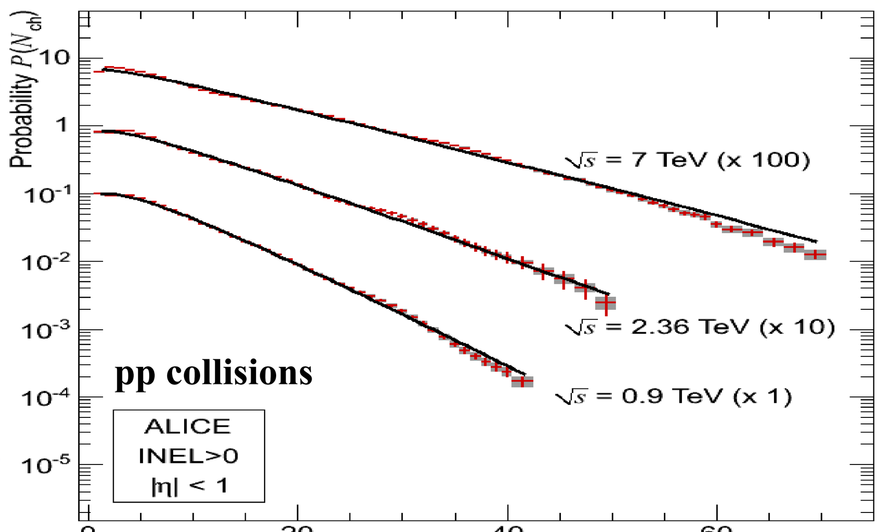
Single μ and J/ψ yields as a function of the collision multiplicity at mid rapidity in pp collisions at 7 TeV with ALICE

Matthieu Lenhardt, for the ALICE Collaboration
SUBATECH, Ecole des Mines de Nantes, Université de Nantes, CNRS-IN2P3, Nantes, France.

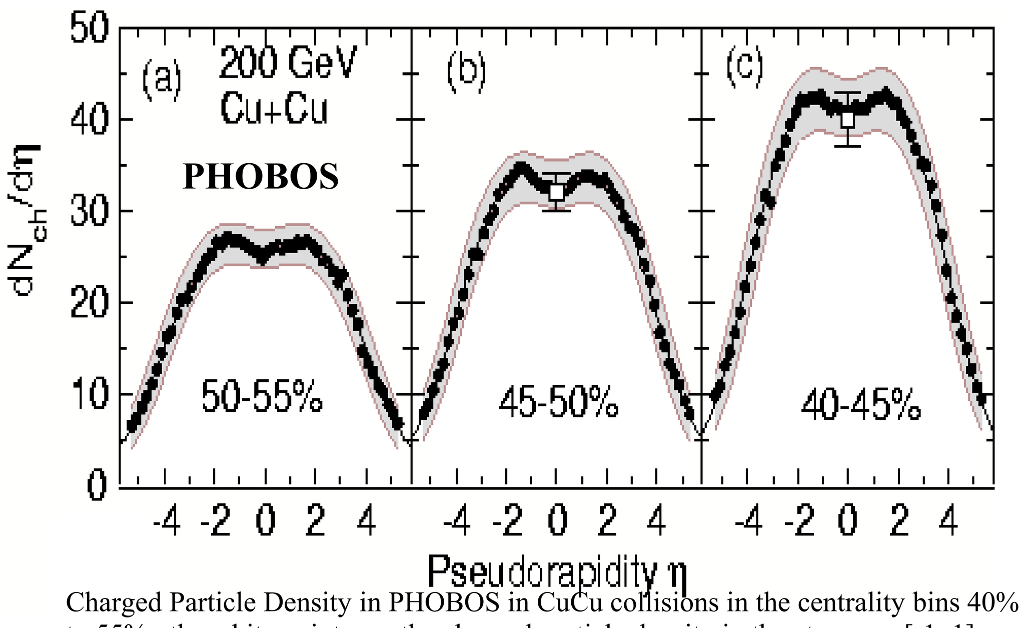
Physics Motivations

The results of the two particles correlation (Δη, Δϕ) in pp collisions at 7 TeV by the CMS collaboration [1] present a pronounced structure around Δϕ = 0 in high multiplicity events. This is the first time such a long range structure has been observed in pp collisions.
It has been argued [2] that this "ridge" can be interpreted as a hydrodynamical effect. Indeed, the charged particle density reached in pp collisions at 7 TeV in the LHC [3] is similar to the density measured by the PHOBOS collaboration in CuCu semi peripheral collisions at 200 GeV [4], $dN_{ch}/d\eta \sim 30$. This could lead to the apparition of phenomena in high multiplicity pp collisions at the LHC only observed in heavy-ion collisions at lower energies.

[1] CMS Collaboration, JHEP 1009:091, 2010 ; [2] K. Werner *et al.*, Phys. Rev. Lett. **106**, 122004 (2011)
[3] ALICE Collaboration, EPJC: Vol. 68 (2010) 345 ; [4] PHOBOS Collaboration. Phys. Rev. C **83**, 024913 (2011)

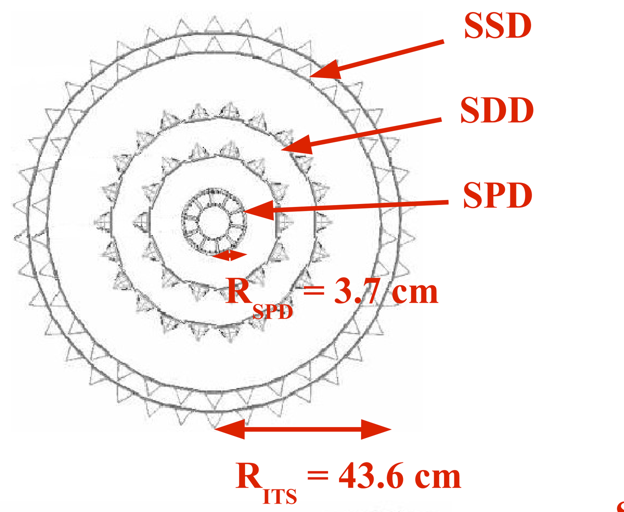


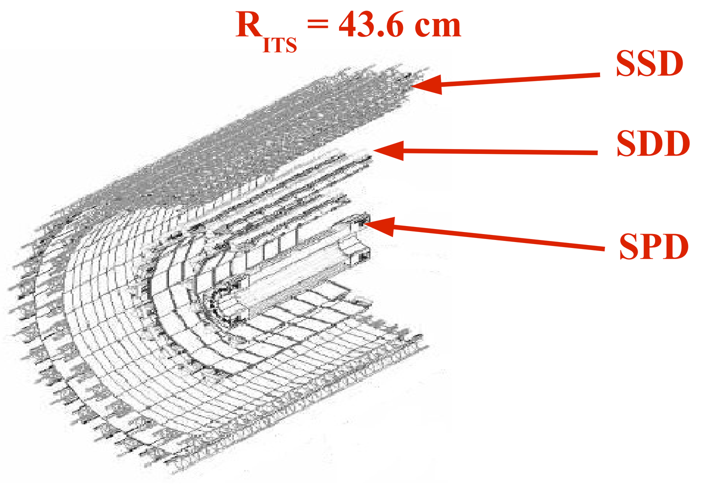
Charged Particle Multiplicity in ALICE in pp collisions : the charged particle density is obtained by dividing N_{ch} by the eta range [-1, 1].

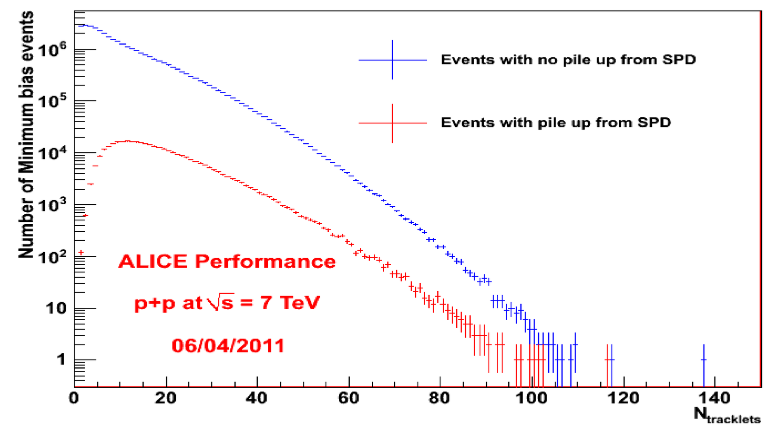


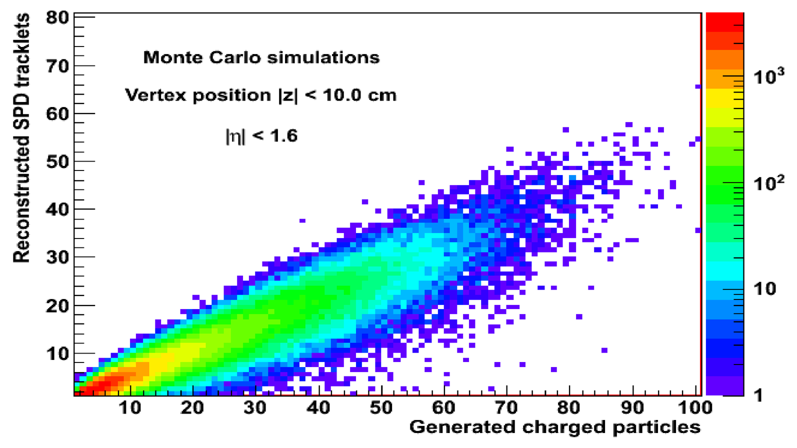
Charged Particle Density in PHOBOS in CuCu collisions in the centrality bins 40% to 55% : the white points are the charged particle density in the eta range [-1, 1].

At LHC, it will be interesting to look for collectiveness in high multiplicity pp collisions, using the usual probes of the Quark Gluon Plasma in heavy-ion collisions.
This study will present the results of the production of J/ψ and single μ at forward rapidity as a function of the charged particle density measured at mid-rapidity in pp collisions at 7 TeV with the ALICE detector.









Multiplicity in ALICE

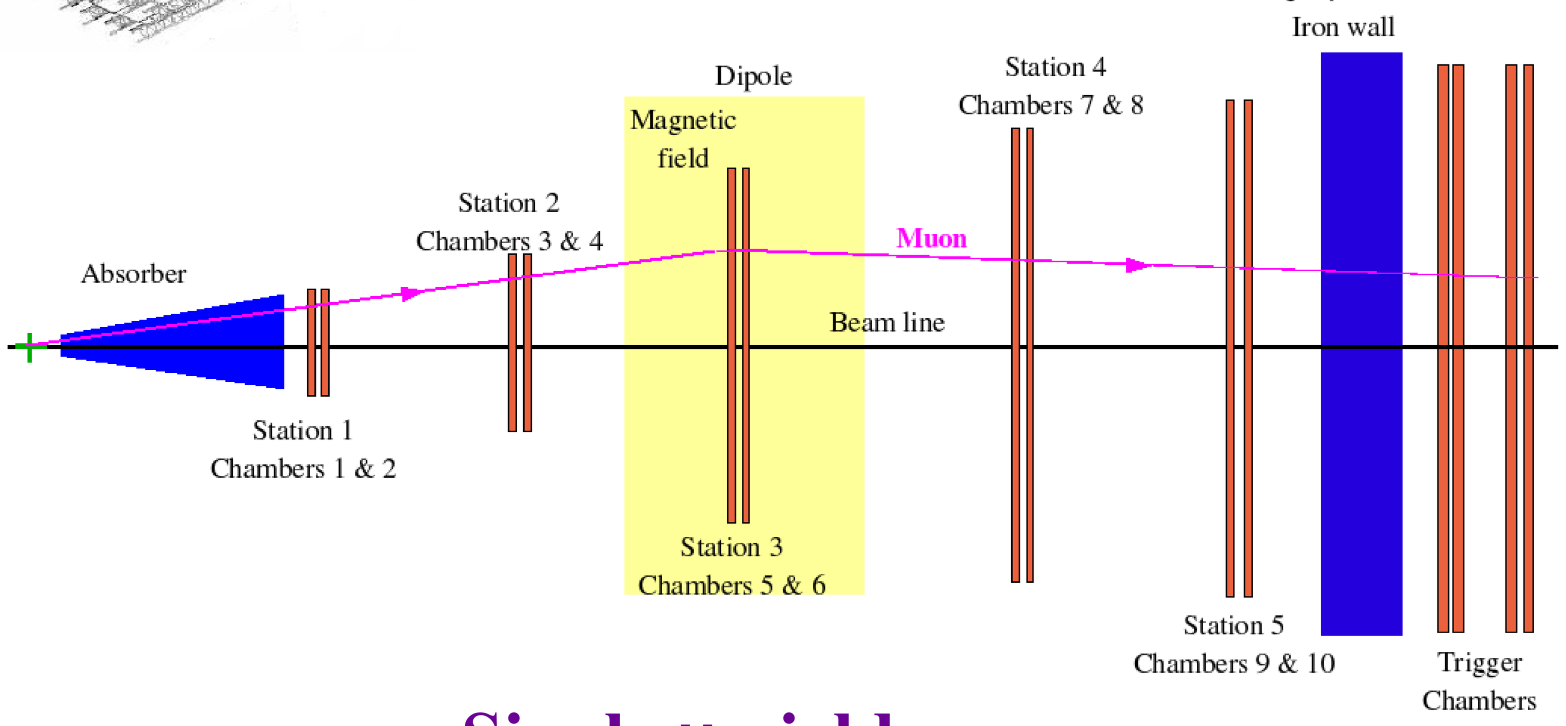
The multiplicity detector in ALICE is the ITS (Inner Tracking System). It is a Silicon detector, composed of three sub-detectors, placed at mid-rapidity, in concentric cylinders around the interaction point. Each of these sub-detectors is itself composed of two layers. The two innermost layers are the SPD (Silicon Pixel Detector). The number of tracklets reconstructed in the SPD, corrected by its efficiency estimated from MC simulations, gives the value of the charged particle density of the collision.

The variable of choice for the multiplicity is the relative charged particle density :

$$dN^R_{ch}/d\eta = \frac{dN_{ch}/d\eta_{\eta=0}}{\langle dN_{ch}/d\eta_{\eta=0}\rangle}$$

This study will go up to $dN_{ch}/d\eta \approx 5.5 \langle dN_{ch}/d\eta\rangle$

The Muon Spectrometer



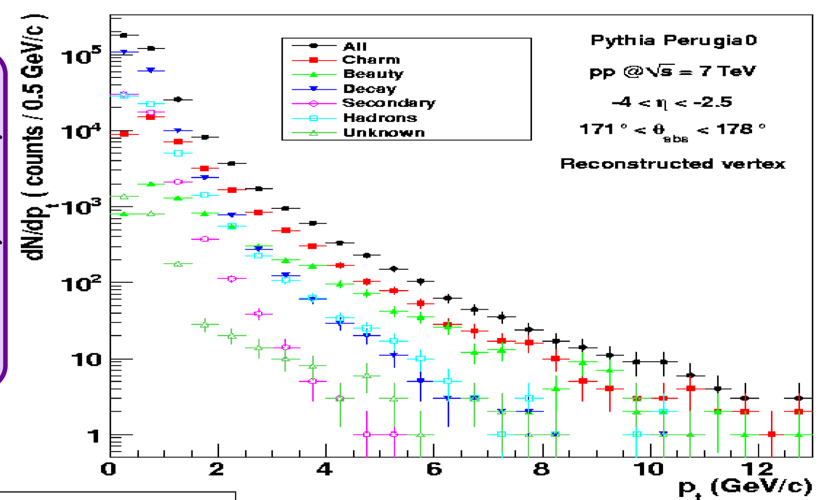
The single μ and J/ψ are detected using the muon spectrometer of ALICE, located at forward rapidity 2.5 < y < 4.0. It consists of :
- Five tracking stations, with two chambers each, reconstructing the trajectory of the μ.
- A magnetic field, bending the trajectory of the μ.
- Two trigger stations, triggering the μ events.
- A frontal absorber between the interaction point and the tracking chambers, stopping the hadrons and low p μ (p < ~4 GeV/c).
- An iron wall between the tracking and trigger chambers, stopping the secondary particles produced in the absorber.

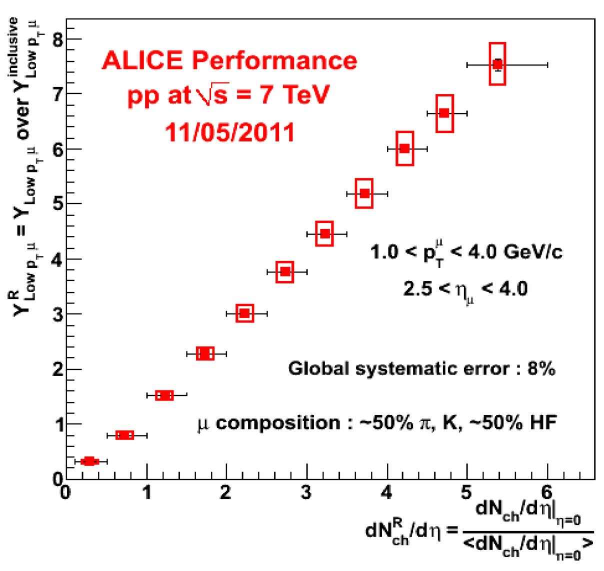
Two observables will be considered, for both single μ and J/ψ
- **The relative yield Y^R : the yield as a function of the multiplicity over the inclusive yield per pp inelastic collisions.**
- **The relative yield over the multiplicity.**

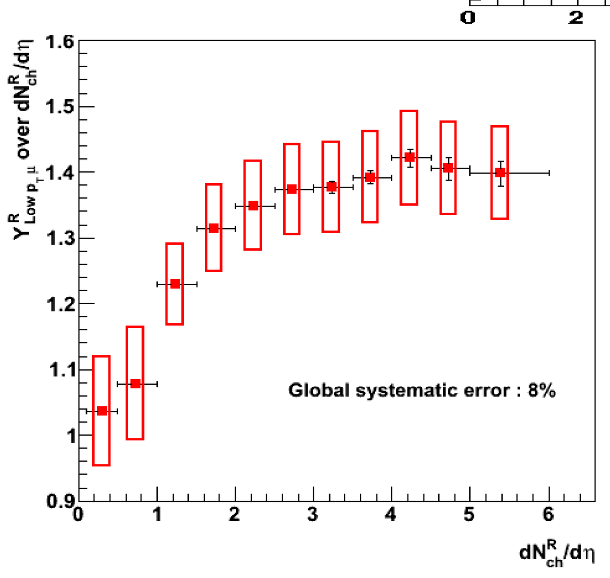
$$Y^R = \frac{Y\left(dN^R_{ch}/d\eta\right)}{Y^{incl}} \qquad \frac{Y^R}{dN^R_{ch}/d\eta}$$

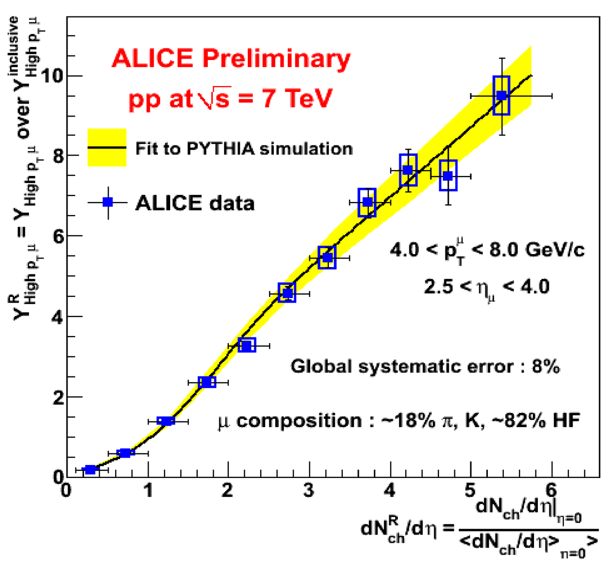
Single μ yield

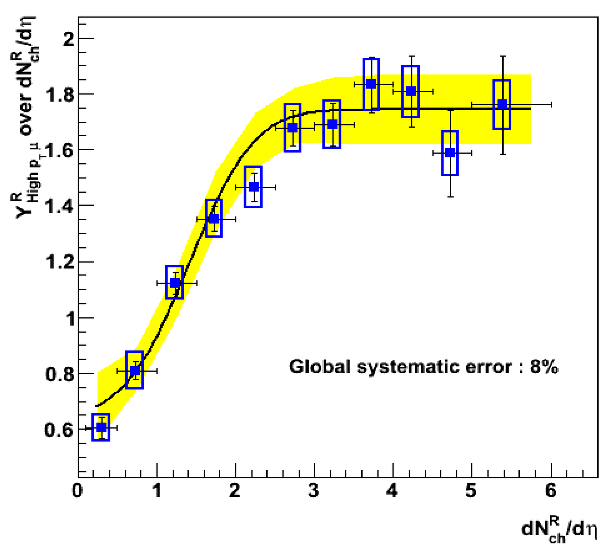
The single μ are separated into two p_T ranges.
Low p_T μ : $1.0 < p_T < 4.0$ GeV/c. These μ come from ~50% of π and K decays, and ~50% of Heavy Flavour decays (C or B).
High p_T μ : $4.0 < p_T < 8.0$ GeV/c. These μ come from ~18% of π and K decays, and ~82% of Heavy Flavour decays.









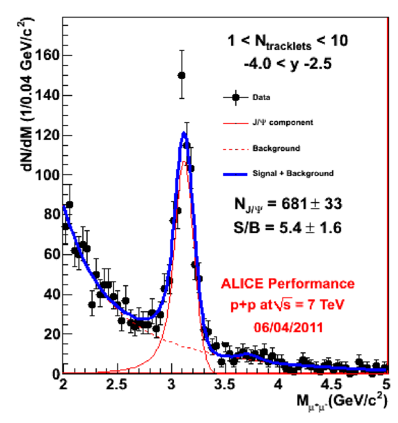


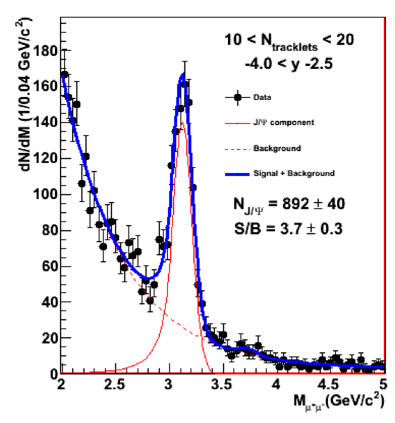
The low p_T μ yield increases with the multiplicity. This increase is close to linear, in particular for relative multiplicities greater than 1.

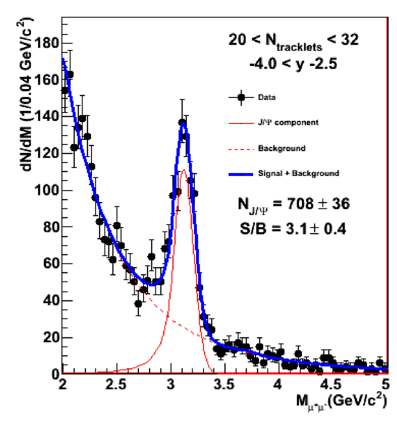
The high p_T μ yield also increases with the multiplicity. However, the increase is faster than for the low p_T μ. It is faster than linear for relative multiplicity < 2.5, and seems linear after.
This yield is well reproduced by Monte-Carlo PYTHIA simulations, using the perugia-0 (320) tune [5].

[5] P.Z. Skands, arXiv:0905.3418

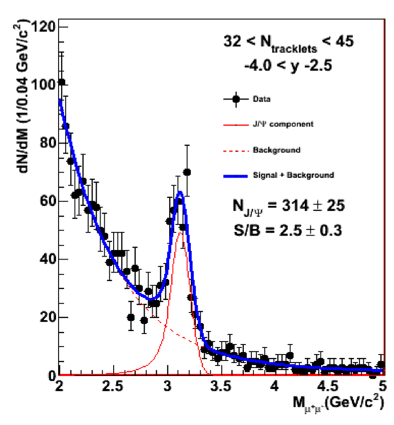
J/ψ yield

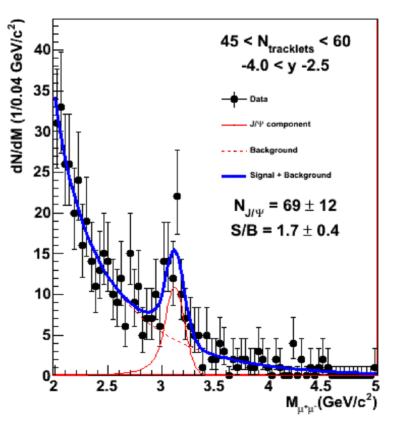






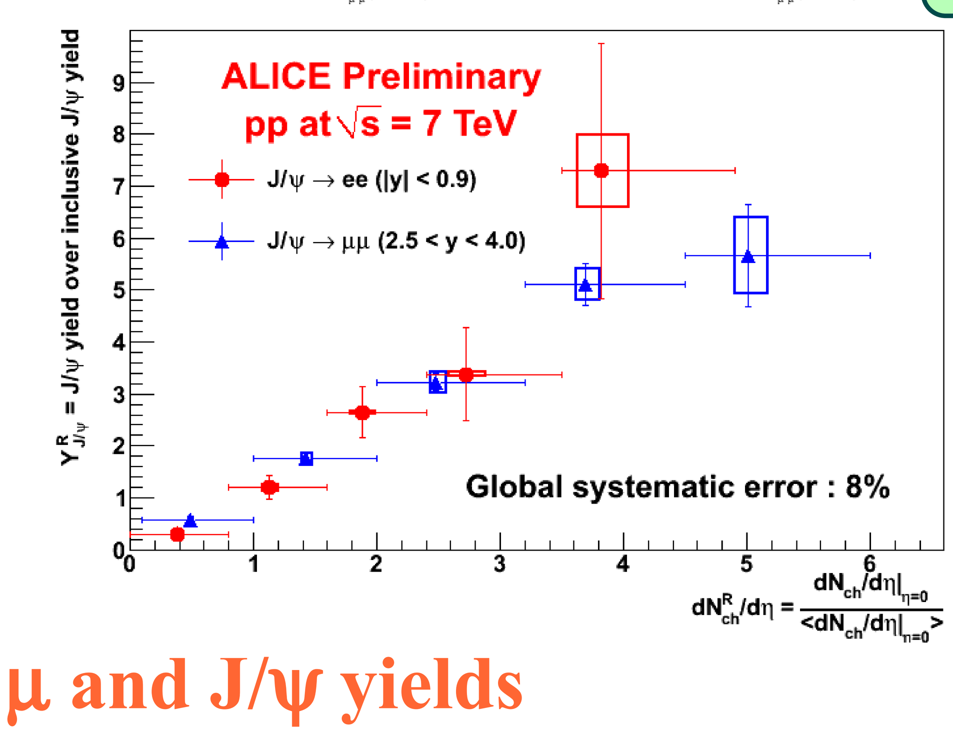
The J/ψ yield is extracted with a fit of the dimuon invariant mass spectrum, in several multiplicity ranges.
The signal to background ratio decreases with the multiplicity. It can be simply explained by an increase of the combinatorial background, as the single μ yield also increases with the multiplicity.

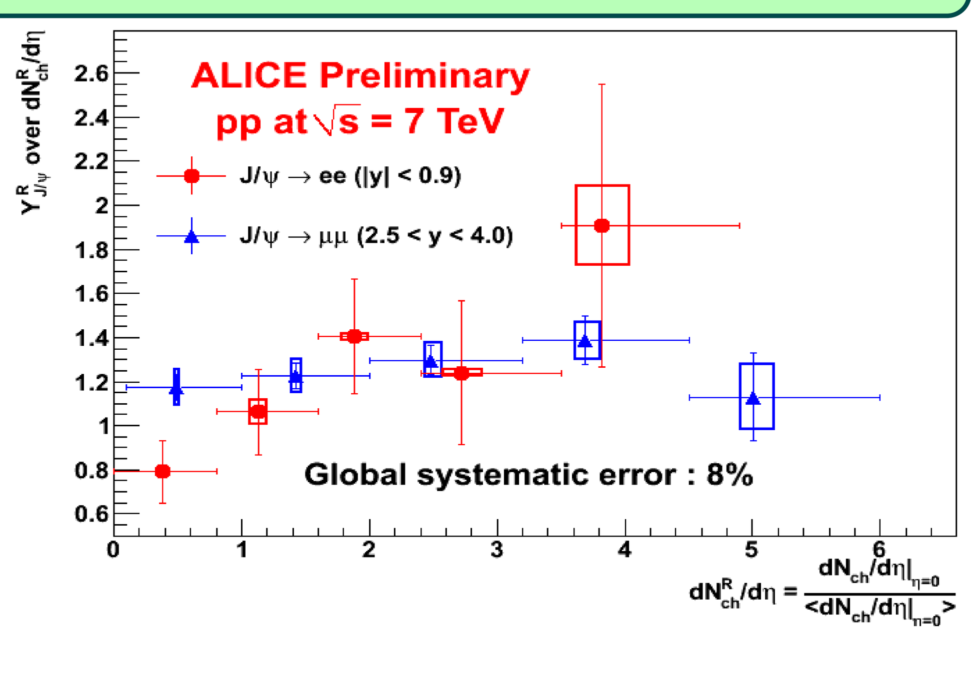




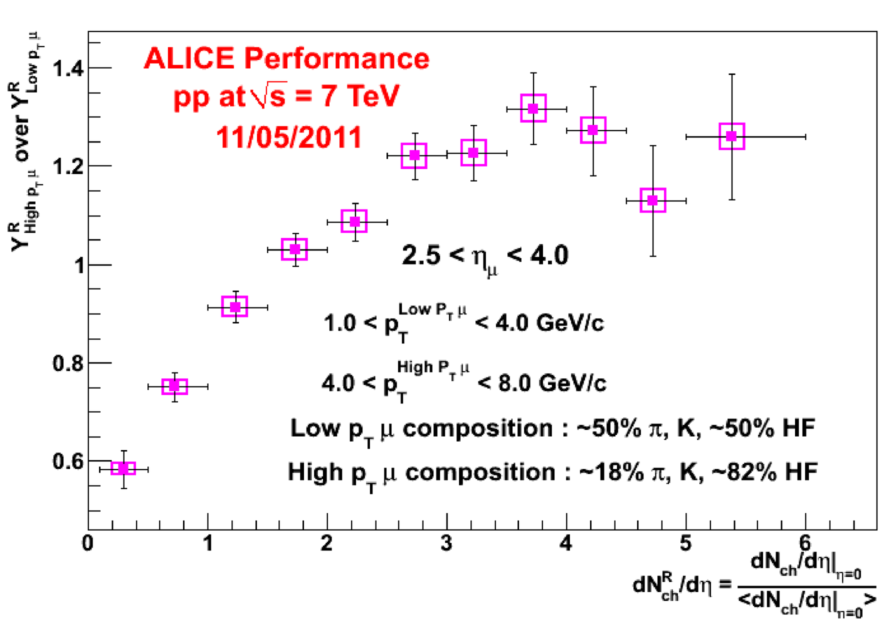
The J/ψ results are presented with the same study done at mid-rapidity (cf poster from F. Kramer). The results are in good agreement.

Similarly to the single μ, the relative J/ψ yield increases with the collision multiplicity. The increase seems faster than linear in the mid-rapidity region. However, it seems to be constant in the forward rapidity region.

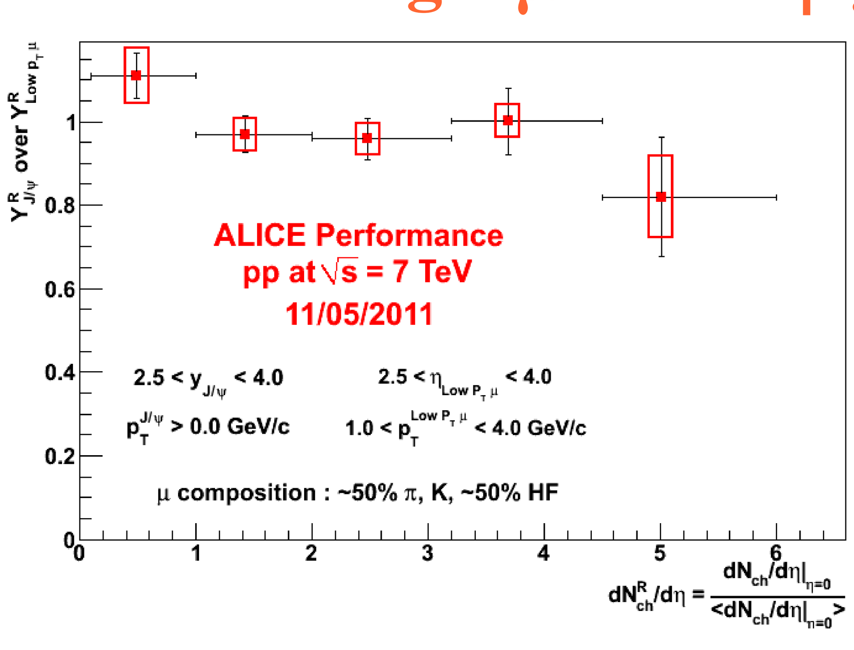


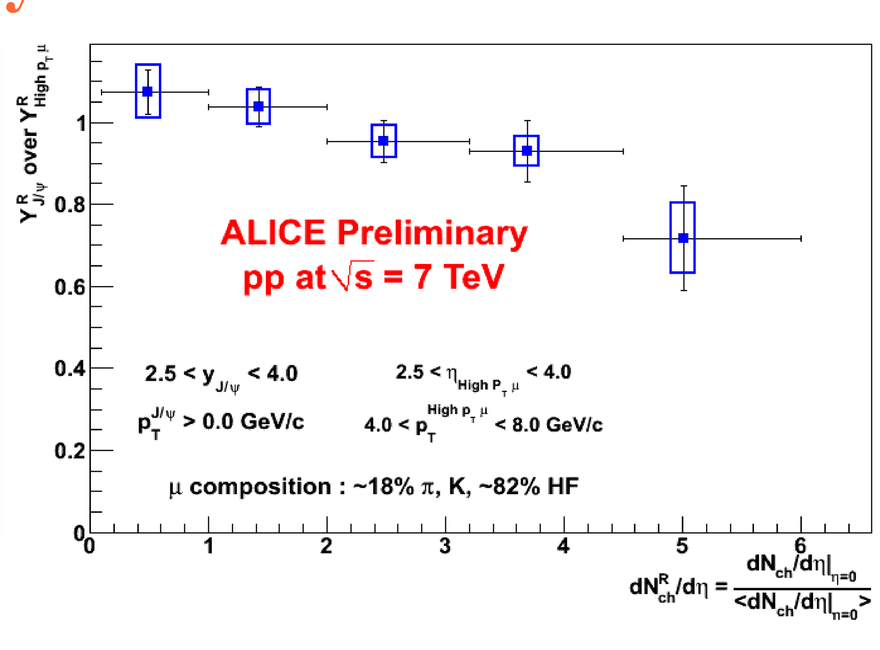


Ratios of single μ and J/ψ yields



This ratio clearly shows the faster increase of the high p_T μ with respect to the low p_T μ.





Those ratios show that the J/ψ yield has the same evolution than the low p_T μ with the collision multiplicity.

However, the J/ψ yield increases more slowly than the high p_T μ. This result is not expected, since the J/ψ and high p_T μ share the same initial effects.