Recent Results from LHCb & B-factories

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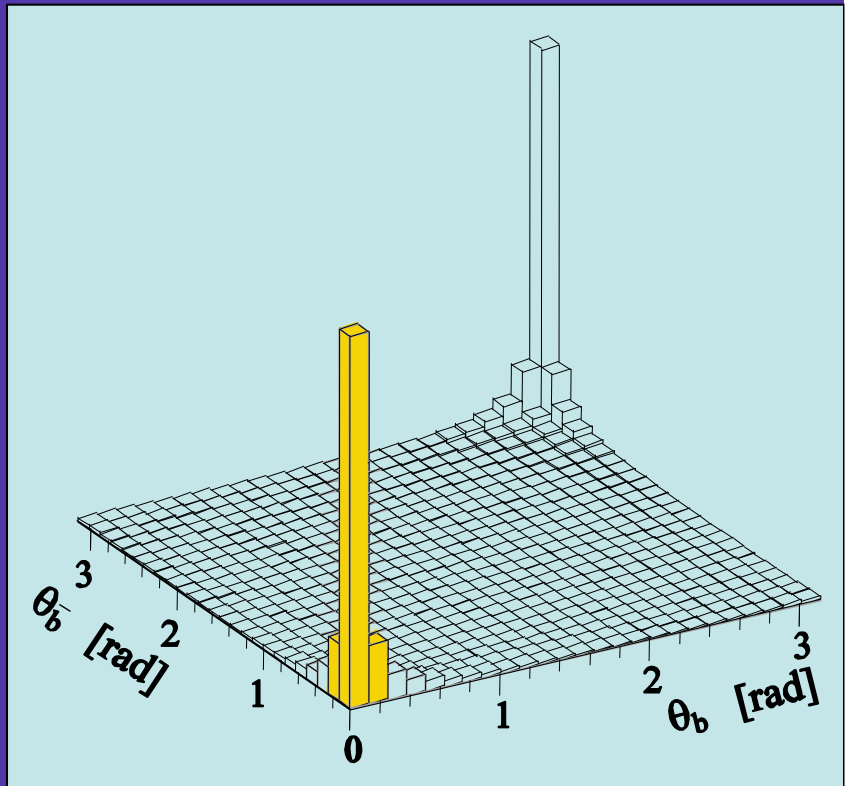
Outline

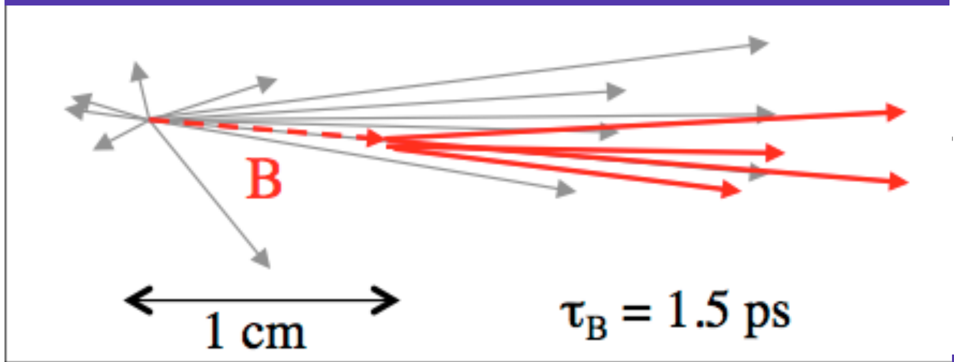
- LHCb performance
- LHCb flagship measurements
  - $B_s \to \mu^+\mu^-$
  - CP violation in B_s decays
- Selected results from BaBar, Belle & LHCb

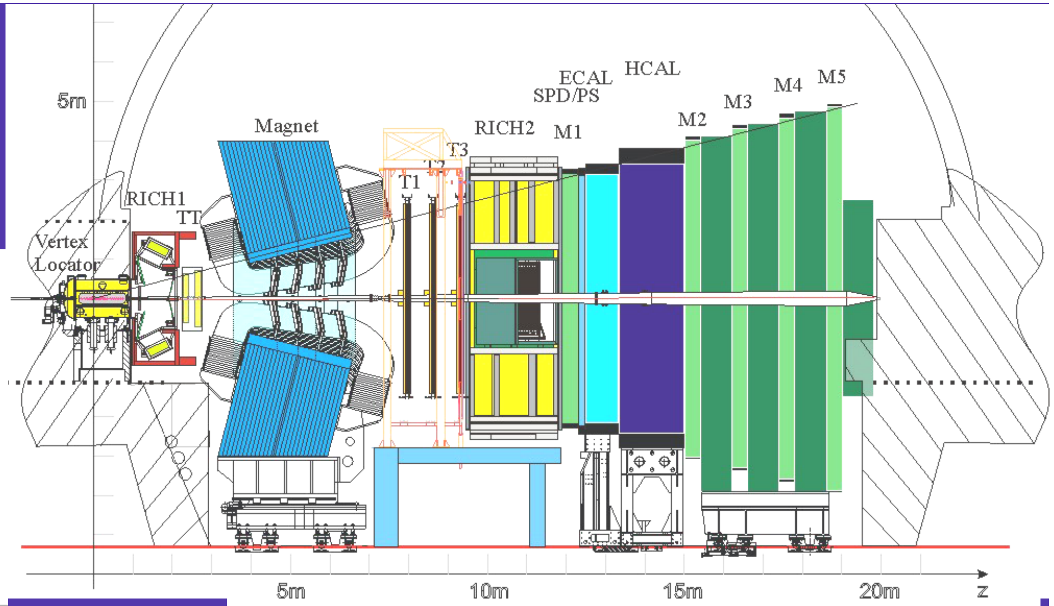
Flavour Physics at the LHC

- 100k bb/sec are expected and all B-Hadron species are produced:
  - B^0, B^+, B_S, B_C, b-baryons
- B-hadrons are produced in the forward (beam) region:
  - A single arm forward spectrometer has been chosen which covers 12 mrad< θ < 300mrad



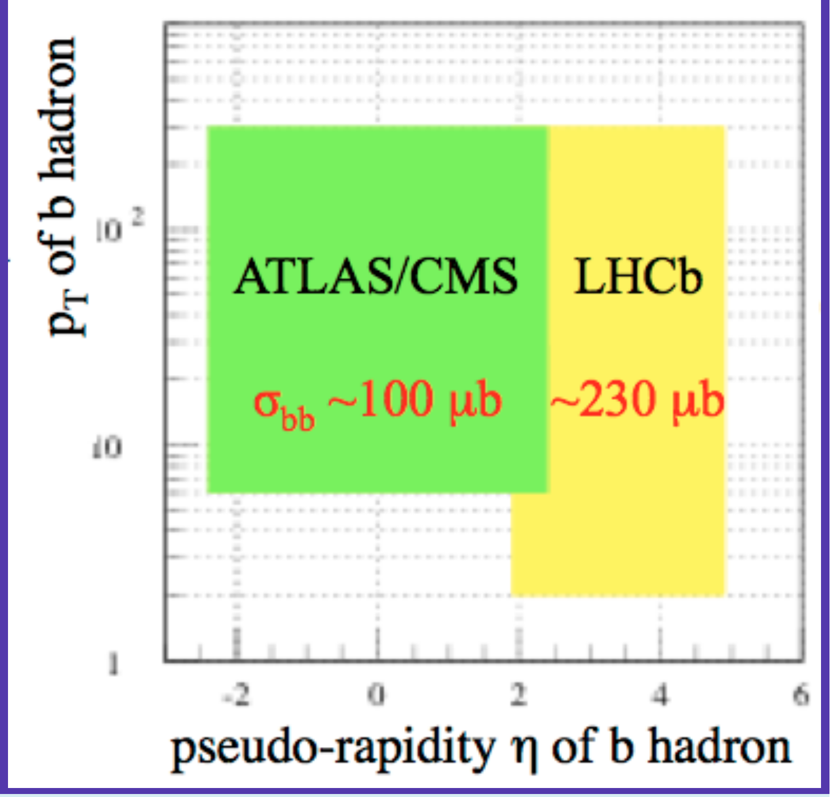
LHCb spectrometer



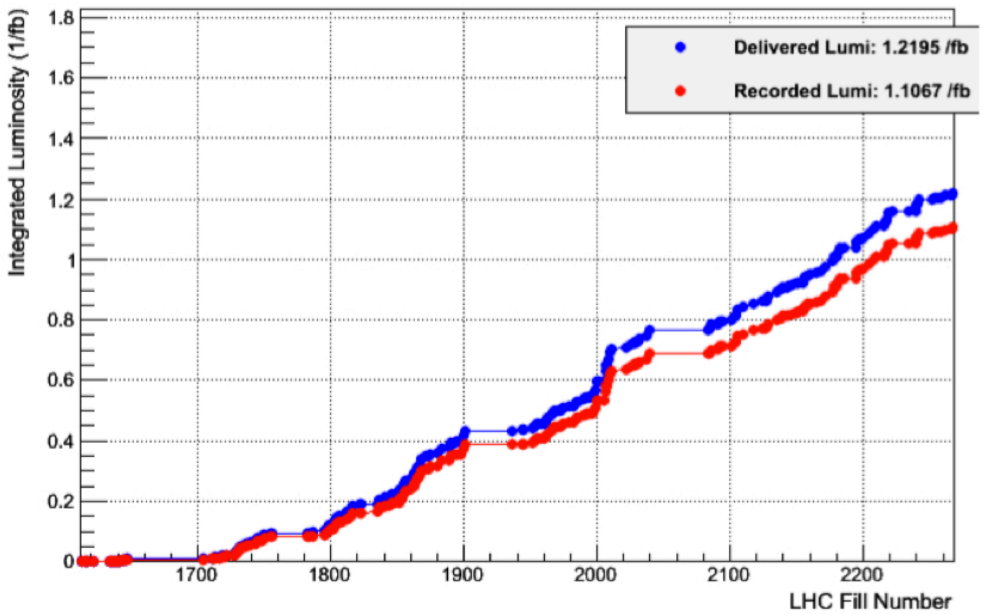


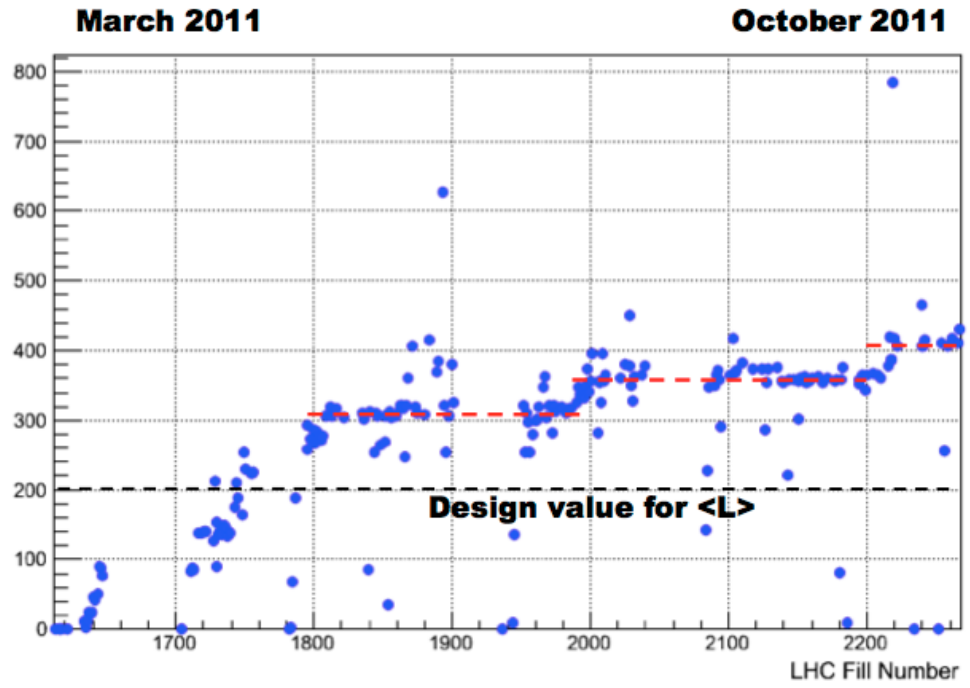
Expt optimised for B-physics:

- *Angular coverage*
- *Efficient trigger for hadronic & leptonic modes*
- *Precision tacking & vertexing (mass, proper time)*
- *Excellent particle ID*



2011 LHCb luminosity

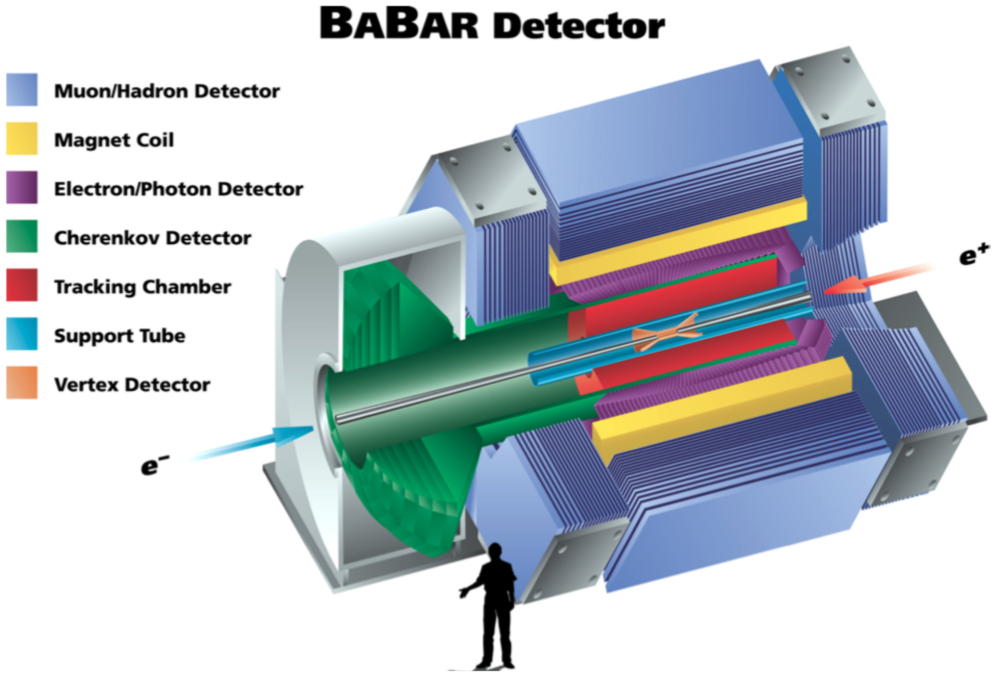




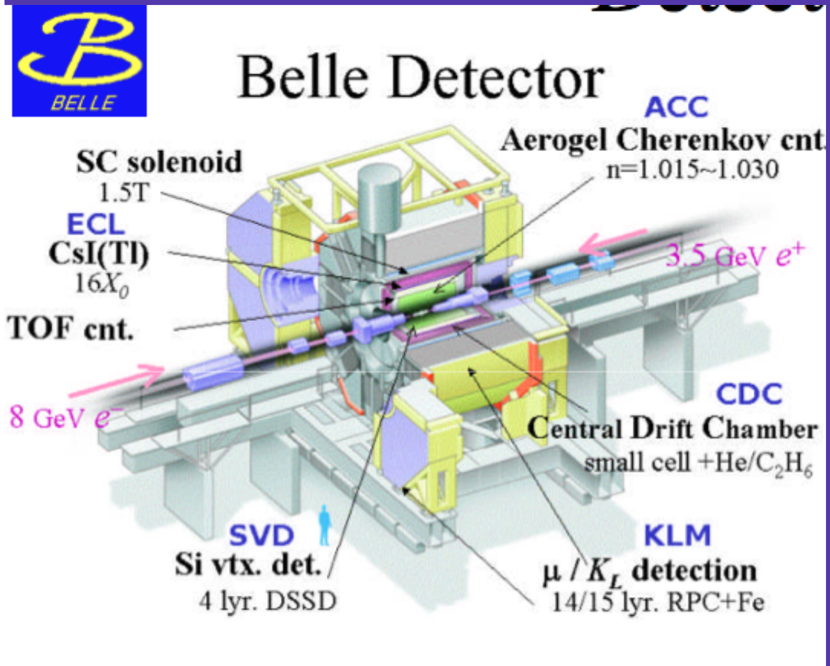
1.1 fb^{-1} on tape
91% data taking efficiency

Peak luminosity a factor of ~2 above LHCb design

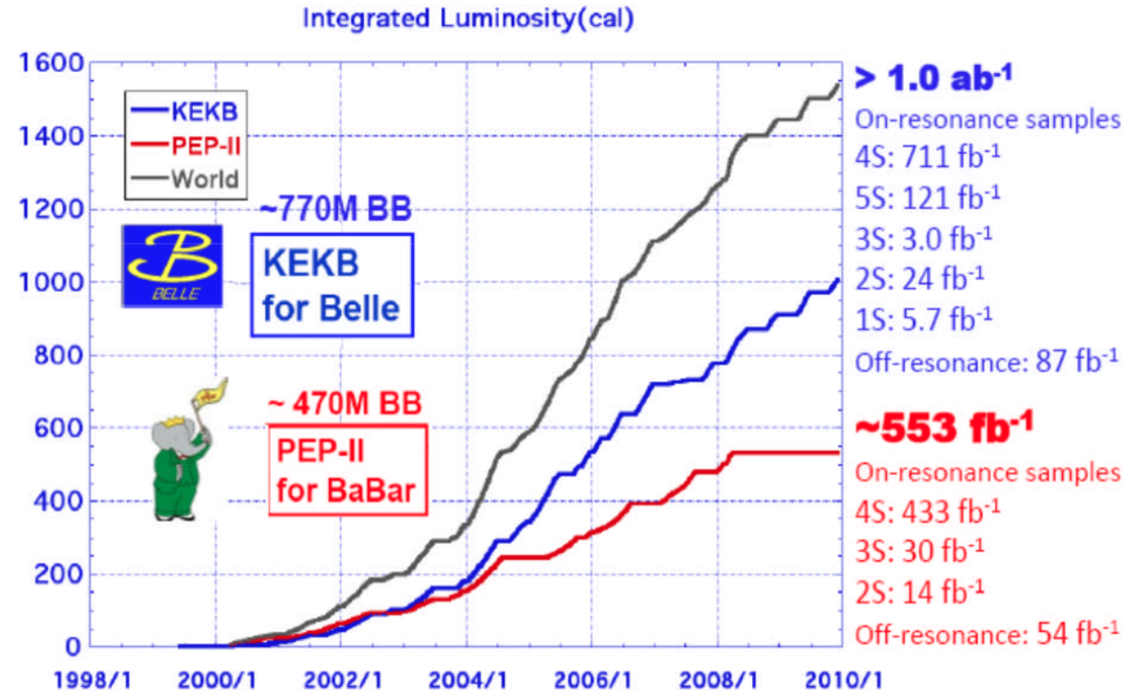
B factories



BABAR Detector
Muon/Hadron Detector
Magnet Coil
Electron/Photon Detector
Cherenkov Detector
Tracking Chamber
Support Tube
Vertex Detector
e+
e-



BELLE
Belle Detector
ACC
Aerogel Cherenkov cnt.
n=1.015~1.030
SC solenoid
1.5T
ECL
CsI(Tl)
16X0
TOF cnt.
3.5 GeV e+
8 GeV e-
CDC
Central Drift Chamber
small cell +He/C2H6
SVD
Si vtx. det.
4 lyr. DSSD
KLM
μ / KL detection
14/15 lyr. RPC+Fe

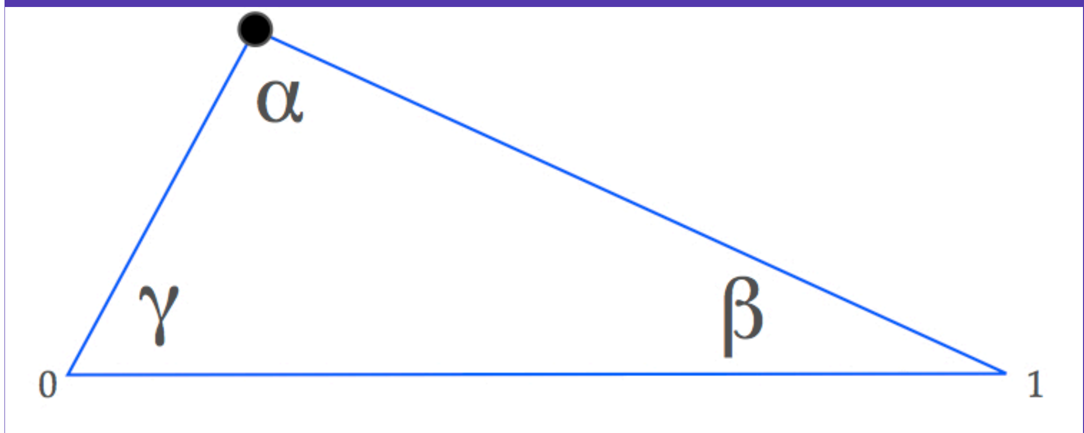


Integrated Luminosity(cal)
KEKB
PEP-II
World
~770M BB
KEKB
for Belle
~ 470M BB
PEP-II
for BaBar
1600
1400
1200
1000
800
600
400
200
0
1998/1
2000/1
2002/1
2004/1
2006/1
2008/1
2010/1
> 1.0 ab-1
On-resonance samples
4S: 711 fb-1
5S: 121 fb-1
3S: 3.0 fb-1
2S: 24 fb-1
1S: 5.7 fb-1
Off-resonance: 87 fb-1
~553 fb-1
On-resonance samples
4S: 433 fb-1
3S: 30 fb-1
2S: 14 fb-1
Off-resonance: 54 fb-1

CKM model

$$V_{CKM} = \begin{matrix} & d & s & b \\ u & 1-\frac{1}{2}\lambda^2 & \lambda & A\lambda^3(\rho - i\eta + \frac{i}{2}\eta\lambda^2) \\ c & -\lambda & 1-\frac{1}{2}\lambda^2 - i\eta A^2\lambda^4 & A\lambda^2(1+i\eta\lambda^2) \\ t & A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{matrix} + \mathcal{O}(\lambda^6)$$

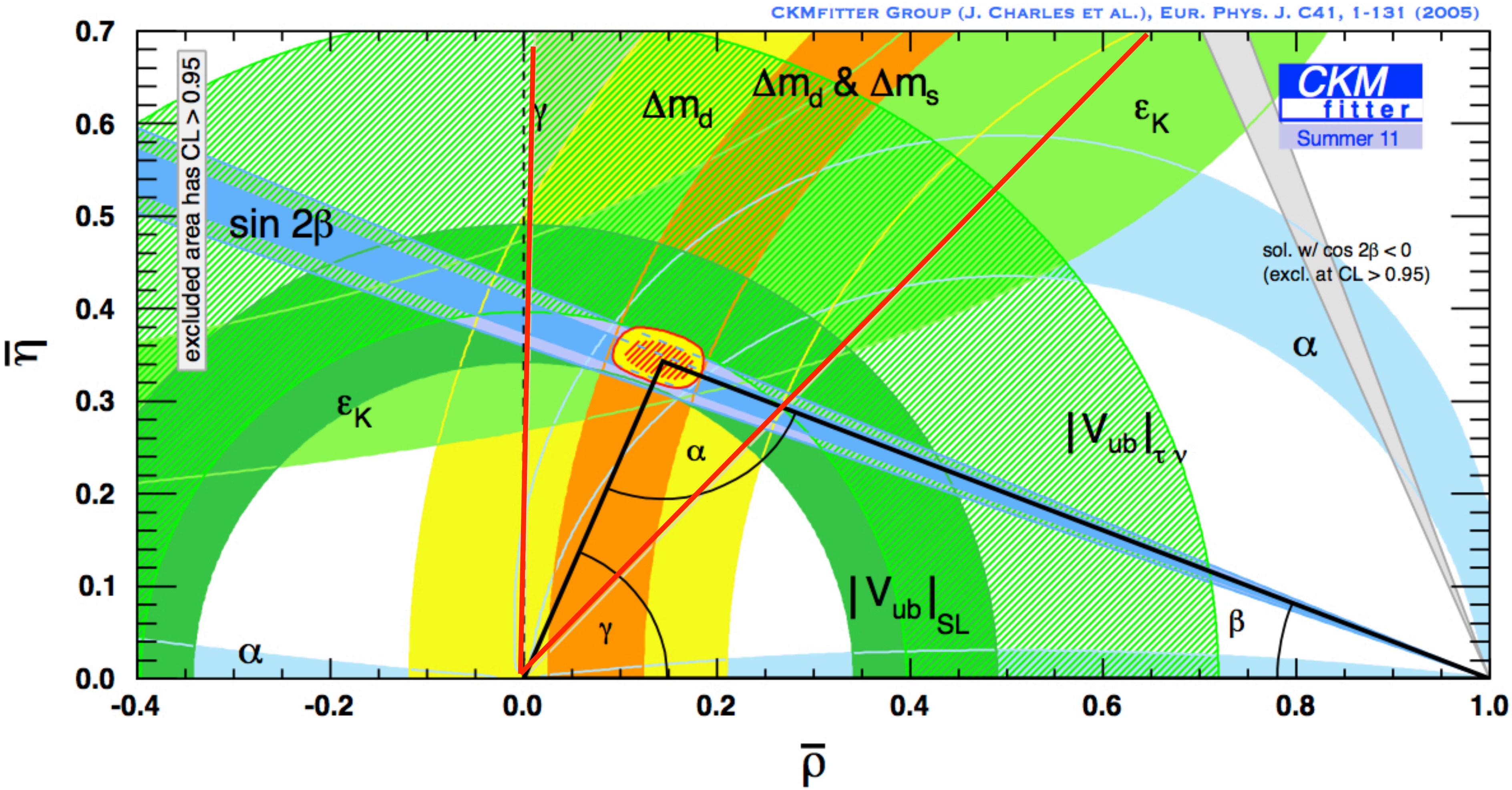
3 real and 1 imaginary indep parameters:
imaginary parameter →CP violation



$$0 = 1 + \frac{V_{tb}^* V_{td}}{V_{cb}^* V_{cd}} + \frac{V_{ub}^* V_{ud}}{V_{cb}^* V_{cd}}$$

$$\gamma = \arg\left(-\frac{V_{ub}^*}{V_{cb}^*}\right)$$

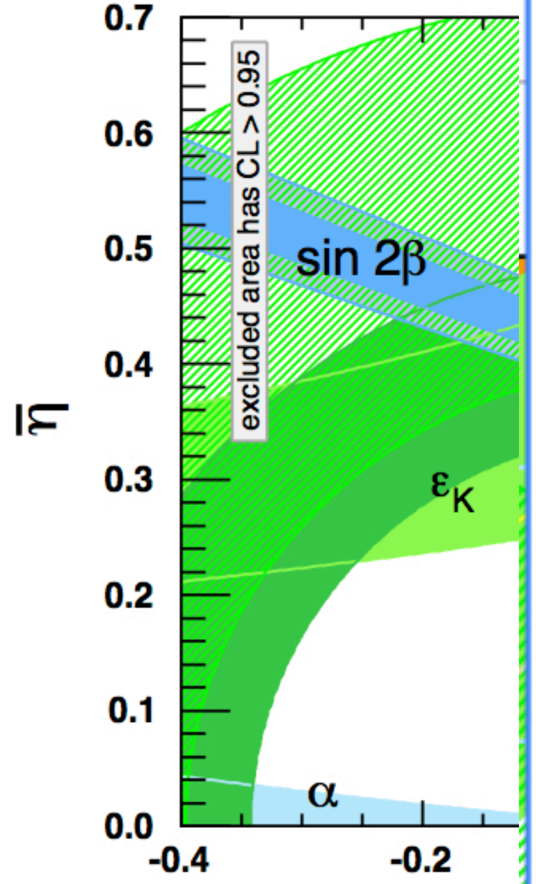
CKM model

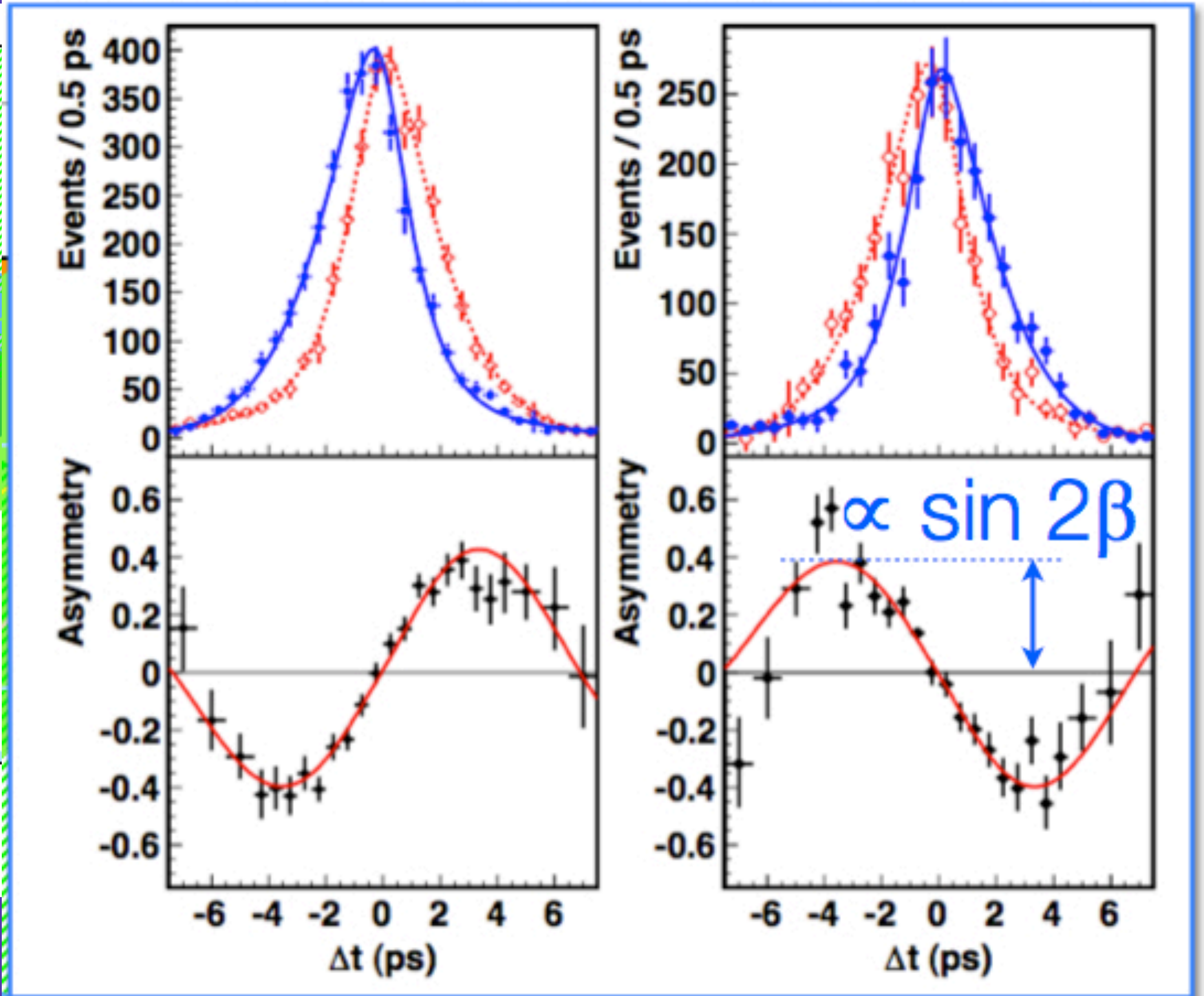

CKMFITTER GROUP (J. CHARLES ET AL.), EUR. PHYS. J. C41, 1-131 (2005)
CKM fitter
Summer 11
excluded area has CL > 0.95
sin 2β
γ
Δm_d
Δm_d & Δm_s
ε_K
sol. w/ cos 2β < 0
(excl. at CL > 0.95)
α
|V_ub|_τν
|V_ub|_SL
β
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
η̄
ρ̄

CKM model

$\sin 2\beta = 0.667 \pm 0.023 \pm 0.012$

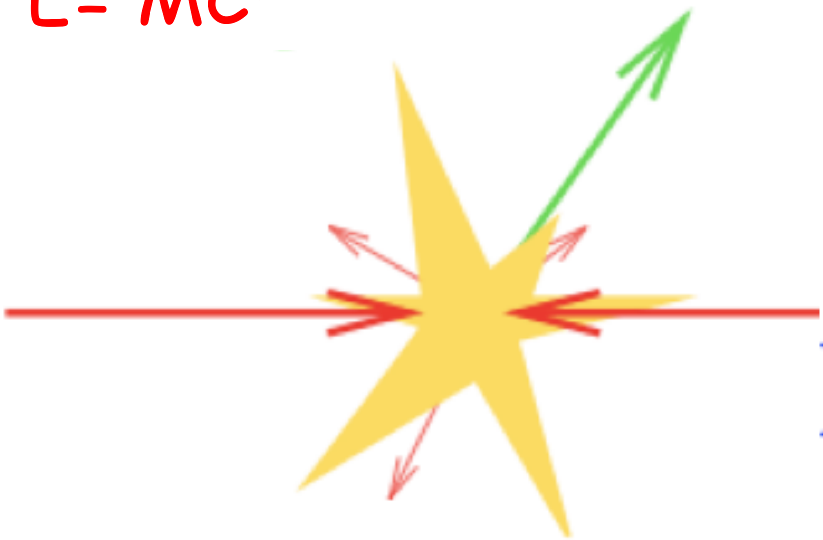
Latest sin 2β measurement from Belle. arXiv:1201.4643v1

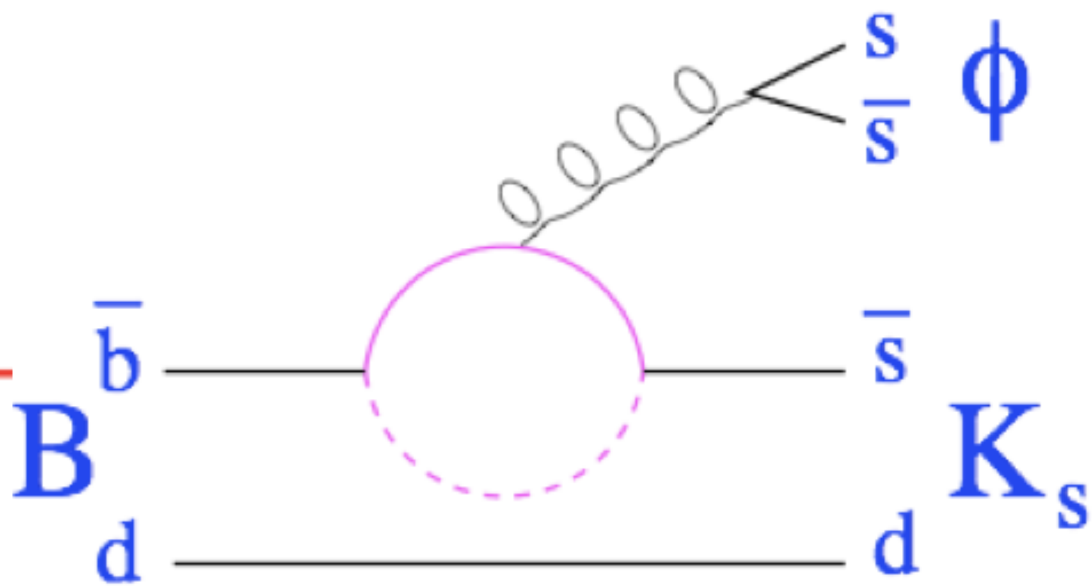




Strategies for New Physics

$E = MC^2$





Direct observations:
- limited by collision energy

Indirect observations:
- limited by statistics

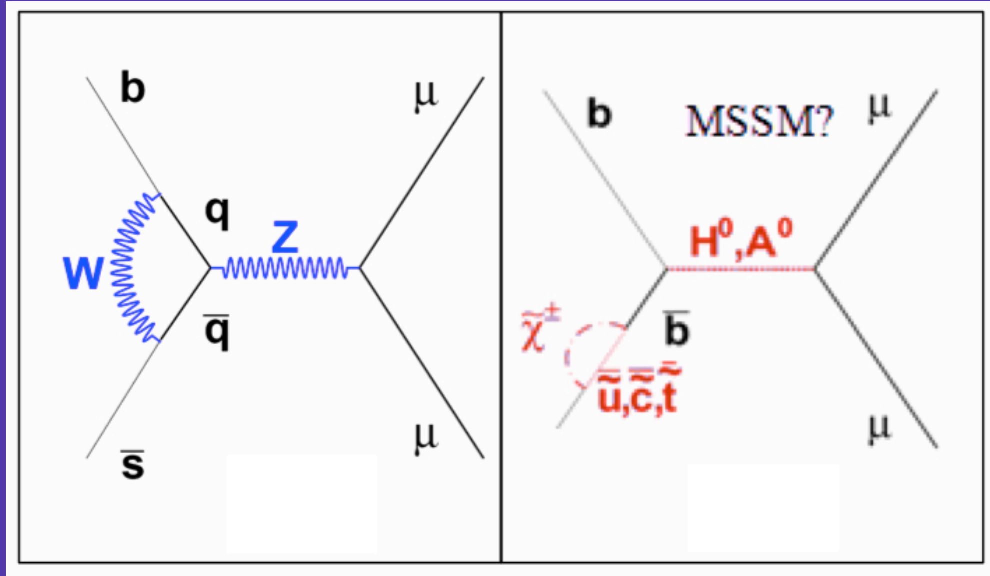
Strategies for Indirect NP Search

- Measure FCNC transitions, where NP s likely to emerge
  - $b \rightarrow s$ transitions
  - rare B decay measurements
- Improved precision of CKM elements
  - Compare measurements of same quantity which may or may not be sensitive to NP
  - Extract CKM angle & sides in different ways
  - Inconsistencies: sign of new Physics

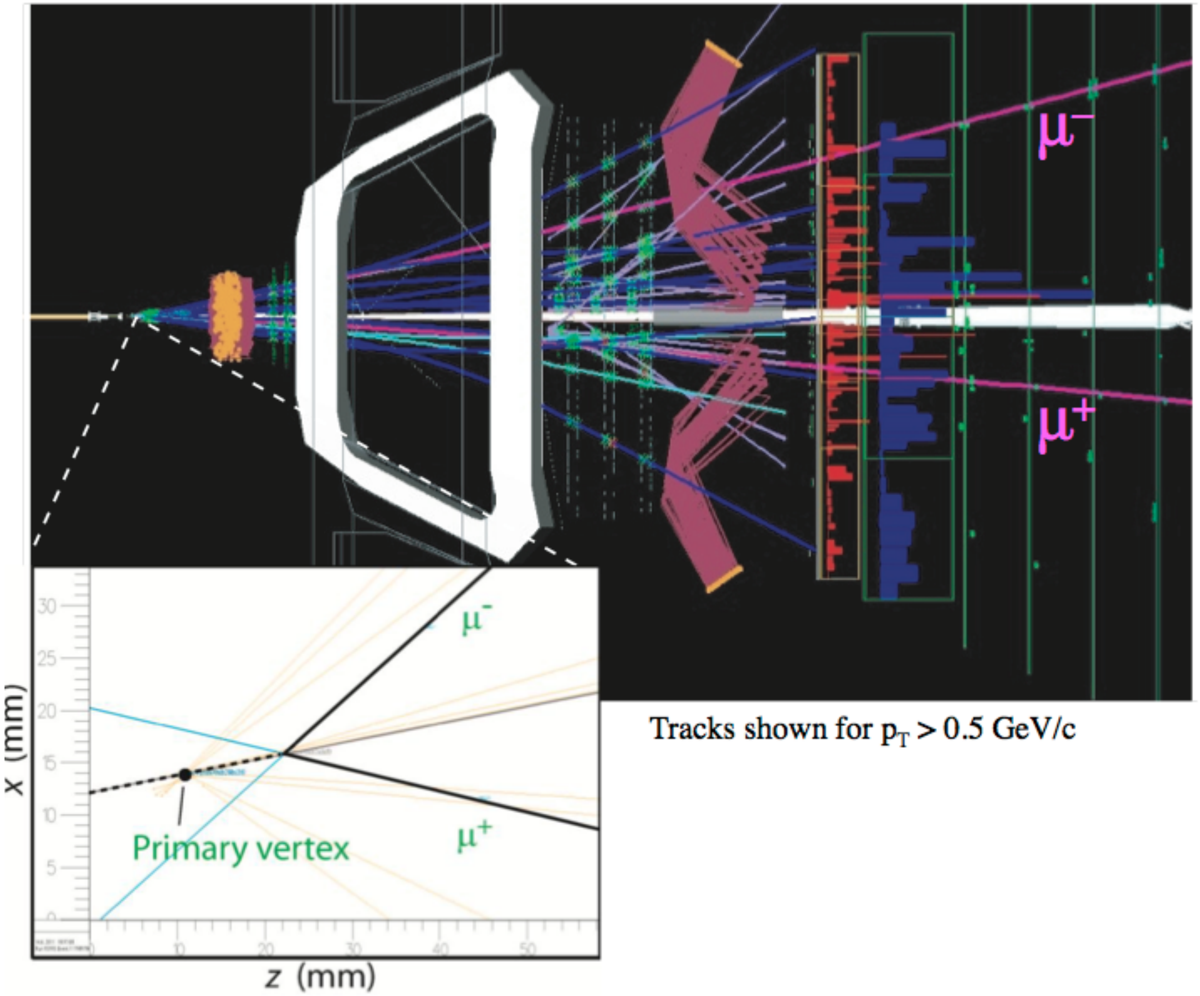
$B_s \to \mu^+\mu^-$

- Very rare FCNC decay
- Standard model
  - $BR_{SM}=(3.2\pm0.2)\times10^{-9}$
- Strongly enhanced in many NP models
  - Eg MSSM with large $\tan\beta$

$$BR \propto \frac{\tan^6\beta}{M_A^4}$$



$B_s \to \mu^+\mu^-$

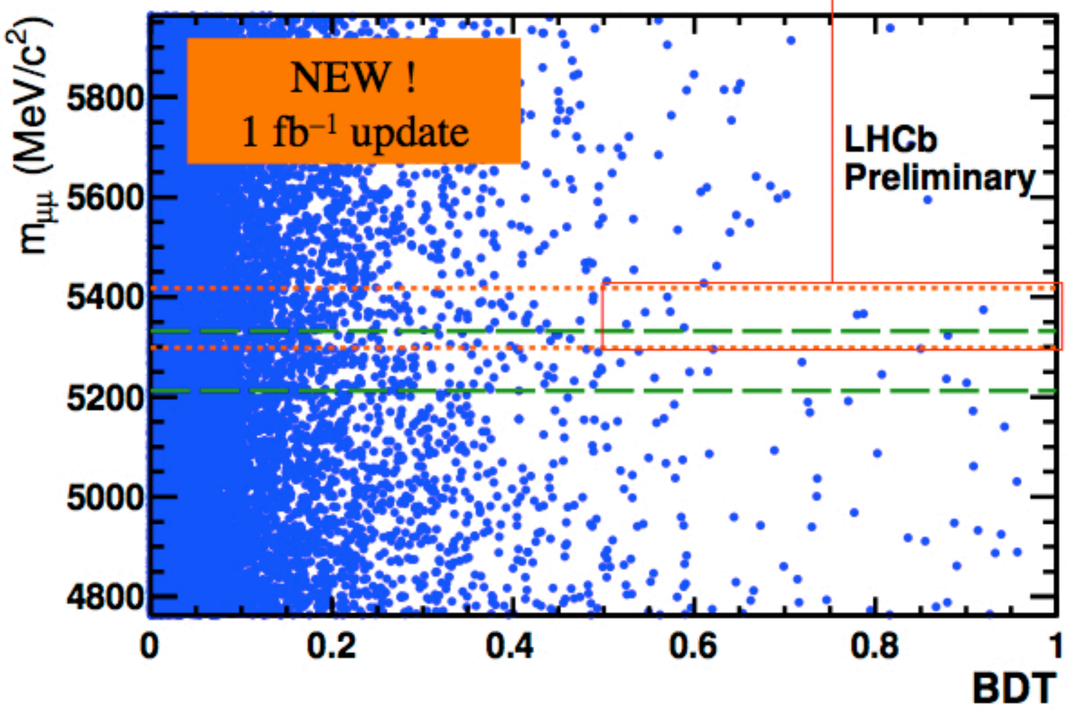


Candidate event

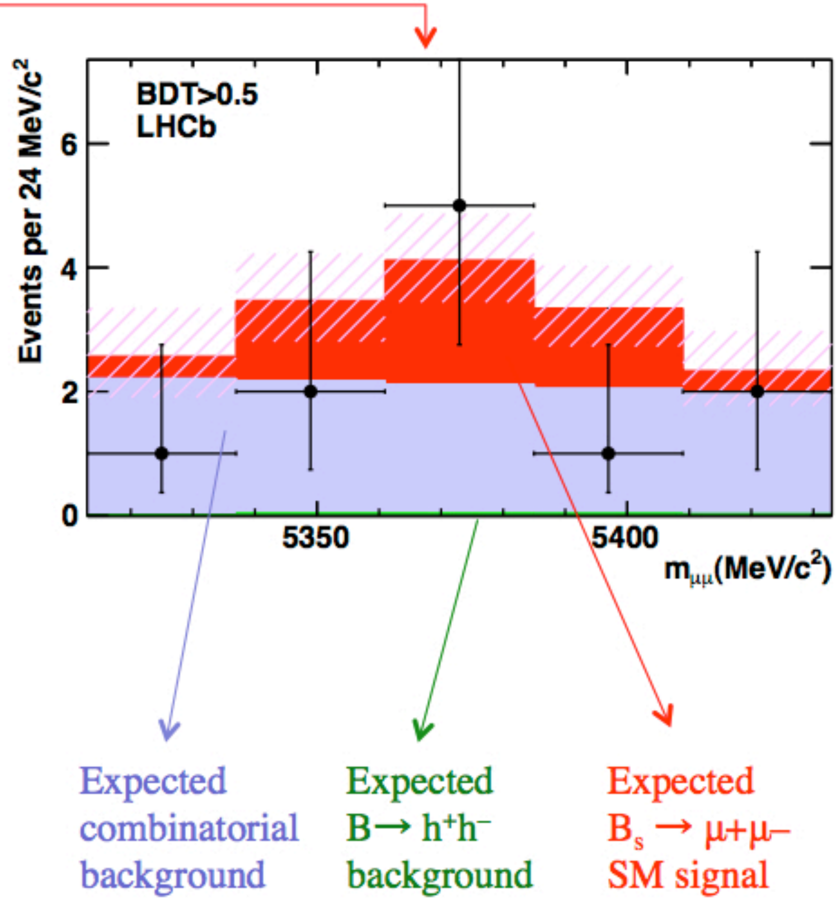
$m(\mu\mu)$=5.374 GeV/c^2
$p_T(\mu^+)$=2.3 GeV/c
$p_T(\mu^-)$=3.5 GeV/c

Proper time = 3.5 ps

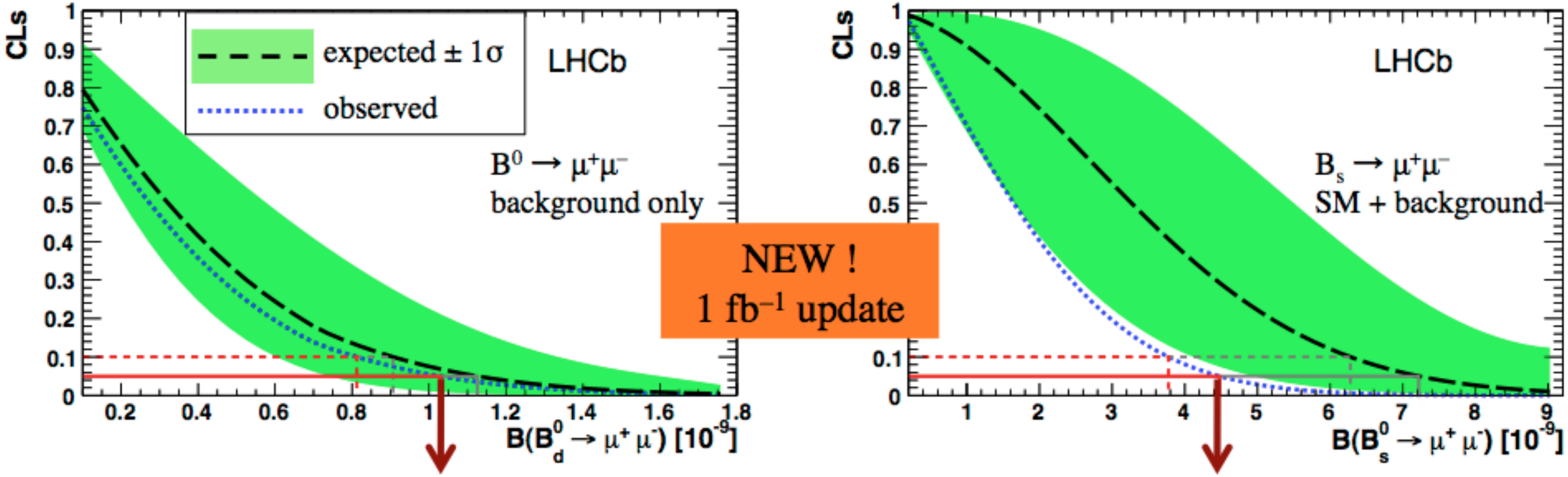
$B_s \to \mu^+\mu^-$



$B_s \to \mu^+\mu^-$ signal region

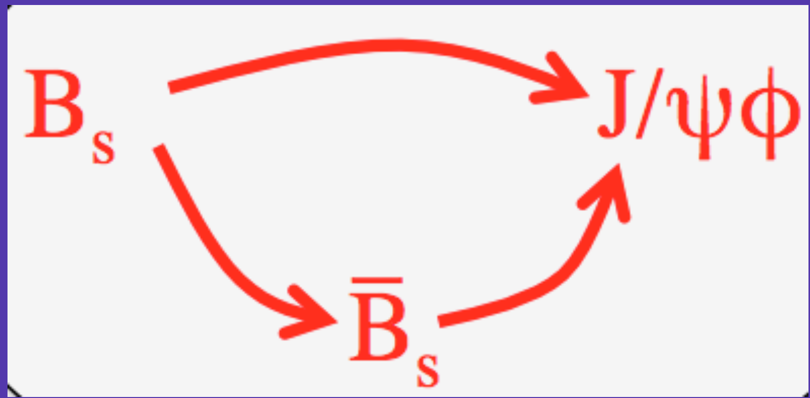


$B_s \to \mu^+\mu^-$



New prelim results 2012		CDF	CMS	ATLAS	LHCb	SM
	$\mathcal{L}(fb^{-1})$	10	4.9	2.4	1.0	
BR ($B^0 \to \mu\mu$)	95% upper CL (10^{-9})	4.6	1.8		1.03	0.1±0.01
BR ($B_s \to \mu\mu$)	95% upper CL (10^{-9})	31	7.7	22	4.5	3.2±0.2

CPV in mixing for the B_s system

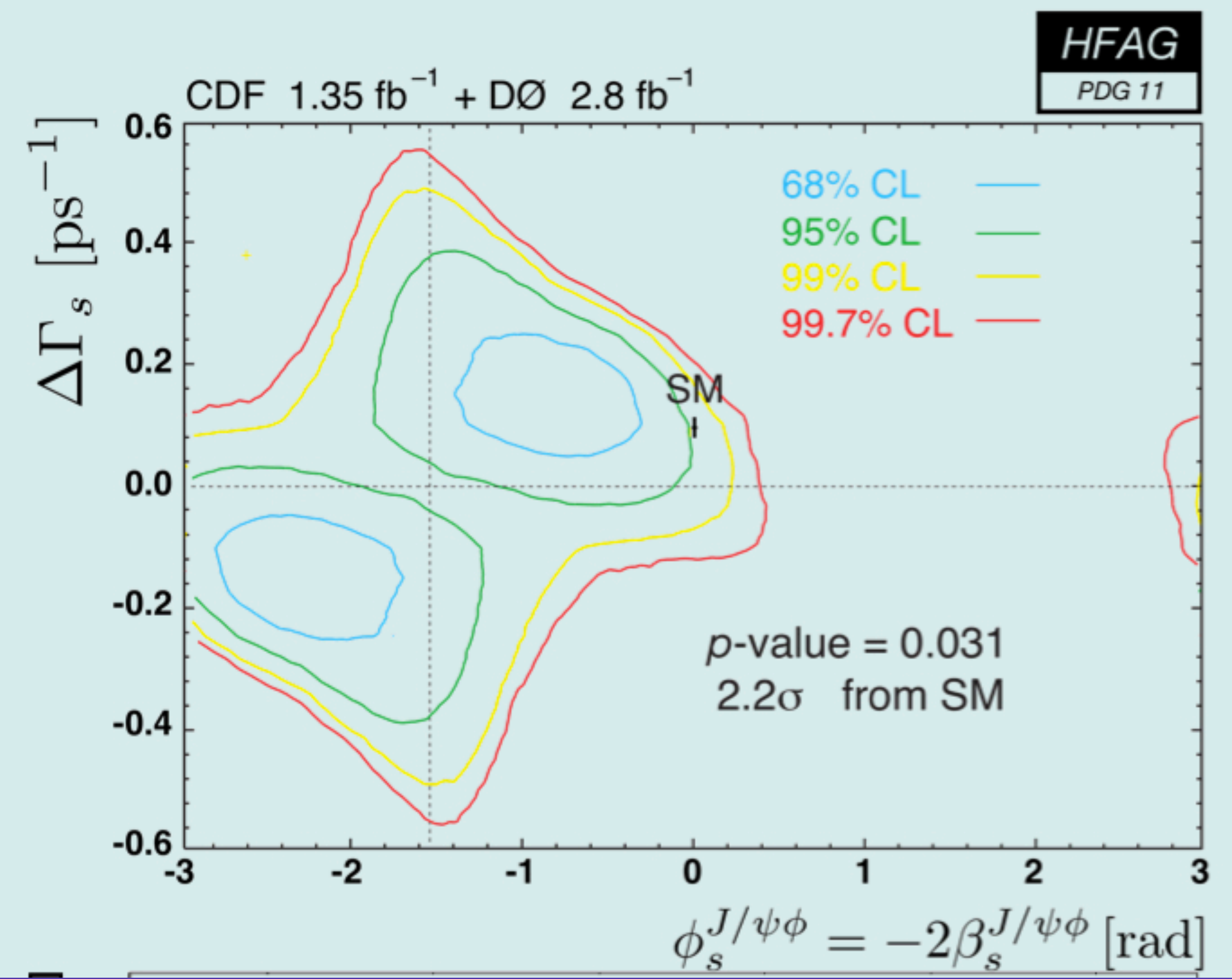


Φ_S - phase difference between decay amplitudes with & without mixing

- Φ_S is small in SM – sensitive to new Physics

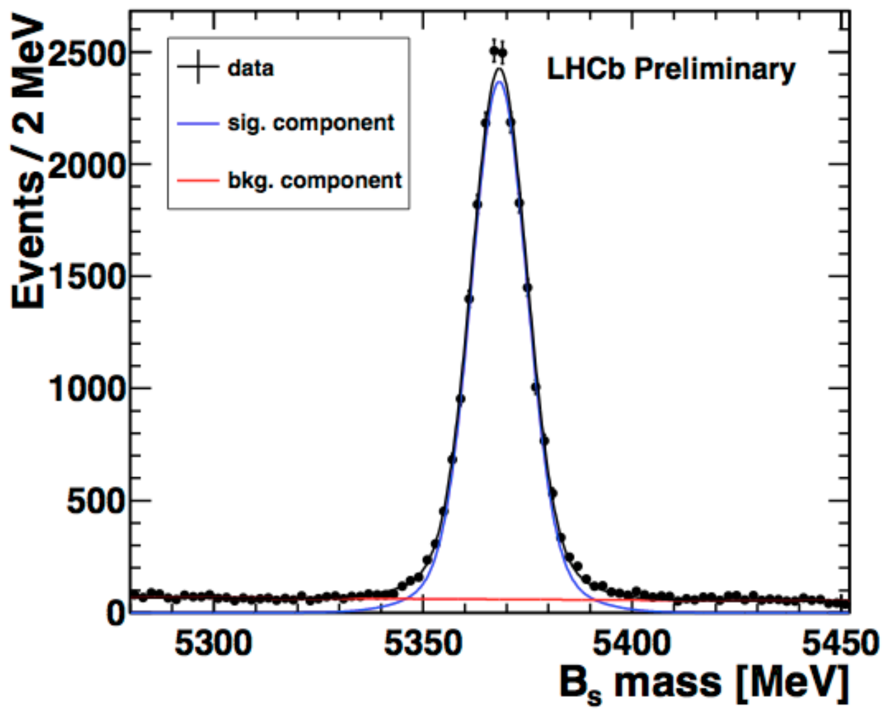
$$\Phi_s^{\mathrm{SM}} \approx -2\arg\left(-\frac{V_{ts}V_{tb}^*}{V_{cs}V_{cb}^*}\right) = -0.036 \pm 0.002$$

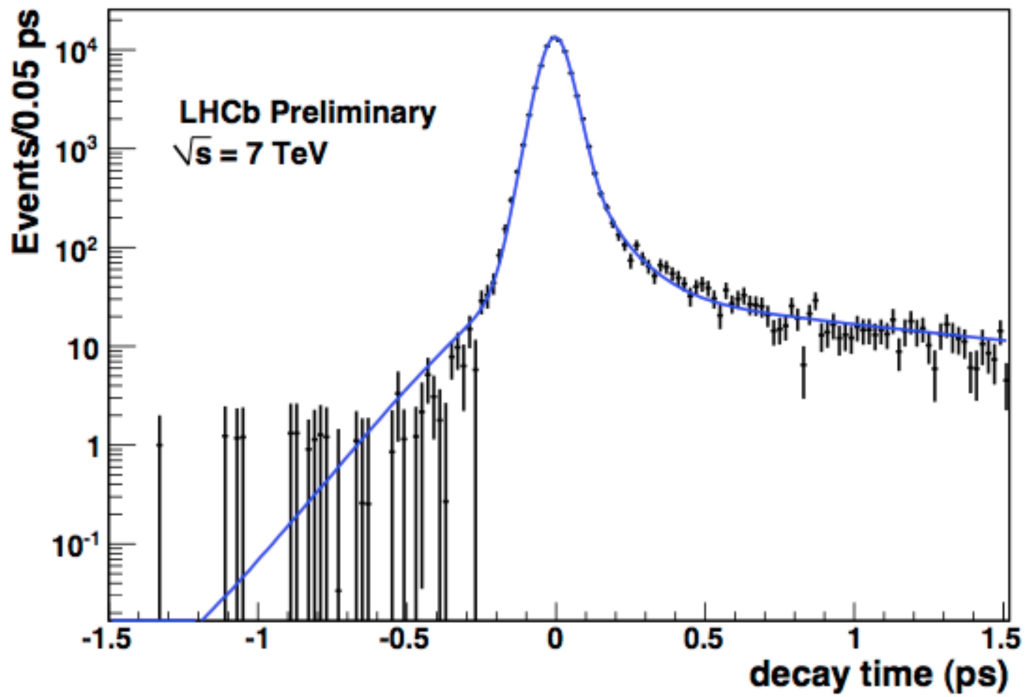
CPV in mixing for the B_s system



Intriguing hints of new Physics from Tevatron

$B_s \to J/\Psi\Phi$





~ 8 MeV/c^2 mass resol
~21200 signal events
(1 fb^{-1})

proper time error from fit to peak (prompt J/ψ)
~45 fs effective time resol

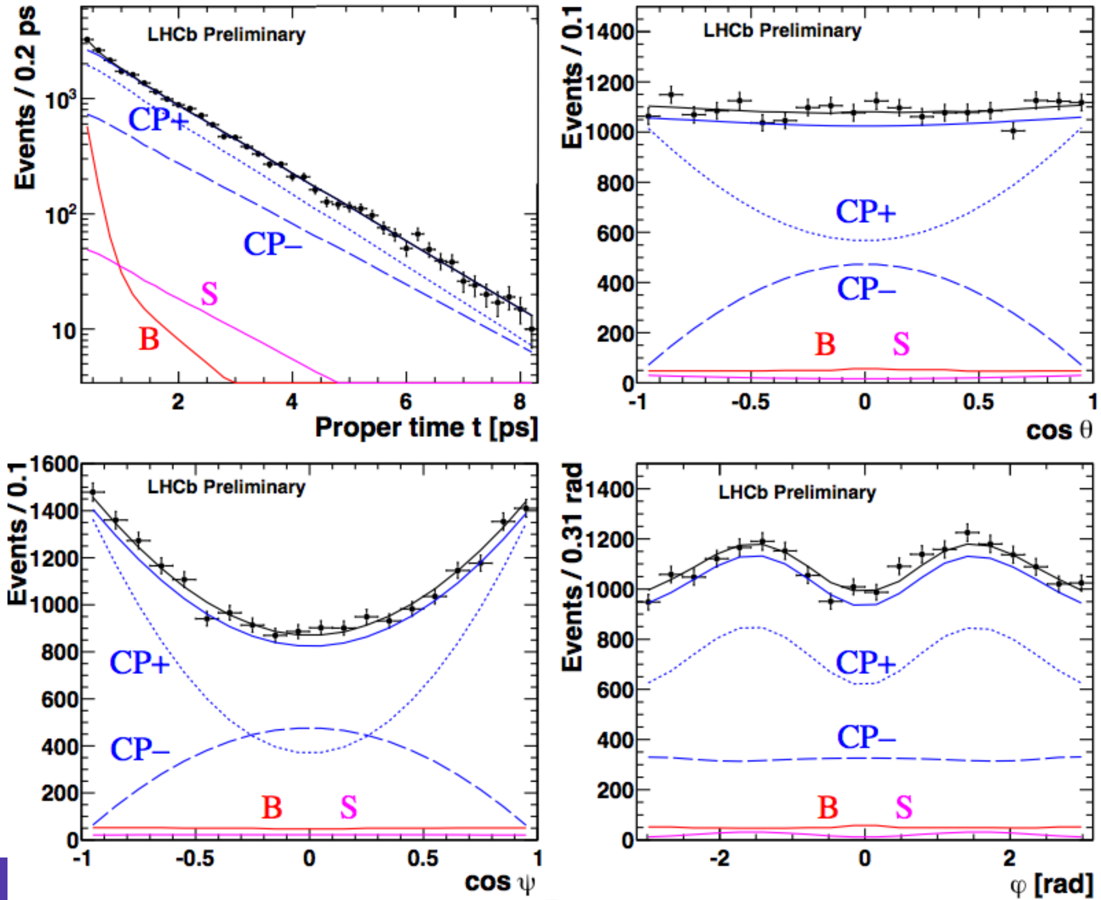
$B_s \to J/\Psi\Phi$

CP+: B_s->J/ψΦ with CP-even final state

CP-: B_s->J/ψΦ with CP-odd final state

S: B_s->J/ψKK signal with J_{KK}=0 (s-wave, CP-odd)

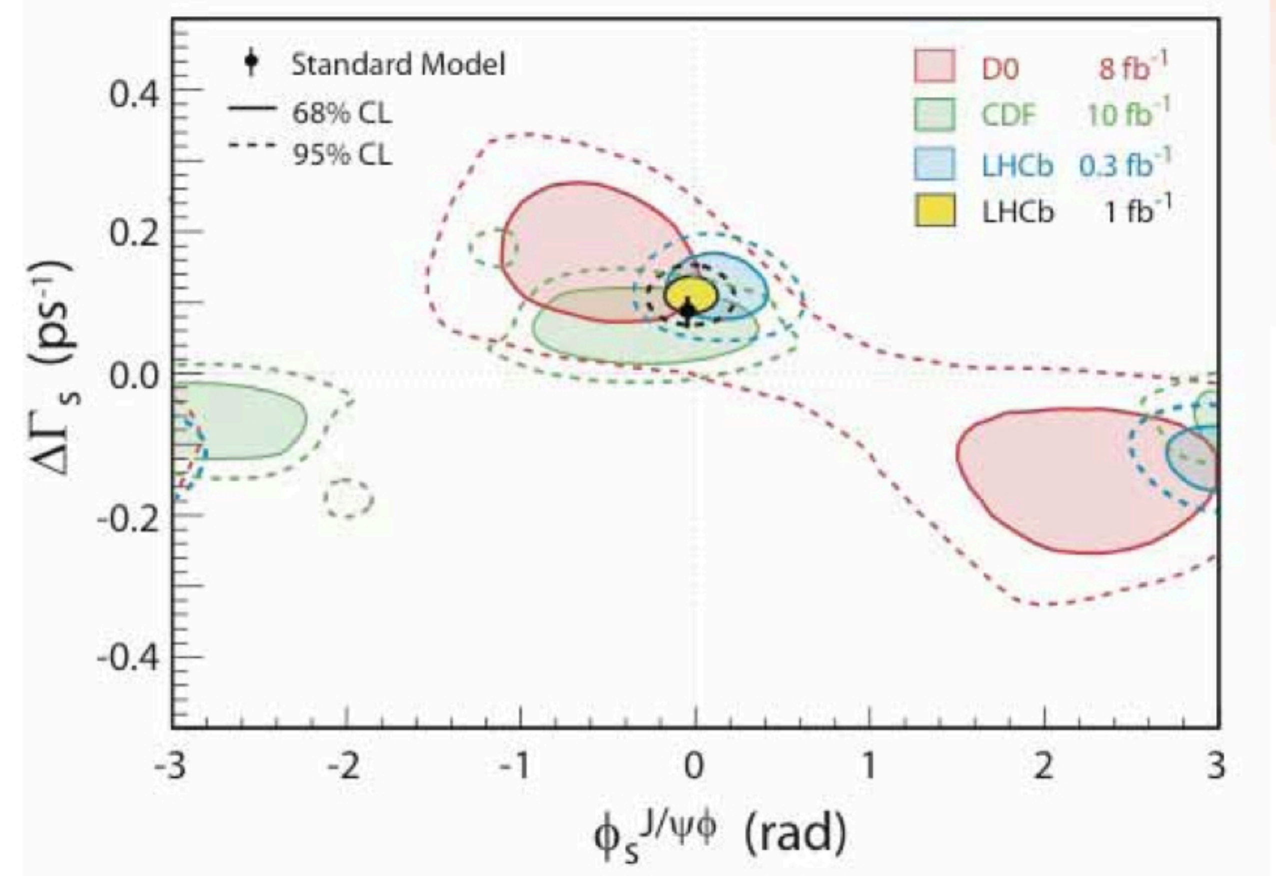
B: combinatorial background



First clear observation of a non-zero $\Delta\Gamma_s$
ie CP- state lives longer than CP+ state

Further analysis reveal $\Delta\Gamma s=\Gamma_L-\Gamma_H>0$
- heavy state lives longer than light state

$B_s \to J/\Psi\Phi$

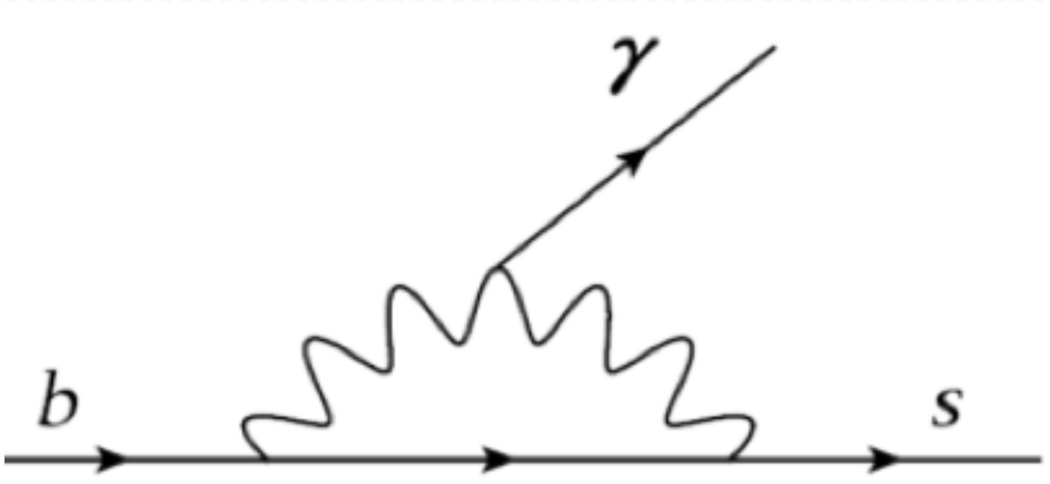


Γ_s=0.6580±0.054(stat) ±0.0066(syst) ps^{-1}

$\Delta\Gamma_s$=0.116±0.018(stat) ±0.006(syst) ps^{-1}

Φ_s=-0.001±0.101(stat) ±0.027(syst) rad

Radiative b->s γ decays



Theory (E $_{\gamma}$>1.6 GeV):

$$\mathrm{BR}(\bar{B} \to X_s\gamma) = (3.15 \pm 0.23) \times 10^{-4}$$

World average (expt, E $_{\gamma}$>1.6 GeV):

$$\mathrm{BR}(\bar{B} \to X_s\gamma) = (3.55 \pm 0.24 \pm 0.09) \times 10^{-4}$$

Radiative b->s γ decays

- Photon energy spectrum
  - Insight into momentum distribution of b-quark inside meson
  - Constrain uncertainty on V_{ub}
- BaBar using a "sum of exclusive" measurement
  - 38 different fully reconstructed X_s states
- Photon energy
  - $1.9 < E_\gamma < 2.61$ GeV
  - $0.6 < m_{Xs} < 2.8$ GeV

X_s final states

X_s = final state of the s quark hadronic system

Mode Num.	Final State	Mode Num.	Final State
1	$K_S\pi^+$	20	$K_S\pi^+\pi^-\pi^+\pi^-$
2	$K^+\pi^0$	21	$K^+\pi^+\pi^-\pi^-\pi^0$
3	$K^+\pi^-$	22	$K_S\pi^+\pi^-\pi^0\pi^0$
4	$K_S\pi^0$	23	$K^+\eta$
5	$K^+\pi^+\pi^-$	24	$K_S\eta$
6	$K_S\pi^+\pi^0$	25	$K_S\eta\pi^+$
7	$K^+\pi^0\pi^0$	26	$K^+\eta\pi^0$
8	$K_S\pi^+\pi^-$	27	$K^+\eta\pi^-$
9	$K^+\pi^-\pi^0$	28	$K_S\eta\pi^0$
10	$K_S\pi^0\pi^0$	29	$K^+\eta\pi^+\pi^-$
11	$K_S\pi^+\pi^-\pi^+$	30	$K_S\eta\pi^+\pi^0$
12	$K^+\pi^+\pi^-\pi^0$	31	$K_S\eta\pi^+\pi^-$
13	$K_S\pi^+\pi^0\pi^0$	32	$K^+\eta\pi^-\pi^0$
14	$K^+\pi^+\pi^-\pi^-$	33	$K^+K^-K^+$
15	$K_S\pi^0\pi^+\pi^-$	34	$K^+K^-K_S$
16	$K^+\pi^-\pi^0\pi^0$	35	$K^+K^-K_S\pi^+$
17	$K^+\pi^+\pi^-\pi^+\pi^-$	36	$K^+K^-K^+\pi^0$
18	$K_S\pi^+\pi^-\pi^+\pi^0$	37	$K^+K^-K^+\pi^-$
19	$K^+\pi^+\pi^-\pi^0\pi^0$	38	$K^+K^-K_S\pi^0$

$$E_\gamma^B = \frac{m_B^2 - m_{X_s}^2}{2m_B}$$

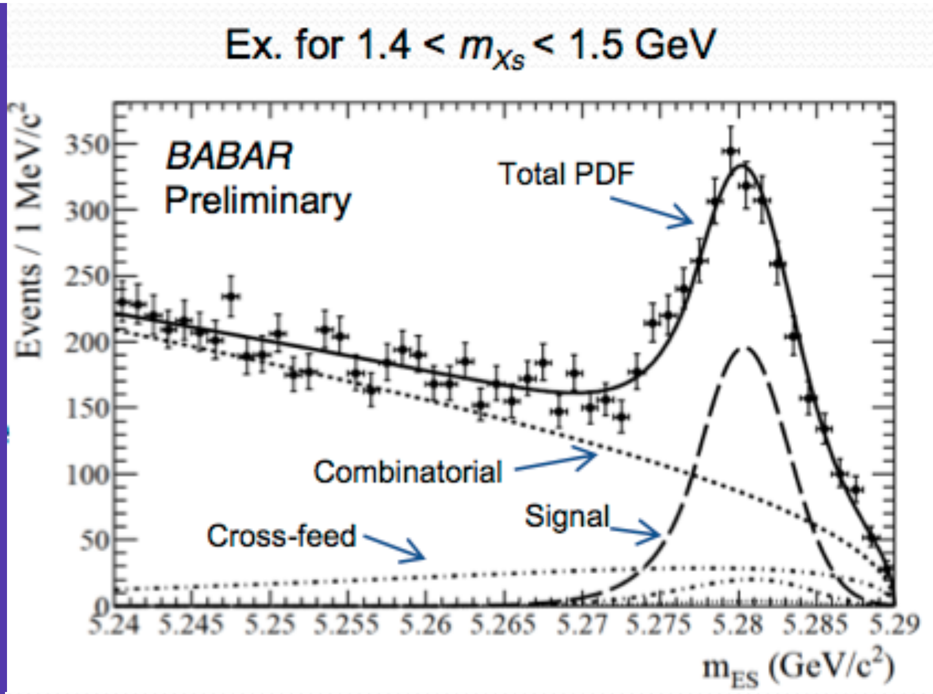
Radiative b->s γ decays

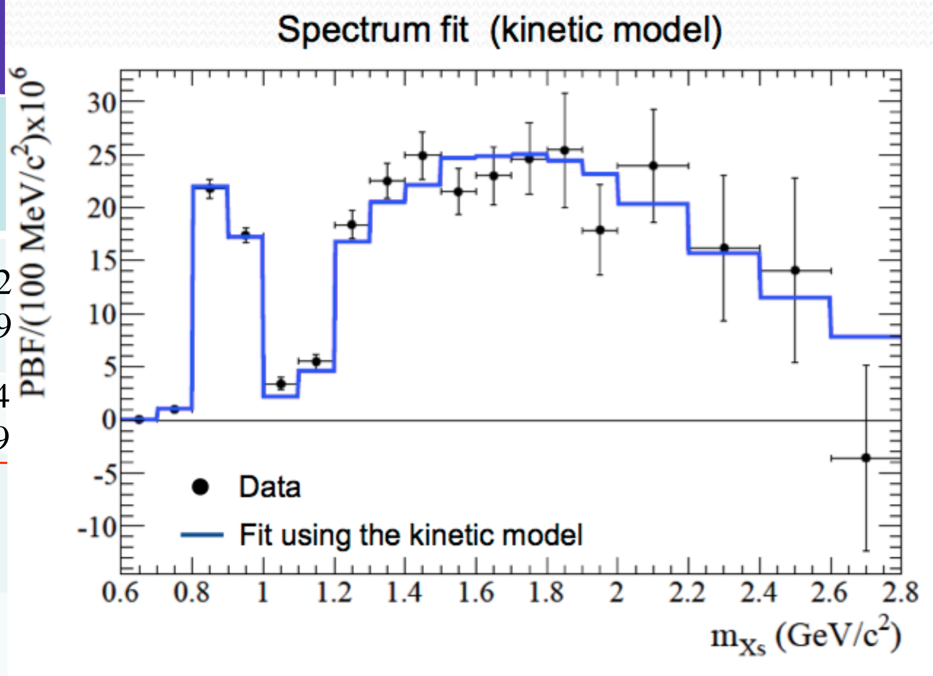
- Signal yield extracted from m_{ES} fit in each m_{Xs} bin

$$m_{ES} = \sqrt{(E^*_{\rm beam})^2 - (\vec{p}^*_B)^2}$$

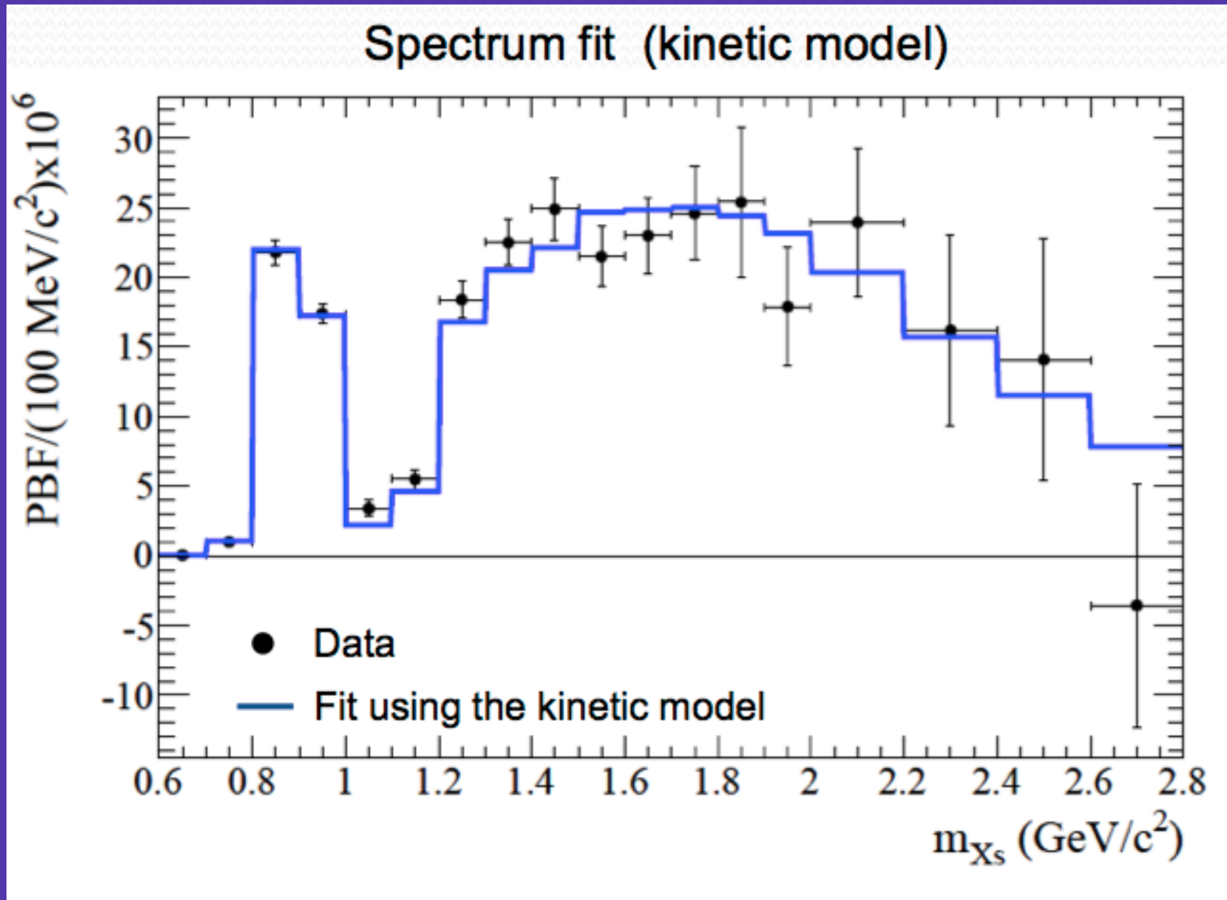
- Fit partial BR(BF) in each m_{Xs} bin & extract HQET parameters

		Kinetic model	Shape function
New BaBar results	m_b (GeV/c^2)	$4.568^{+0.038}_{-0.036}$	$4.579^{+0.032}_{-0.029}$
	μ^2_π(GeV^2)	$0.450^{+0.054}_{-0.054}$	$0.257^{+0.034}_{-0.039}$
World average (HFAG)	m_b (GeV/c^2)	$4.591^{+0.031}_{-0.031}$	$4.620^{+0.039}_{-0.032}$
	μ^2_π(GeV^2)	$0.454^{+0.038}_{-0.038}$	$0.288^{+0.054}_{-0.074}$





Radiative b->s γ decays



Total BR(BF) for E_γ>1.9 GeV:

$$BF(\bar{B} \to X_s \gamma) = (3.29 \pm 0.19 \pm 0.48) \times 10^{-4}$$

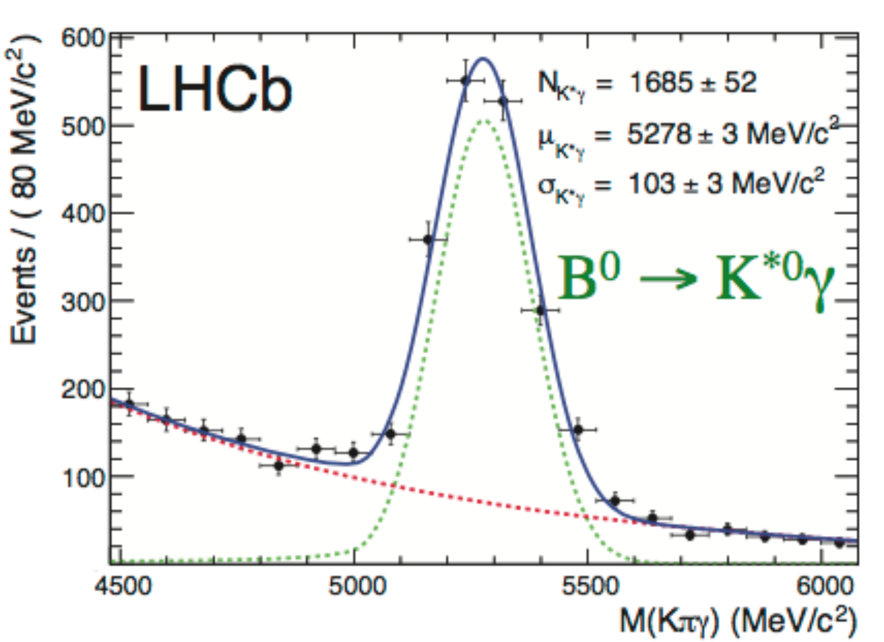
Radiative b->s γ decays

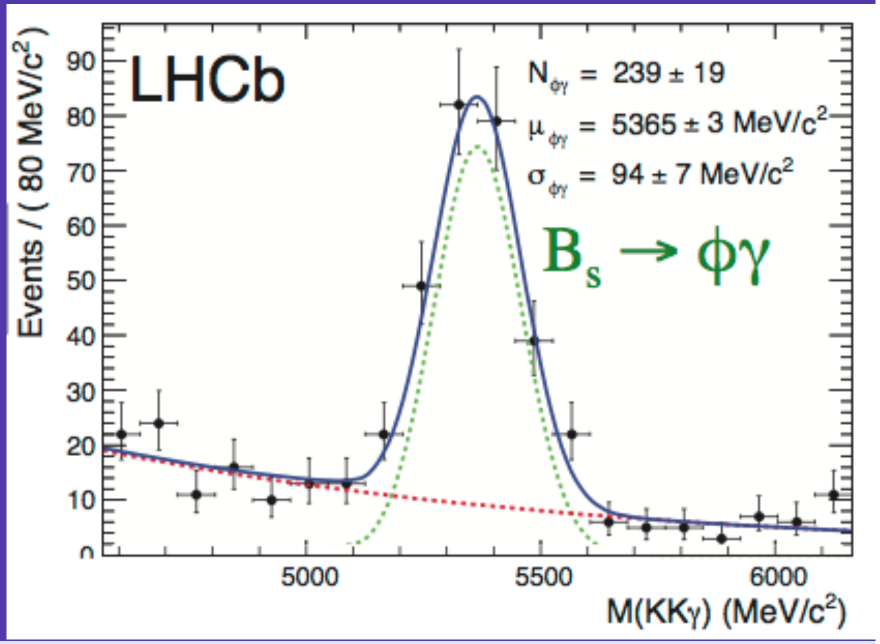
Several exclusive modes observed at LHCb: $B^0 \to K^{*0}\gamma,\ B^+ \to K^{*0}\pi^+\gamma,\ B^+ \to \phi K^+\gamma$

$B_s \to \phi\gamma,\ \Lambda_b \to \Lambda^*(pK^-)\gamma$

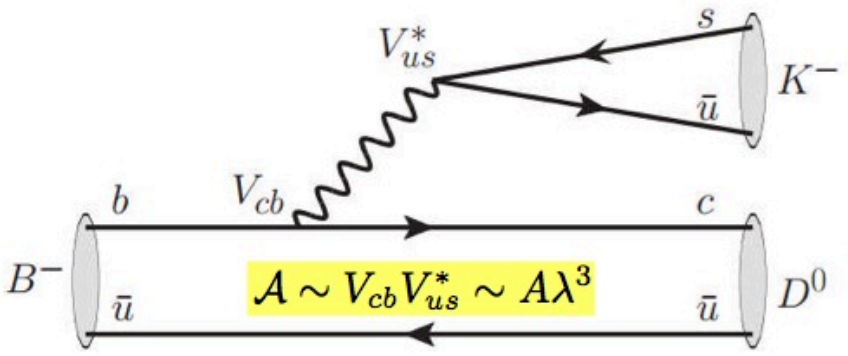
$$\frac{\mathrm{BR}(B^0 \to K^{*0}\gamma)}{\mathrm{BR}(B_s \to \phi\gamma)} = 1.12 \pm 0.08^{+0.06\ +0.09}_{-0.04\ -0.08}$$

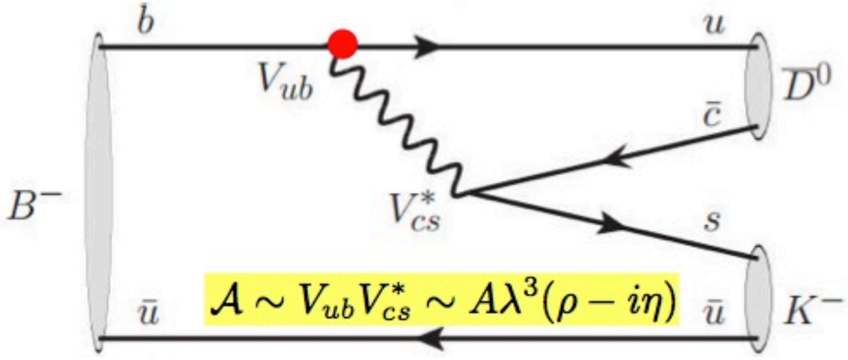
SM: 1.0±0.2





CPV in B±->DK±



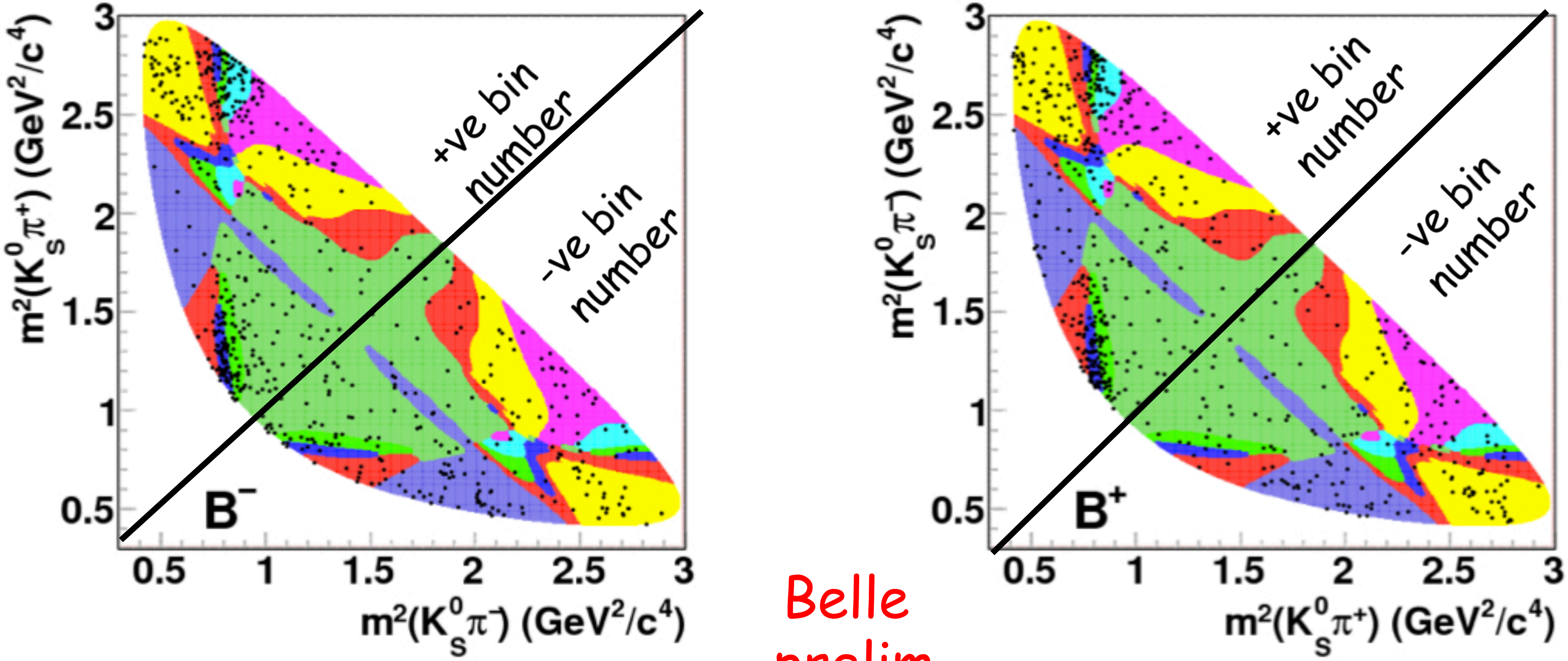


- Interference through final states accessible by both D^0 and anti-D^0
- Access to CKM angle γ
  - Current sensitivity dominated by D decays to 3-body final state
  - exploits difference in decay Dalitz plot -> model dependence

CPV in B±->DK±: model independent DP analysis

- Model independent approach → study of binned DP

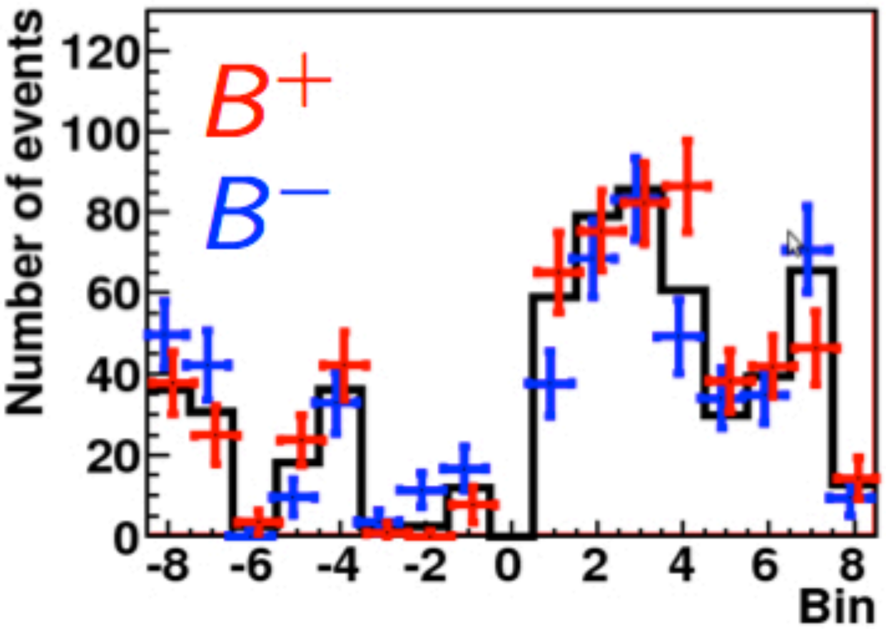
$B^- \to D^0 K^-$: $B^+ \to D^0 K^+$:

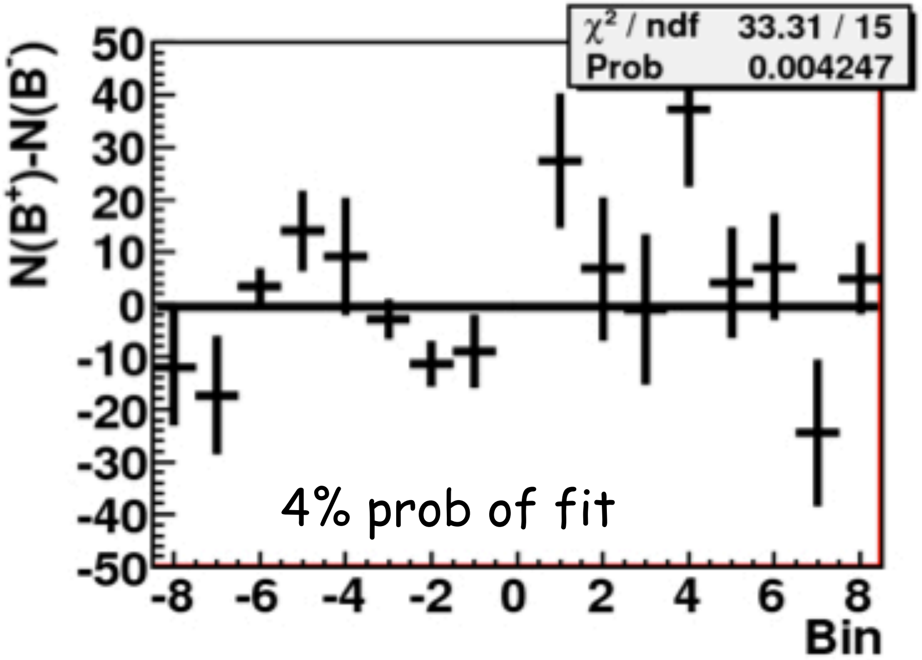


Belle prelim

$B^{\pm}$->$DK^{\pm}$: $\gamma(\Phi_3)$ from DP fit

Belle preliminary





4% prob of fit

$$\gamma = (77.3^{+15.1}_{-14.9} \pm 4.1 \pm 4.3)^\circ$$

$$\delta_B = (129.9 \pm 15.0 \pm 3.8 \pm 4.7)^\circ$$

$$r_B = 0.145 \pm 0.030 \pm 0.010 \pm 0.011$$

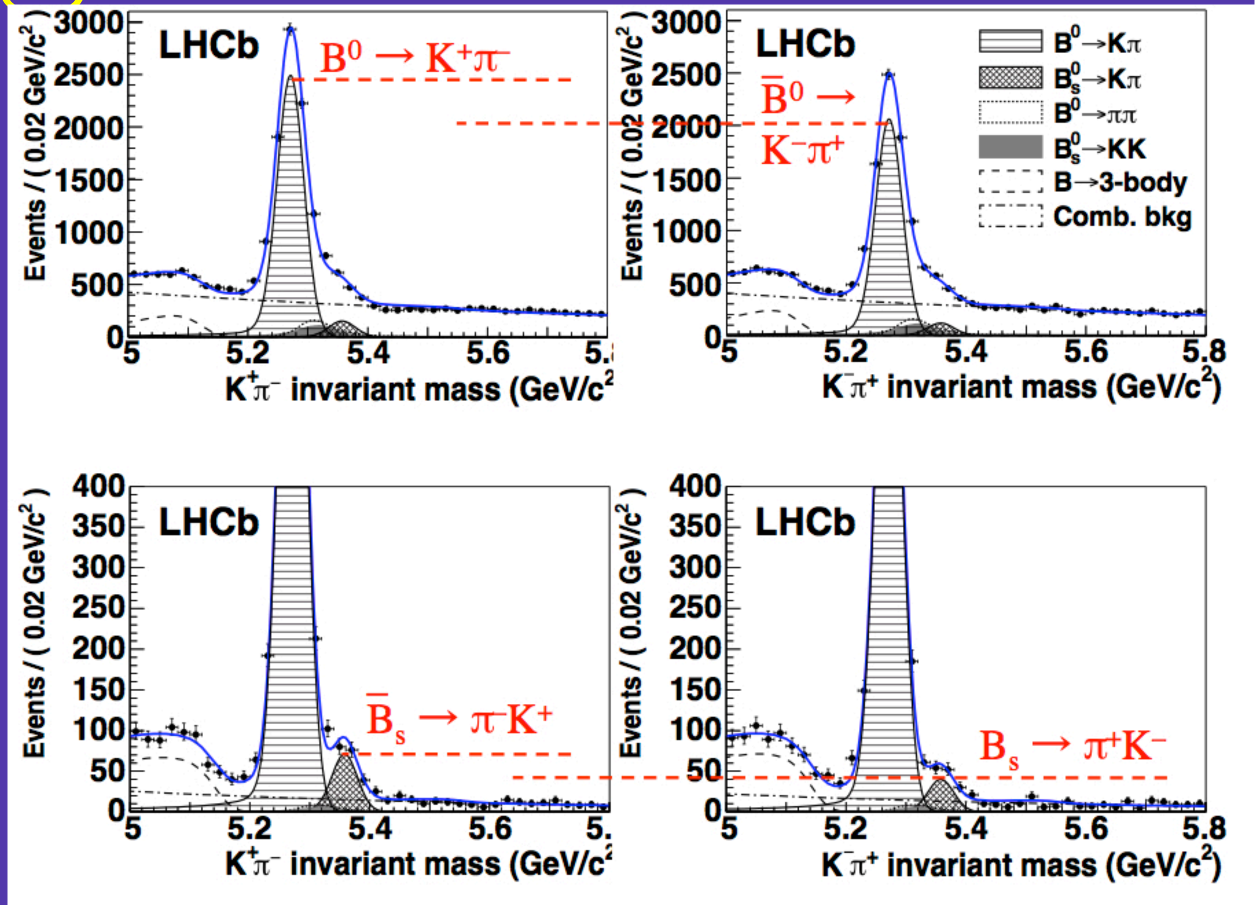
2.7σ evidence for direct CP violation

8.9° model error → 4.3°

Direct CPV in $B_{(s)} \to K\pi$

$$A_{CP}(B^0 \to K\pi) =$$
$$-0.088 \pm 0.011 \pm 0.0008$$

$$A_{CP}(B_s \to \pi K) =$$
$$+0.27 \pm 0.08 \pm 0.003$$

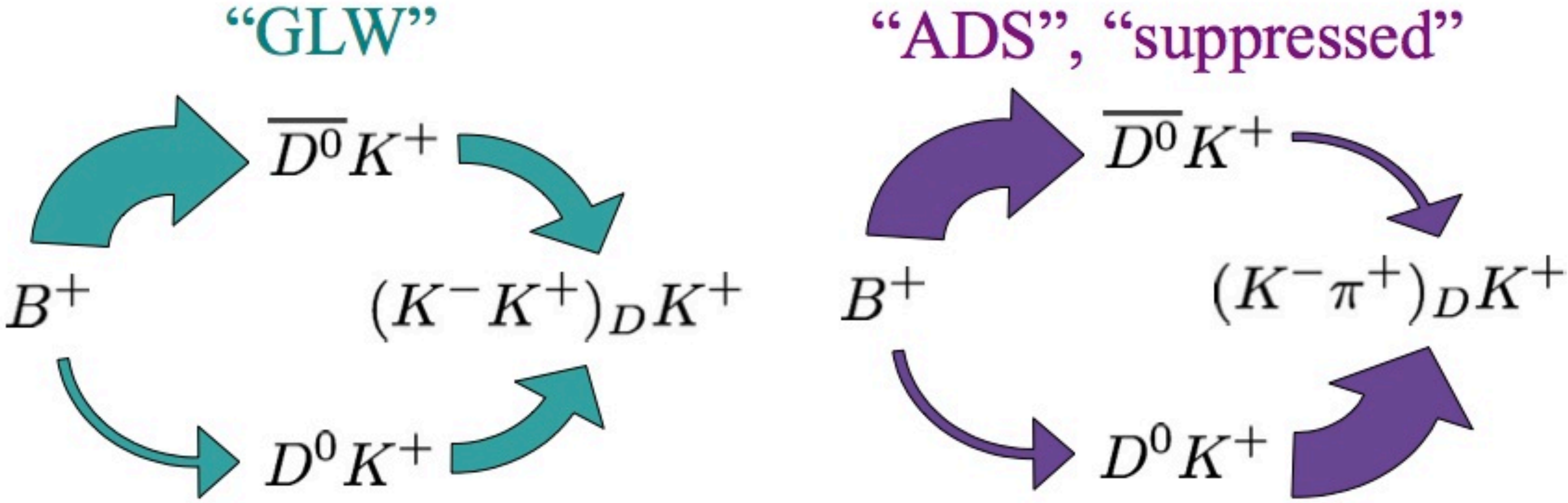


Opp. sign in asymmetry as expected in SM

1st obs of direct CPV in B-decays at hadron collider

1st evidence of direct in B_s decays

$B^{\pm}$->$DK^{\pm}$ CPV: GLW & ADS methods



Phys.Lett. B253 (1991) 483
Phys.Lett. B265 (1991) 172

Phys.Rev.Lett 78 (1997) 3257
Phys.Rev. D63 (2001) 036005

$B^{\pm}$->$DK^{\pm}$ CPV: GLW & ADS methods

$$R_{\rm ADS} = \frac{\Gamma(B^- \to D[\to K^+\pi^-]K^-) + \Gamma(B^+ \to D[\to K^-\pi^+]K^+)}{\Gamma(B^- \to D[\to K^-\pi^+]K^-) + \Gamma(B^+ \to D[\to K^+\pi^-]K^+)}$$

$$A_{\rm ADS} = \frac{\Gamma(B^- \to D[\to K^+\pi^-]K^-) - \Gamma(B^+ \to D[\to K^-\pi^+]K^+)}{\Gamma(B^- \to D[\to K^+\pi^-]K^-) + \Gamma(B^+ \to D[\to K^-\pi^+]K^+)}$$

ADS relations

$$R_{\rm ADS} = r_B^2 + r_D^2 + 2 r_B\, r_D \cos\gamma \cos(\delta_B + \delta_D)$$

$$A_{\rm ADS} = 2 r_B\, r_D \sin\gamma \sin(\delta_B + \delta_D)/R_{\rm ADS}$$

$$R_{\pm} \equiv \frac{\Gamma(B^{\pm} \to [K^{\mp}\pi^{\pm}]_D K^{\mp})}{\Gamma(B^{\pm} \to [K^{\pm}\pi^{\mp}]_D K^{\pm})} = r_B^2 + r_D^2 + 2 r_B r_D \cos(\pm\gamma + \delta_B + \delta_D)$$

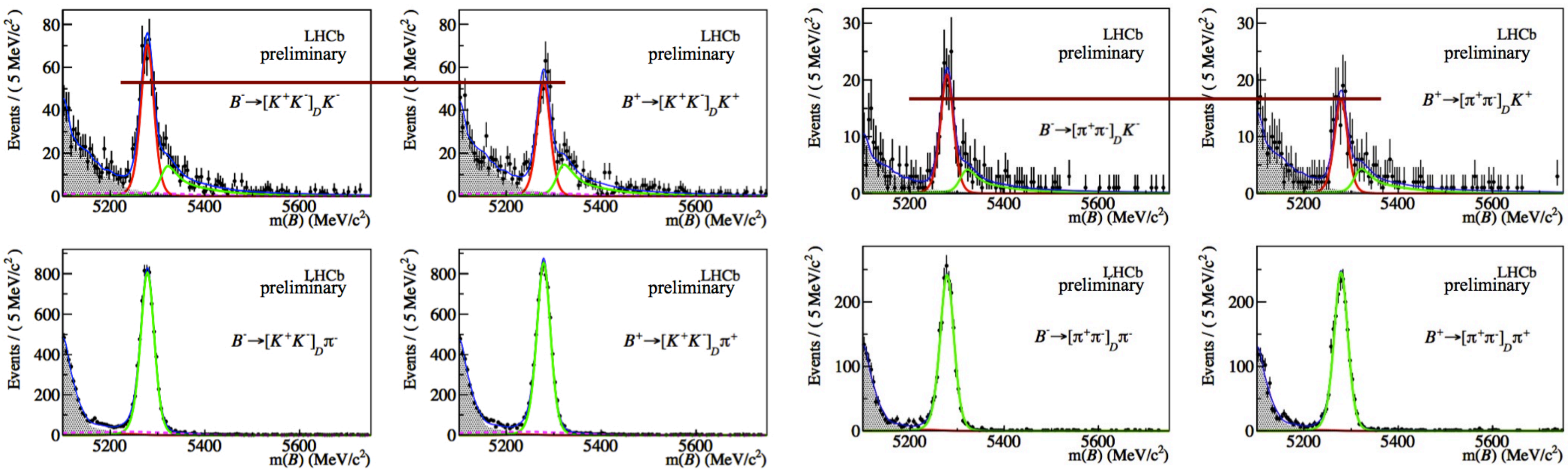
GLW relations

$$R_{CP\pm} = \frac{2[\Gamma(B^- \to D_{CP\pm}K^-) + \Gamma(B^+ \to D_{CP\pm}K^+)]}{\Gamma(B^- \to D^0K^-) + \Gamma(B^+ \to \overline{D}^0K^+)} = 1 + r_B^2 \pm 2 r_B \cos\delta_B \cos\gamma$$

$$A_{CP\pm} = \frac{\Gamma(B^- \to D_{CP\pm}K^-) - \Gamma(B^+ \to D_{CP\pm}K^+)}{\Gamma(B^- \to D_{CP\pm}K^-) + \Gamma(B^+ \to D_{CP\pm}K^+)} = \frac{\pm 2 r_B \sin\delta_B \sin\gamma}{1 + r_B^2 \pm 2 r_B \cos\delta_B \cos\gamma}$$

$B^{\pm}$->$DK^{\pm}$ CPV: GLW method

LHCb prelim



Charge-averaged ratio of D(CP) over D(flavour)

$$R_{CP+} \approx \frac{\langle R^{\pi\pi}_{K/\pi}, R^{KK}_{K/\pi} \rangle}{R^{K\pi}_{K/\pi}}$$

$$= 1.007 \pm 0.038 \pm 0.012$$

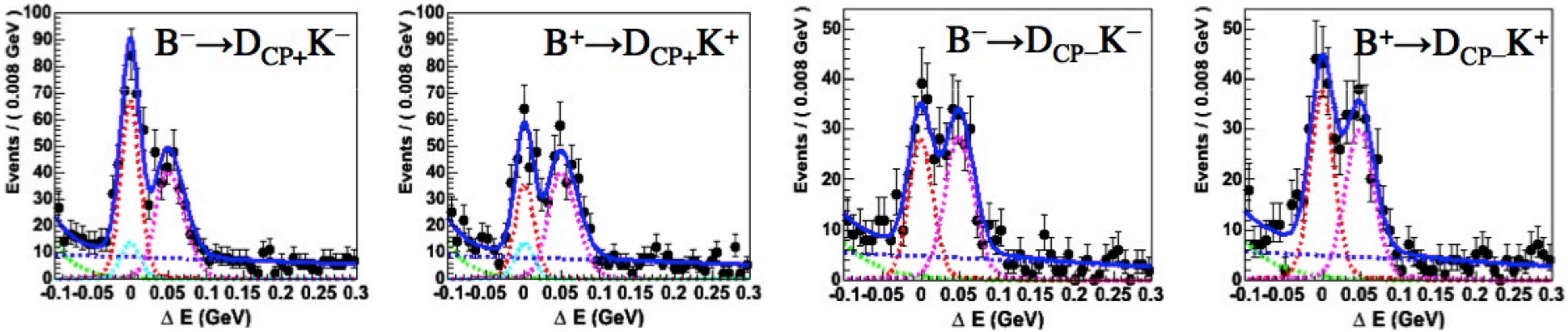
Charge Asymmetry

$$A_{CP+} \approx \langle A^{\pi\pi}_{K/\pi}, A^{KK}_{K/\pi} \rangle$$

$$= 0.145 \pm 0.032 \pm 0.010$$

$B^{\pm}$->$DK^{\pm}$ CPV: GLW method

Belle



$\Delta E = E^*_B - E^*_{beam}$

B→DK, B→Dπ, BBbar bkgnd, qqbar bknd

$$R_{CP+} = +1.03 \pm 0.07 \pm 0.03$$

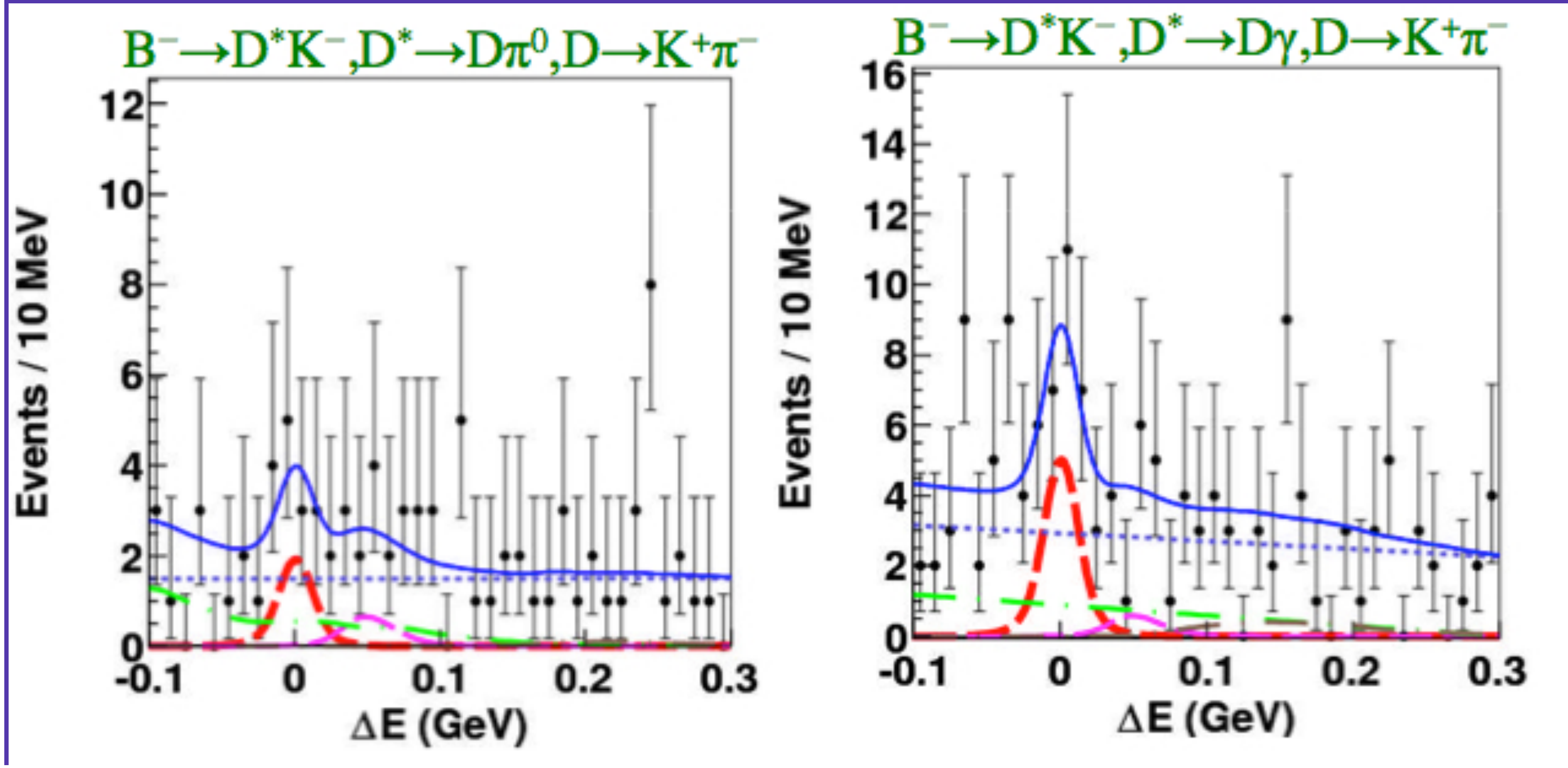
$$R_{CP-} = +1.13 \pm 0.09 \pm 0.05$$

$$A_{CP+} = +0.29 \pm 0.06 \pm 0.02$$

$$A_{CP-} = -0.12 \pm 0.06 \pm 0.01$$

$B^\pm \to DK^\pm$ CPV: ADS method

Belle prelim



$\Delta E = E^*_B - E^*_{beam}$ B→DK, B→Dπ, BBbar bkgnd, qqbar bknd

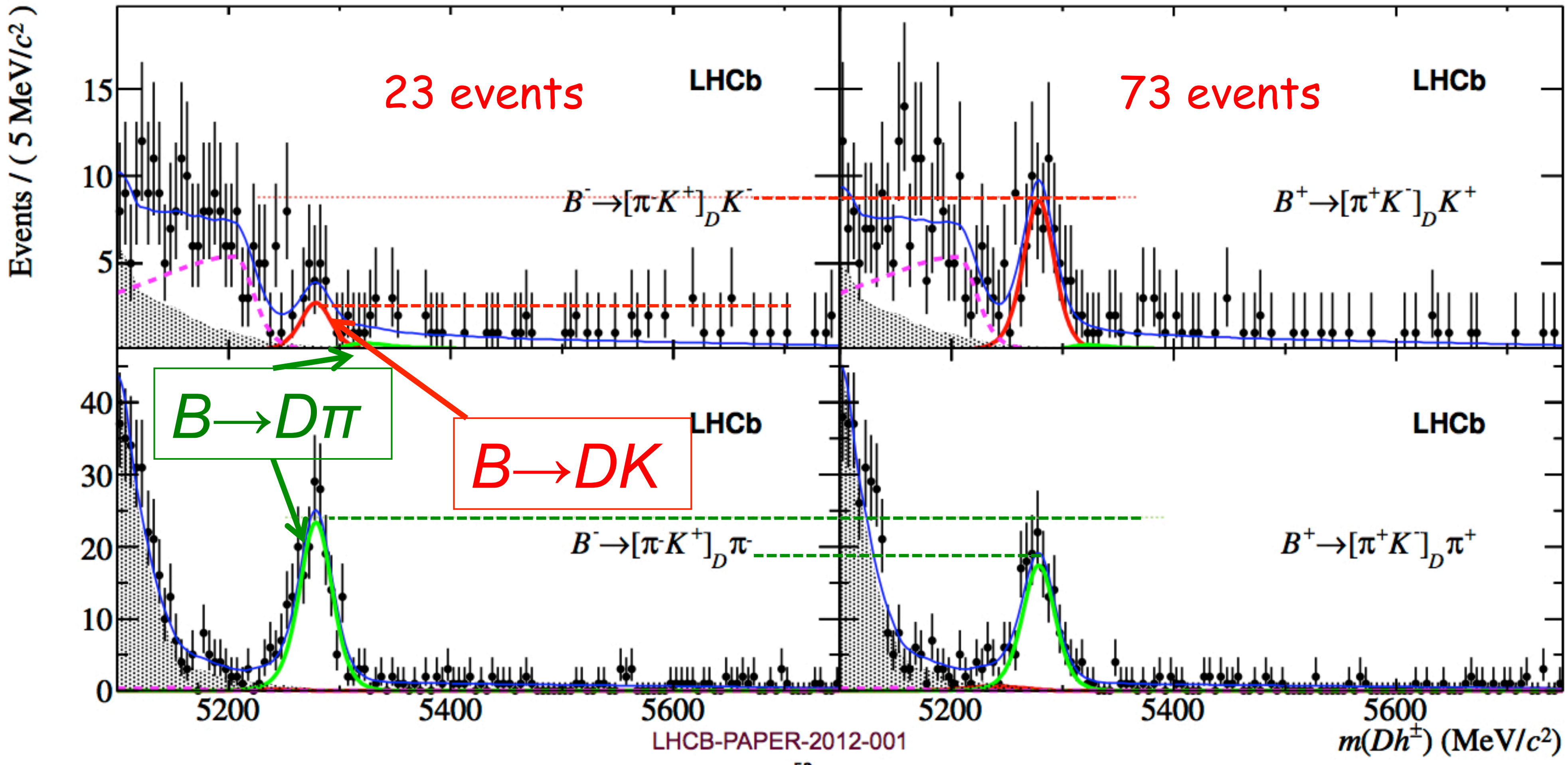
1st obs of D*K signal in γ mode

$$R_{D^*K,D\pi^0} = (1.0^{+0.8}_{-0.7}\,{}^{+0.1}_{0.2}) \times 10^{-2} \qquad R_{D^*K,D\gamma} = (3.6^{+1.4}_{-1.2} \pm 0.2) \times 10^{-2}$$

$$A_{D^*K,D\pi^0} = 0.4^{+1.1}_{-0.7}\,{}^{+0.2}_{-0.1} \qquad A_{D^*K,D\gamma} = -0.51^{+0.33}_{-0.29} \pm 0.08$$

$B^{\pm}$->$DK^{\pm}$ CPV: ADS method

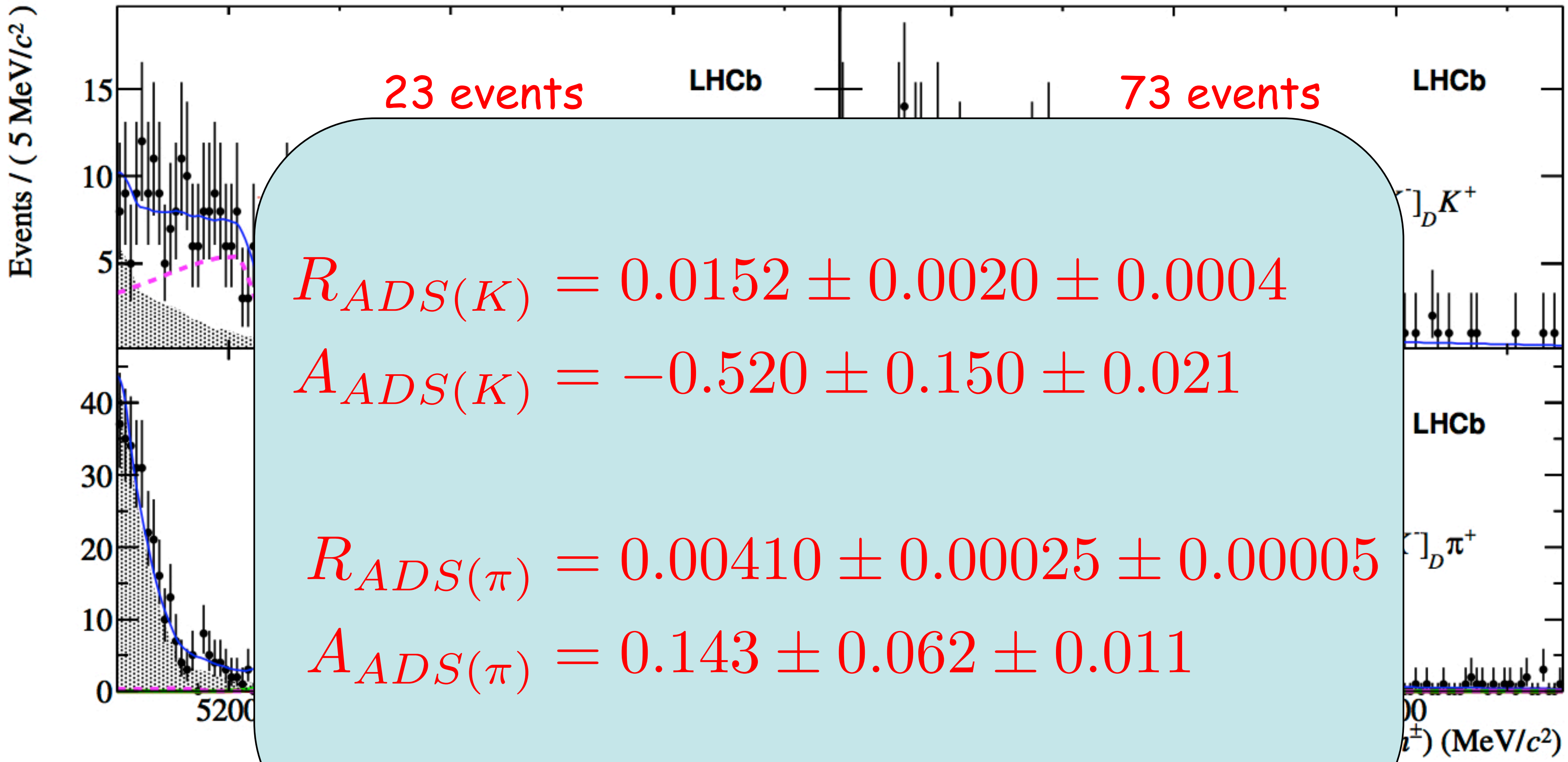
LHCb prelim



"suppressed" mode $BR(B^{\pm} \to D_{ADS}K^{\pm}) \approx 2 \times 10^{-7}$

B±->DK± CPV: ADS method

LHCb prelim



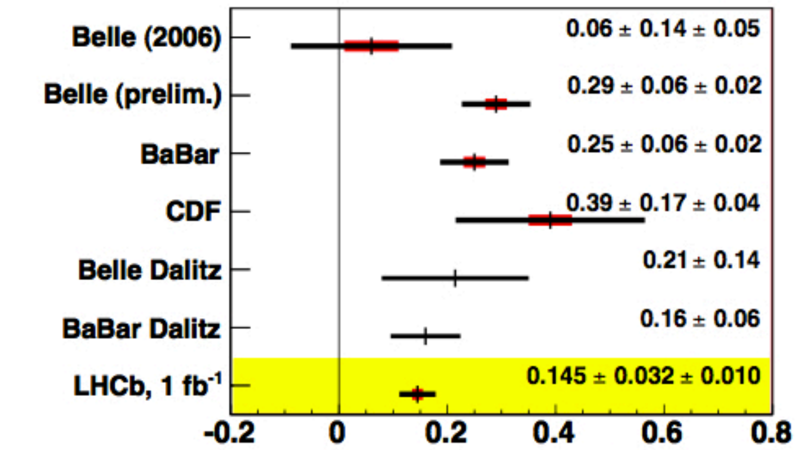
$$R_{ADS(K)} = 0.0152 \pm 0.0020 \pm 0.0004$$

$$A_{ADS(K)} = -0.520 \pm 0.150 \pm 0.021$$

$$R_{ADS(\pi)} = 0.00410 \pm 0.00025 \pm 0.00005$$

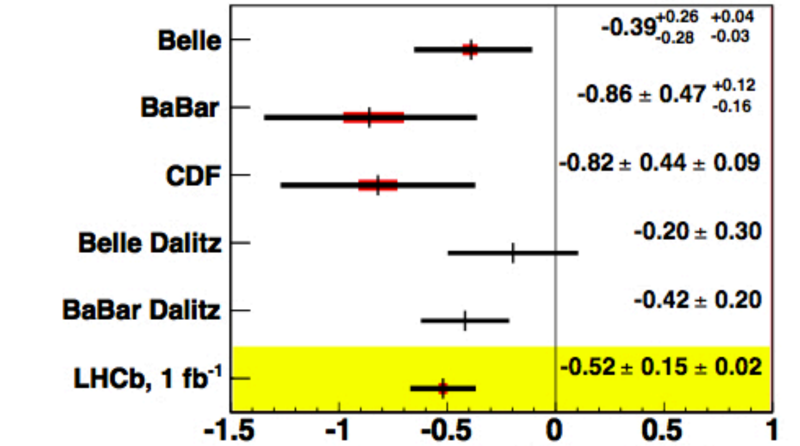
$$A_{ADS(\pi)} = 0.143 \pm 0.062 \pm 0.011$$

$B^{\pm}$->$DK^{\pm}$ CPV: Summary



$$A_{CP+} = \frac{2r_B \sin\delta_B \sin\gamma}{1 + {r_B}^2 + 2r_B \cos\delta_B \cos\gamma}$$

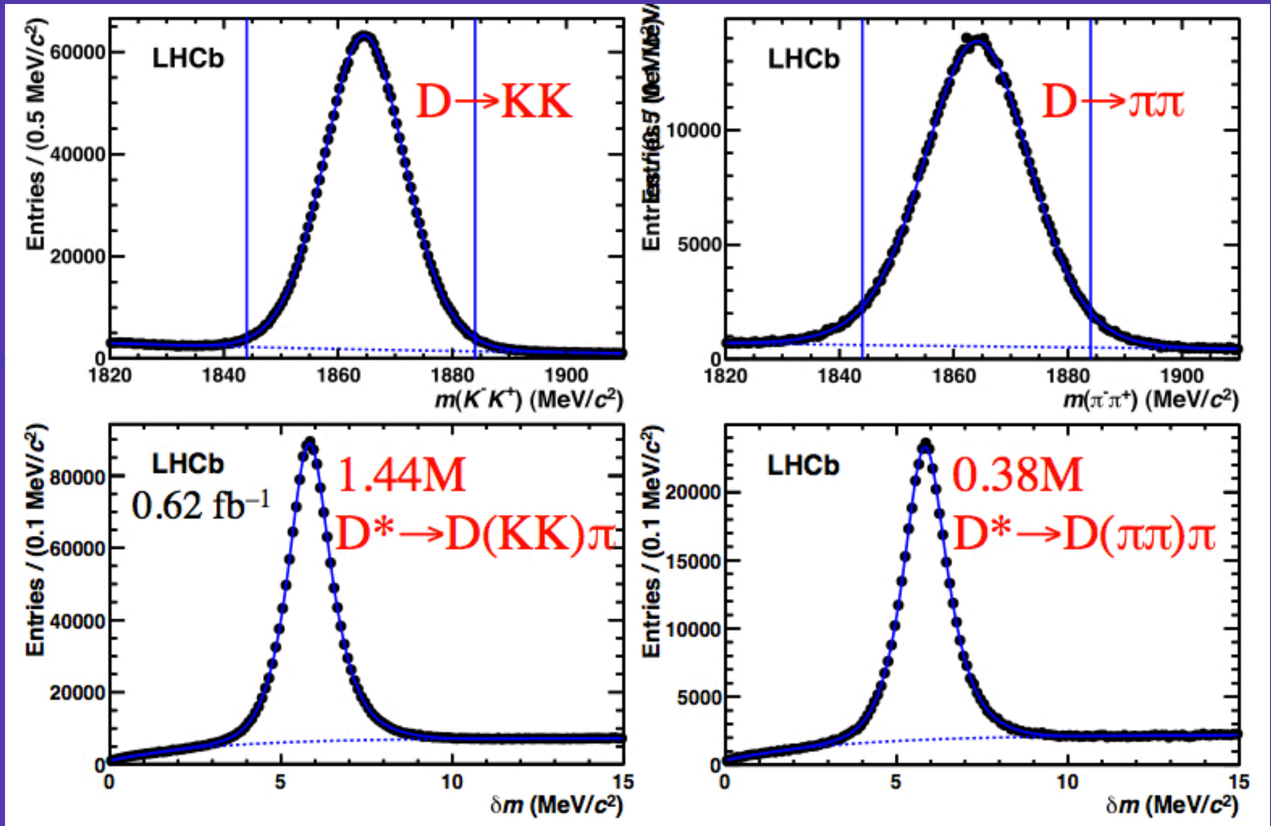
GLW



$$A^{ADS} = \frac{2r_B r_D \sin(\delta_B + \delta_D) \sin\gamma}{{r_B}^2 + {r_D}^2 + 2r_B r_D \cos(\delta_B + \delta_D) \cos\gamma}$$

ADS

CP violation in charm sector



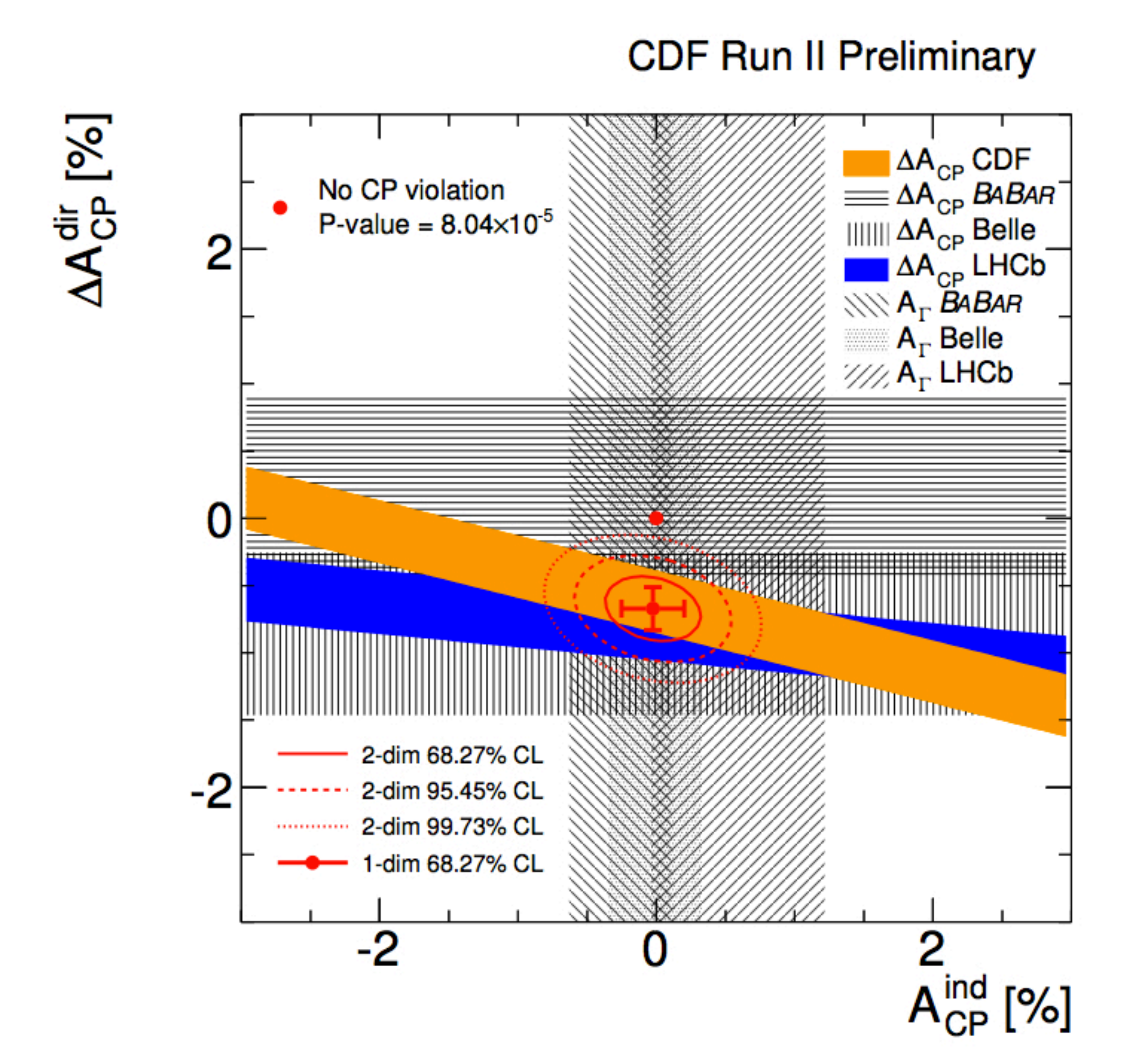
Use $D^0 \to h^+h^-$ decays tagged with $D^{*+} \to D^0\pi^+$

$$\Delta A_{CP}(f) = \frac{\Gamma(D^0 \to f) - \Gamma(\bar{D}^0 \to f)}{\Gamma(D^0 \to f) + \Gamma(\bar{D}^0 \to f)}$$

$$\Delta A_{CP} = A_{CP}(K^+K^-) - A_{CP}(\pi^+\pi^-) = (-0.82 \pm 0.21 \pm 0.11)\%$$

CP violation in charm sector

Also observed at CDF at 2.7σ



Summary

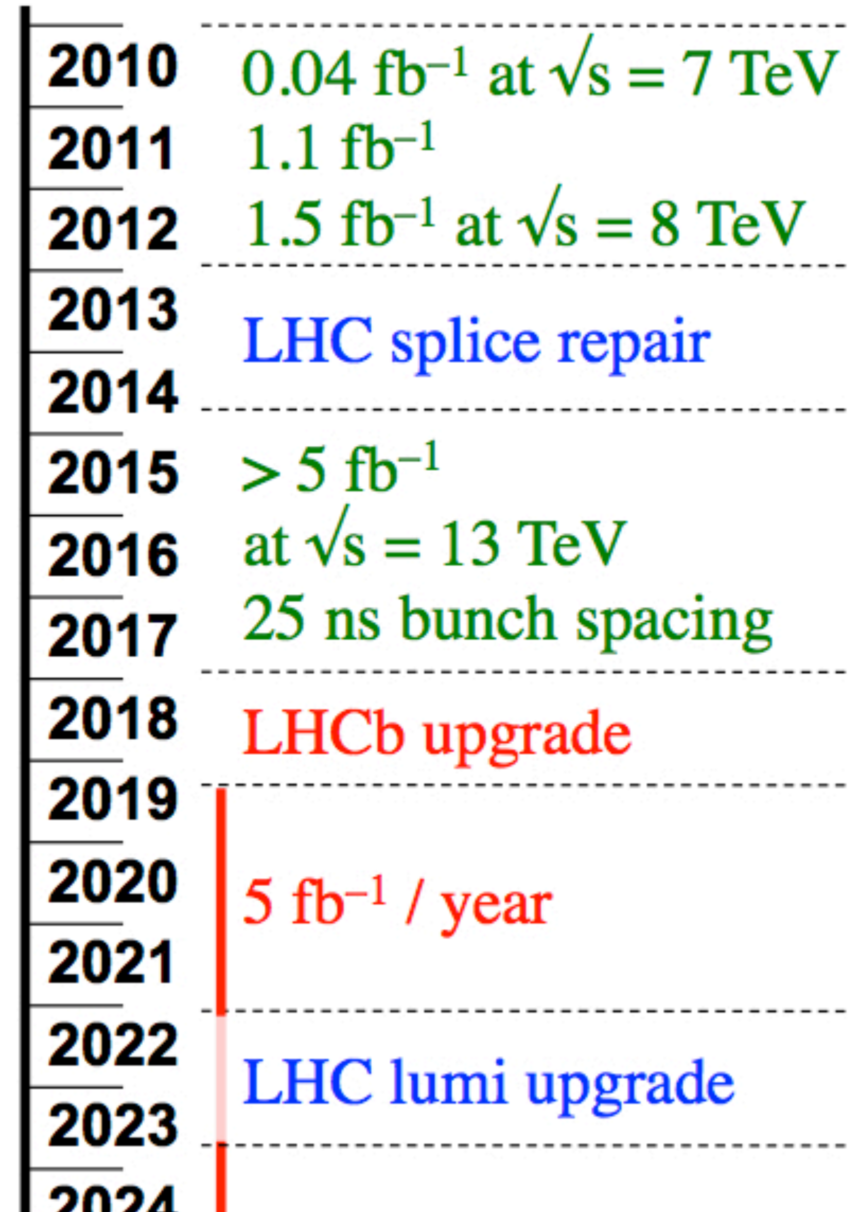
- LHCb is beginning to explore new territory as part of its "core" Physics programme

$BR(B_S \to \mu\mu) < 4.5\times10^{-9}$
Φ_S=-0.001±0.1010±0.027 rad
Heavy B_s lives longer than light
Obs. of B→DK ADS mode
Direct CP violation in B_S
CPV in charm sector :

- LHCb - exciting physics stretching out ahead

LHCb Upgrade

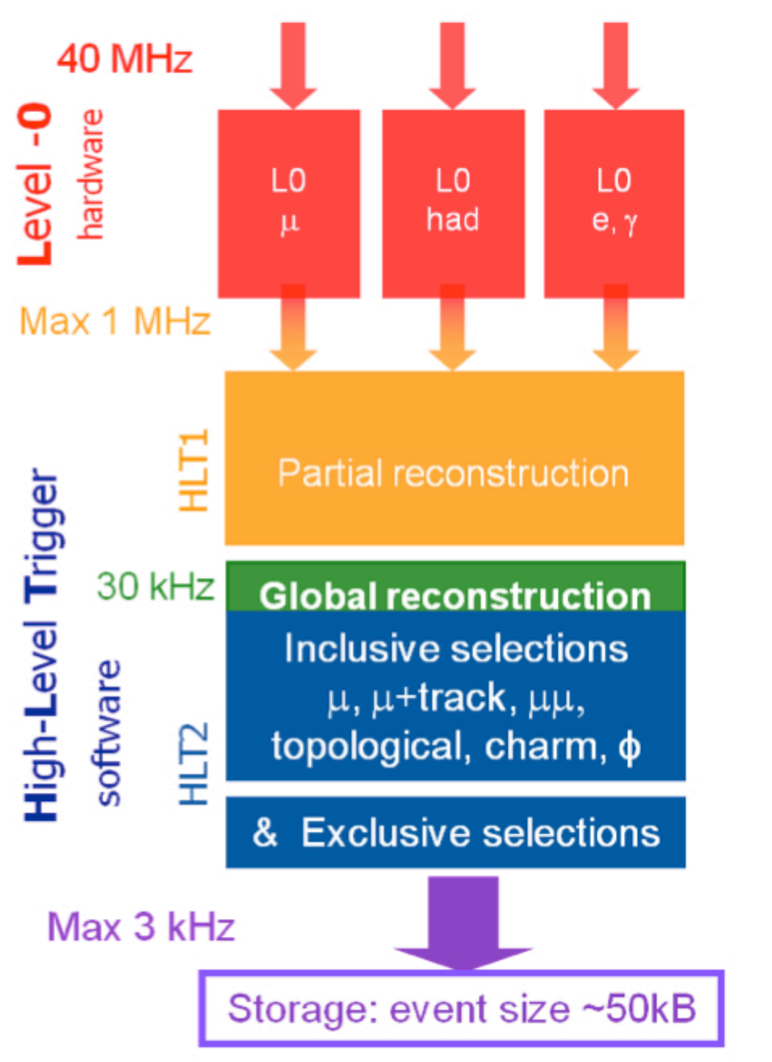
- Goal
  - Collect > 50 fb^{-1}
    - Lumi increase by factor of 5
    - Increase (hadronic) trigger efficiency by factor of 2
- Plan
  - Trigger on displaced vertex early
  - r/o full detector @ 40MHz (from 1 MHz)
- h/w to be replaced
  - All FE electornics
  - VeLo+ tracking stations
  - RICH photodetectors…



LHCb, LoI
CERN-LHCC-2011-001

Backup Slides

LHCb trigger



Level-0:
Hardware trigger at 40 MHz

- Reduce rate to a max. 1 MHz
- Select single objects with large p_T (E_T): μ>1GeV (h,e, γ, π^0)>3-4GeV

HLT:
Software trigger

- stage1: add tracking info, impact parameter cuts
- Stage 2: full recons+selection

o/p: 1kHz charm;1 kHz B, 1kHz others

	Efficiencies
B decays with μμ	70-90%
Fully hadronic B decays	20-45%
Fully hadronic charms decays	10-20%

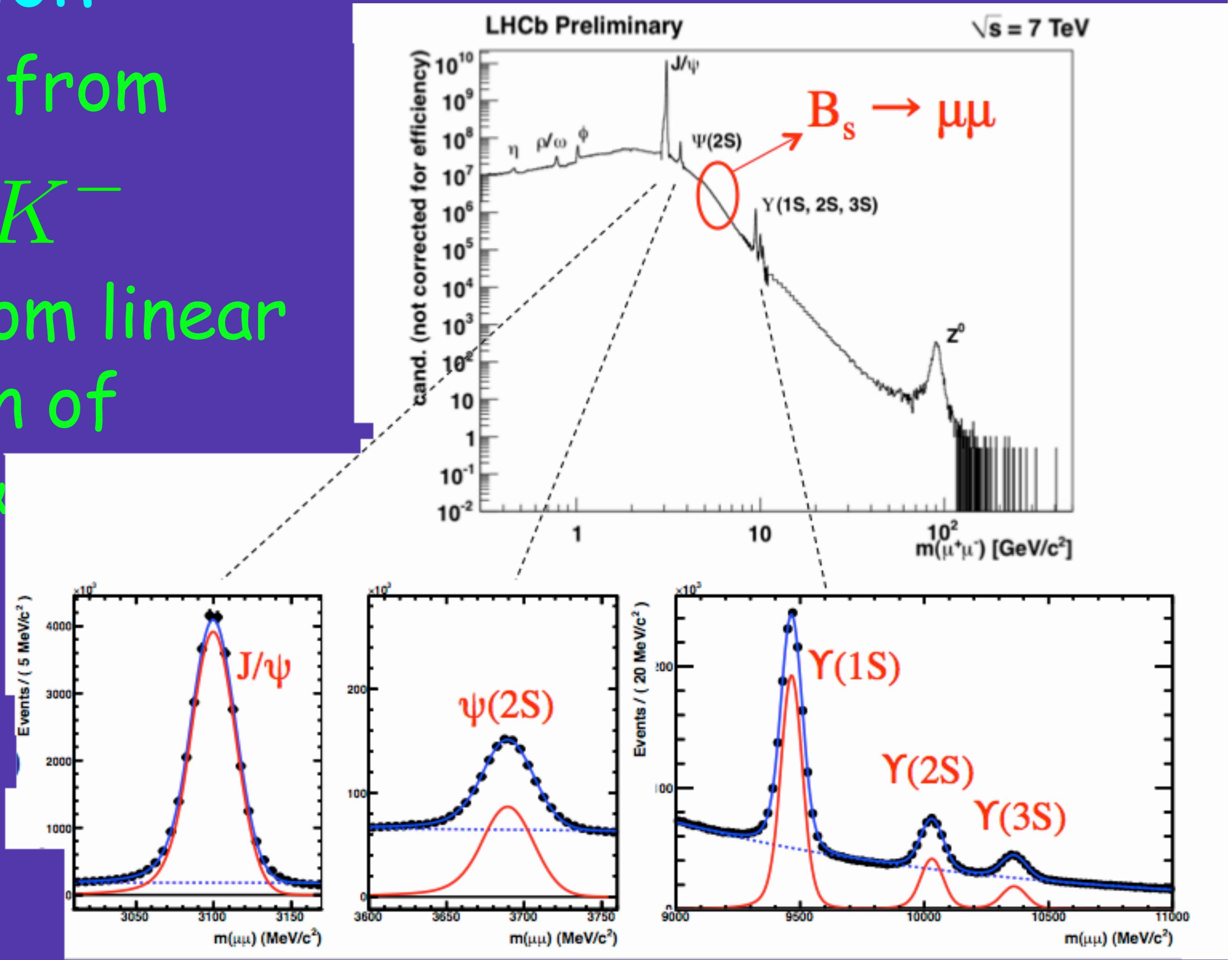
$\mathbf{B}_s \to \mu^+\mu^-$

- Mass calibration:
  - Central value from

$$B_s \to K^+K^-$$

  - Resolution from linear interpretation of charmonium & bottomonium

24.8±0.3±0.7 MeV/c²

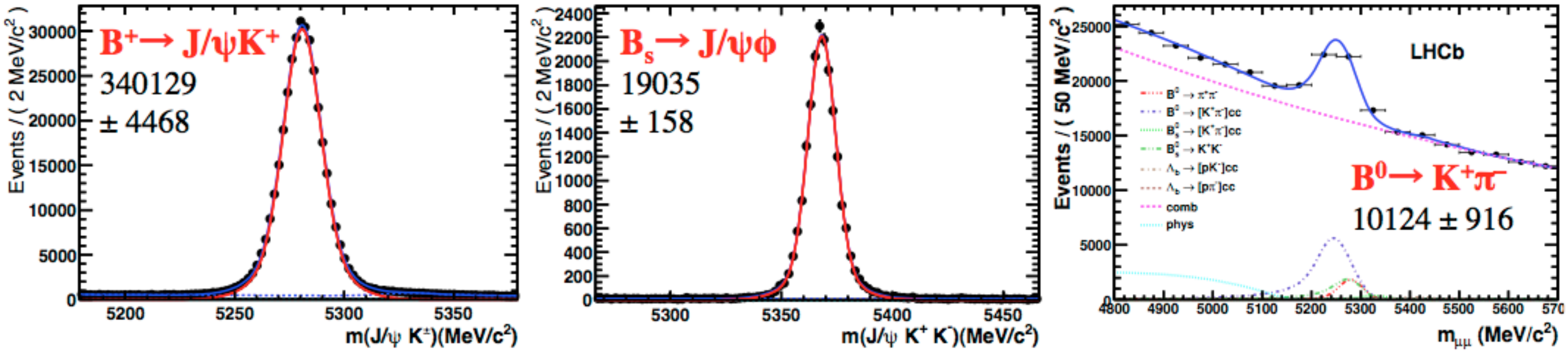


$\mathbf{B}_s \rightarrow \mu^+\mu^-$

- Branching factor normalisation:

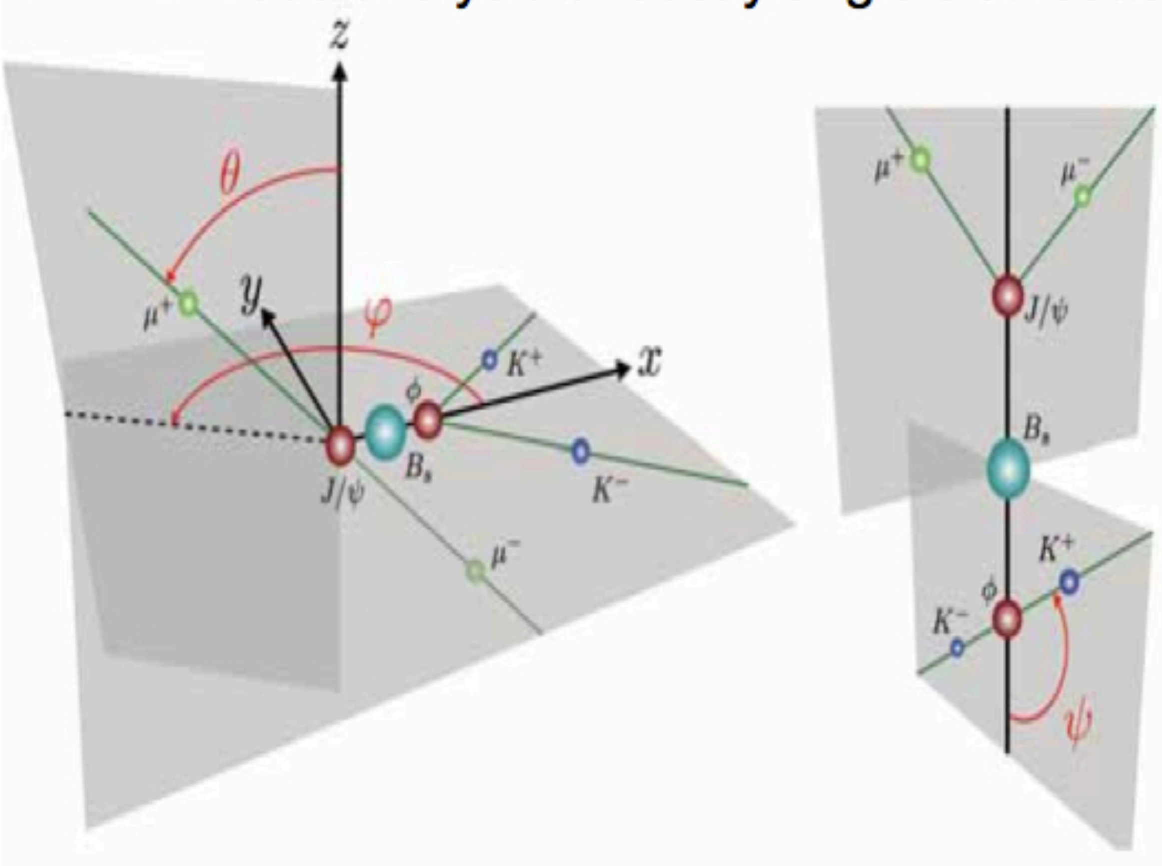
$$\mathrm{BR}_{B_s^0\rightarrow\mu\mu} = \mathrm{BR}_{\mathrm{norm}} \times \frac{N_{B_s^0\rightarrow\mu\mu}}{N_{\mathrm{norm}}} \times \frac{\varepsilon_{\mathrm{norm}}}{\varepsilon_{B_s^0\rightarrow\mu\mu}} \times \frac{f_{\mathrm{norm}}}{f_s}$$

  - B_s fraction from LHCb $\frac{f_s}{f_d} = 0.267^{+0.021}_{-0.020}$



$B_s \to J/\Psi\Phi$

- Decay to CP-odd and CP-even final states,
  → need analysis of decay angle distribution



J/ψ rest frame   Φ rest frame

$B_s \to J/\Psi\Phi$

- There are two ambiguous solutions related by $\phi_s \Leftrightarrow \pi - \phi_s$ and $\Delta\Gamma \Leftrightarrow -\Delta\Gamma$
- We can disambiguate using the P-Wave ⇔ S-Wave interference

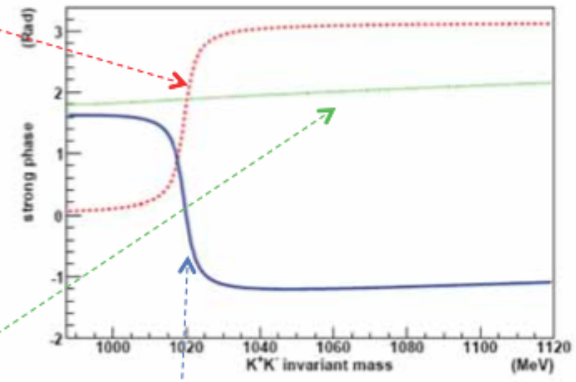
[Y. Xie et al., JHEP 0909:074, 2009]

Similar to Babar measurement of sign of cos(2β), PRD 71, 032005 (2007)

K^+K^- P-wave:

Phase of Breit-Wigner amplitude increases rapidly across ϕ(1020) mass region

$$BW(m_{KK}) = \frac{F_r F_D}{m_\phi^2 - m_{KK}^2 - i m_\phi \Gamma(m_{KK})}$$



K^+K^- S-wave:

Phase of Flatté amplitude for $f_0(980)$ relatively flat (similar for non-resonance)

Phase difference between S- and P-wave amplitudes

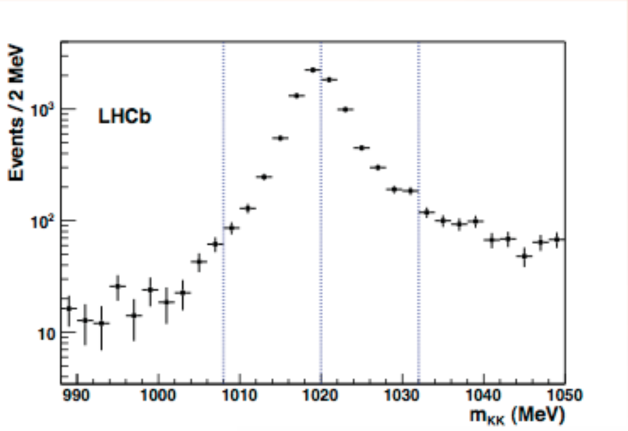
Decreases rapidly across ϕ(1020) mass region

Resolution method: choose the solution with decreasing trend of $\delta_s - \delta_P$ vs m_{KK} in the ϕ(1020) mass region

5

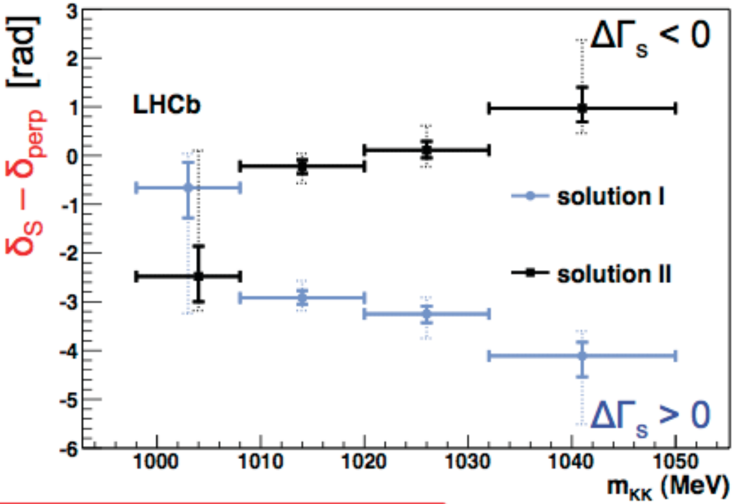
$B_s \to J/\Psi\Phi$

- Split data into 4 bins of m_{KK}



- In each bin measure
  - Fraction of S-wave
  - Measure relative strong phase difference $\delta_S - \delta_{perp}$

Parameter	Solution I	Solution II
ϕ_s (rad)	0.167 ± 0.175	2.975 ± 0.175
$\Delta\Gamma$ (ps^{-1})	0.120 ± 0.028	-0.120 ± 0.028
$F_{S;1}$	0.283 ± 0.113	0.283 ± 0.113
$F_{S;2}$	0.061 ± 0.022	0.061 ± 0.022
$F_{S;3}$	0.044 ± 0.022	0.044 ± 0.022
$F_{S;4}$	0.269 ± 0.067	0.269 ± 0.067
$\delta_{S\perp;1}$ (rad)	$-0.46\,^{+0.35}_{-0.42}$	$-2.68\,^{+0.42}_{-0.35}$
$\delta_{S\perp;2}$ (rad)	$-2.92\,^{+0.15}_{-0.13}$	$-0.22\,^{+0.13}_{-0.15}$
$\delta_{S\perp;3}$ (rad)	$-3.25\,^{+0.16}_{-0.18}$	$0.11\,^{+0.18}_{-0.16}$
$\delta_{S\perp;4}$ (rad)	$-4.11\,^{+0.28}_{-0.43}$	$0.97\,^{+0.43}_{-0.28}$

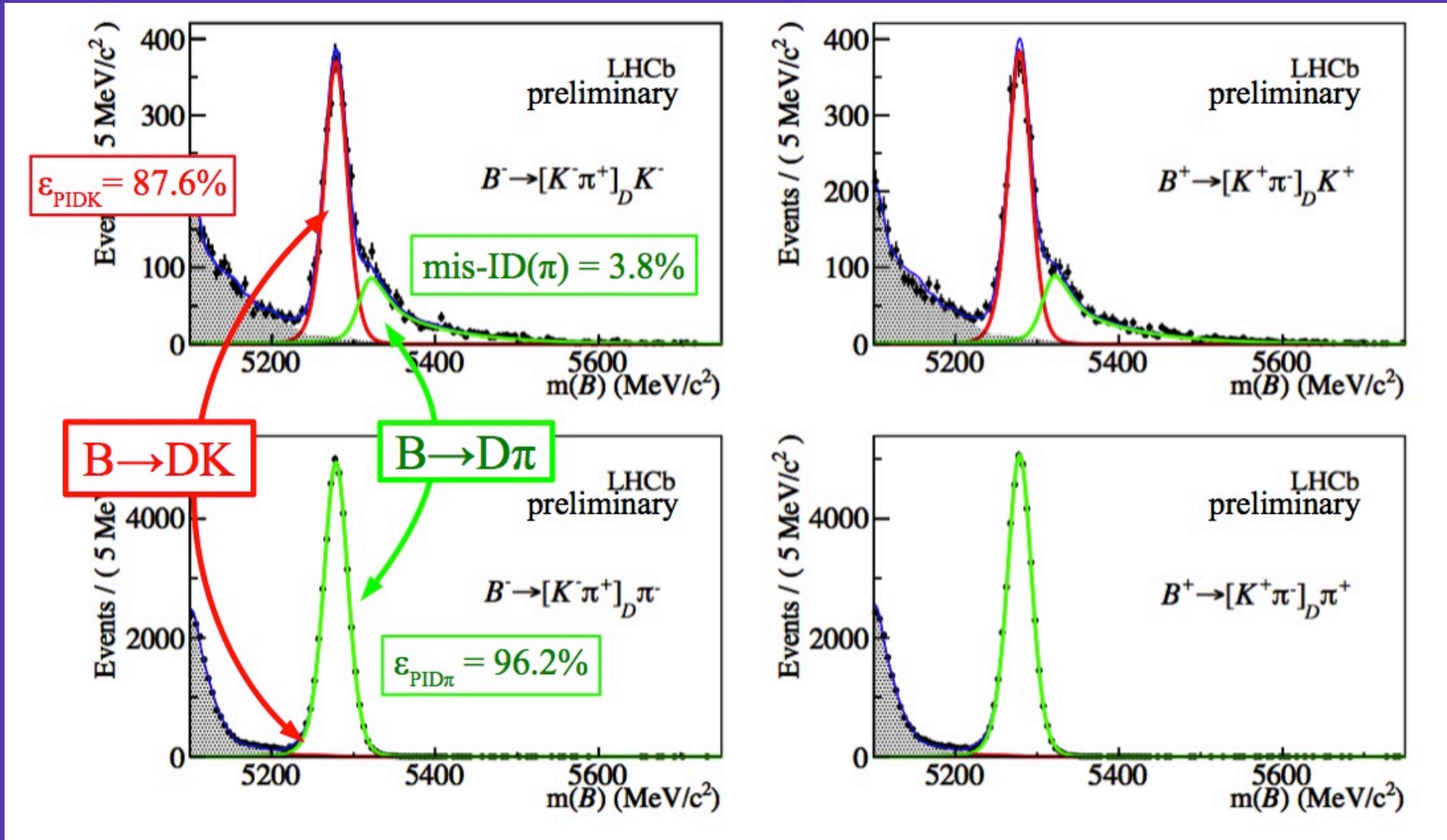


Solution-I is selected [4.7σ from being flat]

$\Delta\Gamma_s > 0$

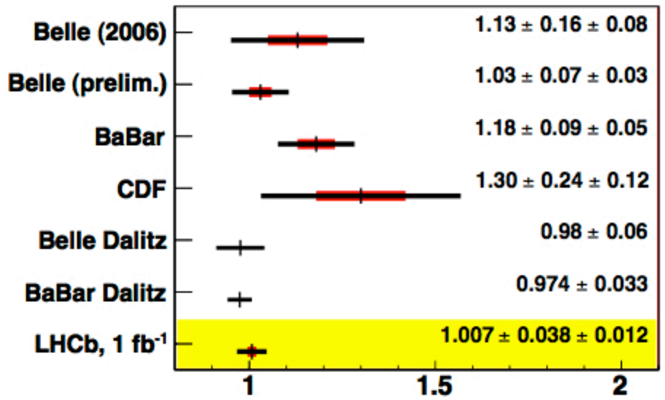
$B^\pm$->$DK^\pm$ CPV: ADS method

LHCb prelim

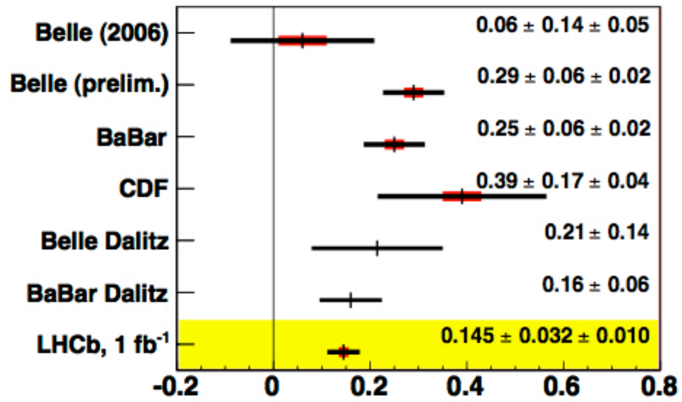


"favoured" mode

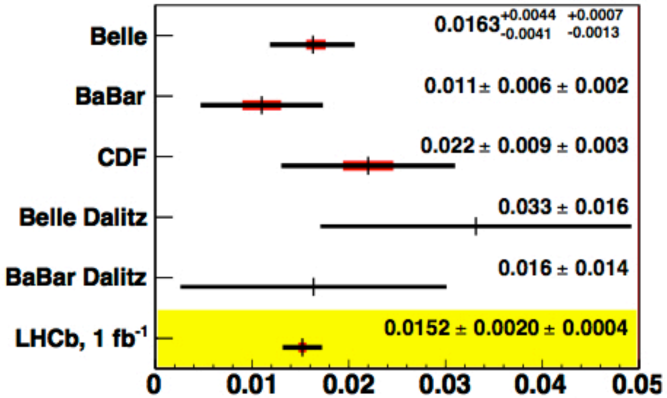
B±->DK± CPV: Summary



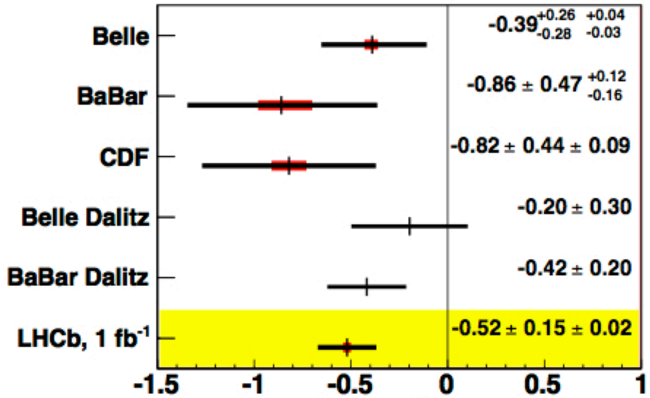
$$R_{CP+} = 1 + r_B{}^2 + 2r_B \cos\delta_B \cos\gamma$$



$$A_{CP+} = \frac{2r_B \sin\delta_B \sin\gamma}{1 + r_B{}^2 + 2r_B \cos\delta_B \cos\gamma}$$



$$R^{ADS} = \frac{r_B{}^2 + r_D{}^2 + 2r_B r_D \cos(\delta_B + \delta_D)\cos\gamma}{1 + (r_B r_D)^2 + 2r_B r_D \cos(\delta_B - \delta_D)\cos\gamma}$$



$$A^{ADS} = \frac{2r_B r_D \sin(\delta_B + \delta_D)\sin\gamma}{r_B{}^2 + r_D{}^2 + 2r_B r_D \cos(\delta_B + \delta_D)\cos\gamma}$$