Heavy Flavour Results from the Tevatron

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- Winter 2012 results - A selection of recent results
  - CDF Bs → μμ search (full dataset)
  - DØ A^b_{sl} Anomalous Dimuon
  - CDF Bs → J/ψΦ (full dataset)
  - DØ Bs → J/ψf'$_2$(1525) (Hot off the press, full dataset)
  - DØ New State decaying to ϒ(1S) + γ
  - DØ Λ_b Lifetime ($\Lambda_b \rightarrow J/\psi\Lambda^0$) (Hot off the press, full dataset)
  - CDF CP Violation in Charm (full dataset)

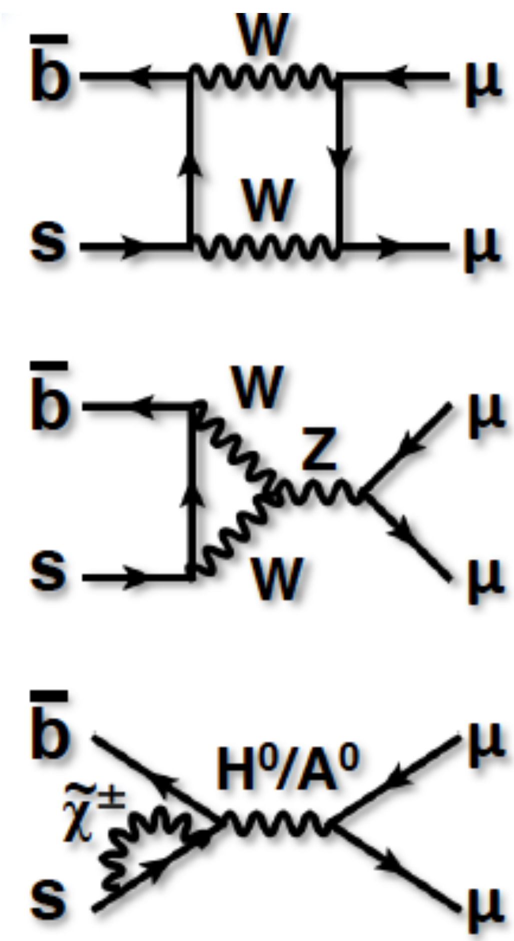
- Other recent results not covered here
  - CDF: Br($Bs \rightarrow D_S^{(*)}D_S^{(*)}$), D Meson Fragmentation, CPV in $D^0 \rightarrow K_s\pi\pi$, ϒ(ns) Spin Alignment, B_c Lifetime
  - DØ: Bs → J/ψf_0(980)

CDF: $B_s \to \mu\mu$ (full dataset)

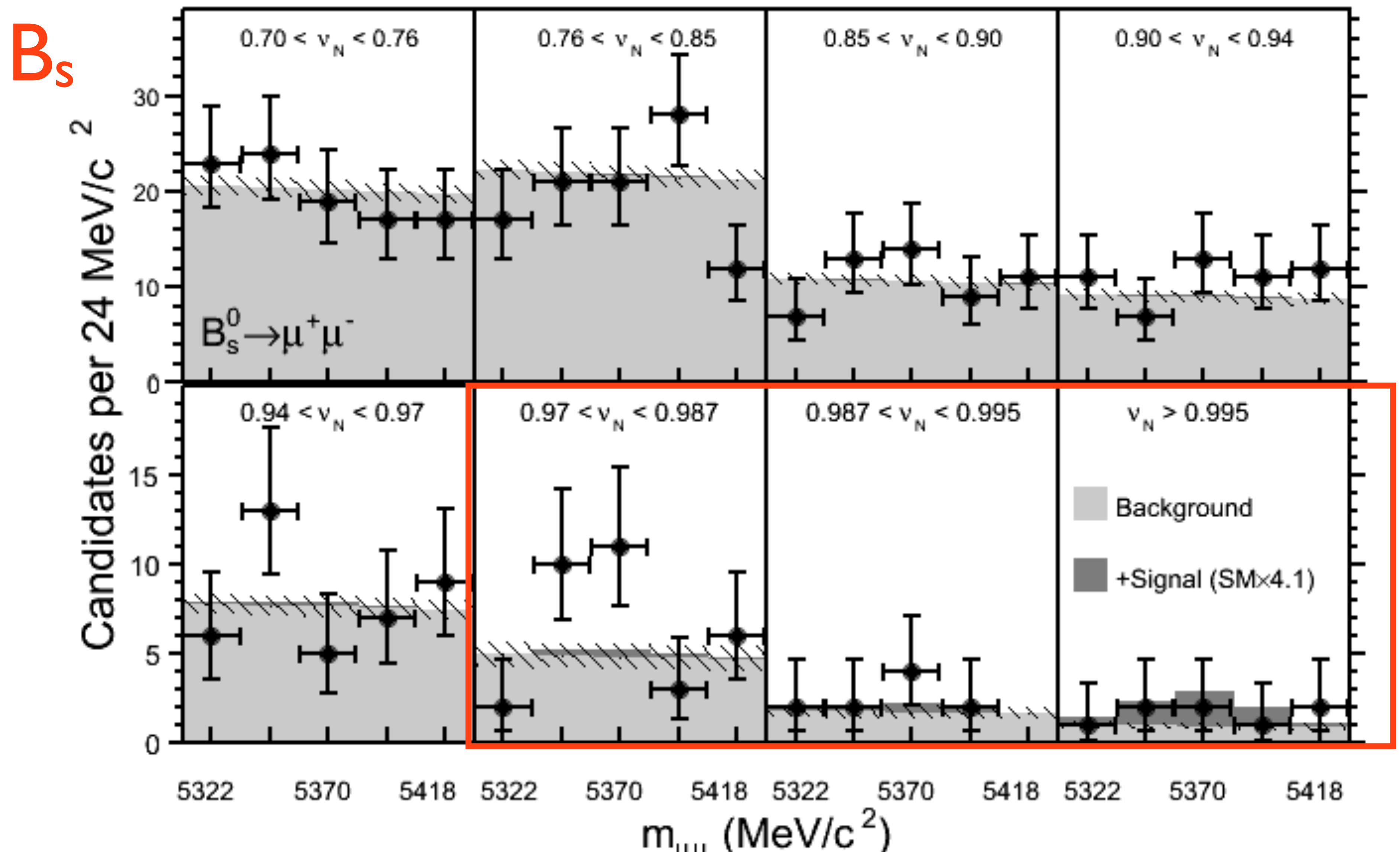
- SM prediction (A. Buras et al., arXiv:1012.2126) :

$$Br\ (B_s \to \mu\mu) = (3.2 \pm 0.2) \times 10^{-9}$$
$$Br\ (B_d \to \mu\mu) = (1.0 \pm 0.1) \times 10^{-10}$$

- New Phenomena could lead to much higher BR.
- CDF 2011 result showed a 2.7σ deviation above the expected background.
  Phys. Rev. Lett. 107, 191801 (2011)
- This result has been updated with the complete Tevatron dataset (30% increase in the dataset) .
- CDF uses the same data selection with no improvements to test the result.
- In B_d the extracted limit is $<4.6\text{x}10^{-9}$ (consistent with background) expected limit $4.2\text{x}10^{-9}$



CDF: $B_s \to \mu\mu$ (full dataset)



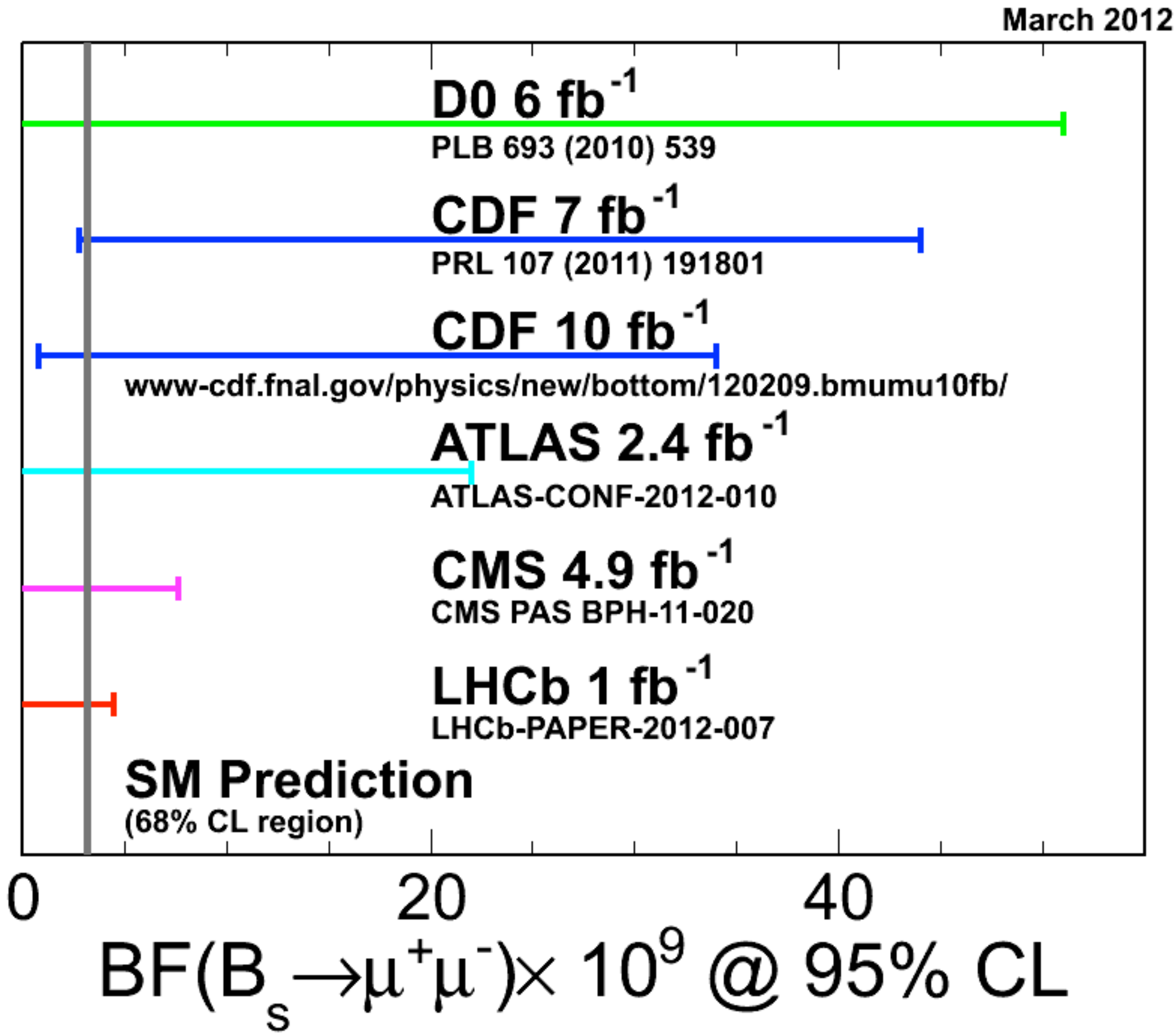
2-sided limit -

reduced significance slightly to about 2.2σ

$$0.8 \times 10^{-9} < BR(B_s \to \mu\mu) < 3.4 \times 10^{-8} @ 95\%$$

$$[\mathrm{BR} = (1.3^{+0.9}_{-0.7}) \times 10^{-8}]$$

CDF: $B_s \rightarrow \mu\mu$ (full dataset)



D0 - Dimuon Charge Asymmetry

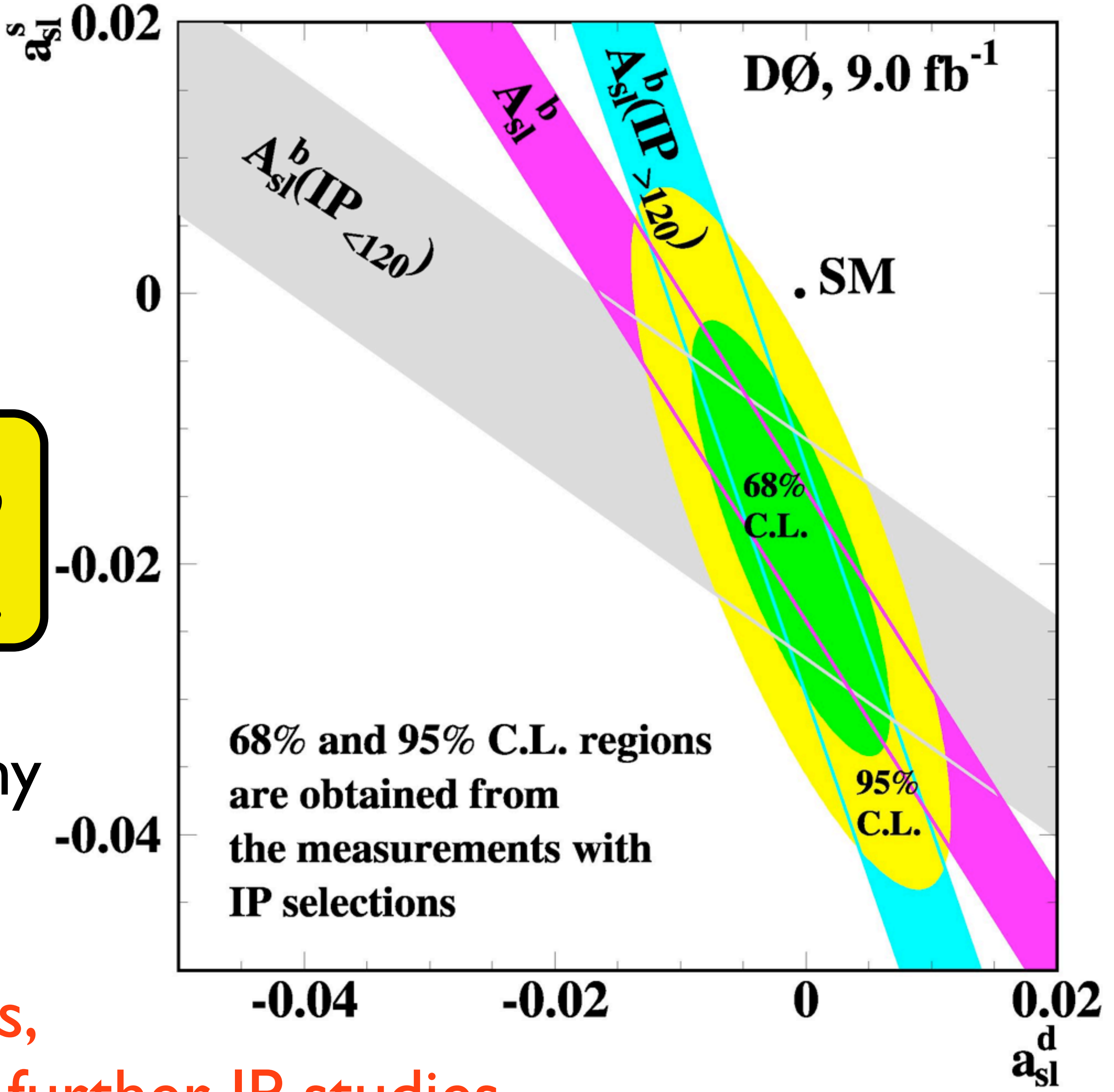
$$A^b_{sl} = (-0.787 \pm 0.172(\text{stat}) \pm 0.093(\text{syst}))\,\%$$

- Anomalous Dimuon - 3.9σ deviation from SM expectations

$$\begin{aligned} a^d_{\text{sl}} &= (-0.12 \pm 0.52)\%, \\ a^s_{\text{sl}} &= (-1.81 \pm 1.06)\%. \end{aligned}$$

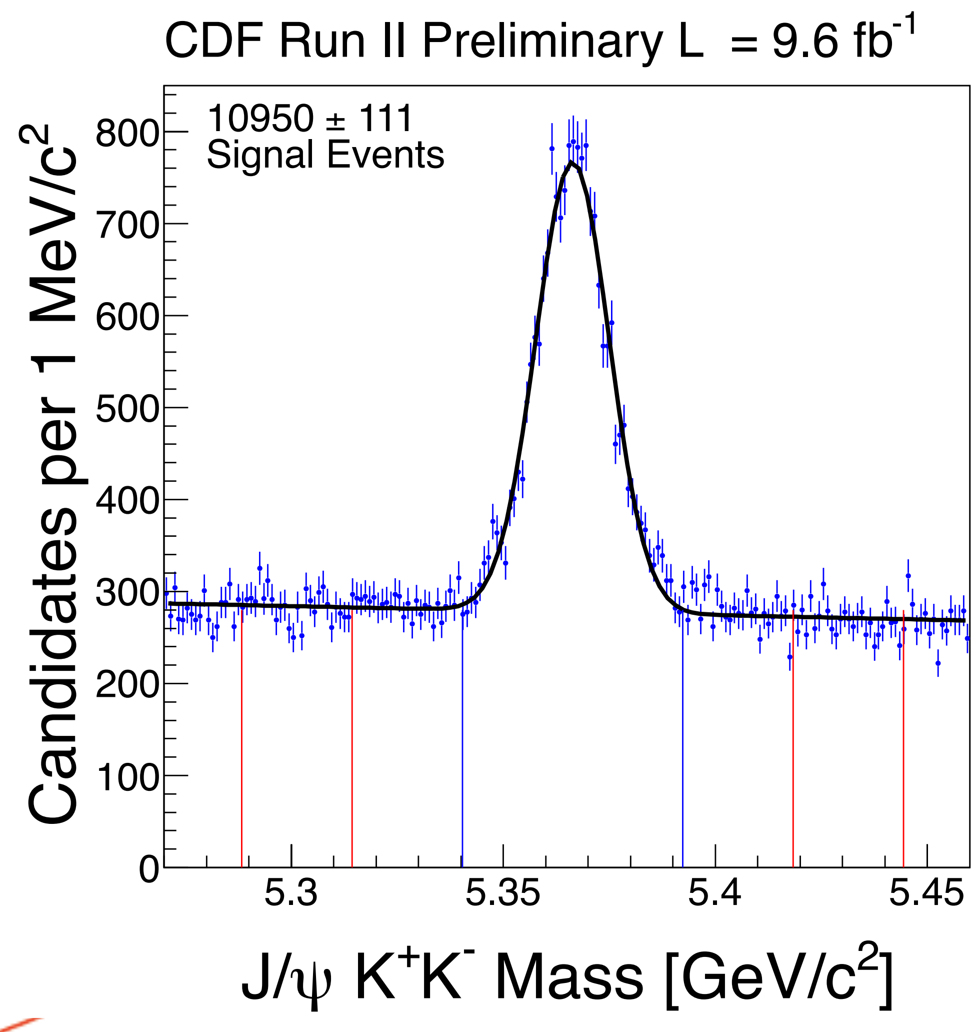
- Need to investigate in as many different ways as possible.

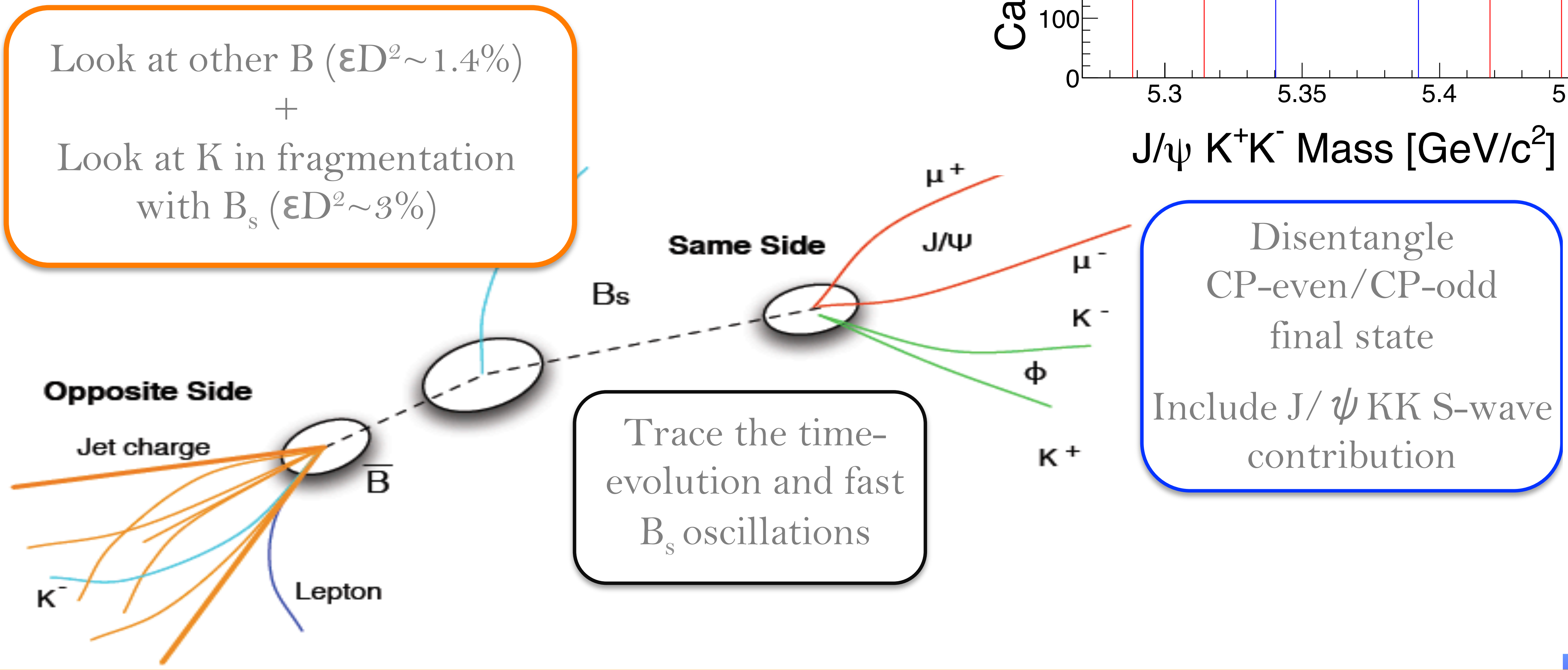
- flavour-specific measurements, integrated mixing probability, further IP studies.



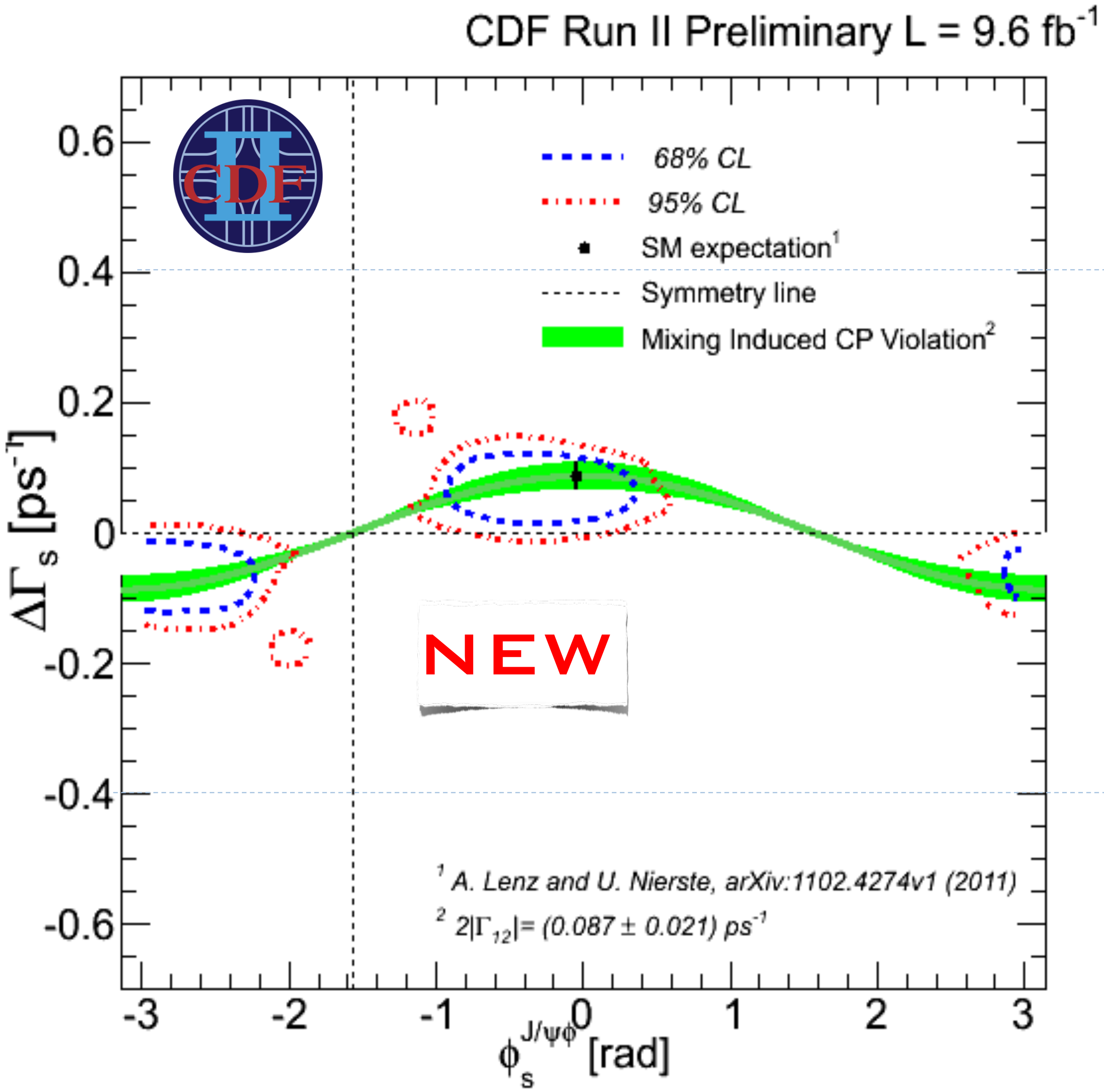
CDF: $B_s \to J/\psi\ \Phi$ (full dataset)

- Analysis of full data set: ~11k events
- low pT dimuon trigger.
  CDF: Off-line optimised NN selection;
  DØ: BDT/square cuts.
- joint fit to mass, production flavour, decay-time, decay-angles

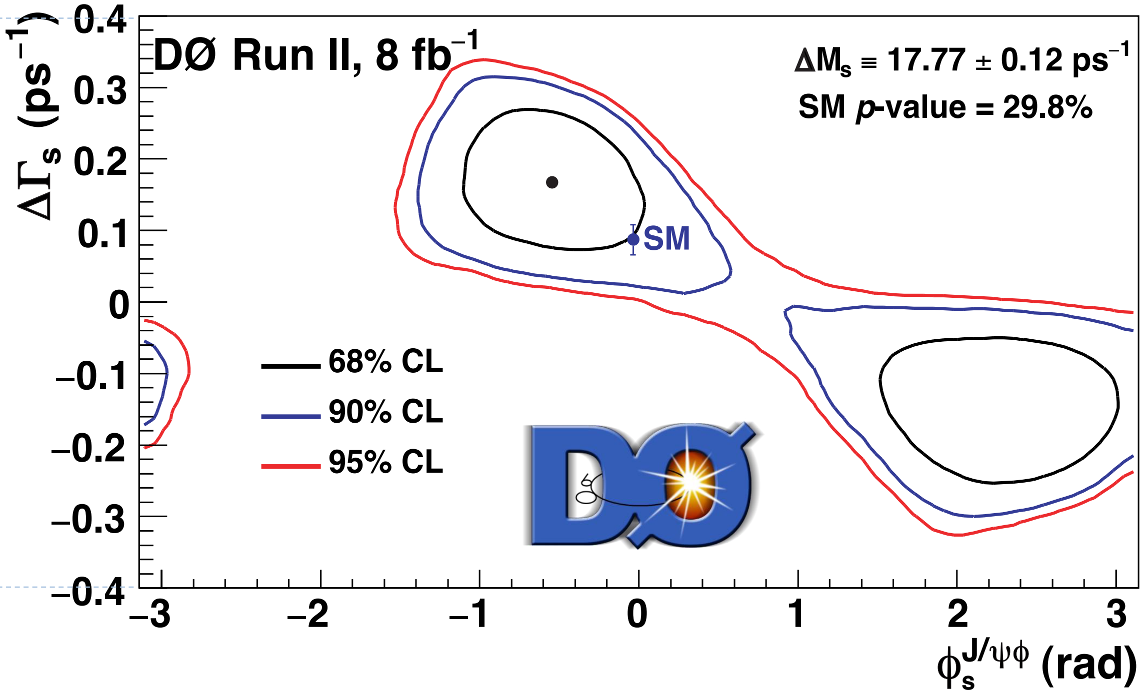




CDF: $B_s \rightarrow J/\psi\ \Phi$ (full dataset)



PRD 85, 032006 (2012)



$$\phi_s = [-0.60, 0.12]\ @68\%CL$$

$\Delta\Gamma_s = 0.068 \pm 0.026 \pm 0.007$ ps^{-1}

$\tau_s = 1.528 \pm 0.019 \pm 0.009$ ps

CDF Note: 10778

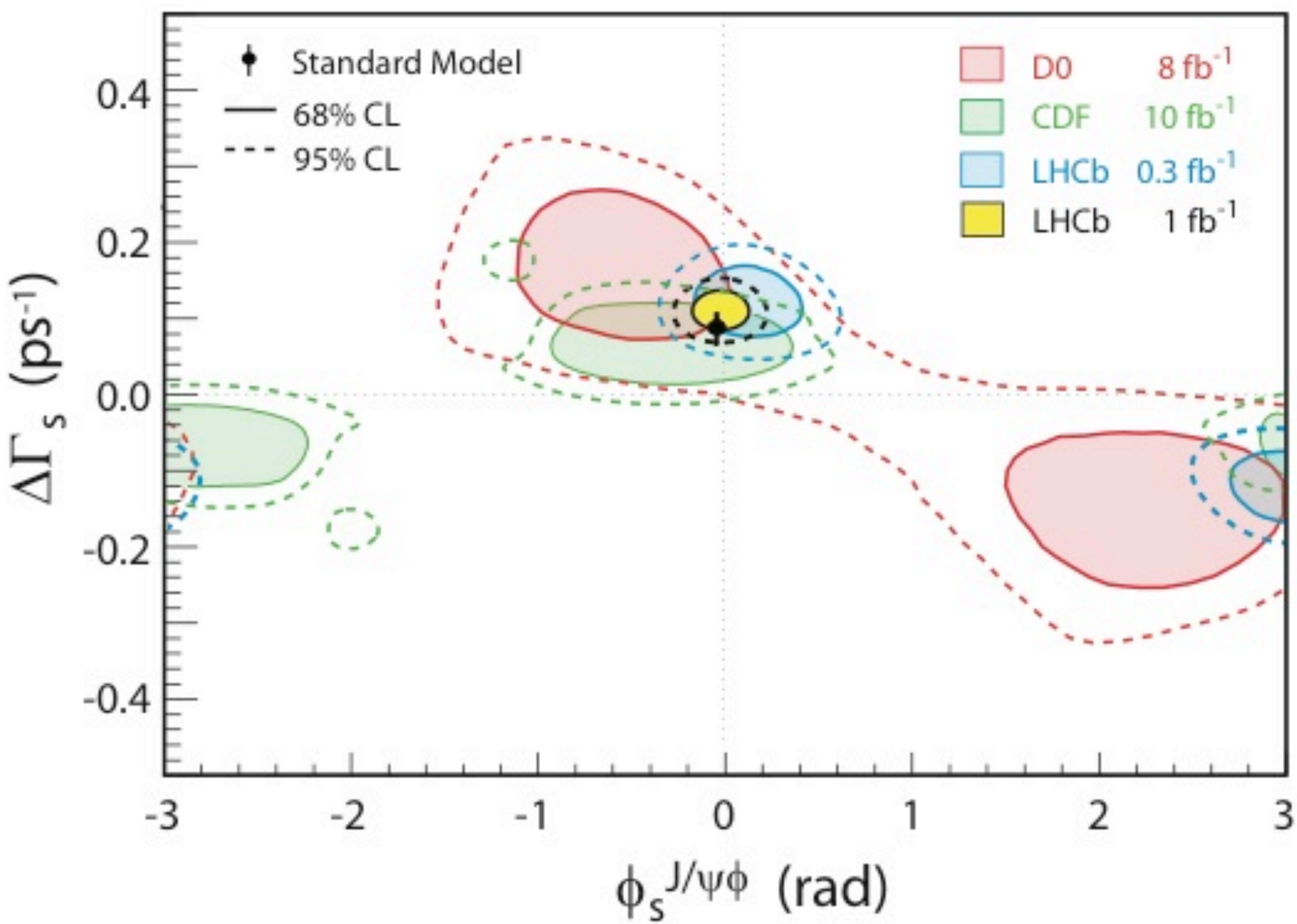
Strong phases fitting range restricted based on $B^0 \rightarrow J/\psi K^*$

$$\phi_s = -0.55^{+0.38}_{-0.36}$$

$\Delta\Gamma_s = 0.163\ ^{+0.065}_{-0.064}$ ps^{-1}

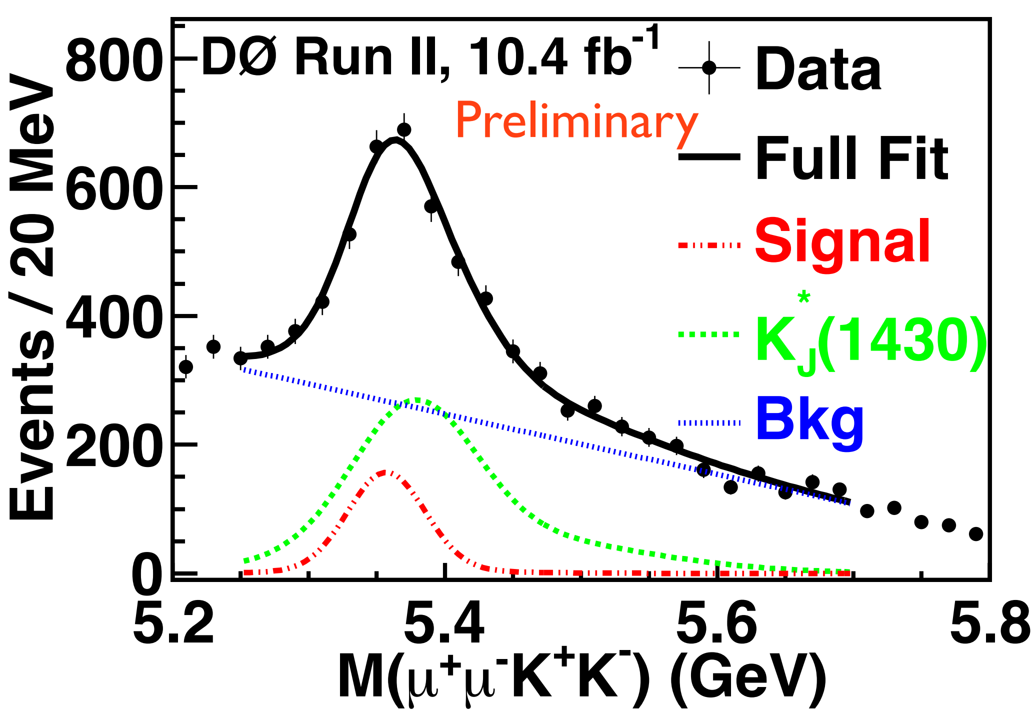
$\tau_s = 1.443\ ^{+0.038}_{-0.035}$ ps

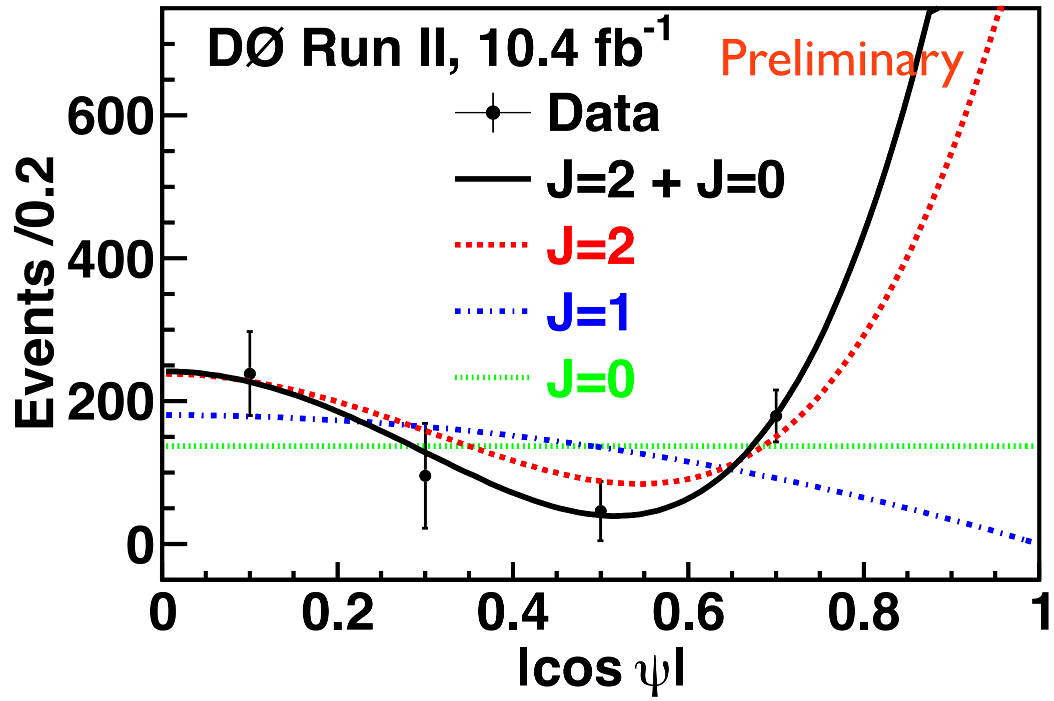
Comparison - All Experiments



DØ $B_s \to J/\psi f'_2(1525)$ (full dataset)

- Preliminary result - to be submitted next week.
- Analysis Outline:
  - Determine identity of decay;
    Extract Bs → $J/\psi f'_2(1525)$ yield from fitting B_s yield vs M(KK);
    Measure the Spin.
- $f'_2(1525)$ decays to KK, $f_0(1500)$ large ππ - observe only KK.
  - Major Background is $K^*_J(1430)$

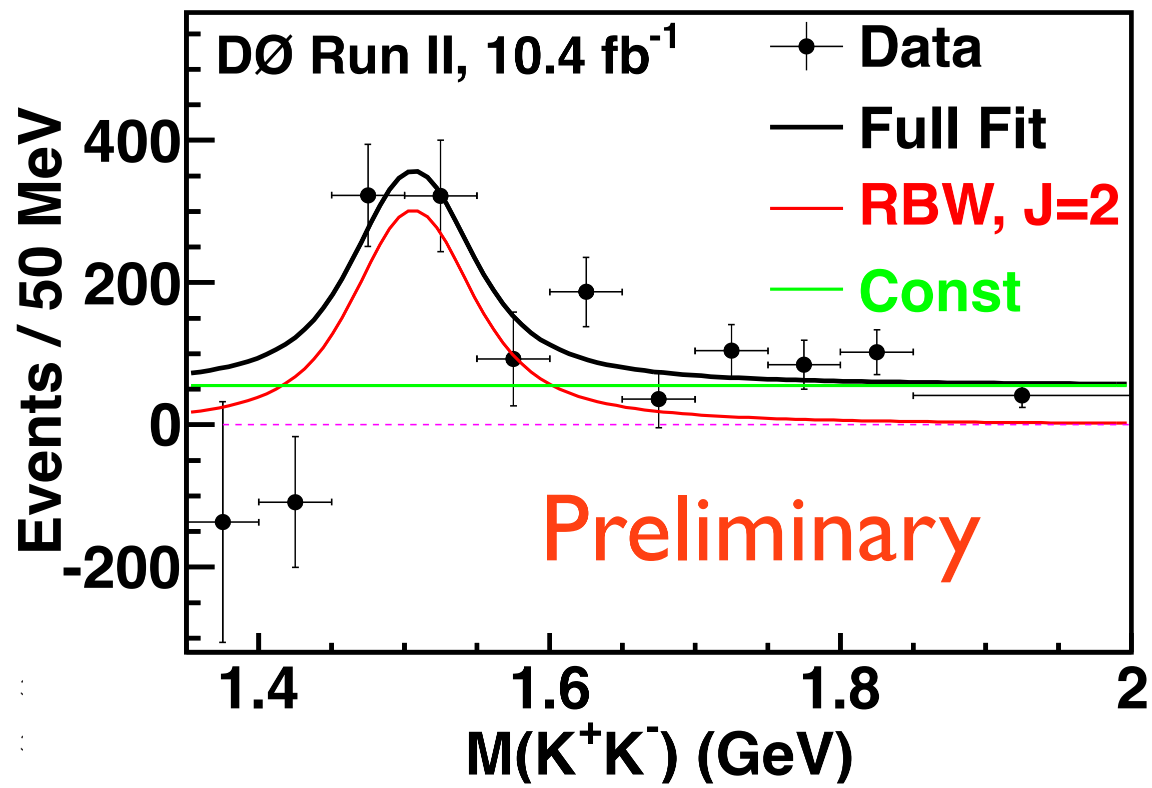


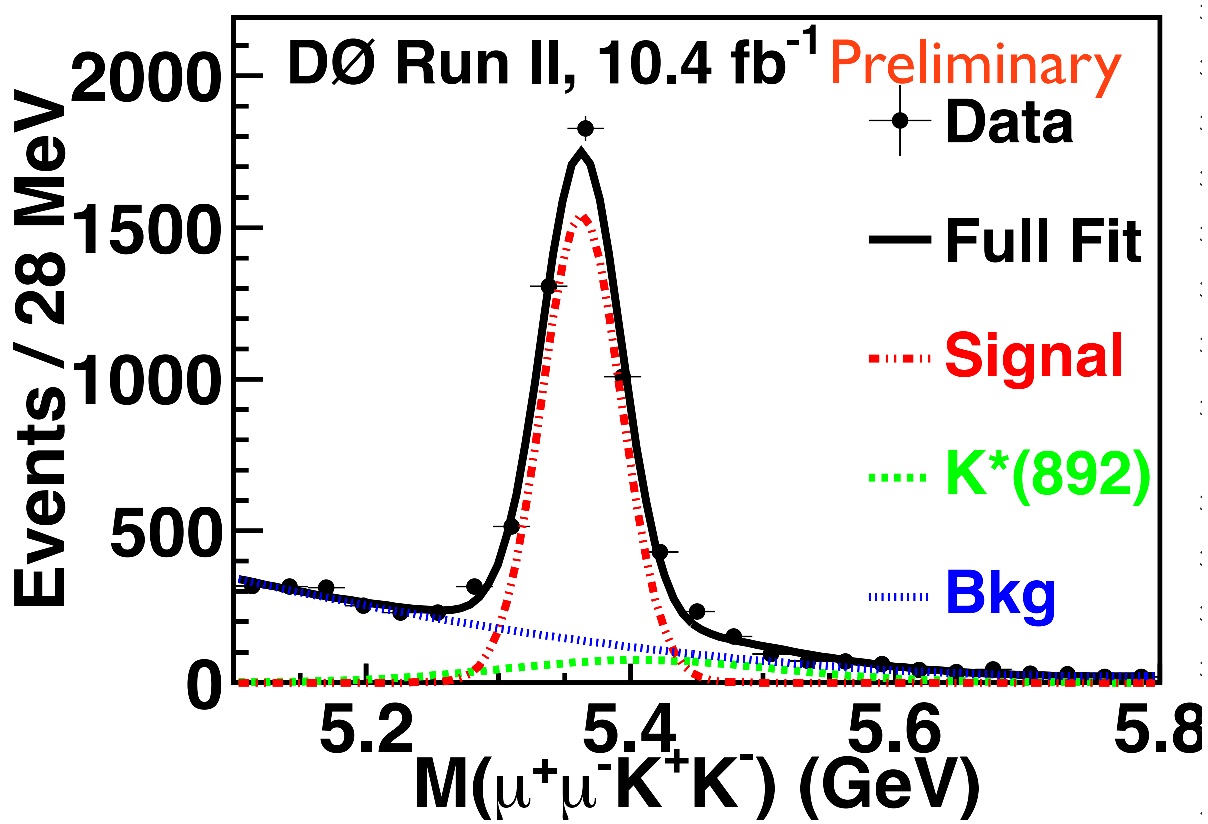


Data favour J=2, but also consistent with a coherent superposition of J=0 and J=2.
Incompatible with J=0 or J=1

DØ $B_s \to J/\psi f'_2(1525)$ (full dataset)

- Combined fit - includes relativistic BW with J=2 plus a constant S-wave contribution
- Constant fraction = 0.33 ±0.09





Preliminary

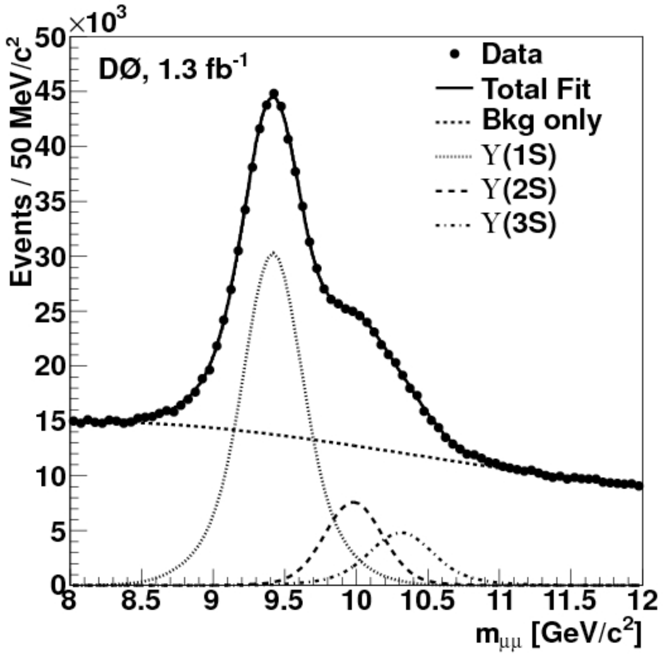
$$R_{f'/\phi} = 0.22 \pm 0.05(\mathrm{stat}) \pm 0.04(\mathrm{syst})$$

Compare with LHCb result (PRL, 108, 151801 (2012)

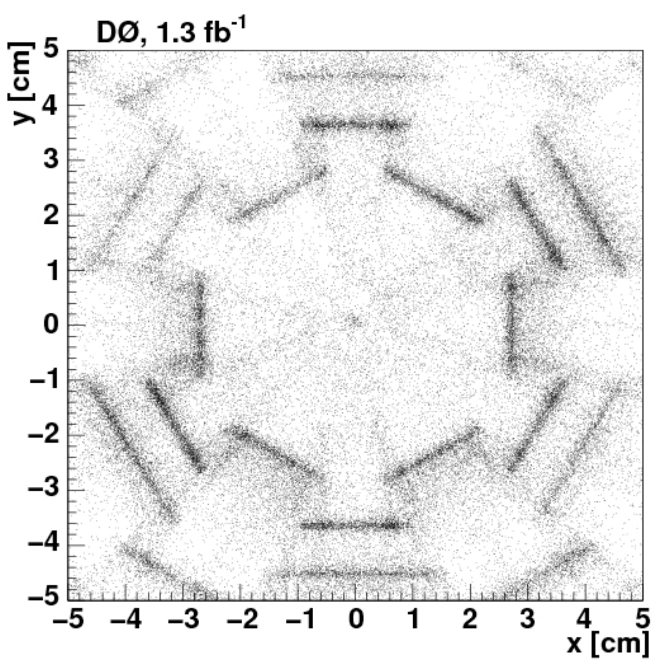
$$R_{f'/\phi} = 0.264 \pm 0.027(\mathrm{stat}) \pm 0.024(\mathrm{syst})$$

DØ: New State decaying to $\Upsilon(1S) + \gamma$

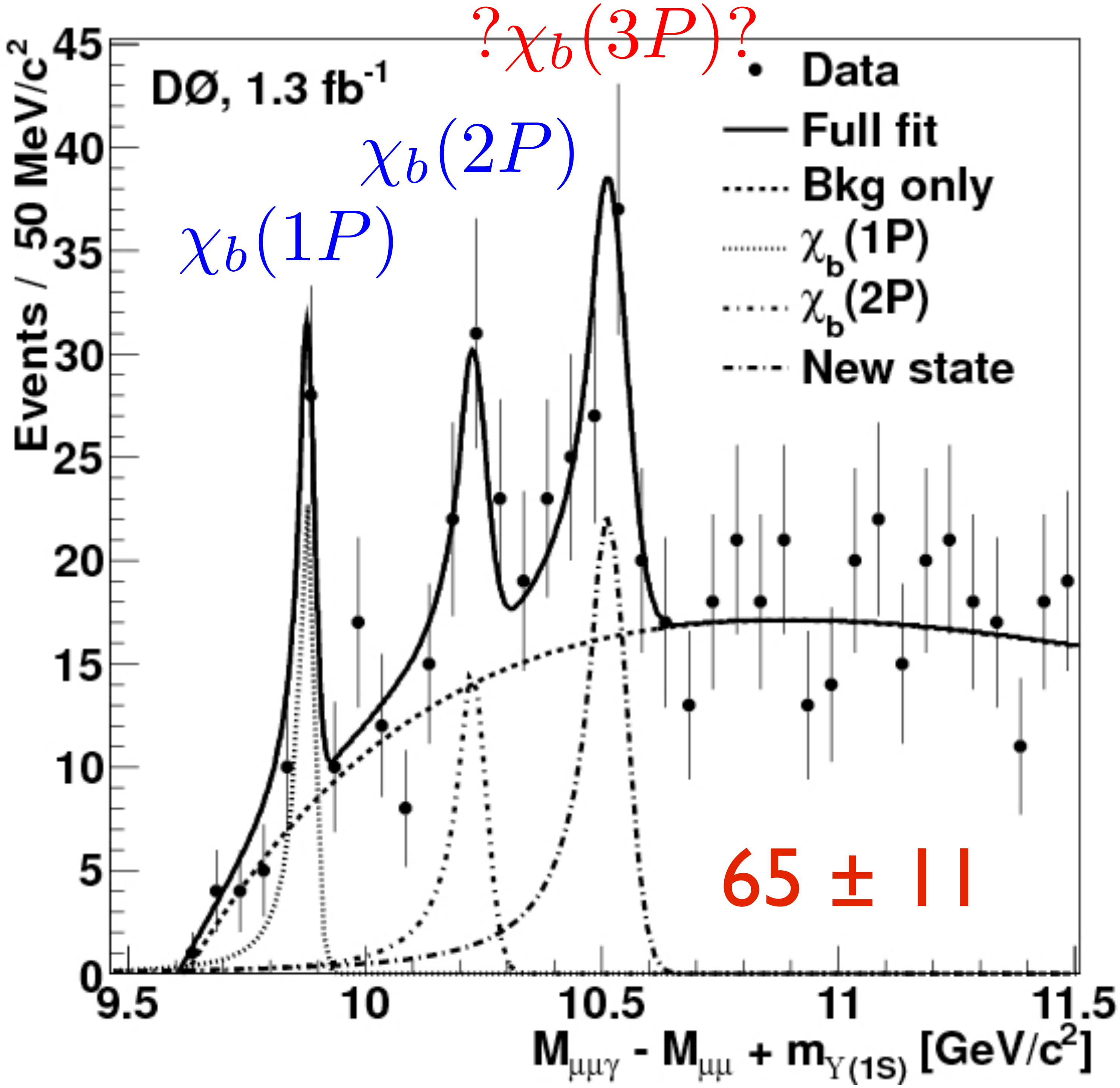
- Confirmation of ATLAS observation (arXiv:1112.5154)



$\Upsilon(1S) \to \mu\mu$



$\gamma \to ee$



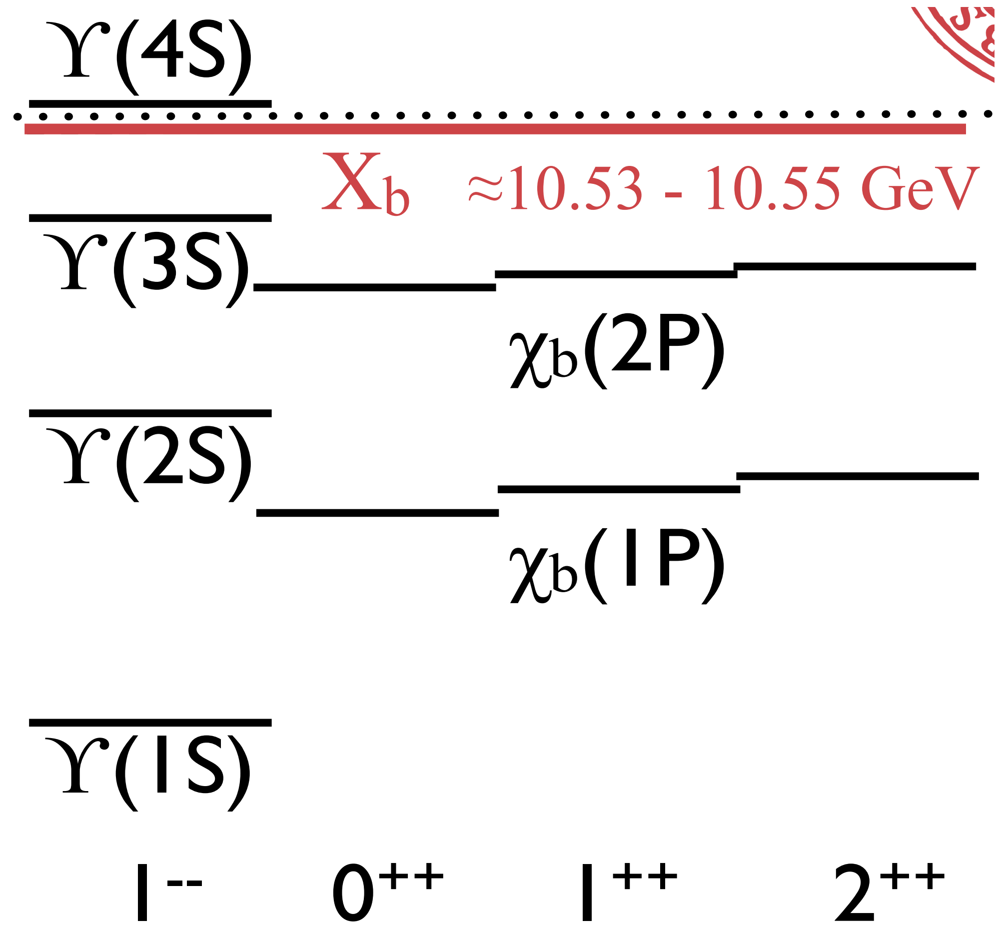
$$M(X) = 10.551 \pm 0.014(\mathrm{stat}) \pm 0.016(\mathrm{syst})\mathrm{GeV/c^2}$$

DØ: New State decaying to $\Upsilon(1S) + \gamma$

$$\text{DØ } M(X) = 10.551 \pm 0.014(\text{stat}) \pm 0.016(\text{syst})\text{GeV}/\text{c}^2$$

$$\text{ATLAS } M(X) = 10.530 \pm 0.005(\text{stat}) \pm 0.009(\text{syst})\text{GeV}/\text{c}^2$$

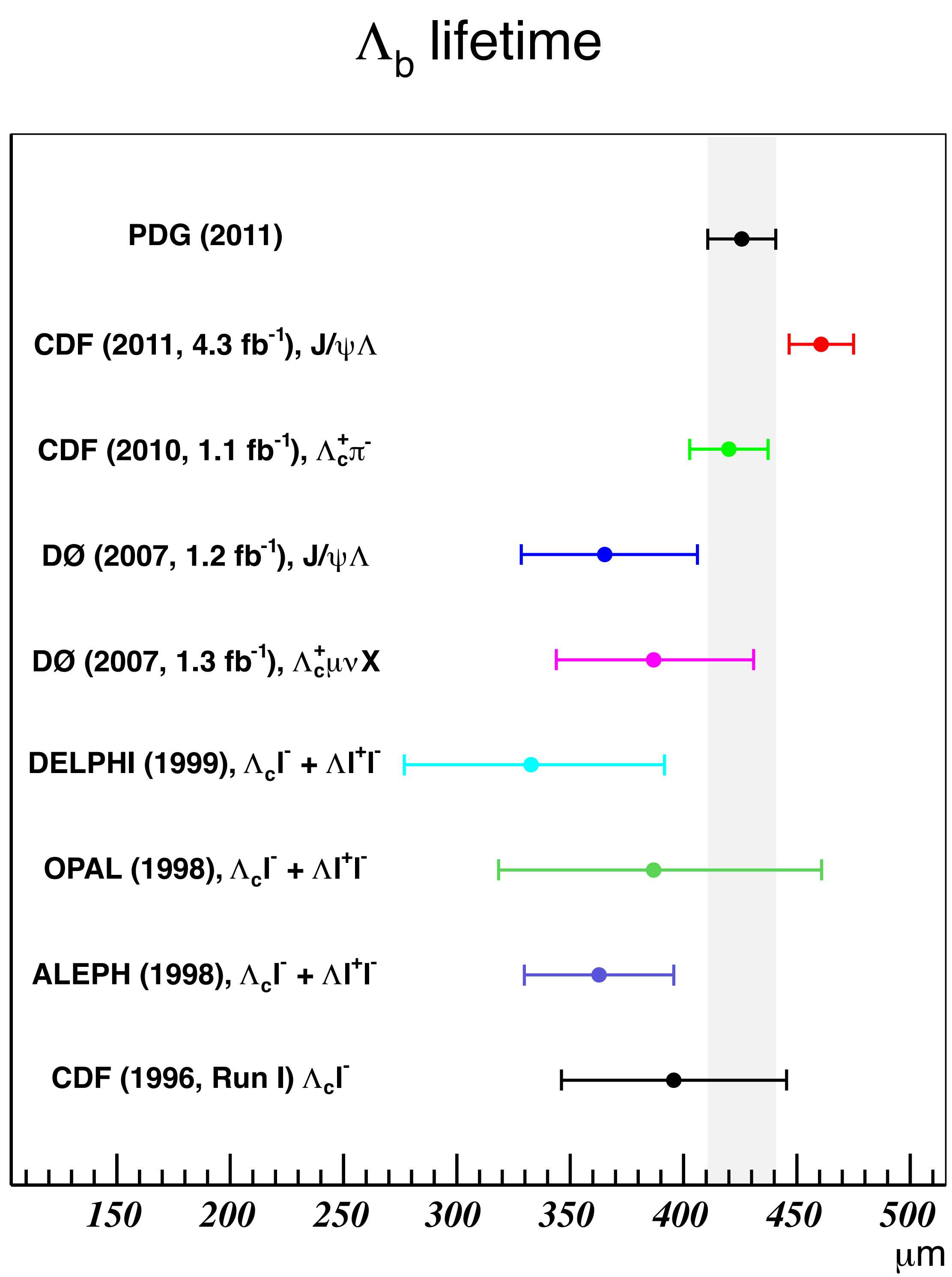
- Interpretation - the new state has not been fully identified.
  - Narrow Structure
  - Branching ratios? Spin structure? Just one state?



Kwong, Rosner
Phys.Rev.D38:279,1988
$m(\chi_b(3P)) \approx 10.520$ GeV

Törnqvist
Phys.Lett.B590:209-215,2004
$m(B\overline{B}^*) \approx 10.545$ GeV

Λ_b Lifetime ($\to J/\psi\Lambda^0$)



- CDF 2011 Result 2σ above WA
- Theoretical prediction (HQET):
  PRD 70, 094031 (2004)

$$\left.\frac{\tau_{\Lambda_b}}{\tau_{B_d}}\right|_{\mathrm{NLO}} = 0.88 \pm 0.05$$

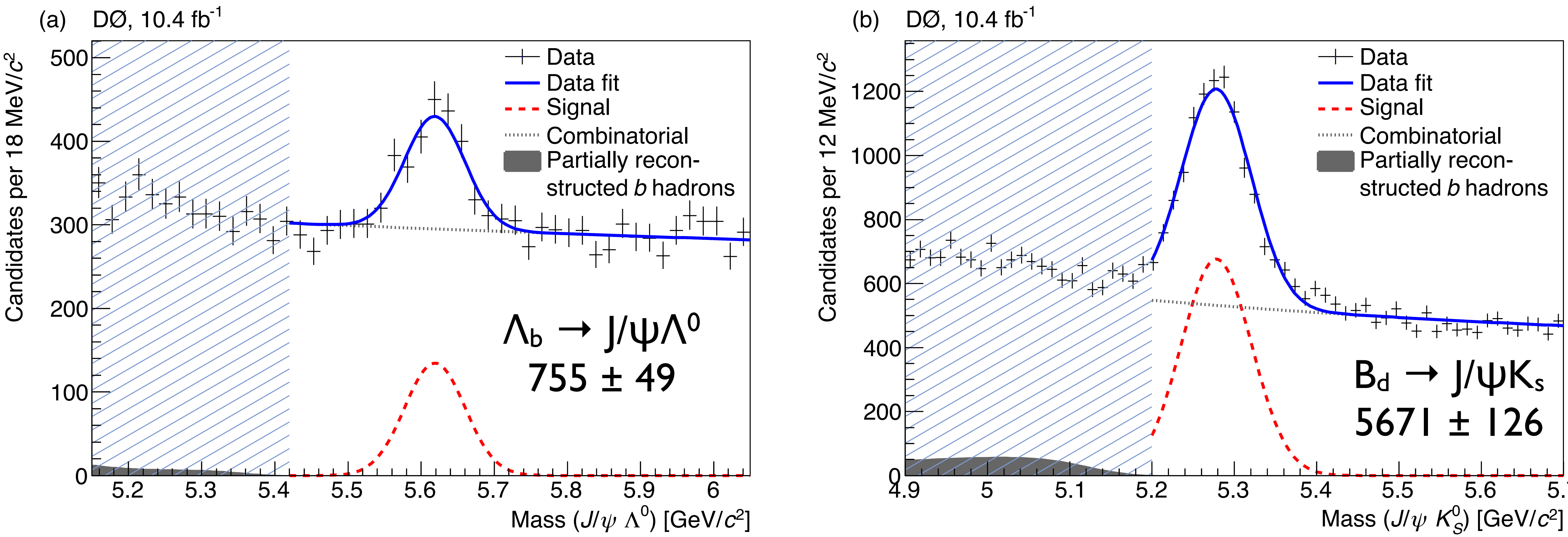
- Current best results

$$\mathrm{CDF} : 1.020 \pm 0.030 \pm 0.008$$

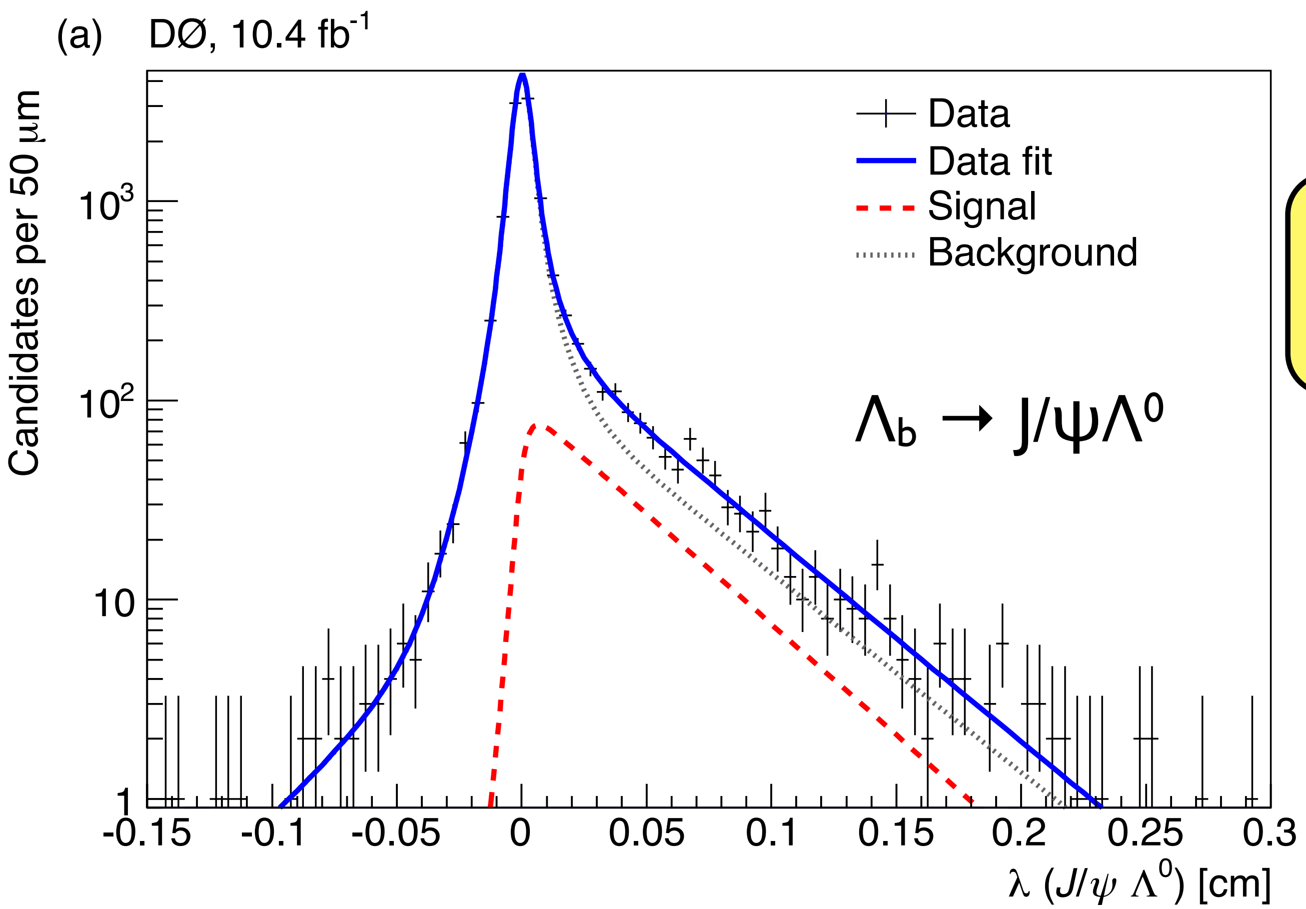
$$\mathrm{D\O} : 0.811^{+0.096}_{-0.087} \pm 0.034$$

DØ Λ_b Lifetime ($\rightarrow J/\psi\Lambda^0$) (full dataset)

- Submitted to PRD-RC on Wednesday (arXiv:1204.2340) Makes use of full dataset
  - Use two similar processes:
    $\Lambda_b \rightarrow J/\psi\Lambda^0$ and $B_d \rightarrow J/\psi K_s$
    where $J/\psi \rightarrow \mu\mu$, $K_s \rightarrow \pi\pi$, $\Lambda^0 \rightarrow p\pi$
  - Use selection criteria that does not bias the lifetime



DØ Λ_b Lifetime ($\rightarrow J/\psi\Lambda^0$) (full dataset)



Extract lifetimes

$$\tau(\Lambda_b^0) = 1.303 \pm 0.075 \text{ (stat.)} \pm 0.035 \text{ (syst.) ps},$$
$$\tau(B^0) = 1.508 \pm 0.025 \text{ (stat.)} \pm 0.043 \text{ (syst.) ps},$$

in agreement with WA results

$$\left.\frac{\tau_{\Lambda_b}}{\tau_{B_d}}\right|_{\text{NLO}} = 0.88 \pm 0.05$$

$$\frac{\tau(\Lambda_b)}{\tau(B_d)} = 0.864 \pm 0.52(\text{stat.}) \pm 0.033(\text{syst.})$$

- Consistent with theoretical prediction
- 2.2σ discrepancy with CDF result
  - Need additional measurement (LHC experiments?)

- Previous results
  - CDF 2011: use displaced track triggers to obtain huge data samples PRD85, 012009 (2012)

$$A_{CP}\left(D^0 \to K^+K^-\right) = (-0.24 \pm 0.22 \pm 0.10)\,\%$$

$$A_{CP}\left(D^0 \to \pi^+\pi^-\right) = (+0.22 \pm 0.24 \pm 0.11)\,\%$$

  - LHCb 2012: 3.5σ deviation from SM PRL 108, 111602 (2012)
  - $\Delta A_{CP} = A_{CP}(D^0 \to K^+K^-) - A_{CP}(D^0 \to \pi^+\pi^-)$ maximally sensitive to NP.

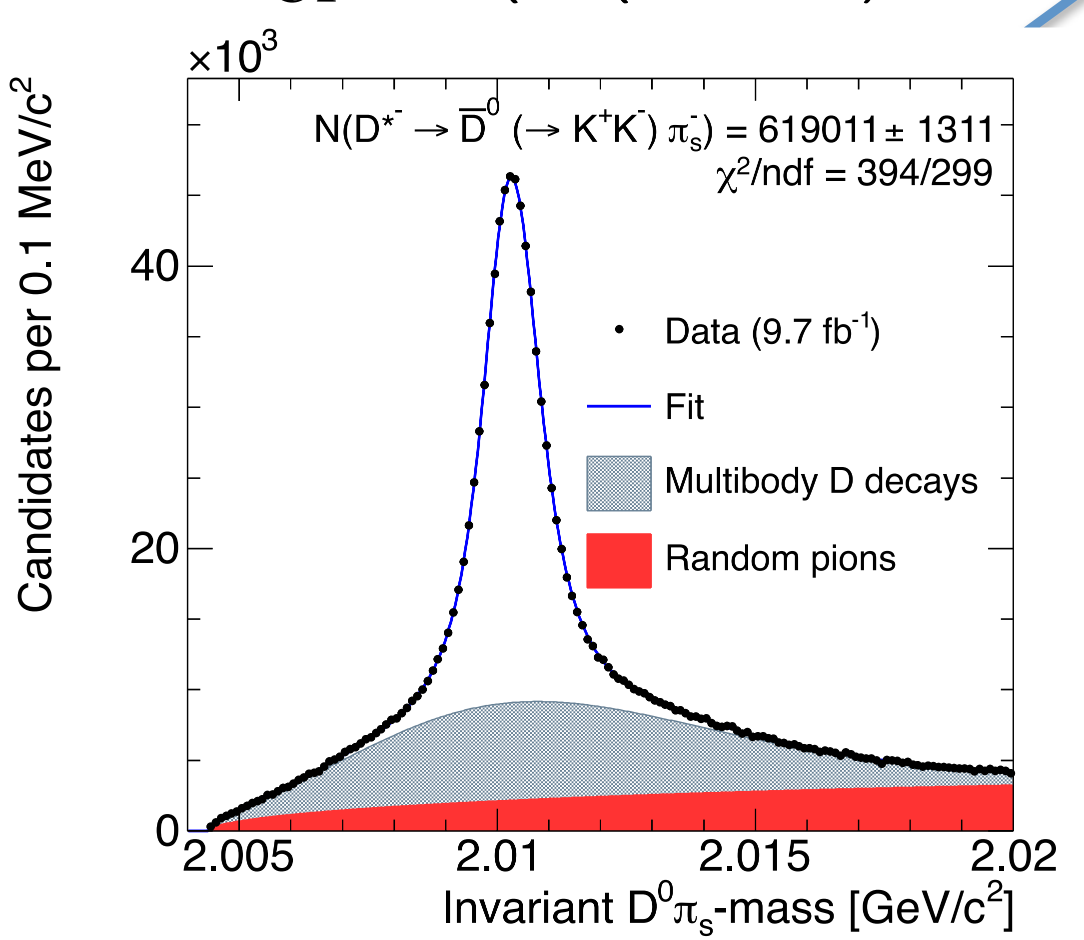
Experimentally convenient: instrumental asymmetries cancel.

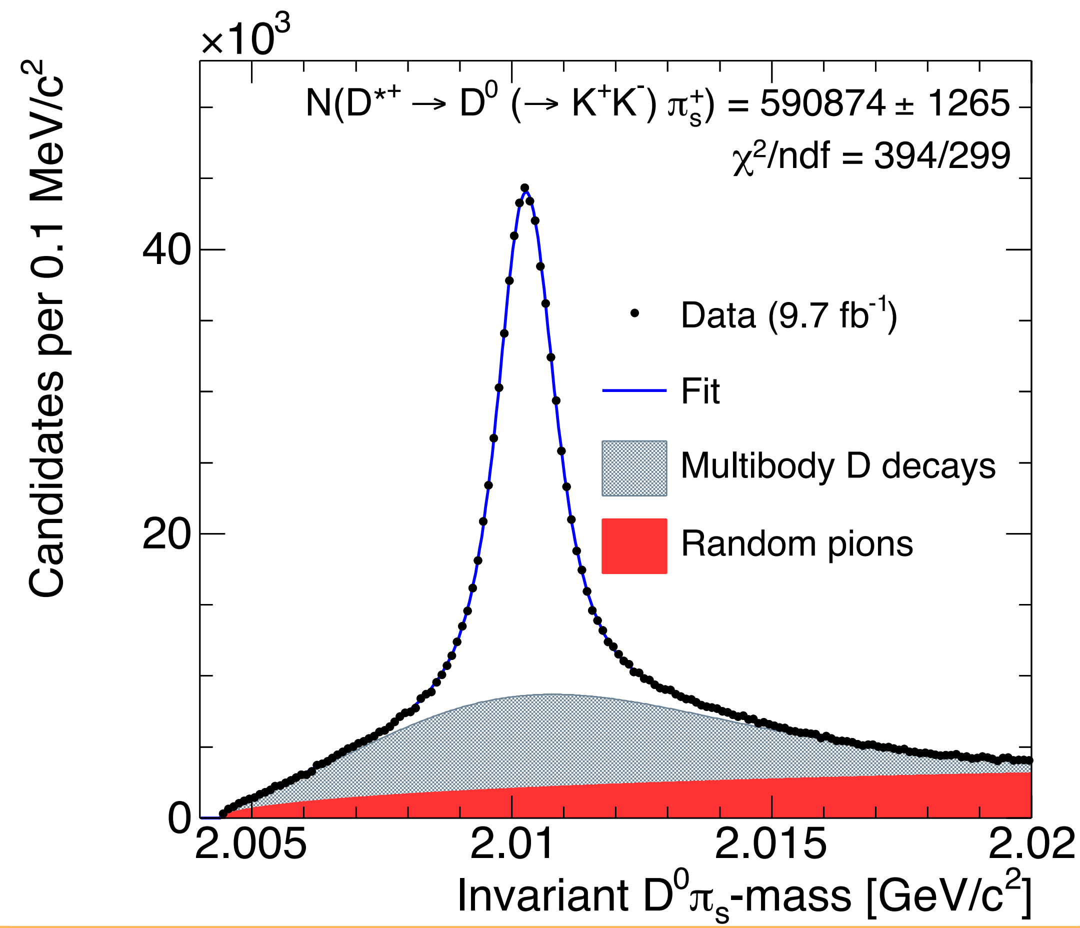
$$\Delta A_{CP} = (-0.82 \pm 0.21 \pm 0.11)\,\%$$

CDF - ΔA_{CP} with the Full Dataset

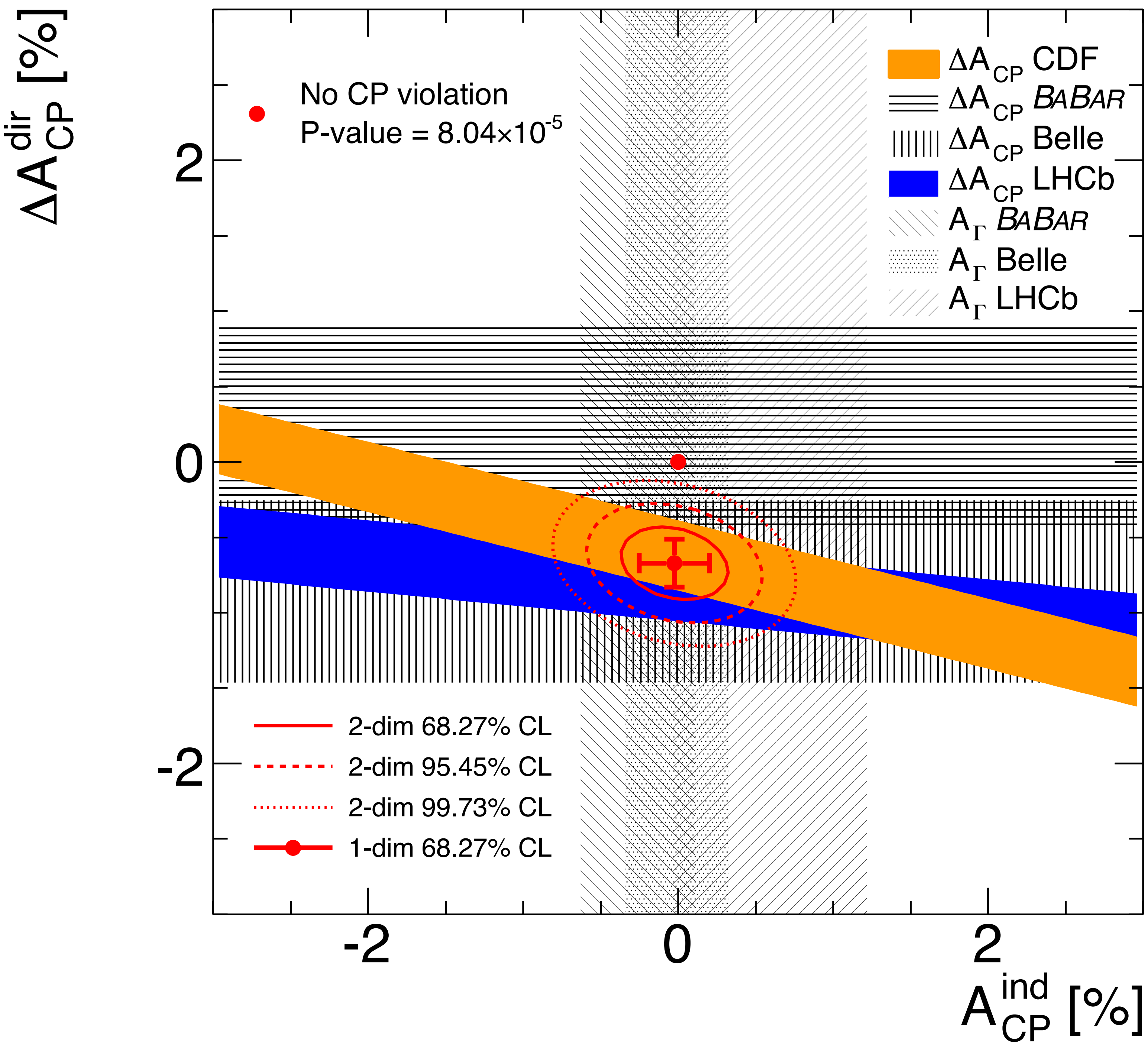
- Optimised data selection for ΔA_{CP} doubling the signal
  - loosened selection (removing IP requirement)
- Get D^0 flavour from $D^* \to D^0\pi$
  - the soft pion induces O(1%) asymmetries - use difference to cancel detector based effects and accentuate effect of NP.

$$\Delta A_{CP} = (A(K^+K^-) + \cancel{\delta(\pi_s)}) - (A(\pi^+\pi^-) + \cancel{\delta(\pi_s)})$$





CDF - ΔA_{CP} with the Full Dataset



- Consistent with the LHVb result (same sensitivity).

$$\Delta A_{CP} = (-0.82 \pm 0.21 \pm 0.11)\,\%$$

- When combining using HFAG method the result is ~4σ from SM result of zero.

$$\Delta A_{CP}{}^{dir} = (-0.67 \pm 0.16)\%$$
$$A_{CP}{}^{ind} = (-0.02 \pm 0.22)\%$$

$$\Delta A_{CP} = [-0.62 \pm 0.21(\mathrm{stat}) \pm 0.10(\mathrm{syst})]\,\%$$

Summary

- Tevatron still producing new, high impact results with the Full Run II dataset
  - CPV in Charm sector!
    CDF confirms LHCB's evidence of CPV in charm with same precision !
  - Rare B decays.
    extension to full sample confirms summer result.
  - Bs mixing
    Closer to SM expectations.
  - Confirmation of $B_s \rightarrow J/\psi f'_2(1525)$ - J=2 confirmed
  - ASL needs independent confirmation!
  - Confirmation of X_b.
  - DØ Λ_b Lifetime consistent with HQET

Summary

- Tevatron still producing new, high impact results with the Full Run II dataset
  - CP… harm sector! … LHCB's evidence of CPV in charm with
  - Ra… extensio… summer result.
  - Bs mixing
    Closer to SM expec…
  - Confirmation of Bs → J/ψ…
  - ASL needs independent confirma…
  - Confirmation of Xb.
  - DØ Λ_b Lifetime consistent with HQET

Many more results to Come