

Minimum Bias and Underlying Event Working Group
31 May 2010

MINIMUM-BIAS MEASUREMENTS WITH ALICE

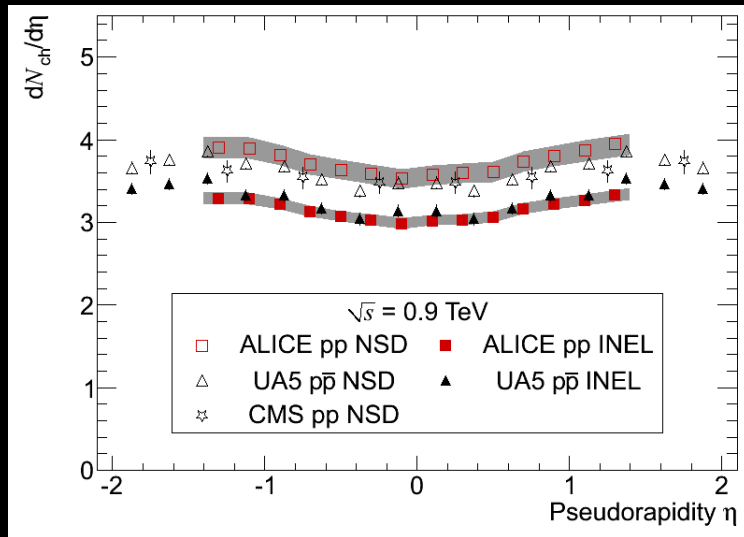
C. Zampolli

Outline

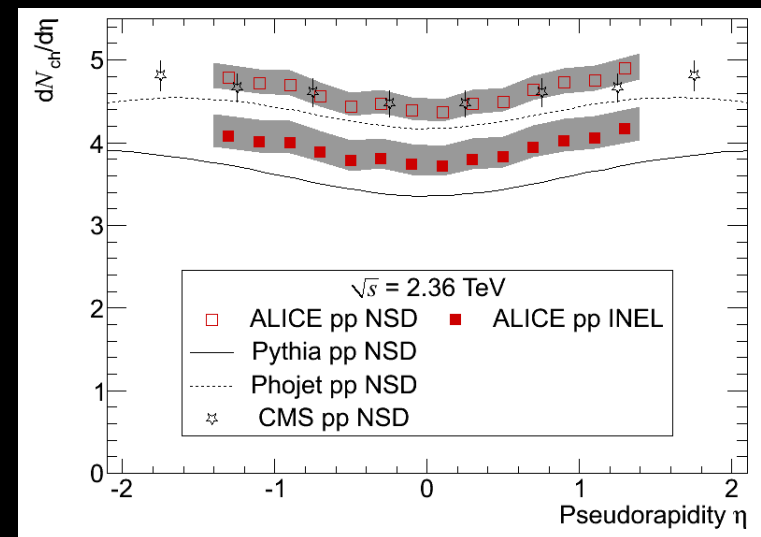
- ALICE Minimum-Bias Physics Program
 - Charged-particle density
 - Charged-particle multiplicity distributions
 - Charged-particle transverse momentum spectra
 - \bar{p}/p
 - Identified charged hadron spectra and yields
 - Strange particle production
 - Charm production, identical particle correlations, azimuthal correlations...
- Work in progress
- Conclusions

Charged-particle η density - I

900 GeV



2.36 TeV

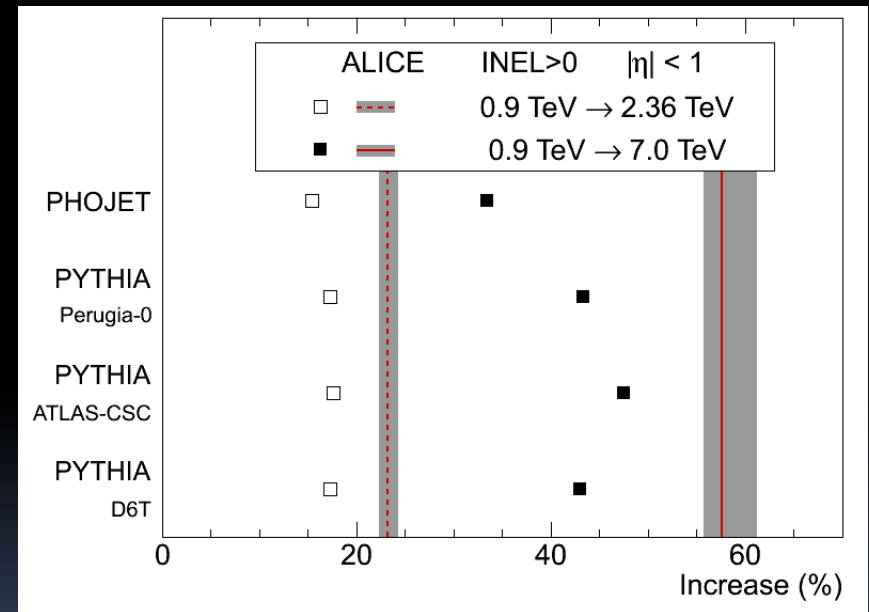
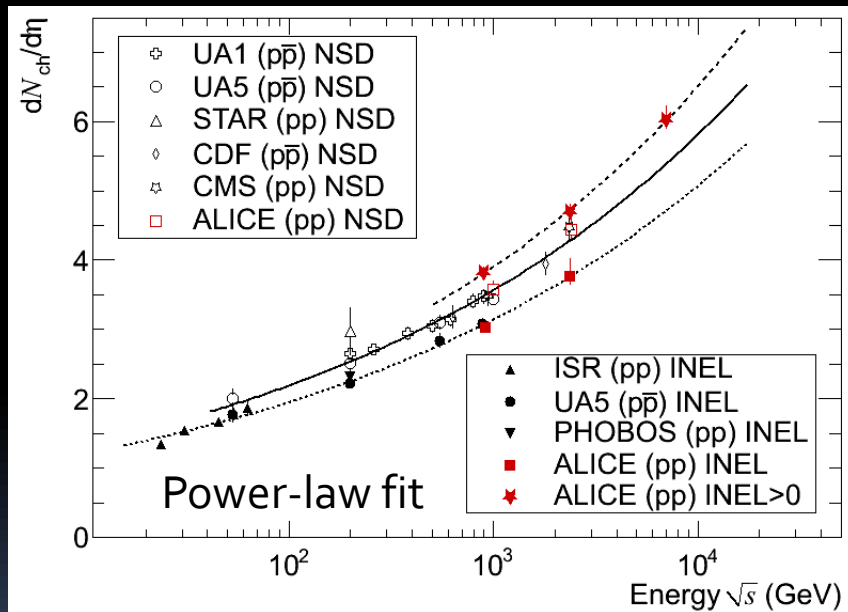


arXiv:1004.3034

| $dN_{ch}/d\eta$ in $ \eta < 0.5$ ALICE, CMS: stat. and syst. uncertainty added quadratically | 0.9 TeV | | 2.36 TeV | |
|---|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| | INEL | NSD | INEL | NSD |
| ALICE arXiv:1004.3034 | 3.02 ± 0.07 | 3.58 ± 0.11 | 3.77 ± 0.23 | 4.43 ± 0.16 |
| ALICE EPJC65:111 (2010) | 3.10 ± 0.26 | 3.51 ± 0.29 | | |
| CMS JHEP 02 (2010) 041 | | 3.48 ± 0.13 | | 4.47 ± 0.16 |
| UA5 Z. Phys. C33 1 (1986) | $3.09 \pm 0.05^*$ | $3.43 \pm 0.05^*$ | | |

Charged-particle η density - II

- Hadron- level definition used (INEL>0)
- The INEL>0 requirement selects 80% of the MB_OR (1 track in 8 η units) events in 7 TeV data
- Model dependent corrections and systematic error minimized



arXiv:1004.3514

- increase from 0.9 to 7 TeV \sim 57% (NSD) – but models predict \sim 35-45%

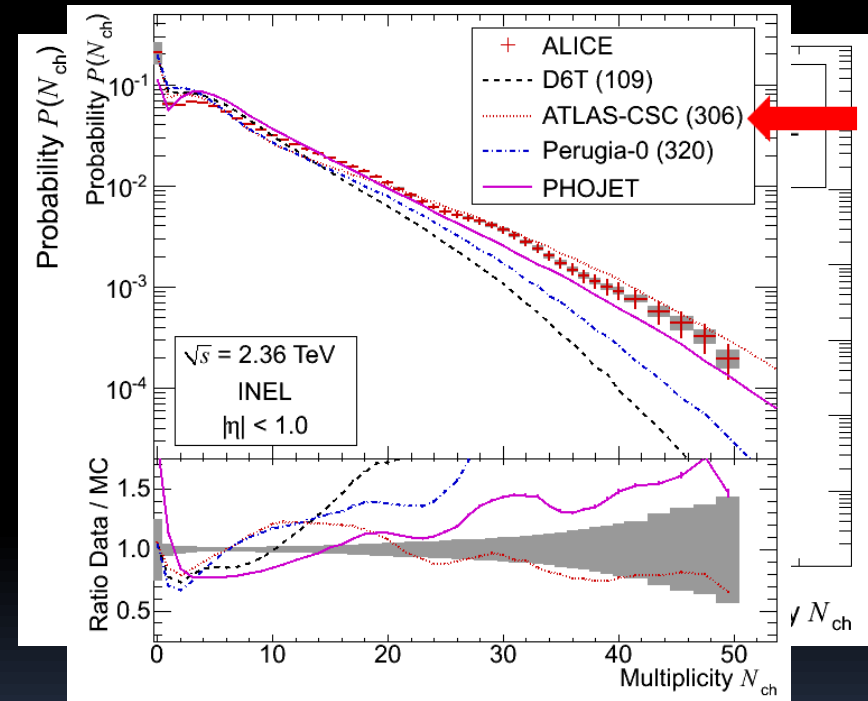
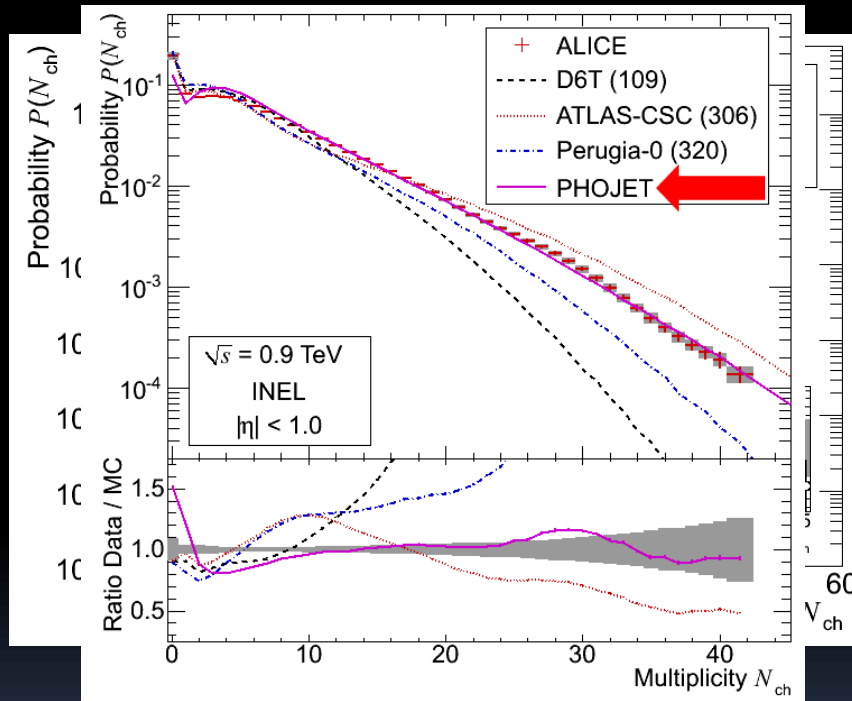
Multiplicity Distributions - I

- Multiplicity distributions of charged particles in 3 η -intervals ($|\eta| < 0.5, 1, 1.3$)

900 GeV

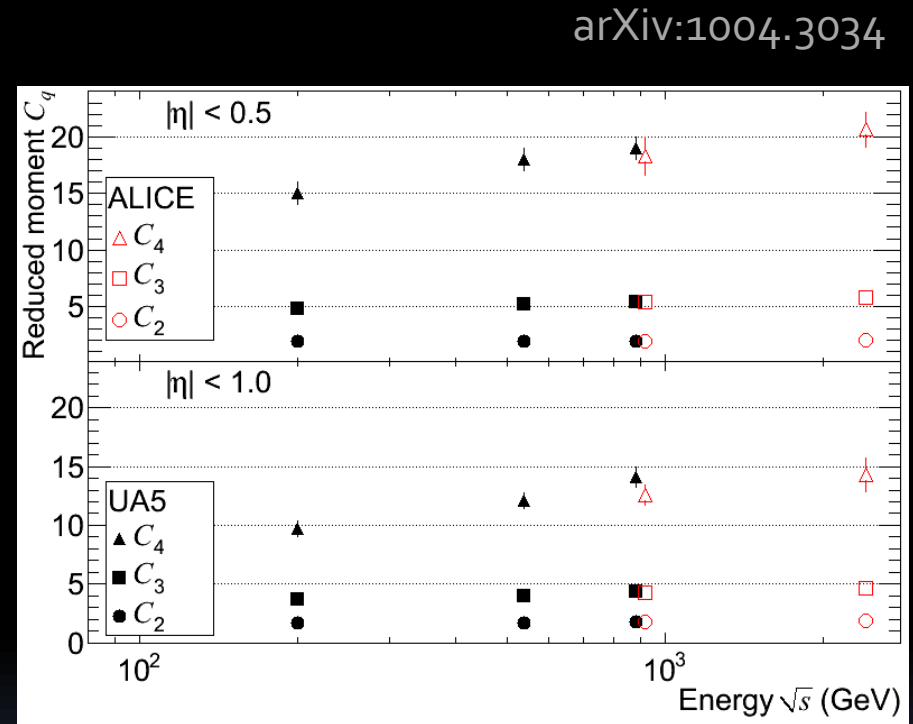
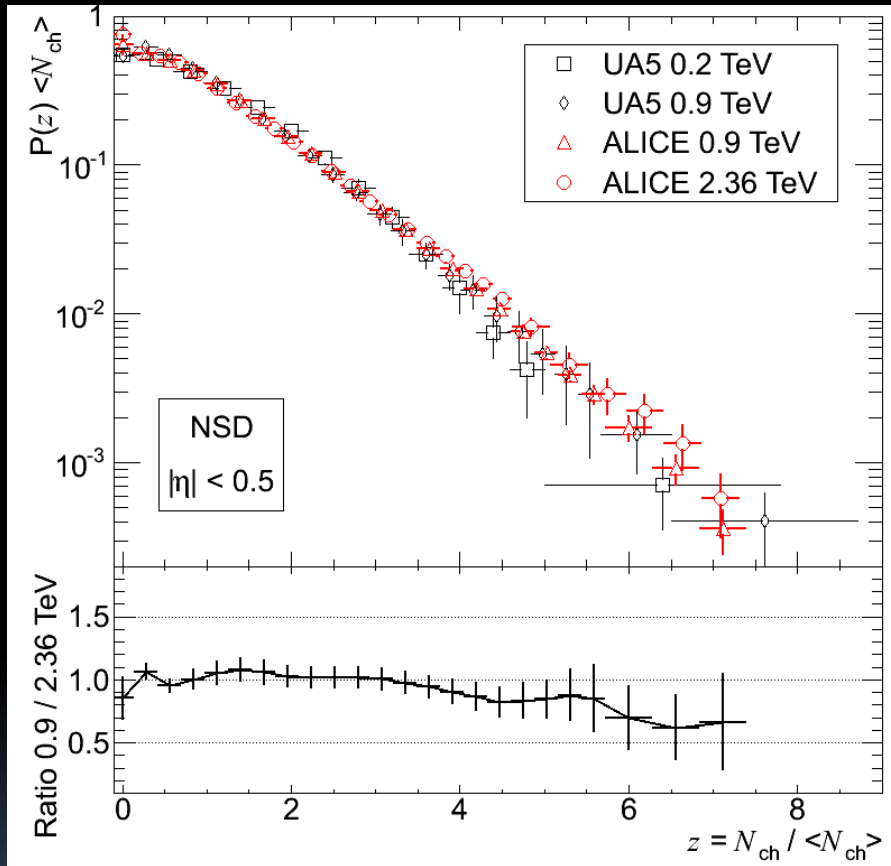
arXiv:1004.3034

2.36 TeV



- Very typical agreement with particle production measured by UA5 in $|\eta| < 0.5$
- Comparison with different models – tail increases faster

Multiplicity Distributions - II

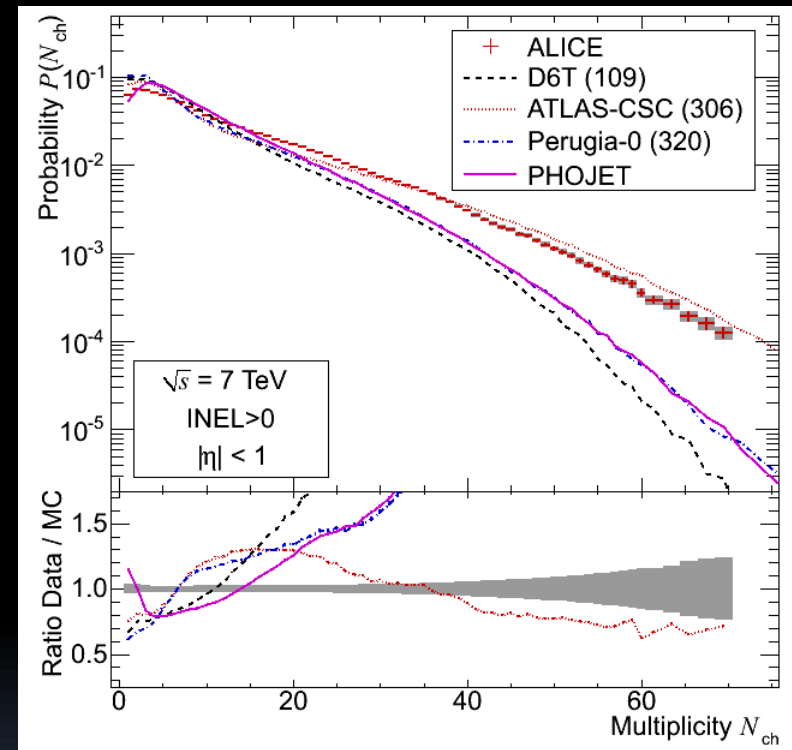
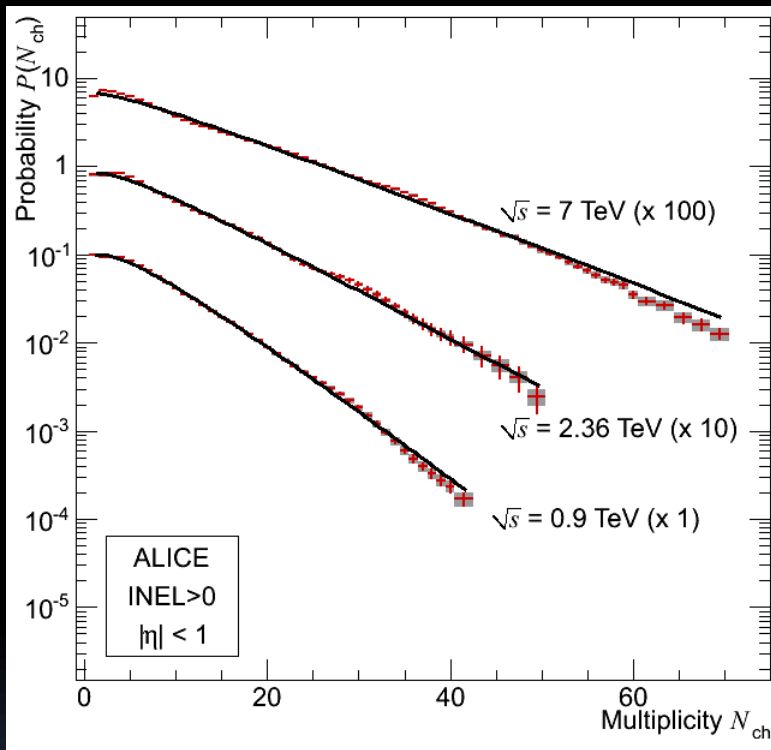


reduced moments: $C_q = \langle N^q \rangle / \langle N \rangle^q$

energy evolution of multiplicity distributions –
KNO scaling variables

Multiplicity Distributions - III

7 TeV



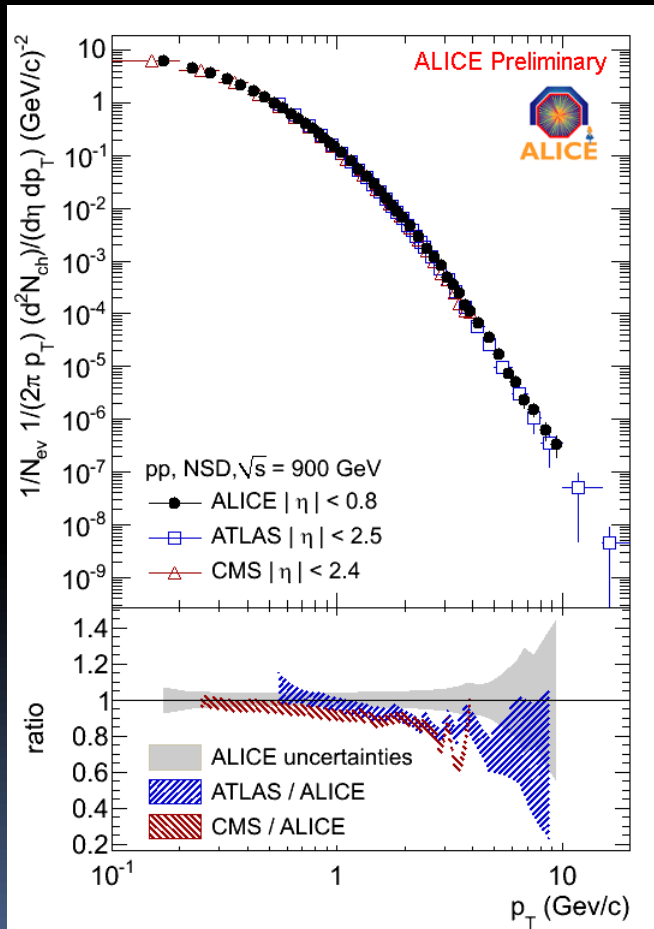
arXiv:1004.3514

- Good description from NBD for all three energies

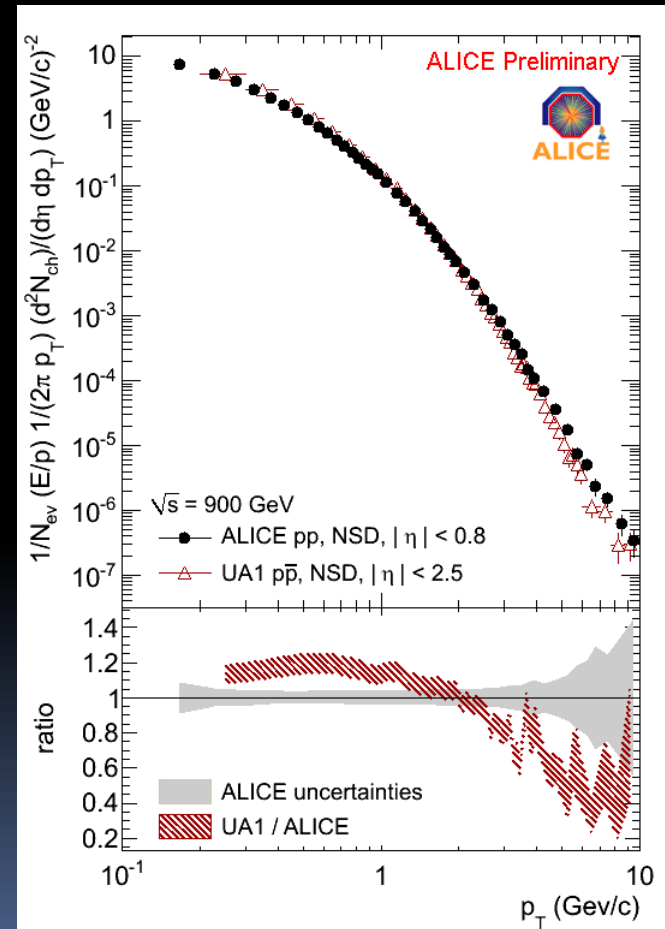
- Comparison with different MC models not satisfactory – increase at high multiplicity not reproduced

Transverse Momentum Distribution – I

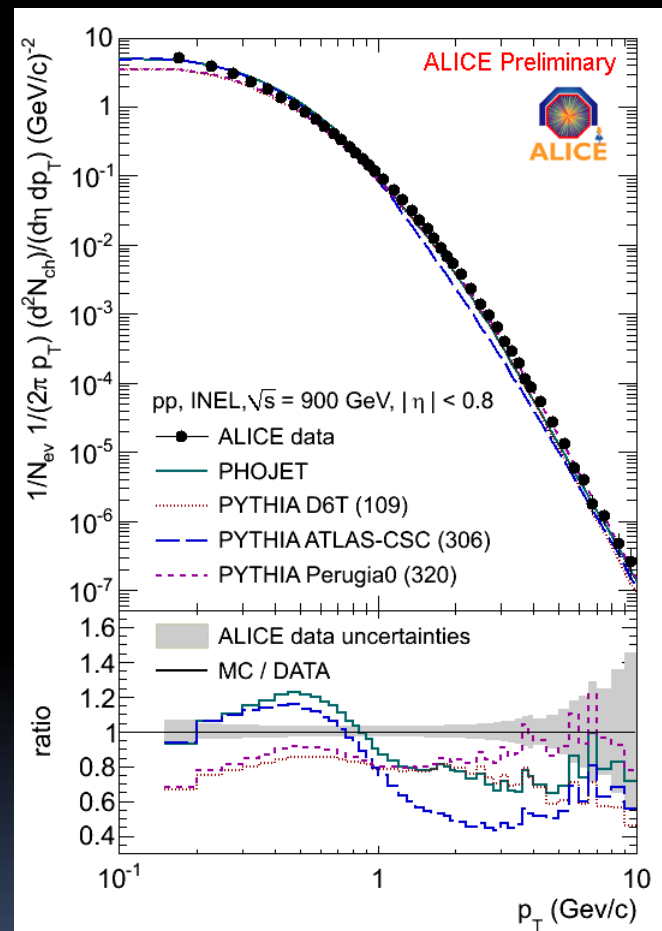
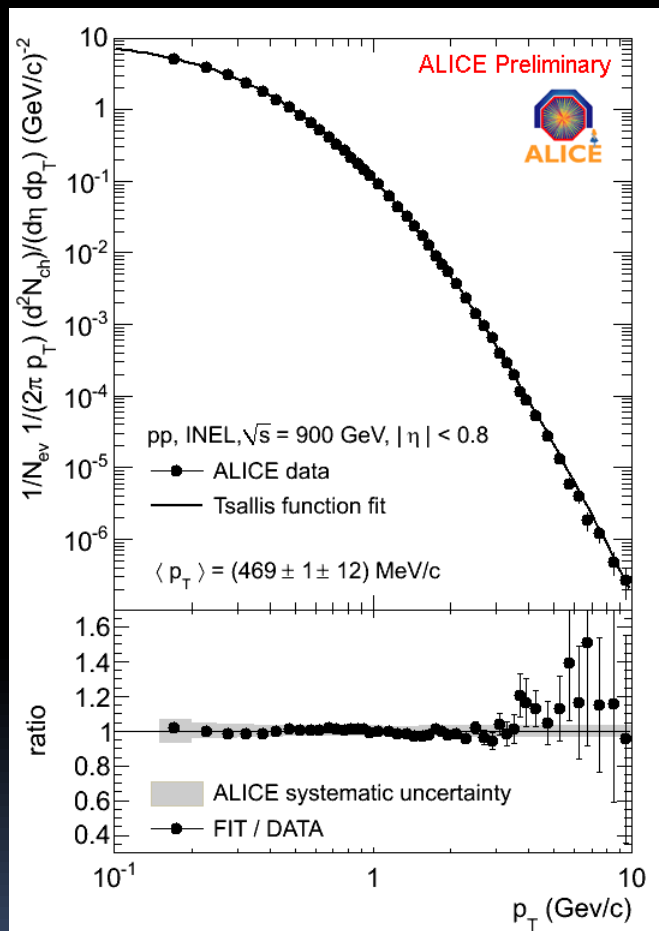
Comparison with ATLAS and CMS



Comparison with UA1



Transverse Momentum Distribution – II

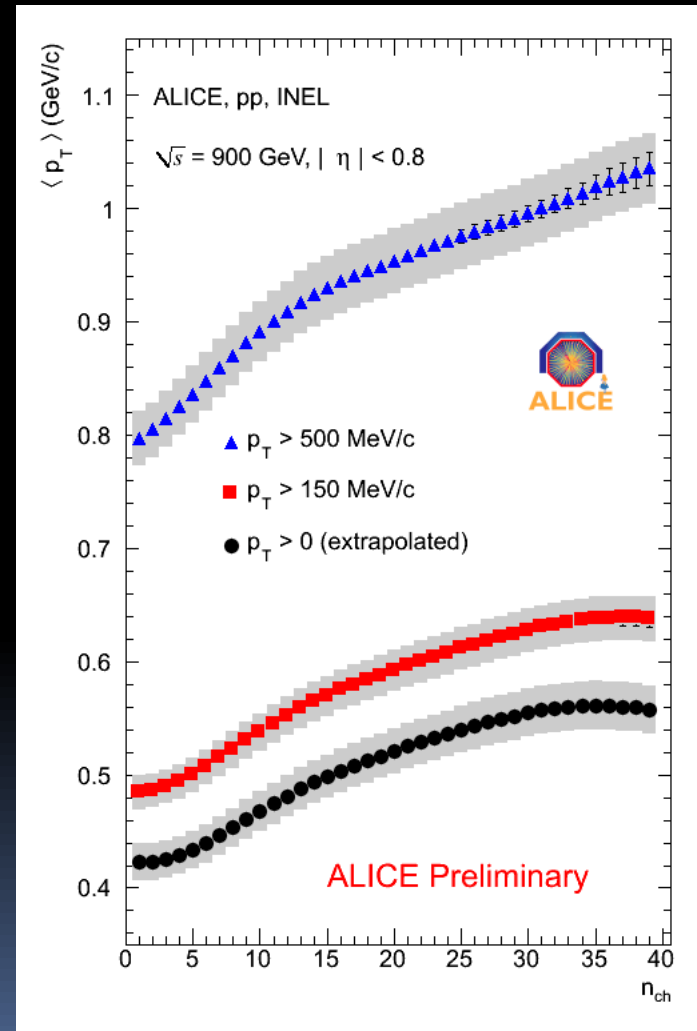
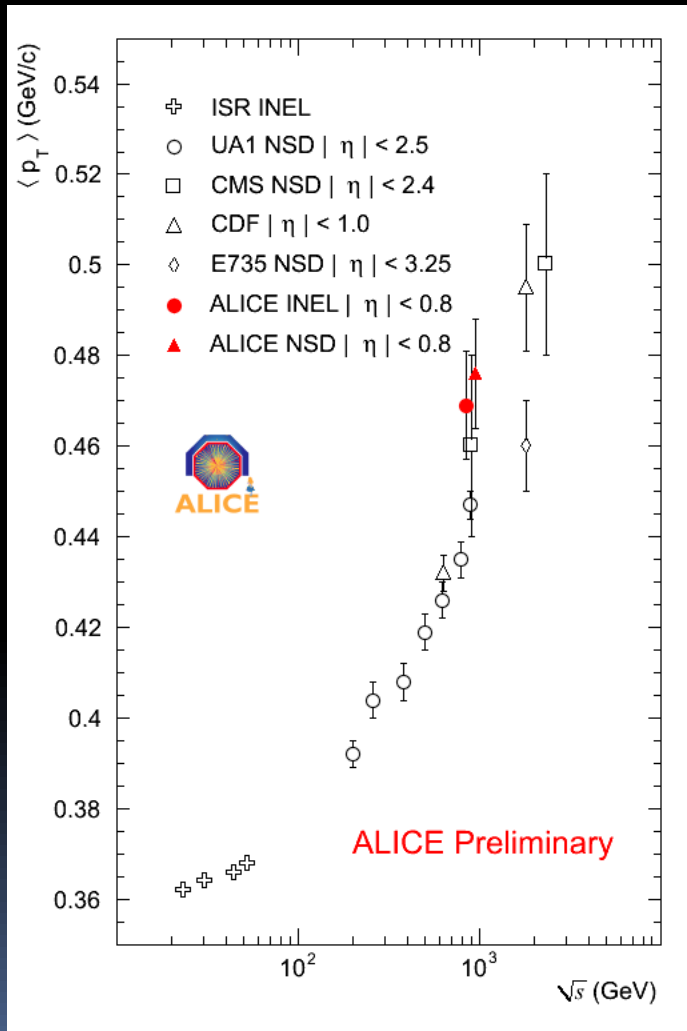


Tsallis function fit:

$$\frac{1}{p_T} \frac{d^2 N_{ch}}{d\eta dp_T} \propto \left(1 + \frac{E_T}{nT} \right)^{-n}$$

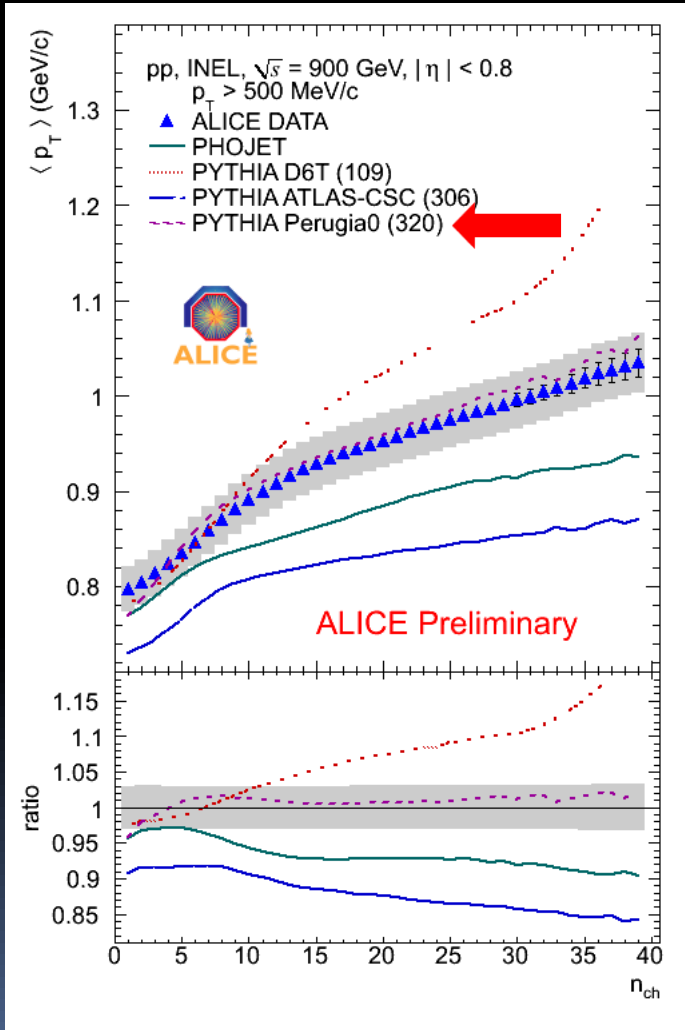
Comparison with models

Mean p_T vs Multiplicity - I

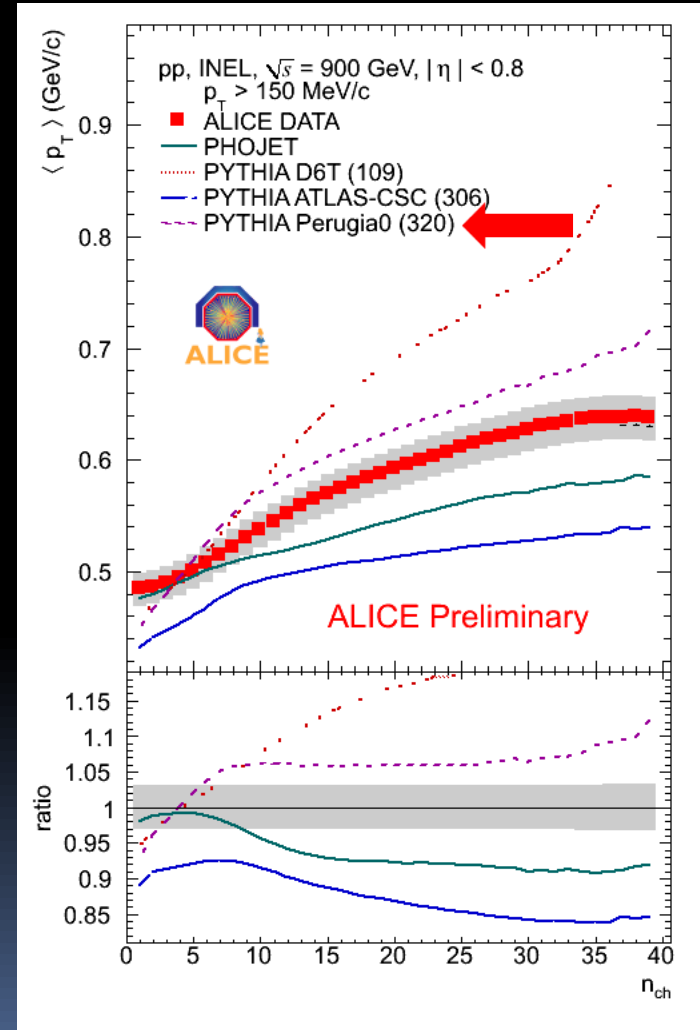


Mean p_T vs Multiplicity - II

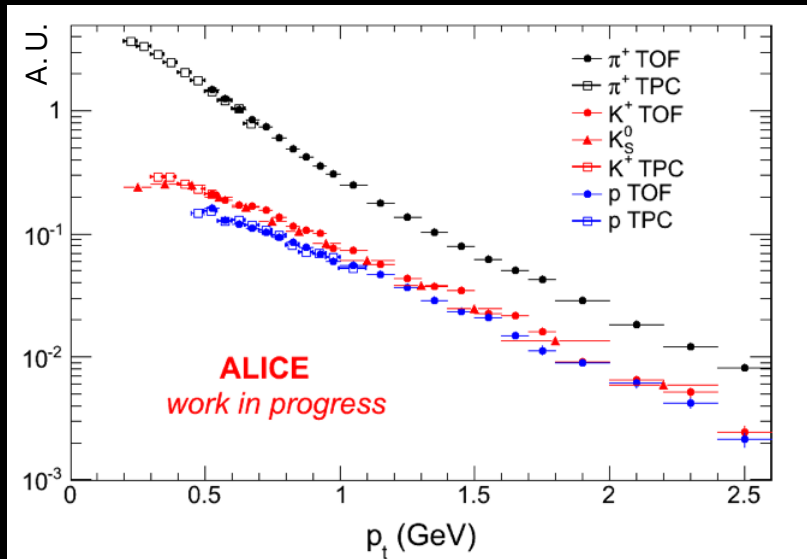
$p_T > 500$ MeV



$p_T > 150$ MeV

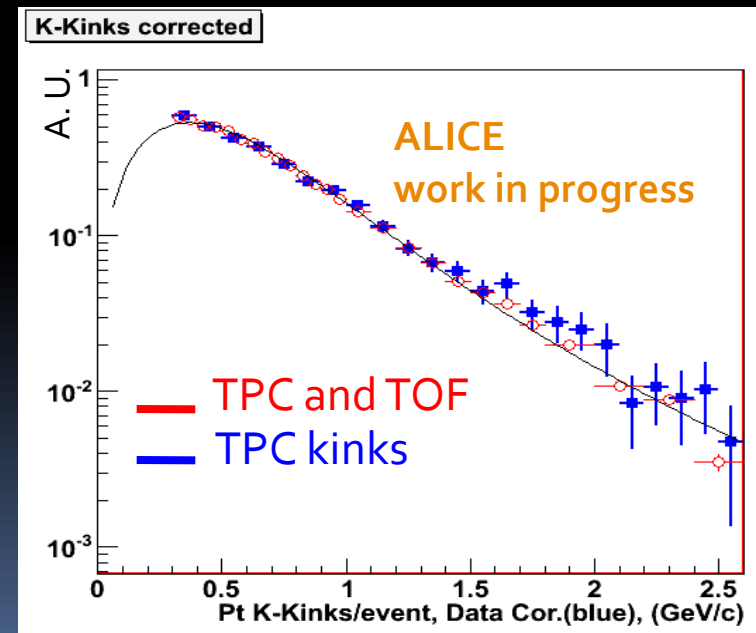


Identified Charged Hadrons

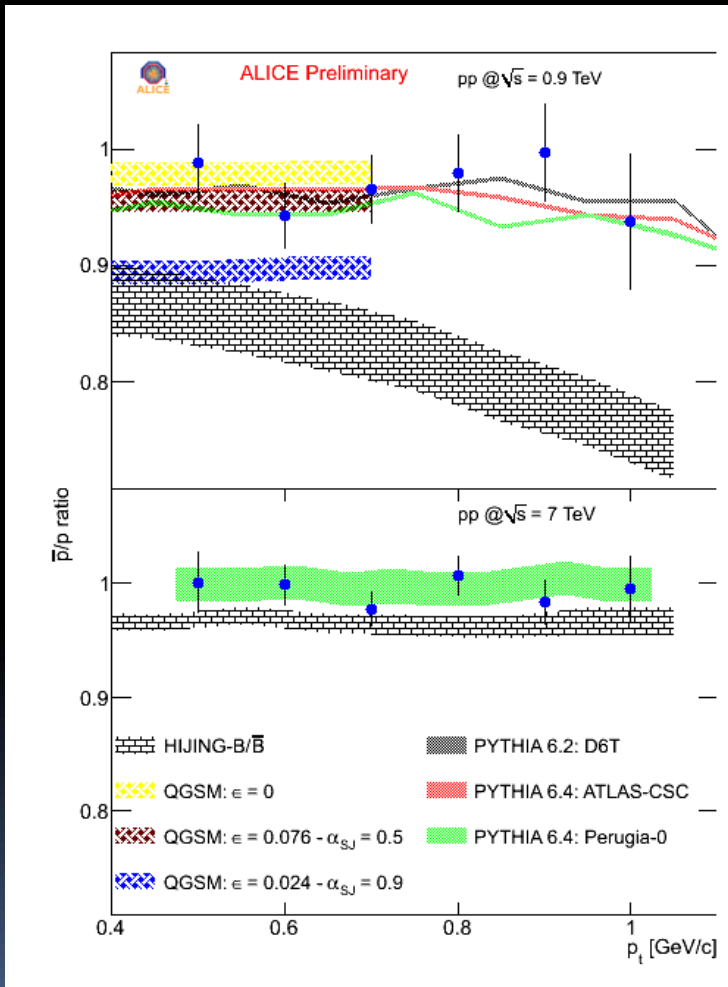


- Charged hadron identification in different p_T ranged performed with different detectors:
 - TPC and TOF agreement within a few percent (no normalization needed)
 - TPC and ITS not far

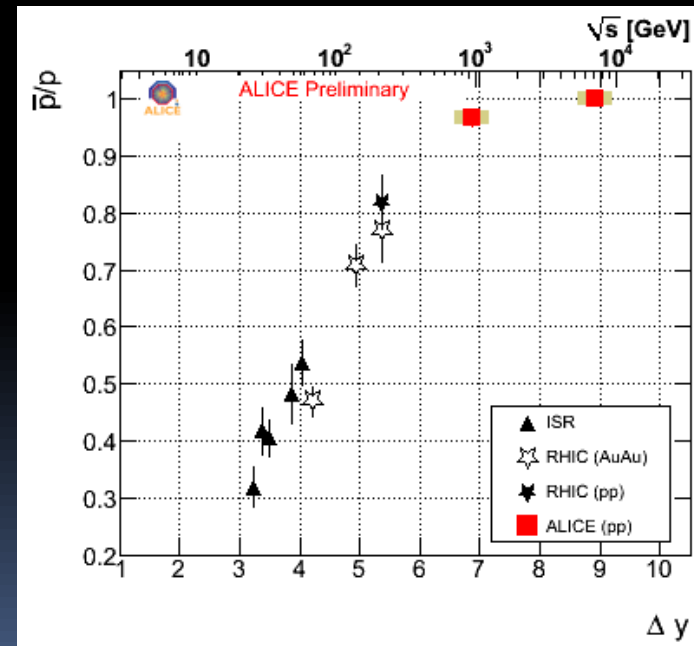
- Charged kaons identified in the TPC in addition to their on flight decays
- Agreement between dE/dx , TOF and kinks



Antibaryon to Baryon Asymmetry



- baryon transfer through large Δy
- string-junction models different predictions
- value close to unity – little place for non-standard mechanism



MC Matching the First ALICE Measurements

S. Vallerio,
ALICE Physics Week 2010, Paris

Results at $\sqrt{s} = 900$ GeV :

- MC under-estimates data
- MC over-estimates data
- Reasonable agreement

| MC/TUNE | D6T | Perugia0 | CSC | DW | CW | PHOJET | |
|-----------------------------|-------------|-------------------|-----|-------------------|-----|-------------------|--------|
| $\eta^{(4)}$ | -20% | -17% | 3% | | | -2% | INEL>0 |
| $N_{ch}^{(5)}$ | $N_{ch}>10$ | $N_{ch}>5$ | | $N_{ch}>15$ | | $N_{ch}>10$ | INEL |
| $p_T^{(6)}$ | | $p_T>4\text{Gev}$ | | $p_T>1\text{GeV}$ | | $p_T>1\text{GeV}$ | INEL |
| $\langle p_T \rangle^{(6)}$ | | | | | | | INEL |
| UE ⁽⁷⁾ | ALICE/CMS | | | CMS | CMS | | INEL |

- Multiplicity measurements: PHOJET preferred
- p_T measurements: PYTHIA-Perugia0 preferred

MC Matching the First ALICE Measurements

S. Vallero,
ALICE Physics Week 2010, Paris

- MC under-estimates data
- MC over -estimates data
- Reasonable agreement

Results at $\sqrt{s} = 2.36$ TeV:

| MC/TUNE | D6T | Perugia 0 | CSC | PHOJET |
|----------------|-----------------|----------------|---------------|---------------|
| $\eta^{(4)}$ | -24% | -21% | -2% | -8% |
| $N_{ch}^{(5)}$ | ■ $N_{ch} > 10$ | ■ $N_{ch} > 5$ | $N_{ch} > 20$ | $N_{ch} > 15$ |

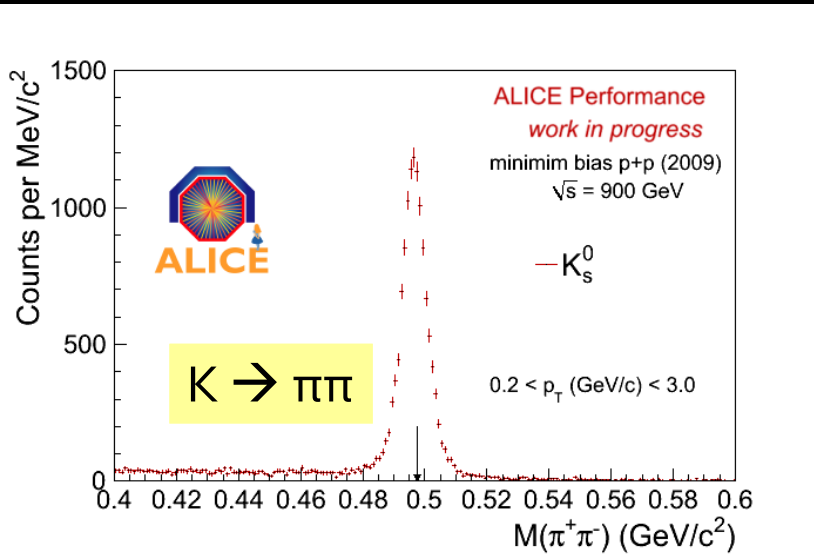
→ Slightly underestimates

Results at $\sqrt{s} = 7$ TeV:

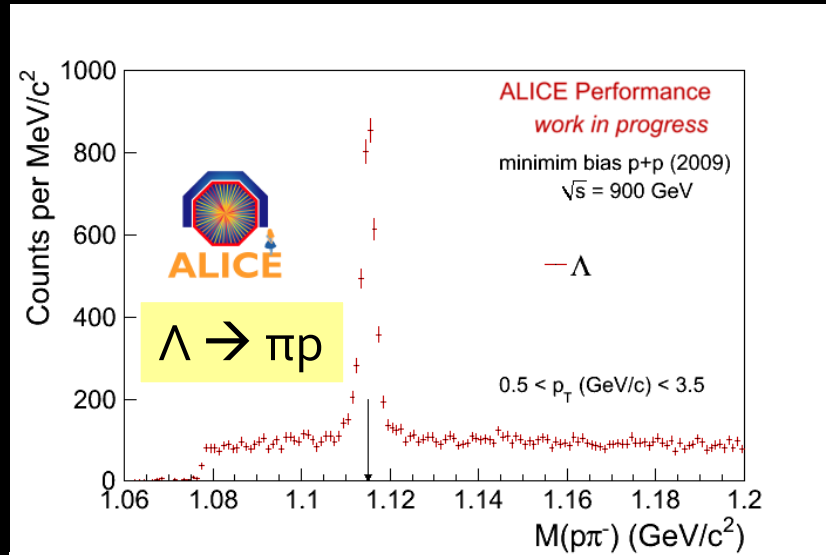
| MC/TUNE | D6T | Perugia 0 | CSC | PHOJET |
|--------------|------|-----------|-----|--------|
| $\eta^{(4)}$ | -27% | -24% | -4% | -17% |
| UE | | | | |

→ Multiplicity measurement: PYTHIA-CSC and PHOJET preferred

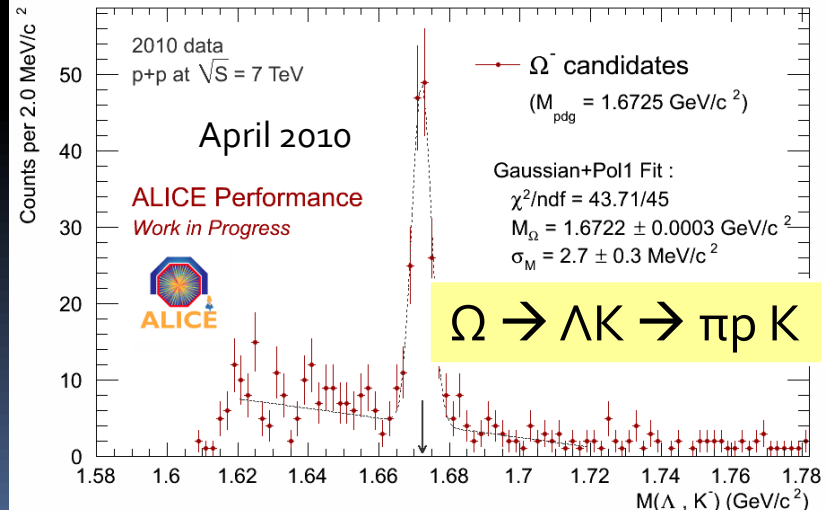
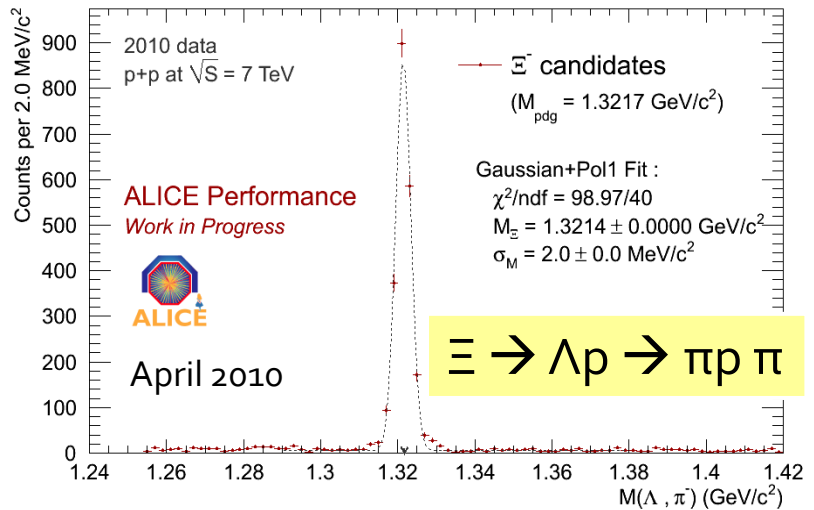
Strangeness Production



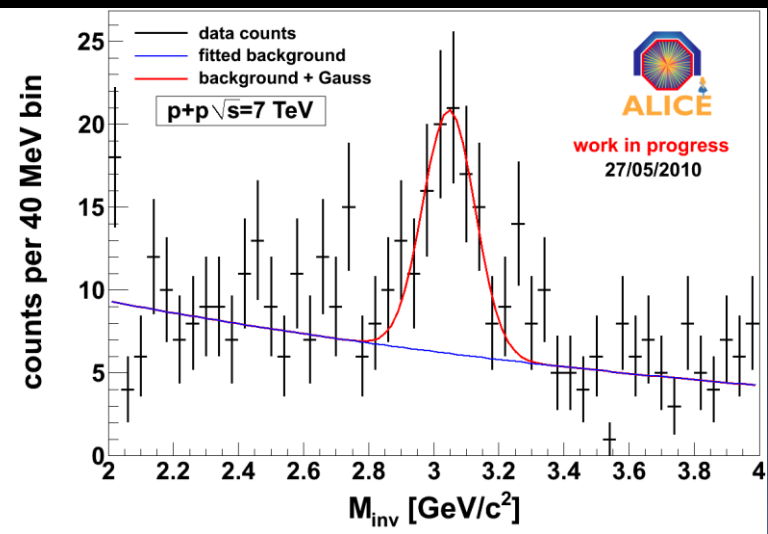
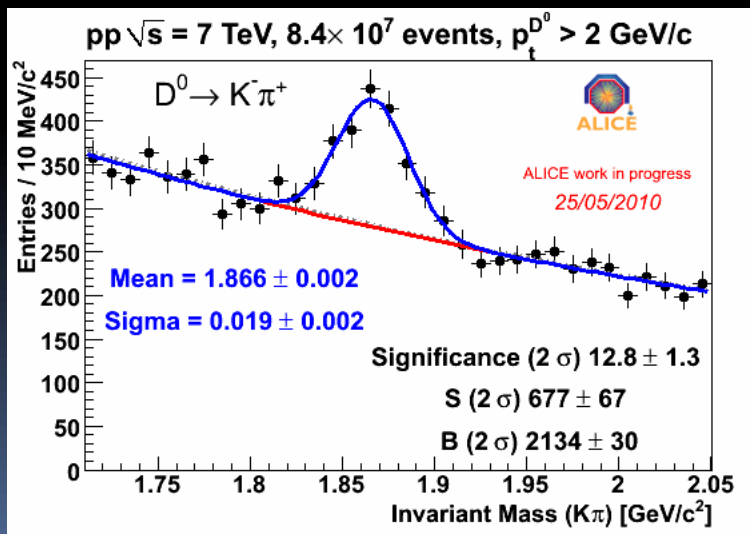
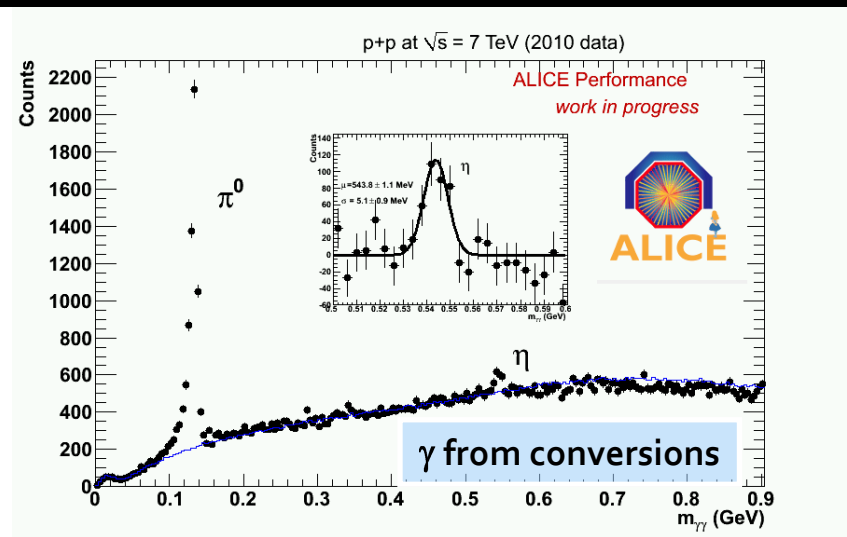
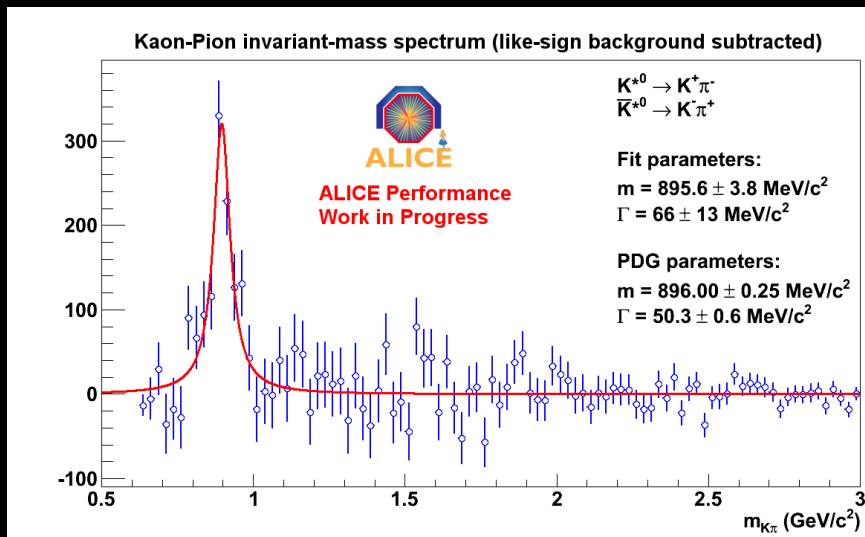
ALICE data, p-p at 7 TeV (sel. runs 114783 - 115401 / GRID pass1) - 5.71 Mev



ALICE data, p-p at 7 TeV (sel. runs 114783 - 115401 / GRID pass1) - 5.71 Mev



$K^{*0}, \pi^0, \eta, D^0, J/\psi$



Work ongoing

- Diffraction @ 7 TeV
- Study in the increase in multiplicity in different p_T regions
- $dN_{ch}/d\eta$ for different p_T cuts in different event classes (for MC tuning)
 - Event class: INEL $>0_{|\eta|<0.8, p_T > 0.15, 0.5, 0.9 \text{ GeV}}$
 - Tracks: $|\eta|<0.8, p_T > 0.15, 0.5, 0.9 \text{ GeV}$
 - well underway
- Many other analyses ongoing (identical particle correlations, azimuthal correlations, event structure, π^0 spectra...)

Conclusion

- The ALICE Minimum Bias program is very rich
 - 3 papers already published,
 - some under internal review or in draft,
 - together with other ongoing analyses
- Monte Carlo models don't reproduce data in a satisfactory way
- More investigation – and more data – needed

People

- H. Appelshaeuser
- M. Broz
- P. Christakoglou
- J.F. Grosse-Oetringhaus
- A. Kalweit
- F. Noferini
- S. Vallerio
- C. Z.
- ...and many more...