COMMENTS

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Comment on ''Measurement of the space-time extent of the hard-photon emitting source in heavy-ion collisions at 100 MeV/nucleon''

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In a recent paper [Phys. Rev. C **55**, 2521 (1997)] two-photon coincidences were studied for three nuclear reactions. From a correlation analysis, the authors evaluated the size and lifetime of the emitting source. In this Comment we correct some arguments used in the comparison of the extracted and estimated sizes, and show that the parametrization of the relative-momentum correlations leads to values which should not be assigned to the space-time extent of the source. [S0556-2813(98)00205-2]

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In a recent work [1] Badalà *et al.* have studied correlations between energetic photons produced from a ^{36}Ar beam on three different targets and obtained values for the space-time extent of the hard-photon source. The authors conclude that their results are in good agreement with a geometrical estimate of the size of the overlap zone between the colliding nuclei. In this Comment we point out two imprecisions, the first concerning the comparison of the extracted and estimated sizes, and the second the parametrization of the relative-momentum correlation function. As the latter represents a major correction, the values obtained for R and τ should not be assigned to a size nor to a lifetime of the source.

In Table V of [1] the authors compare the radii of three different observables but for three different variables: the *root-mean-square* radius of the experimental (Gaussian) parametrization of the source, the *Gaussian* radius of the overlap zone, and the *uniform* radius of the sum of the nuclear radii. The importance of the correct handling of different parametrizations when interpreting source radii was already studied by Zajc *et al.* [2] and more recently in Ref. [3]. The equivalence between a Gaussian (of radius R) and a uniform (of radius R_u) spatial distribution is obtained by equating the root-mean-square (rms) radii, which read

$$\rho(r)=\exp(-r^2/R^2)\rightarrow\sqrt{\langle r^2\rangle}=\sqrt{3/2}R, \tag{1}$$

$$\rho(r)=\exp(-r^2/2R^2)\rightarrow\sqrt{\langle r^2\rangle}=\sqrt{3}R, \tag{2}$$

$$\rho(r)=\begin{cases}1 & ; \quad r\leqslant R_u\\ 0 & ; \quad r>R_u\end{cases}\rightarrow\sqrt{\langle r^2\rangle}=\sqrt{3/5}R_u. \tag{3}$$

After equating these, no feasible intensity interferometry experiment can distinguish between the corresponding squared Fourier transforms of $\rho(r)$ [2,3]. Therefore the relation $R=\sqrt{2/5}R_u$ is only valid when one uses the Gaussian form of Eq. (1). In their Eqs. (4) and (18), the authors [1] have chosen the Gaussian form of Eq. (2), and then the equivalence is found when $R=R_u/\sqrt{5}$ [3].

The size of the overlap zone between nuclei is given by $\langle N_{\rm part}\rangle_{\gamma\gamma}$ [4], defined as the average over the impact parameter (corresponding to reactions producing two hard photons[1]) of the *number of nucleons* [5] participating in this overlap. The authors have replaced $\langle N_{\rm part}\rangle_{\gamma\gamma}$ by the average of the quantity $N_{\rm pn}(N_{\rm pn}-1)$ over the linear impact parameter distribution, which leads to different values. Therefore the Gaussian radius of Eq. (20) in [1] reads

$$R_{\rm ov}=1.2\langle N_{\rm part}\rangle_{\gamma\gamma}^{1/3}/\sqrt{5}. \tag{4}$$

In Table I we compare the values of the same variable, the rms radius, for the experimental parametrization of the source and the geometrical estimate of the overlap zone from Eq. (4). For the lightest system the agreement between experimental and overlap sizes disappears. The ''total radius''

TABLE I. Comparison of the different sizes (all in fm) for the three systems. The first two columns correspond to the Gaussian radius of the overlap zone estimated in Ref. [1] and the one from Eq. (4). The other two columns represent the rms radii extracted from the data and calculated from Eq. (4).

System	$R_{\rm ov}$ [a]	$R_{\rm ov}$	$\sqrt{\langle r^2\rangle_{\rm exp}}$ [a]	$\sqrt{\langle r^2\rangle_{\rm ov}}$
^{36}Ar+^{27}Al	1.95	1.77	1.4±0.7	3.07
^{36}Ar+^{112}Sn	3.00	2.06	3.0±1.2	3.57
^{36}Ar+^{179}Au	3.35	2.10	3.8±1.9	3.64

[a]From Ref. [1].

[1]The linear impact parameter distribution folded with $f(b)=N_{pn}(b)[N_{pn}(b)-1]$.

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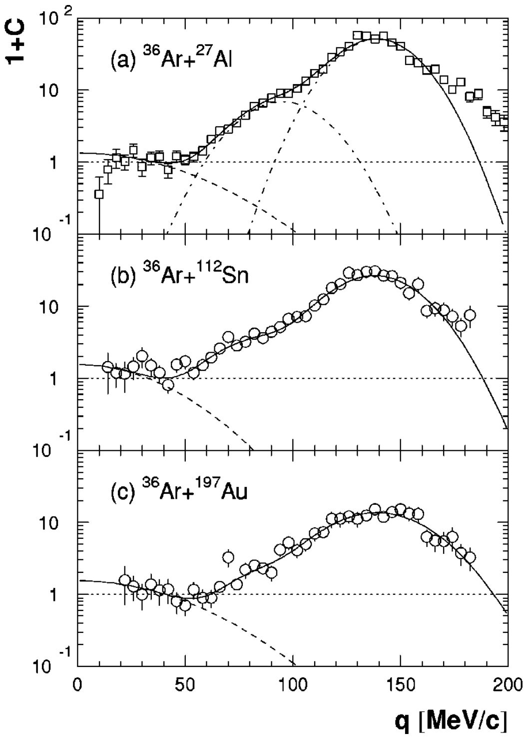

FIG. 1. Correlation distributions as a function of the relative momentum (adapted from Ref. [1]). The solid line corresponds to Eq. (6) and the dashed line to the first term of this expression.

$R_{\mathrm{tot}} = 1.2(A_p^{1/3} + A_t^{1/3})$ used in Table V of [1] represents the radius of a nuclear system with many more nucleons than the entrance channel: $A = (R_{\mathrm{tot}}/1.2)^3 = 250$, 536, and 758, respectively.

We finally analyze the parametrization of the relative-momentum correlation function. The authors state that the solid line in the correlation distributions of Figs. 19 and 20 in [1] corresponds to the expression ($\hbar = c = 1$)

$$f(q) = 1 + \lambda_{R'} e^{-q^2 R'^2} + \sum_{i=1}^{2} A_i e^{-(q-q_i)^2/2\sigma_i^2}. \qquad (5)$$

We find in this expression the three contributions introduced in Refs. [4,6], which correspond respectively to (i) the uncorrelated background, and, on top of it, (ii) the interference term towards low relative momentum, and (iii) the π^0 contribution asymmetric around m_{π^0}. By definition Eq. (5) cannot become smaller than 1, but for two of the systems it does between 40 and 60 MeV/c, and, most surprisingly, it goes to 0 for all the systems above 190 MeV/c (i.e., photons above this value are fully anticorrelated). Analyzing Ref. [1] we have found that the expression used in Figs. 19 and 20 corresponds to

$$f(q) = (1 + \lambda_{R'}) e^{-q^2 R'^2} + \sum_{i=1}^{2} A_i e^{-(q-q_i)^2/2\sigma_i^2}, \qquad (6)$$

where the number of terms has been reduced to two. Equation (6) is represented in Fig. 1 by the solid line, and its first term by the dashed line. Multiplying the uncorrelated term by the interference Gaussian results in a magnification of the interference signal (instead of decreasing from $1 + \lambda_{R'}$ to 1, it does to 0), which does not seem statistically significant, and suppresses the uncorrelated background above 100 MeV/c, which means that photon pairs cannot be produced above this value.

The authors have demonstrated [7] that the size and lifetime of the source are functions $R(R', \tau')$ and $\tau(R', \tau')$. However, since Eq. (6) does not correspond to a correlation function, the values of the parameter R' and hence of R and τ should not be assigned to the size nor the lifetime of the photon emitting source.

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[1] A. Badalá, R. Barbera, A. Palmeri, G. S. Pappalardo, F. Riggi, G. Rizza, A. C. Russo, G. Russo, and R. Turrisi, Phys. Rev. C **55**, 2521 (1996).
[2] W. A. Zajc *et al.*, Phys. Rev. C **29**, 2173 (1984).
[3] F. M. Marqués, G. Martínez, T. Matulewicz, R. W. Ostendorf, and Y. Schutz, Phys. Rep. **284**, 91 (1997).
[4] F. M. Marqués *et al.*, Phys. Rev. Lett. **73**, 34 (1994).
[5] H. Nifenecker and J. P. Bondorf, Nucl. Phys. **A442**, 478 (1985).
[6] F. M. Marqués *et al.*, Phys. Lett. B **349**, 23 (1995).
[7] A. Badalá, R. Barbera, A. Palmeri, G. S. Pappalardo, F. Riggi, A. C. Russo, G. Russo, and R. Turrisi, Nucl. Instrum. Methods **A351**, 387 (1994).