Future Prospects at e+e- Machines

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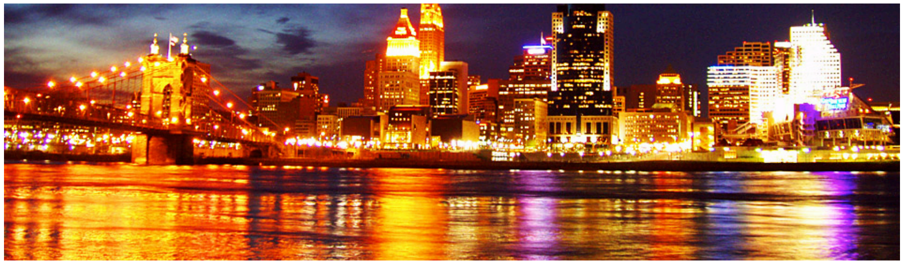
7th International Workshop on the CKM Unitarity Triangle
Cincinnati, Ohio
29 September 2012



Scope of Presentation:

Future prospects at BES-III and the BINP SuperB c/τ

Physics Prospects and Status of Belle-II and SuperB

Future prospects at BES-III and the BINP SuperB c/τ

BES-III Datasets and Future Plans

(Xiaoyan Shen)

- 2009: 106M $\psi(2S)$ (4*CLEO-c $\psi(2S)$ sample

  225M J/ψ 4*BESII J/ψ sample
- 2010: 900 pb^{-1} $\psi(3770)$
- 2011: 1800 pb^{-1} $\psi(3770)$ (3.5*CLEO-c $\psi(3770)$ sample)

  470 pb^{-1} $\psi(4040)$
- 2012: tau mass, $\psi(2S)$: 0.4 billion, J/ψ: 1 billion, R scan

Looking to the future...

2013: E_{CM}=4260 and 4360 MeV for "XYZ" studies, R scan

2014: E_{CM}=4170 MeV for D_s (~2.4 fb^{-1})

2015-... ? Additional 10 fb^{-1} $\psi(3770)$ data

BESIII is scheduled to run another 8-10 years from now

BINP Super c/τ Factory

(B. Shwartz, Tau2012 Nagoya)

Physics program:

- **High statistic spectroscopy and search for exotics**
  - **Charm and charmonium spectroscopy**
  - **Spectroscopy of the highly excited Charmonium states (complementary to Bottomonium)**
  - **Light hadron spectroscopy in charmonium decays**
- **Precision charm physics**
  - **Precision charm→ precision CKM (strong phases, f_D, f_{Ds} ,form-factors…)**
  - **Unique source of coherent D^0/D^0bar states (D^0 mixing, CPV in mixing, strong phases for ϕ_3 measurements at SuperB and LHC)**
- **Precision τ-physics with polarized beams**
  - **Lepton universality, Lorentz structure of τ-decay…**
  - **CP and T-violation in τ and Λ_c decays**
  - **LFV decays (τ->μγ)**
  - **Second class currents (with kinematical constraints at threshold)**
- **Two photon physics and light hadronic cross section via ISR**

BINP Super c/τ Factory

(B. Shwartz, Tau2012 Nagoya)

Technical specifications:

- Beam energy from 1.0 to 2.5 GeV
- Peak luminosity is 10^{35} $cm^{-2}s^{-1}$ at 2 GeV
- Electrons are polarized longitudinally at IP
- On-line energy monitoring (~5-10 x 10^{-5})

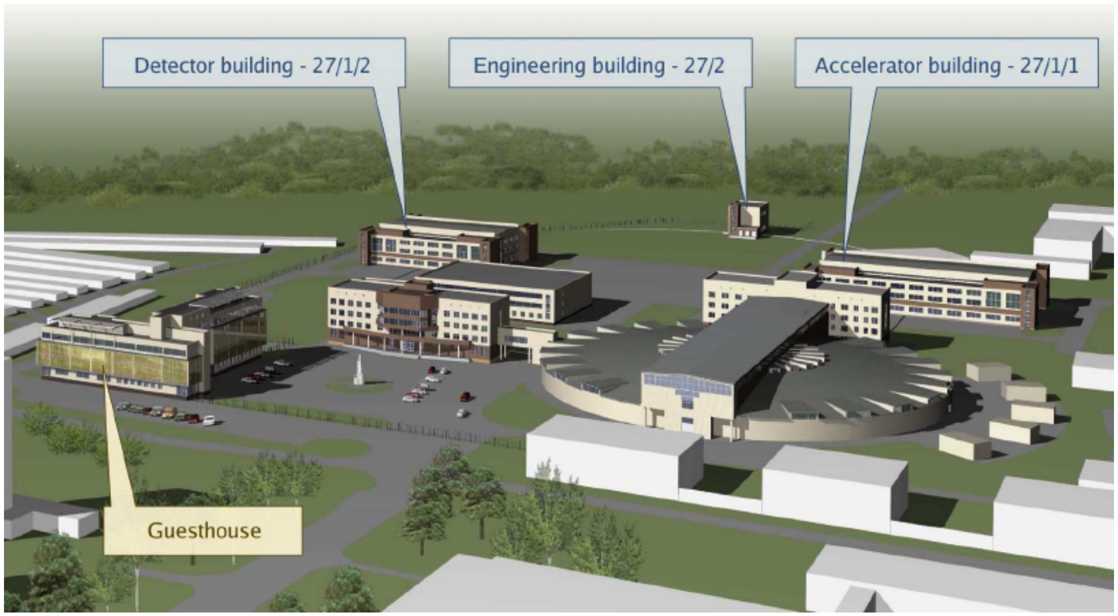
Main design features:

- Two rings with Crab Waist collision scheme and single interaction point
- Sub-mm beta-y at IP
- Preserving of damping parameters (by 4 SC wigglers) through the whole energy range to optimize the luminosity
- 5 Siberian snakes to obtain the longitudinally polarized electrons for the whole energy range
- Highly effective positron source (50 Hz top-up injection)
- Polarized electron source
- 2.5 GeV full energy linac

BINP Super c/τ Factory

(B. Shwartz, Tau2012 Nagoya)

Artistic view of future machine



Accelerator Complex	200 MEuro
Detector	80 MEuro
Buildings Construction and Site Utilities	50 MEuro

Conceptual Design Report: 200 signatories from Germany, Israel, Italy, Slovenia, Russia

In 2012: project was included in top list of the 6 projects approved for further development by the Russian Governmental Commission on the Innovations and High Technologies

BINP Super c/τ Factory

(B. Shwartz, Tau2012 Nagoya)

MOU between Cabibbo Lab and BINP

Source: CabibboLab/INFN Content: Press Release Date Issued: 11 September 2012

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A major agreement was recently signed between the Nicola Cabibbo Laboratory Consortium (CLC) and the Budker Institute for Nuclear Physics (BINP) in Novosibirsk, Russia. The Memorandum of Understanding (MoU) will enable the joint development of projects for the construction of a SuperB Factory (B particles factory) in Rome and a SuperC-Tau Factory (C and tau particles factory) in Novosibirsk .

Physics Prospects and Status of Belle-II and SuperB

Specific talks in parallel sessions:

WG II Tues	Horii, Lindemann
WG IV Sunday	Finocchiaro
WG V Monday	Onuki
WG VII Monday	Branchini, Asner

Plus…

a host of presentations at this meeting in theory and experiment on what this exciting future holds

Physics Program

SuperKEKB and SuperB Accelerators

The Detectors

Status

Physics program

Overview

- e^+e^- collider with centre-of-mass near Υ(4S)
  - just above threshold for B-meson pair production – no fragmentation
- Luminosity 100x previous generation e^+e^- collider $\mathcal{L}=10^{34}$ -> 10^{36} cm^{-2} s^{-1}
  - 5-10 x 10^{10} b, c, τ pairs (50-75 ab^{-1})
- Operate with asymmetric beam energies to give boost to CM allowing for time dependent CPV measurements

Physics at e+e- Super Flavour Factories

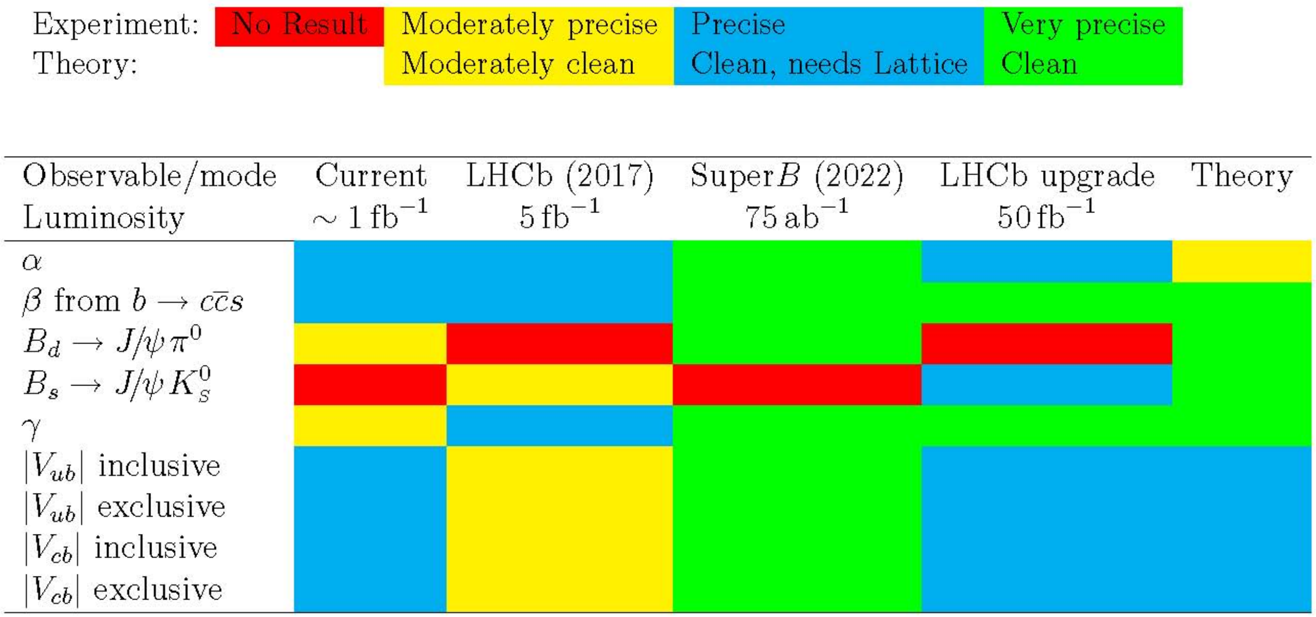
- Test CKM at 1% level
  - CPV in B decays from new physics (non-CKM)
- B-recoil technique for B->K(*)ll, B->τν, B->D*τν
- τ physics: lepton flavour violations, g-2, EDM, CPV,V_{us}…
- Charm: mixing, CPV,…
- Many other topics:
  - ϒ(5S) physics, , ISR radiative return, spectroscopy, Dark Sector probe, low mass Higgs…
- With polarised beam: Precision EW physics
- Physics motivation is independent of LHC
  - If LHC finds NP, precision flavour input essential
  - If LHC finds no NP, high statistics B and τ decays are unique way of probing >TeV scale physics

Need both LHCb and e^+e^-

	Red	Yellow	Blue	Green
Experiment:	No Result	Moderately precise	Precise	Very precise
Theory:		Moderately clean	Clean, needs Lattice	Clean

Observable/mode Luminosity	Current $\sim 1\,\text{ab}^{-1}$	LHCb (2017) $5\,\text{fb}^{-1}$	Super$B$ (2022) $75\,\text{ab}^{-1}$	LHCb upgrade $50\,\text{fb}^{-1}$	Theory	
τ Decays						
$\tau \to \mu\gamma$ $\tau \to e\gamma$	yellow	yellow	green	yellow	green	Benefit from polarised e⁻ beam
$B_{u,d}$ Decays						
$B \to \tau\nu, \mu\nu$	yellow	red	blue	red	blue	very precise with improved detector
$B \to K^{(*)+}\nu\overline{\nu}$	red	red	green	red	green	Statistically limited: Ang anal with >75ab⁻¹
S in $B \to K^0_S\pi^0\gamma$	yellow	red	green	red	yellow	Right handed currents
S (other penguin modes)	yellow	yellow	green	blue	yellow	SuperB measures many more modes
A_{CP} $(B \to X_s\gamma)$	blue	yellow	green	yellow	green	systematic error is main challenge
BR$(B \to X_s\gamma)$	blue	yellow	green	yellow	yellow	control systematic error with data
BR$(B \to X_s ll)$	yellow	red	green	red	green	
BR$(B \to K^{(*)}ll)$	yellow	blue	green	green	yellow	SuperB measures e mode well, LHCb does μ
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	blue	green	green	green	
D Decays						
Mixing parameters	yellow	blue	green	green	green	
CP Violation	red	blue	green	green	green	Clean NP search
Precision Electroweak						
$\sin^2\theta_W$ at $\Upsilon(4S)$	red	red	green	red	green	Theoretically clean
$\sin^2\theta_W$ at Z-Pole	green	blue	red	green	yellow	b fragmentation limits interpretation

Need both LHCb and e^+e^-



LHCb can only use $\rho\pi$

βtheory error B_d
βtheory error B_s

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

LHCb

- Modes where the final states are charged only.
- B_s
- B_c, Λ_b
- …..

B factories

- Modes with γ, π^0 .
- Modes with ν .
- τ decays.
- K_S vertex.

Need both LHCb and e^+e^-

Observable	Expected th. accuracy	Expected exp. uncertainty	Facility
CKM matrix			
$\|V_{us}\|$ $[K \to \pi\ell\nu]$	**	0.1%	K-factory
$\|V_{cb}\|$ $[B \to X_c\ell\nu]$	**	1%	Belle II
$\|V_{ub}\|$ $[B_d \to \pi\ell\nu]$	*	4%	Belle II
$\sin(2\phi_1)$ $[c\bar{c}K_S^0]$	***	$8 \cdot 10^{-3}$	Belle II/LHCb
ϕ_2		$1.5°$	Belle II
ϕ_3	***	$3°$	LHCb
CPV			
$S(B_s \to \psi\phi)$	**	0.01	LHCb
$S(B_s \to \phi\phi)$	**	0.05	LHCb
$S(B_d \to \phi K)$	***	0.05	Belle II/LHCb
$S(B_d \to \eta' K)$	***	0.02	Belle II
$S(B_d \to K^*(\to K_S^0\pi^0)\gamma))$	***	0.03	Belle II
$S(B_s \to \phi\gamma))$	***	0.05	LHCb
$S(B_d \to \rho\gamma))$		0.15	Belle II
A_{SL}^d	***	0.001	LHCb
A_{SL}^s	***	0.001	LHCb
$A_{CP}(B_d \to s\gamma)$	*	0.005	Belle II
rare decays			
$\mathcal{B}(B \to \tau\nu)$	**	3%	Belle II
$\mathcal{B}(B \to D\tau\nu)$		3%	Belle II
$\mathcal{B}(B_d \to \mu\nu)$	**	6%	Belle II
$\mathcal{B}(B_s \to \mu\mu)$	***	10%	LHCb
zero of $A_{FB}(B \to K^*\mu\mu)$	**	0.05	LHCb
$\mathcal{B}(B \to K^{(*)}\nu\nu)$	***	30%	Belle II
$\mathcal{B}(B \to s\gamma)$		4%	Belle II
$\mathcal{B}(B_s \to \gamma\gamma)$		$0.25 \cdot 10^{-6}$	Belle II (with 5 ab^{-1})
$\mathcal{B}(K \to \pi\nu\nu)$	**	10%	K-factory
$\mathcal{B}(K \to e\pi\nu)/\mathcal{B}(K \to \mu\pi\nu)$	***	0.1%	K-factory
charm and τ			
$\mathcal{B}(\tau \to \mu\gamma)$	***	$3 \cdot 10^{-9}$	Belle II
$\|q/p\|_D$	***	0.03	Belle II
$arg(q/p)_D$	***	$1.5°$	Belle II

Belle II Collaboration comparisons with LHCb assuming integrated luminosities:

Belle II: 50 ab^{-1}

LHCb: 10 fb^{-1}

Observable/mode	Current now	LHCb (2017) $5\,\mathrm{fb}^{-1}$	Super$B$ (2021) $75\,\mathrm{ab}^{-1}$	Belle II (2021) $50\,\mathrm{ab}^{-1}$	LHCb upgrade (10 years of running) $50\,\mathrm{fb}^{-1}$	theory now
τ Decays						
$\tau \to \mu\gamma$ ($\times 10^{-9}$)	< 44		< 2.4	< 5.0		
$\tau \to e\gamma$ ($\times 10^{-9}$)	< 33		< 3.0	< 3.7 (est.)		
$\tau \to \ell\ell\ell$ ($\times 10^{-10}$)	$< 150 - 270$	< 244 [a]	$< 2.3 - 8.2$	< 10	< 24 [b]	
$B_{u,d}$ Decays						
BR($B \to \tau\nu$) ($\times 10^{-4}$)	1.64 ± 0.34		0.05	0.04		1.1 ± 0.2
BR($B \to \mu\nu$) ($\times 10^{-6}$)	< 1.0		0.02	0.03		0.47 ± 0.08
BR($B \to K^{*+}\nu\overline{\nu}$) ($\times 10^{-6}$)	< 80		1.1	2.0		6.8 ± 1.1
BR($B \to K^{+}\nu\overline{\nu}$) ($\times 10^{-6}$)	< 160		0.7	1.6		3.6 ± 0.5
BR($B \to X_s\gamma$) ($\times 10^{-4}$)	3.55 ± 0.26		0.11	0.13	0.23	3.15 ± 0.23
$A_{CP}(B \to X_{(s+d)}\gamma)$	0.060 ± 0.060		0.02	0.02		$\sim 10^{-6}$
$B \to K^*\mu^+\mu^-$ (events)	250[c]	8000	10-15k[d]	7-10k	100,000	-
BR($B \to K^*\mu^+\mu^-$) ($\times 10^{-6}$)	1.15 ± 0.16		0.06	0.07		1.19 ± 0.39
$B \to K^*e^+e^-$ (events)	165	400	10-15k	7-10k	5,000	-
BR($B \to K^*e^+e^-$) ($\times 10^{-6}$)	1.09 ± 0.17		0.05	0.07		1.19 ± 0.39
$A_{FB}(B \to K^*\ell^+\ell^-)$	0.27 ± 0.14[e]	[f]	0.040	0.03		-0.089 ± 0.020
$B \to X_s\ell^+\ell^-$ (events)	280		8,600	7,000		-
BR($B \to X_s\ell^+\ell^-$) ($\times 10^{-6}$)[g]	3.66 ± 0.77[h]		0.08	0.10		1.59 ± 0.11
S in $B \to K_S^0\pi^0\gamma$	-0.15 ± 0.20		0.03	0.03		-0.1 to 0.1
S in $B \to \eta' K^0$	0.59 ± 0.07		0.01	0.02		± 0.015
S in $B \to \phi K^0$	0.56 ± 0.17	0.15	0.02	0.03	0.03	± 0.02
B_s^0 Decays						
BR($B_s^0 \to \gamma\gamma$) ($\times 10^{-6}$)	< 8.7		0.3	$0.2 - 0.3$		0.4 - 1.0
A_{SL}^s ($\times 10^{-3}$)	-7.87 ± 1.96 [i]	[j]	4.	5. (est.)		0.02 ± 0.01
D Decays						
x	$(0.63 \pm 0.20\%$	0.06%	0.02%	0.04%	0.02%	$\sim 10^{-2}$ [k]
y	$(0.75 \pm 0.12)\%$	0.03%	0.01%	0.03%	0.01%	$\sim 10^{-2}$ (see above).
y_{CP}	$(1.11 \pm 0.22)\%$	0.02%	0.03%	0.05%	0.01%	$\sim 10^{-2}$ (see above).
$\lvert q/p \rvert$	$(0.91 \pm 0.17)\%$	8.5%	2.7%	3.0%	3%	$\sim 10^{-3}$ (see above).
$\arg\{q/p\}$ ($^\circ$)	-10.2 ± 9.2	4.4	1.4	1.4	2.0	$\sim 10^{-3}$ (see above).
Other processes Decays						
$\sin^2\theta_W$ at $\sqrt{s} = 10.58\,\mathrm{GeV}/c^2$			0.0002	[l]		clean

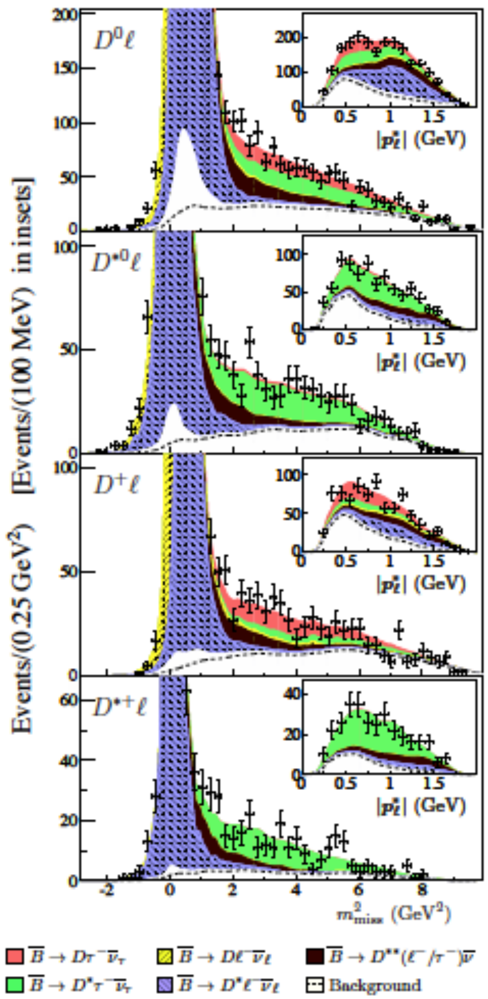
From Meadow's et al arXiv:1109.5028v2

Need both LHCb and e+e-

Observable/mode	Current now	LHCb (2017)	Super$B$ (2021)	Belle II (2021)	LHCb upgrade (10 years of running)	theory now
		$5\,\text{fb}^{-1}$	$75\,\text{ab}^{-1}$	$50\,\text{ab}^{-1}$	$50\,\text{fb}^{-1}$	
α from $u\overline{u}d$	6.1°	$5^{\circ a}$	1°	1°	^{b}	$1-2^\circ$
β from $c\overline{c}s$ (S)	0.8° (0.020)	0.5° (0.008)	0.1° (0.002)	0.3° (0.007)	0.2° (0.003)	clean
S from $B_d \to J/\psi\pi^0$	0.21		0.014	0.021 (est.)		clean
S from $B_s \to J/\psi K^0_S$		?			?	clean
γ from $B \to DK$	11°	$\sim 4^\circ$	1°	1.5°	0.9°	clean
$\lvert V_{cb}\rvert$ (inclusive) %	1.7		0.5%	0.6 (est.)		dominant
$\lvert V_{cb}\rvert$ (exclusive) %	2.2		1.0%	1.2 (est.)		dominant
$\lvert V_{ub}\rvert$ (inclusive) %	4.4		2.0%	3.0		dominant
$\lvert V_{ub}\rvert$ (exclusive) %	7.0		3.0%	5.0		dominant

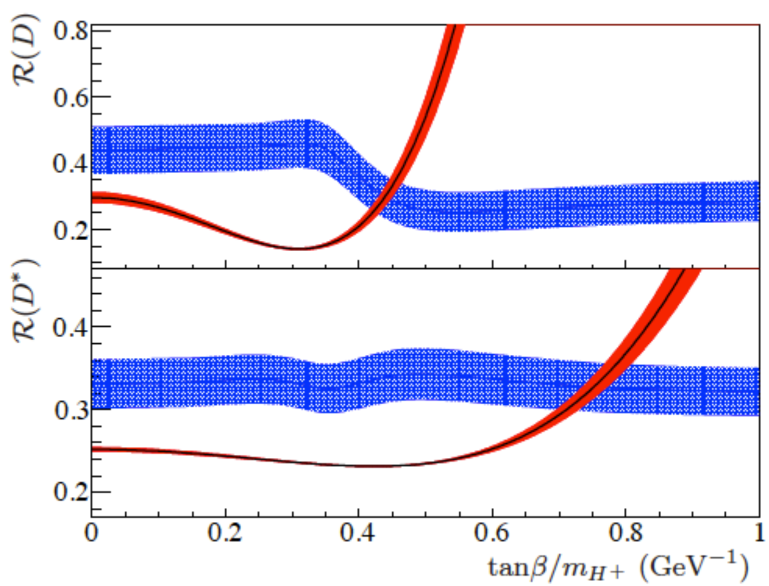
From
Meadow's et al
arXiv:1109.5028v2

…there are a few 3σ effects in the flavour sector that can only be probed with e^+e^- machines



Most recently: *BABAR*'s 3.4σ evidence for an excess of B decays to D(*)τν compared to SM expectations

$$BF(B \to D^{(*)}\tau\upsilon)/BF(B \to D^{(*)}\ell\upsilon)$$



Measure the ratios to minimize systematic errors

NB:this result kills Type II 2HDM

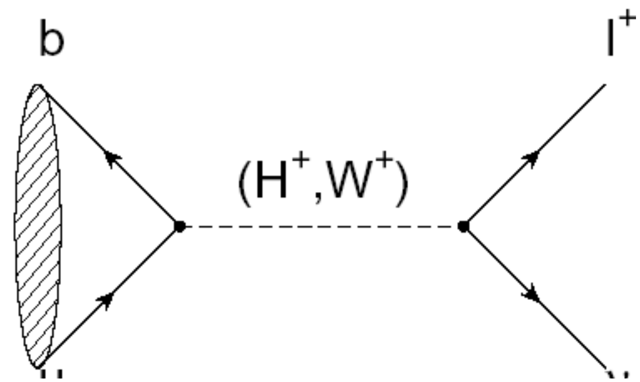
(see D. Lopes Pegna's talk on *BABAR*, D. Zander is showing the Belle result & S. Fajfer's on the theory in WG II Sun. am)

Many physics channels best studied with e^+e^- super flavour factories

a few from that long list…

Rare Leptonic Decays

- $B^{\pm} \rightarrow \tau^{\pm}\nu$ & $B^{\pm} \rightarrow \mu^{\pm}\nu$ directly sensitive to charged higgs.
- important SM parameters V_{ub} and f_B.



$$BF(B \rightarrow l\nu)_{SM} = \frac{G_F^2 m_B}{8\pi} m_l^2 \left(1 - \frac{m_l^2}{m_B^2}\right)^2 f_B^2 |V_{ub}|^2 \tau_B$$ *the most accessible leptonic B decay*

$$BF(B \rightarrow \tau\nu)_{SM} = [1.20 \pm 0.25] \times 10^{-4}$$

$|V_{ub}|=(4.32\pm0.16\pm0.29)\times10^{-3}$ From inclusive semileptonic B decays HFAG ICHEP08

f_B=190±13MeV, From LQCD HPQCD arXiv:0902.1815

$BF(B \rightarrow \mu\nu)_{SM} \sim 5 \times 10^{-7}$ will be measured to ~ 5 - 6%

Measure $BF(B \rightarrow \tau\nu)_{SM} / BF(B \rightarrow \mu\nu)_{SM}$

removes $f_B\,|V_{ub}|$ $\rightarrow$ search for new physics

$B^+ \rightarrow \tau^+ \nu_\tau$ Sensitive to charged Higgs

W. S. Hou, PR D **48**, 2342 (1993)

$$BF(B^+ \rightarrow l^+ \nu_l) = BF(B^+ \rightarrow l^+ \nu_l)_{SM} \times r_H$$

TYPE II 2HDM

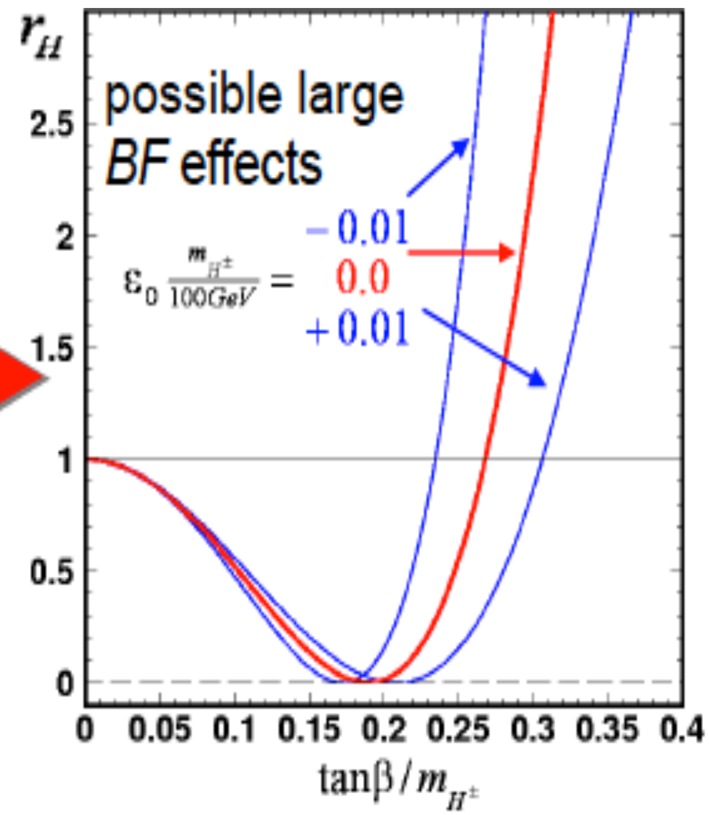
$$r_H = \left(1 - \frac{m_B^2 \tan^2\beta}{m_{H^\pm}^2}\right)^2$$

MSSM

$$r_H = \left(1 - \frac{m_B^2 \tan^2\beta}{m_{H^\pm}^2} \frac{1}{1+\varepsilon_0 \tan\beta}\right)^2$$

e.g. G. Isidori, arXiv:07010.5377

SUSY loop corr.

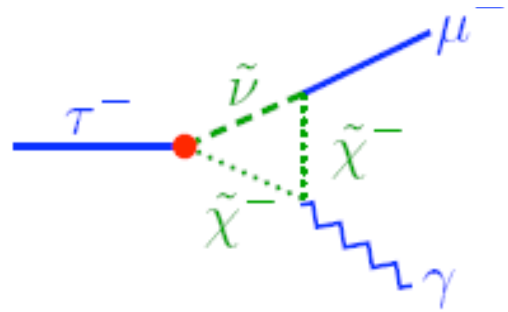


Can use ratio of tau:mu BFs to remove common factors and systematics. Errors on ratio dominated by muon measurement ~5-6%

J. Michael Roney

Lepton Flavour Violation

- e.g. $\tau^{\pm} \rightarrow \mu^{\pm}\gamma$ or $\tau^{\pm} \rightarrow \ell^{\pm}\ell^{\mp}\ell^{\pm}$
- Polarization helps suppress backgrounds, mainly $e^{+}e^{-} \rightarrow \gamma_{ISR}\tau^{+}\tau^{-}$ and identify nature of signal if observed



SuperB, 75 ab^{-1}

Process	Expected 90% CL upper limit	3σ evidence reach
$\mathcal{B}(\tau \to \mu\gamma)$	2.4×10^{-9}	5.4×10^{-9}
$\mathcal{B}(\tau \to e\gamma)$	3.0×10^{-9}	6.8×10^{-9}
$\mathcal{B}(\tau \to \ell\ell\ell)$	2.3–8.2×10^{-10}	1.2–4.0×10^{-9}

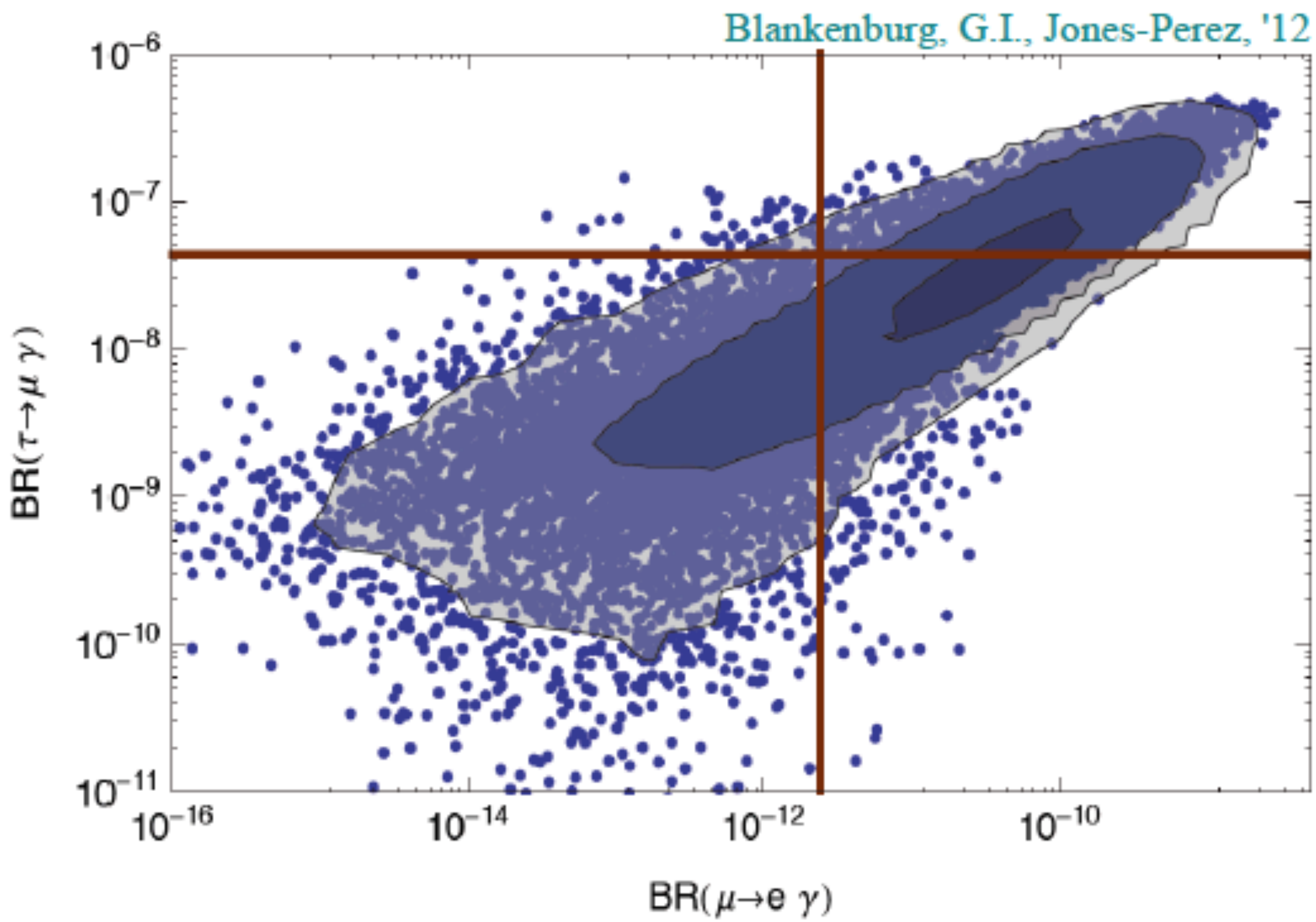
cf 90% cl Limits on B($\tau \rightarrow \mu\gamma$): $<4.5\text{x}10^{-8}$ (Belle)

$<4.4\text{x}10^{-8}$ (BaBar)

* *The key role of LFV and EDMs*

...and there is no doubt that if MEG will see a positive signal, then all other LFV searches would be extremely important to understand the nature of the effect.

E.g.: SUSY with minimally broken $U(3)^5$



SuperB polarised beam

- SuperB is the only e^+e^- high-$\mathcal{L}$ B-factory with a polarised beam: has a unique, and rich, precision electroweak program
- Left-Right Asymmetries (A_{LR}) yield measurements of unprecedented precision of the neutral current vector couplings (g_V) to each of five fermion flavours, f:
  - beauty (D)
  - charm (U)
  - tau
  - muon
  - electron

$$\text{Recall: } g_V^f \text{ gives } \theta_W \text{ in SM} \begin{cases} g_A^f = T_3^f \\ g_V^f = T_3^f - 2Q_f \sin^2\theta_W \end{cases}$$

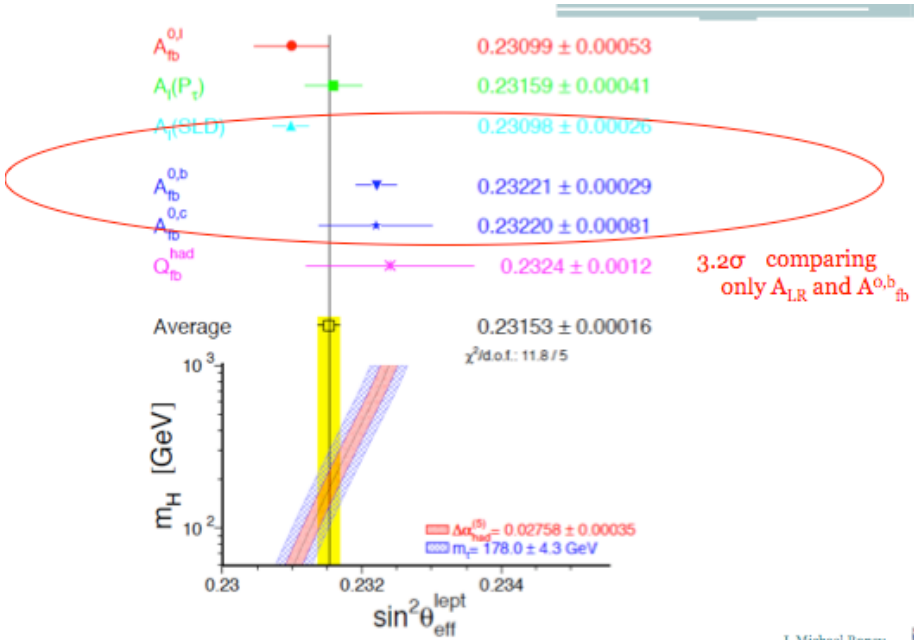
$$A_{LR} = \frac{\sigma_L - \sigma_R}{\sigma_L + \sigma_R} \propto g_V^f = T_3^f - Q_f \sin^2\theta_W$$

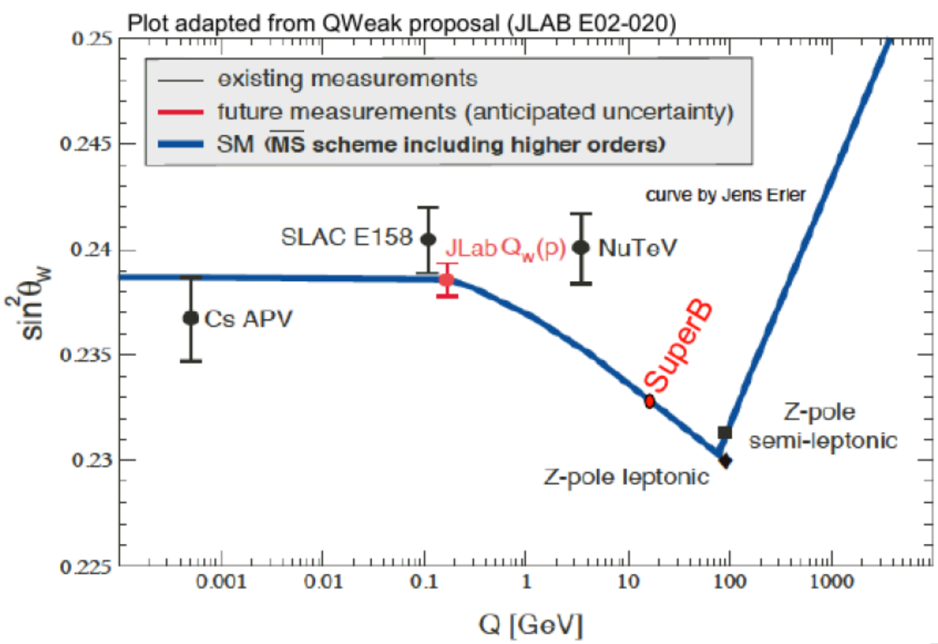
Driven by $\gamma - Z$ interference at $\sqrt{s} = 10.58$ GeV

Similar to SLD's measurement at the Z pole

SuperB polarised beam

Fermion flavour	σ (nb) eff %	Number Selected events (billions)	SM g_V^f (M_Z)	A_{LR} 70% Pol	g_V^f Total Error (%)	$\sin^2\theta_W(M_Z)$ Total Error
beauty	1.1 (95%)	38	-0.3437 ± .0001	-0.013	0.5	0.0026
charm	1.3 (30%)	29	+0.1920 ±.0002	-0.003	0.5	0.00076
tau	0.92 (25%)	17	-0.0371 ±.0003	-3x10^{-4}	2.3	0.00043
muon	1.15 (54%)	46	-0.0371 ±.0003	-3x10^{-4}	1.5	0.00027



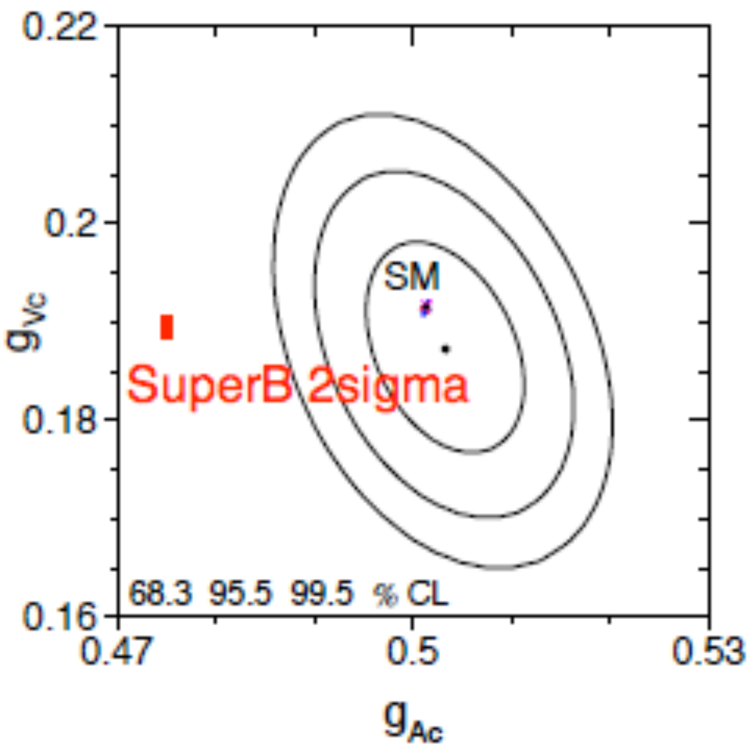


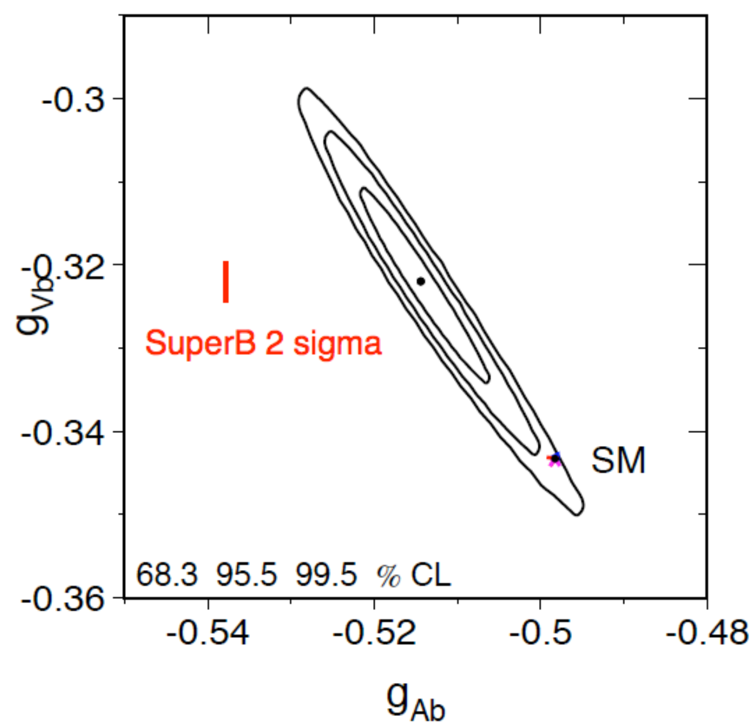
SuperB polarised beam

Comparisons with present neutral current vector coupling uncertainties

Physics Report Vol 427, Nos 5-6 (2006), ALEPH, OPAL, L3, DELPHI, SLD

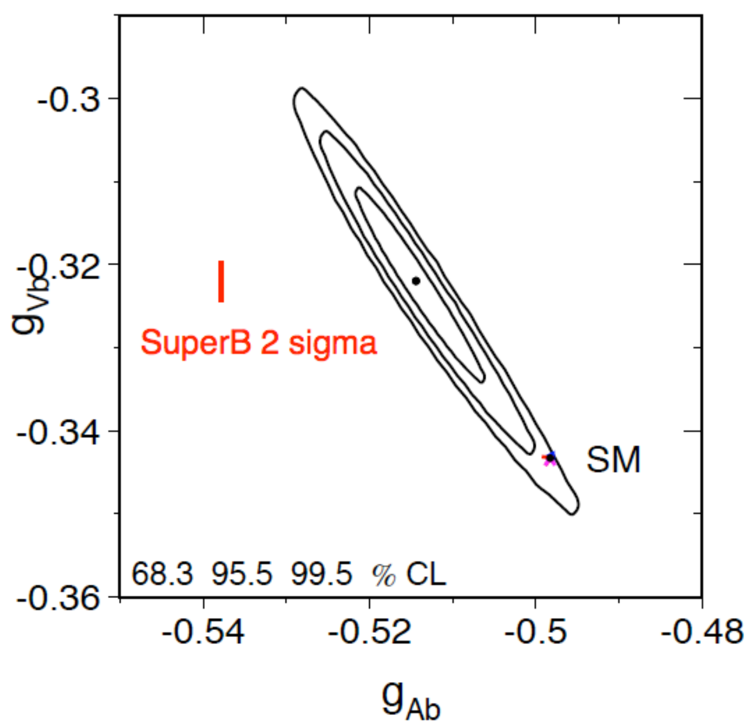
c-quark: SuperB ~7 times more precise **b-quark:** SuperB ~5 times more precise





SuperB polarised beam

Existing tension in data from the Z-Pole:



For a 125GeV Higgs,

g_{Vb} 2.8σ from SM
g_{Ab} 3.1σ from SM

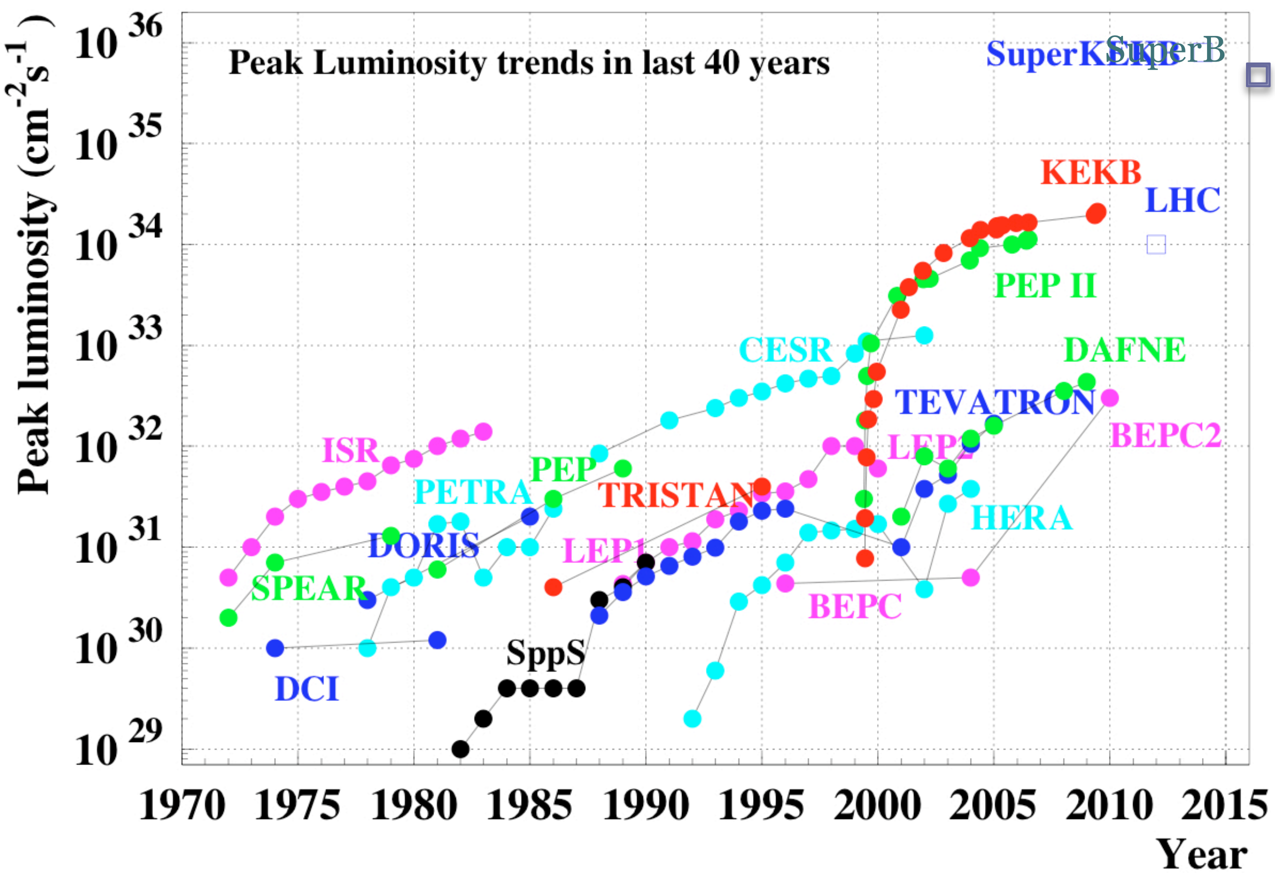
$g_{Rb} = (g_{Vb} - g_{Ab})/2$ is 3σ from SM

SuperB is the only facility in foreseeable future that will be able to experimentally address this 3σ deviation

Physics Report Vol 427, Nos 5-6 (2006)
ALEPH, OPAL, L3, DELPHI, SLD

Super Flavour Factory Accelerators

Colliders… luminosity trends



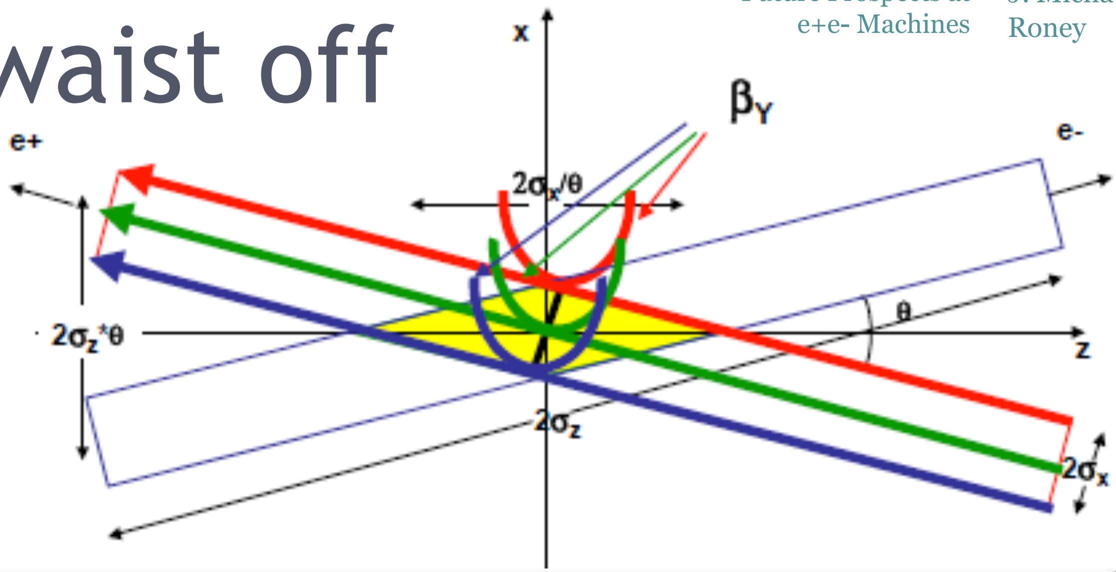
J. Michael Roney

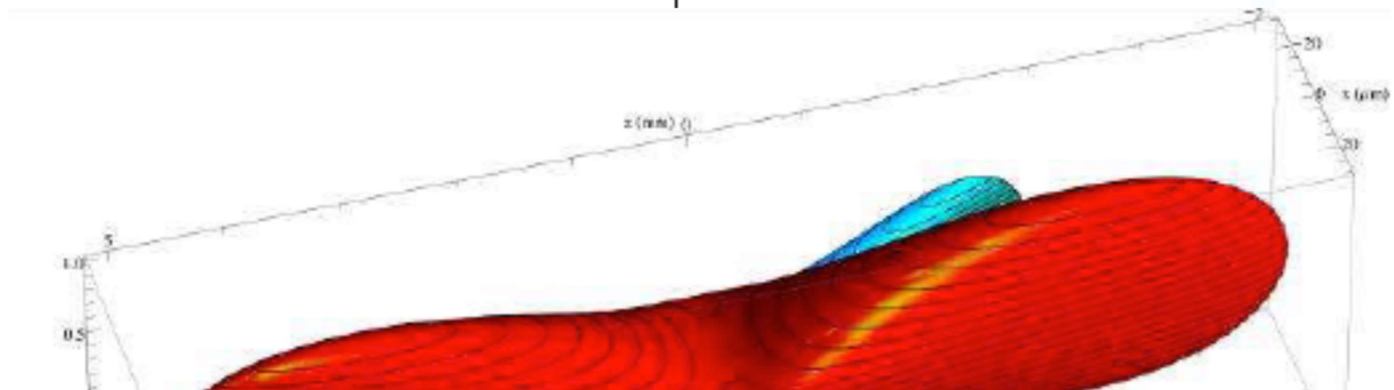
How to get to $\mathcal{L}=10^{36}$ $cm^{-2}s^{-1}$ …

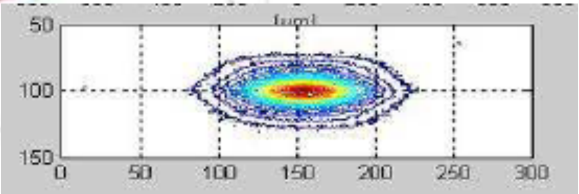
J. Seeman, HEPAP, May 2009

- Crossing angle IR with large Piwinski angle (DAΦNE, KEKB)
- Very low IR vertical and horizontal beta functions (ILC)
- Low horizontal and vertical emittances (Light sources)
- Ampere beam currents (PEP-II, KEKB)
- Crab waist scheme (Frascati, DAΦNE) – SuperB only

Crab waist off



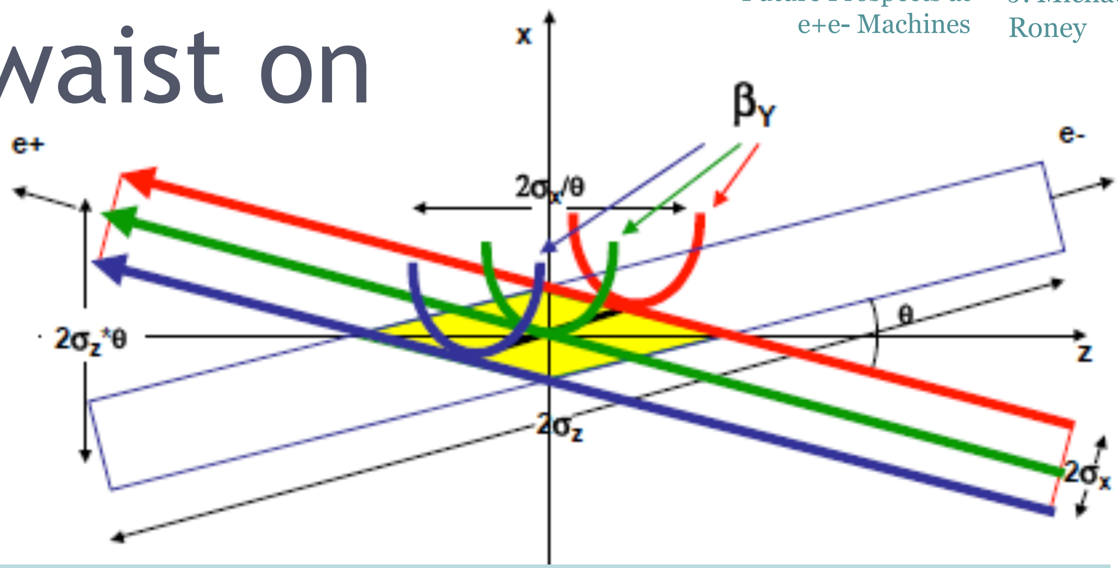




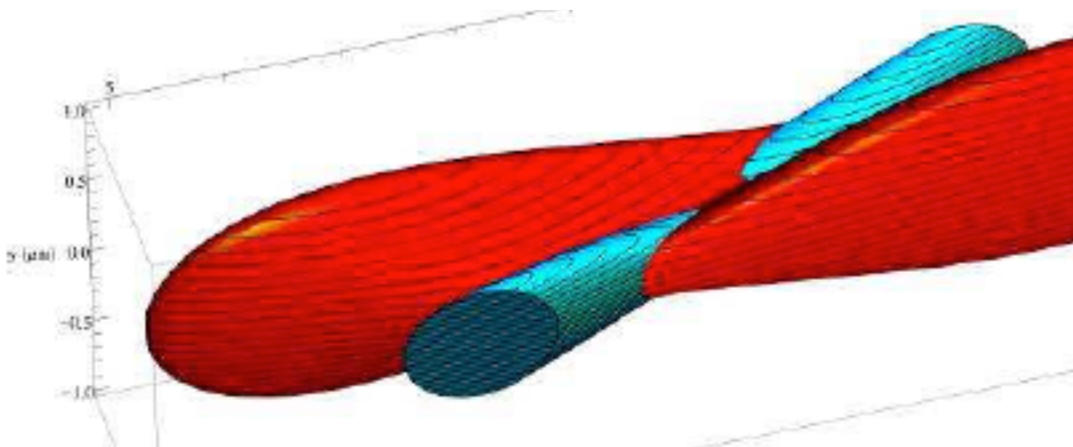
Waist line is orthogonal to the axis of one bunch

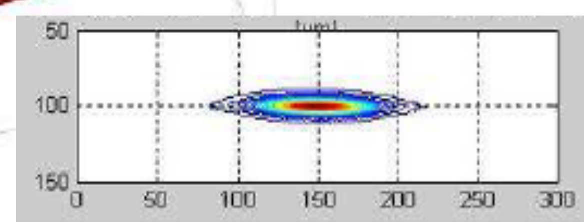
UVic

Crab waist on



All particles in both beams collide in the minimum β_y region, with a net luminosity gain



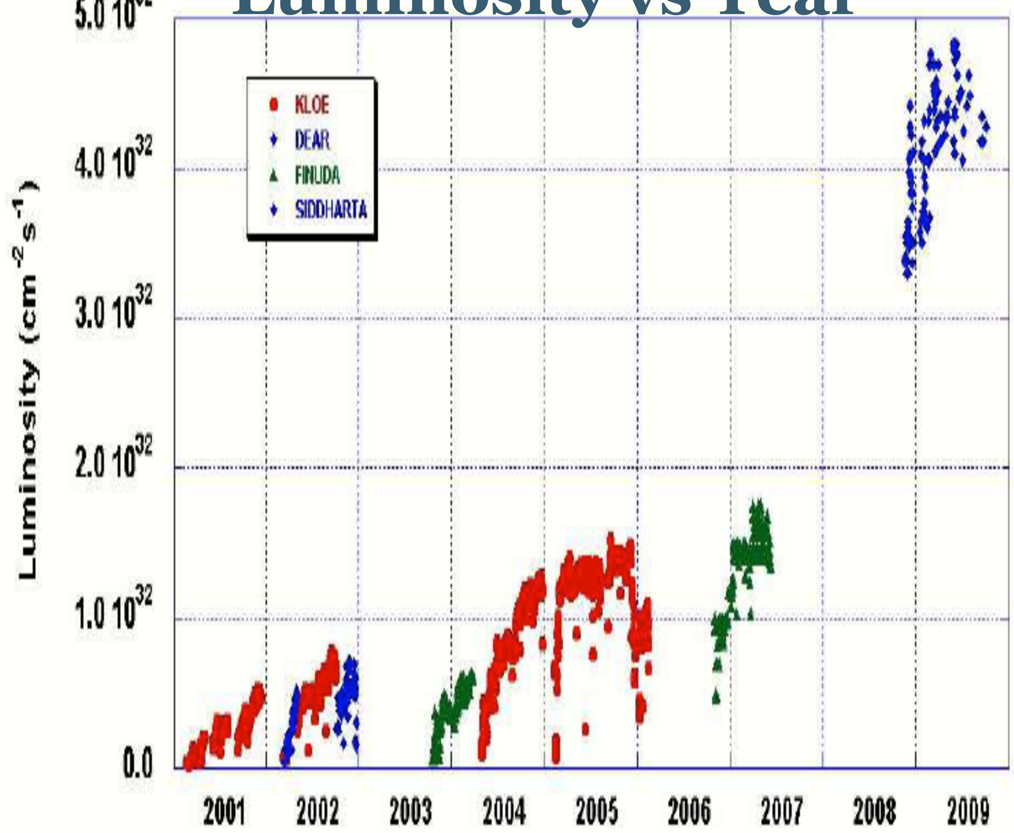


Waist line aligned to the axis of the other beam

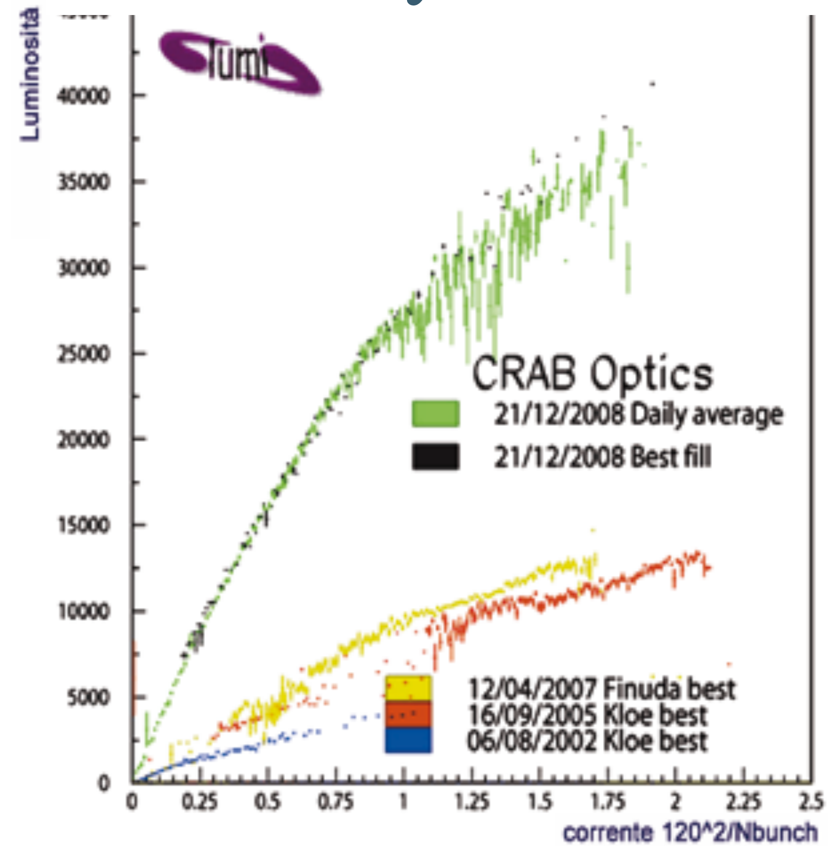
Crab waist Proven at DAΦNE & being deployed at SuperB

- DAΦNE e+e- collider at Frascati with Ecm @ Φ (1020 MeV)
- Upgraded to test crab waist scheme
- Crab Waist effectiveness successfully demonstrated in working collider
- Gains of ~ factor of 3 in luminosity

Luminosity vs Year



Luminosity vs Current



SuperKEKB – upgrade from KEKB

Machine design parameters

Super KEKB
Quest for BSM

parameters		KEKB		SuperKEKB		units
		LER	HER	LER	HER	
Beam energy	E_b	3.5	8	4	7	GeV
Half crossing angle	φ	11		41.5		mrad
Horizontal emittance	ε_x	18	24	3.2	5.0	nm
Emittance ratio	κ	0.88	0.66	0.27	0.25	%
Beta functions at IP	β_x^*/β_y^*	1200/5.9		32/0.27	25/0.31	mm
Beam currents	I_b	1.64	1.19	3.60	2.60	A
beam-beam parameter	ξ_y	0.129	0.090	0.0886	0.0830	
Luminosity	L	2.1×10^{34}		8×10^{35}		$cm^{-2}s^{-1}$

- **Small beam size & high current** to increase luminosity
- **Large crossing angle**
- **Change beam energies** to solve the problem of LER short lifetime

Touschek worse at lower energies

SuperB Parameters

Parameter	Units	Base Line		Low Emittance		High Current		Tau/Charm (prelim.)	
		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	
Piwinski angle	rad	22.88	18.60	32.36	26.30	14.43	11.74	8.80	7.15
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	
Ion gap	%	2		2		2		2	
RF frequency	Hz	4.76E+08		4.76E+08		4.76E+08		4.76E+08	
Harmonic number		1998		1998		1998		1998	
Number of bunches		978		978		1956		1956	
N. Particle/bunch		5.08E+10	6.56E+10	3.92E+10	5.06E+10	4.15E+10	5.36E+10	1.83E+10	2.37E+10
Tune shift x		0.0021	0.0033	0.0017	0.0025	0.0044	0.0067	0.0052	0.0080
Tune shift y		0.0970	0.0971	0.0891	0.0892	0.0684	0.0687	0.0909	0.0910
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)	dE/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	dE/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	17.08		12.72		30.48		3.11	

J. Michael Roney

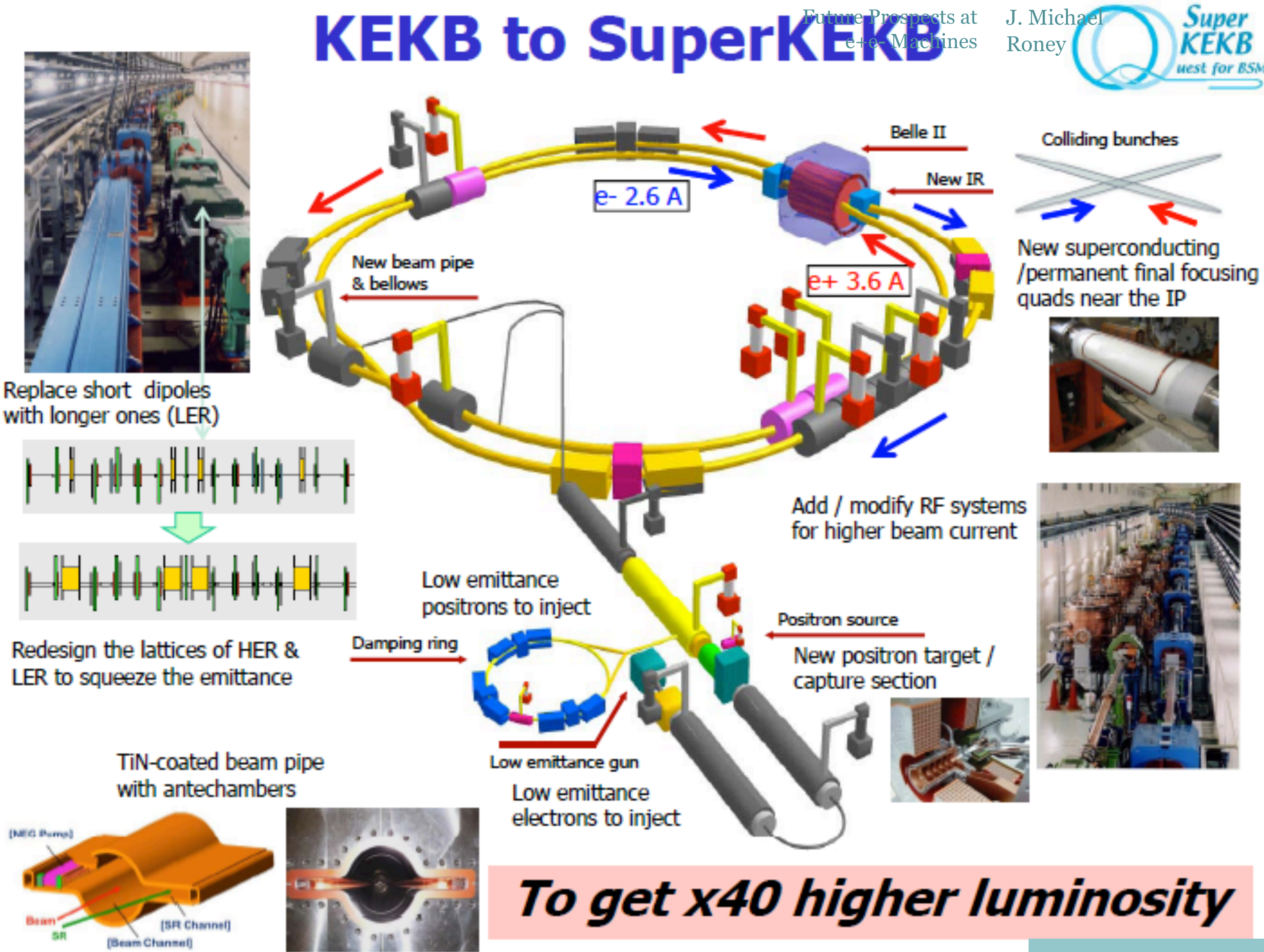
Tau/charm threshold running at 10^{35}

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

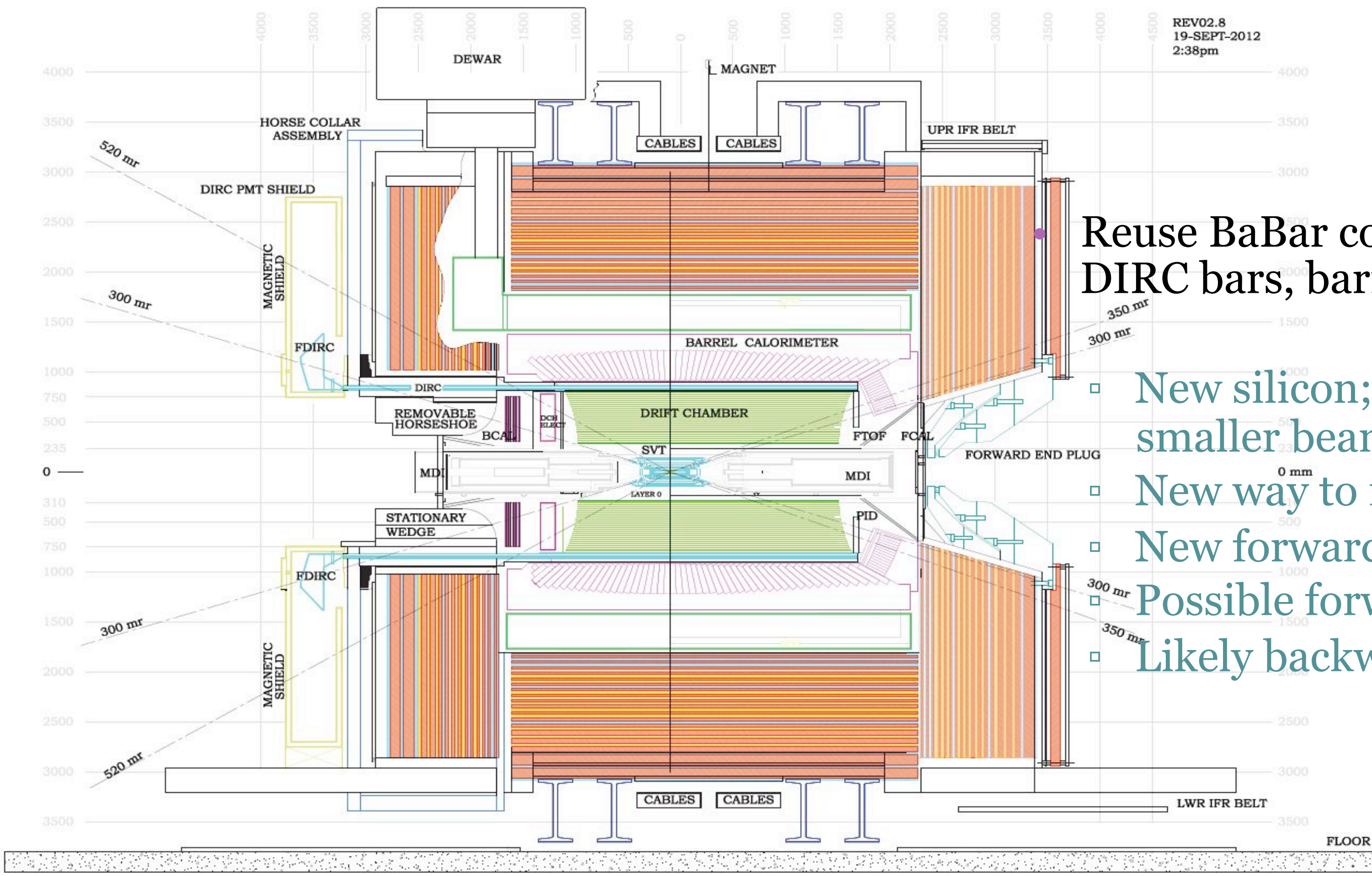
KEKB to SuperKEKB



To get x40 higher luminosity

The Detectors

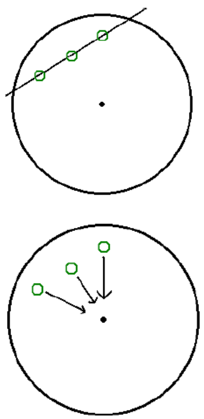
SuperB Detector

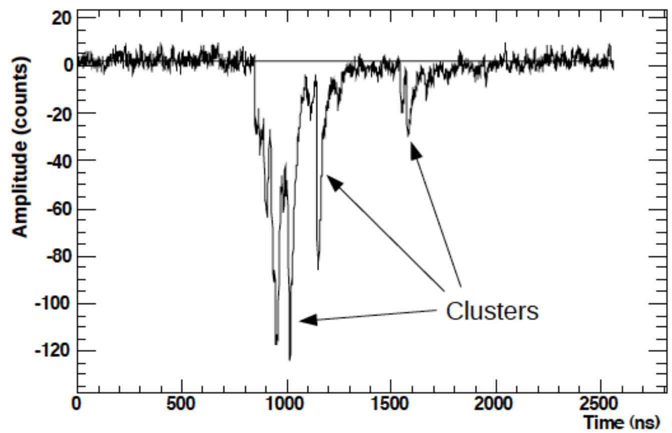


Reuse BaBar components: magnet, DIRC bars, barrel CsI calorimeter.

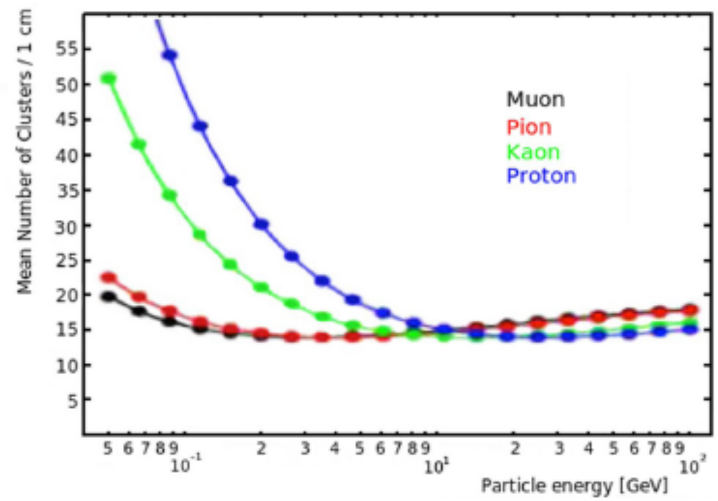
- New silicon; add Layer 0 with smaller beam pipe
- New way to read out DIRC
- New forward calorimeter
- Possible forward PID
- Likely backward EMC

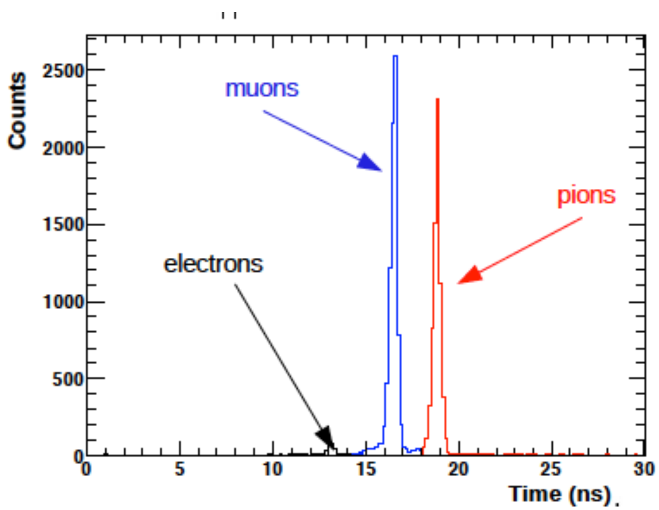
Drift Chamber with ionization "cluster counting" improves particle ID





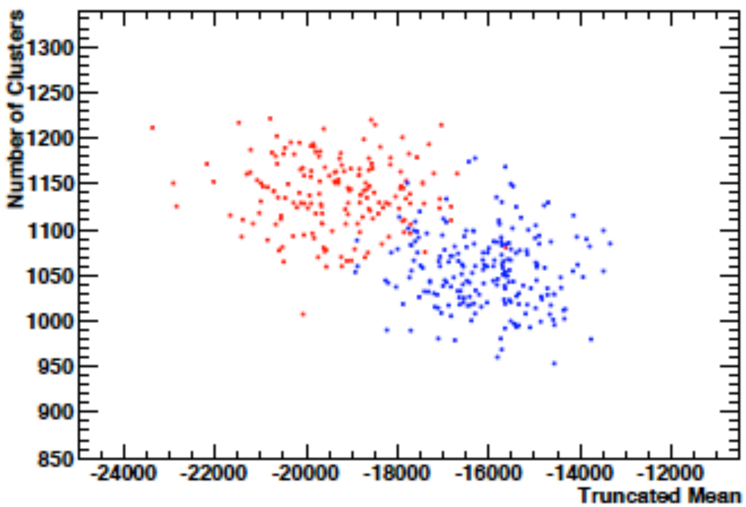
90% Helium, 10% Isobutane





Prototype in TRIUMF test beam with e^+, μ^+, π^+ at 140–350 MeV/c. μ/π separation ≈ SuperB π/K separation at 2–3 GeV/c, use TOF for independent beam particle ID

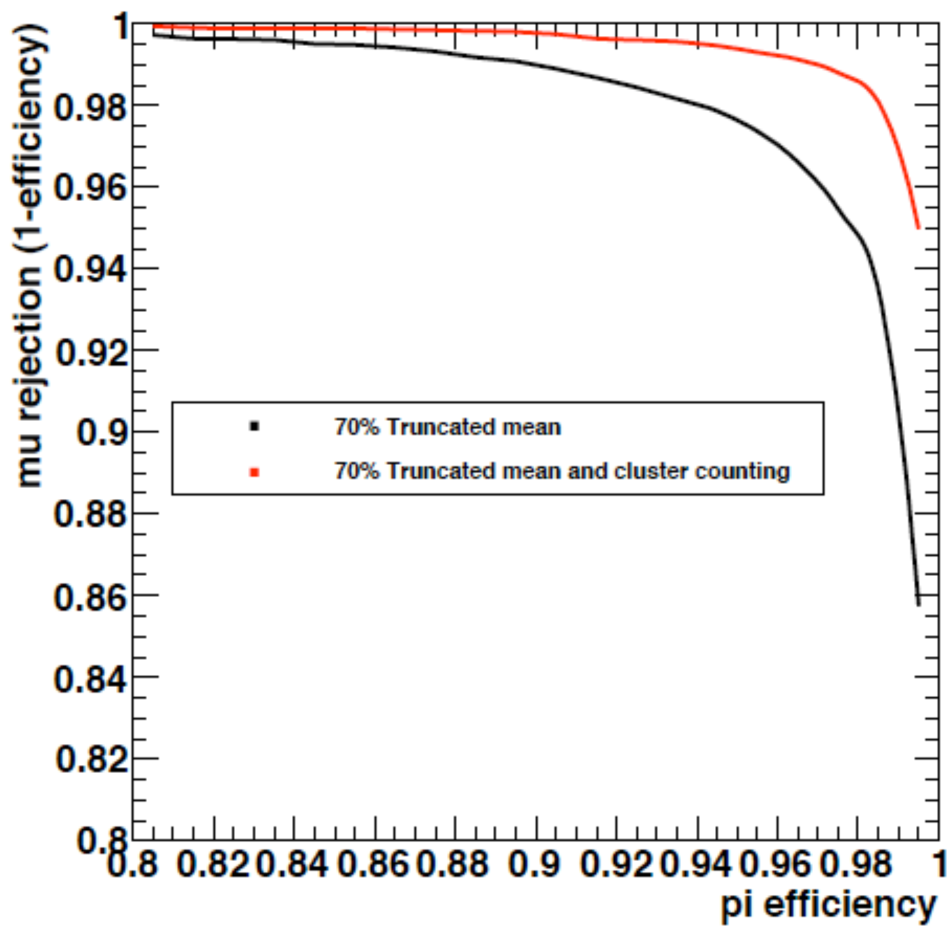
Drift Chamber with ionization "cluster counting" improves particle ID



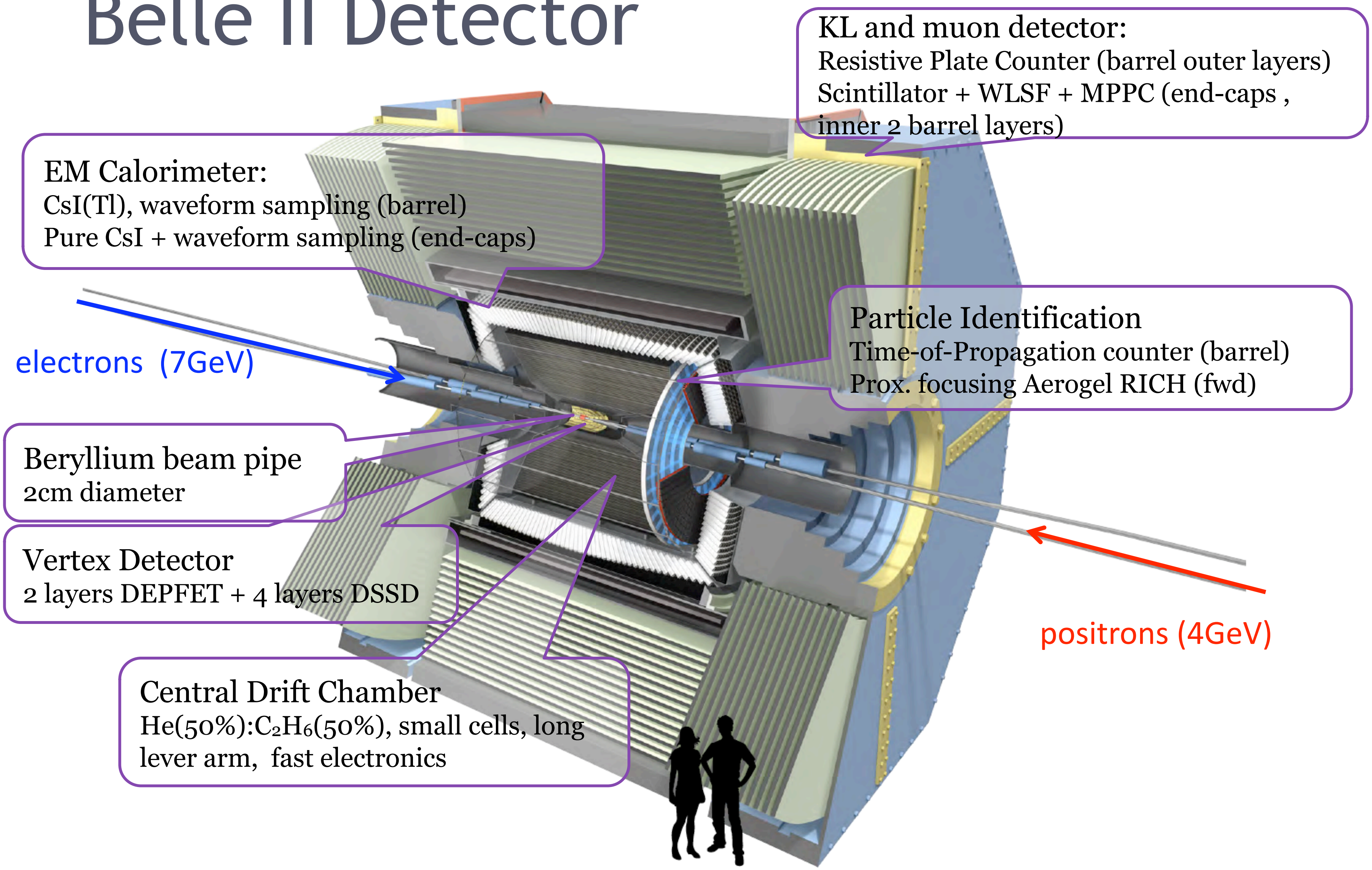
No. clusters vs Truncated Mean

Blue = muons,

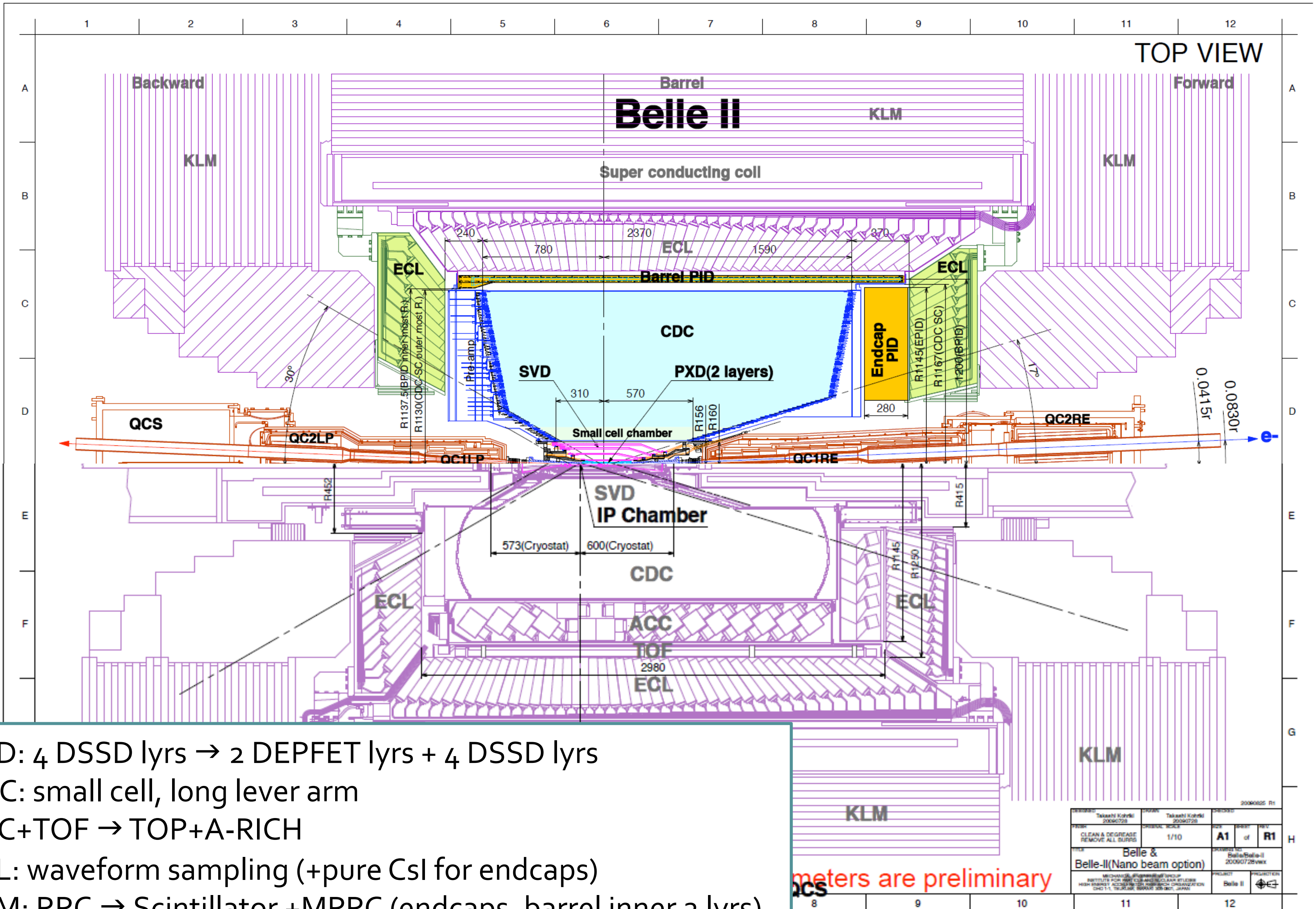
Red = Pions



Belle II Detector



Belle II Detector (in comparison with Belle)



SVD: 4 DSSD lyrs → 2 DEPFET lyrs + 4 DSSD lyrs
CDC: small cell, long lever arm
ACC+TOF → TOP+A-RICH
ECL: waveform sampling (+pure CsI for endcaps)
KLM: RPC → Scintillator +MPPC (endcaps, barrel inner 2 lyrs)

UVic

PID Devices

Barrel PID: Time of Propagation Counter (TOP)

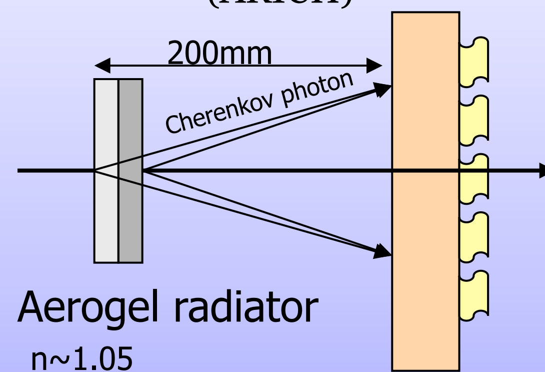
Quartz radiator

Focusing mirror

Small expansion block

Hamamatsu MCP-PMT (measure t, x and y)

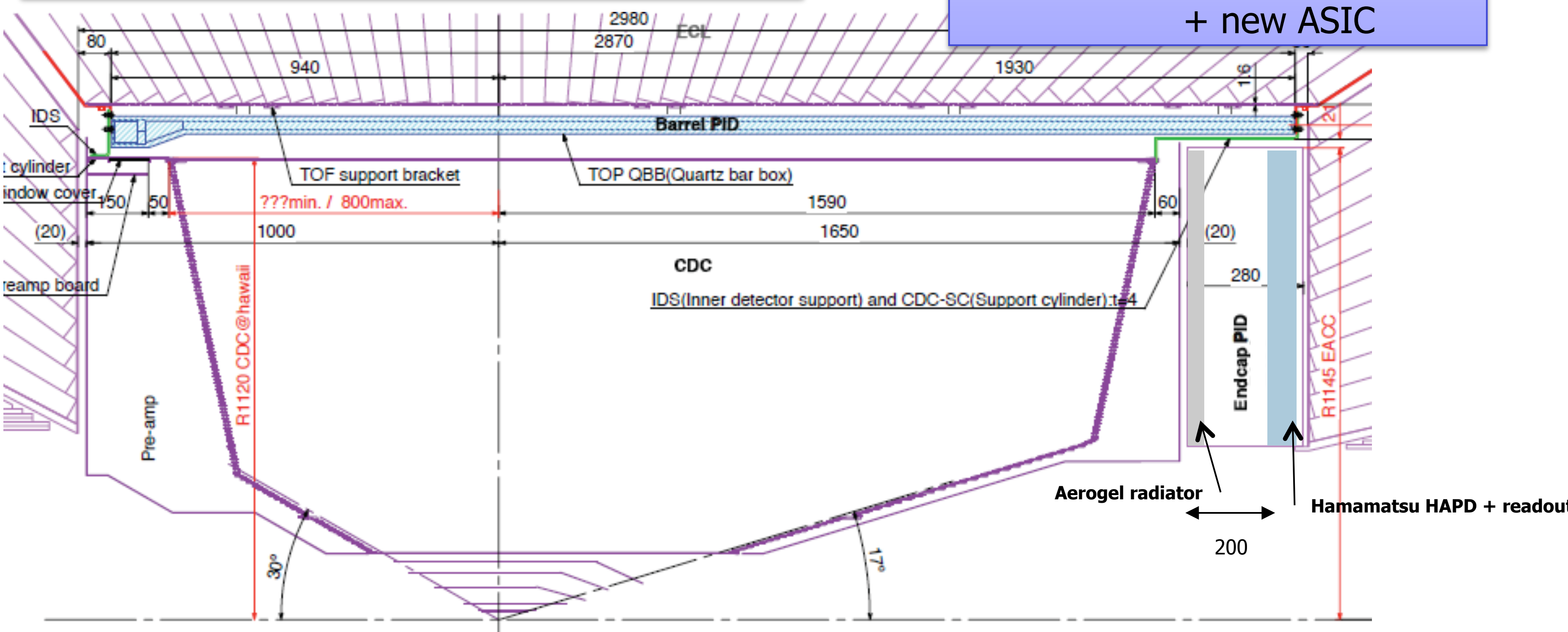
Endcap PID: Aerogel RICH (ARICH)



Aerogel radiator

n~1.05

Hamamatsu HAPD + new ASIC



J. Michael Roney

UVic

Status and outlook

SuperB Status (Ministerial approval press release, Dec 2010)

The Italian Government Funds the Super-B Accelerator

Friday, 24 December 2010 10:02 Media and press release »

The Ministry for Education, University and Research has decided to select the SuperB project conducted by the Italian National Institute of Nuclear Physics (INFN) as one of its "flagship projects" in Italy over the next few years and has delivered an initial funding for 2010 as a part of a multiannual funding program. Reconstructing the history of the Universe by researching the most infrequent events using high-precision technology. This is the INFN idea underlying the construction of SuperB, the particle accelerator based in Italy and with international involvement, which the Ministry for Education, University and Research has decided to sponsor and finance. A large interest has been expressed in many countries, meanwhile physicists from the United States, Germany, France, Russia, the United Kingdom, Israel, Canada, Norway, Spain, Poland are taking part to the design effort. The purpose of the project is to conduct top-level basic research, developing innovative techniques with an important impact in terms of technology and other research areas. In the words of the ministerial decree, "the project involves entities and Universities, as well as companies in various business sectors. It is expected to have a number of effects on relevant issues for the country, especially as regards the expansion of basic scientific perspectives and specific applications concerning particle detection, advanced simulation techniques, nanometre metrology, and others." Istituto Italiano di Tecnologia (IIT) is cooperating to the project with INFN. It will be in fact possible the use of the accelerator as a high brilliancy light source. The machine will be equipped with several photon channels, allowing the extension of scientific program to physics of matter and biotechnology.

The SuperB project basic assumption is that particle accelerators, smaller than the current "giants", operated at a low energy, can allow excellent scientific results complementary to the high energy frontier.

APPROVED

SuperB Status

- SuperB approved as the first in a list of 14 “flagship” projects within the Italian National Research Plan
- National Research Plan endorsed by “CIPE” (institution responsible for infrastructure long term plans)
- A financial allocation of 256 Million Euros over six years approved for the “SuperB Flavour Factory” (total cost and request ~twice that, assuming PEP-II equipment re-use)
- Cabibbo Lab created on Oct 7 , 2011
  - Major step forward: first major particle physics accelerator lab to be created in a generation
  - legal structure needed in order to spend funds, sign MOUs
  - MOUs with various institutions and labs completed or nearing completion
    - most recently completed MOU with Budker Institute

SuperB Status

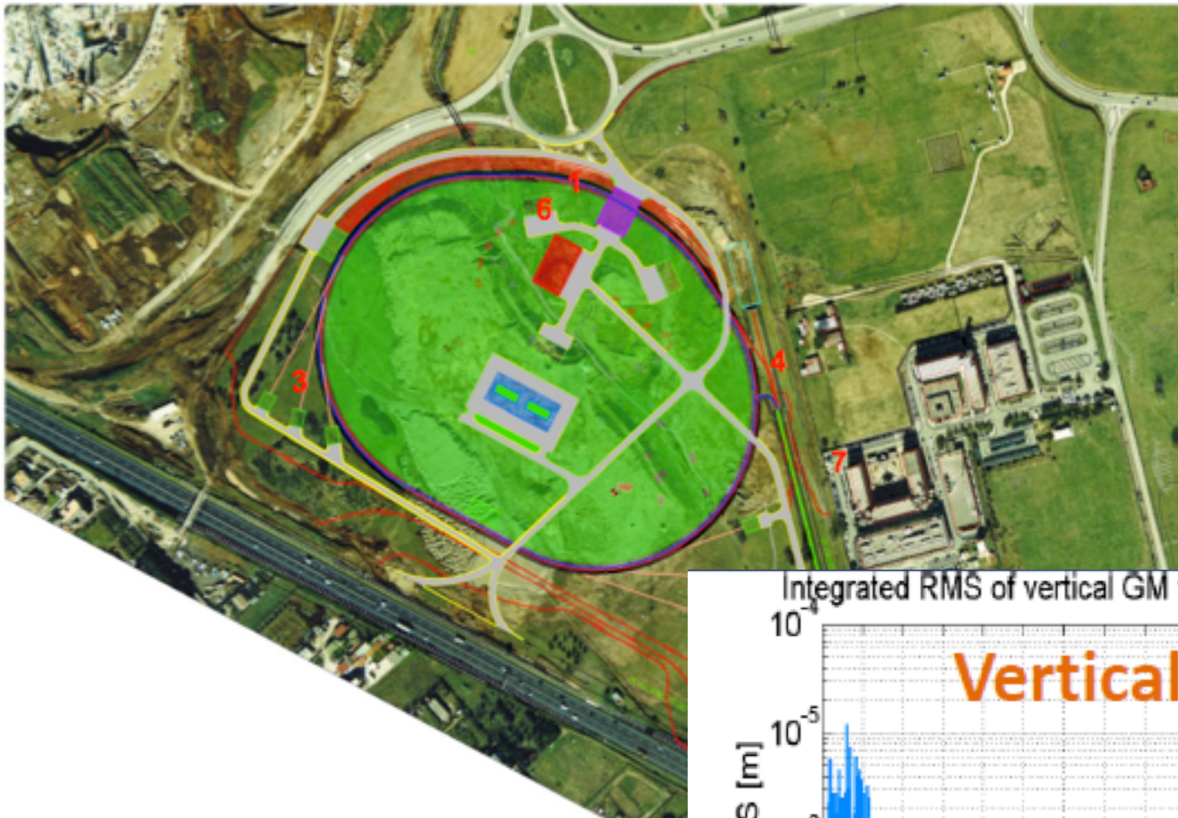
- SuperB Collaboration formally in place since March 2012
- Cabibbo Lab management in place April 2012
- First hires in May/June 2012

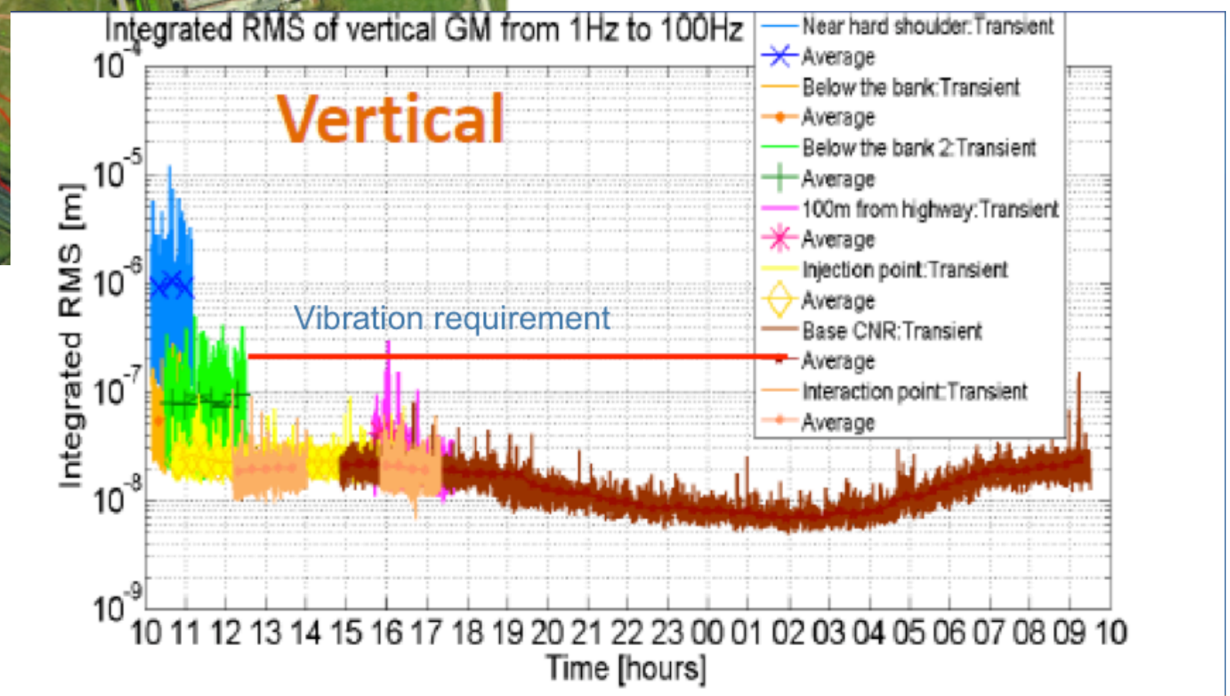
- International Review Committee set up by Italian Ministry of Science (MIUR) to examine the Cost and Schedule of the SuperB project
  - Committee received costing document in July 2012
  - Report of the committee expected this autumn

- Ministerial review for all Flagship projects in autumn 2012


Tor Vergata University campus
SuperB Site
About 4.5 Km
LNF
Via di Passolombardo
A1 dir
SP77b
© 2011 Tele Atlas
SS215
Image © 2011 DigitalGlobe
© 2011 Europa Technologies

Detailed site view





Well within vibration budget

SuperB Status – key milestones

- Site selection: summer 2011
- Machine and Detector TDR end 2012
- Start civil engineering 2013
- Start machine installation early 2014
- First collisions 2018

SuperKEKB/Belle II Status

Funding

- ~100 MUS for machine approved in 2009 -- Very Advanced Research Support Program (FY2010-2012)
- Full approval by the Japanese government in December 2010; the project was finally in the JFY2011 budget as approved by the Japanese Diet end of March 2011
- Most of non-Japanese funding agencies have also already allocated sizable funds for the upgrade of the detector.

→construction started in 2010!

Fortunately little damage during the March 2011 earthquake → no delay

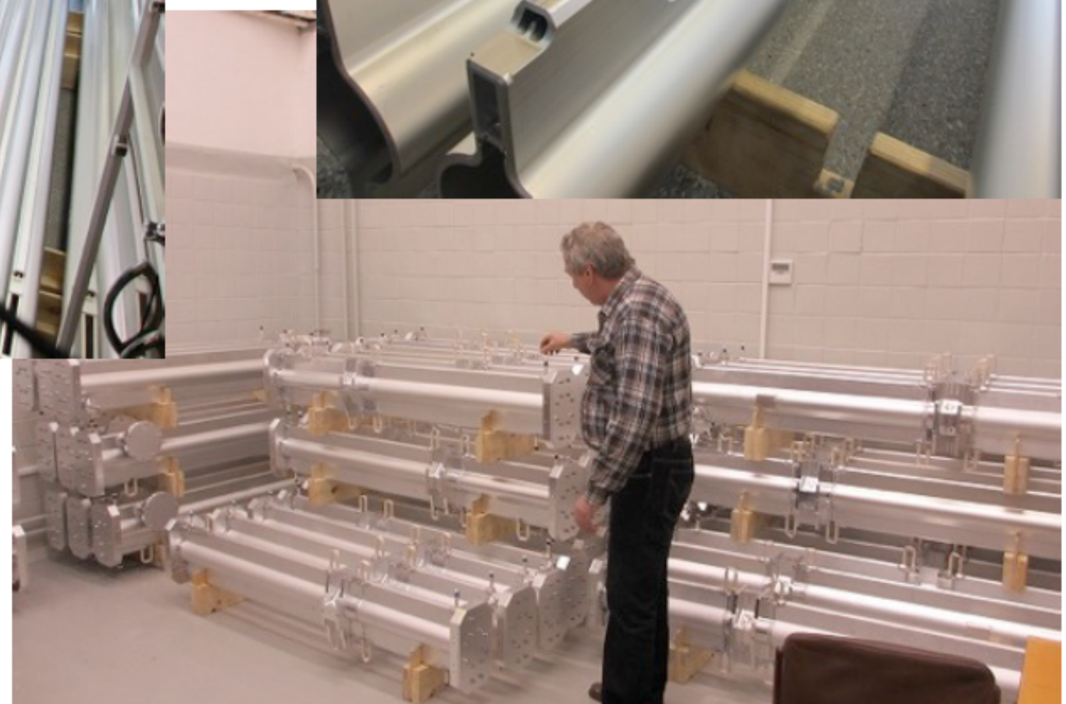
- Ground breaking ceremony in November 2011
- SuperKEKB and Belle II construction proceeding according to the schedule.

1/3 of new dipole magnets have been installed in LER. (July 9, 2012)

Three magnets per day ! Total ~100

- Installing the 4 m LER dipole over the 6 m HER dipole (remain in place).
- All LER dipoles are scheduled to be installed this year.

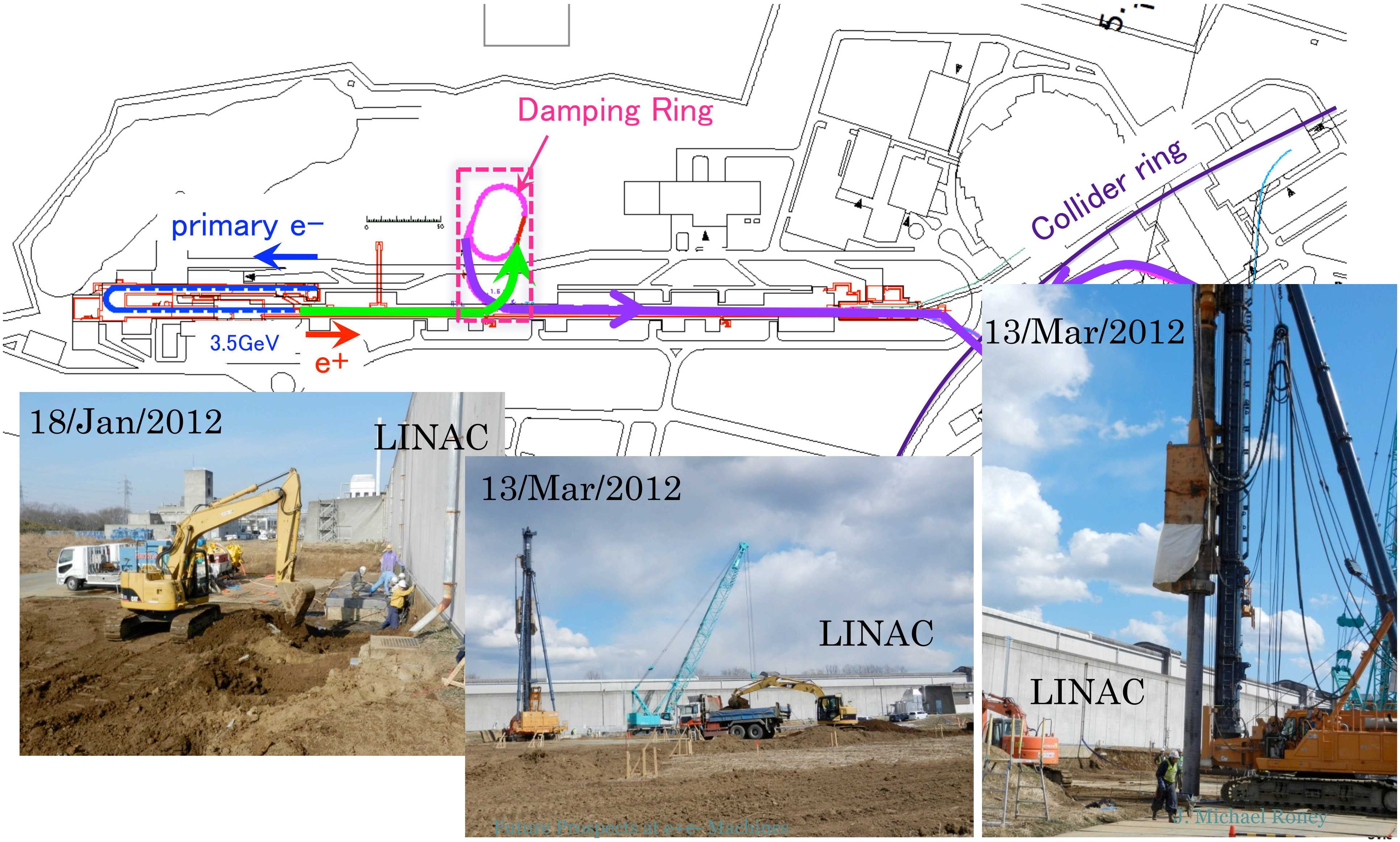
Entirely new LER beam pipe with ante-chamber and Ti-N coating



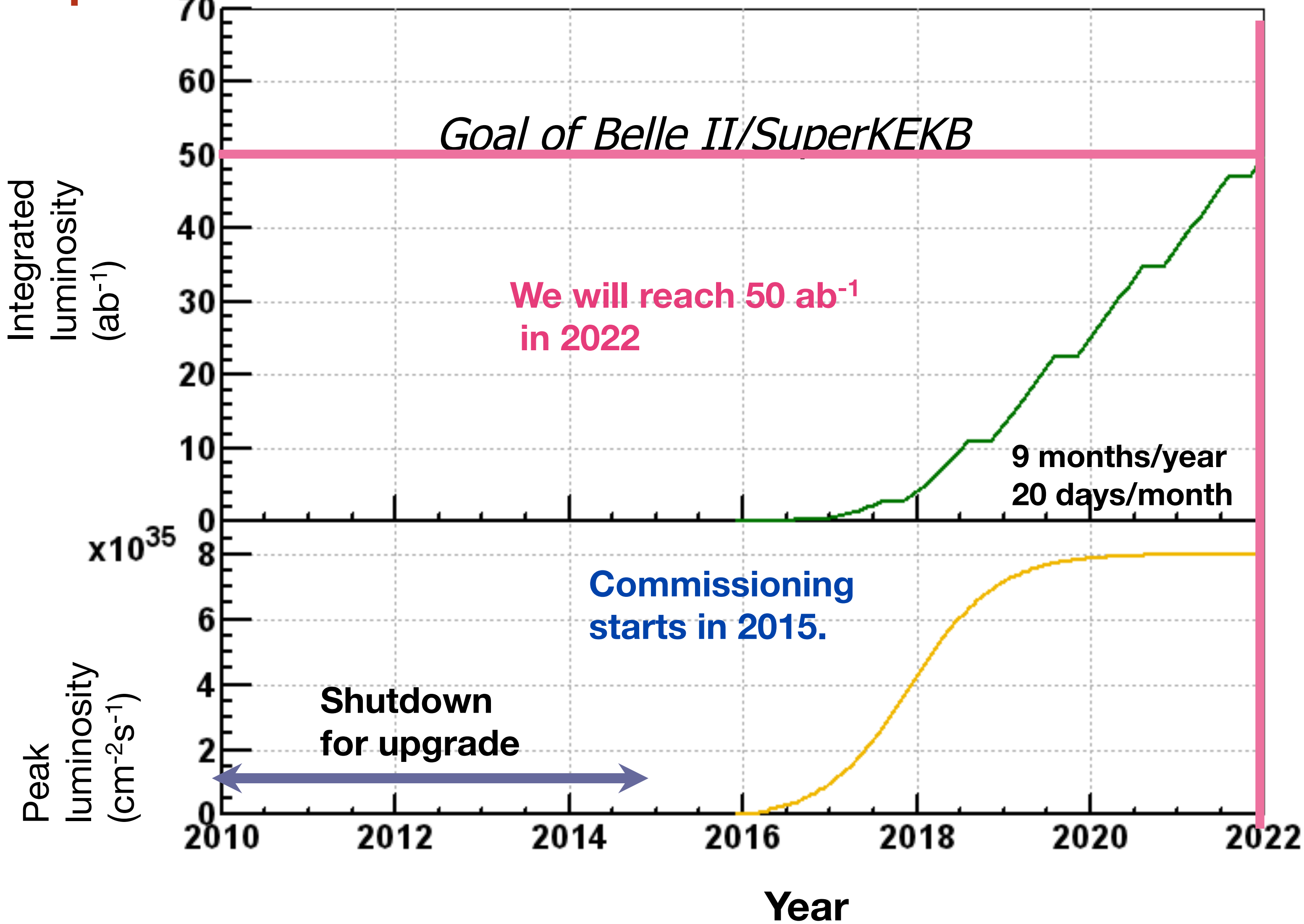
Beam pipe is made of aluminum.

Fabrication of the LER arc beam pipe section is completed

Damping ring construction started in Jan 2012



SuperKEKB Schedule



The schedule is likely to shift by a few months because of a new construction/commissioning strategy for the final quads.

Summary

- BES III: 2015- taking 10 fb^{-1} $\psi(3770)$; runs another 8–10yrs
- Promising developments for c/τ factory in Novosibirsk
- SuperB e^+e^- flavour factories provide extremely broad and exciting physics program with sensitivity to new physics that is complementary to the LHC.
- Flexibility in ways that these machines can achieve 100× luminosity with beam currents and power comparable to current facilities
- SuperB is hosted in CabibboLab: world's newest HEP accelerator lab – Italian parliament approved funding for ~ first half; undergoing cost and schedule review now for the balance; ground breaking in 2013
- SuperKEKB received Japanese Diet approval for complete project in 2011, construction proceeding well!

Additional slides

SuperB funding profile: INFN Piano Triennale 2011-13

Componenti Super B	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Sviluppo Acceleratore (130 M€) Costruzione infrastrutture, Sviluppo damping rings, Sviluppo transfer lines, Messa in funzione linac, Damping lines transfer lines, Costruzione facility end-user	20	50	60							
Sviluppo Centri Calcolo (43 M€) Sviluppo progettazione costruzione centro di calcolo per analisi dati	5	15	23							
Completamento Acceleratore (126 M€) Installazione componenti negli archi acceleratore, Installazione zona di interazione, Messa in funzione acceleratore				42	42	42				
Utilizzo installazione (80 M€) Costi operazione e manutenzione acceleratore							20	20	20	20
Totale Infrastrutture tecniche (379 M€)	25	65	83	42	42	42	20	20	20	20
Overheads INFN (34.3 M€ equivalente al 9%)	2.3	5.9	7.5	3.8	3.8	3.8	1.8	1.8	1.8	1.8
Cofinanziamento INFN (150 M€)	15	15	15	15	15	15	15	15	15	15
Costo Totale del progetto (563.3 M€)	42.3	85.9	105.5	60.8	60.8	60.8	36.8	36.8	36.8	36.8

Super Flavour Factory Physics Program Summary

B Physics at the $\Upsilon(4S)$

A. New Physics in CP violation
  1. ΔS measurements

B. Theoretical aspects of rare decays
  1. New physics in $B \to K^{(*)}\nu\bar{\nu}$ decays
  2. $\bar{B} \to X_s\gamma$ and $\bar{B} \to X_s\ell^+\ell^-$
  3. Angular analysis of $B \to K^* l^+ l^-$
  4. $\bar{B} \to X_d\gamma$ and $\bar{B} \to X_d\ell^+\ell^-$

C. Experimental aspects of rare decays
  1. $B \to K^{(*)}\nu\bar{\nu}$
  2. $B \to \ell\nu$ and $B \to \ell\nu\gamma$
  3. Experimental aspects of $\bar{B} \to X_s\gamma$
  4. Inclusive and exclusive $b \to s\ell^+\ell^-$
  5. More on $B \to X_{s/d}\ell^+\ell^-$ with a hadron tag

D. Determination of $|V_{ub}|$ and $|V_{cb}|$
  1. Inclusive Determination of $|V_{ub}|$
  2. Inclusive Determination of $|V_{cb}|$

E. Studies in Mixing and CP Violation in Mixing
  1. Measurements of the mixing frequency and CP asymmetries
  2. New Physics in mixing
  3. Tests of CPT

F. Why measure γ precisely (and how)?

G. Charmless hadronic B decays

H. Precision CKM

B Physics at the $\Upsilon(5S)$

1. Measurement of B_s Mixing Parameters
2. Time Dependent CP Asymmetries at the $\Upsilon(5S)$
3. Rare Radiative B_s Decays
4. Measurement of $B_s \to \gamma\gamma$
5. Phenomenological Implications

Super Flavour Factory Physics Program Summary

Electroweak neutral current measurements

Spectroscopy
A. Introduction
B. Light Mesons
C. Charmonium
D. Bottomonium
  1. Regular bottomonium
  2. Exotic bottomonium
E. Interplay with other experiments

Direct Searches
A. Light Higgs
B. Invisible decays and Dark Matter
C. Dark Forces

τ physics
A. Lepton Flavor Violation in τ decay
  Predictions from New Physics models
    LFV in the MSSM
    LFV in other scenarios
  Super*B* experimental reach
B. *CP* Violation in τ decay
C. Measurement of the τ electric dipole moment
D. Measurement of the τ $g-2$
E. Search for second-class currents

Super Flavour Factory Physics Program Summary

Charm Physics

A. On the Uniqueness of Charm

B. $D^0 - \bar{D}^0$ Oscillations
   1. Experimental Status
   2. Combination of measurements and *CPV*
   3. Measurements of strong phases
   4. Theoretical Interpretation
   5. Measuring x_D and y_D at Super*B*
   6. Projections for mixing measurements at Super*B*
   7. Estimated sensitivity to *CPV* from mixing measurements

C. CP Violation
   1. Generalities
   2. SM Expectations
   3. Experimental Landscape
   4. Littlest Higgs Models with T Parity – A Viable Non-ad-hoc Scenario

D. Rare Decays
   1. $D^0 \to \mu^+\mu^-, \gamma\gamma$
   2. $D \to l^+l^-X$

E. Experimental possibilities for rare decay searches at Super*B*
   1. $D \to l^+l^-X$

F. A case for Running at the $D\bar{D}$ threshold?