ALICE/TPC 98-47
Internal Note-TPC
11 Nov 1998

# Selection of preamplifier chips to be used for the ALICE TPC prototype.

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## Abstract

A batch of preamplifier dice for ALICE TPC prototype was tested by Dassault Electronics. The results of these tests are discussed. A subset of dice was selected to be mounted on the first two readout planes of the prototype. This selection was made to reduce channel-to-channel spread of detector response.

# 1 Introduction

A prototype of the Time Projection Chamber (TPC) for the ALICE experiment is under construction. It will be tested during data taking period of NA49 experiment [1]. The prototype TPC will incorporate the main features of a full-size detector. The readout elements, Ring Cathode Chambers (RCC), will be mounted on a multi-layer printed circuit board, on which also preamplifiers will be put. A preamplifier chip (integrating four channels in one silicon die) [2] is produced by Alcatel SdM in association with Harris Semiconductor. A die is then mounted on a PC board (called motherboard) by Dassault Electronics using TAB process. Preamplifiers will be then connected by 2 meters long coaxial cable of 0.5mm diameter (produced by AXON) to Analog-to-Digital Converters (Analog Devices AD9200). The readout system will be incorporated into a data taking system of the NA49 experiment.

The good performance of a TPC detector requires that all readout channels provide the same output signal for the same amount of charge in a readout chamber. In principle one can correct for any channel-to-channel differences using results of detector calibration. It is desirable that such corrections be small. Already during building of the detector one can minimize contribution to channel-to-channel non-uniformity corrections resulting from differences in gain of preamplifiers. The grouping of dice with similar gains in the same regions of detector can be done if dice characteristics are known before assembly of the readout plane. This is possible in the TAB process since all dice are tested after being put to tape and before mounting on a detector. When selecting dice it is necessary to remember that any additional work, however small, required from an industrial partner can be considered as an extension to a contract and may have to be paid for. The aim of this note is to present a selection of dice to be used for two motherboards with 144 dice each. The test procedure used by Dassault Electronics (DE) is shortly described in section 2, selection procedure for silicon dice for first two motherboards is presented in section 3 followed by conclusions in section 4.

# 2 Test procedure

The preamplifier dice arrive from manufacturer in batches (separately packed) called lots. Dice are put to tape by Dassault Electronics and tape is then cut to sections called slides. There are two dice per slide. Each die is identified by a lot number, a slide number and a letter A or B to identify position of a die on a slide. The following procedure is applied to each preamplifier channel separately. An amplifier bias voltage is adjusted until output level is within $1.6 - 1.8$V range. Both bias and output voltages are recorded. Then a rectangular pulse (600mV, 5kHz) passed through an attenuator and a RC circuit $(15\text{pF}, 50\Omega)$ is used as an input. Peak amplitude and full-width-at-half-maximum (FWHM) of the output pulse (shown in Fig. 1) are measured and recorded. To help with selection procedure Dassault Electronics provided, together with a written report, an EXCEL file with values of bias voltage, output level, peak amplitude and FWHM for each preamplifier channel. Non functioning dice, and dice with channels for which the peak amplitude lies outside a 50% limit put around mean value for the whole sample (or FWHM outside a 20% limit) were also marked out.

# 3 Selection of dice

There were 376 dice tested. Eight of them (listed in Table 1) did not work at all. For another 10 dice (listed in Table 2) a peak amplitude for all channels was smaller (below 130mV) then a mean value of 490mV for the rest of the sample. These 18 dice were considered non-functioning and will not be used. The distributions of peak amplitude, FWHM, their product (an estimation of total charge Q at the preamplifier output) as well as the peak amplitude and FWHM correlation plot are shown in Figure 2 for 358 functioning dice. Two types of preamplifiers can be distinguished: the first (class A) has a peak amplitude smaller than 500mV and the second (class B) bigger than 500mV. In Table 3 total number of dice per lot, number of dice with all 4 preamplifiers in class A and number of dice with all 4 preamplifiers in class B are shown for every lot.

A selection of dice should be easy to apply in an industrial environment. Therefore selection resulting in picking-up dice scattered between different lots is excluded.

## 3.1 Selection I

From Table 3 one can see, that there are lots with all preamplifiers either in class A or class B. There is not enough dice in either of two classes to equip two boards of 144 dice each. One of two boards can be equipped with dice from class A. For a second board the mixture of dice from two classes has to be used. Readout boards span over two parts of the field-cage of the TPC prototype and one can try to obtain uniformity within half of a readout board (72 dice). For one half of the second board, dice from lots with preamplifiers mostly in class A can be used, while for the second half chips from class B can be mounted.

The first proposal (selection I) of grouping of dice to be mounted on first two motherboards is given in Tables 4,5,6. It is assumed that all non-functioning dice (listed in Tables 1,2) have been already removed from lots but out-of-tolerance dice had to be mounted.

The distributions of peak amplitude, FWHM, their product as well as peak amplitude and FWHM correlation plot are shown in Figures 3,4,5 for the first board and two parts of the second board respectively. The relative spreads for the peak amplitude, FWHM and their products are given in Table 7 for all dice and subsets listed in Tables 4,5,6.

### 3.2 Final selection

The relatively broad distribution of FWHM for second part of the second motherboard (cf. Figure 5 and Table 7) is mostly due to dice already marked as out-of-specification by Dassault Electronics. It was possible to remove these dice from the sample before mounting on the motherboard at no extra cost. The list of out-of-specification dice is given in a Table 8. The selection described in Section 3.1 was then modified by adding dice from lot 3 to fill up the numbers and slightly rearranging the dice on the motherboards. The selected dice are listed in Tables 9,10,11. The splitting of lot 3 between two parts of the motherboard is natural for the placing procedure, where dice are put in two lines perpendicular to the test beam direction, which is the division line for two parts of the motherboard. The only additional complication is skipping two slides (8 and 9) in lot 3 and placing first die of lot 1 as the last one of the first motherboard. This was found acceptable by DE.

The distributions of peak amplitude, FWHM, their product as well as peak and FWHM correlation plot are shown in Figures 6,7,8 for first board and two parts of second board respectively. The relative spreads for a peak amplitude, FWHM and their products are given in Table 12.

## 4 Conclusions

The procedure of testing preamplifier dice used by Dassault Electronics was described. The DE provided test results for 376 chips. The selection of subset of this sample to be used for the first two readout planes of the ALICE TPC prototype (Tables 9,10,11) and expected spread between the channels (Table 12) were presented. The list of selected dice has been sent to Dassault Electronics.

## References

[1] J.Bächler et al., CERN/SPSC 98-4,CERN/SPSLC/P264 Add. 2.

[2] designed by J-C.Legrand (CERN).

Table 1: List of non-working dice.

| Lot | Slide | Die |
|---|---|---|
| 1 | 7 | A |
| 1 | 7 | B |
| 3 | 6 | A |
| 3 | 6 | B |
| 9 | 8 | A |
| 9 | 8 | B |
| 11 | 5 | A |
| 11 | 5 | B |

Table 2: List of dice with an output amplitude below 25% of the average over all dice.

| Lot | Slide | Die |
|---|---|---|
| 1 | 12 | A |
| 1 | 18 | B |
| 2 | 17 | A |
| 8 | 15 | B |
| 9 | 13 | A |
| 10 | 12 | A |
| 11 | 11 | A |
| 13 | 7 | B |
| 14 | 2 | B |
| 15 | 3 | B |

Table 3: Number of dice in class A (peak amplitude smaller than 500mV for all channels on a die) and class B (all channels with peak amplitude bigger than 500mV) for different lots.

| Lot | Total | Class A | Class B |
|---|---|---|---|
| 1 | 30 | 27 | 1 |
| 2 | 35 | 35 | 0 |
| 3 | 30 | 10 | 19 |
| 4 | 32 | 2 | 30 |
| 5 | 28 | 0 | 28 |
| 6 | 26 | 4 | 21 |
| 7 | 24 | 24 | 0 |
| 8 | 29 | 29 | 0 |
| 9 | 23 | 23 | 0 |
| 10 | 23 | 23 | 0 |
| 11 | 19 | 0 | 19 |
| 12 | 16 | 16 | 0 |
| 13 | 13 | 13 | 0 |
| 14 | 7 | 7 | 0 |
| 15 | 5 | 5 | 0 |
| 16 | 18 | 12 | 4 |

Table 4: List of dice to be used for the first readout plane according to selection I.

| Lot | Slides | Dice | Number of dice |
|---|---|---|---|
| 2 | All | All | 35 |
| 8 | All | All | 29 |
| 9 | All | All | 23 |
| 10 | All | All | 23 |
| 12 | All | All | 16 |
| 13 | All | All | 13 |
| 15 | All | All | 5 |
| | | Total | 144 |

Table 5: List of dice to be used for the 1st part of the second readout plane according to selection I.

| Lot | Slides | Die(ce) | Number of dice |
|---|---|---|---|
| 1 | All | All | 30 |
| 7 | All | All | 24 |
| 14 | All | All | 7 |
| 16 | 4-8 | All | 10 |
| 16 | 9 | A | 1 |
| | | Total | 72 |

Table 6: List of dice to be used for the 2nd part of second readout plane according to selection I.

| Lot | Slides | Die(ce) | Number of dice |
|---|---|---|---|
| 4 | 3-14 | All | 24 |
| 4 | 15 | A | 1 |
| 5 | All | All | 28 |
| 11 | All | All | 19 |
| | | Total | 72 |

Table 7: Relative spreads for pulse amplitude (A), FWHM and their product (Q) for all dice and those selected in selection I for readout of the TPC prototype.

| Dice selection | $\sigma(A)/A[\%]$ | $\sigma(FWHM)/FWHM[\%]$ | $\sigma(Q)/Q[\%]$ |
|---|---|---|---|
| all | 12.3 | 11.6 | 23.2 |
| 1st board | 4.2 | 4.6 | 6.0 |
| 2nd board part 1 | 6.1 | 6.8 | 11.1 |
| 2nd board part 2 | 5.5 | 12.0 | 14.5 |

Table 8: List of dice out-of-specification defined by ±50% around mean peak amplitude and ±20% around mean FWHM.

| Lot | Slide | Die |
|---|---|---|
| 3 | 7 | A |
| 3 | 14 | B |
| 3 | 15 | A |
| 4 | 9 | B |
| 4 | 10 | B |
| 4 | 13 | B |
| 4 | 14 | B |
| 4 | 15 | B |
| 4 | 16 | A |
| 5 | 5 | B |
| 5 | 8 | A |
| 5 | 9 | B |
| 5 | 10 | B |
| 5 | 12 | B |
| 5 | 13 | B |
| 5 | 14 | B |
| 5 | 15 | B |
| 6 | 6 | B |
| 6 | 9 | B |
| 6 | 10 | B |
| 6 | 13 | B |
| 11 | 1 | B |
| 11 | 2 | A |
| 11 | 6 | A |
| 11 | 9 | B |
| 11 | 11 | B |
| 12 | 87 | A |
| 16 | 1 | A |

Table 9: List of dice to be used for the first readout plane according to final selection.

| Lot | Slides | Dice | Number of dice |
|---|---|---|---|
| 1 | 1 | A | 1 |
| 2 | All | All | 35 |
| 8 | All | All | 29 |
| 9 | All | All | 23 |
| 10 | All | All | 23 |
| 12 | All | All | 15 |
| 13 | All | All | 13 |
| 15 | All | All | 5 |
| | | Total | 144 |

Table 10: List of dice to be used for the 1st part of the second readout plane according to final selection.

| Lot | Slides | Die(ce) | Number of dice |
|---|---|---|---|
| 1 | 1 | B | 1 |
| 1 | 2-18 | All | 28 |
| 3 | 11 | B | 1 |
| 7 | All | All | 24 |
| 14 | All | All | 7 |
| 16 | 4-8 | All | 10 |
| 16 | 9 | A | 1 |
| | | Total | 72 |

Table 11: List of dice to be used for the 2nd part of the second readout plane according to final selection.

| Lot | Slides | Die(ce) | Number of dice |
|---|---|---|---|
| 3 | 1- 7 | All | 9 |
| 3 | 10 | All | 2 |
| 3 | 11 | A | 1 |
| 4 | All | All | 26 |
| 5 | All | All | 20 |
| 11 | All | All | 14 |
| | | Total | 72 |

Table 12: Relative spreads for pulse amplitude (A), FWHM and their product (Q) for dice selected for readout of the TPC prototype (final selection).

| Dice selection | $\sigma(A)/A[\%]$ | $\sigma(FWHM)/FWHM[\%]$ | $\sigma(Q)/Q[\%]$ |
|---|---|---|---|
| 1st board | 4.2 | 4.5 | 5.9 |
| 2nd board part 1 | 6.2 | 7.0 | 11.6 |
| 2nd board part 2 | 6.7 | 7.0 | 10.7 |

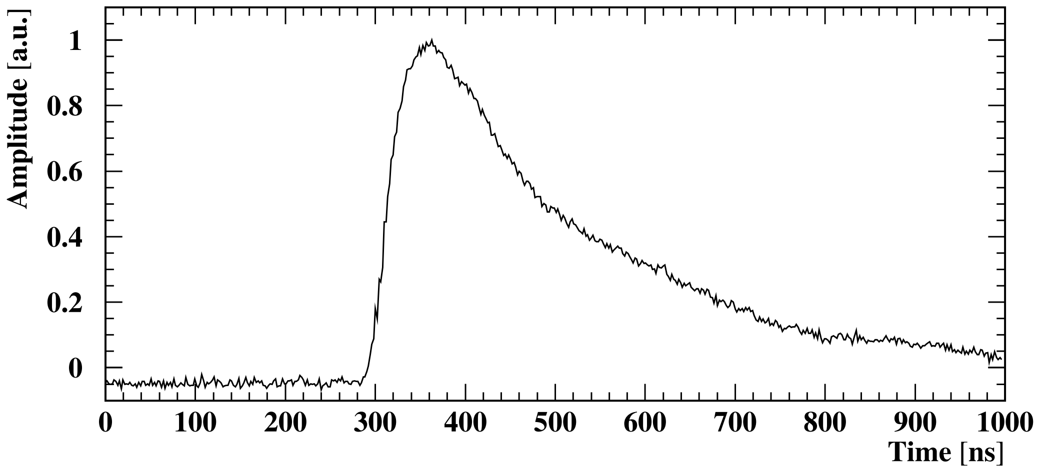


Figure 1: The pulse shape of a typical preamplifier output.

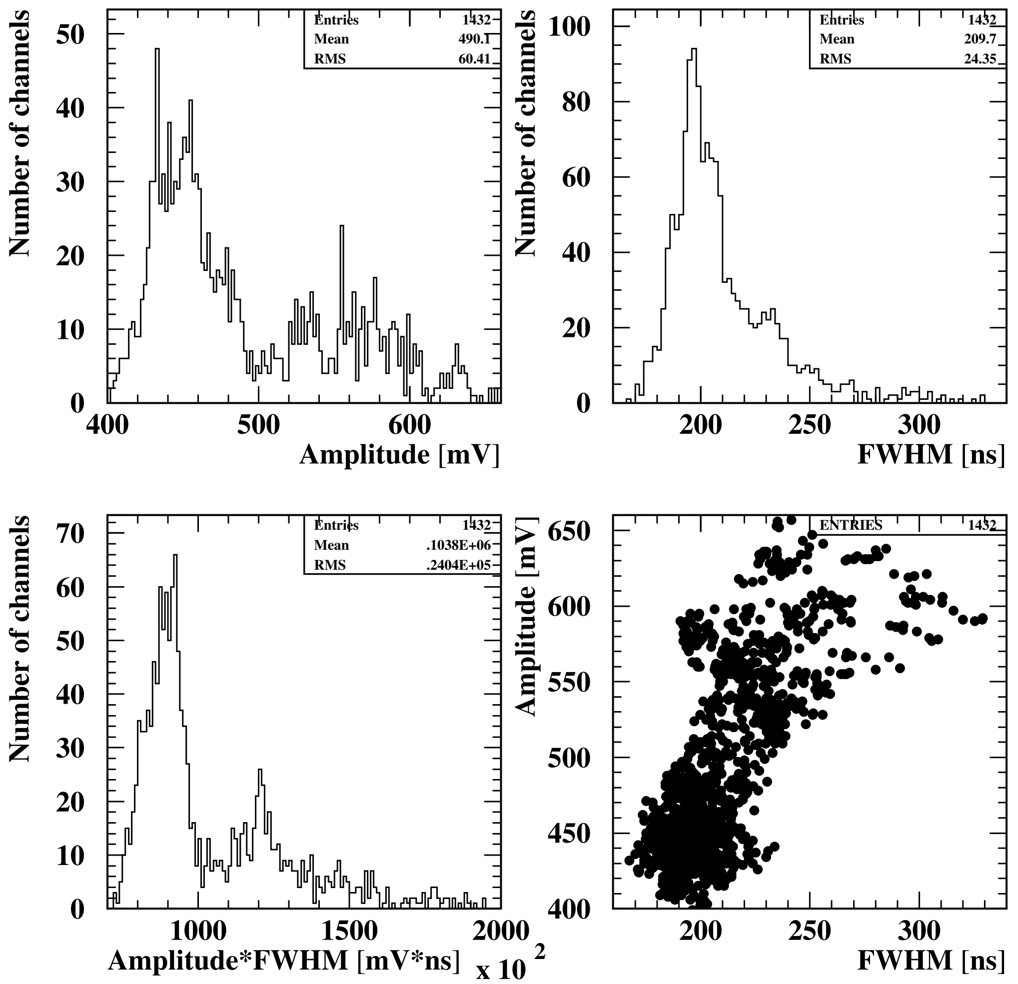


Figure 2: The distributions of pulse amplitudes, FWHM and charges at the preamplifier output for all functioning dice.

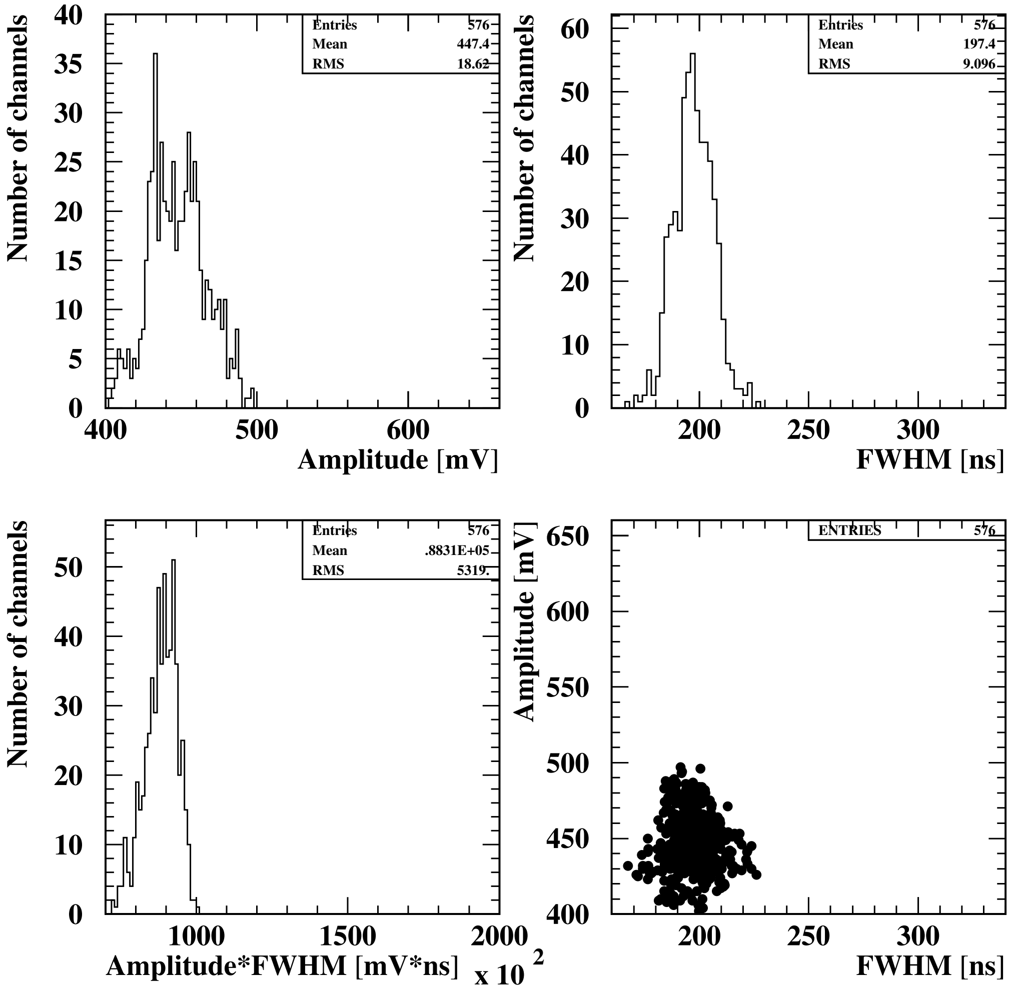


Figure 3: The distributions of pulse amplitudes, FWHM and charges at the preamplifier output for dice chosen in selection I for the first motherboard (see Table 4).

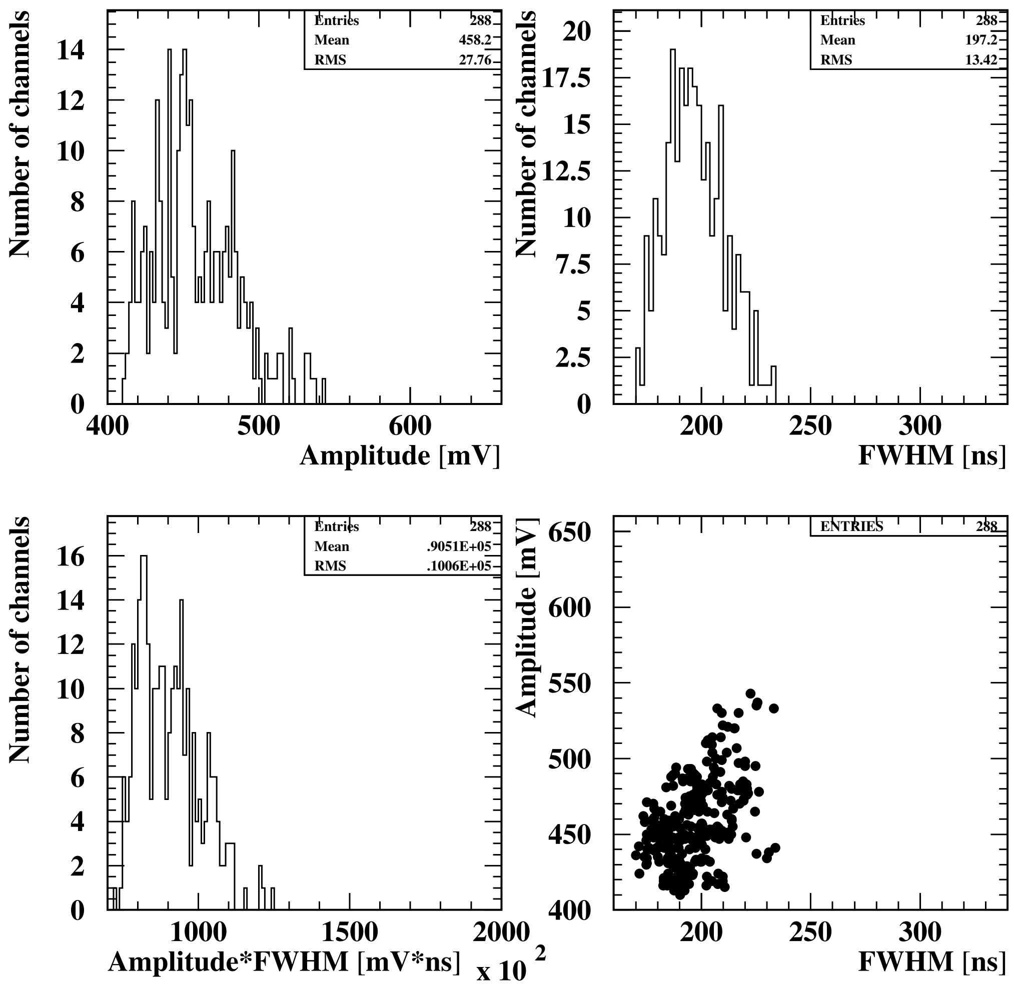


Figure 4: The distributions of pulse amplitudes, FWHM and charges at the preamplifier output for dice chosen in selection I for the 1st part of the second motherboard (see Table 5).

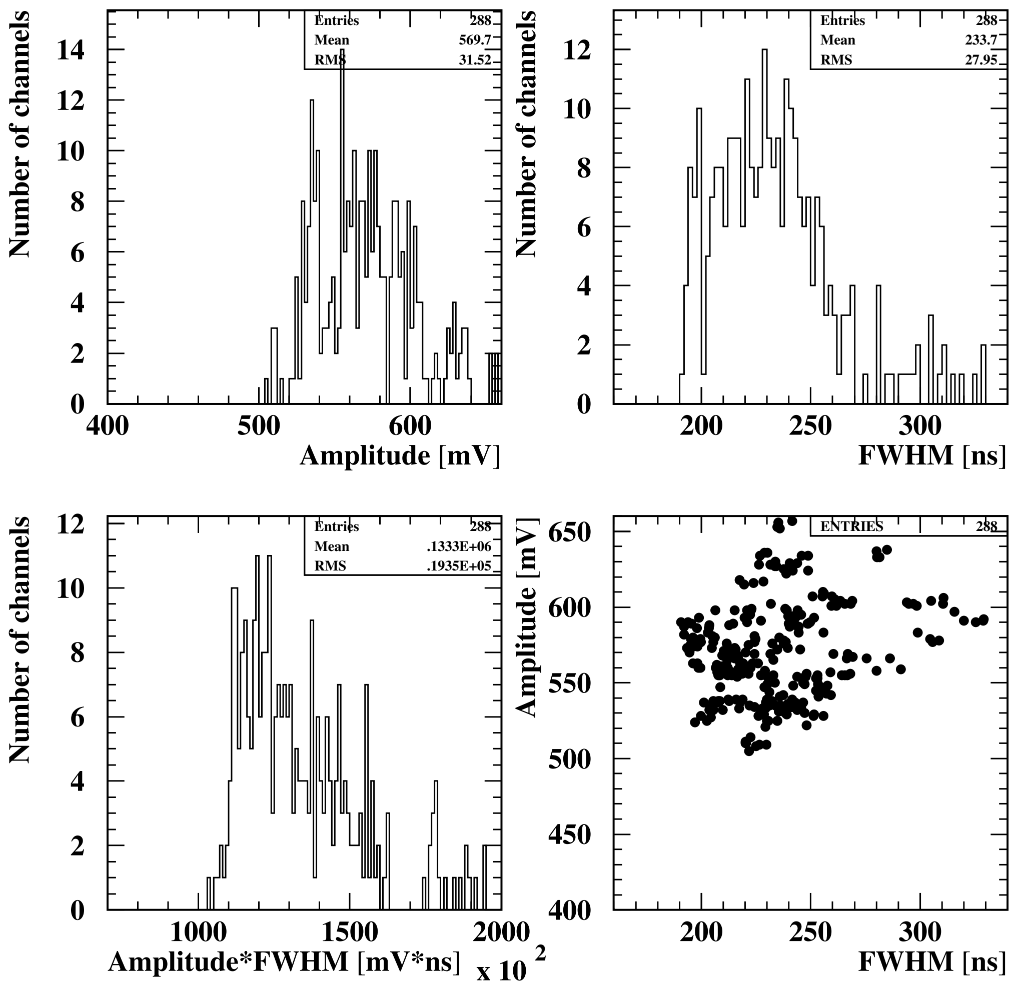


Figure 5: The distributions of pulse amplitudes, FWHM and charges at the preamplifier output for dice chosen in selection I for the 2nd part of the second motherboard (see Table 6).

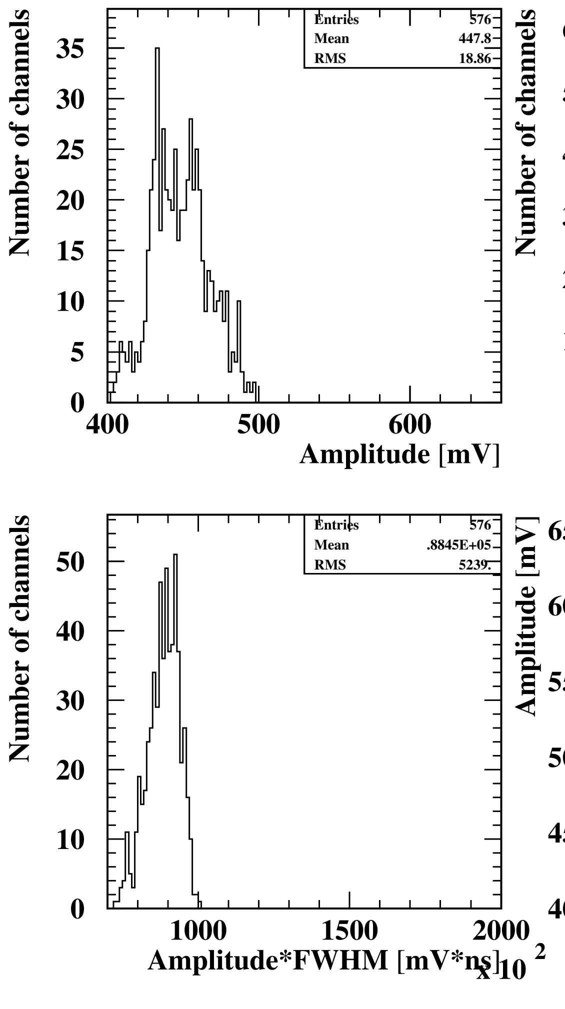


Figure 6: The distributions of pulse amplitudes, FWHM and charges at the preamplifier output for dice finally selected for the first motherboard (see Table 9).

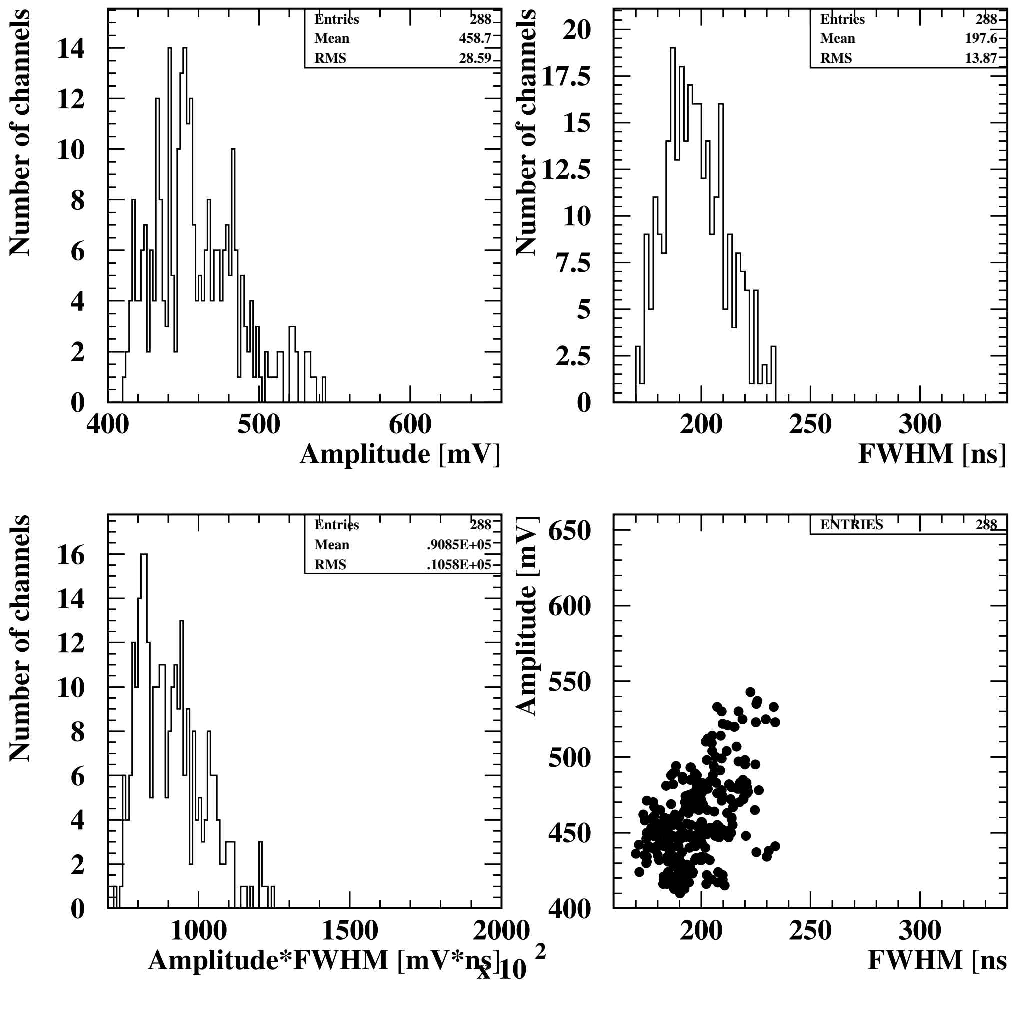


Figure 7: The distributions of pulse amplitudes, FWHM and charges at the preamplifier output for dice finally selected for the 1st part of the second motherboard (see Table 10).

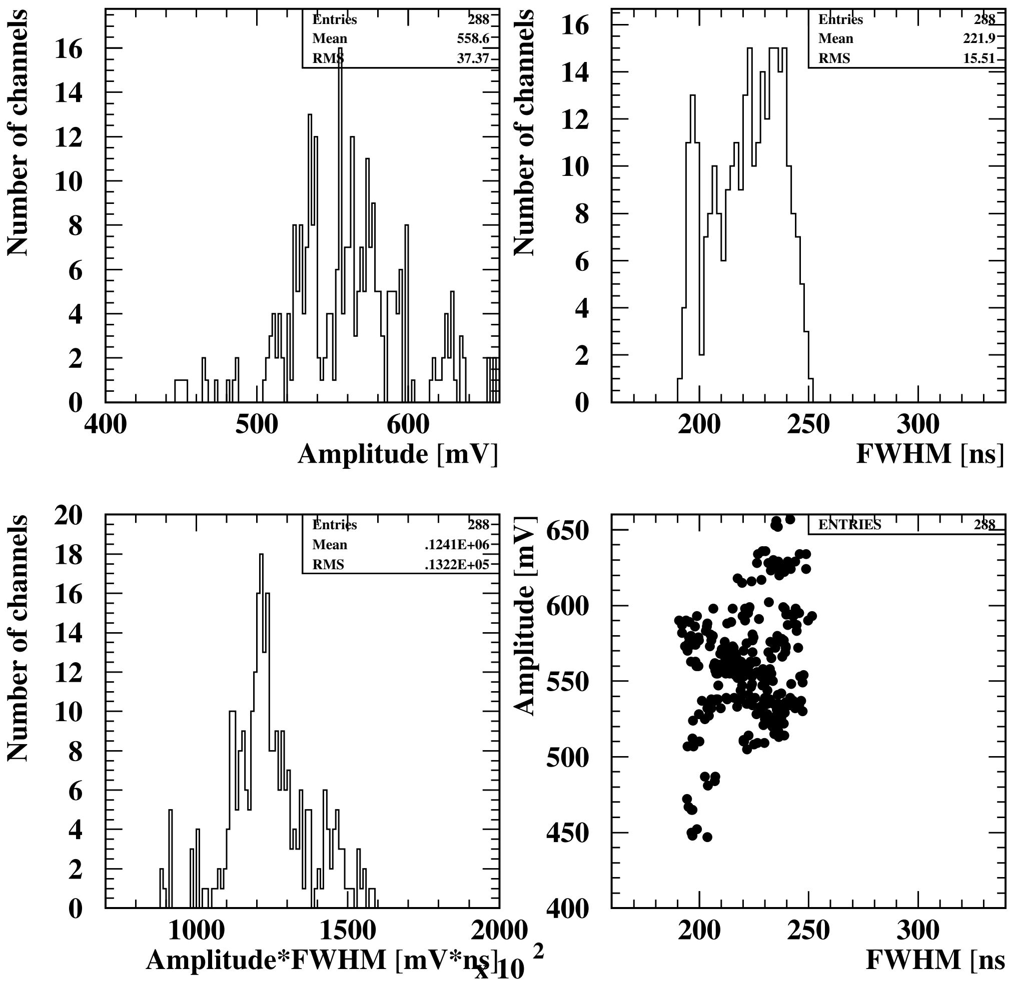


Figure 8: The distributions of pulse amplitudes, FWHM and charges at a preamplifier output for dice finally selected for 2nd part of the second motherboard (see Table 11).