4th Budapest Winter School on Heavy Ion Physics

Comparative Study of Pion Production in p+p and Pb+Pb Collisions at the CERN SPS

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- Pion production in p+p and Pb+Pb collisions
- π^+/π^- ratios: Coulomb effect
- Average pion yields: enhancement pattern in A+A vs. N+N

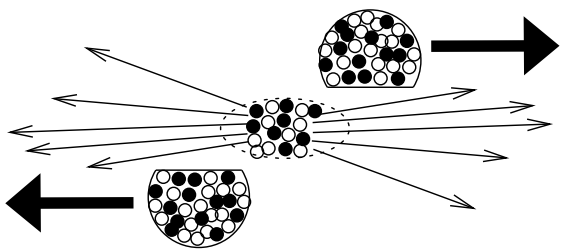
Introduction

- NA49 in the SPS energy range: $\sqrt{s} = 17.2GeV$ (158 GeV beam)
- Perturbative QCD region (very high p_T, above 4-5 GeV) not very well developed: this talk addresses from low to medium-high p_T (up to 1.5 GeV).

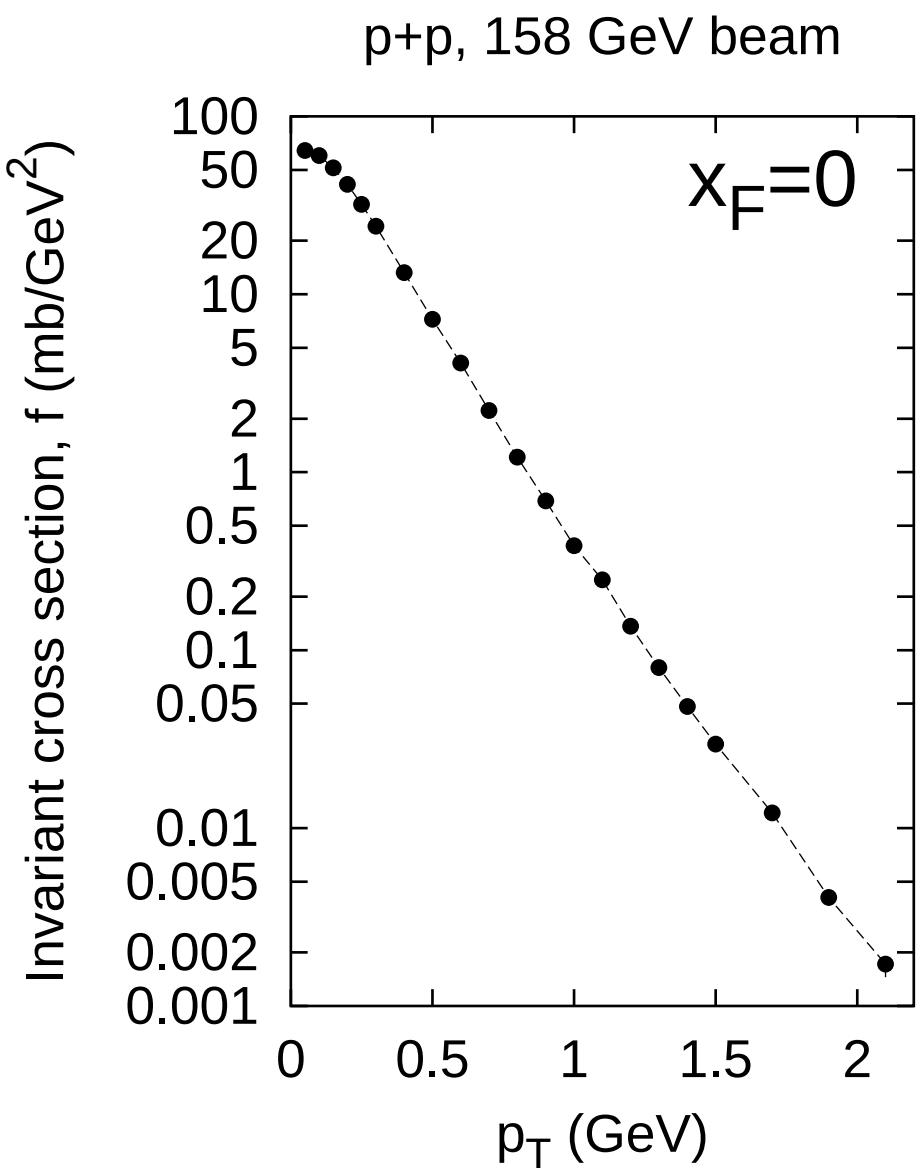
Variables, quantities that will be talked about:

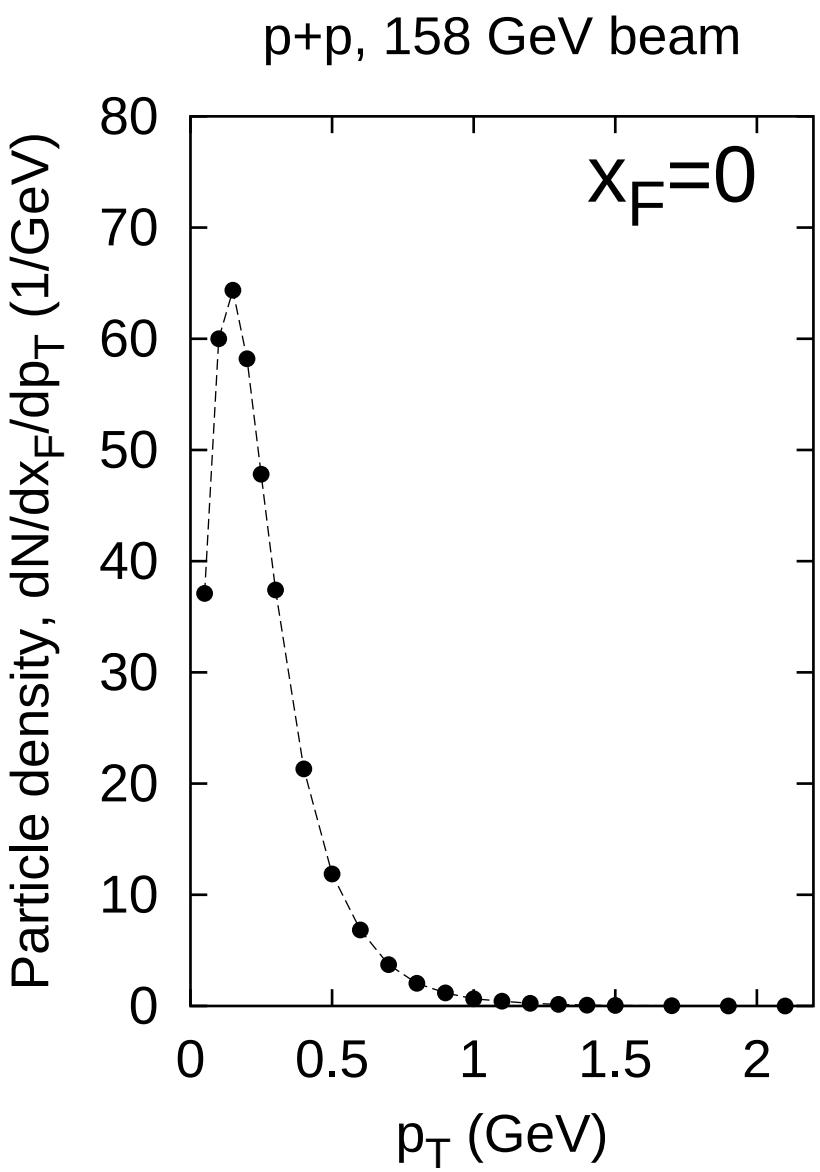
- p_T: momentum component perpendicular to beam axis.
  $x_F = p_z/p_{max}$, scaled longitudinal momentum in the CM system
- Invariant cross section: $f = E\frac{d^3\sigma}{dp^3} = E\sigma_{inelastic}\frac{d^3N}{dp^3}$

Which are "trivial" differences in (peripheral) Pb+Pb, when comparing to N+N

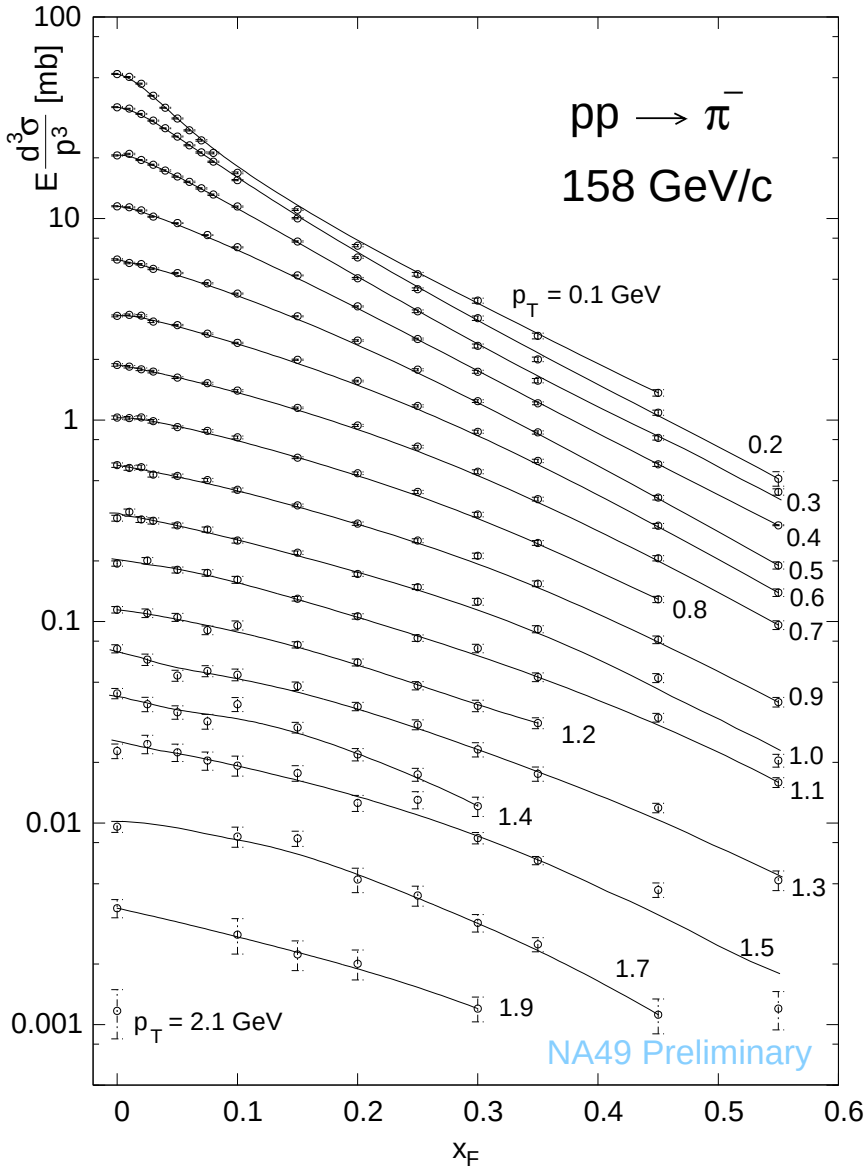


- Isospin effects
- Spectator system
- Multiple collisions


p+p, 158 GeV beam
x_F=0
Invariant cross section, f (mb/GeV^2)
100
50
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.005
0.002
0.001
0
0.5
1
1.5
2
p_T (GeV)


p+p, 158 GeV beam
x_F=0
Particle density, $dN/dx_F/dp_T$ (1/GeV)
80
70
60
50
40
30
20
10
0
0
0.5
1
1.5
2
p_T (GeV)

Pion production in p+p interactions



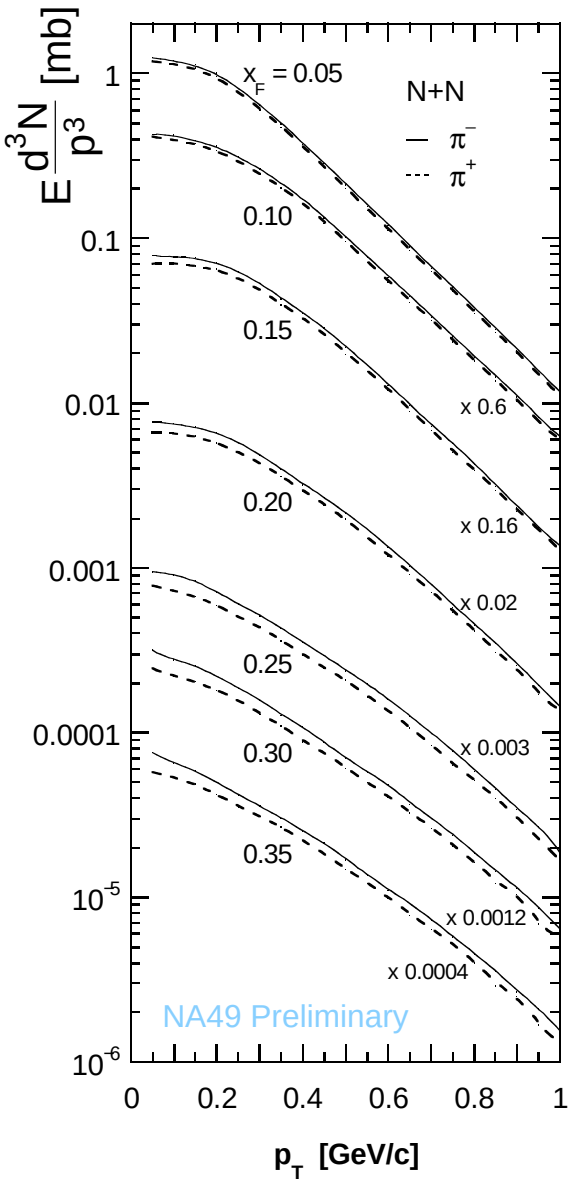
- p+p: reference interaction when comparing to Pb+Pb
- Pb nucleus: built up from 60% neutrons and 40% protons.

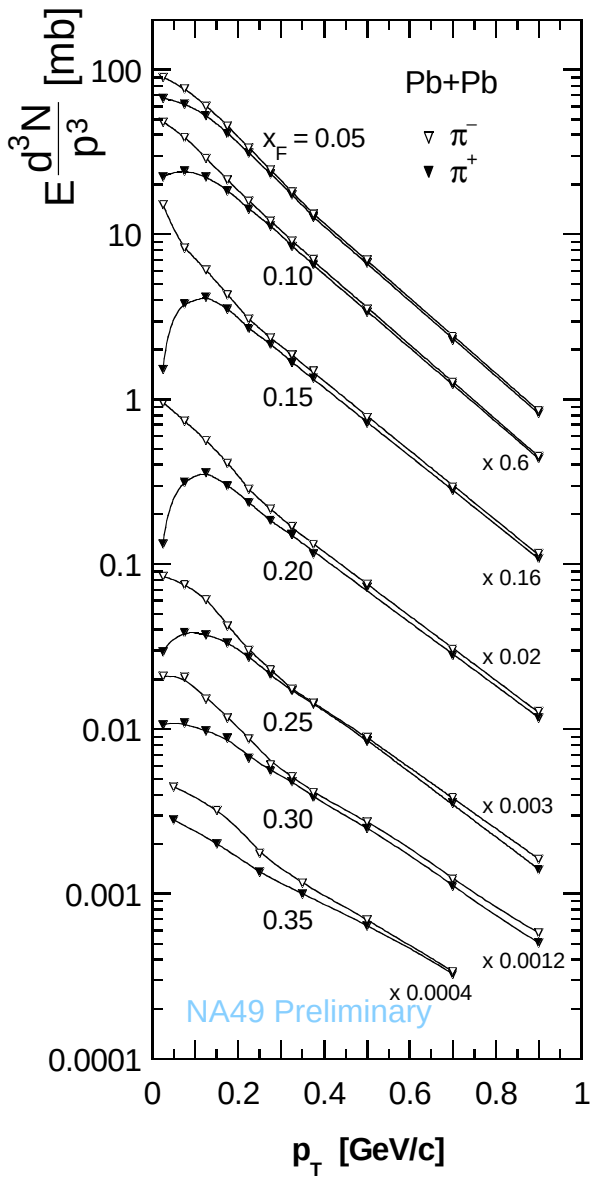
$$n + p \longrightarrow \pi^{\pm} \approx p + p \longrightarrow \pi^{\mp}$$

(precisely true above $x_F = 0.05$)

$\Rightarrow$ N+N reference constructed from 60/40 proportion of neutrons and protons

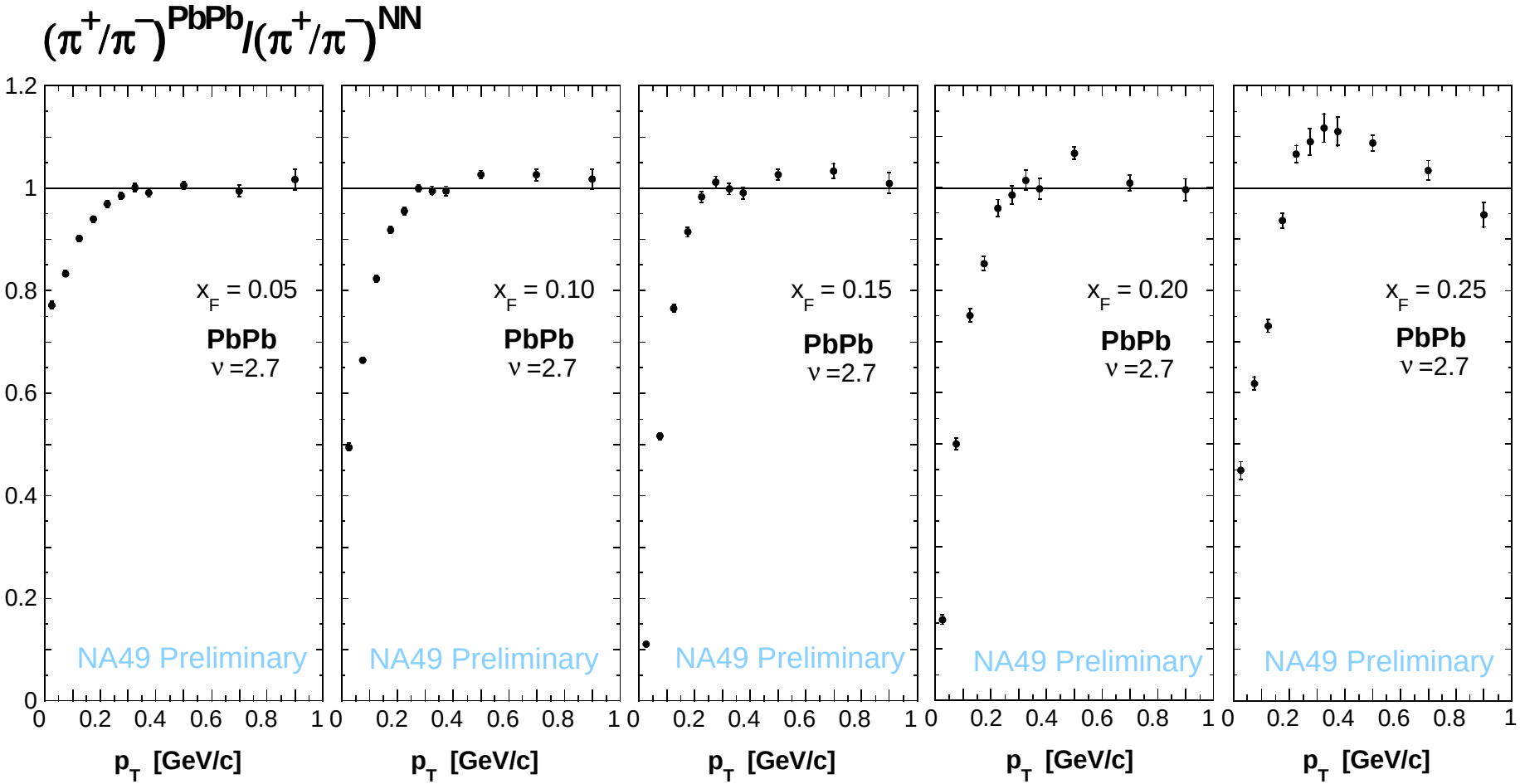
Pion production in N+N and Pb+Pb interactions



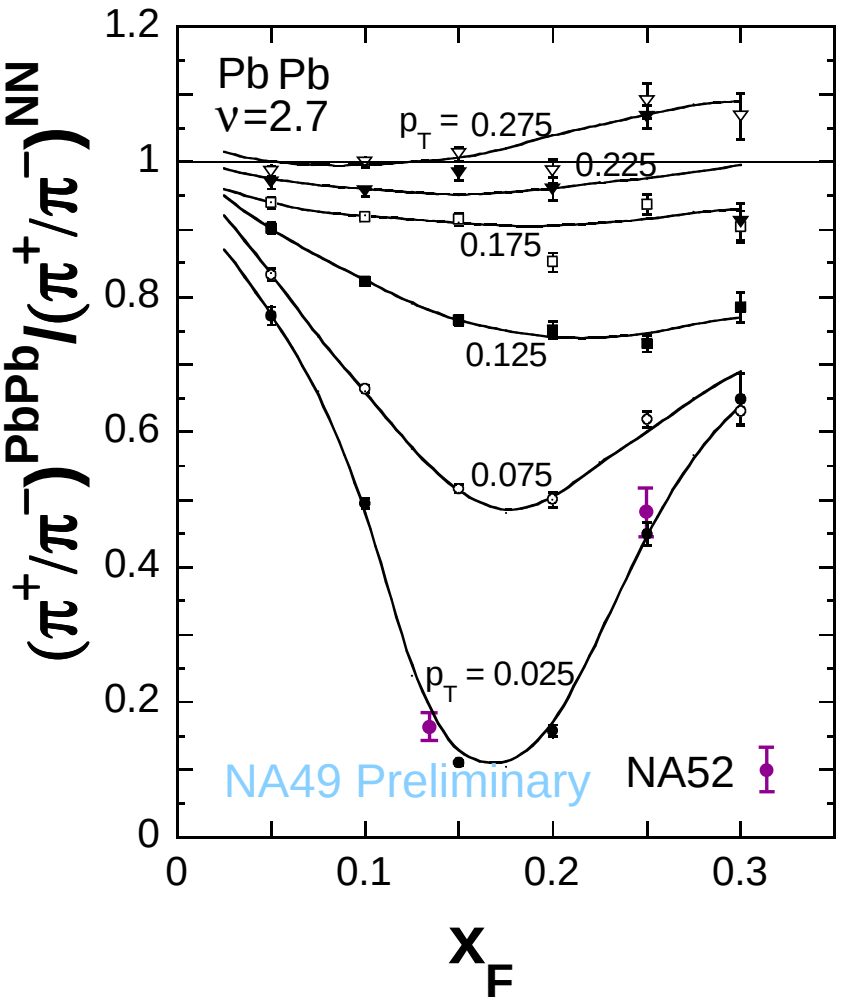


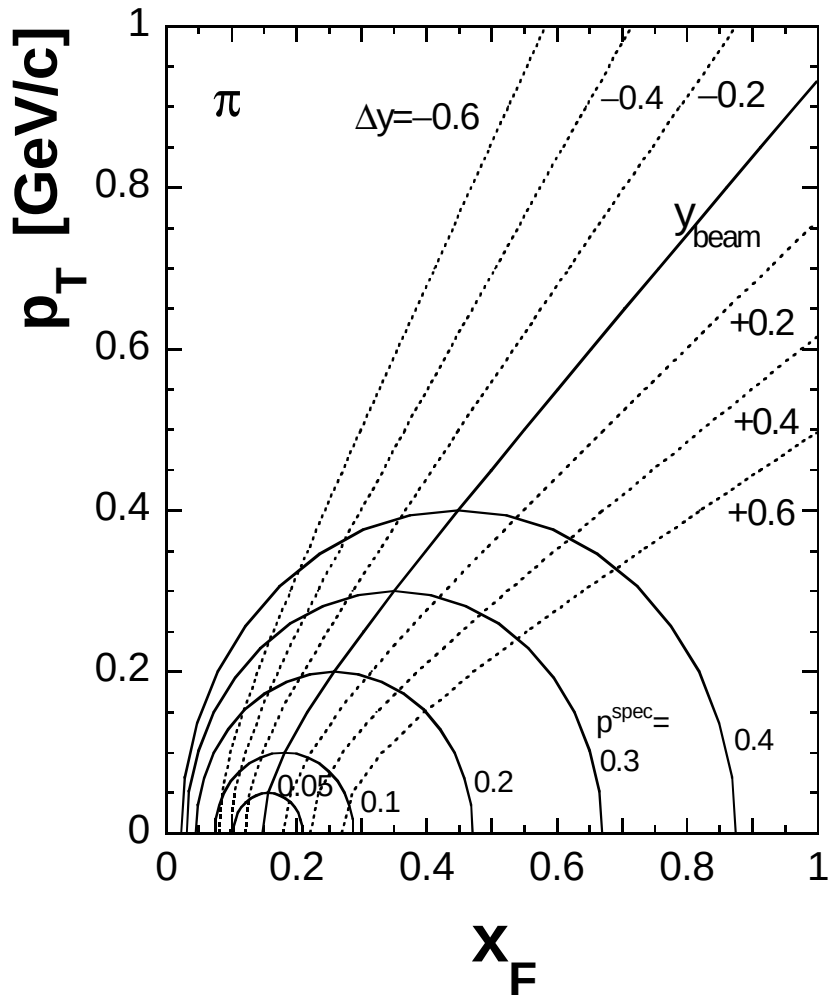
- Peripheral Pb+Pb interactions, with
  34 ± 3 participant pairs
  Number of collisions: $\nu = 2.7$.

π^+/π^- ratios

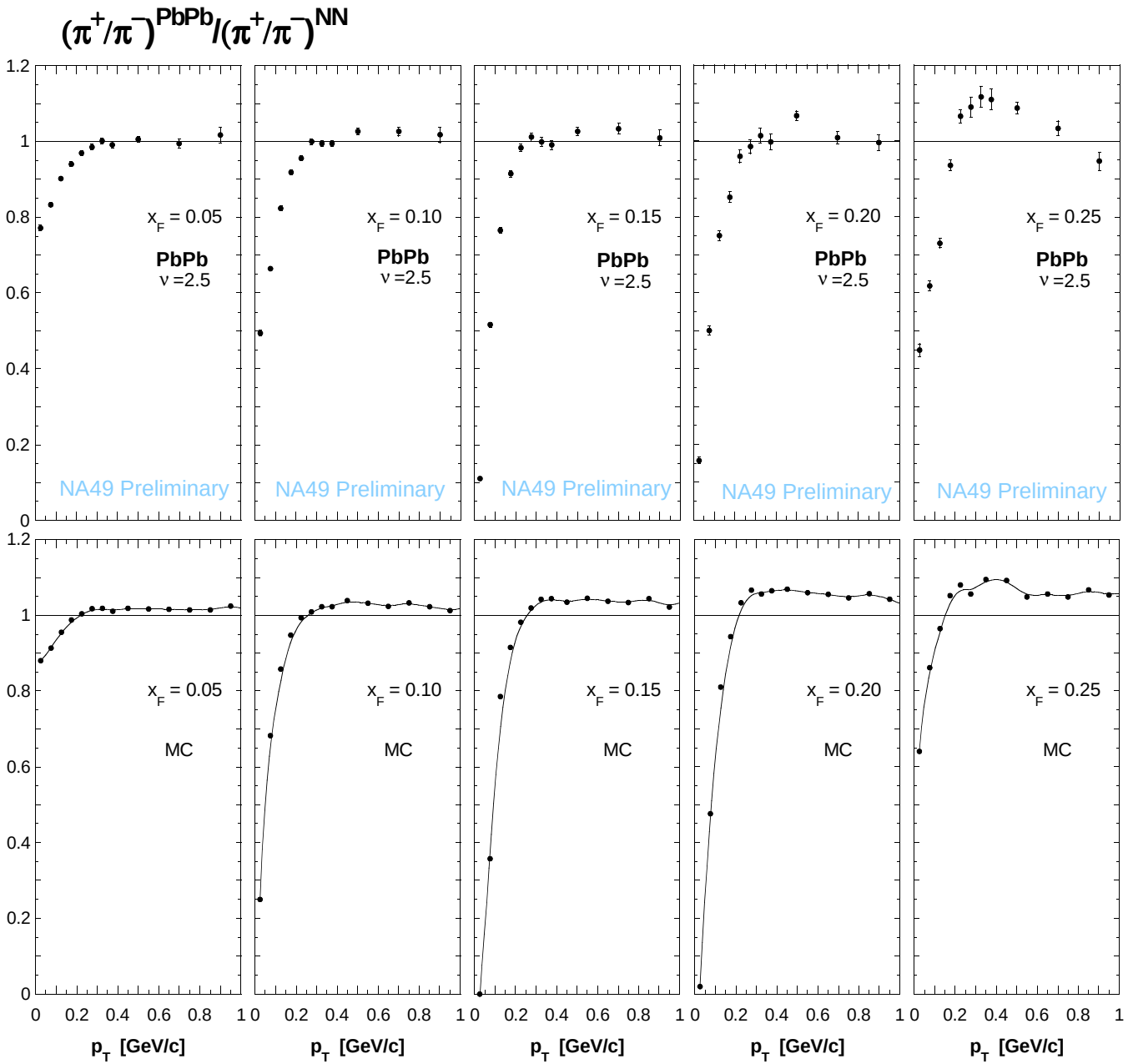


- Low p_T, around $x_F = 0.15$: very small π^+/π^- ratio, compared to the isospin expectation





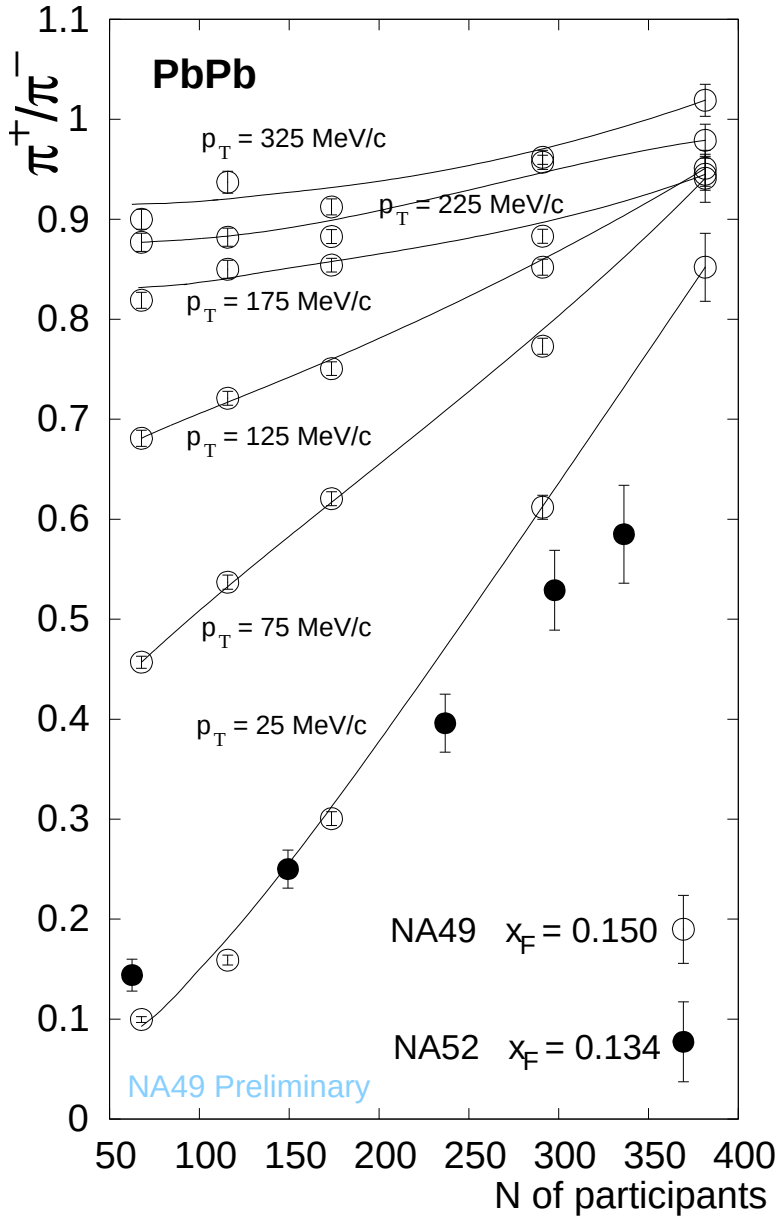
- Dip at $x_F = 0.15$ for pions: close to beam rapidity.
  Ratio lower than from any hadronic source ⇒ Coulomb effect from spectators



Simplified Monte-carlo, containing:

- Coulomb-field from spectator protons
- Emission of pions from N+N collisions
- Tracking emitted pions

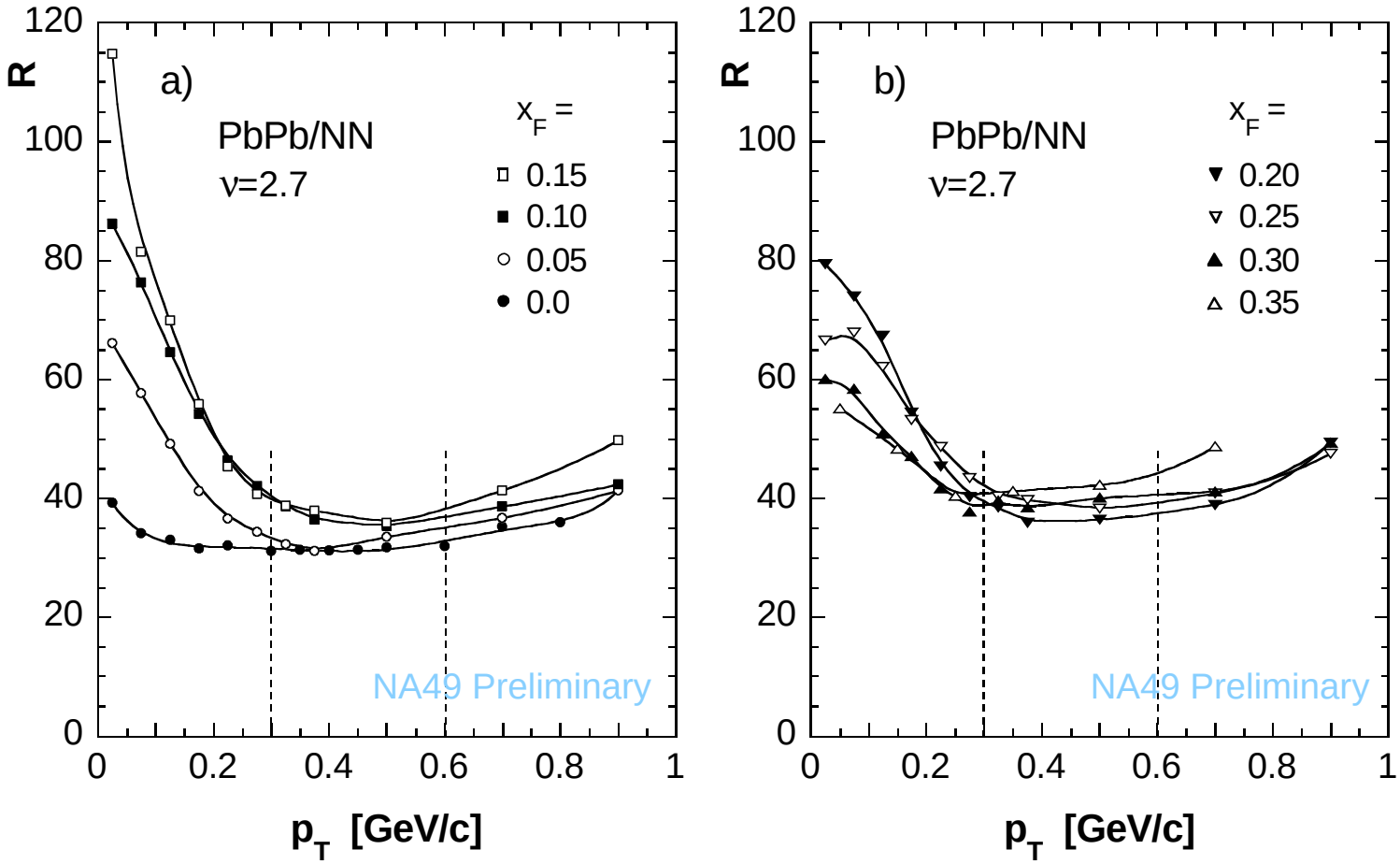
π^+/π^- ratios: Centrality dependence



- Observed effect decreases with increasing centrality
  $\Rightarrow$ connected to spectator system

Average pion ($\frac{\pi^+ + \pi^-}{2}$) yields

Yield increase relative to N+N: $R(x_F, p_T) = \frac{<\pi>^{PbPb}}{<\pi>^{NN}}(x_F, p_T)$

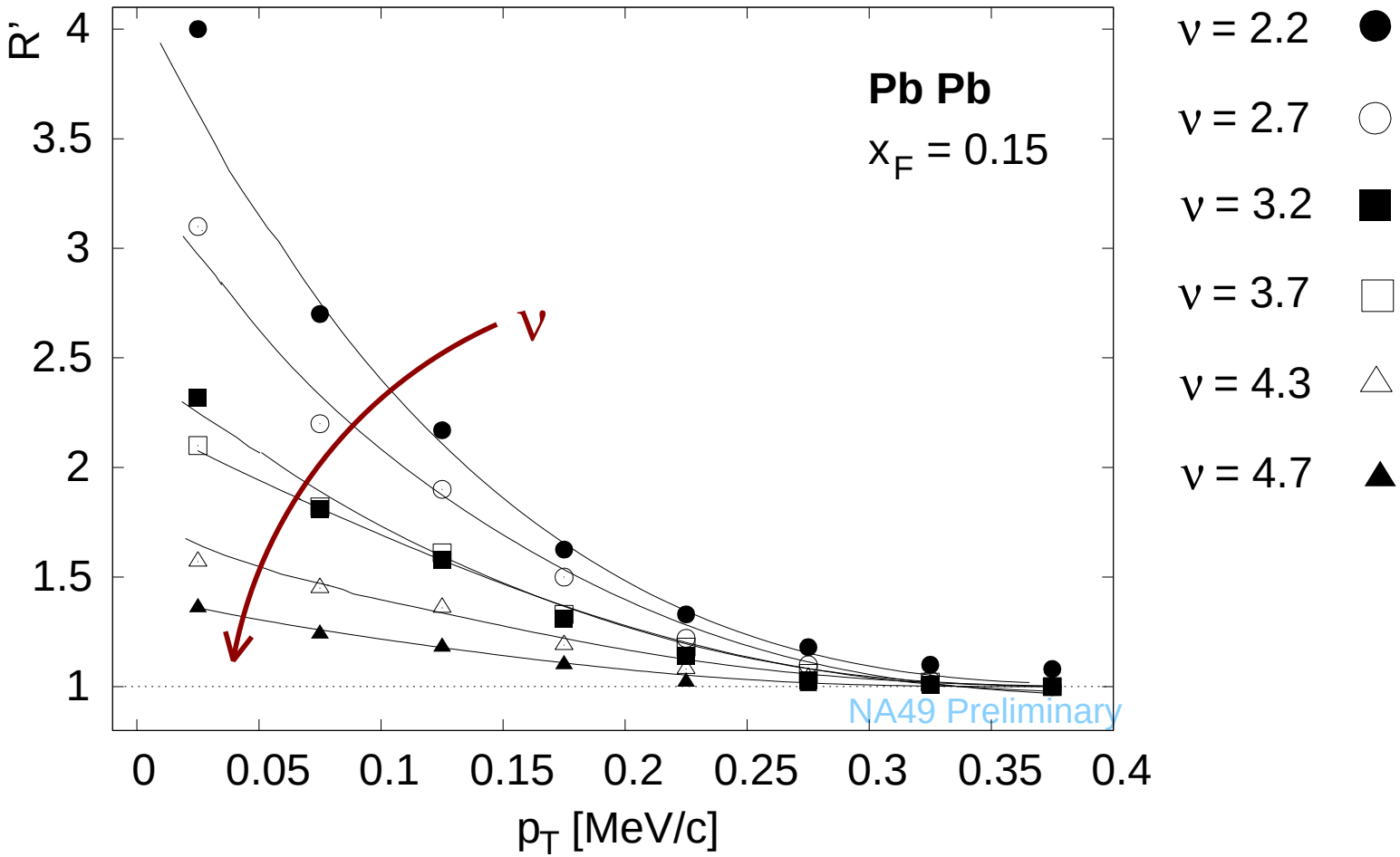


- Yield increase close to beam rapidity (Not expected from Coulomb effect!)

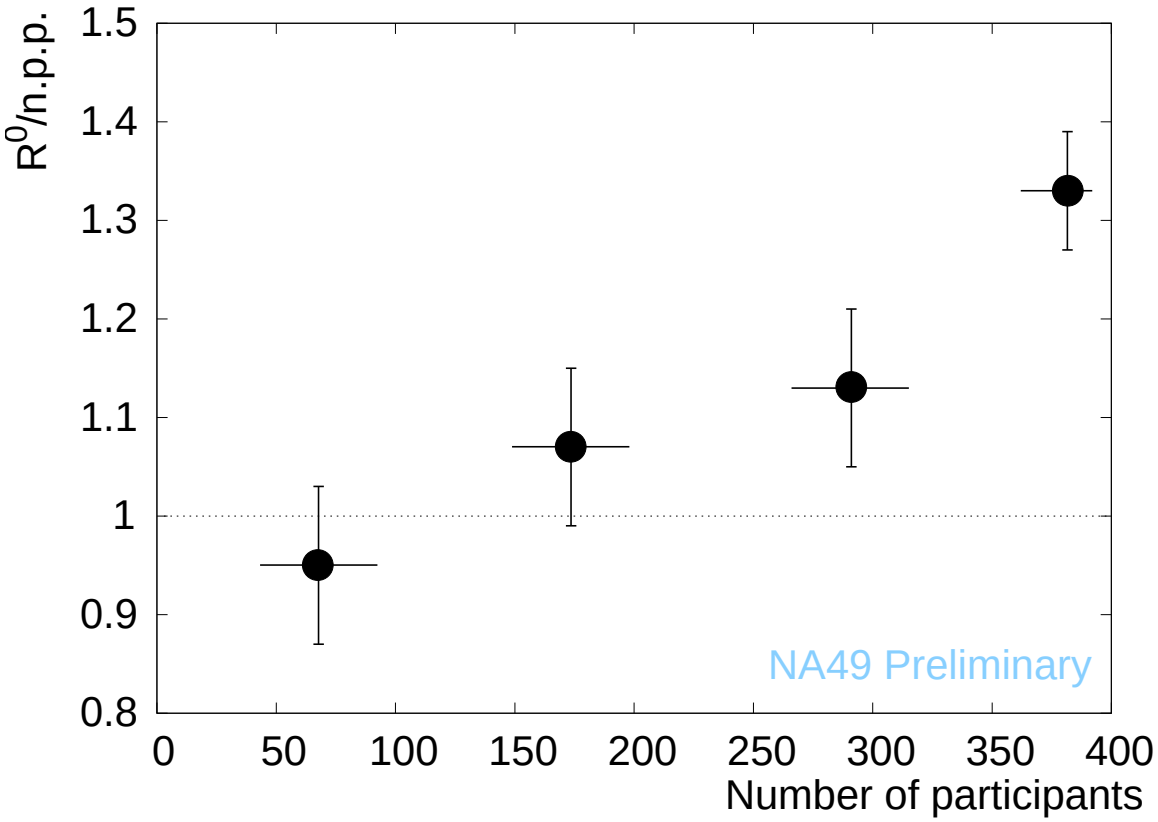
$$p_T < 0.3GeV$$

- Yield relative to plateau height decreases with increasing centrality

⇒ again connected to spectator system

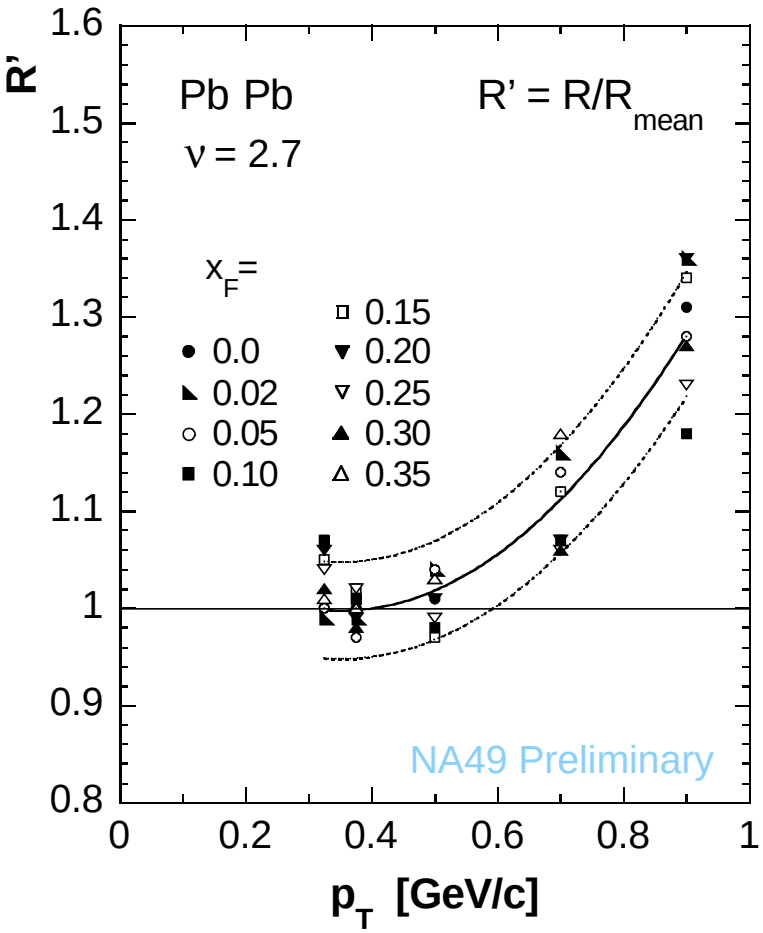


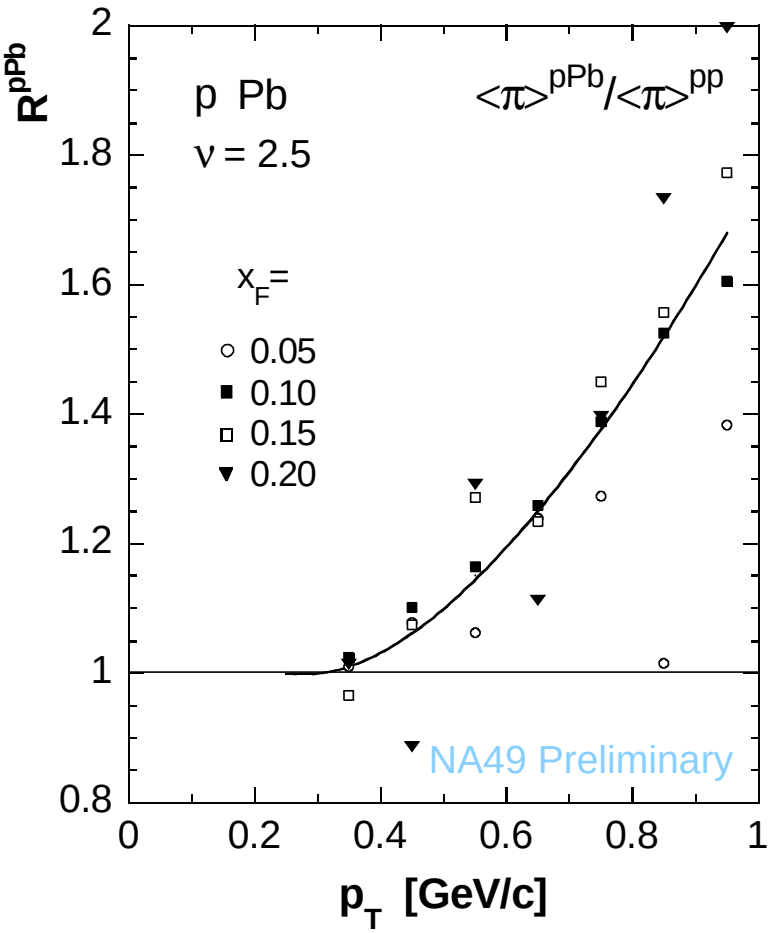
$0.3 < p_T < 0.6 GeV$: Plateau region



- Increase of plateau height with centrality, faster than number of participants: real increase of pion production in Pb+Pb

$p_T > 0.6GeV$: medium-high p_T enhancement





- Enhancement of pion yield with increasing p_T in Pb+Pb relative to the plateau
- Similar pattern as Cronin-effect in p+A: multiple collision phenomenon

Conclusions

- Low p_T, below 0.3 GeV: strong spectator-system connected phenomena, such as Coulomb effect, spectator decay
- Medium p_T, between 0.3 and 0.6 GeV: increase of yield with centrality
- Higher p_T, above 0.6 GeV: enhanced pion production (low side of Cronin-effect)