Operating the FADC-250

for the PEPPo Experiment

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1 Introduction

The purpose of this document is to specify and help establishing the different modes of operation of the FADC-250 required for the phyiscs program of the PEPPo experiment.

2 Experimental Detectors

The FADC-250 is used for the read-out of the diagnostic annihilation detector and the measurement of the Compton transmission asymmetry. Both detectors constitute of several slow scintillating crystals attached to their specific photo-multiplier tube. In normal operation, these detectors are running sequentially as opposed to simultaneously.

2.1 Annihilation Detector

The main purpose of the annihilation counter detection system is to indirectly confirm the presence of positrons by detecting the 511 keV photons produced when the positrons annihilate inside a target. The annihilation counters for PEPPo consist of a pair of NaI(Tl) detectors located perpendicular to the beam line and positioned to detect the back-to-back photons emitted either in coincidence or individually.

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The typical decay constant of the signals is ∼1 μs. For these measurements, the FADC-250 trigger consists of the single or the coincidence signal delivered by a CAEN V895 leading edge discriminator. For a specific event, the basic experimental data of each scintillator consists of 250-500 ADC sample values (1-2 μs time sampling window) together with a timing information provided by a CAEN V775 TDC.

It is desirable but not mandatory to have the ability to record only the integral value of the signal over the 1-2 μs time window instead of the 250-500 samples, in the perspective of reducing the data acquisition dead-time.

2.2 Compton Transmission Polarimeter

The operation of the PEPPo polarimeter relies on the Compton absorption of polarized photons inside a polarized target. Transmitted photons are measured in a 3×3 CsI(Tl) crystal array located at the exit of the analyzing magnet polarizing the target. Each crystal is connected to a photomultiplier tube R6236-100 which signals are fed into the FADC-250.

The polarimeter detector system is the most demanding part of PEPPo, as far as the FADC-250 is concerned. Its operation requires the ability to record data following 3 different modes: sample, semi-integrated, integrated. For each running mode, the signals delivered by the 9 polarimeter crystals as well as the helicity signal are recorded by the FADC-250.

The decay constant of the CsI(Tl) crystals is ∼1 μs, similar to the annihilation counters. Depending on the FADC-250 running mode the trigger is alternatively made out of the crystal signals (sample, semi-integrated) or the T-settle signal (integrated). The information recorded by the VME CPU consists of the FADC-250 data and the TDC data for the sample and semi-integrated mode.

3 Running Modes

3.1 Sample

In the sample or raw data mode, the 250-500 samples constituting the 1-2 μs time window are transferred to the VME CPU when at least 1 out of the 9 PMTs is above a user defined threshold. This trigger is delivered by the CAEN V895 leading edge discriminator.

The data flow for this configuration is particularly significant, leading to a very high DAQ dead-time. This method is therefore essentially used for detector checks, radioactive source calibrations, LED monitoring, cosmic rays and crystal background measurements. The sample data are processed off-line to provide the relevant energy spectra.

3.2 Semi-integrated

The semi-integrated method is designed to reduce the dead-time due to the data transfer by substituting the signal integral to the full sampled signal. In this configuration, the sum of all the samples over the 1-2 μs duration of the signal is performed on the FADC-250, and transferred to the VME CPU for the same trigger as the sample mode. The firmware should give the ability to sum the samples of the time window above a user specified threshold and provide a value corrected from pedestal. The firmware should also allow for integration with no threshold, for example by having a threshold below the pedestal. The pedestal subtraction may be determined by averaging over the 5-10 first samples of the time window.

The data collected during one helicity gate are stored in the form of 9 signal integral values and TDC information corresponding to the 9 crystals, together with the helicity state. The experimental asymmetry is built off-line from this information. This running mode is expected to operate without significant pile-up effects up to ∼10 kHz, and is the basic mode for the measurement of the positron polarization.

3.3 Integrated

For very high rate operation (∼1 MHz), individual pulses will pile up generating a semi-DC level preventing proper triggering on the pulse. The way to still carry out the measurement for PEPPo is to make an integrated measurement since the total integral of the pulses will be proportional to the deposited energy. The trigger is then replaced by the T-settle signal which indicates when the pockel cell is settled for a particular helicity state. The FADC-250 would compute the integral over a full helicity window (30-960 Hz trigger rate) by summing all the samples (Fig. 1) and providing a value corrected from pedestal. The firmware should also have the ability to integrate the samples over a user specified threshold.

By recording those integrals for each helicity window and each crystal one is able to generate the physics asymmetry, both on- and off-line. This running mode is the only viable mode for the measurement of the electron beam polarization.

Tsettle

Helicity
signal

PMT
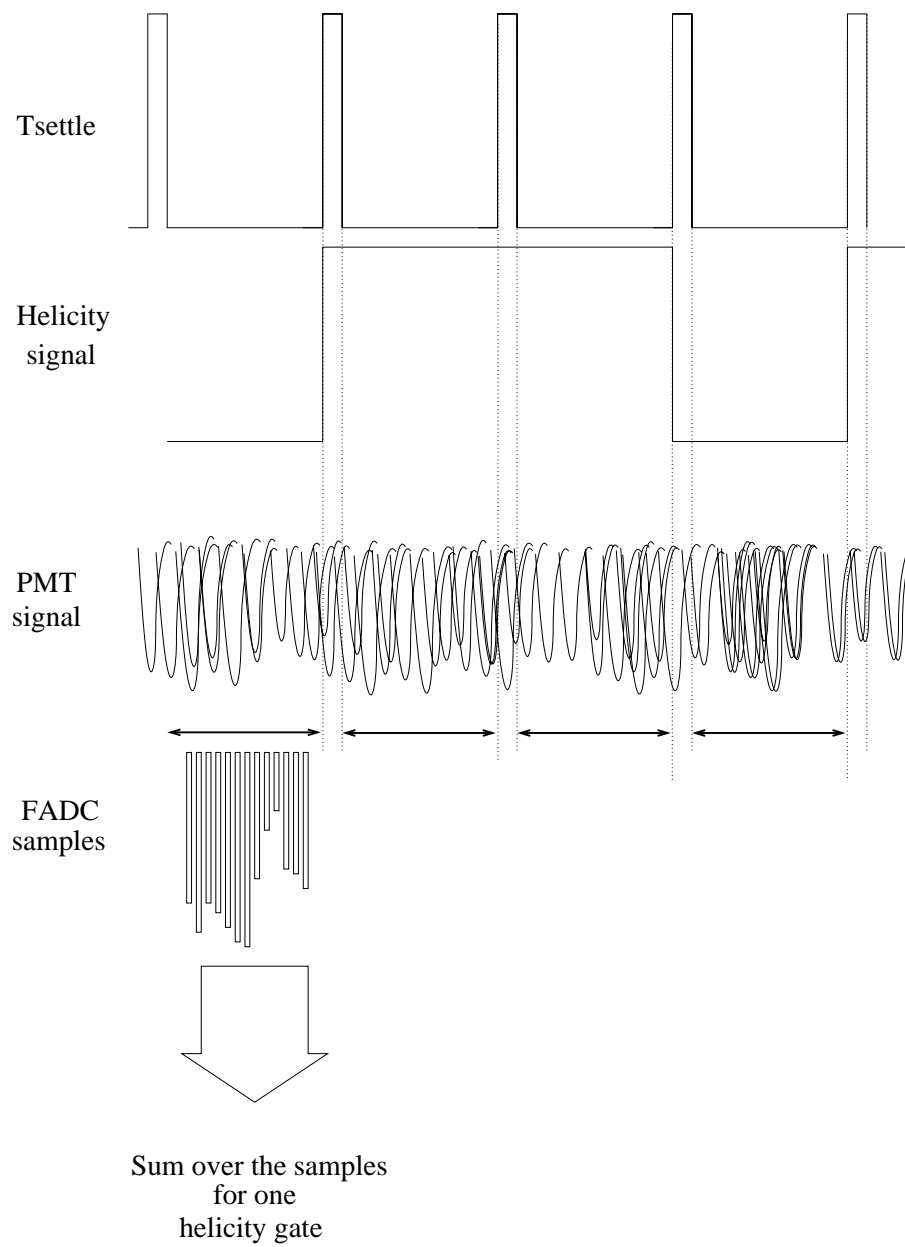signal

FADC
samples

Sum over the samples
for one
helicity gate

Figure 1. Principle of the integrated running mode.