S. Stone

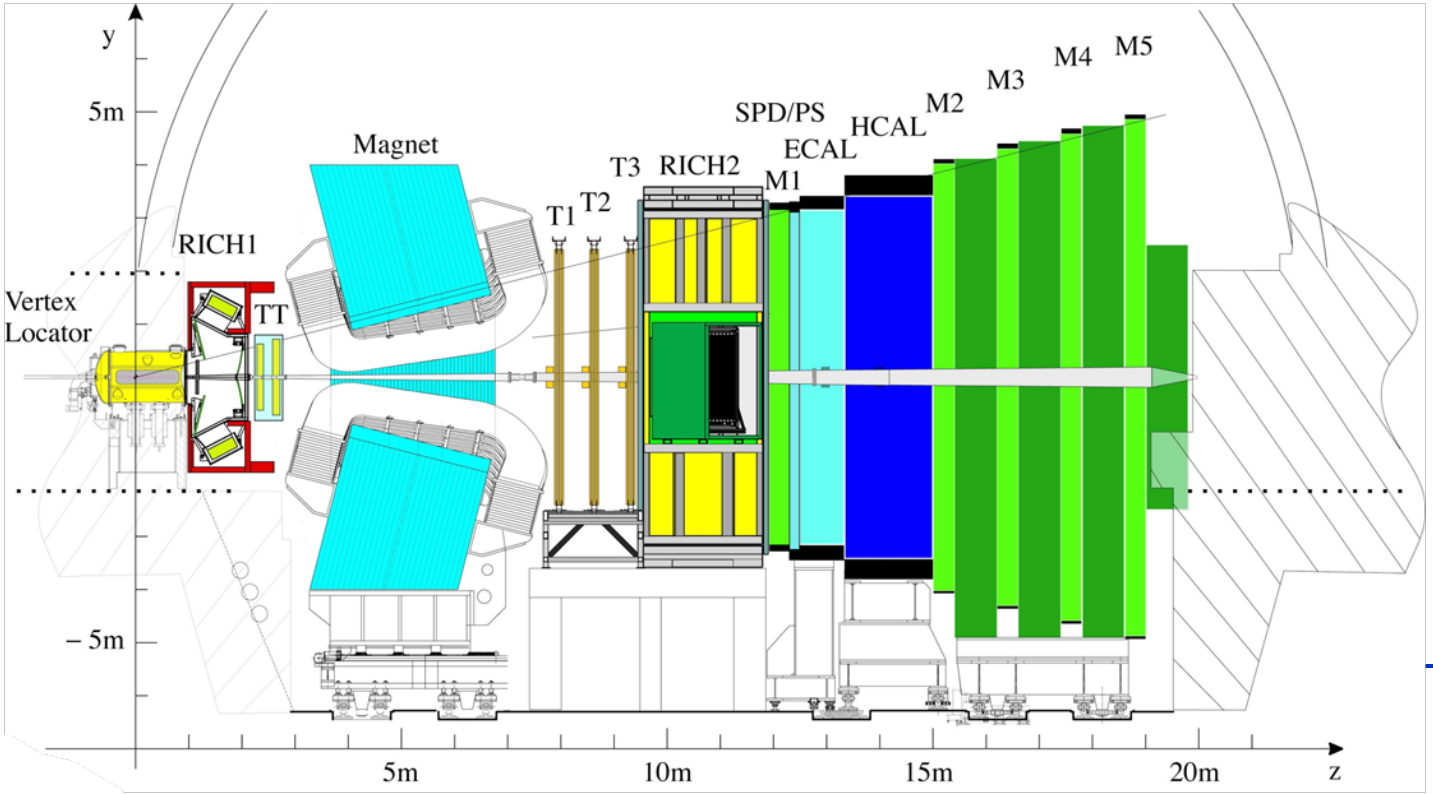
1st Physics Results from LHCb

For the LHCb collaboration

ICHEP, Paris, July 23, 2010

Introduction

- I will report on results from two data samples ~3nb^{-1} that is "untriggered," all interactions taken, & ~12 nb^{-1} that uses selective triggers. Some plots with up to ~100 nb^{-1} will be shown



Measurement of $\sigma(pp \to b\bar{b}X)$ using $B \to D^0 X \mu^- \nu$

Strategy

- Signal: Measure right-sign D^o μ^- combinations using tracks not pointing at primary vertex but which form a common vertex. (Use $D^o \rightarrow K^-\pi^+$ decays)
- The two types of D^o produced are "Prompt" and those from B's "DfB." They can be separated statistically by examining the impact parameter (IP) with respect to the primary vertex (Definition IP: smallest distance between D^o direction and primary vertex position.)

D^o selection criteria – general

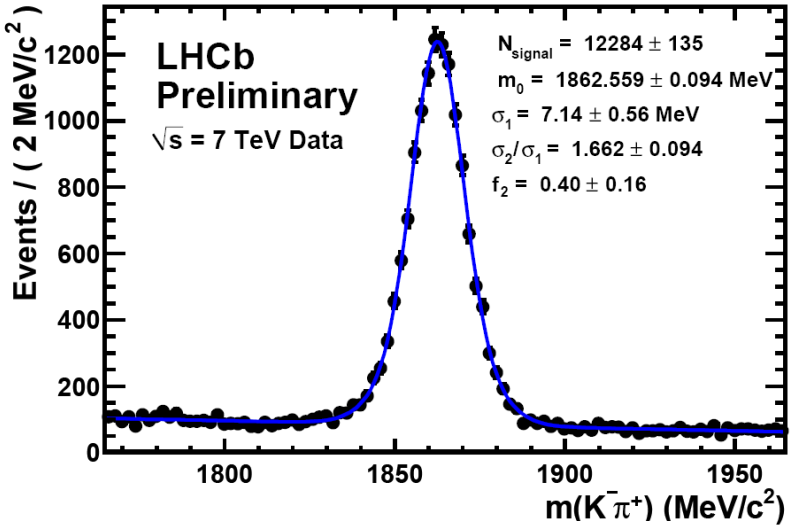
- We want to get D^o's from $B \rightarrow D^o X \mu \nu$ decays, We know $B(b \rightarrow D^o X \mu^- \nu) = (6.82 \pm 0.35)\%$
- Want to separate D^o from background events and mass combinations. A good way to do this is to require that both K & π tracks don't come from the primary vertex & that they form a vertex detached from the primary
- Require minimum p_t so that IP is well defined
- Make sure D^o is separated from primary
- Most cuts insensitive to detailed detector performance

Analysis with untriggered sample

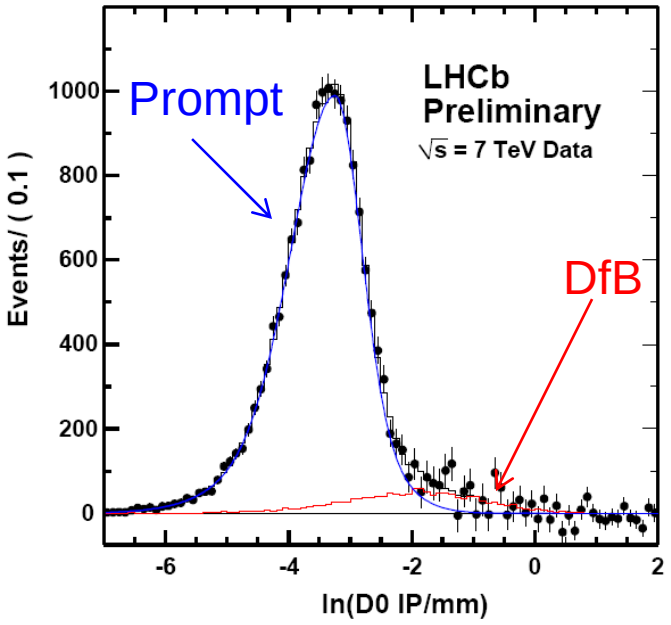
~3 nb^{-1}

Analysis with Untriggered Sample

- $K^-\pi^+$ mass spectrum used to define signal shape

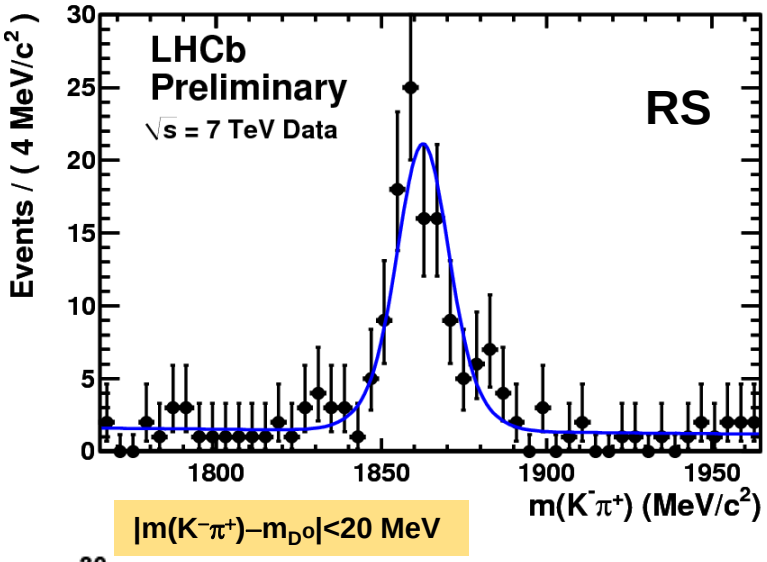


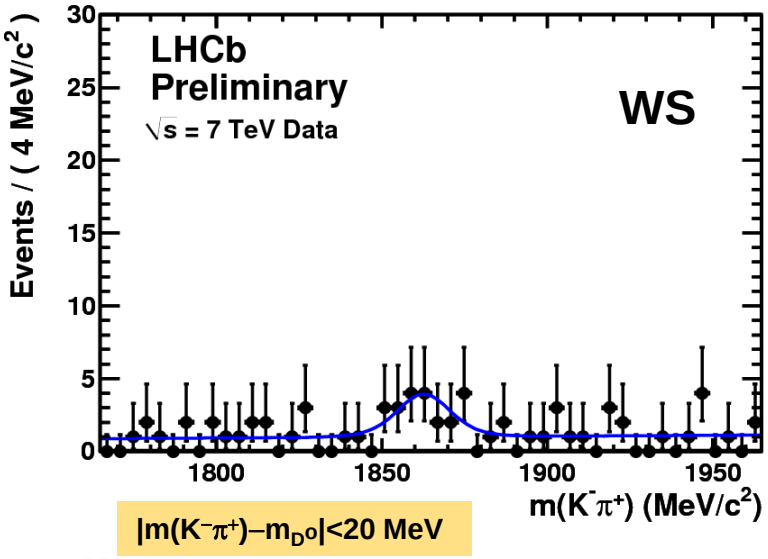
- IP distribution used to separate Prompt & DfB



~3 nb^{-1}

Fits to $D^0\mu$


LHCb
Preliminary
√s = 7 TeV Data
RS
Events / (4 MeV/c²)
m(K⁻π⁺) (MeV/c²)
|m(K⁻π⁺)–m_D0|<20 MeV


LHCb
Preliminary
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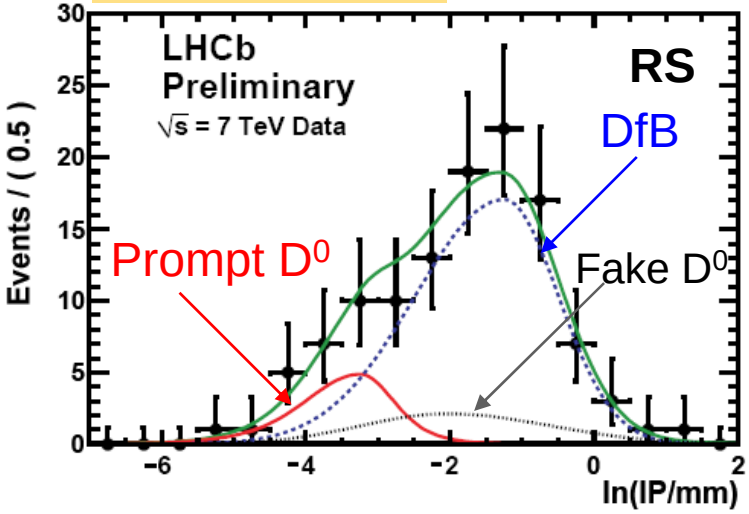
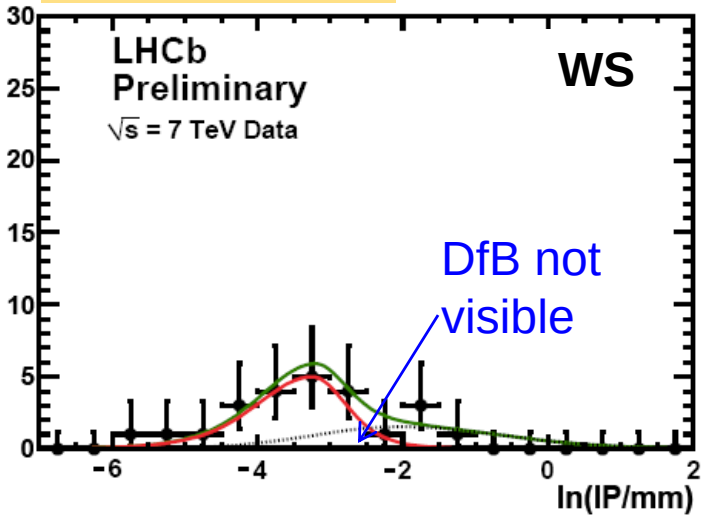
WS
Events / (4 MeV/c²)
m(K⁻π⁺) (MeV/c²)
|m(K⁻π⁺)–m_D0|<20 MeV


LHCb
Preliminary
√s = 7 TeV Data
RS
DfB
Prompt D⁰
Fake D⁰
Events / (0.5)
ln(IP/mm)


LHCb
Preliminary
√s = 7 TeV Data
WS
DfB not
visible
ln(IP/mm)

Fit procedure and results

- Unbinned log-likelihood fit simultaneously to $m(K^-\pi^+)$ & ln(IP). Separate fits for RS and WS samples
- We take the $m(K^-\pi^+)$ shape from the Prompt.
- The ln(IP) shape for Prompt is determined from data & that of DfB from MC that matches the IP resolution of the Prompt
- $m(K^-\pi^+)$ sidebands then give the background under the D^0 peak
- Only free parameters are yields

Yields in $|m(K^-\pi^+)-m_{D^0}|<20$ MeV

$\eta \in [2, 6]$

Yields	RS	WS
Prompt	16.3±5.4	14.9±4.2
DfB	84.1±10.4	0.0±1.1
Fake D^0	14.0±1.9	10.1±1.5

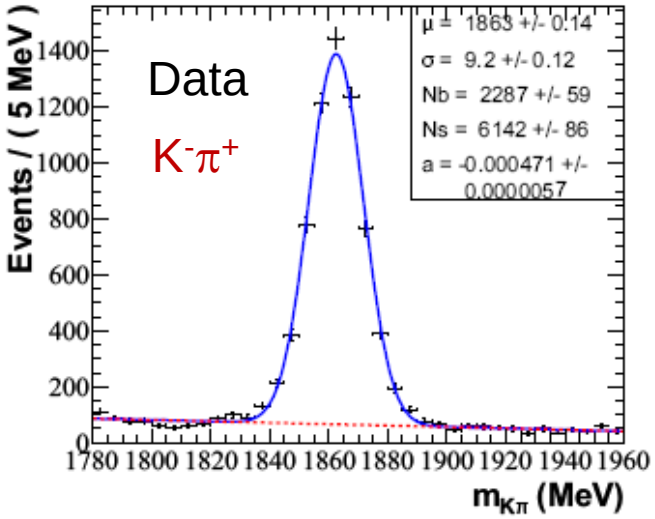
Systematic Errors

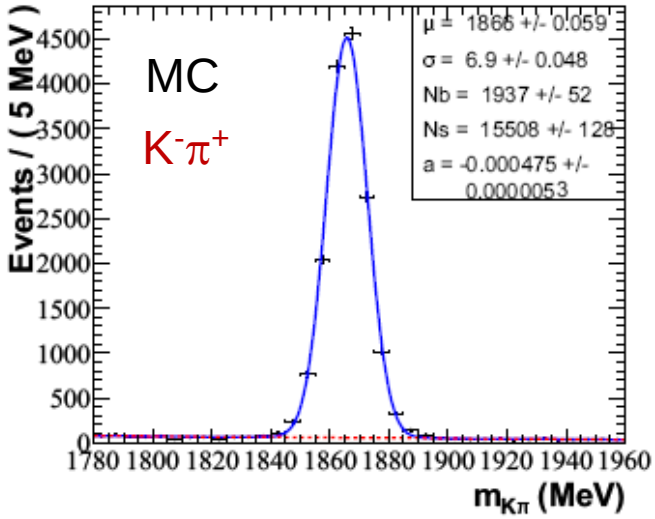
- Determined from data whenever possible
- Ex: Tracking efficiency

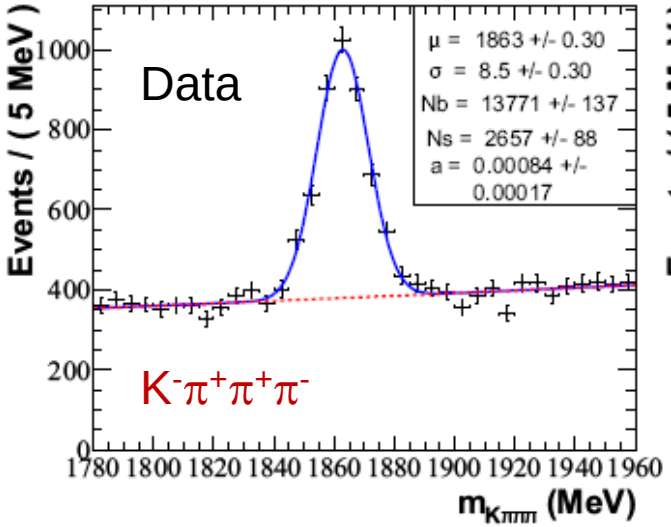
Source	Error (%)
IP χ^2	2.5
D^0 Flight Distance	0.4
D^0 vertex χ^2	0.6
π^+ identification	0.3
D^0 mass cut	1.0
Tracking	10.0
$D^0\mu^-$ vertex χ^2	1.2
Muon identification	2.5
Muon fakes	1.0
Kaon identification	1.2
Prompt & DfB Shapes	1.4
$\mathcal{B}(b \to D^0 X \mu^- \overline{\nu})$	5.1
Fragmentation fractions	4.2
Luminosity	10.0
Efficiency MC Statistics	1.5
Efficiency assumed branching ratios	4.4
Efficiency assumed p_t distribution	3.0
Total	17.2

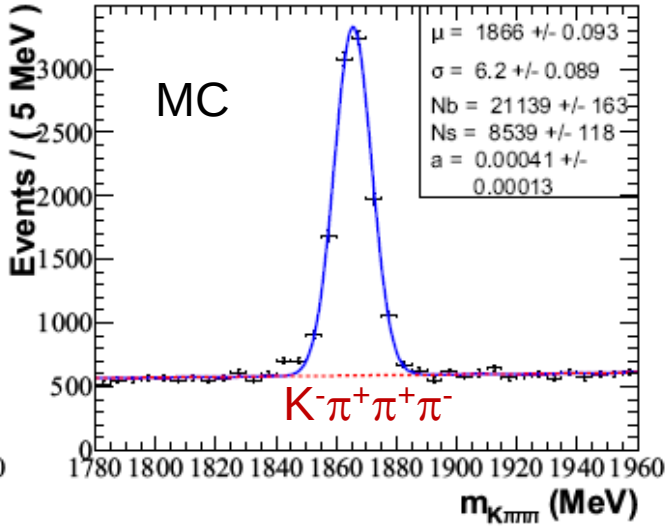
Tracking efficiency

- Ratio of K3π/Kπ data/MC gives 1.00±0.03 per track





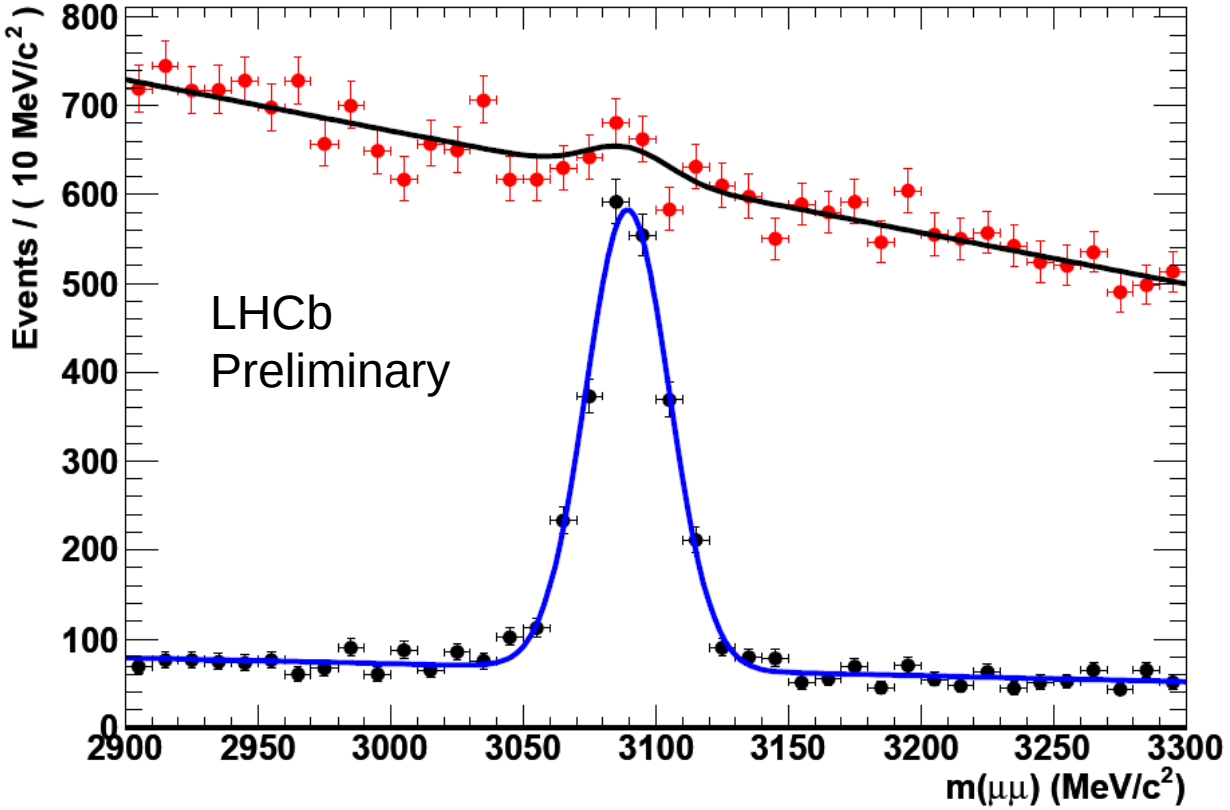




LHCb preliminary
~3 nb⁻¹

Muon Efficiency Determination

- Measure single μ efficiency by using J/ψ with only one μ identified. ε data/MC = $(96.9^{+2.4}_{-2.5})\%$



Dependence due to fragmentation

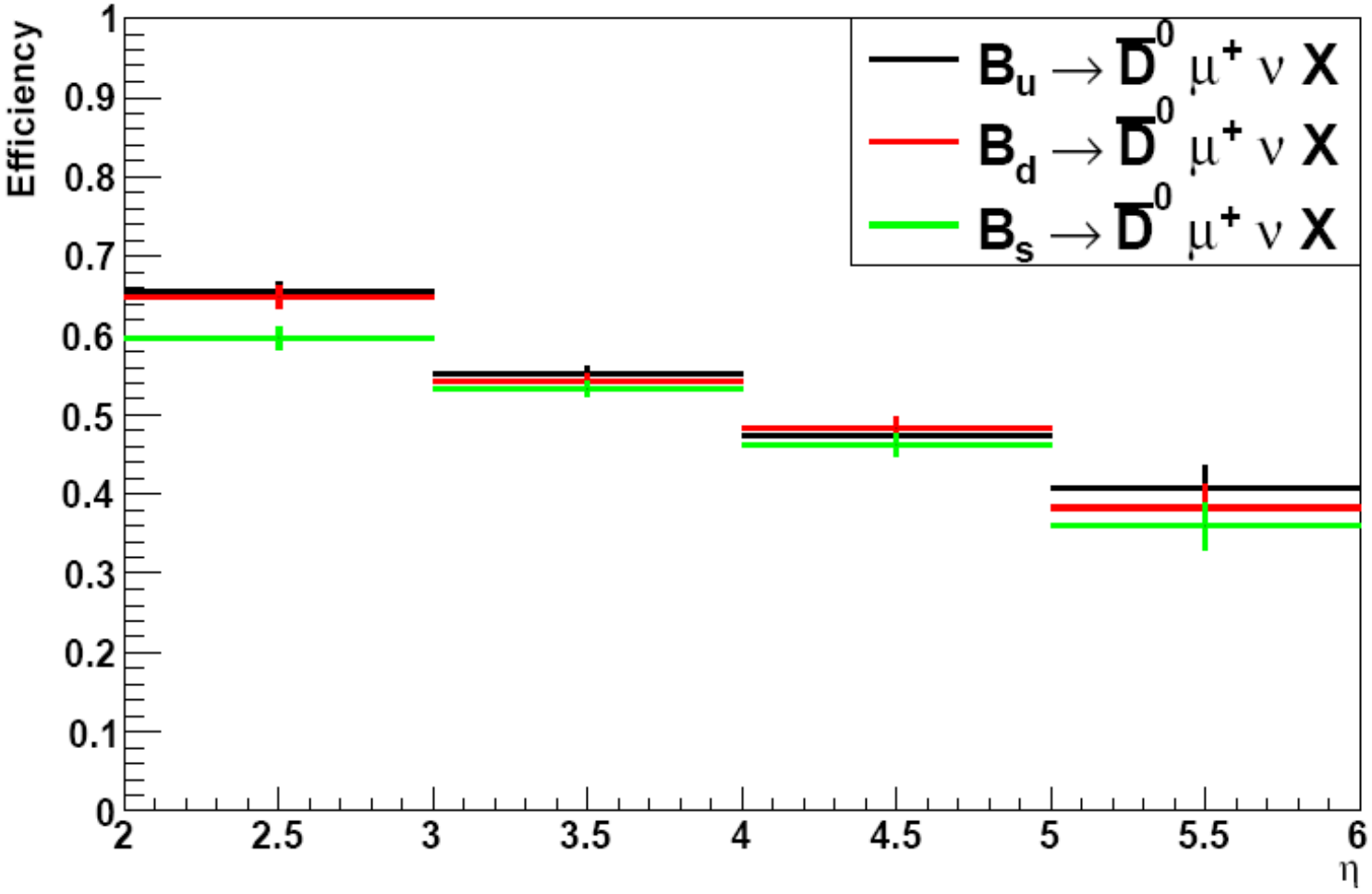
Species	Z^o fraction (%)	Tevatron fraction (%)
B^-	40.3±0.9	33.3±3.0
B^0	40.3±0.9	33.3±3.0
B_s	10.4±0.9	12.1±1.5
Λ_b	9.1±1.5	21.4±6.8

- Using the Tevatron numbers rather than LEP, raises the cross-section by 19%

HLT1 Triggered additional 12 nb^{-1}

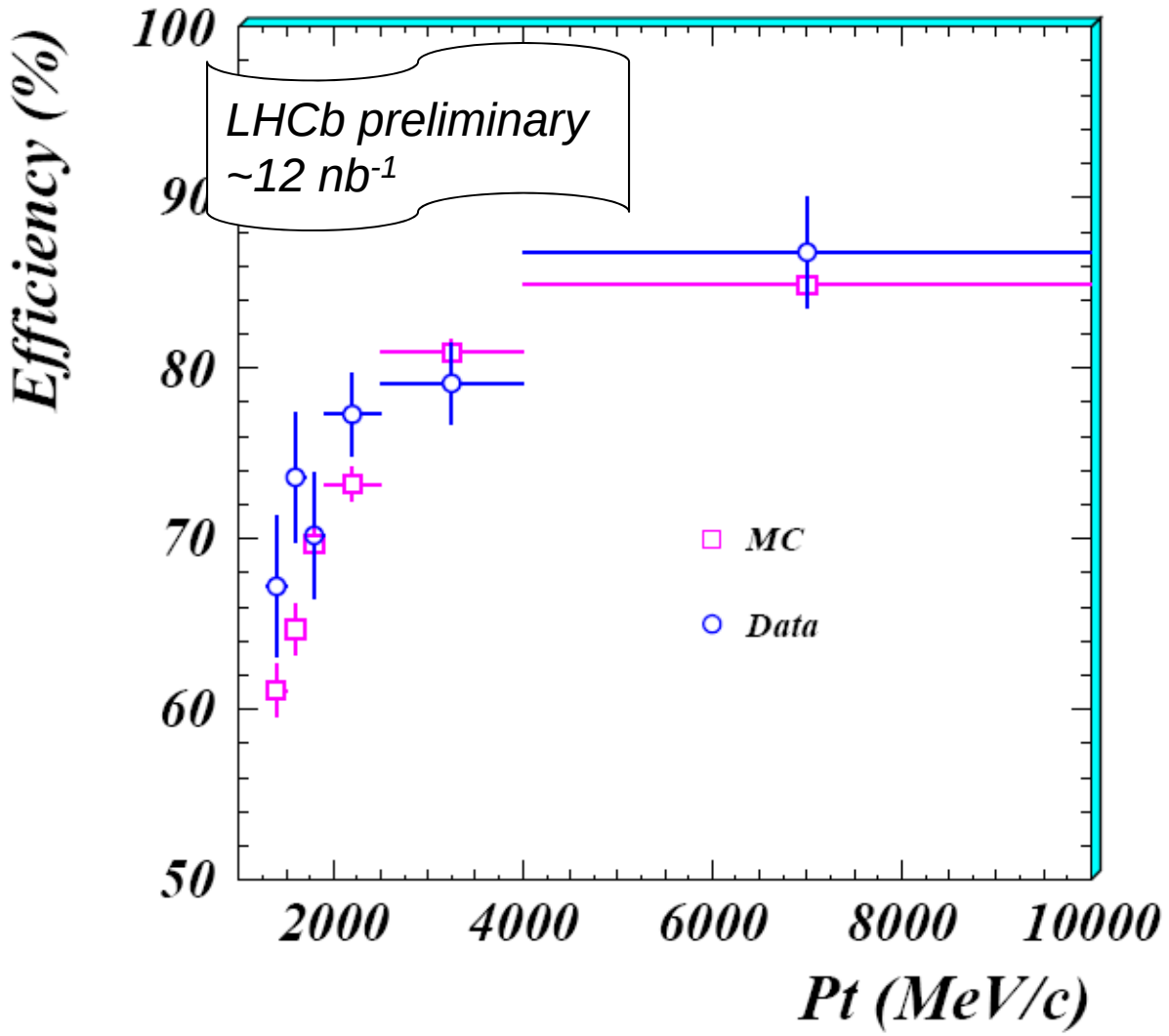
Use single muon trigger with p_t>1.3 GeV/c (0.5 GeV/c in untriggered sample)

Extra problem: Trigger Efficiency



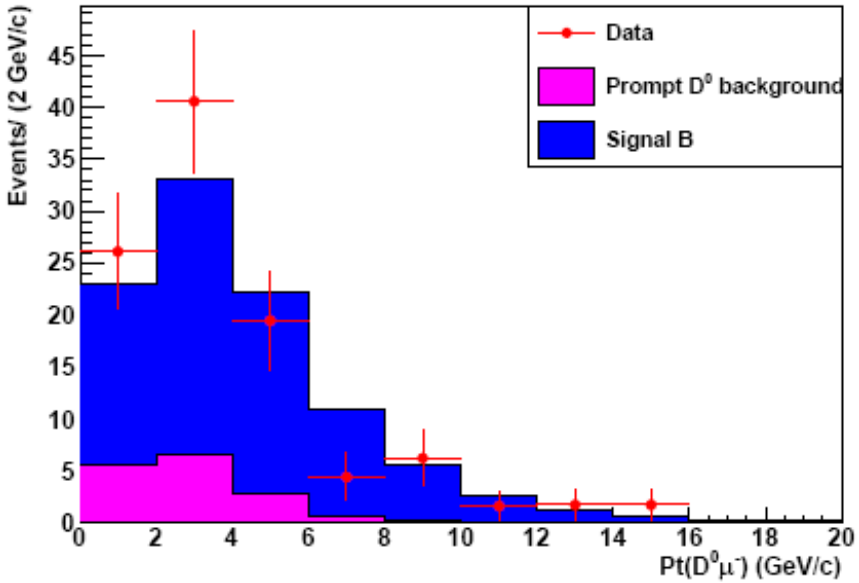
Checked with data

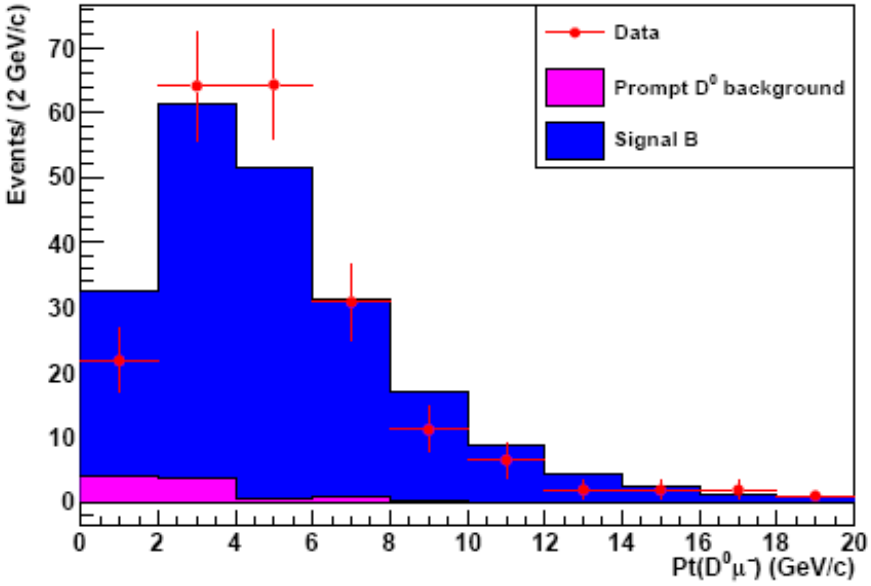
- Evaluated using other triggers that fired independently of the single muon trigger that we use for our signal (TIS)



p_t

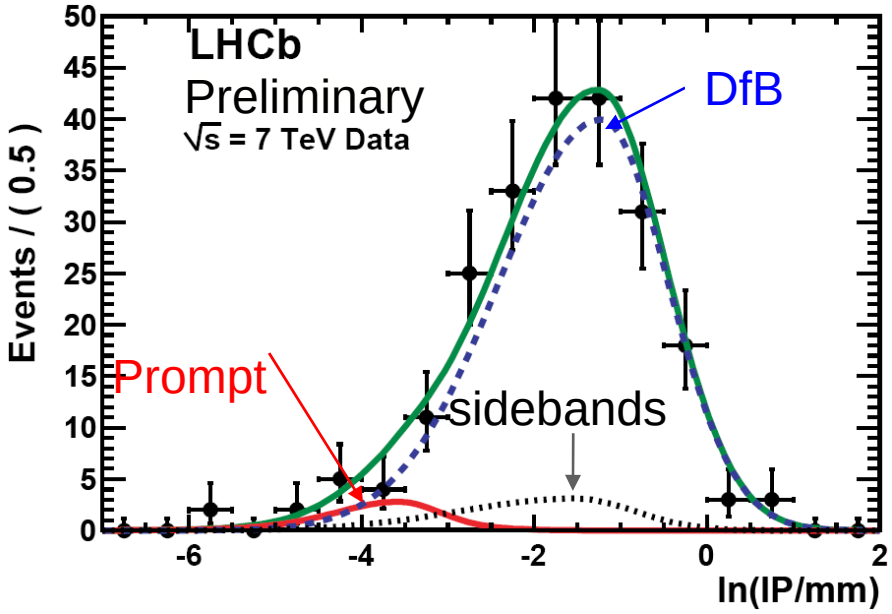
- Checked that $p_t(D^o + \mu^-)$ agrees with Monte Carlo simulation of b production x detector acceptance





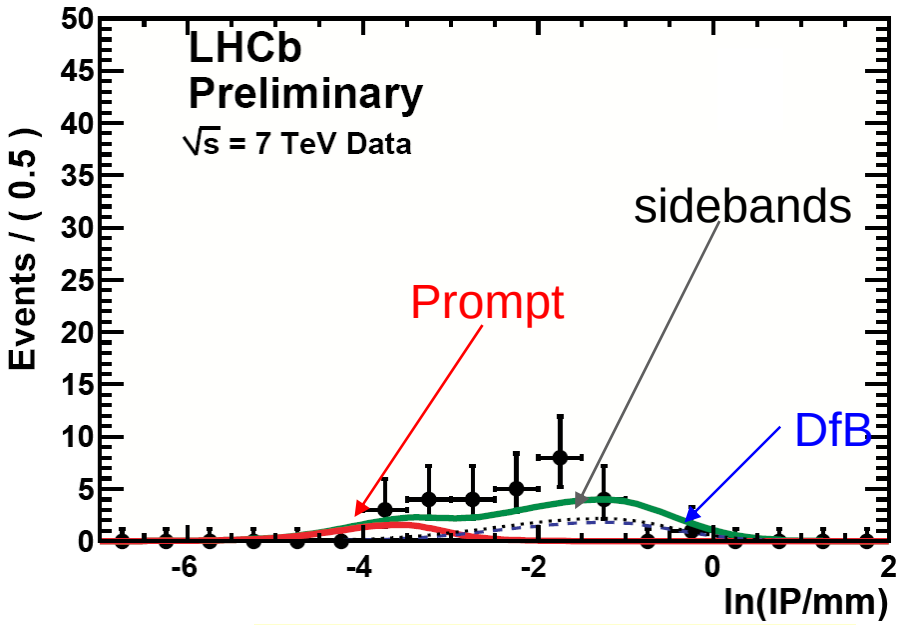
IP distributions from 12/nb

RS



195±15 events

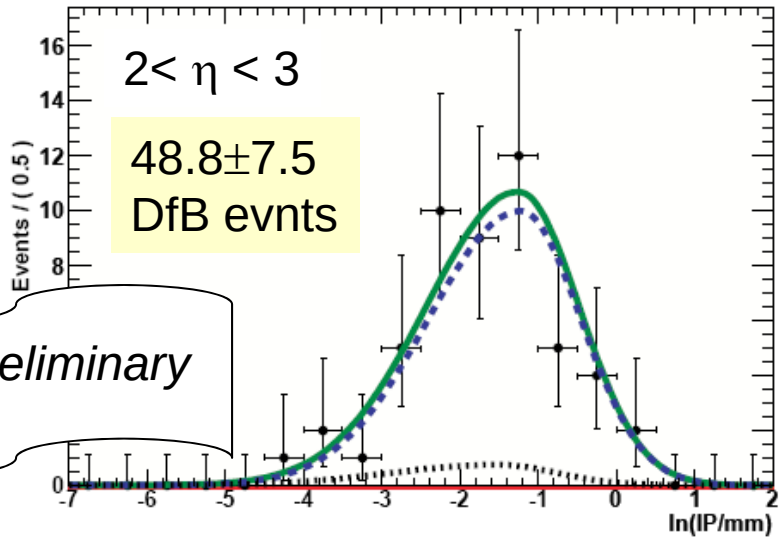
WS

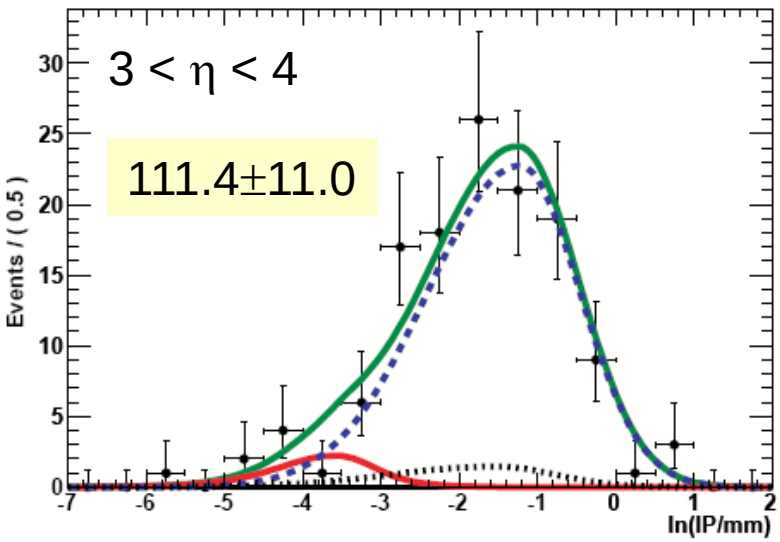


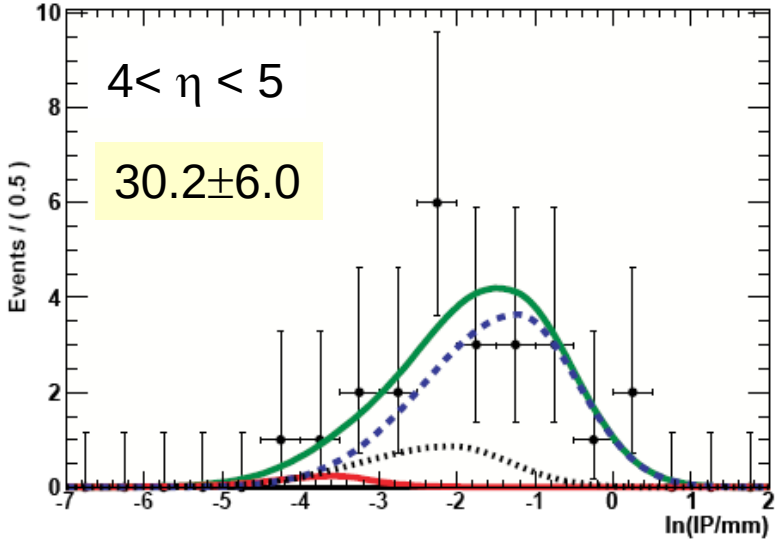
WS: 8.8±5.1 events

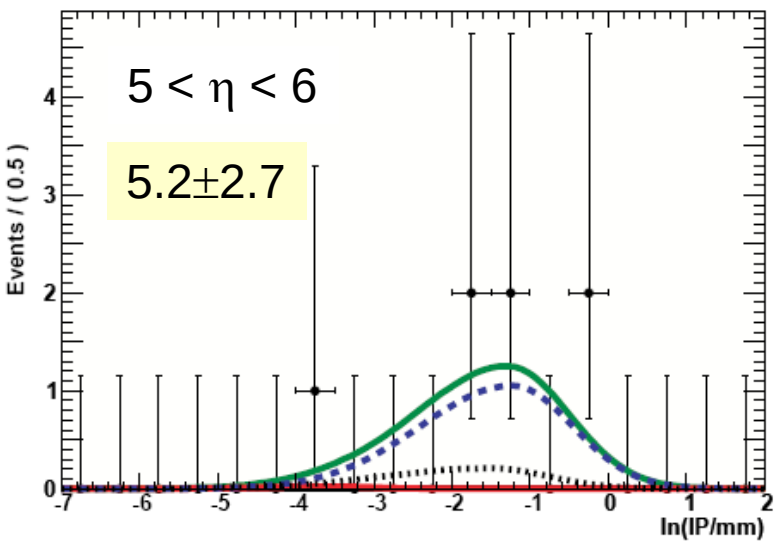
$2 < \eta < 6$

IP distributions from 12/nb in η bins







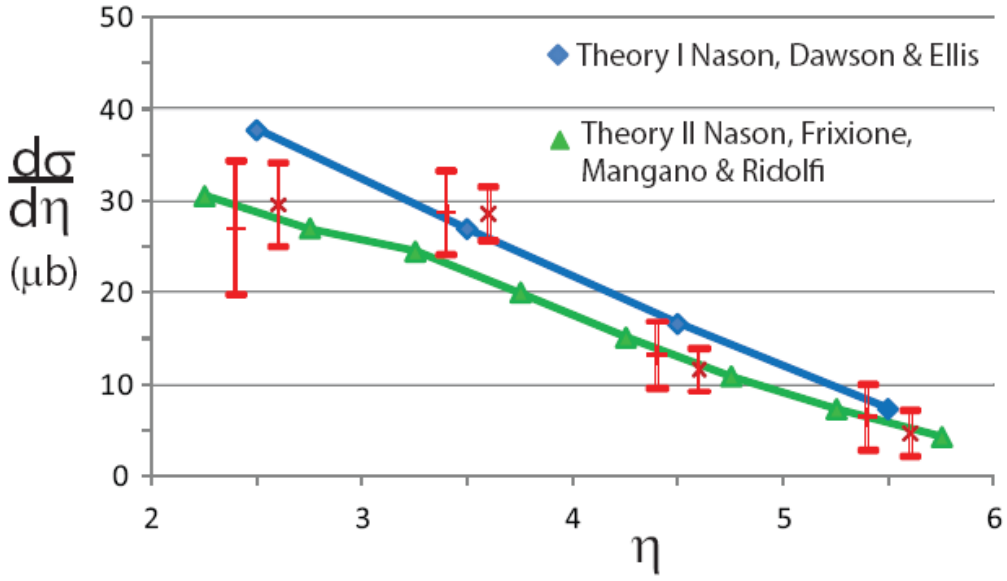


LHCb preliminary
~12 nb^{-1}

Systematic Errors in Triggered Sample

- Same as in untriggered sample PLUS η dependent trigger efficiency
- We use the uncertainties in the corrections to the trigger efficiency measured using the data (TIS check described earlier) as the systematic error
- This error is added in quadrature to the statistical error in each η bin

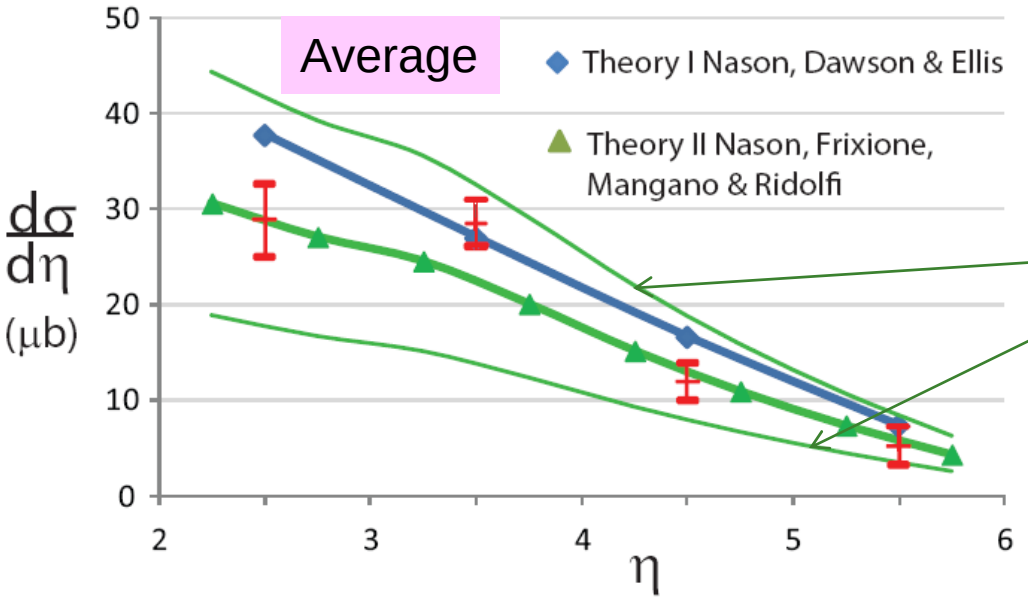
$d\sigma/d\eta$ Summary



+ -Untriggered

x - Single Muon Trigger

$$\sigma_{H_b/2} = \frac{\#\text{ of detected } D^0\mu^- \ \&\ \bar{D}^0\mu^+}{L \text{ x efficiency x } 2}$$



Error on theory

$\sigma(pp \to b\bar{b}X)$ using $D^0 X \mu\nu$ at 7 TeV

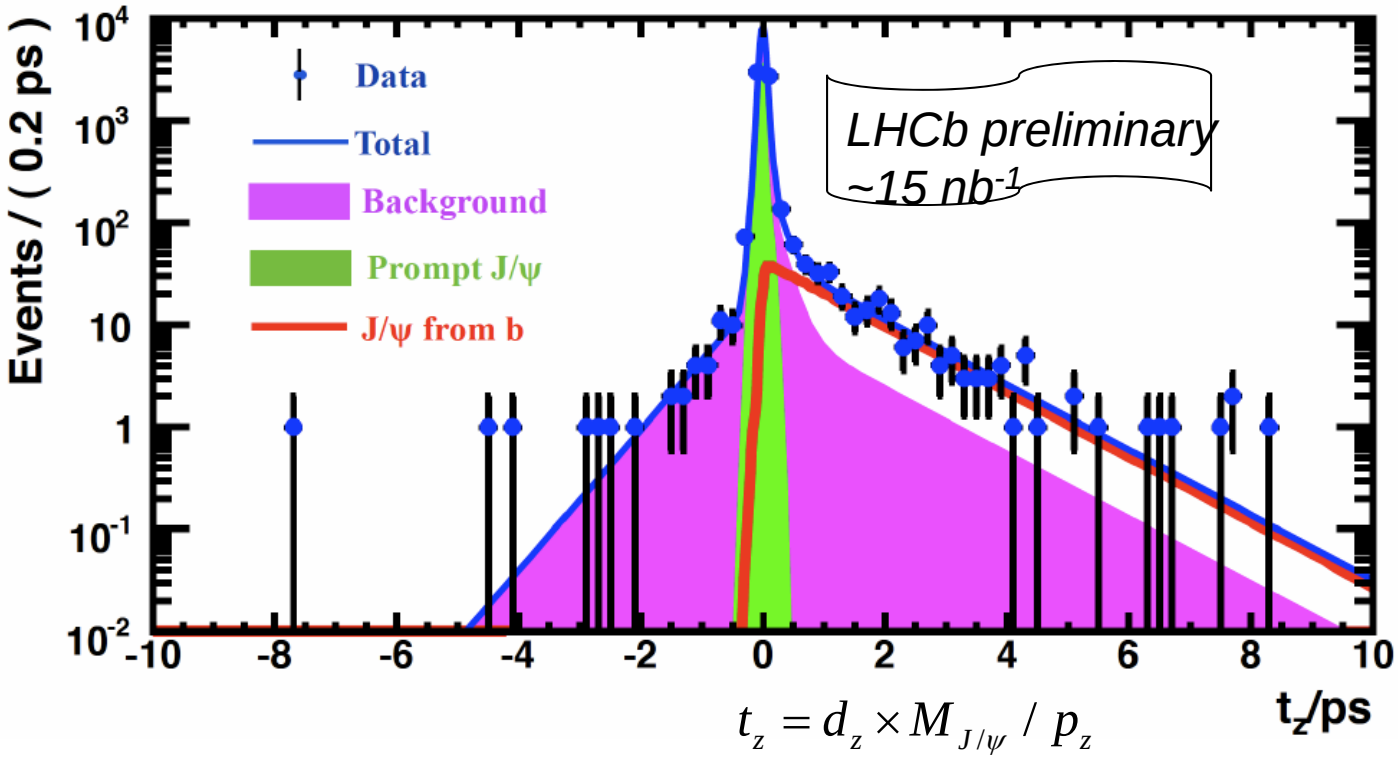
- Exp. Central values assuming LEP fragmentation fractions: All numbers in μb

η	Theory I	Theory II	Untriggered	Single muon trigger	Average
2,6	89	70^{+39}_{-44}	$75.4 \pm 10.0 \pm 13.0$	$74.6 \pm 6.4 \pm 12.8$	$74.9 \pm 5.3 \pm 12.8$
all	332	253^{+114}_{-96}			$282 \pm 20 \pm 48$

- Using Tevatron b-hadron fractions would get 336 μb

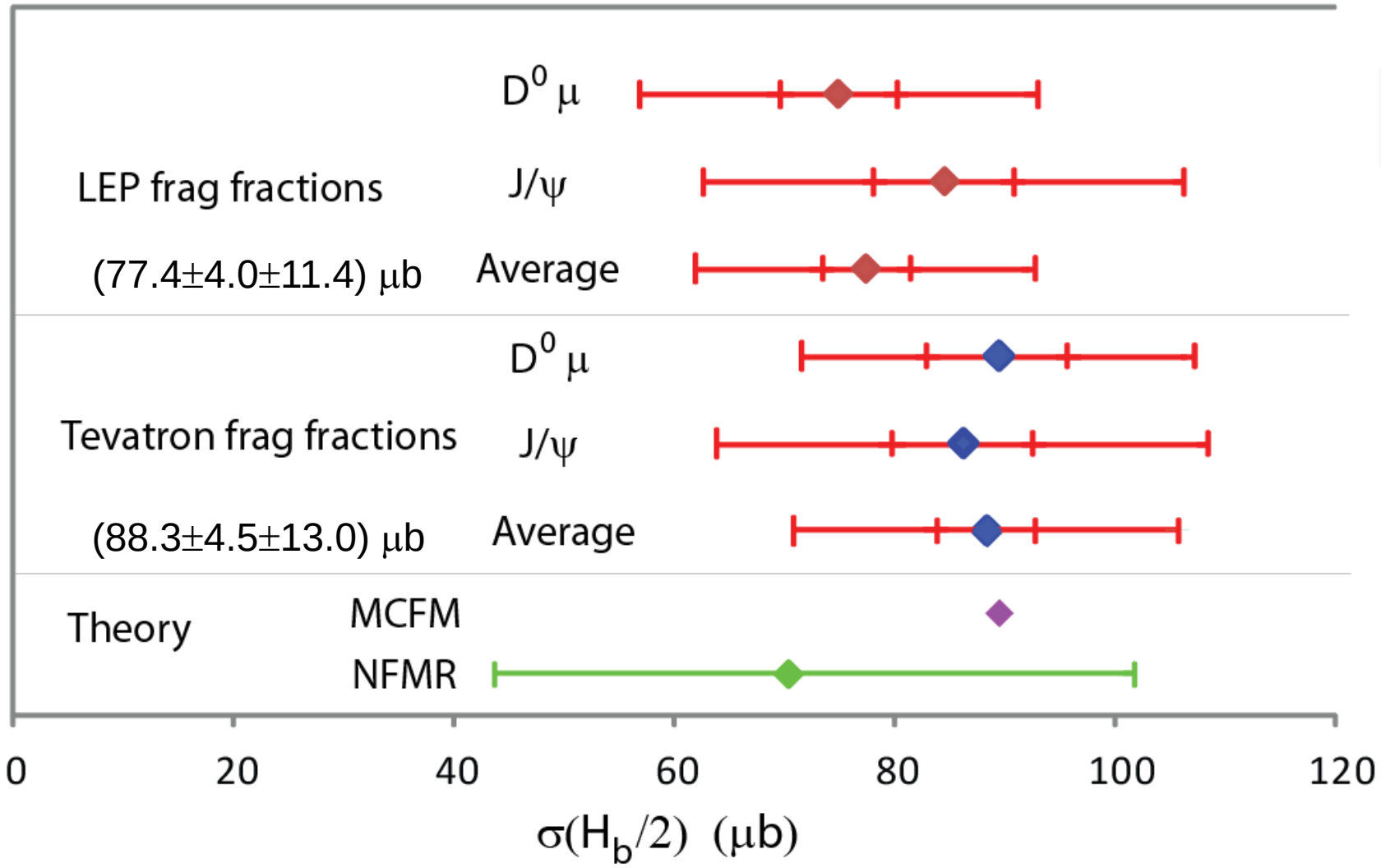
$\sigma(pp \to b\bar{b}X)$ using $b \to J/\psi X$

- See talk of G. Passaleva track 5 22/7 9:30



- In $2<\eta<6$, $(84.5 \pm 6.3 \pm 15.6)$ μb LEP frag
- In $2<\eta<6$, 86.2 μb Tevatron frag

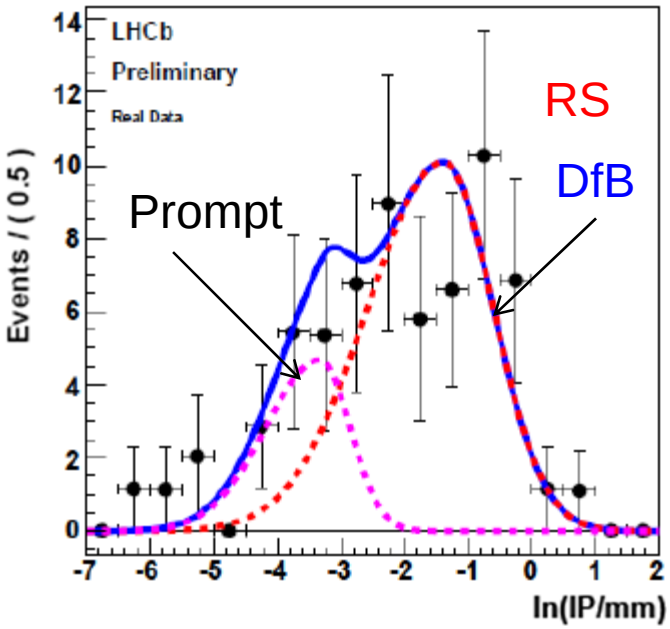
Average $\sigma(pp \to b\bar{b}X)$

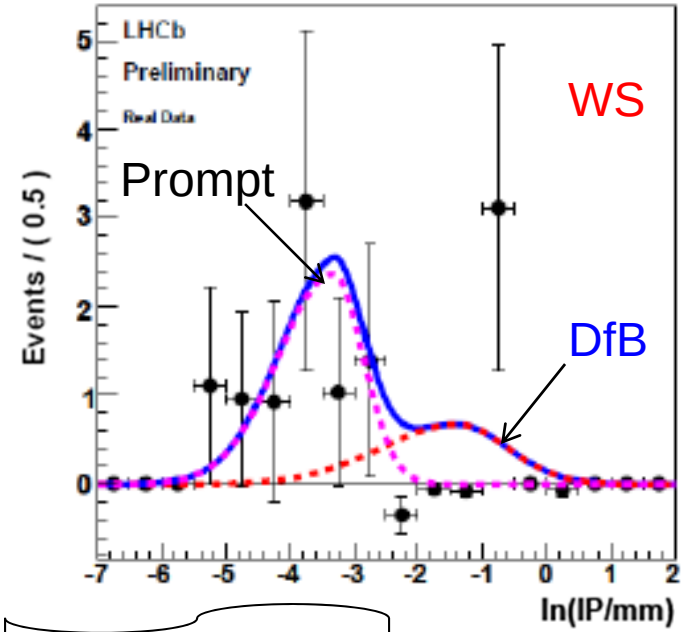


$\sigma(pp \to b\bar{b}X)$ Over all phase space

- To get over all η multiply by 3.77 (Pythia), 3.63 (MCFM), 3.73 (NFMR)
- $\sigma = (292 \pm 15 \pm 43)$ μb LEP frag fractions
- $\sigma = 333$ μb Tevatron frag functions
- Theory: MCFM 332 μb, NFMR 254 μb

$B^0 \to D^{*+} \mu \nu$



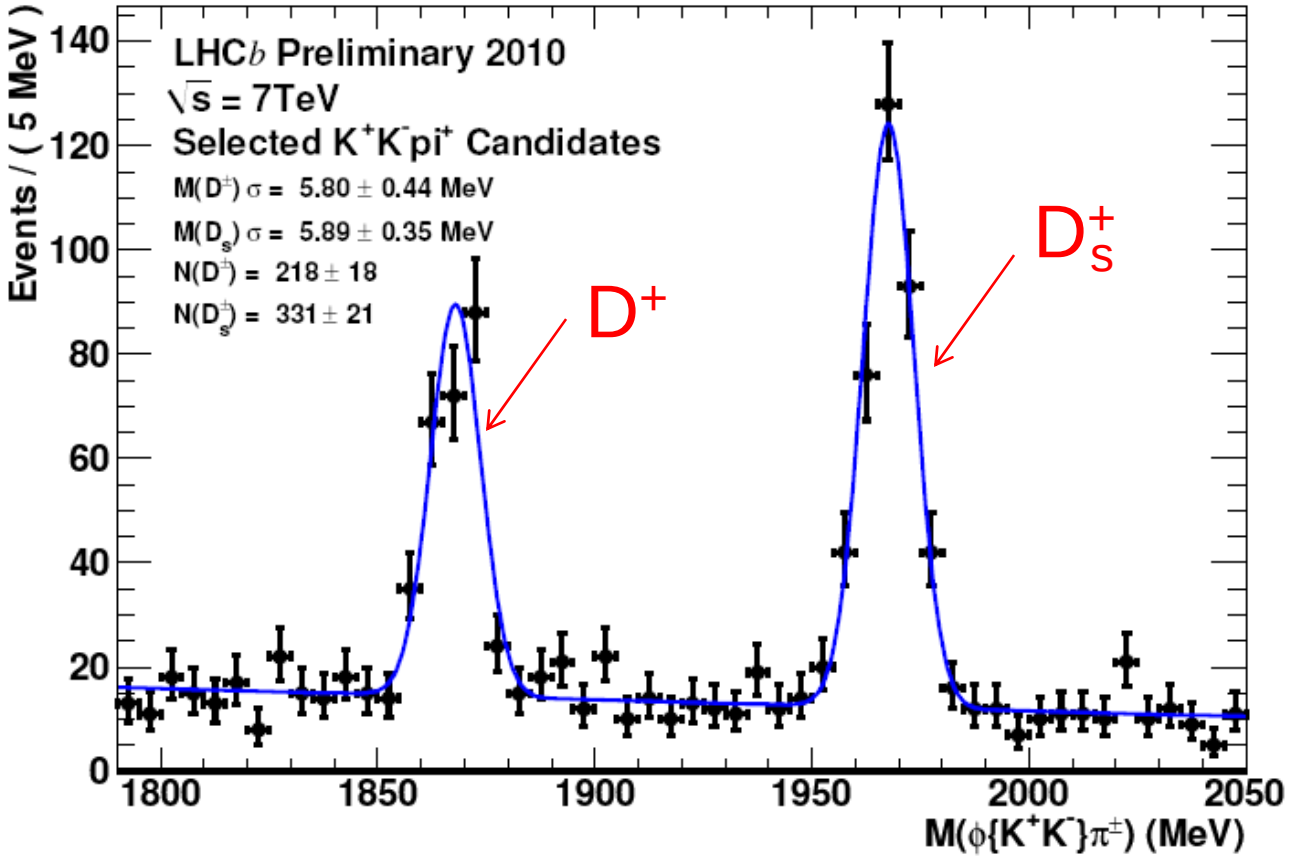


LHCb preliminary
~15 nb^{-1}

- Used as a check
- σ = (275±44±66) μb LEP frag fractions
- σ = 333 μb Tevatron frag functions

Also Charm Production Results

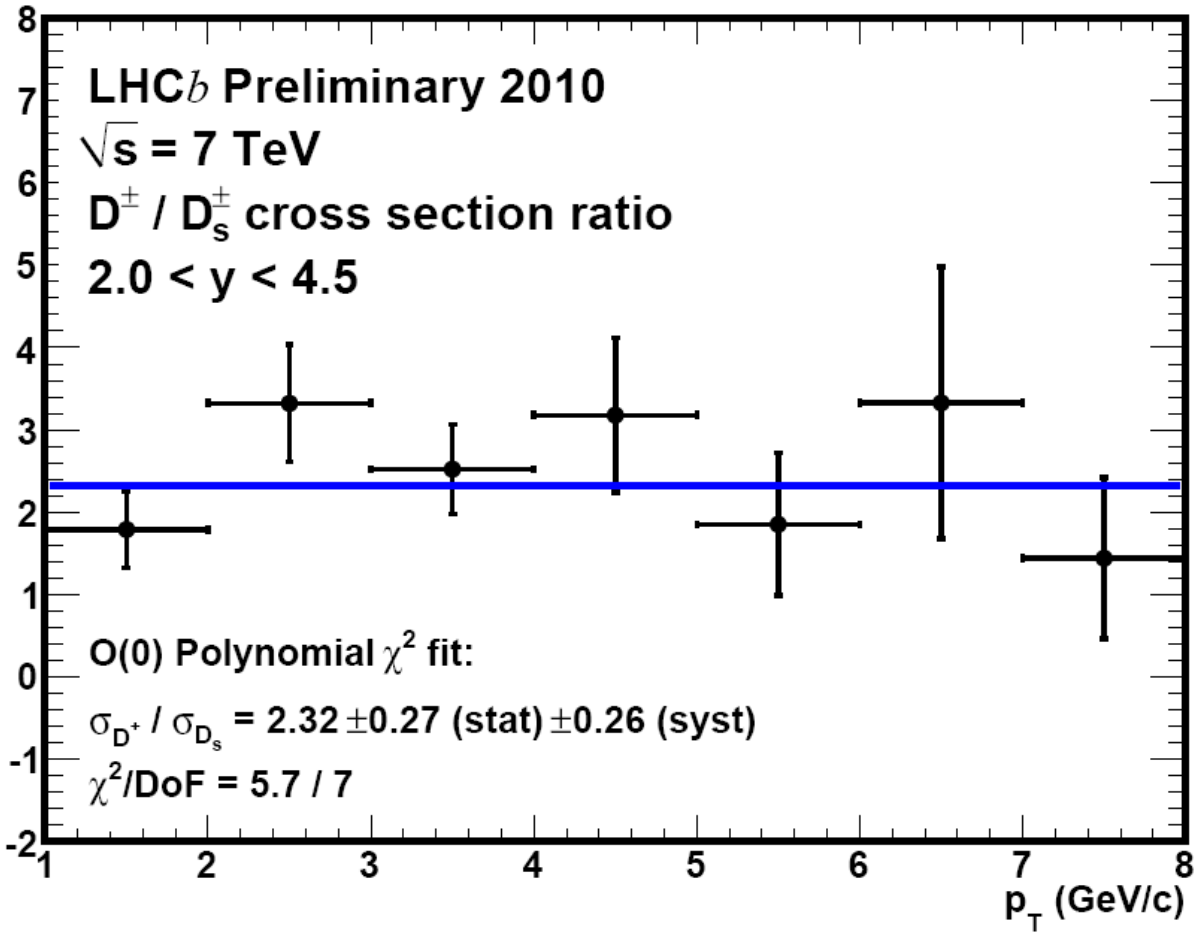
- See talk of Vanya Belyaev track 6, 23-Jul-2010 17:30



LHCb preliminary
~2 nb^{-1}

D^+/Ds Ratio

$$\frac{\sigma\left(D^+\right)}{\sigma\left(D_s^+\right)}$$



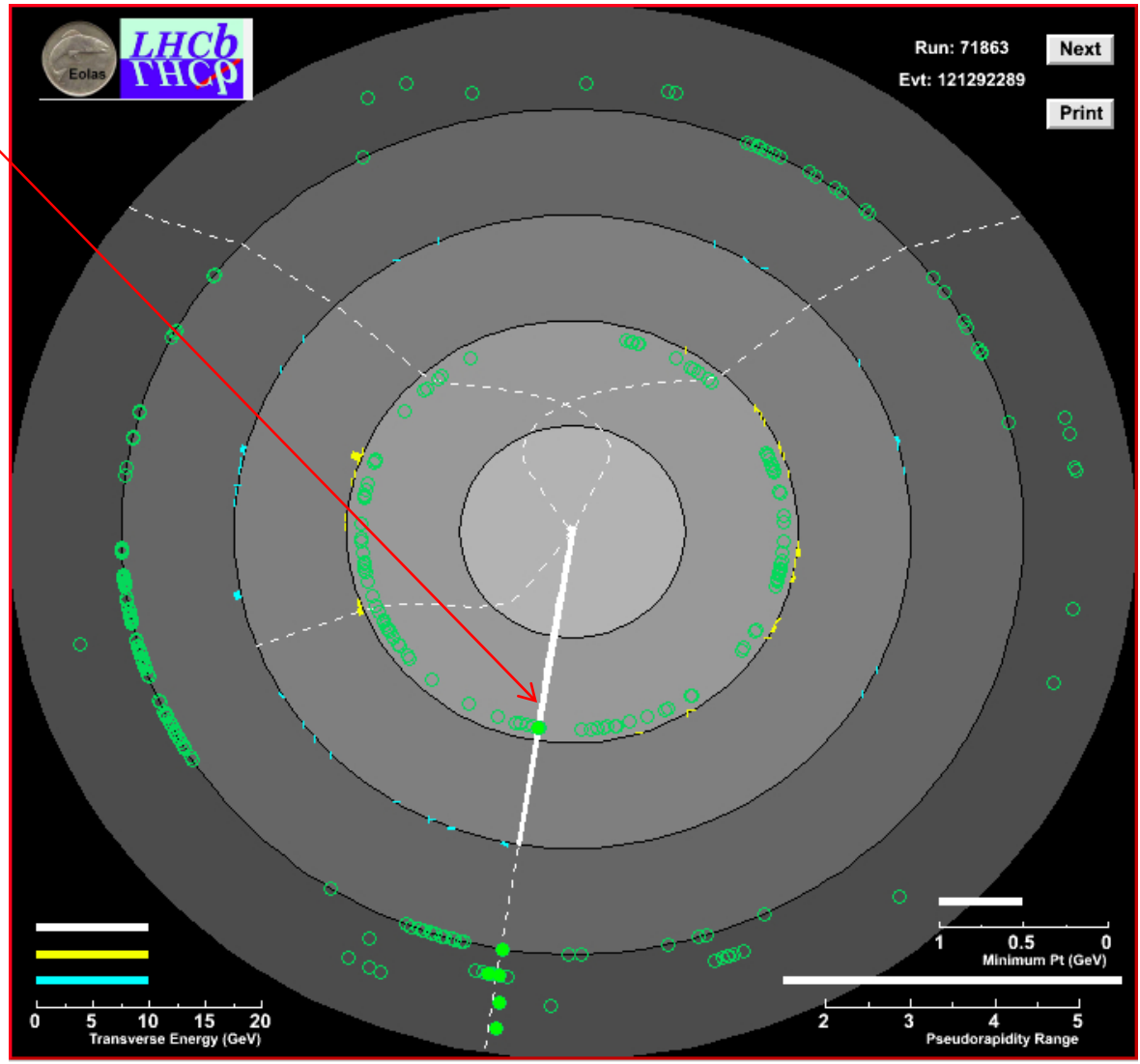
- Consistent with PDG review = 3.08±0.70

$W^{\pm}$ Search

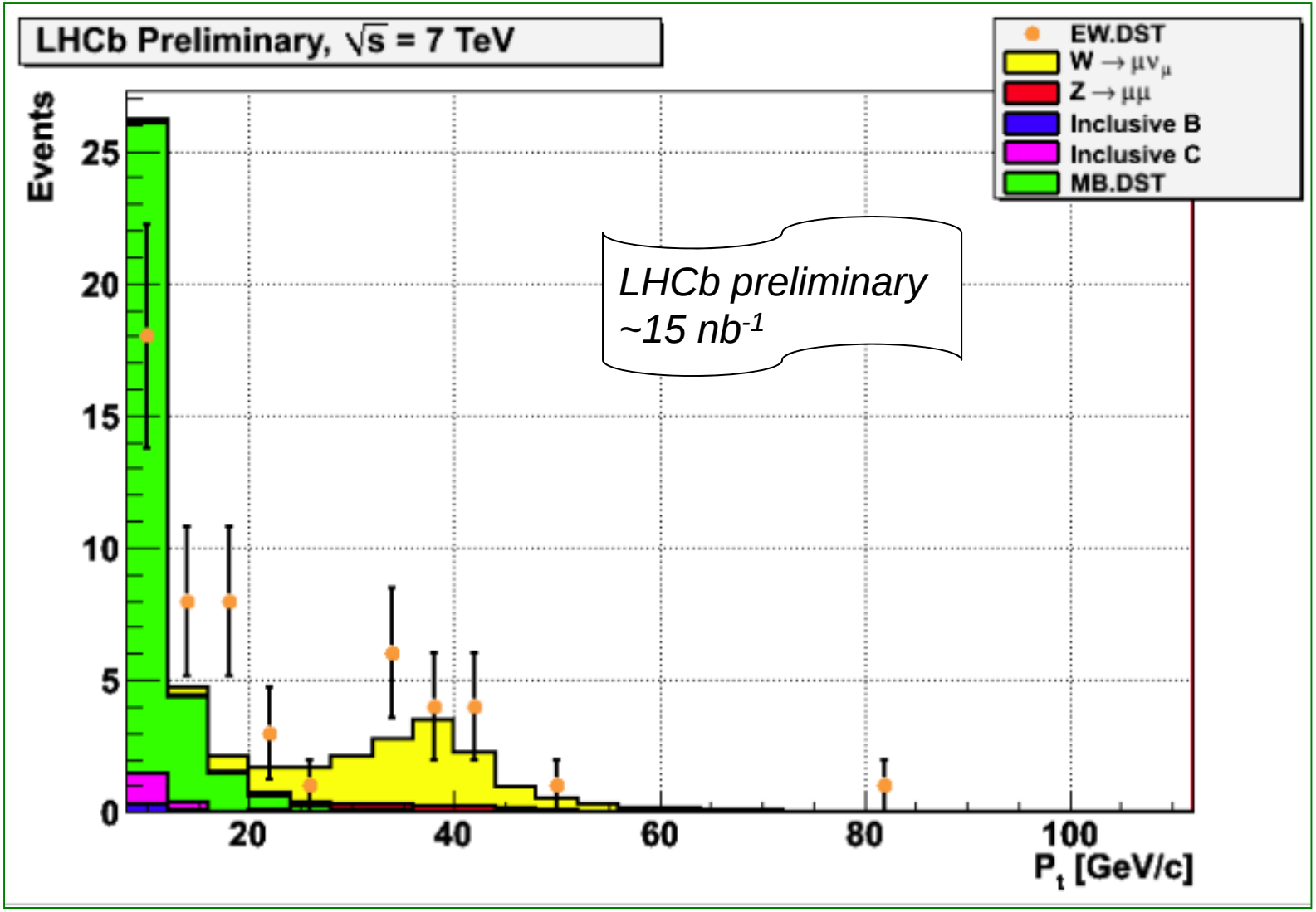
- While LHCb is optimized for studying physics beyond the Standard Model in b & c decays we can do quite a bit in the $2<\eta<6$ region in other areas
- We search for W decays by looking for events with isolated muons without a transverse energy balance & isolation in a surrounding cone in $\Delta\eta\times\Delta\phi=1$ phase space

W Candidate

- High p_t μ track
- Minimal energy in surrounding cone
- No energy opposite in transverse plane

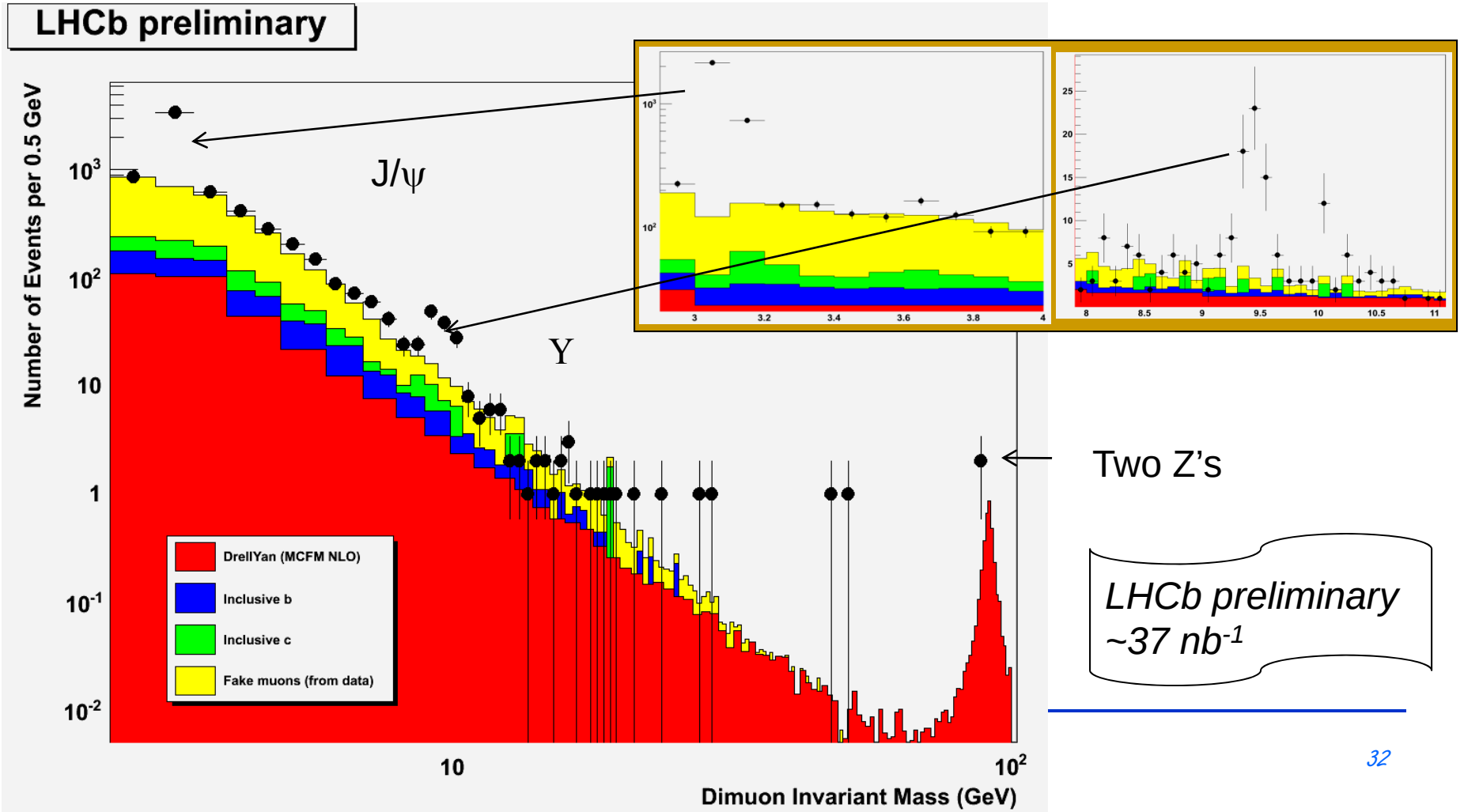


Single Muon p_t distribution

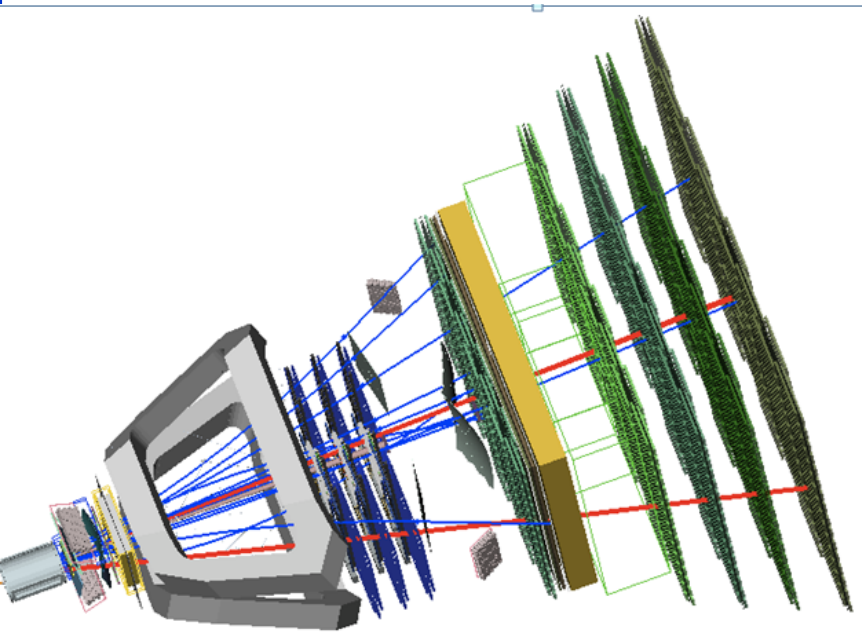


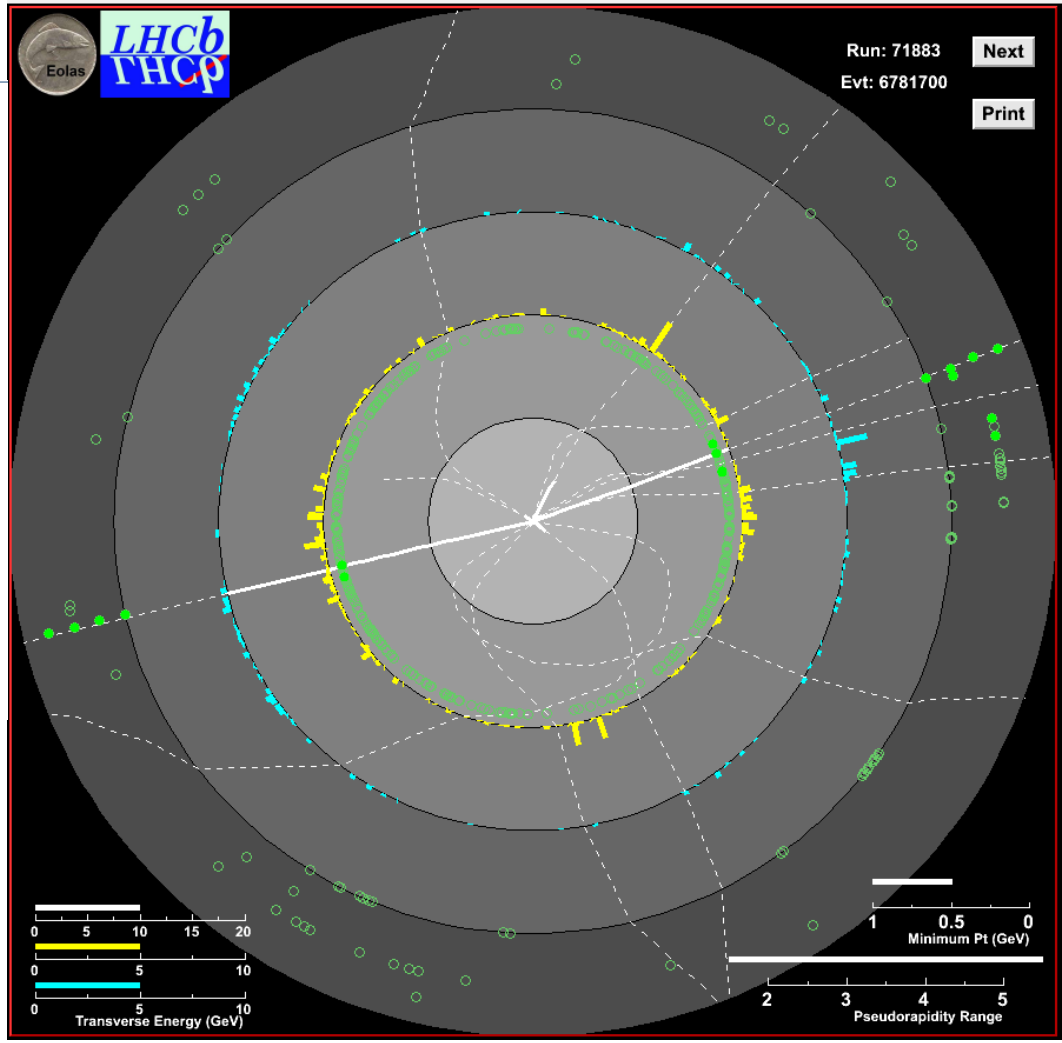
Also Dimuons

- See talk of Ronan McNulty, track 4, 22/7, 15:20
- Plan to measure Drell-Yan cross-section etc.

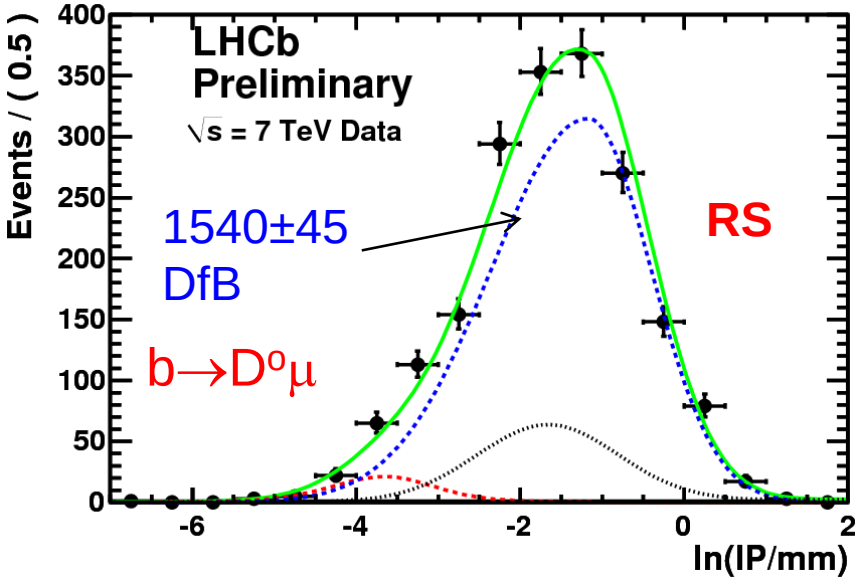


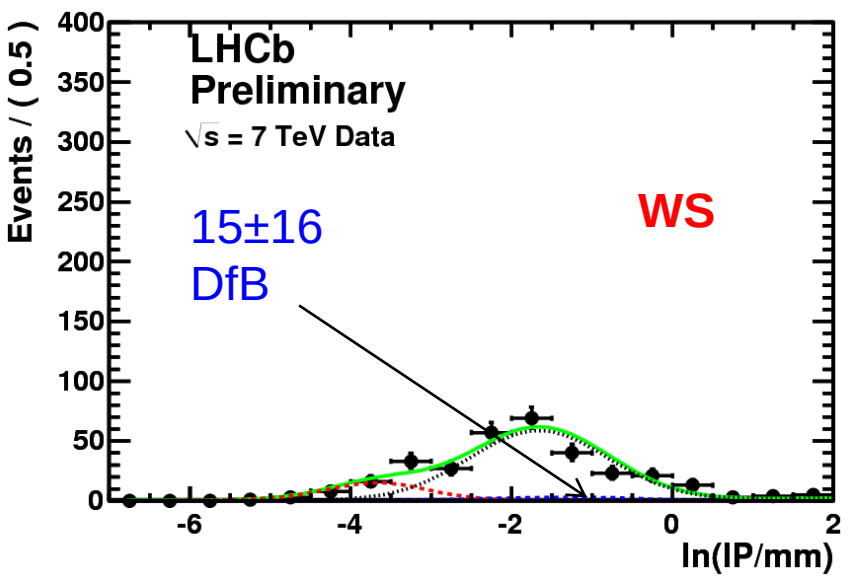
Z⁰ Event

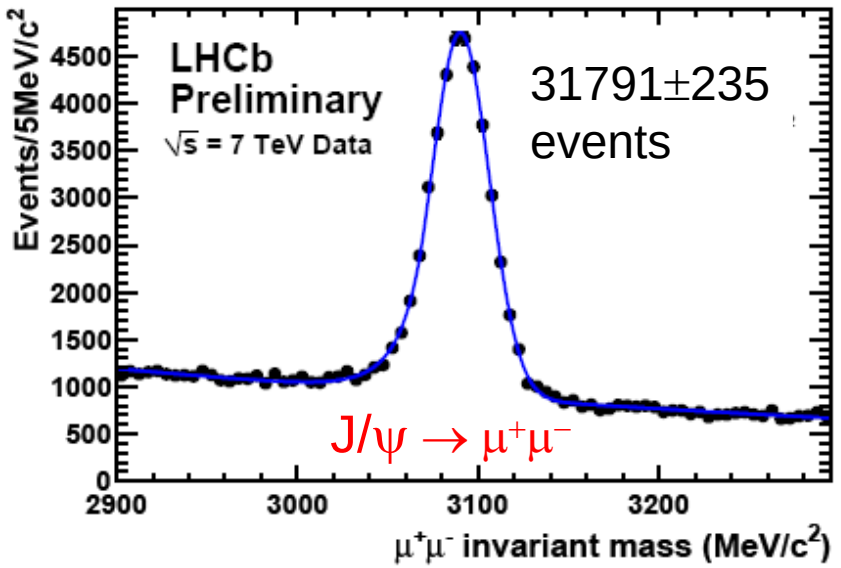


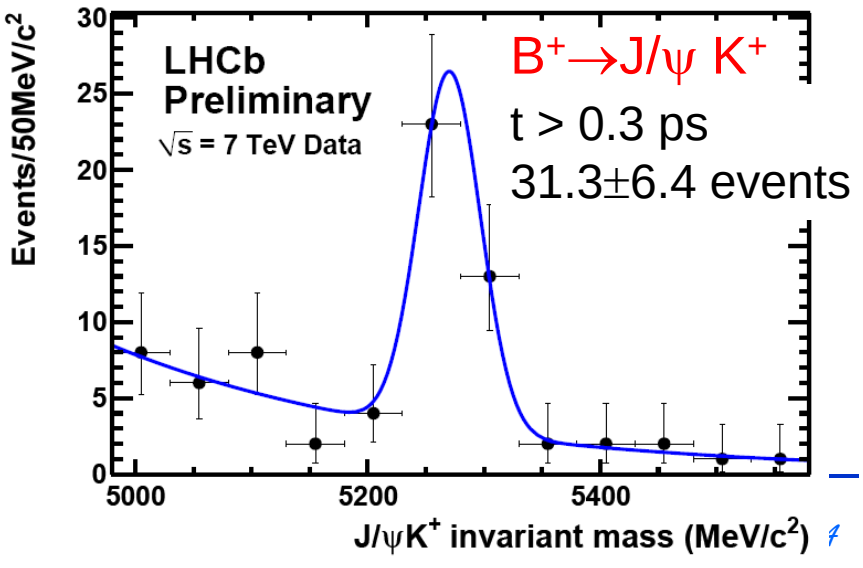

LHCb
Eolas
Run: 71883
Evt: 6781700
Next
Print
0 5 10 15 20
0 5 10
0 5 10
Transverse Energy (GeV)
1 0.5 0
Minimum Pt (GeV)
2 3 4 5
Pseudorapidity Range

Very near term future ~100 nb^{-1}









Conclusions

- LHCb producing physics quality measurements
- First determination of $b\bar{b}$ cross-section in forward direction at 7 TeV
- Measurements of charm
- Drell-Yan W & Z cross-section measurements to come soon
- Looking forward to more data, & Upgrade

The End