

# LHCb: update on Minimum Bias results

*Sebastian Schleich on behalf of the LHCb collaboration*

Minimum Bias and Underlying Event  
Working Group meeting 07.02.2011

# Outline

## 1. The LHCb experiment

Phase space coverage

PID system

LHCb data

## 2. $K_S^0$ production

## 3. $V0$ ratios

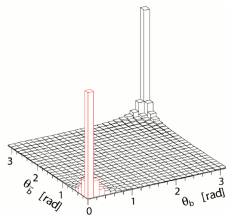
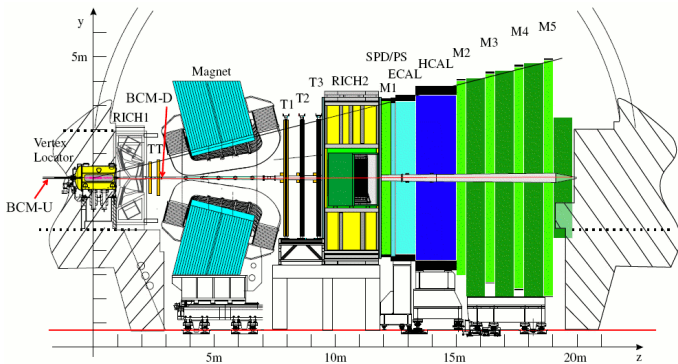
$\bar{\Lambda} / \Lambda$  ratio

$\bar{\Lambda} / K_S^0$  ratio

## 4. $\bar{p} / p$ ratio

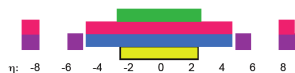
## 5. $\phi$ production

# The LHCb experiment

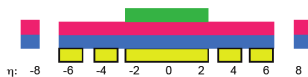


- ▶ single arm forward spectrometer  $1.9 < \eta < 4.9$
- ▶ aims at precision measurements of  $CP$  violation in the b sector
- ▶ excellent lifetime resolution:
  - VELO, 5 mm distance to beam, movable device
- ▶  $2 \cdot 10^4$  b-quarks per second

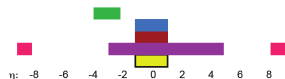
## Phase space coverage



ATLAS



CMS + TOTEM



ALICE



LHCb

muon  
 HCAL  
 ECAL  
 PID  
 tracking  
 lumi counters

LHCb fully instrumented in the forward region

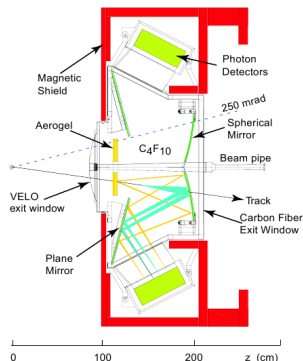
- ▶ studies in high- $\eta$  and low- $p_T$  region at unprecedented CM energy

# PID system

dedicated PID system based on RICH detectors:

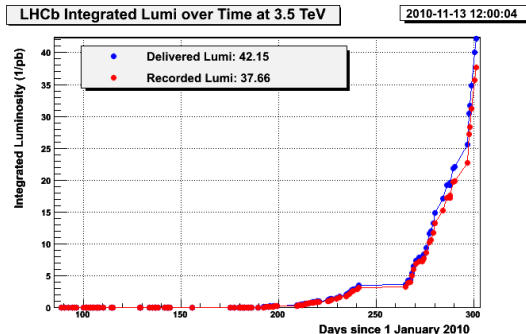
- ▶ RICH1:
  - ▶ Aerogel  $p < 10 \text{ GeV}/c$
  - ▶  $\text{C}_4\text{F}_{10}$   $p < 60 \text{ GeV}/c$
- ▶ RICH2:
  - ▶  $\text{CF}_4$   $15 < p < 100 \text{ GeV}/c$

important ingredient e.g. to  $p\bar{p}$  and  $\phi$  studies



## Recorded luminosity

year	luminosity	$\sqrt{s}$ /TeV
2009	$6.8 \mu\text{b}^{-1}$	0.9
2010	$0.3 \text{nb}^{-1}$	0.9
2010	$38 \text{pb}^{-1}$	7.0



...90% data taking efficiency!

*in this talk:*

	$\sqrt{s} = 900 \text{ GeV}$	$\sqrt{s} = 7 \text{ TeV}$
$K_S^0$ cross section	X	
$\phi$ cross section		X
V0 ratios	X	X
$p/\bar{p}$ ratio	X	X

# Trigger conditions

the LHCb trigger system

- ▶ Level 0: custom hardware (40 MHz  $\rightarrow$  1 MHz)
- ▶ Higher Level Trigger: computing farm
  - ▶ Hlt1: (1 MHz  $\rightarrow$  40 kHz)
  - ▶ Hlt2: (40 kHz  $\rightarrow$  2 kHz)

first data:

- ▶ started with Minimum Bias trigger (CALO or 1 track)
- ▶ commissioned full system with growing event rate

$K_S^0$  production

**Physics Letters B 693 (2010) pp. 69-80 arXiv:1008.3105v2**

- ▶  $K_S^0$  reconstructed in  $K_S^0 \rightarrow \pi^+ \pi^-$
- ▶ analyzed data from pilot run 2009
- ▶ low requirements on reconstruction, no PID...
  - ▶ ideal 'first physics' channel
  - ▶ testing ground for detector understanding/calibration
- ▶  $K_S^0$  decay far away from primary vertex
- ▶ two separate analyses done (with/without VELO information)

*key systematics:*

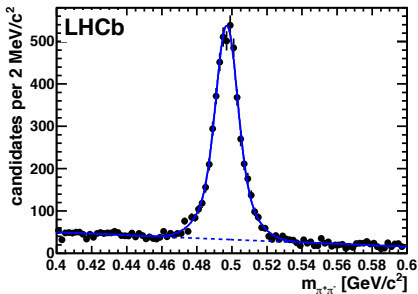
luminosity            12%

tracking efficiency   10%

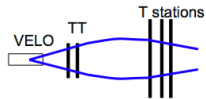
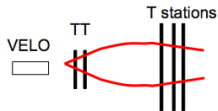
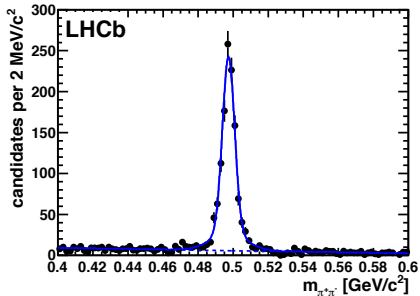


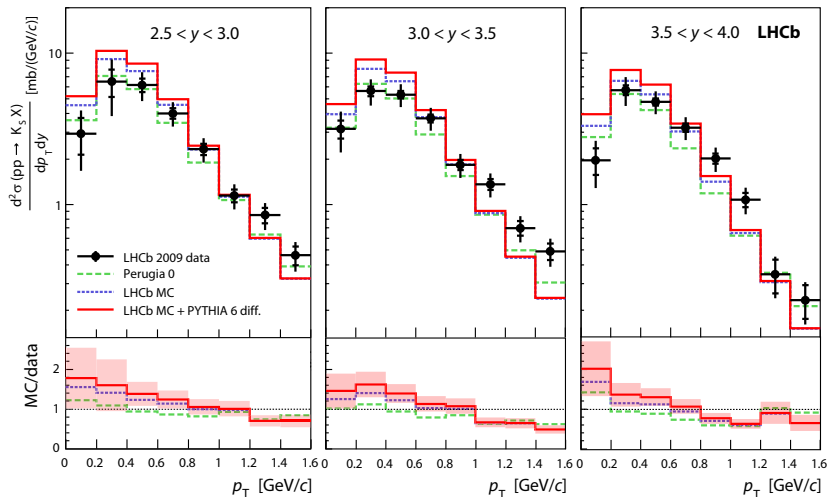
$K_S^0$  production

downstream tracks  
 resolution:  $9.2 \text{ MeV}/c^2$



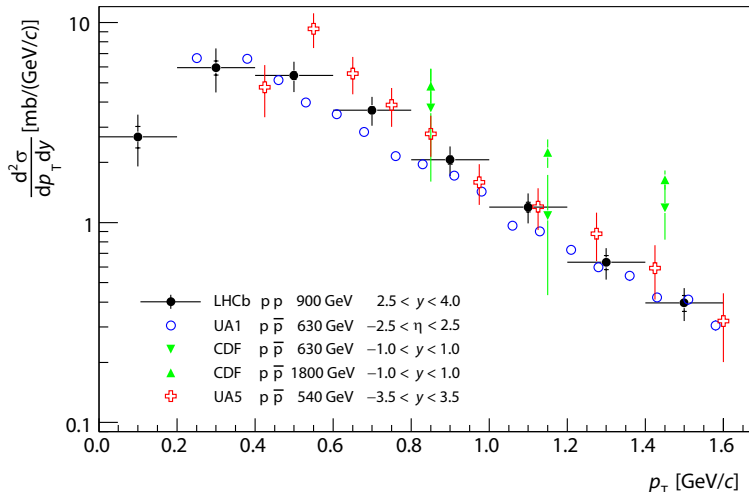
long tracks  
 resolution:  $5.5 \text{ MeV}/c^2$



$K_S^0$   $p_T$  spectra at  $\sqrt{s} = 900$  GeV

► harder  $p_T$  spectrum in data than MC

# Comparison with other experiments



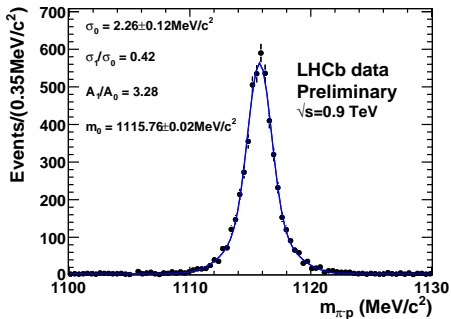
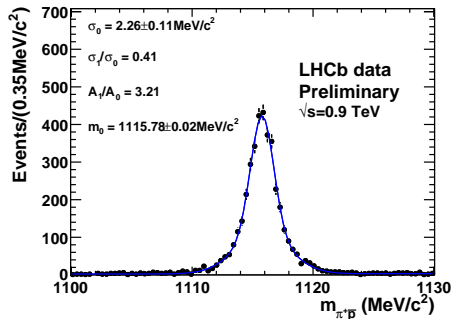
- ▶ first measurement at  $\sqrt{s} = 900$  GeV
- ▶  $y$  and  $p_T$  range extended

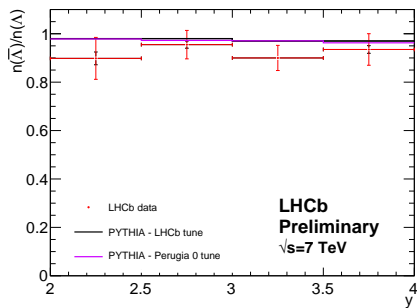
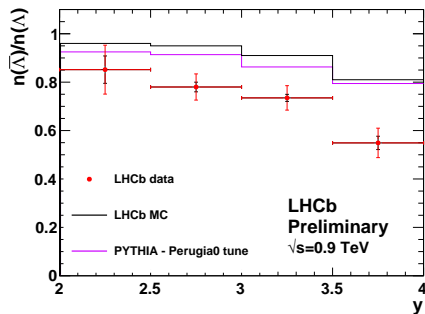
# V0 ratios

identification:

$$\begin{aligned} \Lambda & \quad \Lambda \rightarrow p \pi^- \\ \bar{\Lambda} & \quad \bar{\Lambda} \rightarrow \bar{p} \pi^+ \\ K_S^0 & \quad K_S^0 \rightarrow \pi^+ \pi^- \end{aligned}$$

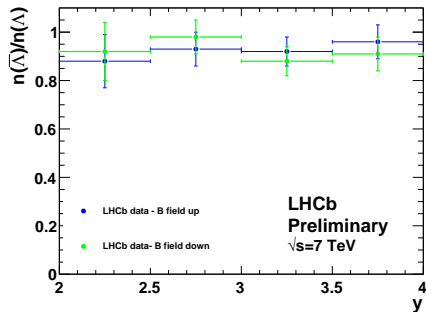
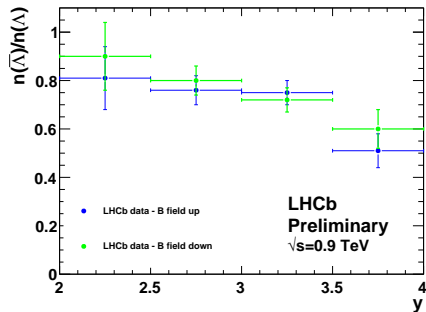
- ▶  $K_S^0$  and  $\Lambda$  selection based on impact parameters
- ▶ independent from luminosity
- ▶ low systematic uncertainties (cancel partially)

$\bar{\Lambda} / \Lambda$  mass peaks at  $\sqrt{s} = 900$  GeV

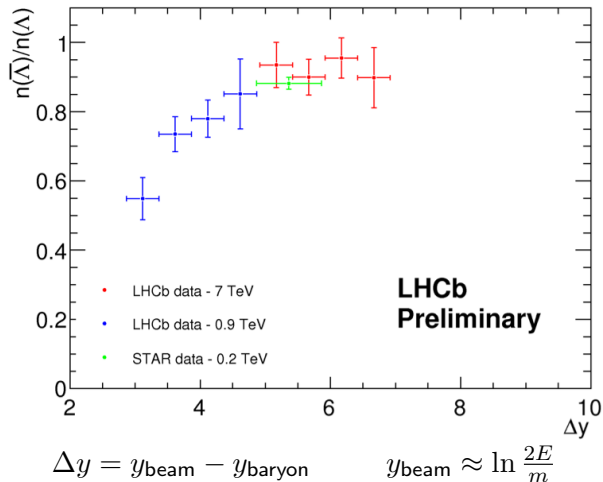
$\bar{\Lambda} / \Lambda$  ratio

⇒ energy dependence:

- ▶ ratio overestimated by MC at  $\sqrt{s} = 900$  GeV
- ▶ better agreement at  $\sqrt{s} = 7$  TeV, but data still on the low side

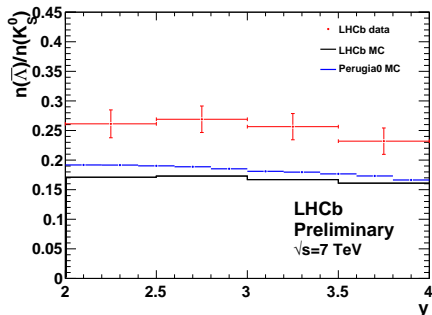
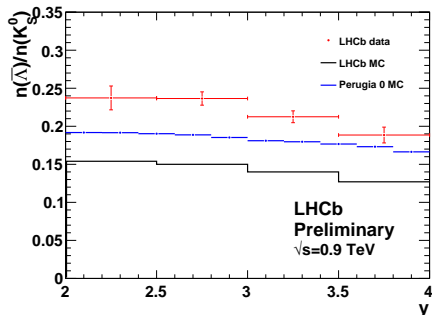
$\bar{\Lambda} / \Lambda$  ratio – LHCb magnet polarity comparison

no polarity dependence. OK!

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

- consistency between  $\sqrt{s} = 900$  GeV, 7 TeV and previous measurement

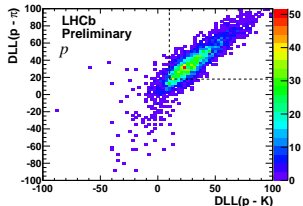
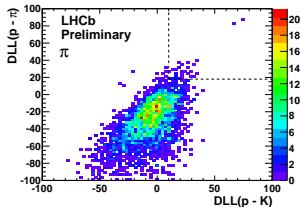
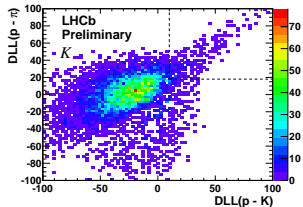


$\bar{\Lambda} / K_S^0$  ratio

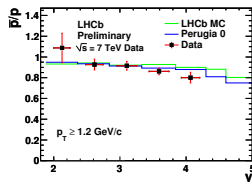
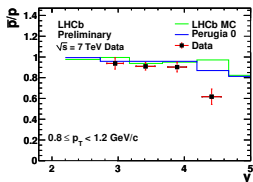
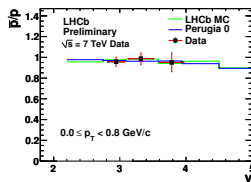
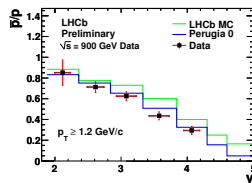
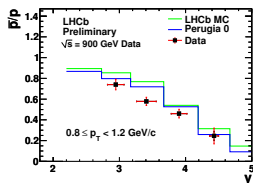
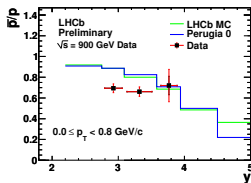
- ▶ ratio underestimated by MC at both beam energies

$\bar{p}/p$  ratio – PID

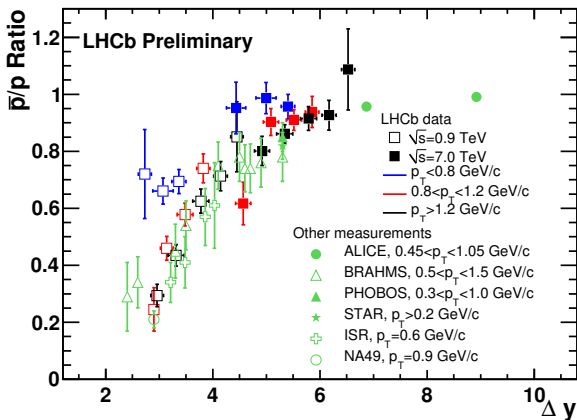
- ▶ analysis strongly depends on PID system
- ▶ PID calibrated on data:
  - ▶  $\pi$  and  $p$  from  $K_S^0 \rightarrow \pi^+\pi^-$  and  $\Lambda \rightarrow p\pi$
  - ▶  $K$  from  $\phi \rightarrow KK$



background rejection (top)  
and signal retention (left)  
 $\Rightarrow$  high purity  $\bar{p}/p$  sample

$\bar{p}/p$  ratio

- ▶ ratio overestimated at  $\sqrt{s} = 900$  GeV
- ▶ good MC-data agreement at  $\sqrt{s} = 7$  TeV

Baryon transport  $\bar{p}/p$ 

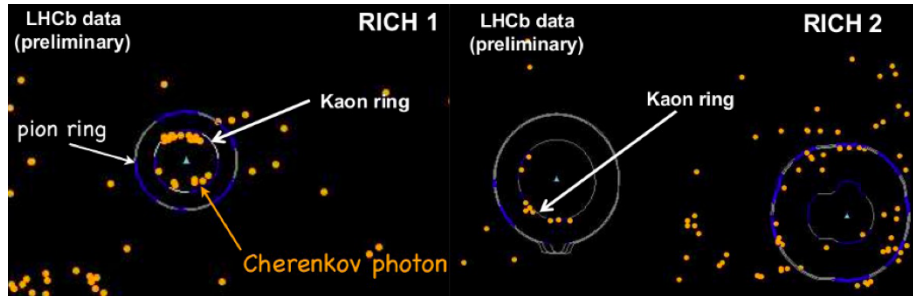
$$\Delta y = y_{\text{beam}} - y_{\text{baryon}}$$

- consistency with other measurements, better at high  $p_T$ .

# $\phi$ production

two fold purpose:

- ▶ extremely good test for strangeness production (100% strange final state)
- ▶ study RICH PID system



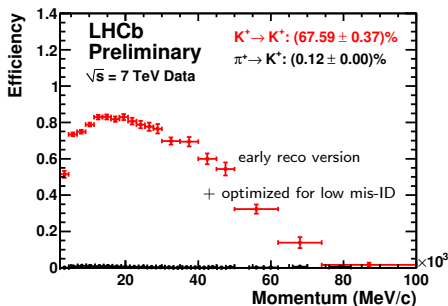
$\phi$  production

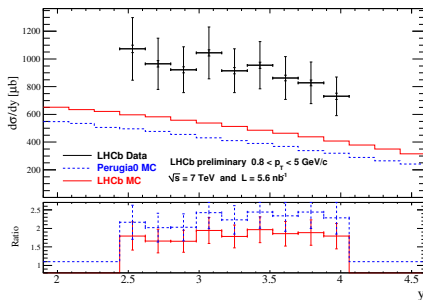
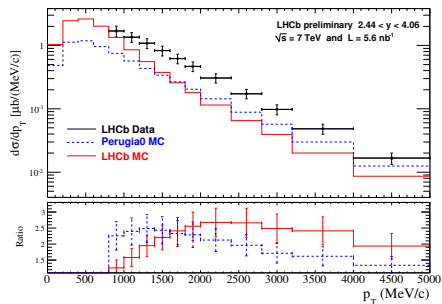
- ▶  $\phi$  production cross section measured in bins of transverse momentum  $p_T$  and rapidity  $y$

only reconstruction efficiency  
relies on MC

RICH PID cut efficiency  
determined on data (tag&probe)

- ▶ apply PID cut on *at least one* kaon
- ▶ subsequently cut on the *second* kaon
- ▶ deduce PID cut efficiency



$\phi$  cross section projections

- ▶ error bars show total uncertainties, including correlated systematics
- ▶  $\phi$  production underestimated in the measured kinematic range by both, LHCb-MC and Perugia0
- ▶ harder  $p_T$  spectrum as compared to MC

# Conclusions

LHCb delivers splendid input to MB physics in the high- $\eta$  region

- ▶  $K_S^0$  production at  $\sqrt{s} = 900$  GeV  
harder  $p_T$  spectrum as compared to MC
- ▶  $\bar{\Lambda}/\Lambda$  ratios at  $\sqrt{s} = 900$  GeV lower than MC,  $y$  dependence differs
- ▶  $\bar{\Lambda}/\Lambda$  ratios at  $\sqrt{s} = 7$  TeV slightly on the low side
- ▶  $\bar{\Lambda}/K_S^0$  ratio at  $\sqrt{s} = 900$  GeV and  $\sqrt{s} = 7$  TeV:  
predicted baryon suppression is too high
- ▶  $\bar{p}/p$  ratio overestimated by MC at  $\sqrt{s} = 900$  GeV
- ▶  $\phi$  production at  $\sqrt{s} = 7$  TeV production  
above MC in the considered kinematical range

*(comparing LHCb data to PYTHIA 6.4 with Perugia0)*