Dusk or Dawn ? Flavour Physics in the Hadron Collider Era

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University of Oxford
7/9/10

Onset of the Dark Ages - an (e^+e^-) flavour-physicist's lament

In the heavy flavour community at present, the below sentiment is not uncommon:

"My fate is to live among varied and confusing storms. But for you perhaps, if as I hope and wish you will live long after me, there will follow a better age. This sleep of forgetfulness will not last for ever. When the darkness has been dispersed, our descendants can come again in the former pure radiance."

Petrarch, 1330

Thus Petrarch bemoaned the end of the classical age and his despair at living in a time of ignorance and low civilisation. Such words also reflect the despondence of some that we are in an era when e^+e^- experiments for B/D physics no longer operate*

* Apart from BES III

Guardians of knowledge

In the dark ages, the pursuit of new knowledge ceased. Instead, lone scholars in remote monasteries, defying the bleakness outside, concentrated on recording all that was known, so that existing learning would not be lost to future generations.

And so it is now...

B-factory Legacy Book:
Status of the project

http://www.slac.stanford.edu/xorg/BFLB/

1st B-factory Legacy Book Meeting
SLAC National Laboratory
30th - 31st October 2009

Editors:

Awaiting the renaissance

"This sleep of forgetfulness will not last for ever. When the darkness has been dispersed, our descendants can come again in the former pure radiance."

For the patient, the resumption of the classical ways will arrive in due course...

Barbarians at the gate

...meanwhile all around, brutish, uncivilised and terrible new forces roam unchecked

I scorn your effete ways!

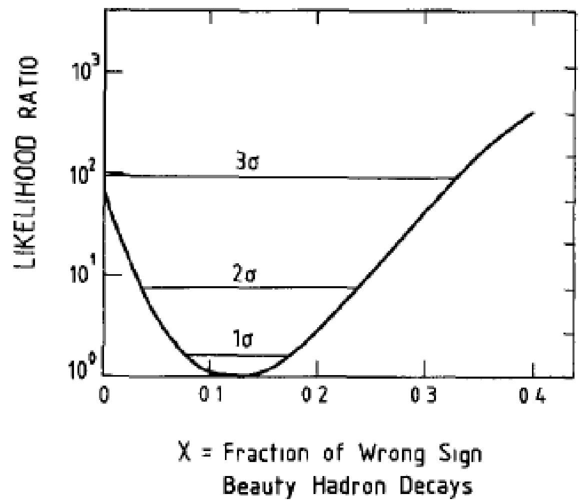
I lay waste to your inclusive,
low background reconstructions.

I bring desolation to all that is not
high-p_t with leptons in the final state

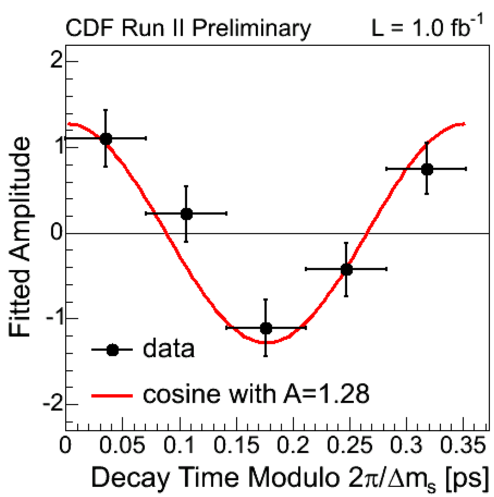
The p-$\overset{(-)}{p}$ enlightenment

An alternative view is that we are embarked on a new golden age

Historically, hadron colliders have made important contributions to flavour physics, e.g. observation of B-mixing (UA1, 1987)



UA1, PLB 186 (1987) 247



CDF, PRL 97 (2006) 242003

But dawn of the present era of enlightenment can be dated to Tevatron's observation of B_s oscillations in 2006

Since then, Tevatron has produced many flavour results of similar interest, with *lots* of data left to be analysed.

And it is not unlikely that flavour physics will provide the headline measurements of the 2010-11 LHC run

Contents

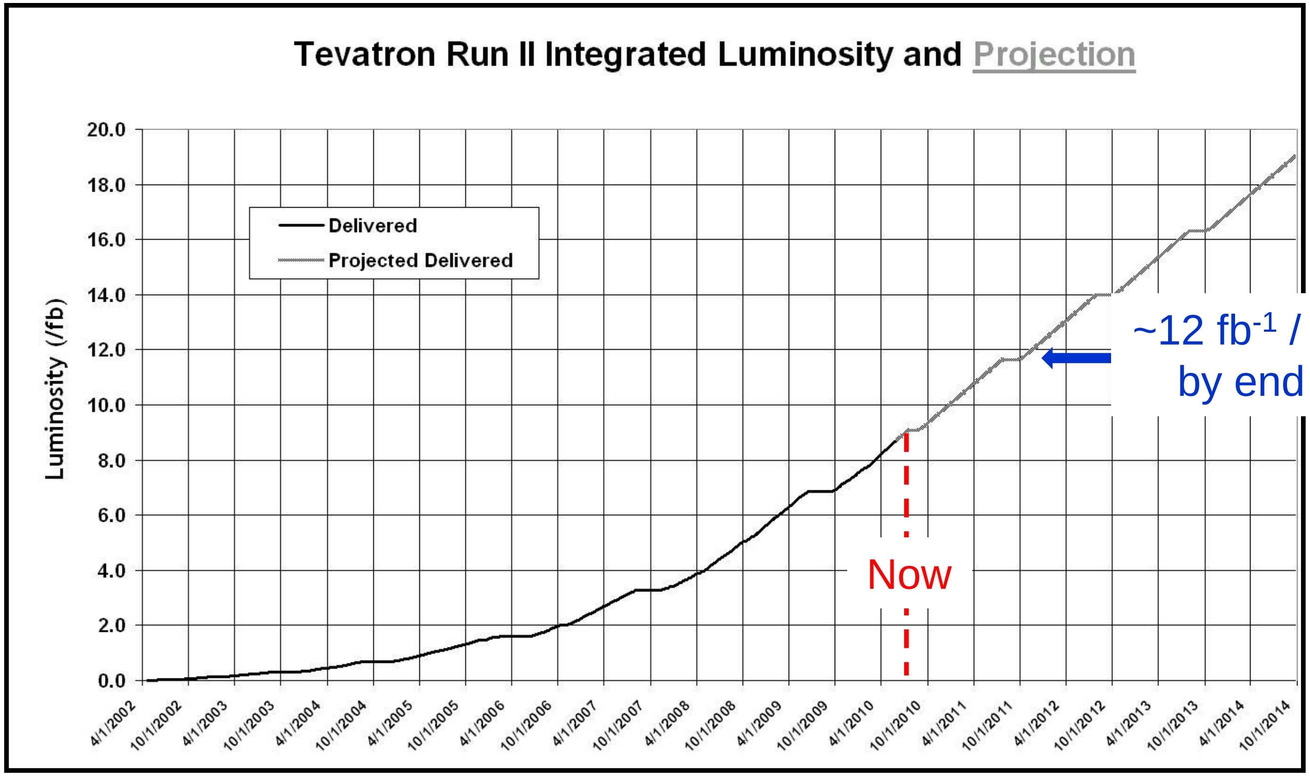
- State of play with the Tevatron and LHC
- First flavour results from the LHC
- Expectations with the data until the end of 2011 - both from the Tevatron and from the LHC
- Conclusions

(Declaration of interest: I work on LHCb and many of my examples will be drawn from this experiment)

Collider performance and expectations

Tevatron integrated luminosity and prospects

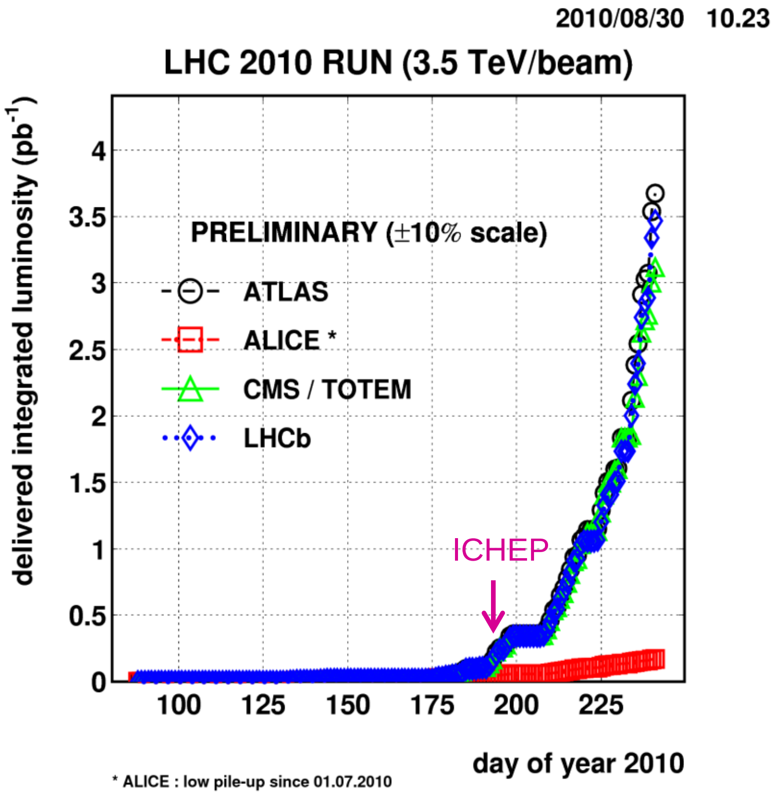
Tevatron will run until end of 2011 (at least)



...by then statistics will be 2 to 3 times that used for results shown here

LHC – the journey so far & the way ahead

- Over 3 pb^{-1} delivered to each of ATLAS, CMS and LHCb
- Luminosity at start of fill now ~10^{31} cm^{-2} s^{-1}
- Goal for 2010 – to reach luminosity of 10^{32} cm^{-2} s^{-1} Looks very achievable !
- Should end up with several 10's of pb^{-1} this year (sufficient for many interesting measurements)
- Steady running at this sort of luminosity in 2011 will deliver ~ 1 fb^{-1} / experiment

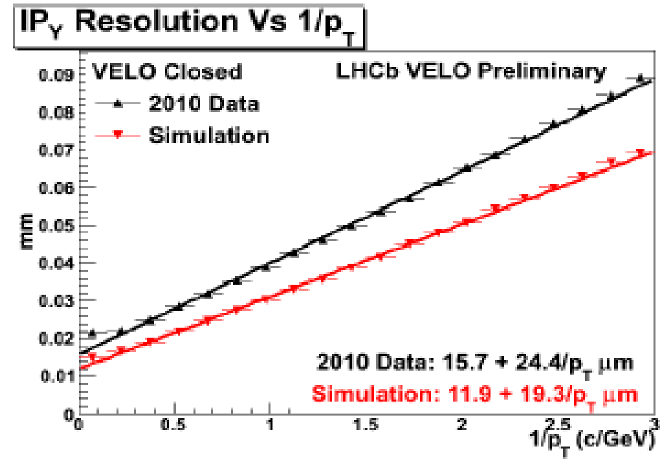


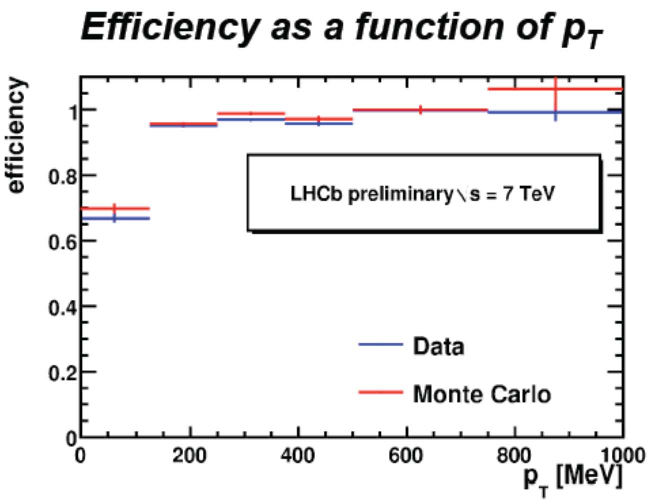
Many of results I will show achieved with only ~10 nb^{-1} (all that was available until a week or so before ICHEP); many plots with a few 100 nb^{-1}; some with up to 1 pb^{-1}

ATLAS & CMS performed to ~ specification from day 1 of collisions (full advantage taken from extended cosmic running). LHCb also functioning well

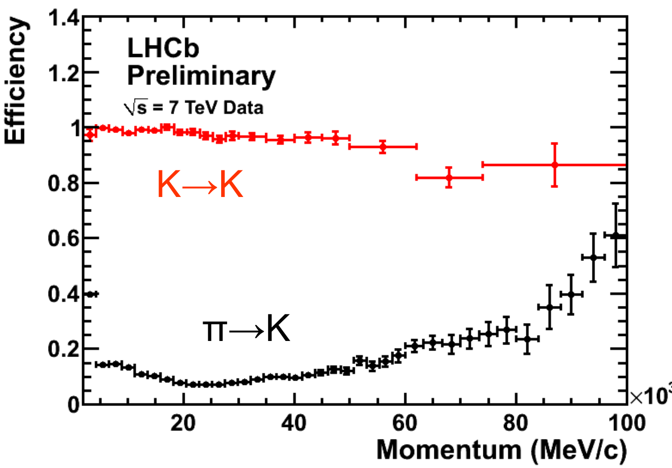
LHCb detector performance

IP resolution best at LHC – but not yet quite at MC level. Internal VELO alignment improvements should make a difference





Track finding efficiency is as it should be !



RICH system performing very well

Trigger also in good shape, as shown by event yields, and improvements under development.

(tighter cuts can be dialled up to suppress background further)

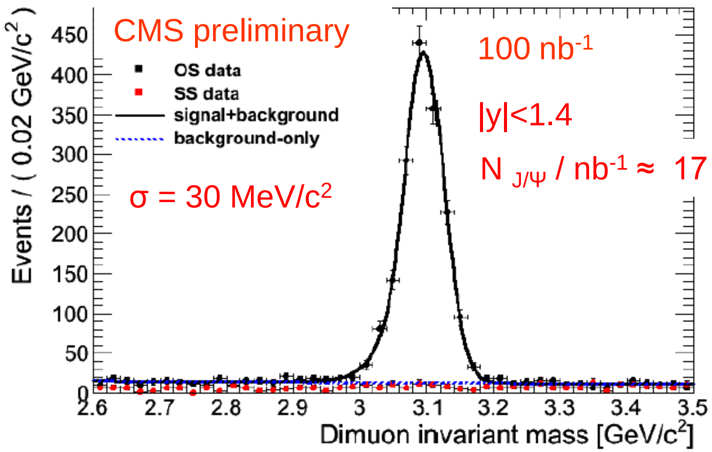
First LHC Heavy Flavour Results

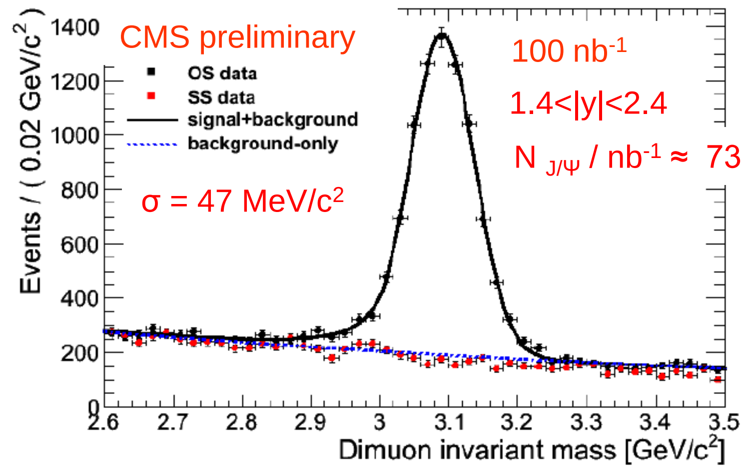
• J/Ψ and Υ studies – to probe production mechanisms (colour octet vs singlet etc) and to prepare for CP-studies

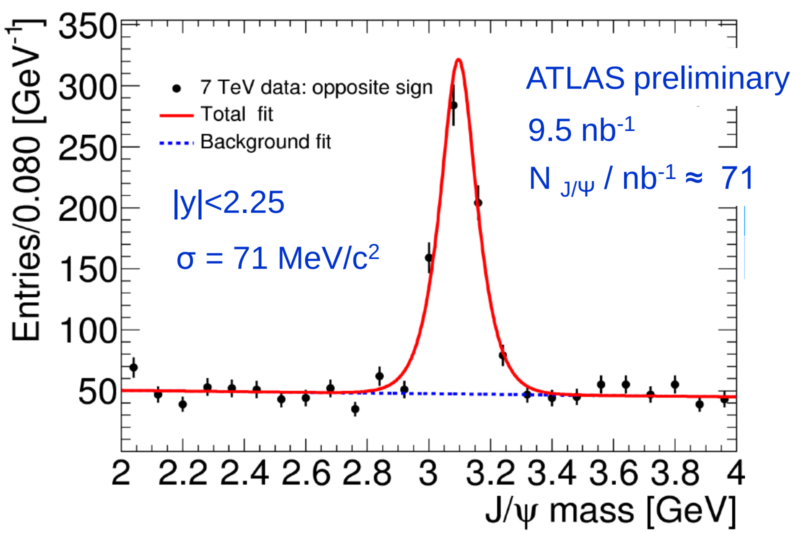
• Open beauty and charm production measurements

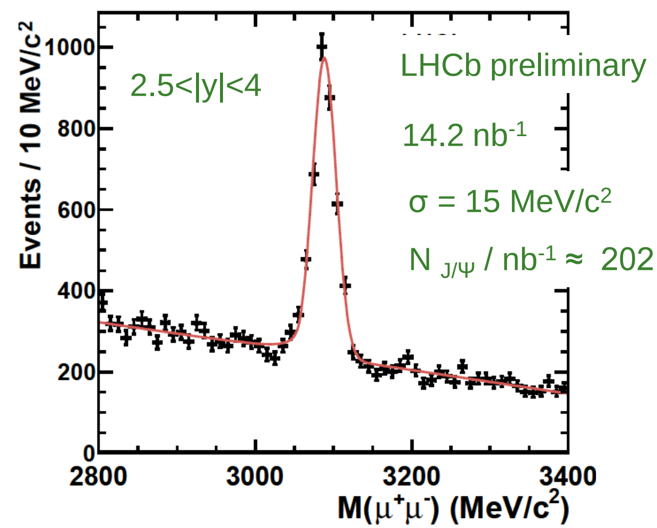
ICHEP J/ψ event samples

[CMS PAS BPH-10-002;
ATLAS-CONF-2010-062;
LHCb-CONF-2010-010]





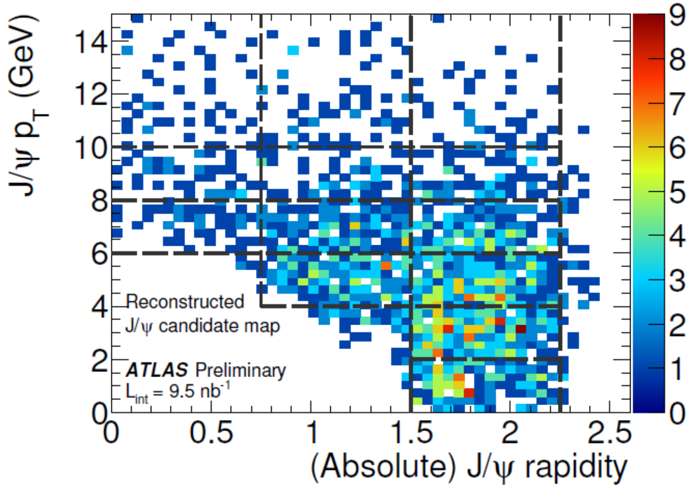


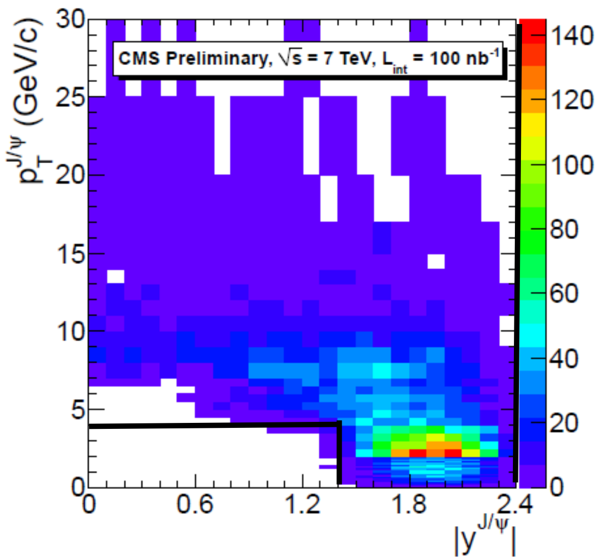


ALICE results also available !

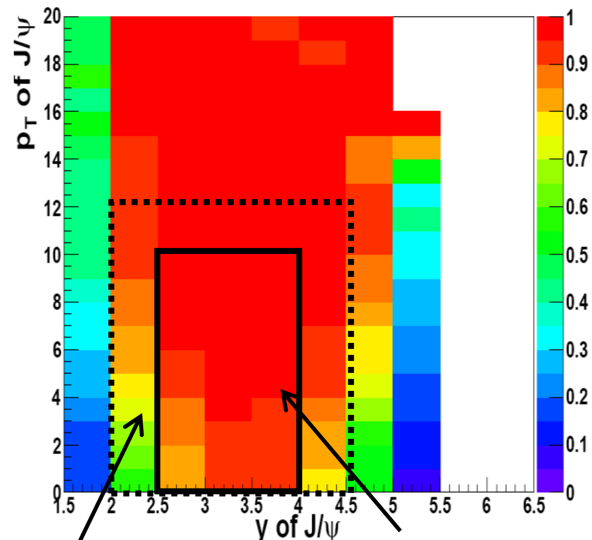
ICHEP J/ψ acceptances: y vs p_T

ATLAS and CMS candidates





LHCb acceptance

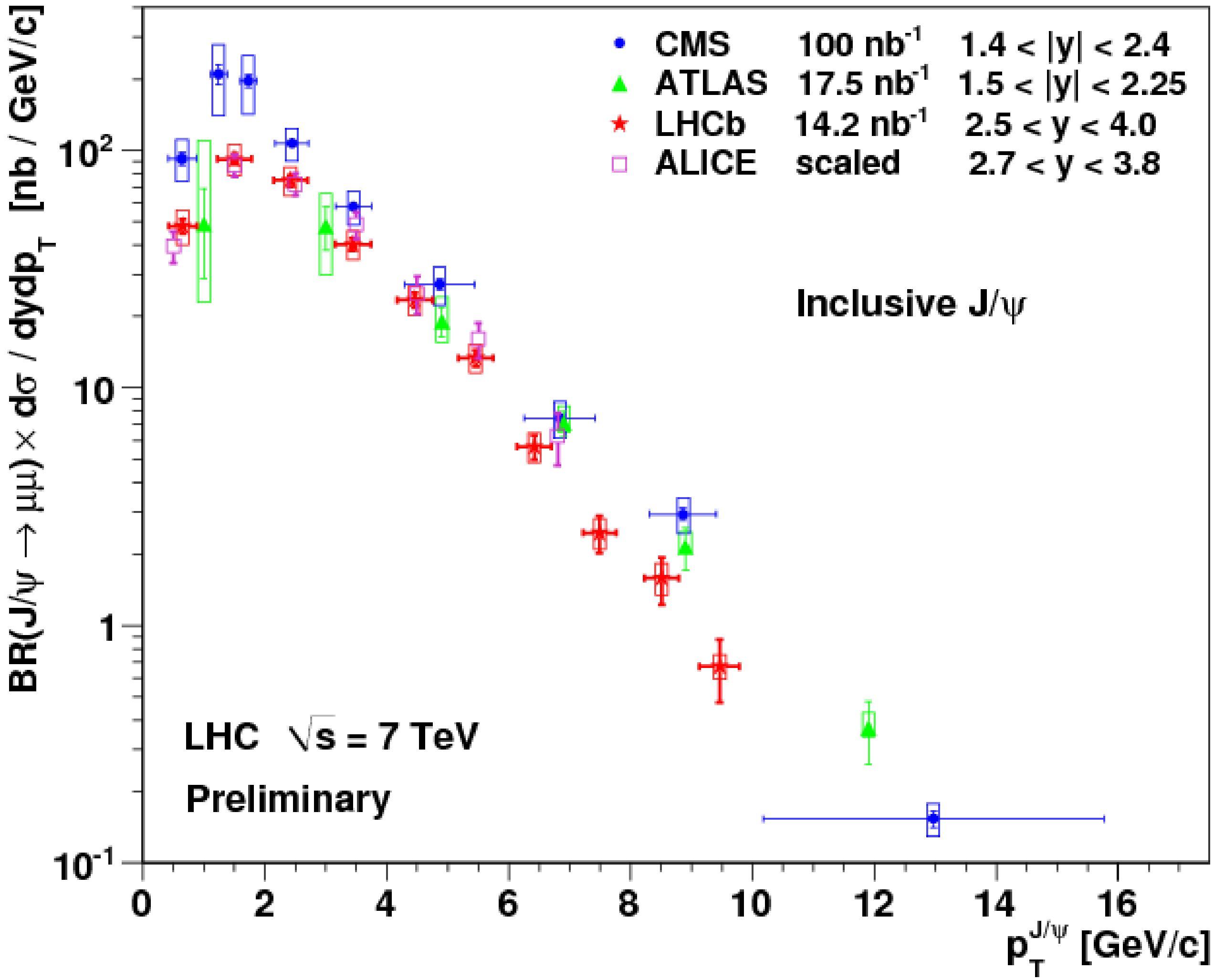


future analysis
(overlap with GPDs)

present analysis

Trigger requirements at increased interaction rate will probably mean some reduction in GPD acceptance at low p_T

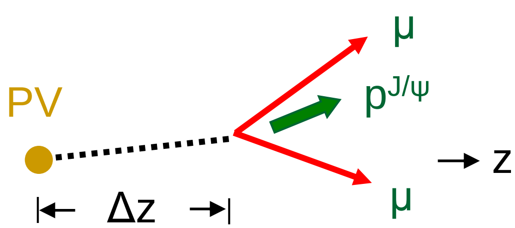
Compilation of preliminary LHC J/ψ results



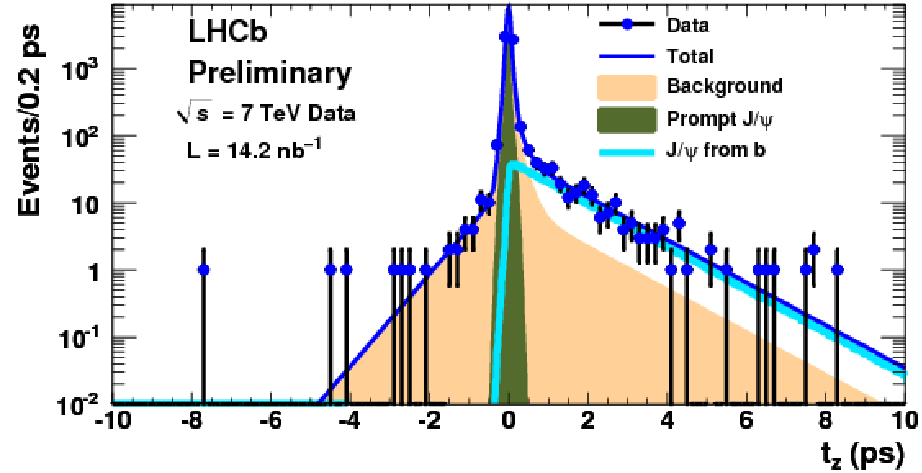
Hermine Woehri and Carlos Lourenco

Fitting prompt and secondary J/Ψ

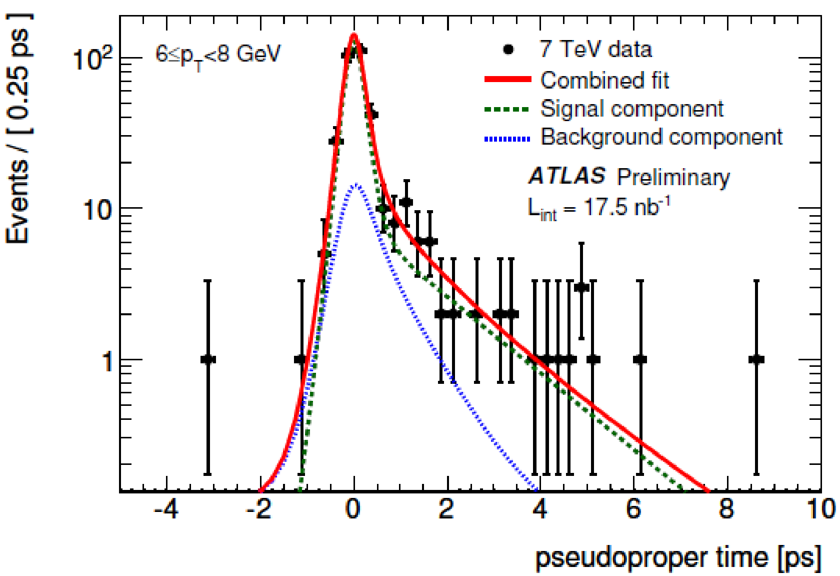
Experiments fit a 'pseudo-proper time' to separate prompt and secondary.
For LHCb this is defined in z-direction.



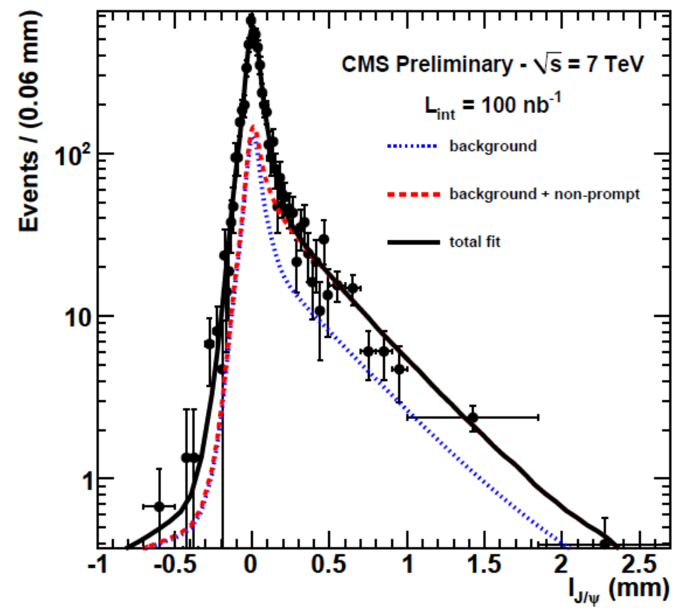
$$t_z = \frac{\Delta z}{p_z^{J/\psi}} m_{J/\psi}$$



For GPDs it is defined in x-y projection.

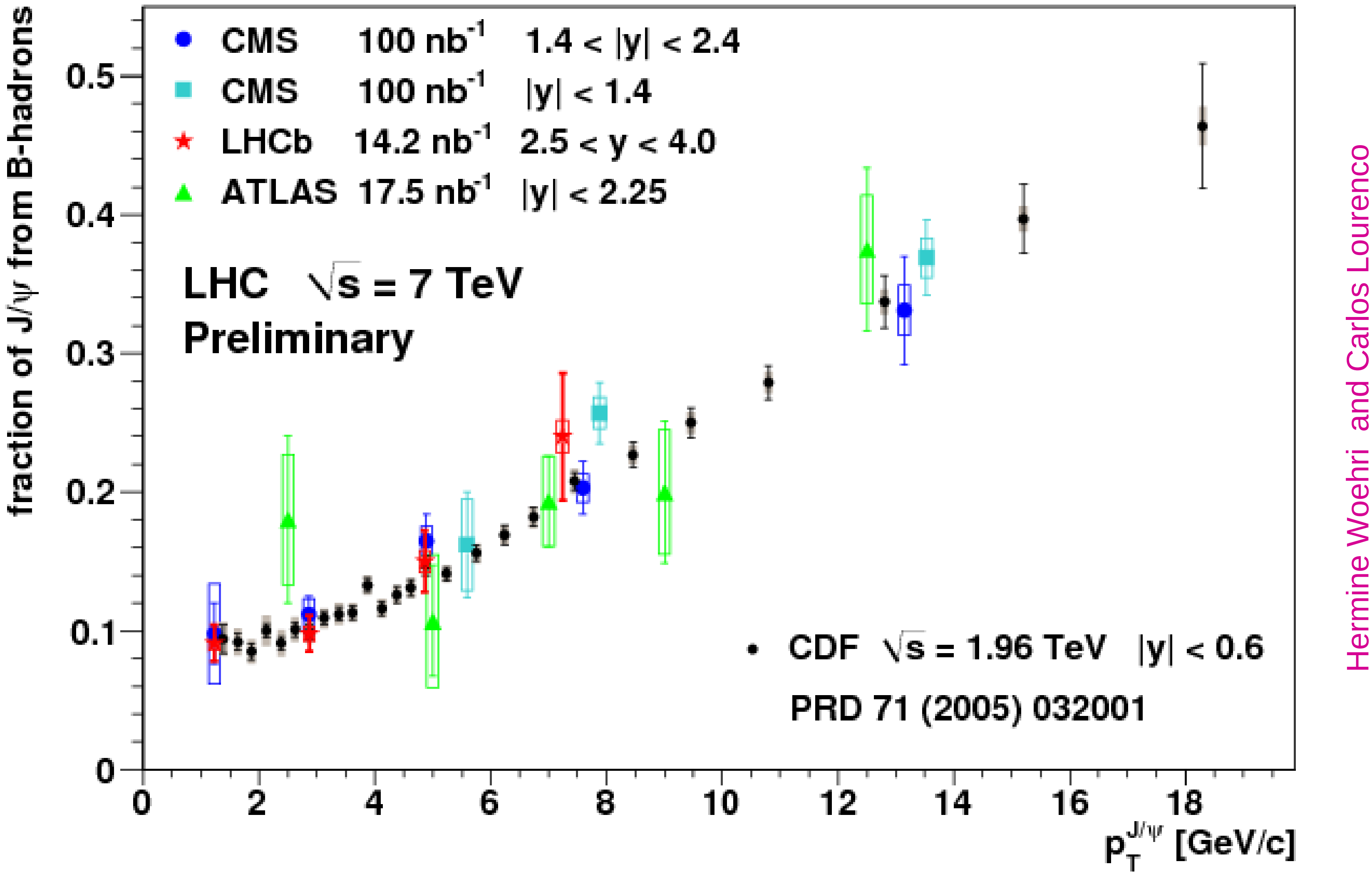


$6<p_T^{J/\Psi}<8$ GeV/c



$6<p_T^{J/\Psi}<10$ GeV/c; $|y|<1.4$

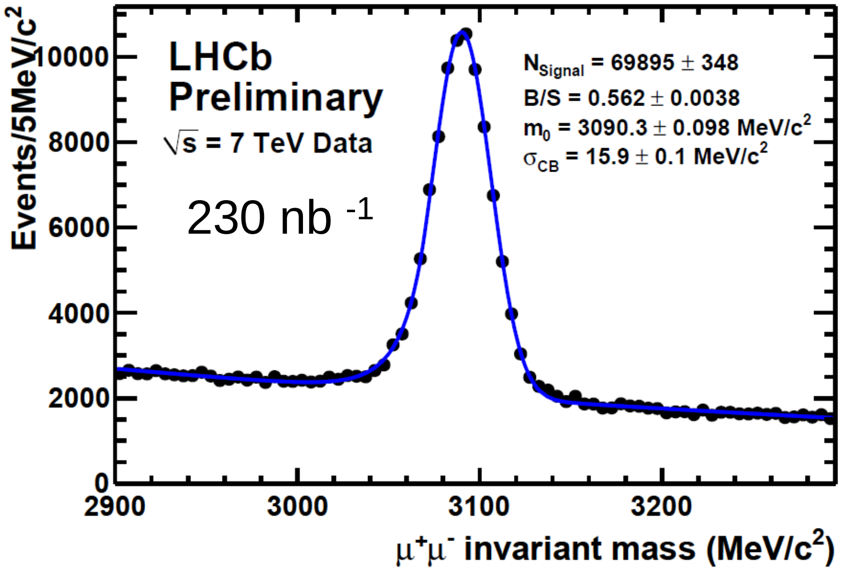
Compilation of preliminary LHC J/ψ results

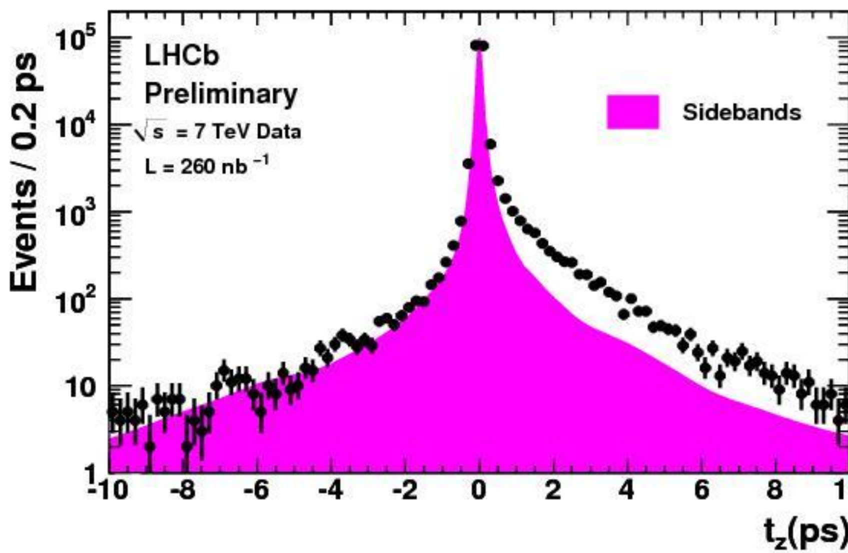


LHCb J/ψ post-ICHEP update

Much more data since ICHEP analysis – expect high precision with first publications!

Example: LHCb mass peak and pseudo-proper time distributions with ~1/4 pb^{-1}



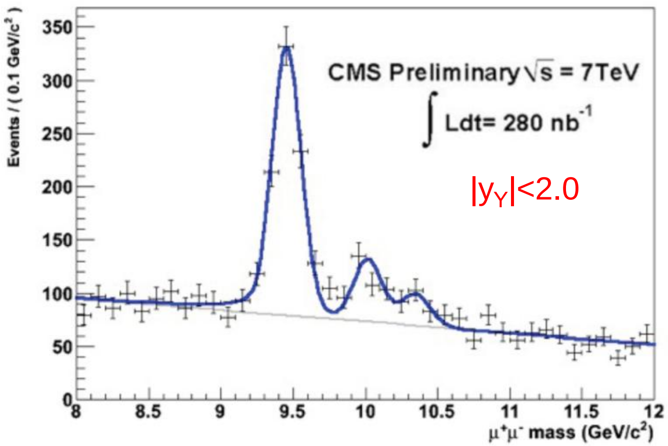


(Selection not identical to ICHEP analysis)

several 100k events / pb^{-1}

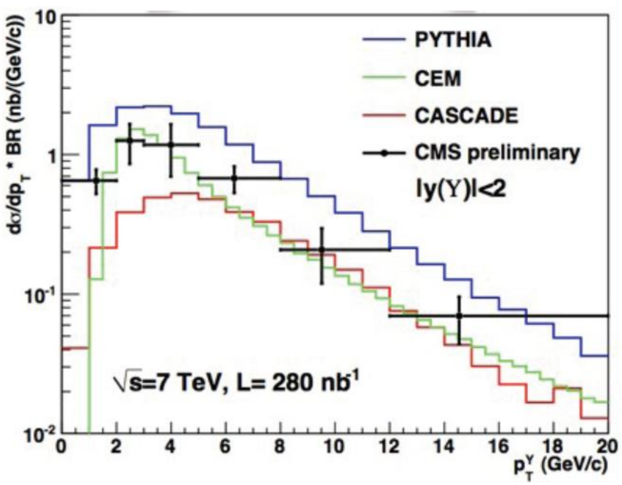
LHC upsilons

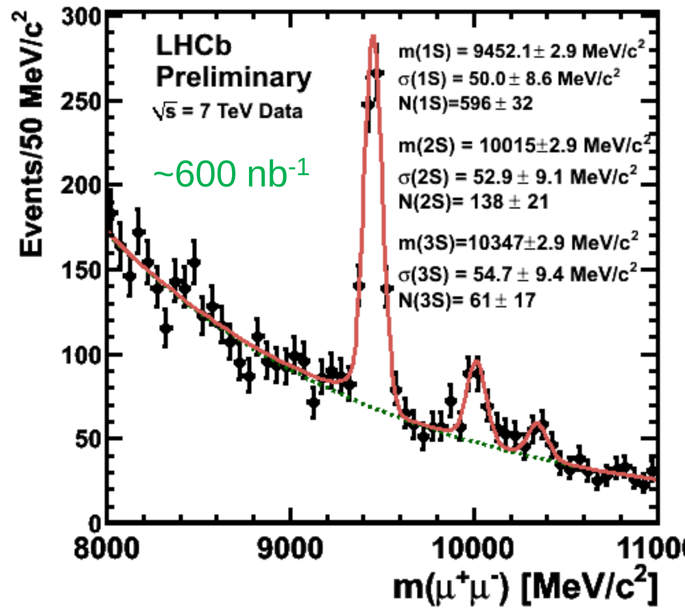
CMS upsilon spectrum…

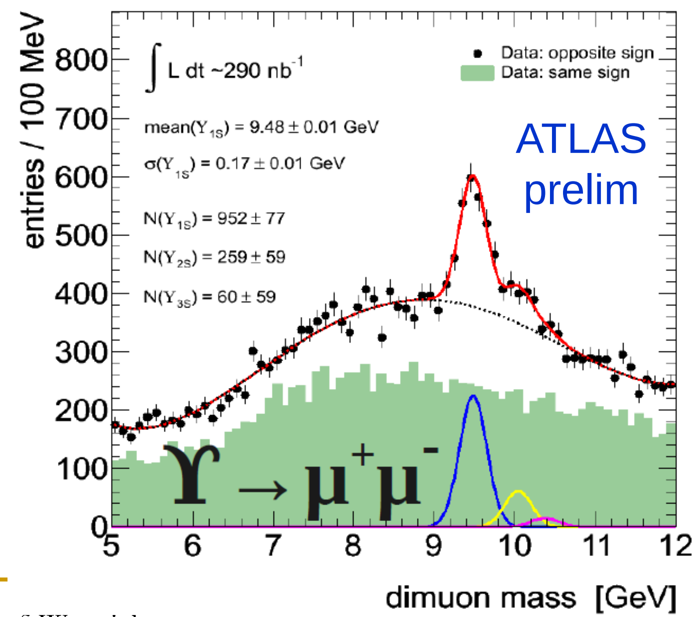


…and preliminary differential cross-section measurements

[CMS PAS BPH-10-003]



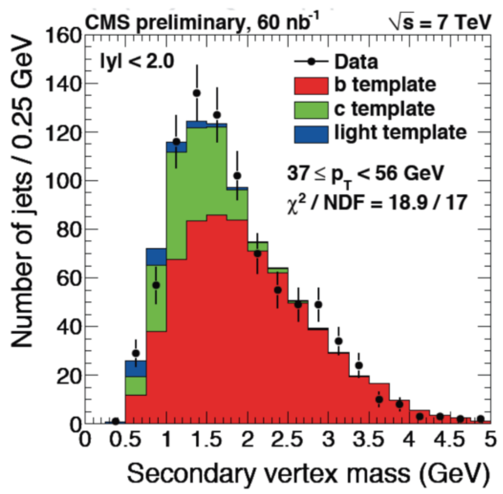


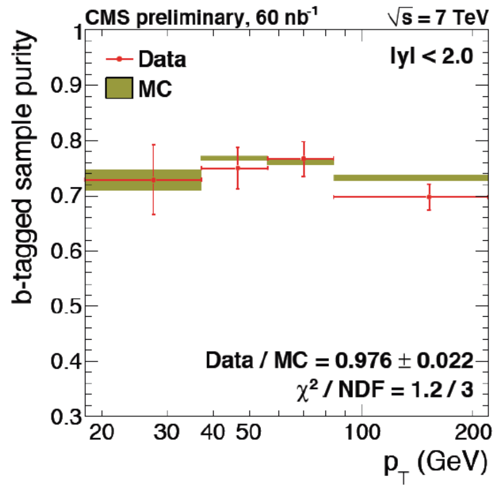


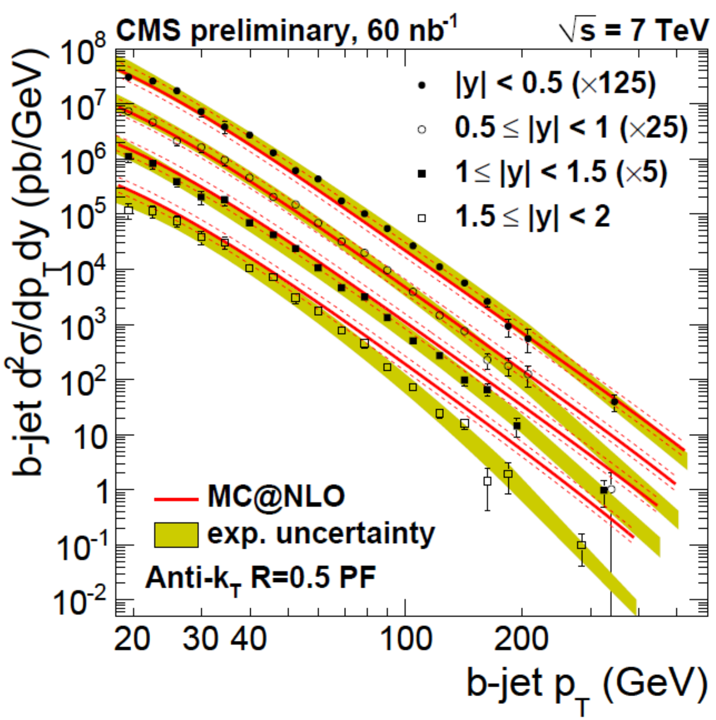
b-tagged jets in CMS

[CMS PAS BPH-10-009]

b-tag jets by asking for ≥3 tracks in displaced vertex. Determine efficiency from MC & cross-check in data through fits to vertex mass.







Measure differential cross-section (and ratio of b to light-flavour jets)

Reasonable agreement with MC@NLO, apart from high |y| and high jet pT

Parallel measurement performed with inclusive muons using p_T w.r.t. jet axis as discriminant.

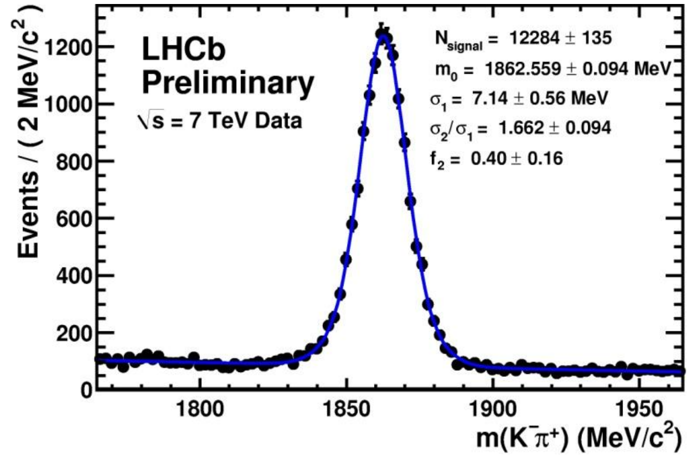
[CMS PAS BPH-10-007]

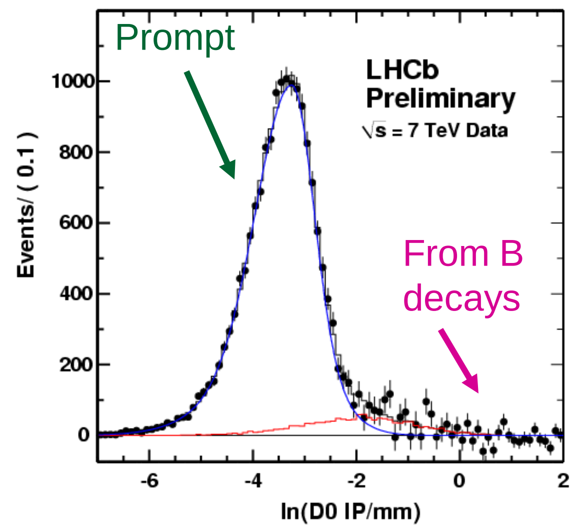
LHCb measurement of b production cross-section with $D^0\mu X$ events

- Take clean $D^0 \rightarrow K\pi$ sample
- Impact parameter of D^0 direction w.r.t. primary vertex (or ln[D^0 IP]) used to separate prompt and secondary component
- Looking for μ in event with correct charge correlation allows background to be suppressed and a decay mode with known BR to be isolated

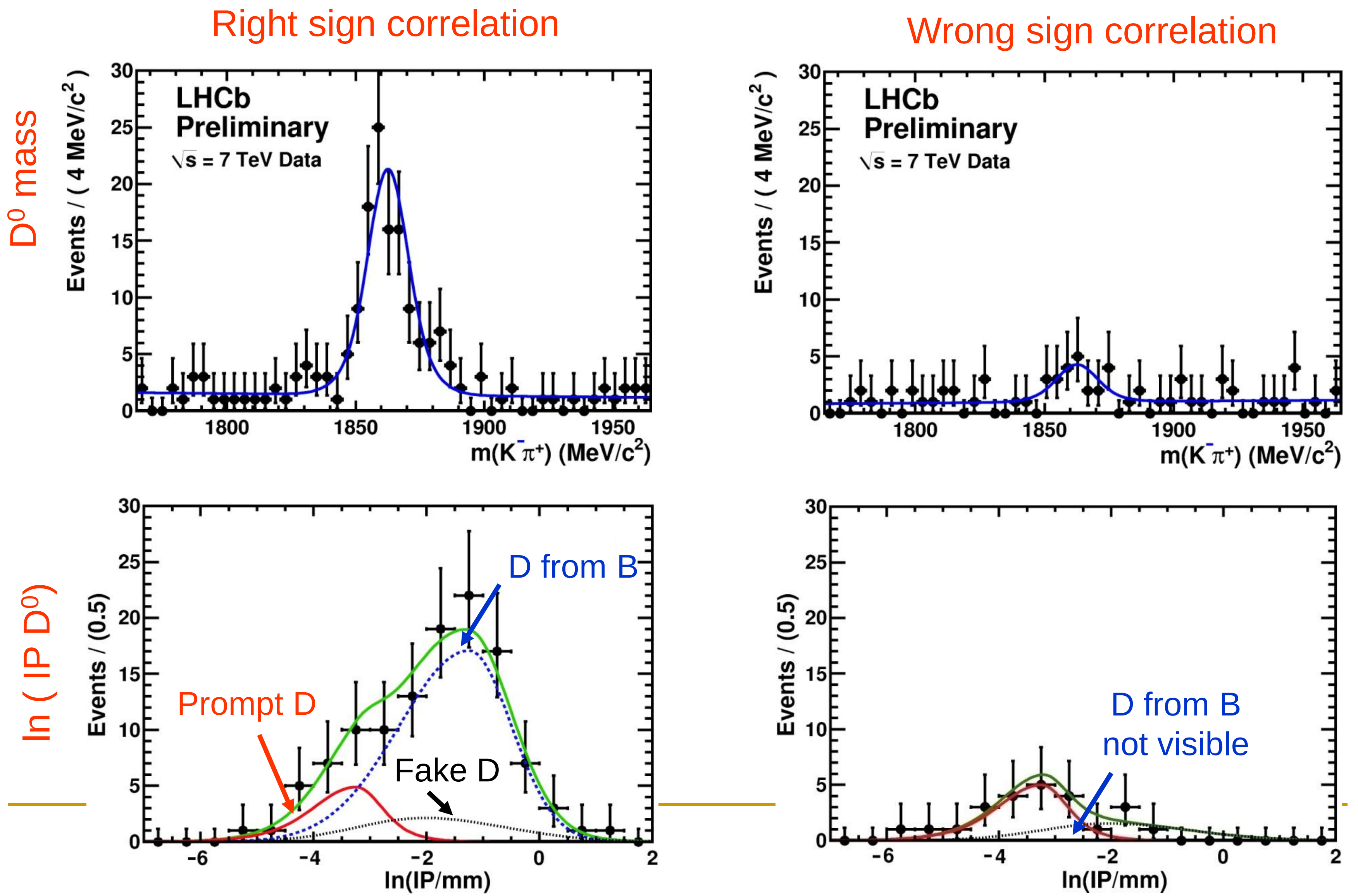
  $BR(b \rightarrow D^0 \mu^- \bar{\nu} X) = 6.82 \pm 0.35$ %

- Perform analysis both on open triggered sample (~ 3 nb^{-1}) and on sample collected with p_T > 1.3 GeV/c muon trigger (~12 nb^{-1})
- Measure / cross-check efficiencies on data





LHCb $D^0\mu X$ events – open trigger



LHCb $D^0\mu X$ Systematics

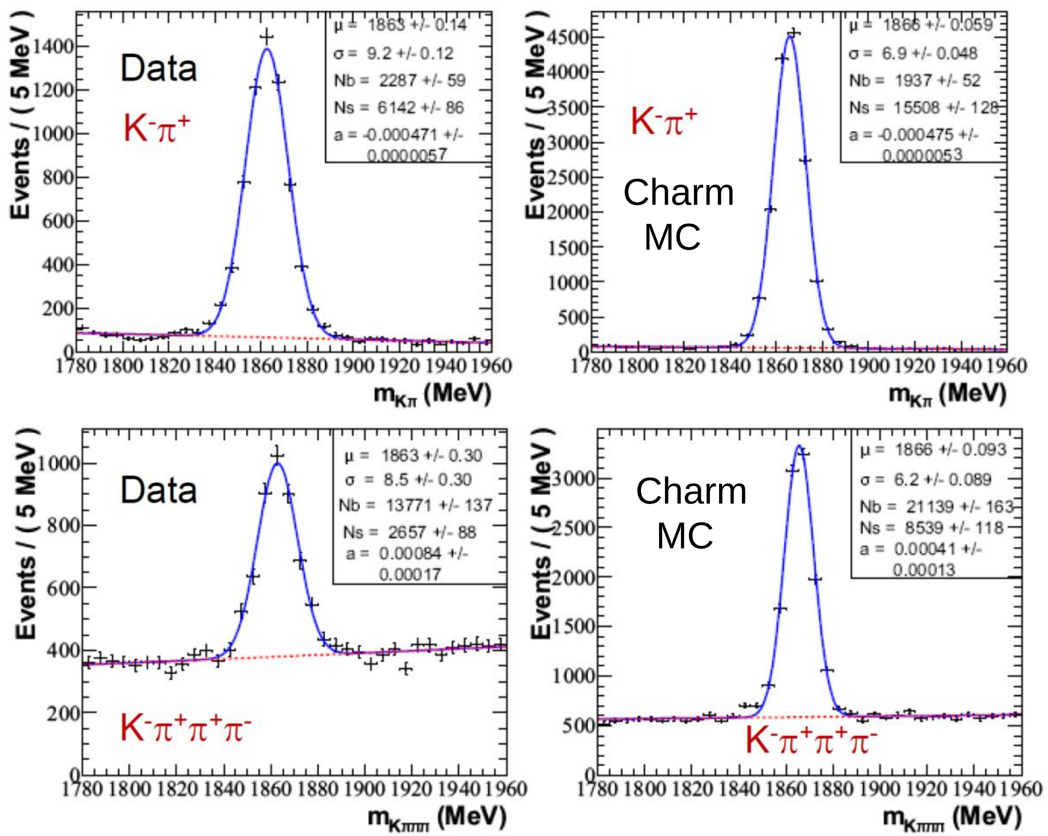
Source	Error (%)	Source	Error (%)
Luminosity	10.0	Prompt & DfB shapes	1.4
Tracking efficiency	10.0	$D^0\mu^-$ vertex χ^2	1.2
$\mathcal{B}(b \to D^0 X \mu^- \overline{\nu})$	5.1	Kaon identification	1.2
Efficiency assumed branching ratios	4.4	Muon fakes	1.0
Fragmentation fractions	4.2	D^0 mass cut	1.0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

Determined from data whenever possible

LHCb tracking efficiency in data vs MC

Use variety of methods:

- tag and probe
- relative rates of D→Kπ vs D→Kπππ (below)



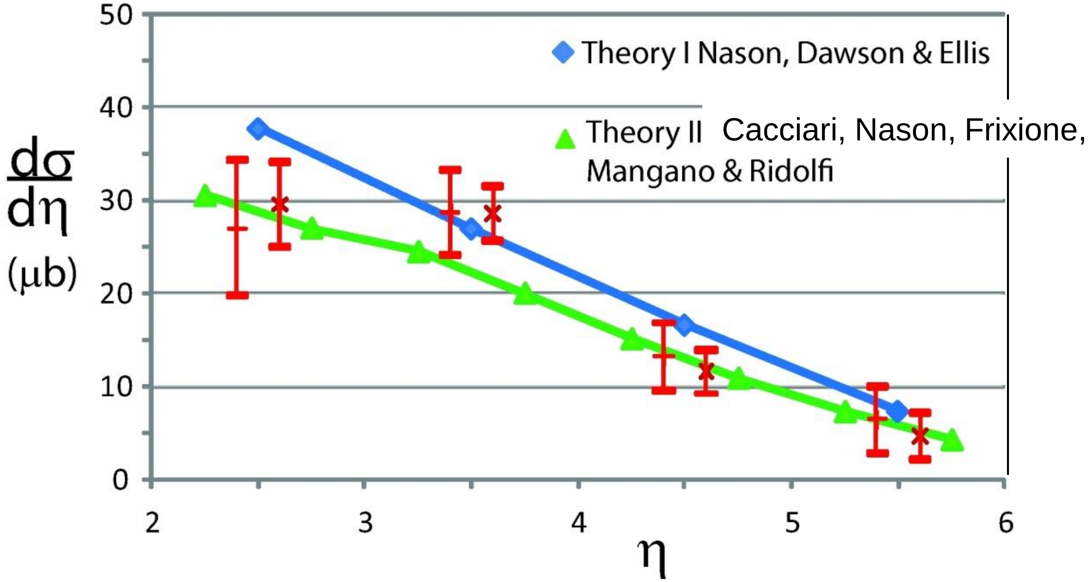
This study gives data / MC = 1.00± 0.03 per track

LHCb $D^0\mu X$ Preliminary Results

Measure cross-section in four bins of η

$$\sigma(pp \to H_b X) = \frac{\#\text{ of detected } D^0\mu^- \text{ and } \overline{D}^0\mu^+ \text{ events}}{\mathcal{L} \times \text{efficiency} \times 2}.$$

Compare with theory predictions for $b\bar{b}$ production



open trigger

muon trigger

- datasets consistent, so average
- shape and scale agrees well with theories

σ ($pp \to H_b X$; $2 < \eta < 6$) = $74.9 \pm 5.3 \pm 12.8$ μb

Averaging preliminary b-production results

All LHCb preliminary measurements of σ ($pp \rightarrow H_b X$; $2 < \eta < 6$) compatible
(There exists a third result using D*μν events, not shown here)

Determine weighted average of J/ψ and D^0μX results
(D*μν measurement less precise and strongly correlated with D^0μX)

$$\sigma(pp \rightarrow H_b X; 2 < \eta < 6) = 77.4 \pm 4.0 \pm 11.4\ \mu b$$ LHCb preliminary

Consistent with central values for bb cross-section in theory

I: Nason, Dawson, Ellis	89 μb
II: Nason, Frixione, Mangano and Ridolfi	70 μb

Using Pythia to extrapolate to full phase space

$$\sigma(pp \rightarrow b\bar{b}X) = 292 \pm 15 \pm 43\ \mu b$$ LHCb preliminary

Compare with expectation - theory I: 332 μb ; theory II: 254 μb

Note that all √s = 7 TeV LHCb sensitivity studies until now assumed ~ 250 μb

NB: experimental numbers assume $B^+/B^0/B_s/\Lambda_b$ ratios measured at LEP.

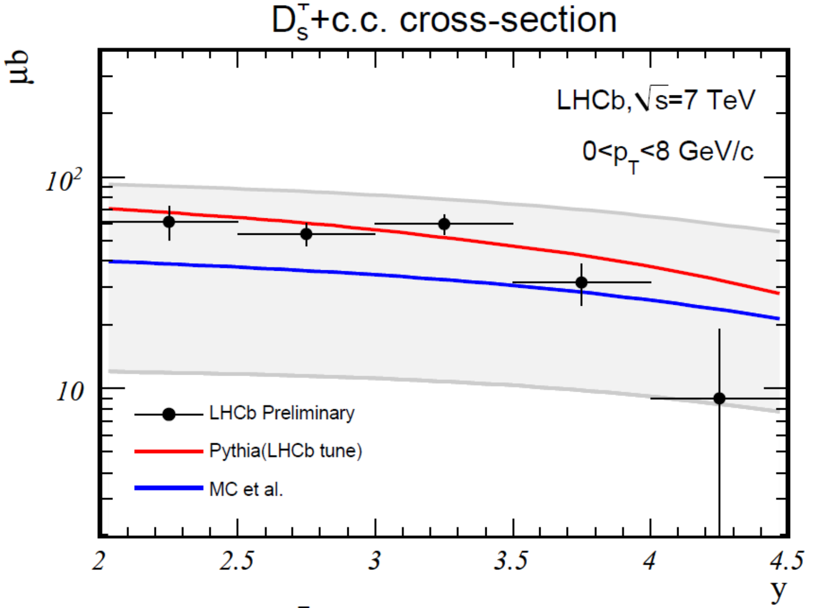
Open charm cross-sections

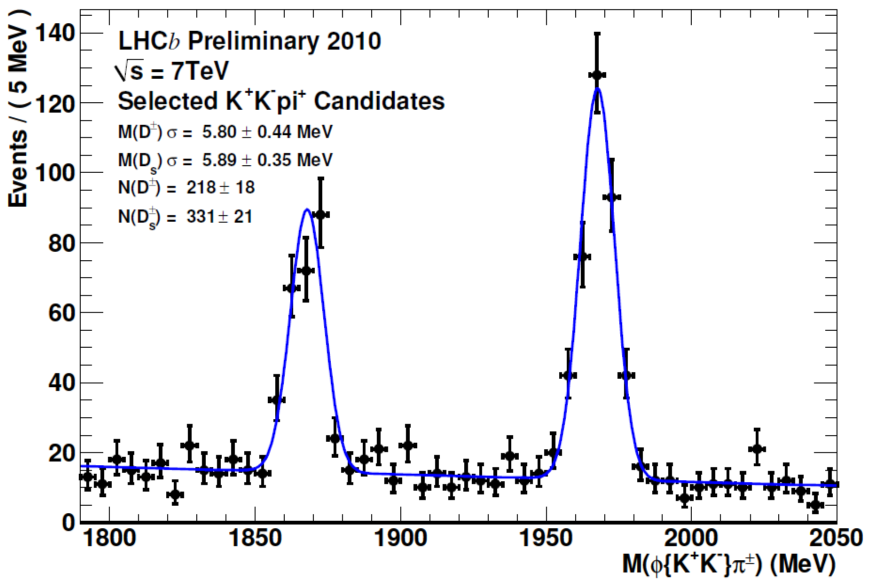
New for this workshop – preliminary LHCb measurements of cross-section vs y, p_t for D^{*+}, D^0, D^+ and D_s (shown here)

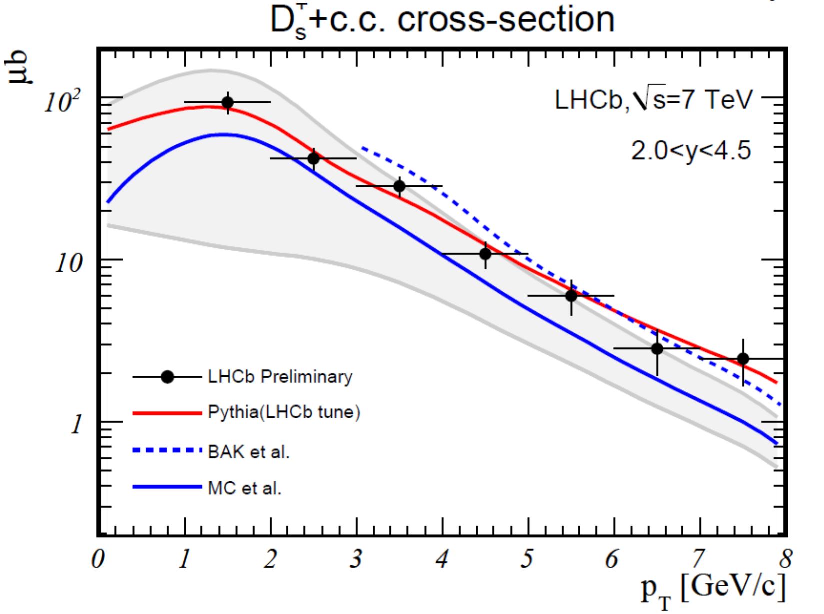
See Gersabeck, WG 4

Performed with ~ 2 nb^{-1} using open trigger (see later for plots with flavour trigger)

Good agreement with expectation – charm production is *huge* at $\sqrt{s}$ = 7 TeV !







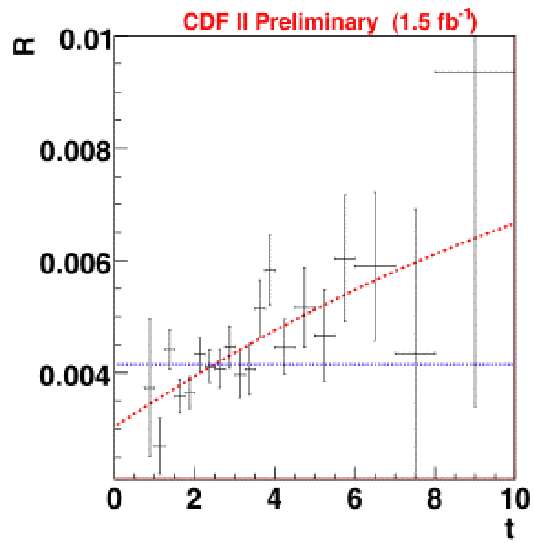
Looking forward – what will be possible with the ≤ 2011 data ?

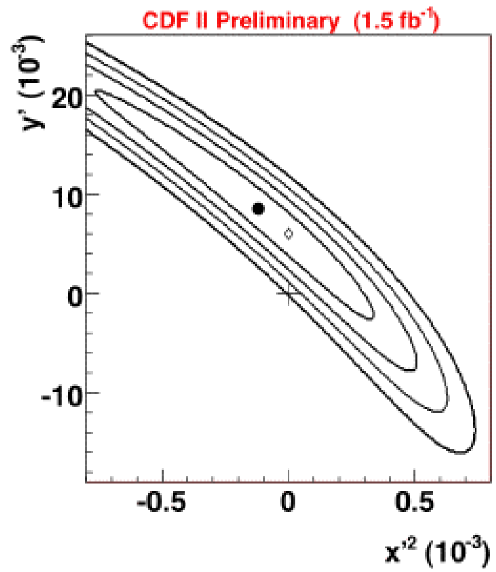
Charm – the new frontier

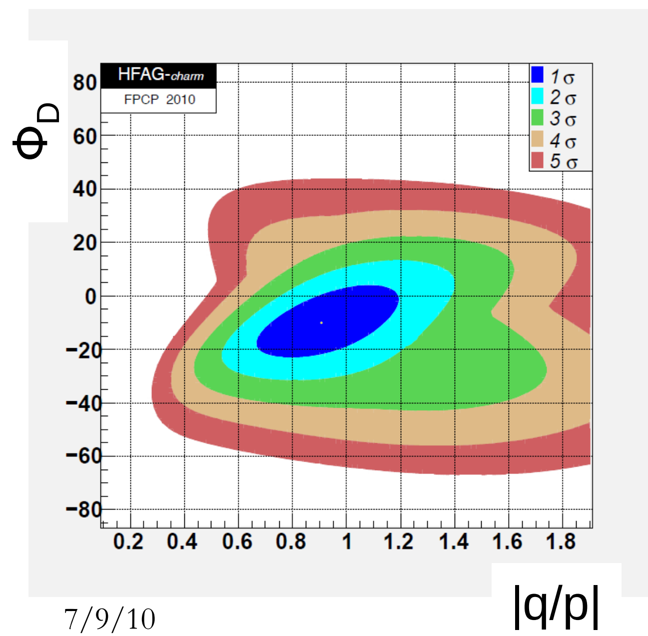
Discovery of charm mixing one of highlights of recent years.

Hadron colliders have played their part – CDF WS Kπ study [PRL 100 (2008) 121802]

Next, and most exciting goal, is to find CPV, both direct and in mixing related phenomena







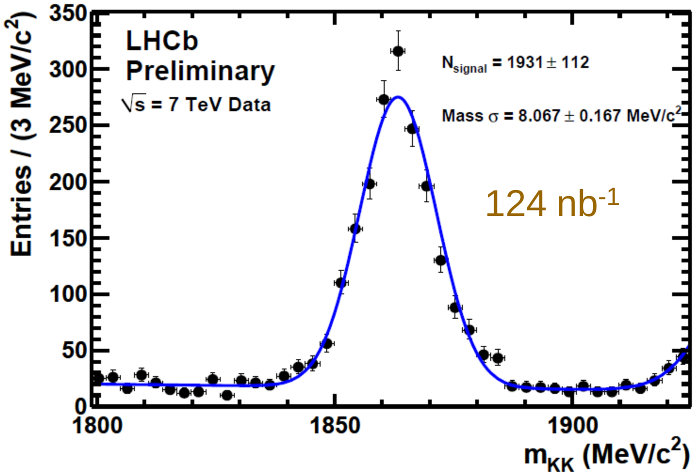
Present constraints on φ_D & (|q/p|-1) are weak.

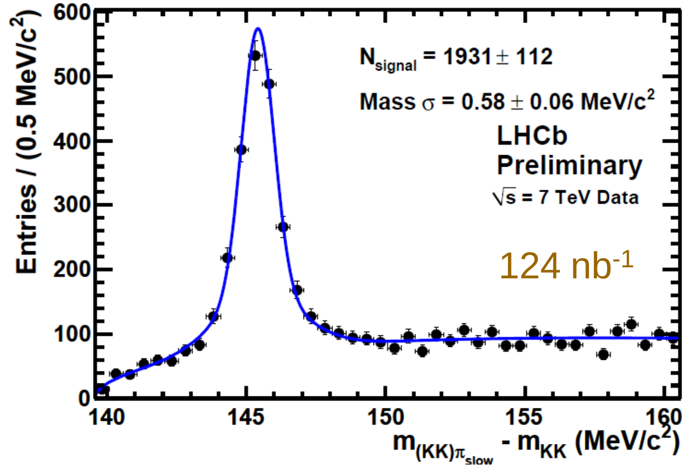
Significant progress requires order of magnitude improvement in sensitivity to mixing phenomena.

Feasible at LHCb in 2010-11 run !

CPV in charm mixing at LHCb

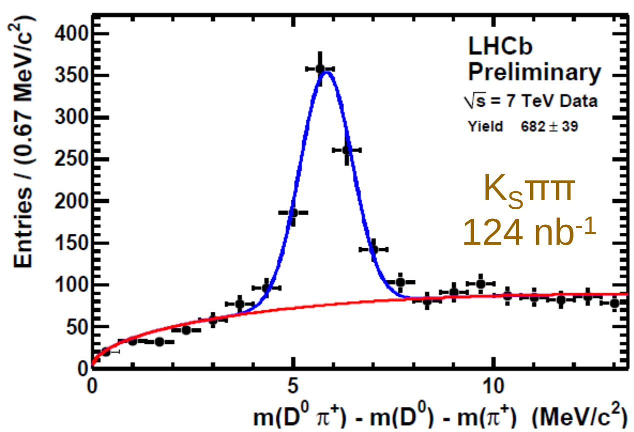
LHCb trigger has good efficiency for such critical final states as $D^* \to D^0\pi$, $D^0 \to KK$.
In such modes should surpass the total B-factory yield within next couple of months.

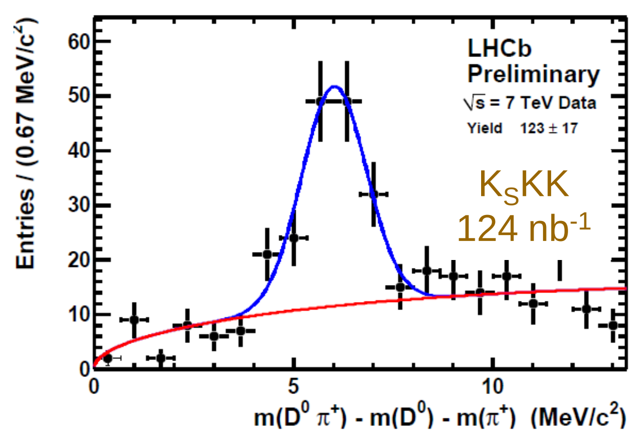




Other topologies, e.g. with K_S,have lower trigger efficiency,

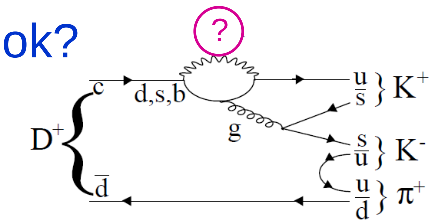
Still, large samples will be available by end of 2011 run





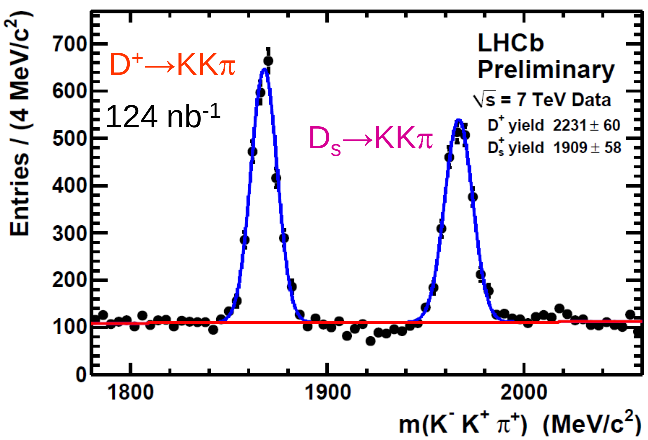
Search for direct CPV in charm at LHCb

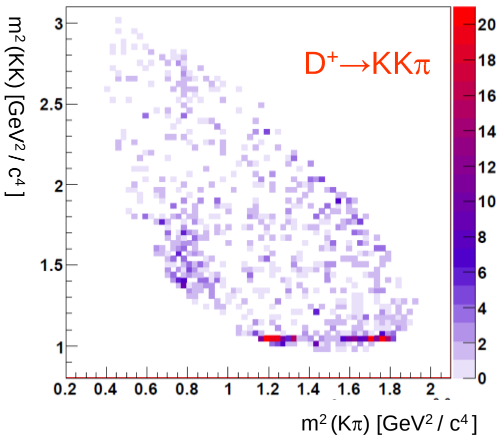
Of equal interest is search for direct CPV in charm. Where to look?

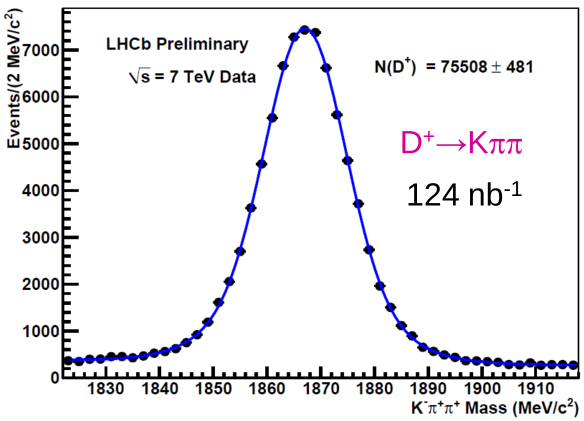


- Singly Cabibbo Suppressed decays – significant contribution of gluonic Penguins gives clear 'entry point' for New Physics
- 3-body decays: analysis of Dalitz plane allows for many interference effects to be probed & is more robust against systematics than two-body rate analysis

Excellent candidate: $D^+ \to K^+K^-\pi^+$ with $D_s^+ \to K^+K^-\pi^+$ & $D^+ \to K^-\pi^+\pi^+$ as control channels







Can be confident of acquiring signal sample of several million events in 100 pb^{-1}

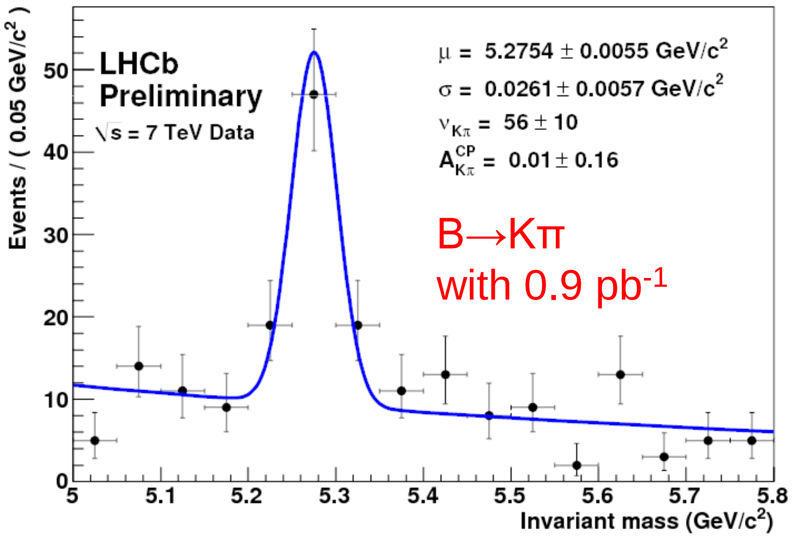
$B_{(s)} \rightarrow hh'$ (h,h'=π,K,p) at LHCb

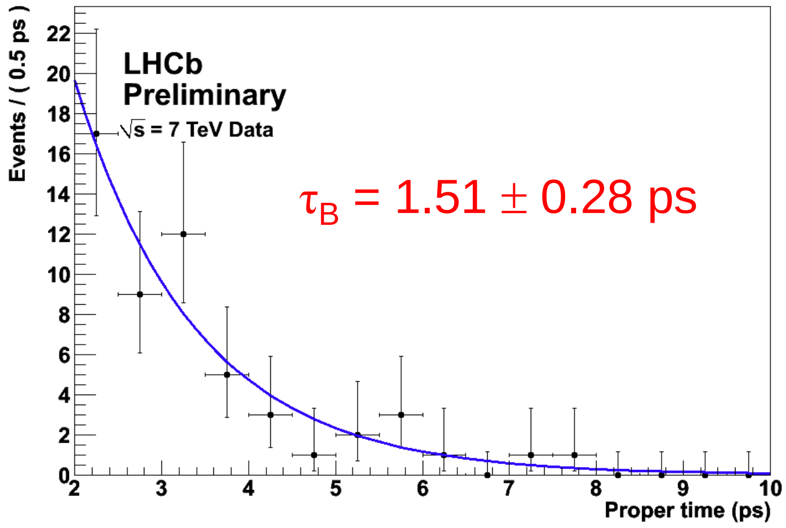
Study of two body charmless B decays (BR ~ 10^{-5}) are core to LHCb programme: γ measurement, study of loop effects etc.

Capabilities of hadron machines demonstrated by CDF [note 8579; PRL 97 (2006) 211802]

Signals already emerging at LHCb – particular benefit provided by RICH system

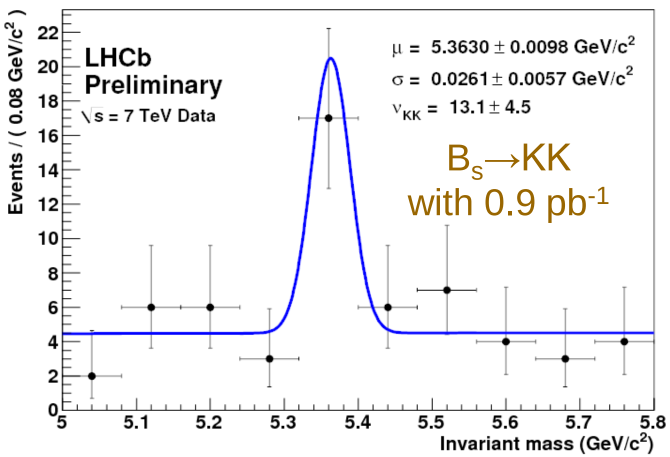
Yields so far ~ match expectations





$B_{(s)} \to hh'$: prospects with early LHCb data

Exciting measurements possible already with a few 100 pb^{-1}, when sample size will be world's largest in both B^0 and B_s decays



	Current knowledge	LHCb stat sensitivity with 200 pb^{-1}
$\mathcal{A}^{CP}_{K^+\pi^-}$	$-0.098^{+0.012}_{-0.011}$	0.008
$\mathcal{A}^{CP}_{\pi^+K^-}$	$0.39 \pm 0.15 \pm 0.08$	0.05
$\mathcal{A}^{CP}_{p\pi^-}$	$0.03 \pm 0.17 \pm 0.05$	0.05
$\mathcal{A}^{CP}_{pK^-}$	$0.37 \pm 0.17 \pm 0.03$	0.03
$\mathcal{A}^{dir}_{\pi^+\pi^-}$	0.38 ± 0.06	0.13
$\mathcal{A}^{mix}_{\pi^+\pi^-}$	-0.65 ± 0.07	0.13
$\mathrm{Corr}(\mathcal{A}^{dir}_{\pi^+\pi^-}, \mathcal{A}^{mix}_{\pi^+\pi^-})$	0.08	-0.03
$\mathcal{A}^{dir}_{K^+K^-}$	**Still unmeasured**	0.15
$\mathcal{A}^{mix}_{K^+K^-}$		0.11
$\mathrm{Corr}(\mathcal{A}^{dir}_{K^+K^-}, \mathcal{A}^{mix}_{K^+K^-})$		0.02
$\frac{\mathcal{BR}(B^0\to\pi^+\pi^-)}{\mathcal{BR}(B^0\to K^+\pi^-)}$	0.264 ± 0.011	0.006
$\frac{\mathcal{BR}(B^0\to K^+K^-)}{\mathcal{BR}(B^0\to K^+\pi^-)}$	$0.020 \pm 0.008 \pm 0.006$	0.005
$\frac{f_s\,\mathcal{BR}(B^0_s\to K^+K^-)}{f_d\,\mathcal{BR}(B^0\to K^+\pi^-)}$	$0.347 \pm 0.020 \pm 0.021$	0.006
$\frac{f_s\,\mathcal{BR}(B^0_s\to\pi^+K^-)}{f_d\,\mathcal{BR}(B^0\to K^+\pi^-)}$	$0.071 \pm 0.010 \pm 0.007$	0.004
$\frac{f_s\,\mathcal{BR}(B^0_s\to\pi^+\pi^-)}{f_d\,\mathcal{BR}(B^0\to K^+\pi^-)}$	$0.007 \pm 0.004 \pm 0.005$	0.002
$\frac{f_{\Lambda_b}\,\mathcal{BR}(\Lambda_b\to p\pi^-)}{f_d\,\mathcal{BR}(B^0\to K^+\pi^-)}$	$0.0415 \pm 0.0074 \pm 0.0058$	0.0016
$\frac{f_{\Lambda_b}\,\mathcal{BR}(\Lambda_b\to pK^-)}{f_d\,\mathcal{BR}(B^0\to K^+\pi^-)}$	$0.0663 \pm 0.0089 \pm 0.0084$	0.0018

Some possible goals:

- $B_s \to K\pi$ charge asymmetries
- Relative BR measurements
- $B_s \to KK$ lifetimes
- $B_s \to KK$ CP-violation
- $B^0 \to KK$, $B_s \to \pi\pi$ discovery

See Carbone, WG 6

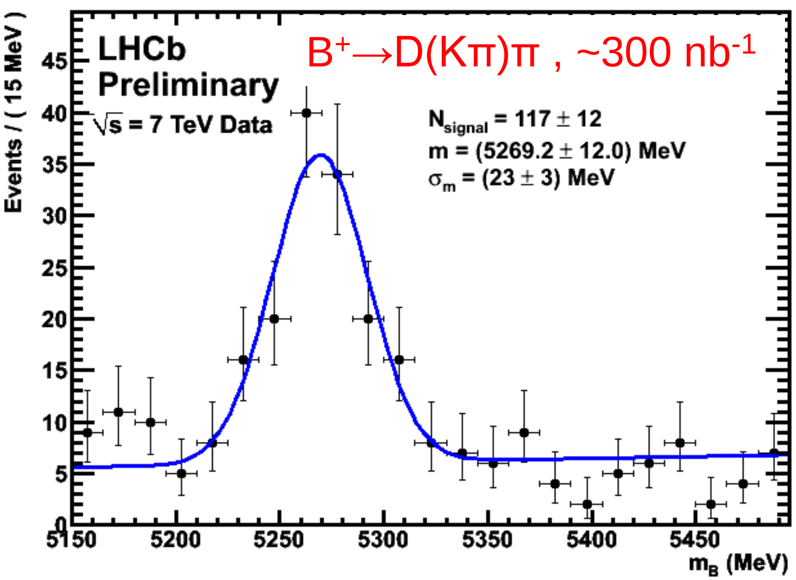
Multibody hadronic final states – the road to γ

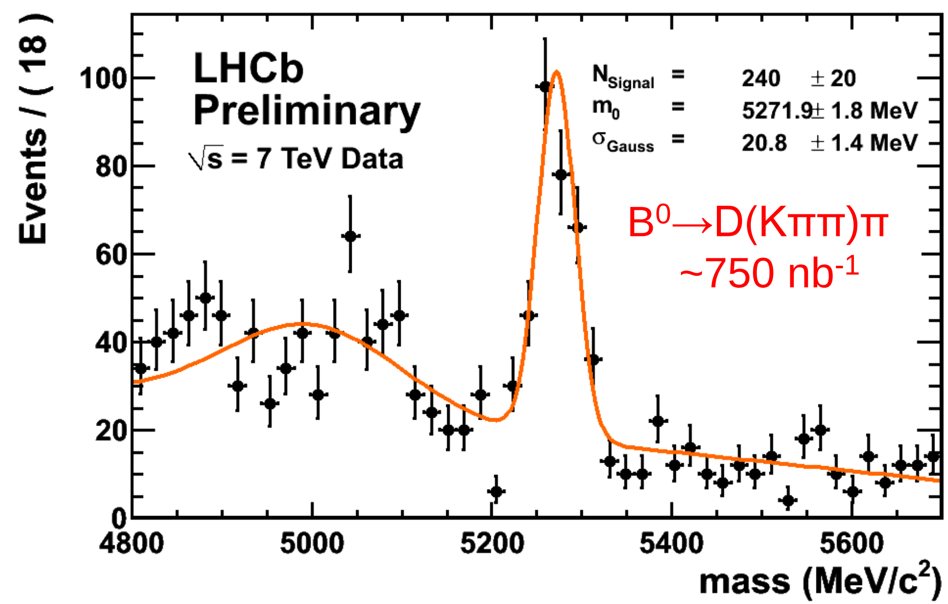
Important long term goal of LHCb: precision (~2°) measurement of tree level γ which will provide critical Standard Model benchmark in CKM tests.

Advantages of hadron machines:

1. High statistics !
2. No need for flavour tagging with time integrated strategies, e.g. $B^+ \to DK^+$
3. Time dependent measurements with B_s mesons, e.g. $B_s \to D_s K$

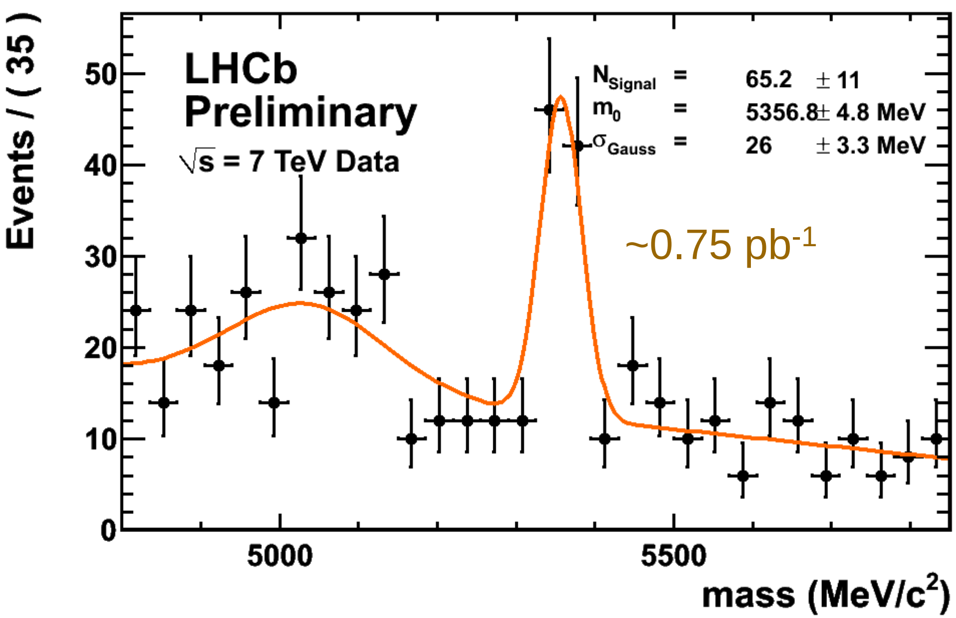
First signals emerging at ~ expected rate. Conclusions: trigger, tracking and PID all working well ! (And further improvements to trigger in preparation)



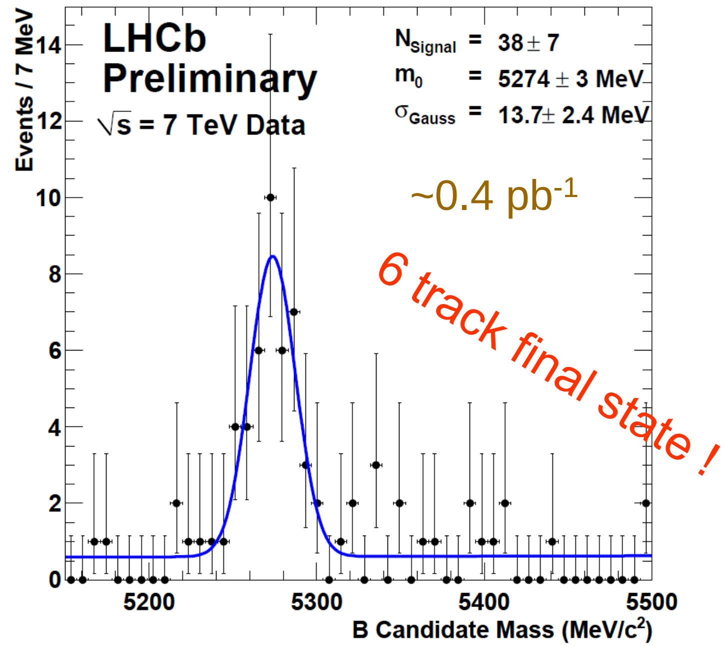


More multibody hadronic final states

$B_s \rightarrow D_s(KK\pi)\ \pi$



$B^0 + B^+ \rightarrow D\ (K\pi,\ K\pi\pi)\ \pi\pi\pi$



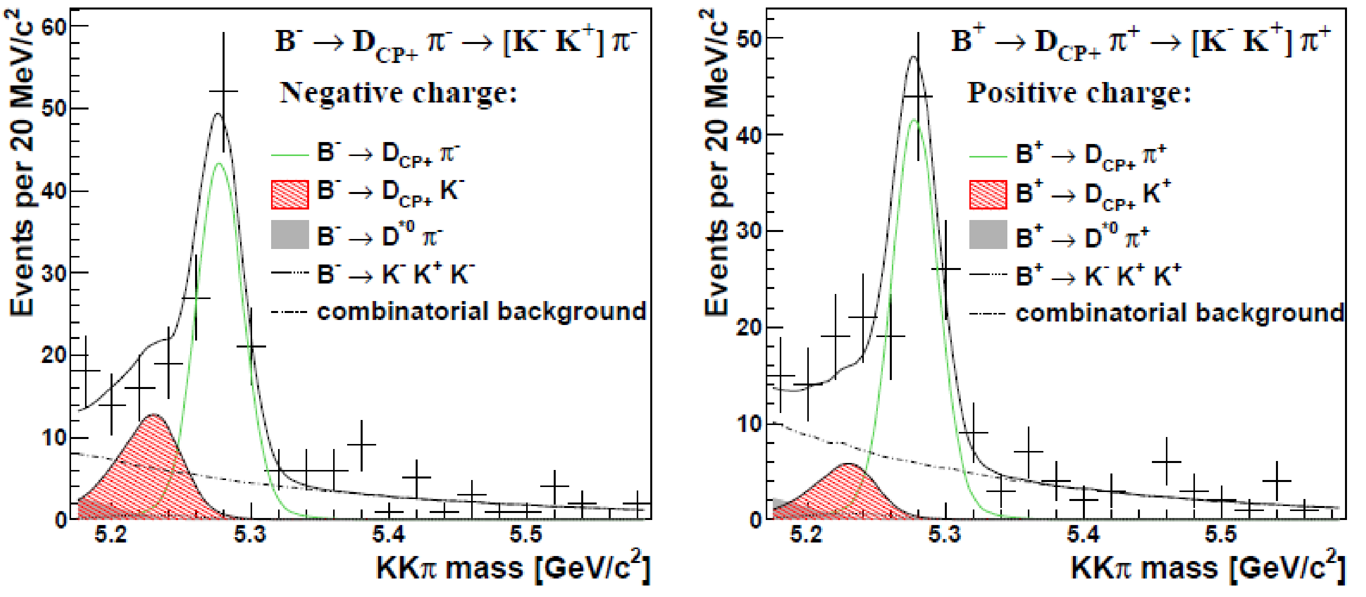
Opportunity to make significant contribution to knowledge of γ with 2010-11 data !

See Gligorov & Williams, WG 5

γ studies at CDF

Capabilities of hadron experiments in γ studies already demonstrated by CDF

GLW studies with 1 fb^{-1} [PRD 81 (2010) 031105(R)]



New this week: preliminary ~5 fb^{-1} ADS study – Paola Squillacioti, WG V

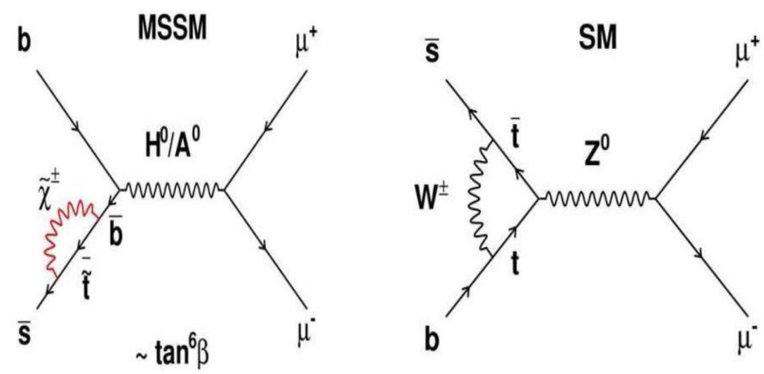
The golden mode: $B_s \to \mu\mu$

B physics rare decay par excellence:

$BR(B_s \to \mu\mu)_{SM}$ = (3.35 0.32) x 10^{-9}

(Blanke et al., JHEP 0610:003,2006)

Precise prediction (which will improve) !



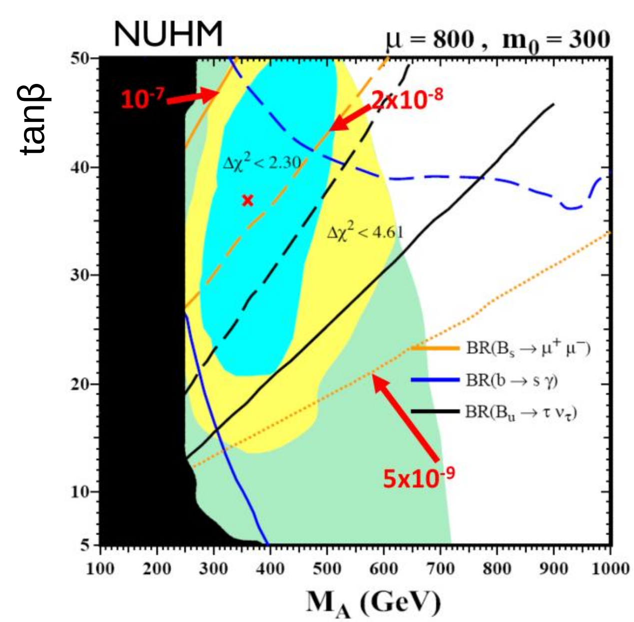
Very high sensitivity to NP, eg. MSSM:

$$Br^{MSSM}(Bq \to l^+ l^-) \propto \frac{m_b^2 m_l^2 \tan^6 \beta}{M_{A0}^4}$$

One example (Ellis et al., JHEP 0710:092,2007) with NUHM (= generalised version of CMSSM)

- $b \to s\gamma$ and Higgs > 114.4 GeV
  - ⟹ M_A > ~ 300 GeV & $\tan\beta$ < ~50
- $(g_\mu\text{-}2)$ is 3.4σ from SM
  - ⟹ M_A < ~ 500 GeV & $\tan\beta$ > ~20

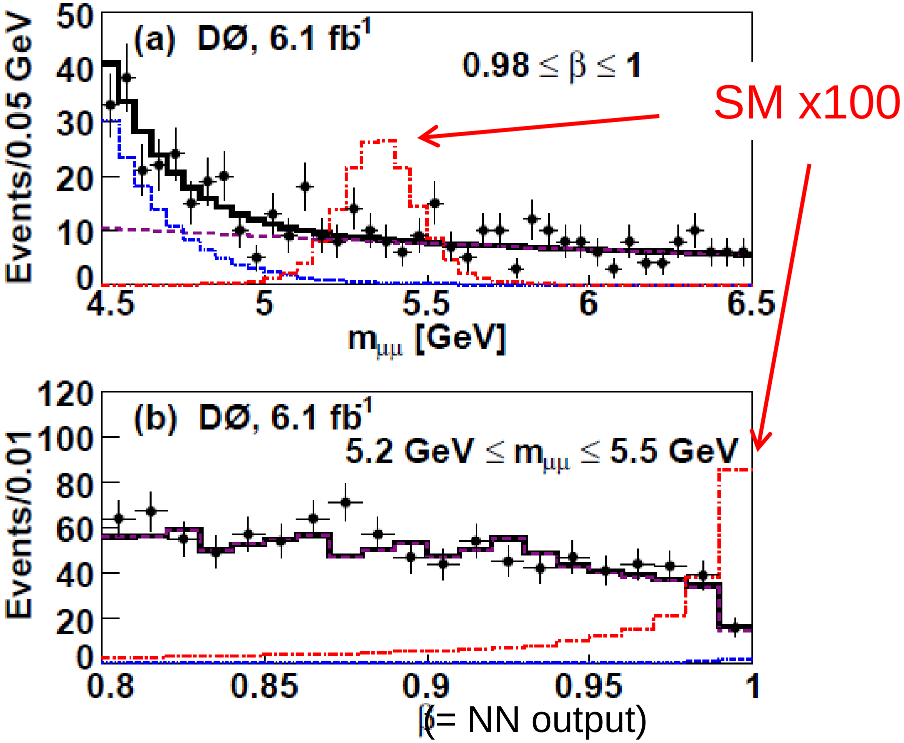
} $BR(B_s \to \mu\mu) \approx 2 \times 10^{-8}$



$B^0_s \to \mu\mu$ search at the Tevatron

Recent D0 update [arXiv:1006.3469] with 6.1 fb^{-1} and several analysis improvements:

- improved muon id and trigger selection
- construct Bayesian NN with all discriminant variables apart from $m_{\mu\mu}$
- limits calculated in bins on NN and $M_{\mu\mu}$



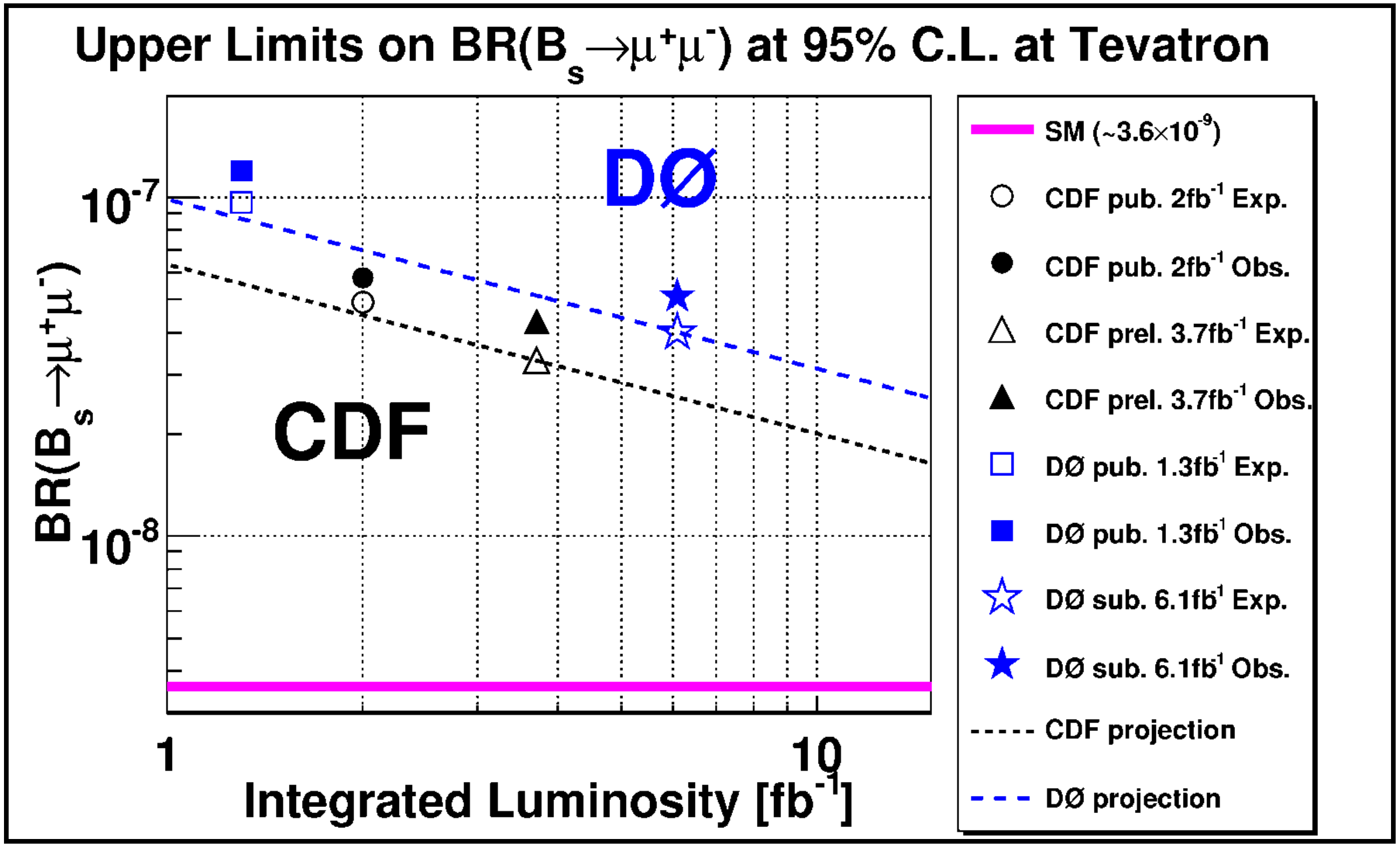
Compare with 3.7 fb^{-1} CDF update [CDF note 9892] using similar method:

		95% CL
D0 observed	(6.1 fb^{-1})	< 5.1 x 10^{-8}
	expected	4.2 x 10^{-8}
CDF observed	(3.7 fb^{-1})	< 4.2 x 10^{-8}
	expected	3.3 x 10^{-8}

For both limit is slightly worse than expectation....

See Bertram, WG 3

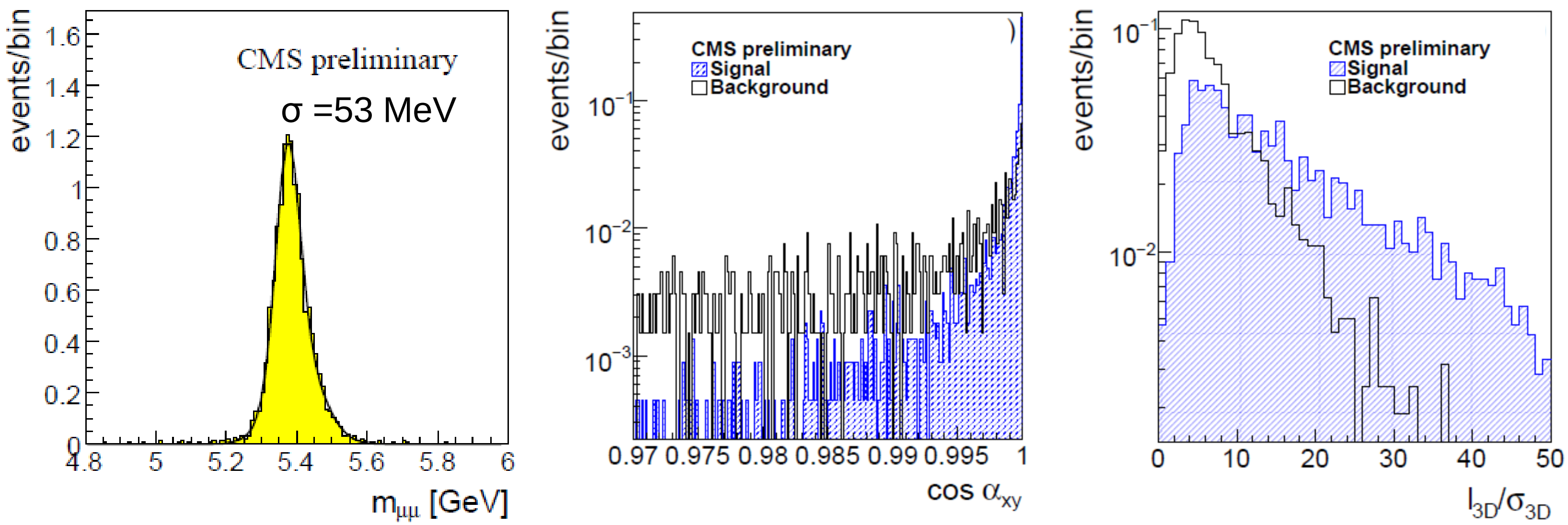
$B^0_s \to \mu\mu$: Tevatron future prospects



Expected 95% CL will be 2-3 x 10^{-8} for both experiments with integrated lumi that will be collected up to end of 2011. Combination will improve things further.

$B^0_s \to \mu\mu$ at LHC: GPD prospects

$B^0_s \to \mu\mu$ search is a flavour-physics topic well suited to GPDs.
Some example discriminant variables from CMS MC @ 14 TeV [BPH-07-001-PAS] :



Invariant mass — Cosine of 'pointing angle' — Flight length significance

$BR(B^0_s \to \mu\mu) < 2.1 \times 10^{-8}$ (90% CL) with 1 fb^{-1} at $\sqrt{s}$ = 7 TeV *

* Scaling quoted result by ratio of LHCb measured x-sec at $\sqrt{s}$ = 7 TeV to 14 TeV value assumed in MC study.

$B_s \to \mu\mu$ at LHCb

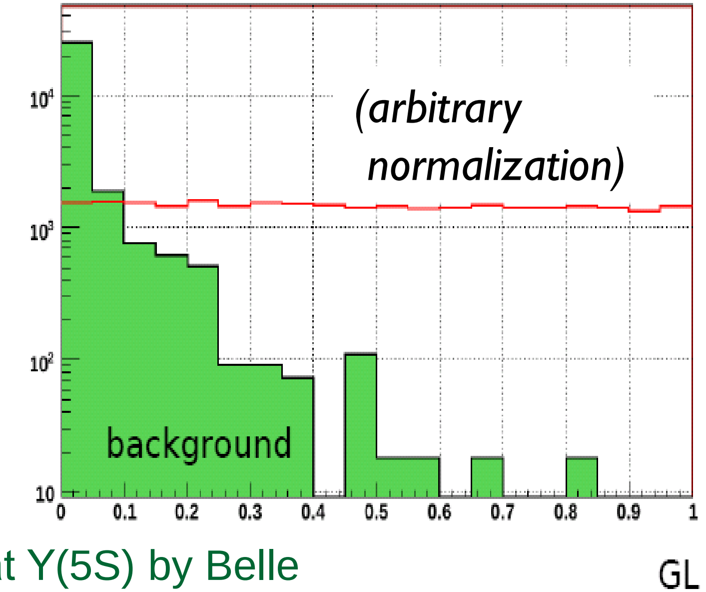
LHCb approach will be philosophically similar to Tevatron's: loose preselection (which is optimised to have similar efficiency for signal and control channels: $B_{(s)} \to h^+h^-$, $B^+ \to J/\psi K^+$, $B \to J/\psi K^*$), and then construction of global likelihood

Global likelihood built from:

- 'Geometrical likelihood' (topology & lifetime info)
- Invariant mass likelihood
- Particle id likelihood

(Signal calibrated on control channels; background from sidebands)

Observation then turned into limit or BR measurement after comparing with known control channel, eg. $B^+ \to J/\psi K^+$



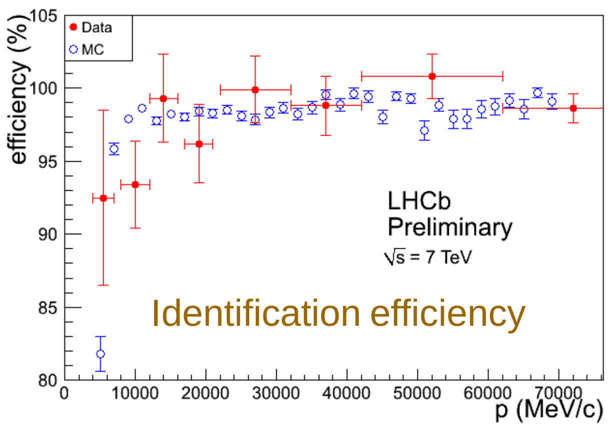
Uncertainty on B_s/B^+ production ratio (~13%) an annoying systematic. Hopes for future:

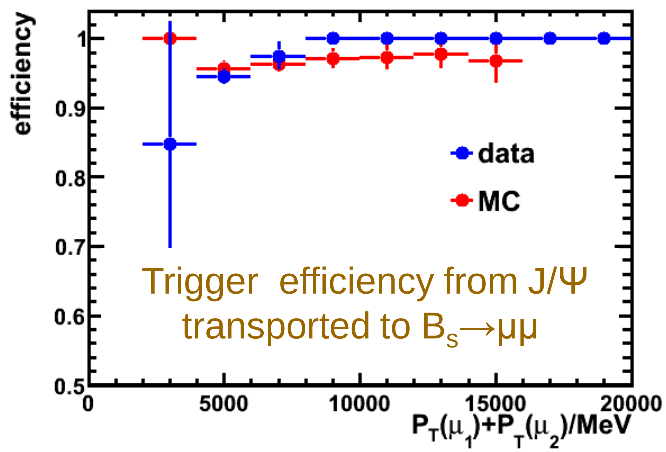
- Perform measurements of ratio at LHCb, using some assumptions eg. with $B_s \to D_s\pi$ vs. $B \to DK$ [Fleisher *et al.*, PRD 82 (2010) 034038]
- Exploit improved B_s BR's measurements made at Y(5S) by Belle

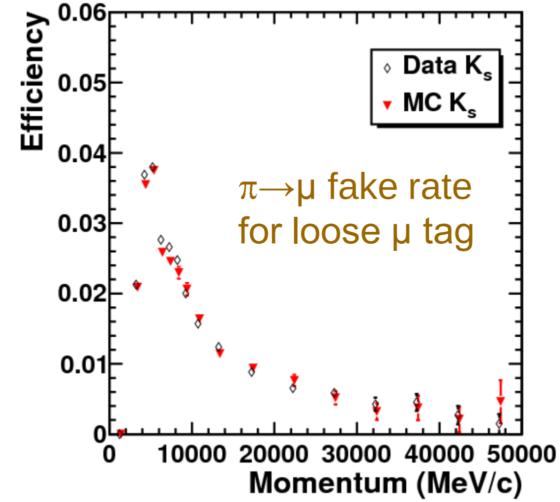
See Serra, WG 3

$B_s \to \mu\mu$ at LHCb: critical analysis inputs

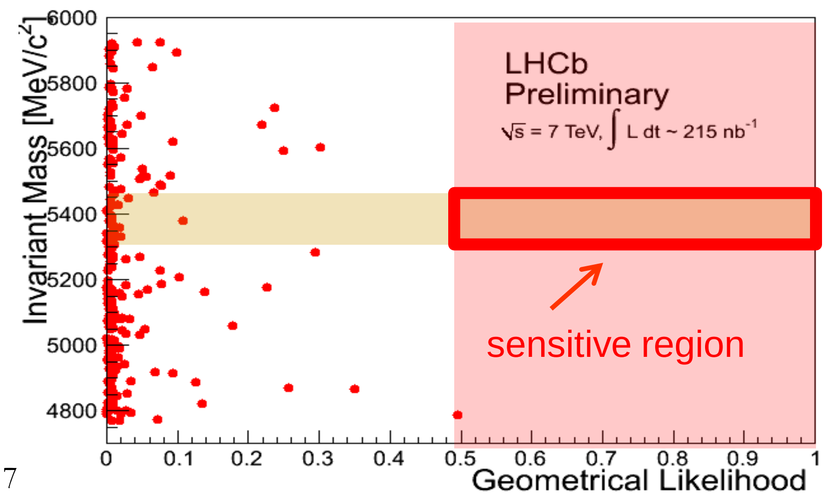
Muon identification, trigger & misidentification performing as expected from MC:

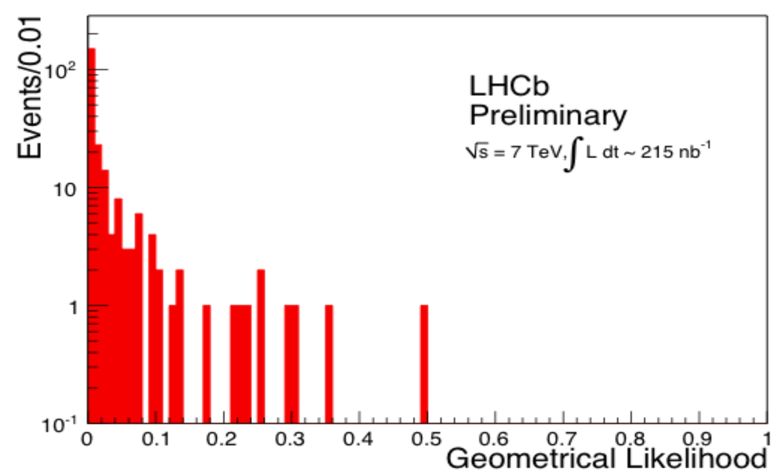






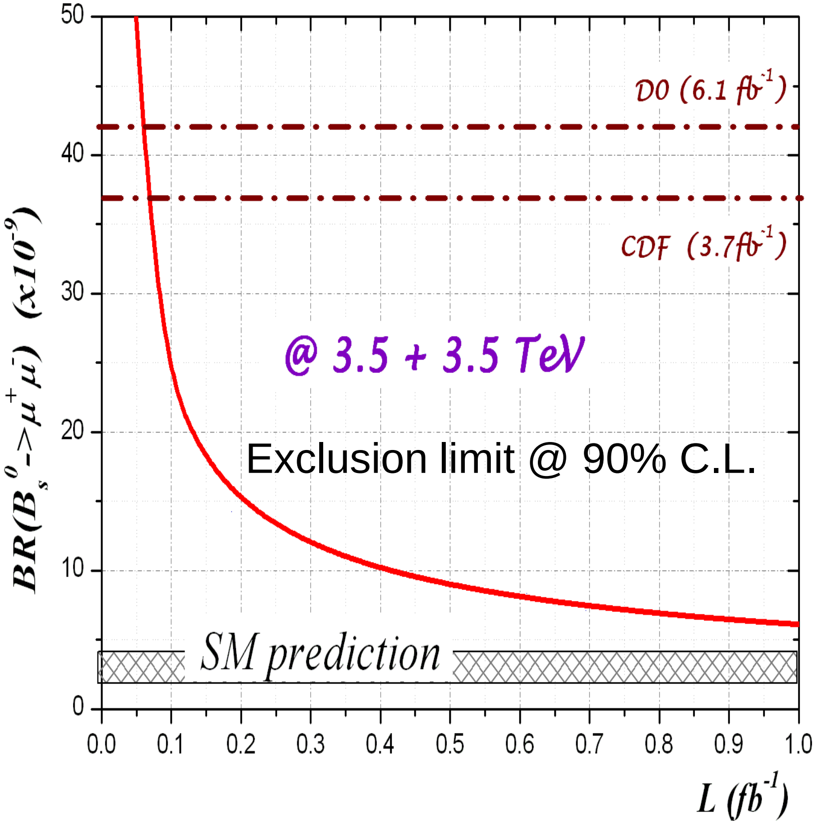
Geometrical likelihood vs invariant mass for 0.2 pb^{-1}:
no events in sensitive region and general properties of background as expected

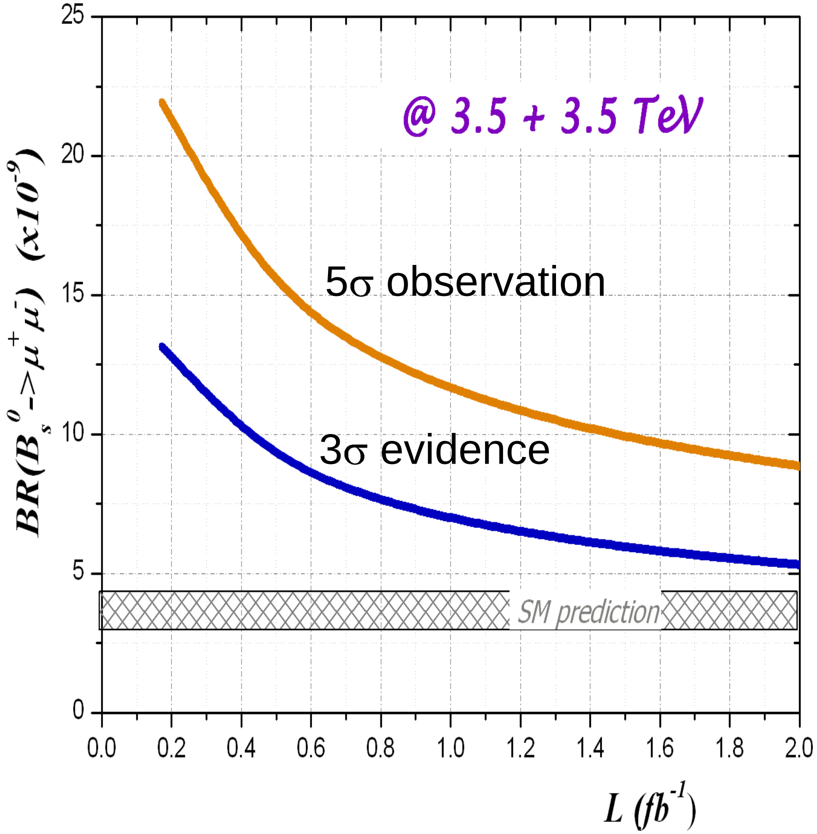




Prospects for $B_s \to \mu\mu$ at LHCb

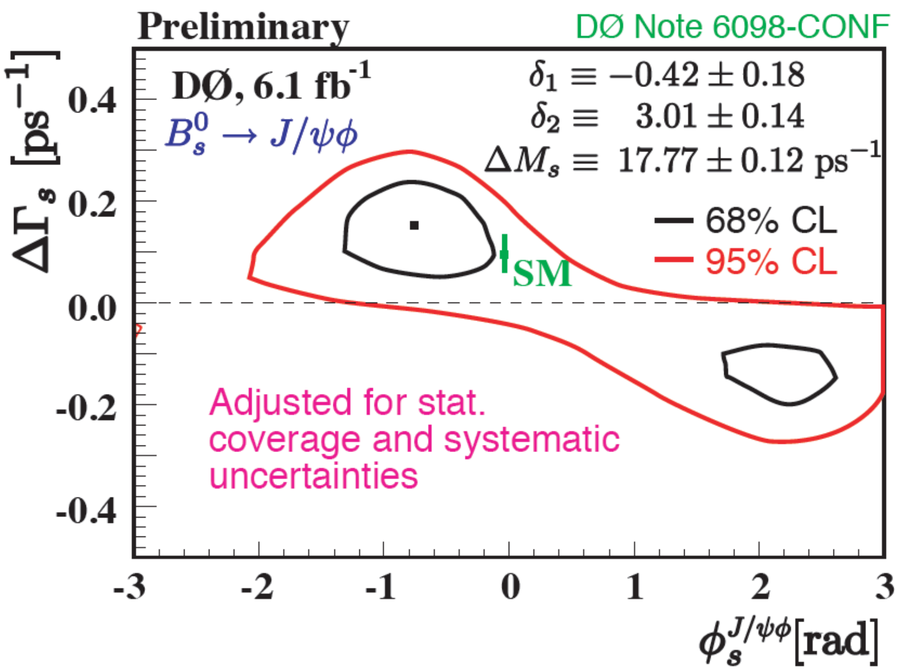
Expected sensitivity at LHCb assuming measured $b\bar{b}$ cross-section (292 μb)



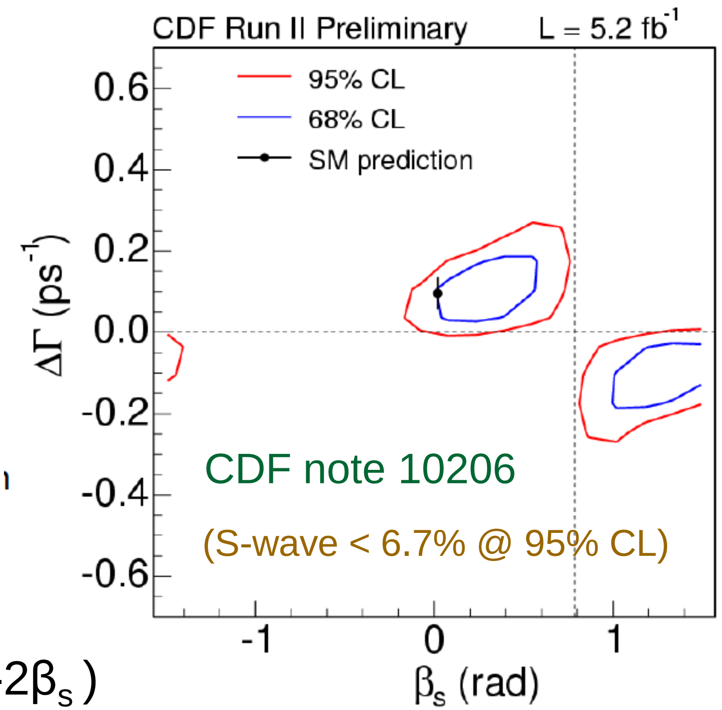


CPV in $B_s \rightarrow J/\psi\Phi$ at the Tevatron

Recent updates to the Tevatron $B_s \rightarrow J/\Psi\Phi$ analyses have increased the data Sample (6.1 fb^{-1} D0, 5.2 fb^{-1} CDF) and some refinements to the analyses.
e.g. S-wave under Φ: D0 have checked this is small, and CDF include it in the fit



(= $-2\beta_s$)

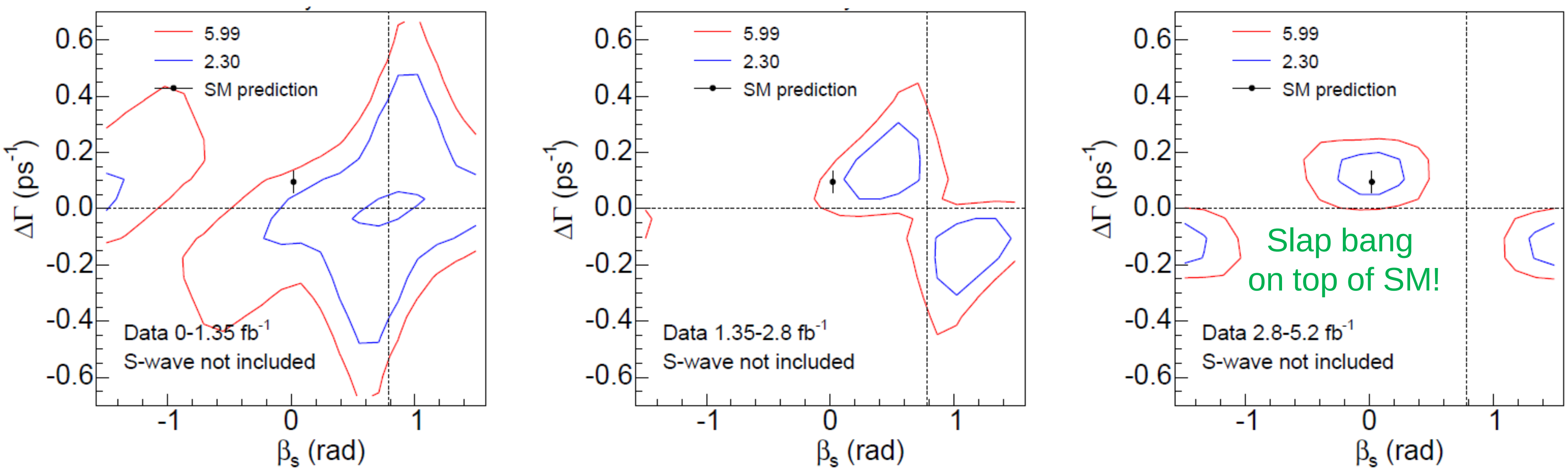


Results are consistent, & both are 1σ away from SM. 2σ discrepancy observed in combination of the earlier analyses (2.8 fb^{-1}) has diminished (but no new comb. yet)

See Tues pm, WG 4

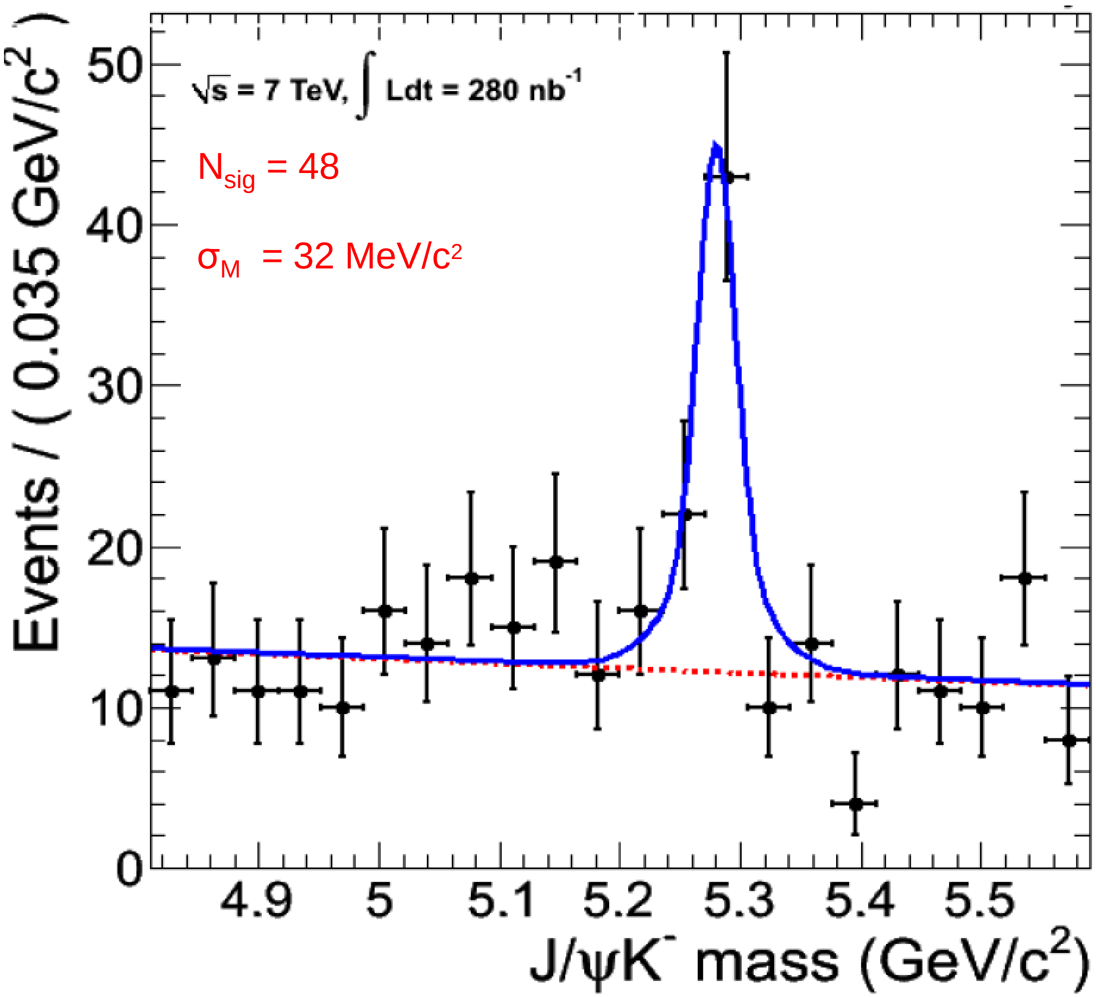
Time dependent CPV measurements

Dividing the CDF dataset into 3 parts yields a result which evolves in time (albeit in a manner which has internal statistical consistency)

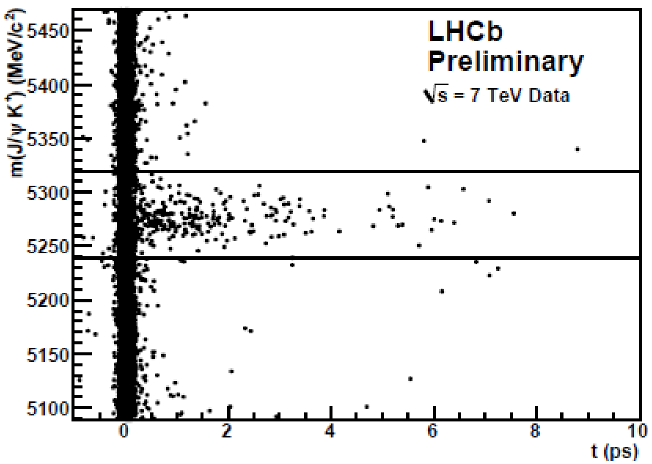


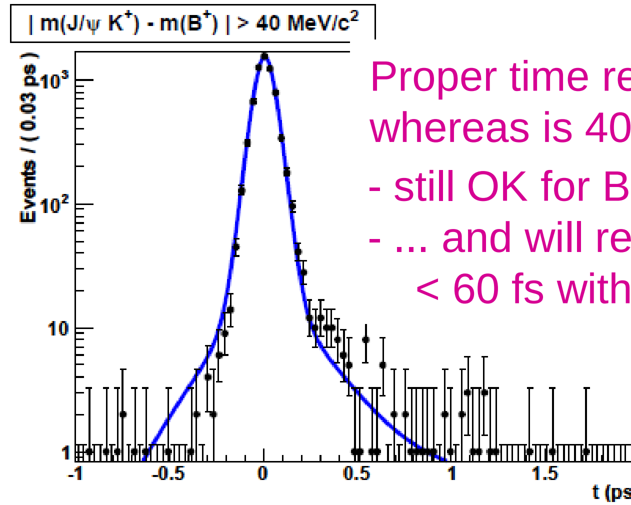
Let's hope it will oscillate back with the next 5 fb^{-1} ...

$B^+ \to J/\psi K^+$ at CMS with ~280 nb^{-1}



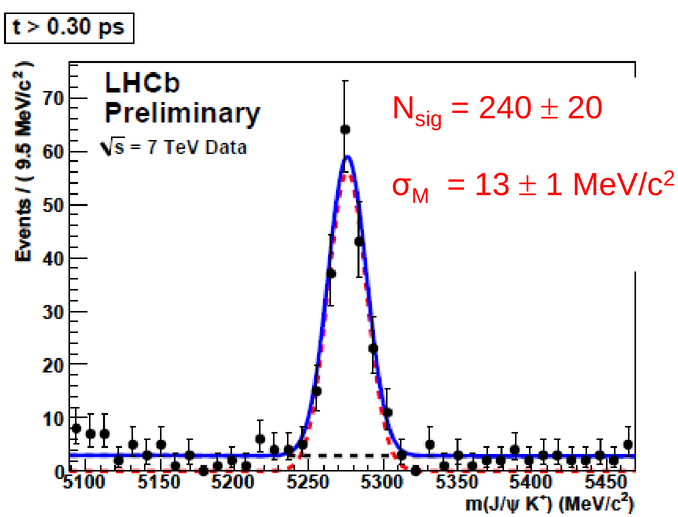
$B^+ \to J/\psi K^+$ at LHCb with ~600 nb^{-1}

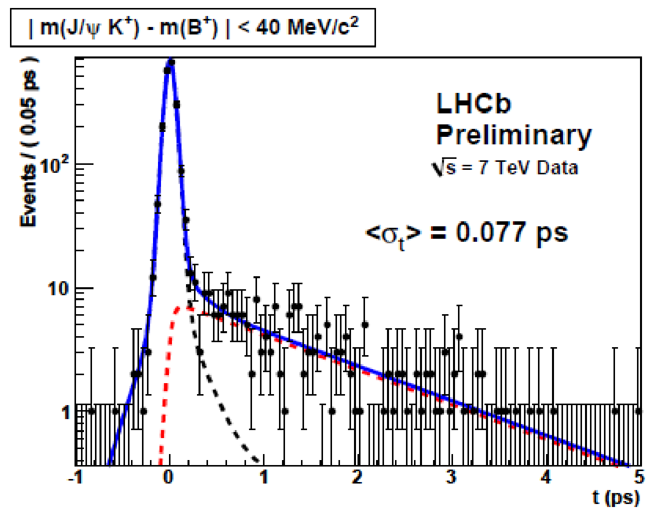




Proper time resolution 77 fs, whereas is 40 fs in MC:

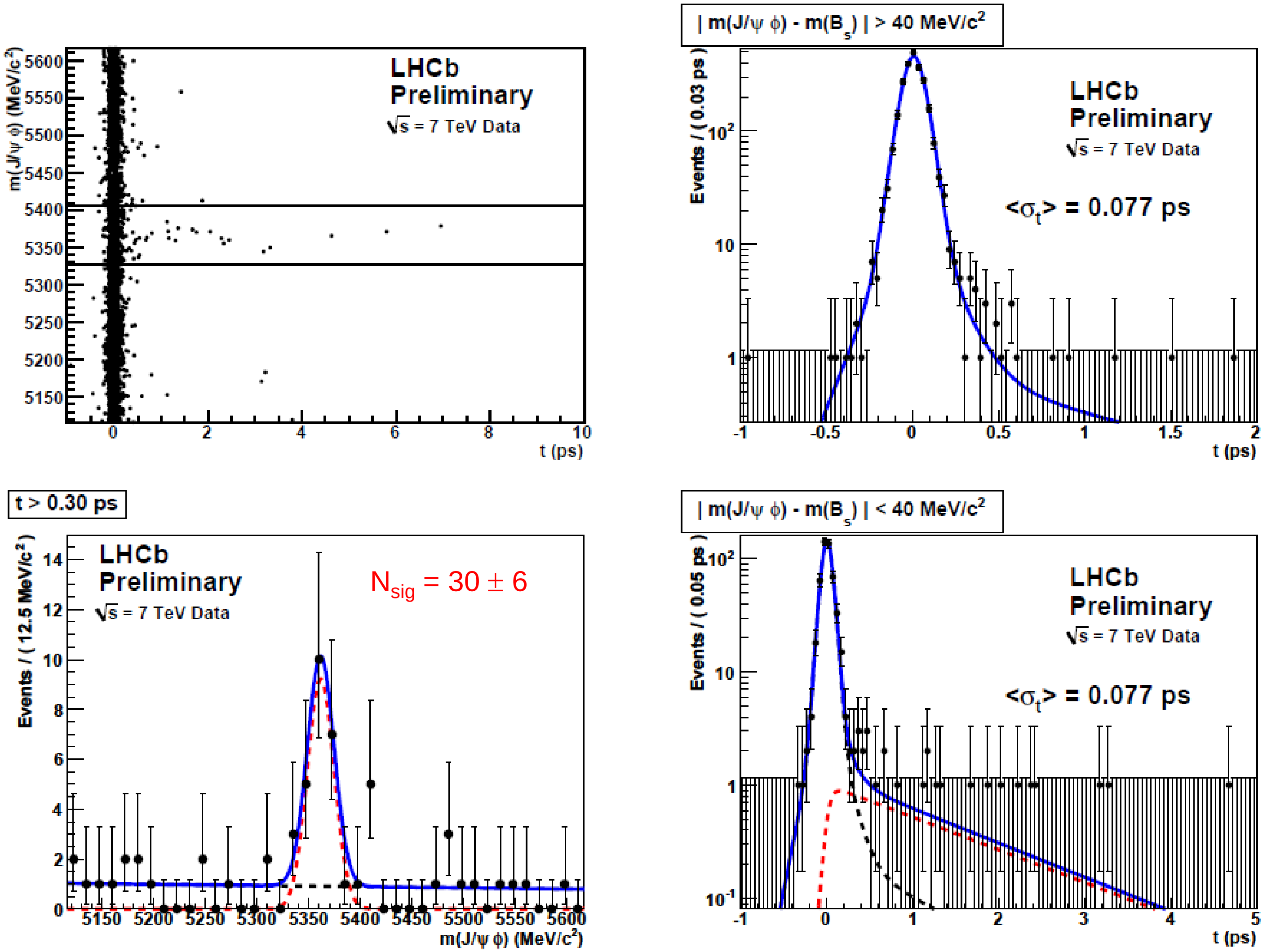
- still OK for B_s physics !...
- ... and will reduce to < 60 fs with new alignment

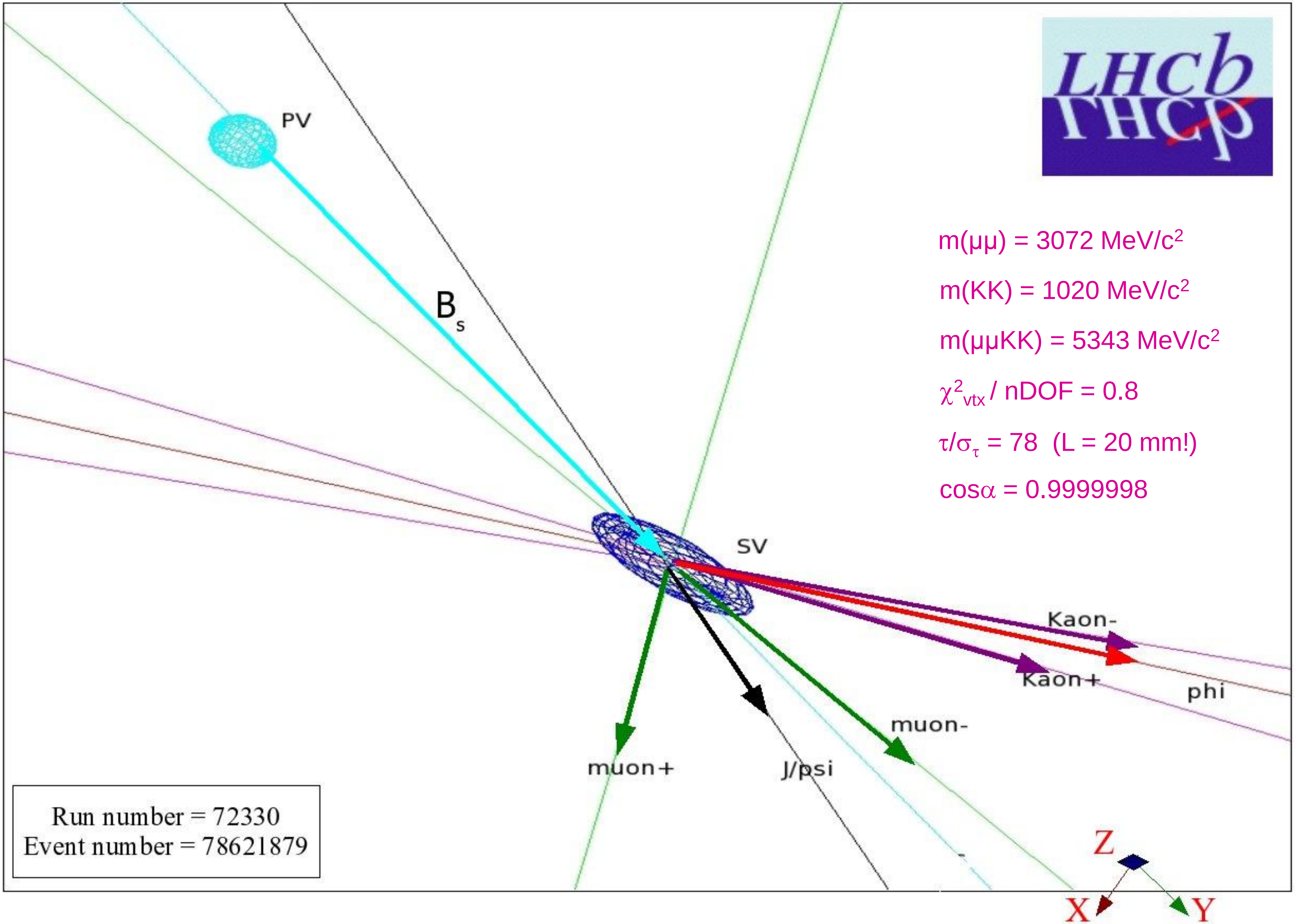




Rate as expected !

$B_s \to J/\psi\Phi$ at LHCb with ~600 nb^{-1}





$m(\mu\mu) = 3072$ MeV/c^2

$m(KK) = 1020$ MeV/c^2

$m(\mu\mu KK) = 5343$ MeV/c^2

χ^2_{vtx} / nDOF = 0.8

$\tau/\sigma_\tau = 78$ (L = 20 mm!)

$\cos\alpha = 0.9999998$

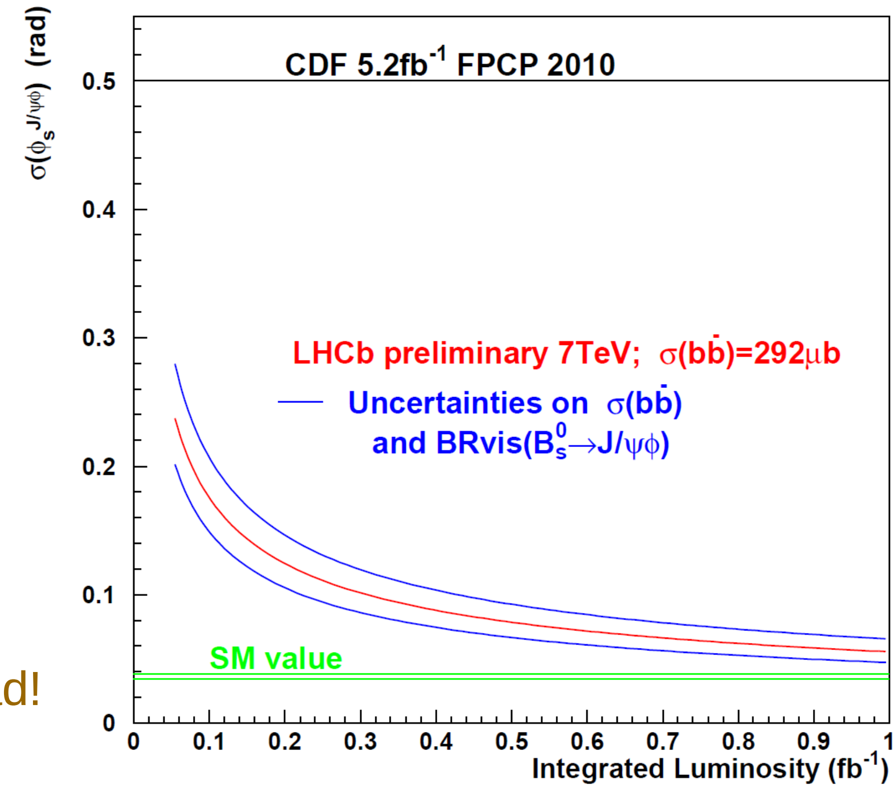
Φ_s prospects at LHCb in 2010

Sensitivity to Φ_s at LHCb vs. Integrated luminosity using $B_s \rightarrow J/\Psi\Phi$ alone

Reality checklist

- Measured cross-section: consistent with expectations
- Rate of signal events: consistent with expectations
- Proper time resolution: with new alignment sensitivity will be within 40% of MC performance
- Tagging performance: we will know about this soon

Promising, but lots of hard work ahead!



Performance will be augmented
using other modes, e.g. $B_s \rightarrow J/\Psi f0(\pi\pi)$ – CP eigenstate, so simpler analysis

New physics in a^s_{sl} (&/or a^d_{sl}) ?

If New Physics enhances CP-violation in $B^0_S \to J/\psi\Phi$, it will likely also dominate over the (negligible) SM CP-violation predicted in the like-sign lepton asymmetry.

D0 collaboration: arXiv:1007.0395 [hep-ph]

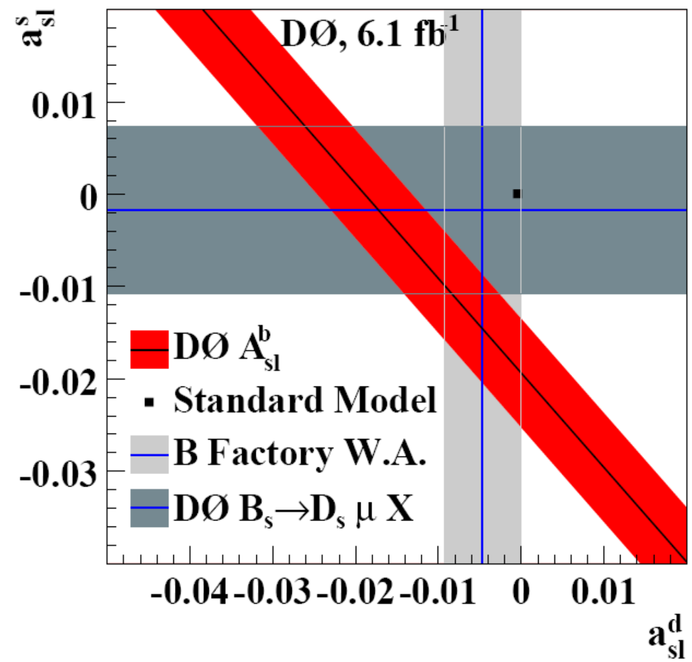
$$A^b_{sl} = \beta_d a^d_{sl} + \beta_s a^s_{sl}\ , \quad \beta_d \approx \beta_s \approx 0.5$$

$$A^b_{sl}(\mathrm{SM}) = (-2.3^{+0.5}_{-0.6}) \times 10^{-4}$$

$$A^b_{sl} = -0.00957 \pm 0.00251\,(\mathrm{stat}) \pm 0.00146\,(\mathrm{sys})$$

3σ tension with SM

Very challenging systematics ! D0 'trick' is to exploit correlation in background between single lepton & dilepton samples



CDF performed preliminary measurement with 1.6 fb^{-1} which used IP significance

$$A_{SL} = 0.0080 \pm 0.0090(stat) \pm 0.0068(syst)$$

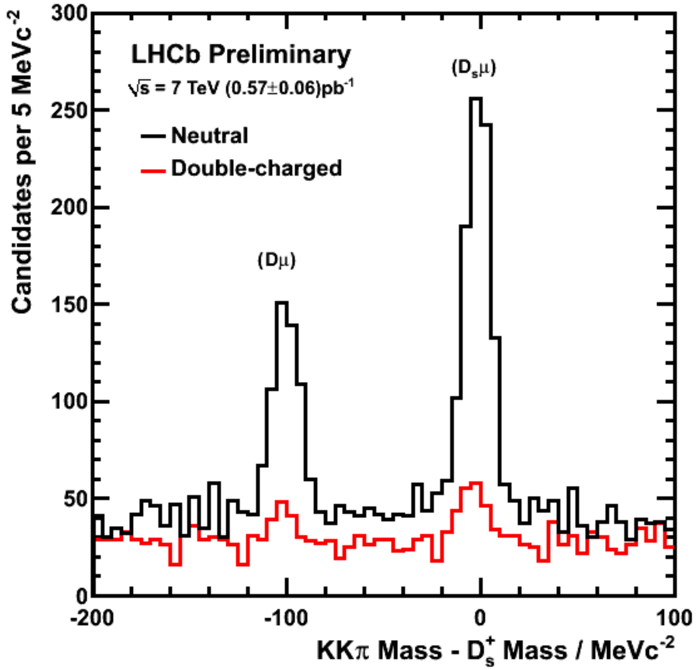
[CDF note 9015]

D0 aim to improve analysis method and add more statistics – update Spring 2011?

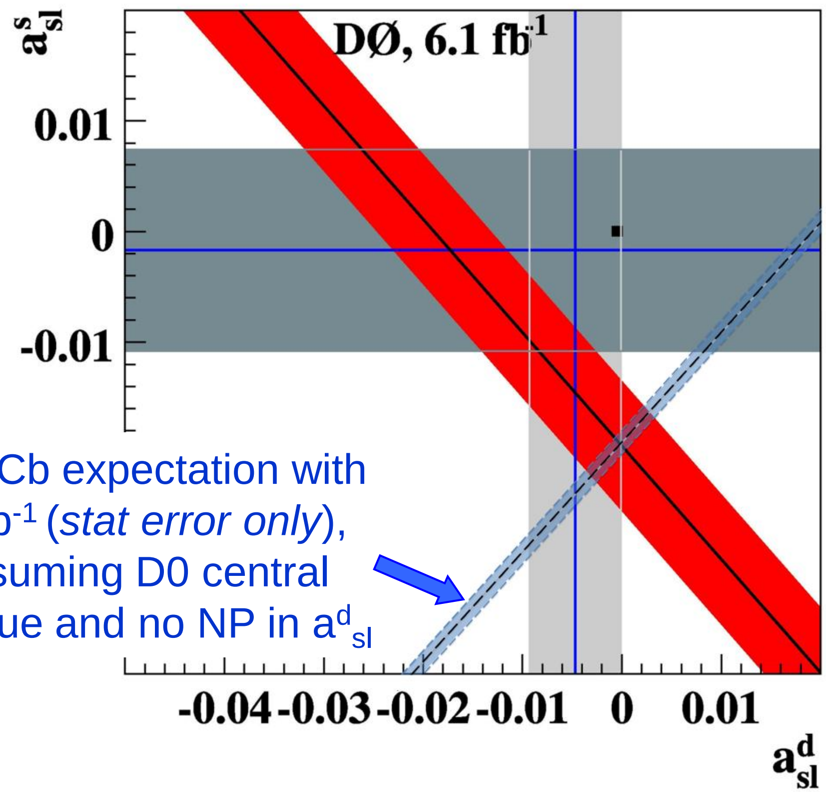
See Tues pm, WG 4

a^s_{sl} & a^d_{sl} at LHCb

LHCb proposes to measure $a^s_{sl} - a^d_{sl}$, by determining the difference in the asymmetry measured in $B_s \to D_s(KK\pi)\mu\nu$ & $B^0 \to D^+(KK\pi)\mu\nu$ - same final state suppresses detector biases. Provides orthogonal constraint to D0 dileptons.



Events already being accumulated



LHCb expectation with 1 fb^{-1} (*stat error only*), assuming D0 central value and no NP in a^d_{sl}

Conclusions

Harvest of heavy-flavour results from the Tevatron has only just begun – barely half the final data set has so far been analysed

First indications from the LHC machine and experiments is that MC sensitivity studies are reasonable indicators of performance. All is working well and no show-stoppers identified.

First LHC run offers many possibilities of discovery:

- Charm CPV
- A^{FB} in $B \rightarrow K^{*}\mu\mu$ (see backups)
- $B_s \rightarrow \mu\mu$
- CPV in B_s sector

No dark age for flavour physics –
Here comes the sun !

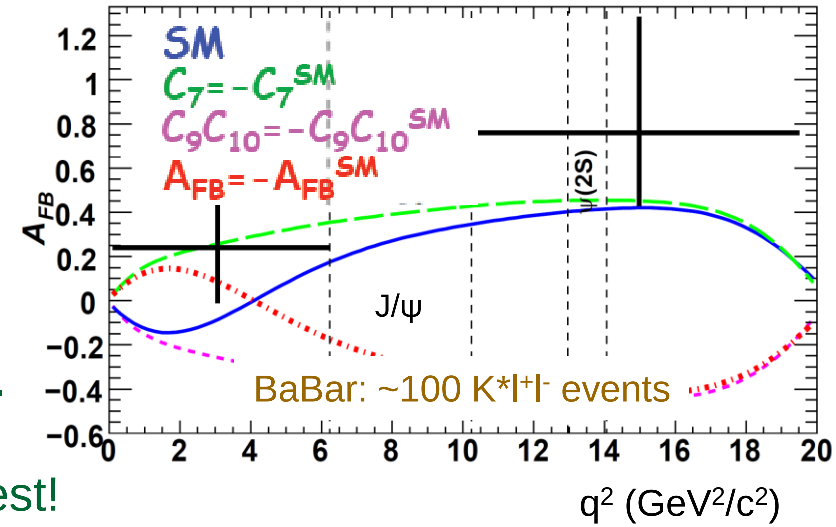
Backups

Intriguing hints from $B \to K^{(*)} l^+ l^-$

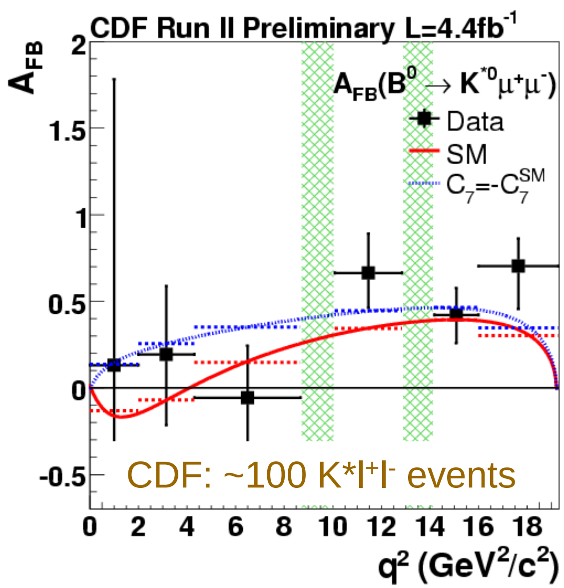
Forward backward asymmetry in $B^0 \to K^* l^+ l^-$ is a extremely powerful observable for testing SM vs NP

Most reliable predictions are at low q^2 - below & up to crossing-point

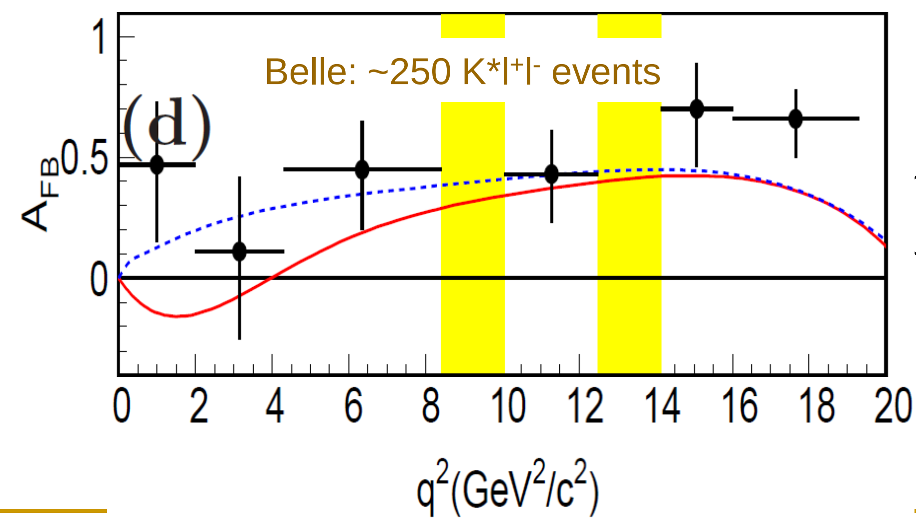
Early results are showing intriguing hints. Not yet an 'anomaly', but any deviation where one is hoped for has special interest!



PRD 79 (2009) 031102



CDF note 10047



PRL 103 (2009) 171801

See Eigen, WG 3

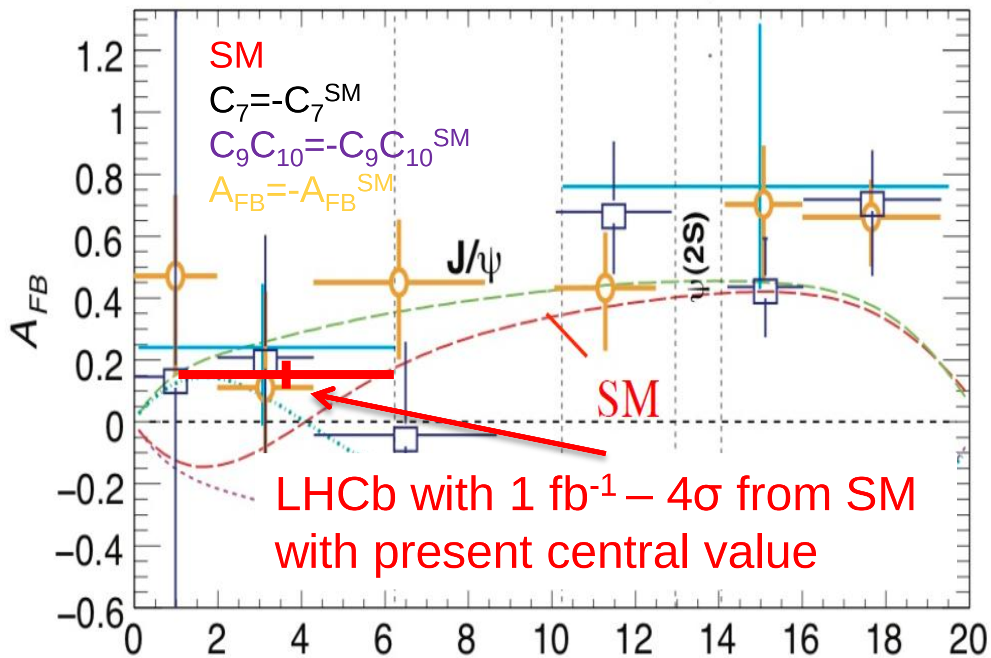
Prospects for B→K(*)l+l-

Present number of events worldwide: ~450

CDF could presumably add ~200 in data collected up to and including next year

Possibilities for significant measurement at D0 too ?

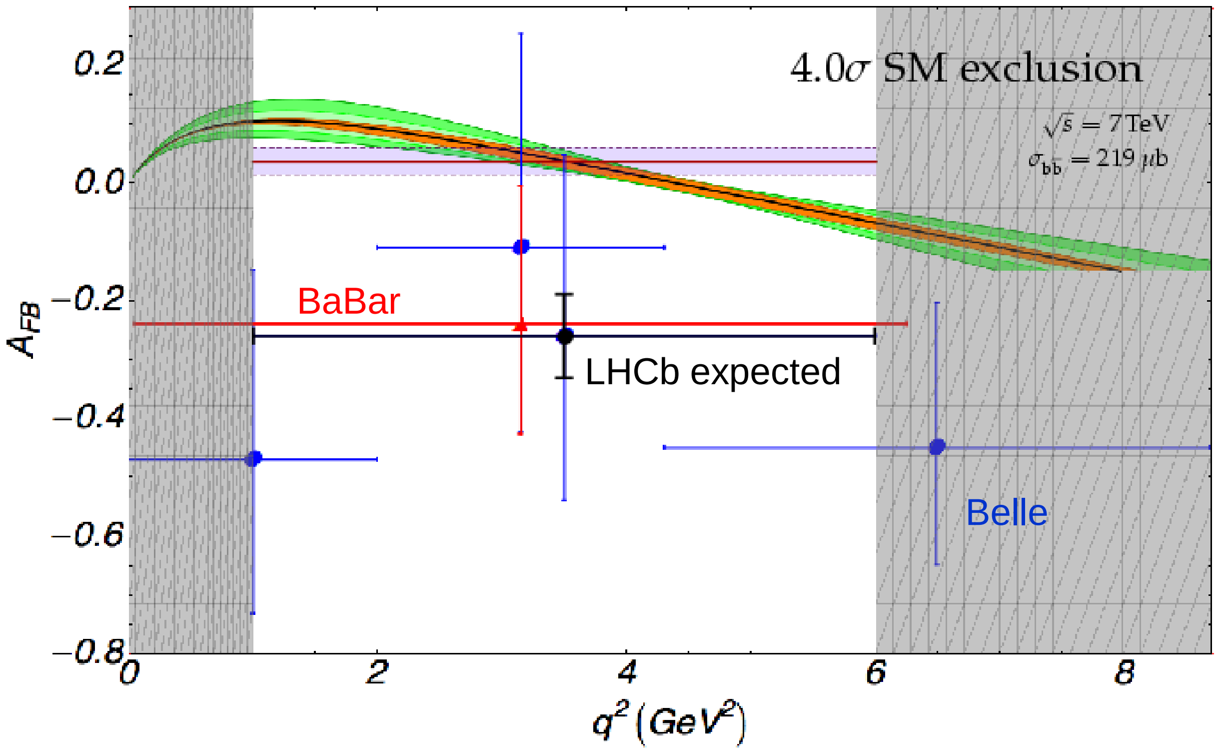
LHCb expects ~1200 events in 1 fb^{-1}



If anomaly is real, the next couple of years will be most interesting !

$B \to K^{(*)} l^+ l^-$ prospects

With 1 fb^{-1} LHCb expects 1200 events, and should clarify existing situation



Flipped sign in asymmetry definition compared with slide on existing results

If picture becomes more SM-like then next task will be to pin down position of A_{FB}=0 which is cleanly predicted. Precision of 0.8 GeV^2 in 1 fb^{-1}