$B_s \to J/\psi f_0$ and progress towards ϕ_s

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Flavor Physics and CP Violation 2011

Outline

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  - Motivation $B_s \rightarrow J/\psi f_0$
  - s-waves
- New $B_s \rightarrow J/\psi f_0$ results
  - LHCb
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- Results for other ϕ_s modes
  - Belle $B_s \rightarrow J/\psi \eta(')$
  - LHCb $B_s \rightarrow \psi(2S)\phi$
  - LHCb $B_s \rightarrow K^{*0}$ anti-K^{*0}
- Summary/Outlook
- Conclusions

Introduction

- $B_s \to J/\psi\phi$
  - golden mode to measure weak CP violating phase ϕ_s
  - very sensitive to New Physics since $\phi_s = -2\beta_s \approx 0$ in SM
  - for experimental status

See talks by Brad Abbott and Marta Calvi

- Other methods to measure ϕ_s
  - decays based on same tree diagram
    - e.g. $B_s \to J/\psi\eta'$
  - colour allowed tree decay $B_s \to D_s^+ D_s^-$
  - $B_s \to VP$, PP decays
    (V = Vector, P = Pseudoscalar)

List of VP, PP modes

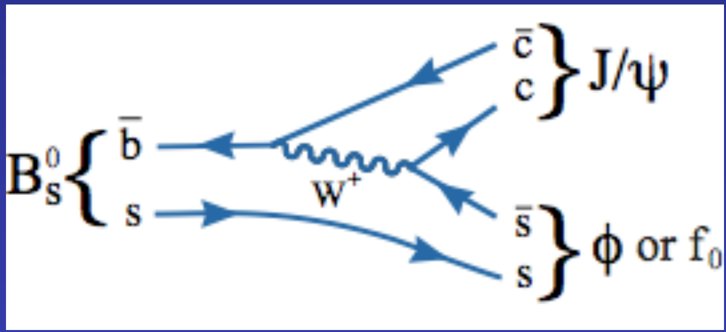
$$B_s \to J/\psi f_0(\pi^+\pi^-)$$
$$B_s \to J/\psi\eta(\gamma\gamma, \pi^+\pi^-\pi^0)$$
$$B_s \to J/\psi\eta'(\rho\gamma, \pi^+\pi^-\eta)$$
$$B_s \to J/\psi(e^+e^-)\phi$$
$$B_s \to \psi(2S)\phi$$
$$B_s \to \eta_c(4\pi, 2\pi 2K, 4K(\phi\phi))\phi$$
$$B_s \to D_s^+ D_s^-, D_s^{*+} D_s^{*-}$$

Motivation for $B_s \to J/\psi f_0$

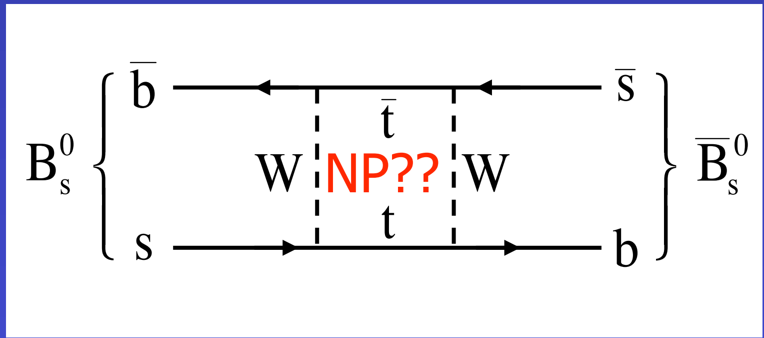
- "how to make a profit out of a nuisance"

- $B_s \to J/\psi f_0$ ($f_0 \to K^+K^-$)
  - same final state as $B_s \to J/\psi\phi$
  - introduces s-wave K^+K^- component below ϕ-meson mass peak
  - is "background" to $B_s \to J/\psi\phi$
- $B_s \to J/\psi f_0$ ($f_0 \to \pi^+\pi^-$)
  - same tree diagram as $B_s \to J/\psi\phi$
  - CP odd eigenstate (if $\phi_s \sim 0$)
  - sensitive to Γ_H and $\Delta\Gamma_s$
- $B_s \to VP$ mode
  - no angular measurement required for measuring ϕ_s ($-2\beta_s$)

SM tree diagram



New Physics in mixing?



S. Stone and L.Zhang, arXiv:0909.5442

S-wave Implications

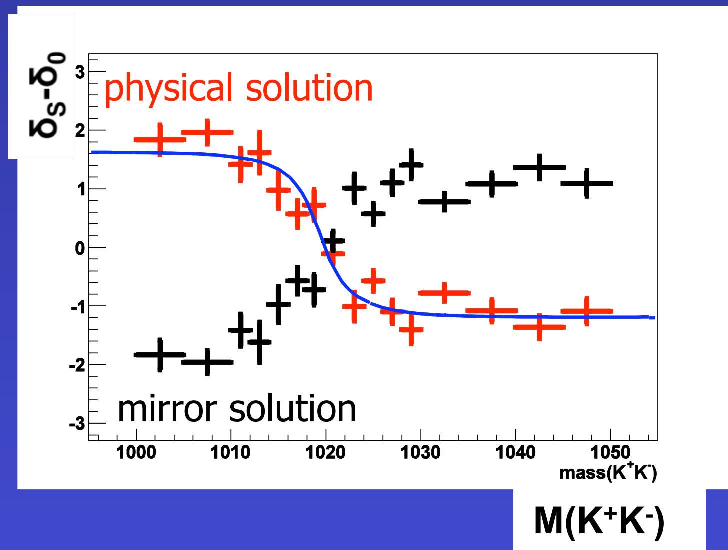
Y. Xie *et al.*, JHEP 0909:074, 2009

- ϕ_s measurement in $B_s \to J/\psi\phi$
  - ignoring s-waves causes bias of O(10%)
- Including s-wave $B_s \to J/\psi K^+K^-$
  - adds $(|A_s(t)|^2$ rate term and 3 interference terms to angular analysis
  - removes bias
  - increases ϕ_s ($-2\beta_s$) error by <15%
  - solves 2-fold ambiguity

$$(\delta_{//} - \delta_0, \delta_\perp - \delta_0, \delta_S - \delta_0, \Phi_s, \Delta\Gamma_s) \Leftrightarrow$$
$$(\delta_0 - \delta_{//}, \pi + \delta_0 - \delta_\perp, \delta_0 - \delta_S, \pi - \Phi_s, -\Delta\Gamma_s)$$

  - measures sign of cos $2\beta_s$

k	$h_k(t)$	$\bar{h}_k(t)$	$f_k(\theta_l, \theta_K, \varphi)$
1	$\lvert A_0(t)\rvert^2$	$\lvert \bar{A}_0(t)\rvert^2$	$4\sin^2\theta_l\cos^2\theta_K$
2	$\lvert A_{\parallel}(t)\rvert^2$	$\lvert \bar{A}_{\parallel}(t)\rvert^2$	$(1+\cos^2\theta_l)\sin^2\theta_K - \sin^2\theta_l\sin^2\theta_K\cos 2\varphi$
3	$\lvert A_{\perp}(t)\rvert^2$	$\lvert \bar{A}_{\perp}(t)\rvert^2$	$(1+\cos^2\theta_l)\sin^2\theta_K + \sin^2\theta_l\sin^2\theta_K\cos 2\varphi$
4	$\Im\{A_{\parallel}^*(t)A_{\perp}(t)\}$	$\Im\{\bar{A}_{\parallel}^*(t)\bar{A}_{\perp}(t)\}$	$2\sin^2\theta_l\sin^2\theta_K\sin 2\varphi$
5	$\Re\{A_0^*(t)A_{\parallel}(t)\}$	$\Re\{\bar{A}_0^*(t)\bar{A}_{\parallel}(t)\}$	$-\sqrt{2}\sin 2\theta_l\sin 2\theta_K\cos\varphi$
6	$\Im\{A_0^*(t)A_{\perp}(t)\}$	$\Im\{\bar{A}_0^*(t)\bar{A}_{\perp}(t)\}$	$\sqrt{2}\sin 2\theta_l\sin 2\theta_K\sin\varphi$
7	$\lvert A_S(t)\rvert^2$	$\lvert \bar{A}_S(t)\rvert^2$	$\frac{4}{3}\sin^2\theta_l$
8	$\Re\{A_S^*(t)A_{\parallel}(t)\}$	$\Re\{\bar{A}_S^*(t)\bar{A}_{\parallel}(t)\}$	$-\frac{2}{3}\sqrt{6}\sin 2\theta_l\sin\theta_K\cos\varphi$
9	$\Im\{A_S^*(t)A_{\perp}(t)\}$	$\Im\{\bar{A}_S^*(t)\bar{A}_{\perp}(t)\}$	$\frac{2}{3}\sqrt{6}\sin 2\theta_l\sin\theta_K\sin\varphi$
10	$\Re\{A_S^*(t)A_0(t)\}$	$\Re\{\bar{A}_S^*(t)\bar{A}_0(t)\}$	$\frac{8}{3}\sqrt{3}\sin^2\theta_l\cos\theta_K$

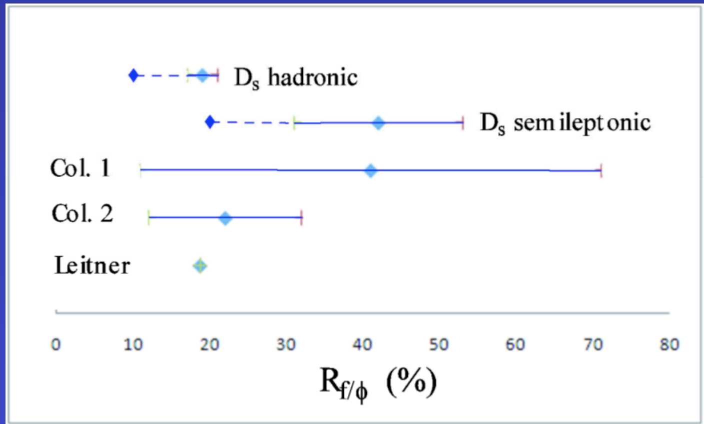


S-waves

- Predictions
  - reported at FPCP 2010 (S. Stone)
  - Stone and Zhang use $D_s^+ \rightarrow K^+K^-\pi^+$ and $D_s^+ \rightarrow \phi e^+ \nu$ vs $D_s^+ \rightarrow f_0 e^+ \nu$
  - Colangelo, De Fazio and Wang use Light Cone Sum Rules
  - Leitner et al. again use QCD factorization

S. Stone and L. Zhang, PRD 79, 074024);
P. Colangelo, F. de Fazio and W. Wang, arXiv:1002.2880[hep-ph] and arXiv:1009.4612[hep-ph].
O. Leitner, et al., [arXiv:1003.5980]

$$R_{f_0/\phi} \equiv \frac{\Gamma\left(B_s^0 \rightarrow J/\psi f_0, f_0 \rightarrow \pi^+\pi^-\right)}{\Gamma\left(B_s^0 \rightarrow J/\psi \phi, \phi \rightarrow K^+K^-\right)}$$

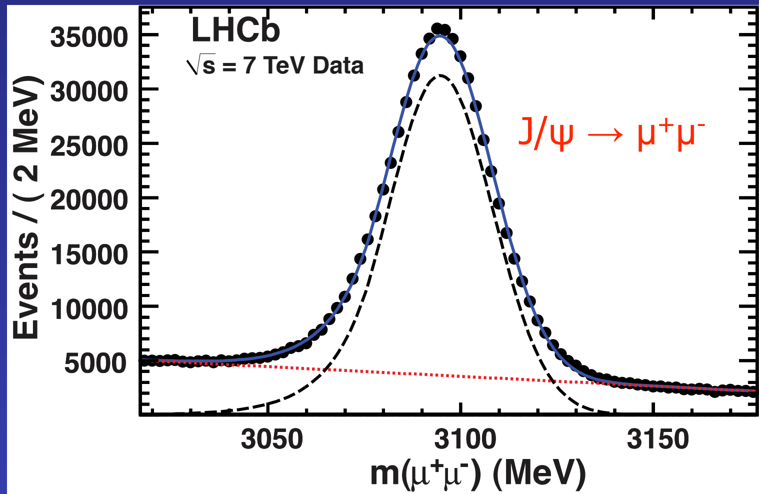


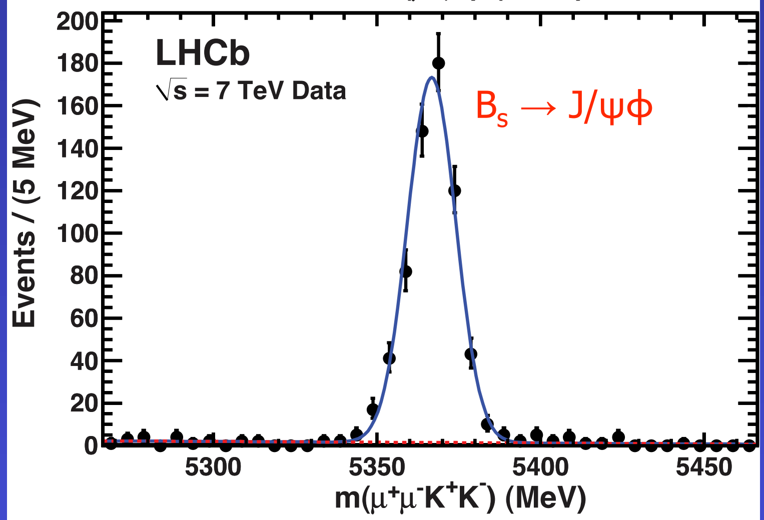
- $B_s \rightarrow J/\psi f_0$ ($f_0 \rightarrow \pi^+\pi^-$)
  - expect sizable event rate with respect to $B_s \rightarrow J/\psi\phi$

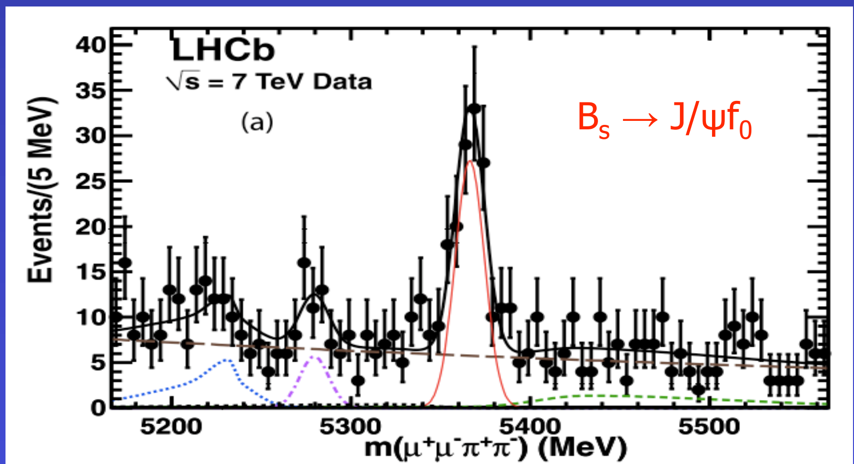
First Observation of $B_s \to J/\psi f_0$

Physics Letters B **698** (2011) 115
arXiv:1102.0206[hep-ex]

- New LHCb result
  - based on 33 pb^{-1} data set
- Selection
  - $J/\psi \to \mu^+\mu^-$ trigger
  - 549k J/ψ signal events
- Signal yields
  - $N(B_s^0 \to J/\psi f_0) = 111 \pm 14$
  - Significance 12.8σ
  - $N(B_s^0 \to J/\psi \phi) = 635 \pm 26$

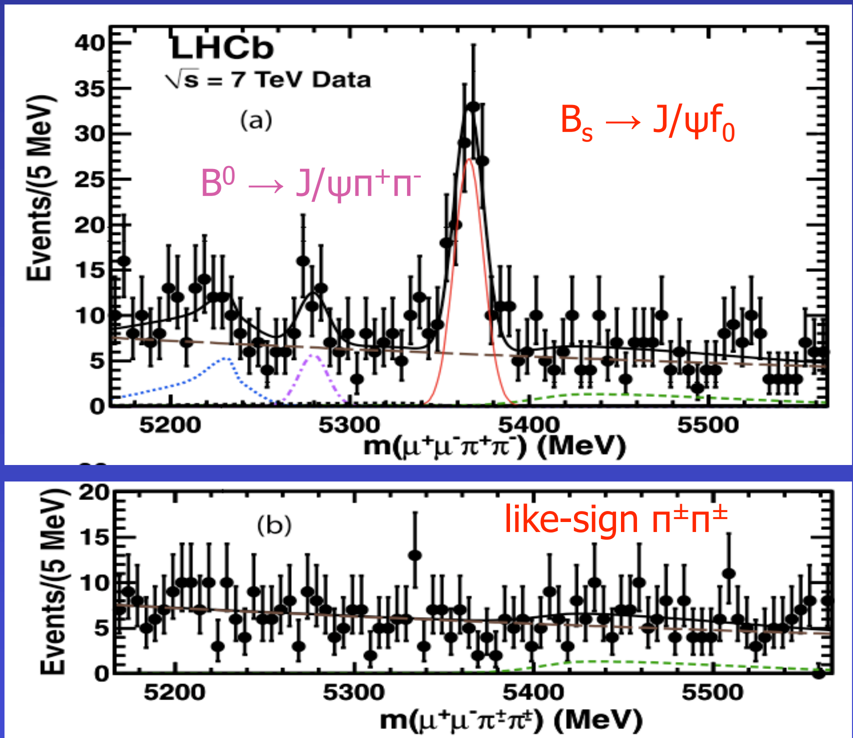


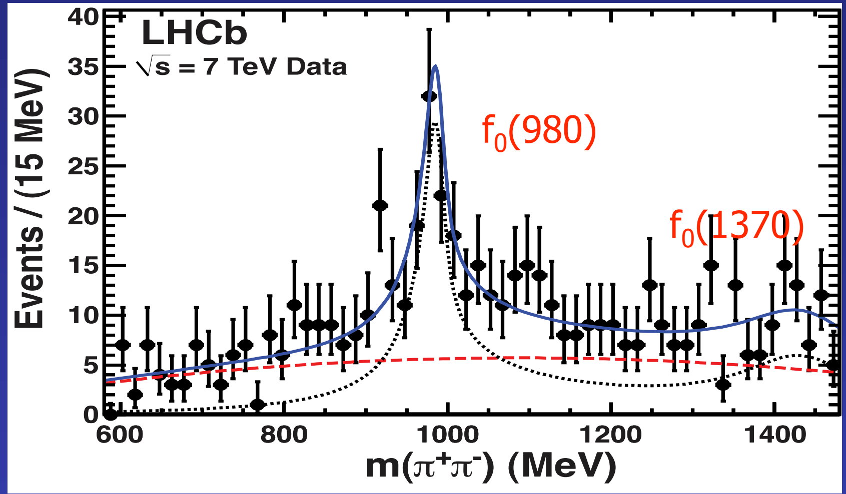




$B_s \to J/\psi f_0$ Signal and Background

- Background components
  - from physics: $B^0 \to J/\psi\pi^+\pi^-$
    $B^+ \to J/\psi K^+(\pi^+)$, $B^0 \to J/\psi K^{*0}$
    $B_s \to J/\psi\eta'$ and $B_s \to J/\psi\phi$
  - from combinatorics
    use like-sign pion pairs ($\pi^\pm\pi^\pm$)





- Signal shape $M(\pi^\pm\pi^\pm)$
  - Flatté f_0 (980)
  - Breit-Wigner f_0 (1370)

$$\text{Flatte}'(m) = \frac{1}{m_0^2 - m^2 - i m_0\left(g_1\rho_{\pi\pi} + g_2\rho_{KK}\right)}$$

$$A(m) = N_0 m p(m) q(m) \left|\text{Flatte}'\left[f_0(980)\right] + A_1 e^{i\delta}\,\text{BW}\left[f_0(1370)\right]\right|^2$$

  - with input from BES & E791

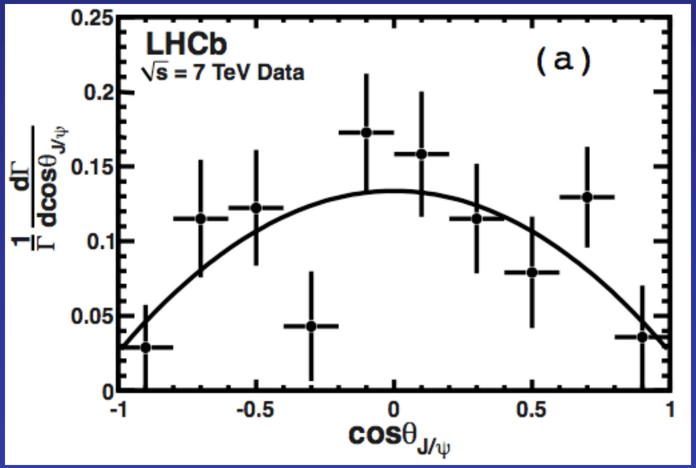
S.M. Flatté, Phys. Lett. B63 (1976) 224.
M. Ablikim *et al.*, Phys. Lett. B **607** (2005) 243.
E.M. Aitala *et al.*, Phys. Rev. Lett. 86 (2001)765.

$B_s \rightarrow J/\psi f_0$ Results

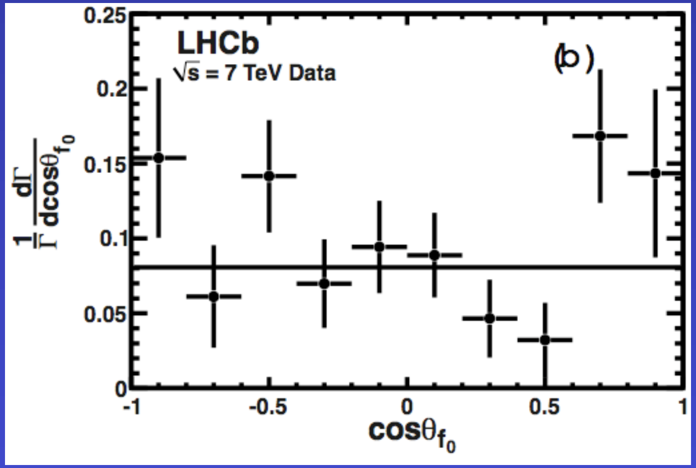
- Branching ratio
  - fit to 580 < M($\pi^+\pi^-$) < 1480 MeV

$$R_{f_0/\phi} \equiv \frac{\Gamma\left(B_s^0 \to J/\psi f_0, f_0 \to \pi^+\pi^-\right)}{\Gamma\left(B_s^0 \to J/\psi\phi, \phi \to K^+K^-\right)} = 0.252^{+0.046+0.027}_{-0.032-0.033}$$

$$R_{f_0/\phi} \equiv \frac{\Gamma\left(B_s^0 \to J/\psi\pi^+\pi^-\,\middle|\, \left|m\left(\pi^+\pi^-\right) - 980\text{MeV}\right| < 90\text{MeV}\right)}{\Gamma\left(B_s^0 \to J/\psi\phi, \phi \to K^+K^-\right)} = 0.162 \pm 0.022 \pm 0.016$$



- J/ψ and f_0 helicity angles
  - like-sign subtracted
  - χ2/NDoF = 10.3/8 and 15.9/9
  - consistent with spin 0 hypothesis
  - f_0 scalar meson

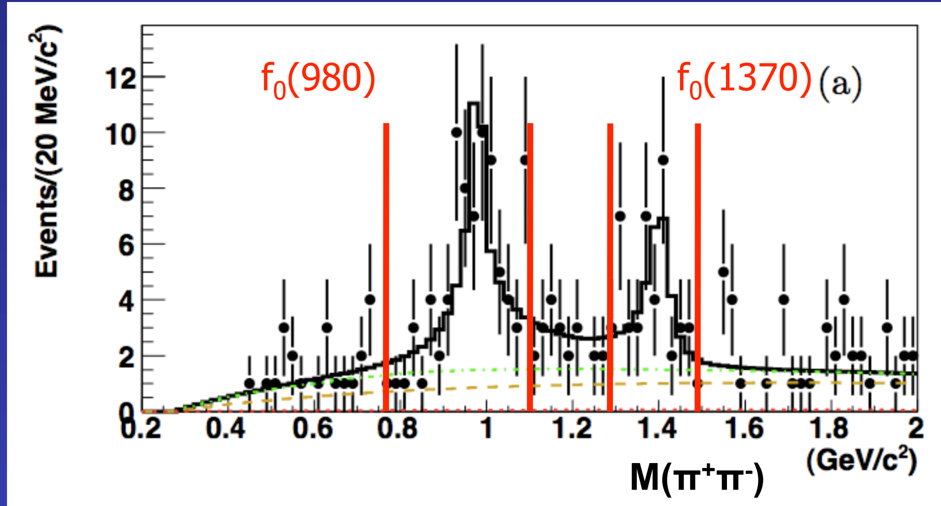


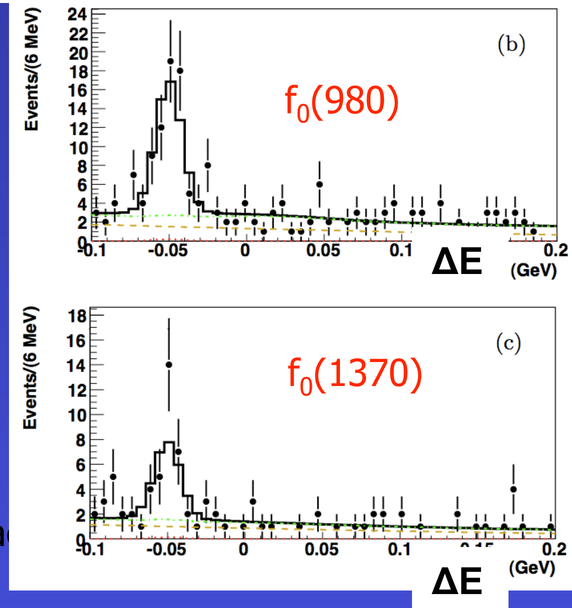
Belle: Observation of $B_s \to J/\psi f_0$

arXiv:1102.0206
PRL 106, 121802 (2011)

- New Belle result
  - 121 fb^{-1} data set
  - upper limit at FPCP 2010
    23.6 fb-1 data set
- Method
  - $\Upsilon(5S) \to B_s^*$ anti-B_s^* using M_{bc}
  - 2D fit to ΔE and $M(\pi^+\pi^-)$
  - Signal PDF
    - $\text{Flatte}(980) + a\, e^{i\theta}\, BW(1370)$
    - non-resonant $J/\psi\ \pi^+\pi^-$ background
    - other (combinatorial) background
- Signal yield

Mode	Yield	Significance
$B_s^0 \to J/\psi f_0(980)$	63^{+16}_{-10}	8.4σ
$B_s^0 \to J/\psi f_0(1370)$	19^{+6}_{-8}	4.2σ





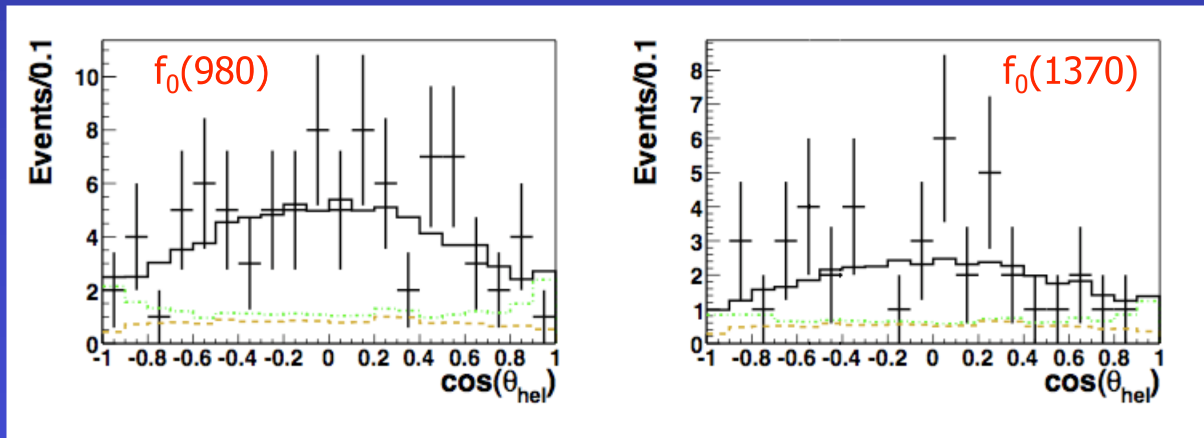
Observation of $B_s \to J/\psi f_0$ (980) and evidence for $B_s \to J/\psi f_0$ (1370)

$B_s \rightarrow J/\psi f_0\,(980)$ and $J/\psi f_0(1370)$

- Branching ratios
  - $f_0(980)$
  - $f_0(1370)$

$\mathcal{B}(B_s^0 \to J/\psi F; F \to \pi^+\pi^-)$
$(1.16^{+0.31}_{-0.19}(\text{stat.})^{+0.15}_{-0.17}(\text{syst.})^{+0.26}_{-0.18}(N_{B_s^{(*)}\bar{B}_s^{(*)}})) \times 10^{-4}$
$(0.34^{+0.11}_{-0.14}(\text{stat.})^{+0.03}_{-0.02}(\text{syst.})^{+0.08}_{-0.05}(N_{B_s^{(*)}\bar{B}_s^{(*)}})) \times 10^{-4}$

- Mass, width $f_0(1370)$
  - $$M = 1.405 \pm 0.015^{+0.001}_{-0.007}\ \text{GeV}/c^2$$
    $$\Gamma = 0.054 \pm 0.033^{+0.014}_{-0.003}\ \text{GeV}$$
  - in agreement with PDG
- J/ψ helicity angle
  - consistent with spin 0 scalar resonance



$B_s \to J/\psi f_0$ (980) at CDF

CDF-PUB-10404(2011)

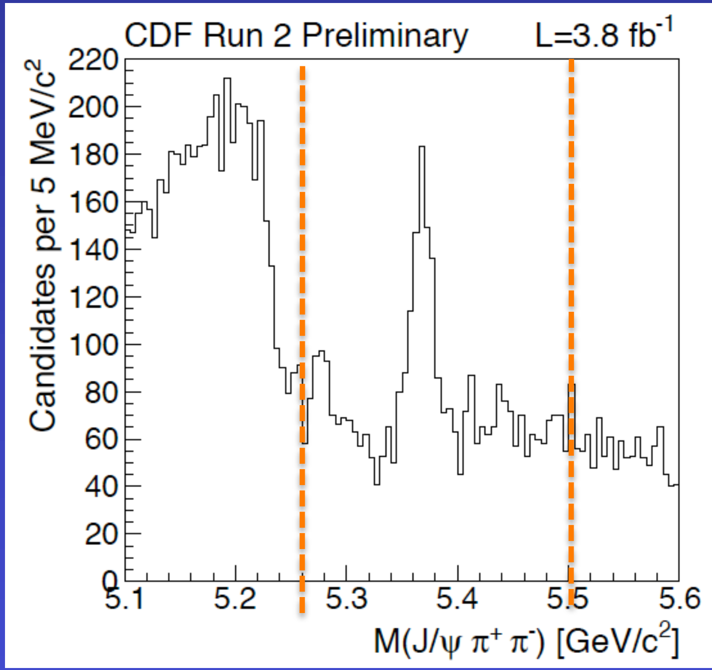
- New CDF Result
  - 3.8 fb^{-1} data set

$$\frac{\mathcal{B}(B_s^0 \to J/\psi f_0(980))}{\mathcal{B}(B_s^0 \to J/\psi\phi)} = \frac{N(B_s^0 \to J/\psi f_0)}{N(B_s^0 \to J/\psi\phi)} \frac{\varepsilon_{J/\psi\phi}}{\varepsilon_{J/\psi f_0}}$$

from data

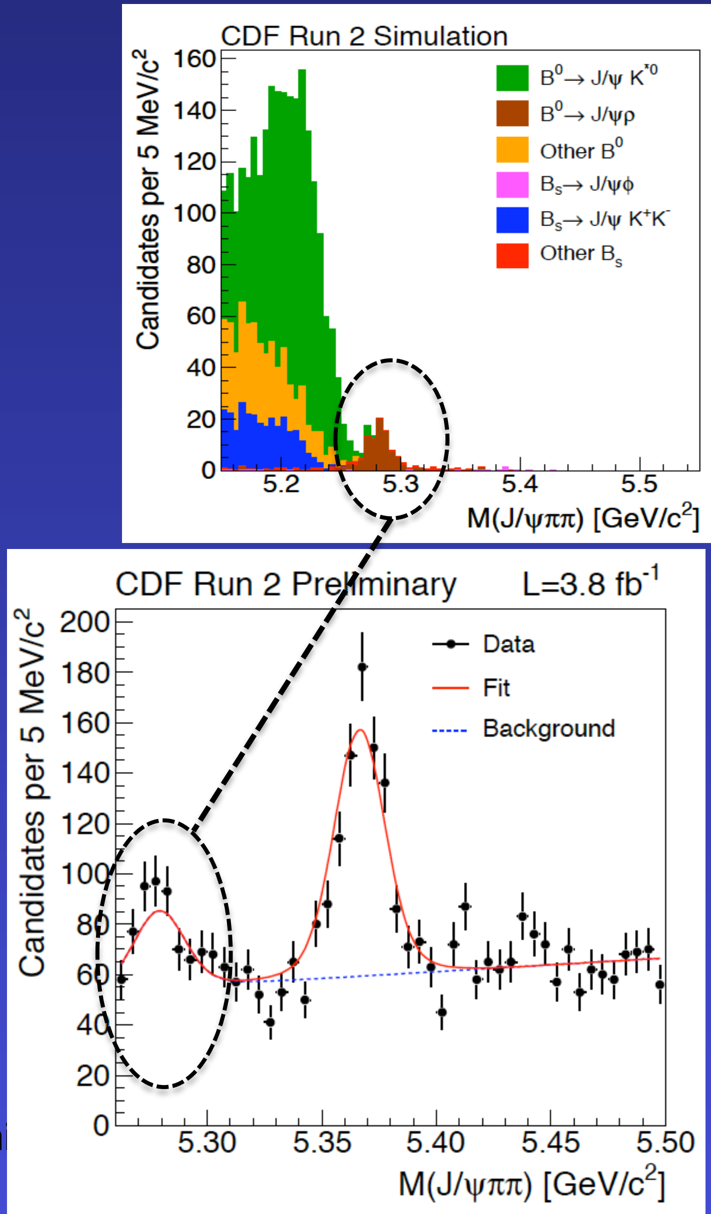
from MC

- Selection
  - dimuon trigger
  - Neural Net for unbiased optimisation of $\varepsilon/(2.5+\sqrt{B})$
  - efficiency ε from simulaton, background B from mass sideband



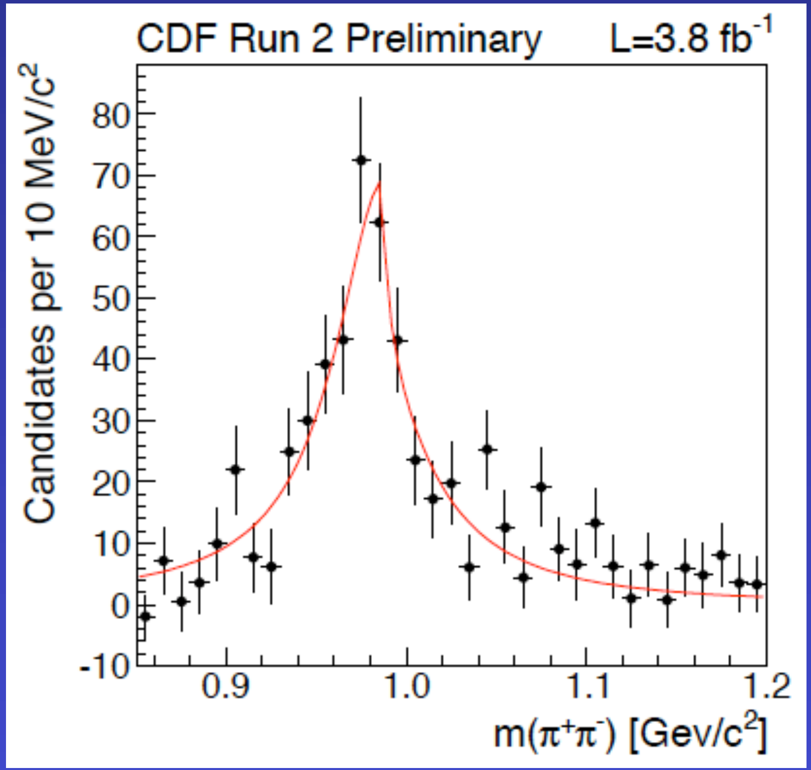
$B_s \rightarrow J/\psi f_0$ (980) Fit

- Backgrounds
  - physics: MC simulation
    e.g. $B^0 \rightarrow J/\psi\pi^+\pi^-$
  - combinatorial: linear shape
- Signal Yield
  - $N(B_s^0 \rightarrow J/\psi f_0) = 571 \pm 37 \pm 25$
  - $N(B_s^0 \rightarrow J/\psi\phi\ ) = 2302 \pm 49 \pm 49$
  - observe also $B^0 \rightarrow J/\psi\pi^+\pi^-$ peak
- Significance
  - 17.9σ for $B_s^0 \rightarrow J/\psi f_0$
- Efficiency
  - ratio $\varepsilon(J/\psi f_0)$ / $\varepsilon(J/\psi\phi)$
    = 1.178 ± 0.040 from full MC



$B_s \to J/\psi f_0$ (980) Signal

- $B_s \to J/\psi f_0$ Signal shape
  - Flatté in $M(\pi^+\pi^-)$
  - input from BES, PLB 607, 243(2005)
- Fit to $M(\pi^+\pi^-)$
  - $0.85 < M(\pi^+\pi^-) < 1.20$ GeV/c^2
  - describes data well
- Systematics
  - signal-background modeling
  - MC-data agreement,
  - input uncertainties



$B_s \to J/\psi f_0$ (980) Results

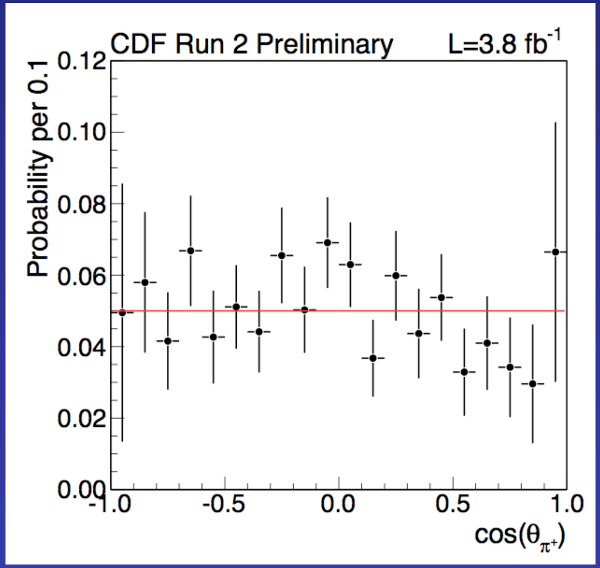
- Branching ratio

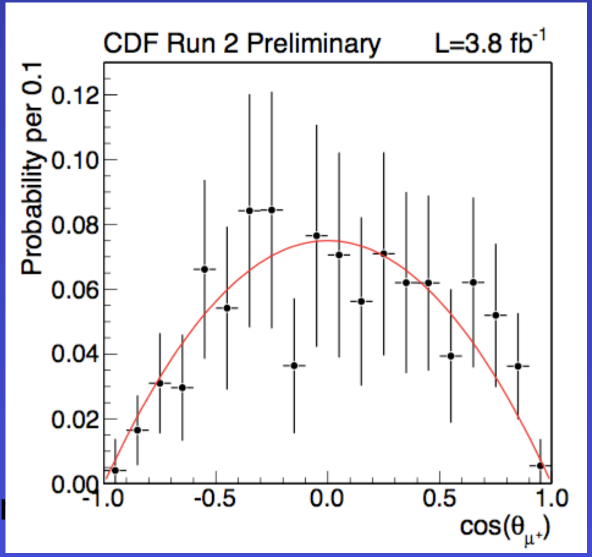
$$R_{f_0/\phi} \equiv \frac{B\left(B_s^0 \to J/\psi f_0(980)\right)}{B\left(B_s^0 \to J/\psi\phi\right)} \frac{B\left(f_0(980) \to \pi^+\pi^-\right)}{B\left(\phi \to K^+K^-\right)} = 0.292 \pm 0.020 \pm 0.017$$

- Branching fraction
  - Fixing BR($B_s^0 \to J/\psi\ \phi$) to PDG value

$$B\left(B_s^0 \to J/\psi f_0(980)\right)B\left(f_0(980) \to \pi^+\pi^-\right) = (1.85 \pm 0.13 \pm 0.11 \pm 0.57) \cdot 10^{-4}$$

- Helicity angles
  - for μ^+ and π^+
  - consistent with spin 0 scalar resonance

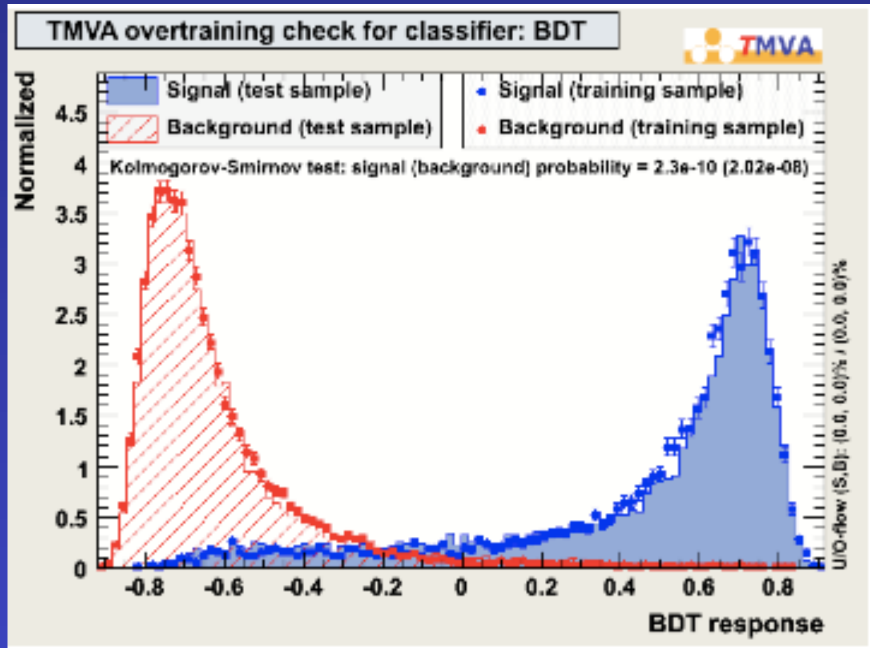




$B_s \rightarrow J/\psi f_0$ (980) at D0

D0 Note 6152-Conf (2011)

- New D0 Result
  - 8 fb^{-1} data set
- Selection
  - muon trigger
  - identical criteria for $J/\psi f_0$ and $J/\psi\ \phi$
  - minimise systematics
- 2 Boosted Decision Trees
  - to discriminate B_s signal from prompt J/ψ and non-prompt J/ψ background
  - 36 variables used

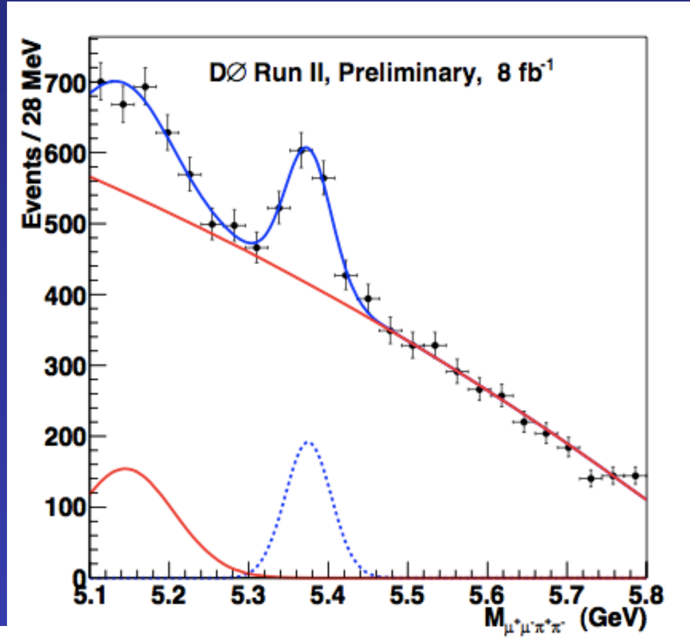


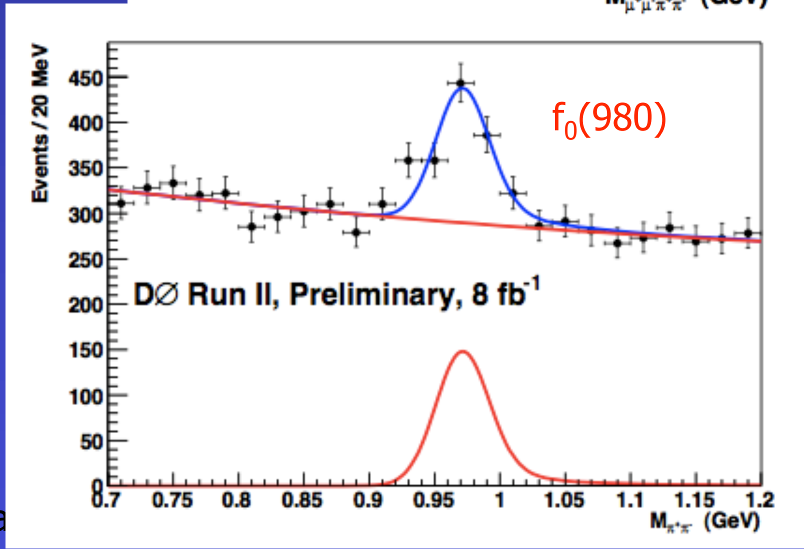
$B_s \to J/\psi f_0$ (980)

- $B_s \to J/\psi f_0$ Signal shape
  - Flatté in $M(\pi^+\pi^-)$

- Signal yield
  - $0.91 < M(\pi^+\pi^-) < 1.05$ GeV/c^2
  - 498 ± 76 $B_s \to J/\psi f_0$

- Backgrounds
  - $B^0 \to J/\psi \pi^+\pi^-$ studied in region $0.85 < M(\pi^+\pi^-) < 1.20$ GeV/c^2





$B_s \rightarrow J/\psi f_0$ (980) Results

- Efficiencies
  - from MC simulation, determined for each run range
  - efficiencies vary, but ratio $\varepsilon(J/\psi f_0)$ / $\varepsilon(J/\psi\phi)$ is constant

data sample	$\varepsilon^{J/\psi f0}_{reco}$	$\varepsilon^{J/\psi\phi}_{reco}$	ratio R
Run IIa	0.0231 ± 0.0004	0.0191 ± 0.0004	0.210 ± 0.0321
Run IIb1	0.0191 ± 0.0004	0.0146 ± 0.0003	0.228 ± 0.0353
Run IIb2	0.00636 ± 0.00018	0.00529 ± 0.00015	0.210 ± 0.032

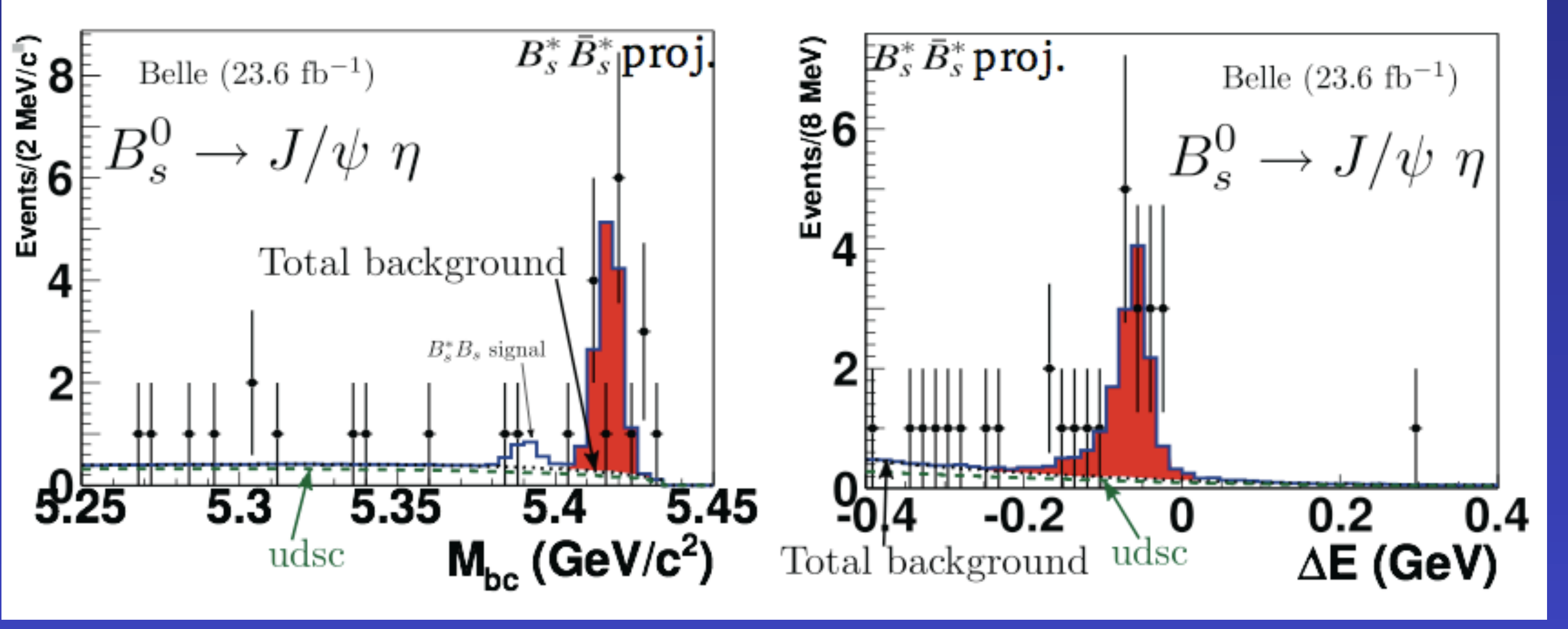
- Branching ratio

$$R = \frac{\mathcal{B}(B^0_s \rightarrow J/\psi f_0(980); f_0(980) \rightarrow \pi^+\pi^-)}{\mathcal{B}(B^0_s \rightarrow J/\psi\phi; \phi \rightarrow K^+K^-)} = 0.210 \pm 0.032\,(\text{stat}) \pm 0.036\,(\text{syst}).$$

Observation of $B_s \to J/\psi\eta$

arXiv:0912.1434

- Belle Result from 2009
  - uses 23.6 fb^{-1}, full data set in preparation



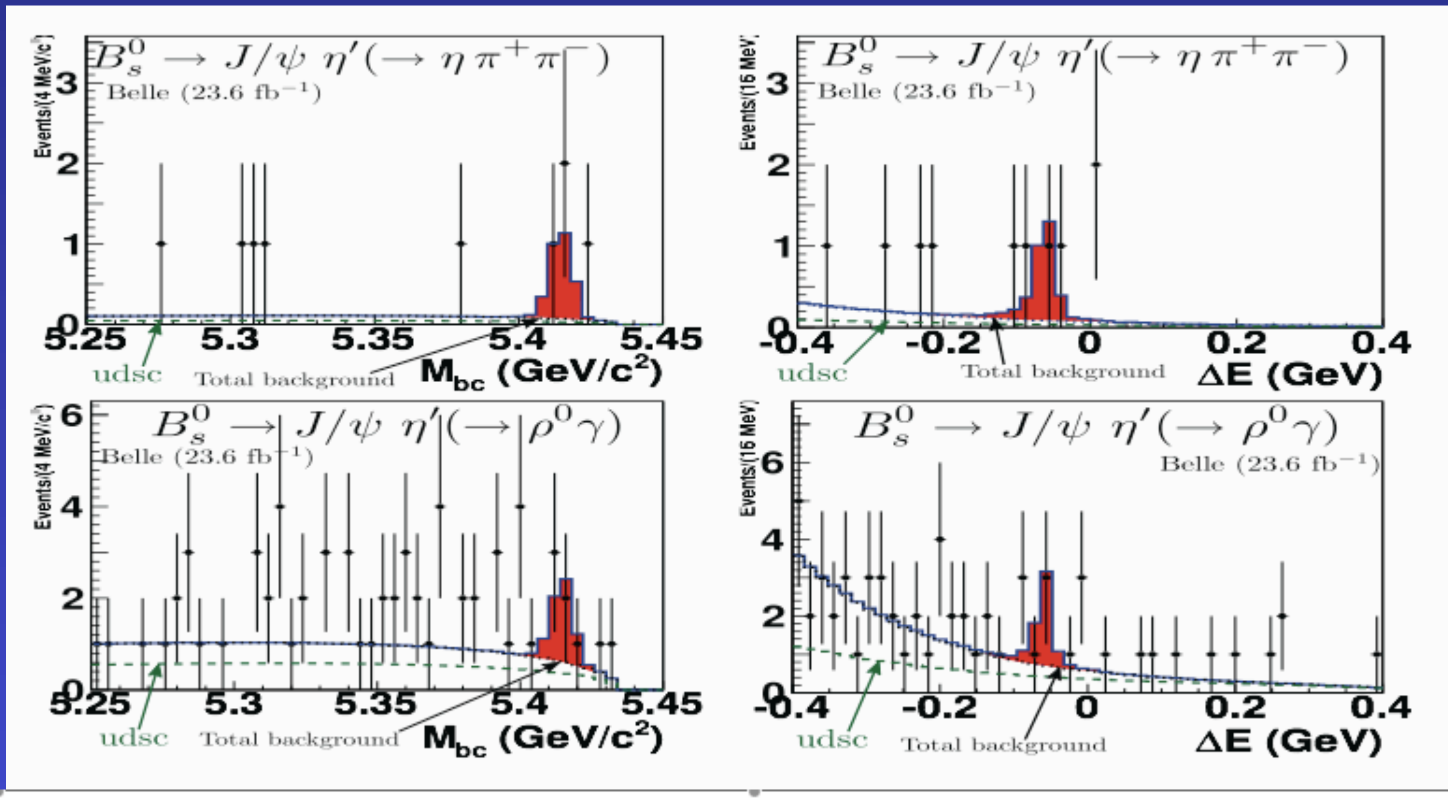
- $\eta \to \gamma\gamma + \eta \to \pi^0\pi^+\pi^-$ channels
- First Observation of 14.9 ± 4.1 events (7.3σ)

$$\mathcal{B}\left(B_s^0 \to J/\psi\eta\right) = \left(3.32 \pm 0.87^{+0.32}_{-0.28} \pm 0.42(f_s)\right) \times 10^{-4}$$

Evidence for $B_s \to J/\psi\eta'$

arXiv:0912.1434

- Belle Result from 2009
  - uses 23.6 fb^{-1}, full data set in preparation



- 3 η' channels: $\eta' \to \eta(\to \gamma\gamma)\pi^+\pi^-$, $\eta' \to \eta(\to \pi^0\pi^+\pi^-)\pi^+\pi^-$ and $\eta' \to \rho^0\gamma$
- First Evidence of 10.7 ± 4.6 events (3.8σ)

$$\mathcal{B}\left(B_s^0 \to J/\psi\,\eta'\right) = \left(3.1 \pm 1.2^{+0.5}_{-0.6} \pm 0.4(f_s)\right) \times 10^{-4}$$

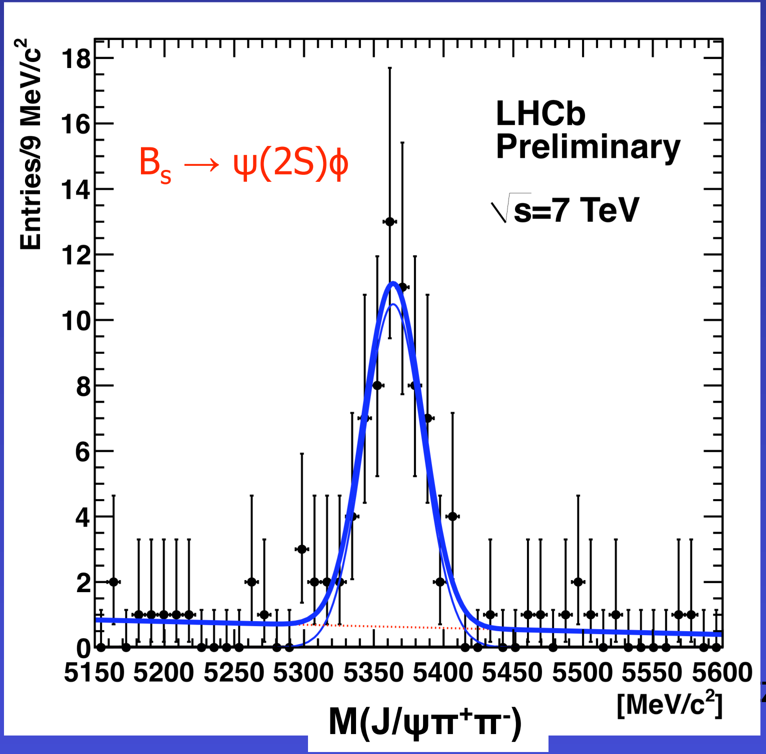
BR($B_s \rightarrow \psi(2S)\phi$)/BR($B_s \rightarrow J/\psi\phi$)

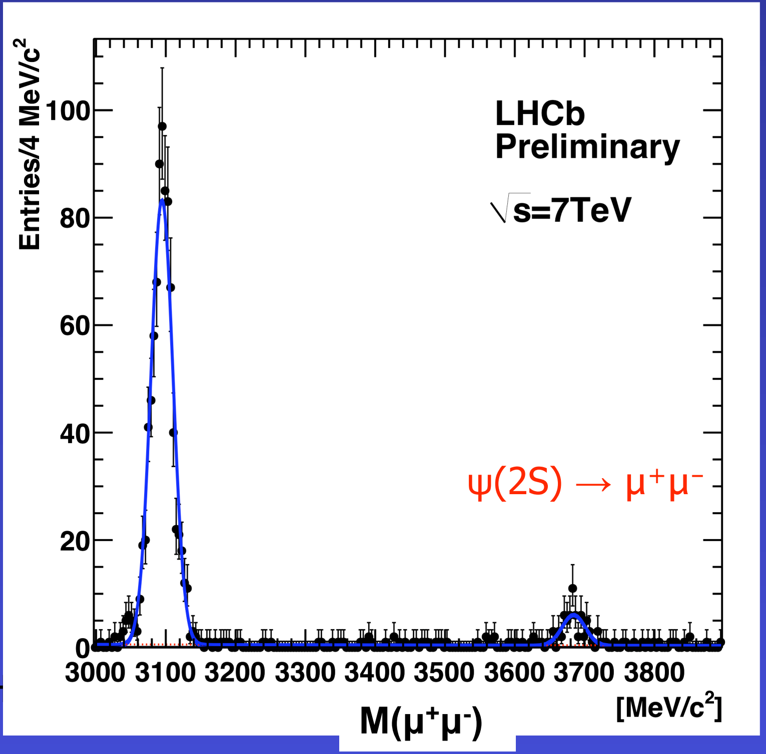
LHCb-CONF-2011-014

- New preliminary LHCb result
  - based on 36 pb^{-1}
  - Signal yield:
    62±9 $B_s \rightarrow \psi(2S)\phi$
  - Result consistent with CDF and D0

Branching Ratio

$$\frac{\mathcal{B}(B_s^0 \to \psi(2S)\phi)}{\mathcal{B}(B_s^0 \to J/\psi\,\phi)} = 0.68 \pm 0.10(\mathrm{stat}) \pm 0.09(\mathrm{syst}) \pm 0.07(\mathcal{B})$$





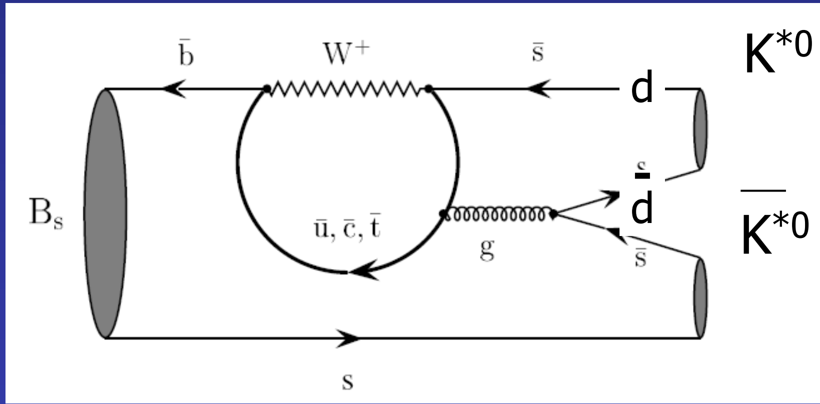
z Maale H

Physics of $B_s \to K^{*0}\overline{K}^{*0}$

M. Ciuchini, M. Pierini, L. Silvestrini, PRL 100, 031802

- $b \to s$ penguin diagram
  - similar to $B_s \to \phi\phi$

See talk by Fabrizio Ruffini



- Standard Model Amplitude

$$A(B_s \to K^{*0}\bar{K}^{*0}) = -V_{tb}^* V_{ts}\, P_s - V_{ub}^* V_{us}\, P_s^{\rm GIM}$$

  - dominated by top loop
  - CKM suppressed up and charm loops
  - controlled using d ↔ s channel $B_d \to K^{*0}\overline{K}^{*0}$
- CP Violation
  - in $b \to s$ penguin decays
  - In SM $\phi_{Mixing} - 2\phi_{Decay} = 0$
  - sensitive to NP that affects weak phases in box and penguin diagrams

Null test of SM

$$S\left(B_s \to K^{*0}\overline{K}^{*0}\right) = 0$$

$$C\left(B_s \to K^{*0}\overline{K}^{*0}\right) = 0$$

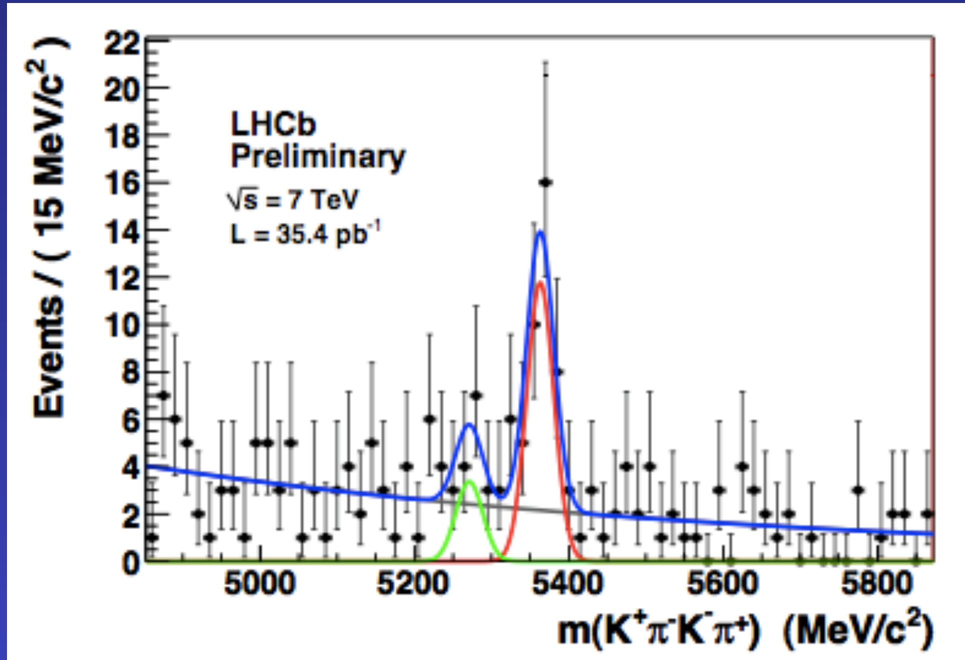
Observation of $B_s \to K^{*0}\overline{K}^{*0}$

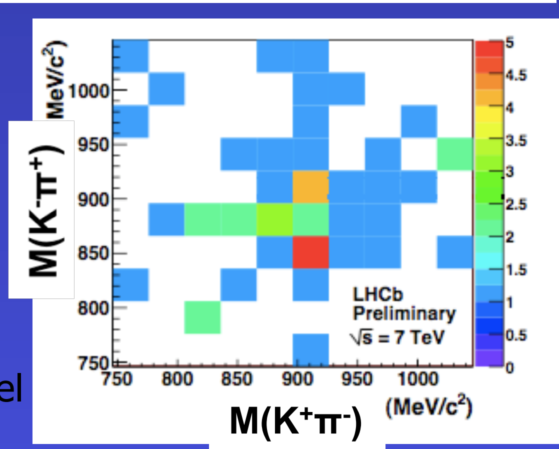
LHCb-CONF-2011-019

- New preliminary LHCb result
  - with 36 pb^{-1} data set
- Selection
  - topological hadron trigger
  - tracks with large impact parameters
- Signal yield
  - 34.5±7.4 events
  - 7.3σ significance
- Branching ratio

$$B\left(B_s \to K^{*0}\overline{K}^{*0}\right) = (1.95 \pm 0.47 \pm 0.51 \pm 0.29) \cdot 10^{-5}$$

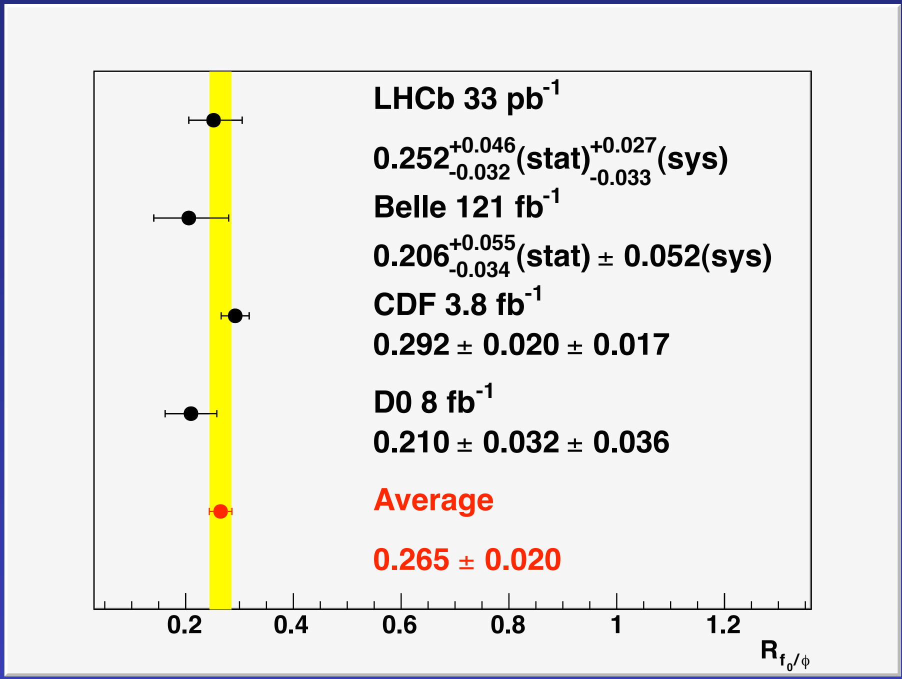
  - 3^{rd} error (f_d/f_s ratio)





Summary of Results

- $B_s \to J/\psi f_0$ (980)
  - 4 new results in 2011
  - Belle results divided by BR($B_s \to J/\psi\phi$)
  - Results are consistent
- $B_s \to J/\psi\eta$ and $B_s \to J/\psi\eta'$
  - Belle 2009 results
- $B_s \to \psi(2S)\phi$
  - preliminary LHCb result
  - compatible with Tevatron results
- Penguin modes
  - LHCb - observation of $B_s \to K^{*0}\overline{K^{*0}}$



Outlook for ϕ_s

LHCb Collaboration, arXiv:0912.4179

- $B_s \to J/\psi\phi$
  - LHCb – described in roadmap (for 2 fb^{-1} at $\sqrt{s}$ = 14 TeV)
  - In 2011, expect ~30k events in 1 fb^{-1} at $\sqrt{s}$ = 7 TeV
    expect most precise ϕ_s determination, could reveal New Physics
  - Tevatron (CDF and D0) will update ϕ_s analysis with full data
  - ATLAS and CMS plan to measure ϕ_s in this mode

See talks by Brad Abbott and Marta Calvi

- ϕ_s sensitivity of other modes
  - based on "old" LHCb MC studies
  - estimated yields for most modes
    3% to 10% of $B_s \to J/\psi\phi$
  - corresponding ϕ_s sensitivity
  - 3.5 to 7.0 times $\sigma(\phi_s)$ of $B_s \to J/\psi\phi$

$$B_s \to J/\psi f_0\left(\pi^+\pi^-\right)$$
$$B_s \to J/\psi\eta\left(\gamma\gamma,\pi^+\pi^-\pi^0\right)$$
$$B_s \to J/\psi\eta'\left(\rho\gamma,\pi^+\pi^-\eta\right)$$
$$B_s \to J/\psi(e^+e^-)\phi$$
$$B_s \to \psi(2S)\phi$$
$$B_s \to \eta_c\left(4\pi,2\pi 2K,4K(\phi\phi)\right)\phi$$
$$B_s \to D_s^+D_s^-,D_s^{*+}D_s^{*-}$$

G. Buchalla et al., Eur.Phys.J.C57:309, (2008)
and references therein

Outlook for ϕ_s

- ϕ_s sensitivity for $B_s \rightarrow J/\psi f_0$
  - ~25% yield relative to $B_s \rightarrow J/\psi\phi$
  - no angular analysis needed ($B_s \rightarrow VP$), but larger background
  - studied in LHCb by S. Stone and L.Zhang, arXiv:0909.5442
  - updated with yield and S/B from LHCb data
    estimated ϕ_s sensitivity "back-of-the-envelope"
    ~1.8 x $\sigma(\phi_s)$ of $B_s \rightarrow J/\psi\phi$
  - will improve considerably overall ϕ_s sensitivity

See talk by Fabrizio Ruffini

- Penguin modes
  - $B_s \rightarrow \phi\phi$ CDF ~300 events, 1st CP violation study
    LHCb expects O(1k) events in 2011
  - LHCb will use $B_s \rightarrow \phi\phi$ and $B_s \rightarrow K^{*0}\overline{K}^{*0}$ to measure ϕ_s

Conclusions

- $B_s \to J/\psi f_0$ ($f_0 \to K^+K^-$)
  - s-wave contribution to $B_s \to J/\psi\phi$ analysis
  - can be accounted for without bias
- $B_s \to J/\psi f_0$ ($f_0 \to \pi^+\pi^-$)
  - is a very sensitive ϕ_s probe
  - Observed in 2011 by LHCb, Belle, CDF and D0 experiments
- Outlook for ϕ_s
  - New Physics could reveal itself in near future.
  - Tevatron will include full data set for $B_s \to J/\psi\phi$
  - Tevatron plans to include $B_s \to J/\psi f_0$ for ϕ_s analysis
  - LHCb is collecting much larger dataset (~$1 fb^{-1}$ in 2011)
    preparing to make world's best ϕ_s measurement with $B_s \to J/\psi\phi$
  - LHCb will use $B_s \to J/\psi f_0$ for ϕ_s
  - Penguins in B_s decays will become interesting: $B_s \to \phi\phi$ and $B_s \to K^{*0}\overline{K}^{*0}$