# Exploring Anti-Li4 by Momentum Correlation Function


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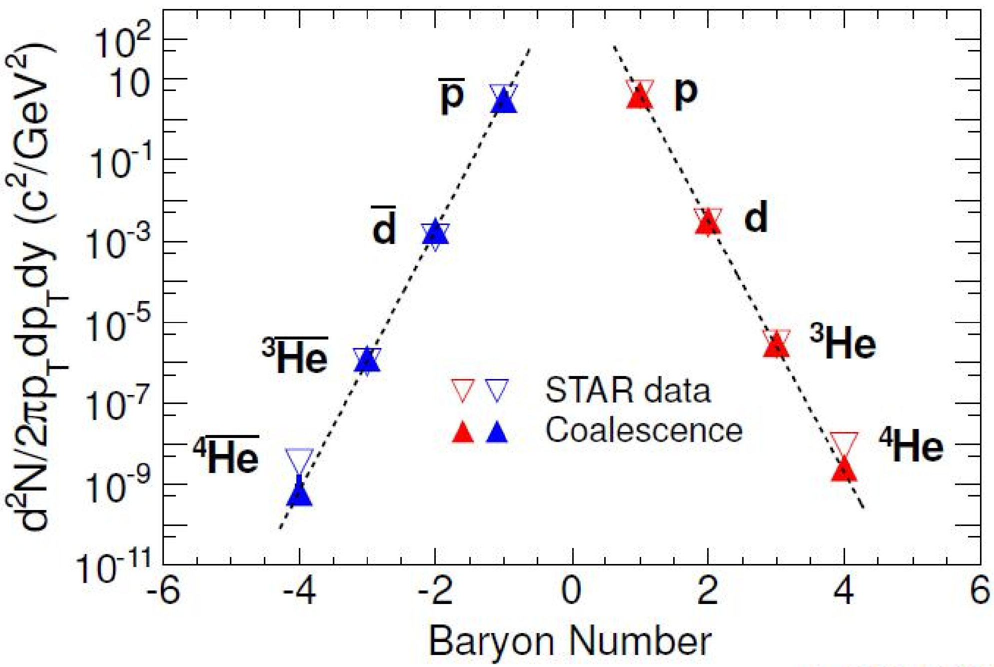
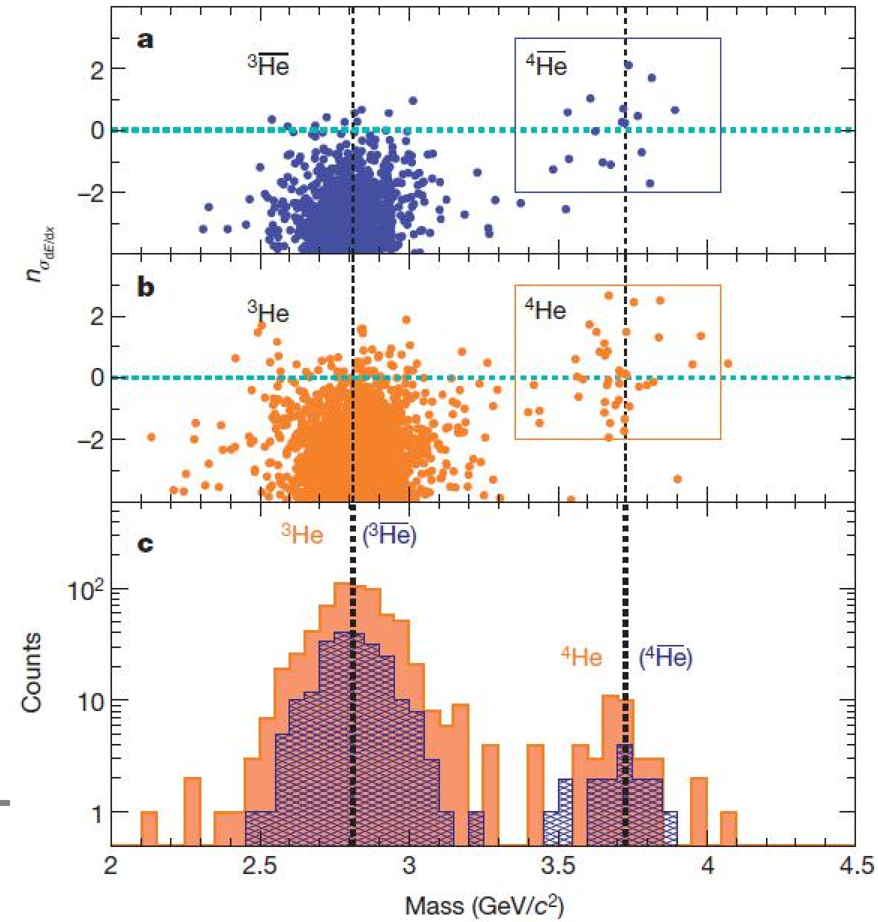
# Outline

- Introduction
- Blast-Wave Models
- Results
- Summary & Outlook

# Introduction

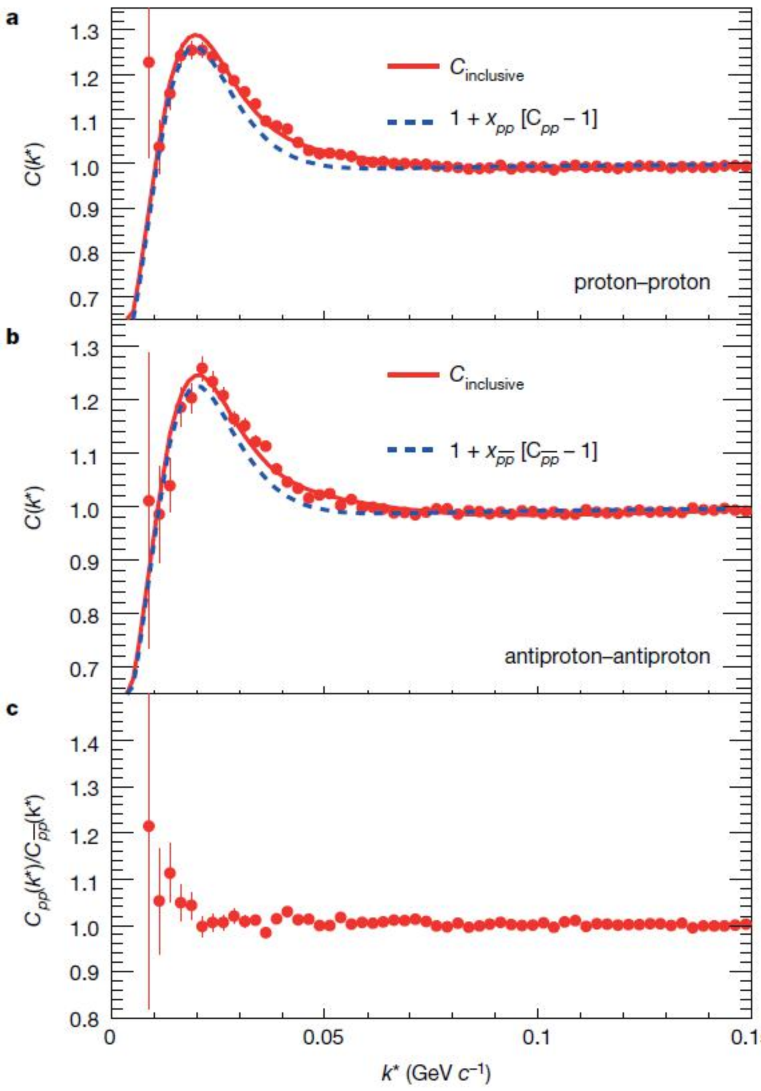
- Observed heaviest anti-nucleus



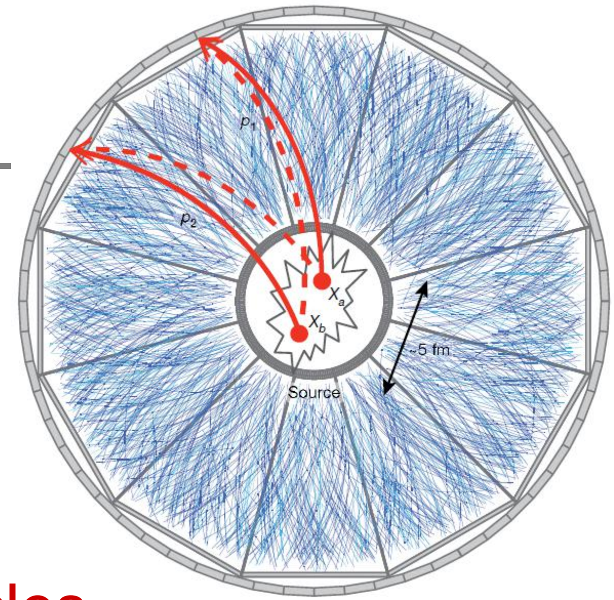

doi:10.1038/nature10079

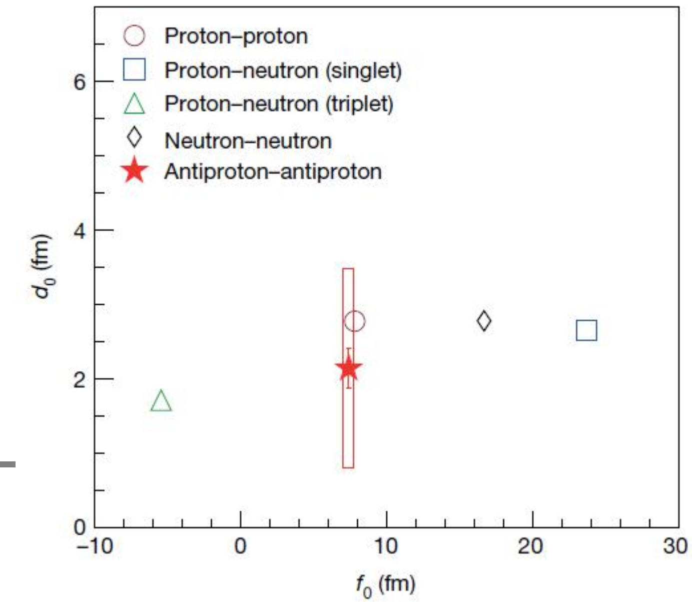
# Introduction




HBT refers to probability.

secondary particles.




doi:10.1038/nature15724

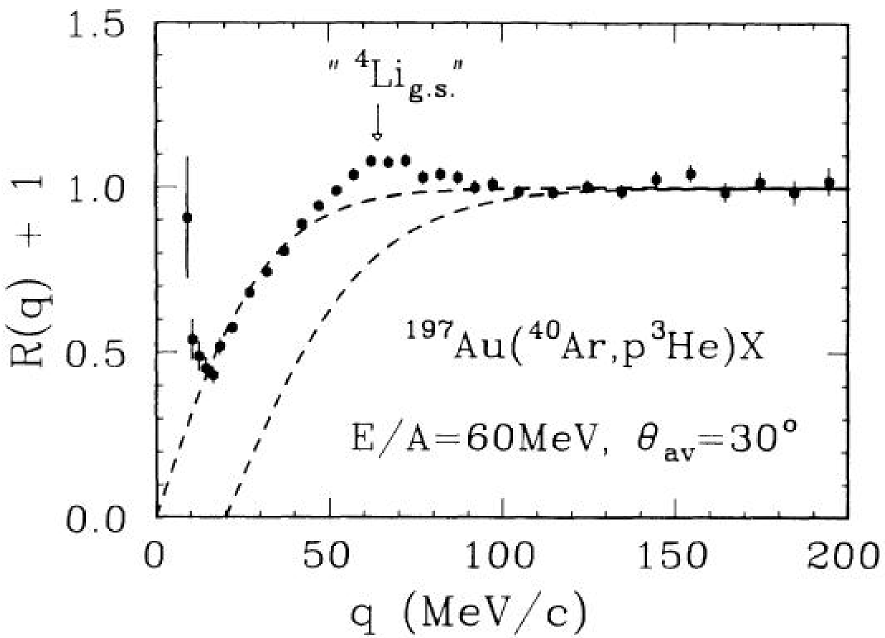
# Blast-Wave Model

- Monte Carlo Generator
- All hadrons are produced directly by fireballs
- Boosted to the global frame
- Chose resonance decay channels and determine the momenta and positions of final state hadrons
- Lifetime of unstable particles


- Phys. Rev. C 85, 064912 (2012)
- Nature 473, 353 (2011)
- Phys. Lett. B 754 6 (2016)

# Two-Body Decay

If a resonance with mass M decays via two-body decay to daughters with masses m1 and m2, their energies can be get and they will be receding back-to-back with momenta




J. Pochodzalla *et al.*,Phys. Rev. C **35**, 1695 (1987)

$$E_1 = \frac{M^2 - m_2^2 + m_1^2}{2M}$$

$$E_2 = \frac{M^2 - m_1^2 + m_2^2}{2M}$$

$$|\vec{p}_1| = |\vec{p}_2| = \frac{\sqrt{(M^2 - (m_1 + m_2)^2)(M^2 - (m_1 - m_2)^2)}}{2M}$$

$$^4\overline{Li} \rightarrow \overline{p} + {}^3\overline{He}$$

# Chemical Composition

Relative abundances of the individual species follow the prescription of chemical equilibrium with temperature Tch and chemical potentials for baryon number and strangeness

$$n_i(T_{ch}, \mu_B, \mu_S) = g_i \int \frac{d^3p}{(2\pi)^3} \left[ \exp\left( \frac{\sqrt{p^2 + m_i^2} - (\mu_B B_i + \mu_S S_i)}{T_{ch}} \right) \mp 1 \right]^{-1} = \frac{g_i}{2\pi^2} T_{ch}^3 I\left( \frac{m_i}{T_{ch}}, \frac{\mu_i}{T_{ch}} \right),$$

$$w_i(T_{ch}, \mu_B, \mu_S) = \frac{n_i(T_{ch}, \mu_B, \mu_S)}{\sum_i n_i(T_{ch}, \mu_B, \mu_S)}$$

$${}^4\overline{Li} : {}^3\overline{He} = 0.0148$$

# Correlation Function

- Experimentally the correlation function can be constructed by a ratio
- influenced by quantum statistical effect and FSI
- sensitive & non-sensitive

$$C(\boldsymbol{k}^*) = \frac{A(\boldsymbol{k}^*)}{B(\boldsymbol{k}^*)} \qquad \boldsymbol{k}^* = \frac{1}{2}(\vec{p}_1 - \vec{p}_2)$$

- In theory, we can calculate the correlation function by

$$CF(k^*) = \frac{\sum_{pair} \delta(k^*_{pair} - k^*) w(k^*, r^*)}{\sum_{pair} \delta(k^*_{pair} - k^*)}$$

# Lednicky-Lyuboshitz Model

Here, we use L-L model to calculate the correlation function From s-wave scattering amplitude and equal-time reduced Bethe-Salpeter amplitude, the weight of pair with r* and k* can be obtained.

At last, the theoretical correlation function can be obtained by

$$f\left(k^{*}\right)=\left[\frac{1}{f_{0}}+\frac{1}{2} d_{0} k^{* 2}-\frac{2}{a_{c}} h\left(k^{*} a_{c}\right)-i k^{*} A_{c}(\eta)\right]^{-1}$$

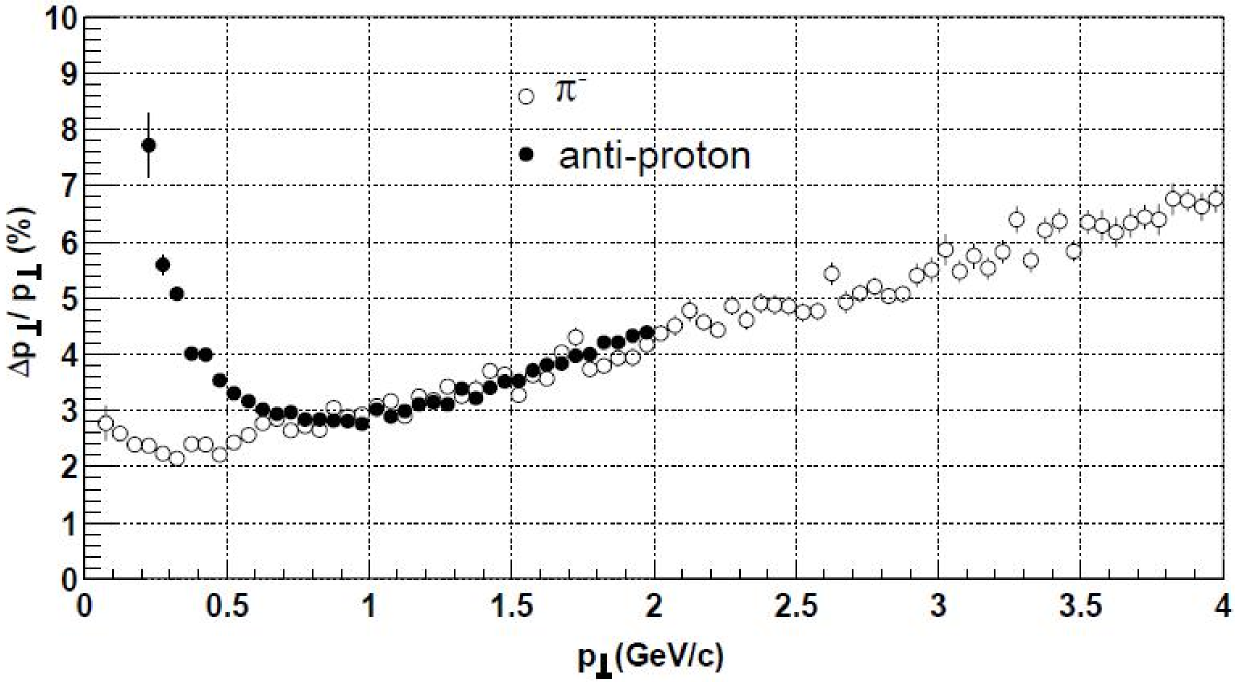
$$\psi_{-\boldsymbol{k}^{*}}^{S(+)}\left(\boldsymbol{r}^{*}\right)=e^{i \delta_{c}} \sqrt{A_{c}(\eta)}\left[e^{-i \boldsymbol{k}^{*} \cdot \boldsymbol{r}^{*}} F(-i \eta, 1, i \xi)+f_{c}\left(k^{*}\right) \frac{\widetilde{G}(\rho, \eta)}{r^{*}}\right]$$

$$w\left(\boldsymbol{k}^{*}, \boldsymbol{r}^{*}\right)=\frac{1}{2}\left|\psi_{-\boldsymbol{k}^{*}}^{S(+)}\left(\boldsymbol{r}^{*}\right)+(-1)^{S} \psi_{\boldsymbol{k}^{*}}^{S(+)}\left(\boldsymbol{r}^{*}\right)\right|^{2}$$

$$CF\left(k^{*}\right)=\frac{\sum_{pairs} \delta\left(k_{pair}^{*}-k^{*}\right) w\left(k^{*}, r^{*}\right)}{\sum_{pairs} \delta\left(k_{pair}^{*}-k^{*}\right)}$$

# Momentum Resolution

In the STAR experiment, the tracks of particles are reconstructed by the TPC. An estimate of the momentum resolution of reconstructed particles has been made.




M. Anderson et al.,

Nucl. Instrum. Meth. A 499, 659 (2003).

# Correlation Function at Radius is 5.5fm

The emission source of high energy heavy ion collisions can be considered spherically symmetric.
For central Au + Au collision at 200GeV, the radius of the emission source is about 5-6 fm measured by STAR.

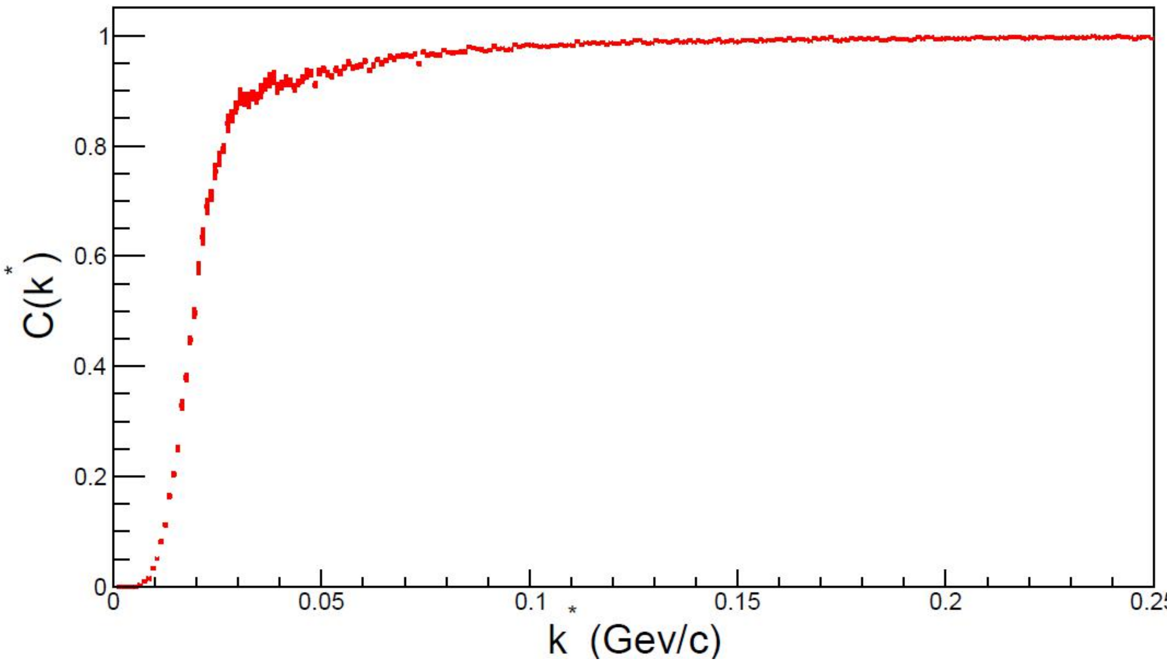
We assume a spherically symmetric Gaussian distribution source with a radius of 5.5fm for the phase-space.

L. Adamczyk et al. (STAR Collaborat
arXiv:1403.4972 [nucl-ex].

$$f_0^{(1)} = 10.3 fm \quad d_0^{(1)} = 1.85 fm$$

$$f_0^{(3)} = 8.2 fm \quad d_0^{(3)} = 1.68 fm$$

arXiv:0812.4081v1[nucl-th]

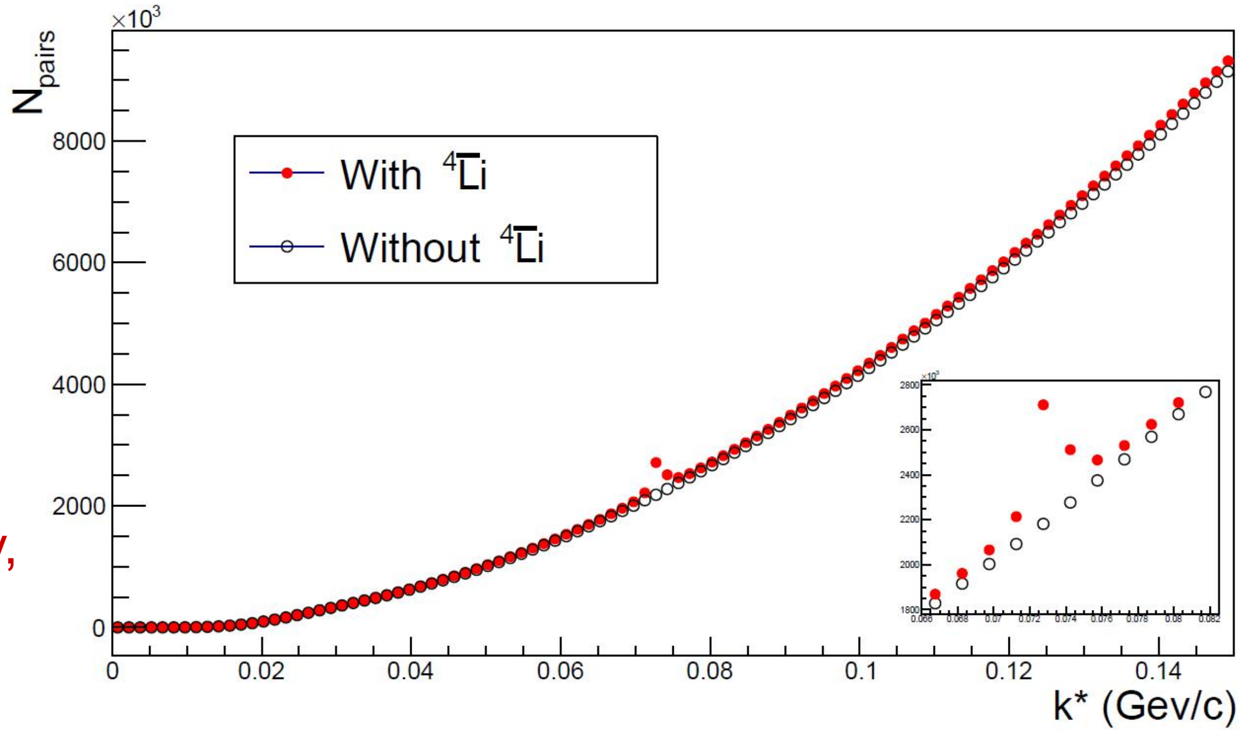


# k* Distributions of the Same Events

The phase space used for the correlation function calculation is generated by the blast-wave model.

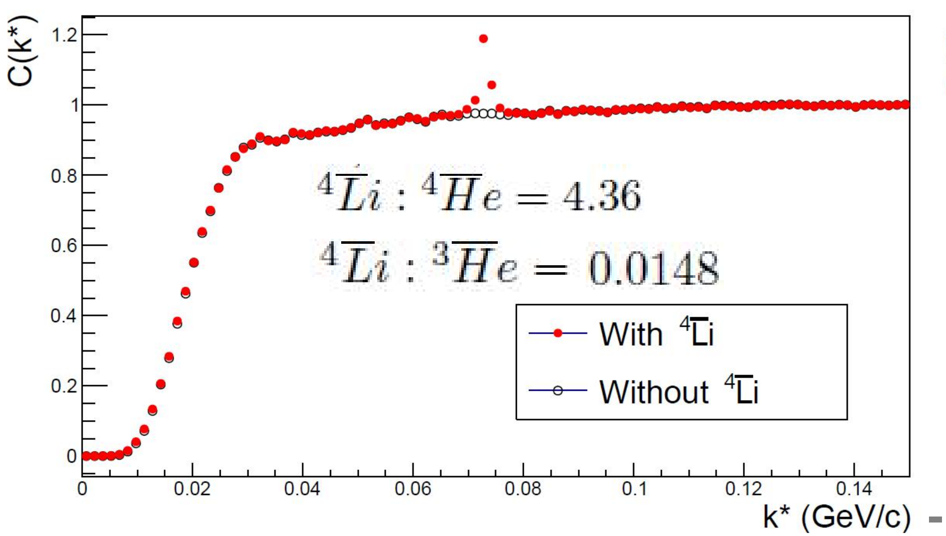
This figure shows the k* distributions from phase space with and without anti-Li4 decay.

In the k* distribution that containing anti-Li4 decay, there is a peak at k* around 0.073 GeV/c.

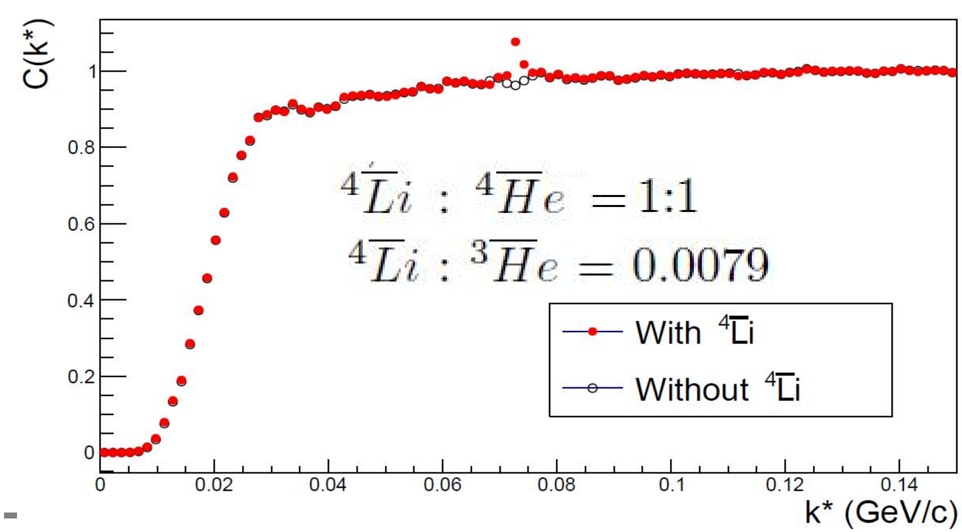


# Correlation Function of Anti-p and Anti-He3

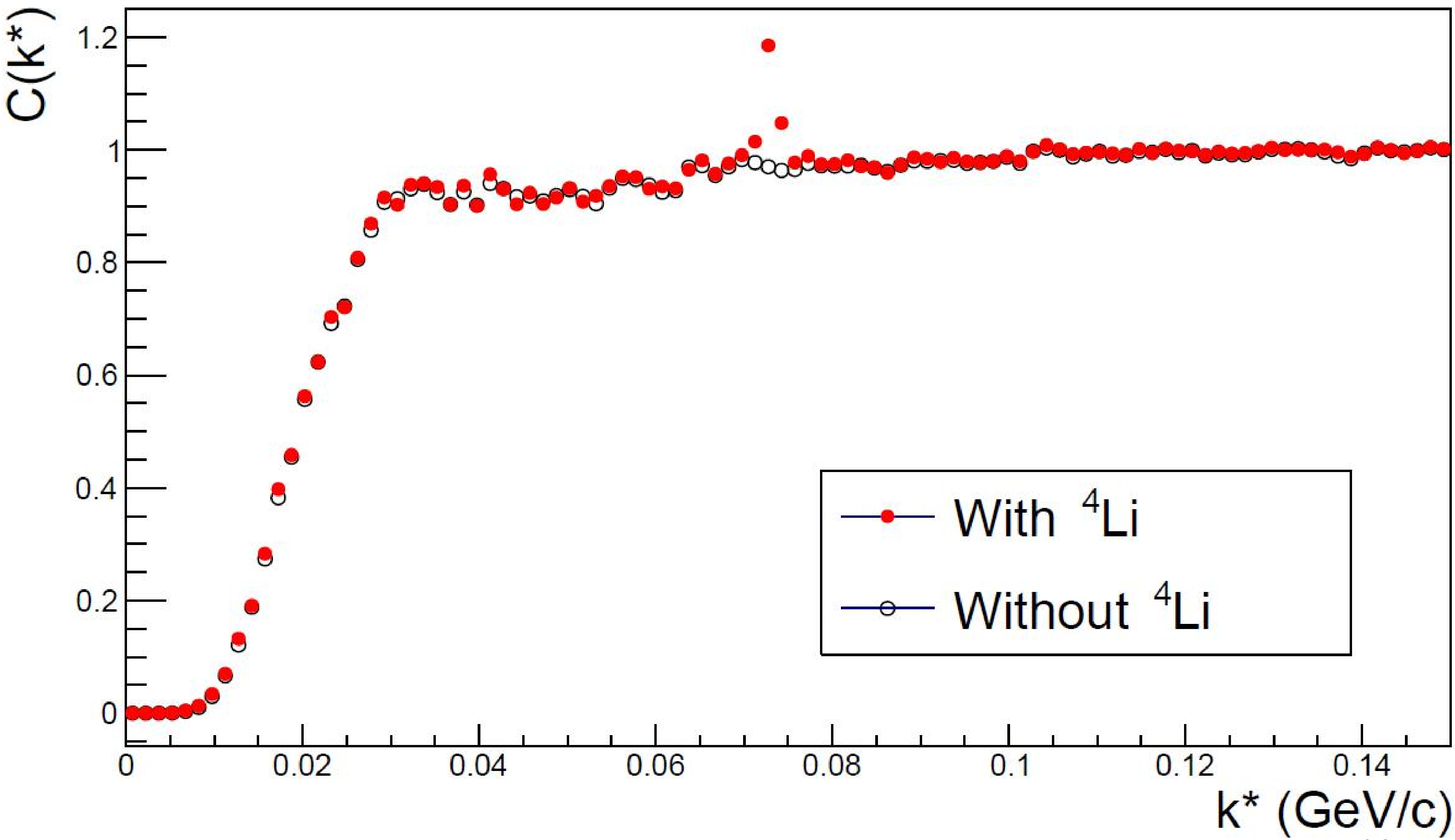
The yield of anti-Li4 is according to the thermal model.




Lower yield of anti-Li4
(lower than thermal model predicted)

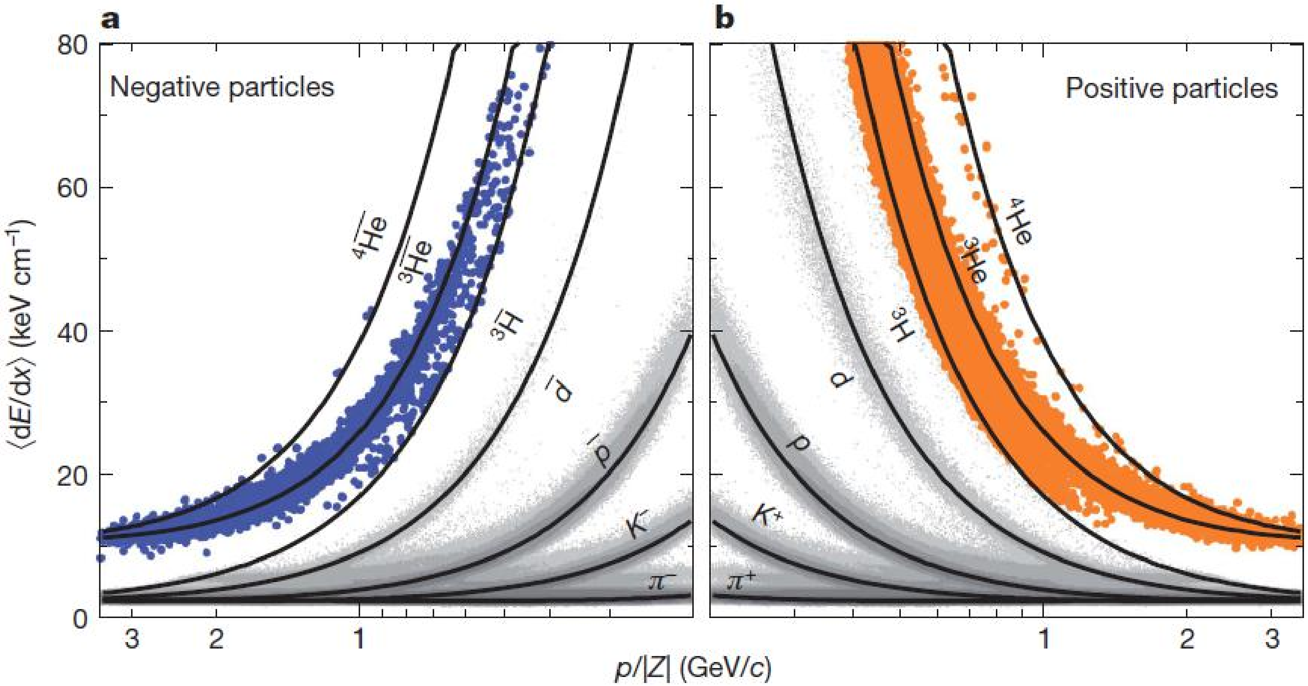


# As a Contrast, the Correlation Function of p and He3



# Summary & Outlook

- In experiment, the correlation function of anti-p and anti-He3 offers us a method to measure the yield of anti-Li4.
- The result offers a guide for the experimental search for anti-Li4 in relativistic heavy ion collision.
- Next step is to analyze the data of STAR and search for anti-Li4.




doi:10.1038/nature10079

# Thanks for your attention !