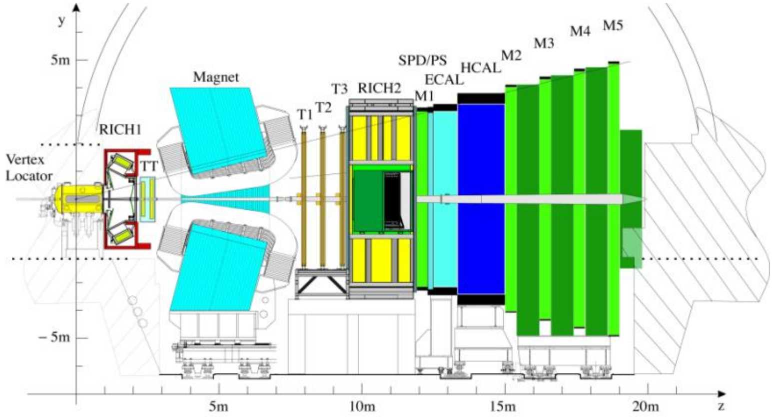
LHCb status

103rd LHCC meeting
22.09.2010

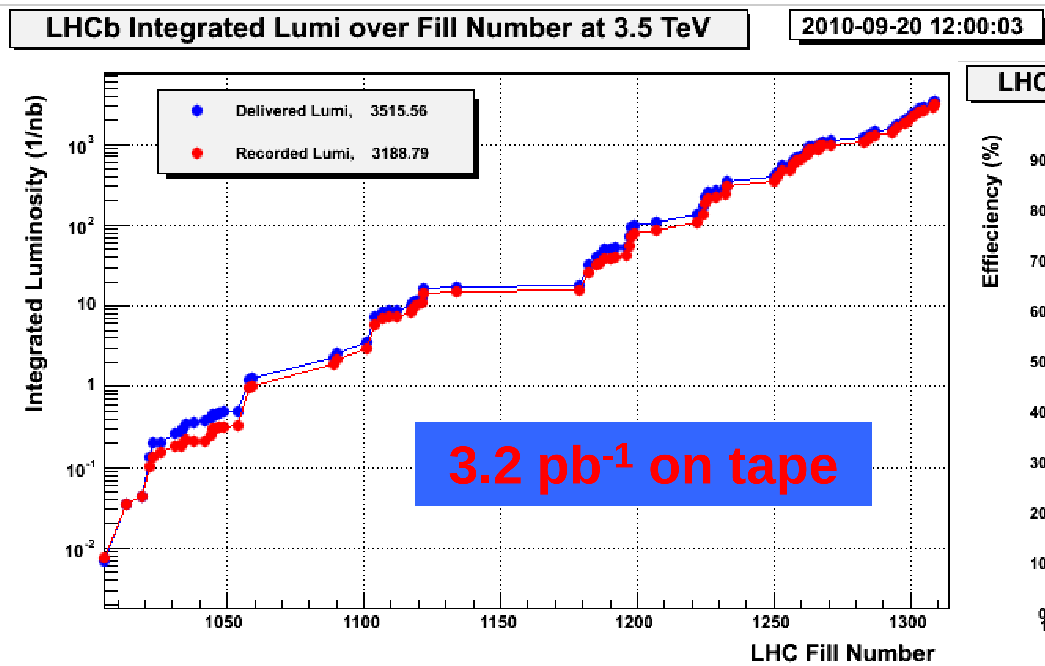


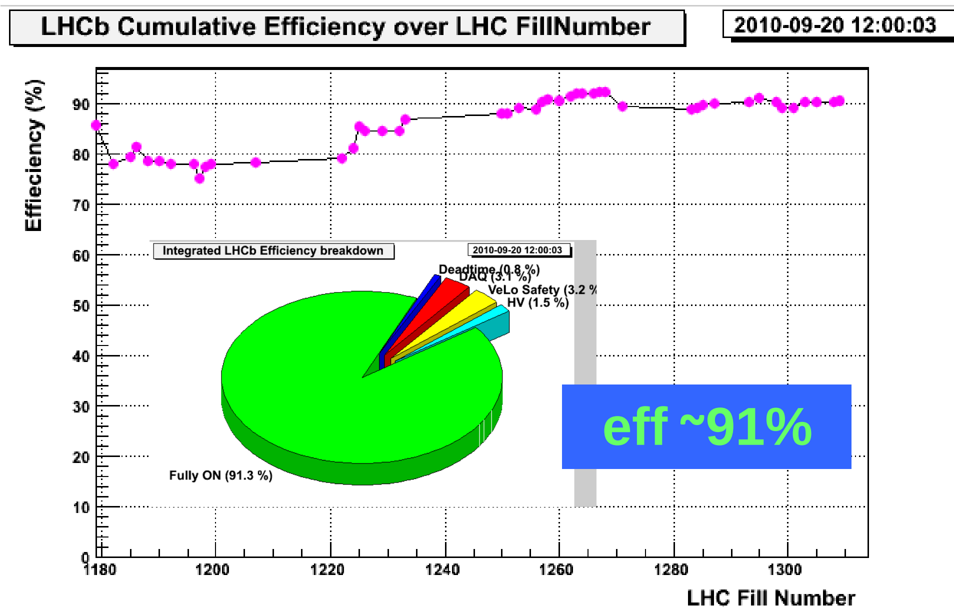
Marta Calvi

University Milano-Bicocca and INFN

for the LHCb Collaboration

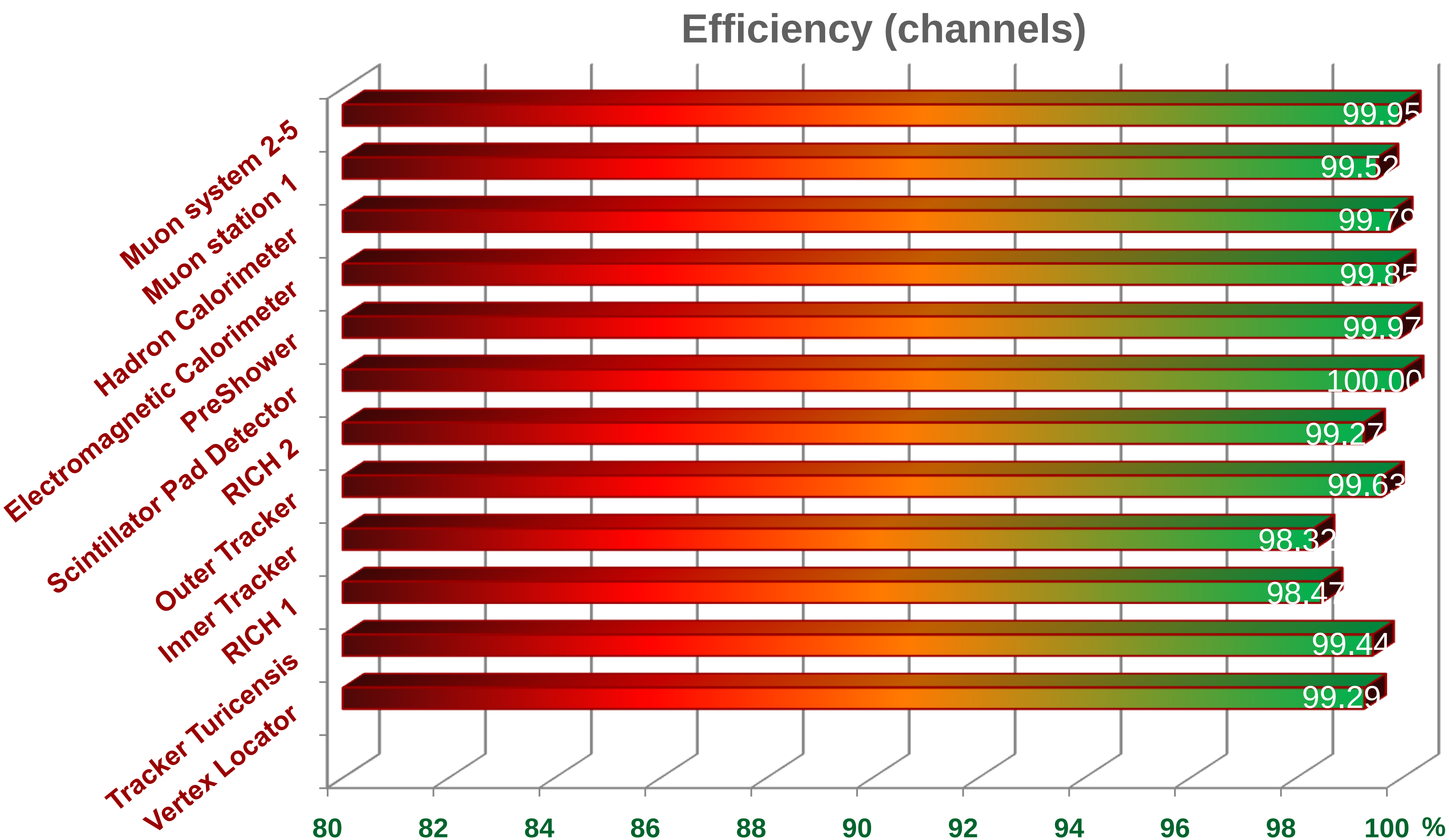
Data taking



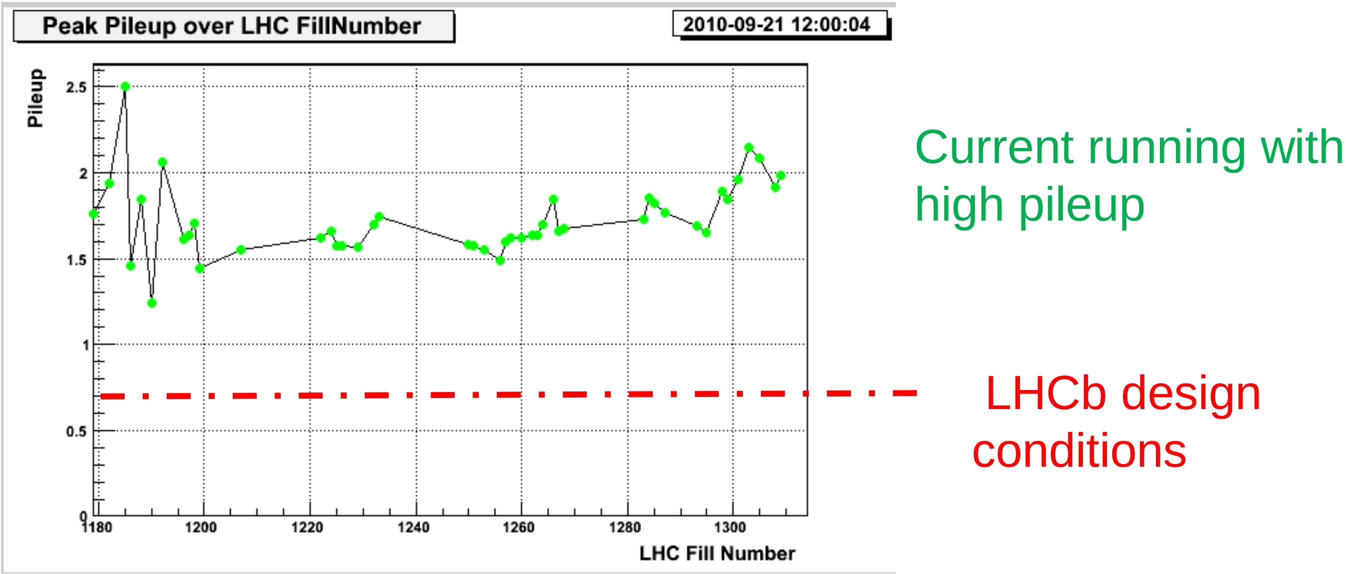


- Stable data taking, high efficiency in all systems, globally increasing with time.

Detectors' efficiency

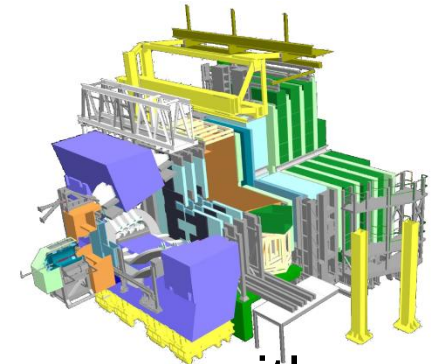


Running conditions



- Running LHCb with multiple interactions affects trigger, computing, reconstruction and analysis.
- Work on-going to fully understand all implications to exploit high luminosity and get best performance.

Detector performance

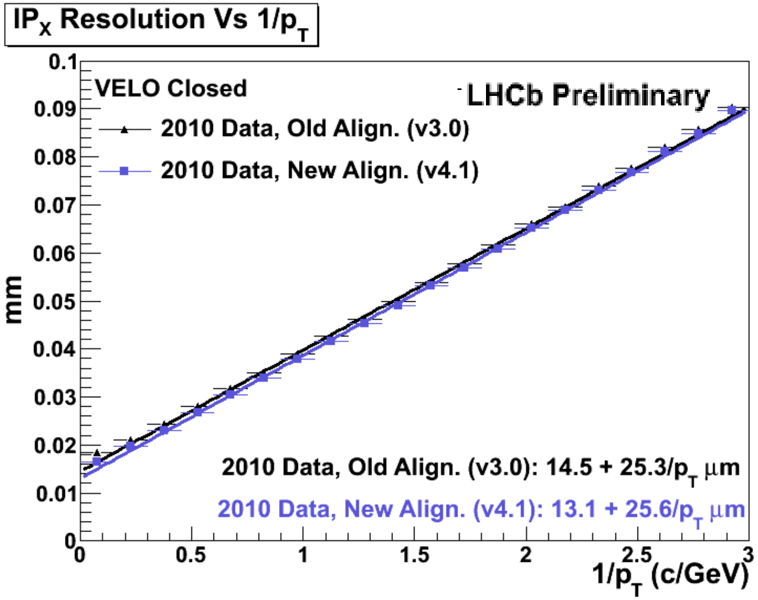


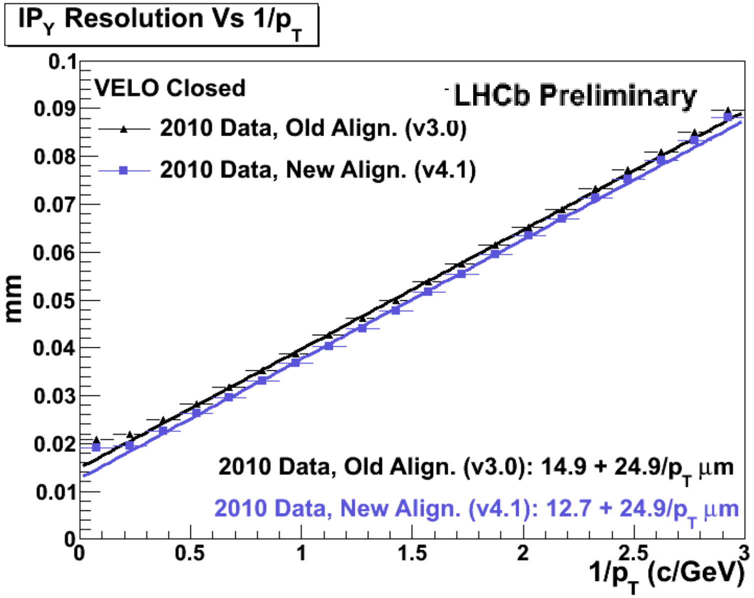
- Good trigger performance, raise thresholds to cope with increasing rate while keeping always maximum efficiency for most channels.
- All detectors performing well, no major concern.
- Use of new larger samples of data to complete calibration, alignment and progessive understanding of performance.
- Preparing for remaining 2010 run (≈50 pb^{-1}) and 2011 running (≈1 fb^{-1}).

→ recent updates in next slides

VELO: IP resolution

- New alignment based on 2010 data:
  sensor and module alignment and 2 halves alignment.

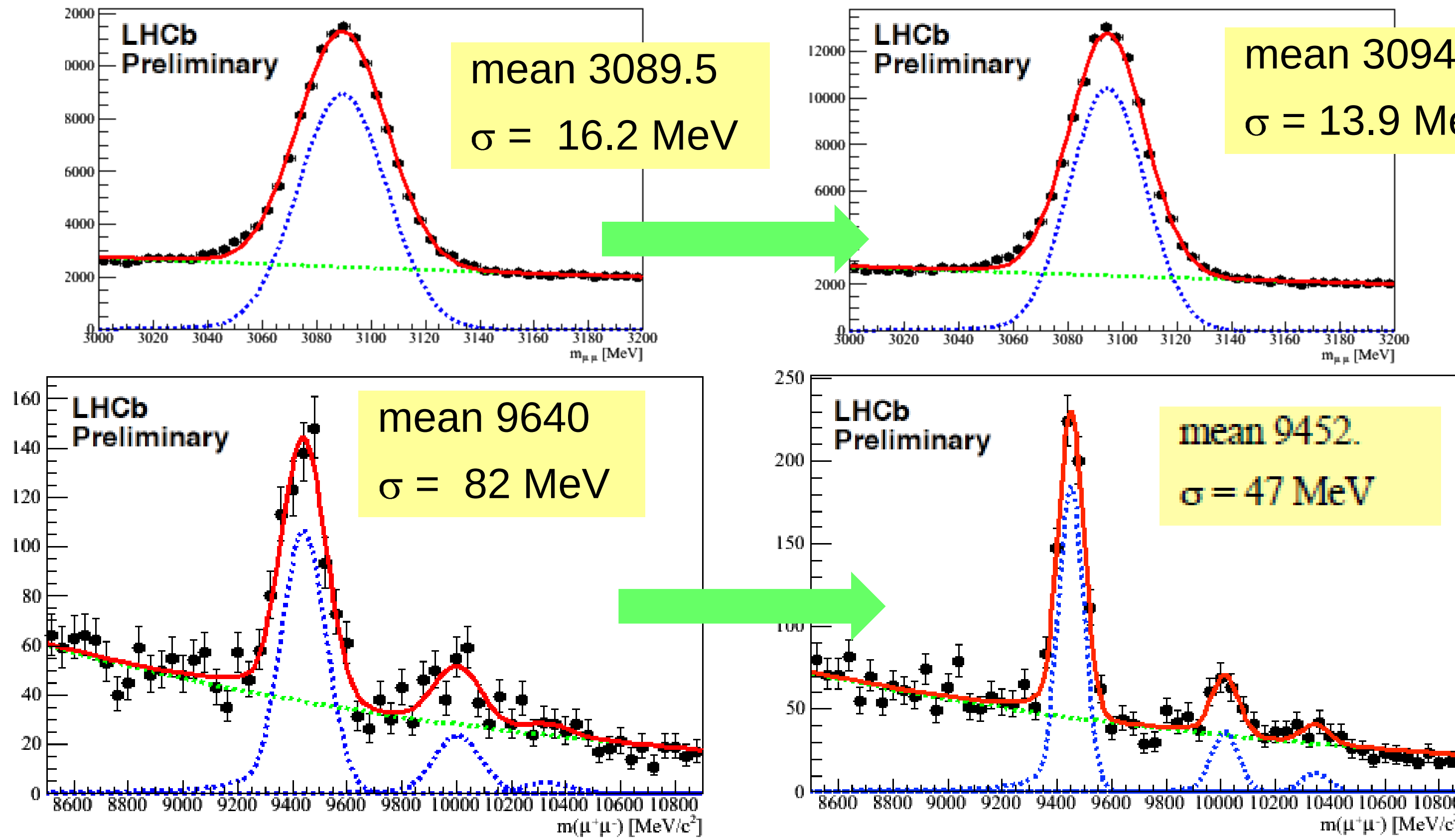




- Resolution at high p_T in agrees with MC.

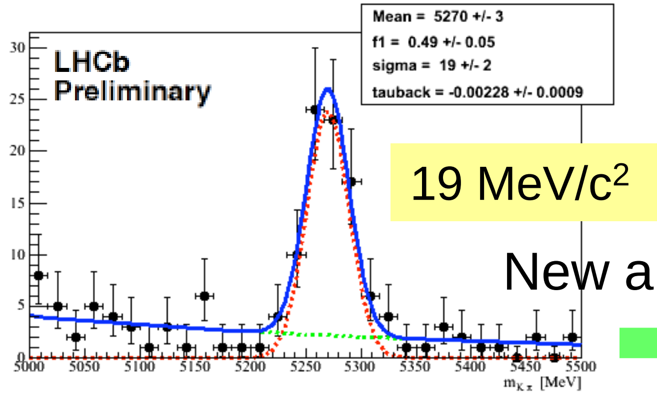
Mass resolution: J/ψ→μμ &Υ→μμ

- New alignment of all tracking system.
- Good improvement in momentum resolution for high momentum tracks and mass resolution.

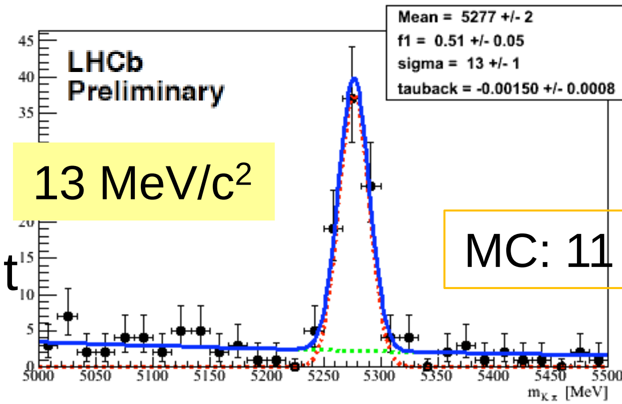


Mass resolution: $B^+ \rightarrow J/\psi K^+$

- Mass resolutions approaching MC expectations.

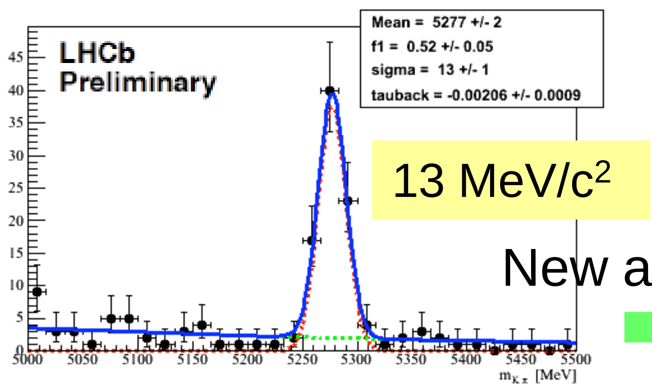


New alignment

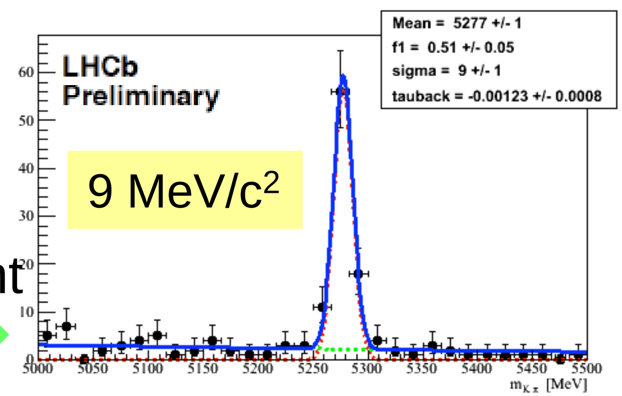


MC: 11 MeV/c^2

With J/ψ mass constraint:



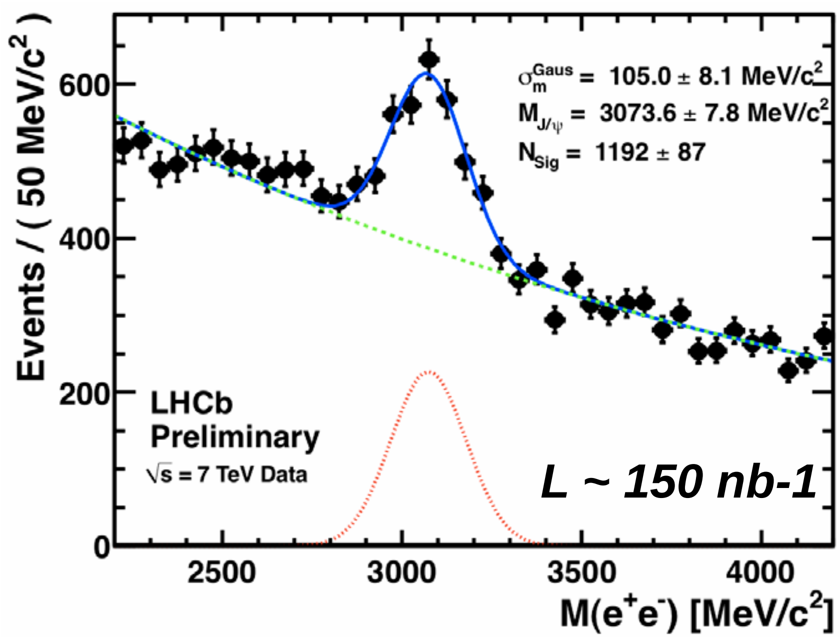
New alignment



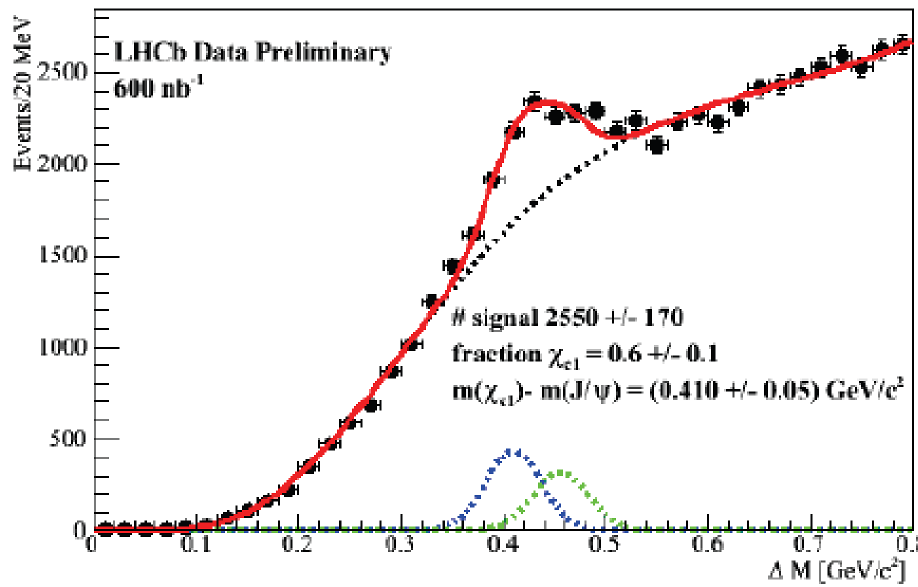
Calorimeter

- Refining calibration with converted photons and electrons.
- Promising new signal of of $\chi_c \rightarrow J/\psi\gamma$.

$J/\psi \rightarrow ee$

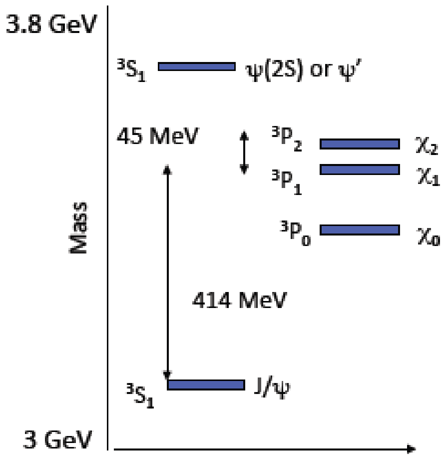


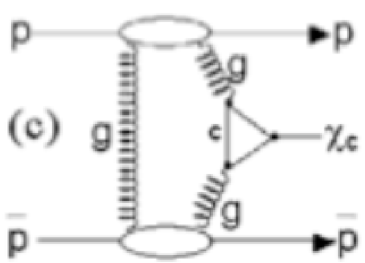
$\chi_c \rightarrow J/\psi(\mu\mu)\ \gamma$



ΔM = M (J/ψγ) – M(J/ψ)

$\chi_c \rightarrow J/\psi(\mu\mu)\ \gamma$

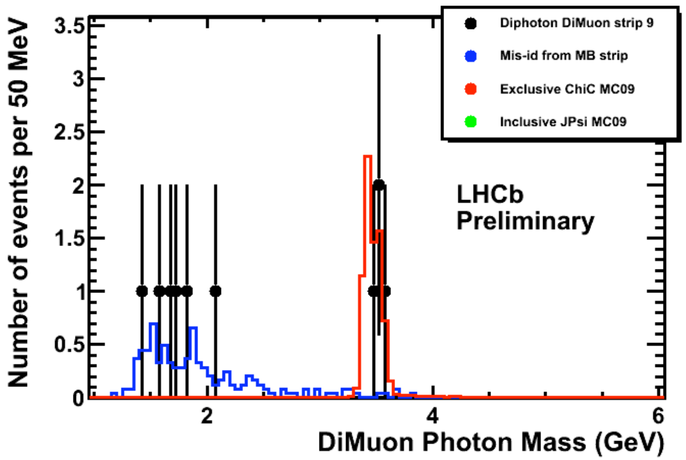


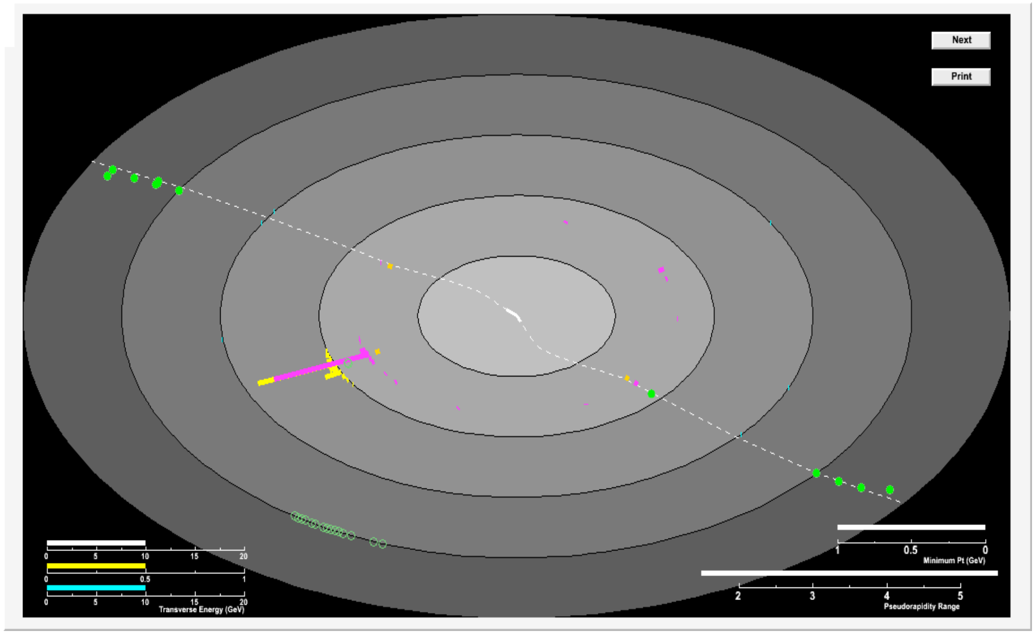


$\chi_c \rightarrow J/\psi\ \gamma$ also for physics studies:

- separation of different states.
- exclusive χ_c production

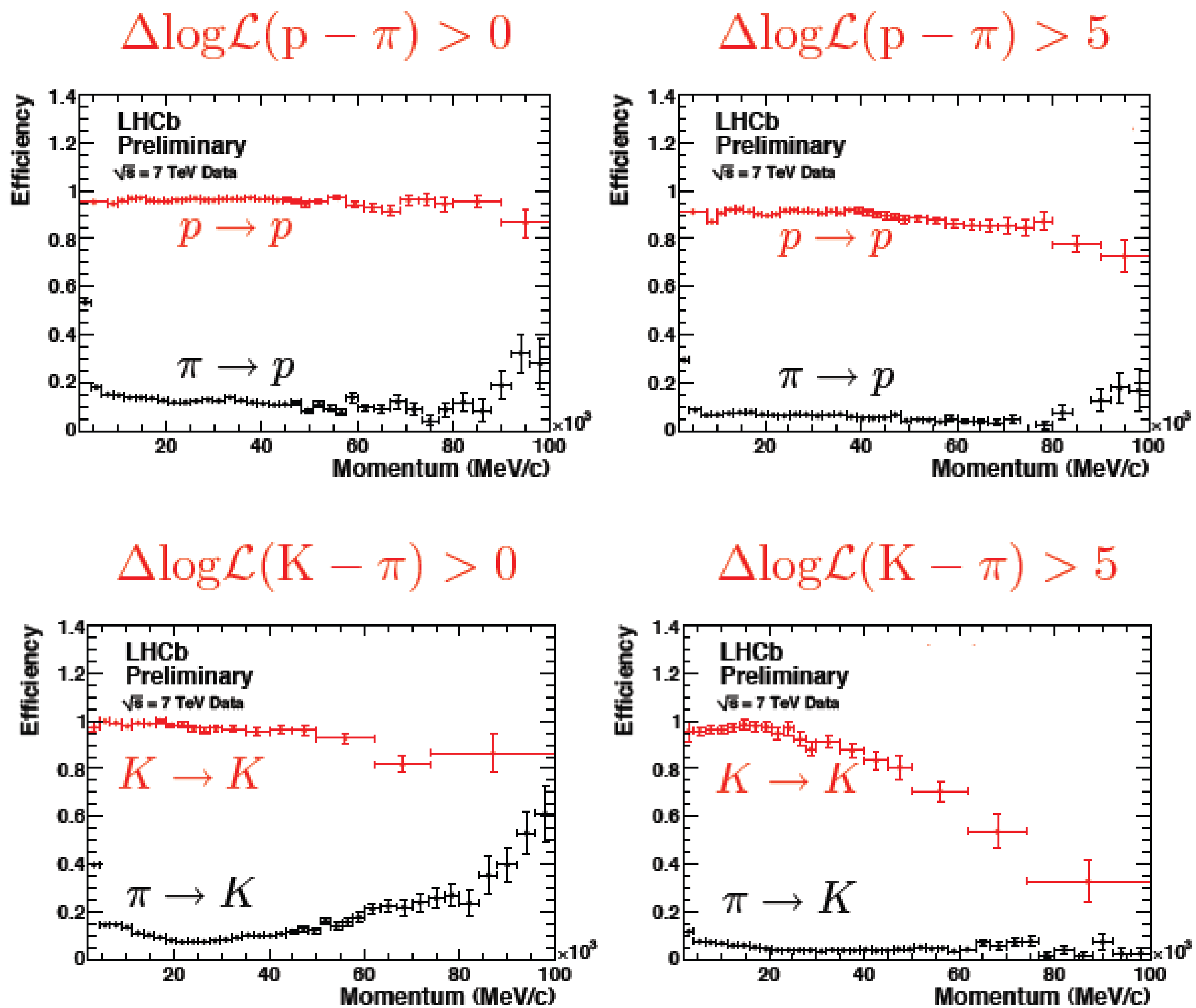
- Require SPD Mult <4 and 1 Photon





RICH

- PID performances measured on data with selected samples of π,K,p from $K_S \rightarrow \pi\pi$, $\Lambda \rightarrow K\pi$, $\phi \rightarrow KK$
- Performance at time of ICHEP



RICH: CK angle resolution

- Alignment of RICH1 and RICH2 mirrors progressing with data.
- New improvement in alignement of the photodetector silicon sensors.

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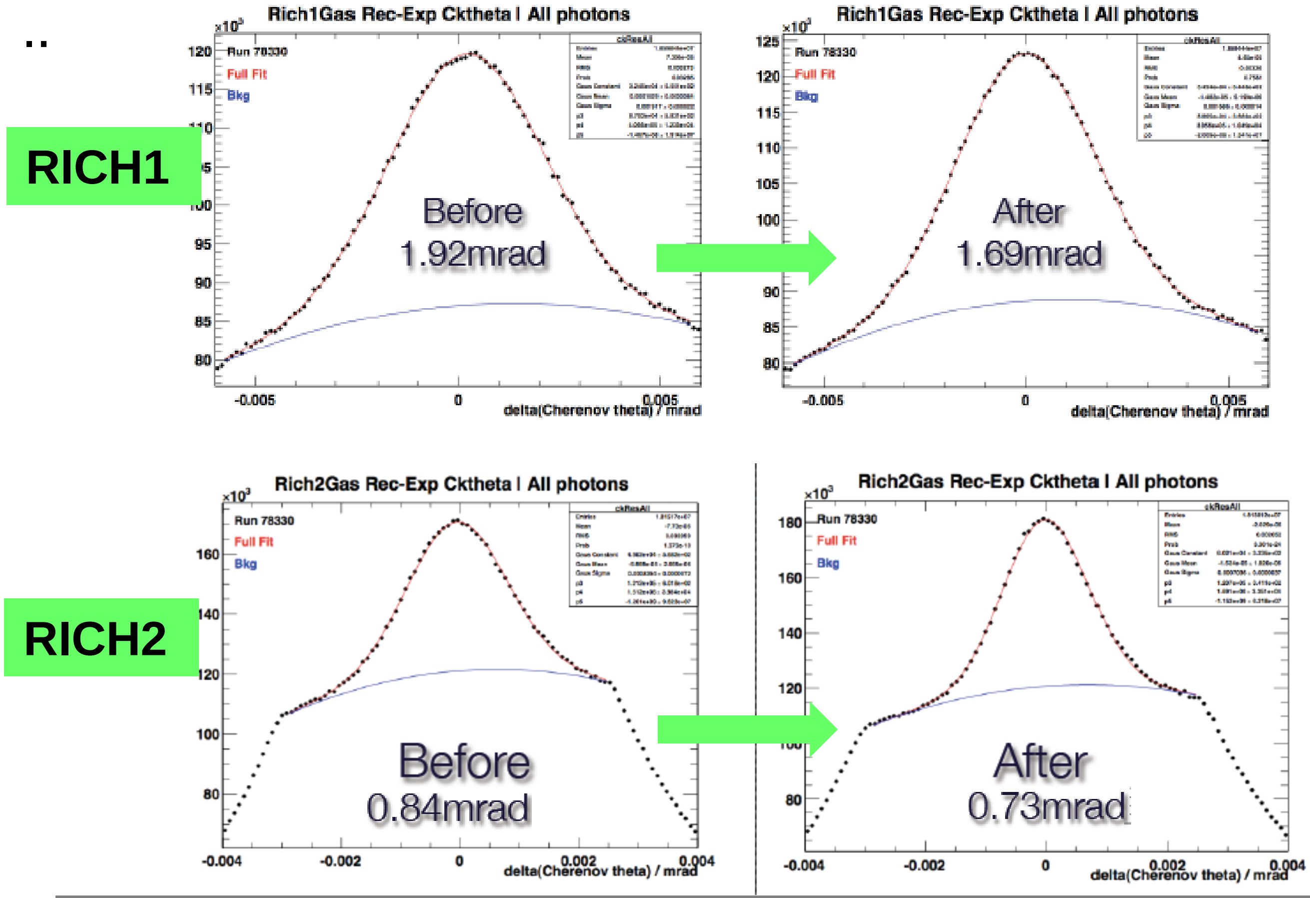


MC: 1.57 mrad

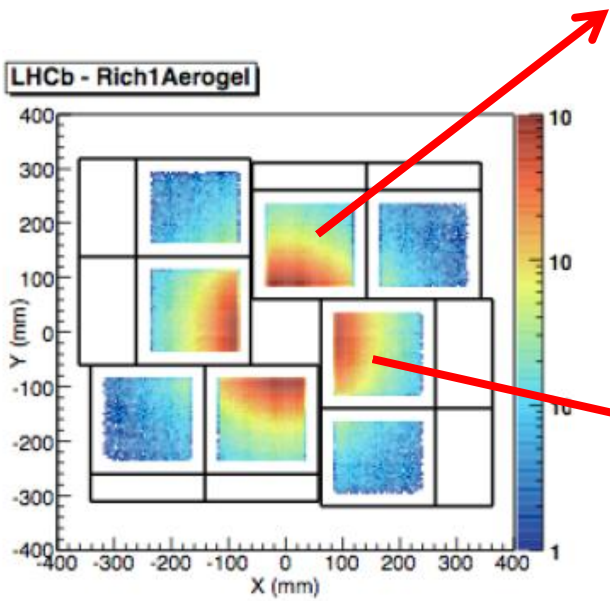
Good improvement on Cherenkov angle resolution

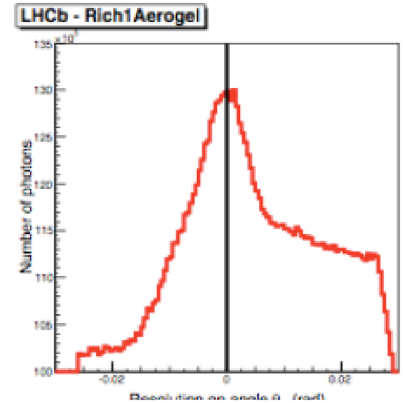
→ Will go into next processing

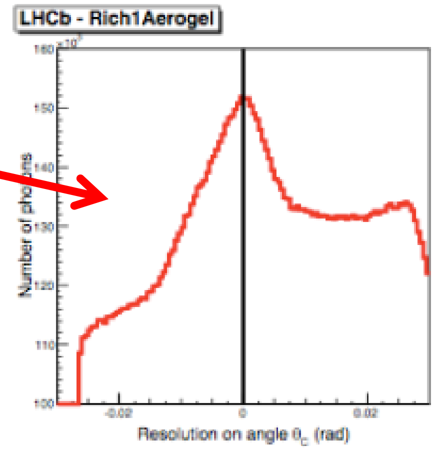
MC: 0.67 mrad

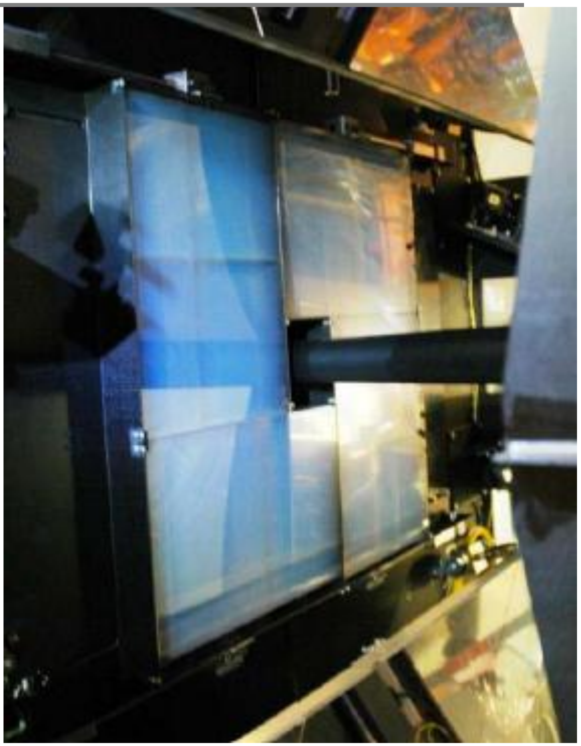
RICH- aerogel

- Areogel radiator made of 16 tiles.
- Need to calibrate refraction index tile by tile. Ongoing work.





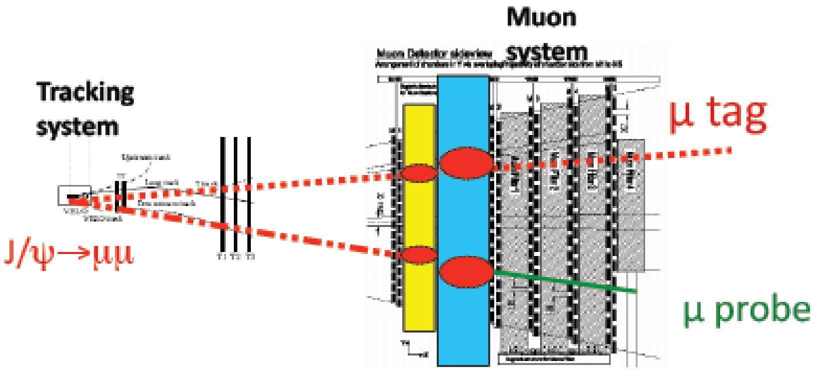




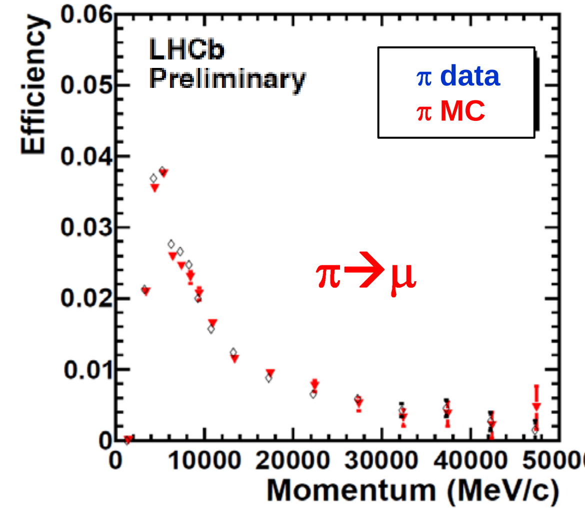
$\sigma_{\mathbf{FWHM}} \approx$ **3.5 - 4** mrad

Expected from Montecarlo = 2.6 mrad
(as quoted in JINST 3 S08005)

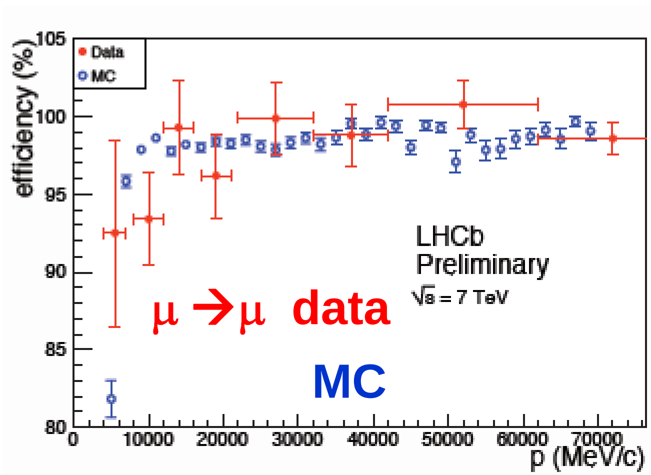
Muon ID



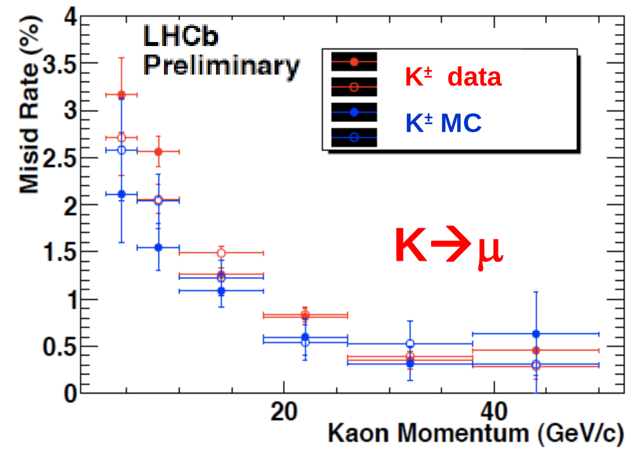
$K_S \to \pi\pi$



$J/\psi \to \mu\mu$



$\phi \to KK$



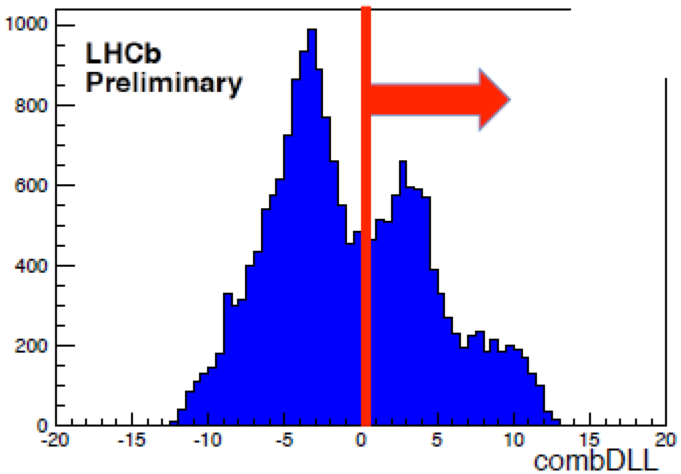
- Muon ID efficiency above 90% and mis-ID rate below 2% for p>10 GeV/c

Muon ID

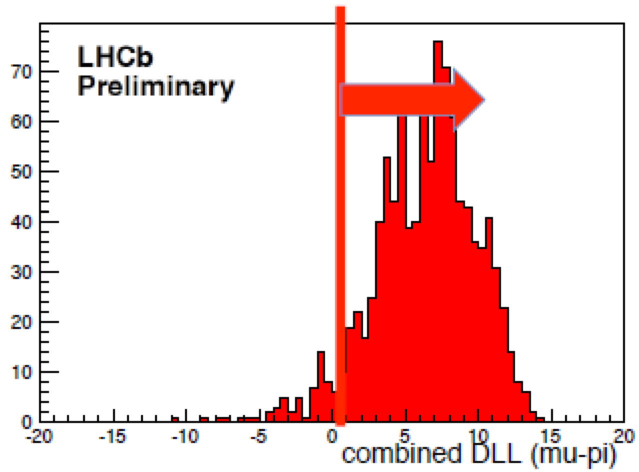
- Cut on global likelihood for muon vs pion hypotesis:

  reduce mis-ID of a factor about two with few percentage loss in efficiency. In agreement with MC expectations.

KS→ ππ: DLL (μ-π)

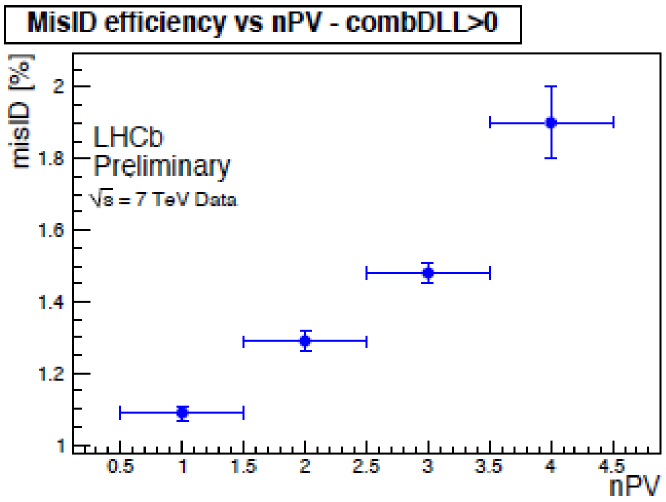


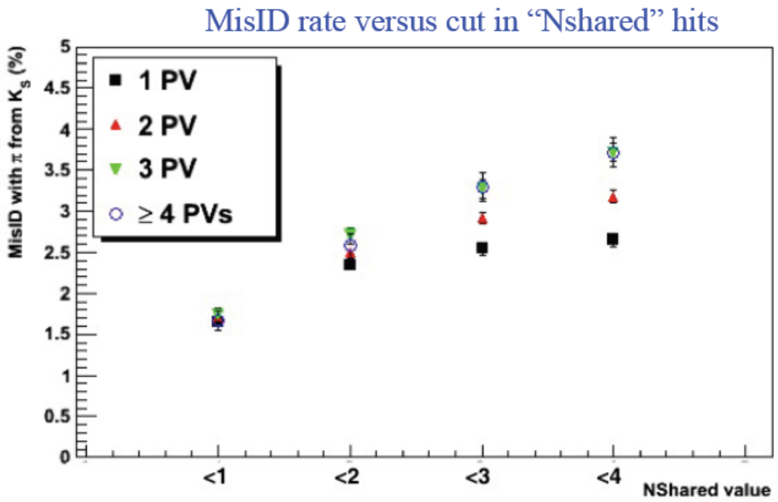
J/ψ→ μμ: DLL (μ-π)



Muon ID in multiple-collision

- Recent studies prove performance also in multiple-collision events.
- μID efficiency constant within few percent.
- The mis-ID increase can be controlled with a correct sharing of hits to closeby tracks

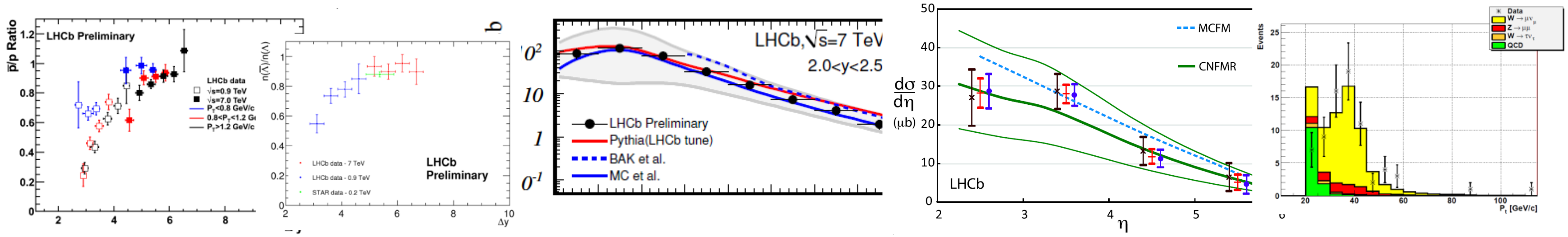




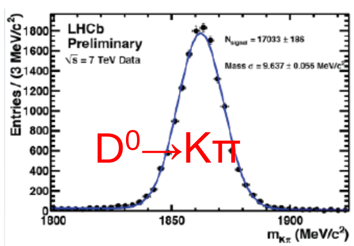
- Restriction on number of shared hits gives constant performance with number of interactions..

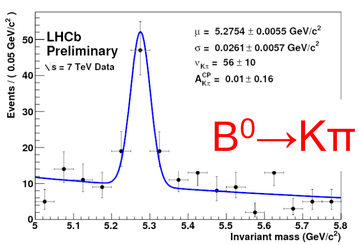
Analysis working for .....

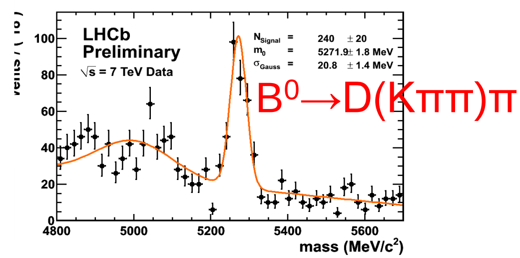
- Production: in mbias, J/ψ, open charm, beauty … EW



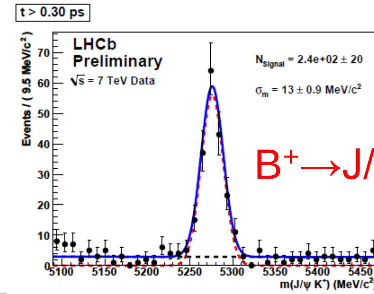
- Plenty of charm and first two/multibody hadronic B decays for CPV studies





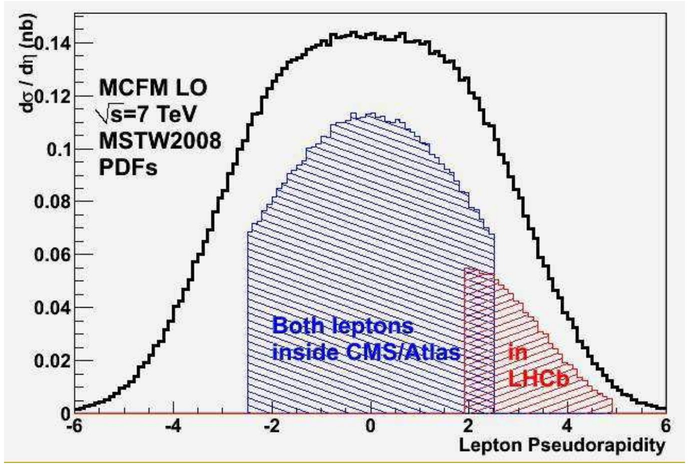


- Preparation for key measurements: $B_s \rightarrow J/\psi\phi$, $B_s \rightarrow \mu\mu$, $B_d \rightarrow K^*\mu\mu$

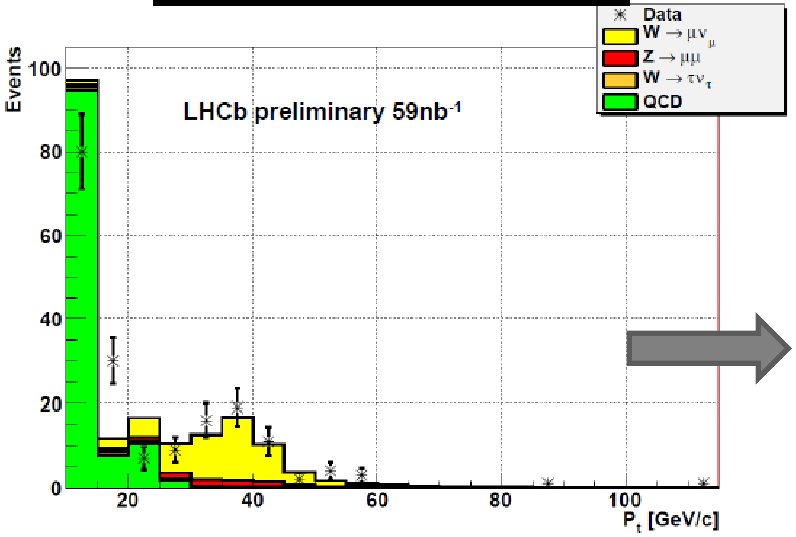


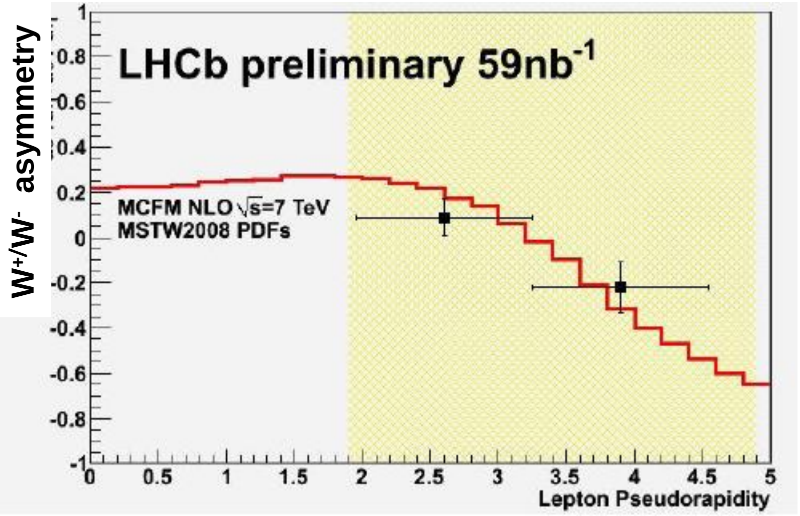
EW Physics at LHCb

- Unique LHCb η coverage, allows for interesting W,Z production studies
- First result: charge asymmetry in $W^{\pm} \rightarrow \mu^{\pm} \nu$ events



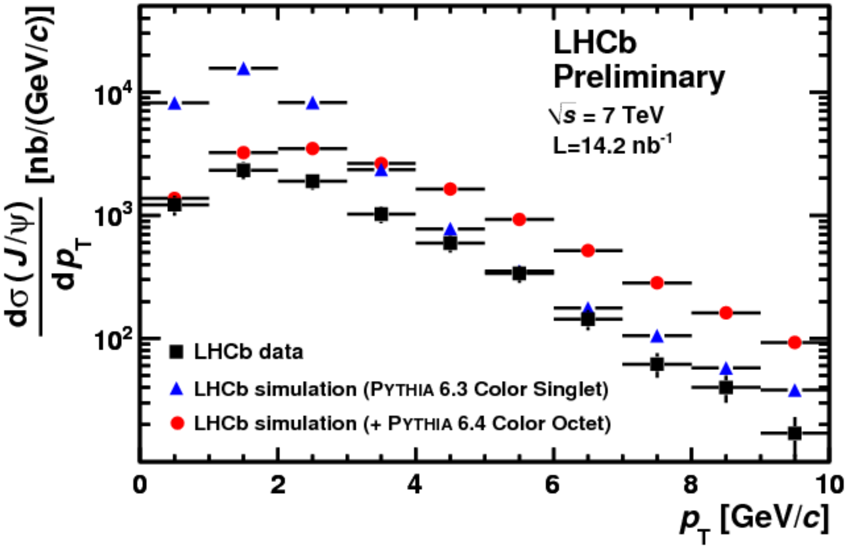
Muon pt spectrum





J/ψ→μμ production

- Preliminary cross section measurement with ~14 nb^{-1} (ICHEP):



- Scale and shapes not well described by colour singlet nor by octet models→ new studies are coming.

- Inclusive J/ψ production:

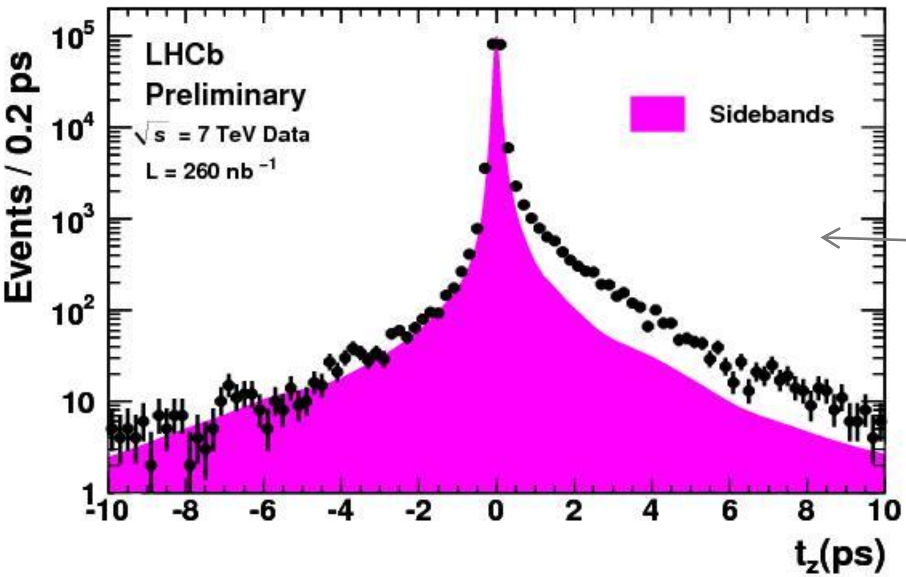
$\sigma(2.5<y<4, p_T<10\ GeV/c)=7.65\pm0.19\pm1.10^{+0.87}_{-1.27}\ \mu b$

polarization uncertainty

- J/ψ production from b:

$\sigma(2.5<y<4, p_T<10\ GeV/c)= 0.81\pm0.06\pm0.13\ \mu b$

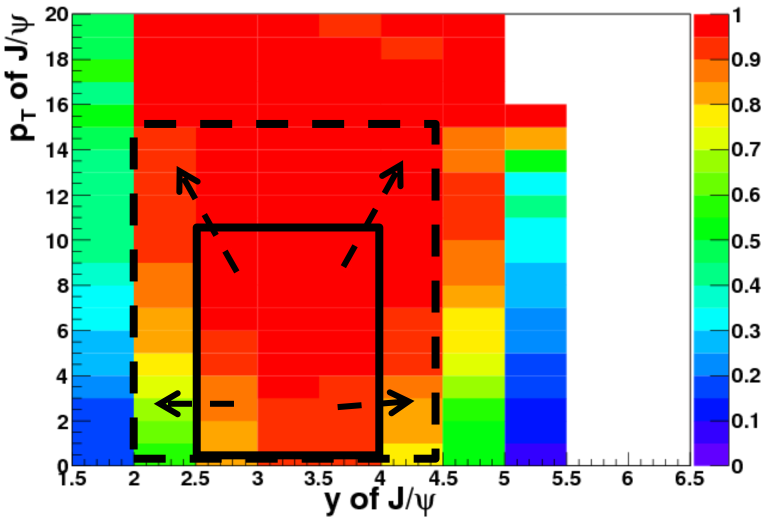
$J/\psi \rightarrow \mu\mu$ production



- Much more data since ICHEP several 100k events/pb^{-1}

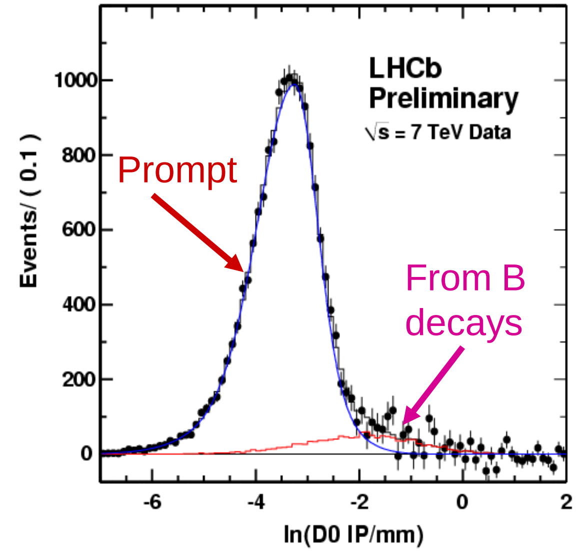
Pseudo propertime: $t_z = d_z\, M(J/\psi)/p_z$ used to separate prompt and J/ψ from b decays

- Will measure also polarization
- Region of measurement (y, p_T) will be extended with more data, will overlap with GPD.

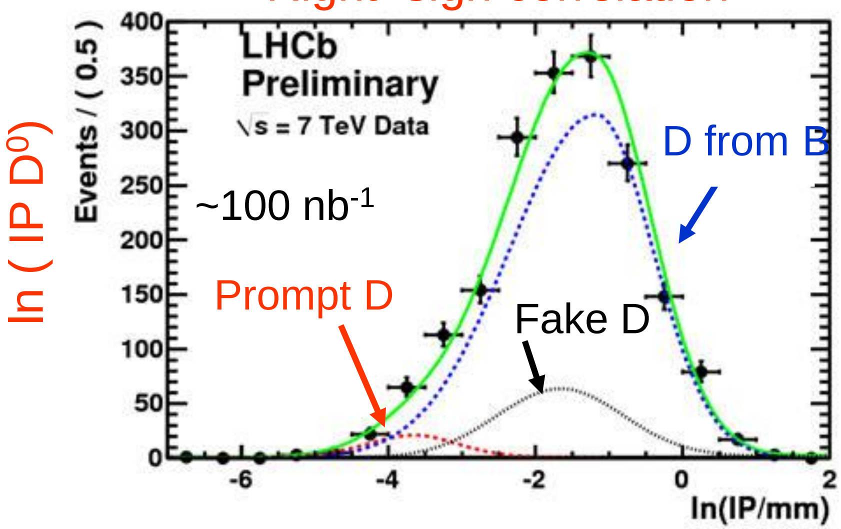


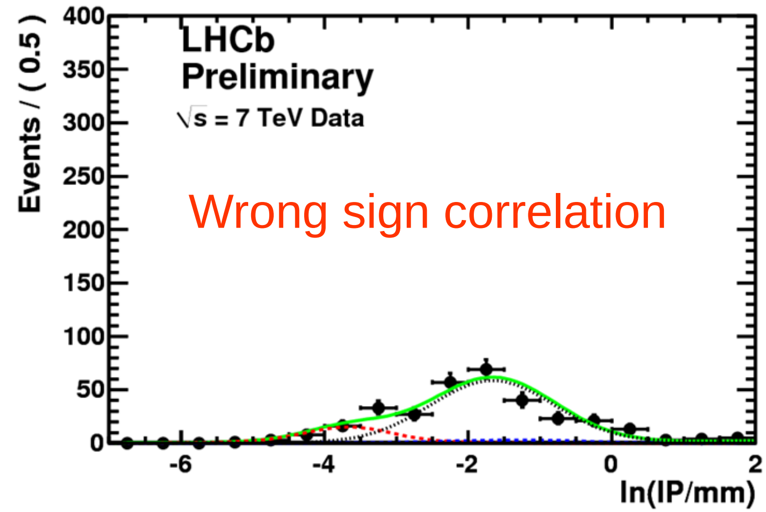
Beauty cross-section with B→$D^0\mu X$

- BR(b→ $D^0 \mu\nu X$) = 6.82±0.35 %
- Use impact parameter of D^0 direction w.r.t. primary vertex to separate D produced in B decays from prompt.
- Correlate the D^0 with a muon of a right (wrong) charge



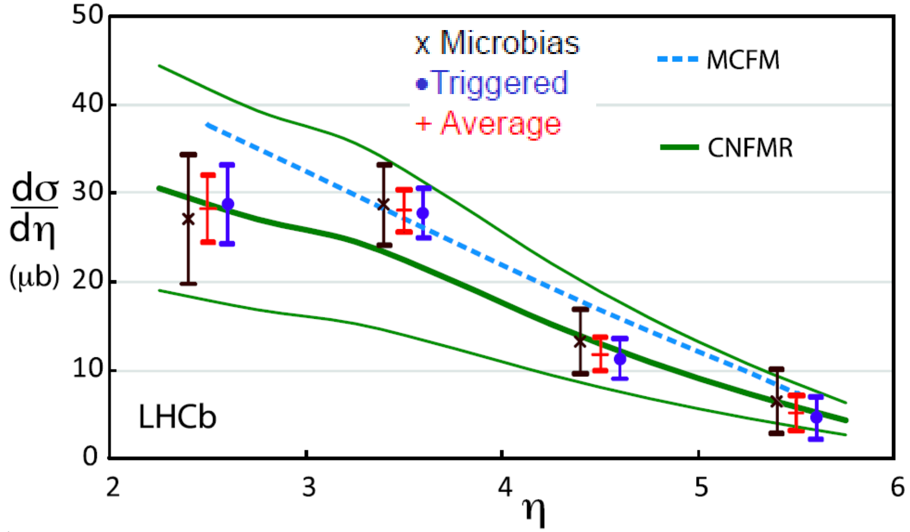
Right sign correlation





Beauty cross-section with $B \rightarrow D^0 \mu X$

Cross section in four η bins, open trigger (~3 nb^{-1}) and muon trigger sample (~12 nb^{-1}) submitted to PLB (arXiv:1009.2731)



Shapes and scales agree well with expectation. Validates QCD predictions at LHC energies

σ (pp→H_bX) = 75.3±5.4±13.0 μb for 2<η<6, any p_T, $\sqrt{s}$=7 TeV

Extrapolating to 4π with PYTHIA 6.4: **$\sigma(pp \rightarrow b\bar{b}X) = 284 \pm 20 \pm 49$ μb**

Averaging with prel. result from b→J/ψ: **$\sigma(pp \rightarrow b\bar{b}X) = 292 \pm 15 \pm 43$ μb**

Theory:
MCFM 332 μb,
NFMR 254 μb

→ b rate (at least) as high as assumed in LHCb sensitivity studies.

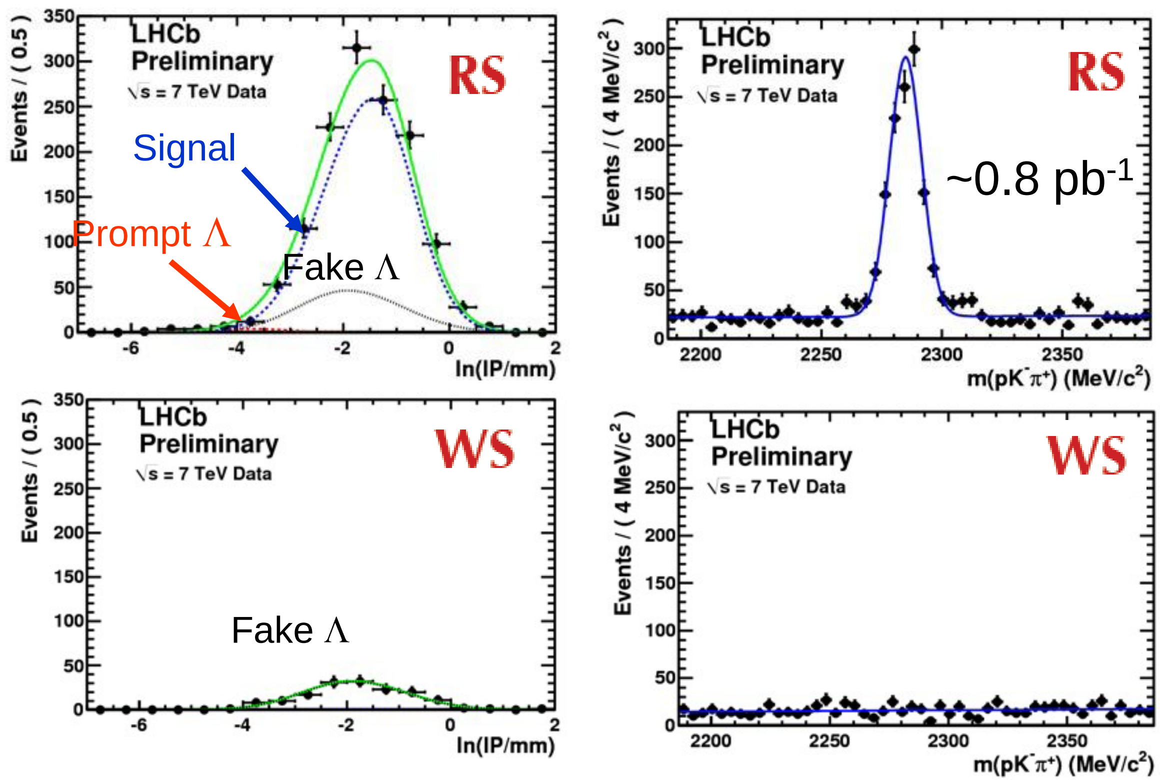
b→D$^0\mu$X future prospects

- Same technique can be exploited to reconstruct b →D^+,D_s,Λ_b μX decays.
- Give access to several b semi-leptonic measurements, like b-hadrons fragmentation fractions

Example:

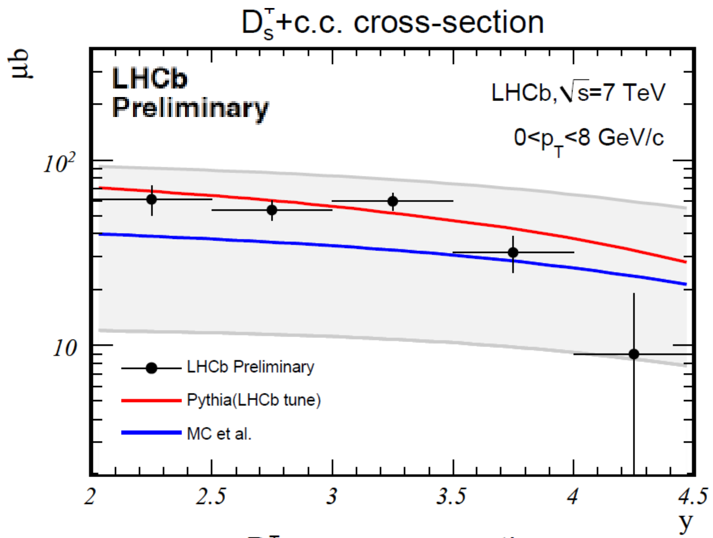
$\Lambda_b \rightarrow \Lambda_c\, \mu\, \nu X$

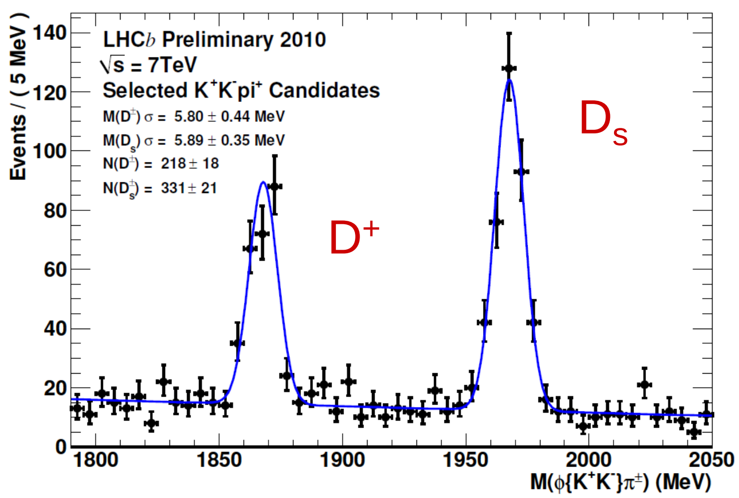
$\Lambda_c^+ \rightarrow p^+K^-\pi^+$ (BR=5.0±1.3%)

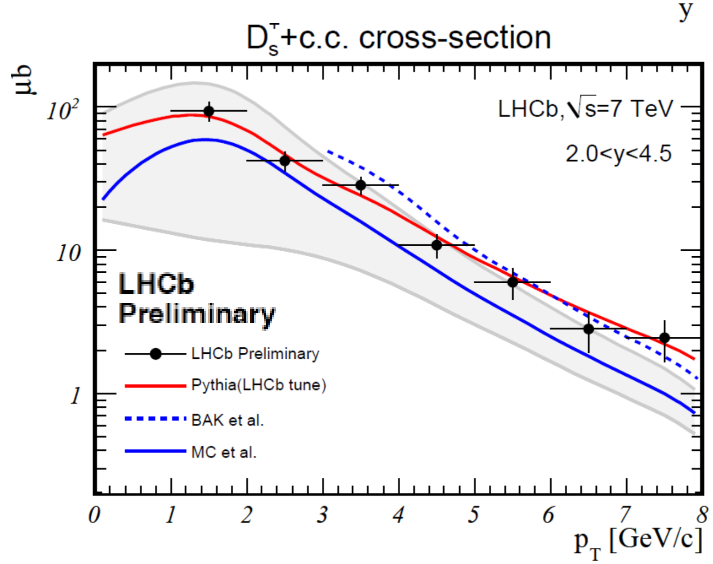


Open charm (D^0,D^*,D^+,D_s) cross-sections

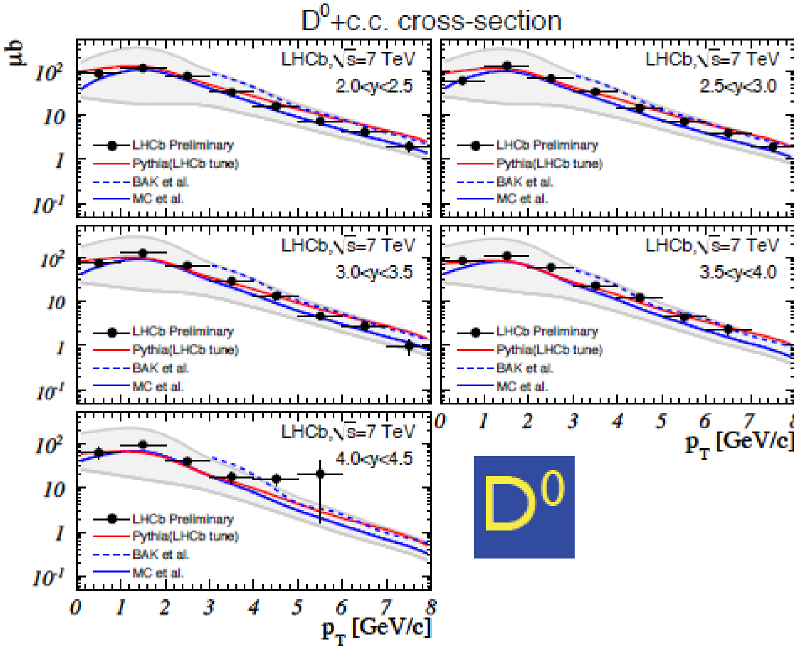
- First measurement at $\sqrt{s}$=7 TeV.
- Measure cross section vs y, p_T in ~2 nb^{-1}, with open trigger.
- Impact parameter distribution used to separate prompt $D^{0,+}$,D^+, D_s from secondary.
- Good agreement with expectations!

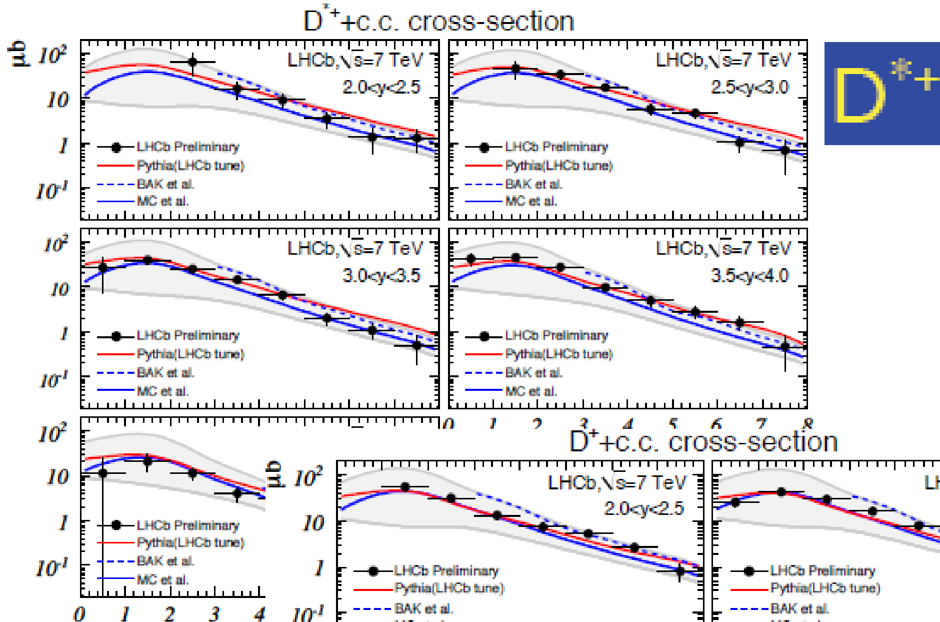


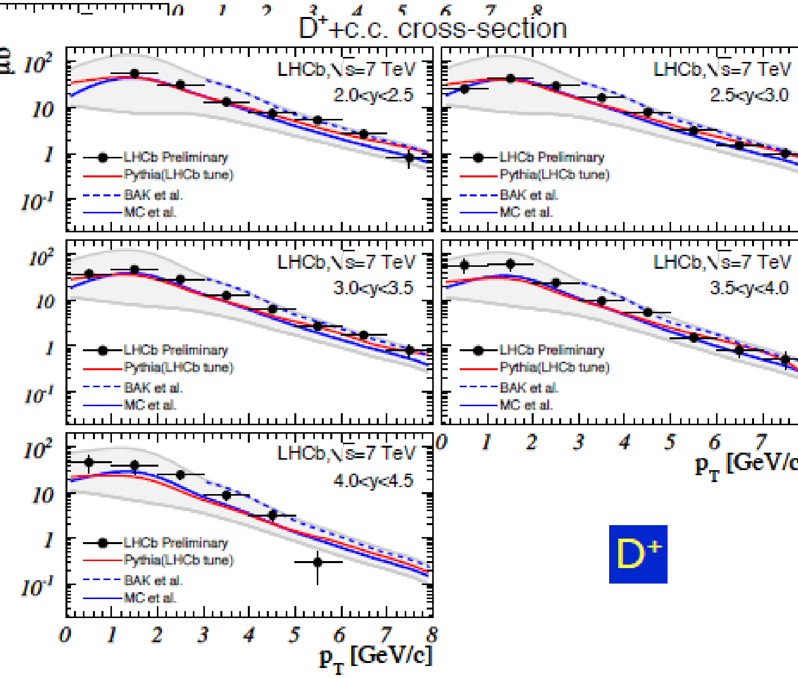




Open charm cross-sections







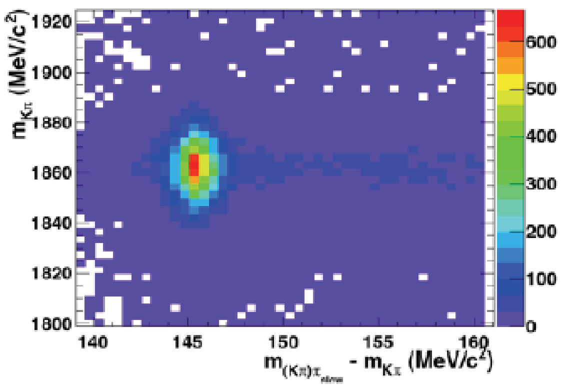
Extrapolating to all p_T and 4π can also confirm the expectation on ratio at $\sqrt{s}$=7TeV

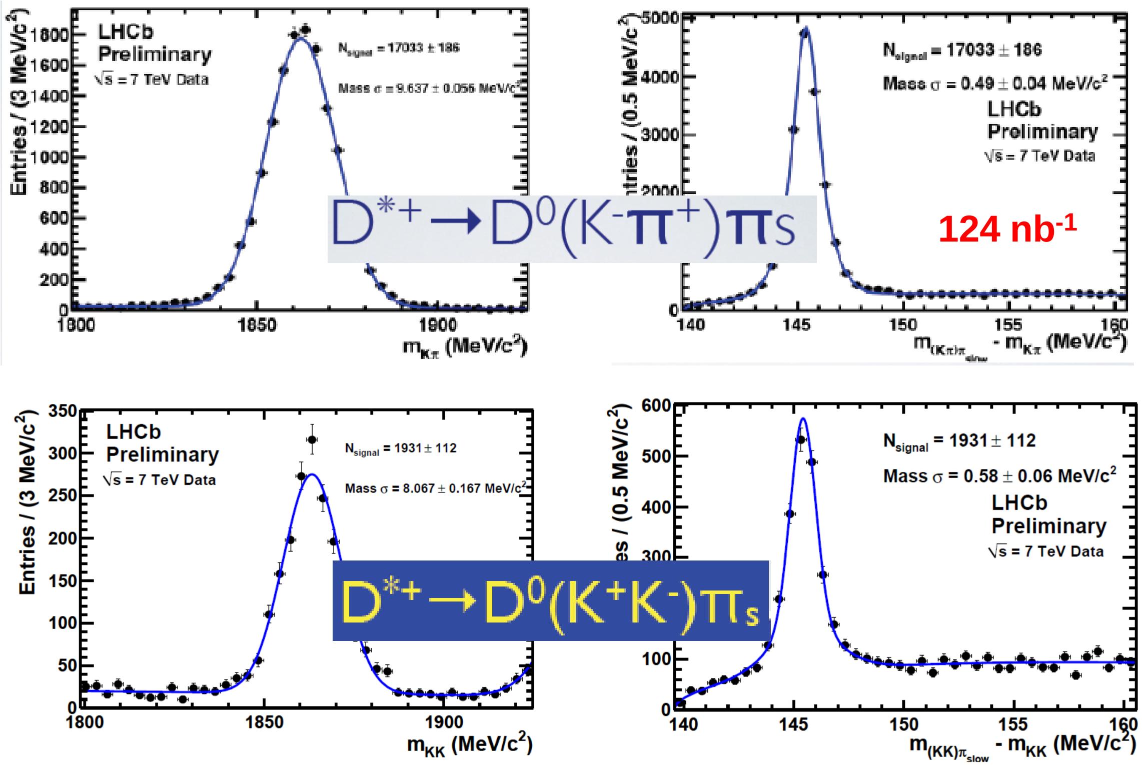
$$\sigma(pp\to c\bar{c}X) \approx 20 \times \sigma(pp\to b\bar{b}X)$$

→ Good news for LHCb charm program

2 body charm for mixing and CPV

- Collecting large samples of $D^* \rightarrow D^0\pi$ tagged events in $D^0 \rightarrow K\pi$, KK, $\pi\pi$



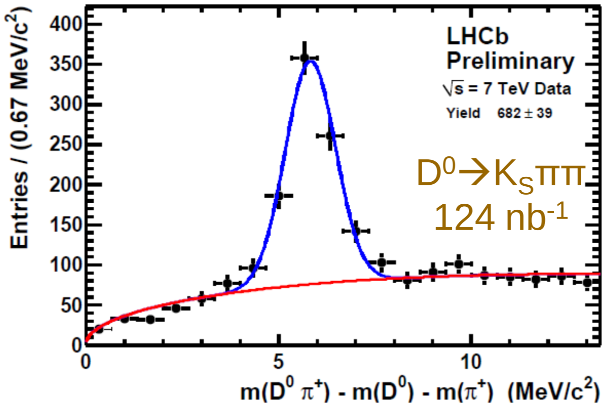


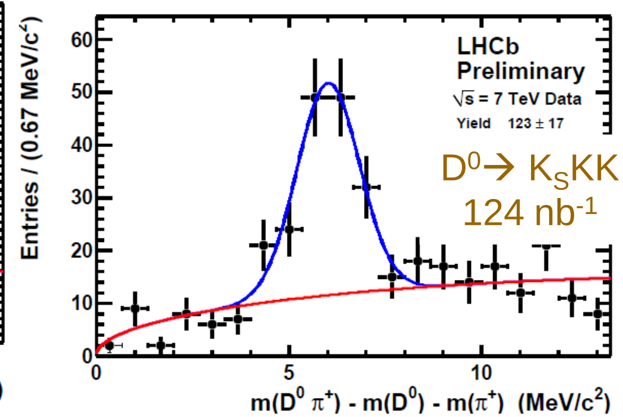
- Should surpass B-factory yield in 2010.

- Immediate opportunity to probe for finite CPV in D^0 mixing at new sensitivities. A crucial test of the SM vs New Physics.

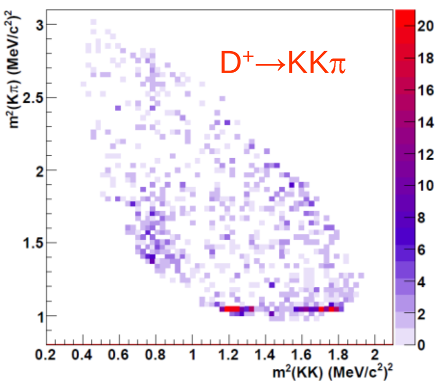
Charm mutibody for Dalitz analysis

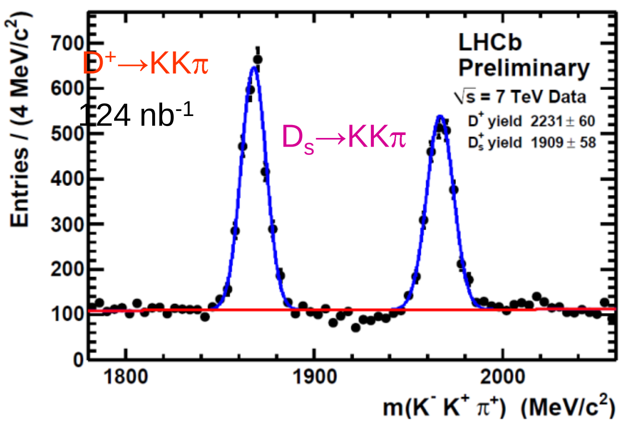
D→$K_s$hh for mixing and CPV

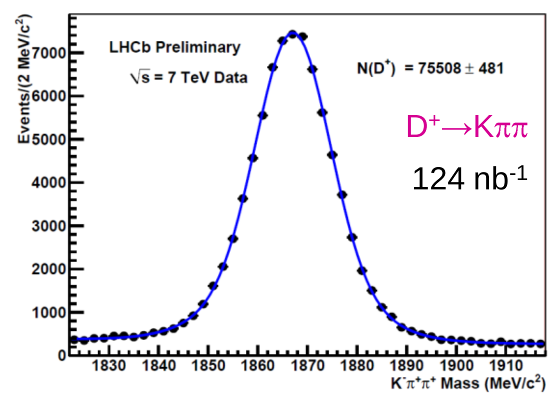




D→KKπ for direct CPV



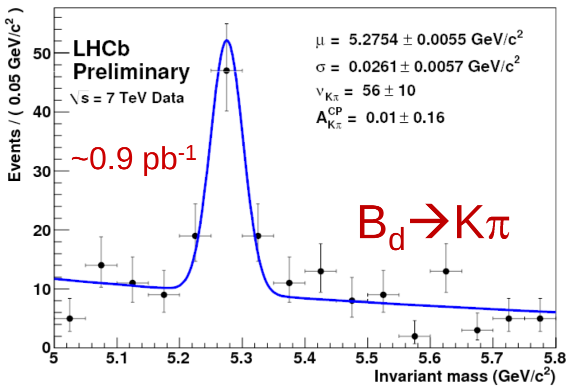


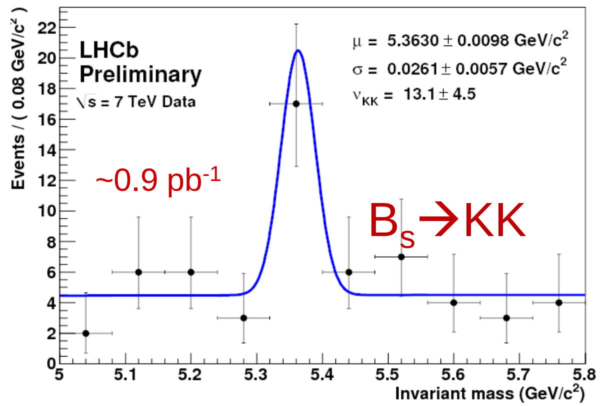


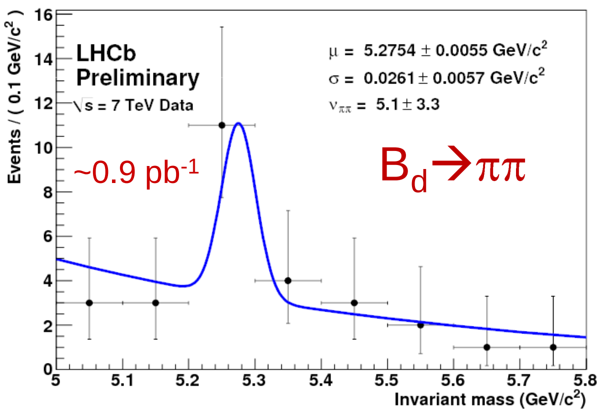
- $D^+ \to K^+K^-\pi^+$ with $D_s^+ \to K^+K^-\pi^+$ & $D^+ \to K^-\pi^+\pi^+$ as control channels. Expect in 2010 order of magnitude increase in statistics wrt published yields.

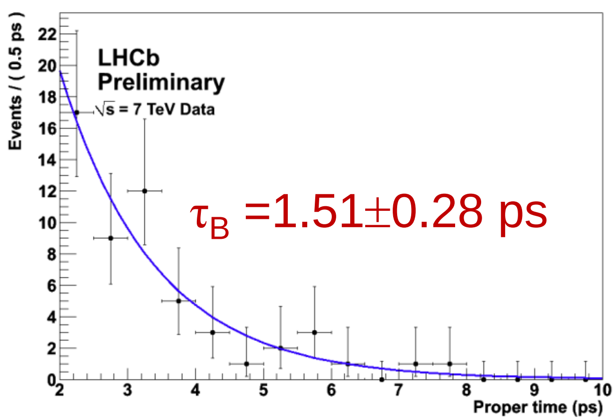
$B_{(s)} \rightarrow K\pi, KK, \pi\pi ...$

- Two body charmless B decays are core to LHCb programme: γ angle, loop effects etc.
- Crucial use of PID from RICH and very good mass resolution.





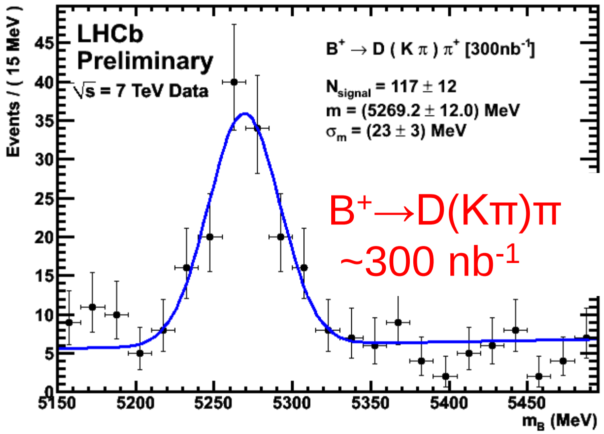


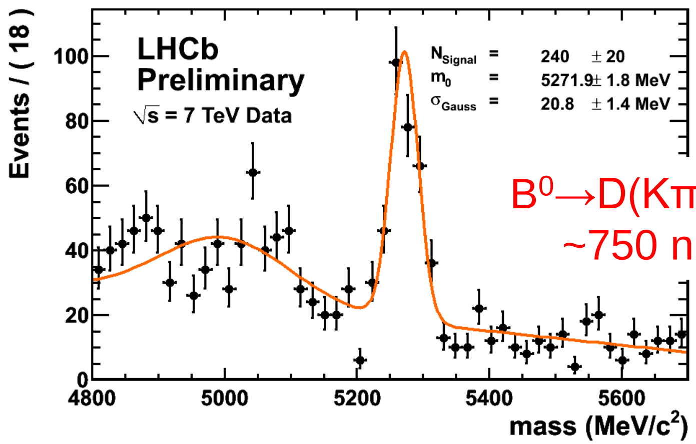


Yields so far ~match expectations. In 2011 running will get largest world samples both in B^0 and B_s.

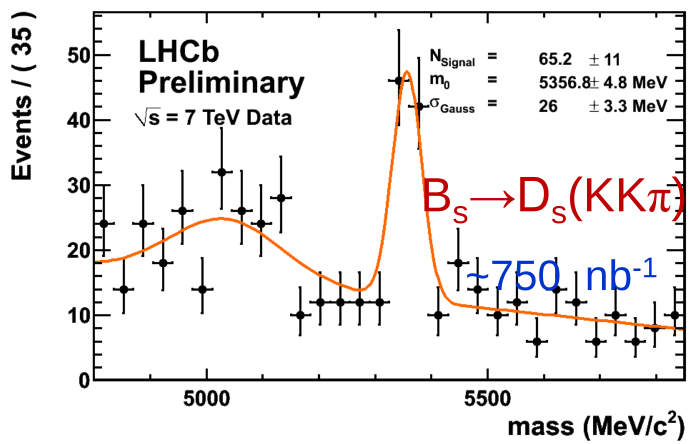
Beauty multibody final states

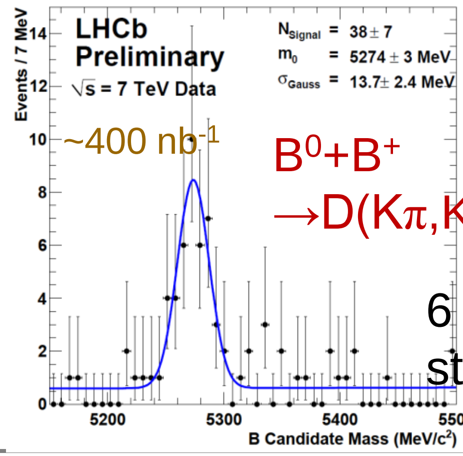
On the road for tree level γ measurement: many channels and strategies will give a complete picture. Trigger and tracking performing well.





Clean samples with high S/B



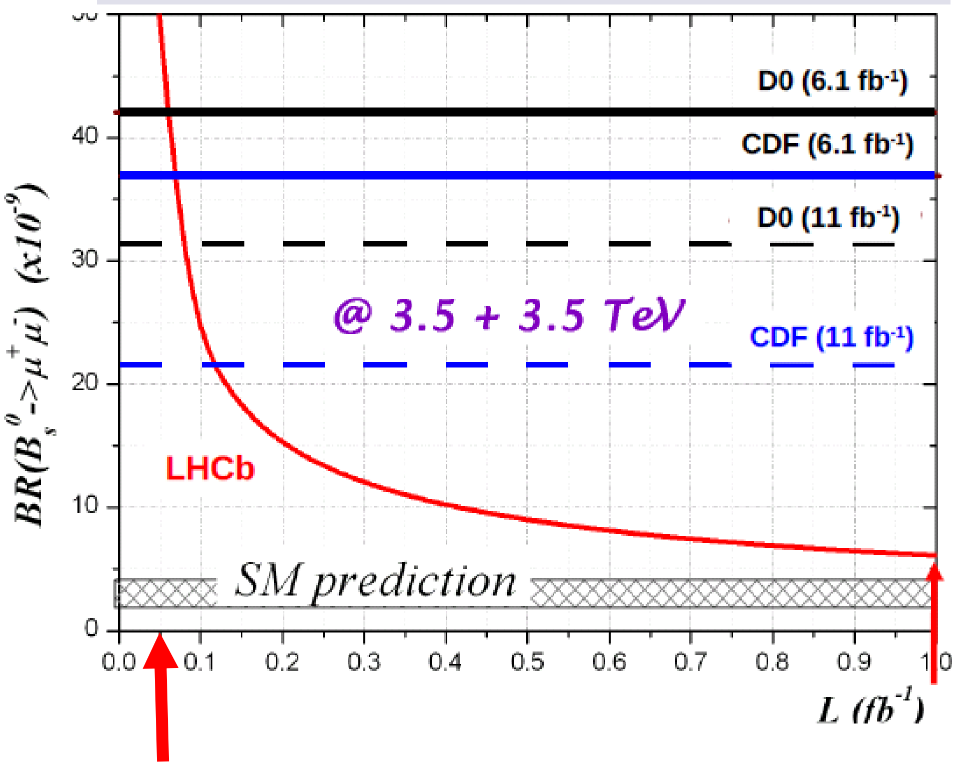


6 track final state !

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

Very rare decay in SM, well predicted BR($B_s \rightarrow \mu\mu$) =(3.35 0.32) x10^{-9} .

Exclusion limit at 90% CL at $\sqrt{s}$=7TeV



- Sensitive to NP, in particular new scalars.

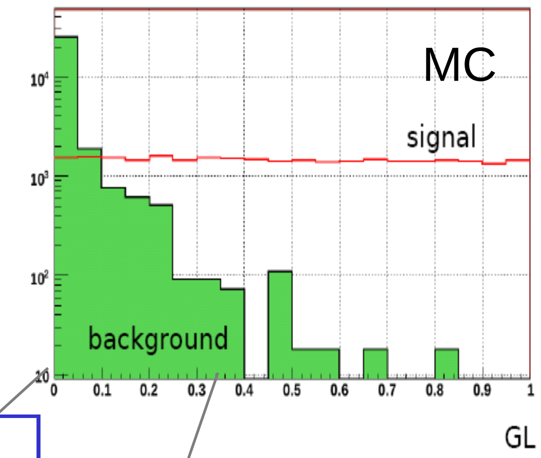
  In MSSM: BR $\propto \tan^6\beta / M_H^2$

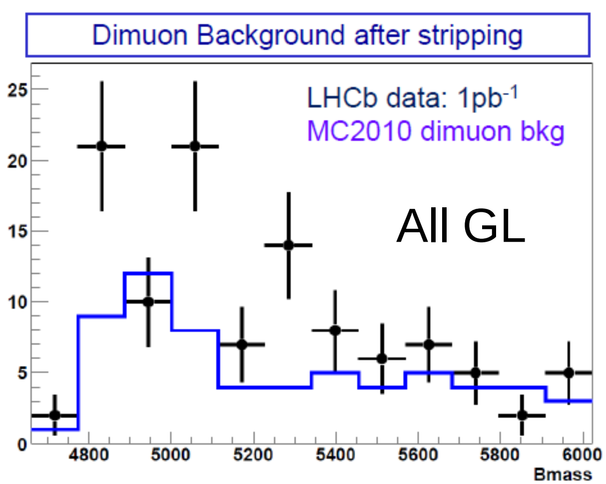
- Sensitivity from MC assuming measured $b\bar{b}$ cross-section
- Expectation being confirmed by tests on data.

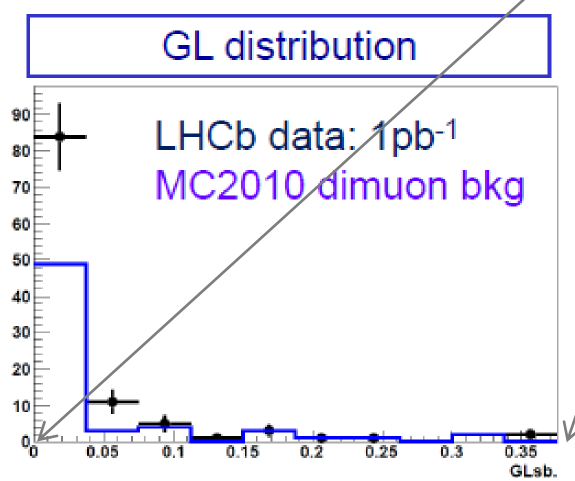
approaching new limit possible already with 50 pb^{-1}

$B_s \rightarrow \mu\mu$: prospects from data

- Mass resolution measured on B→hh now 26 MeV/c²: getting closer to MC expectation (22 MeV/c²).
- IP resolution approaching MC at high p_T.
- Geometrical Likelihood for B/S separation (combining geometrical, kinematic quantities) :
  - → no excess of background in signal region.

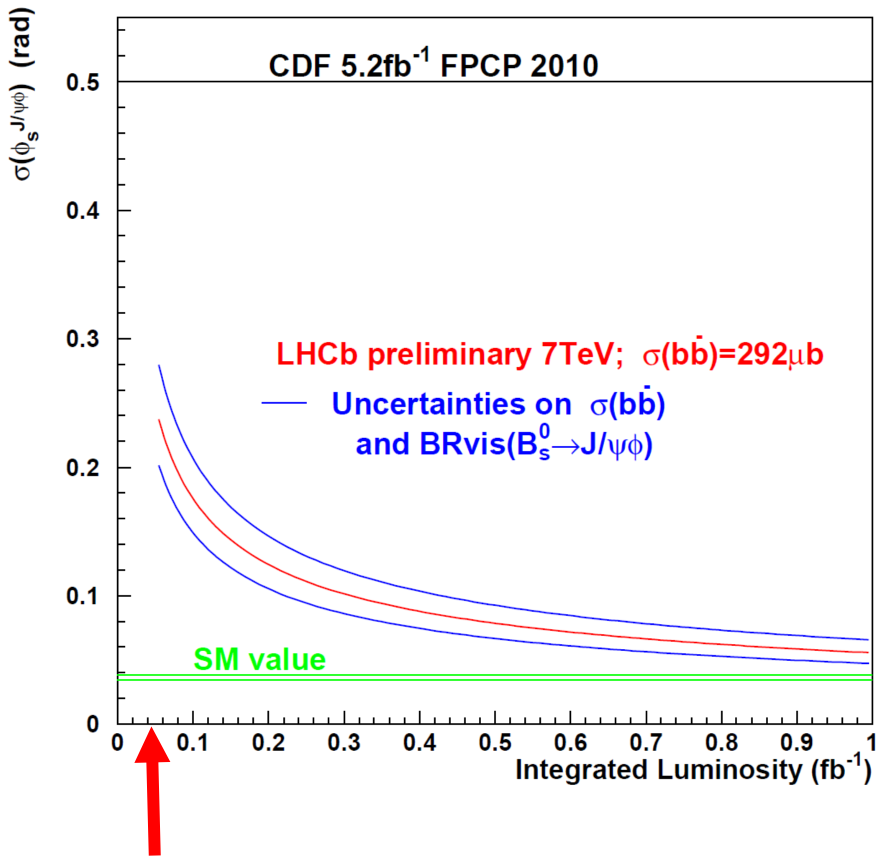






Prospects for CPV in $B_s \rightarrow J/\psi\phi$

Expected sensitivity

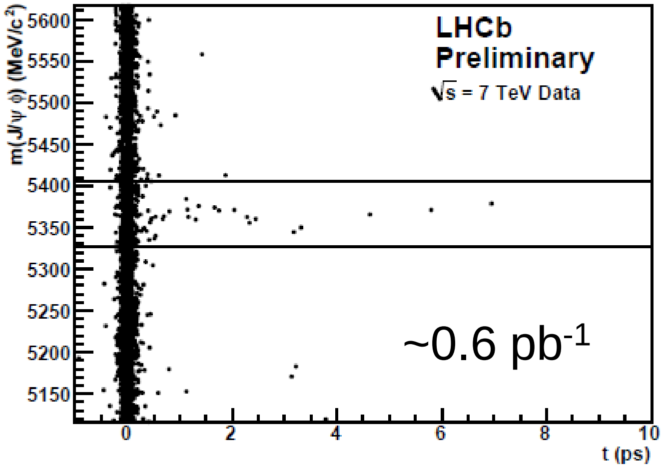


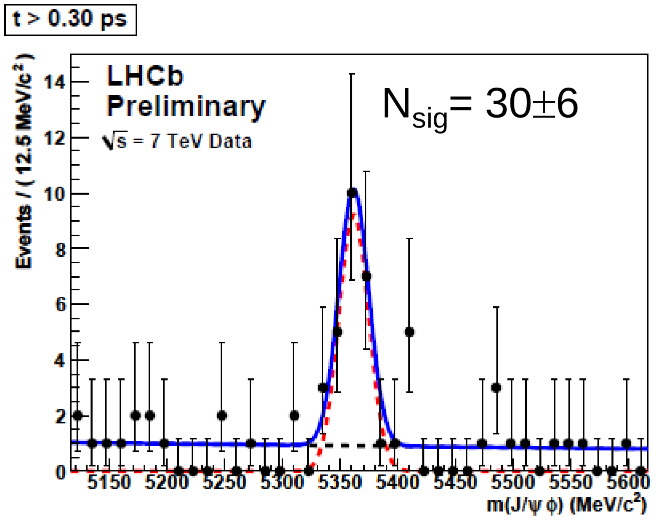
Working on data:

- Signal yield, mass and propertime resolution
- Control channels: preparing auxiliary measurements on $B \rightarrow J/\psi X$
- Flavour Tagging

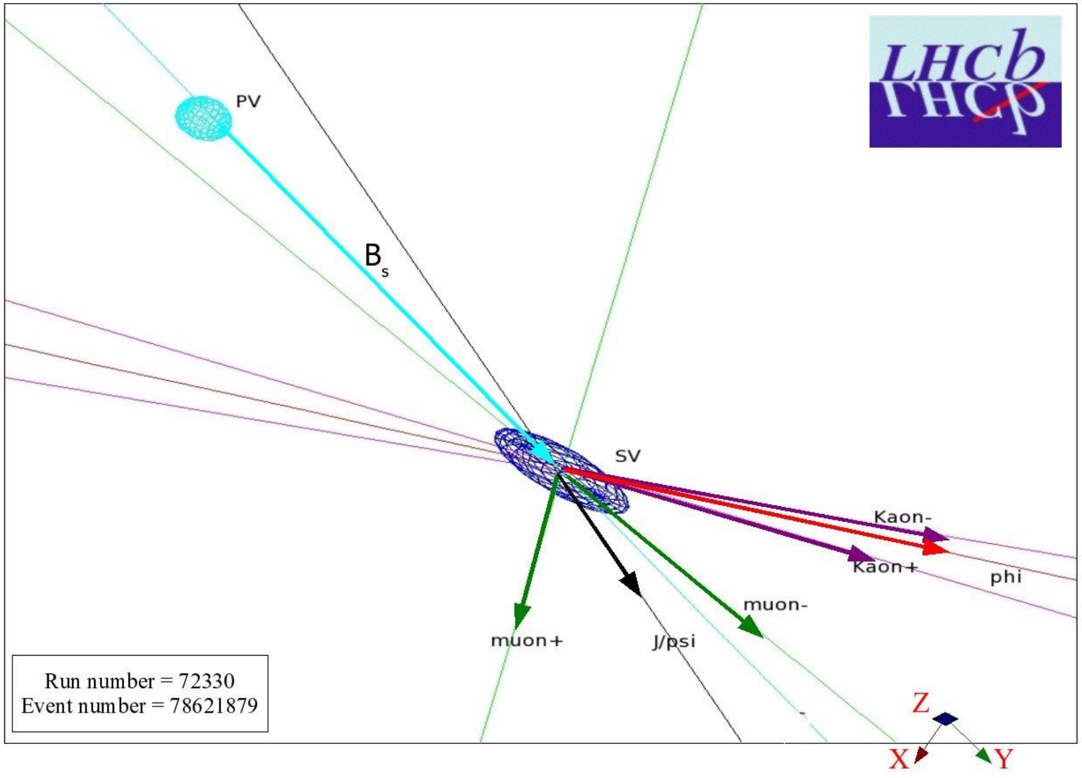
First result possible already with 50 pb^{-1} data

$B_s \rightarrow J/\psi\phi$: prospects from data



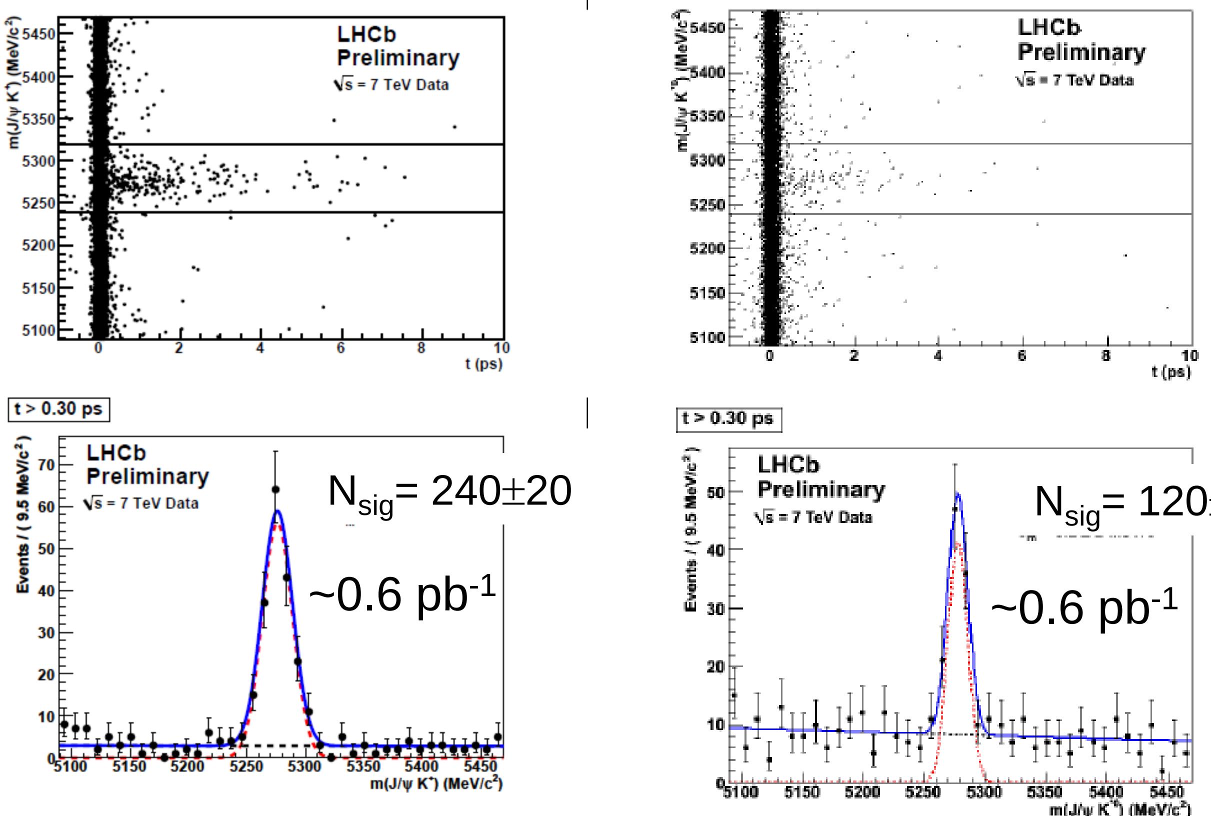


- Signal yield in ≈ agreement with expectation.



$B^+ \to J/\psi K^+$ and $B^0 \to J/\psi K^*$

$J/\psi K+$

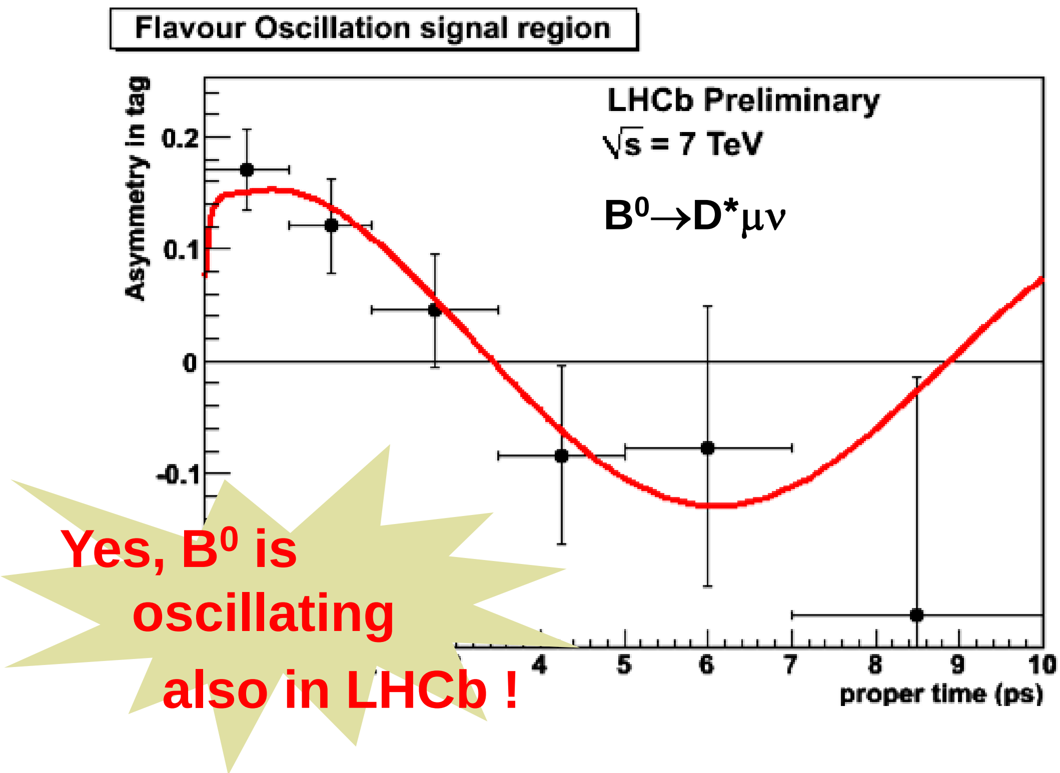


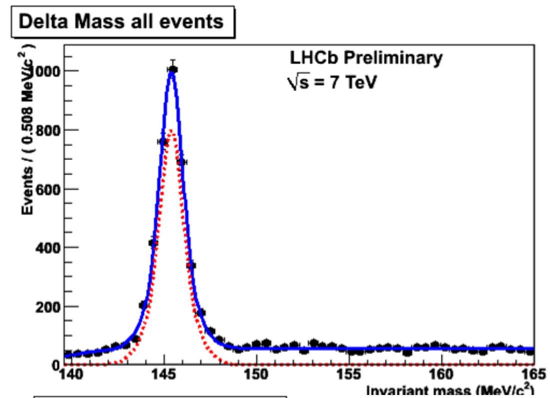
$J/\psi K^*$

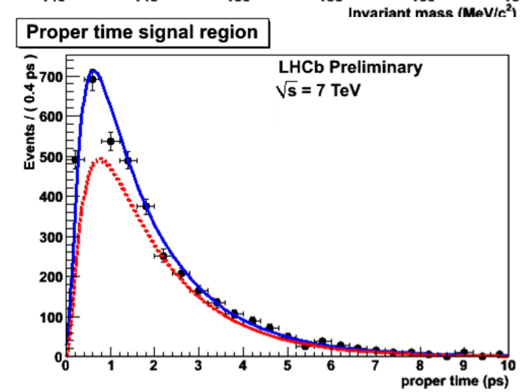
- Rate as expected.
- Propertime resolution not yet as in MC. Expect ~50 fs with new alignment Still very good for B_s physics (would give a ~20% decrease in sensitivity).

Flavour tagging

- First signal of flavour oscillation from $B^0_d \to D^{*-}(D^0\pi^-)\mu^+\nu$ events .







- “Out of the box” un-calibrated tagging performance (algorythm tuning, tagger combination etc..) already at 60% of expected performance.

Conclusion

- Detector is working very well !
- First important physics results emerging, many more studies underway with present data on production, minimum bias and electroweak.

- With ≈ 50 pb^{-1} hope to approach or surpass world best sensitivity in:
  - Search for super-rare $B_s \to \mu\mu$
  - CP-violation in B_s system, e.g. $B_s \to J/\psi\phi$
  - Search for CPV in D^0 system.

clear opportunity to enter a new regime in Discovery Physics with 2010 run!

- We are successfully operating in pile-up conditions beyond our design values. Challenge is even greater because we are determined to exploit LHCb fully for charm (as well as for beauty) physics !