Prospects of SuperKEKB and Belle-II

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- Highlights from Belle
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- Summary

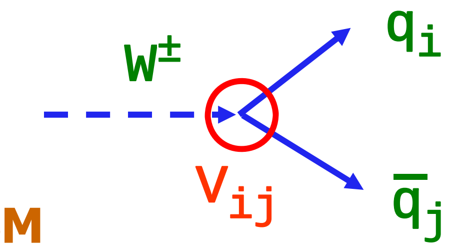
B factory physics program

B factory main task: **measure CP violation in the system of B mesons**

specifically: various measurements of complex elements of Cabbibo-Kobayashi-Maskawa matrix

CKM matrix is unitary

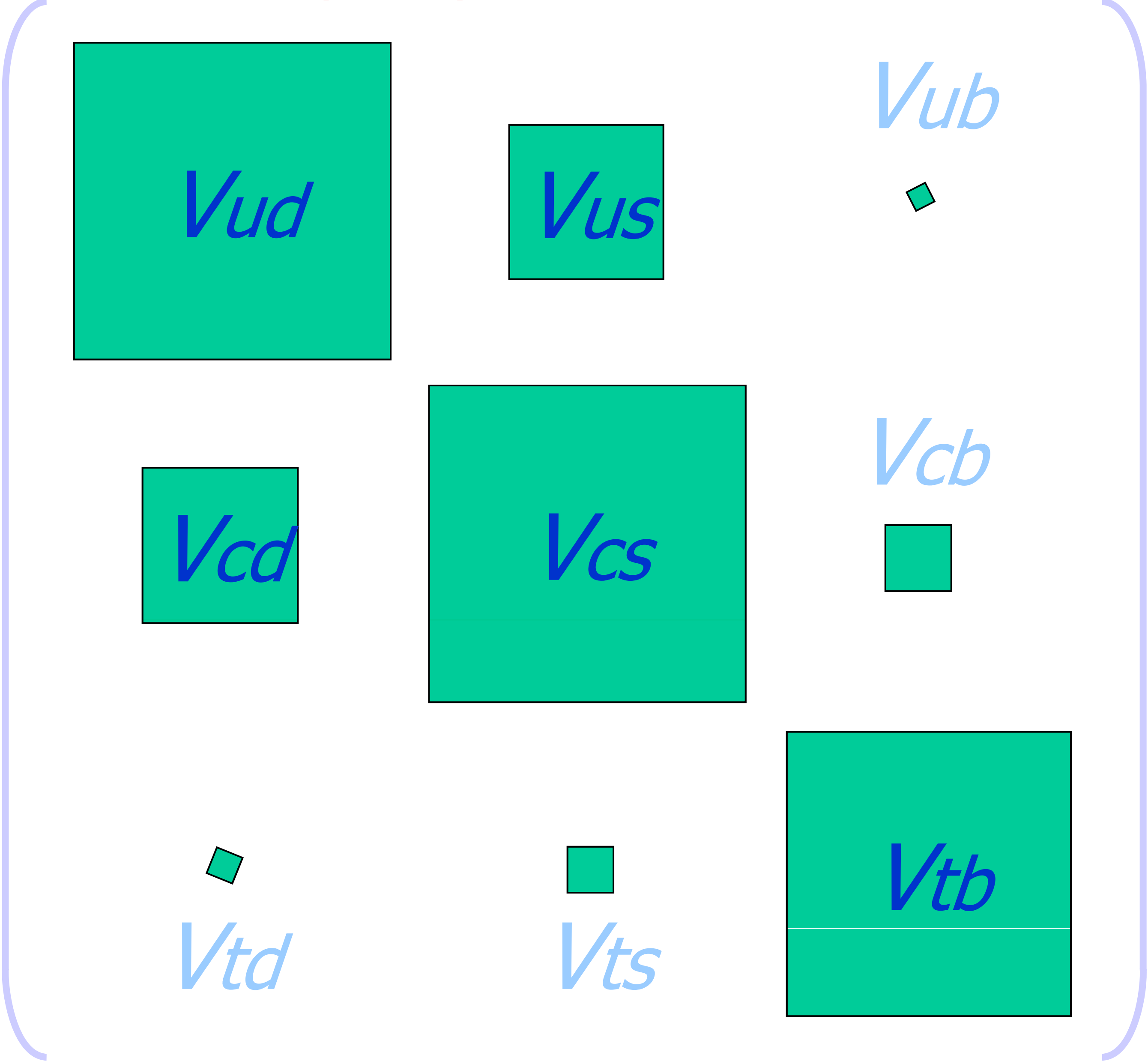
deviations could signal processes not included in SM



$$\begin{bmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{bmatrix} = \begin{pmatrix} 1-\frac{\lambda^2}{2} & \lambda & A\lambda^3(\bar{\rho}-i\bar{\eta}) \\ -\lambda & 1-\frac{\lambda^2}{2} & A\lambda^2 \\ A\lambda^3(1-\bar{\rho}-i\bar{\eta}) & -A\lambda^2 & 1 \end{pmatrix}$$

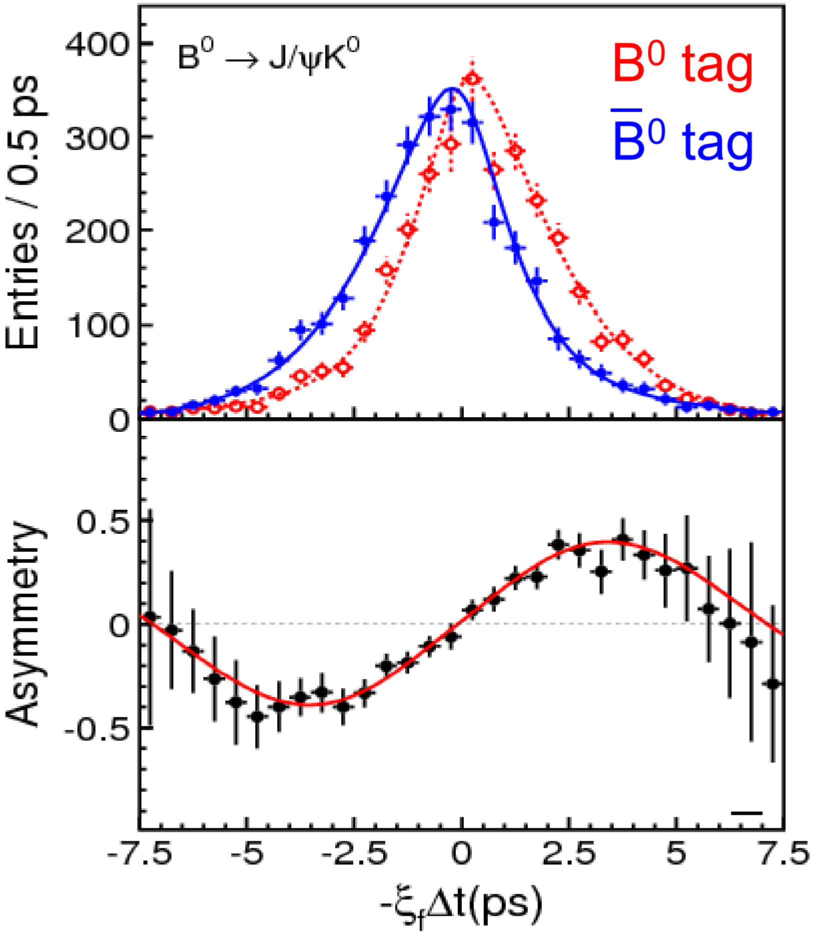
CKM: almost a diagonal matrix, but not completely

CKM: almost real, but not completely!



CP violation in the B system

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

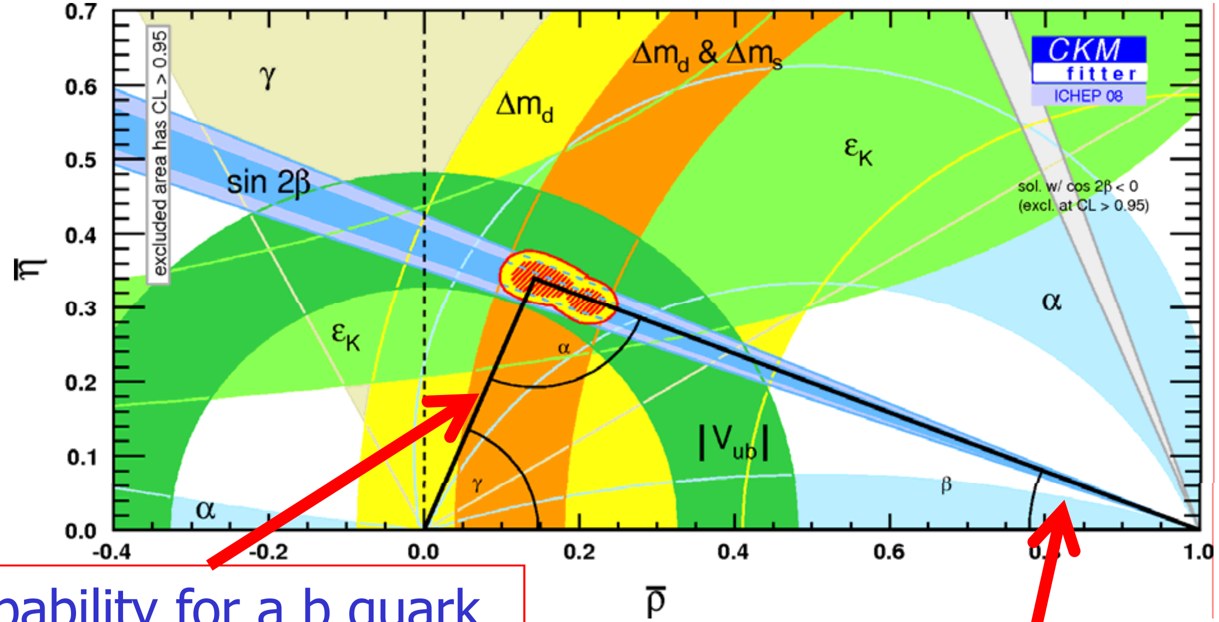


$\sin 2\phi_1 = \sin 2\beta$ from $b \to c\bar{c}s$

535 M $B\overline{B}$ pairs

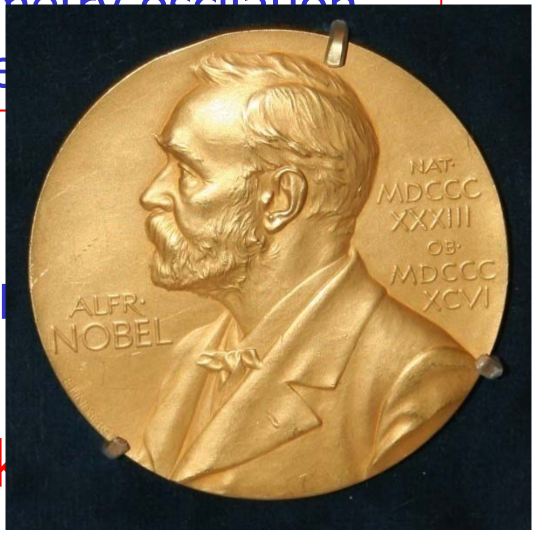
$\sin 2\phi_1 = 0.642 \pm 0.031$ (stat) ± 0.017 (syst)

All measurements combined...



Probability for a b quark to turn into a u quark → determines the length of the side **V_{ub}**

CP asymmetry oscilation amplitude



Constraints from measurements of angles a
unitarity triangle

Nobel prize 2008

→ Remark

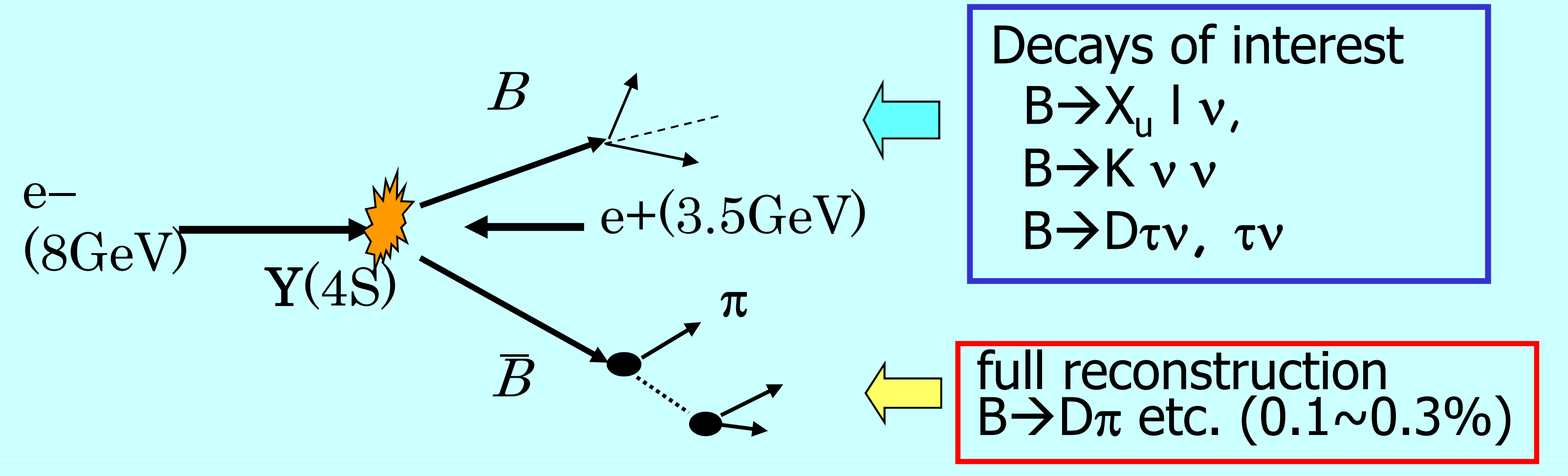
Also for us a good reason to celebrate...

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., $B \to \tau\nu$, $D\tau\nu$)
- Observation of D mixing
- CP violation in $b \to s$ transitions: probe for new sources if CPV
- Forward-backward asymmetry (A_{FB}) in $b \to s l^+ l^-$ has become a powerfull tool to search for physics beyond SM.
- Observation of new hadrons

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



Decays of interest
$B \rightarrow X_u\, l\, \nu$,
$B \rightarrow K\, \nu\, \nu$
$B \rightarrow D\tau\nu$, $\tau\nu$

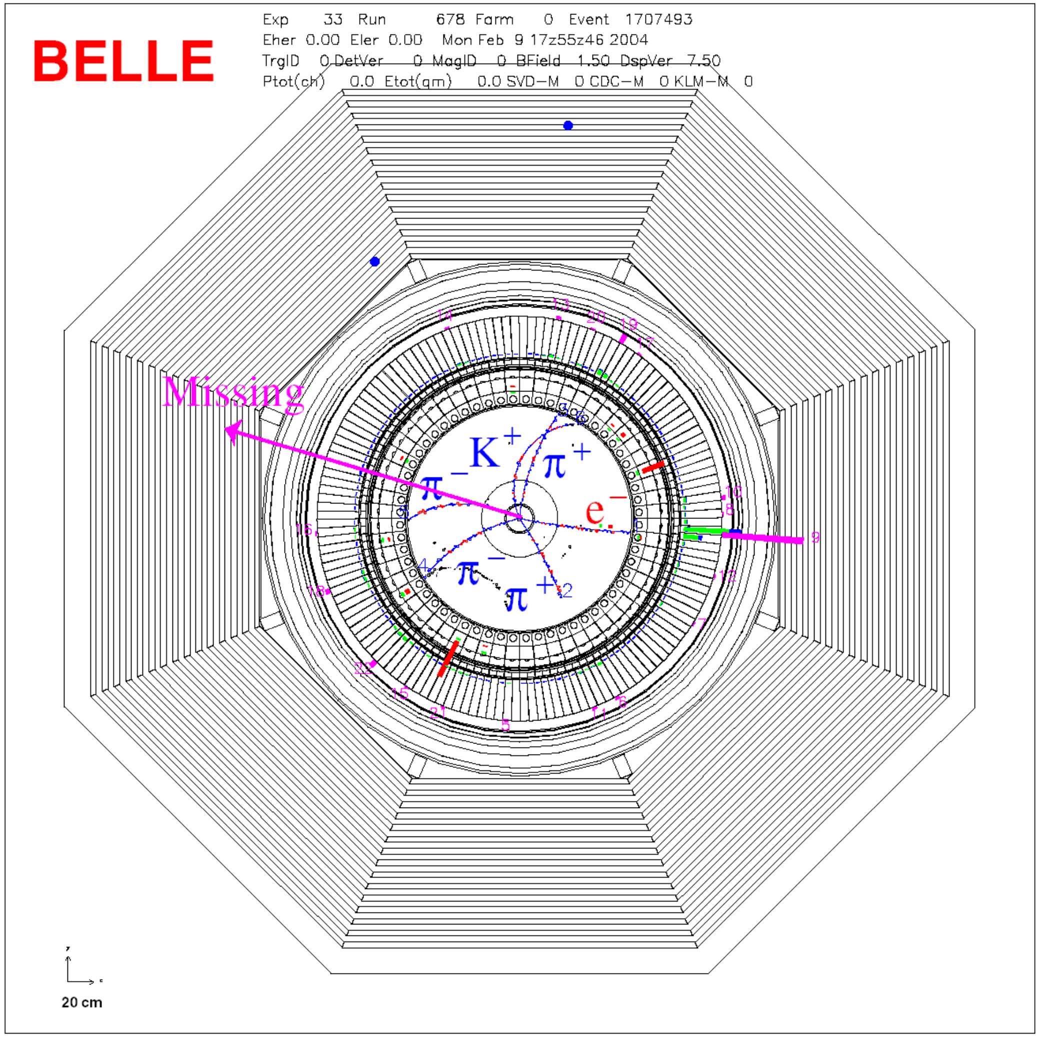
full reconstruction
$B \rightarrow D\pi$ etc. (0.1~0.3%)

→ Offline B meson beam!

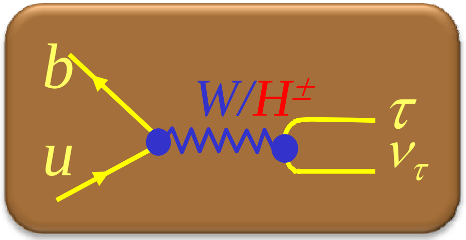
Powerful tool for B decays with neutrinos

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

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

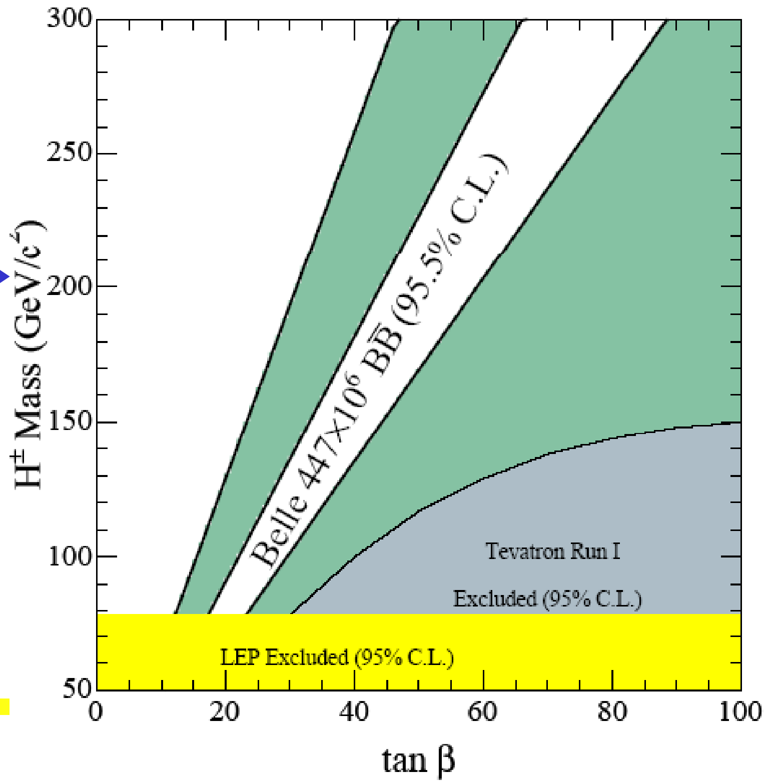


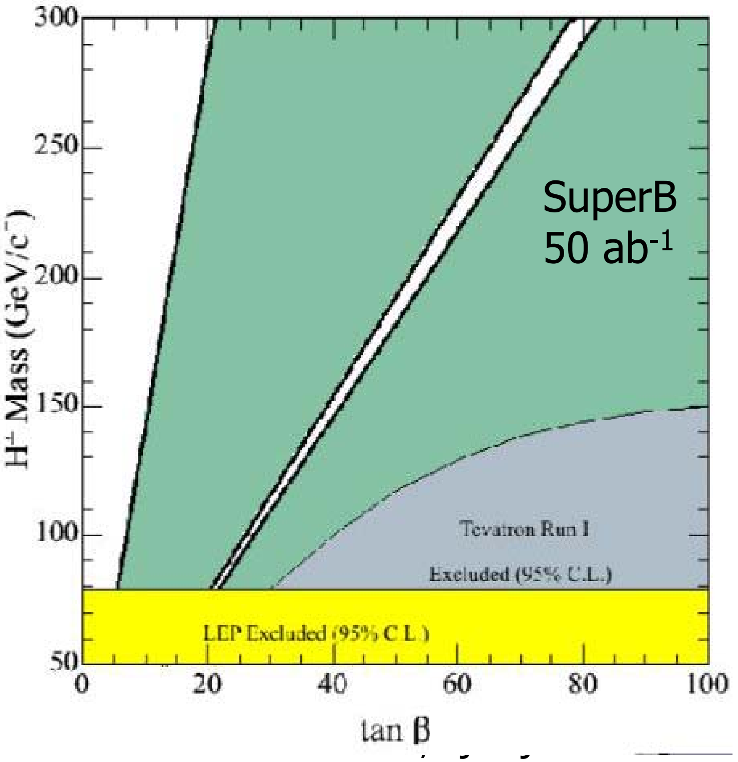
Charged Higgs limits from $B^- \to \tau^- \nu_\tau$



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

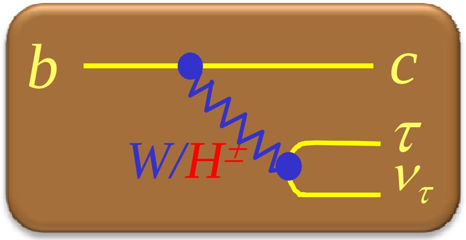
→ limit on charged Higgs mass vs. tanβ





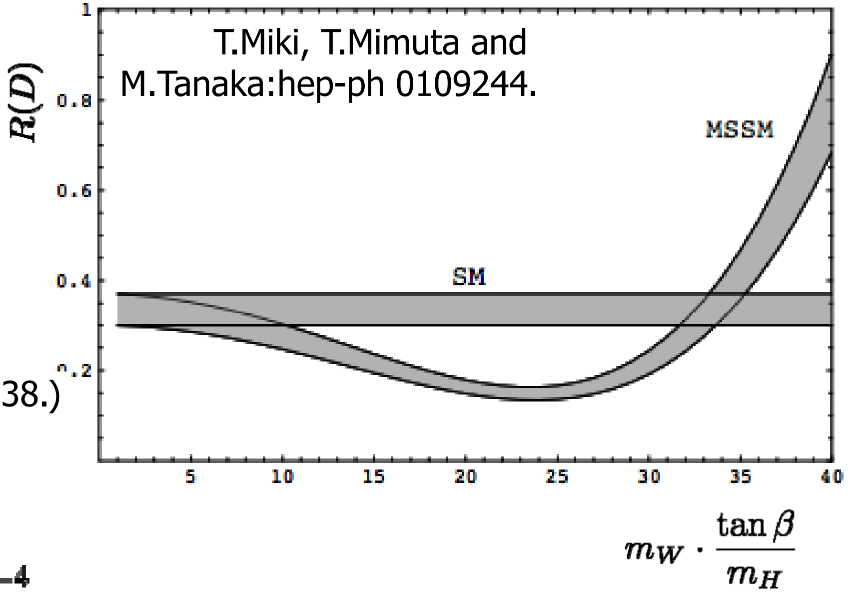
$B\to D^{(*)}\tau\nu$

Semileptonic decay sensitive to charged Higgs



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

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



T.Miki, T.Mimuta and M.Tanaka:hep-ph 0109244.

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.)

$$\mathcal{B}(B^-\to D^0\tau^-\bar{\nu}_\tau)^{SM} = (0.71\pm0.09)\%$$

$$\mathcal{B}(\bar{B}^0\to D^+\tau^-\bar{\nu}_\tau)^{SM} = (0.66\pm0.08)\%$$

$$\mathcal{B}(B\to\tau\nu)=[1.65^{+0.38}_{-0.37}(stat)^{+0.35}_{-0.37}(syst)]\times10^{-4}$$

3.The decay shape of 3 body decay 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→D*τν

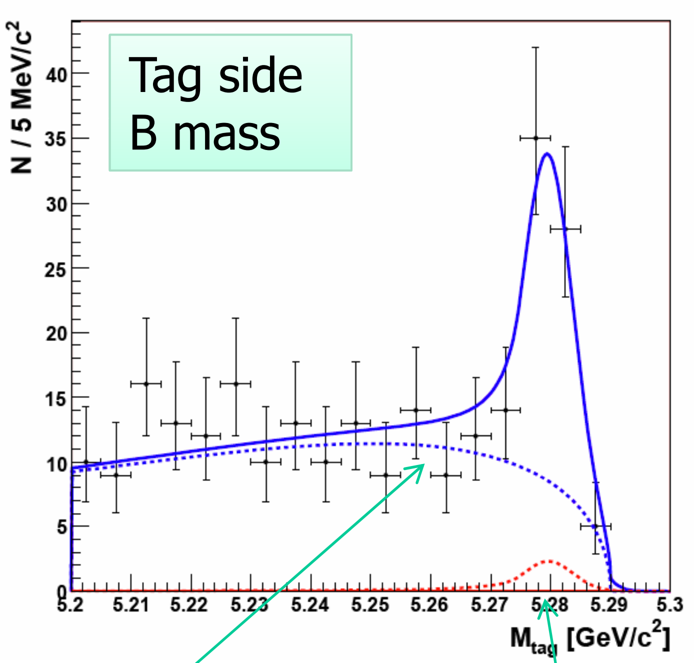
[PRL 99, 191807 (2007)]

FIRST OBSERVATION - 2007

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

535M $B\bar{B}$

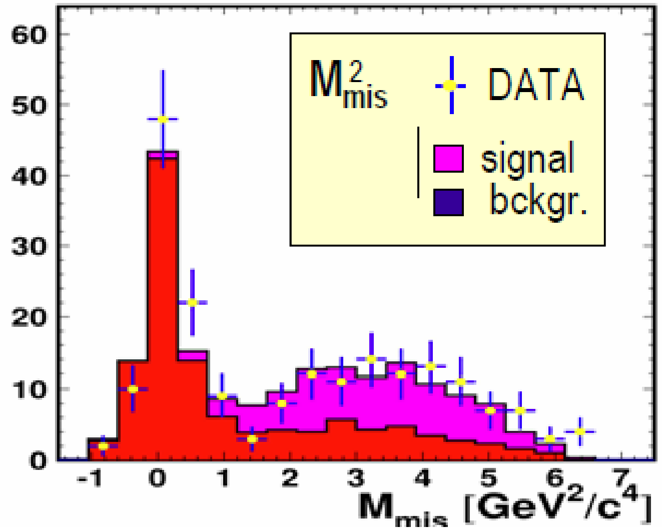
SIGNAL YIELD $N_s = 60^{+12}_{-11}$ **6.7σ (5.2σ with syst.)**



combinatorial background

peaking background (D*-eν)

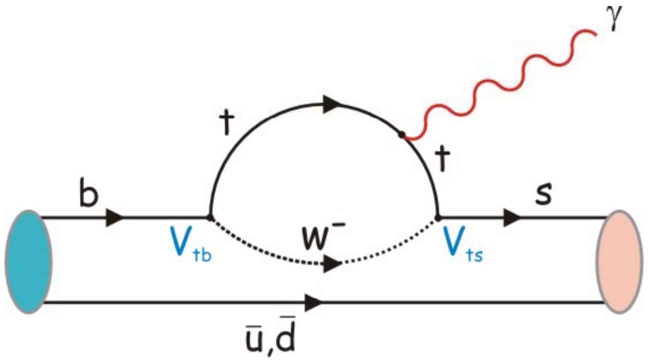
$$M^2_{mis} = (E_b - E_{D^{(*)}} - E_{l/h})^2 - (-\vec{p}_{tag} - \vec{p}_{D^{(*)}} - \vec{p}_{l/h})^2$$

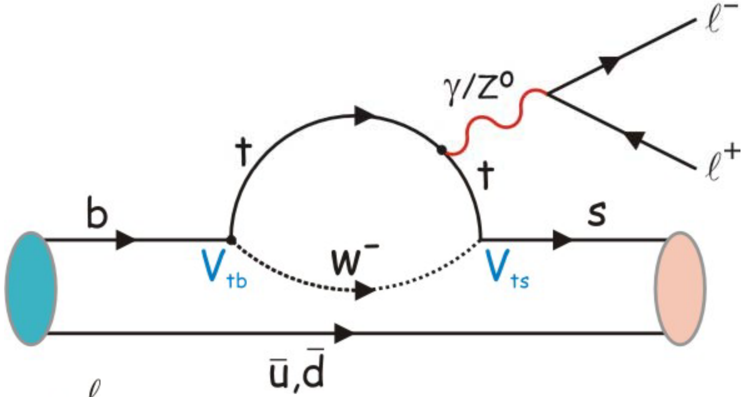


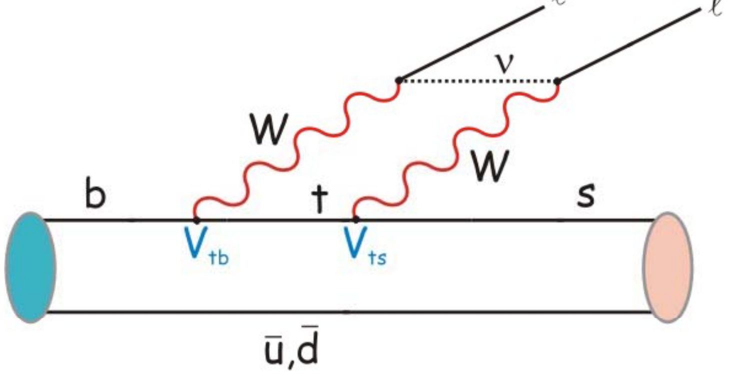
Update with more data to be published soon!

Why FCNC decays?

Flavour changing neutral current (FCNC) processes (like b→s, b→d) are fobidden at the tree level in the Standard Model. Proceed only at low rate via higher-order loop diagrams. Ideal place to search for new physics.



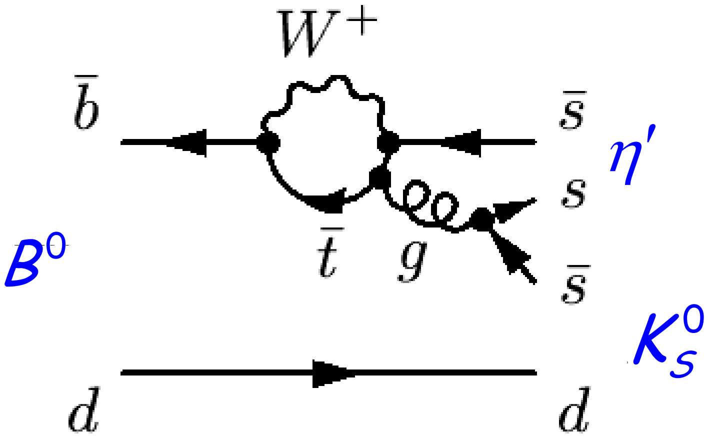




How can New Physics contribute to b→s?

For example in the process:

$$B^0 \to \eta' K^0$$



Ordinary penguin diagram with a t quark in the loop

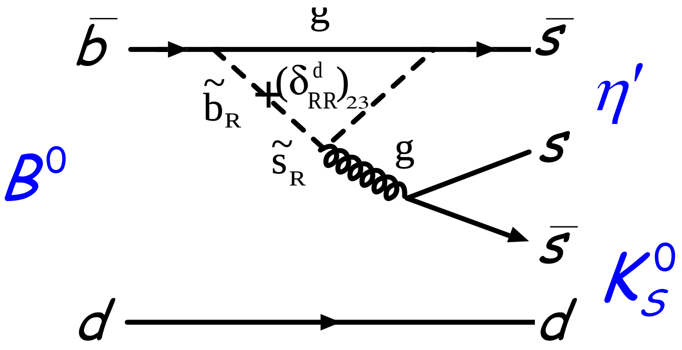


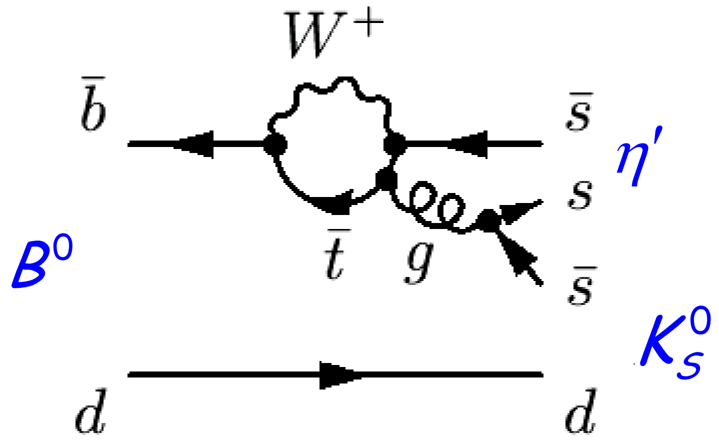
Diagram with supersymmetric particles

Searching for new physics phases in CP violation measurements in b→s decays

Prediction in SM: CP violation parameter

$B^0 \to \eta' K^0$

$$a_f = -\mathrm{Im}(\lambda_f)\sin(\Delta m t)$$

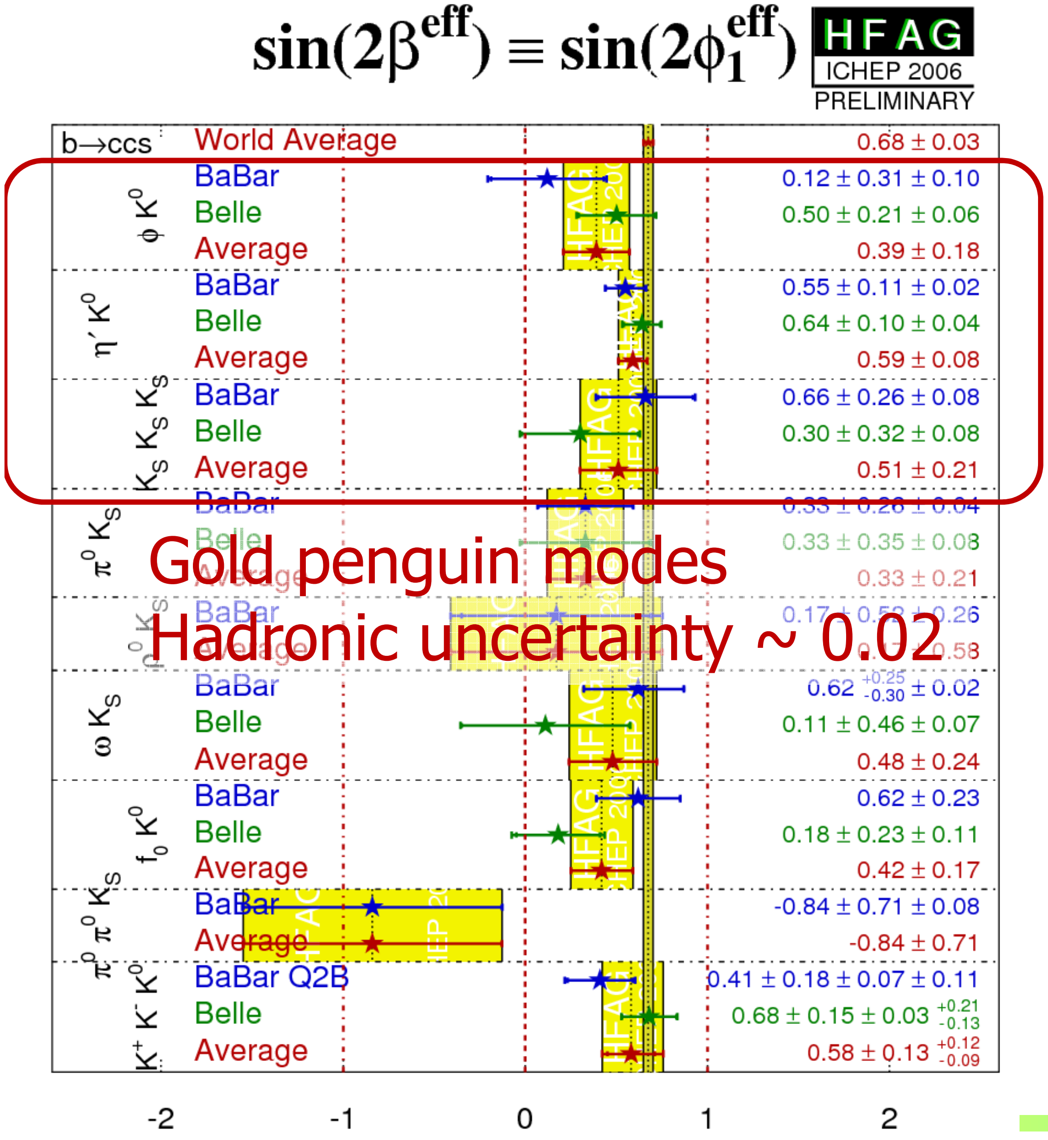


$$\boxed{\mathrm{Im}(\lambda_f) = \xi_f \sin 2\phi_1}$$

The same value as in the decay $B^0 \to J/\psi\, K_S$!

This is only true if there are no other particles in the loop! In general the parameter can assume a different value $\sin 2\phi_1^{\mathrm{eff}}$

Search for NP: $b \to s\bar{q}$



Gold penguin modes

Hadronic uncertainty ~ 0.02

ICHEP08

BaBar

Belle

Naïve average

$0.26 \pm 0.25 \pm 0.04$

$0.67 \pm ^{0.25}_{0.27} \pm 0.07$

0.45 ± 0.18

$0.57 \pm 0.08 \pm 0.02$

$0.64 \pm 0.10 \pm 0.04$

0.60 ± 0.07

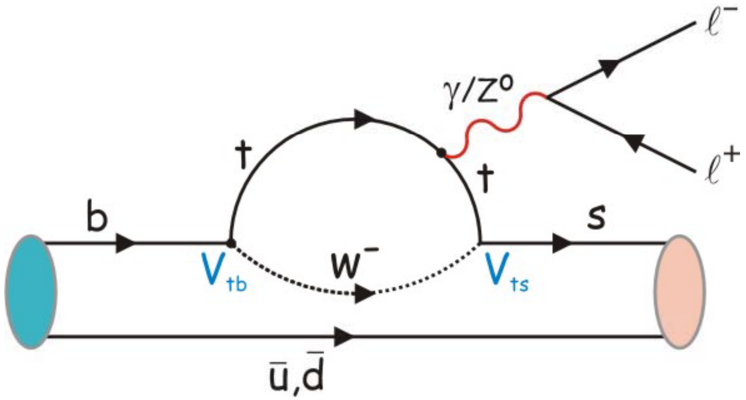
$0.71 \pm 0.24 \pm 0.04$

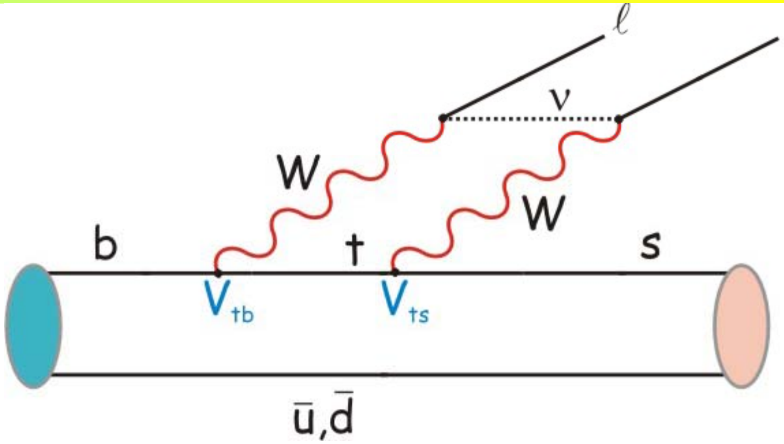
$0.30 \pm 0.32 \pm 0.08$

0.57 ± 0.20

Need much more data to clarify the issue

Another FCNC decay: B → $K^* l^+ l^-$





b → s l^+l^- was first measured in B → K l^+l^- by Belle (2001).

Important for further searches for the physics beyond SM

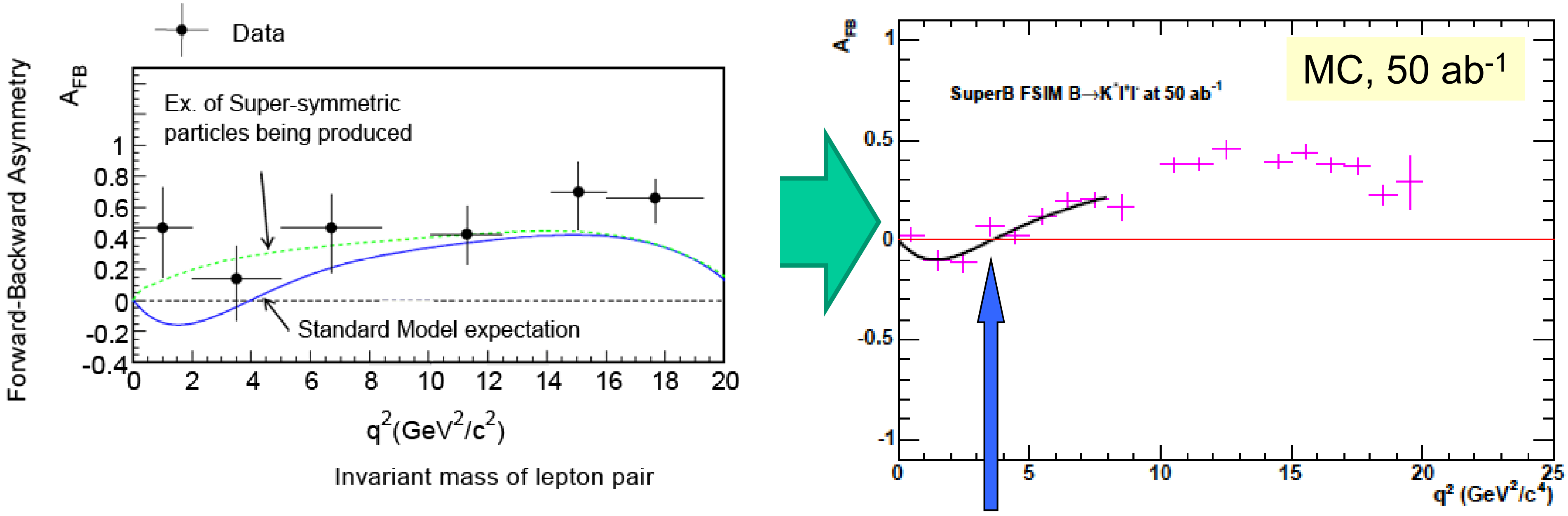
Particularly sensitive: backward-forward asymmetry in $K^* l^+ l$

$$A_{FB} \propto \Re\left[C_{10}^{*}\left(sC_9^{eff}(s)+r(s)C_7\right)\right]$$

C_i : Wilson coefficients, abs. value of C_7 from b→sγ

s=lepton pair mass squared

$A_{FB}(B \rightarrow K^* l^+ l^-)[q^2]$



Data: very interesting!

Zero-crossing q^2 for A_{FB} will be determined with a 5% error with 50ab^{-1}.

Strong competition from LHCb and ATLAS/CMS

A difference in the direct violation of CP symmetry in B+ and B0 decays

CP asymmetry

$$\mathcal{A}_f = \frac{N(\overline{B} \to \bar{f}) - N(B \to f)}{N(\overline{B} \to \bar{f}) + N(B \to f)}$$

Difference between B+ and B0 decays

In SM expect $\mathcal{A}_{K^\pm\pi^\mp} \approx \mathcal{A}_{K^\pm\pi^0}$

Measure:

$$\mathcal{A}_{K^\pm\pi^\mp} = -0.094 \pm 0.018 \pm 0.008$$

$$\mathcal{A}_{K^\pm\pi^0} = +0.07 \pm 0.03 \pm 0.01$$

$$\Delta\mathcal{A} = +0.164 \pm 0.037$$

A problem for a SM explanation
(in particular when combined with other measurements)
A hint for new sources of CP violation?

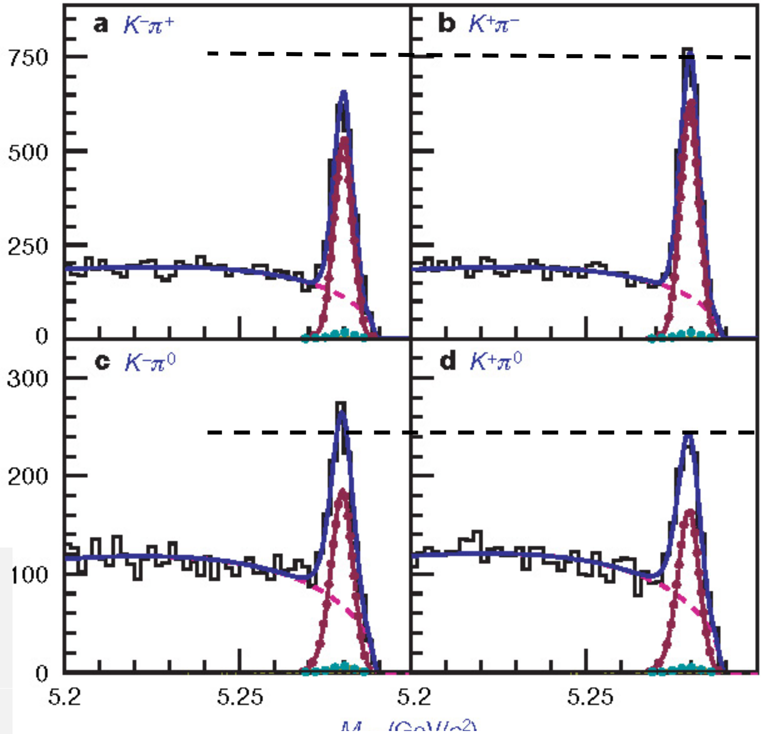
nature International weekly journal of science

nature Vol 452|20 March 2008|doi:10.1038/nature06827

LETTERS

Difference in direct charge-parity violation between charged and neutral *B* meson decays

The Belle Collaboration*

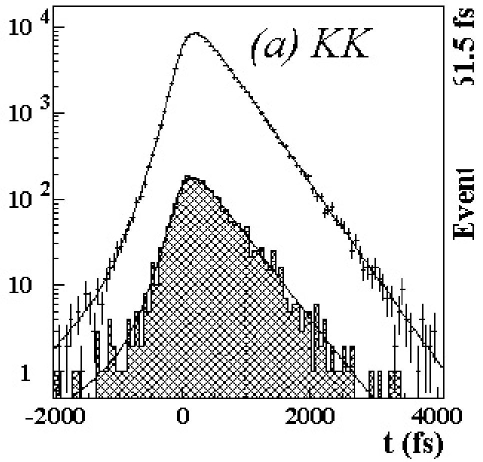


~1 in 10^5 B mesons decays in this decay mode

Belle, Nature 452, 332 (2008)

D^0 mixing in K^+K^-, $\pi^+\pi^-$

Decay time distributions for KK, ππ, Kπ



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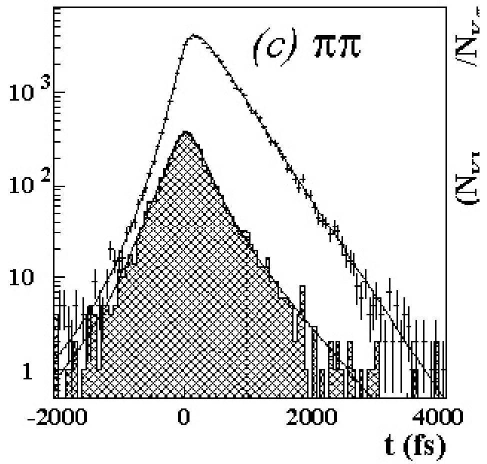
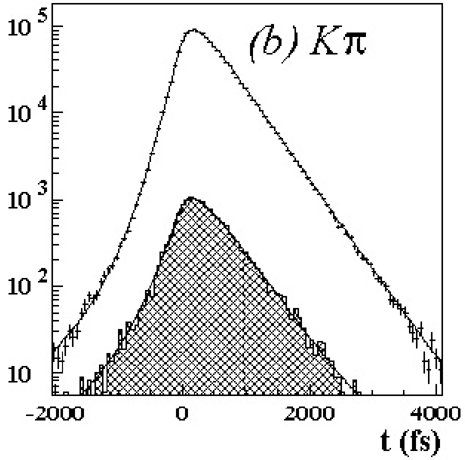
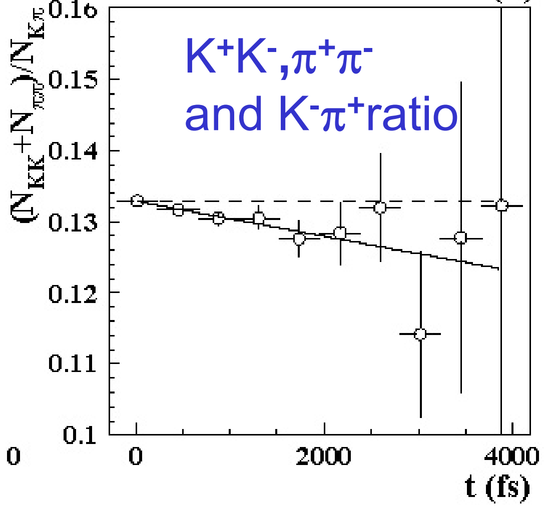




Difference of lifetimes visually observable in the ratio of the distributions →



K^+K^-,$\pi^+\pi^-$ and $K^-\pi^+$ratio

Real fit:

y_{CP} = (1.31 ± 0.32 ± 0.25) **%**

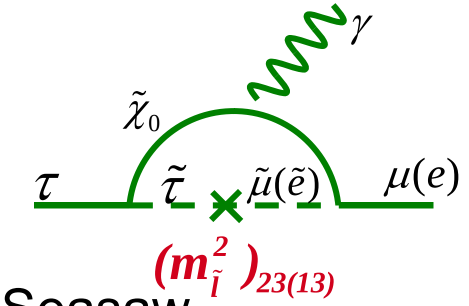
→ Observation of D mixing!

→ on a high side of SM predictions

CP violation in the D system would be a clear sign of new physics

LFV and New Physics

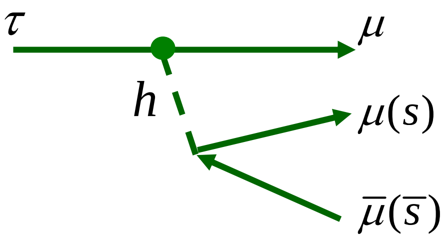
τ→lγ



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

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

τ→3l,lη



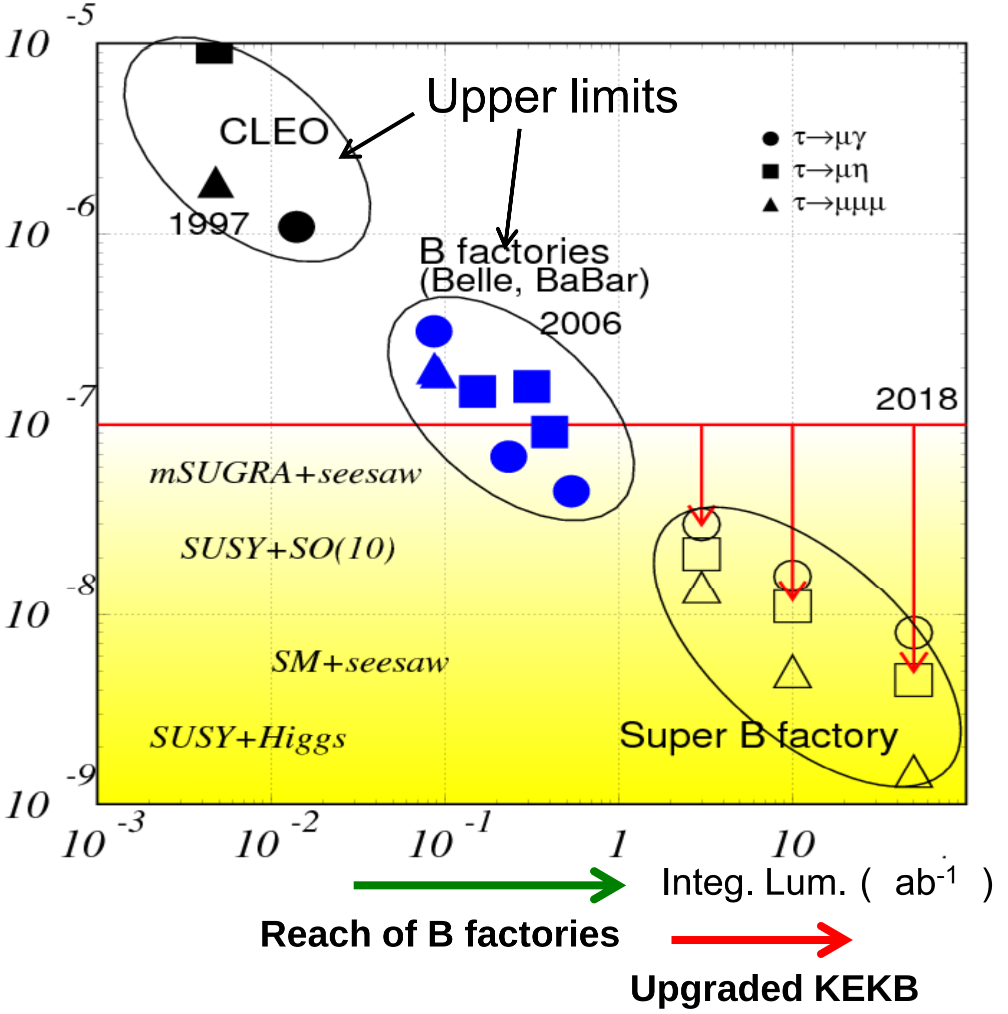
- Neutral Higgs mediated decay.
- Important when MSUSY >> EW scale.

$$Br(\tau \to 3\mu) = 4\times10^{-7} \times \left(\frac{(m^2_{\tilde{L}})_{32}}{\bar{m}^2_{\tilde{L}}}\right)\left(\frac{\tan\beta}{60}\right)^6\left(\frac{100GeV}{m_A}\right)^4$$

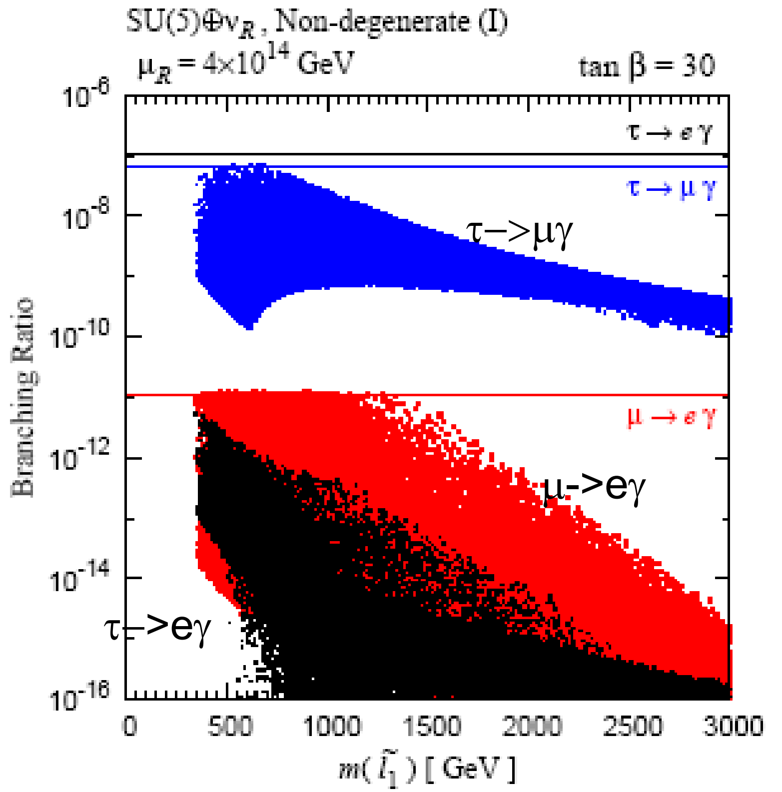
model	Br(τ→μγ)	Br(τ→lll)
mSUGRA+seesaw	10^{-7}	10^{-9}
SUSY+SO(10)	10^{-8}	10^{-10}
SM+seesaw	10^{-9}	10^{-10}
Non-Universal Z’	10^{-9}	10^{-8}
SUSY+Higgs	10^{-10}	10^{-7}

Precision measurements of τ decays

LF violating τ decay?



Theoretical predictions compared to present experimental limits



T.Goto et al., 2007

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 constraint (if not found) new physics models.
- Even in the worst case scenario (such as MFV), $B\to\tau\nu$, $D\tau\nu$ can probe the charged Higgs in large $\tan\beta$ 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.

Super B Factory Motivation 2

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

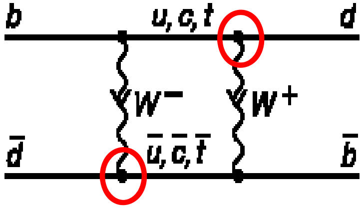
- Lessons from history: the top quark

Physics of top quark

First estimate of mass: BB mixing → ARGUS

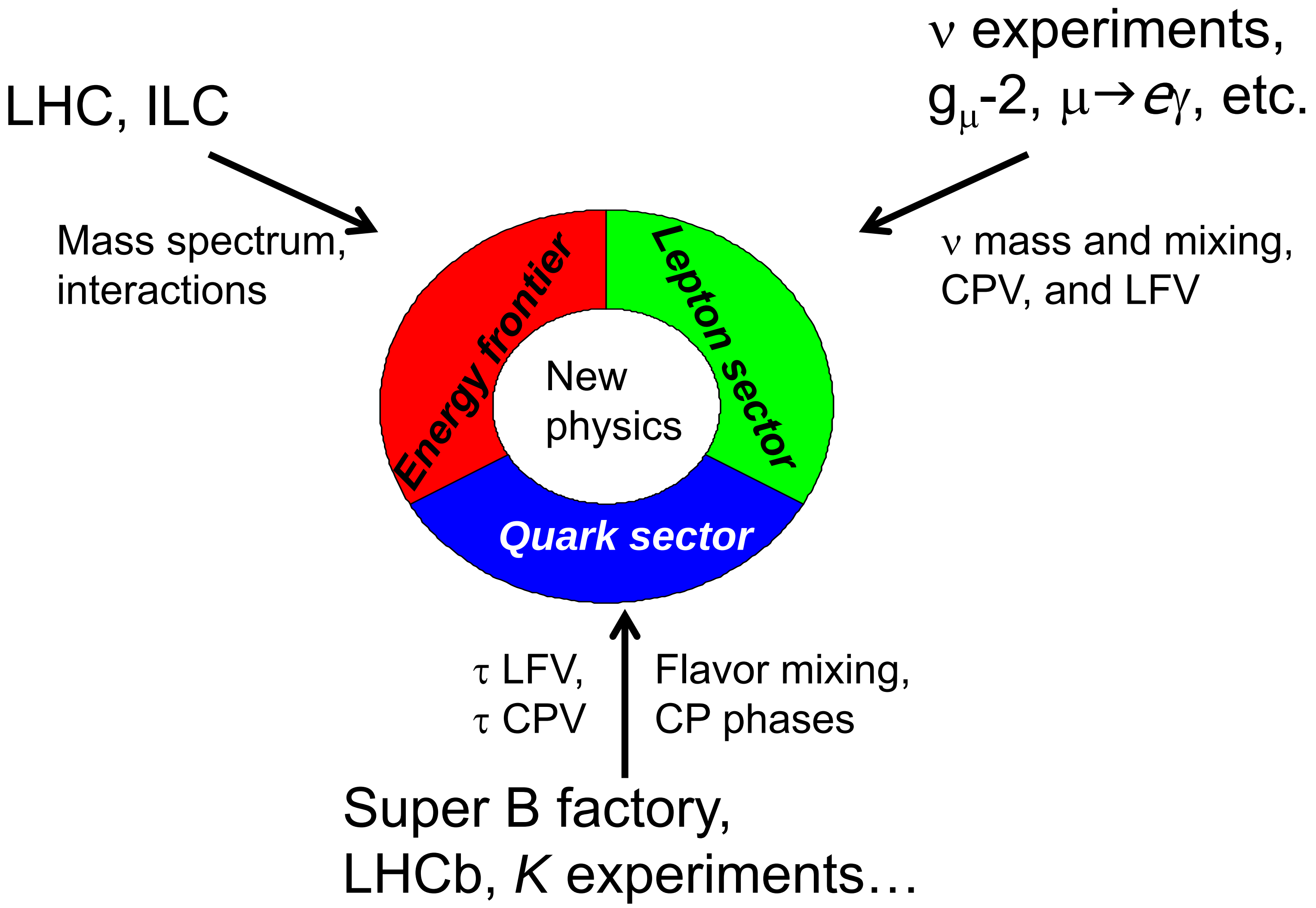
Direct production, Mass, width etc. → CDF/D0

Off-diagonal couplings, phase → BaBar/Belle



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

Super B factory: an important part of a broad unbiased approach to New Physics



ν experiments, g_μ-2, $\mu \rightarrow e\gamma$, etc.

LHC, ILC

Mass spectrum, interactions

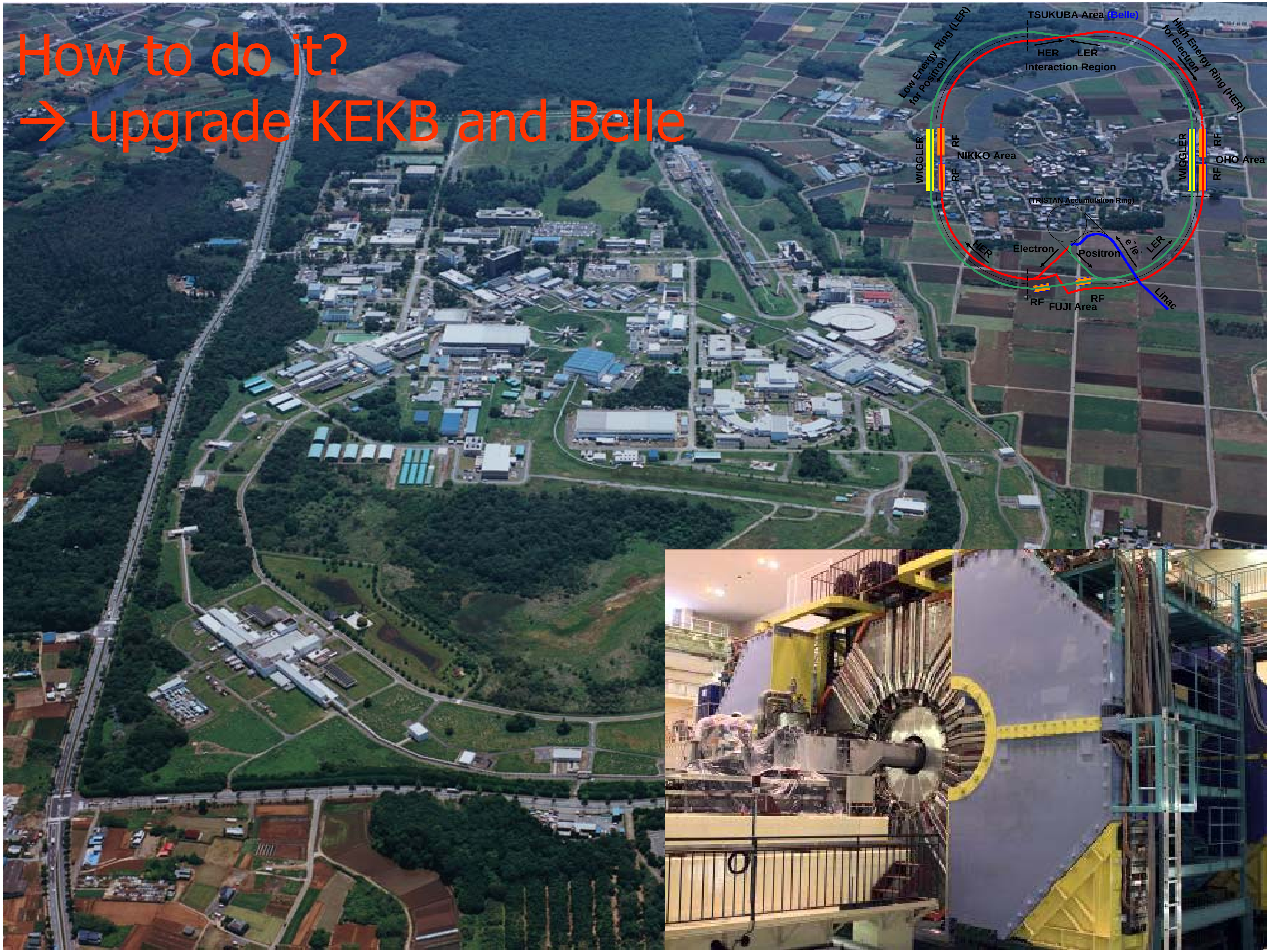
ν mass and mixing, CPV, and LFV

τ LFV, τ CPV

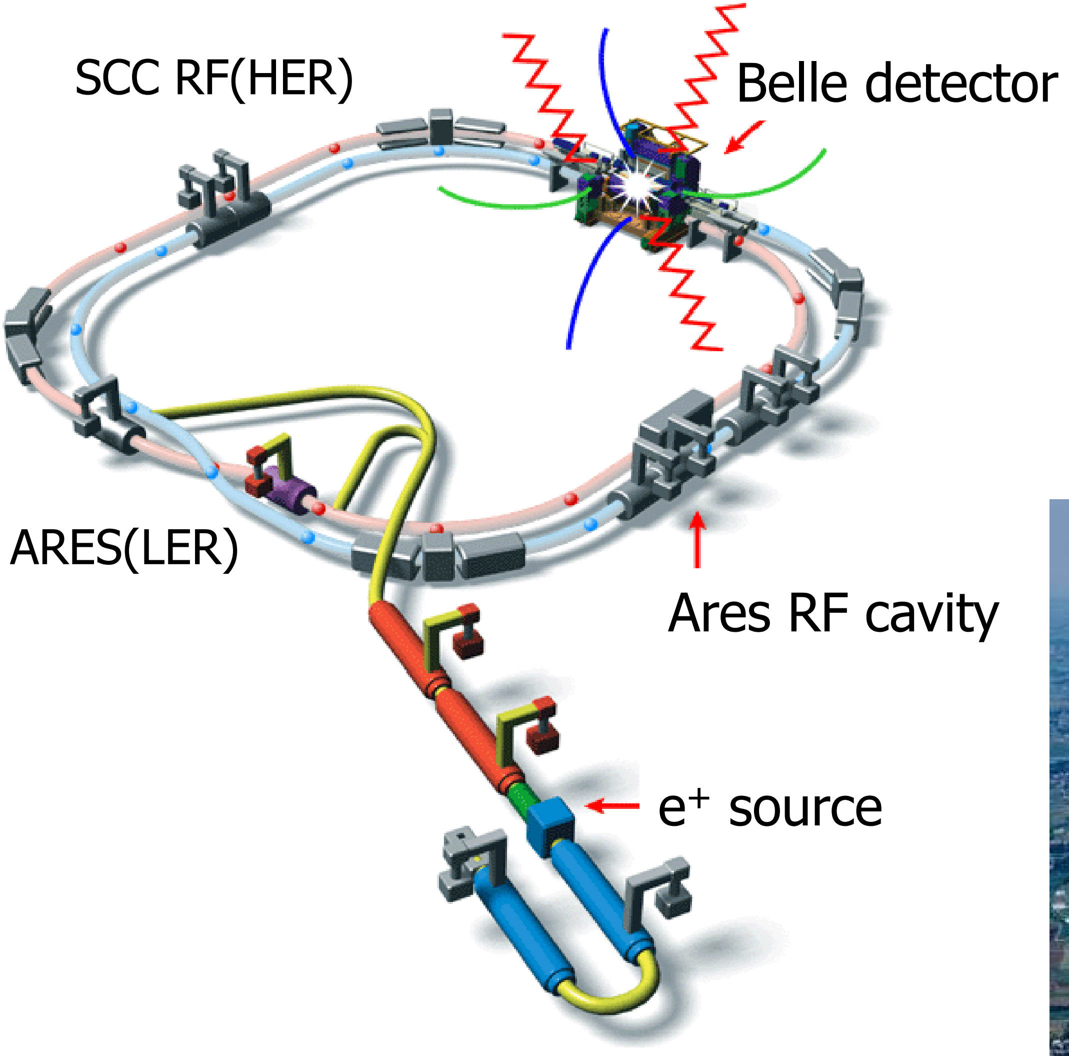
Flavor mixing, CP phases

Super B factory, LHCb, *K* experiments…

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

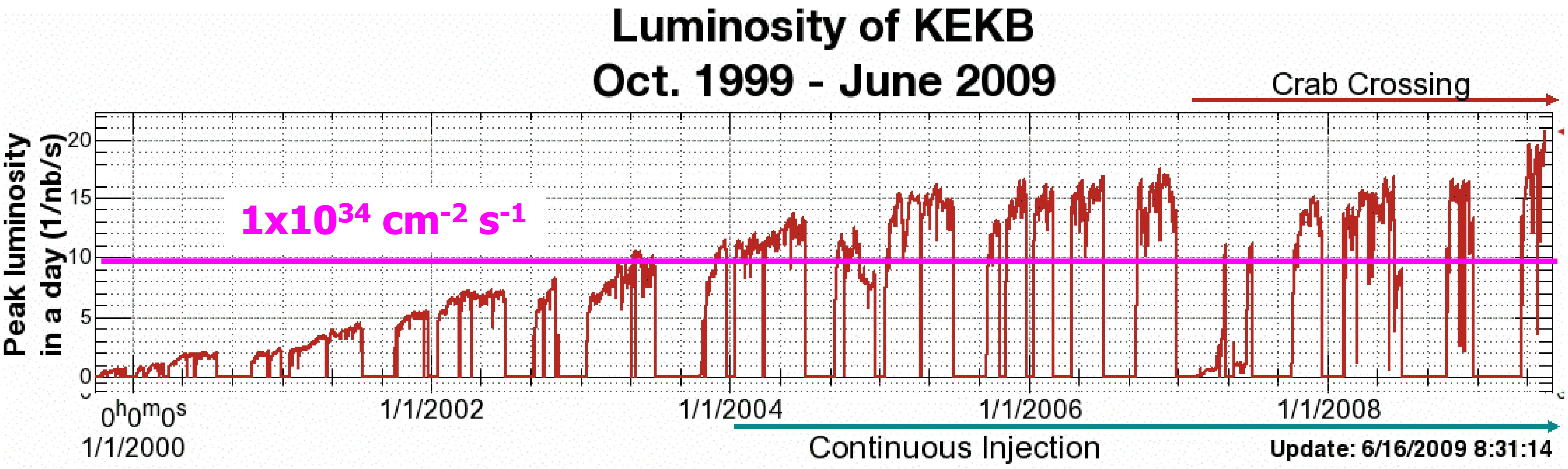
Peak luminosity (WR!) :

$2.1 \times 10^{34}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$

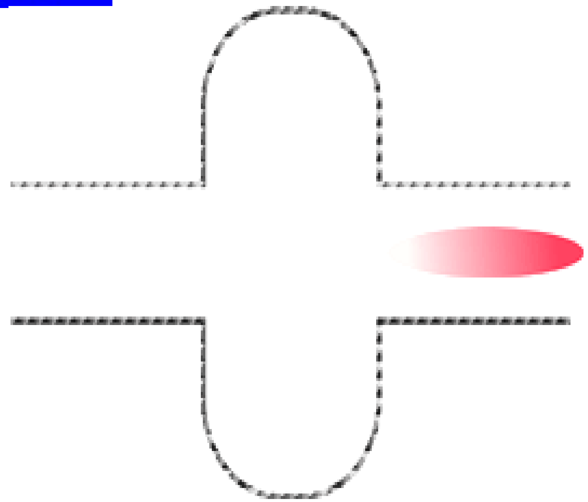
The KEKB Performance

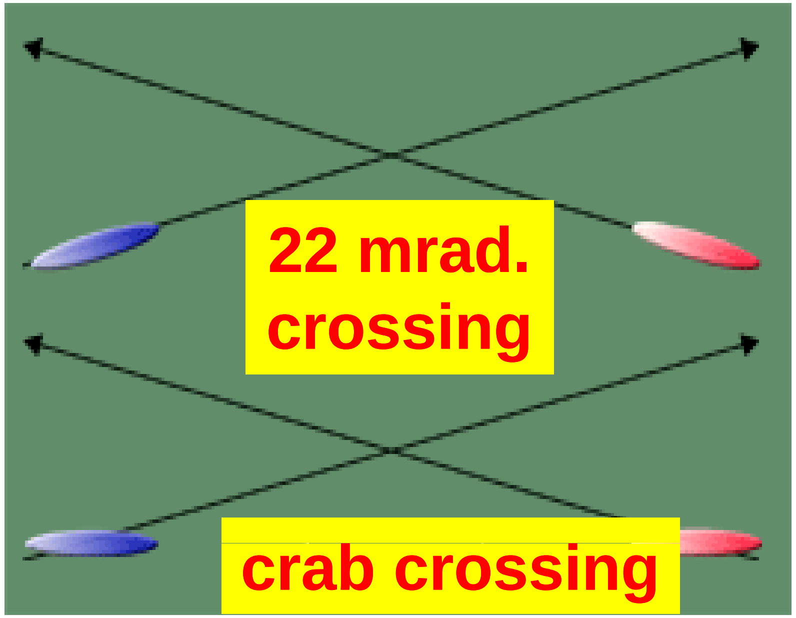
Luminosity Records:

- **Peak L = 2.1x10^{34} cm^{-2} s^{-1}** (2x the design value)
- **Daily ∫Ldt = 1.5 fb^{-1}** (2.5 x the design value)
- **Total ∫Ldt ~ 950 fb^{-1}** (as of July 2009)



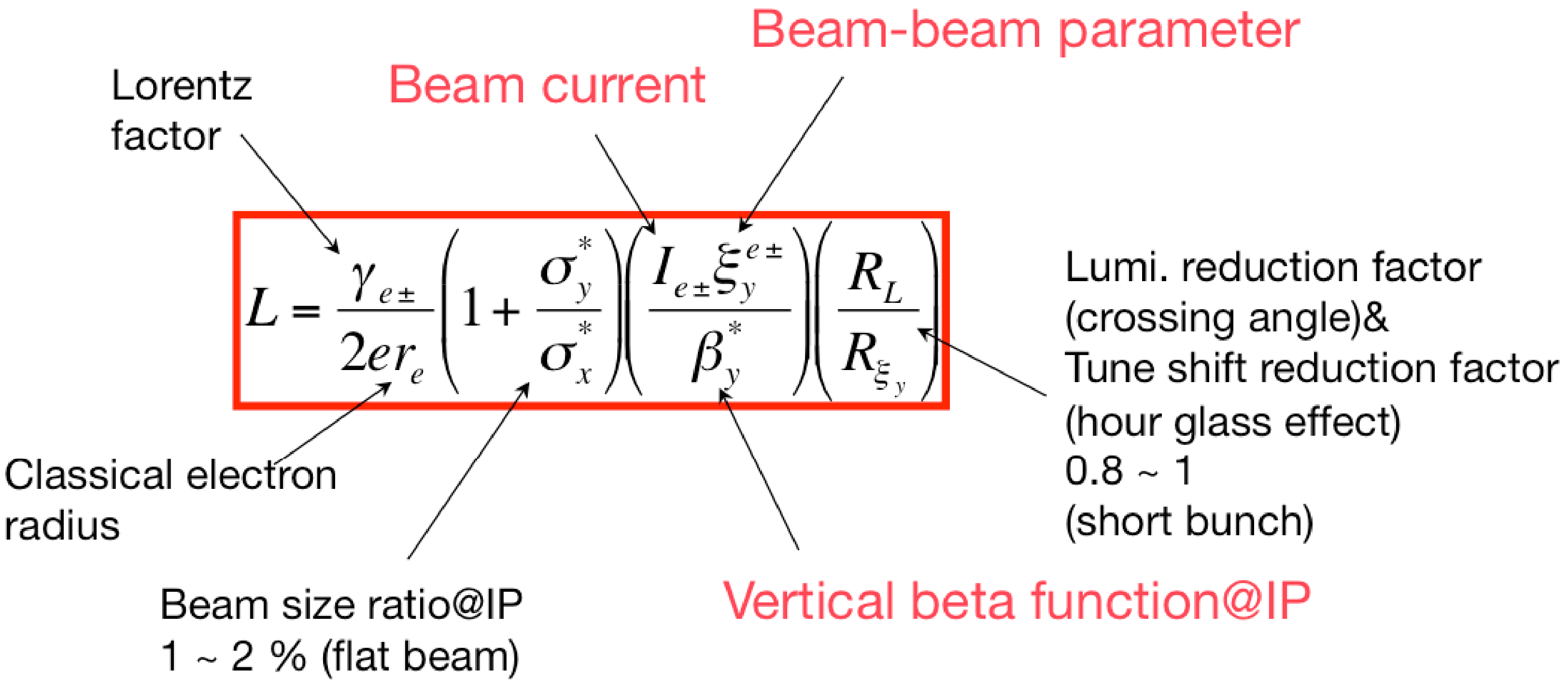
The latest improvements in KEKB performance: crab cavity



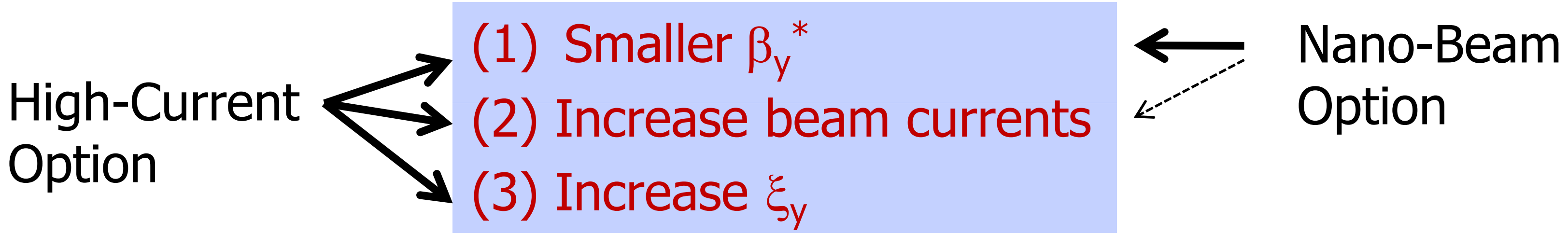


Installed in the KEKB tunnel
(February 2007)

Strategies for Increasing Luminosity



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



High-Current Option

(1) Smaller β_y^*

(2) Increase beam currents

(3) Increase ξ_y

Nano-Beam Option

Accelerator upgrade strategy

Why did we give up the “high current scheme”?

- To achive the required luminosity, we had to assume a beam-beam parameter of 0.3 while with Belle we achieved 0.09
- Bunch length could not be reduced to 3mm because of the coherent synchrotron radiation.
- No solution was found for IR design to realize β^*_x=20cm.
- Higher operating costs.

→Adopted the “Nano-beam scheme” as proposed by P. Raimondi and the SuperB group → design is on-going - no showstoppers up to now.

To achieve a luminosity of 8.0×10^{35} $\mathrm{cm^{-2}s^{-1}}$ (x40 of peak KEKB value),

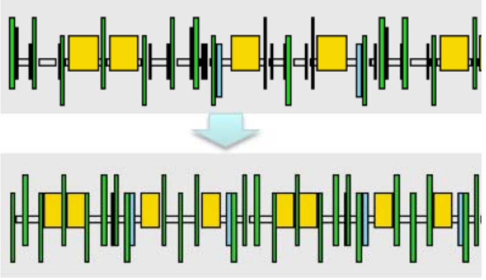
- Beam current 1.7/1.4 → 3.6/2.6 A (x2)
- Beam-beam parameter 0.09 → 0.09 (x1)
- Small beta function at IP (x 1/20): horiz.: 1200→ 32/25mm / vert.: 5.9→0.27/0.42mm; beam size 100μm(H) x 2μm(V) → 10μm(H) x 59nm(V)
- Crab waist is considered as an option

Design parameters

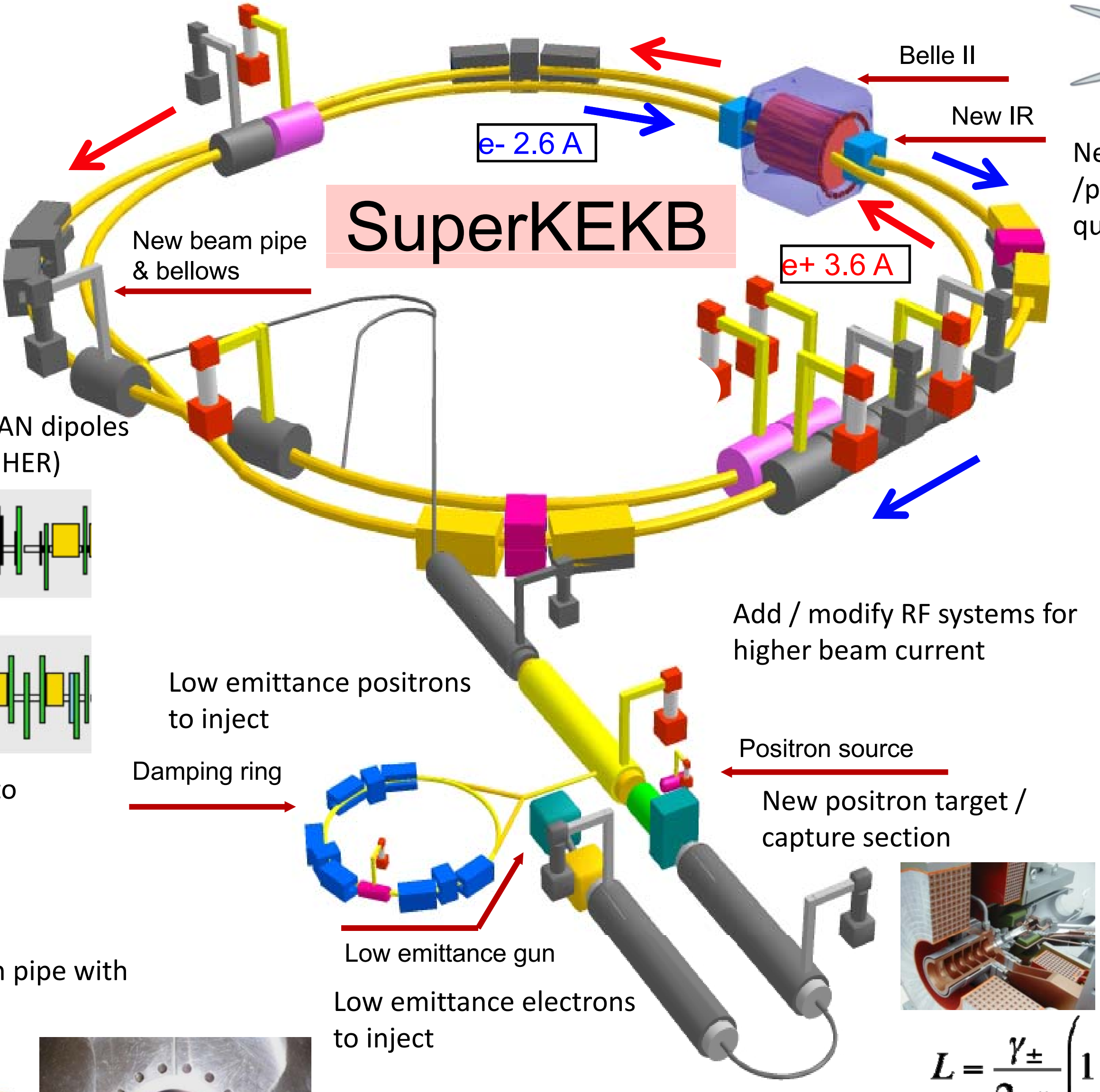
	KEKB Design	KEKB Achieved : with crab	SuperKEKB High-Current	SuperKEKB Nano-Beam
Energy (GeV) (LER/HER)	3.5/8.0	3.5/8.0	3.5/8.0	4.0/7.0
β_x^* (cm)	100/100	120/120	20/20	3.2/2.5
β_y^* (mm)	10/10	5.9/5.9	3/6	0.27/0.42
ε_x (nm)	18/18	18/24	24/18	3.2/1.7
$\sigma_y(\mu m)$	1.9	0.94	0.85/0.73	0.059
ξ_y	0.052	0.129/0.090	0.3/0.51	0.09/0.09
σ_z (mm)	4	~ 6	5/3	6/5
I_{beam} (A)	2.6/1.1	1.64/1.19	9.4/4.1	3.6/2.6
$N_{bunches}$	5000	1584	5000	2500
Luminosity (10^{34} cm^{-2} s^{-1})	1	2.11	53	80

SuperKEKB

Replace long TRISTAN dipoles with shorter ones (HER)



Redesign the HER arcs to squeeze the emittance



Belle II

New IR

e- 2.6 A

e+ 3.6 A

New beam pipe & bellows

Low emittance positrons to inject

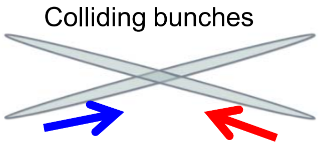
Damping ring

Low emittance gun

Low emittance electrons to inject

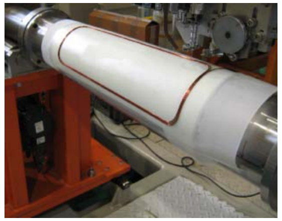
Positron source

New positron target / capture section



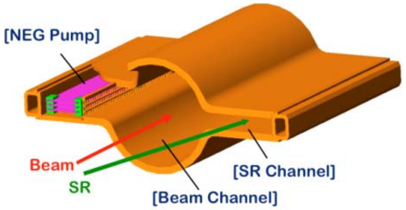
Colliding bunches

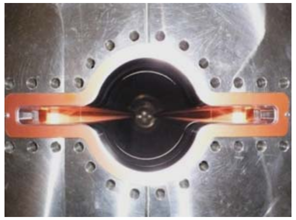
New superconducting /permanent final focusing quads near the IP



Add / modify RF systems for higher beam current

TiN coated beam pipe with antechambers





$$L = \frac{\gamma_\pm}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\boxed{\frac{I_\pm\xi_{\pm y}}{\beta_y^*}}\left(\frac{R_L}{R_y}\right)$$

40x Belle luminosity

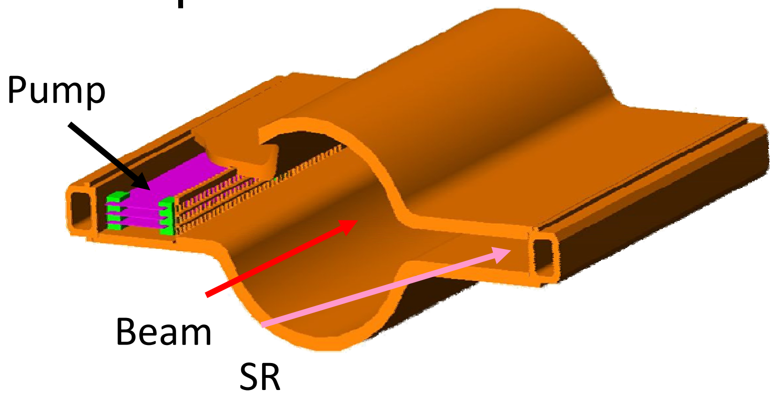
Beam duct for SuperKEKB

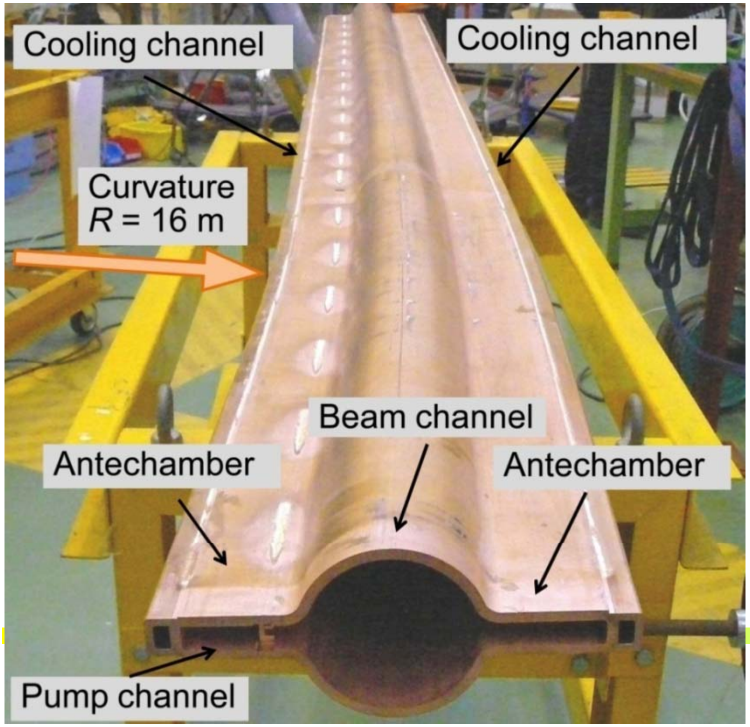
Copper beam duct with ante-chambers

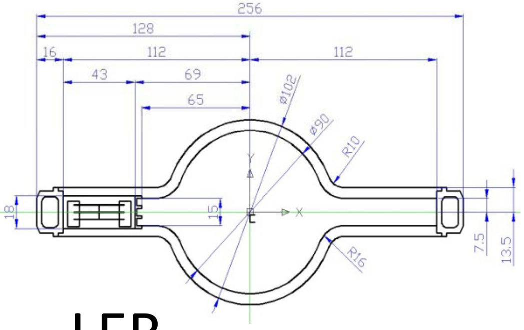
- ◆ Copper is required to withstand intense SR power

Features (compared to simple pipe):

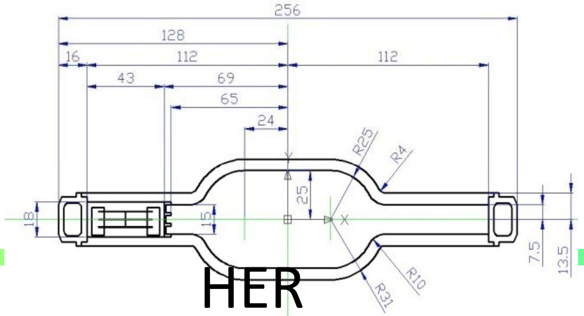
- ◆ Low SR power density
- ◆ Less photoelectrons in beam pipe
- ◆ Low beam impedance





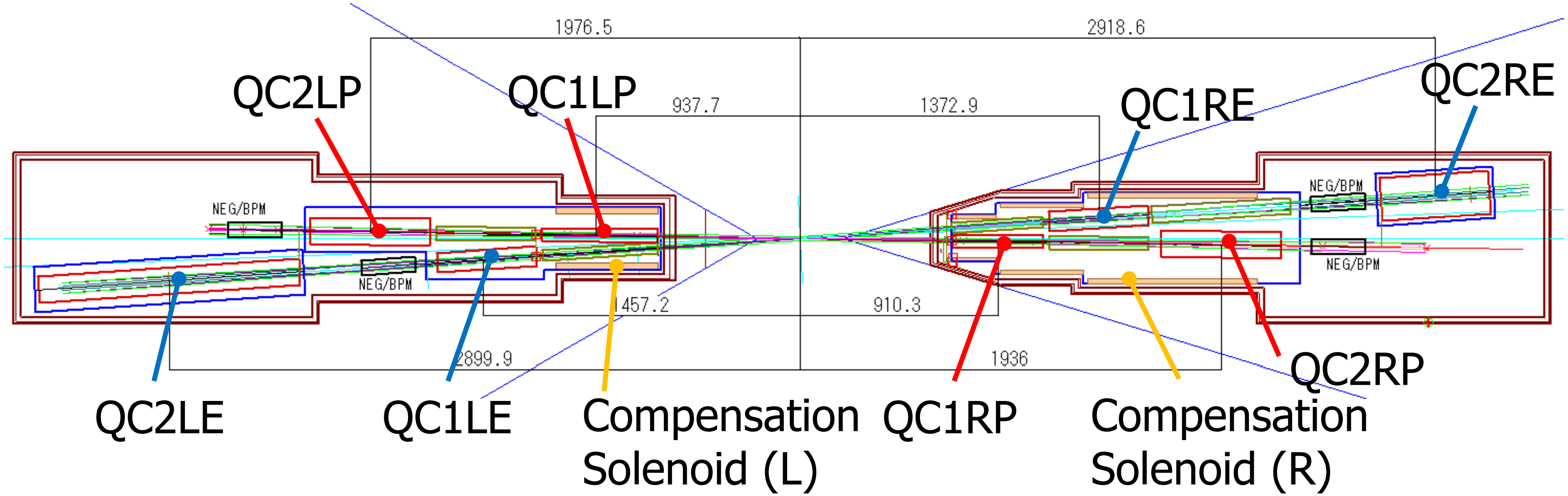


LER



HER

IR Superconducting Magnets



IR Superconducting magnets: main quads(8), corrector solenoids(2), corrector coils(43)

Preliminary! Under optimisation

Accelerator design → detector design

- For the nano-beam option

→ There are two final-Q magnets in both L / R sides

- 7 GeV + 4 GeV beam energies

To solve the problem of dynamic aperture.

.

- Crossing angle becomes 83 mrad

to put the final-Q magnets closer to the IP

- The QCS chamber radius is 1cm

→ to avoid the resonant cavity structure

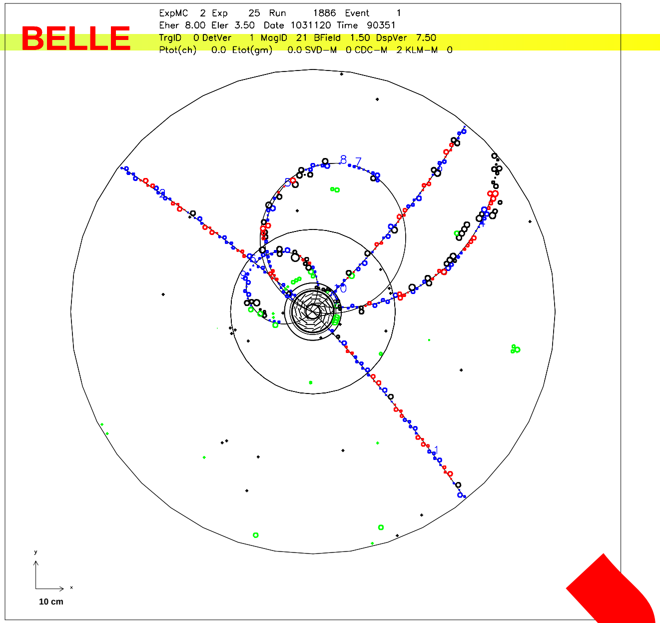
→IP beam-pipe radius should be 1cm

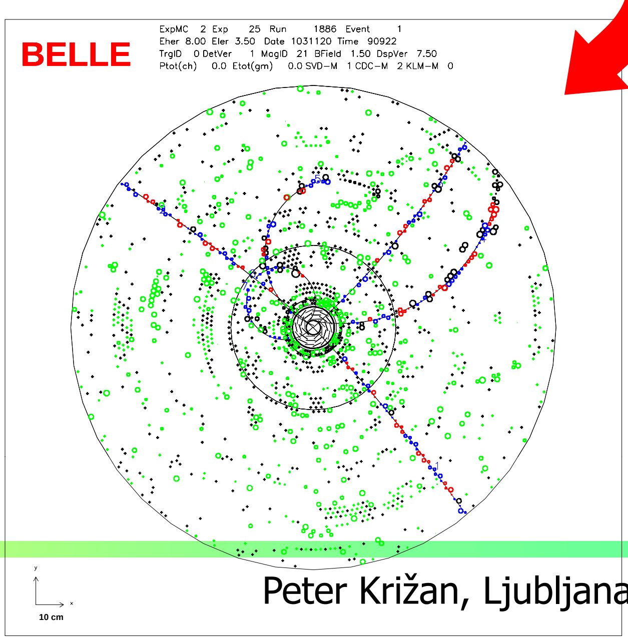
Detector backgrounds are under study – depend on the new machine parameters. Different in the nano-beam option than for the high current version

Requirements for the Belle II detector

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

- **Higher background (×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"

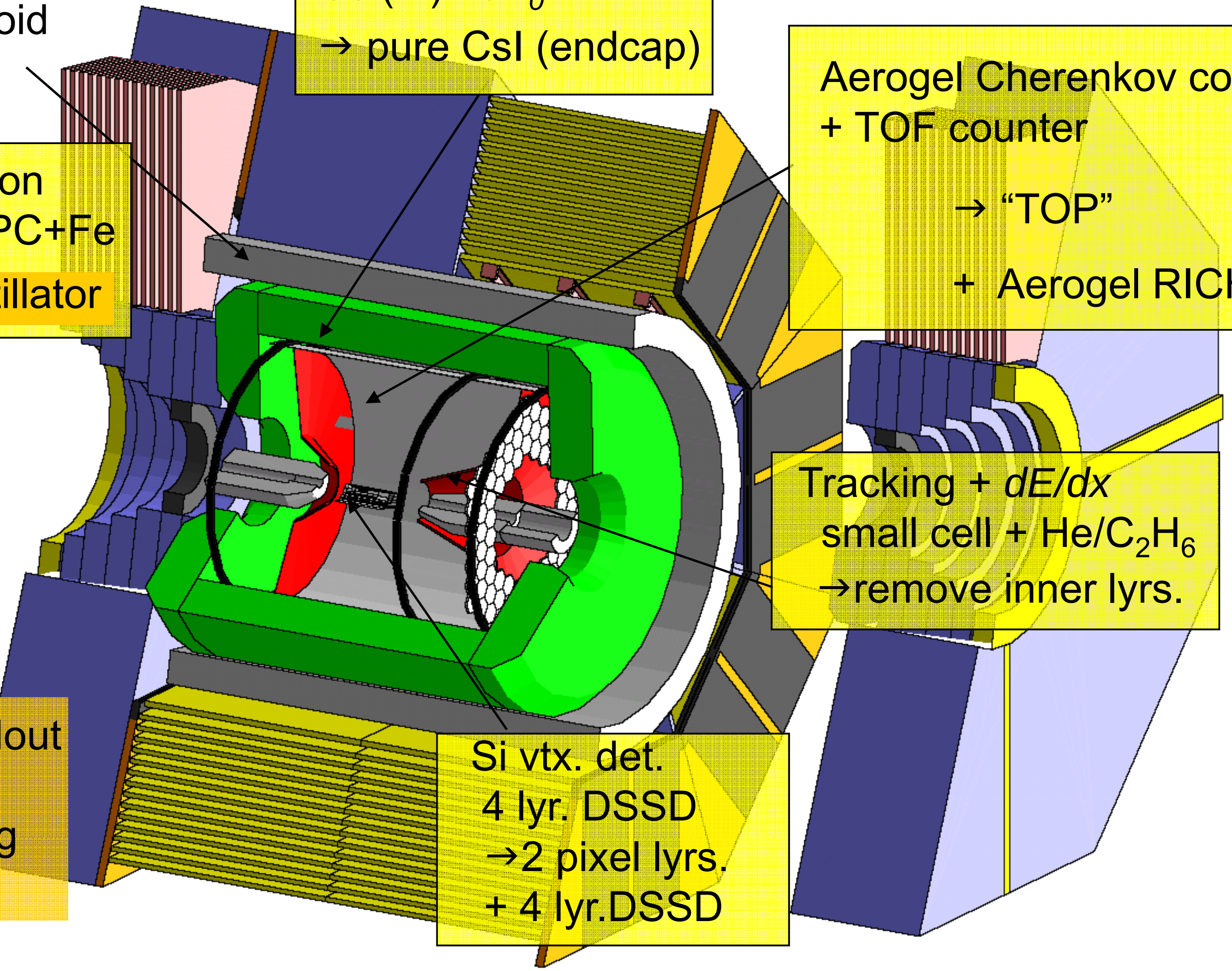




Solutions:

- 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.

Belle Upgrade for Super-B



SC solenoid
1.5T

CsI(Tl) 16X_0
→ pure CsI (endcap)

Aerogel Cherenkov counter
+ TOF counter
→ “TOP”
+ Aerogel RICH

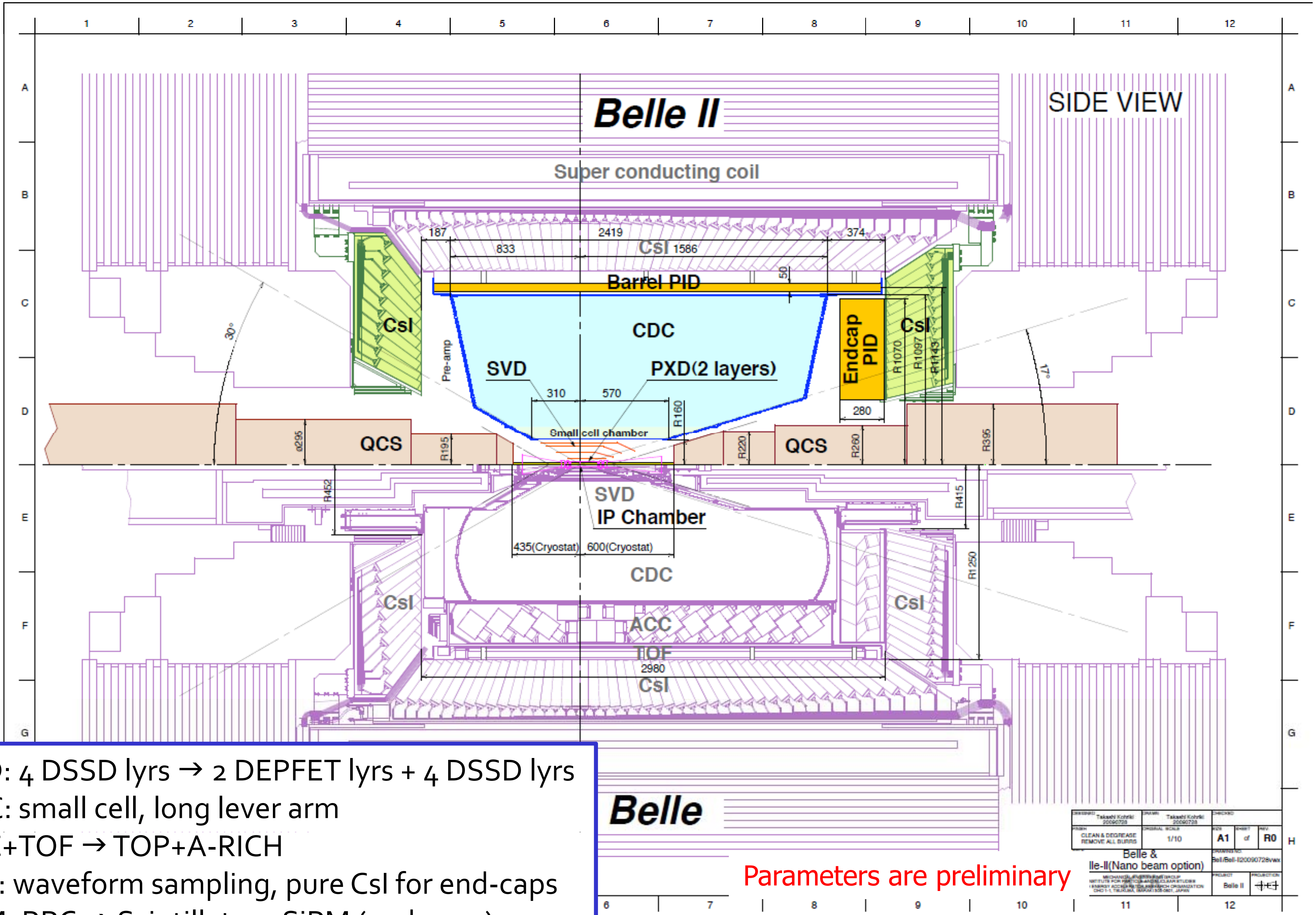
μ / K_L detection
14/15 lyr. RPC+Fe
→ tile scintillator

Tracking + *dE/dx*
small cell + He/C_2H_6
→remove inner lyrs.

New readout
and
computing
systems

Si vtx. det.
4 lyr. DSSD
→2 pixel lyrs.
+ 4 lyr.DSSD

Belle II in comparison with Belle

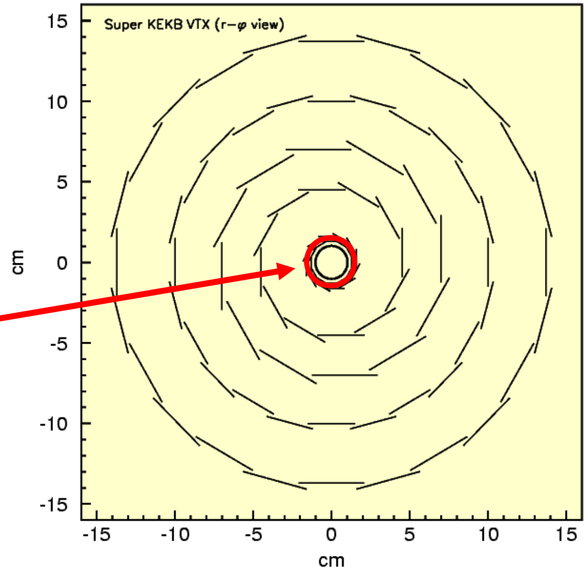


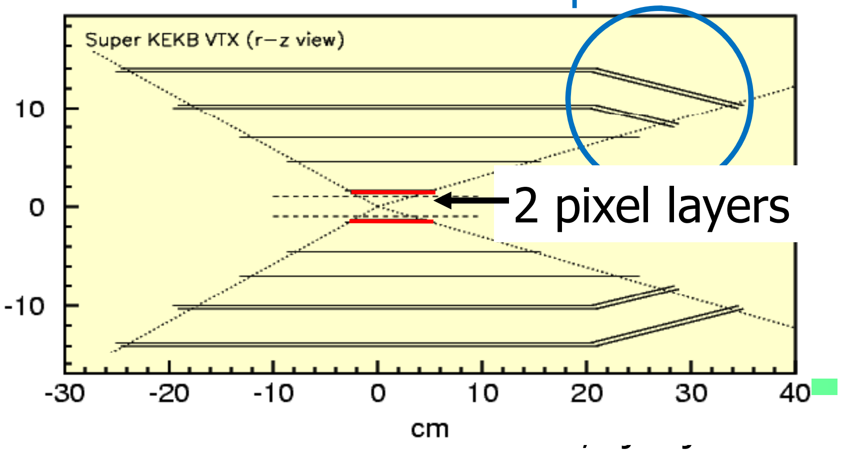
SVD: 4 DSSD lyrs → 2 DEPFET lyrs + 4 DSSD lyrs
CDC: small cell, long lever arm
ACC+TOF → TOP+A-RICH
ECL: waveform sampling, pure CsI for end-caps
KLM: RPC → Scintillator +SiPM (end-caps)

Parameters are preliminary

Vertex detector upgrade: PXD+SVD

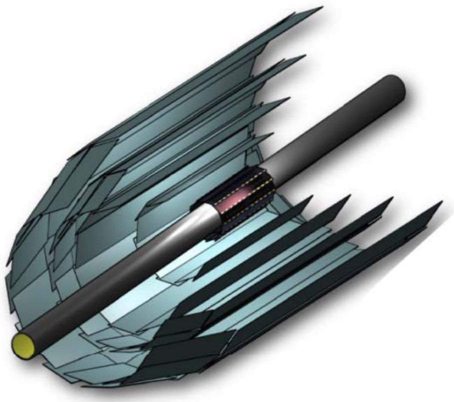
- Configuration: 4 layers → 6 layers (outer radius = 8cm→14cm)
  - More robust tracking
  - Higher Ks vertex reconstr. efficiency
- Inner radius: 1.5cm → 1.3cm
  - Better vertex resolution
- Sensors of the two innermost layers L1+L2: DEPFET Pixel sensors →PXD
- Layers 3-6: normal double sided Si detector (DSSD) →SVD
- Strip readout chip: VA1TA → APV25
  - Reduction of occupancy coming from beam background.
  - Pipeline readout to reduce dead time.




Slanted layers to keep the acceptance

2 pixel layers

Vertex Detector

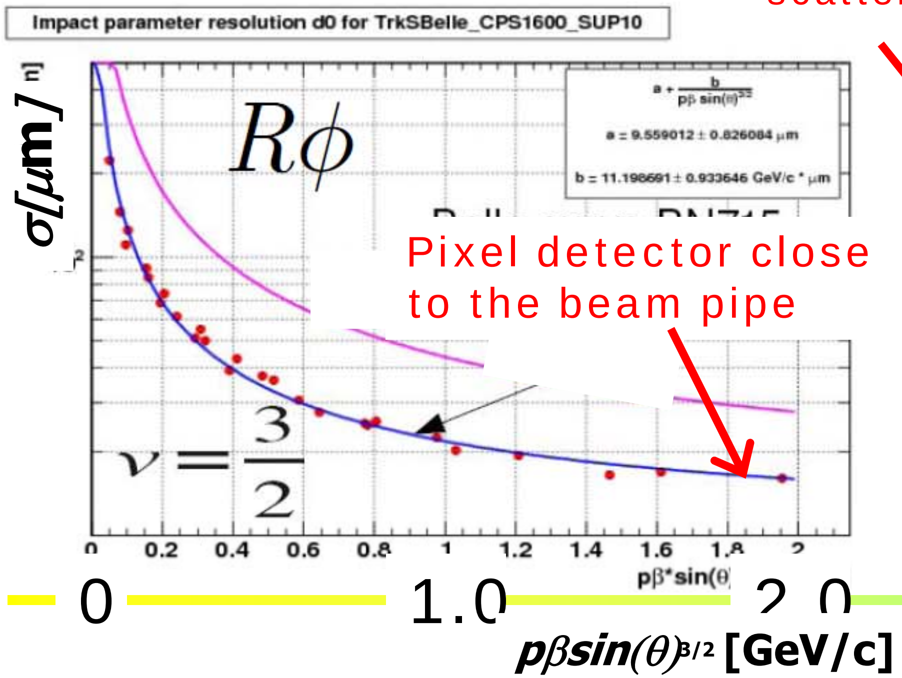


Beam Pipe		**r = 1cm**
DEPFET		
	Layer 1	**r = 1.3cm**
	Layer 2	**r = 2.2cm**
DSSD		
	Layer 3	**r = 3.8cm**
	Layer 4	**r = 8.0cm**
	Layer 5	**r = 11.5cm**
	Layer 6	**r = 14.0cm**

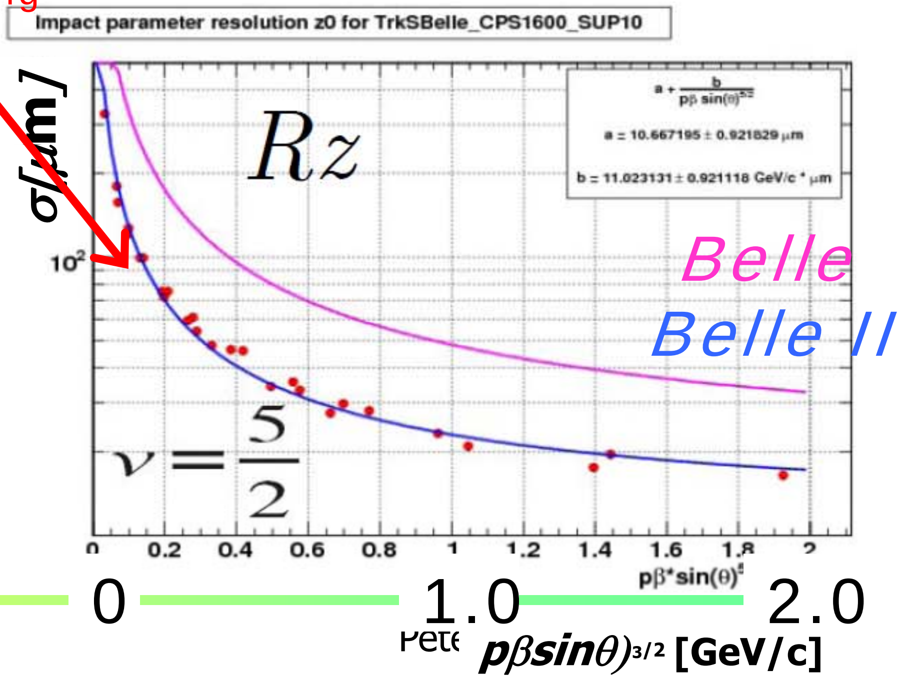
Significant improvement in IP resolution!

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

Less Coulomb scattering



Pixel detector close to the beam pipe



Current system

- Barrel: TOF + ACC
- End cap: ACC

(ACC: Threshold type
Aerogel Cherenkov Counter)

Upgrade

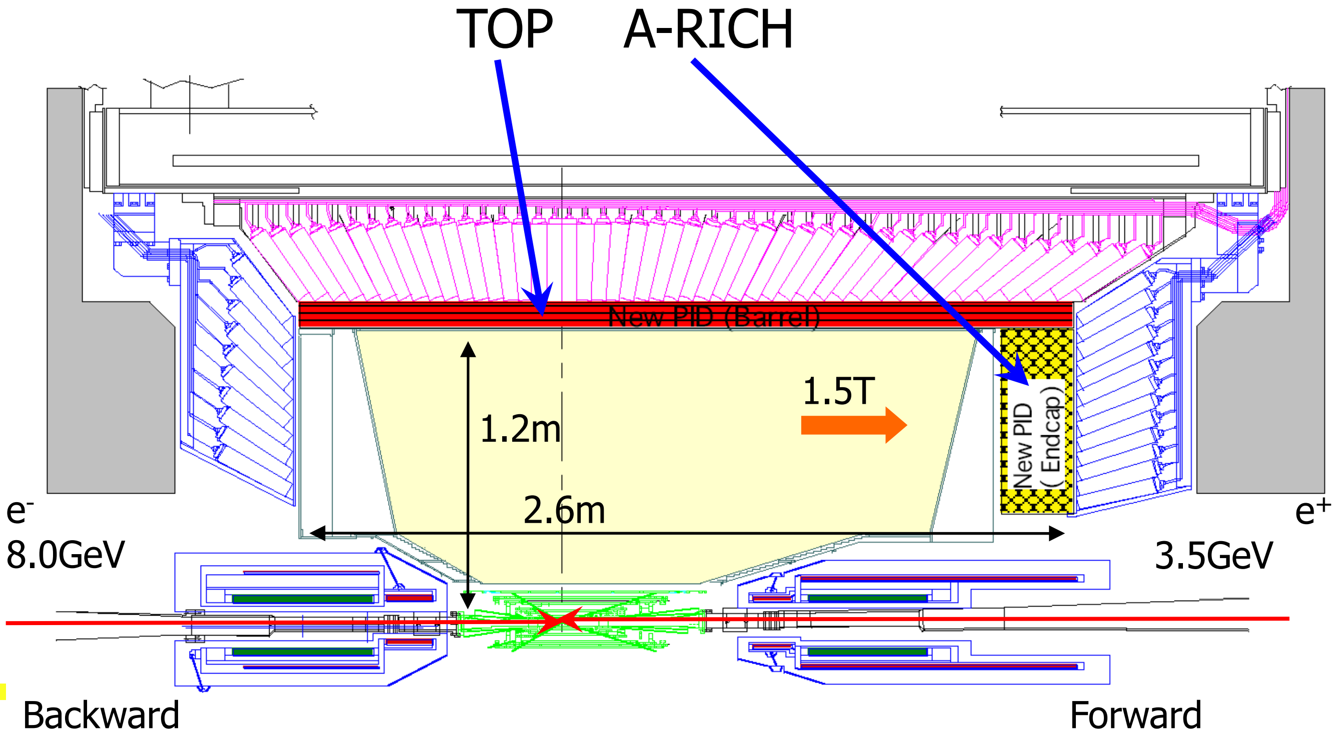
Belle-II

- ■ Barrel: TOP counter
- ■ End cap: Aerogel RICH

(TOP: Time-of-Propagation)

3σ K/pi separation

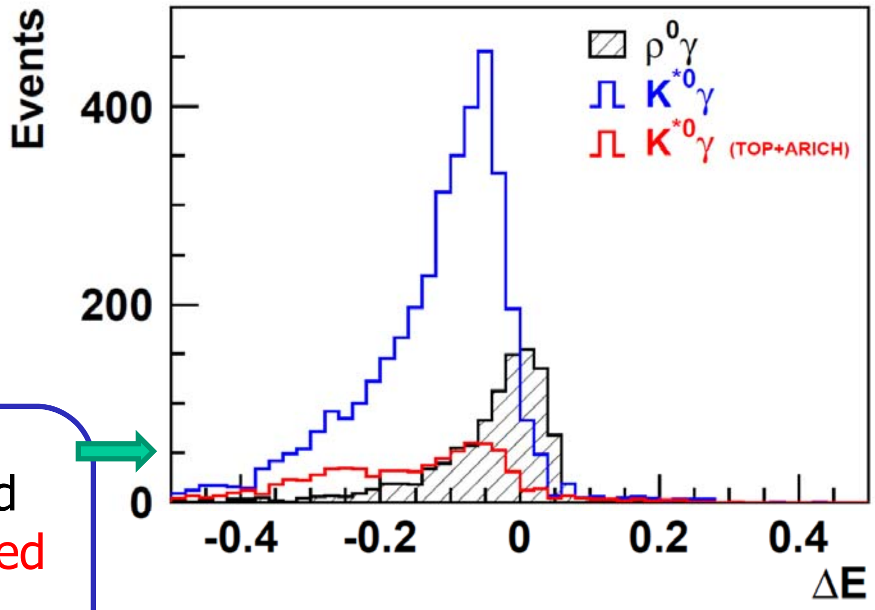
4σK/pi separation up to 4GeV

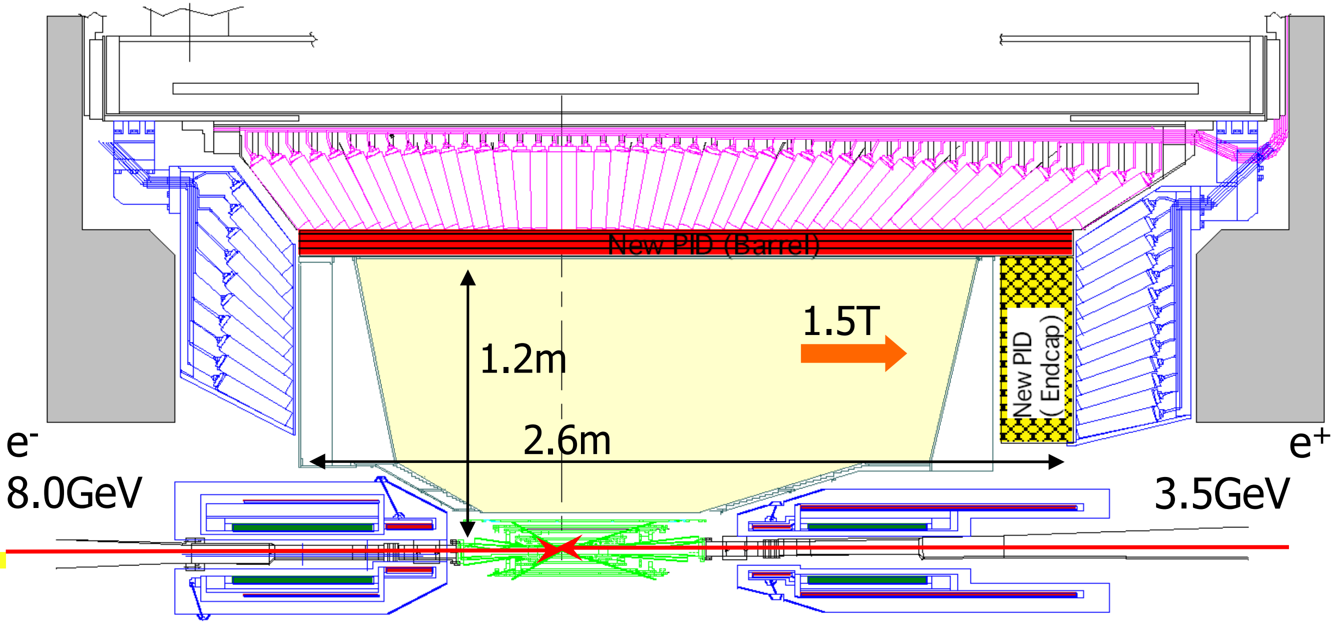


- Barrel: TOP counter
- End cap: Aerogel RICH

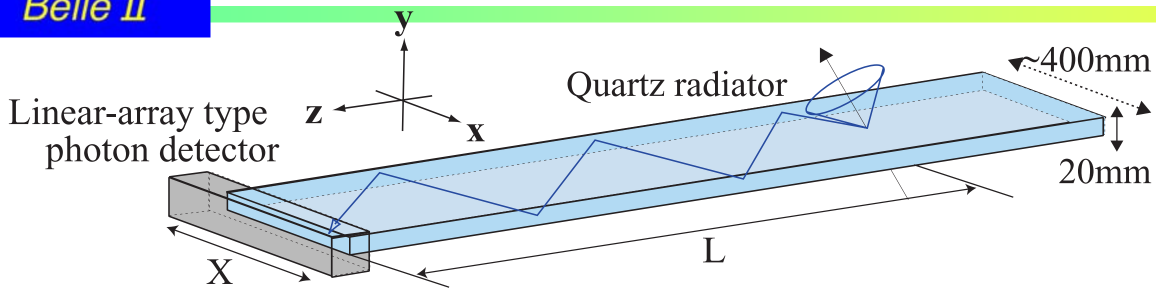
Expected impact, example B→K*γ: background reduced from blue (present Belle) to red

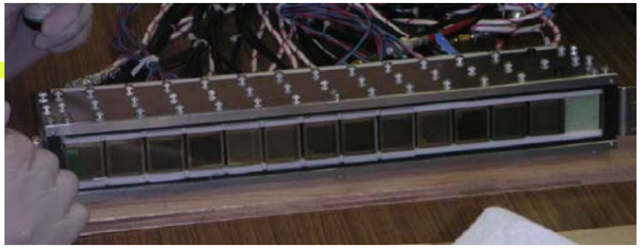
→Up to 80% gain in sensitivity



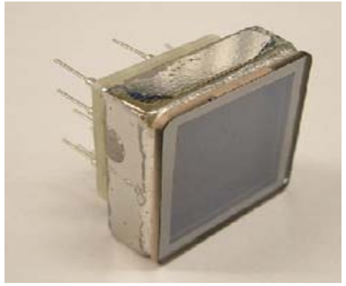


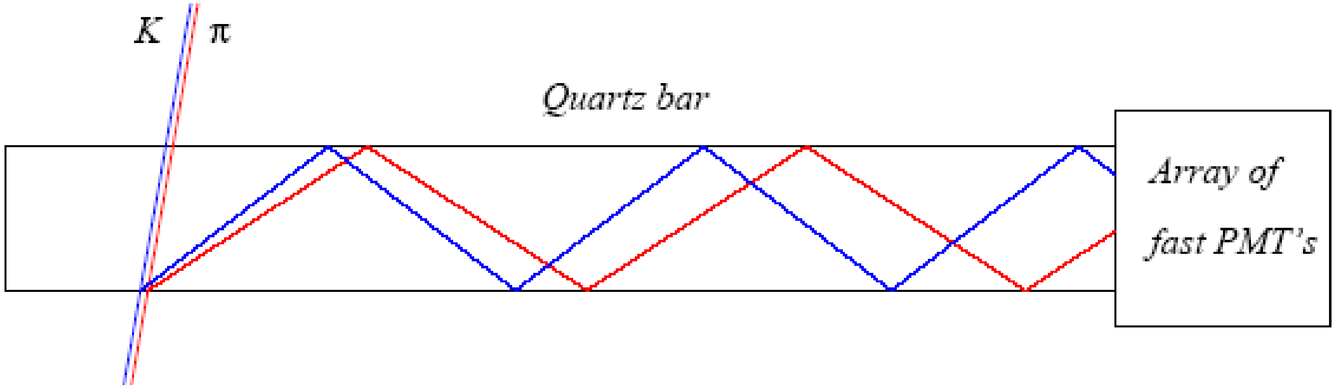
Barrel PID: Time of propagation (TOP) counter

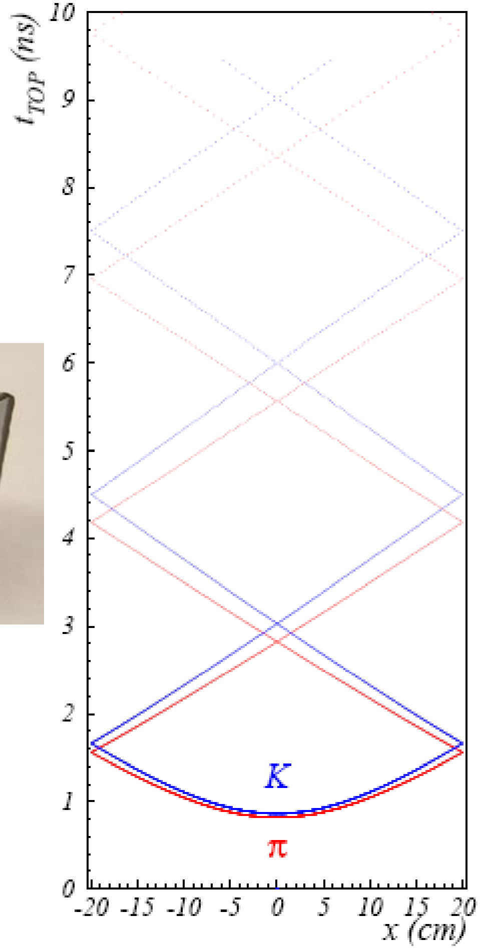




- Cherenkov ring imaging with precise time measurement.
- Reconstruct angle from two coordinates and the time of propagation of the photon
  - Quartz radiator (2cm)
  - Photon detector (MCP-PMT)
    - Good time resolution ~ 40 ps
    - Single photon sensitivity in 1.5



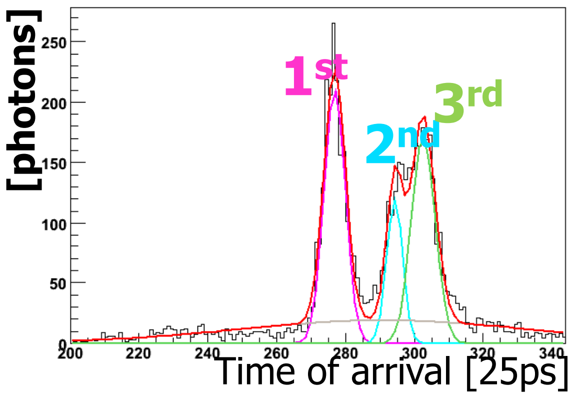




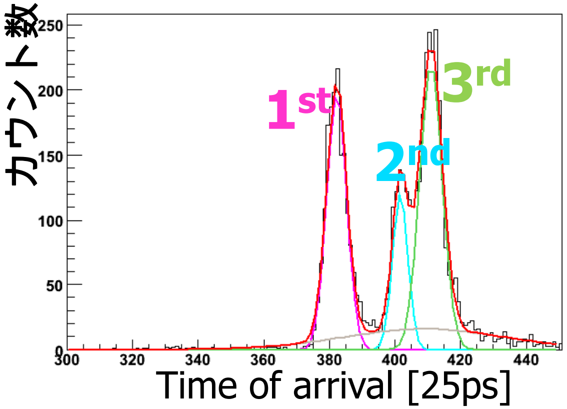
TOP test beam performance: proof-of-principle

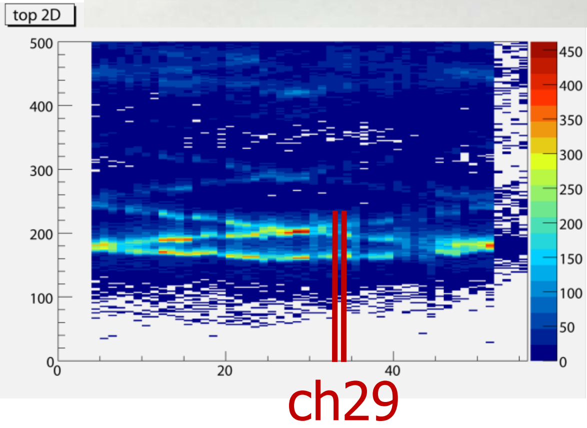
Photon detector: Hamamatsu MCP-PMT 27.5x27.5 mm^2

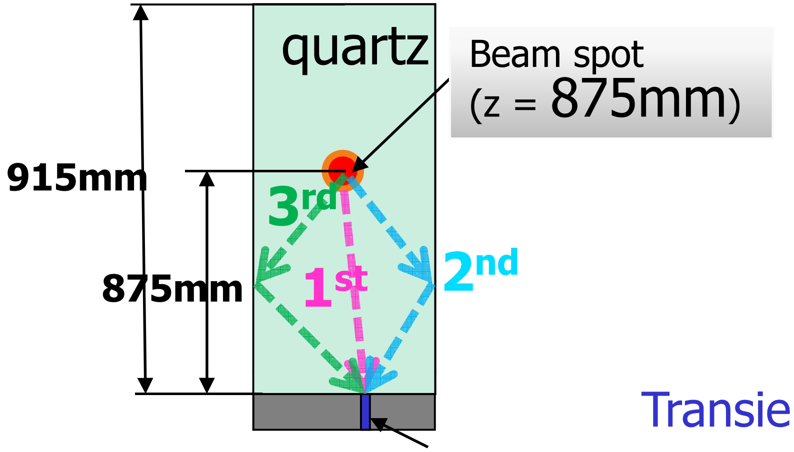
Test beam (2008)



simulation







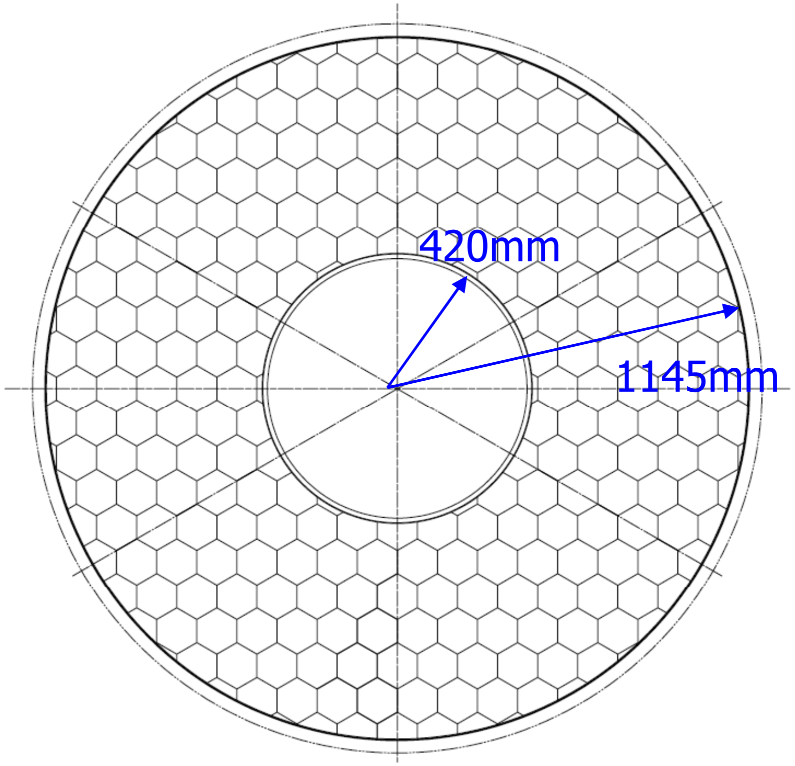
$$\sigma_{\text{top}} = \sqrt{\sigma^2_{\text{MCP-PMT}} + \sigma^2_{\text{chromatic}}}$$

	TTS (1st peak)
Data	**76.0±2.0 [ps]**
Simulation	**77.7±2.3 [ps]**

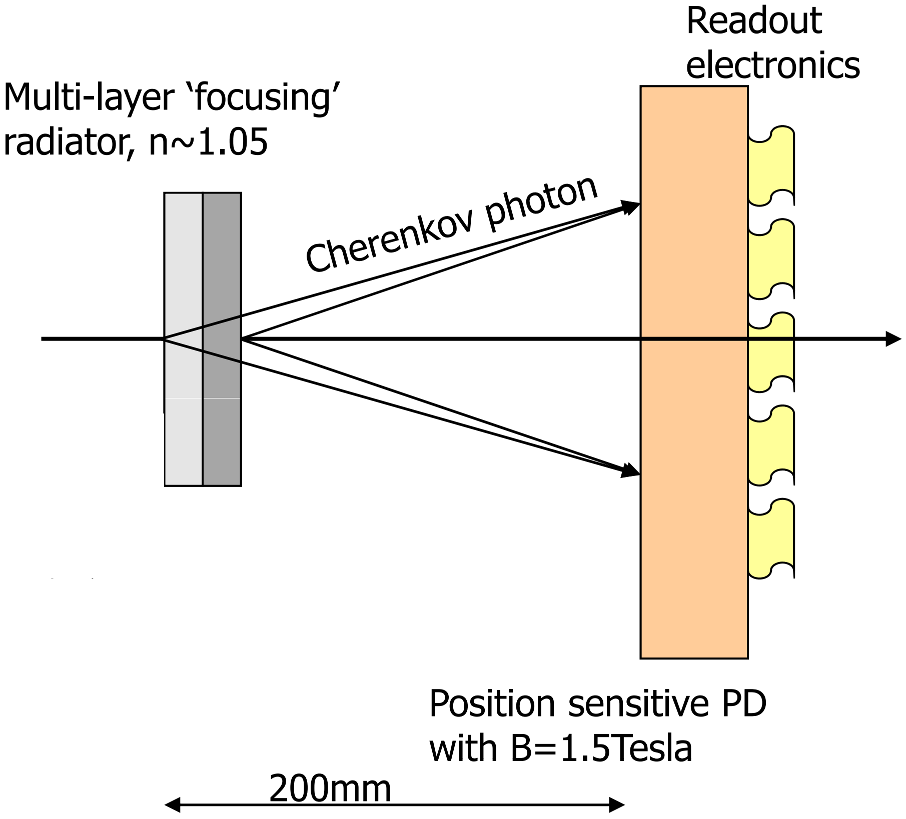
Transient time spread determined from the data

End-cap PID

Proximity focusing RICH with silica aerogel as Cherenkov radiator in a 'focusing' configuration



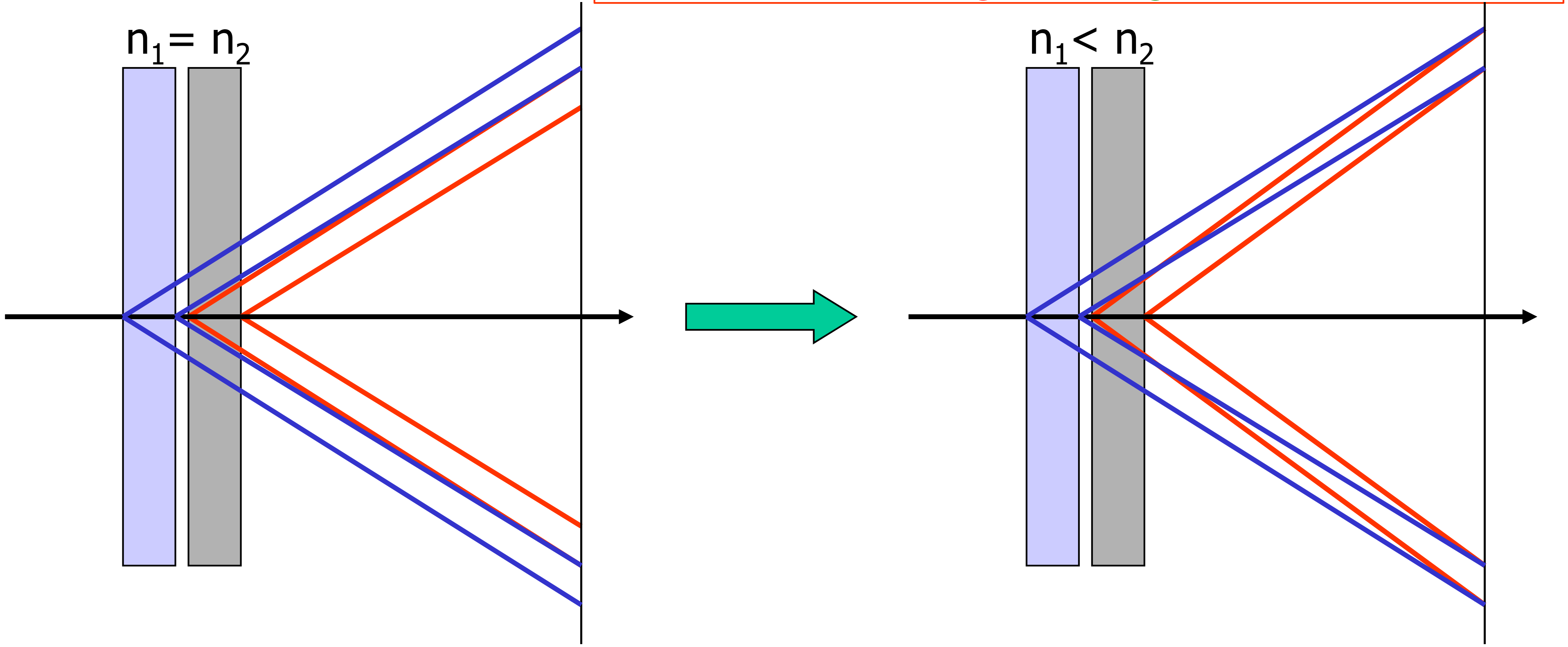
x-y view of forward end-cap



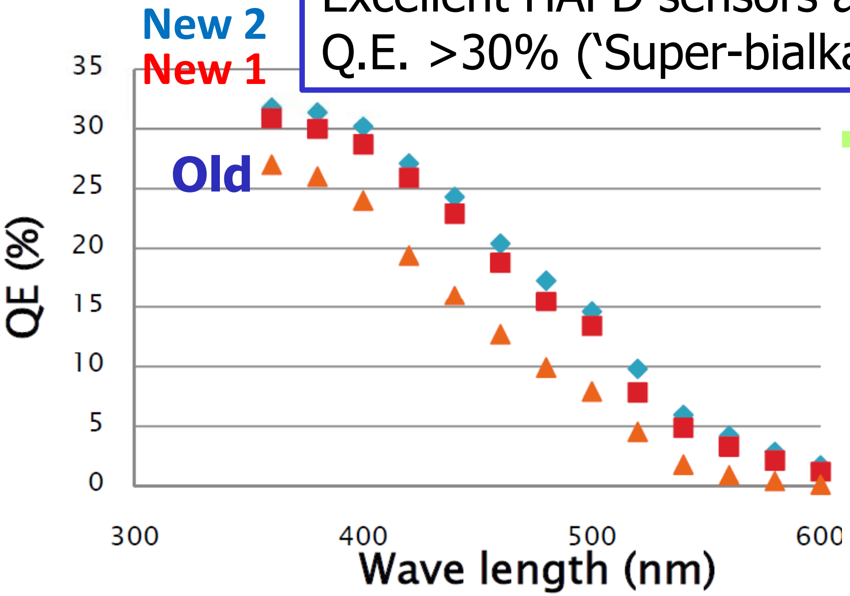
Radiator with multiple refractive indices

How to increase the number of photons without degrading the resolution?

→ stack two tiles with different refractive indices: "focusing" configuration

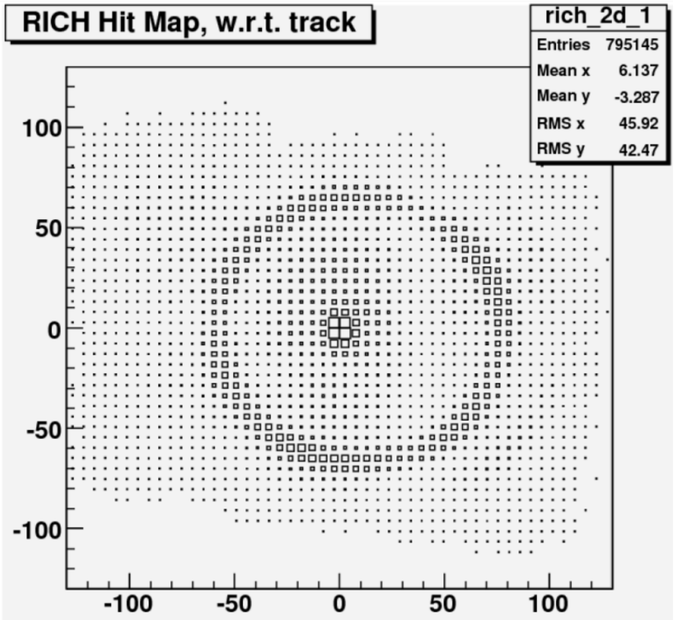


→ focusing radiator

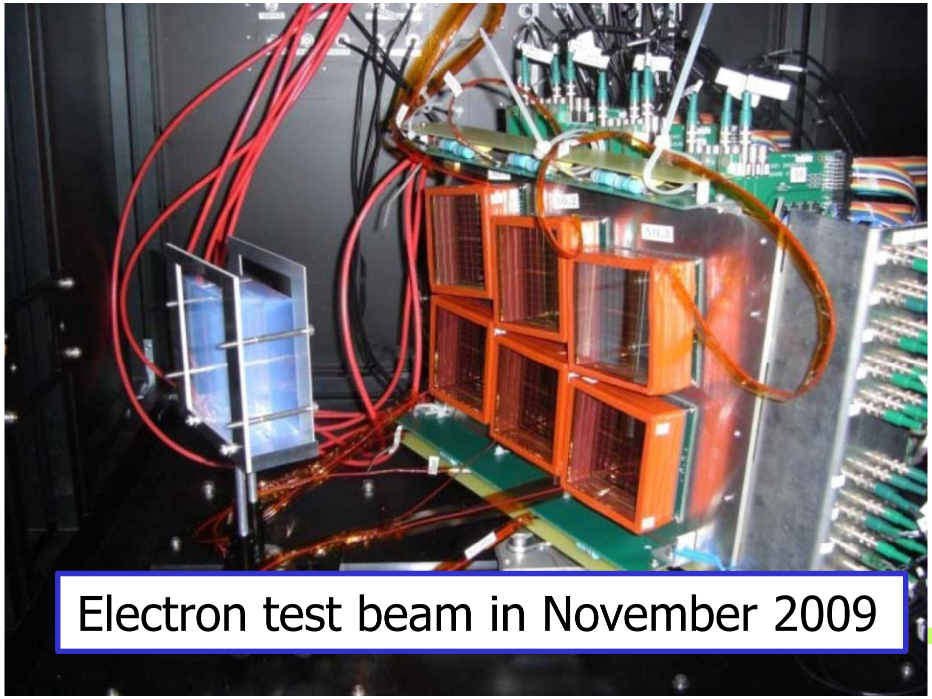


Excellent HAPD sensors at hand
Q.E. >30% ('Super-bialkali')

Proximity focusing RICH:
Beam test performance

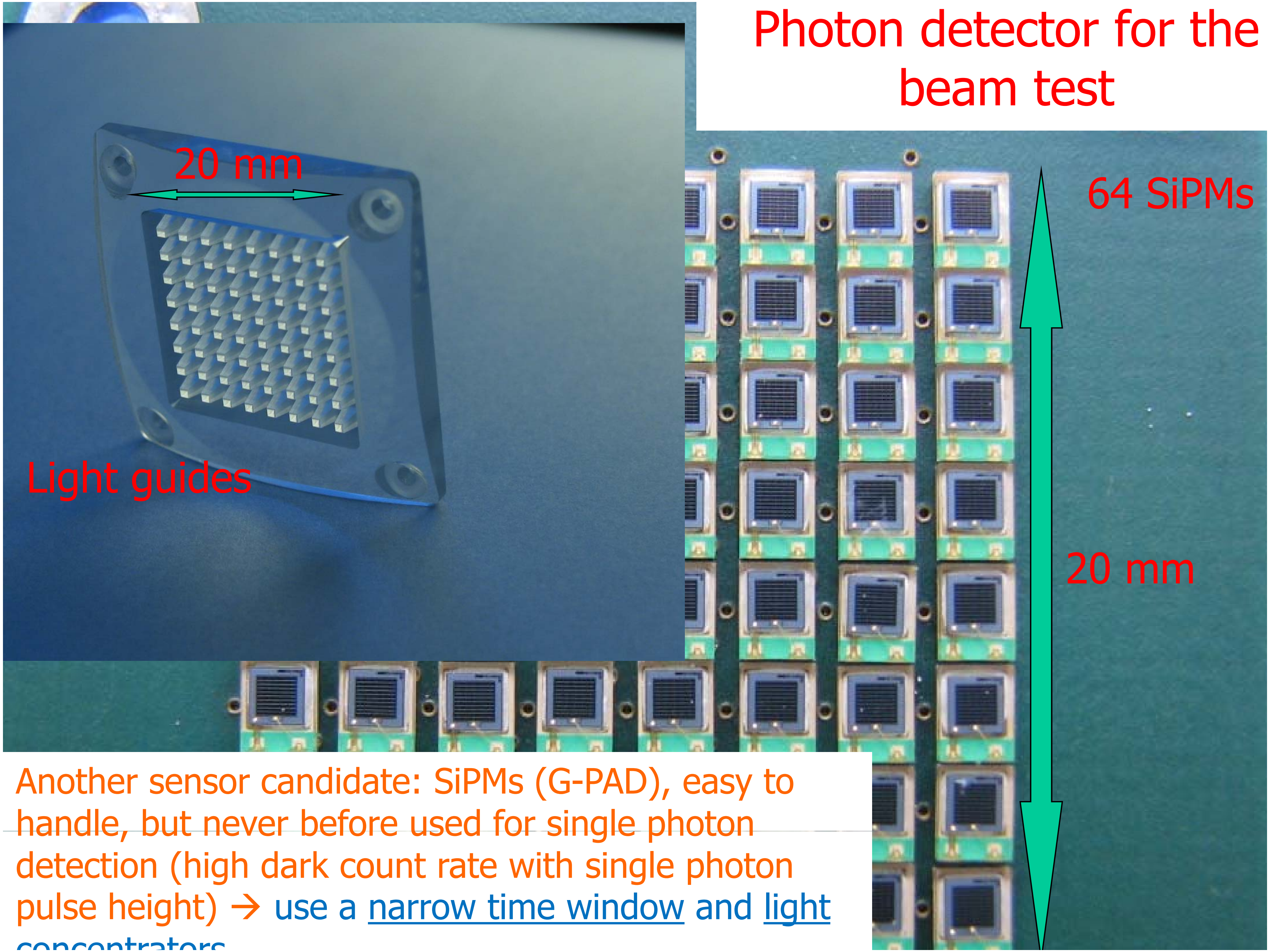


Number of photons / track = 14.3
Resolution / photon = 15.2 mrad
Resolution / track = 4.0 mrad



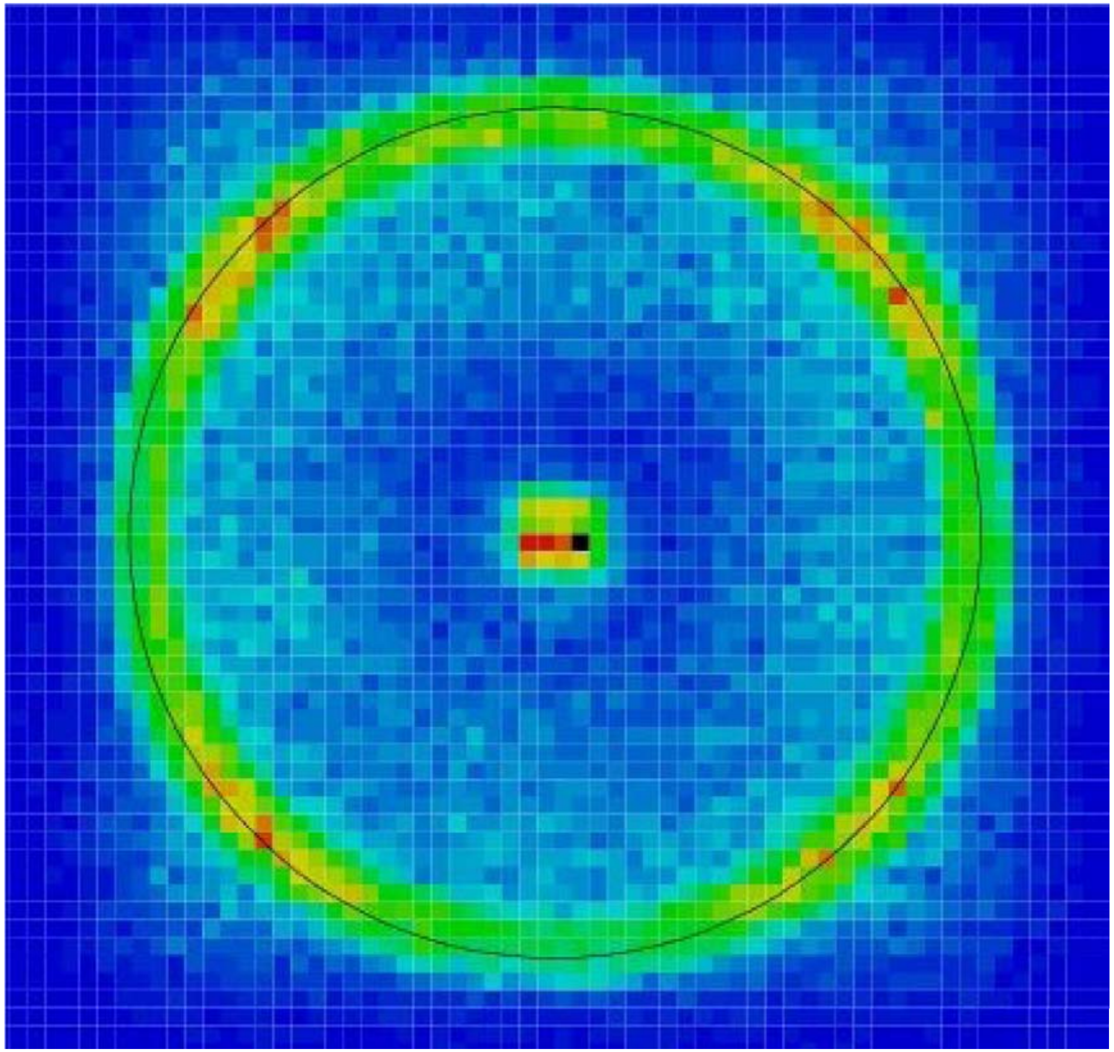
Electron test beam in November 2009

Photon detector for the beam test



Another sensor candidate: SiPMs (G-PAD), easy to handle, but never before used for single photon detection (high dark count rate with single photon pulse height) → use a narrow time window and light concentrators

Cherenkov ring with SiPMs



First successful use of SiPMs as single photon detectors in a RICH counter!

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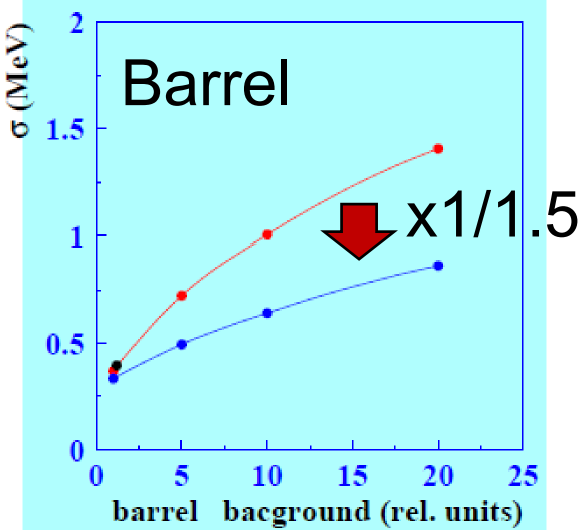
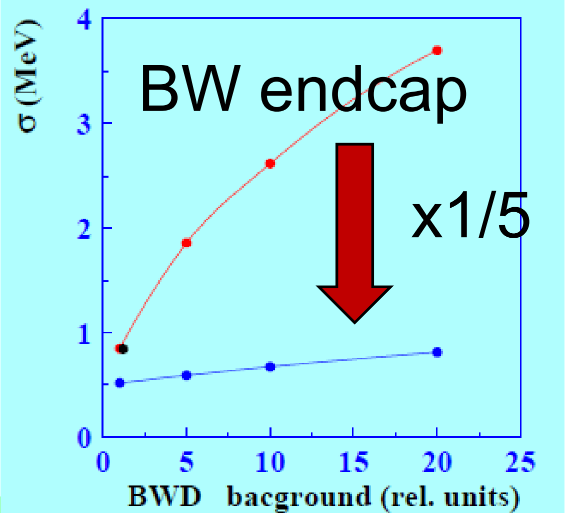
Calorimeter (ECL) Upgrade

- Increase of dark current due to neutron flux
- Fake clusters & pile-up noise

- Barrel:
  0.5μs shaping + 2MHz w.f. sampling.
- Endcap:
  rad. hard crystals with short decay time (e.g. pure CsI) + photopentodes
  30ns shaping + 43MHz w.f. sampling



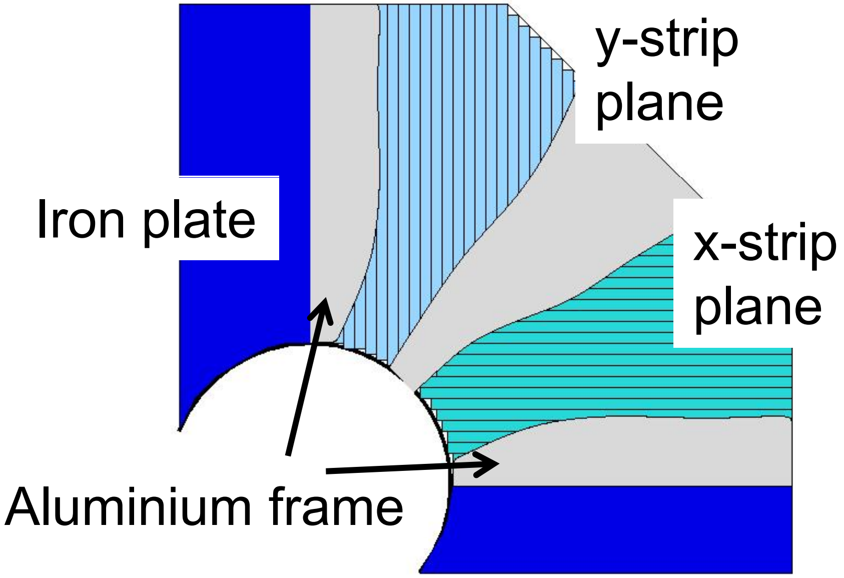


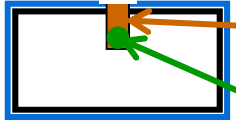
Pure CsI &
photopentodes

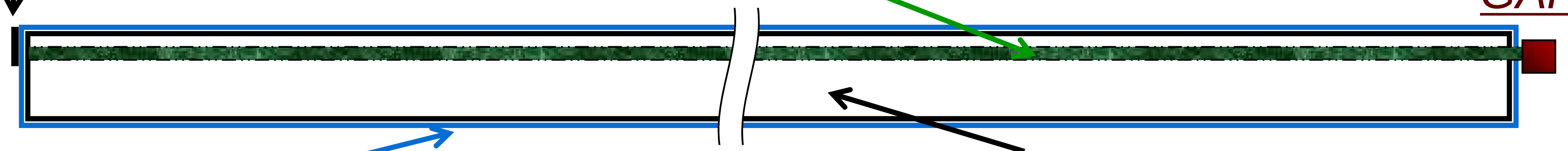
KLM upgrade in the endcaps

Scintillator-based KLM (endcap)

- Two independent (x and y) layers in one superlayer made of orthogonal strips with WLS read out
- Photo-detector = avalanche photodiode in Geiger mode (SiPM)
- ~120 strips in one 90º sector (max L=280cm, w=25mm)
- ~30000 read out channels
- Geometrical acceptance > 99%







Mirror 3M (above groove & at fiber end)

Optical glue increase the light yield ~ 1.2-1.4)

WLS: Kurarai Y11 ∅1.2 mm

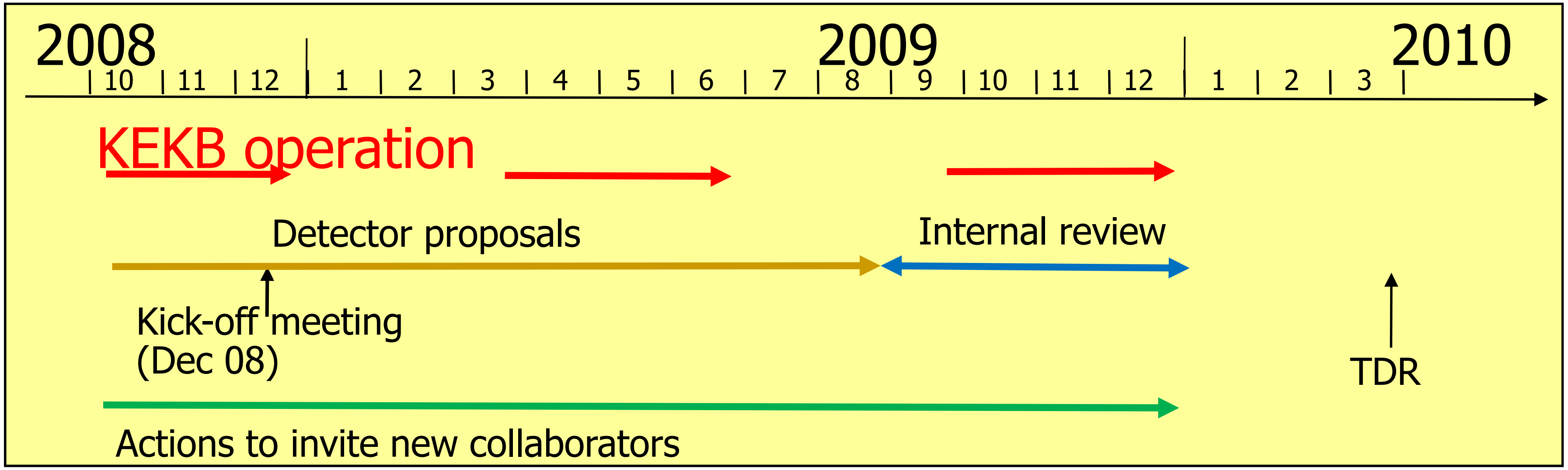
GAPD

Diffusion reflector (TiO$_2$)

Strips: polystyrene with 1.5% PTP & 0.01% POPOP

Project timetable

- Status and near-term plan
  - Detector proposals (Dec. 2009)
  - Decisions on technology choices (Barrel PID configuration/photon detector, ECL endcap crystalls and photosensors)
  - TDR by March 2010

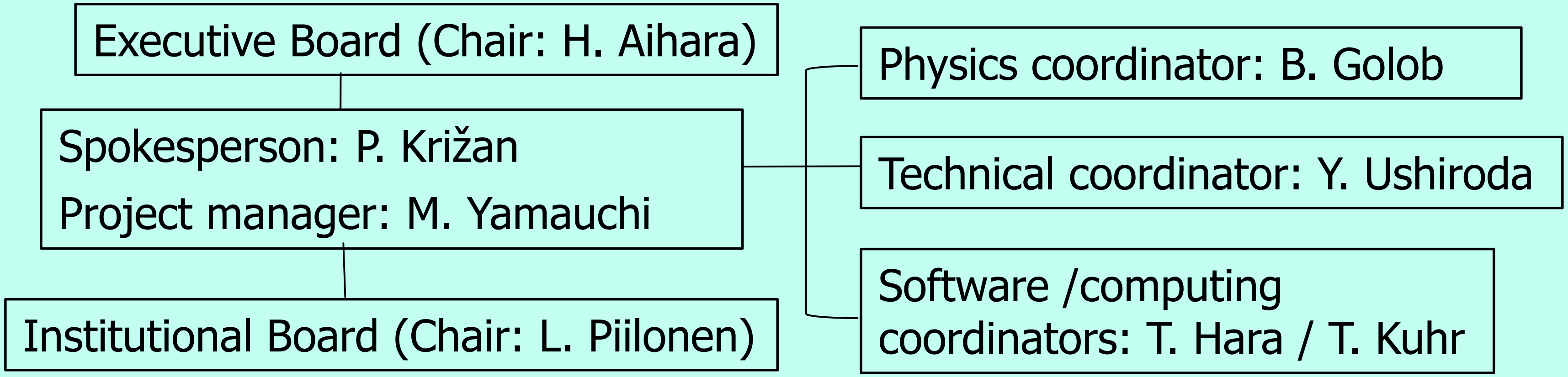


Belle-II Collaboration

2004.06: LoI for SuperKEKB
2008.01: KEK Roadmap → identified as high priority project at KEK
2008.12: New collaboration (Belle-II) officially formed

- ❖ 13 countries/regions, 43 institutes, ~300 members

Separate group/organization from Belle



Executive Board (Chair: H. Aihara)

Spokesperson: P. Križan
Project manager: M. Yamauchi

Institutional Board (Chair: L. Piilonen)

Physics coordinator: B. Golob

Technical coordinator: Y. Ushiroda

Software /computing coordinators: T. Hara / T. Kuhr

2009.11: 4th Open Collaboration Meeting

3rd collab. meeting

7-9,July-2009

European groups of Belle-II

- Austria: HEPHY (Vienna)
- Czech republic: Charles University in Prague
- Germany: U. Bonn, KIT Karlsruhe, MPI Munich, U. Giessen
- Poland: INP Krakow
- Russia: ITEP (Moscow), BINP (Novosibirsk),
- Slovenia: J. Stefan Institute (Ljubljana)

Already a sizeable fraction of the collaboration: in total 100 collaborators out of 287!

→ More DEPFET groups are expected to join

Krakow in Belle and Belle-II

Krakow@Belle:

- One of the funding groups, first EU group
- Large impact in hardware (SVD, silicon vertex detector)
- Important analyses (including the hot $B \rightarrow D\tau\nu$ and $B \rightarrow \phi K^*$ polarisation puzzle, discovery of $D_{sJ}(2700)$) and coordination of the largest analysis group (charm)

The Krakow group is planning to make a significant contribution to the Belle-II detector:

- SVD, silicon vertex detector, much bigger than in Belle
- PXD, pixel detector based on the DEPFET technology
- Software: reconstruction, calibration and analysis

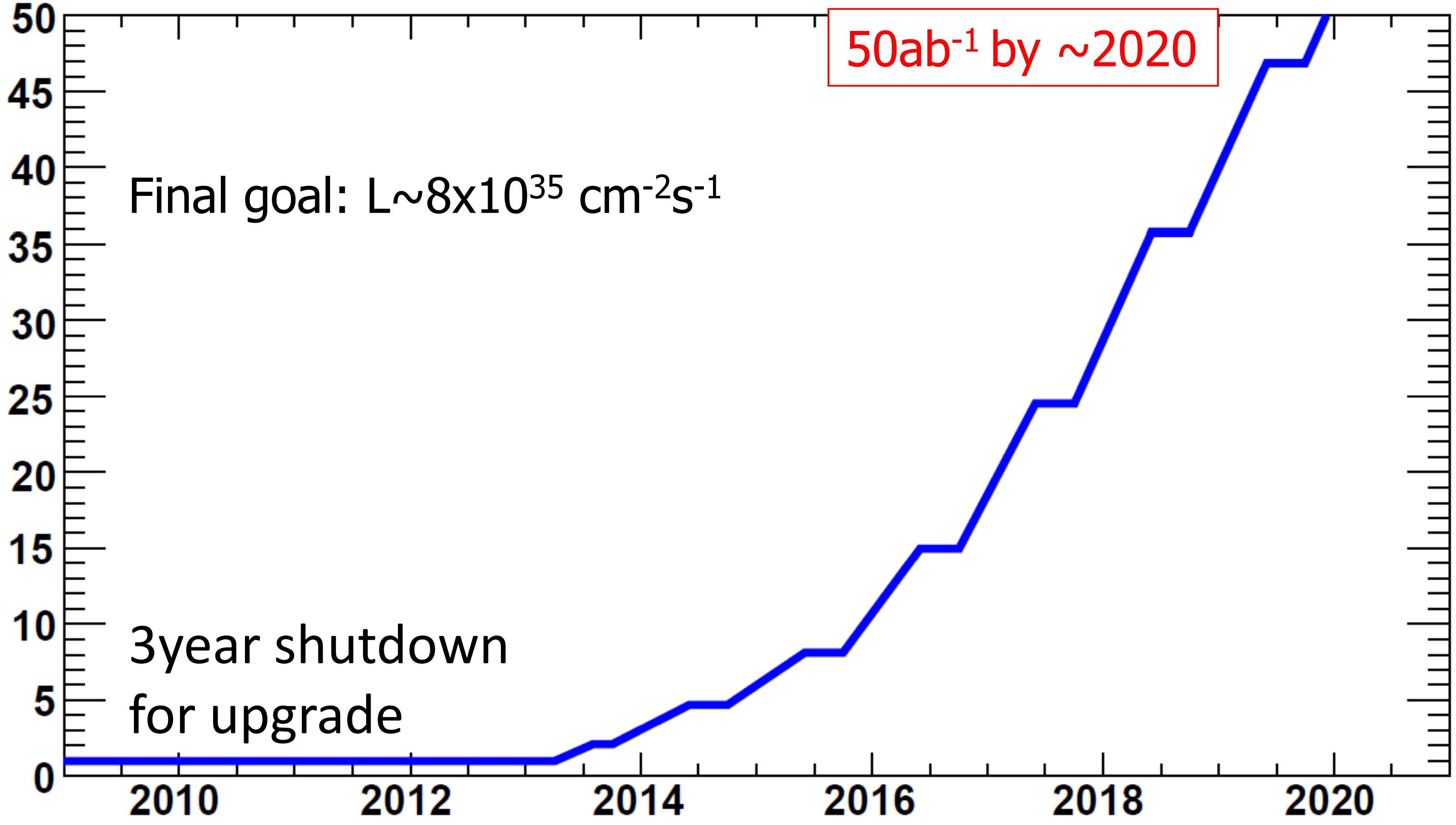
Belle II is looking forward to a continuation of the excellent collaboration with Krakow

Peter Križan, Ljubljana

Project plans

Long term plan:

- 3 year shut-down for upgrade of the accelerator and detector
- Start machine operation in 2013



50ab^{-1} by ~2020

Final goal: L~8x10^{35} cm^{-2}s^{-1}

3year shutdown for upgrade

Project status

- SuperKEKB and Belle-II are priorities of KEK
- The Japanese government has allocated 32 oku-yen (32 M$) for upgrade R&D in FY 2009, as a part of its economic stimulus package. This was considered as a very important sign in Japan.
- KEK has submitted to the Ministry of education, science, and technology (MEXT) a budget request for FY 2010 and beyond for 350 M$ for the construction of SuperKEKB. MEXT submitted a request for the upgrade budget to the Ministry of finance.
- The recently elected Japanese government reviewed all major projects → provisional approval (parts of accelerator already fully funded, construction begins in April).
- Several non-Japanese funding agencies have already allocated sizable funds for the upgrade.

Summary

- B factories have proven to be an excellent tool for flavour physics, with reliable long term operation, constant improvement of the performance.
- Major upgrade at KEK in 2010-13 → Super B factory, L x40
- Essentially a new project, all components have to be replaced, options to be frozen in the next few months
- The project has a strong European participation (about 1/3!)
- A physics reach update is being prepared – to be made public soon
- Expect a new, exciting era of discoveries, complementary to LHC

Additional slides

Design parameters

		LER	HER	
Emittance	ε_x	3.2	1.7	nm
Coupling	$\varepsilon_y/\varepsilon_x$	0.40	0.48	%
Beta Function at IP	β_x^* / β_y^*	32 / 0.27	25 / 0.42	mm
Beam Size	σ_x^* / σ_y^*	10.1 / 0.059	6.5 / 0.059	μm
Bunch Length	σ_z	6	5	mm
Half Crossing Angle	ϕ	41.3		mrad
Beam Energy	E	4	7	GeV
Beam Current	I	3.6	2.6	A
Number of Bunches	n_b	2500		
Energy Loss / turn	U_0	2.28	2.15	MeV
Total Cavity Voltage	V_c	6.3	6.3	MV
Energy Spread	σ_δ	$7.92\text{x}10^{-4}$	$5.91\text{x}10^{-4}$	
Synchrotron Tune	ν_s	-0.0185	-0.0114	
Momentum Compaction	α_p	$2.85\text{x}10^{-4}$	$1.90\text{x}10^{-4}$	
Beam-Beam Parameter	ξ_y	0.09	0.09	
Luminosity	L	$8\text{x}10^{35}$		$\text{cm}^{-2}\text{s}^{-1}$