

First ALICE results

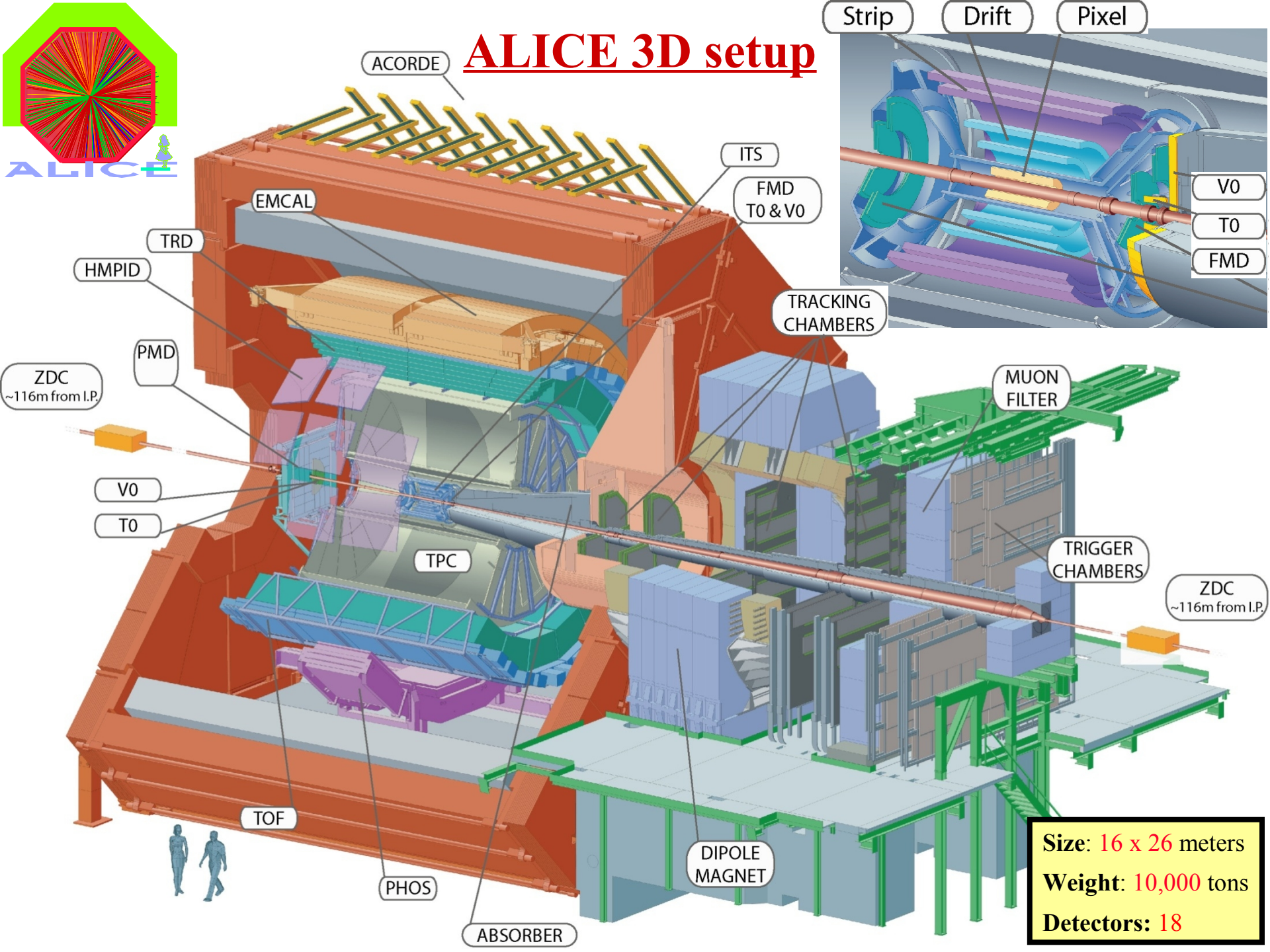
Serguei Sadovsky
for the ALICE Collaboration

Protvino, 19 October 2010





ALICE 3D setup



ACORDE

ITS

FMD
T0 & V0

EMCAL

TRD

HMPID

PMD

ZDC
~116m from I.P.

V0

T0

TPC

TRACKING
CHAMBERS

MUON
FILTER

TRIGGER
CHAMBERS

ZDC
~116m from I.P.

TOF

PHOS

ABSORBER

DIPOLE
MAGNET

Strip

Drift

Pixel

V0

T0

FMD

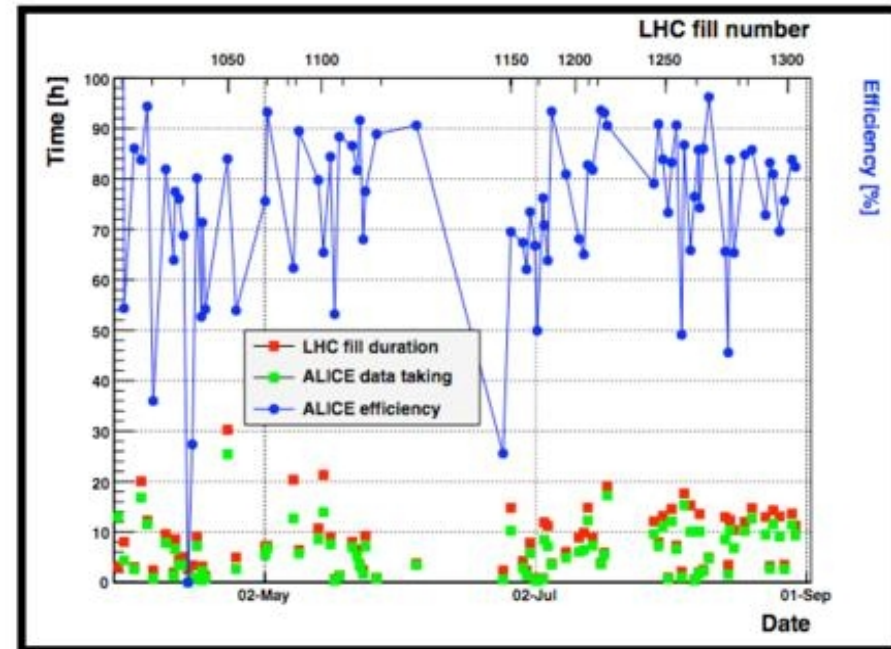
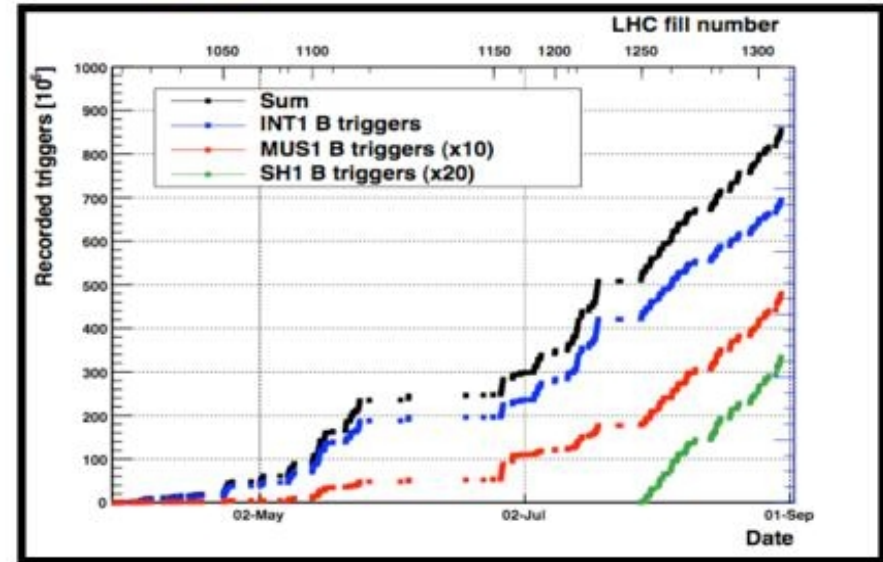
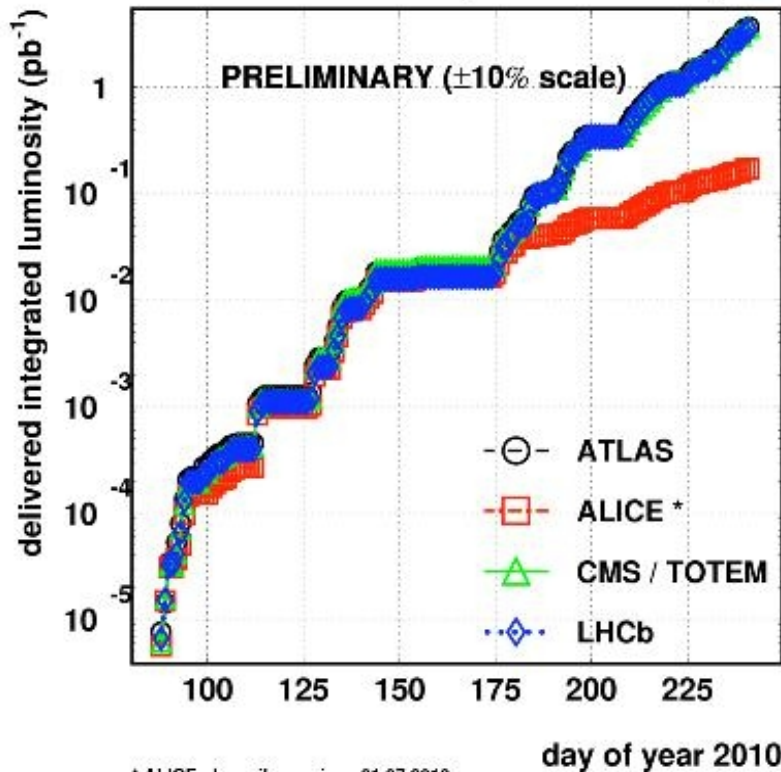
Size: 16 x 26 meters
Weight: 10,000 tons
Detectors: 18

ALICE Data taking at 7 TeV

- 900 GeV \approx 10 Mevents
- 2.36 TeV \approx 40 kevents
- 7 TeV \approx 700 Mevents

2010/09/06 08.36

LHC 2010 RUN (3.5 TeV/beam)



ALICE triggers / Event classes

- Minimum bias trigger:
 - pp @ 0.9 and 7 TeV
 - **SPD ($|\eta| < 2$) or V0-A or V0-C** (at least one particle in 8 units of η)
 - in coincidence with passing bunches (**BPTX beam pickups**)
 - also control triggers to measure beam-induced and accidental background
 - pp @ 2.36 TeV
 - **SPD only + BPTX**

- 7 TeV data:
 - diffraction cross sections unknown
 - hadron level definition (**INEL > 0**):
 - at least one charged particle in $|\eta| < 1$ (similar to ATLAS)
 - **minimizes model dependence**

- Event classes:
 - **INEL:** ***MB_{OR} (SPD or V0-A or V0-C) and offline bkg suppression***
 - **NSD:** ***MB_{AND} (V0-A and V0-C) and offline bkg suppression***
 - **INEL > 0:** ***INEL and at least one charged particle in $|\eta| < 1$***

The first physics

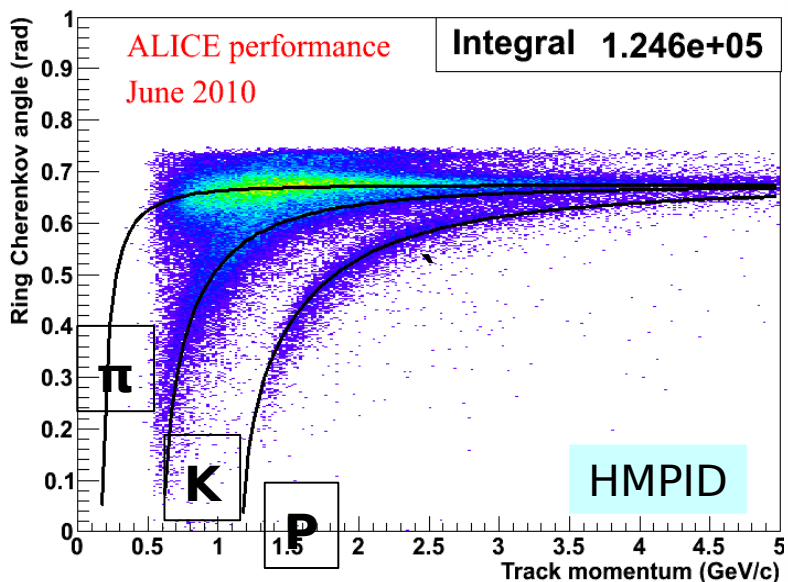
Publications:

- Charged multiplicity at
 - 900 **GeV** EPJC, Vol. 65 (2010) 111
 - 900 GeV & 2.36 TeV EPJC, Vol. 68 (2010) 89
 - 7 TeV EPJC, Vol. 68 (2010) 345
- p_{bar}/p ratio at 900 GeV & &TeV PRL, Vol. 105 (2010) 072002
- P_{T} momentum distribution at 900 GeV PRL, Vol. B693 (2010) 63-68
- Bose-Einstein correlation at 900 GeV PRD, Vol. 82 (2010) 052001

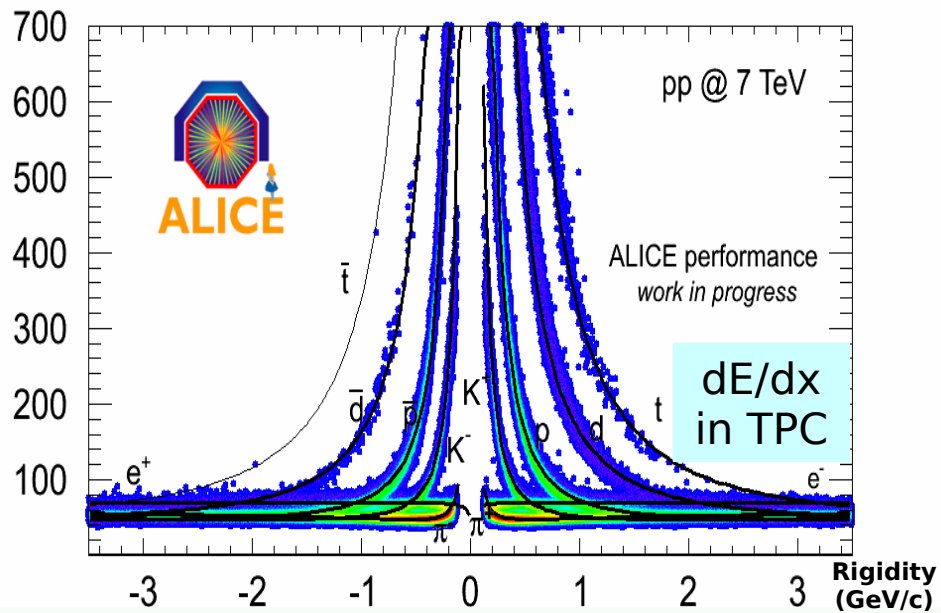
Papers in preparation/Ongoing analyses:

- Particle identification: π , K, p
- Neutral meson spectra: π^0 , η , ω
- Strangeness production: K^0 , Λ , Ξ , Ω , φ
- 7 TeV data: particle spectra, Bose-Einstein correlations, event topology etc.
- J/ Ψ production
- Charm mesons: D^0 , D^+ , D^*
- Heavy flavours
- Jet identifications, azimuth correlations in hard QCD processes

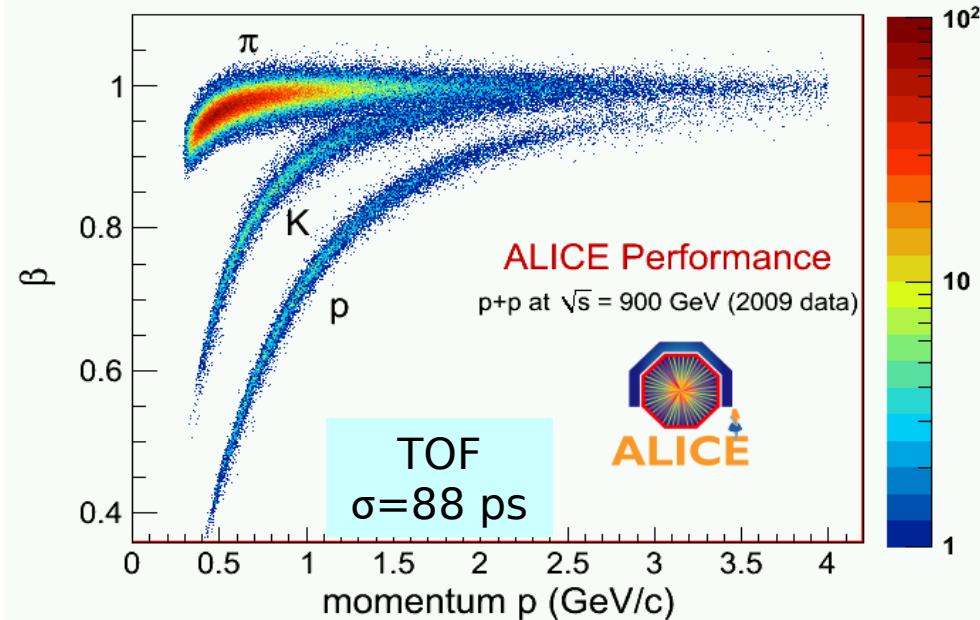
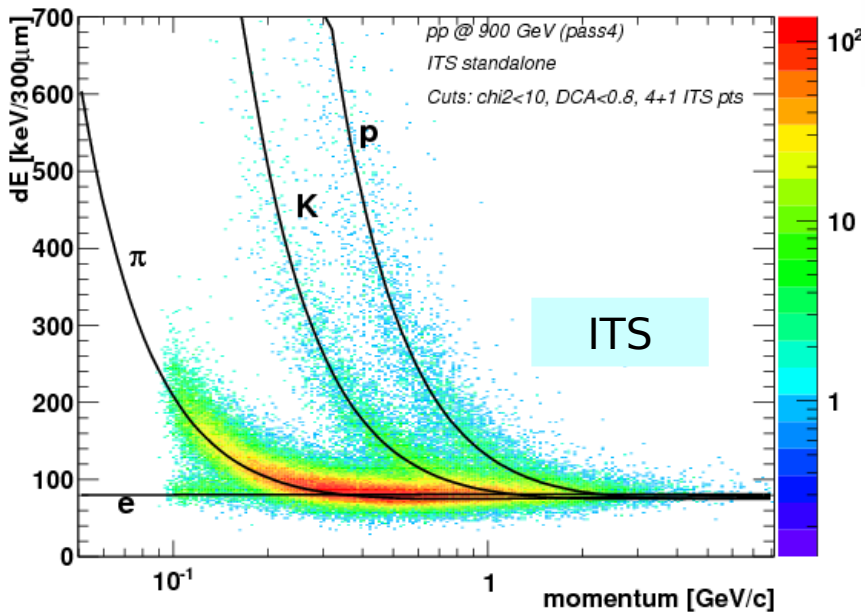
ALICE performance: PID at 0.9 & 7 TeV



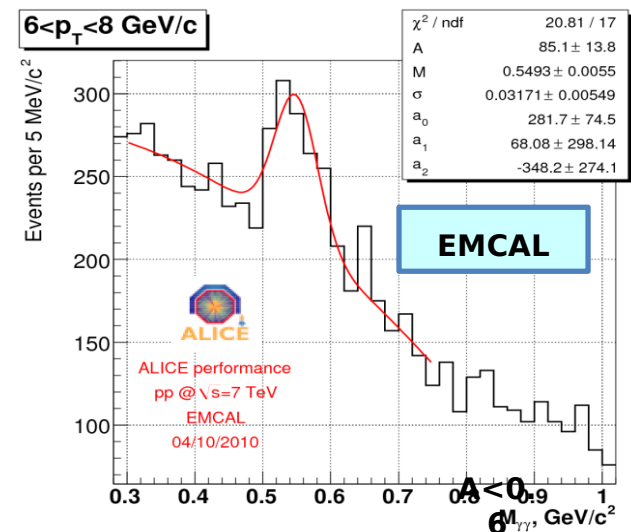
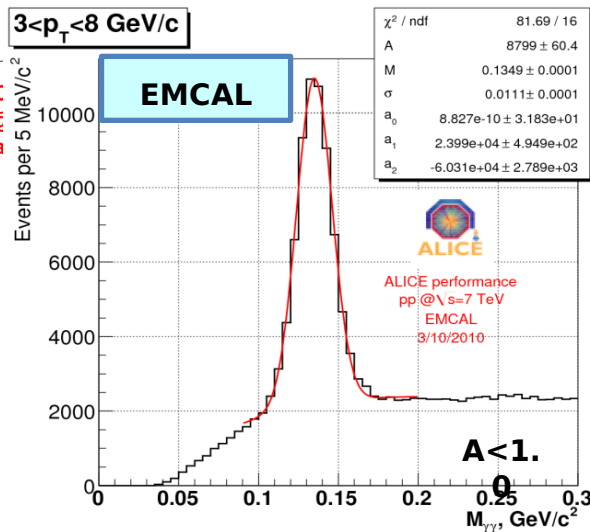
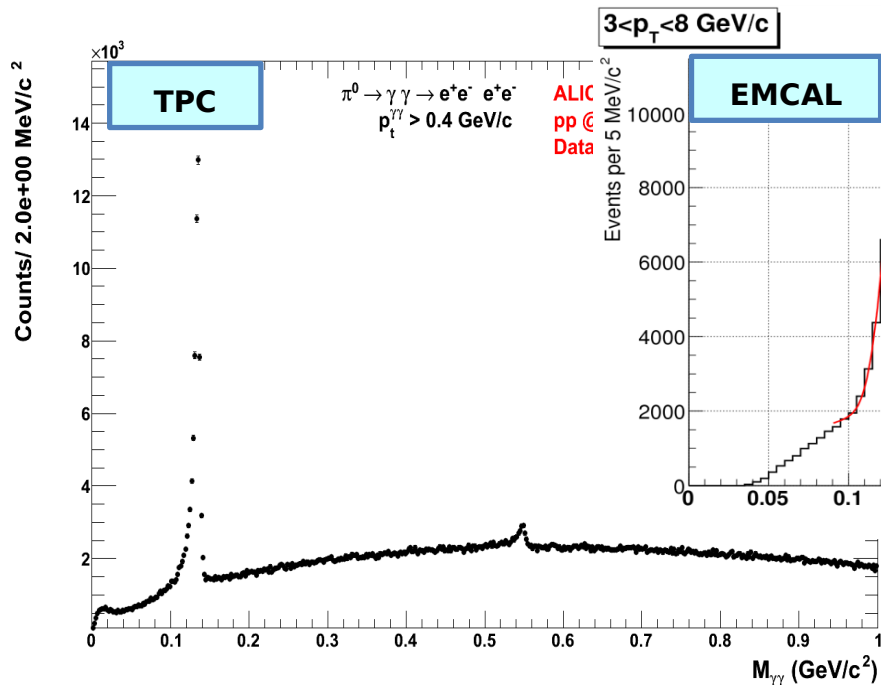
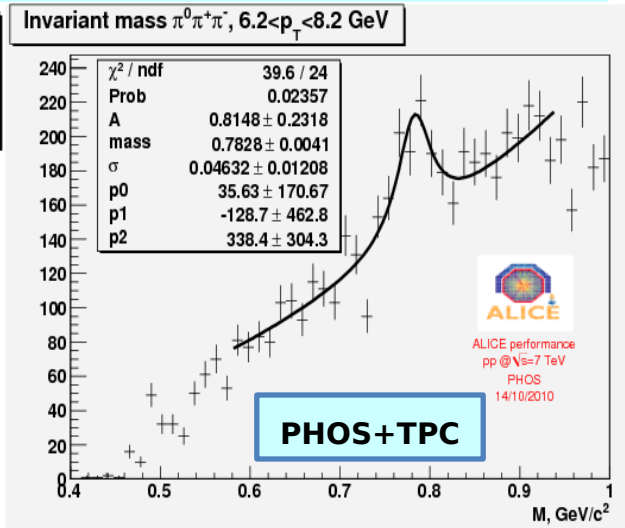
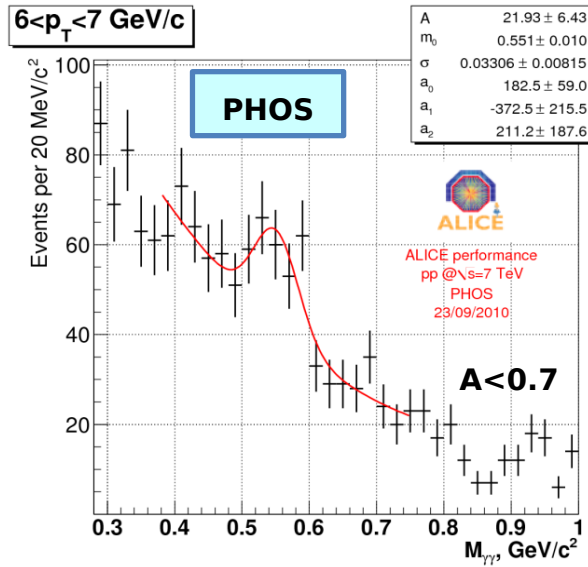
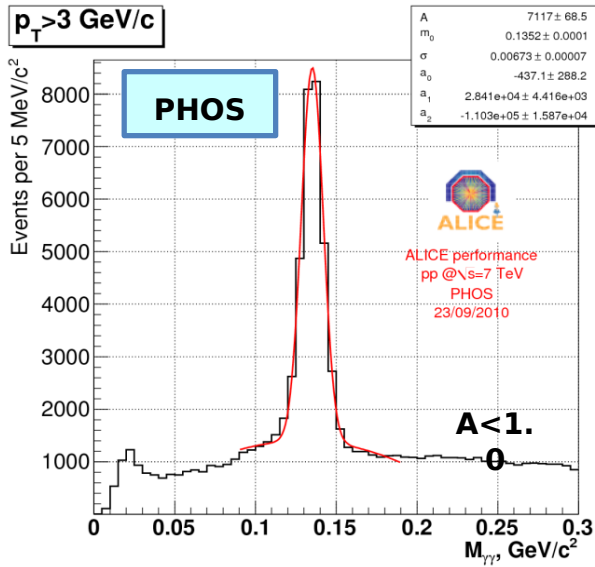
TPC signal (a.u.)



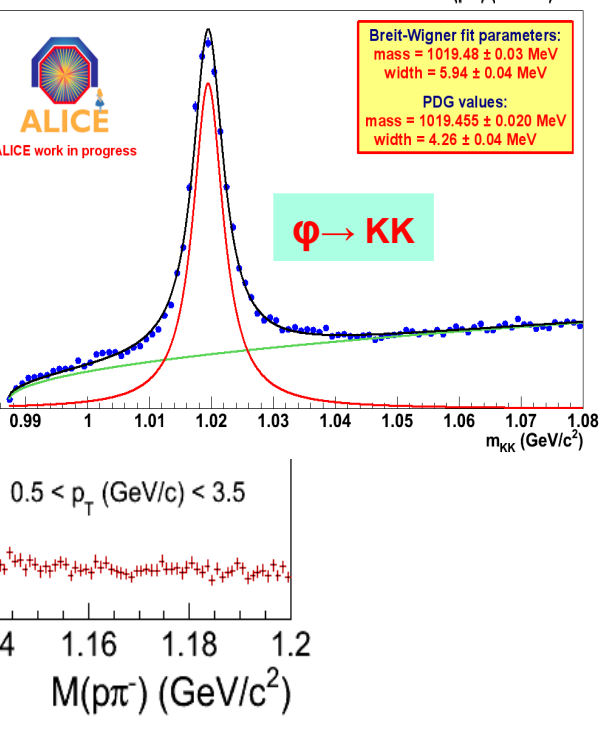
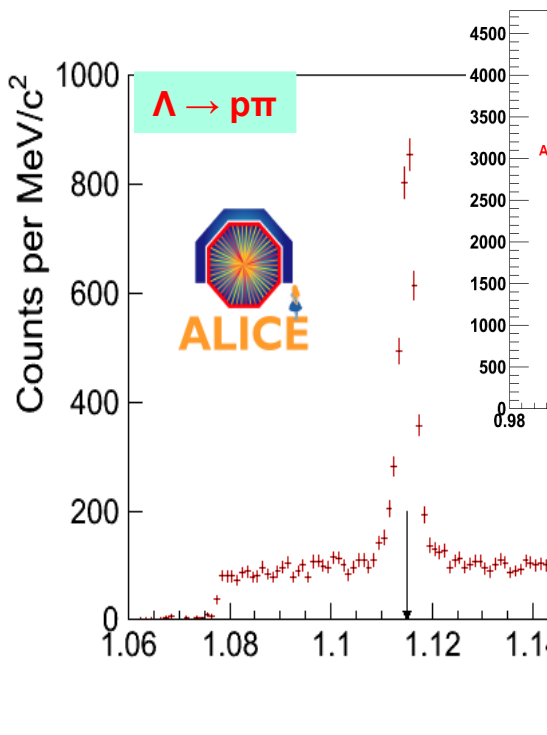
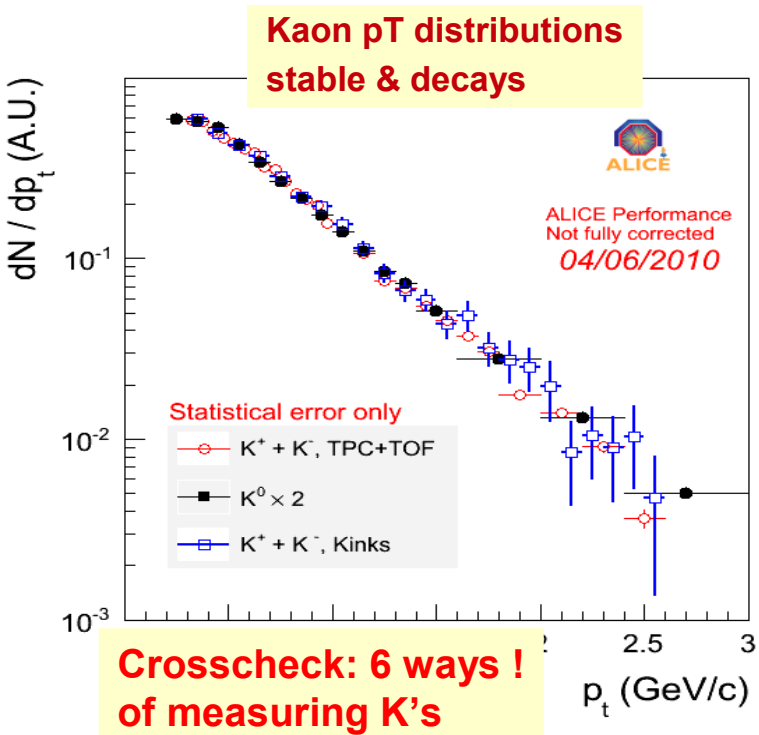
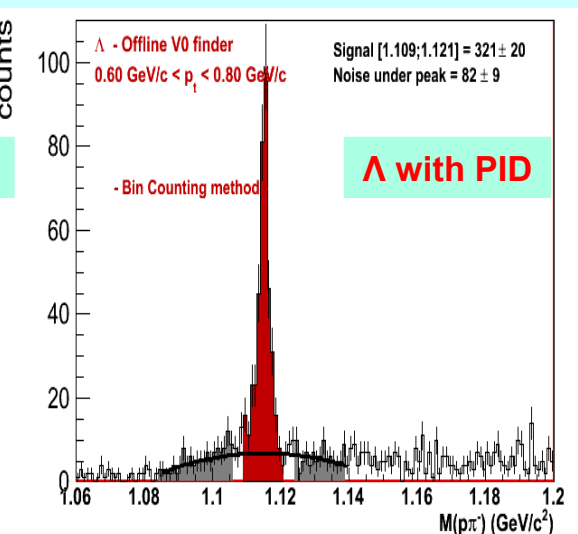
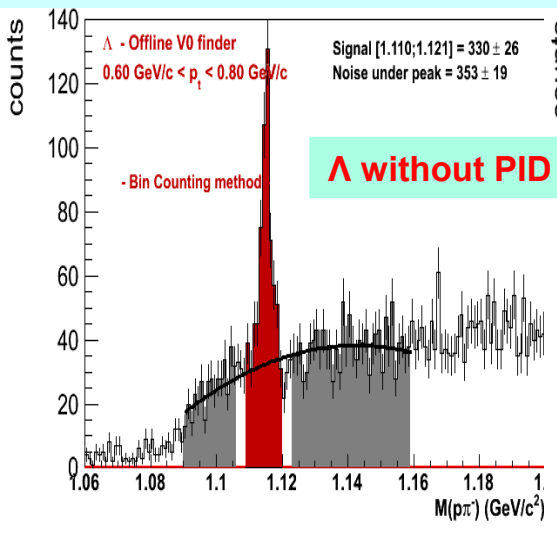
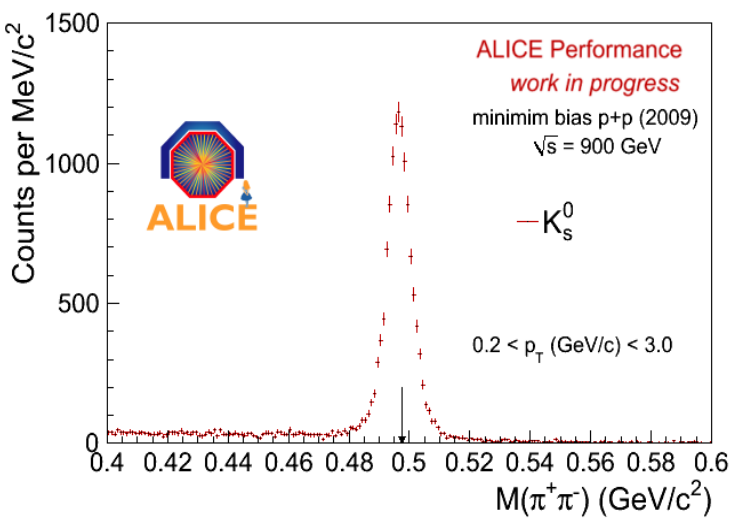
dEdX distribution (ITS signal, truncated mean) Entries 148725



ALICE performance: neutral mesons

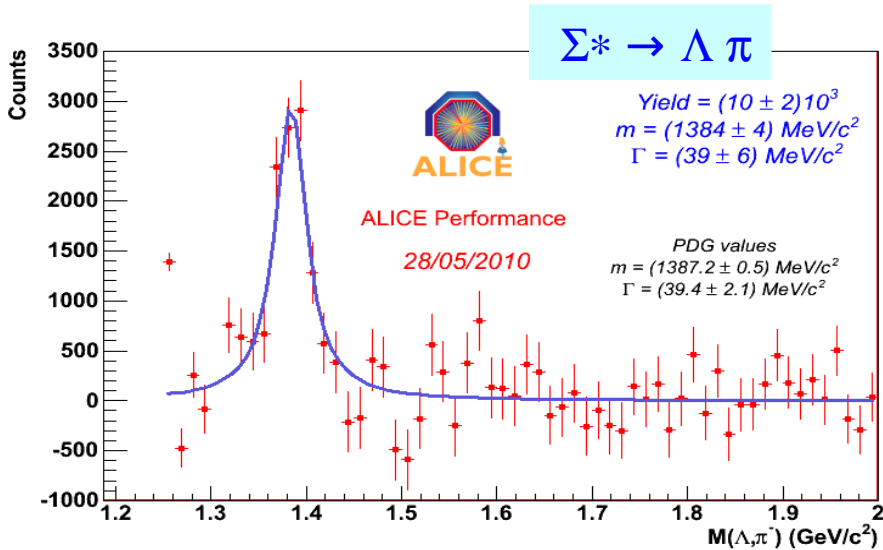


ALICE performance: strange particles

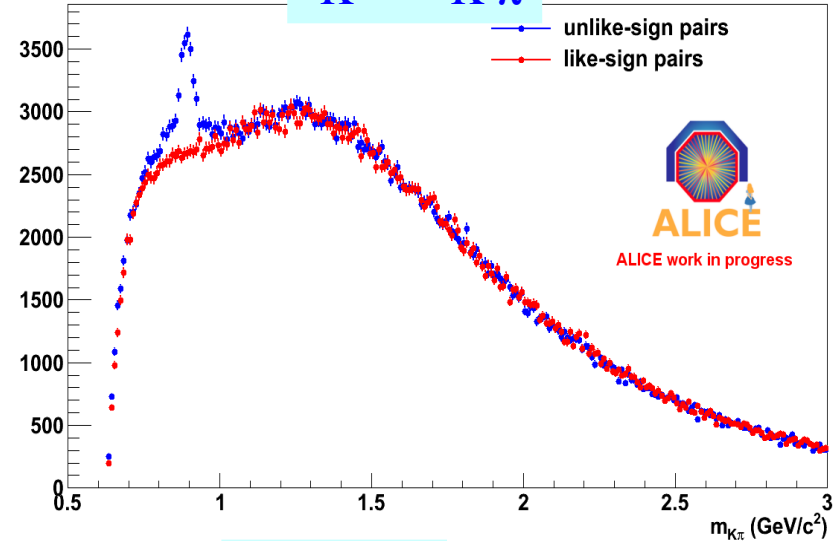


ALICE performance: strange particles (2)

$\Lambda \pi^-$ invariant mass spectrum (side-bands background subtracted)



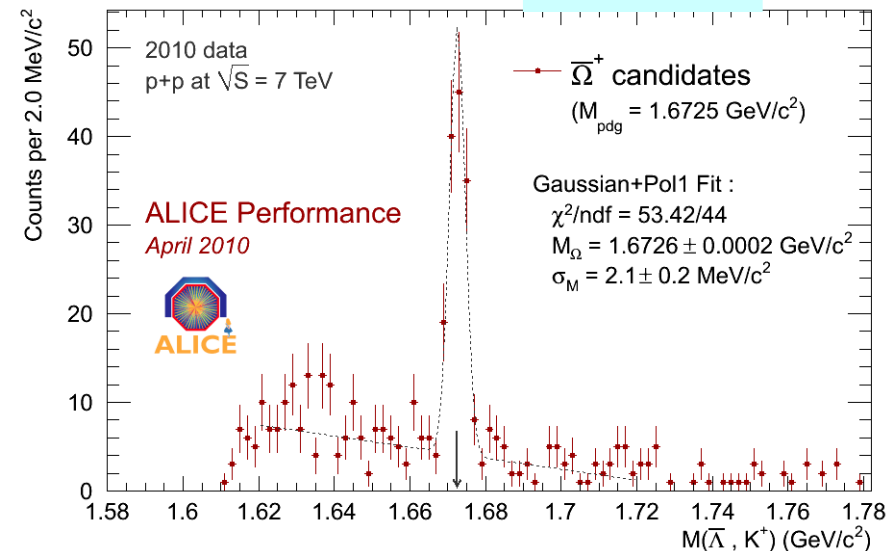
$K^* \rightarrow K \pi$



ALICE data, p-p at 7 TeV (sel.

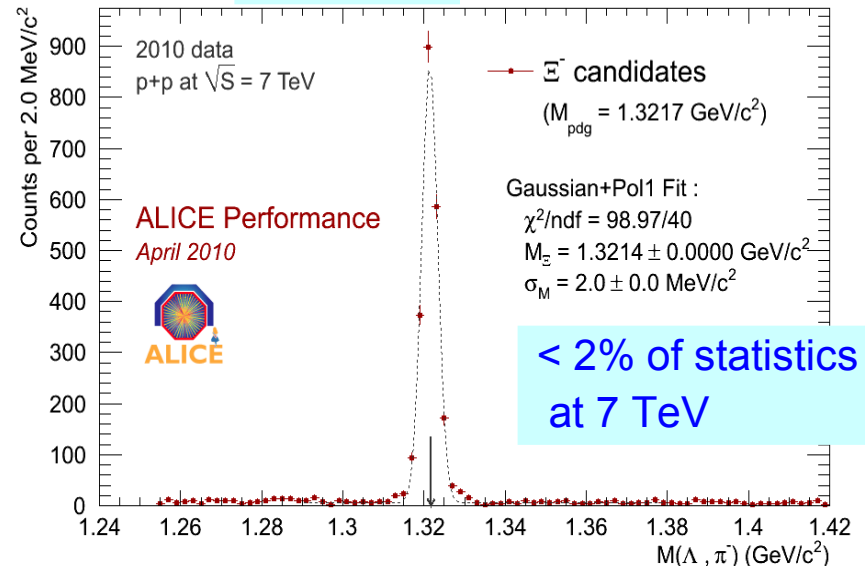
$\Omega \rightarrow \Lambda K$

ass1) - 5.71 Mevents



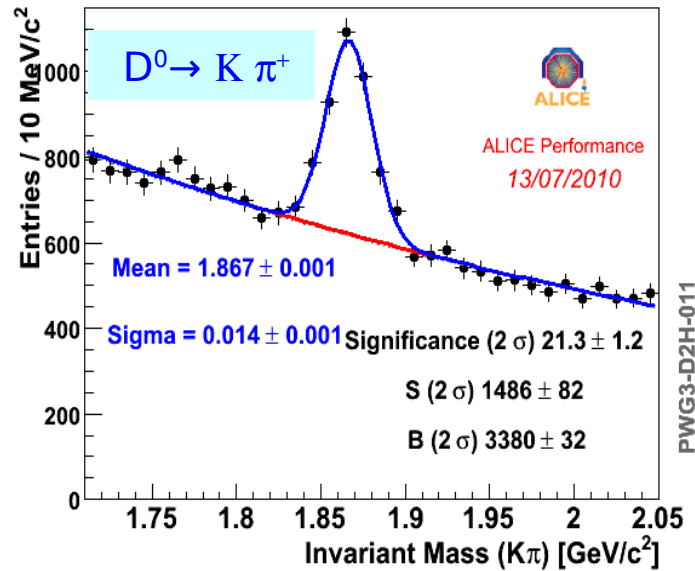
$\Xi \rightarrow \Lambda \pi$

(sel. runs 114783 - 115401 / GRID pass1) - 5.71 Mevents

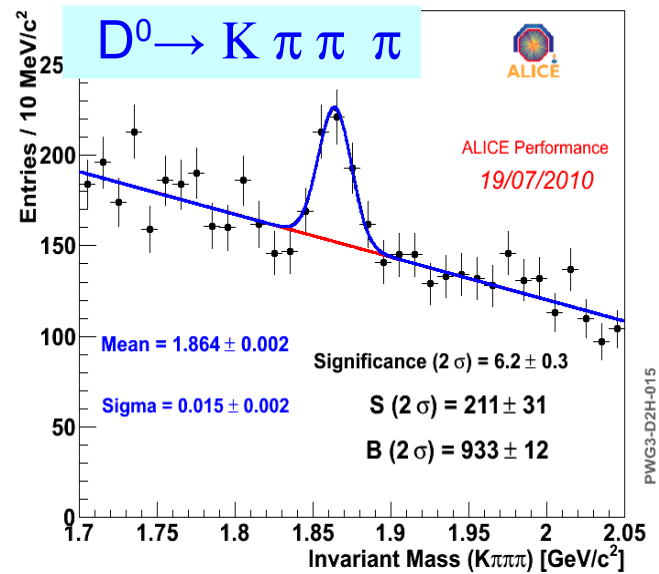


ALICE performance: Charm at 7 TeV

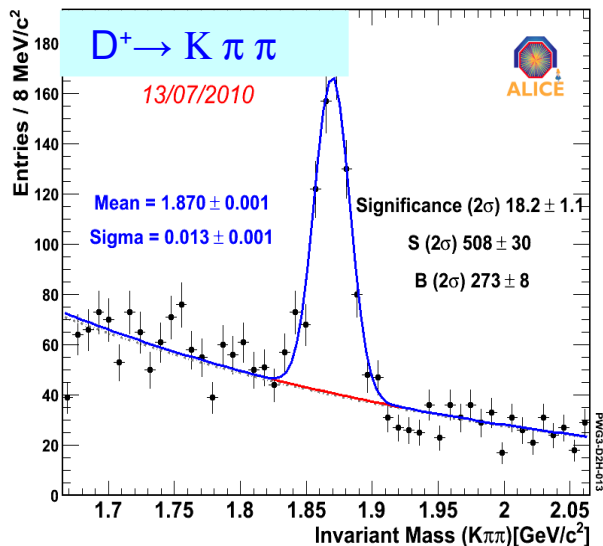
pp \sqrt{s} = 7 TeV, 1.4×10^8 events, $p_t^{D^0} > 2$ GeV/c



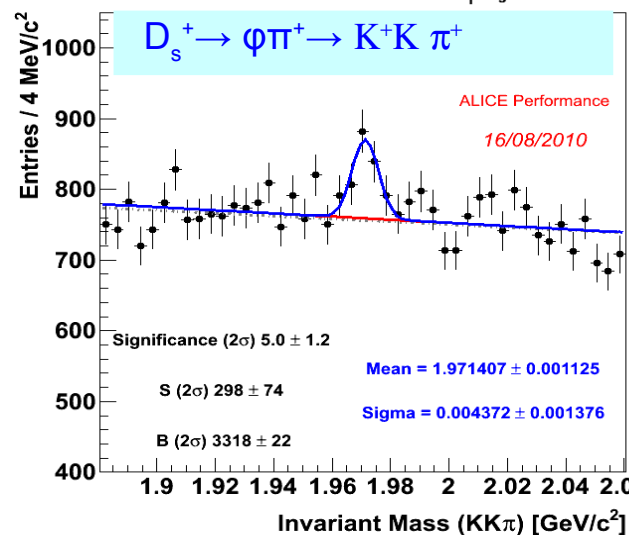
pp \sqrt{s} = 7 TeV, 1.4×10^8 events, $p_t^{D^0} > 3$ GeV/c



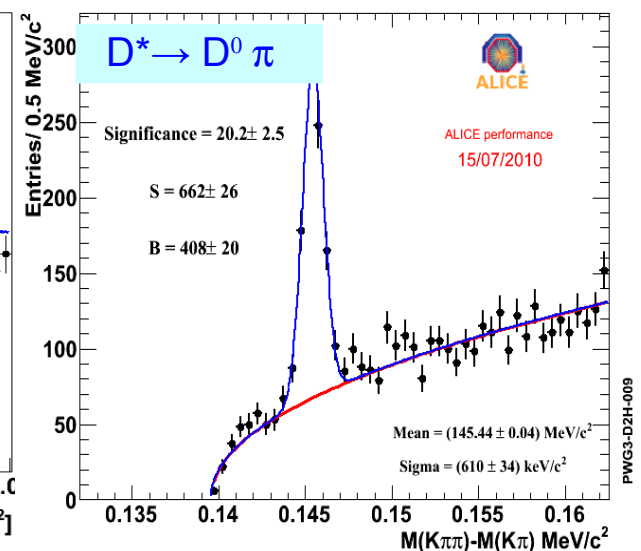
pp \sqrt{s} = 7 TeV, 1.41×10^8 events, $p_t^{D^+} > 2$ GeV/c



p-p, \sqrt{s} = 7 TeV, 1.41×10^8 events, $3 < p_t(D_s) < 5$ GeV/c

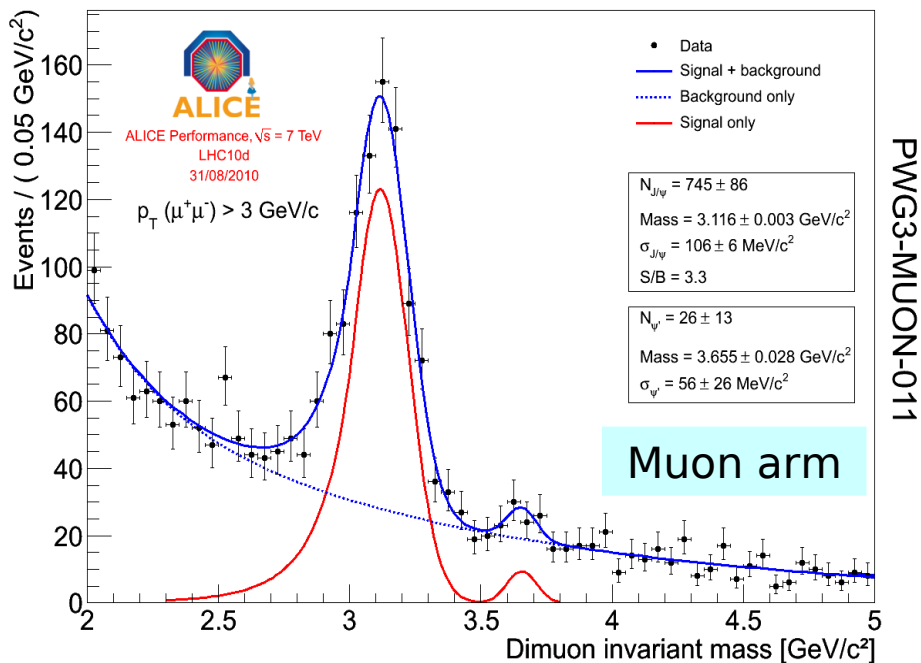


pp \sqrt{s} = 7 TeV, 1.40×10^8 events, $p_t^{D^*} > 2$ GeV/c

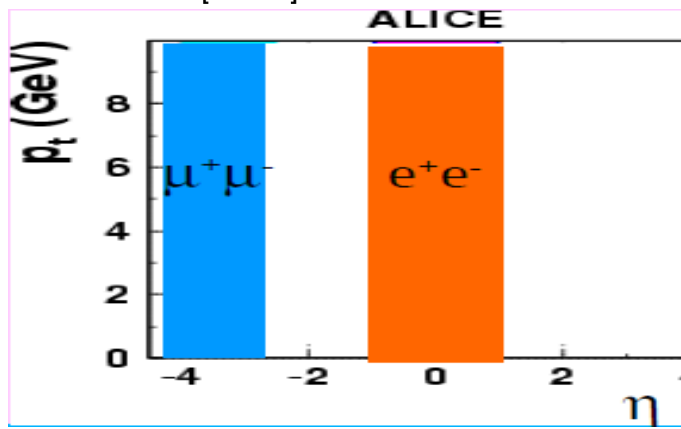
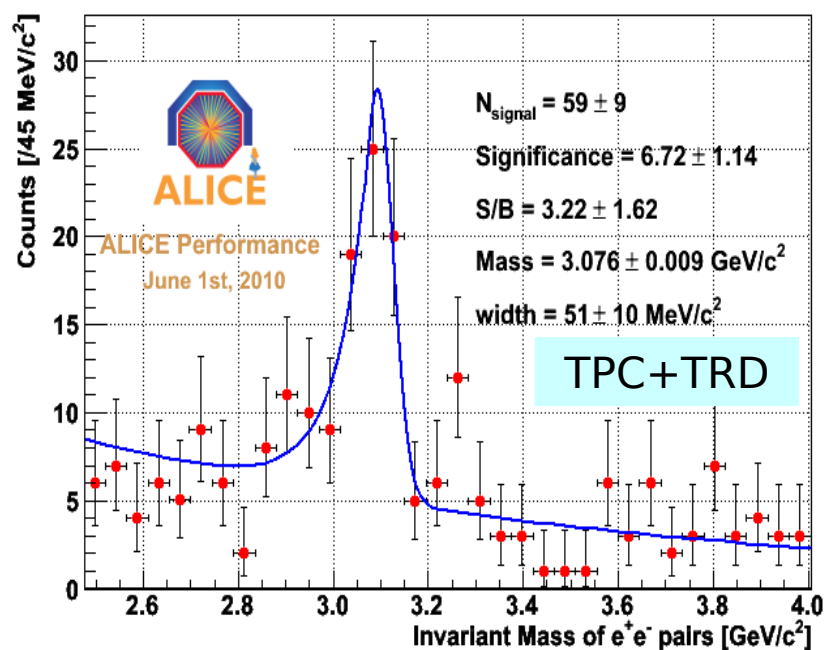


ALICE performance: J/ψ at 7 TeV

J/ψ → μ⁺μ⁻, y = 2.5-4.1

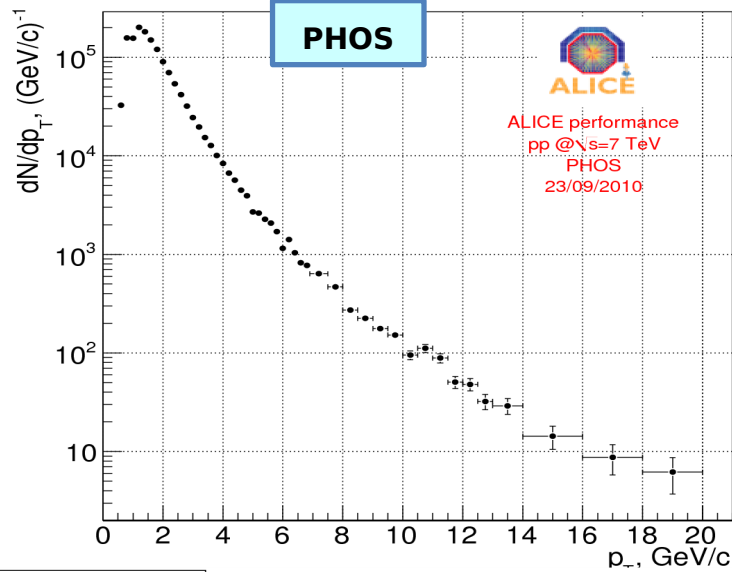


J/ψ → e⁺e⁻ |y| < 1

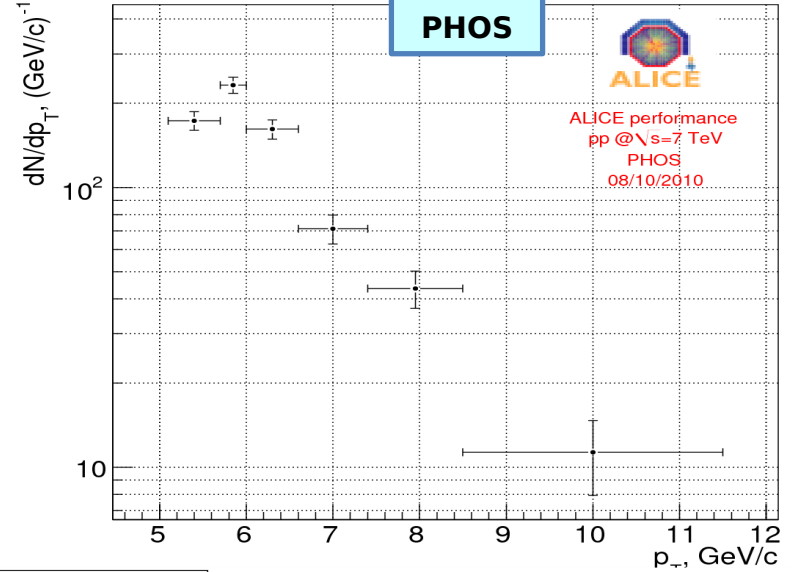


ALICE performance: P_T spectra of π^0 and η

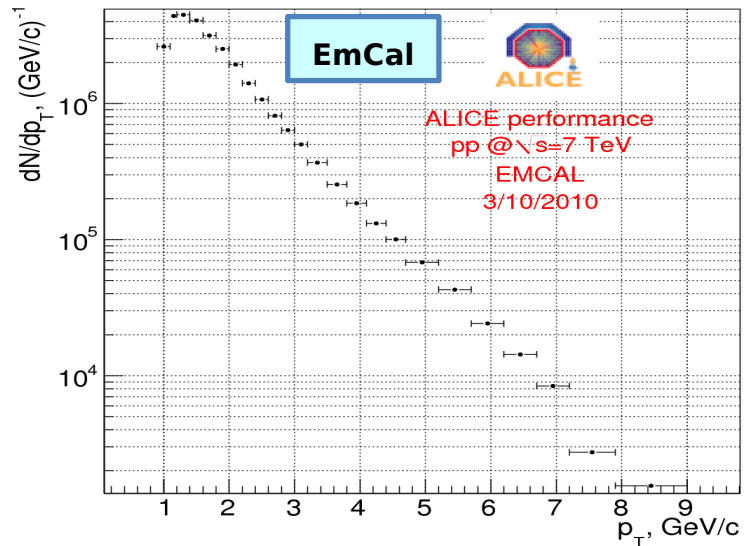
Raw π^0 spectrum



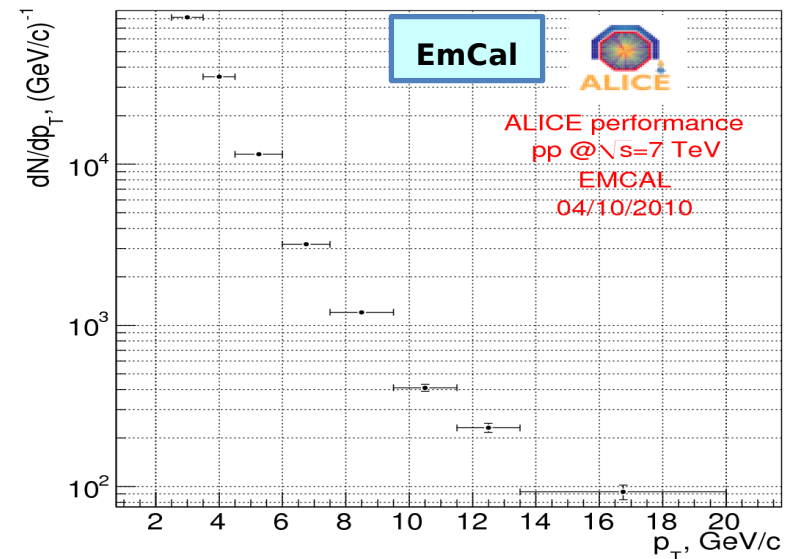
Raw η vs p_T



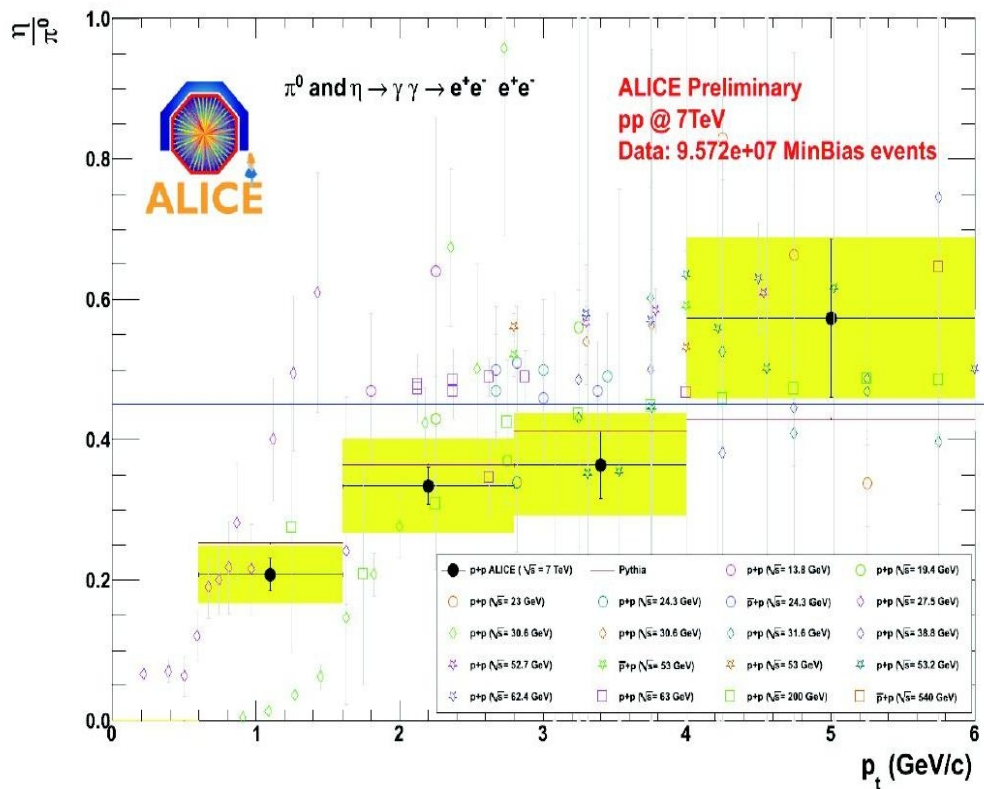
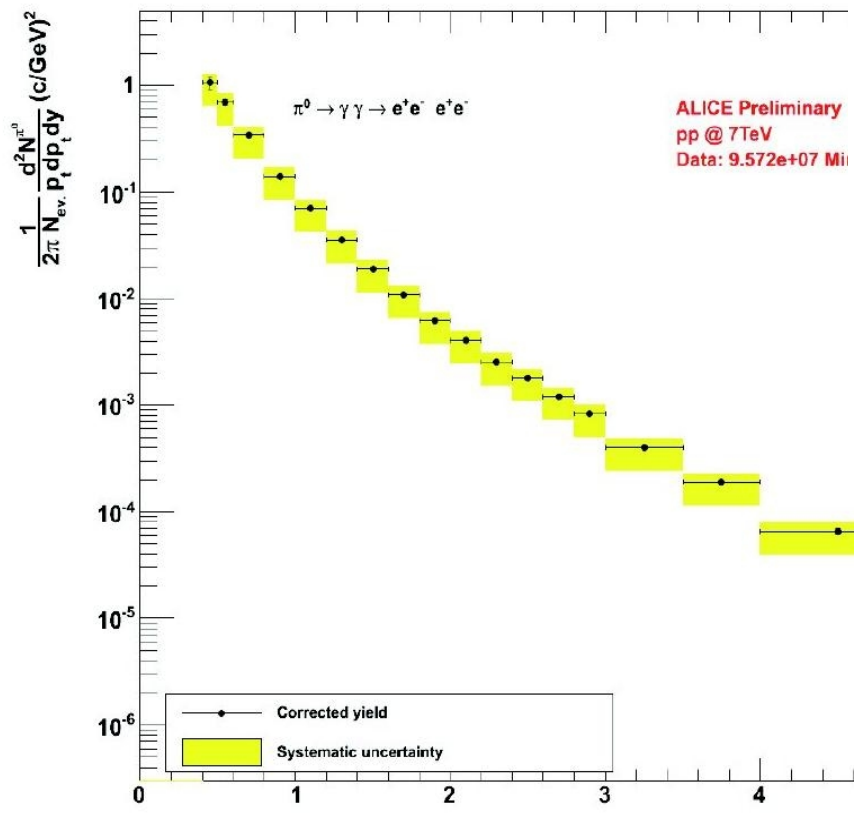
Raw π^0 vs p_T



Raw η vs p_T



ALICE performance: P_T spectra of π^0 and η in TPC

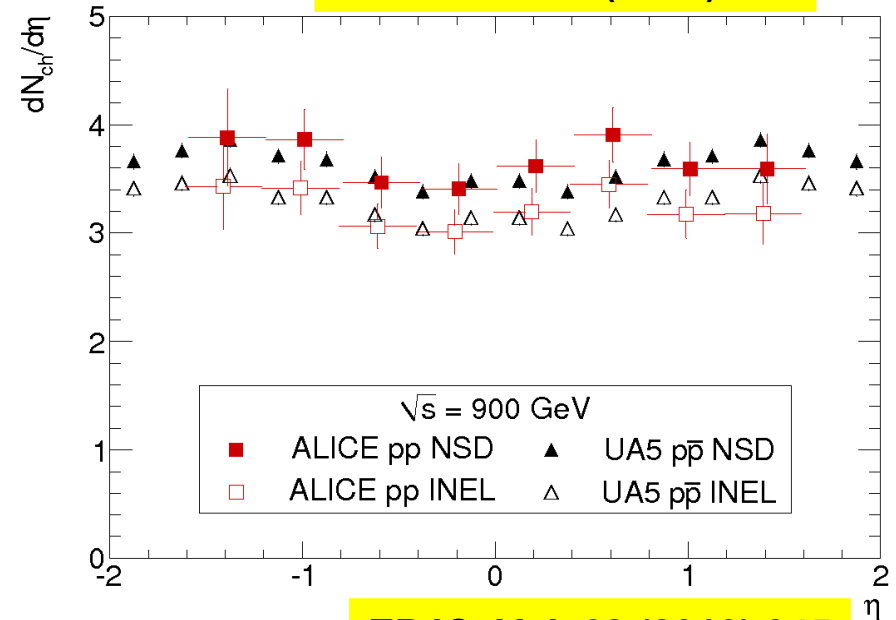


First measurements: $dN/d\eta$

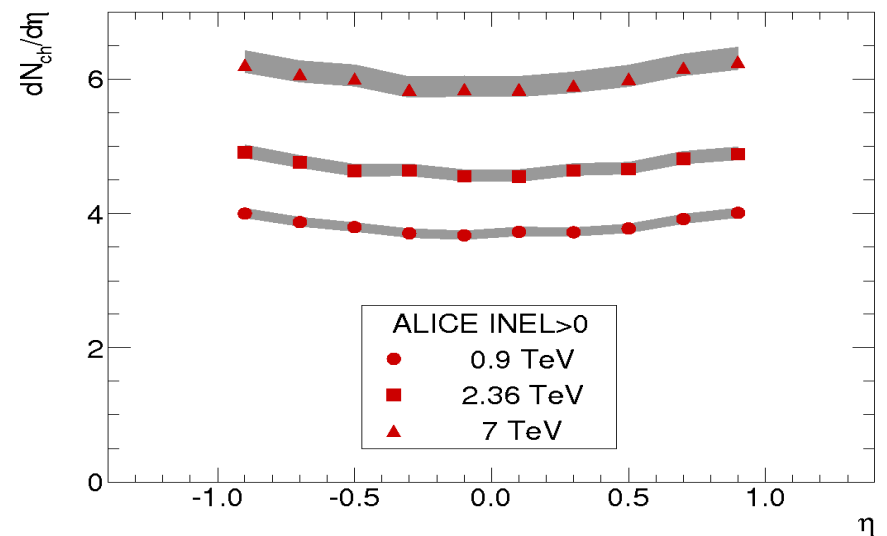
EPJC: Vol. 65 (2010) 111

- **First measurement @ 0.9 TeV:**
 - 284 events, 23rd November 2009
 - magnetic field off
 - consistent with pp
 - systematic error $\sim 7\%$ (fraction and kinematics of diffractive processes)
 - **first paper at LHC**

- **Following measurements:**
 - $dN/d\eta$ and multiplicity distributions
 - @ 0.9, 2.36 and 7 TeV:
 - **first paper @ 7 TeV**
 - all three first multiplicity papers published on EPJC



EPJC: Vol. 68 (2010) 345

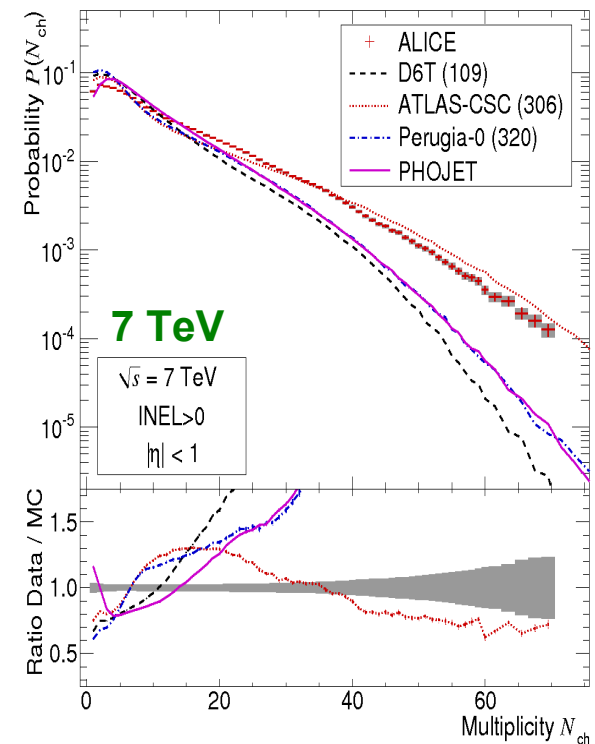
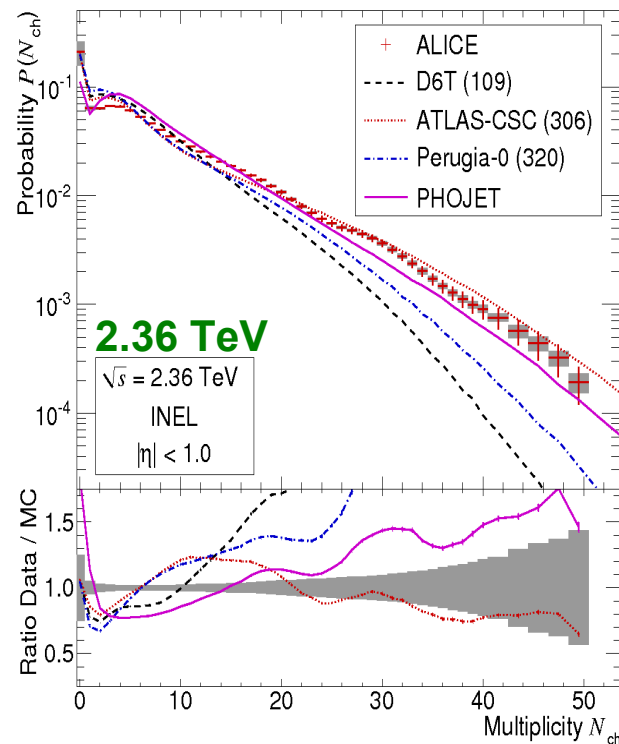
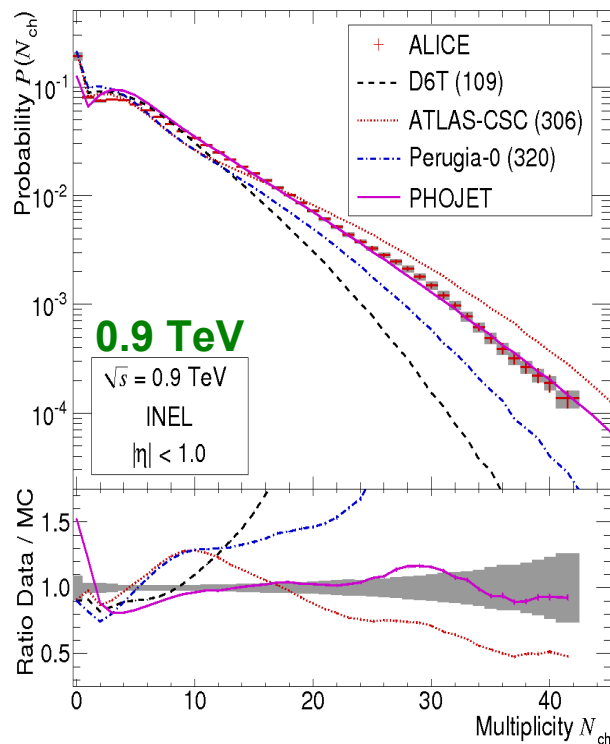


First measurements: multiplicity data vs MC

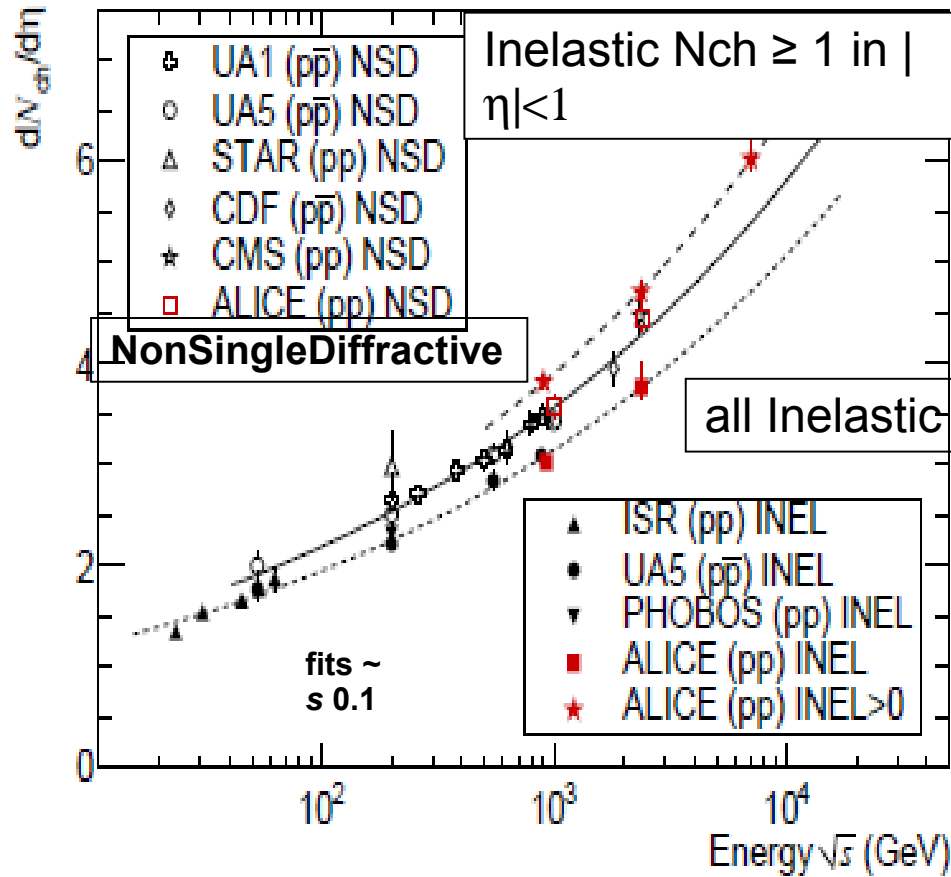
- Comparison with MC @ 0.9, 2.36 and 7 TeV:
 - tails increase faster wrt MC, not satisfactory @ 7 TeV
 - PHOJET**: good @ 0.9 TeV, fails @ 2.36 and 7 TeV
 - PYTHIA ATLAS tuning**: fails @ 0.9 TeV, reasonably close @ 2.36 and 7 TeV but deviations around 10-20
 - PYTHIA D6T** and **Perugia-0**: far from data @ all energies

EPJC: Vol. 68 (2010) 89

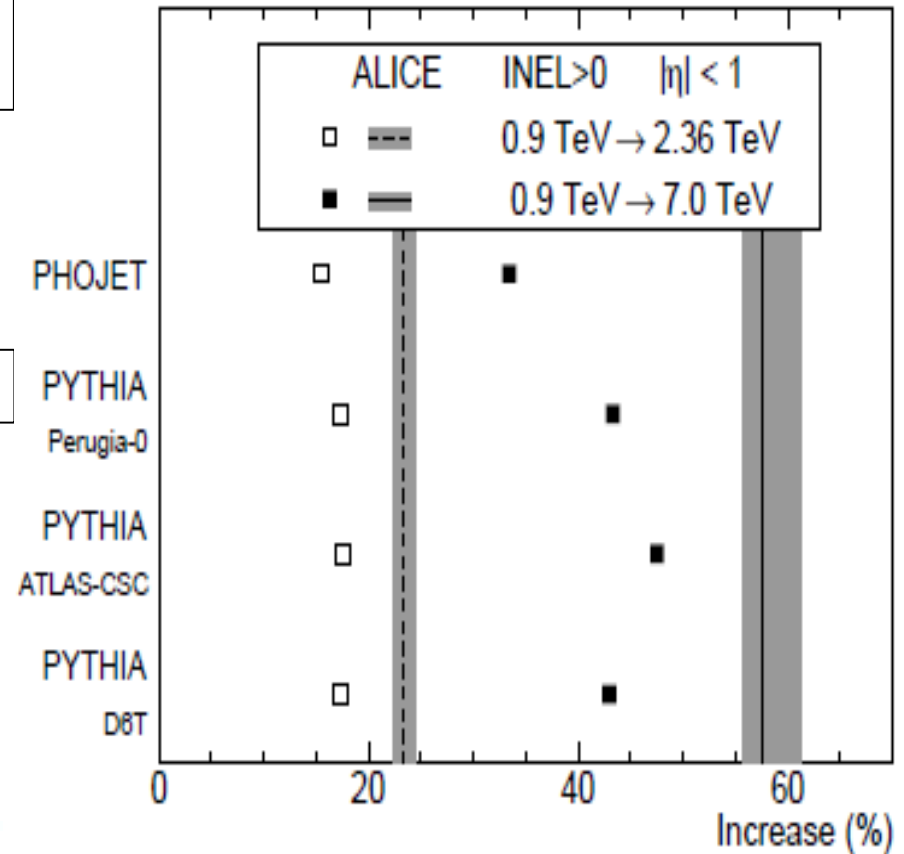
EPJC: Vol. 68 (2010) 345



Multiplicity: ALICE vs other experiments and MC



Relative increase in $dN_{ch}/d\eta$



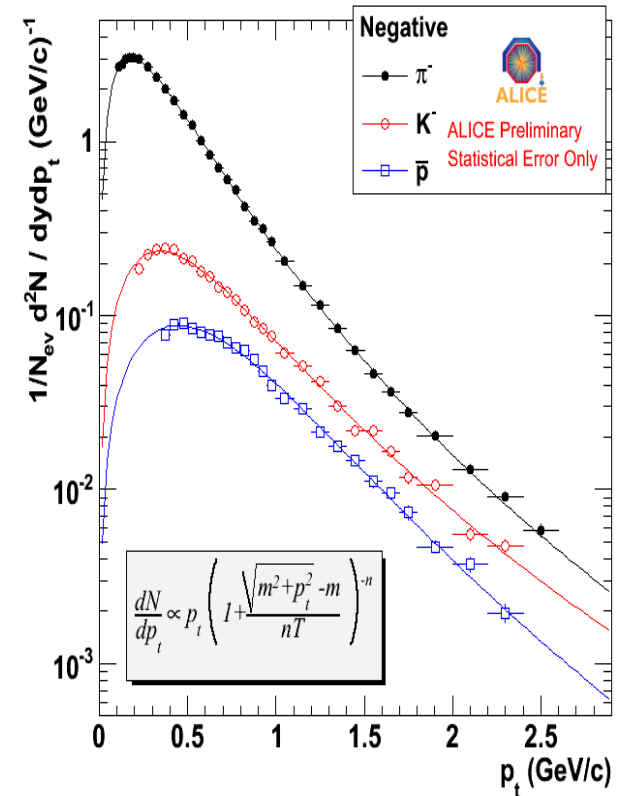
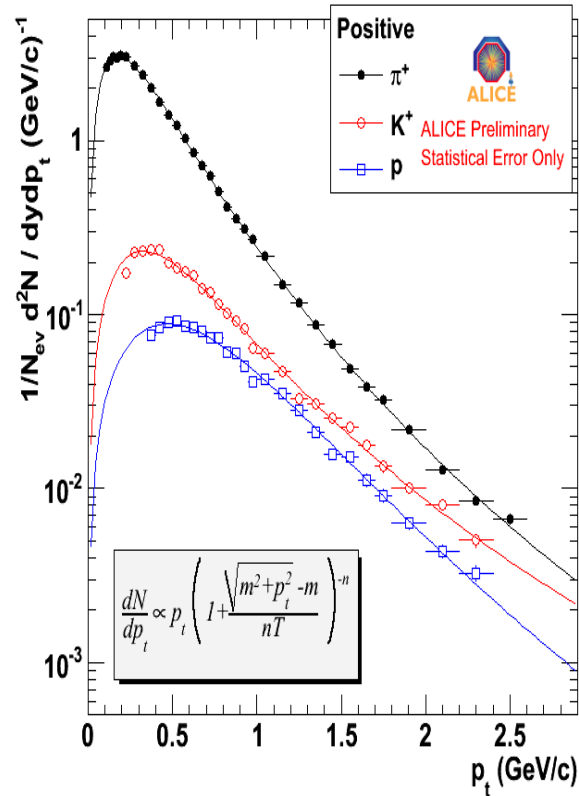
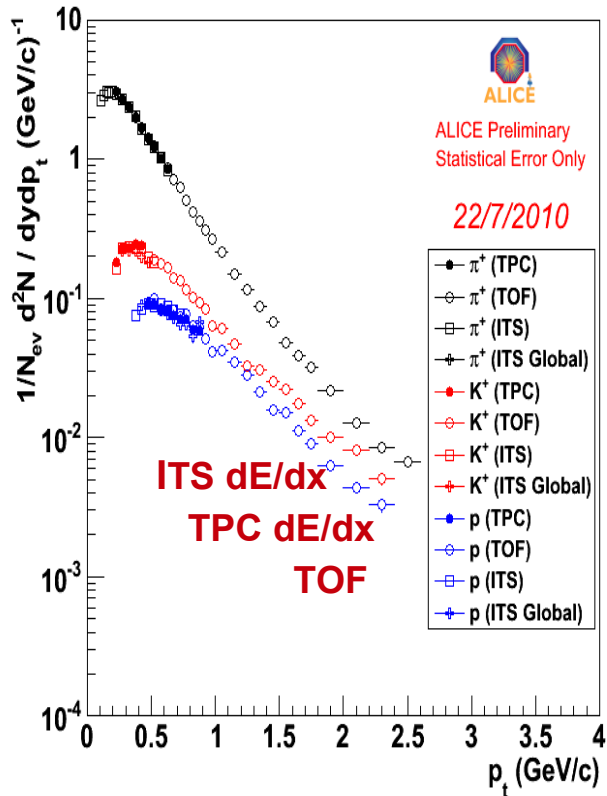
$dN_{ch}/d\eta$ agree with other experiments

$dN_{ch}/d\eta$ increase with \sqrt{s} well described by a power law

Increase with energy significantly stronger in data than in MC

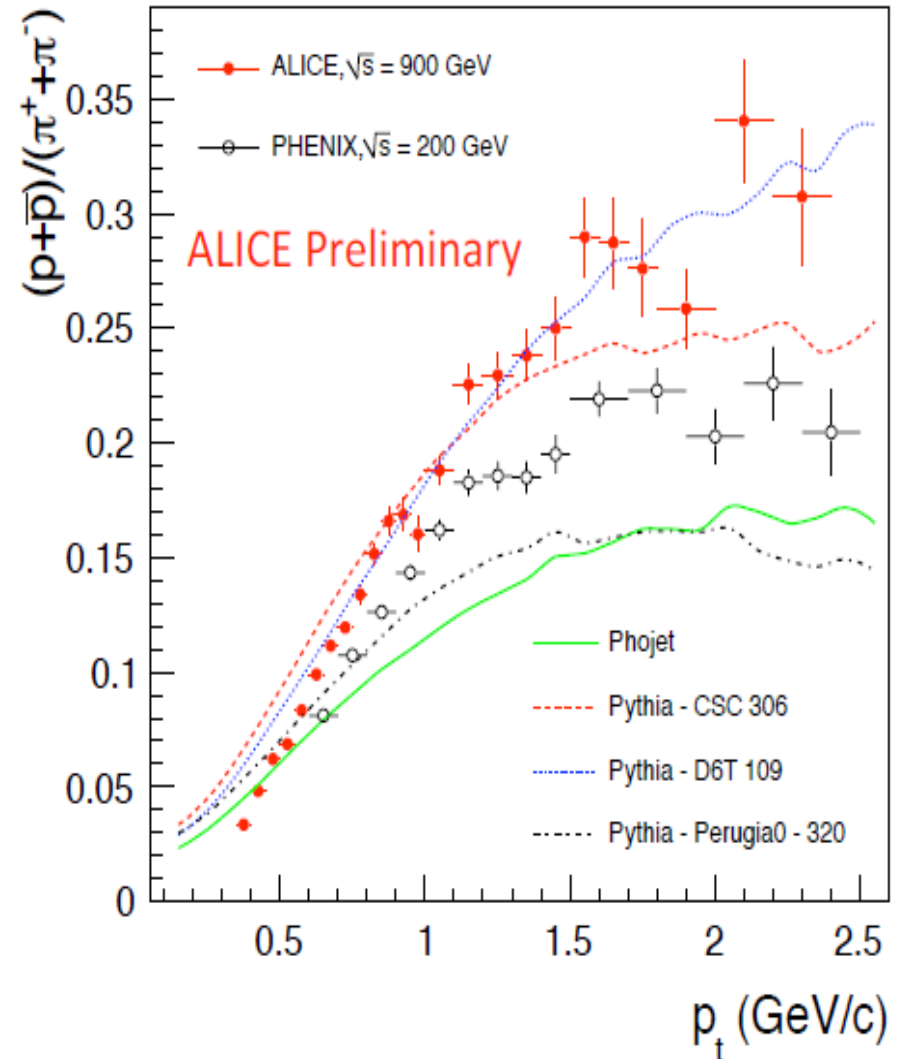
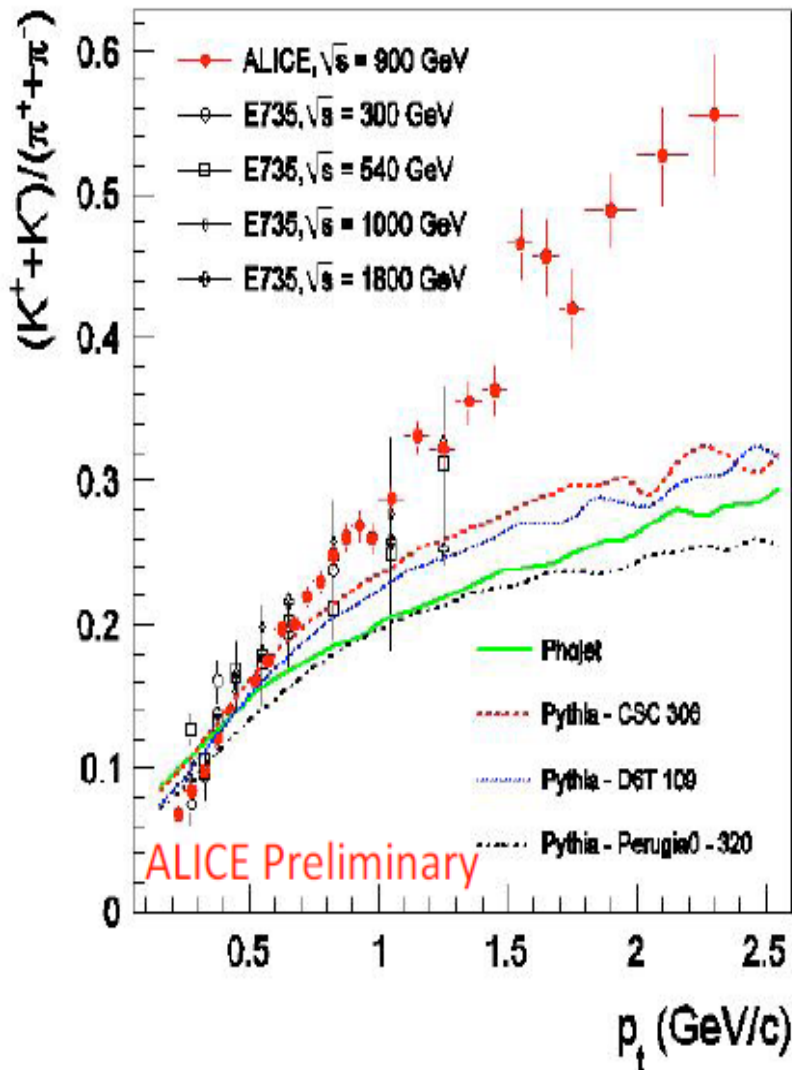
First measurements: P_T spectra at 900 GeV

Identified particle p_T : π , K , P



π , K , p spectra with statistical and systematic uncertainties are described by Lévy function quite well

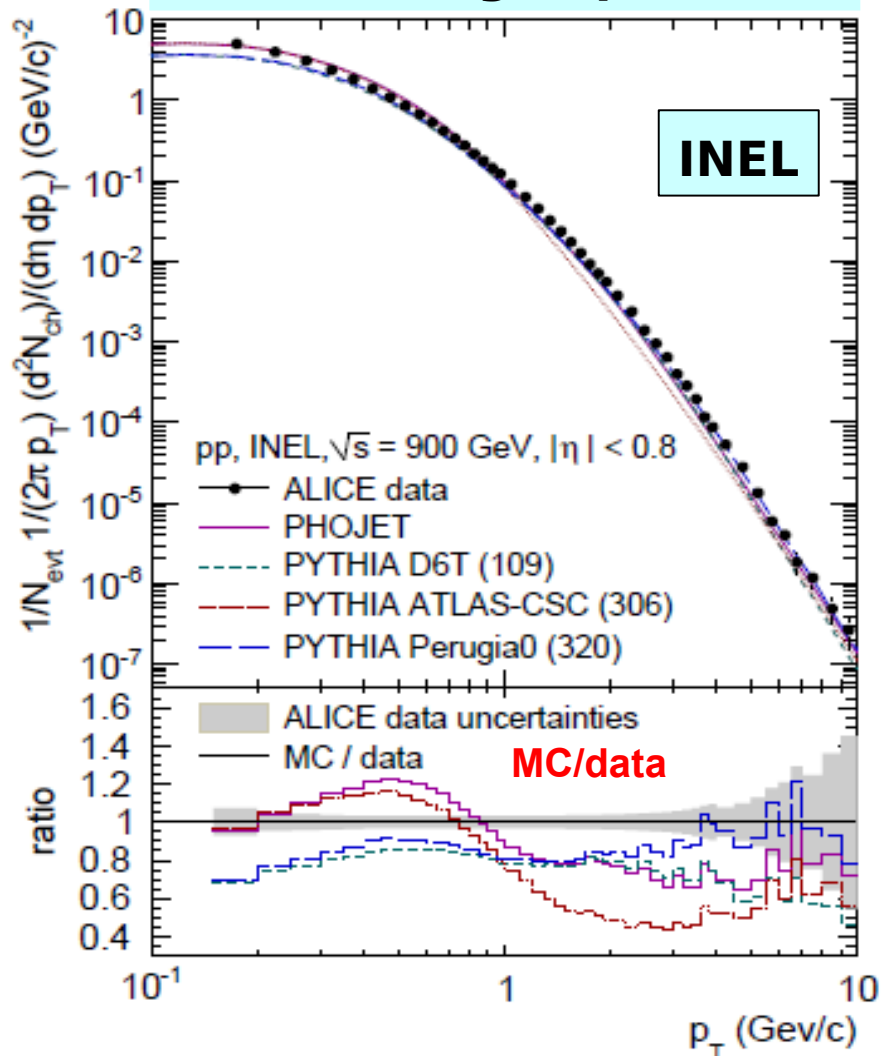
First measurements: particle p_T ratios at 900 GeV



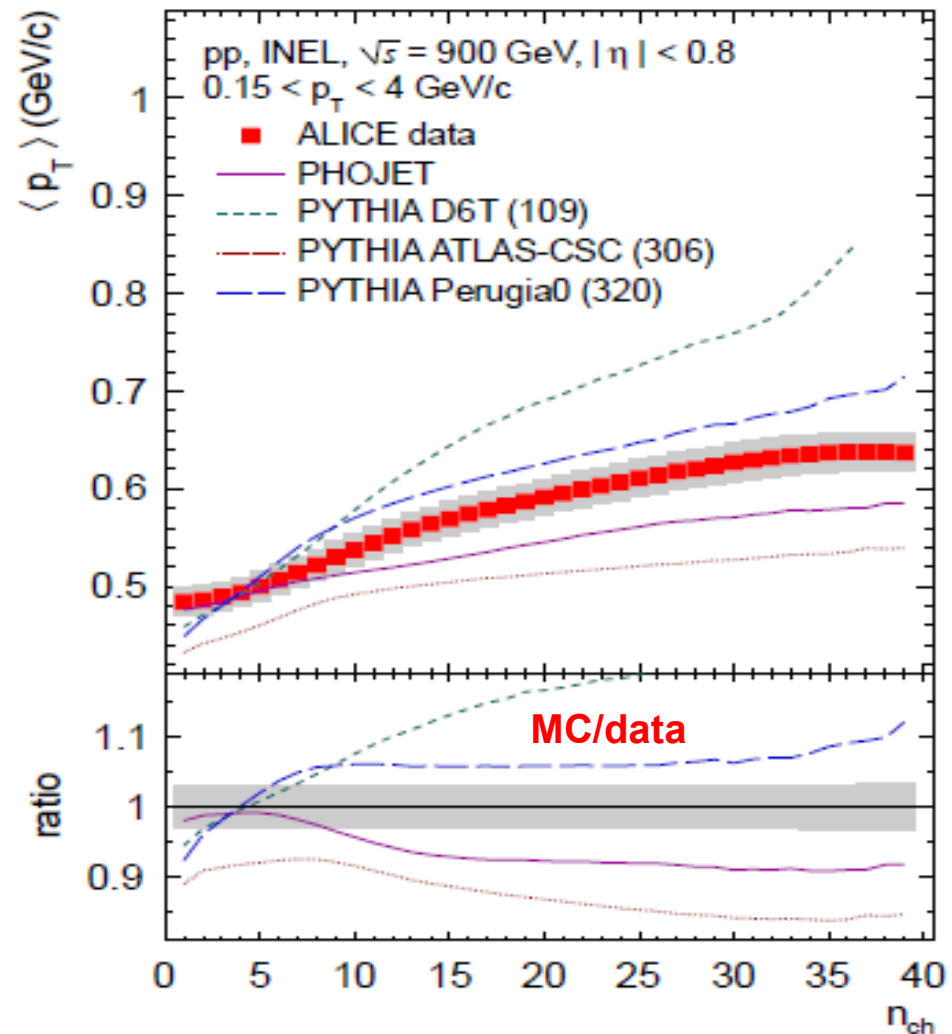
Poor agreement with models, but a good agreement with E735 and PHENIX

P_T spectra in comparison with models

P_T for charged particles

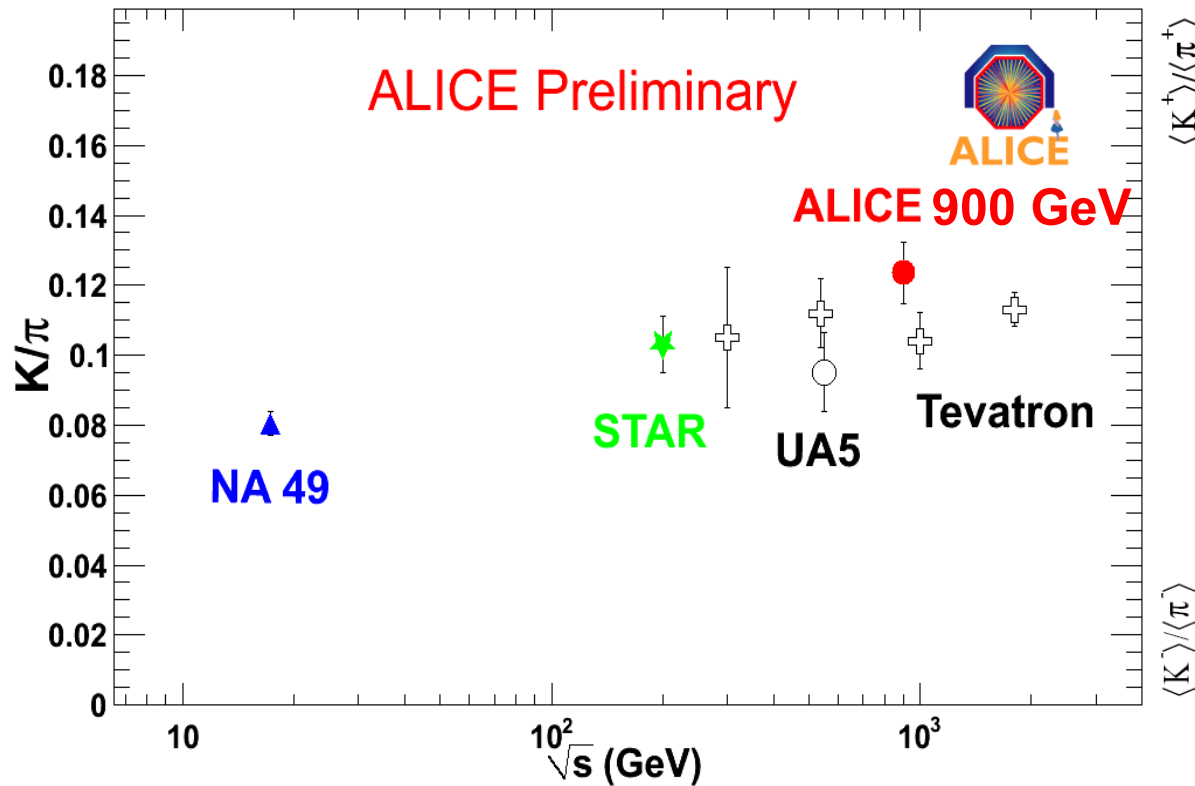


$\langle P_T \rangle$ versus Multiplicity



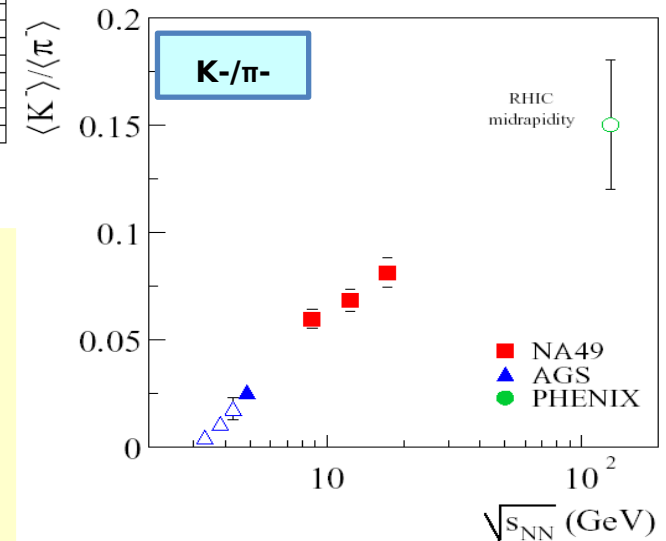
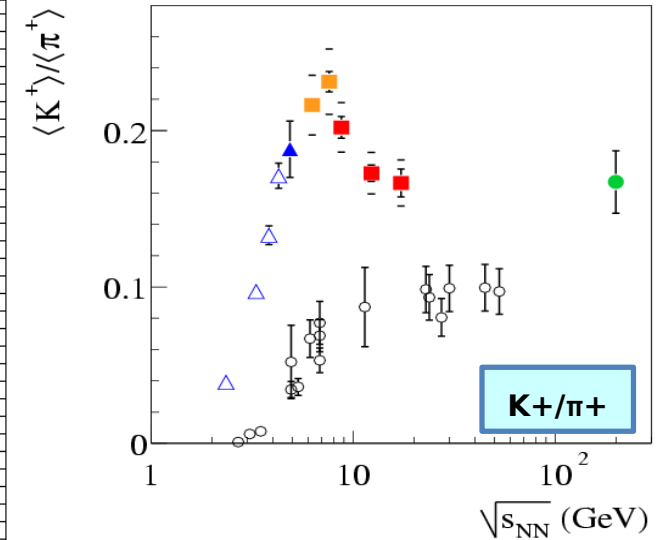
Poor agreement with the models ...

K/ π ratio in comparison with other experiments



- K/ π ratio is in a good agreement with other experiments
- Slow rise with \sqrt{s} ?: 7 TeV point important !
- Energy of pp collisions at $\sqrt{s} = 2.36$ and 7 TeV is comparable and beyond the total energy in PbPb collisions in the range of K $^+$ / π^+ horn
- Collective phenomena could be expected

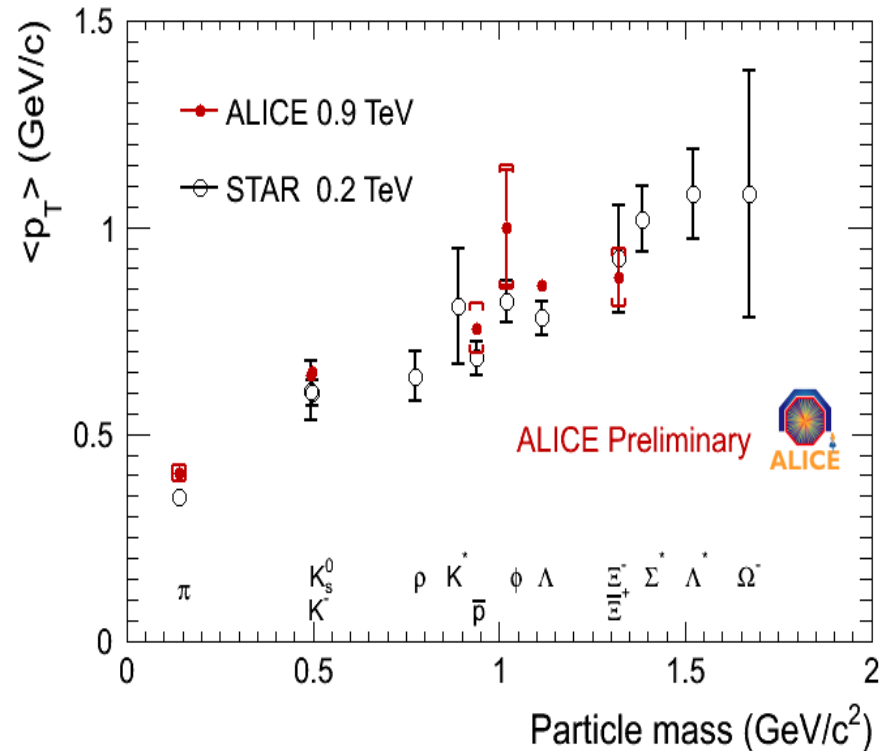
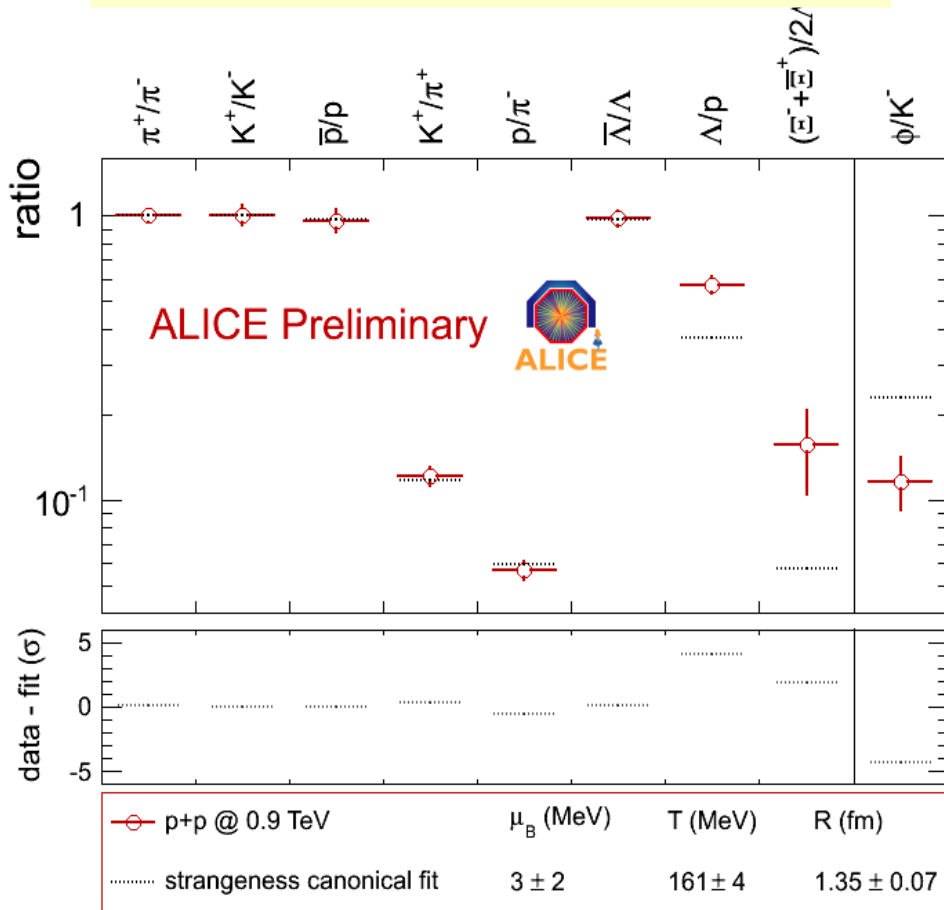
K $^+$ / π^+ horn in AA-collisions



More ratios at 900 GeV

Comparison of yield ratios to fits with the THERMUS statistical model (S.Wheaton, J.Cleymans and M.Hauer)

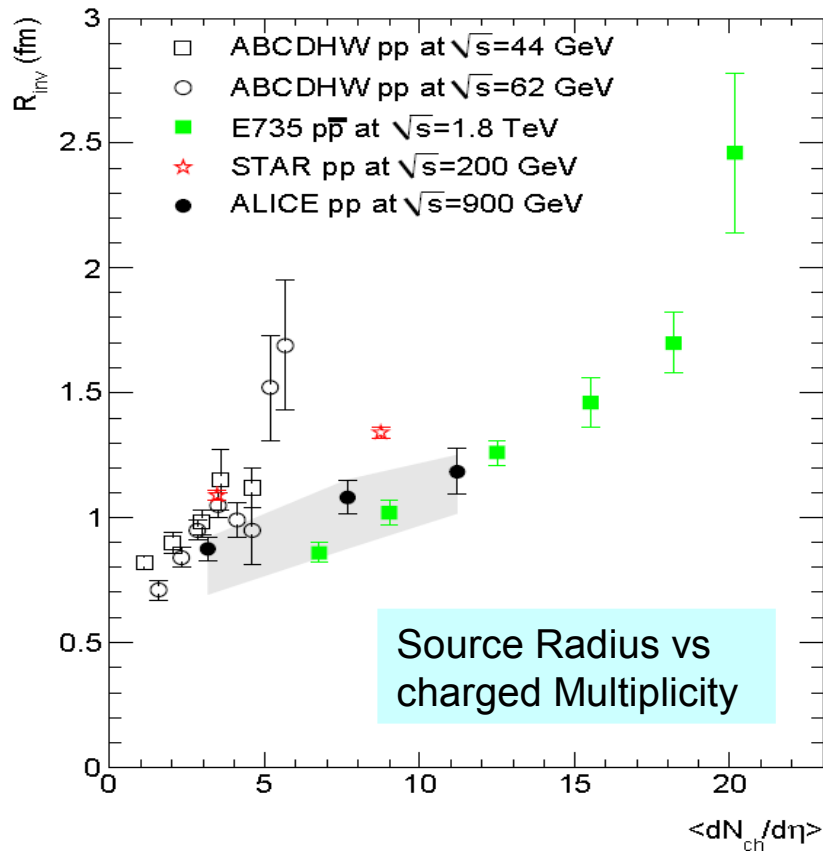
$\langle P_T \rangle$ as function of particle mass



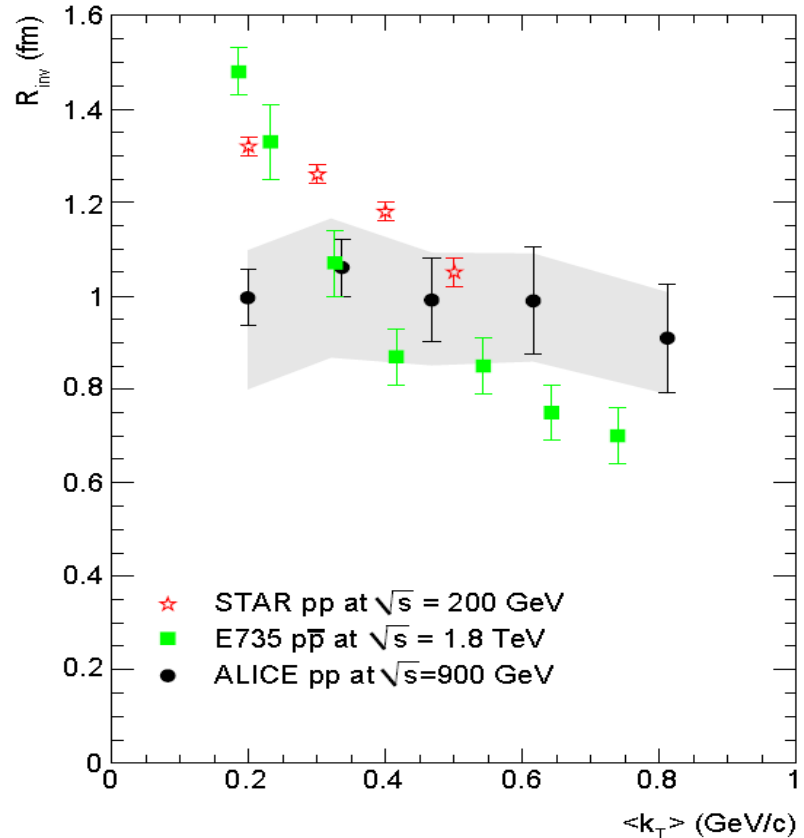
$T=161 \pm 4$ MeV; $\mu_B = 3 \pm 2$ MeV, $R = 1.35 \pm 0.07$ fm

Same trend as in STAR in 200 GeV pp collisions

Bose-Einstein correlations at 900 GeV



- One dimensional Gaussian HBT radius as function of the multiplicity
 $0.1 \text{ GeV}/c < k_T < 0.55 \text{ GeV}/c$, $\langle k_T \rangle = 0.32 \text{ GeV}/c$
- Used PHOJET and PYTHIA to subtract the baseline correlations
- **Similarly to heavy ion collisions the radius increases with the multiplicity**



- One dimensional Gaussian HBT radius as function of $\langle k_T \rangle$, $\langle dN/d\eta \rangle = 3.6$
- Used PHOJET and PYTHIA to subtract the baseline correlations
- Tevatron data at much higher multiplicity but STAR multiplicity is comparable

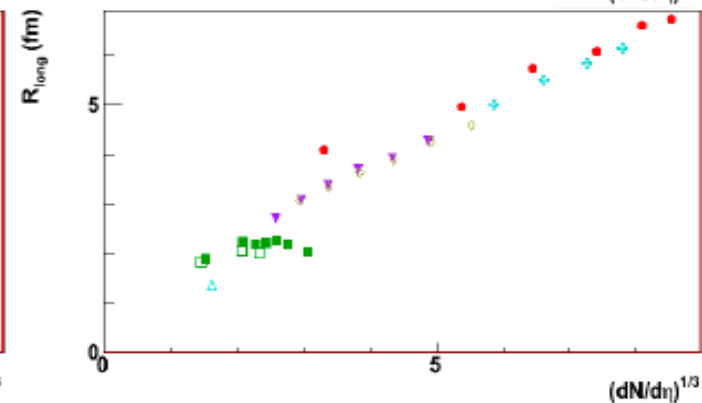
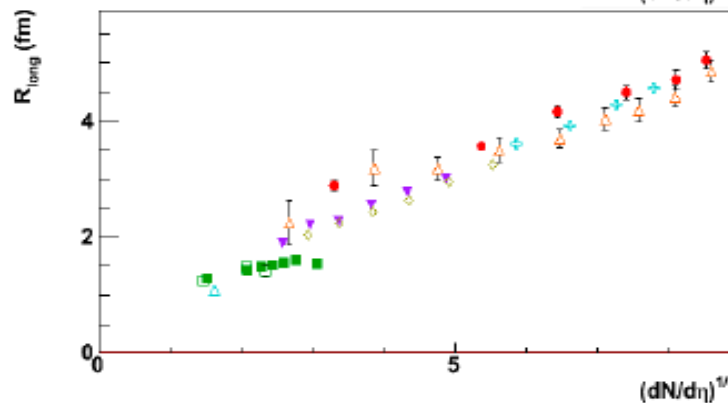
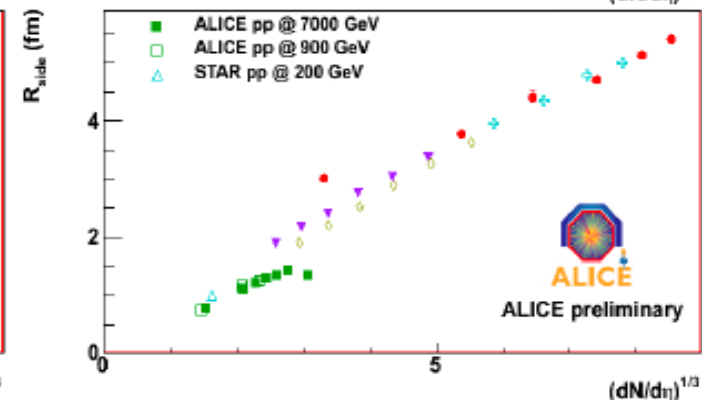
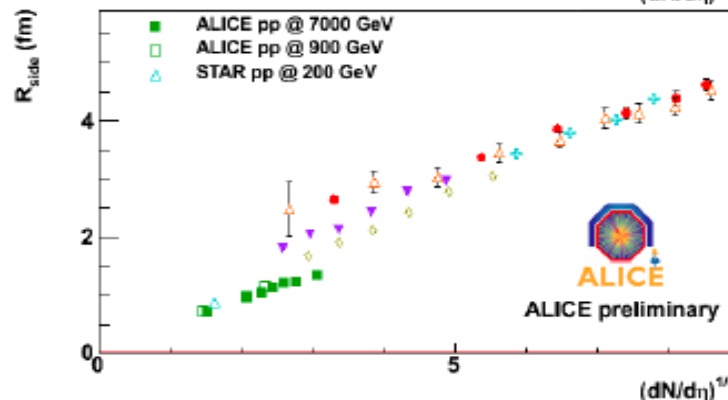
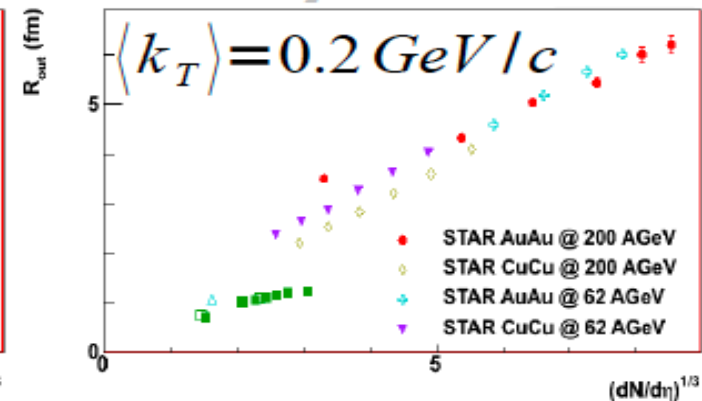
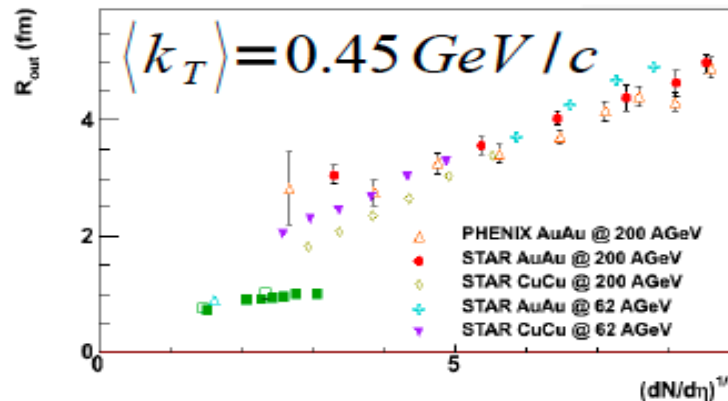
Bose-Einstein correlations (cont.)

- Multiplicity overlap between pp and HI.

- Scaling with M similar to STAR but different from HI.

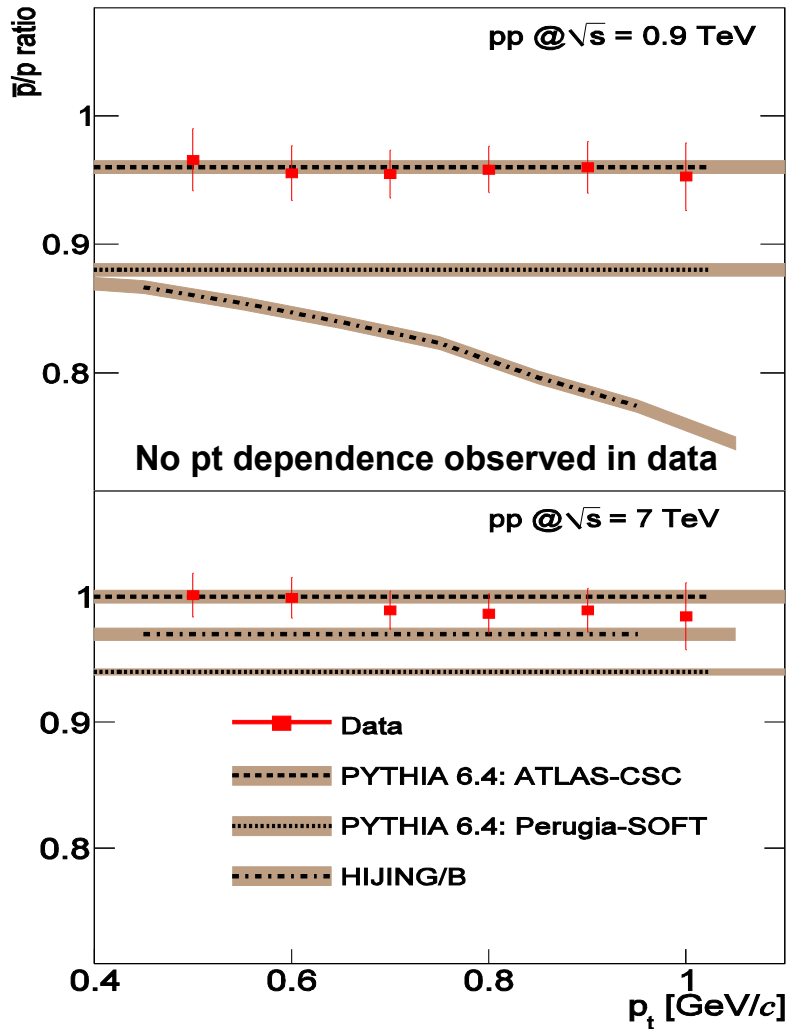
- Enhancement of like-sign pions at low momentum difference $q_{inv}=|p_1-p_2|$, as function of multiplicity and pair momentum $k_T = |p_{T1}+p_{T2}|/2$

- pp sizes smaller than HI at same multiplicities



Baryon – antibaryon asymmetry in pp

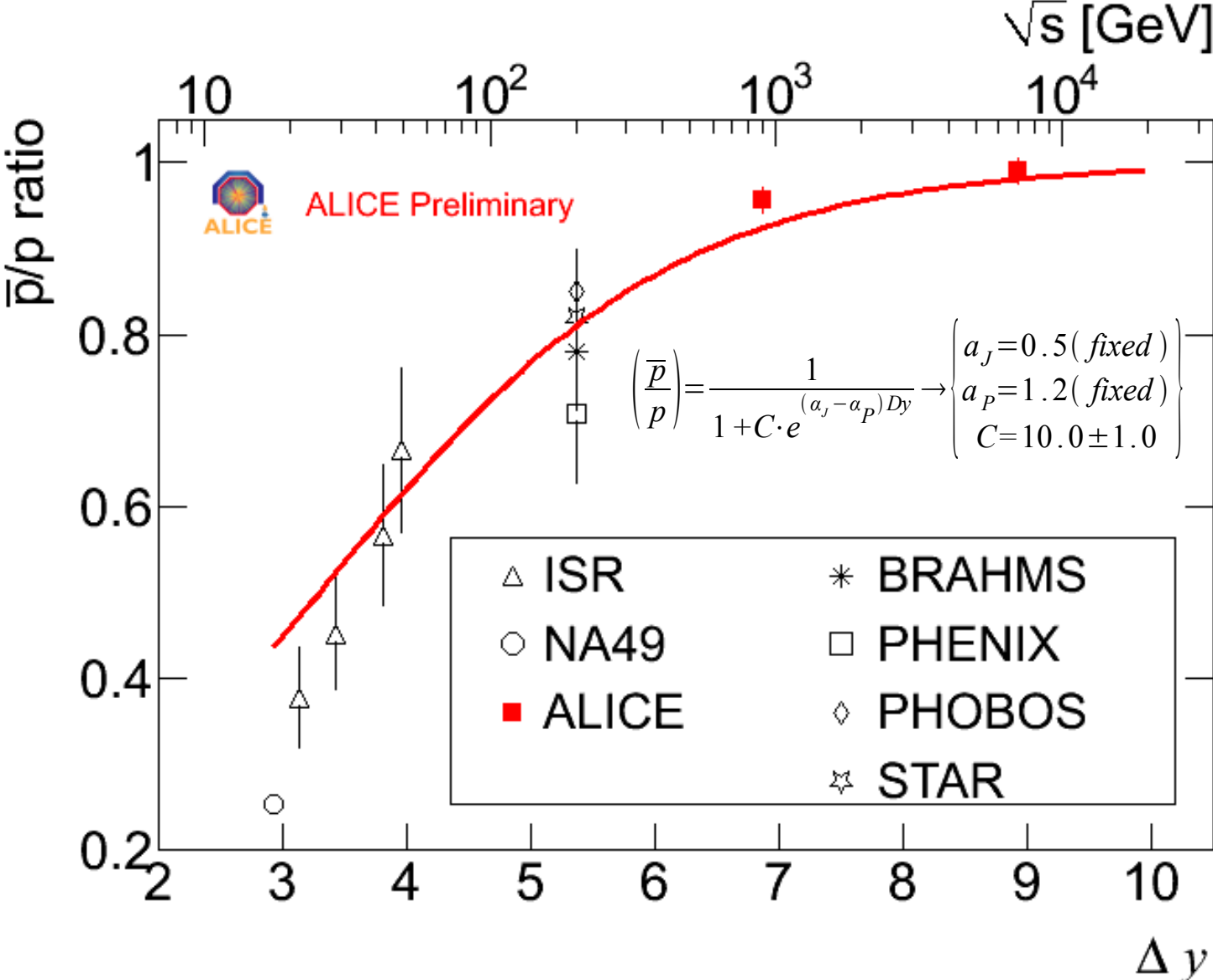
Phys.Rev.Lett.105:072002, 2010



Energy [TeV]		0.9 TeV	7 TeV
ALICE		$0.957 \pm 0.015^*$	$0.991 \pm 0.015^*$
PYTHIA	ATLAS-CSC	0.96	1.0
	Perugia-0 (320)	0.95	1.0
	Perugia-SOFT	0.88	0.94
QGSM	$\epsilon=0$	0.98	1.0
	$\epsilon = 0.076, \alpha_J =$	0.96	0.99
	$\epsilon = 0.024, \alpha_J =$	0.89	0.95
HIJING-B		0.83	0.97

Hijing-B, Perugia-SOFT, QGSM($\epsilon = 0.024, \alpha_J=0.9$)
incompatible with the data

pbar/p ratio in comparison with other experiments



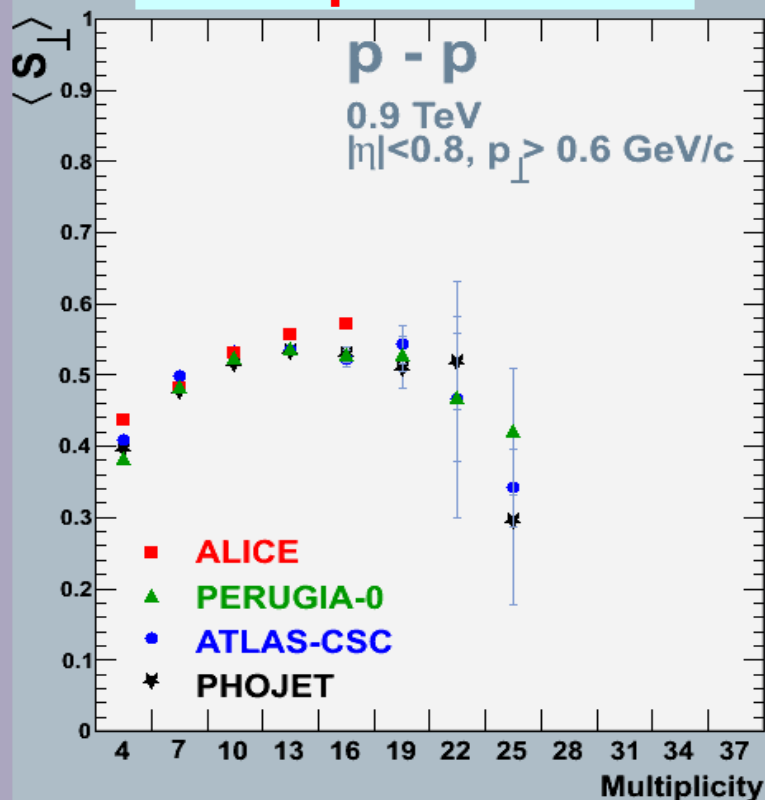
Event shape analysis in P_T space

Transverse **sphericity** S_{\perp} ,
defined as a function of
eigenvalues of the
momentum tensor S_{xy}

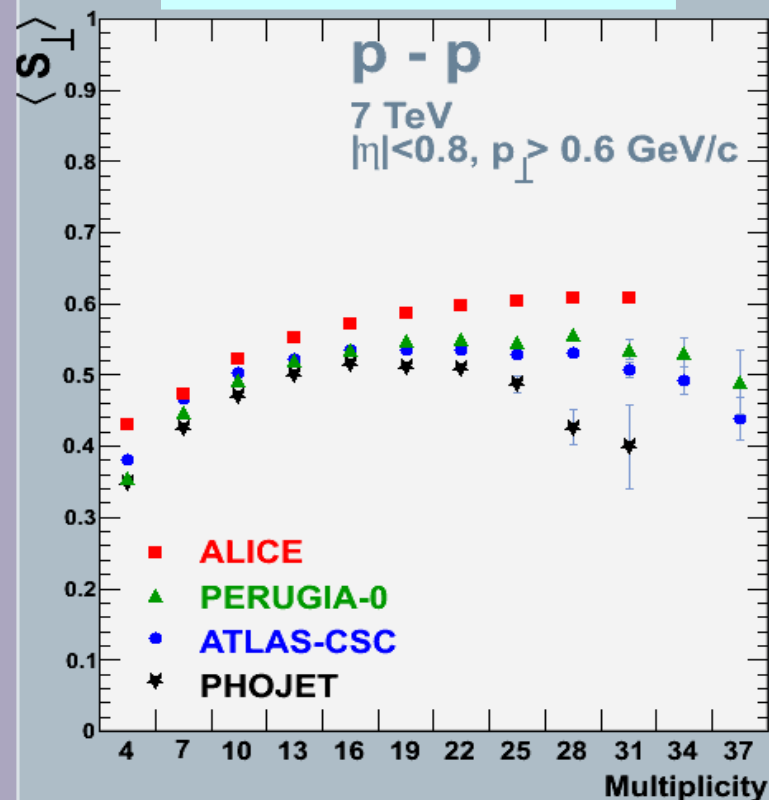
$$S_{\perp} \equiv \frac{2\lambda_2}{\lambda_2 + \lambda_1} \quad S_{xy} = \sum_i \begin{pmatrix} p_x^{(i)2} & p_x^{(i)} p_y^{(i)} \\ p_x^{(i)} p_y^{(i)} & p_y^{(i)2} \end{pmatrix}$$

$\langle S_{\perp} \rangle$ vs Multiplicity in pp Collisions at LHC energies

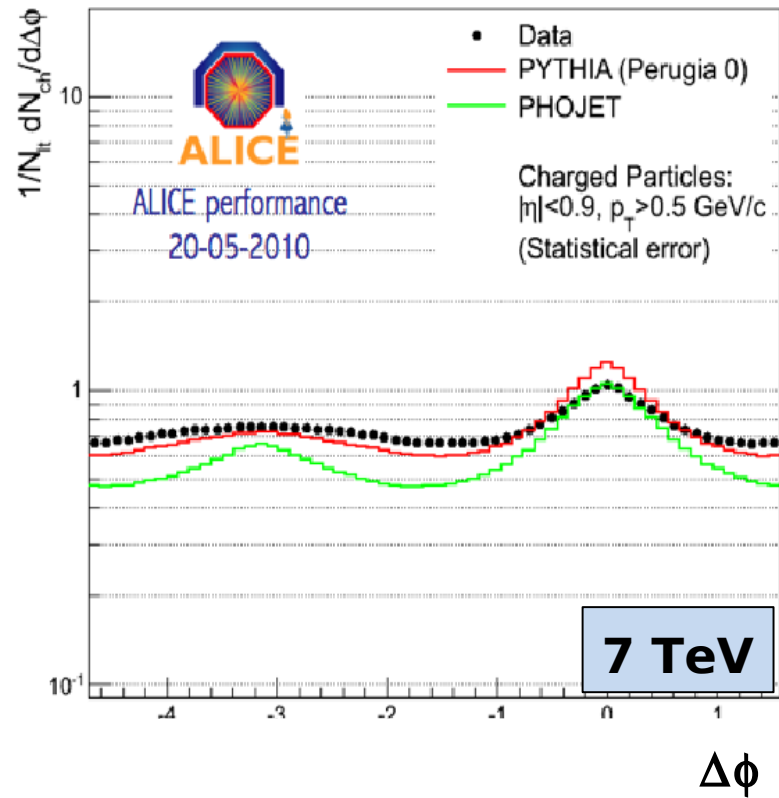
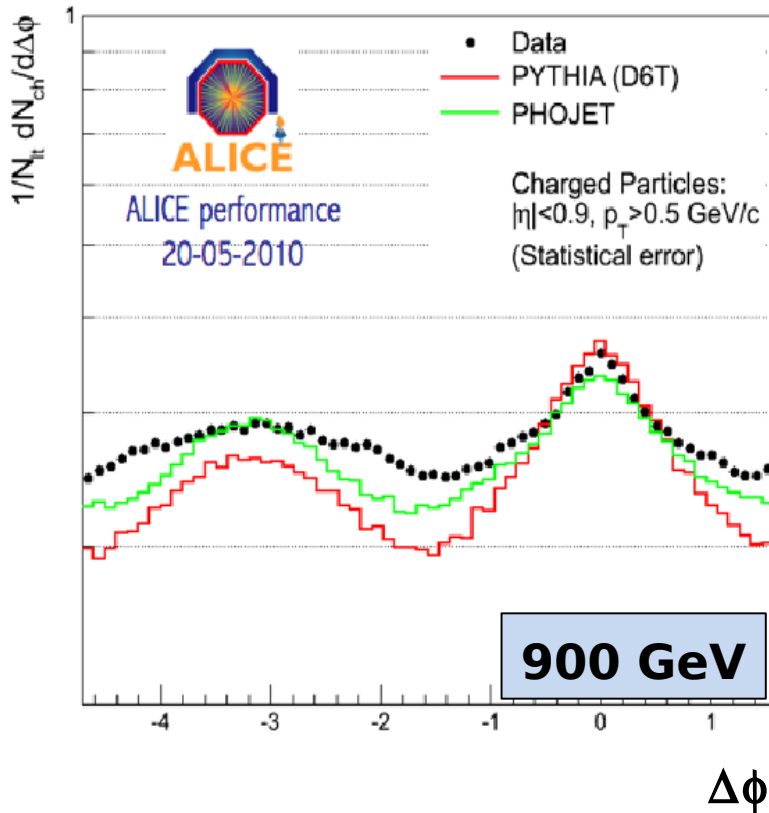
ALICE performance



HM events are more
spherical than models



Underlying Event Studies

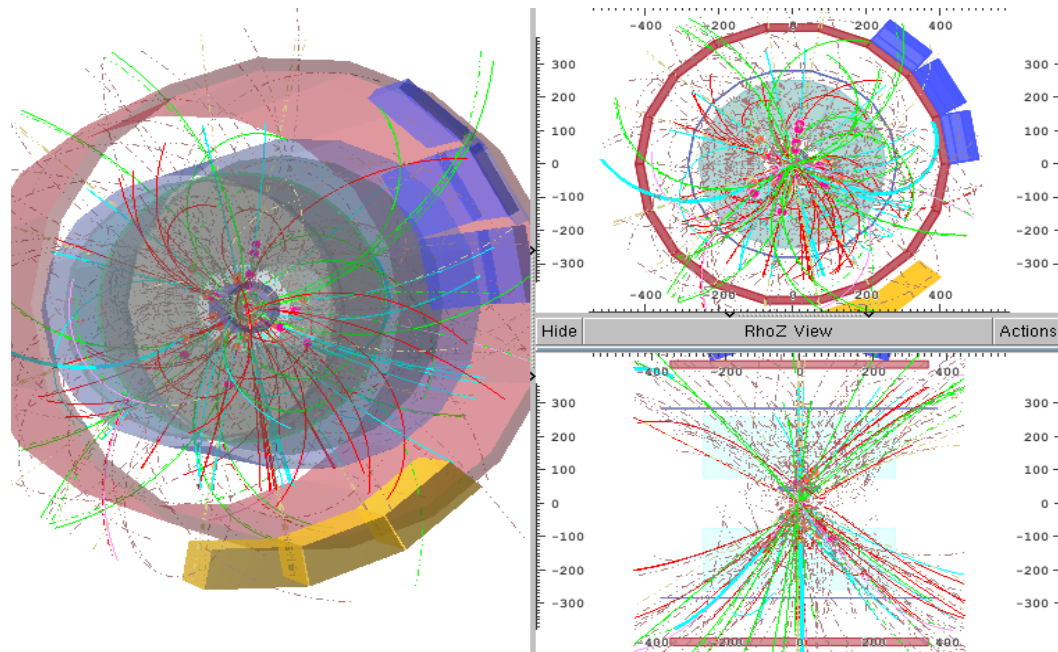


**Less back-to-back correlation than in MC events,
i.e. the experimental events are more spherical than those in MC**

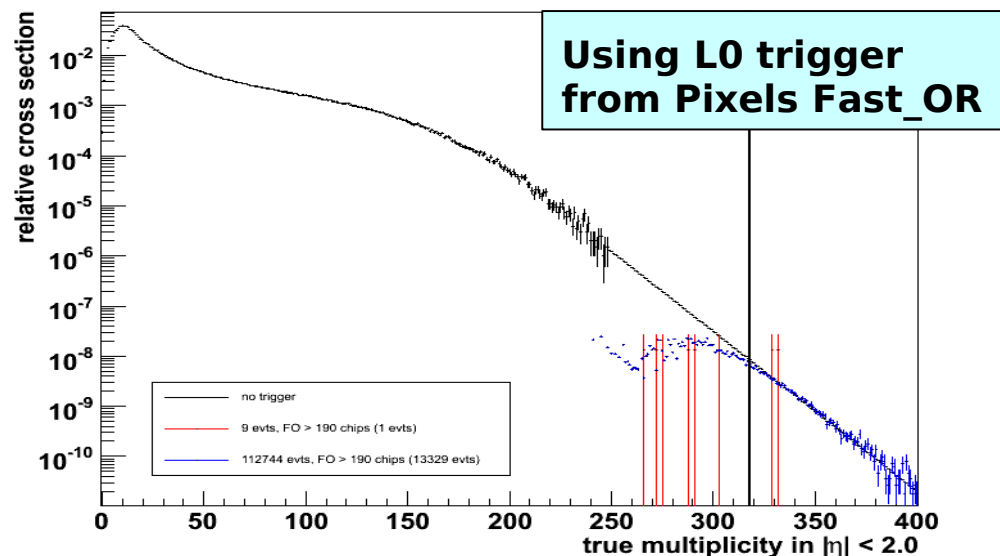
High multiplicity studies:

High multiplicity event in ALICE

- Motivation for high multiplicity pp:
 - Measure the multiplicity distribution up to highest reachable value 10 times average pp multiplicity → **potentially new physics**
 - Study collision properties vs multiplicity:
 - › Topology (p_t distribution, jets, sphericity, flow etc)
 - › Strangeness, baryon, charm content, HBT etc vs multiplicity
 - › Dependence of $\langle pT \rangle$, size of interaction region, correlations, p_{bar}/p , etc.
 - To be extended using **High multiplicity trigger from Pixels fast_OR**



SPD Layer 1



Summary

- ALICE setup is in a very good shape
- As a rule the first data are in agreement with previous experiments
- In the same time a poor agreement with MC models
- Energies, 0.9, 2.36 and 7 TeV, of pp collisions at LHC are comparable with the total energy in PbPb collisions at $\sqrt{s_{nn}} = 4.3, 11.3$ (region of K^+/π^+ horn) and 33.7 GeV of respectively, and thus collective phenomena could be expected
- Total charged multiplicity, particle yield ratios, back-to-back correlations, event sphericity etc. indicate that collective phenomena in pp collisions are stronger than expected in MC models
- It would be quite interesting to study different distributions and parameters versus the collective variables, i.e. Multiplicity, Sphericity, Transfer energy etc.
- The High Multiplicity trigger is a key to the new physics in pp collisions

Instead of the Conclusion:

- J.D.Bjorken, Fermilab Pub 82/59 THY, Aug. 1982:

For hadron-hadron collisions with high associated multiplicity and with transverse energy dE/dy in excess of 10 GeV per unit rapidity it is possible that quark-gluon plasma produced in the collision. If so, a produced secondary high P_t quarks or gluon must lost tens of GeV of its initial transverse momentum while flowing through quark-gluon plasma produced in its local environment.

- J.P.Revol, LHC days in Split, 04 Oct. 2010:

Many reasons for ALICE to take pp collisions very seriously

