Electroweak and QCD measurements @ LHCb

2nd International Conference on Particle Physics, Istanbul

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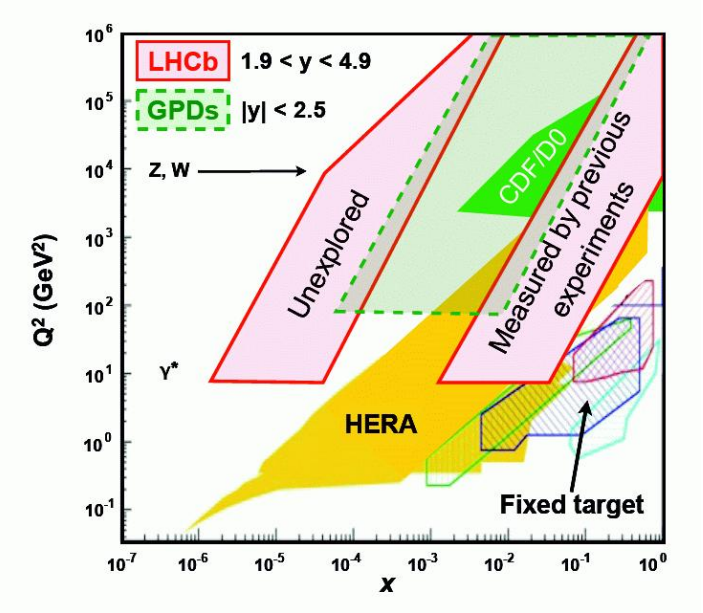
NIKHEF

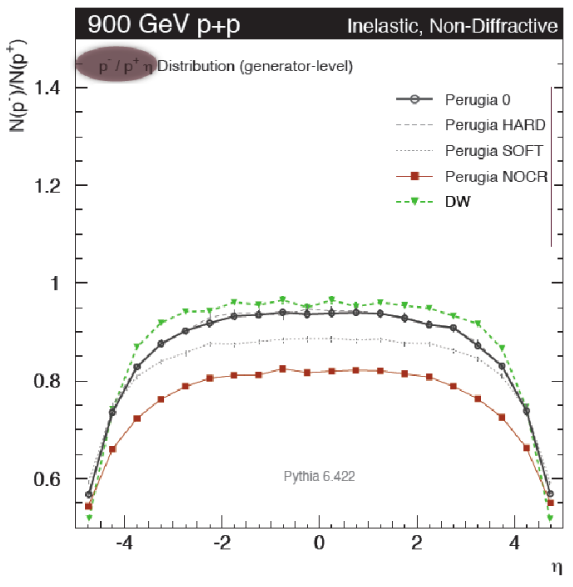
June 20th-25th, 2011

On behalf of the LHCb collaboration

Introduction

- LHCb experiment is fully instrumented over a unique region of pseudo rapidity at LHC ($2 < \eta < 5$).
- Probe large-x high Q^2, small-x high Q^2.
- W and Z production measurements.
- Forward region is also interesting for testing particle production in MC models.





P. Skands http://home.fnal.gov/~skands/

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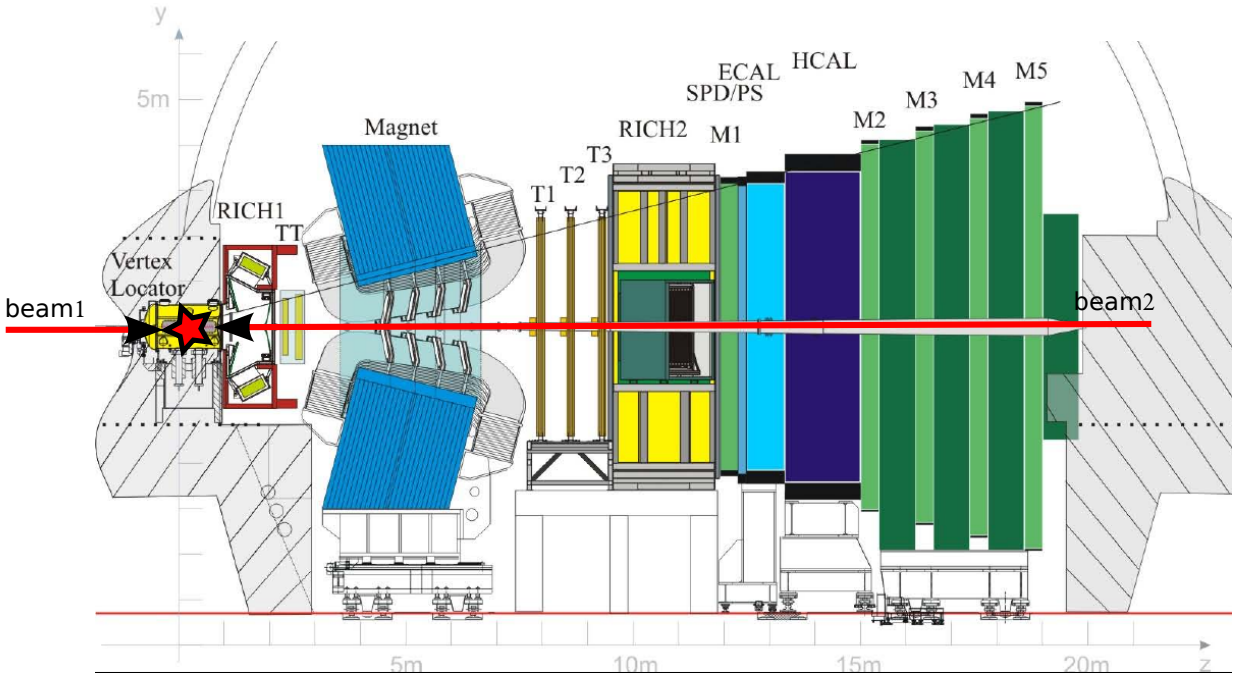

- Designed for CP violation studies in B decay and rare decays.
- Single arm spectrometer, 40% of $b\bar{b}$ pairs produce in the acceptance.
- Collision at $\sqrt{s} = 900GeV$ ($\sim 0.3nb^{-1}$) in 2009 and $\sqrt{s} = 7TeV$ ($\sim 35pb^{-1}$) in 2010.

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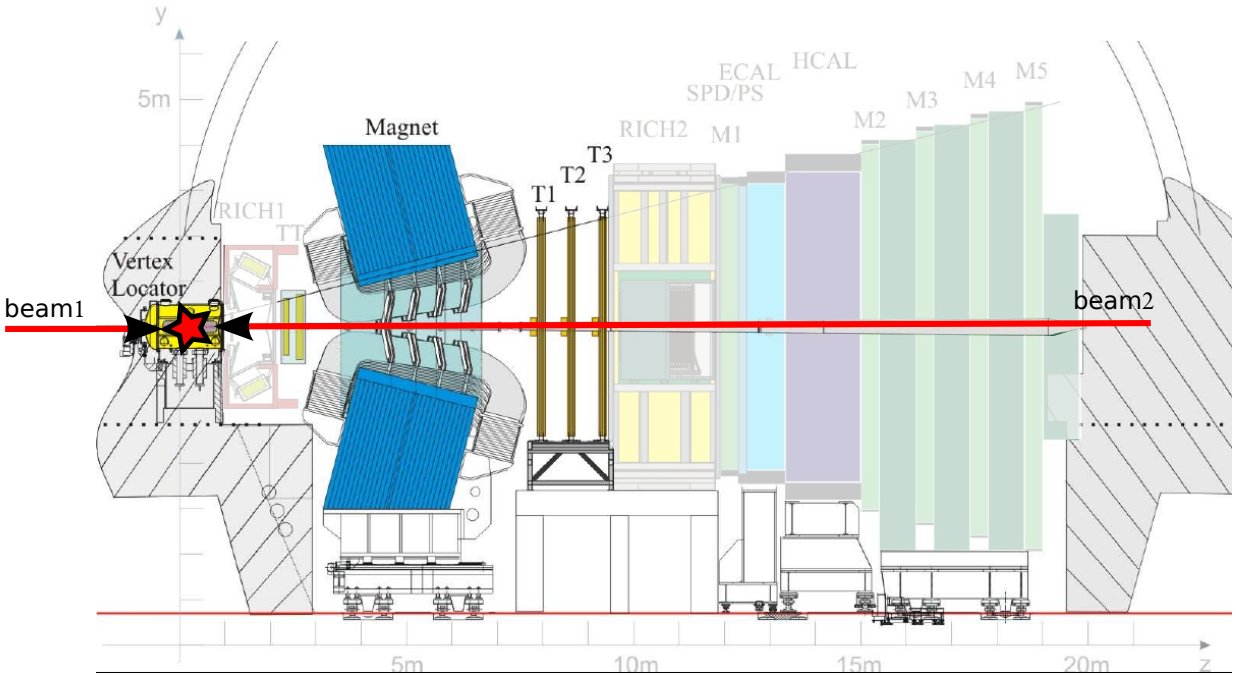
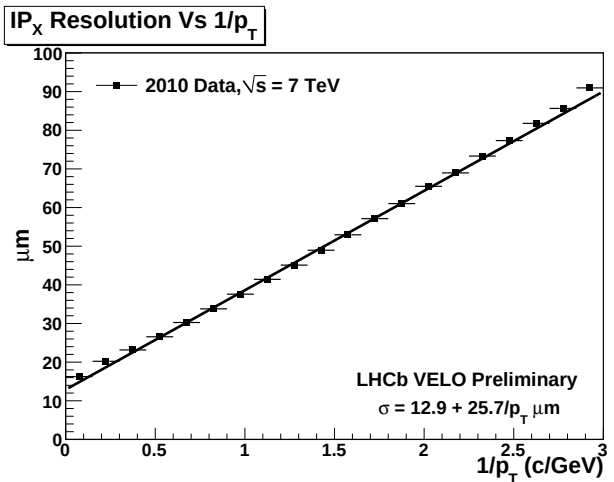


- Tracking efficiency $\sim 95\%$
- $\delta p/p \sim 0.5\%$
- Primary vertex resolution $50\mu m$
- VELO partially open at $\sqrt{s} = 900GeV$



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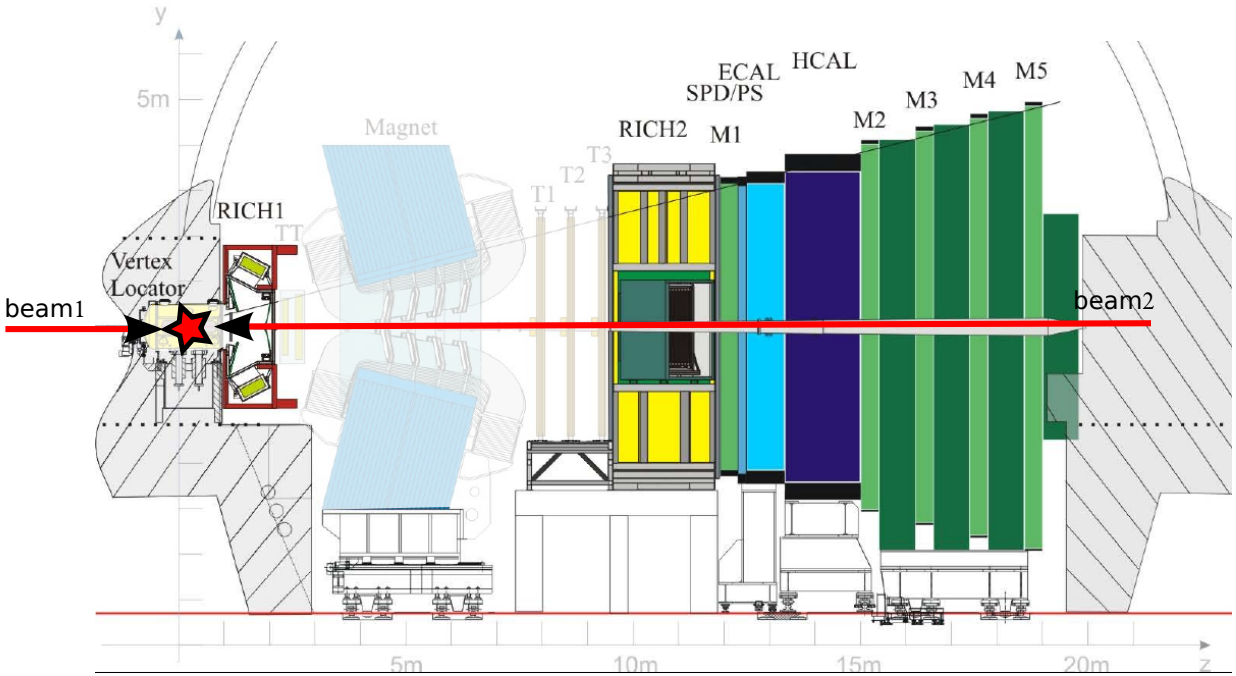
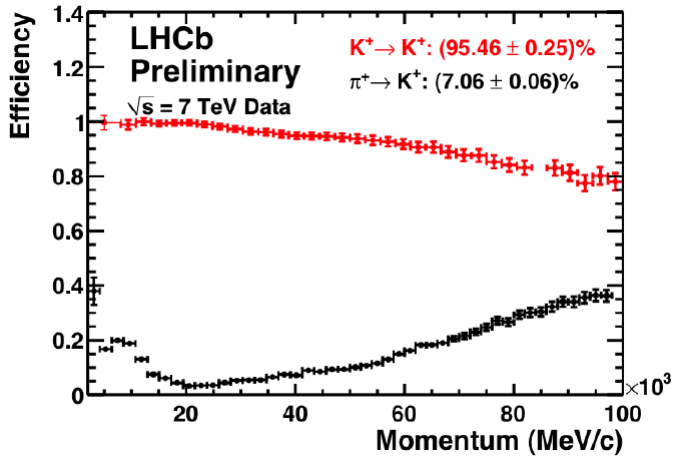


- RICH1 cover momentums from 2 to 60 GeV/c
- RICH2 cover momentums from 20 to 100 GeV/c
- Muon ID for μ from W $>$ 98%.



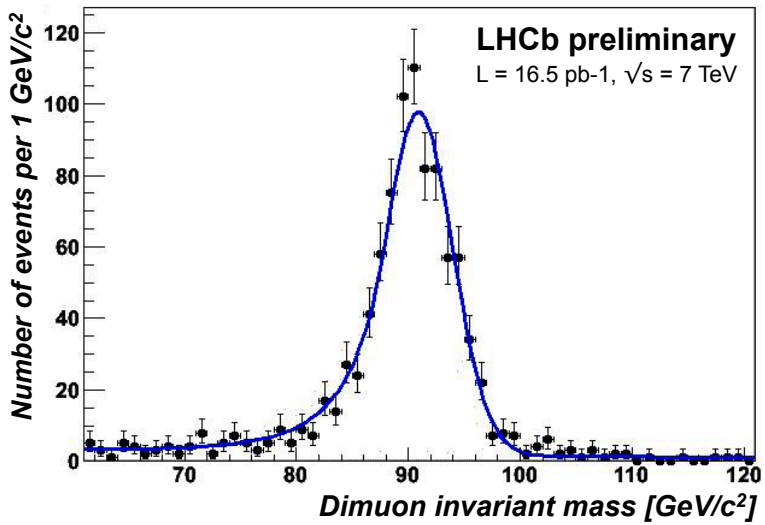
Electroweak Measurements

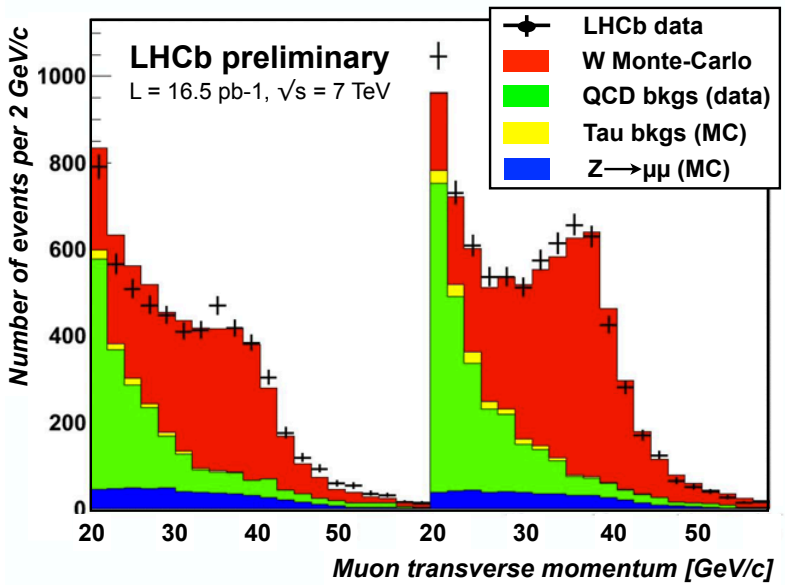
LHCb-CONF-2011-012

$$\sigma = \frac{N_{cand} - N_{bkg}}{A \times \epsilon_{trigger} \times \epsilon_{tracking} \times \epsilon_{\mu ID} \times \epsilon_{selection} \times \int L}$$

All efficiency evaluated on data ($Z \to \mu\mu, W \to \mu\nu$):

- Trigger on μ with $p_T > 10 GeV/c$, $\epsilon_{trigger} = 86 \pm 1\%, \epsilon_{trigger} = 73 \pm 1\%$
- Tracking efficiencies: $\epsilon_{tracking} = 83 \pm 3\%, \epsilon_{tracking} = 73(78) \pm 3\%$
- μ_{ID} efficiencies: $\epsilon_{\mu ID} = 97 \pm 1\%, \epsilon_{\mu ID} = 98.2 \pm 0.5\%$
- Selection with μ $p_T > 20 GeV/c$, $2 < \eta < 4.5$, for Z: $81 < m_{\mu\mu} < 101 GeV/c^2$, for W: μ isolation.
- Selection efficiencies: $\epsilon_{selection} = 100\%, \epsilon_{selection} = 55 \pm 1\%$
- Background for Z: QCD, $Z \to \mu\mu$, b and c semi-leptonic decays, $Z \to \tau\tau$
- Background for W: QCD, $Z \to \mu\mu$, $W \to \tau\nu$, $Z \to \tau\tau$.





Yields:

- $Z \to \mu\mu$: $N_Z = 883$, $N_{back} = 1.2 \pm 1.2$
- $W \to \mu\nu$: $N_{W^+} = 7624$, $N_{back^+} = 2194 \pm 150$ / $N_{W^-} = 5732$, $N_{back^+} = 1654 \pm 150$.

Main source of systematics:

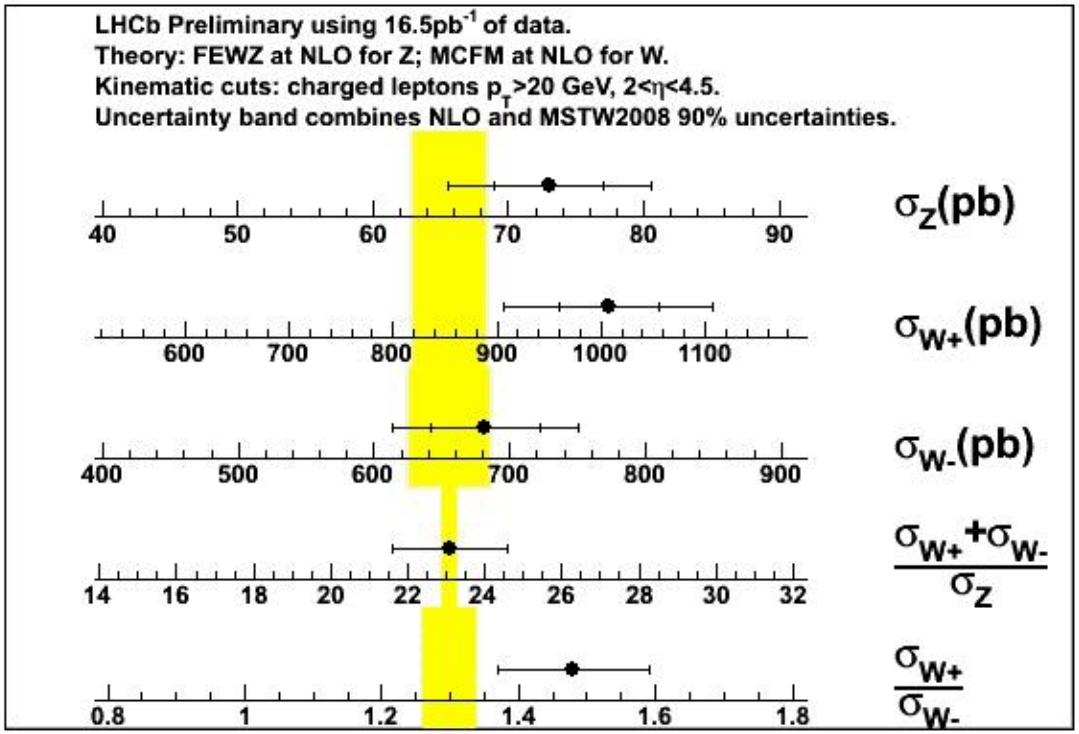
	Z	W+	W-	
Background	0.1	3	5	Uncertainty on shape
Tracking efficiency	1	1	1	Statistics
μ ID	0.7	0.5	0.5	Statistics
Trigger	4	4	4	Statistics
Selection	-	2	2	Statistics
$\int L$	10	10	10	Method

Preliminary cross sections at $\sqrt{s} = 7\,TeV$ for μ with $p_T > 20\,GeV/c$ and $2 < \eta < 4.5$ (and for Z $81. < m_Z < 101\,GeV/c^2$):

$$\sigma_{Z\to\mu\mu} = 73 \pm 4(stat\&sys) \pm 7(lumi)pb$$
$$\sigma_{W^+\to\mu^+\nu} = 1007 \pm 48(stat\&sys) \pm 101(lumi)pb$$
$$\sigma_{W^-\to\mu^-\nu} = 680 \pm 40(stat\&sys) \pm 68(lumi)pb$$

Preliminary measurements are not corrected for QED FSR.

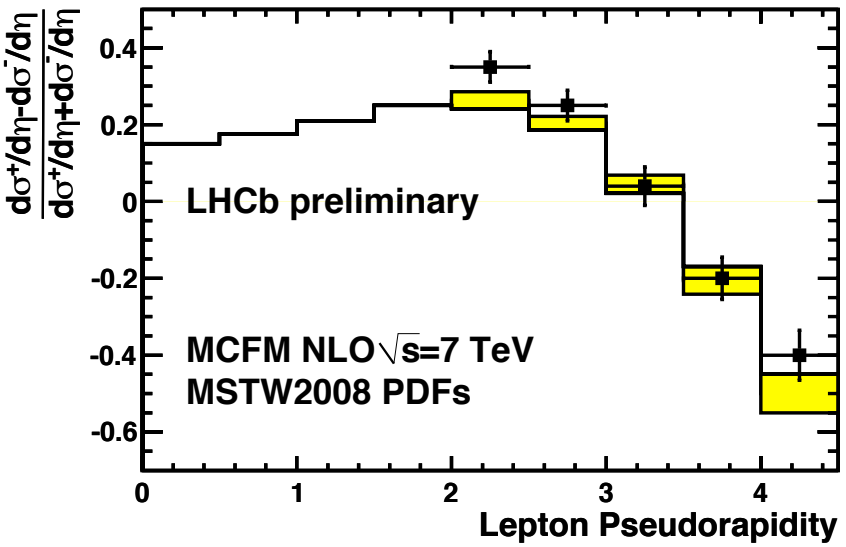
- Measurements are compatible with NLO prediction (MSTW2008NLO)
- For these rapidity, uncertainty of the prediction due to PDF is between 4 and 7%.



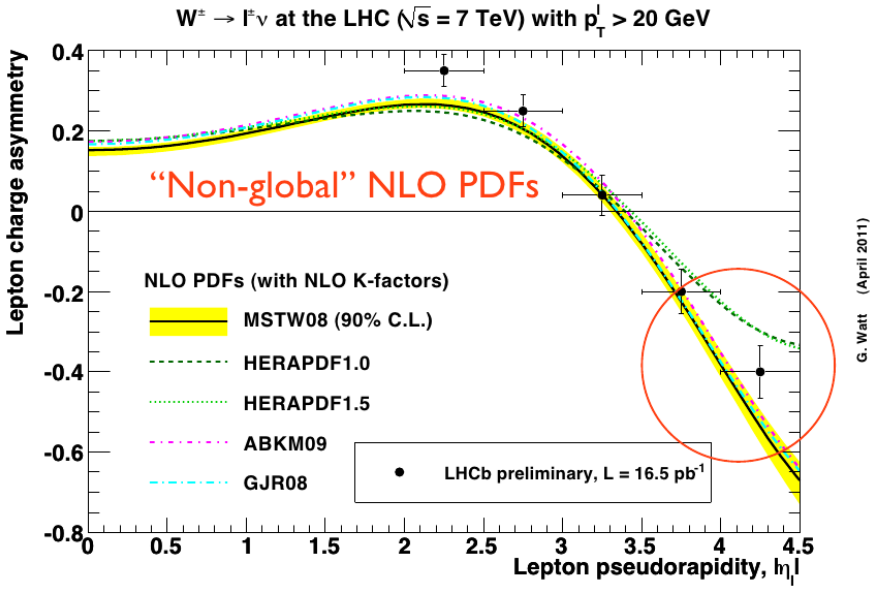
Electroweak Measurements

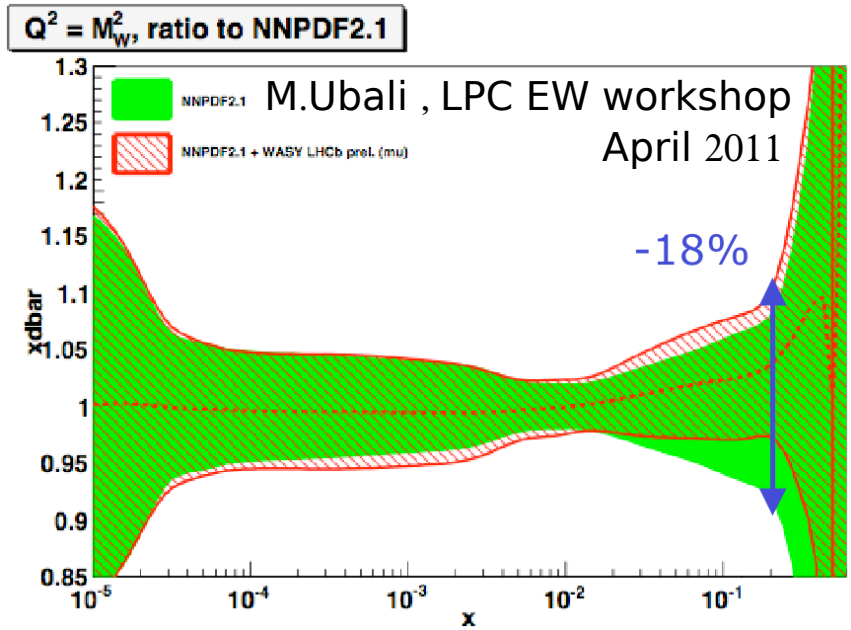
W charge assymetry $A_W = \frac{\sigma W^+ - \sigma W^-}{\sigma W^+ + \sigma W^-}$

- Asymmetry changes sign in the forward region.
- In this region, PDF uncertainty on A_W is of the order of $2-8\%$ (MSTW2008NLO, 68% C.L.)
- LHCb measurements already constraint PDFs with present analysis.



G. Watt , Physics@LHCb, BadHonnef 2011





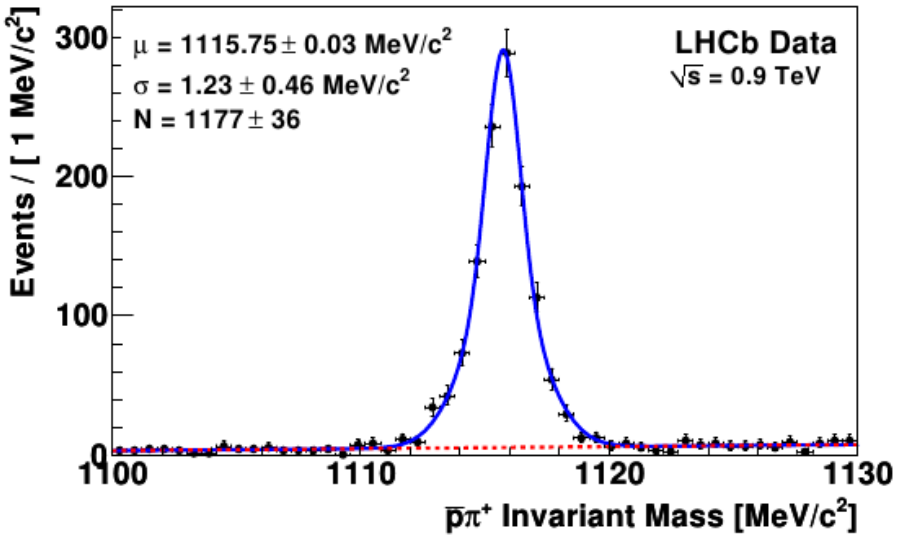
QCD Measurements

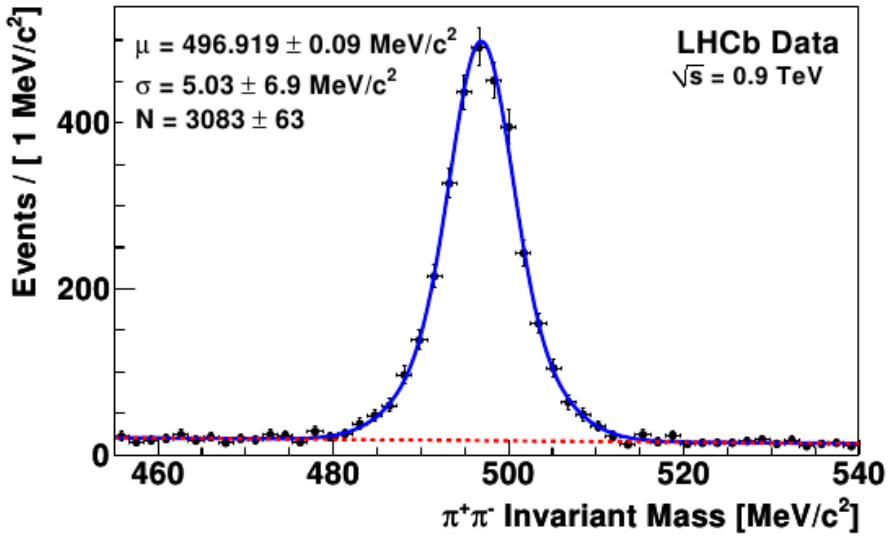
Production ratio: $\bar{\Lambda}/\Lambda$, $\bar{\Lambda}/K_s^0$

Particle selection

Paper soon submitted to JHEP

- $\bar{\Lambda}/\Lambda$ probe the baryon transport number. $\bar{\Lambda}/K_s^0$ probe the strange baryon suppression.
- Measurements performed at $\sqrt{s} = 900GeV$ $(0.3nb^{-1})$ and $\sqrt{s} = 7TeV$ $(1.8nb^{-1})$.
- Very loose trigger: one track seen in the VELO or downstream.
- A primary vertex is required.
- Prompt K_s^0 and $\Lambda(\bar{\Lambda})$ decaying to $\pi^+\pi^-$ and $p\pi^-(\bar{p}\pi^+)$.
- Cut on IP combination of the Λ and K_s^0 and daughters, to reduce combinatorial background and non-prompt contribution.





- Measurements are done in 6 bins of p_T $(250 < p_T < 2500MeV/c)$ and 4 bins of rapidity $2 < y < 4$.

Production ratio: $\bar{\Lambda}/\Lambda$, $\bar{\Lambda}/K_s^0$

Systematics

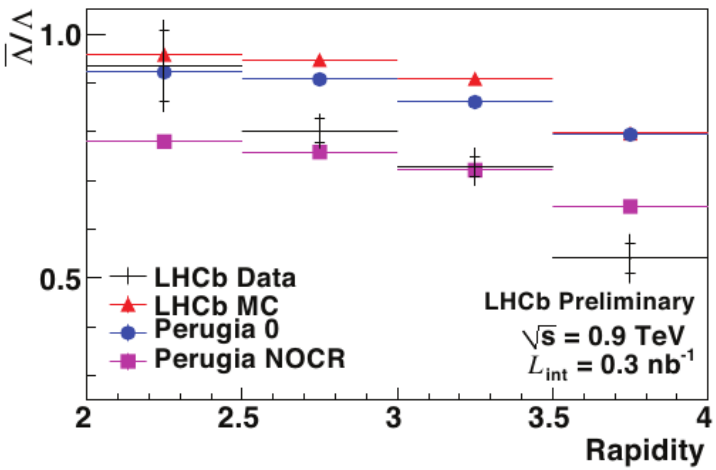
- Efficiency of selection prompt Λ and K_s^0 estimated from MC after reweighing of p_T,y distribution to match data.
- Most systematics cancel through the ratio.

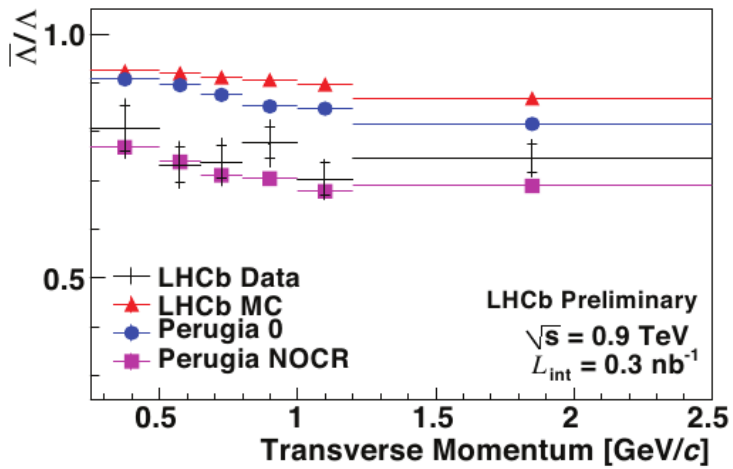
	$\bar{\Lambda}/\Lambda$	$\bar{\Lambda}/K_s^0$
Material interaction (*)	0.02	0.02
Diffractive event fraction(*)	$0.01 - 0.02$	$0.01 - 0.02$
Primary vertex finding (*)	< 0.02	< 0.01
Non prompt fraction (*)	< 0.01	< 0.01
Track finding (*)	negligible	0.01
MC kinematic correction	$0.01 - 0.05$	< 0.03
Signal extraction	0.001	0.001
Total	$0.02 - 0.06$	$0.02 - 0.03$

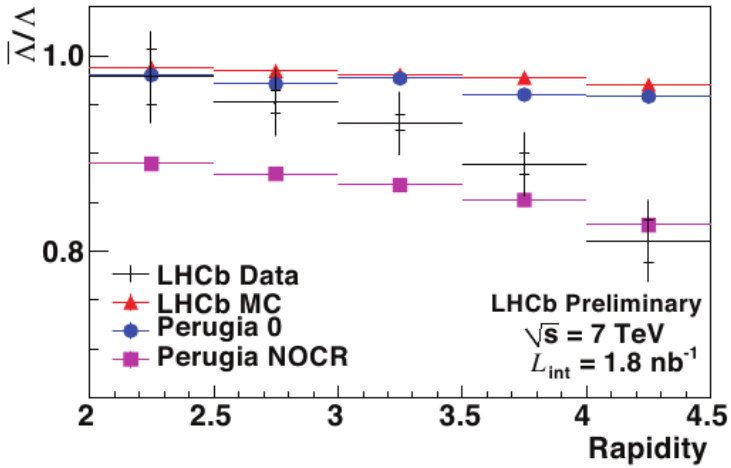
After corrections, the two magnet polarity sample are in good agreement $\rightarrow$ combined in the results, taking (*) into account.

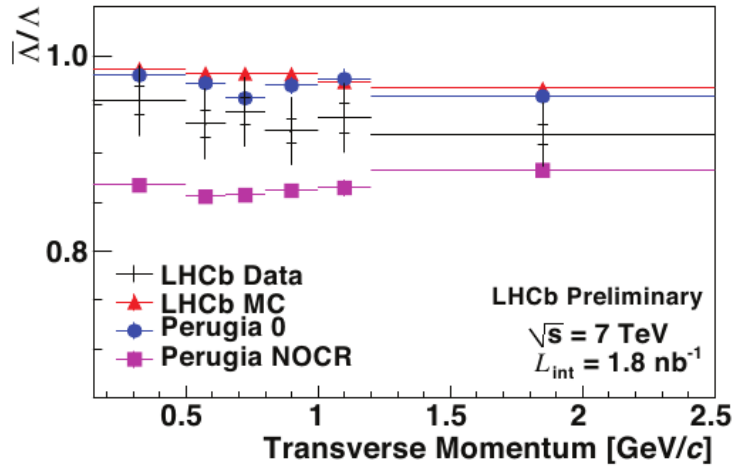
Baryon transport Number: $\bar{\Lambda}/\Lambda$

Results





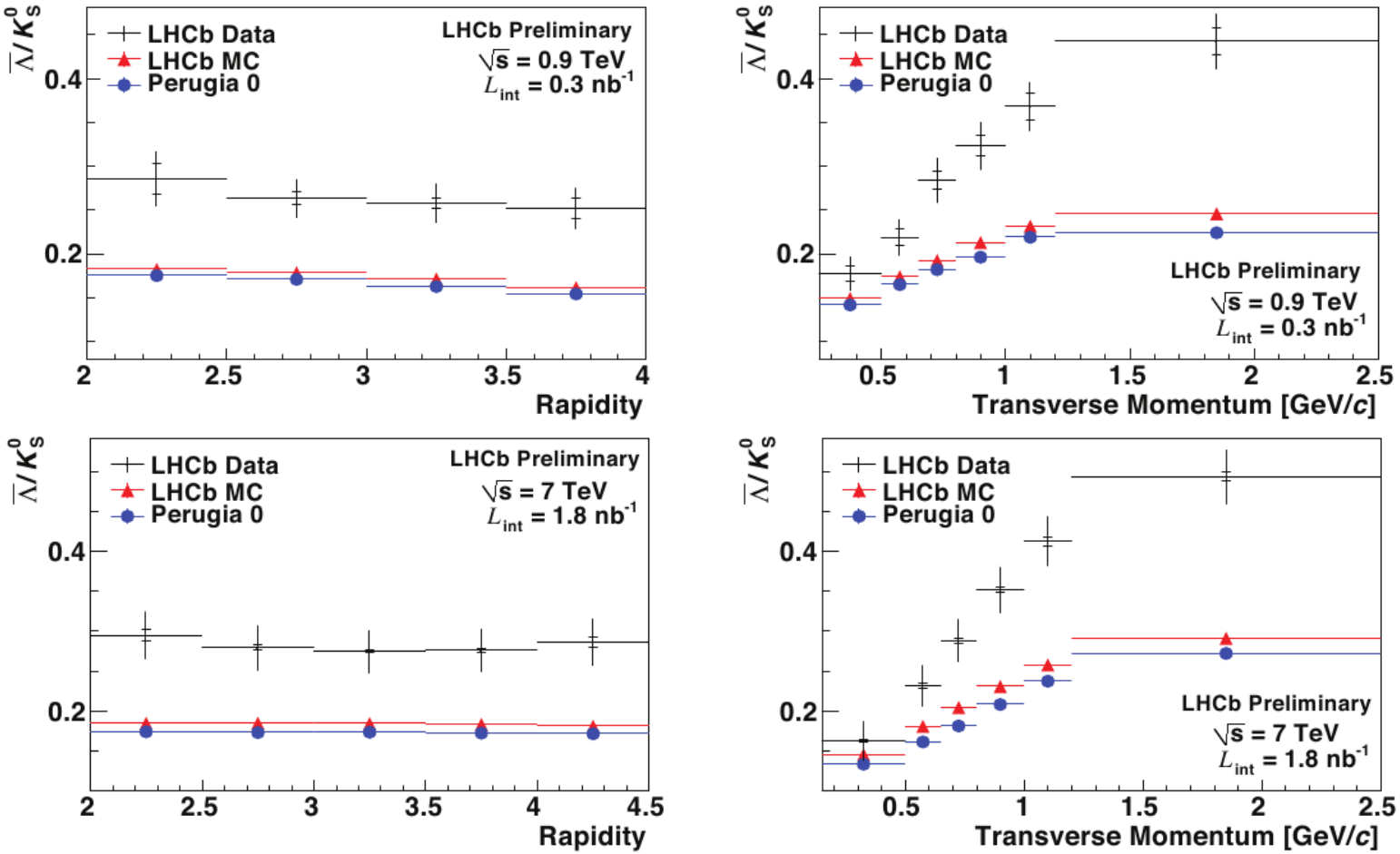




- Good agreement with MC at low rapidity.
- Extreme models of baryon transport favoured at high rapidity.

Strange baryon suppression: $\bar{\Lambda}/K^0_s$

Results



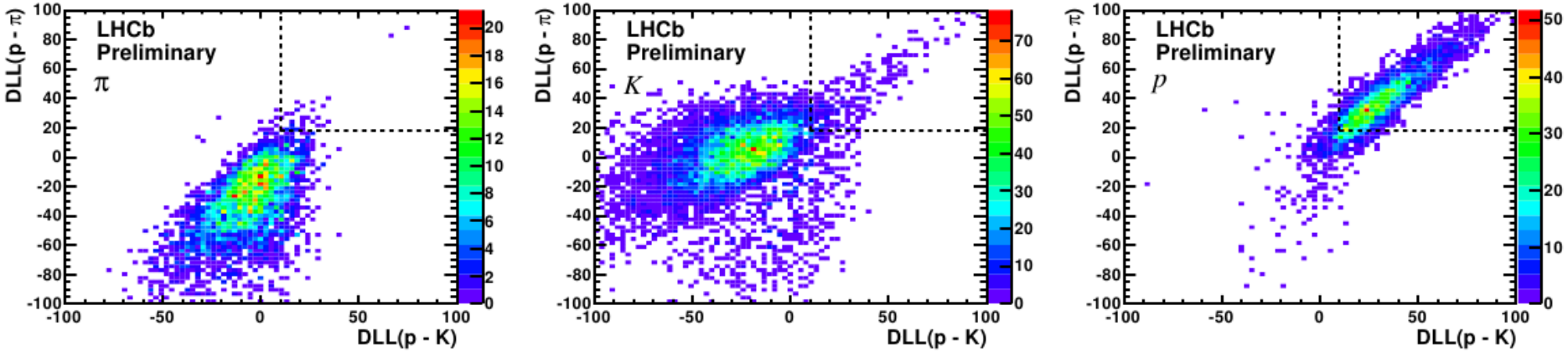
- The ratio Λ/K^0_s, measuring the suppression of strange baryons in hadronisation, is signifcantly larger than expected.

Baryon transport Number: $\bar{p}/p$

Proton selection

LHCb-CONF-2010-009

- $\bar{p}/p$ probe the baryon transport number.
- Measurements performed at $\sqrt{s} = 900 GeV$ $(0.3 nb^{-1})$ and $\sqrt{s} = 7 TeV$ $(0.2 nb^{-1})$ with loose trigger.
- Prompt protons with $p > 5 GeV/c$ are selected with PID requirements ($\sim 95\%$ purity on MC, with efficiency $\sim 85\%$).



- Measurements are done in 3 bins of p_T $(0.8; 1.2 GeV/c)$ and 5 bins of rapidity $2 < y < 4.5$.

Baryon transport Number: $\bar{p}/p$

Correction for reconstruction bias and systematics

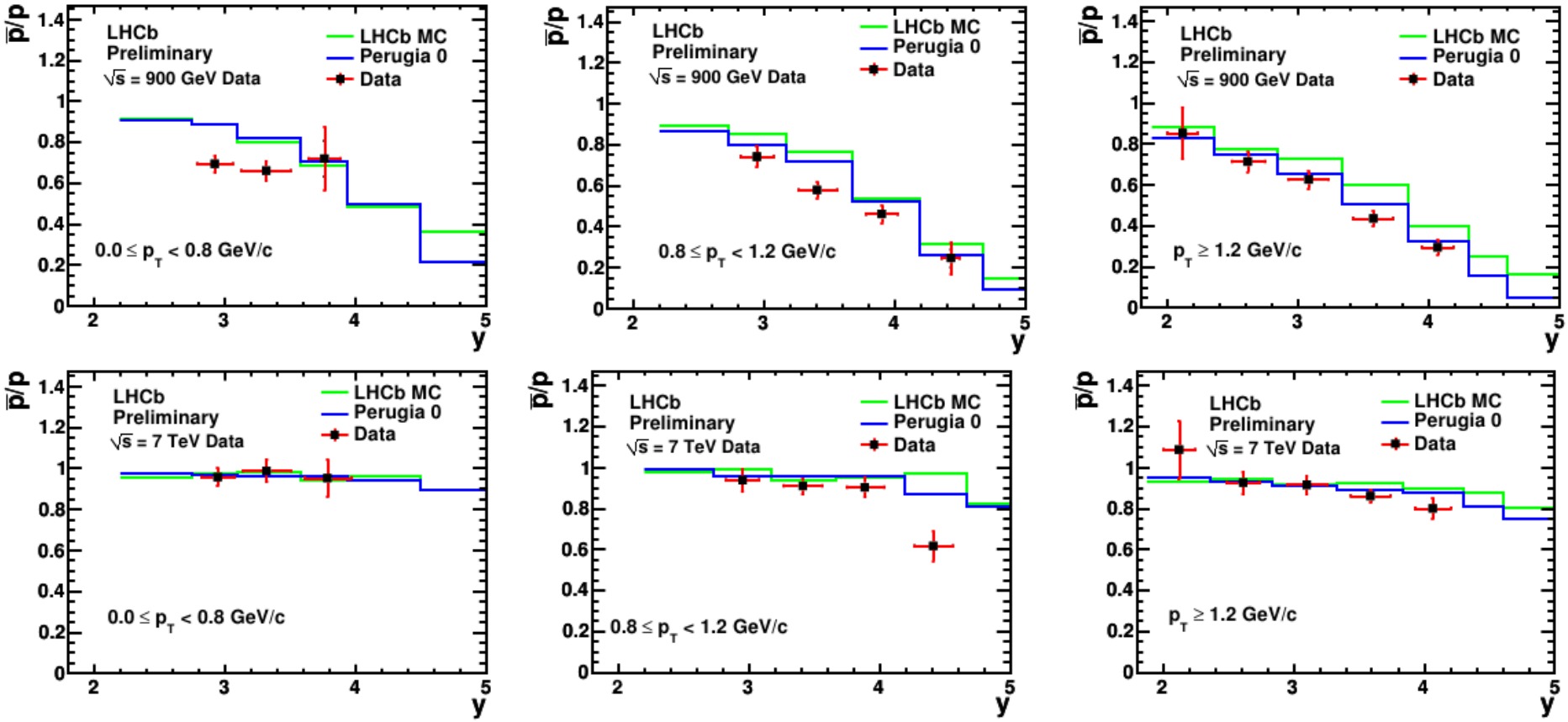
- Efficiency and purity of the PID evaluated on data using tag and probe method on calibration samples: $\phi \to K^+K^-$, $K_s \to \pi^+\pi^-$ and $\Lambda \to \pi p$.
- Cross contamination effect for ID efficiency and misID extracted from calibration sample for each p_T, η bins, magnet polarity and particle/anti particle.
- Correction of particle losses through interaction with material extracted from MC for each p_T, η bins, magnet polarity and particle/anti particle.

Main systematics

	$\sqrt{s} = 900 GeV$	$\sqrt{s} = 7 TeV$
PID contamination	0.02-0.14	0.02-0.08
Magnet polarity	0.001-0.03	0.01-0.03
Beam crossing angle	0.005	0.03

Baryon transport Number: $\bar{p}/p$

Results



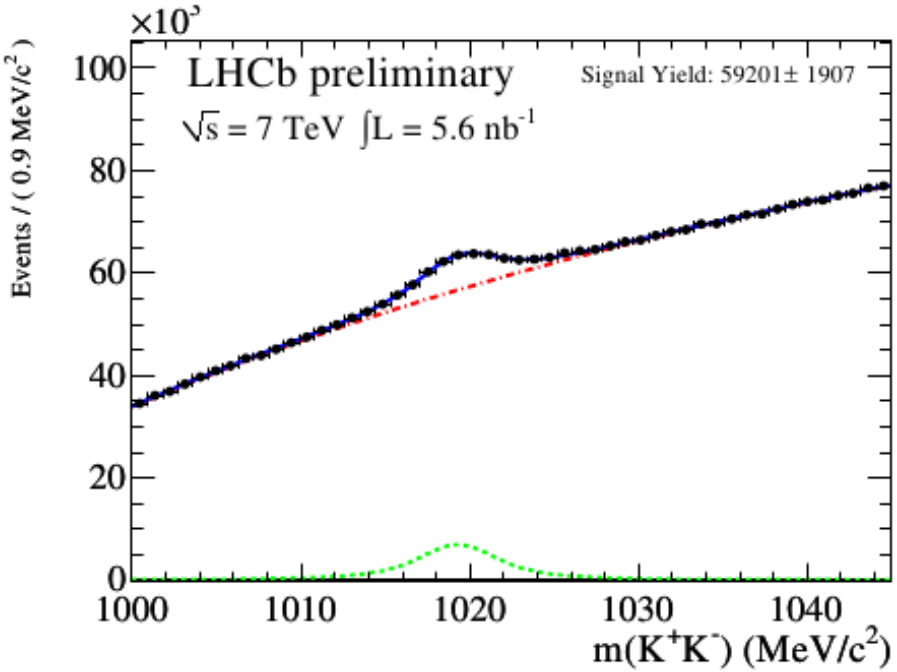
Higher than expected at $\sqrt{s} = 900 GeV$. Consistent with $\bar{\Lambda}/\Lambda$

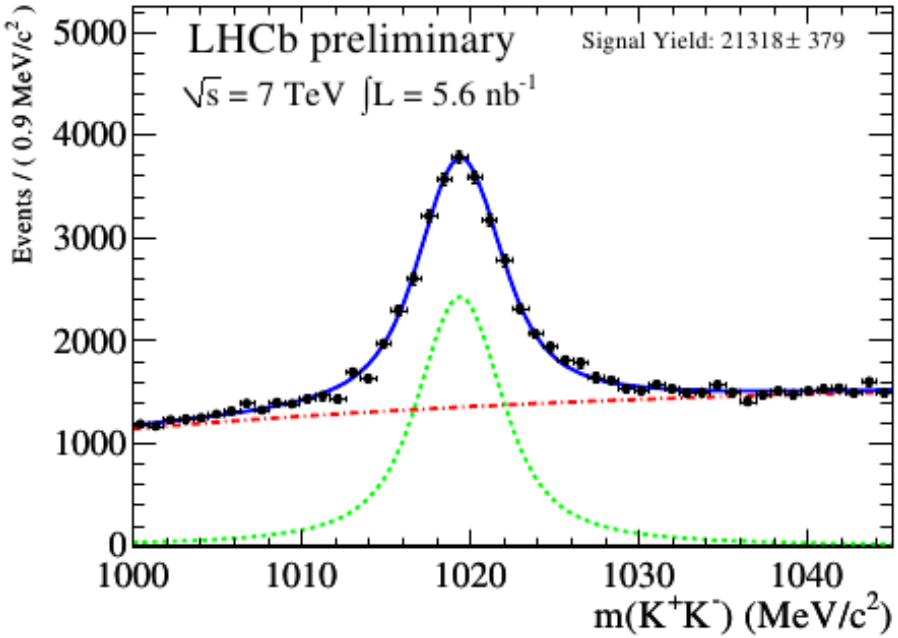
Inclusive ϕ cross section @ $\sqrt{(s)} = 7\,TeV$

Selection

LHCb-CONF-2010-014

- Probe strangeness production $\rightarrow$ information on fragmentation, tuning of MC models in our pseudorapidity region.
- Measurements performed at $\sqrt{s} = 7\,TeV$ $(5.6 nb^{-1})$ with loose trigger.
- Events with 1 primary vertex.
- $\phi \rightarrow K^+K^-$ are selected with at least one K PID requirements (tag), $1. < m_{KK} < 1.045\,GeV/c^2$
- Resolution dominated by the natural width of the ϕ



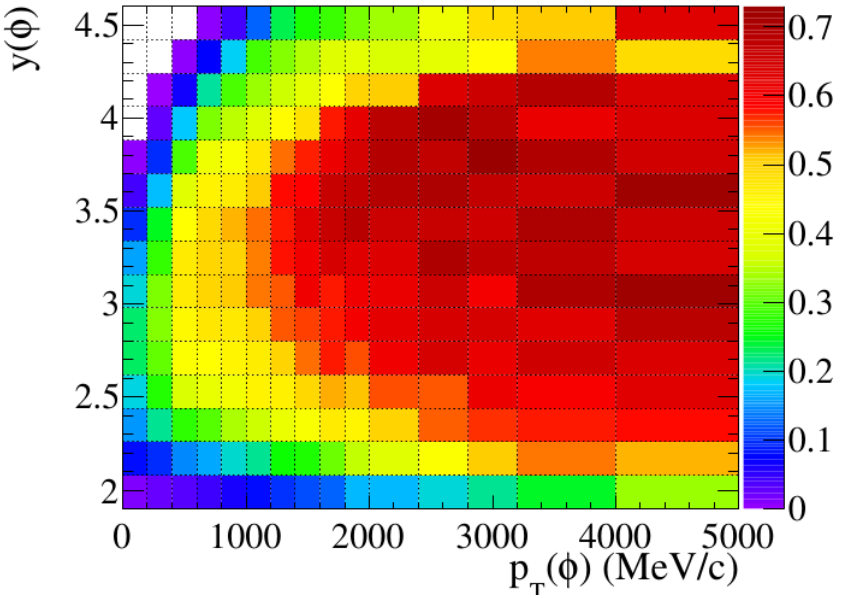


Inclusive ϕ cross section @ $\sqrt{(s)} = 7\,TeV$

Corrections and systematics

$$\sigma_{pp\to\phi X} = \frac{N_{tag}}{\epsilon_{PID} \times \epsilon_{reco} \times \epsilon_{trigger} \times \epsilon_{PV} \times B(\phi\to KK) \int L}$$

- Number of ϕ candidates is extracted for the tag candidate mass distribution.
- Trigger efficiency is a known prescale.
- PID efficiency is extracted from data, per bins of p_T, y ($> 80\%$ in most of the bins).
- Reconstruction efficiency is extracted from MC per bins of p_T, y.
- PV efficiency $\sim 99.3 \pm 0.3\%$.

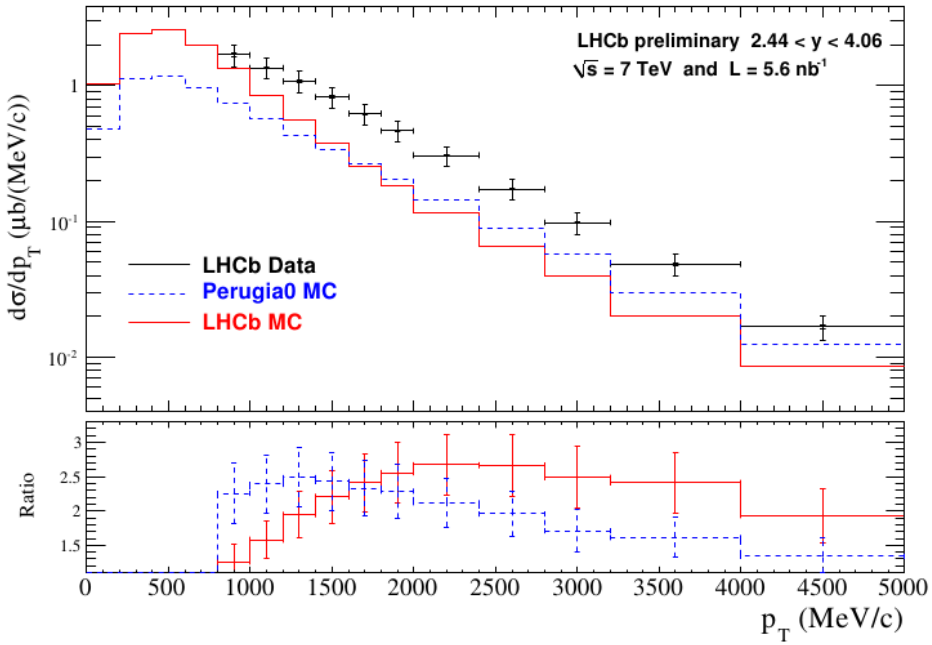


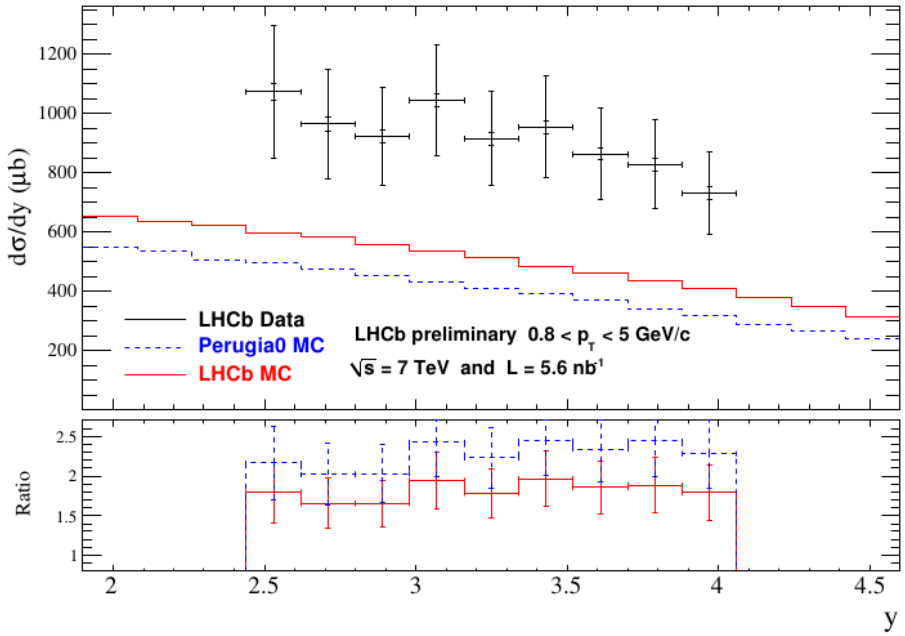
Main systematics

	%
Luminosity	10
Tracking efficiency	8
Track Multiplicity	5
PID	1-14
Reconstruction	1-6

Inclusive ϕ cross section @ $\sqrt{(s)} = 7\,TeV$

Results





- At $\sqrt{s} = 7\,TeV$, for ϕ with $p_T \in [0.8, 5.\,GeV/c]$ and $y \in [2.44, 4.06]$:

$$\sigma_{pp\to\phi X} = 1493 \pm 12(stat) \pm 12(uncorr.syst) \pm 209(corr.sys)\mu b$$

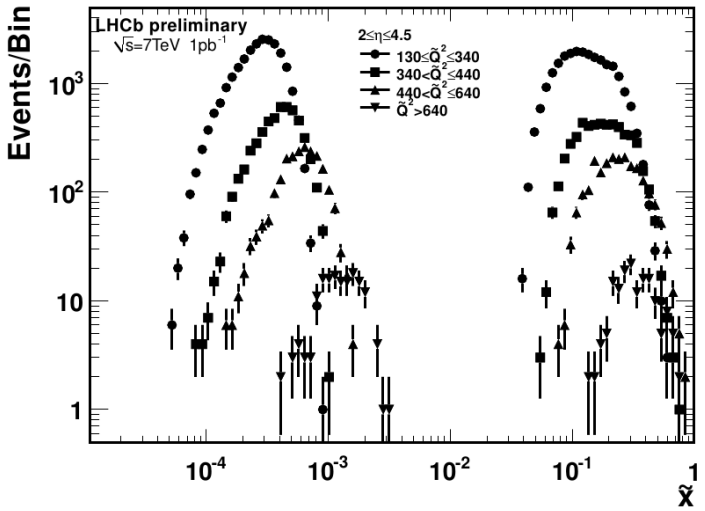
- More strange mesons produced forward than expected from MC models.

Inclusive jet and di-jets production @ $\sqrt{(s)} = 7\,TeV$

A preliminary study

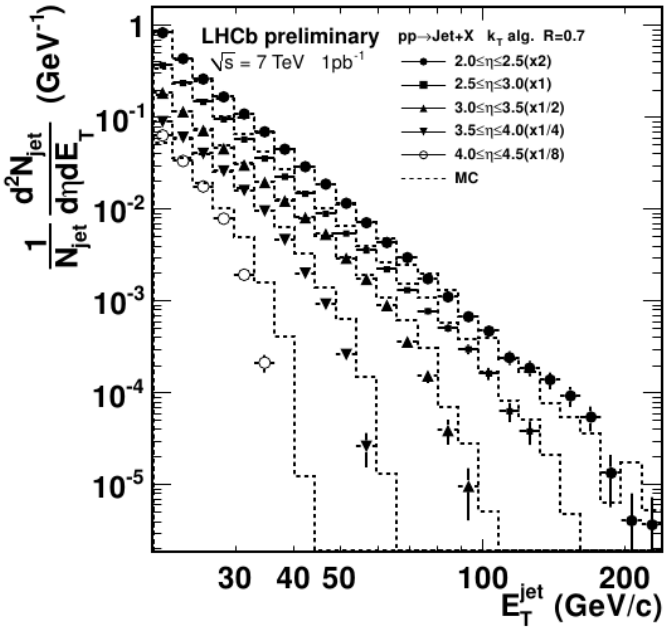
LHCb-CONF-2011-015

- Forward jet production at LHC probe the uncharted low-x high Q^2 region.
- Jets a reconstructed out of charged particles and π^0.
- k_T with R=0.7.
- No correction for energy yet.
- No acceptance correction.



Work on-going:

- Improvement of input selections under study.
- Study of extraction of JES and efficiencies on going.
- Update will use anti-kT with R=0.6.



Conclusion

- LHCb probe high rapidity region at LHC.
- With the coming 2011 data, sensitivity to constraint PDF from W and Z measurements.
- Valuable results for improving MC models:
  - Baryon number transport is higher than expected.
  - Λ/K_s^0 lower than expected.
  - More strange mesons produced than expected.