Light hadron production studies in pp collisions at 0.9 and 7 TeV with the LHCb detector

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University of Antwerp, Belgium

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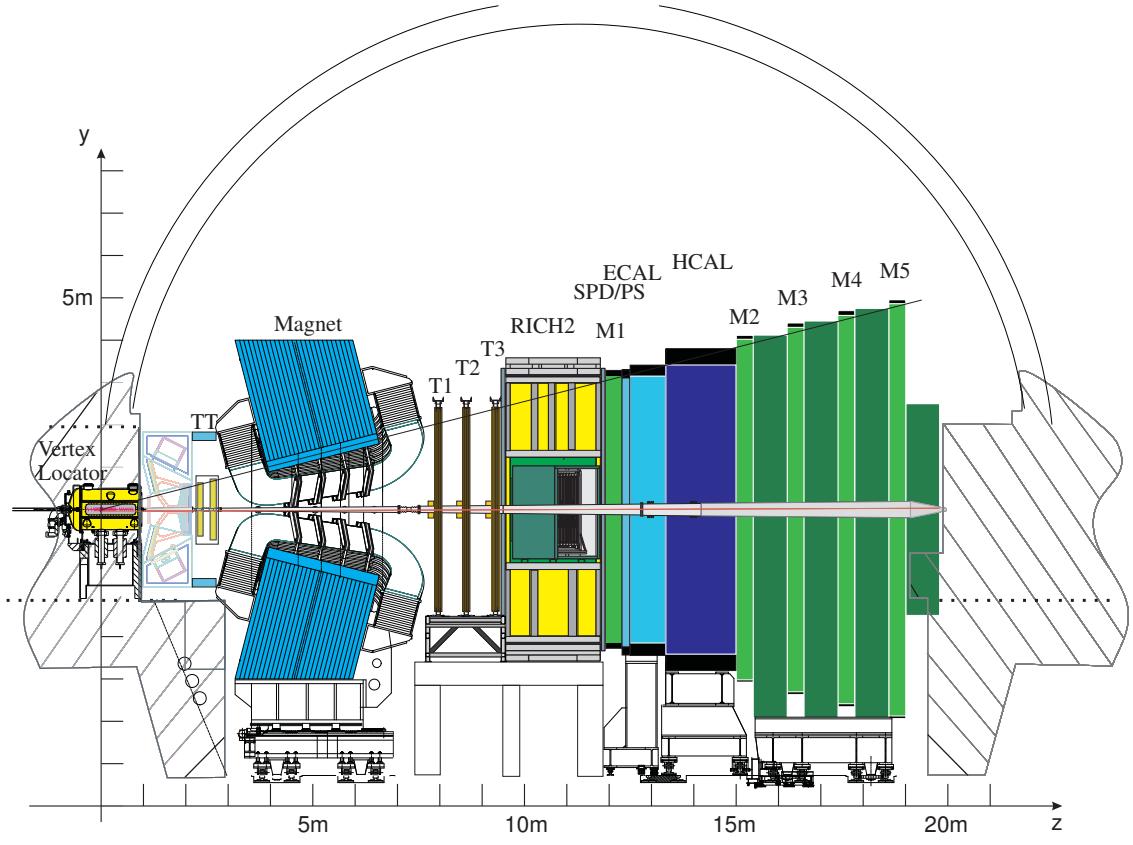
On behalf of LHCb collaboration

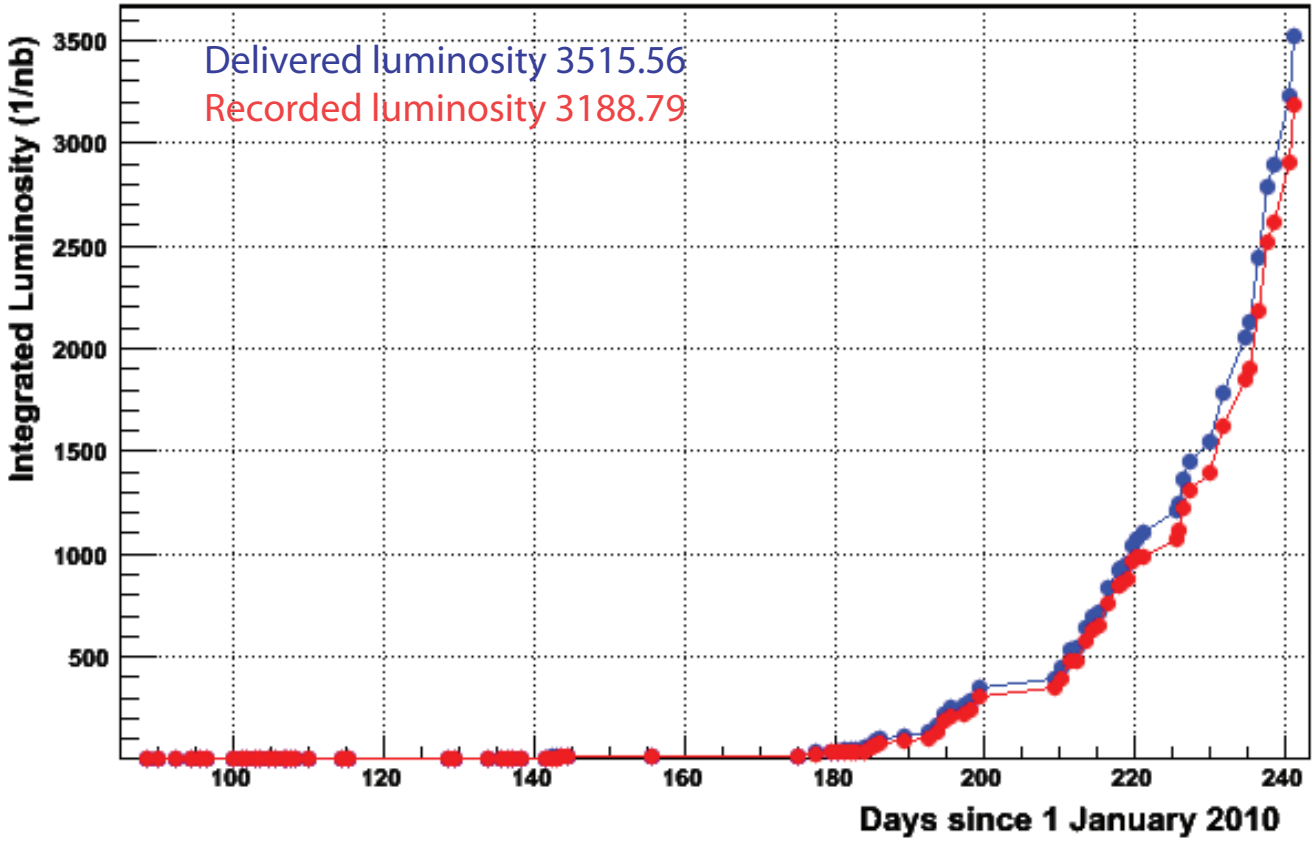
LHCb detector



- Look for New Physics through precise measurements of CP violation and rare decays in the b-sector.
- Forward single arm spectrometer - large and correlated $b\bar{b}$ quark production in the forward region.
- Coverage: 15-300(250) mrad

LHCb data sample

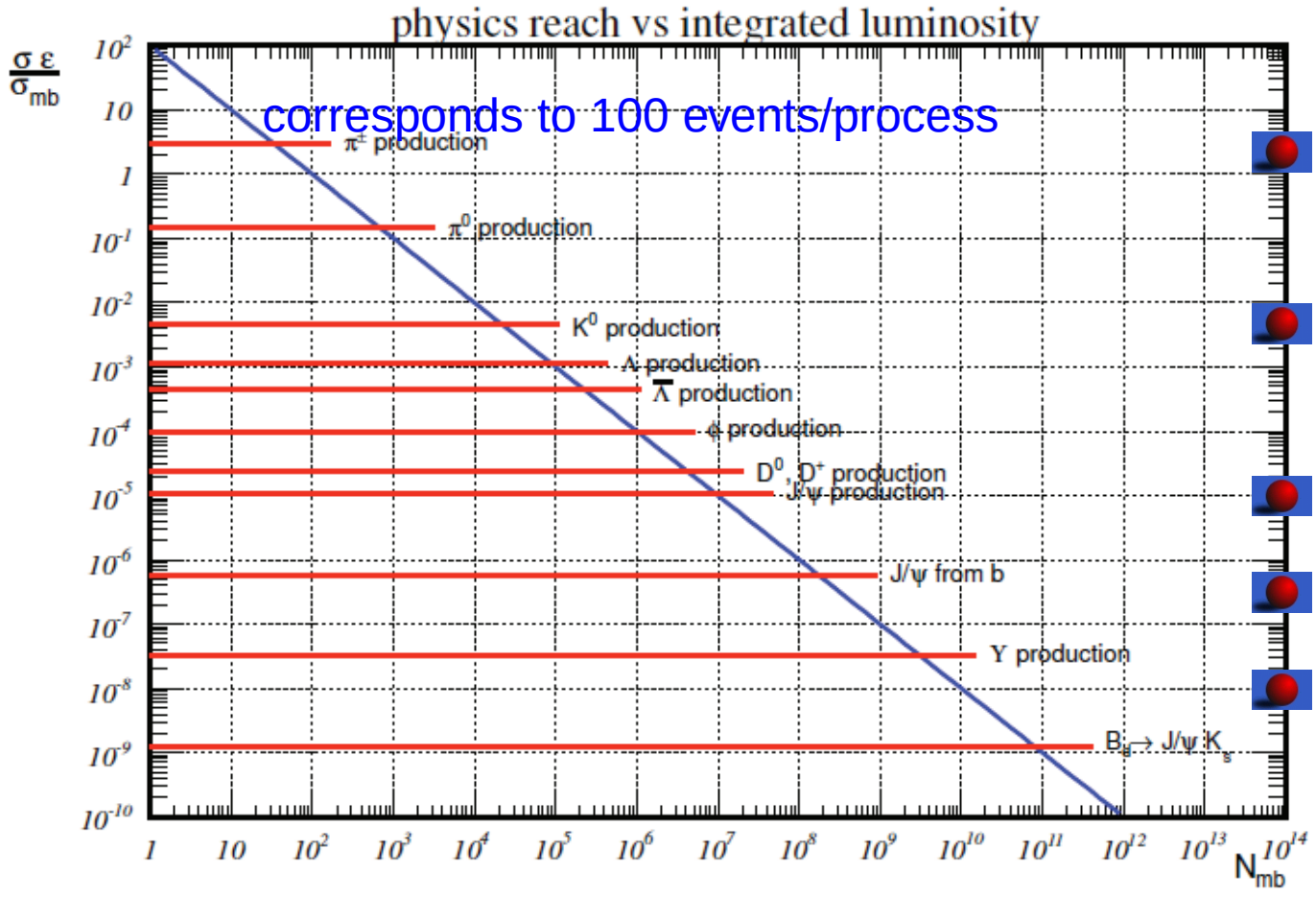
7 TeV



0.9 TeV

6.8 μb^{-1} in the pilot run of 2009 and 0.31 nb^{-1} in 2010

Physics reach

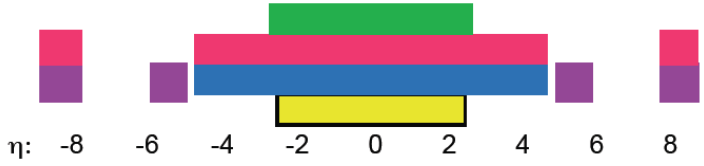


- Inclusive distributions
- Strangeness production
- Charm signals
- J/ψ production
- we are here
  first b results...

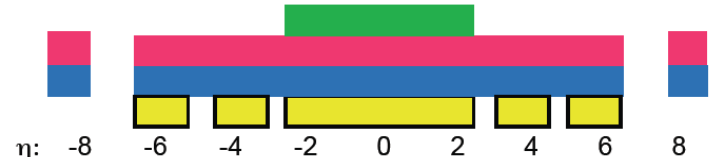
See also Jonathan Anderson talk on the Low-x pdf from LHCb on Thursday.

Pseudorapidity range

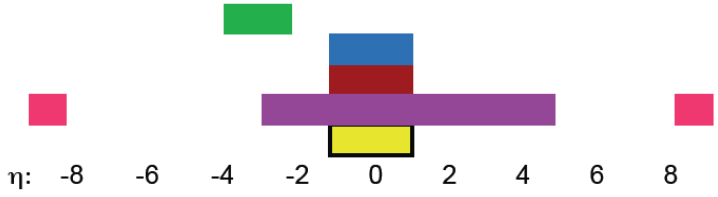
First LHCb public physics results - light hadron production - exploiting the interest for measurements in the forward region where production models were extrapolated not only in energy but also in rapidity.



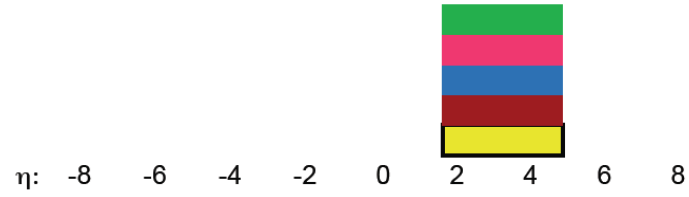
ATLAS



CMS&TOTEM



ALICE



LHCb

LHCb fully instrumented in the forward region: tracking, ECAL, HCAL, counters lumi, muon, hadron PID

Light hadron production studies

Are the production/fragmentation mechanisms rapidity or p_t dependent? Different dominating mechanisms?

- K^0_S cross-section - 2009 pilot run data at 0.9TeV;
- Production ratios (preliminary):
  - $\bar{\Lambda}/K^0_S$ - baryon vs. meson suppression in hadronisation;
  - $\bar{\Lambda}/\Lambda$, $\bar{p}/p$ - baryon number transport.

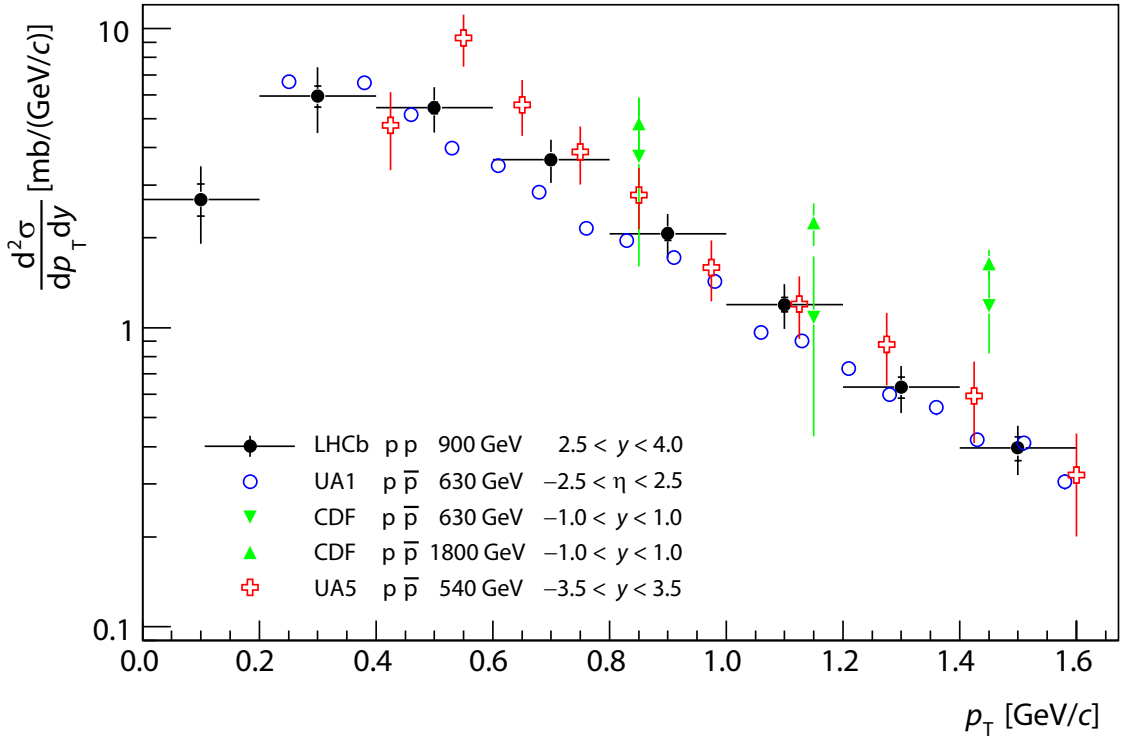
  2010 data @ 0.9 TeV and 7 TeV

- V^0 studies - prompt V^0 produced at the PV or e.m or strong decays, only tracking & vertexing;
- $\bar{p}/p$ - RICH particle identification.

K^0_S production

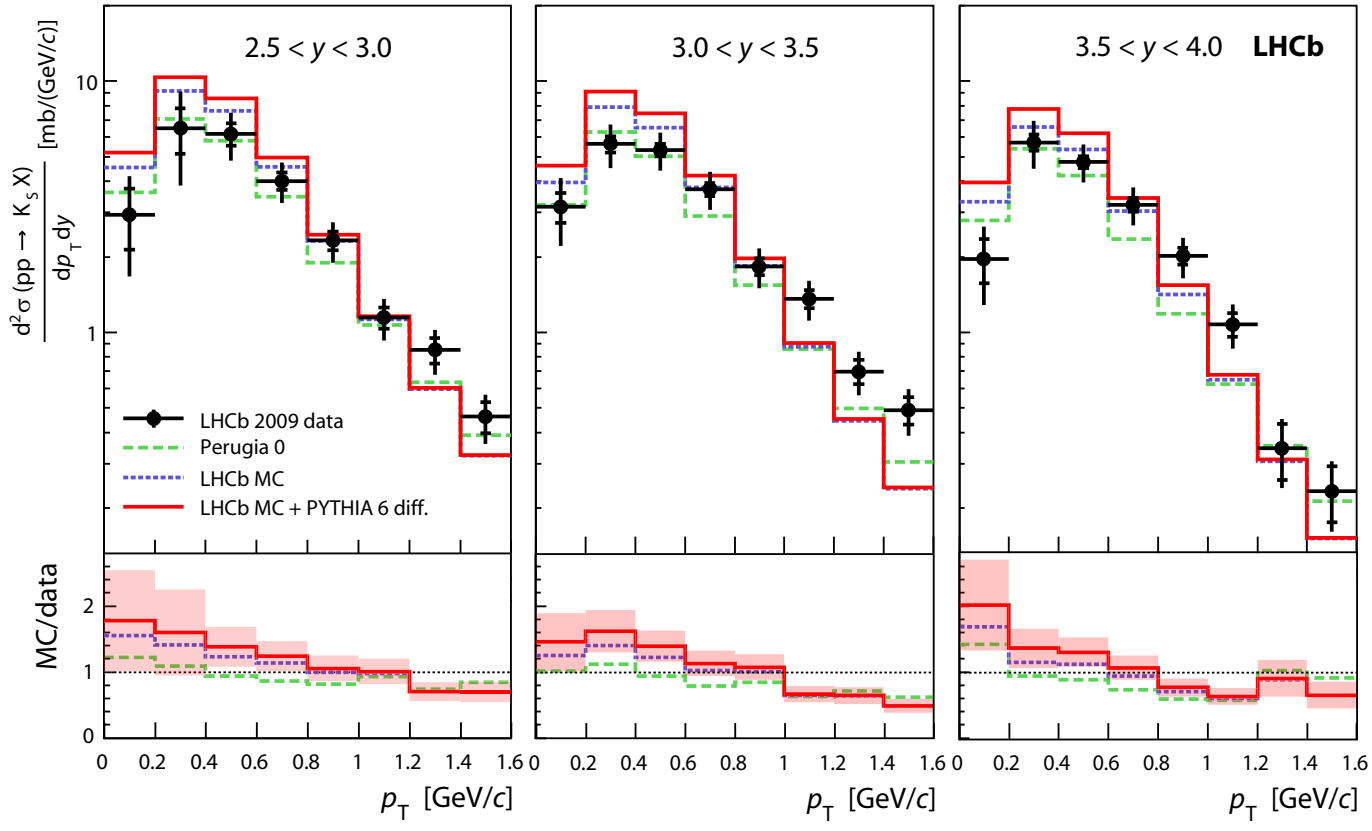
Ideal first measurement for LHCb - high-purity selection without requiring particle identification

2009 Data



- Using the 6.8 μb^{-1} recorded in the pilot run;
- K^0_S cross-section not measured before at 0.9 TeV;
- y and p_T range were extended;
- Main systematic contributions: luminosity $\sim$ 12%, tracking efficiency $\sim$ 10%

K^0_S production



Important input for hadronization models, measured in bins of y and p_T and compared to LHCb MC and Perugia 0 (arXiv:1005.3457).

Physics Letters B 693 (2010) pp. 69-80.

V^0 ratio measurements

High-purity, prompt K^0_s and Λ samples selection based on a combination of impact parameters (IP):

$$\nu = \ln IP^+ + \ln IP^- - \ln IP^{V^0}$$

PV requirement ensures that only the V^0 coming from non-diffractive events are kept (model based definition PYTHIA 6 & PYTHIA 8).

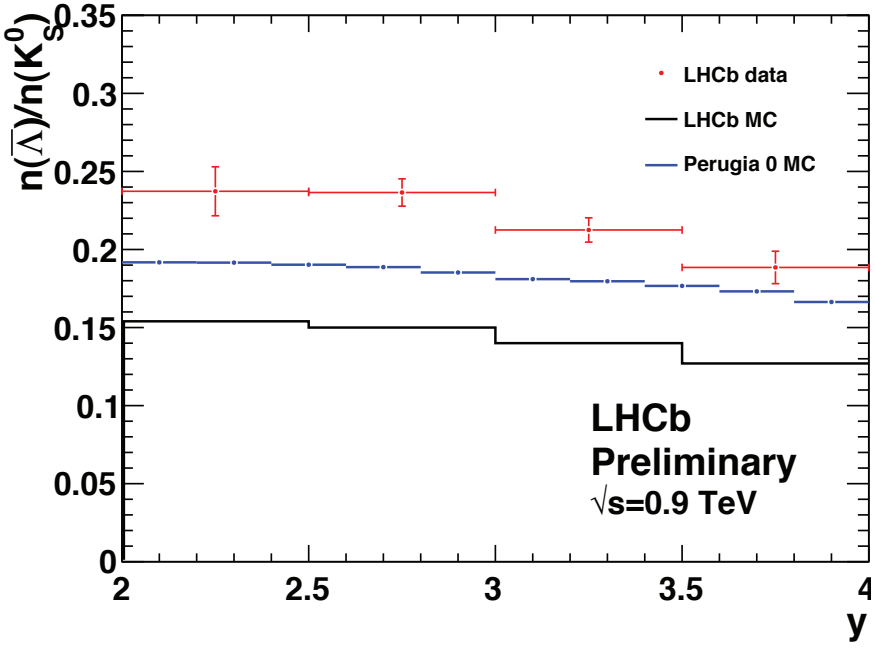
Efficiency from LHCb-MC (PYTHIA & EvtGen) and GEANT simulation for prompt, non-diffractive events.

Ratios benefit from reduced systematic uncertainties since absolute luminosity not required.

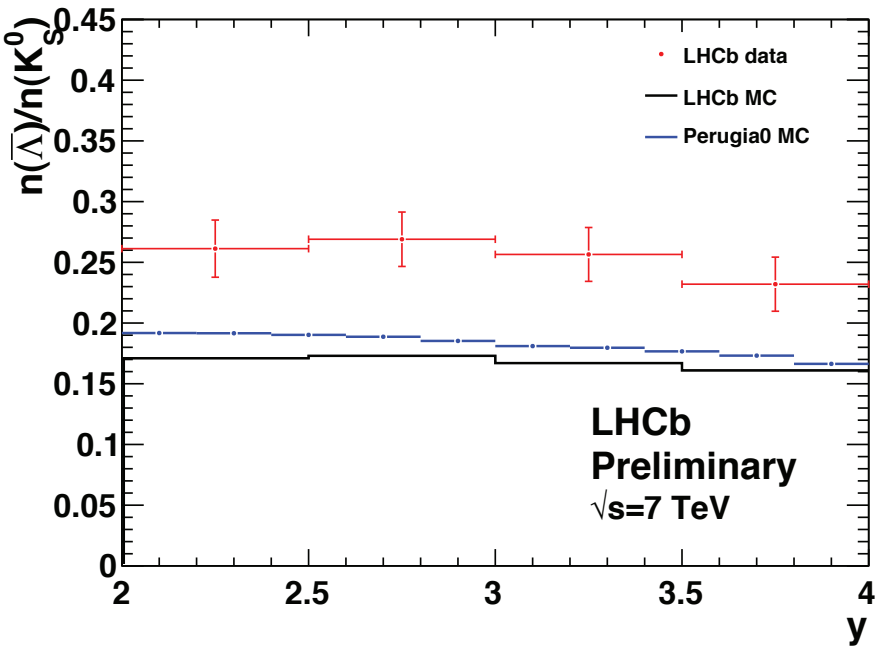
0. 31 nb^{-1} @ 0.9 TeV and 0.2 nb^{-1} @ 7 TeV as V^0s abound in minimum bias data: 5 K^0_S& 1 Λ selected per 100 triggers in data at $\sqrt{s}$ = 7 TeV.

Baryon suppression with $\bar{\Lambda}/K^0_S$

0.9 TeV



7 TeV



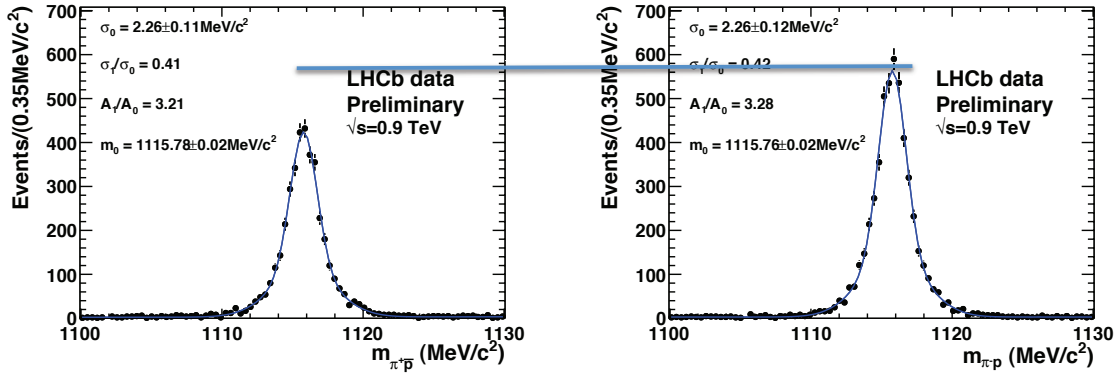
Ratio of $\bar{\Lambda}/K^0_S$ higher than expectation at both energies.

Might be consistent with indications on the ratio of Λ to K^0_s production at Tevatron (http://home.fnal.gov/$\sim$ skands/leshouches-plots).

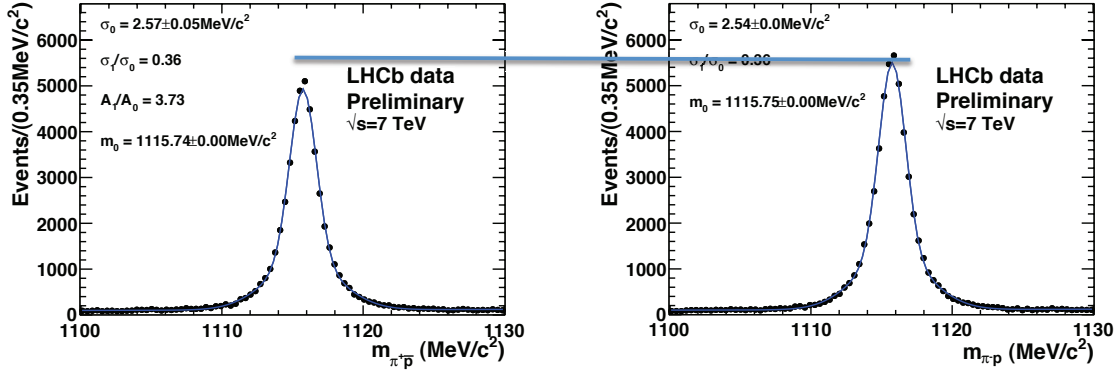
Baryon number transport $\bar{\Lambda}/\Lambda$

Baryon number conservation requires the destroyed beam particles in inelastic non-diffractive collisions must be balanced by creation of baryons elsewhere. How close a baryon and the antibaryon are produced in the phase space?

$\bar{\Lambda}$ Λ



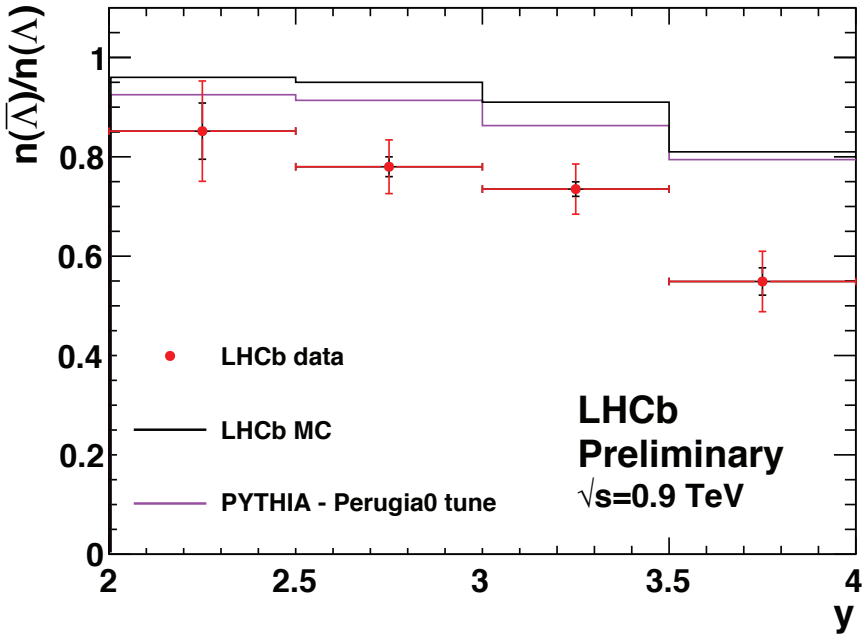
0.9 TeV



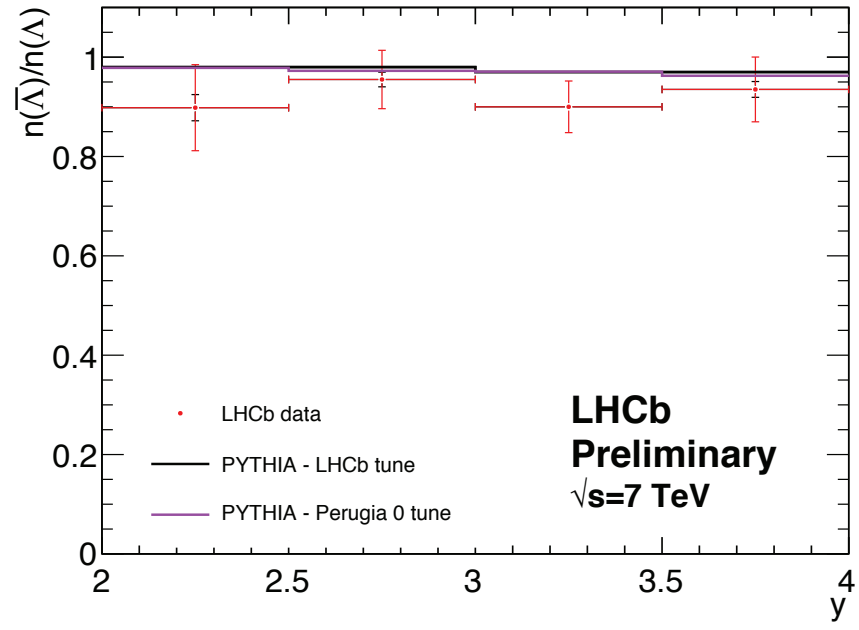
7 TeV

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

0.9 TeV



7 TeV



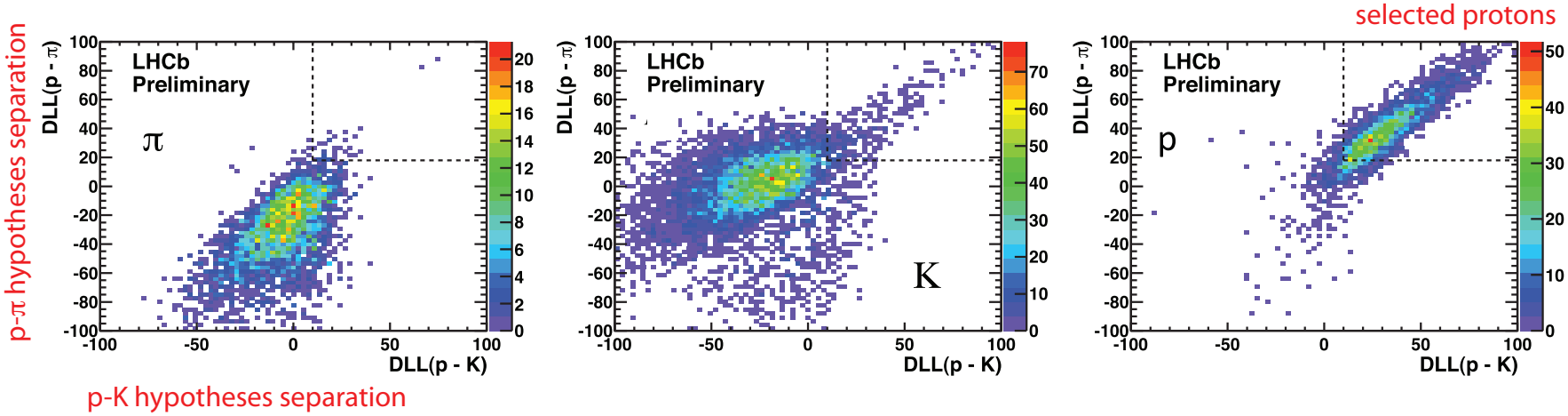
Measurements lie significantly under MC predictions at 0.9 TeV;

Reasonable agreement farther from the beam (in y), at 7 TeV, where the ratio must be very close to the unity.

Protons @ LHCb

PID performance calibrated in data:

- π and p are obtained from $K^0_S \to \pi^+\pi^-$ and $\Lambda \to p\pi^-$ selected with kinematic cuts only.
- K come from the $\phi \to K^+K^-$ decay with one track identified by RICH and the other one is left unbiased for PID measurements.



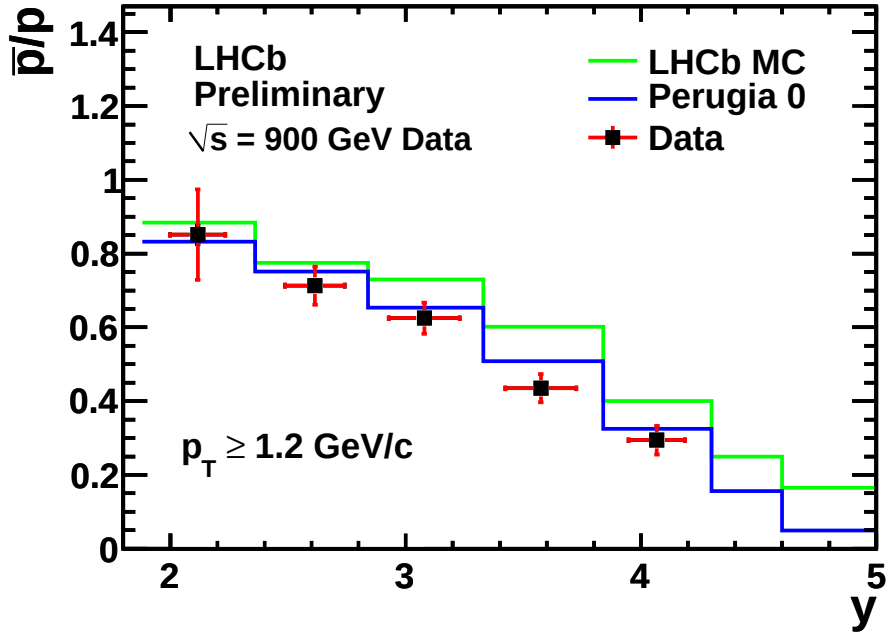
High purity (anti)proton samples of 90-95% obtained over full LHCb acceptance.

15 MEvts @ 0.9 TeV and 13 MEvts @ 7 TeV for the $\bar{p}/p$.

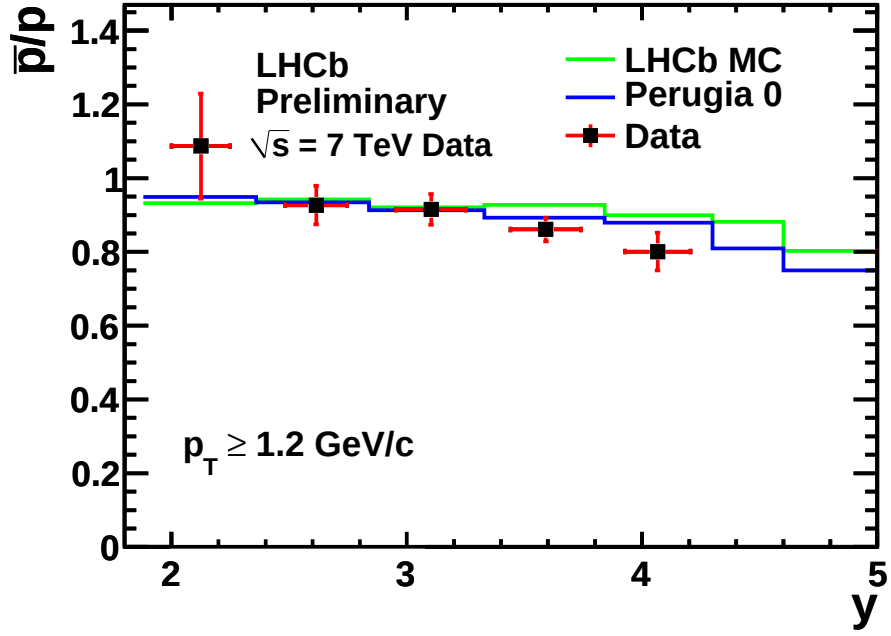
Baryon number transport $\bar{p}/p$

Measured in bins of y and p_T. Below example results for the high p_t bins.

0.9 TeV

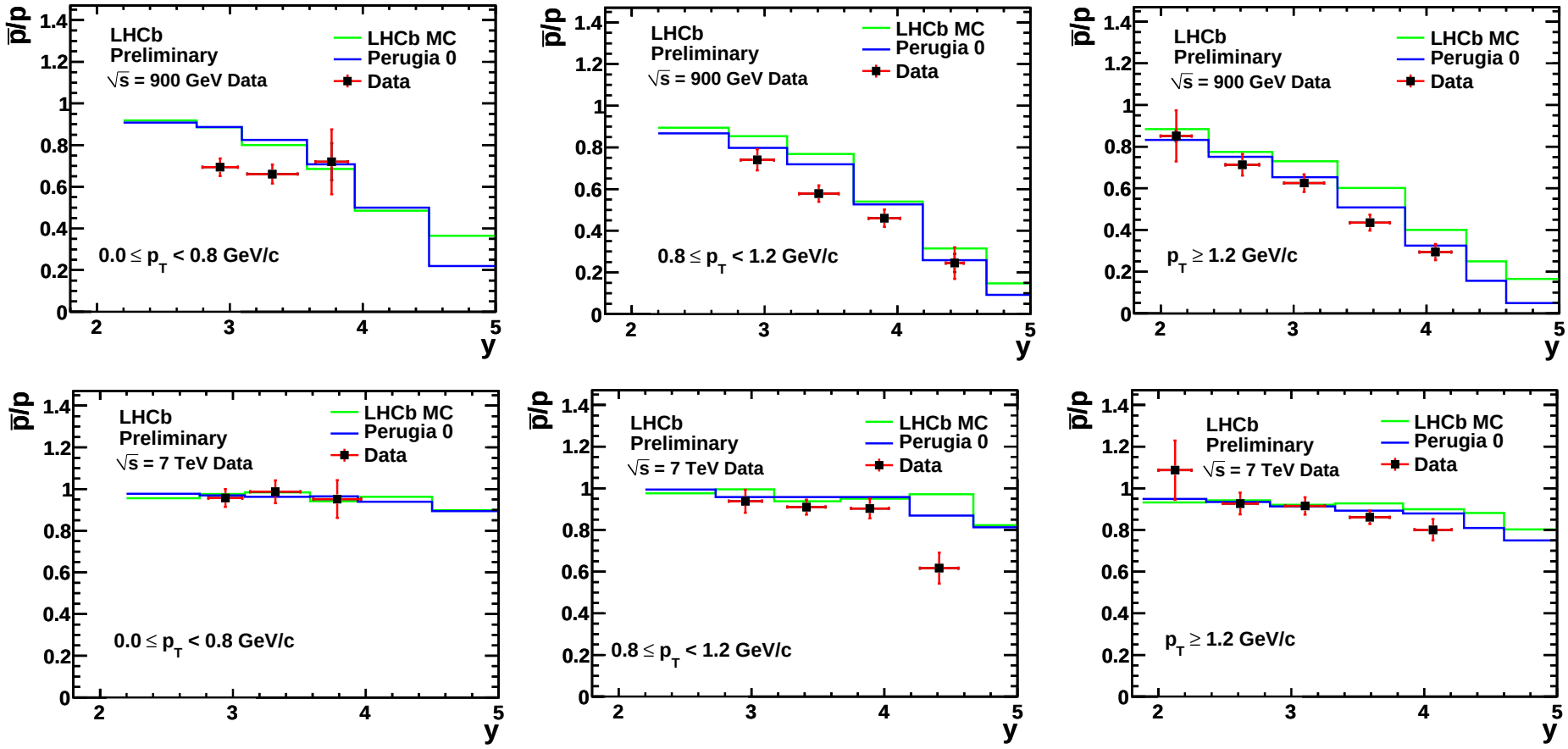


7 TeV



Uncertainty dominated by finite statistics of RICH calibration sample.

Baryon number transport $\bar{p}/p$



Big deviation in ratio from unity at low energy. Much less so at 7 TeV. Reasonable agreement observed with Perugia 0.

Systematics on the ratios

Most of the systematics cancel in the ratios. Remaining systematics relate mainly to MC, data comparisons.

Uncertainties	Errors
p,π interaction cross-sections	$\sim$ 10%
V^0production & interaction cross-sections	$\sim$10%
LHCb material description	<10%
Λ transverse polarisation	<1%
Selection cuts (dominated by PID)	1-14%
Ghost tracks	<2%
Acceptance asymmetries	$\sim$ 2%
Non-prompt contamination	<1%

Ratio	Total
$\bar{\Lambda}/\Lambda$	$\sim$2%
$\bar{\Lambda}/K^0_S$	2-12%
$\bar{p}/p$	3-14%

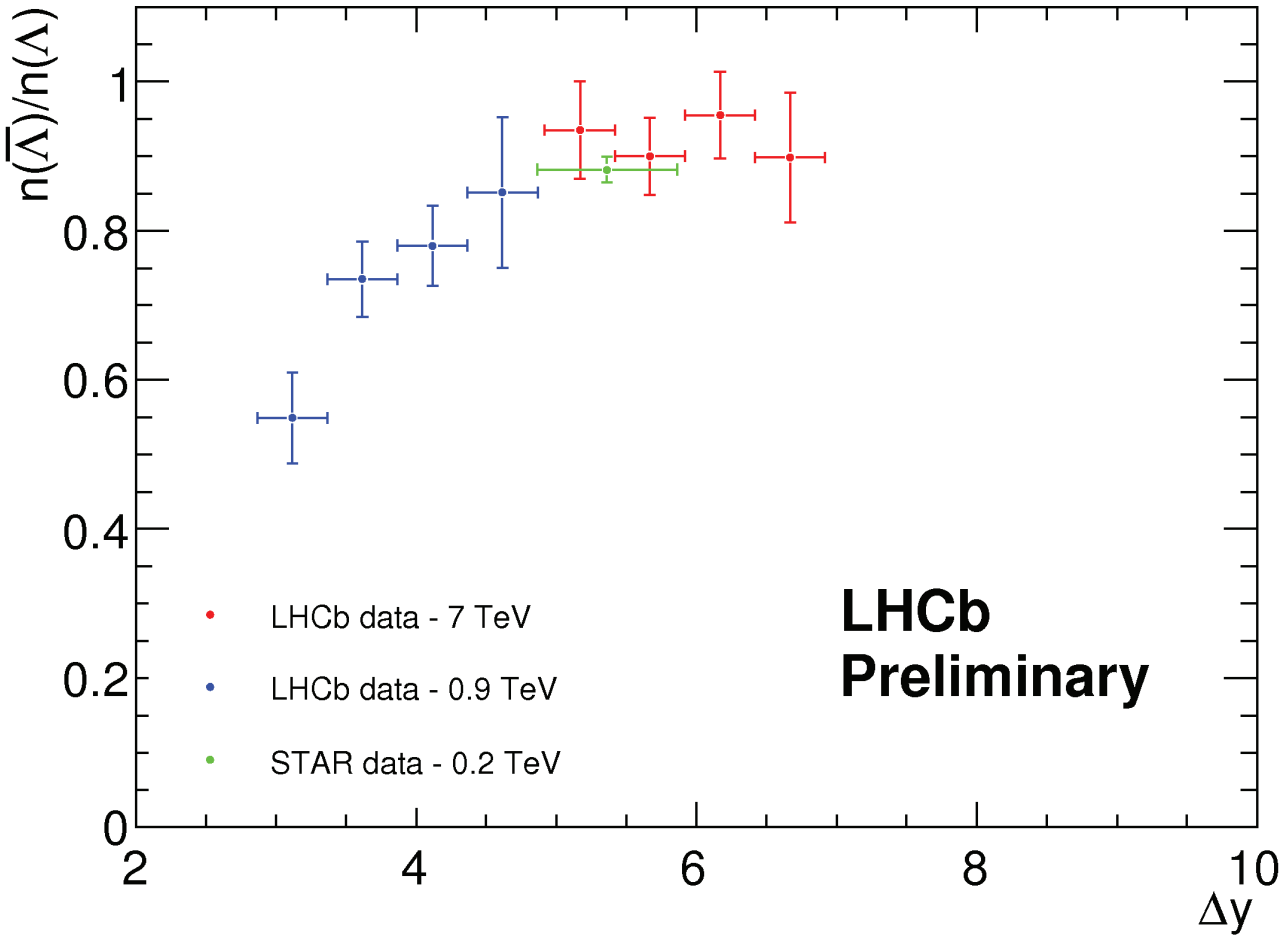
Baryon number transport $\bar{\Lambda}/\Lambda$

Comparing rapidity bins equally away from the beam

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

probes scaling violations.

Consistency between the two energy measurements and previous result.

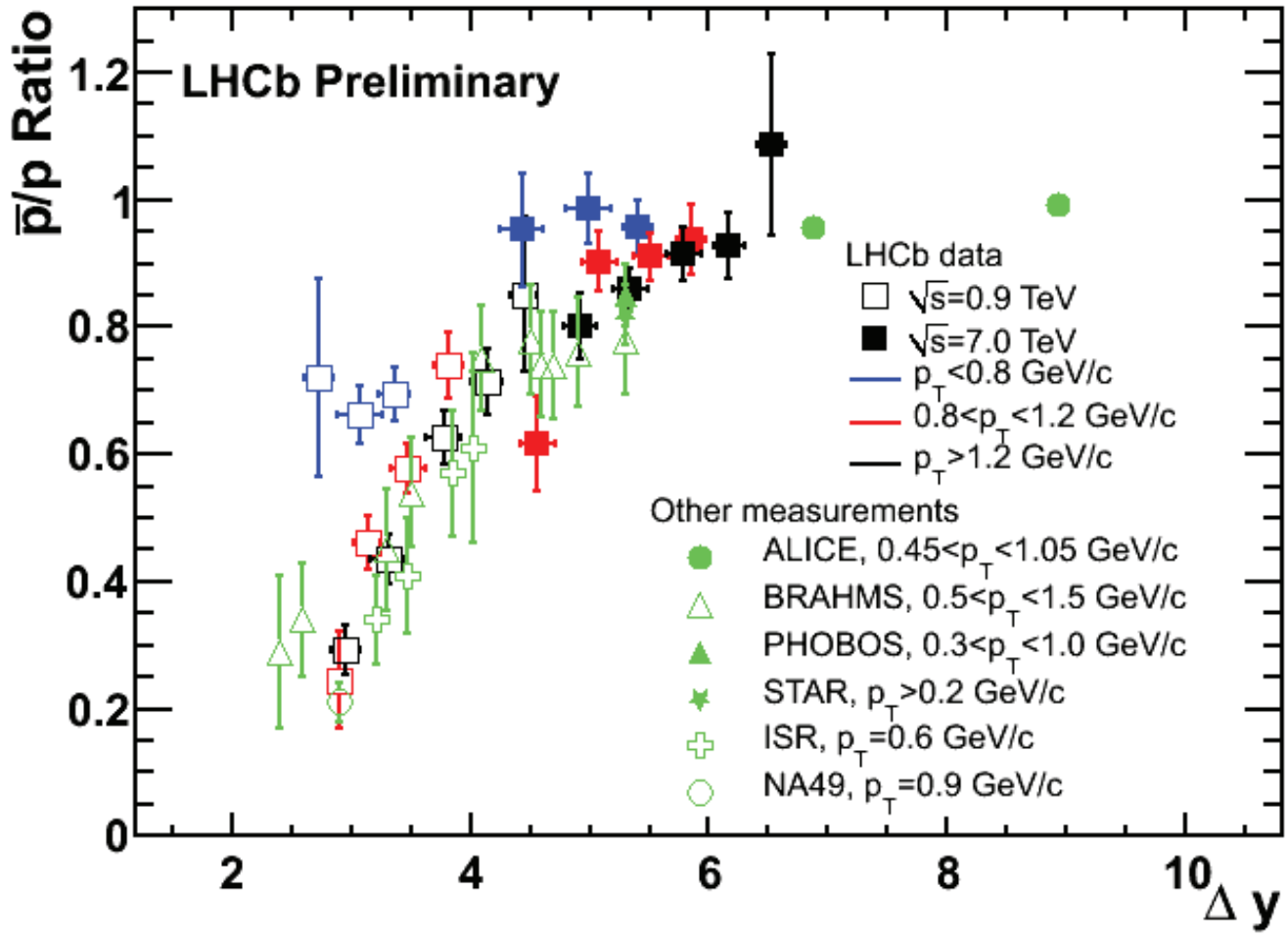


$$\Delta y = y_b - y$$

Baryon number transport $\bar{p}/p$

Reasonable consistency with previous measurements.

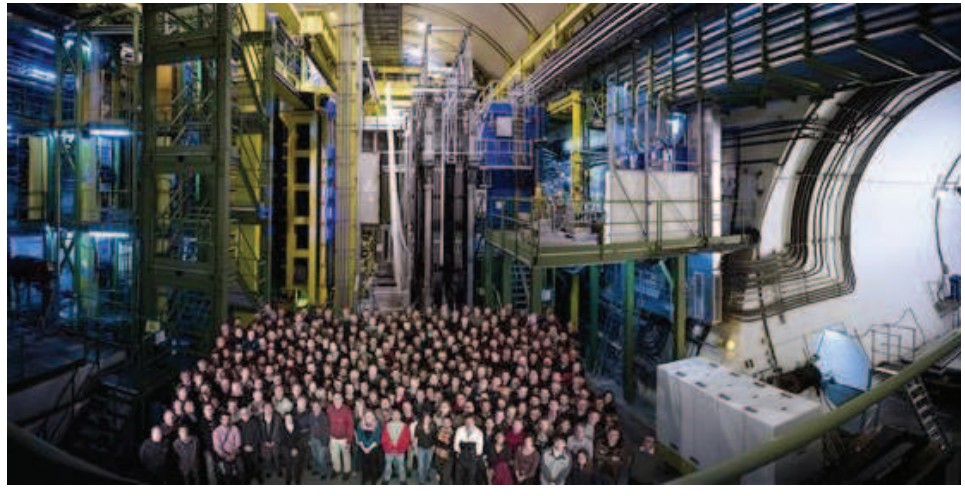
Good agreement if the same p_t range is covered (high p_t).



$$\Delta y = y_b - y$$

Summary

- LHCb produced unique minimum bias physics results exploiting the unique rapidity and transverse momentum acceptance of the experiment;
- Preliminary results for ratios of V^0 and protons suggest lower baryon suppression and higher baryon transport in data than in the MC models investigated.
- Reasonable consistency with previous measurements.



STAY TUNED FOR THE LHCb PUBLICATIONS