A pellet tracking (PTR) system for the PANDA and WASA experiments is under development [1]. Tests and measurements done at the Uppsala pellet test station (UPTS) at TSL is an important component in this work. A system based on two line-scan (LS) cameras and diode lasers has been used during the last years. Here we present the results from measurements done in 2011 on pellet time correlations between different detection levels (Fig. 1). The results are compared with a detailed simulation.

In the simulation, the desired number of pellets are generated with a certain time distribution given by the frequency and smeared according to a chosen distribution. All initial parameters of each pellet (velocity, direction, position) are simulated according to pre-defined distributions. The inter-pellet interactions are also simulated as well as loss of pellets during the flight.

True pellet time, position and velocity are calculated for chosen positions of measurement points. This information is used for simulation of the measurement procedure. Knowing the structure of the camera cycle - its period (typically 11 - 20 µs) and exposure time (typically 8 - 16 µs), the measured pellet time is calculated and it is checked if the pellet was detected by the camera. The pellet could be detected if it was long enough in front of the camera during the exposure. The sizes of the pellets and the pixels are taken into account in this step. Pellets may be also randomly omitted at each measurement point with desired probability, which simulates additional detection inefficiencies.

Figure 2. Time difference (line = 20 µs (camera period)) between pellets recorded at VIC exit and PTR gen (distance 270 mm) with magnification of the correlation peak region. Experiment - blue line, MC - solid red area.

Figure 3. Time difference (line = 12.5 µs (camera period)) between pellets recorded directly above skimmer and at PTR lower (distance 420 mm) with magnification of the correlation peak region. Experiment - blue line, MC - solid red area.
Measurements were done in different configurations with different distances between measurement levels, with different detection efficiencies and at different pellet rates. The spectra seen in Fig. 2 - 4 show the distributions of time differences between pellets recorded by the upper and lower camera. The peak seen in the spectra (correlation peak) indicates, that we compare the times of the same pellet in the two cameras. The background is a result of comparing the times of different pellets. The position of the correlation peak indicates pellet time of flight between measurement levels, i.e. given by the velocity \( v \approx 70 \text{ m/s} \), and the peak width is a result of the velocity spread \( \Delta v / v \approx 0.5 \% \).

The linear slope of the background comes from the current data taking technique. By limiting the time interval of compared pellets, we obtain an edge at the right part of the spectrum. The height of the correlation peak depends on the detection efficiency. For lower efficiency the peak is smaller, because the probability to record the same pellet at both measurement levels is lower.

The detection efficiency is currently mainly limited by the camera dead time. However, since a pellet may be seen by the camera during \( \approx 1 \mu s \), the actual camera efficiency is slightly higher than the Exposure-Time/Cycle-Period ratio.

The efficiency is also limited by the illumination conditions. The MC simulations of the measurements for the different cases are consistent and reproduce the experimental time-difference spectra well. A good understanding of these results is important for the design of a full scale tracking system for the hadronic physics experiments.

The project is supported by COSY-FFE, EC FP7 HP2 and HP3, Swedish Research Council and by the Foundation for Polish Science - MPD program, co-financed by the European Union within the European Regional Development Fund.

References


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