Pellet track reconstruction

Pellets - frozen microspheres of hydrogen
used as targets in the hadron physics experiment WASA (Forschungszentrum Jülich, Germany) and planned to be used in the future PANDA experiment at FAIR (GSI, Darmstadt, Germany).

- Diameter: 25-30 µm;
- Generated: 2 - 3 meters above the interaction region;
- Distance between pellets: a few millimeters;
- Diameter of the stream: ≈ 4 mm.

Problem

Present situation

The interaction region is given by the overlap of the pellet stream and the accelerator beam

→ has a size of a few millimeters;

Goal

To know the interaction point more precisely:
- to have better possibility to reconstruct the particle tracks coming from the interaction point.
- to suppress background events that do not come from a pellet, but e.g. may occur in rest-gas, present in the beam pipe.

Pellet stream behavior and measurements

Various aspects of pellet stream behavior and the measurement process are taken into account in simulations:

Pellet behavior
- generation frequency
- mean velocity in the stream
- velocity spread
- direction and position spread
- loss at generation and during the way
- fluctuations of the rate

Measurements
- pellet size and camera sensor shape and size
- camera cycle structure (period and exposure time)
- illumination - effects of optics - apparent pellet size, its center of brightness

The simulations are able to reproduce experiments with pellets at the Uppsala Pellet Test Station. They are used in further design work.

Pellet track reconstruction

For each pellet recorded at the first measurement level we want to collect all information needed to reconstruct the time and position of this pellet at the interaction region.

- The mean velocity of pellets is used to get the expected pellet time at the second measurement level.
- The measurement closest to the expected time is assumed to be the measurement of the correct pellet.
- This time is used to calculate a new, improved velocity
- The velocity is then used to search for the pellet at the next measurement level.
- This is continued until the last measurement level.

Having information from all measurement levels, one can fit pellet tracks. The pellet position at generation may also be used as an additional point in the track fitting.

Basic Concept

To measure pellet position and time in a few planes along the pellet stream...

... and extrapolate their tracks to the interaction region.

Measurements done with fast line-scan CCD cameras (≈ 10 µs cycle, 25 µm pixels). Pellets illuminated by lasers.

Tracking resolution

Tracking resolution obtained in the simulations, by comparing reconstructed and true pellet position at the interaction region.

Transverse resolution

Depending on the position measurement resolution and on the distance between the measurement levels.

- resolution σ ≈ 250 µm
- σ ≈ 70 µm when the nominal pellet generation point is an additional point in the track fitting.

Longitudinal resolution

Depends on the time resolution from the cameras and the distance between first and last level in the measurement section.

- resolution σ ≈ 0.8 mm for 4 µs effective measurement resolution.

Questions:
- What number of pellets is found by the tracking, if a certain number of pellets is in the beam?
- What is the true number of pellets, when the tracking gives a certain number?

For 5 mm accelerator beam diameter and pellet rate 5000/s:
- about 70% of the hadronic events would have correct information from the tracking system.
- for about 50% of the events there would be unambiguous position information.

Long Range TDC at WASA

A suppression of events from rest-gas, one of the advantages given by the pellet tracking, may be demonstrated with another system using standalone information similarly to the pellet tracking.

- Pellets are in the beam only for a some fraction of the time
- Events from rest-gas happen all the time
- When a pellet is in the beam it’s much more probable, that the event came from the pellet.

One can exploit an alternative method, based on the integrated event rate of interactions, to check when pellets are in the beam.

Further reading


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A Pellet Tracking System for Hadron Physics Experiments

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