Study of group TDC

PrimEx note 84

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1 Introduction

The goals of this analysis are:
1) to find group TDC efficiency;
2) to find alignment constants for group TDC for further studies;
3) to study time walk correction.
Group TDCs were used for determination of time of reconstructed gammas in HYCAL. Each TDC group consists of 6x6, 5x6, 6x5 or 5x5 modules. Information from each group TDC contains in HARDWARE bank. Structure of this bank:
1) rocid - read out controller ID;
2) slot - TDC slot (CAMAC slot allocation);
3) channel - TDC channel ID;
4) value - TDC value from slot-channel "intersection";
More information about group TDC can be found in [1].

2 TDC efficiency

2.1 Determination of efficiency

We studied efficiency in events with HYCAL trigger and signal from MOR trigger. In this case efficiency equals to (N2|N1)/N0; where N0 - number of events in tagger, N1 - number of events satisfying condition fabs(Time_SQ - T_MOR) <20ns, N2 - number of events satisfying condition fabs(Time_SQ - T_HYCAL) <20ns, T_MOR - tagger trigger time, T_HYCAL - HYCAL trigger

time, Time_SQ - group TDC time, N2|N1 - conditional probability (set of N2 when condition N1 is true).

2.2 Event selection

TDC efficiency was obtained from 2nd Snake Scan data. The following cuts were applied to select data for analysis:

1) ADC_ERROR take off events with error code;

2) Bank TRIGGER contains signal from MOR trigger (latch);

3) exactly one reconstructed TAGGER hit within $\pm 20ns$;

banks $\rightarrow TAGM\_LR \rightarrow bank.nrow == 1$;

4) reference time exists;

5) coincidence between group TDC time and time from HYCAL trigger exclude bogus events; fabs(group_time-HYCALtime-HYCALalignment) <20 ns;

6) one hit in TRIGTHIT bank with id=2 and time within 20 ns;

7) other than studied modules should not have energy deposition greater than 0.4 GeV;

8) bank TRIGGER contains signal from HYCAL trigger(latch); (counting here how many events pass and pass not this cut $\rightarrow efficiency$);

then plot dependence between 1) beam energy 2) individual ADC energy 3) group TDC energy and efficiency.

2.3 Results

We checked all groups and find inefficiency (1-efficiency) for each one. For most of groups inefficiency close to 0, but exist some of them have inefficiency close to 1. These groups are #3, #30, #31, #32, #34. Pictures for dependence between beam/module/group energy and inefficiency for one typical "good" group (TGW #21) and one typical "bad" group (TGW #32) are present on pictures 1-6 for comparison.

We found that for groups 3,30,31,32,34 efficiency level is about 0.1%. Information about group TDC from lead glass is limited. For further analysis we exclude groups 3, 30, 31, 32, 34 and all lead glass groups. At this point we found preliminary approximate alignment which equals average difference between time from group TDC and HYCAL trigger time. This alignment will be used in follow paragraphs.

3 Alignment

In previous paragraph we determine alignment as aproximate difference between time from group TDC and time from HYCAL trigger. In reality this alignment worked with low precise because it was same for different groups and individual modules. To found more precise and sensitive for each group and individual module TDC alignment we looked at next expression on pi0 runs with carbon

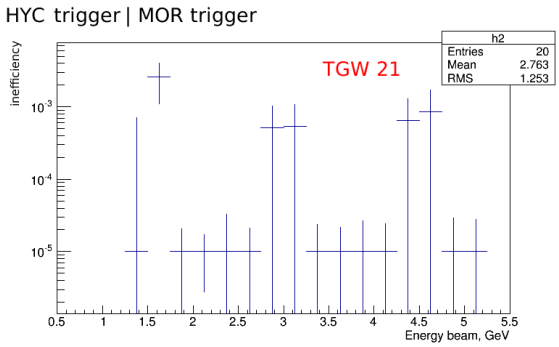

Figure 1: Dependence between beam energy and inefficiency(1-efficiency) for "good" group #21

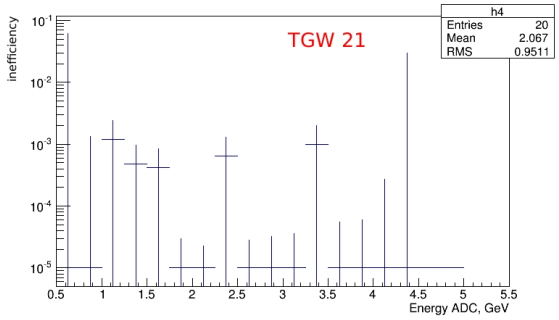

Figure 2: Dependence between module energy and inefficiency(1-efficiency) for "good" group #21

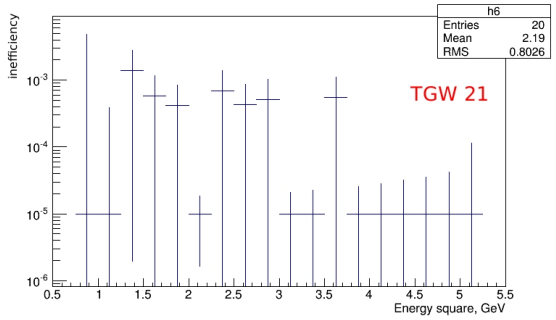

Figure 3: Dependence between group energy and inefficiency(1-efficiency) for "good" group #21

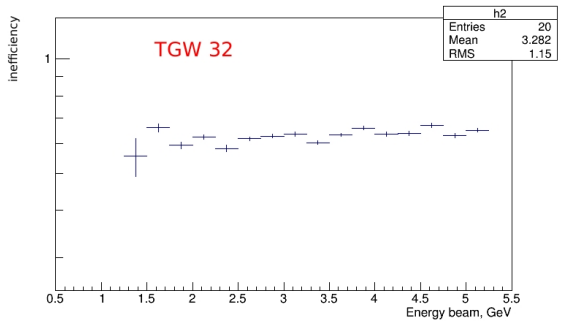

Figure 4: Dependence between beam energy and inefficiency(1-efficiency) for "bad" group #32

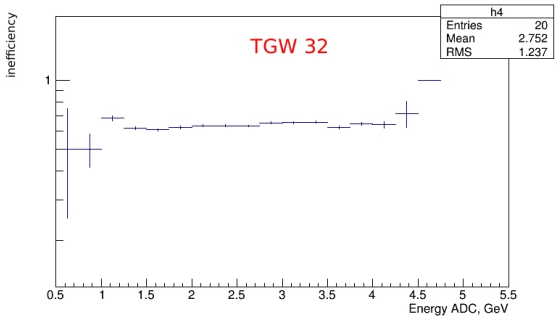

Figure 5: Dependence between module energy and inefficiency(1-efficiency) for "bad" group #32

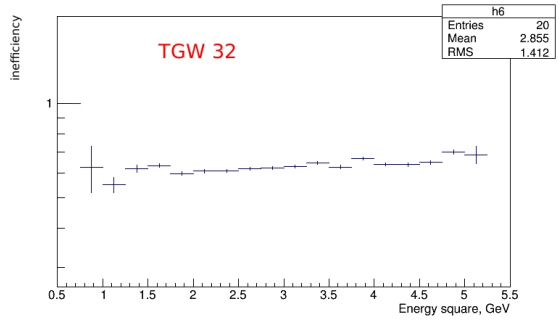

Figure 6: Dependence between group energy and inefficiency(1-efficiency) for "bad" group #32

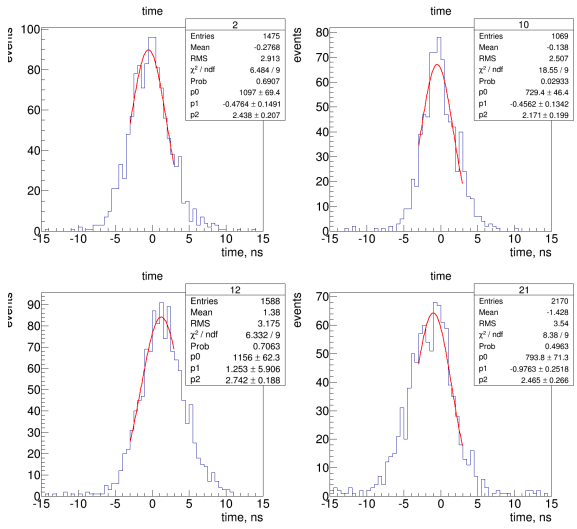

Figure 7: Time difference between group TDCs (between two groups where gammas from pi0 decay hit)

target (all skim files 65000):

$$(Time\_SQ\_1 - align1(module\_id\_1) - align2(group\_id\_1)) -$$

(Time_SQ_2 - align1(module_id_2) - align2(group_id_2)) (1)

where
Time_SQ_1, Time_SQ_2 - time from group TDC for gamma 1 and gamma 2 respectively;

align1(module_id_1) , align1(module_id_2) - Ilya's Larin previously calculated alignment for individual module for first and second γ from π^0 decay [2];

align2(group_id_1), align2(group_id_2) - approximate alignment for group TDC for gammas 1 and 2 which was received from snake scan analysis (see previous paragraph).

Applied cuts for this selection are:

1) ADC_ERROR - take off events with error code;

2) bank TRIGGER contains signal from HYCAL trigger (latch);

3) number of clusters from HYCALCLUSTER $\rightarrow$ *bank.nrow more or equal* 2;

On picture #7 we can see value of expression(1) for groups #2, #10, #12, #21 (here and follow presents only this four groups for show dynamics of progress).

If we look at Figure #7 we see that our signals have some shift from zero. To exclude this effect we add to expression(1) additional alignment constants

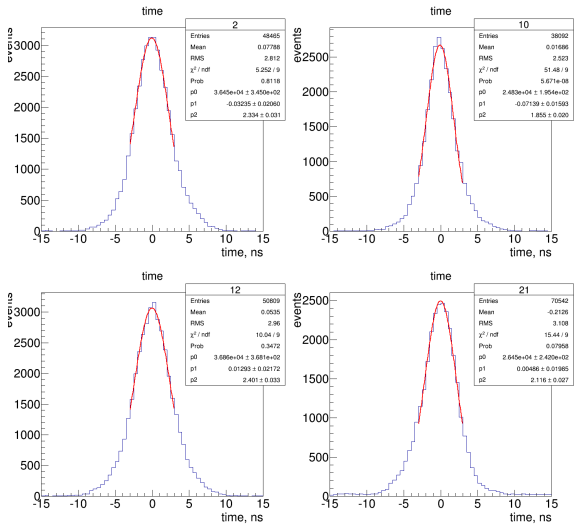

Figure 8: Time difference between groups TDC after approximatelly 20 iterations

and analyzed statistic again. Then we received new time difference distributions with their own mean values (p1 on Figure #7) then add these new mean values to formula(1) and then repeat this iteration until all will be at zero (see Fig. #8).

Important to note that here resolution is about 2.0 - 2.8 ns for all groups (see p2 on Figure #7).

4 Time walk correction

To improve resolution we introduced time walk correction (alignment constant dependence on energy). We fixed gamma 1 energy on it's "most probable" level: $3 <$ E1 < 3.6 GeV and looked what time diff we have for second gamma for each bin (0.1 GeV) for energy range $0.5 <$ E2 < 2.0 GeV ("left leg"). Same thing we did for gamma 2 - we fixed it's energy on it's "most probable" level $1 <$ E2 < 1.2 GeV and look what time diff we have for first gamma for each bean (0.1 GeV) $2.5 <$ E1 < 5 GeV ("right leg"). In Fig. #9 present both "legs" which clearly describe dependence between time difference from 1st and 2nd TDC (where gammas hit) and each energy of them.

We added this dependence to formula (1) and found final alignment constants. After using final alignment time difference for all grous looks like see on 10 - blue line (for comparison red line - without time walk correction).

Now we see that resolution for time difference between two gammas in HYCAL is about 0.6 - 0.8 ns. It means that time resolution for each group TDC is about 0.4 - 0.55ns.

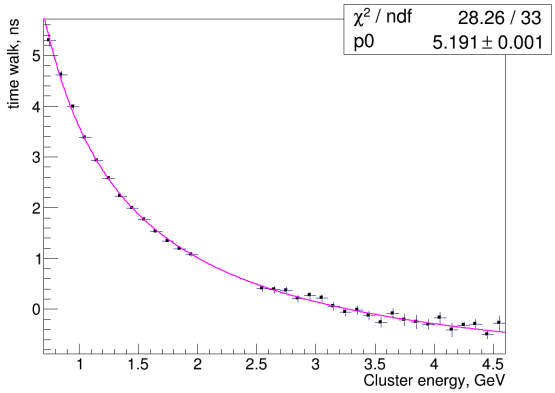

Figure 9: Dependence between time difference and cluster energy

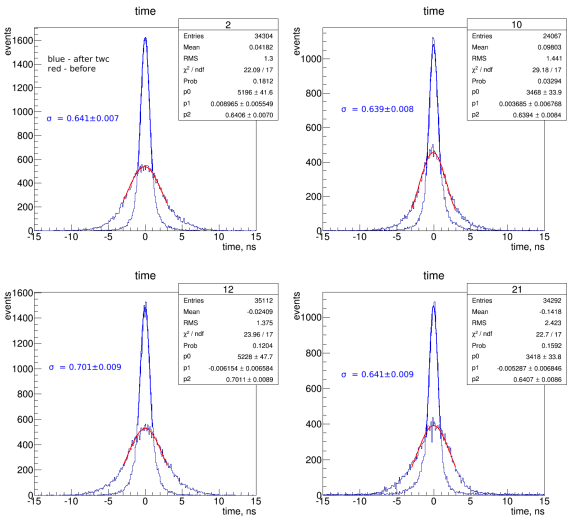

Figure 10: Time diff between two gammas for π^0 events with(blue)/without(red) time walk correction and group TDC calibration

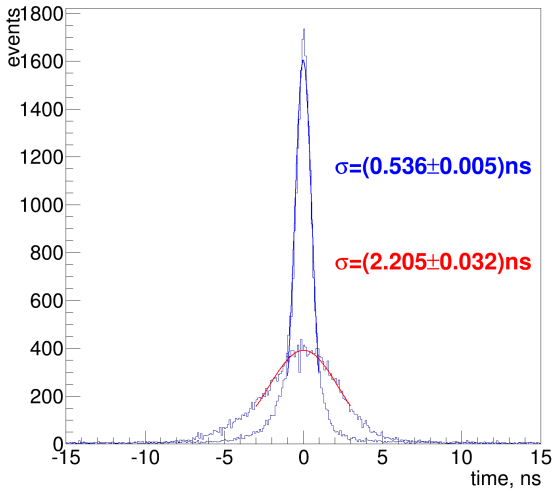

Figure 11: Time diff between two gammas for π^0 events with(blue) with time walk correction and individual and group TDC calibration, red - without everything

5 Individual modules alignment

Next step was to find alignment for individual modules. Procedure was the same as we have been using to move peaks to zero position (see section 3). But now we are doing same iterations for each module. We excluded modules near the beam hole - behind absorber (# 1526-1529, #1560,#1563, #1594, #1597, #1628-1631) which have too small statistics. Also we exclude module #1690 which has dead dynode[2]. Final result of all aligments (group, time walk correction, individual) presents on Fig. 11. Resolution was improved to 0.5-0.64 ns for both gammas (see Tab #1).Time resolution for each group TDC also droped and is about 0.35-0.5 ns (which can also be interpretated as HYCAL time resolution).

6 Conclusion

We found fine alignment constants for all group TDCs in PWO and described time walk correction function. The following information was written to PrimEx data base:
1) hycaltgroup_numb[id] - number of TDC group;
2) hycaltgroup_mean[id] - alignment for each module (for crystall only);
3) hycaltgroup_stat[id] - status for each module (for crystall only).
Function tmachClusters.cc added to reconstruction analysis data. It's output value meaning:
0 - all is ok;

1 - we don't have information from group TDC totally;
2 - one of two pi0 cluster has id with no information from group TDC;
3 - dead modules.

References

[1] Private communications with Ilya Larin

[2] https://www.jlab.org/primex/subsystems/electronics/hycal_groups/index.php

[3] Victor Tarasov, Hycal Trigger Efficiency, **Primex note #73**, August 2013