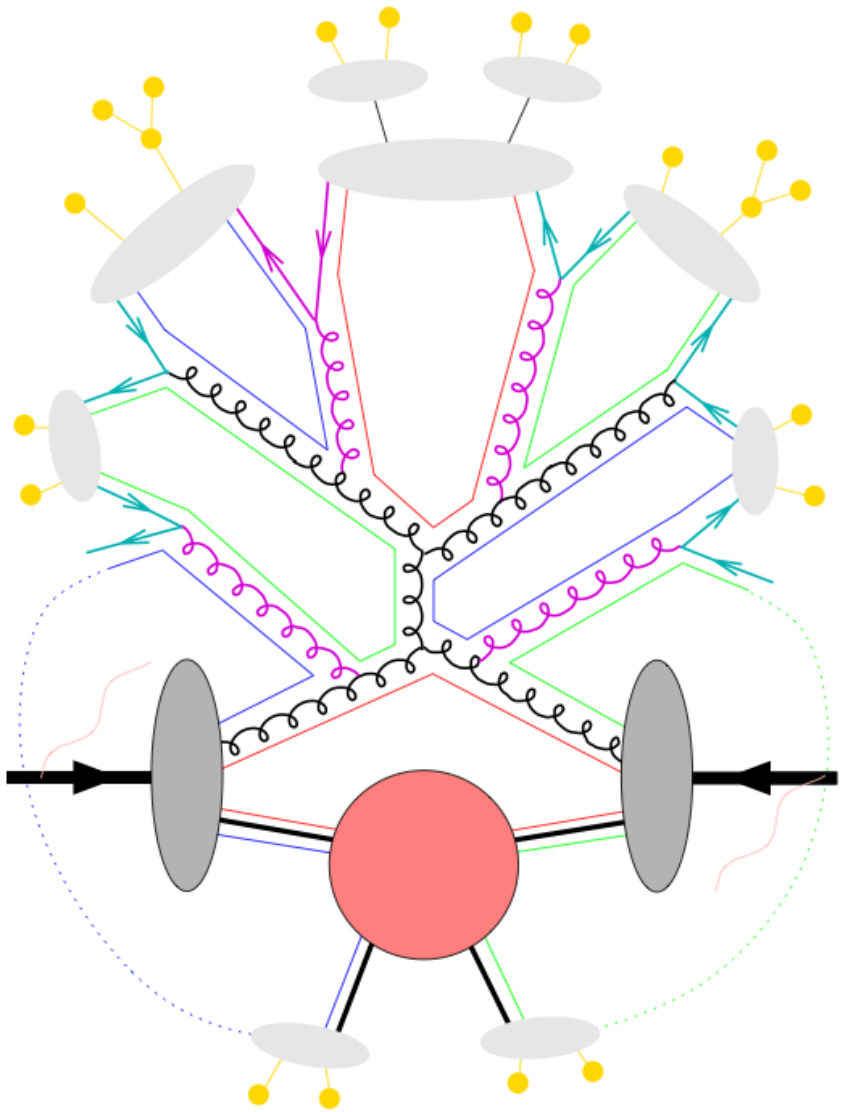
Particle Production & Minimum Bias Distributions at the LHC

Nick Brook

Motivation

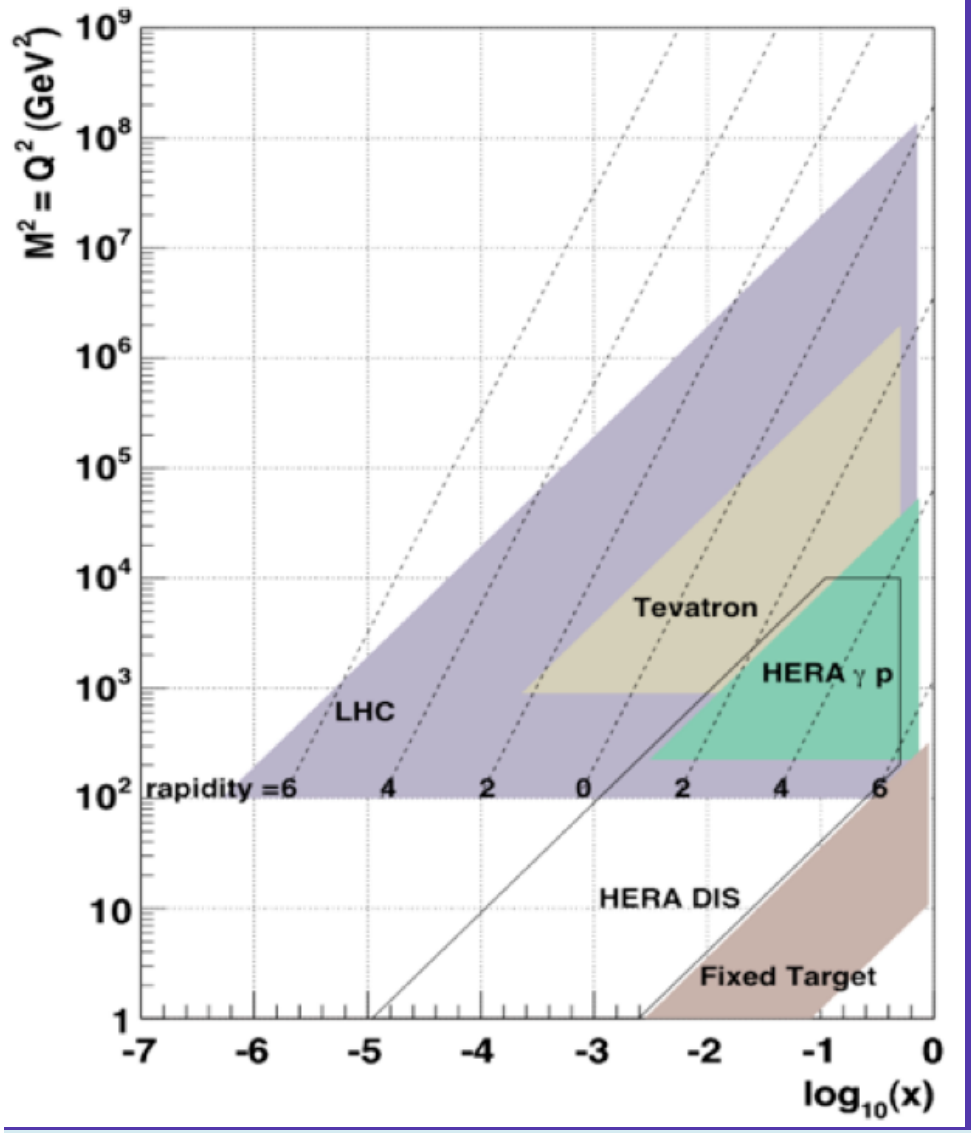


p-p collision reveal rich structure of QCD

- Parton densities
- Parton showers
- Hard scattering
- Multiple parton interactions
- Hadronisation

Not as clear cut but convenient process breakdown

Motivation



LHC opens up a brand new kinematic regime for QCD

- Soft particle production
- Improve event generators
- Multi-parton interactions
- pQCD calculations
- PDF constraints
- Multijet production

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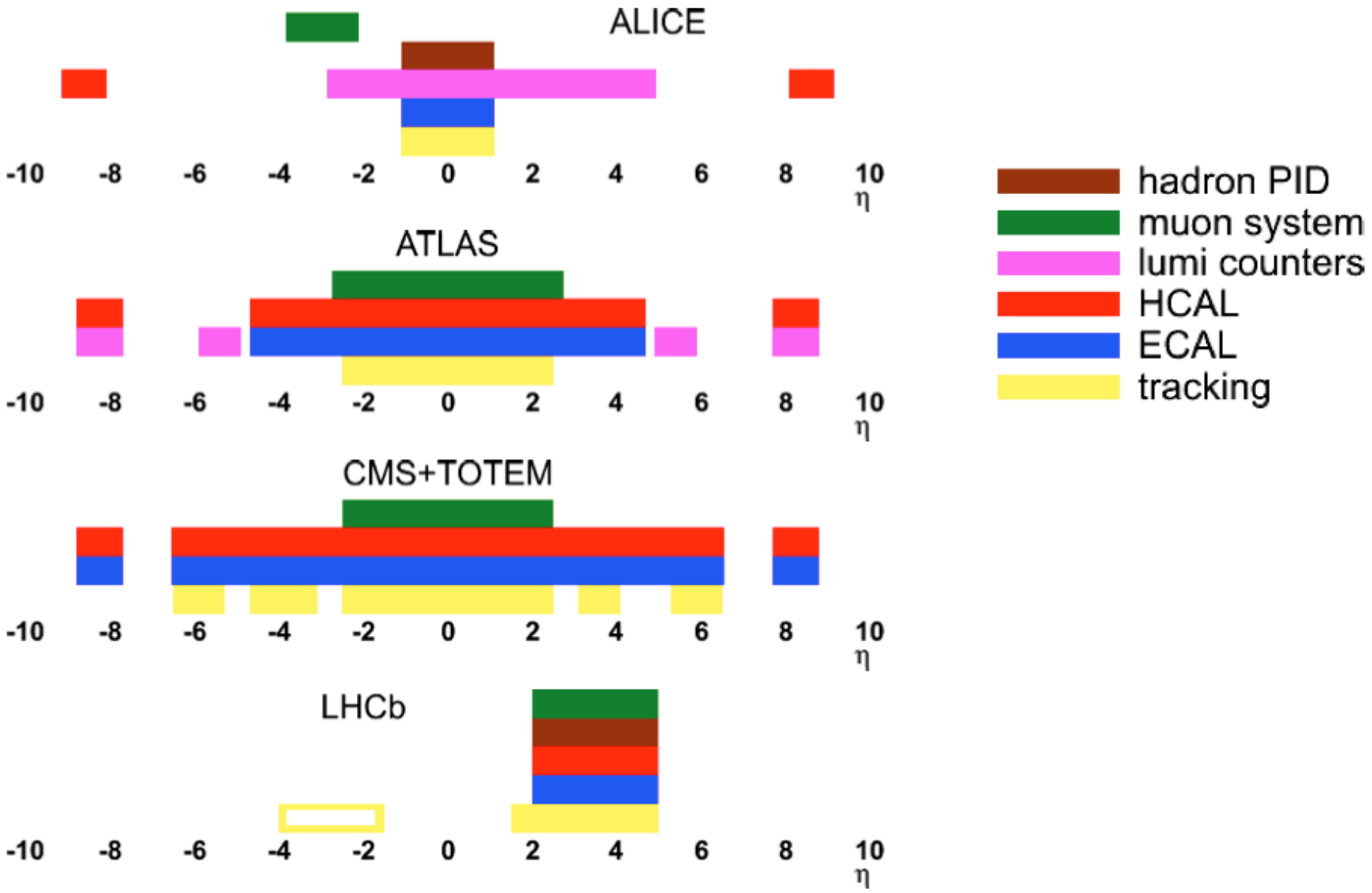
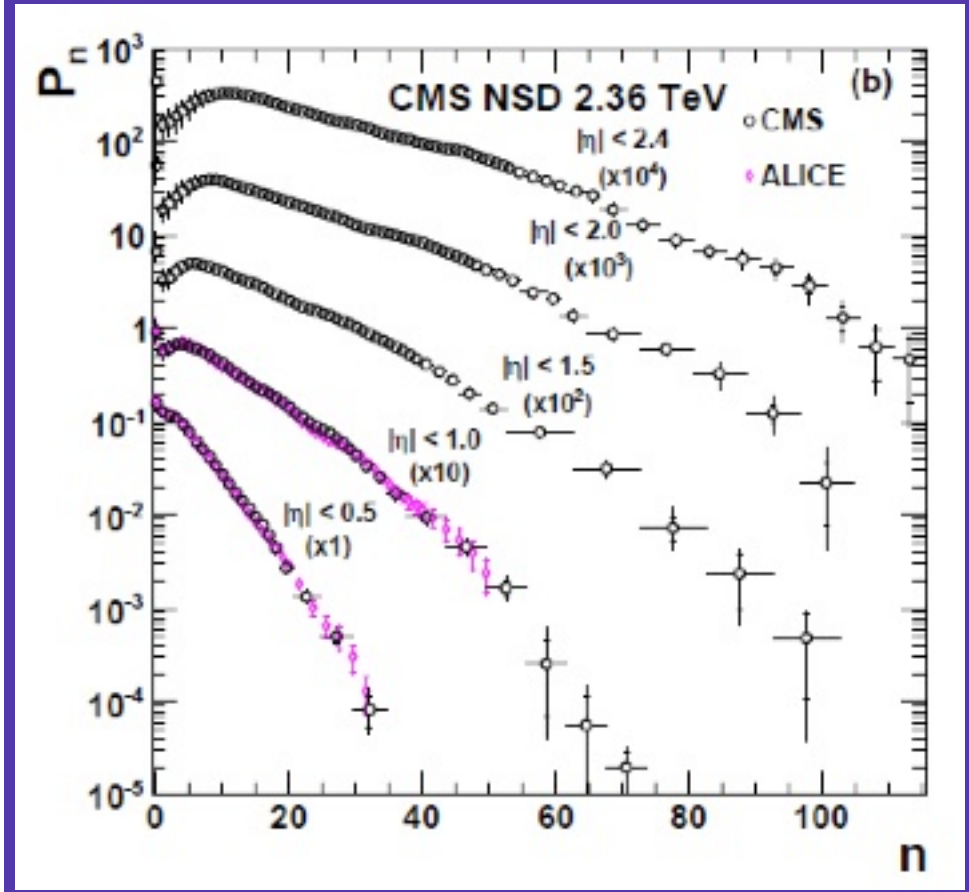
Acceptance of LHC Expts

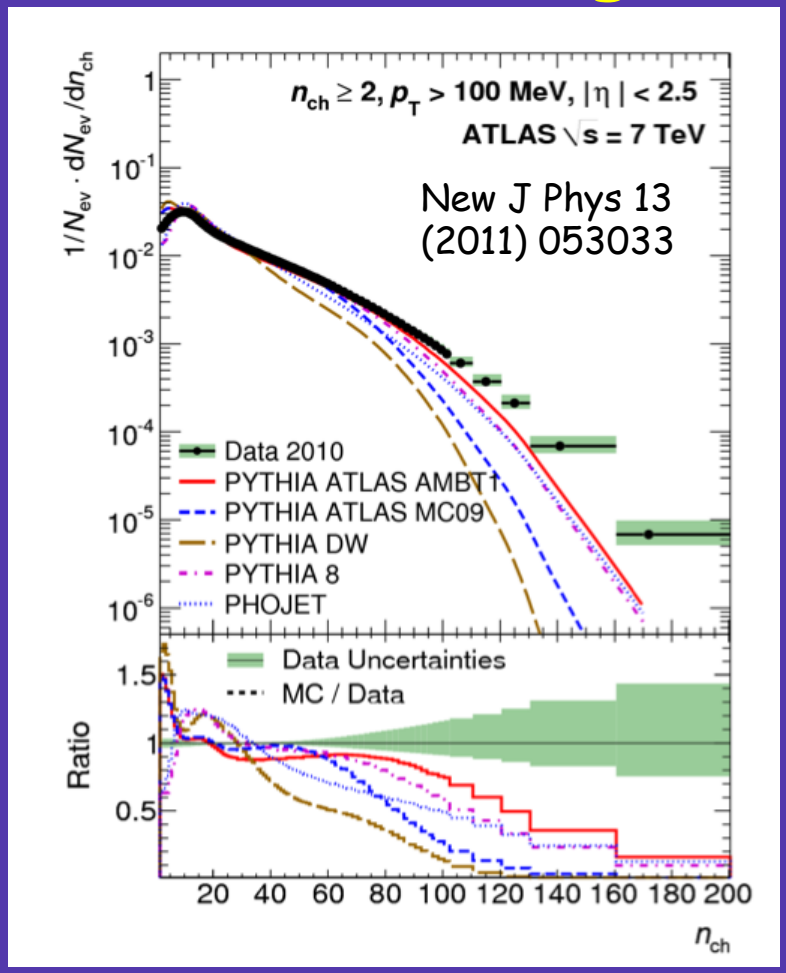


Multiplicity distributions – central region



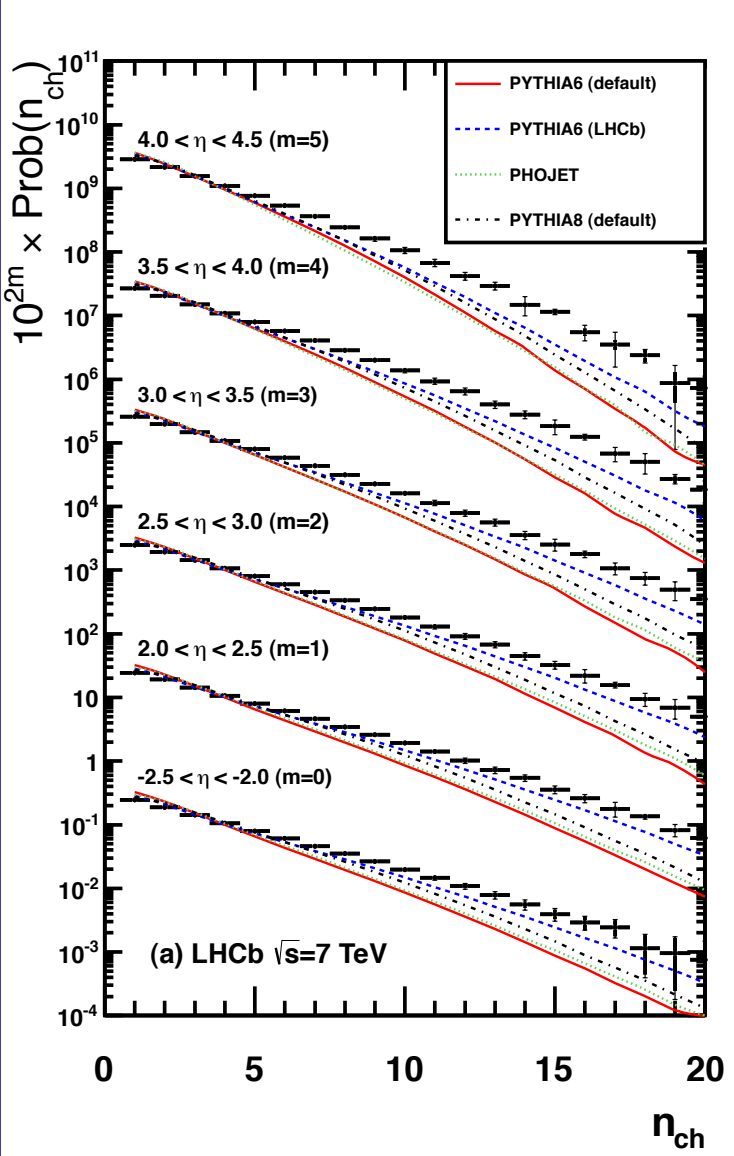
Good agreement between ALICE & CMS

(JHEP 01 (2011) 079 & Eur Phys J C68 (2010) 89)



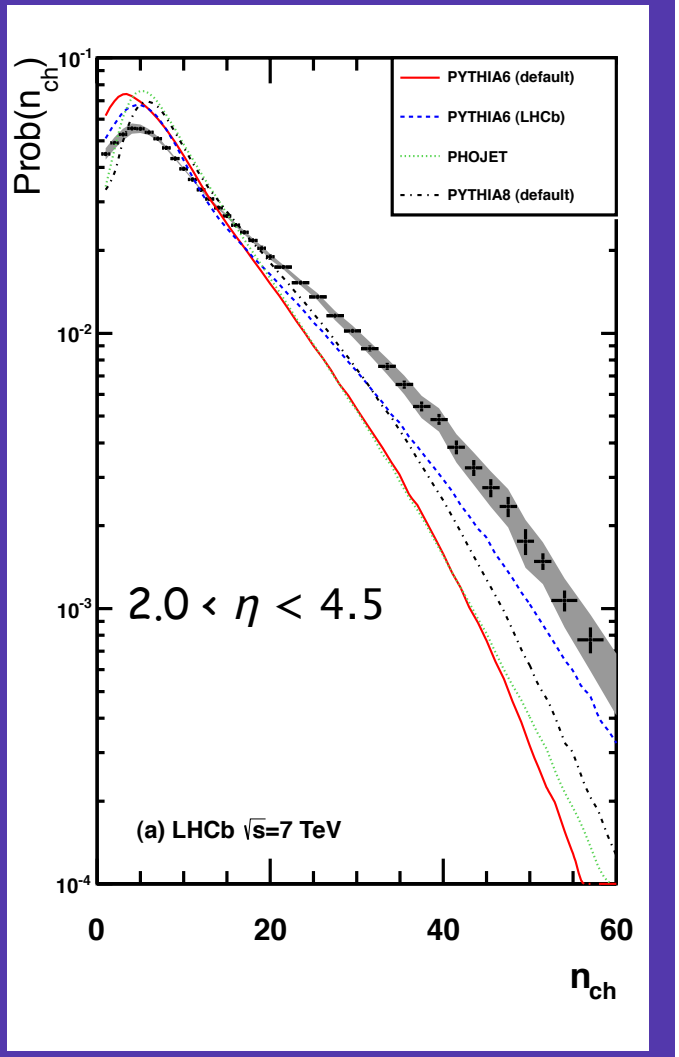
Pre-LHC MC tune fail to describe high n_{ch} tails

Multiplicity distributions – forward region



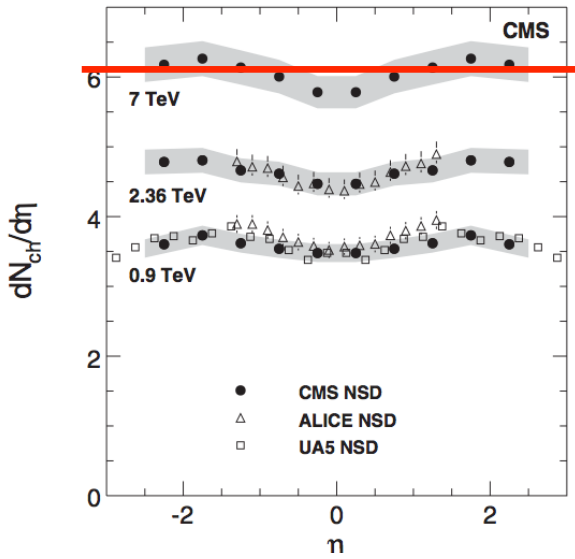
CERN-PH-EP-2011-209

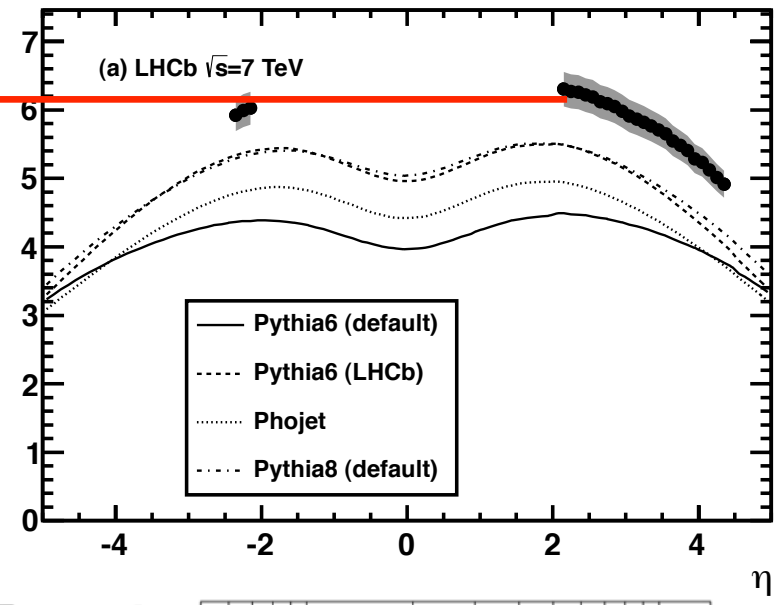
At least 1 track in η range under study

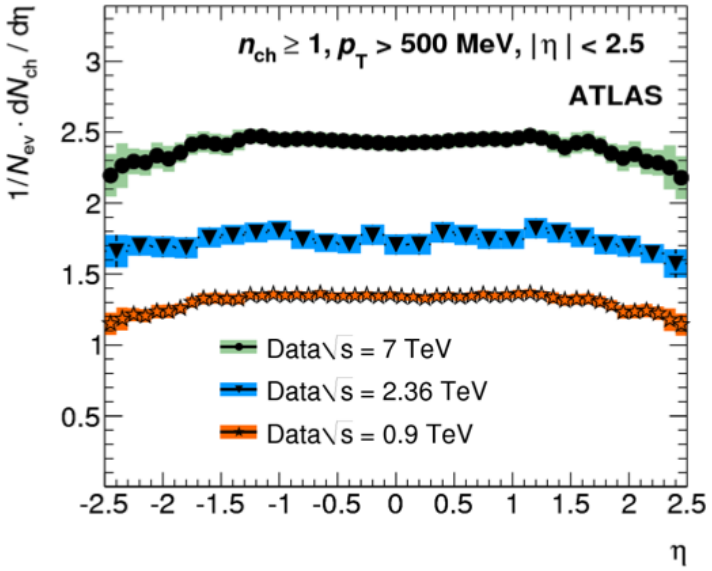


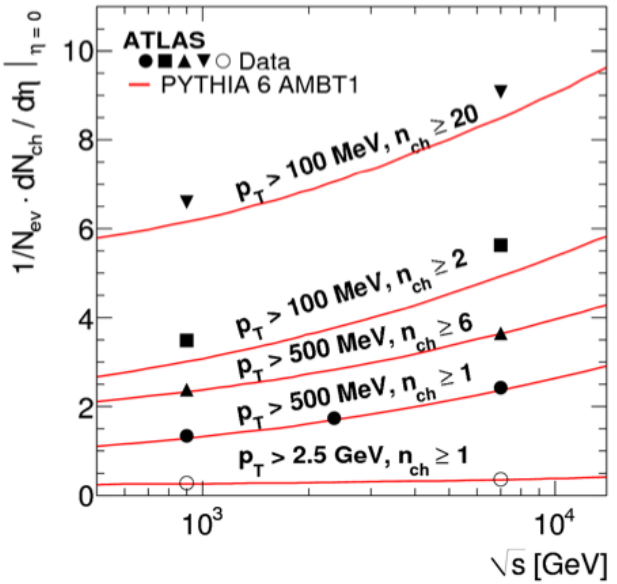
Same trends observed as in central production

Charged particle pseudorapidity distributions





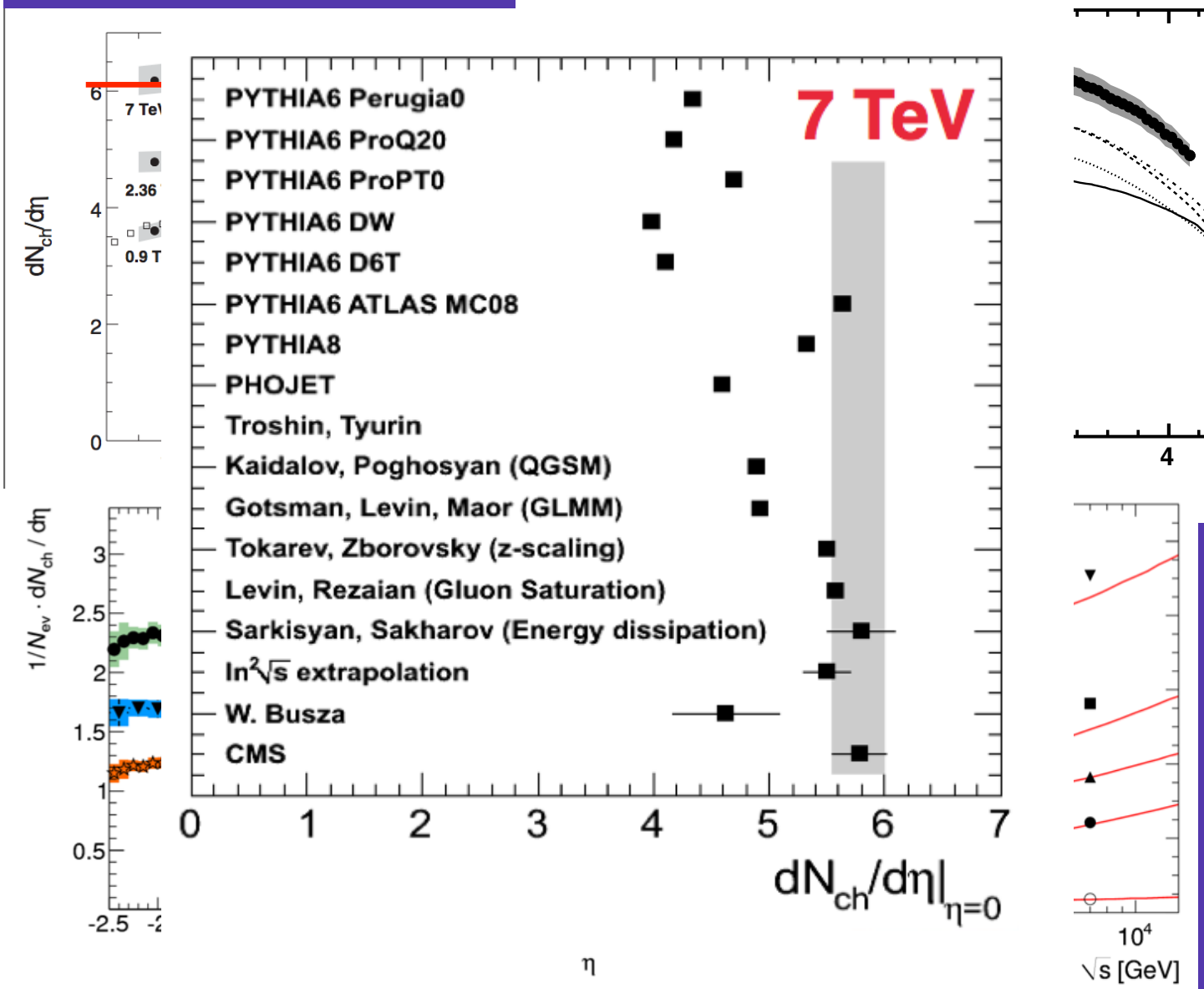




Expts in agreement

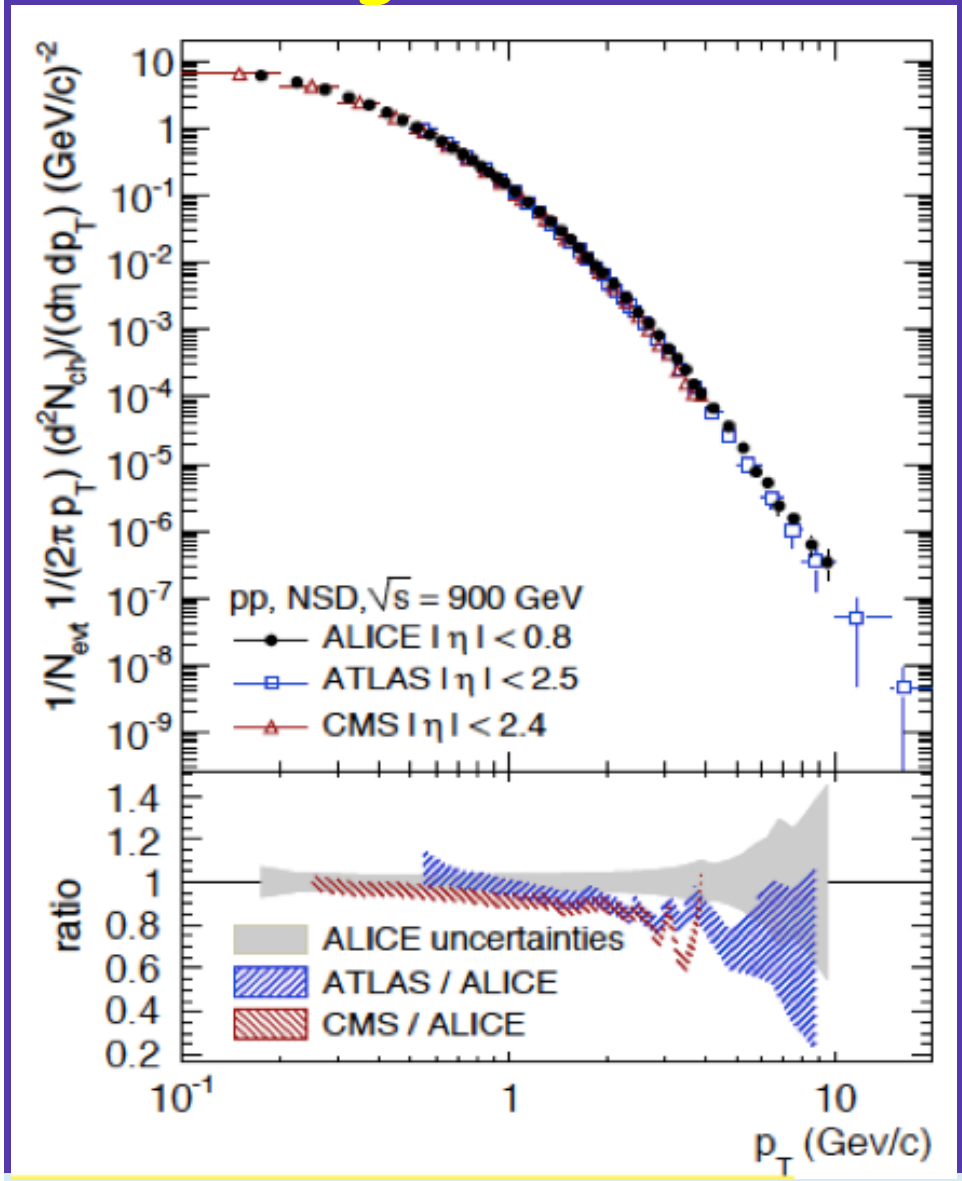
Generator tunes improve without low p_T region

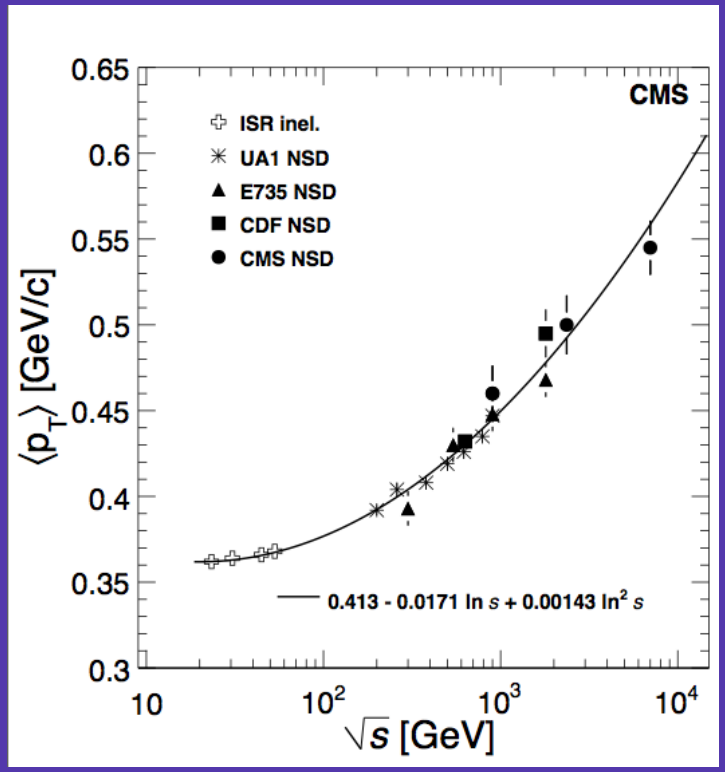
Charged particle pseudorapidity distributions



Same analytic models in good agreement

Charged Particle Transverse Momentum

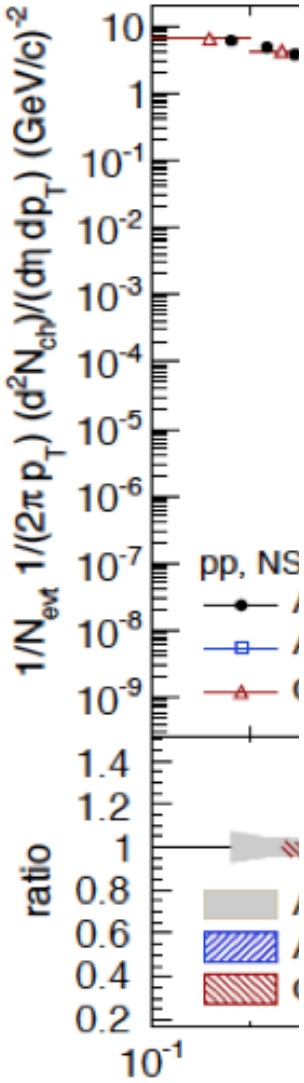


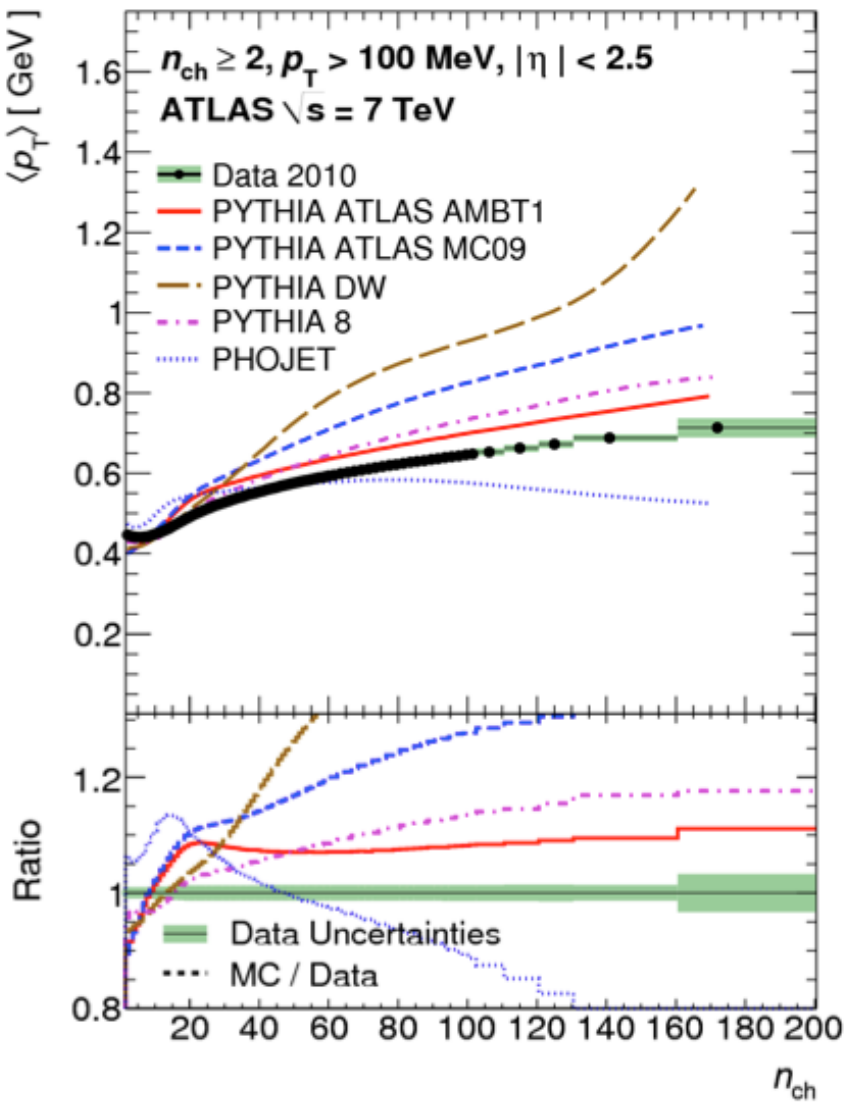


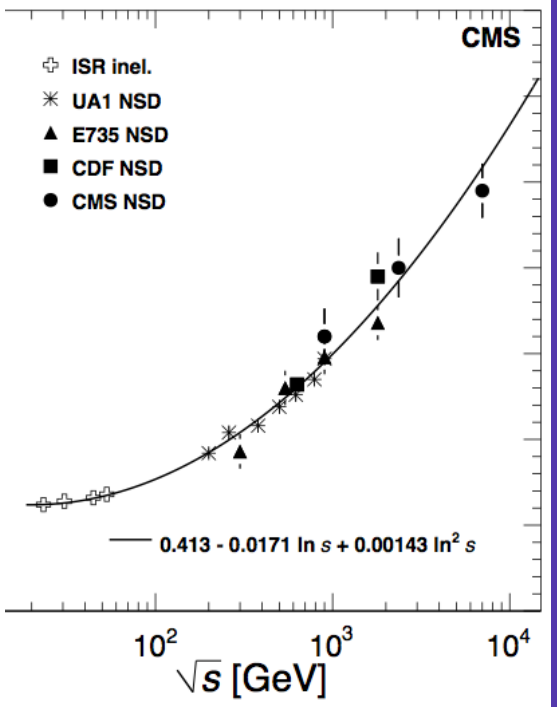
Mean p_T grows with CoM energy

LHC measurement in line with lower energy data

Charged Particle Transverse Momentum



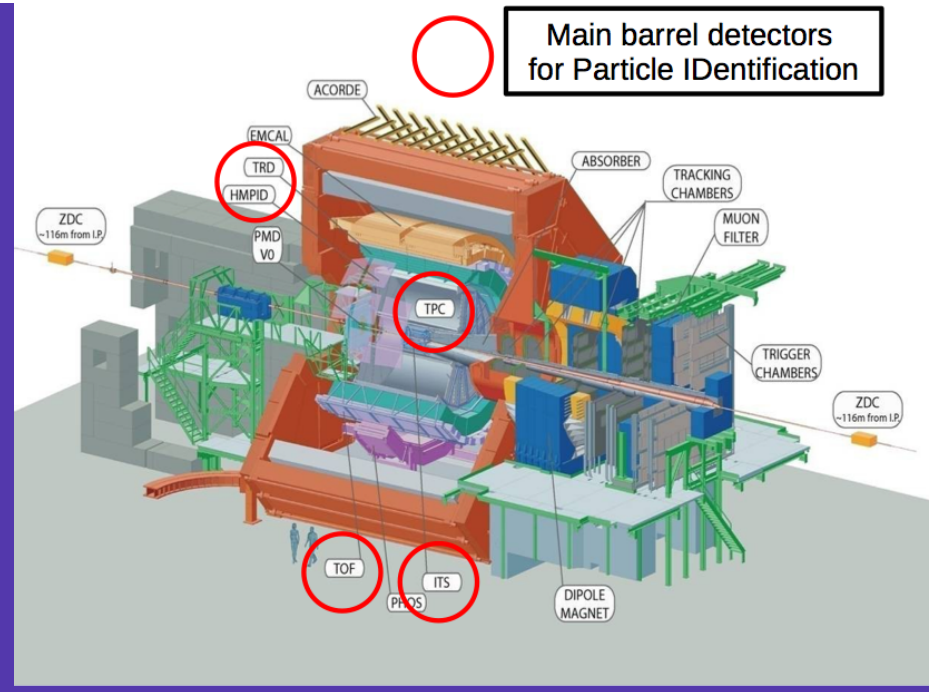




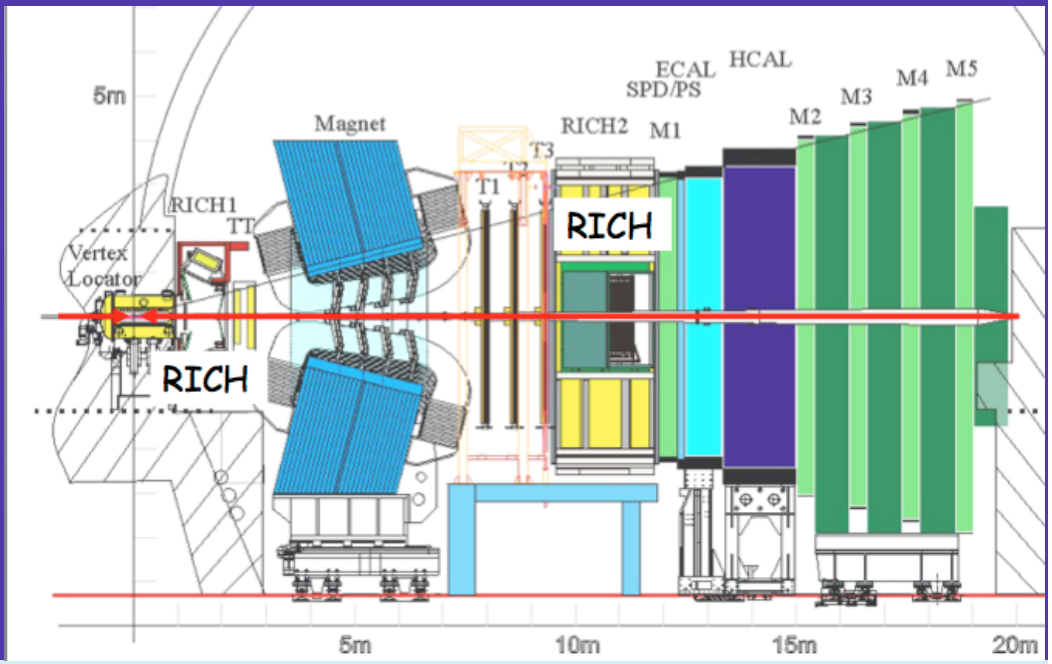
Event generator predictions expected a greater $\langle p_T \rangle$

Identified Charged Particles

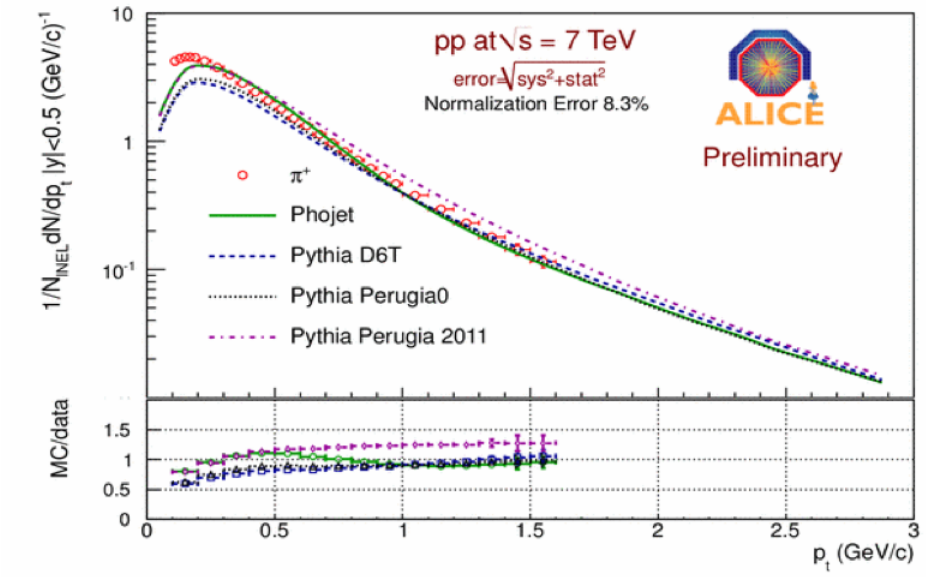
- ALICE has several barrel detectors dedicated to PID
  - dE/dx, transition radiation, ToF, Cherenkov radiation



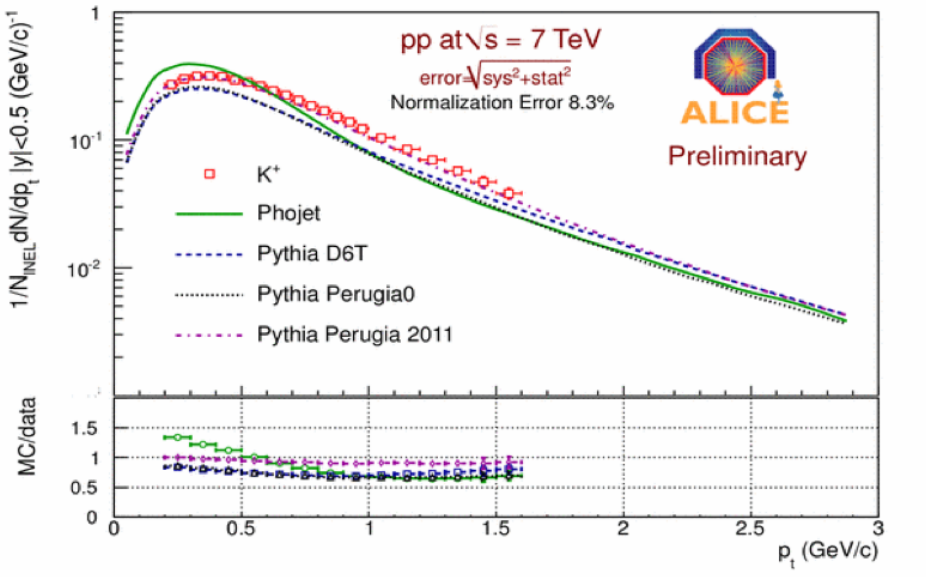
- LHCb has dedicated PID detectors
  - 2 RICH detectors



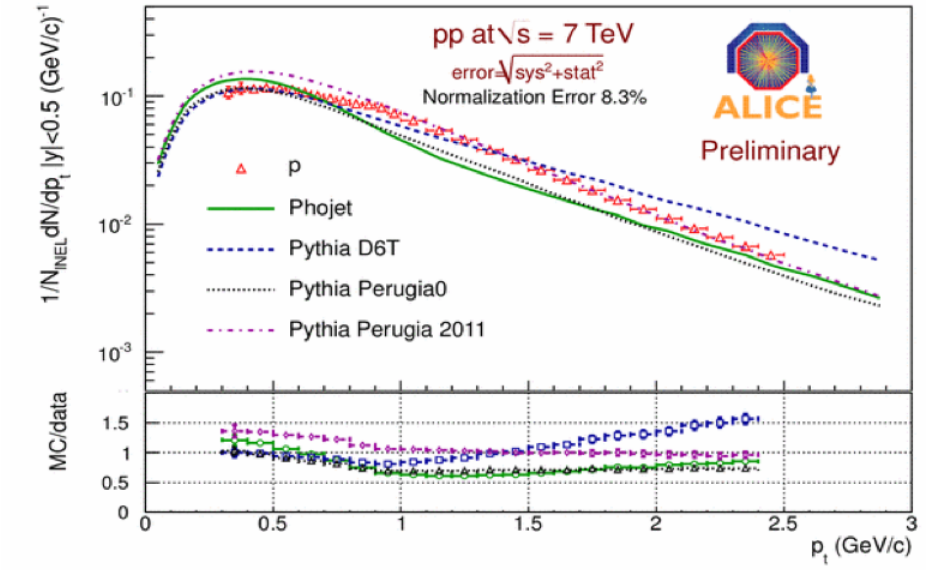
Identified Charged Particles



ALI-PREL-10373



ALI-PREL-10385

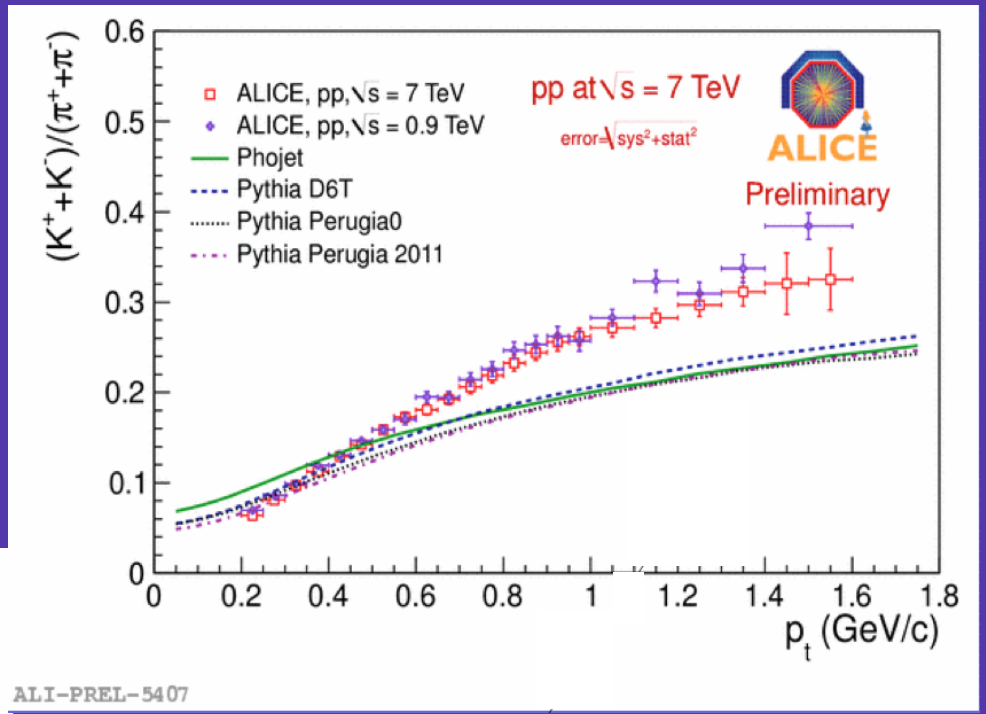


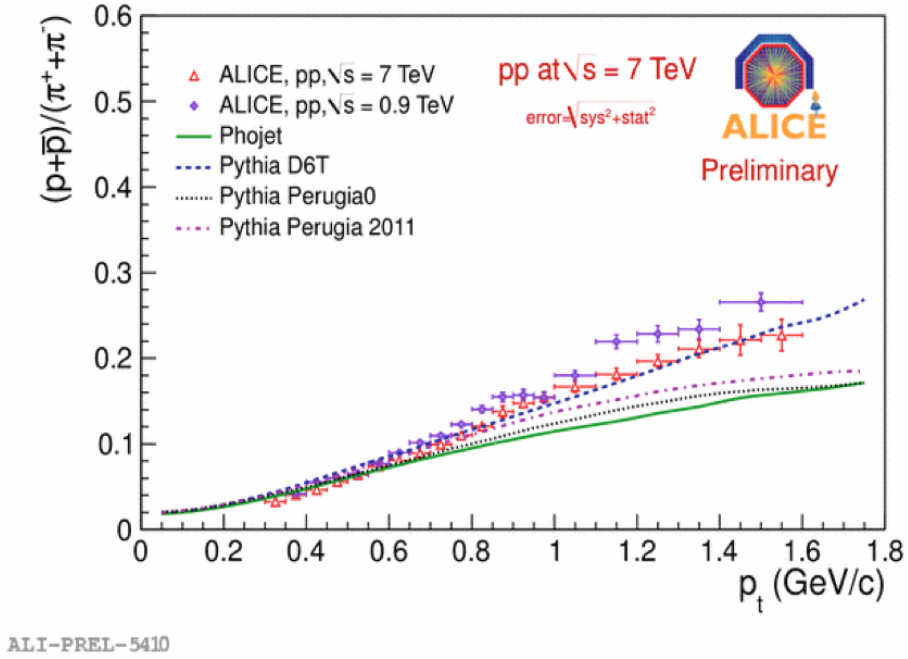
ALI-PREL-10393

MC models do not describe detail of particle spectra at low p_T

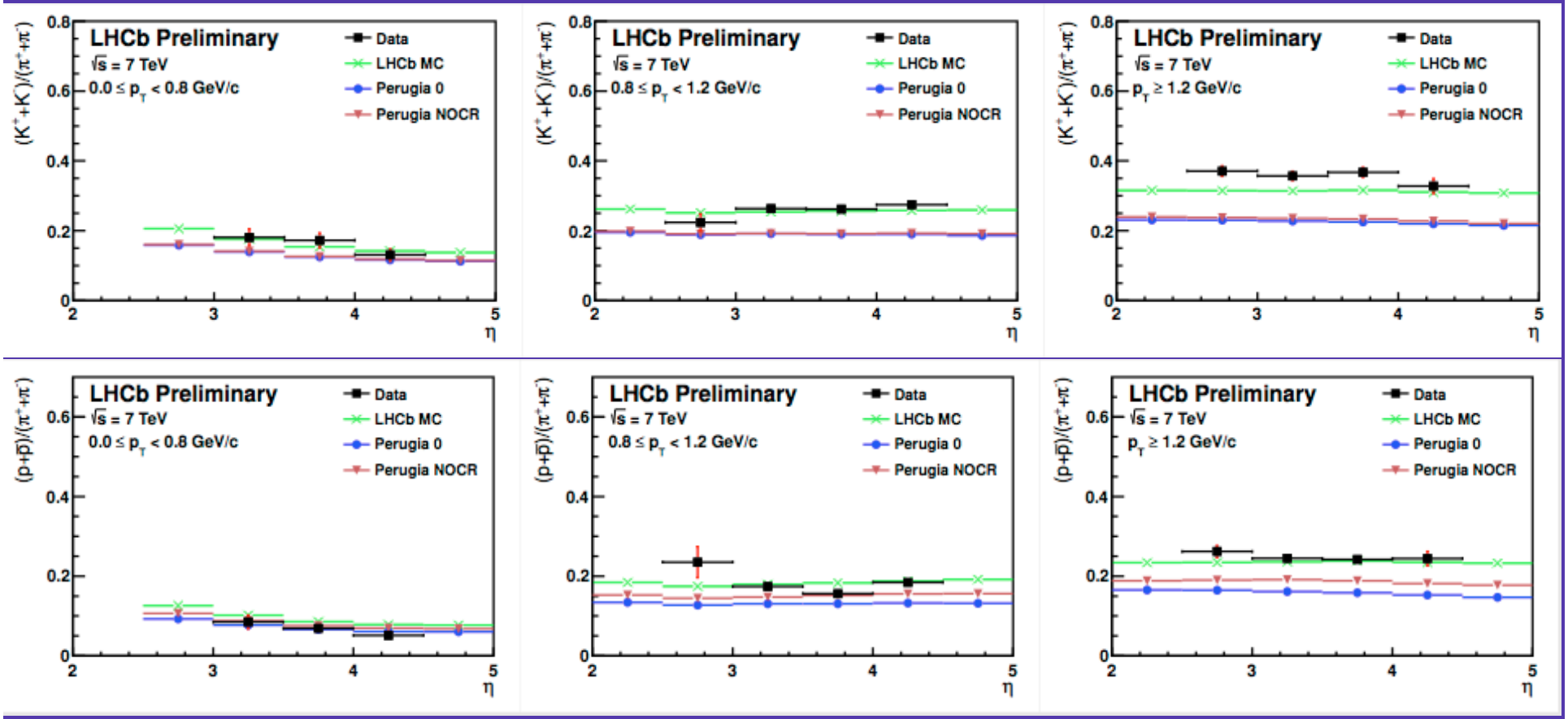
Charged Particle Ratios

ALICE results





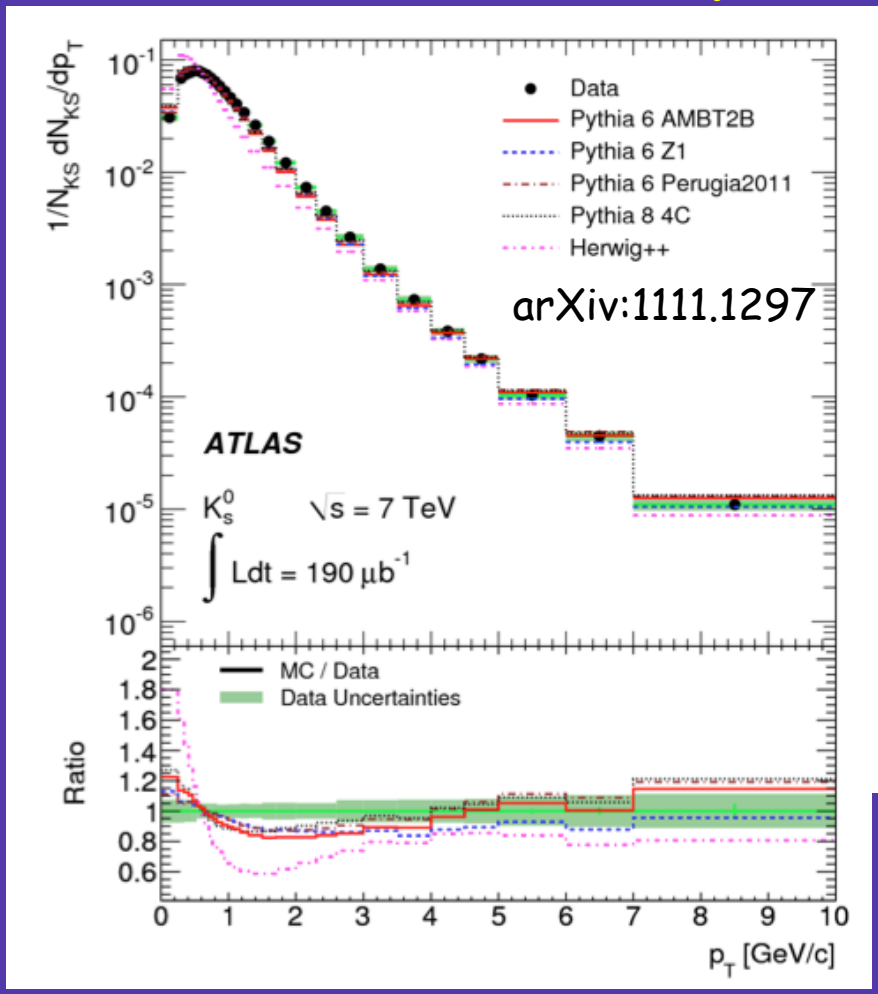
Charged Particle Ratios

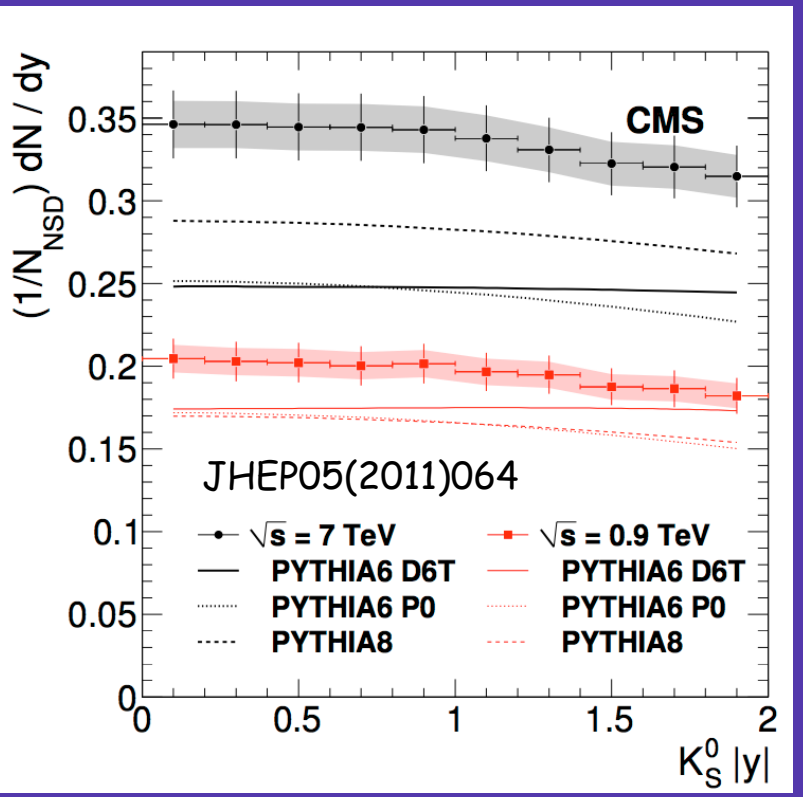


P/π,K/π ratio underestimated by models at high p_T

LHCb tune – specifically looked at species production

K_S^0 production



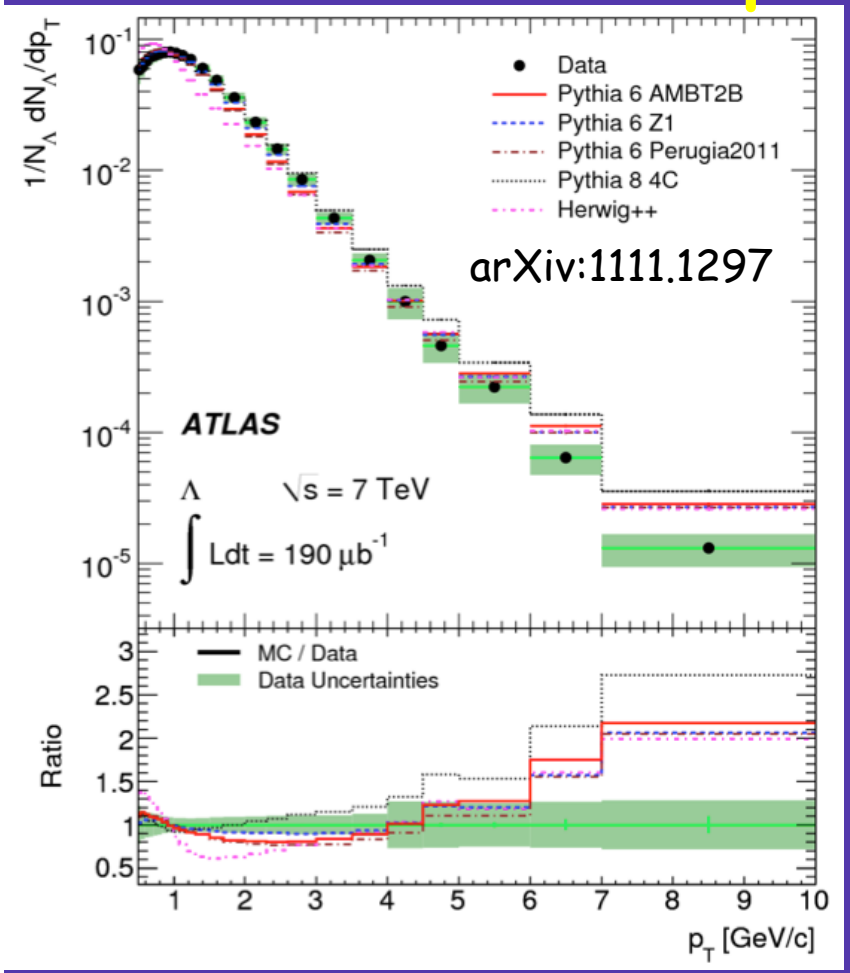


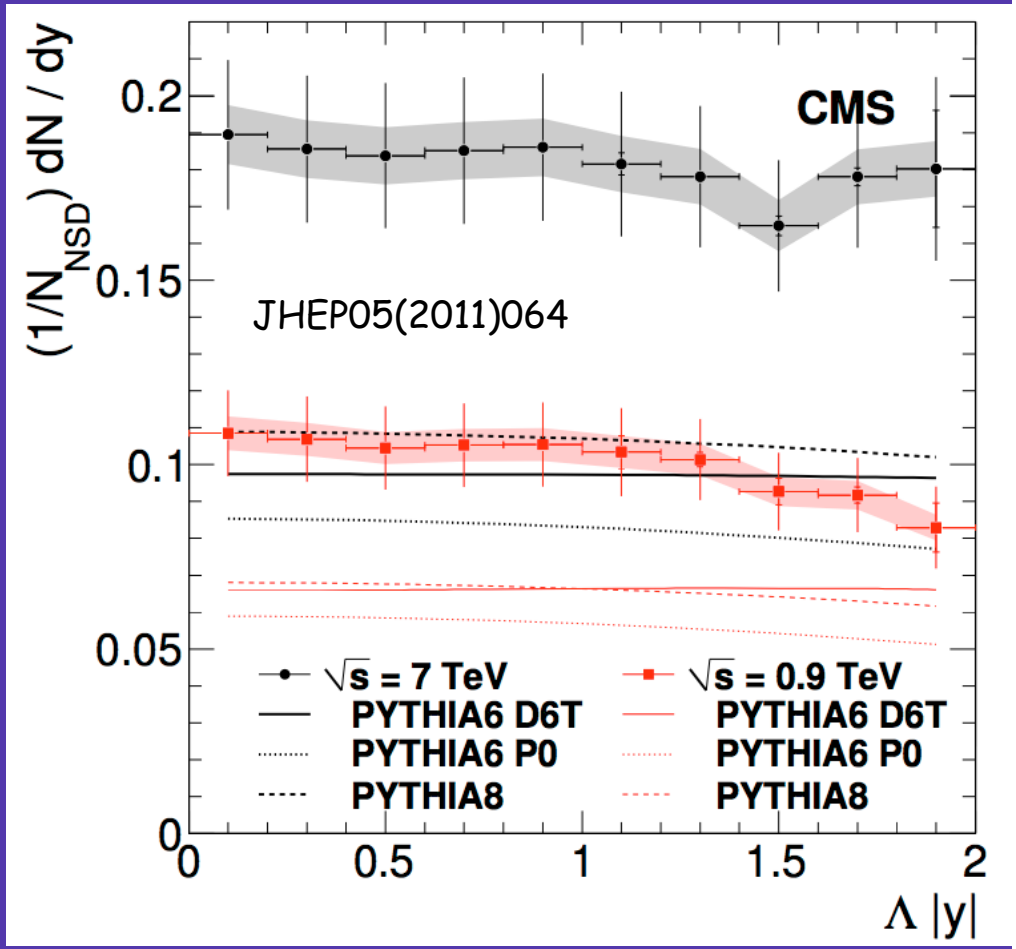
Not too surprising given n_{ch} results – K_S^0 is also underestimated

Rapidity shape is well described

$p_T > 2$ GeV/c - MC falls more slowly than data

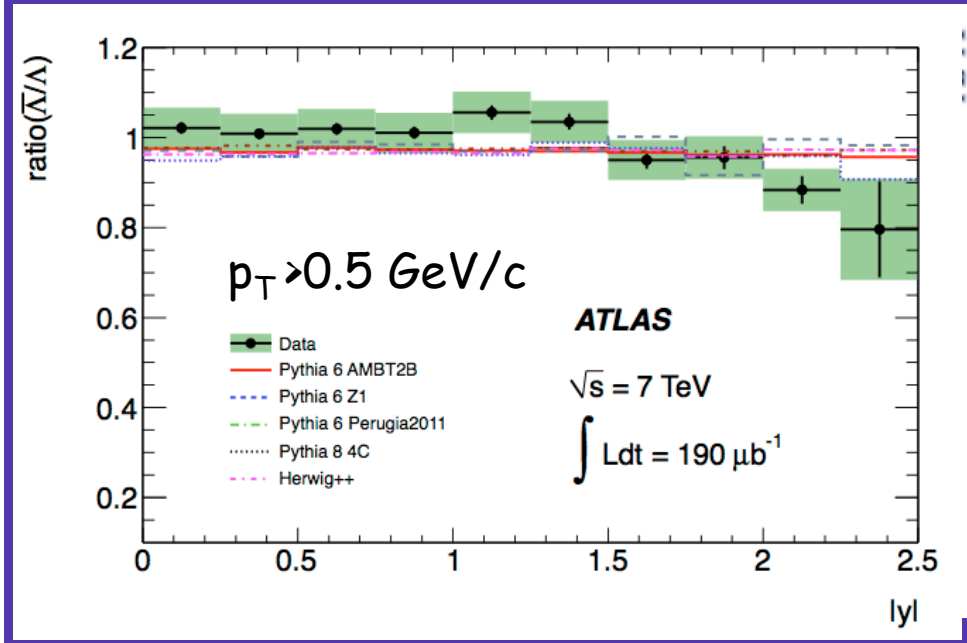
Λ production

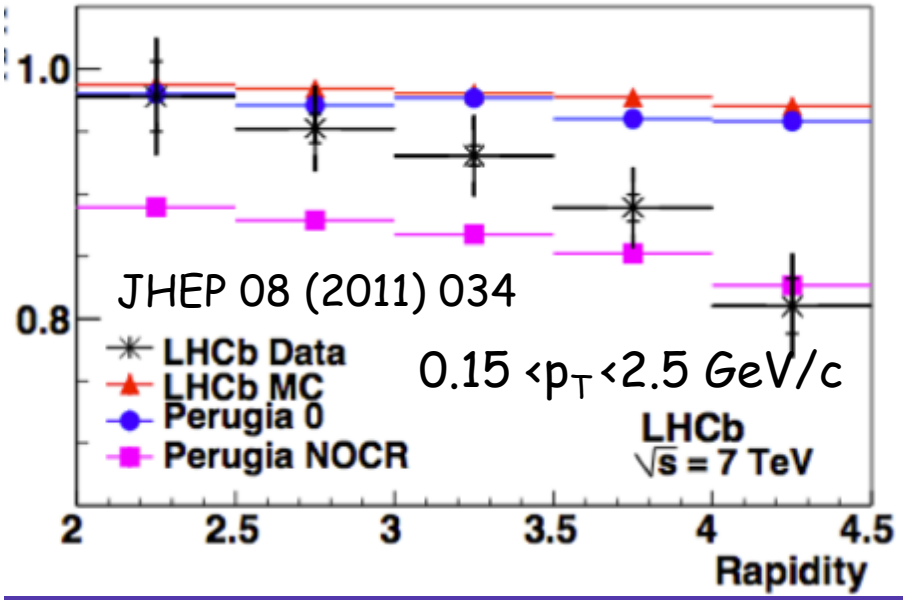




Λ production not as well described as K_S^0

Λ production ratios



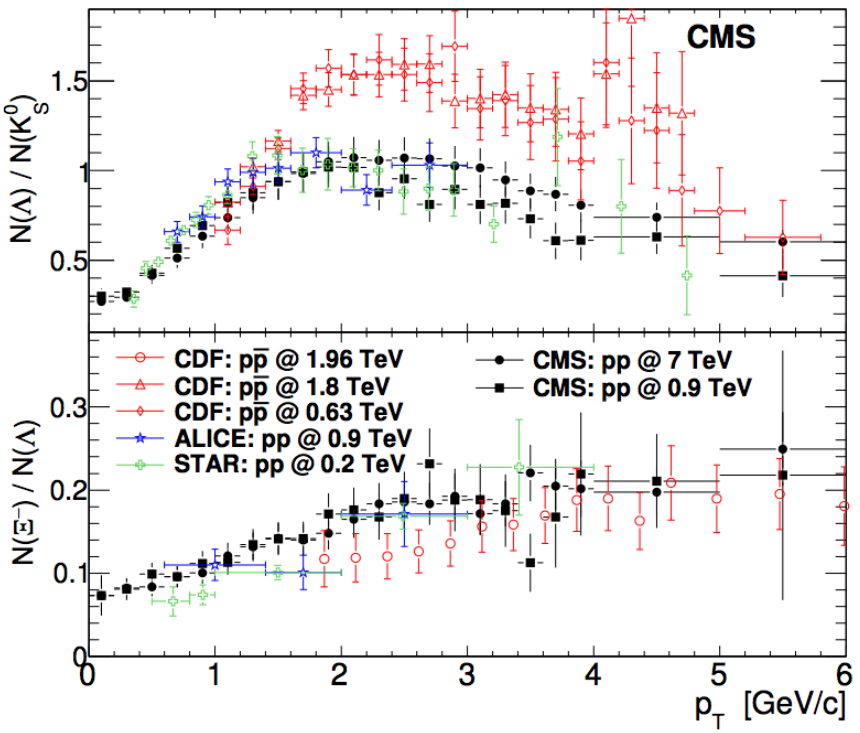


AntiParticle/particle ratio flat (~1) in central region

Ratio falls off go to forward region

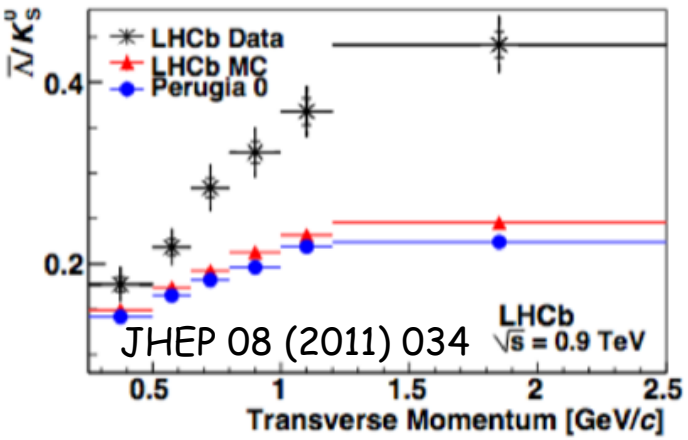
MC predictions remain essentially flat

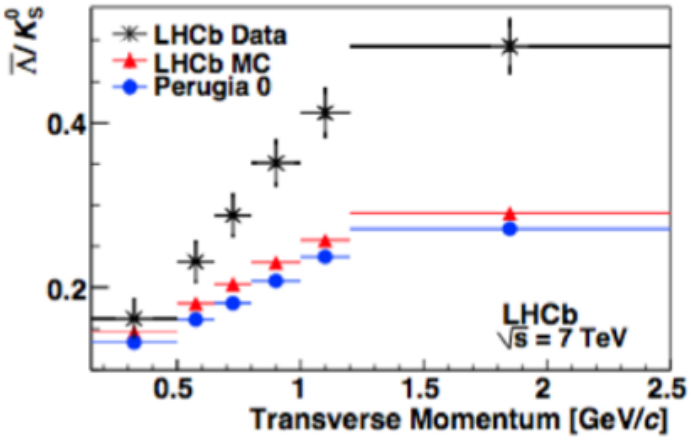
$\Lambda(\bar{\Lambda})/K_S^0$ production ratios



Ratio rises at p_T raises as expected

Rise in forward region greater than MC predictions



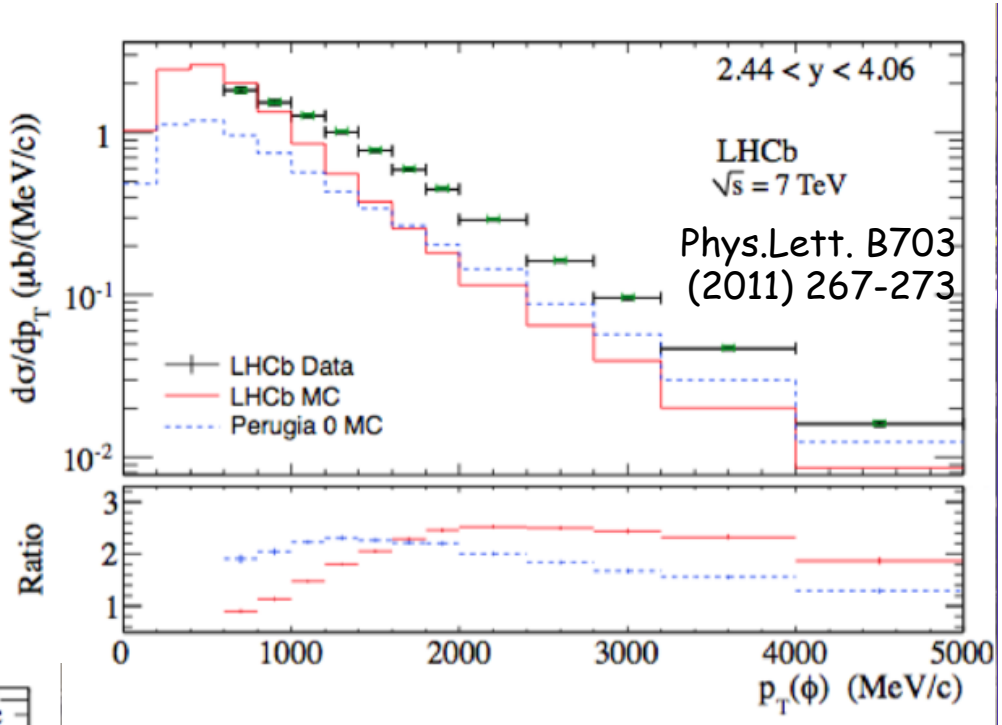


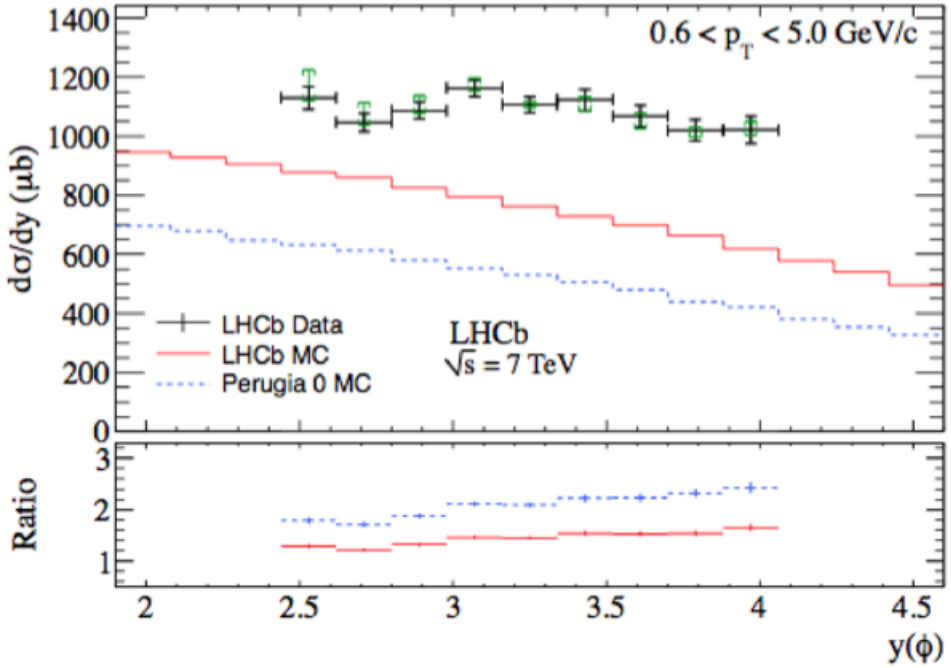
ϕ production

X-section underestimated by MC

Flatter rapidity distribution than MC

p_T spectra closer to PO tune



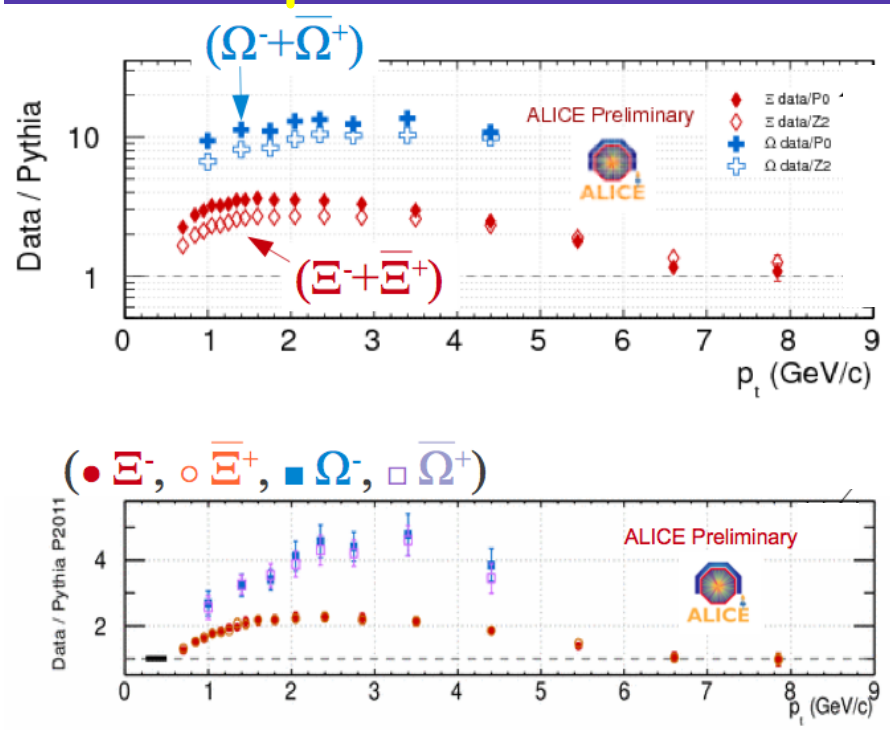


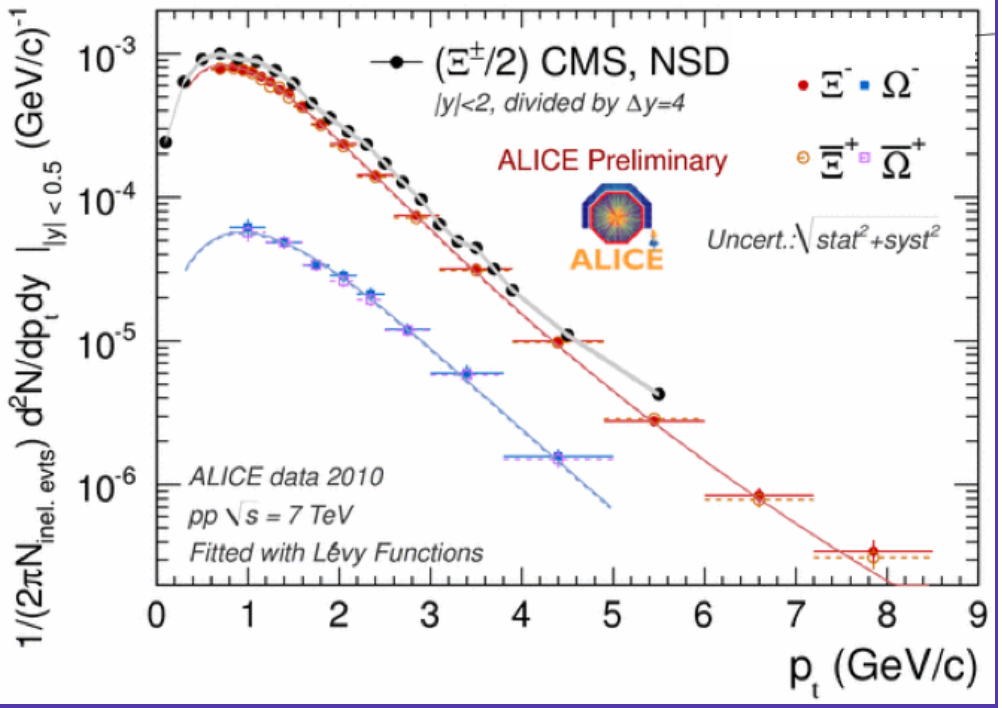
$$\sigma_{pp\to\phi X} = 1758 \pm 19(\text{stat}) \; {}^{+43}_{-14}(\text{syst}) \pm 182(\text{scale})\mu b$$

$$p_T \in [0.6, 5.0 \text{ GeV/c}]$$

$$y \in [2.44, 4.06]$$

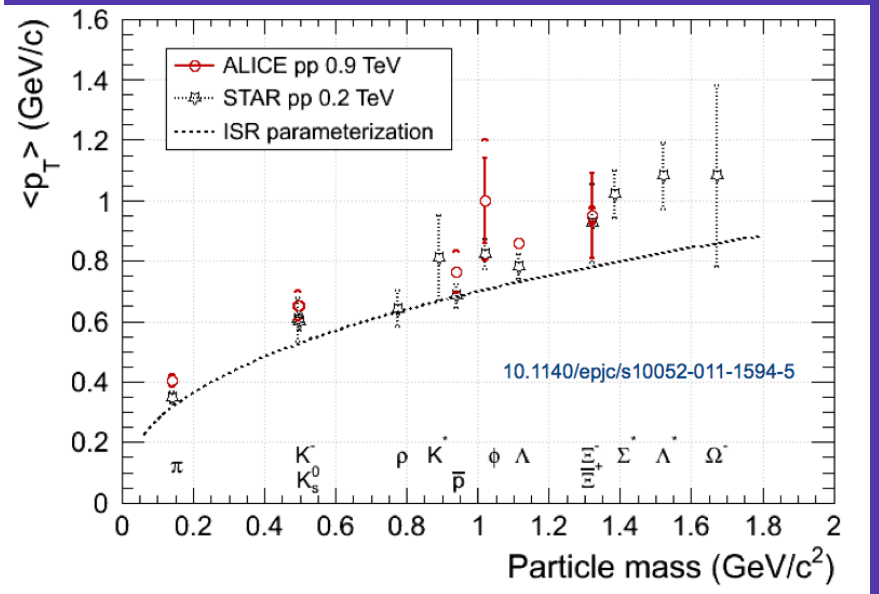
Ξ, Ω production

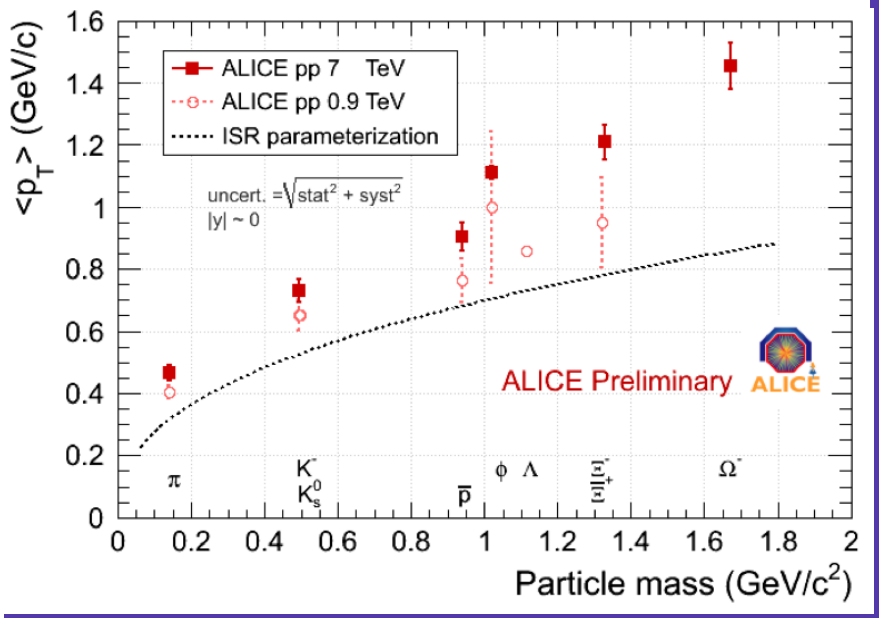




- Agreement between ALICE & CMS
  - Slightly different samples inelastic vs NSD
- MC yields greatly underestimate data

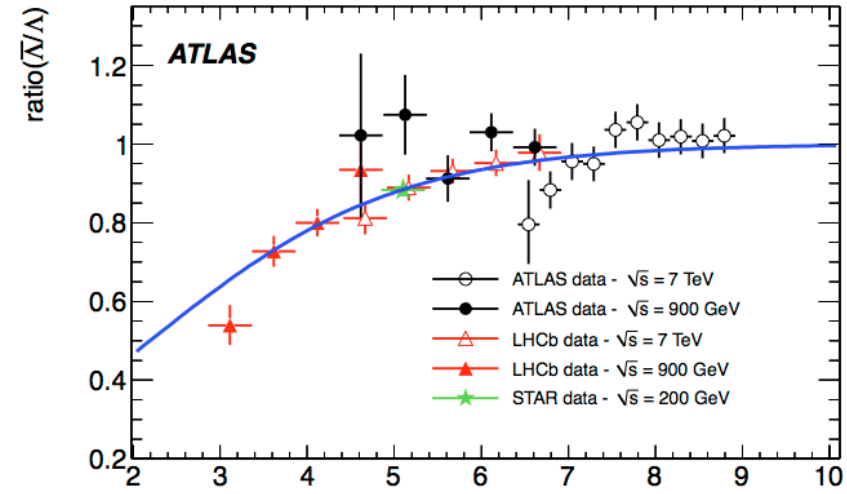
$\langle p_T \rangle$ versus mass





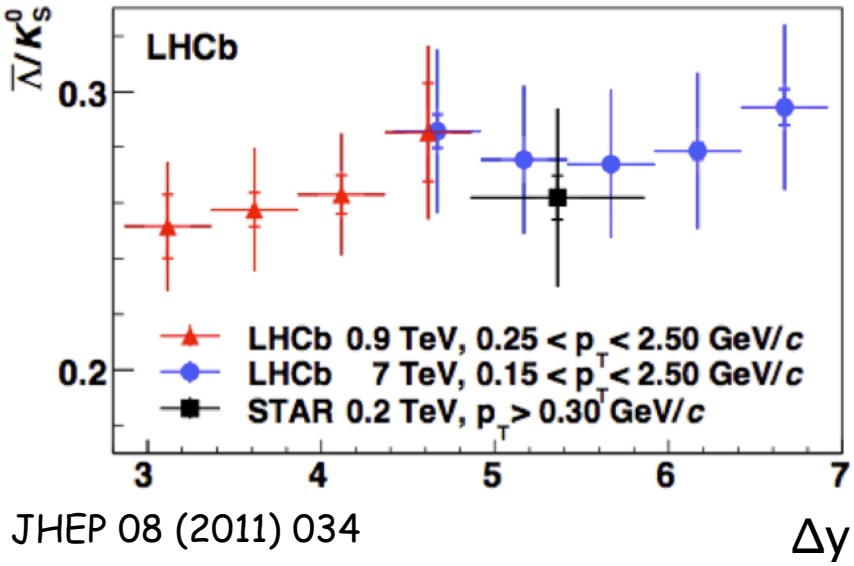
- $\langle p_T \rangle$ increases with mass as expected
- ISR parameterisation significantly below data @ 7 TeV
  - Nucl.Phys. B114 (1976) 334

Baryon transport

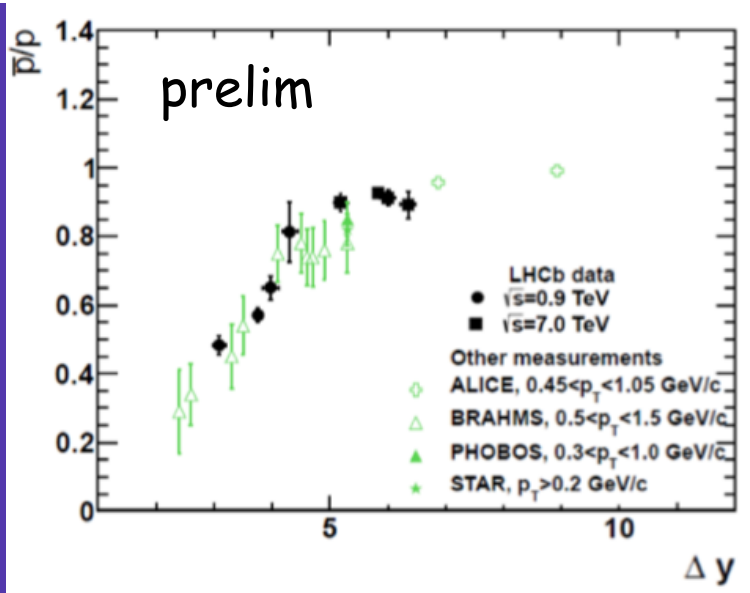


arXiv:1111.1297

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



JHEP 08 (2011) 034



Motivated by string-junction & Pomeron models

$$\frac{1}{\text{ratio}} = 1 + C \times e^{(\alpha_J - \alpha_P)\Delta y}$$

α parameters fixed ($\alpha_J = 0.5$, $\alpha_P = 1.2$)

LHC data consistent with lower energy data

Summary

- Plethora of soft QCD measurements coming from the LHC
  - Many papers from all 4 experiments
  - Consistency across the experiments + complementarity
- Overall MC generators need further tuning
  - Pre-LHC tunes struggle to describe data
  - Strangeness & baryon production problematic
- Further measurements to come