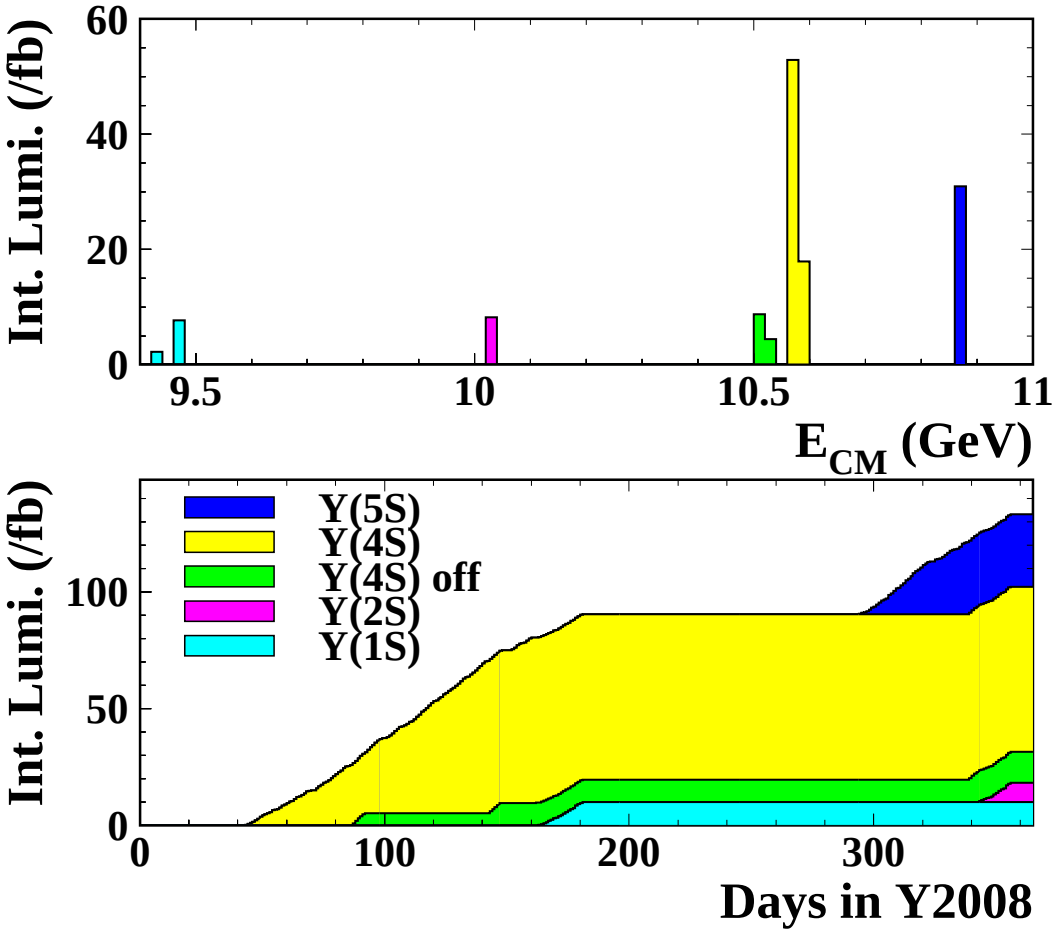
Belle 2008

14th KEKB Accelerator Review Committee, 9–11.Feb.2009

中村 勇 / KEK

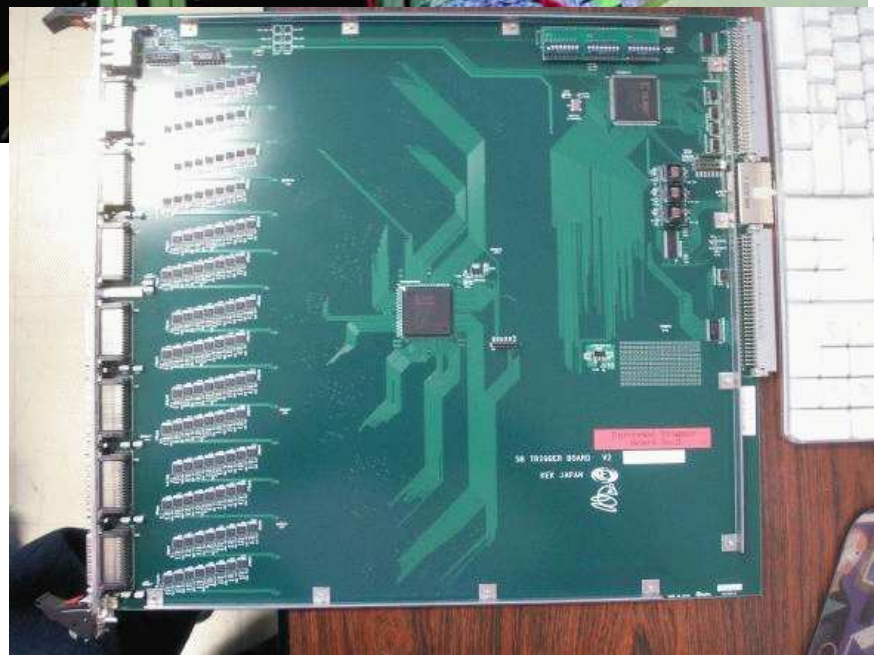
Belle 2008 Run

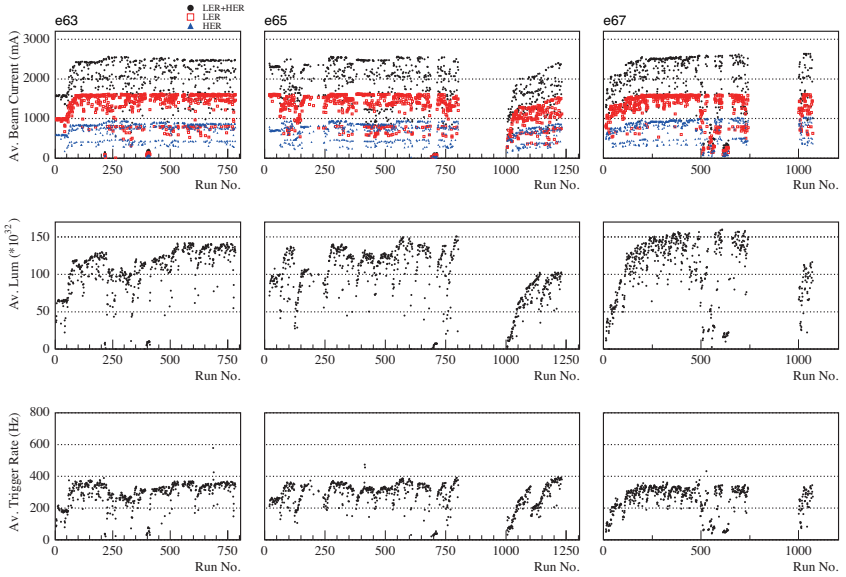


$\sqrt{s}$	Υ(1S)	Υ(2S)	Υ(4S) off.	Υ(4S)	Υ(5S)
Lumi. (/fb)	9.8	10.1	13.5	74.6	31.0

- Two periods (~ 8 months.)
  Feb.11 – Jun.30, Oct.16 – Dec.22
- Five Different Energy Points
- Efficiency ~ 95 %
  (Troubles not included)
- Troubles (~no effect to analyses)
  - CDC HV (0.5% dead, repaired)
  - ECL Readout (2 ch no signal)
  - KLM Readout
    (2 layers down for 10 days)

Belle 2008 Improvements



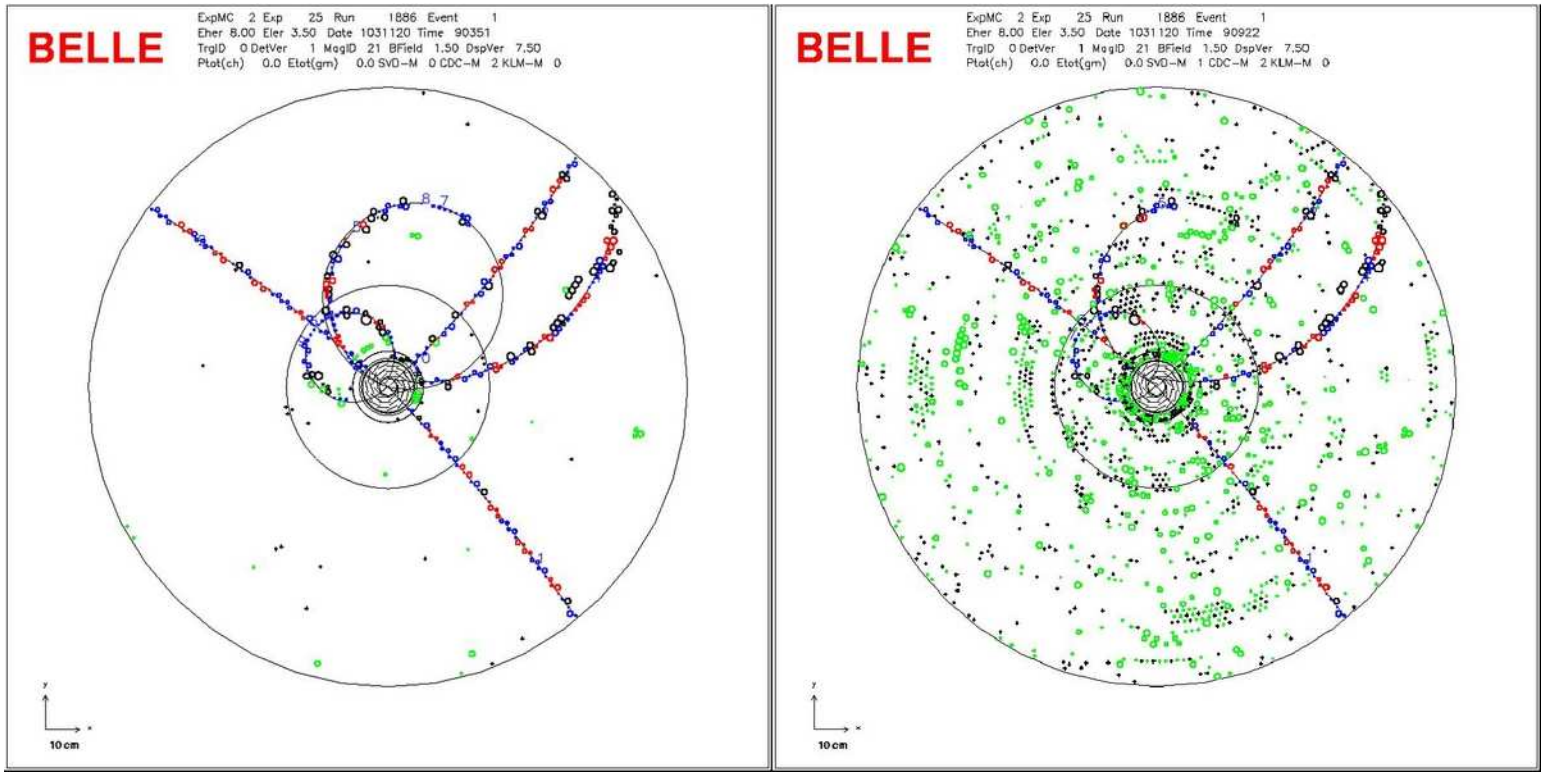


- Trigger Data read out by COPPER
- New Global Trigger Decisioin Logic
  - upto 64 trigger input
  - upto 160 different trigger output
  - flexible injection veto
  - ANN trigger test
  - new Bhabha trigger test

Belle Upgrade R&D Highlights

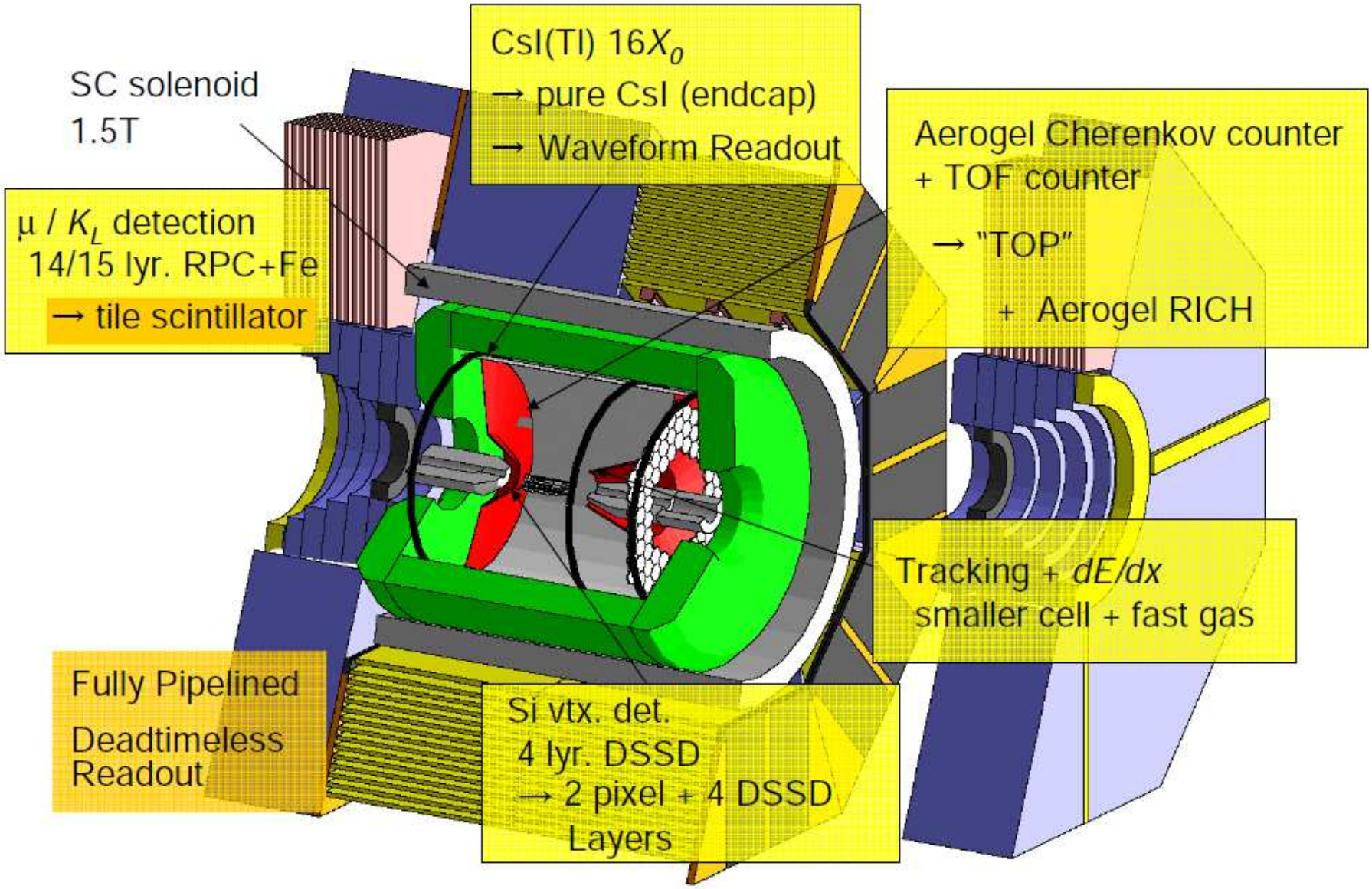
Belle Upgrade Concept

- More physics events ($\propto$ Lumi $\Rightarrow$ $\times$10 trigger Rate $O(10)$ kHz)
- More background ($\propto$ Beam Current $\times$ Vacuum $\Rightarrow$ $\times$20)



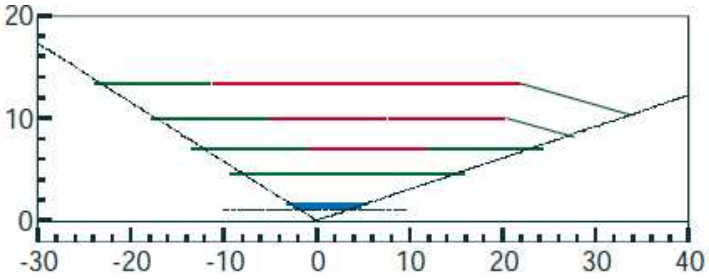
- Faster and Finer
  - Small-Cell Drift Chamber, Pixel Detector
  - "Deadtimeless" Pipelined readout
  - More Timing information
- Better PID

Baseline Design

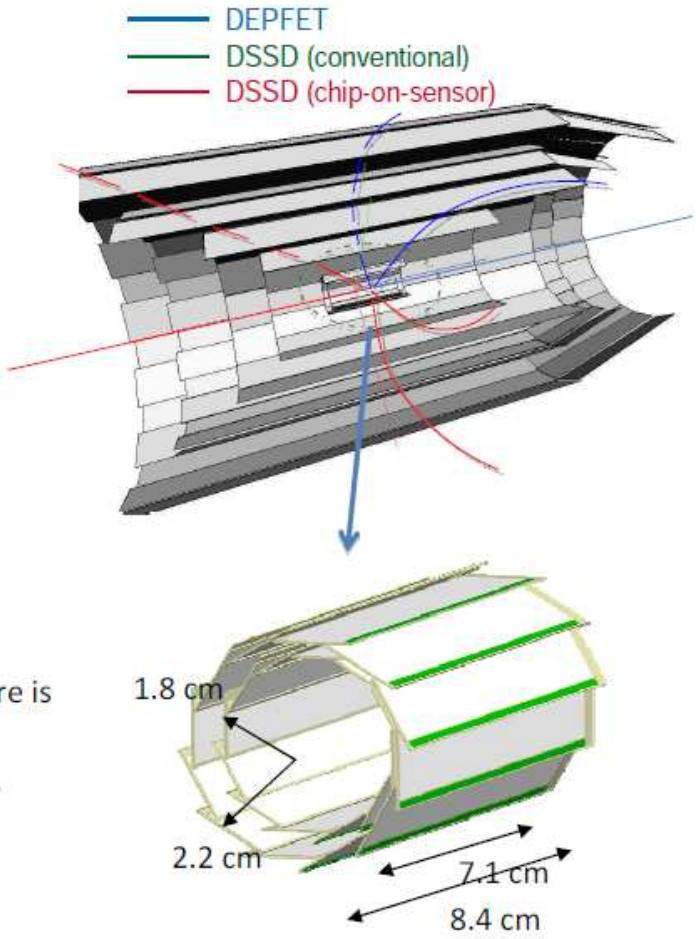


Vertex Detector

Belle vertex detector



- Measure the position of B decay vertices.
- 4 layers (Belle) → 6 layers (Super Belle)
- Outer radius 10 cm → 14 cm
  - Better tracking efficiency/ self tracking
  - Larger acceptance (x1.5 than Belle) for Ks
- Silicon strip layer (Layer 3-6)
  - R=4, 8, 12, 14 cm (Design not finalized)
  - 300 µm thick, double sided silicon strip detector.
  - Readout: APV25 ASIC
    - Developed for the CMS silicon tracker.
    - Radiation hard, short shaping time and pipelined readout.
- Pixel layer (Layer 1-2)
  - Pixel detector with DEPFET technology
    - Originally developed for the ILC vertex detector.
    - Modified readout scheme because the beam bunch train structure is different.
  - Thinned to 50 µm in order to minimize the multiple coulomb scattering.
    - Less material thickness than other active pixel technology.



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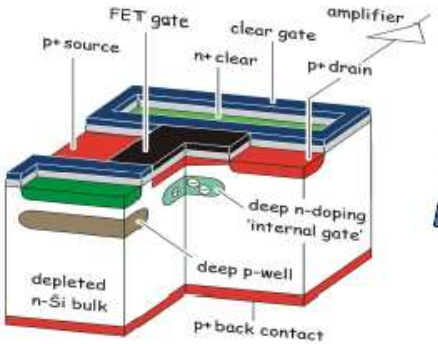
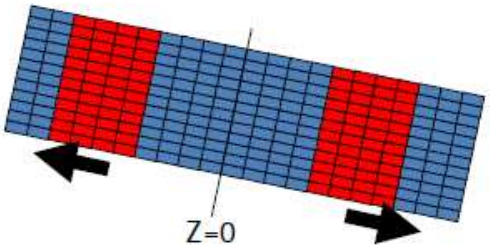
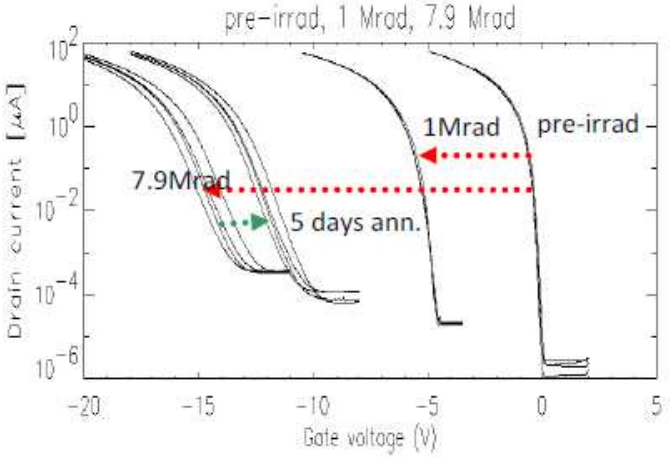
DEPFET Pixel Detector

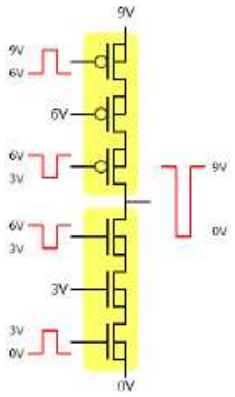
DEPFET collaboration

- DAQ scheme
  - KEKB: Collision occurs every 2 nsec.
  - Continuous, high-bandwidth readout is necessary
  - Column parallel, 4-fold readout is necessary in order to readout a sensor < 10 µsec, KEKB revolution.
- Immunity to total integrated dose.
  - DEPFET sensor.
    - Operation voltage shift due to induced charge in the gate silicon oxide.
    - For 7.9 Mrad
      - Threshold voltage (Vth): 0 → 13 V.
      - Slope: 100mV/decade → 650 mV/decade.
      - Variation of V(th) : ~ 1V.
    - A new batch with thinner SiO_2 is in preparation.
      - Far better result is expected from previous experiences.
  - Support chips
    - DEPFET needs high-voltage clocks for readout and reset the charge in the cell.
    - 10 V clock can be generated with the 0.35 µm technology by a new circuit design.









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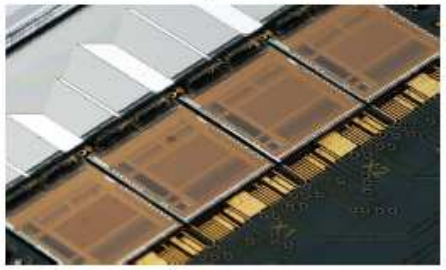
Silicon Strip Detector

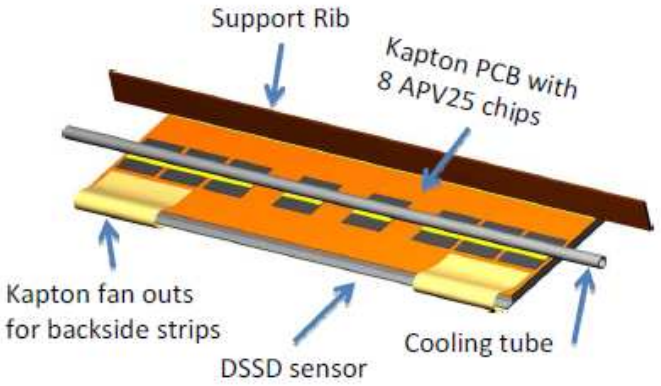
Silicon Vertex detector group

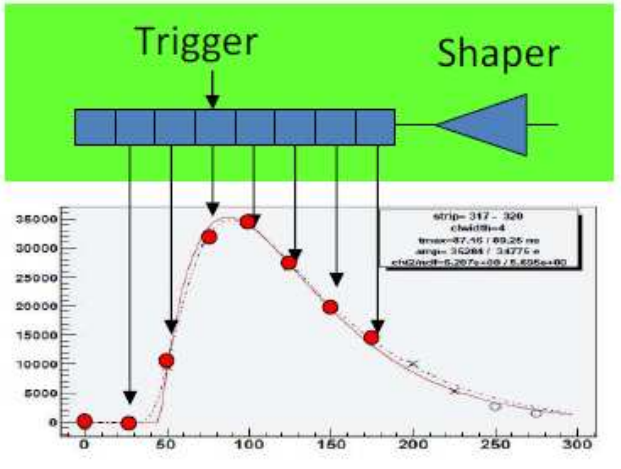
KEK, Niigata U., IFJ Krakow, HEPHY Vienna, Hawaii U., JSI Ljubljana, Kyungpook U., Tata Institute, Karlsruhe U., Tokyo U., Osaka U.

- Chip-on-sensor configuration
  - Both sides of DSSD sensors are readout with single flexible APV25 hybrid.
  - Parasitic capacitance is minimized resulting a high S/N.
- Reconstruction of hit timing using waveform digitization.
  - The analog date in the APV25 pipe line is fitted to a waveform.
  - Time resolution as good as 2nsec has been achieved.
- Sensor R&D
  - Detector thickness < 300 μm for reasonable vertex resolution.
  - Sensors from 6" allow design flexibility.
  - DSSD source other than HPK?
    - Companies: Micron, SINTEF
    - Research institutes: Kyungpook Univ., Tata Institute.

APV25 chips (8x7 mm^2)







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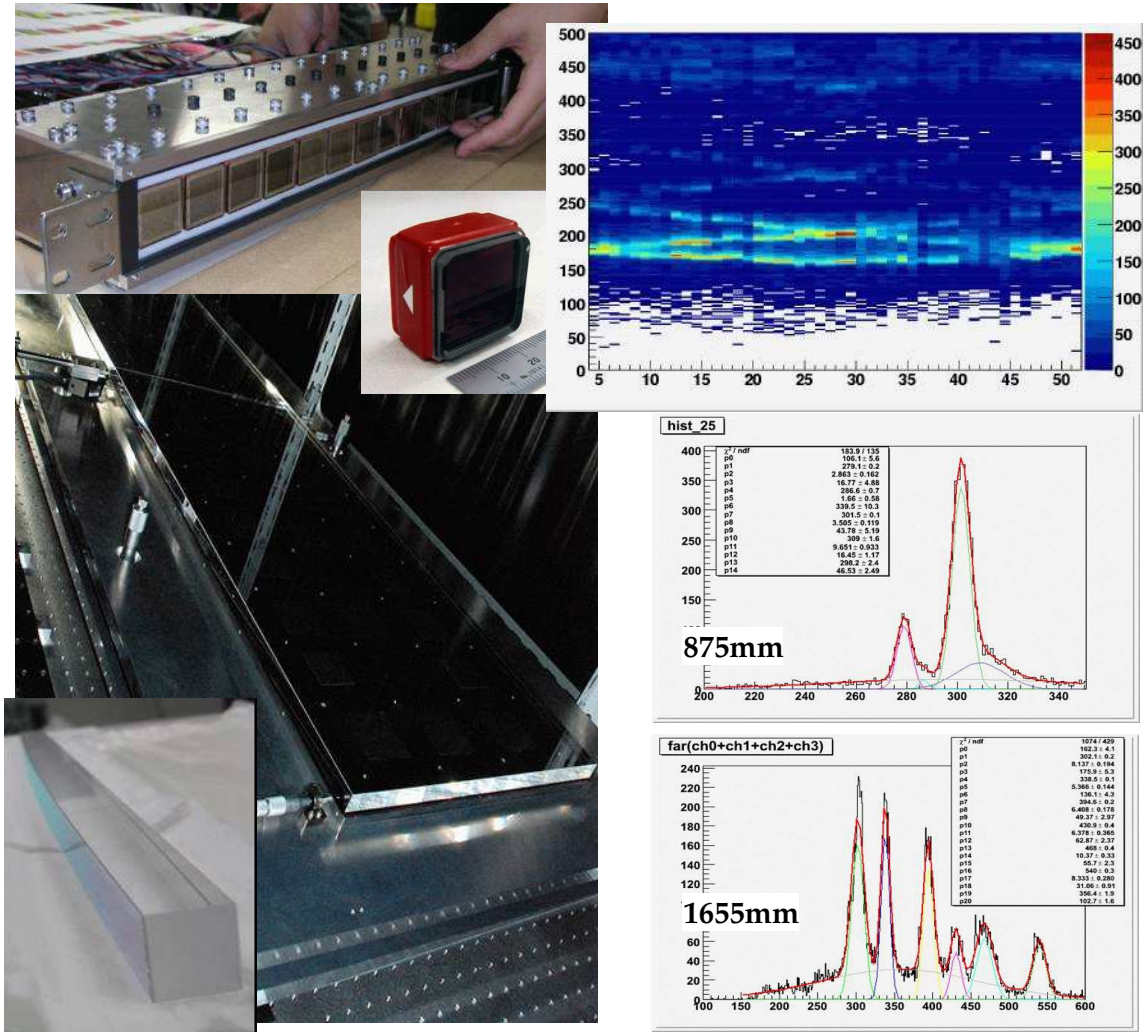
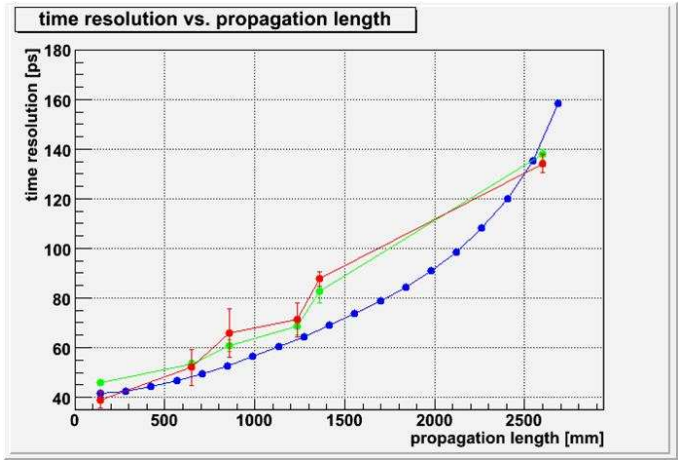
Barrel PID TOP (Time-Of-Propagation)

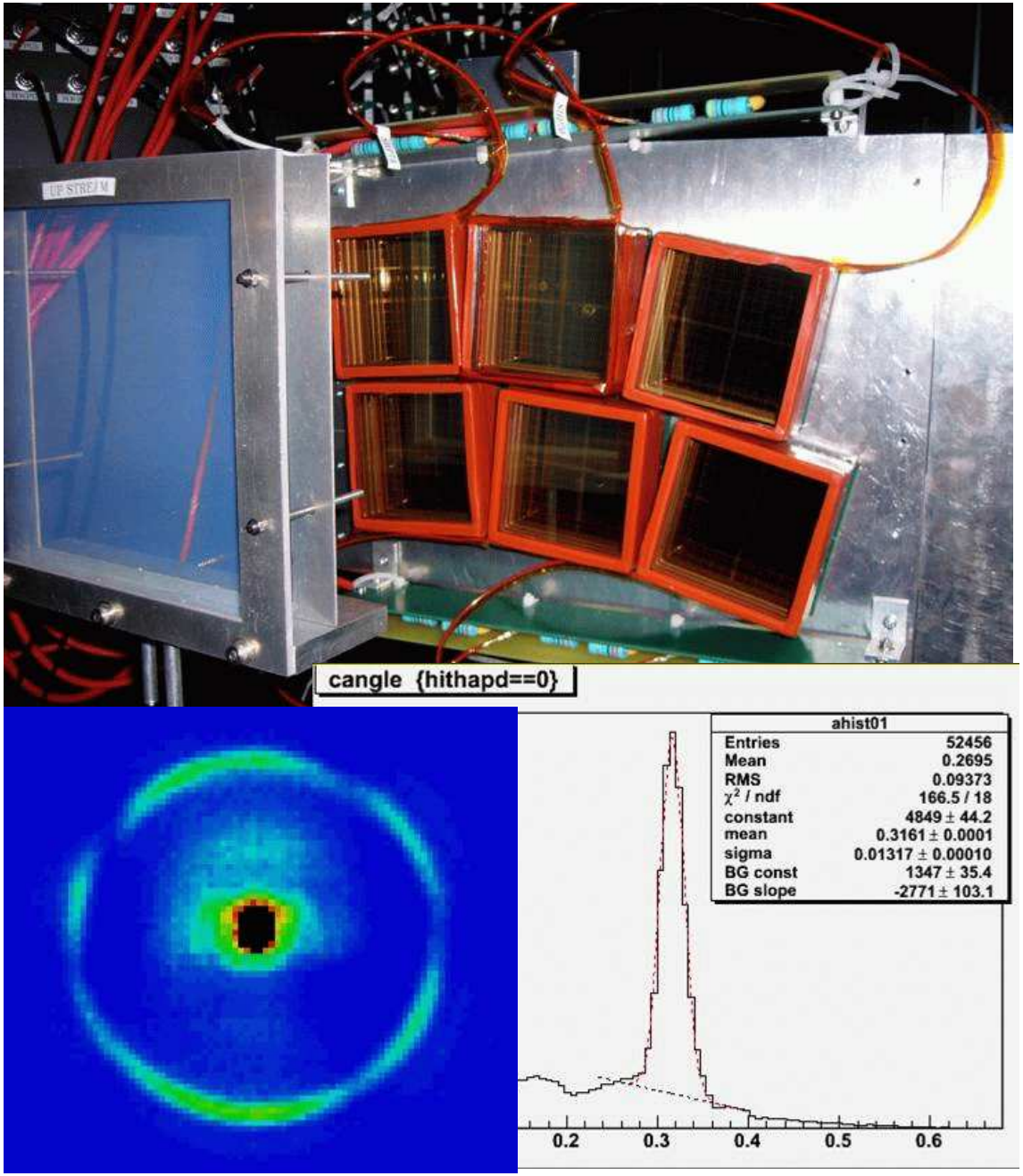


- Complete/realistic prototype
  - MCP-PMT
  - Focusing Mirror
  - Container
  - Amp+CFD
    (constant fraction discriminator)
- Test at KEK Fuji beam line (2 GeV e^-)



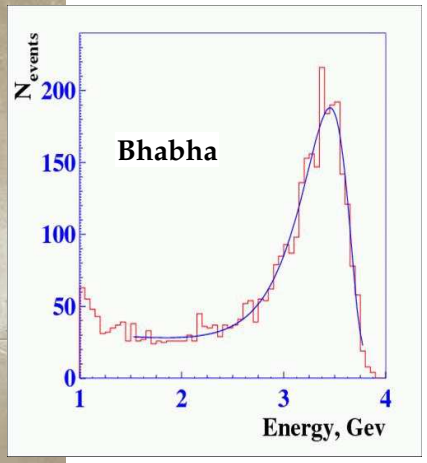
- Timing Resolution as expected

Endcap PID ARICH (Aerogel Ring Image CHerenkov)



- Focusing Radiator
- Six 144ch HAPD
  (Single Photon Sensitive)
- dedicated readout ASIC
- Test at KEK Fuji beam line (2 GeV e^-)
  - Cherenkov Ring observed
  - 6 p.e./track
  - 13.2 mrad Resolution obtained

ECL



- TKO Waveform Digitizer
- Waveform Fitting in COPPER
- Installed in Endcap for Test
  - Took Data for 1 week
  - Energy Reconstruction confirmed
- VME Version first prototype

Belle Physics Highlights

from our
52 published Journal papers
and
32 conference contribution papers

Pure Leptonic B decay $B \to \tau\nu$ with semileptonic Tag

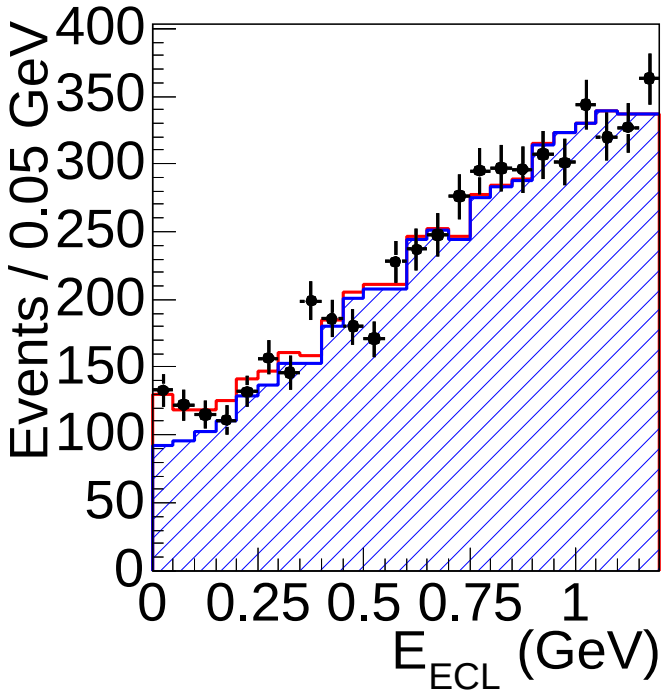
- Confirmation of $B \to \tau\nu$ search Hadronic Mode, PRL 97, 251802 (2006)
- require semileptonic decay in other B
  - exclusive reconstruction of $B \to D^{(*)}\ell\nu$
- 657 Million $B\overline{B}$
- No additional activity in ECL

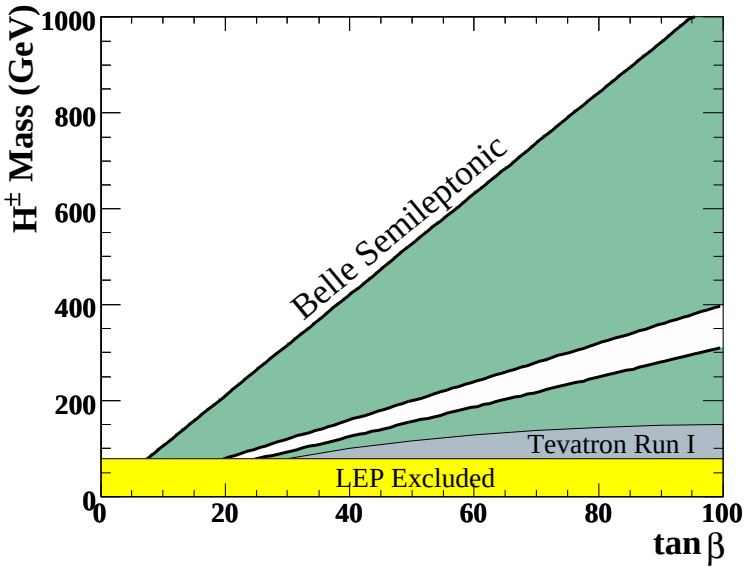
$$N_{sig} = 154^{+36}_{-35}(stat.)^{+21}_{-22}(syst.)$$

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

- 3.8 σ excess
- consistent with hadronic tag result

arXiv:0809.3834

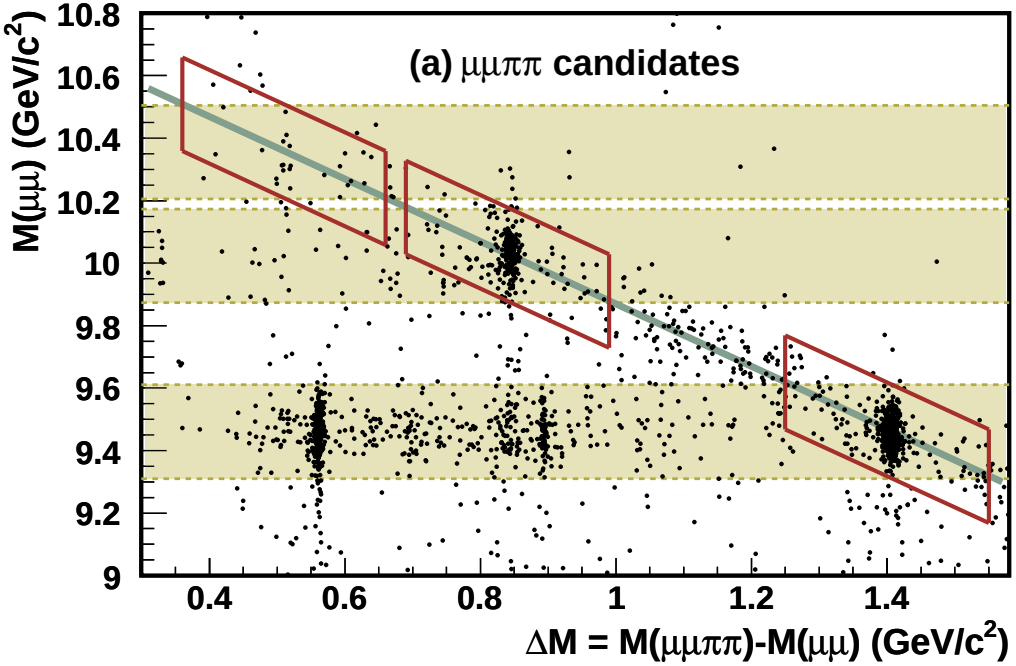




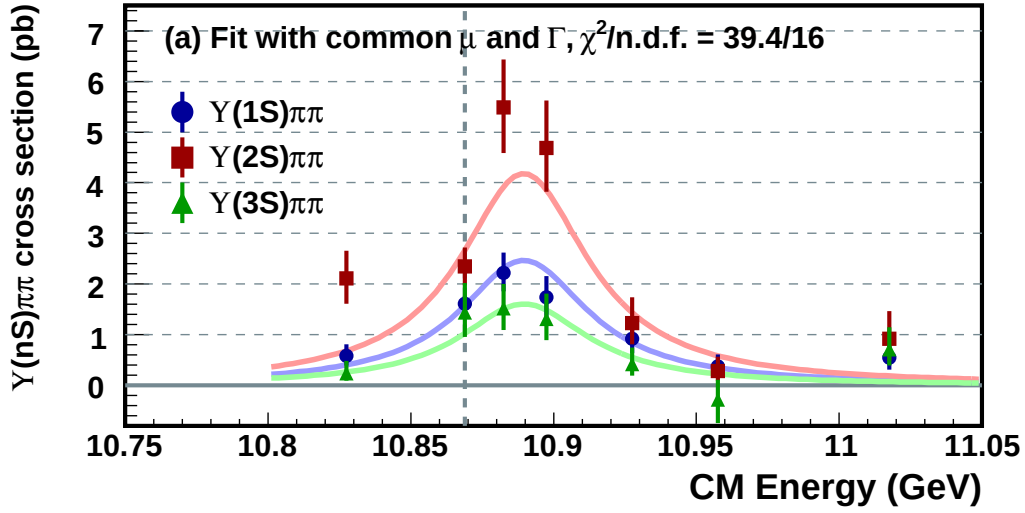
- constrain in SUSY parameter

"Υ(5S)"→ Υ(nS)$\pi^+\pi^-$

PRL 100, 112001 (2008)



arXiv:0808.2445



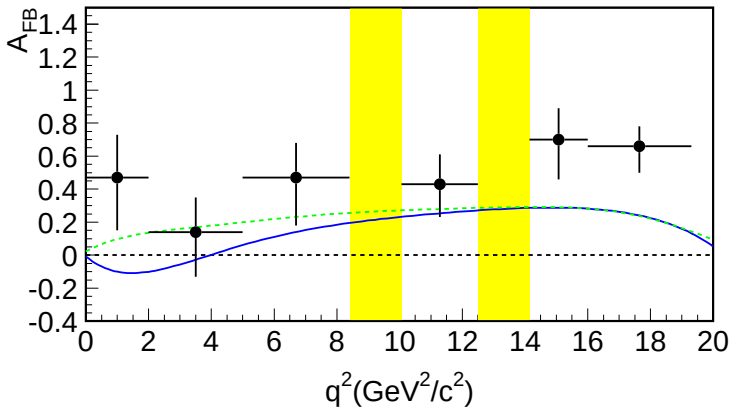
- Measurement of Process $e^+e^-\rightarrow$"Υ(5S)"→ Υ(nS)$\pi^+\pi^-$
- Anomalously large width observed only in "Υ(5S)"

	Γ_{total}	$\Gamma_{\Upsilon(nS)\pi^+\pi^-}$
Υ(2S)	0.032 MeV	60 keV
Υ(3S)	0.020 MeV	9 keV
Υ(4S)	20.5 MeV	19 keV
"Υ(5S)"	110 MeV	590 keV

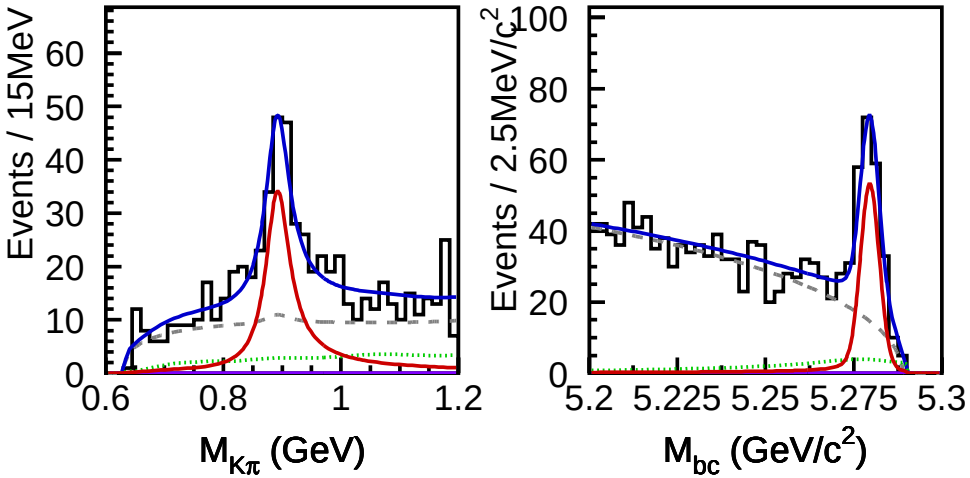
- Dedicated scan performed
  - 10 $\sqrt{s}$ points
  - 7.6 fb^{-1}
- Mass Peak at 10889.6±2.3 MeV
- different from Υ(5S) (10865±8 MeV)
- Analogous to Y(4260) for charmonium

Properties of $B \to K^{(*)}\ell^+\ell^-$ decay

- Loop process ⇒ sensitive to New Physics
- Major Topic in Super B Factory
- Many K, K* decay modes
  $K^+\pi^-$, $K^0_S\pi^+$, $K^+\pi^0$ and K^0_S
- + e^+e^- or $\mu^+\mu^-$
- 657 million $B\overline{B}$

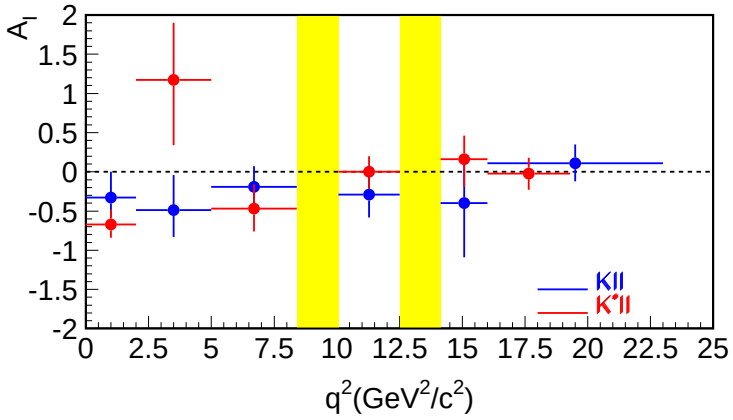


arXiv:0810.0335v1



	N_{sig}	$\mathcal{B}(\times 10^{-7})$
$B \to K^*\ell^+\ell^-$	230^{+24}_{-23}	$10.8^{+1.1}_{-1.0} \pm 0.9$
$B \to K\ell^+\ell^-$	166^{+15}_{-16}	$4.8^{+0.5}_{-0.4} \pm 0.3$

- $\mathcal{A}_{FB}$ deviates from the SM?

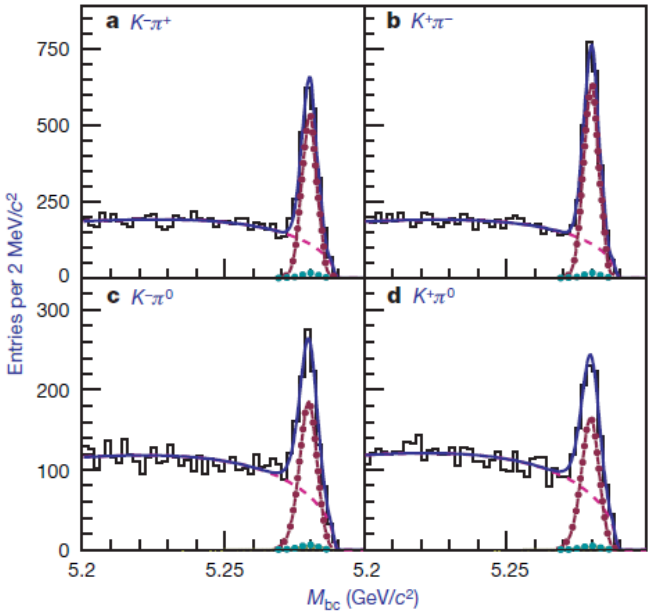


- Isospin symmetry consistent with 0?
- **Need More Luminosity**

$B \to K\pi$ Puzzle in Nature

- Paper published in Nature

Nature Vol.452 20 March 2008



$$\mathcal{A}_{K^\pm\pi^\mp} = \frac{N(\overline{B}^0 \to K^-\pi^+) - N(B^0 \to K^+\pi^-)}{N(\overline{B}^0 \to K^-\pi^+) + N(B^0 \to K^+\pi^-)} = -0.094 \pm 0.018 \pm 0.008$$

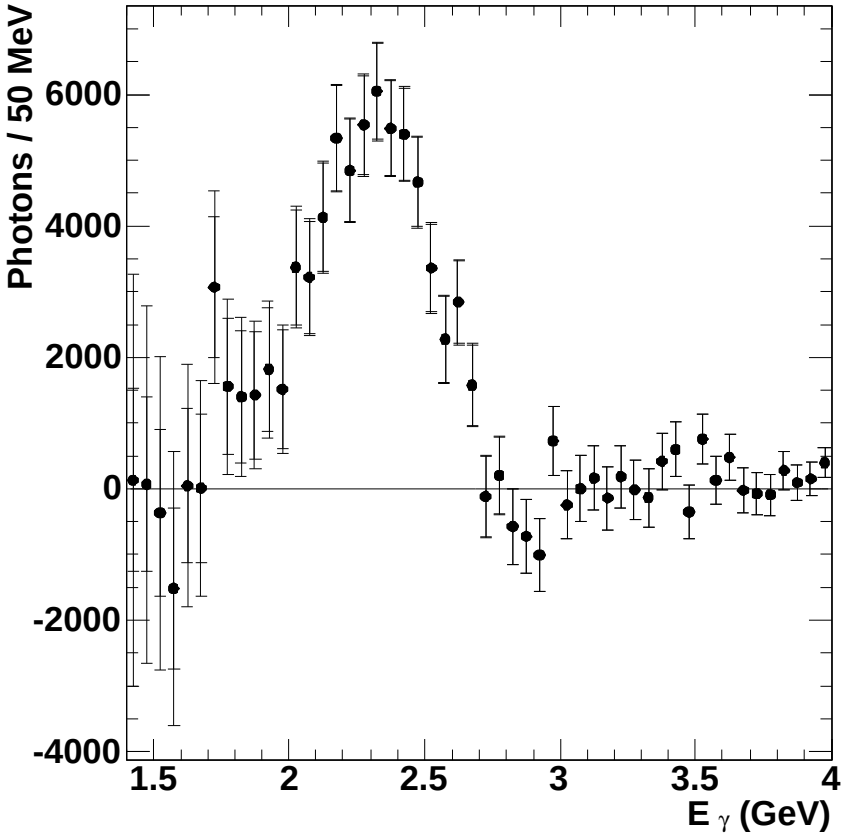
$$\Delta\mathcal{A} \equiv \mathcal{A}_{K^\pm\pi^0} - \mathcal{A}_{K^\pm\pi^\mp} = +0.164 \pm 0.037$$

- both more than 4 σ significant
- These significant deviations indicate,
  - missing knowledge of strong interaction,
  - Something "unknown" in loop diagram, or
  - Possible New source of CP violation

Inclusive B → $X_s\gamma$

- Full usage of 657 milion $B\overline{B}$
- E_γ Cut lower to 1.7 GeV

arXiv:0804.1580



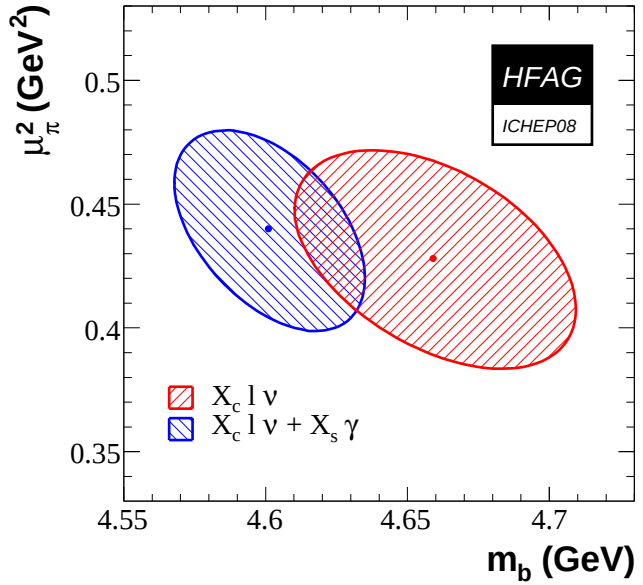
$$\mathcal{B}(B \to X_s\gamma) = (3.31 \pm 0.19 \pm 0.37 \pm 0.01) \times 10^{-4}$$

- moments of E_γ spectrum

$$\langle E_\gamma \rangle = 2.281 \pm 0.032 \pm 0.053 \pm 0.002 \text{ GeV}$$

$$\langle E_\gamma^2 \rangle - \langle E_\gamma \rangle^2 = 0.040 \pm 0.016 \pm 0.02 \text{ GeV}^2$$

- important input for HQET parameters



- crucial for determination of V_{cb}, V_{ub}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