The BELLE II project

and other…

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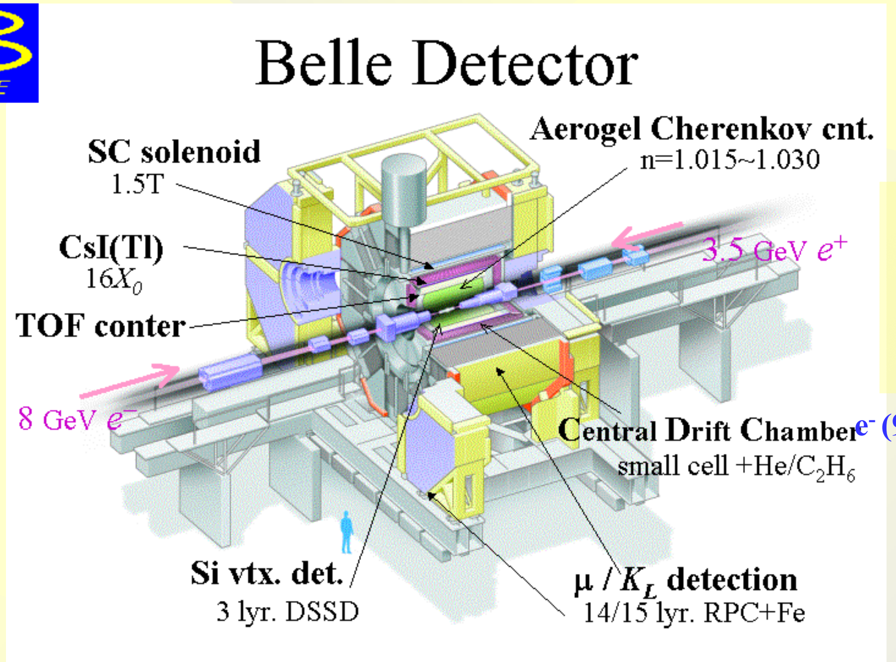
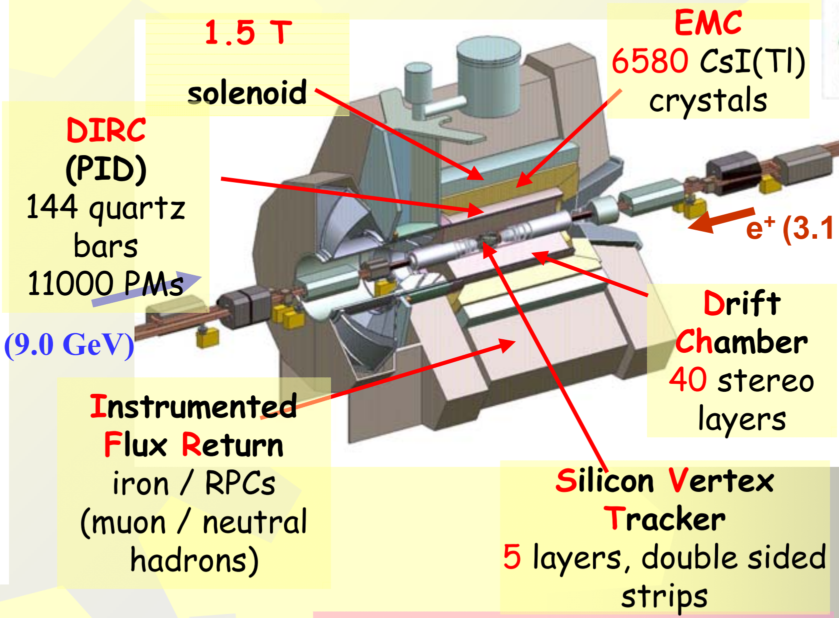
Introduction

- During last decade, from 1999 up to 2010, physical society enjoyed the high quality goods from two B-factories – KEKB and PEP-II. Now both factories are closed.
- Fortunately, at present one new super B-factory is under construction, another one is at the start line and the c-tau project is in R&D stage.
- This talk concentrates on the SuperKEKB/Belle II project with a brief survey of other projects.

During last ten years a lot of physics results came from two B-factories – Belle and BaBar



BaBar detector



$$\sum_{BaBar}^{Belle}\int_{1999}^{2010} Ldt \approx 1.5ab^{-1}$$

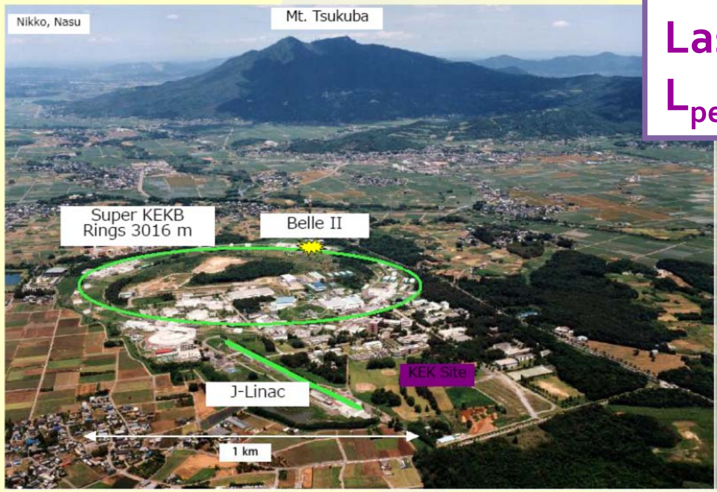
F/B asymmetric detectors

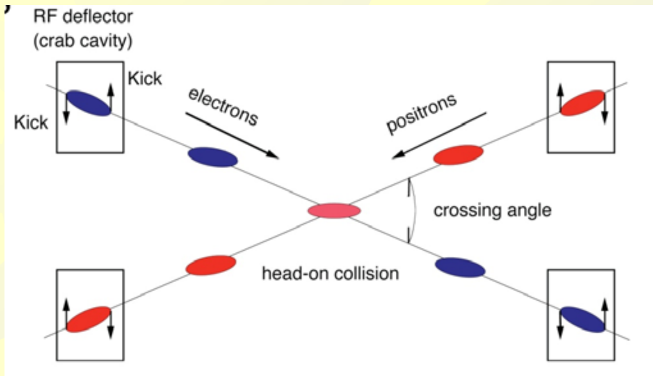
High vertex resolution, magnetic spectrometry, excellent calorimetry and sophisticated particle ID ability

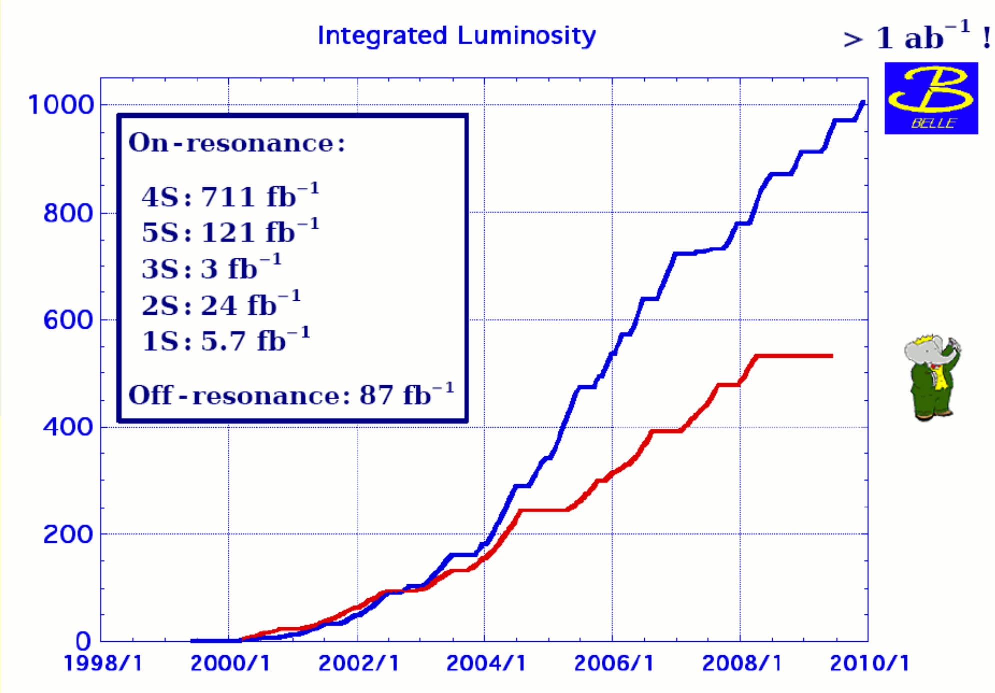
World maximum luminosity – at KEKB

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

KEKB:
HER: 8.0 GeV
LER: 3.5 GeV
crossing: 22 mrad
E_{CMS}=M(U(4S))
bg=0.425



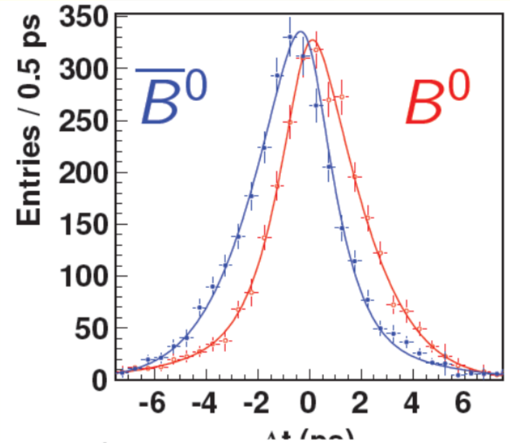


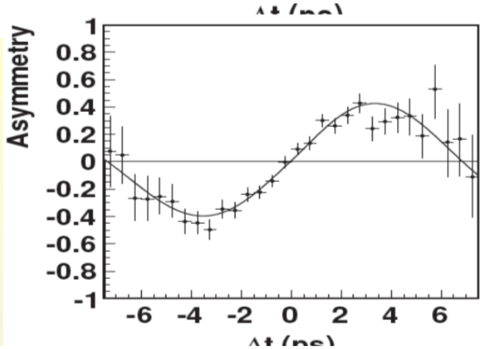


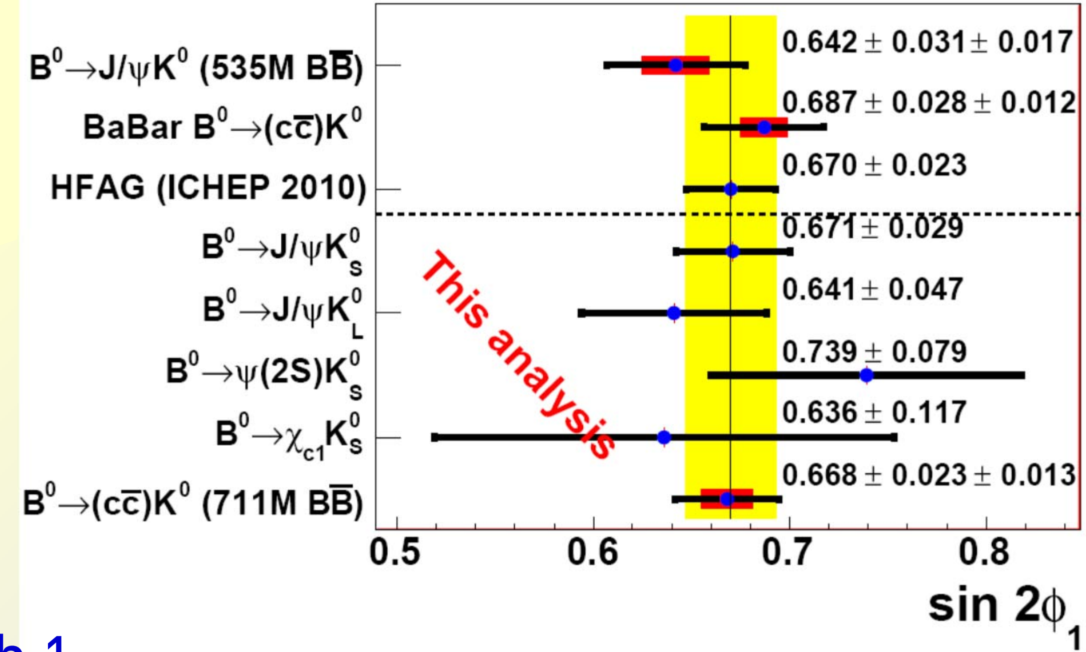
Peak lumi record at KEKB: $L = 2.1 \times 10^{34}/cm^2/sec$ with crab cavities

Physics results: CPV in B decays

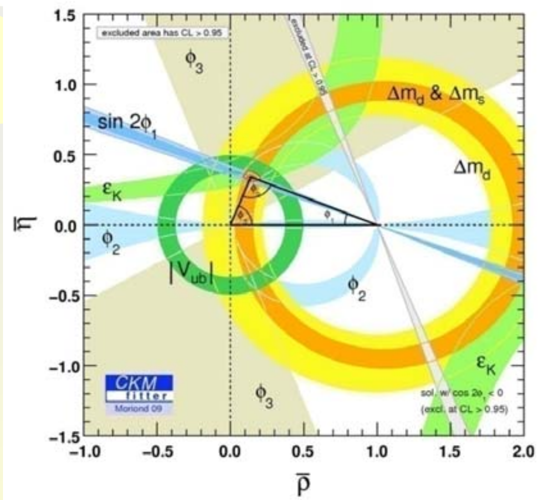
$B \to J/\psi K_S^0$







711 fb-1
(772M BB).



Combination of four modes:

Belle preliminary

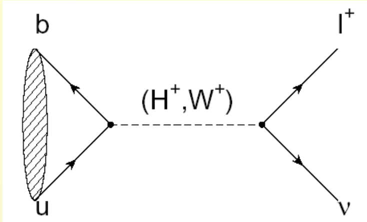
$$S = 0.668 \pm 0.023 \pm 0.013\ (\mathrm{syst})$$
$$A = 0.007 \pm 0.016 \pm 0.013\ (\mathrm{syst})$$

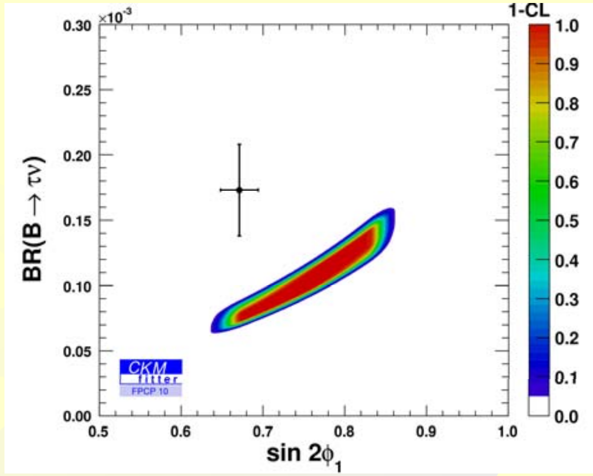
Search for New Physics

Sensitivity to new physics from charged Higgs

$B^+ \to \tau^+ \nu_\tau$

$$Br(B^+ \to \tau\nu) = (1.65 \pm^{0.38}_{0.37} \pm^{0.35}_{0.37}) \cdot 10^{-4}$$



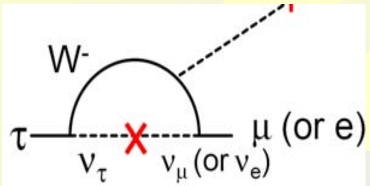


In the SM

$$\mathcal{B}(B^+ \to \tau^+\nu_\tau) = \frac{G_F^2 m_B}{8\pi} m_\tau^2 \left(1 - \frac{m_\tau^2}{m_B^2}\right)^2 f_B^2 |V_{ub}|^2 \tau_B$$

$$0.76^{+0.11}_{-0.06} \times 10^{-4}$$ CKM fit

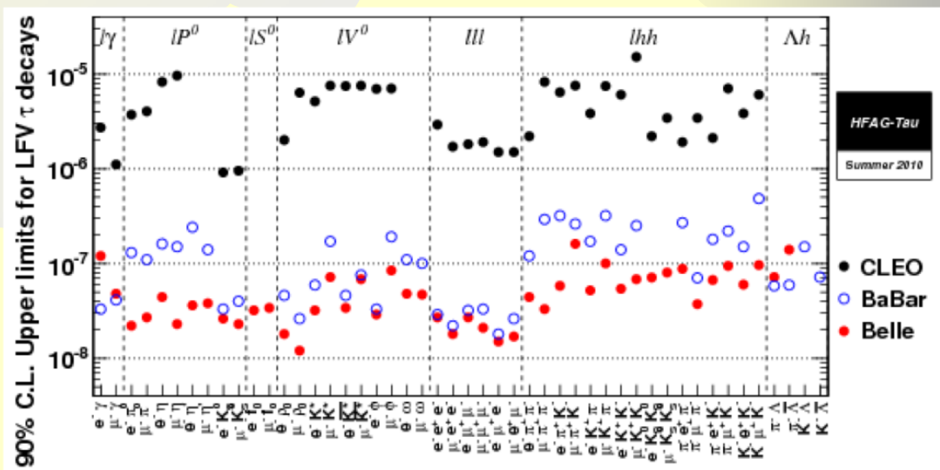
Searches for lepton flavour violation in tau decays



In the SM the lepton flavour violation decays are extremely small:

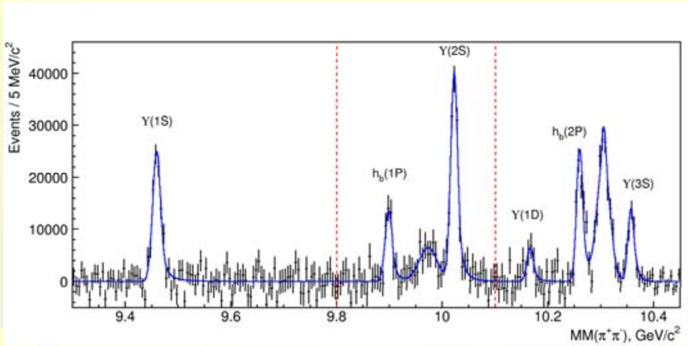
$Br(\tau \to l\gamma) \sim 10^{-54}$

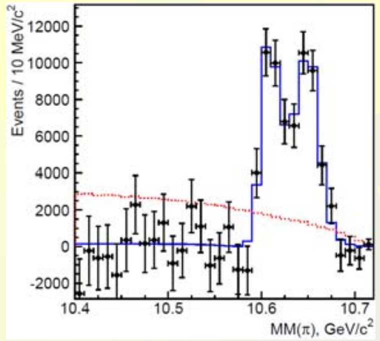
$Br(\tau \to 3\ \text{leptons}) \sim 10^{-14}$



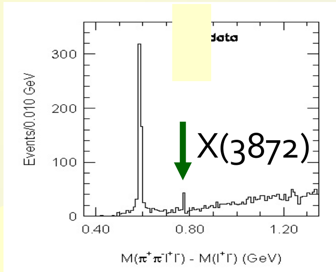
Hadron spectroscopy at B factories - examples

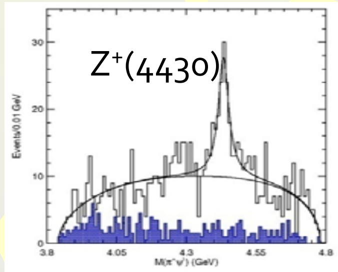
B family – new states (A.Kuzmin talk)



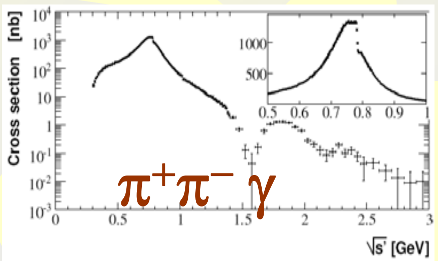


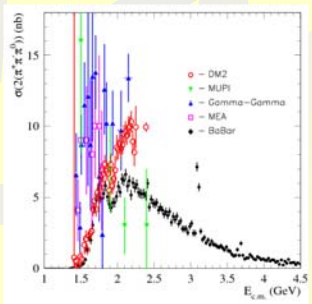
C family – XYZ states – (see S.Eidelman talk)

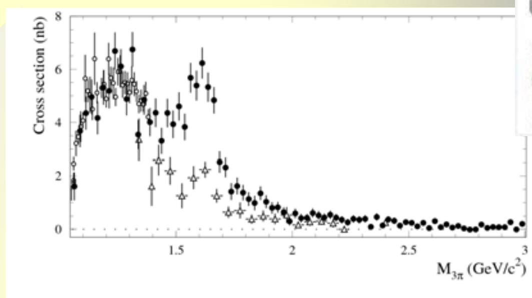


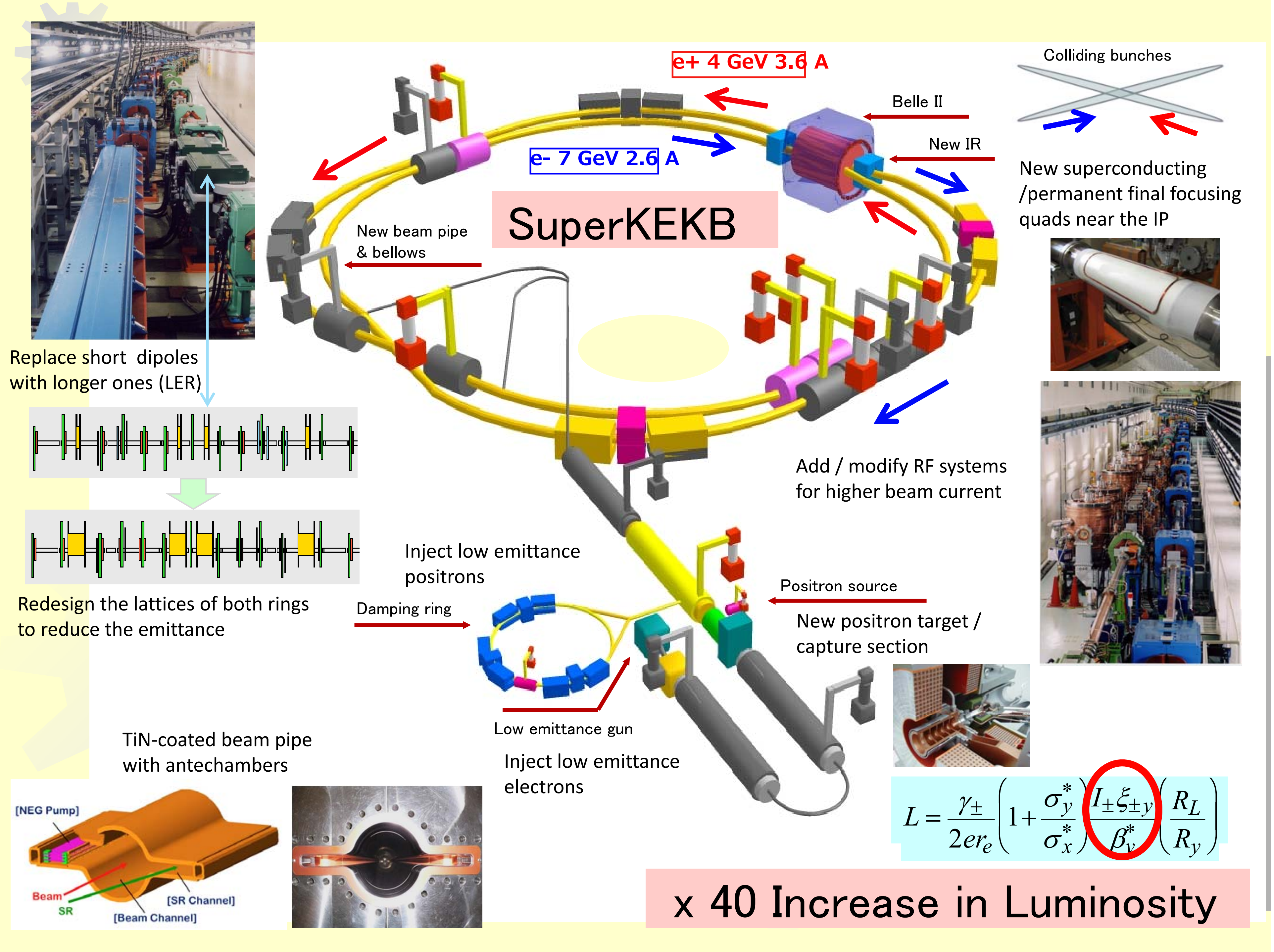


Light hadrons spectroscopy via ISR (E.Solodov report)

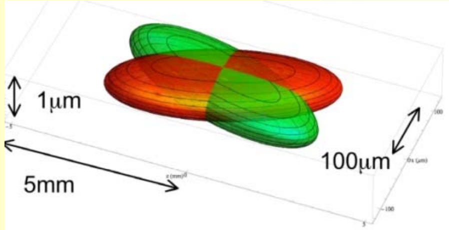




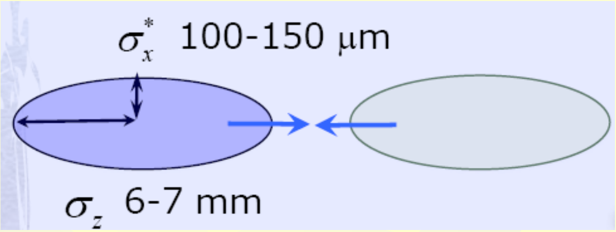



SuperKEKB
e+ 4 GeV 3.6 A
e- 7 GeV 2.6 A
Belle II
New IR
Colliding bunches
New superconducting /permanent final focusing quads near the IP
New beam pipe & bellows
Replace short dipoles with longer ones (LER)
Redesign the lattices of both rings to reduce the emittance
Add / modify RF systems for higher beam current
Inject low emittance positrons
Damping ring
Positron source
New positron target / capture section
Low emittance gun
Inject low emittance electrons
TiN-coated beam pipe with antechambers
[NEG Pump]
Beam
SR
[SR Channel]
[Beam Channel]
$L = \frac{\gamma_{\pm}}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\frac{I_{\pm}\xi_{\pm y}}{\beta_y^*}\left(\frac{R_L}{R_y}\right)$
x 40 Increase in Luminosity

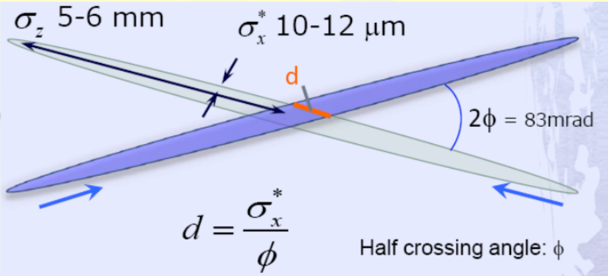
KEKB – no crab crossing



KEKB head-on (crab crossing)



Nano-Beam SuperKEKB



Design Concept of SuperKEKB

- Increase the luminosity by 40 times based on "Nano-Beam" scheme, which was first proposed for SuperB by P. Raimondi.

Luminosity Gain

- Vertical β function at IP: 5.9 → 0.27/0.30 mm (× 20)
- Beam current: 1.7/1.4 → 3.6/2.6 A (× 2)
- Beam-beam parameter: .09 → .09 (× 1)

$$L = \frac{\gamma_\pm}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\left(\frac{I_\pm \xi_{\pm y}}{\beta_y^*}\right)\left(\frac{R_L}{R_y}\right) = 8 \times 10^{35}\ \mathrm{cm^{-2}s^{-1}}$$

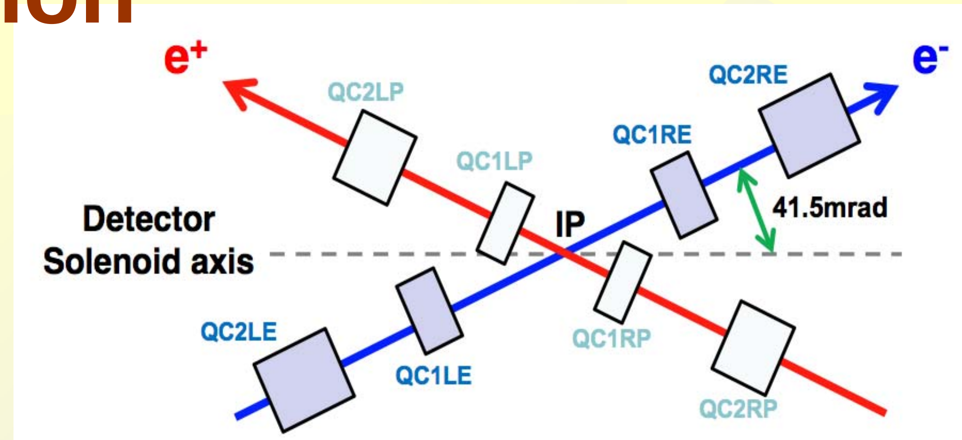
- Beam energy: 3.5/8.0 → 4.0/7.0 GeV

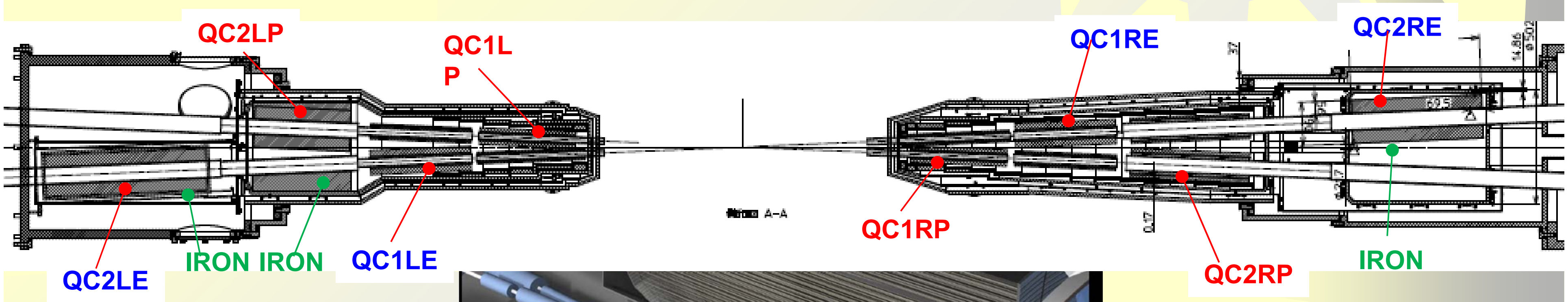
LER : Longer Touschek lifetime and mitigation of emittance growth due to the intra-beam scattering
HER : Lower emittance and lower SR power

- Re-use the KEKB tunnel.
- We have no option for polarization at present.
- Re-use KEKB components as much as possible.
- Preserve the present cells in HER.
- Replace dipole magnets in LER, re-using other main magnets in the LER arcs.

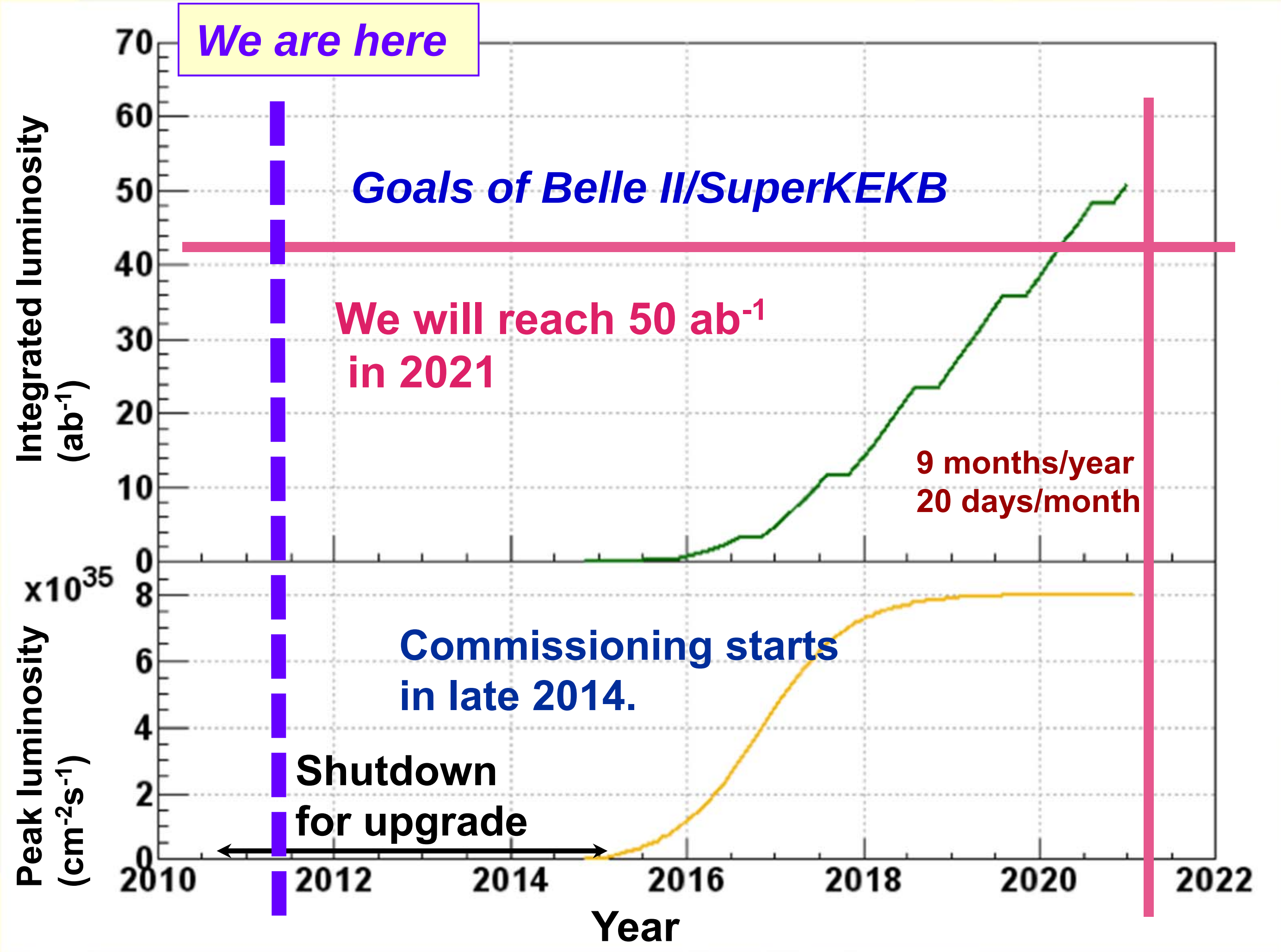
SuperKEKB/Belle II Interaction Region

Many new superconducting magnets at the IP; Belle detector currently aligned with LER will have to be *rotated*.





SuperKEKB luminosity profile



Y. Ohnishi

Demands on the detector

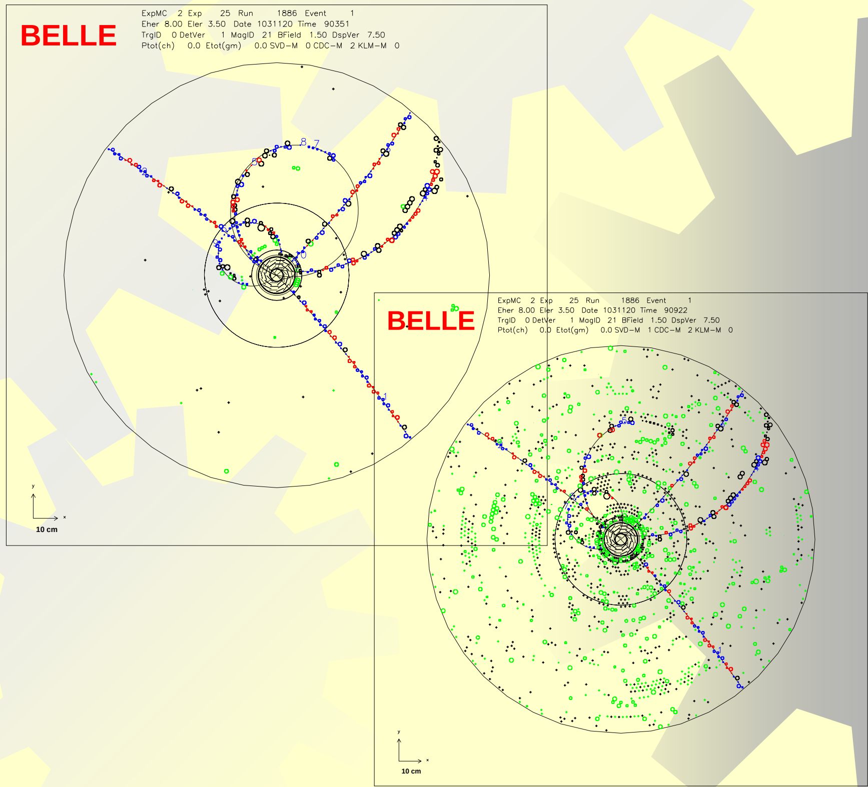
Total cross section and trigger rates with $L = 8\times10^{35}$ $cm^{-2}\ s^{-1}$ from various physics processes at $\Upsilon(4S)$.

Physics process	Cross section (nb)	Rate (Hz)
$\Upsilon(4S) \to BB$	1.2	960
Hadron production from continuum	2.8	2200
$\mu^+\mu^-$	0.8	640
$\tau^+\tau^-$	0.8	640
Bhabha (θlab> 17°)	44	350[(a)]
γγ (θlab> 17°)	2.4	19 [(a)]
2γ processes (θlab> 17°, pt > 0.1GeV/c)	~80	~ 15000
Total	~130	~20000

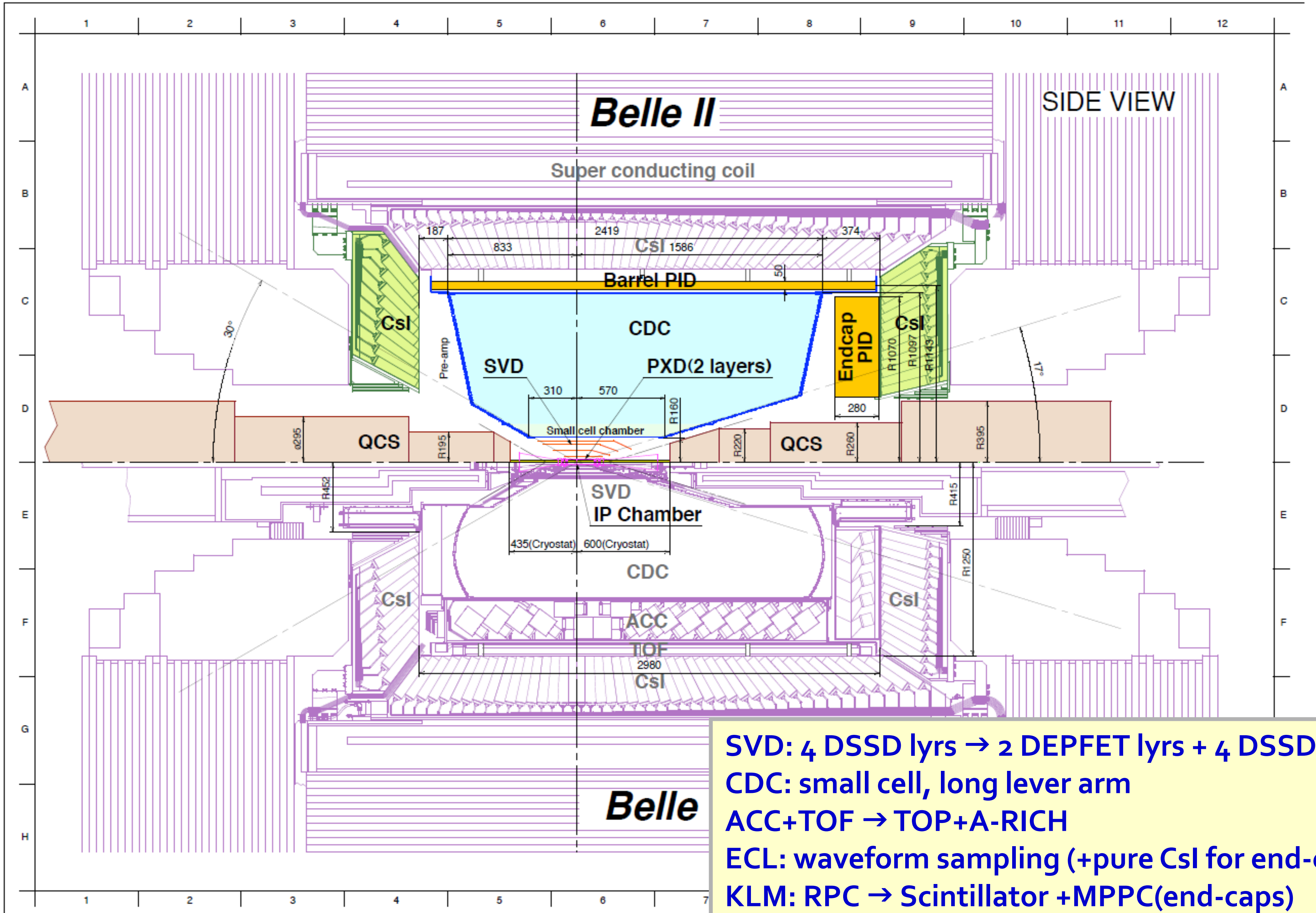
(a) rate is pre-scaled by a factor of 1/100

The requirements for the trigger system are:

1. high efficiency for hadronic events;
2. maximum average trigger rate of 30 kHz;
3. fixed latency of about 5 μs;
4. timing precision of less than 10 ns;
5. minimum two-event separation of 200 ns;
6. trigger configuration that is flexible and robust.

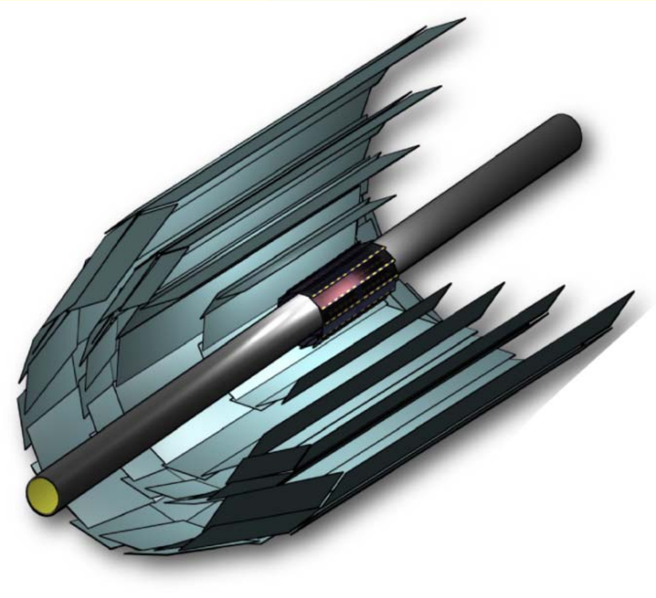


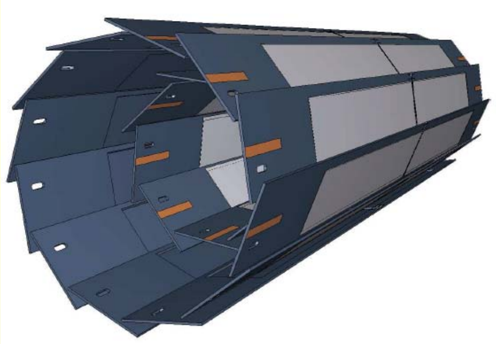
Belle II Detector (in comparison with Belle)

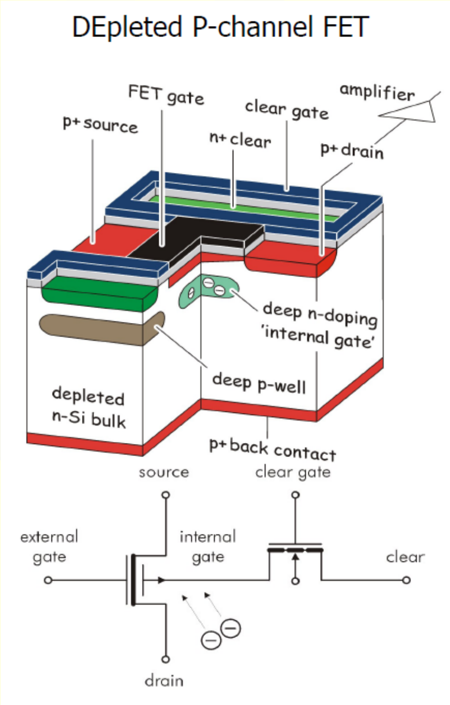


SVD: 4 DSSD lyrs → 2 DEPFET lyrs + 4 DSSD lyrs
CDC: small cell, long lever arm
ACC+TOF → TOP+A-RICH
ECL: waveform sampling (+pure CsI for end-caps)
KLM: RPC → Scintillator +MPPC(end-caps)

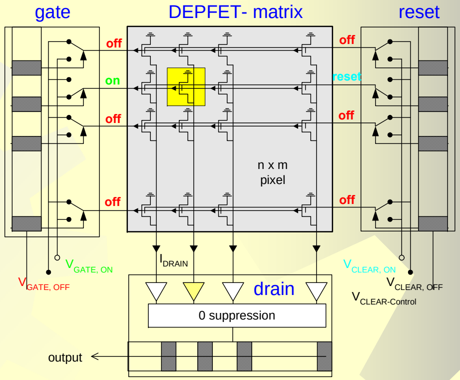
Vertex Detection via Pixels and DSSDs







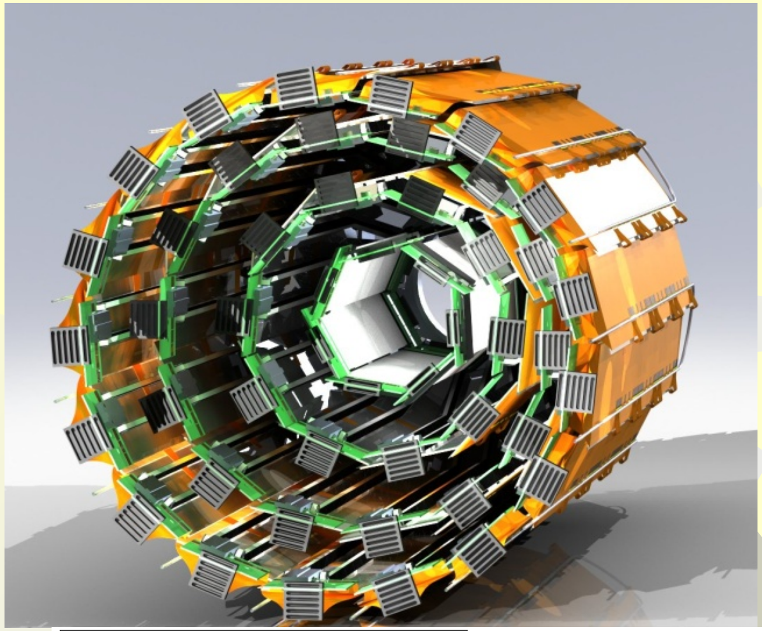
Beam Pipe		r = 10mm
DEPFET		
	Layer 1	r = 14mm
	Layer 2	r = 22mm
DSSD		
	Layer 3	r = 38mm
	Layer 4	r = 80mm
	Layer 5	r = 115mm
	Layer 6	r = 140mm

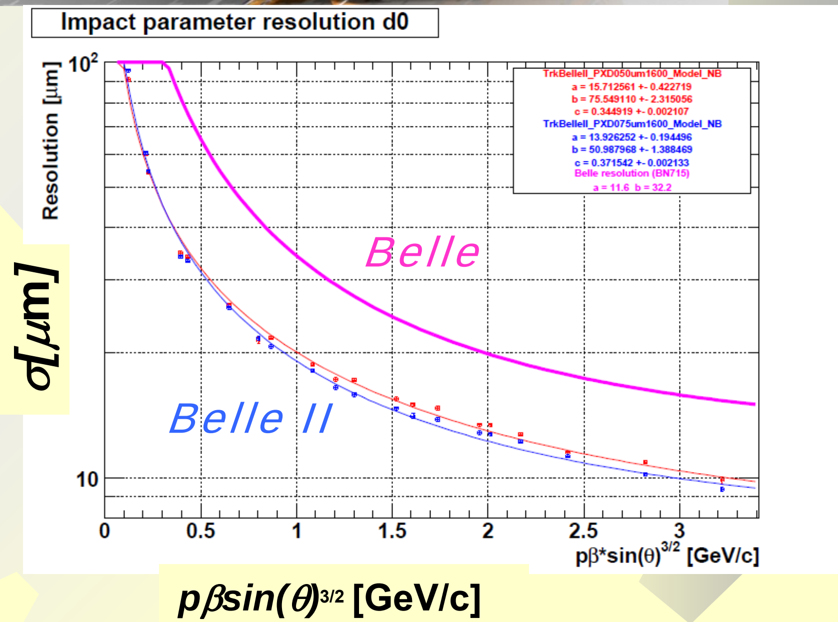


DEPFET:
http://aldebaran.hll.mpg.de/twiki/bin/view/DEPFET/WebHome

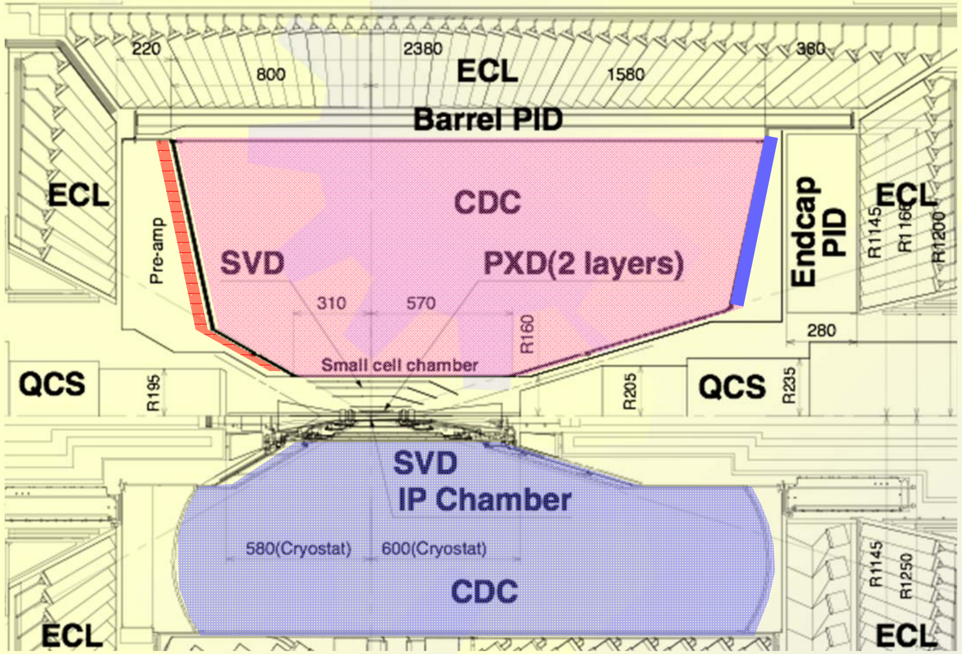
DSSDs

		Belle II	Belle
Beam Piper = 10mm			15mm
DEPFET			
	Layer 1	r = 14mm	
	Layer 2	r = 22mm	
DSSD			
	Layer 3	r = 38mm	
20mm			
	Layer 4	r = 80mm	
43.5mm			
	Layer 5	r = 115mm	
70mm			
	Layer 6	r = 140mm	
			88mm





Central Drift Chamber



	Belle	Belle II
inner most sense wire	r=88mm	r=168mm
outer most sense wire	r=863mm	r=1111.4mm
Number of layers	50	56
Total sense wires	8400	14336
Gas	He:C_2H_6	He:C_2H_6
sense wire	W(Φ30 μm)	W(Φ30 μm)
field wire	Al(Φ120 μm)	Al(Φ120 μm)

longer lever arm

Improved momentum resolution and dE/dx

$$\sigma_{P_t}/P_t = 0.19 P_t \oplus 0.30/\beta$$

$$\sigma_{P_t}/P_t = 0.11 P_t \oplus 0.30/\beta$$

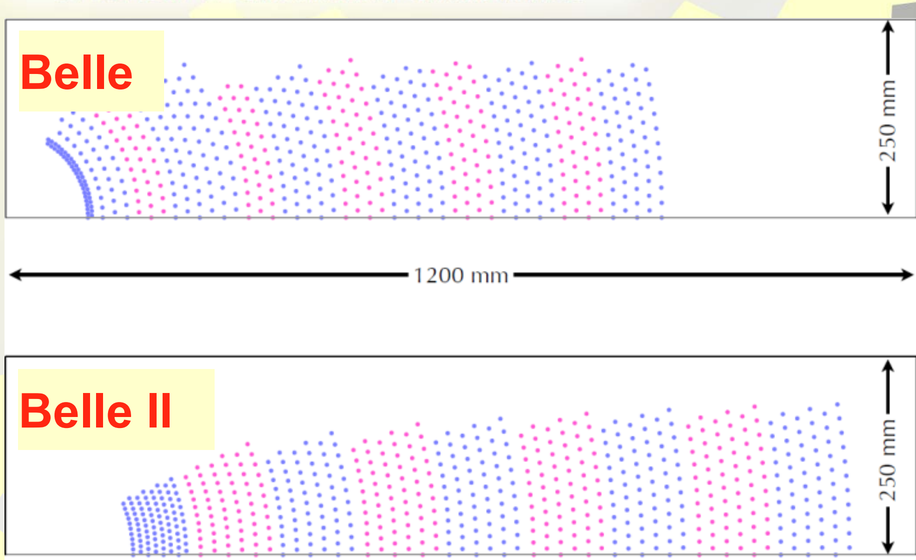
new readout system

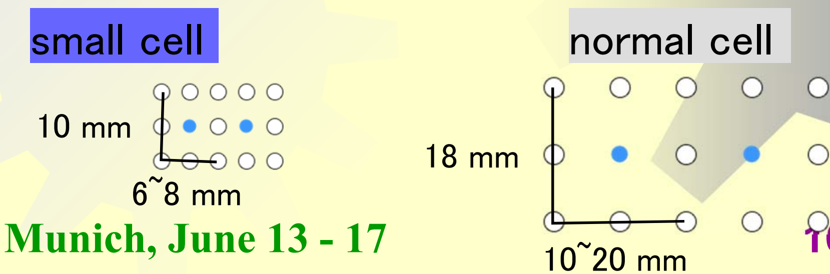
dead time 1-2μs → 200ns

small cell

smaller hit rate for each wire

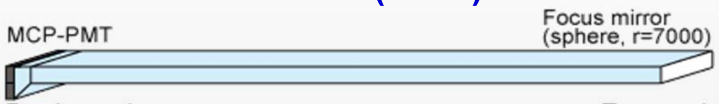
shorter maximum drift time





Particle Identification in Belle II

Barrel PID: Time of Propagation Counter (iTOP)

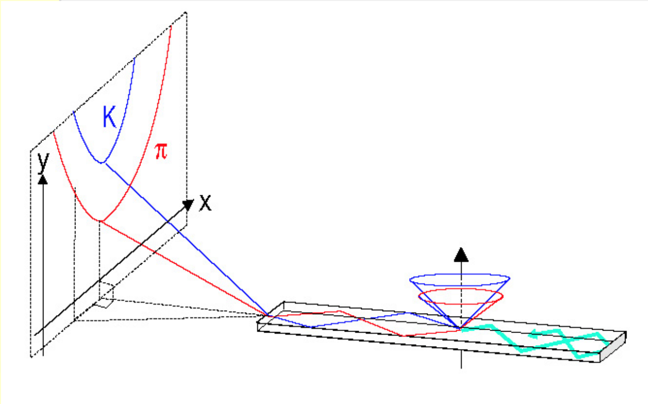


Quartz radiator

Focusing mirror

Small expansion block

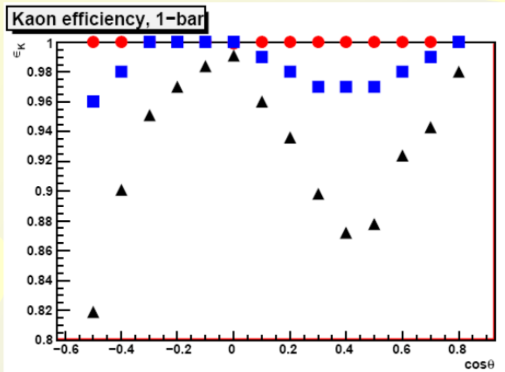
Hamamatsu MCP-PMT (measure t, x and y)

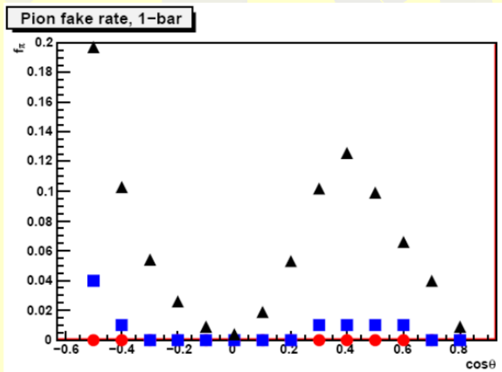


Quartz radiator
- **2.6m^L x 45cm^W x 2cm^T**
- **Excellent surface accuracy**

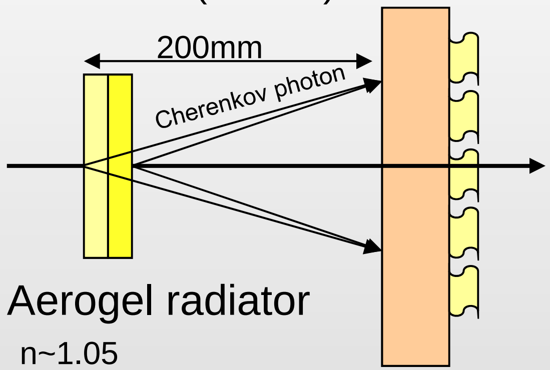
MCP-PMT
- **Hamamatsu 16ch MCP-PMT**
  - **Good TTS (<35ps) & enough lifetime**
  - **Multialkali photo-cathode → SBA**

Beam test done in 2009
- **# of photons consistent**
- **Time resolution OK**





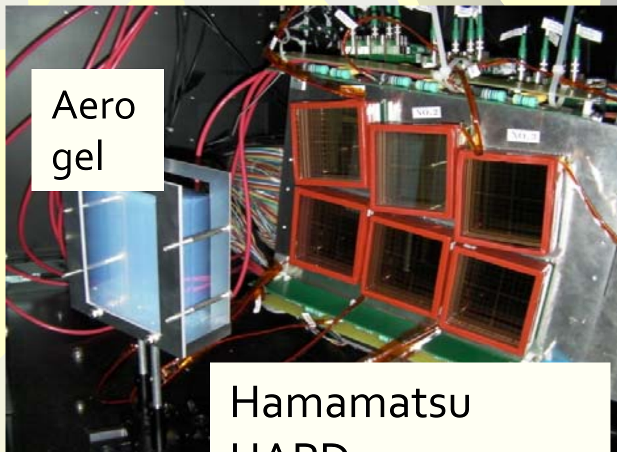
Endcap PID: Aerogel RICH (ARICH)



Aerogel radiator

n~1.05

Hamamatsu HAPD + new ASIC

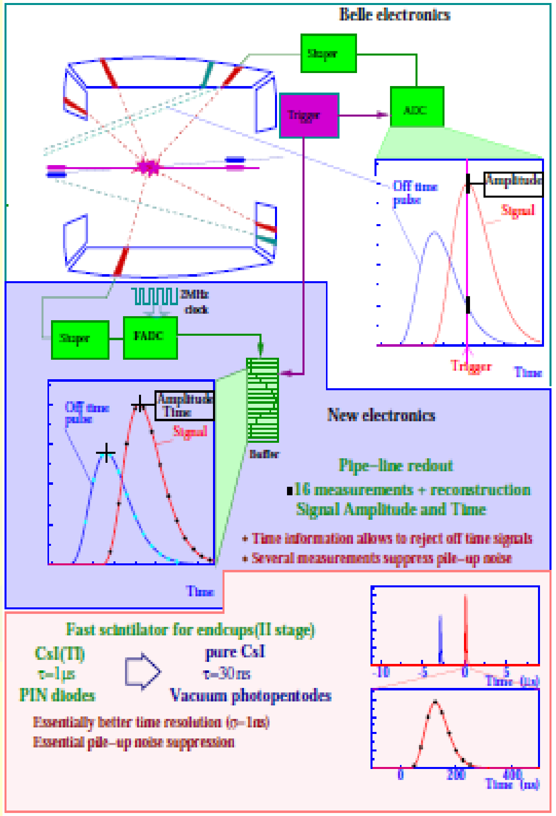


Aero gel

Hamamatsu HAPD
Q.E. ~33% (recent good ones)

ECL (Electromagnetic Crystal Calorimeter)

1. Upgrade electronics to do waveform sampling & fitting
2. Upgrade endcap crystal (baseline option: pure CsI + photomultipliers); upgrade will have to be staged.



- Belle II can get advantage in π^0 and soft photon-detection efficiency and resolution in comparision with LHCb experiment
- Modify electronics for the barrel.
- Pipe-line readout with waveform analysis:
- 16 points within the signal are fitted by the signal function $F(t)$:

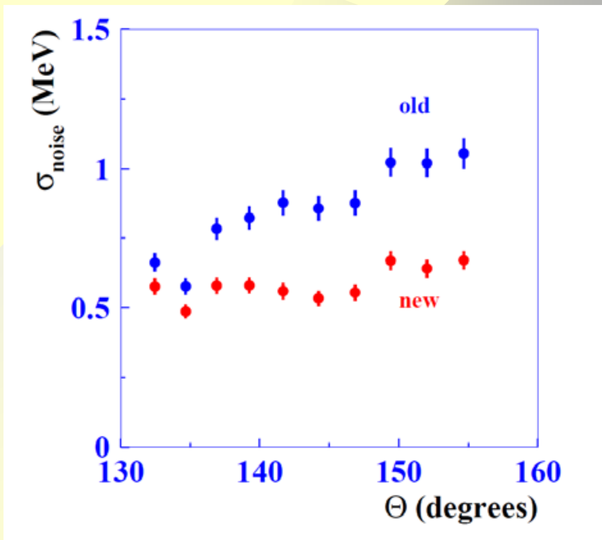
$$F(t) = A\ f(t - t_0)$$

A - amplitude of the signal and
t_0 − time of the signal,

$$\chi^2 = \sum (y_i - A\ f(t_i - t_0)) S^{-1}_{ij} (y_i - A\ f(t_i - t_0))$$

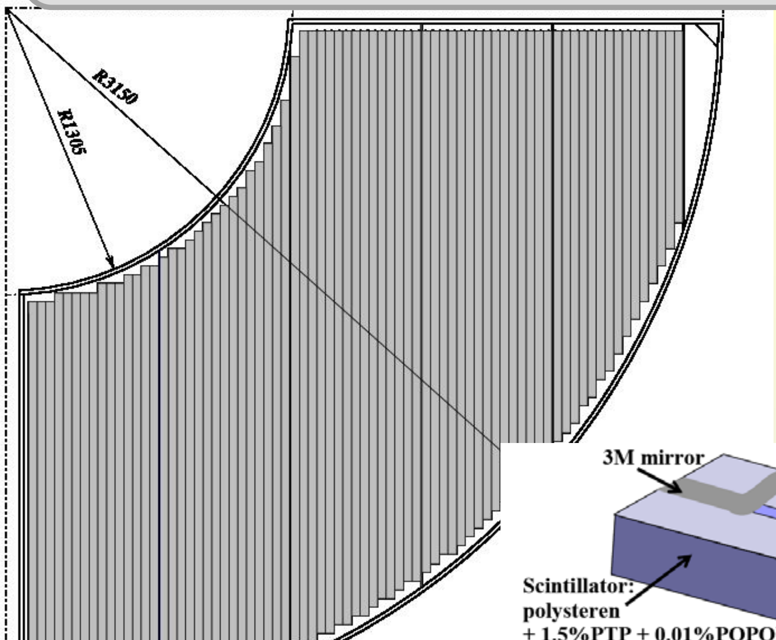
- Both amplitude and time information are reconstructed:
- Next stage: Replace the CsI(Tl) by the pure CsI crystals in endcaps.

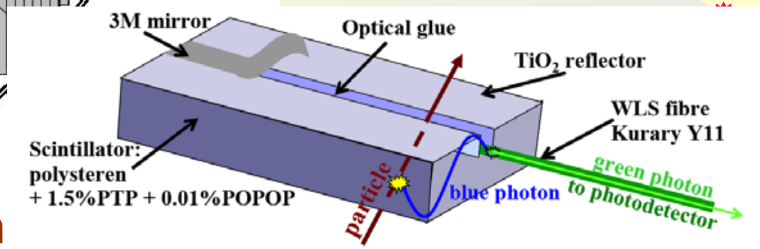
One module of new electronics tested in Belle



KLM: K_L&Muon detector

RPC → Scintillator (Endcap)
also inner 1,2, or 3 layers of Barrel(TBD)



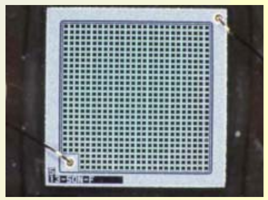


Endcap muon detecton limited by backgrounds. Endcap RPCs will not work at full luminosity and higher backgrounds. Inner barrel is *marginal.*

LAYOUT

- **One layer: 75 strips (4 cm width)/sector**
- **5 segments**
  1 segment = 15strips
- **Two orthogonal layer = superlayer**
- **F&B endcap KLM:**
  - **Total area ~1400 m^2**
  - **16800 strips**
  - **the longest strip 2.8 m; the shortest 0.6 m**
- **WLS fiber in each strip**
- **Hamamatsu MPPC at one fiber end**

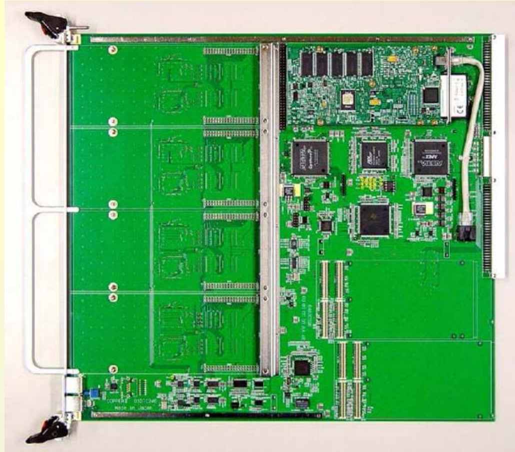
mirrored far fiber end



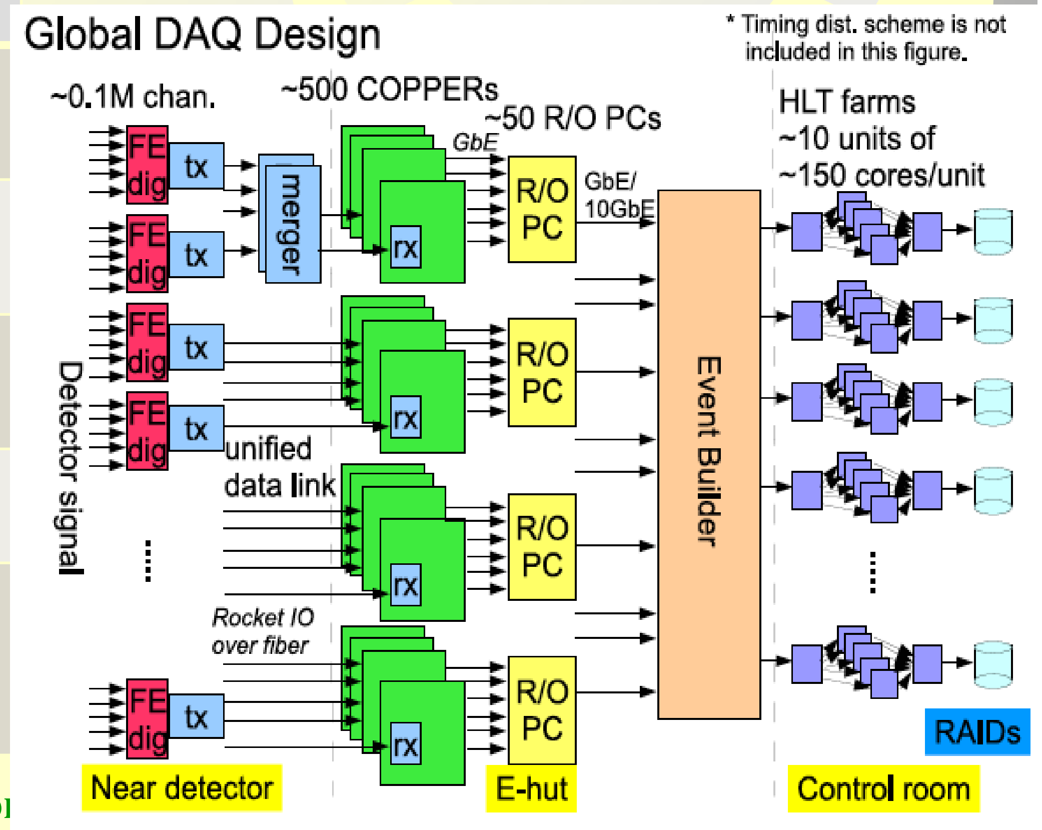
MPPC: Hamamatsu 1.3×1.3 mm 667 pixels (used in T2K Near Detector)

DAQ Overview

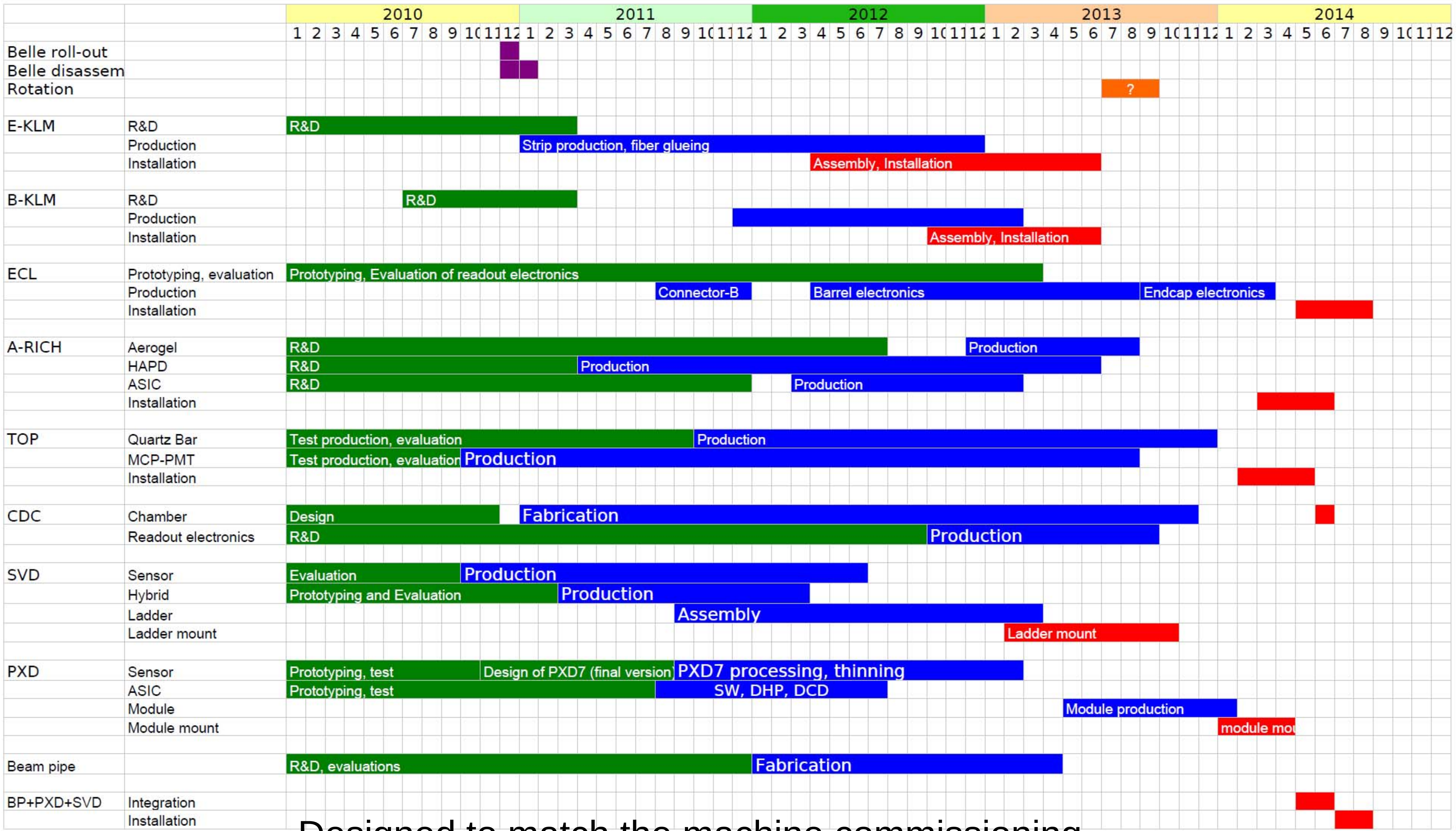
- At full luminosity, the data rate is 600 MB/sec.
- A high performance DAQ system is being designed by KEK and IHEP Beijing



		Belle	Belle II
Level 1 Trigger	Trigger rate (kHz)	0.3-0.5	20-30
	Event size (kBytes)	40	300
	Data rate (MB/s)	20	6000
High Level Trigger	Reduction	1/ 2	1/10
	Storage Bandwidth (MB/s)	20	600



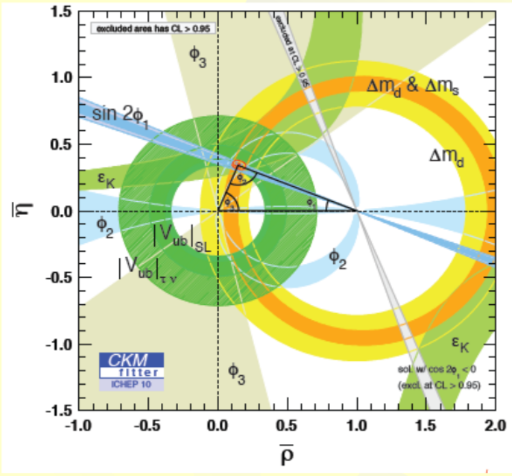
Status: approved, under construction



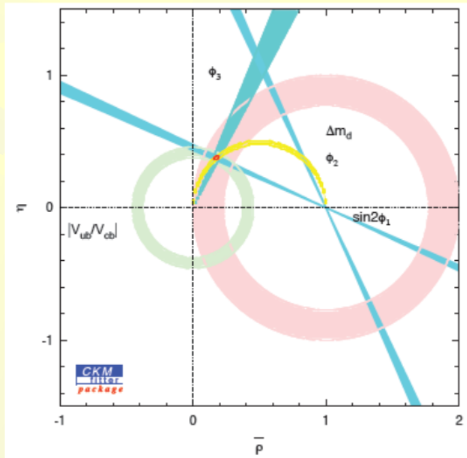
Designed to match the machine commissioning schedule and keep up with flavor physics at LHC

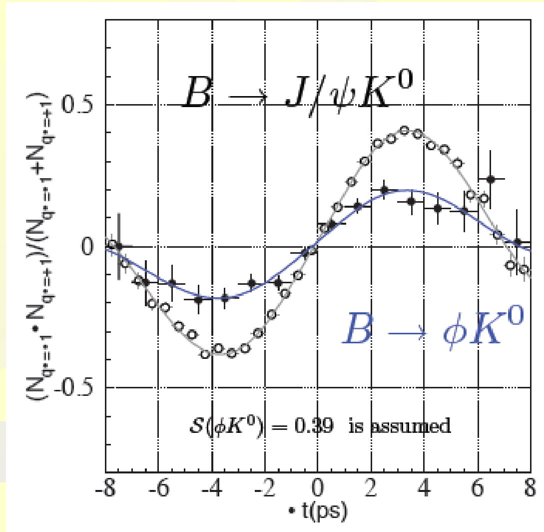
Physics at 50/ab, a few examples

2010 ICHEP



202X@50/ab

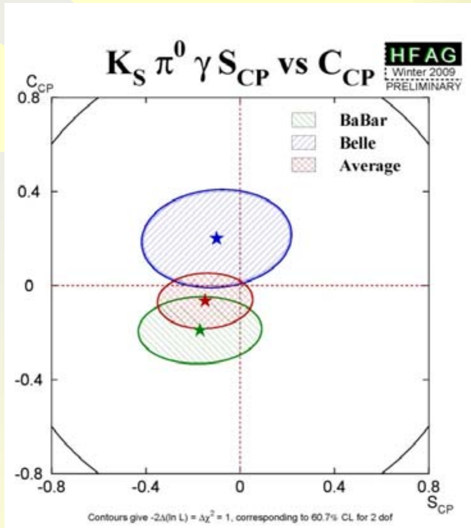




B → K*γ t-dependent CPV

SM: $S_{CP}^{K^*\gamma} \sim (2m_s/m_b)\sin 2\phi_1 \sim -0.04$

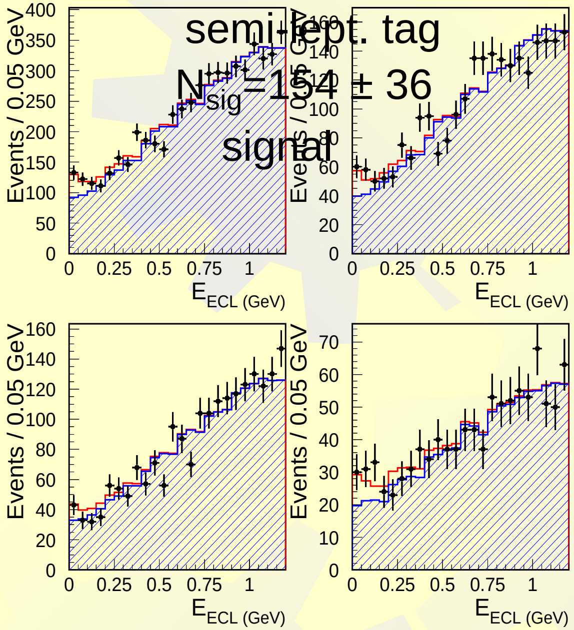
$S_{CP}^{K_s\pi 0\gamma}$ = -0.15 ±0.20
$A_{CP}^{K_s\pi 0\gamma}$ = 0.07 ±0.12

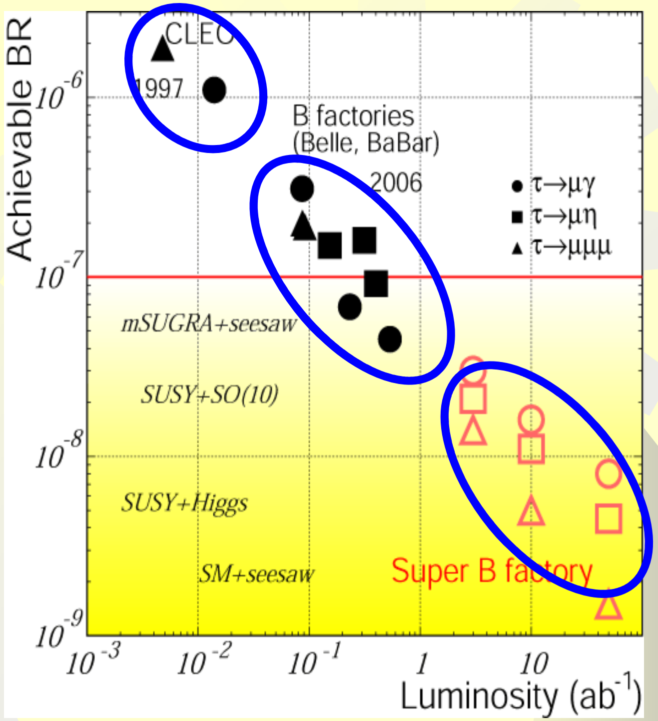


Expected sensitivity - 0.03 for

S in Ks pi0 gamma with 50 ab-1

NP search with 50 ab^{-1}





$$Br(B^+ \to \tau\nu) = (1.65 \pm^{0.38}_{0.37} \pm^{0.35}_{0.37}) \cdot 10^{-4}$$

Belle, arXiv: 0809.3834, 600 fb^{-1}

$$\Rightarrow \sigma(\Gamma/\Gamma_{SM}) \approx 0.08$$

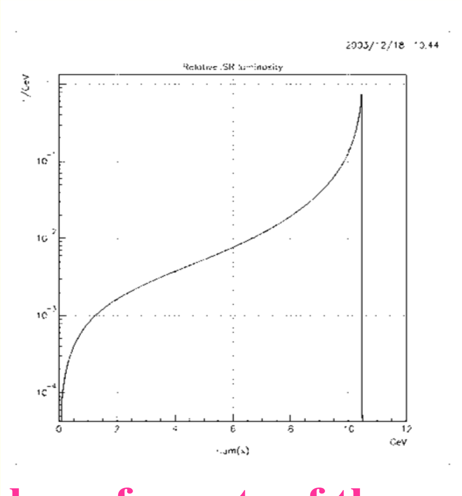
includes uncertainties from theory (on Vub and f_B), 0.04 purely exp.

Expected sensitivity

$\tau \to \ell\gamma$ Br~O($10^{-8\sim9}$)

$\tau \to \ell\ell\ell$, l+meson Br~O($10^{-9\sim10}$)

Potential of ISR: competition or complementarity?



$$\frac{dl}{Ldm} = \frac{2\alpha m}{\pi s}\left\{\frac{s+m^4}{s(s-m^2)}(\ln\frac{s}{m_e^2}-1)\right\}$$

	KEKB	VEPP-2000	BEPC-II
Luminosity, см$^{-2}$ s^{-1}	$8{\cdot}10^{35}$	10^{32}	10^{33}
Integrated lum. (per 10^7 s)	8000 fb^{-1}	1 fb^{-1}	10 fb^{-1}
Integrated in the range [1-2] GeV	8 fb^{-1} (~0.8 @ θ>0.7)	1 fb^{-1}	
Integrated in the range [2-3] GeV	20 fb^{-1} (~2 @ θ>0.7)		10 fb^{-1}

Number of events of the vector meson production at 8000 fb^{-1} (@Υ(4s)

φ	1.5×10^8
ψ	2.3×10^8
ψ(2S)	7.8×10^7
ψ(3770)	9.7×10^6
Υ(1s)	1.3×10^8
Υ(2s)	1.2×10^8
Υ(3s)	2.4×10^8

The Belle II Collaboration

16 countries, 57 institutes, about 300 members

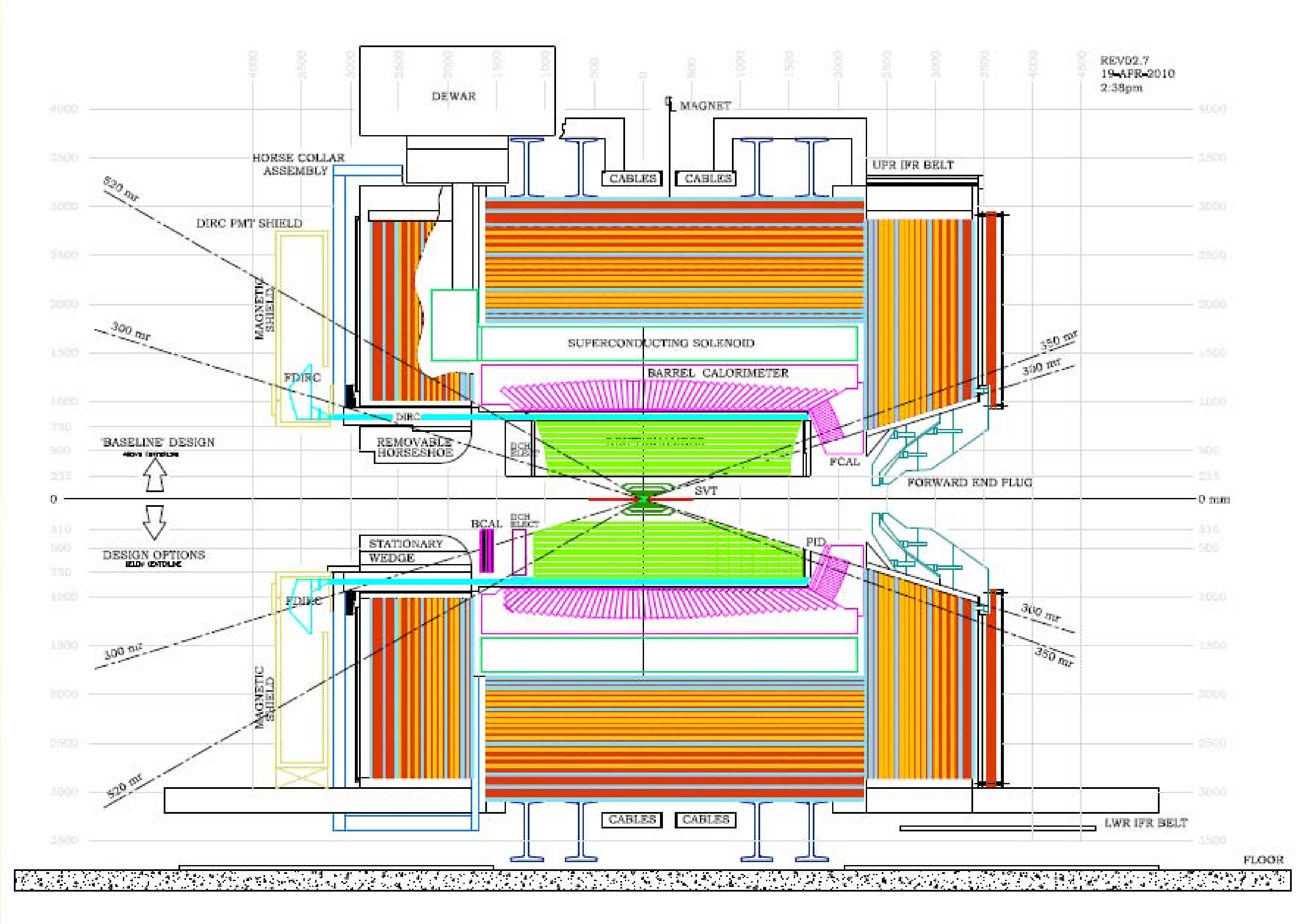
SuperB in Italy

M. Biagini, INFN-LNF
on behalf of the SuperB Accelerator Team
XVII SuperB Workshop and Kick-off Meeting
Elba, May 29-June 1, 2011

- SuperB is a 2 rings, asymmetric energies (e^- @ 4.18, e^+ @ 6.7 GeV) collider with:
  - large Piwinski angle and "crab waist" (LPA & CW) collision scheme
  - ultra low emittance lattices
  - longitudinally polarized electron beam
  - target luminosity of 10^{36} cm^{-2} s^{-1} at the $\Upsilon(4S)$
  - possibility to run at τ/charm threshold with L = 10^{35} cm^{-2} s^{-1}
- Design criteria :
  - Minimize building costs
  - Minimize running costs (wall-plug power and water consumption)
  - Reuse of some PEP-II B-Factory hardware (magnets, RF)
- SuperB can also be a good "light source": work is in progress to design Synchrotron Radiation beamlines (collaboration with Italian Institute of Technology)

http://arxiv.org/abs/1009.6178

SuperB Detector



Forward and backward regions are still under discussions and study

BINP Super c/τ factory project

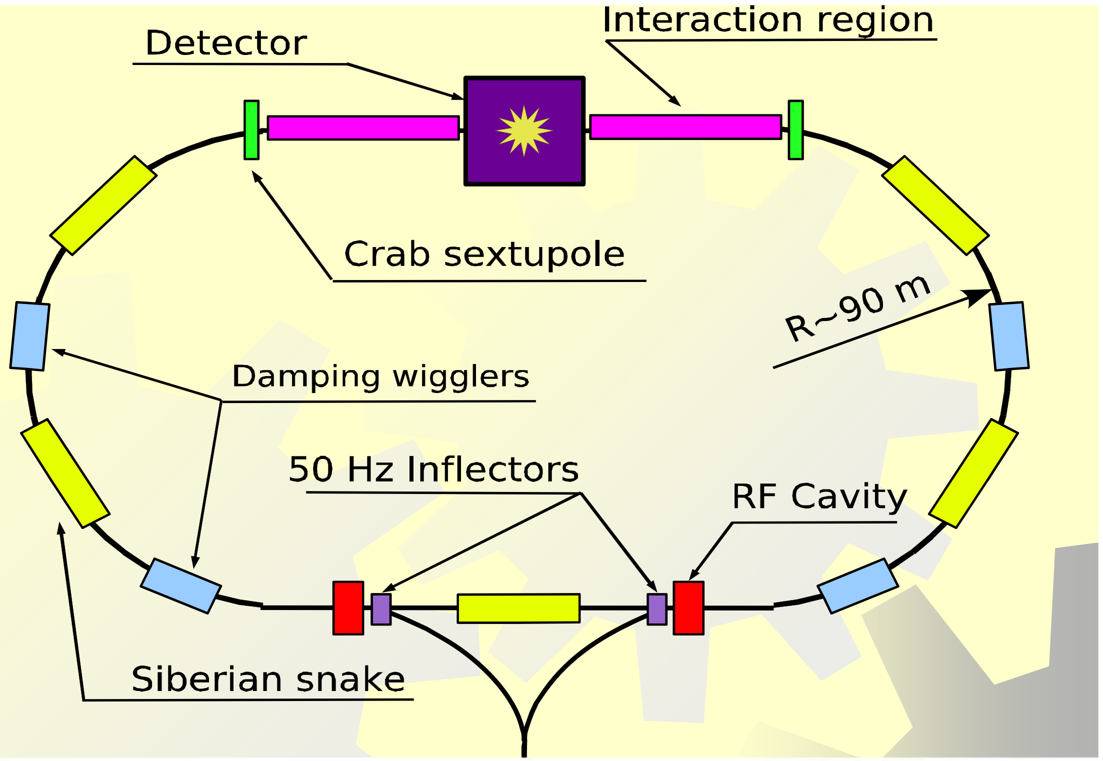
- **Beam energy from 1.0 to 2.5 GeV**
- **Peak luminosity is 10^{35} cm^{-2}s^{-1} at 2 GeV**
- **Electrons are polarized longitudinally at IP**
- **On-line energy monitoring ($\sim 5 \div 10 \cdot 10^{-5}$)**

- **Precision charm physics**
  - **Precision charm$\rightarrow$ 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 ($\tau \rightarrow \mu\gamma$)**
  - **Second class currents (with kinematical constraints at threshold)**
- **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**

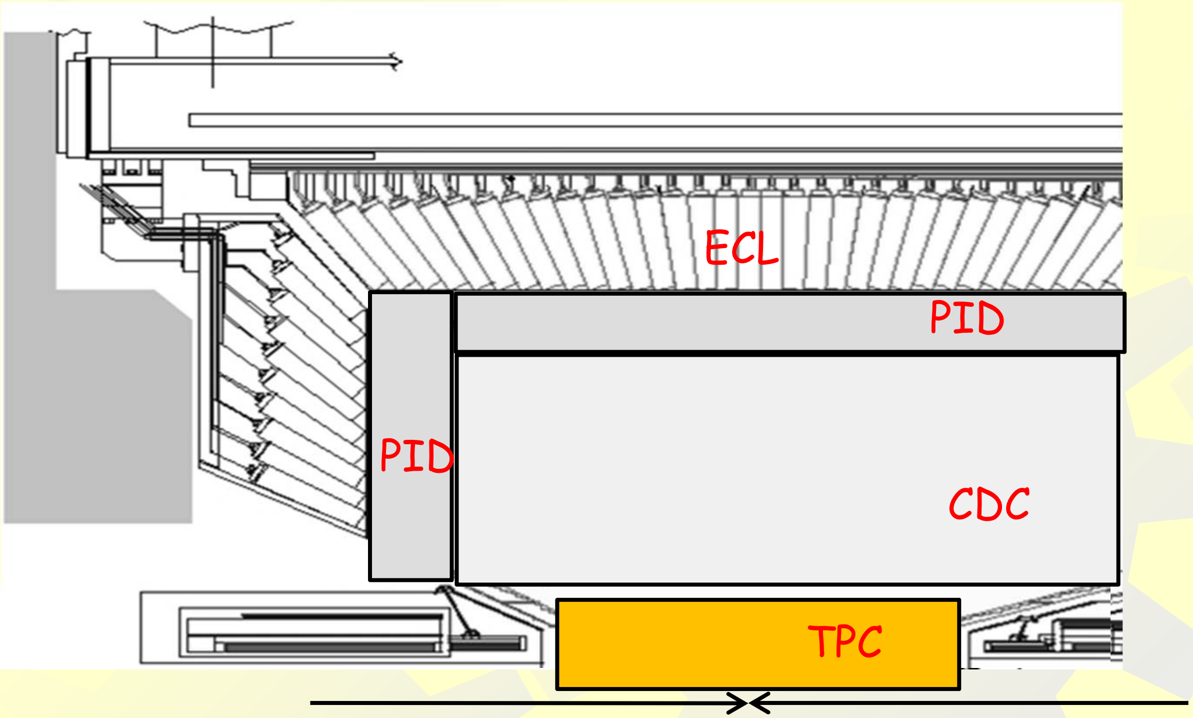
Main ring schematically

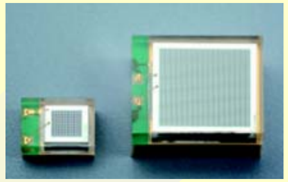
Two rings with Crab Waist collision scheme and single interaction point

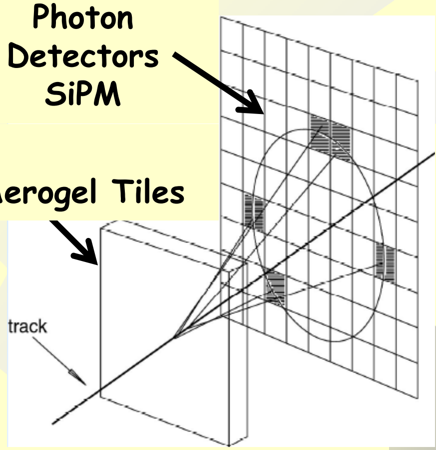
- Sub-mm beta-y at IP
- Preserving of damping parameters (by 4 SC wigglers) through the whole energy range to optimize the luminosity
- 5 Siberian snakes to obtain the longitudinally polarized electrons for the whole energy range
- Highly effective positron source (50 Hz top-up injection)
- Polarized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



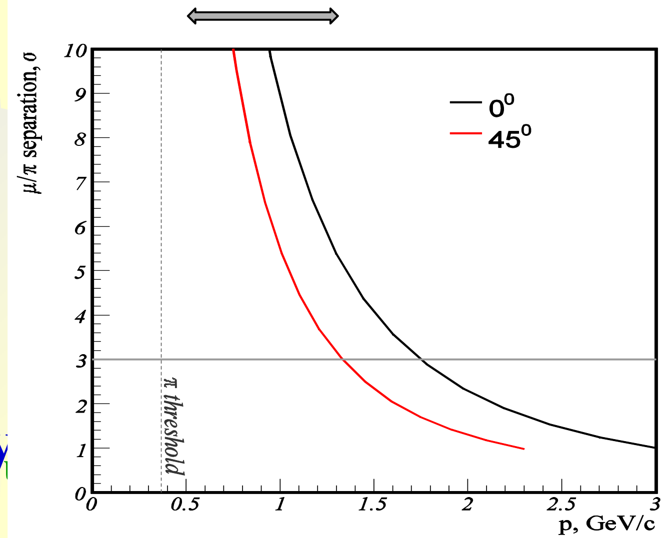
Detector (BINP C-tau)







μ momentum range in $\tau\to\mu\gamma$



- Ultimate Hermeticity
- PID e/m/p/K separation up to 2GeV/c
- Momentum resolution
- Low p_T track efficiency
- ECL energy resolution
- Low energy (~20MeV) photons efficiency

Conclusion

•Last decade demonstrated the fruitfulness and efficiency of the flavor “factory” approach in the particle physics.

•Huge amount of results was obtained at the B-factories, but many new questions were put and the large field of researches will be opened by the super B factories.

• It is clear that the super B factories will produce the information complementary to the LHC.

•At present superKEKB/Belle II project is under construction and another B factory and c-tau factories projects are in a design stage.

•We can wait for new exciting results in the next decade.

Back up

On Earthquake

As is now well known, Japan suffered a terrible earthquake and tsunami on March 11, which has caused tremendous damage, especially in the Tohoku area. Fortunately, all KEK personnel and users are safe and accounted for. The injection linac did suffer significant but manageable damage, and repairs are underway. The damage to the KEKB main rings appears to be less serious, though non-negligible. No serious damage has been reported so far at Belle. Further investigation is necessary. We would like to convey our deep appreciation to everyone for your generous expressions of concern and encouragement.