Tagger Hodoscpe (TAGH) Timewalk and Timing Calibrations for the GlueX experiment - Summary of Procedure

Internal Memo

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Abstract

The Hall D photon tagging spectrometer is used to determine the energy of bremsstrahlung photons delivered to the GlueX target, with accurate account of event timing being vital for reconstruction. Hits in the tagger must be match events in GlueX and the RF time of CEBAF in order to correctly identify these events and the particles detected in them. This document summarises the procedure for timing calibrations of the tagger hodoscope, one of two devices in the tagger focal plane used to determine photon beam energy.

1 Introduction

The GlueX experiment uses a coherent bremsstrahlung facility to produce a real photon beam for use in high-energy photoproduction experiments.

Accurate event timing information is vital for assigning hits in the GlueX detector systems to electrons delivered by CEBAF to the bremsstrahlung facility, and timing calibrations allow the RF time from CEBAF to be associated to an event produced by the secondary photon beam.

2 The GlueX Tagged Photon Beam Facility

The photon beam in GlueX is secondary beam, produced using the primary electron beam from CEBAF and the tagged photon beam facility for Hall D. The CEBAF electron beam is delivered to the photon tagger hall, passing through a radiator and emitting bremsstrahlung photons as it interacts. The mixed photon-electron beam then enters the photon tagging spectrometer ("tagger"), where the electrons are swept out of the beamline by a dipole magnet and detected by one of two systems in the tagger focal plane; the broadband hodoscope or the high resolution microscope. Both devices are used to determine the photon beam energy via the relation $E_\gamma = E_0 - E_e$, where E_0 is the primary electron beam energy from CEBAF, before interation with the radiator, and E_e is the energy of the electron determined by its detected position in the focal plane.

The photon beam then continues to the experimental hall, where it is collimated and interacts with a target positioned within the GlueX detector. A schematic of the GlueX photon beamline is shown in figure 1.

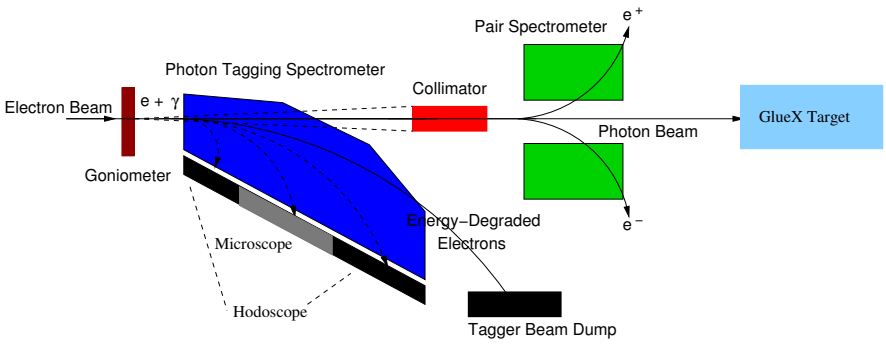

Figure 1: Schematic view of the tagged photon beam facility in Hall D (not to scale)

2.1 Hodoscope

(adapted from GlueX wiki)

The tagger hodoscope is a device consisting of ∼220 scintillators distributed over a length of 9.25 m and mounted just behind the focal plane of the tagger magnet. It is intended to provide coarsely sampled coverage spanning the energy range of electrons produced in the bremsstrahlung process in the tagger hall. For a 12 GeV beam, the scintillator array detects scattered electrons in the energy range of 0.22 to 9.0 GeV, tagging photons between 3.0 GeV and 11.78 GeV. The gap in the coverage of the hodoscope scintillators is filled by the higher-resolution tagger microscope (see 2.2).

The construction of the hodoscope allows for later addition of counters to fully cover the energy range above the coherent peak for other microscope positions by filling the gaps between sampling scintillators. The mounting frame of the hodoscope is suspended from the Tagger-Hall ceiling to provide full flexibility of microscope positioning.

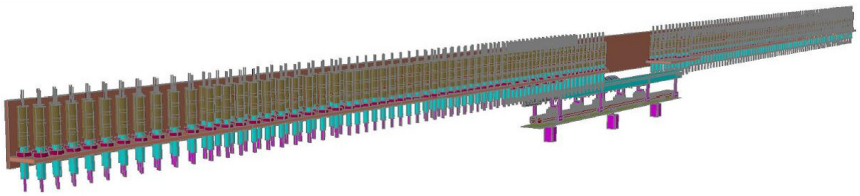

Figure 2: GlueX tagger hodoscope. Note the gap in which the microscope is placed.

2.2 Microscope

The Tagger Microscope is a movable, high-resolution hodoscope that counts post-bremsstrahlung electrons corresponding to the photon energy band of interest to the experiment in Hall D. Scintillating fiber bundles are oriented towards the incoming electron axis in the tagger focal plane, and read out by silicon photomultipliers at the other end. This detector provides fine segmentation along the direction of electrons' spread, increasing the energy resolution, as well as allowing selective readout to match the photon collimator acceptance through segmentation in the y-direction.

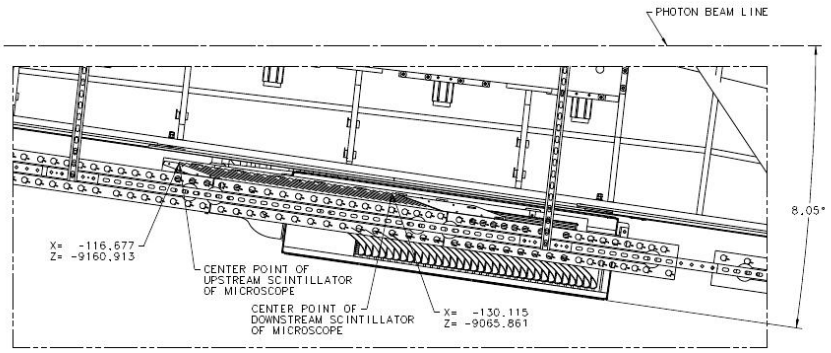

Figure 3: Schematic drawing of the GlueX tagger focal plane, showing the microscope in position at the gap in hodoscope coverage

3 Tagger Hodoscope (TAGH) Timing Calibration

The procedure for calibrating the hodoscope is similar to that employed by other tagged bremsstrahlung photon facilities (CLAS, A2@MAMI). TDC and ADC counters are aligned with events in the GlueX detector and the RF time from CEBAF, before event-by-event alignment and a *timewalk* calibration. Details of these procedures are discussed below.

3.1 TDC/ADC Alignment

The alignment of TDCs and ADCs with events in GlueX and the RF time of CEBAF is performed within the reconstruction plugin `HLDetectorTiming`. Within this plugin, double hits, where an electron is detected in two scintillators in the hodoscope, are accounted for and merged, TDC and ADC values are aligned, and event-by-event TDC offsets calculated.

The code for doing this is fairly mature and the calibration should be relatively straightforward, however cases have been seen where TDC and ADC alignment fails and a double peak is seen in the time offset distribution, indicating the need for further improvements in this stage of the calibration (see figure 4).

3.2 Timewalk calibration

The timewalk calibration accounts for the time taken for the ADC pulse in a PMT to rise, and is contained in the reconstruction plugin `TAGH_timewalk`.

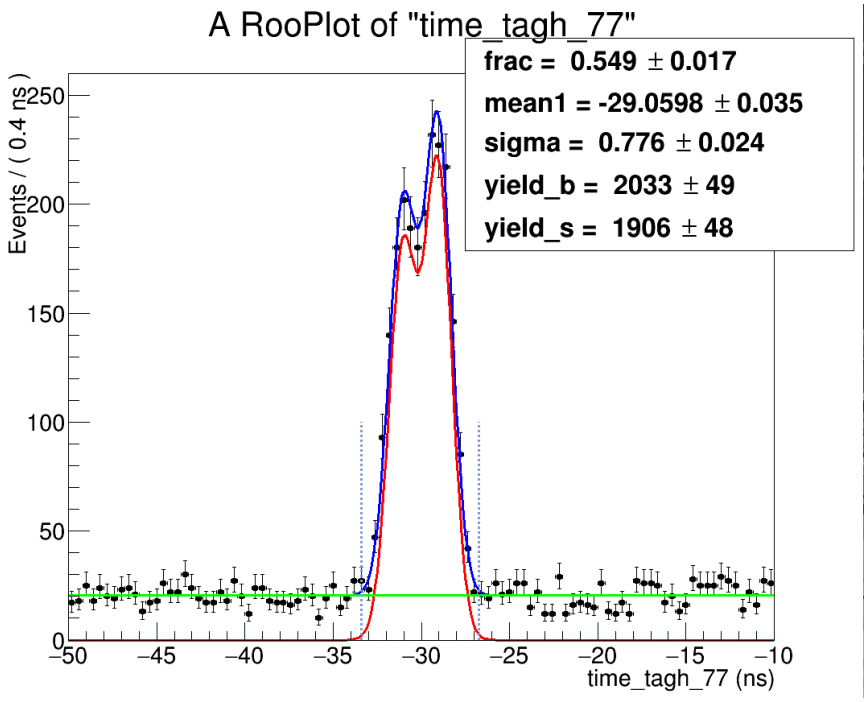

Figure 4: Time offset for tagger hodoscope counter 77. A double peak shows misalignment of the ADC and TDC time values not accounted for by the calibration software.

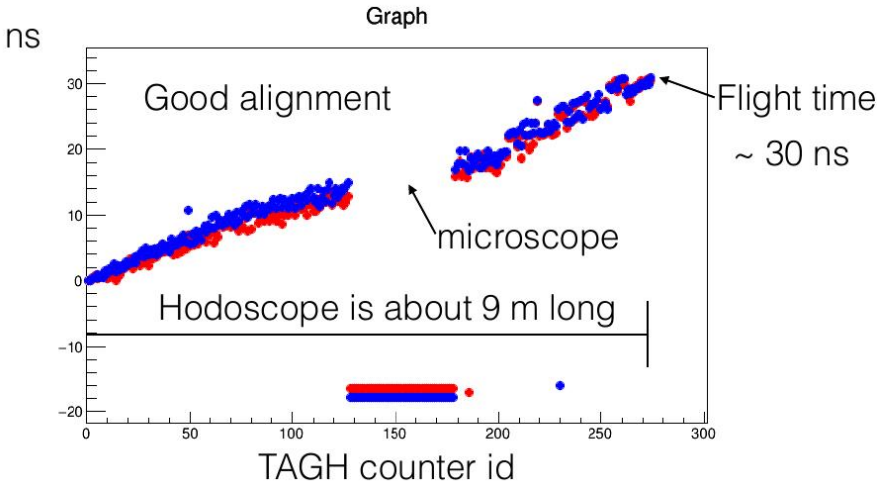

Figure 5: Time offset vs counter ID for the tagger microscope. The flat region centered around counter 150 corresponds to the gap in hodoscope coverage filled by the microscope.

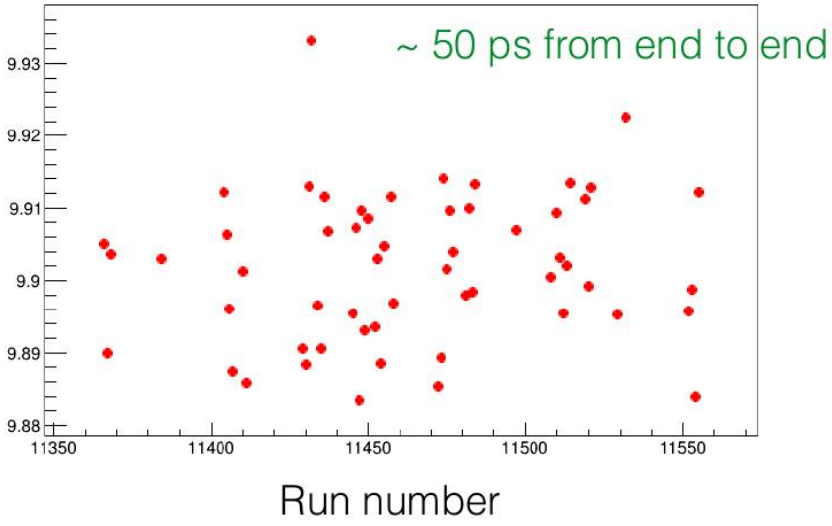

Figure 6: TDC time offset for hodoscope counter ID 101 vs run number for the 2016 run. Furhter timing adjustments are neccesary to account for drifts in the TDCs as a run progresses.

The calibration involves the calculation of an addidional correction factor to the TDC time values, of the form

$$t = t_{TDC} - tw(A)$$

where $tw(A)$ is fit function defined from a fit to a distribution of TDC - RF time difference against pedastal-subtracted ADC pulse amplitude, an example of which is shown in figure 7.

Fit functions have been defined for obtaining $tw(A)$, but again, scope remains for improvements to low statistics counters and increasingly rare situations where the fits may fail Currently, fit functions of the following form are used

$$tw(A) = p0 + \frac{p1}{A^{p2}} \qquad \text{if } A < p3$$

$$tw(A) = p0 + \frac{p1}{p3^{p2}}(1 + p2) - \frac{p1p2}{p3^{(p2+1)}}A \qquad \text{if } A > p3$$

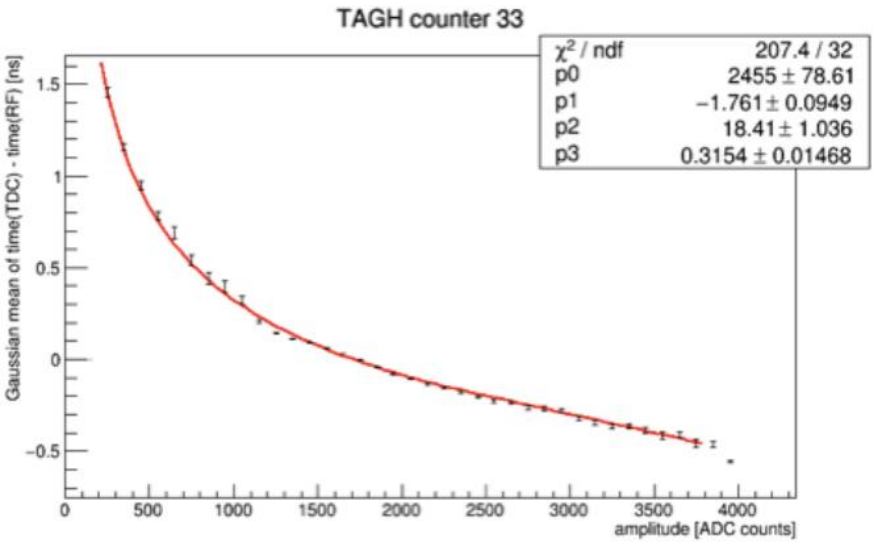

Figure 7: TDC - RF time difference vs pedastal-subtracted ADC pulse amplitude for hodoscope counter number 33. The fit function is used to define the addidional TDC time correction due to timewalk.