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Abstract

A beam test of the 4m protoype module for the GlueX barrel calorimeter (BCal) was carried out in Hall B at the Thomas Jefferson National Accelerator Facility (Jefferson Lab) with the intent of measuring the energy, timing and position resolution of the module. The data were collected in September 2006. Preliminary analysis results of the timing reolution will be shown here.

1. Introduction and Goals

The protoype module for the GlueX Barrel Calorimeter (BCal) is constructed of alternating layers of pure, grooved lead and blue Poli-Hi-Tech scintillating fibres bonded together with Bicron-600 optical epoxy. Construction took place at the University of Alberta. The design of the BCal is very similar to the KLOE electromagnetic calorimeter which had a reported energy resolution of $5.4\%/\sqrt{E(GeV)}$ plus a negligable constant term and a timing resolution of 54 ps$/\sqrt{E(GeV)}\oplus$140 ps **??**. GlueX expects similar resolutions for the BCal.

2. Experimental Details

2.1. *Alcove*

The module was placed in the down stream alcove of Hall B at Jefferson Lab. The use of a remote controlled cart allowed for the module to be rotated to various angles. A hall access needed to be made to change the lateral position of the module with respect to the beam. Limitations due to the smaller dimensions of the alcove limited the number of angles and postions the module could be placed in but a length scan from -100cm to +25 perpendicular to the beam was able to be performed along with multiple positons at shallow angles with respect to the beam. We shall only look at the data where the module was perpendicular to the beam for this note.

2.2. *Beam*

The photon beam in hall beam provided a spectra of photons from 150 MeV up to 650 Mev produced by the electron beam from CEBAF incident on a radiator. The electron beam current was 1 nA. The electrons are tagged and provide us timing and energy information for the photons. The trigger is formed from the Master OR from the tagger of the T-counters and an OR signal from the BCal module. On average the event rate was around 1 to 4 kHz for the dutration of the beam test. The beam was collimated with a 2.6mm collimator giving a beam spot size on the BCal module of 2cm in diameter.

2.3. *Readout and Electronics*

The module was segmented into 18 2×2 cells with 6 rows in depth with respect to the beam and 3 columns in width. They were then numbered 1 through 18. The readout scheme can be seen in Figure **??**. Square light guides with a 45 degree mirrored surface channeled the light from the fibres to PMTs on either end of the BCal labeled North and

South. Silicon sheets approximately 2.5 mm thick were used to interface the lightguides with the BCal and the PMTs. Everything was then inclosed in a steel box to maintain light-tightness. The light boxes and PMT's can be seen in Fig.lightguides. The first 3 rows are readout using XP2020 photomultiplier tubes because of their better timing characteristics and most of the energy is deposited in the first 12cm of the BCal. The last 3 rows are readout using Burle 8575 tubes.

The bases for the PMTs were designed with dual BNC outputs on the anode. One signal was sent to a CAEN C 207 (equivalent leading edge) descriminator. An F1 TDC was used. The sum of the descriminator output was sent to a second dectriminator and was required to reach a minumum threshold such that at least 4 PMTS each from the North and Southend of the BCal must fire. The OR of the BCal end sums AND the Master OR signal of the tagger established the trigger for the BCal beamtest.

3. Timing Analysis

3.1. *Time walk corrections*

Due to the fact that leading edge descriminators were used the timing had a dependance on pulse height and must be corrected for. A plot of ADC versus TDC for cell 8 can be seen in Figure 1. Similar fits have been done to North and South cells 7,8,9 and 10 so far. The corrected TDC distribution can be seen in Figure 2.

3.2. *Timing resolution*

The distribution of the mean timer over the entire tagger energy spectrum for cell 8 can be seen in Figure 3. The timing from the tagger, tphoton, has been used as the reference time for the BCal which has a contribution to the constant term in the resolution of 113 ps . The distribution for the difference $ts8 - tn8$ can seen in Figure 4. The mean value is the offsets $(ts8_o - tn8_o)$. A plot of the timing resolution of cell 8 can be seen in Figure **??**. The width of the photon beam, 2 cm, will contribute 123 ps to the resolution where the speed of light in the BCal is measured to be 16.2 cm/ns.

If one looks at Figure 6 where one would expect there to be one mean values for the offset for (ts8+tn8)/2 - (-tphoton) it appears to deviate from this by over 100 ps.

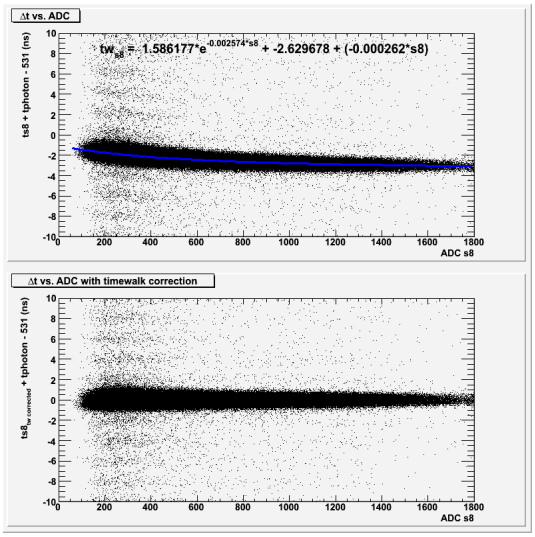

Fig. 1. ADC vs. TDC for cell South 8. The uncorrected time walk is seen in the top plot. The bottom plot shows the corrected time.

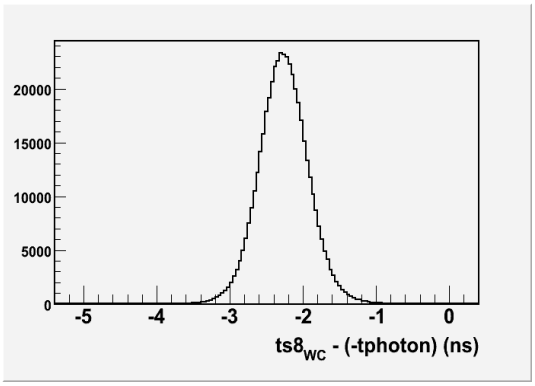

Fig. 2. TDC distribution for South 8 corrected for time walk

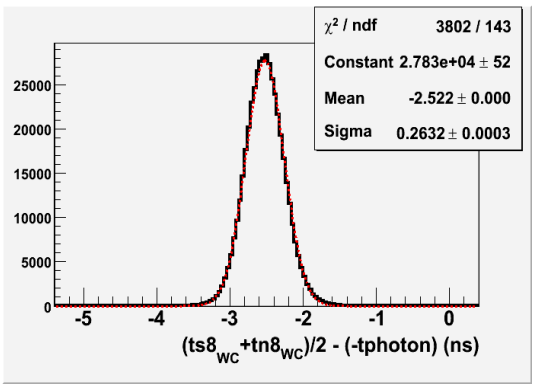

Fig. 3. The mean timer distribution of cell 8 corrected for time walk and referenced with the tagger

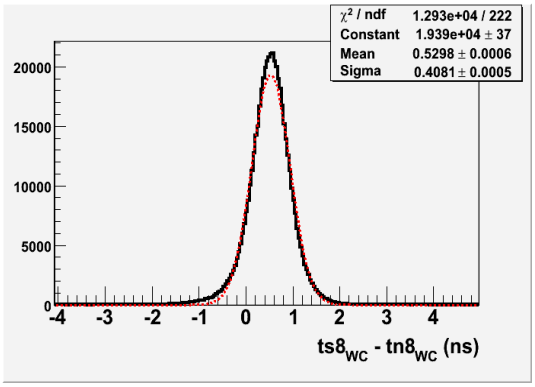

Fig. 4. The distribution of the difference between North 8 and South 8

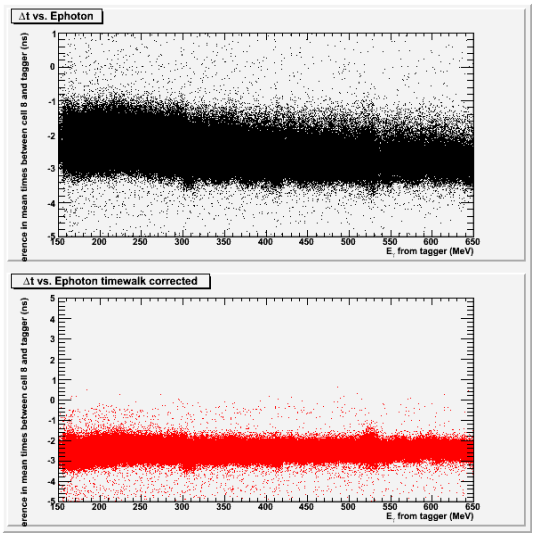

Fig. 5. (tn8+ts8)/2 - (-tphoton) vs. Tagger Energy(MeV for Cell 8). The top plot is before time walk corrections. The bottom plot is after corrections.

Subtracting the contribution of the tagger to the resolution, 113 ps, we are left with a resolution for the meant timer of cell 8 equal to

$$\sigma_{t8_{MT}} = \frac{86ps}{\sqrt{E(GeV)}} \oplus 159ps \tag{1}$$

The meant timer of cell 7 ends up being

$$\sigma_{t7_{MT}} = \frac{61ps}{\sqrt{E(GeV)}} \oplus 176ps \tag{2}$$

Since this is for the sum of 2 detectors the resolution for reading out one end will be $\sigma_{t7_{MT}}/\sqrt{2}$ so that we have the resolution for one end of cell 8 being

$$\sigma_{t8} = \frac{61ps}{\sqrt{E(GeV)}} \oplus 112ps \tag{3}$$

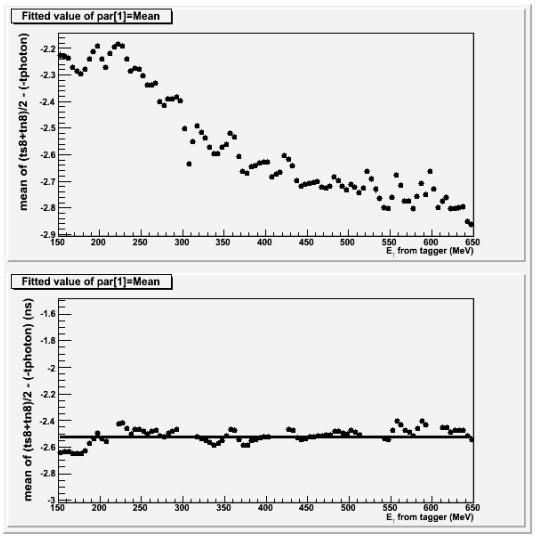

Fig. 6. The mean of the distribution in Figure 5 The top plot is before time walk corrections. The bottom plot is after corrections.

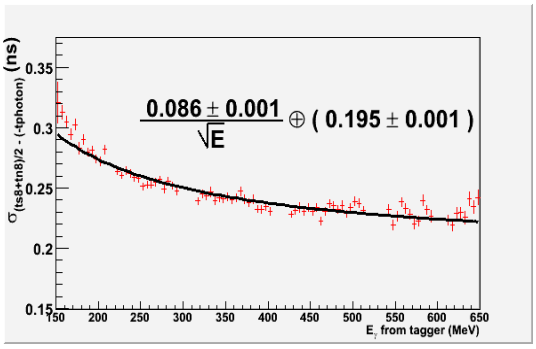

Fig. 7. Timing resolution from fitting the slices of Figure 5

and reading one end of cell 7

$$\sigma_{t7} = \frac{43ps}{\sqrt{E(GeV)}} \oplus 124ps \tag{4}$$

Weighting the time of each cell $1/\sigma_i^2$ we get the time for a cluster being equal to

$$t_{cl} = \frac{\sum_i \frac{t_{MT}(i)}{\sigma_i^2}}{\sum_i \frac{1}{\sigma_i^2}} \tag{5}$$

where there are i cells in the cluster. For now, just adding cells 7 and 8 (4 PMTs) together gives a resolution of

$$\sigma_{t7\&8} = \frac{60ps}{\sqrt{E(GeV)}} \oplus 187ps \tag{6}$$

Subtracting the contribution from the tagger we have

$$\sigma_{t7\&8} = \frac{60ps}{\sqrt{E(GeV)}} \oplus 149ps \quad (7)$$

Adding in cell 9 gives a timing resolution of $93ps/\sqrt{E} + 157ps$, a much higher energy dependent term compared to (6) but this is possibly from the low statistics in the lower energies where one cuts on a large enough adc signal seen in each cell in the cluster or there is still some miscallibrations in the BCal or tagger. (Since there is 6 PMTs do we divide by $\sqrt{6}$ now?)

References

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