Inclusive production of K_S and Λ at $\sqrt{s}$ = 0.9 and 7 TeV

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On behalf of the LHCb Collaboration

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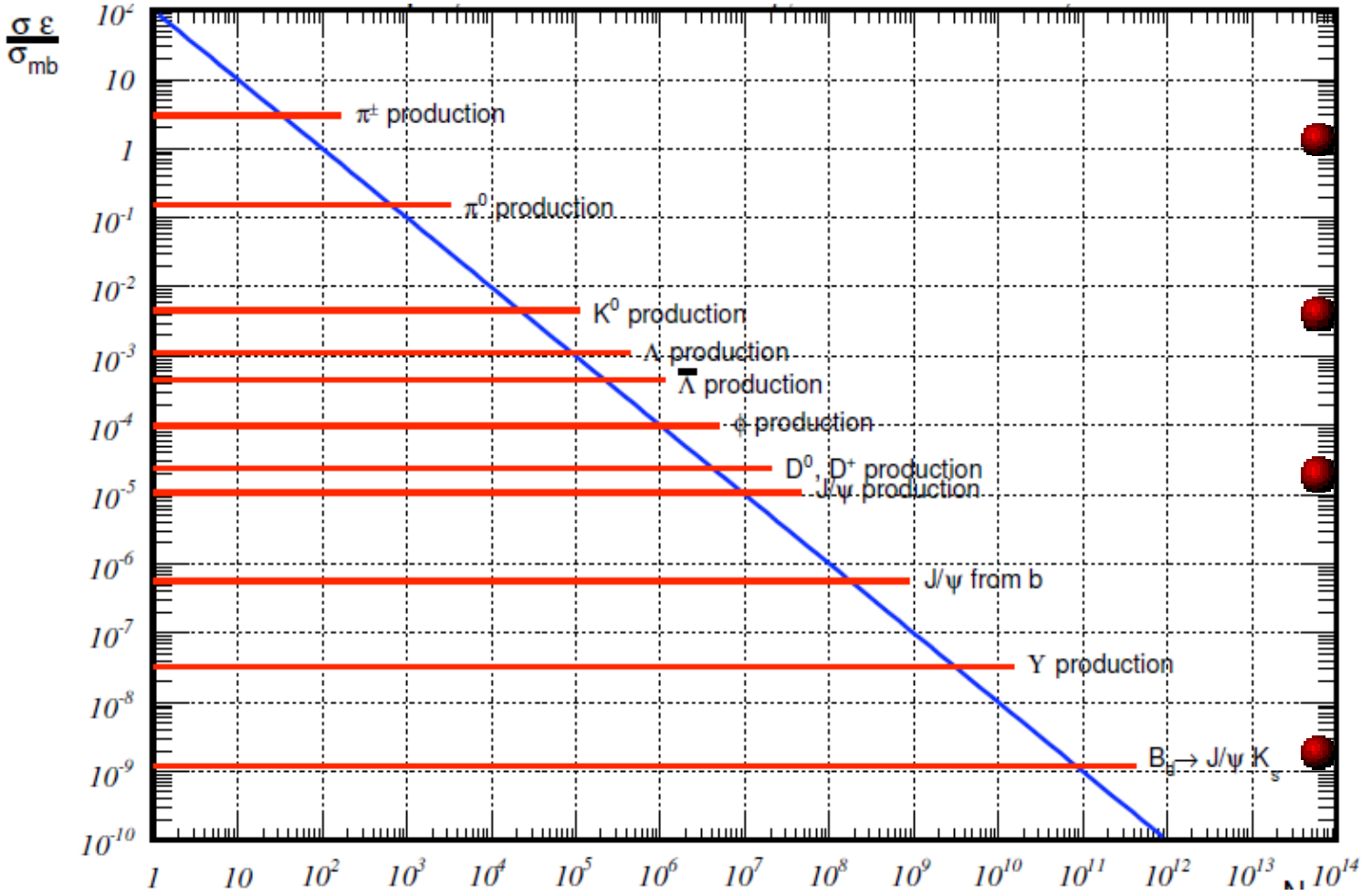
Physics at the beginning of LHC



Inclusive distributions

Strangeness production

Charm signals

We are here
first b results …

the number of recorded minimum bias events needed to observe 100 events of the process X

For more details see talk of I.Belyaev

Motivation for K_S and Λ analysis

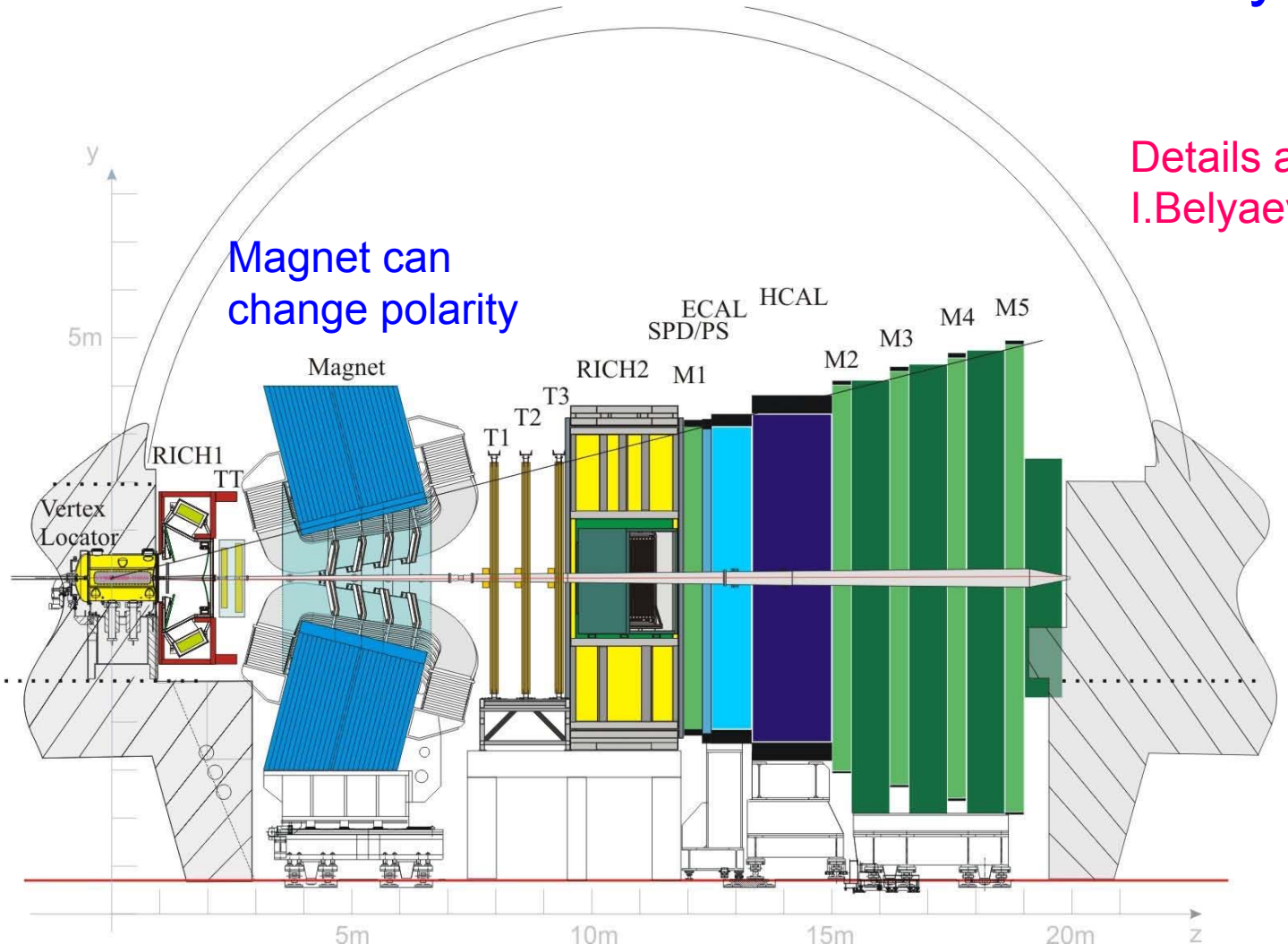
- Strangeness production very good to test fragmentation models since valence quarks are not strange
- Highest CM energy so far 1.96 TeV (but for ppbar) at Tevatron
- Models tuned for central rapidity and p_T>0.4 GeV/c
- LHCb covers the forward rapidity and can provide a measurement down to p_T=0
- Theoretical interest in ratios:
  - baryon number transport
  - baryon vs. meson suppression in hadronisation
- For V^0-ratios $\bar{\Lambda}/\Lambda$, $\bar{\Lambda}/K_S$ measurements only tracking & vertexing are needed

A forward detector (2<η<5) for precision measurement of CP violation and rare B-decays:

Details are in I.Belyaev talk

Magnet can change polarity

VELO is movable detector

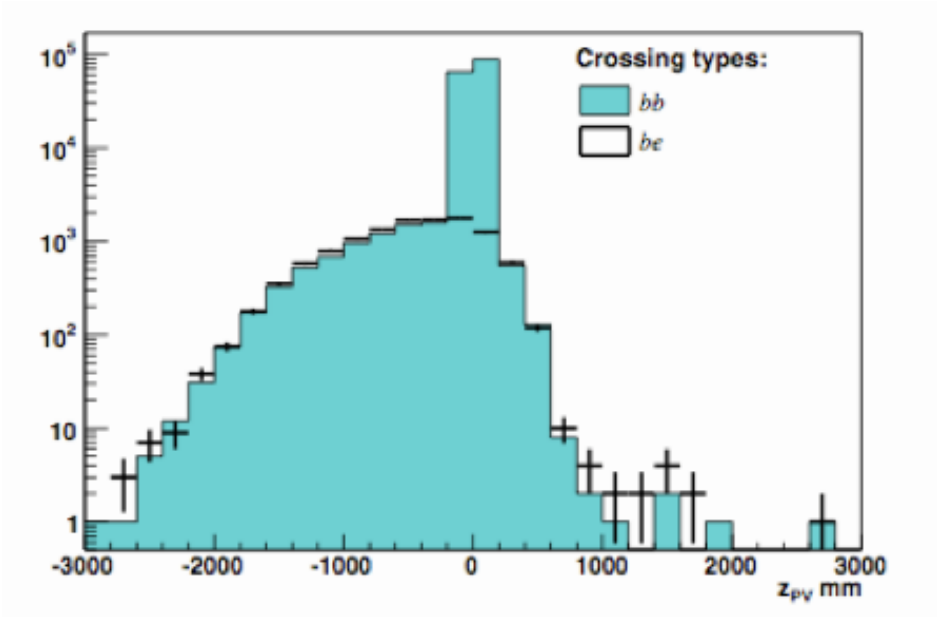


Outline

- Prompt K_S^0 production cross-section in 2009 data @$\sqrt{s}$=0.9TeV
  - $\int\mathcal{L}$=6.8μb^{-1}
  - published in PLB 693 (2010) 69-80
- Prompt $\overline{\Lambda}/\Lambda$ and $\overline{\Lambda}/K_S$ production ratio in 2010 data:
  - $\sqrt{s}$=0.9 TeV
    - $\int\mathcal{L}\approx$0.3nb^{-1}
  - $\sqrt{s}$=7 TeV
    - $\int\mathcal{L}\lesssim$1nb^{-1}
  - preliminary results

Primary vertex position

- In 2009 the pp interactions were at √s=0.9 TeV.
- Beam-gas interactions were a background in 2009. It was reduced by vertex region cuts (to ≈1%) and statistically subtracted.
- Only first level hardware trigger used for the analysis
  - minimum bias trigger based on CALO

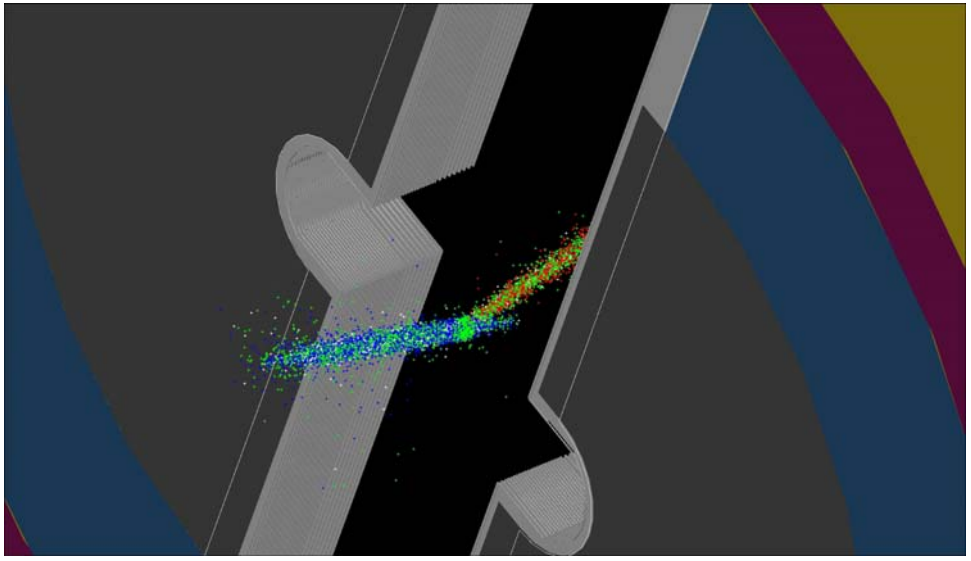


bb – beam-beam + beam-gas interactions

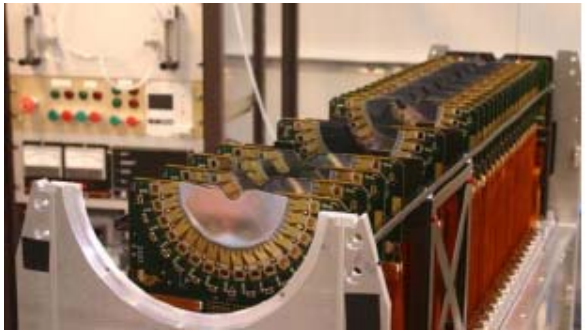
be – beam-gas interactions only

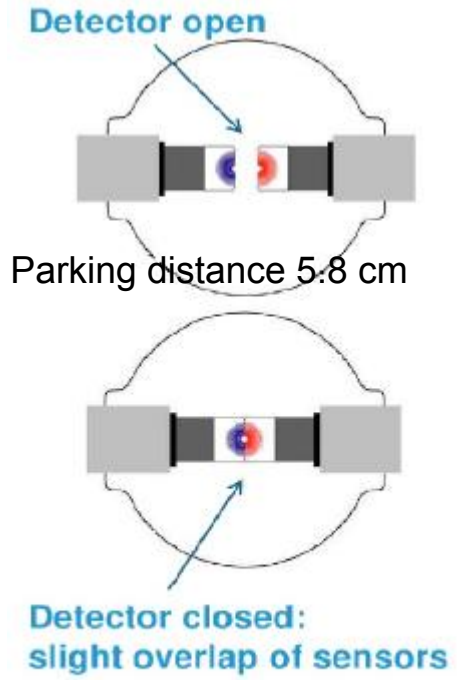
VELO position

- Our vertex detector could not be closed at 0.9 TeV due to internal beam crossing angle (due to our magnet)
  - In 2009 was kept at 15mm from nominal position
  - In 2010 it was kept at 10mm



- For the 7 TeV runs the VELO was closed

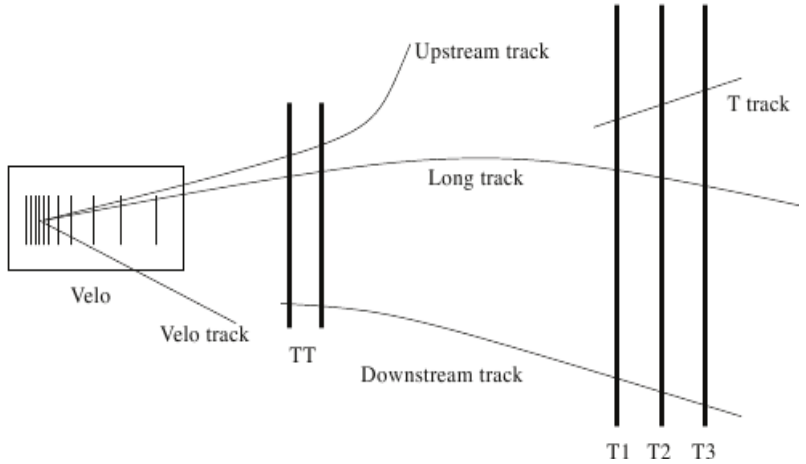


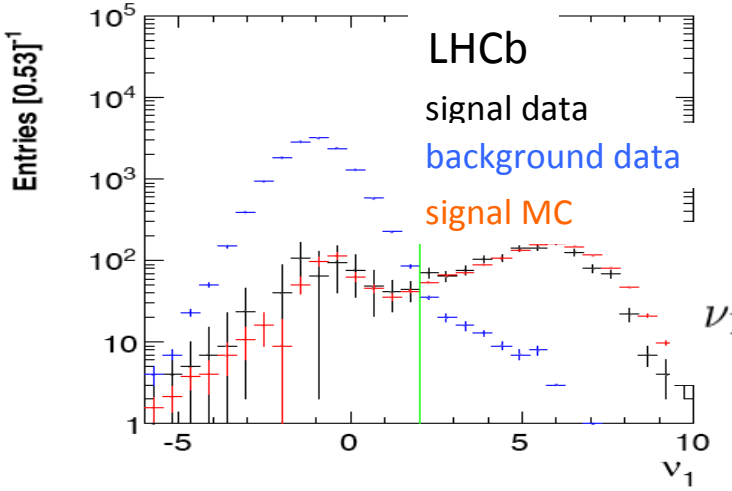


Event selection

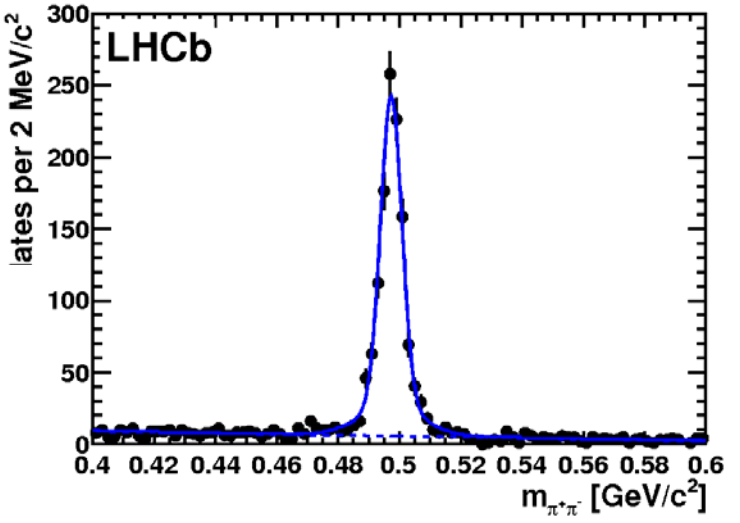
- We have performed two analyses

1) with LONG tracks
  - Make long tracks with VELO hits
  - low statistics due to VELO open but good background rejection
  - Separation from combinatorial background based on ν_1





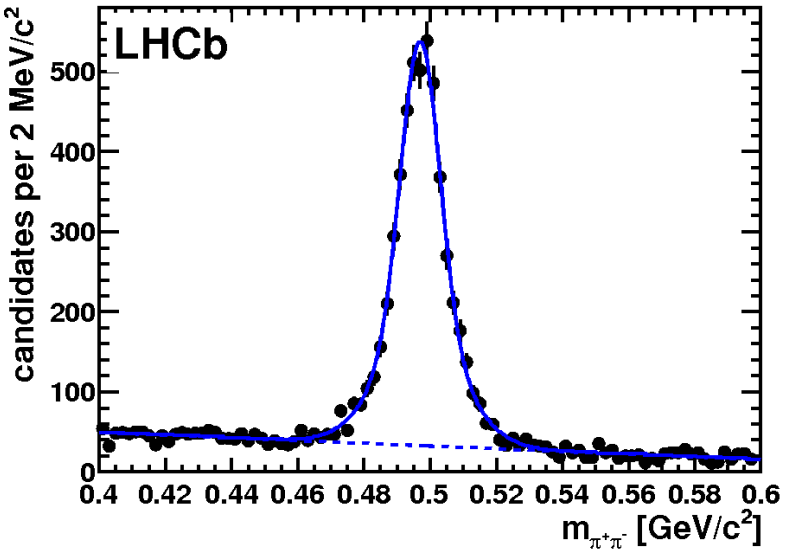
$$\nu_1 = \ln\left(\frac{\mathrm{IP}_{d^+} \cdot \mathrm{IP}_{d^-}}{\mathrm{IP}_{V^0} \cdot 1\mathrm{mm}}\right)$$



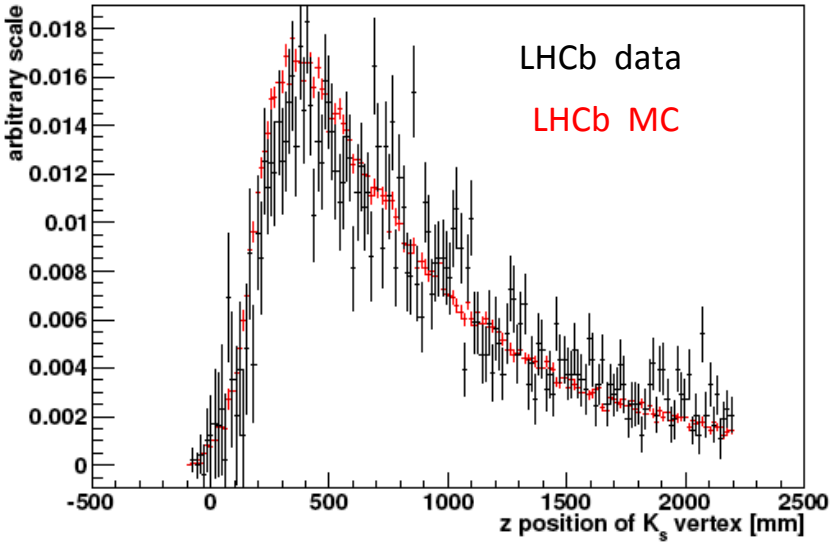
Event selection

2) with DOWNSTREAM tracks

- no VELO hits used in the reconstruction
- large statistics
- Ks required to point to the z axis



invariant mass with downstream tracks



reconstructed z position of the decay vertex

Efficiency corrections

Strategy: determine efficiencies in p_T,y bins from Monte Carlo

Use data to cross check in certain areas of phase space

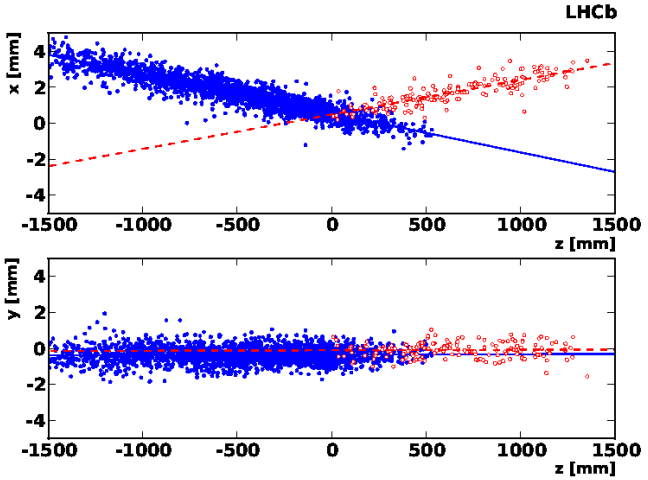
- Uncertainty of the selection efficiency: determine ratio data/MC after a loose pre-selection
  - systematic uncertainty ≈ 4%
- Trigger efficiencies between 96.5% and 99%
  - systematic difference data-MC <1%

Luminosity measurement

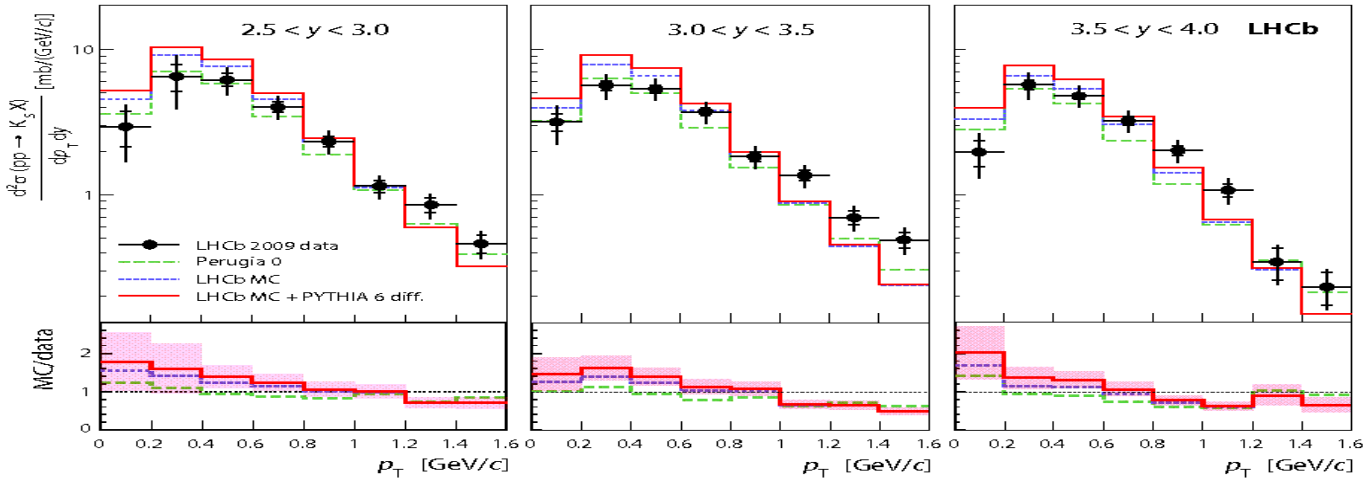
- Used a direct method based on beam currents from **BeamCurrentTransformers (BCT)** bunch-by-bunch and reconstruction of beam transverse size (in b1-gas and b2-gas events) by the VELO

$$\mathcal{L} = f \sum_{i}^{N} \frac{n_{1i} n_{2i}}{4\pi \sigma^{x}{}_{i} \sigma^{y}{}_{i}}$$

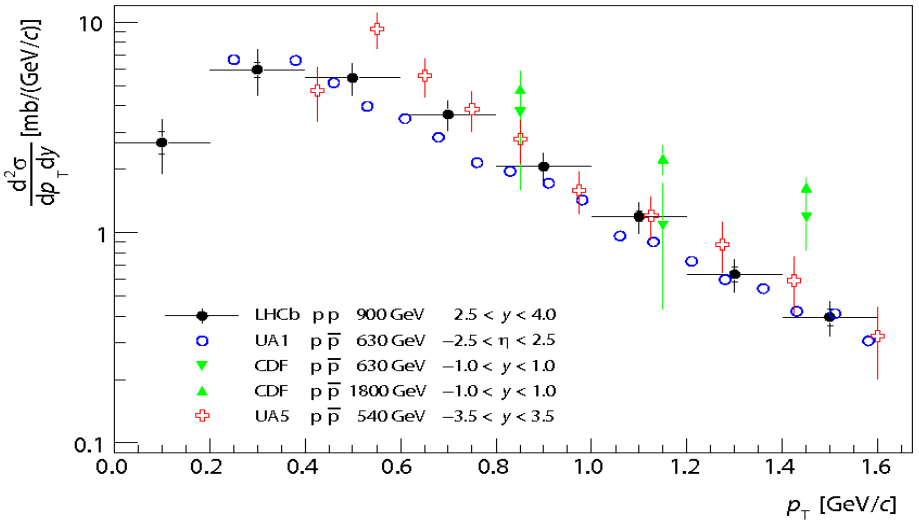
- Need to take into account the crossing angle (2mrad) in X-Z plane due to LHCb B field
- Systematic on beam sizes evaluated comparing b1-gas, b2-gas and b1-b2 events
- Total systematic error ≈15% dominated by **BCT** current measurements



Prompt K_S results at $\sqrt{s}$ = 0.9 TeV



Comparison with different PYTHIA tunings → data tend to be slightly harder



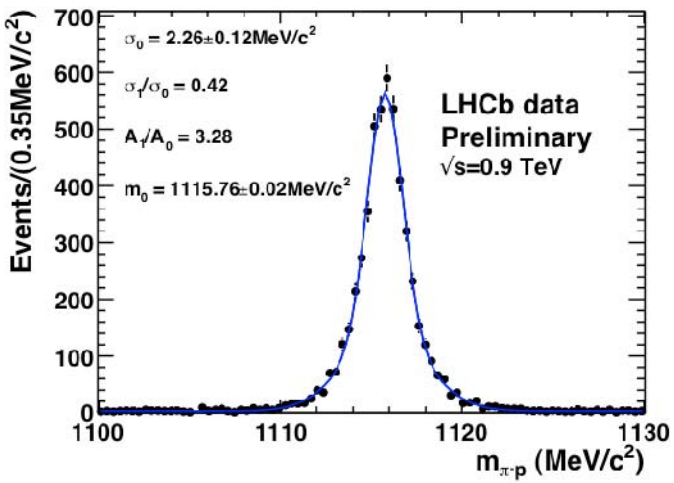
Comparison with other experiments
→ extended measurement range

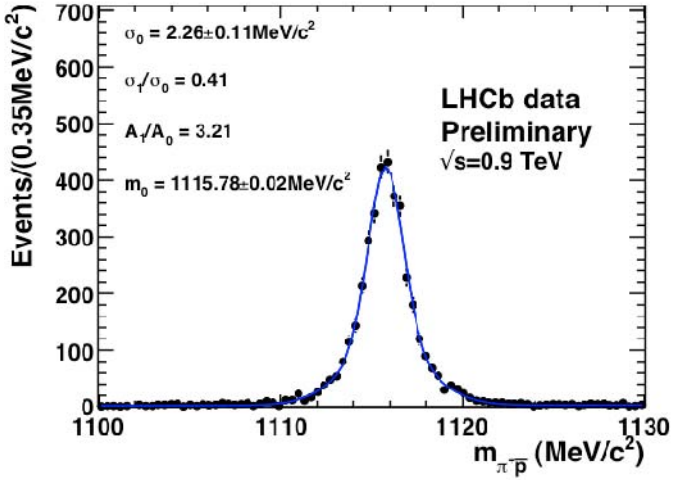
Selection criteria for Λ

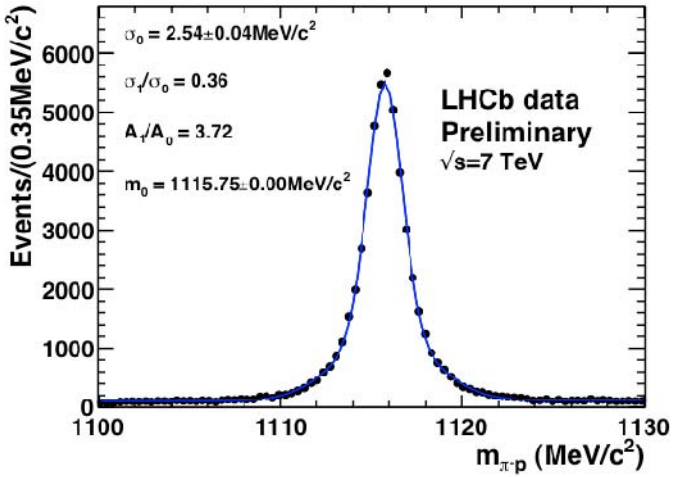
- analysis made with long tracks only
- no particle id. used: Λ and $\overline{\Lambda}$ selected by the Armenteros-Podolansky variables
- combinatorial background reduced using the same variable ν_1 as in the K_S analysis
- pointing of the Λ to the primary vertex required
- selected events:

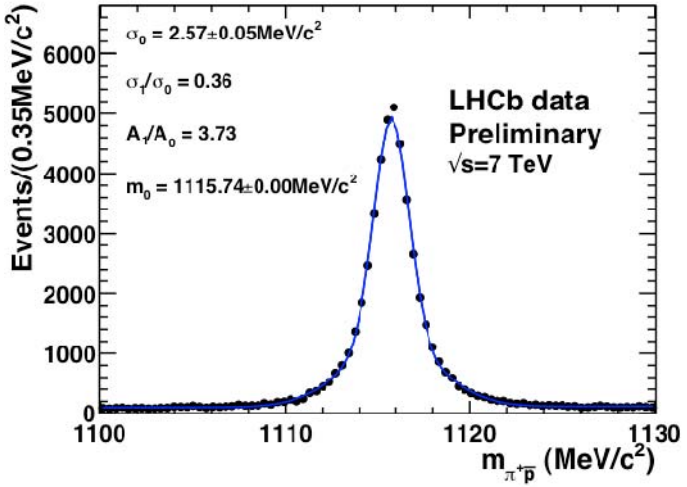
	0.9 TeV field up data	0.9 TeV field down data	7 TeV field up data	7 TeV field down data
Λ	4803	4421	20790	24815
$\overline{\Lambda}$	3629	3173	19115	22077

Invariant mass distributions

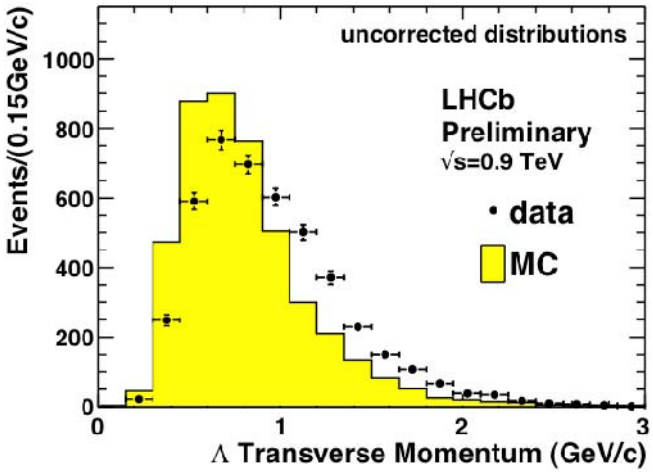


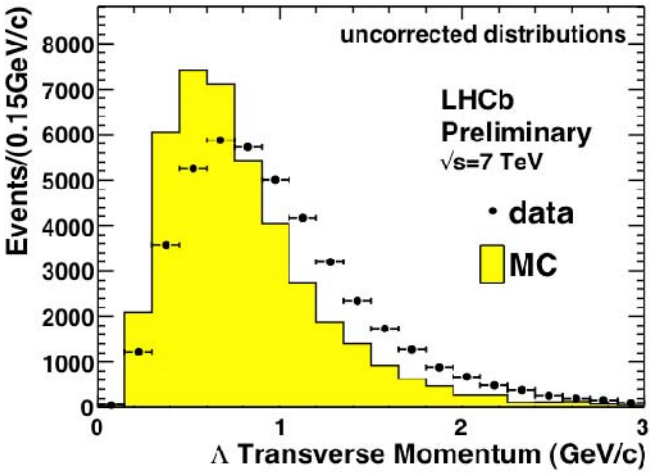




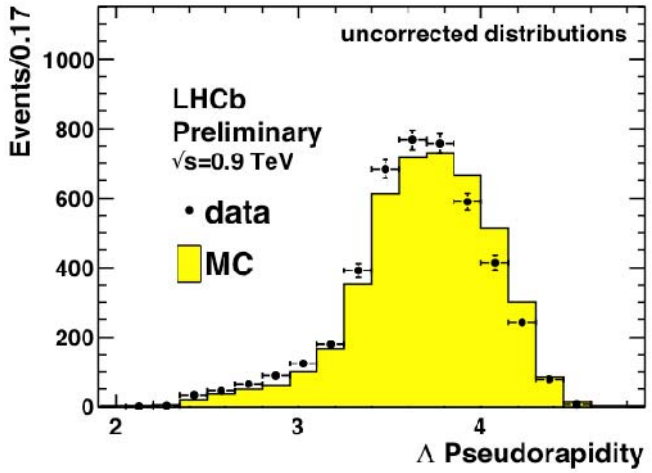


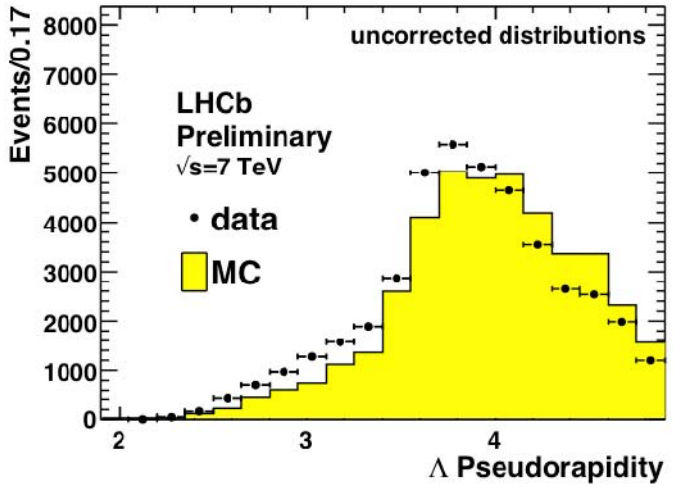
Kinematic distributions of Λ's



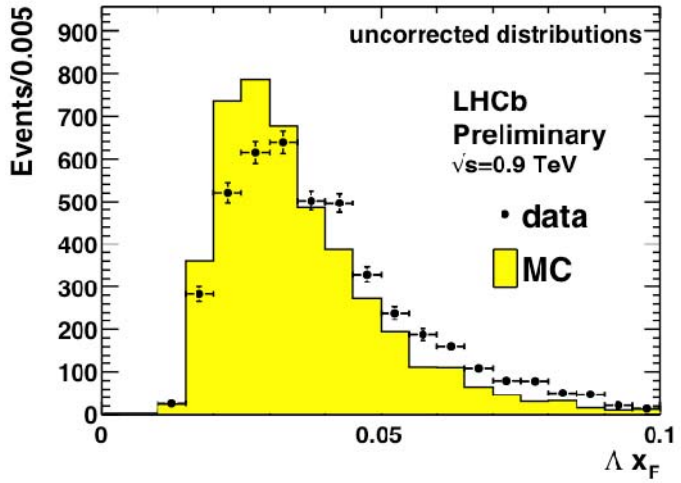


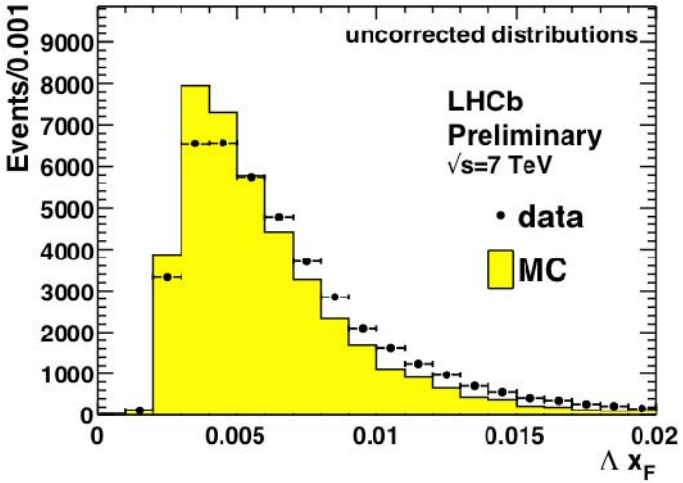
Data distributions "harder" than MC





Feynman x of Λ's





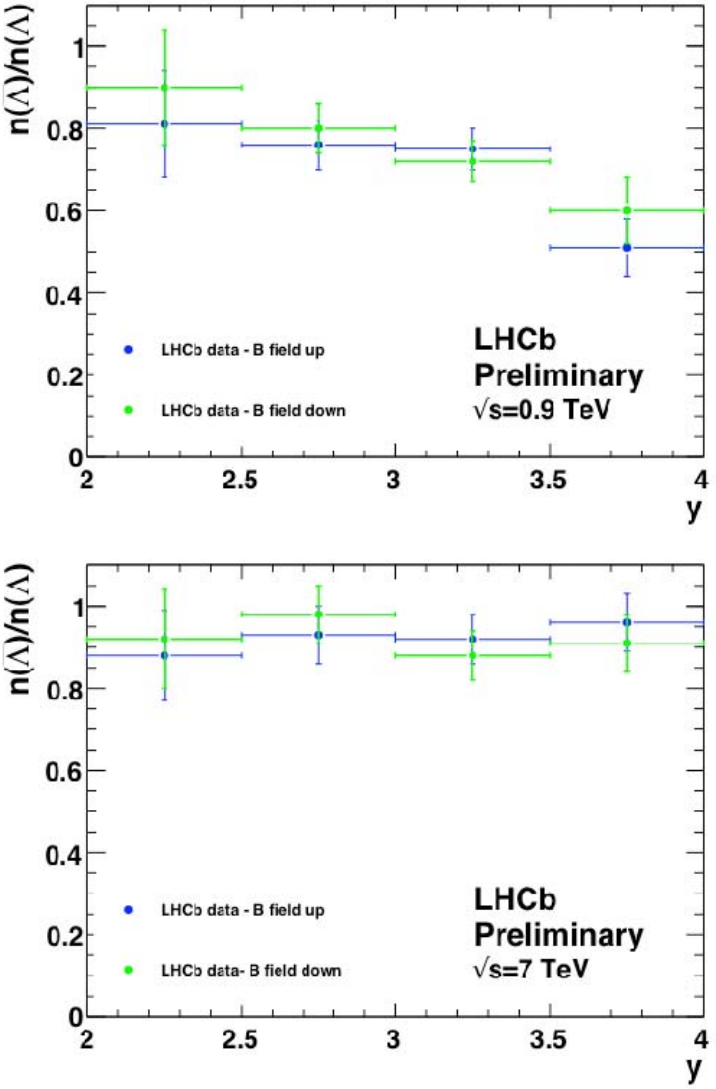
0.9 TeV ➔ x_F<0.1

7 TeV ➔ x_F<0.02

very small x_F values

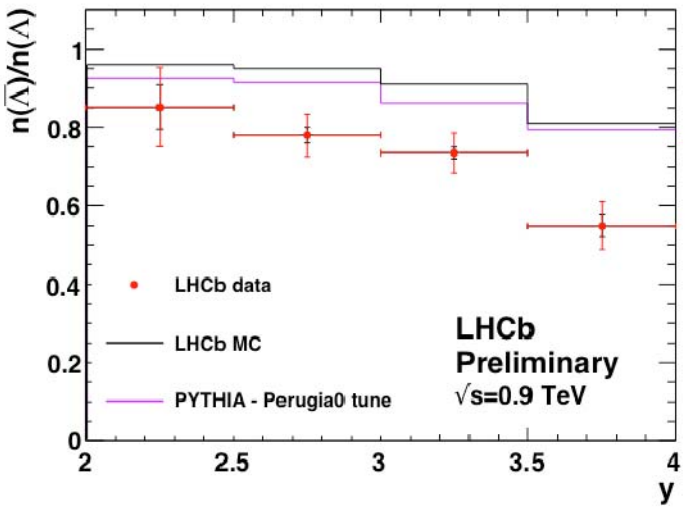
Study of systematics

- The analyzed sources of systematics are:
  - p, π interaction cross-sections
  - V0 production and interaction cross-sections
  - LHCb material description
  - Selection cuts
  - Acceptance asymmetry
  - Ghost tracks
- Most of the systematics cancel in the ratios.
- Cross check was done for different magnet polarities.
- The total systematics for ratios:
  - $\overline{\Lambda}/\Lambda \approx 2\%$
  - $\overline{\Lambda}/K_S \approx 2\text{-}12\%$

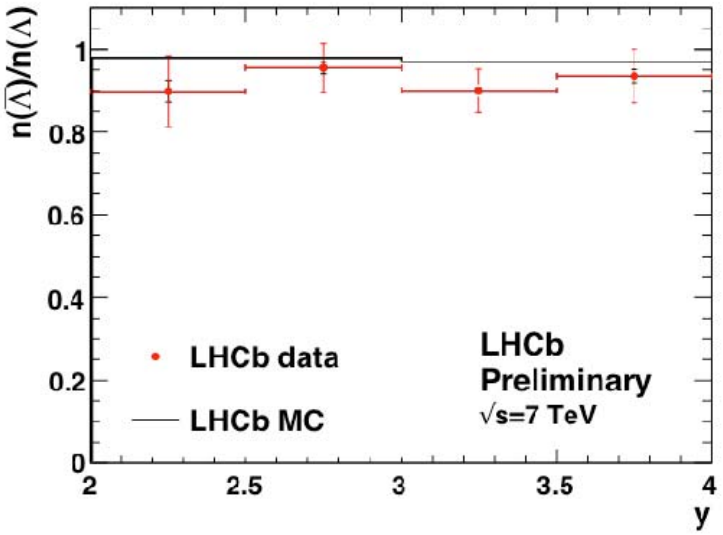


Results for $\bar{\Lambda}/\Lambda$

Efficiency corrected ratios for "prompt" Λ

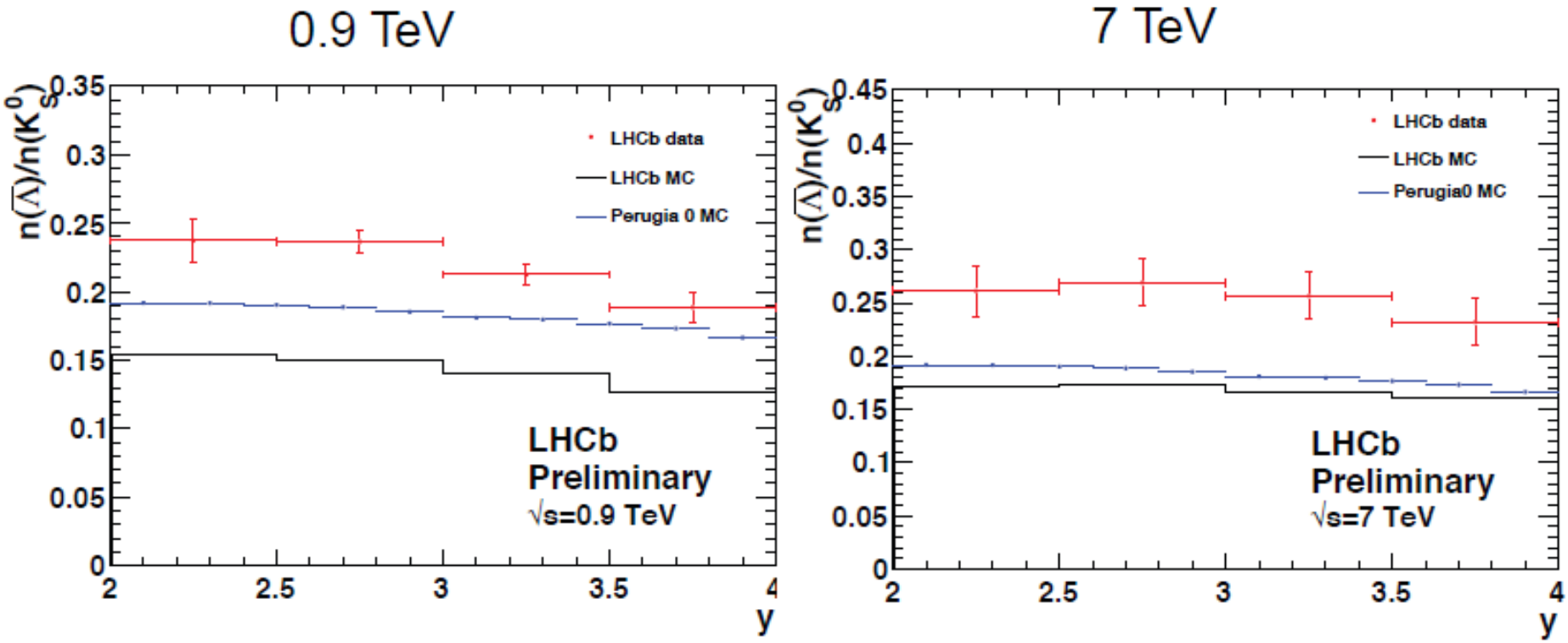


Plots include both statistical and systematic error
Field up and down results were averaged being consistent with each other



Perugia tunes do not include diffraction
LHCb tune include diffraction
(<1% after selection cuts)

Baryon suppression with $\overline{\Lambda}/K_S$



- Ratio of $\overline{\Lambda}/K_S$ higher than expectation at both energies.

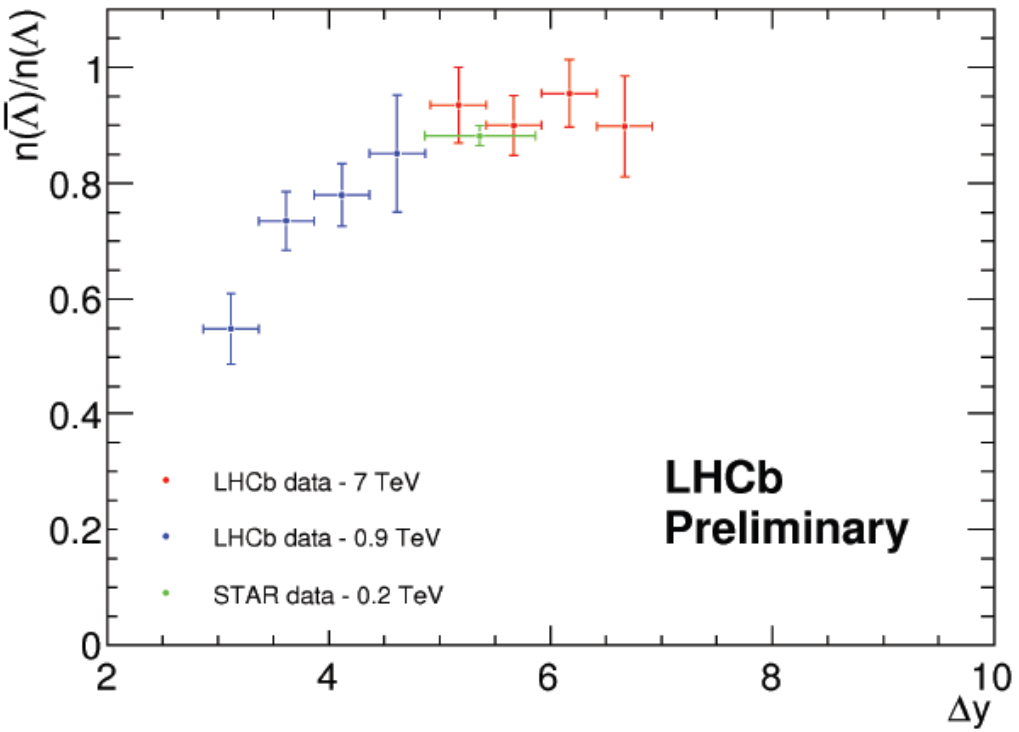
Baryon number transport $\overline{\Lambda}/\Lambda$

Comparing rapidity bins equally away from the beam probes scaling violations.

$$y_1 = y_2 + \ln\left(\frac{E_{b1}}{E_{b2}}\right)$$

Consistency between the two energy measurements and previous result.

y_{beam} = 6.6 at $\sqrt{s}$ = 0.9 TeV
8.3 at $\sqrt{s}$ = 7.0 TeV



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

Conclusion

- prompt K_S absolute production cross section at $\sqrt{s}$=0.9 TeV
  - p_T spectra tend to be “harder” than PYTHIA predictions
  - extended measurement range to low p_T and new y range
- prompt $\overline{\Lambda}/\Lambda$ ratio at $\sqrt{s}$=0.9 TeV
  - tends to be lower than PYTHIA Perugia 0 tune and LHCb tune, lower with larger y
- prompt $\overline{\Lambda}/\Lambda$ ratio at $\sqrt{s}$=7 TeV
  - in fair agreement with PYTHIA LHCb tune and quite flat vs. y
- prompt $\overline{\Lambda}/K_S$ ratio at 0.9 and 7 TeV
  - Baryon suppression in hadronisation is less than predicted