

Operating the FADC-250

for the PEPPo Experiment

Alexandre Camsonne¹, Jean-Sébastien Réal², Eric Voutier^{1,2}

¹*Thomas Jefferson National Accelerator Facility
12000 Jefferson Avenue
Newport News, Virginia 23606, USA*

²*Laboratoire de Physique Subatomique et de Cosmologie
IN2P3/CNRS, Université Joseph Fourier, INP
53 rue des Martyrs
38026 Grenoble cedex, France*

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 physics 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.

15 February 2012

The typical decay constant of the signals is $\sim 1 \mu\text{s}$. 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 a 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**, the latter being impossible with the current firmware. 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 $\sim 2 \mu\text{s}$, 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 (semi-integrated, 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.

This method is currently implemented in the present firmware.

3.2 *Semi-integrated*

The semi-integrated method is designed to reduce the dead-time due to the data transfer by substituting the signal integration to the signal's samples. In this configuration, the sum of all the samples over the $2\ \mu\text{s}$ duration is performed on the FADC-250. The firmware should give the ability to sum the samples with a pedestal subtraction over the time window without any sample threshold. The pedestal value should be determined event by event and channel by channel by averaging over the 5-10 first samples (user defined) of the time window. As a further but not essential capability, the firmware should also give the possibility to integrate only the samples over a user specified threshold. The standard mode of getting the data is an event by event basis. The trigger of the FADC and the VME CPU are the same and the integrals and TDC information of the 9 channels and transferred to the VME CPU for the same trigger as the sample mode. This mode is already implemented in the firmware and is currently tested.

Transferring data for each event is expected to generate dead-time. We intend to reduce the dead-time by using the FADC-250 buffer. For each event, the integrals of the 9 channels are stored in the FADC buffer. The buffer is then readout by the VME CPU during helicity change. In this configuration, the FADC-250 trigger is still delivered by the V895 discriminator but the DAQ read-out trigger is coming from the T-settle helicity signal. It is mandatory to not loose any event and to be able to readout the whole buffer during the helicity flip. T-settle frequency and rates will be adapted in order to not over fill the buffer. For protection, the FADC-250 busy signal should be used to veto the trigger when the buffer is full. This running mode has not yet been implemented.

The data collected during one helicity gate are stored in the form of 9 signal integral values 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 $\sim 10\ \text{kHz}$, and is the basic mode for the measurement of the positron polarization.

3.3 *Integrated*

We are requiring a **new feature** of the firmware for very high rate operation ($\sim 1\ \text{MHz}$). Under such conditions, 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. This signal can be fed through the FADC via one input channel dedicated to this. The FADC-250 would compute the integral over a full helicity window ($\sim 1\ \text{ms}$ duration) by summing all the samples (Fig. 1). The best will be to provide an external integration time window constructed using a precision timing board that would be triggered by the T-settle, having then the possibility to adjust the integration time window. The electronics group should specify the possible limitations of this

time window. For this mode a pedestal subtraction is required. The pedestal will be constant over the run, should be user defined and different for each channel. The integral method is required to operate with no threshold on the samples. The ability to integrate the samples over a user specified threshold is desirable.

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 mandatory for the measurement of the electron beam polarization.

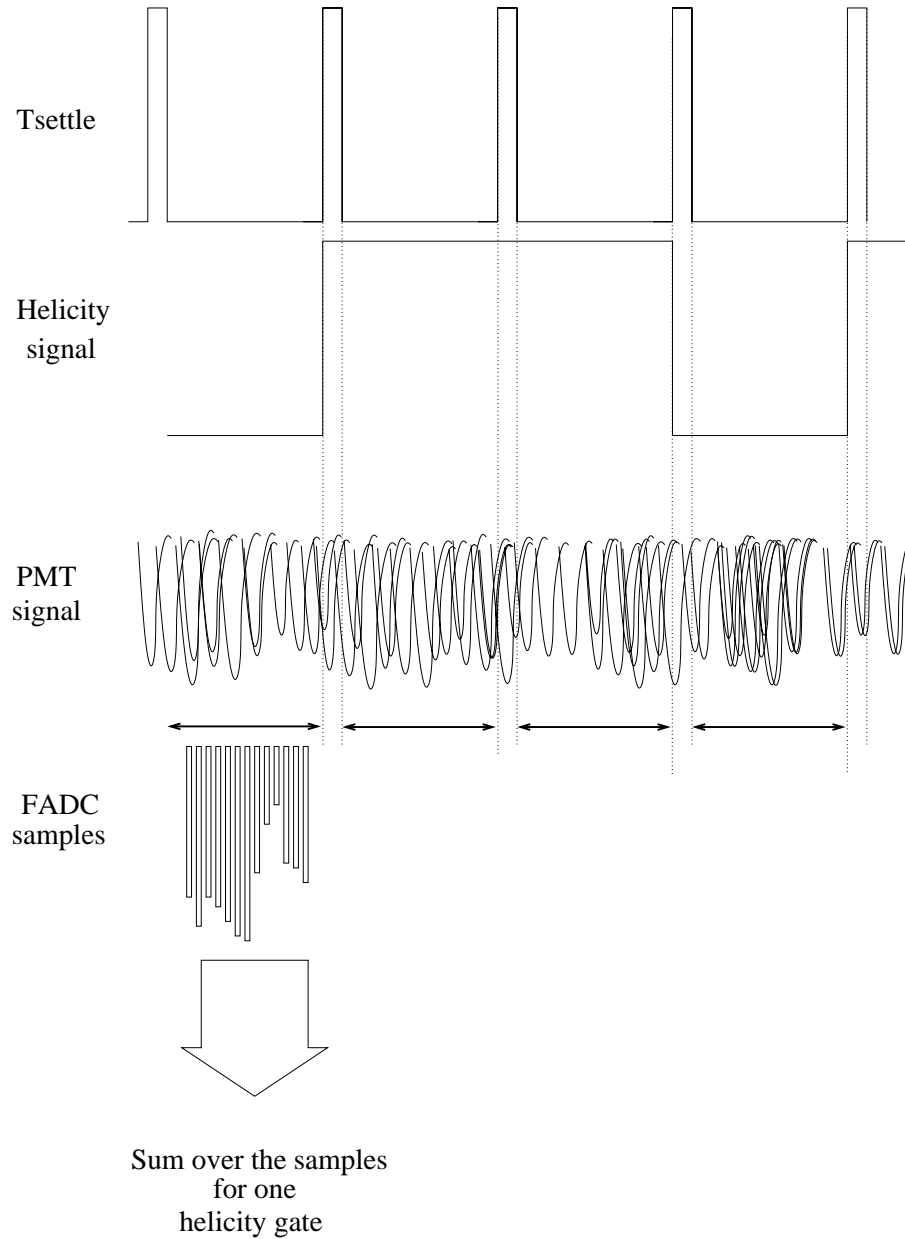


Figure 1. Principle of the integrated running mode.