Imperial College London

# Particle Production Studies at LHCb

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*on behalf of the LHCb collaboration*

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LHCb

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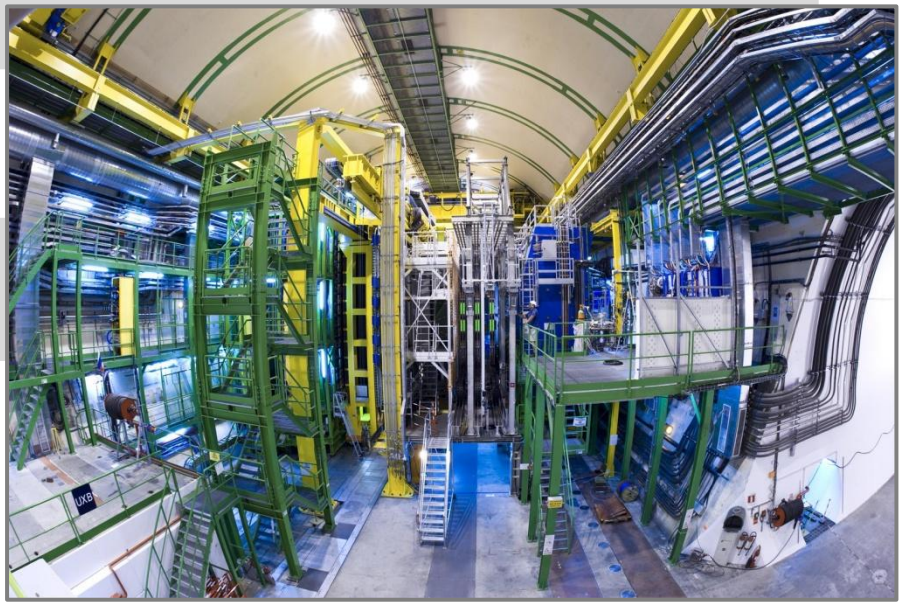
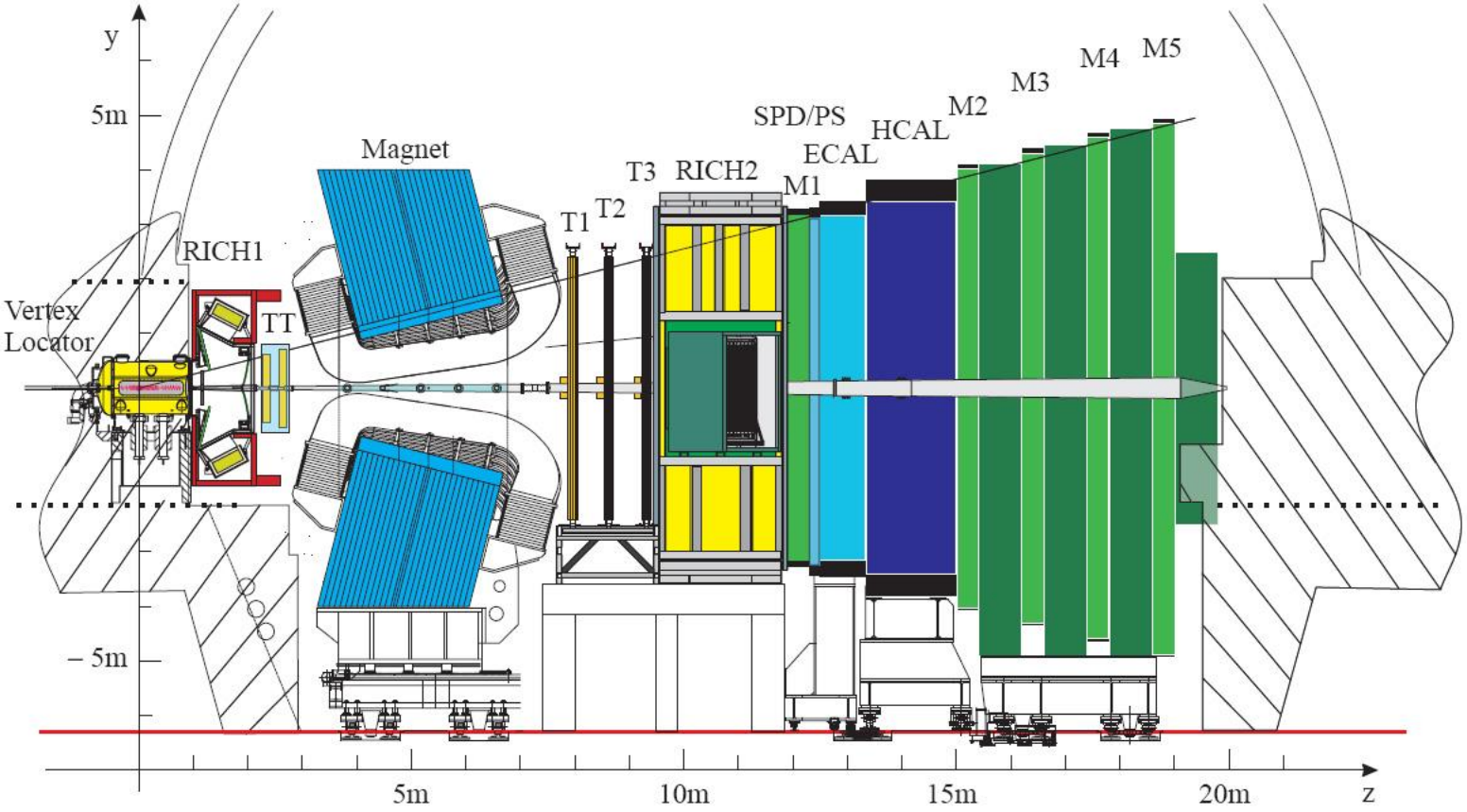


The LHCb detector in the point 8 cavern at CERN

# The LHCb Experiment

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



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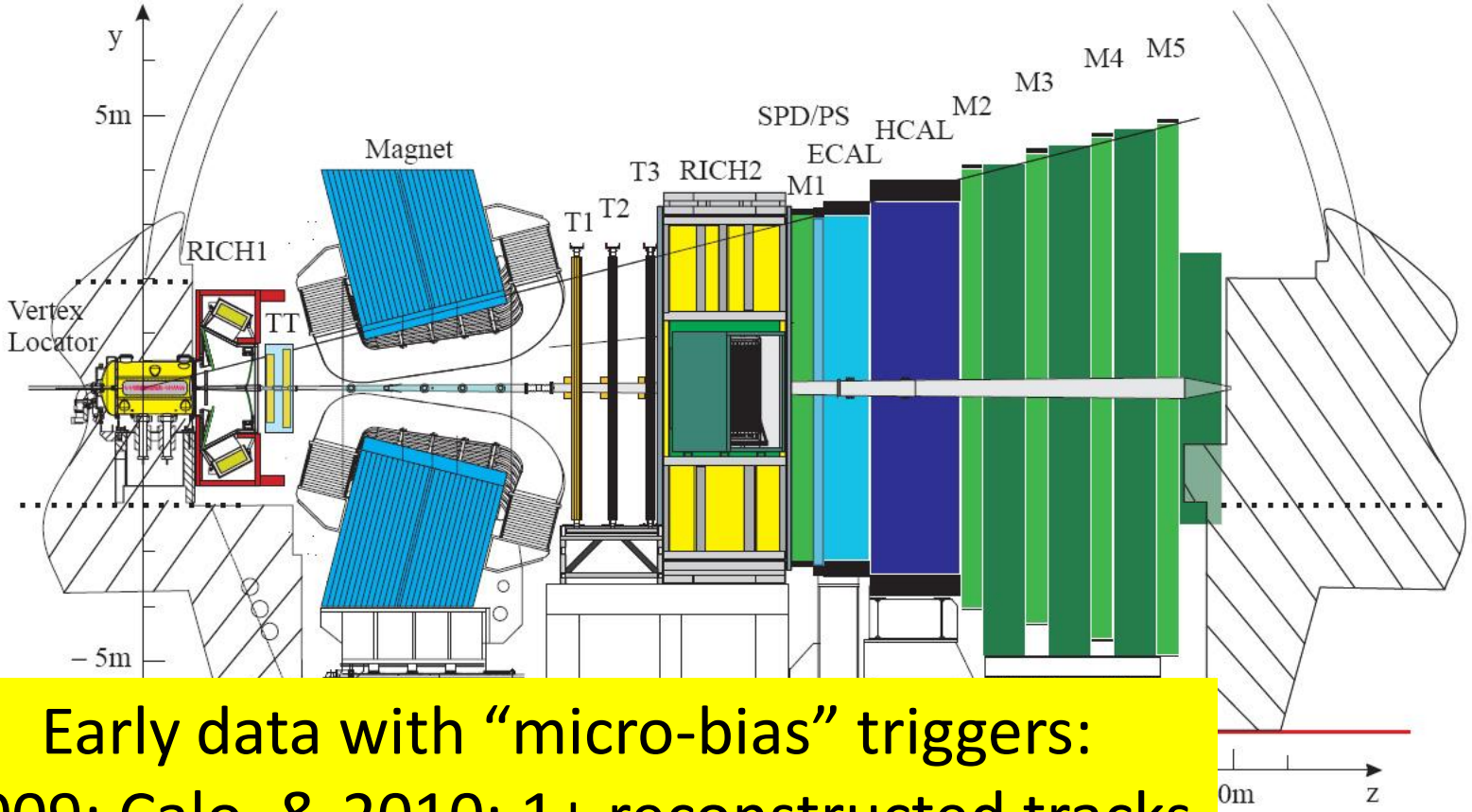
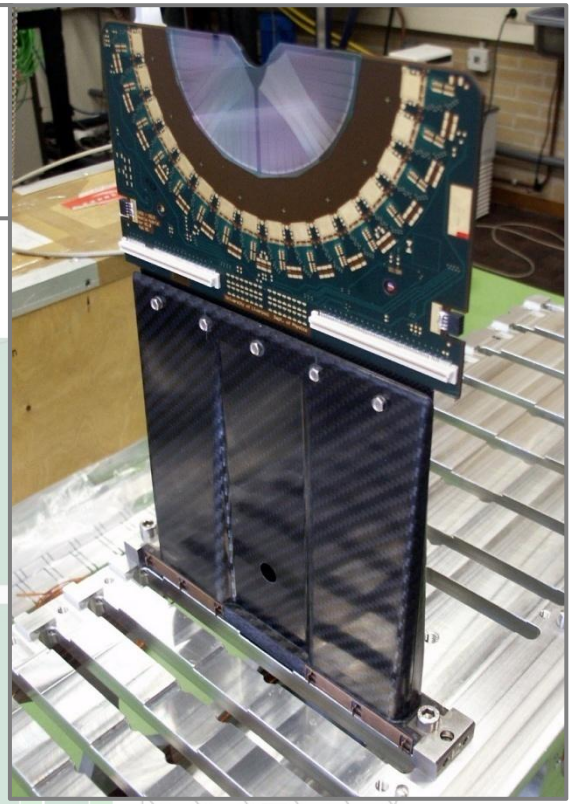


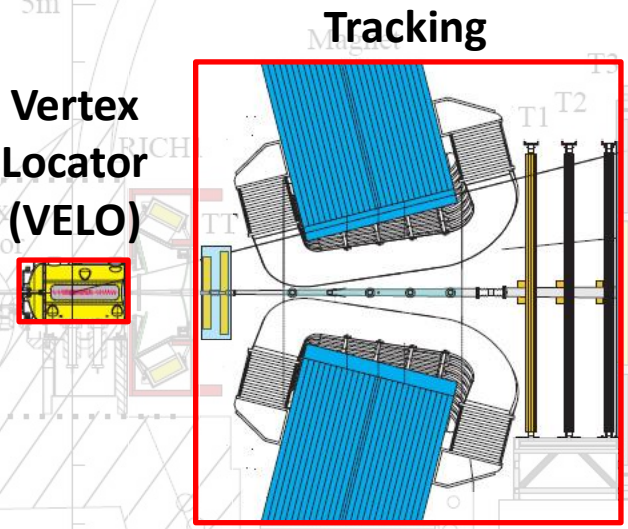

Early data with “micro-bias” triggers:
2009: Calo. & 2010: 1+ reconstructed tracks

# LHCb Tracking

A forward detector (2<$\eta$<5
CP violation and rare B-de

A completed VELO module before installation






Tracking $\delta p/p \approx 0.4\%$ with 95% reconstruction efficiency

VELO precision $\sigma(z) \approx 50$ (150) μm for Primary (Secondary) Vertex [*see talk by Sylvia Borghi*]

# LHCb Tracking

A forward detector (2<$\eta$<5
CP violation and rare B-de

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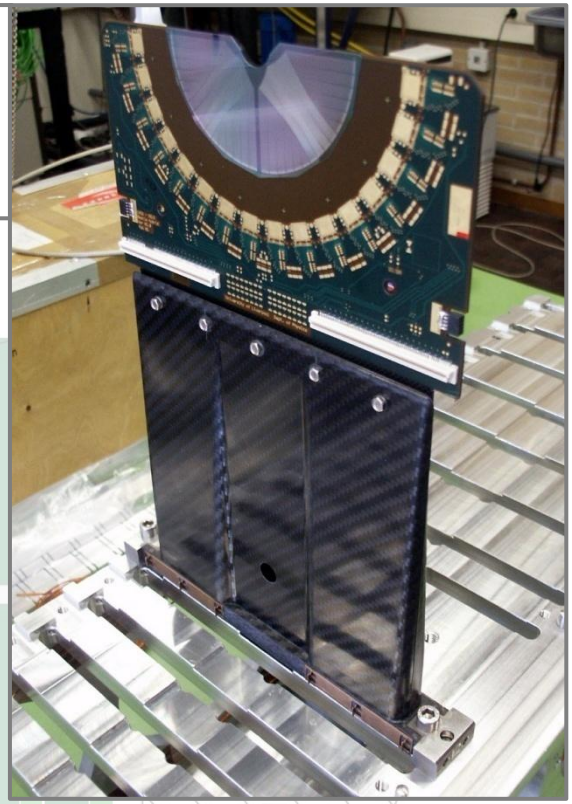
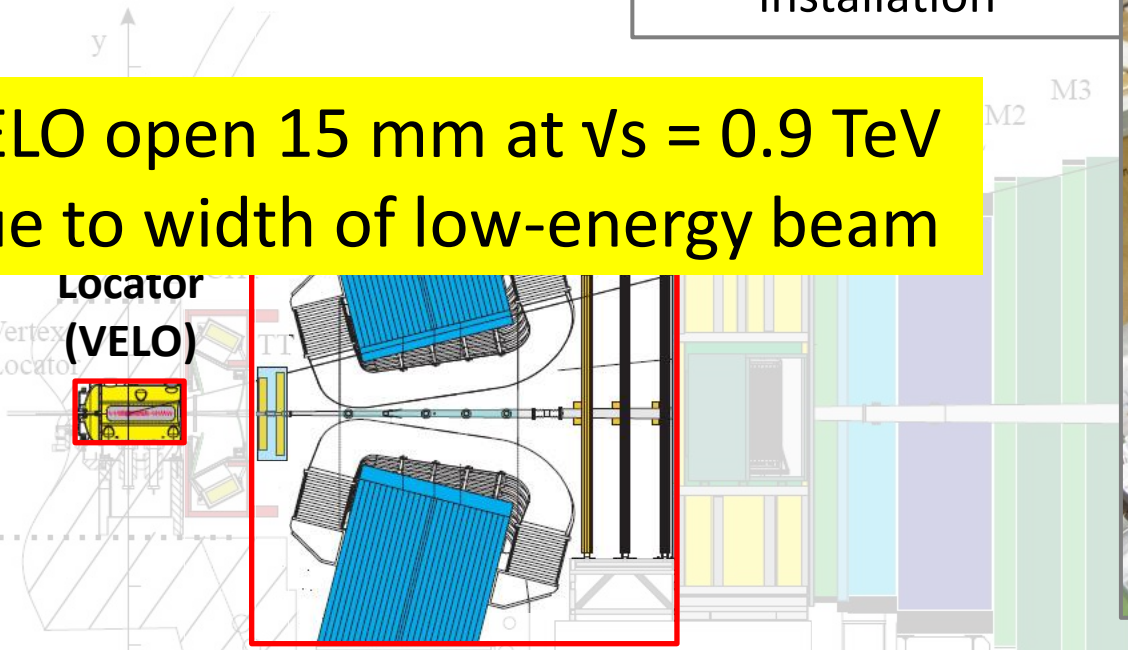


VELO open 15 mm at √s = 0.9 TeV due to width of low-energy beam



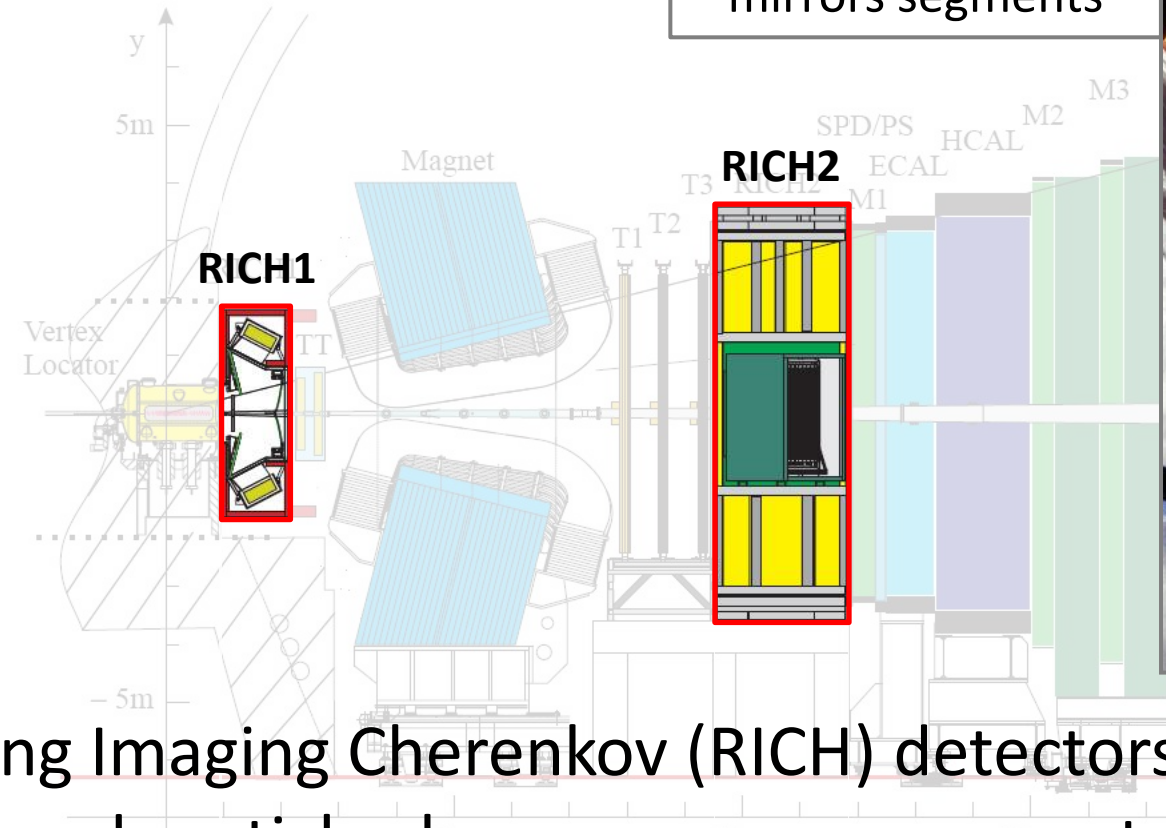

Tracking δp/p ≈ 0.4% with 95% reconstruction efficiency

VELO precision σ(z) ≈ 50 (150) μm for Primary (Secondary) Vertex [*see talk by Sylvia Borghi*]

# LHCb RICH Detectors

A forward detector (2<$\eta$<5
CP violation and rare B-de

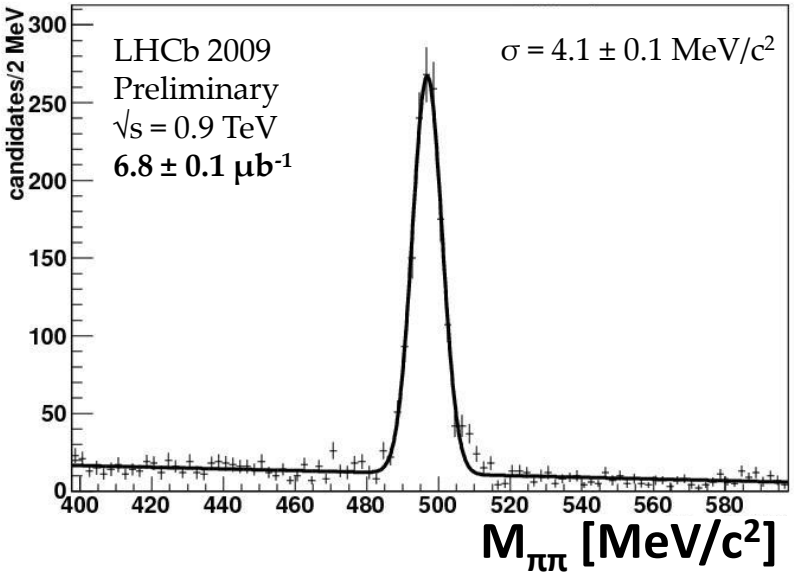
Installation of the RICH2 spherical mirrors segments




2 Ring Imaging Cherenkov (RICH) detectors distinguish charged particles by mass over a momentum range of 2 to ~100 GeV/c [*see talk by Andrew Powell*]

# $K_S$ Production Cross-Section

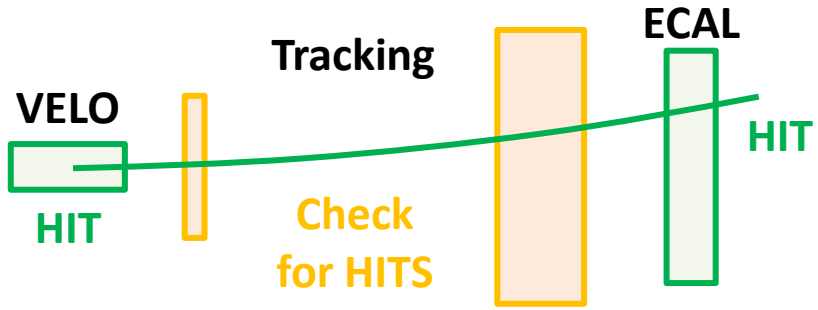
An ideal first measurement for LHCb, with high-purity selections requiring no particle identification




$K_S$ -> ππ selection based on track and $K_S$ impact parameters

**Key Systematic Contributions:**

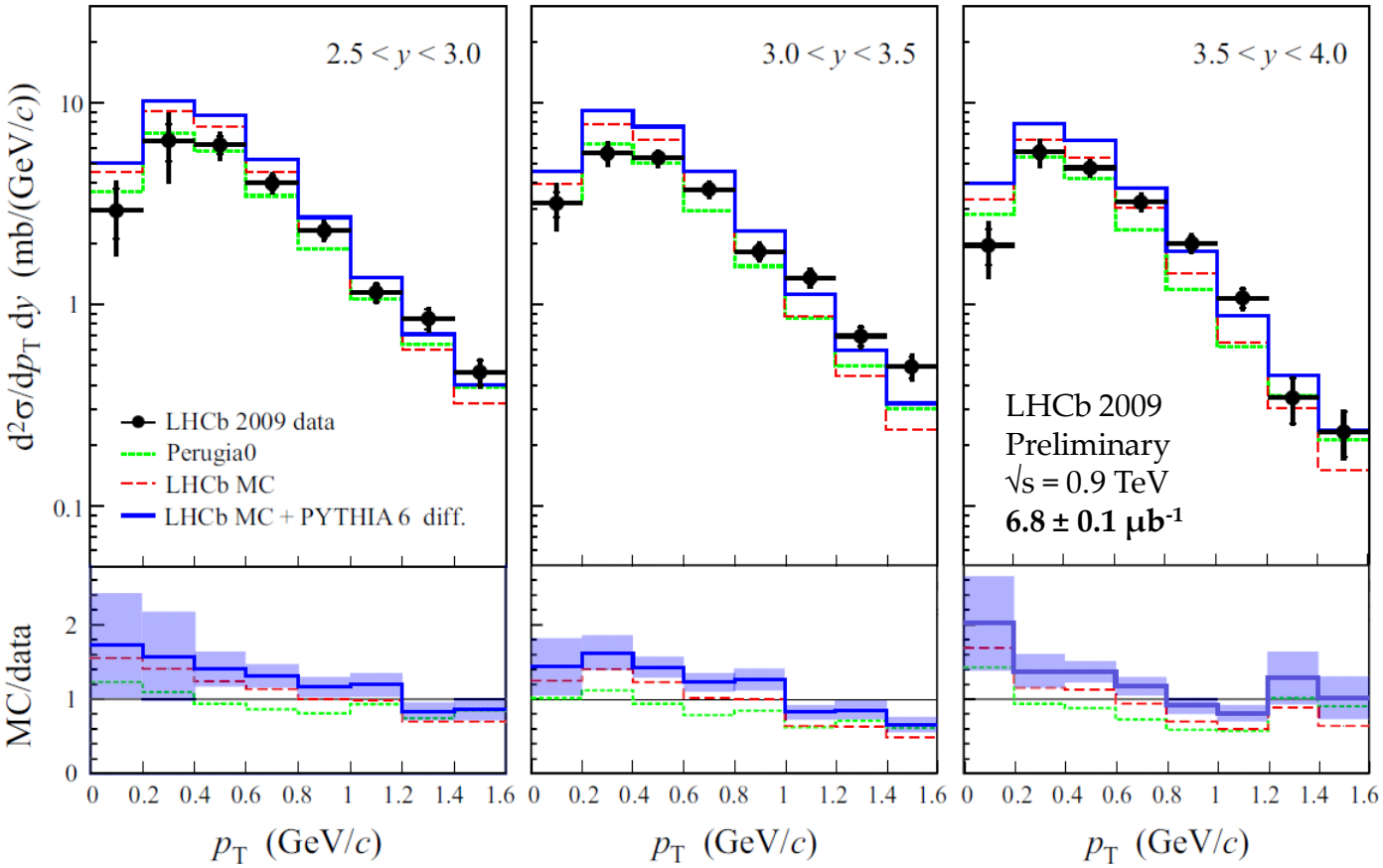
- Luminosity (*beam current measurement*) ~12%
  [*see talk by Massi Ferro-Luzzi*]
- Tracking efficiency ~10%




[*see talk by Sylvia Borghi*]

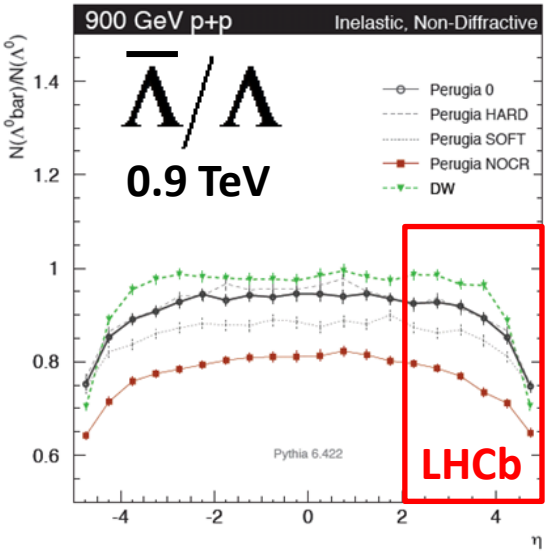
# $K_S$ Cross-Section Results

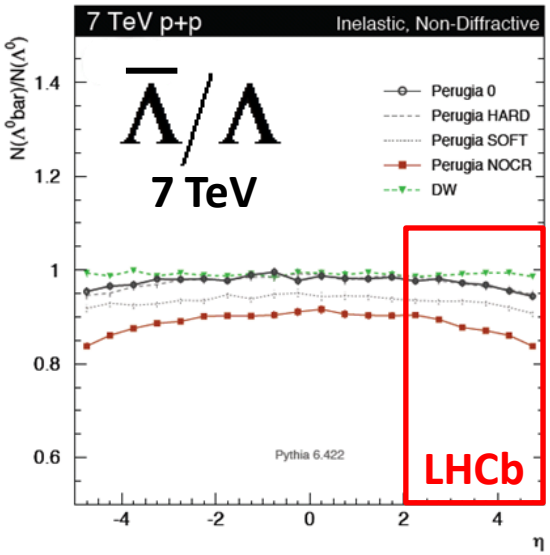
A unique measurement at high rapidity & at lower $p_T$ than previous experiments *(see back up slide)*



# Ratio Measurements

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




Theoretical interest in ratios *e.g.*

- baryon number transport,
- baryon *vs.* meson suppression in hadronisation

**$V^0$ ratios** $\overline{\Lambda}/\Lambda$ $\overline{\Lambda}/K_S$

Only tracking & vertexing

**Proton ratio** $\overline{p}/p$

RICH particle identification

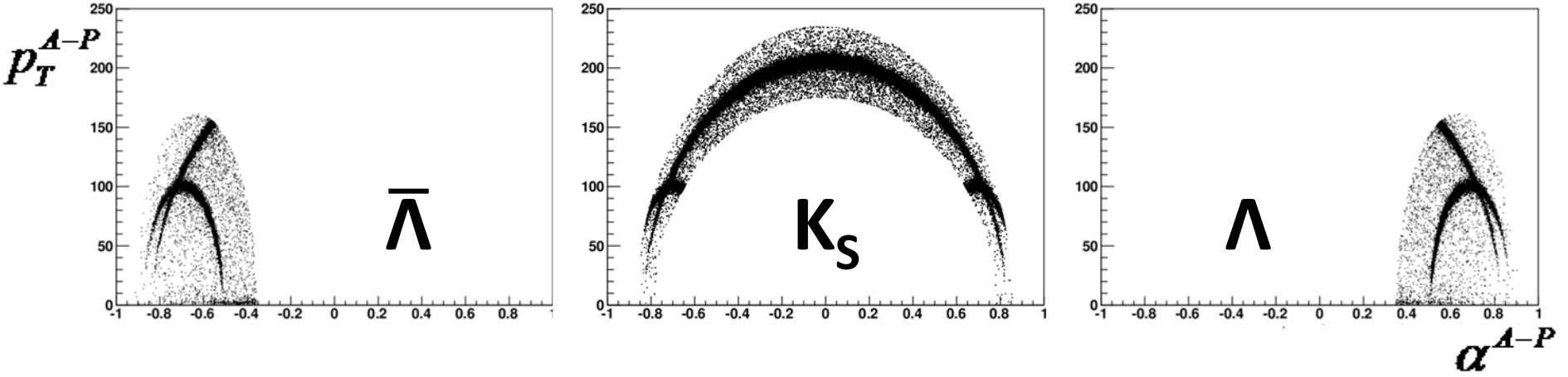
All abundant in minimum bias data

# $V^0$ Ratios

High-purity $K_S$ & Λ selection based on a combination of impact parameters (IP):

$$\nu = \log \frac{IP^+ \times IP^-}{IP^{V^0}}$$

$V^0$ background removed by changing daughter hypotheses

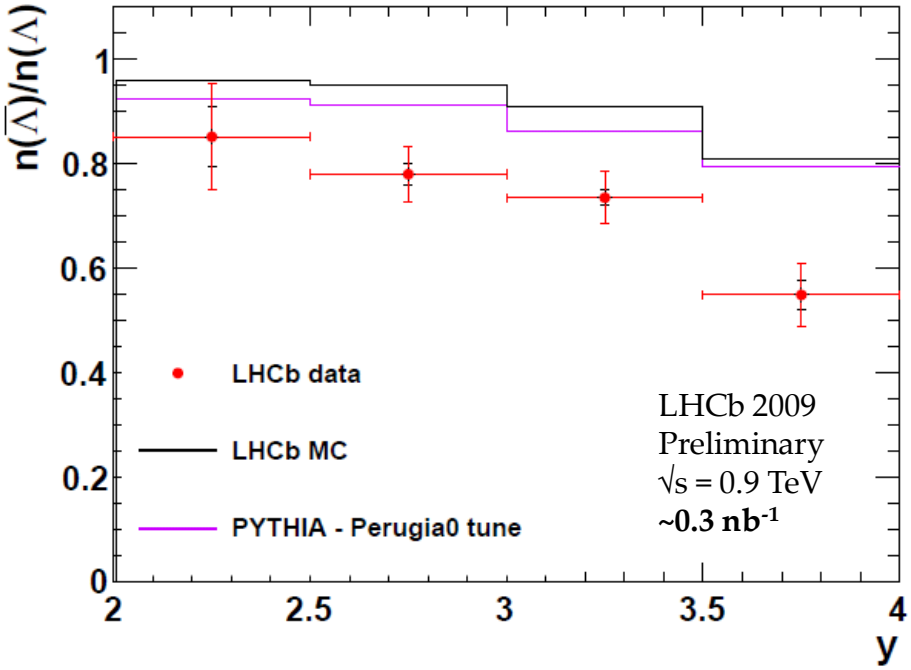


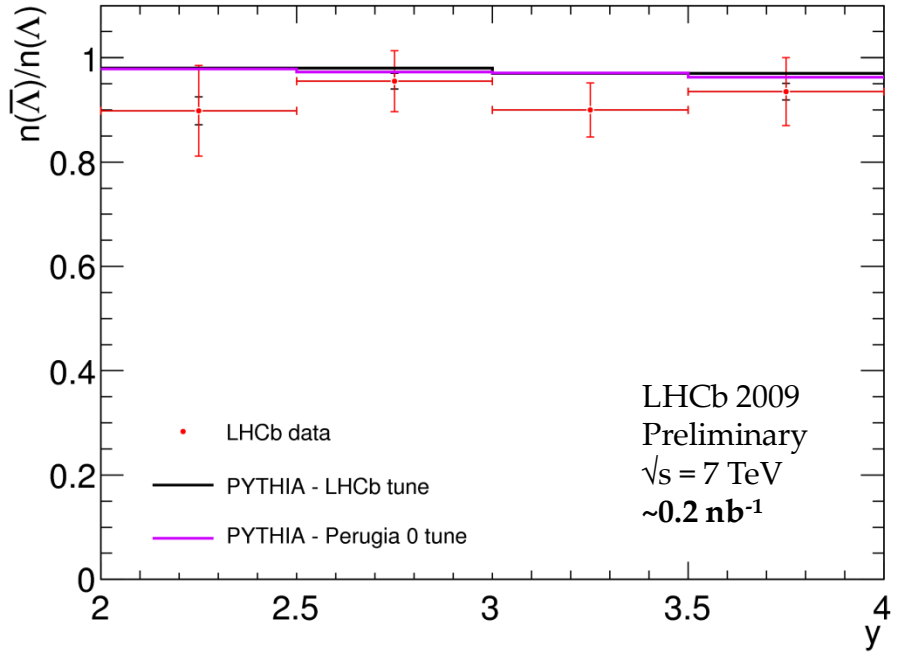

Binning $p_T$,y after boost correction for beam crossing angle

Efficiency from LHCb-tuned PYTHIA generation and GEANT simulation for **prompt**, **non-diffractive** events

# Preliminary Results $\bar{\Lambda}/\Lambda$

Another unique measurement at high rapidity with pp collisions at √s = 0.9 & 7 TeV

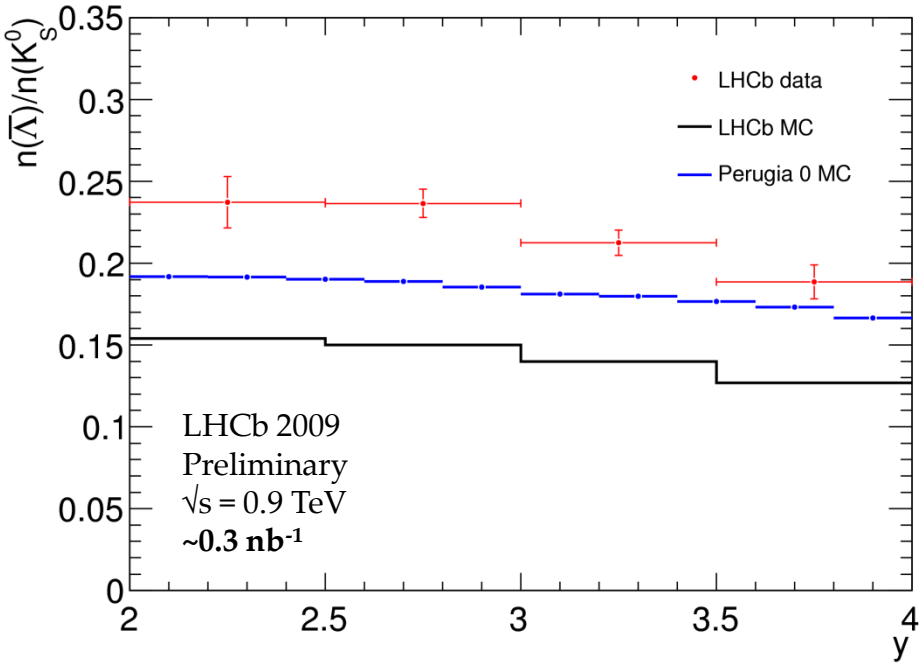


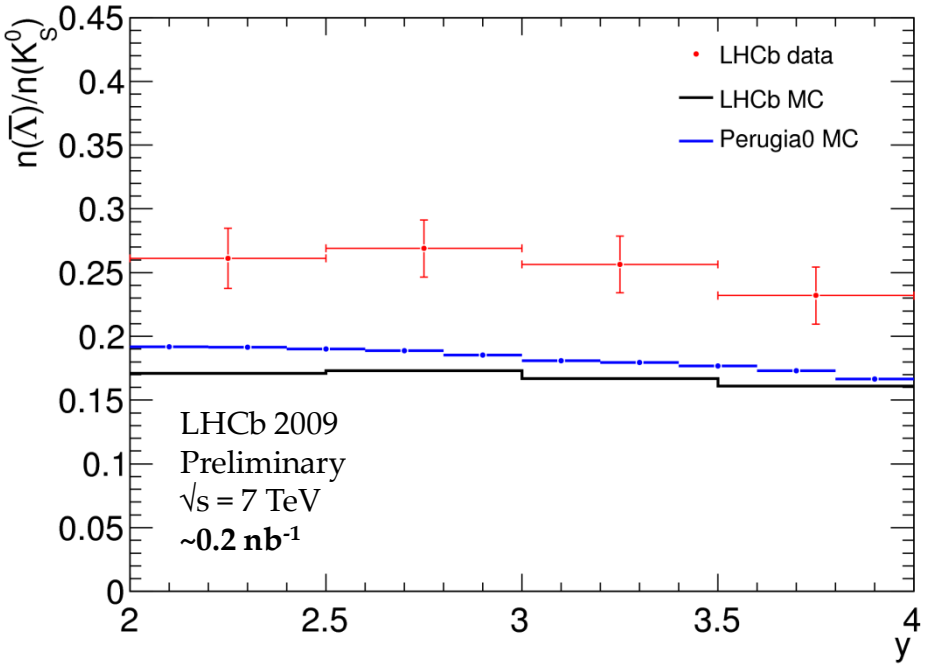




Baryon number transport appears higher than predicted at √s = 0.9 TeV

# Preliminary Results $\bar{\Lambda}/K_S$

Baryon *vs.* meson production ratio measurement with pp collisions at √s = 0.9 & 7 TeV

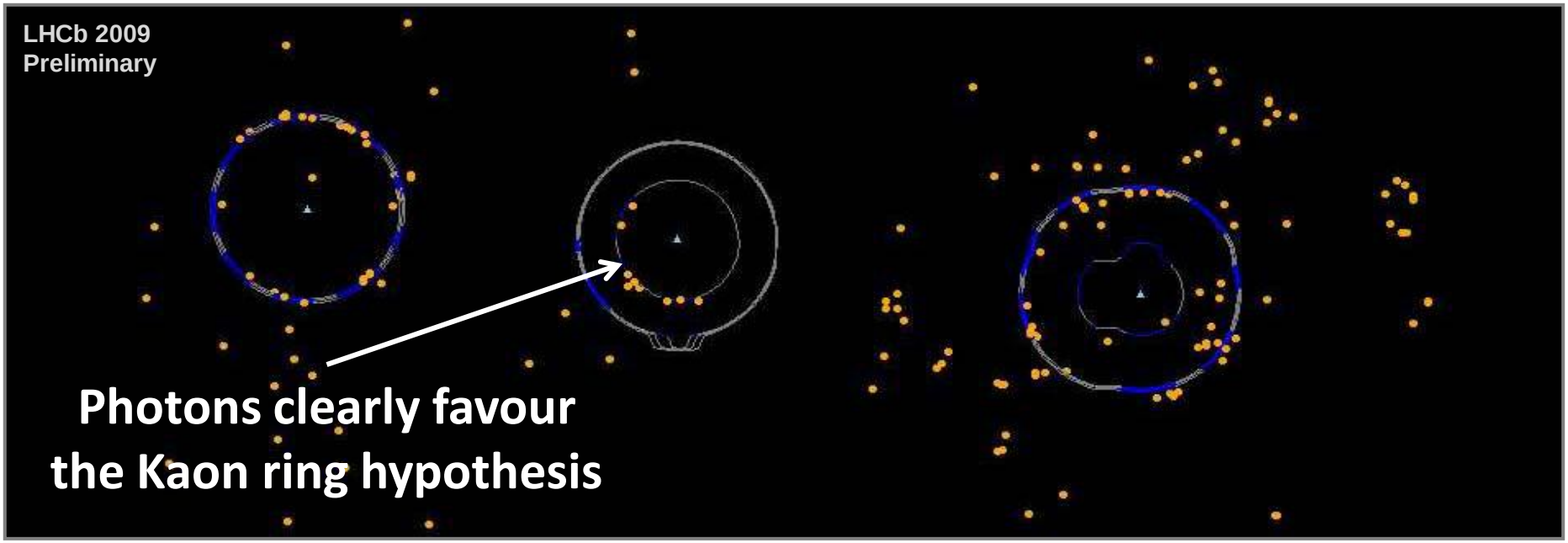



Baryon suppression in hadronisation significantly lower than predicted

# Proton Ratio

Pure samples Protons selected with RICH particle ID



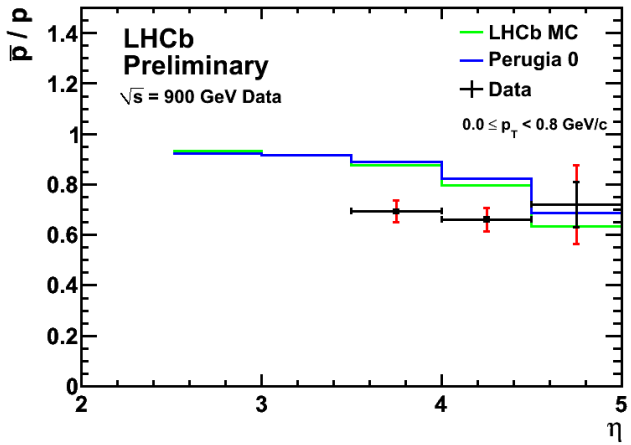

**Detector acceptance**

Particle identification (*DLL*) calibrated with tracking-selected samples: $\pi(K_S)$, $p(\Lambda)$ & $K(\phi)$ [*see talk by Andrew Powell*]

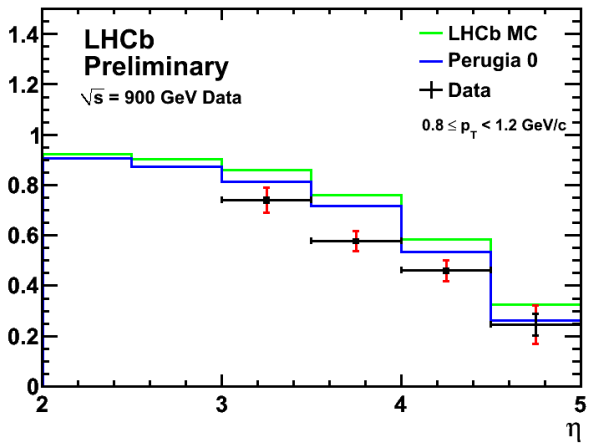
Cuts tuned for purity in MC, efficiency measured in data

# Preliminary Results $\bar{p}/p$

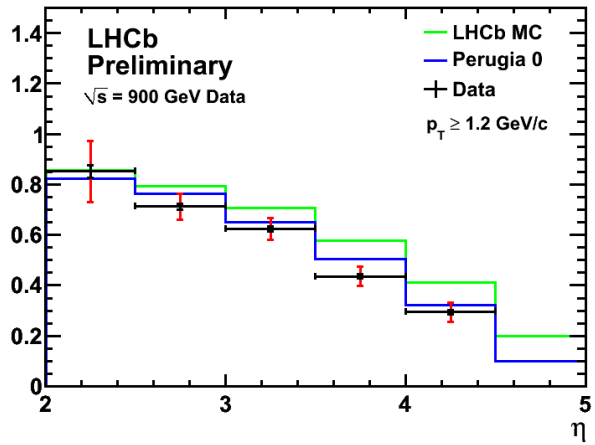
## $\sqrt{s}$ = 0.9 TeV




$p_T < 0.8$ GeV/c

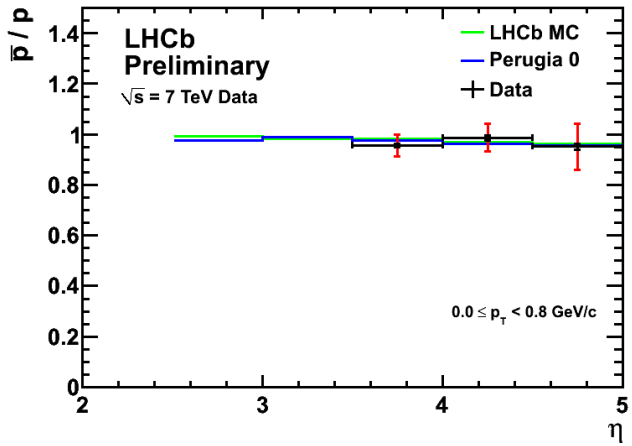


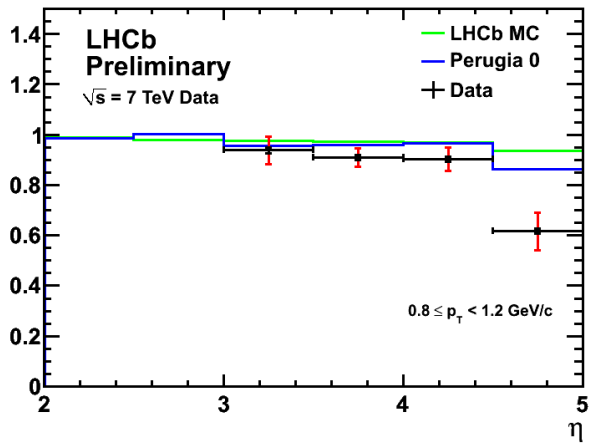

$0.8 < p_T < 1.2$ GeV/c

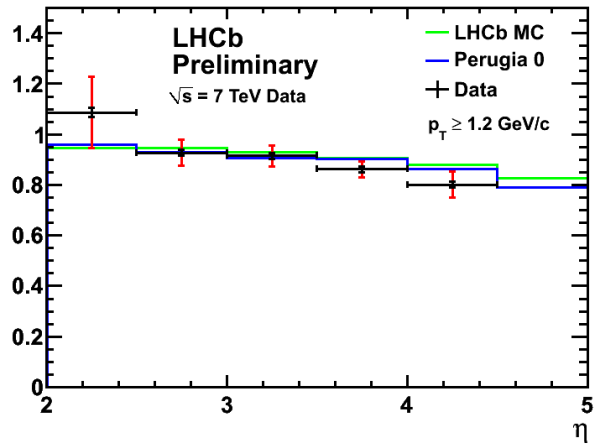



$p_T > 1.2$ GeV/c

## $\sqrt{s}$ = 7 TeV




Baryon number transport closer to predictions

# Preliminary Ratio Systematics

Ratios a great target for early measurements since absolute luminosity measurement not required

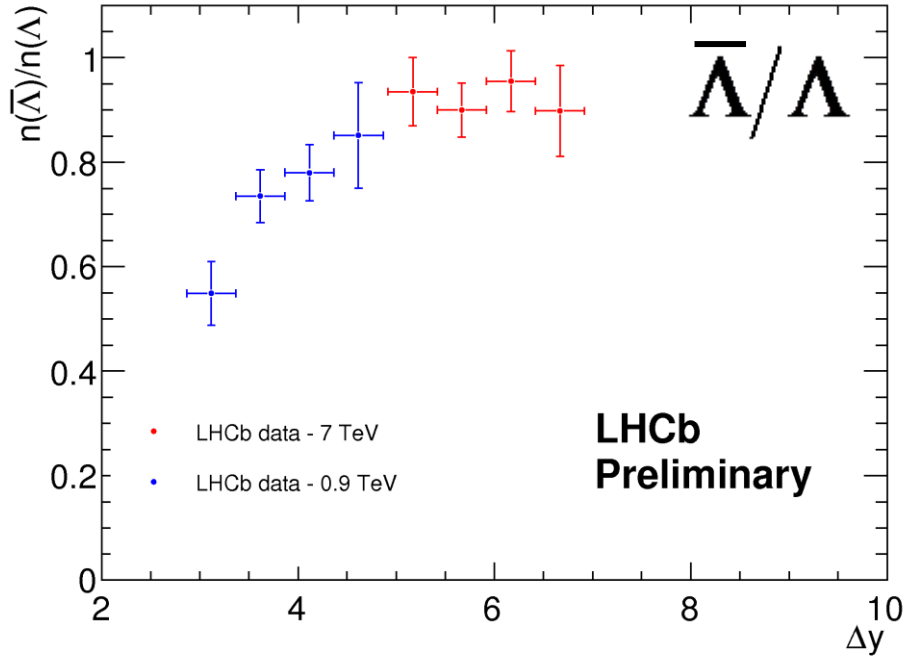
Remaining systematics relate to MC, data comparisons

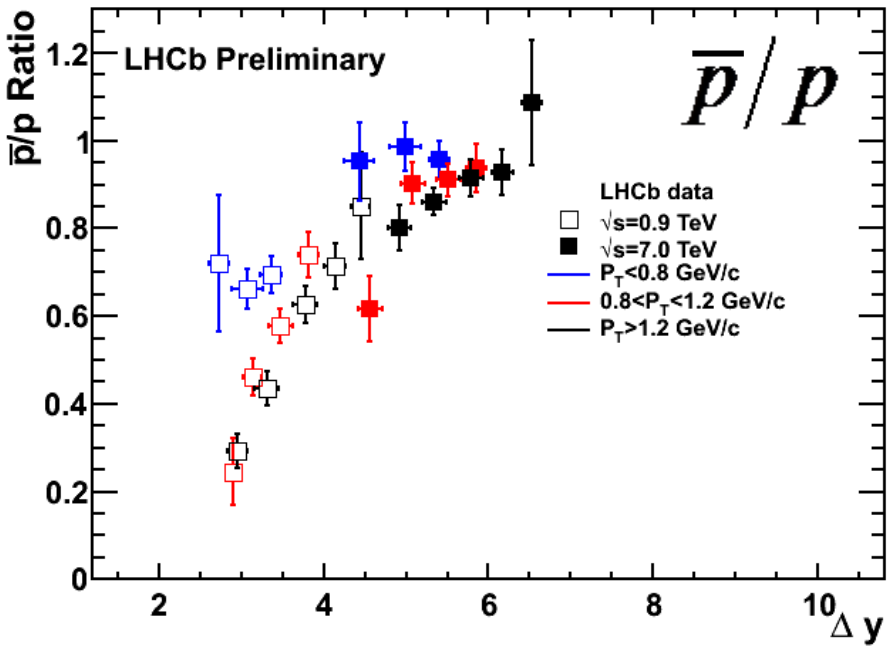
| Uncertainties | Errors |
|---|---|
| p,π interaction cross-sections | ~10% |
| $V^0$ production & interaction cross-sections | ~10% |
| LHCb material description | <10% |
| Λ transverse polarisation | <1% |
| Selection cuts (*dominated by PID*) | 1-14% |
| Ghost tracks | <2% |
| Acceptance asymmetries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

| Ratio | Total |
|---|---|
| $\bar{\Lambda}/\Lambda$ | ~2% |
| $\bar{\Lambda}/K_S$ | 2-12% |
| $\bar{p}/p$ | 3-14% |

# Preliminary Results Comparison

Results at both beam energies compared in ***Δy*** show consistency, also with other experiments :




***Δy = y(beam) – y(Λ,p)***

*y(beam)*: 6.6 : √s = 0.9 TeV
8.3 : √s = 7 TeV

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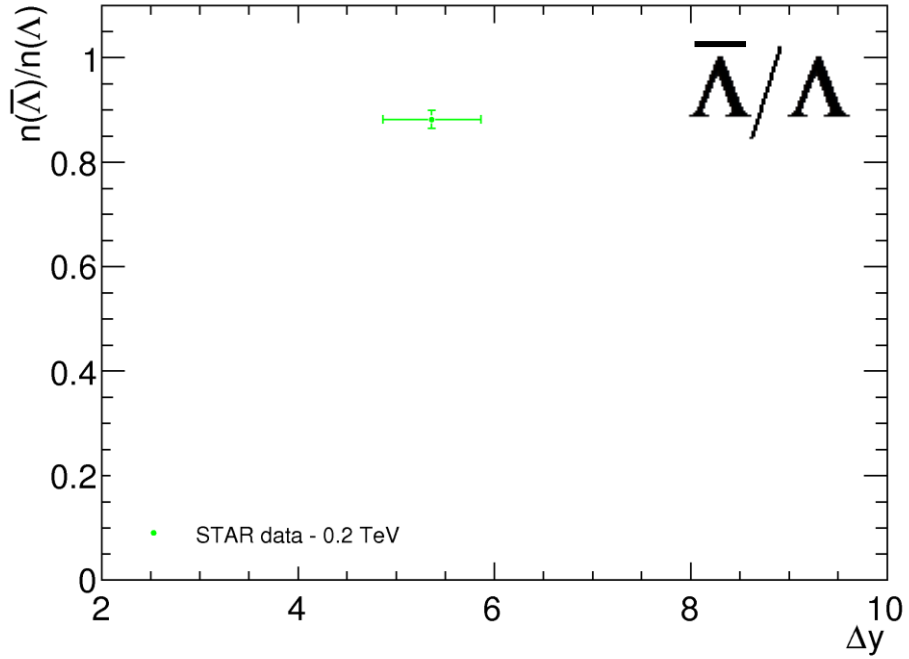


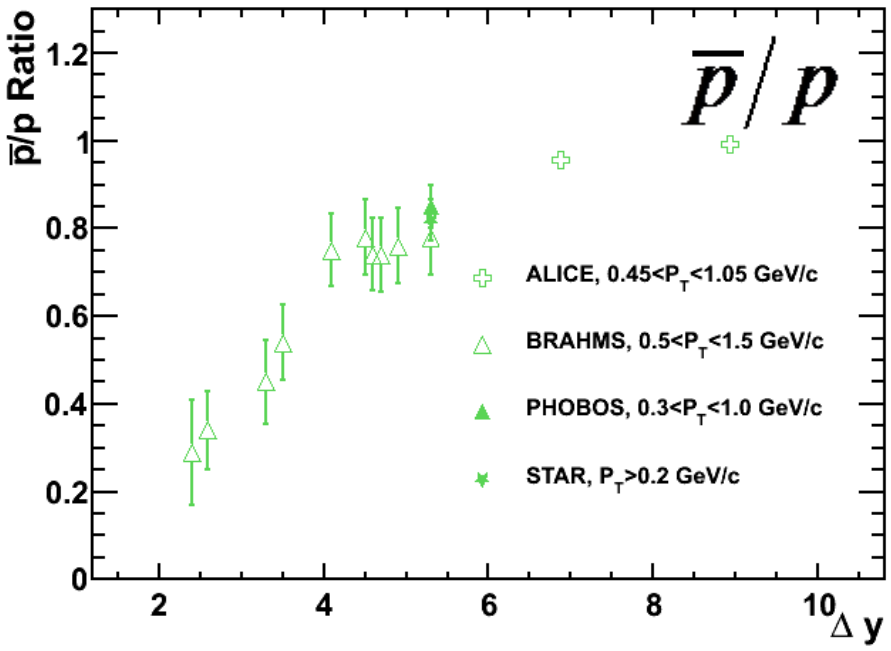


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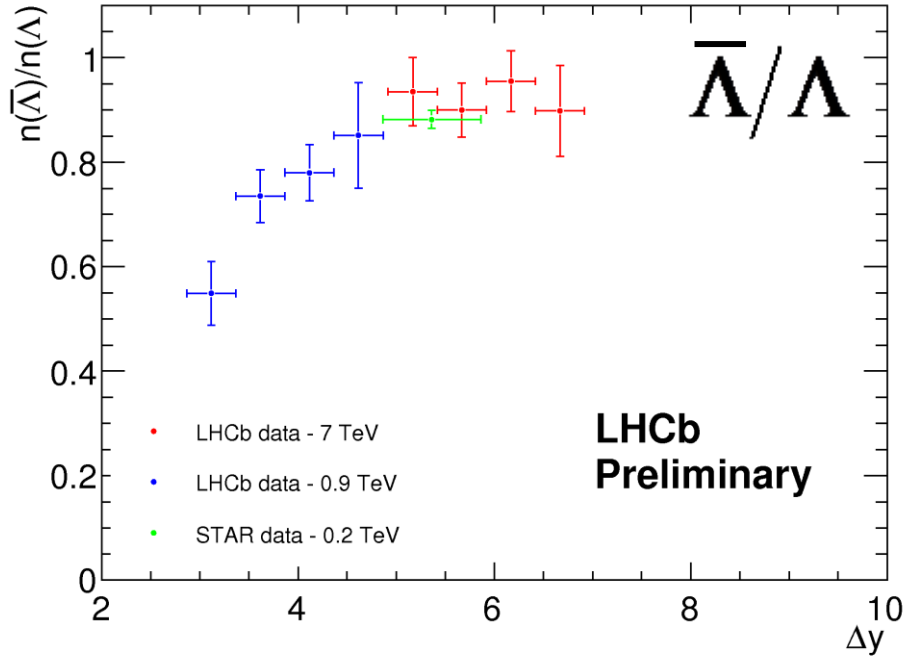


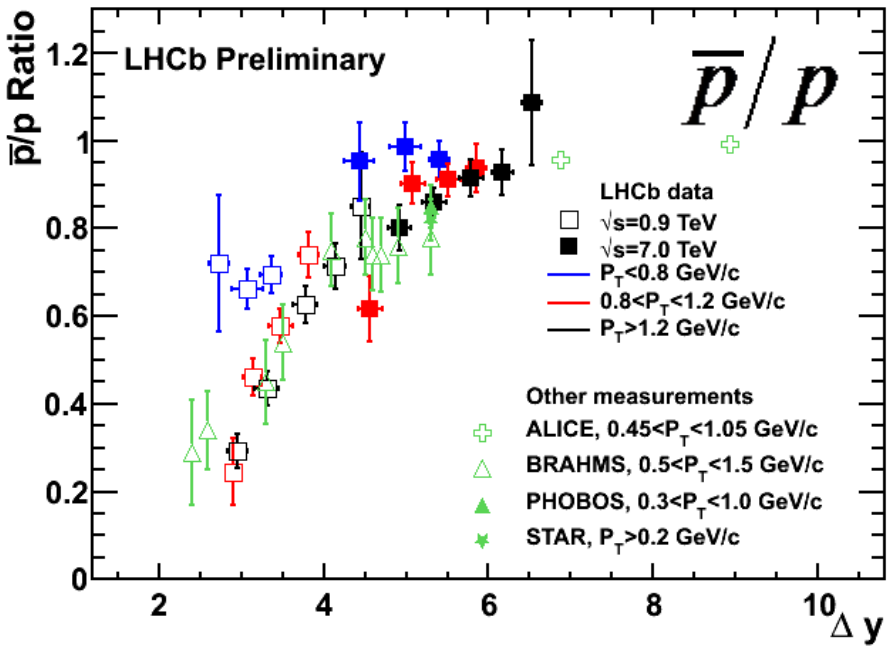


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*y(beam)*: 6.6 : √s = 0.9 TeV

8.3 : √s = 7 TeV

# Summary

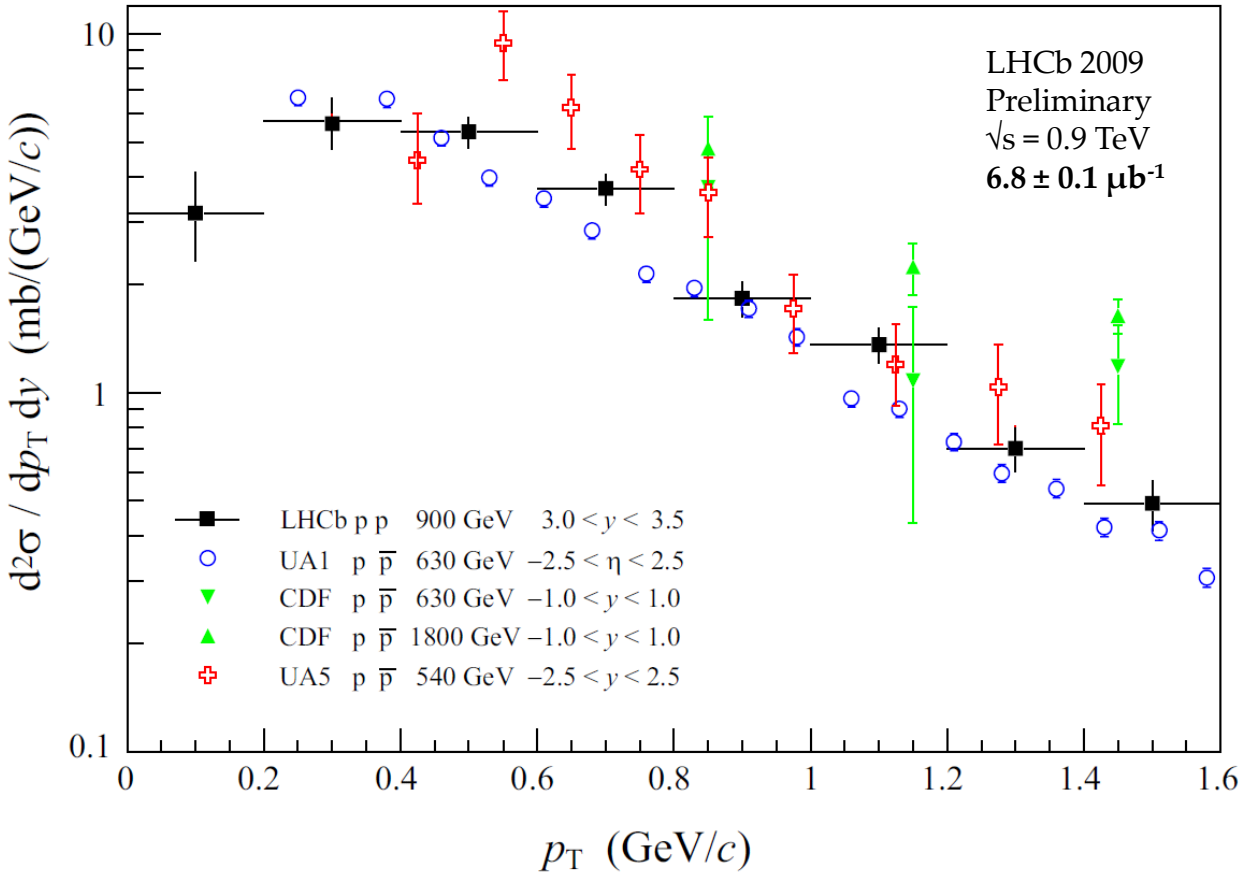
- $K_S$ cross-section measured with 2009 data
- Preliminary results in 2010 for ratios of $V^0$ & protons
- Results suggest **lower Baryon suppression** & **higher Baryon transport** in data than predicted

**Look out for new LHCb publications soon!**

# Back up

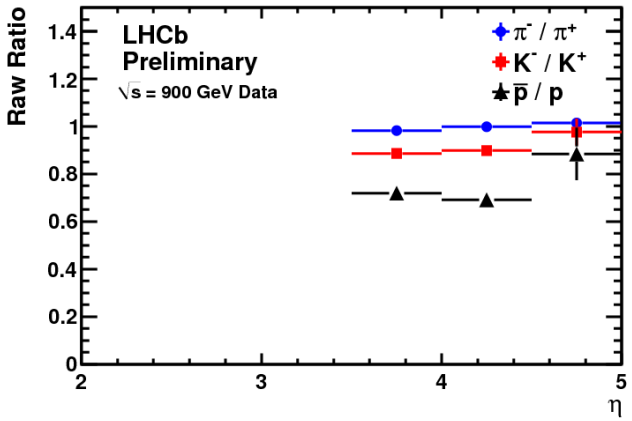
# $K_S$ Cross-section Comparison

A measurement with lower $p_T$ coverage than CDF, UA1, UA5

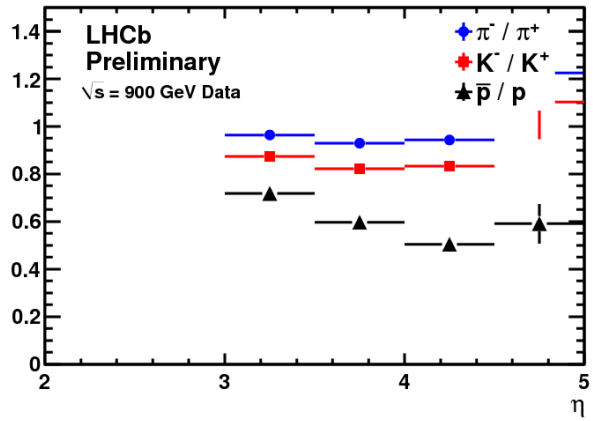


# Raw Charged Particle Ratios

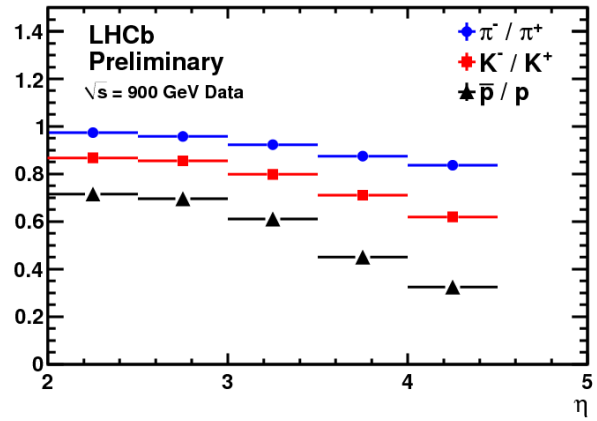
## √s = 0.9 TeV




$p_T < 0.8$ GeV/c

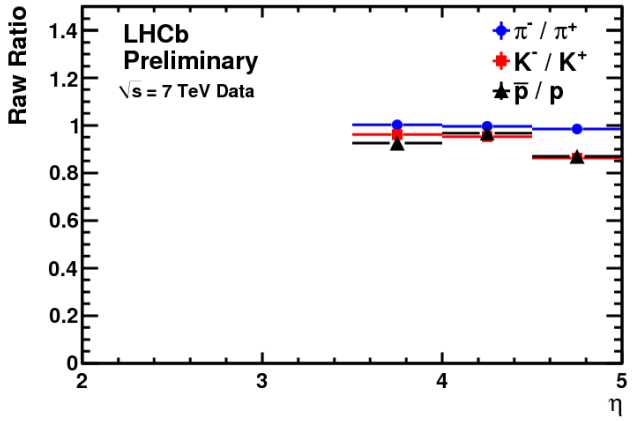


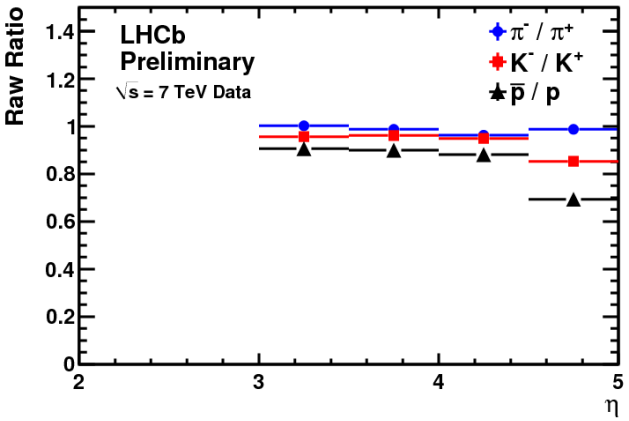

$0.8 < p_T < 1.2$ GeV/c

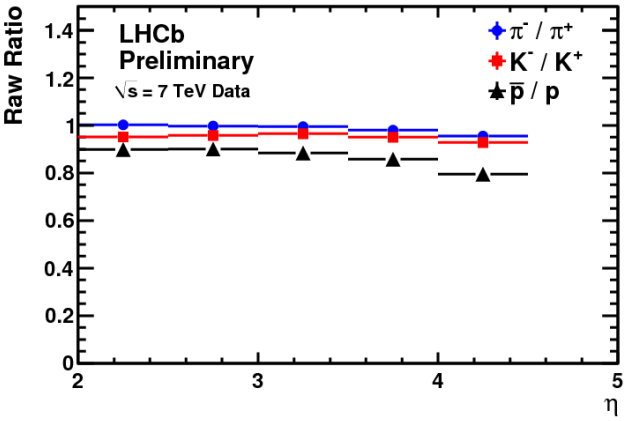



$p_T > 1.2$ GeV/c

## √s = 7 TeV




Corrected ratios for K,π are a work in progress…