FUTURE BFACTORIES and….

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Outline

1. Introduction:
   - The Particle Physics Panorama beginning of XXI Century
   - Quest for Physics Beyond Standard Model
2. The Flavor way and the Physics Potential of future Super Flavor Factories
3. The machine options
4. The Detectors Design
5. Conclusions

Look for example

. https://superb-af.infn.it:5210/alfresco/d/a/workspace/SpacesStore/7650b097-7e73-4ee9-a732-fb4d8245157d/ESG2012-Physics.pdf

https://superb-af.infn.it:5210/alfresco/d/d/workspace/SpacesStore/1aec8f75-75a3-48db-a8e6-99eed65daf27/ESG2012-Detector.pdf

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Particle Physics Panorama

Extraordinary success of Standard Model of Particle Physics:

•Discovery of W and Z @ CERN SPS

•Measurement of electroweak parameters at Z peak (CERN LEP and SLAC SLD) and with LEPII (W pair production)

•Top quark discovery @FNAL Tevatron

Inside the Standard Model the confirmation of the Cabibbo-Kobayashi-Maskawa (CKM) paradigm:

•Discovery of direct CP Violation in K meson decay @CERN (Confirmed @FNAL)

•Discovery of Indirect and Direct CP Violation in b quark sector by BABAR and BELLE @Slac and @KEKB (confirmed by Tevatron experiments @FNAL)

•Preliminary precision measurement of CKM parameters.

DISCOVERY OF THE HIGGS BOSON @LHC

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Quest for Physics Beyond the Standard Model

Open Issues and facts:

Neutrino results including the last Daya Bay measurements indicate neutrino oscillations ($\sin^2 2\theta_{13} = 0.089 \pm 0.010(stat.) \pm 0.005(syst.)$).

The dominance of Dark Matter versus Visible Matter in the Universe

The huge amount of Dark Energy in the Universe.

It is enough to impose the exploration BSM

Tools:

- ❖Non accelerator experiments (as astrophysics observations….)
- ❖Experiments at particle accelerators

Two Paths to New Physics

Relativistic path

HIGH ENERGY FRONTIER

LHC

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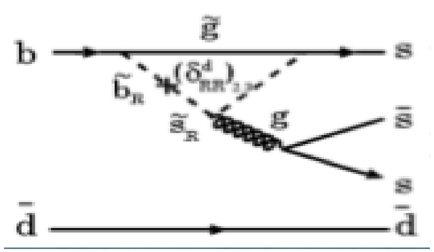
LHC Upgrade

Quantum path



HIGH INTENSITY FRONTIER

FLAVOR EXPERIMENTS

@High intensity Hadron Machines

&

@ e+e- Super Flavor Factories

Two Paths to New Physics

Relativistic path

HIGH ENERGY FRONTIER

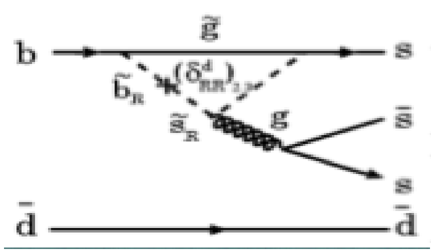
LHC

&

LHC Upgrade

Look for mass of new states

Quantum path



HIGH INTENSITY FRONTIER

FLAVOR EXPERIMENTS

@High intensity Hadron Machines

&

@ e+e- Super Flavor Factories

Look for Quantum Effects in Rare Decays

Beyond SM

Flavor Physics : search for NP through VIRTUAL EFFECTS

$$\mathcal{L}^{NP}_{eff} = \mathcal{L}_{SM} + \sum_k \Big(\sum_i C_i^k\, Q_i^{(k+4)}\Big)/\Lambda^k$$

New Physics effects in Flavor could come from :

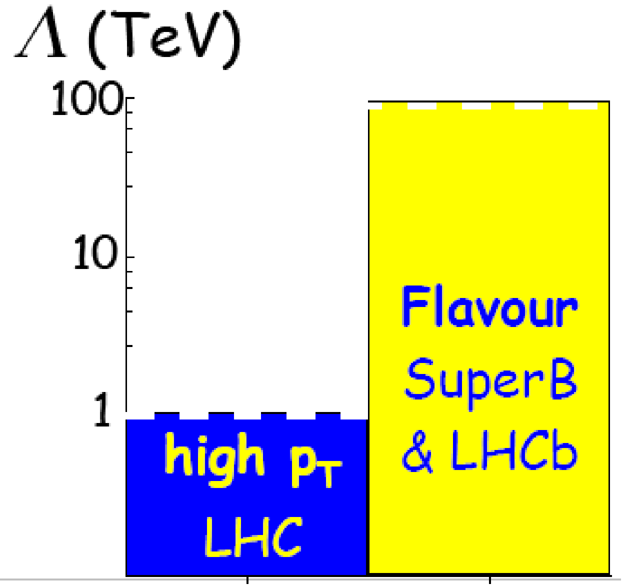
- New Physics Scale Λ
- Effective Flavor Violating couplings

The “flavour problem”:

if $\Lambda \approx 1$ TeV, $C's \ll 1$

The bright side:

flavour physics could probe NP scales beyond the reach of the LHC



See M.Ciuchini Talk at Orsay SuperB workshop. Feb.17,09

Future flavor prospects to explore BSM

• B_d angles	SLHCb Super Bfactories
• B_d sides from exclusive measurements	Super Bfactories
• $B_0 \to l^+ l^-$	in future all LHC Super Bfactories (only B_d)
• CPV in B_s (Φ_s)	in future all LHC
• CPV in B_s (A_{sl})	Super Bfactories
• Rare B decays	SLHCb Super Bfactories
• Charm CPV	SLHCb Super Bfactories Super TauCharm
• Charm CPV phase measurements	Super Bfactories Super TauCharm
• Full Tau studies	Super Bfactories Super TauCharm
• Entanglement studies	DaΦne Super Bfactories Super TauCharm
• K rare decays	Na62 KOTO ORKA

Future flavor prospects to explore BSM

- B_d angl
- B_d sides
- $B_0 \rightarrow l^+$ (only B_d)
- CPV in
- CPV in
- Rare B d
- Charm C TauCharm
- Charm C n
- Full Tau n
- Entangle TauCharm
- K rare d

My interpretation:

Complementarity between hadron, e+e- and kaon experiments.

To cover all eventualities, we need all areas supported.

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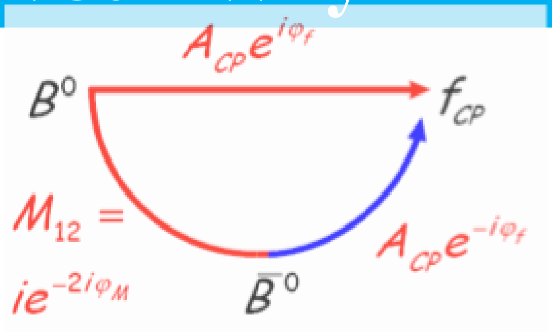
Some examples along the Flavour Way

Statistics

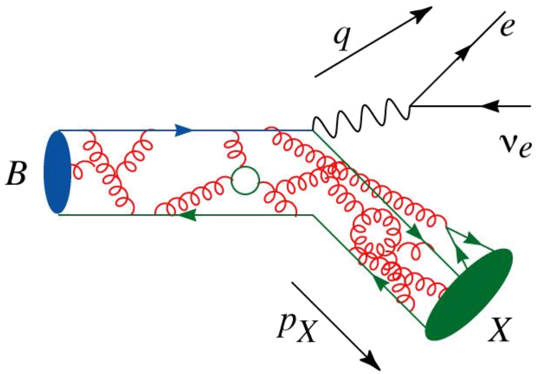
1. Explore the origin of CP violation

- 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



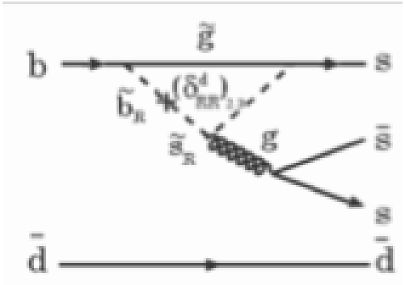
2. Precisely measure parameters of the standard model

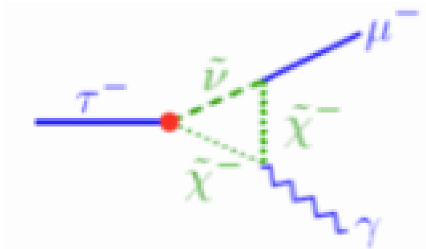
- For example the elements of the CKM quark mixing matrix
- Disentangle the complicated interplay between weak processes and strong interaction effects



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





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Physics Channels

B Physics

Time dependent CP Violation
$\boldsymbol{B \to \tau \nu}$
$\boldsymbol{B_s}$ Decays

Charm Physics

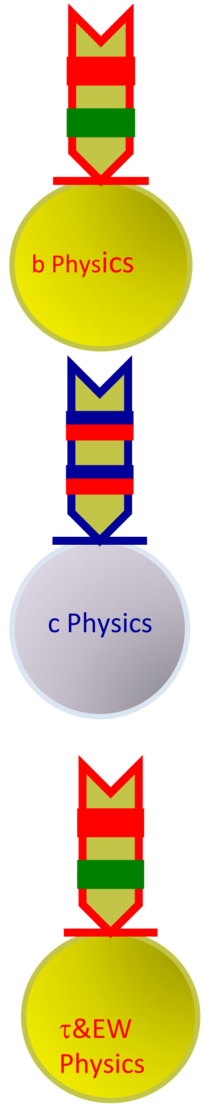
Charm mixing
CP violation in mixing
Time dependent CP Violation
Spectroscopy

τ Physics

LFV
τ g-2
EDM &CPV

Precision Measurements

$\sin^2\theta_W$
Lepton Universality **(*)**



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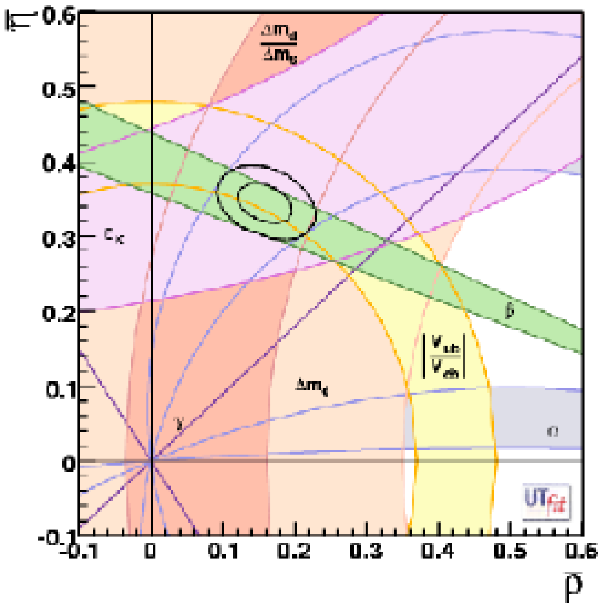
(*) @ Y(4S) and @4 GeV in production and in decay similar to NA48

B Physics CKM Matrix



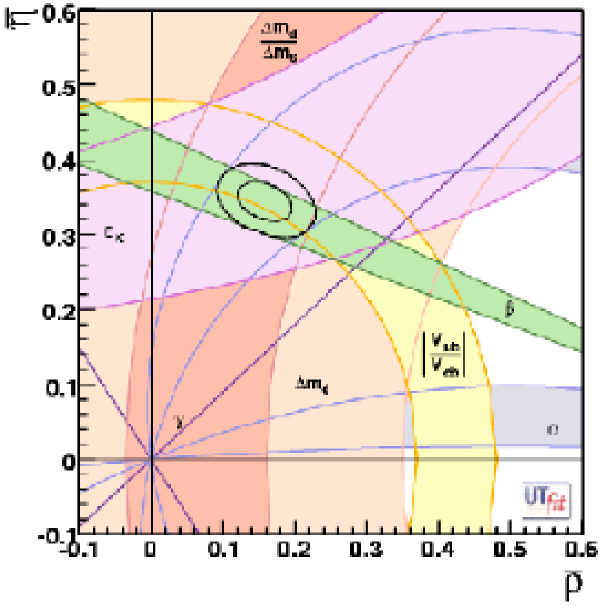
$$\Delta\overline{\eta} = 0.016$$

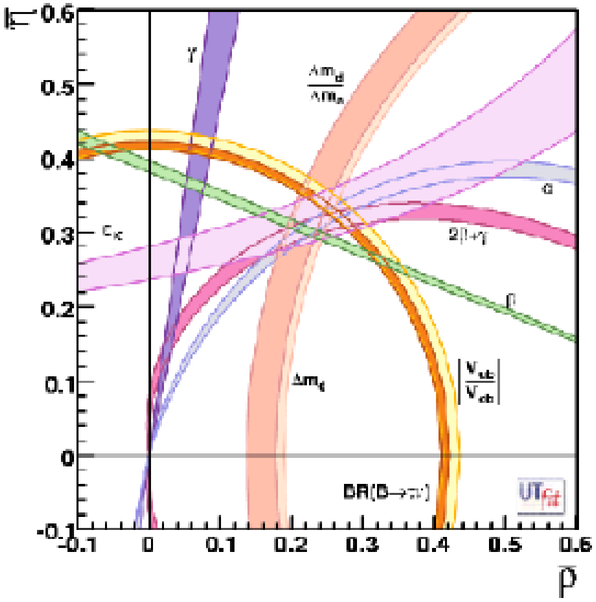
$$\Delta\overline{\rho} = 0.028$$

now L≤ 2ab $^{-1}$

B Physics CKM Matrix

b Physics





$$\Delta\overline{\eta} = 0.016$$

$$\Delta\overline{\rho} = 0.028$$

now L≤ 2ab $^{-1}$

$$\Delta\overline{\eta} = 0.0024$$

$$\Delta|V_{cb}|_{incl} = 0.5\% \quad \Delta|V_{cb}|_{excl} = 1.0\%$$

$$\Delta\overline{\rho} = 0.0028$$

$$\Delta|V_{ub}|_{incl} = 1.0\% \quad \Delta|V_{ub}|_{excl} = 3.0\%$$

75ab $^{-1}$ =5 years @ full luminosity of SuperB

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B Physics Time Dependent CP violation

b Physics

Time-dependent CP analysis can show signs of new physics. One has to study a set of modes:

$b \to s\bar{s}c$, $b \to s$

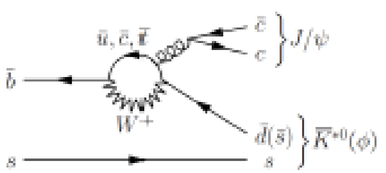
Current experimental results show Δ(SM - Observed):

$\Delta sin(2\beta) = 2.7\sigma$, penguin

$\Delta sin(2\beta) = 2.1\sigma$, tree

Golden modes in SuperB: $B \to J/\psi K^0$, $B \to \eta' K^0$, $B \to f_0 K^0_S$

Mode	Current Precision			Predicted Precision (75 ab^{-1})		
	Stat.	Syst.	ΔS^f (Th.)	Stat.	Syst.	ΔS^f (Th.)
$J/\psi K^0_S$	0.022	0.010	0 ± 0.01	0.002	0.005	0 ± 0.001
$\eta' K^0_S$	0.08	0.02	0.015 ± 0.015	0.006	0.005	0.015 ± 0.015
$\phi K^0_S \pi^0$	0.28	0.01	–	0.020	0.010	–
$f_0 K^0_S$	0.18	0.04	0 ± 0.02	0.012	0.003	0 ± 0.02
$K^0_S K^0_S K^0_S$	0.19	0.03	0.02 ± 0.01	0.015	0.020	0.02 ± 0.01
ϕK^0_S	0.26	0.03	0.03 ± 0.02	0.020	0.005	0.03 ± 0.02
$\pi^0 K^0_S$	0.20	0.03	0.09 ± 0.07	0.015	0.015	0.09 ± 0.07
ωK^0_S	0.28	0.02	0.1 ± 0.1	0.020	0.005	0.1 ± 0.1
$K^+ K^- K^0_S$	0.08	0.03	0.05 ± 0.05	0.006	0.005	0.05 ± 0.05
$\pi^0 \pi^0 K^0_S$	0.71	0.08	–	0.038	0.045	–
ρK^0_S	0.28	0.07	-0.13 ± 0.16	0.020	0.017	-0.13 ± 0.16



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Golden Measurements: CKM

- Comparison of relative benefits of Super BFactories ($75ab^{-1}$) vs. existing measurements and LHCb ($5fb^{-1}$)

Observable/mode	Current (now)	LHCb (2017)	Super BFactory	LHCb upgrade (2030?)	Theory
α	Blue	Blue	Green	Blue	Yellow
β from $b \to c\bar{c}s$	Blue	Blue	Green	Green	Green
$B_d \to J/\psi\pi^0$	Yellow	Red	Green	Red	Green
$B_s \to J/\psi K^0_S$	Red	Yellow	Red	Blue	Green
γ	Yellow	Blue	Green	Green	Green
$\lvert V_{ub}\rvert$ inclusive	Blue	Yellow	Green	Blue	Blue
$\lvert V_{ub}\rvert$ exclusive	Blue	Yellow	Green	Blue	Blue
$\lvert V_{cb}\rvert$ inclusive	Blue	Yellow	Green	Blue	Blue
$\lvert V_{cb}\rvert$ exclusive	Blue	Yellow	Green	Blue	Blue

LHCb can only use ρπ

βtheory error B_d

βtheory error B_s

Need an e^+e^- environment to do a precision measurement using semi-leptonic B decays.

Experiment: Red = No Result, Yellow = Moderate Precision, Blue = Precise, Green = Very Precise

Theory: Yellow = Moderately clean, Blue = Clean Need lattice, Green = Clean

B Physics $B \to \tau\nu$

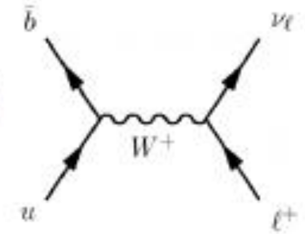
b Physics

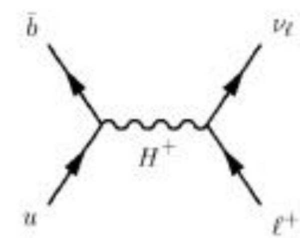
Precise SM prediction:

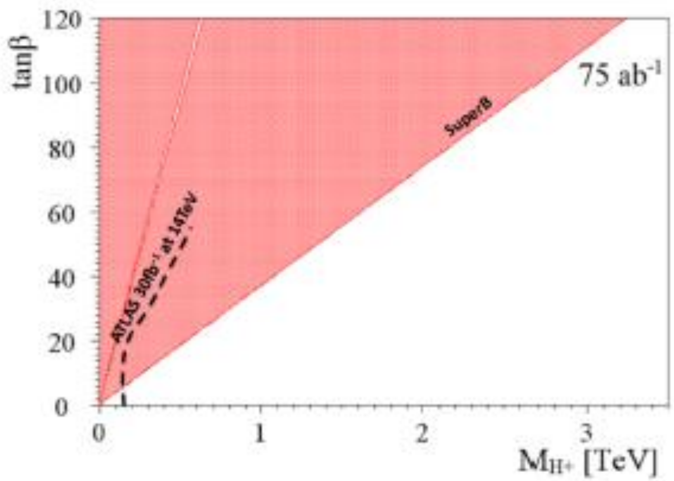
$$Br(B \to l\nu) = \frac{G_F^2 m_B}{8\pi} m_l^2 \left(1 - \frac{m_l^2}{m_B^2}\right) f_B^2 |V_{ub}|^2 \tau_B$$

In SUSY:

$$Br(B \to l\nu) = \frac{G_F^2 m_B}{8\pi} m_l^2 \left(1 - \frac{m_l^2}{m_B^2}\right) f_B^2 |V_{ub}|^2 \tau_B \left(1 - \frac{\tan^2\beta}{1 + \bar{\epsilon}\tan\beta} \frac{m_B^2}{m_H^2}\right)$$







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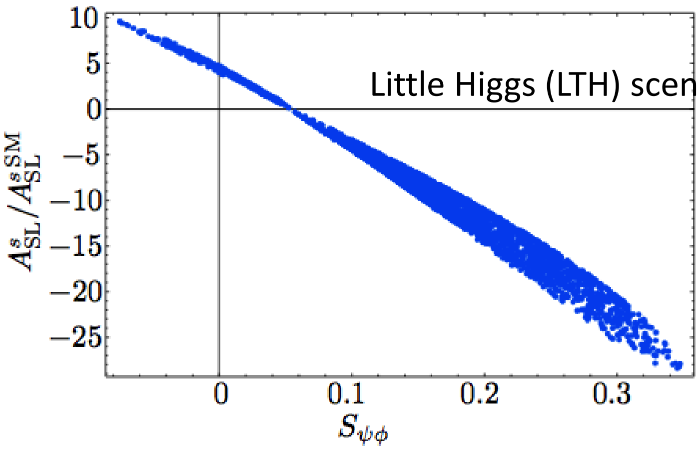
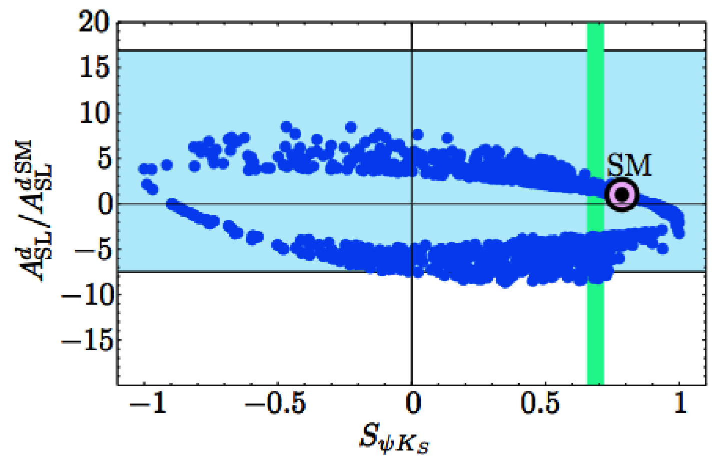
B_s physics with Bfactories @Y(5s)

- Can cleanly measure A^s_{SL} using 5S data

$$A^s_{\rm SL} = \frac{\mathcal{B}(B_s \to \overline{B}_s \to D_s^{(*)-} l^+ \nu_l) - \mathcal{B}(\overline{B}_s \to B_s \to D_s^{(*)+} l^- \nu_l)}{\mathcal{B}(B_s \to \overline{B}_s \to D_s^{(*)-} l^+ \nu_l) + \mathcal{B}(\overline{B}_s \to B_s \to D_s^{(*)+} l^- \nu_l)} = \frac{1 - |q/p|^4}{1 + |q/p|^4}.$$

$$\sigma(A^s_{SL}) \sim 0.004 \text{ with a few } ab^{-1}$$

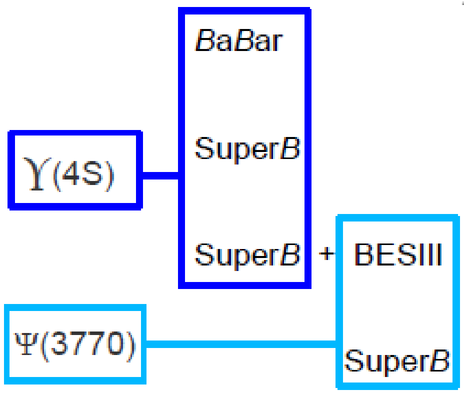




- Super Bfactory can also study rare decays with many neutral particles, such as $B_s \longrightarrow \gamma\gamma$, which can be enhanced by SUSY.

c Physics

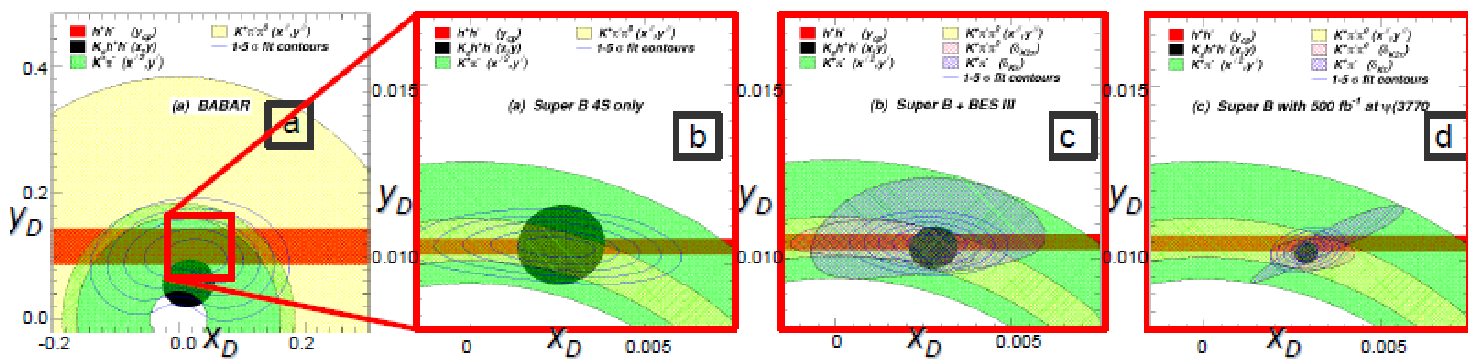
Charm Mixing, x_D and y_D: improving the picture



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)
(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)
(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)
(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)

SuperB

ArXiv: 1008.1541v1



Is it possible to further reduce the systematic uncertainties from Dalitz plots analysis? Maybe, using a model-independent approach: Bondar et al. Phys. Rev. **D** 82, 034033 (2010)

Interest of some run @ threshold

- *Major topics of charm threshold physics are*: search for new physics beyond Standard Model, overcome the non-perturbative QCD roadblock, test pQCD calculations.
- I*mpact of charm physics at threshold on flavor physics measurements is important*:
  - semileptonic asymmetries - a_{SL}
  - search for new physics effects in rare or forbidden decays: $D^0 \rightarrow ⌠^+⌠^-$, $D^0 \rightarrow hl^+l^-$
  - remove Dalitz model dependency in D^0 mixing and CP violation measurements and γ/Φ_3 measurements;
  - precision measurement of $|V_{cs}|$, $|V_{cd}|$ and $D_{(s)}$ form factors;
  - precision measurement of decay constants f_D, f_{Ds};
- Systematic errors do not seem to be a roadblock for the relevant measurements and future high statistics data sample will be beneficial.

D^0 yields for 1 year for machine running@ Charm threshold vs running @Y(4s)

1 year running at Ψ(3770) 10^{35}:

– $n(D^0)$=1.5 ab^{-1}·3.7 nb·2 = $11.2 \cdot 10^9$

1 year running at Υ(4S) with 10^{36}:

– $n(D^0)$=15 ab^{-1}·1.3 nb ·0.45= $8.8 \cdot 10^9$

Integrated luminosity

Cross section

Average number of D^0 per event

(from $c\bar{c}$ events only)

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Sensitivity of low energy high luminosity experiments to rare charm channels

- What is rare? At least
  - CLEO-c at ψ(3770): $0.8fb^{-1}$ .... sensitivity of a few $\times 10^{-5}$
  - BES III at ψ(3770): ~$10fb^{-1}$ .... sensitivity of a few $\times 10^{-6}$
  - SuperB at ψ(3770): $1ab^{-1}$ .... sensitivity of a few $\times 10^{-8}$
    - Two large jumps in data samples could change the perspective on rare decays with time ...
    - Superb will approach a single event sensitivity at ~10^{-9} at threshold
  - BaBar/Belle at the ϒ(4S): ~$0.5\text{-}1ab^{-1}$ of data [all charm 0.6-1.2 $\times 10^{9}$ events]
  - SuperB/Belle II at the ϒ(4S): $50\text{-}75ab^{-1}$ of data

LHCb:

- Vast numbers in a hadronic environment: good for charged track final states if channel can be triggered on efficiently.
- Not good with neutral final states (ν's, γ's, π^0's etc.)

TDCPV also @ threshold

c Physics

0.5 ab-1 @Ψ(3770)

ϕ_{MIX} $\beta_{c,\,eff}$

Parameter	SuperB Ψ(3770) SL	SuperB Ψ(3770) SL+K	SuperB Υ(4S) $\pi_s^\pm$	LHCb $\pi_s^\pm$	Belle II $\pi_s^\pm$
$\sigma_{\phi_{\pi\pi}} = \sigma_{arg(\lambda_{\pi\pi})}$	5.7°	2.4°	2.2°	3.0°	2.8°
$\sigma_{\phi_{KK}} = \sigma_{arg(\lambda_{KK})}$	3.5°	1.4°	1.6°	1.8°	1.8°
$\sigma_{\beta_{c,eff}}$	3.3°	1.4°	1.4°	1.9°	1.7°

$$\sigma_{\phi_{KK}} = \sigma_{arg(\lambda_{KK})} = \sigma_{\phi_{MIX}}$$

$$A_{CP}^{Phys}(t) = \frac{\overline{\Gamma}^{Phys}(t) - \Gamma^{Phys}(t)}{\overline{\Gamma}^{Phys}(t) + \Gamma^{Phys}(t)} = -\Delta\omega + \frac{(D+\Delta\omega)e^{\Delta\Gamma t/2}(|\lambda_f|^2-1)\cos\Delta M t + 2\Im(\lambda_f)\sin\Delta M t}{(1+|\lambda_f|^2)h_+/2 + h_-\Re(\lambda_f)}$$

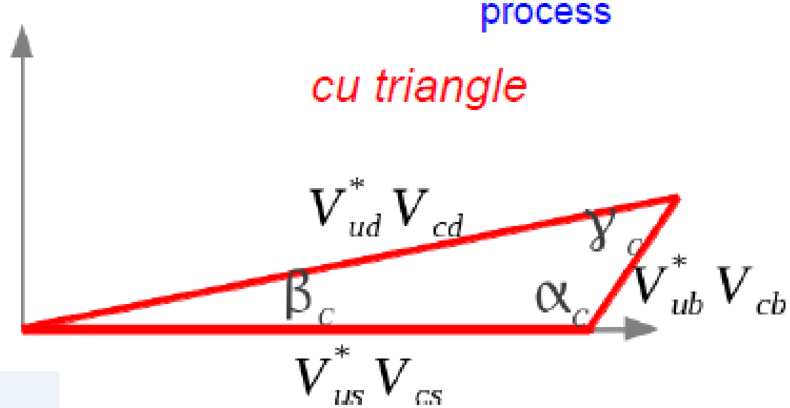
$$\lambda_f = \left|\frac{q}{p}\right| e^{i\phi_{MIX}} \left|\frac{\bar{A}}{A}\right| e^{i\phi_{CP}} = \left|\frac{q}{p}\right| e^{i\phi_{MIX}} e^{-2i\phi_T^W}$$

if tree-dominated process

Remember from the mixing Part of this talk:

$$x = \frac{\Delta M}{\Gamma}$$

$$y = \frac{\Delta\Gamma}{2\Gamma}$$



$$\alpha_c = arg\left[\frac{-V_{ub}^* V_{cb}}{V_{us}^* V_{cs}}\right] = (111.5 \pm 4.2)^o$$

$$\beta_c = arg\left[\frac{-V_{ud}^* V_{cd}}{V_{us}^* V_{cs}}\right] = (0.0350 \pm 0.0001)^o$$

$$\gamma_c = arg\left[\frac{-V_{ub}^* V_{cb}}{V_{ud}^* V_{cd}}\right] = (68.4 \pm 0.1)^o$$

Selection of some interesting measurements on Charm sector for a few ab^{-1} taken @/near charm threshold

Decay mode	*Expected precision*
• $D^0 \to \mu^+\mu^-, e^+e^-, e^+\mu^-, \ldots$	few 10^{-9} at 90% C.L.
• $D^+ \to \pi^+ \nu\nu$, $D^0 \to K^0 \nu\nu$, $D_s^+ \to \pi^+ \nu\nu$	TBD but only @ Threshold
• A_{CP} in $D^0 \to \pi^+ \pi^0$	10^{-3}
• A_{CP} in $D \to V \gamma$	10^{-3}
• cos (delta_kpi) and other strong phases [they improve measurements of UT gamma and D mixing]	1 deg
• $D^0 \to X l^+l^-$ (BF vs $M(l^+l^-)$)	TBD
• a_{SL}	15%
Interesting but limited in theoretical interpretation	
• $\sin(2\beta_c$_eff)	<2 deg
• $D^0 \to \gamma\gamma$	10^{-8} (~SM value)

REMARK: Need an asymmetric energy machine at low energy

$1ab^{-1}$ of data at the $\psi(3770)$ is equivalent to about $75ab^{-1}$ of data at the $Y(4S)$.

~3 ab^{-1} before 2020 should be the target to ensure results are relevant (≈twice the precision of Belle II).

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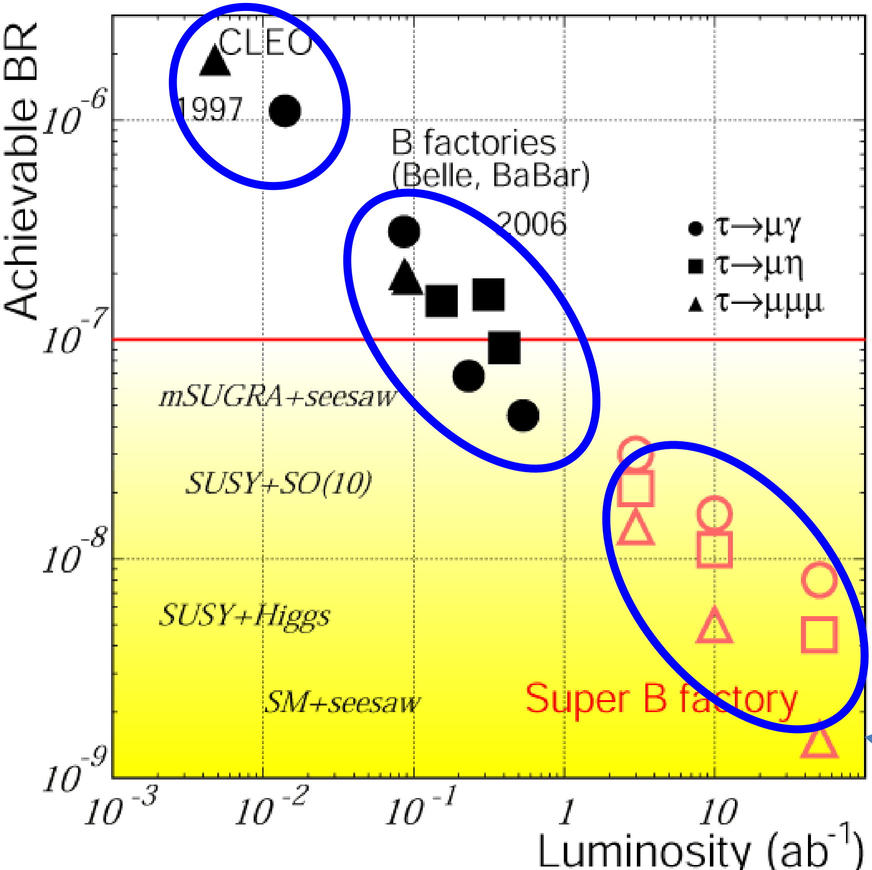
Tau Physics LFV from $\tau \rightarrow \mu \gamma$

τ&EW Physics

Present limit from Belle with 7 10^{10} $\tau\tau$ pairs at Υ(4s) is : ~ 3×10^{-8} ,slightly lower than BABAR's with a double of the events.



SuperB with 75 ab-1 has 7 10^{10} $\tau\tau$ pairs at Υ(4s) (Similar for BELLEII)

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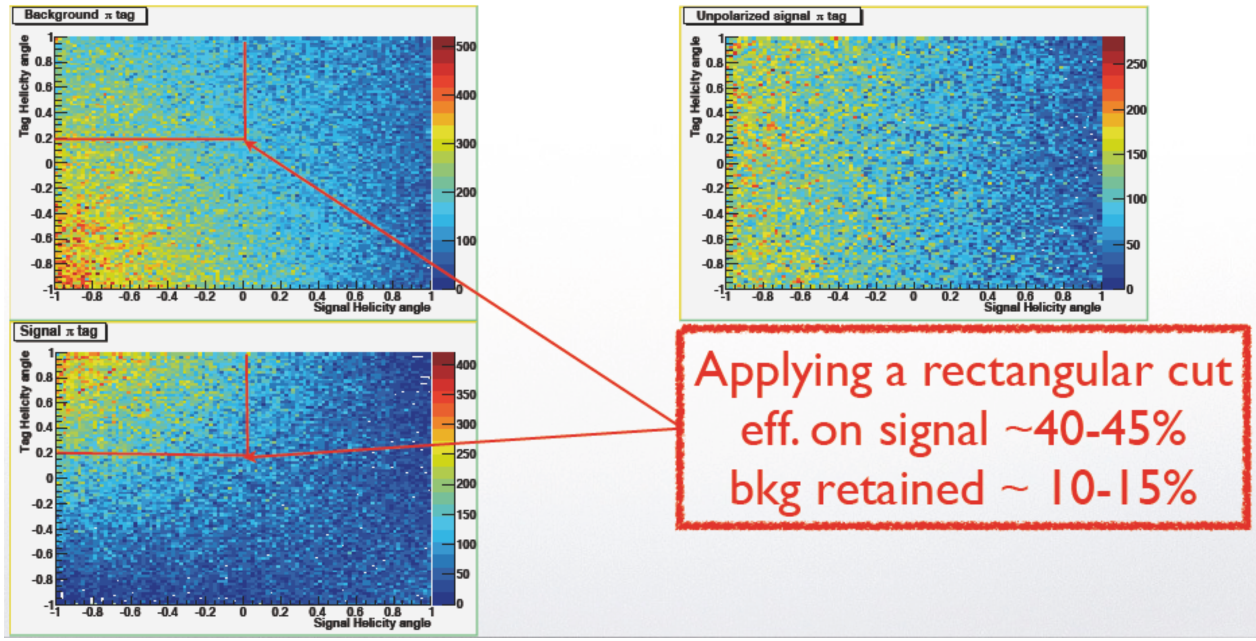
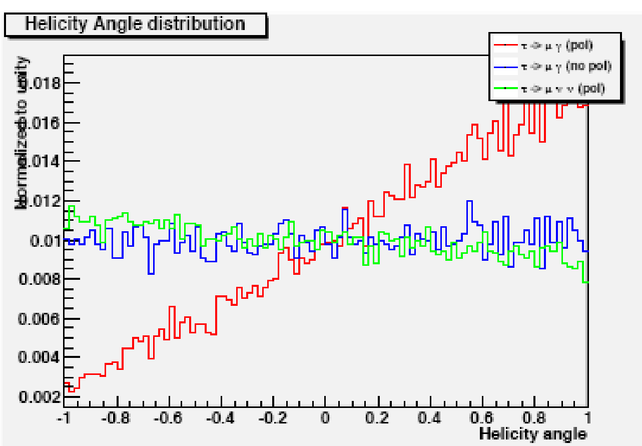
Polarized beam and tag on leptons and on hadrons (t→ p n /t→ r n) reduces irreducible background!



75 ab^{-1}

Sensitivity improves at least by a factor ≥1.5
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

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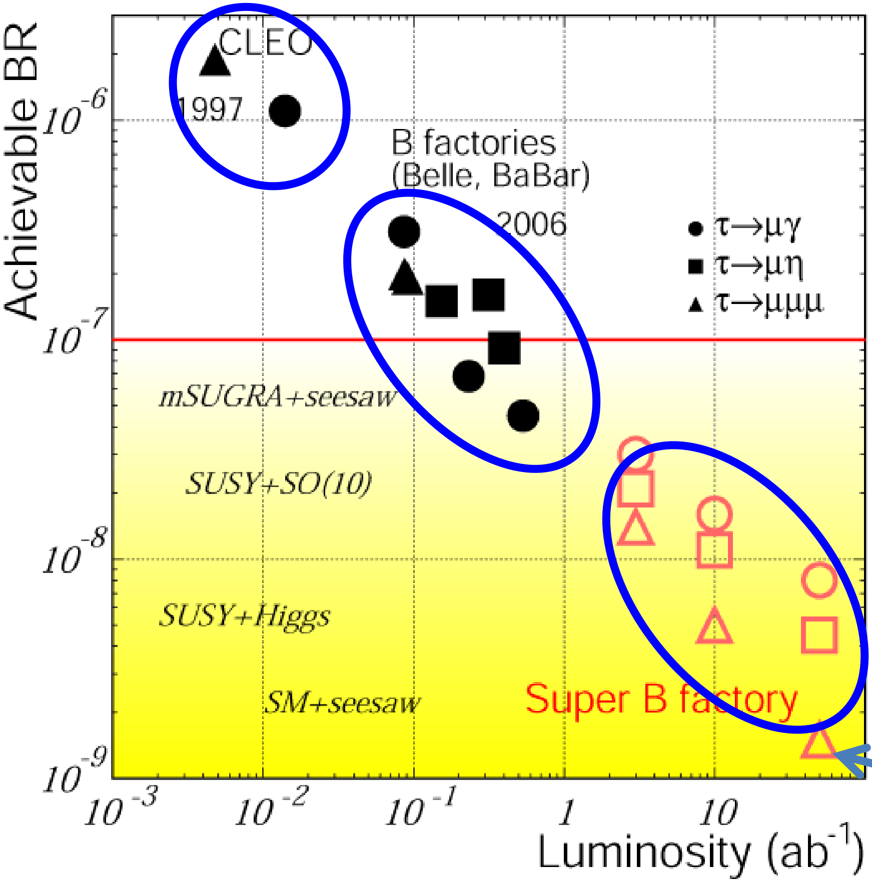
Tau Physics LFV from $\tau \rightarrow \mu \gamma$

τ&EW Physics

Present limit from Belle with 7 10^{10} $\tau\tau$ pairs at Y(4s) is : ~ 3×10^{-8} ,slightly lower than BABAR's with a double of the events.



The SuperB analysis considers the use of the polarization and the tag with pions and rhos. If the violating term is left handed its contribution (as shown in many presentations) is a reduction of the BKG due to q qbar and normal decays with a gamma in the final state by a factor ≥ 1.5. We can expect a limit <2 10 -9. If anyway LFV is discovered, the chirality of LFV source can be determined with polarization.

SuperB with 75 ab-1 has 7 10^{10} $\tau\tau$ pairs at Y(4s)

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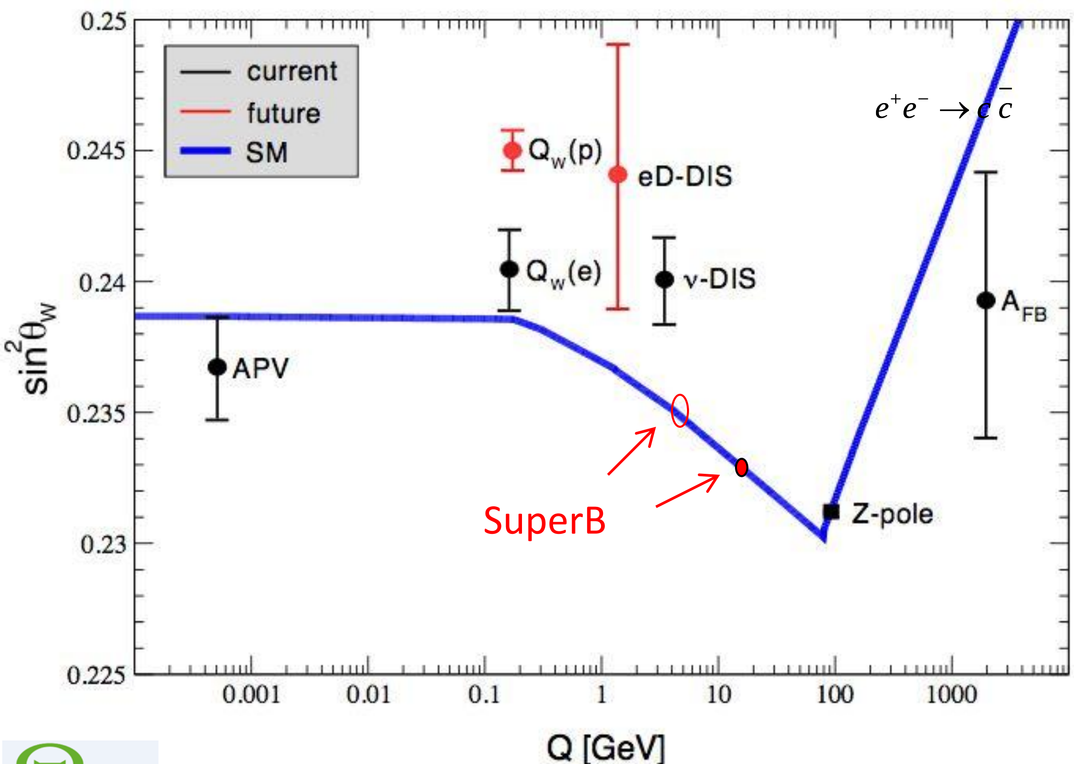
τ&EW Physics

POLARIZATION: Precision Electroweak

- $\sin^2\theta_W$ can be measured with polarized e^- beam at $\sqrt{s}=\Upsilon(4S)$ is theoretically clean, c.f. b-fragmentation at Z pole



Measure LR asymmetry in

$$e^+e^- \to b\bar{b}$$

$$e^+e^- \to \mu^+\mu^-$$

$$e^+e^- \to \tau^+\tau^-$$

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

Can also perform crosscheck at ψ(3770) and use $c\bar{c}$ instead of $b\bar{b}$

$$e^+e^- \to cc$$

Summary SuperB Factory with 75 ab^{-1}

Similar values for BELLEII (a part for polarisation)

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

Theory: Moderately clean · Clean Need lattice · Clean

	Observable/mode Luminosity	Current $\sim 1\ \mathrm{ab}^{-1}$	Super BFactory	Theory	
Tau	$\tau \to \mu\gamma$ $\tau \to e\gamma$	Moderate Precision	Very Precise	Clean	Benefit from polarised e⁻ beam
B_u, B_d	$B \to \tau\nu, \mu\nu$	Moderate Precision	Precise	Clean Need lattice	very precise with improved detector
	$B \to K^{(*)+}\nu\bar{\nu}$	No Result	Very Precise	Clean	Statistically limited: Ang. analysis with >75ab⁻¹
	S in $B \to K^0_S\pi^0\gamma$	Moderate Precision	Very Precise	Moderately clean	Right handed currents
	S (other penguin modes)	Moderate Precision	Very Precise	Moderately clean	SuperB measures many more modes
	$A_{CP}\ (B \to X_s\gamma)$	Precise	Very Precise	Clean	systematic error is main challenge
	$\mathrm{BR}(B \to X_s\gamma)$	Precise	Very Precise	Moderately clean	control systematic error with data
	$\mathrm{BR}(B \to X_s ll)$	Moderate Precision	Very Precise	Clean	
	$\mathrm{BR}(B \to K^{(*)}ll)$	Moderate Precision	Very Precise	Moderately clean	SuperB measures e mode well, LHCb does μ
B_s	$B_s \to \mu\mu$	No Result	No Result	Clean	
	β_S from $B_s \to J/\psi\,\phi$	No Result	No Result	Clean	
	$B_s \to \gamma\gamma$	No Result	Precise	Clean	
	a_{sl}	No Result	Very Precise	Clean	
Charm	Mixing parameters	Moderate Precision	Very Precise	Clean	
	CP Violation	No Result	Very Precise	Clean	Clean NP search
Eweak	$\sin^2\theta_W$ at $\Upsilon(4S)$	No Result	Very Precise	Clean	Theoretically clean
	$\sin^2\theta_W$ at Z-Pole	Very Precise	No Result	Moderately clean	b fragmentation limits interpretation

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	≥80%	Enables τ *CP* and *T* violation studies, measurement of τ *g*-2 and improves sensitivity to lepton flavor-violating decays. Precise measurements of $\sin^2\theta_W$.

1 year @ $\Upsilon(4S)$ integrates 15 ab^{-1}
1year @ ~4GeV integrates 1.5 ab^{-1}

~

		Base Line		Low Emittance		High Current		τ/charm	
Parameter	Units	HER (e+)	LER (e-)	HER (e+)	LER (e-)	HER (e+)	LER (e-)	HER (e+)	LER (e-)
LUMINOSITY (10^{36})	cm^{-2} s^{-1}	1		1		1		0.1	
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	60		60		60		60	
Piwinski angle	rad	20.80	16.91	29.42	23.91	13.12	10.67	8.00	6.50
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
ε_x (without IBS)	nm	1.97	1.82	1.00	0.91	1.97	1.82	1.97	1.82
ε_x (with IBS)	nm	2.00	2.46	1.00	1.23	2.00	2.46	5.20	6.4
ε_y	pm	5	6.15	2.5	3.075	10	12.3	13	16
σ_x @ IP	μm	7.211	8.872	5.099	6.274	10.060	12.370	18.749	23.076
σ_y @ IP	μm	0.036	0.036	0.021	0.021	0.054	0.054	0.092	0.092
Σ_x	μm	11.433		8.085		15.944		29.732	
Σ_y	μm	0.050		0.030		0.076		0.131	
σ_L (0 current)	mm	4.69	4.29	4.73	4.34	4.03	3.65	4.75	4.36
σ_L (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	
Buckets distance	ns	4.20		4.20		2.10		2.10	
Ion gap	%	2		2		2		2	
RF frequency	MHz	476		476		476		476	
Harmonic number		1998		1998		1998		1998	
Number of bunches		465		465		931		931	
N. Particle/bunch (10^{10})		5.08	6.56	3.92	5.06	4.15	5.36	1.83	2.37
Tune shift x		0.0026	0.0040	0.0020	0.0031	0.0053	0.0081	0.0063	0.0096
Tune shift y		0.1067	0.1069	0.0980	0.0981	0.0752	0.0755	0.1000	0.1001
Long. 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	0.166
σ_E (full current)	δE/E	6.43E-04	7.34E-04	6.43E-04	7.34E-04	6.43E-04	7.34E-04	6.94E-04	7.34E-04
CM σ_E	δE/E	5.00E-04		5.00E-04		5.00E-04		5.26E-04	
Total lifetime	min	4.23	4.48	3.05	3.00	7.08	7.73	11.41	6.79
Total RF Power	MW	16.38		12.37		28.83		2.81	

Parameter Table

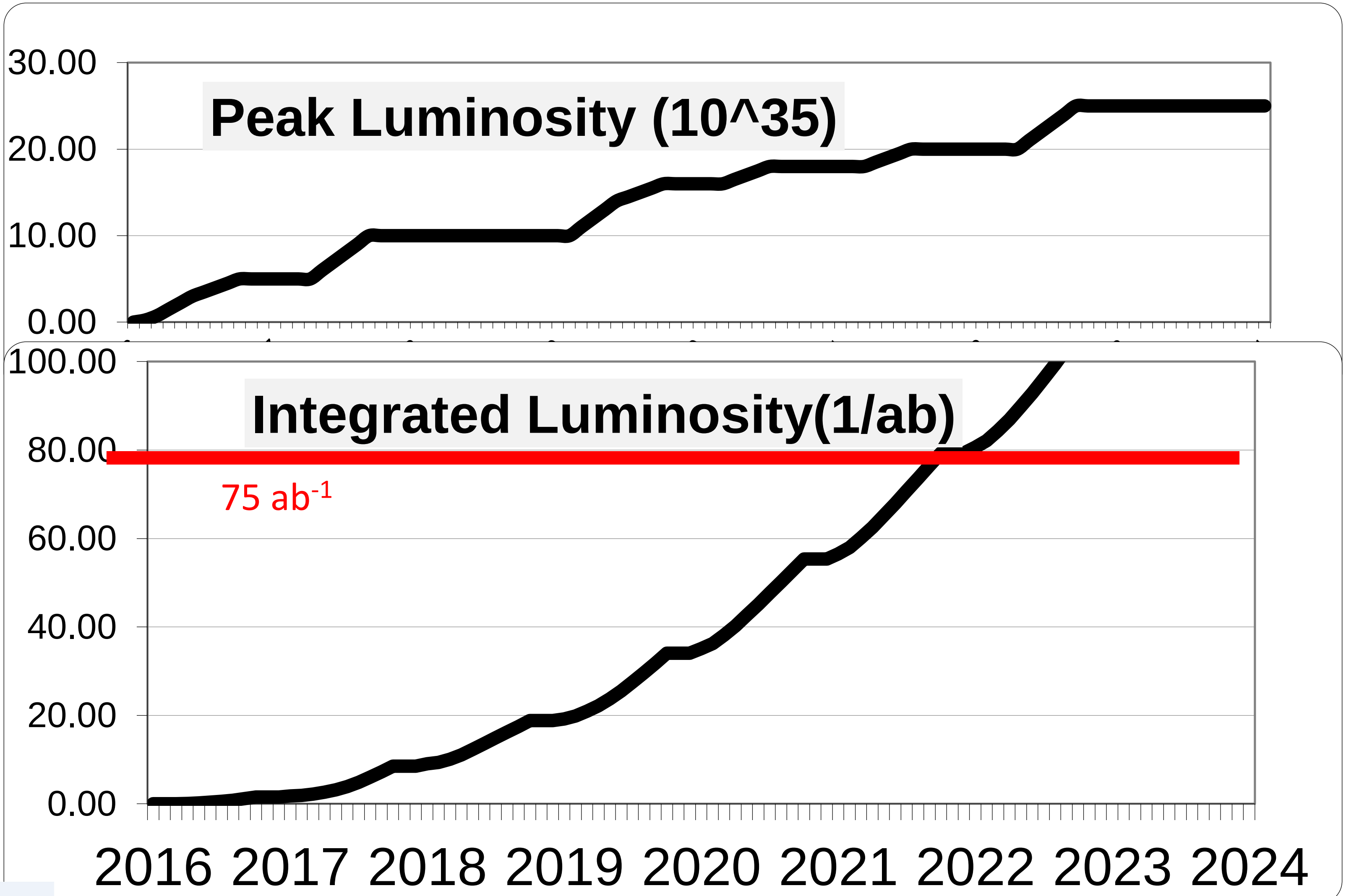
Tau/charm threshold running at 10^{35}

Baseline + other 2 options:
- **Lower y-emittance**
- **Higher currents (twice bunches)**

Baseline:
- **Higher emittance due to IBS**
- **Asymmetric beam currents**

RF power includes SR and HOM

A recent but obsolete slide of the SuperB Luminosity model



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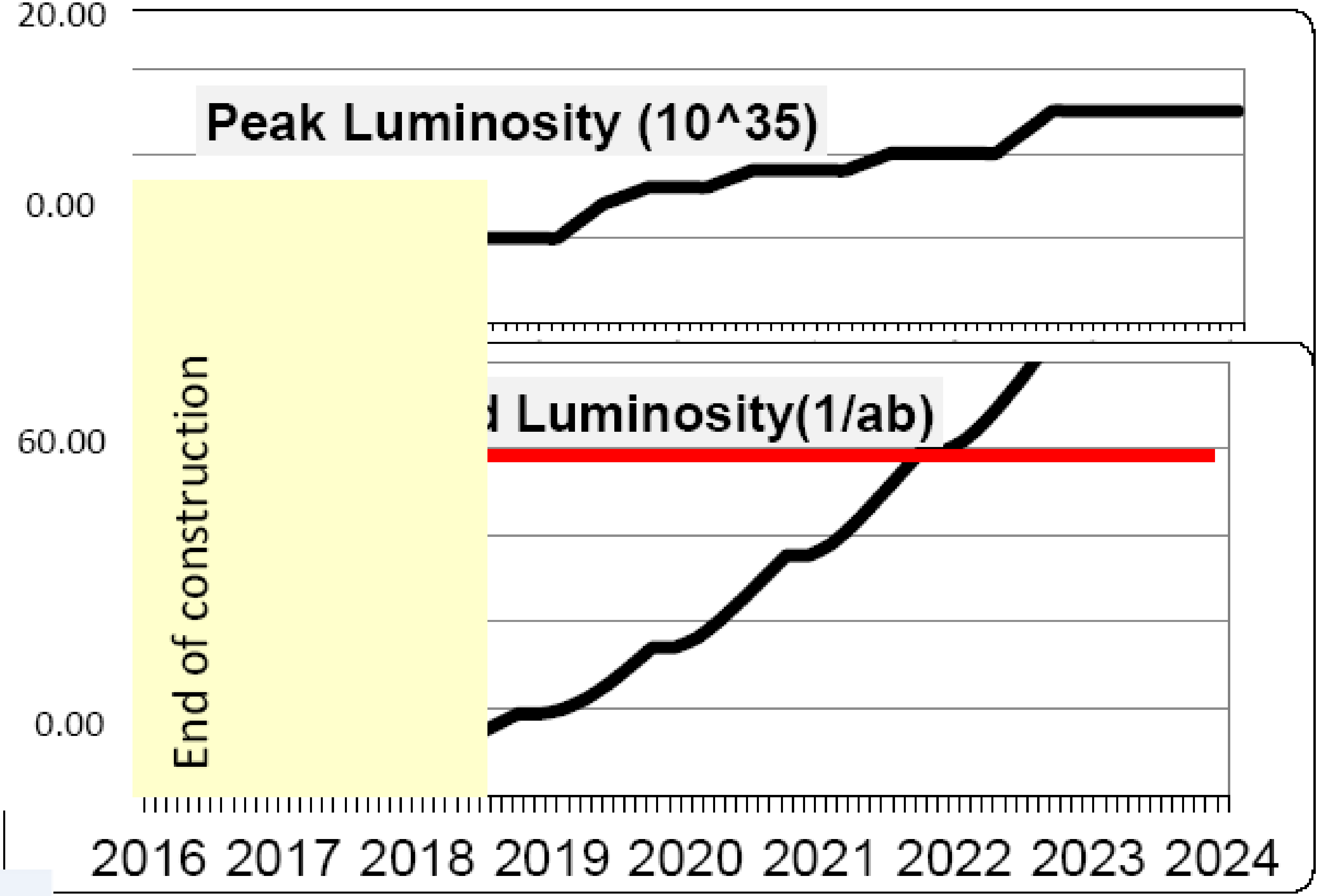
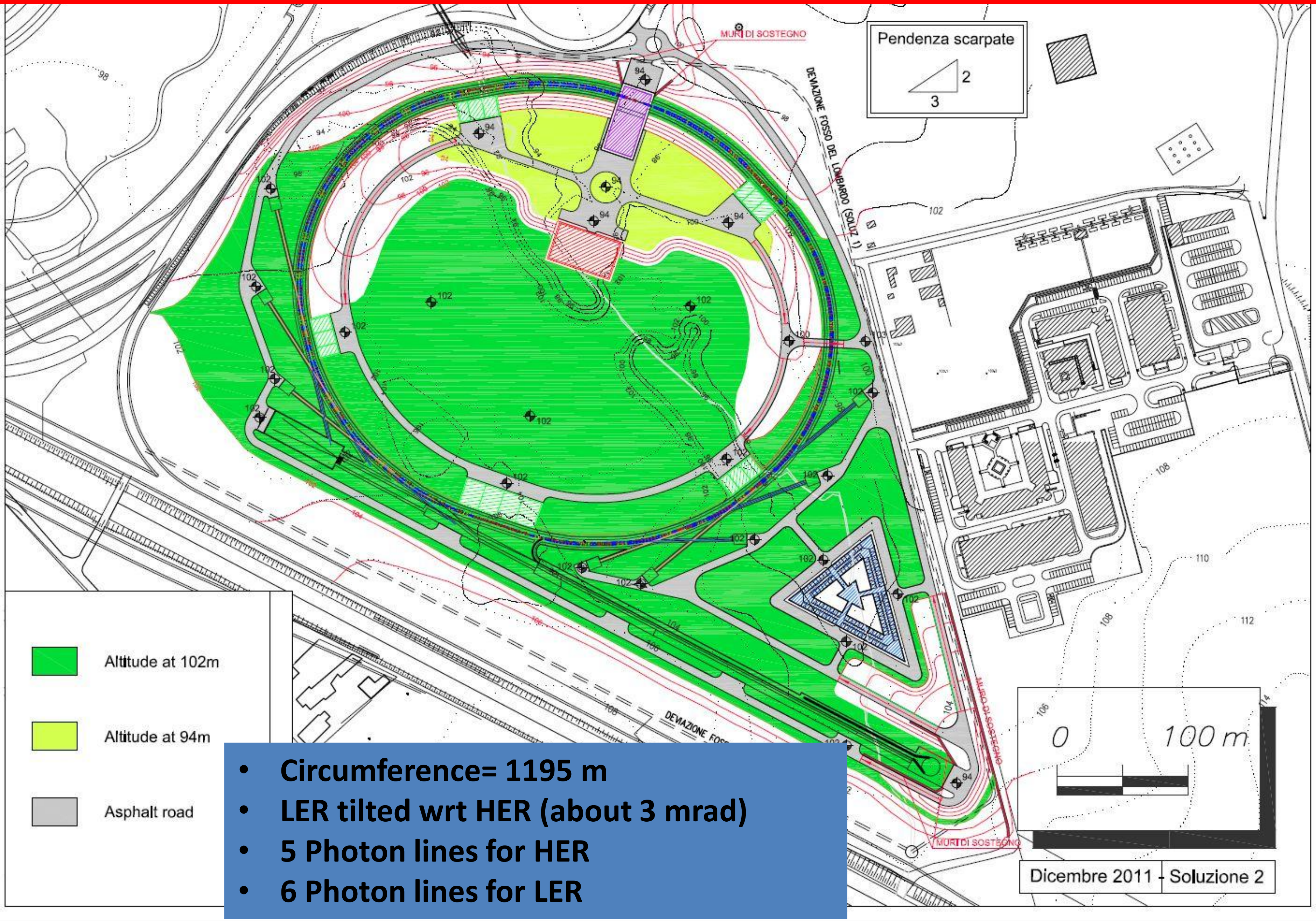
A more recent but obsolete slide of the SuperB Luminosity model



SuperB footprint @ Tor Vergata for the V16



- **Circumference= 1195 m**
- **LER tilted wrt HER (about 3 mrad)**
- **5 Photon lines for HER**
- **6 Photon lines for LER**

SuperKEKB

- Double-ring, asymmetric energy collider
  - 4 GeV (e+) x 7 GeV (e-)
- Design luminosity
  - 8×10^{35} $cm^{-2}s^{-1}$
  - 50 ab^{-1} (integrated)
- Nano-beam scheme
  - low emittance and low beta at IP, finite crossing angle of 2 x 41.5 mrad at IP

Onishi

Schedule for Installation: (official: Sept. 15)

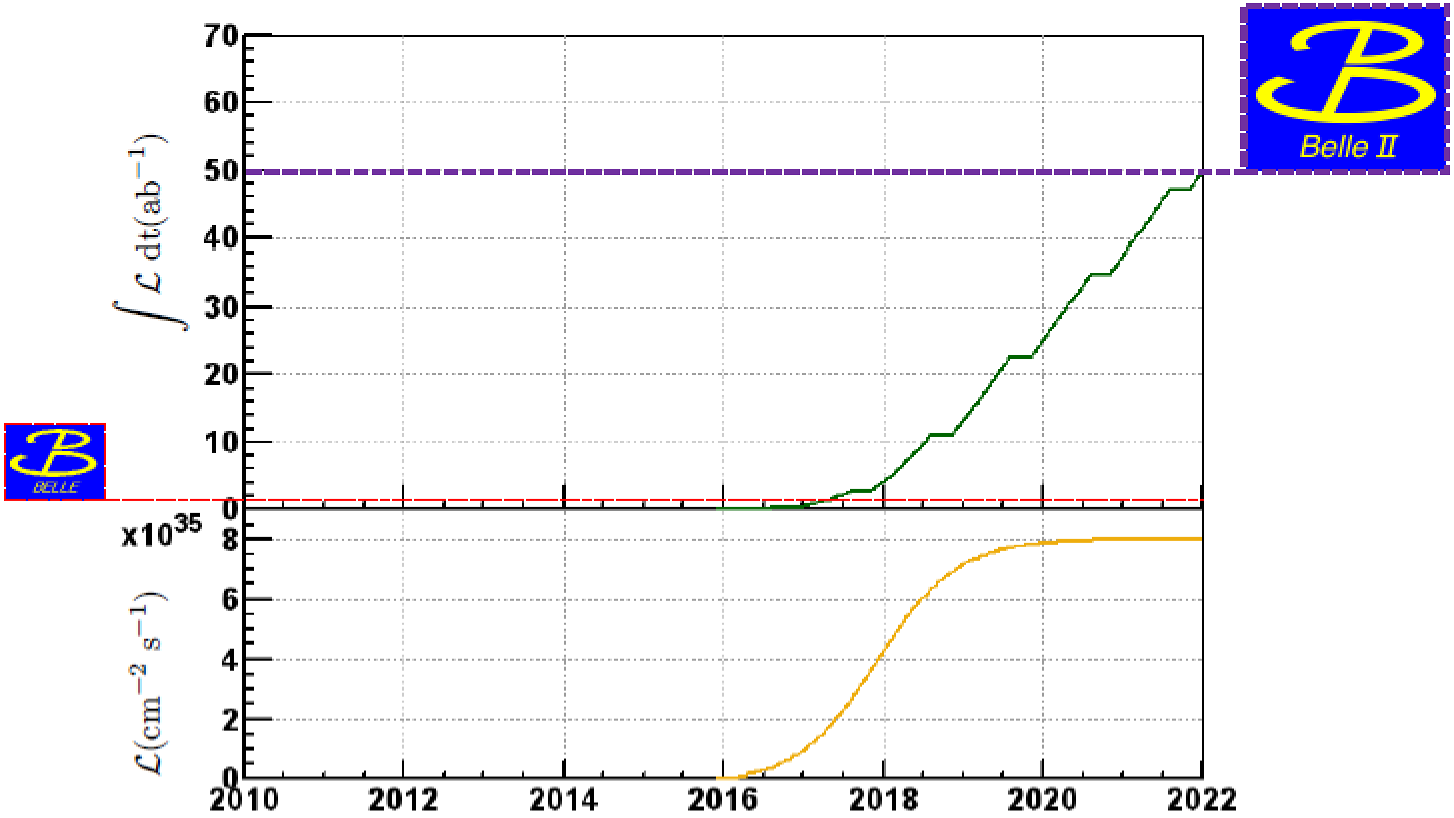
2014			2015						July 2015		
10	11	12	1	2	3	4	5	6	7	8	9
↑	BEAST 2 →								Summer Shutdown		
machine ready **with** QCS	**Day-1**				Belle Roll-out					PXD ready	VXD Integration
Belle roll-in (no TOP/A-RICH/PXD/SVD/CDC)										GCR	
↑ July 2014						install			Roll-In	Contract over	COMP ready by Oct. 1
						TOP/RICH/CDC					

2015			2016								
10	11	12	1	2	3	4	5	6	7	8	9
VXD Comm.		**Day-2** →							Summer Shutdown		
	VXD inst.	Physics Run									

S. Tanaka

Charm Production at SuperKEKB, Belle II

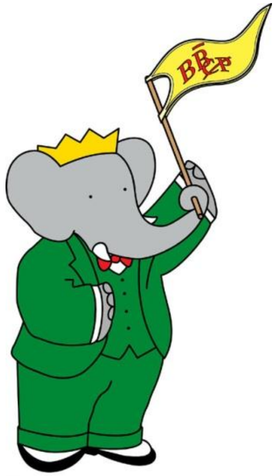
- Belle II, 50 ab^{-1} in 2022: > 6×10^{10} charm events!



Detector starts from Babar

Babar and Belle designs have proven to be very effective for B-Factory physics

Follow the same ideas for SuperB Detector and try to reuse the same components as much as possible



SuperB Detector

- Moderate R&D and engineering to improve performance
  - Small beam pipe technology
  - Thin silicon pixel detector for first layer
  - Drift chamber CF mechanical structure, gas and cell size
  - Cluster counting readout of DCH
  - Photon detection for DIRC quartz bars
  - Forward PID system
  - Forward calorimeter crystals (LYSO)
  - Minos-style scintillator for Instrumented flux return
  - Electronics and trigger Computing – large data amount
- Many of these developments already concluded!
- Conservative baseline detector

TDR is READY!

Detec ptions)

Electronics, Trigger, DAQ: all new

IFR: Replace LSST with scintillator + WLS Fibers + SiPM

Solenoid

PID: Focu
Reuse qu
New Ligh

EMC: Opti
Pb / Scinti

SVT: Fiv
strips +

Backgrou
Toushek,

)barrel with

d, faster

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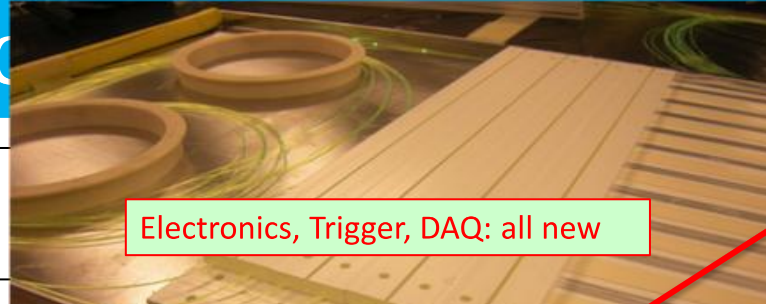
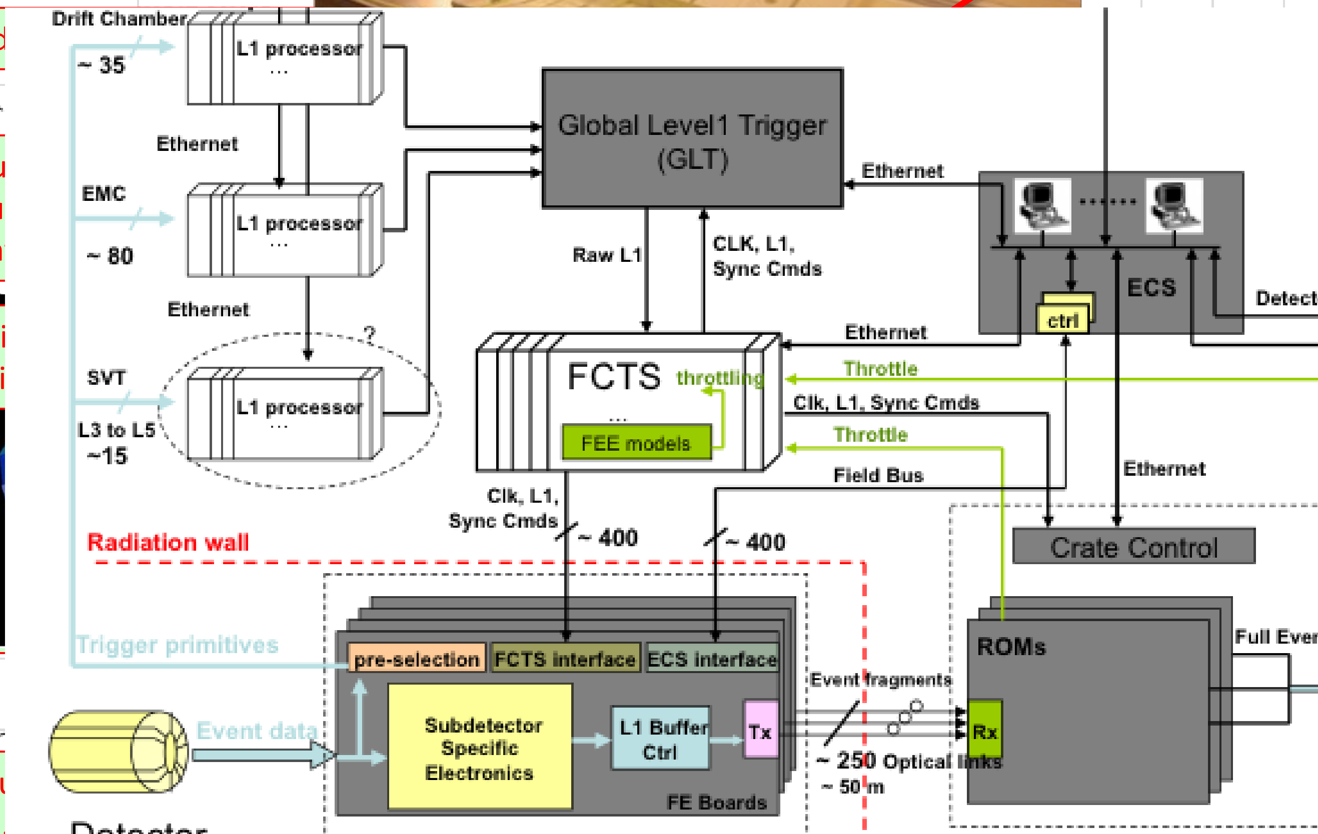
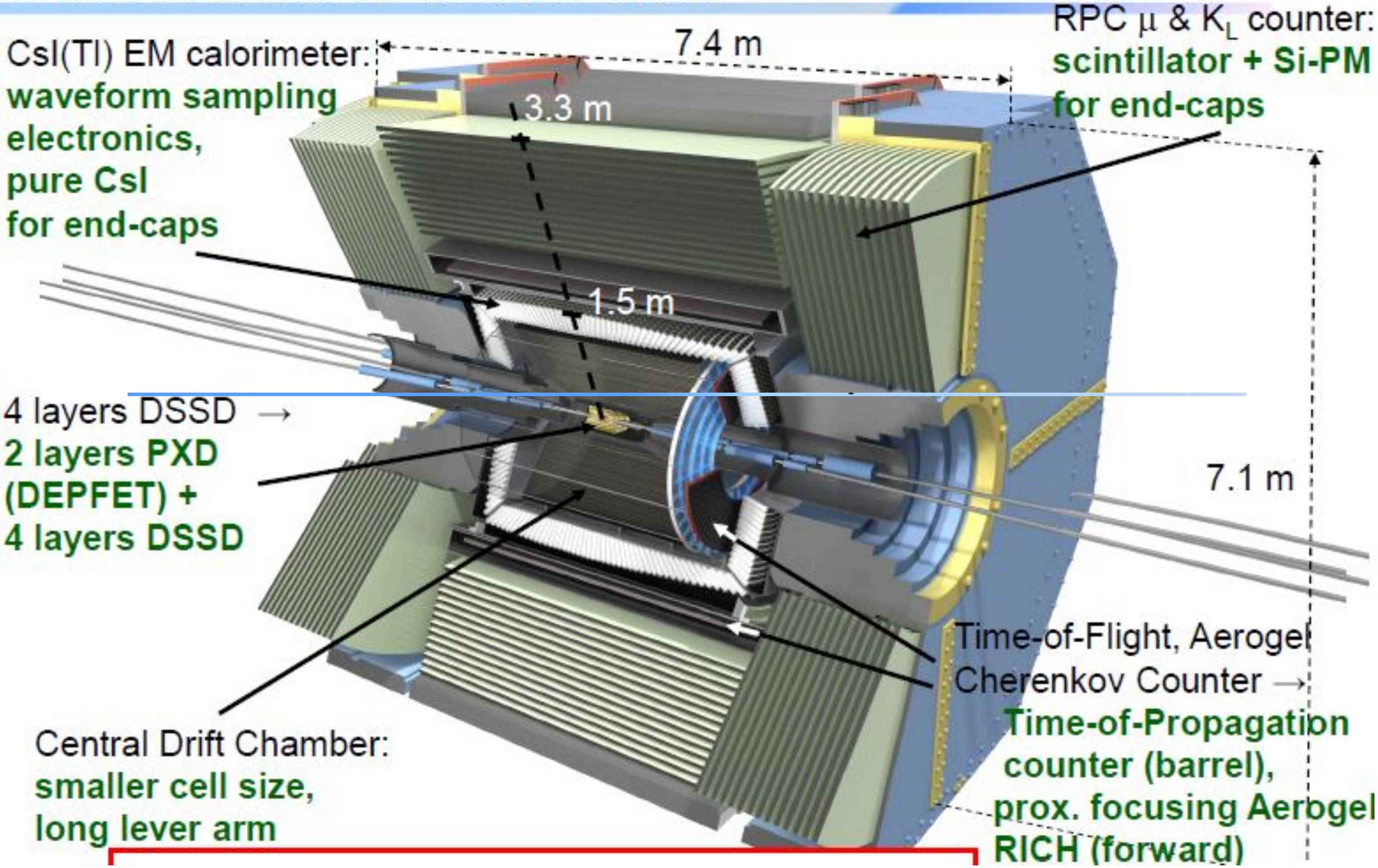




The Belle II Detector



BELLEII Detector

The BELLEII collaboration is solid and appears in a good shape for the completion and installation of the Detector in time according to the official machine schedule

Conclusion SuperB (10 days ago)

SuperB costs has been reviewed last November 19 and 20 by a finance committee appointed by the italian Ministry of education university and research (MIUR). The committee has reported to the Minister, they find adequate to the purpose the value of SuperB as presented by the Cabibbolab, the institution set up to build the Super Flavor Factory SuperB.

As reported in the following release:

•From INFN (in italian)

http://www.infn.it/comunicazione/index.php?option=com_content&view=article&id=349:linfn-rivede-il-suo-progetto-bandiera&catid=46:comunicati-2012&Itemid=396

•From babibbolab (in english)

http://www.cabibbolab.it/

The Minister Francesco Profumo met with the leaders of INFN and susequently with those of Cabibbolab.

The Minister pointed out that the importance and quality of the program were out of discussion, but that the economic conditions of the country and the limits foreseen by the National Research Plan were incompatible with the estimated cost of the project. The Minister, showing great helpfulness, has made it possible for INFN to propose other projects, always under the category of "flagship projects", as long as they are compatible with the initially planned budget.

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Conclusion SuperB (10 days ago)

………The original proposal submitted to CIPE, the italian governamental body for infrastructures, quotes: *"Il Progetto SuperB riguarda la costruzione di un acceleratore di particelle dedicato alla produzione di coppie di quark pesanti, detti quark Bottom o quark Charm, con intensità cento volte superiori a quelle raggiunte finora nel mondo"..*

Translating into " the SuperB project aims at the construction of a particle accelerator dedicated to the production of heavy quark pairs, bottom or *charmed* quarks, with luminosity values exceeding by a factor one hundred the existing ones…… *The decision tu fund the project was voted and approved by both branches of the Italian parliament in December 2010* …..

As a consequence of the developments above, the Consortium will stop since today the ongoing activity dedicated to the optimization of the engineered version of a heavy bottom pairs factory with polarization and explore the feasibility of a charmed quarks pair and of course tau pairs factory with polarization, already part of the original SuperB project.

This possibility was originally considered as an option for a period of data taking less then one year corresponding to an integrated luminosity of 500 fb^{-1} obtained by downgrading the energy of the full-energy b factory, but, taken as a standalone option, may well fit the order of magnitude of the sum today allocated to the project, that, it may be recalled, amounts to roughly one half the sum originally requested…………. As a starting approach, the layout of the main ring will not be moved from the one currently considered for the B factory and the study will be carried out bearing in mind, as much as this will be compatible with a high tau-charm luminosity, a possible later upgrade that, should be clearly stated, is however out of the horizon today.

The current progress on the B factory can speed up the new evaluation as well as the existence of a similar project from BINP that recently signed an MOU with Cabibbo Lab on the B option

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LFV from $\tau \rightarrow \mu \gamma$ @ Low energy (4 GeV)

τ&EW Physics

(Lumi at 10^{35} cm^{2} s^{-1} level is the prediction of P. Raimondi and included in the Project of the Super CTau Factory of BINP by E.Levichev. Polarization at 80% is also included)

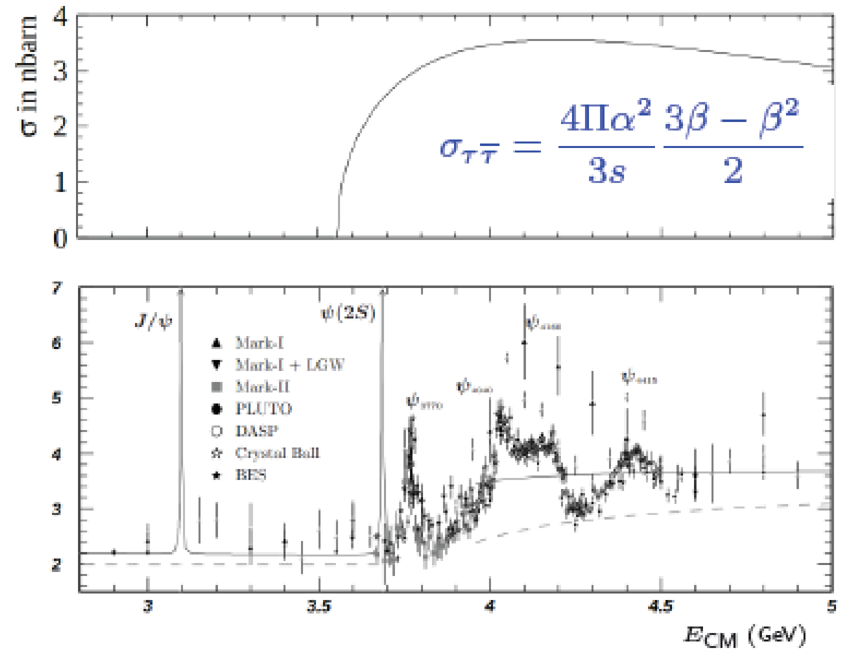
The last event selection in BABAR for the golden LFV Channel $\tau \rightarrow \mu \gamma$ removes many background contributions the irreducible are $\tau \tau \gamma$ from ISR and a small fraction (a few %) from q qbar γ and from tau decay with 2 neutrinos.

Super charm-tau factory

- $\sigma_{\tau\overline{\tau}}(m_{\tau\overline{\tau}}) \simeq 0.1$ nb
- $\sigma_{\tau\overline{\tau}}(\Psi(3770)) = 2.5$ nb
- $\sigma_{\tau\overline{\tau}}(4.25\text{ GeV}) = 3.5$ nb (max)
- $\mathcal{L} \simeq 10^{35}\ \text{cm}^{-2}\text{s}^{-1}$
- integrated $\mathcal{L} = 7.5\ \text{ab}^{-1}$
- **Number of $\tau\overline{\tau} \approx 2.3 \cdot 10^{10}$**

SuperB

- $\sigma_{\tau\overline{\tau}}(\Upsilon(4S)) = 0.92$ nb
- $\mathcal{L} \simeq 10^{36}\ \text{cm}^{-2}\text{s}^{-1}$
- integrated $\mathcal{L} = 75\ \text{ab}^{-1}$
- **Number of $\tau\overline{\tau} = 6.9 \cdot 10^{10}$**



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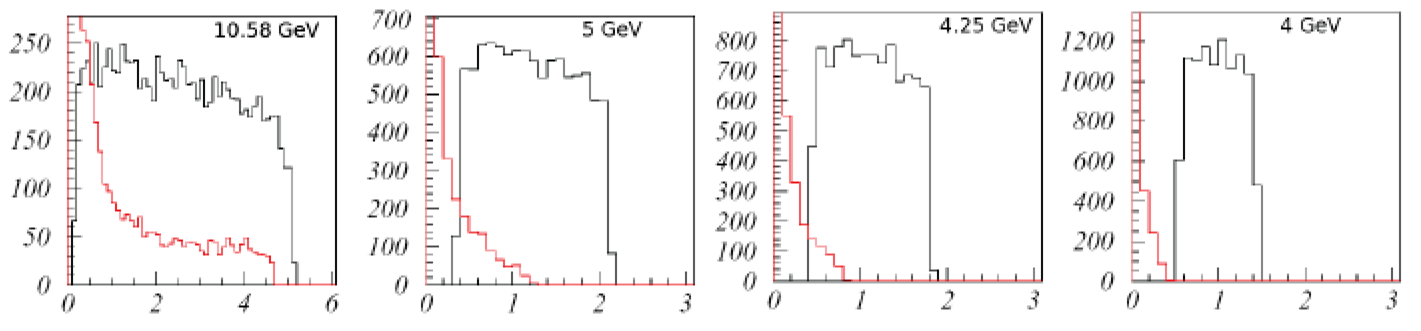
Background reduction in $\tau \to \mu\gamma$ as for Novosibisk Super CTAU

τ Physics

$\tau \to \mu\gamma$ background from ISR photon + SM $\tau \to \mu\nu\overline{\nu}$ decay

at $\tau - c$ factory, ISR photon has lower energy than the photon from $\tau \to \mu\gamma$

- H.Hayashii, "Search for $\tau \to \mu/e\gamma$ at the Super-τ-charm Factory", Tau 2008 Workshop Satellite meeting on the Super τ-charm factory



BR expected 90% CL upper limit for SuperB with $75\,\text{ab}^{-1} = 2.4 \cdot 10^{-9}$ (SuperB physics reports)

BR sensitivity of $\tau{-}c$ factory with $7\,\text{ab}^{-1} \approx 10^{-9}$

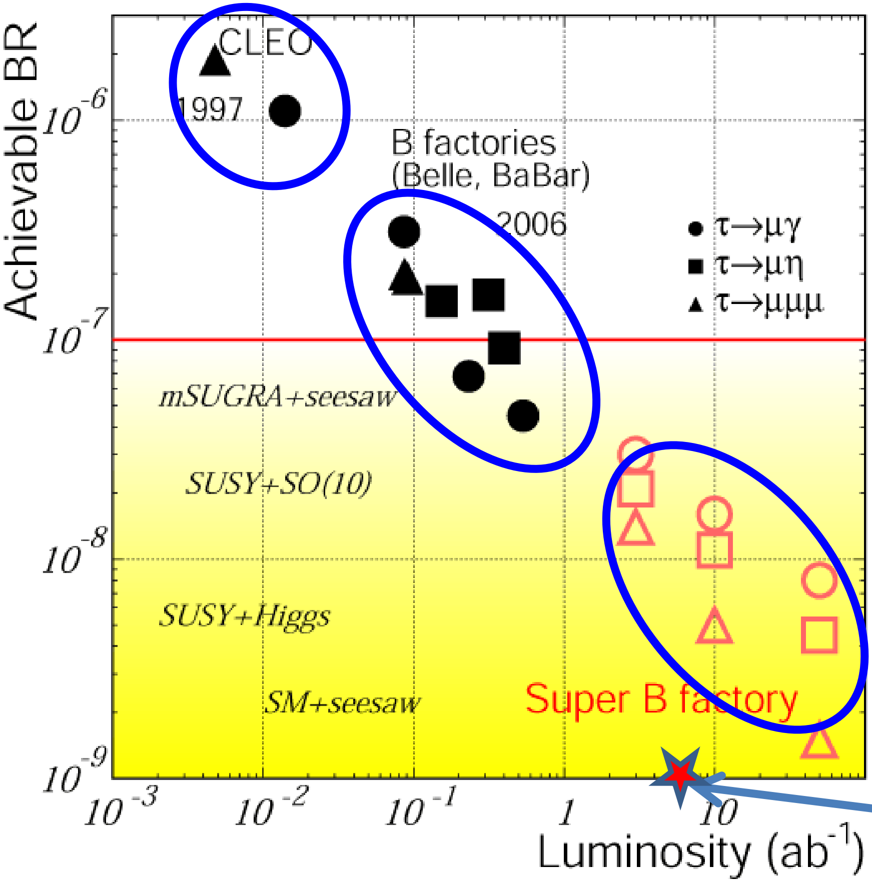
A.V.Bobrov, A.E.Bondar, Search for $\tau \to \mu\gamma$ decay at Super $c{-}\tau$ factory, Nucl.Phys.B (Proc.Suppl.) 225 (2012), arXiv:1206.1909 [hep-ex], (PHIPSI 2011 proceegings)

- Monte Carlo simulation of expected backgrounds
- less bkg from ISR than at $\Upsilon(4S)$ (see next slide)

beam polarization provides additional benefits in sensitivity and New Physics models testing

Tau Physics LFV at low energy ($\tau \rightarrow \mu \gamma$)

τ&EW Physics



Present limit from Belle with 7 10^{10} ττ pairs at Y(4s) is : ~ 3×10^{-8} ,slightly lower than BABAR's with a double of the events.

The SuperB analysis considers the use of the polarization and the tag with pions and rhos. If the violating term is left handed its contribution (as shown in many presentations) is a reduction of the BKG due to q qbar and normal decays with a gamma in the final state by a factor ≥ 1.5. We can expect a limit of ≤10 -9 at low energy using the kinematical rejection of ISR BKGD. If anyway LFV is discovered, the chirality of LFV source can be determined with polarization.

7 ab-1 at 4.0 GeV with polarizatiion

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Conclusion

There is a solid Physics Program for the Super Flavour Factories .

SuperKEKB and BELLEII are in a good shape and the physics run could start in a few years

SuperB Detector R&D is complete and TDR ready. (The low energy option under consideration can profit of the already done studies)

SuperLHCb, BelleII and the Super Factory at low energy could cover large part of the flavor physics in the next 10 years .

But a full study of potentiality for a long run at low energy, 10 ab^{-1} or more must be investigated and will require some time.

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END

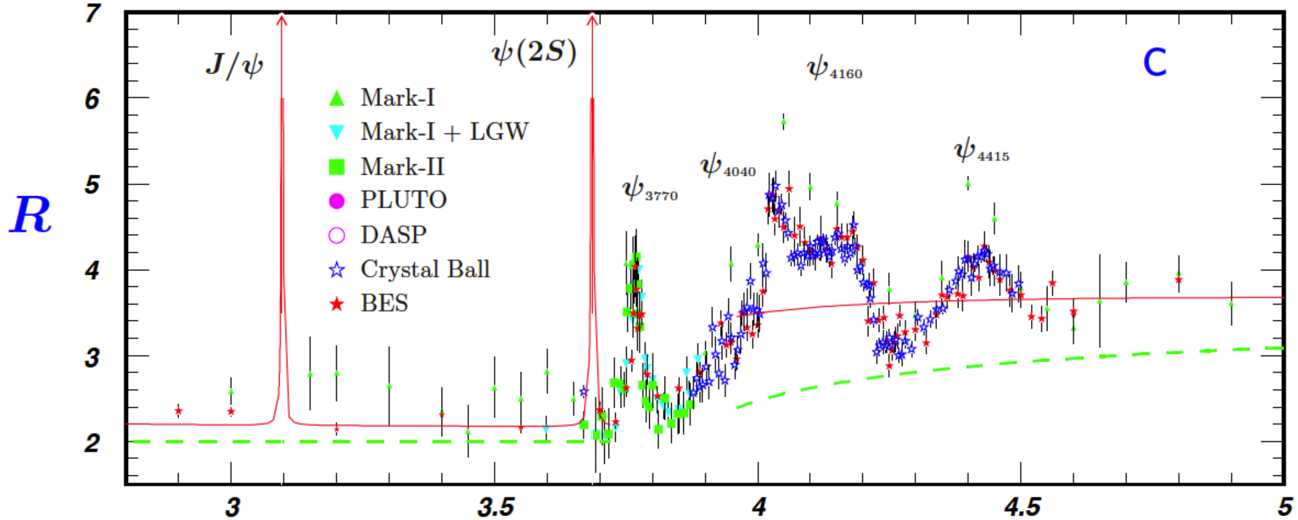
Some extra slides ……

Energies of interest

- Assume several different energies:
  - ~3ab^{-1} at ψ(3770) → ~10.8e10^{9} D^0 pairs / 7.2 10^{9} $\tau^+\tau^-$
  - ~4ab^{-1} at other energies ~ a further 9.6–14.0 10^9 $\tau^+\tau^-$

	CMS Mass	Peak Lum.	σ	No. of Events
J/ψ	3.097	0.6	3400	10×10^9
$\tau^+\tau^-$	3.670	1.0	2.4	12×10^6
$\psi(2S)$	3.686	1.0	640	3.2×10^9
$D^0\bar{D}^0$	3.770	1.0	3.6	18×10^6
D^+D^-	3.770	1.0	2.8	14×10^6
D_sD_s	4.030	0.6	0.32	1.0×10^6
D_sD_s	4.170	0.6	1.0	2.0×10^6

BES III Physics Book: Assumed L=10^{33}cm^{-2}s^{-1}



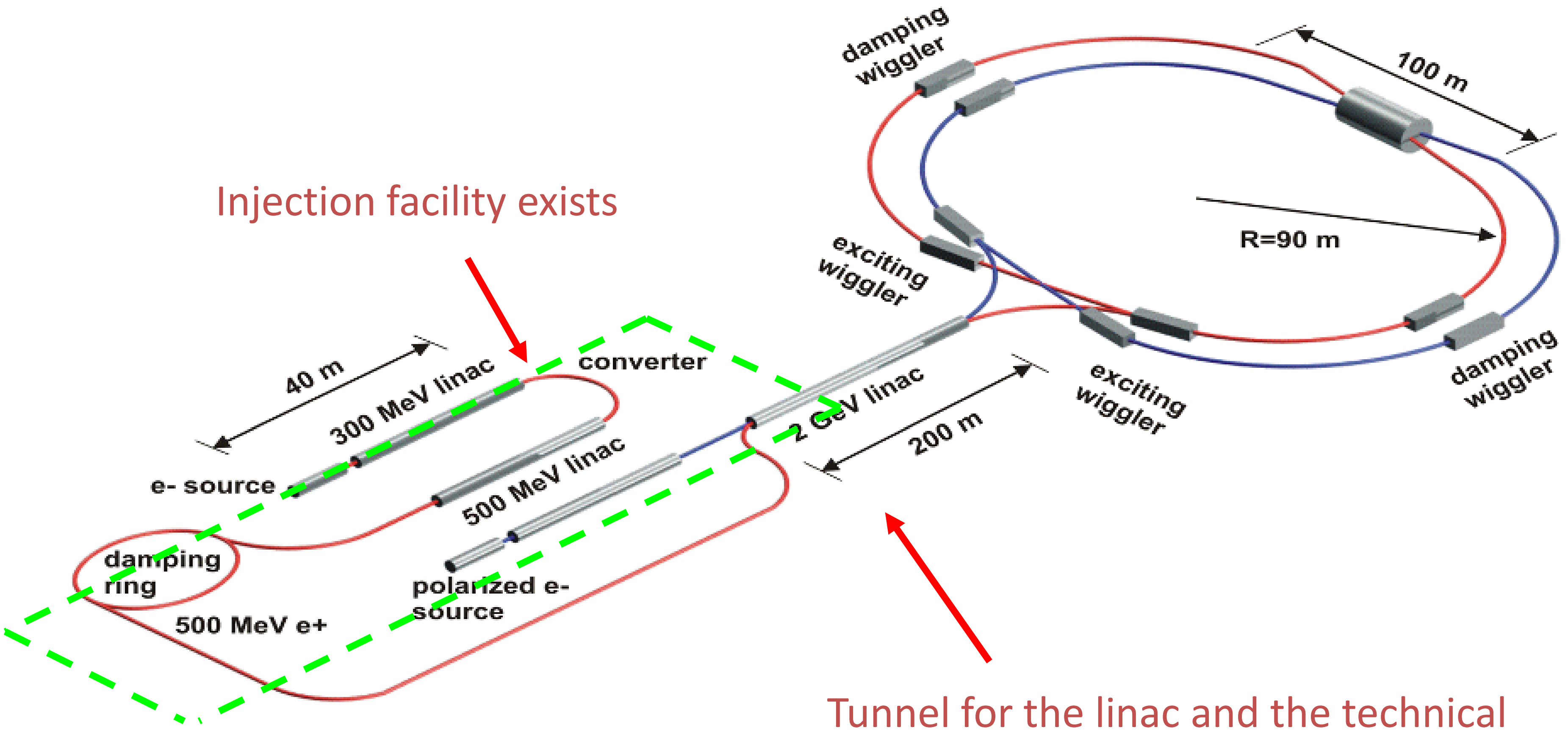
Main accelerator parameters

Energy	1.0 GeV	1.5 GeV	2.0 GeV	2.5 GeV
Circumference	766.6 m			
Emittance hor/ver	8 nm/0.04 nm @ 0.5% coupling			
Damping time hor/ver/long	30/30/15 ms			
Bunch length	16 mm	11 mm	10 mm	10 mm
Energy spread	$10.1 \cdot 10^{-4}$	$9.95 \cdot 10^{-4}$	$8.43 \cdot 10^{-4}$	$7.38 \cdot 10^{-4}$
Energy loss/turn	170 keV	256 keV	343 keV	434 keV
Momentum compaction	$0.89 \cdot 10^{-3}$	$0.90 \cdot 10^{-3}$	$0.91 \cdot 10^{-3}$	$0.91 \cdot 10^{-3}$
Synchrotron tune	0.013	0.014	0.012	0.010
Wiggler field	4.5 T	4.0 T	2.8 T	0
RF frequency	500 MHz			
Particles/bunch	$7 \cdot 10^{10}$			
Number of bunches	390			
Bunch current	4.4 mA			
Total beam current	1.7 A			
Beam-beam parameter	0.15	0.15	0.15	0.12
Luminosity	$0.63 \cdot 10^{35}$	$0.95 \cdot 10^{35}$	$1.08 \cdot 10^{35}$	$1.08 \cdot 10^{35}$

6 m of the SC wigglers with 20-cm-period are used to control the beam parameters at different energies

General Layout of the Novosibirsk c/τ factory

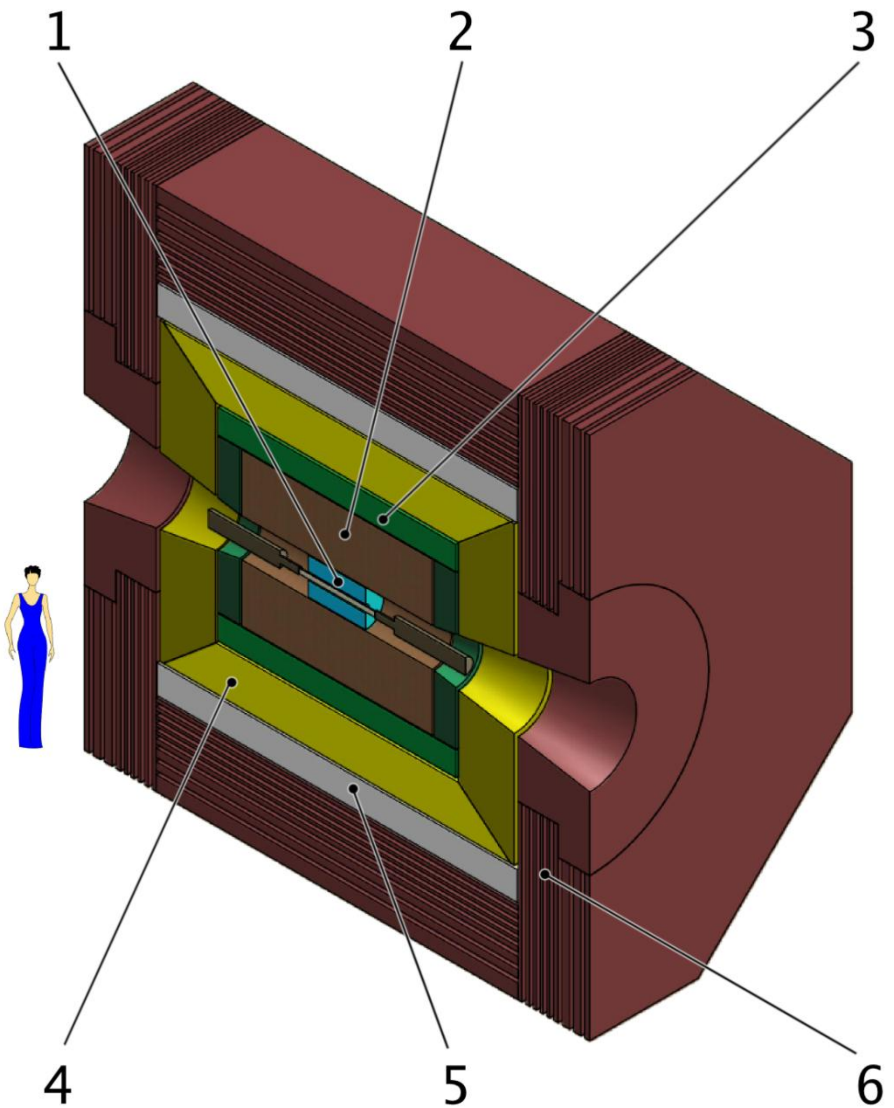
Injection facility exists



Tunnel for the linac and the technical straight section of the factory is ready

Super Charm-Tau detector

- Standard set of subsystems (1-Vertex Detector, 2 – Drift Chamber, 3 – PID => FARICH, 4 – EMC, 5 – Superconducting Solenoid, 6 – IFR)



Conclusion SuperB (10 days ago)

SOURCE: INFN
http://www.infn.it/comunicazione/index.php?option=com_content&view=article&id=349:linfn-rivede-il-suo-progetto-bandiera&catid=46:comunicati-2012&Itemid=396

ENGLISH TEXT (Translation by F.Forti)
The results of the international committee appointed by the MIUR(Ministry of University and Research) for the costing review of the SuperB flagship project were examined yesterday by the Minister of Research who wanted to discuss with the leaders of INFN and subsequently with those of Cabibbolab.
The Minister pointed out that the importance and quality of the program were out of discussion, but that the economic conditions of the country and the limits foreseen by the National Research Plan were incompatible with the estimated cost of the project. The Minister, showing great helpfulness, has made it possible for INFN to propose other projects, always under the category of "flagship projects", as long as they are compatible with the initially planned budget.
Proposals should be evaluated within a few months and INFN is therefore examining the possible ideas. Among the possibilities, however, it will be explored with conviction the hypothesis of presenting the project for the construction of an international laboratoray aimed at building an accelerating machine in the Frascati area.
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Conclusion SuperB (10 days ago)

………The original proposal submitted to CIPE, the italian governamental body for infrastructures, quotes: *"Il Progetto SuperB riguarda la costruzione di un acceleratore di particelle dedicato alla produzione di coppie di quark pesanti, detti quark Bottom o quark Charm, con intensità cento volte superiori a quelle raggiunte finora nel mondo"..*

Translating into " the SuperB project aims at the construction of a particle accelerator dedicated to the production of heavy quark pairs, bottom or *charmed* quarks, with luminosity values exceeding by a factor one hundred the existing ones…… *The decision tu fund the project was voted and approved by both branches of the Italian parliament in December 2010* …..

As a consequence of the developments above, the Consortium will stop since today the ongoing activity dedicated to the optimization of the engineered version of a heavy bottom pairs factory with polarization and explore the feasibility of a charmed quarks pair and of course tau pairs factory with polarization, already part of the original SuperB project.

This possibility was originally considered as an option for a period of data taking less then one year corresponding to an integrated luminosity of 500 fb^{-1} obtained by downgrading the energy of the full-energy b factory, but, taken as a standalone option, may well fit the order of magnitude of the sum today allocated to the project, that, it may be recalled, amounts to roughly one half the sum originally requested………….

As a starting approach, the layout of the main ring will not be moved from the one currently considered for the B factory and the study will be carried out bearing in mind, as much as this will be compatible with a high tau-charm luminosity, a possible later upgrade that, should be clearly stated, is however out of the horizon today.

The current progress on the B factory can speed up the new evaluation as well as the existence of a similar project from BINP that recently signed an MOU with Cabibbo Lab on the B option