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T. CSÖRGŐ
J. ZIMÁNYI
J. BONDORF
H. HEISELBERG
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Hungarian Academy of Sciences
CENTRAL
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INSTITUTE FOR
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T. CSÖRGŐ, J. ZIMÁNYI, J. BONDORF*, H. HEISELBERG*
S. PRATT**

Central Research Institute for Physics
H-1525 Budapest 114, P.O.B. 49, Hungary

*Niels Bohr Institute and NORDITA
Blegdamsvej 17, DK-2100 Copenhagen 0, Denmark

**University of Wisconsin-Madison
1150 University Avenue, Department of Physics
Madison, WI 53706, USA

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ABSTRACT

We calculate, without free parameters, the correlation function for π^- and π^0 in ultrarelativistic heavy ion collisions based on a spacetime version of the LUND model FRITIOF, called SPACER. Effects arising from correlations between spacetime and momentumspace are discussed. Results are compared with NA35 and WA80 data.

Т. Чёргё, Й. Зимани, Я. Бондорф, Х. Хейзельберг, С. Пратт: Корреляция пионов из SPACER. KFKI-1989-56/A

АННОТАЦИЯ

Без свободных параметров рассчитана корреляционная функция частиц π^- и π^0 в ультрарелятивистском столкновении тяжелых ионов по одной из пространство-временных версий LUND модели FRITIOF, названной SPACER. Полученные результаты сравниваются с результатами экспериментов NA35 и WA80.

Csörgő T., Zimányi J., Bondorf J., Heiselberg H., Pratt S.: Pionpárok korrelációja a SPACER modellből. KFKI 1989 56/A

KIVONAT

Szabad paraméterek nélkül számítjuk ki a π^- és π^0 *részecskék korrelációs függvényét* az ultrarelativisztikus nehézion ütközésekben, a LUND i FRITIOF modell egy téridőbeli, SPACER nek nevezett változatából. Eredményeinket összevetjük az NA35 és a WA80 kísérletek adataival.

1. Introduction

For the study of spacetime evolution of a relativistic heavy ion collision (RHIC) the FRITIOF model [1] was extended [2] by connecting the momentum space with spacetime with the help of the LUND string picture [3]. In ref. [2] a model (henceforth referred to as SPACER = Simulation of Phase space distribution of Atomic nuclear Collisions in Energetic Reactions) was described and applied to the description of space and time evolution of the heavy ion reactions at 14.5 and 200 AGeV bombarding energy. In the present paper SPACER is applied to the calculation of the two pion correlation functions. SPACER yields the (x_i, p_i) spacetime and momentumspace production points of all the particles in a RHIC event, where $x_i = (t_i, \vec{x}_i), p_i = (E_i, \vec{p}_i)$. Using these production points we calculate the correlation function in the plane wave approximation. Then we compare our calculation with the results of NA35 [4] and WA80 [5] experiments.

The one pion distribution measured by a detector with resolution $\Delta^3\vec{p}$ around a given momentum $\vec{p}$ is given by

$$N(\vec{p}_1) = \int_{\Delta^3\vec{p}_1} d^3\vec{p} \sum_{i=1}^{N} \sum_{j=1}^{N_i} \delta^{(3)}(\vec{p} - \vec{p}_j(x_i)) = \sum_{\vec{p}_j(x_i)\epsilon\Delta^3\vec{p}_1} 1, \tag{1}$$

where x_i denotes the different emission points of pions and $p_j(x_i)$ the different fourmomenta of pions emitted at x_i; N_i is the number of pions emitted at x_i; the integration extends over the $\Delta^3\vec{p}$ volume. The two pion detection yield is given as :

$$N(\vec{p}_1, \vec{p}_2) = \sum_{\substack{\vec{p}_l(x_i)\epsilon\Delta^3\vec{p}_1 \\ \vec{p}_k(x_j)\epsilon\Delta^3\vec{p}_2}} \left\{ 1 + (1 - \delta_{ij}) \cos[(p_l(x_i) - p_k(x_j)) \cdot (x_i - x_j)] \right\}. \tag{2}$$

In eq. (2) final state interactions are not taken into account. We note, that eqs. (1),(2) are very similar to the formulas of e.g. ref [6] and the present form was obtained in ref. [7].

SPACER containes correlations between space and momentum space caused by the underlying string picture. We visualize its consequences in Fig. 1. where the spacetime production regions for particles emitted in different rapidity intervals are shown. We remark that the pion production region in the (z, t) plane decreases significantly, roughly by a factor of 3, when resonance decays are turned off.

In SPACER pions are created either from the fragmentation of the strings, formed from the participant nucleons of the colliding nuclei according to [2] or from the resonances produced also by the strings. In the latter case the creation point of the resonance $(t_r, \vec{x}_r)$ was determined in the same way as in the case of direct pions. The event of the decay of the resonance, and thereby also the creation of its decay products, was than given as

$\vec{x}_d = \vec{x}_r + \vec{v}_r(t_d - t_r)$ where $\vec{v}_r$ is the velocity of the resonance. The quantity t_d was randomised corresponding to the probability distribution of exponential decay:

$$dP = \Gamma e^{-\Gamma s} ds \tag{3}$$

where Γ is the full decay width of the resonance and $s = (t_d - t_r)/\sqrt{1 - \vec{v}_r^2}$ is the proper time of particle, measured from its birth. The four momenta of the decay products were determined according to the Lorentz-invariant matrix elements and appropriate kinematical factors already implemented in the JETSET6.2 LUND code [8]. Our approach contains no new free parameters over those already built in into the FRITIOF model. The calculation of the two pion yields is done in a Lorentz-covariant way, the statistical analysis of the pion yields is performed however in the participant center of mass system in a noncovariant way. Since pion wave phases do not appear in the LUND strings, we use a chaoticity parameter of $\lambda = 1$. We also note that in SPACER2.0 pions do not exert any collisions after their creations.

2. Dynamical correlations

Now we shall briefly review the role of quantities which determine the Bose–Einstein correlation function. To do this, we go to the continuum limit of eq. (1),(2) and consider the case of infinite detection resolution:

$$N(\vec{p}_1) = \int d^4x \ \rho(x, \vec{p}), \tag{4}$$

$$N(\vec{p}_1, \vec{p}_2) = \int d^4x d^4x' \rho(x, \vec{p}_1)\rho(x', \vec{p}_2)\Big(1 + \cos[(p_1 - p_2)(x - x')]\Big). \tag{5}$$

The quantitiy $\rho(x, \vec{p})$ denotes the phase space distribution of the pion production points. If there are no dynamical correlations, the space and the momentum space variables factorize:

$$\rho_{ND}(x, \vec{p}) = \rho(x) f(\vec{p}), \tag{6}$$

where $f(\vec{p})$ denotes the momentum space distribution function and $\rho(x)$ denotes the spacetime density of pion production points. In this case the correlation function $C_{ND}(p_1 - p_2)$ depends only on the relative four momentum of the two pions:

$$C_{ND}(p_1 - p_2) = \frac{\int d^4x d^4x' \rho(x)\rho(x')\big(1 + \cos[(p_1 - p_2)\cdot(x - x')]\big)}{\int d^4x d^4x' \rho(x)\rho(x')}. \tag{7}$$

In eqs.(6) and (7) the ND index refers to the case of no dynamical correlations between spacetime and momentum space. Note that C_{ND} will reach its highest value 2 when $\vec{p}_1 = \vec{p}_2$, or $Q_T = Q_L = 0$ and $\Delta E = E_1 - E_2 = 0$. We call attention to the fact that in case of spacetime – momentum space correlations the two pion correlation function will depend not only on the relative four momenta of the pions but also on the sum of their momenta, in other words on the momentum vectors of both pions. This kind of dependence is present in a number of descriptions, e.g. see [10] or [11]. Thus the experimental correlation function should be in general analysed as a function of six variables. Even in the case of no dynamical correlations and central collisions, the correlation function depends on 3 variables which can be chosen as $Q_T, Q_L, \Delta E$. As a matter of fact, the data of NA35 and WA80 clearly indicate that the correlation function strongly depends on the momentum cuts applied in the measurements (NA35 applied different rapidity cuts, whereas WA80 used different p_T windows). This observation shows that correlations between spacetime and momentum space are dearly present in 200 AGeV relativistic heavy ion collisions. Thus one can conclude that data should be analysed as a function of $\vec{p}_1, \vec{p}_2$. Of course the more variables the correlation function depends on, the worse is the statistics for a given set of data. This means that the statistics of the experiments should be drastically increased. We note that similar conclusion was drawn also in ref. [11] where outward and sideward projected correlation functions were compared for a hadronic resonance gas model and a quark–gluon plasma model. In ref. [11] the pion freeze-out phase–space distribution was parametrized. Their parameters were estimated using the ATTILA version [12] of FRITIOF and also were varied to fit data.

3. Comparison with NA35 data

In order to compare our calculations with the NA35 data we averaged over 1000 central events of $O^{16} + Au^{197}$ 200 AGeV collisions in a way, which to our knowledge is equivalent to the method of the NA35 group [4]. In ref. [4], the two pion correlation function was determined as a function of the longitudinal and transverse momentum differences, $Q_L = | p_{1z} - p_{2z} |$, $Q_T = \sqrt{(p_{1x} - p_{2x})^2 + (p_{1y} - p_{2y})^2}$ (and also with Kolehmainen – Gyulassy parametrization). We determined the correlation function as a function of Q_T, Q_L . We accepted pion pairs with $Q_L < 500$ MeV/c and applied a 10 MeV/c bin width, when determining the correlation function parameters. On the Figures 2.a and 3.a we show the $Q_L < 100$ MeV/c projections. The correlation function, $C(\vec{p}_1, \vec{p}_2)$ is proportional to the ratio of the number of correlated pion pairs to the number of the uncorrelated pion pairs,

$$C(\vec{p}_1, \vec{p}_2) = \frac{< N(\vec{p}_1, \vec{p}_2) >}{< N(\vec{p}_1) >< N(\vec{p}_2) >} = N_{ev} \frac{\sum_{k=1}^{N_{ev}} N_k(\vec{p}_1, \vec{p}_2)}{\sum_{k \neq l = 1}^{N_{ev}} N_k(\vec{p}_1) N_l(\vec{p}_2)}. \quad (8)$$

The index k refers to a given RHIC event. The quantitiy N_k denotes the number of pions within the specified momentum bin. The number of correlated pairs is $NC(\vec{p}_1, \vec{p}_2) = \sum_{k=1}^{N_{ev}} N_k(\vec{p}_1, \vec{p}_2)$ and that of the uncorrelated ones is $NU(\vec{p}_1, \vec{p}_2) = \sum_{k \neq l = 1}^{N_{ev}} N_k(\vec{p}_1) N_l(\vec{p}_2)$. Thus $C(\vec{p}_1, \vec{p}_2) = N_{ev} NC(\vec{p}1, \vec{p}_2)/NU(\vec{p}_1, \vec{p}_2)$. We mention, that instead of mixing all the events, we have mixed the first 105 events when we calculated the uncorrelated pairs: $NU^{(\bullet)}(\vec{p}_1,\vec{p}_2) = \sum_{k\neq l=1}^{105} N_k(\vec{p}_1)N_l(\vec{p}_2)$ and $C^{(105)}(\vec{p}_1,\vec{p}_2) \propto NC(\vec{p}_1,\vec{p}_2)/NU^{(\bullet)}(\vec{p}_1,\vec{p}_2)$. In order to be as close to the experimental evaluation method as possible we determined the parameters of the correlation function with the code of the NA35 group.

Now we can compare the parameters of the SPACER pion source distribution with the parameters of the SPACER correlation function and the parameters of the measured correlation function. On Fig. 2.a we show the results of the SPACER2.0 code which were obtained for the simulation of the NA35 experiment in $1 < y < 4$ rapidity window. First of all we have to observe that a Gaussian fit

$$C(Q_T) = 1 + \lambda_{eff} e^{-R_{T,eff}^2 Q_T^2/2} \tag{9}$$

to the SPACER2.0 correlation function yields an effective chaoticity parameter $\lambda_{eff} = 0.46 \pm 0.03$ seemingly in contradiction with our choice within the Monte-Carlo simulation where we have used $\lambda = 1$. On Fig.2.b we also show the distribution of the pion production points as a function of the r_T transverse distance, which can also be fitted with a Gaussian shape:

$$\frac{1}{2\pi r_T}\frac{dN}{dr_T} = N_r e^{-\frac{r_T^2}{2R_T^2}} \tag{10}$$

where R_T measures the transverse size of the pion source. Another feature of the calculation is that this transverse source size and the effective source size $R_{T,eff}$ obtained by fitting the calculated correlation function, are different : $R_{T,eff} > R_T$ by 50 %. This indicates that this analysis with restricted set of variables enlarges the transverse radius of the pion source, and the fitted chaoticity parameter is connected with the original one also in a nontrivial way. Thirdly, the NA35 data and the SPACER calculations disagree both in λ_{eff} and $R_{T,eff}$. SPACER yields an $\approx$ 50% higher effective chaoticity parameter and an $\approx$ 50% smaller spatial extension than the data. This latter can be understood as a consequence of the fact that SPACER, as FRITIOF, is a superposition model where the particles are assumed to move freely after their creation from jets or resonances. Cascading among these particles naturally leads to a larger transverse source size. We note that in ref. [13], where the pions are evaporated from quark-gluon plasma blobs and allowed to cascade however resonance decays are not treated, the calculated source size is also smaller than the measured one.

The parameters λ and R_T are distorted by experimental cutoffs. This distortion may be the consequence of the following three reasons: i., Spacetime - momentum space correlations exist within SPACER. ii., We have averaged over the whole ΔE range. iii., As in the NA35 analysis procedure, the first 3 bins were excluded from the fit, which has no significant effect if the fitted function is really a Gaussian. On the other hand they might gain importance when the fitted function differs from the Gaussian shape, possibly giving an increase to the value of λ.

Fig 3.a,b show SPACER results in the $2 < y < 3$ midrapidity range. We can observe similar effects as in Fig 2.a,b, in the case of the larger rapidity interval $1 < y < 4$. However SPACER2.0 gives about the same transverse radius R_T in both rapidity window whereas NA35 data indicate that in the $2 < y < 3$ window the experimental R_T is twice the R_T value for the $1 < y < 4$ window. The same effects can be observed for the longitudinal radius, R_L, too. We note that we could not fit the distribution of pion production points along the z axis with a simple Gaussian, when analyzing the source directly. However, the correlation function, calculated from the same distribution of pion source pionts, did not exclude a Gaussian fit in $R_{L,eff}$, and so we could determine *this* parameter.

4. Comparison with WA80 data

Fig. 4.a. shows the correlation function for π^0-s as a function of invariant momentum difference $Q_I = \sqrt{-(p_1 - p_2)^2}$ as determined from averaging over 1000 central $O^{16} + Au^{197}$ reactions without cutoffs. This function can be fitted with an exponential function as follows:

$$C(Q_I) = 1 + \lambda_{eff}^{exp} e^{-\tau_{I,eff}^{exp} Q_I}. \tag{11}$$

with parameters $\tau_{I,eff}^{exp} = 3.86 \pm 0.18$ fm/c and $\lambda_{eff}^{exp} = 0.90 \pm 0.06$. We show on Fig. 4.a. that a Gaussian parametrization

$$C(Q_I) = 1 + \lambda_{eff} e^{-\tau_{I,eff}^2 Q_I^2/2}. \tag{12}$$

is also possible with $\lambda_{eff} = 0.3$ and $\tau_{I,eff} = 1.97$ fm/c. The correlation function in dependence of Q_I was investigated by WA80, they found that the correlation length is a factor of 2 smaller in different p_T windows: $\tau_{I,experimental} \approx 1.0$ fm/c, in the $p_T > 800$ MeV and $p_T > 1.$ GeV windows, ref. [5]. The measured correlation length is a subject of possible corrections for the combinatorial background effects, and its present error is ≈ 0.5 fm/c, thus our estimated 1.97 fm/c source size is actually in agreement with their data, ref.[9]. The reason of the acceptable Gaussian and good exponential fit could be that the distribution of the pion production points in the boost invariant, time like parameter, $\tau = \sqrt{(t^2 - z^2)}$ is a kind of mixture of a Gaussian and of an exponential distribution, as shown in Fig. 4.b. The Gaussian part describes the ignition period where the colliding nuclei overlap and a lot of direct pions are produced from the excited hadrons, while the long exponential tail corresponds to pions emerging from the resonance decays. Actually, this assumption on the nature of the process can be expressed as

$$\frac{dn}{d\tau} = \int_0^\infty P(x) P(\tau \mid x) dx \tag{13}$$

where the function $P(x)$ describes the production points of the resonances and $P(\tau \mid x)$ is the probability of emitting a π^0 at τ under the condition that the resonance was produced at x. This latter process can be approximated with an exponential decay with an average decay time τ_{exp} as:

$$P(\tau \mid x) = \Theta(\tau - x)\exp(-\frac{(\tau - x)}{\tau_{exp}}) \tag{14}$$

where the step function $\Theta(\tau - x)$ takes into account the condition that the resonance was produced at x. Now the resonance production is supposedly increasing linearly form zero for very early times, later it can take a Gaussian shape. So for this process

$$P(x) = xC_x\exp(-\frac{(x - <\tau>)^2}{2\tau_{Gauss}^2}). \tag{15}$$

With these assumptions the $dn/d\tau$ distribution can be evaluated as follows:

$$\frac{dn}{d\tau} = \exp(-\frac{\tau}{\tau_{exp}})\left[g(\frac{\tau}{\tau_{Gauss}}) - g(0)\right] \tag{16}$$

where

$$g(x) = A\left[\alpha\sqrt{\frac{\pi}{2}}\mathrm{erf}(\frac{x-\alpha}{\sqrt{2}}) - \exp(\frac{(x-\alpha)^2}{2})\right], \tag{17}$$

$$\alpha = \frac{<\tau>}{\tau_{Gauss}} + \frac{\tau_{Gauss}}{\tau_{exp}}, \tag{18}$$

$$A = \frac{C_x}{\tau_{exp}}\tau_{Gauss}^2\exp(\frac{<\tau>}{\tau_{exp}} + \frac{\tau_{Gauss}^2}{2\tau_{exp}^2}). \tag{19}$$

In eq. (17) error function $\mathrm{erf}(x) = 2/\sqrt{\pi}\int_0^x \exp(-t^2)dt$ appears. The functional form of the eq. (16) distribution can be easily determined for the small and high values of τ. More precisely: if $\tau >> \max(\tau_{exp}, \tau_{Gauss}, <\tau>)$ then

$$\frac{dn}{d\tau} \approx \exp(-\frac{\tau}{\tau_{exp}})\left[g(\infty) - g(0)\right], \tag{20}$$

elseif $\tau << \tau_{exp}$ then

$$\begin{aligned}\frac{dn}{d\tau} &\approx \frac{\tau}{2}\left[P(\tau)P(\tau \mid \tau) + P(0)P(0 \mid 0)\right] \\ &= \exp\left(-\frac{(\tau - <\tau>)^2}{2\tau_{Gauss}}\right).\end{aligned} \tag{21}$$

Thus we could determine the parameters of the eq. (16) distribution from an exponential fit to $dn/d\tau$ in the 2.5 fm/c $< \tau <$ 15.0 fm/c interval and from a Gaussian fit to $\tau^{-2}dn/d\tau$

in the 0.0 fm/c $< \tau <$ 1.25 fm/c interval, using the HBOOK fitting routines [14]. The distribution of eq. (16) substituted with the fitted τ_{exp} = 2.88 $\pm$ 0.01 fm/c, $< \tau >$= 0.77 $\pm$ 0.01 fm/c, τ_{Gauss} = 0.26 $\pm$ 0.01 fm/c parameter values is shown on Fig. 4.b. together with the SPACER2.0 source distribution. Both curves are divided by τ^2, as used for the Gaussian fit.

Finally we emphasize, that al! figures and parameter values in this paper refer to the case of 200 AGeV O^{16} + Au^{197} central collisions. The parameters of the functions shown in Fig 2.a. - Fig. 4.b. are summarized in Table I, where also the relevant WA80 and NA35 data are shown for comparison.

5. Conclusions:

1., The phasespace description of ref. [2], henceforth called SPACER, has been extended to include the Bose correlations for the emitted pion pairs. Parameter-free correlation functions are calculated. With this method it is possible to analyse the spacetime distribution of the pion production points directly, based on a microscopic simulation of ultrarelativistic heavy ion collisions, as well as indirectly, based on the form of the two pion correlation function.

2., Considerations on the experimental data of NA35 and WA80 indicate that the two pion correlation function depends on more variables than Q_T and Q_L (NA35) or than the single variable Q_I (WA80 and also NA35). This behaviour can be interpreted as a consequence of spacetime and momentum space correlations. In order to make an advanced analysis the statistics of the experiments should be drastically increased.

3., When comparing with (ultrarelativistic heavy ion collision) measurements, the detailed experimental cuts have to be built in into the theoretical calculations in order to avoid misinterpretation of parameters.

4., The SPACER simulation resulted in different parameters for the source distribution (R_T, R_L, τ_I) as for the correlation function ($R_{T,eff}, R_{L,eff}, \tau_{I,eff}$).

5., From 2.,3., and 4., it follows that in general we fail if we interprete the parameters of a one or two variable correlation function ($R_{T,eff}, R_{L,eff}, \tau_{I,eff}$) directly as parameters determining the spacetime region of pion production points (R_T, R_L, τ_I).

6., The input to the correlation function calculation is chaoticity parameter $\lambda = 1$. Due to the averaging procedure the output is $\lambda_{eff} \approx 0.5$. This implies that the measured $\lambda_{eff} < 1$. values cannot immediately be interpreted by a coherent source contribution.

7., SPACER2.0 without free parameters, assuming free streaming of particles, using plane wave approximation for the Bose correlation, overestimates the chaoticity parameter λ by 50 % and underestimate the transverse source size R_T by 50 % when comparing

with the results of NA35 collaboration. This latter might indicate the importance of secondary collisions or collective phenomena present in ultrarelativistic heavy ion collisions. Our calculation without p_T cuts and π^0 decay agrees with the preliminary $\tau_I \approx 1 \pm 0.5$ fm/c typical duration in invariant time, measured by the WA80 collaboration, within two standard deviations of data. However SPACER gave an exponential correlation function as a function of Q_I instead of a Gaussian shape.

8., We have shown that the SPACER2.0 invariant time distribution for the production points of the pions can be described as a superposition of exponential decays, whose starting points are distributed according to a Gaussian in $\tau^{-1} dn/d\tau$.

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Figure captions:

Fig. 1. Spacetime production regions of pions viewed in the center of mass system of participants, shown for different laboratory rapidity windows: a, $1 < y_L < 4$; b, $1 < y_L < 2$; c, $2 < y_L < 3$; d, $3 < y_L < 4$. The minimum contour line of $d^2N/(dzdt)/N_{events}$ is set to 0.2, the step size is 0.8. Note, that the resonance decays cause an enlarged pion production region compared to the "straight line geometry" picture.

Fig. 2. NA35 like analysis in $1 < y_L < 4$ rapidity window. Note, that both the transverse source size and the chaoticity parameter is distorted if we measure it by the correlation function.

a., Correlation function from SPACER2.0 (*) fitted with a Gaussian (dashed line).

b., Transverse distance distribution of the production points of pions calculated from SPACER2.0 (+) and fitted with a Gaussian (dashed line).

Fig. 3. NA35 like analysis in $2 < y_L < 3$. A new feature compared to Fig.2.a,b is the fact, that the transverse source size does not change significantly in SPACER results, in contrast to NA35 data.

a., Correlation function from SPACER2.0 fitted with a Gaussian (dashed line).

b., Transverse distance distribution of the production points of pions calculated from SPACER2.0 (+) and fitted with a Gaussian (dashed line).

Fig. 4. WA80 like analysis in the invariant momentum difference Q_I, without p_T cut.

a., Correlation function from SPACER2.0 (×). An exponential fit to the correlation function,(++), eq. (11), is shown together with a Gaussian curve, (dashed line, eq. (12)), which is also close to the SPACER2.0 result.

b., Distribution of production points, $\tau^{-2}dn/d\tau$, as a function of boost invariant "time" $\tau = \sqrt{t^2 - z^2}$, parametrized with the distribution of eq. (16). This distibution is a superposition of exponential decays whose starting points are smeared by a Gaussian in $\tau^{-1}dn/d\tau$, eqs. (13-15).

Table I. Summary of source parameters. Note that only one Gaussian function, belonging to Fig. 4.b., has a nonvanishing expectation value, $<\tau>= 0.77 \pm 0.01$ fm/c . Errors shown are purely statistical ones.

Group, Cutoff, Particle	Parameter [unit]	SPACER source distribution	SPACER correlation function	Measured correlation function
NA35	λ	1.	0.46±0.03	$0.31 \pm ^{0.07}_{0.03}$
1<y<4	$R_T[fm]$	1.76±0.01	2.68±0.13	4.1±0.4
π^-	$R_L[fm]$	no good fit	1.91±0.13	$3.1 \pm ^{0.7}_{0.4}$
NA35	λ	1.	0.43±0.04	0.77±0.19
2<y<3	$R_T[fm]$	1.88±0.02	2.93±0.18	8.1±1.6
π^-	$R_L[fm]$	no good fit	1.68±0.27	$5.6 \pm ^{1.2}_{0.8}$
WA80	λ^{exp}	1.0	0.90±0.06	–
p_T >1.0 GeV	$\tau^{exp}[fm/c]$	2.88±0.01	3.86±0.18	–
π^0	λ^{Gauss}	1.0	0.3	$0.13 \pm ^{0.12}_{0.06}$
SPACER: no cut	$\tau^{Gauss}[fm/c]$	0.26±0.01	1.97	$1.04 \pm ^{0.96}_{0.70}$

Table I.

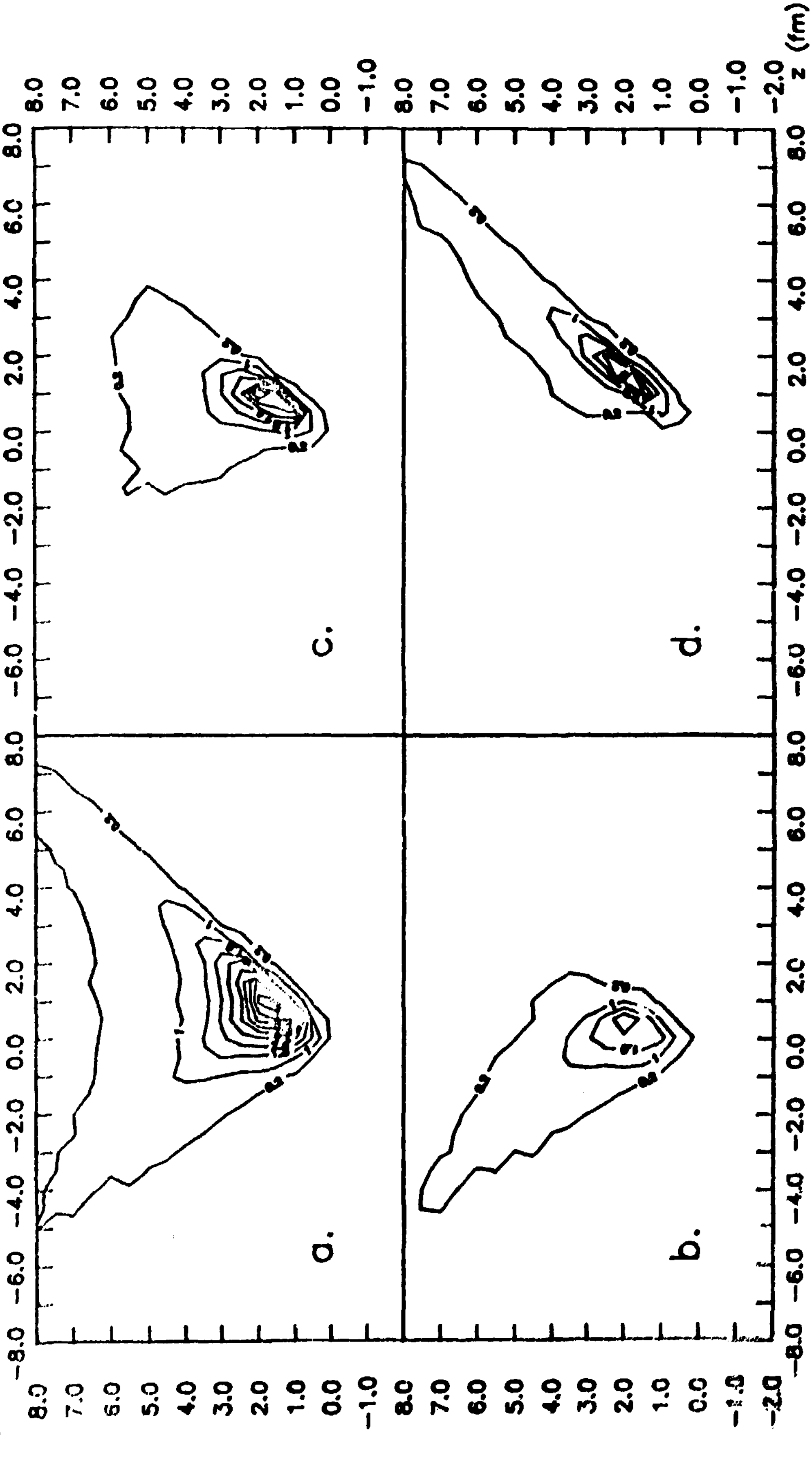
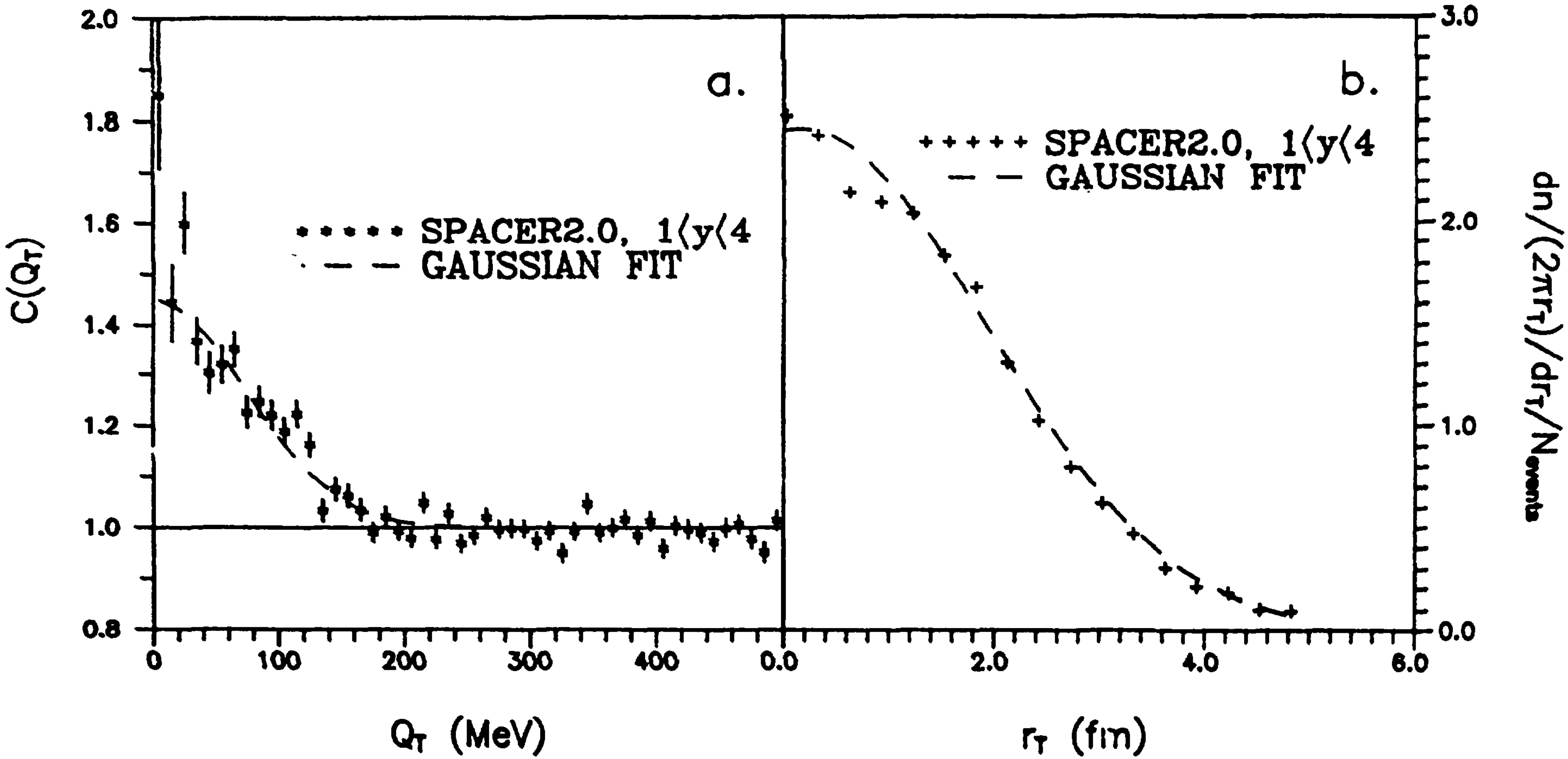


Fig. 1.

Fig. 2.



C(Q_T)
a.
SPACER2.0, 1<y<4
GAUSSIAN FIT
Q_T (MeV)
b.
SPACER2.0, 1<y<4
GAUSSIAN FIT
r_T (fm)
dn/(2πr_T)/dr_T/N_events

Fig. 3.

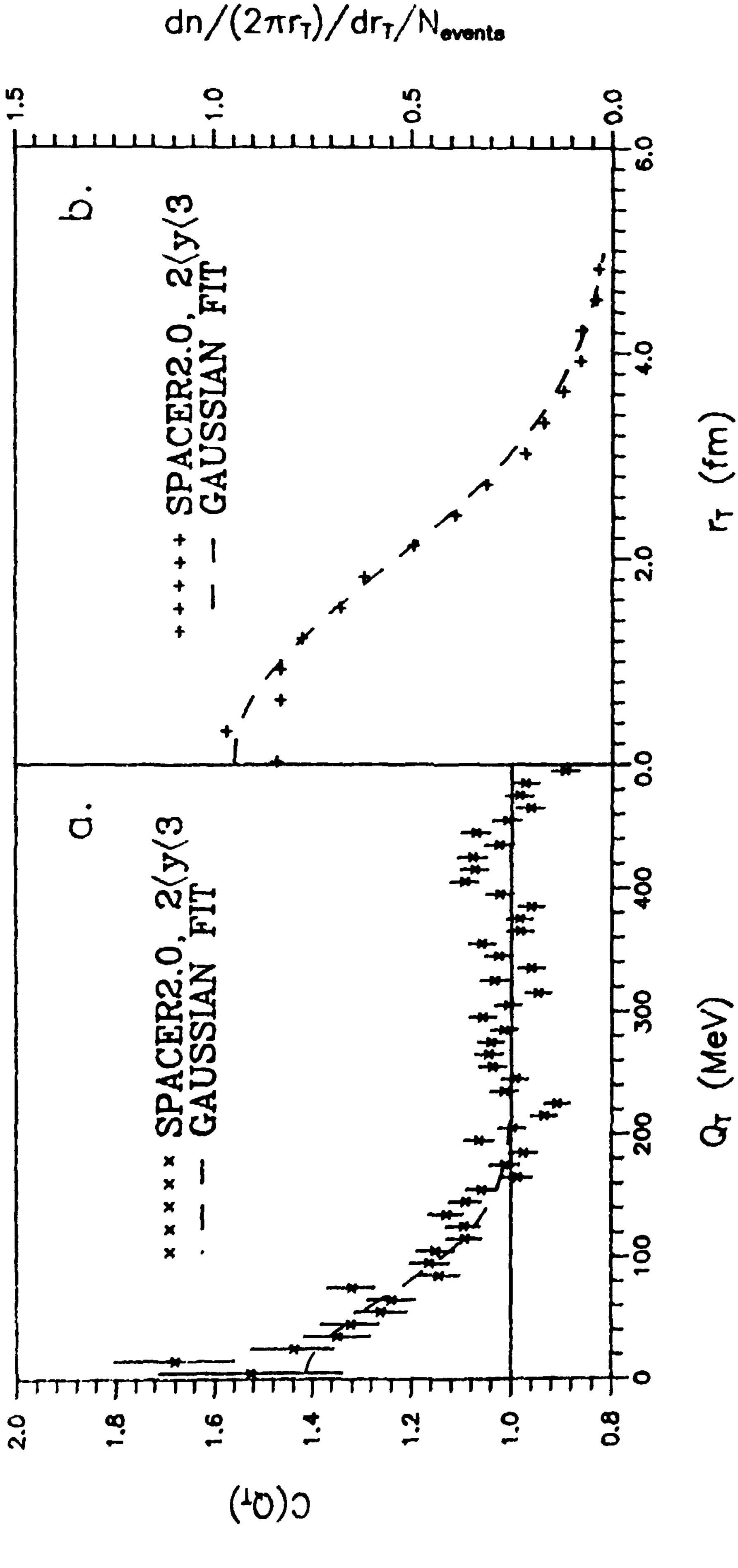
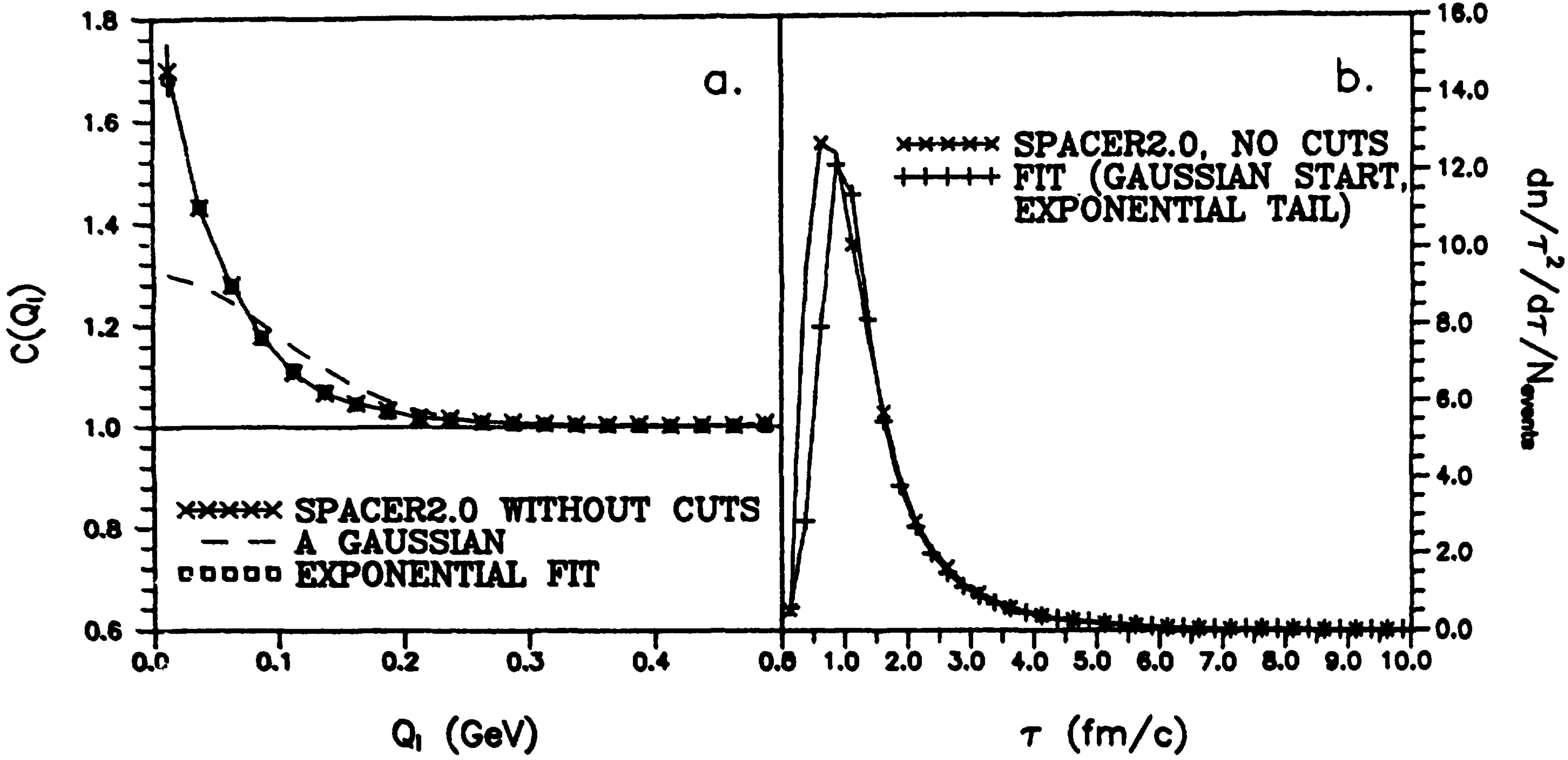

dn/(2πr_T)/dr_T/N_events
c(Q_T)
a.
× × × × × SPACER2.0, 2<y<3
— — GAUSSIAN FIT
b.
+ + + + + SPACER2.0, 2<y<3
— — GAUSSIAN FIT
Q_T (MeV)
r_T (fm)
0
100
200
300
400
0.0
2.0
4.0
6.0
0.8
1.0
1.2
1.4
1.6
1.8
2.0
0.5
1.5

Fig. 4.



a.
b.
C(Q_l)
Q_l (GeV)
SPACER2.0 WITHOUT CUTS
A GAUSSIAN
EXPONENTIAL FIT
SPACER2.0, NO CUTS
FIT (GAUSSIAN START, EXPONENTIAL TAIL)
dn/τ²/dτ/N_events
τ (fm/c)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.0
0.1
0.2
0.3
0.4
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
1.0
3.0
5.0
7.0
9.0

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Felelős kiadó: Szegő Károly
Szakmai lektor: N.L. Balazs
Nyelvi lektor: Lukács Béla
Példányszám: 348 Törzsszám: 89 396
Készült a KFKI sokszorosító üzemében
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