Initial geometry effect on HBT correlation in C+Au collisions in AMPT model

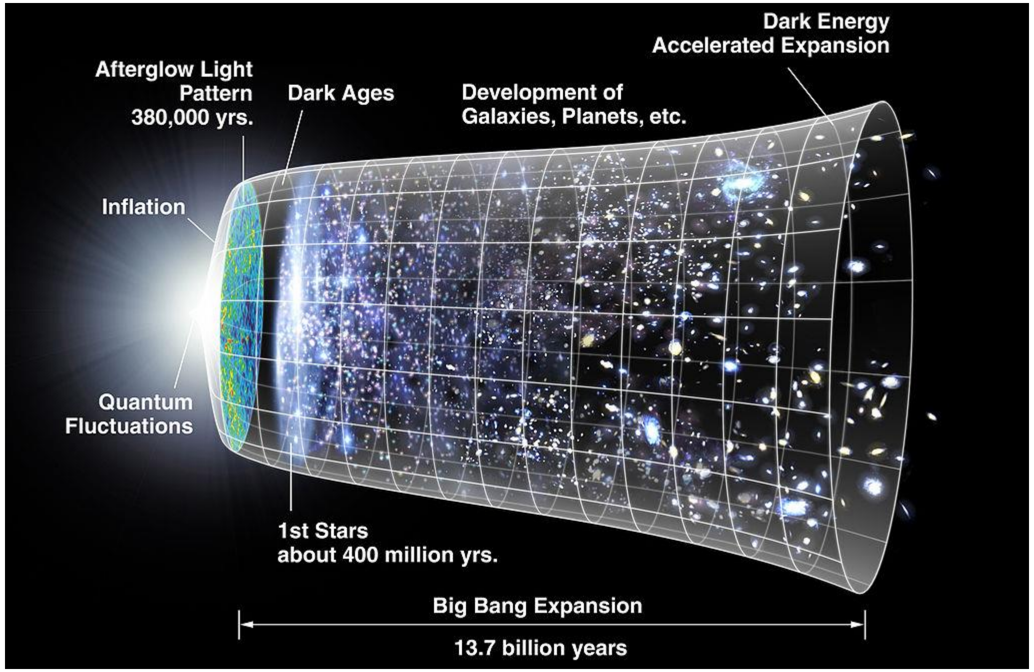
Junjie He（何俊杰）
Supervisor: Yu-Gang Ma, Song Zhang
Shanghai Institute of Applied Physics, CAS
2018.8.24

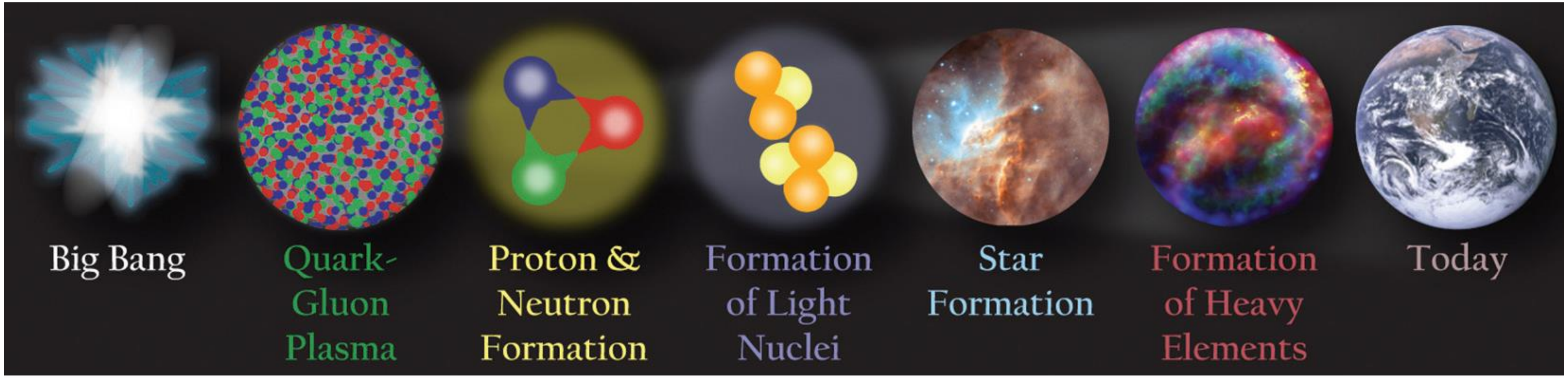
Outline

- Background
- AMPT
- HBT
- Results
- Summary

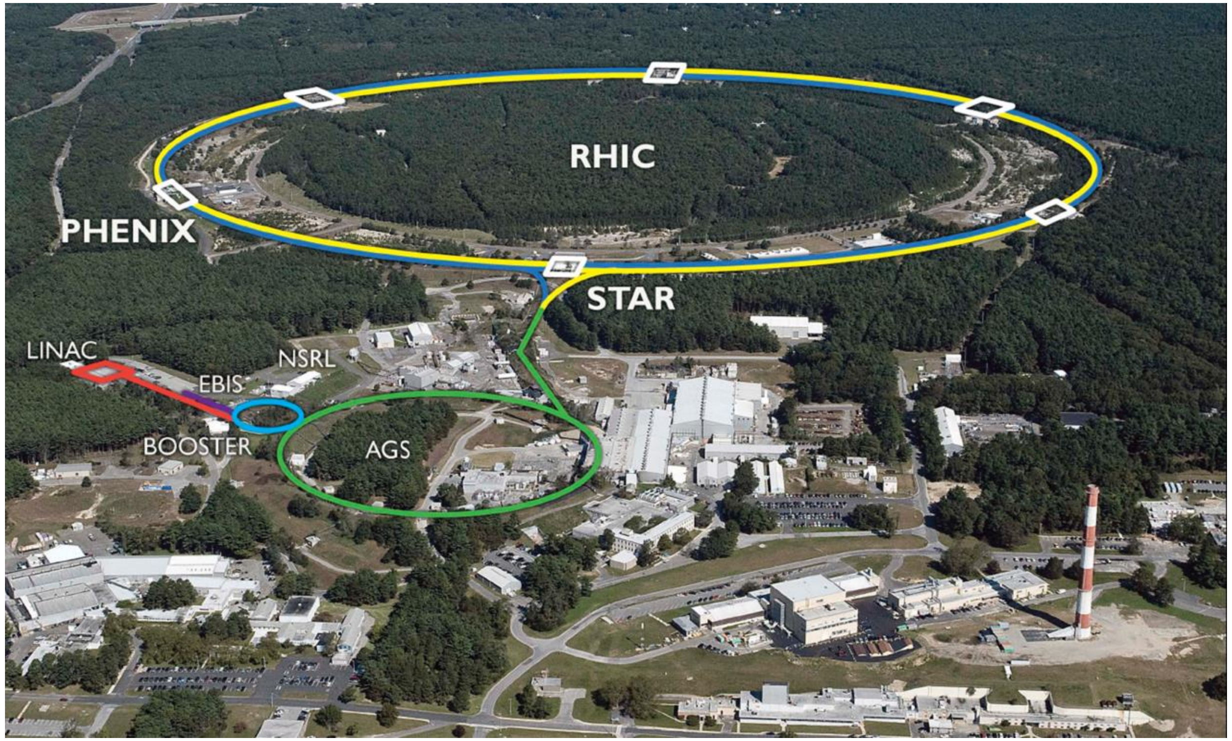
Background

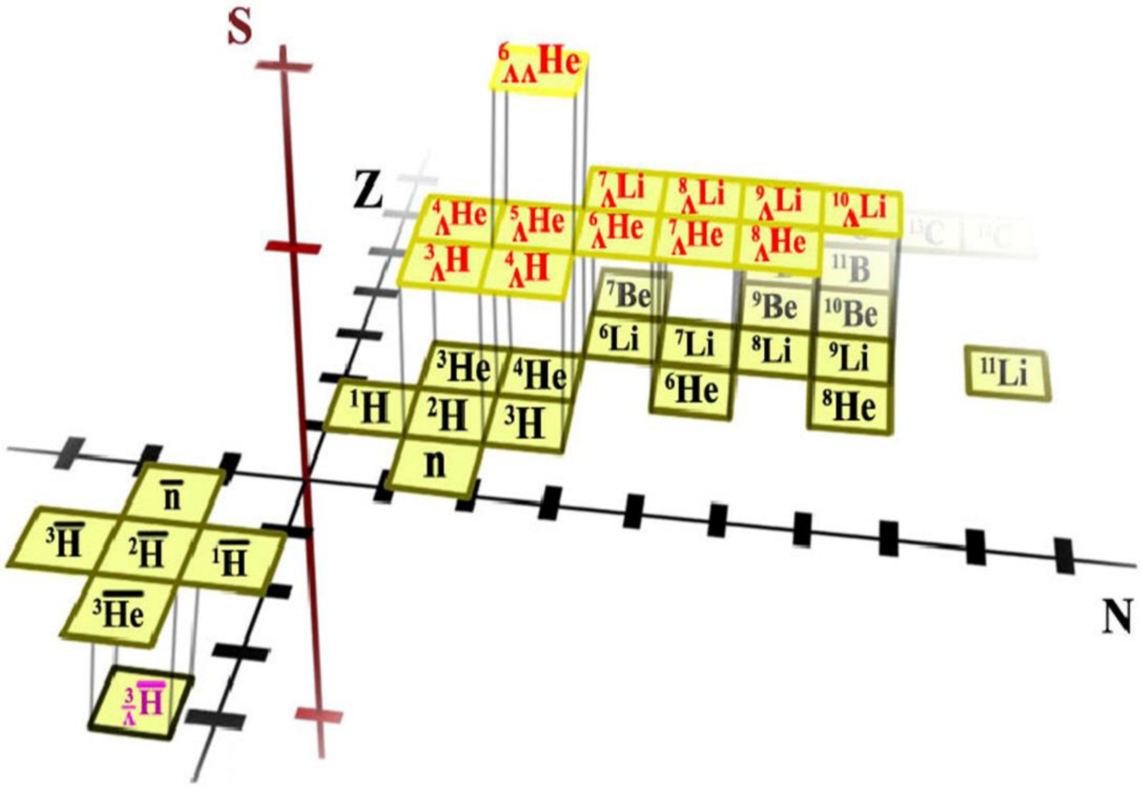
- QGP
- Light Nuclei





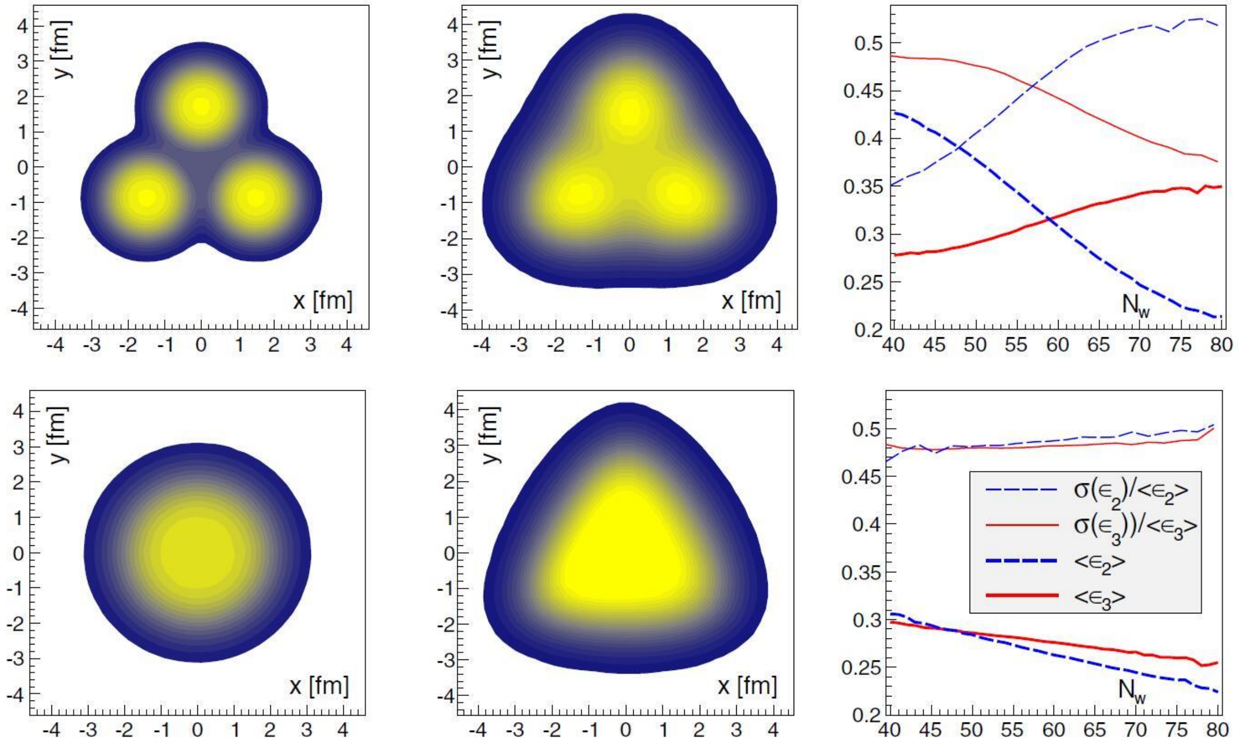
Background





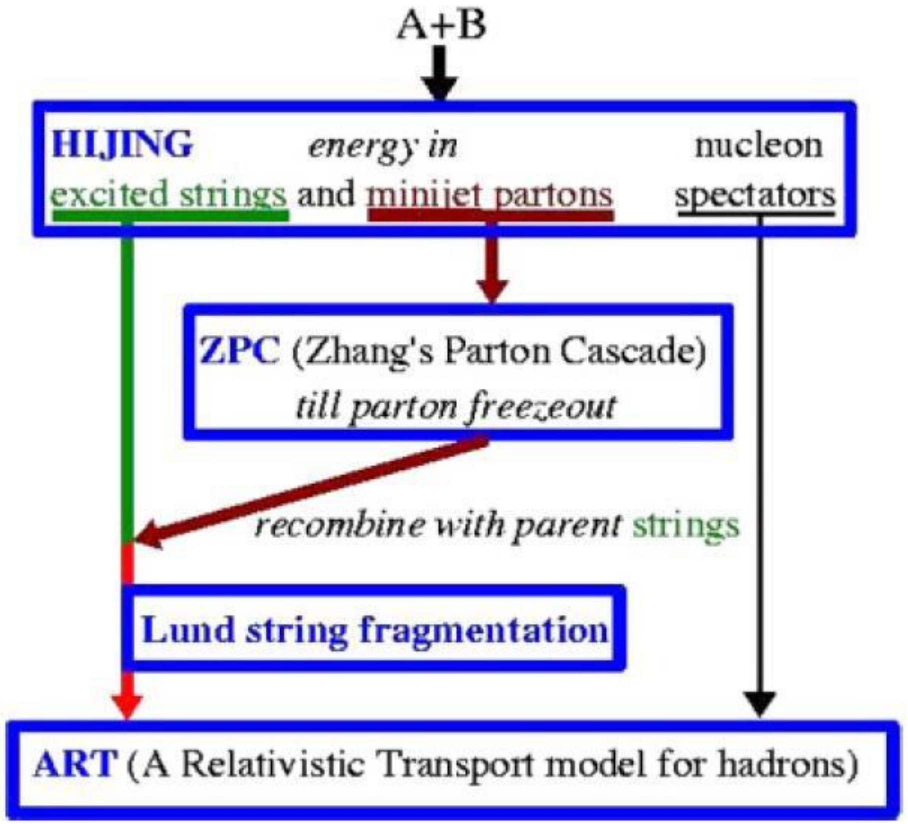
Background

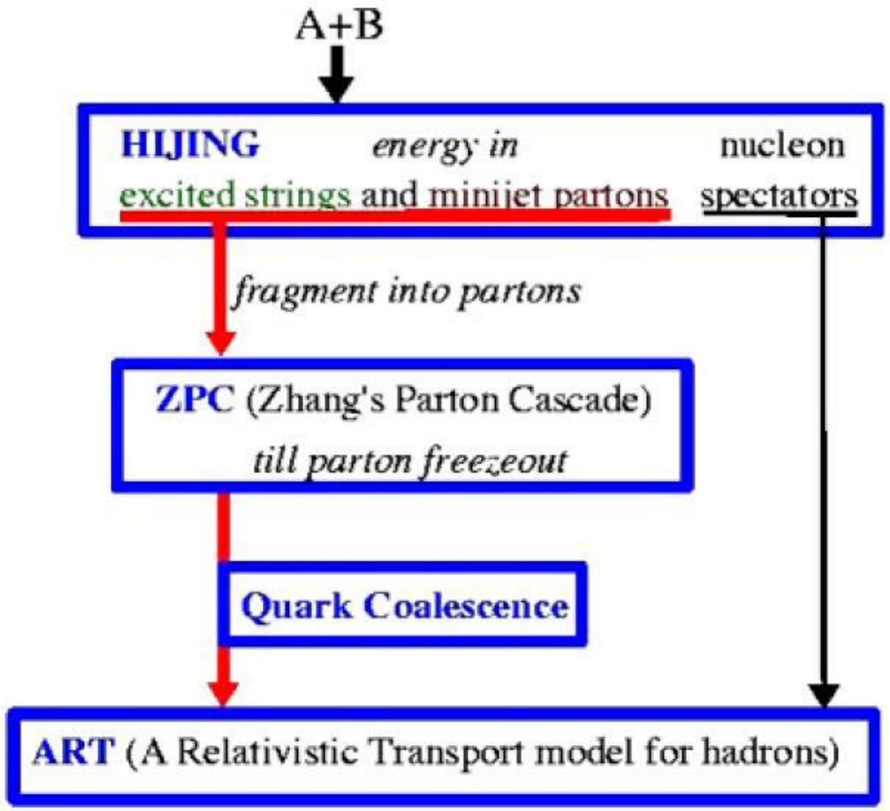
- In 2014, Broniowski, Arriola et al. proposed that through relativistic heavy-ion collision, collective flow can be the signature of α clustering in light nuclei in their ground state



PhysRevLett.112.112501

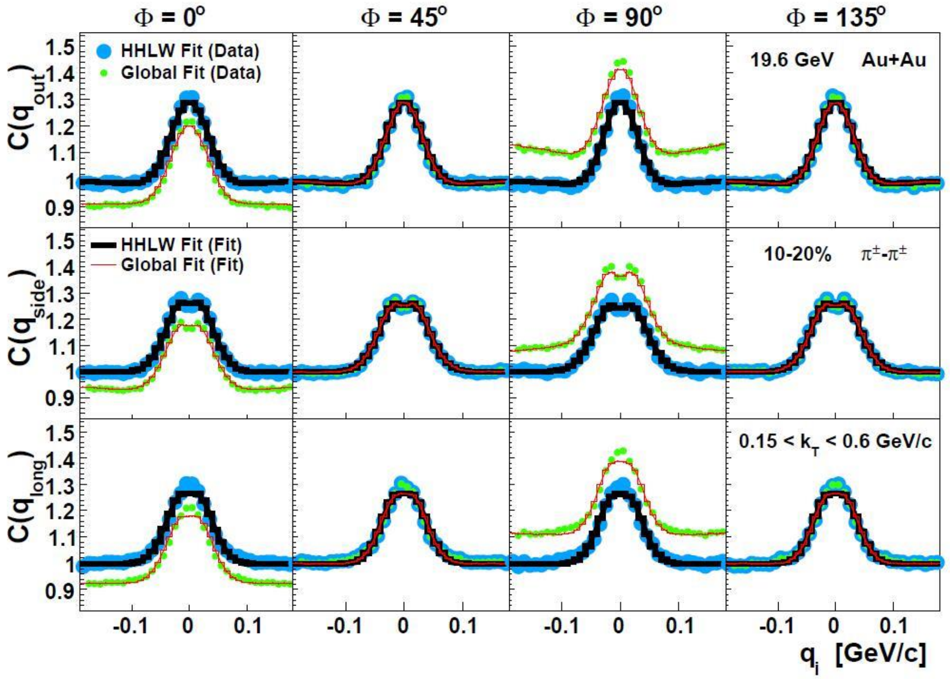
A Multiphase Transport Model



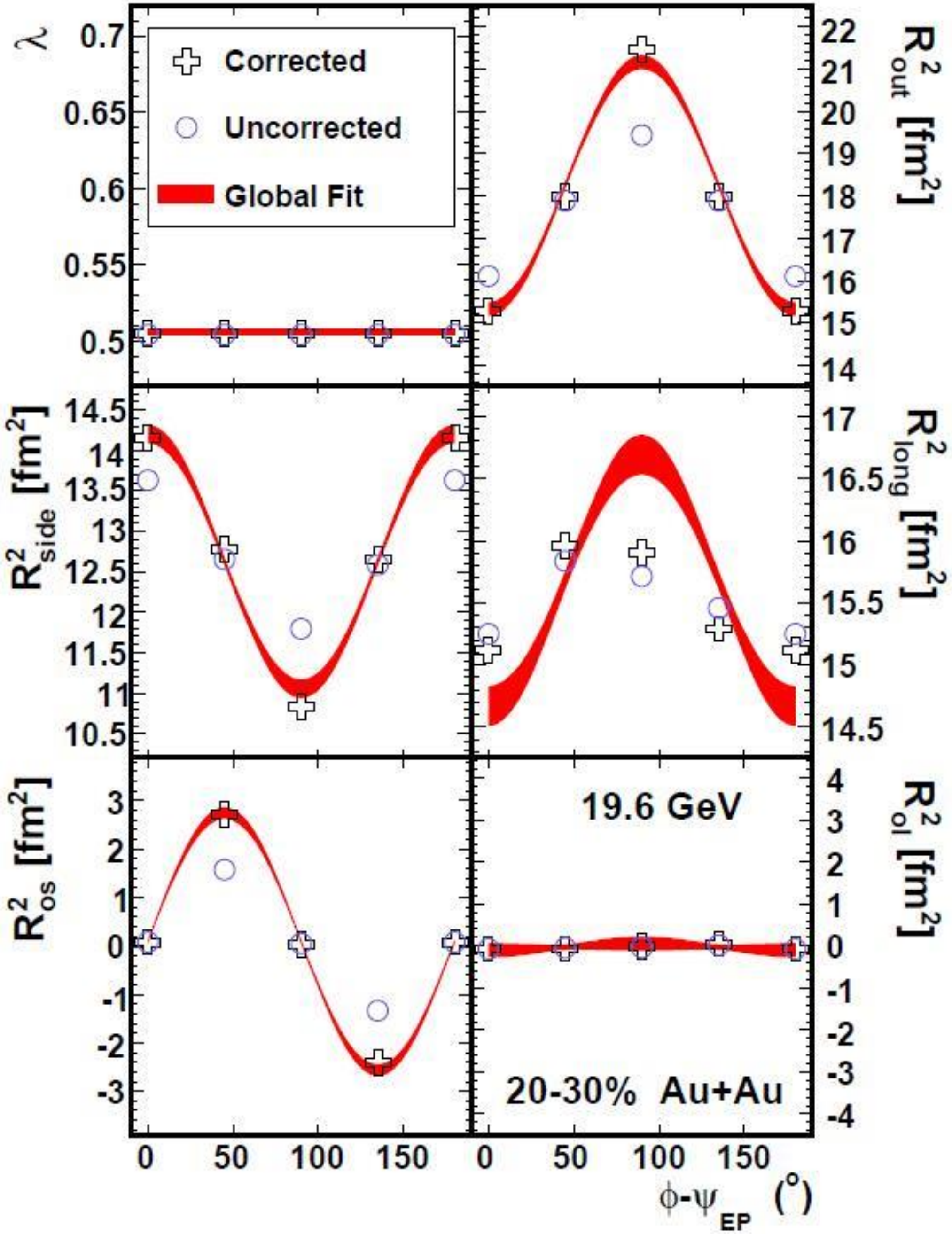


HBT

- 1956 Hanbury Brown and Twiss
- 1960 Goldhaber-Goldhaber-Lee-Pais effect

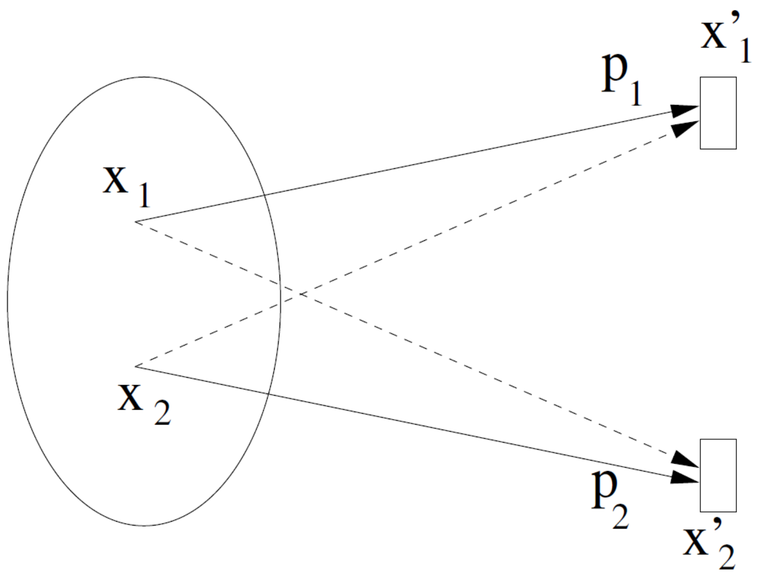


STAR PhysRevC.92.14904



HBT： Simple example

Mercedes Lopez Noriega's PhD thesis(2004)



$$P(\vec{p}) = \int d^4 x S(x,p)|_{p_0=E_p}.$$

$$\Psi = \frac{1}{\sqrt{2}}[e^{i(x_1'-x_1)p_1}e^{i(x_2'-x_2)p_2} \pm e^{i(x_1'-x_2)p_1}e^{i(x_2'-x_1)p_2}].$$

$$P(\vec{p}_1,\vec{p}_2) = \int d^4x_1 d^4x_2 S(x_1,p_1)S(x_2,p_2)|\Psi|^2.$$

$$\begin{aligned} P(\vec{p}_1,\vec{p}_2) &= \int d^4x_1 S(x_1,p_1) \int d^4x_2 S(x_2,p_2) \\ &\pm \int d^4x_1 d^4x_2 S(x_1,p_1)S(x_2,p_2)\cos((p_1-p_2)(x_1-x_2)). \end{aligned}$$

HBT

- Smoothness approximation

$$S(x_1,p_1)S(x_2,p_2)=S(x_1,k+\frac{1}{2}q)S(x_2,k-\frac{1}{2}q)\approx S(x_1,k)S(x_2,k),$$

$$x = x_1 - x_2 \qquad X = \tfrac{1}{2}(x_1+x_2)$$

$$P(\vec{p}_1,\vec{p}_2)=P(\vec{p}_1)P(\vec{p}_2)\pm\int d^4x\ \cos(qr)\cdot\int d^4X\ S(x+\frac{X}{2},k)S(x-\frac{X}{2},k),$$

$$C(\vec{q},\vec{k})=\frac{P(\vec{p}_1,\vec{p}_2)}{P(\vec{p}_1)P(\vec{p}_2)}\approx 1\pm\frac{\int d^4x\cos(qr)d(x,k)}{\left|\int d^4xS(x,k)\right|^2},$$

HBT

- With the mass-shell constraint $q^0 = \vec{\beta} \cdot \vec{q}$,

$$C(\vec{q}, \vec{k}) = 1 \pm \frac{\int d^3x \cos(\vec{q}\vec{x}) \int dt d(\vec{x} + \vec{\beta}t, k)}{\left| \int d^4x S(x, p) \right|^2} = 1 \pm \frac{\int d^3x \cos(\vec{q}\vec{x}) S_{\vec{k}}(\vec{x})}{\left| \int d^4x S(x, p) \right|^2},$$

- More generally

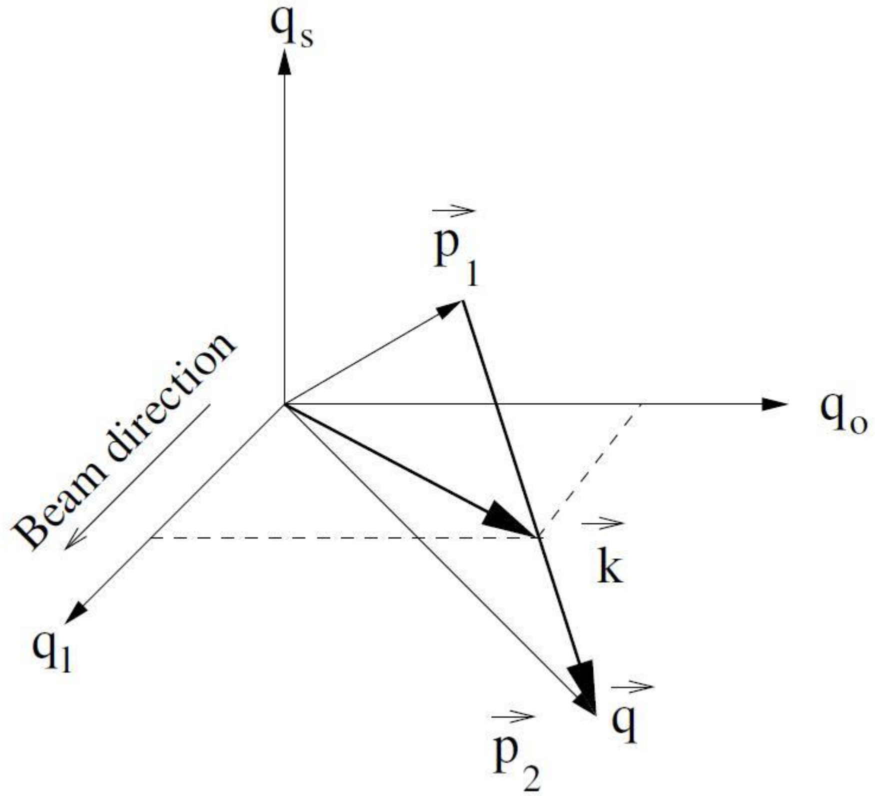
$$C(\vec{q}, \vec{k}) = 1 \pm \left| \frac{\int d^4x S(x, k) e^{iqx}}{\int d^4x S(x, k)} \right|^2.$$

HBT

- Parametrization

$$S(x,k) \approx S(\bar{x}(k),k)\exp[-\frac{1}{2}\tilde{x}^{\mu}(k)B_{\mu\nu}(k)\tilde{x}^{\nu}(k)],$$

$$C(q,k) = 1 + \lambda(k)\exp(-q_{\mu}q_{\nu} < \tilde{x}_{\mu}\tilde{x}_{\nu} > (k)).$$



$$C(\vec{q},\vec{k}) = 1 + \lambda(\vec{k})\exp(-R_o^2(\vec{k})q_o^2 - R_s^2(\vec{k})q_s^2 - R_l^2(\vec{k})q_l^2 - 2R_{ol}^2(\vec{k})q_oq_l).$$

HBT

$$\tilde{x}_\mu = x_\mu - \langle x_\mu \rangle$$

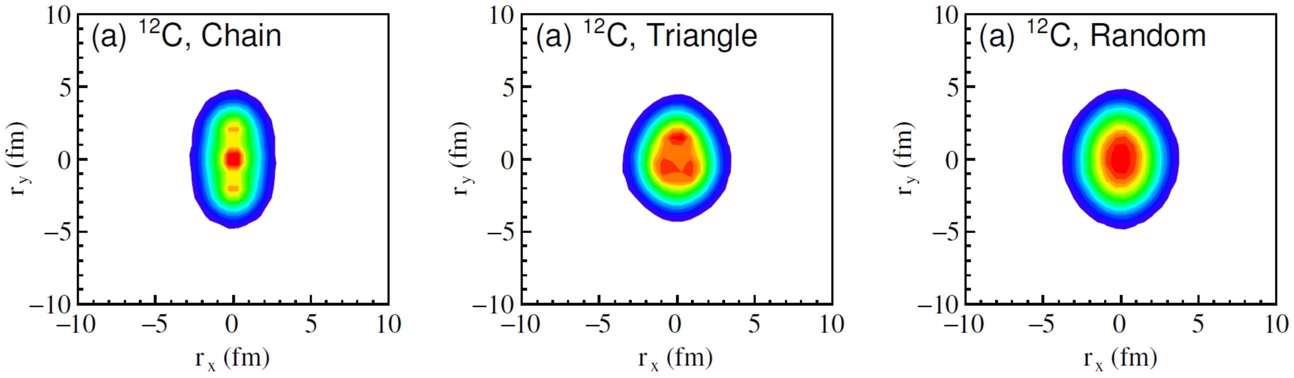
$$R_s^2(K_\perp, \Phi, Y) = \langle \tilde{x}^2 \rangle \sin^2 \Phi + \langle \tilde{y}^2 \rangle \cos^2 \Phi - \langle \tilde{x}\tilde{y} \rangle \sin 2\Phi,$$

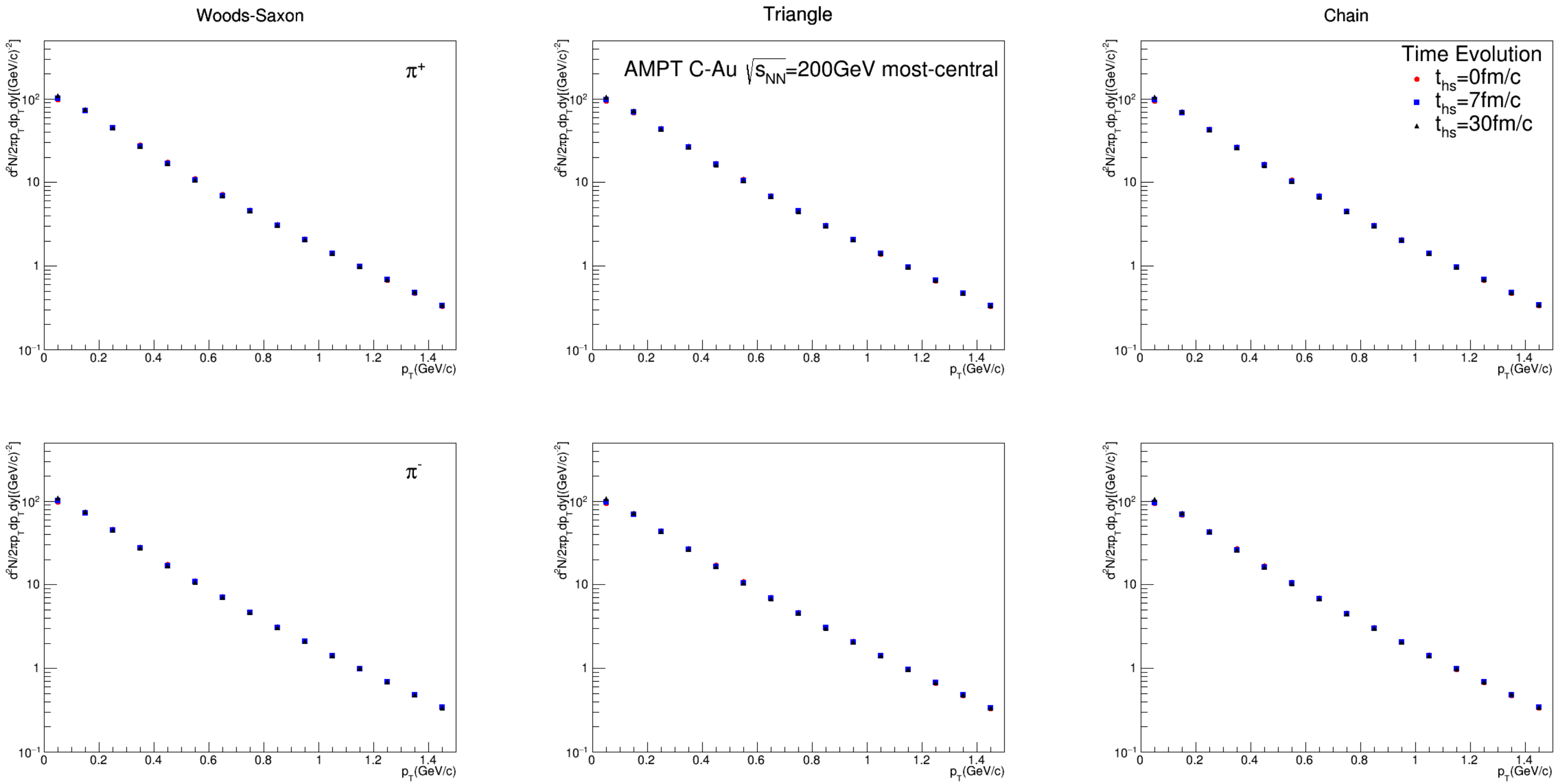
$$R_o^2(K_\perp, \Phi, Y) = \langle \tilde{x}^2 \rangle \cos^2 \Phi + \langle \tilde{y}^2 \rangle \sin^2 \Phi + \beta_\perp^2 \langle \tilde{t}^2 \rangle$$
$$- 2\beta_\perp \langle \tilde{t}\tilde{x} \rangle \cos \Phi - 2\beta_\perp \langle \tilde{t}\tilde{y} \rangle \sin \Phi$$
$$+ \langle \tilde{x}\tilde{y} \rangle \sin 2\Phi,$$

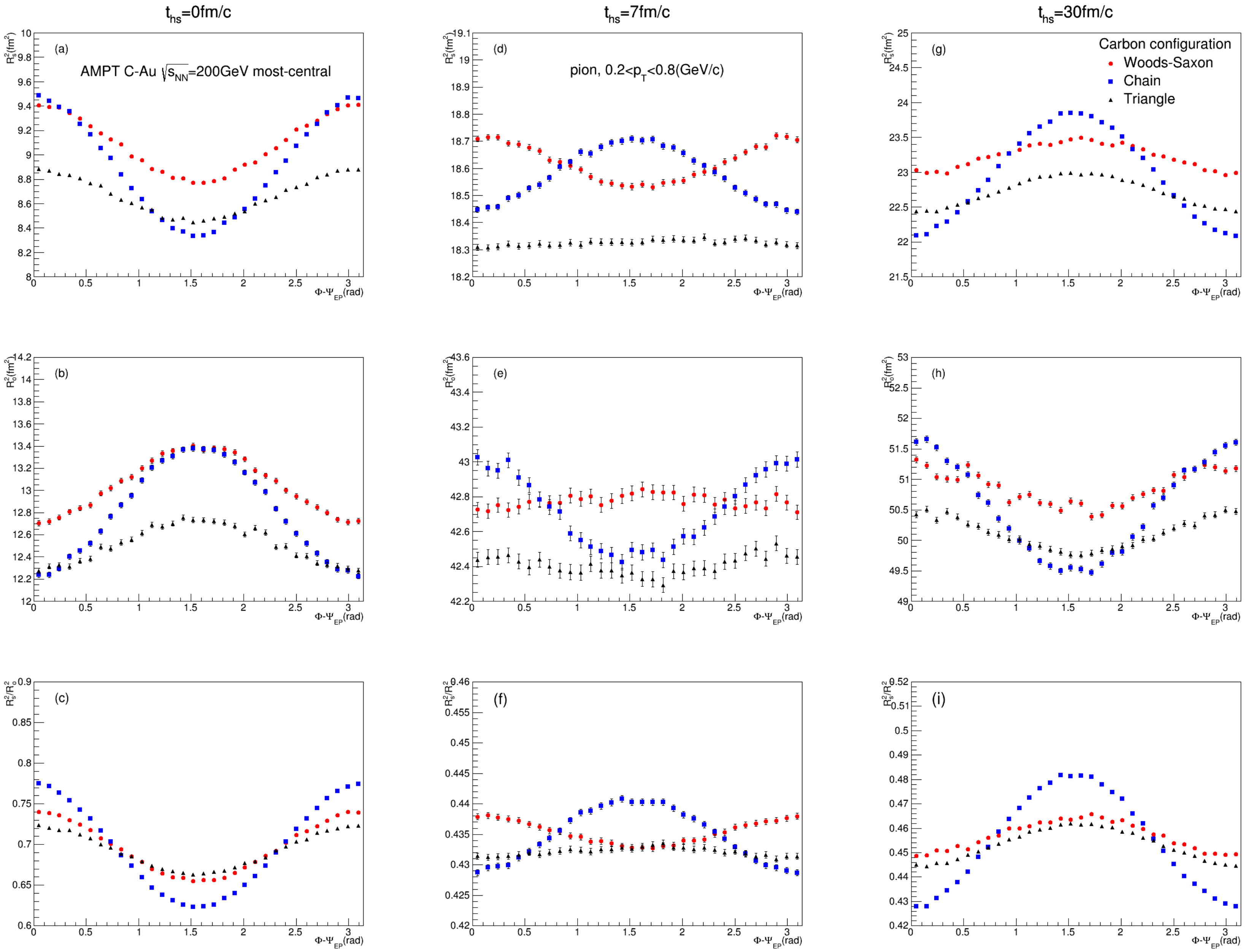
$$R_l^2(K_\perp, \Phi, Y) = \langle (\tilde{z} - \beta_l \tilde{t})^2 \rangle,$$

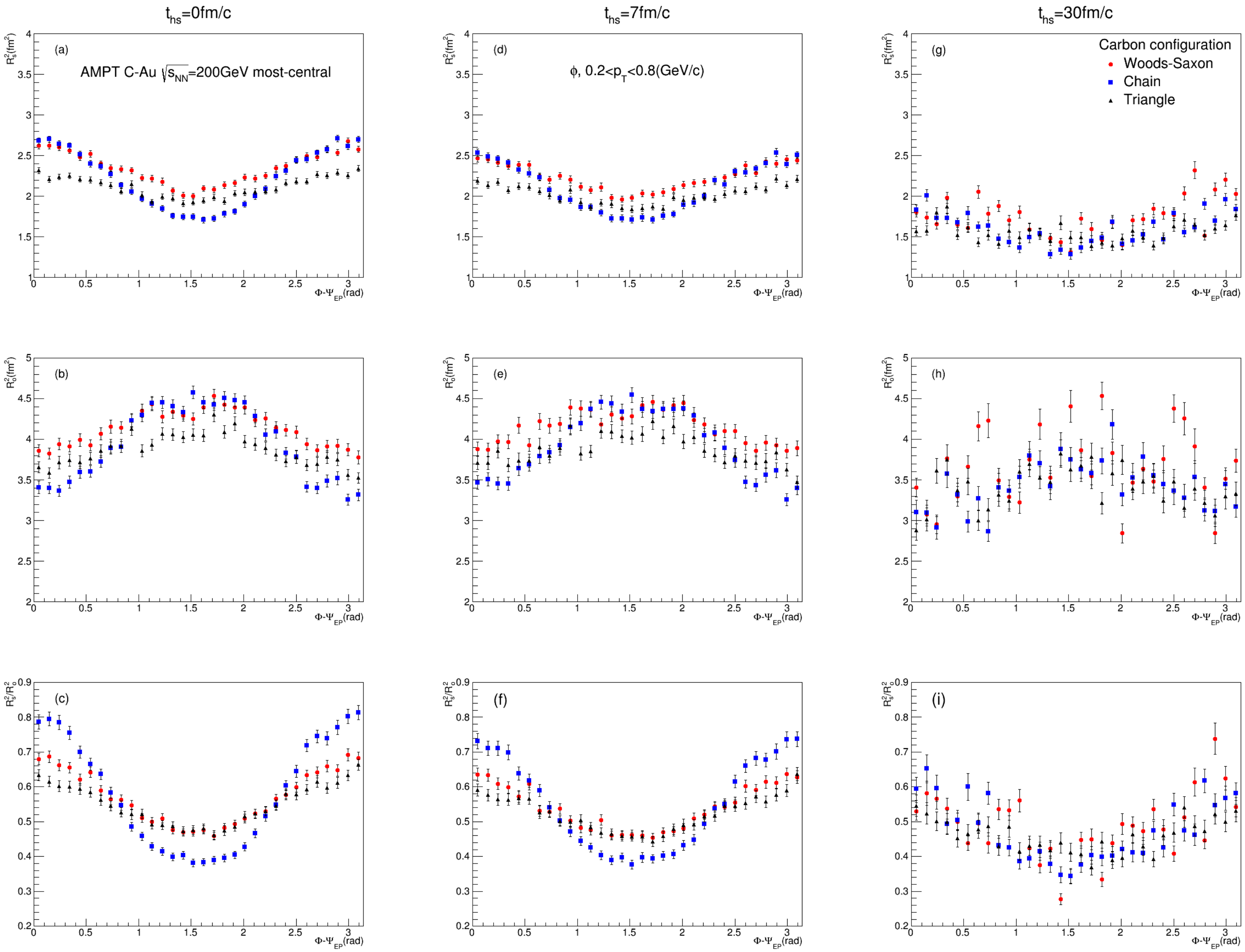
Wiedemann PhysRevC.57.266

Results


(a) ^{12}C, Chain
(a) ^{12}C, Triangle
(a) ^{12}C, Random
r_y (fm)
r_x (fm)


Woods-Saxon
Triangle
Chain
π^+
π^-
AMPT C-Au $\sqrt{s_{NN}}$=200GeV most-central
Time Evolution
t_{hs}=0fm/c
t_{hs}=7fm/c
t_{hs}=30fm/c
$d^2N/2\pi p_T dp_T dy[(GeV/c)^{-2}]$
p_T(GeV/c)


t_{hs}=0fm/c
t_{hs}=7fm/c
t_{hs}=30fm/c
(a)
AMPT C-Au $\sqrt{s_{NN}}$=200GeV most-central
(d)
pion, 0.2<p_T<0.8(GeV/c)
(g)
Carbon configuration
Woods-Saxon
Chain
Triangle
(b)
(e)
(h)
(c)
(f)
(i)
$R_s^2(fm^2)$
$R_o^2(fm^2)$
R_s^2/R_o^2
$\Phi-\Psi_{EP}$(rad)


t_{hs}=0fm/c
t_{hs}=7fm/c
t_{hs}=30fm/c
(a)
AMPT C-Au $\sqrt{s_{NN}}$=200GeV most-central
(d)
ϕ, 0.2<p_T<0.8(GeV/c)
(g)
Carbon configuration
Woods-Saxon
Chain
Triangle
(b)
(e)
(h)
(c)
(f)
(i)
$R_s^2(fm^2)$
$R_o^2(fm^2)$
R_s^2/R_o^2
$\Phi-\Psi_{EP}$(rad)

Summary

- HIC can be used to study the structure of light nuclei
- The HBT correlation can be a probe for α clusters in carbon
- Further research is needed on differentiating similar configurations more effectively

Thank you for your attention