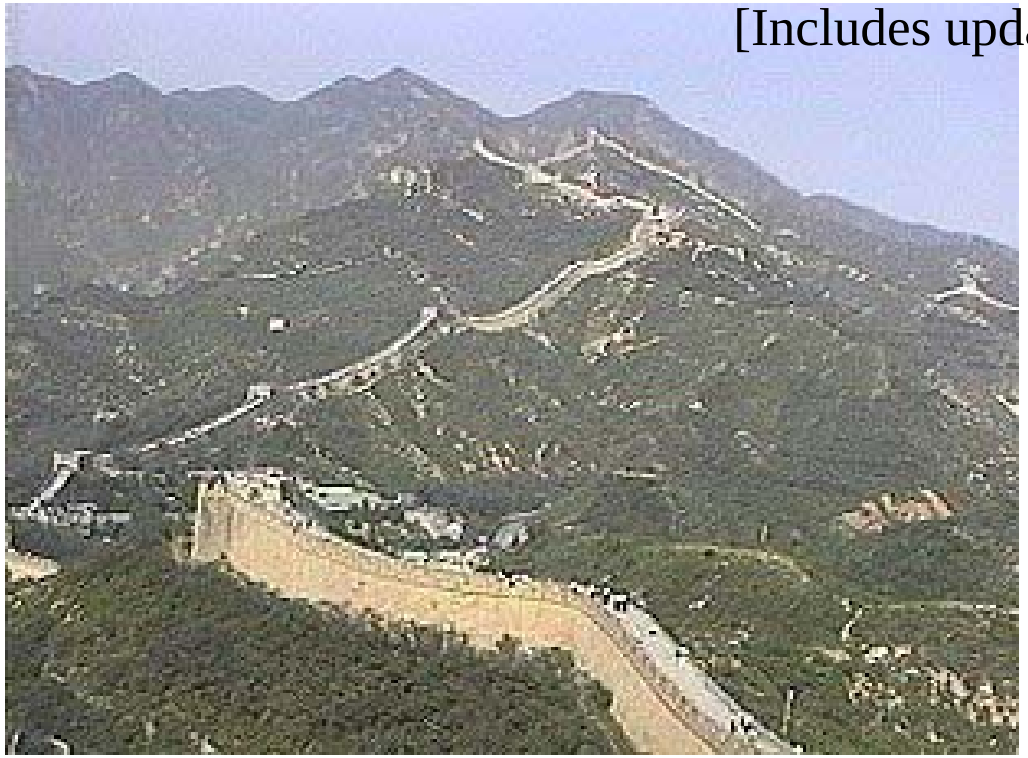
Recent Results on B decays

- Rare B Decay Highlights

+ Belle $b \to s\bar{q}q$ Time-dependent CPV -

[Includes updates/corrections after ICHEP04 talk]



Y.Sakai (Belle/KEK)

Outline

- Introduction
  KEKB and Belle Detector [PEP-II/BaBar: by Giorgi]
- New Results on Rare decays (Belle/BaBar)
  (Highlights)
- Updated/New results on $b \to s$ TCPV from Belle

[Results are preliminary unless references are given]

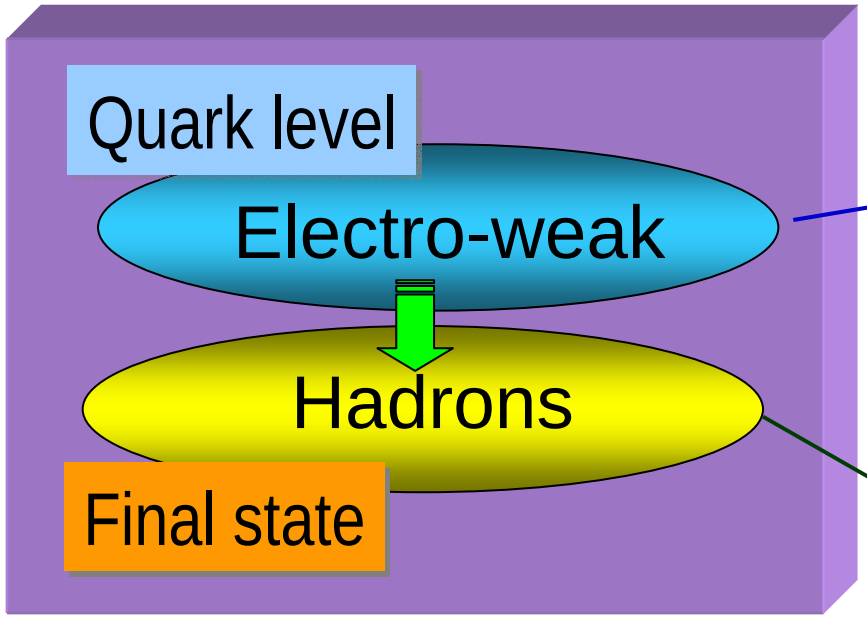
Apology; cannot cover all of the many interesting results from the parallel sessions

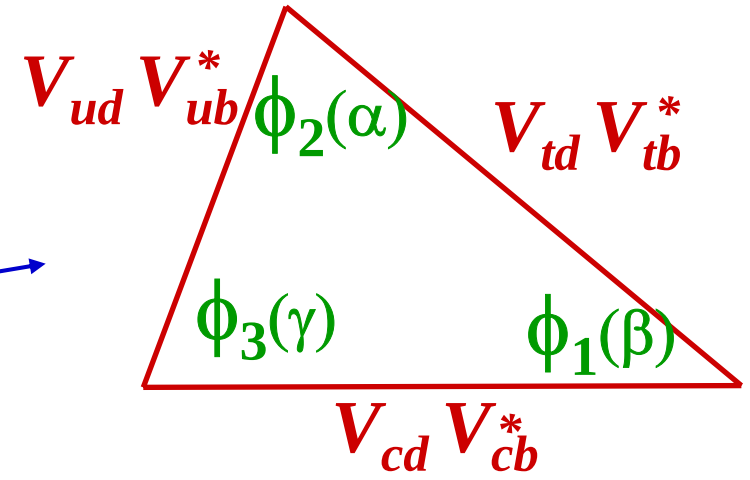
Contributed papers available

Belle: http://belle.kek.jp/conferences/ICHEP2004/

BaBar: http://www.slac.stanford.edu/BFROOT/www/Public/ichep2004/

B Decays & the SM



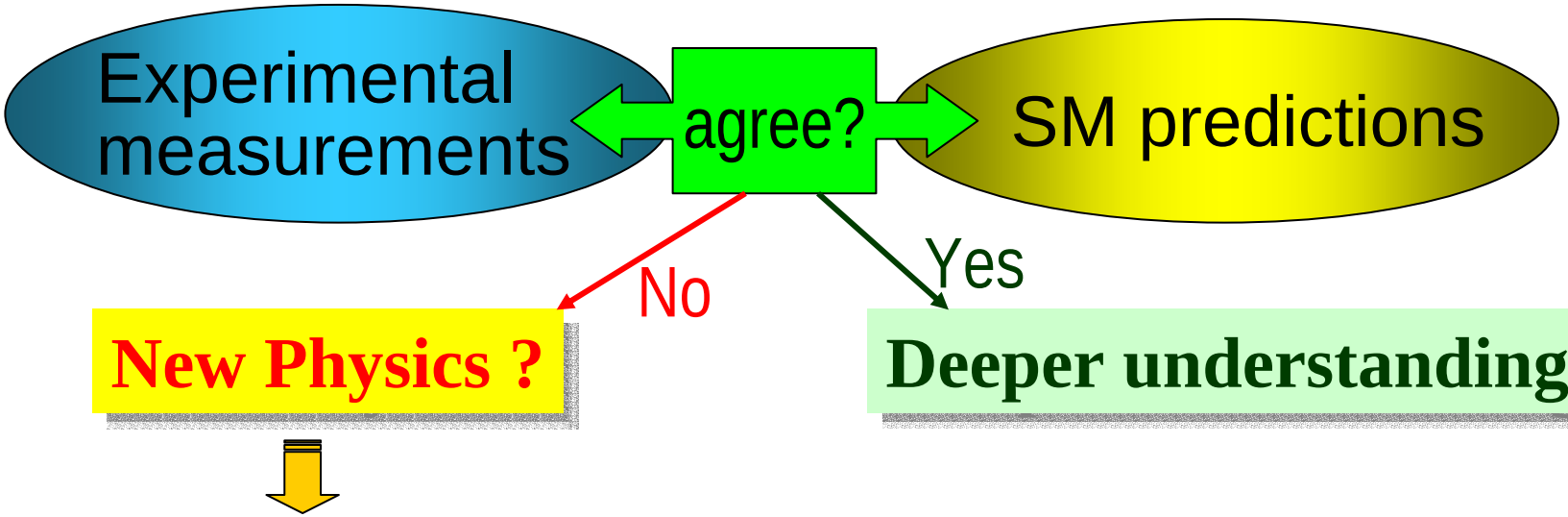


QCD/Lattice
New Resonances

b-quark: Heavy → variety of decay modes

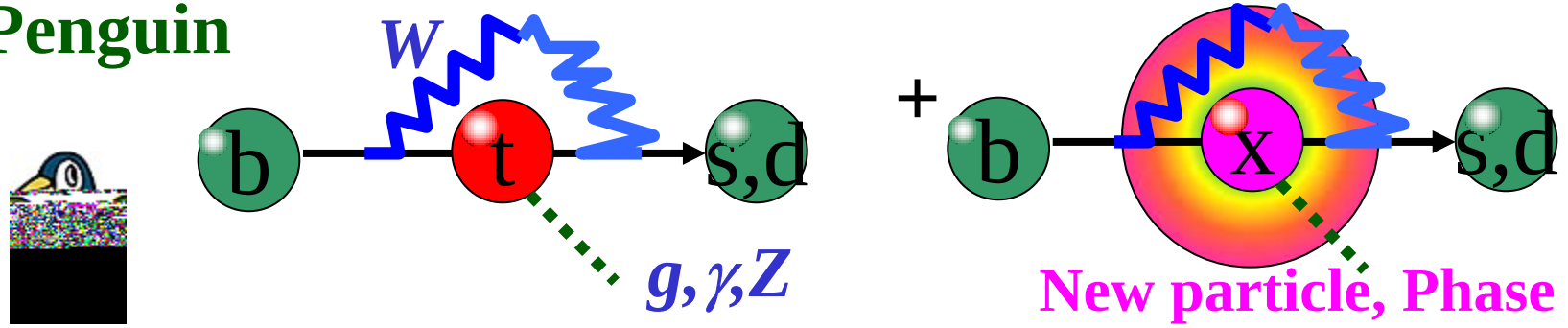
Rich field for fundamental SM parameters

B decays & New Physics

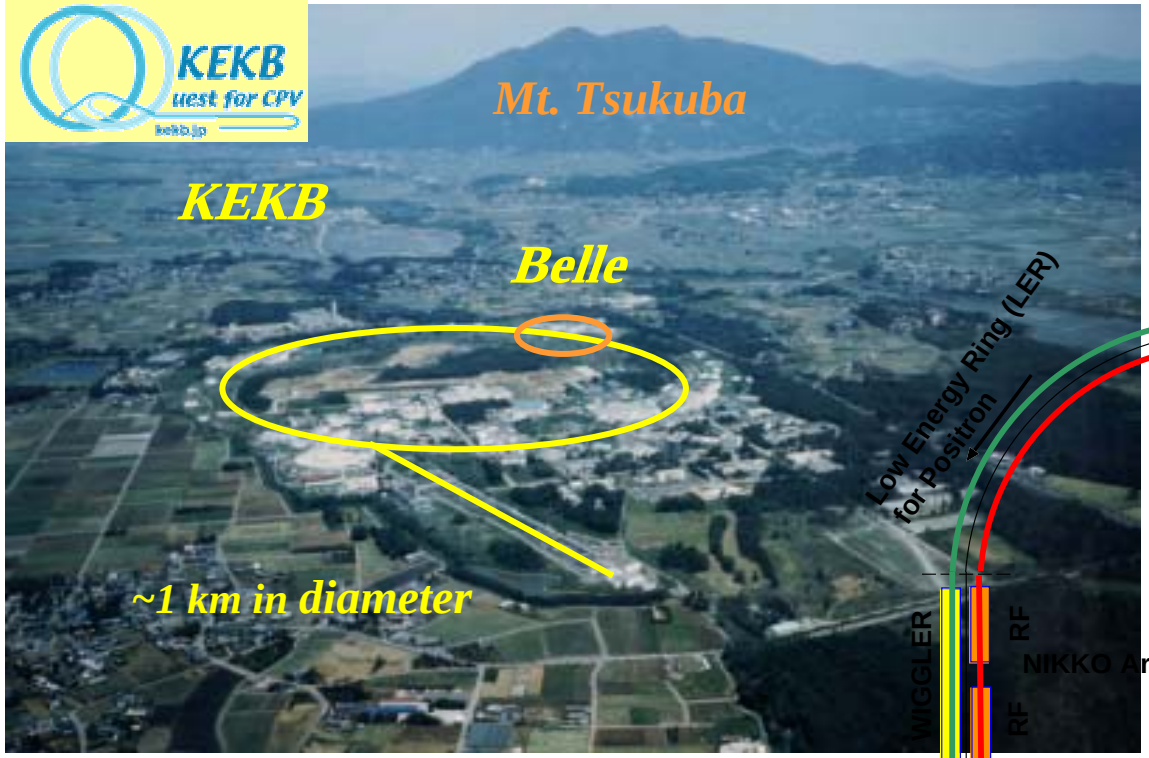


Key point: $A_{NP} \sim A_{SM}$ (small/forbidden)

Penguin

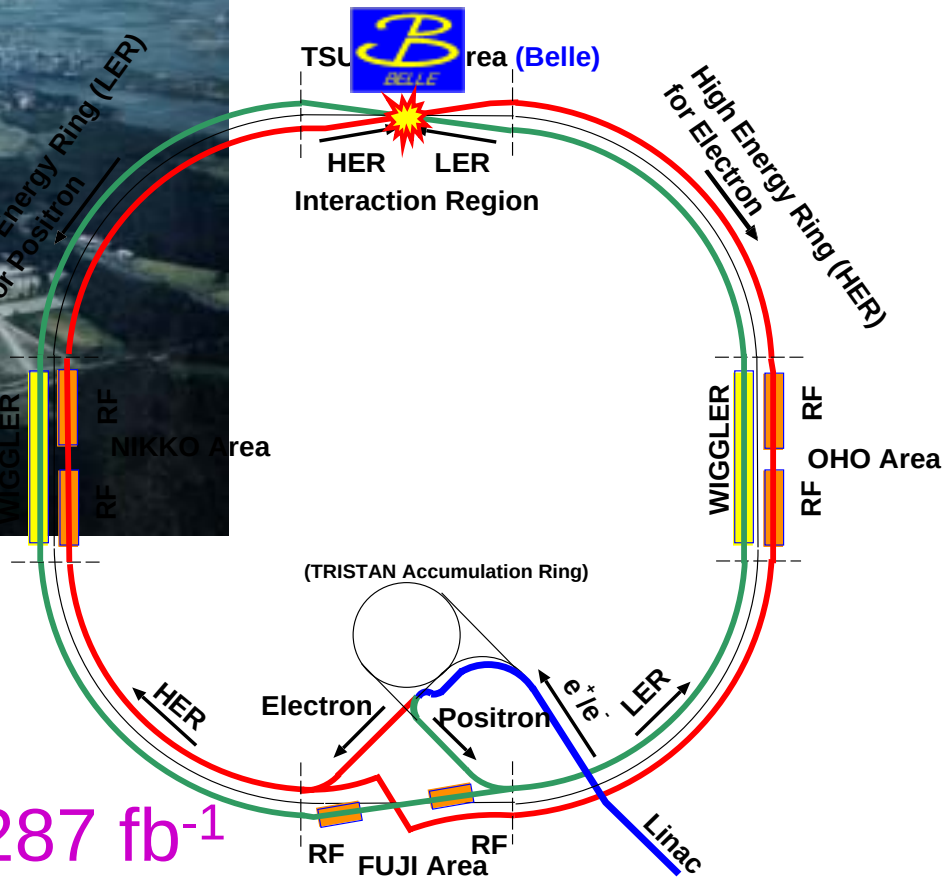


KEKB Collider



8 GeV e^- x 3.5 GeV e^+

±11mrad crossing



$L_{peak} = 1.39 \times 10^{34}\ sec^{-1}cm^{-2}$

@ 1.2A x 1.6A

253 fb^{-1} on Y(4S) 275M $B\bar{B}$

28 fb^{-1} below Y(4S)

~287 fb^{-1}

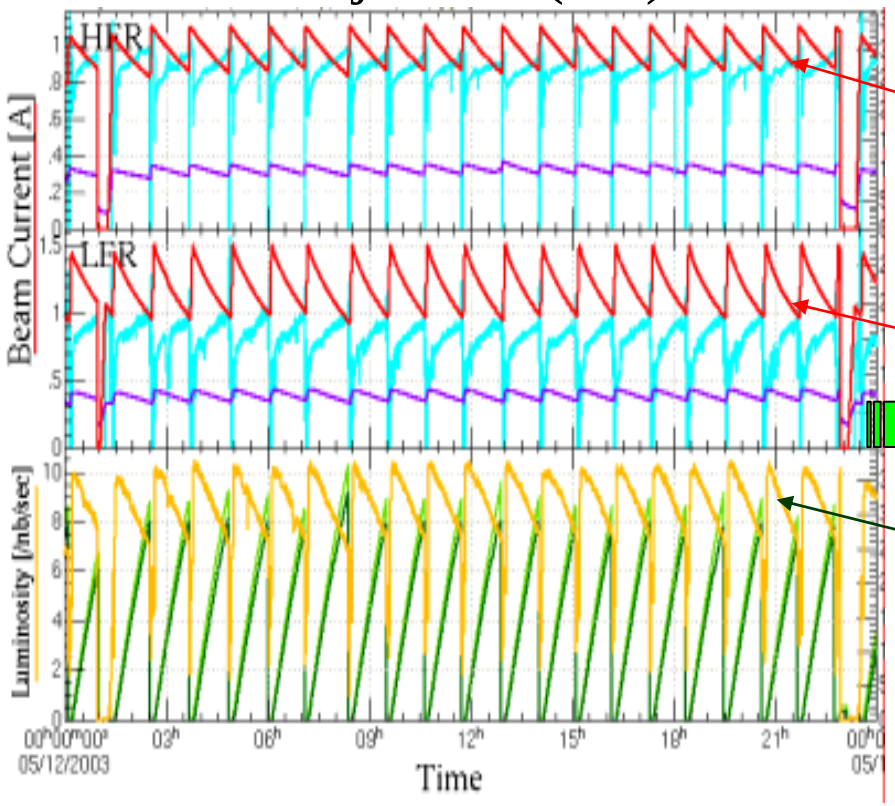
Continuous Injection

No need to stop run
Always at ~max. currents, luminosity

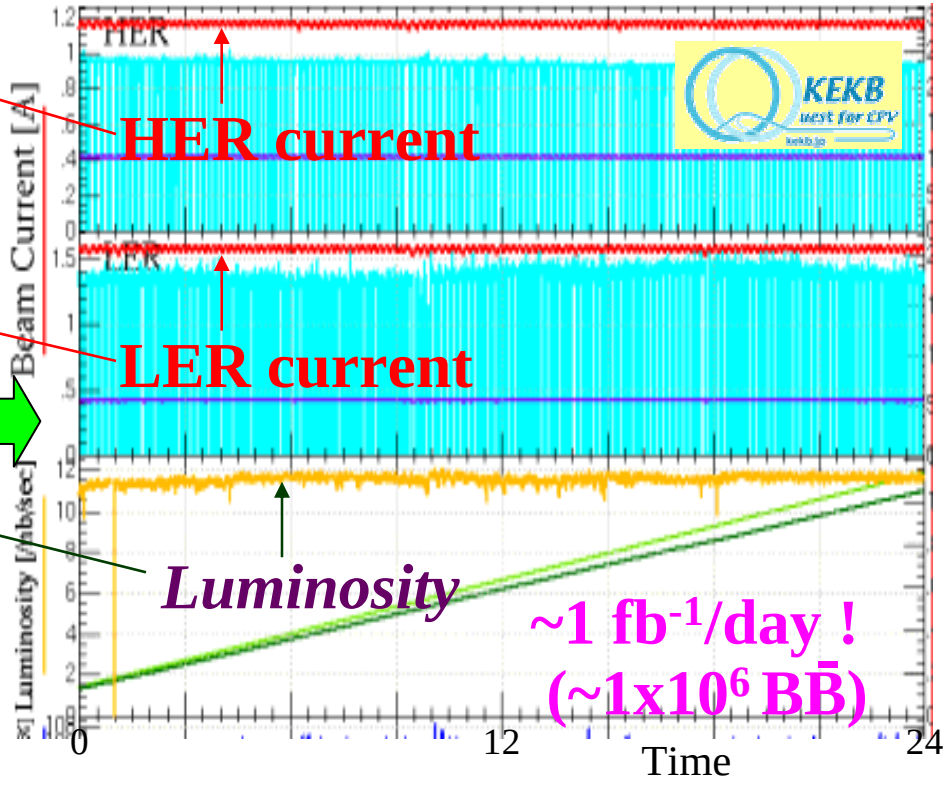
➡ **~30% more $\int L\,dt$**

[CERN courier Jan/Feb 2004]
both KEKB & PEP-II

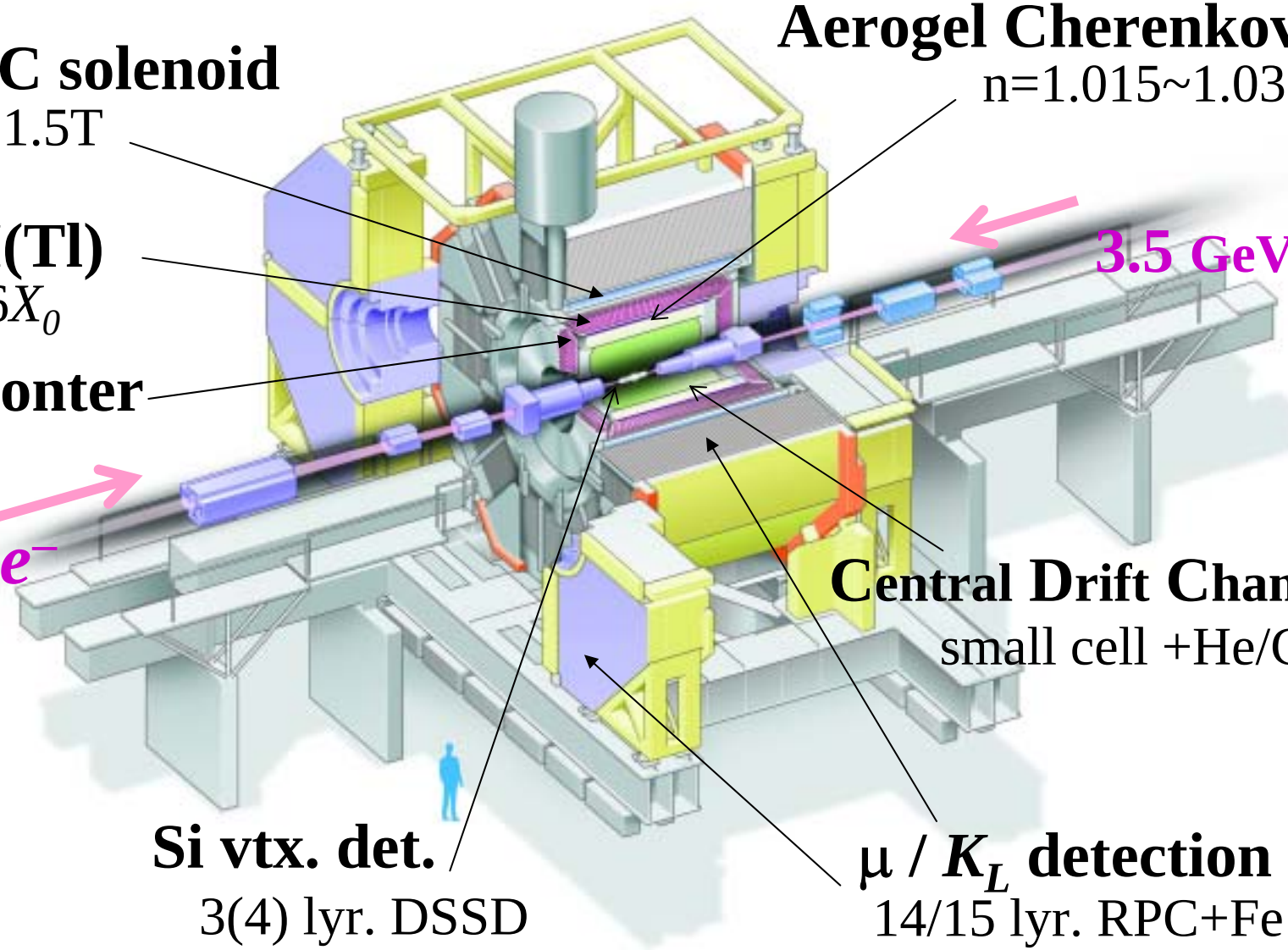
normal injection (old)



continuous injection (new)

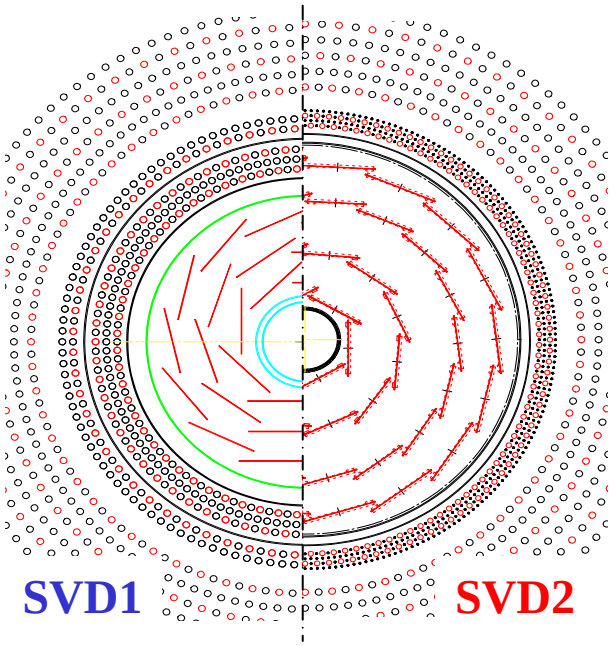


Belle Detector



SVD Upgrade

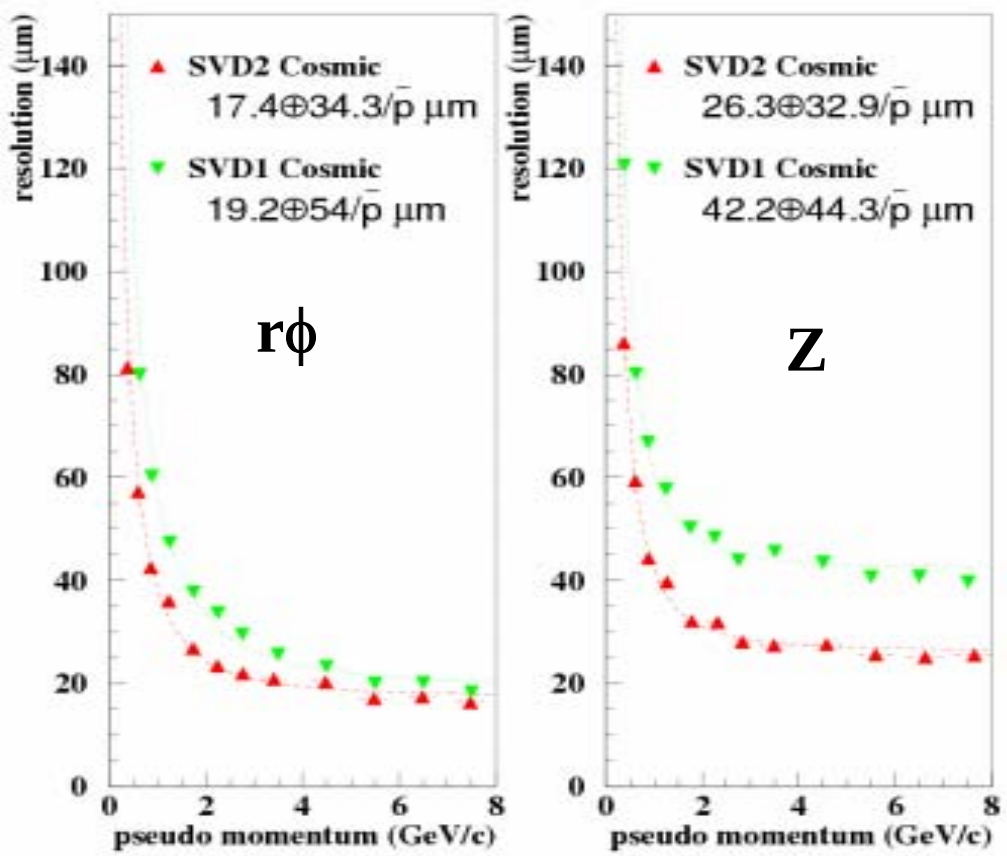
2003 summer



- 1 MRad → >20 MRad
- 3 layers → 4 layers
- 23°<θ<139° → 17°<θ<150°
- R_{bp} = 2.0 cm → 1.5 cm

➡ Better I.P. resolutions

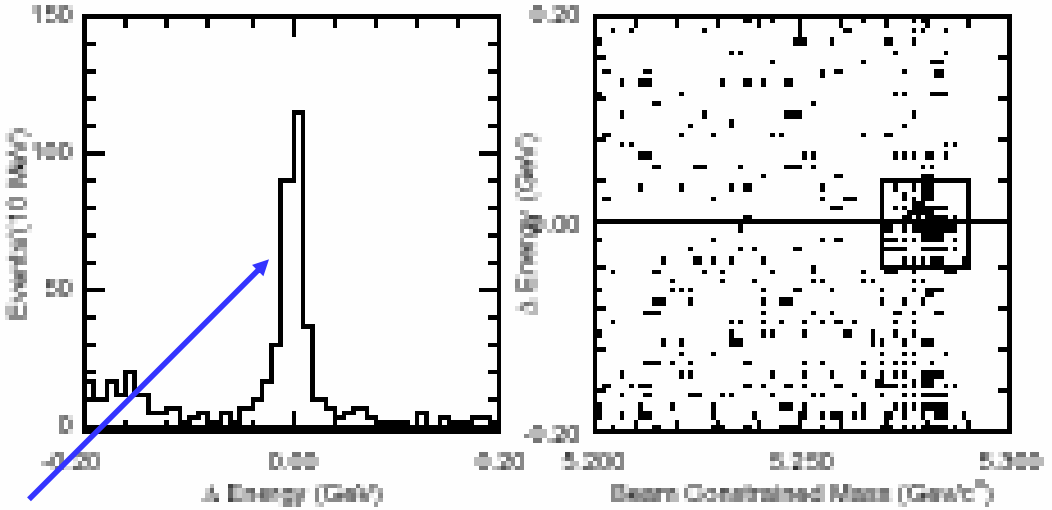
Impact parameter resolution



152M $B\bar{B}$ pairs with SVD1
+ 123M BB pairs with SVD2

B-meson Reconstruction

Utilize special Kinematics at Y(4S)

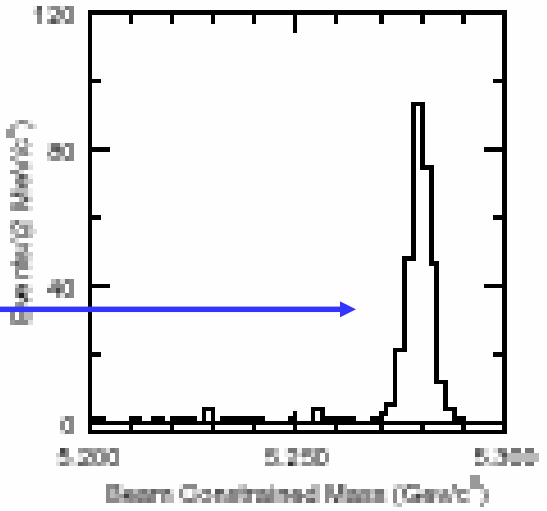


Energy difference:

$$\Delta E \equiv \sum E_i - E_{CM}/2$$

Beam-constrained mass:

$$M_{\underset{(ES)}{bc}} = \sqrt{(E_{CM}/2)^2 - (\sum \vec{p}_i)^2}$$



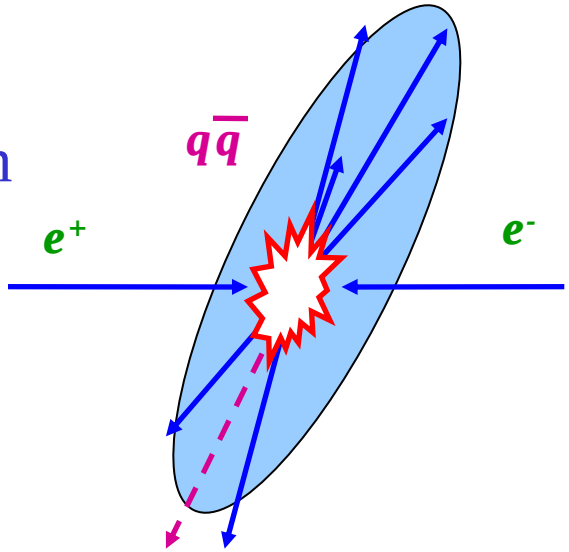
Continuum Suppression

Dominant Background for rare decays:

$e^+e^- \to q\bar{q}$ "continuum" (~3x $B\bar{B}$)

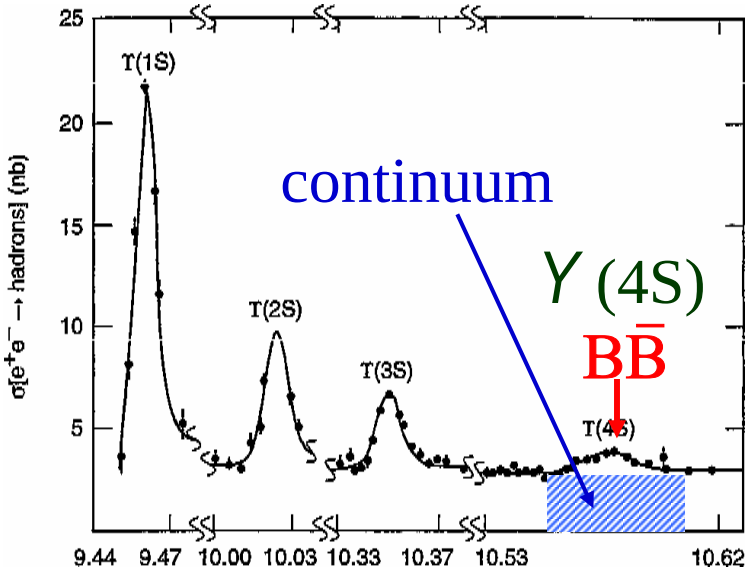
Continuum

Jet-like



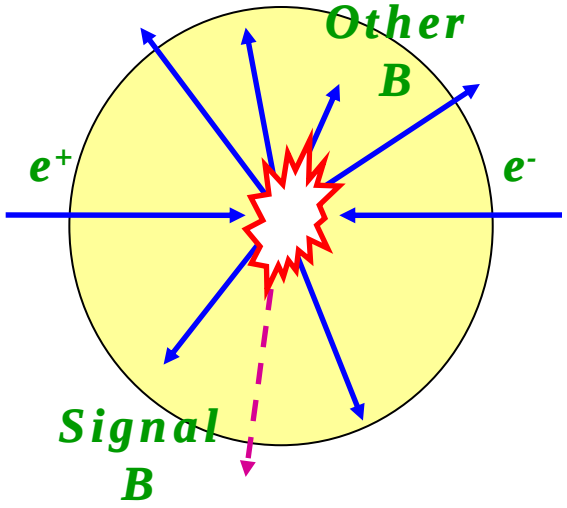
To suppress:

use event shape variables

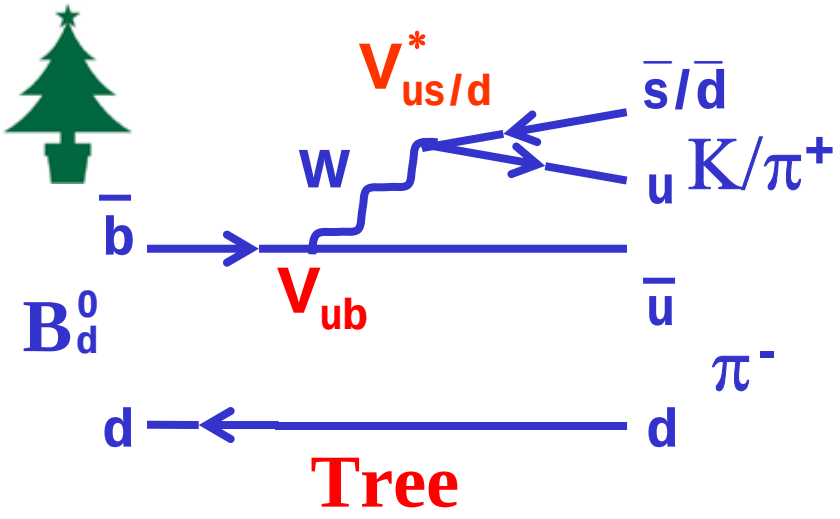


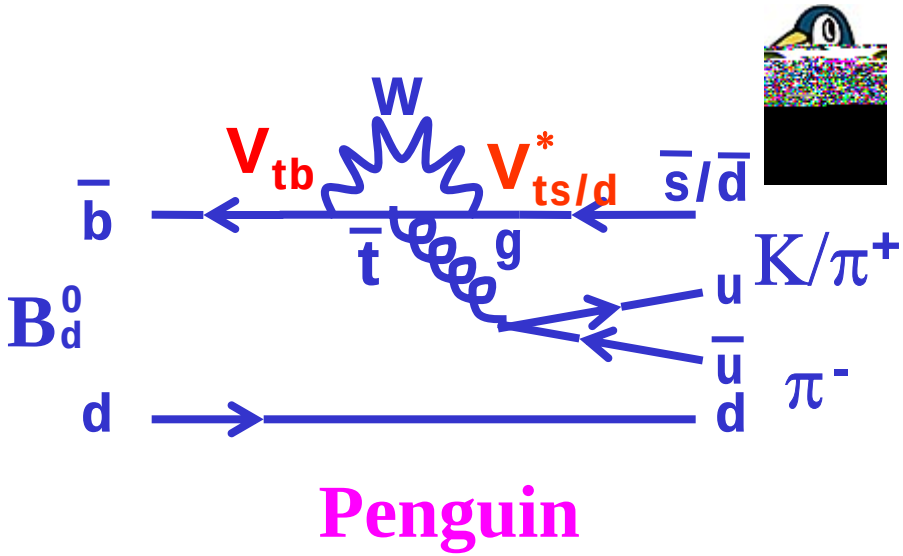
$B\bar{B}$

spherical



$B \to K\pi/\pi\pi$





- Simplest charmless rare decay modes
- Tree - Penguin interference → **Direct CP Violation**

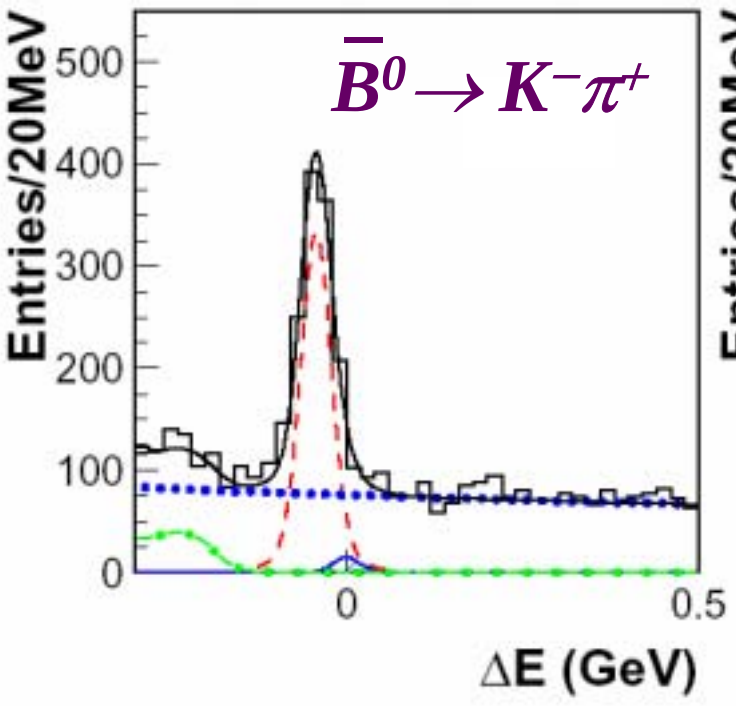
Key prediction of **Kobayashi-Maskawa model**

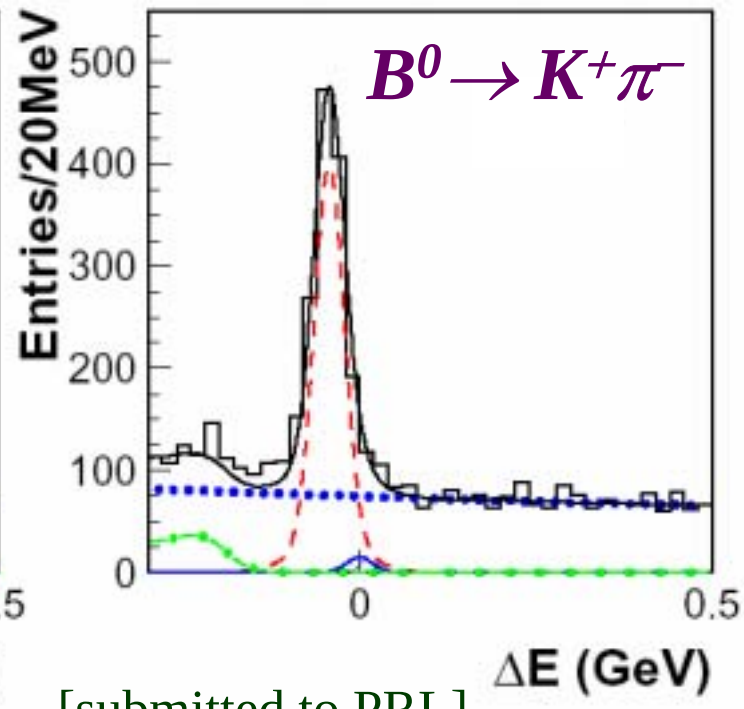
$$A_{CP} = \frac{\Gamma(\bar{B} \to \bar{f}) - \Gamma(B \to f)}{\Gamma(\bar{B} \to \bar{f}) + \Gamma(B \to f)}$$

Understanding of Penguin ⇨ Anomaly (New Physics)

$A_{CP}(B^0 \to K^+\pi^-)$

275M $B\bar{B}$ New





Signal:
2139 ±53

[submitted to PRL]

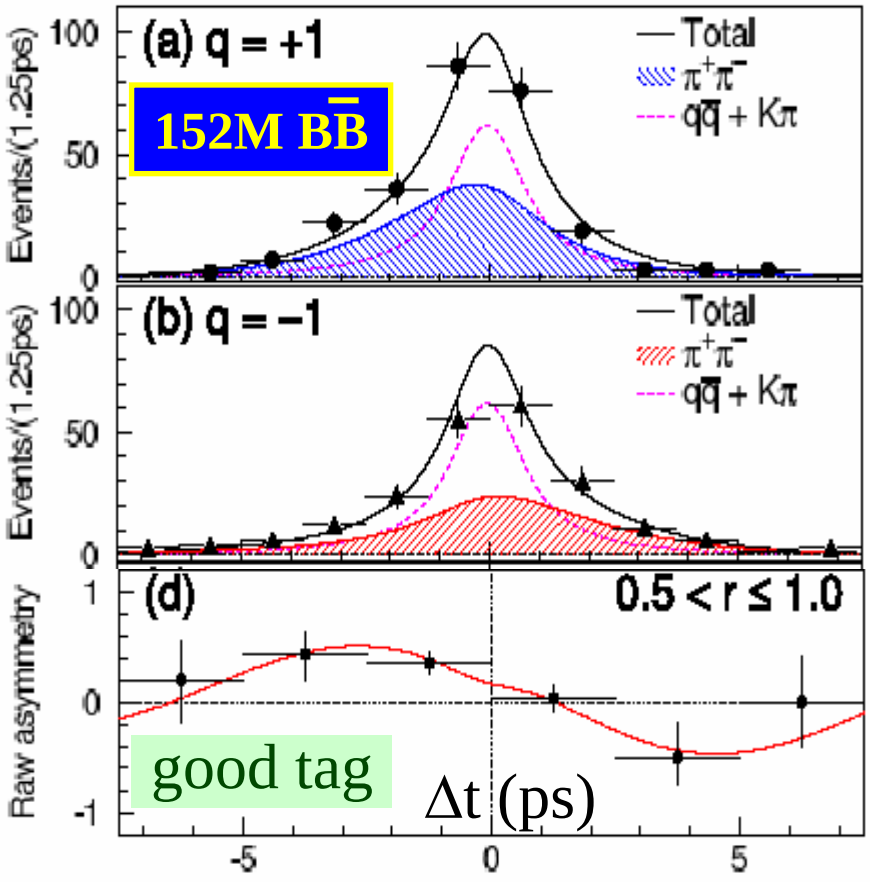
A_{CP} = -0.101 ± 0.025 ± 0.005

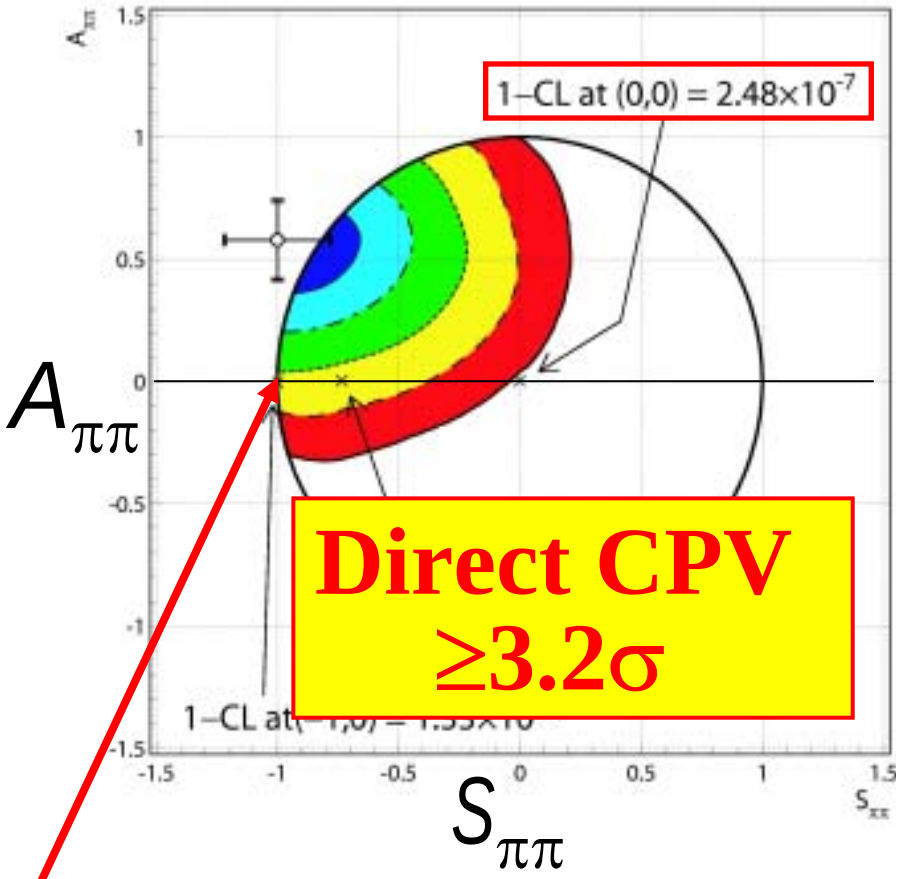
3.9σ significance

[PID efficiency bias correction: δA = -0.01 ± 0.004]

2nd Evidence for DCPV at Belle ! [$A(\pi^+\pi^-)$ 3.2σ]

$B^0 \to \pi^+\pi^-$ CPV Result





$A_{\pi\pi}$ = +0.58 ±0.15(stat) ±0.07(syst)

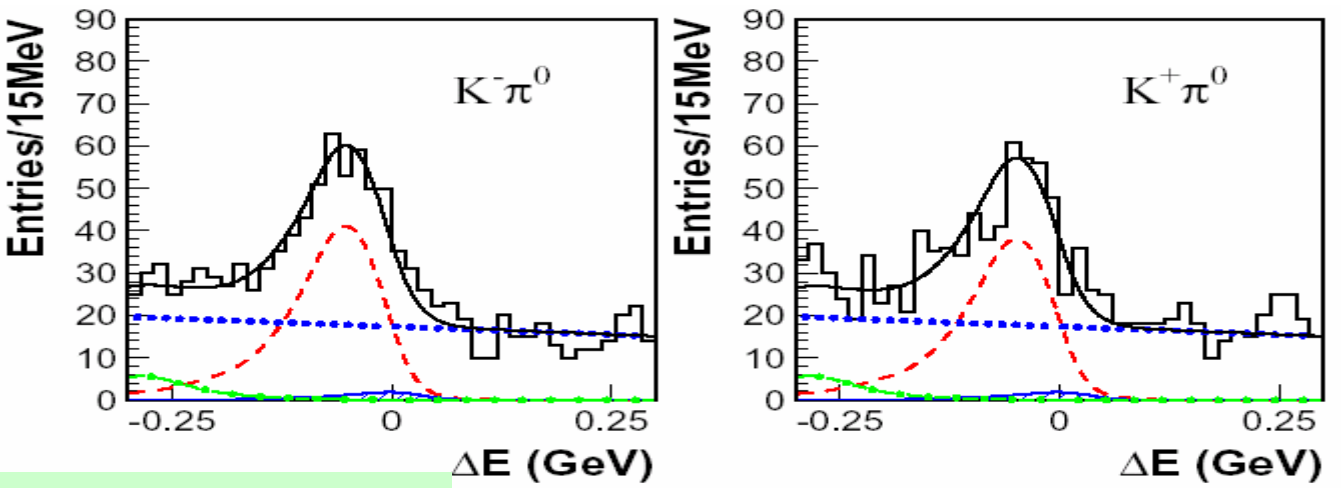
$S_{\pi\pi}$ = −1.00 ±0.21(stat) ±0.07(syst)

[PRL93,021801 (2004)]

$A_{CP}(B \to K^+\pi^0)$

275M $B\bar{B}$
New

$K^\pm\pi^0$: 728 ±53

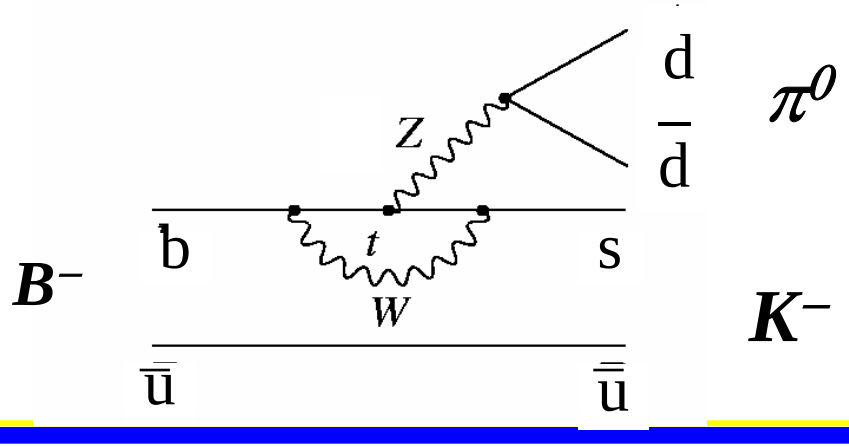


$A_{CP}(K^\pm\pi^0) = 0.04 \pm 0.05 \pm 0.02$

hint that $A_{CP}(K^+\pi^-) \neq A_{CP}(K^\pm\pi^0)$? (2.4σ) [also seen by BaBar]

Large EW penguin (Z^0) ?

New Physics ?



Observation of $B^0 \to \pi^0\pi^0$

275M $B\bar{B}$, New

Key mode for $\phi_2(\alpha)$ in $B \to \pi\pi$ CPV isospin analysis

Evidence (LP03) → **Observation !**

Signal: 82 ± 16 (6.0σ)

$B = (2.32 \pm^{0.44}_{0.48} \pm^{0.22}_{0.18}) \times 10^{-6}$

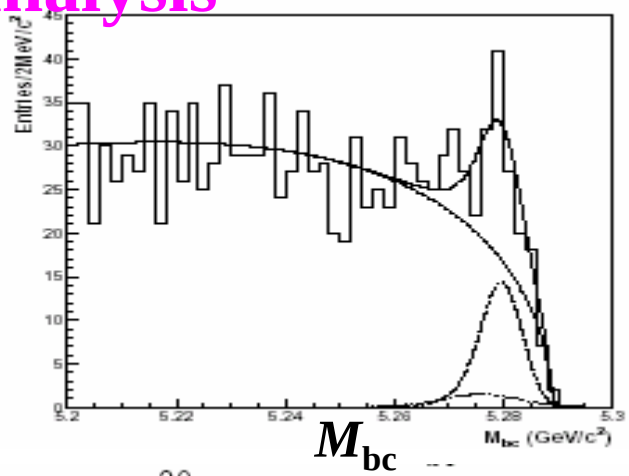
Large Br established

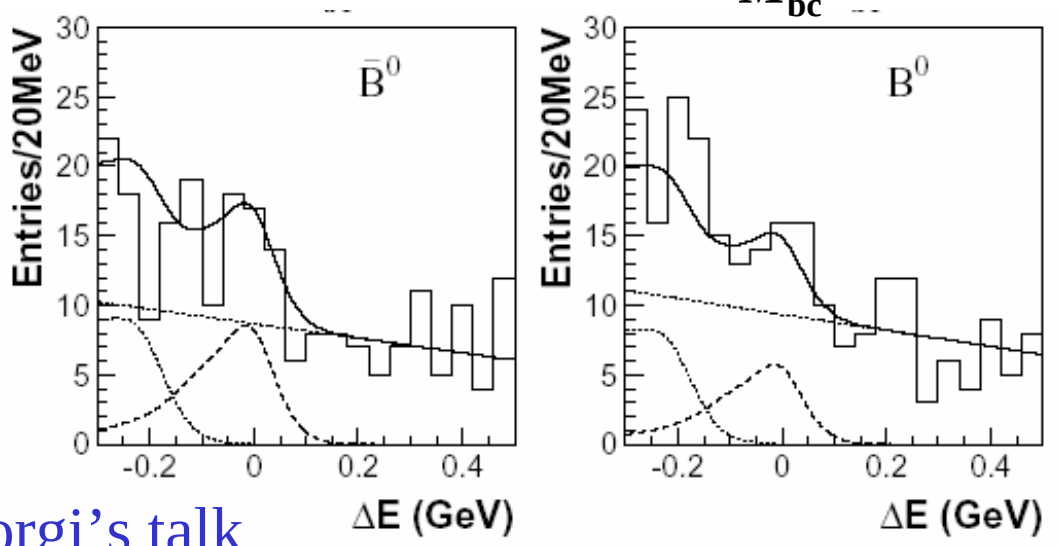
[Belle-conf-0406]

$$A_{CP} = 0.44 \pm 0.51 \pm^{0.17}_{0.16}$$

uses same Flavor-tagging as TCPV analysis

1st measurement !





BaBar results & $\phi_2(\alpha)$ → Giorgi's talk

$B^0 \to K\bar{K}$

224M B$\bar{\text{B}}$

$B^0 \to K^0\bar{K}^0$

$N_{sig} = 23 \pm^{7.7}_{6.7} \pm 2.0$ (4.5σ)

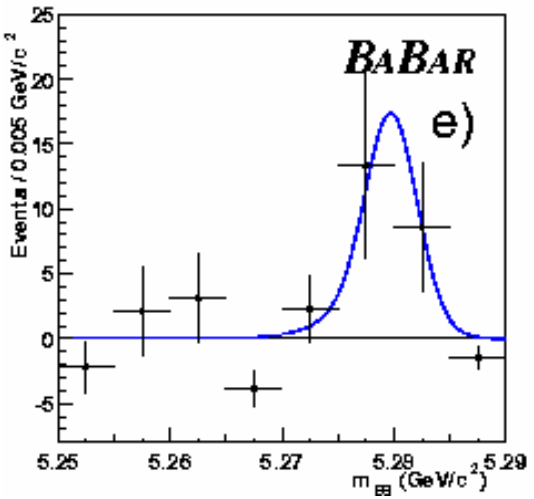
$B = (1.19 \pm^{0.40}_{0.35} \pm 0.13) \times 10^{-6}$

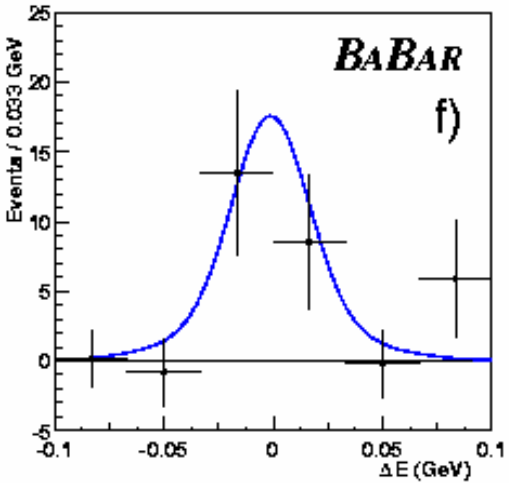
"pure $b \to d$ Penguin"

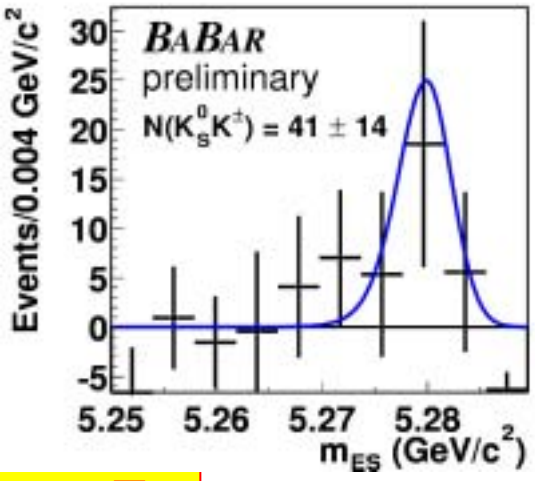
$B^0 \to K^0K^+$

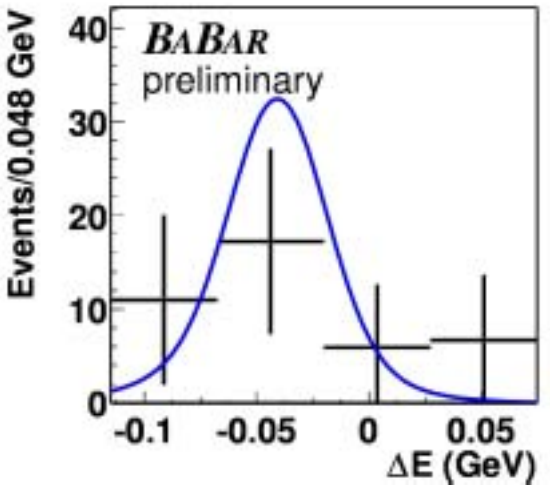
$N_{sig} = 41 \pm 14 \pm 3$ (3.5σ)

$B = (1.46 \pm 0.50 \pm 0.07)$ $(<2.35) \times 10^{-6}$









First signals for $B^0 \to K\bar{K}$

$B \to VV$: Polarization Puzzle

Naïve Factorization : Longitudinal $f_L = 1 - O(1/m_b^2)$

- $\rho^+\rho^-, \rho^+\rho^0, (\rho^0 K^{*+})$: $f_L \approx 1$
  Tree dominated
- $f_L(\phi K^*) \sim 0.5$
  Penguin only

(BaBar/Belle)

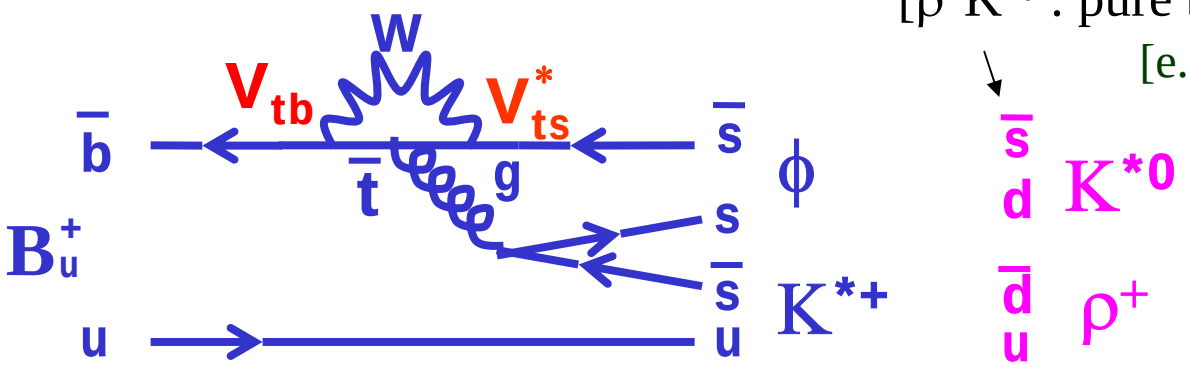
Penguin Anomaly ?
New physics effect ?
$\phi K^*(b \to s\bar{s}s)$ only ?

QCD penguin annihilation: $O(1/m_b^2) \to O(1)$

$f_\perp / f_{//} = 1 + O(1/m_b)$? $f_L(\rho^+ K^{*0}) < f_L(\phi K^*)$?

[$\rho^+ K^{*0}$: pure b$\to$ s Penguin]

[e.g. A.Kagan hep-ph/0405134]



$B \to \rho^+ K^{*0}$ Polarization

152M $B\bar{B}$

ρ^+, K^{*0} mass region

2D(M_{bc},ΔE,) ML fit

peak: 6.3σ signif.

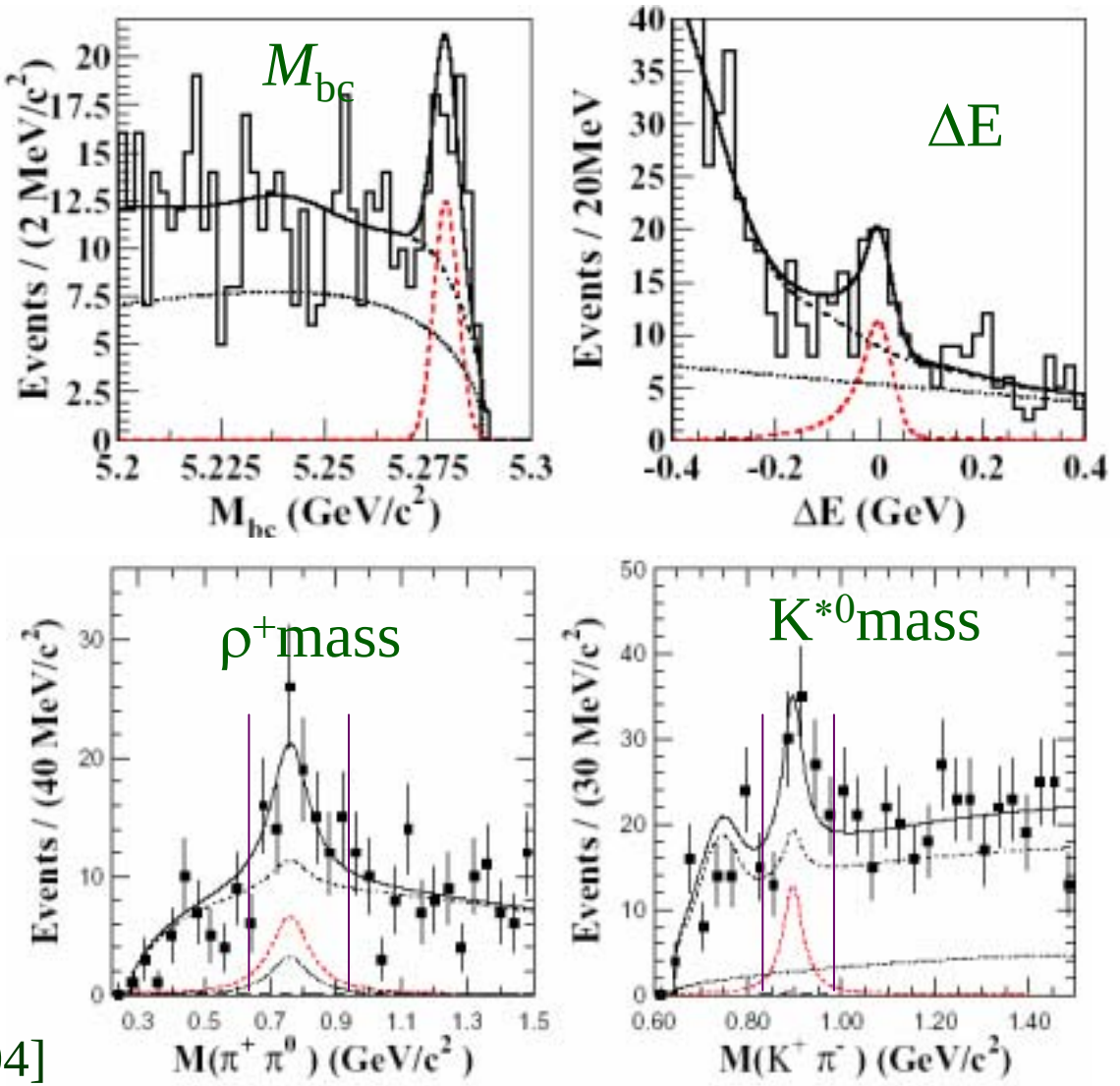
M_{bc}, ΔE signal region

simultaneous fit to ρ,K* masses

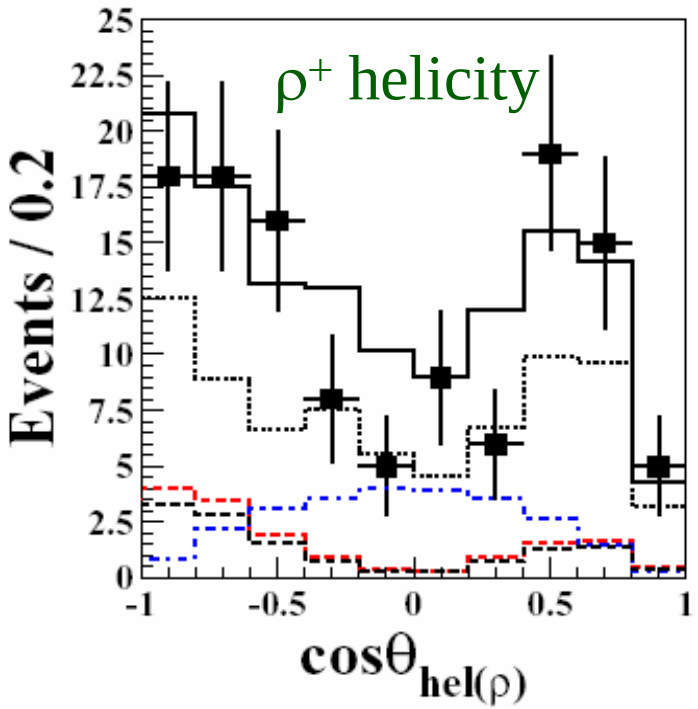
$\rho^+ K^{*0}$: 26.6 $\pm$8.7

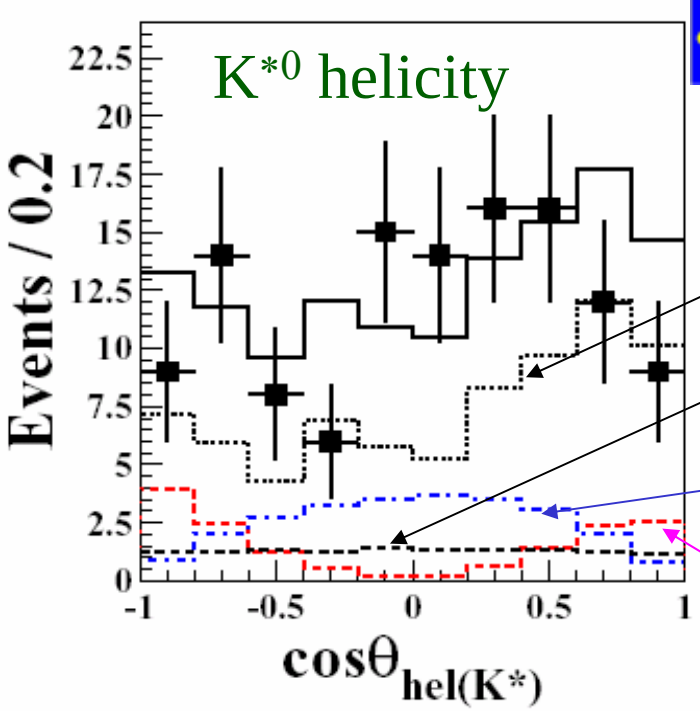
(Stat. sig: 3.2σ)

[Belle-conf-0404]



$B \to \rho^+ K^{*0}$ Polarization





152M $B\bar{B}$

2D(ρ,K* helicity) ML-fit (**M_{bc}, ΔE, mass signal region**)

$f_L = 0.50 \pm 0.19 \pm^{0.05}_{0.07}$ (3.1σ away from $f_L = 1$)

$B = (6.6 \pm 2.2 \pm 0.8) \times 10^{-6}$

[Belle-conf-0404]

$B \to \rho^+ K^{*0}$ Polarization

89M $B\bar{B}$

[BaBar-conf-04/34]

ML fit to all distributions simultaneously

1st observation

Nsig = $141 \pm {}^{23}_{24}$ (>5σ)

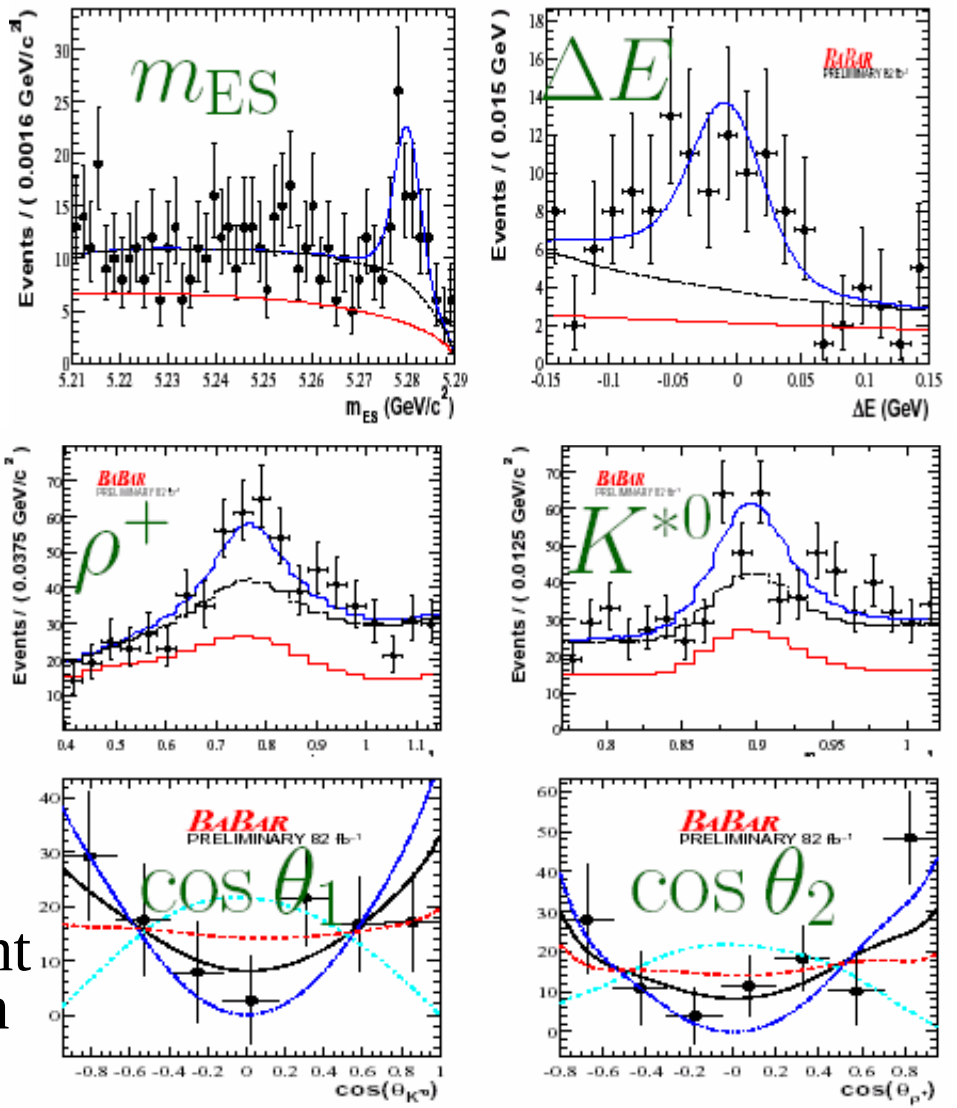
f_L =0.79 ± 0.08 ±0.04 ±0.02

$B = (17.0 \pm 2.9 \pm 2.9 \pm {}^{0.0}_{1.9}) \times 10^{-6}$

$A_{CP} = -0.14 \pm 0.17 \pm 0.04$

BaBar + Belle likely $f_L < 1$

non-resonant contribution

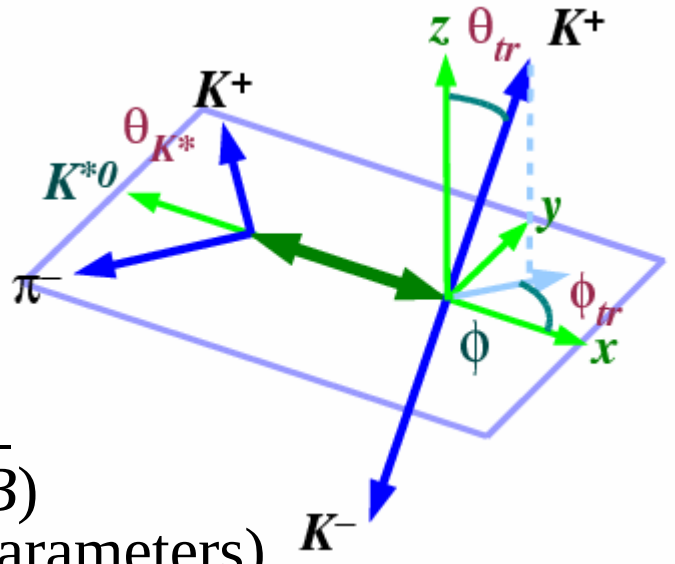


$B \to \phi K^*$: New Physics Search

Transversity basis:

Angular distribution

$P_{\phi K^*}(\theta_{tr}, \phi_{tr}, \theta_{K^*} ; A_0, A_{//}, A_\perp)$



A_0 : longitudinal (CP= +1)
$A_{//}$: transverse CP= +1
$A_\perp$: transverse CP= –1

} 2 sets $(B, \bar{B})$ (12-1 parameters)

$\Lambda_{\lambda\lambda} = f_\lambda = (|A_\lambda|^2 + |\bar{A}_\lambda|^2)/2$,
$\Sigma_{\perp i} = -\mathrm{Im}(A_\perp A_i^* + \bar{A}_\perp \bar{A}_i^*)$,
$\Lambda_{//0} = \mathrm{Re}(A_{//} A_0^* + \bar{A}_{//} \bar{A}_0^*)$,

$\Sigma_{\lambda\lambda} = (|A_\lambda|^2 - |\bar{A}_\lambda|^2)/2$
$\Lambda_{\perp i} = -\mathrm{Im}(A_\perp A_i^* - \bar{A}_\perp \bar{A}_i^*)$
$\Sigma_{//0} = \mathrm{Re}(A_{//} A_0^* - \bar{A}_{//} \bar{A}_0^*)$

Direct CPV

Triple-prod. (T-violation)

$(i = 0, //)$

$(|A_0|^2 + |A_{//}|^2 + |A_\perp|^2 = 1)$

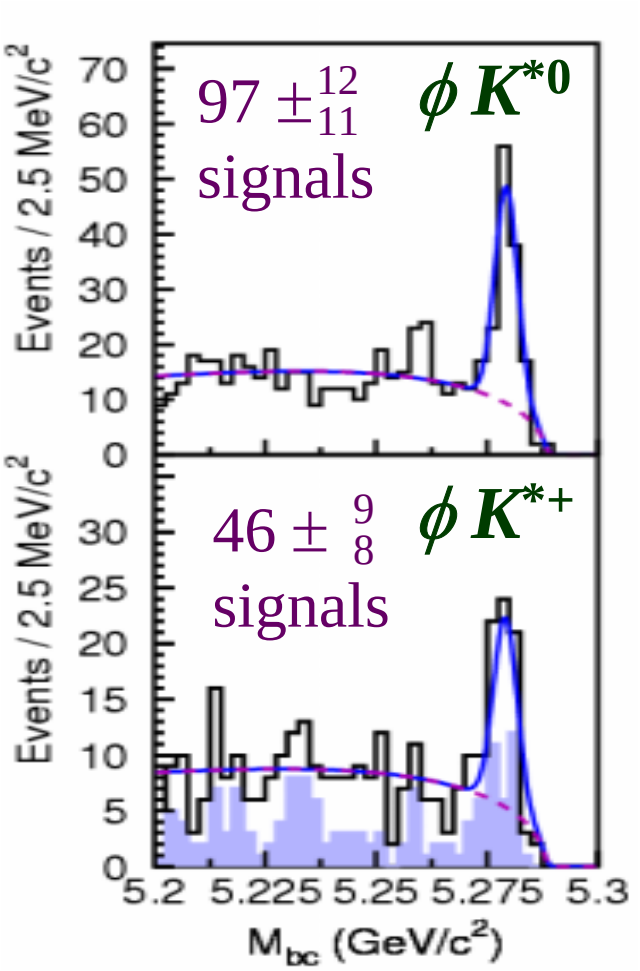
"≠0" → NP

[e.g. London, Sinha², PRD69,114013(04)]

$B \to \phi K^*$

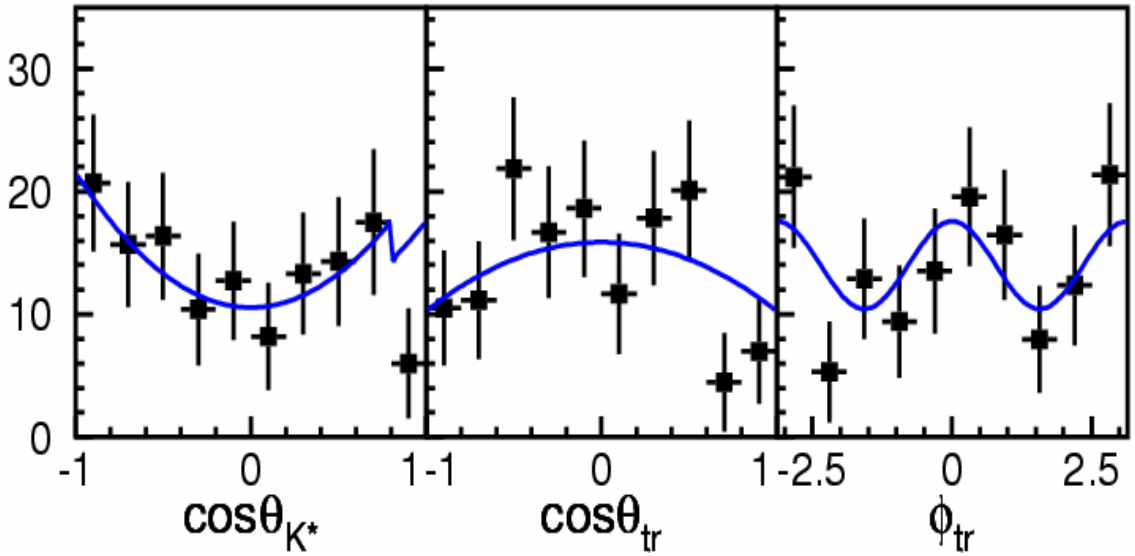
152M $B\bar{B}$

[Belle-conf-0419]



$f_L = 0.51 \pm 0.06 \pm 0.04$

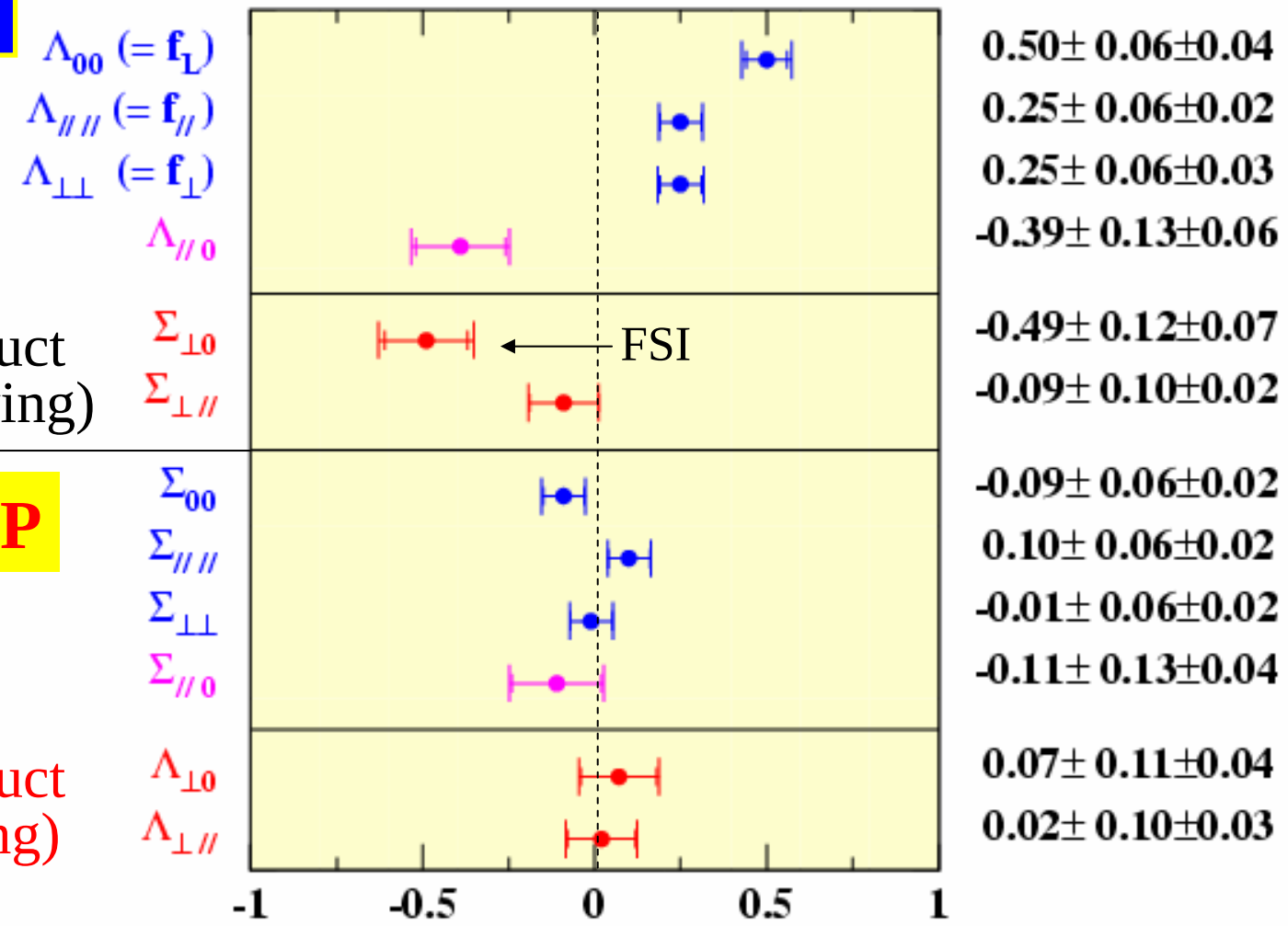
confirm low f_L



$B \to \phi K^*$: New Physics Search

152M $B\bar{B}$

$f_\perp / f_{//} \sim 1$



Triple product (T-conserving)

"≠0" → NP

Triple product (T-violating)

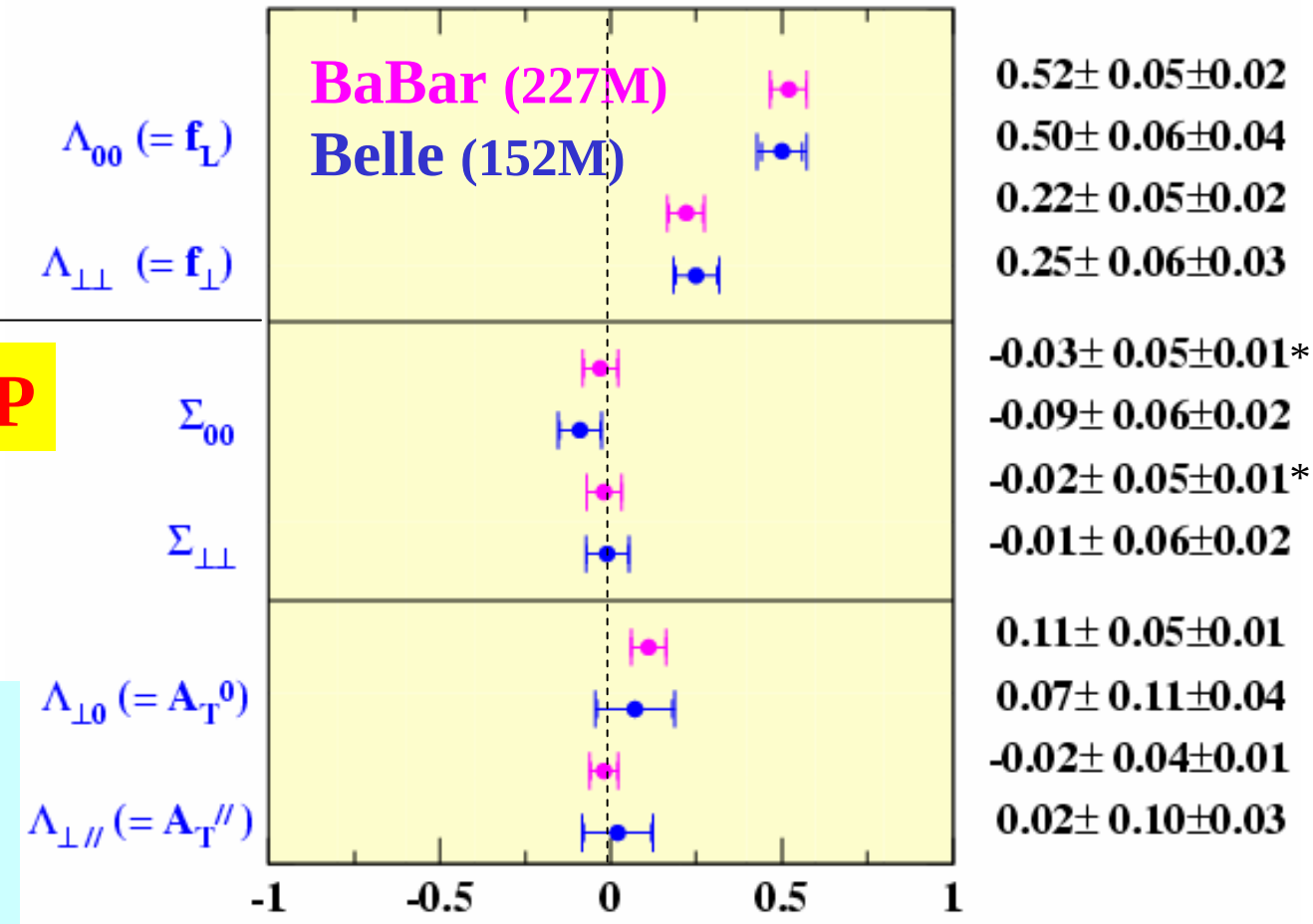
[Belle-conf-0419]

$B \to \phi K^*$: New Physics Summary

BaBar/Belle consistent

"≠0" → NP

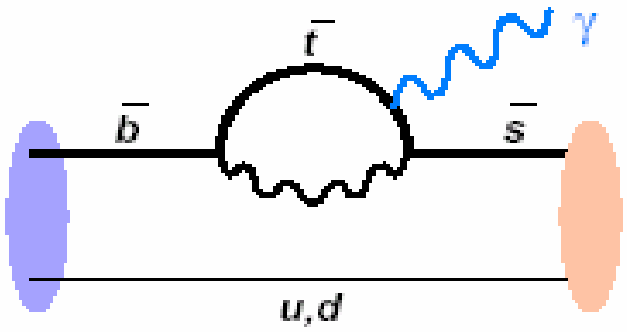
No indication of NP except f_L puzzle



(* recalculated from fit values)

Radiative & EW Penguins

Loops → Sensitive to New Physics



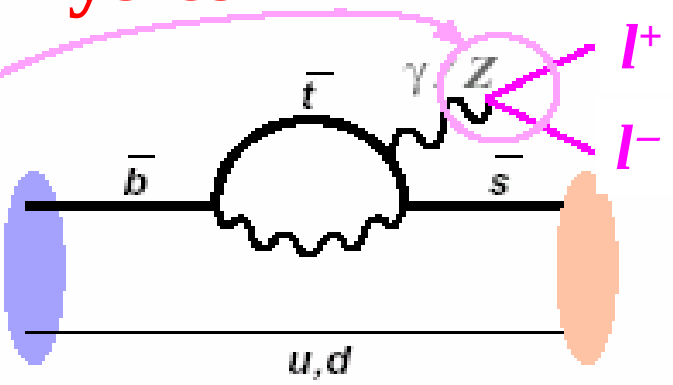
b → sγ penguin

Br, A_{CP} ~SM

↓

$K^*\gamma$ TCPV

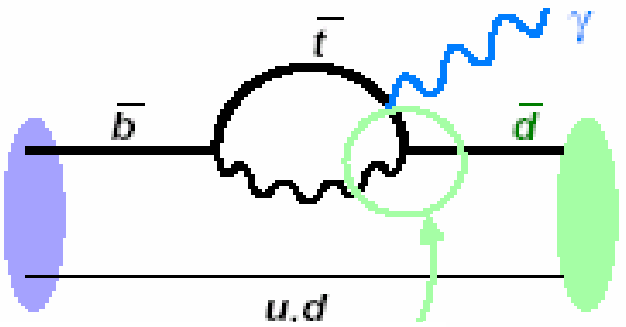
α_{EW}



b → sl^+l^- penguin

~1/100

$\left|\frac{V_{td}}{V_{ts}}\right|^2$



b → dγ penguin

$B \to K^{(*)} l^+ l^-$

[Belle-conf-0415]

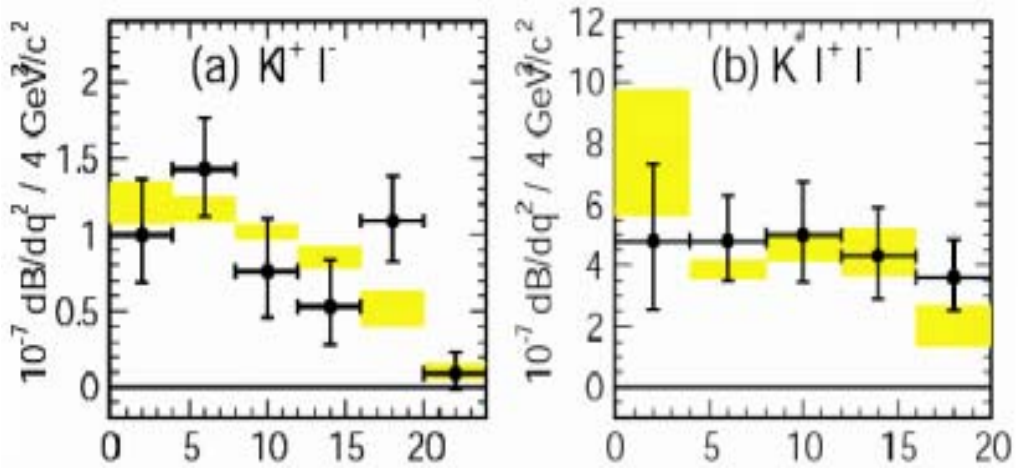
LP03: $B \to X_s ll$, $K^{(*)} ll$: Belle/BaBar
Br, A_{CP} ~SM

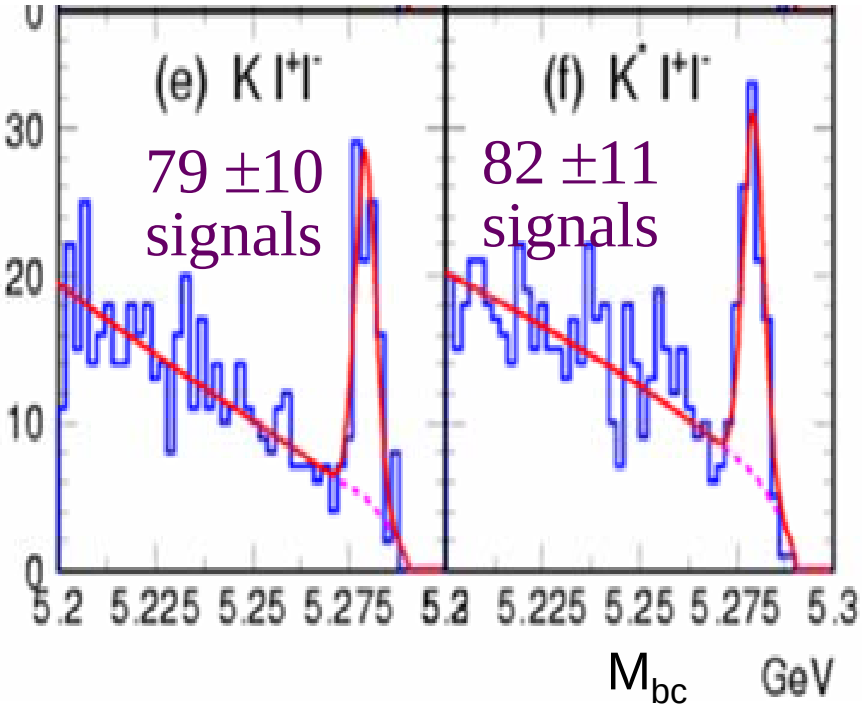
275M $B\bar{B}$ update **>10σ signals**

B (Kll)= $(5.50 \pm {}^{0.75}_{0.70} \pm 0.27 \pm 0.02)$

B (K*ll)= $(16.5 \pm {}^{2.3}_{2.2} \pm 0.9 \pm 0.4)$

x 10^{-7}



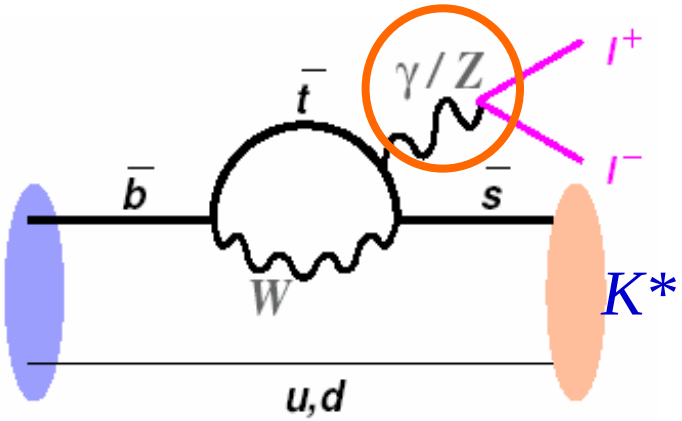


$B \to K^* l^+ l^-$:FB Asymmetry

275M $B\bar{B}$

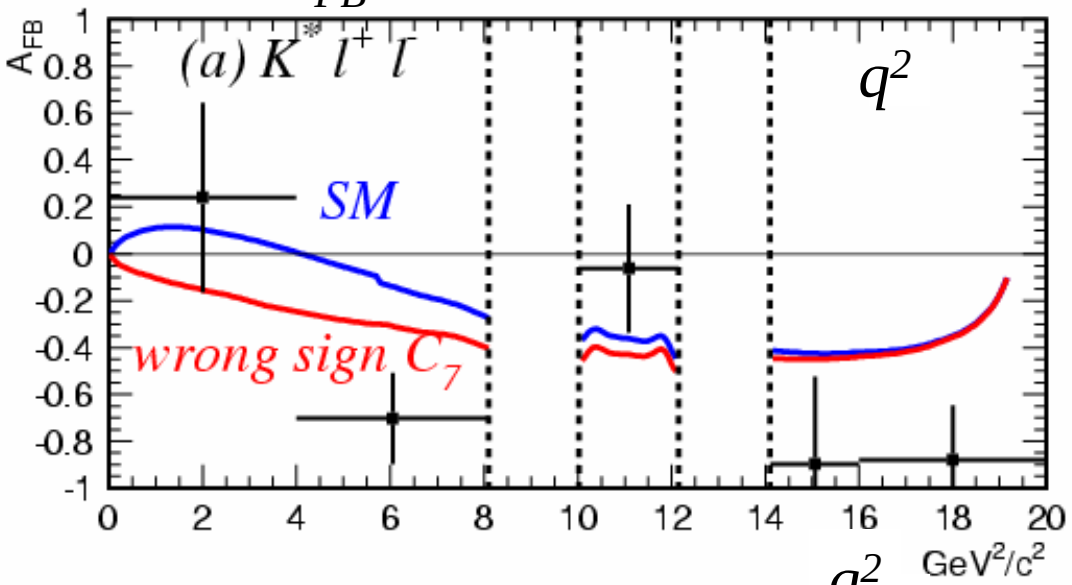
$A_{FB}(K^*ll)$: very sensitive to NP that may not be seen in $B(b \to s\gamma)$

$$A_{FB} = \frac{\Gamma(\theta_{Bl^+} < \pi/2) - \Gamma(\theta_{Bl^+} > \pi/2)}{\Gamma(\theta_{Bl^+} < \pi/2) + \Gamma(\theta_{Bl^+} > \pi/2)}$$



$b \to sll$ penguin

raw A_{FB}



First Look !

[Belle-conf-0415]

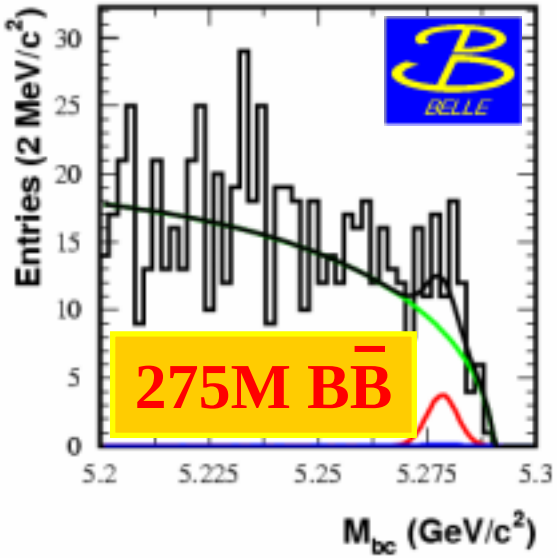
$b \to d\gamma$: $B \to (\rho,\omega)\gamma$

Suppress K*γ with PID and M('K'π) cut

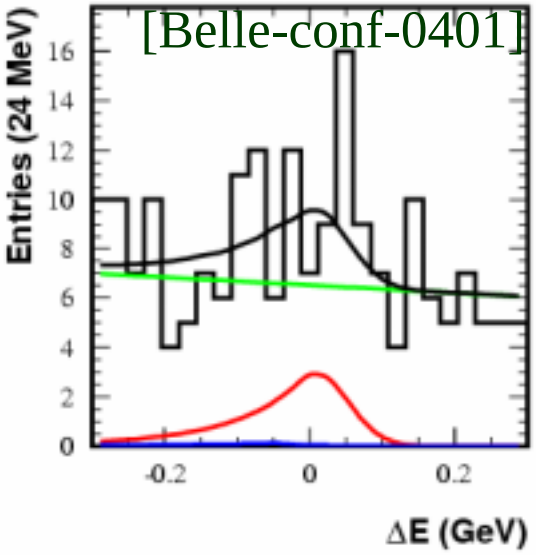
$B(B\to(\rho,\omega)\gamma) = (0.72\ ^{+0.43}_{-0.39} \pm 0.27) \times 10^{-6}$ (1.9σ)
[< 1.4 x 10^{-6} @90% CL]

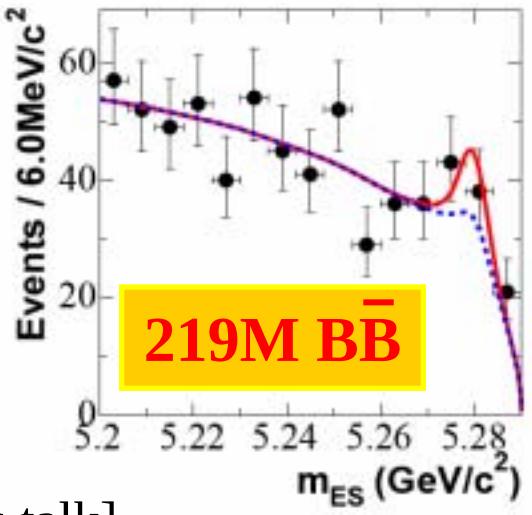
Simultaneous fit to 3 modes:
$\Gamma(B\to(\rho,\omega)\gamma) = \Gamma(B^+\to\rho^+\gamma)$
$= 2\Gamma(B^0\to\rho^0\gamma) = 2\Gamma(B^0\to\omega\gamma)$

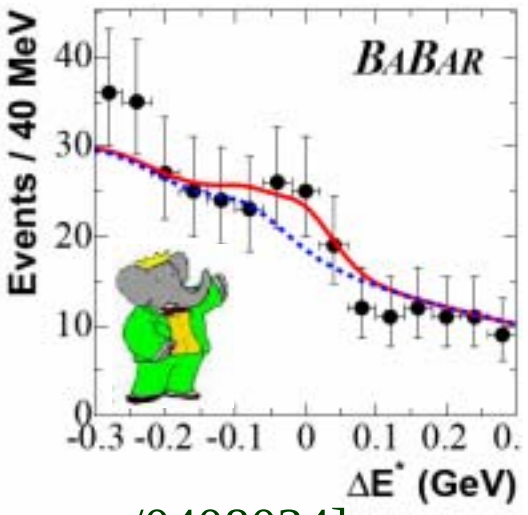
$B(B\to(\rho,\omega)\gamma) = (0.6 \pm 0.3 \pm 0.1) \times 10^{-6}$ (2.1σ)
[< 1.2 x 10^{-6} @90% CL]



[Belle-conf-0401]





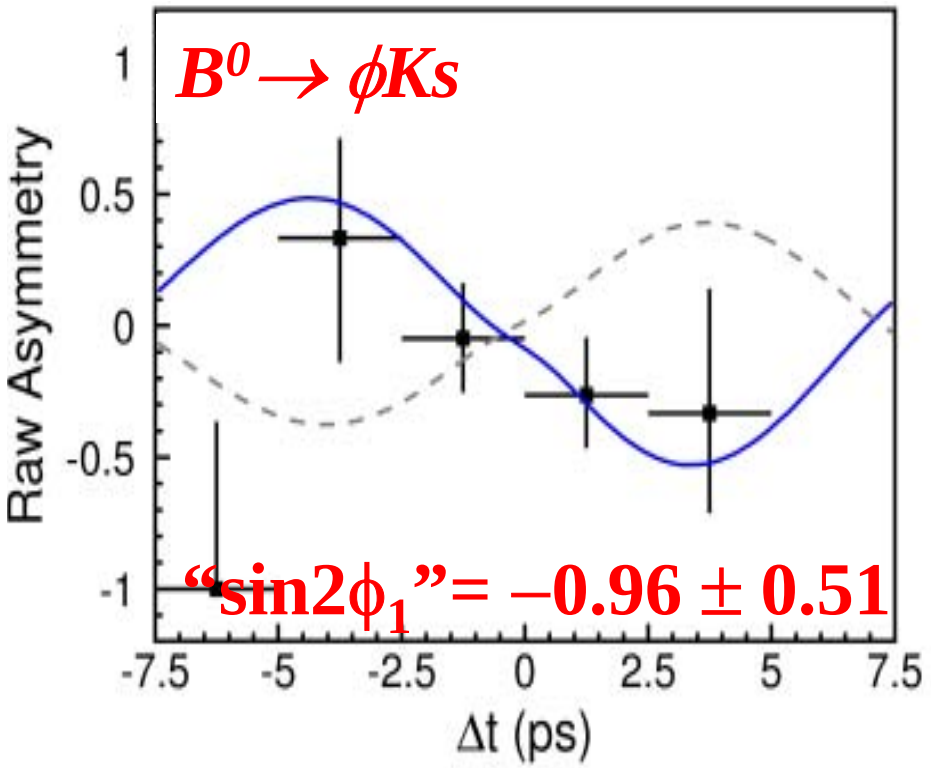


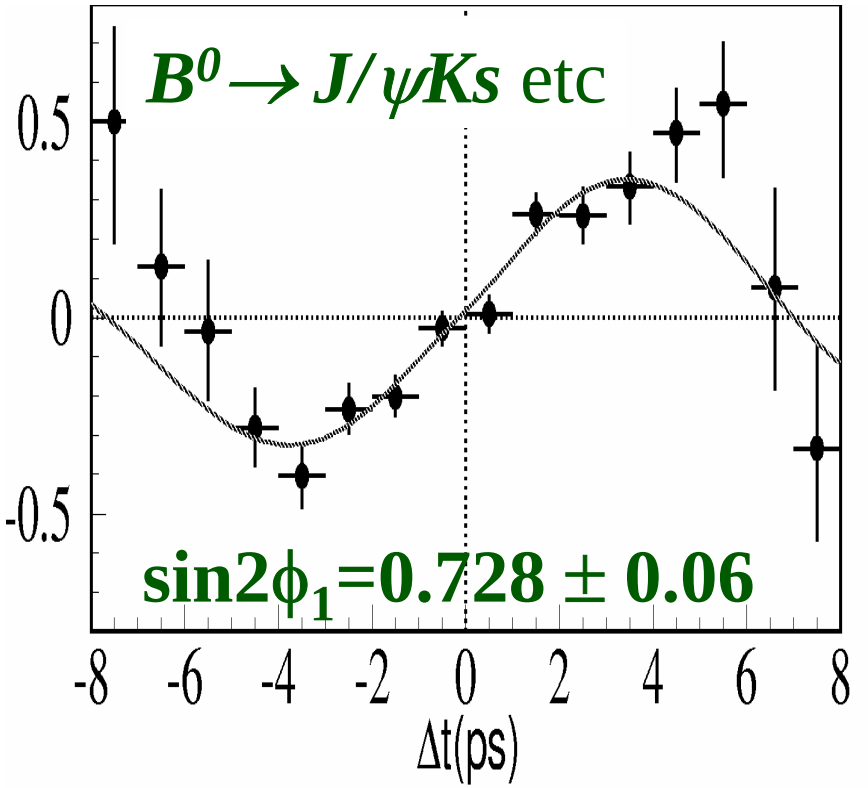
[hep-ex/0408034]

⇒ |Vtd|/|Vts| [→ A.Ali's talk]

$b \to s\bar{q}q$ Penguin CPV

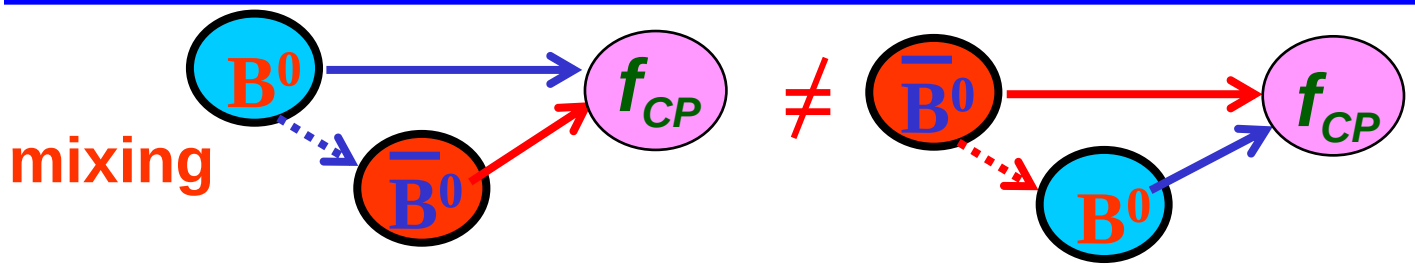
Belle @LP03 (140 fb^{-1}) [PRL 91, 261602 (2003)]





3.5σ deviation from the SM !

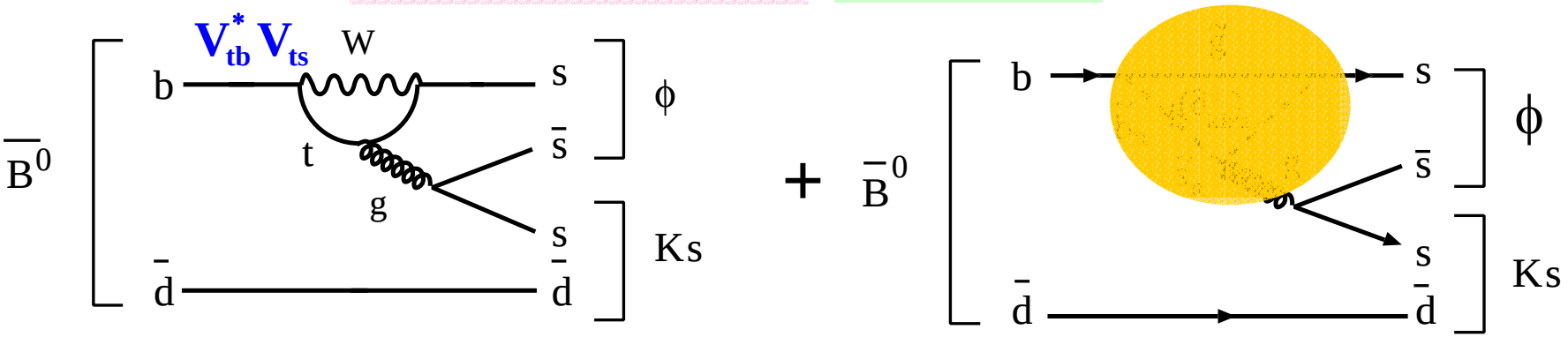
Time-dependent CP Violation



(TCPV)

$$A_{CP}(\Delta t) = S \sin(\Delta m \Delta t) + A \cos(\Delta m \Delta t)$$

Mixing induced CPV **Direct CPV**



SM: $b \to s$ Penguin

phase = $J/\psi K_S$ $(b \to c)$

$S_{b\to s} = \sin 2\phi_1$, $A = 0$

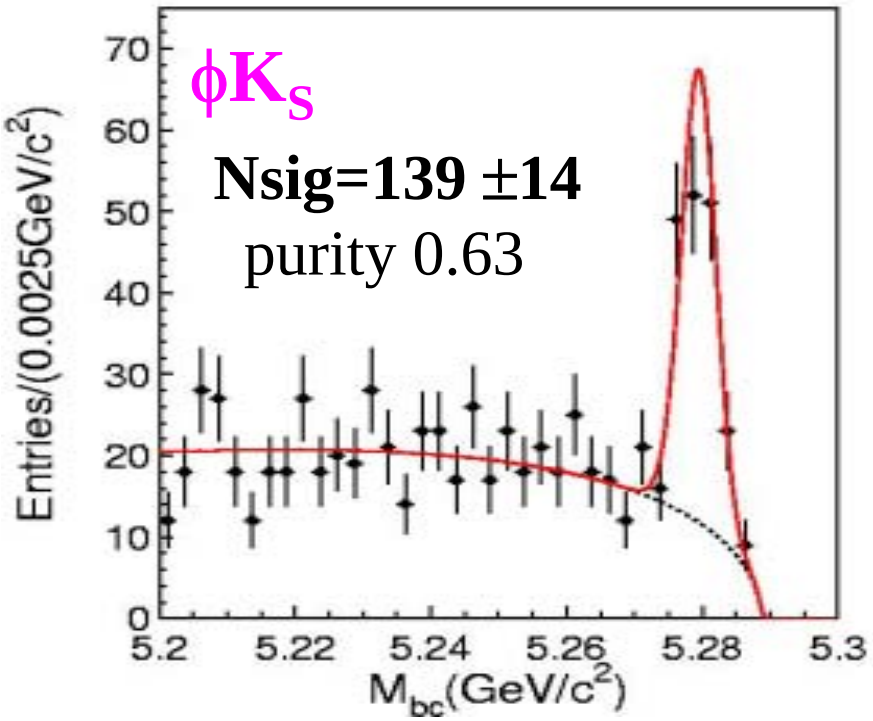
+ New Physics

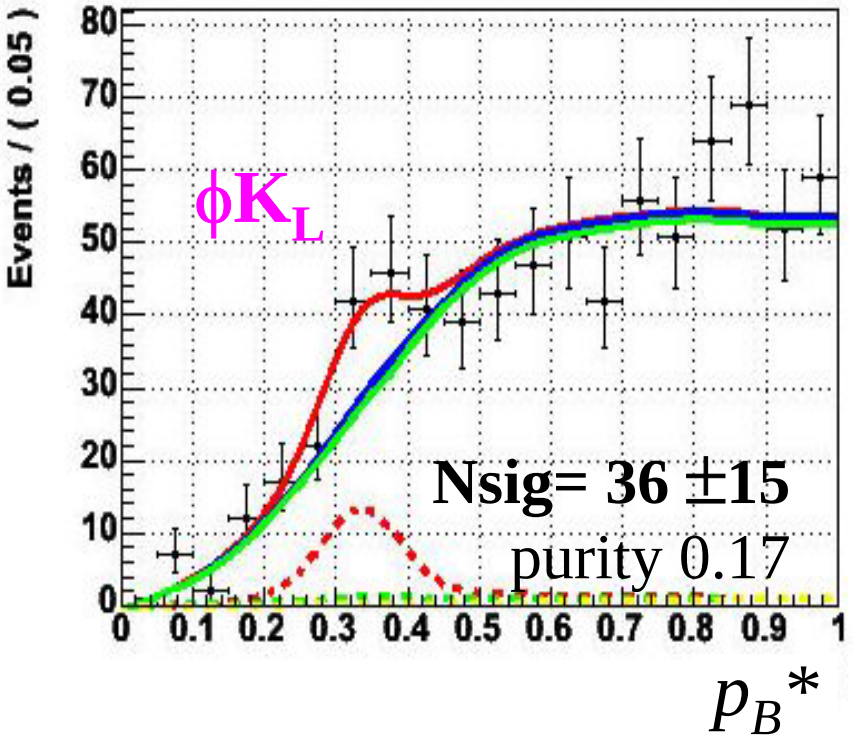
with New Phase

$S_{b\to s} \neq \sin 2\phi_1$, A can $\neq 0$

$B^0 \to \phi K^0$

275M $B\bar{B}$

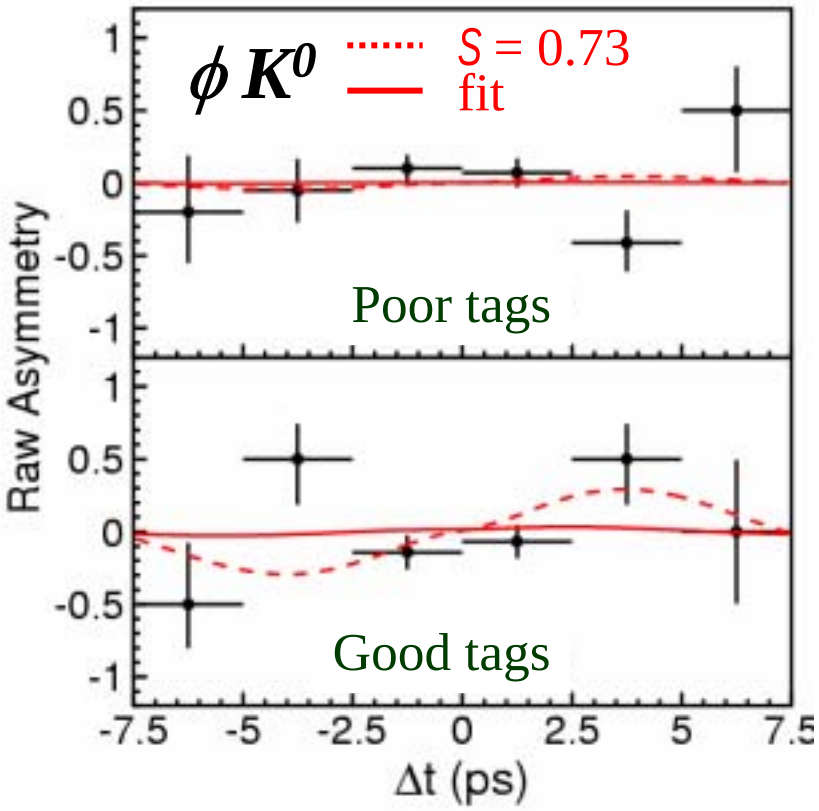


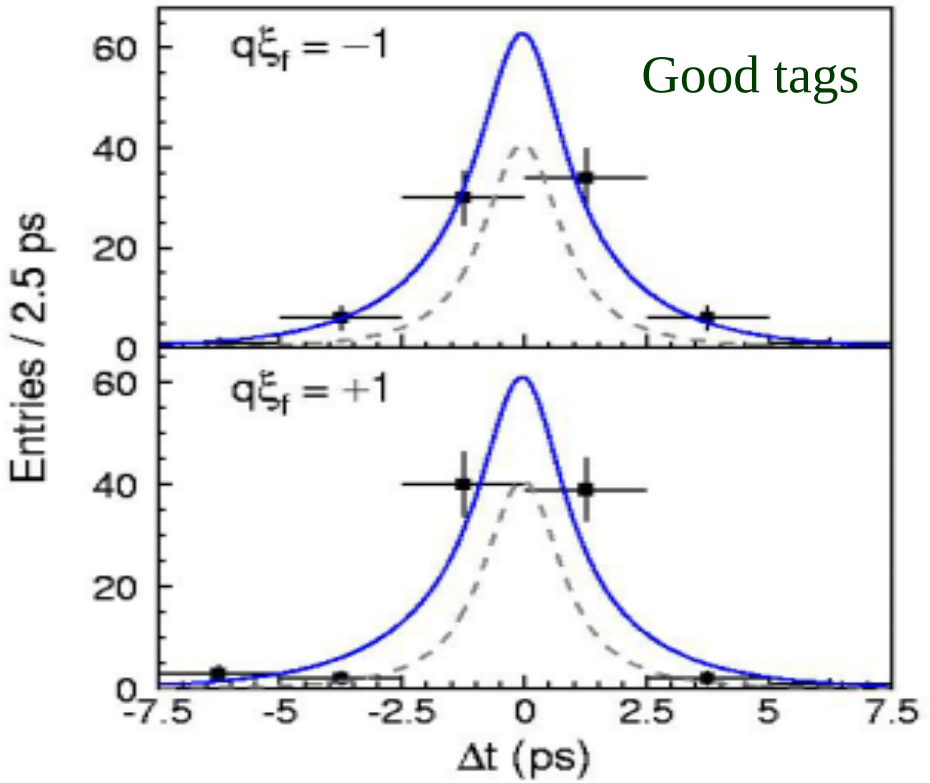


includes Ks $\to \pi^0\pi^o$
(Nsig=13 ±5)

Similar to J/ψK_L recon.
+ sophisticated continuum suppression

$B^0 \to \phi K^0$: CPV Result





$\phi K_S + \phi K_L$: $S\ (\phi K^0) = +0.06 \pm 0.33 \pm 0.09$

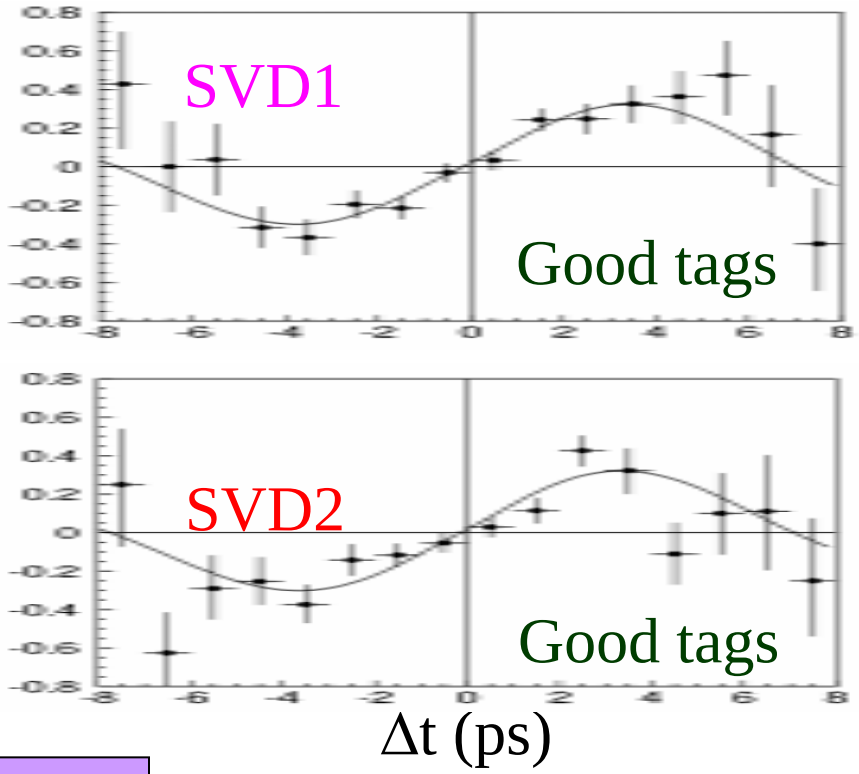
$A\ (\phi K^0) = +0.08 \pm 0.22 \pm 0.09$

~2σ away from SM

275M $B\bar{B}$

Checks: sin2ϕ_1 ($B^0 \to J/\psi K_{S/L}$)

Validation of new data sample (SVD2)



SVD1: 152M $B\bar{B}$

$S = 0.696 \pm 0.061$ (stat)
$A = 0.011 \pm 0.043$ (stat)

SVD2: 123M $B\bar{B}$

$S = 0.629 \pm 0.069$ (stat)
$A = 0.035 \pm 0.044$ (stat)

ϕK^0

SVD1:
$S = -0.68 \pm 0.46$
$A = -0.02 \pm 0.28$

~2.3σ ↔

SVD2:
$S = +0.78 \pm 0.45$
$A = +0.17 \pm 0.33$

many systematic checks, all ok

$B^0 \to \eta' K_S$ & $K^+K^-K_S$

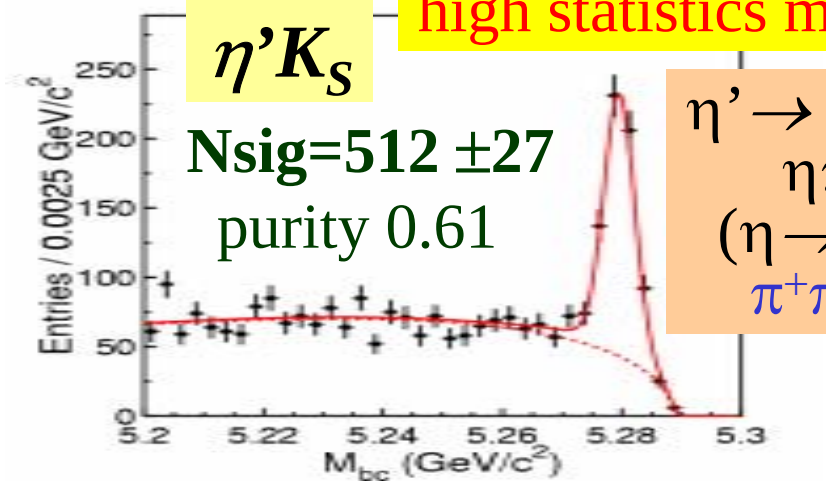
high statistics modes

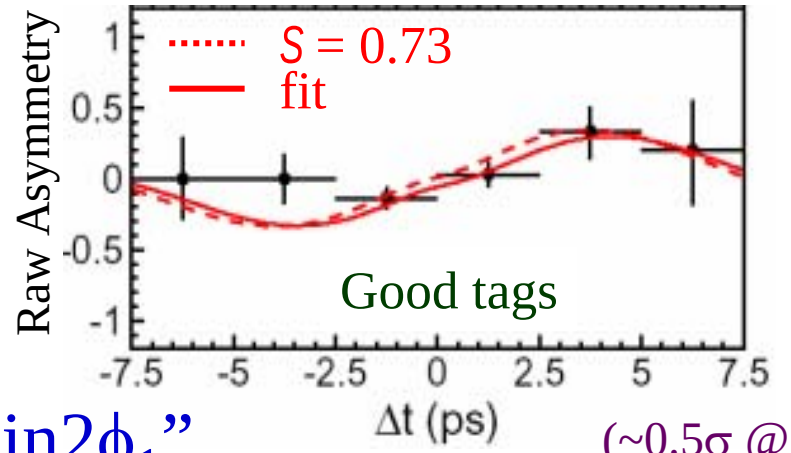
$\eta' K_S$

Nsig=512 ±27

purity 0.61

$\eta' \to \rho\gamma$, $\eta\pi^+\pi^-$ ($\eta \to \gamma\gamma$, $\pi^+\pi^-\pi^0$)

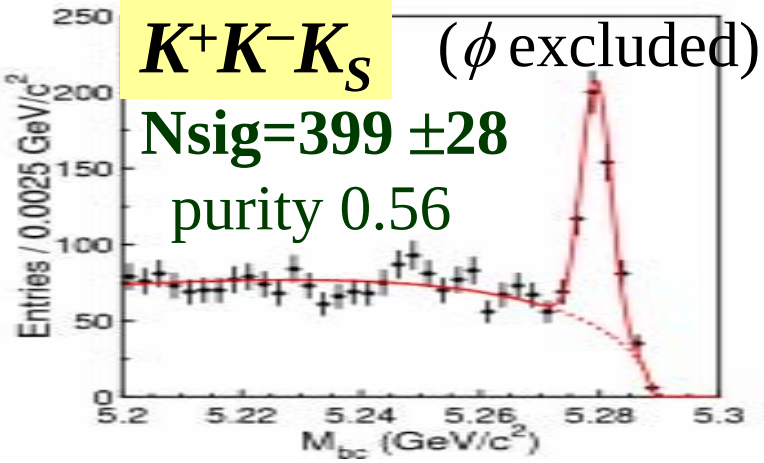


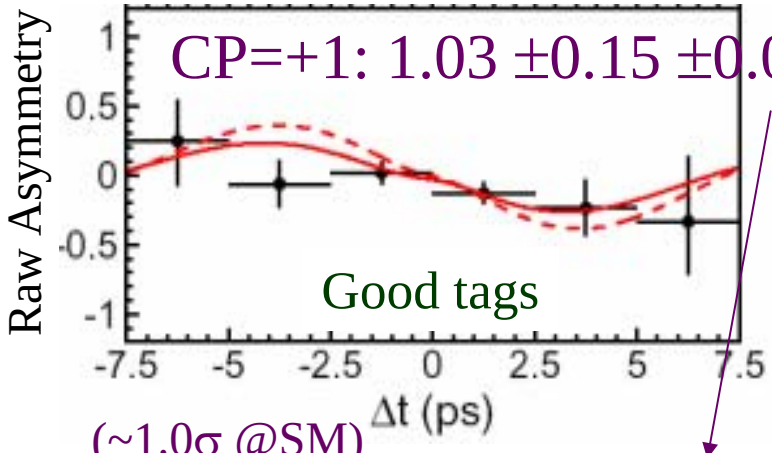


$K^+K^-K_S$ (ϕ excluded)

Nsig=399 ±28

purity 0.56





"$\sin 2\phi_1$"

(~0.5σ @SM)

$S = +0.65 \pm 0.18 \pm 0.04$

$A = -0.19 \pm 0.11 \pm 0.05$

(~1.0σ @SM)

$-S = +0.49 \pm 0.18 \pm 0.04 \left(\pm^{0.17}_{0.0}\right)$

$A = -0.08 \pm 0.12 \pm 0.07$

275M $B\bar{B}$

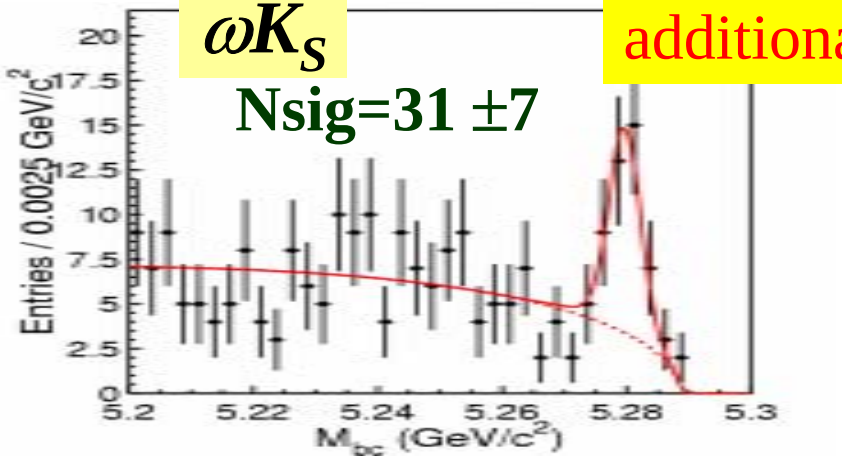
$B^0 \to \omega K_S$ & $f_0(980)K_S$

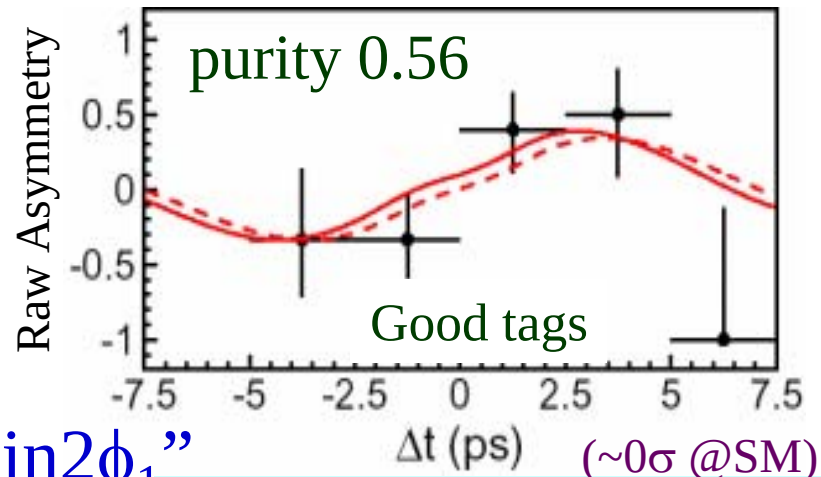
275M $B\bar{B}$

additional modes

ωK_S

Nsig=31 ±7

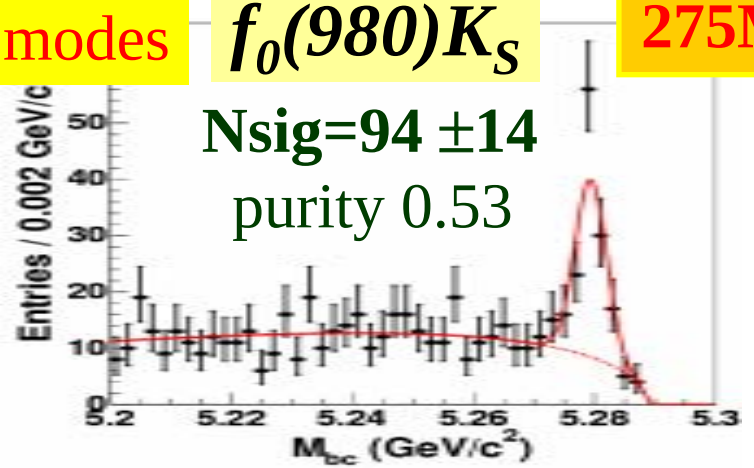


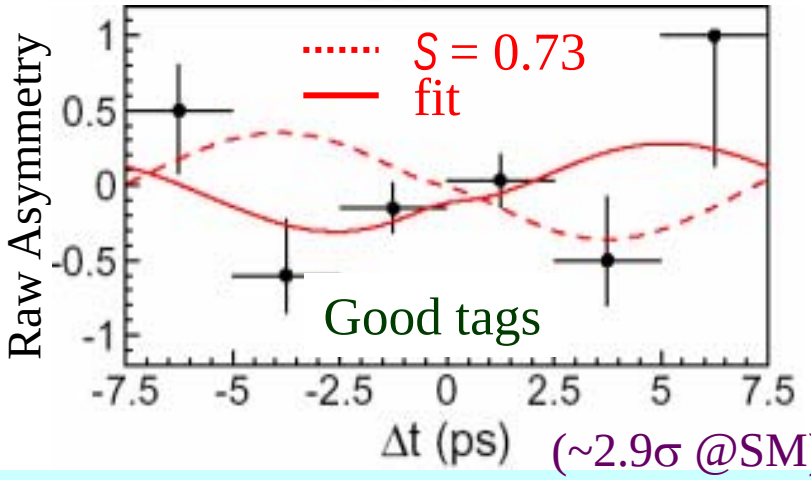


$f_0(980)K_S$

Nsig=94 ±14

purity 0.53





"$\sin 2\phi_1$"

(~0σ @SM)

$S = +0.75 \pm 0.64 \pm {}^{0.13}_{0.16}$

$A = +0.26 \pm 0.48 \pm 0.15$

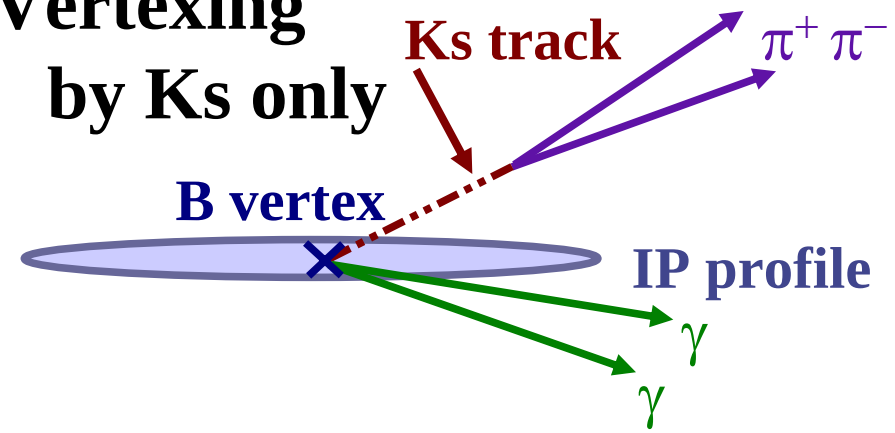
(~2.9σ @SM)

$-S = -0.47 \pm 0.41 \pm 0.08$

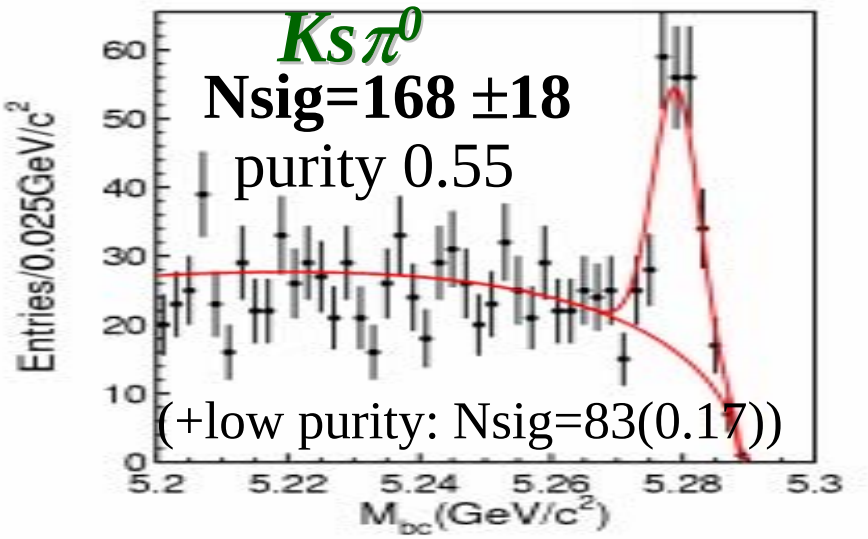
$A = -0.39 \pm 0.27 \pm 0.08$

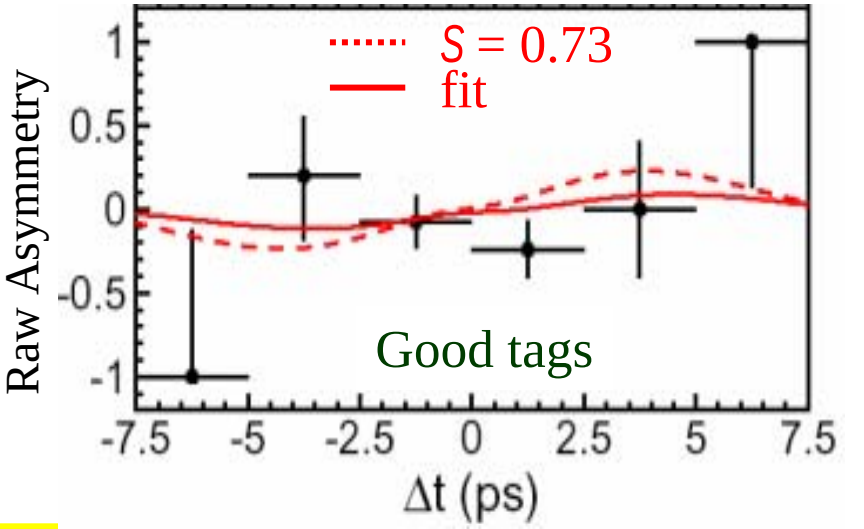
$B^0 \to Ks\pi^0$

Vertexing by Ks only



Validated by J/ψ Ks (use Ks only)





(~0.7σ @SM)

"$\sin 2\phi_1$"

$S = +0.30 \pm 0.59 \pm 0.11$

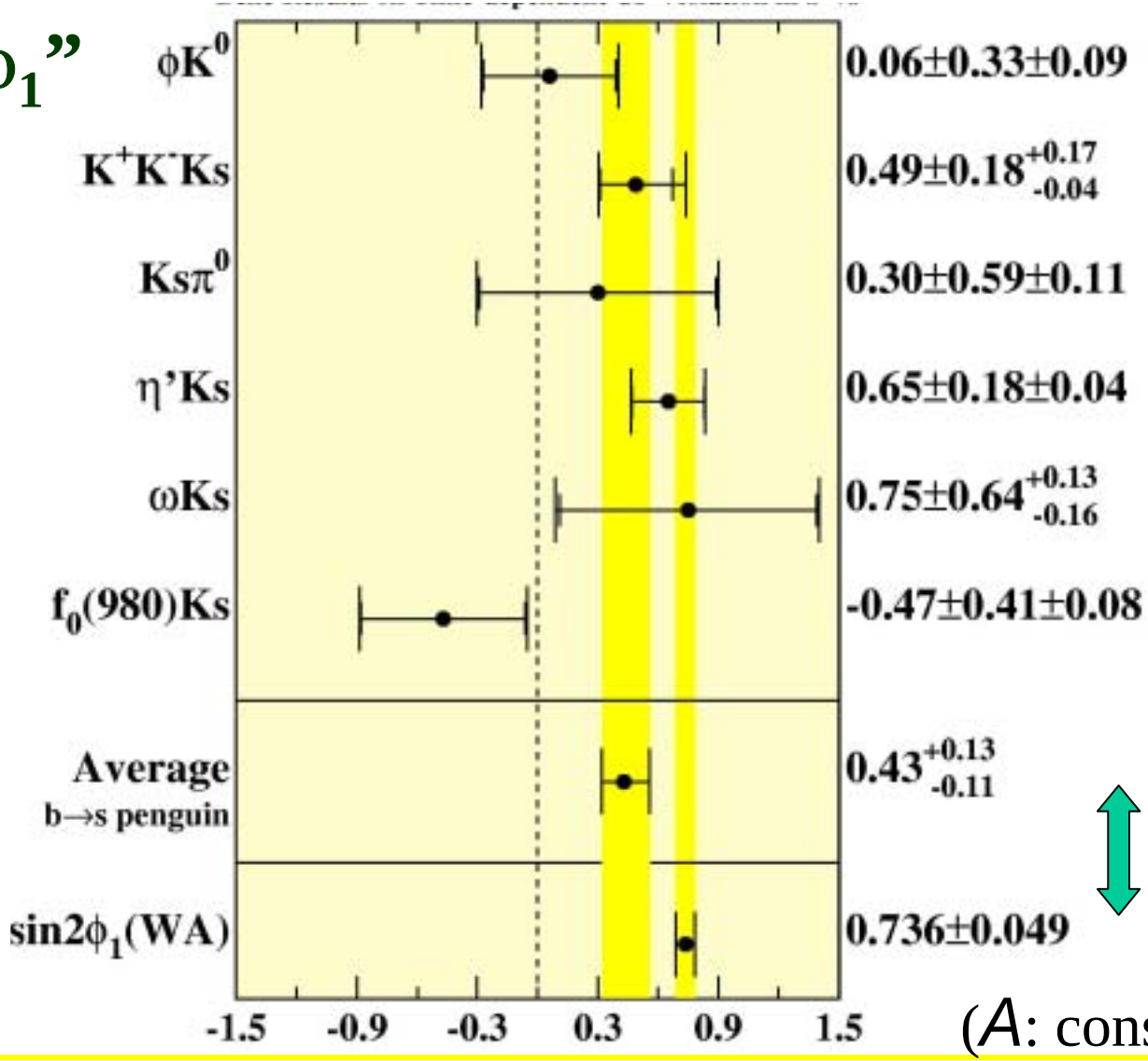
$A = -0.12 \pm 0.20 \pm 0.07$

275M $B\bar{B}$

Summary of $b \to s\bar{q}q$ CPV

"$\sin 2\phi_1$"

275M $B\bar{B}$



2.4σ

(A: consistent with 0)

$B \to K^*\gamma$ TCPV: New Physics

SM: $\gamma \approx$ polarized

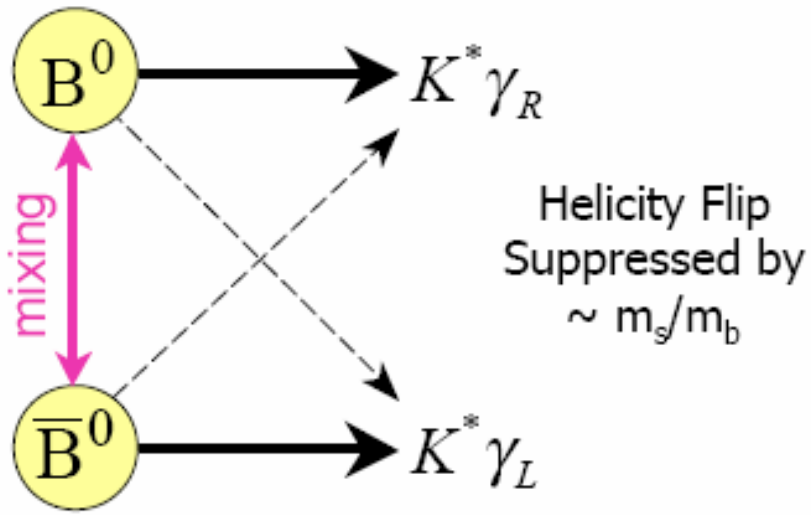
B^0 & $\bar{B}^0$ opposite

$S \approx 2(m_s/m_b)\sin 2\phi_1 \approx 4\%$

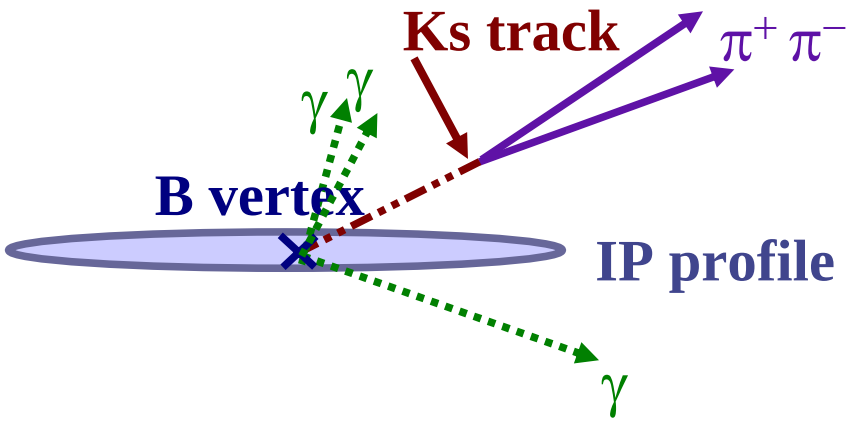
$A \sim 1\%$

New Physics $\leftrightarrow$ Large S, A

[e.g. Atwood,Gronau,Soni]



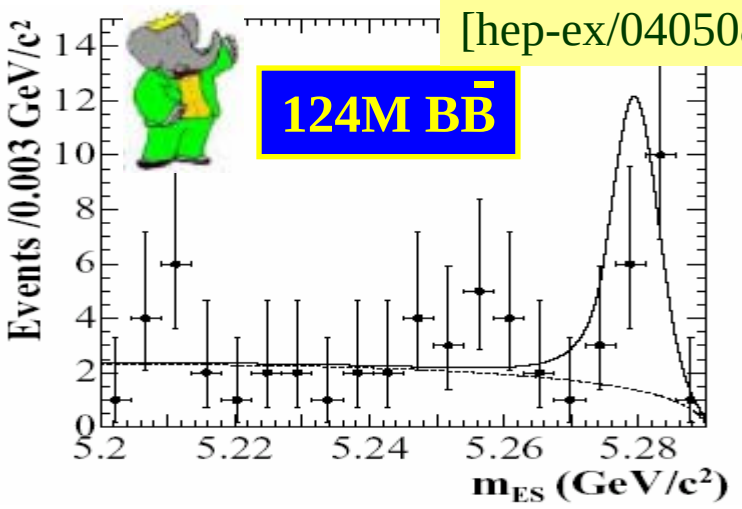
$B^0 \to K^*[Ks\pi^0]\gamma$

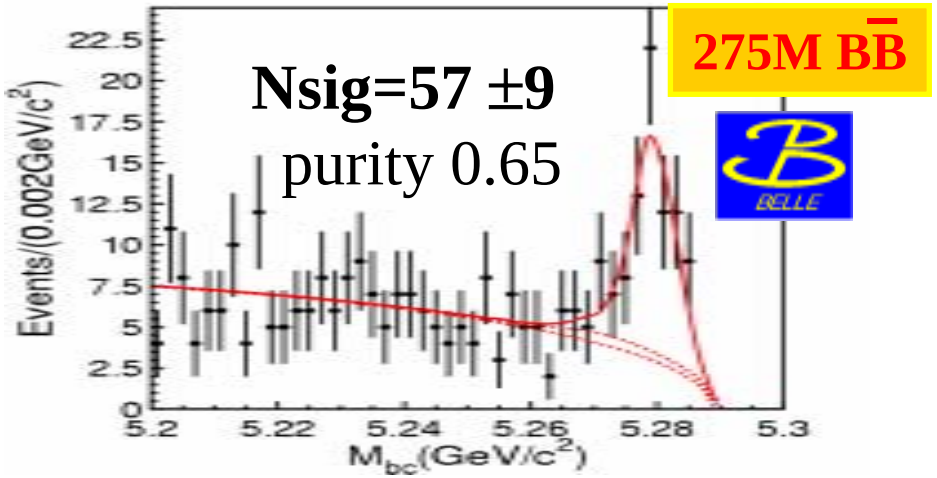


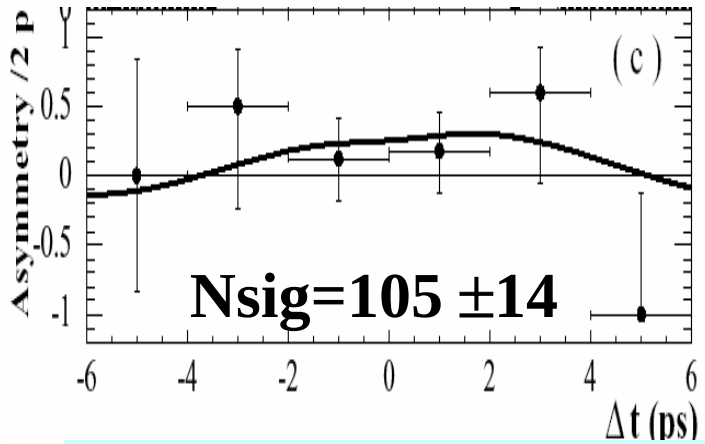
Analysis Technique: similar to $B^0 \to Ks\pi^0$

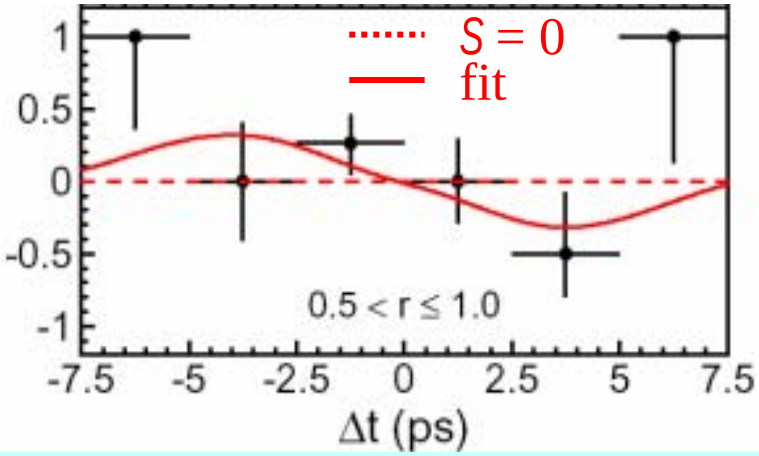
$B \to K^*[K_S\pi^0]\gamma$ TCPV

[hep-ex/0405082]









$S = +0.25 \pm 0.63 \pm 0.14$

$A = +0.57 \pm 0.32 \pm 0.09 = -C$

$S = -0.79 \pm^{0.63}_{0.50} \pm 0.09$

$A = -0.00 \pm 0.38$

First step for new era of $b \to s\gamma$!

Summary

☆B decays: many new results from BaBar/Belle

- Evidence for Direct CPV, $A_{CP}(K^+\pi^-) \neq A_{CP}(K^+\pi^0)$?
- $B \to \pi^0\pi^0$ decay established, 1st measurement of $A_{CP}(\pi^0\pi^0)$
- $f_L(\phi K^*)$ Polarization Puzzle: $f_L(\rho^+ K^{*0}) < 1$
  No hint of T-violating NP in $B \to \phi K^*$
- A first look at $B \to K^* ll$ FB-asymmetry
- 1st $B^0 \to K^*[Ks\pi^0]\gamma$ TCPV measurements

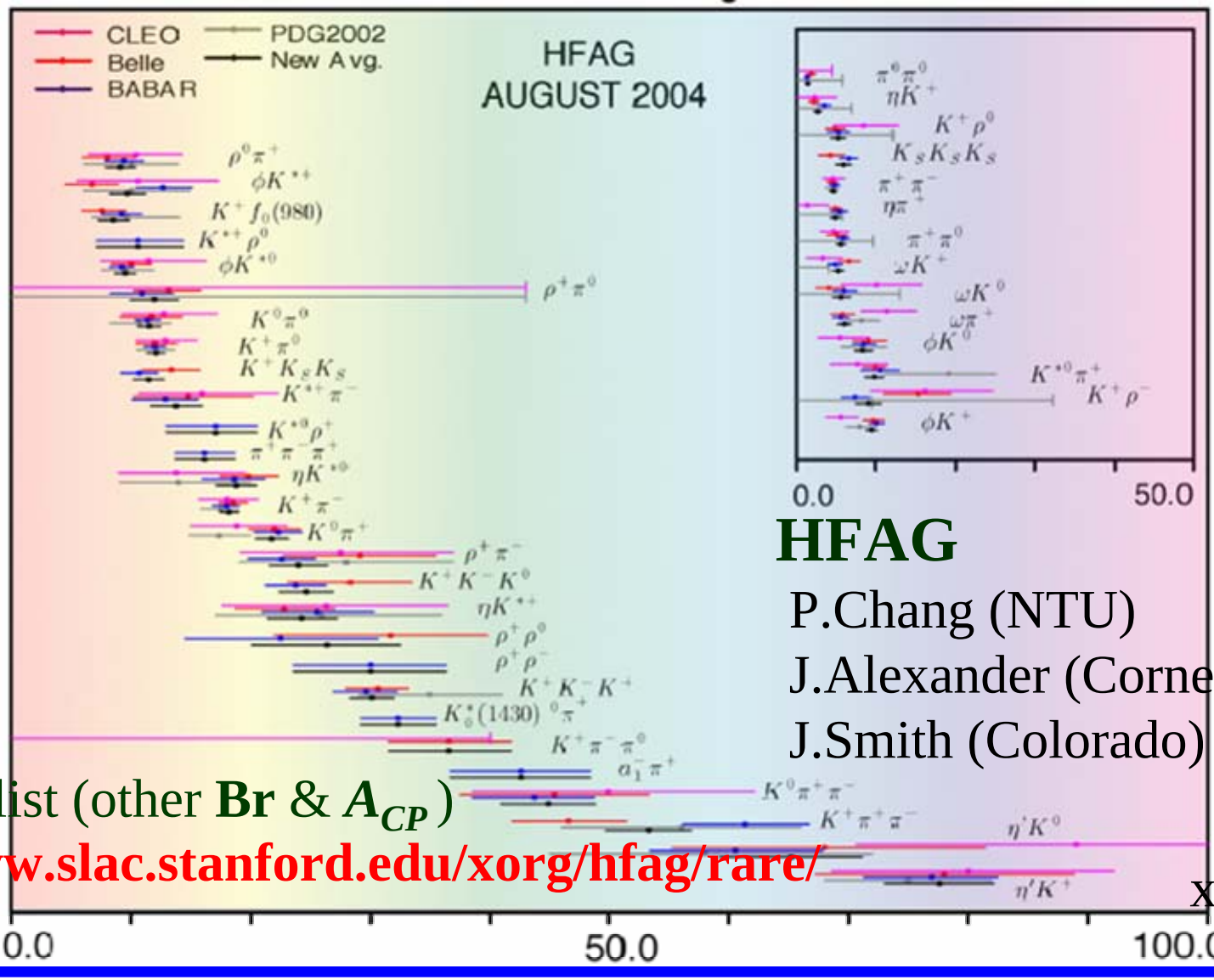
☆Belle $b \to s\bar{q}q$ TCPV updates

- $S(\phi K^0) = +0.06 \pm 0.33 \pm 0.09$ (~2σ away from SM)
- average of $b \to s\bar{q}q$: $+0.43 \pm {}^{0.13}_{0.11}$ (~2.4σ from SM)

(Giorgi's review for BaBar results)

More data needed to conclusively establish New Physics

Charmless B Br Summary



HFAG

P.Chang (NTU)

J.Alexander (Cornell)

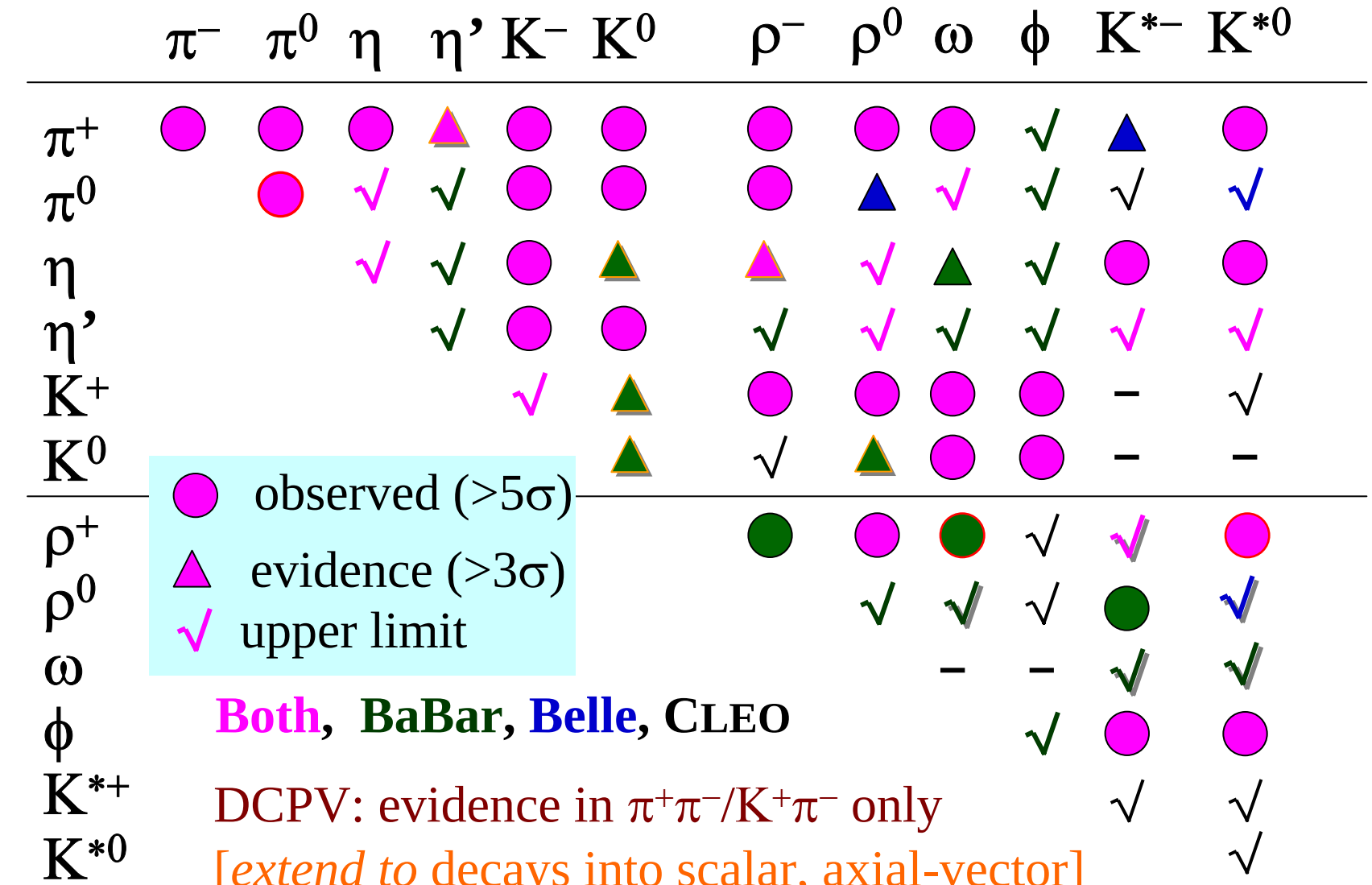
J.Smith (Colorado)

Complete list (other **Br** & A_{CP})

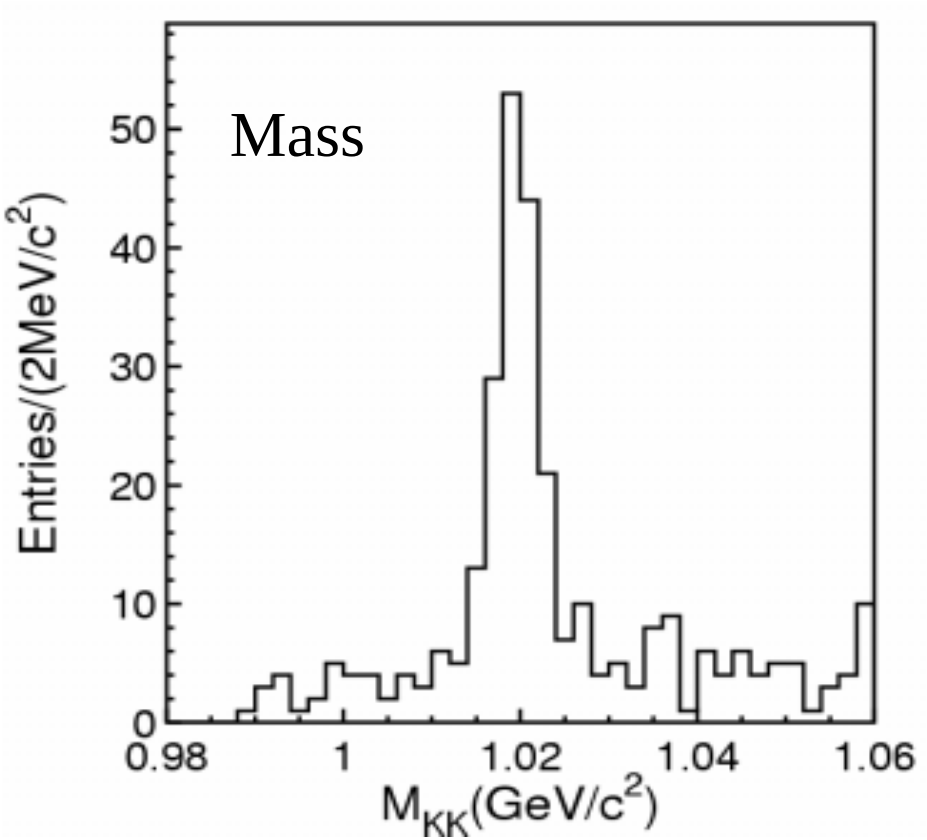
http://www.slac.stanford.edu/xorg/hfag/rare/

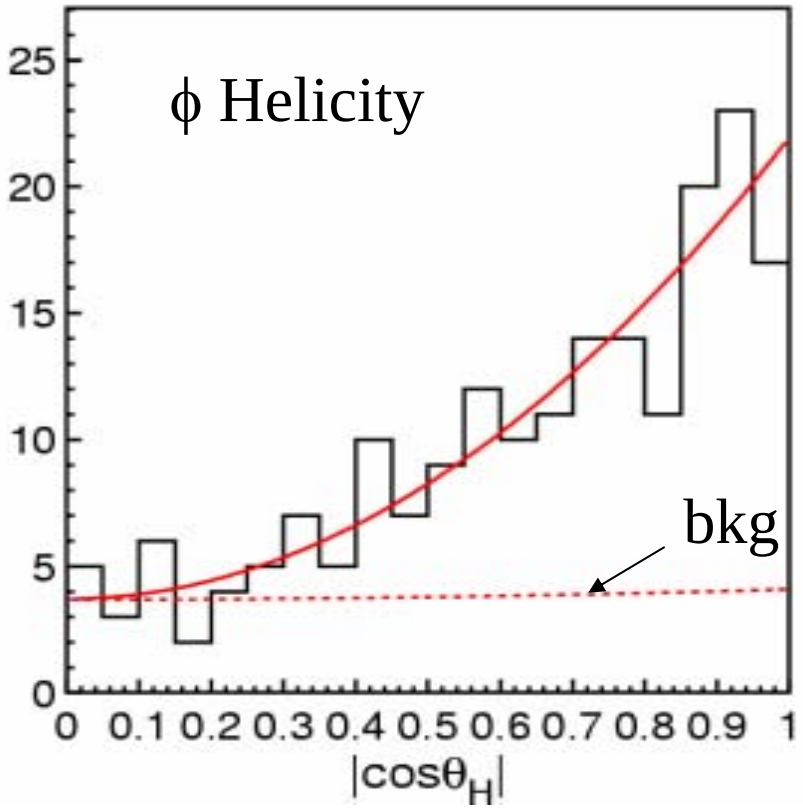
Backup

$B \to PP/PV/VV$ Summary



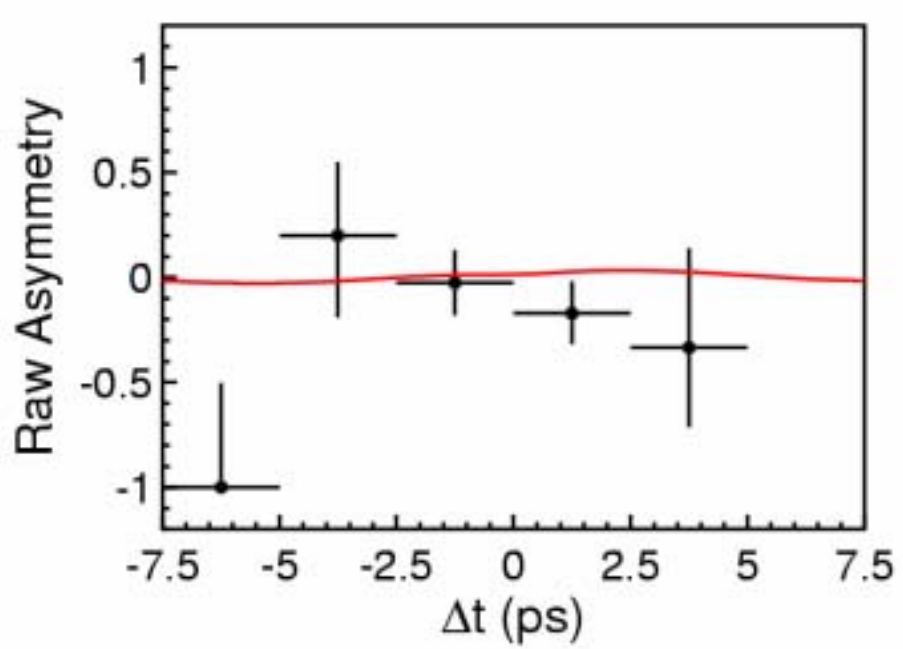
$B^0 \to \phi K_S$: Mass & Helicity



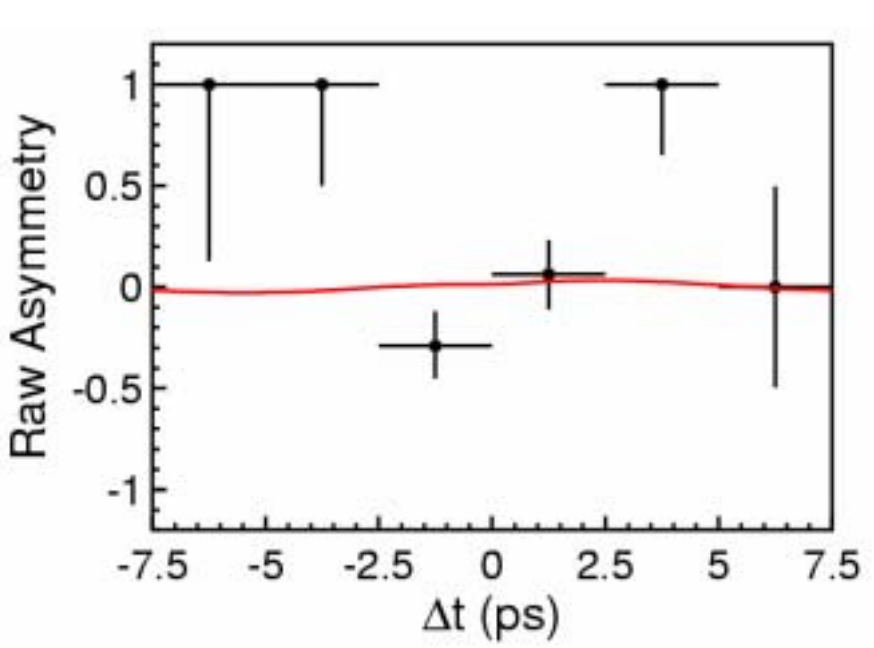


$B^0 \to \phi K^0$: SVD1,2

SVD1 only



SVD2 only



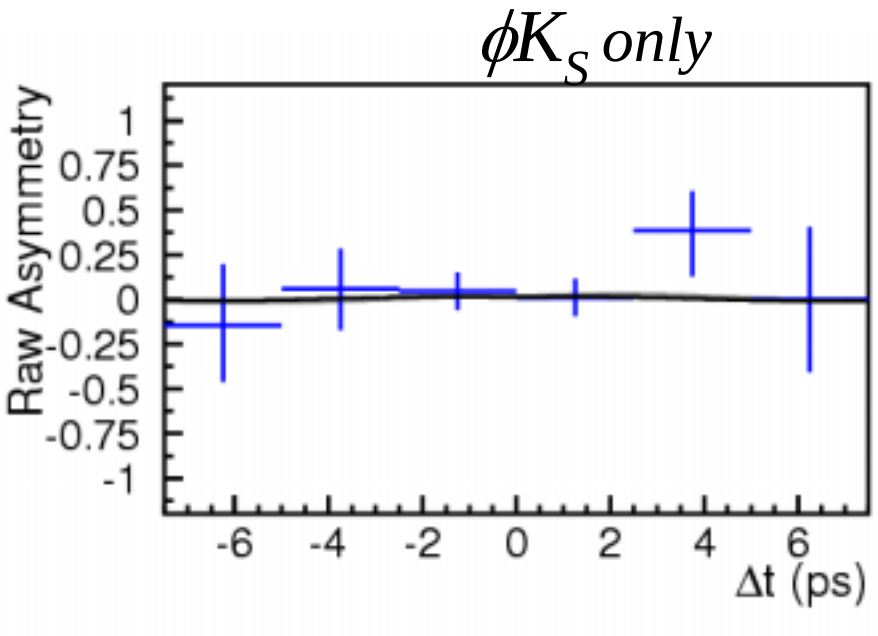
SVD1:
$S = -0.68 \pm 0.46$
$A = -0.02 \pm 0.28$

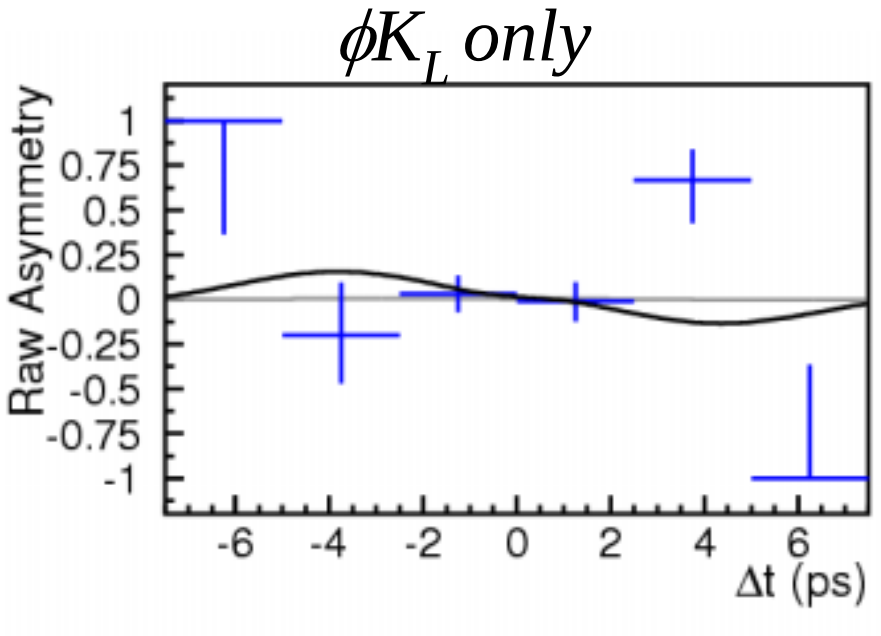
~2.3σ ↔

SVD2:
$S = +0.78 \pm 0.45$
$A = +0.17 \pm 0.33$

many systematic checks, all ok

$B^0 \to \phi K_S, \phi K_L$: CPV





$S = +0.00 \pm 0.33$

$A = +0.06 \pm 0.22$

$-S = +2.3 \pm 2.0$

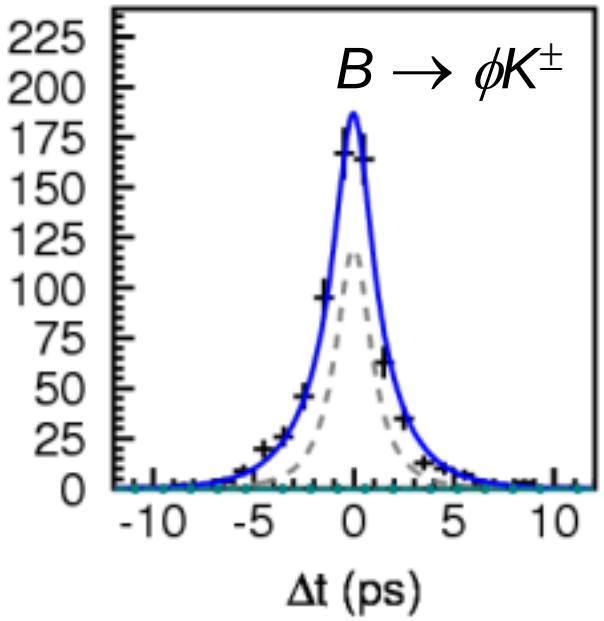
$A = +0.6 \pm 1.2$

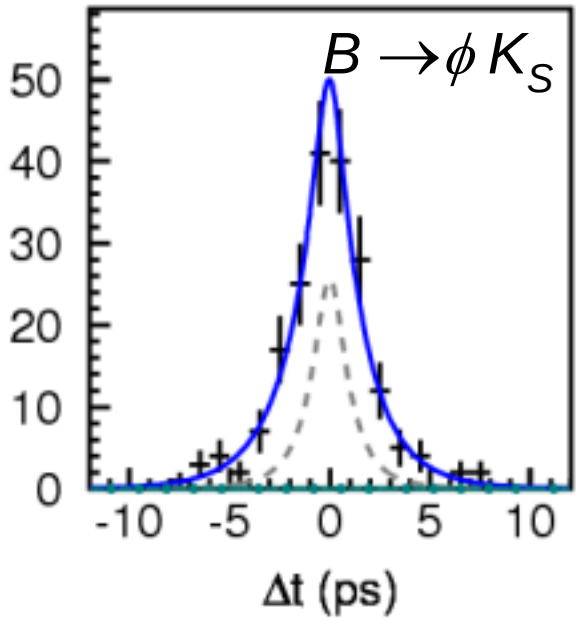
$B^0 \to \phi K^{\pm}$: Validations

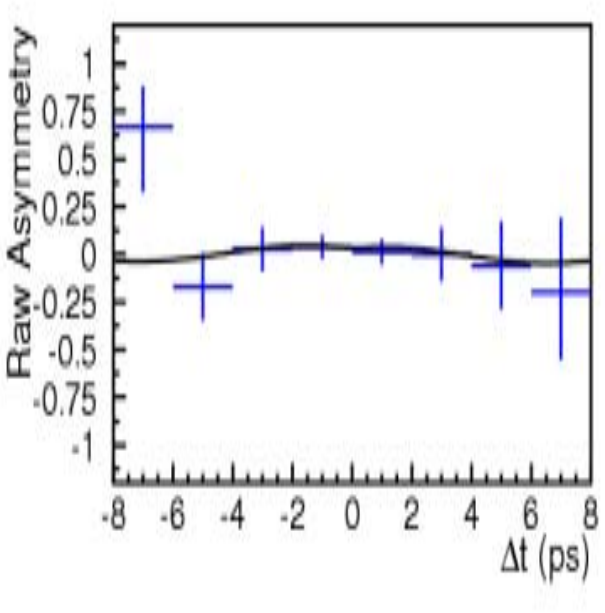
Control sample

Lifetime fit w/ $B \to \phi K^{\pm}/K_S$

Asymmetry fit w/ $\phi K^{\pm}$







$\tau_{B^+} = 1.67\ ^{+0.12}_{-0.11}$

$\tau_{B^0} = 1.59\ ^{+0.20}_{-0.19}$

$S(\phi K^{\pm}) = -0.03 \pm 0.20$

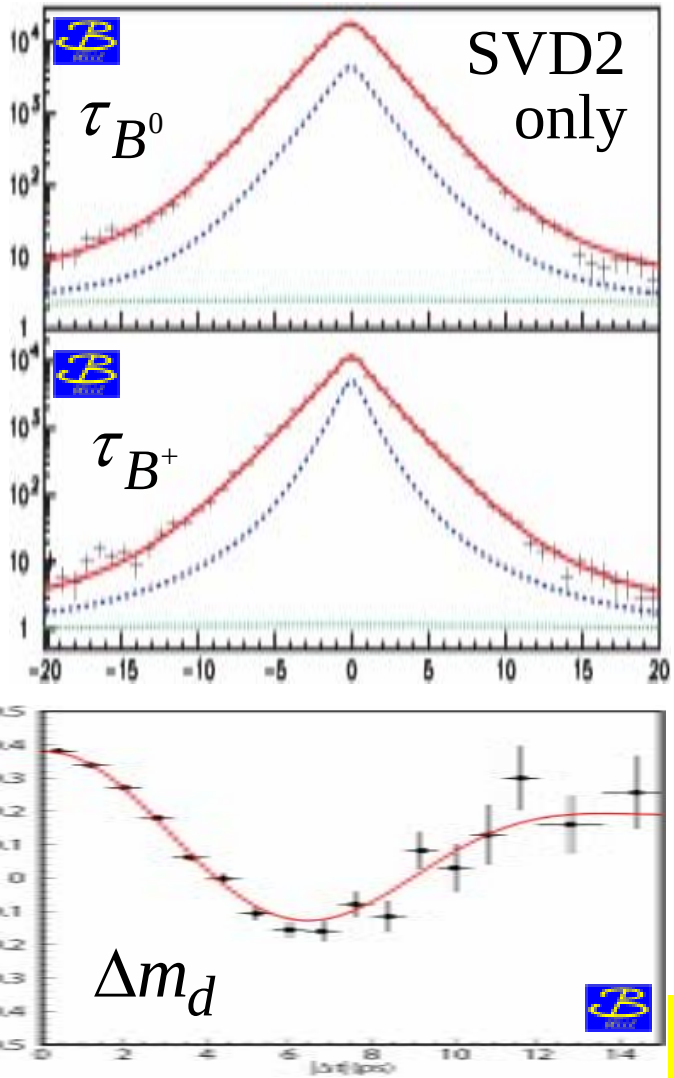
$A(\phi K^{\pm}) = +0.22 \pm 0.15$

Systematic errors on S

	Ks π^0	K*γ	ω Ks	η' Ks	f_0 Ks	ϕ K^0	K^+K^-Ks
VTX	0.02	0.06	0.01	0.01	0.02	0.01	0.01
flavor tag	0.01	0.02	0.04	0.01	0.01	0.01	<0.01
resolution	0.05	0.05	0.07	0.03	0.03	0.04	0.03
fit bias	0.03	0.03	+0.01 –0.10	0.01	0.03	0.01	0.01
signal fraction	0.07	0.02	0.10	0.02	0.05	+0.08 –0.06	0.02
physics parameters	0.02	0.01	0.01	<0.01	0.01	<0.01	<0.01
background Δt shape	0.04	0.03	0.02	<0.01	0.04	0.01	<0.01
tag side interference	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
TOTAL	0.11	0.10	+0.13 –0.16	0.04	0.08	0.09	0.04

KKKS: effective sin2ϕ_1 → 0.17 for CP-even fraction

SVD2: lifetime & Δm_d



$D^0\pi^+$, $J/\psi K^\pm$, $D^-\pi^+$, $D^{*-}\pi^+/\rho^+$, $D^*l\nu$

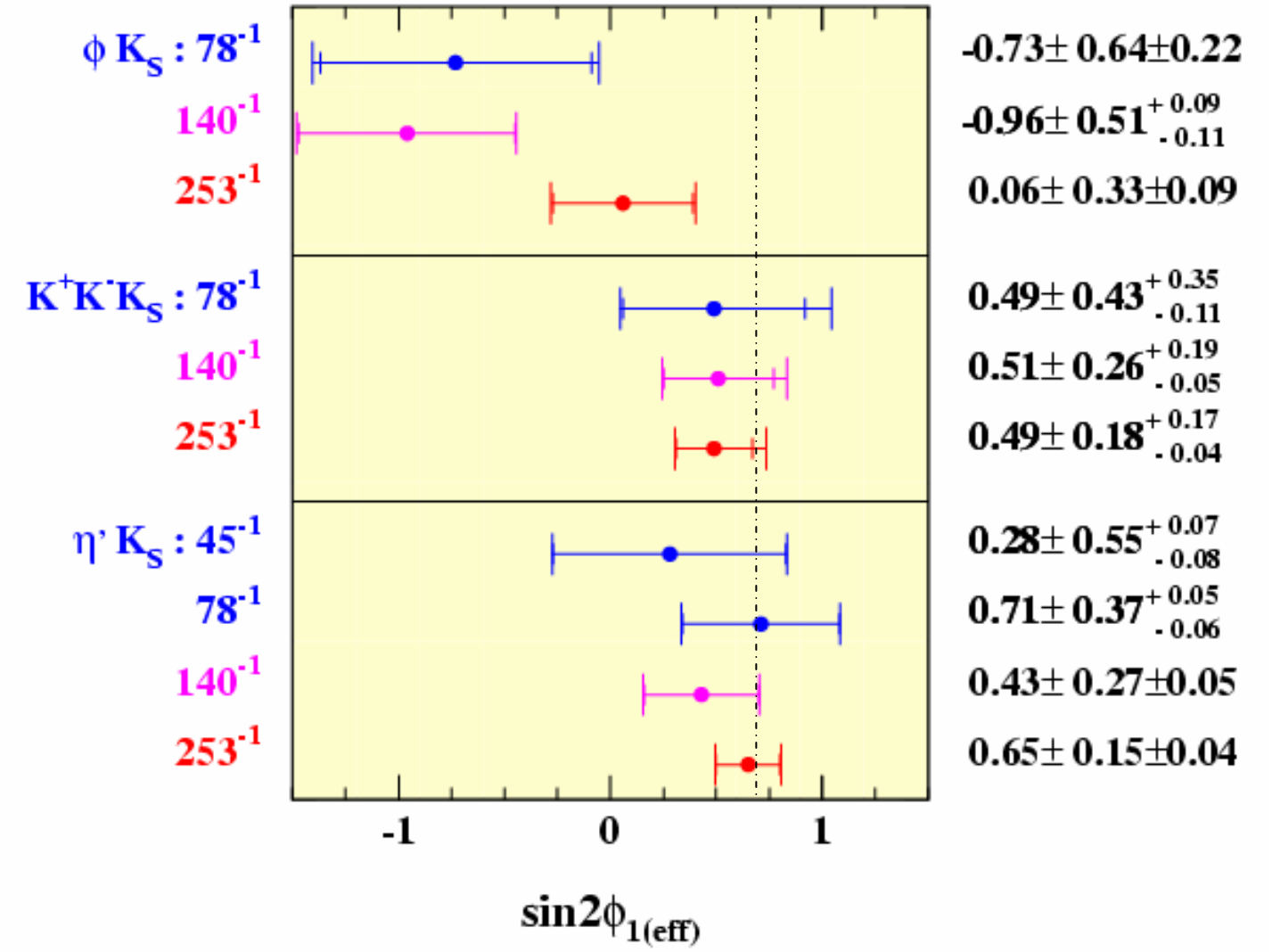
Belle preliminary

	SVD1 (152M $B\bar{B}$)	SVD2 (123M $B\bar{B}$)
τ_{B^0} [ps]	$1.534 \pm 0.008 \pm 0.010$	1.518 ± 0.012 (stat)
τ_{B^+} [ps]	$1.635 \pm 0.011 \pm 0.011$	1.652 ± 0.014 (stat)
Δm_d [ps^{-1}]	$0.511 \pm 0.005 \pm 0.006$	0.516 ± 0.007 (stat)

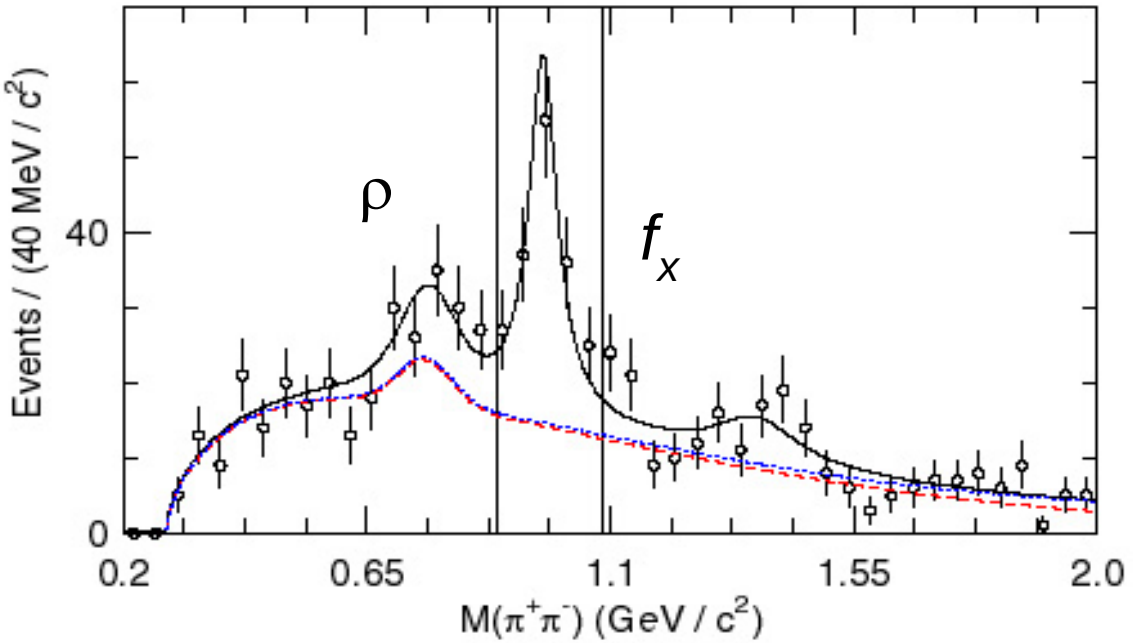
[Belle-conf-0436]

New detector resolution is well understood

History of $b \to s\bar{q}q$ CPV



$f_0(980)K_S$:$\pi^+\pi^-$ Mass didtribution



Non-f_0 components are determined from the M($\pi^+\pi^-$) distribution

- f(f_0K_S) = 91%
- f($\pi^+\pi^-K_S$) = 2.3%
- f(ρ^0K_S) = 4.8%
- f(f_xK_S) = 1.6%

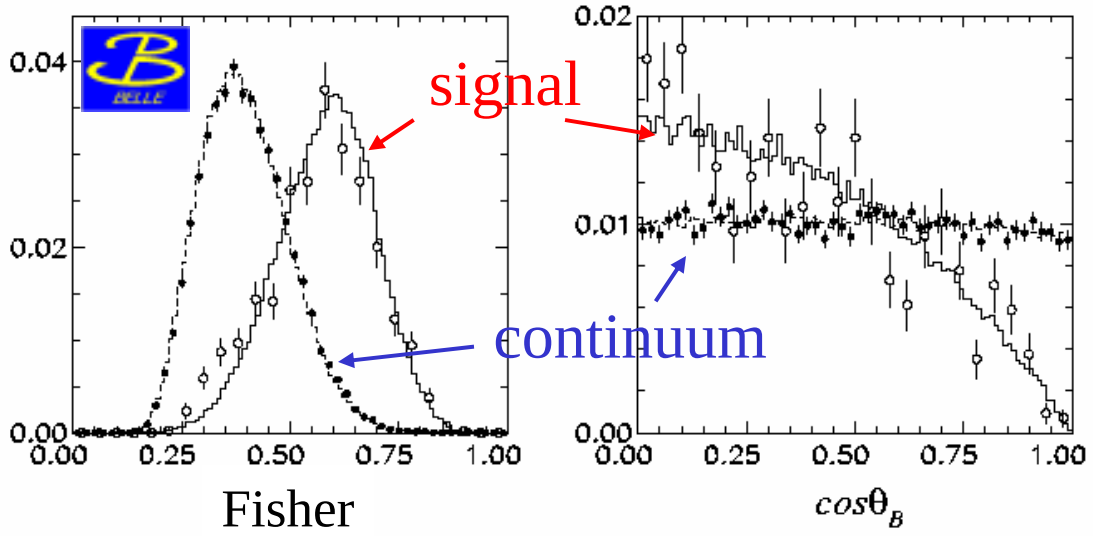
Continuum Suppression

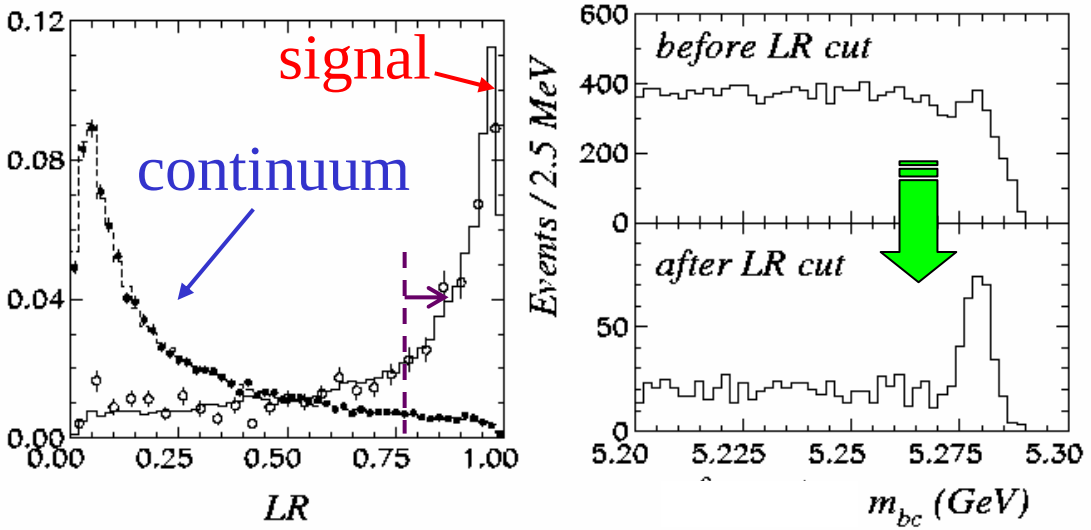
Event-shape variables combine → **Fisher**

Belle: cut on **Likelihood Ratio** $L_S/(L_S + L_B)$

BaBar: loose cut Fisher (or NN) pdf in fit

Flavor tagging info. also useful





CKM Matrix & UT

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

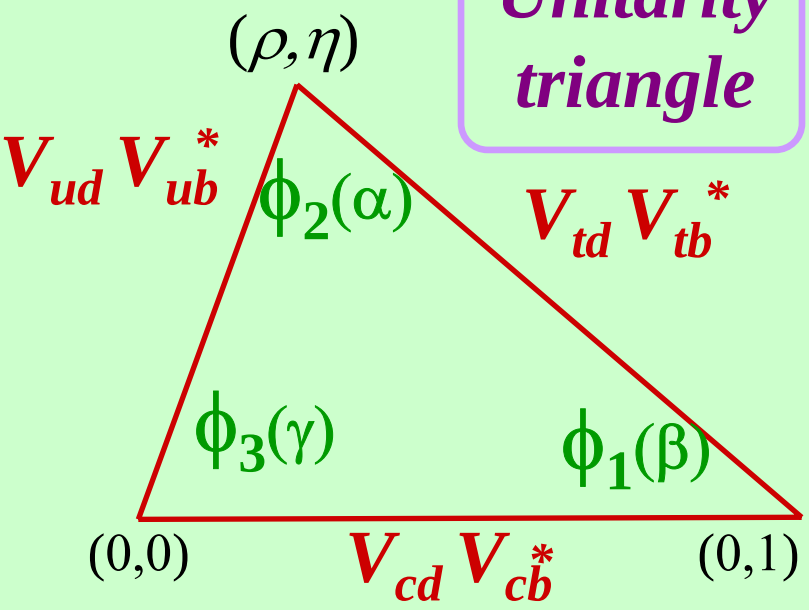
CKM matrix

Complex phase
↔ CP violation

Wolfenstein representation

$$\begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\rho-i\eta) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix}$$

Unitarity triangle



BaBar $B \to \phi K^*$

use helicity basis angles:

Angular distribution

$P_{\phi K^*}(\theta_1, \theta_2, \Phi ; A_0, A_{//}, A_\perp)$

2 sets $(B, \bar{B})$

227M $\bar{B}B$

$B^0 \to \phi K^{*0}$

201 signals

$A_{CP} = -0.01 \pm 0.09 \pm 0.02$

[hep-ex/0408017]