, Cu/NbTi = 1.0, Ic 2450 A @ 4T, 4.2K

P. Fabbricatore, S. Farinon, R. Musenich (Genova) Paoloni (Pisa)

The QD0



Grooved Al support

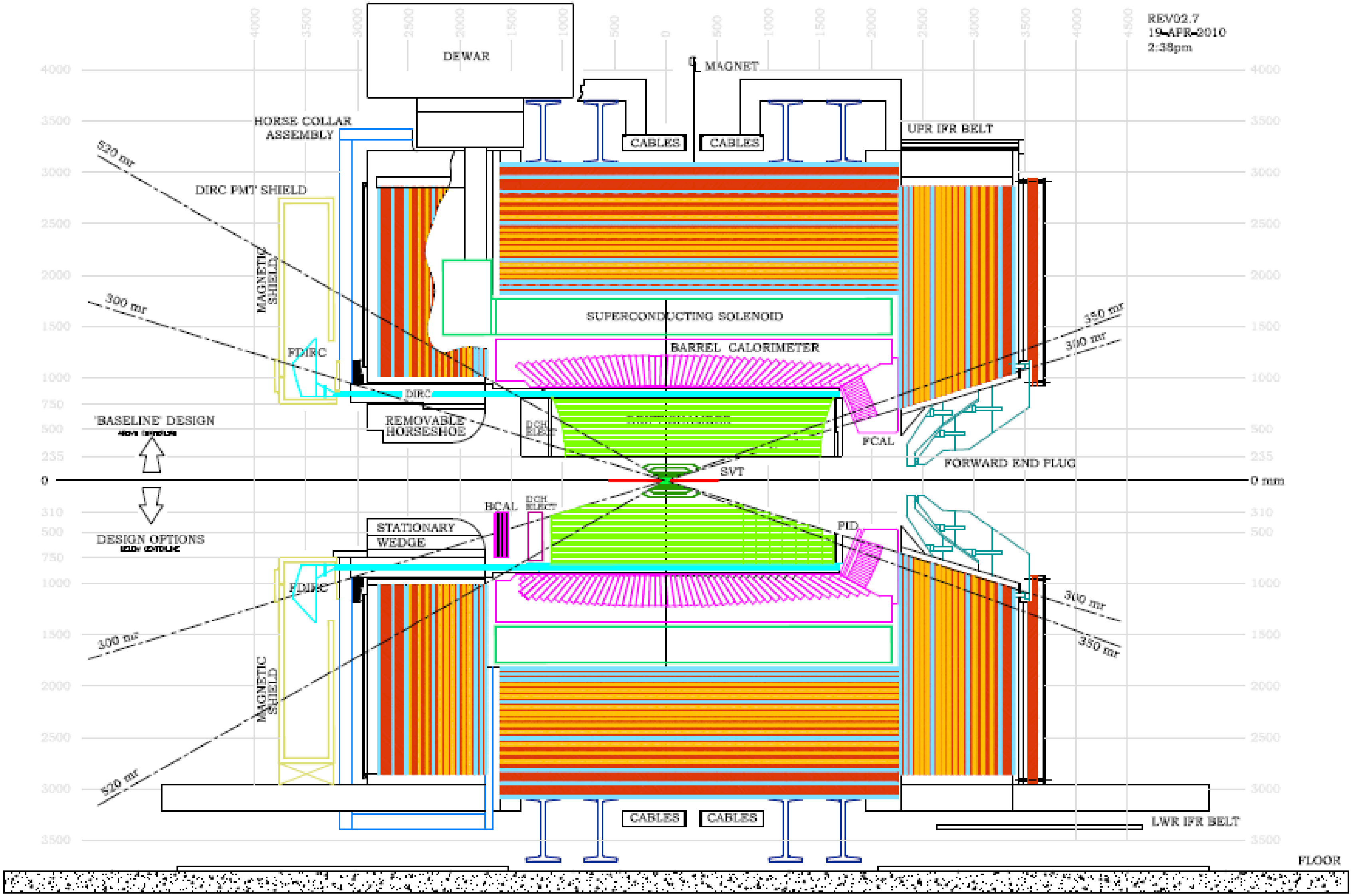


Ready this Summer for tests and field measurements @ CERN

Detector Overview

- Detector design well advanced
  - Based on BaBar “prototype”
  - CDR (2007) http://web.infn.it/superb/images/stories/upload_file/superb-cdr.pdf
  - Detector Progress Report(2010): http://arxiv.org/abs/1007.4241
- Remaining Generic Detector Options to be decided following Detector Geometry Task Force reports and DGWG studies
- Proto-Detector Organization is in place. Needs to be enhanced/modified as collaboration develops.
- R&D ongoing across detector systems allow final designs to proceed.

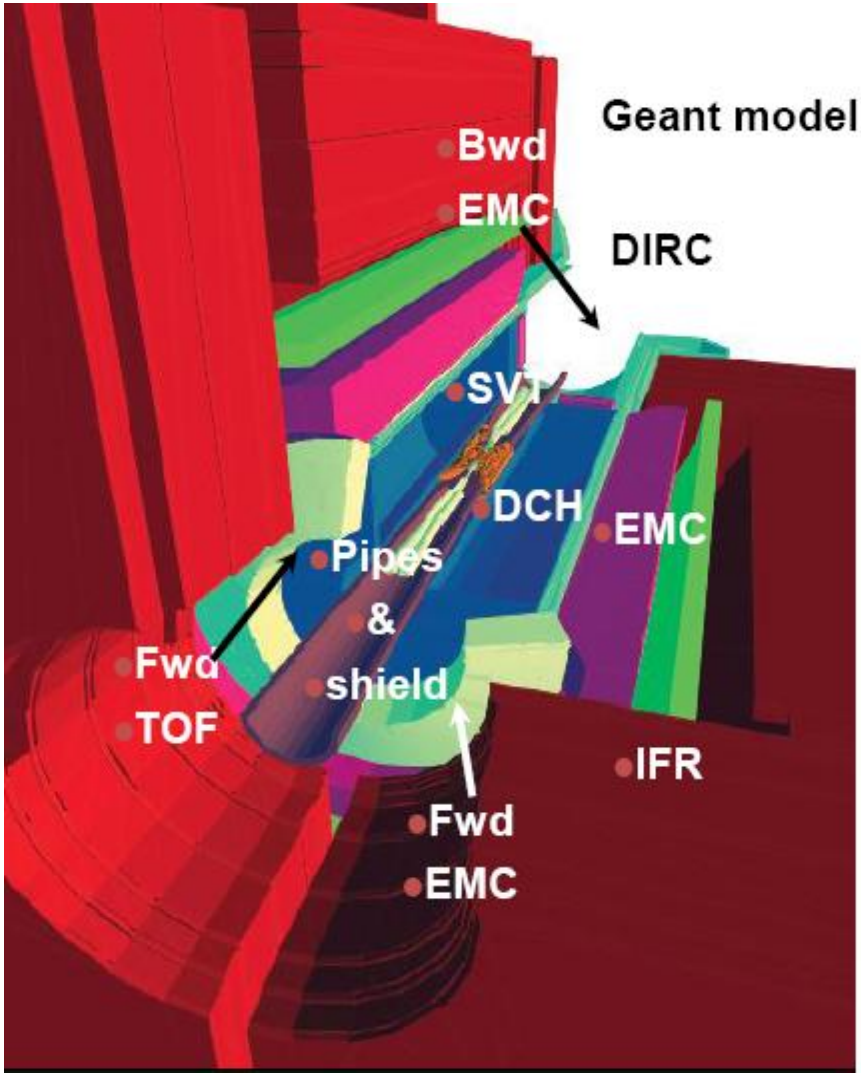
SuperB Detector (with options)

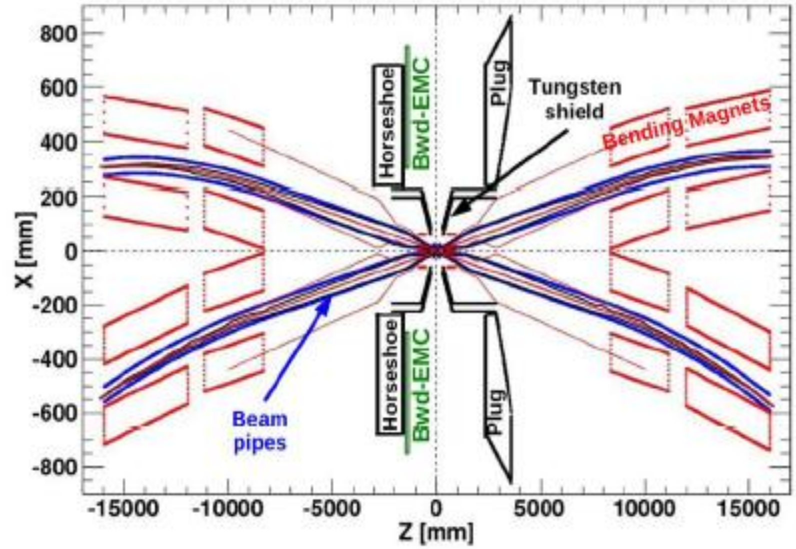


Detector Evolution- from to

- CDR Baseline based on BaBar. It reuses
  - Fused Silica bars of the DIRC
  - DIRC & DCH Support
  - Barrel EMC CsI(Tl) crystals and mechanical structure
  - Superconducting coil & flux return (with some redesign).
- **Some elements have aged and need replacement. Others require moderate improvements to cope with the high luminosity environment, the smaller boost (4x7 GeV), and the high DAQ rates.**
  - Small beam pipe technology
  - Thin silicon pixel detector for first layer, and a new 5 layer SVT.
  - New DCH with CF mechanical structure, modified gas and cell size
  - New Photon detection for DIRC fused silica bars
  - Possible Forward PID system (TOF in Baseline option)
  - New Forward calorimeter crystals (LYSO).Backward veto
  - Minos-style extruded scintillator for instrumented flux return
  - Electronics and trigger- x100 real event rate
  - Computing- to handle massive date volume

Detector Modeled





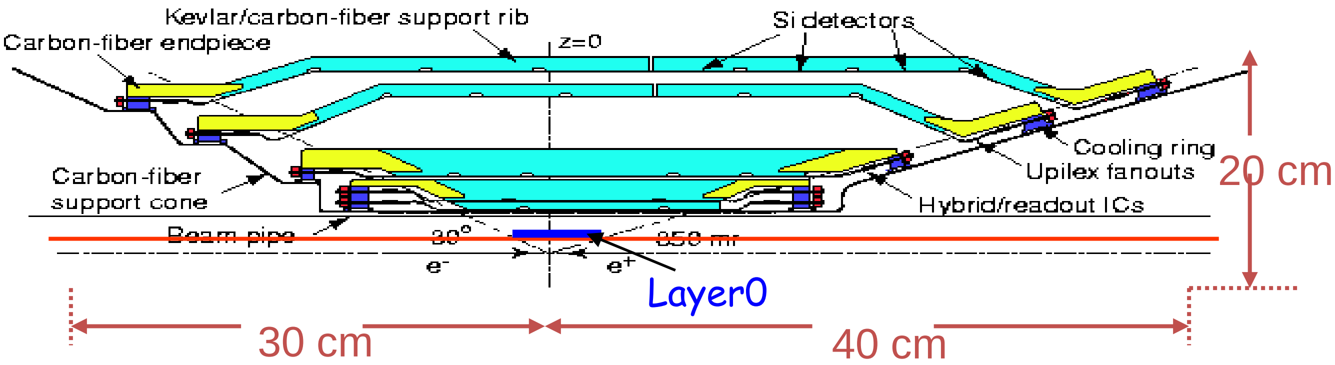
- The whole detector is modeled
- The beam lines and their magnets are modeled +/- 15m from IP
- Recent developments:
  - packaging
  - newest IR layout
  - additional truth information

Background Rates as expected from preliminary studies

	Cross section	Evt/bunch xing	Rate	Generator
Radiative Bhabha	~340 mbarn (Eγ/Ebeam > 1%)	~850	0.3THz	BBBrem
e^+e^- pair production	~7.3 mbarn	~18	7GHz	Diag36
e^+e^- pair (seen by L0 @ 1.5 cm)	~0.3 mbarn	~0.8	0.3GHz	Diag36
Elastic Bhabha	$O(10^{-4})$ mbarn (Det. acceptance)	~250/Million	100KHz	Bhabhayaga/BHwide
Υ(4S)	$O(10^{-6})$ mbarn	~2.5/Million	1 KHz	
	Loss rate	Loss/bunch pass	Rate	
Touschek (LER)	14 kHz / bunch (+/- 2 m from IP)	~6/100	~14 MHz	Star (M.Boscolo)

- Primary Background Particle will eventually hit the beam pipe showering in the surrounding material
- Ad hoc Monte Carlo generator for primary particles
- Geant4 Based full simulation code for the simulation of the interaction of primary particles with the material

Detector Issues:



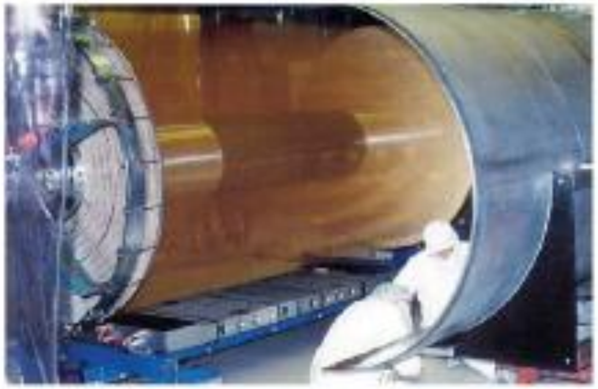
SVT

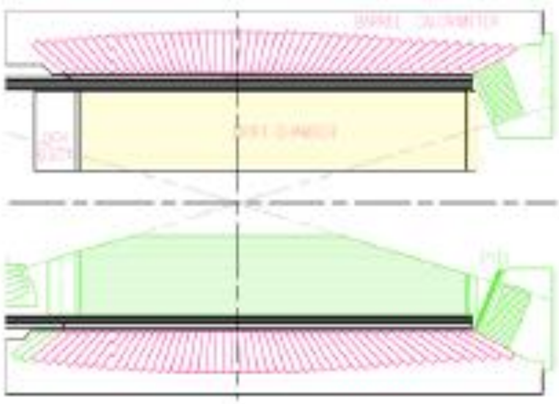
- Smaller machine asymmetry

➔ Need a new SVT (very similar to that of the 5 layer BaBar SVT) supplemented by a new layer 0 to measure the first hit as close as possible to the production vertex. Goal is coverage to 300 mrad both forward and backward.

- Beam pipe radius and thickness are crucial to obtain adequate resolution in vertex separation.

Options:MAPS, Hybrid Pixels, Striplets (the latter is difficult due to the expected Bhabha occupancy)

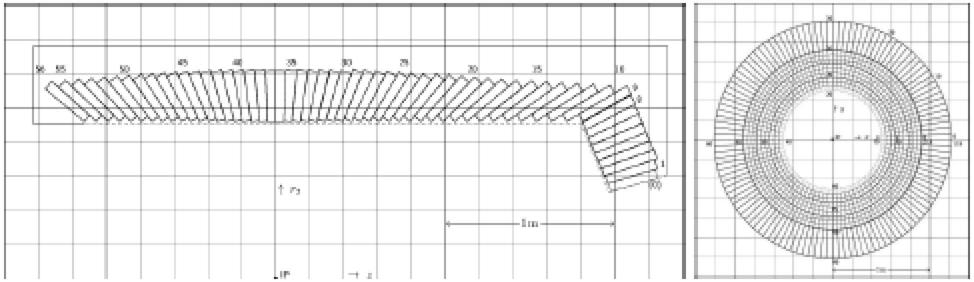




DC

Drift Chamber on Babar concept : no major R&D. But: lighter structure (carbon fiber), dome shaped end plates with x 2% (Babar was 13-16%

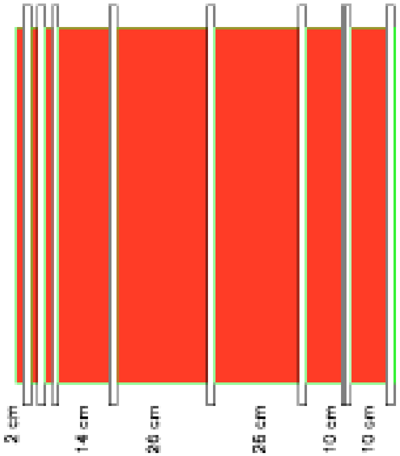
Forward EMC

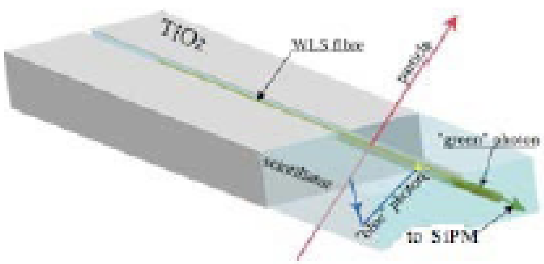


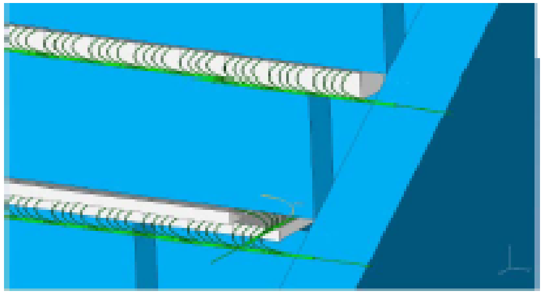
- Forward Endcap EMC
  - Inner BaBar Crystals are radiation damaged. Need replacement.
  - At forward angles in SuperB, CsI(Tl) is too slow (occupancy) and radiation soft.
  - Propose LYSO.

IFR

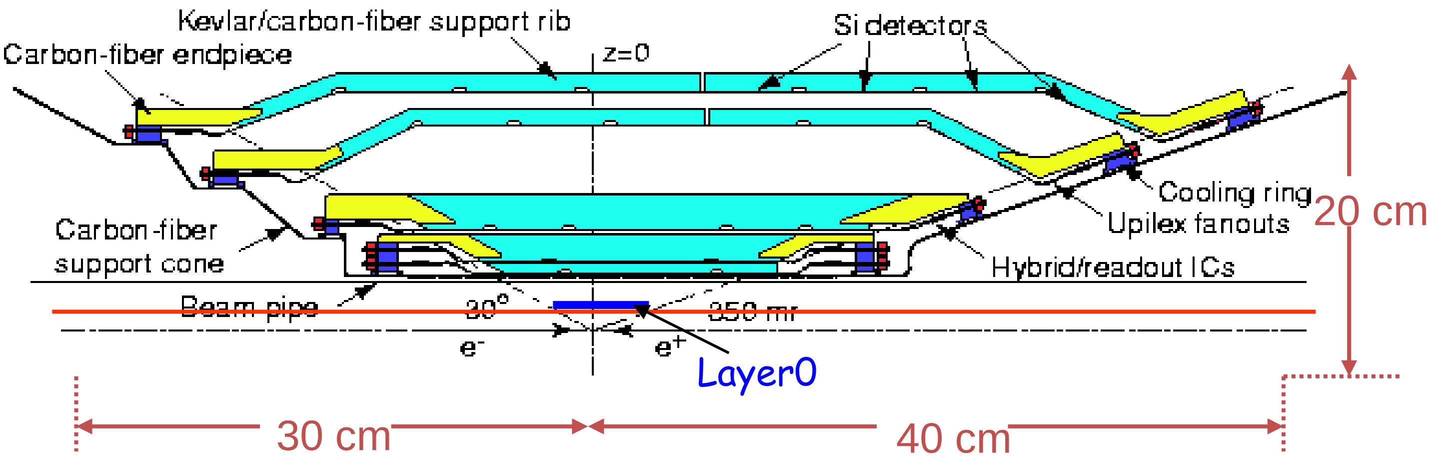
- Composed by 1 hexagonal barrel + 2 endcaps as in BaBar
- Add absorber w.r.t. BaBar to improve π/μ separation. Amount and distribution to be optimized
  - 7-8 absorber layers
  - reuse of BaBar IFR iron under evaluation
- Use extruded scintillator a la MINOS coupled to geiger mode APDs through WLS fibers
  - expected hit rates of O(100) Hz/cm²d
  - single layer or double coord. layout depending on the x-y resolution needs



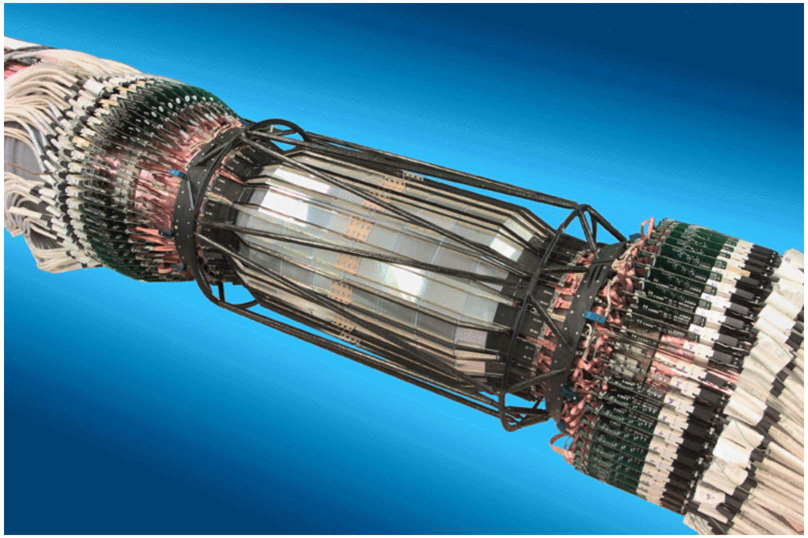




Vertex Detector (SVT)



Bergamo
Bologna
Milano
Pavia
Pisa
Strasbourg
Torino
Trieste
QMUL
(TBC)RAL



in BABAR

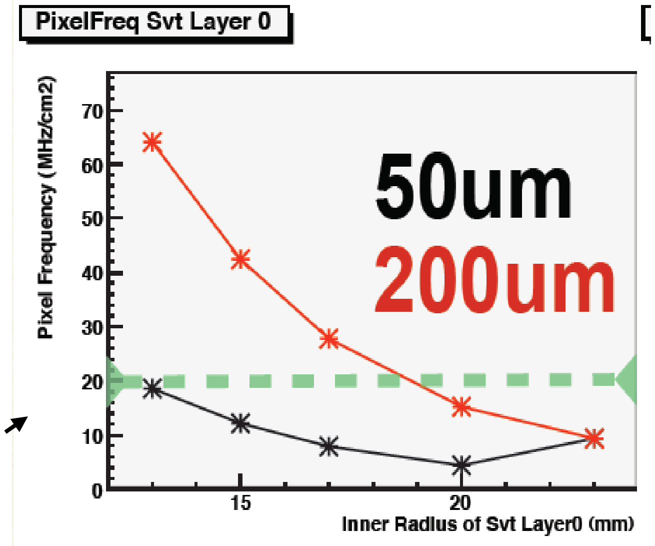
SVT

Definition of Layer0 configuration & performance for the different technologies (striplets-baseline, thin pixel - upgrade)

Update on background:

Hit rate vs Layer0 radius from pairs production depends strongly on sensor thickness: large cluster width for low momentum tracks with large crossing angle

Large difference for thin pixels (50 um) and striplets (200 um).



- Sustainable background hit rate (radius) depends on technology: striplets vs pixel area and readout chip.

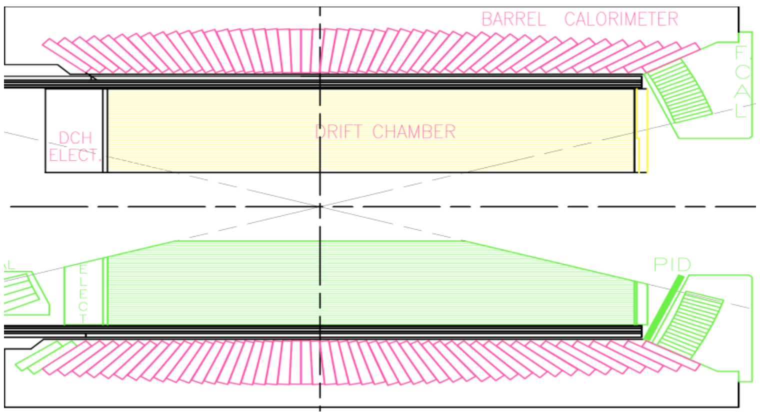
1. Development of pixel chip readout architecture continue: data push and triggered with target 100MHz/cm2 (safety x5 included) with timestamp 100 ns. → radius ~1.3cm
2. Evaluate efficiency of FSSR2 readout chip (striplets) vs rate (goal still 100 MHz/cm2):
   - Verilog simulation results not very encouraging! Significant drop in efficiency ~ 20 MHz/cm2
   - Need to interact with Fermilab designers to understand if this is a real issue and in case if modification to digital part is possible.
3. Started to investigate alternative option for striplets readout chip.

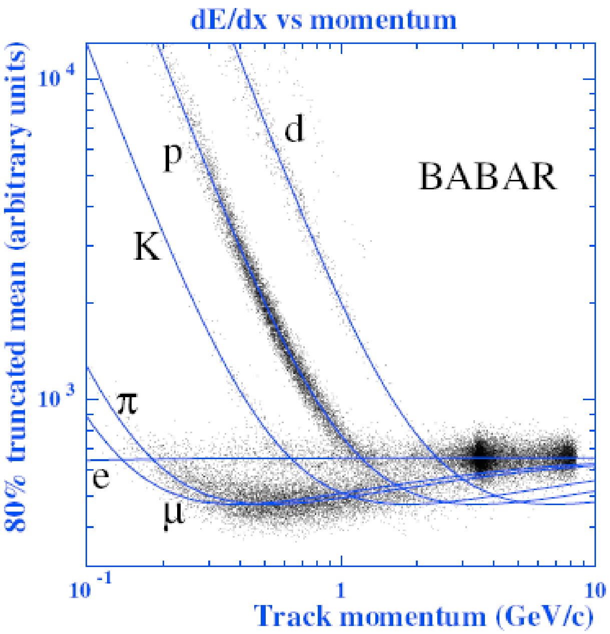
DCH Baseline Design

- Provides precision momentum
- Provides particle ID via dE/dx for all low momentum tracks, even those that miss the PID system.
- A new DCH (similar to now aged BaBar DCH, which must be replaced)
  - Similar gas & cell shape (small improvements may be possible)
  - Carbon Fiber end plates (to reduce material before endcaps)
  - New electronics with location optimized.
- R&D Issues including:
  - Electronics location and/or mass to reduce effect on backward EMC,
  - Low Mass Endplates
  - Can we do better on dE/dx (counting clusters)?
  - Conical/stepped endplates or other ways to reduce sensitivity close to the beam.
  - Background simulation/shielding optimization.
- R&D has been started.
- Need to test all solutions on prototype,

Canada (UBC,Victoria, McGill, Un. Montreal)
LNF

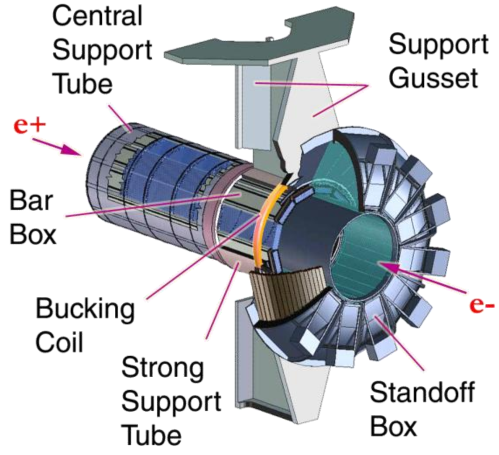
DCH





Particle ID

- Baseline is to reuse BaBar DIRC barrel-only design.
  - Excellent performance to 4 GeV/c.
  - Robust operation.
  - Elegant mechanical support.
  - Photon detectors outside field region.
  - Radiation hard fused silica radiators.
  - But...PMTs are slow and aging. Need replacement. Large SOB region senstive to backgrounds so volume reduction is desirable.



- Photon detector replacement
  - Baseline... Use pixelated fast PMTs with a smaller SOB to improve background performance by ~x50-100 with ~ identical PID performance.
  - Several other photon detector options are considered in the CDR.

OPTIONS for the Forward PID

- Modest solid angle but event acceptance for “veto physics” or decays with multiple particles (e.g., $B \rightarrow K_s KK$) scale much faster than linearly. Physics case needs to be established.

- Not just a PID problem. Overall detector optimization required.
  - Adds material before EMC.
  - Takes space from tracking or EMC.

- Aerogel RICH and Very Fast Cherenkov-based TOF seem plausible.
  - Space requirements.
  - Fast tubes have substantial material. SiPMs are noisy and neutron sensitive.
  - R&D underway

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    - Excellent performance to 4 GeV/c.
    - Robust operation.
    - Elegant mechanical support.
    - Photon detectors outside field region.
    - Radiation hard fused silica radiators.
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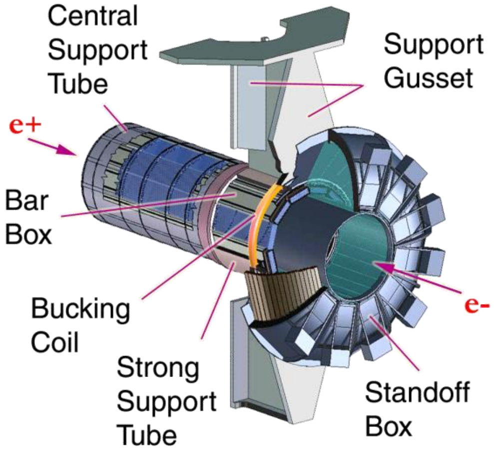

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???

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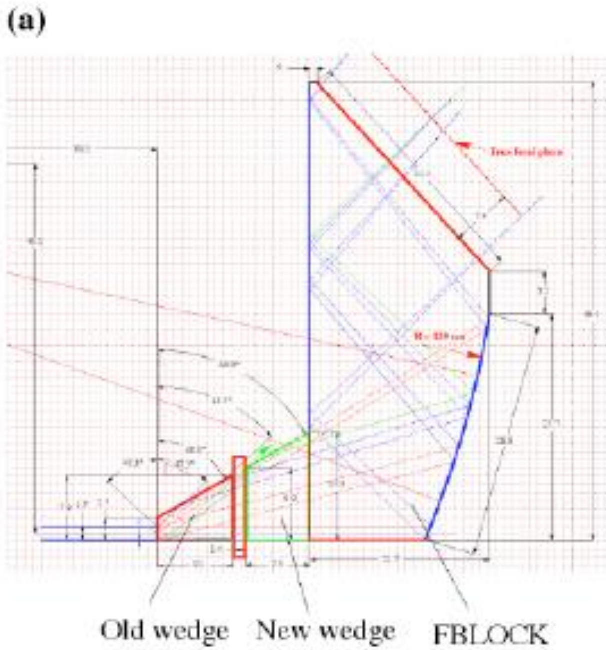
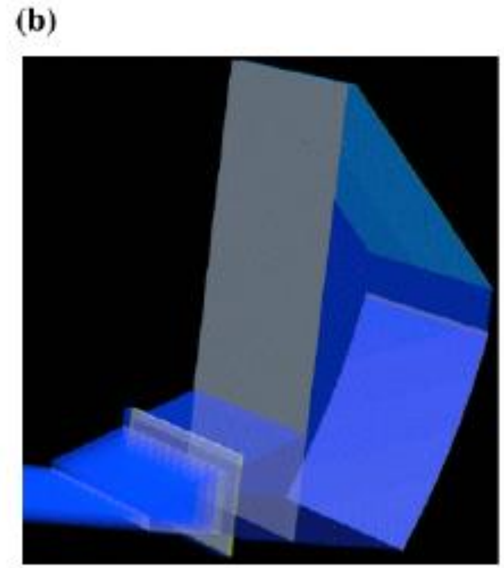
    - Space requirements.
    - Fast tubes have substantial material. SiPMs are noisy and neutron sensitive.
    - R&D underway

Barrel PID



(a) FDIRC optical design (dimensions in cm).



(b) Its equivalent in the GEANT 4 MC model.

Figure 17: Barrel FDIRC Design.

DPR Design

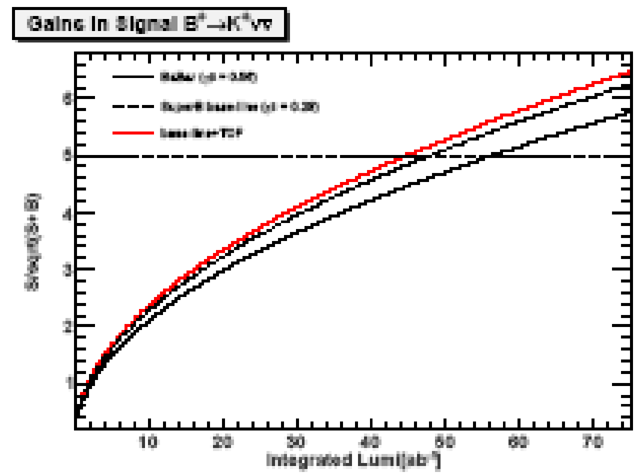
SLAC
Padova
Maryland
LAL Orsay
LPHNE

Forward PID option

Forward PID option ? ? ?

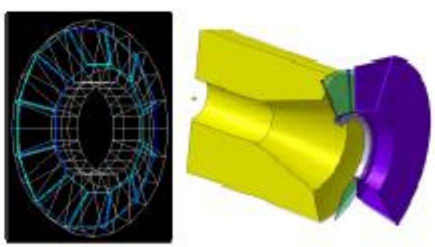
Decision about forward PID has not been taken yet. It is one of the issues in the agenda of the coming General SuperB Collaboration Meeting (Caltech December 14-18).

One benchmark is $B \to K^{(*)} \nu \bar{\nu}$.



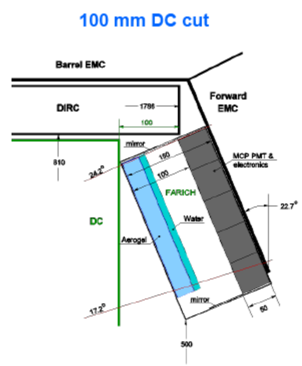
If decision would be YES to Forward PID then there are two options:

TOF



and FARICH.

BINP
Slac
Padova



FARICH has:

- Good K/p separation in 0.6 to 6.0 GeV
- Improves Momentum resolution By > 10%

But about 28% x0 in front of calorimeter

Many channel

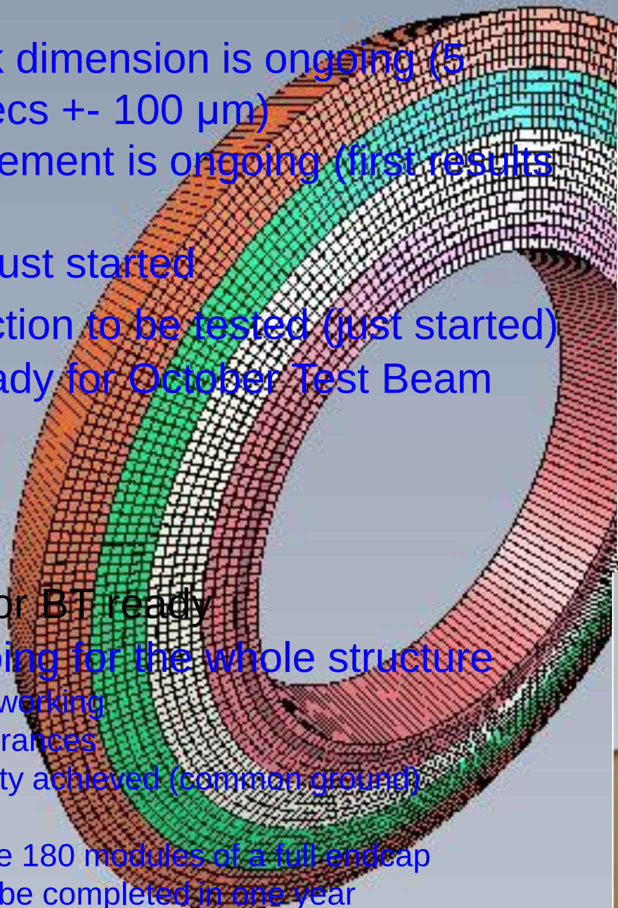
CALORIMETER

CRYSTAL STUDY

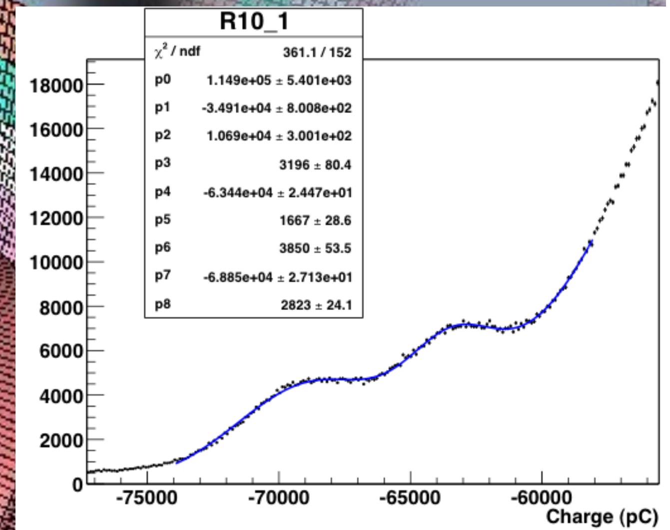
St. Gobain: 12 crystals received for the Beam Test

- Metrology to check dimension is ongoing (5 measured within specs +- 100 μm)
- Light Yield measurement is ongoing (first results as expected)
- Uniformity testing just started

SIPAT: new production to be tested (just started) schedule is to be ready for October Test Beam



LY(1.17MeV)=1003 p-e/MeV
LY(1.33MeV)=962 p-e/MeV



MECHANICS

Prototype structure for BT ready

Development is ongoing for the whole structure

- Production method working
- Precision within tolerances
- Electrical conductivity achieved (common ground)

What remains:

- Cost estimate in view of the 180 modules of a full endcap
- schedule for production to be completed in one year
- optical performance (to be studied with single cells)
- structural behavior (module elastic characterization, FEA of the support shell….)

Caltech
Perugia
Roma

Forward & Backward Calorimeter

The SuperB calorimeter will reuse the Babar barrel of CsI crystals. In the forward endcap CsI will be replced with YLSO crystals, while for the backward the solution is lead+scintillating fibers 2.8 mm Pb alternated with scintillator for different layers there are different

patterns :

- Right handed logarithmic spiral
- Left-handed logarithmic spiral
- Radial wedge

The readout fibers are embedded in grooves cut in scintillator.

As Photo-Detector a pixel device will be used Either MPPC or SiPM.

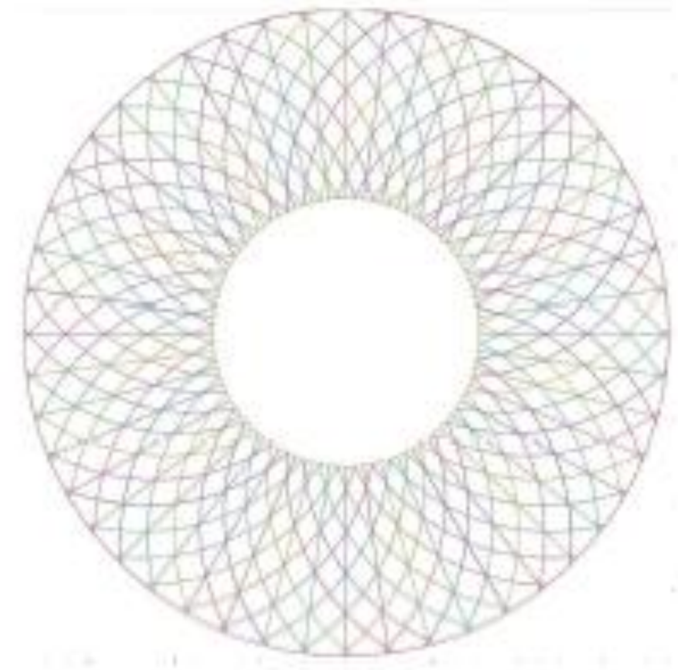


Figure 27: The backward EMC, showing the scintillator strip geometry for pattern recognition.

Bergen

IFR Advancements): Simulations

Fast Simulation

PID tables for muons and pions, based on optimization results, are in preparation and will replace the BaBar tables in the next event production

Ferrara
Krakow

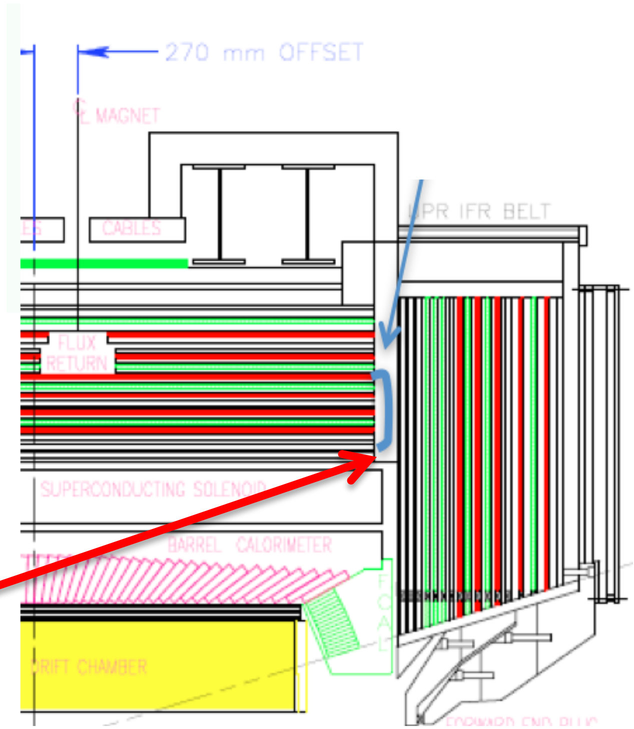
Detector Optimization

Added and tested a 9-layers configuration

Started with K_L study.

Background studies

Neutron background analysis continues with the study of possible shielding and remediation: added polyethylene shielding, investigating the possibility to move the SiPM of the inner layers in a outer gap.



Baseline Design from DPR

Bologna
Napoli
.....
LAL Orsay
SLAC

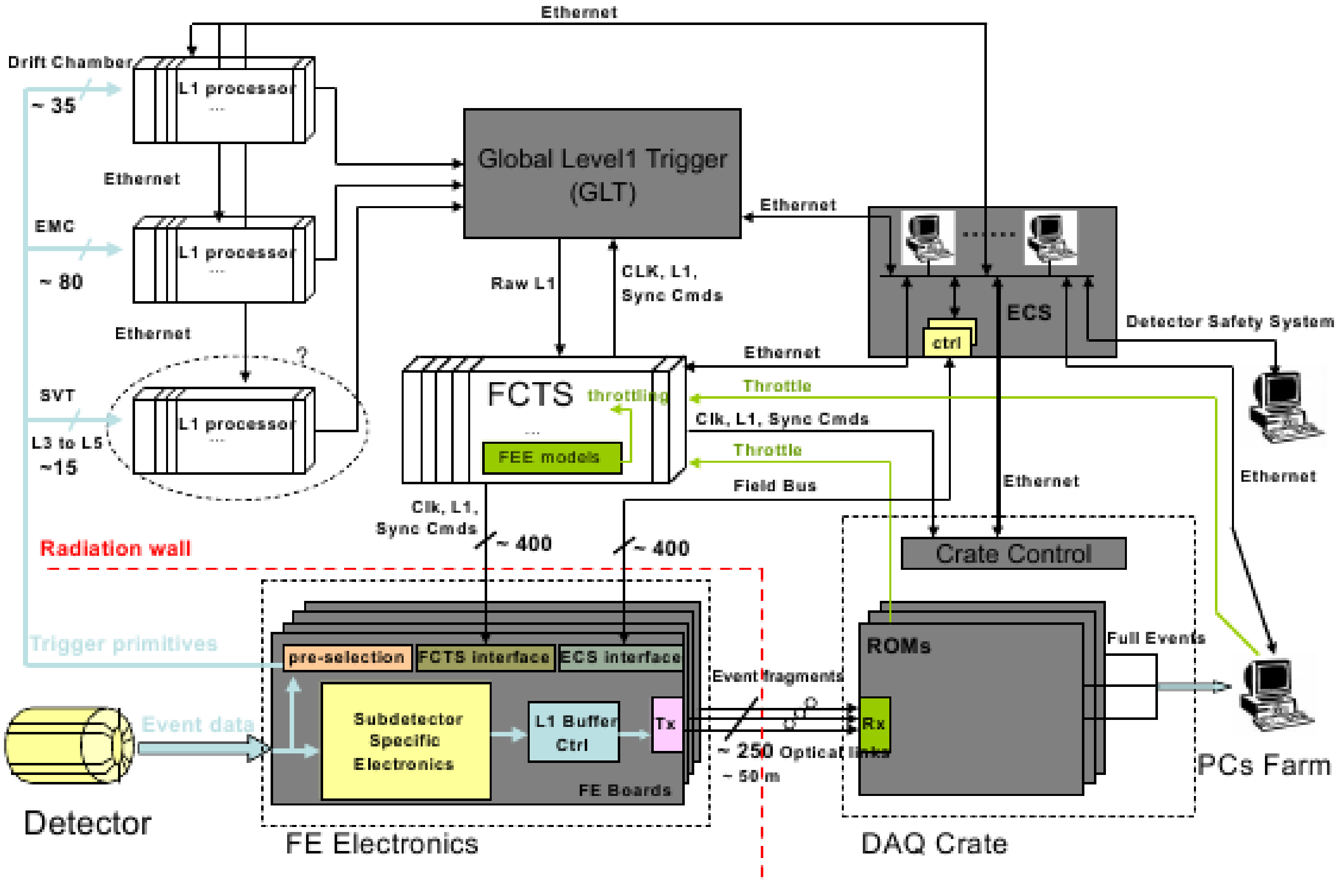


Figure 34: Overview of the ETD and Online global architecture

Systems with not yet assigned responsibilities

Luminosity monitors

Polarimeter measurements

Radiation monitors

Options by:
- Cagliari
- Catania
- Roma II
- Krakow
- Ohio

Technologies and Responsibilities should be agreed as soon as possible

Proto Technical Coordination

Detector Coordinators – B.Ratcliff, F. Forti
Technical Coordinator – W.Wisniewski

- SVT – G. Rizzo
- DCH – G. Finocchiaro, M.Roney
- PID – N.Arnaud, J.Vavra
- EMC – F.Porter, C.Cecchi
- IFR – R.Calabrese
- Magnet – W.Wisniewski
- Electronics, Trigger, DAQ – D. Breton, U. Marconi
- Online/DAQ – S.Luitz
- Offline SW
  - Simulation coordinator – D.Brown
  - Fast simulation – M. Rama
  - Full Simulation/Computing – F. Bianchi
- Background simulation – M.Boscolo, E.Paoloni
- Rad monitor –
- Lumi monitor –
- Polarimeter -
- Machine Detector Interface –
- Mechanical Integration Team F. Rafelli, W. Wisniewski, System Reps
- Central Electronics Team -
- +DGWG – A. Stocchi, M. Rama
- +Geometry Selection Task Forces- H. Jawahery, W. Wisniewski

In Preparation of TDR

INFN/AE_10/5, LAL-1

SuperB
Progress Reports

Physics

arXiv:1008.1541v1

SuperB
Progress Reports

The Collider

arXiv:1007.4241

SuperB
Progress Reports

Physics
Accelerator
Detector

arXiv:1009.6178v1

Since September 2010 the three SuperB Progress Reports have been published, it was an important step forward to the completion of the TDR , in time during 2011.
Machine parameters are fixed including the tunnel length , a Physics update after the 2008 Valencia document, the Detector is almost frozen.

The **XVII SuperB Workshop and Kick off Meetiing**

Meeting schedule

Kick off Day

May – June 2011						
Sa	*Su*	*Mo*	*Tu*	*We*	*Th*	*Fr*
28	29	30	31	1	2	3

Arrival

2nd Departure

Working Sessions

End Working Sessions

1st Departure

Det. Board
Accel. Board
Project. Board
Steering Committee

11:00	PLENARY
SML	KICK-OFF DAY
30	Status of the SuperB Project (R.Petronzio)
30	SuperB e il Piano Nazionale della Ricerca (A.Agostini)
30	SuperB nel Campus dell'Università di Tor Vergata (P.Masi)
30	SuperB as High Brilliance Light Source (E. Di Fabrizio)
13:30	*Lunch - Fuoco di Bosco*
15:30	PLENARY
SML	KICK-OFF DAY
30	The European Strategy Session and the New Particle Physics Roadmap (S. Stapnes)
30	Super Flavour Collires and ECFA (T. Nakada)

KICK-OFF DAY

Tuesday,May 31, 2011	
15.30	**Special MINI-PLENARYY**

17:00	The LHC(B) Discovery Potential (20') (Slides)	Guy Wilkinson (*University of Oxford*)
17:20	The Super-KEKB and Belle-II Projects (20') (Slides)	Peter Krizan (*Ljubljana Univ. and J. Stefan Institute*)
17:40	The BINP Super Tau-Charm Factory (20') (Slides)	Vladimir Druzhinin (*BINP, Novosibirsk, Russia*)
18:00	The BES-III Project (20') (Slides)	Hai-Bo Li

18:45	PLENARY
SML	Experiment Collaboration Forming

Real Kick-Off

Real Kick-Off

END