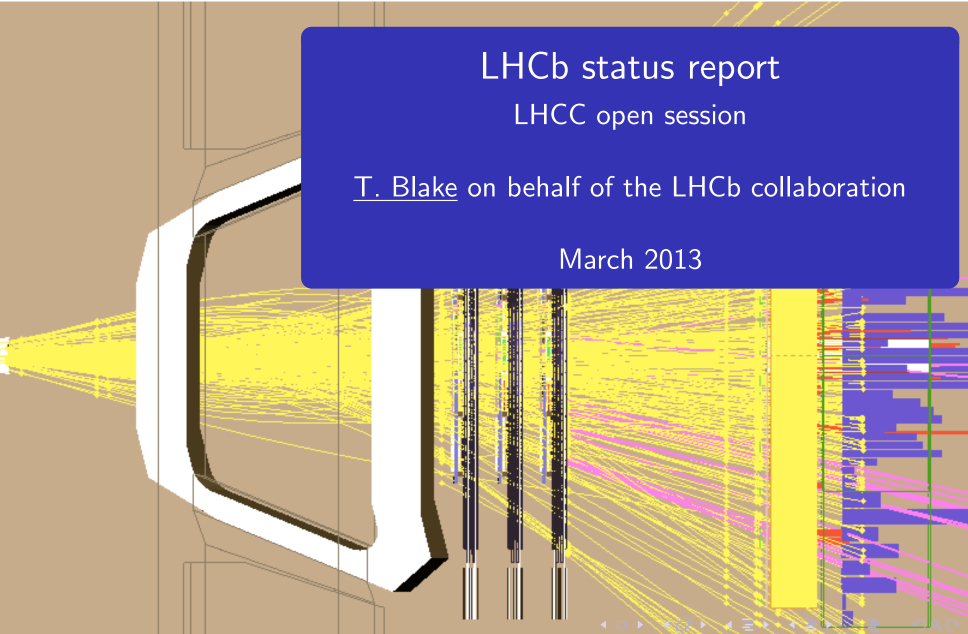
LHCb status report

LHCC open session

T. Blake on behalf of the LHCb collaboration

March 2013



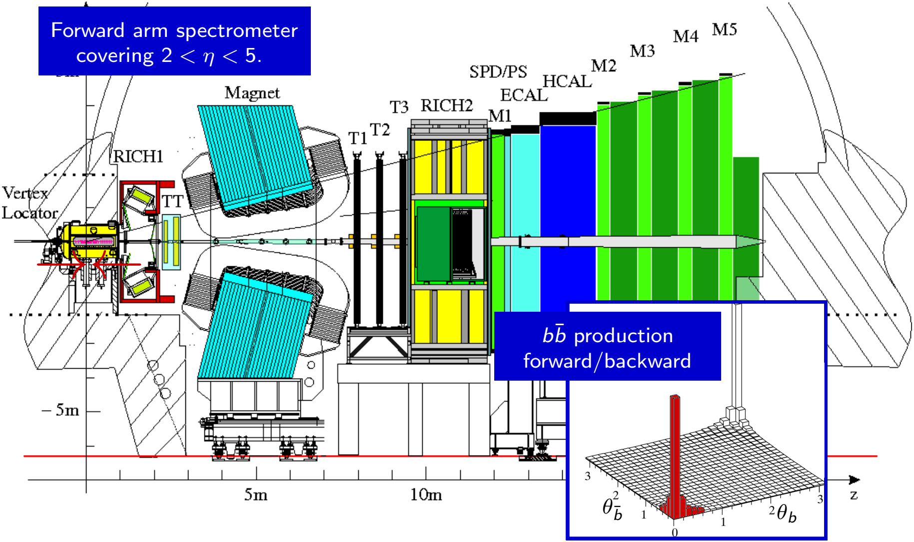
Outline

1. Data taking, data processing and computing.
2. Tour of recent LHCb results.
3. Proton-ion data taking.
4. The LHCb upgrade.

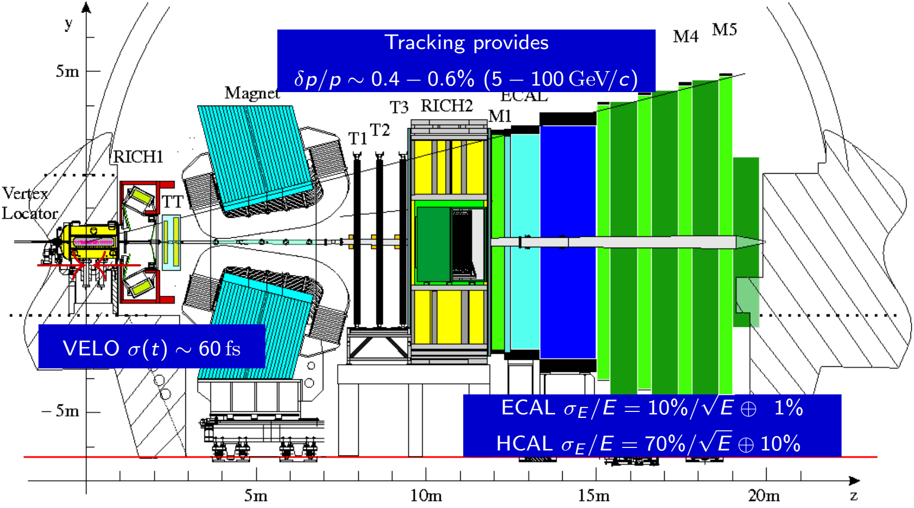
The LHCb detector

Forward arm spectrometer covering $2 < \eta < 5$.

$b\bar{b}$ production forward/backward



The LHCb detector



Tracking provides

$\delta p/p \sim 0.4 - 0.6\%$ ($5 - 100$ GeV/c)

VELO $\sigma(t) \sim 60$ fs

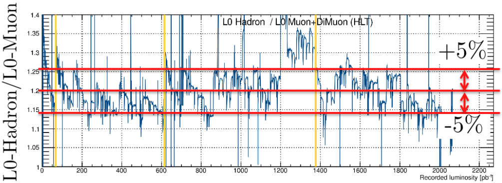
ECAL $\sigma_E/E = 10\%/\sqrt{E} \oplus 1\%$

HCAL $\sigma_E/E = 70\%/\sqrt{E} \oplus 10\%$

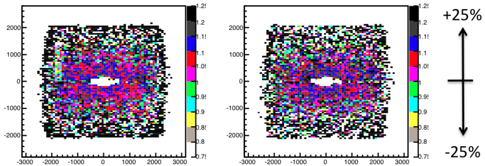
Particle ID: $\varepsilon(K \to K) \sim 95\%$ for $\varepsilon(\pi \to K) \sim 5\%$, $\varepsilon(\mu \to \mu) \sim 97\%$ for $\varepsilon(\pi \to \mu) \sim 1\%$.

Detector aging

- CALO: Perform regular gain calibrations to account for aging of the detector.
- OT: Small decrease in gain but no strong evidence of aging of the OT straw tubes.
- VELO: Depletion voltages are evolving in good agreement with expectations (replacement detector prepared).

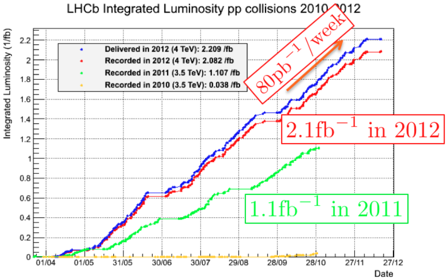


relative gain Feb 2013 / December 2010



Data taking during 2012

- LHCb collected an additional $2.1\,\text{fb}^{-1}$ of integrated luminosity at $\sqrt{s} = 8\,\text{TeV}$ in 2012.
- Average data taking efficiency $\sim 95\%$.
- Further, gain statistics for many analyses due to the increased $b\bar{b}$ and $c\bar{c}$ cross-sections ($\sim 8/7$) at $8\,\text{TeV}$.

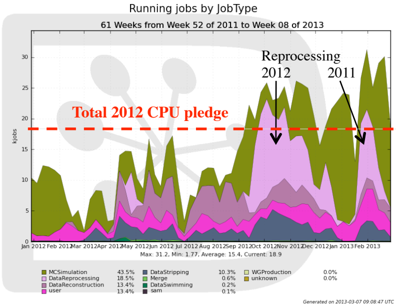


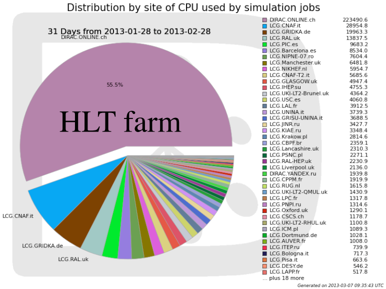
- Reminder:
  - $\sigma_{b\bar{b}} = 75 \pm 14\mu\text{b}$ at $\sqrt{s} = 7\,\text{TeV}$ [LHCb-PAPER-2010-002]
  - $\sigma_{c\bar{c}} = 1419 \pm 134\mu\text{b}$ at $\sqrt{s} = 7\,\text{TeV}$ [LHCb-PAPER-2012-041]

  in the LHCb acceptance.

Data re-processing and simulation

- Re-processing of 2011 and 2012 data (Reco 14) with latest alignment and calibration is now complete → consistent 3 fb^{-1} dataset.
  - Reco 14 will be used for all new analyses during LS1.





- The LHCb HLT farm has also been fully commissioned for offline use.
  - Already deployed during February (in parallel to proton-ion data taking) for MC simulation → 55% of simulation CPU came from the HLT farm.

Recent LHCb results

Submitted papers (since the last LHCC open session)

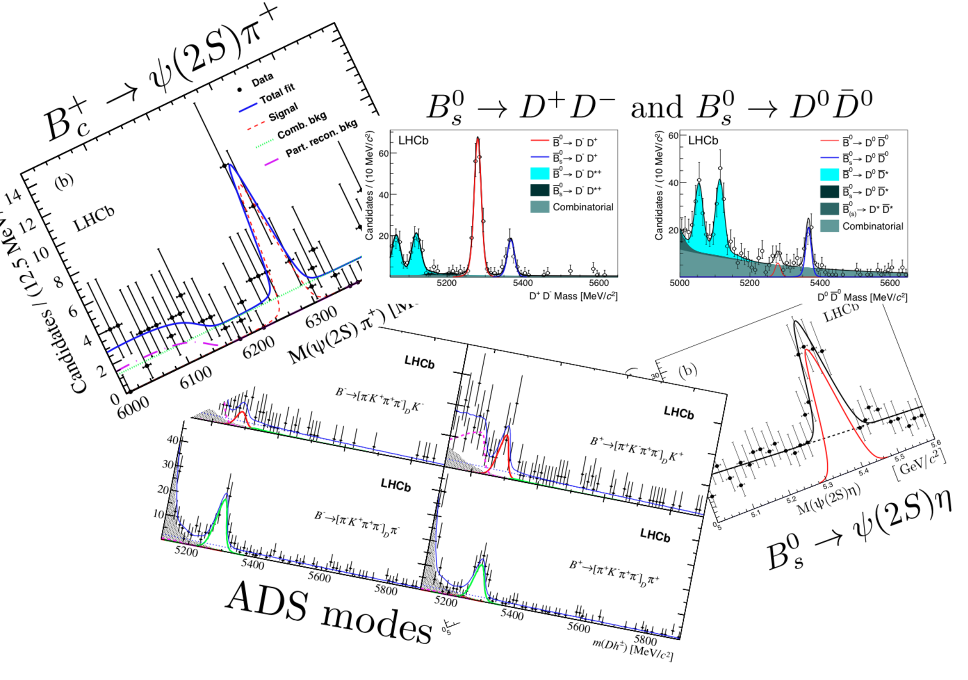
In total, LHCb has now submitted 100 papers for publication.
Another 23 will be submitted shortly.
We have also prepared 105 conference reports.

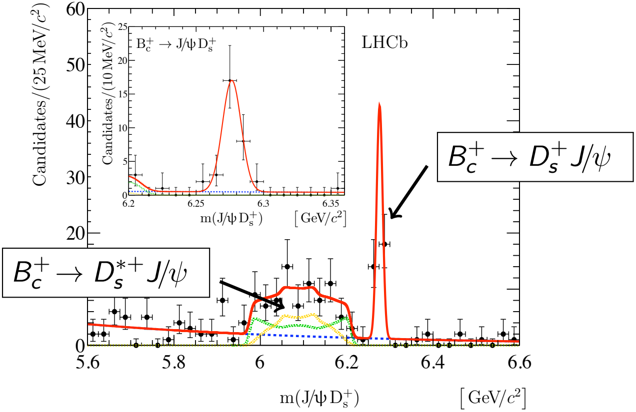
- Since the last LHCC open presentation (December 2012) we have submitted papers on:

- "Observation of the decay $B_c^+ \to \psi(2S)\pi^+$" [CERN-PH-EP-2013-028]
- "Measurements of the $\Lambda_b^0 \to J/\psi\Lambda$ decay amplitudes and the Λ_b^0 polarisation in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$" [CERN-PH-EP-2013-020]
- "Observation of the $B_s^0 \to \psi(2S)\eta$ and $B_{(s)}^0 \to \psi(2S)\pi^+\pi^-$ decays" [CERN-PH-EP-2013-024]
- "Determination of the $X(3872)$ meson quantum numbers" [CERN-PH-EP-2013-017]
- "Prompt charm production in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$" [CERN-PH-EP-2013-009]
- "Amplitude analysis and the branching fraction measurement of $\overline{B}_s^0 \to J/\psi K^+K^-$" [CERN-PH-EP-2013-008]
- "Search for the decay $B_s^0 \to D^{*\pm}\pi^{\pm}$" [LHCb-PAPER-2012-056]

Submitted papers (since the last LHCC open session)

- "Measurement of the Λ_b^0, Ξ_b^- and Ω_b^- baryon masses" [CERN-PH-EP-2013-013]
- "Exclusive J/ψ and $\psi(2S)$ production in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$" [CERN-PH-EP-2013-005]
- "Analysis of the resonant components in $\overline{B}^0 \to J/\psi\,\pi^+\pi^-$" [CERN-PH-EP-2013-004]
- "Measurement of the fragmentation fraction ratio f_s/f_d and its dependence on B meson kinematics" [CERN-PH-EP-2013-006]
- "Measurement of CP observables in $B^0 \to DK^{*0}$ with $D \to K^+K^-$" [CERN-PH-EP-2012-362]
- "Measurement of the cross-section for $Z^0 \to e^+e^-$ production in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$" [CERN-PH-EP-2012-363]
- "Measurement of the forward energy flow in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$" [CERN-PH-EP-2012-346]
- "Measurement of J/ψ production in pp collisions at $\sqrt{s} = 2.76\,\mathrm{TeV}$" [CERN-PH-EP-2012-349]
- "Search for direct CP violation in $D^0 \to h^+h^-$ modes using semileptonic B decays" [LHCb-PAPER-2013-003]
- "Search for the rare decays $B^0_{(s)} \to \mu^+\mu^-\mu^+\mu^-$ decays" [LHCb-PAPER-2012-049]
- "First observation of $\overline{B}^0_s \to D^+D^-$, $D_s^+D_s^-$ and $D^0\overline{D}^0$ decays" [LHCb-PAPER-2012-050]

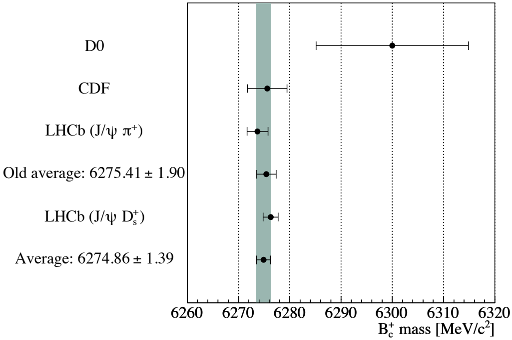

$B_c^+ \to \psi(2S)\pi^+$
$B_s^0 \to D^+D^-$ and $B_s^0 \to D^0\bar{D}^0$
ADS modes
$B_s^0 \to \psi(2S)\eta$
LHCb
Data
Total fit
Signal
Comb. bkg
Part. recon. bkg
Combinatorial
Candidates / (10 MeV/c^2)
D^+D^- Mass [MeV/c^2]
$D^0\bar{D}^0$ Mass [MeV/c^2]
$M(\psi(2S)\pi^+)$
$M(\psi(2S)\eta)$ [GeV/c^2]
$m(Dh^\pm)$ [MeV/c^2]
$B^- \to [\pi^- K^+ \pi^+ \pi^-]_D K^-$
$B^+ \to [\pi^+ K^- \pi^+ \pi^-]_D K^+$
$B^- \to [\pi^- K^+ \pi^+ \pi^-]_D \pi^-$
$B^+ \to [\pi^+ K^- \pi^+ \pi^-]_D \pi^+$



- [LHCb-PAPER-2013-010] using the full $3\,\mathrm{fb}^{-1}$ dataset
- Allows for a precise determination of the B_c^+ mass:

$$m_{B_c^+} = 6276.28 \pm 1.44 \pm 0.36\,\mathrm{MeV}/c^2$$

Determining the B_c^+ mass



- The new result is more precise than the old world average, $m_{B_c^+} = 6275.41 \pm 1.90$, and is statistically dominated.

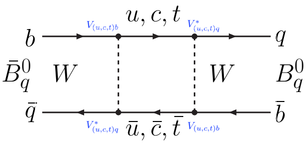
B_s^0 mixing and mixing induced CP violation

[LHCb-PAPER-2013-006]
[LHCb-PAPER-2013-002]
[LHCb-PAPER-2013-007]

B_s^0-$\overline{B}_s^0$ oscillation frequency

- Mass eigenstates $\neq$ flavour eigenstates.

$\rightarrow$ Oscillation frequency $\propto \Delta m_s = m_H - m_L$.



- Ignoring decay time acceptance and detector resolution, the decay time distribution of tagged candidates to a flavour specific final state is:

$$P(t) \propto \left[e^{-\Gamma t} \left(\cosh\left(\frac{\Delta\Gamma_s}{2} t \right) \pm \mathcal{D} \cos(\Delta m_s t) \right) \right]$$

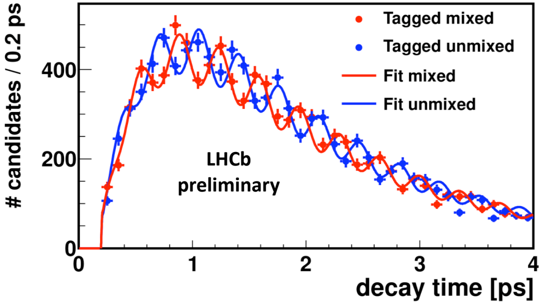
where $\mathcal{D}$ is the flavour tagging dilution.

B_s^0-$\overline{B}_s^0$ oscillation frequency

- Mixing analysis performed using $1\,\mathrm{fb}^{-1}$ of integrated luminosity using flavour specific $B_s^0 \to D_s^- \pi^+$ and $\overline{B}_s^0 \to D_s^+ \pi^-$ final states.
- Use opposite side + same-side kaon taggers to tag the initial flavour of the $B_s^0/\overline{B}_s^0$ (effective tagging power $\varepsilon \mathcal{D}^2 \sim 3.1\%$).

- Excellent propertime resolution in LHCb

→ can resolve B_s^0-$\overline{B}_s^0$ oscillations.

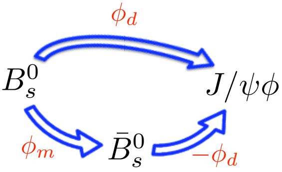


$$\Delta m_s = 17.768 \pm 0.023(\text{stat.}) \pm 0.006(\text{syst.})\,\mathrm{ps}^{-1}$$

c.f. $17.77 \pm 0.10 \pm 0.07\,\mathrm{ps}^{-1}$ @ CDF [PRL 97 242003 (2006)]

Mixing induced CP violation in B_s^0-system

- Interference between mixing and decay gives rise to a $\not{C}\not{P}$ phase: $\phi_s = \phi_m - 2\phi_d$.
- For $B_s^0 \to J/\psi\,\phi$, $\phi_d = -2\arg(V_{cs}V_{cb}^*) \approx 0$ and

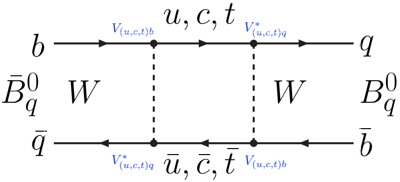


$$\phi_s^{\mathrm{SM}} = -2arg\left(\frac{V_{ts}V_{tb}^*}{V_{cs}V_{cb}^*}\right) = -0.036 \pm 0.002\,\mathrm{rad}$$

Charles et al. [Phys. Rev. D84 (2011) 033005]

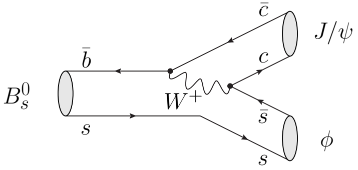
- Mixing phase, ϕ_m, from $\Delta B = 2$ box diagram.

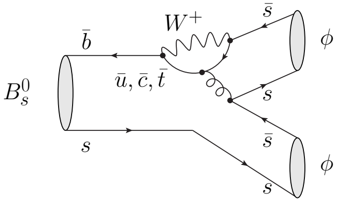
$\rightarrow$ Sensitive to NP contributions.



Mixing induced CP violation in B_s^0-system

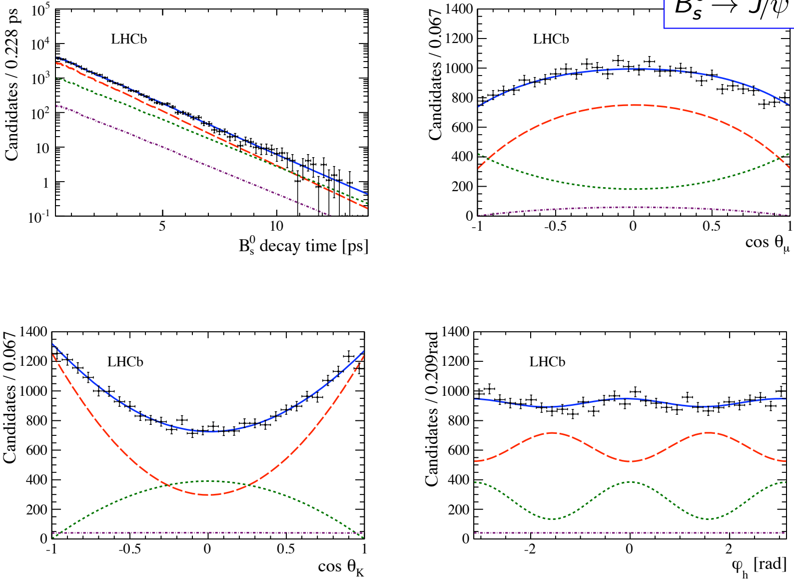
- Can also look at $B_s^0 \to \phi\phi$ decays (gluonic penguin).
- Loop suppressed $\to 880 \pm 31$ candidates. Can also receive NP contribution to the decay.
- In the SM, partial cancellation between ϕ_m and ϕ_d $\to$ expect $\phi_s^{s\bar{s}s} \sim 0$.



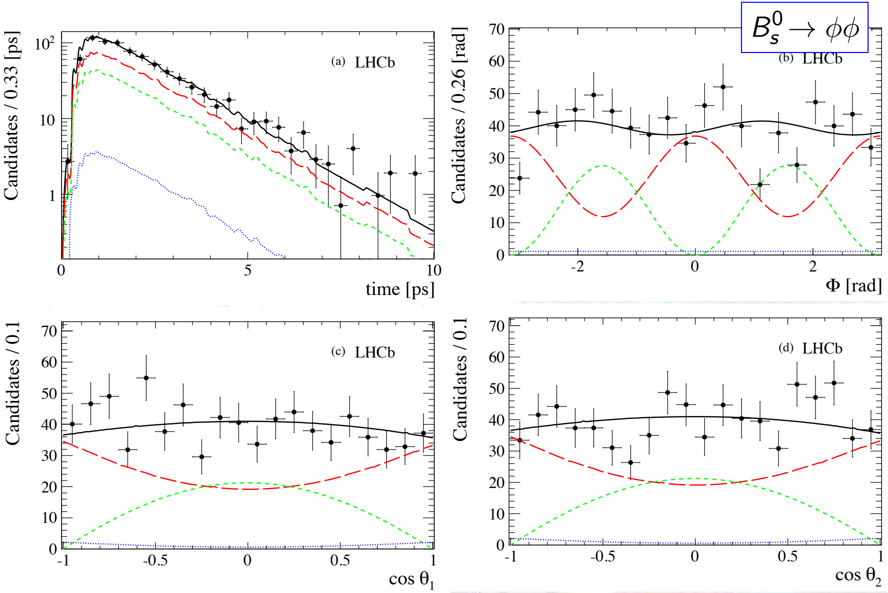


- In both cases, perform a time dependent, flavour tagged, angular analysis to separate the CP-odd and CP-even final states.

$B_s^0 \to J/\psi\,\phi$



CP even, CP odd, S-wave



CP even, CP odd, S-wave

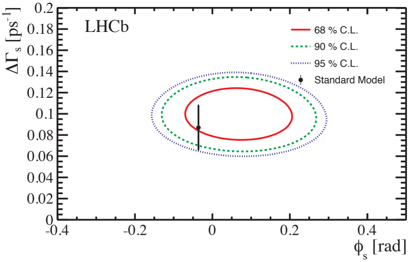
Mixing induced CP violation in $B_s^0 \to J/\psi\,\phi$

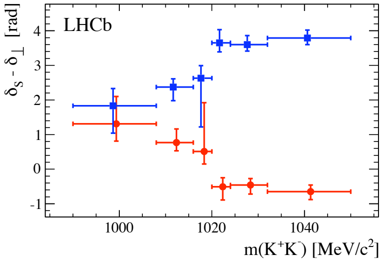
- Several improvements in the analysis from the preliminary result:

1. Added same-side kaon tagging, $\varepsilon\mathcal{D}^2 = (0.89 \pm 0.17)\%$.
2. Simultaneous fit in six bins of $m_{K^+K^-}$. The strong phase dependence across the ϕ pole-mass is used to resolve the sign of $\Delta\Gamma_s$.
3. Allow for CP violation in the decay,

$$|\lambda| = \left|\frac{q}{p}\frac{\bar{A}_f}{A_f}\right| = 0.94 \pm 0.03 \pm 0.02.$$

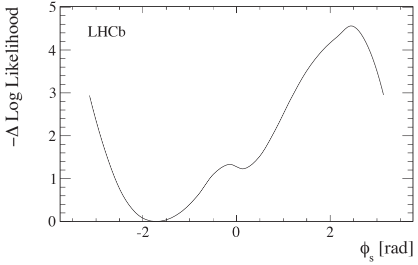
- Dominant source of systematic uncertainty arises from the angular acceptance (limited MC statistics).





Mixing induced CP violation in $B_s^0 \to \phi\phi$

- Small dataset $\rightarrow$ Feldman Cousins (pseudo-experiments) are used to provide the correct coverage.
- The result is statistically limited.

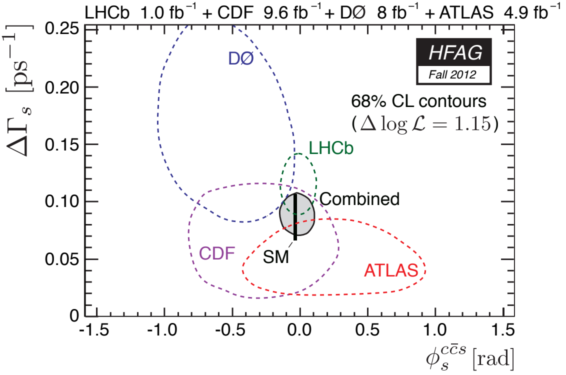


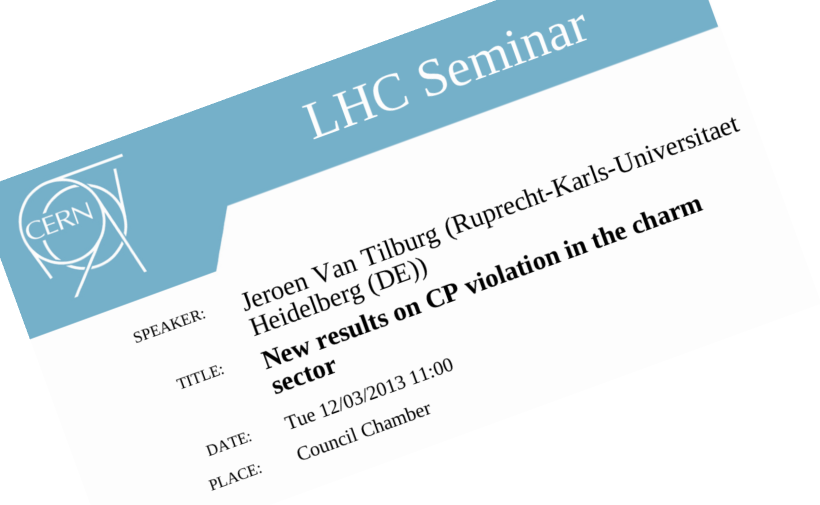
ϕ_s in interval $[-2.46, -0.76]\,\mathrm{rad}$ at 68% CL.

- p-value of $\phi_s = 0$ is 16%.
- The dominant sources of systematic uncertainty arise from:
  - the description of the decay time acceptance;
  - the knowledge of the S-wave contamination from $B_s^0 \to f^0\phi$ and $B_s^0 \to f^0 f^0$.
- Interesting analysis to pursue with larger datasets (NB: we have an additional $2\,\mathrm{fb}^{-1}$ on tape).

Mixing induced CP violation in the B_s^0-system

- HFAG Fall 2012 combination of results from CDF & D0, the old LHCb preliminary result and an untagged analysis from ATLAS.





CP violation in the charm sector

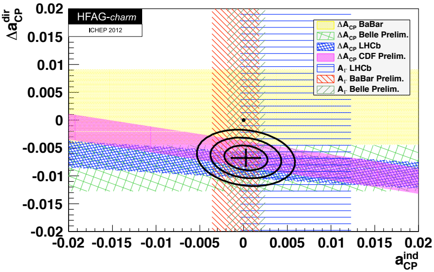
[LHCB-PAPER-2013-003], [LHCB-CONF-2013-003]

Link to seminar: http://indico.cern.ch/conferenceDisplay.py?confId=240082

Direct CP violation in charm

- CP violation is well established in the K and B systems.
- Not yet established in the charm sector:
  - CP violation in singly-Cabibbo suppressed charm decays is expected to be small $\lesssim 0.1\%$ (but is difficult to calculate).
- With $0.6\,\text{fb}^{-1}$ LHCb measured $\Delta A_{CP} = (-0.82 \pm 0.21 \pm 0.11)\,\%$ between $K^+ K^-$ and $\pi^+ \pi^-$ final states.

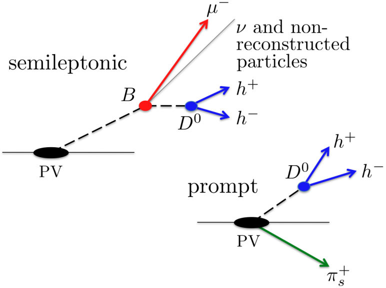
- HFAG world average shows 4.6σ evidence for CP violation in $D \to h^+ h^-$ decays. For charm system $\Delta A_{CP} \approx \Delta a^{\text{dir}}_{CP}$.
- Triggered a detailed discussion in the theory community on SM predictions and possible NP interpretations.



Measuring ΔA_{CP}

- To determine the CP asymmetry of $D \to h^+h^-$ decays need to tag the flavour of the $D^0/\overline{D}^0$:
  - Use the charge of π_s in $D^{*+} \to D^0\pi_s^+$.

NEW Use D's from semileptonic B decays and use the $\mu^\pm$ charge.



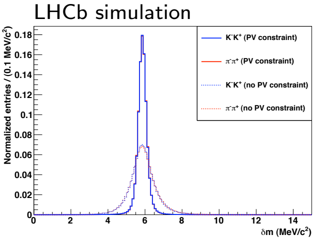
- Raw CP asymmetry $A_{\mathrm{RAW}}(h^+h^-) \approx A_{CP} + A_D + A_P$ depends on the D^{*+}/D^{*-} ($B/\bar{B}$) production asymmetry and the $\pi_s^\pm$ ($\mu^\mp$) detection asymmetry. Can cancel A_P and A_D to first order by taking:

$$\Delta A_{CP} = A_{\mathrm{RAW}}(K^+K^-) - A_{\mathrm{RAW}}(\pi^+\pi^-) \approx A_{CP}(K^+K^-) - A_{CP}(\pi^+\pi^-)$$

NB $A_{CP}(K^+K^-)$ and $A_{CP}(\pi^+\pi^-)$ expected to have opposite sign in SM.

Updating the $D^{*\pm}$ tagged analysis to 1 fb^{-1}

- Several analysis improvements:
  - Added an additional 0.4 fb^{-1}.
  - Improved alignment and calibration used for the full dataset.
  - Improved $\delta m = m_{h^+h^-\pi^+} - m_{h^+h^-} - m_{\pi^+}$ mass resolution, by introducing a PV constraint in the vertex fit.



→ Updated value of:

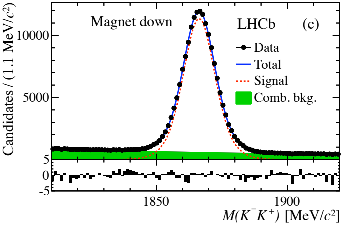
$$\Delta A_{CP} = (-0.34 \pm 0.15 \pm 0.10)\% \quad \text{(Preliminary)}$$

- Statistically compatible with the previous result.

- The dominant sources of systematic uncertainty arise from the:
  - treatment of possible peaking backgrounds (0.04%);
  - dependence of ΔA_{CP} on the impact parameter of π_s (0.08%).

- Estimate ΔA_{CP} by performing a simultaneous fit to the h^+h^- mass for D^0 and $\overline{D}^0$ tagged events.
  - Candidates are re-weighted to account for kinematic differences between $D \to K^+K^-$ and $D \to \pi^+\pi^-$.
  - Average results from two LHCb magnet polarities to further cancel detector asymmetries.

$D \to K^+K^-$ $\qquad$ $D \to \pi^+\pi^-$

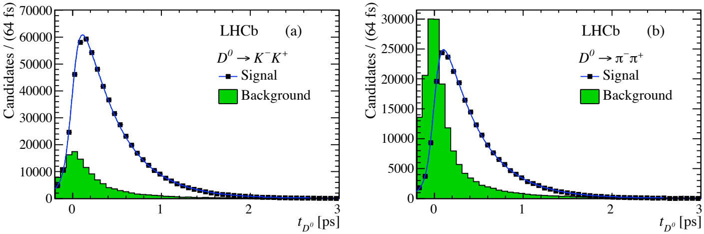


ΔA_{CP} using semileptonic tags

- Signal samples of 560 k $D \to K^+K^-$ and 220 k $D \to \pi^+\pi^-$ decays.
- For the semileptonic tagged analysis:

$$\Delta A_{CP} = (+0.49 \pm 0.30 \pm 0.14)\%$$

- The dominant sources of systematic uncertainty come from the:
  - treatment of low lifetime backgrounds in $D \to \pi^+\pi^-$ (0.11%);
  - kinematic re-weighting (0.05%);
  - modelling of the D line-shape (0.05%).

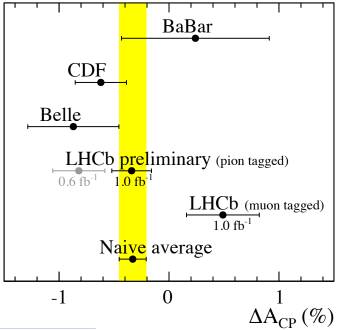


ΔA_{CP} summary

- Measurements compatible at 2.2σ level:

$$\begin{array}{rl} D^{*+}\text{ tag} & \Delta A_{CP} = (-0.34 \pm 0.15 \pm 0.10)\%\text{ (preliminary)} \\ \text{Semileptonic tag} & \Delta A_{CP} = (+0.49 \pm 0.30 \pm 0.14)\% \end{array}$$

NB Naive average, ignores $a_{CP}^{\text{ind.}}$ and possible correlations between experimental uncertainties.



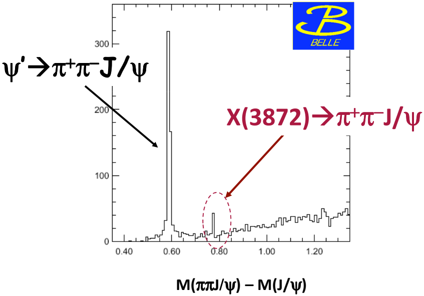
→ Initial evidence for CP violation in the charm sector is not confirmed.

Exotic charmonium states

[LHCb-PAPER-2013-001]

$X(3872)$ meson quantum numbers

- $X(3872)$ is an exotic charmonium state first observed by Belle [PRL 91 (2003)] in $B^+ \to K^+\pi^-\pi^+ J/\psi$ decays.
- $X(3872)$ also observed to decay as $X(3872) \to \gamma J/\psi$ by BaBar and Belle ($\to C = +1$)
- CDF excluded all J^{PC} except 1^{++} and 2^{-+} [PRL 98 (2007)] using a 3D angular fit.



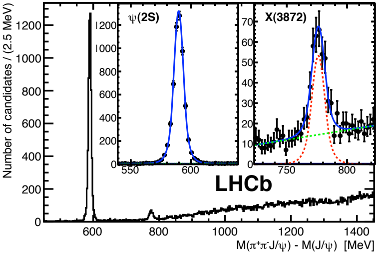
- Determination of quantum numbers important for interpreting the nature of the $X(3872)$:

  1^{++} $\bar{D}^0 D^{*0}$ molecule? Tetra-quark? $\chi_{c1}(2^3P_1)$?

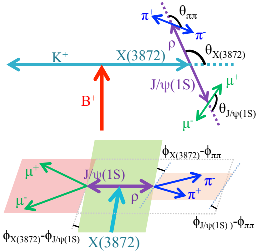
  2^{-+} $\eta_{c2}(1^1D_2)$?

$X(3872)$ meson quantum numbers

- In 1 fb^{-1} LHCb observes 313 ± 26 $B^+ \to K^+ X(3872)$ decays, with $X(3872) \to J/\psi \pi^+\pi^-$.
- Can distinguish between 1^{++} and 2^{-+} using the 5-dimensional angular distribution of the decay:



$$|\mathcal{M}|^2 = \sum_{\lambda_\mu=-1,+1} \left| \sum_{\lambda_{J/\psi},\lambda_{\pi\pi}=+1,0,-1} \mathcal{A}_{\lambda_{J/\psi},\lambda_{\pi\pi}} \times \mathcal{D}^J_{0,\lambda_\psi-\lambda_{\pi\pi}}(\phi_X,\theta_X,-\phi_X) \times \mathcal{D}^1_{\lambda_{\pi\pi},0}(\phi_{\pi\pi},\theta_{\pi\pi},-\phi_{\pi\pi}) \times \mathcal{D}^1_{\lambda_{J/\psi},\lambda_\mu}(\phi_{J/\psi},\theta_{J/\psi},-\phi_{J/\psi}) \right|^2$$



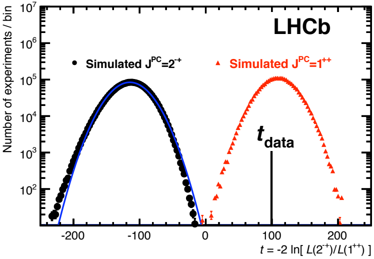
- Background subtracted using the $_s\mathcal{P}lot$ technique.

- Use the likelihood ratio:

$$t = -\log\left[\mathcal{L}(2^{-+}|\vec{\alpha})/\mathcal{L}(1^{++})\right]$$

as a test statistic.

- $t_{\text{data}} = 99 \rightarrow$ rejects 2^{-+} at 8.4σ



$J^{PC} = 1^{++}$ consistent with molecular, tetra-quark and $\chi_{c1}(2^3P_1)$ models

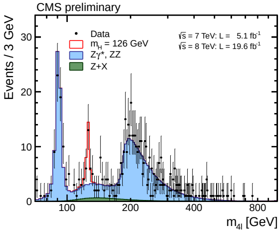
(which leaves room from for some of the more exotic interpretations)

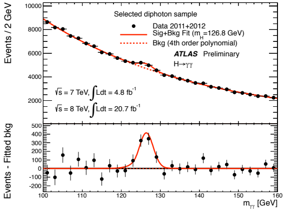
Neutral Higgs production

[LHCb-PAPER-2013-009]

Neutral Higgs production

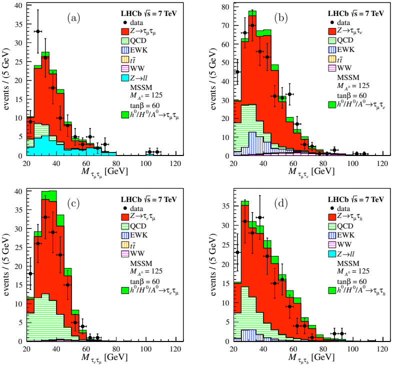
- SM "Higgs" like object has already been seen by ATLAS/CMS.





- At LHCb, search for neutral Higgs decaying to $\tau^+\tau^-$ in the $2 < \eta < 5$ region.
  - Search performed with $1\,\text{fb}^{-1}$ of integrated luminostiy at $\sqrt{s} = 7\,\text{TeV}$.
- ✓ Unique acceptance in the forward-region.
  - Sensitive to models where Higgs production in the forward region can be enhanced.
- ✗ Low efficiency to reconstruct both daughters inside the LHCb acceptance.

- Analysis performed using 5 categories: $\tau^-\tau^+ \to \mu^+\mu^-$, $\mu^\pm e^\mp$, $e^\pm\mu^\mp$, $\mu^\pm h$, $e^\pm h$.
- Follow LHC Higgs Cross Section Working Group recommendations for the signal (FeynHiggs, HIGLU, GGH@NNLO, BBH@NNLO). Signal efficiency is data driven.



Backgrounds:

$Z \to \tau\tau$ Using theoretical cross-section, shape from MC.

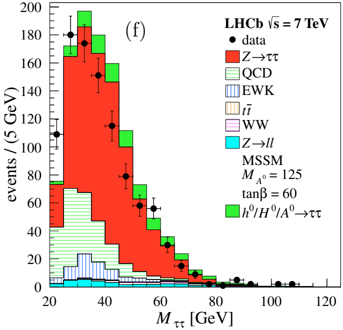
QCD Semileptonic $b-$ and $c-$hadron decays.
Shape from isolation sideband, normalised w.r.t. same-sign.

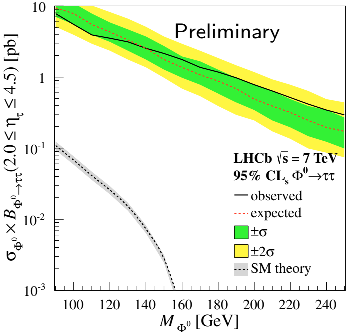
EWK Lepton from $W^\pm$ or Z plus track from underlying event.
Shape from simulation, normalised w.r.t. same-sign.

$t\bar{t}/WW$ Taken from simulation.

$Z \to \ell\ell$ Shape from sidebands, normalised to peak.

- Combining the 5 channels, set model independent upper limits on $\sigma_{\Phi^0} \times \mathcal{B}(\Phi^0 \to \tau\tau)$ of 9.4pb ($90\,\mathrm{GeV}/c^2$) – 0.3pb ($250\,\mathrm{GeV}/c^2$)



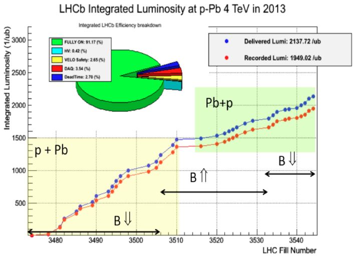


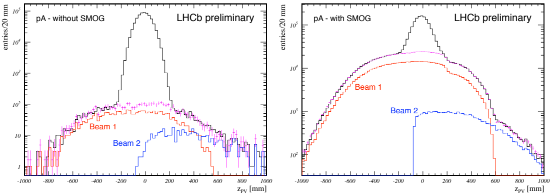
proton–ion running

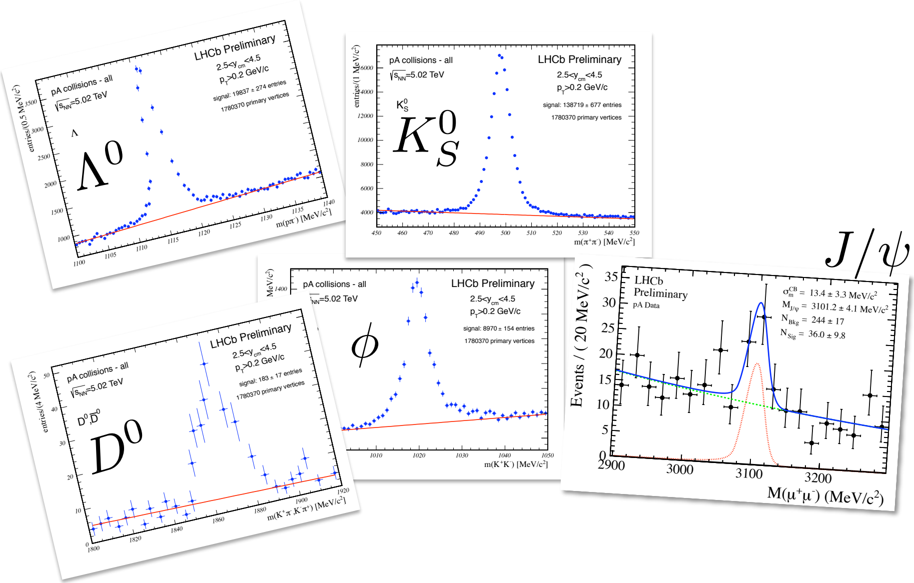
proton-ion running

- LHCb has collected $\sim 2\mathrm{nb}^{-1}$ of proton-ion data:
  - $1.4\mathrm{nb}^{-1}$ of *pPb* and $0.6\mathrm{nb}^{-1}$ of *Pbp*
- Using SMOG system:
  - injection of *Ne* gas in interaction region.
  - → increased rate of beam-gas interactions for luminosity measurement.

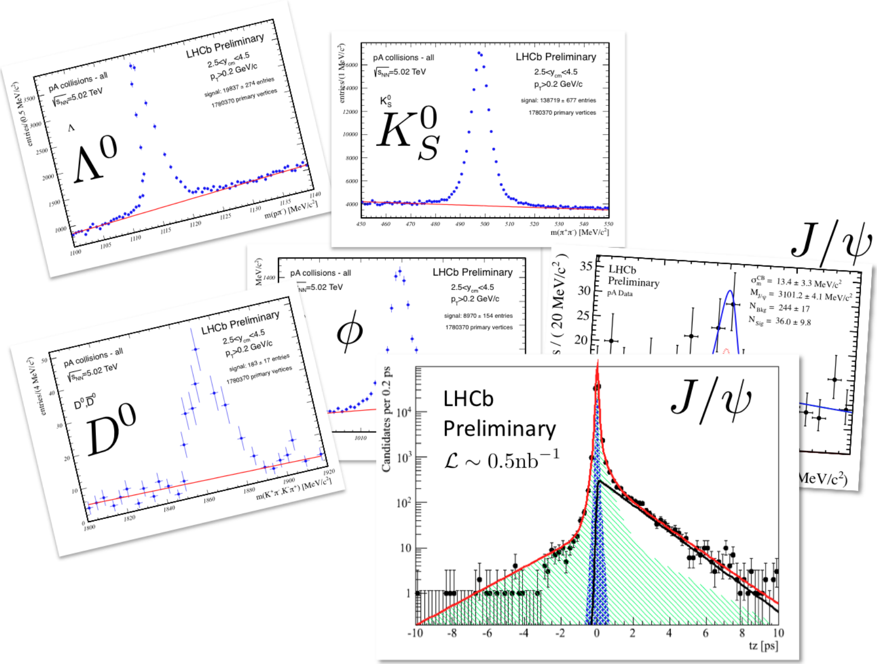
we have also collected samples of minimum bias, fixed-target, *pNe* and *PbNe* data.







pPb pilot run [LHCb-CONF-2012-034] $\mathcal{L} \sim 0.9\mu\mathrm{b}^{-1}$


LHCb Preliminary
pA collisions - all
$\sqrt{s_{NN}}$=5.02 TeV
2.5<y_{cm}<4.5
p_T>0.2 GeV/c
Λ^0
signal: 19837 ± 274 entries
1780370 primary vertices
m($p\pi^-$) [MeV/c²]
K^0_S
signal: 138719 ± 677 entries
m($\pi^+\pi^-$) [MeV/c²]
ϕ
signal: 8970 ± 154 entries
D^0
signal: 183 ± 17 entries
m($K^+\pi^-$,$K^-\pi^+$) [MeV/c²]
J/ψ
LHCb Preliminary
pA Data
σ_m^{CB} = 13.4 ± 3.3 MeV/c²
$M_{J/\psi}$ = 3101.2 ± 4.1 MeV/c²
N_{Bkg} = 244 ± 17
N_{Sig} = 36.0 ± 9.8
J/ψ
LHCb Preliminary
$\mathcal{L} \sim 0.5\text{nb}^{-1}$
Candidates per 0.2 ps
tz [ps]

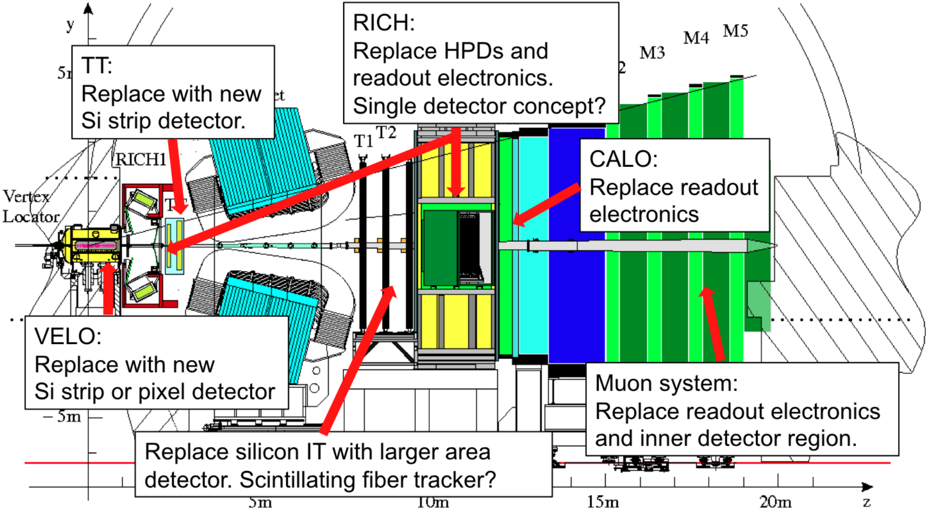
LHCb upgrade

LHCb upgrade

Aim to upgrade the LHCb detector during LS2 (2018), with the goal of reading out the full detector into a software farm at 40 MHz.

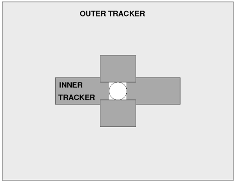
- LoI submitted in March 2011.
  - Physics case endorsed by the LHCC.
- Framework TDR submitted in May 2012.
  - Endorsed by the LHCC in September 2012.
- LHCb upgrade approved by Research Board in November 2012.
- We are now starting reviews in the individual sub-detectors (with external referees). These reviews will be completed this year.
- A supporting document on the upgrade physics and trigger is also being prepared.

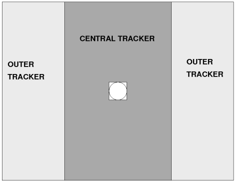
The LHCb upgrade



First review: scintillating fiber tracker

- A scintillating fiber tracker is a possible replacement for the existing IT and OT .





250 μm scintillating fibers readout by 128 channel SiPM.

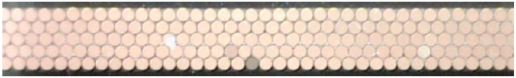


Figure 4: Cross section photograph of a recently built 2.5 m long scintillating-fibre module.

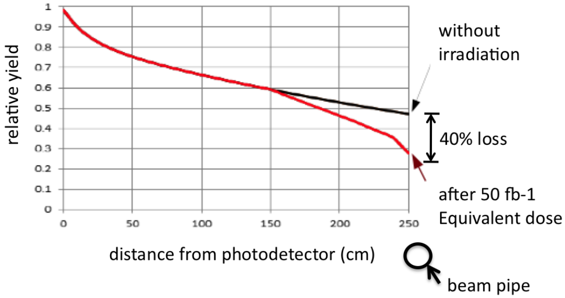
- Review focussed mainly on the radiation tolerance of the fibers/SiPM (see next slide).

Scintillating fiber tracker is viable from point of view of radiation tolerance.

First review: scintillating fiber tracker radiation tolerance

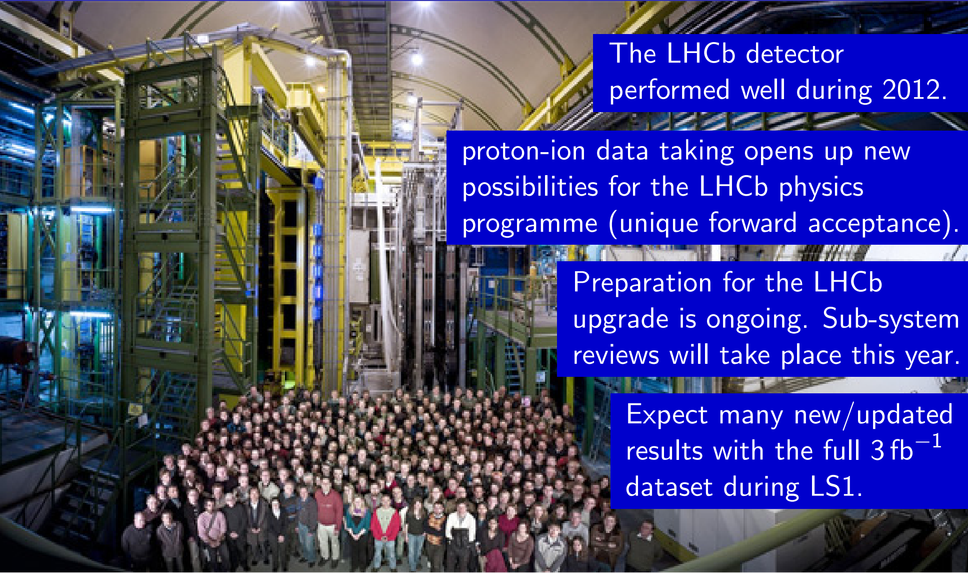
- Known issues with SiPM exposed to neutron fluence.
  - Existing SiPM technologies can keep noise/PDE at acceptable levels with a combination of cooling (-40°C) and shielding.
- Radiation tolerance of the scintillating fibers has also been explored.
  - Fibers have been exposed to $50\,\text{fb}^{-1}$ equivalent of protons $\rightarrow$ degradation of the fibers is within the upgrade tolerance (40% closest to the beam line). A sizable fraction of the light loss can be recovered using a mirror at the end of the fiber.

Expected relative light yield before and after irradiation



For more details see the talk in the LHCC upgrade session.

Summary



The LHCb detector performed well during 2012.

proton-ion data taking opens up new possibilities for the LHCb physics programme (unique forward acceptance).

Preparation for the LHCb upgrade is ongoing. Sub-system reviews will take place this year.

Expect many new/updated results with the full 3 fb^{-1} dataset during LS1.

SHUTDOWN: NO BEAM

Finally, we would like to express our thanks to the CERN accelerator groups for the excellent performance of the LHC in 2012-2013

Comments (21–Feb–2013 09:05:25)

Phone:77600

*** END OF RUN 1 ***
No beam for a while. Access required
time estimate: ~2 years

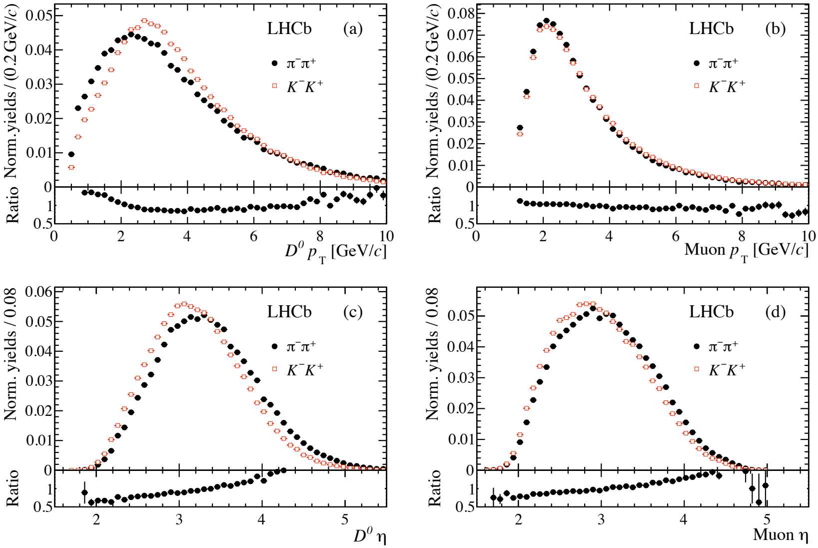
BIS status and SMP flags	B1	B2
Link Status of Beam Permits	false	false
Global Beam Permit	false	false
Setup Beam	true	true
Beam Presence	false	false
Moveable Devices Allowed In	false	false
Stable Beams	false	false

AFS: Single_36b_4_16_16_4bpi9inj

PM Status B1 ENABLED PM Status B2 ENABLED

ΔA_{CP} using semileptonic tags

Available phase-space $\rightarrow \pi^{\pm}$ kinematically harder than $K^{\pm}$



Difference with previous result

$\Delta A_{CP} = (-0.82 \pm 0.21 \pm 0.11)\%$ ⇨ $\Delta A_{CP} = (-0.34 \pm 0.15)\%$

- The central value is considerably closer to zero than the previous result
- Several factors can contribute to the change
  - larger data sample
  - change in detector calibration (PID and alignment)
  - difference in the analysis technique

Data overlap within the same run period (0.6 fb^{-1})

- In new result, 15% (K^-K^+) and 14% ($\pi^-\pi^+$) of events no longer selected
- ~85% of events selected in both old and new processing.
  - Old: $\Delta A_{CP} = (-0.80 \pm 0.23)\%$
  - New: $\Delta A_{CP} = (-0.78 \pm 0.23)\%$
- In new result, 17% (K^-K^+) and 34% ($\pi^-\pi^+$) of additional events selected
  - Including additional events: $\Delta A_{CP} = (-0.55 \pm 0.21)\%$.
  - Additional events statistically in agreement with old result.

Difference with previous result

New data 0.4 fb^{-1}

- Last 0.4 fb^{-1} recorded by LHCb in 2011 :
  - $\Delta A_{CP} = (-0.28 \pm 0.26)\%$
- Fitting all the 1.0 fb^{-1} :
  - $\Delta A_{CP} = (-0.45 \pm 0.17)\%$

Effect of constraining D* to primary vertex

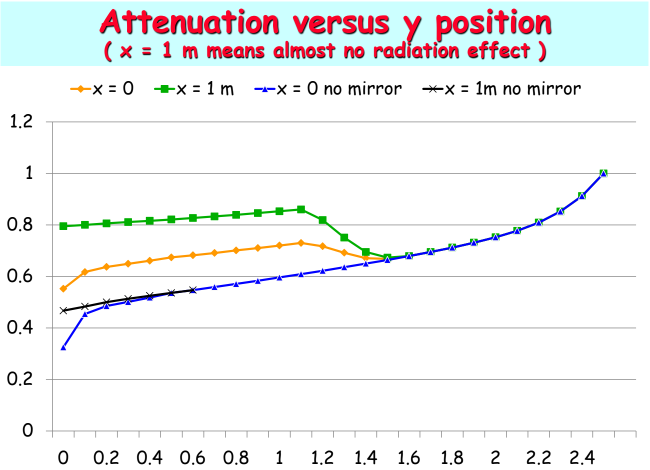
- Constraint improves the δm resolution by a factor 2.5.
  - Better background rejection and reducing the statistical uncertainty
- Change in ΔA_{CP} is 0.11%
  - Expected variation (pseudo-experiments): ±0.05%

Difference between old and new result understood.
Compatible with statistical fluctuations.

$B_s^0 \to J/\psi\,\phi$ systematic uncertainties

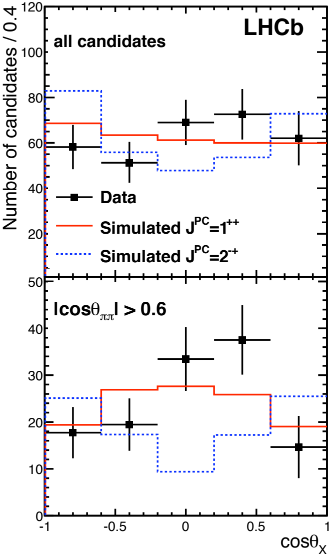
Source	Γ_s [ps^{-1}]	$\Delta\Gamma_s$ [ps^{-1}]	$\lvert A_\perp\rvert^2$	$\lvert A_0\rvert^2$	$\delta_\parallel$ [rad]	$\delta_\perp$ [rad]	ϕ_s [rad]	$\lvert\lambda\rvert$
Stat. uncertainty	0.0048	0.016	0.0086	0.0061	$^{+0.13}_{-0.21}$	0.22	0.091	0.031
Background subtraction	0.0041	0.002	-	0.0031	0.03	0.02	0.003	0.003
$B^0 \to J/\psi K^{*0}$ background	-	0.001	0.0030	0.0001	0.01	0.02	0.004	0.005
Ang. acc. reweighting	0.0007	-	0.0052	0.0091	0.07	0.05	0.003	0.020
Ang. acc. statistical	0.0002	-	0.0020	0.0010	0.03	0.04	0.007	0.006
Lower decay time acc. model	0.0023	0.002	-	-	-	-	-	-
Upper decay time acc. model	0.0040	-	-	-	-	-	-	-
z + p scale	0.0009	-	-	-	-	-	-	-
Fit bias	-	-	0.0010	-	-	-	-	-
Quadratic sum of syst.	0.0063	0.003	0.0064	0.0097	0.08	0.07	0.009	0.022
Total uncertainties	0.0079	0.016	0.0107	0.0114	$^{+0.15}_{-0.23}$	0.23	0.091	0.038

Light yield loss: with mirror and timing cut



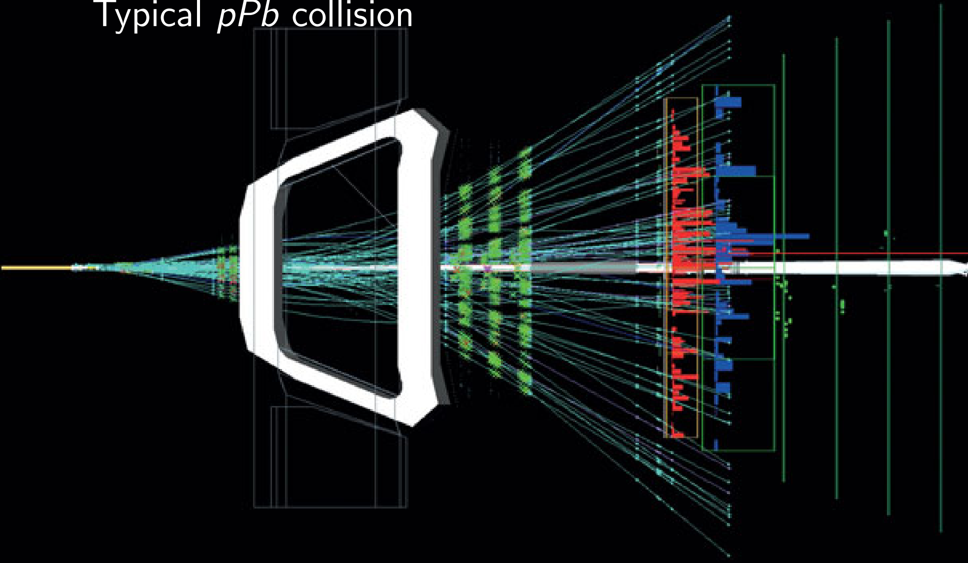
- Effect of mirror and timing cut is to reduce light yield spread for all hits along the 2.5m long fiber

X(3872) angular distribution



- Background subtracted angular distribution (of $\cos\theta_X$).
- Overlaid with the expected angular distribution of $J^{PC} = 1^{++}$ and 2^{-+} X(3872) decay decays.

Typical *pPb* collision



Λ_b^0 production polarisation

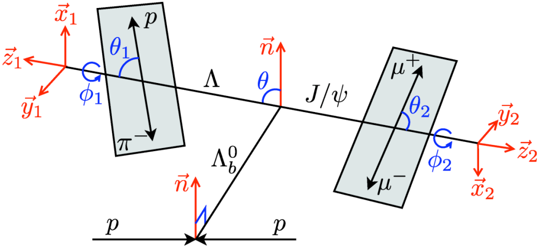
[LHCb-PAPER-2012-057]

Λ_b^0 production polarisation

- Longitudinal polarisation vanishes but, transverse polarisation could be large ($\sim 20\%$) at the LHC [PLB 614 (2005)].
- Non-zero transverse polarisation has consequences for rare decay measurements.
  - Take advantage of production polaristation in $\Lambda_b^0 \to \Lambda^0\gamma$ and $\Lambda_b^0 \to pK\gamma$ decays to determine the photon polarisation, e.g. G. Hiller et al. [arXiv:hep-ph/0702191]

  NB In SM expect γ_R supressed by m_s/m_b w.r.t. γ_L. Could be enhanced in many NP models.

- $\Lambda_b^0 \to \Lambda^0 J/\psi$ angular distribution depends on the polarisation factor (P_b) and 4 helicity amplitudes.

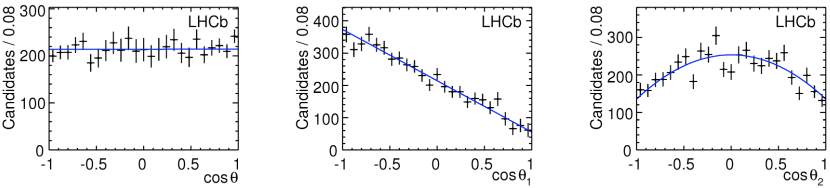


Λ_b^0 production polarisation

- Simplify the angular distribution by integrating over 2 of the 5 angles.
- Polarisation (P_b) and Parity violating asymmetry factor (α_b) consistent with zero:

P_b	$0.05 \pm 0.07 \pm 0.02$
α_b	$0.04 \pm 0.17 \pm 0.07$

$\rightarrow$ Rejects HQET prediction of large α_b [PLB 614 (2005)].



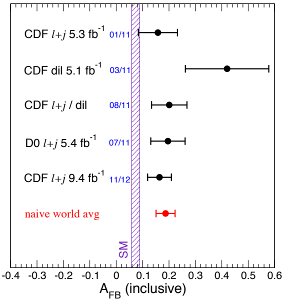
$$\propto (1 + P_b \alpha_b \cos\theta)$$

$b\overline{b}$ forward central asymmetry

[LHCb-CONF-2013-001]

$t\bar{t}$ forward-backward and forward-central asymmetries

- Large $t\bar{t}$ A_{FB} seen in $p\bar{p}$ collisions at TeVatron (2.5σ from SM).
  - SM contribution arises from interference between LO and NLO $q\bar{q} \rightarrow t\bar{t}$ diagrams.
- At LHC we don't know the direction of the initial partons, measure a forward-central asymmetry:

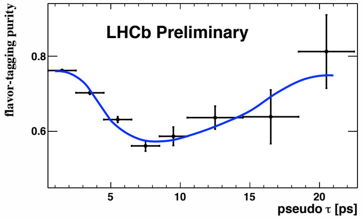


$$A_{FC} = \frac{N(\Delta|y| > 0) - N(\Delta|y| < 0)}{N(\Delta|y| > 0) + N(\Delta|y| < 0)}$$

- ATLAS and CMS see $A_{FC}^{t\bar{t}}$ close to SM predictions, what about $A_{FC}^{b\bar{b}}$?

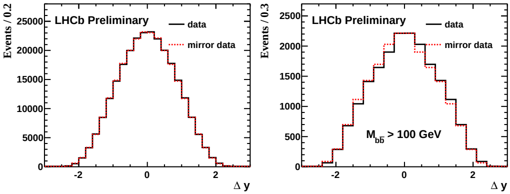
$b\bar{b}$ forward-central asymmetry

- Two back-to-back anti-k_T jets ($R = 0.5$) with $p_{\mathrm{T}} > 15\,\mathrm{GeV}/c$, corrected back to the quark level using MC ($\sigma(\Delta y) \sim 0.1$).
- b-tag based on 2-, 3 and 4-track displaced vertices (profit from the LHCb trigger).
- Tag b-flavour by requiring that the hardest track is a muon.



Preliminary result:

$$A_{FC}^{b\bar{b}} = (-0.5 \pm 0.5 \pm 0.5)\%$$



$m_{b\bar{b}} > 100\,\mathrm{GeV}/c^2$: $A_{FC}^{b\bar{b}} = (-4.3 \pm 1.7 \pm 2.4)\%$