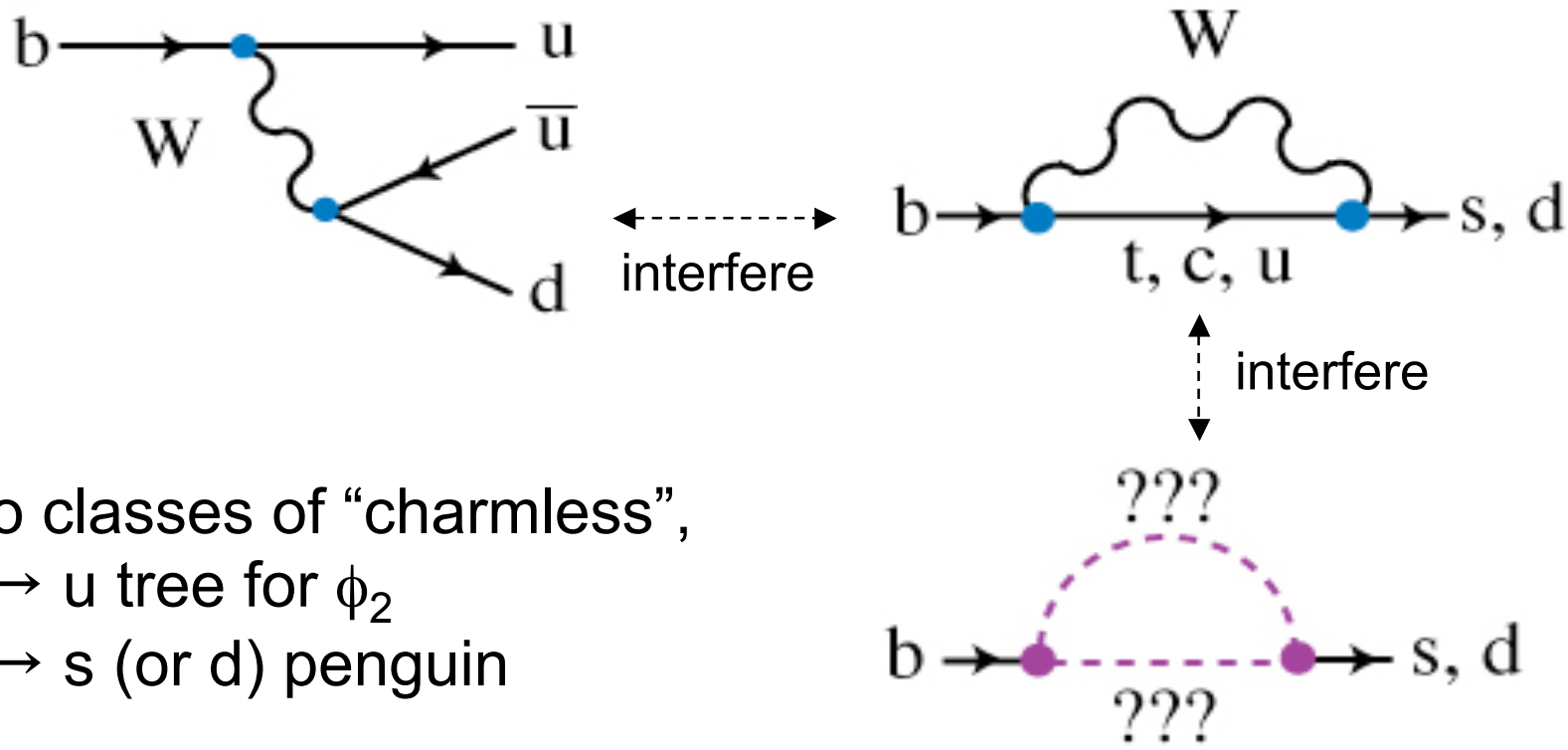
Time-dependent CPV in Charmless B decays

Kenkichi Miyabayashi

2008/Dec./10th

SuperBelle Meeting

Outline

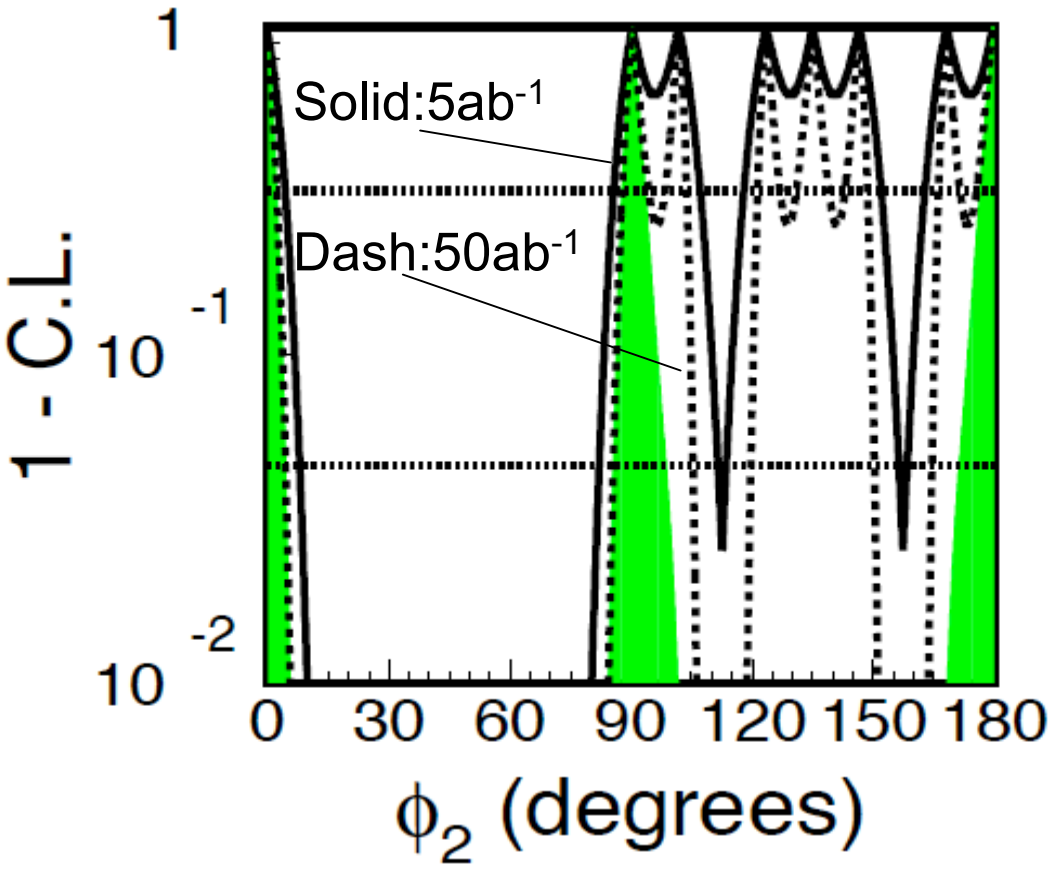


Two classes of "charmless",
- b → u tree for ϕ_2
- b → s (or d) penguin

Note that B → K* γ and B → Kπ puzzle are covered by M. Nakao's talk.

CPV angle ϕ_2 by $B \rightarrow \pi\pi$

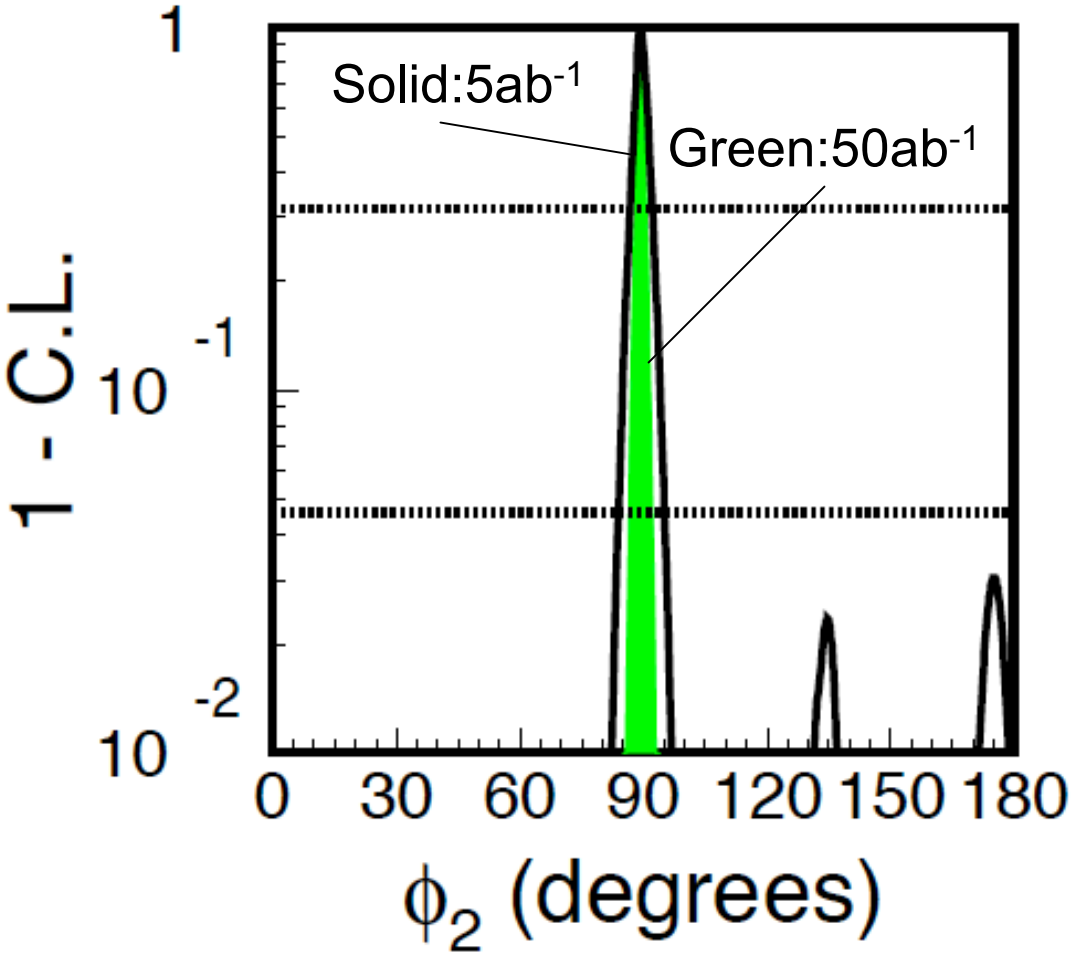
- Handle “penguin pollution” by isospin analysis.
- Solutions around ϕ_2=0 and 180° can still remain.



Green : when time-dep. CPV in $B^0 \rightarrow \pi^0\pi^0$ measurable.

CPV angle ϕ_2 by $B \rightarrow \rho\pi$

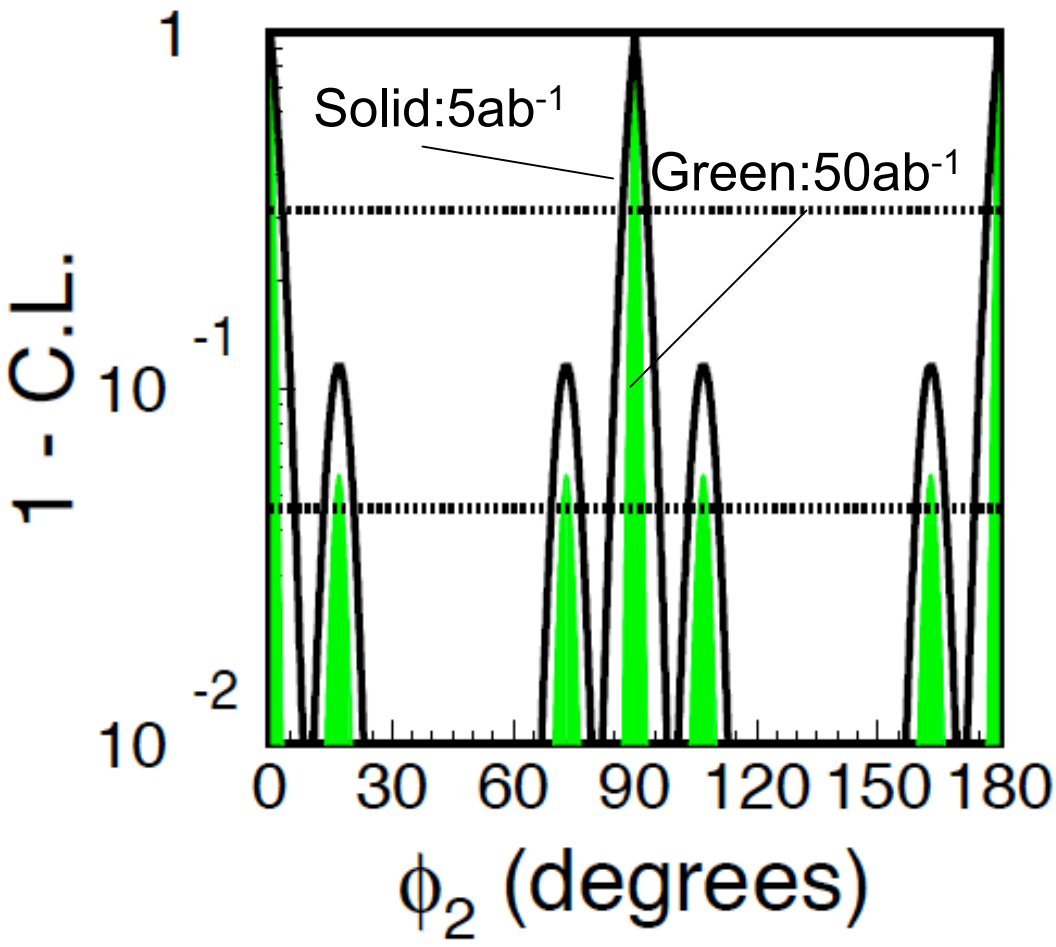
- Require Dalitz analysis because $\rho^0\pi^0$, $\rho^+\pi^-$ and $\rho^-\pi^+$ can contribute and interfere.
- Dalitz analysis turned out to be powerful tool with high statistics available by the upgraded B-factory.



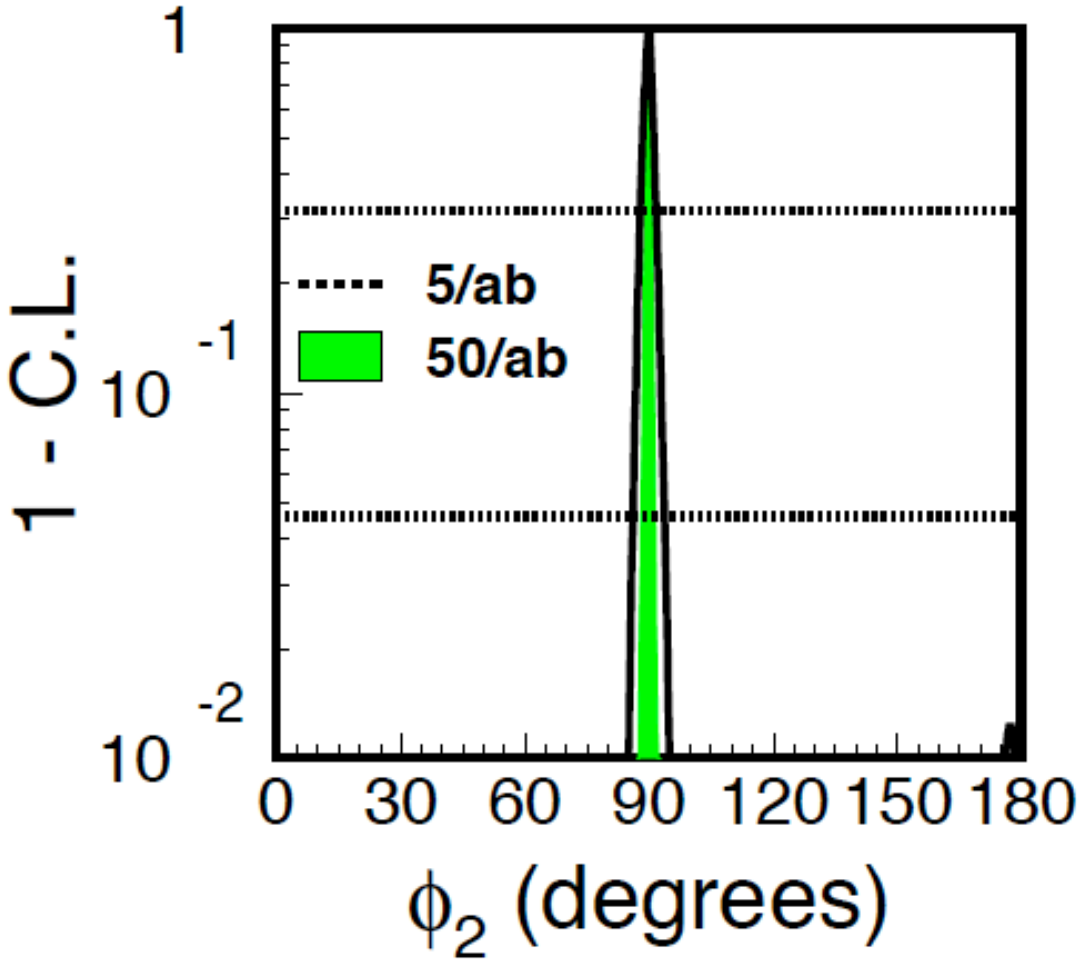
CPV angle ϕ_2 by $B \rightarrow \rho\rho$

There are two miracles

- Small $B^0 \rightarrow \rho^0\rho^0$ br., i.e. small penguin pollution.
- Almost purely longitudinal polarized, I.e. almost CP eigenstate.
- CPV is not significant, $S=\sin 2\phi_2$, $\phi_2 \sim 90^o$.



Combine B → ππ, ρπ, ρρ



Expected $\delta\phi_2$=2° at 5ab^{-1} (1° at 50ab^{-1}))

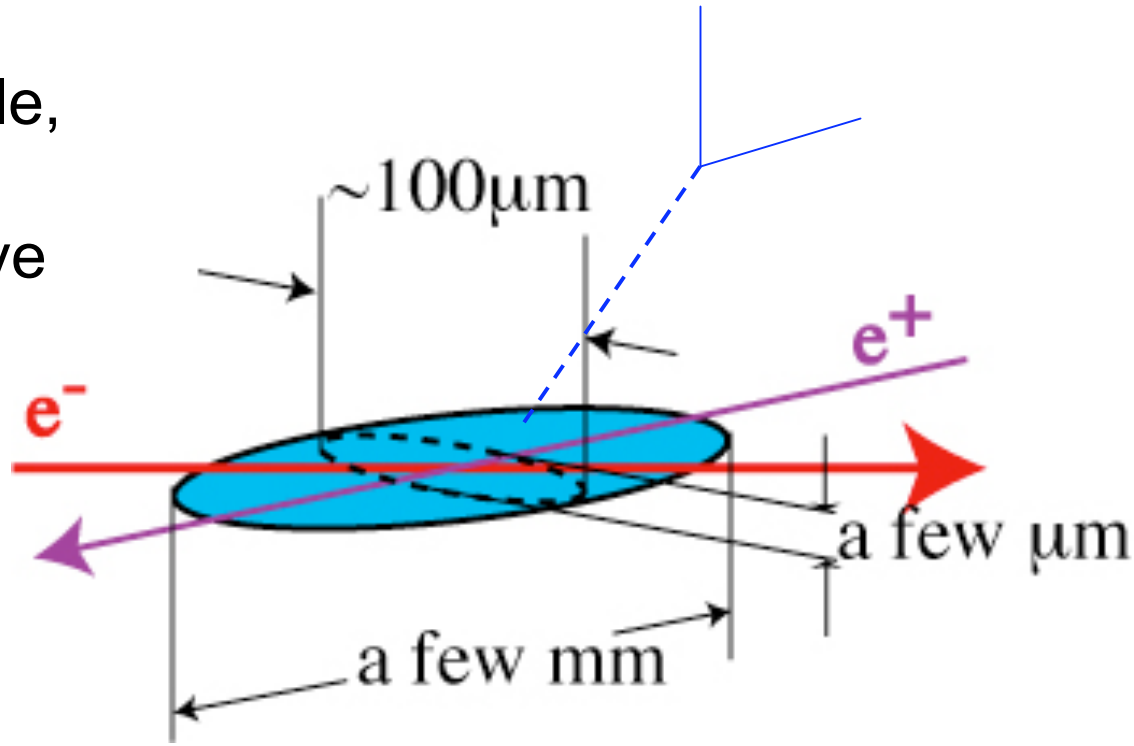
Time-dep. CPV in $b \to s$ penguin modes.

- Three "golden penguin" modes.
  - $B^0 \to \phi K^0$ and $B^0 \to K_S K_S K_S$ are theoretically clean, small "tree pollution".
  - $B^0 \to \eta' K^0$ has highest statistics(significant CPV with $0.5 ab^{-1}$; PRL98, 031802(2008)).

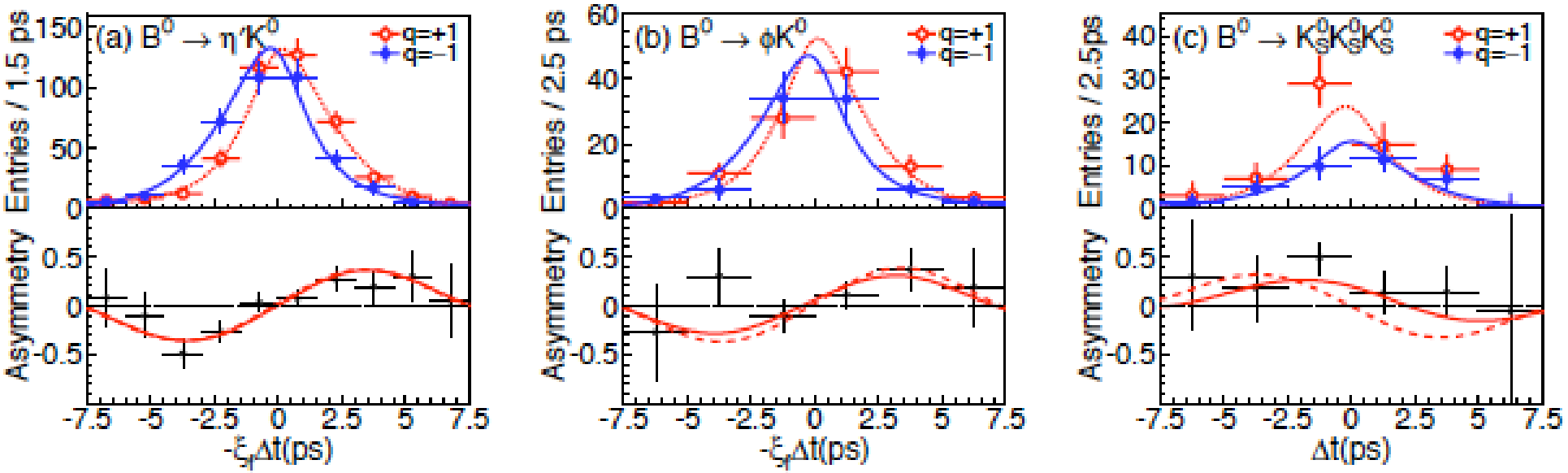
B decay vertex reconstruction with $K_S \rightarrow \pi^+\pi^-$

Utilize Interaction Point profile, extrapolate K_S momentum vector from its vertex can give us B decay vertex with reasonable resolution.

Confirmed by $B^0 \rightarrow J/\psi\ K_S$.

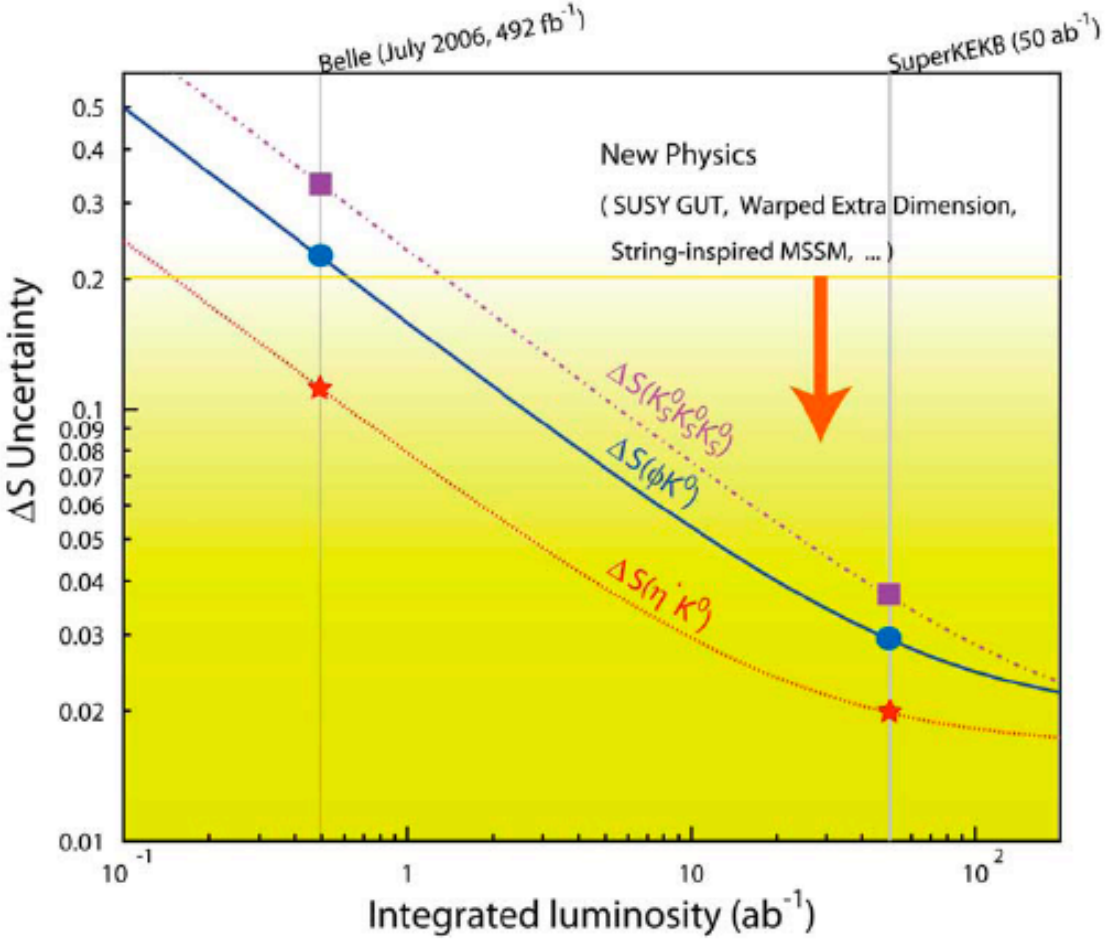


Three “golden penguin” modes at 0.5ab^{-1}.



Background-subtracted Δt distributions and asymmetries with 0.5ab^{-1}(PRL98,031802(2008)).

Future sensitivity



Error of S_f would be $0.03(\eta' K^0) \sim 0.1(K_S K_S K_S)$.

Improved approach; $B^0 \to K^+K^-K_S$, $\pi^+\pi^-K_S$ time-dep. Dalitz

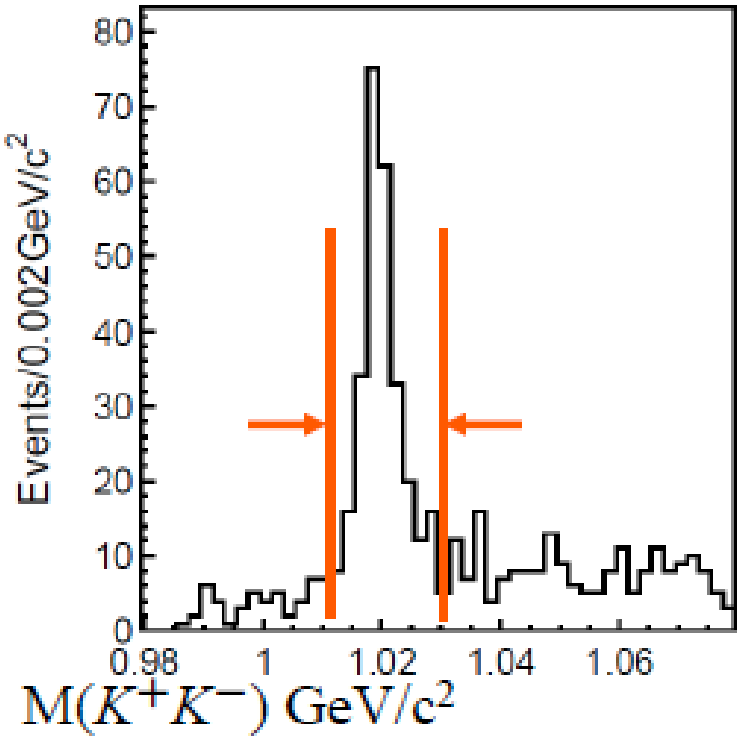
To reconstruct $B^0 \to \phi K_S$,
ϕ is found by K^+K^- pair.

↓

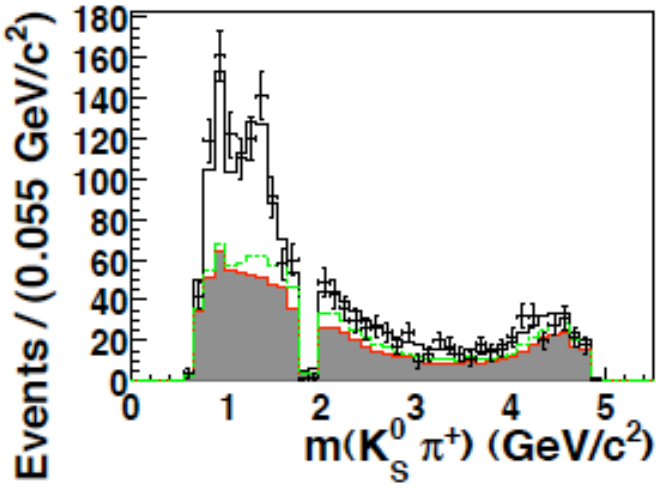
But $f_0(980) \to K^+K^-$ as well as other components would overlap and interfere each other.

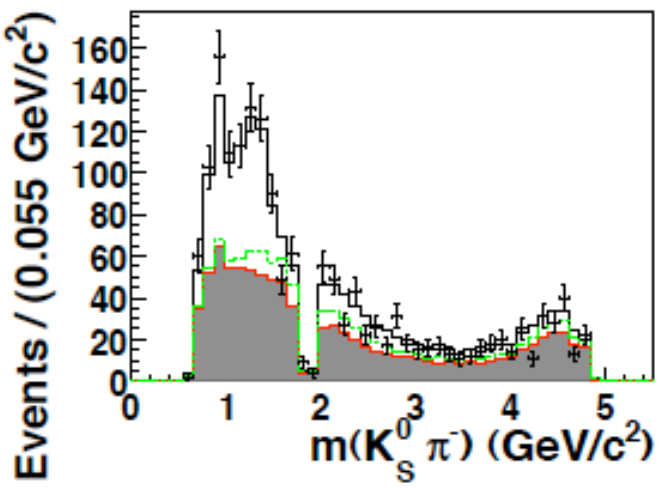
↓

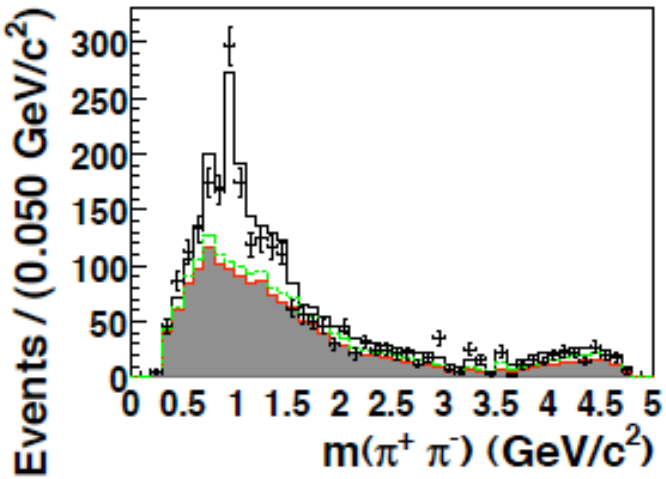
Resolve this situation by Dalitz distribution.
For $B^0 \to \pi^+\pi^-K_S$, same story holds.



Example; $B^0 \rightarrow \pi^+\pi^-K_S$ projection







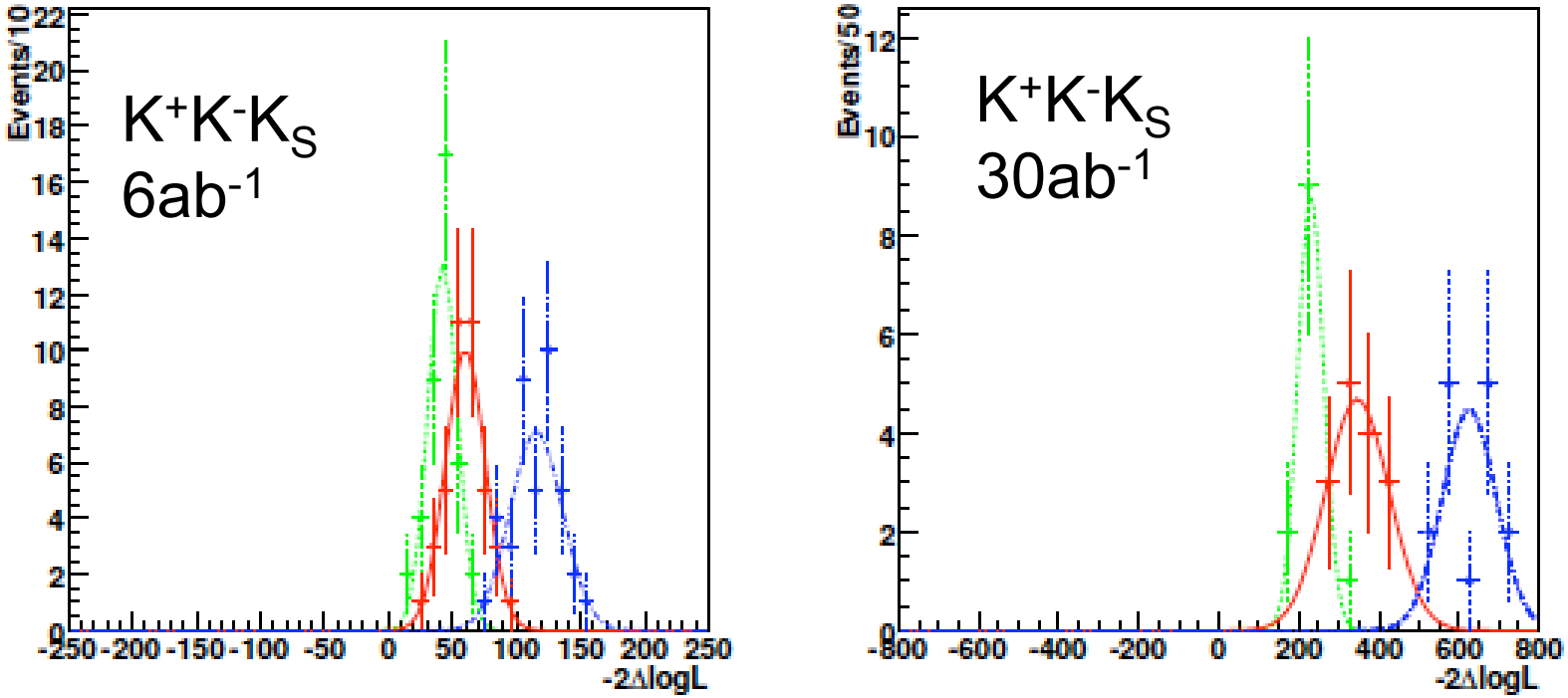
arXiv:0811.3665
Submitted to PRD.

Comments

- As the Dalitz approach nature, not effective $\sin 2\phi_1$ but effective ϕ_1 is obtained.
- Precision of the effective ϕ_1 at $0.6 ab^{-1}$ is;
  - Typically $\pm 9^o$(stat)$\pm 3^o$(syst)$\pm 3^o$(Dalitz model)
- Multiple solutions; can not be distinguished by $-2\ln(L)$.

With Super B-factory statistics

According to ToyMC study

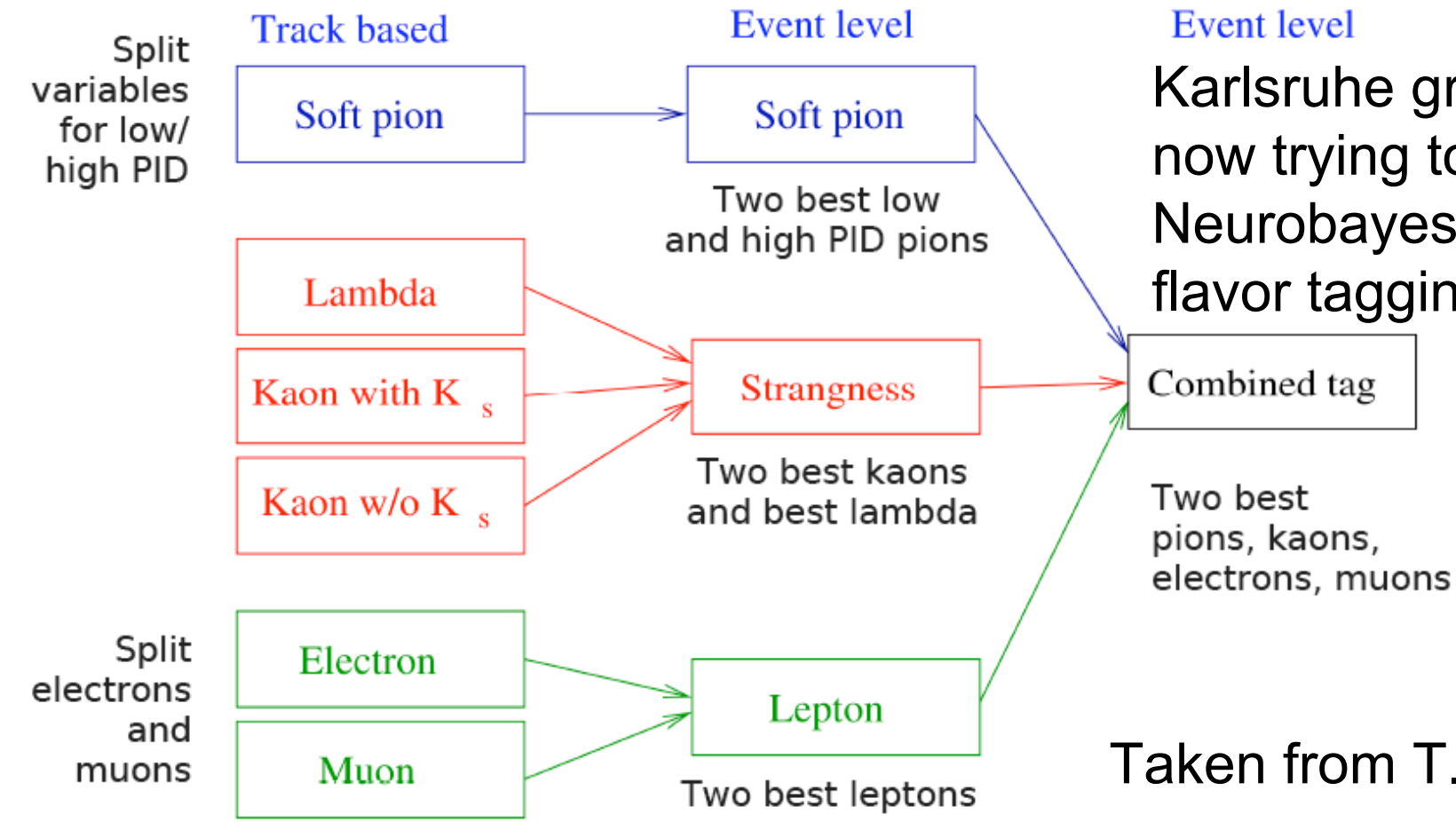


- Other solutions would exhibit distinguishable -2ln(*L*) change.
- Precision of the effective ϕ_1 would be a few degrees.

Plots made by Y. Nakahama

Other attempt to improve

New Tagging Algorithm

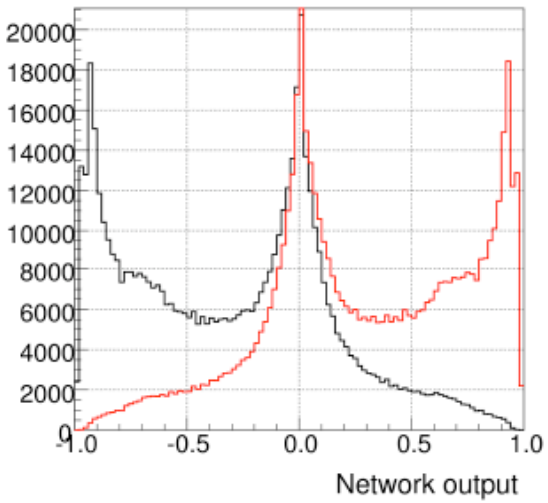


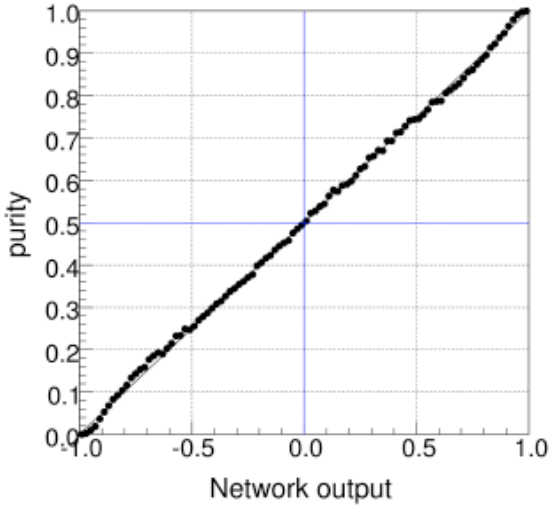
Karlsruhe group now trying to utilize Neurobayes for flavor tagging.

Taken from T.Kuhr slide

According to MC study, effective tagging efficiency improved.

Tagging Performance

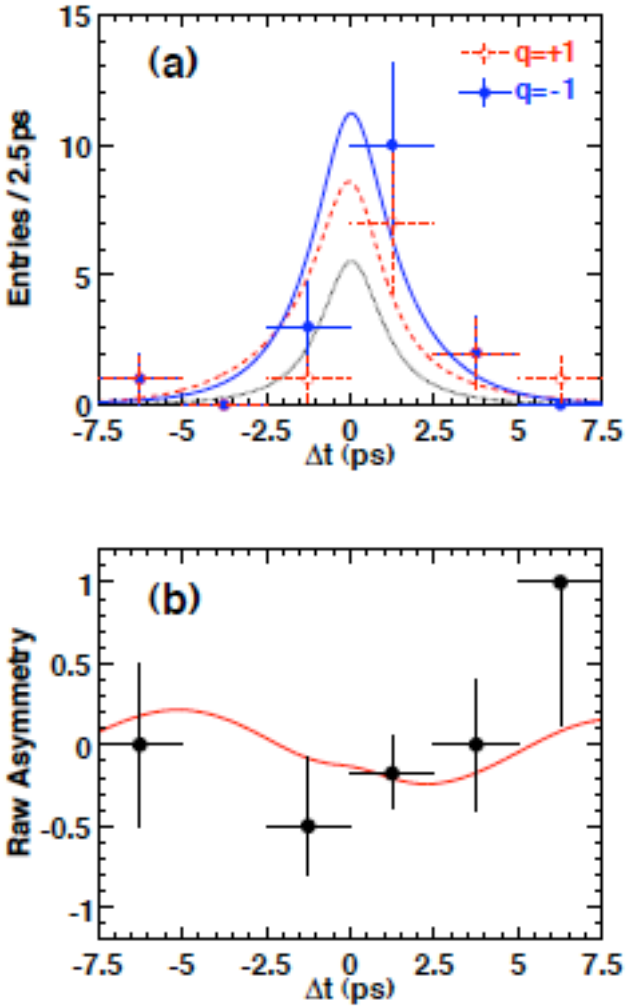




D^2	Likelihood tag	NN tag
Soft pion	9.7 %	10.6 %
Strangeness	18.7 %	18.9 %
Lepton	18.1 %	19.8 %
Combination	27.1 %	29.2 %

Taken from T.Kuhr's slide

Hadronic b → d mode



In SM, mixing-induced CPV would be very small, because V_{td} in decay and mixing candel each other.

Time-dep. CPV in $B^0 \rightarrow K_S K_S$ mode has been measured (PRL100,121601).

S_f = -0.38+0.69/-0.77(stat)±0.09(syst)

A_f = -0.38±0.38(stat)±0.05(syst)

↓

Testing SM/Probing New Physics in the precision of ±0.15~0.20 at 10ab^{-1}.

Search for/adding similar modes, ($K_S K_S \pi^0$ etc.?) would be interesting.

Summary

- Measurement of ϕ_2
  - Precision of ~2^o would be expected at $5ab^{-1}$.
  - $B^0 \rightarrow (\rho\pi)^0$ Dalitz analysis is most powerful.
- Some b → s hadronic modes are to be treated by time-dep. Dalitz.
  - Effective ϕ_1 precision ~ a few degrees.
- Flavor tagging improvement attempt is there.
- Try to extend b → d hadronic modes would be interesting.