**HBT Measurements for p-p and IMFs from Projectile-Like and Nucleon-Nucleon Sources for $^{40}Ar + ^{27}Al$, $^{48}Ti$ and $^{58}Ni$ at 47 MeV/Nucleon**

Y. G. Ma, R. Wada, K. Hagel, M. Murray, J. S. Wang, L. J. Qin, A. Makeev, P. Smith, J. B. Natowitz, E. Martin, S. Liddick, D. Rowland, A. Ruangma, D. Shetty, G. Souliotis, M. Veselsky, E. Winchester, S. J. Yennello, A. Samant,[1] M. Cinausero,[1] D. Fabris,[1] E. Fioretto,[1] M. Lunardon,[1] G. Nebbia,[1] G. Prete,[1] G. Viesti,[1] J. Cibor,[2] Z. Majka,[2] P. Staszel,[2] S. Kowalski,[3] W. Zipper,[3] M. E. Brandan,[4] A. Martinez-Davalos,[4] A. Menchaca-Rocca,[4] T. Keutgen,[5] Y. El. Masri[5]

[1]*INFN-Legnaro, Padova, Italy*

[2]*Jagiellonian University, Krakov, Poland*

[3]*Silesian University, Katowice, Poland*

[4]*UNAM, Mexico*

[5]*UCL, Louvain-la-Neuve, Belgium*

Information about particle and fragment emission times can be obtained by using the two-particle intensity interferometry method developed by Hanbury Brown and Twiss (HBT) [1]. The method employs the two-particle correlation function from the distribution of particles emitted from a spatially localized hot source.

Considering that light charged particles (LCP) and fragments in heavy ion collisions may come from various sources, such as Projectile-like fragments (PLF), a mid-rapidity or so-called Nucleon-Nucleon source, and Target-like Fragments (TLF), a source selection and identification should be taken to minimize the mixing effects on time and size information [2, 3]. For LCP, we have used a Monte-Carlo Particle Assignment Method based on three source fits which we proposed in [4] to select different emission sources. For fragments, a rapidity cut was applied to choose the different sources. We assigned a fragment as being emitted from the PLF source if its rapidity is above 0.65Yp (Yp is the beam rapidity), while a fragment assigned to TLF source if its rapidity is below 0.35Yp. Fragments emitted from NN sources are those with rapidities between two limits. In addition, five impact parameter bins (called B1, B2, B3, B4 and B5 ranging from the most central to the most peripheral) were used to sort NIMROD data. These bins were determined by windows on the total multiplicity of charged particles and neutrons.

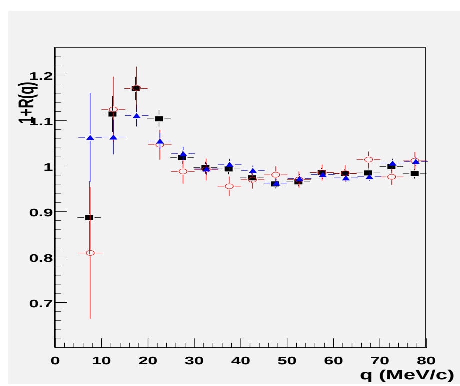


**Figure 1:** Two proton HBT correlation function from PLF source in peripheral collisions (B5) for NIMROD-data $^{40}Ar + ^{27}Al$ (up-triangles), $^{48}Ti$ (open circles) and $^{58}Ni$ (solid squares) at 47 MeV/nucleon.

Fig. 1 shows the pp correlation function from the PLF source. The enhancement at relative momentum q ~ 20 MeV/c is cleanly observed and allows the determination of source radius and time information. This peak is the well-known $^{2}$H-resonance.

The Coulomb repulsion between emitted fragments leads to a suppression of the correlation function at small relative velocities (i.e., a “Coulomb hole”). A shorter fragment emission time leads to a larger Coulomb repulsion between fragments, thus, a wider Coulomb hole. The two-fragment reduced velocity correlation function is defined as $1+R(V_{red}) = N_{corr}(V_{red})/N_{uncorr}(V_{red})$, where $N_{corr}(V_{red})$ is the observed reduced-velocity distribution ($V_{red} = |V_1-V_2|/(Z_1+Z_2)^{1/2}$) for fragment pairs selected from the same event (coincidence distribution) and $N_{uncorr}(V_{red})$ is the reduced-velocity distribution for fragment pairs from mixed events (background distribution).

Experimental impact-parameter-gated two-fragment pairs with charge number $3 \leq Z \leq 6$ from $^{40}$Ar + $^{58}$Ni reaction at 47 MeV/nucleon, are shown in Fig. 2. For the PLF part (top panel), even though the errors are large, the increasing tendency of Coulomb suppression with the decreasing impact parameter is cleanly observed. This reflects an emission time scale decrease with decreasing impact parameter. For the NN part (bottom panel), there is nearly no change with the impact parameter for Coulomb suppression at low $V_{red}$. This indicates that fragments are emitted in almost the same time from the mid-rapidity zone. Comparing the two-fragment correlation functions function of the PLF and NN component, the correlation function pf the NN component demonstrates a stronger suppression than for the PLF source, reflecting a shorter emission time for the mid-rapidity component than for the PLF source.

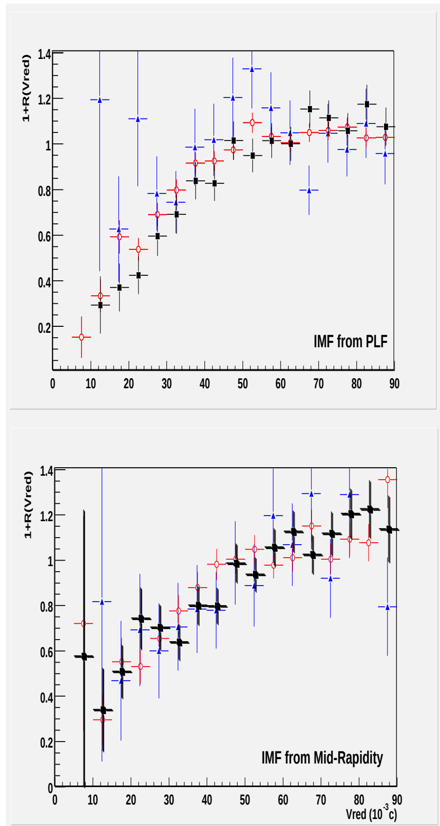


**Figure 2:** The two-fragment correlation function from PLF source (top panel) and NN source (bottom panel) for 47MeV/nucleon $^{40}$Ar+$^{58}$Ni in different impact parameter (solid squares represent the most central collision: B1, the open circles for middle impact parameter: B3, and upper-triangle for the most peripheral collision: B5).

## References


[1] R. Hanbury Brown and R. Q. Twiss, *Nature* **178**, 1046 (1956).

[2] L. Beaulieu *et al.*, Phys. Rev. Lett. **84**, 5971 (2000).

[3] Z. Y. He *et al.*, Phys. Rev. C **63**, 011601R (2000).

[4] Y. G. Ma *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2001-2002), p. II-18.