Particle Production and Correlation from the Recombination Model

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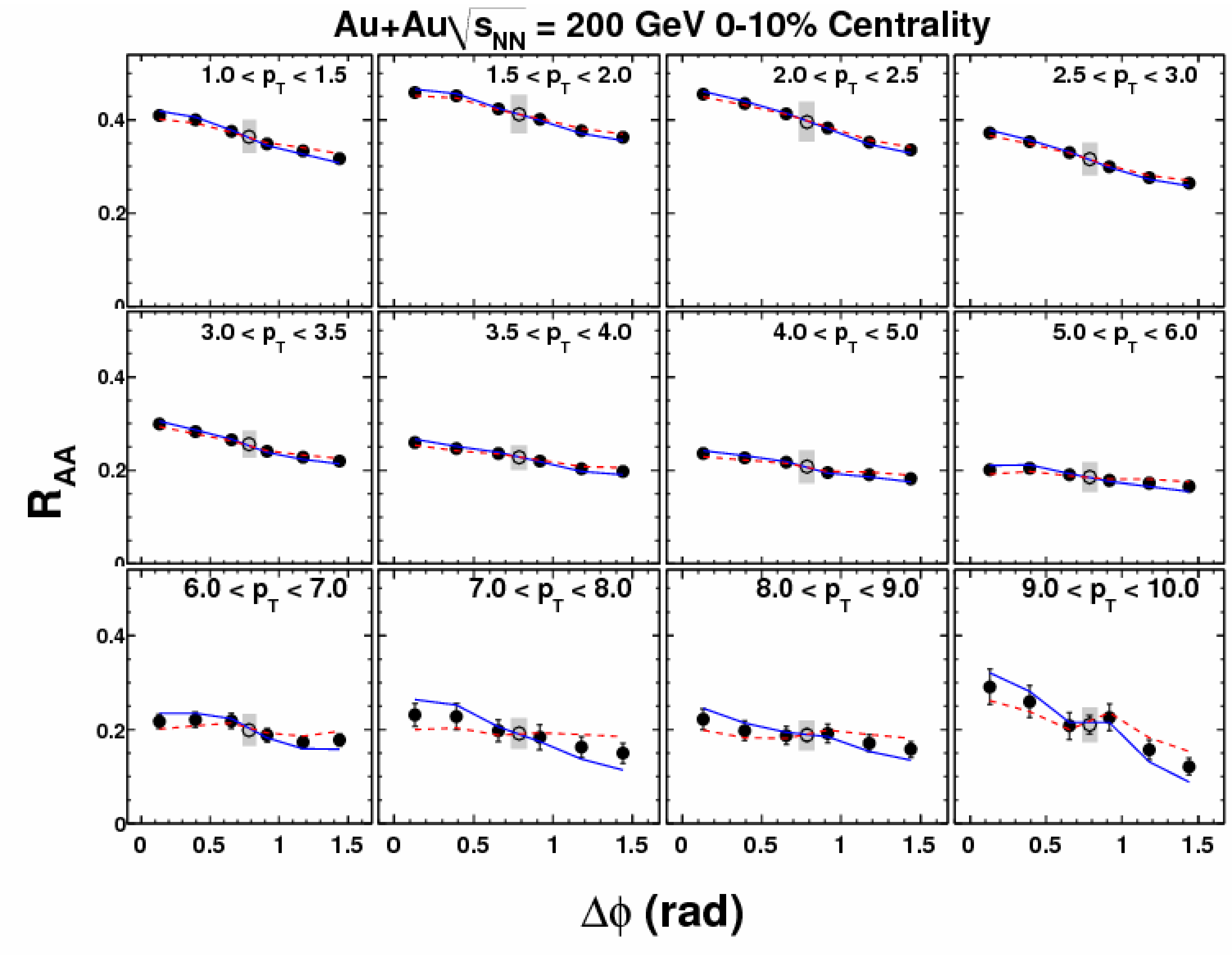
Outline

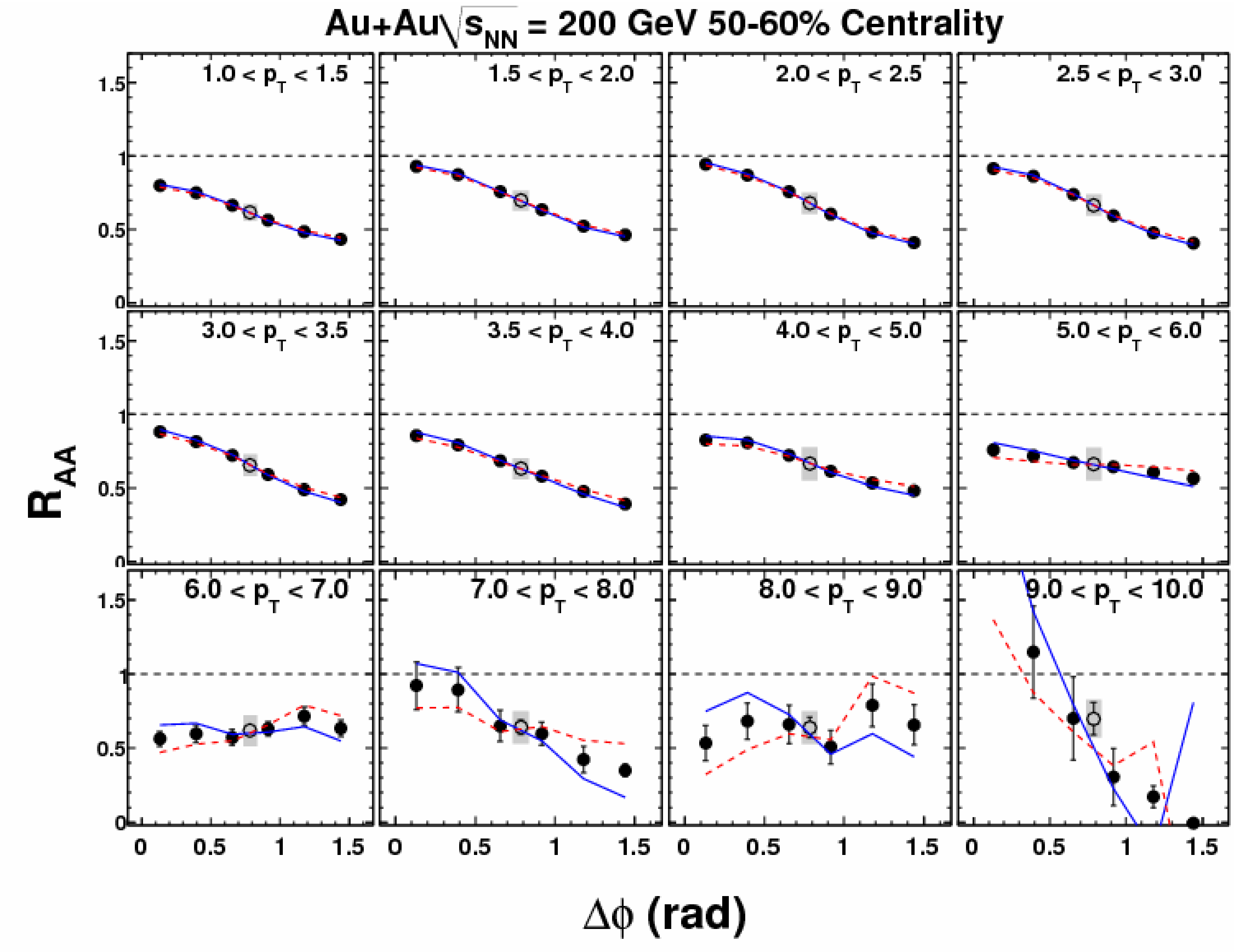
- Data and our motivation
- Quark recombination model
- Scaling of dynamical path length dis
- Particle spectrum
- Correlations in jet
- Discussion

PHENIX



Au+Au $\sqrt{s_{NN}}$ = 200 GeV 0-10% Centrality
1.0 < p_T < 1.5
1.5 < p_T < 2.0
2.0 < p_T < 2.5
2.5 < p_T < 3.0
3.0 < p_T < 3.5
3.5 < p_T < 4.0
4.0 < p_T < 5.0
5.0 < p_T < 6.0
6.0 < p_T < 7.0
7.0 < p_T < 8.0
8.0 < p_T < 9.0
9.0 < p_T < 10.0
R_{AA}
0
0.2
0.4
0.5
1
1.5
$\Delta\phi$ (rad)

PHENIX



Au+Au $\sqrt{s_{NN}}$ = 200 GeV 50-60% Centrality
1.0 < p_T < 1.5
1.5 < p_T < 2.0
2.0 < p_T < 2.5
2.5 < p_T < 3.0
3.0 < p_T < 3.5
3.5 < p_T < 4.0
4.0 < p_T < 5.0
5.0 < p_T < 6.0
6.0 < p_T < 7.0
7.0 < p_T < 8.0
8.0 < p_T < 9.0
9.0 < p_T < 10.0
R_{AA}
Δφ (rad)

Our aim

- Find simplifying features of the data
- Relation with nuclear geometry
- Dynamical hadronization mechanism
- New understanding of the data
- Implications for LHC/ALICE

Recombination models

- Hadrons formed by combining two (three) constituent quarks
- Combining probabilities, determined by wave functions, called the recombination functions
- There are soft and hard partons
- Hard parton will lose energy in traversing the medium
- There are different implementations
- Hard partons evolve into semi-hard showers

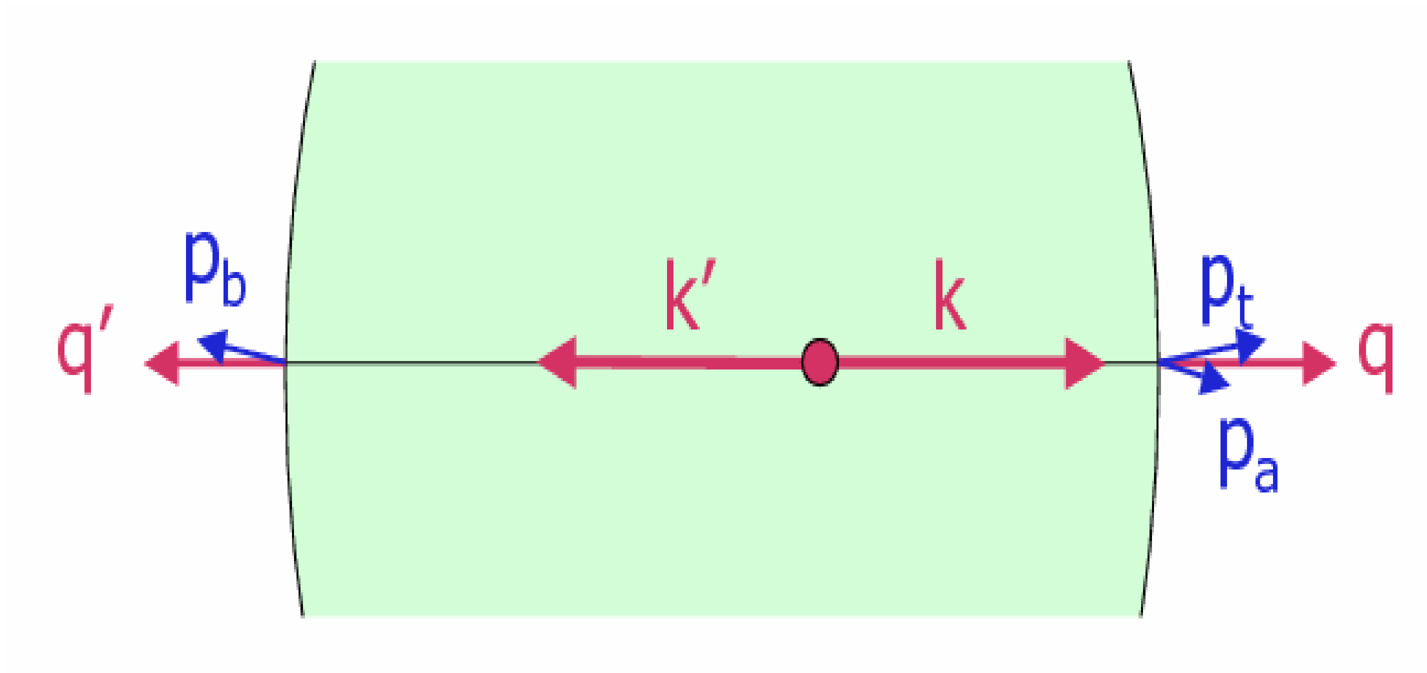
$$p\frac{dN_\pi}{dp} = \int \frac{dq_1}{q_1}\frac{dq_2}{q_2} F_{q\bar{q}}(q_1, q_2) R_\pi(q_1, q_2, p)$$

$$F_{q\bar{q}}(q_1, q_2) = \mathcal{TT} + \mathcal{TS} + \mathcal{SS}$$

$$R_\pi(q_1, q_2, p) = \frac{q_1 q_2}{p^2}\delta\left(\frac{q_1}{p} + \frac{q_2}{p} - 1\right)$$

$$\mathcal{T}(q_1) = q_1 \frac{dN_q^{\mathrm{th}}}{dq_1} = C q_1 e^{-q_1/T}$$

Relevant partonic and hadronic variables



1. Position of hard scattering can be differen
2. Hard momentum k=k' fluctuates

$$\frac{dN}{p_T dp_T d\varphi}(b)\bigg|_{jet} = \int \frac{dq}{q} \sum_i F_i(q,b,\varphi) H_i(q,p_T)$$

Hadronization dynamics, independent of centrality and azimuthal angle

Degraded parton distribution

$$F_i(q,b,\varphi) = \int dxdy Q(x,y) \int dkk f_i(k) G(q,k,l(x,y,b,\varphi))$$

$f_i(k)$ *given by pQCD*

Hard parton energy loss (model) depending on the traversed length

Weight for each point (Geometry)

Last equation can be rewritten as

$$F_i(q,b,\varphi) = \int d\xi P(\xi,b,\varphi) F_i(q,\xi)$$

$$F_i(q,\xi) = \int dkkf_i(k) G(k,q,\xi)$$

ξ called dynamical length

$$P(\xi,b,\varphi) = \int dxdy Q(x,y) \delta(\xi - \gamma l(x,y,b,\varphi))$$

Dynamical path length distribution

$$T_A(s) = A\int dz\,\rho(s,z)$$

$$L_{A,B}(x,y) = \frac{1}{\rho_o}\int dz\,\rho(s,z)$$

$$Q(x,y,b) = \frac{T_A(x,y,-b/2)T_B(x,y,b/2)}{\int d^2 s T_A(\vec{s}+\vec{b}/2)T_B(\vec{s}-\vec{b}/2)}$$

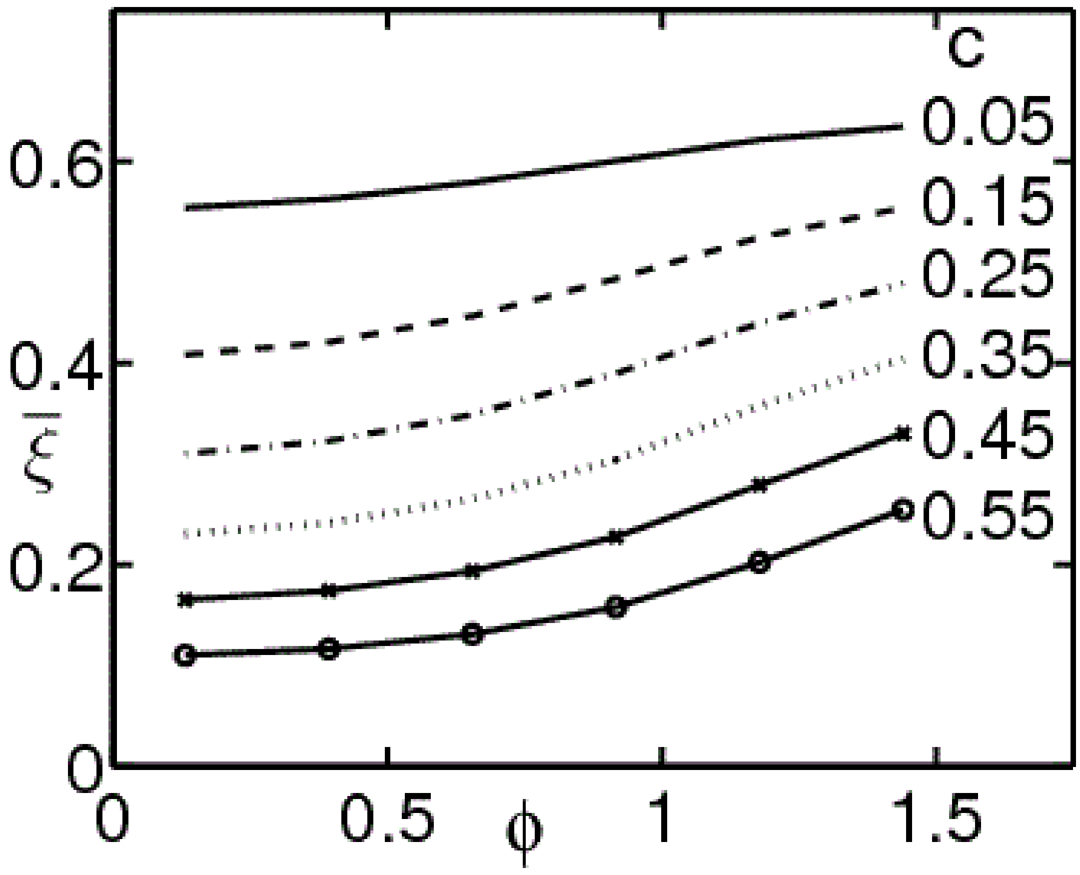
$$D(x,y) = \omega L_A(x,y)(1-e^{-\omega L_B(x,y)}) + \omega L_B(x,y)(1-e^{-\omega L_A(x,y)})$$

$\omega = 4.6$

$$l(x_0,y_0,b,\varphi) = \int dt D(x(t),y(t))$$

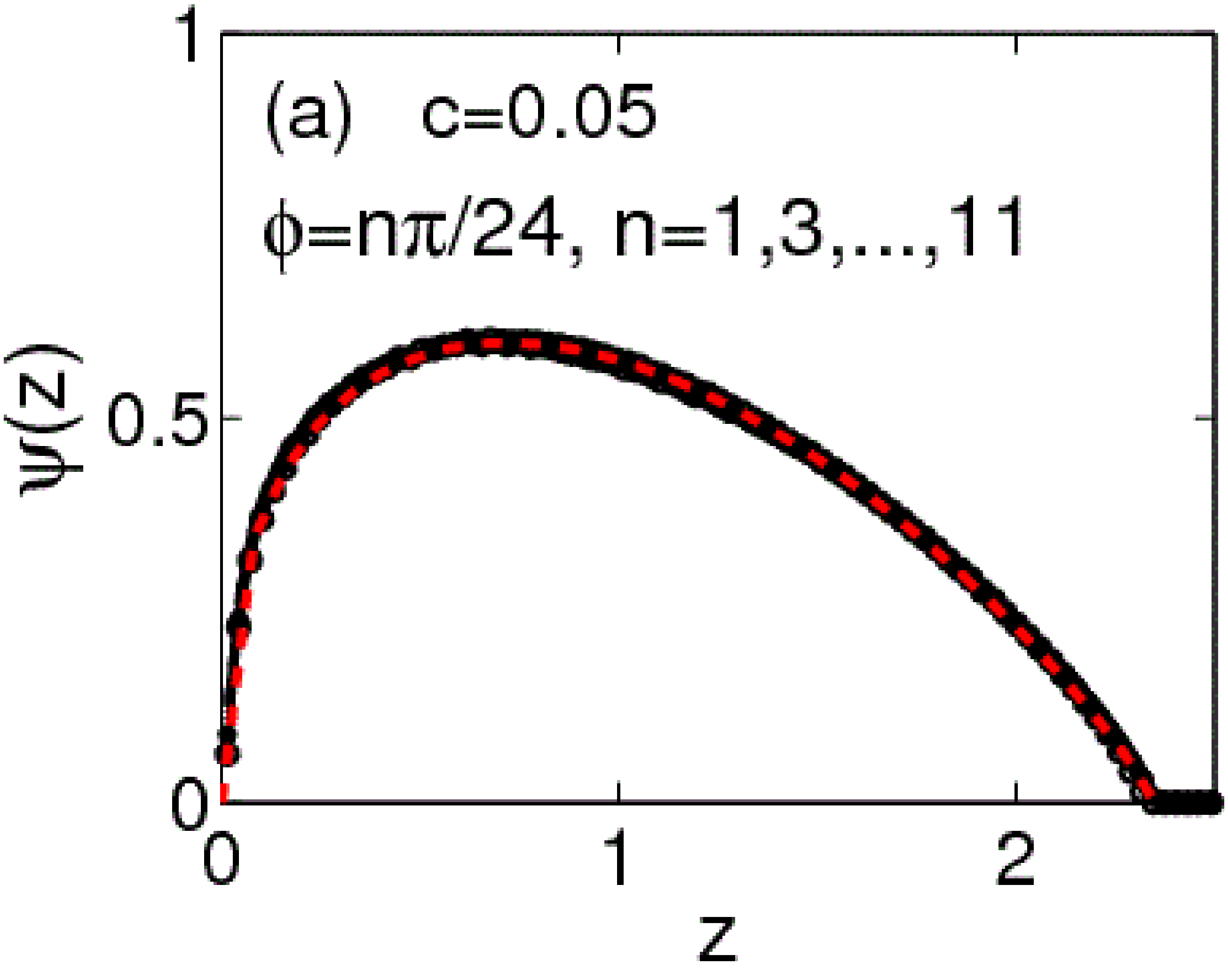
$$\int d\xi P(\xi, b, \varphi) = 1$$

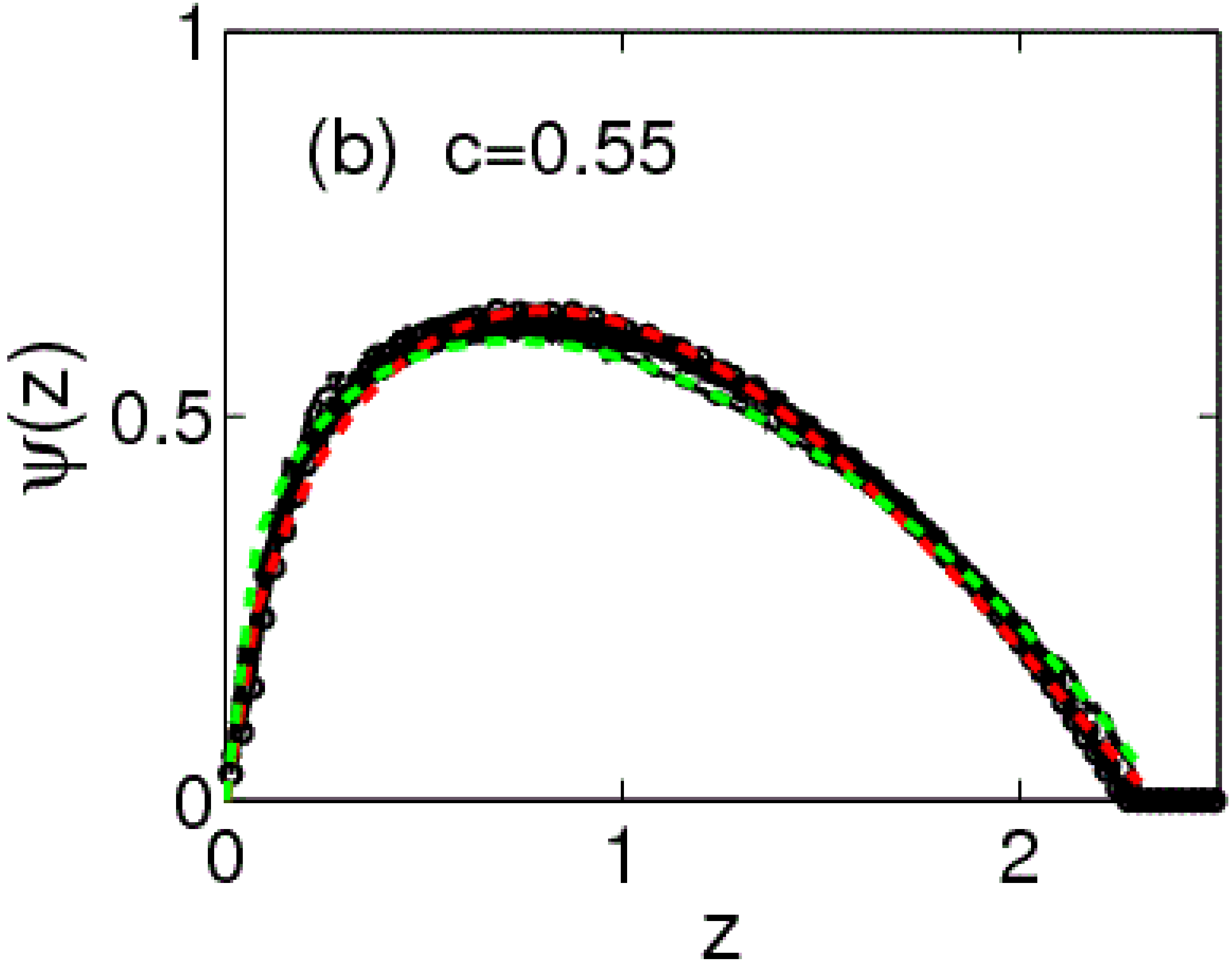
$$\bar{\xi} = \int d\xi \xi P(\xi, b, \varphi)$$



$z = \xi / \bar{\xi}$

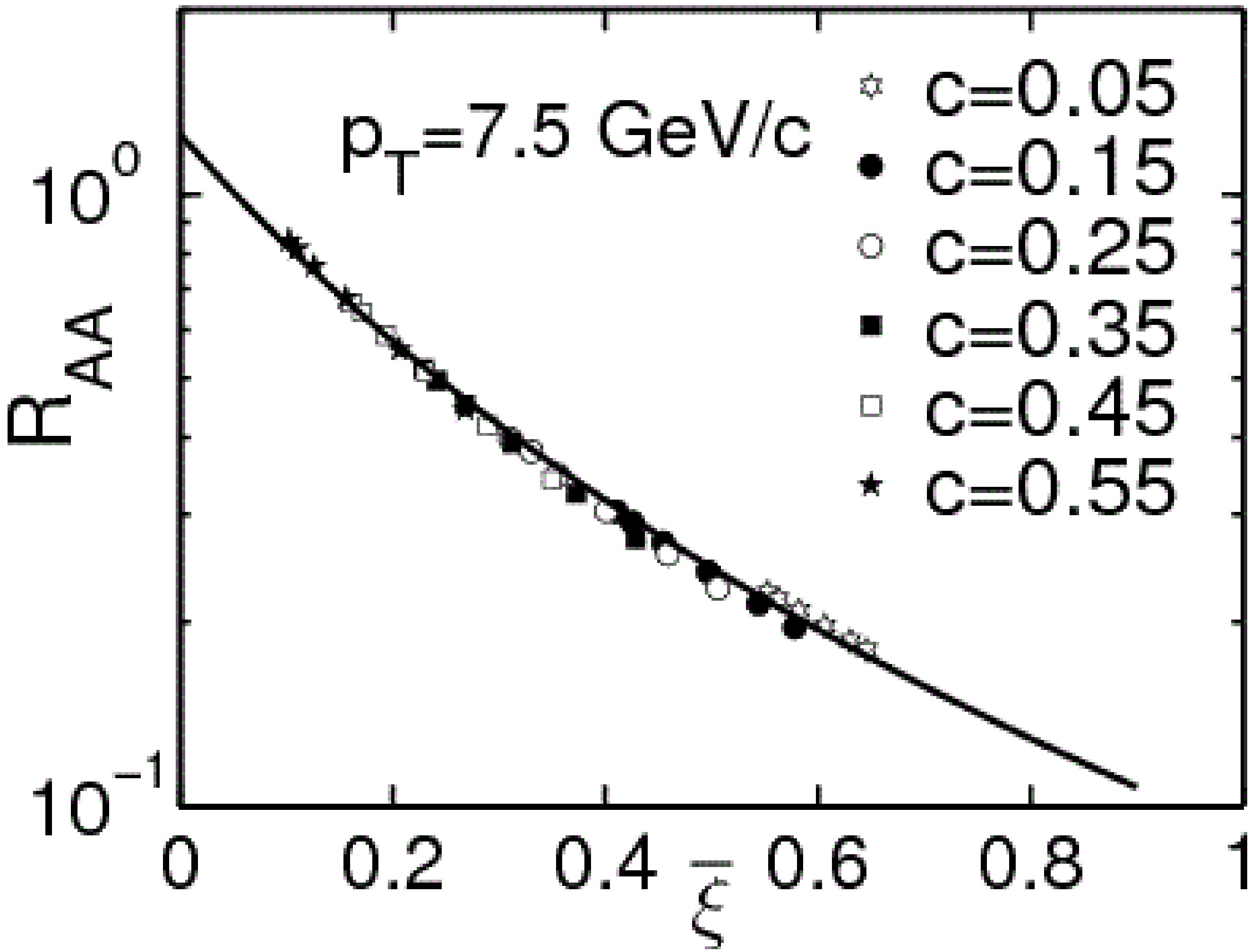
$\psi(z) = \bar{\xi} P(\xi, b, \varphi)$



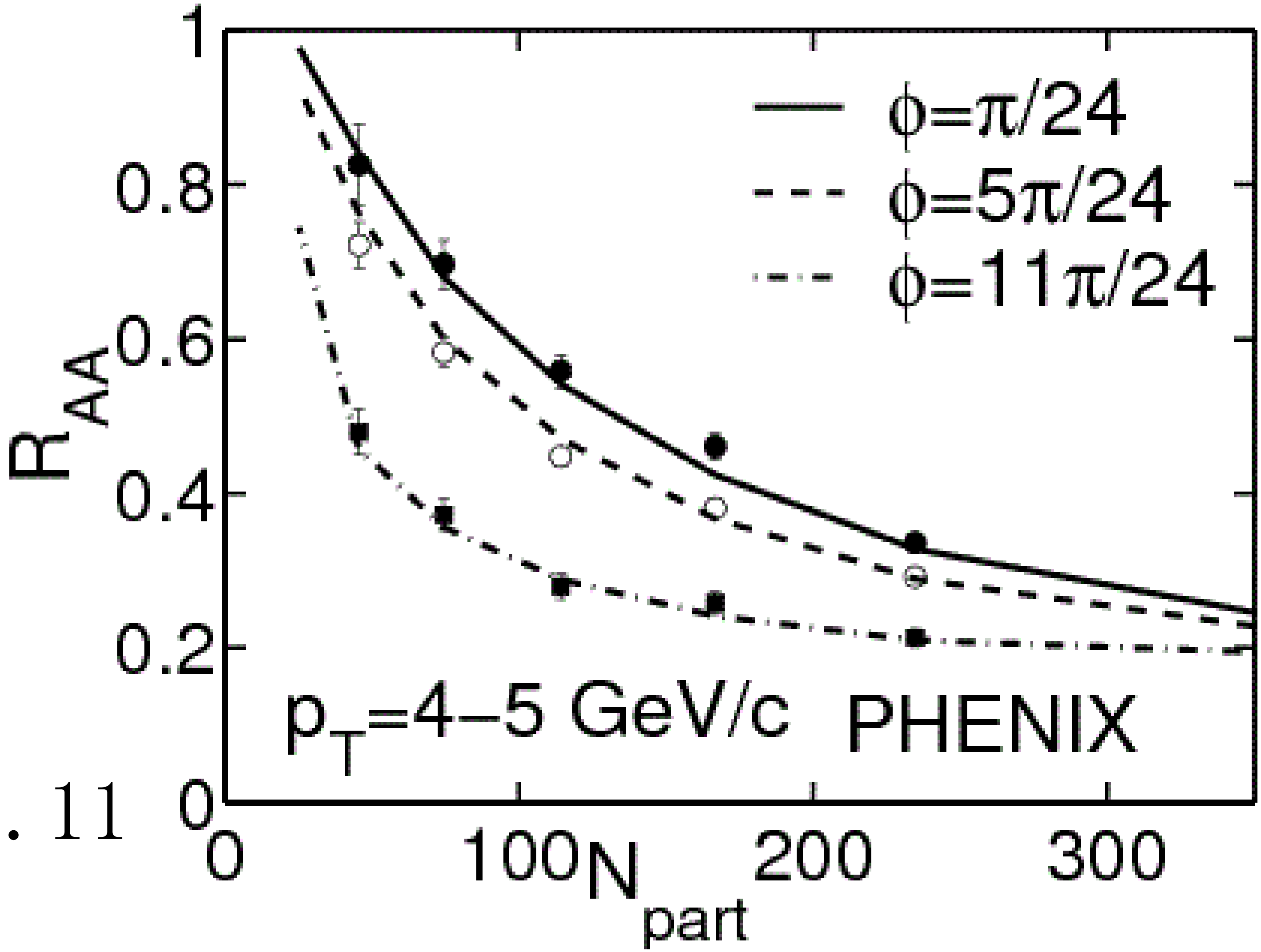


Scaling dynamical path length distribution!

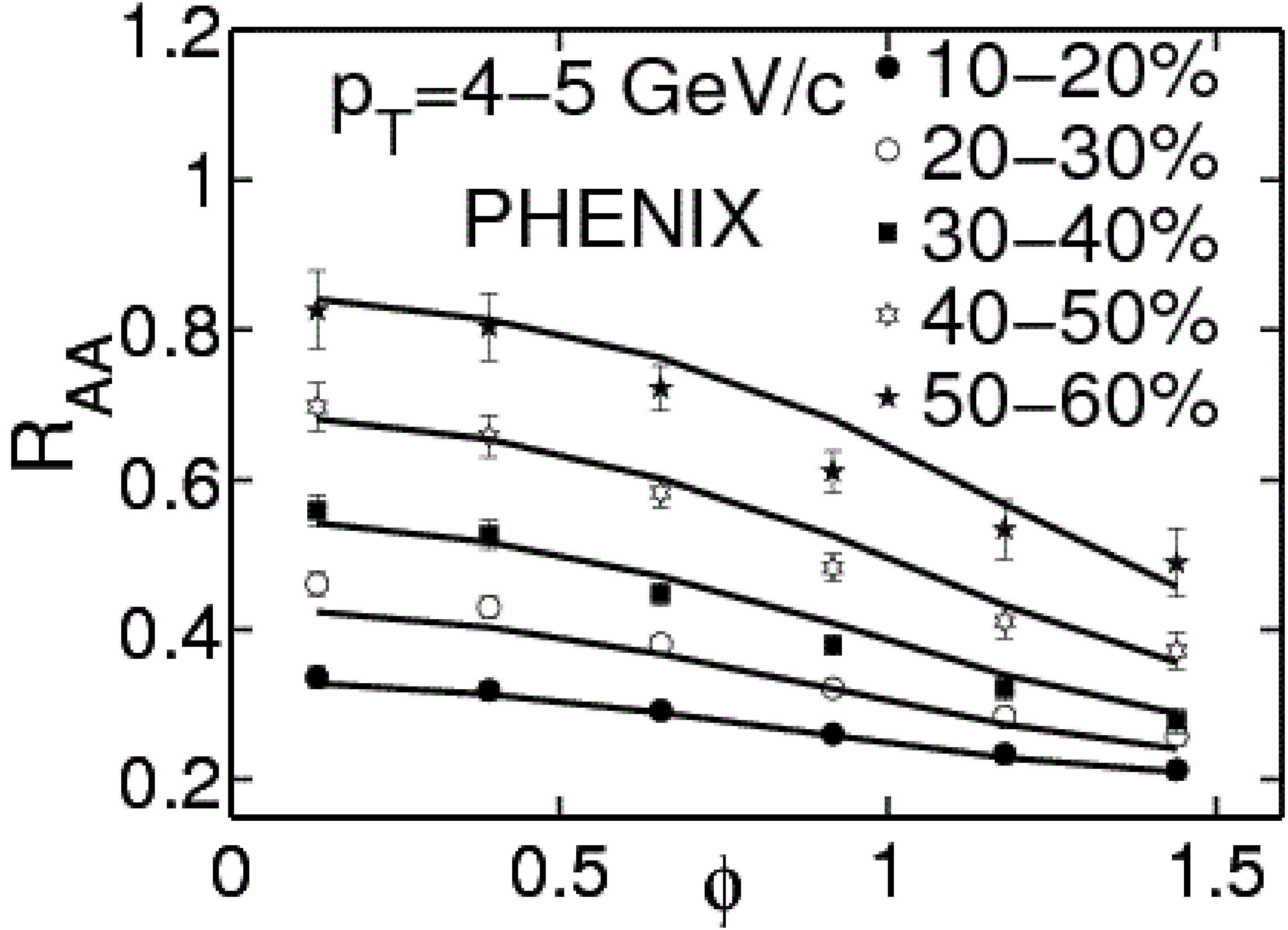
Scaling of R_{AA} (Theoretical results)



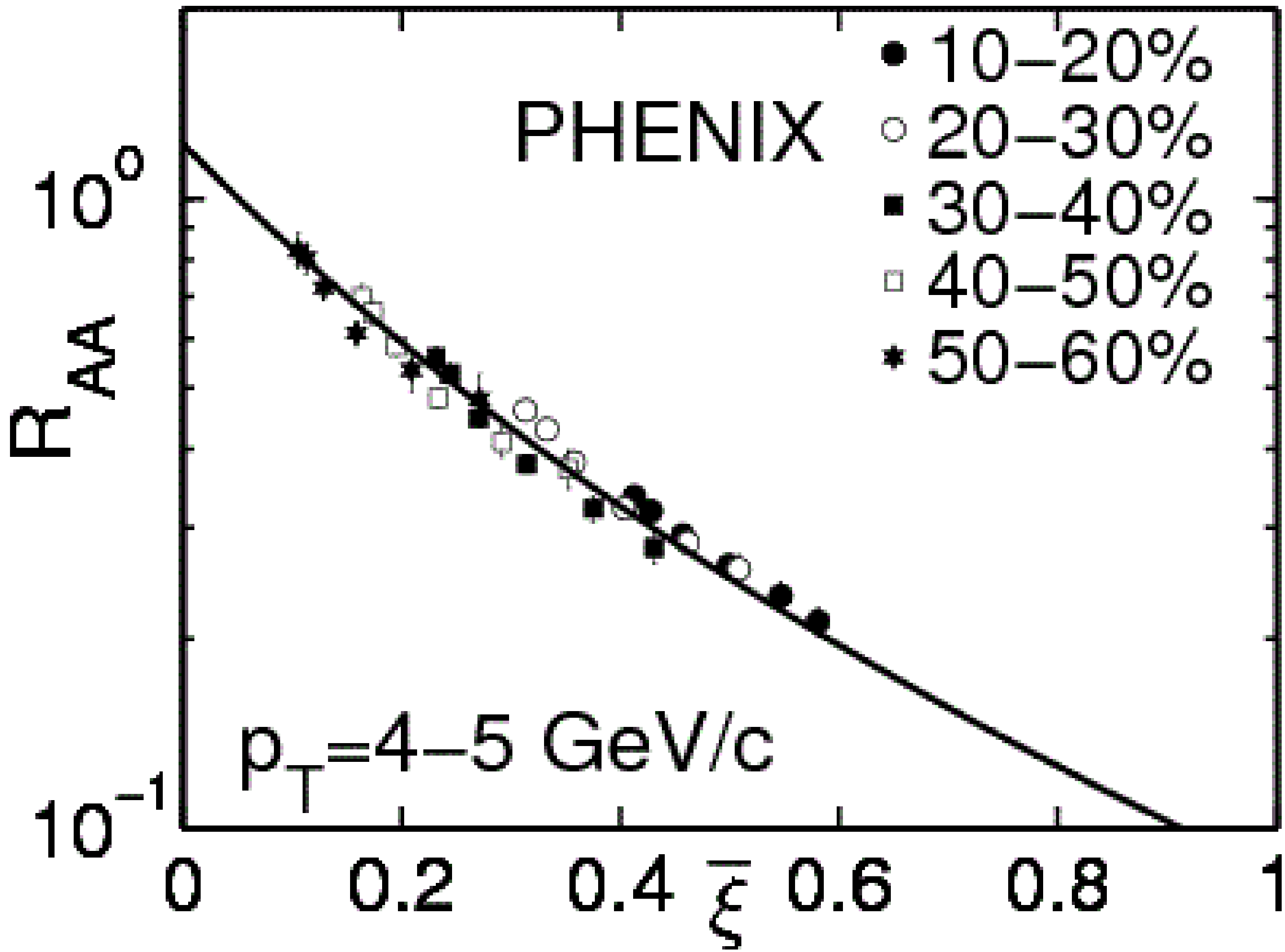
R_{AA} vs N_P (Th vs Data)



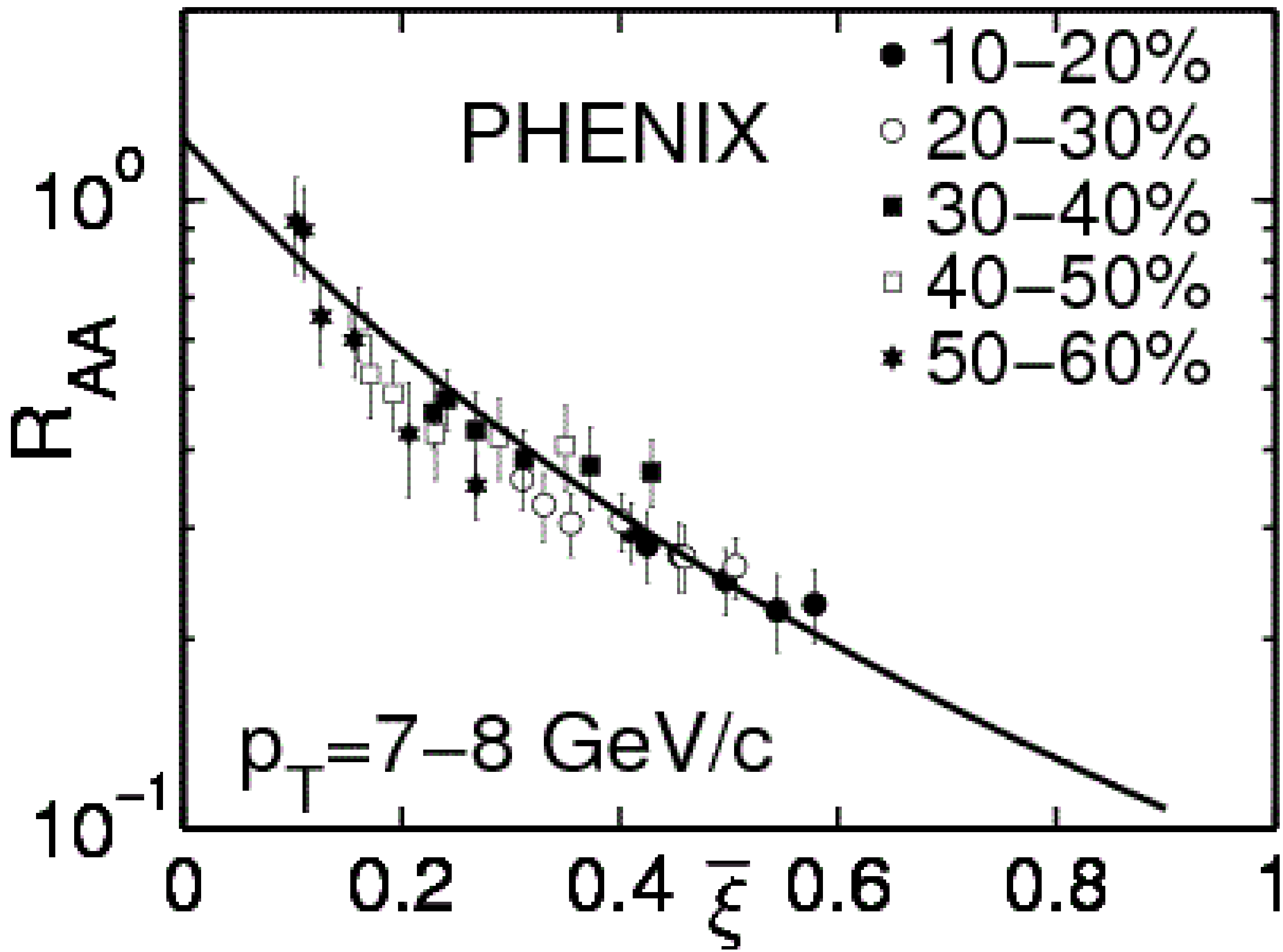
$\gamma = 0.11$



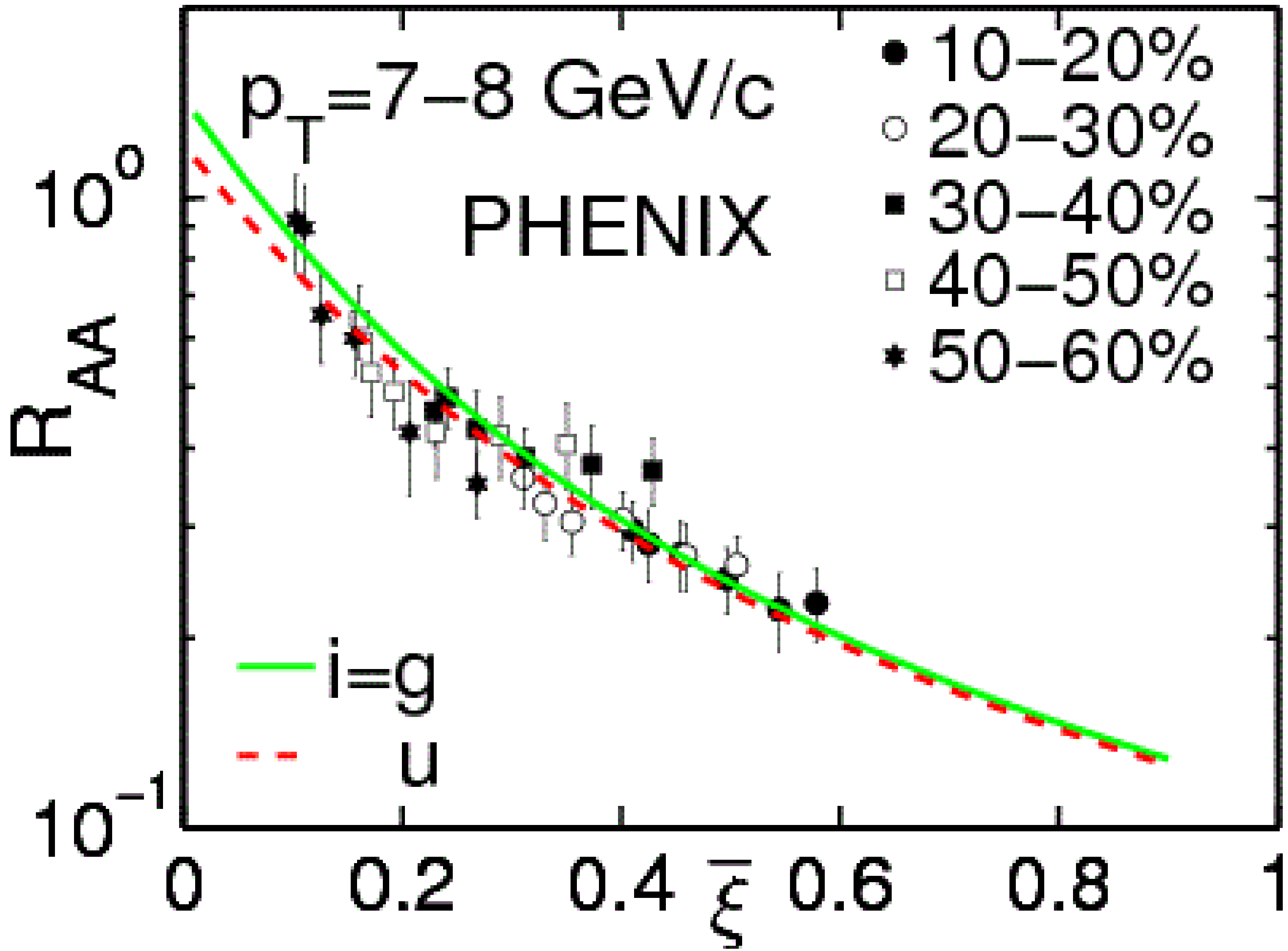
p_T=4–5 GeV/c
PHENIX
10–20%
20–30%
30–40%
40–50%
50–60%
R_{AA}
1.2
1
0.8
0.6
0.4
0.2
0
0.5
1
1.5
ϕ



PHENIX
10–20%
20–30%
30–40%
40–50%
50–60%
10^0
10^{-1}
R_{AA}
p_T=4–5 GeV/c
0
0.2
0.4
0.6
0.8
1
$\overline{\xi}$



PHENIX
10–20%
20–30%
30–40%
40–50%
50–60%
R_{AA}
10^0
10^{-1}
p_T=7–8 GeV/c
0
0.2
0.4
$\bar{\xi}$
0.6
0.8
1



p_T=7–8 GeV/c
PHENIX
10–20%
20–30%
30–40%
40–50%
50–60%
i=g
u
R_{AA}
10^0
10^{-1}
0
0.2
0.4
$\bar{\xi}$
0.6
0.8
1

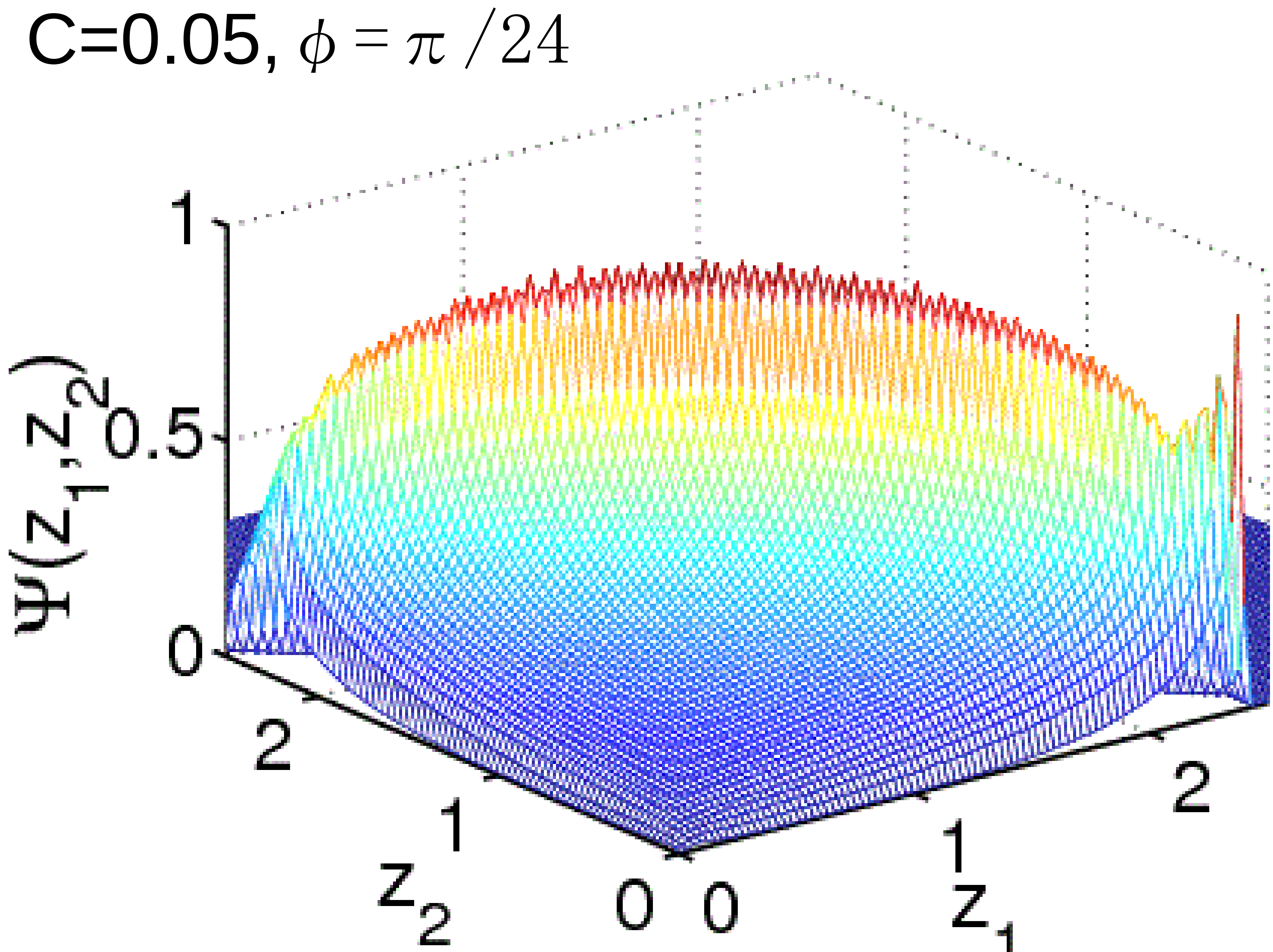
Back-to-Back Jets

$$\frac{dN}{p_t p_b dp_t dp_b d\varphi} = \int \frac{dq_1}{q_1}\frac{dq_2}{q_2}\sum_i F_i(q_1,q_2,b,\varphi) H_i(q_1,q_2,p_t,p_b)$$

Hadronization dynamics

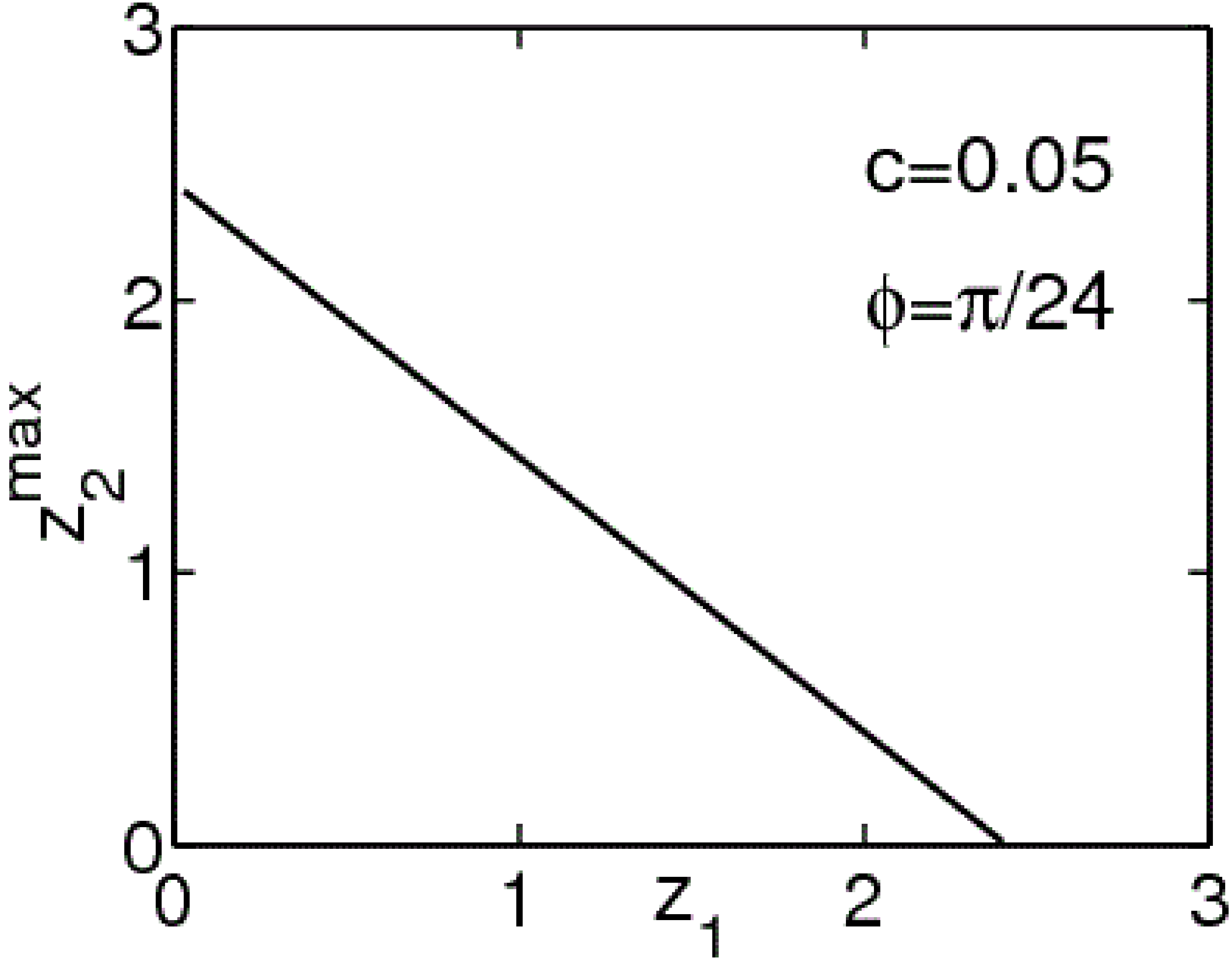
$$F_i(q_1,q_2,b,\varphi) = \int d\xi_1 d\xi_2 P(\xi_1,\xi_2,b,\varphi) F_i(q_1,q_2,\xi_1,\xi_2)$$

$$F_i(q_1,q_2,\xi_1,\xi_2) = \int dk k f_i(k) G(k,q_1,\xi_1) G(k,q_2,\xi_2)$$

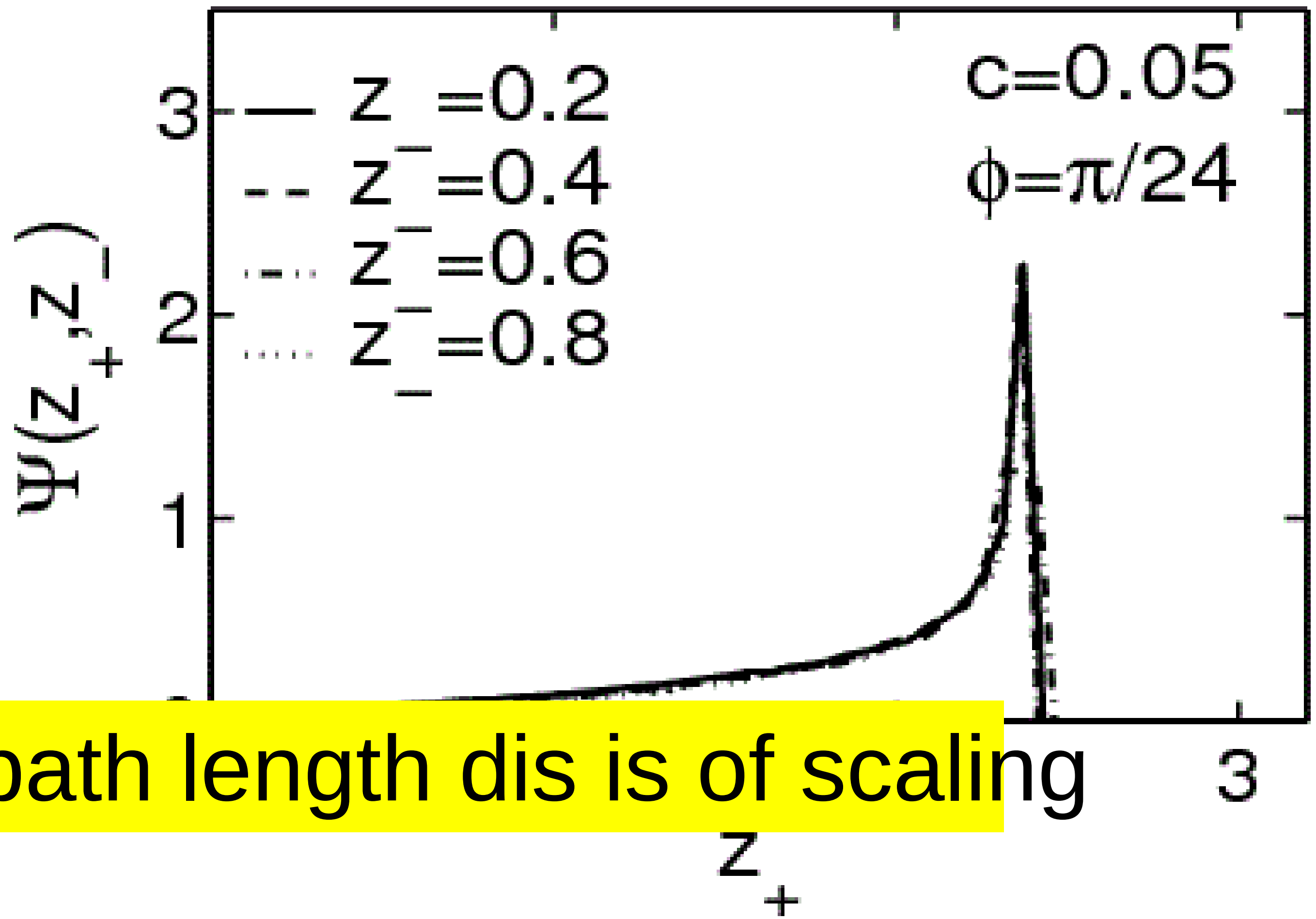


C=0.05, $\phi = \pi / 24$
1
0.5
0
$\Psi(z_1, z_2)$
2
1
0
z_2
0
1
2
z_1

Boundary of last plot

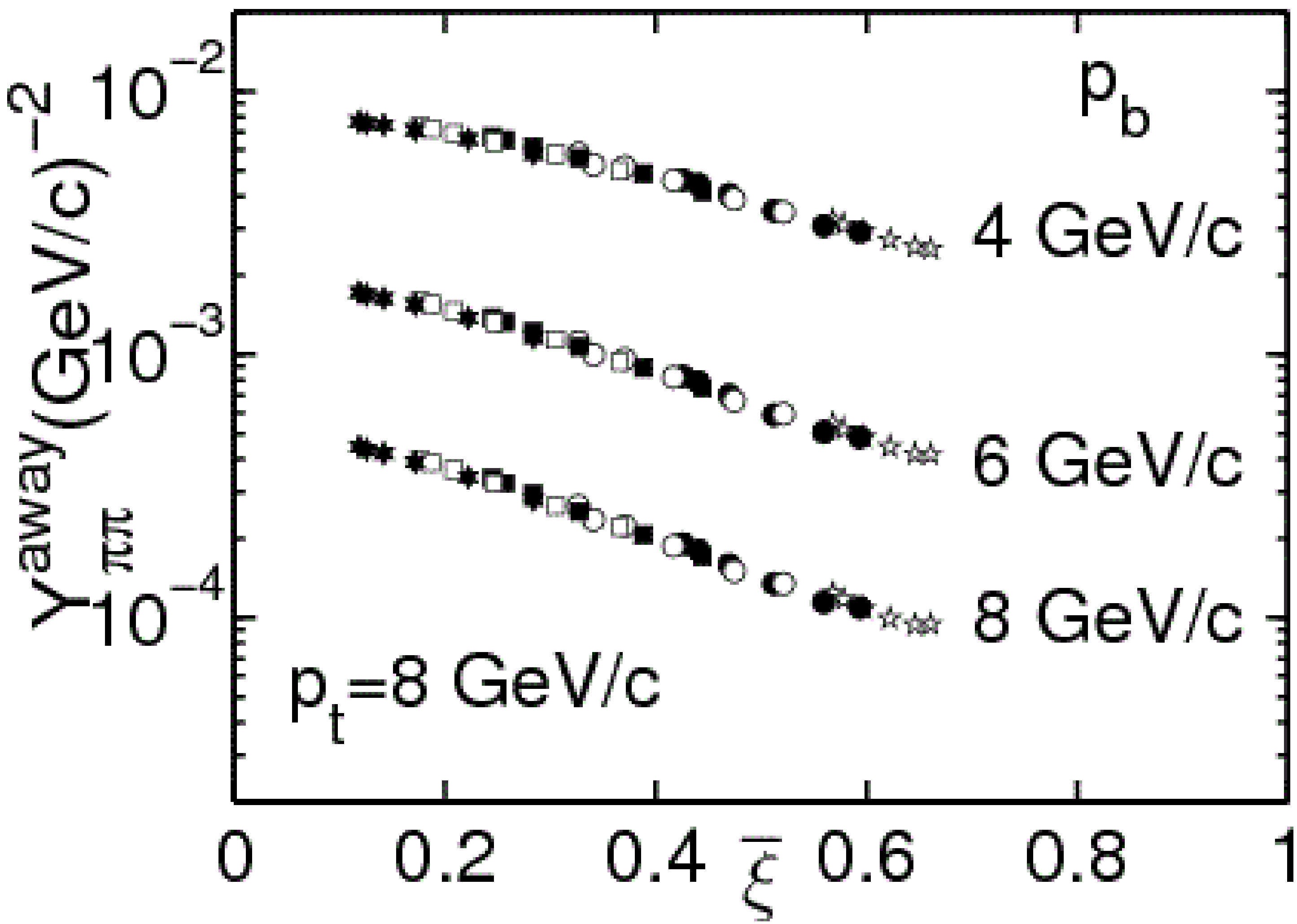


$$z_{\pm} = z_1 \pm z_2$$

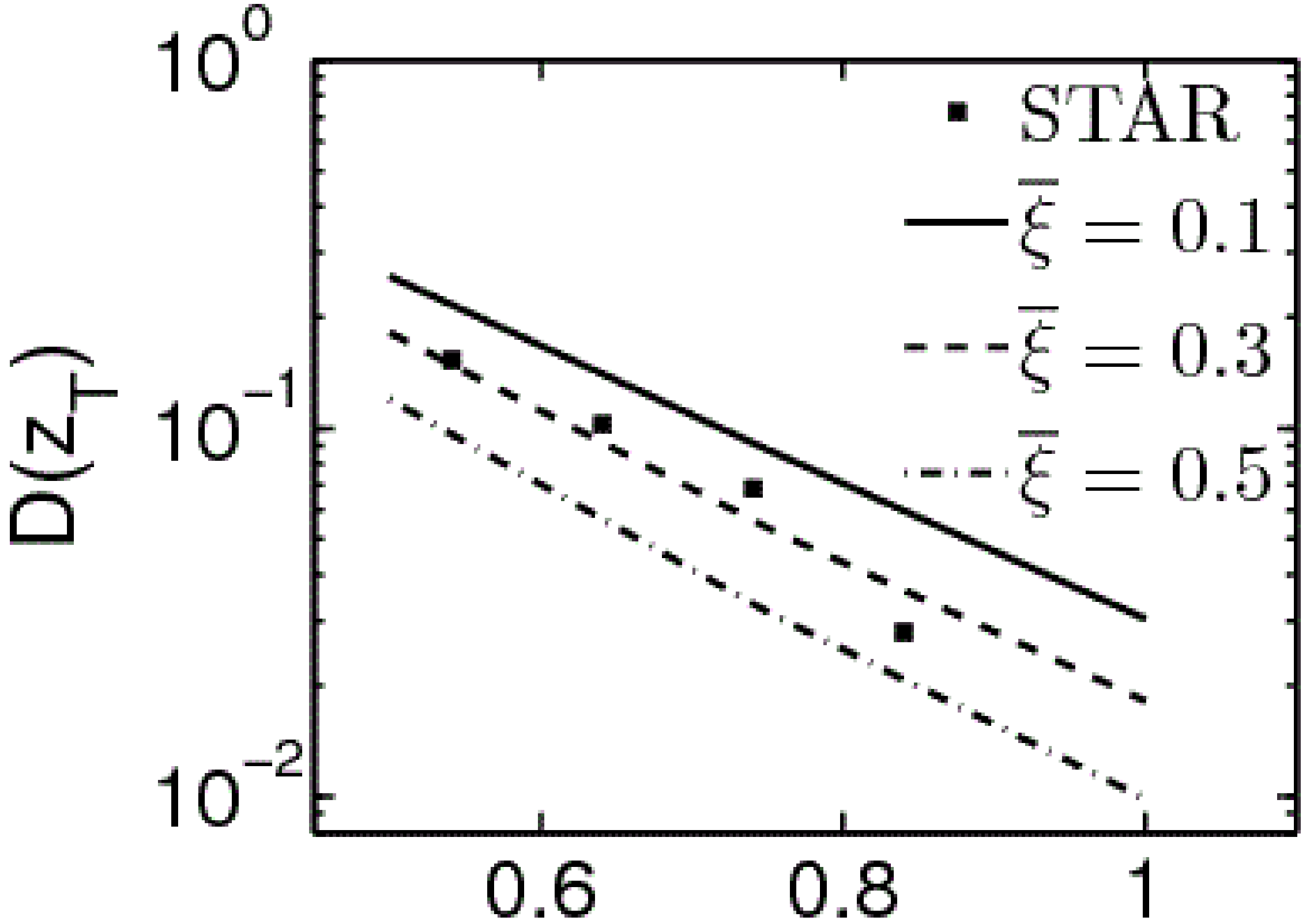


2d path length dis is of scaling

Yield per trigger



Trigger-normalized FF

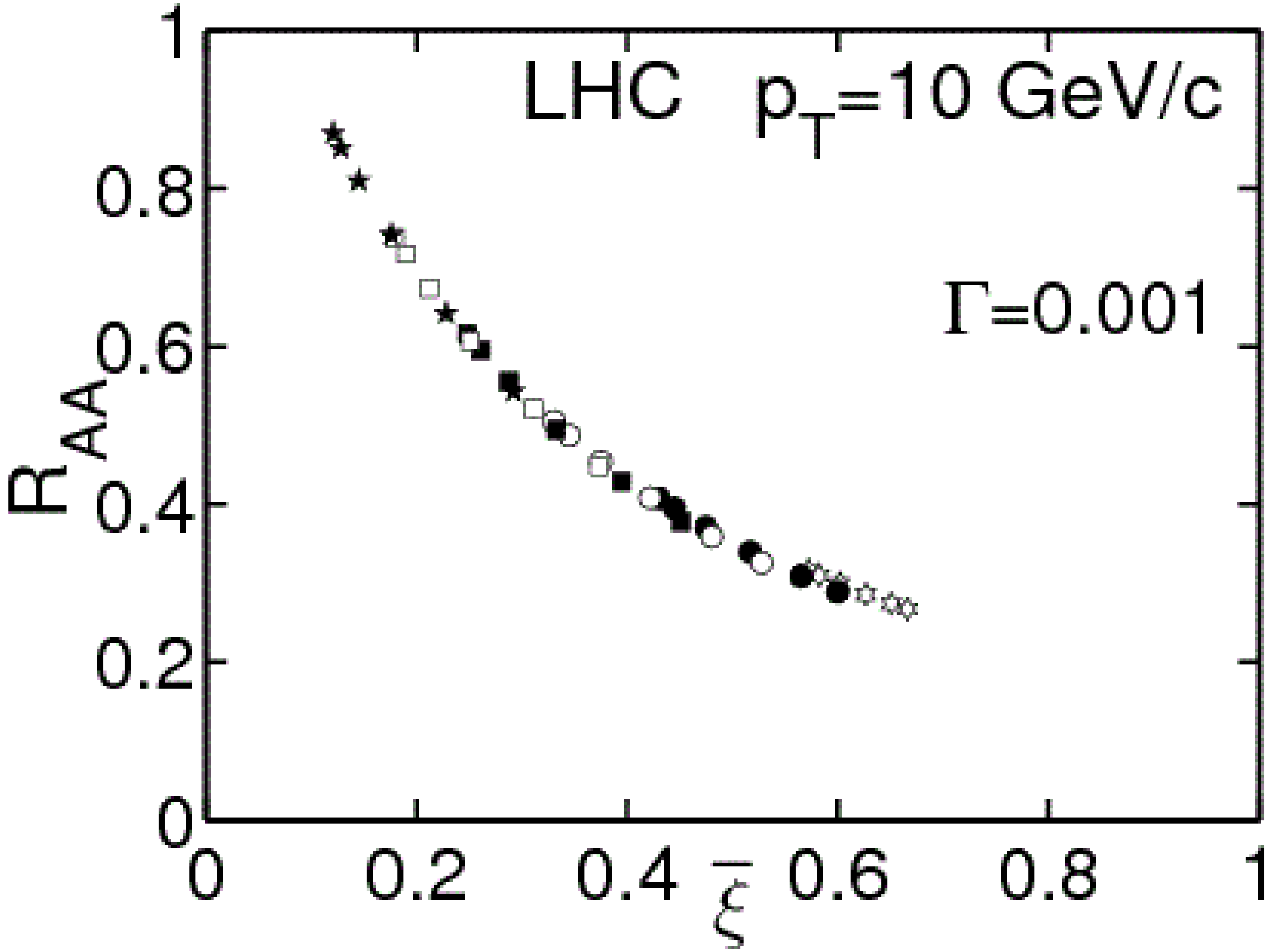


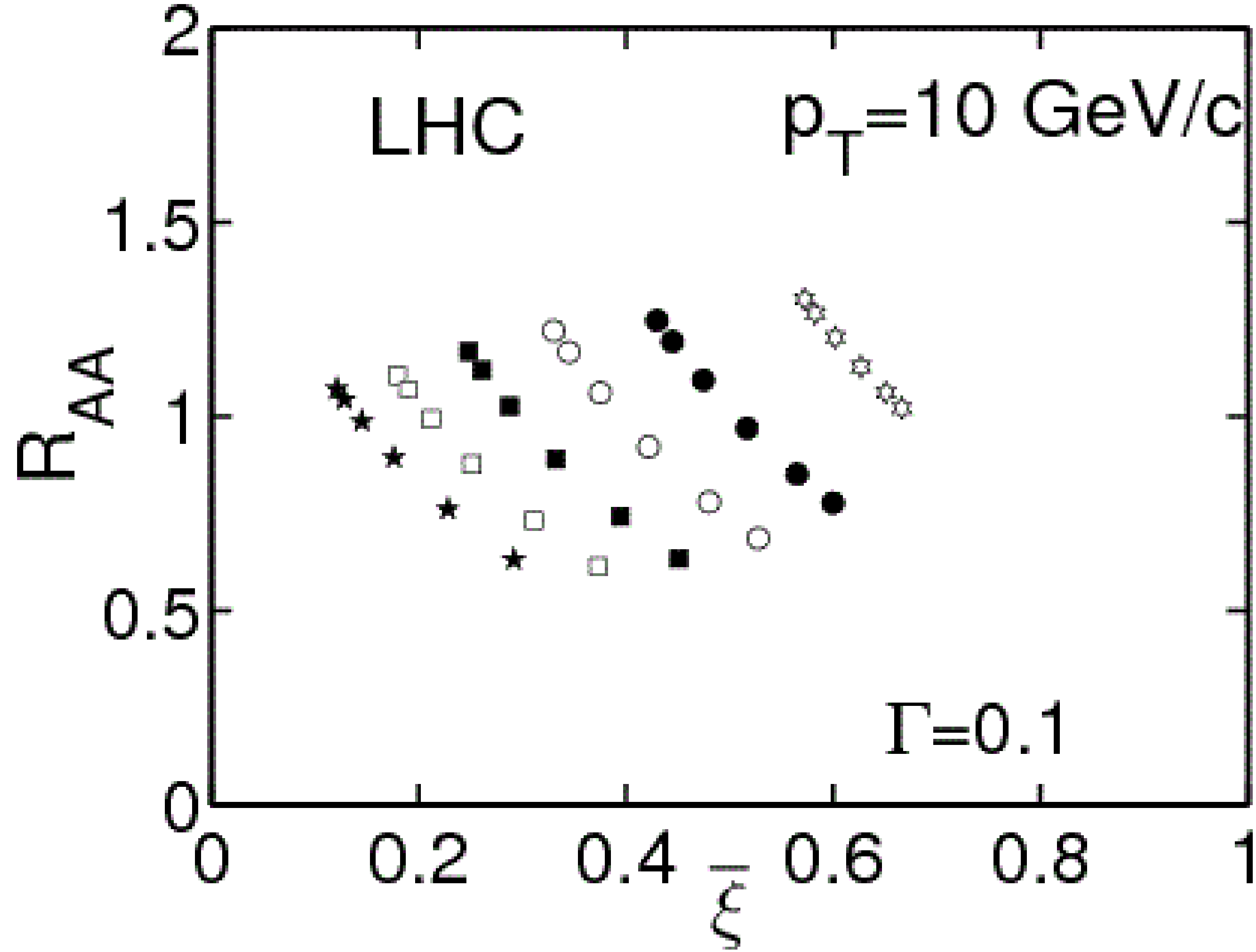
Data: 8GeV/c<p_t<16GeV/c, 0-10%

Two-jet recombination at LHC

- At LHC/ALICE, # of init hard partons is huge
- They may overlap in space-time
- Huge p/π ratio
- New signal?

$$\frac{dN_{AA}^{2j}}{p_T dp_T d\varphi}(b) = \int \frac{dq}{q}\frac{dq'}{q'}\sum_{i,i'} F_i(q,b,\varphi)F_{i'}(q',b,\varphi)H_{ii'}(q,q',p_T)$$





LHC
p_T=10 GeV/c
Γ=0.1
R_{AA}
$\bar{\xi}$
0
0.5
1
1.5
2
0
0.2
0.4
0.6
0.8
1

Discussions

- R_{AA} at large p_T depend on $\bar{\xi}$
- Scaling of R_{AA} seen at RHIC
- b and ϕ dependence of R_{AA} encoded in mean path length
- Yield per trigger depends on ξ-bar universally
- At LHC, R_{AA} can be huge and its scaling may b violated due to overlap of two-jets
- Can be checked easily!

Thank you!