Azimuthally Sensitive HBT Analysis

Peter Filip

Based on talk given at Lawrence Berkeley Laboratory
1 Cyclotron Road, Berkeley, CA 94720, USA
(16 July 1996)

Abstract

In this paper we investigate a possibility to perform shape-sensitive
HBT analysis in transversal plane. We study presently used Side-Out
decomposition of the correlation function and we do not find it to be
very sensitive for the detection of a shape of source distribution in
transversal plane. Therefore we suggest to use X-Y decomposition of
the correlation function for the HBT analysis of non-central heavy ion
collisions. We test the method suggested on artificial and non-central
Pb-Pb 158GeV/n events produced by CASCUS event generator. Further
possible enhancement of the method is sketched.

PACS numbers: 25.75

1. Introduction

HBT interferometry analysis has become a powerful method in present day
heavy ion collision (HIC) experiments. Nice theoretical and experimental work
has been done in the field of HBT analysis of central HIC events. Long-Side-
Out decomposition of correlation function enabled us to separate space and
time properties of source distribution of bosons \( \rho(\vec{x}, t) \). Even more sophisti-
cated models of emission functions containing flow and velocity parameters
have been analyzed in various coordinate systems \([1]\).

On the other hand HBT analysis is still apparently not fully accomplished
 technique. For example Gamov factor correction which was expected to de-
scribe influence of coulomb final state interactions \([2]\) on the correlation func-
tion was found to be in disagreement with recent experimental results \([3]\).

Recently HBT analysis of non-central HIC events has been performed on
data taken at SPS \([4]\) and AGS \([5]\). Extracted radius parameters were found
to be dependent on centrality of collision and also on azimuthal orientation of

\[^1\]Permanent address: Institute of Physics, SAS, Bratislava, SK-842 28
the momentum of pions in respect to the reaction plane \( \vec{x} \). For this analysis of non-central events a methods originally developed for cylindrically symmetric systems were used.

We think that a more comprehensive information about the source distribution \( \rho(\vec{x}, t) \) can be obtained. The purpose of this paper is to introduce an HBT analysis method which is suitable for the study of geometrical properties of source distributions e.g. a shape or structure of \( \rho(\vec{x}) \).

This paper is organized as follows: In Section 2 we study Side-Out decomposition of correlation function and we find it to be unsensitive to the shape of the source distribution in transversal plane. In Section 3 we introduce X-Y decomposition of correlation function and we show it to be suitable for the study of the geometrical properties of source distribution. A possibility to perform azimuthally sensitive HBT analysis of non-central events in the case when orientation of impact parameter \( \vec{b} \) is not known is investigated in Section 4. In subsequent sections we study influence of \( \vec{x} - \vec{p} \) correlation of source distribution \( \rho(\vec{x}, t) \) on transversal HBT analysis and also possible further enhancement of the HBT interferometry method.

2. Side-Out Decomposition of Correlation Function

In this section we shall recall advantages of the Side-Out decomposition of correlation function. We start with simplified expression for the correlation function produced by \( \vec{x} - \vec{p} \) non-correlated source \( \rho(\vec{x}, t) \). Assuming that probability of emission of a single boson does not depend on momentum and that emission of bosons is incoherent we write:

\[
C(\Delta \vec{p}) = \int \int d^3\vec{x}_1 d^3\vec{x}_2 \left[ \rho(\vec{x}_1, t_1) \cdot \rho(\vec{x}_2, t_2) |\Psi_{12}|^2 \right] dt_1 dt_2
\]  

(1)

where

\[
|\Psi_{12}|^2 = \frac{1}{2} \left[ e^{ip_1 x_1} e^{ip_2 x_2} + e^{ip_2 x_1} e^{ip_1 x_2} \right]^2 = 1 + \cos(\Delta \vec{x} \cdot \Delta \vec{p} - \Delta t \cdot \Delta E)
\]  

(2)

By simple kinematic relations we can prove \[5\]:

\[
\Delta E = \Delta \vec{p} \cdot \vec{\beta}_{out} \ ; \ \vec{\beta}_{out} = \frac{\vec{p}_1 + \vec{p}_2}{E_1 + E_2} \ , \ \Delta \vec{p} = \vec{p}_1 - \vec{p}_2
\]  

(3)

Thus decomposing scalar product in Eq.(2) into Out and Side orthogonal components we can separate time information about the emission source from the Side component of correlation function:

\[
1 + \cos(\Delta \vec{p}_{side} \cdot \Delta \vec{x}_{side} + \Delta \vec{p}_{out} \cdot [\Delta \vec{x}_{out} - \Delta t \cdot \vec{\beta}_{out}])
\]  

(4)

This Side-Out decomposition of correlation function allows to study time properties of source \( \rho(\vec{x}, t) \) as a differnce of \( R_{out}, R_{side} \) extracted parameters. One of the main messages contained in this paper is:
Side-Out decomposition of correlation function destroys information about possible transversal shape of source distribution $\rho(\vec{x}, t)$.

Also for the sake of simplicity we concentrate on the study of transversal properties of source distribution $\rho(\vec{x}, t)$ in this paper. For this purpose we shall investigate properties of transversal correlation function constructed from pairs with very small longitudinal component of relative momentum $|\Delta p_l| \ll |\Delta \vec{p}_t|$. Then we can neglect longitudinal term in scalar product $\Delta \vec{p} \cdot \Delta \vec{x}$ in equation (2):

$$\Delta \vec{p} \cdot \Delta \vec{x} = \Delta p_l \cdot \Delta x_l + \Delta \vec{p}_t \cdot \Delta \vec{x}_t \approx \Delta \vec{p}_t \cdot \Delta \vec{x}_t$$

and for the transversal correlation function we write:

$$C_T(\Delta \vec{p}_t) = \int \int d^2\vec{x}_1 d^2\vec{x}_2 \left[ \rho'(\vec{x}_1, t) \rho'(\vec{x}_2, t) \left[ 1 + \cos(\Delta \vec{p}_t \cdot \Delta \vec{x}_t - \Delta t \cdot \Delta E) \right] \right] dt_1 dt_2$$

Source distribution $\rho'(\vec{x})$ in (4) is a projection of three-dimensional source distribution $\rho(\vec{x})$ onto the transversal plane: $\rho'(\vec{x}_t) = \int \rho(\vec{x}_t, x_l) dx_l$.

On Fig.1 we show transversal correlation function in Side-Out decomposition for artificially asymmetric S-Pb events. Momenta of bosons were generated in agreement with experimentally measured $p_t$ and rapidity distributions of pions in central S-Pb $200\text{GeV}/n$ collisions in the same way as it was done in computer simulation [7]. Space distribution of emission points of pions in transversal plane was changed artificially as it is shown on Fig.1a.

![Fig.1 Side-Out Correlation function for asymmetric source in transversal plane. Pions are assumed to be emitted at the same time ($\Delta t = 0$).](image)

Transversal correlation function $C_T(\Delta p^t_{side}, \Delta p^t_{out})$ does not exhibit any azimuthal asymmetry as a consequence of asymmetrical shape of source distribution in Fig.1a - it is azimuthally non-sensitive. In the next section we show that another decomposition of correlation function is sensitive to the shape properties of $\rho(\vec{x}, t)$. Here we shall try to explain what is a mechanism of destroying the shape information in Side-Out decomposition analysis.
Let us study a very simple case – static two-point source emitting pairs of bosons simultaneously (Fig.2). If bosons are emitted as it is shown on Fig.2a then separation of emission points in Out and Side directions is:

\[ \Delta x_{\text{out}} = 0 ; \quad \Delta x_{\text{side}} = D \tag{7} \]

On Fig.2b the orientation of sum \( \vec{p}_1 + \vec{p}_2 \) leads to a totally different situation:

\[ \Delta x_{\text{out}} = D ; \quad \Delta x_{\text{side}} = 0 \tag{8} \]

Since the orientation of vector \( \vec{p}_{\text{out}} = \frac{\vec{p}_1 + \vec{p}_2}{E_1 + E_2} \) is random values of \( \Delta x_{\text{out}}, \Delta x_{\text{side}} \) are randomly distributed but fulfilling condition \( \Delta x_{\text{out}}^2 + \Delta x_{\text{side}}^2 = D^2 \). It means that source behaves as a rotating in Side-Out transversal HBT analysis.

In the next section we introduce X-Y approach to HBT which does not exhibit this feature and we find it to be sensitive to a non-trivial geometrical structure of source distribution in transversal plane.

### 3. X-Y Decomposition of Transversal Correlation Function

Let us imagine that orientation of impact parameter \( \vec{b} \) is known with rather high precision for each non-central HIC event. In this case we can rotate measured momenta of particles in all events to have the same orientation of impact parameter.

Because of asymmetrical overlapping region of colliding ions in non-central events the shape of source distribution is asymmetrical in transversal plane. This shape information would be destroyed if Side-Out type of HBT analysis without any additional cuts was applied\(^2\).

On Fig.3 we show transversal correlation function in X-Y decomposition for the same source distribution as shown on Fig.1a. Correlation function \( C_T(\Delta p_x, \Delta p_y) \) is clearly asymmetrical and this reflects the shape of original source distribution \( \rho(\vec{x}, t) \).

\(^{2}\)See Section 5 for a possibility to apply directional cuts in momentum space.
In the first approximation we suggest to use following gaussian parametrization of the correlation function:

\[ C^T(\Delta p_x, \Delta p_y) = 1 + \lambda e^{-\Delta p_x^2/R_x^2 - \Delta p_y^2/R_y^2/2} \]  

(9)

which corresponds to the static (sharp freeze-out) source distribution

\[ \rho^T(x, y) = c e^{-x^2/R_x^2 - y^2/R_y^2} \]  

(10)

Results of this simple X-Y decomposition HBT analysis for Pb+Pb non-central 158 GeV/n HIC events generated by CASCUS generator are presented in next section. Here we shall discuss the question of lifetime of source which was the main reason for Side-Out decomposition of \( C(\Delta \vec{p}) \) as it is described in the preceding section.

Scalar product in the argument of \( \cos \) in equation (2) in X-Y coordinate system (\( \Delta p_z \approx 0 \)) is:

\[ \cos(\Delta x \cdot \Delta p_x + \Delta y \cdot \Delta p_y - \Delta t \cdot \Delta E) \]  

(11)

It means that time information contained in \( \rho(\vec{x}, t) \) is mixed in the same way with \( R_x \) and \( R_y \) parameters of the source extracted by fit of the experimentally measured correlation function to equation (9). Consequently if source \( \rho(\vec{x}, t) \) is asymmetrical in X-Y coordinate system then size parameters \( R_x, R_y \) extracted by the fit should still exhibit asymmetry \( R_x \neq R_y \).

Moreover if we rely on the argument of \( \cos \) in equation (2) then influence time dependet factor \( \Delta t \cdot \Delta E \) on our \( C^T(\Delta p_x, \Delta p_y) \) formally vanishes if only pairs fulfilling the following condition

\[ \Delta E = E_1 - E_2 \approx 0 \quad \Rightarrow \quad |\vec{p}_1| \approx |\vec{p}_2| \]  

(12)

are selected for HBT analysis. Condition (12) together with our previous requirement \( \Delta p_z \approx 0 \) still leaves enough freedom in the distribution of pairs in relative momentum space (\( \Delta p_x, \Delta p_y \)).
We finish this section by schematic diagram depicting advantages of the above described Side-Out and X-Y HBT methods.

**Fig. 4** Advantages of Side-Out and X-Y HBT analysis.

Side-Out decomposition of \(C(\Delta \vec{p})\) allows to study mainly lifetime \(\tau\) and flow \(\eta\) parameters of source (besides total size \(R\)). X-Y decomposition is sensitive to the shape and possibly other non-trivial geometrical structure of source distribution \(\rho(\vec{x})\).

4. Pb+Pb 158 GeV/n Non-central Events CASCUS Simulation

Azimuthally sensitive X-Y approach described in preceding section was tested using a computer simulation of Pb+Pb 158 GeV/n non-central events \(|\vec{b}| = 7 fm\). Main structure of the simulation is shown on Fig. 5.

**Fig. 5** CASCUS generator setup used for the simulation of non-central Pb+Pb 158 GeV/n HIC events.

Initial positions and momenta of pions created in non-central Pb+Pb collisions were produced by Cascading Generator [6]. Pions were evolved in time using enhanced version [8] of rescattering program [7]. Resulting distribution of last interactions of pions was used for HBT analysis.

Events with random orientation of impact parameter \(|\vec{b}| = 7 fm\) were rotated to have the same orientation of impact parameter \(\vec{b}\). Cascading generator program [3] was run at Czech Academy of Sciences (CAS) and rescattering program [8] was written at Comenius University in Slovakia (CUS).

Correlation function was constructed in the way similar to that used in simulation [7] but in X-Y coordinate system. Result was fitted to analytical expression (9). Parameters \(R_x, R_y\) obtained by the fit are summarized in the
The following table.

| X-Y HBT RESULTS | ORIGINAL | BEFORE RESCATTERING | AFTER RESCATTERING |
|------------------|----------|---------------------|--------------------|
| TOY EVENTS       | $S_x = 16\text{ fm}$ | $R_x = 8.76 \pm 0.02\text{ fm}$ | $R_x = 8.12 \pm 0.02\text{ fm}$ |
|                  | $S_y = 4\text{ fm}$  | $R_y = 2.35 \pm 0.02\text{ fm}$ | $R_y = 3.67 \pm 0.02\text{ fm}$ |
|                  | $S_y - S_y = 12\text{ fm}$ | $\Delta R_x = 8.4\text{ fm}$ | $\Delta R = 7.2\text{ fm}$ |
| Pb + Pb EVENTS   | $S_x = 11\text{ fm}$  | $R_x = 5.28 \pm 0.05\text{ fm}$ | $R_x = 5.48 \pm 0.05\text{ fm}$ |
|                  | $S_y = 6\text{ fm}$   | $R_y = 3.44 \pm 0.05\text{ fm}$ | $R_y = 4.64 \pm 0.05\text{ fm}$ |
|                  | $S_x - S_y = 9\text{ fm}$ | $\Delta R_x = 4.0\text{ fm}$ | $\Delta R = 2.9\text{ fm}$ |

Tab.1 Results of X-Y HBT analysis. $R_x, R_y$ parameters are extracted by fit to Eq.(9). $S_x, S_y$ are size parameters of source distribution $\rho(\vec{x})$.

As a consequence of asymmetrical shape of source distribution $\rho(\vec{x})$ extracted parameters $R_x, R_y$ are not of the same value what is demonstrated also by non-zero value of $\Delta R = \sqrt{R_x^2 - R_y^2}$ in the above table.

Comparing results obtained by HBT analysis of the events before and after rescattering proces we conclude that rescattering process smears the shape of the original source distribution. On the other hand $\vec{x} - \vec{p}$ correlation in the resulting source distribution $\rho(\vec{x}, \vec{p})$ after the rescattering process allows to perform another type of shape sensitive analysis based on directional cuts in momentum space (see next section).

5. Influence of $\vec{x} - \vec{p}$ Correlation

Let us imagine that there is no $\vec{x} - \vec{p}$ correlation in the distribution of pions before the rescattering process. It means we assume that pions are created in individual nucleon - nucleon collisions and that there is no collective behaviour of nucleons before the emission of pions. Then geometrical properties of the emission points distribution of pions $\rho(\vec{x}, \vec{p}) = \rho(\vec{x}) \cdot \rho(\vec{p})$ do not depend on cuts in momentum space. On the other hand rescattering process creates $\vec{x} - \vec{p}$ correlation in last interactions distribution of pions $\rho^{LI}(\vec{x}, \vec{p})$ (see Fig.5).

![Fig.5](image-url) Emission points of pions (CASCUS Pb+Pb 160 GeV/n ; $\vec{b} = 7\text{ fm}$) in transversal plane. Distribution of Last Interactions depends on $p_t$ cut.
Distribution of last interactions depends on absolute value of transversal momentum. This explains dependence of extracted HBT radii parameters on \( p_t \) which was measured experimentally \([9]\). Moreover rescattering process creates also a directional \( \vec{x} - \vec{n}_t \) type of correlation \([10]\). This type of correlation can also be used for detection of the transversal shape of \( \rho^{LI}(\vec{x}, \vec{p}) \) distribution. On Fig.6 we show \( \rho^{LI}(\vec{x}, \vec{p}) \) distribution of pions for selected directional cuts in transversal momentum space.

![Directional cuts in momentum space select pions from different regions of Last Interactions distribution. Distribution of pairs in relative momentum space (\( \Delta \vec{p}_t \)) still allows two-dimensional HBT analysis.](image)

Pions with different directions of transversal momentum come from different regions of \( \rho^{LI}(\vec{x}, \vec{p}) \). If distribution \( \rho^{LI}(\vec{x}) \) is asymmetrical in transversal plane (see Fig.6) then directional cuts in momentum space select spatial regions of different size what leads to different radii parameters extracted by HBT method. Azimuthally sensitive HBT analysis based on directional momentum cuts was already performed on AGS data \([4]\).

\[\text{Fig.6} \quad \text{Directional cuts in momentum space select pions from different regions of Last Interactions distribution. Distribution of pairs in relative momentum space (\( \Delta \vec{p}_t \)) still allows two-dimensional HBT analysis.}\]

\[\text{Pions with different directions of transversal momentum come from different regions of } \rho^{LI}(\vec{x}, \vec{p})].\]

\[\text{If distribution } \rho^{LI}(\vec{x}) \text{ is asymmetrical in transversal plane (see Fig.6) then directional cuts in momentum space select spatial regions of different size what leads to different radii parameters extracted by HBT method. Azimuthally sensitive HBT analysis based on directional momentum cuts was already performed on AGS data.}\]

\[\text{Directional cut in transversal momentum space (} p_x, p_y \text{) does not restrict distribution of pion pairs in relative momentum space (} \Delta p_x, \Delta p_y \text{) significantly.}\]
Common feature of the method based on $\vec{x} - \vec{n}_p$ correlation and X-Y HBT is that orientation of impact parameter is determined for each event (e.g. by transversal flow analysis). In the next section we sketch a possibility to perform azimuthally sensitive HBT without information about impact parameter orientation.

5. Can We See the Reaction Plane via HBT?

In experiment the orientation of impact parameter $\vec{b}$ is random for non-central collisions. Thus transversal shape of source distribution will not be visible by HBT if the correlation function is constructed as a sum of randomly oriented single event contributions. This situation is similar to transversal flow analysis \[11\] where event by event (EbyE) technique allows to determine a presence of azimuthal asymmetry \[12\].

Here we sketch EbyE HBT technique similar to that utilized in transversal flow analysis \[13\]. Let us rewrite X-Y decomposition of transversal correlation function

$$ C_T(\Delta p_x, \Delta p_y) = 1 + e^{-\Delta p^2 x R^2_x / 2 - \Delta p^2 y R^2_y / 2} $$

in spherical coordinate system:

$$ \Delta p_x = \Delta p_r \cdot \cos(\phi) \quad ; \quad \Delta p_y = \Delta p_r \cdot \sin(\phi) $$

After substitution (14) into (13) we obtain:

$$ C_T(\Delta p_r, \phi) = 1 + e^{-\frac{\Delta p^2_r}{4} \left[ R^2_0 + \Delta R^2 \cos(2\phi) \right]} $$

where $R^2_0 = R^2_x + R^2_y$ ; $\Delta R^2 = R^2_x - R^2_y$. Thus non-zero value of $\Delta R$ parameter is a signature of transversal asymmetry of the correlation function and consequently also of the source distribution. Random orientation of impact parameter means a simple random shift in azimuthal angle $\phi \rightarrow \phi + \Delta^i$ in spherical coordinate system. Equation (15) can then be rewritten in the form:

$$ C_T(\Delta p_r, \phi) = 1 + e^{-\frac{\Delta p^2_r}{4} \left[ R^2_0 + E_x \cos(2\phi) + E_y \sin(2\phi) \right]} $$

where parameters $E_x = \Delta R^2 \cos(\Delta^i)$ ; $E_y = \Delta R^2 \sin(\Delta^i)$ depend on $\Delta^i$ which is different for each event. This expression for single-event correlation function is similar to the second order fourier decomposition of azimuthal distribution $R(\phi)$ used in transversal flow analysis \[13\]:

$$ R(\phi) = x_o + x_2 \cos(2\phi) + y_2 \sin(2\phi) $$

Non-zero positioned maximum in $v^2 = \sqrt{x_2^2 + y_2^2}$ distribution constructed from many single event fit results is a signature of non-zero value of average $\bar{v}_2$.
parameter \[^{[13]}\]. Based on this analogy we imply that non-zero positioned maximum of \(\Delta R^2 = \sqrt{E_x^2 + E_y^2} \) distribution obtained by many single-event HBT fit procedures could be a signature of asymmetrical shape of \(\rho(\vec{x}) \) distribution in transversal plane.

In this EbyE approach the orientation of impact parameter is not determined by other (e.g. flow) method. Therefore we dare to say that experimentally observed non-zero average value of \(\Delta R \) parameter extracted by this method would mean observation of the reaction plane via HBT.

We are aware that here we give a very rough description of this method. We have not touched other important topics e.g. the construction of single-event correlation function or final state interactions correction \[^{[14]}\].

There exists also a possibility to perform HBT search for the reaction plane based on \(\vec{x} - \vec{n}_p \) correlation described in the preceeding section. This approach would be based on the study of (anti)correlation of the radii \(R_{\phi_1}, R_{\phi_2} \) extracted for e.g. orthogonal directional cuts in momentum space.

These topics are however beyond the scope of this paper now. In the next section we describe shortly a previously reported \[^{[15, 16]}\] possibility of further enhancement of HBT analysis.

6. Inverse Transformation

General principle of HBT is the following: We measure a result of interference phenomenon (correlation function \(C(\Delta \vec{p}) \)) and by analysis of \(C(\Delta \vec{p}) \) we reconstruct some information about a source emitting bosons.

This principle is similar to holography methods where however full spatial information about source can be obtained. Full reconstruction is allowed by the interference of coherent radiation. In most of literature about HBT a statement for degenerated (constant) correlation function in the case of coherent emission of bosons can be found. However it is not excluded that for coherently emitted bosons (produced by e.g. Chiral Condensates \[^{[17]}\] ) a slightly different - holographic\[^{[18]}\] approach to HBT exists. Nevertheless experimental situation is the main Veto device which decides the fate of theoretically existing methods. Therefore we shall deal only with uncoherently radiated bosons in this section.

As it was shown in work \[^{[15]}\] for a static (sharp freeze-out) \(\vec{x} - \vec{p} \) uncorrelated source we can write:

\[
C(\Delta p_x, \Delta p_y) = \int \int S(D_x, D_y)[1 + \cos(\Delta p_x \cdot \Delta D_x + \Delta p_y \cdot \Delta D_y)]dD_x dD_y \quad (18)
\]

where \(S(D_x, D_y) \) is a probability distribution for emission of bosons at a relative distance \(\vec{D} = (D_x, D_y) \). Inverse transformation from \(C(\Delta p_x, \Delta p_y) \) to

\[^{[18]}\]For the inverse transformation based on Helmholtz-Kirchhoff theorem see \[^{[20]}\].
$S(D_x, D_y)$ in equation (18) exists. It is quite tempting to perform this procedure on our simulated CASCUS events.

On Fig.7 we show $S(D_x, D_y)$ - symmetrized result of inverse transformation of correlation function $C(\Delta \vec{p}_t)$ for artificial S-Pb events (see Fig. 1a) in X-Y decomposition and Side-Out decomposition. Images c), d) are result of the same procedure performed for two-point source (see Fig.2).

![Fig.7](image)

**Fig.7** Results of inverse transformation of equation (18) for correlation function of toy S-Pb events in a) X-Y (Fig.3b) and b) Side-Out (Fig.1b) decomposition. Images c), d) are obtained by the same procedure for two-point source (Fig.2). Distance between two dots in X-Y decomposition Image c) is 6fm. All images have the same scale.

Distance distribution $S(\vec{D})$ in X-Y decomposition reflects clearly shape of the original source distribution shown on Fig.3a. This feature allows to study a transversal shape of the source distribution in non-central collisions. Image Fig.7c) confirms that X-Y HBT method is sensitive also to a non-trivial structure of $\rho(\vec{x})$. This feature might allow to perform a search for non-statistical inhomogeneities possibly generated by a phase transition in central heavy ion collisions [19].

\[5\text{See [15, 16] for the explanation of symmetrized } S(\vec{D}) \text{ distribution.}\]
Conclusions

We have shown that X-Y decomposition HBT analysis is suitable for the investigation of geometrical properties of the source distribution. This opens a possibility to study shape of the volume radiating bosons in non-central heavy ion collisions and possibly also non-trivial structure (inhomogeneities) in central heavy ion collisions.

Acknowledgements

Author is indebted to professor Hans-Georg Ritter and to members of NA49 Collaboration for valuable support.

Special thanks are directed to P. Závada for the possibility to use output of cascading generator [3] and to Anna Nogová for help during the work on rescattering program [8]. This work was supported in part by Lawrence Berkeley National Laboratory, by QM’96 Heidelberg fund and by VEGA Grant 1001 at Slovak Academy of Sciences.
References

[1] U.A. Wiedemann, P. Scotto, U. Heinz, *Phys. Rev. C* 53 918 (1996)

[2] M.G. Bowler, *Phys. Lett. B* 270 69-74 (1991)

[3] K. Kadija for NA49 Coll. at *Quark Matter ’96* conference.

[4] D. Miskowiec for E877 Coll. *Nucl. Phys. A* 590 473 (1995)

[5] W.A. Zajc, A Pedestrians Guide to Interferometry: *Particle Production*; Plenum Press, New York (1993)

[6] P. Závada, *Phys. Rev. C* 42 1104 (1990)

[7] T.J. Humanic, *Phys. Rev. C* 50 2525 (1994)

[8] P. Filip, *Acta Physics Slovaca* Vol. 50 9 (1996)

[9] NA 44 Collaboration *Phys. Rev. Lett.* 74 17; 3340 (1995)

[10] U.A. Wiedemann, P. Filip; in preparation.

[11] H.A. Gustafsson et.al. *Phys. Rev. Lett.* 52 1590 (1984)

[12] J.-Y. Ollitrault, *Phys. Rev. D* 48 1132 (1993)

[13] S. Voloshin, Y. Zhang *Zeitschrift für Physik* C 70 665 (1996)

[14] D.H. Boal et.al. *Reviews of Modern Physics* 62 579 (1990)

[15] P. Filip, *Acta Physica Polonica* B 26 925 (1995)

[16] P. Filip, *Prog. Part. Nucl. Phys.* 36 405 (1996)

[17] M. Asakawa et.al. *Phys. Rev. Lett.* 74 3126 (1995)

[18] S. Fadley et.al. *Nature* 380 (1996); *Phys. Rev. Lett.* 76 3132 (1996)

[19] L.P. Csernai and J.I. Kapusta, *Phys. Rev. Lett.* 69 737 (1992)

[20] J. Barton, *Phys. Rev. Lett.* 61, 1356 (1988)