The LHCb experiment

A. C. dos Reis
on behalf of the LHCb Collaboration

LISHEP 2013

17/3/2013

The LHCb Physics Programme

The purpose of the LHCb experiment is to perform precision tests of the Standard Model and to search for New Physics.

Historically, new particles have first been observed through their virtual effects (e.g., CP violation in the kaon system). This approach probes higher mass scales than direct searches.

LHCb explores the high precision frontier, complementary to ATLAS and CMS, which explore the high energy limit.

LHCb: an experiment designed for the study of rare decays and CP violation in hadrons containing quarks c and b.

Two important questions:

- Does the CP-violating phase of the CKM matrix account for all known CP-violating processes?
- Is the CKM matrix with its four parameters capable to describe all FCNC processes?

Answers to these questions involve some key measurements:

1) CP-violating angle γ from in tree-level decays ($B \to DK$, free from NP);

2) mixing-induced CP-violating phase in $B_s^0 \to J/\psi\ \phi$;

3) analysis of $B_s^0 \to \phi\,\gamma$ and other radiative decays;

4) analysis of the rare decays $B_{(s)}^0 \to \mu^+\mu^-$ and $B^0 \to K^{*0}\mu^+\mu^-$;

5) BR's and CP asymmetries of $H_b \to h^+ h^{'-}$, $(H_b = B_{(s)}^0, \Lambda_b, \quad h = K, \pi, p)$.

But LHCb has much more

100 publications, almost all with 2011 data only:

- $B^0 - \overline{B}^0$ mixing and CP violation;
- $D^0 - \overline{D}^0$ mixing and CP violation in neutral and charged Ds;
- radiative and other rare B decays and D decays, LFV searches;
- masses and branching fractions of b- and c-hadrons;
- Dalitz plot analysis;
- B_c physics;
- charmonium and bottomonium production;
- open charm and beauty production and spectroscopy;
- b- and c-baryon spectroscopy, production and polarization;
- new hadrons (X(3872), Z(4330), etc...);
- forward jets;
- W and Z production, eletroweak physics...

A comprehensive programme in heavy flavor physics!

LHCb results in this conference

Don't miss the very interesting LHCb talks:

Production in the forward direction
M. Rangel, today at 16:40

Mixing and CP violation in charm system
M. Combes, Wednesday at 10:50

Rare decays
F. Polci, Wednesday at 11:20

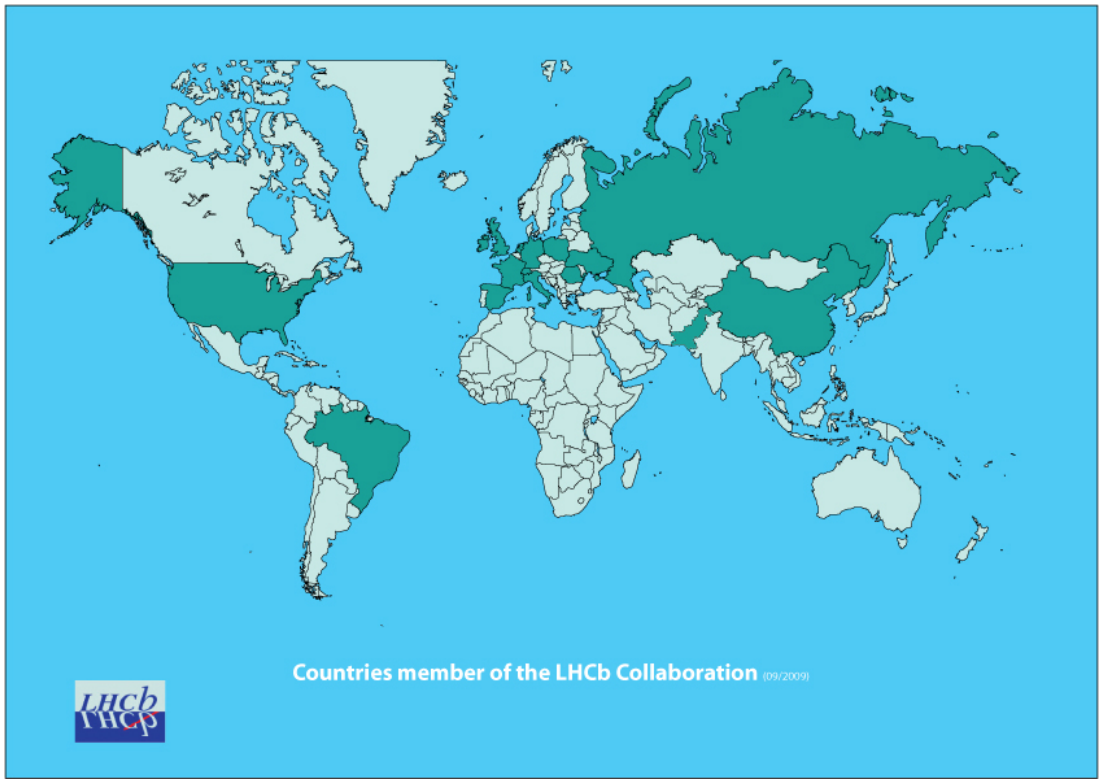
CP violation in $B^0_{(s)}$ to final states including charmonia
B. Paula, Wednesday at 14:00

CP violation in charmless hadronic B decays
F. Rodrigues, Wednesday at 14:30

The LHCb upgrade
A. Massafferri, Thursday at 11:30

The LHCb Experiment

The LHCb Collaboration

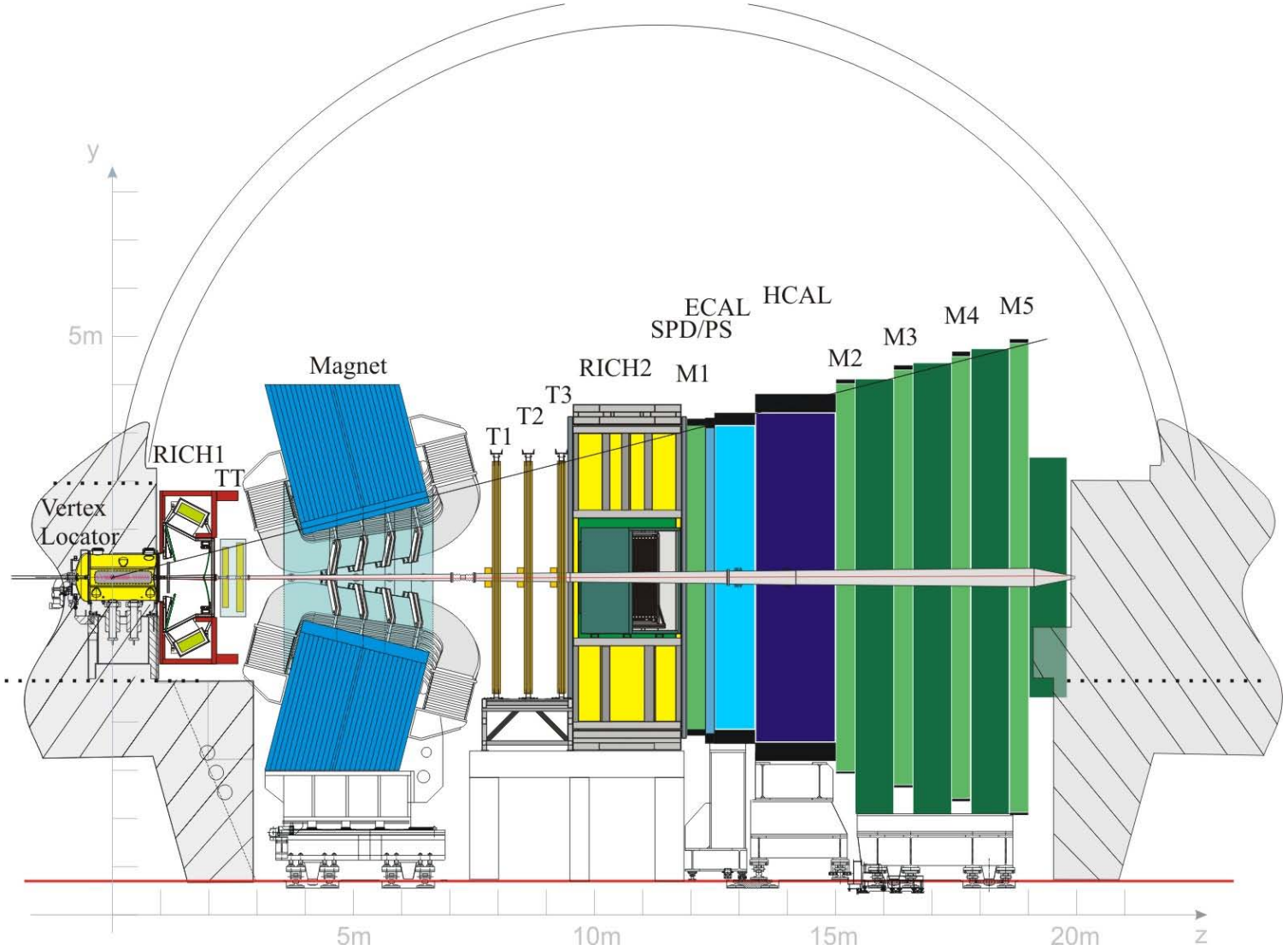


16 countries

60 institutes

819 members

The LHCb Detector



LHCb acceptance: $2 < \eta < 5$

At 7 TeV : $\sigma_{pp}^{\text{inel}} \sim 60mb$

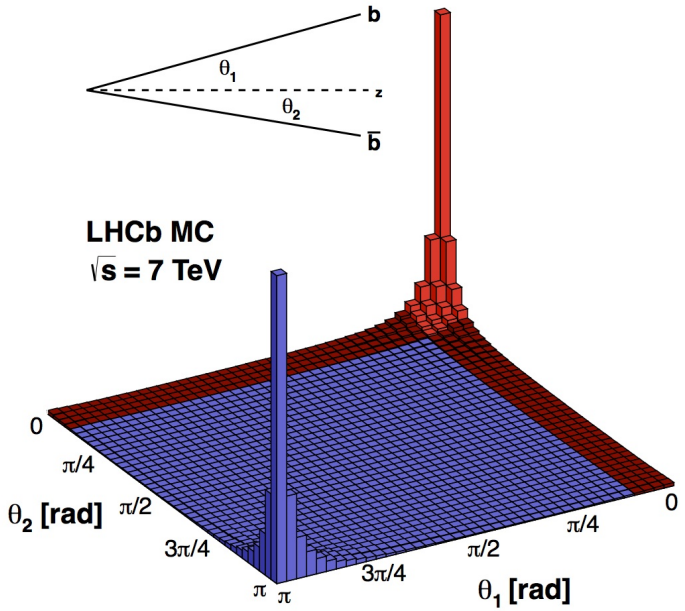
$\sigma(pp \to c\bar{c}X) \sim 6mb$

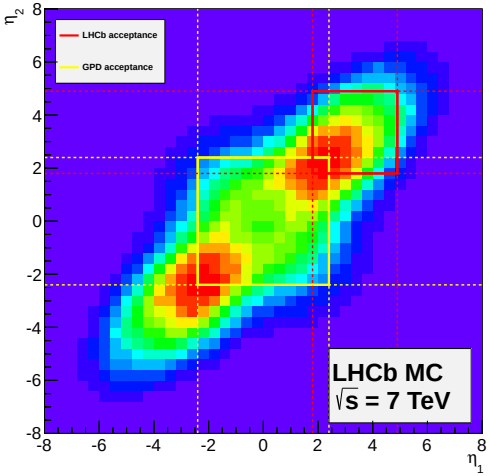
$\sigma(pp \to b\bar{b}X) \sim 0.3mb$

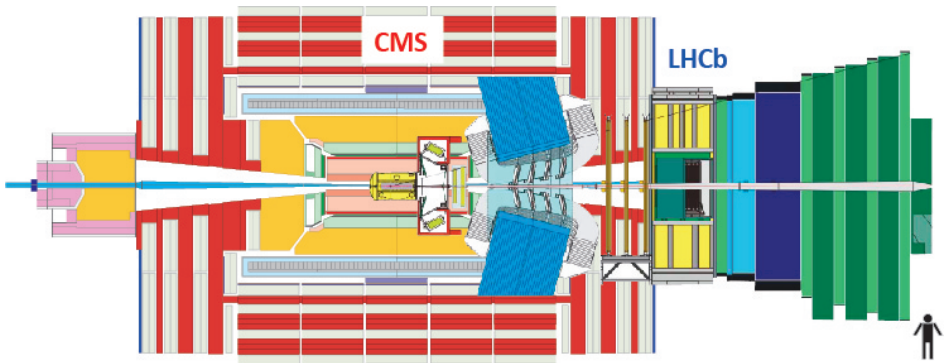
$\sim$ 30% within LHCb acceptance:

$\sigma(pp \to b\bar{b}X) = (89.6 \pm 6.4 \pm 15.5)\ \mu b$

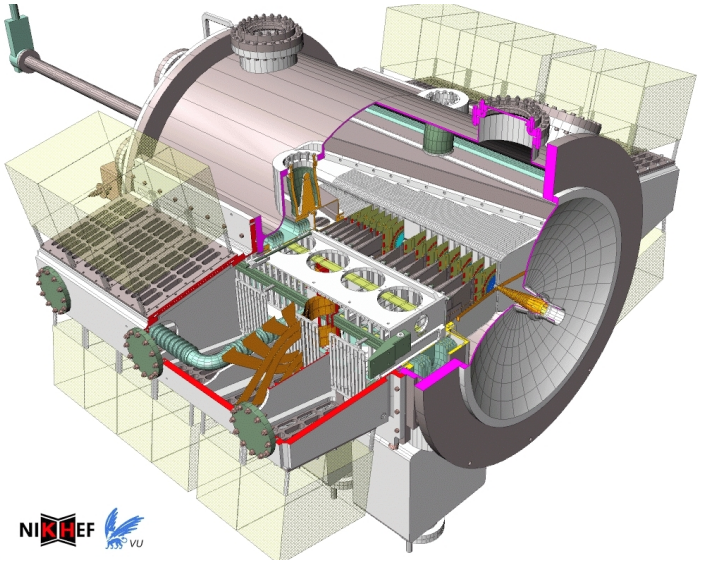
PLB 684 (2010) 209

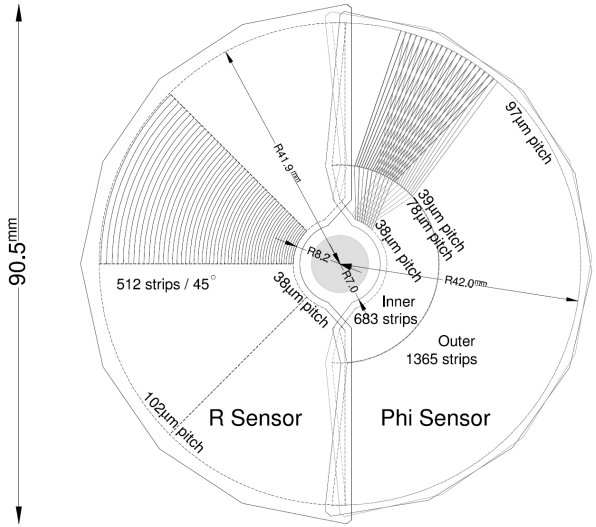




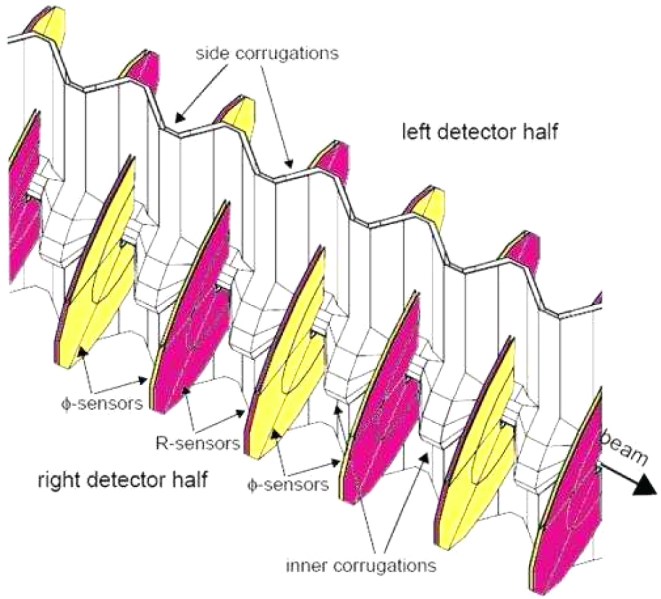


VErtex LOcation - VELO

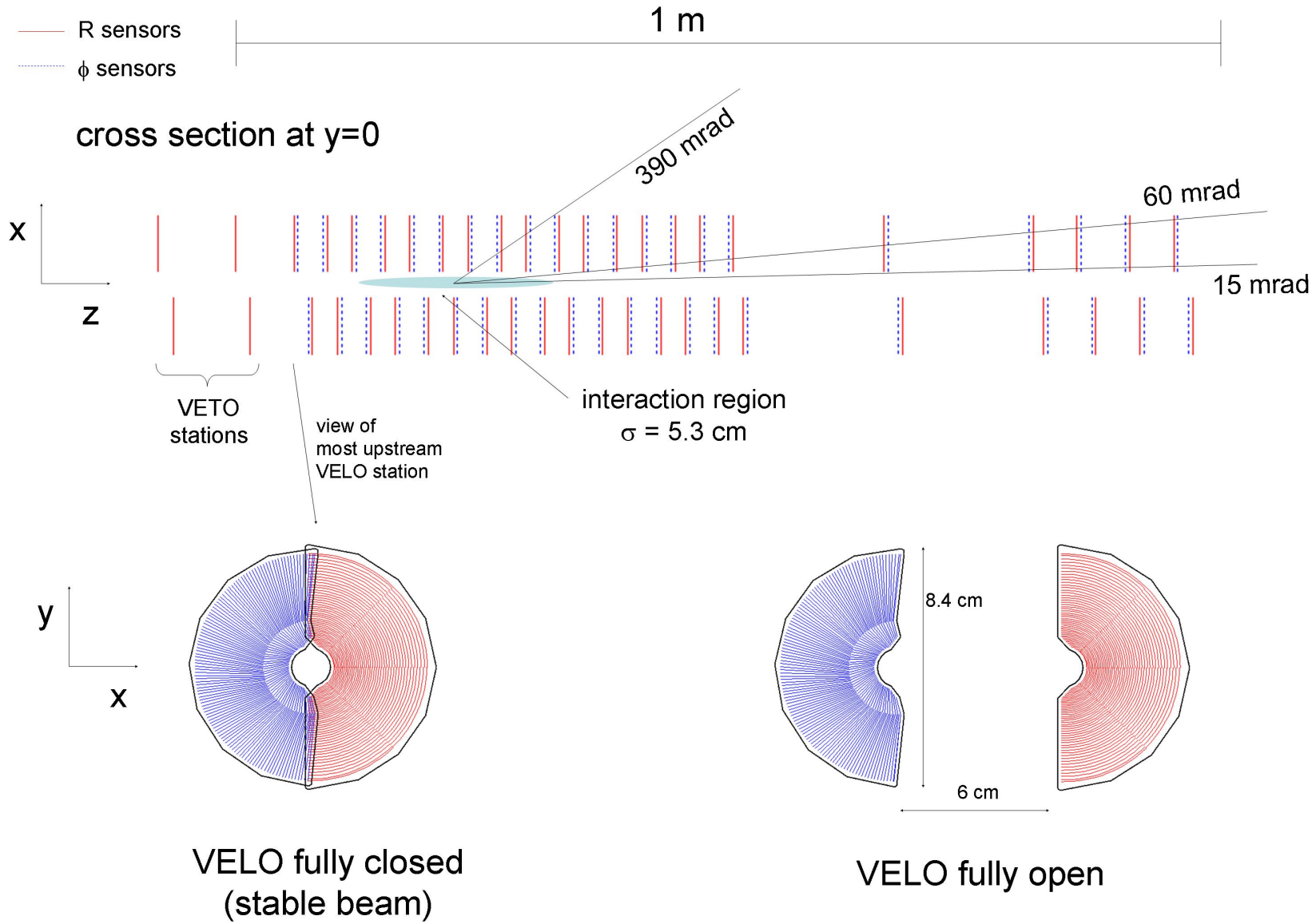


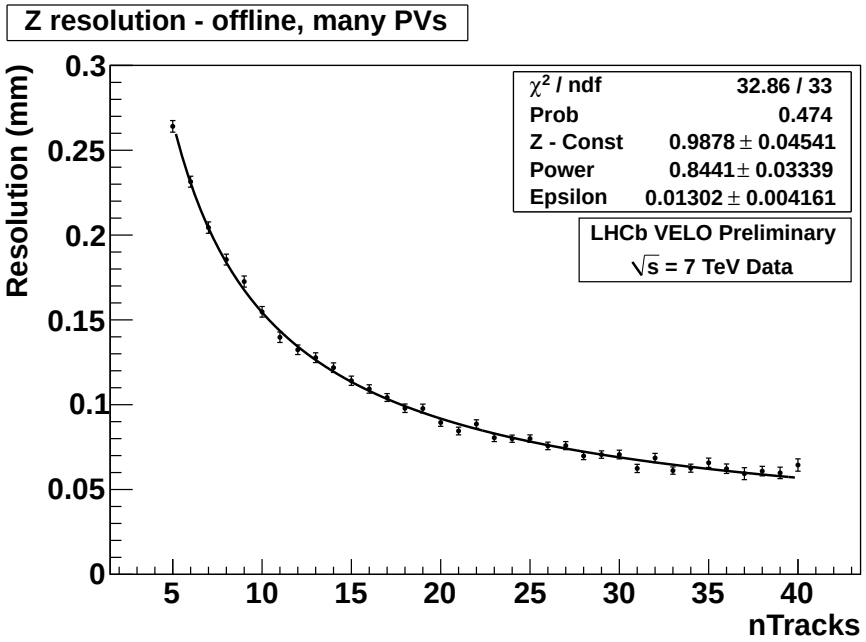


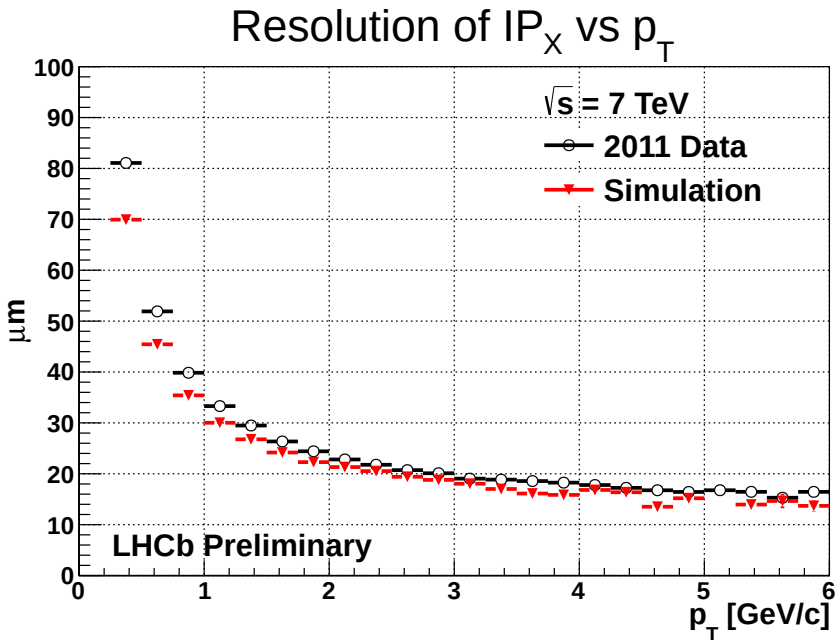
- 2 retractable halves at 8 (60) mm from beam when closed (open);
- 21 stations with double-sided modules (R and ϕ sensors);
- cilindrical geometry allows fast reconstruction for triggering.



VErtex LOcation - VELO





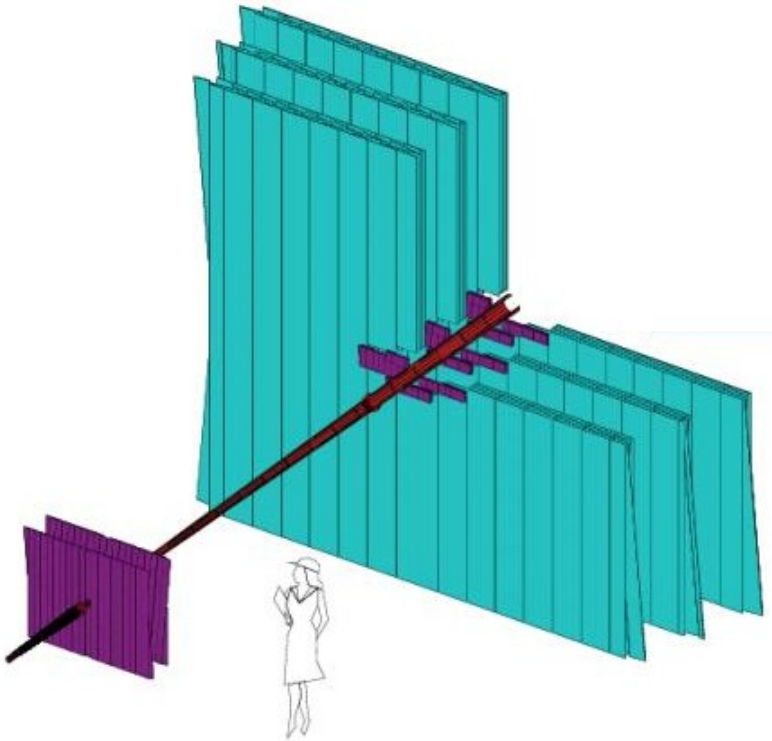


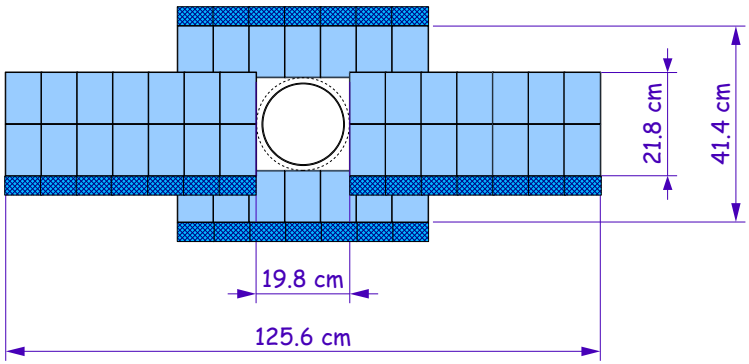
Tracking efficiency above 98%.

z resolution of $\sim$80 μm for primary vertices with 25 tracks.

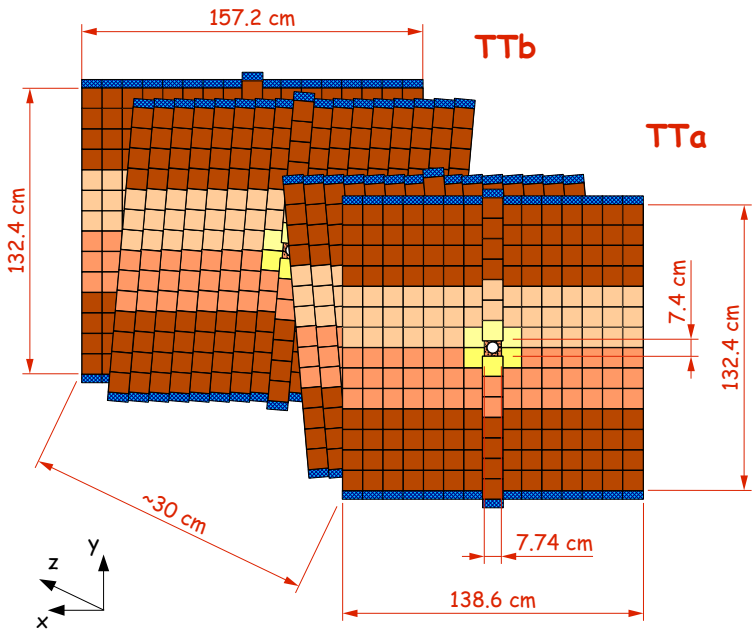
IP resolution of $\sim$22 μm for tracks with $p_T > 2$ GeV/c.

Tracking stations

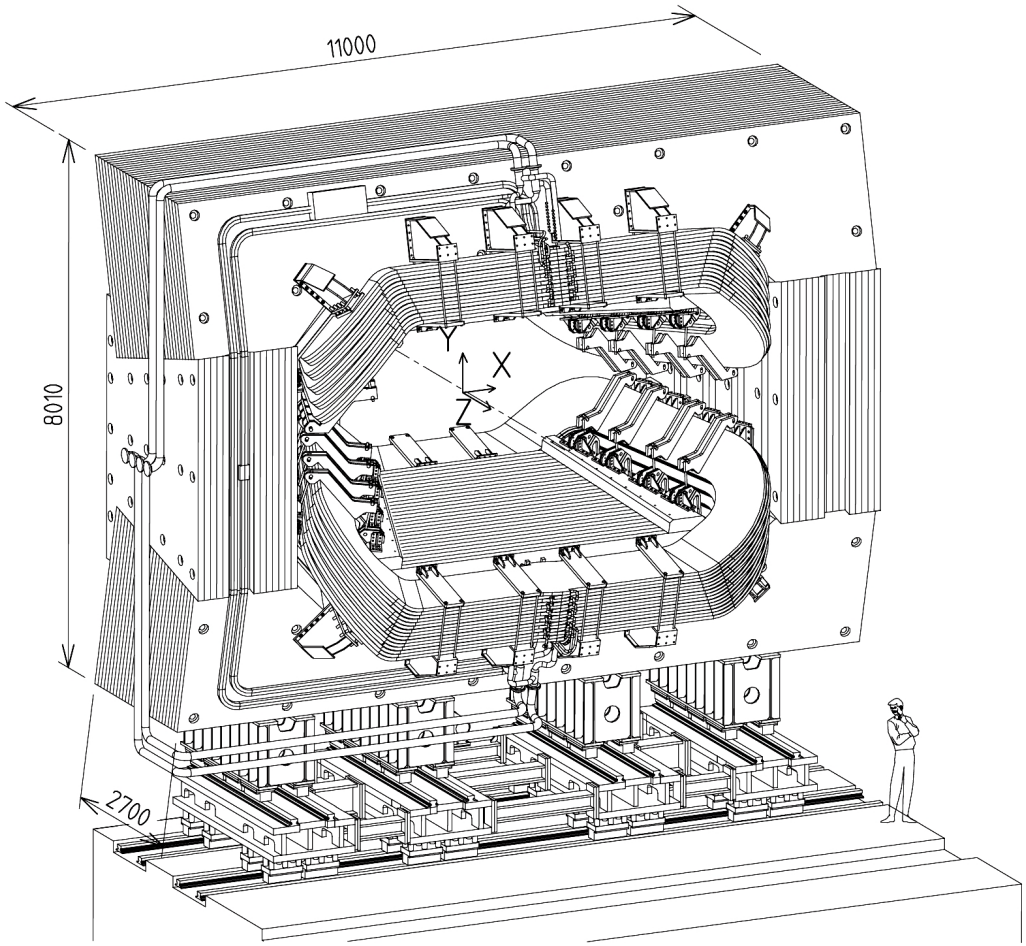




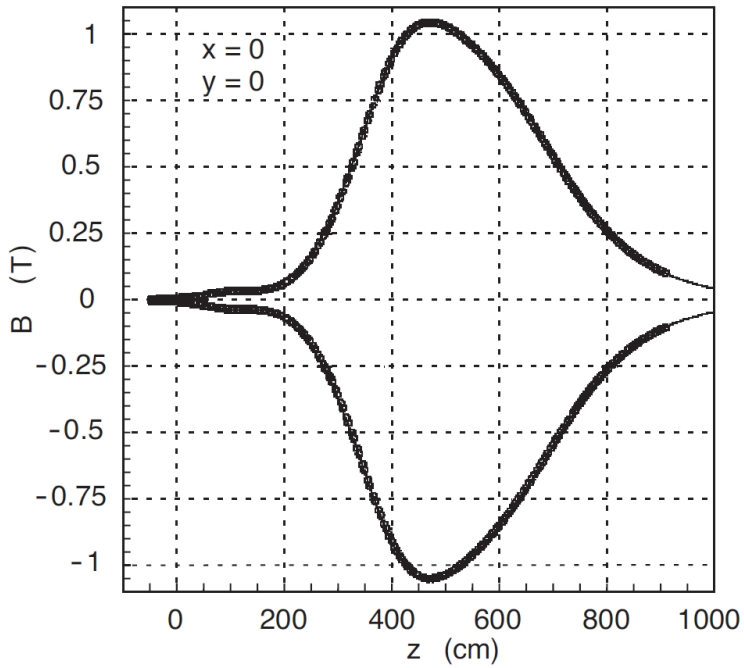
- 1 upstream station (TT) equiped with silicon micro-strips;
- 3 downstream stations (T1-3) with silicon micro-strips in the inner region (IT) and straw tubes (OT) in the outer part.



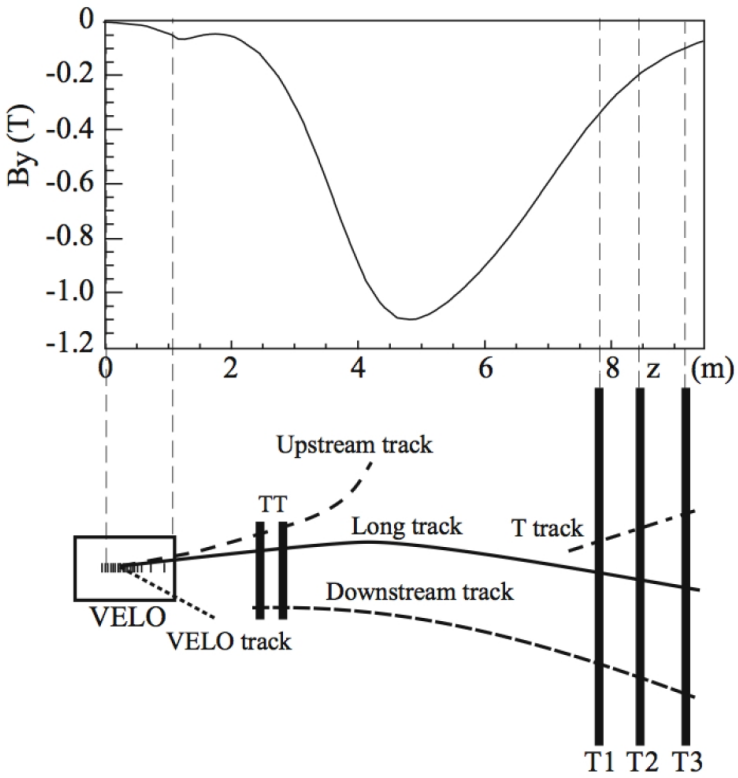
The dipole magnet

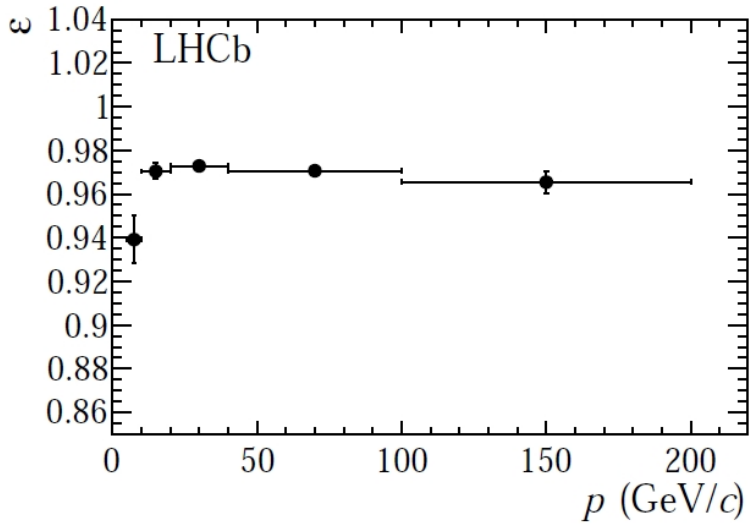


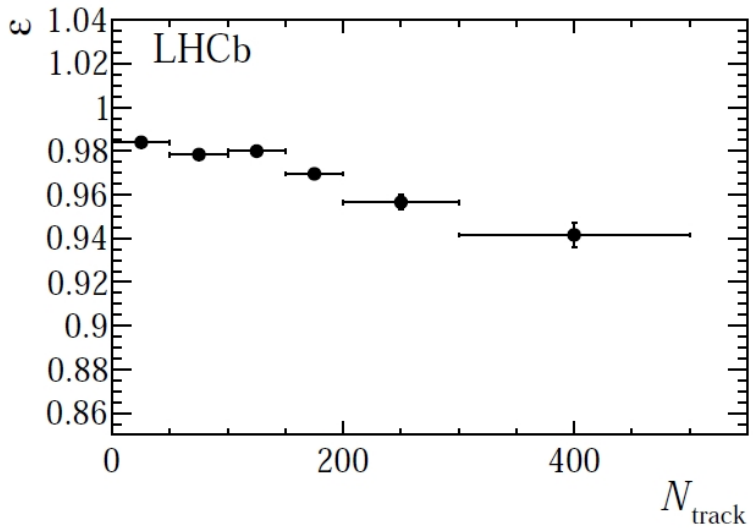
- acceptance: ± 250 mrad vertically, ± 300 mrad horizontally (the bending plane);
- $\int Bdl = 4$ Tm for tracks of 10 m lenght;
- $\delta B/B \sim 4\text{x}10^{-4}$



Tracking performance





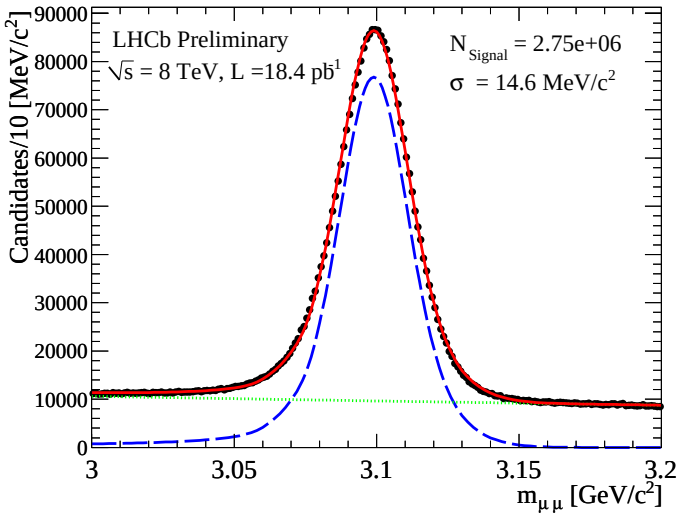


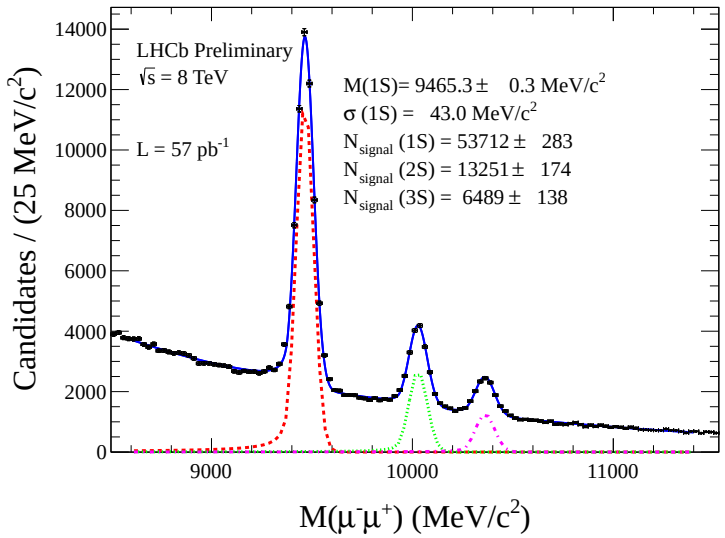
LHCb-PUB-2011-025

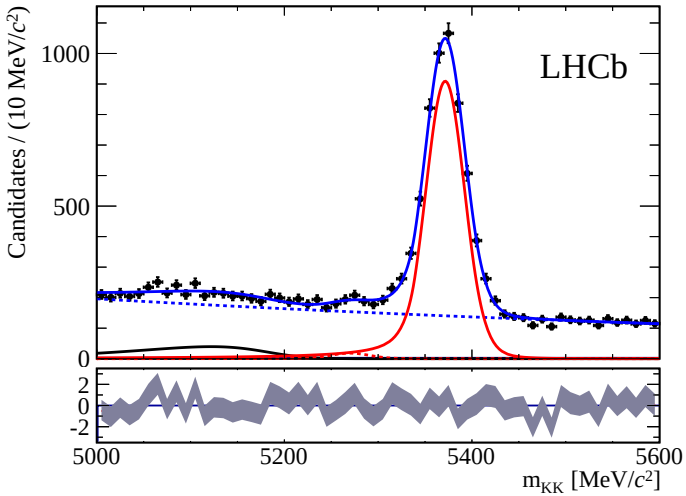
Tracking efficiency measured from data ($J/\psi \to \mu^+\mu^-$).

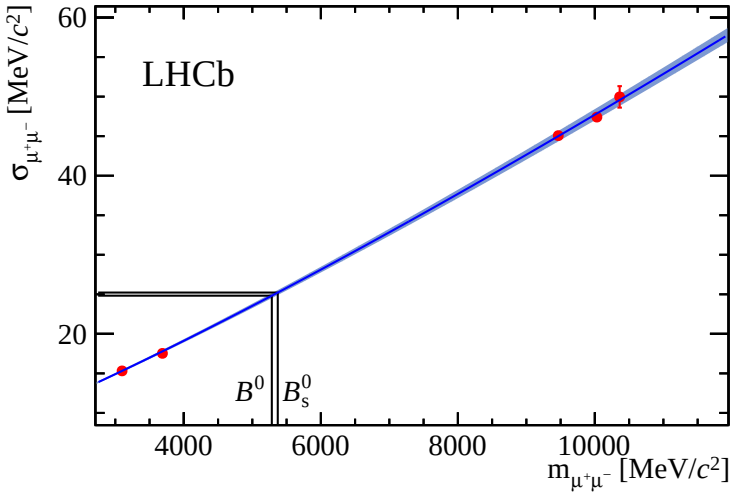
Efficiency $>$ 96% for long tracks (depends on p, p_T, multiplicity).

Momentum and mass resolution







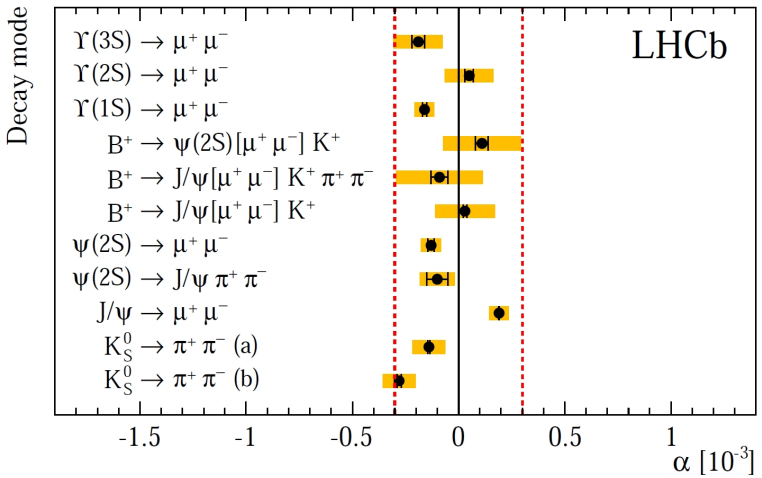


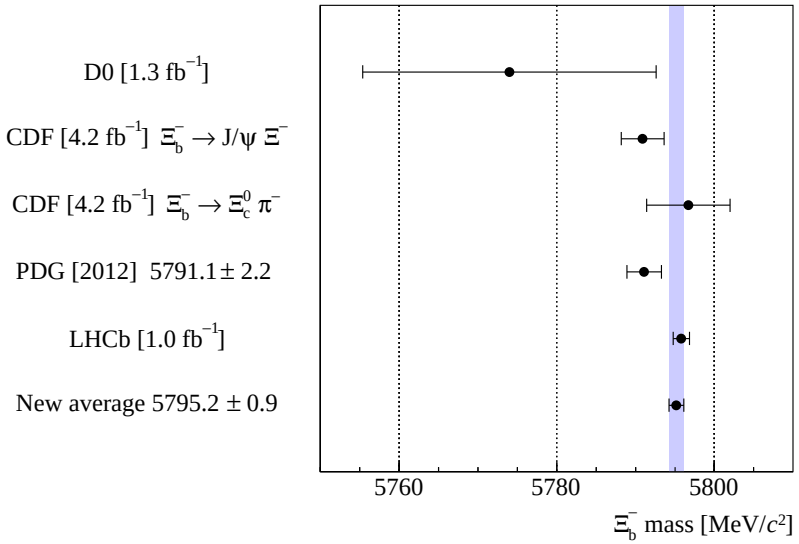
- $\delta p/p$: 0.4 - 0.6% (5-100 GeV/c);
- $\sigma_{\mu\mu} = 15$ MeV/c^2 for J/ψ;
- $\sigma \sim 22$ MeV/c^2 for $B \rightarrow$hh;
- $\sigma_{\mu\mu} = 43$ GeV/c^2 for $\Upsilon(1S)$;

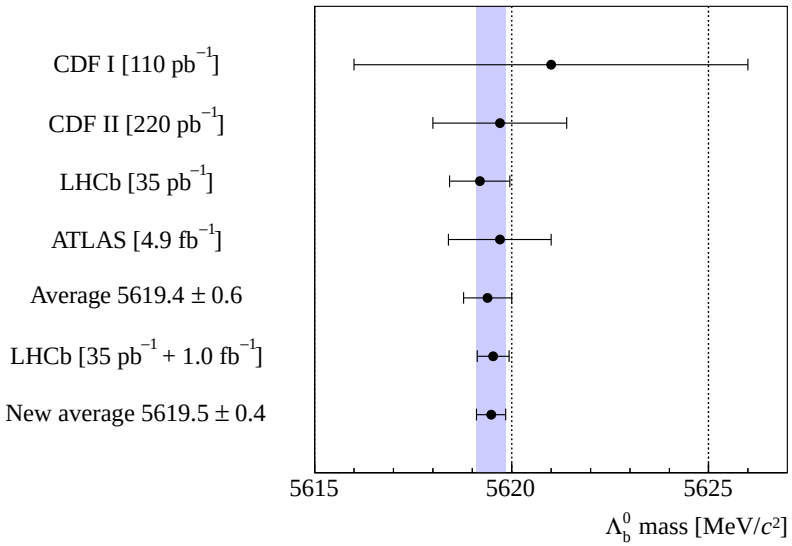
LHCb-CONF-2012-025, PRL 110, 021801 (2013)

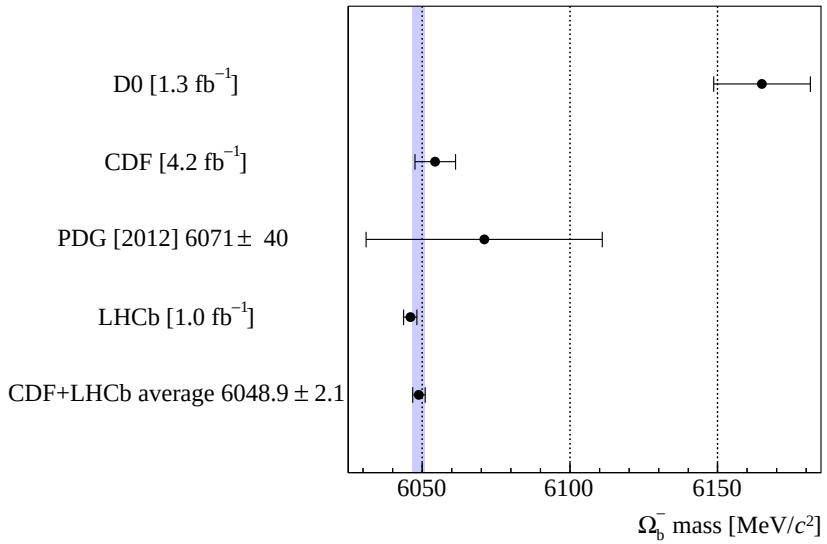
Momentum and mass resolution

Uncertainties in the magnetic field and tracker alignment imply a small bias in the momentum scale (α). The momentum scale is calibrated using $B^+ \to J/\psi K^+$.







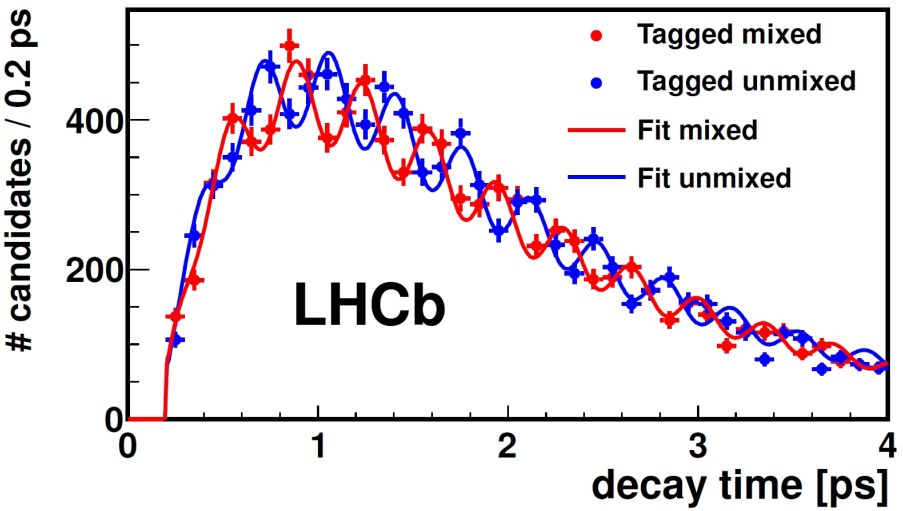


arXiv:1302.1072

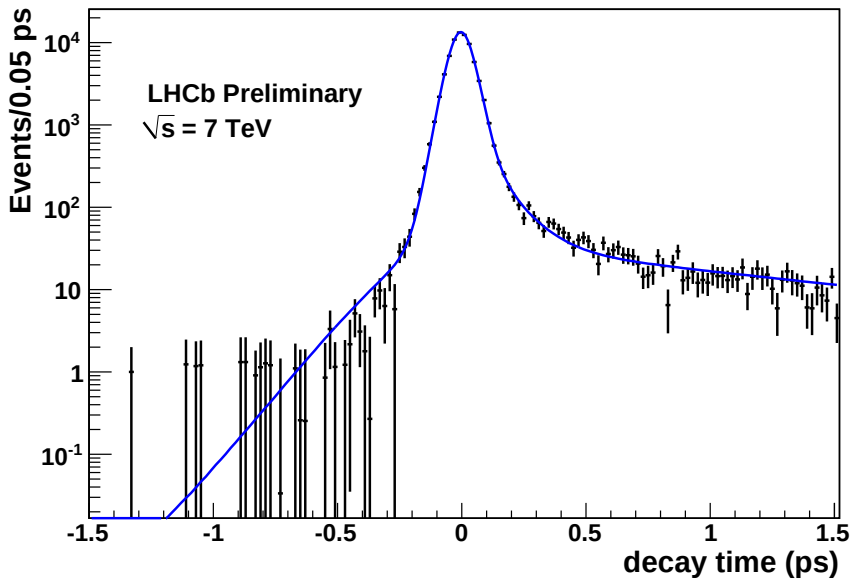
Decay time resolution

The excellent vertex resolution translates into an excellent proper time resolution, necessary to measure the fast oscillation frequency of the $B_s^0 - \overline{B}_s^0$ mixing.

preliminary



LHCB-PAPER-2013-006 (in preparation)

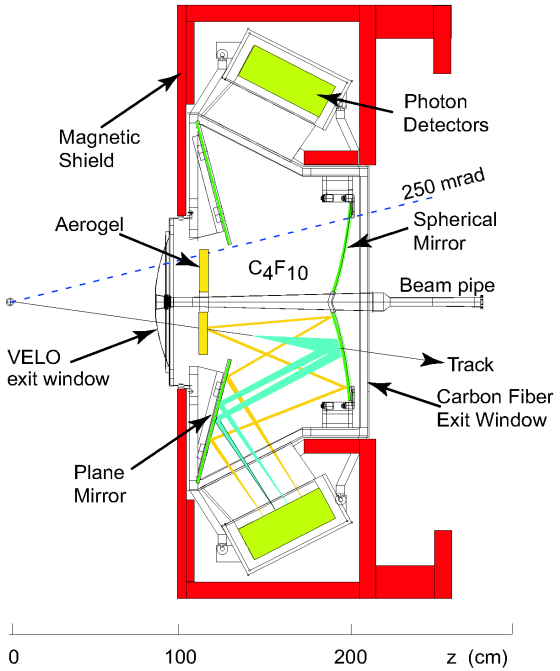


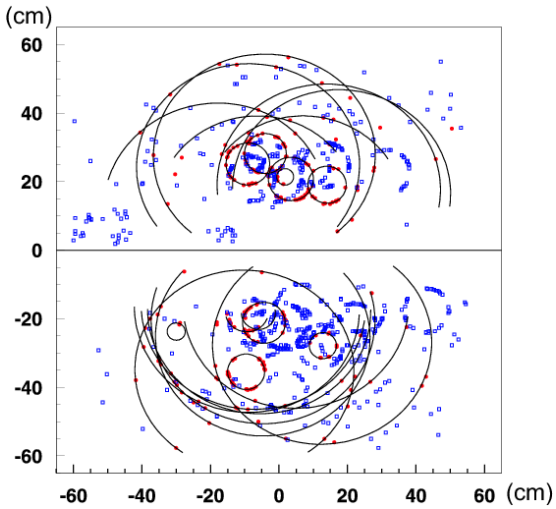
LHCb-CONF-2012-002

The decay time resolution is measured from data fitting the decay time distribution of $B_s^0 \to J/\psi\phi$. The time dependent signal PDF is convolved with a Gaussian distribution.

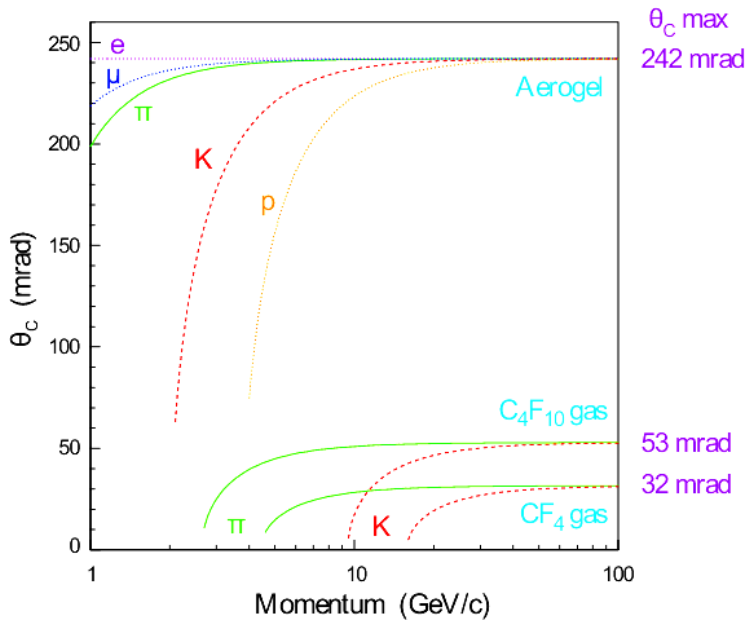
Decay time resolution of 45 fs for $B_s^0 \to J/\psi\phi$ and $B_s^0 \to D_s\pi$.

Charged particle identification

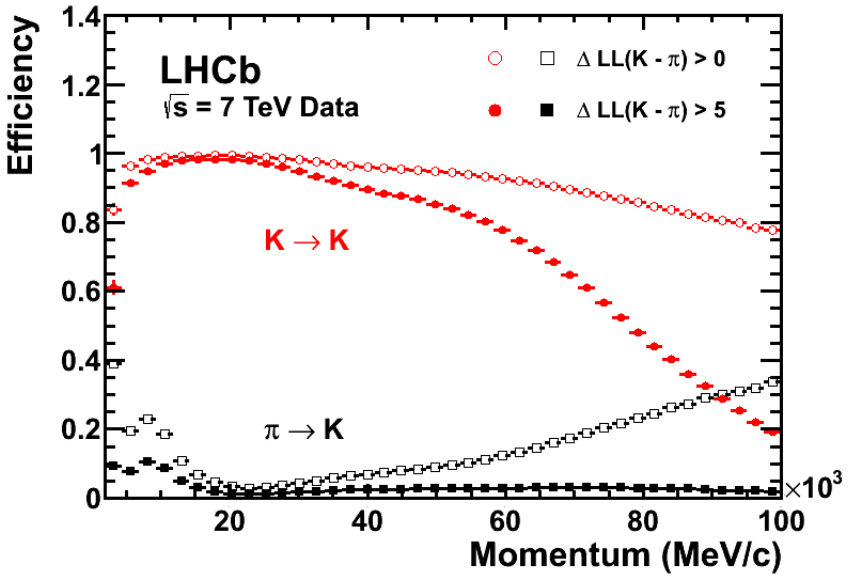


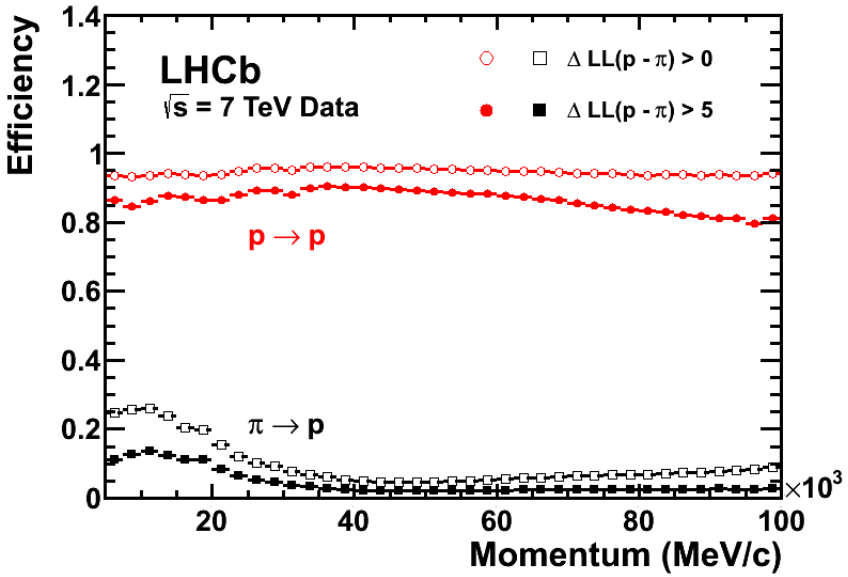


- Two **R**ing **I**maging **CH**erenkov detectors (RICH1,2);
- RICH1 (upstream) operating with 2 different radiators, aerogel and C_4F_{10} - low momentum particles;
- RICH2 (downstream): CF_4 - high momentum particles.



Charged particle identification





- efficiency and misID rates measured directly from data:

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

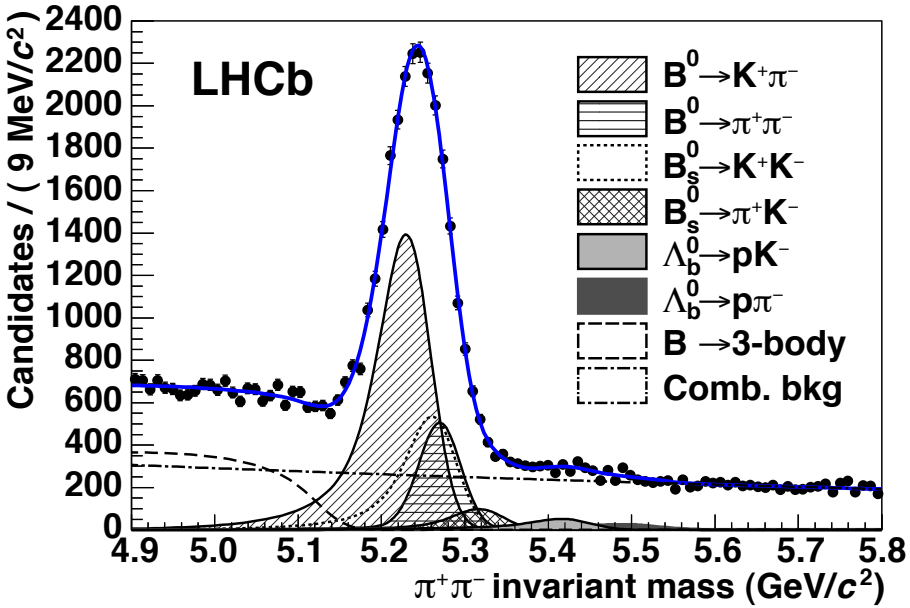
  $D^{*+} \to D^0(K^-\pi^+)\pi^+$,

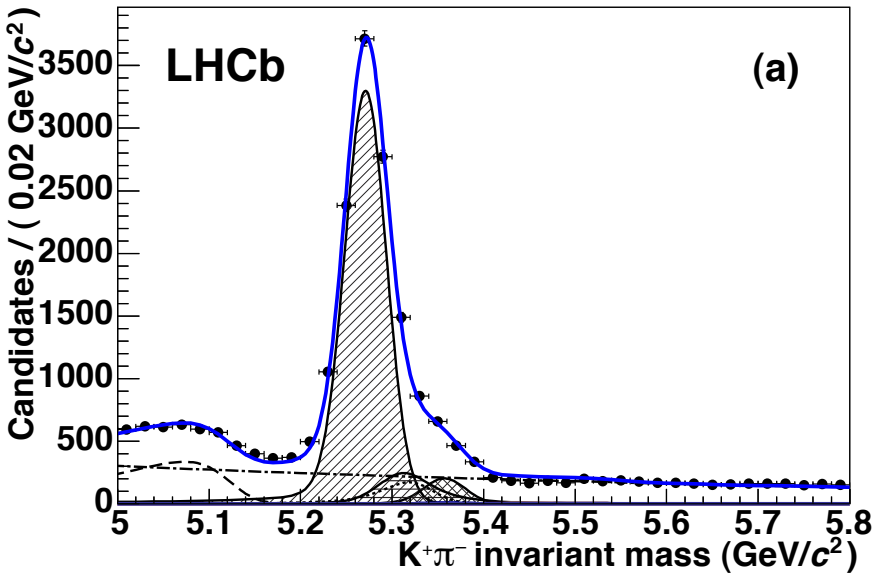
  $\Lambda^0 \to p\pi^-$

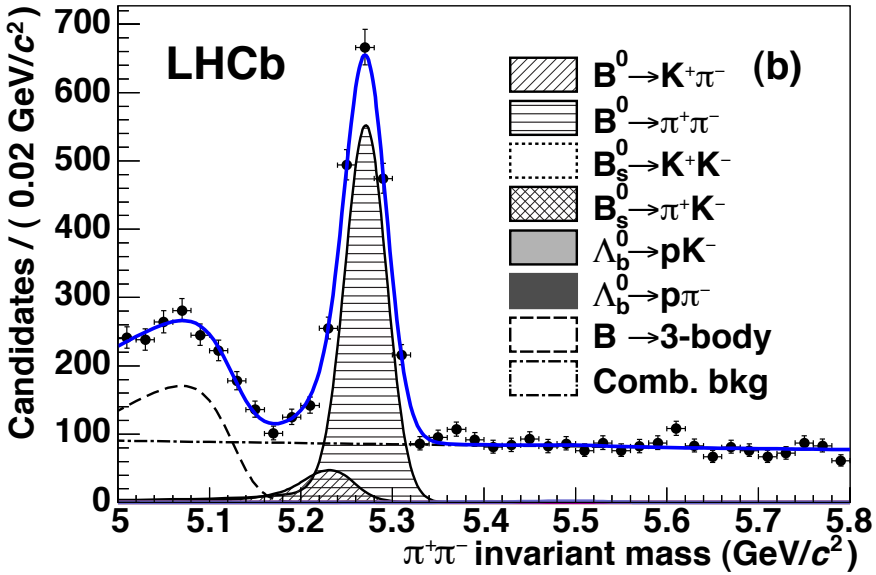
- $K-\pi$ and $p-\pi$ separation up to 100 GeV/c;

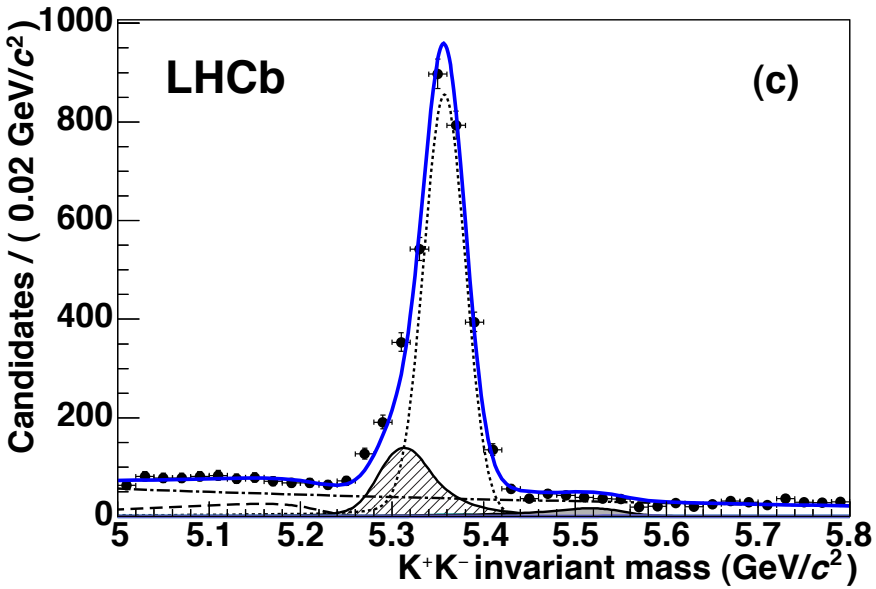
- Kaon ID effciency $\sim$95% for $\sim$5% pion contamination.

Charged particle identification: $B^0 \to hh$









JHEP 10 (2012) 037

Scintilator **P**ad **D**etector / **P**re **S**hower

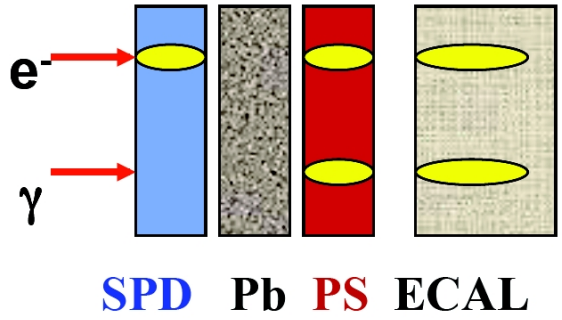
- $e - \gamma$ and e-hadron separation;
- single layer scintilator tiles with a Pb sheet (2.5 X_0);
- $\varepsilon(e^{\pm}) \sim 90\%$ for 5% e-hadron misid.

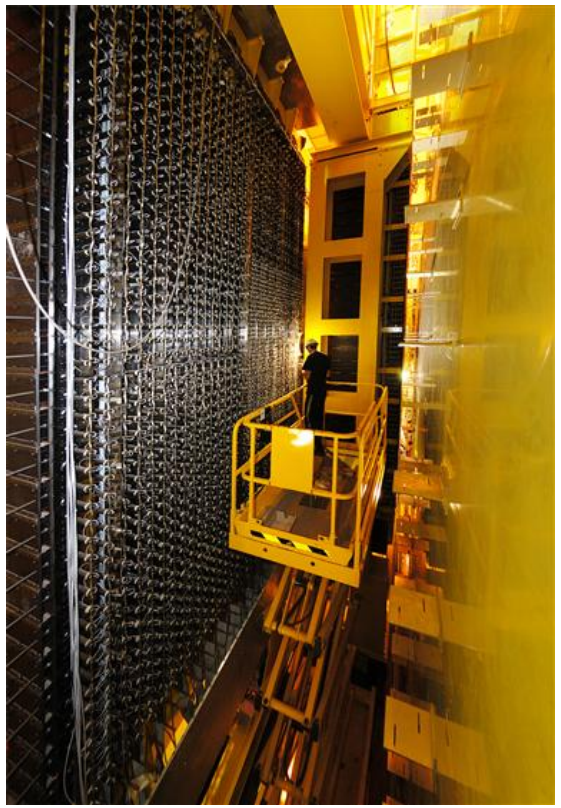
Electromagnetic **CAL**orimeter

- $e-\gamma$ energy measurement;
- Pb plates + scintilator tiles (25 X_0);
- $\sigma(E)/E = 10\%/\sqrt{E}$ (GeV) + 1%

Hadronic **CAL**orimeter

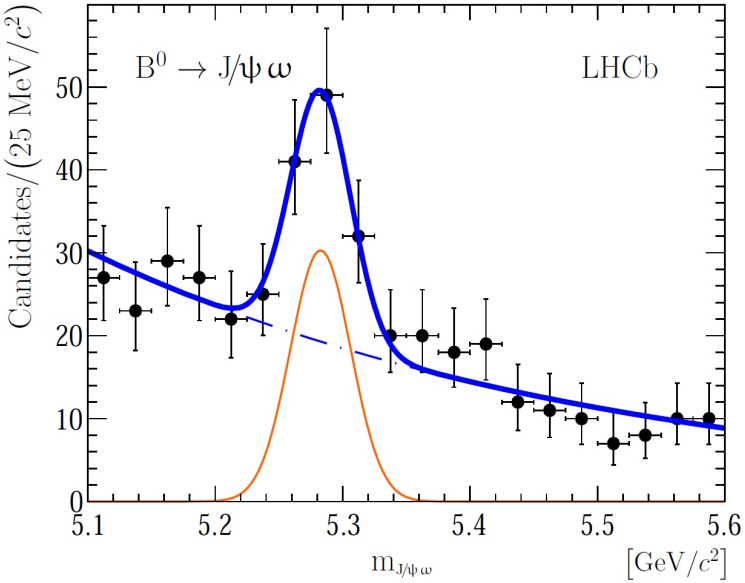
- energy measurement for level 0 trigger;
- Fe plates + scintilator tiles;
- $\sigma(E)/E = 69\%/\sqrt{E}$ (GeV) + 9%

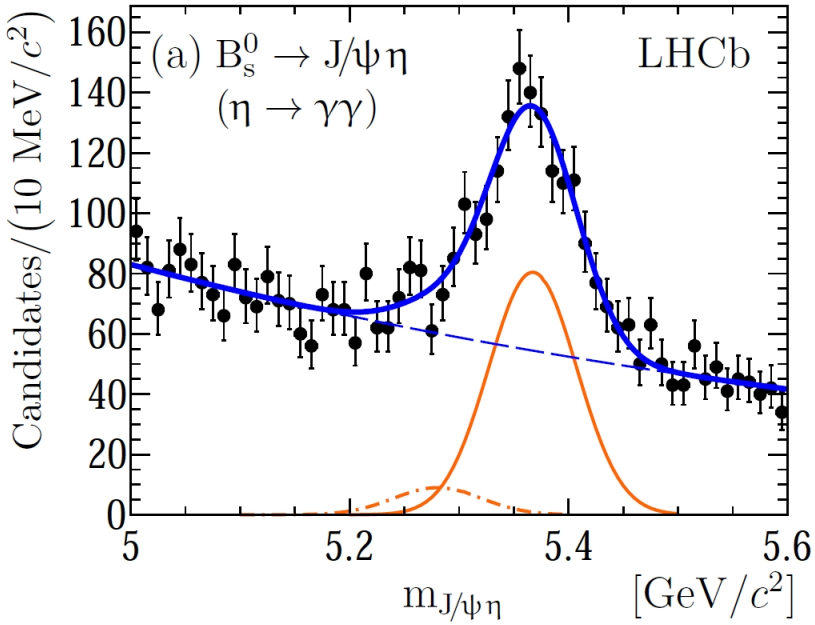




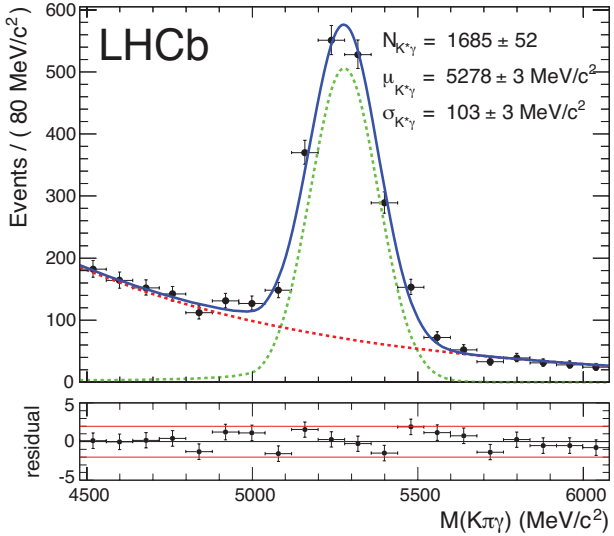
The ECAL detector

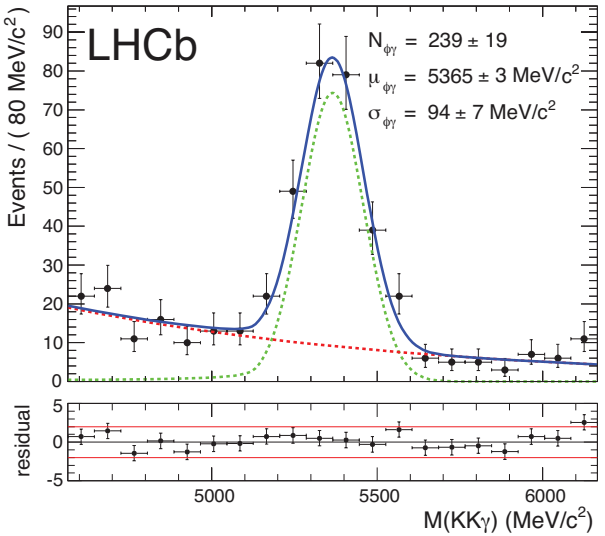
Calorimeters performance





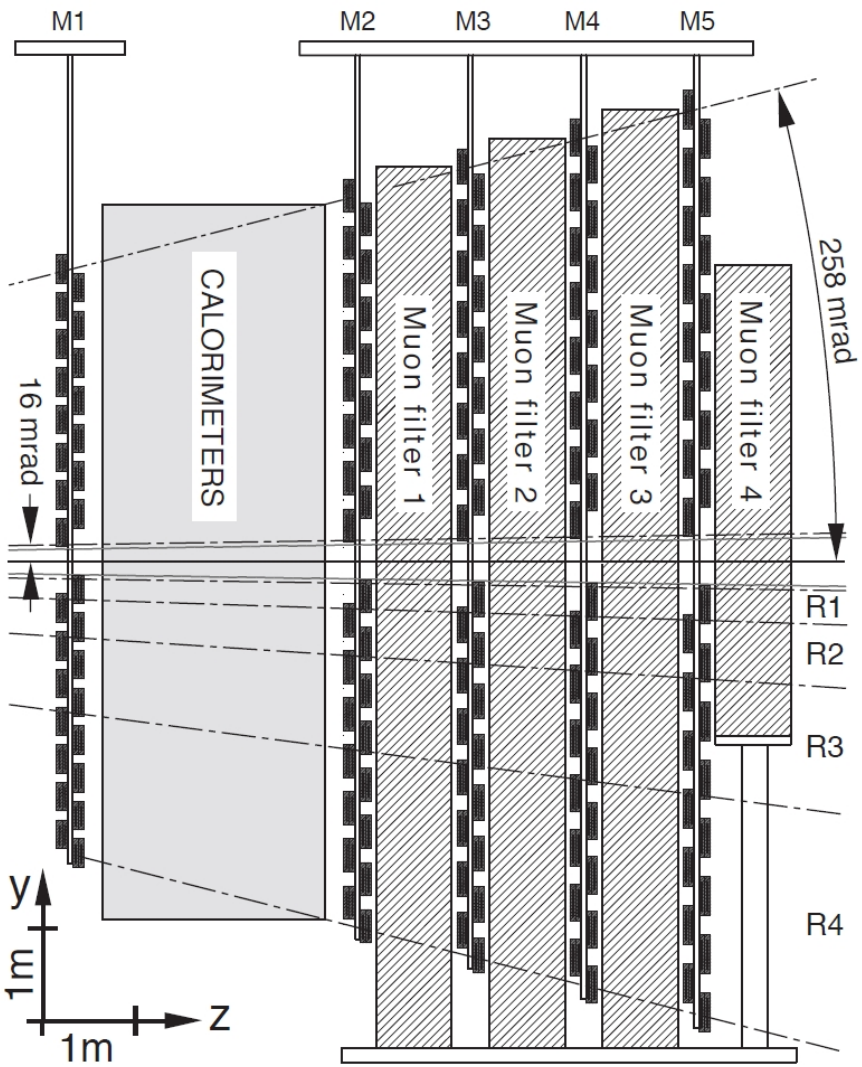
arXiv:1210.2631





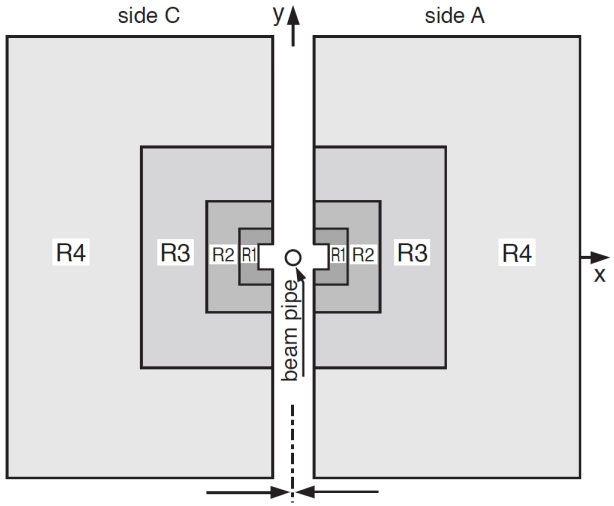
PRD 85 (2012) 112013

Muon detection

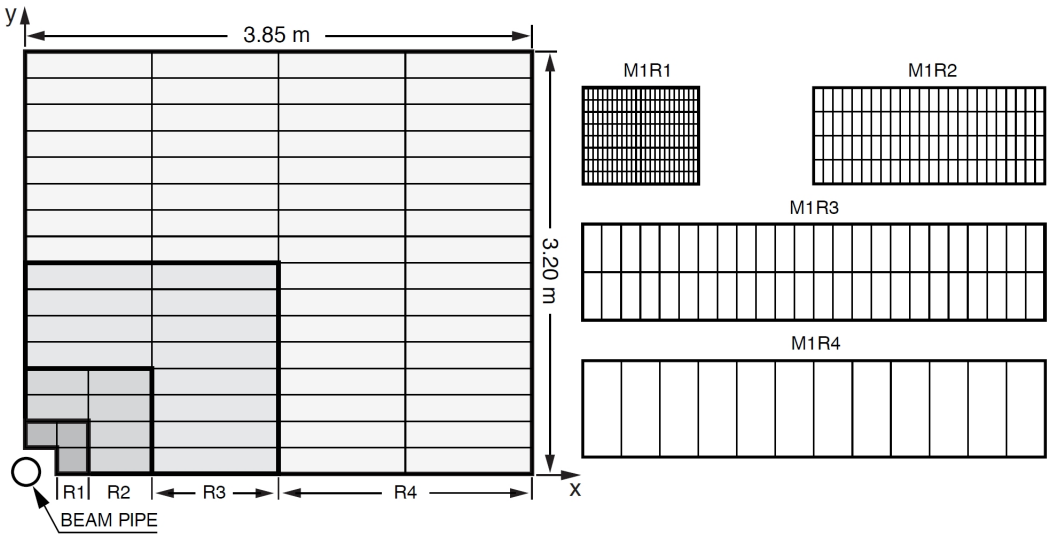


- 1 station before the calorimeters equiped with GEM (inner part) and MWPC detectors;
- all others equiped with MWPCs (double-sided), interleaved by iron walls;
- as in the Calo system, projective geometry, covering the maximum LHCb acceptance;
- variable granularity according to track density;

Muon detection

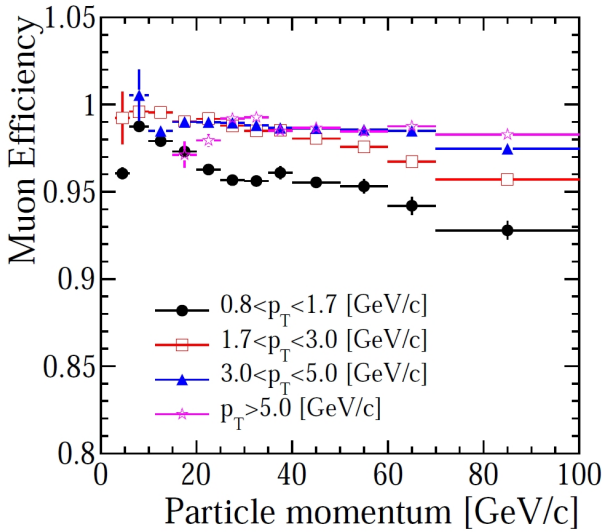


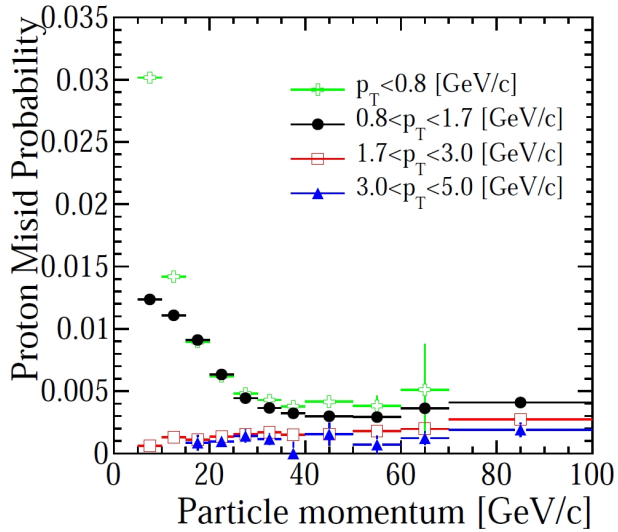
Granularity depending on particle density:

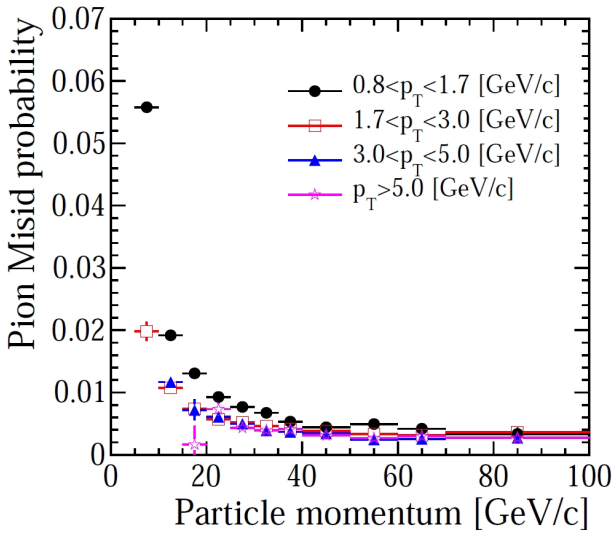


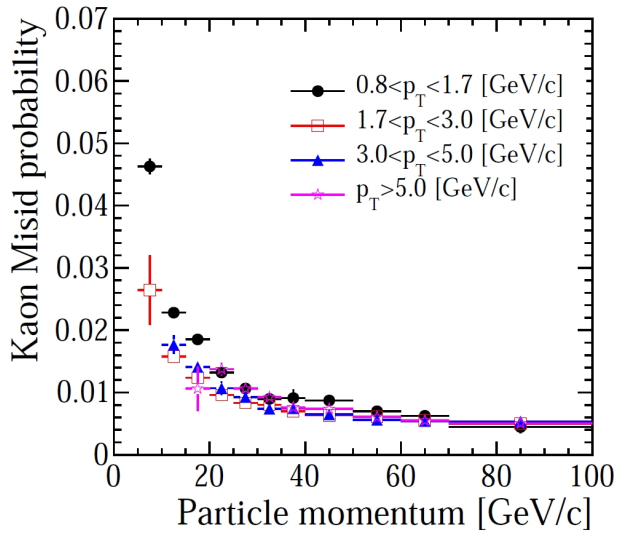
- 435 m^2 of instrumented area;
- 1380 chambers of 20 different types;
- physical channels combined into 55296 logical pads;
- chambers efficiency above 99%;

Muon Identification





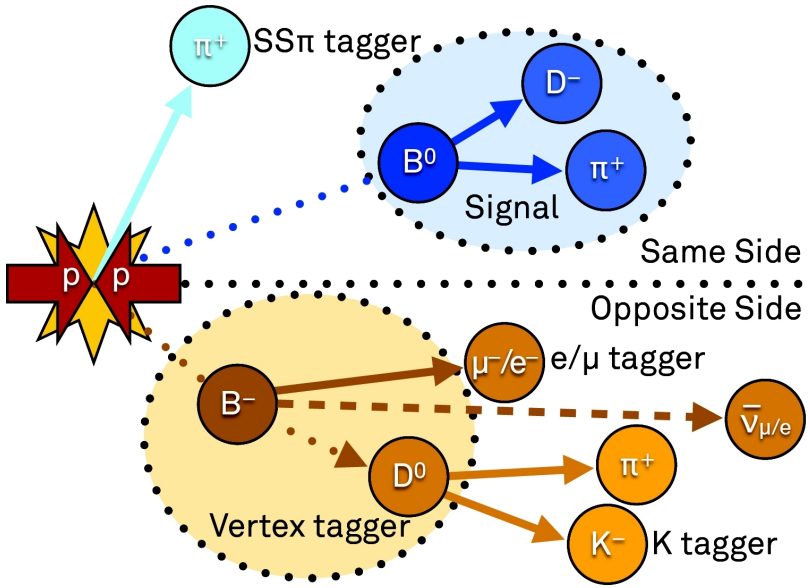




muon ID efficiency: $\sim$ 97% for 1-3% $\pi \rightarrow \mu$ misID probability.

Flavor tagging

Flavour tagging at production: a necessary condition for measurements of oscillations and time-dependent asymmetries of $B^0_{(s)}$ mesons.



Combination of several algorithms:

Same Side tagging: correlations between "fragmentation tracks" of signal b quark. Pions for $B_{u,d}$ and kaons for B_s.

Opposite Side tagging: information from the decay products of the other (tagging) B in the event. Independent of the signal B.

Flavor tagging performance

The performance of the tagging algorithm is determined by the effective tagging efficiency, or tagging power, ε_{eff},

$$\varepsilon_{\text{eff}} = \varepsilon_{\text{tag}}(1-2\omega)^2 = \varepsilon_{\text{tag}}\mathcal{D}^2_{\text{tag}}, \qquad \varepsilon_{\text{tag}} = \frac{R+W}{R+W+U}, \quad \omega = \frac{W}{R+W},$$

R,W,U = *right*, *wrong*, *untagged*

The effective *OS* tagging efficiency is measured from the flavor specific decay $B^+ \to J/\psi K^+$, and cross-checked with $B^0 \to D^{*-}\mu^+\nu$ and $B^0 \to J/\psi K^{*0}$,

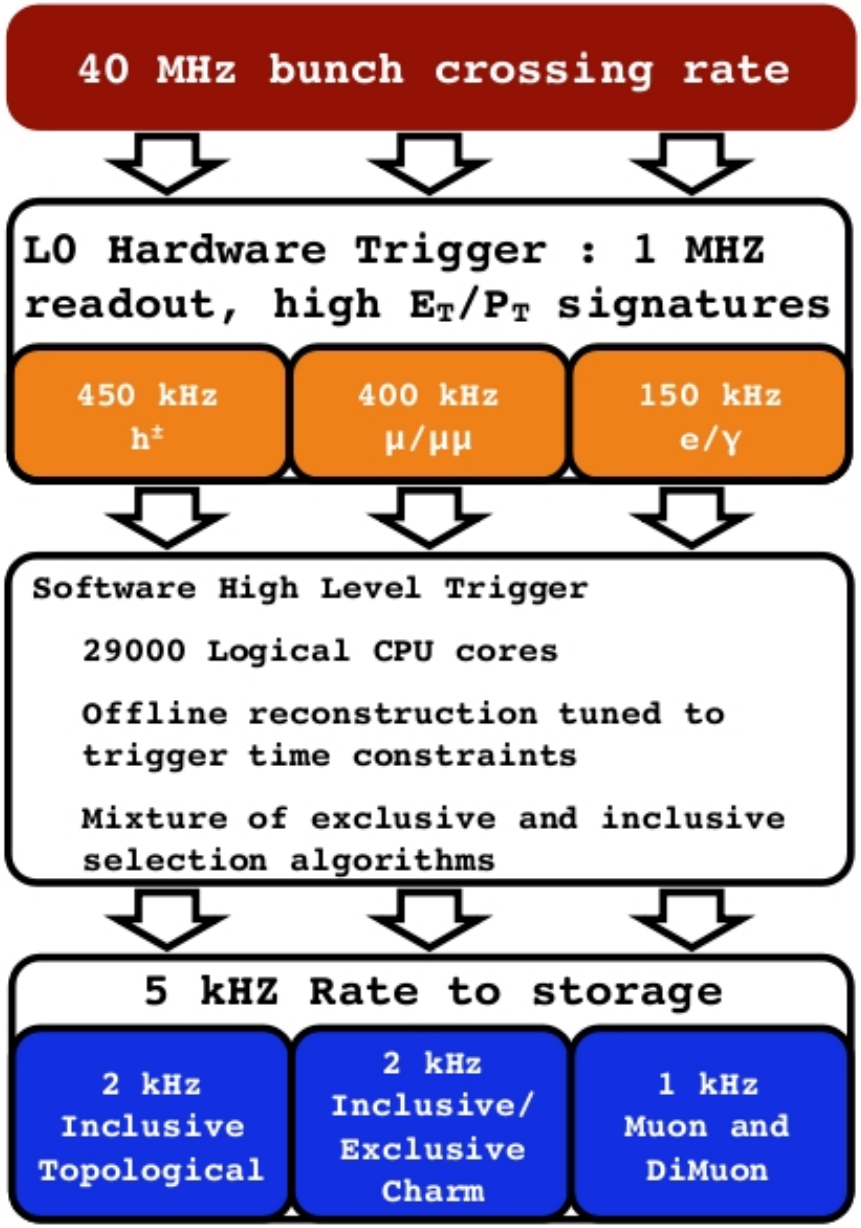
$$\varepsilon^{OS}_{\text{eff}} = (2.35 \pm 0.6)\% \qquad \text{EPJ C72 (2012) 2022}$$

The effective *SSK* tagging efficiency is measured from $B^0_s \to D^-_s \pi^+$,

$$\varepsilon^{SSK}_{\text{eff}} = (1.5 \pm 0.4)\% \qquad \text{LHCB-CONF-2012-033}$$

The combination of *SSK* and *OS* taggers for $B^0_s \to D^-_s \pi^+$ yield

$$\varepsilon_{\text{eff}} = (3.8 \pm 0.7)\%$$



L0: hardware trigger based on calorimeters and muon systems.

Selects events with high E_T HCAL or ECAL clusters; high p_T muons.

$\sim 4\mu s$ latency, up to 1 MHz output.

HLT: two-stage software application running on 15K processors. Consists of independent trigger "lines".

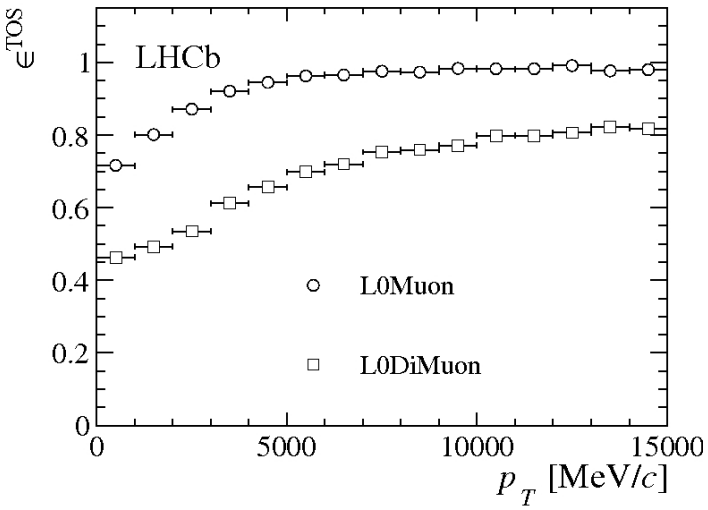
HLT1: partial event reconstruction, inclusive selection algorithms.

HLT2: full event reconstruction, inclusive and exclusive selections.

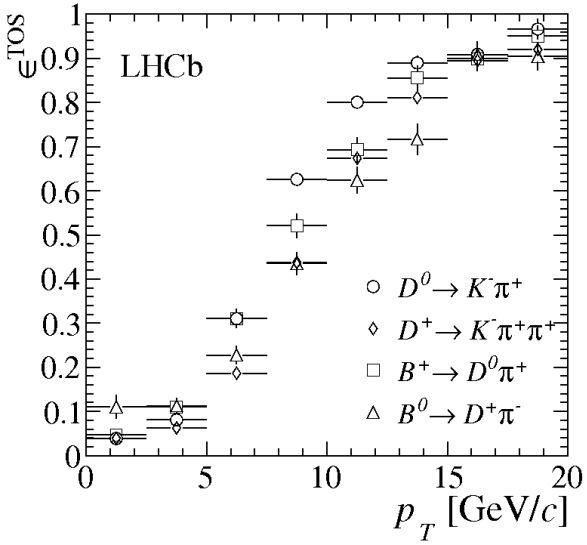
decision in ~ 30 ms, rate of 5 kHz

Trigger performance

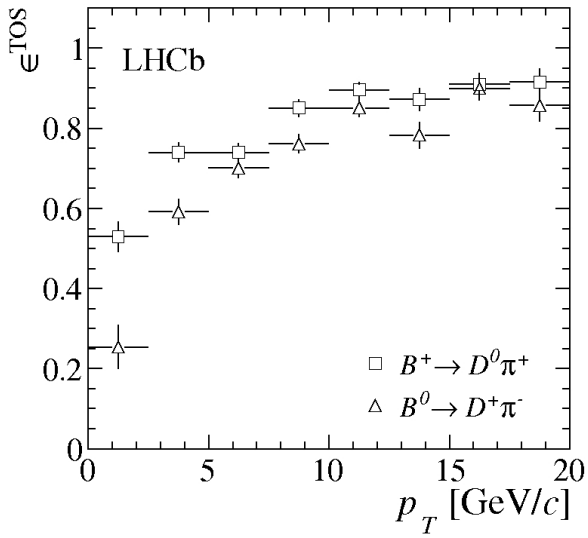
L0: $B^+ \to J/\psi K^+$



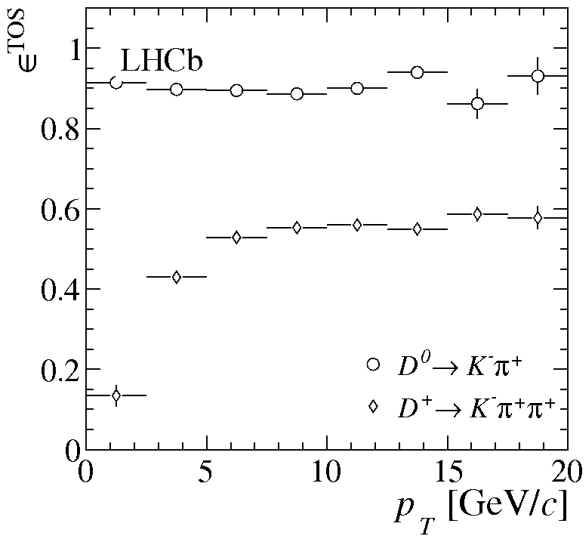
L0: hadronic channels



HLT2: Topo lines

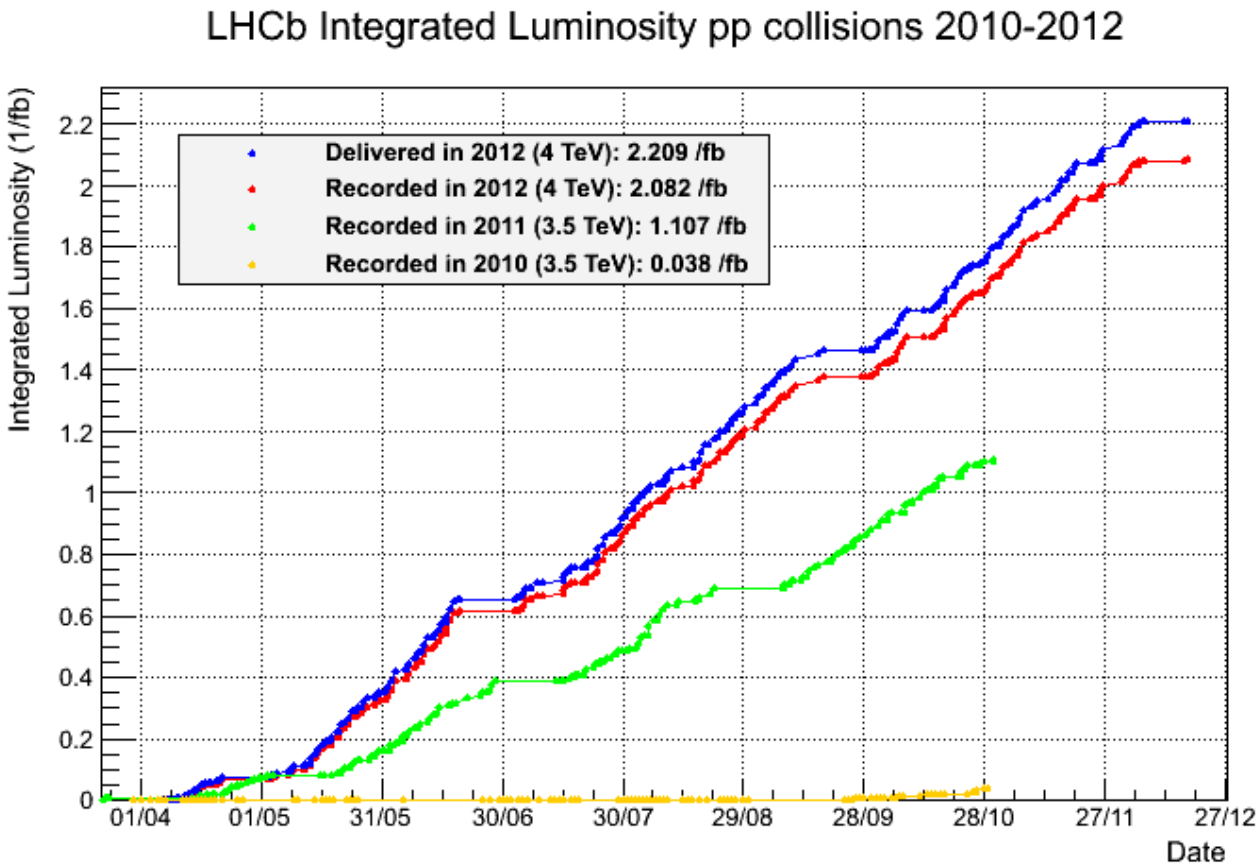


HLT2: charm



arXiv:1211.3055

Data taking

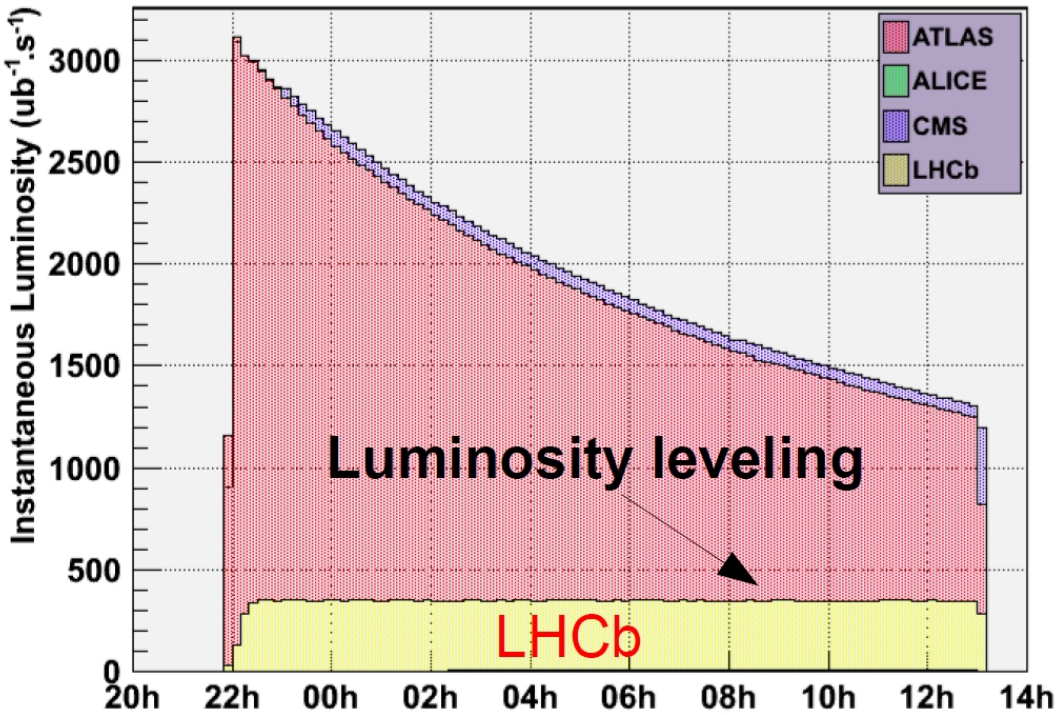


Luminosity: 2-4 x 10^{32} cm^2 s^{-1}.

Visible interactions/bunch crossing : $<\mu>\sim$ 1.4-1.6

Magnet polarity reversed periodically.

Data taking



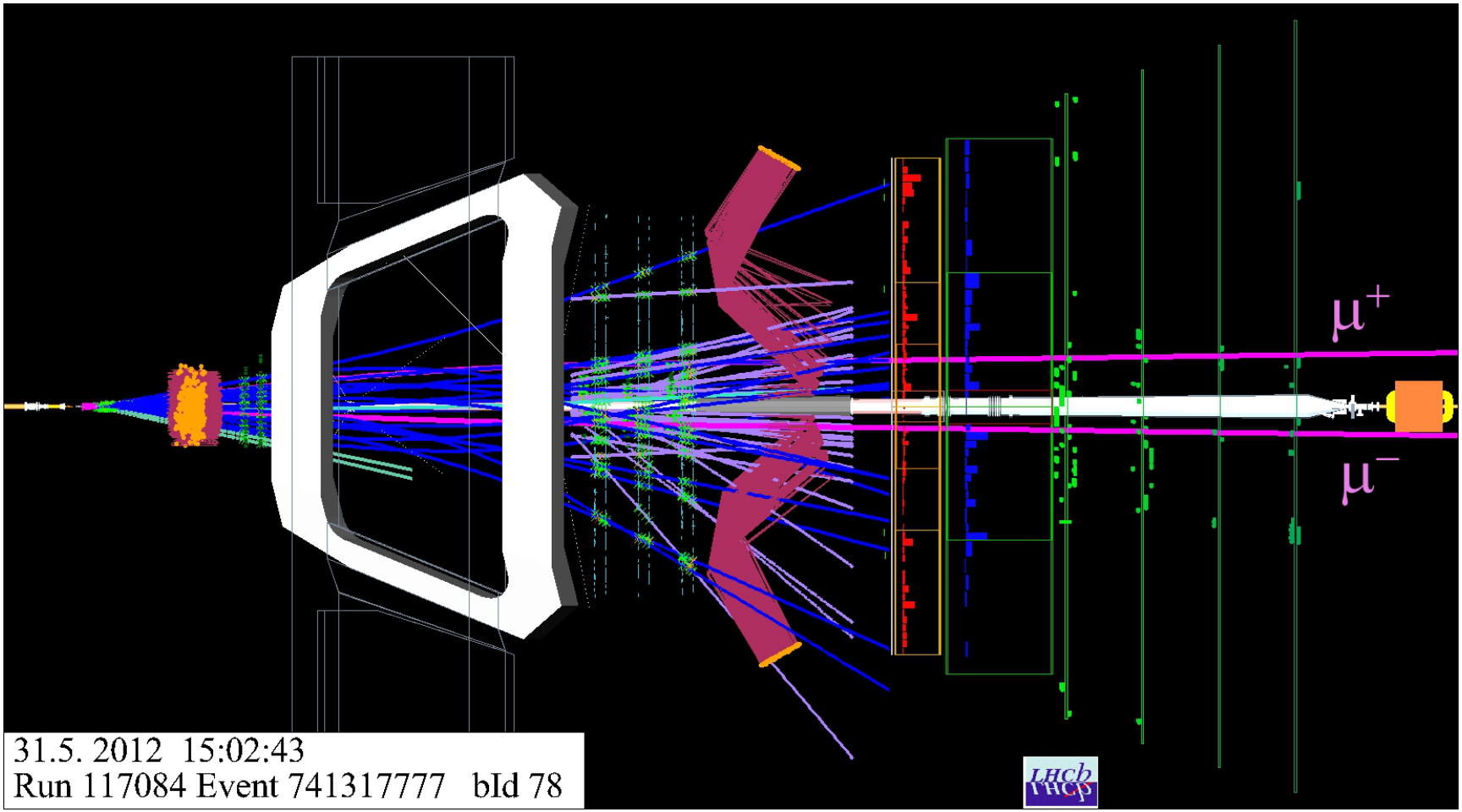
Beam deplacement kept instantaneous luminosity constant.

- ∼99% of working channels for all subdetectors;
- data taking efficiency over 90%;
- over 99% of data taken is good for analysis;

2011 (7 TeV): 1.0 fb^{-1}

2012 (8 TeV): 2 fb^{-1}

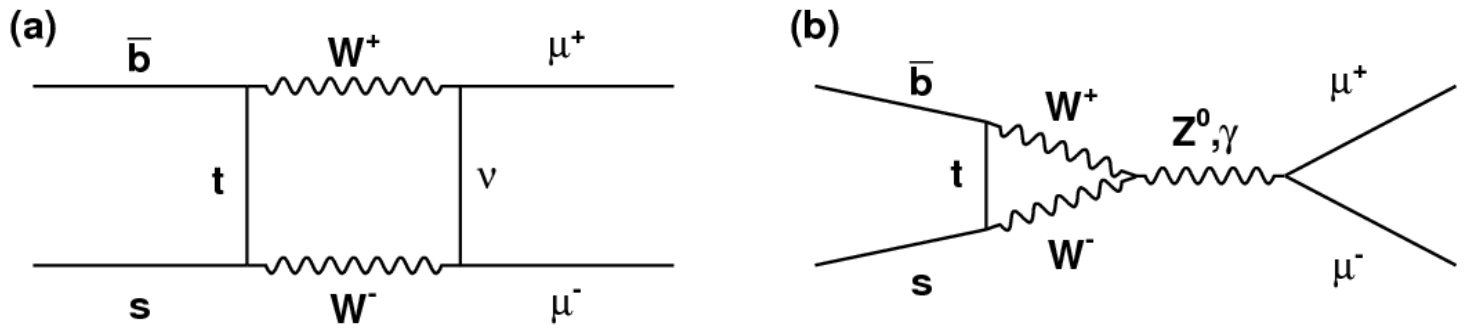
Selected results



$1.0\ \text{fb}^{-1}$ (7 TeV) $+$ $1.1\ \text{fb}^{-1}$ (8 TeV).

$B^0_{(s)} \to \mu^+\mu^-$ in the SM

In the SM FCNC processes can only occurs via diagrams with quantum loops:



SM predictions of $\mathcal{B}(B^0_{(s)} \to \mu^-\mu^+)$ are computed with good accuracy:

$$A(B \to \mu\mu) = <\mu\mu|\mathcal{H}_{\rm eff}|B>, \qquad \mathcal{H}_{\rm eff} = -\frac{4G_F}{\sqrt{2}} V_{tb}V^*_{tq} \frac{e^2}{16\pi} \sum_i (C_i O_i) + \text{h.c.},$$

$\mathcal{B}(B^0 \to \mu^-\mu^+) = (1.07 \pm 0.10) \times 10^{-10}$,

$\mathcal{B}(B^0_s \to \mu^-\mu^+) = (3.23 \pm 0.27) \times 10^{-9}$.

Buras et al., arXiv:1208.0934

The finite difference in the B^0_s and $\overline{B}^0_s$ lifetimes introduce a small correction,

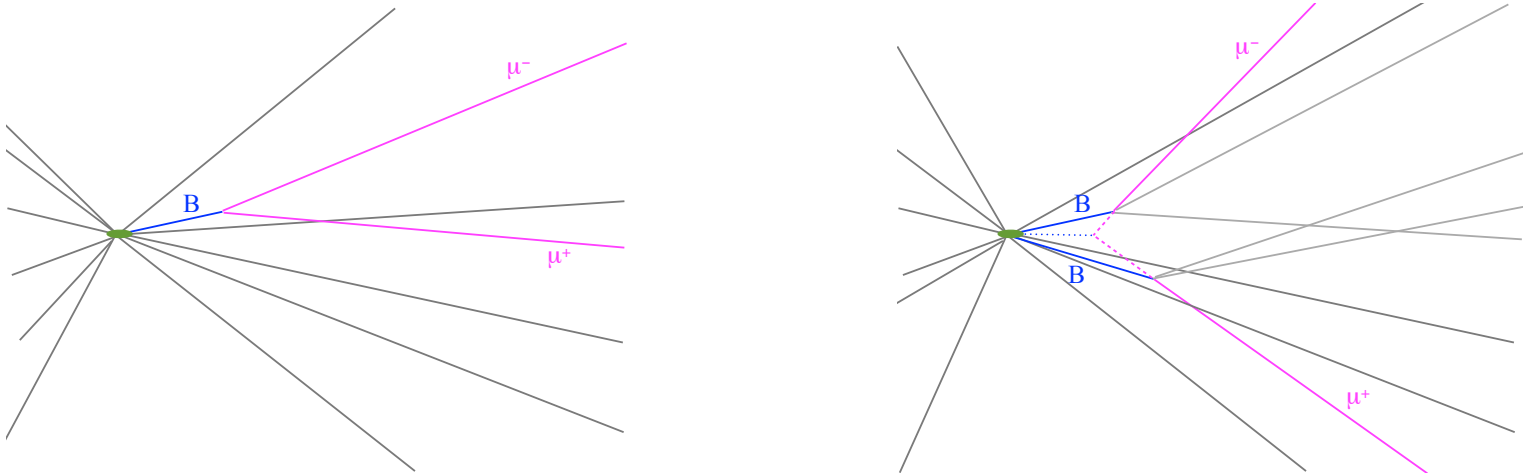
$\mathcal{B}(B^0_s \to \mu^-\mu^+) = (3.54 \pm 0.30) \times 10^{-9}$.

De Bruyn et al., PRL 109, 041801 (2012)

New particles contributing to the loops could significantly increase branching ratios:

$$\mathcal{H}_{\rm eff} = -\frac{4G_F}{\sqrt{2}} V_{tb}V^*_{tq} \frac{e^2}{16\pi} \sum_i (C_i O_i + C'_i O'_i) + \text{h.c.},$$

$B^0_{(s)} \to \mu^+\mu^-$ - selection and analysis strategy



Initial loose selection: two high quality muon candidates (track χ^2, p_T, IP and μID) forming a well detached vertex (χ^2, IP, FD) (rejects most of the background);

A two-stage multivariate selection (BDT) is applied to the $B^0_{(s)} \to \mu^+\mu^-$ candidates.
BDT is trained using $B^0_s \to \mu^+\mu^-$ MC for signal and $b\bar{b} \to \mu^+\mu^- X$ for background.

The probability of an event to have a given value of BDT output is extracted from data using $B^0_{(s)} \to h_1^+ h_2^-$, $h_i = K, \pi$, for signal, and sideband $B^0_{(s)} \to \mu^+\mu^-$ for background.

The first step removes 80% of remaining background. The second step and the dimuon invariant mass classify the remaining candidates in a 2-dimensional space.

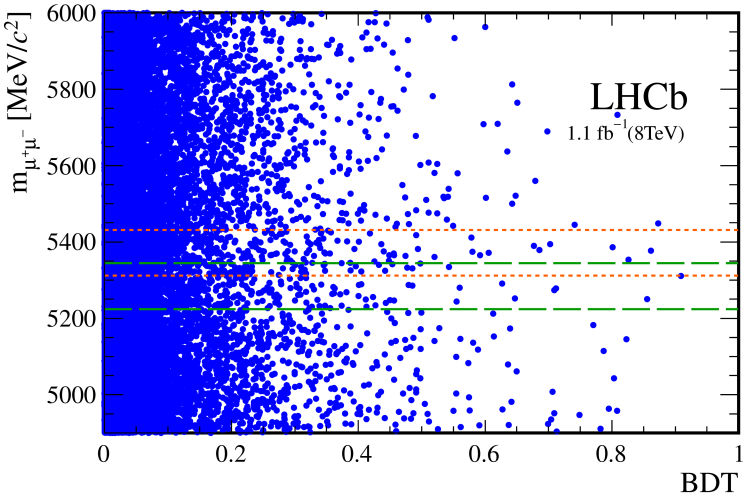
The number of observed events is compared to the number of expected signal and background events in bins of the BDT output and $m_{\mu\mu}$.

Background estimation:

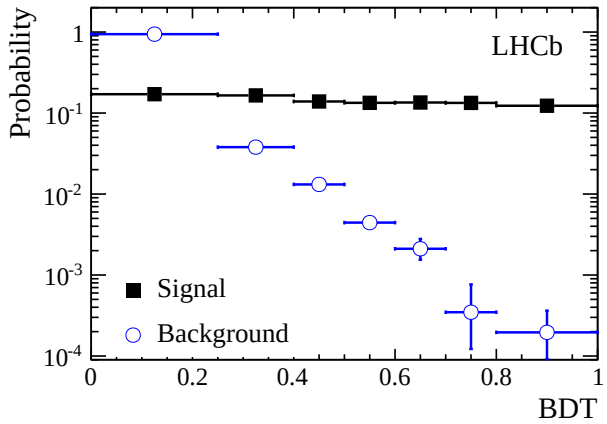
combinatorial $b\bar{b} \to \mu^+\mu^- X$;

various exclusive backgrounds: $B^0_{(s)} \to h_1^+ h_2^-$, $B^+ \to \pi^-\mu^+\nu$, $B_s^0 \to K^-\mu^+\nu$, $B^{0(+)} \to \pi^{0(+)}\mu^+\mu^-$, $\Lambda_b^0 \to \pi^-\mu^+\nu$, $B_c^+ \to J/\psi\mu^+\nu$.

This analysis: $\varepsilon(\mu \to \mu) \sim 98\%$, $\varepsilon(\pi \to \mu) \sim 0.6\%$, $\varepsilon(K \to \mu) \sim \varepsilon(p \to \mu) \sim 0.3\%$.



For signal and background, the BDT output is independent of the invariant mass.



Signal BDT distribution is nearly uniform.

Background shape peaks at zero.

$B^0_{(s)}$ peak position from $B^0_{(s)} \to h_1^+ h_2^-$.

Mass resolution: interpolation of dimuon resonances ($\psi(nS)$, $\Upsilon(nS)$) and $B^0_{(s)} \to h_1^+ h_2^-$.

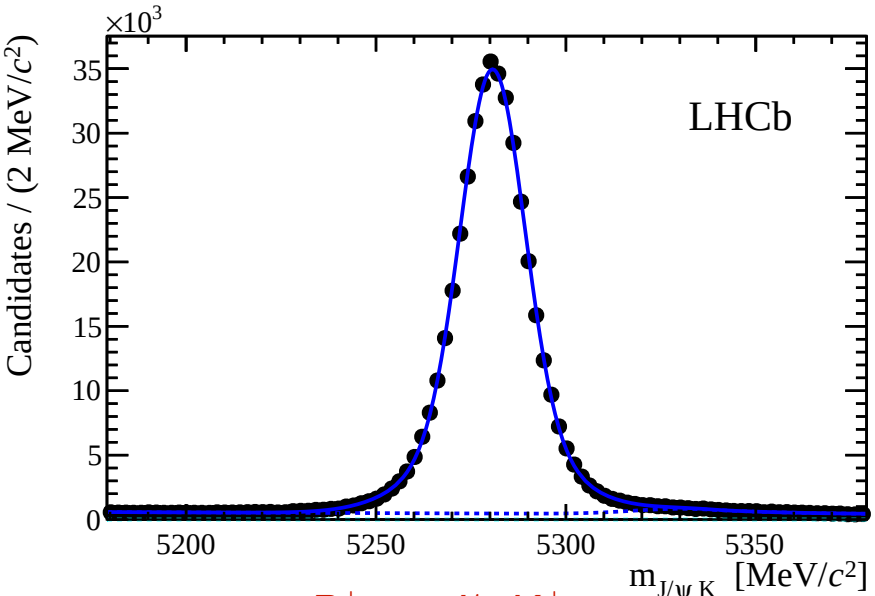
$B^0_{(s)} \to \mu^+\mu^-$ - normalization

The number of observed events is translated into a branching ratio using

$$\mathcal{B} = \mathcal{B}_{\text{norm}} \times \frac{\varepsilon^{\text{rec}}_{\text{norm}}\ \varepsilon^{\text{sel|rec}}_{\text{norm}}\ \varepsilon^{\text{trg|sel}}_{\text{norm}}}{\varepsilon^{\text{rec}}_{\text{sig}}\ \varepsilon^{\text{sel|rec}}_{\text{sig}}\ \varepsilon^{\text{trg|sel}}_{\text{sig}}} \times \frac{f_{\text{norm}}}{f_{d(s)}} \times \frac{N_{B^0_{(s)}\to\mu^+\mu^-}}{N_{\text{norm}}},$$

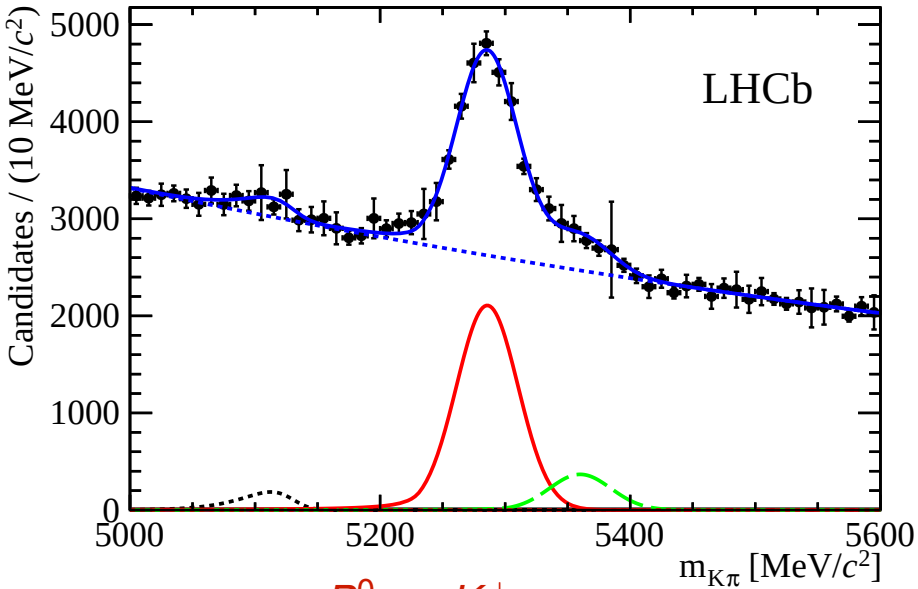
$\varepsilon^{\text{rec}}_{\text{norm/sig}}, \varepsilon^{\text{sel|rec}}_{\text{norm/sig/}} \to$ MC

$\varepsilon^{\text{trg|sel}}_{\text{norm/sig/}} \to$ data



$B^+ \to J/\psi K^+$:

Similar trigger, different topology



$B^0 \to K^+\pi^-$:

different trigger, same topology.

f_d/f_s: ratio of $B^0_s \to D_s\mu X$ to $B \to D^+\mu X$;
ratio of $B^0_s \to D^+_s\pi^-$ to $B^0 \to D^-K^+, D^-\pi^+$

Combined result: $f_d/f_s = 0.256 \pm 0.020$ (PRD 85 (2012) 032008, LHCb-PAPER-2012-037)

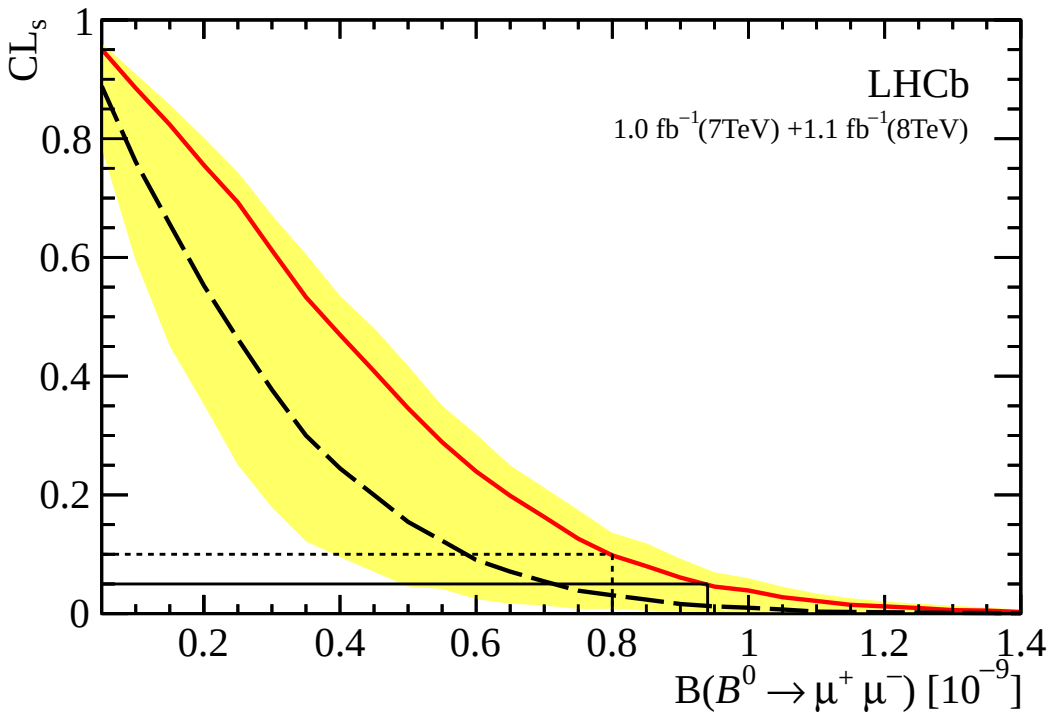
The compatibility between the observed and expected distribution of events is computed using the CL_s method.

95% CL upper limit: $CL_s = 0.05$

$CL_b \to$ background-only hypothesis;

$CL_{s+b} \to$ signal+background hypothesis;

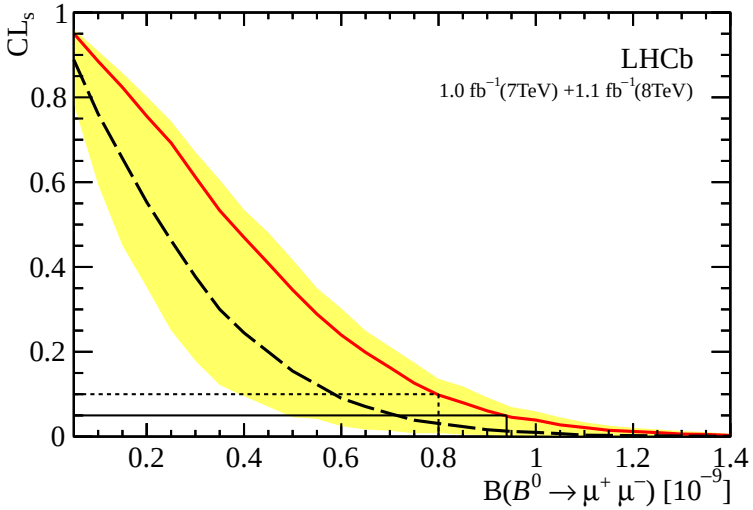
$CL_s = CL_{s+b}/CL_b$.



$$\mathcal{B}(B^0 \to \mu^+\mu^-) < 9.4 \times 10^{-10} \text{ at 95\% CL}$$

PRL 110, 021801 (2013)

$B^0_{(s)} \to \mu^+\mu^-$ - results



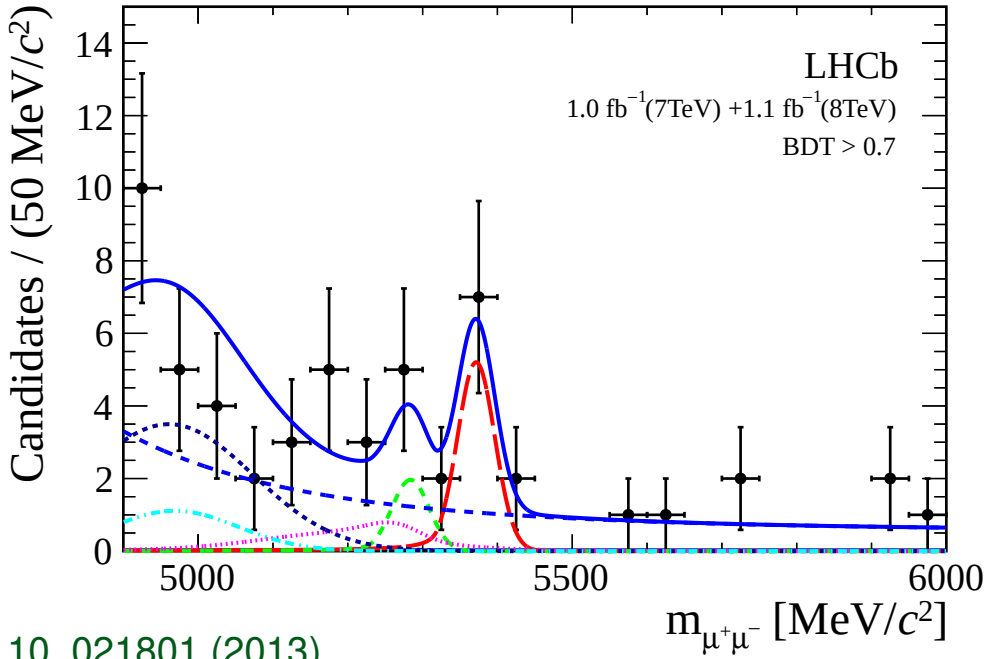
$$\text{SM: } (3.54 \pm 0.3) \times 10^{-9}$$

$$\mathcal{B}(B^0_s \to \mu^+\mu^-) = (3.2^{+1.4}_{-1.2}\ ^{+0.5}_{-0.3}) \times 10^{-9}$$

p-value for bkg-only: 5.3 x 10^{-4}

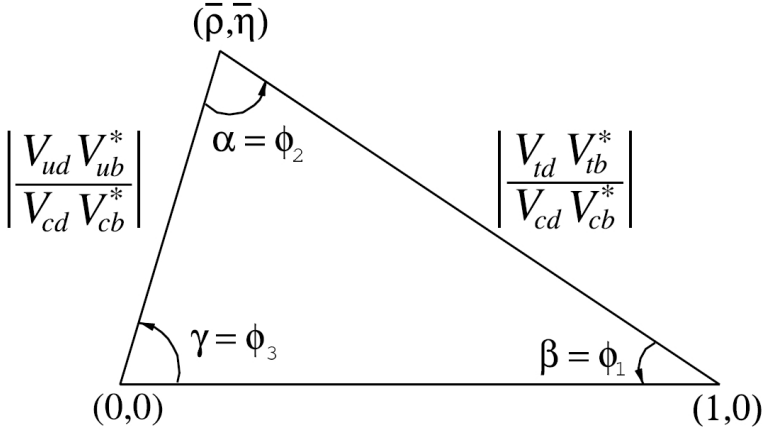
a 3.5σ excess,

first evidence!



PRL 110, 021801 (2013)

Measurements of γ using tree-mediated decays



$\gamma = \arg\left[-V_{ud}V_{ub}^*/(V_{cd}V_{cb}^*)\right]$

γ is the least well constrained angle:

$(66 \pm 12)^\circ$ (CKMFitter)

$(72 \pm 9)^\circ$ (UTFitter)

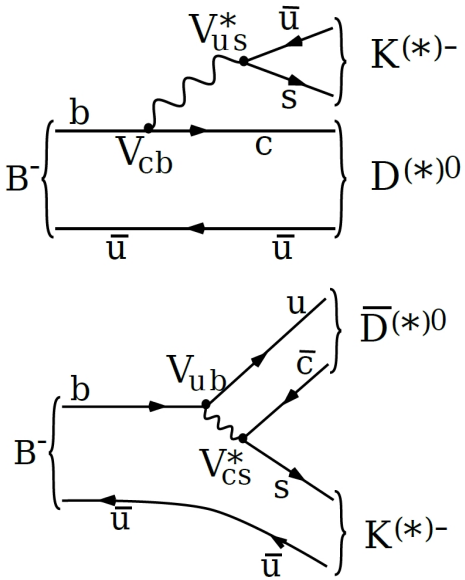
Determination from tree-level decays: negligible theoretical uncertainty, $\mathcal{O}(10^{-6})$, making it a "standard candle".

Several established methods to measure γ in $B \to DK$ decays.

$B \to DK = B^+ \to DK^+$, $B^0 \to D^{(*)}\mp\pi^\pm$, $B_s^0 \to D_s^\mp K^\pm$, $B^0 \to DK^{*0}$ and $B_s^0 \to D\phi$, where D refers to an admixture of D^0 and $\overline{D}^0$.

All based on the interference between $b \to u$ and $b \to c$ tree amplitudes when $D^0 \to f \leftarrow \overline{D}^0$.

Best sensitivy obtained combining different methods.



Extracting γ from $B \to DK$: methods

The amplitudes of the $B^- \to D^0 K^-$ and $B^- \to \overline{D}^0 K^-$:

$$A(B^- \to D^0 K^-) = A_c e^{i\delta_c}, \quad A(D^0 \to f) = A_f e^{i\delta_f},$$
$$A(B^- \to \overline{D}^0 K^-) = A_u e^{i(\delta_u - \gamma)}, \quad A(D^0 \to \overline{f}) = A_{\overline{f}} e^{i\delta_{\overline{f}}},$$

$$A(B^- \to [f]_D K^-) = A_c A_f e^{i(\delta_c + \delta_f)} + A_u A_{\overline{f}} e^{i(\delta_u + \delta_{\overline{f}} - \gamma)}, \quad B^- \to B^+, \gamma \to -\gamma$$

The total decay rate is:

$$\Gamma(B^- \to DK^-) = |A(B^- \to [f]_D K^-)|^2 \propto A_c^2 \left(A_f^2 + r_B^2 A_{\overline{f}}^2 + 2 r_B A_f A_{\overline{f}} \mathrm{Re}(e^{i(\delta_B + \delta_D - \gamma)}) \right),$$

$r_B = |A(b \to u)/A(b \to c)|$, $\delta_B = \delta_u - \delta_c$ and $\delta_D = \delta_{\overline{f}} - \delta_f$.

So far LHCb has analysed different combinations of B/D decays (1.0 fb^{-1}, 7 TeV):

- $B^\pm \to DK^\pm$, $D^0 \to K^-K^+, \pi^-\pi^+, \pi^-K^+$ (GLW/ADS); (PLB 712 (2012) 203)
- $B^\pm \to DK^\pm$, $D^0 \to K^+\pi^-\pi^+\pi^-$ (ADS); (LHCb-CONF-2012-030)
- $B^\pm \to DK^\pm$,$D^0 \to K_s\pi^-\pi^+, K_sK^-K^+$ (GGSZ) (PLB 718 (2012) 43);
- $B_s^0 \to D_s^\mp K^\pm$; (LHCb-CONF-2012-029)
- $B^0 \to DK^{*0}$, $D \to K^+K^-$. (LHCb-CONF-2012-024)

Extracting γ from $B \to DK$: observables

Observables are ratios of partial widths and CP asymmetries:

$$R_{\mathrm{CP,ADS}} = \frac{\Gamma(B^- \to DK^-) + \Gamma(B^+ \to DK^+)}{\Gamma(B^- \to D^0 K^-) + \Gamma(B^+ \to \overline{D}^0 K^+)}, \qquad A_{\mathrm{CP,ADS}} = \frac{\Gamma(B^- \to DK^-) - \Gamma(B^+ \to DK^+)}{\Gamma(B^- \to D^0 K^-) + \Gamma(B^+ \to \overline{D}^0 K^+)}$$

$$\text{GLW} \quad \Rightarrow \quad R_{\mathrm{CP}} = 1 + r_B^2 \pm 2 r_B \cos\delta_B \cos\gamma, \qquad A_{\mathrm{CP}} = \pm 2 r_B \sin\delta_B \sin\gamma / R_{\mathrm{CP}}.$$

$$\text{ADS} \quad \Rightarrow \quad R_{\mathrm{ADS}} = r_B^2 + r_D^2 + 2 r_B r_D \cos\gamma \cos(\delta_B + \delta_D), \qquad A_{\mathrm{ADS}} = 2 r_B r_D \sin\gamma \sin(\delta_B + \delta_D) / R_{\mathrm{ADS}}.$$

$B \to D\pi$ has limited sensitivity to γ, but it is a convenient control channel used for the ratios

$$R^f_{K/\pi} = \frac{\Gamma(B^- \to [f]_D K^-) + \Gamma(B^+ \to [f]_D K^+)}{\Gamma(B^- \to [f]_D \pi^-) + \Gamma(B^+ \to [f]_D \pi^+)},$$

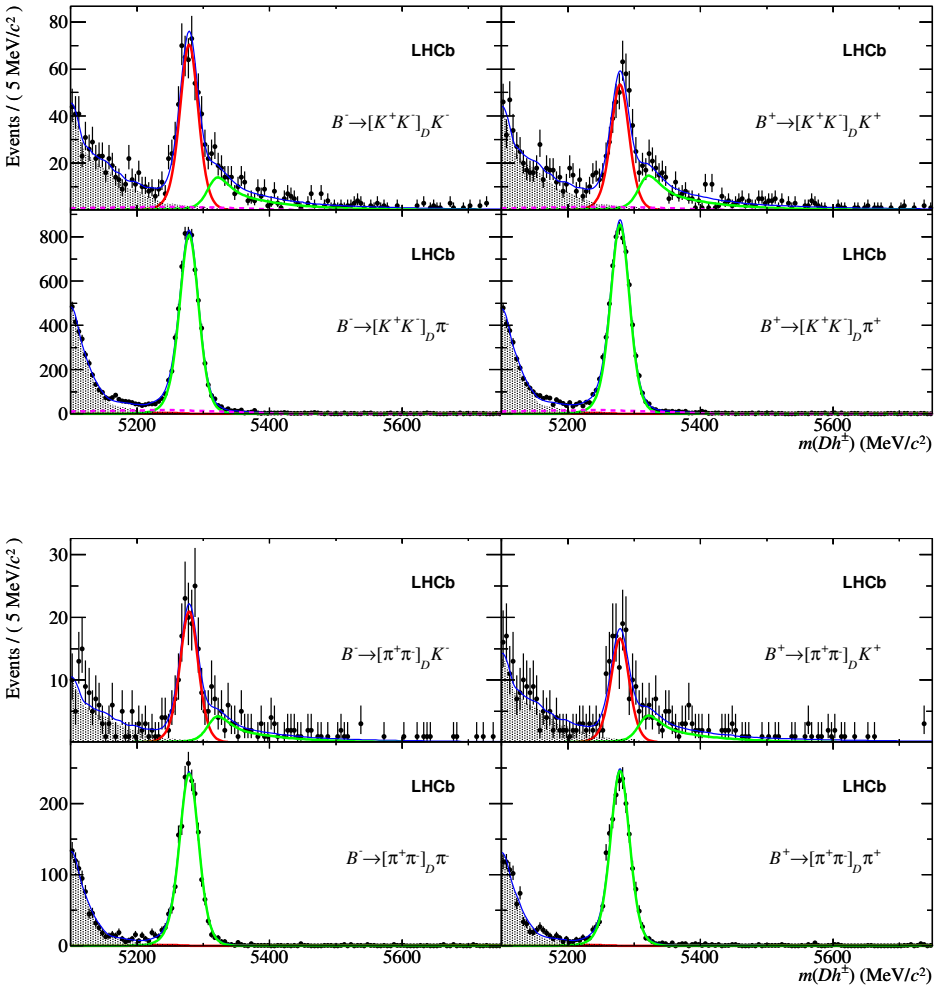
from which we compute a weighted average

$$R_{\mathrm{CP}} = \frac{\langle R^{KK}_{K/\pi}, R^{\pi\pi}_{K/\pi} \rangle}{R^{K\pi}_{K/\pi}}.$$

For ADS is more convenient to define the two statistically ratios

$$R_\pm \equiv \frac{\Gamma(B^\pm \to [K^\mp \pi^\pm]_D h^\pm)}{\Gamma(B^\pm \to [K^\pm \pi^\mp]_D h^\pm)} = r_B^2 + r_D^2 + 2 r_B r_D \cos(\delta_B + \delta_D \pm \gamma), \quad (h = K, \pi)$$

GLW signals (1.0 fb^{-1} at $\sqrt{s} = 7$ TeV)



PLB 712 (2012), 203

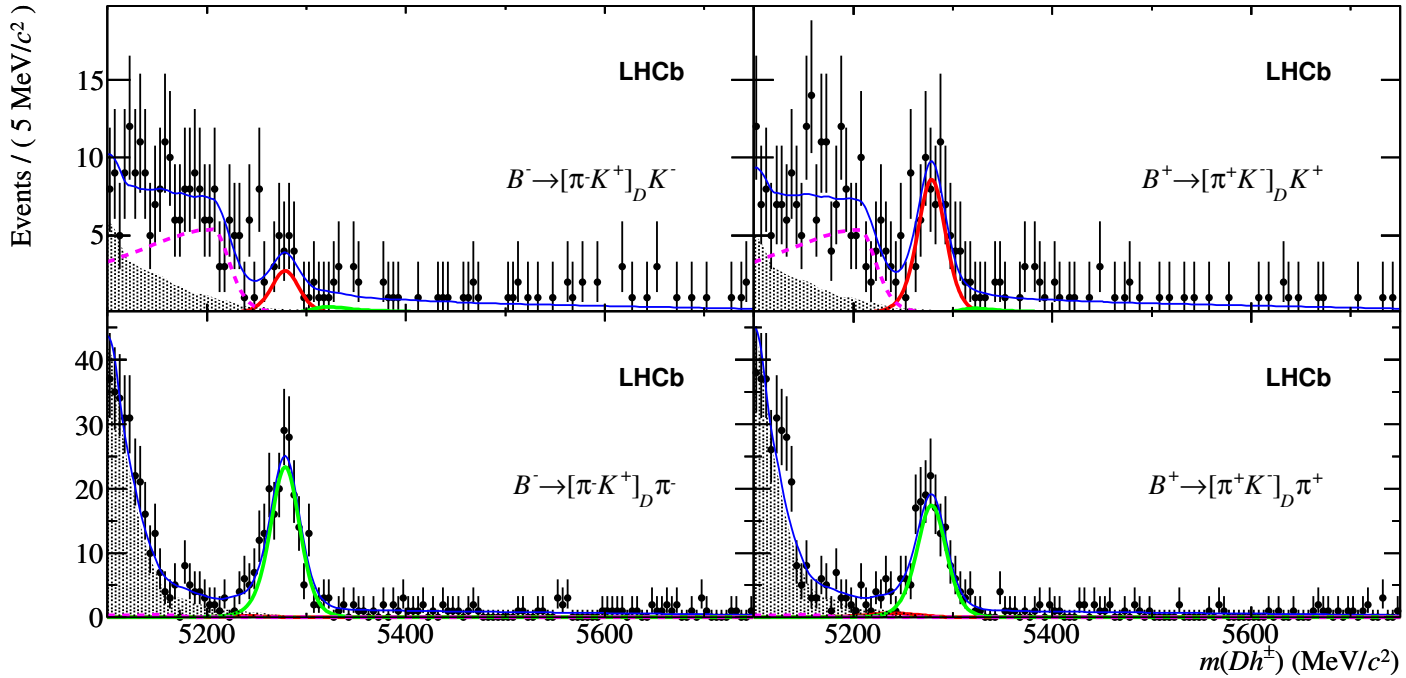
A common multivariate selection (BDT) used for 16 combinations of $B^\pm \to Dh_1^\pm$, $D \to h_2^\pm h_3^\mp$

Similar CP asymmetry in KK and $\pi\pi$.

$$A_{CP} = \langle A_K^{KK}, A_K^{\pi\pi} \rangle = 0.145 \pm 0.032 \pm 0.010$$

$$R_{CP} = \frac{\langle R_{K/\pi}^{KK}, R_{K/\pi}^{\pi\pi} \rangle}{R_{K/\pi}^{K\pi}} = 1.007 \pm 0.038 \pm 0.012$$

Two-body ADS signals (1.0 fb^{-1} at $\sqrt{s} = 7$ TeV)



PLB 712 (2012), 203

First observation of $B^\pm \to [\pi^\pm K^\mp]_D K^\pm$.

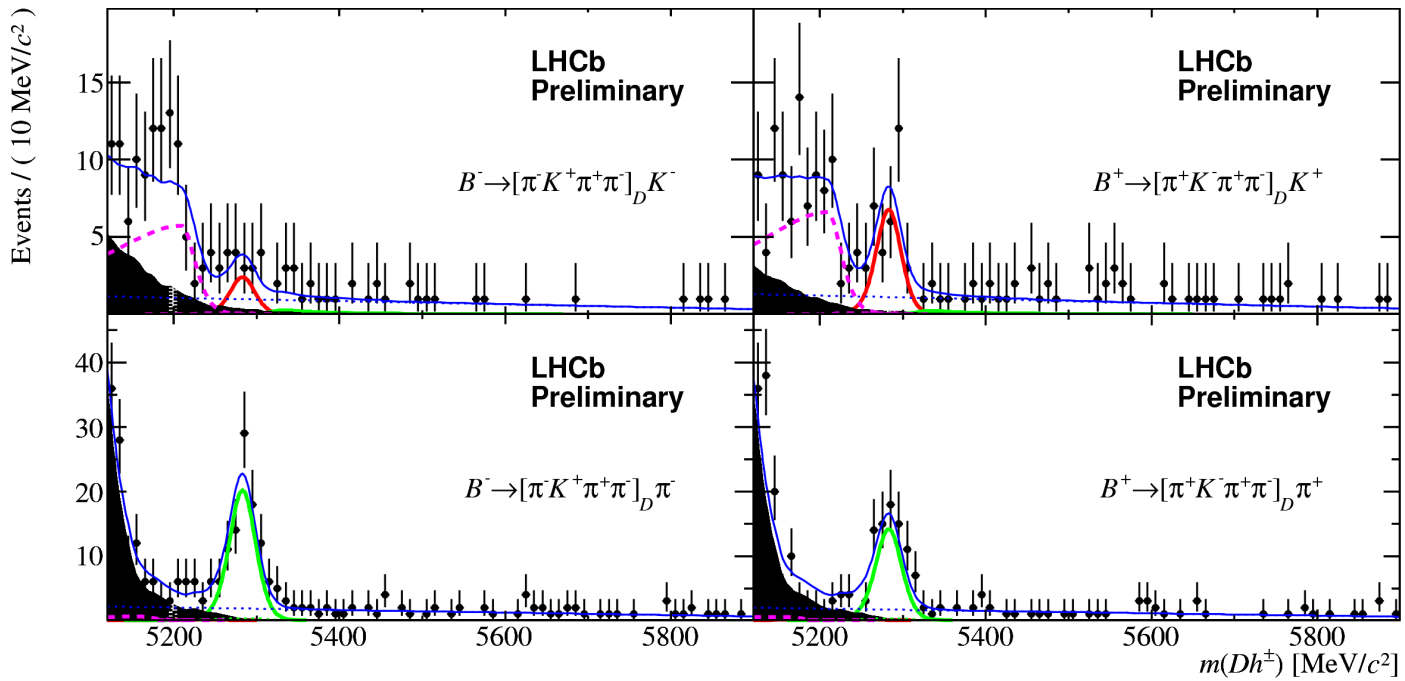
Direct CPV in $B^\pm \to DK^\pm$ decays observed with a significance of 5.8σ.

$$A_{\mathrm{ADS(K)}} = (R_K^- - R_K^+)/(R_K^- + R_K^+) = -0.52 \pm 0.15 \pm 0.02.$$

$$A_{\mathrm{ADS}(\pi)} = (R_\pi^- - R_\pi^+)/(R_\pi^- + R_\pi^+) = 0.143 \pm 0.062 \pm 0.011.$$

$r_D = A_f/A_{\bar{f}} = |A(D^0 \to \pi^- K^+)/A(D^0 \to K^- \pi^+)|$ and δ_D taken from CLEO-c (arXiv:0903.4853).

Four-body ADS signals (1.0 fb^{-1} at $\sqrt{s} = 7$ TeV)



LHCb-CONF-2012-030

First observation of $B^\pm \to [\pi^\pm K^\mp \pi^+ \pi^-]_D \pi^\pm$ and $B^\pm \to [\pi^\pm K^\mp \pi^+ \pi^-]_D K^\pm$.

Same formalism as for 2-body case, but less sensitivity due to the coherence factor.

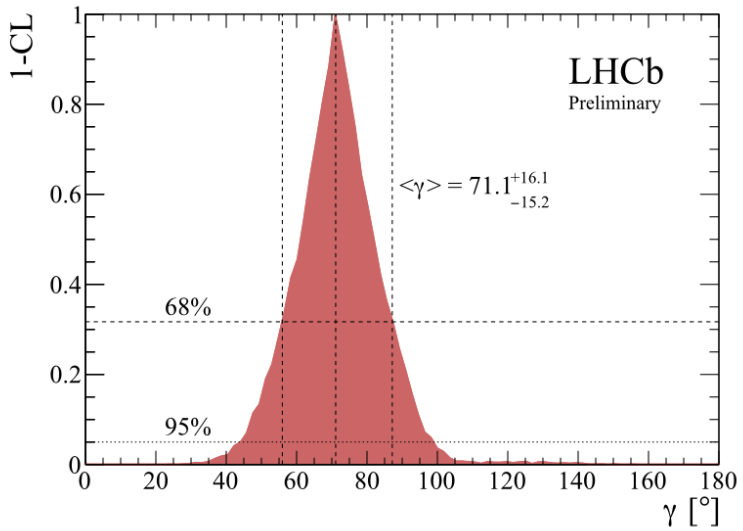
$$A^{K3\pi}_{\mathrm{ADS(K)}} = (R_K^{K3\pi,-} - R_K^{K3\pi,+})/(R_K^{K3\pi,-} + R_K^{K3\pi,+}) = -0.42 \pm 0.22.$$

$$A^{K3\pi}_{\mathrm{ADS}(\pi)} = (R_\pi^{K3\pi,-} - R_\pi^{K3\pi,+})/(R_\pi^{K3\pi,-} + R_\pi^{K3\pi,+}) = 0.13 \pm 0.10.$$

(Statistical and systematic errors combined.)

Combining $B \to DK$ results (1.0 fb^{-1} at $\sqrt{s} = 7$ TeV)

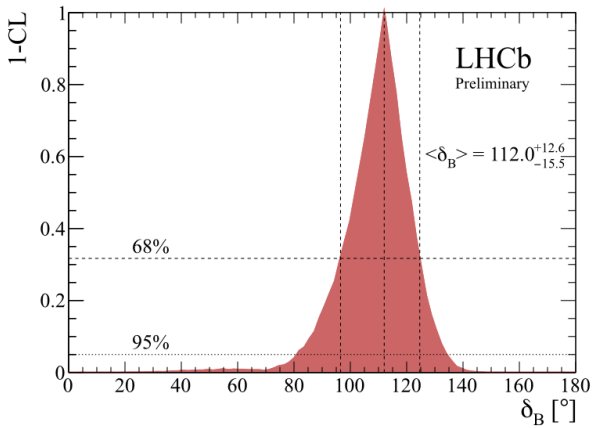
A frequentist approach was used for the combination with additional input from CLEO-c for the $D \to K\pi$ and $D \to K\pi\pi\pi$ decay parameters (PRD80,031105 (2009)).

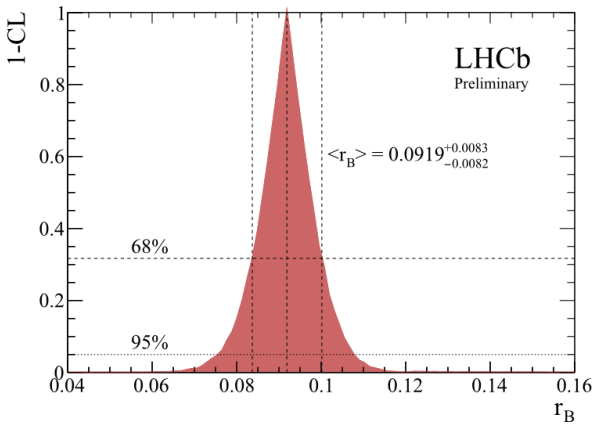


$$\gamma = (71.1^{+16.6}_{-15.7})^\circ \,,$$

$$r_B = 0.092 \pm 0.008 \,,$$

$$\delta_B = 112.0^{+12.6}_{-15.5}(^\circ) \,.$$

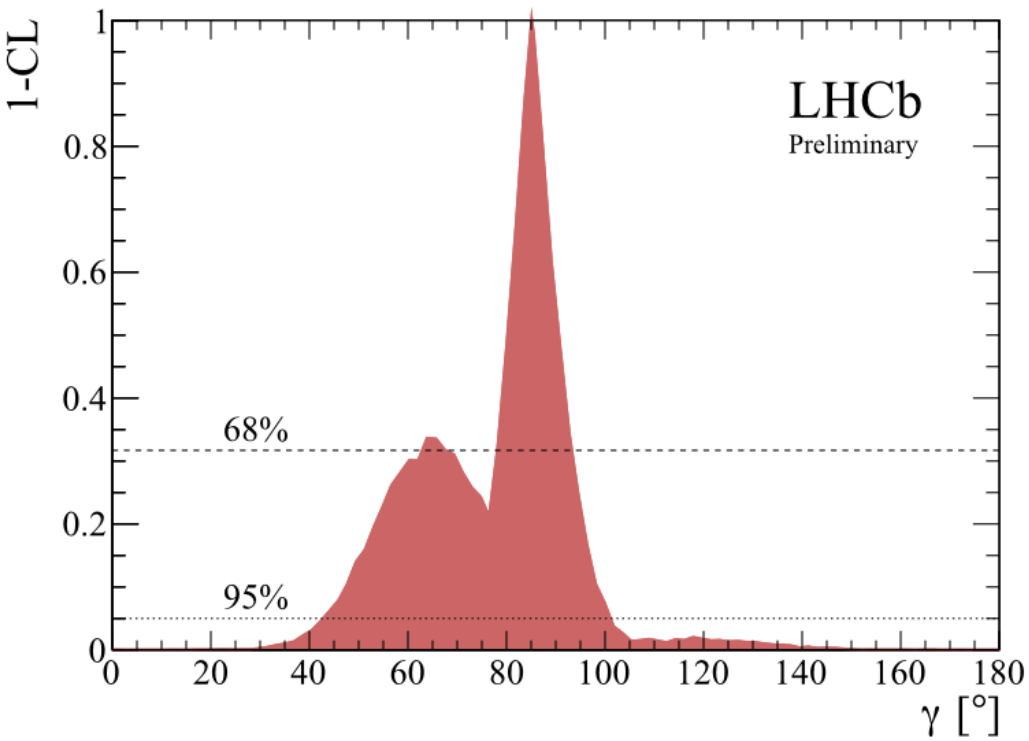




LHCb-CONF-2012-032

Combining $B \to DK$ and $B \to D\pi$ results (1.0 fb^{-1} at $\sqrt{s} = 7$ TeV)

When $B \to DK$ and $B \to D\pi$ measurements are combined a new solution appears at 1σ. The best-fit value of γ is shifted to 85.1°. The 2σ interval remains stable.



LHCb-CONF-2012-032

γ	63.7°	85.1°
68% CL	$[61.8, 67.8]°$	$[77.9, 92.4]°$
95% CL	$\leftarrow [43.8, 101.5]° \rightarrow$	
$r_{B(K)}$	0.0948	
68% CL	$[0.0860, 0.1032]$	
95% CL	$[0.078, 0.111]$	
$\delta_{B(K)}$	119.0°	
68% CL	$[107.0, 129.1]°$	
95% CL	$[79.7, 137.9]°$	
$r_{B(\pi)}$	0.0239	
68% CL	$[0.0153, 0.0310]$	
95% CL	$[0.0, 0.037]$	
$\delta_{B(\pi)}$	373.7°	321.4°
68% CL	$[365.7, 387.0]°$	$[311.2, 328.4]°$
95% CL	$\leftarrow [160.5, 333.6]° \rightarrow$	

The whole 2012 data set is to be analysed.

Many other decay modes are to be added.

Concluding remarks

Thanks to the superb performance of the LHC, to the levelling technique and to the excellent performance of the LHCb detector we have on disk over 3 fb^{-1} of high quality data.

So far most public results have only the 2011 data and are already the most precise individual measurements, or even more accurate than the previous world averages.

Analysis of the core physics channels is well advanced.
So far the SM remains unchallenged.

Great prospects for CP violation and flavor physics measurements in the near future, in both *b* and *c* sectors.
Lots of fresh results in the pipeline.

LHCb: an experiment with plenty of opportunities!

Javier Edgardo Magnin

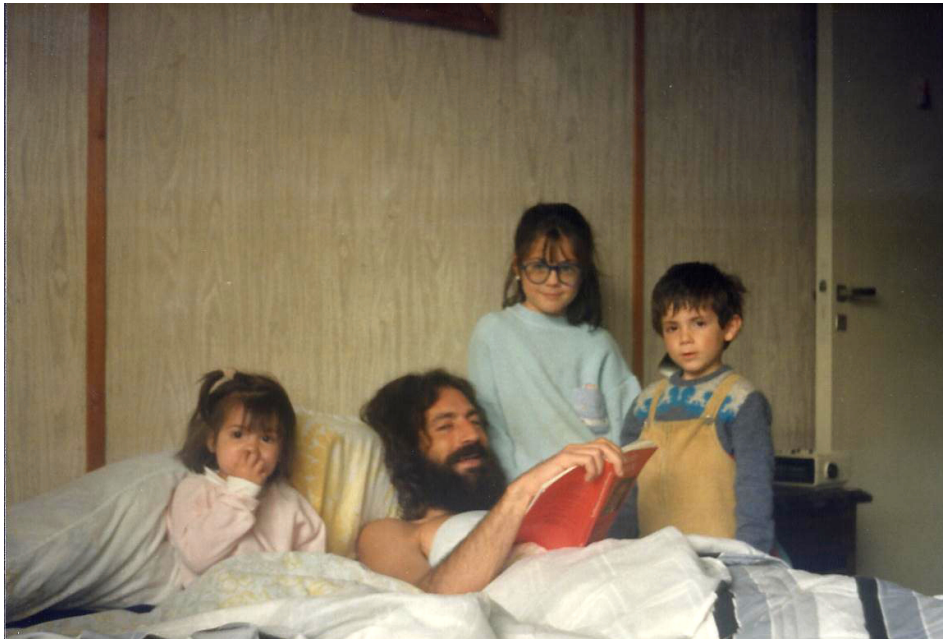
In memorian

1963-2012

Javier was born in 1963 in Necochea, Argentina.

He got his degree in Physics at Universidad de San Luis;

In 1994 he got his PhD degree at Instituto Balseiro, Bariloche, under the supervision of Luis Masperi.



Still in Argentina he had three beautiful sons:

Ana, Maria Ines and Andres;

In 1995 he came to CBPF as a PosDoc. At that time he was interested in the production mechanisms of polarized hyperons.

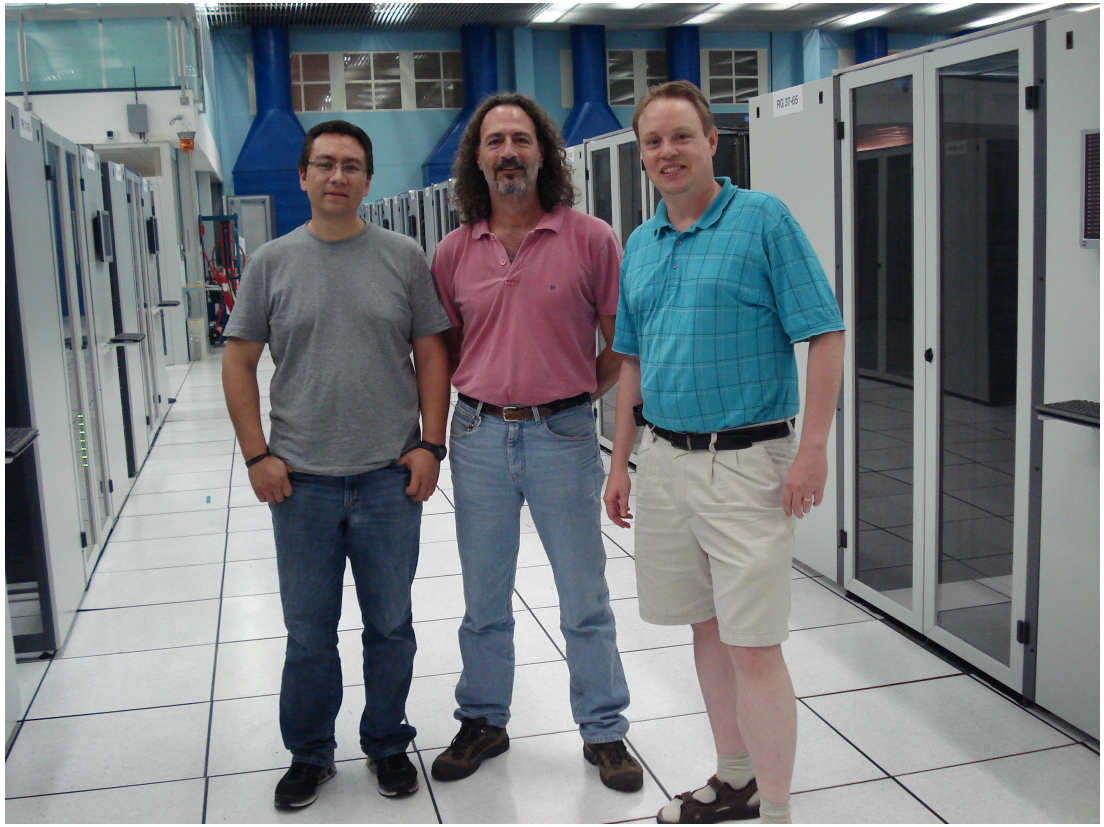
In the same year he joined his first HEP experiment:

Fermilab E791,
our first common project;

In 1999, after his PosDoc at CBPF, he took a position in Universidad de los Andes, Bogota, Colombia, as Assistent Professor.

He mantained a strong collaboration with other Latin American groups, especially with Colombia and Mexico, in theoretichal physics.

Having multiple interests and skills, he worked on various topics as hadron structure, quark-gluon plasma, charm production, computing, electronics...



In 2003 Javier joined LHCb. He manage to reconcile an intense teatching activity with theoretical research and with his experimental activities. He was the first one to propose a charm program at LHCb.

He playied a decisive role in the creation the CBPF GRID, and was the main responsible for the creation of the Resource Operator Center for Latin American, ROC_LA.

From his second marriage Javier had two new "daughters".

Farewell, "Pibe"!