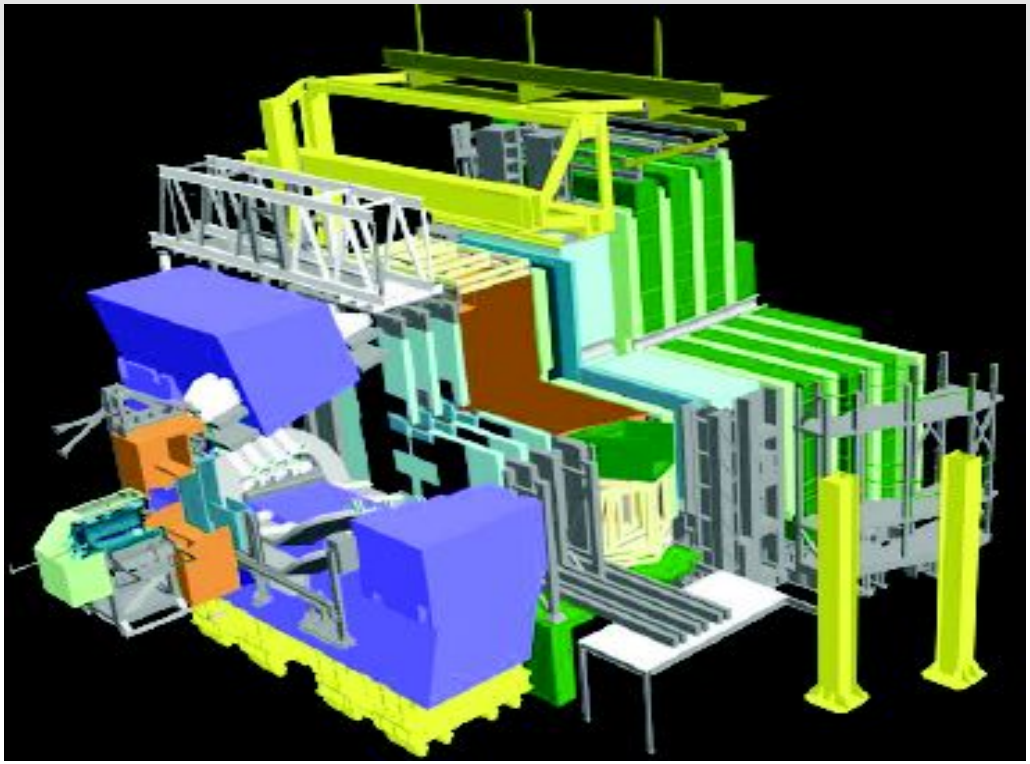
Prospects for CP measurements with charmless hadronic B decays @ LHCb



ICHEP PARIS 2010

Ignacio Bediaga,
on behalf of the LHCb collaboration
Centro Brasileiro de Pesquisas Físicas
(CBPF-Brazil)

Outline

- *Motivation and Analysis strategies*
- B^0, B^0_s *and* $\Lambda^o_b \to hh$ *and* $B^+ \to hhh$ *selections.*
- *Yields for* $1fb^{-1}$*: first charmless B decay signal at* $122nb^{-1}$
- ~~*CP sensitivity studies*~~
- *Summary*

Motivation

- *Study of the known sources of direct CP with the high LHCb statistics.*
- *Search for new sources of CP.*
- *Independent extraction of CKM phase γ.*
- *Search for new charmeless B decays.*
- *Study of $\Delta\Gamma_s$ linked to the $B^0_s \to (K^+K^-)$ lifetime.*

Charmless two and three body B and Λ^0_b decays @ LHCb

Neutral two body

- $B^0 \to \pi^- \pi^+$
- $B^0 \to K^+ \pi^-$
- $B^0_s \to K^- \pi^+$
- $B^0_s \to K^+ K^-$
- $\Lambda^0_b \to p \pi^-$
- $\Lambda^0_b \to p K^-$
- **$B^0 \to K^+ K^-$**
- **$B^0 \to \bar{p} p$ (BR~10^{-7})**
- **$B^0_s \to \pi^- \pi^+$**

Not observed yet

Charged three body

- $B^+ \to \pi^+ \pi^+ \pi^-$
- $B^+ \to K^+ \pi^+ \pi^-$
- $B^+ \to \pi^+ K^+ K^-$
- $B^+ \to K^+ K^+ K^-$
- $B^+ \to \pi^+ \bar{p} p$
- $B^+ \to K^+ \bar{p} p$
- **$B^+ \to \pi^- K^+ K^+$ (BR~10^{-11})**
- **$B^+ \to K^- \pi^+ \pi^+$ (BR~10^{-14})**

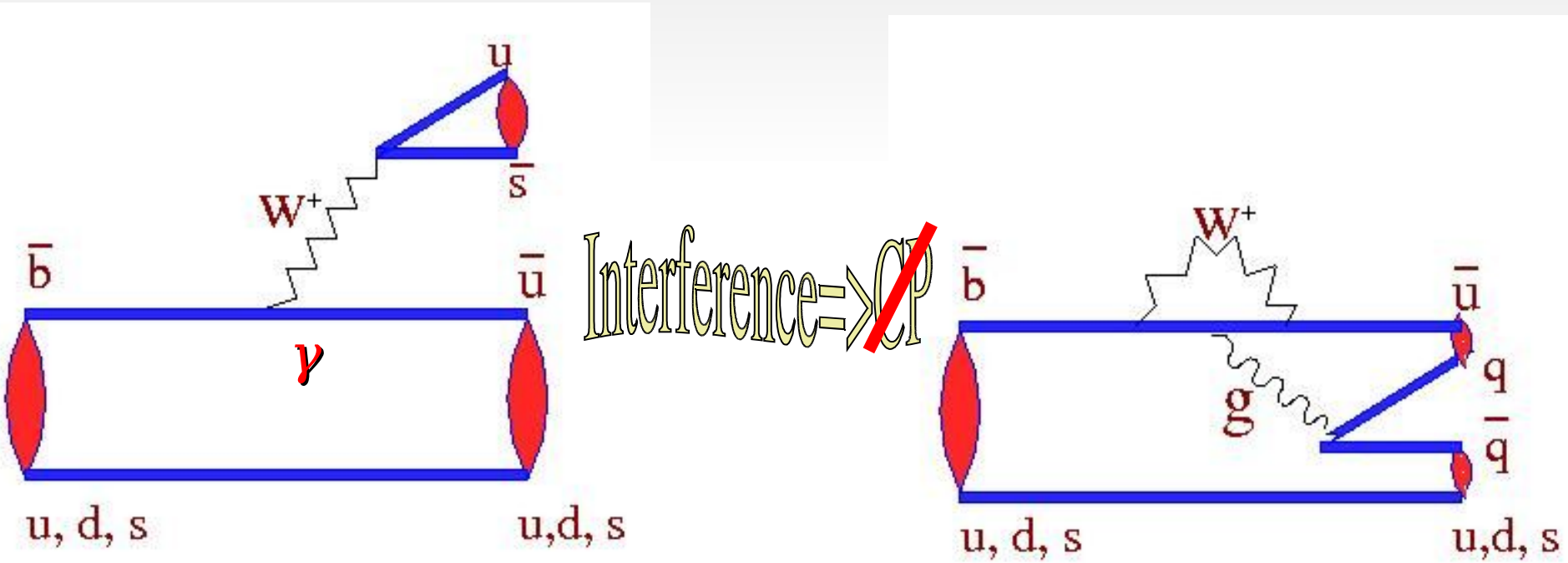
Neutral three body

- $B^0, B^0_s \to K^0_s \pi^- \pi^+$ and $B^0, B^0_s \to K^0_s K^- K^+$

Preparing analysis

~~CP~~ in Standard Model: contributions to the charmless B decays

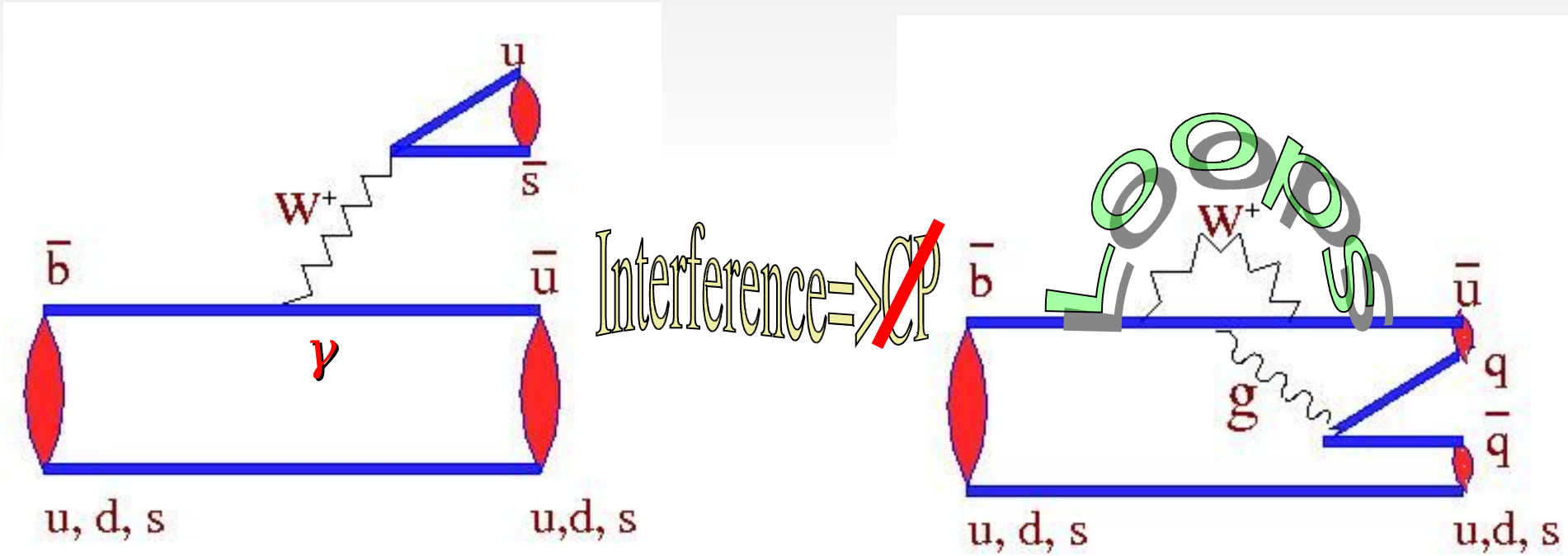
Tree *Penguin*



+ Penguin Annihilation + Electroweak Penguin + W-Exchange

$\not{CP}$ beyond Standard Model: contributions to the charmless B decays

Tree *Penguin*



+ Penguin Annihilation + Electroweak Penguin + W-Exchange

Analysis implemented for B^0, B^0_s, B^+ and Λ^0_b decays for $1fb^{-1}$

ACP puzzle

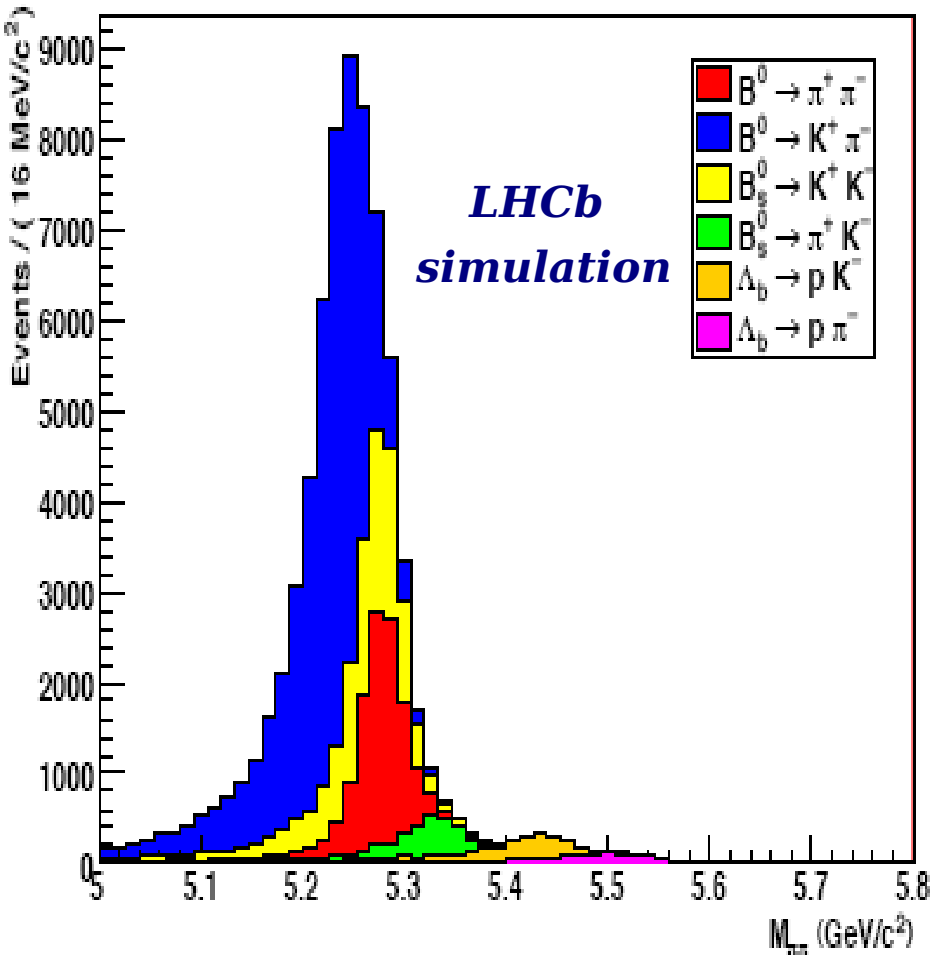
- Direct CP in two body decays:
$A_{cp}(B^0_s \to \pi^+ K^-)$, $A_{cp}(\Lambda^o_b \to p\,\pi^-)$, $A_{cp}(\Lambda^o_b \to p\,K^-)$ and $A_{cp}(B^0 \to K^+\pi^-)$
- Sources of CP in three body decay through interference in the Dalitz
- Search for $B^0 \to p\bar{p}$ and other two and three body charged decays
- $B^0_s \to K^+K^-$ lifetime: indirect measurement $\Delta\Gamma_s$

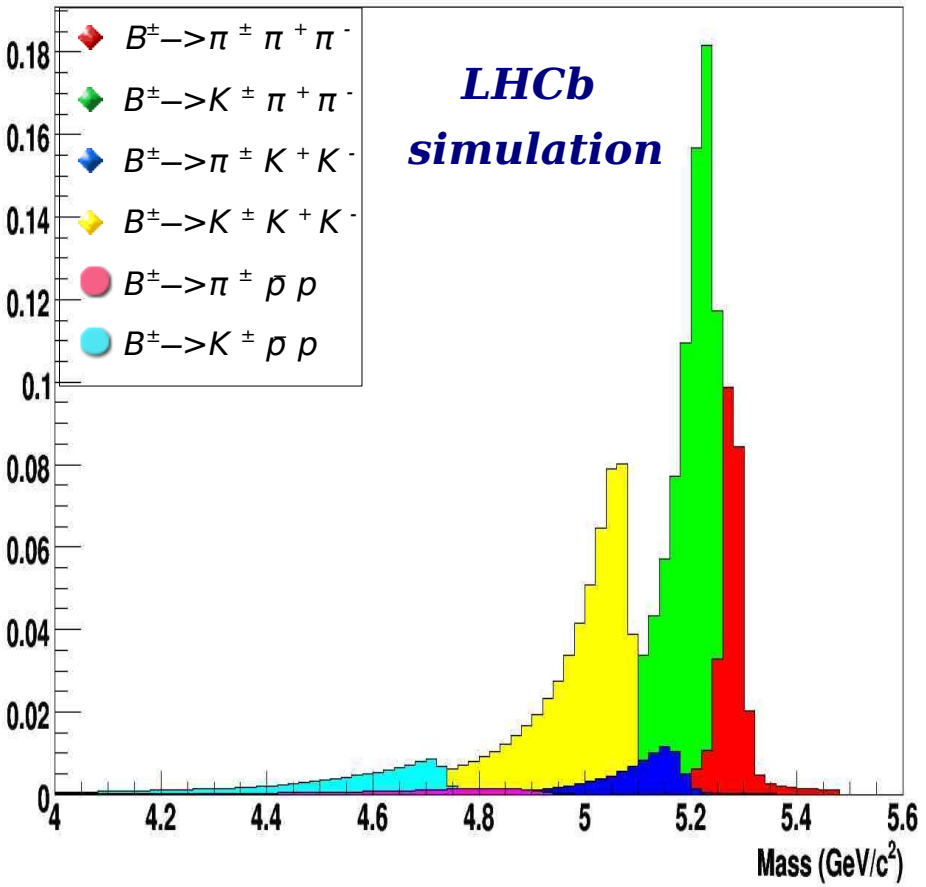
More Complex analysis

- Tagged and time dependent studies for:
$Acp(B^0_s \to K^+K^-)$, $Acp(B^0 \to \pi^+\pi^-)$ and CKM γ
- Dalitz Analysis: CP asymmetry in resonant intermediary states $Acp(B^+ \to Ressonances^0\ h^+)$ and CKM γ

Selection

- *Inclusive pre-selection: 2 or 3 tracks without particle identification*
- *Pion mass hypothesis for all hh and hhh decays*
- *Vertex cuts*

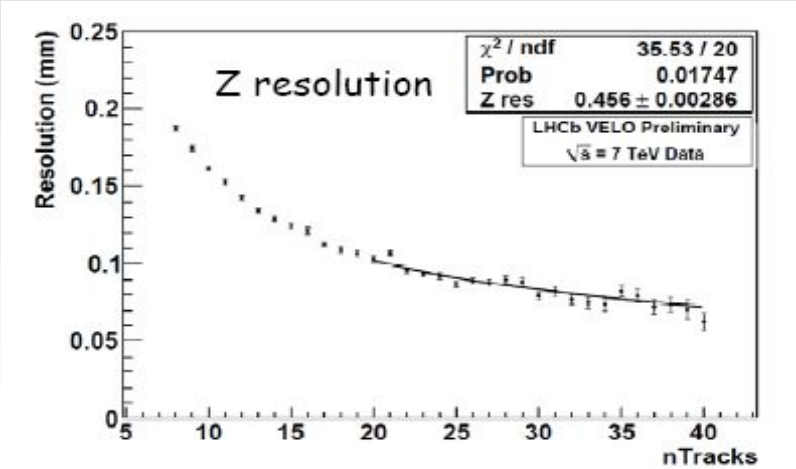




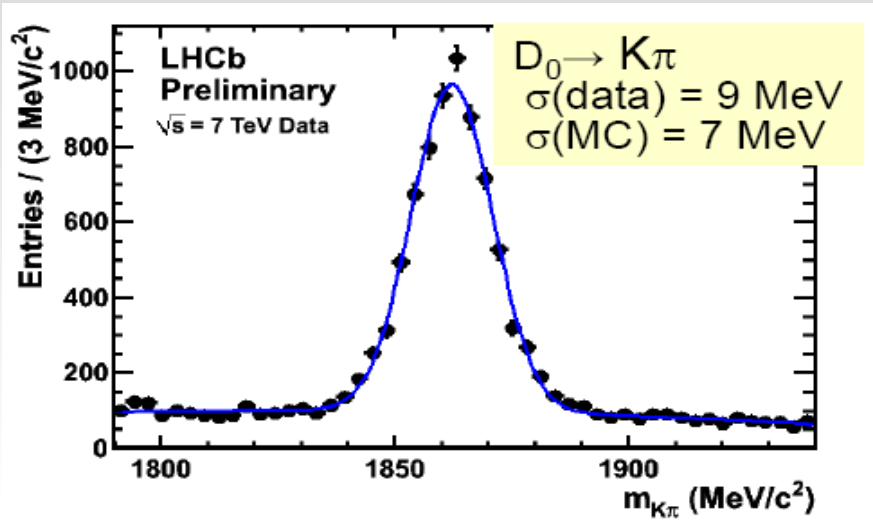
Exclusive pre-selection for $B^0_s \to K^+K^-$ lifetime: uses PID with kaon mass hypothesis

Vertex selection

PV resolution

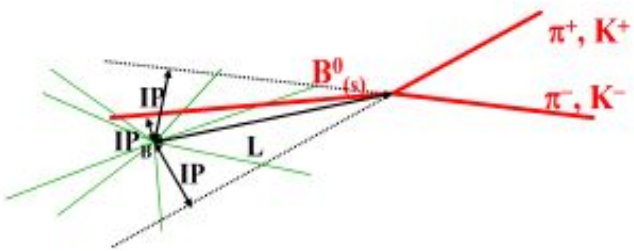


Mass resolution in Charm signal



Tracking and mass resolution see:
S. Borghi in Performance of the tracking system @ LHCb ICHEP2010

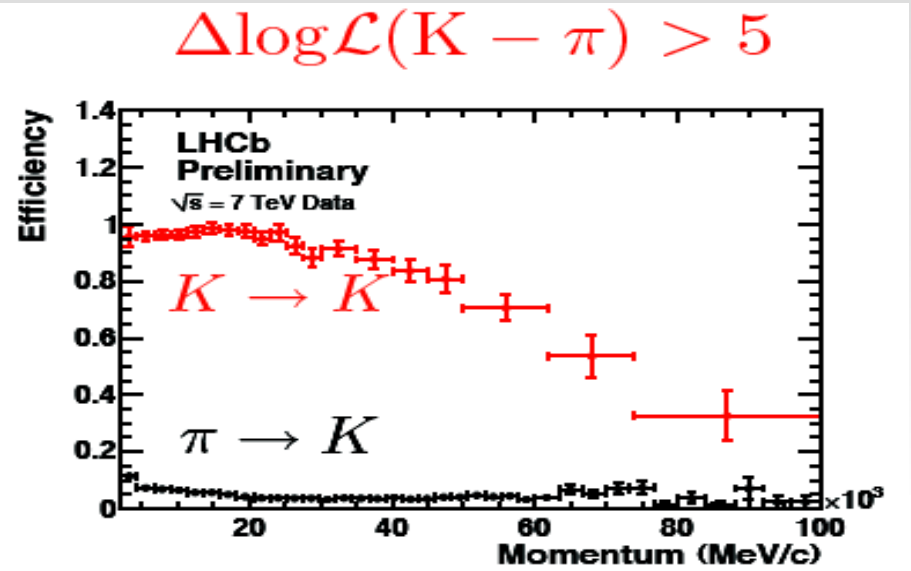
Vertex selection based on transverse momentum, impact parameter, displacement significances, vertex χ^2

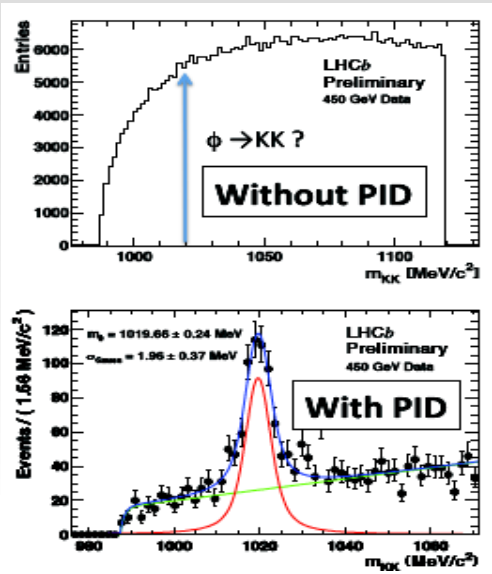


Special attention to avoid bias with these cuts:

- *Time resolution study: avoid Displacement and Impact Parameter cuts*
- *Dalitz plot acceptance: avoid Impact Parameter and PT all three tracks*

Particle ID selection

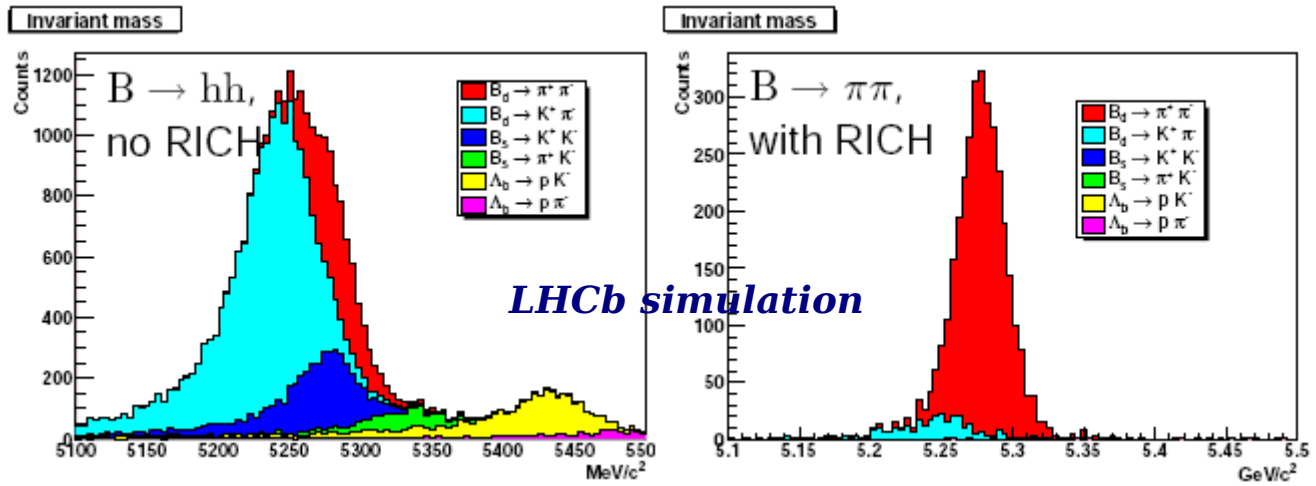




$\Phi \to KK$ signal

See, A. Powell in PID @ LHCb ICHEP2010

Final selection with the good LHCb particles identification distinguish between different modes



hh Yields

run 2010-2011 →1fb^{-1}

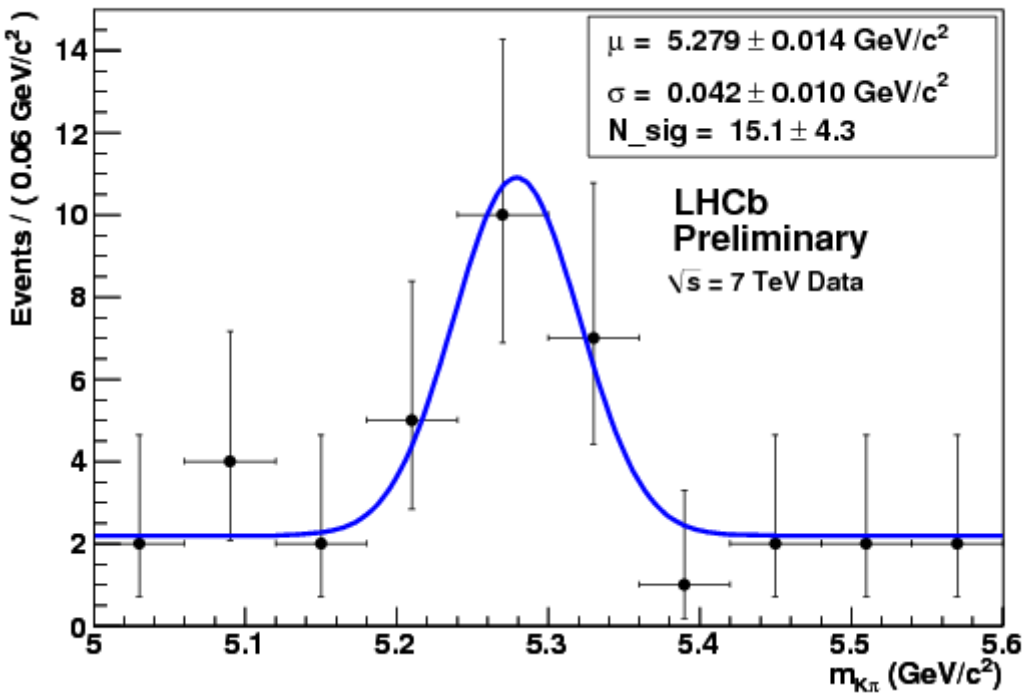
Estimated Luminosity 1 fb^{-1}	Total Efficiency*	Branching Fraction(10^{-6})	**Estimated** Number of events**
B→ ππ	1.4%	5.13 ± 0.24	**40 K**
B→ Kπ	1.4%	19.4 ± 0.06	**130 K**
B_s→ πK	1.4%	5.27 ± 1.17	**10K**
B_s→ KK	1.4%	25.8 ± 4.2	**40 K**
Λ→ pπ	1.2%	3.1 ± 0.9	**4 K**
Λ→ pK	1.2%	5.0 ± 1.2	**7 K**

More than one order of magnitude than world statistic

** Total Efficiency = Geometry X Trigger X Selection efficiency*

*** B cross section preliminary LHCb measurement: see S. Stone ICHEP2010*

$B^0 \rightarrow K^+\pi^-$ signal $122nb^{-1}$



First charmless B decay signal

K, π: IP/σ>6
P_T >1GeV

K: Δ_{LL}(K- π)>0

π: Δ_{LL}(π-K)>0

B0: χ^2(vertex)<5
P_T >1.0GeV
L/σ > 18
IP/σ <2.5

hh' CP sensitivity at 1fb^{-1}

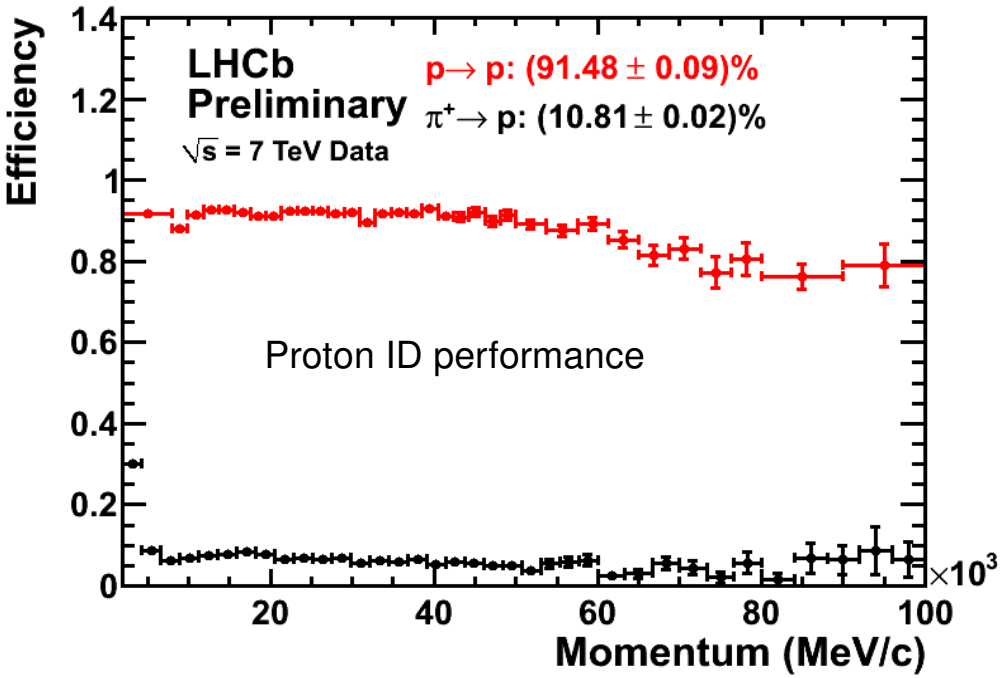
Estimated Luminosity 1 fb^{-1}	Currrent experiment or prediction	LHCb statistic sensitivity
$A_{cp}(B \to K^+\pi^-)$	-0.098± 0.012	0.004
$A_{cp}(B_s \to \pi^+K^-)$	0.39 ± 0.15	0.025
$A_{cp}(\Lambda_b \to p\pi^-)$	0.03 ± 0.17	0.025
$A_{cp}(\Lambda_b \to pK^-)$	0.37 ± 0.17	0.015

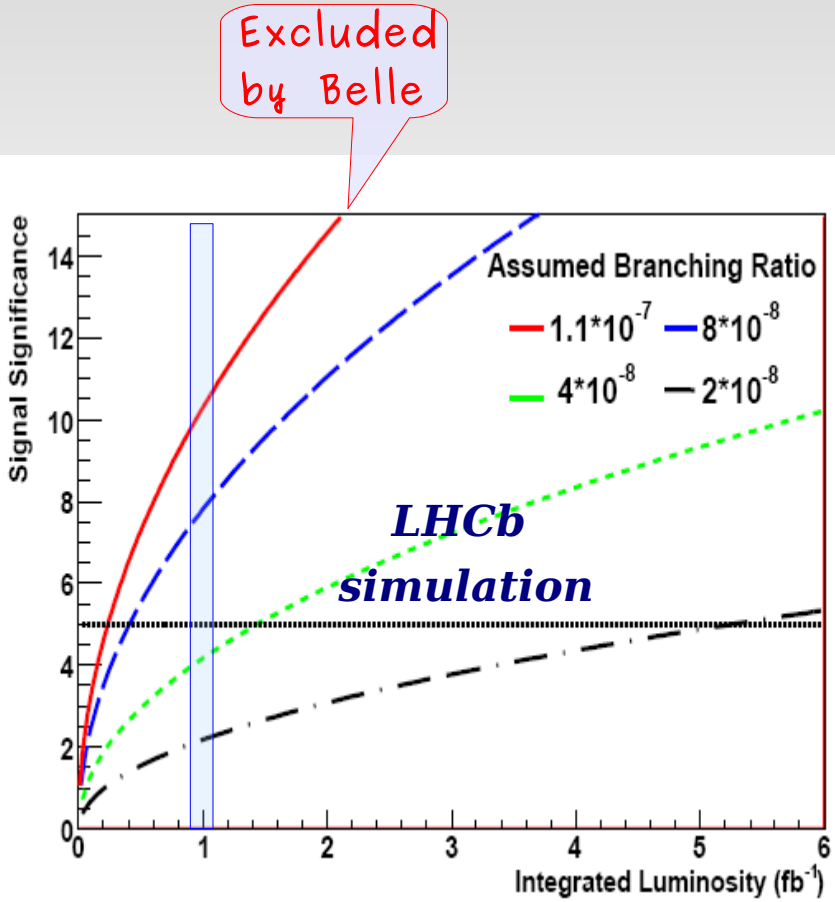
Contribution to understand the ACP Puzzle

Substantial improvement for B^0_s and Λ^0_b

Sensitivity for $B^0 \to p\bar{p}$

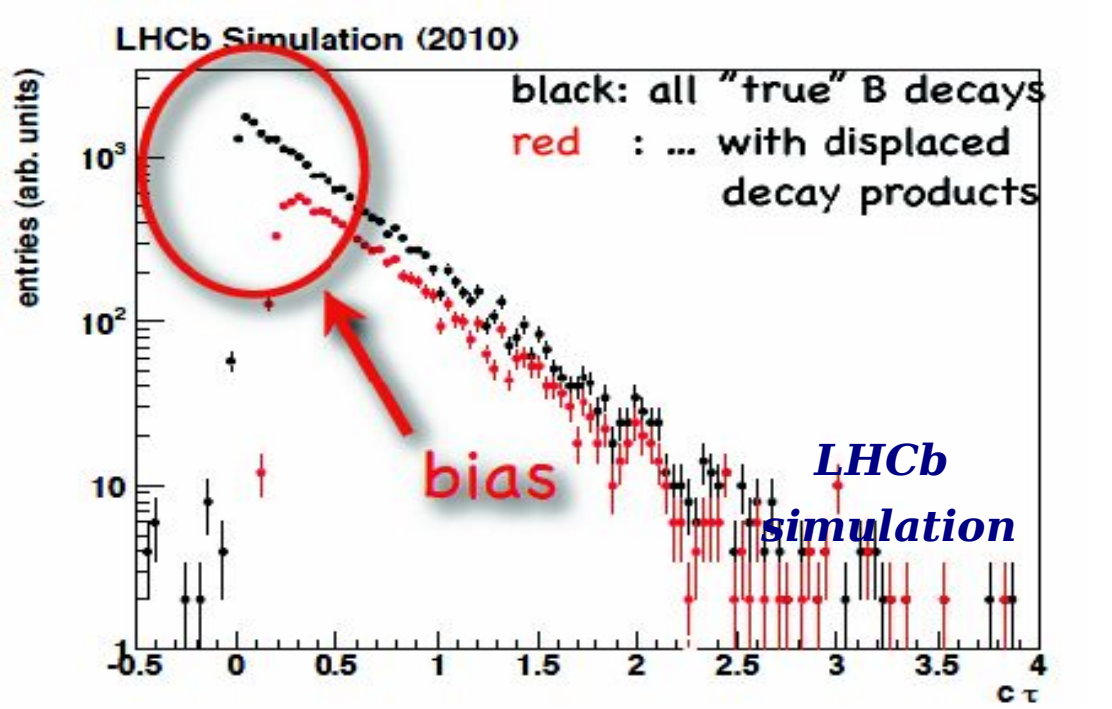
run 2010-2011 $\to 1fb^{-1}$





Observation for BR> 4 10^{-8}

$B^0_s \to K^+K^-$ Precise lifetime measurement



- *Special unbiased trigger line for this channel*
- *Sensitivity for σ (cτ) ~ 10 μm at 5K events with low bias*

hhh Yields

run 2010-2011 →1fb^{-1}

Estimated Luminosity 1 fb^{-1}	Total Efficiency*	Branching Fraction(10^{-5})	**Estimated** Number of events**
πππ	2.4%	1.62 ± 0.15	**100K**
Kππ	2.4%	5.5 ± 0.70	**300K**
KKπ	2.4%	0.50 ± 0.07	**30K**
KKK	2.4%	3.37 ± 0.22	**200K**
ppπ	2.3%	0.16 ± 0.02	**10K**
ppK	2.3%	0.59 ± 0.05	**30K**

More than one order of magnitude than world statistic

** Total Efficiency = Geometry X Trigger X Selection efficiency*

*** B cross section preliminary LHCb measurement: see S. Stone ICHEP2010*

Search for sources of CP in $B^+ \to hhh$: Mirandizing

Possibility of probing regions of the Dalitz plot looking at interference with CP:

1- resonant intermediary asymmetries like: $A_{cp}(B^+ \to K^+ \rho^0)$

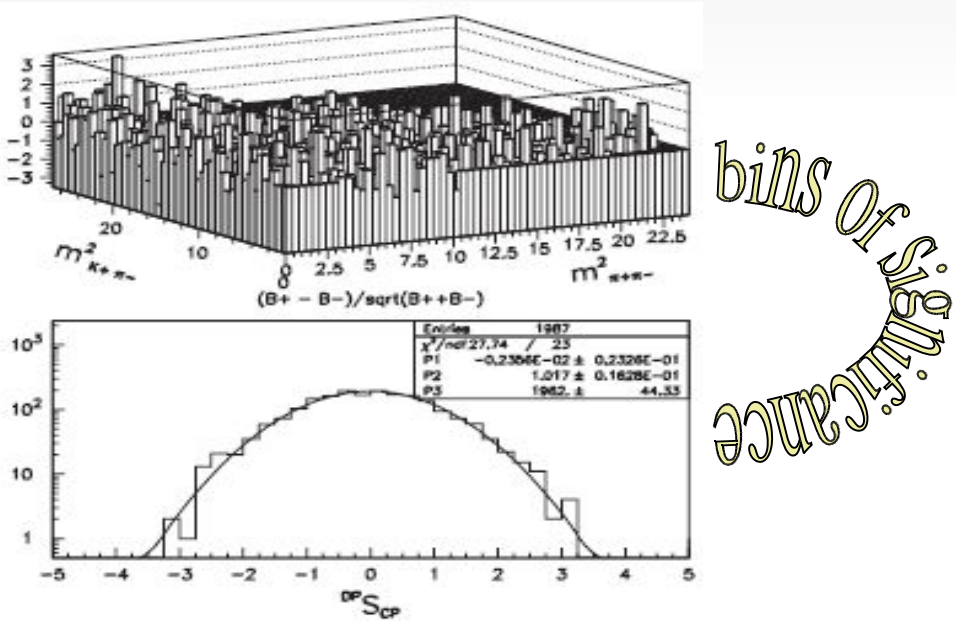
2- CP in interferences between intermediary resonant states with CP

model independent method

For $B^+ \equiv B^- \Longrightarrow$ **CP**

Subtract B^+ *and* B^- *Dalitz surface and write the significance of each bin:*

$$ {}^{DP}S_{CP}(i) = \frac{(N^+(i) - N^-(i))}{\sqrt{(N^+(i) + N^-(i))}} $$



Pure statistical fluctuation: centred Gaussian of unit width **$g_0(0,1)$**.

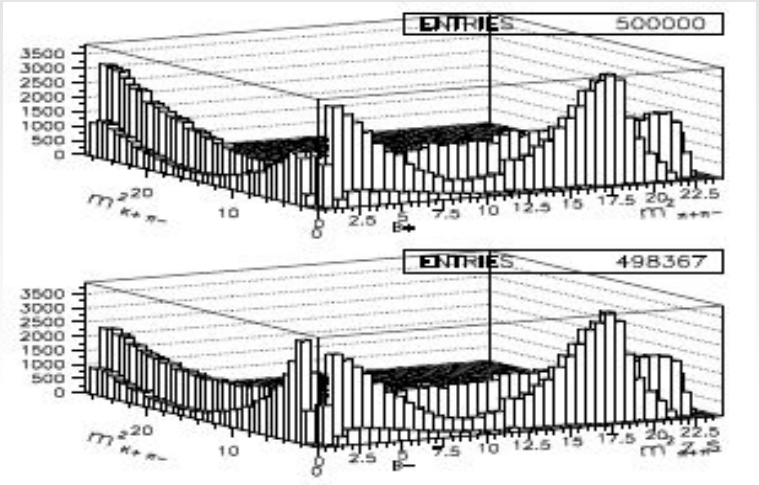
CP invariance => g(0,1)

"imported" from astrophysical community:

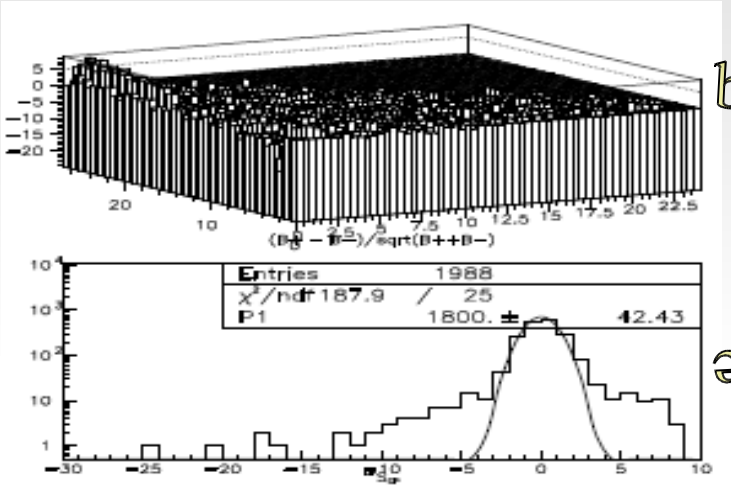
Ti-pei Li and Yu-qian Ma, Astr.Jour.272(1983) ,317 by
I.B., I.I. Bigi, A. Gomes, G. Guerrer,
J. Miranda and A.C. Dos Reis
-Phys. Rev. D 80, 096006 (2009)

Search for sources of CP in $B^+ \to hhh$: Mirandizing

$B^+ \neq B^- \Longrightarrow \not{CP}$



DP S_{CP}

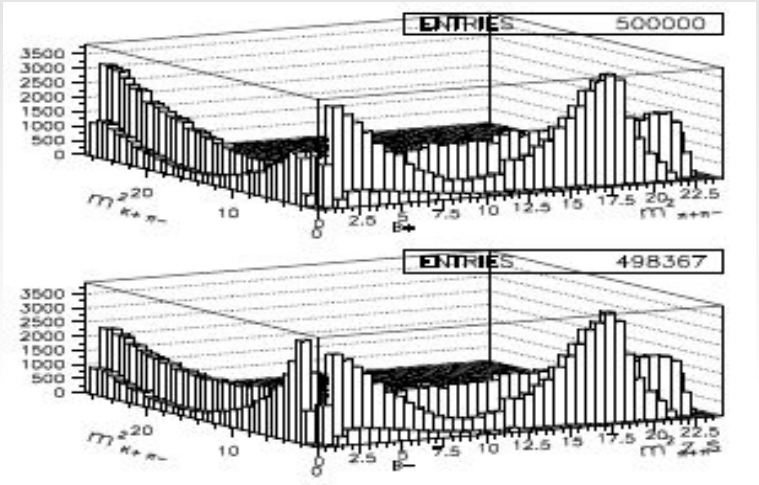


bins of significance

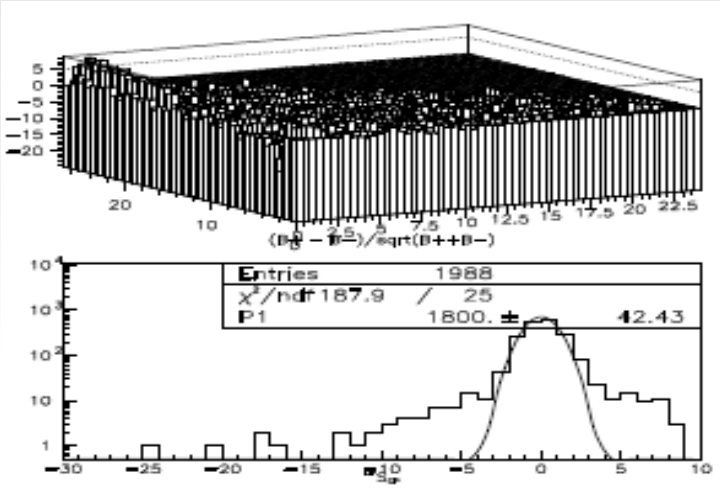
$\not{CP} \Rightarrow g(0,1)$

Search for sources of CP in $B^+ \to hhh$: Mirandizing

$B^+ \neq B^- \Longrightarrow CP$

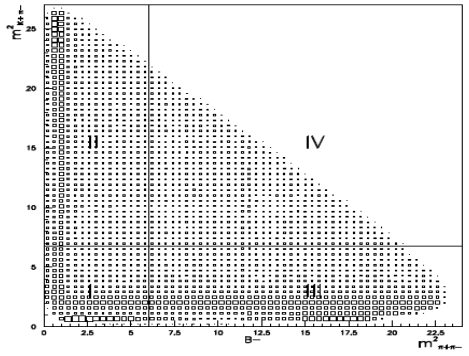


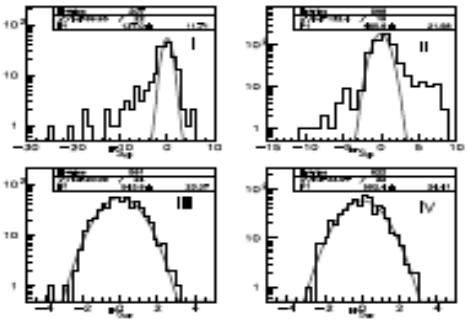
DP S_{CP}



bins of significance

probing regions of the Dalitz plot





$CP \Rightarrow g(0,1)$

Summary

- *Study of the charmless two and three charged body B decays @ LHCb in good shape.*

- *The estimated 1fb^{-1} for the 2010-2011 run, would give at least, one order of magnitude more events than the nowadays world statistic.*

- *Analysed strategies well defined.*

- *Expected important reduction in the CP measurement*

- *Expected important reduction in the measurement in the γ CKM phase*