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Heavy flavour production and asymmetry measurements from the D0 experiment

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B^+B^- F-B Asymmetries

$\Lambda_b\bar{\Lambda}_b$ F-B Asymmetries

$\Lambda\bar{\Lambda}$ F-B Asymmetries

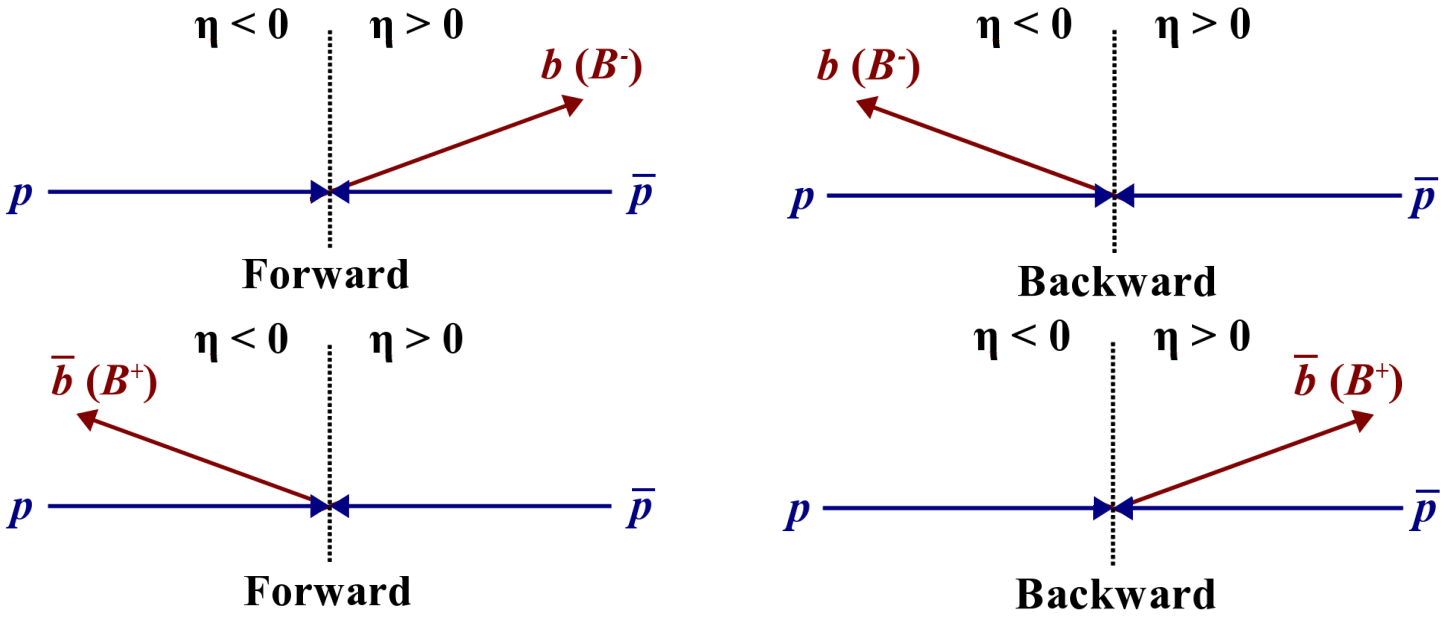
X(4140)

D0

- DØ has a well understood detector & dataset with well developed analysis techniques.
  - small levels of pile-up
  - p−anti-p CP symmetric initial state
  - regular flipping of magnet polarities
- These are all used in asymmetry measurements to minimise systematic uncertainties

$B^{\pm}$ F-B Asymmetry

- Forward-backward asymmetry may probe for new physics.
- D0 uses $B^{\pm} \rightarrow J/\Psi K^{\pm}$ to probe asymmetry of b-quarks.

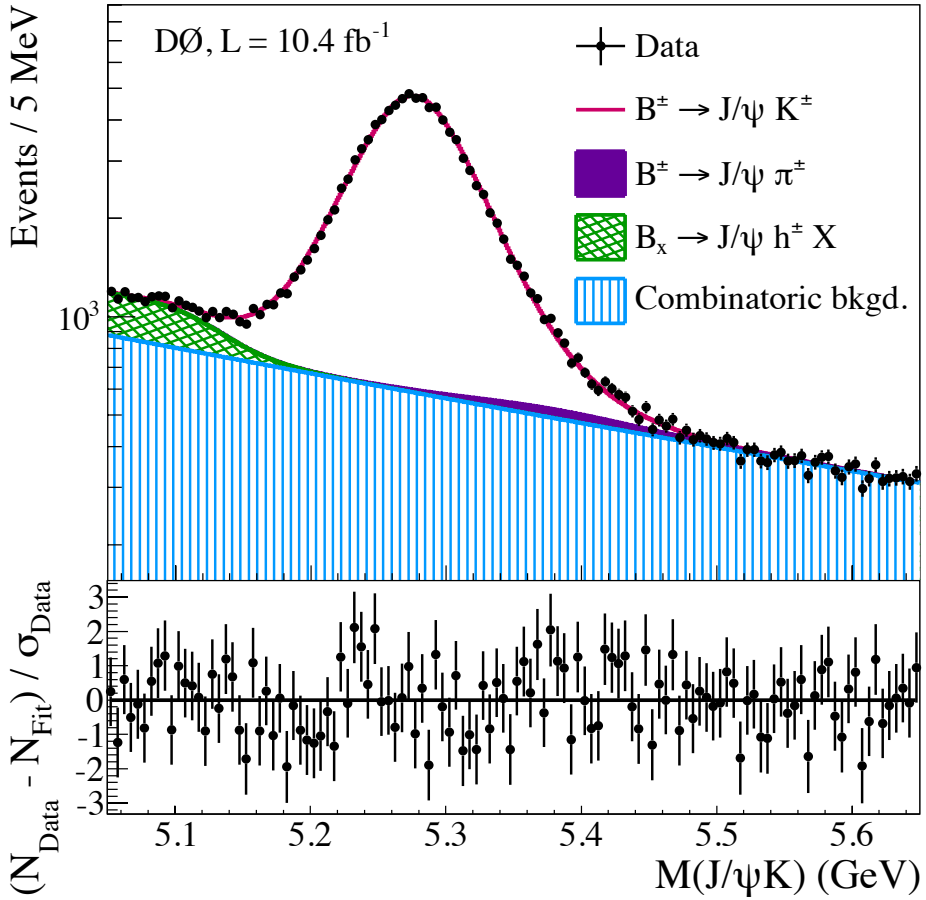


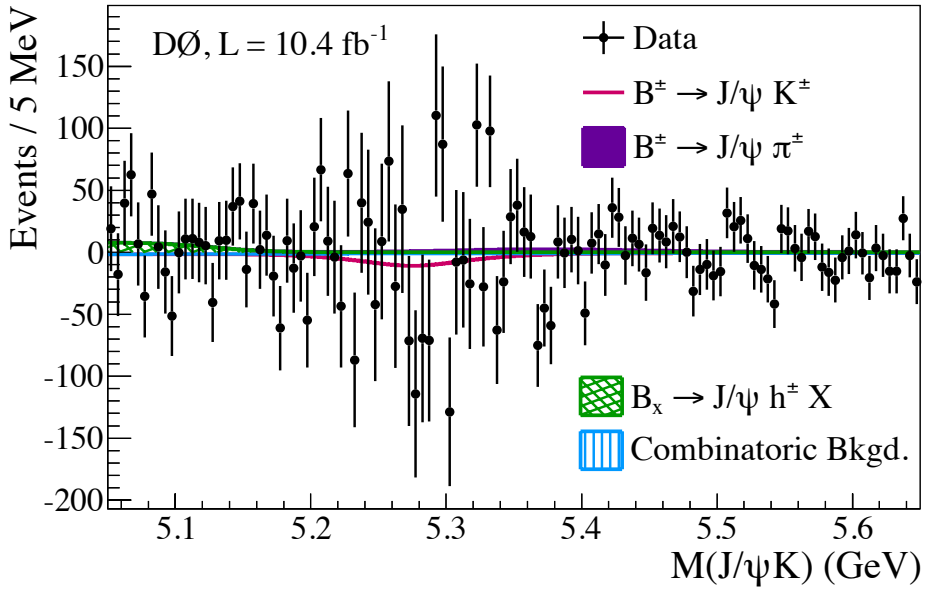
$$A_{FB} = \frac{N_F - N_B}{N_F + N_B}$$

Forward: b-quark in same direction as proton
$\bar{b}$ in same direction as anti-proton

$B^{\pm}$ F-B Asymmetry

- An unbinned maximum likelihood fit is used to extract the number of B meson decays in each category.
- Unblinded projections: Phys. Rev. Lett. 114, 051803 (2015)





Correct for F-B reconstruction asymmetries, muon and kaons using weights: A_{corr} = -0.06%.

$B^{\pm}$ F-B Asymmetry

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TABLE I: Summary of uncertainties on $A_{\mathrm{FB}}(B^{\pm})$ in data.

Source	Uncertainty
Statistical	0.41%
Alternative BDTs and cuts	0.17%
Fit Variations	0.06%
Reconstruction Asymmetries	0.05%
Fit Bias	0.02%
Systematic Uncertainty	0.19%
Total Uncertainty	0.45%

$$A_{\mathrm{FB}}(B^{\pm}) = [-0.24 \pm 0.42\,(\mathrm{stat}) \pm 0.19\,(\mathrm{syst})]\,\%$$

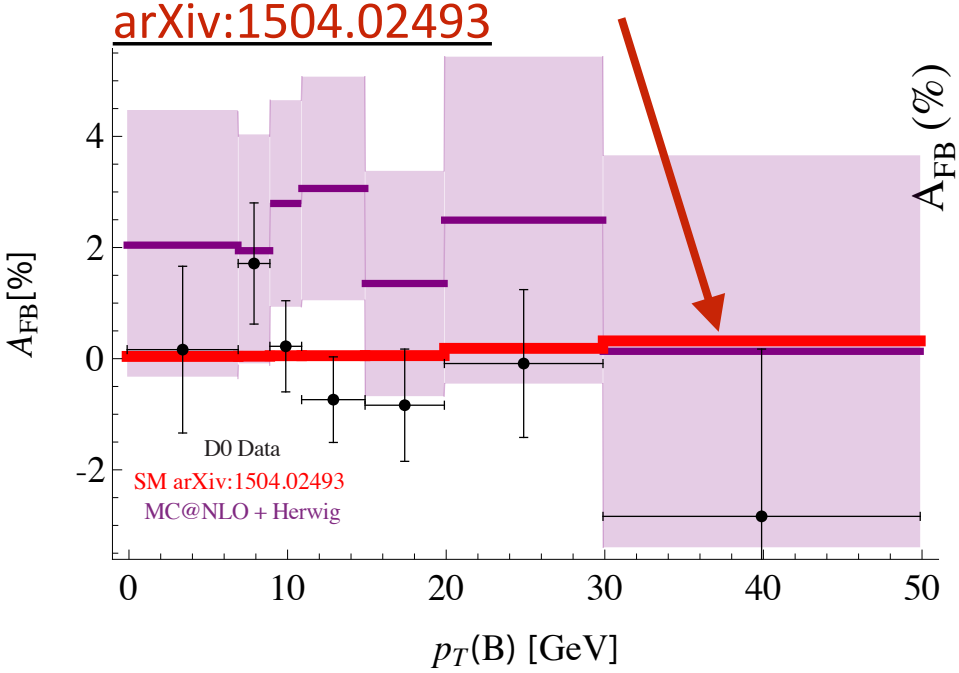
We observe no significant forward-backward asymmetry

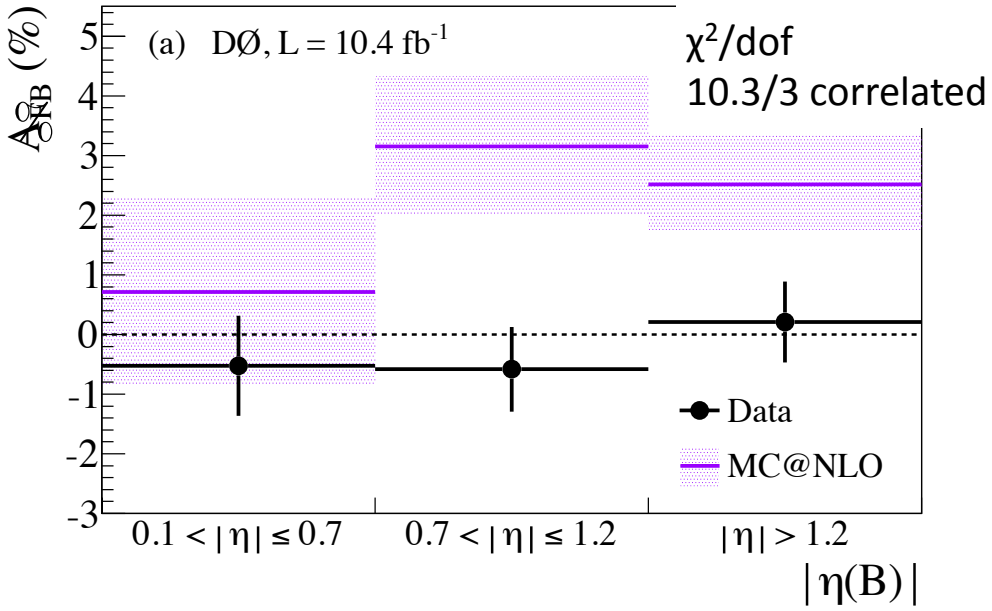
$B^{\pm}$ F-B Asymmetry

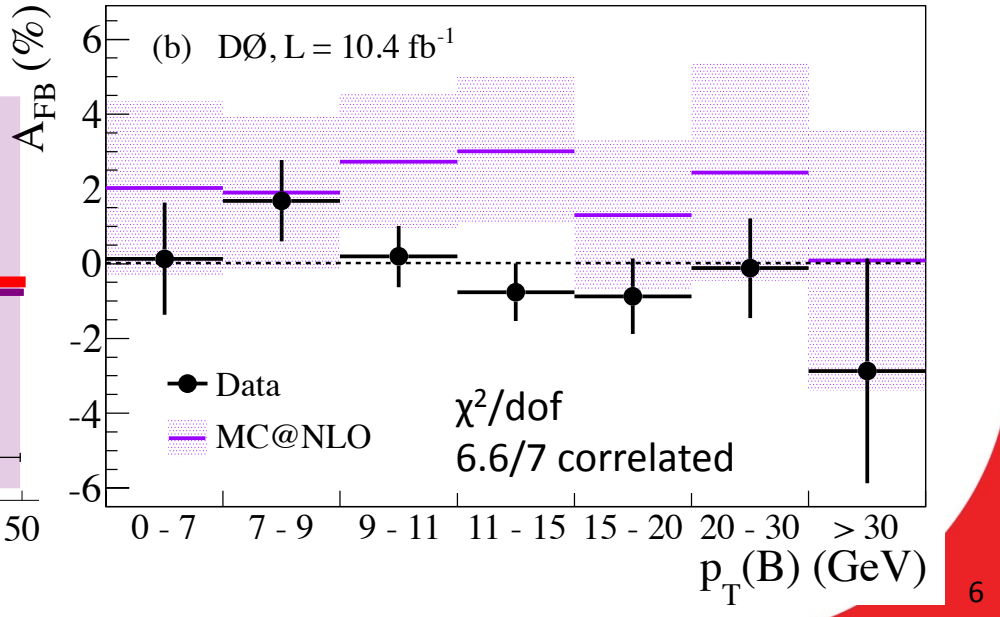
- Comparison with MC@NLO

$$A_{\mathrm{FB}}^{\mathrm{SM}} = [2.31 \pm 0.34\,(\mathrm{stat}) \pm 0.44\,(\mathrm{scale})]\,\%$$

- 3.5σ discrepancy
- Data is systematically less than the prediction.
- Improved Calculations by Christopher W. Murphy arXiv:1504.02493





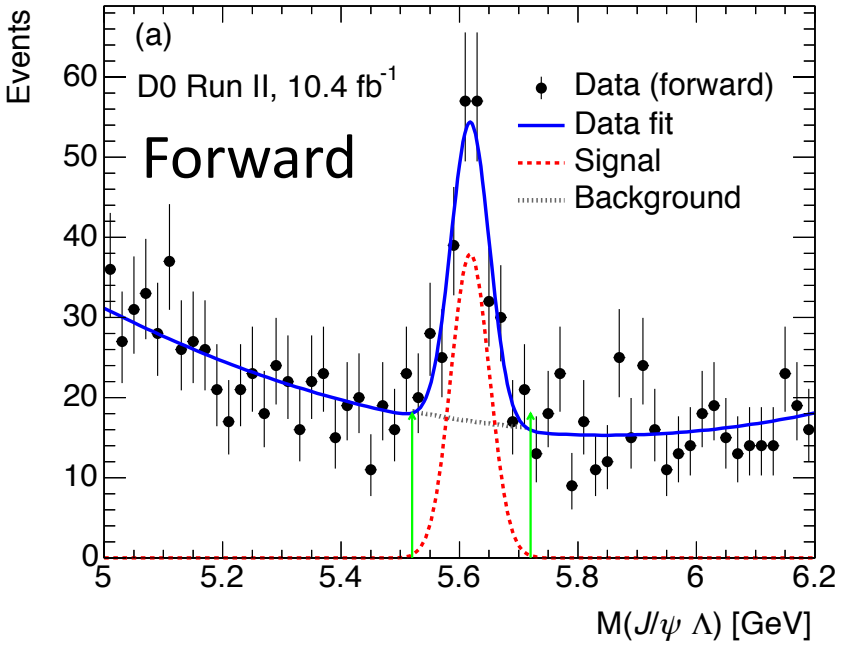


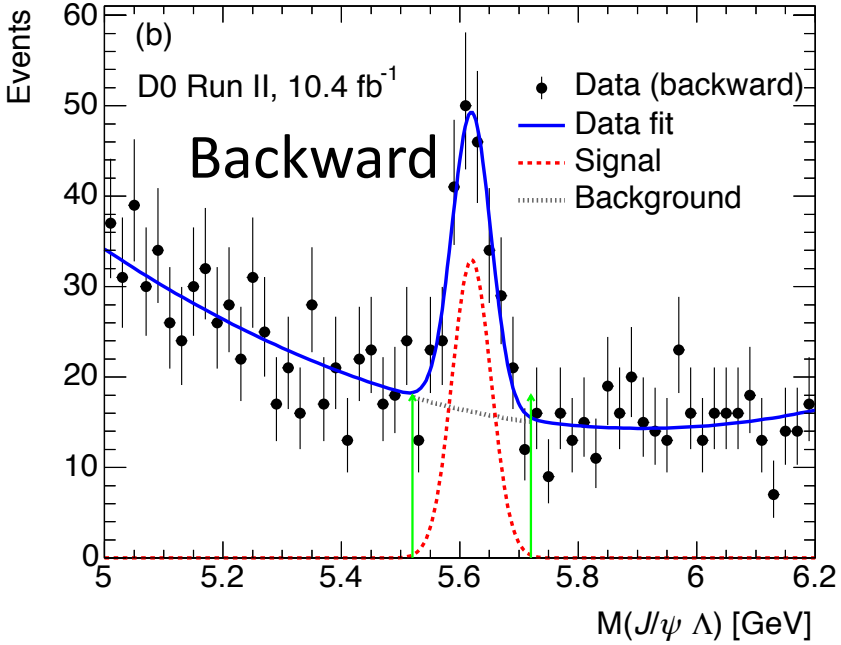
$\Lambda_b\bar{\Lambda}_b$ F-B Asymmetry

- As with B^+ the forward direction corresponds to b quark travelling in the direction of the proton.
  - Forward Λ_b in direction of proton
  - Forward $\bar{\Lambda}_b$ in direction of anti-proton

$$A_{FB} = \frac{N_F - N_B}{N_F + N_B}$$

- Search for $\Lambda_b \rightarrow J/\psi\Lambda$, $J/\psi \rightarrow \mu^+\mu^-$, $\Lambda \rightarrow p\pi^-$
- Fit with binned maximum likelihood. Gaussian signal and 2nd order Chebyshev polynomial for background.

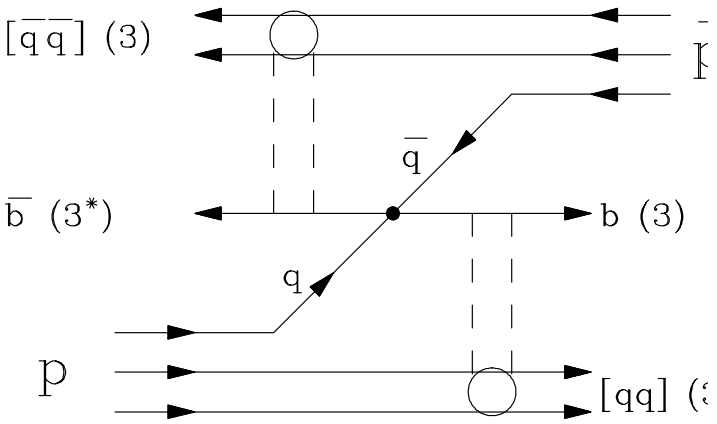


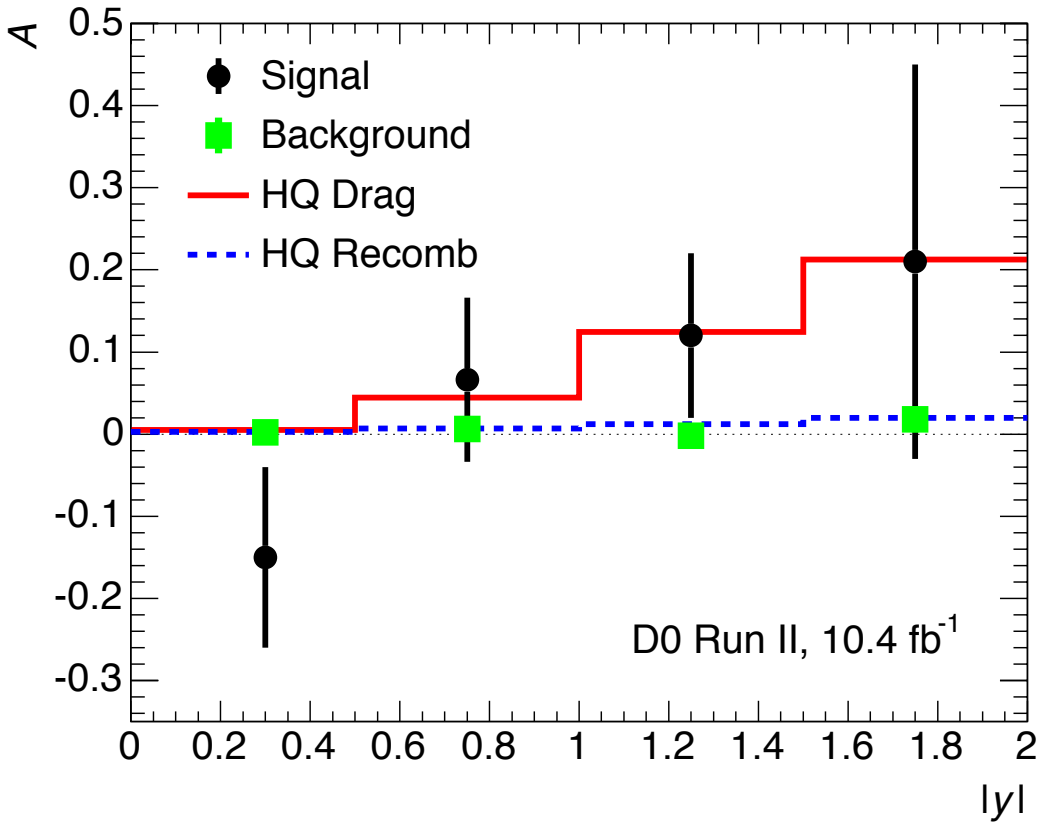


$\Lambda_b\bar{\Lambda}_b$ F-B Asymmetry

- Asymmetry vs Rapidity: 0.1 < |y| < 2.0 Phys. Rev. D 91, 072008

- "String drag" mechanism proposed by J. Rosner may favour production of Λ_b baryons in proton beam direction

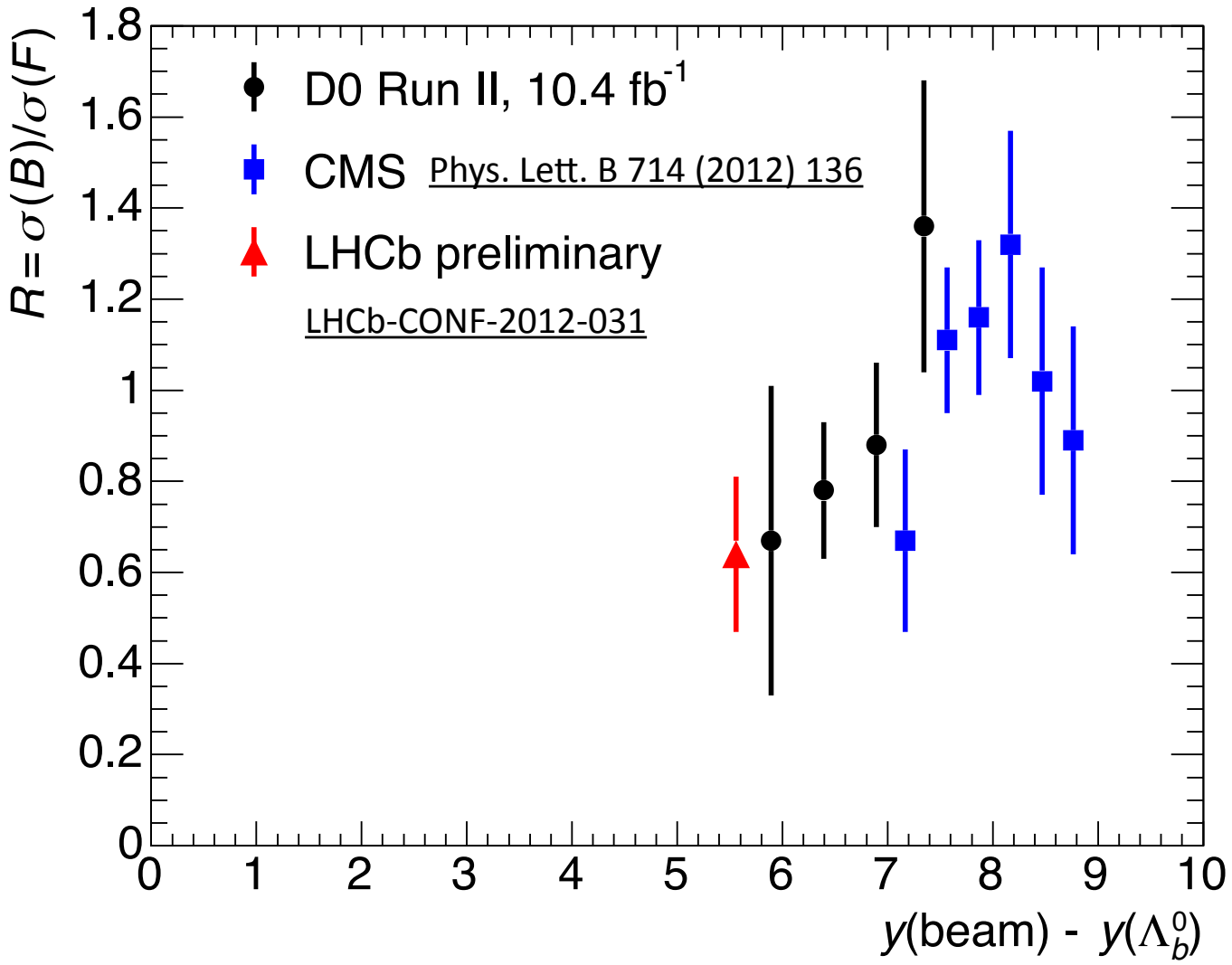




$$A_{\mathrm{FB}} = 0.04 \pm 0.07\,(\mathrm{stat}) \pm 0.02\,(\mathrm{syst})$$

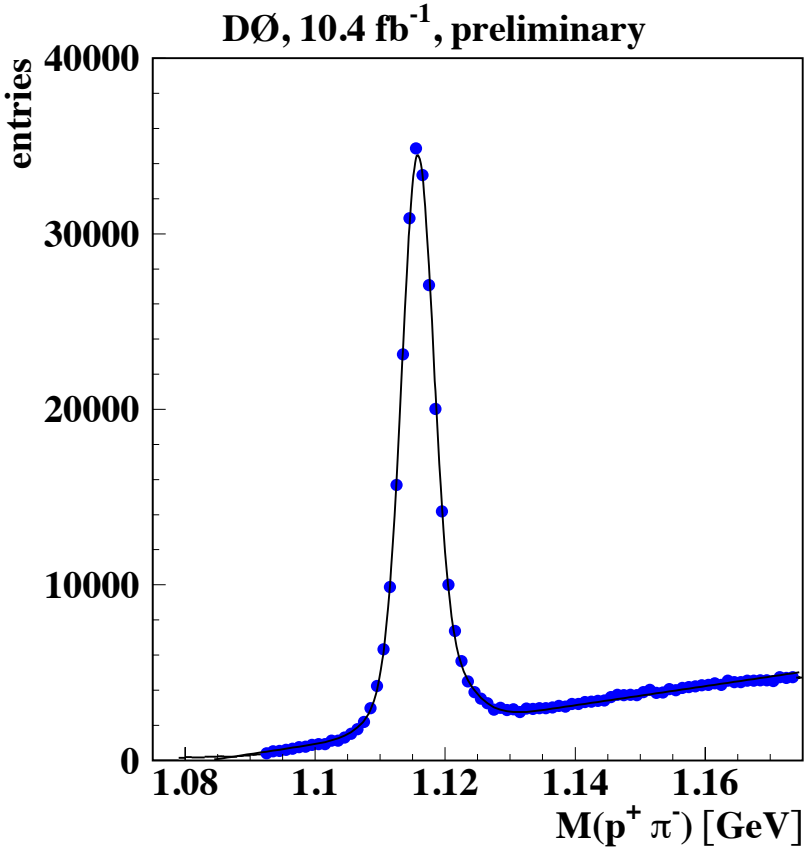
$\Lambda_b\bar{\Lambda}_b$ F-B Asymmetry

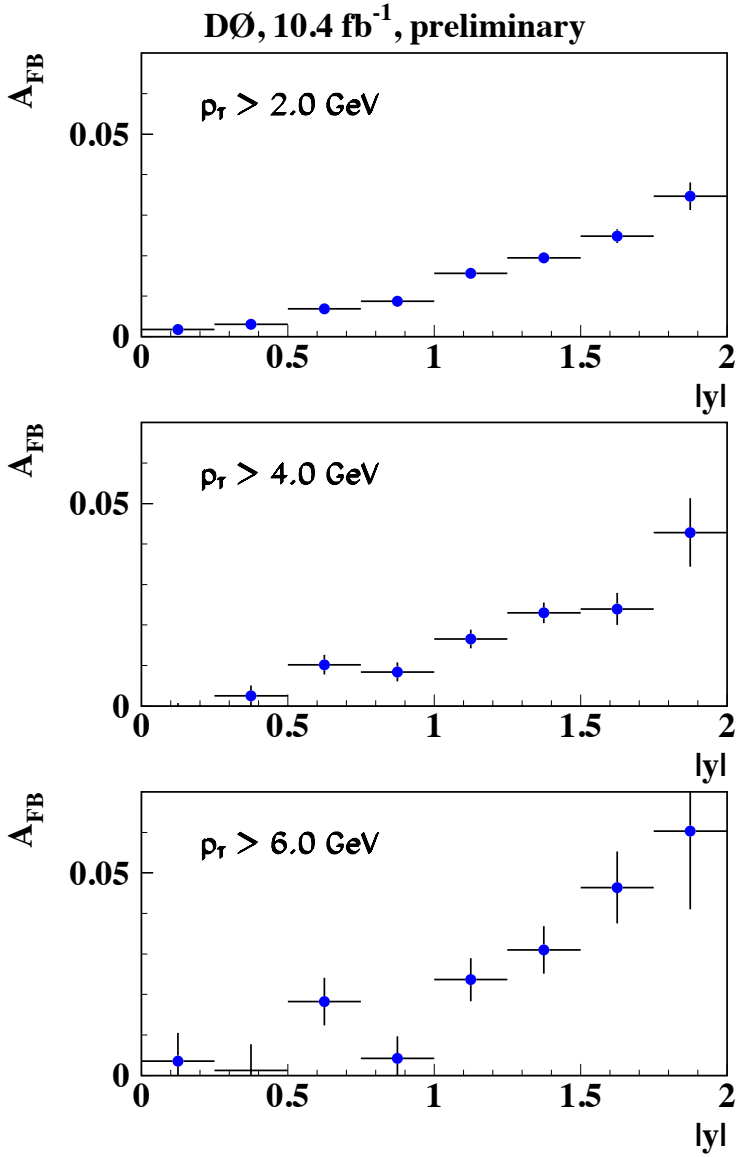
- Ratio of $\bar{\Lambda}_b/\Lambda_b$ vs rapidity loss y(beam)-y(Λ_b)



$\Lambda\bar{\Lambda}$ F-B Asymmetry

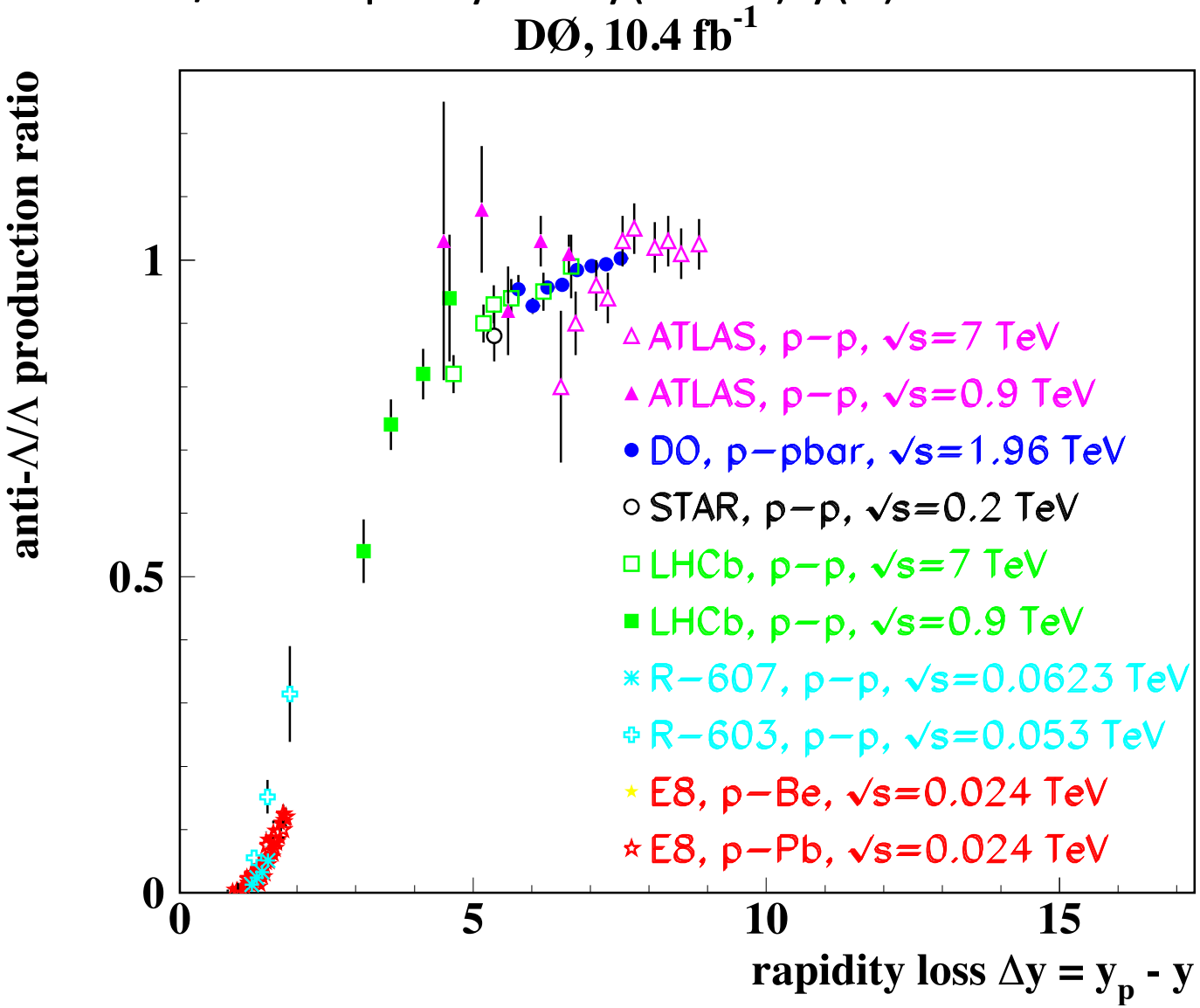
- Preliminary result: Conference Note 6464-CONF
- $\Lambda \rightarrow p\pi^-$





$\Lambda\bar{\Lambda}$ F-B Asymmetry

- Ratio of $\bar{\Lambda}/\Lambda$ vs rapidity loss y(beam)-y(Λ)

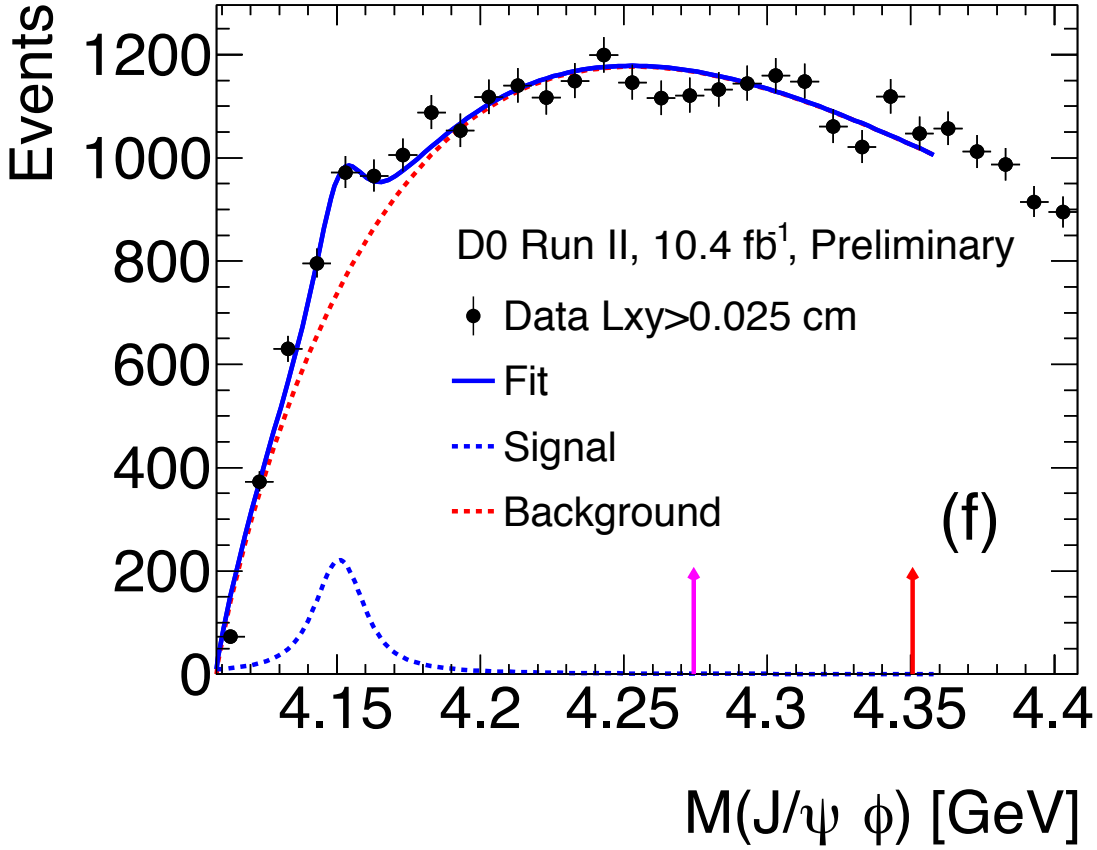


Inclusive production of X(4140)

- X(4140) is a peak in the J/ψϕ mass spectrum
  - currently seen in B^+ decays.
- Preliminary D0 Result: Conference Note 6468-CONF
- Carry out search for inclusive/prompt production of X(4140)
  - Is it produced by other b-hadron decays?
  - Is it produced directly in $\bar{p}p$ collisions?
- Measure as a function of L_{xy} and normalise to $B_s^0 \rightarrow J/\psi\phi$

Inclusive production of X(4140)

- X(4140) Signal at $L_{xy} > 250$ μm

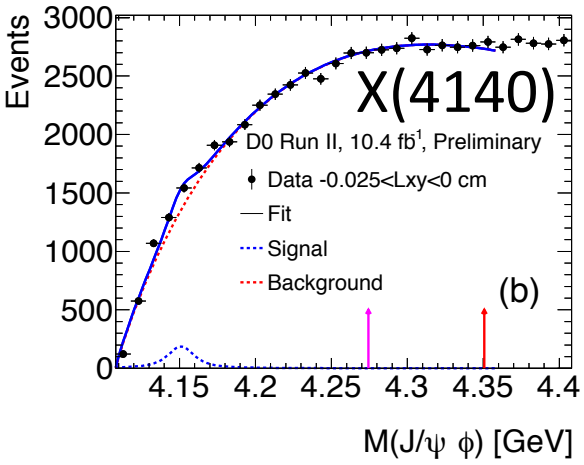


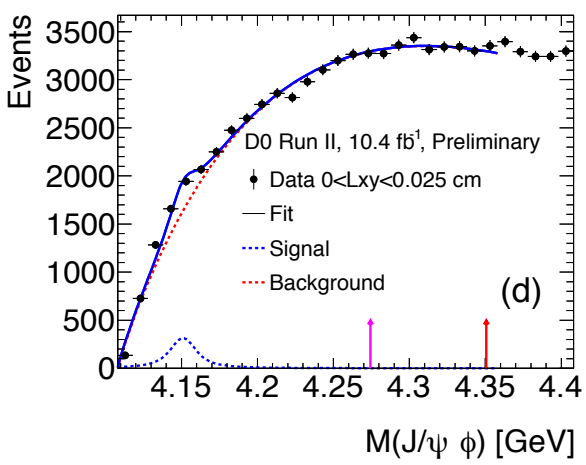
Signal: relativistic BW with free M and Γ convolved with σ = 4 MeV.

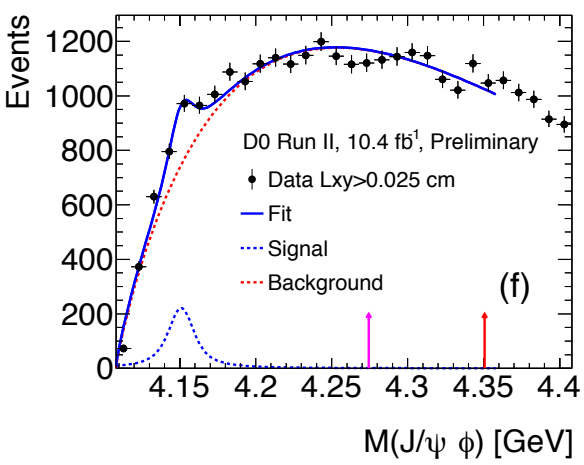
Background: $m \cdot (m^2/m_{th}^2 - 1)^c \exp(-bm)$

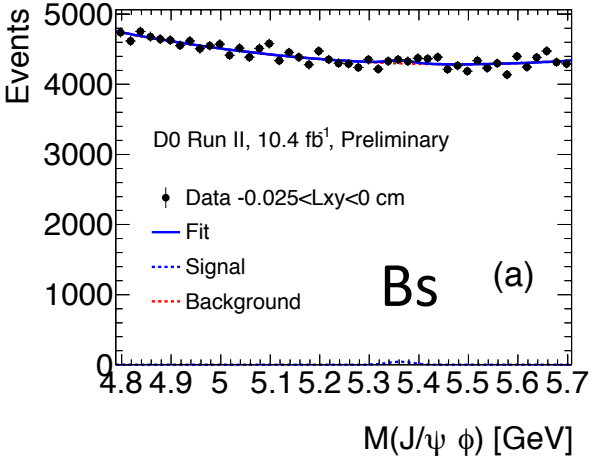
N = 616±170 M = 4152.5±1.7 MeV Γ = 16.3±5.6 MeV

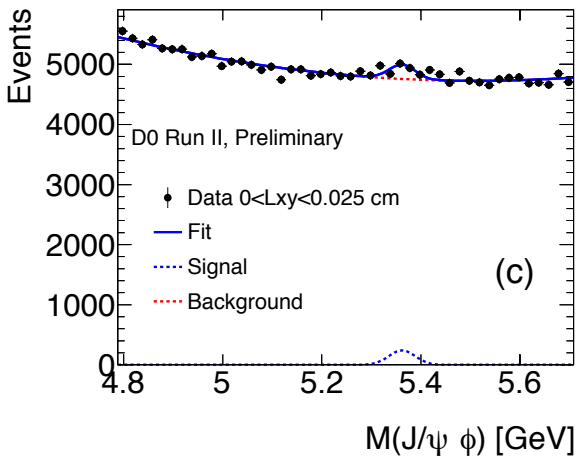
Inclusive production of X(4140)

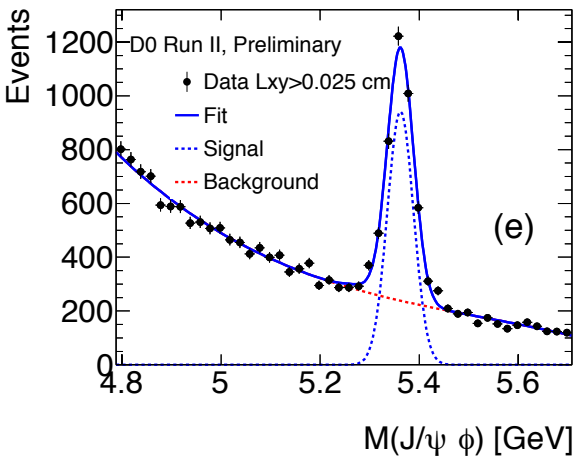












$-250 < L_{xy} < 0$ µm

$0 < L_{xy} < 250$ µm

$L_{xy} > 250$ µm

Inclusive production of X(4140)

TABLE III: Summary of $X(4140)$ measurements

Experiment	Process	Mass (MeV)	Width (MeV)
CDF [2]	$B^+ \to J/\psi\phi K^+$	$4143.0 \pm 2.9 \pm 1.2$	$11.7^{+8.3}_{-5.0} \pm 3.7$
CMS [4]	$B^+ \to J/\psi\phi K^+$	$4148.0 \pm 2.4 \pm 6.3$	$28^{+15}_{-11} \pm 19$
D0 [5]	$B^+ \to J/\psi\phi K^+$	$4159.0 \pm 4.3 \pm 6.6$	$19.9 \pm 12.6^{+3.0}_{-8.0}$
D0 (this work)	$\overline{p}p \to J/\psi\phi + \text{anything}$	$4152.5 \pm 1.7^{+4.7}_{-3.6}$	$16.3 \pm 5.6 \pm 10.3$

- The non-prompt production rate of X(4140) relative to B_s^0 is

$$R = 0.19 \pm 0.05\,(\text{stat}) \pm 0.07\,(\text{syst})$$

- The fraction originating from b hadrons

$$f_b = 0.39 \pm 0.07\,(\text{stat}) \pm 0.10\,(\text{syst})$$

  which implies prompt production of the X(4140).

- For $L_{xy} > 250$ μm total number of events is 616 ± 170 whilst the number from B^+ decays is 130 ± 60.

Conclusions

- Still producing results that are complimentary to the LHC in niche areas.
  - new tests of FB asymmetries and HF production
  - more results to come…