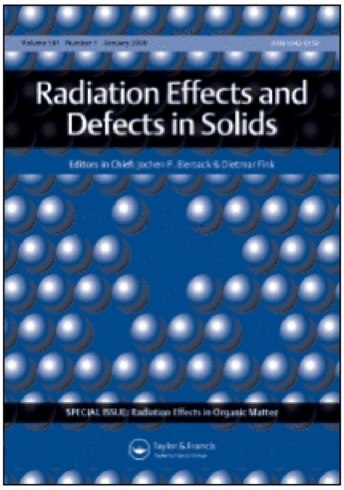

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Vertex identification of events in photonuclear reactions by cylindrical multiwire proportional chambers

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In the framework of investigation of meson photo-production on proton and neutron in a deuterium target at the GRAAL experiment, we present a method to identify the vertex of interaction when in reaction products there are at least two charged particles, by the information provided by the cylindrical multiwire proportional chambers. By this device, we are able to obtain the direction of charged particles that leave the target after a photo-production reaction. For each charged particle, the device provides the coordinates of two points in the laboratory reference system, and the z-axis represents the beam direction. We calculate the trajectory of each charged particle and its cross point, representing the vertex of the reaction.

Keywords: photonuclear reaction; reaction vertex; C-MWPC; deuterium target; $\gamma + n \to \pi^- + p$ reaction channel; Fermi momentum

PACS: 76.30Fc; 71.55.-i; 61.72.Ww

1. Introduction

The cylindrical multicurie proportional chamber (C-MWPC), used in the GRAAL experiment (*1–5*), is a detector able to measure the direction of each charged particle leaving the target after a nuclear reaction. The information given by the C-MWPC allows us to track the trajectory of the

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charged particles detected. The C-MWPC is composed of two co-axial chambers surrounding the target along the beam direction (z-axis). They cover the polar angle between 16° and 160°; the diameter of the internal and external chamber is 10 and 17 cm, respectively; their length is 40 and 50.5 cm, respectively. The centre of both chambers is moved forward with respect to the centre of the target, and this increases the efficiency of detection of charged particles, which tend to be emitted in the forward direction in the laboratory system by the Lorentz boost.

The anodes of each chamber are golden Tungsten wires, stretched alongside the z-axis and having a diameter of 20 µm. The cathodes are made of adjacent copper strips (3.5 mm wide, with an interval of 0.5 mm between the two strips), deposited on Kapton sheets, glued on a shell of polymethacrilate foam. The Kapton foils are glued on both the internal and external shells of the chambers to form helixes wrapped in opposite directions. Each strip crosses a wire only once. This technique allows us to discriminate (for each MWPC) signals generated by the transit of many charged particles. The gas in chambers is an argon (85%)–ethane (15%) mixture.

2. Vertex identification: method and results

The C-MWPC provides, for each charged particle track, two points in the laboratory system by internal and external chambers, respectively (index i and e in Equation (1)). From the two points, we can reconstruct a straight line passing in the three-dimensional space:

$$\begin{aligned} x(h_n) &= x_{ni} + (x_{ne} - x_{ni}) \cdot h_n, \\ y(h_n) &= y_{ni} + (y_{ne} - y_{ni}) \cdot h_n, \\ z(h_n) &= z_{ni} + (z_{ne} - z_{ni}) \cdot h_n, \end{aligned} \tag{1}$$

where n is the track index. To reconstruct the vertex reaction, it is necessary to have at least two tracks.

Having at least two different tracks in the detector and the two calculated straight lines, we can define the function $F(h_1, h_2)$, representing the distance between two generic points belonging to the first and the second straight line, respectively:

$$F(h_1, h_2) = \sqrt{(\alpha + Ah_1 - Dh_2)^2 + (\beta + Bh_1 - Eh_2)^2 + (\gamma + Ch_1 - Fh_2)^2}, \tag{2}$$

where $A = (x_{1e} - x_{1i})$, $B = (y_{1e} - y_{1i})$, $C = (z_{1e} - z_{1i})$, $D = (x_{2e} - x_{2i})$, $E = (y_{2e} - y_{2i})$, $F = (z_{2e} - z_{2i})$, $\alpha = (x_{1i} - x_{2i})$, $\beta = (y_{1i} - y_{2i})$ and $\gamma = (z_{1i} - z_{2i})$.

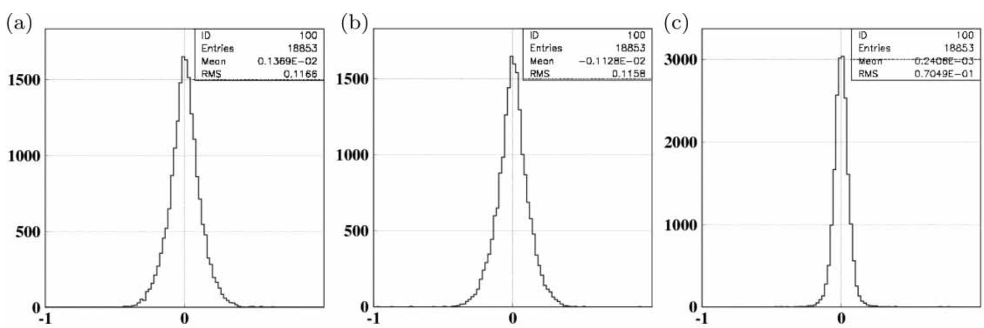

Figure 1. (a–c) Difference between the x, y and z coordinates of the "true-vertex" and "reconstructed-vertex", respectively (simulation).

The absolute minimum of the function $F(h_1, h_2)$ is for:

$$h_{1\min} = \frac{\Omega\rho - \psi\xi}{\chi\psi - \Omega^2},$$
$$h_{2\min} = \frac{\chi\rho - \Omega\xi}{\chi\psi - \Omega^2}, \qquad (3)$$

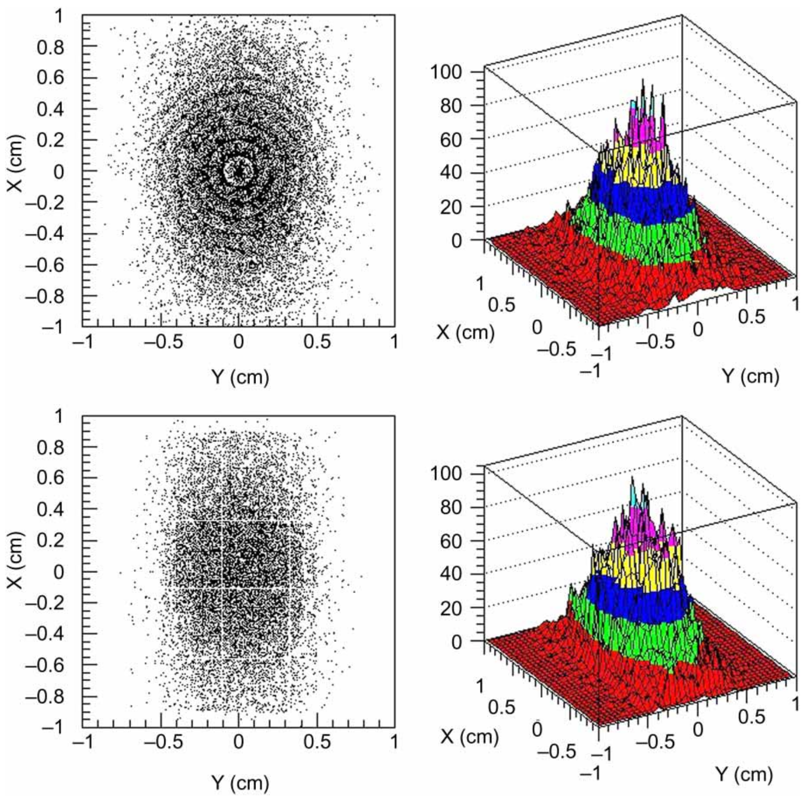

Figure 2. Upper panels: distribution of x versus y coordinates of the "reconstructed-vertex"(simulation). Lower panels: distribution of the "true-vertex" (simulation).

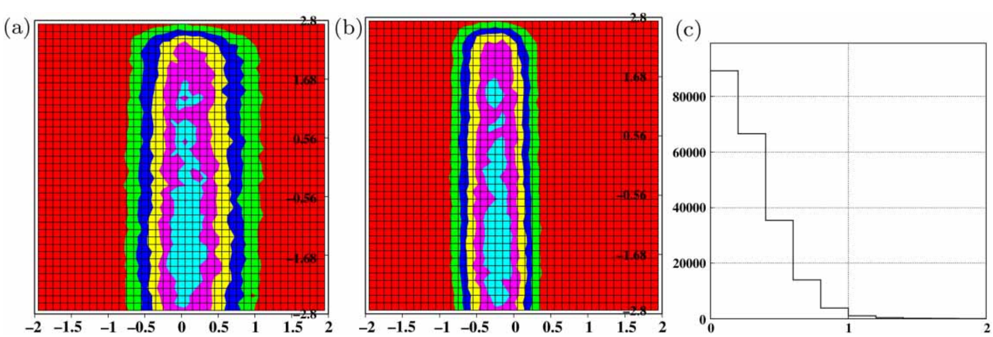

Figure 3. (a–b) Distribution of the x versus z and y versus z coordinates of the vertex (data). (c) The minimum distance $F(h_{\min 1}, h_{\min 2})$ between the two reconstructed straight lines in a period of the experimental data on deuteron target (data).

where $\chi = A^2 + B^2 + C^2$, $\psi = D^2 + E^2 + F^2$, $\Omega = AD + BE + CF$, $\xi = A\alpha + B\beta + C\gamma$ and $\rho = D\alpha + E\beta + F\gamma$.

Finally, using $h_{1\mathrm{min}}$ and $h_{2\mathrm{min}}$ in Equation (1), we determine the closest points of the two straight lines. We assume the average of their coordinates as a reliable estimation of the reaction vertex:

$$x_{\mathrm{min}} = \frac{(x_{1\mathrm{min}} + x_{2\mathrm{min}})}{2},$$
$$y_{\mathrm{min}} = \frac{(y_{1\mathrm{min}} + y_{2\mathrm{min}})}{2},$$
$$z_{\mathrm{min}} = \frac{(z_{1\mathrm{min}} + z_{2\mathrm{min}})}{2}.$$

To verify our vertex identification method, we chose the reaction channel $\gamma + n \rightarrow \pi^- + p$ obtained by the photonuclear reaction on deuteron target. In the experimental and simulation data of the GRAAL experiment, we discriminate protons and pions using a bidimensional cut on the total energy in the BGO detector versus the energy lost in the barrel detector (see Figure 2 of (*6*)). The noise generated by the competing channels was strongly reduced by the cut on the Fermi momentum ($\mathrm{P}_f < 0.2\,\mathrm{GeV/c}$) (for more details, see (*2*)). The simulation data were generated by the LAGGEN code based on the simulation tool GEANT 3.21 (*7, 8*). Such a simulation code works in two steps: in the first step, it generates the events (it generates all information characterising the reaction, among which its vertex position); in the second, it simulates the response of the different detectors of the GRAAL experiment. Hereinafter, we will call the “true-vertex” the values of the reaction vertex coming from the first step of the simulation code, and “reconstructed-vertex” the values of the reaction vertex obtained by our method applied to the simulation data coming from the second step of the LAGGEN code or to the experimental data.

Figure 1, we present the differences between the coordinates (x, y and z) of the “true-vertex” and “reconstructed-vertex” of simulation data in order to show the reliability of our analysis method. The figure shows an uncertainty in the determination of the vertex of about 1 mm.

In Figure 2, we stress again the quality of our results showing the very similar x versus y distribution of the “reconstructed-vertex” (upper panels) and “true-vertex” (lower panels).

Figure 3 shows the distribution of the reconstructed reaction vertex inside the target after the cut $F(h_{\mathrm{min}1}, h_{\mathrm{min}2}) < 0.4\,\mathrm{cm}$ (Figure 3(c)), whose application provides a better estimation of the vertex. This information is useful during experiment runs in order to check the correct position of the beam in the target, and it can be used in the data analysis to estimate the position of the centre of the target cell. This estimation can also be used to improve the tracking method of neutral particles giving a signal only in the BGO device of the GRAAL experiment.

References

(1) Schaerf, C.; Levi Sandri, P.; Bocquet, J.P; Hourany, E. *Nupecc News* **1998,** *8*, 24.

(2) Fantini, A.; Di Salvo, R.; Bartalini, O.; Bellini,V.; Bocquet, J.P.; Casano, L.; Castoldi, M.; D’Angelo, A.; Franco, D.; Gervino, G.; Ghio, F.; Giardina, G.; Girolami, B.; Giusa, A.; Kuznetsov, V.; Lapik, A.; Sandri, P. Levi; Lleres, A.; Mammoliti, F.; Mandaglio, G.; Manganaro, M.; Moricciani, D.; Mushkarenkov, A.N.; Nedorezov, V.; Nicoletti, L.; Randieri, C.; Rebreyend, D.; Renard, F.; Rudnev, N.; Russo, G.; Schaerf, C.; Sperduto, M.-L.; Sutera, M.-C.; Turinge, A.; Vegna, V.; Fix, A.; Tiator, L.; Kamalov, S. *Phys. Rev. C* **2008,** *78*, 015203–015215.

(3) Nicoletti, L. Mesure des observables de polarisation dans la photoproduction de mésons à Graal. Ph.D. Thesis, Université Joseph Fourier – Grenoble 1, France, 2002.

(4) Franco, D. Measurement of Beam Asymmetry in Deuteron Photodisintegration at Graal. Ph.D. Thesis, Universitá di Roma “Tor Vergata”, Italy, 2007.

(5) Bartalini, O.; Bellini, V.; Bocquet, J.P.; Capogni, M.; Casano, L.; Castoldi, M.; Calvat, P.; D’Angelo, A.; Di Salvo, R.; Fantini, A.; Gaulard, C.; Gervino, G.; Ghio, F.; Girolami, B.; Giusa, A.; Kouznetsov, V.; Lapik, A.; Sandri, P.L.; Lleres, A,; Moricciani, D.; Mushkarenkov, A.N.; Nedorezov, V.; Nicoletti, L.; Perrin, C.; Rebreyend, D.; Renard, F.; Rudnev, N.; Russew, T.; Russo, G.; Schaerf, C.; Sperduto, M.L.; Sutera, M.C.; Turinge, A. *Eur. Phys. J. A* **2005,** *26*, 399–419.

(6) Bartalini, O.; Bellini, V.; Bocquet, J.P.; Capogni, M.; Casano, L.; Castoldi, M.; Calvat, P.; D'Angelo, A.; Di Salvo, R.; Fantini, A.; Gaulard, C.; Gervino, G.; Ghio, F.; Girolami, B.; Giusa, A.; Kouznetsov, V.; Lapik, A.; Sandri, P.L.; Lleres, A.; Moricciani, D.; Mushkarenkov, A.N.; Nedorezov, V.; Nicoletti, L.; Perrin, C.; Rebreyend, D.; Renard, F.; Rudnev, N.; Russew, T.; Russo, G.; Schaerf, C.; Sperduto, M.L.; Sutera, M.C.; Turinge, A. *Nucl. Instrum. Methods A* **2006,** *562*, 85–91.

(7) Corvisiero, P.; Mazzaschi, L.; Ripani, M.; Anghinolfi, M.; Mokeev, V.I.; Ricco, G.; Taiuti, M.; Zucchiatti, A. *Nucl. Instrum. Methods A* **1994,** *346*, 433–440.

(8) GEANT, *Detector Description and Simulation Tool*, CERN Program Library Long Writeup.