Possibilties and problems for $b \to c$ Dalitz plot analyses at LHCb

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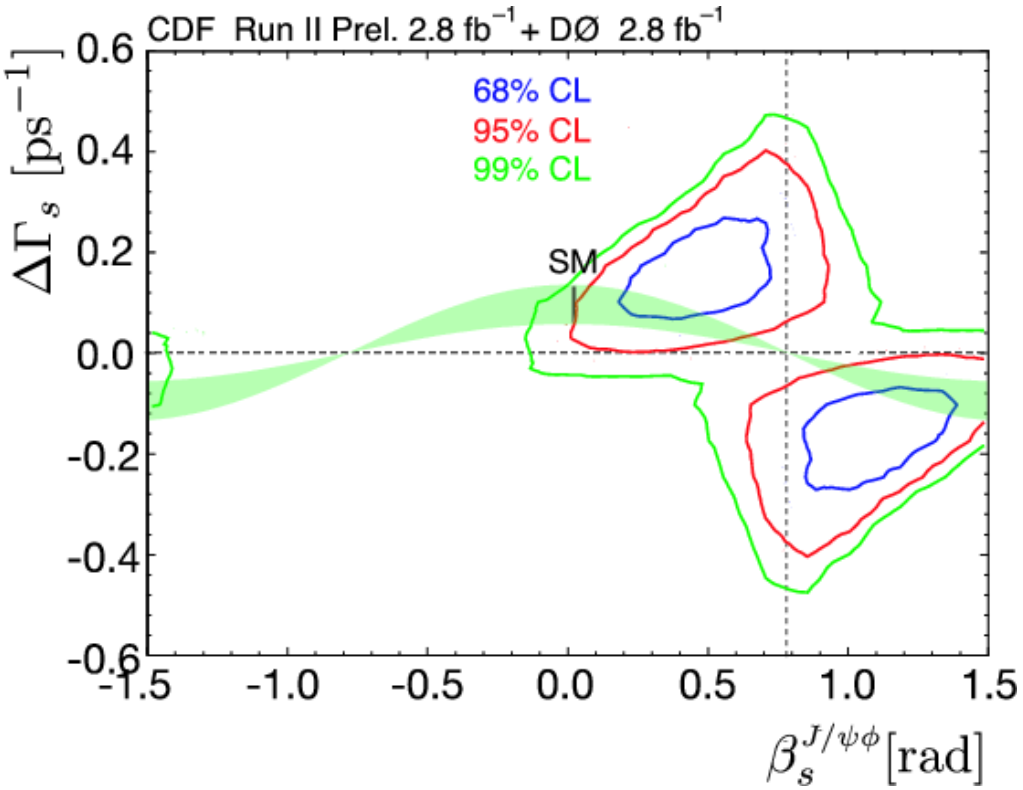
- $B^0_{d,s} \to J/\psi\, h^+ h'^-$
- $B^0_{d,s} \to D\, h^+ h'^-$

Possible physics interests

- $B^0_{d,s} \to J/\psi\, h^+ h'^-$
  - $B^0_{d.s} \to J/\psi\, \pi^+\pi^-$
    $\mapsto$ measure 2β in $b \to c\bar{c}d$ decay, measure ϕ_s in $B \to PV$ $b \to c\bar{c}s$ decay, probe $\pi^+\pi^-$ system
  - $B^0_{d,s} \to J/\psi\, K^\pm\pi^\mp$
    $\mapsto$ search for BSM DCPV, search for $Z^+(4430)$ state, probe $K^+\pi^-$ system
  - $B^0_s \to J/\psi\, K^+K^-$
    $\mapsto$ measure ϕ_s, probe K^+K^- system
- $B^0_{d,s} \to D\, h^+ h'^-$
  - $B^0_{d,s} \to D\, \pi^+\pi^-$
    $\mapsto$ measure 2β in $b \to c\bar{c}d$ decay, probe $\pi^+\pi^-$ system
  - $B^0_{d,s} \to D\, K^\pm\pi^\mp$
    $\mapsto$ measure γ
  - $B^0_{d,s} \to D\, K^+K^-$
    $\mapsto$ measure γ

- Measurement of ϕ_s from $B_s^0 \to J/\psi\, \phi$ one of LHCb's highest priorities
- Current status of CDF and D0:



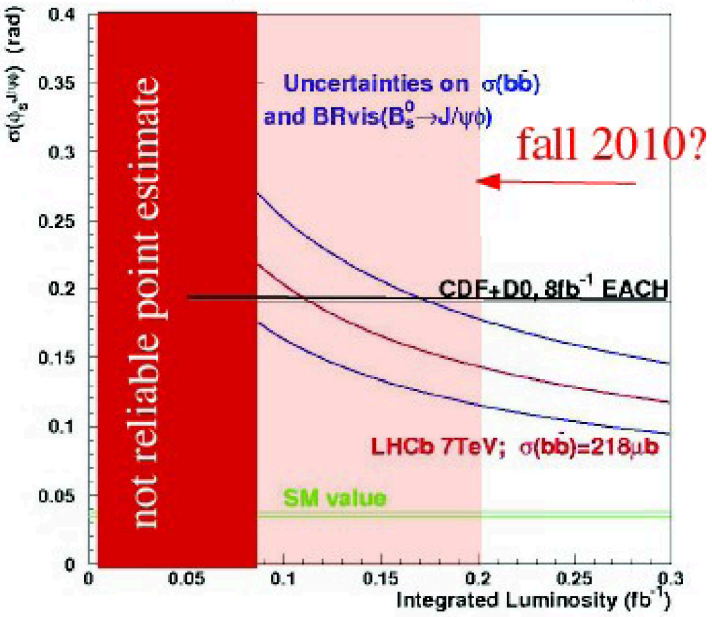
LHCb prospects for $B_s^0 \to J/\psi K^+K^-$

LHCb

G.Lanfranchi at Firenze
LHCb Collaboration meeting

ϕs: where we could be in ~14 months

LHCb: ϕs statistical sensitivity



LHCb with 0.2 fb^{-1}:

→ σ(2βs)< σ(Tevatron)

→ 5σ NP discovery if 2βs=0.8

Competition with CDF/D0 for the first [true] evidence of NP is started.....

... Time is ticking.....

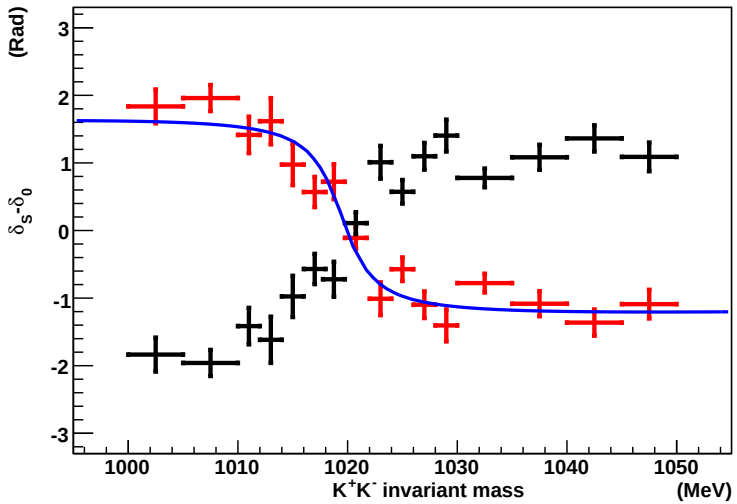
Very high priority for Tevatron updates next summer

A possible complication

- Analyses to date have neglected possible contributions from K^+K^- S-wave under the ϕ peak
  $\mapsto$ such terms can cause a dilution of the CP violation
  not essential for first measurements but needed for precision

A possible complication – resolved

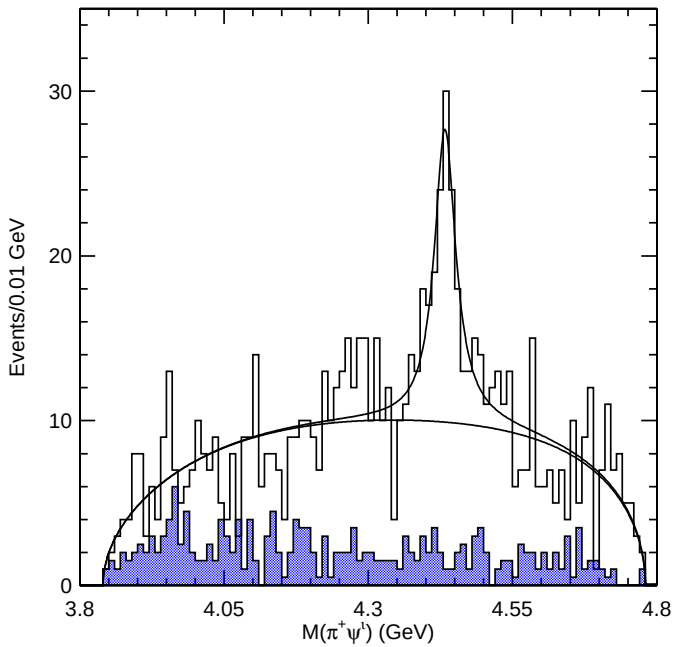
- S-wave contribution can be included model-independently
  Y. Xie *et al.*, JHEP 0909:074,2009 (arXiv:0908.3627 [hep-ph])
  $\mapsto$ improves determination of ϕ_s (add sensitivity to $\cos(\phi_s)$)
  similar approach to determination of $\cos(2\beta)$ in
  $B^0_d \to J/\psi\, K\pi$ BaBar PRD71:032005,2005 (hep-ex/0411016)



- Improved theoretical description of KK S-wave very useful for comparison

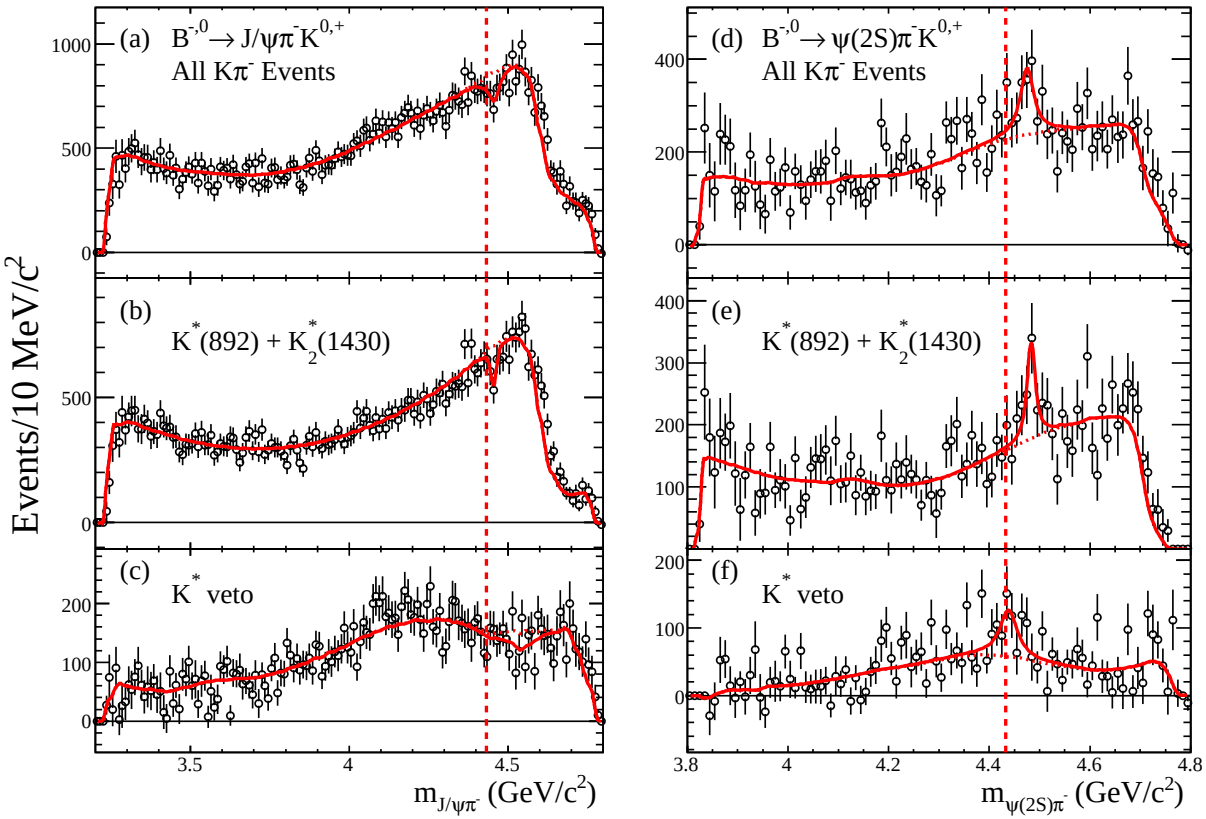
The $Z^+(4430)$

- Charged charmonium-like state seen by Belle in $B^0_d \to \psi' K^+ \pi^-$ PRL100:142001,2008 (arXiv:0708.1790 [hep-ex])



The $Z^+(4430)$

- Not seen by BaBar in either $B^0_d \to J/\psi\, K^+\pi^-$ or $\psi'\, K^+\pi^-$ PRD79:112001,2009 (arXiv:0811.0564 [hep-ex])
- Detailed understanding of reflections from $K^+\pi^-$ structures necessary – improved theoretical description very helpful



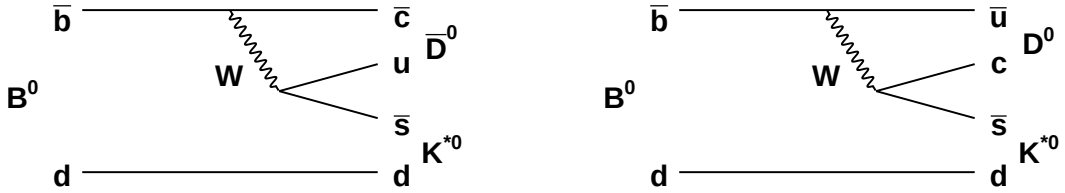
$B_d^0 \to J/\psi\, K^+K^-$ and $B_s^0 \to J/\psi\, \pi^+\pi^-$

- Tree-level diagrams contain annihilation topologies – highly suppressed
- Potential to study final state interactions / rescattering
  $\mapsto B_d^0 \to J/\psi\, K^+K^-$: $(d\bar{d}) \to (s\bar{s})$
  $\mapsto B_s^0 \to J/\psi\, \pi^+\pi^-$: $(s\bar{s}) \to (d\bar{d})$
- One interesting example: $B_s^0 \to J/\psi\, f_0(980) \to J/\psi\, \pi^+\pi^-$
  S. Stone and L. Zhang, PRD79:074024,2009 (arXiv:0812.2832 [hep-ph]), arXiv:0909.5442 [hep-ex]
  - measure ϕ_s in $B \to PV$ $b \to c\bar{c}s$ decay
  - new experimental information to constrain S-waves

γ from $B^0_d \to DK^{*0}$

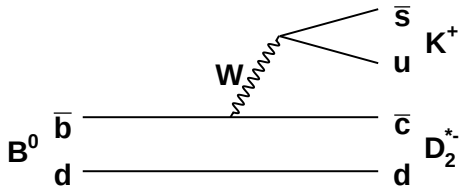
I. Dunietz, PLB 270 (1991) 75

- Interfering amplitudes in $B^0 \to DK^{*0}$ are of comparable size
  $\longrightarrow$ large interference effects sensitive to γ
- charge of kaon in $K^{*0} \to K^+\pi^-$ tags flavour of B



T.G., PRD79 (2009) 051301(R)

- Exploit interference with $B^0 \to D_2^{*-}K^+$
  $\longrightarrow$ provides reference amplitude in full Dalitz plot analysis
- charge of pion in $D_2^{*-} \to D\pi^-$ tags flavour of D



γ from $B_d^0 \to DK^{*0}$

T.G. and M. Williams, PRD80 (2009) 092002

- Toy Monte Carlo studies for proof-of-principle
- Extension of method to include all $D \to h^+h'^-$ decays:
  $D \to K\pi\,(\mathrm{fav})$, $D \to K\pi\,(\mathrm{sup})$, $D \to KK$, $\pi\pi\,(CP)$
- Comparison of γ sensitivity to quasi-two-body (Q2B) analysis

Compared to the Q2B analysis, the DP analysis provides:

- at least 50% better sensitivity to γ
  (depends on value of δ_B as well as $DK\pi$ Dalitz plot structure)
- resolution of ambiguous solutions
- much reduced dependence of the sensitivity on δ_B

Potential problems in $B \to DK\pi$ Dalitz plot analysis

- Dalitz plot analysis will have model uncertainties
  $\mapsto$ initial studies suggest effect on γ is small, but we are aiming for high precision
- Modelling of nonresonant amplitudes
  - amplitudes for both $b \to c$ and $b \to u$ transitions
    $\mapsto$ potentially different Dalitz plot structures
- Possible contributing $K\pi$, $D\pi$ and DK resonances
  - existence of a "dabba" pole?

- Alternative: model-independent approach
  T.G. and A. Poluektov, PRD81 (2010) 014025
  - double Dalitz plot analysis of $B \to DK\pi$, $D \to K^0_S\pi^+\pi^-$
  - measure effective hadronic parameters in Dalitz plot bins

Summary

- Dalitz plot analyses provide exciting physics opportunities for LHCb
  - Improve sensitivity to key benchmark measurements
  - Create new possibilities for discovery
- To exploit fully this potential will need improved theoretical descriptions
  - nonresonant amplitudes
  - structures in $\pi\pi$, $K\pi$, KK, $D\pi$, DK channels
  - ... and maybe other exotic structures
- Unprecedented statistics are coming in the next few years
  $\mapsto$ we need to aim for high precision

University of Warwick, UK, September 6-10, 2010

http://ckm2010.warwick.ac.uk

The end