Precise Time calibration of the gas detectors of the GARFIELD apparatus

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I. INTRODUCTION

In the framework of the GARFIELD-STREGA experiment, three position sensitive Parallel Plate Avalanche Counters (PPAC) have been designed and mounted to detect the main fragments produced in dissipative collisions.
These counters, together with the GARFIELD [1] telescopes will be emploied to investigate reaction mechanisms at the ALPI bombarding energies. In fact, at these rather low energies, a large fraction of the reaction cross-section can be ascribed to deep-inelastic processes [2] which produce two main excited fragments in the outgoing channel, the projectile-like fragment (PLF) and the target-like fragment (TLF). Several charged particles are emitted by these hot nuclei before reaching their ground-states. Large gas detectors of the type of the PPAC's are particulary apt to efficiently measure the velocity vectors of ions with charge greater than about Z=8, giving the arrival time on the detector and the relative position (within 2-3 mm). From the measured velocities, by means of the kinematic coincidence method [3], one can reconstruct the primary quantities, i.e. the quantities which characterize the PLF and TLF before particle evaporation. The successful use of these detectors demands pulsed beams with good timing properties (well under $1ns$ (FWHM)) and excellent stability. In addition, to get precise time-of-flight (tof) measurement, one needs to know (and correct for) possible dependences of the time-signal on the impact position due to both the transit time of the signal on the aluminized cathode and to possible construction imperfections.

II. EXPERIMENTAL SET-UP AND RESULTS

To study the above mentioned time-position dependences we performed a first calibration run by detecting elastically scattered projectiles impinging on the three PPAC's. The geometry of these detectors has been carefully measured with a surveying instrument (Total Station) mounted in the target position. At a given beam energy the expected tof can be calculated and compared to the measured one, event by event, for each PPAC. At the same time, position spectra for the scattered ions are obtained thus allowing an overall check for the spatial resolution.

A pulsed beam of ^{58}Ni impinging on a thin ^{197}Au target (100 $\mu g/cm^2$) was accelerated by the TANDEM-ALPI system. The kinetic energy of the beam (318 MeV) was chosen in order to make reasonably negligible in the measured spectra the contributions of nuclear reactions. The machine staff succeeded in providing rather good quality beams in term of stability and time structure; this was continuously monitored during the experiment by means of a small fast plastic scintillator mounted at about 200 cm from the target and at roughly 4 deg with respect to the beam direction. Fig. 1 shows tof spectra obtained with this detector for two runs with the same gold target. The time resolution, of the order of 1 ns, was sufficient for calibration purposes. The tail visible at long times should be carefully suppressed in nuclear physics experiments.

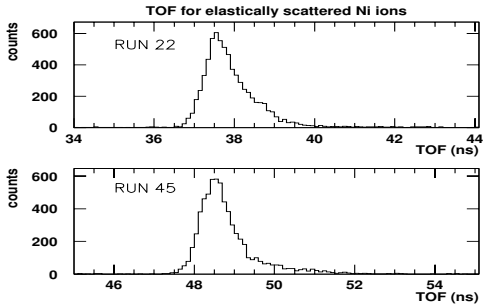

FIG. 1. *Tof spectra for elastic Ni ions from the fast plastic scintillator. The time resolution is around* 1 *ns(FWHM). The estimated total spread due to both the intrinsic plastic resolution and electronic precision is less than* 300 *ps. Note that the X-scale is time-calibrated apart from an offset.*

The PPAC's have an active area of $200*200\ mm^2$. The good position resolution obtained with these detectors on the whole area is demonstrated, for one of the PPAC's, in Fig. 2 which shows, for both coordinates, the wire structure of the anode grids. The distance between two wires is 2 mm. Exploiting this position resolution, each detector has been divided in a matrix of $10 \cdot 10$ cells with an area of 4 cm^2. For each cell, the spectrum of the difference between the calculated and measured tof has been obtained and the first moment of the distribution has been evaluated.

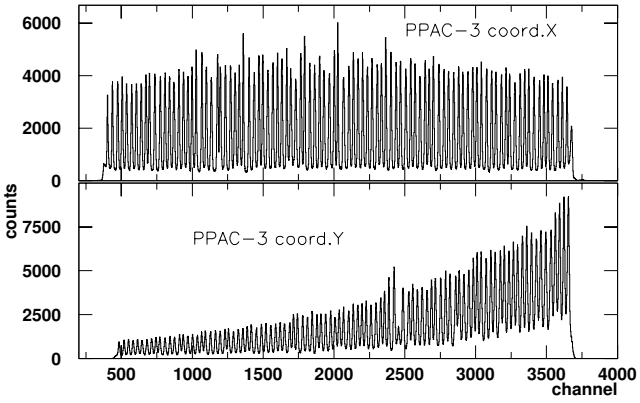

FIG. 2. *Position spectra for PPAC n.3. The distance between two peaks corresponds to a wire gap of 2 mm.*

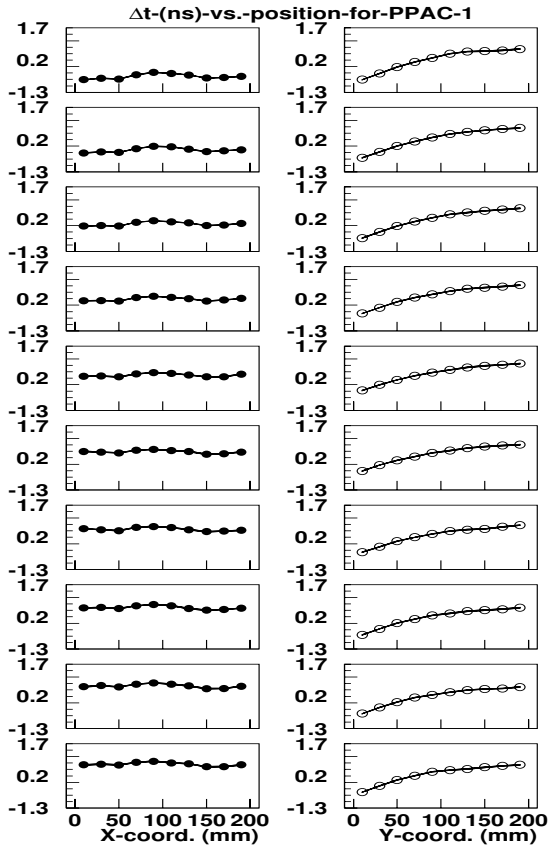

FIG. 3. *Time-position dependence for the PPAC n.1 as a function of the X (left) and of the Y (right) coordinate.*

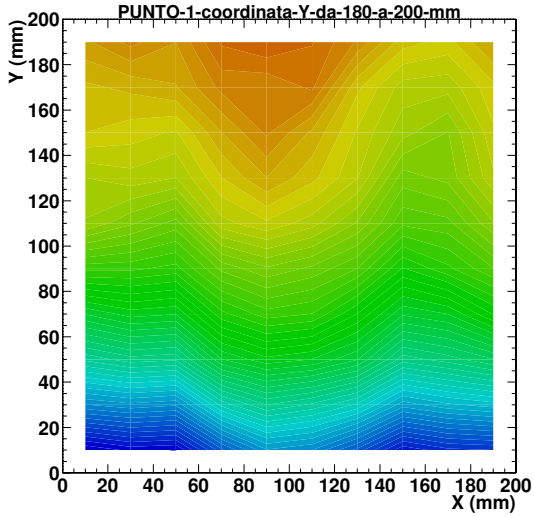

FIG. 4. *Time-position dependence for the PPAC n.1 as a function of the X and of the Y coordinate. The grey-code goes from black ($\Delta t \approx -1.3$ ns) to bright-gray ($\Delta t \approx 0.5$ ns)*

The results are summarized in Fig. 3 where these differences (Δt) are plotted as a function of the X (left) or of the Y (right) coordinate for the PPAC n.1. The different behaviour versus the two coordinates is apparent. This is due to the construction details of the counters for which the electric pick-up of the cathode signal is done at two points ($X = 40$ and $X = 160$ mm) along the Y=0 axis. Thus the delay Δt, while increasing with increasing Y, is modulated in X by the presence of the two collecting points. The overall amount of the tof-position dependence is within 1.7-2.0 ns. Fig. 4 reports the same measured dependence in a more pictorial way. For each cell, the Z-value corresponds to the value of Δt and the different grey-tones correspond to the various Δt bins. The previously described dependencies are even more clear.

Using these results, for each PPAC, a time-position correction data-base can be stored and used in future experiments to correct the measured tof of nuclear fragments produced in heavy-ion reactions.

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[2] J. Tõke and W. U. Schröder, Ann. Rev. Nucl. Part. Sci. **42**, 401 (1992)

[3] G. Casini *et al.*, Nucl. Instr. Methods A **277**, 445 (1989)