

The logo for HEPHY (Institut für Hochenergiephysik) is displayed in a large, white, outlined font. The background is a dark blue field filled with numerous small, glowing blue spheres and thin, white lines that radiate from a central point, resembling particle tracks or a network of connections.

# HEPHY

Institut für Hochenergiephysik

## The HEPHY Belle group

Christoph Schwanda

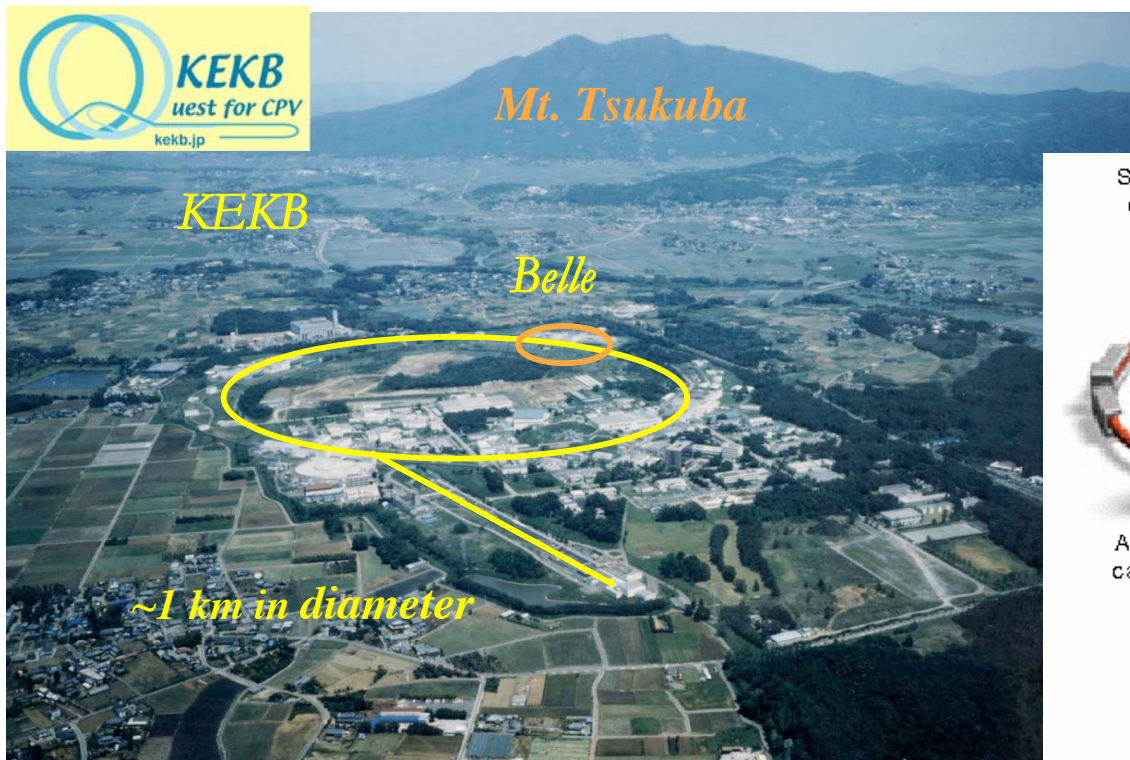
HEPHY Scientific Advisory Board Meeting

Oct. 1, 2008

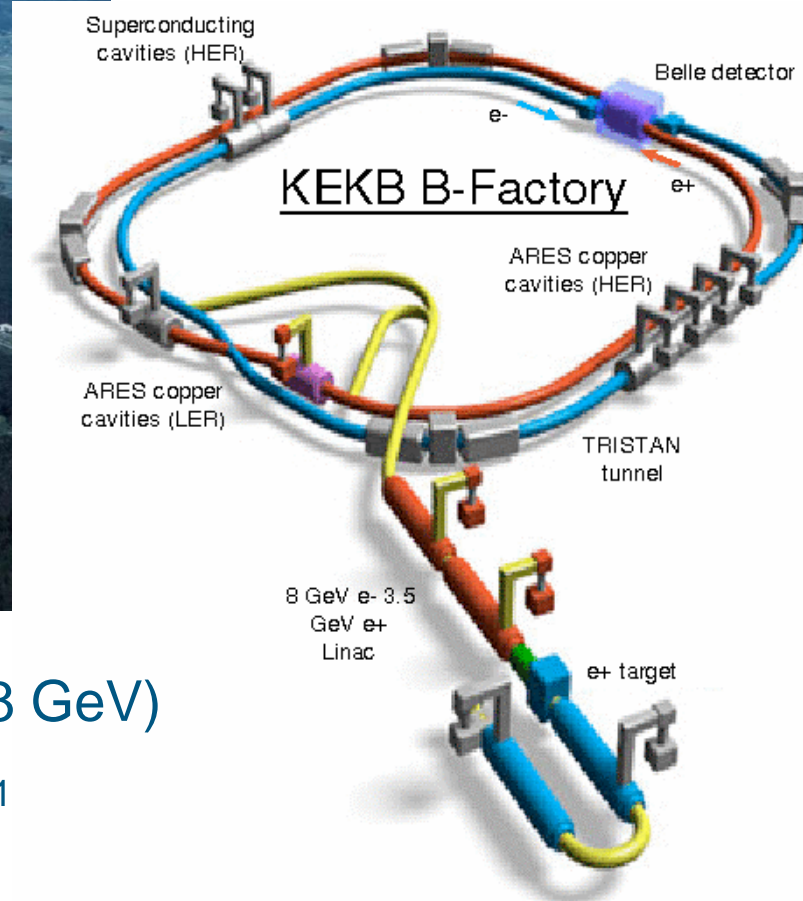
## The Belle experiment

- Belle is a **collider experiment** located at KEK, the Japanese national lab for particle physics in Tsukuba, 50 km from Tokyo
- Belle sits on the **KEKB asymmetric energy  $e^+e^-$  collider**, which has been operating since 1999
- It probes the flavor sector of the Standard Model, mainly through measuring **CP violation in B meson decays**

## KEKB and Belle @ KEK



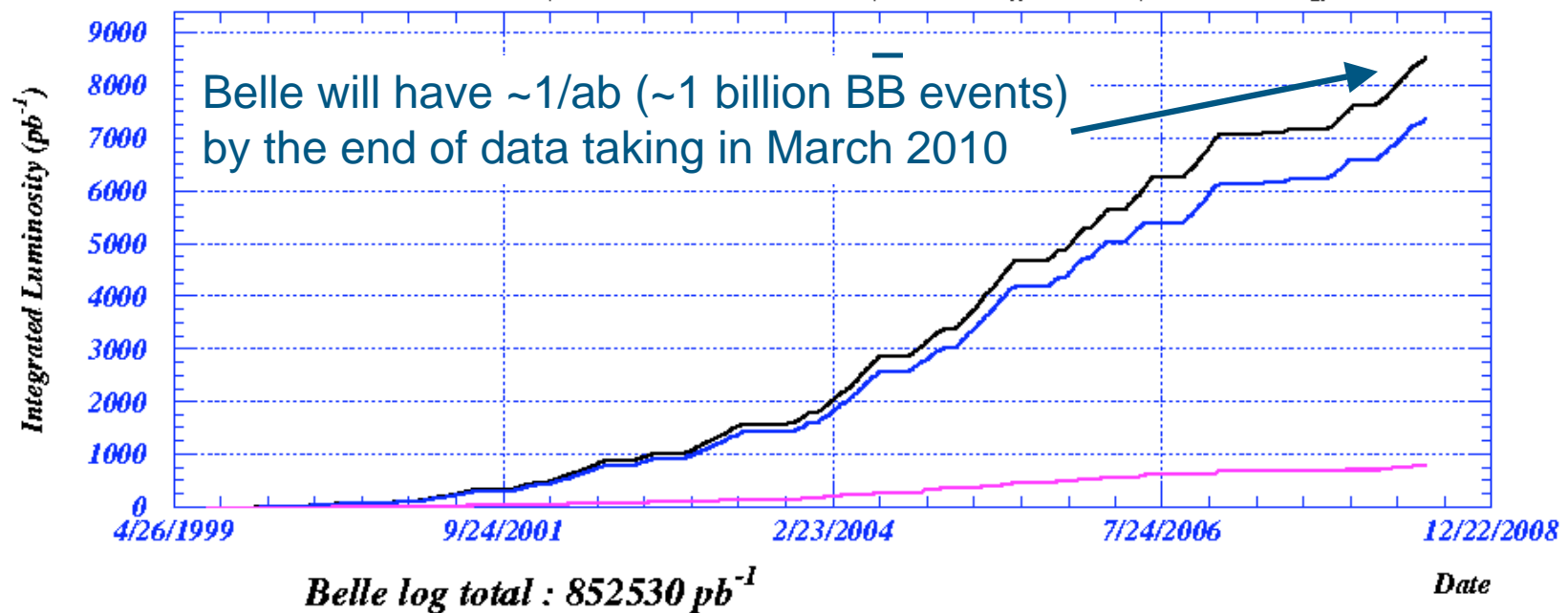
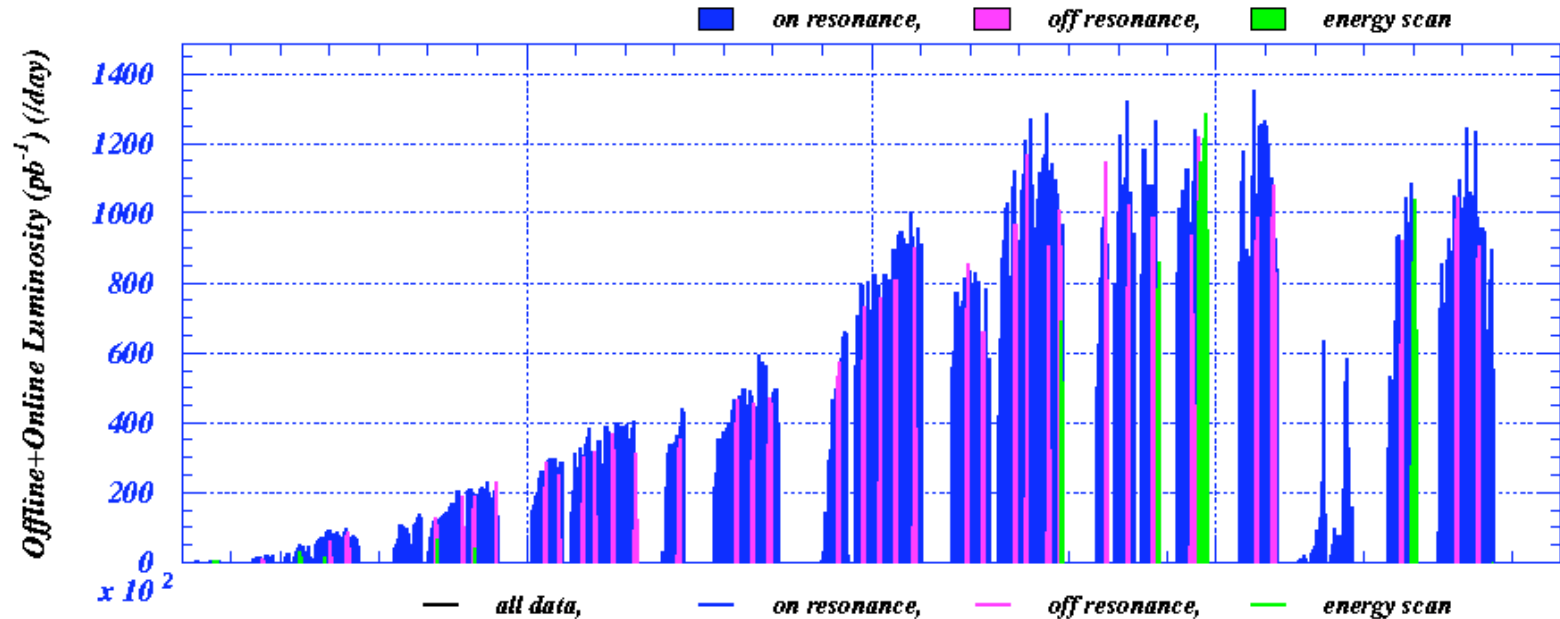
8 GeV  $e^-$  on 3.5 GeV  $e^+$

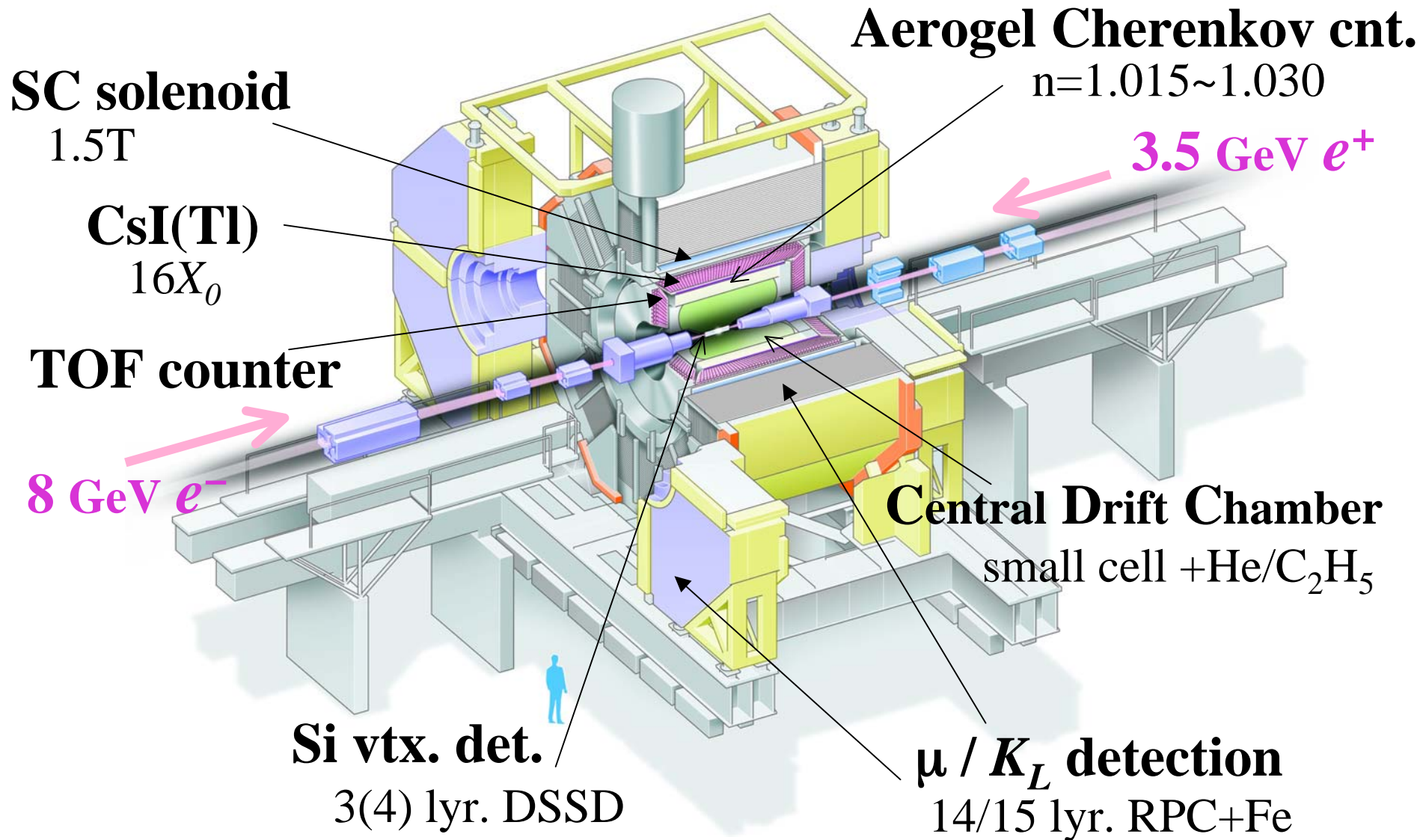


- Center of mass energy:  $Y(4S)$  (10.58 GeV)
- Peak luminosity:  $1.712 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$   
(design was  $10^{34} \text{ cm}^{-2}\text{s}^{-1}$ )

# Offline+Online Luminosity ( $pb^{-1}$ ) (/day)

2008/07/09 07.27





## The Belle collaboration



- 
- Aomori U.
  - BINP
  - Chiba U.
  - Chonnam Nat'l U.
  - U. of Cincinnati
  - Ewha Womans U.
  - Frankfurt U.
  - Gyeongsang Nat'l U.
  - U. of Hawaii
  - Hiroshima Tech.
  - IHEP, Beijing
  - IHEP, Moscow
  - HEPHY Vienna
  - ITEP
  - Kanagawa U.
  - KEK
  - Korea U.
  - Krakov Inst. of Nucl. Phys.
  - Kyoto U.
  - Kyungpook Nat'l U.
  - EPF Lausanne
  - Jozef Stefan Inst. / U. of Ljubljana / U. of Maribor
  - U. of Melbourne
  - Nagoya U.
  - Nara Women's U.
  - National Central U.
  - National Taiwan U.
  - National United U.
  - Nihon Dental College
  - Niigata U.
  - Osaka U.
  - Osaka City U.
  - Panjab U.
  - Peking U.
  - U. of Pittsburgh
  - Princeton U.
  - Riken
  - Saga U.
  - USTC



**13 countries, 55 institutes, ~400 collaborators**  
 plus Karlsruhe U., MPI Munich, Chennai and  
 Wayne U. (joined in summer 2008)

## The Cabibbo-Kobayashi-Maskawa mechanism

- Charged current interaction in the Standard Model

$$-\mathcal{L}_{W^\pm} = \frac{g}{\sqrt{2}} \overline{u_{Li}} \gamma^\mu (V_{CKM})_{ij} d_{Lj} W_\mu^\pm + \text{h.c.}$$

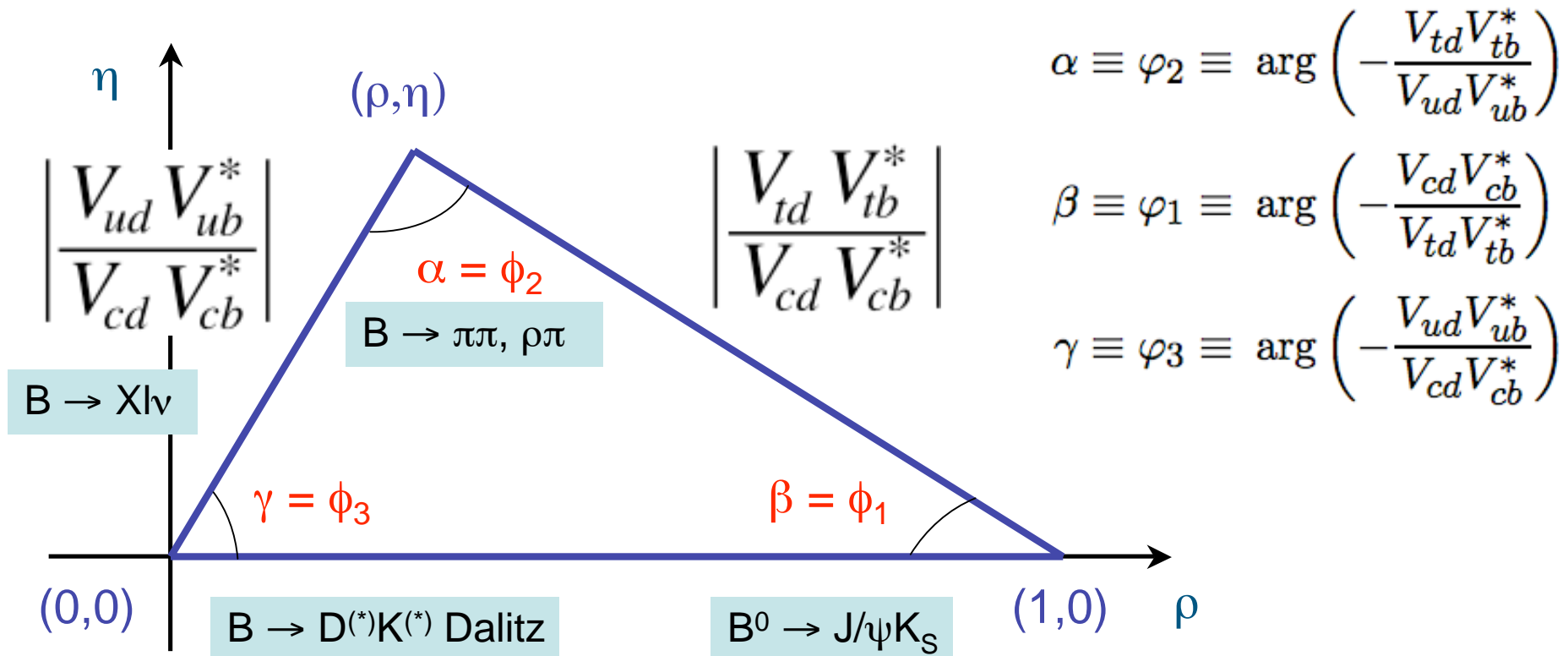
$$V_{CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

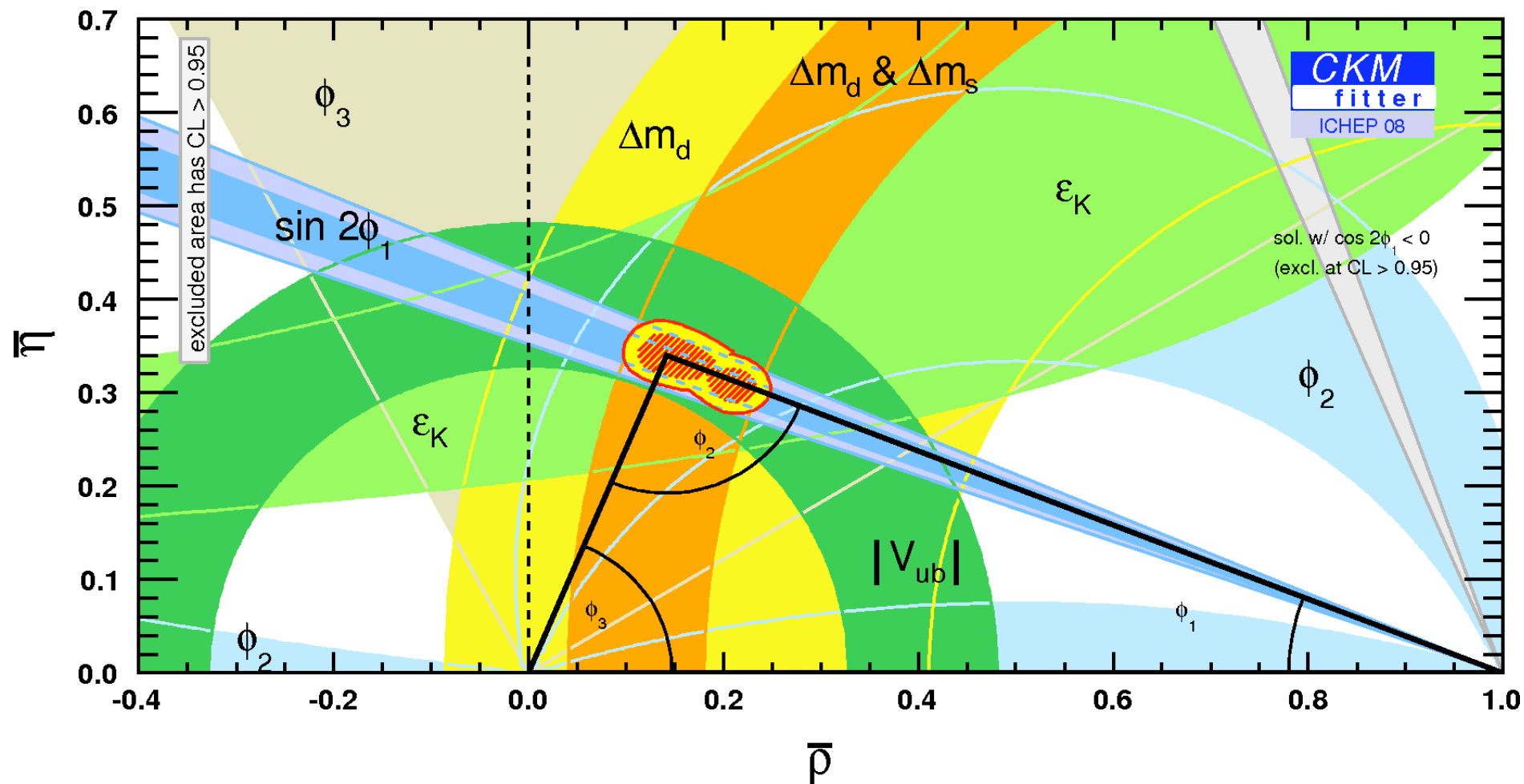
[Kobayashi, Maskawa,  
Prog. Theor. Phys. 49,  
652 (1973)]

- $V_{CKM}$  is the unitary 3x3 matrix of coupling constants of weak transitions
- It also contains the KM phase, responsible for all CP violating phenomena observed so far!

## The unitarity triangle

$$\sum_i V_{ij} V_{ik}^* = \delta_{jk} \Rightarrow V_{ud} V_{ub}^* + V_{cd} V_{cb}^* + V_{td} V_{tb}^* = 0$$





## List of Members

- Wolfgang Dungen, Ph.D. student
- Markus Friedl, electronics
- Christian Irmler, electronics
- Franz Mandl, physics analysis
- Winfried Mitaroff, physics analysis
- Manfred Pernicka, electronics
- \*Christoph Schwanda, physics analysis
- Laurenz Widhalm, physics analysis

## Belle physics output

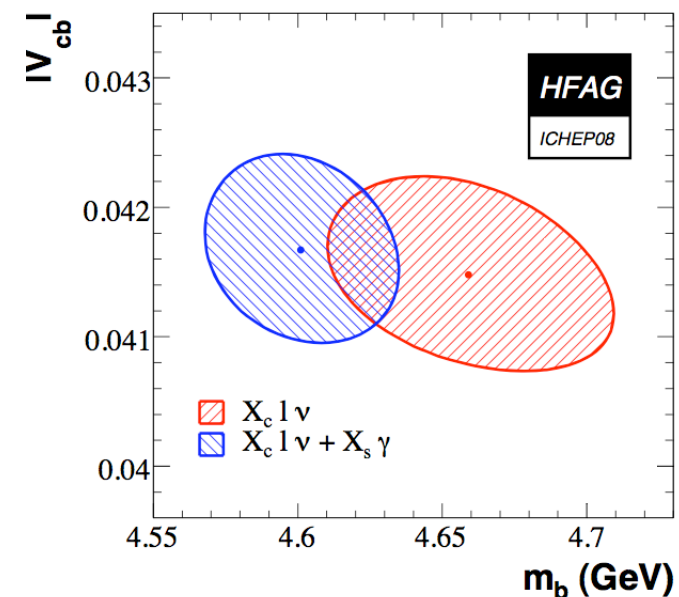
- As of today, there are **275 Belle papers** published mainly in Phys.Rev.Lett. and Phys.Rev.D; one paper published in Nature
- 5 Belle papers have a **Vienna first author**
- Number of Belle presentations by Vienna members at **international conferences/workshops**

year	2006	2007	2008
physics	5	4	4
instrumentation	2	2	3

## Our main fields of interest

- Semileptonic B decays ( $|V_{ub}|$ ,  $|V_{cb}|$ )
  - First observation  $B^+ \rightarrow \omega l^+ \nu$  [PRL93, 131803]
  - $|V_{cb}|$  inclusive [PRD75, 032005], [PRD78, 032016]
  - $B^0 \rightarrow D^{*} l^+ \nu$  ( $|V_{cb}|$  exclusive and form factors)  
[ICHEP08 prel.]
- I'm also convenor of the semileptonic decay group in Belle and co-chair of HFAG semileptonic

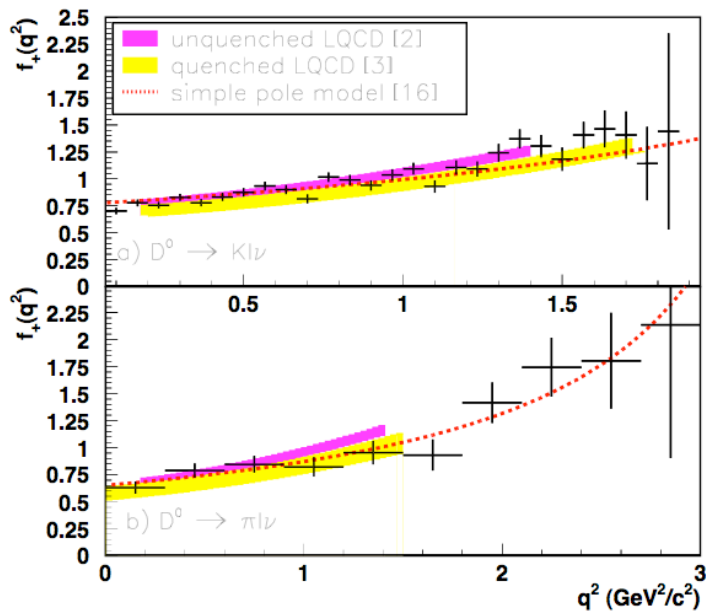
$|V_{cb}|$  and  $m_b$



- Charm decays

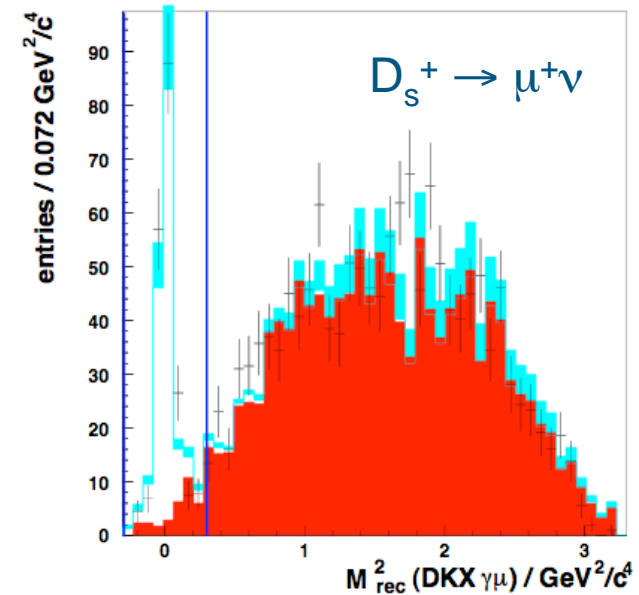
- $D^0 \rightarrow K^-(\pi^-)l^+\nu$  [PRL97, 061804]

- $D_s^+ \rightarrow \mu^+\nu$  [PRL100, 241801]



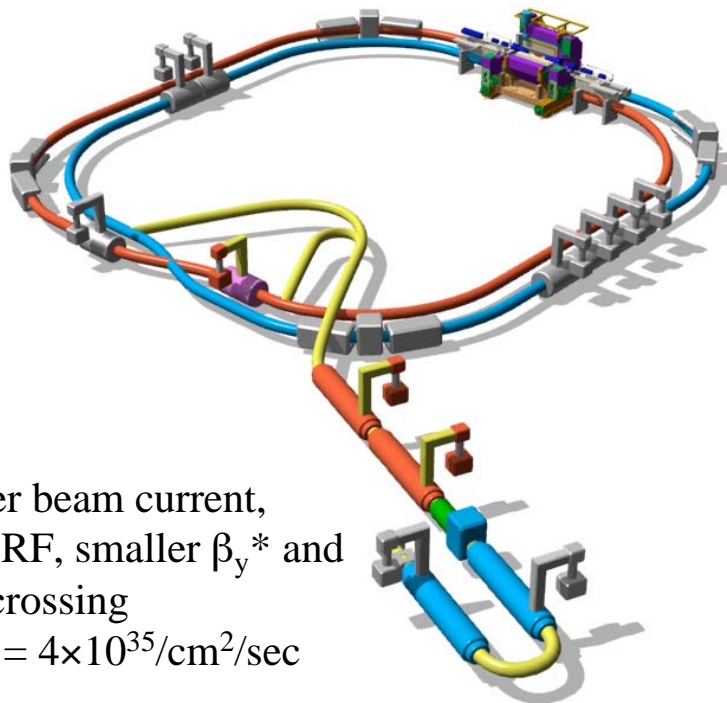
$D^0 \rightarrow K^-\ell^+\nu$

$D^0 \rightarrow \pi^-\ell^+\nu$

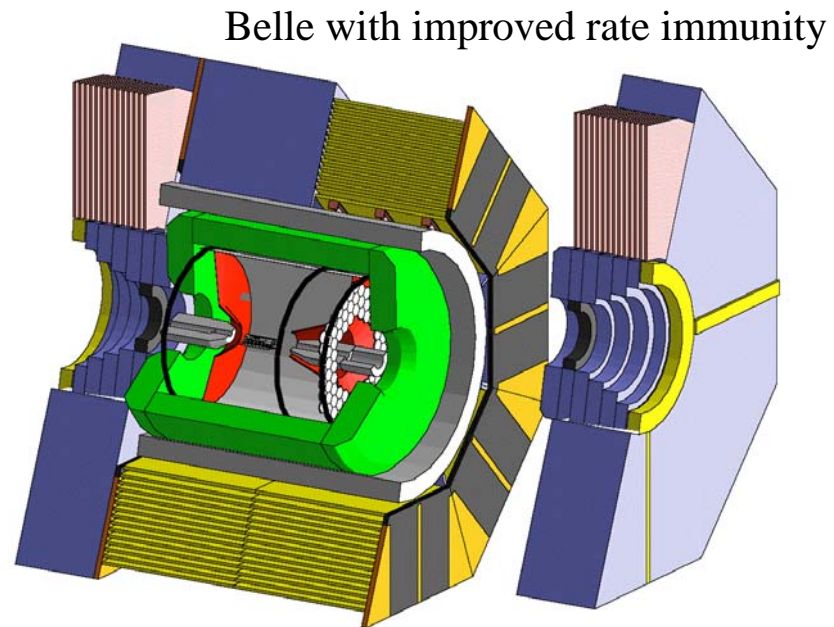


## KEKB/Belle upgrade

- Asymmetric energy  $e^+e^-$  collider at  $E_{CM}=m(\Upsilon(4S))$  to be realized by upgrading the existing KEBB collider.
- Super-high luminosity  $\cong 8 \times 10^{35}/\text{cm}^2/\text{sec} \rightarrow 1 \times 10^{10}$  BB per yr.  
 $\rightarrow 9 \times 10^9 \tau^+\tau^-$  per yr.

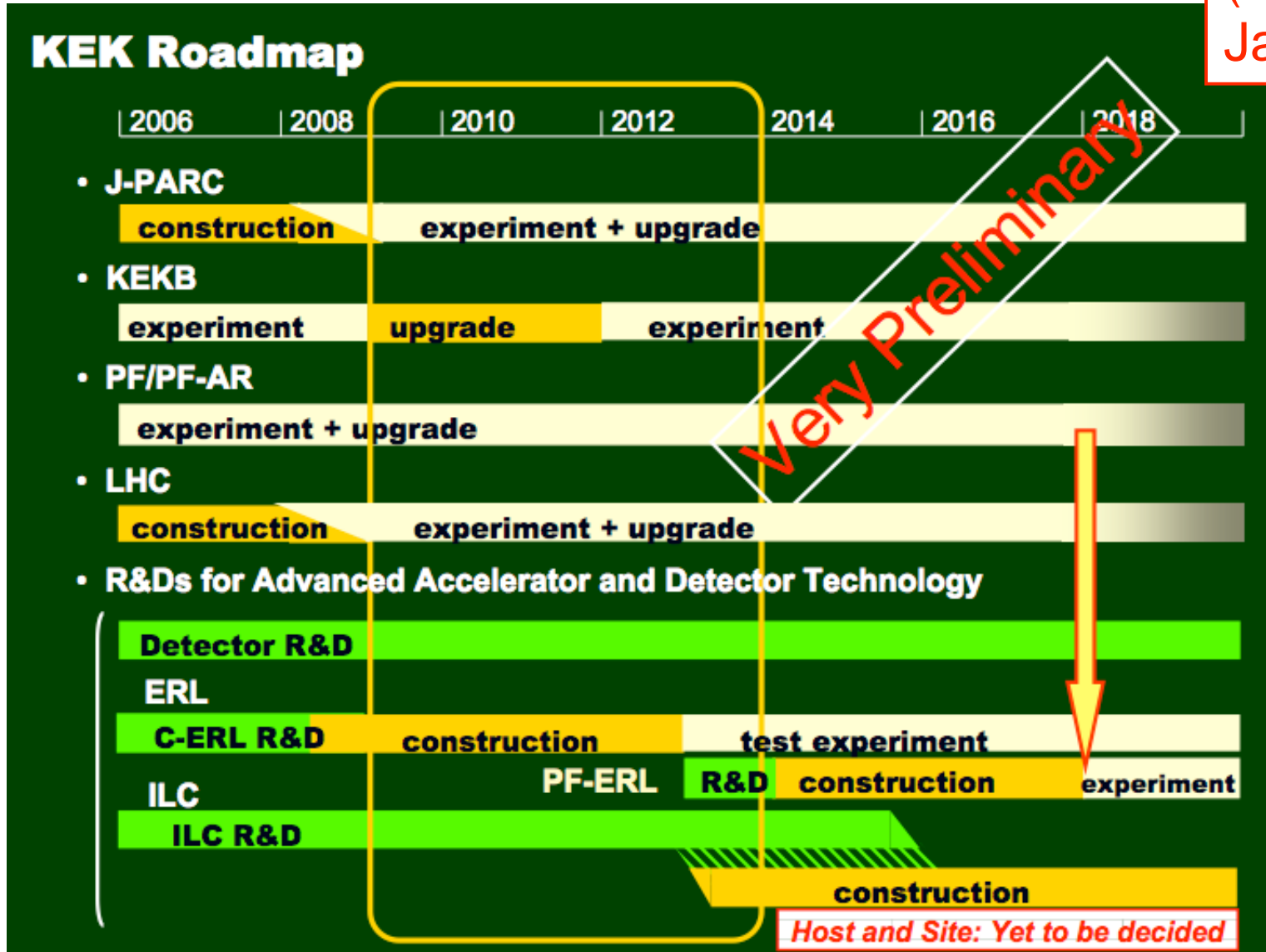


Higher beam current,  
more RF, smaller  $\beta_y^*$  and  
crab crossing  
 $\rightarrow L = 4 \times 10^{35}/\text{cm}^2/\text{sec}$



<http://belle.kek.jp/superb/loi>

A.Suzuki  
 (KEK DG)  
 Jan-4, 2008

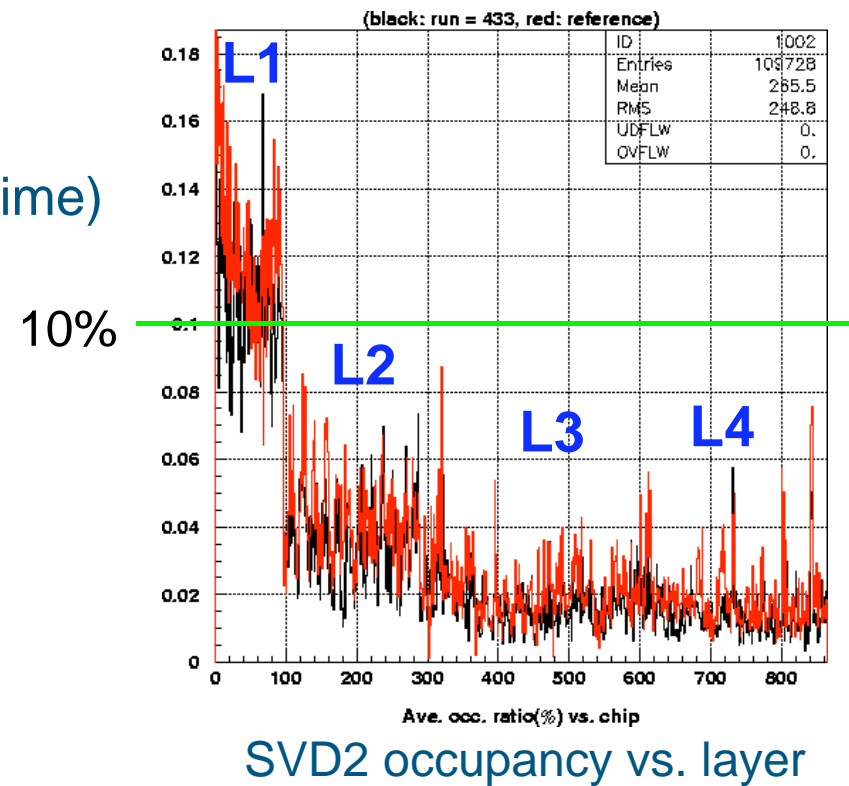


## Belle upgrade at Vienna

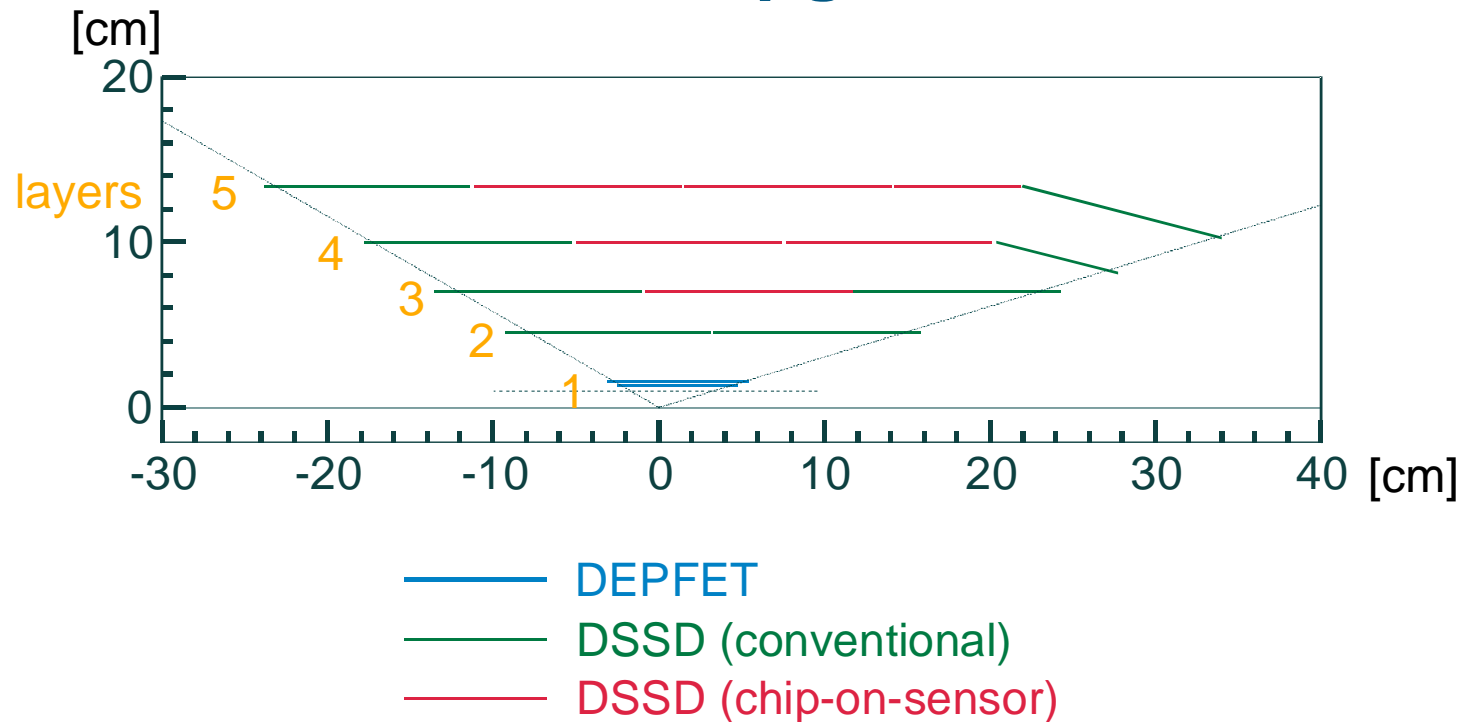
- The Vienna institute has expressed its **interest in the Belle upgrade**
- I'm a member of the Super-Belle Steering Committee (SBSC)
- We intend to make a significant contribution to the **upgrade of the Silicon Vertex Detector** (module design/production, readout)

## Belle Silicon Vertex Detector

- Present: SVD2 (installed 2003)
  - 4 layers, total of 246 double-sided silicon detectors (DSSDs)
  - Readout electronics (FADCs) built by the Vienna group
  - Extremely low material budget but slow readout (~800ns peaking time)



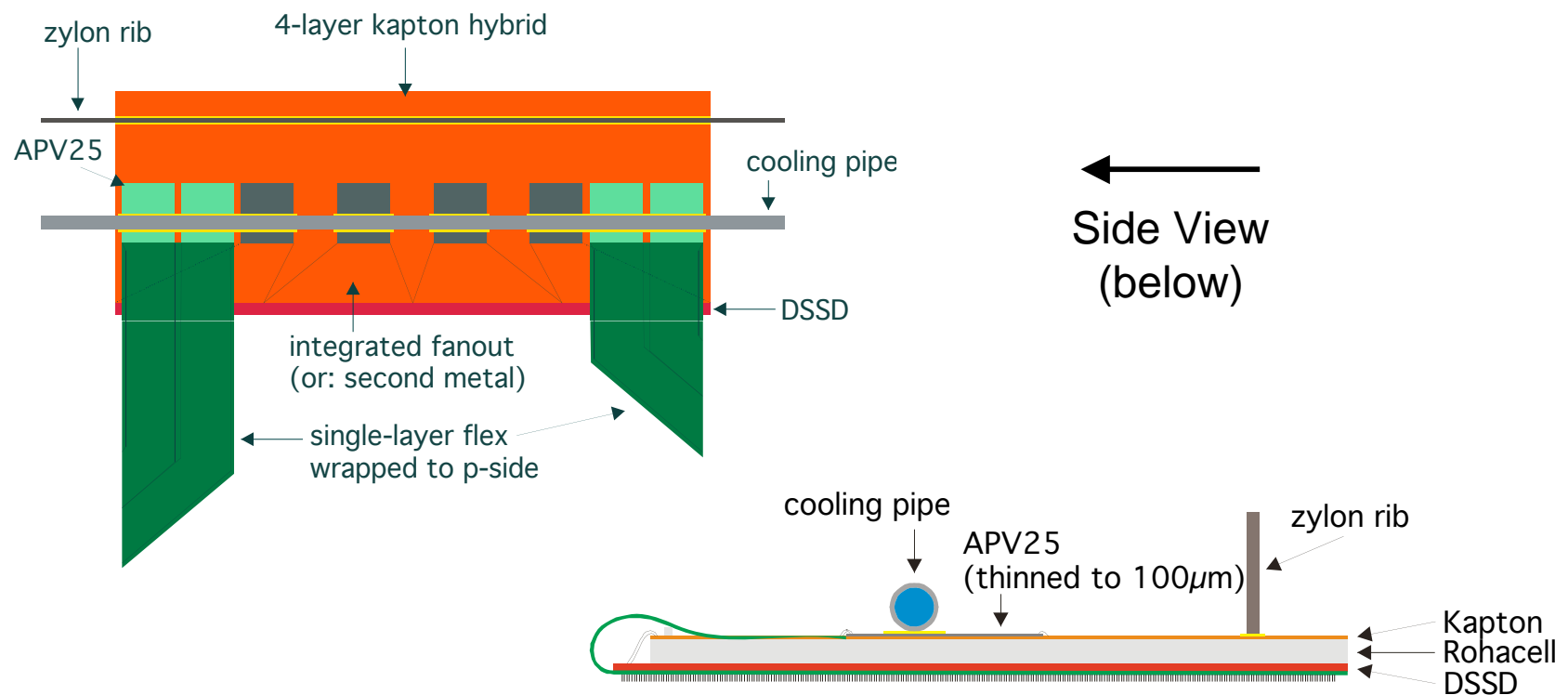
## SVD upgrade



- New readout chip: DSSD layers will be readout by APV25 chips (50 ns shaping time)
- Challenge: maintain good S/N, minimize material

## Vienna Origami Concept

- Extension of chip-on-sensor to double-sided readout
- All chips aligned on one side → single cooling pipe



## Summary

- Belle and KEKB are running successfully since 1999
  - The Vienna group has made significant contributions to both analysis and detector hardware
- The end of Belle data taking is foreseen for March 2010; the upgraded experiment will resume in April 2013
  - The Vienna group is heavily involved in the upgrade effort of the Silicon Vertex Detector