CKM Workshop, Warwick, September 7, 2010

Plans for future B factories

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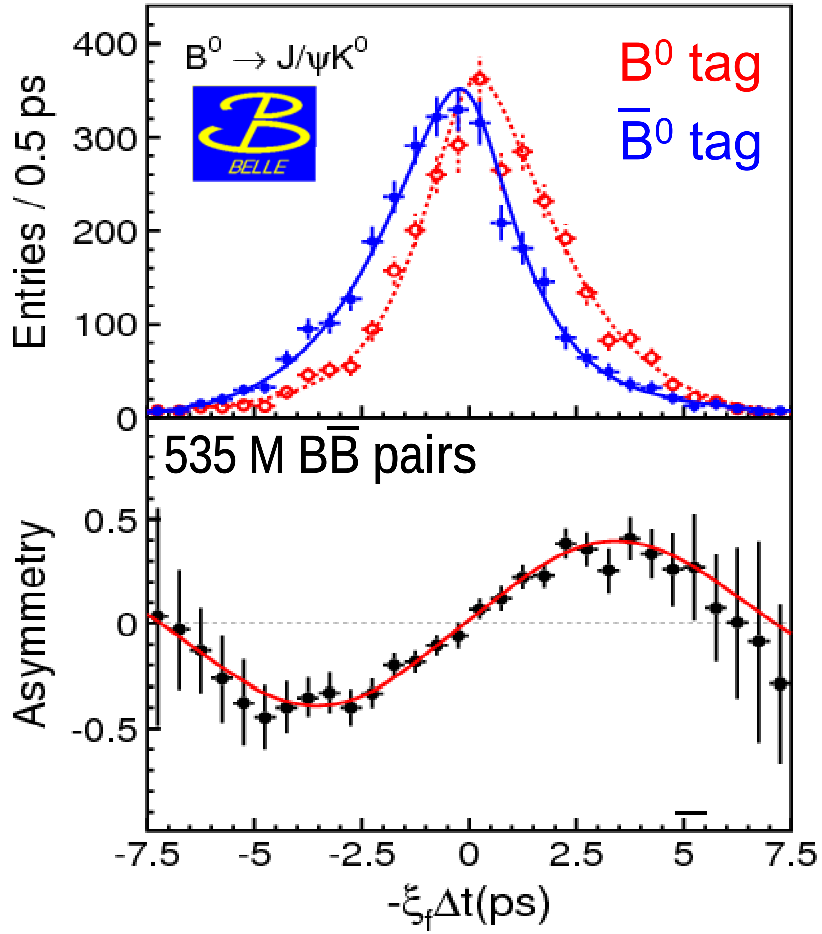
- Physics case for a Super B factory
- SuperKEKB/Belle-II@KEK and SuperB@Frascati
- Accellerators
- Detectors
- Status and prospects of the projects

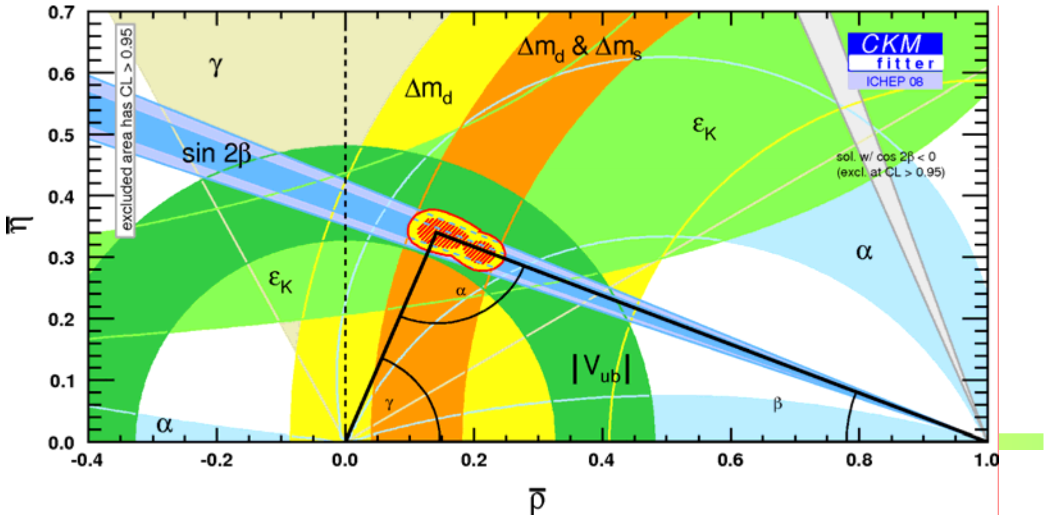
B factories: CP violation in the B system

CP violation in B system: from the discovery (2001) to a precision measurement (2006)

$\sin 2\phi_1/\sin 2\beta$ from $b \rightarrow ccs$

World average 2008:
$\sin 2\phi_1 = 0.681 \pm 0.025$



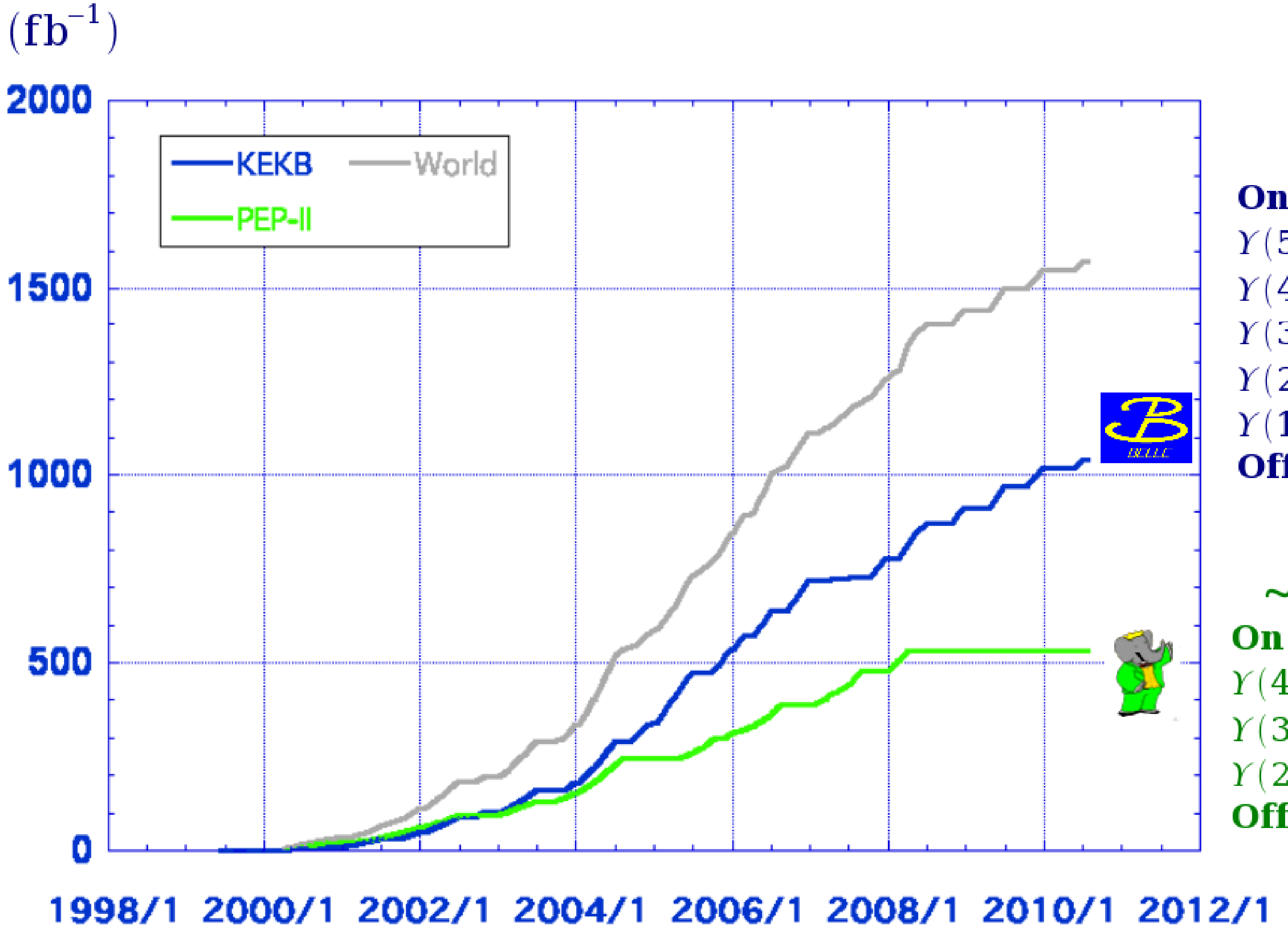


Constraints from measurements of angles and sides of the unitarity triangle → Remarkable agreement

B factories: a success story

- Measurements of CKM matrix elements and angles of the unitarity triangle
- Observation of direct CP violation in B decays
- Measurements of rare decay modes (e.g., $B \to \tau\nu$, $D\tau\nu$)
- $b \to s$ transitions: probe for new sources of CPV and constraints from the $b \to s\gamma$ branching fraction
- Forward-backward asymmetry (A_{FB}) in $b \to sl^+l^-$ has become a powerfull tool to search for physics beyond SM.
- Observation of D mixing
- Searches for rare τ decays
- Observation of new hadrons

Luminosity at B factories



> 1 ab^{-1}

On resonance:

$\Upsilon(5S)$: 121 fb^{-1}

$\Upsilon(4S)$: 711 fb^{-1}

$\Upsilon(3S)$: 3 fb^{-1}

$\Upsilon(2S)$: 24 fb^{-1}

$\Upsilon(1S)$: 6 fb^{-1}

Off reson./scan:

~ 100 fb^{-1}

~ 550 fb^{-1}

On resonance:

$\Upsilon(4S)$: 433 fb^{-1}

$\Upsilon(3S)$: 30 fb^{-1}

$\Upsilon(2S)$: 14 fb^{-1}

Off resonance:

~ 54 fb^{-1}

Fantastic performance much beyond design values!

What next?

B factories → is SM with CKM right?

Next generation: Super B factories → in which way is the SM wrong?

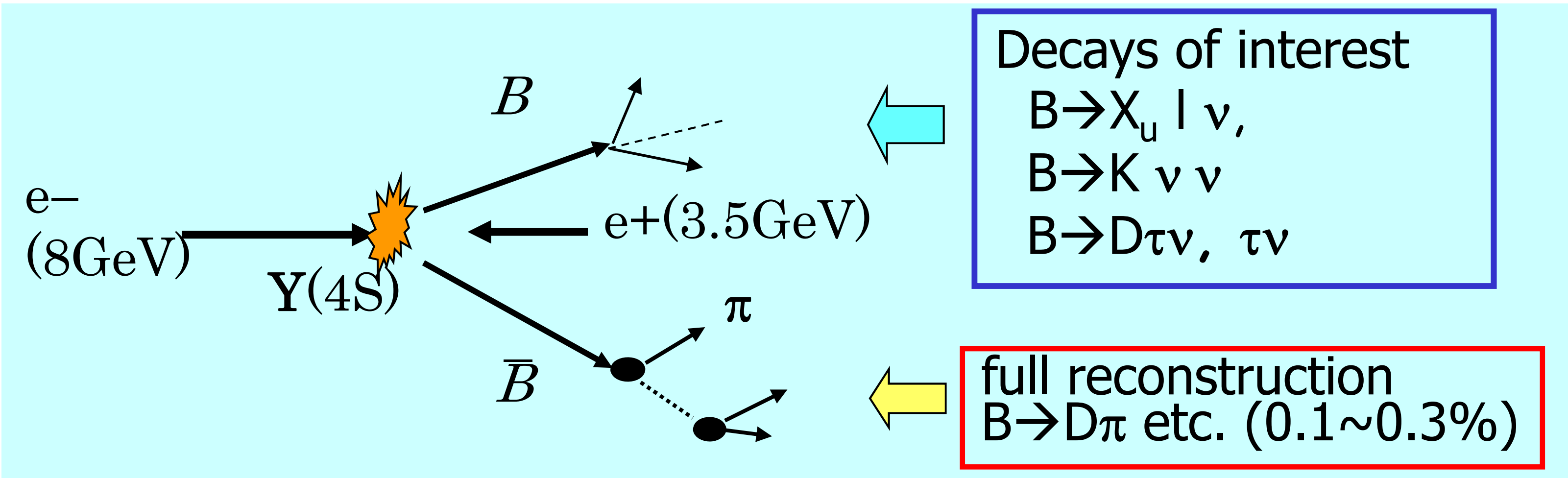
→ Need much more data (two orders!) because the SM worked so well until now → Super B factory

However: it will be a different world in four years, there will be serious competition from LHCb and BESIII

Still, e^+e^- machines running at (or near) Y(4s) will have considerable advantages in several classes of measurements, and will be complementary in many more

Power of e^+e^-, example: Full Reconstruction Method

- Fully reconstruct one of the B's to
  - Tag B flavor/charge
  - Determine B momentum
  - Exclude decay products of one B from further analysis

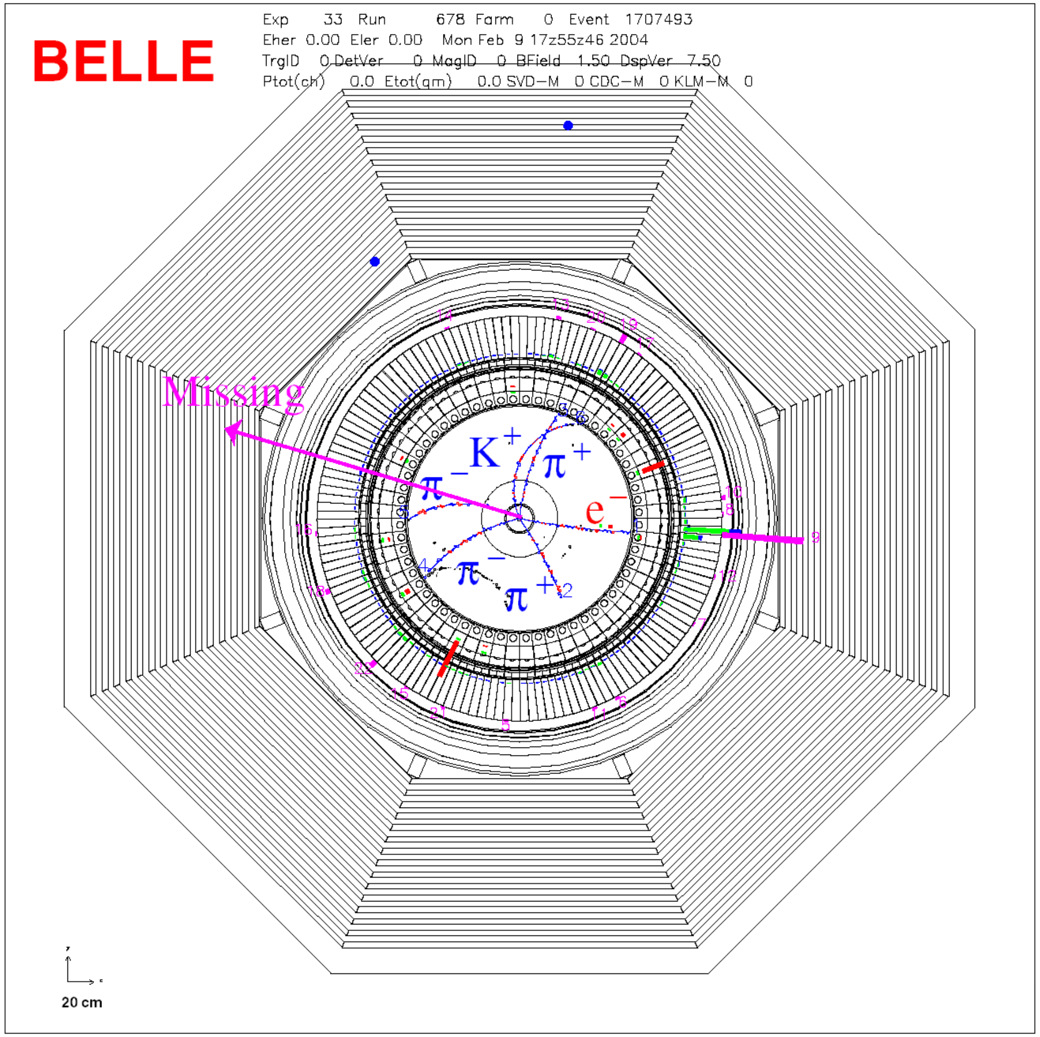


→ Offline B meson beam!

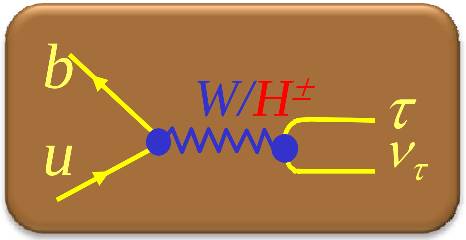
Powerful tool for B decays with neutrinos

Event candidate $B^- \to \tau^- \nu_\tau$

$$B^+ \to D^0 \pi^+$$
$$(\to K\pi^-\pi^+\pi^-)$$
$$B^- \to \tau(\to e\nu\bar{\nu})\nu$$

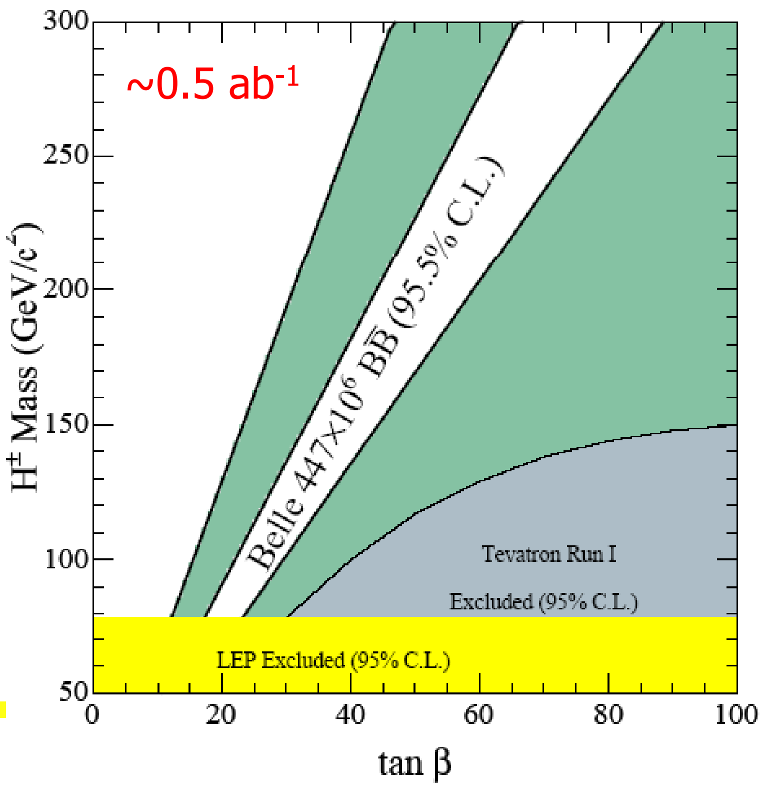


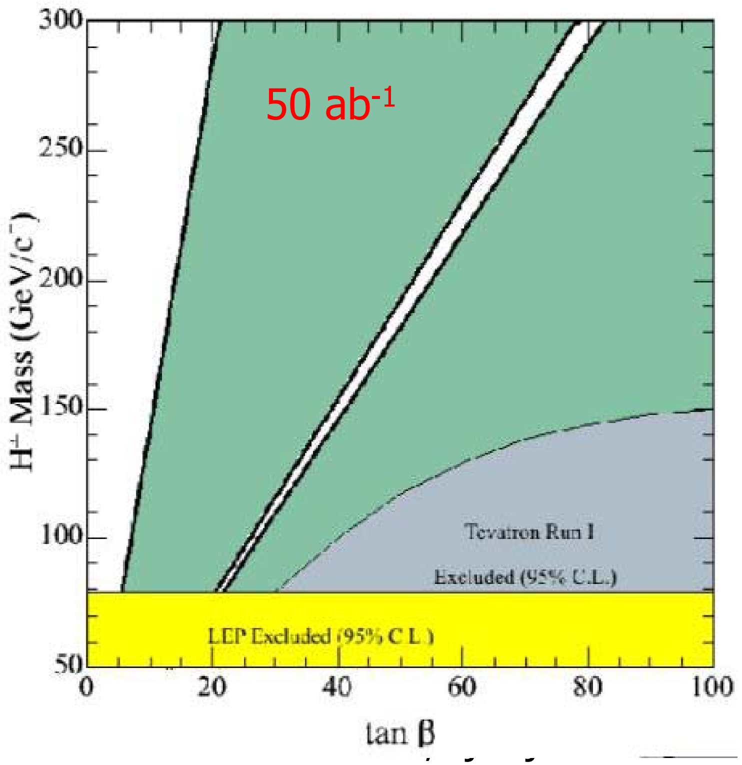
Charged Higgs limits from $B^- \to \tau^- \nu_\tau$



$$r_H = \frac{BF(B \to \tau\nu)}{BF(B \to \tau\nu)_{SM}} = \left(1 - \frac{m_B^2}{m_H^2}\tan^2\beta\right)^2$$

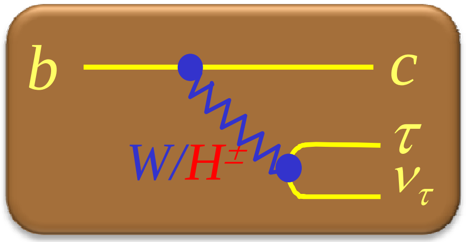
→ limit on charged Higgs mass vs. tanβ





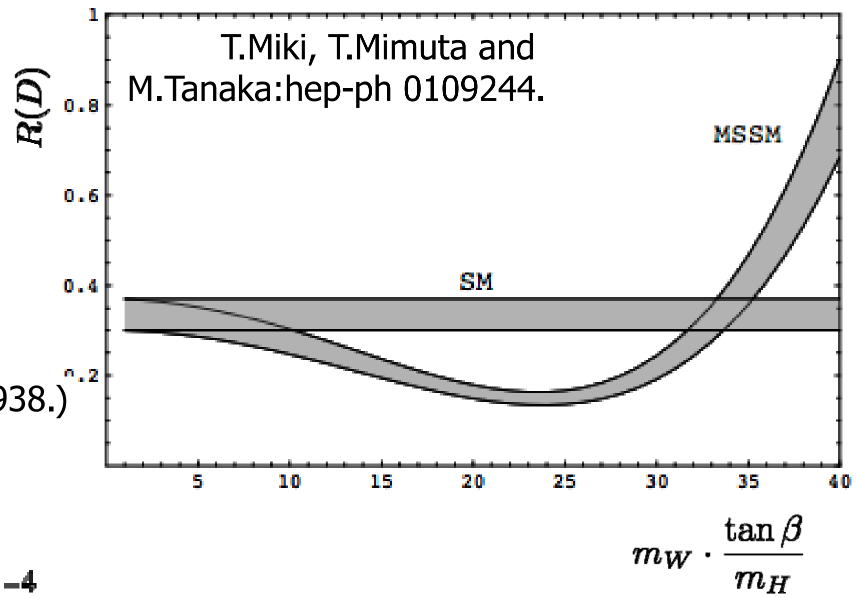
B→D$^{(*)}$τν

Semileptonic decay sensitive to charged Higgs



Ratio of τ to μ,e could be reduced/enhanced significantly

$$R(D) \equiv \frac{\mathcal{B}(B \to D\tau\nu)}{\mathcal{B}(B \to D\ell\nu)}$$



Compared to B→τν

1.Smaller theoretical uncertainty of R(D)

(For B→τν,
There is O(10%) f_B uncertainty from lattice QCD)

2.Large expected Br (Ulrich Nierste arXiv:0801.4938.)

$$\mathcal{B}(B^- \to D^0\tau^-\bar{\nu}_\tau)^{SM} = (0.71 \pm 0.09)\%$$

$$\mathcal{B}(\bar{B}^0 \to D^+\tau^-\bar{\nu}_\tau)^{SM} = (0.66 \pm 0.08)\%$$

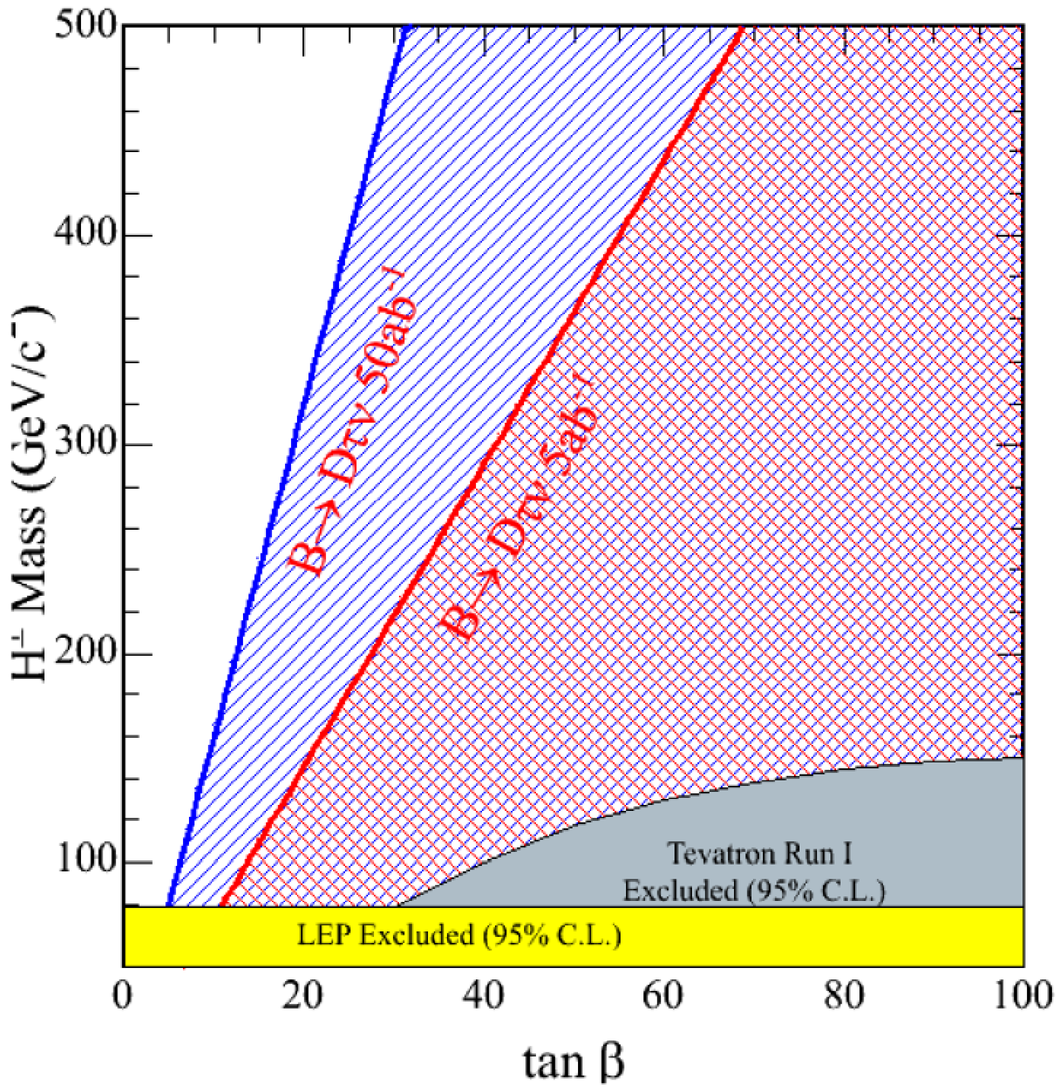
$$\mathcal{B}(B \to \tau\nu) = [1.65^{+0.38}_{-0.37}(stat)^{+0.35}_{-0.37}(syst)] \times 10^{-4}$$

3. Differential distributions can be used to discriminate W^+ and H^+

4. Sensitive to different vertex B→τ ν: H-b-u, B→Dτν: H-b-c
(LHC experiments sensitive to H-b-t)

B→Dτν

Exclusion plots for
tanβ and H⁺ mass
for 5ab⁻¹ and 50ab⁻¹



$B \to D^{*}\tau\nu$ – similar constraints on H^{+}

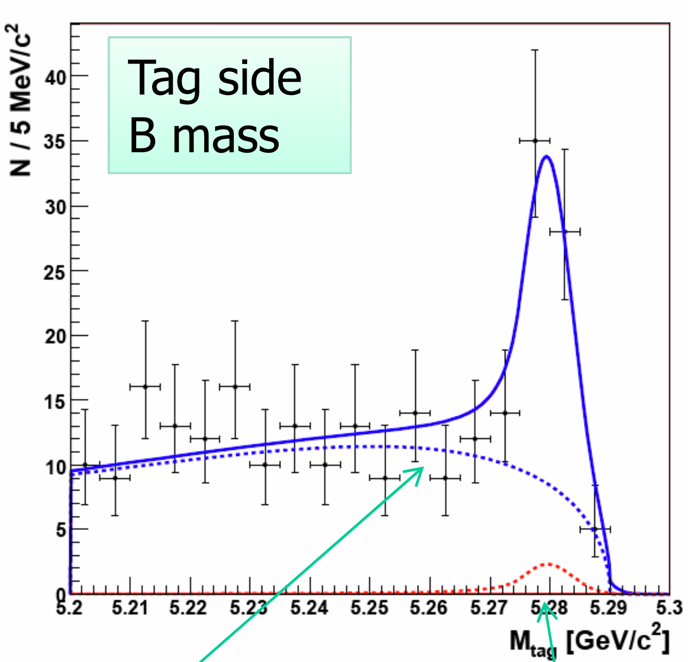
[PRL 99, 191807 (2007)]

535M $B\bar{B}$

FIRST OBSERVATION - 2007

$$BF(B^0 \to D^{*-}\tau^+\nu_\tau) = (2.02\,^{+0.40}_{-0.37}(stat) \pm 0.37(syst)) \times 10^{-2}$$

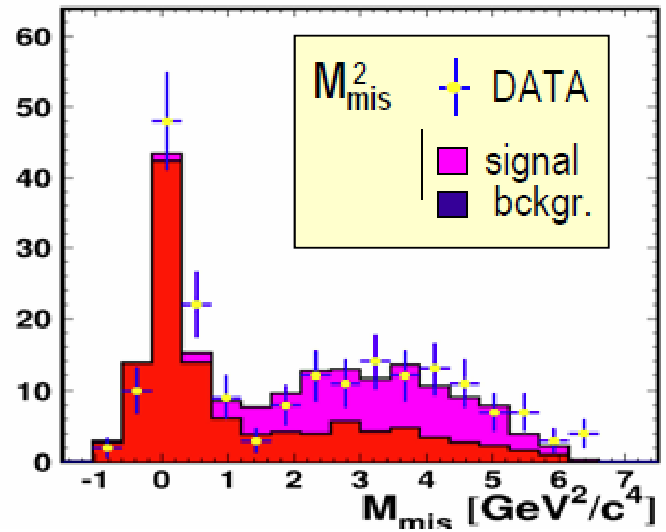
SIGNAL YIELD $N_s = 60\,^{+12}_{-11}$ **6.7σ (5.2σ with syst.)**



combinatorial background

peaking background ($D^{*}e\nu$)

$$M^2_{mis} = (E_b - E_{D^{(*)}} - E_{l/h})^2 - (-\vec{p}_{tag} - \vec{p}_{D^{(*)}} - \vec{p}_{l/h})^2$$



Update at this workshop

$B \to K^{(*)}\nu\nu$

arXiv:1002.5012

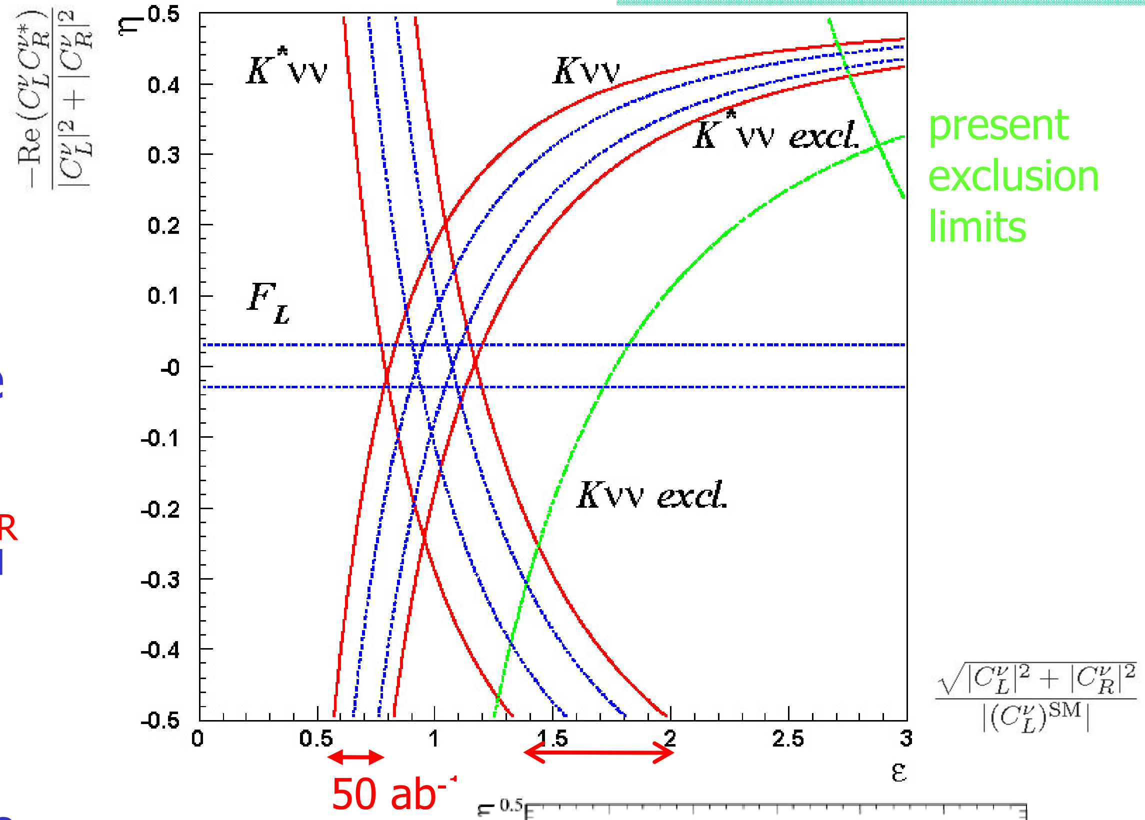
adopted from W. Altmannshofer et al., JHEP 0904, 022 (2009)

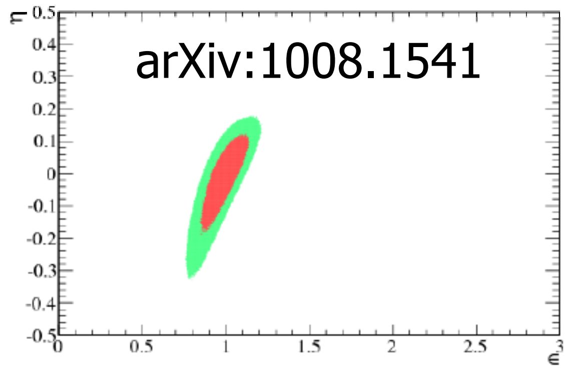
$B \to K\nu\nu$, $\mathcal{B} \sim 4{\cdot}10^{-6}$
$B \to K^*\nu\nu$, $\mathcal{B} \sim 6.8{\cdot}10^{-6}$

SM: penguin+box

Look for departure from the expected value → information on couplings C^{ν}_{R} and C^{ν}_{L} compared to $(C^{\nu}_{L})^{SM}$

Again: fully reconstruct one of the B mesons, look for signal (+nothing else) in the rest of the event.





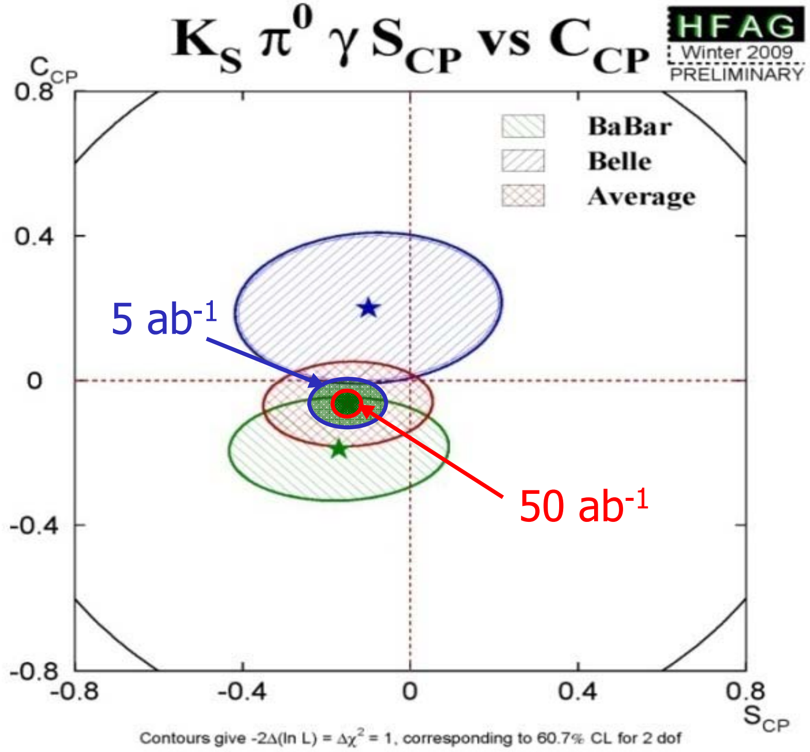
not possible @ LHCb

CP violation in $B \to K_S \pi^0 \gamma$

CP violation in $B \to K_S \pi^0 \gamma$ decays:
Search for right-handed currents

$B \to K^* \gamma$, $\mathcal{B} \sim 4.0 \cdot 10^{-5}$

$\delta S \sim 0.2$ (present)
→ ~a few % at 50 ab^{-1}

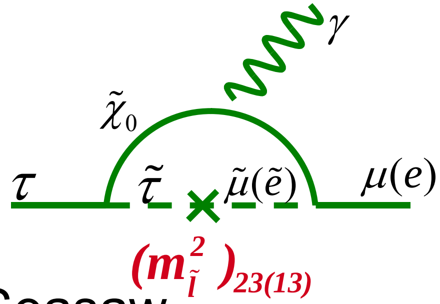


adopted from HFAG

not possible @ LHCb

LFV and New Physics

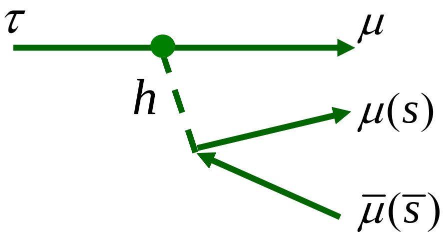
τ→lγ



- SUSY + Seasaw
- Large LFV   Br(τ→μγ)=O($10^{-7\sim9}$)

$$Br(\tau \to \mu\gamma) \simeq 10^{-6} \times \left(\frac{(m^2_{\tilde{L}})_{32}}{\bar{m}^2_{\tilde{L}}} \right) \left(\frac{1\,TeV}{m_{SUSY}} \right)^4 \tan^2\beta$$

τ→3l,lη



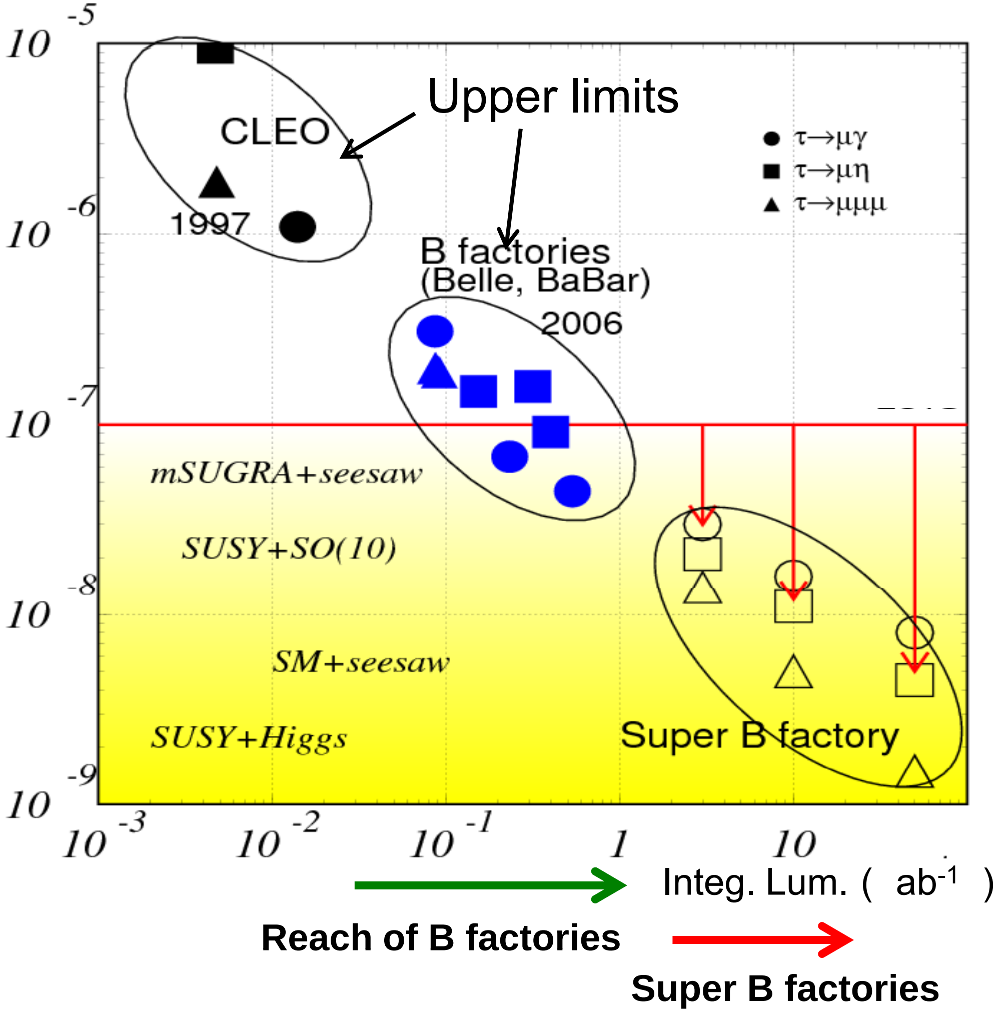
- Neutral Higgs mediated decay.
- Important when MSUSY >> EW scale.

$$Br(\tau \to 3\mu) = 4 \times 10^{-7} \times \left(\frac{(m^2_{\tilde{L}})_{32}}{\bar{m}^2_{\tilde{L}}} \right) \left(\frac{\tan\beta}{60} \right)^6 \left(\frac{100GeV}{m_A} \right)^4$$

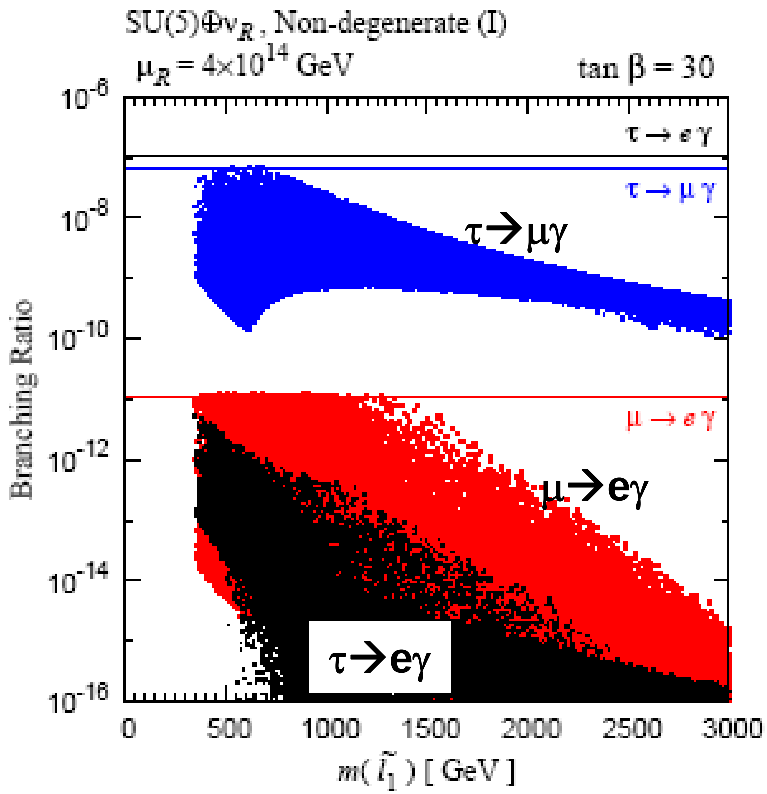
model	Br(τ→μγ)	Br(τ→lll)
mSUGRA+seesaw	10^{-7}	10^{-9}
SUSY+SO(10)	10^{-8}	10^{-10}
SM+seesaw	10^{-9}	10^{-10}
Non-Universal Z'	10^{-9}	10^{-8}
SUSY+Higgs	10^{-10}	10^{-7}

Rare τ decays

LF violating τ decay?



Theoretical predictions compared to present experimental limits



T.Goto et al., 2007

B Physics @ Υ(4S)

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
$S(\phi K^0)$	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 (∗)
γ $(B \to DK,\, D \to CP$ eigenstates)	$\sim 15^\circ$	2.5°
γ $(B \to DK,\, D \to$ suppressed states)	$\sim 12^\circ$	2.0°
γ $(B \to DK,\, D \to$ multibody states)	$\sim 9^\circ$	1.5°
γ $(B \to DK$, combined)	$\sim 6^\circ$	1–2°
α $(B \to \pi\pi)$	$\sim 16^\circ$	3°
α $(B \to \rho\rho)$	$\sim 7^\circ$	1–2° (∗)
α $(B \to \rho\pi)$	$\sim 12^\circ$	2°
α (combined)	$\sim 6^\circ$	1–2° (∗)
$2\beta+\gamma$ $(D^{(*)\pm}\pi^\mp,\, D^\pm K^0_S \pi^\mp)$	20°	5°

Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab^{-1})
$\lvert V_{cb}\rvert$ (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% (∗)
$\mathcal{B}(B \to \tau\nu)$	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

Charm mixing and CP

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

Charm FCNC

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

τ Physics

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

B_s Physics @ Υ(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_{SL}	0.006	0.004
A_{CH}	0.004	0.004
$\mathcal{B}(B_s \to \mu^+\mu^-)$	-	$< 8 \times 10^{-9}$
$\lvert V_{td}/V_{ts}\rvert$	0.08	0.017
$\mathcal{B}(B_s \to \gamma\gamma)$	38%	7%
β_s from $J/\psi\phi$	10°	3°
β_s from $B_s \to K^0\bar{K}^0$	24°	11°

M. Giorgi, ICHEP2010

Physics with $50ab^{-1}$ / $75ab^{-1}$

→More during this workshop

→Two recent publications:

- Physics at Super B Factory (Belle II authors + guests)

hep-ex > arXiv:1002.5012

- SuperB Progress Reports: Physics (SuperB authors + guests)

hep-ex > arXiv:1008.1541

Physics at a Super B Factory

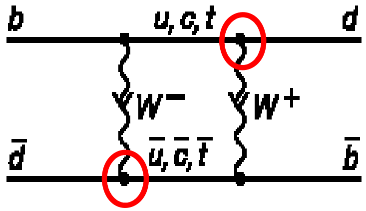
- There is a good chance to see new phenomena;
  - **CPV in B decays from the new physics (non KM).**
  - **Lepton flavor violations in τ decays.**
- They will help to diagnose (if found) or constrain (if not found) new physics models.
- $B \to \tau\nu$, $D\tau\nu$ can probe the charged Higgs in large tanβ region.
- **Physics motivation is independent of LHC.**
  - If LHC finds NP, precision flavour physics is compulsory.
  - If LHC finds no NP, high statistics B/τ decays would be a unique way to search for the >TeV scale physics (=TeV scale in case of MFV).

There are many more topics: CPV in charm, new hadrons, …

Super B Factory Motivation 2

- Lessons from history: the top quark

<u>Physics of top quark</u>
First estimate of mass: BB mixing → ARGUS
Direct production, Mass, width etc. → CDF/D0
Off-diagonal couplings, phase → BaBar/Belle

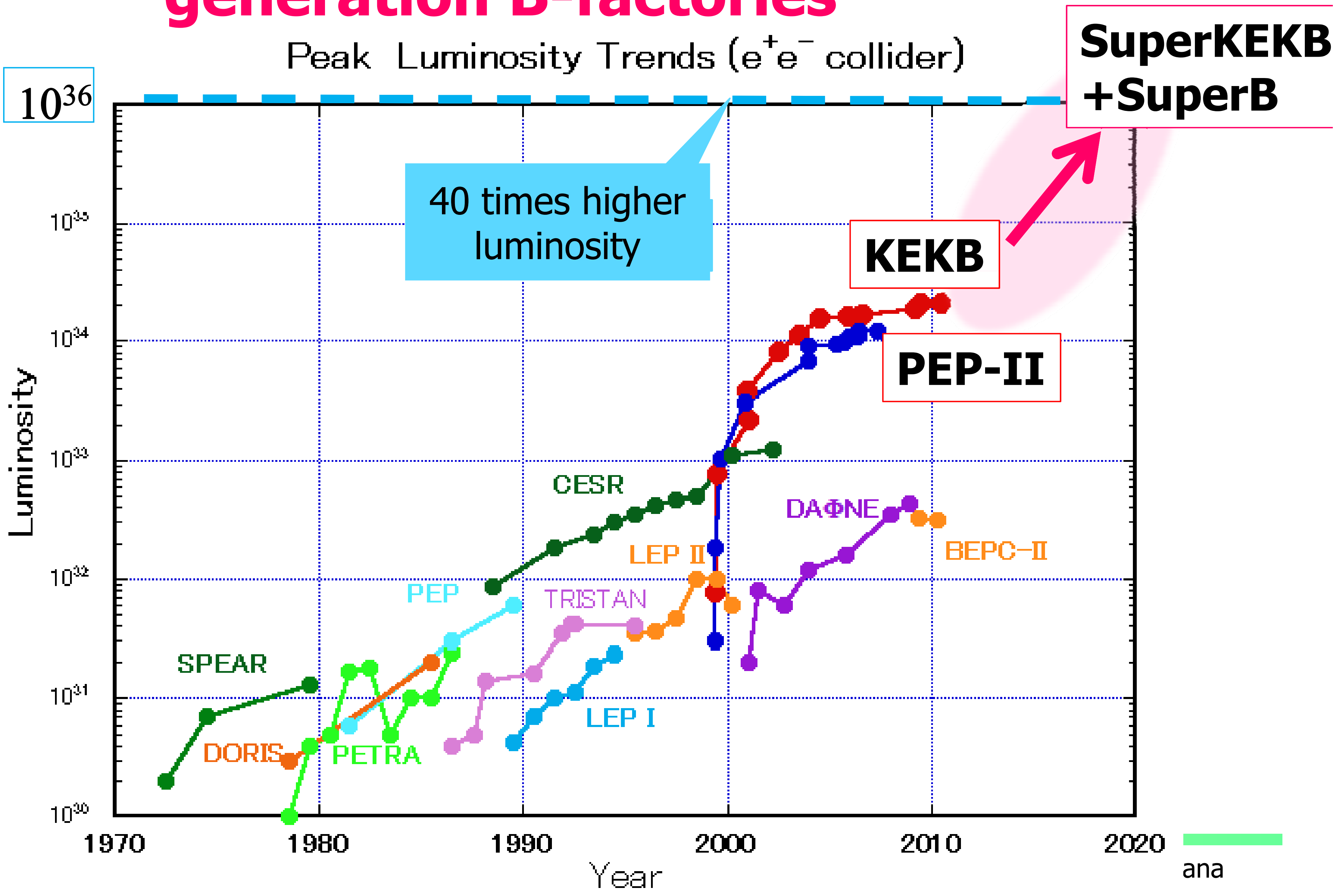


$$V_{CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

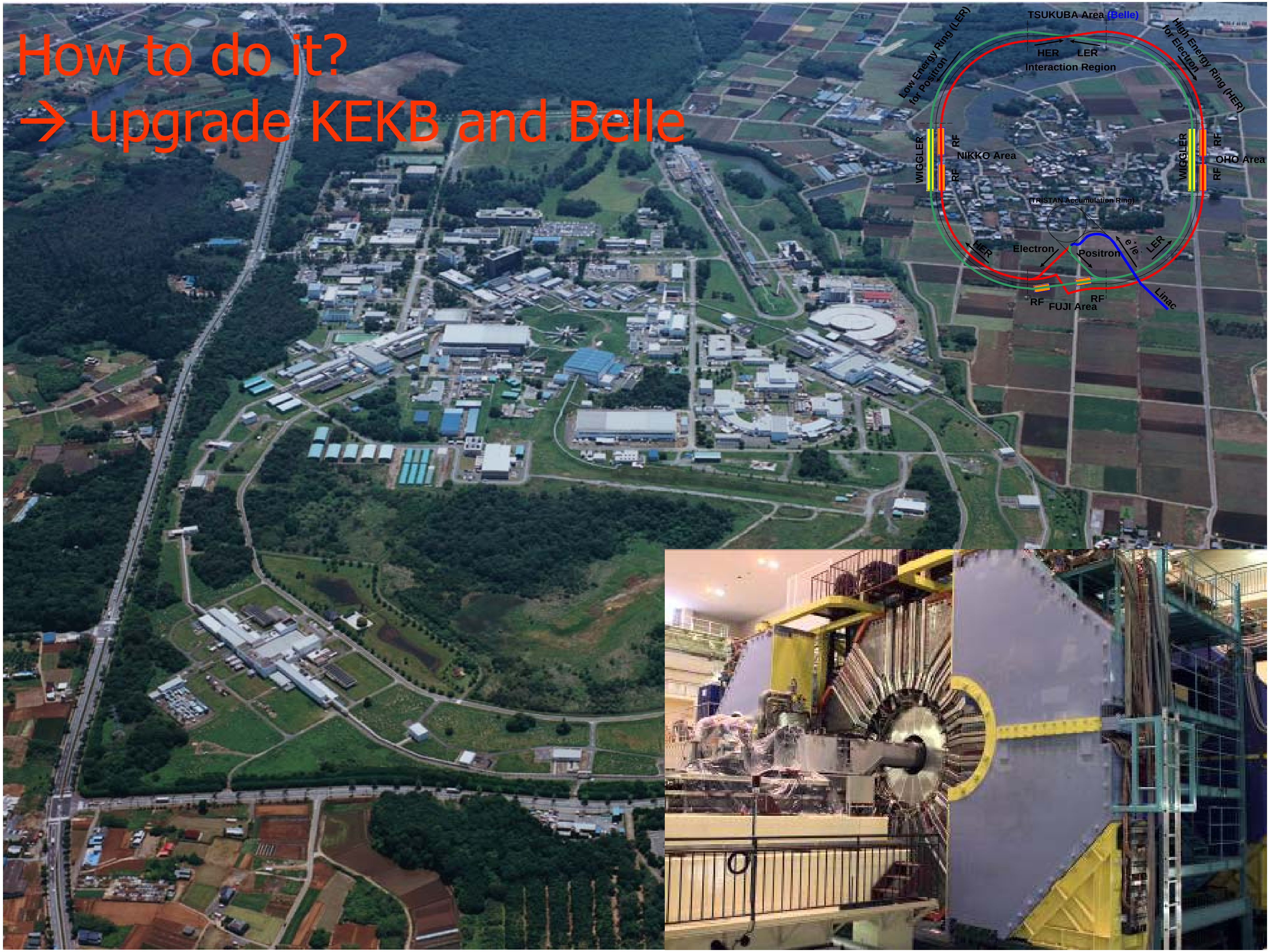
- Even before that: prediction of charm quark from the GIM mechanism, and its mass from K^0 mixing

Accelerators

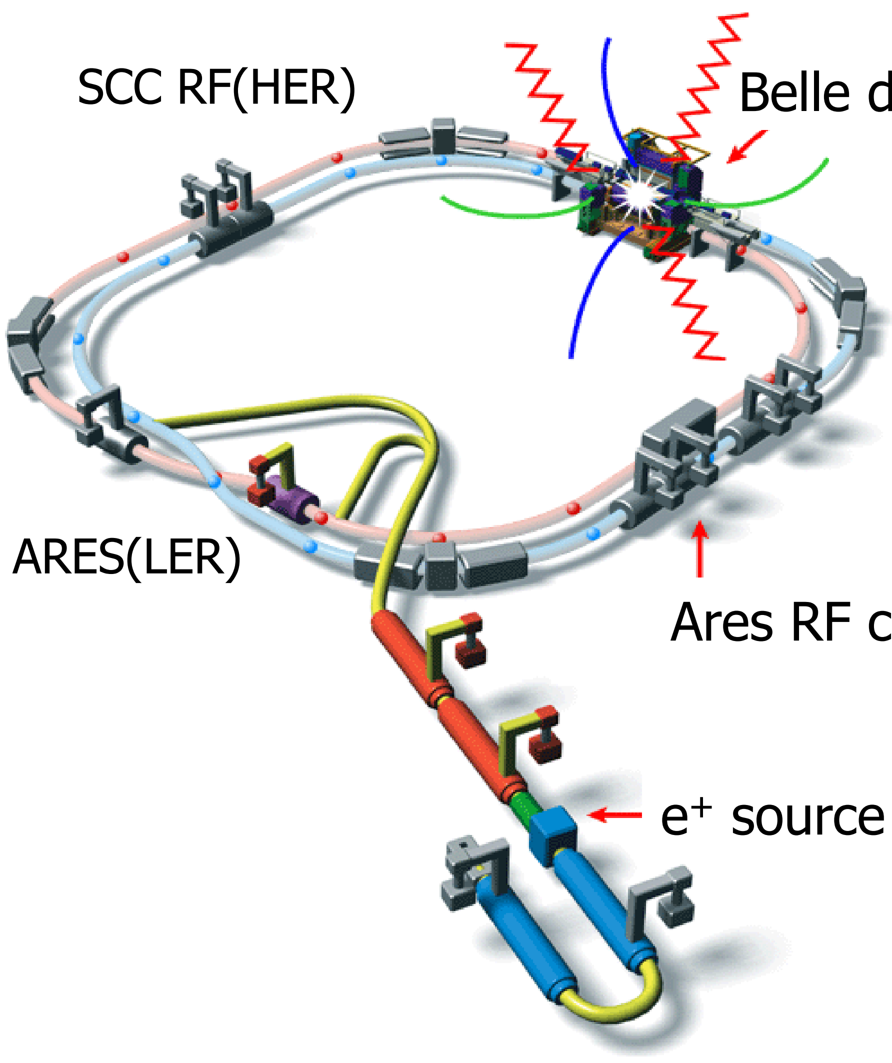
Need O(100x) more data →Next generation B-factories



How to do it?
→ upgrade KEKB and Belle



The KEKB Collider & Belle Detector



- e^- (8 GeV) on e^+(3.5 GeV)
  - $\sqrt{s} \approx m_{\Upsilon(4S)}$
  - Lorentz boost: $\beta\gamma$=0.425
- 22 mrad crossing angle
- Operating since 1999

Peak luminosity (WR!) :

2.1×10^{34} cm^{-2}s^{-1}

=2x design value

First physics run on June 2, 1999
Last physics run on June 30, 2010
L_{peak} = 2.1×10^{34}/cm^2/s
L > 1ab^{-1}

The last beam abort of KEKB on June 30, 2010

→ Can start construction of SuperKEKB and Belle II

Strategies for increasing luminosity

Beam-beam parameter

Beam current

Lorentz factor

$$L = \frac{\gamma_{e\pm}}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\left(\frac{I_{e\pm}\xi_y^{e\pm}}{\beta_y^*}\right)\left(\frac{R_L}{R_{\xi_y}}\right)$$

Lumi. reduction factor (crossing angle)&
Tune shift reduction factor (hour glass effect)
0.8 - 1
(short bunch)

Classical electron radius

Beam size ratio@IP
1 - 2 % (flat beam)

Vertical beta function@IP

(1) Smaller β_y^*
(2) Increase beam currents
(3) Increase ξ_y

"Nano-Beam" scheme

Collision with very small spot-size beams

Invented by Pantaleo Raimondi for SuperB

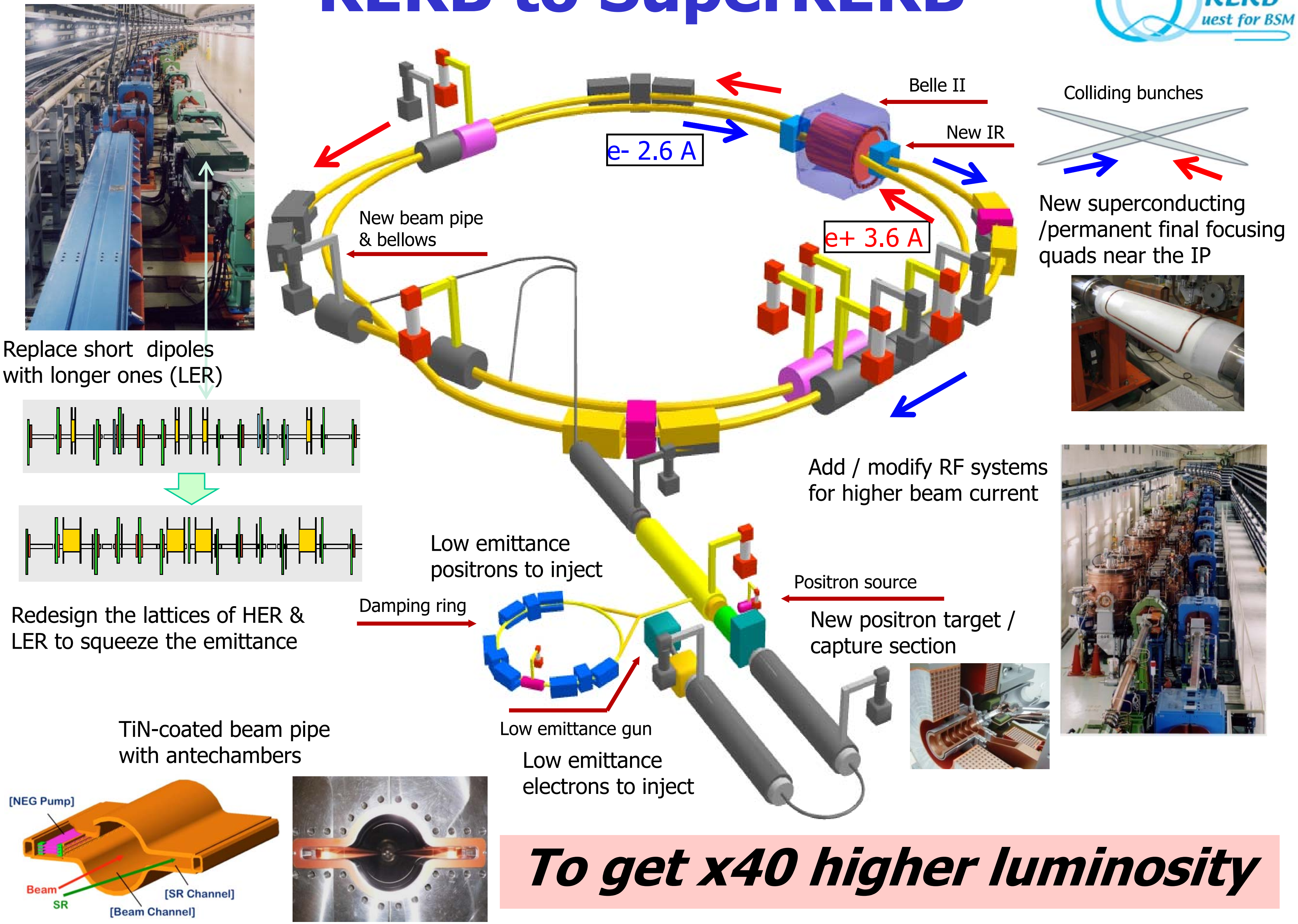
Machine design parameters

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

M. Iwasaki, ICHEP2010

KEKB to SuperKEKB



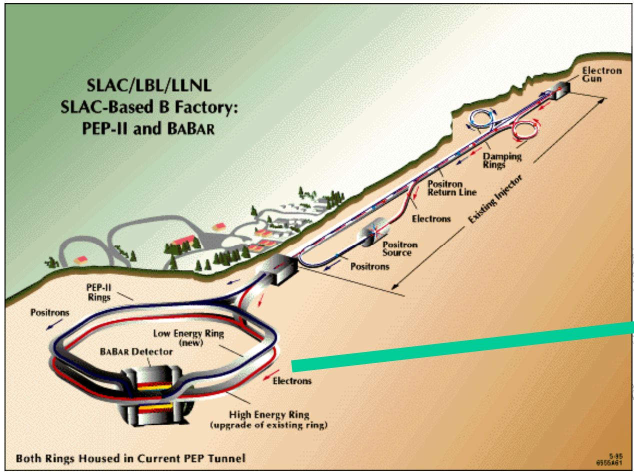
To get x40 higher luminosity

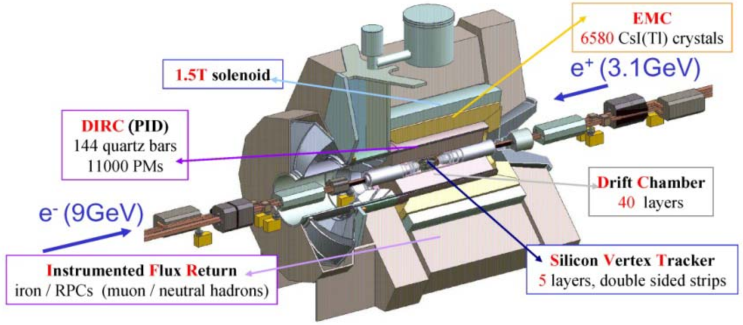
How to do it? (2)

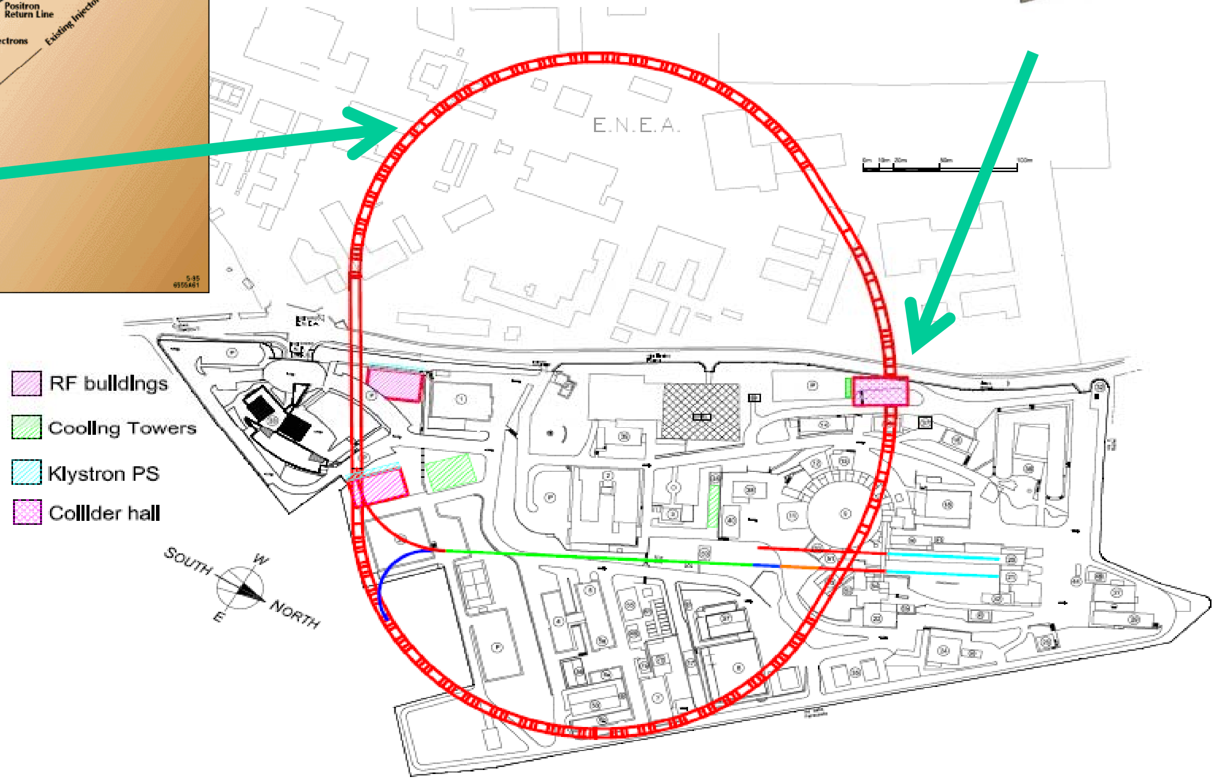
→Construct a new tunnel at LNF Frascati

→Move magnets from PEP-II

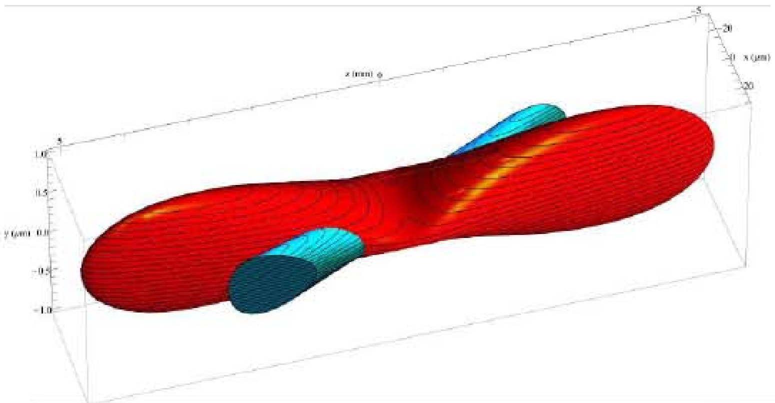
→Move BaBar, upgrade



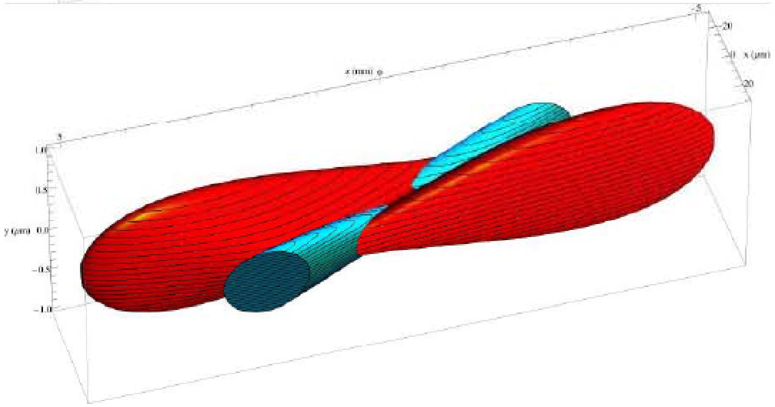




Nano-beam collisions with crab waist



Without
Crab-sextupoles



With
Crab-sextupoles

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

Crab waist scheme: successfully tested in the DAΦNE ring

Parameters for 1×10^{36} Lumi (max 4×10^{36})

Parameter	Units	Base Line HER (e+)	Base Line LER (e-)	Low Emittance HER (e+)	Low Emittance LER (e-)	High Current HER (e+)	High Current LER (e-)	Tau/Charm (prelim.) HER (e+)	Tau/Charm (prelim.) 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	5.000	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	

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

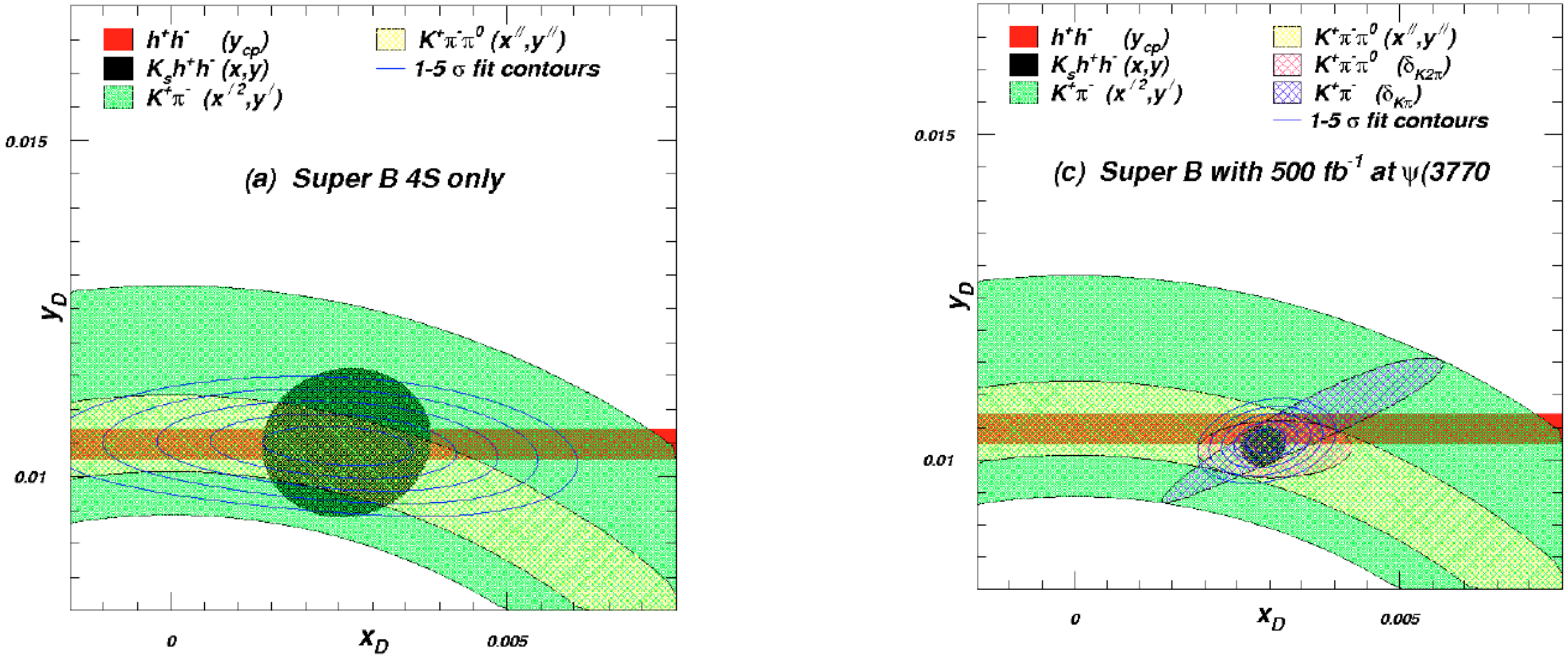
RF power includes SR and HOM

M. Giorgi, ICHEP2010

Interest of running at charm threshold

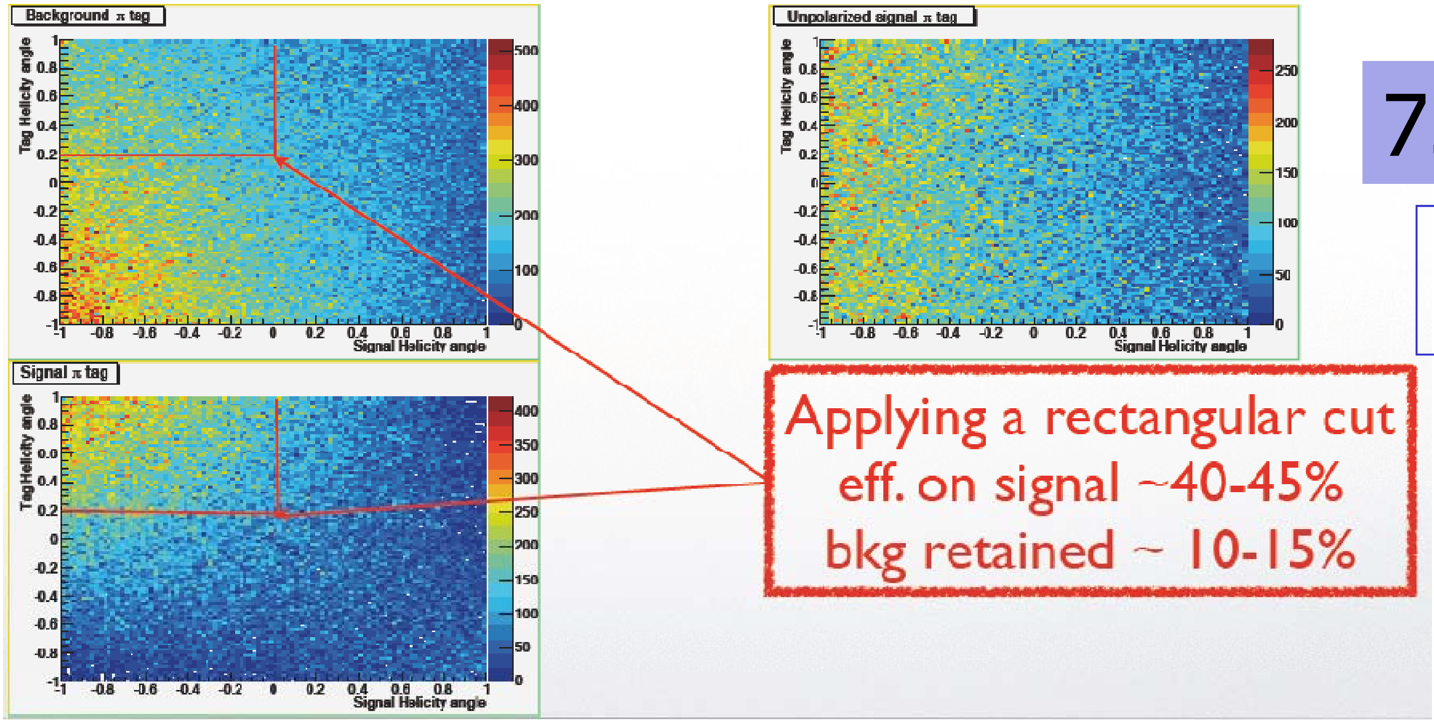
Decays of *$\psi(3770) \rightarrow D^0 D^0$* produce coherent *(C=-1)* pairs of *D^0*'s.

- 3 months of running will give 500fb^{-1}: 50x BES-III



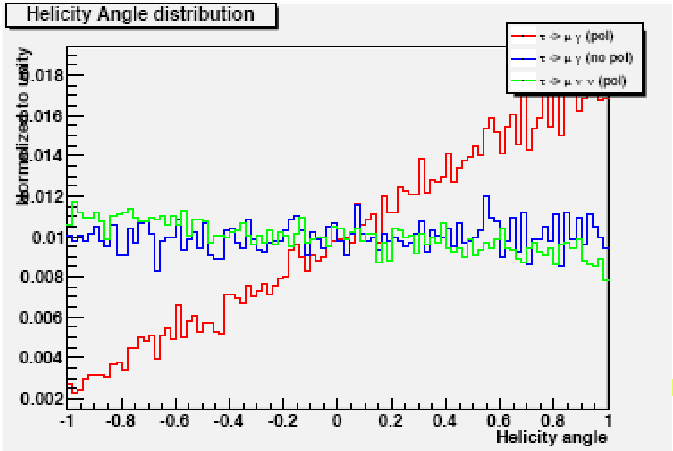
- Precision charm mixing,
- CPT Violation, rare decays, CPV using quantum correlations, decay constants, ...

Polarized beam helps to reduce irreducible background in tau decays (e.g. $\tau \to \mu\gamma$)



75 ab^{-1}

arXiv:1008.1541v1 [hep-ex]



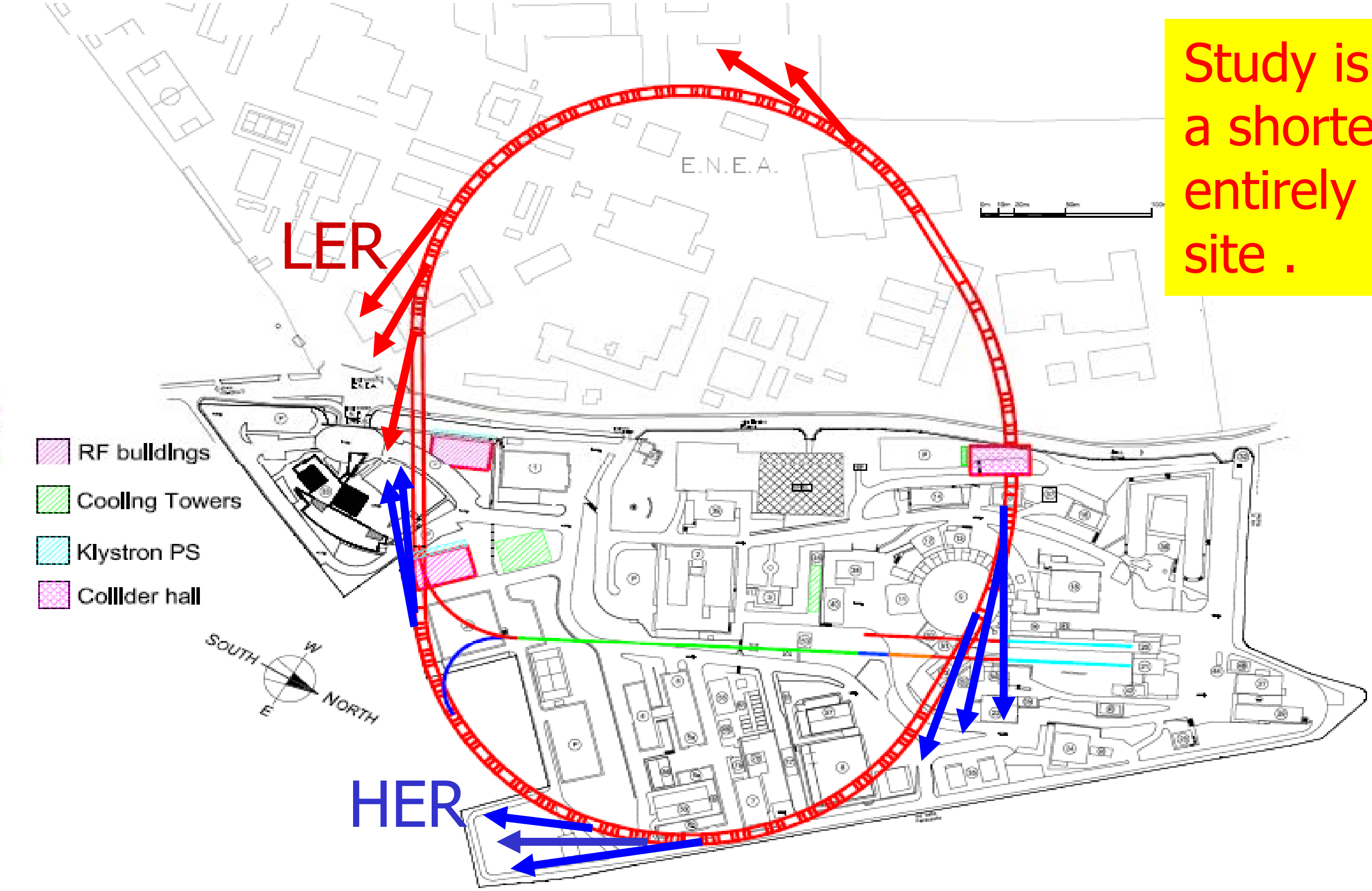
$B(\tau \to \mu\gamma)$ 2 10^{-9} → $B(\tau \to \mu\gamma)$ 1 10^{-9}

$B(\tau \to e\gamma)$ 2 10^{-9} → $B(\tau \to e\gamma)$ 1 10^{-9}

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

M. Giorgi, ICHEP2010

Machine layout



Study is in progress on a shorter version, entirely fitting the LNF site .

Polarization is understood and feasible!

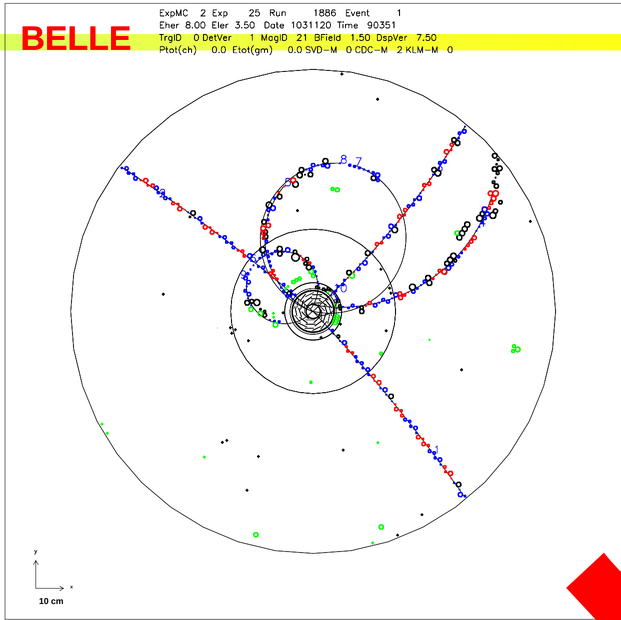
Parameter flexibility allows 10^{36} peak lumi without stressing limits!

No impediment caused by the photon operation is seen so far to prevent design operations of SuperB for HEP.

M. Giorgi, ICHEP2010

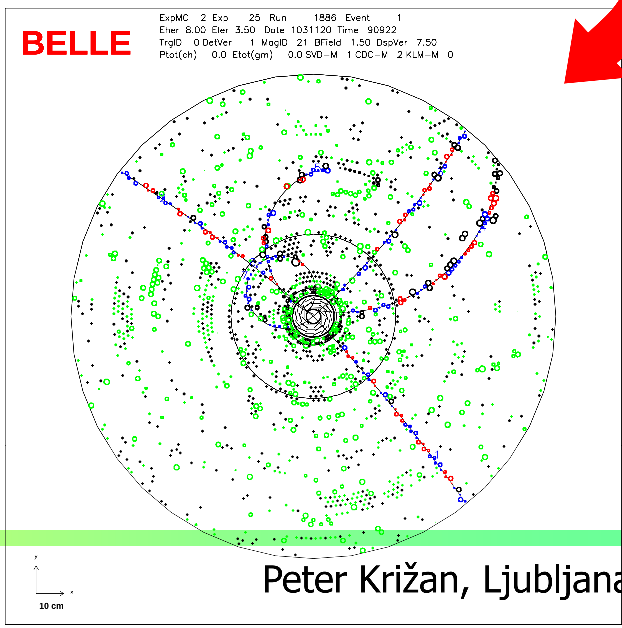
Detectors

Requirements for the Belle II detector



Critical issues at L= 8 x 10^{35}/cm^2/sec

- **Higher background (×10-20)**
  - radiation damage and occupancy
  - fake hits and pile-up noise in the EM
- **Higher event rate (×10)**
  - higher rate trigger, DAQ and computing
- **Require special features**
  - low p μ identification ← sμμ recon. eff.
  - hermeticity ← ν “reconstruction”

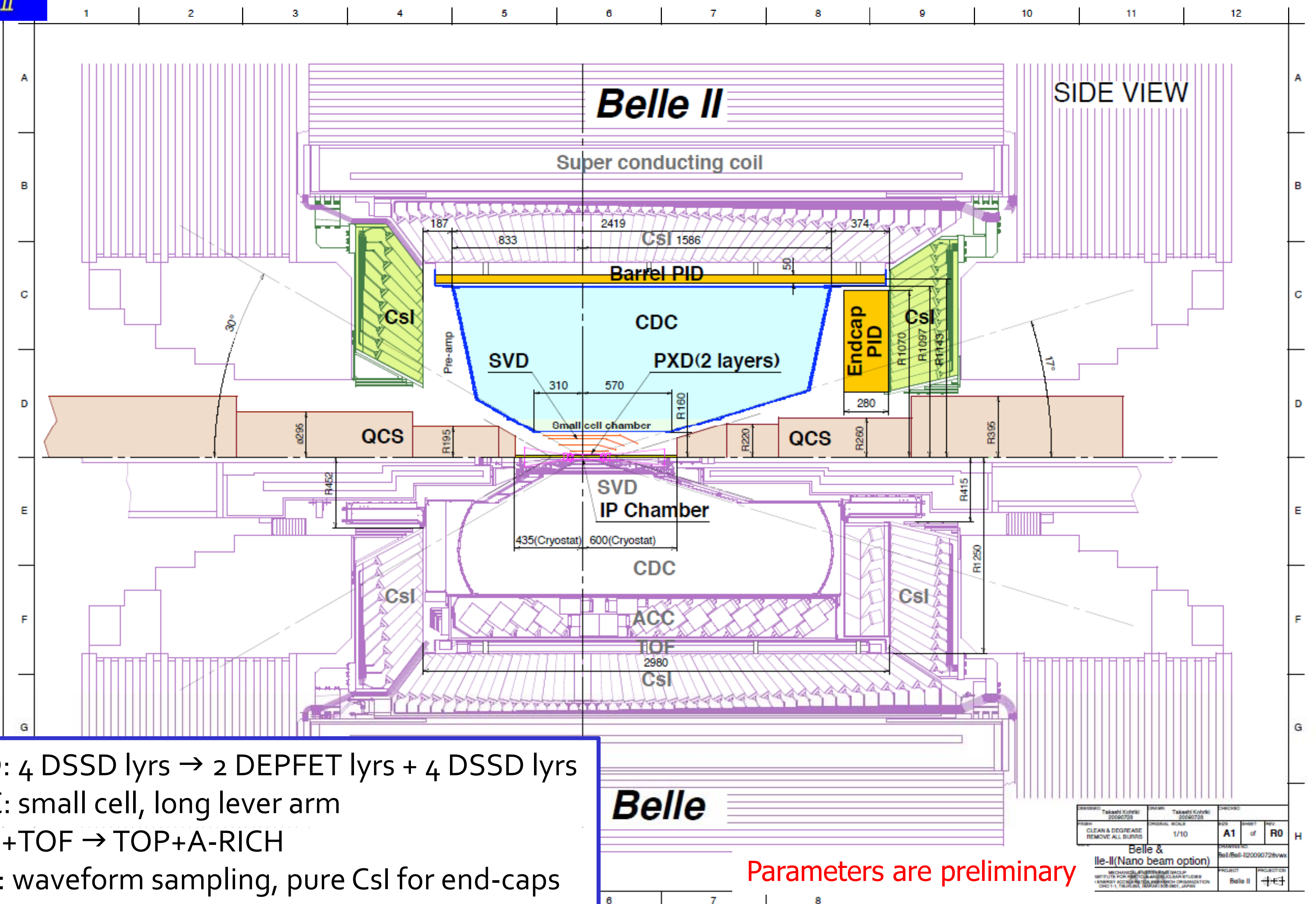


Solutions:

- Replace inner layers of the vertex detector with a pixel detector.
- Replace inner part of the central tracker with a silicon strip detector.
- Better particle identification device
- Replace endcap calorimeter crystals
- Faster readout electronics and computing system.

Very similar reasoning also for SuperB

Belle II in comparison with Belle



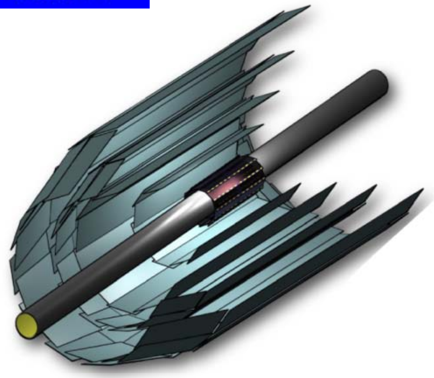
SVD: 4 DSSD lyrs → 2 DEPFET lyrs + 4 DSSD lyrs
CDC: small cell, long lever arm
ACC+TOF → TOP+A-RICH
ECL: waveform sampling, pure CsI for end-caps
KLM: RPC → Scintillator +SiPM (end-caps)

Parameters are preliminary

Y. Ushiroda, ICHEP2010

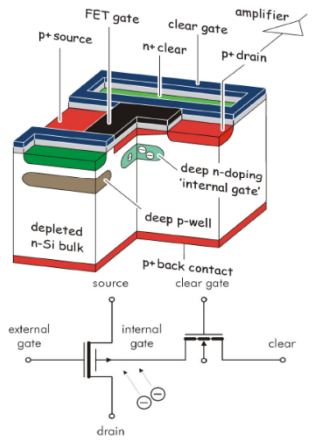
Vertex Detector

DEPFET:
http://aldebaran.hll.mpg.de/twiki/bin/view/DEPFET/WebHome

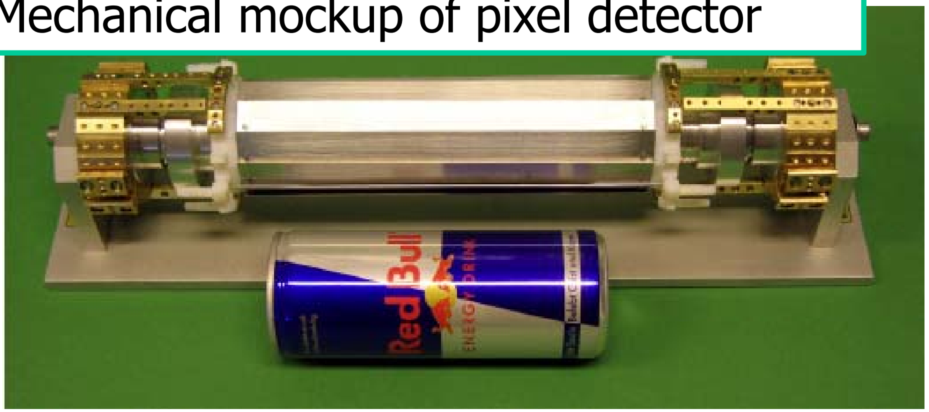


Beam Pipe		**r = 10mm**
DEPFET		
	Layer 1	**r = 14mm**
	Layer 2	**r = 22mm**
DSSD		
	Layer 3	**r = 38mm**
	Layer 4	**r = 80mm**
	Layer 5	**r = 115mm**
	Layer 6	**r = 140mm**

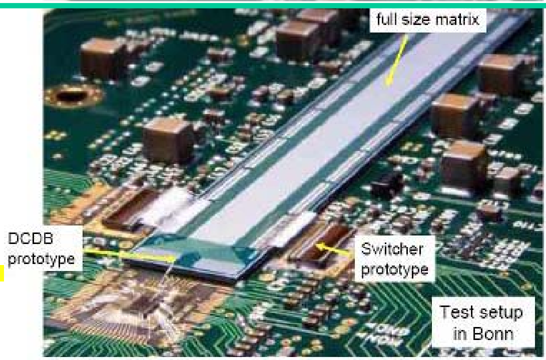
DEpleted P-channel FET

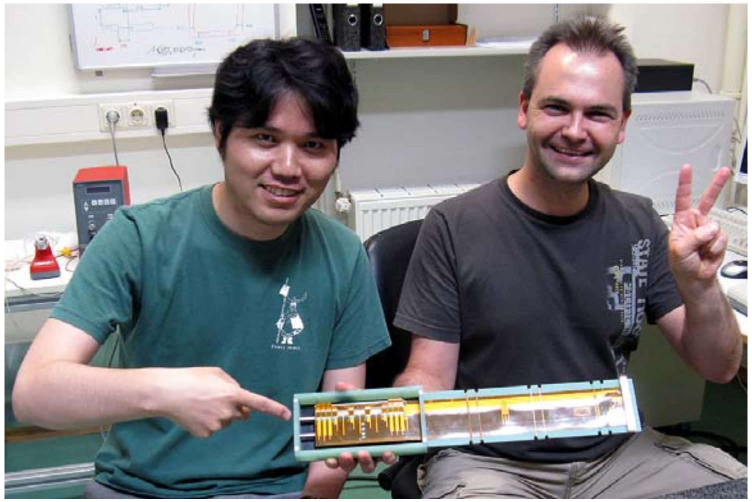


Mechanical mockup of pixel detector



Prototype DEPFET pixel sensor and readout



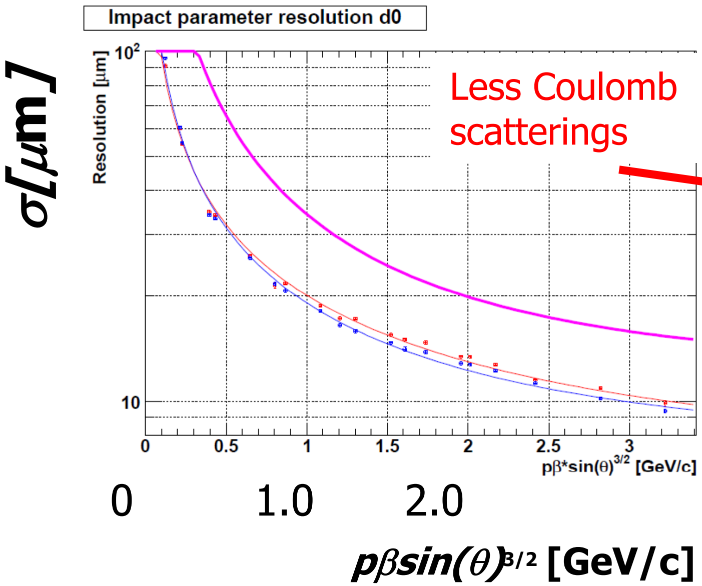


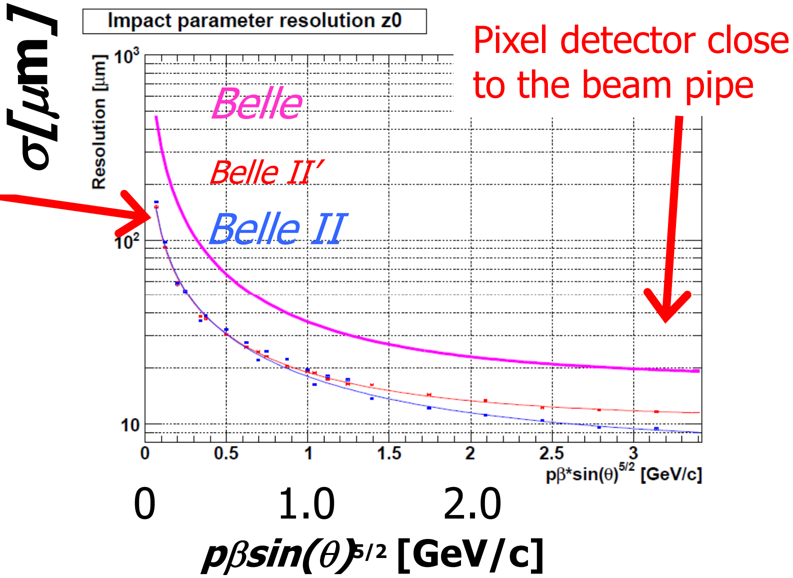
A prototype ladder using the first 6 inch DSSD from Hamamatsu has been assembled and tested.

Expected performance

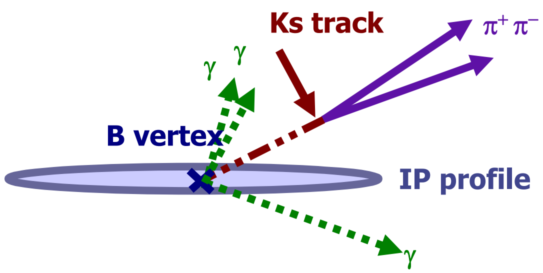
$$\sigma = a + \frac{b}{p\beta \sin^{\nu}\theta}$$

Significant improvement in IP resolution!

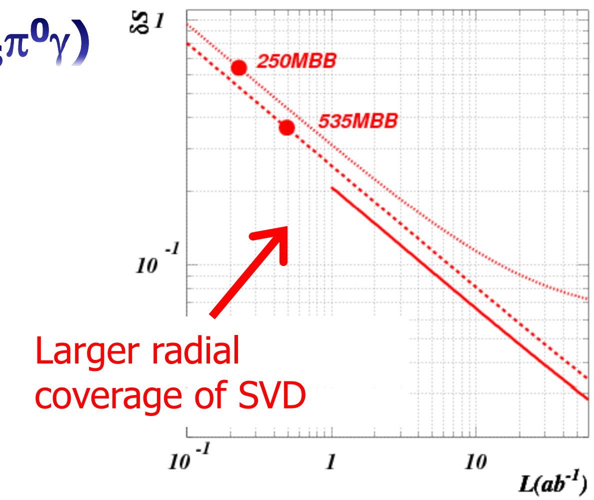




Significant improvement in $\delta S(K_S\pi^0\gamma)$

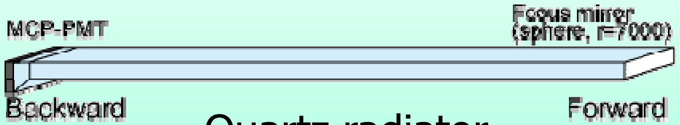


B decay point reconstruction with K_S trajectory



Particle Identification Devices

Barrel PID: Time of Propagation Counter (TOP)



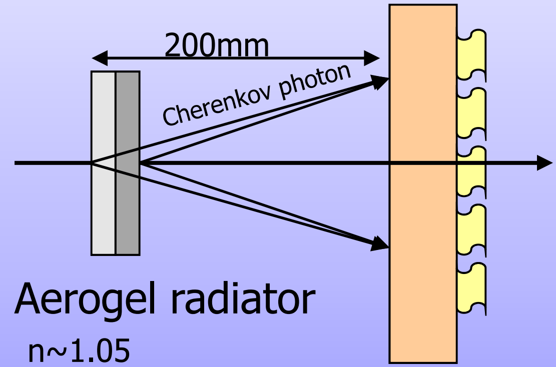
Quartz radiator

Focusing mirror

Small expansion block

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

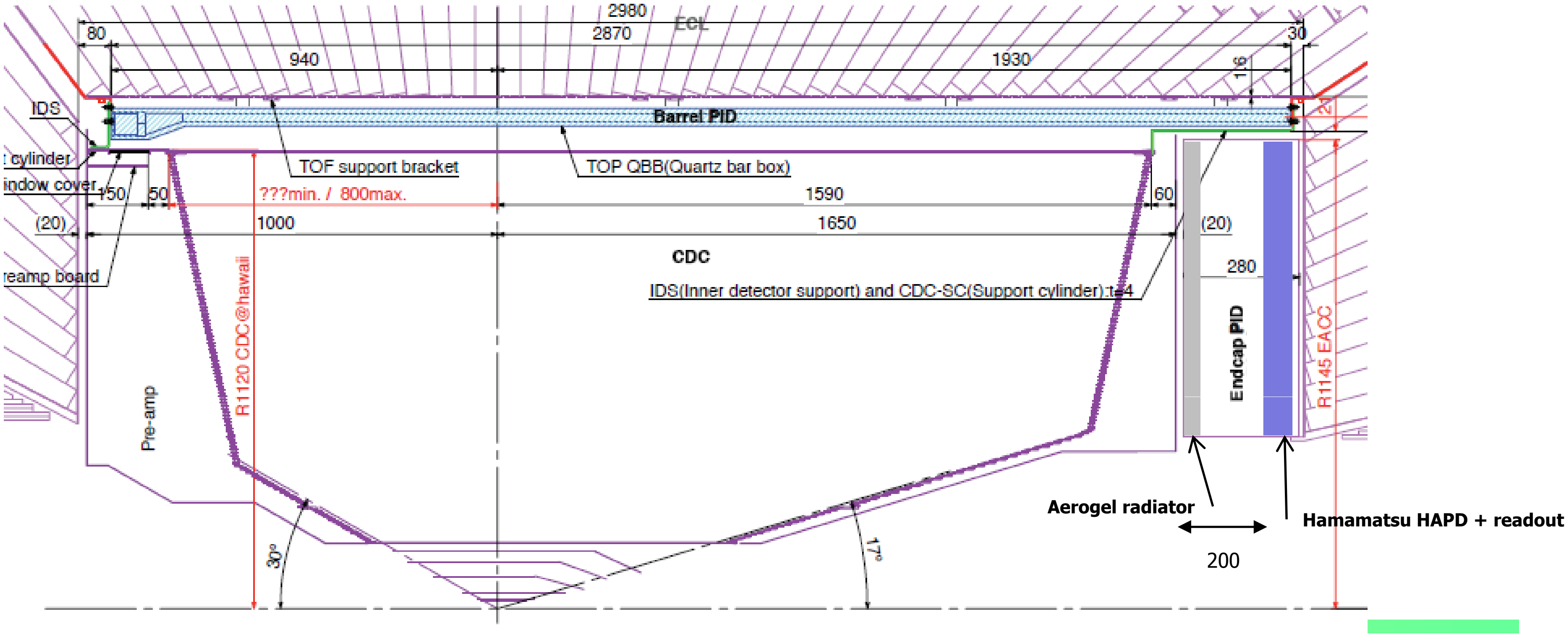
Endcap PID: Aerogel RICH (ARICH)



Aerogel radiator

n~1.05

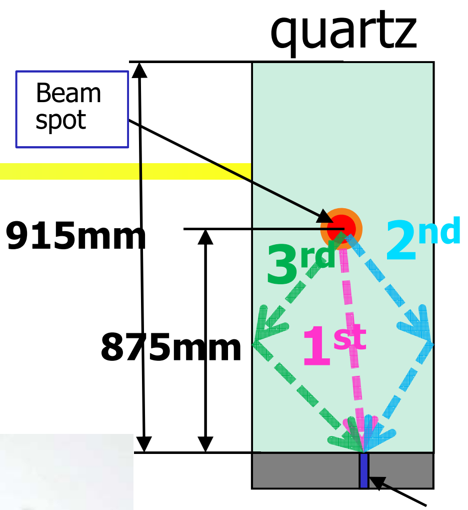
Hamamatsu HAPD
+ new ASIC

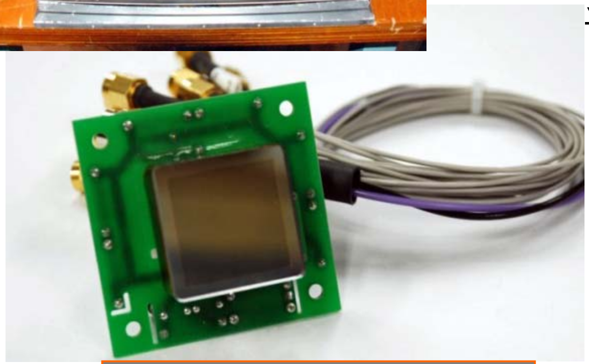


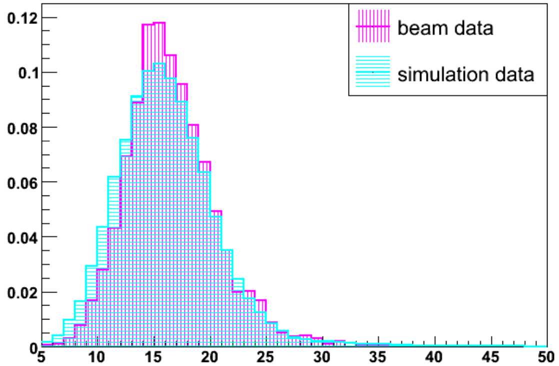
Peter Križan, Ljubljana

TOP (Barrel PID)

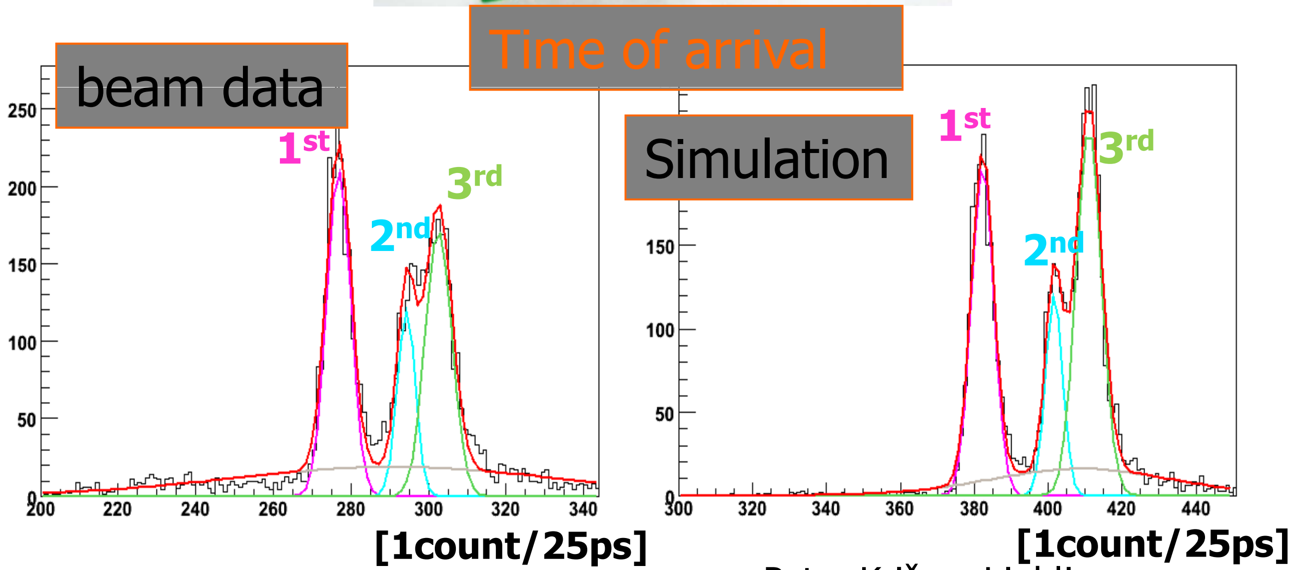
- Quartz radiator
  - 2.6m^L x 45cm^W x 2cm^T
  - Excellent surface accuracy
- MCP-PMT
  - Hamamatsu 16ch MCP-PMT
    - Good TTS (<35ps) & enough lifetime
    - Multialkali photo-cathode → SBA
- Beam test in 2009
  - # of photons consistent
  - Time resolution OK





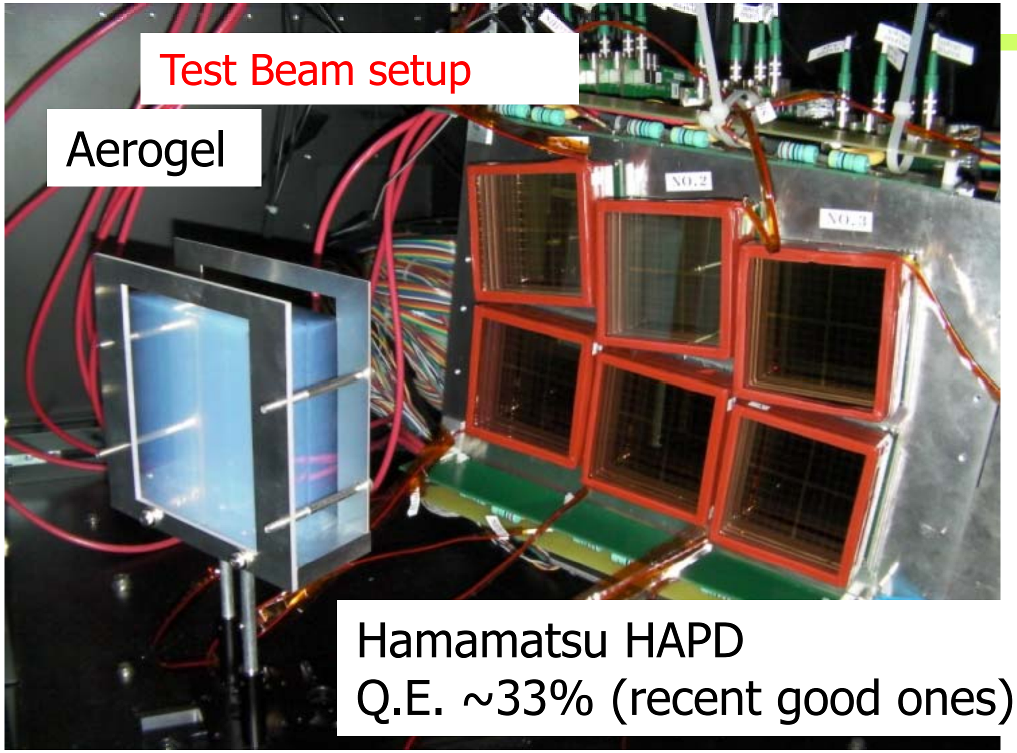


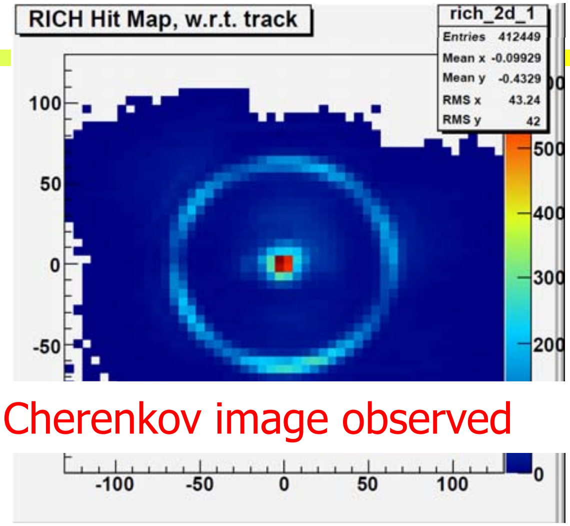
# of photons



Peter Križan, Ljubljana

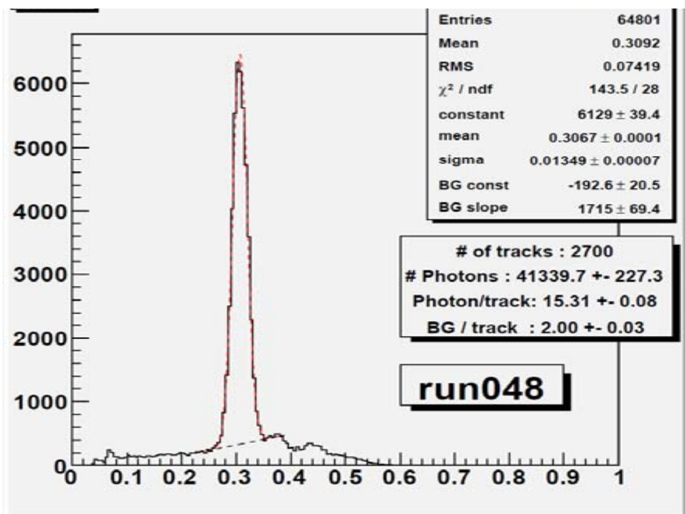
Aerogel RICH (endcap PID)



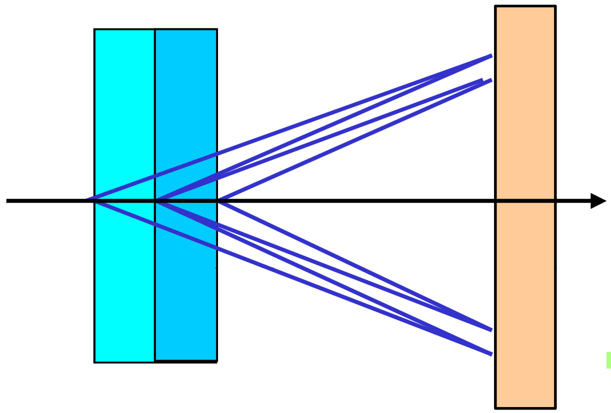


Clear Cherenkov image observed

Cherenkov angle distribution



RICH with a novel "focusing" radiator – a two layer radiator



Employ multiple layers with different refractive indices→ Cherenkov images from individual layers overlap on the photon detector.

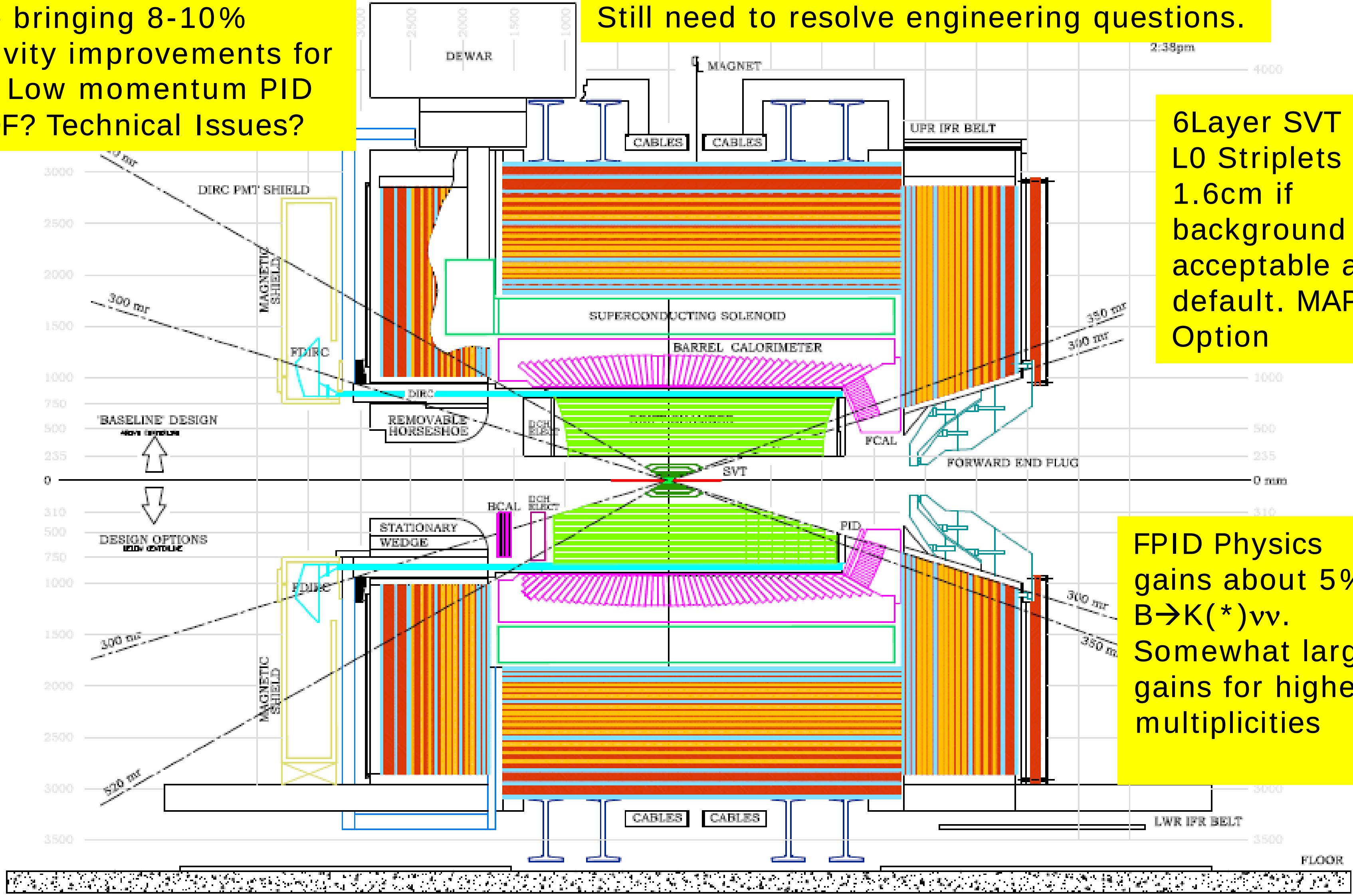
6.6 σ π/K at 4GeV/c !

Peter Križan, Ljubljana

SuperB Detector (with options)

BEMC Inexpensive Veto device bringing 8-10% sensitivity improvements for B→τ ν. Low momentum PID via TOF? Technical Issues?

IFR Optimized layout. Plan to reuse yoke. Still need to resolve engineering questions.



6Layer SVT
L0 Striplets @ 1.6cm if background is acceptable as default. MAPS Option

FPID Physics gains about 5% in B→K(*)νν. Somewhat larger gains for higher multiplicities

M. Giorgi, ICHEP2010

Background Issue: sources

	Cross section	Evt/bunch xing	Rate
Beam Strahlung	~340 mbarn ($E\gamma$/Ebeam > 1%)	~850	0.3THz
e^+e^- pair production	~7.3 mbarn	~18	7GHz
e^+e^- pair (seen by L0 @ 1.5 cm)	~0.07 mbarn	~0.2	70 MHz
Elastic Bhabha	O(10^{-4}) mbarn (Det. acceptance)	~250/Million	100KHz
Y(4S)	O(10^{-6}) mbarn	~2.5/Million	1 KHz
	Loss rate	Loss/bunch pass	Rate
Touschek (LER)	4.1kHz / bunch (+/- 2 m from IP)	~3/100	~5 MHz

Two colliding beams :
- radiative Bhabha → *dominant effect on lifetime*
- e+e- e+e- production → *important source for SVT layer-0*

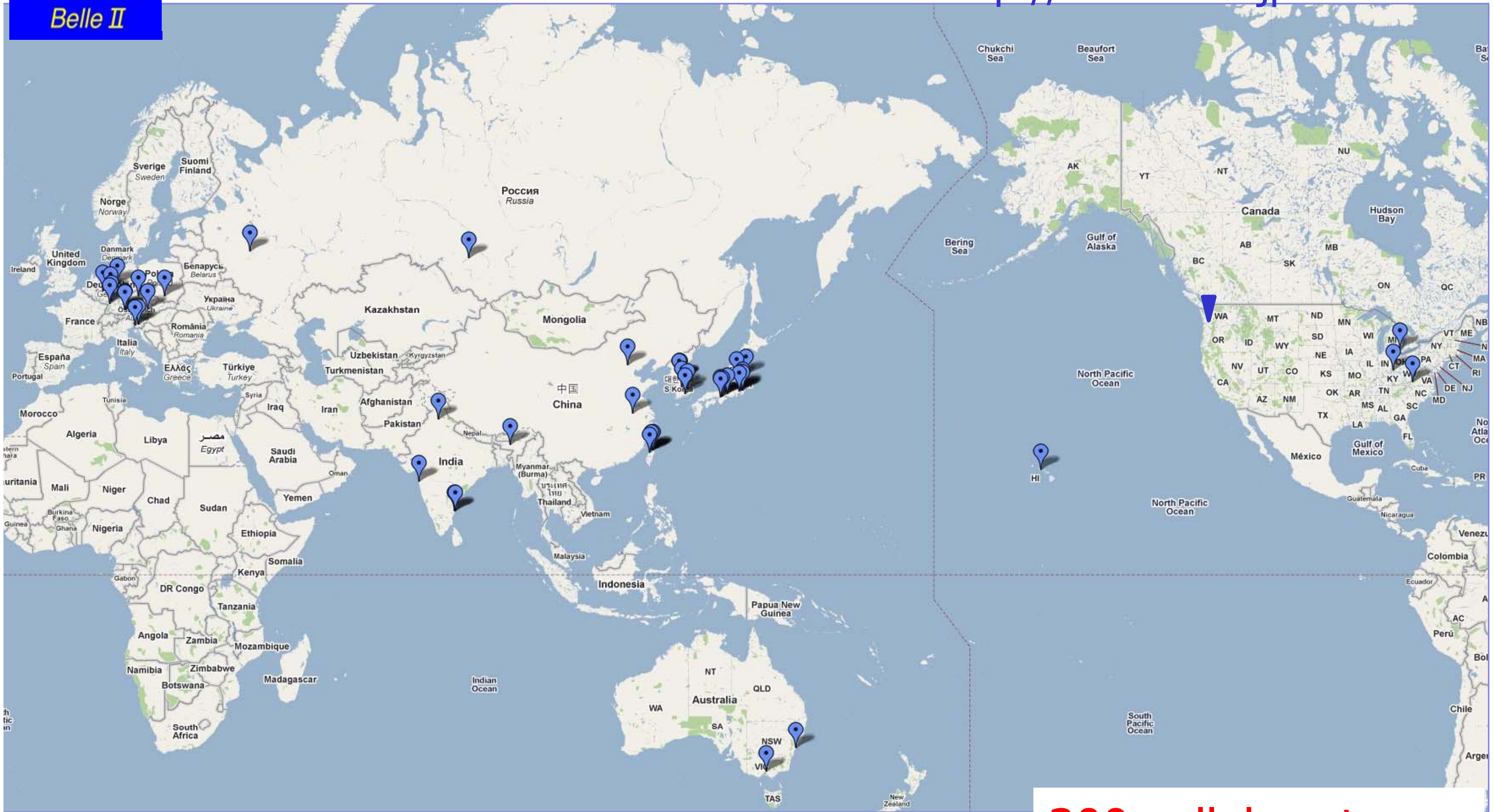
Single beam :
- synchrotron radiation → *strictly connected to IR design*
- Touschek → *negligible in BaBar, important in SuperB*
- beam-gas
- intra-beam scattering

Collimators, dynamic aperture and energy acceptance optimization solve the problem of Touschek background in LER

Status of the projects

Belle II Collaboration

http://belle2.kek.jp



13 countries/regions, 54 institutes

300 collaborators,
>100 from Europe

SuperKEKB/Belle II funding Status

KEKB upgrade has been approved

- 5.8 oku yen (~MUSD) for Damping Ring (FY2010)
- **100 oku yen** for machine -- Very Advanced Research Support Program (FY2010-2012)

Continue efforts to obtain additional funds to complete construction as scheduled.

Several non-Japanese funding agencies have **already allocated sizable funds** for the upgrade.

→construction started!


Press Release

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last update: 10/06/23

Press Release

KEKB upgrade plan has been approved

June 23, 2010
High Energy Accelerator Research Organization (KEK)

The MEXT, the Japanese Ministry that supervises KEK, has announced that it will appropriate a budget of 100 oku-yen (approx $110M) over the next three years starting this Japanese fiscal year (JFY2010) for the high performance upgrade program of KEKB. This is part of the measures taken under the new "Very Advanced Research Support Program" of the Japanese government.

"We are delighted to hear this news," says Masanori Yamauchi, former spokesperson for the Belle experiment and currently a deputy director of the Institute of Particle and Nuclear Studies of KEK. "This three- year upgrade plan allows the Belle experiment to study the physics from decays of heavy flavor particles with an unprecedented precision. It means that KEK in Japan is launching a renewed research program in search for new physics by using a technique which is complementary to what is employed at LHC at CERN."

[Media Contact] Youhei Morita,
Head of Public Relations Office, KEK
tel. +81-29-879-6047

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1-1 Oho, Tsukuba, Ibaraki 305-0801 Japan

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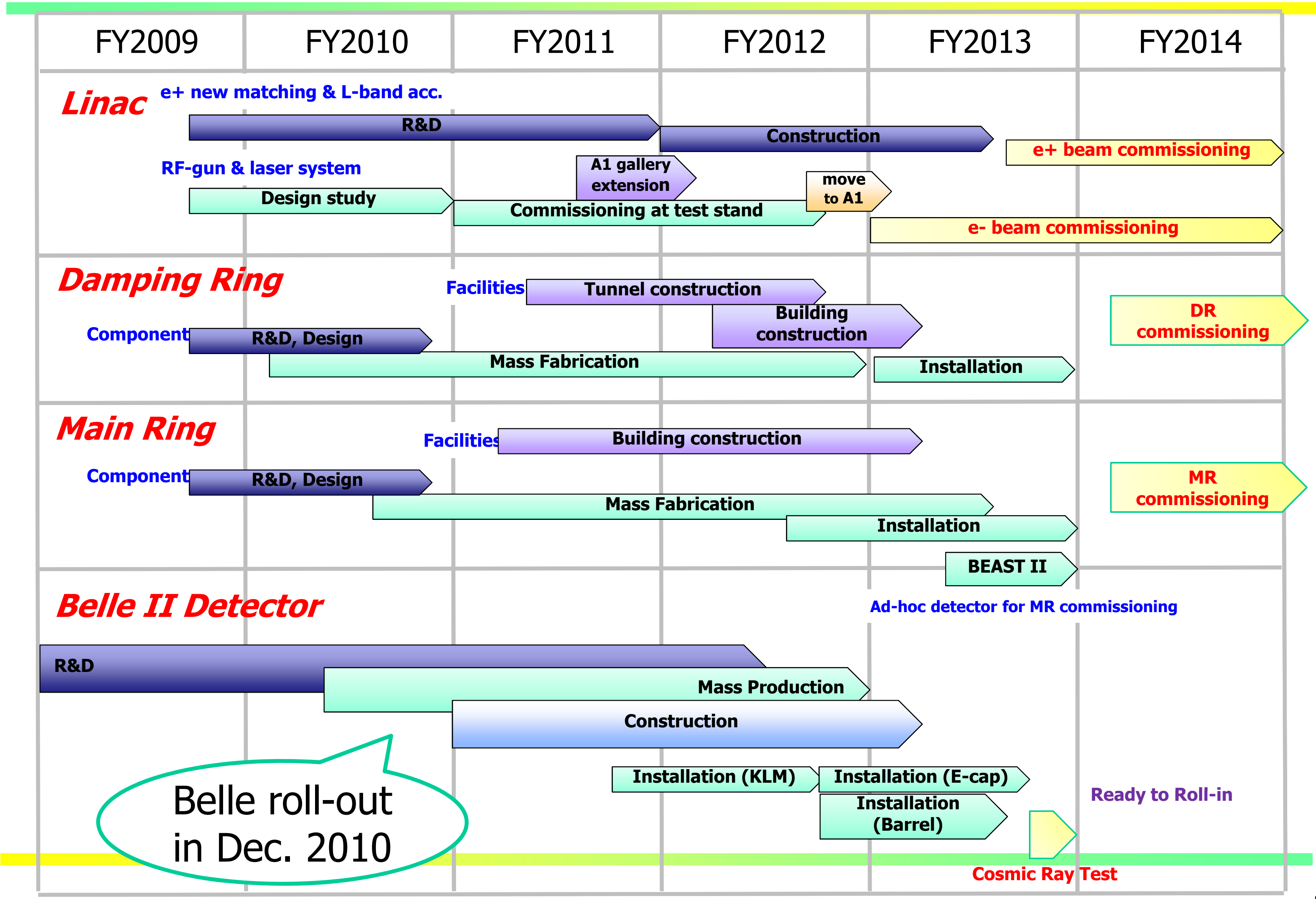
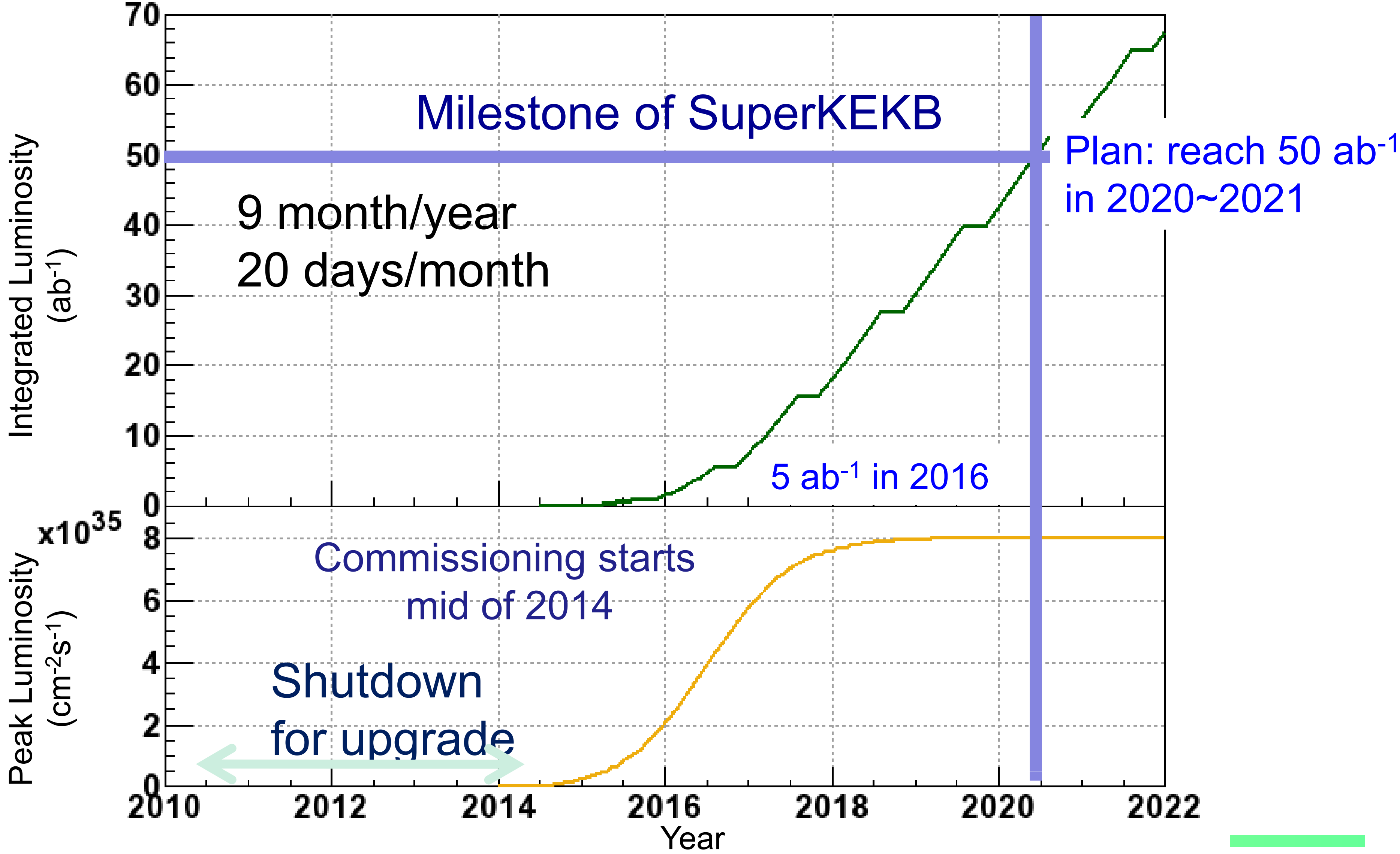
Construction Schedule of SuperKEKB/Belle II

Jun. 24, 2010



Luminosity upgrade projection



Towards green light

- The project is the first “flagship project” of the new national research plan
- The project has been mentioned as a reciprocity condition in a Russian-Italian agreement on ignitor (nuclear fusion)

•A formal commitment with INFN for the project with the declaration of some available budget in the current year is expected.

•This commitment will set the start of the project.

PNR on newspapers & Minister press release

Mer 14/04/2010 | Il Sole 24 ORE

Innovazione. Più spazio all'industria

Gelmini aggiorna il piano nazionale

Eugenio Bruno

ROMA

Un acceleratore di particelle complementare a quello del Cern di Ginevra. Un network dei laboratori di nanotecnologia. Una «fabbrica del futuro» per rilanciare il manifatturiero. Uno studio approfondito nell'epigenetica. Sono alcuni dei «progetti bandiera» che il ministro dell'Istruzione Mariastella Gelmini punta a inserire tra le priorità del programma nazionale della ricerca (Pnr) 2010-2012.

La lista degli interventi su cui il Miur vuole dirottare le prime risorse che il Pnr intercetterà contiene 14 voci. Fermo restando che da qui alla sua ufficializzazione potrebbe anche subire delle modifiche, l'elenco si presenta estremamente variegato. Alle azioni sulla formazione nel campo del nucleare, sull'approfondimento dei rapporti tra invecchiamento e Dna e alle misure per l'agroalimentare e i beni culturali – anticipati dallo stesso ministro al Sole 24 Ore il 26 marzo scorso – si è aggiunta

Gli interventi

Progetto	Settore	Valore stimato (milioni)
Super B Factory	Fisica	680
Cosmo - Skymed II generation	Aerospazio	N.D.
Epigenomica	Medicina	N.D.
3N - Network nazionale delle nanotecnologie	Industria	300
Ritmare - Ricerca ita. per il mare	Industria	795
Sintonia - Sistema integrato di telecomunicazioni	Aerospazio	671
Ipi - Invecchiamento e pop. isolate	Medicina	90
Agro Alimentare	Agricoltura	100
L'ambito nucleare	Energia	53,8
Recupero e rilancio della Villa dei Papiri	Beni culturali	20
Elettra-Fermi-Eurofel	Industria	191
Astri - Astrofisica con specchi a tecnologia replicante italiana	Aerospazio	8
Controllo delle crisi nei sistemi complessi socio-economici	Economica	30
La fabbrica del futuro	Industria	30

ra: «Cosmo-Skymed II generation», «Sintonia» e «Astri». Con i primi due orientati a potenziare i metodi di osservazione della terra dallo spazio e il terzo che, quasi fosse un contro-campo, si concentra sull'osser-

Se ne dovrebbe sapere di più tra fine aprile e i primi di maggio quando ministri e governatori si siederanno allo stesso tavolo. Dopodiché il Pnr sarà pronto per andare a Palazzo Chigi, prima, e al Cipe, poi.

Estratto da pag. **25**

Comunicato stampa del 26 Aprile 2010 - Miur

Ministero dell'Istruzione, dell'Università e della Ricerca

Home » Ministero » Il Ministro » Comunicati Stampa » 2010 » 260410

Ministero

Istruzione

Ufficio Stampa

Roma, 26 Aprile 2010

RICERCA, VERTICE ITALIA-RUSSIA, GELMINI FIRMA ACCORDO SU RICERCA NUCLEARE

Oggi, il ministro Mariastella Gelmini, in occasione del vertice italo-russo di Lesmo, ha firmato una dichiarazione d'intenti tra il MIUR e il Ministero della ricerca scientifica russo per la realizzazione di due importanti progetti per la promozione della ricerca nel settore della fusione nucleare.

L'intesa riguarda i programmi di ricerca denominati "IGNITOR" e "SUPER B". Il programma "IGNITOR" prevede la realizzazione in Russia di un innovativo reattore sperimentale a fusione nucleare che verrà utilizzato come fonte di energia.

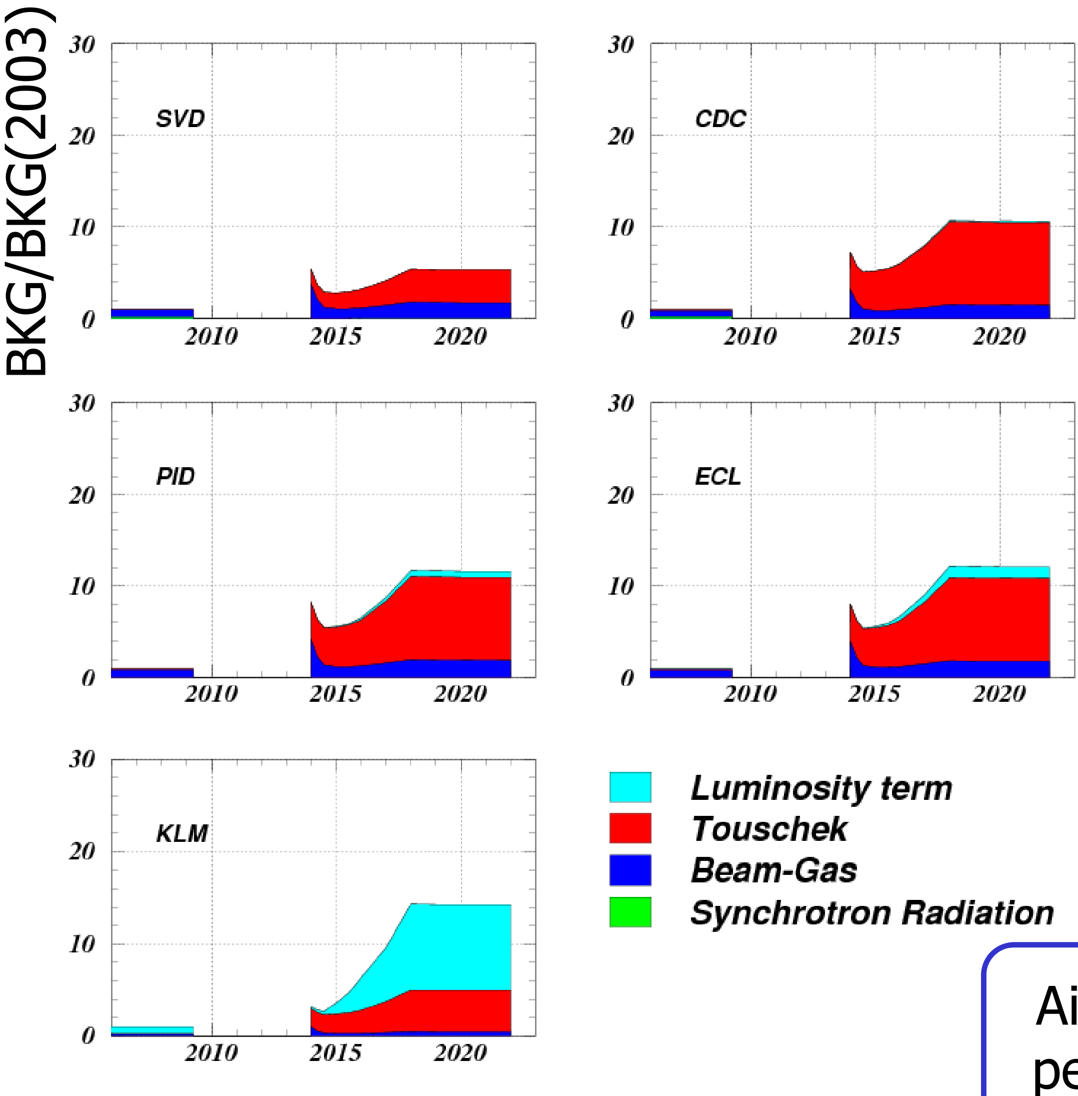
Il programma "SUPER B" riguarda la realizzazione in Italia di un acceleratore di particelle di nuova generazione che consentirà una più alta intensità di collisioni tra particelle, permettendo la produzione di "quark pesanti".

Summary

- B factories have proven to be an excellent tool for flavour physics, with reliable long term operation, constant improvement of the performance, achieving and surpasing design perfomance
- Major upgrade at KEK in 2010-14 → SuperKEKB+Belle II, L x40, construction started
- SuperB in Frascati: build a new tunnel, reuse (+ugrade) PEP-II and BaBar, waiting for approval
- Physics reach updates available
- Expect a new, exciting era of discoveries, complementary to the LHC

Additional slides

Beam Background

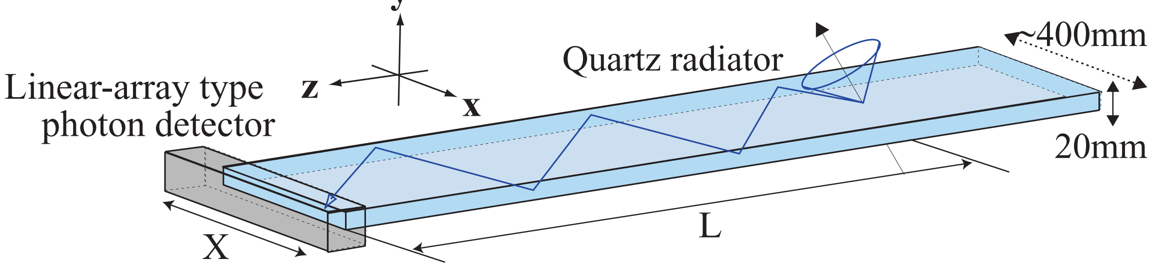


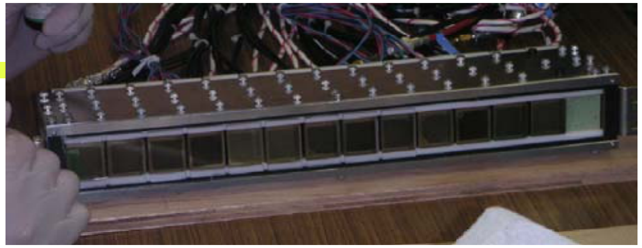
Background composition derived from background study data, which is then scaled by Luminosity, beam current etc.

x10 to x20 as large background as that of 2003 conditions (~worst during Belle running)

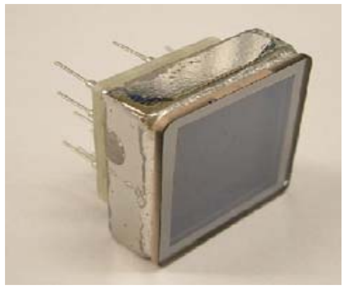
Aim for similar or better detector performance even under x20 bkg

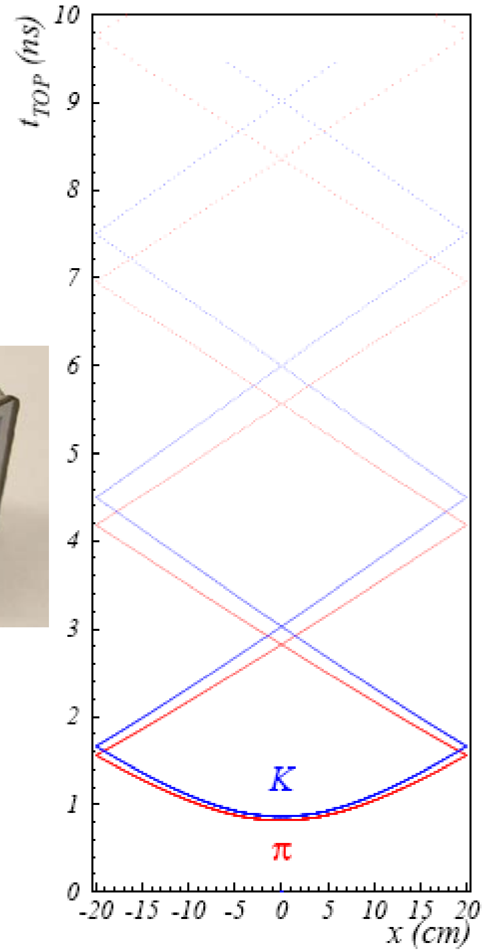
Barrel PID: Time of propagation (TOP) counter

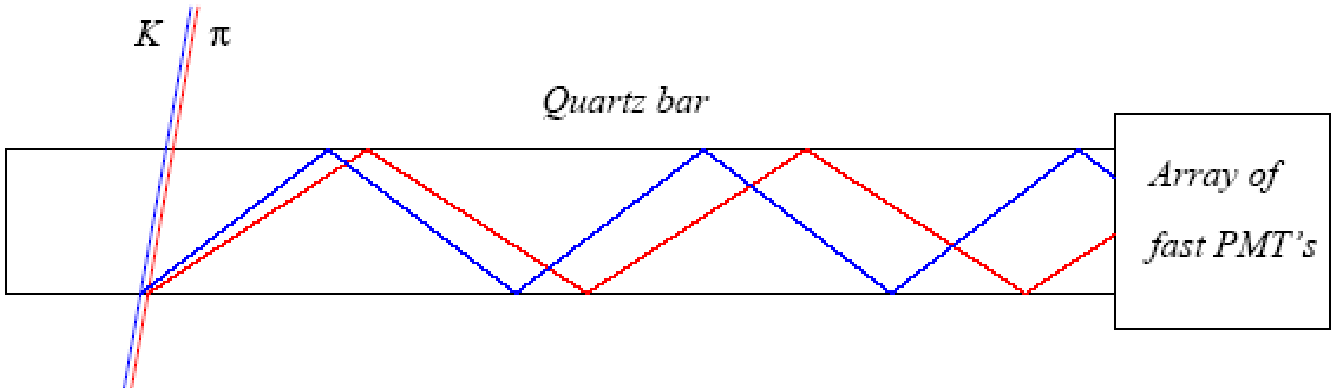




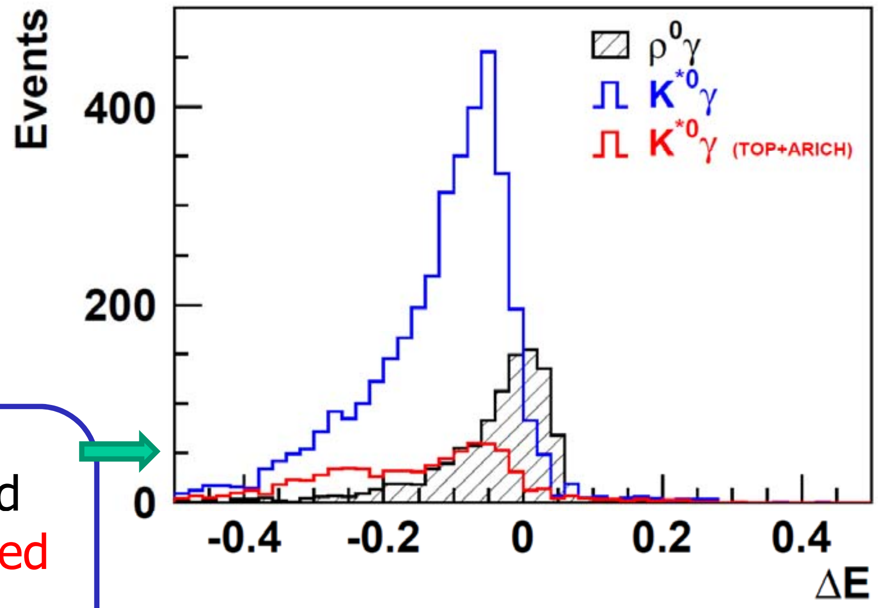
- Cherenkov ring imaging with precise time measurement.
- Reconstruct angle from two coordinates and the time of propagation of the photon
  - Quartz radiator (2cm)
  - Photon detector (MCP-PMT)
    - Good time resolution ~ 40 ps
    - Single photon sensitivity in 1.5





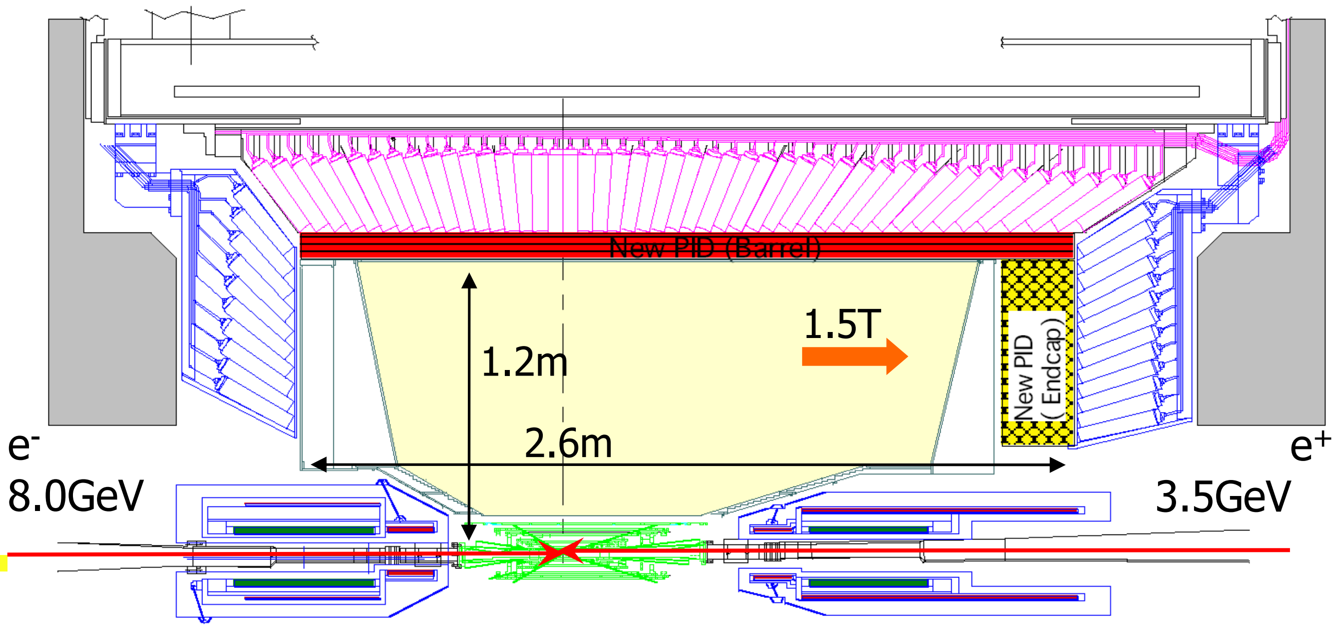


- Barrel: TOP counter
- End cap: Aerogel RICH



Expected impact, example $B \rightarrow K^*\gamma$: background reduced from blue (present Belle) to red

→Up to 80% gain in sensitivity



Ljubljana