EXL detector in E744

Rux,Cri,Giu,Jar

2018/05/18-22

Abstract

Run 302 and 339 contain the 60Co calibration. Run 347 contains the background overnight.

Mechanical setup

The EXL detector comprises from 18 crystals in total, that are organized in pairs. Each crystal pair has a common pair of PMs. The PM come from **Photohis** XP14D5. There are no details on Photonis web now, however the information persists on internet.

Crystals The CsI crystal pair has a trapezoidal shape with 2.81°, 110mm long, faces 415mm^2 and 718mm^2[lefebvre]

Photomultiplier (PM) XP14D5 has two photocathodes that are behind the (probably) quartz glass of a (probable) thickness from 1mm (nearest) to 3mm (deep middle). These numbers come from a Hammamatsu drawing on the right panel. Also Peyre [peyre2008], who worked with these PMs claims the glass thicknesses 2-3mm for different types. The crystals are glued to the PM, the glue thickness is probably inferior to the quartz glass.

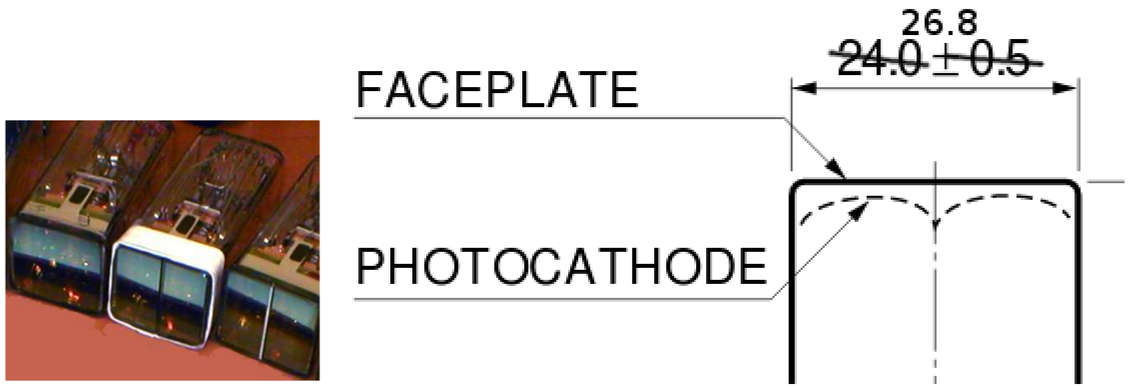

Figure 1: XP14D5

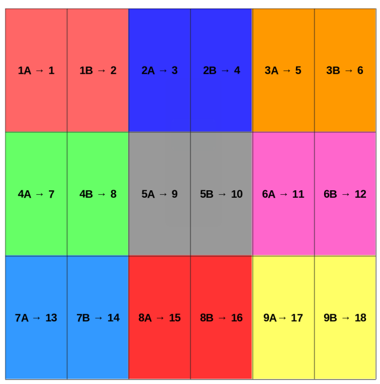

Figure 2: EXL crystals

Collection effects

From the setup, it is evident, there are actually two (at least) effects that influence the measurement this crystal setup. **Energy sharing** (we mean a standard situation, where the energy of the gamma is deposited into two neighbouring crystals.) and **Light leak**.

Light leak

The crystal pairs (1-2, 3-4, 5-6, ... , 17-18) have few milimeters of a common quartz glass and thus some light from (the photon deposited in) one crystal can travel into the PM of the other crystal. This effect was studied in [zamora] and [peyre2008].

An interesting insight is found in Zamora theses[zamora].

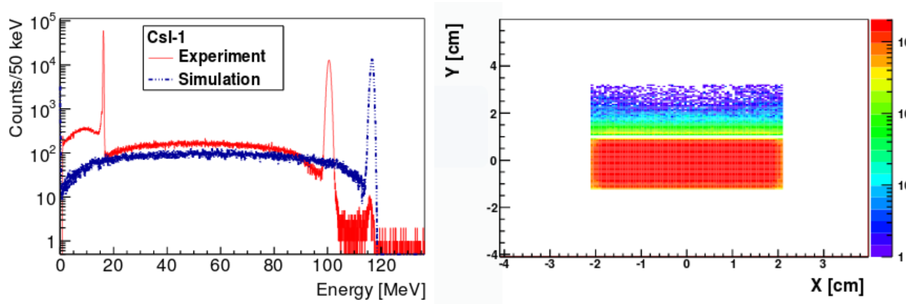

Figure 3: Zamora simulation (blue) and a real measurement (red) of energy deposition (120 MeV protons). Left: a simulation of the light collection, when the energy is deposited ONLY in crystal 1 (at 0 cm on y-axis).

Zamora shows the leak effect on protons 130 MeV. Zamora was able to reproduce this effect in a simulation by manipulation of ADC signals (N?) by a matrix

$$\begin{pmatrix} N1' \\ N2' \end{pmatrix} = \begin{pmatrix} 1-\alpha & \alpha \\ \alpha & 1-\alpha \end{pmatrix} \begin{pmatrix} N1 \\ N2 \end{pmatrix}$$

where $\alpha$is a light cross-talk percentage. $\alpha = \frac{R}{1+R,}$, where R is the ratio of the two **experimental** peaks in the Zamora spectrum (15 Mev and 100 MeV).

Questions However, the details of Zamora are not 100% clear - the values are summarized in the following table:

Table 1: Zamora xtalk values

total light intensity leak - simulation	R- experimental ratio	α- calculated xtalk
0.02	0.15	0.13

Note: Zamora sees that the correlation between crystals are highly linear. And global gains were assumed to be the same (probably, see below).

Peyre findings

Peyre [peyre2008]studied the XTALK of this XP14D5 double PM in three settings. His point of view included also the GLOBAL GAIN G of the system (number of photoelectrons are translated to the signal PMT+charge preamp+shaper gains). **We hope** that the global gains (G1 and G2) in the pair of PM system in our case are the same an thus G1/G2 will be always =1. Actually, the same was assumed by Zamora.

Measurements Peyre crosstalk was measured from signals S (obviously) and he describes XTALK as the ration of number of photoelectrons NbPhE. Here is crosstalk from crystal 2 into crystal 1.

$\frac{NbPhE2}{NbPhE1} = \frac{S2}{S1} * \frac{G1}{G2}$

He supposes that the both crosstalks are similar (variation 12%). Averaging the both cases G1/G2 factor disappears.

Table 2: Peyre xtalk values

xtalk for 3mm glass	xtalk for 2mm glass	xtalk when saw line with Si present
0.09	0.08	0.04-0.06

Summary 1

The signal ratio of the light leak is estimated 13% in one 8-9% in the other study. Could be also affected by particle type. Every signal coming from CsI PM is lowered because of the light leak. The pairs might be compensated directly by addition.

E744 data

We have analyzed the run 302. In all PAIRS - we observe a similar bidimensional picture (triangle like) for PM-pair as Zamora [zamora] had with protons 120 MeV (not presented here).

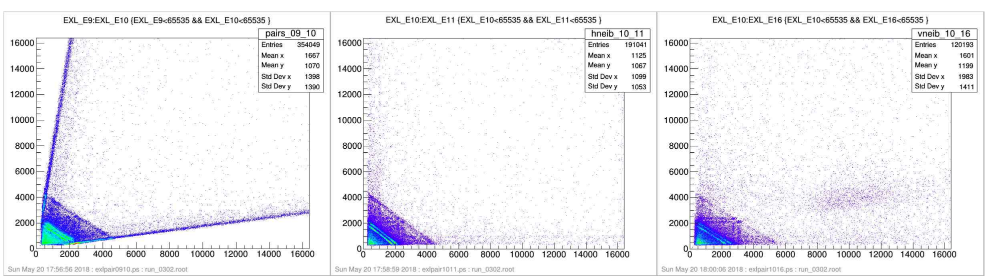

Figure 4: Run 302 - PM-Pair, horizontal neighbors and vertical neighbors. PM-pair has always the positive-slope lines, vertical neighbors have always a high energy dense area. As already discussed by Zamora, negative slope lines come from the energy sharing, the positive slope lines from light leak.

It is evident, that the **negative slope lines** are Compton-like events and true coincidences. The Comptons should be addbacked.

The **light leak** lines show that the leak is a constant fraction in all energies (at least in higher energies).

Single spectra vs. bidim - statistics loss in bidim\biggr)

The bidim spectra have 20% of events of the single spectra (300k vs. 1.4M) in run 302 and 50% (in later runs like 40.

Solution: Already before the experiment the validation is from OR EXL. This should read the energies for both PMs.

Two step calibration - step 1 - gain compensation

We know now, that the calibration done to singles do not really reflect the real gamma energies. But - at least it compensates the gains (see the mentioned G1/G2 ratio above - [peyre2008]). We did this "gain compensation" and that way new matrices (pairsCAL) PM-pairs were constructed - they look more rectangular. The 'positive slope' lines are much more similar for every PM-pair. We extracted the factor R - the signal leak ratio from the line's slopes.

Table 3: Experimental ratios - Rexp - signal leak from the EXL data run 302 - The values represent signal ratios

Rexp	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18
highline	0.14	0.18	0.15	0.16	0.18	0.1	0.15	0.08	0.17
lowline	0.16	0.15	0.14	0.15	0.15	0.23	0.16	0.42	0.16

The table sometimes shows HUGE differences like for the 11-12 pair. These Rexp contain GAINS.

Formulas Rexp are experimental ratios that also include Gains

R^{1exp}=$\mathrm{G}_2/G_1\mathrm{R}_1$

$R^{2exp} = G_1/G_2R_2$

$$\begin{pmatrix} Sig1 \\ Sig2' \end{pmatrix} = \begin{pmatrix} G1 & 0 \\ 0 & G2 \end{pmatrix} \begin{pmatrix} 1-\alpha & \alpha \\ \beta & 1-\beta \end{pmatrix} \begin{pmatrix} Ngamma1 \\ Ngamma2 \end{pmatrix} + \begin{pmatrix} Offs1 \\ Offs2 \end{pmatrix}$$

When alpha = beta we can deduce ratio G1/G2

$\mathrm{G}_1 = \sqrt{R2exp/R1exp}\mathrm{G2}$

We did that assumption and 7 matrices were compensated. The matrix 11-12 and 15-16 are terrible and it seems that alpha is different from beta.

If alpha differs from beta We have 4 parameters G1 G2 R1 R2 to determine and only 2 experimental values R1exp and R2exp.

For the pairs 1-2, 3-4, 5-6, 7-8, 9-10 and 13-14 $\alpha = \beta$, but this is does not looks to be the case for 11-12 and 15-16:R^{1exp} and R^{2exp} strongly differ in both cases (11% and 34%). Thereforeα andβ probably differ very much, that means that gains are really different. A way to correctly identify those two values must be found. A way could be to deduce the ratio $G_2/G_1$from the Compton, but how?????

In the end we still do not know the values for α and β, but **PROBABLY** I managed to find the correct values for R^1 and R^2in pairs 15-16 and 11-12: basically the in the first case amplification looks to be much higher in EXL 16 than in 15; and the values in the chart above must be reversed (at least like that it seems to work)...probably this is due to some high value of β. About 11 and 12, with R^{1exp}=0.16 and $R^{2exp} = 0.16$ the matrix looks much better. This is probably also due to some $\beta > \alpha$, but in this case the effect is less severe. My guess is that also in amplification there should be some catch that we do not know about, probably for those two cases $G_2 > G_1$, and this would eventually explain the behaviour of pair 15-16. Also the difference could be due to a different light leak between the two crystals, and that leads to different values for alpha and beta.

Summary 2

To summarize the previous:

1. Light leak compensation does not recover any events.

2. Light leak compensation recovers good energies in CsI, that are always recorded **partially**.

3. Three different cases are present in a matrix a) mtx of pairs, b) mtx of neighbors, c) singles

4. Pairs can get energy restored by adding both axes. Neighbors must be compensated using a coefficient, singles also.

5. Double counting should be avoided when adding the events from matrices to singles.

6. Everything can look nicer when trigger is MUST and validation is OR of CsI

Tests

The tests are in /home/e748/analysis/nptool/Projects/e744/Analysis/EXL_Analysis/Jaromir_tests

The code was created by t->MakeSelector("Selector")

This code is called by AutoTree->Process("Selector.C")

The analysis is done using root rootdir/run_302_0.root -b batch -q

References

[zamora] http://tuprints.ulb.tu-darmstadt.de/5263/1/Zamora_thesis_final.pdf; Appendix A, page 87

[lefebvre] https://tel.archives-ouvertes.fr/tel-00875639/file/VD2_LEFEBVRE_LAURENT_20092013.pdf; page 123, page 77

[peyre2006] Jean Peyre, Measurements of CsI crystals, R3B Presentation Milano Oct 2006 [peyre2008] Jean Peyre, Goeteborg R&D on calorimeters - presentation, https://www.slideserve.com/lorie/ipn-orsay-r-d-on-calorimeters-jean-peyr-g-teborg-october-2008, October 2008

[R3B] http://ipnwww.in2p3.fr/Exl_R3B?date=2018-03&lang=en