

# Discussion items

- Physics (1 slide)
- Accelerator (2 slides)
- Detector (3 slides)
- Funding/Politics (1 slide)

Picked a few items related to new developments. Since I have a small number of slides, please make comments and start discussion immediately.

# New Physics Signatures

(there are hints in the current data)

Author: Michael Peskin !!

Commentary on the Belle paper in Nature

Vol 452 | 20 March 2008

## NEWS & VIEWS

### PARTICLE PHYSICS

## Song of the electroweak penguin

Michael E. Peskin

An unexpected imbalance in how particles containing the heaviest quarks decay might reveal exotic influences — and perhaps help to explain why matter, rather than antimatter, dominates the Universe.

Here, in this issue, the Belle collaboration, based at the electron-positron particle collider of the high-energy collider laboratory KEK in Japan, announces their measurement of an anomalous asymmetry in the decay rates of exotic particles known as B mesons (Lin *et al.*, page 332). Combined with recent measurements of the same decays from the BaBar collaboration<sup>12</sup>, a similar experiment at the Stanford Linear Accelerator Center (SLAC) in California, the new finding provides a tantalizing glimpse of a possible new source for a very fundamental asymmetry: the dominance of matter over antimatter in our Universe.

The two great principles of modern physics, quantum mechanics and Einstein's relativity together imply that every particle in nature — among them the quarks and the leptons, the elementary particles of matter — has an antimatter counterpart with exactly the same mass, and exactly the opposite electric charge. Over the past 20 years, the theories of the weak and strong nuclear forces that have been built up on this basis have passed numerous rigorous experimental tests. The mathematical form of these theories allows little space for interactions that treat particles and antiparticles differently.

And yet the Universe, as far out as we can see, is made of matter, not of antimatter. We see no signs of the matter-antimatter annihilation that would happen on the edge of our local region if only this region were dominated by matter. So did the initial conditions of the Big Bang perhaps contain more matter than antimatter? It is possible. But in inflationary cosmology, the model that has successfully explained the large-scale distribution of matter in the Universe, any such initial asymmetry would have been erased very early on. We are forced to conclude that the current asymmetry has evolved from a asymmetric situation since the end of the cosmic inflation that followed the Big Bang. Nature, it seems, treats matter and antimatter differently.

In 1975, Makoto Kobayashi and Toshihide Maskawa pointed out that a term could be added to the theory of the weak interaction (which changes one type of quark to another, for example in a radioactive decay) to make this

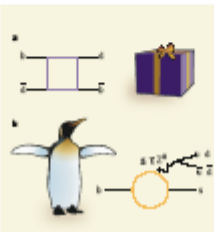


Figure 1 | Weak quark-antiquark interactions. (a) A Feynman diagram represents the tree-level interaction of a quark-antiquark pair (shown here from left to right) via a standard 'tree' diagram of weak quark-antiquark interactions, a quark change type by exchanging a pair of particles, for example a heavy top (t) quark and a W boson, the intermediary of the weak force. Here, a B<sup>0</sup> meson (quark content b) converts into a B<sup>+</sup> (s, t, b). In a penguin process, the charge is quark type occurs via a particle loop, which connects via a gluon (heavy line), a photon, or Z boson (a 'strong penguin', a Z<sup>0</sup> or 'electroweak penguin', a γ or Z<sup>0</sup>) to a final particle. Here, for example, a B<sup>0</sup> or B<sup>+</sup> could be decaying into a K<sup>0</sup> (t, b) or K<sup>+</sup> (t, s), plus an additional t or c quark that combines with a s or d antiquark in the B meson. The other product is a s' or d' particle, which can have quark content a s' or d'. In both penguin and box processes, the particle types listed by the heavy lines (quarks, gluons, photons) could be any mixture of weak and exotic particles. Recent results from the Belle<sup>12</sup> and BaBar<sup>13</sup> collaborations led to the conclusion that penguin processes involving exotic particles are contributing to B-meson decays in their experiments. The overall mass of the penguin diagrams is a penguin is hard to discern. The ratio of the amplitude of the penguin process to the tree-level process is a ratio of the masses of the quarks and leptons. This difference would appear only if there were at least six types of quark.

This was a bold prediction, because at the

time only three types of quark were known: up (u), down (d) and strange (s). But in the following decades, three more were discovered: charm (c), and the heavy bottom (b) and top (t) quarks. This astounding success led to the proposal<sup>14</sup> that specific experiments on B mesons — quark-antiquark pairings in which one of the particles is a b quark or B anti-quark — could test the Kobayashi-Maskawa (KM) theory directly. The idea, proposed by Bar Okada<sup>15</sup>, that these experiments could be performed by colliding two beams of different energies, one of electrons and one of positrons (the antiquark of the electron), motivated the construction of new accelerators at KEK and SLAC. In 2002, both BaBar<sup>12</sup> and Belle<sup>13</sup> reported the first observation of a KM asymmetry in a B-meson decay.

Since then, evidence accumulated by BaBar and Belle, in a data set of more than 1.2 billion B-meson decays, has been used to fit the two crucial parameters of the KM theory to an accuracy of about 2%. Complementary measurements from other processes involving B mesons<sup>16,17</sup> have confirmed these parameters to accuracies of between 10% and 20%. It would seem that we are well on the way to understanding the basis of particle-antiparticle asymmetry in the early Universe.

In fact, we are not. The KM predictions depend crucially on the masses of the intermediate-mass s and c quarks. But the high temperature of the Universe just after the Big Bang makes these masses irrelevant in calculations of the cosmic-matter excess. The degree of asymmetry predicted by the KM model is ten orders of magnitude too small.

So where does this extra asymmetry come from? If we go beyond the standard picture of particle physics, there are many possible sources. For example, there might be new, heavier types of elementary particles beyond quarks and leptons. The search for these exotic particles is one motivation for building the Large Hadron Collider (LHC) which will soon begin operating at CERN near Geneva, Switzerland. Particle-antiparticle asymmetries are much easier to accommodate in the interactions of very heavy particles.

If these heavier particles exist, they could

## B → Kπ puzzle

Datta's slides

Table 1:

| Mode  | BR(10 <sup>-6</sup> ) | A <sub>dir</sub> | A <sub>mix</sub> (S) |
|---|-----------------------|------------------|----------------------|
| B <sup>+</sup> → π <sup>+</sup> K <sup>0</sup>              | 23.1 ± 1.0            | 0.009 ± 0.025    |                      |
| B <sup>+</sup> → π <sup>0</sup> K <sup>+</sup>              | 12.9 ± 0.6            | 0.050 ± 0.025    |                      |
| B <sub>d</sub> <sup>0</sup> → π <sup>-</sup> K <sup>+</sup> | 19.4 ± 0.6            | -0.097 ± 0.012   |                      |
| B <sub>d</sub> <sup>0</sup> → π <sup>0</sup> K <sup>0</sup> | 9.9 ± 0.06            | -0.14 ± 0.11     | 0.38 ± 0.19          |

### •Puzzles:

**Puzzle 1:**  $A_{dir}(B^+ \rightarrow \pi^0 K^+) = A_{dir}(B_d^0 \rightarrow \pi^- K^+)$  using isospin if electroweak penguins(EWP) are neglected. In the SM the EWP are not big enough to explain the data. Need new EWP to explain the data.

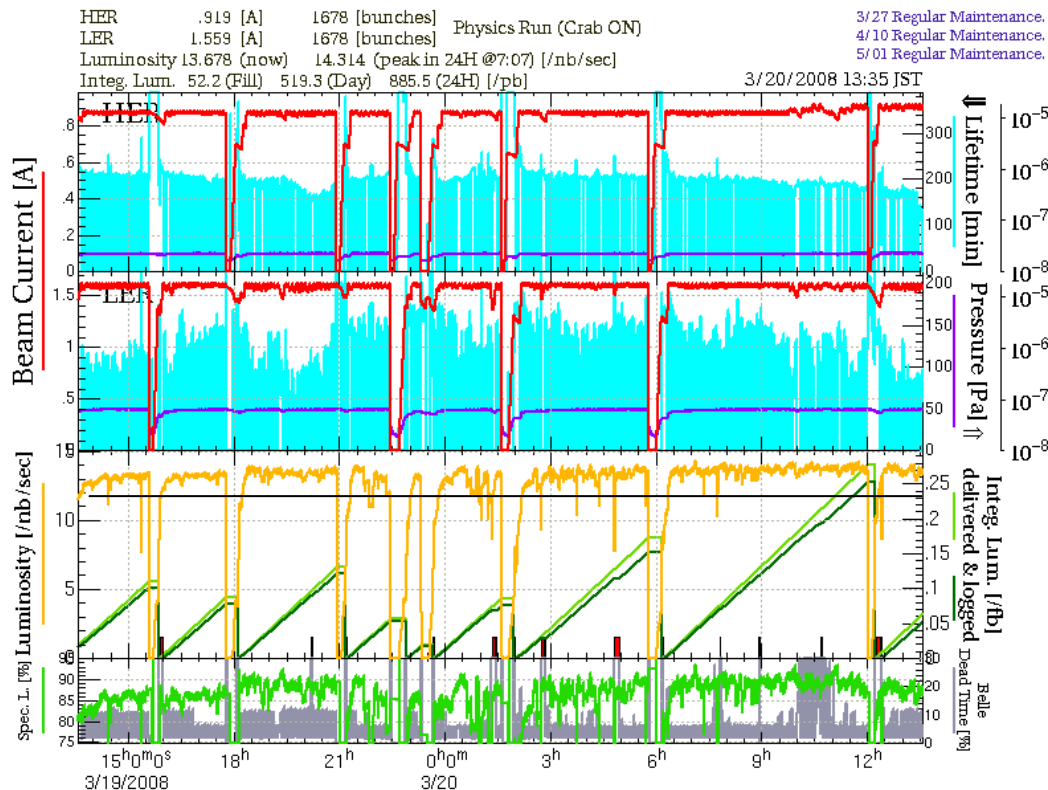
**Puzzle 2:**  $B_d^0 \rightarrow \pi^0 K^0$  is dominated by a single amplitude and so in SM and hence,

$A_{dir} = 0$  and  $A_{mix} = \sin 2\beta = 0.68 \pm 0.03$  in disagreement with data. Again need new EWP to explain the data.

# Discussion Items

Accelerator:

*Belle PAC recommended that we allow enough running time for crab cavity development. There was an apparent breakthrough in the past few days.*

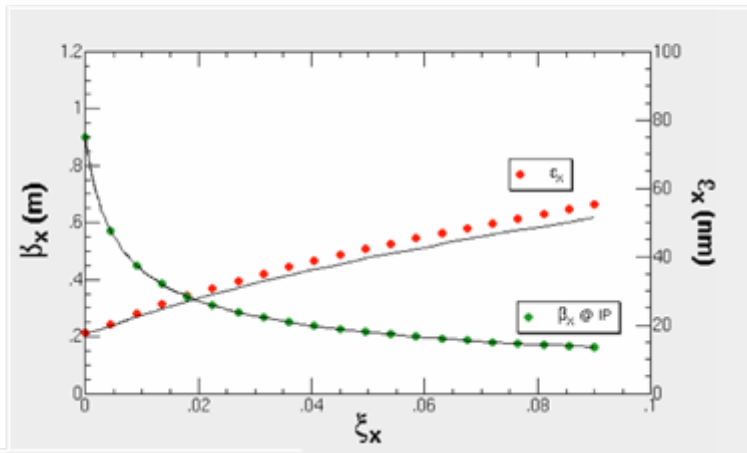


# Accelerator plan is becoming increasingly more realistic

Accelerator dynamic aperture:  
importance of dynamic emittance effect  
(close to  $\frac{1}{2}$  tune) rediscovered.

IR needs redesign will invade even more  
of the super Belle detector zone

## LER dynamic- $\beta$ and emittance



Electron Cloud  
countermeasures

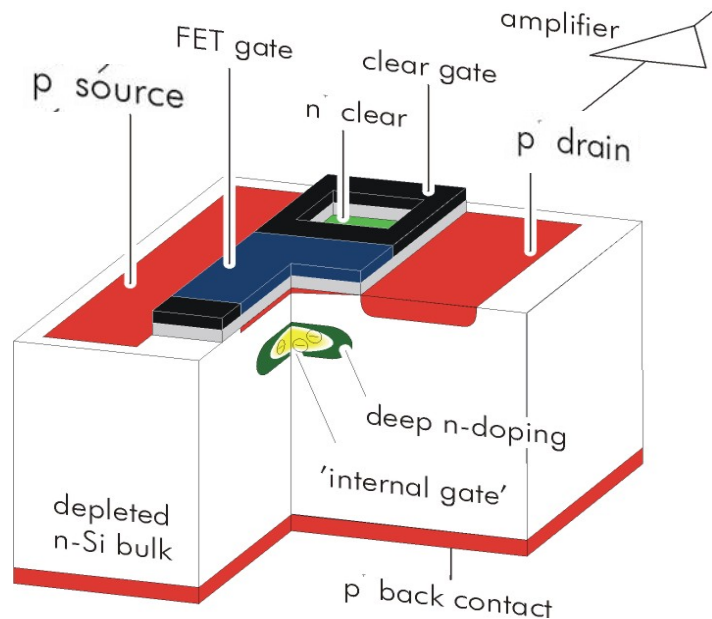


Test of ante-chamber  
in LER, good results



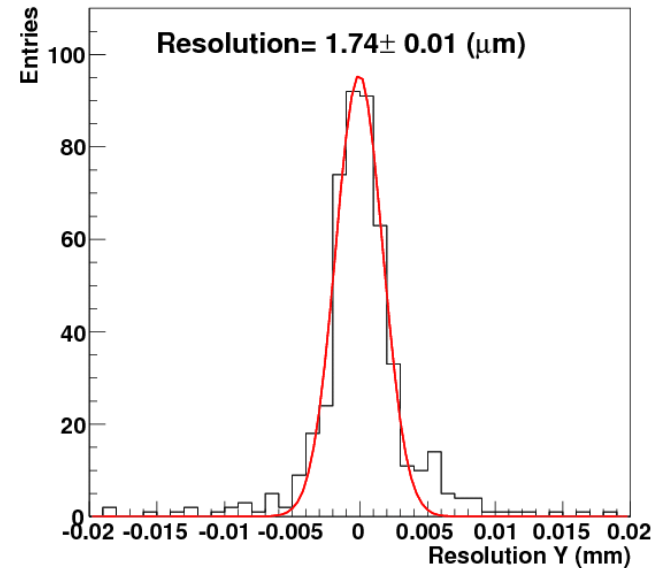
*IR interface beam background issues  
need more attention.*

# Some detector discussion items



DEPFET from MPI Munich a new and promising possibility for inner vertexing

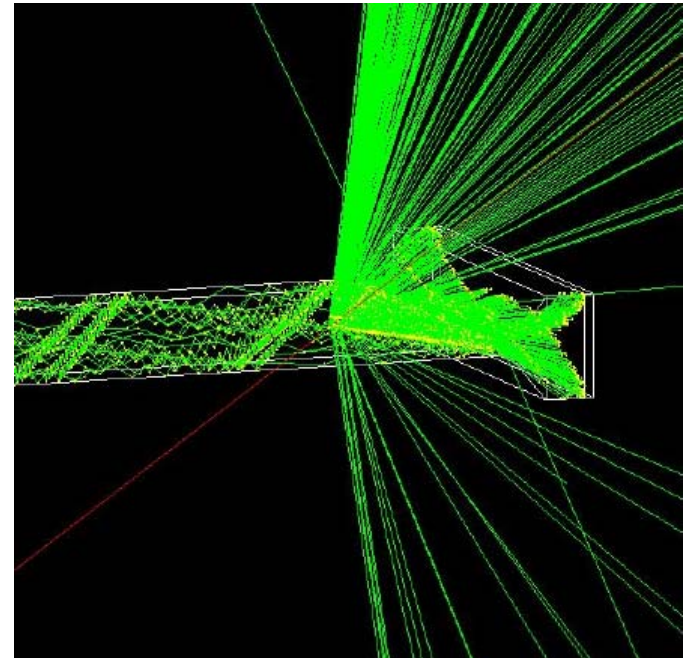
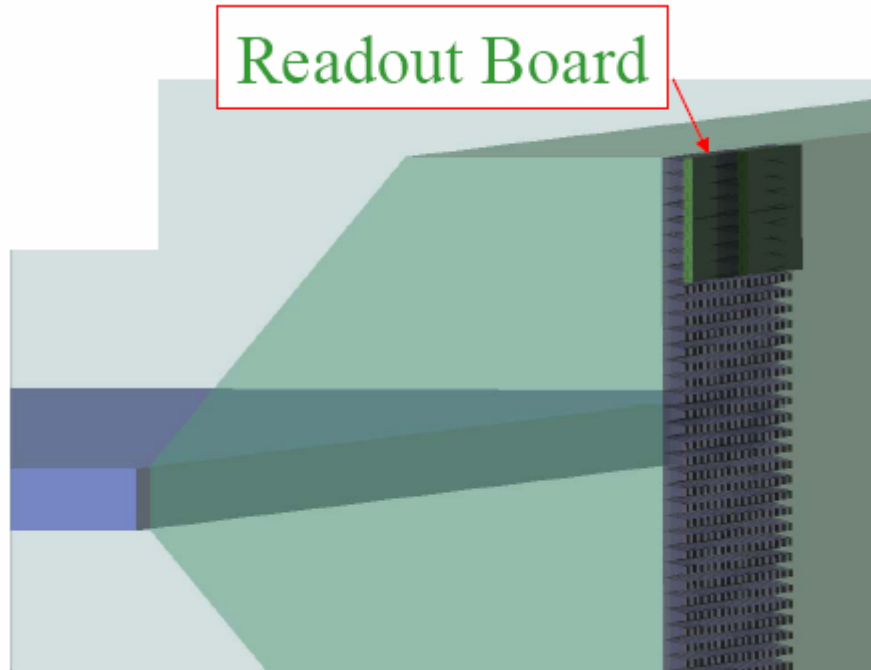
*Do we need a inner vertex detector shootout too ?*



DEPFET beam test results

Ans: No. We will take any pixel detector that works.

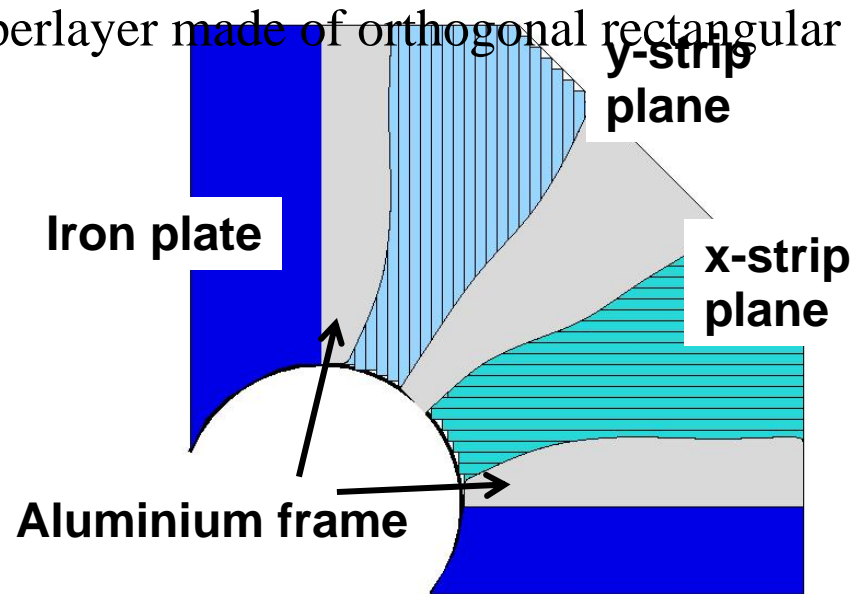
# PID detector discussion items



*PID will not be based on established technologies(TOP, iTOP, fDIRC). Will need a shootout to decide on barrel configuration and photodetectors*

# “Elegant RPC cannot survive at Super Schmulator based KL muon detector KEKB” – E. Nakano

- The geometry is fixed by the requirement to use the existing 4cm gaps in the iron magnet flux return yoke divided into 4 quadrants. It is also economical to use the existing RPC frames as a support structure.
- Two independent (x and y) layers in one superlayer made of orthogonal rectangular strips with WLS read out
- Photodetector = avalanche photodiode in Geiger mode (*GAPD*)



**Mirror 3M (above groove & at fiber end)**

**Optical glue increase the light yield ~ 1.2-1.4)**

**WLS: Kurarai Y11  $\varnothing$ 1.2 mm**

***GAPD***

**Diffusion reflector ( $\text{TiO}_2$ )**   **Strips: polystyrene with dye (1.5% PTP & 0.01% POPOP)**

# Politics/Funding/Collaboration

- More activities to promote the SuperKEKB collaboration (message to Suzuki-sama: important to speed up the MEXT internal review).
- Hunt down new collaborators around the world (my experience: many groups on many continents are very interested but are blocked/limited by various political constraints.)
- Try to preserve the openness, democracy and other good features of the Belle collaboration in the new group
- More internationalization 国際化 (kokusaika)