The ALICE maiden run 2010: first results and outlook

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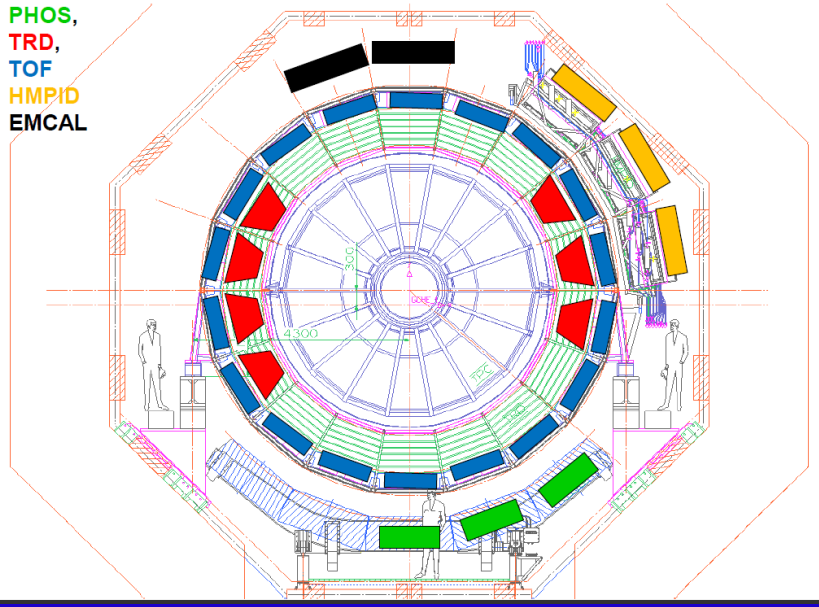
on behalf of the ALICE Collaboration

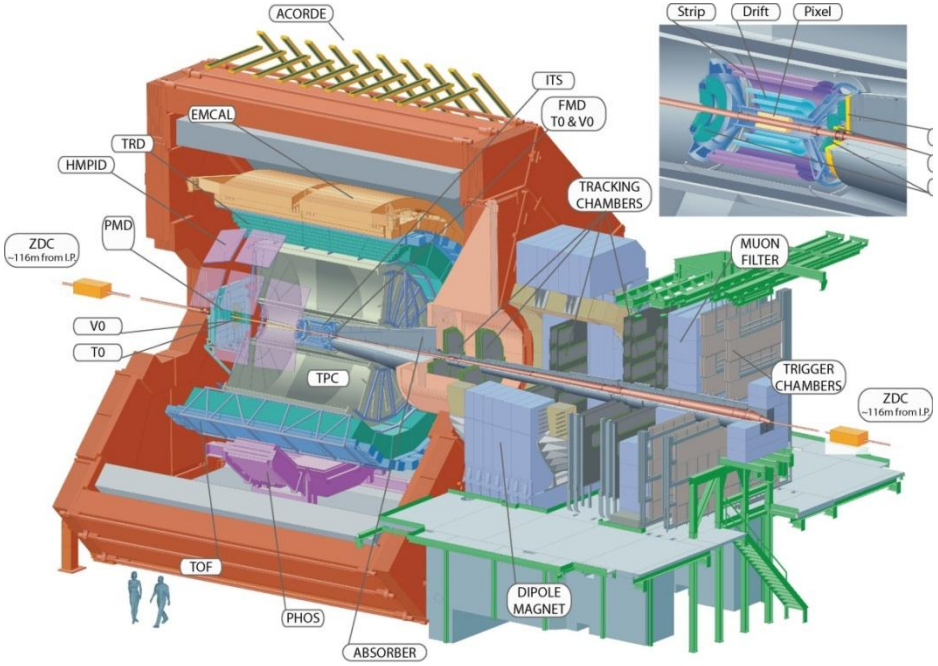
Contents

- Running configuration
- First results and prospects from pp
- Outlook for the Pb-Pb run
- Conclusions

Detector configuration

- ITS, TPC, TOF, HMPID, MUON, V0, To, FMD, PMD, ZDC (100%)
- TRD (7/18)
- EMCAL (4/12)
- PHOS (3/5)
  - at nominal T (-25 C)
- HLT (60%)



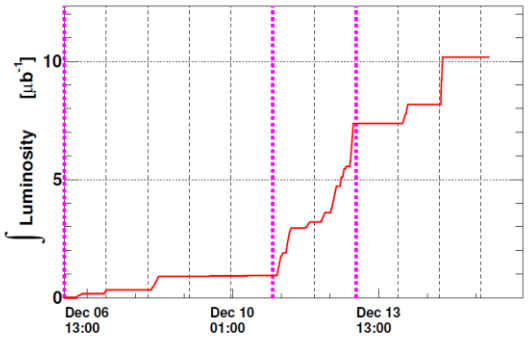


Trigger configuration

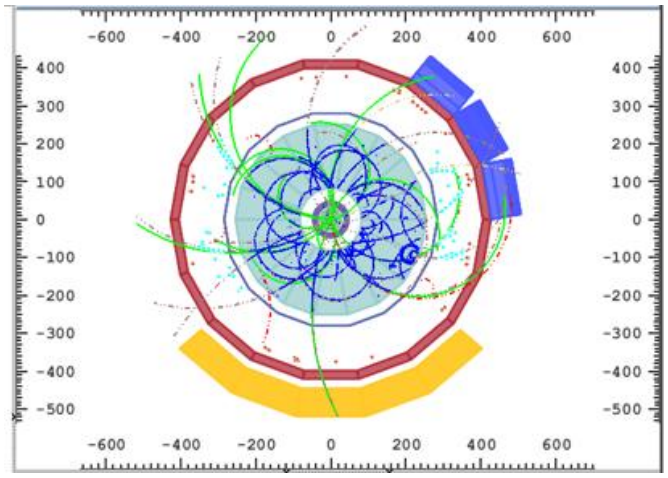
- minimum bias interaction trigger
  - Si pixels (two inner layers of ITS) OR V0 (scintillators)
  - → ~ at least one charged particle in 8 pseudorapidity units
- + rare triggers:
  - single-muon in muon arm
  - high multiplicity (> 65 charged detected in three central units of η)
- activated in coincidence with the bunch crossings (BX):
  - BX with bunches from both sides
  - for control BX with bunch from side A or C only
  - for control BX with no bunches
- + a fraction of 'bunch-crossing' trigger (no condition on trigger detectors)
  - for control
  - for diffraction studies
- no further event rejection in High Level Trigger

ALICE running so far

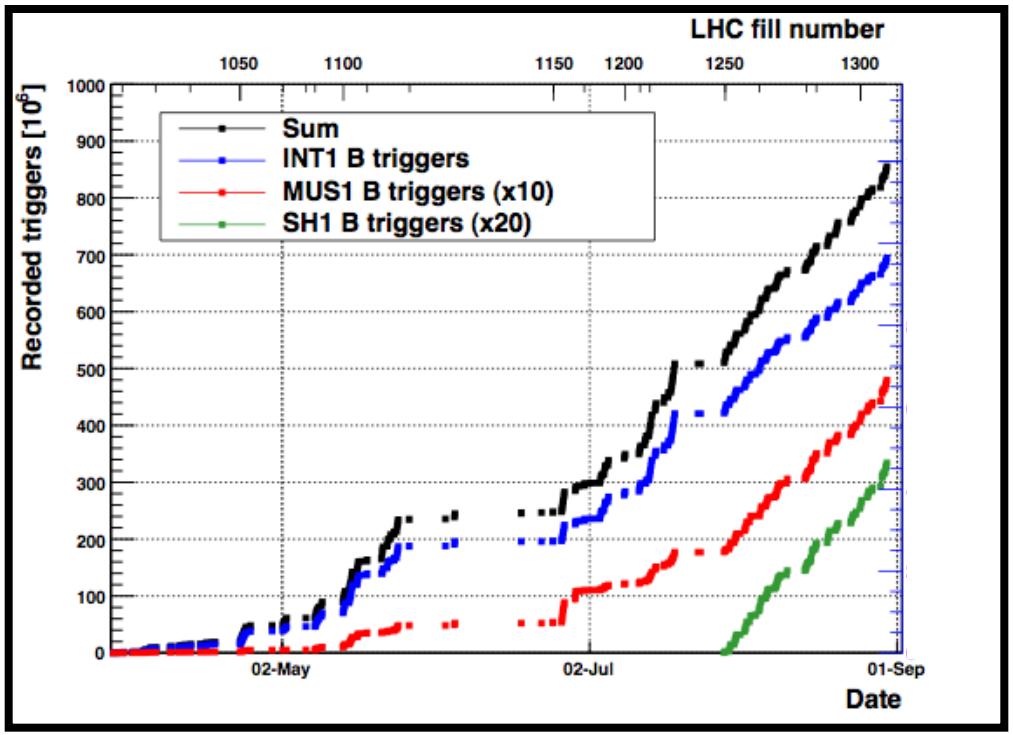
- 2009 (0.9 and 2.36 TeV)
  - ~10.3 μb^{-1}



  - ~ 500 k min bias



- 2010 (so far)

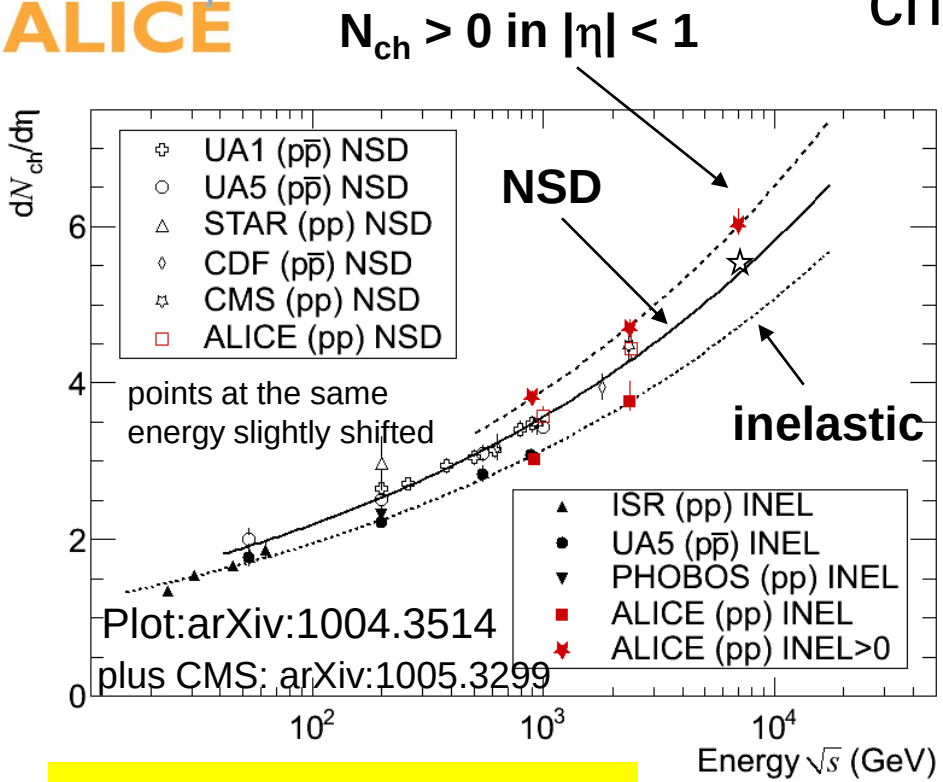


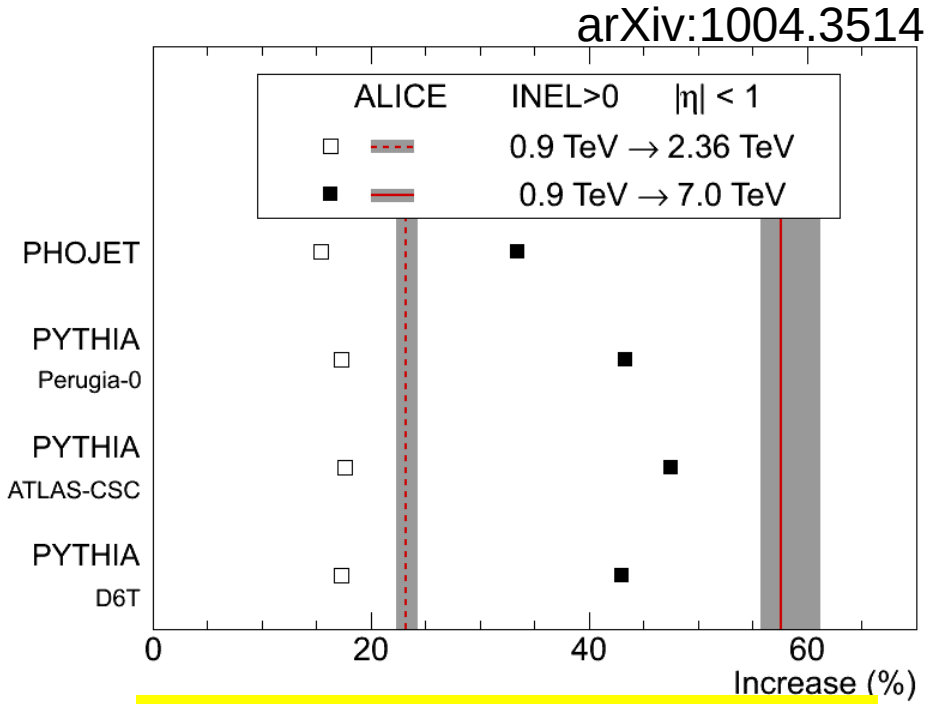
- ~ 700 M min bias triggers
- ~ 50 M single muon triggers
- ~ 15 M high multiplicity triggers

Six papers so far

- First proton-proton collisions at the LHC as observed with the ALICE detector: measurement of the charged particle pseudorapidity density at sqrt(s) = 900 GeV
  → K Aamodt et al: EPJ C 65 (2010) 11, arXiv:0911.5430
- Charged-particle multiplicity measurement in proton-proton collisions at sqrt(s) = 0.9 and 2.36 TeV with ALICE at LHC
  → K Aamodt et al: EPJ C 68 (2010) 89, arXiv:1004.3034
- Charged-particle multiplicity measurement in proton-proton collisions at sqrt(s) = 7 TeV with ALICE at LHC
  → K Aamodt et al: arXiv:1004.3514, accepted by EPJ C
- Midrapidity antiproton-to-proton ratio in pp collisions at sqrt(s) = 0.9 and 7 TeV measured by the ALICE experiment
  → K Aamodt et al: PRL 105 (2010) 072002, arXiv:1006.5432
- Two-pion Bose-Einstein correlations in pp collisions at sqrt(s) = 900 GeV
  → K Aamodt et al: arXiv:1007.0516, submitted to Phys. Rev. D
- Transverse momentum spectra of charged particles in proton-proton collisions at sqrt(s) = 900 GeV with ALICE at the LHC
  → K Aamodt et al: arXiv:1007.0719, accepted by Phys Lett B

$dN_{ch}/d\eta$ vs. $\sqrt{s}$



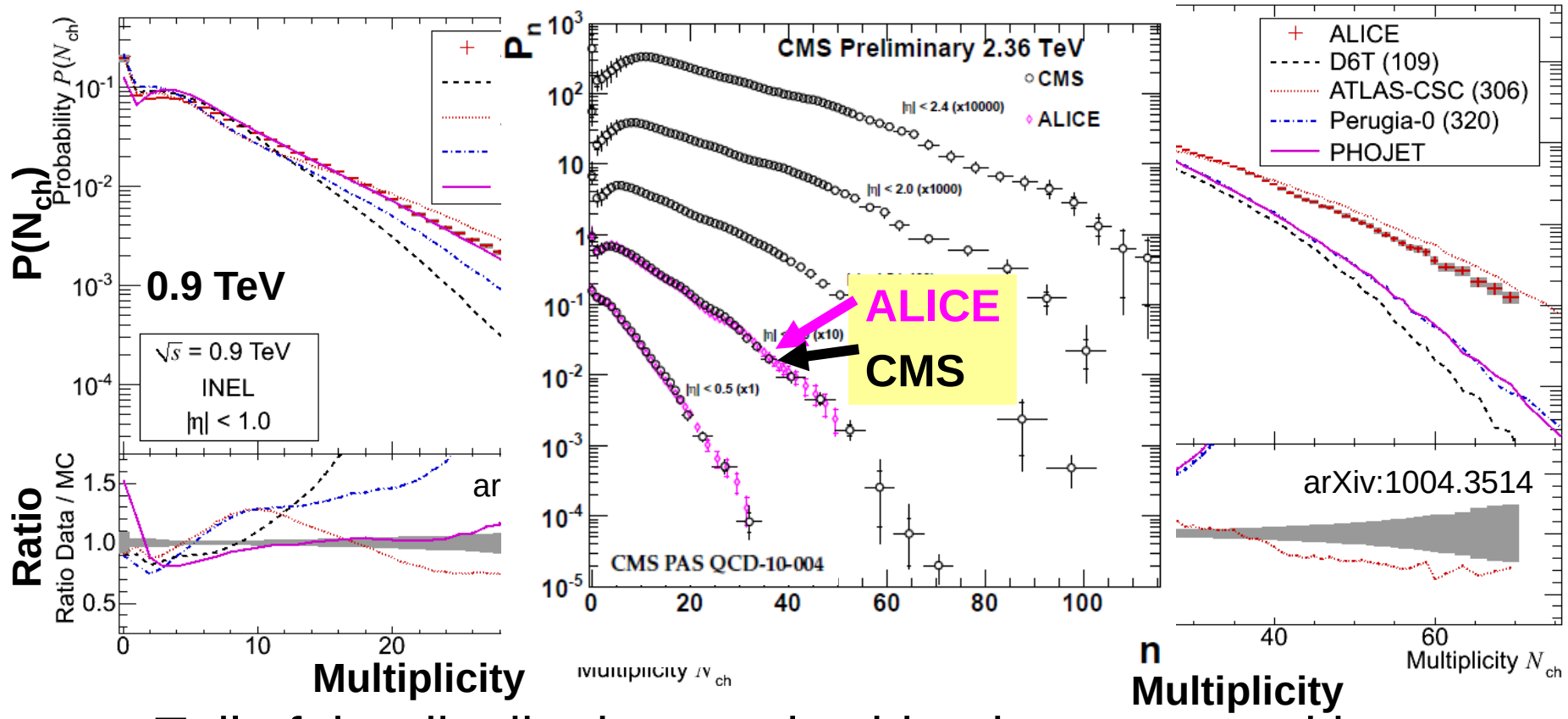


Power law dependence fits well

Significantly larger increase from 0.9 to 7 TeV than in MCs

Increase in $dN_{ch}/d\eta$ in $\|\eta\| < 1$ for INEL > 0 arXiv:1004.3514	**$\sqrt{s}$**	**ALICE (%)**	**MCs (%)**
	0.9 → 2.36 TeV	**23.3 $0.4\ ^{+1.1}_{-0.7}$**	**15 – 18**
	0.9 → 7 TeV	**57.6 $0.4\ ^{+3.6}_{-1.8}$**	**33 – 48**

Multiplicity Distributions

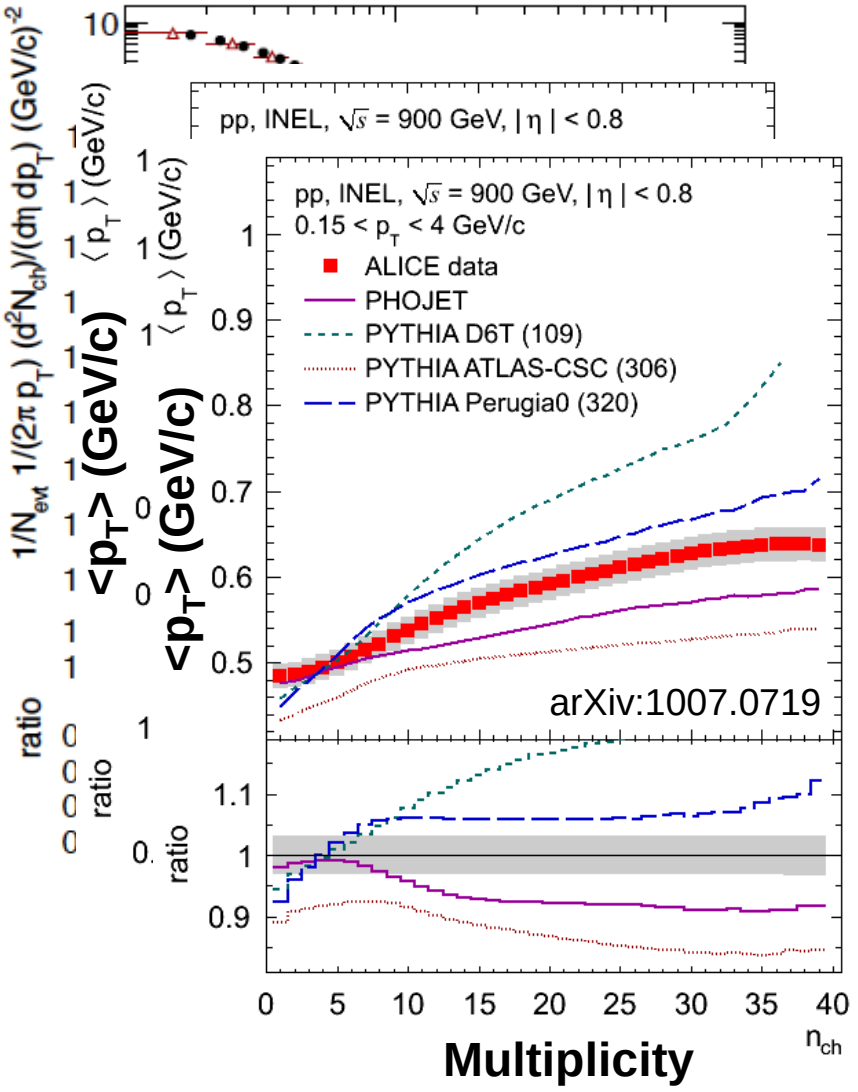


- Tail of the distribution much wider than expected by most MCs
- Excellent agreement between ALICE and CMS

Momentum Distributions

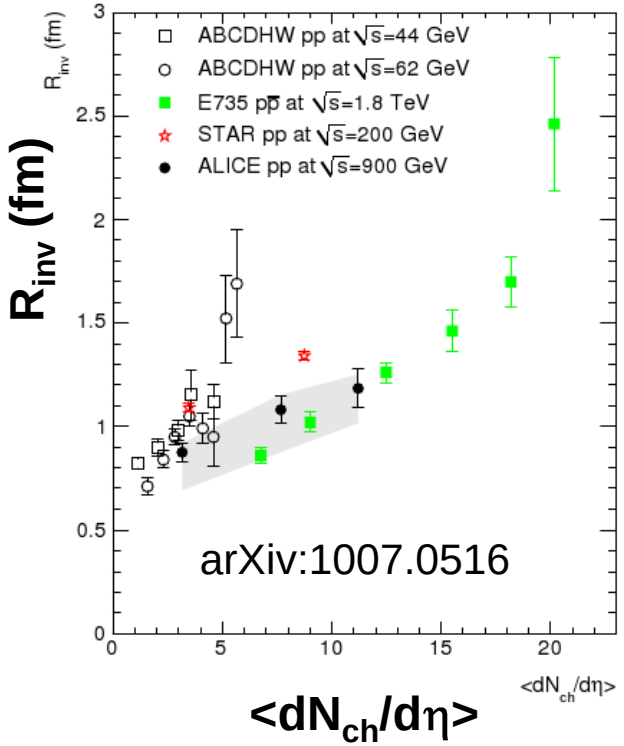
- dN_{ch}/dp_T
  - Seems to get harder towards midrapidity / smaller rapidity window
  - Modified Hagedorn function fits full range
  - Exponential fits above 3 GeV/c
- $\langle p_T \rangle$ vs. N_{ch}
  - Perugia-0 reproduces distribution for $p_T > 0.5$ GeV/c
  - But not for $p_T > 0.15$ GeV/c

→ Soft particle production important to measure (strong point of ALICE)

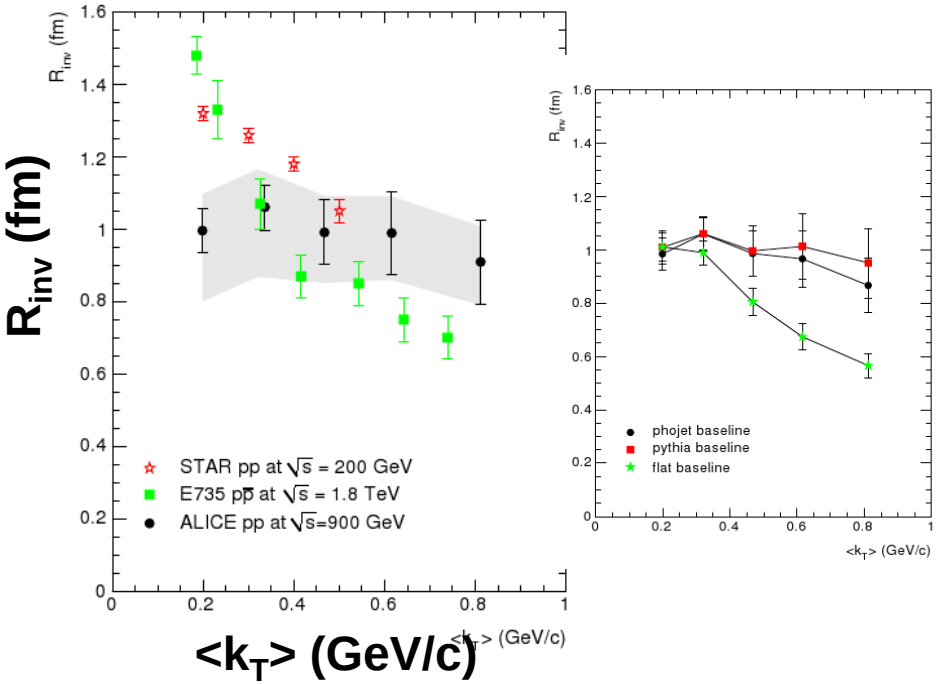


HBT interferometry

- R_{inv} increases v multiplicity



- R_{inv} ~ flat v centrality
  - in contrast with STAR, E735



NB: STAR, E735 both used flat baseline

similar results in ALICE when using flat baseline

→ jet-like correlations are important (at least at the LHC)

Antiproton-to-Proton Ratio

- Can one stop a proton 'on its track' at LHC?
- Where does the conserved baryon number reappear after the pp collision?

$z^a \rightarrow e^{-a\Delta y} = e^{-(1-\alpha)\Delta y}$ ($\Delta y \gg 1$)

α = intercept of relevant Regge trajectory

$\Delta y = y_{beam} - y_{baryon}$ = 'rapidity loss'

- Fragmentation function f(z) of baryon number
  - Di-quark qq: z^2 => $\alpha = -1 \ldots -0.5$, small Δy
  - Single q: $\sqrt{z}$ => $\alpha = 0.5$, medium Δy
  - Baryon junction? (no valence q): α = ??; large Δy ??

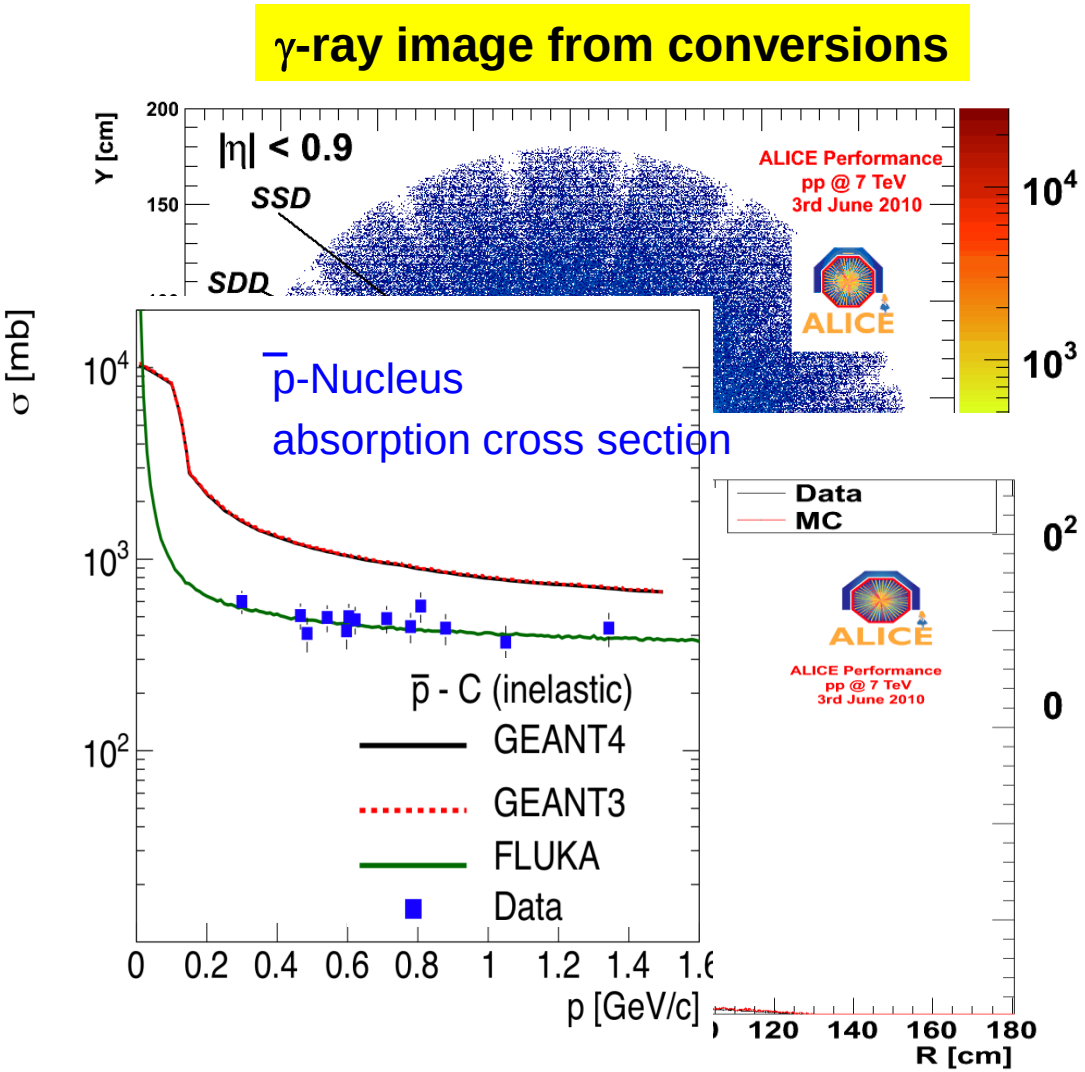
Veneziano: $\alpha \approx 0.5$ others: $\alpha \approx 1$ (pQCD estimates, σ(p-pbar annihilation), 'odderon')

$\alpha \approx 1$ => f(y) = constant, pbar/p < 1 at all energies (< 0.93 at LHC)

G.C. Rossi and G. Veneziano, Nucl. Phys. B123, (1977) 507
B.Z. Kopeliovich, Sov. J. Nucl. Phys. 45, 1078 (1987)

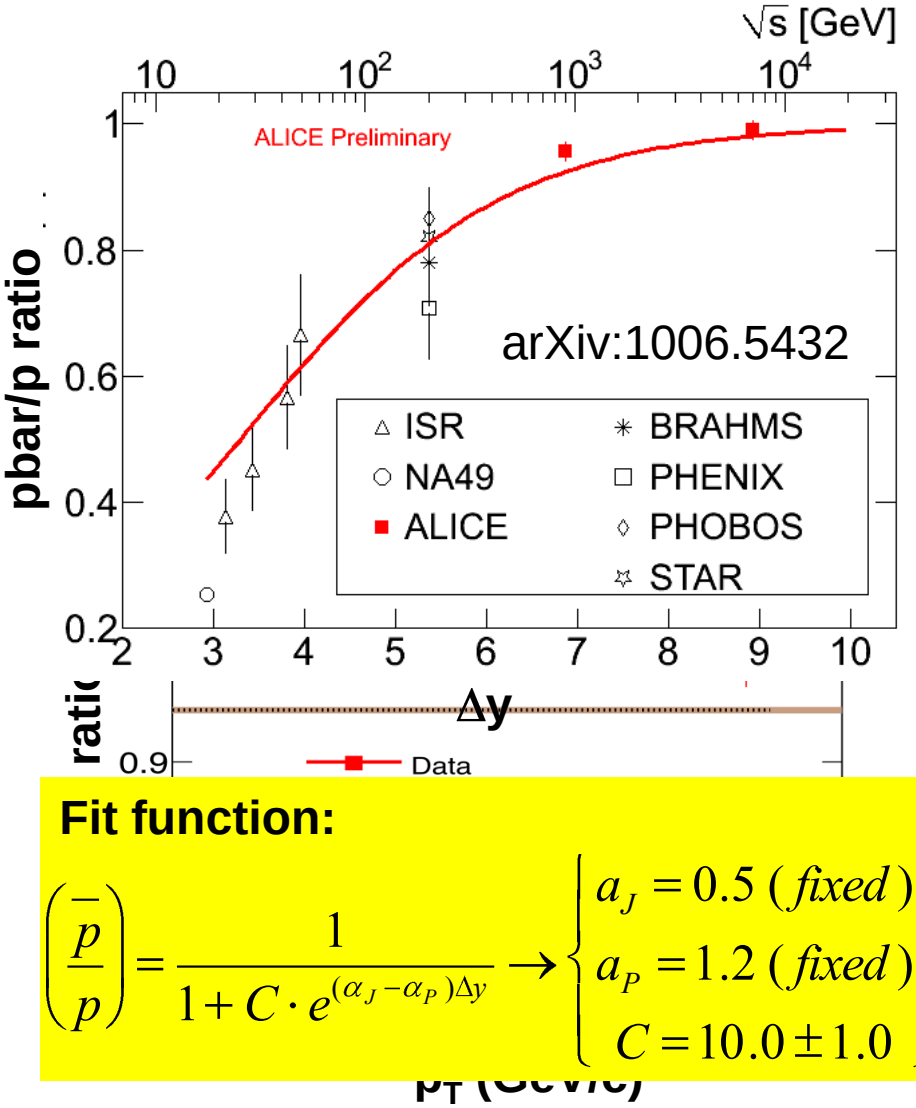
Antiproton-to-Proton Ratio (2)

- Very challenging measurement
  - Measure the ratio to 1% precision
- Assess material budget from data
- pbar-nucleus cross-section not consistent between transport codes



Antiproton-to-Proton Ratio (3)

- Results show no p_T dependence for both energies
  - Results are compared with model predictions with different BN transport mechanisms
    - MCs with enhanced stopping do not reproduce data
- Energy dependence of the ratio parametrized based on the contribution of different diagrams describing the p(bar) production (pair production at mid-rapidity and BN transfer)
  - Junction intercept set to 0.5
  - Little room for additional diagrams which transport baryon number over large rapidity gaps

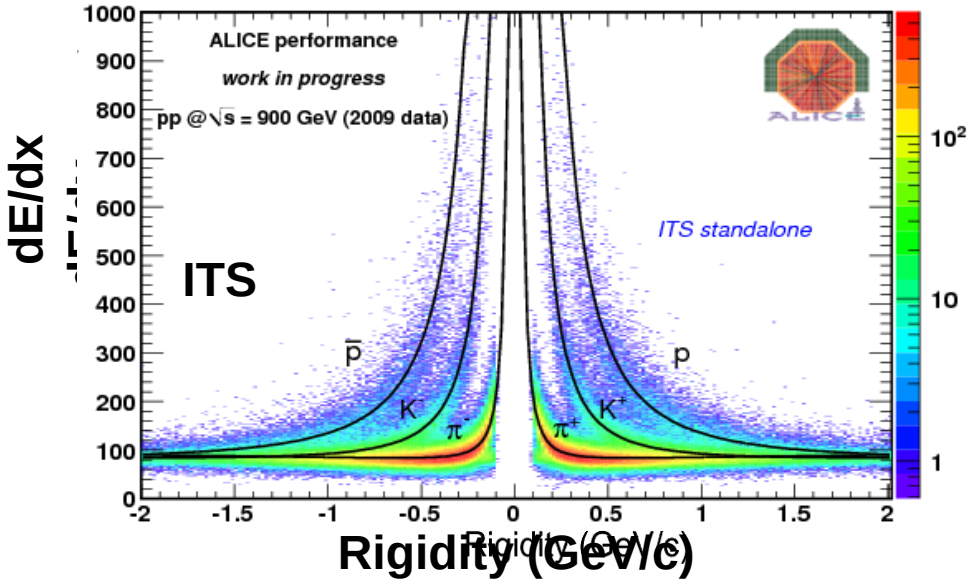


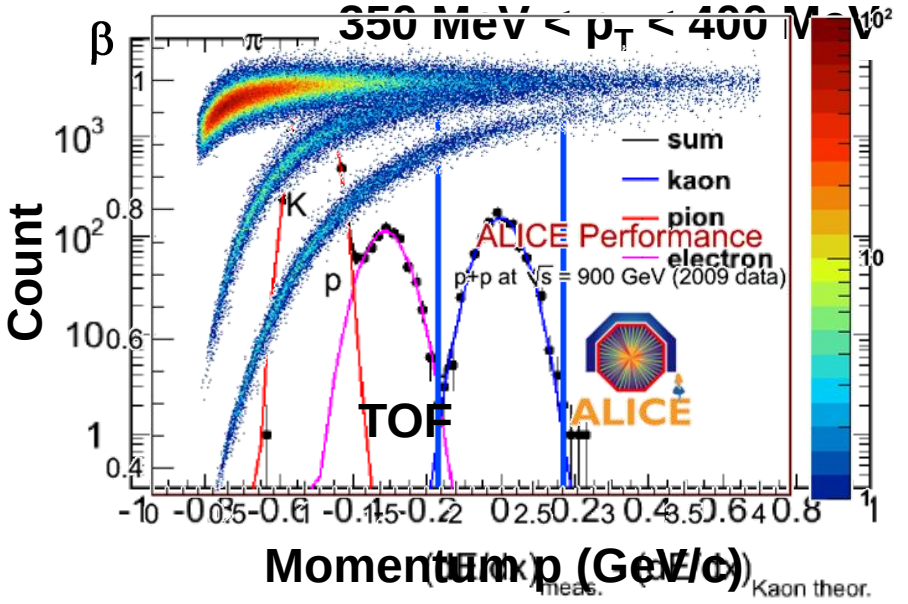
Fit function:

$$\left(\frac{\bar{p}}{p}\right) = \frac{1}{1 + C \cdot e^{(\alpha_J - \alpha_P)\Delta y}} \rightarrow \begin{cases} a_J = 0.5\ (fixed) \\ a_P = 1.2\ (fixed) \\ C = 10.0 \pm 1.0 \end{cases}$$

Particle Identification

- Use ITS, TPC and TOF for identification of charged hadrons
- Identified particle spectra
  - Baseline for HI
  - Tuning of MC generators
- Identified particles used in further analysis (e.g. strange particles)



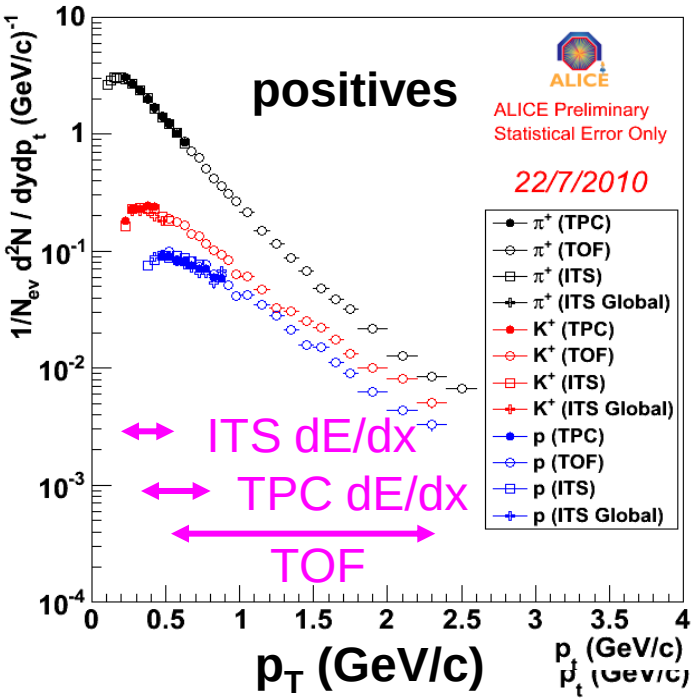


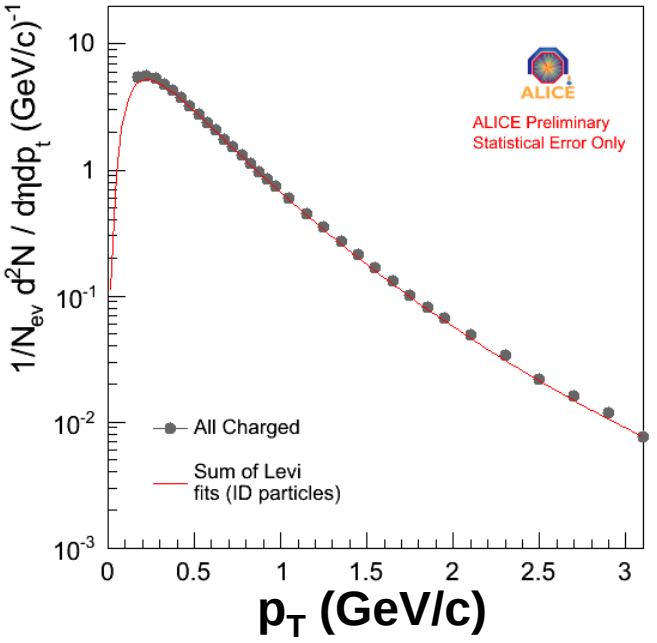
Identified Particle Spectra

- Spectra from different detectors consistent
- Levi (Tsallis) function fits the data at low p_T

$$\frac{dN}{dp_T} \alpha\ p_T \left(1 + \frac{m_T - m}{nT_l}\right)^{-n}$$

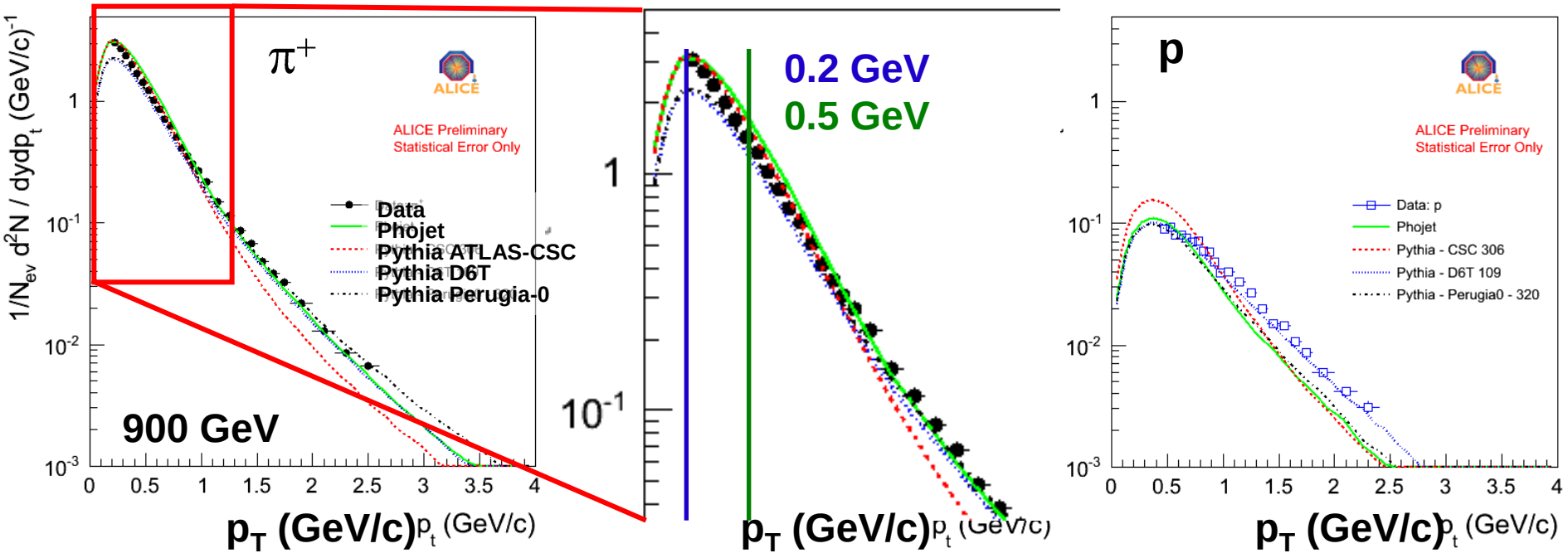
- Sum of fits (π+K+p) matches well with dN_{ch}/dp_T (all charged) result
- Fit also allows to extract integrated yields





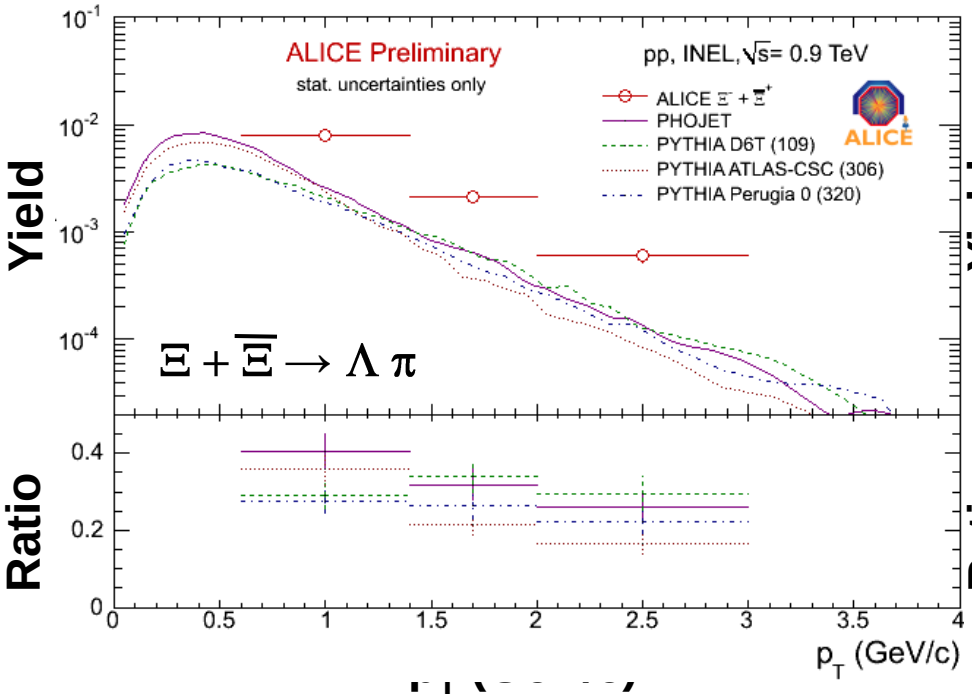
Hadron Yields

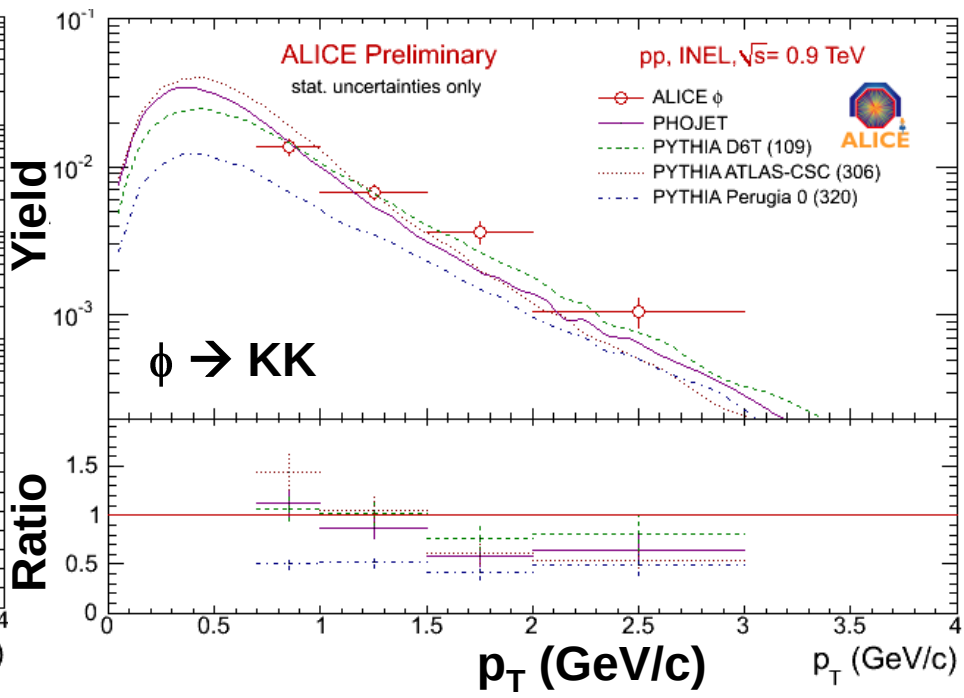
- Yields of π, K, p as function of p_T (here for pos. particles, similar for neg.)
- Pions reasonably described by Phojet, Pythia D6T, Perugia-0
- Kaon yield underestimated above p_T of 1 GeV/c
- Proton yield underestimated except by Pythia D6T



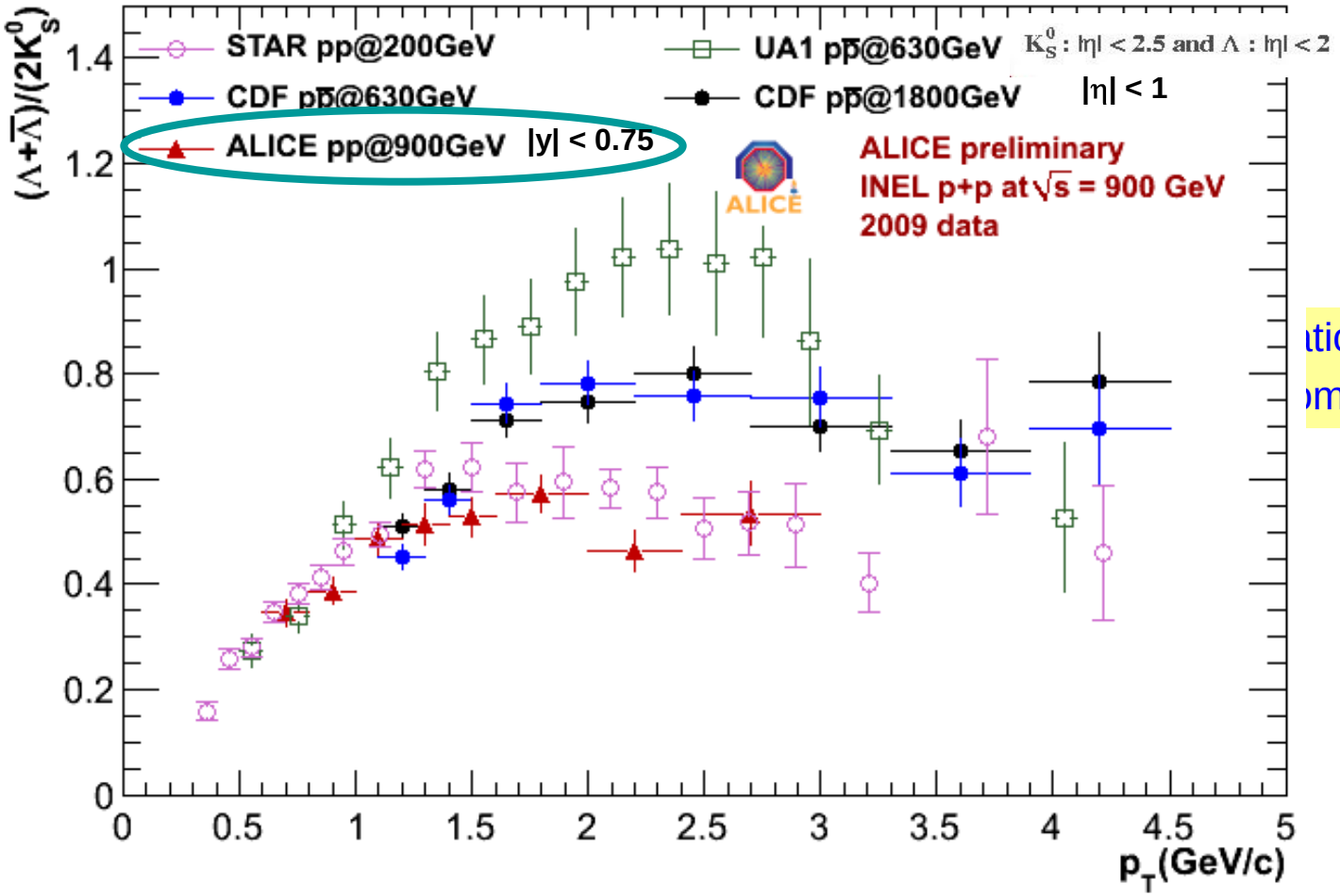
Strange Particle Yields

- Yields of K_0^S, Λ, Ξ as function of p_T
- Pythia 6 (D6T, ATLAS-CSC, Perugia-0) and Phojet underestimate overall yields
- Larger discrepancy with increasing particle mass, strangeness and p_T
- But the ϕ is ~ ok within uncertainties





Λ/K^0_S ratio 900 GeV

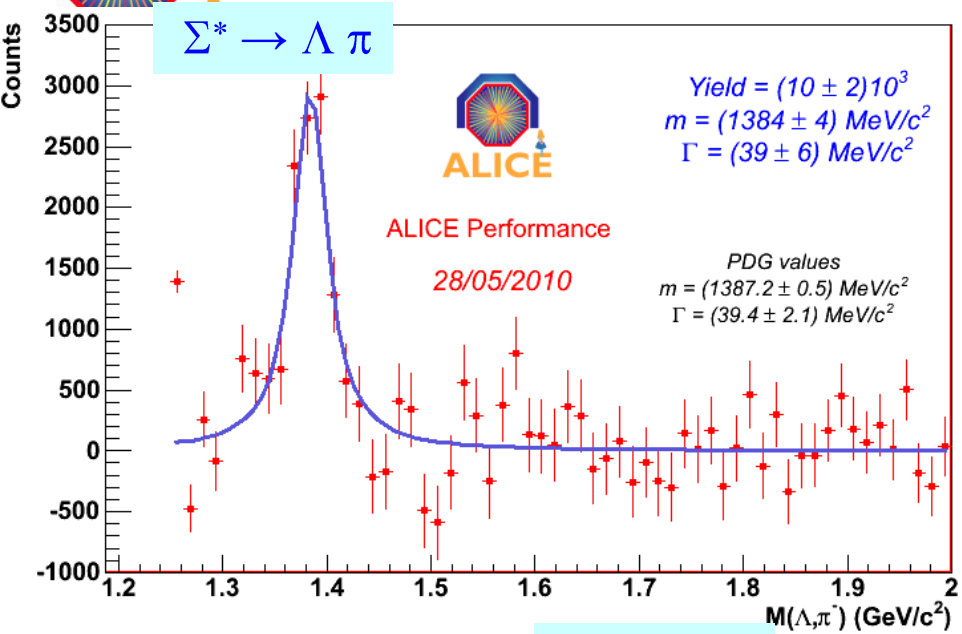


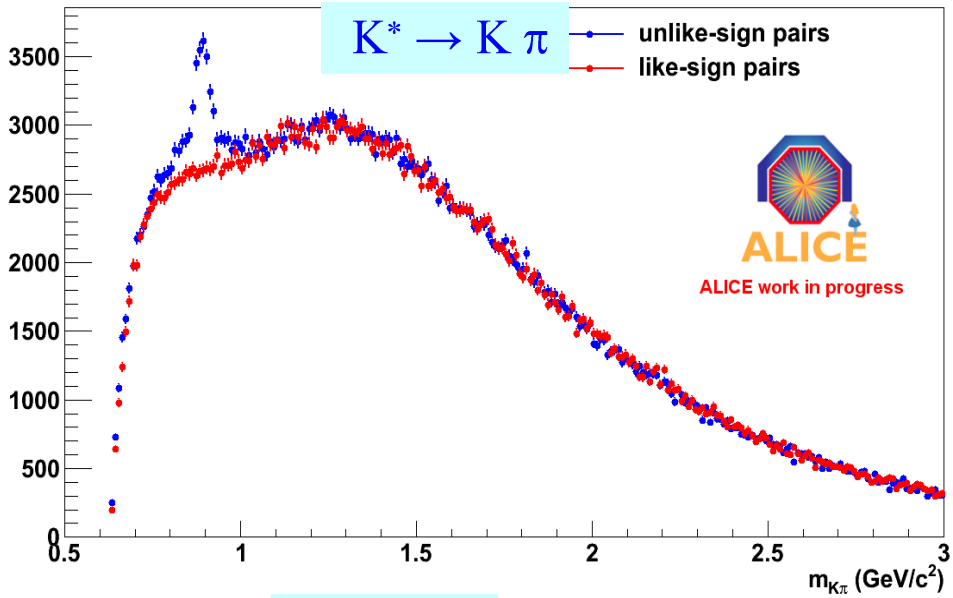
tio:
m QGP ?

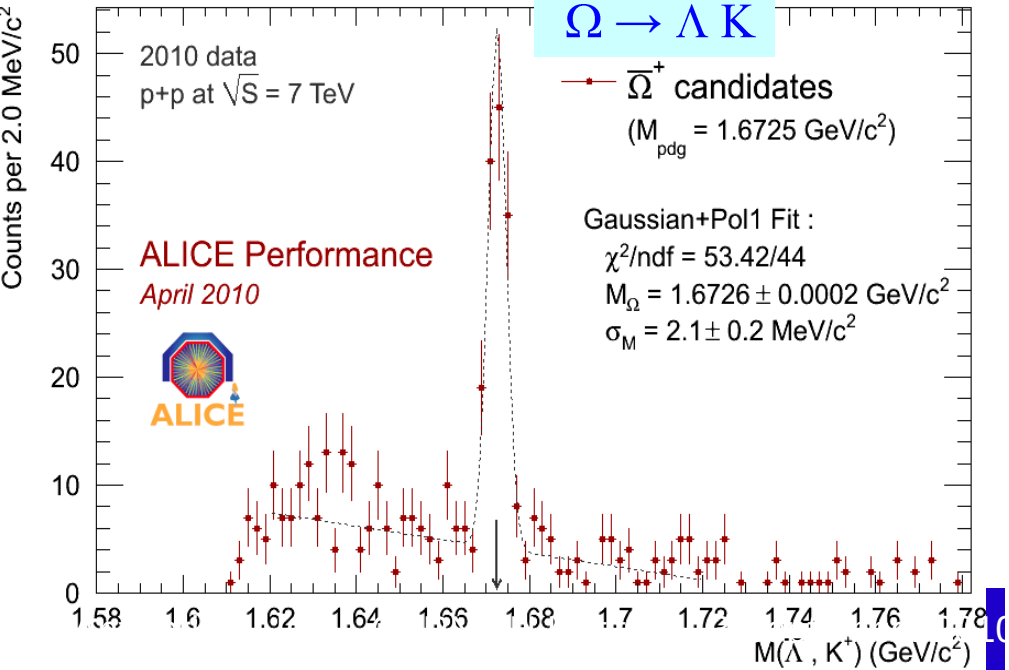
- very good agreement between STAR (200 GeV) and ALICE (900 GeV)
- very different from CDF (630/1800) and UA1 (630) for $p_T > 1.5$ GeV
- UA1(630) and CDF(630) don't agree either …

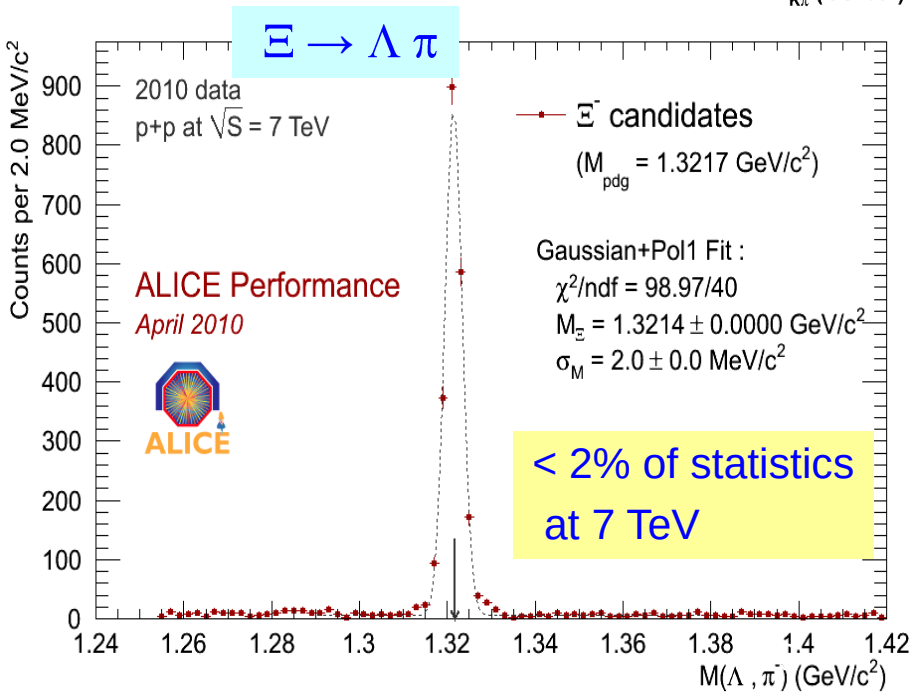
to be further investigated (different triggers, acceptance, feed-down correction ?)

…and much more to come...

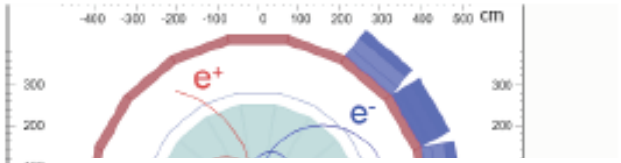






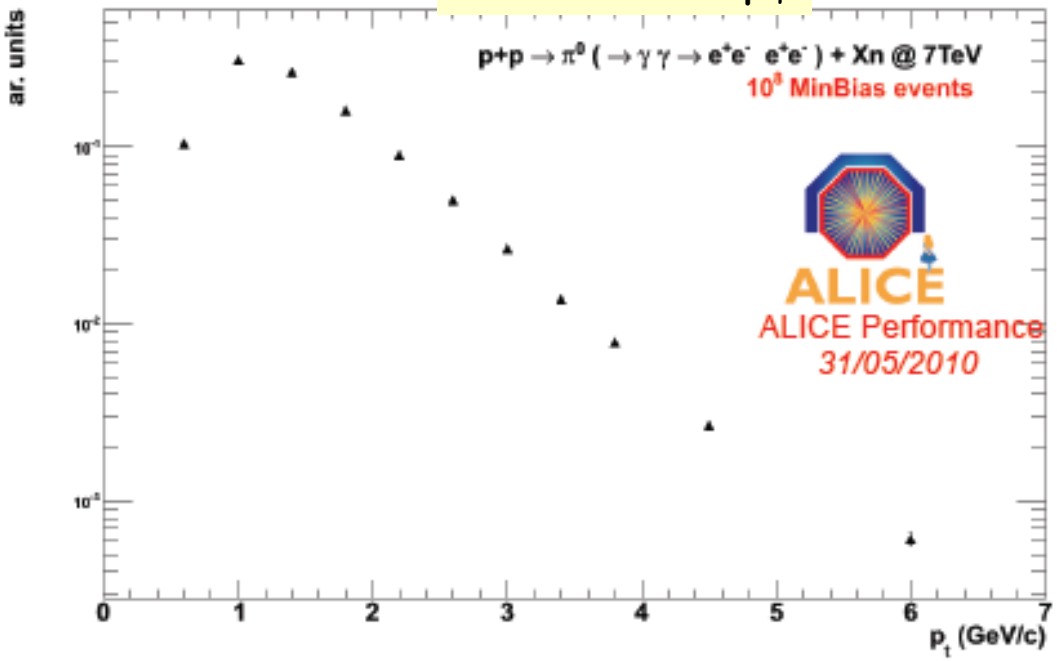


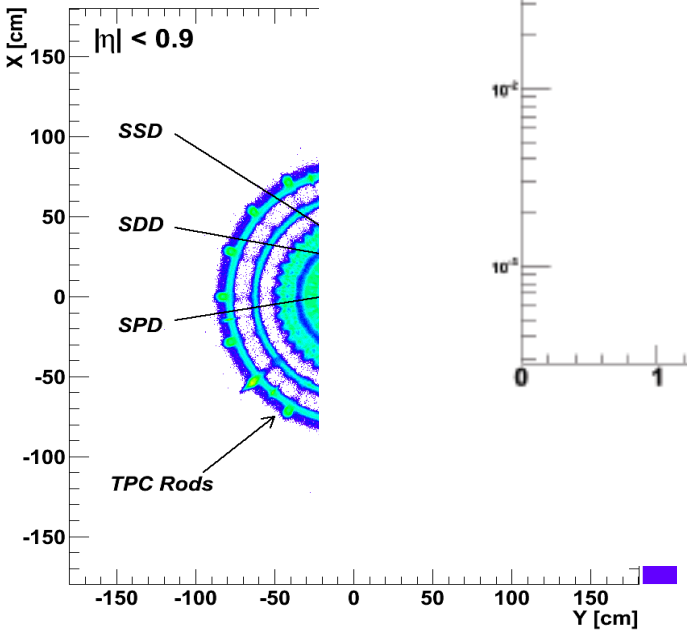
π^0 and η from γ conversion

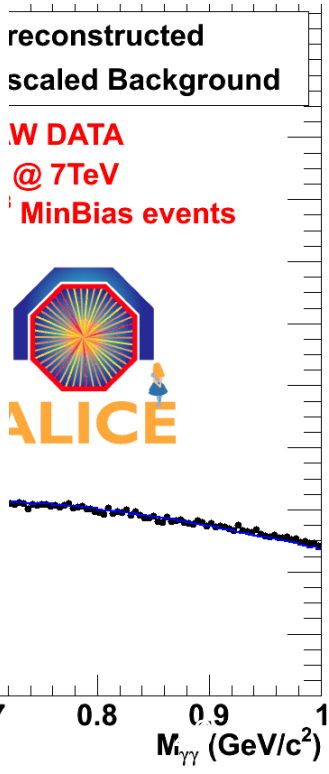


- e identification in TPC (TRD soon)
- study of γ conversion points/material

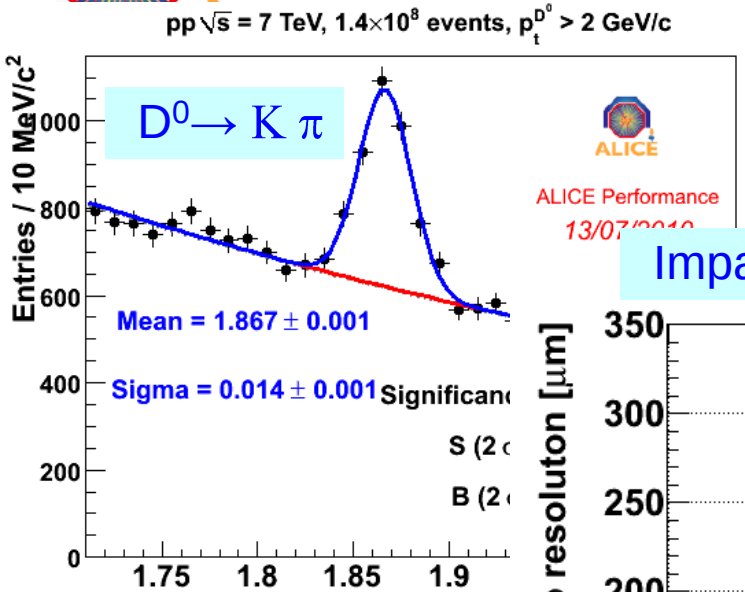
Raw π^0 dN/dp_T

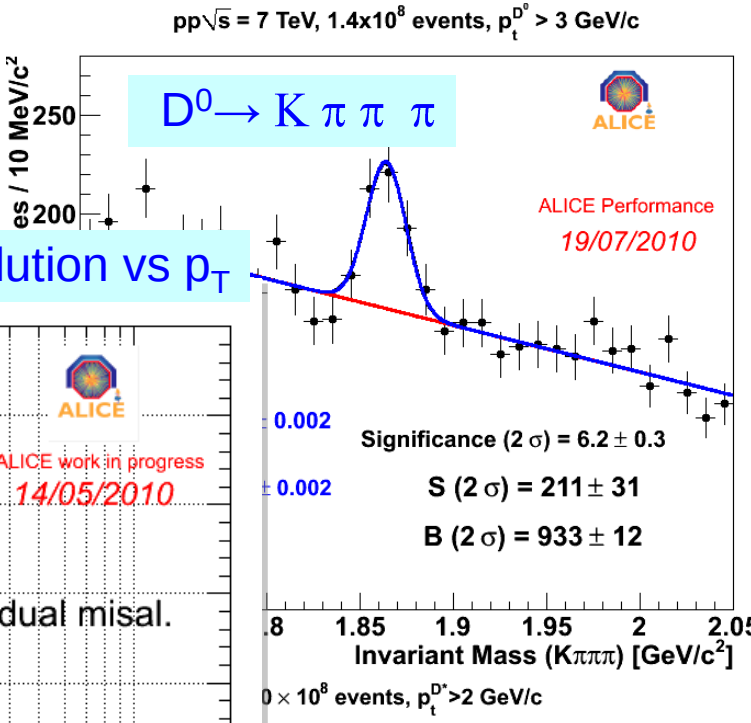


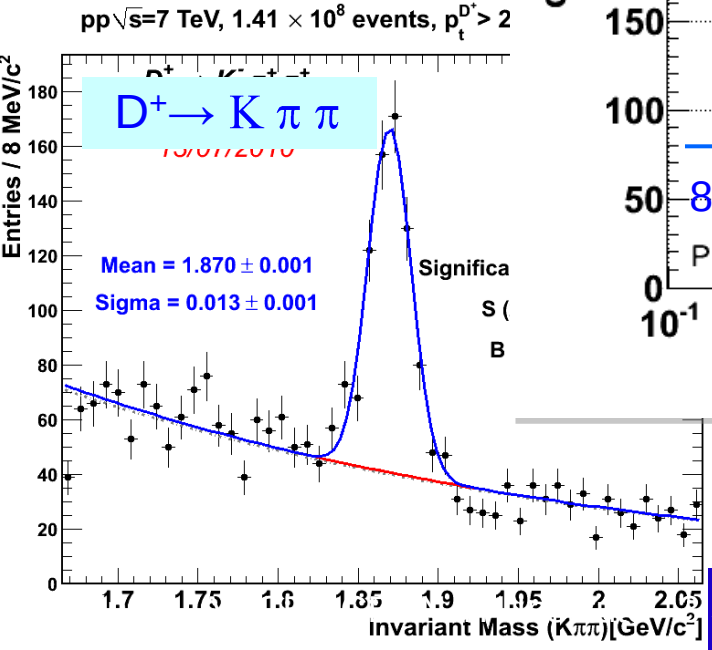


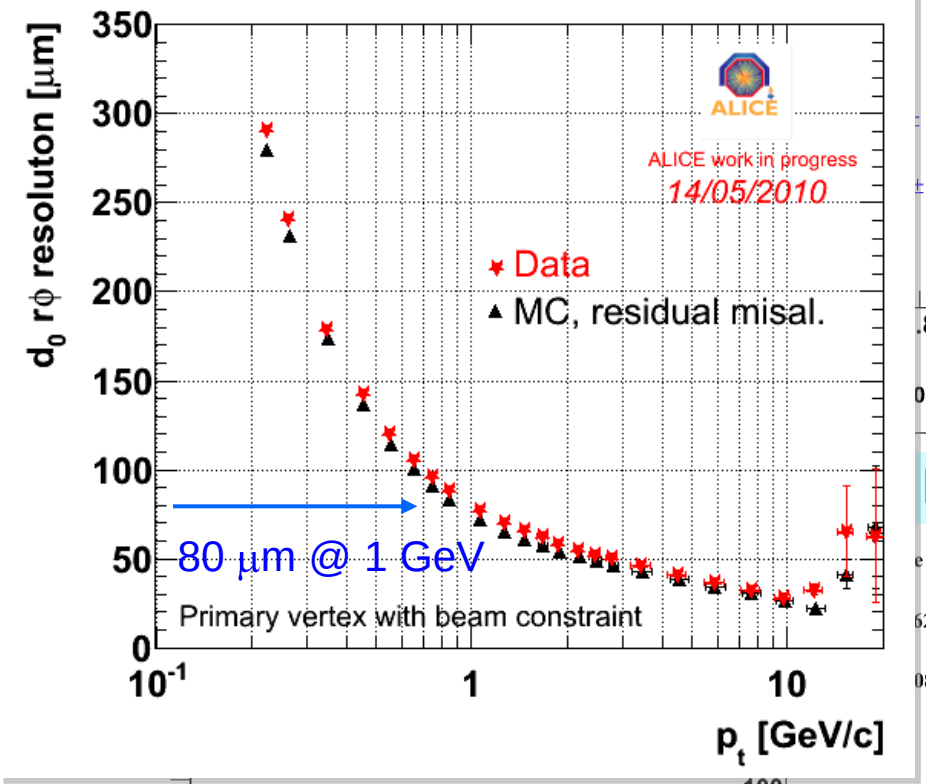


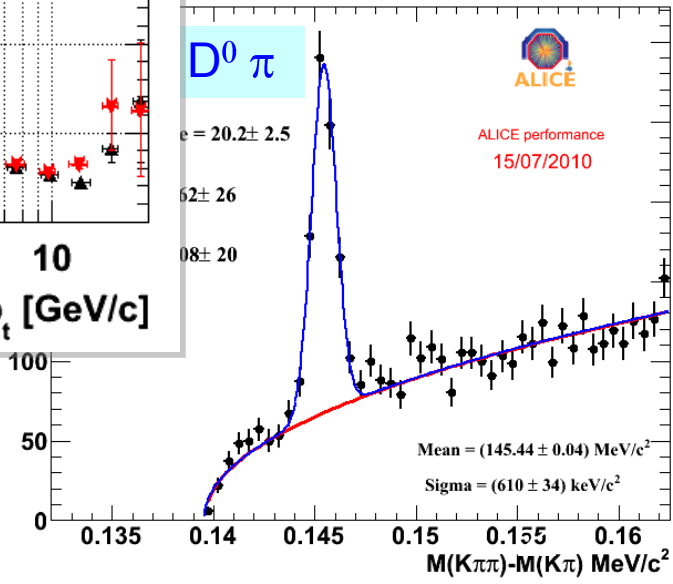
Charm at 7 TeV











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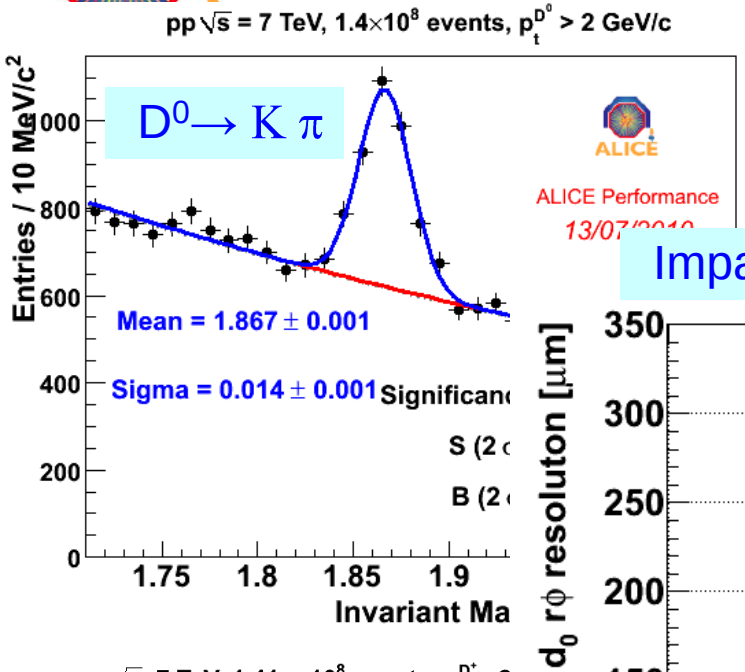
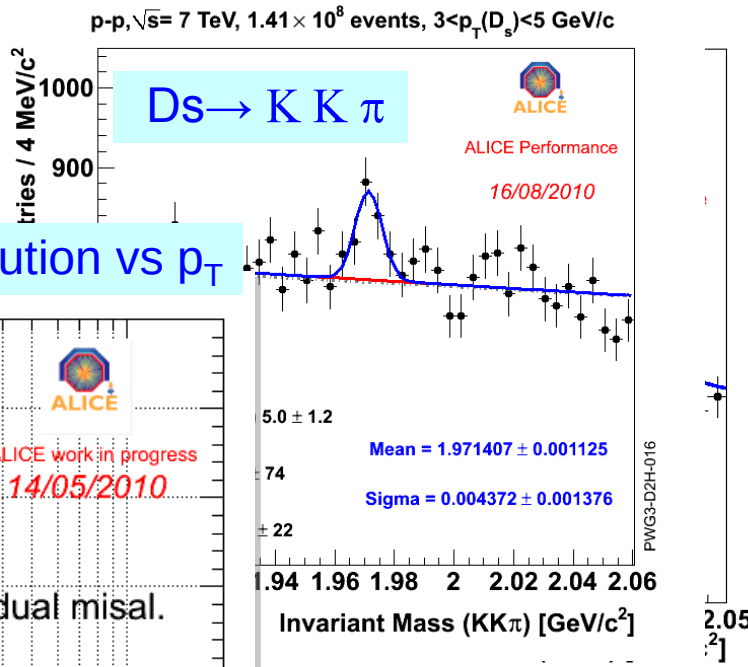
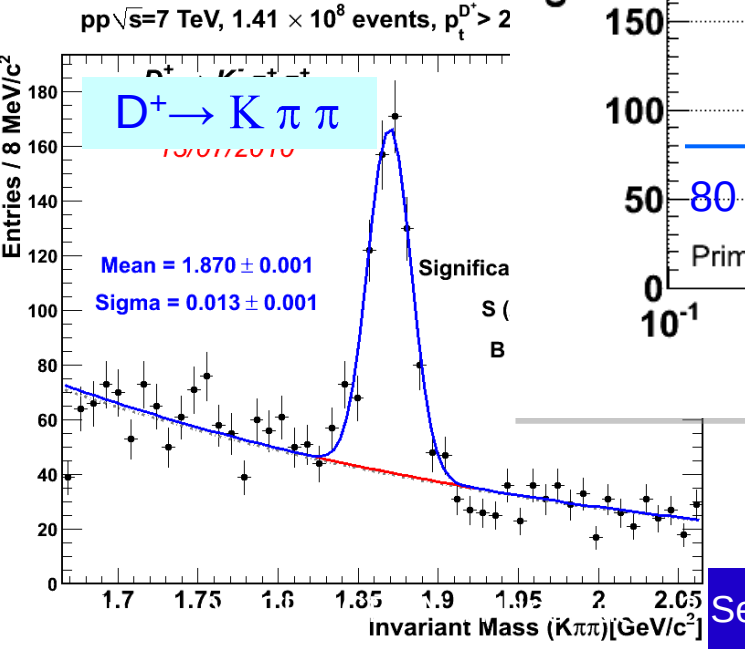
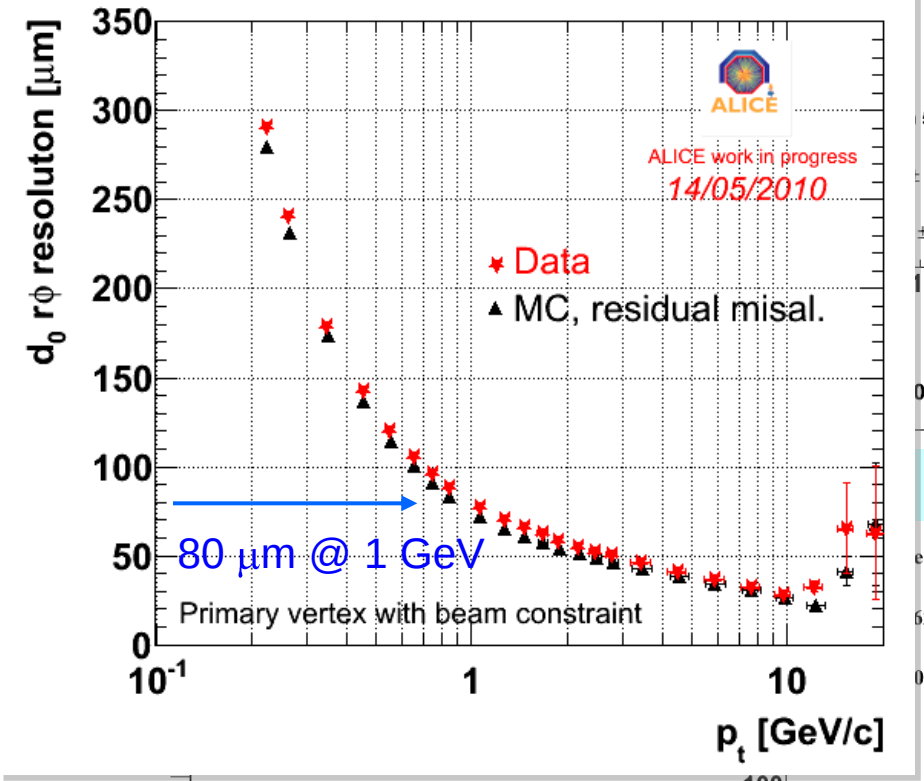
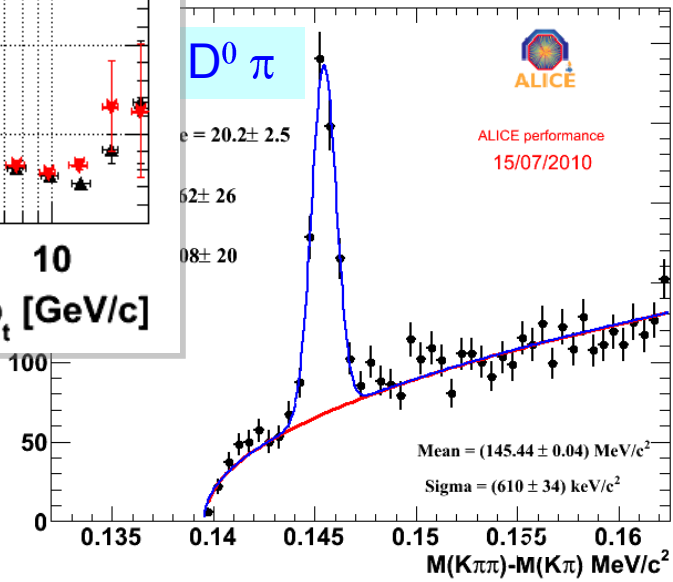
Charm at 7 TeV







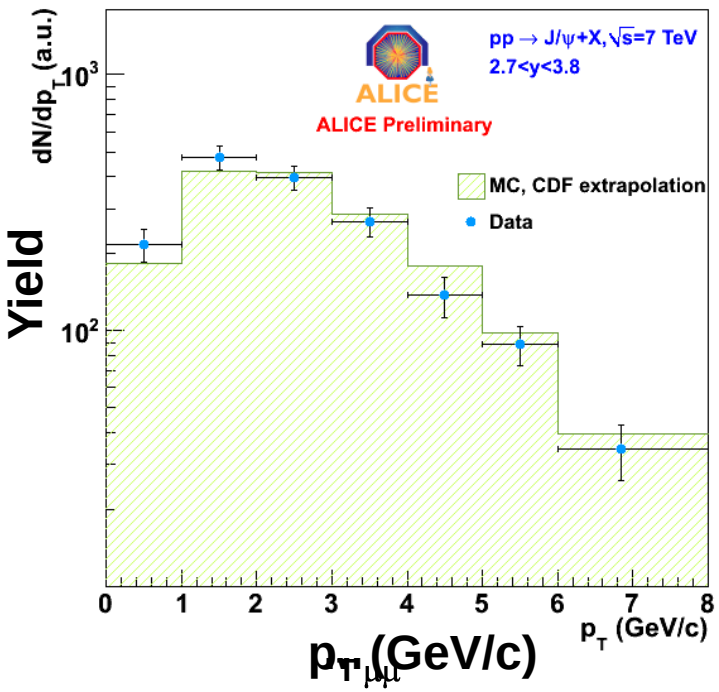


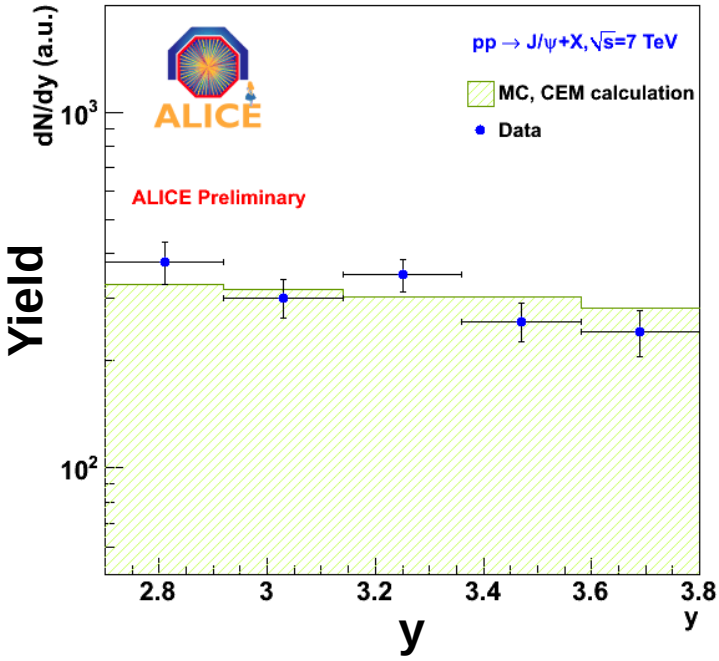


September 2010

$J/\psi \rightarrow \mu^+\mu^-$

- Acceptance
  - $2.7 < y < 3.8$
  - Starting from $p_T \sim 0$
- Yields without absolute normalizations
- Compared to an extrapolation based on
  - CEM parameterization
  - J/ψ p_T measurement of CDF
    - Fit extrapolation uses $\langle p_T^2 \rangle$ vs. $\sqrt{s}$ dependence
- Dielectron analysis (at mid-rapidity) ongoing

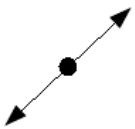


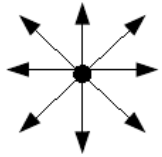


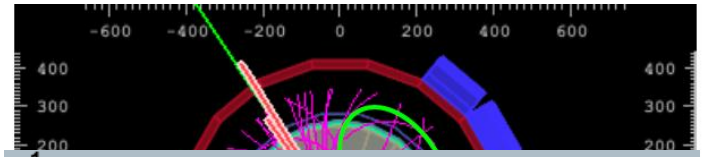
Extrapolation: J. Phys. G 32 (2006) 1295

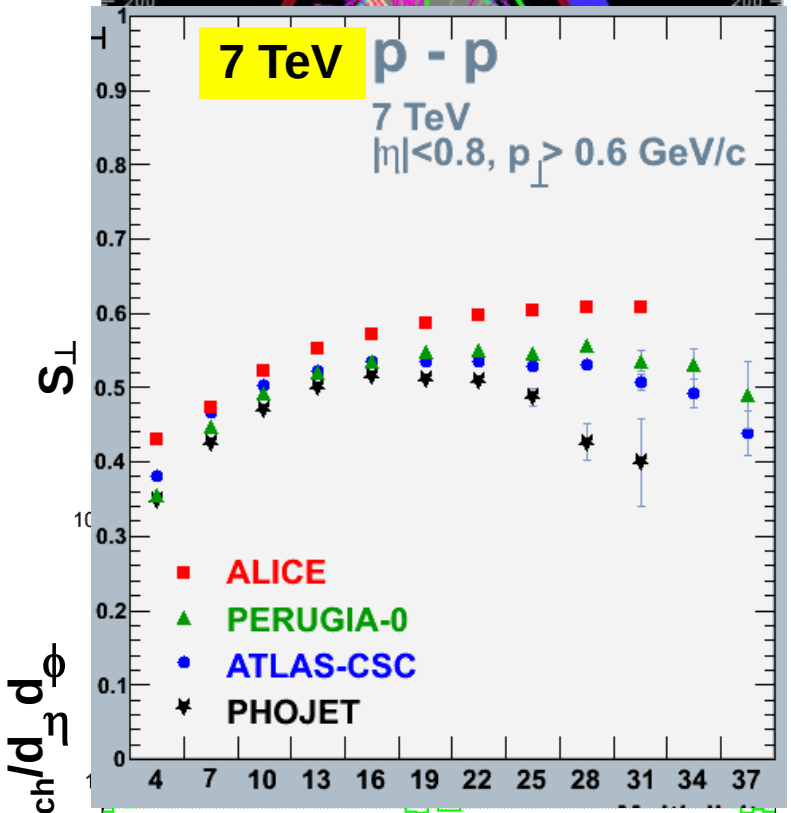
Prospects

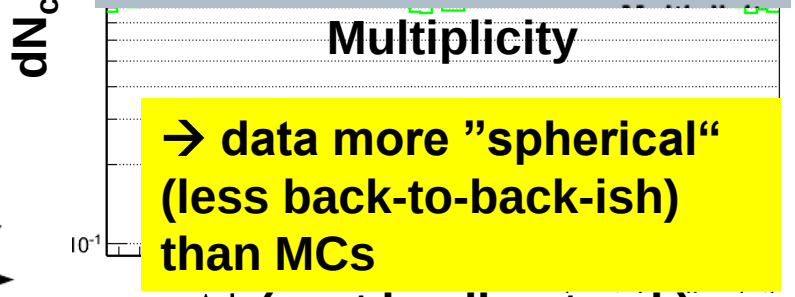
- MB measurements at 7 TeV
  - $dN_{ch}/d\eta$ for INEL and NSD (presently only “INEL>0”)
  - dN_{ch}/dp_T, $\langle p_T \rangle$ vs. N_{ch}
  - Two-Pion HBT
- Underlying event
  - Transverse regions to leading track
  - Event topology
    - Classify topologies, e.g. transverse sphericity $S_\perp$:

small $S_\perp$: 

large $S_\perp$: 



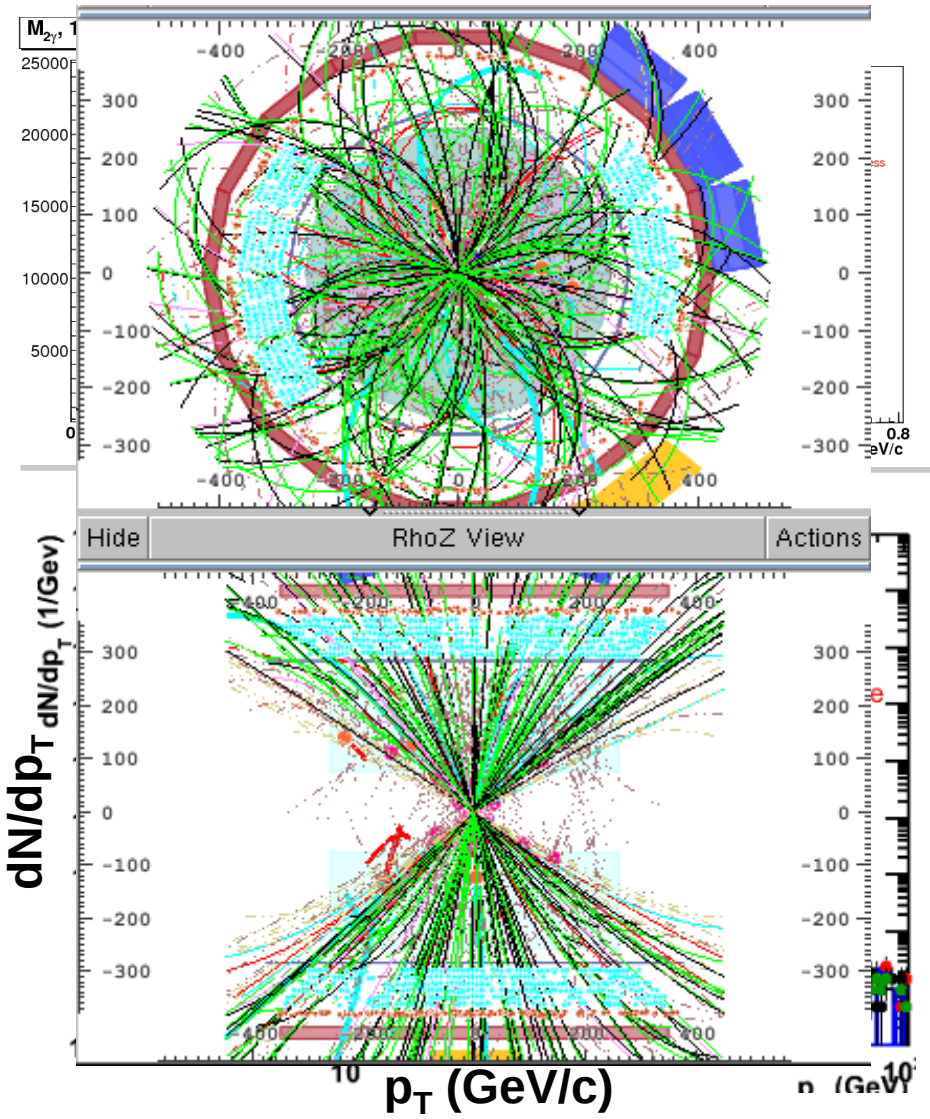




→ data more ”spherical“ (less back-to-back-ish) than MCs

Prospects (2)

- π^0 with calorimeters
  - Calibration still ongoing
- Jet reconstruction
- High-multiplicity physics
  - Enhanced by high-multiplicity trigger



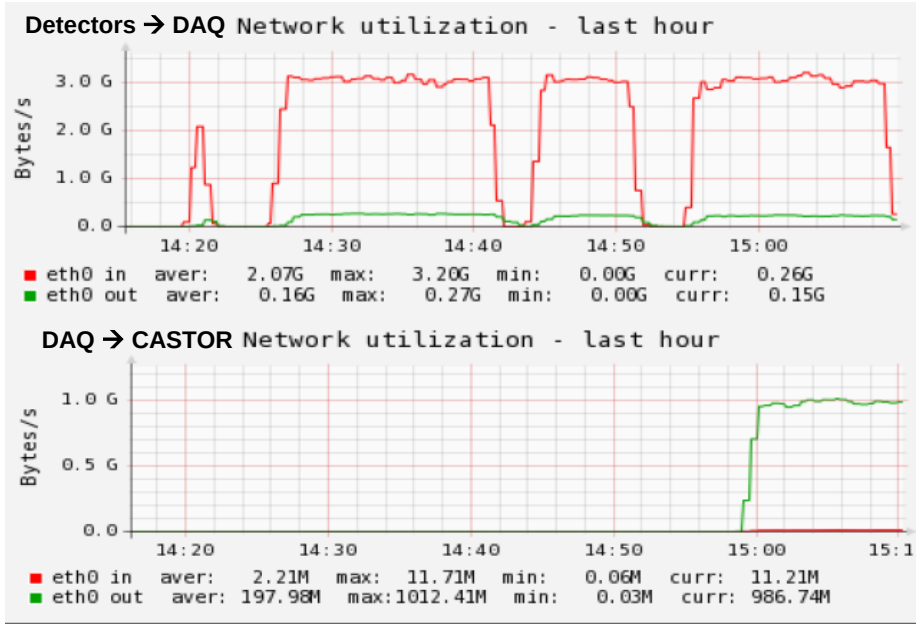
Outlook for Pb-Pb run

- expected luminosity ~ 2 orders of magnitude below nominal
  - 10^{27} cm^{-2} s^{-1} → 10^{25} cm^{-2} s^{-1}
  - ~ /10 from number of bunches
  - ~ /10 from increased beam size (lower energy, less focussing)
    (see talk by John Jowett)

- expected data sample?
  - depends critically on overall duty factor and number of days at 10^{25}
  - e.g.: 20 days at 50 Hz min bias at 20% overall duty factor
    → ~ 1.5 10^{7} min bias events
    (as opposed to target of a few 10^{7} central!)
  - caveat: any of the parameters could swing up or down…

Ready for high data rates

- extensive tests at Point 2 with artificially created Pb-Pb-like event sizes
  - verify correct operation of DAQ/Trigger
    → OK (3 hours operation without problems)
  - test data transfer bandwidths



→ at expected luminosity for this year we should not even need HLT filtering

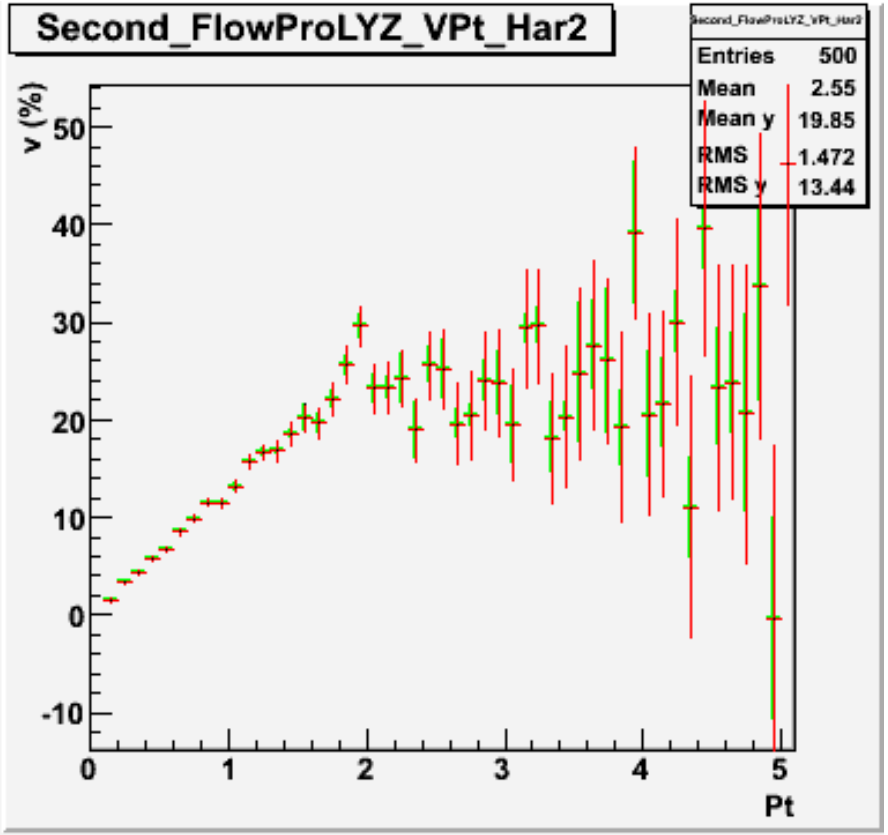
Physics reach?

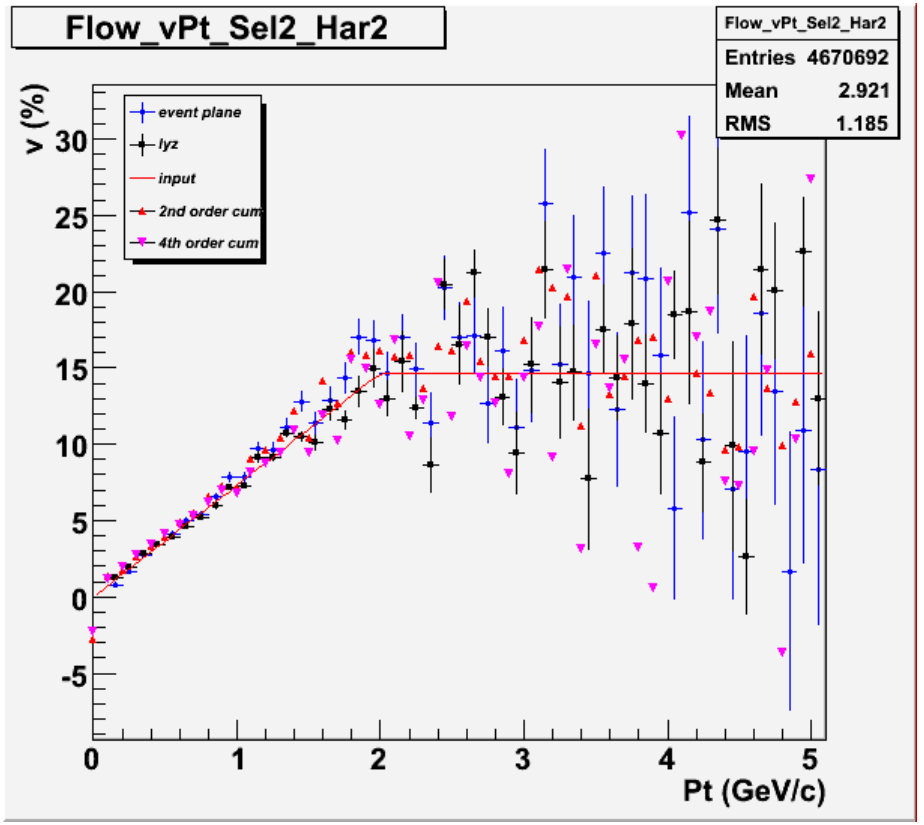
- global event properties
  - multiplicity
  - v2
  - HBT
  - bulk strangeness
- with a p_T reach dependent on statistics…
  - particle correlations
  - nuclear modification factors
  - strange, identified particle spectra
- a first glimpse of hard probes?
  - jets
  - J/ψ
  - heavy flavour

v_2 measurement studies

Standard event-plane method

500 HIJING events
centrality b = 8fm
multiplicity <M> = 1900
integrated v_2 = 3.3%





Lee-Yang Zero method

1100 HIJING event
centrality b = 9fm
multiplicity <M> = 1200
integrated v_2 = 6%

red – modified LYZ method (J-Y Ollitrault)

$\rho, \phi, K^*, K^0_s, \Lambda, \Xi, \Omega \ldots$

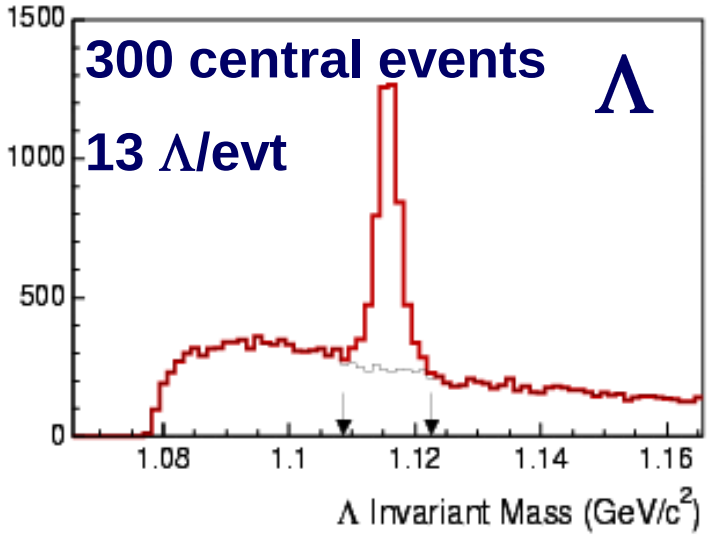
10^7 events:

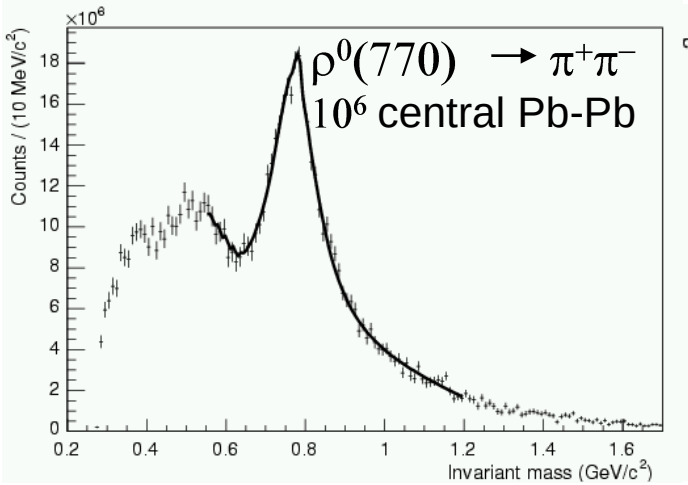
p_t reach ϕ,K,Λ

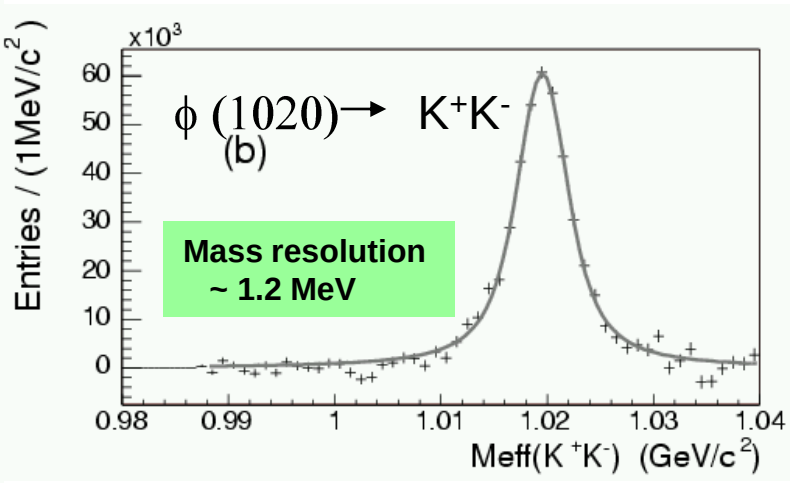
~ 13-15 GeV

p_t reach ρ,Ξ,Ω

~ 9-12 GeV







- **hadrochemical analysis**
- **chemical/kinetic freeze-out**

- **medium modifications of mass, widths**

Quarkonia

- critically dependent on integrated luminosity…
- taking, as an example:
  - 2 μb^{-1}
  - no suppression, no enhancement

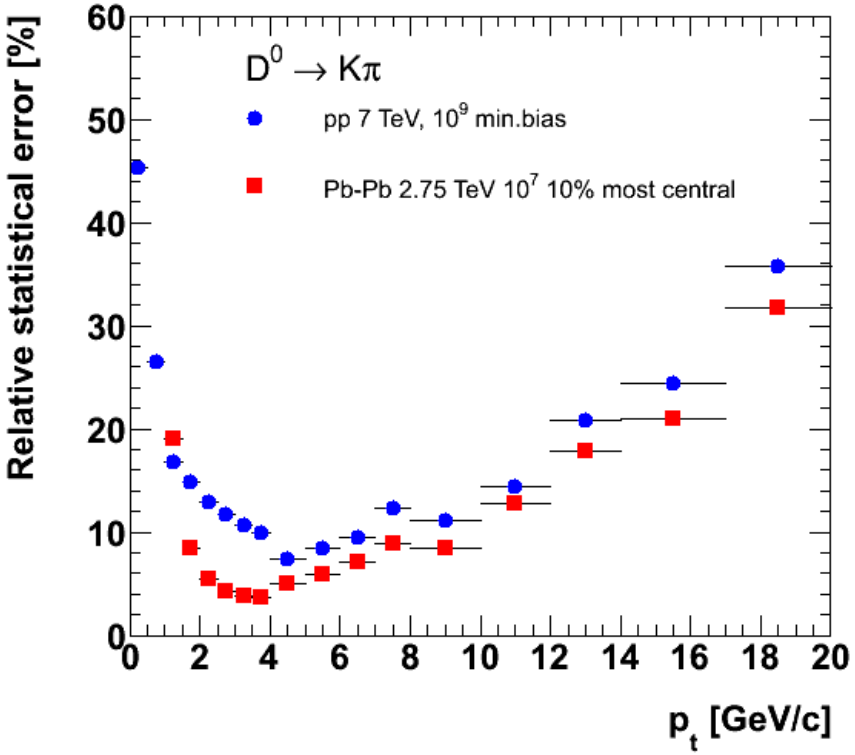
  →a few 1000s J/ψ
  - say 5 centrality bins → significance ~ 15-20
  - out to 6-7 GeV pT?

  →ψ' marginal…

  →a few 10s of Y at significance ~ 5?

What about charm?

- expected performance for 10^7 central Pb-Pb events at 2.75 TeV:



- for O(10^6) central, ~ multiply errors by 3

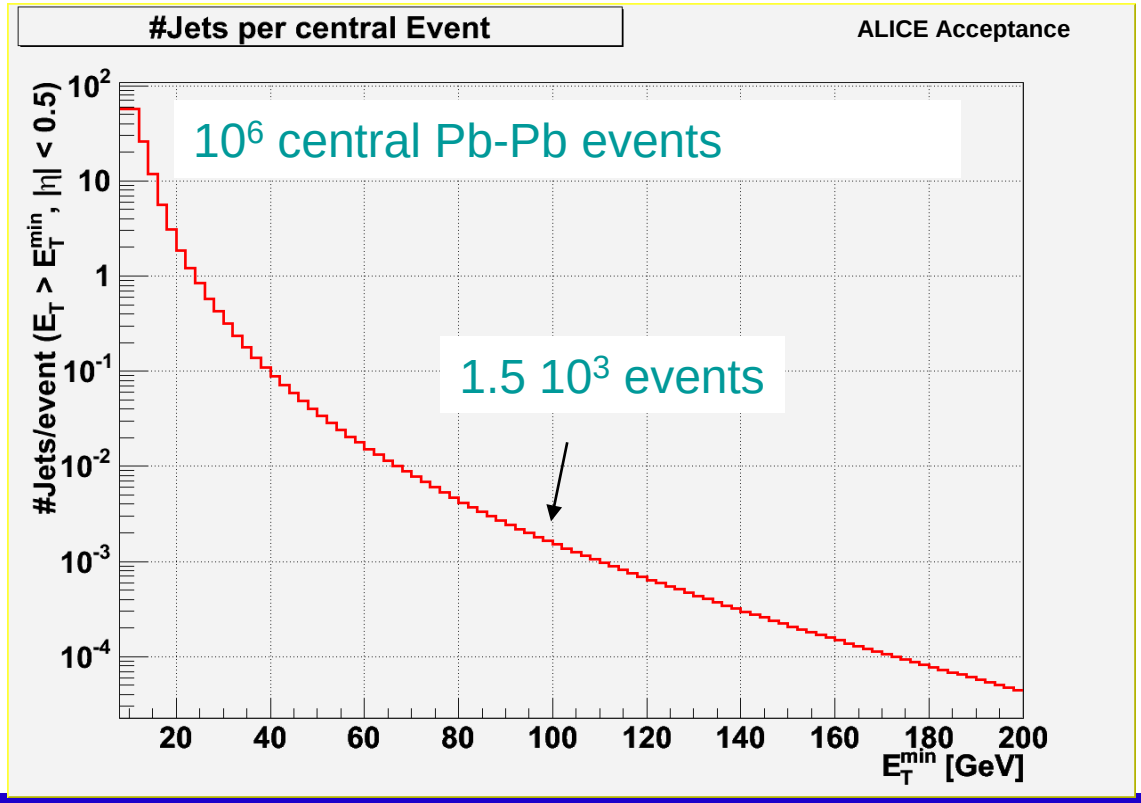
→ needs as much statistics as possible!

Jet statistics in pilot Pb run

Jets are copiously produced…

2 20 100 200 p_t (GeV)

100/event 1/event 10^3 in first 10^6 Pb-Pb events



10^6 central PbPb events

E_T threshold	N_{jets}
50 GeV	5×10^4
100 GeV	1.5×10^3
150 GeV	300
200 GeV	50

Conclusions

- the ALICE maiden run is ongoing succesfully
  - experiment is in stable operation
  - it is producing good quality data
  - first physics results in pp
- first Pb-Pb run should provide basic information on global event properties at LHC

  + a glimpse of harder physics…
- we are ready for the Pb beam…


...bring it on!!!