Review of latest MB results

MPI@LHC 2012

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INFN Cagliari

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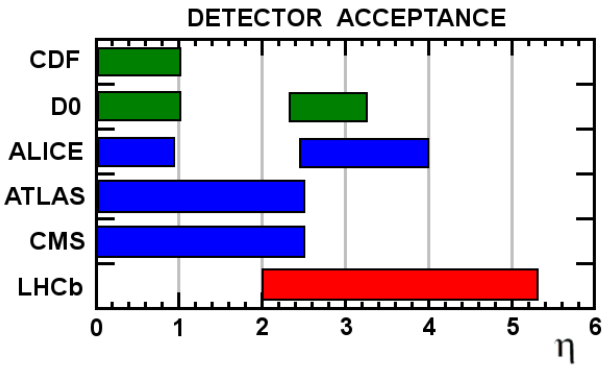
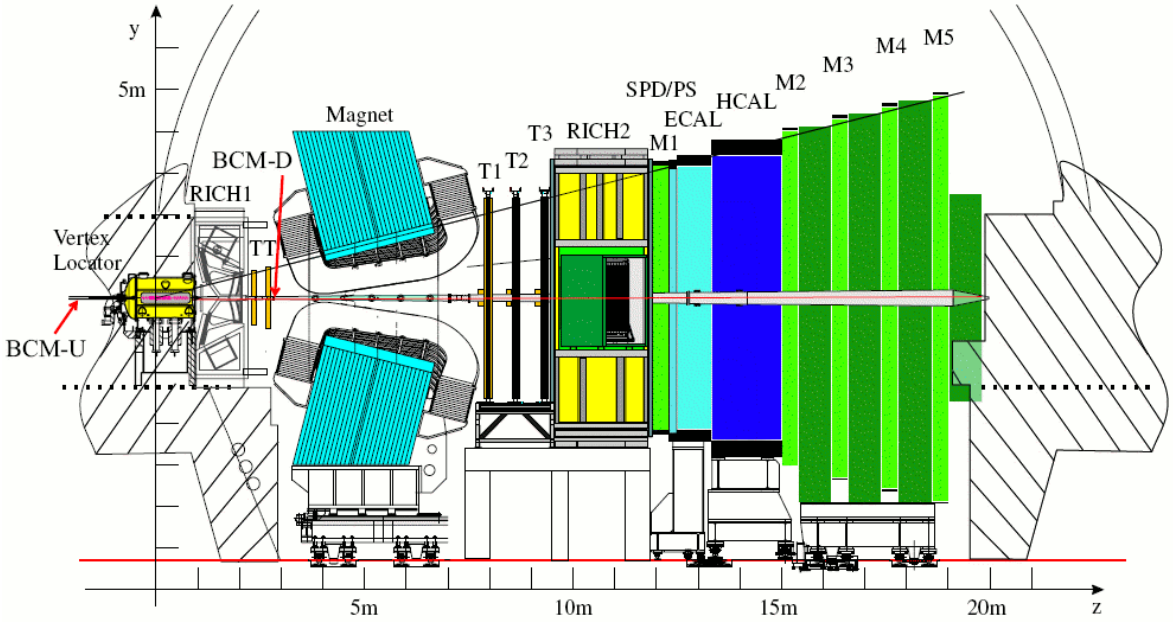
Outline

The LHCb detector





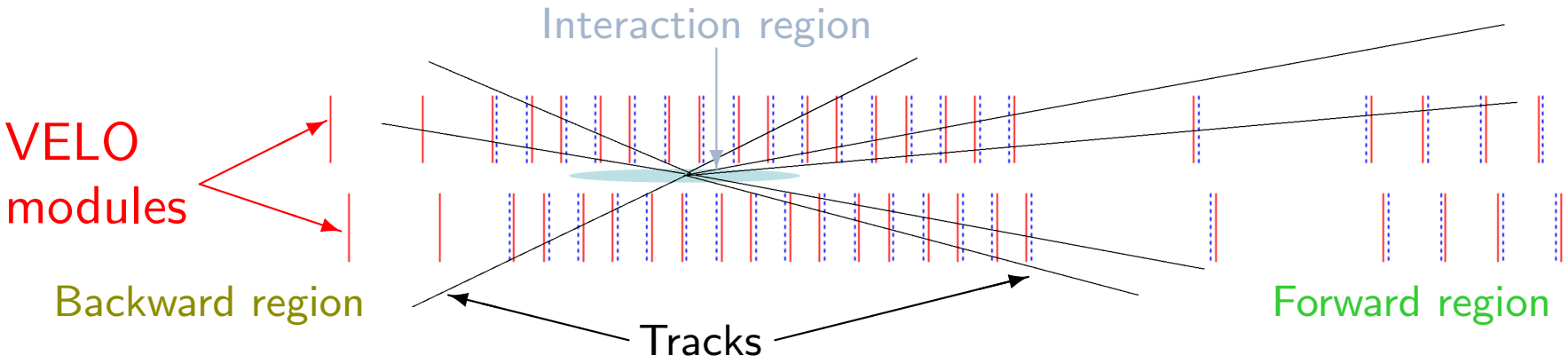
JINST 3 (2008) S080005

- Multi-stage trigger:
  - First level is hardware
  - Subsequent two levels are software
- Performances:
  - $\Delta p/p = 0.35\% - 0.55\%$
  - Mass resolution$= 10 - 25\,\mathrm{MeV/c^2}$
  - ECAL $\sigma(E)/E = 10\%(E/\mathrm{GeV})^{-1/2} \oplus 1\%$
  - Excellent particle ID thanks to RICH detectors (2-100 GeV/c^2)

Charged particle multiplicity

Sensitive to low-x QCD dynamics and multi-parton interaction (MPI)

- Count reconstructed tracks in VELO detector, magnetic field negligible
- High efficiency in the region $[-2.5 < \eta < -2]$ and $[2 < \eta < 4.5]$



- Multiplicity distribution determined using unfolding procedure
- Results given in η bins of 0.5, at least one track in forward acceptance
- Systematic (few percent) from tracking efficiency, ghosts, non-prompt and pile-up

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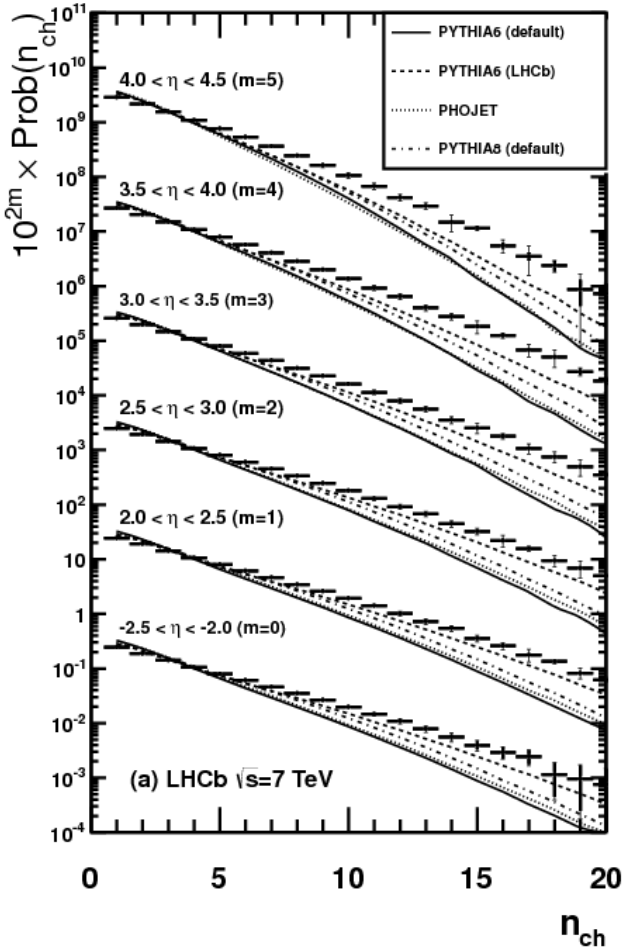
Charged particle multiplicity

No single model is able to fully reproduce the data.

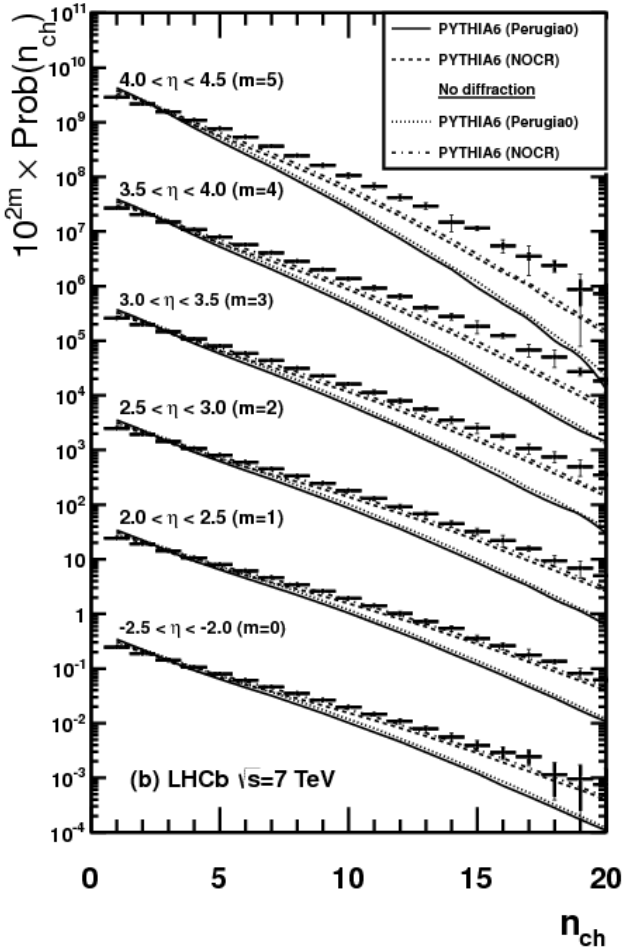
In general multiplicities are underestimated.

Switching off diffraction in PYTHIA Perugia tunes improves the description.

Diffraction ON



Diffraction OFF



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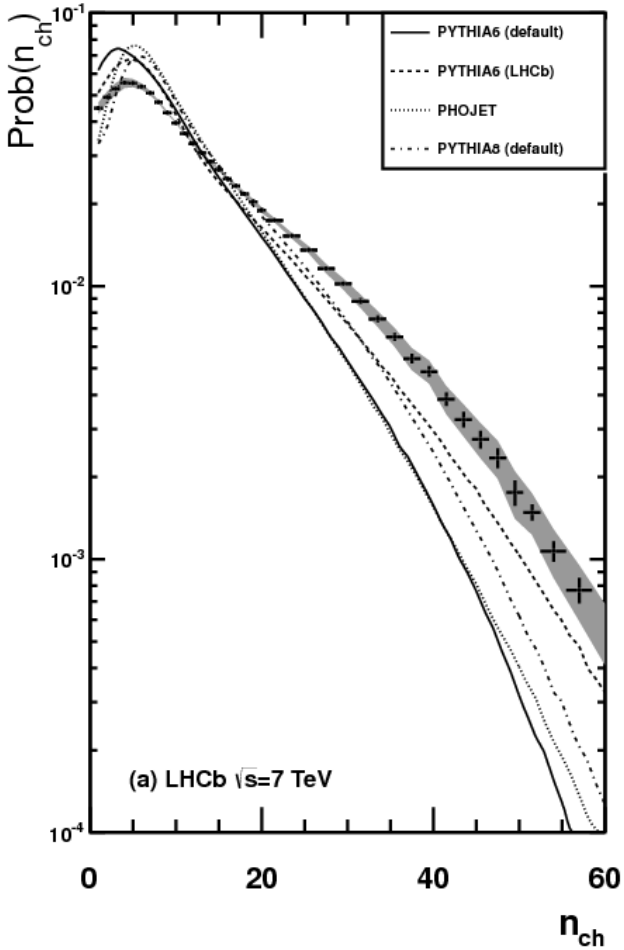
Charged particle multiplicity, full forward η range

No single model is able to fully reproduce the data.

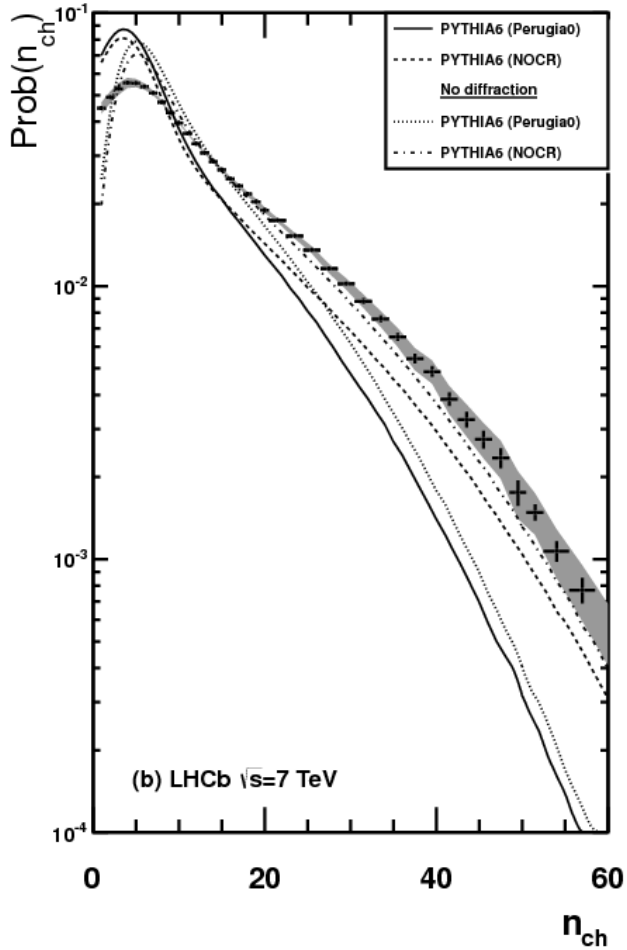
In general multiplicities are underestimated.

Switching off diffraction in PYTHIA Perugia tunes improves the description.

Diffraction ON



Diffraction OFF



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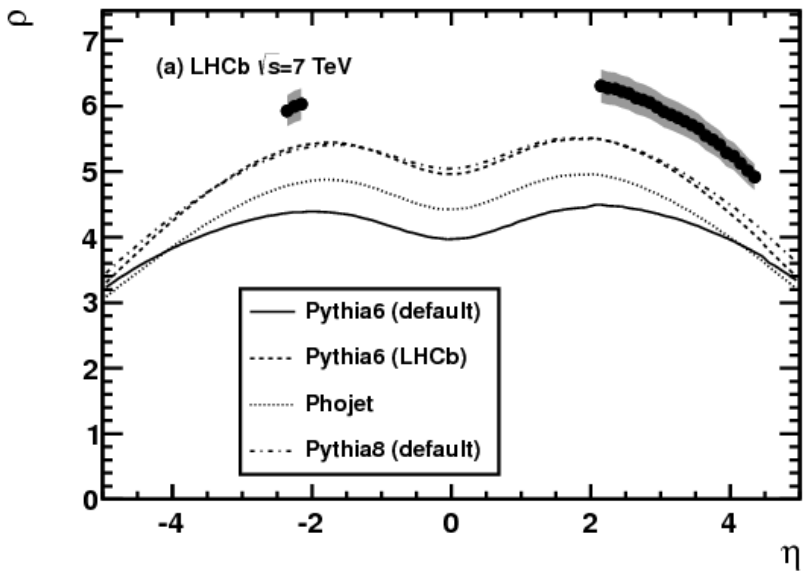
Charged particle densities

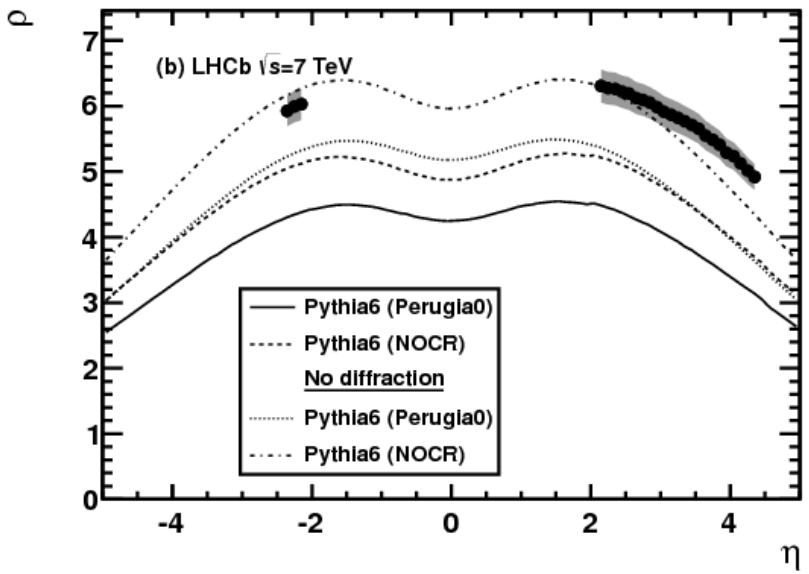
Forward-backward asymmetry due to the requirement of one track in forward acceptance

No single model is able to fully reproduce the data.

Forward-backward asymmetry more pronounced in data.

Particle densities are underestimated.





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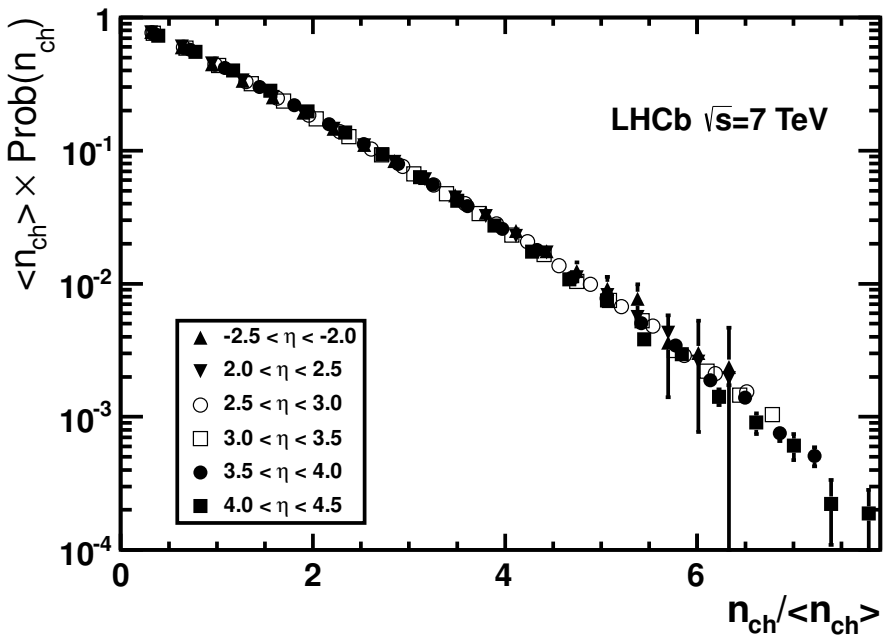
Charged particle multiplicity, KNO

Koba-Nielsen-Olesen (KNO) scaling variable used to compare data in different η bins.

$\langle n_{ch} \rangle$ extracted from fit (distributions are truncated).



Distributions in different η bins are equivalent.

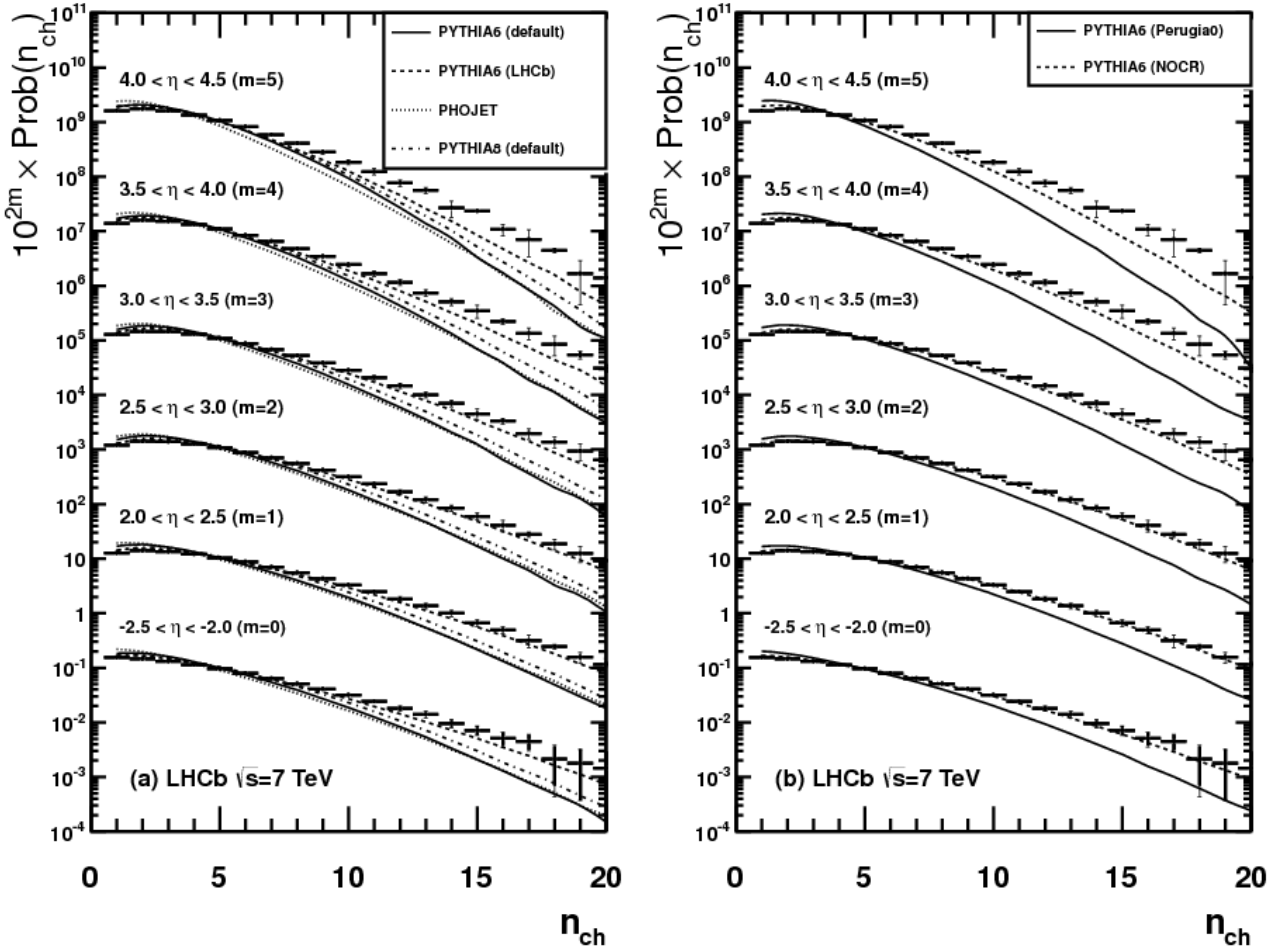
In particular forward = backward.

Charged particle multiplicity, hard QCD

Hard QCD events studied by requiring at least one track with $p_T > 1\,\mathrm{GeV}/c$ within $[2.5 < \eta < 4.5]$

No single model is able to fully reproduce the data.

In general multiplicities are underestimated.



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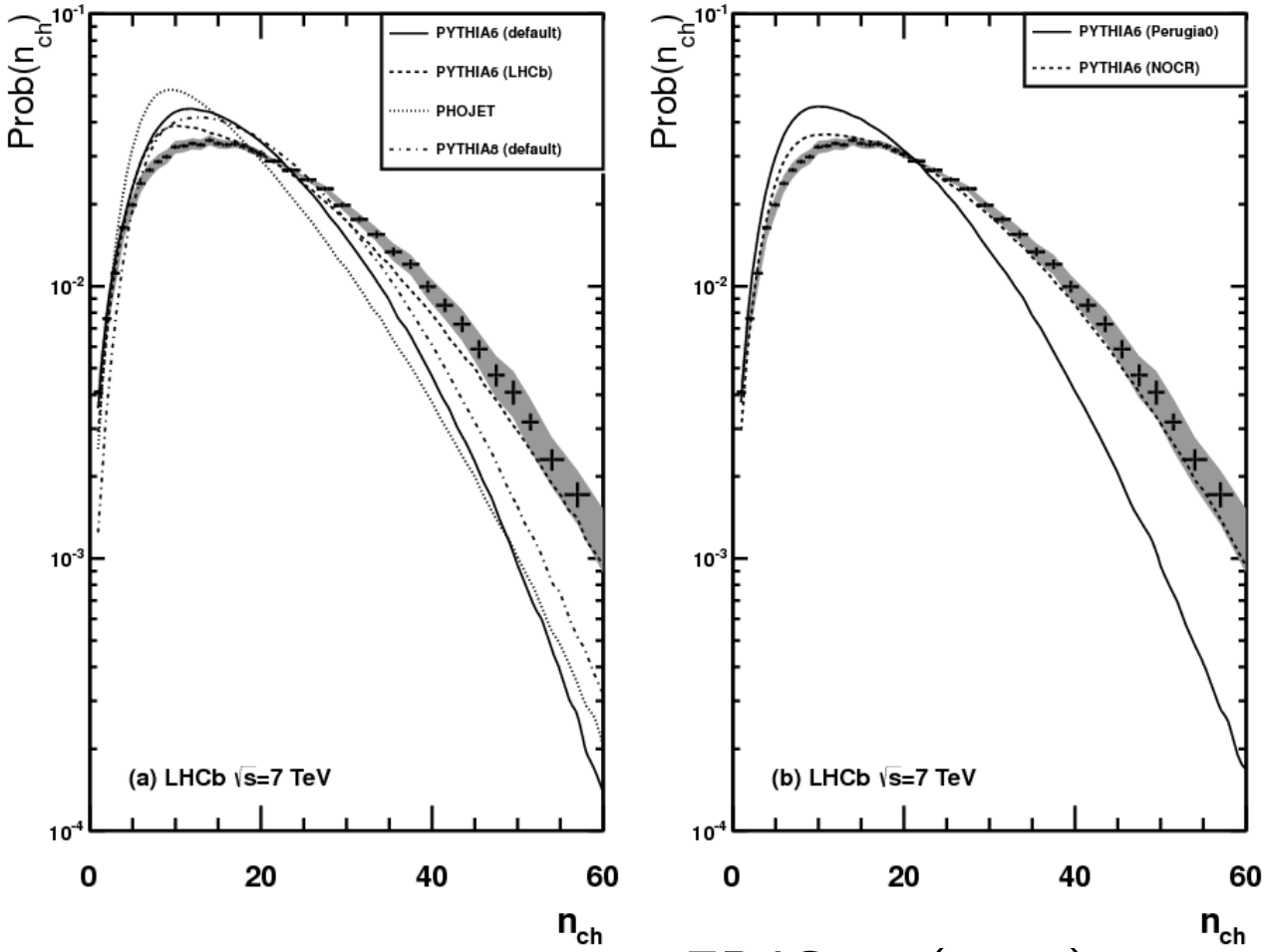
Charged particle multiplicity, full forward η range, hard QCD

Hard QCD events studied by requiring at least one track with $p_T > 1\,\mathrm{GeV}/c$ within $[2.5 < \eta < 4.5]$

No single model is able to fully reproduce the data.

In general multiplicities are underestimated.



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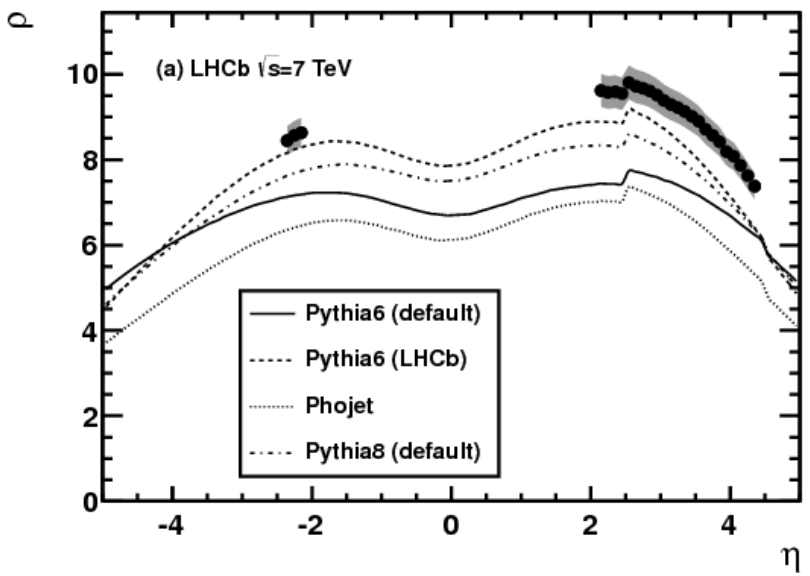
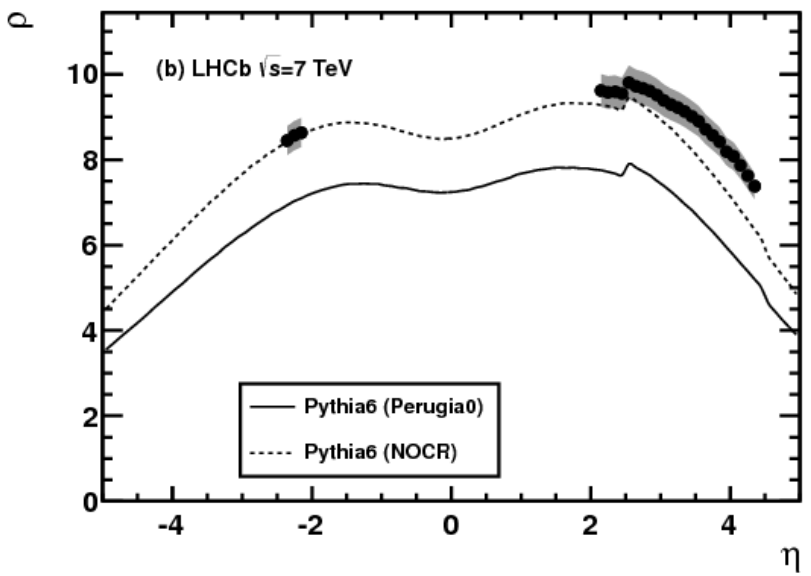
Charged particle densities, hard QCD

Hard QCD events studied by requiring at least one track with $p_T > 1\,\mathrm{GeV}/c$ within $[2.5 < \eta < 4.5]$

No single model is able to fully reproduce the data.

Particle densities are underestimated.





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Prompt hadron production ratios

Production ratios of identified charged hadrons:

$$\frac{\bar{p}}{p}, \frac{K^-}{K^+}, \frac{\pi^-}{\pi^+}, \frac{p+\bar{p}}{\pi^+ + \pi^-}, \frac{K^+ + K^-}{\pi^+ + \pi^-}, \frac{p+\bar{p}}{K^+ + K^-}$$

Probe baryon number transport (BNT) and hadronisation mechanisms
Important input for tuning of MC event generators

Measurements performed at 0.9 and 7 TeV, 0.3 and 1.8 nb^{-1} respectively
Particles selected using RICH information only $\rightarrow$ Cross contamination

$$\underbrace{\begin{bmatrix} p_{Sel} \\ K_{Sel} \\ \pi_{Sel} \end{bmatrix}}_{V_{Sel}} = \underbrace{\begin{bmatrix} \epsilon_{\mathbf{p}\rightarrow\mathbf{p}} & \epsilon_{K\rightarrow p} & \epsilon_{\pi\rightarrow p} \\ \epsilon_{p\rightarrow K} & \epsilon_{\mathbf{K}\rightarrow\mathbf{K}} & \epsilon_{\pi\rightarrow K} \\ \epsilon_{p\rightarrow\pi} & \epsilon_{K\rightarrow\pi} & \epsilon_{\boldsymbol{\pi}\rightarrow\boldsymbol{\pi}} \end{bmatrix}}_{M_{ID}} \underbrace{\begin{bmatrix} p_{True} \\ K_{True} \\ \pi_{True} \end{bmatrix}}_{V_{True}} \quad \Rightarrow V_{True} = M_{ID}^{-1} V_{Sel}$$

Acceptance and reconstruction efficiencies from MC
Main systematics from PID calibration.

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Prompt hadron production ratios, PID corrections

PID efficiencies and extracted from data using RICH calibration samples of $\Lambda \to p\pi^-$, $K^0_S \to \pi^+\pi^-$, $\phi \to K^+K^-$

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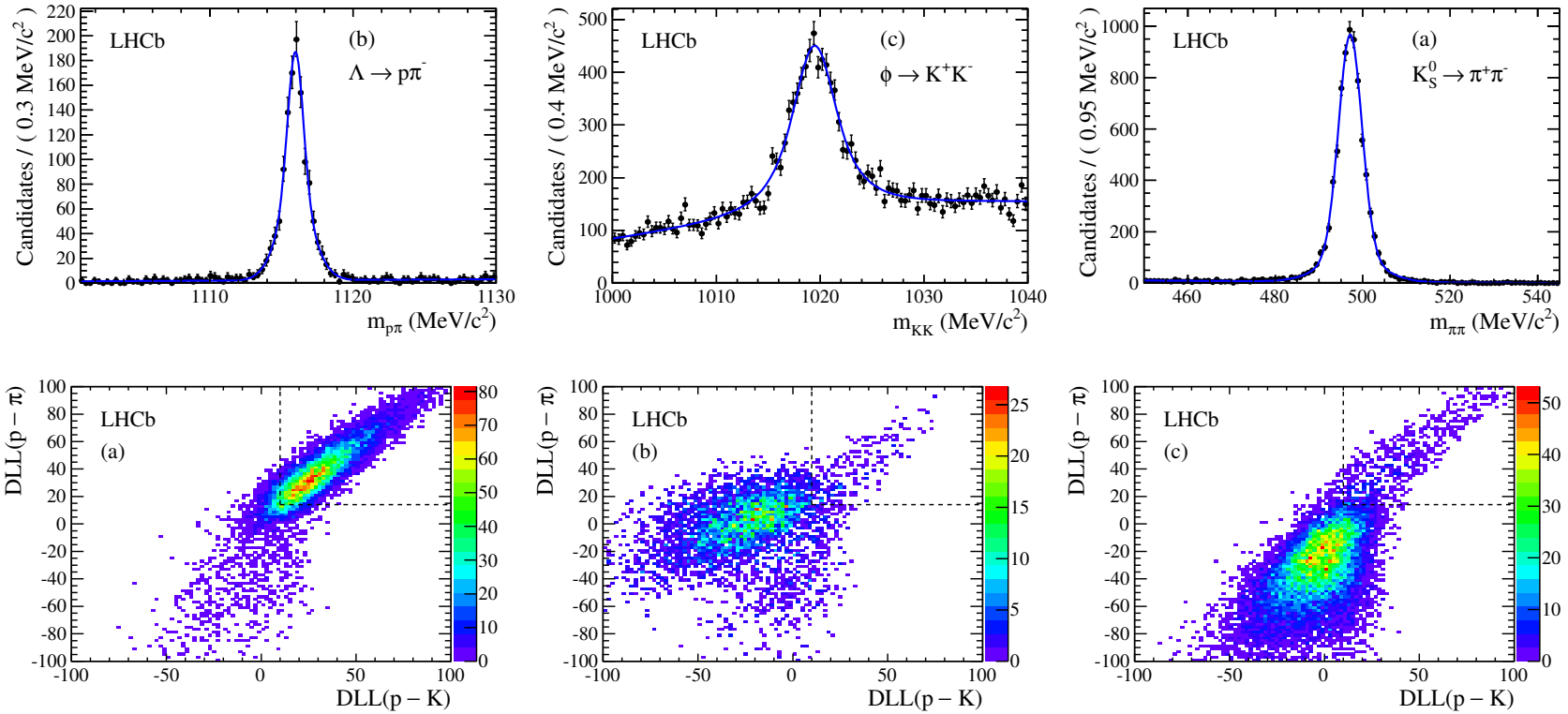

$DLL(X - Y)$ = Delta Log Likelihood between particle hypothesis X and Y.

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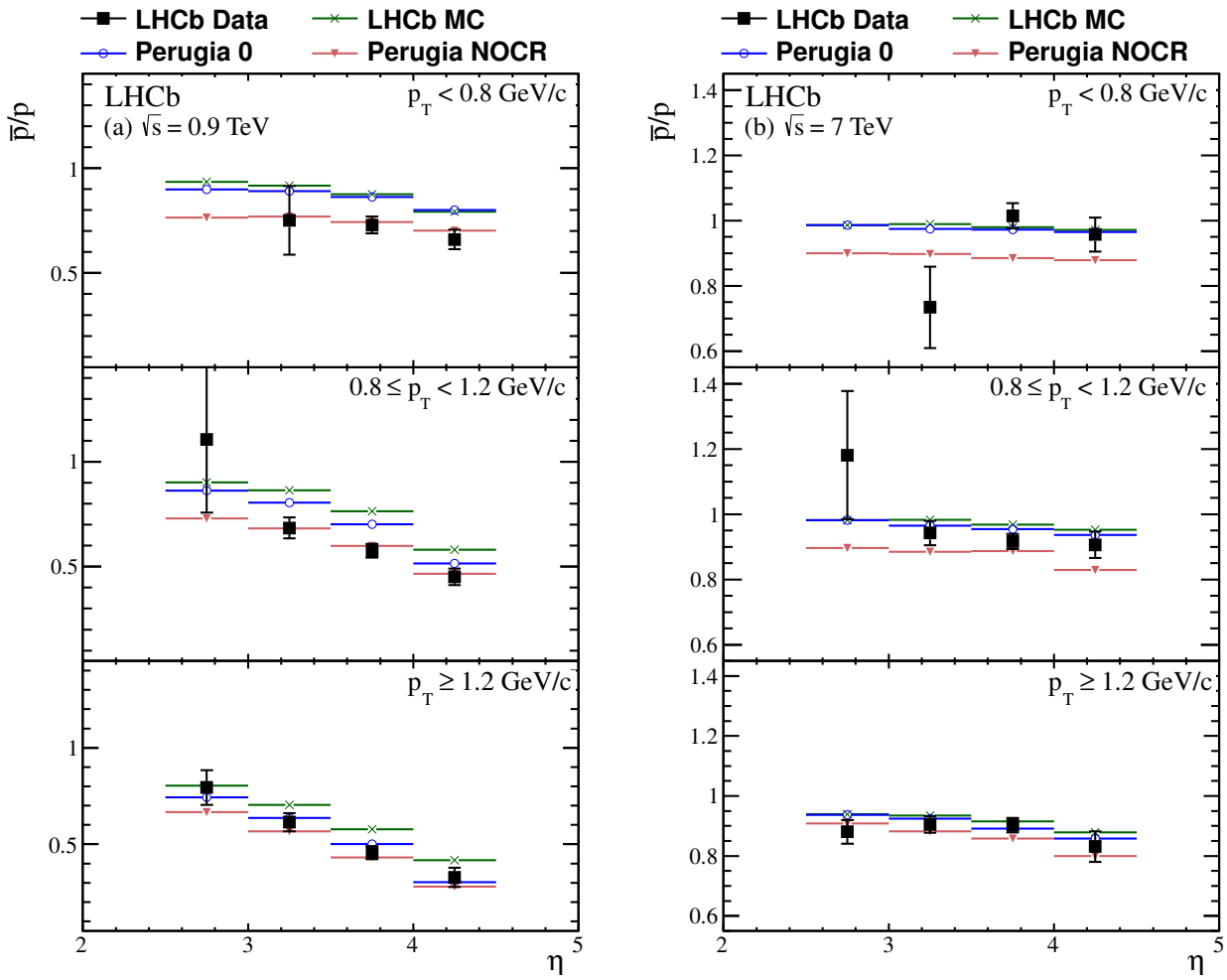
Prompt hadron production ratios, $\bar{p}/p$

Ratio systematically below LHCb MC and Perugia 0, particularly at low energy.

Data closer to Perugia NOCR prediction.

NO p_T dependence.



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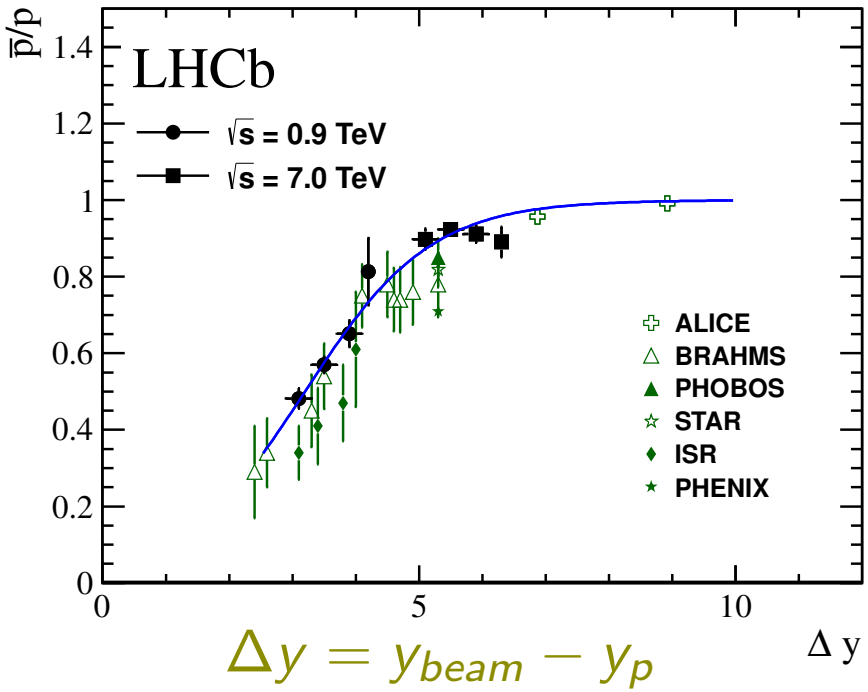
Baryon number transport (P_T averaged), $\bar{p}/p$

LHCb covers a wide rapidity loss, measurements significantly more precise than previous ones.



Fit to LHCb+ALICE data with

$$\frac{\bar{p}}{p} = \frac{1}{1 + C \exp\left[(\alpha_J - \alpha_P)\Delta y\right]}$$

to determine string-junction (SJ) and Pomeron contributions.

Results:

$C = 22.5 \pm 6.0$

$(\alpha_J - \alpha_P) = -0.98 \pm 0.07$

$\chi^2/ndf = 8.7/8$

Considering $\alpha_P \sim 1.2$ suggests a value for α_J lower than 0.5 (expected if SJ is associated with standard Reggeon)

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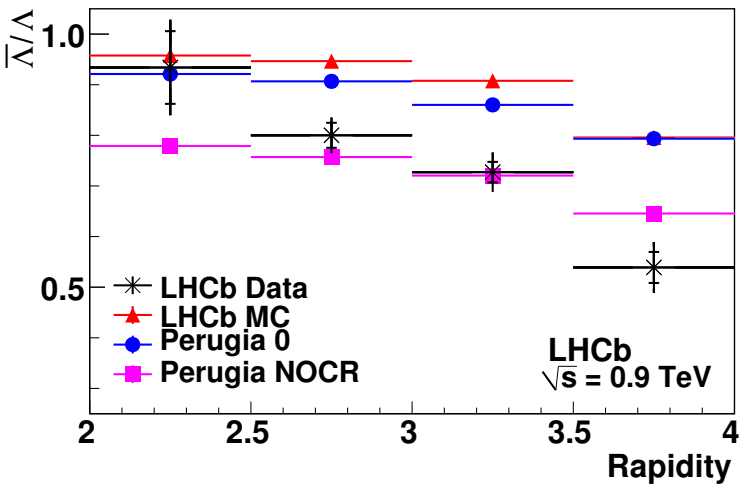
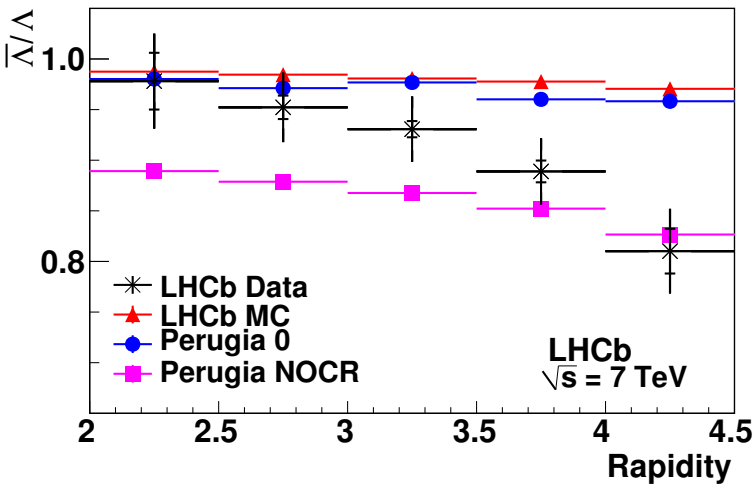
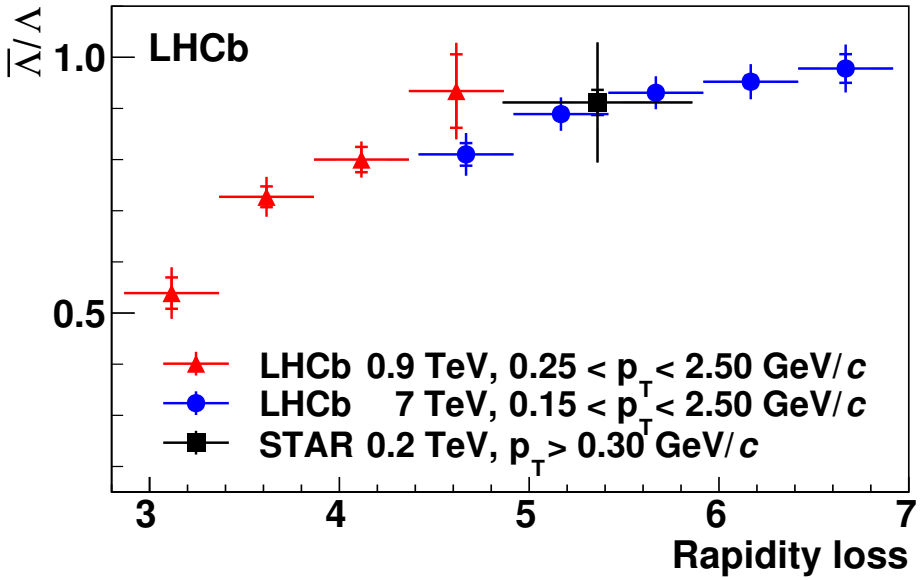
Prompt hadron production ratios, $\bar{\Lambda}/\Lambda$





Compatible with $\bar{p}/p$ ratio.

Perugia NOCR gives a good description



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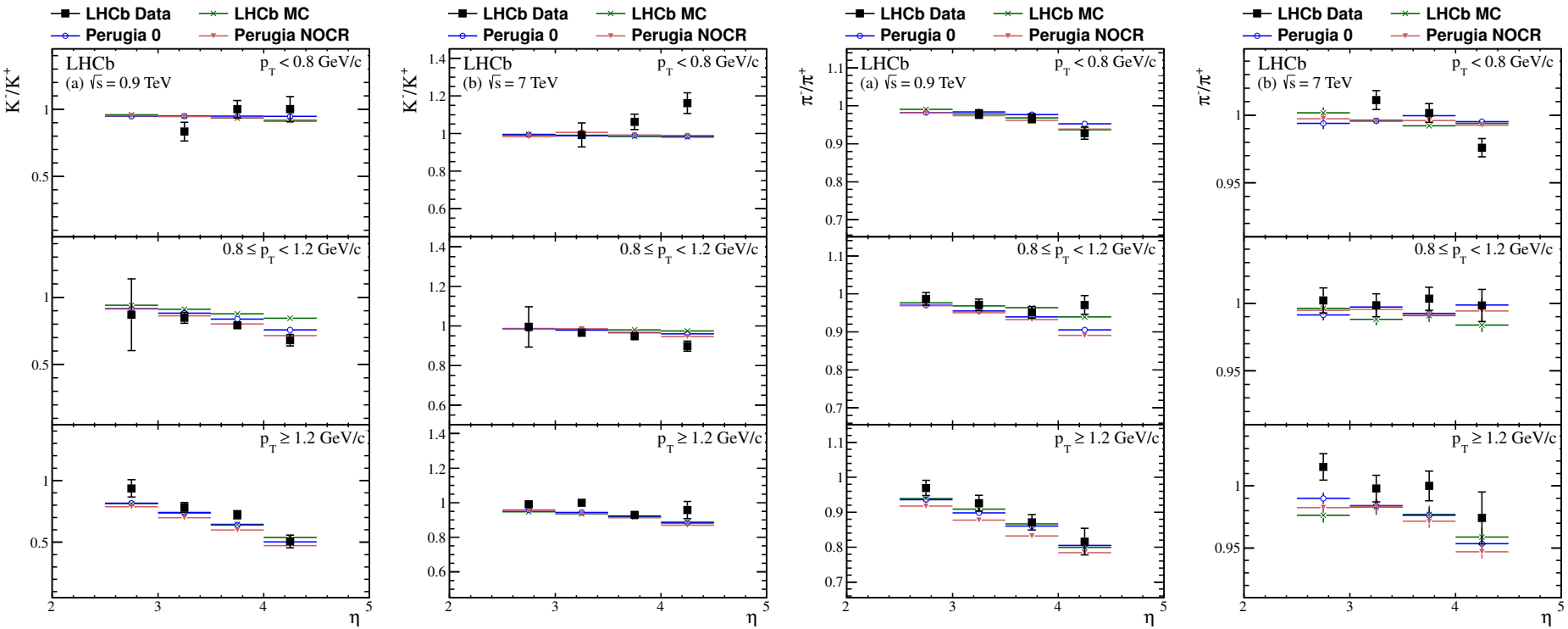
Prompt hadron production ratios, K^-/K^+ and π^-/π^+



Ratios differ from unity, especially at high η, p_T.
Behaviour generally well described by generators.

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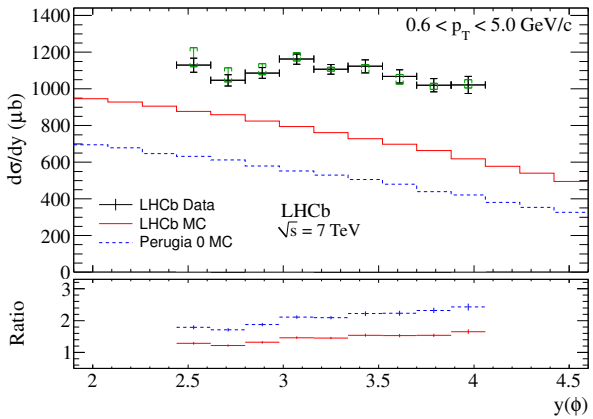
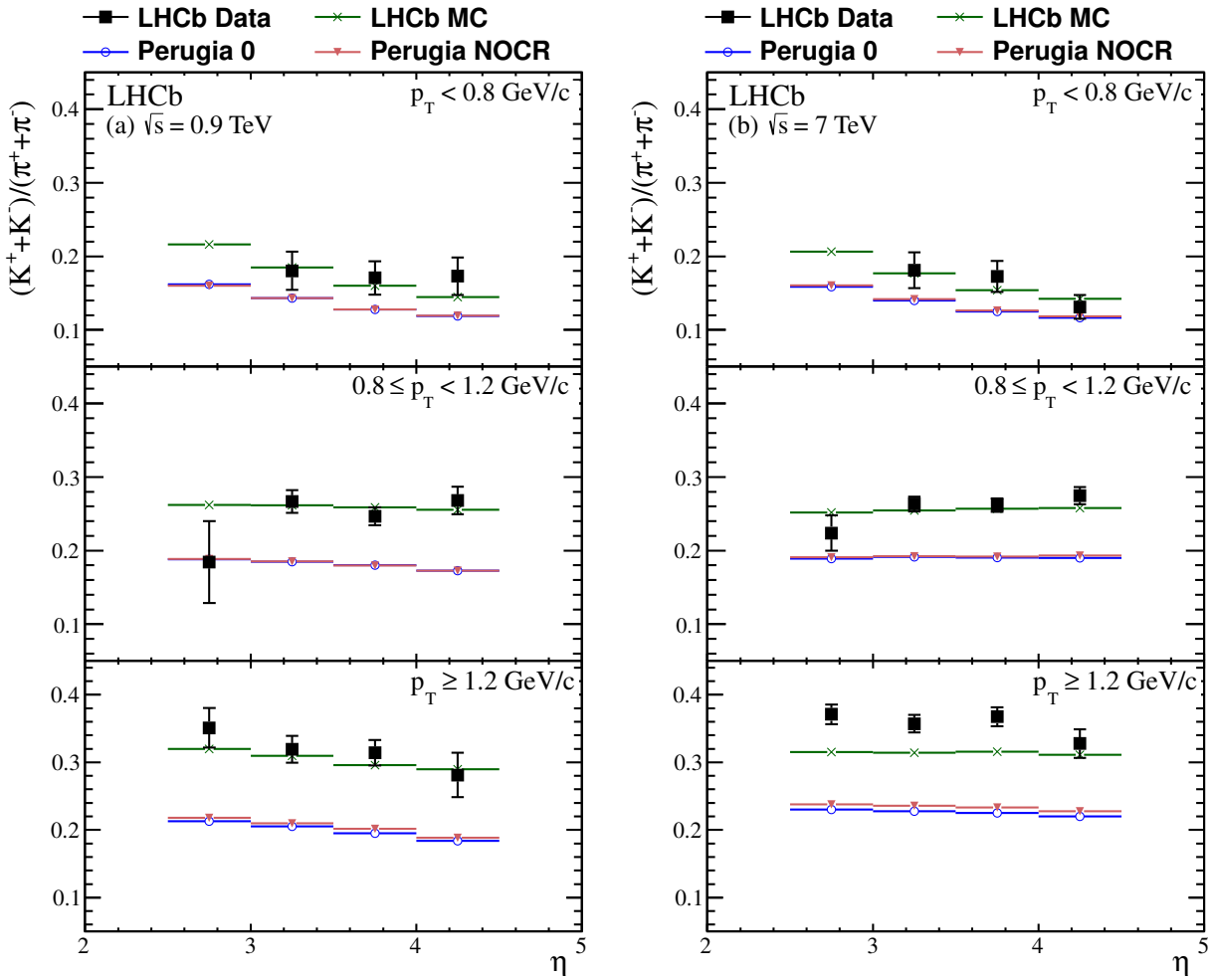
Prompt hadron production ratios, $(K^+ + K^-)/(\pi^+ + \pi^-)$

Data tends to lie at higher values for all tunes.
Expected from strange production being underestimated

Phys. Lett. B703 (2011)





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Prompt hadron production ratios, $(p + \bar{p})/(\pi^+ + \pi^-)$

Data tends to lie higher values for all tunes.

Baryon/meson suppr. is overestimated

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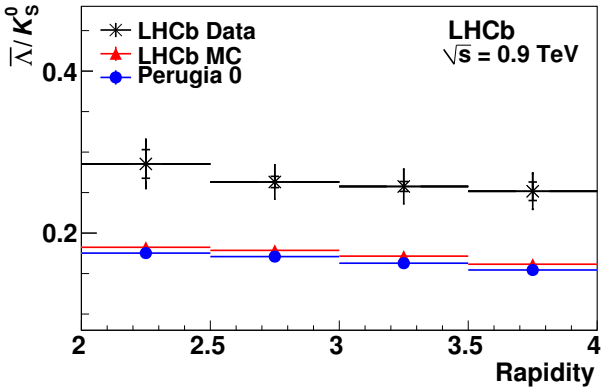

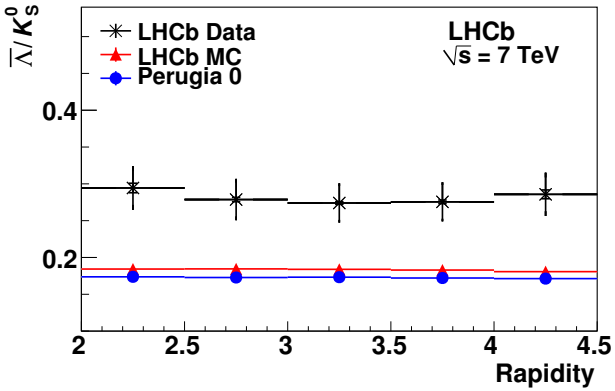

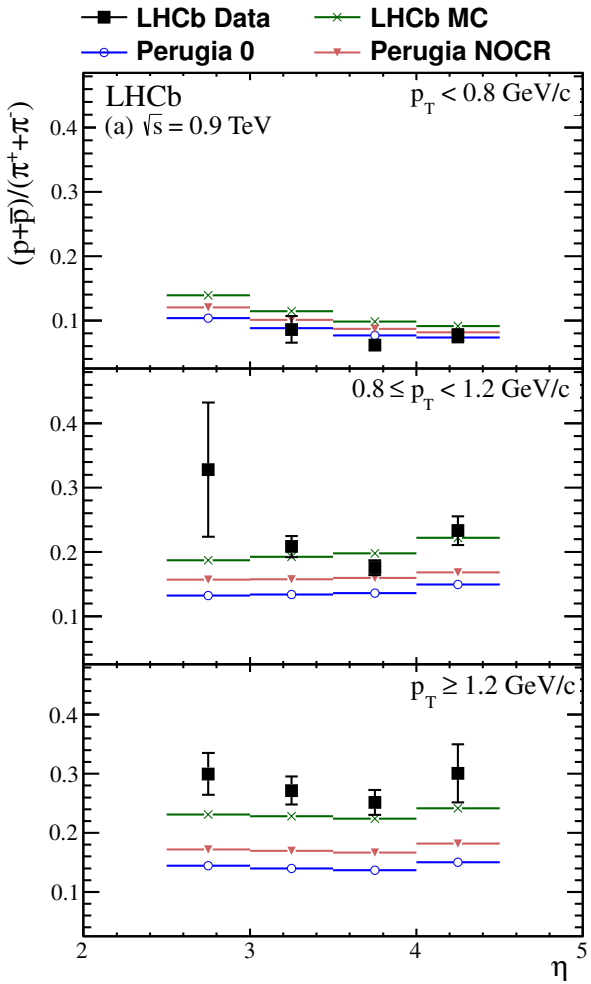

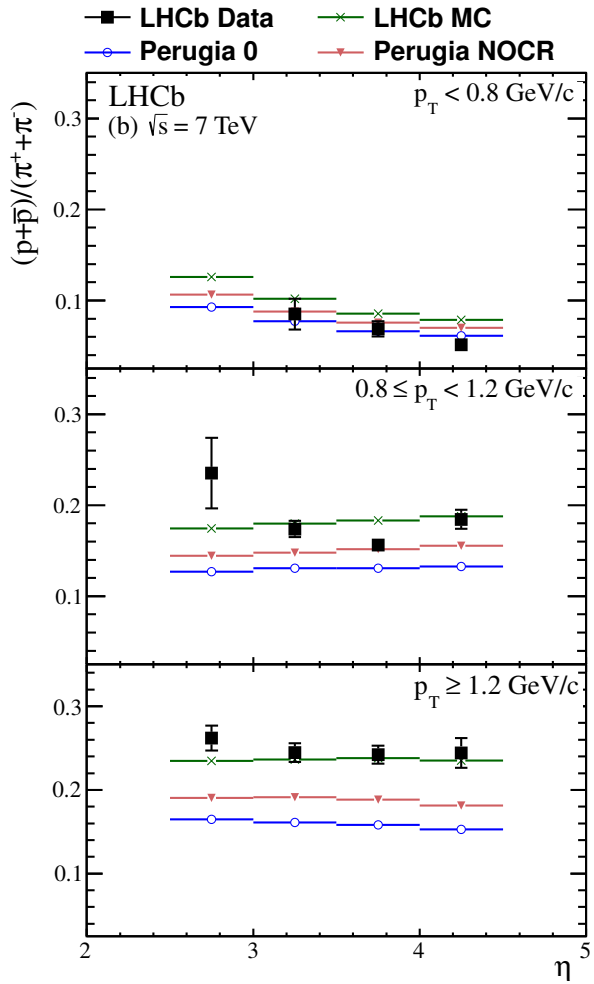

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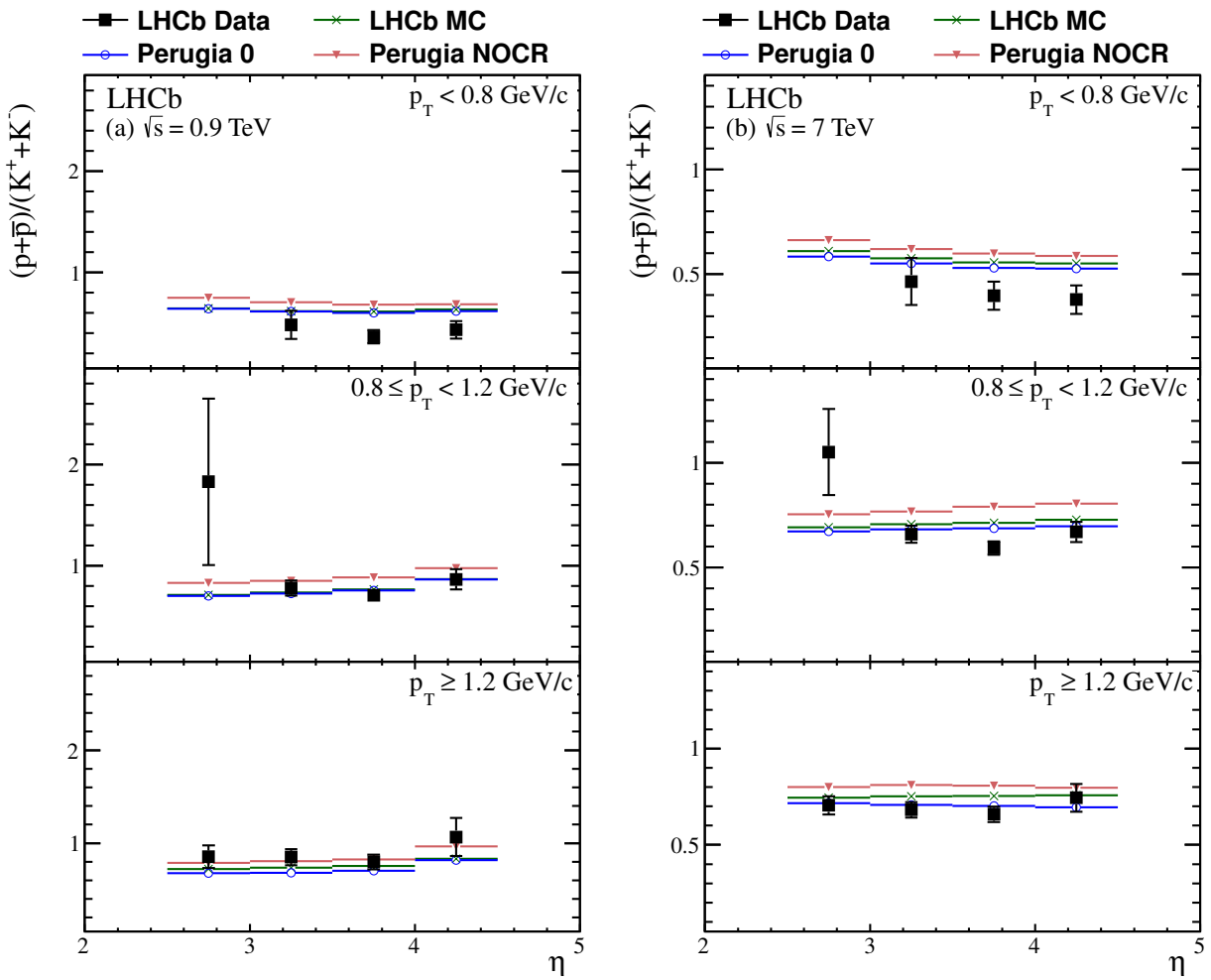
Prompt hadron production ratios, $(p + \bar{p})/(K^+ + K^-)$

General agreement for all tunes.
Difficult to interpret.



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Conclusions

- LHCb explored a unique kinematic region (low p_T and high η).
- Valuable input for tuning of MC generators.
- Hadron ratios available on HepData and Rivet plugin are ∼ready.

- Charged particle multiplicities are generally underestimated.
- BT investigated over a wide rapidity loss range, results more precise than previous ones.
- Hadron ratios not very well described by single tune.
- Consistency between LHCb measurements.