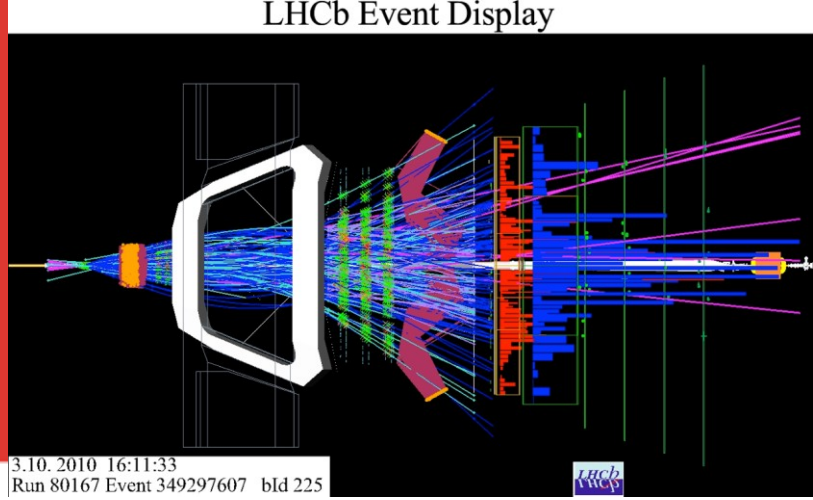


Studies of hadronic B decays with early LHCb data

Aurélien MARTENS
(LAL – Univ. Paris Sud 11 – Orsay)
On behalf of the LHCb Collaboration

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

γ and the current status of the CKM matrix

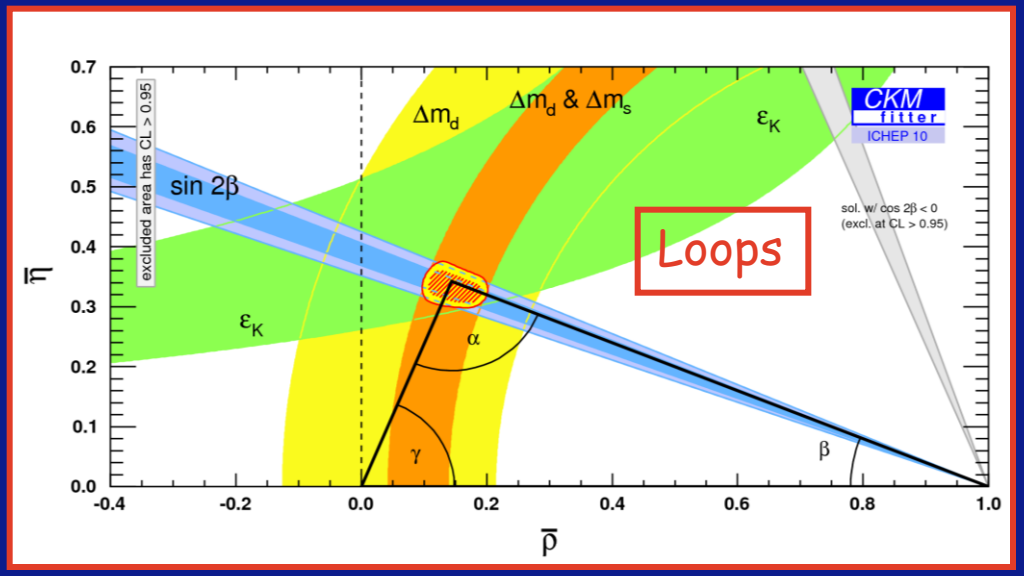
Full fit :

CKMfitter : γ = (67.2 ± 3.9)°

UTfit : γ = (65.6 ± 3.3)°

Loop constraints are more precise than tree ones.

Good agreement with some small tension

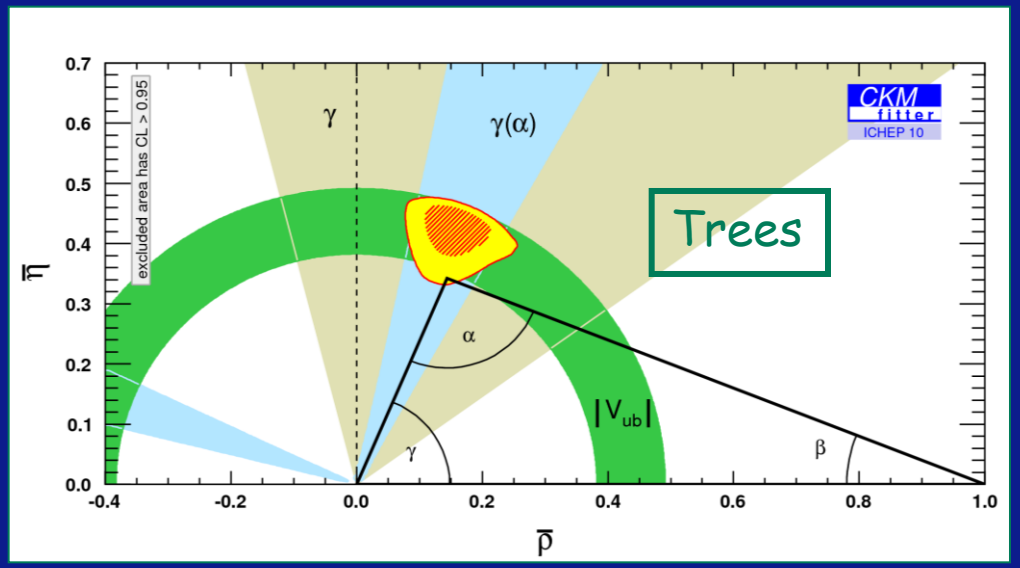


Direct measurements :

CKMfitter : γ = (71 ± 23)°

UTfit : γ = (78 ± 12)°

Interest in more precise direct measurements



CKMfitter Group (J. Charles et al.), EPJC41, 1-131(2005), Bona et al. (UTfit Collaboration), JHEP 0507 028(2005)

Introduction : γ extraction at LHCb

- Current direct determination of γ is mainly dominated by Dalitz measurements in B→DK, D→$K_s$hh

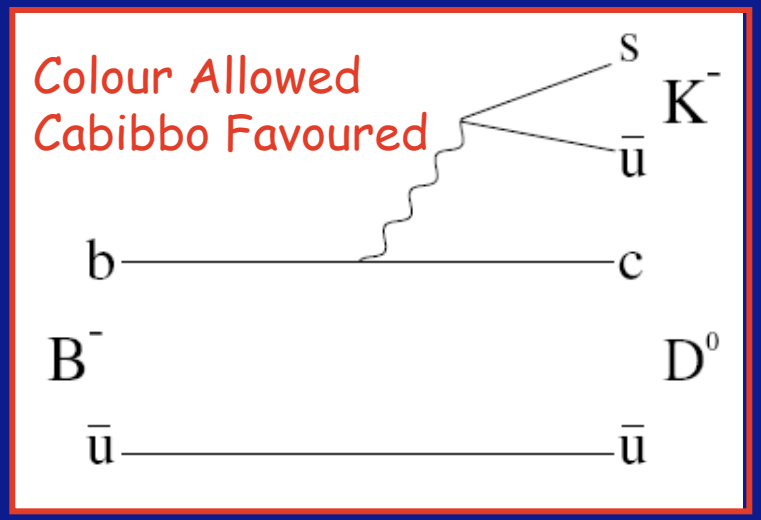
- There are two direct ways to access the CKM angle γ
  - In tree diagrams : B → DX decays
    - Time integrated
    - Time dependent
  - In loop diagrams : B → hh or hhh charmless decays
    - Assumes U-spin to extract γ
  - All of these accessible with unprecedented precision at LHCb

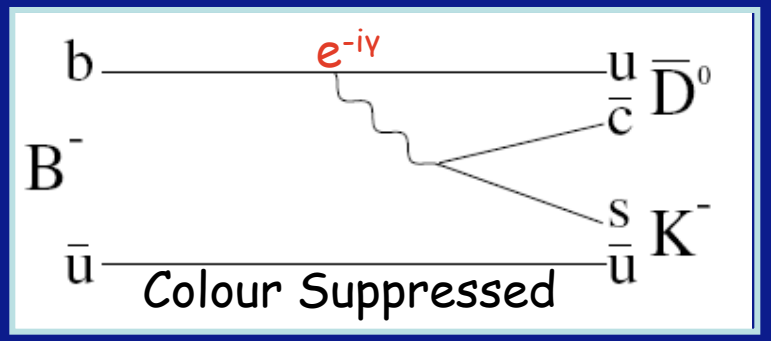
- Precise measurements of direct, mixing induced and interferences induced CPV
- Measurements within Standard Model channels and new physics polluted ones
  - uncover new physics contributions in loops
    - by comparing it with trees
    - By comparing with global fit

Roadmap for selected key measurements of LHCb, arXiv:0912.4179v2

Time integrated γ from trees

- An ideal Standard Model candle
  - Tree diagrams → no contribution from new physics in B decays
  - Neglect D mixing : dominant bias but still negligible (~1°)
  - Neglect CPV in D decays : negligible contribution
  - Absolute relative theoretical uncertainty (EW corrections) : $\Delta\gamma/\gamma \sim 10^{-6}$





b→u and b→c transitions interfere

	BR	r_B
$B^+ \to D^0 K^+$	$(3.7 \pm 0.3)\ 10^{-4}$	0.1
$B^0 \to D^0 K^{*0}$	$(4.2 \pm 0.6)\ 10^{-5}$	~0.3

D^0's reco. in the same final state :
CP eigenstate KK, ππ [GLW]
2 bodies & al. Kπ, K$\pi\pi^0$, K3π [ADS]
Dalitz Kshh [GGSZ]

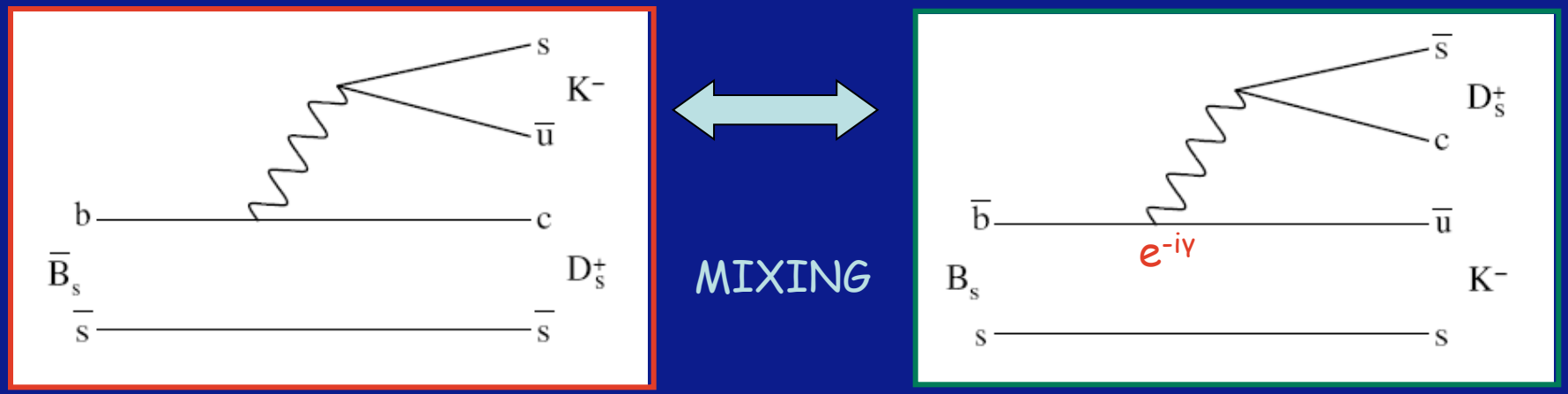
ADS : CLEOc constraints on D decay

Extentions :
$D^0 K\pi$ Dalitz analysis with higher statistics
$B_s \to D\Phi$ integrated-untagged measurment

ADS [PRL 78 3257(1997); PRD 63 036005(2001)], *GLW* [PLB 253 483(1991); PLB 265 172(1991)], *GGSZ* [PRD 68 054018(2003)]

Time dependent γ from trees

- An additional information from time dependent measurements
  - Measure $\gamma+\Phi_M$ → need an external model independent measurement of the mixing phase
  - Benefits from non vanishing lifetime differences [☺ for B_s, ☹ for B_d]



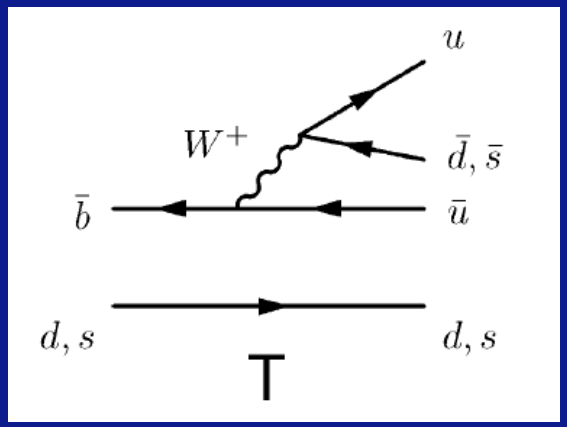
	BR	x [R]	angle
$B_s \to D_s^+ K^-$	$(3.0 \pm 0.7)\ 10^{-4}$	0.4	$\gamma+\Phi_s$
$B_d \to D^+ \pi^-$	$(2.7 \pm 0.1)\ 10^{-3}$	0.02	$\gamma+2\beta$

Simultaneous U-spin based extraction :
resolve 8-fold ambiguities (degenerated at low statistics) in $B_d \to D^+ \pi^-$

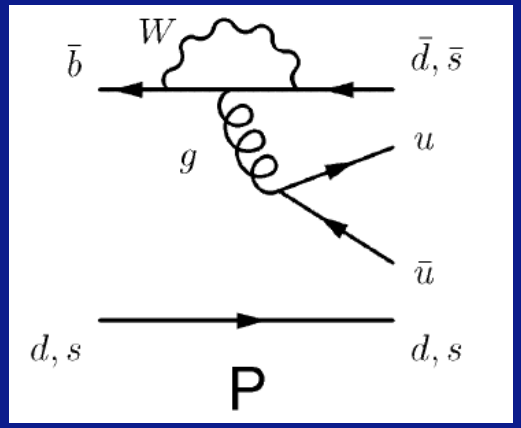
Aleksan & al. [ZPC 54 653(1992)], *Dunietz & al.* [PRD 37 3186(1988) ; 39 3515E(1989)], *Dunietz* [PLB 427 179(1998)]

γ from loops

- Inclusive B→hh or hhh analyses
  - b→u involved in many (2,3)-bodies charmless B decays
  - Less particles in the final state → more efficient trigger and reconstruction ☺



Examples of contributing and interfering diagrams
(more in backup)



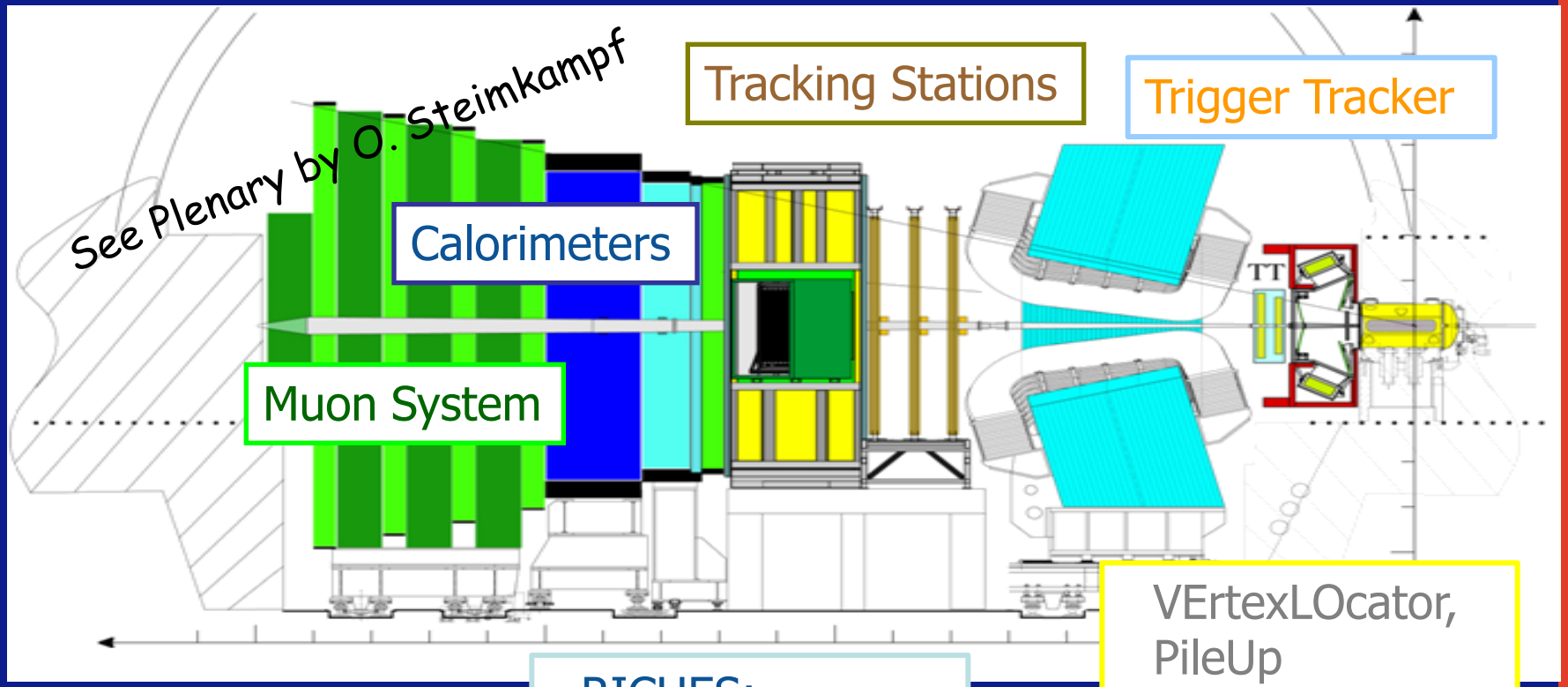
Decay mode	Contributing diagrams	
$B^0 \to \pi^+\pi^-$	$T,\ P,\ PA,\ P^C_{EW},\ E$	BR 10^{-6}→10^{-5}
$B^0 \to K^+\pi^-$	$T,\ P,\ P^C_{EW}$	
$B^0_s \to \pi^+K^-$	$T,\ P,\ P^C_{EW}$	
$B^0_s \to K^+K^-$	$T,\ P,\ PA,\ P^C_{EW},\ E$	
$B^0 \to K^+K^-$	$PA,\ E$	Upper limits 10^{-6}
$B^0_s \to \pi^+\pi^-$	$PA,\ E$	

Fleischer [PLB 459(1999) 306 arXiv:9903456, EPJ C52(2007) 267 arXiv:0705.1121]

LHCb in a nutshell

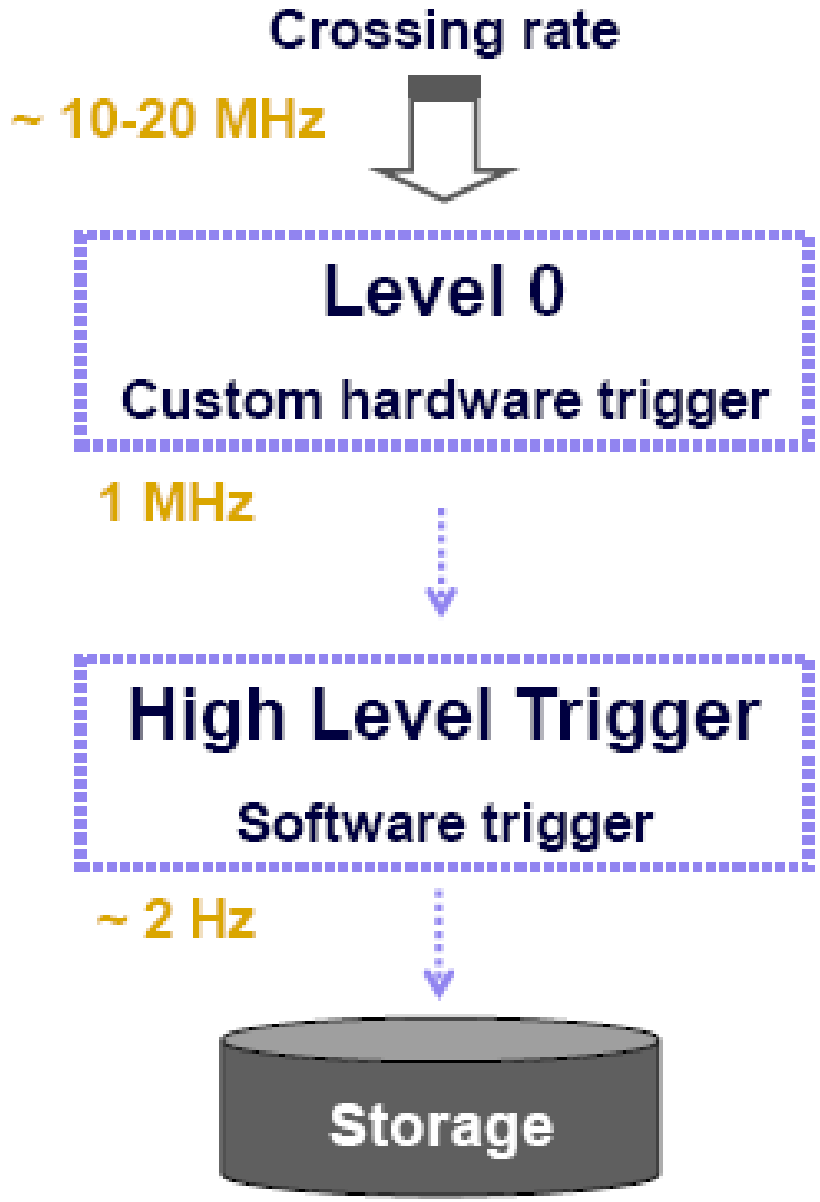
The Challenge: precise rare decays and time-dependent CP asymmetries in a high background environment.

Needs excellent vertexing, p reconstruction, particle-ID



The LHCb Detector at the LHC [JINST 3 S08005]

Trigger



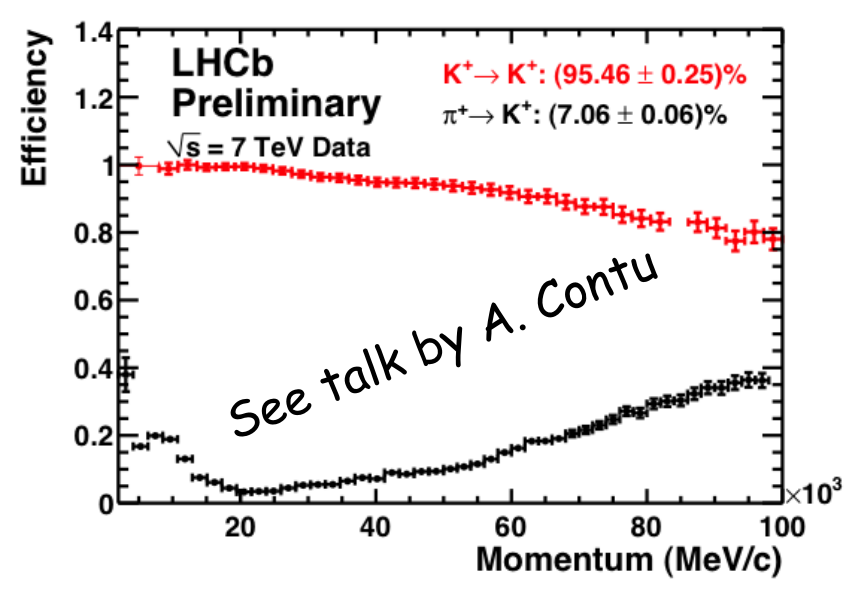
The bottleneck :
- Bandwidth and rate limitations
- Already high (3.6 GeV) E_T hadronic triggers

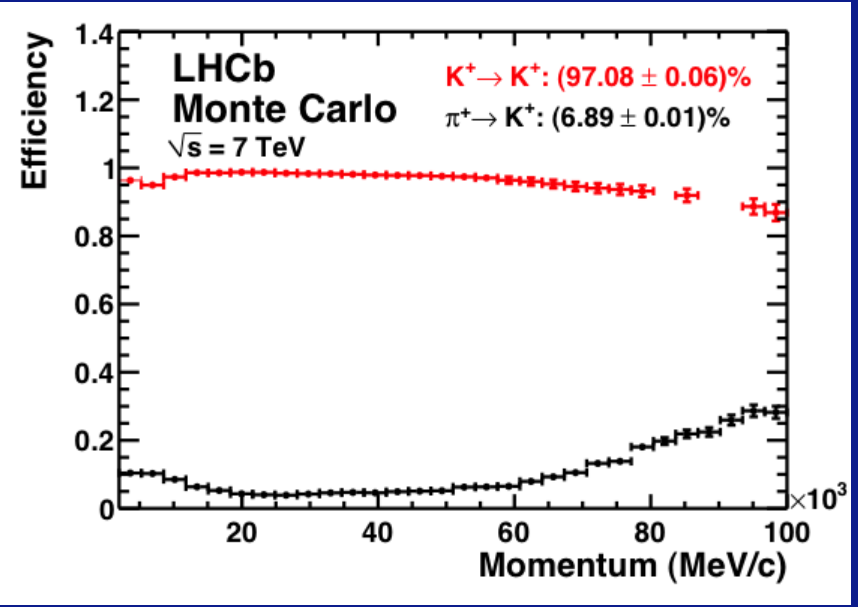
HLT1 :
- Build a 'good' track from any L0
→ Recover some efficiency for hadronic triggers

HLT2 :
Inclusive Topological Trigger :
- Build a B using 2,3,4 tracks
- Compensate for missing p_T

Analysis requirements : PID

Hadronic B decays → intensive use of PID in any analysis

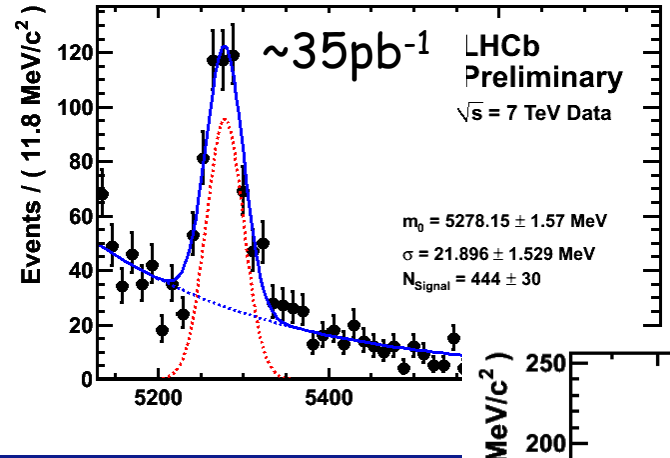




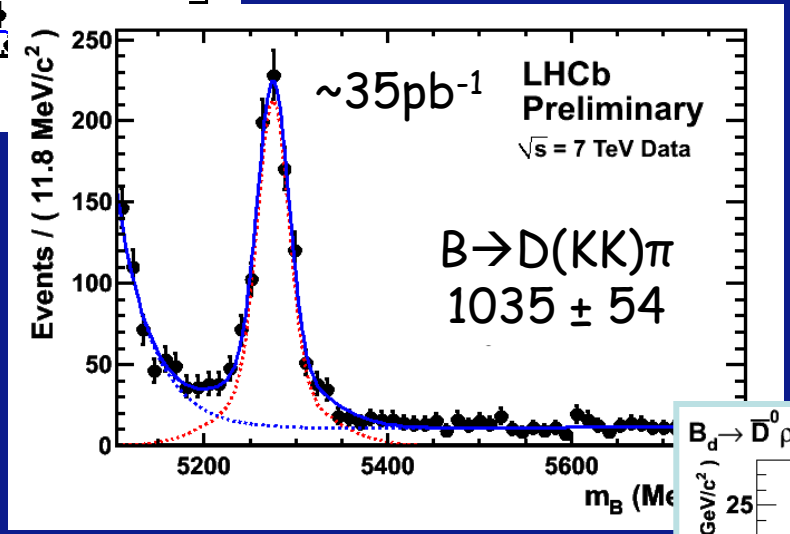
Performance is close to MC expectations

Lifetime and Tagging performance studies also under progress

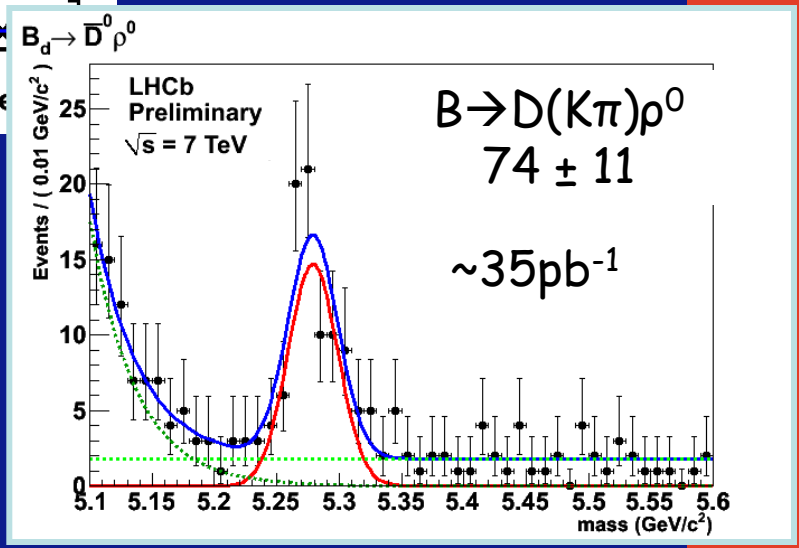
Observations : time integrated γ trees



Clean hadronic B signals observed reasonably in agreement with expectations



Wait for full 2010 run reprocessing to observe B→DK with D→KK



First observation of pure colour suppressed hadronic B decays in a hadron collider (?)

Expect 15 to 50 $B_s \to D^0 K^{*0}$ in the full 2010 reprocessing

Prospects : time integrated γ trees

DK	A_{CP+}
BaBar	0.25 ± 0.06 ± 0.02
CDF	0.39 ± 0.17 ± 0.04
DK	A_{ADS}
Belle	$-0.39 \pm 0.26\ ^{+0.06}_{-0.04}$
CDF	−0.63 ± 0.40 ± 0.23

Current status on the measurement of asymmetries

$$A_{\rm ADS} = \frac{\Gamma(B^- \to D(K^+\pi^-)K^-) - \Gamma(B^+ \to D(K^-\pi^+)K^+)}{\Gamma(B^- \to D(K^+\pi^-)K^-) + \Gamma(B^+ \to D(K^-\pi^+)K^+)} = \frac{2r_B r_D \sin(\delta_B + \delta_{K\pi}) \sin\gamma}{r_B^2 + r_D^2 + 2r_B r_D \cos(\delta_B + \delta_{K\pi}) \cos\gamma},$$

ADS

LHCb 1fb^{-1} @ $\sqrt{s}$=7TeV : Competitive measurements with current dominating measurements

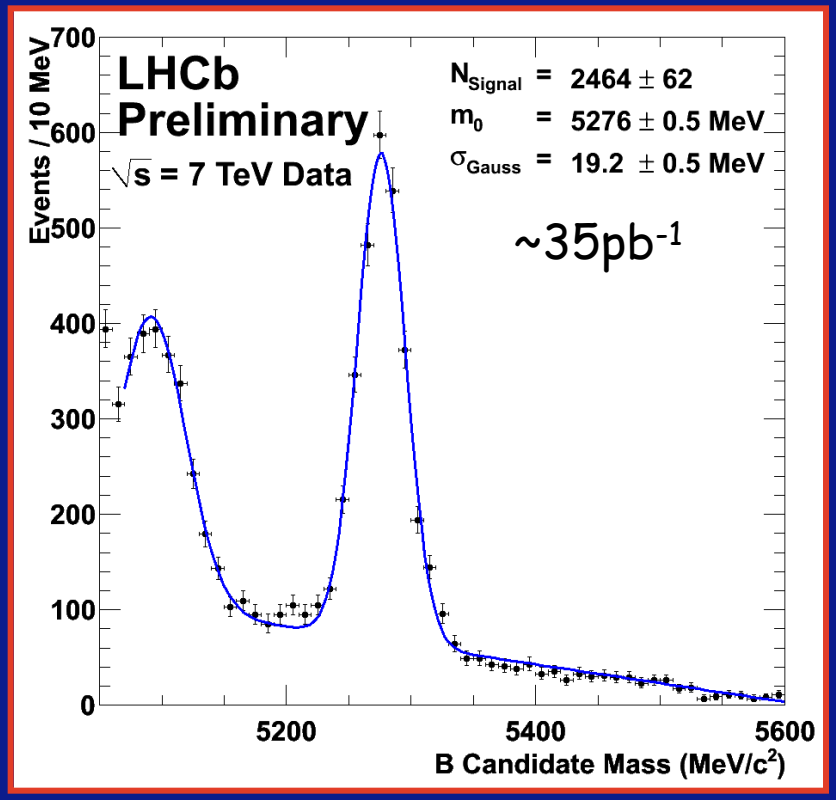
possible first results from LHCb @ Winter 2011 conferences :
- A_{CP+} and R_{CP+} competing with CDF
- ratios of BR(B→DK)/BR(B→Dπ)
- First observation of $B_s \to D^0 K^{*0}$ and BR($B_s \to D^0 K^{*0}$)/BR($B_d \to D^0 \rho^0$)

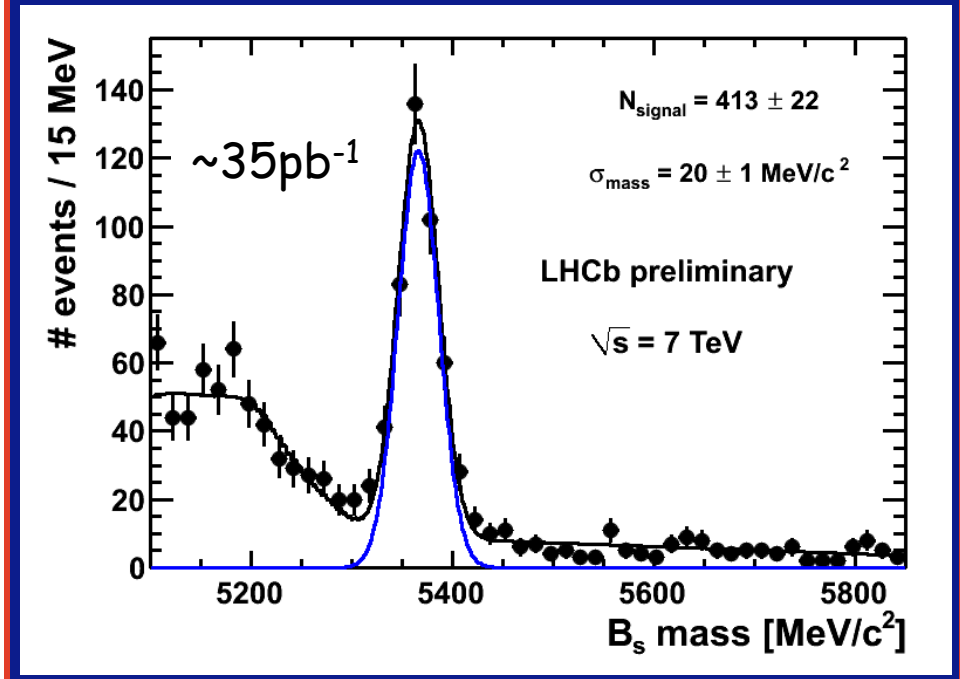
~15° LHCb combined sensitivity on time integrated γ in 2011

Arxiv:1007.0504, PRD 81, 031105(R)(2010) + preliminary results @ CKM 2010

Observations : time dependent γ trees

$B^+ \to D^0\pi\pi\pi$ & $B^0 \to D^+\pi\pi\pi$



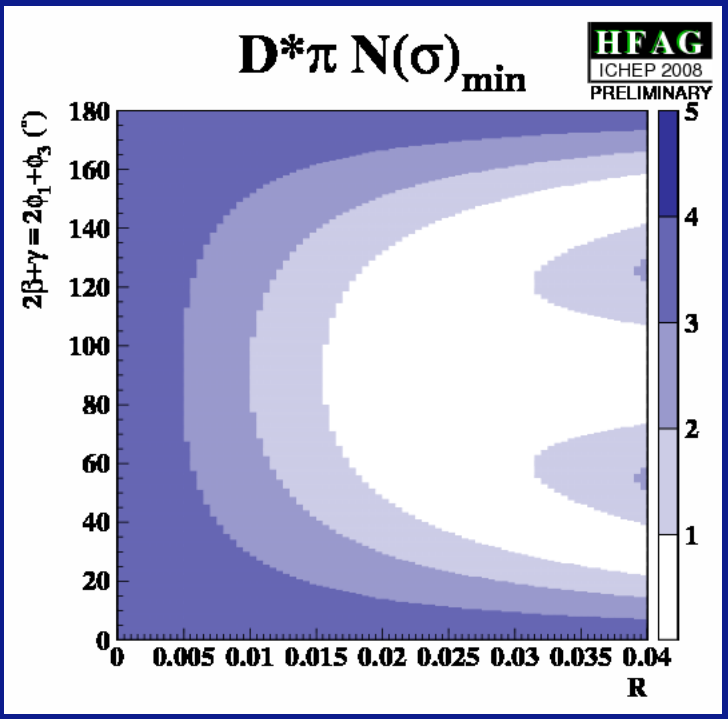


Six body final states observed !

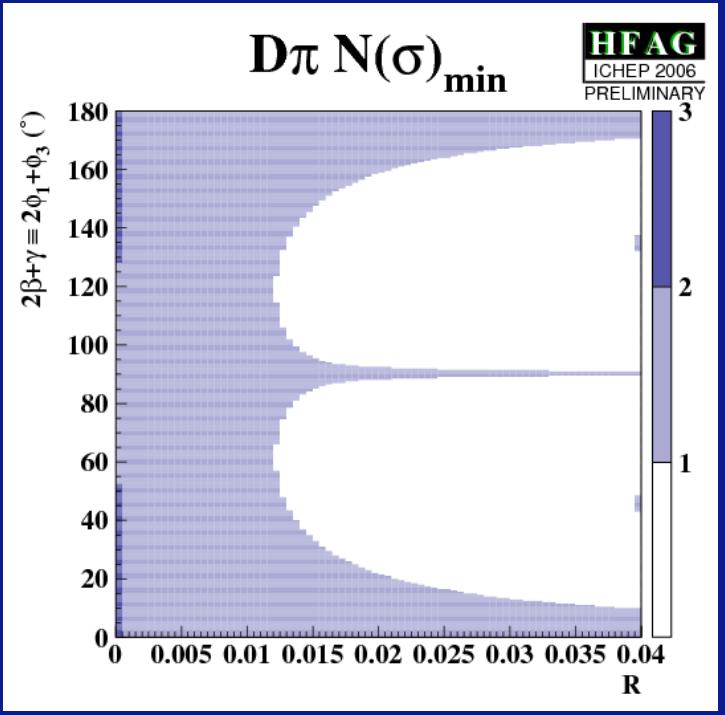
$B_s \to D_s(\Phi\pi)\pi$

$B_s \to D_s\pi\pi\pi$ also seen

Prospects : time dependent γ trees



B factories legacy

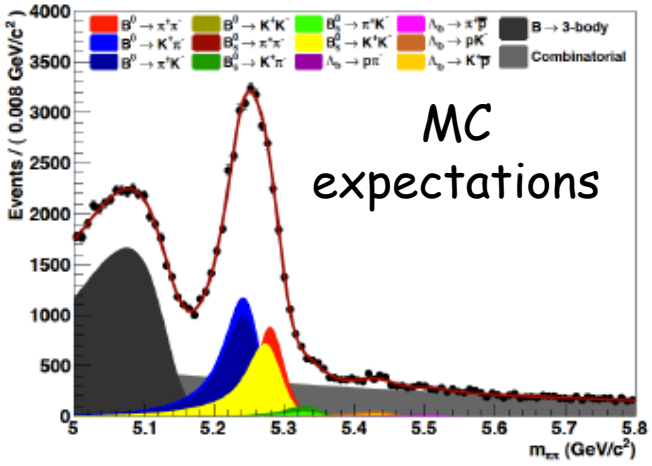


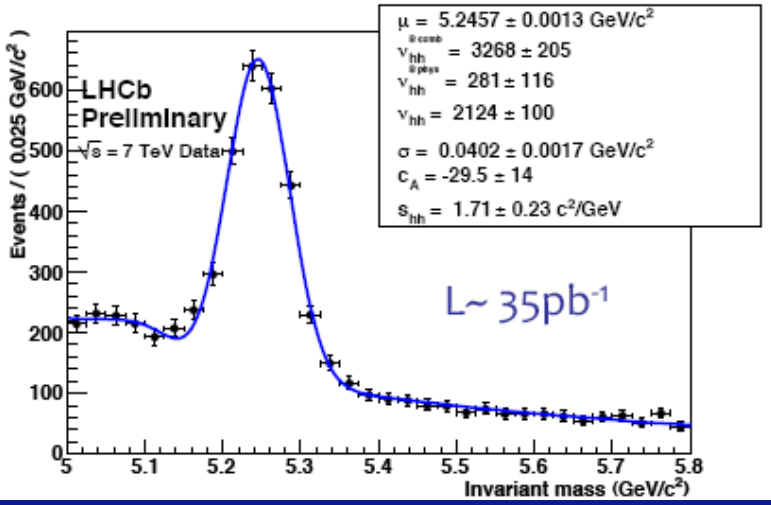
possible first results from LHCb @ Winter 2011 conferences :
- Measurements of ratio of BR($B^0 \to DK$)/BR($B^0 \to D\pi$)
- Upper limits on $B_s \to D(K,\pi)$
- First observations of $D_{(s)}(K\pi\pi)$ and best measurements of $D_{(s)}$ $(\pi\pi\pi)$
- fd/fs from N($B^0 \to DK$)/N($B_s \to D_s\pi$)

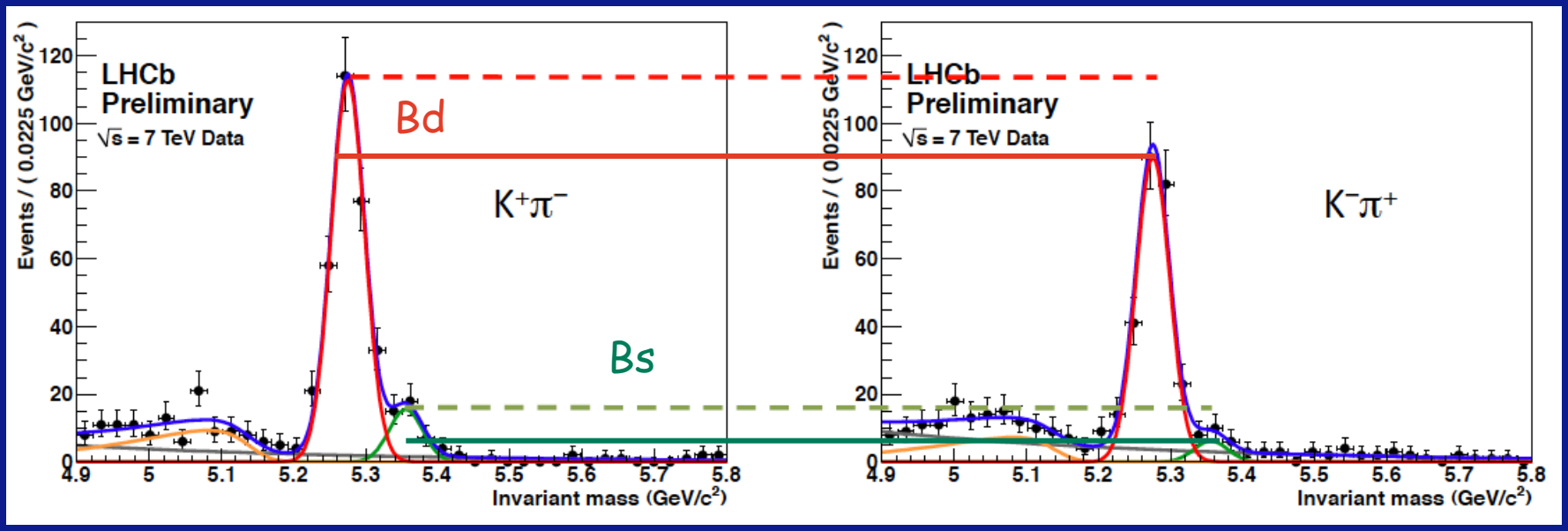
~15° statistical sensitivity on time dependent γ in 2011

Fleischer, Serra, Tuning [Arxiv:1004.3982v3]
http://www.slac.stanford.edu/xorg/hfag/

Observations : γ loops



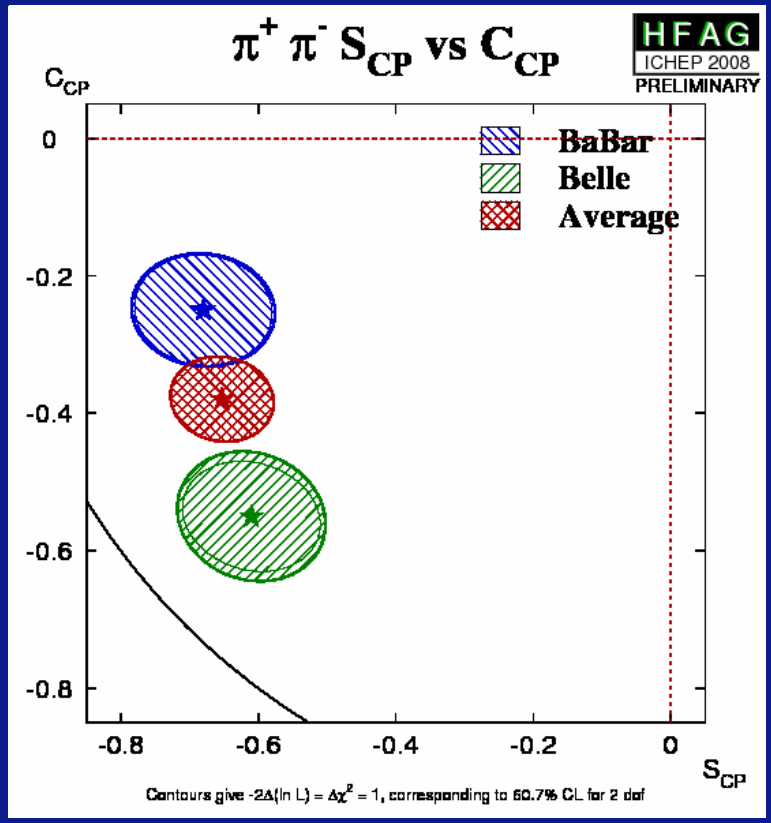




Raw asymmetries already visible by eye ! → work ongoing on proper estimates

Prospects : γ loops

	$B^0 \to K\pi$
PDG10Aver.	−0.098 ± 0.013
CDF	−0.086 ± 0.023 ± 0.009
	$B_s \to K\pi$
CDF	0.39 ± 0.15 ± 0.08



possible first results from LHCb @ Moriond 2011 :
- Measurement of $BR(B_s \to K\pi)/BR(B_d \to K\pi)$
- A_{CP} measurements competitive with CDF results

~15° sensitivity on γ loops for LHCb by fall 2011

CDF, [N PB (Proc. Suppl.) 170 (2007) 39-45] http://www.slac.stanford.edu/xorg/hfag/

Summary

- LHCb is performing well and is already able to observe hadronic B decays
  - 10^{-5} and 10^{-6} hadronic decays are observed or about to be so
    - Discoveries of new expected B_s decay modes hopefully for Winter conf.
  - Raw asymmetries observed in some channels
    - Hopefully calibrated by Winter conf. to produce first CPV results

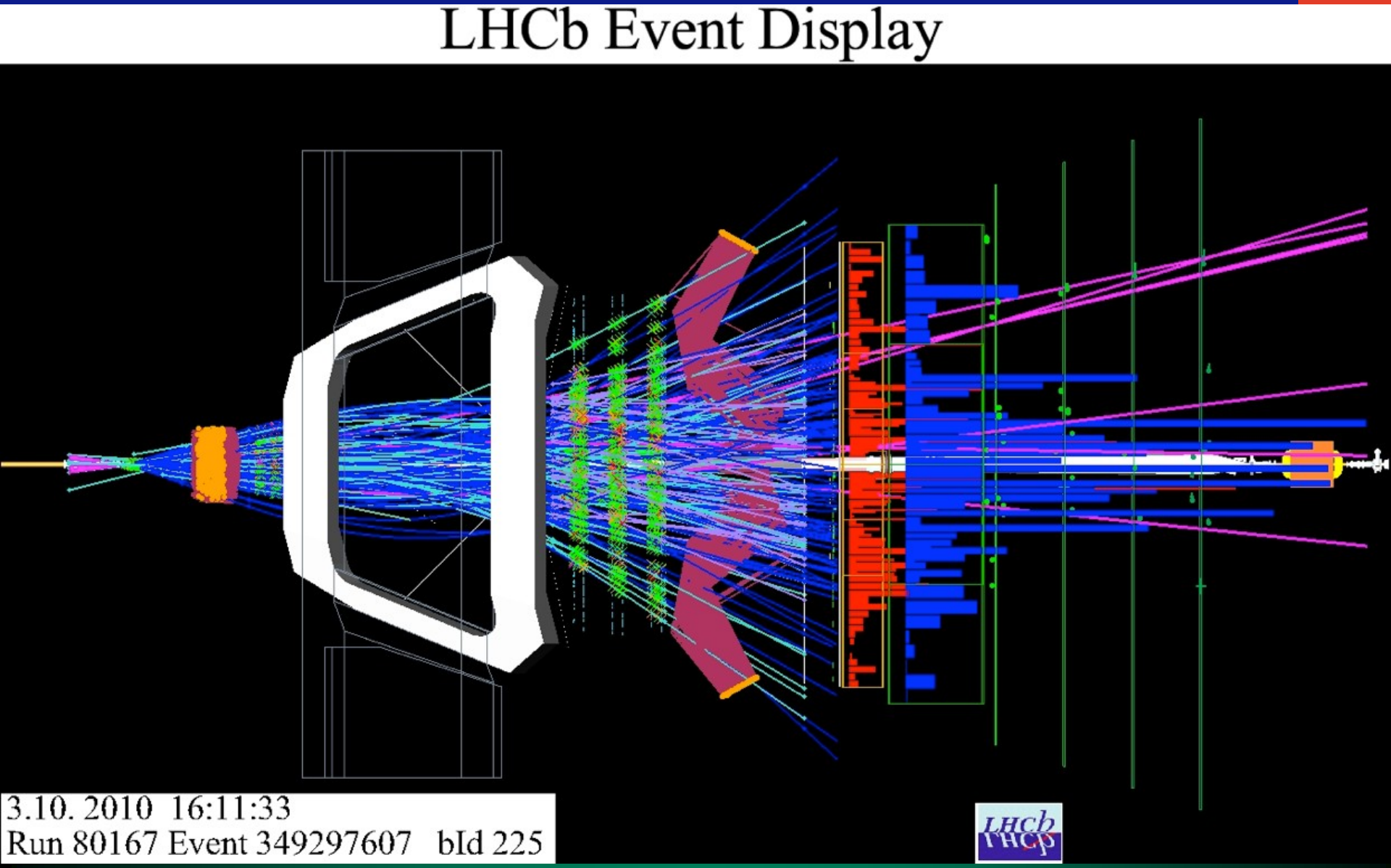
LHCb will be competitive with CDF results

- Wait for even more exciting data taking periods in 2011
  - γ sensitivity is going to be of the order of 15° in loops AND trees
  - γ sensitivity of 15° both in time independent AND time dependent trees
    - Competitive with existing measurements

LHCb will improve our knowledge on γ by the end of 2011

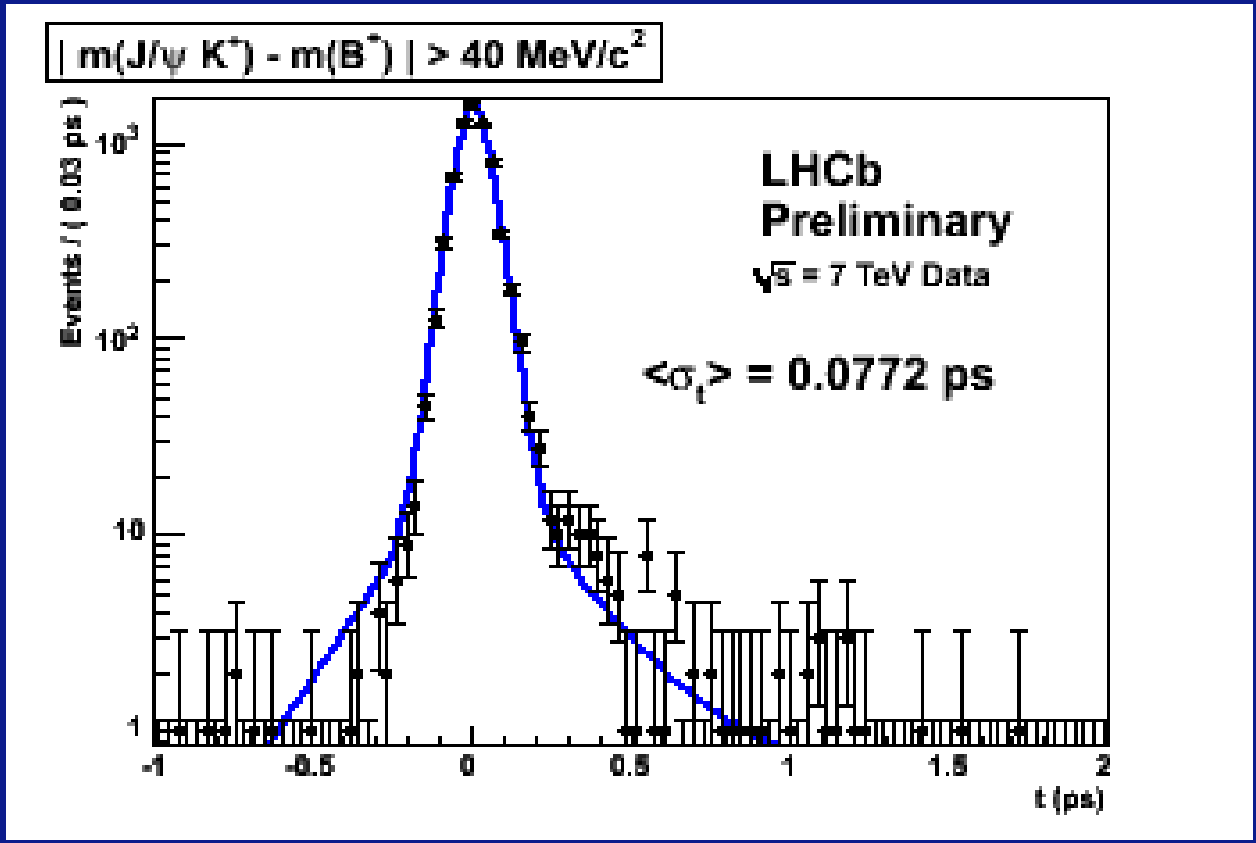
Thank you

Have fun : find the 4 PV's !



Additional requirements : Lifetime & tagging

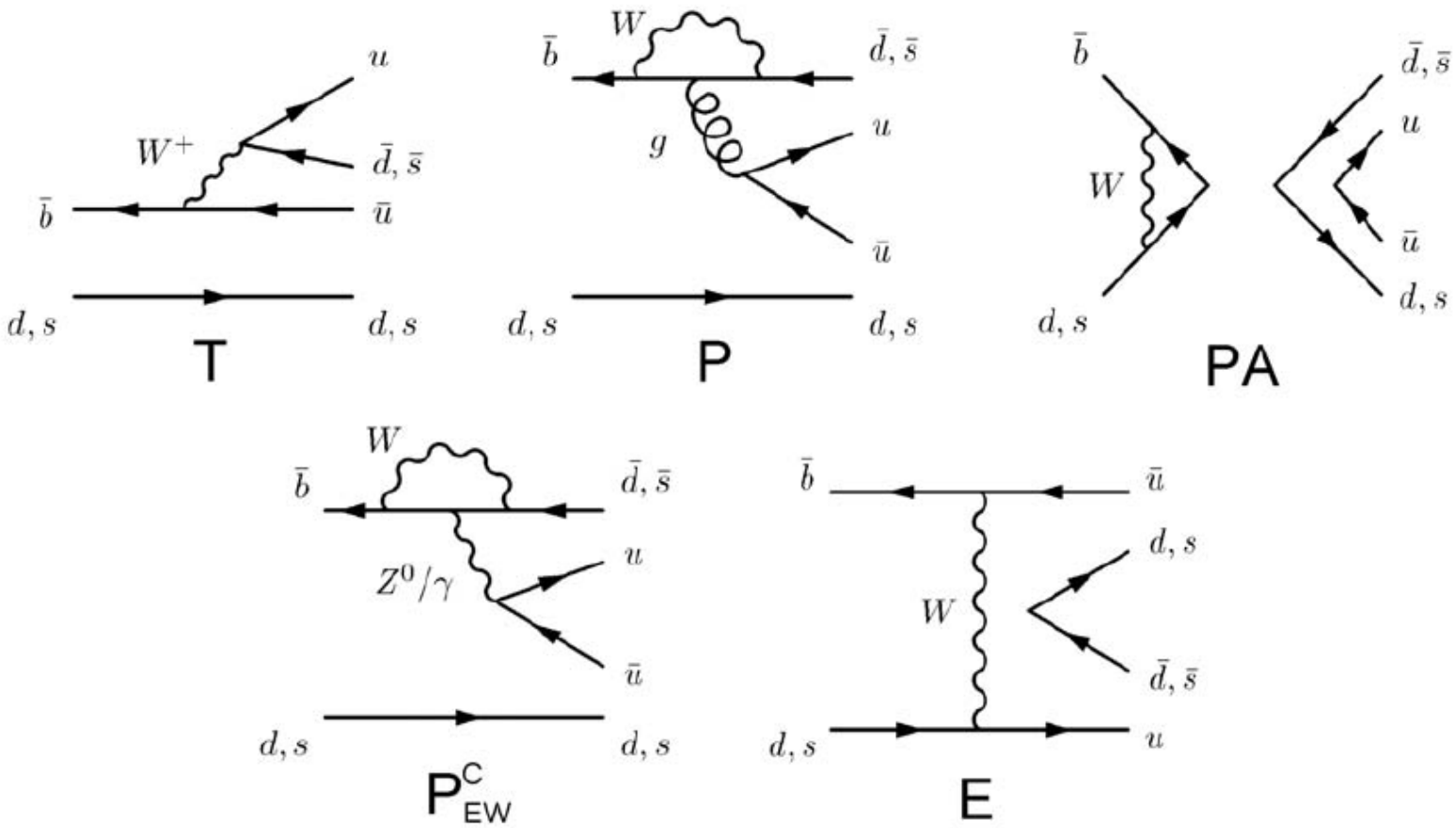
- Lifetime and Tagging are key ingredients for time dependent and B→hh

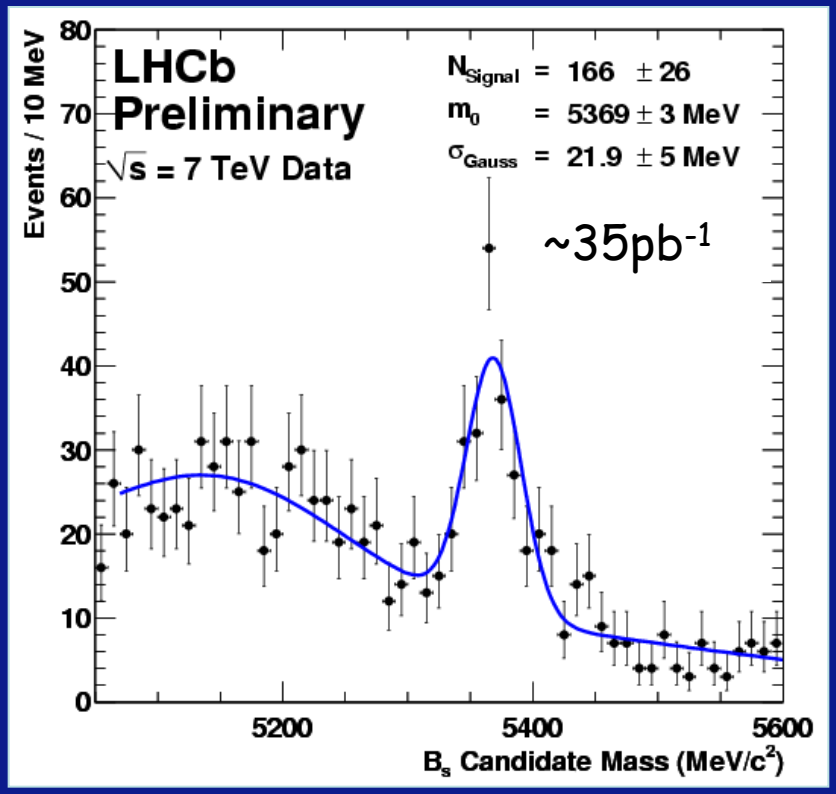


Lifetime resolution of 77fs (worse than expected)
Recent improvements obtained

Tagging performance studies under progress

Charmless diagrams




LHCb
Preliminary
√s = 7 TeV Data
N_Signal = 166 ± 26
m_0 = 5369 ± 3 MeV
σ_Gauss = 21.9 ± 5 MeV
~35pb^-1
Events / 10 MeV
B_s Candidate Mass (MeV/c^2)
0
10
20
30
40
50
60
70
80
5200
5400
5600