J/PSI FORMATION VIA IN-MEDIUM RECOMBINATION

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Predictions for Rapidity and Transverse Momentum Spectra at 5.5 TeV

Workshop on Heavy Ion Collisions at LHC

May-June 2007

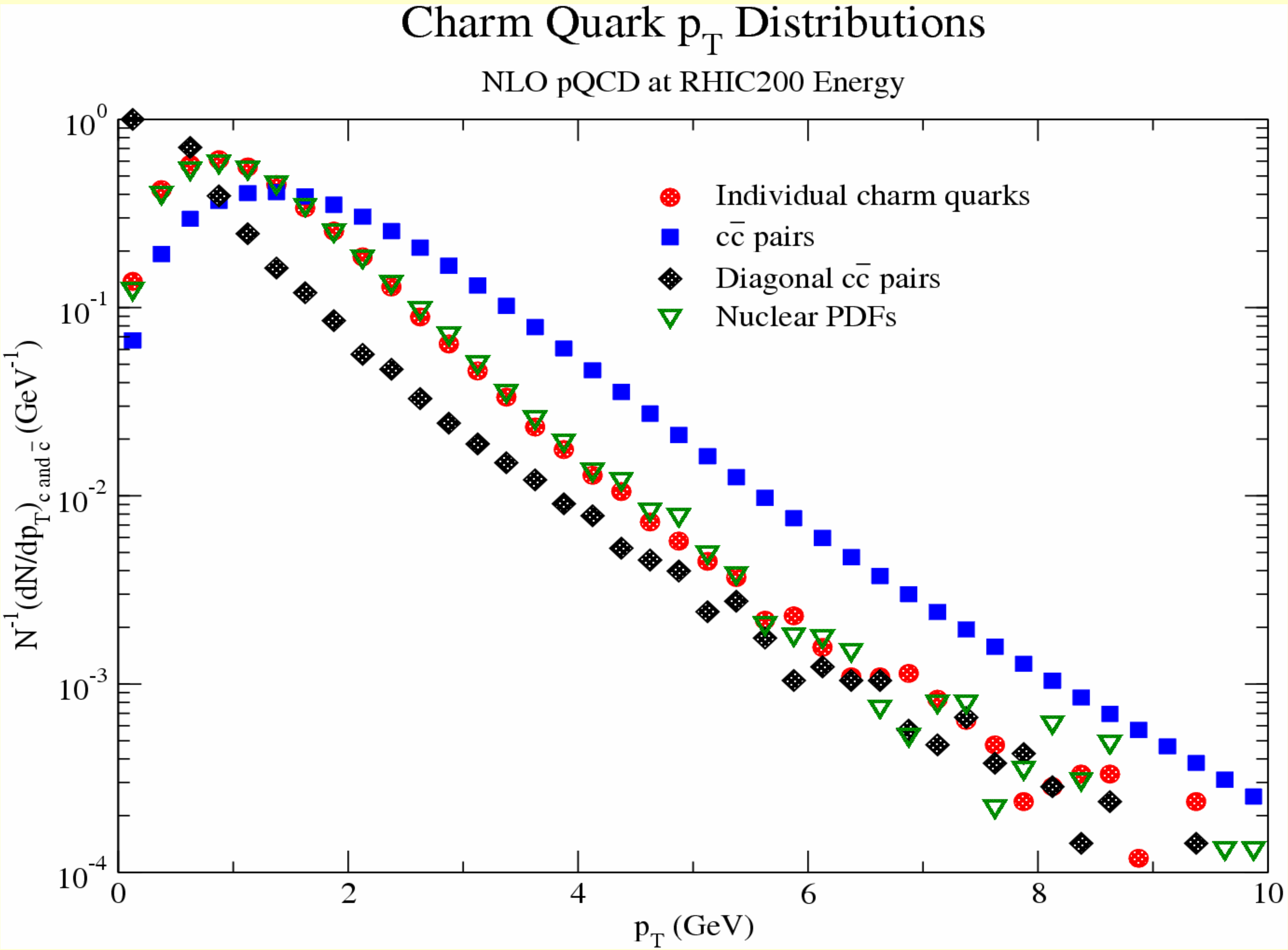
CAN Y AND P_T SPECTRA PROVIDE SIGNATURES OF IN-MEDIUM FORMATION?

R. L. Thews and M. L. Mangano Phys. Rev. C73, 014904 (2006) [nucl-th/0505055]

1. Generate sample of ccbar pairs from NLO pQCD (smear LO q_t)
2. Supplement with k_t to simulate initial state and confinement effects
3. Integrate formation rate using these events to define particle distributions (no cquark-medium interaction)
4. Repeat with cquark thermal+flow distribution (maximal cquark-medium interaction)

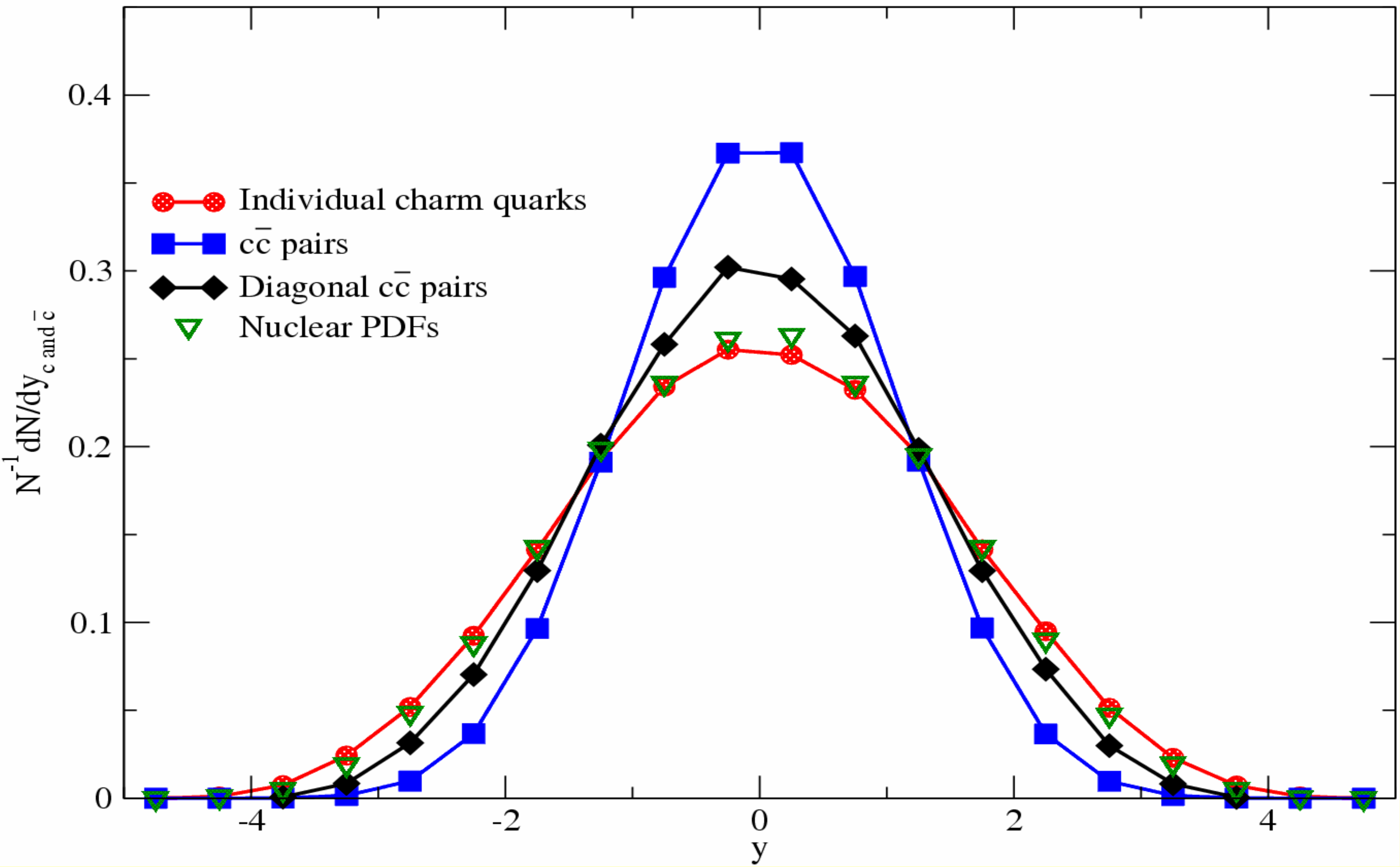
$$\frac{dN_{J/\psi}}{d^3p_{J/\psi}} = \int \frac{dt}{V(t)} \sum_{i=1}^{N_{c\bar{c}}} \sum_{j=1}^{N_{c\bar{c}}} v_{rel} \frac{d\sigma(p_i + p_j \to p_{J/\psi} + X)}{d^3p_{J/\psi}}$$

- All combinations of c and cbar contribute
- Total has expected $(N_{ccbar})^2$ / V behavior
- Prefactor is integrated flux per ccbar pair
- "Off-Diagonal" Pair y and p_T distributions differ from "Diagonal", should survive in J/ψ
- Weighting with in-medium formation probability introduces additional modification

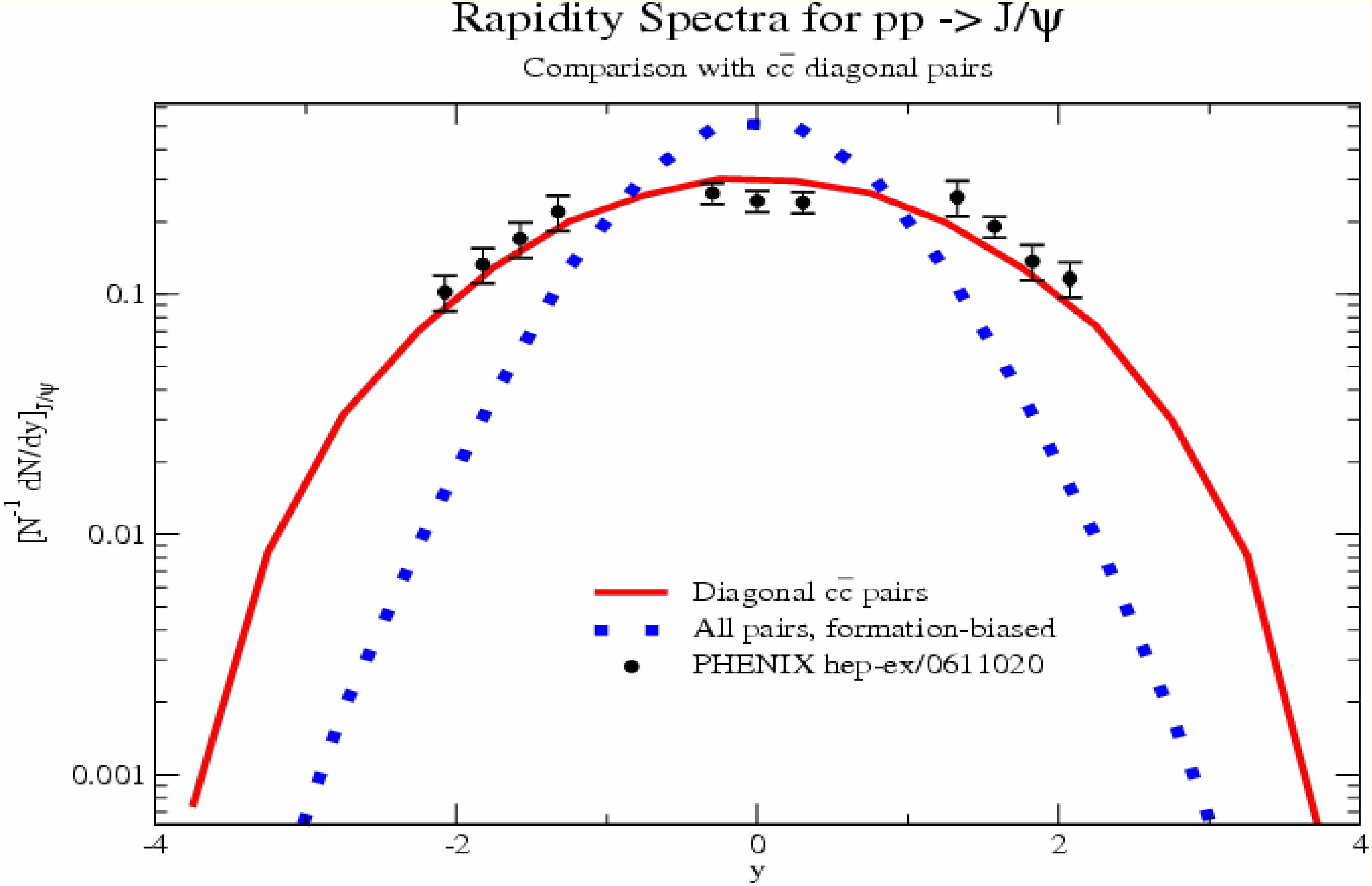

Charm Quark p_T Distributions
NLO pQCD at RHIC200 Energy
Individual charm quarks
$c\bar{c}$ pairs
Diagonal $c\bar{c}$ pairs
Nuclear PDFs
$N^{-1}(dN/dp_T)_{c\ \mathrm{and}\ \bar{c}}$ (GeV^{-1})
p_T (GeV)
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
2
4
6
8
10

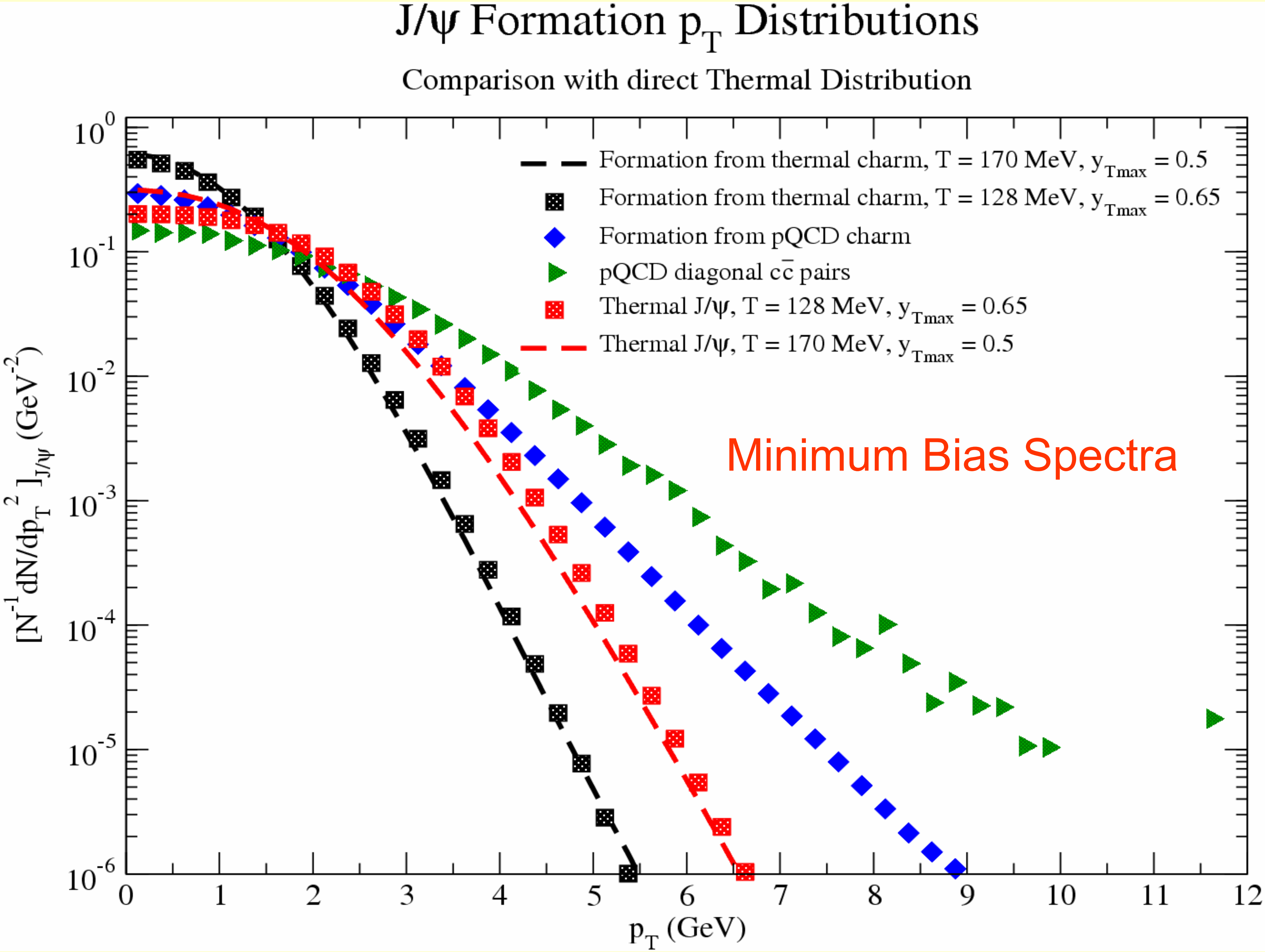
Charm Quark y Distributions

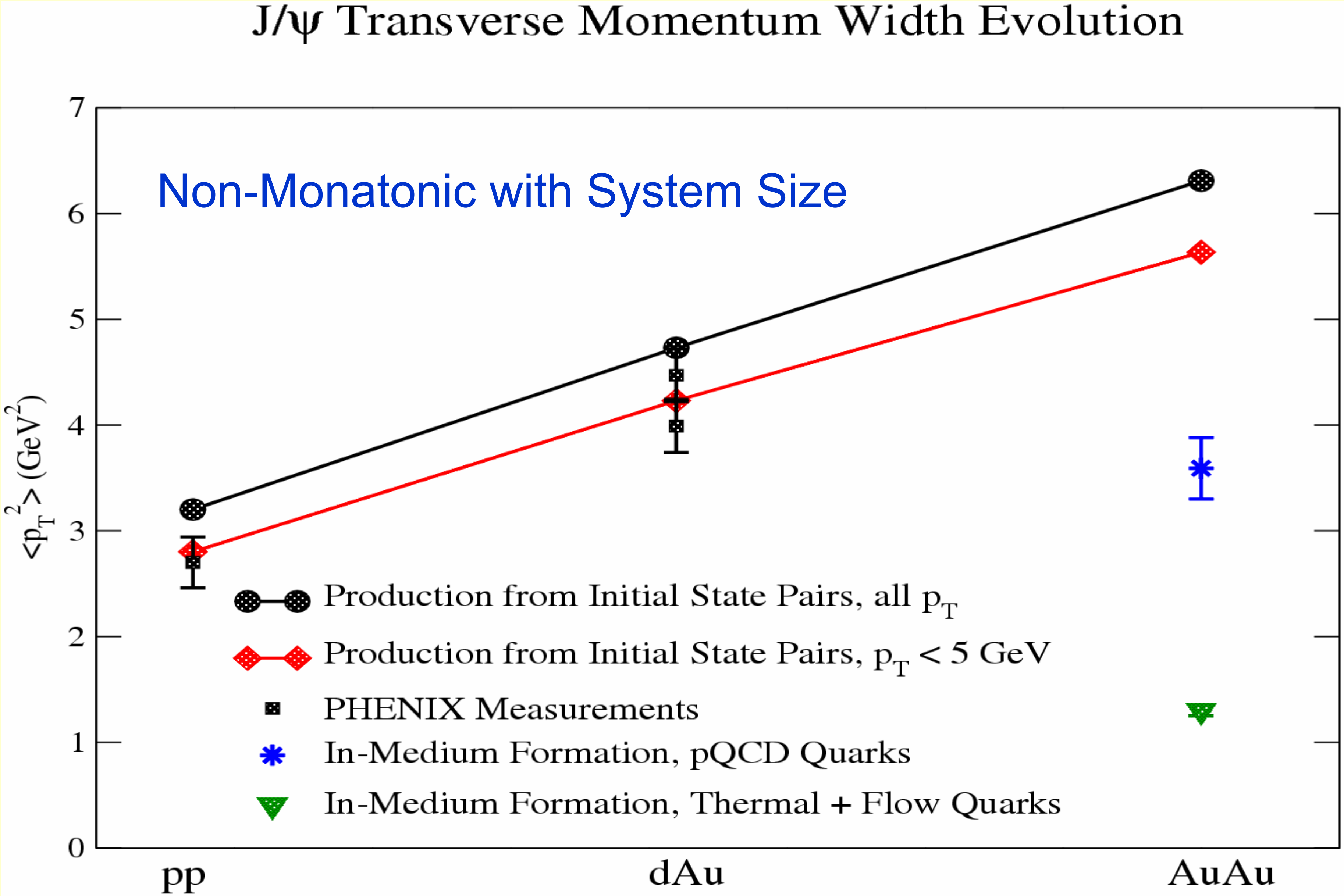
NLO pQCD at RHIC200 Energy



pp at RHIC "selects" unbiased diagonal pairs




J/ψ Formation pT Distributions
Comparison with direct Thermal Distribution
Formation from thermal charm, T = 170 MeV, yTmax = 0.5
Formation from thermal charm, T = 128 MeV, yTmax = 0.65
Formation from pQCD charm
pQCD diagonal cc̄ pairs
Thermal J/ψ, T = 128 MeV, yTmax = 0.65
Thermal J/ψ, T = 170 MeV, yTmax = 0.5
Minimum Bias Spectra
[N-1dN/dpT2]J/ψ (GeV-2)
pT (GeV)

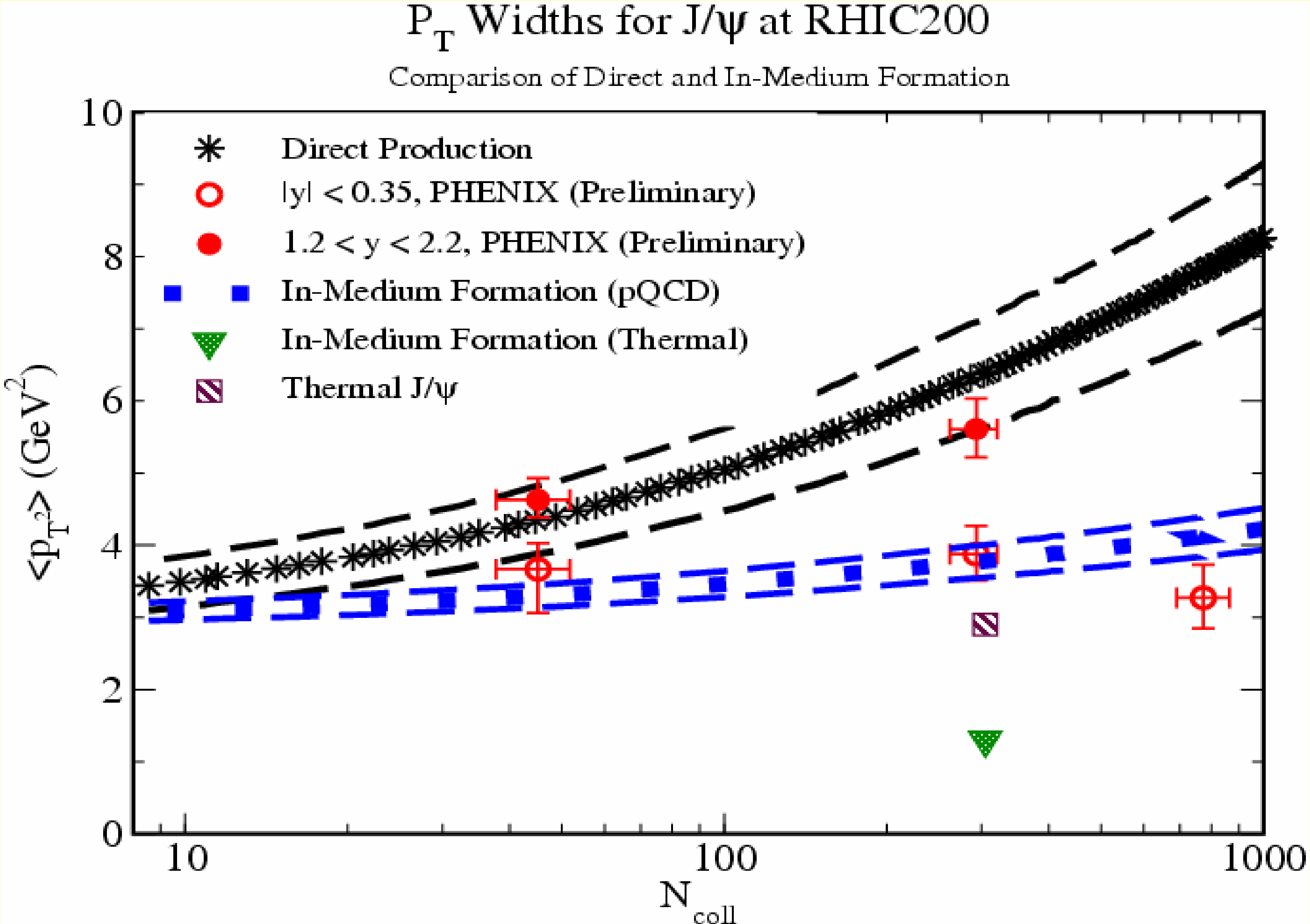

J/ψ Transverse Momentum Width Evolution
Non-Monatonic with System Size
<p_T^2> (GeV^2)
0
1
2
3
4
5
6
7
pp
dAu
AuAu
Production from Initial State Pairs, all p_T
Production from Initial State Pairs, p_T < 5 GeV
PHENIX Measurements
In-Medium Formation, pQCD Quarks
In-Medium Formation, Thermal + Flow Quarks

$$< p_T^2 >_{AB} = < p_T^2 >_{pp} + \lambda^2 \{\bar{n}_A + \bar{n}_B - 2\}$$

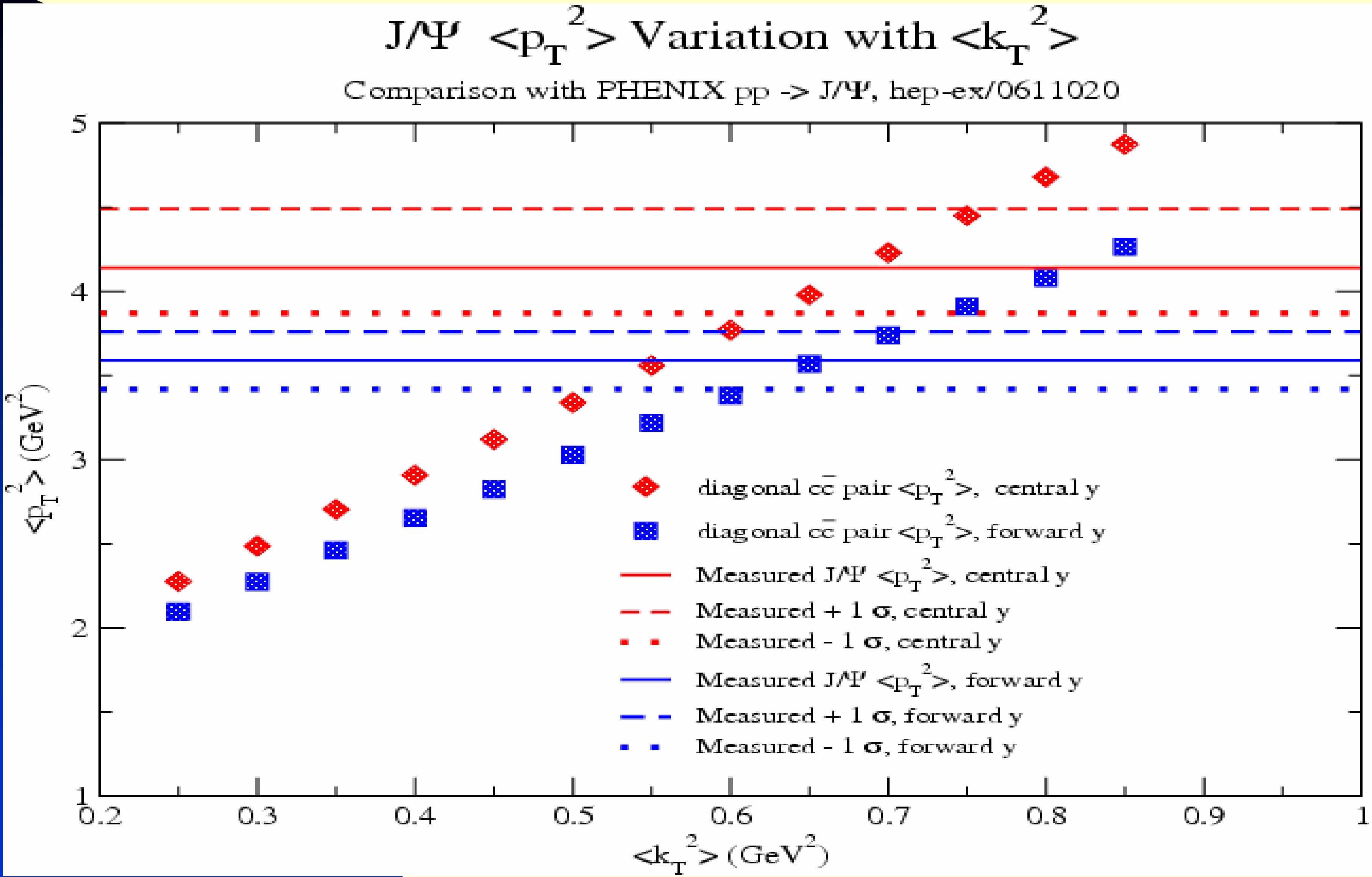
Nuclear broadening from Initial state parton scattering, extract $\lambda^2 =$ 0.56 +/- 0.08 GeV^2 from preliminary pp and dAu at RHIC, compare with 0.12 +/- .02 GeV^2 at fixed-target energy.

Final extracted values give 0.22 +/- 0.11 GeV^2

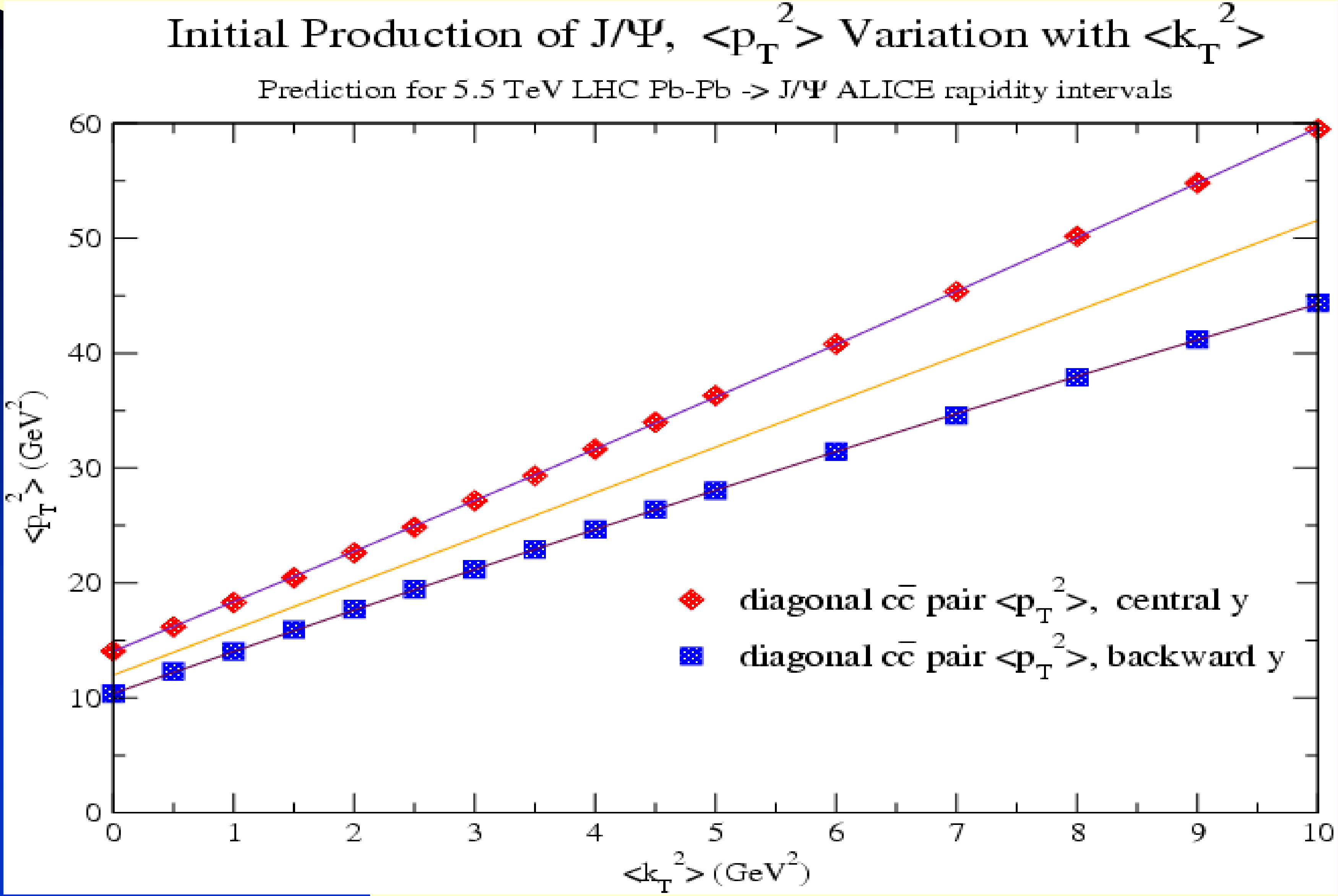
Use geometry to calculate centrality behavior in nbar



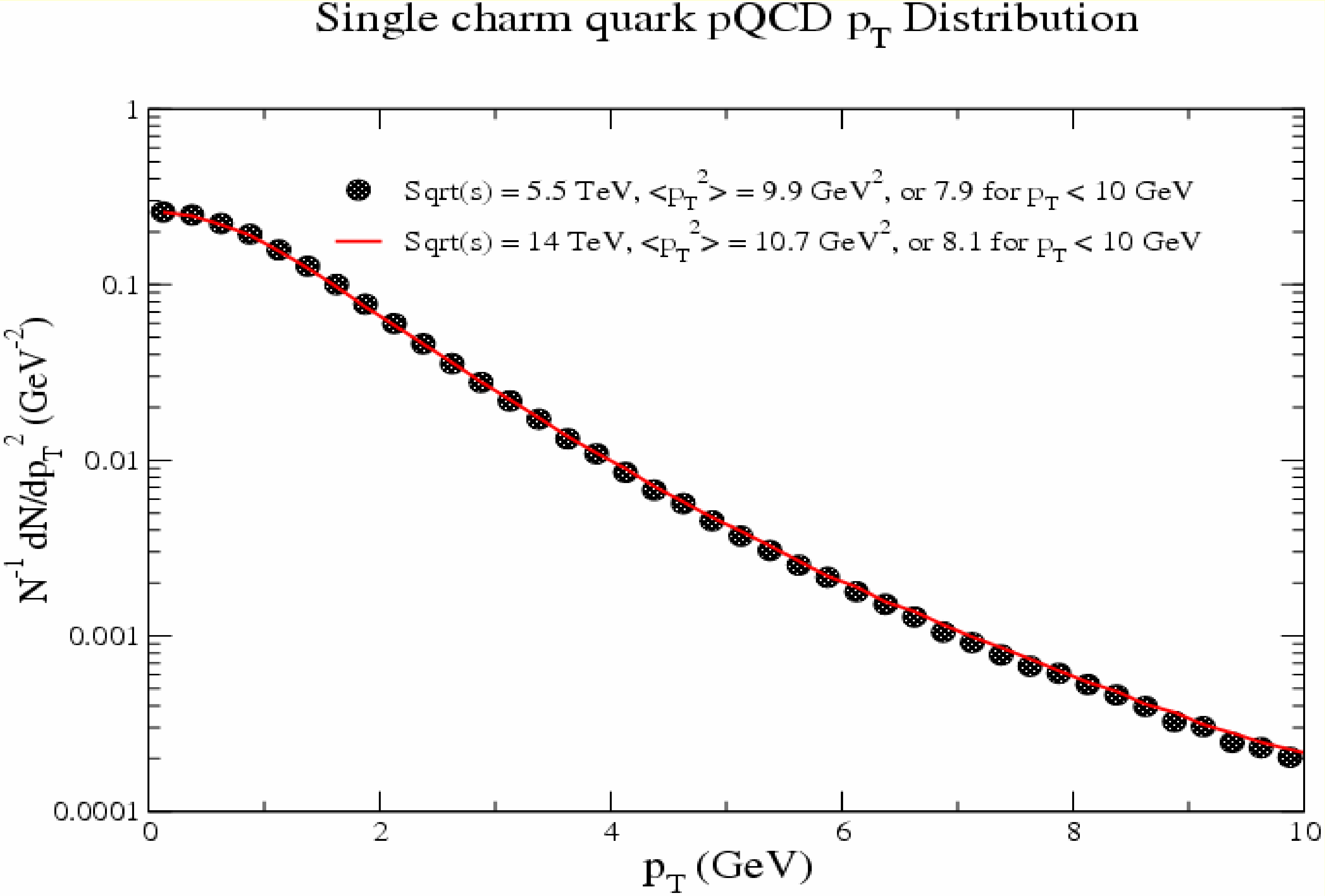
Use combination of rapidity intervals to fix $\langle k_T^2 \rangle_{pp}$



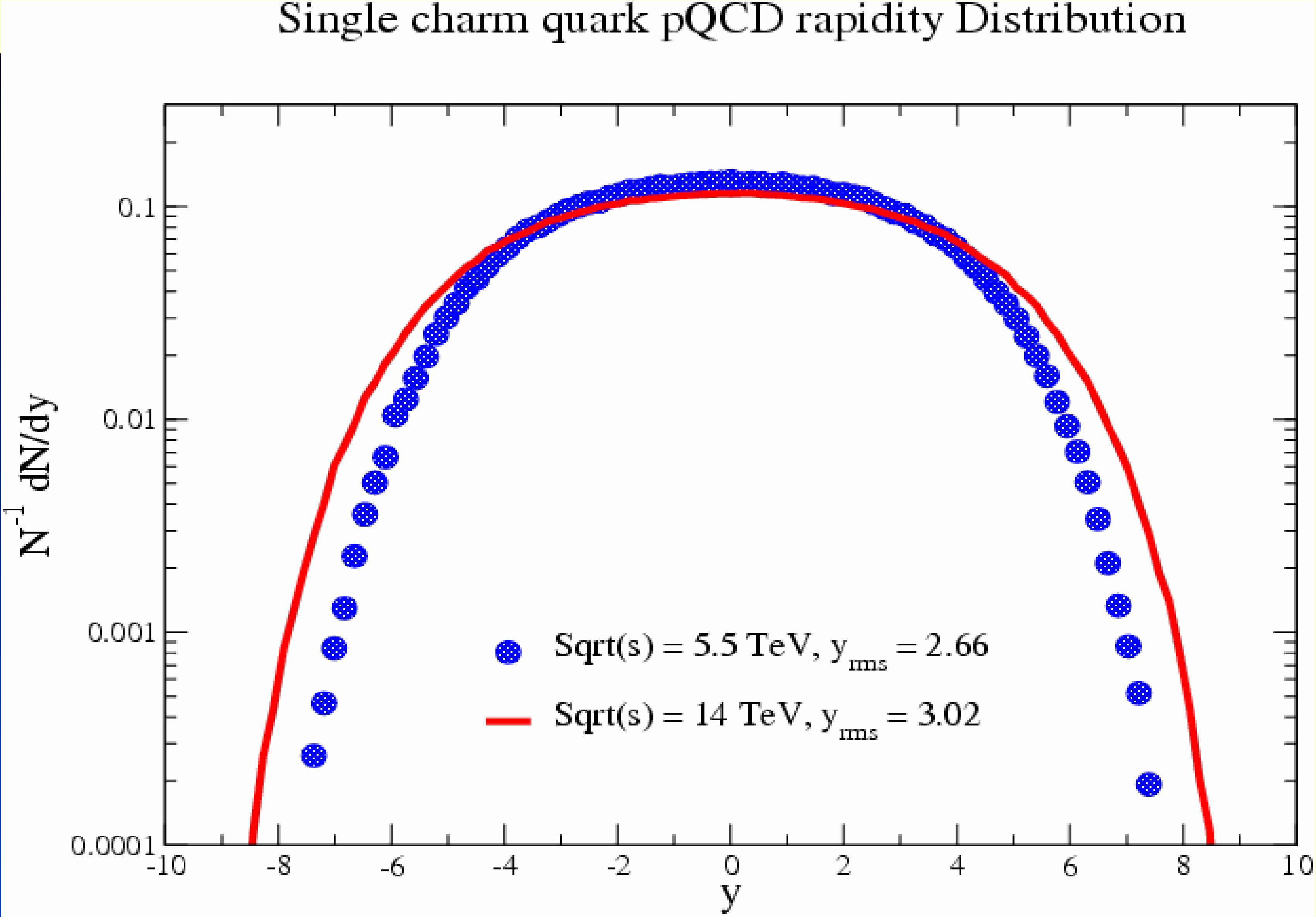
Same procedure possible for LHC, with larger scale



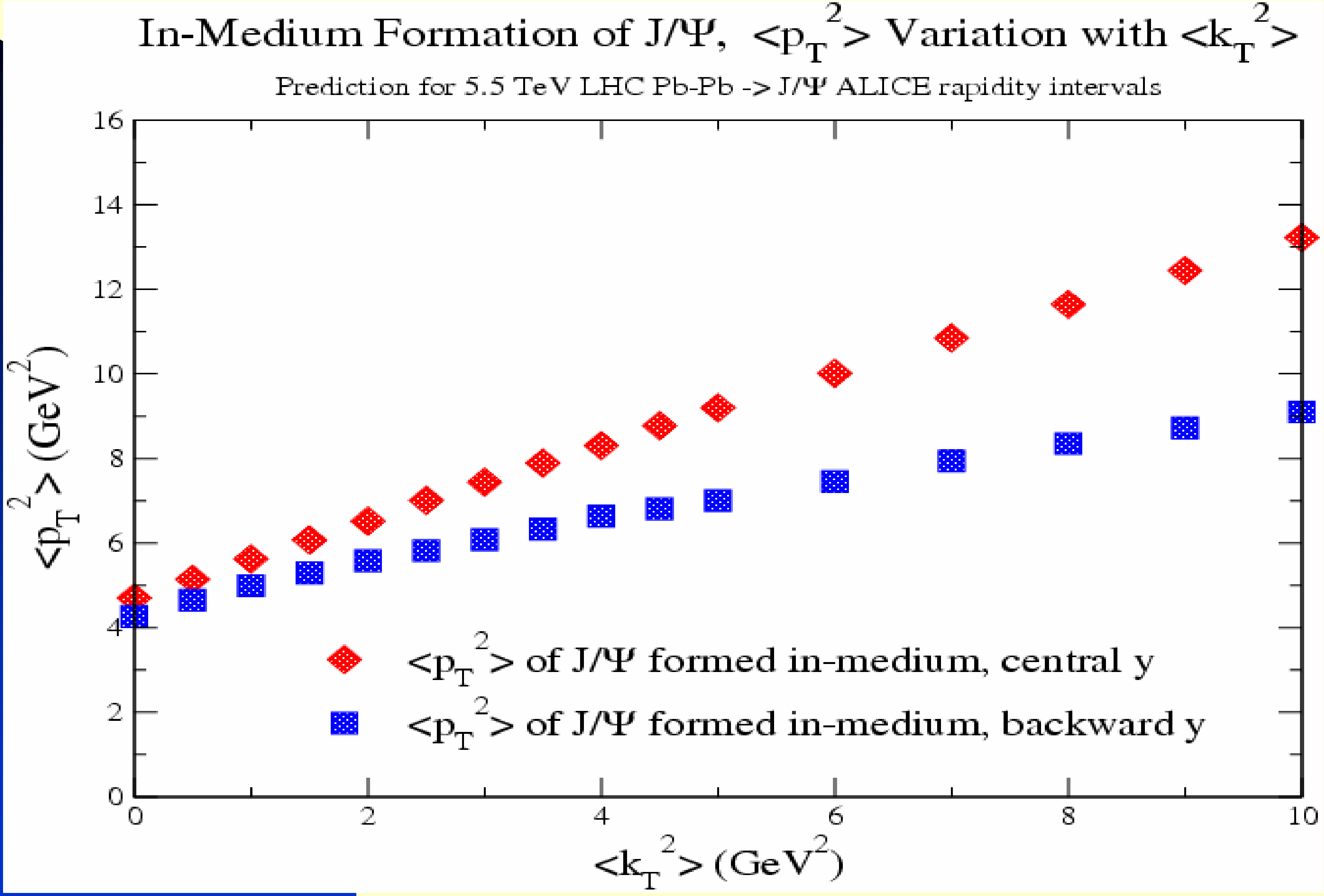
We can use pp results at 14 TeV as approximate p_T input for in-medium formation calculations at 5.5 TeV

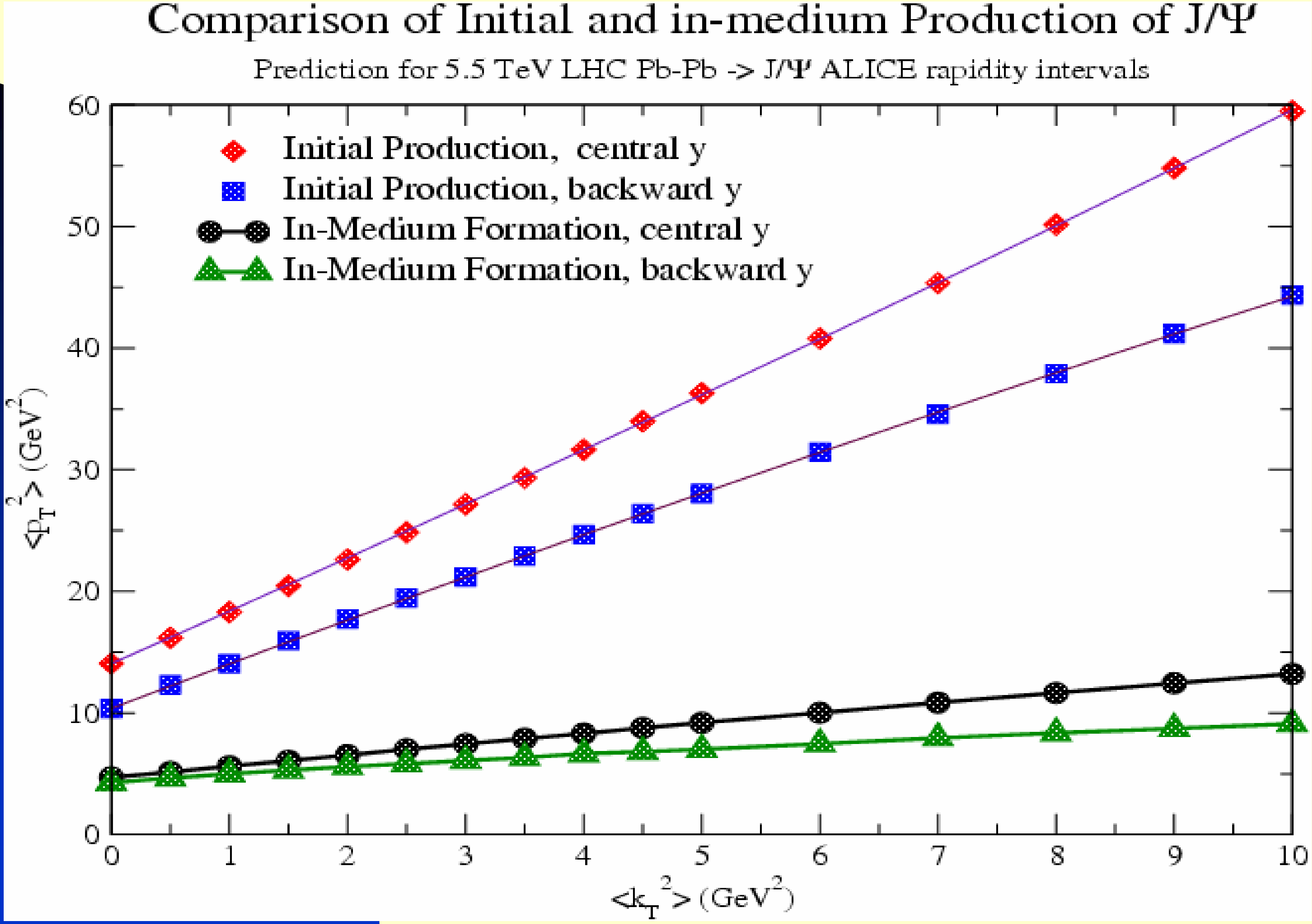


Same for approximate rapidity input distributions

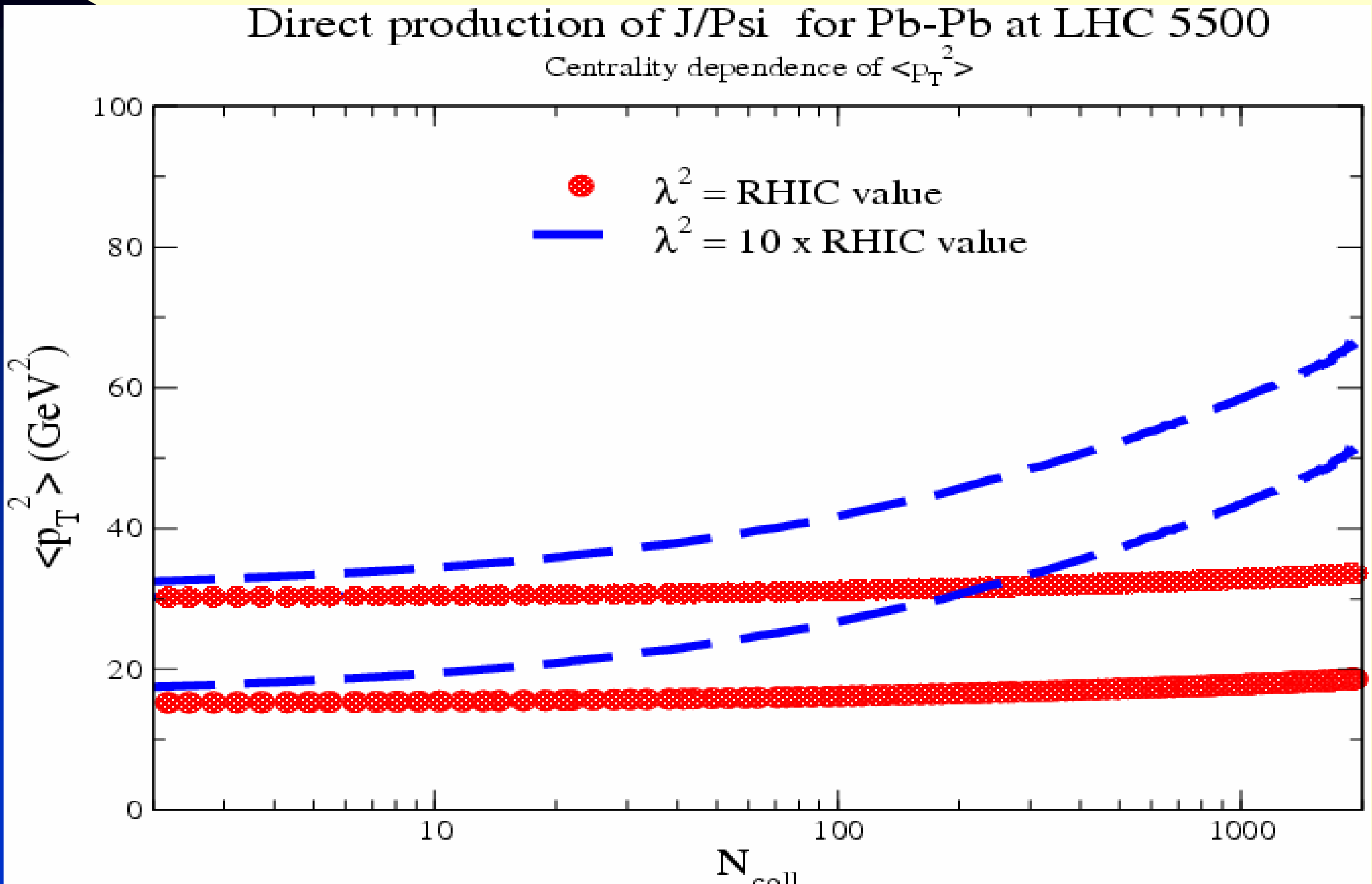


In-medium formation continues to exhibit narrowing

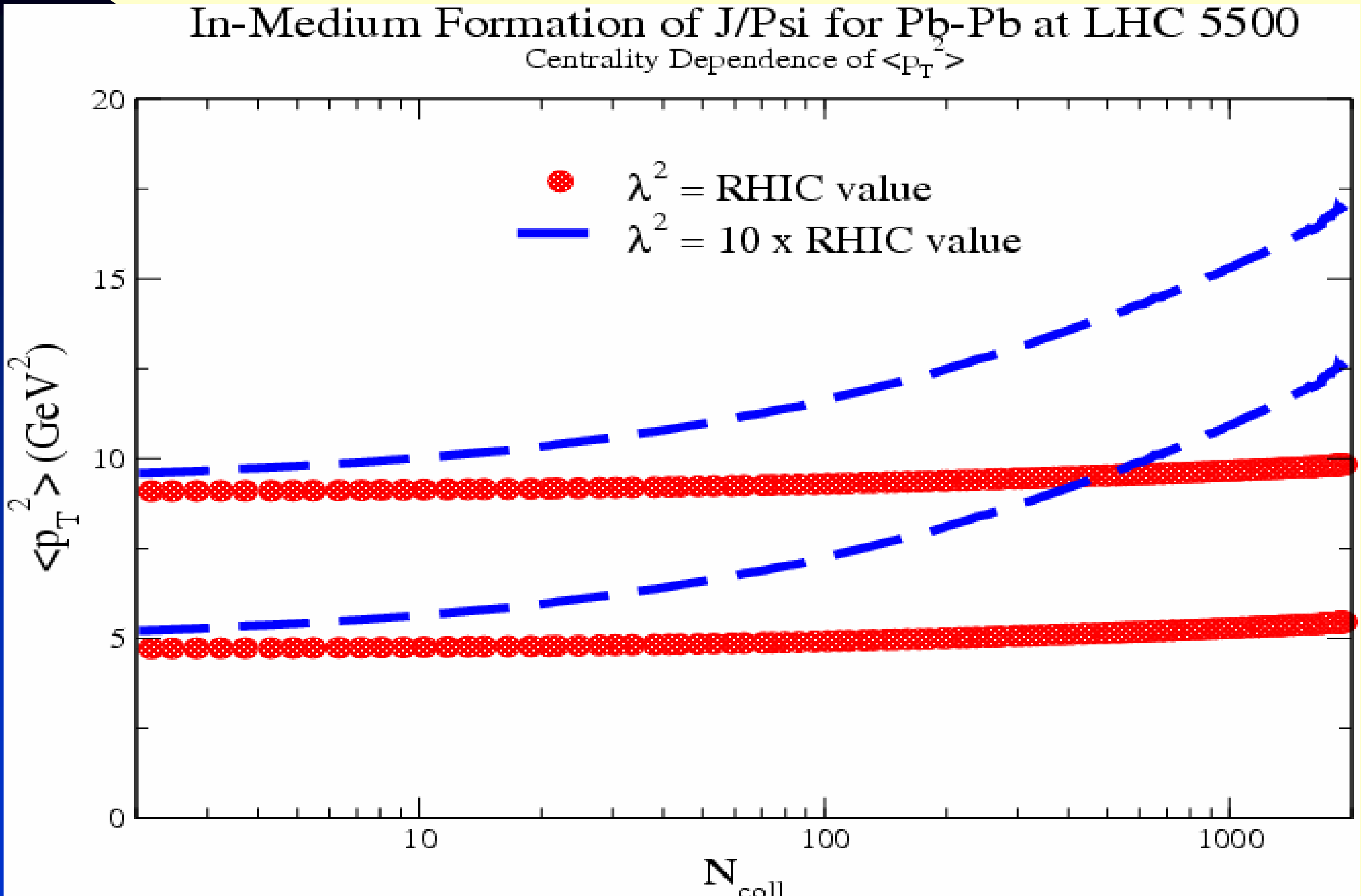



Comparison of Initial and in-medium Production of J/Ψ
Prediction for 5.5 TeV LHC Pb-Pb -> J/Ψ ALICE rapidity intervals
Initial Production, central y
Initial Production, backward y
In-Medium Formation, central y
In-Medium Formation, backward y
$<p_T^2>$ (GeV^2)
$<k_T^2>$ (GeV^2)
0
10
20
30
40
50
60
0
1
2
3
4
5
6
7
8
9
10

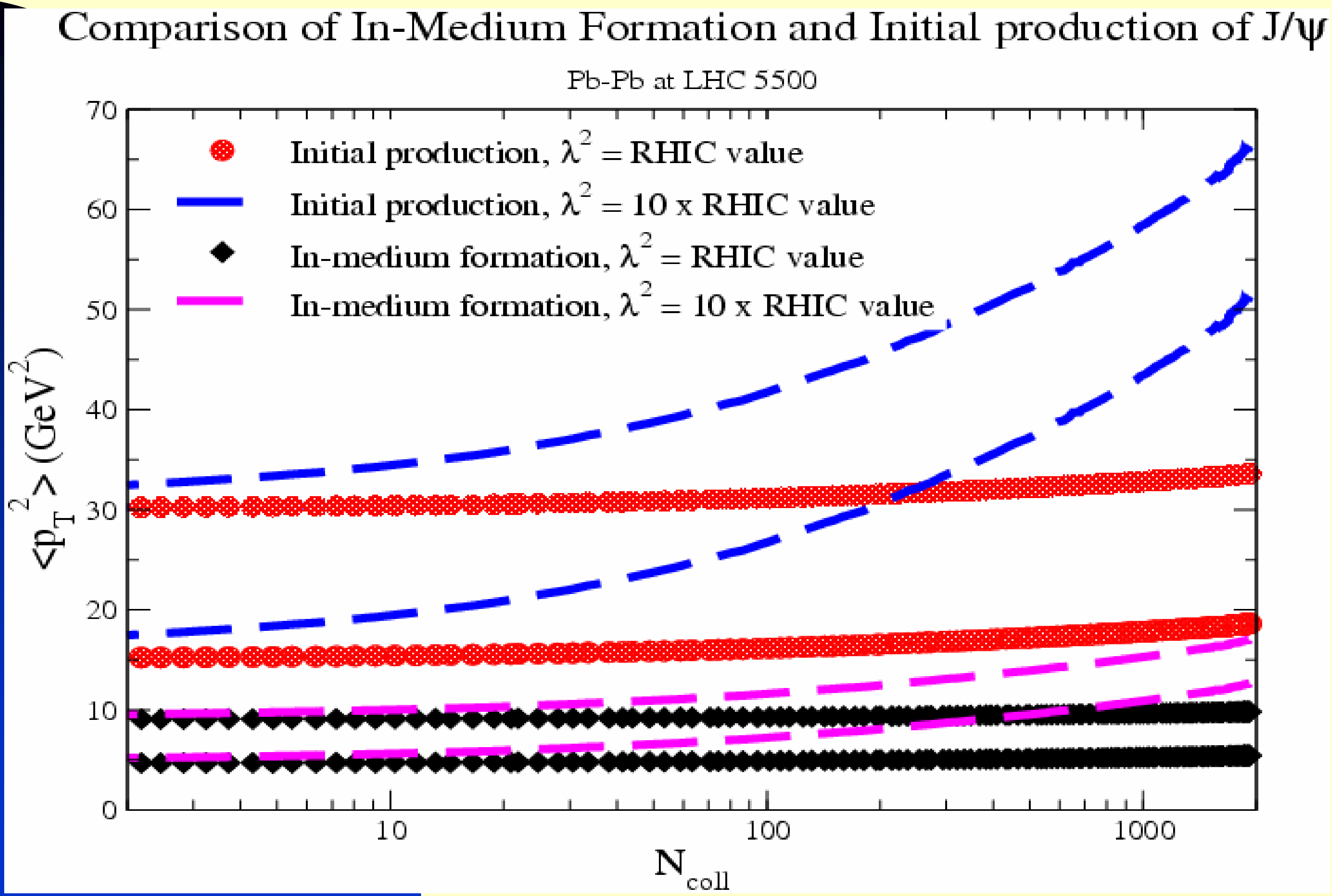
Choice of curve pairs determined by <p_T^2> in pp and p-Pb



In-Medium formation narrows by factor of 4



Measurement of pp and pA will select parameters



SUMMARY

- Predictions of p_T spectra for J/ψ produced in Pb-Pb collisions at 5.5 TeV require two input parameters which can be extracted from measurements in pp and p-Pb systems at energy in the 5.5 to 14 TeV range.
- The widths of the p_T spectra and their centrality dependence exhibit characteristic features which can differentiate between in-medium formation and direct initial production from charm quark pairs with pQCD momentum distributions.