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Study of test results for preamplifiers for the TPC prototype for ALICE.

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Abstract

The test procedure for silicon dies used by Dassault Electronics is described. The results of tests performed by industry on 84 prototype silicon dies are discussed.

1 Introduction

One of the milestones in the design and construction of the large Time Projection Chamber (TPC) for the ALICE experiment is a smaller-scale prototype detector. It will be used as forward TPC of the NA49 experiment running on the proton and ion beams at CERN[1]. The prototype TPC is designed to incorporate main features of the full-size detector. The readout elements, Ring Cathode Chambers (RCC), will be mounted on a multilayer printed circuit board, on which preamplifiers will be put. The preamplifier chip (integrating four channels in one silicon die) [2] is produced by Alcatel SdM in association with Harris Semiconductor. The die is then mounted on a PC board by Dassault Electronics using the TAB process.

It is imperative to keep the cost of production as low as possible without jeopardising the quality of the product. Some reduction in overall cost can be achieved through taking away some tasks from industry and performing them in laboratories participating in the TPC project. One of such tasks is testing and selection of silicon dies before placing them on printed circuit boards. In addition to reducing the production costs this would allow us to use a more extensive definition of the performance parameters and to base selection criteria on statistical analysis of quality of large samples of dies. The selection criteria could be, if necessary, adjusted during the production process to keep acceptable yield with sufficient quality. This have advantages in comparison with (the cheapest) simple industrial Go-No Go test in which the basic performance parameters of dies are compared to values defined well in advance of production and the rejection decision is taken immediately after a particular die has been tested.

The construction of the TPC prototype provides a good opportunity to check the feasibility of the quality control in collaboration with industry. The first step would be to have the tests performed by Dassault Electronics with an already existing setup and analysis of results done at CERN. In this note the analysis of results of tests of a prototype series of dies provided by Dassault Electronics is presented. The test procedure used by Dassault Electronics is shortly described in section 2, analysis of results in shown in section 3 followed by conclusions in section 4.

2 Test procedure

The preamplifier dies (with 4 channels each) are put to tape and the tape is then cut to sections called slides. There are two dies per slide identified by the slide number and a letter A or B to identify position of a die on a slide. Each channel of a die is tested separately. The input signal is a rectangular pulse (600mV, 5kHz) passed through an attenuator and a RC circuit ($15\text{pF}, 50\Omega$). The amplifier bias voltage is changed in 100 mV steps between -0.5V and 1.5V and the amplitude of the output pulse (shown in Fig. 1) is studied. The bias voltage corresponding to maximum amplitude of the output pulse is recorded, together with pulse amplitude, full-width-at-half-maximum (FWHM) and the information if oscillations were observed. The date and time of the measurement and input pulse parameters are also stored. The shape of output pulse is written to separate file.

3 Analysis of test results

The results of tests for 84 dies were provided by Dassault Electronics. One channel (die 19A channel 1) was not working correctly, the pulse amplitude being by a factor 10 smaller than for other dies. This die was excluded from further study. In addition, the bias voltage for two other channels (48A channel 2 and 41A channel 4) was not recorded properly and these two channels were also excluded. There were 330 preamplifier channels left.

The distributions of the pulse amplitude, FWHM, sum of charge at the preamplifier output (estimated by FWHM multiplied by a peak amplitude) and bias voltage are shown in Figure 2. The spread of 7% of the peak amplitude might have been smaller if the bias voltage adjustments were done to minimise the gain spread, not to maximise the gain for each channel. One can expect some systematic differences between different channels on the same die. The amplitude and FWHM distributions, separately for each of 4 channels, are presented in Figures 3 and 4 showing the spread of $\simeq 6\%$ and $\simeq 8\%$ respectively. However, for the total charge at the preamplifier output the systematic spread between the channels is smaller, $\simeq 3\%$ (cf. Figure 5). There is also possibility that some systematic differences due to position of a die on slide exist. The distributions of the amplitude, FWHM and charge for all channels for silicon dies A and B are shown in Figures 6, 7 and 8 as a function of channel number and position of a die on a slide.

4 Conclusions

The test methodology for preamplifier dies, as used by Dassault Electronics, was described. The analysis of the test results for 84 silicon dies suggested that:

- Instead of adjusting the bias voltage for highest gain one should attempt to obtain gain equilibration. This would require an adjustment of bias voltage to obtain the gain as given by the die with the lowest acceptable gain in the standard test and then repeating the procedure if necessary. The steps in bias voltage should be smaller, e.g. 20 mV. However, for the next version of the preamplifier chip, the bias voltage adjustment will not be necessary.

- The standard recording data format used by Dassault Electronics can be used as the exchange format between Dassault Electronics and CERN.

- There are small ($\simeq$ 3%) systematic differences between channels on a die. There is also an indication for some differences due to the die position on the TAB slide (available statistics is not sufficient). This however should not influence seriously the selection of the dies to be used for the TPC prototype and will be corrected for in the calibration of the electronics.

- The test procedure and analysis of results are manpower consuming and their contribution to the cost of the project are not negligible. Therefore performing (some of) these tasks in a laboratory participating in the TPC construction should be considered.

References

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

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

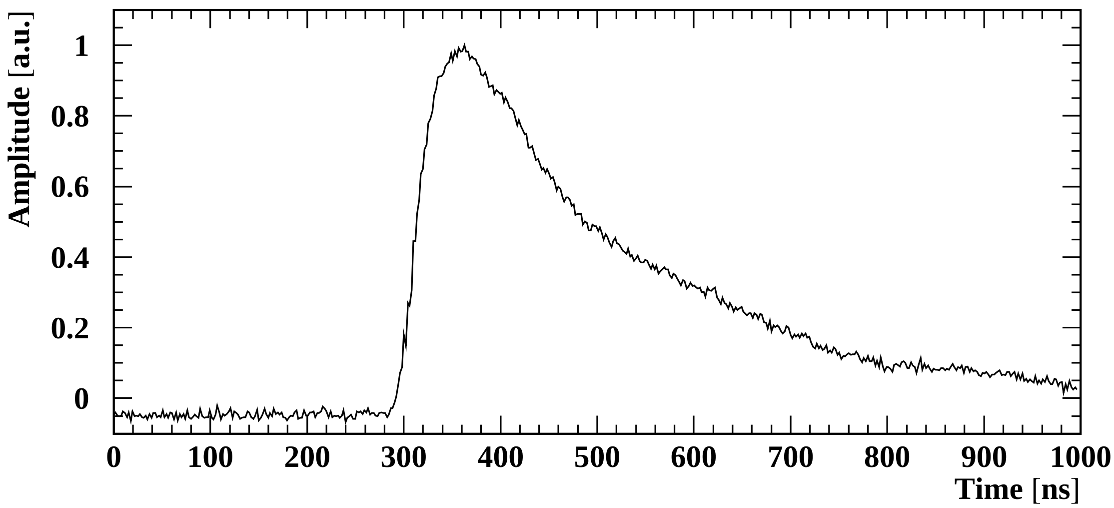

Figure 1: The example of the pulse shape at a preamplifier output, as measured by Dassault Electronics.

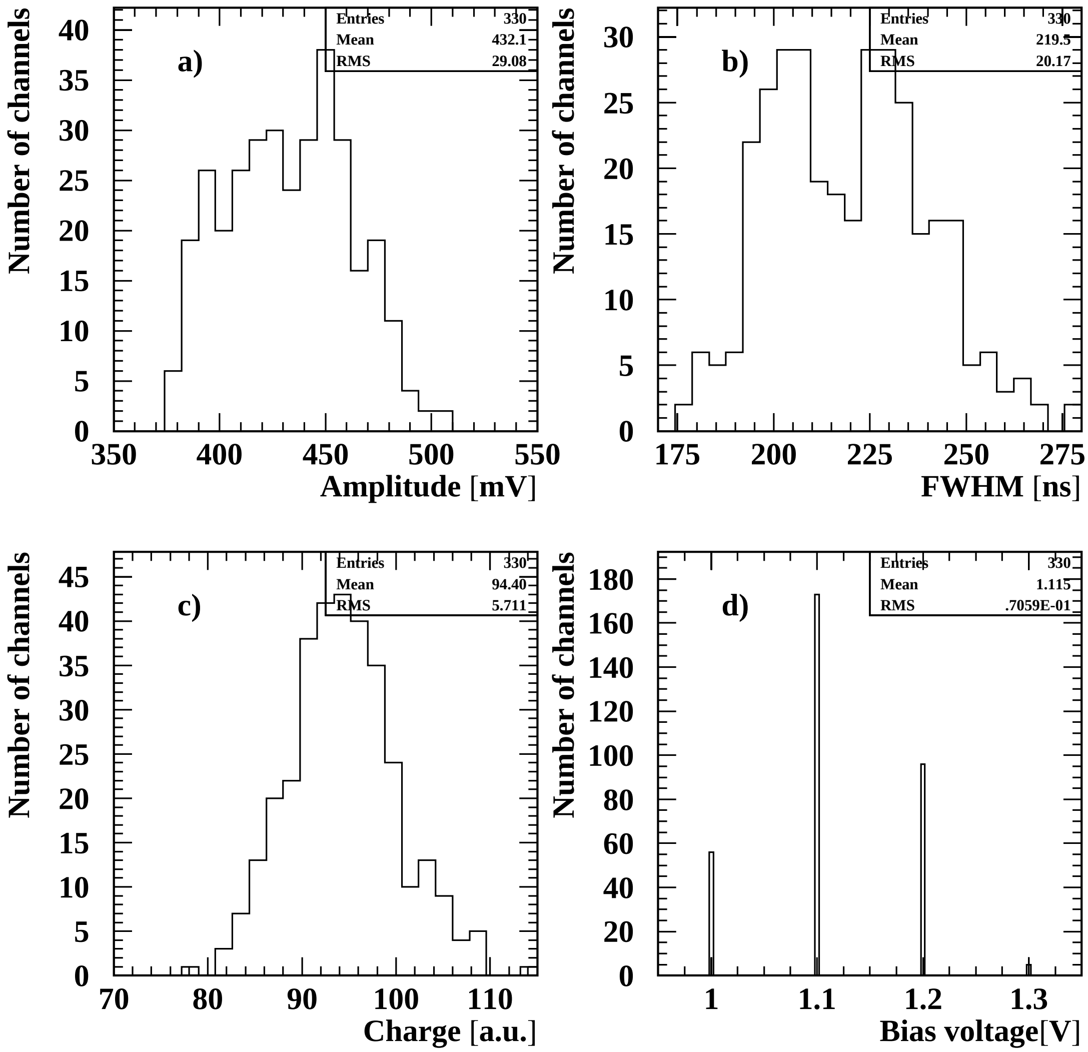

Figure 2: The distributions of pulse amplitude, FWHM and charge at the preamplifier output and bias voltage.

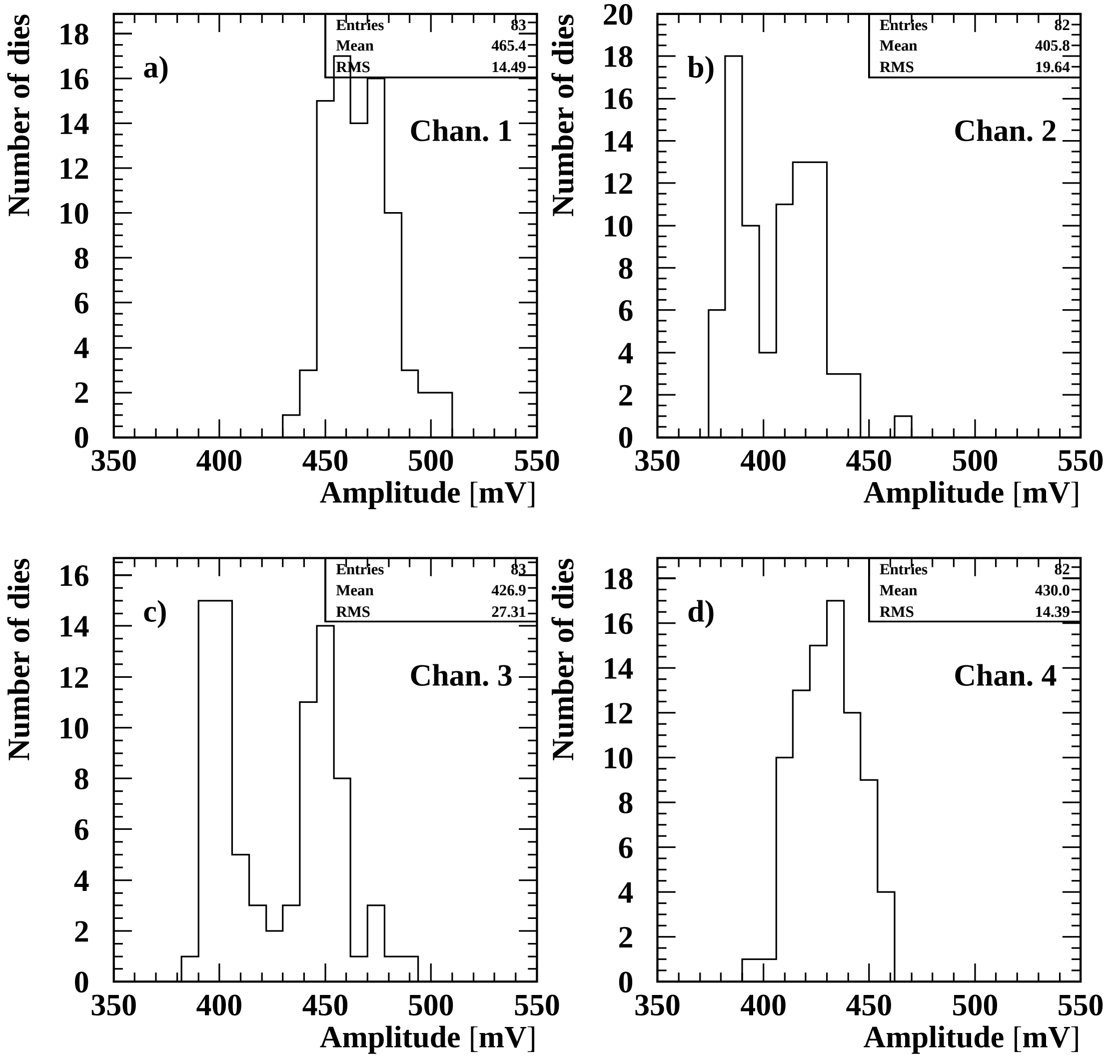

Figure 3: The distributions of amplitude of the pulse at the preamplifier output for different channels in silicon dies.

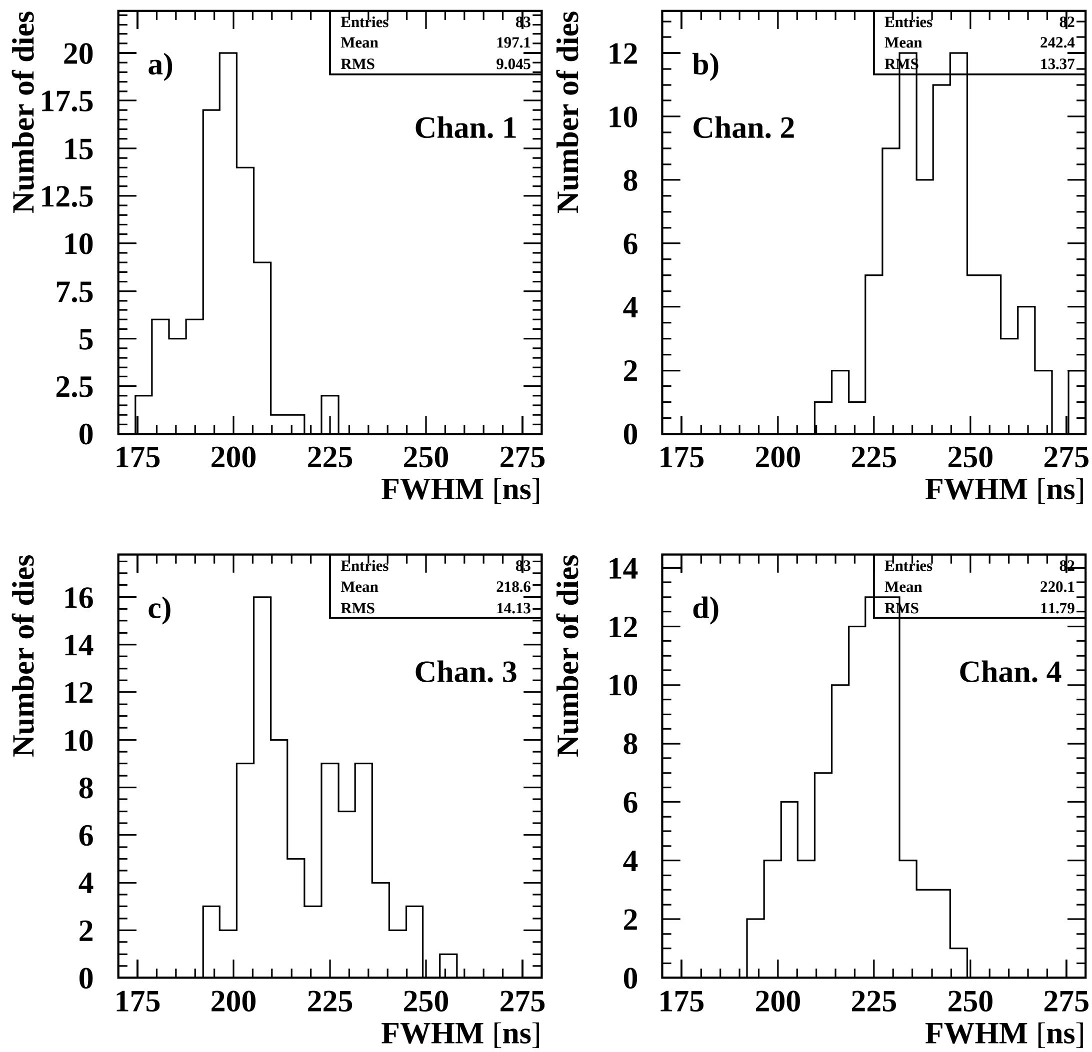

Figure 4: The distributions of FWHM of the pulse at the preamplifier output for different channels in silicon dies.

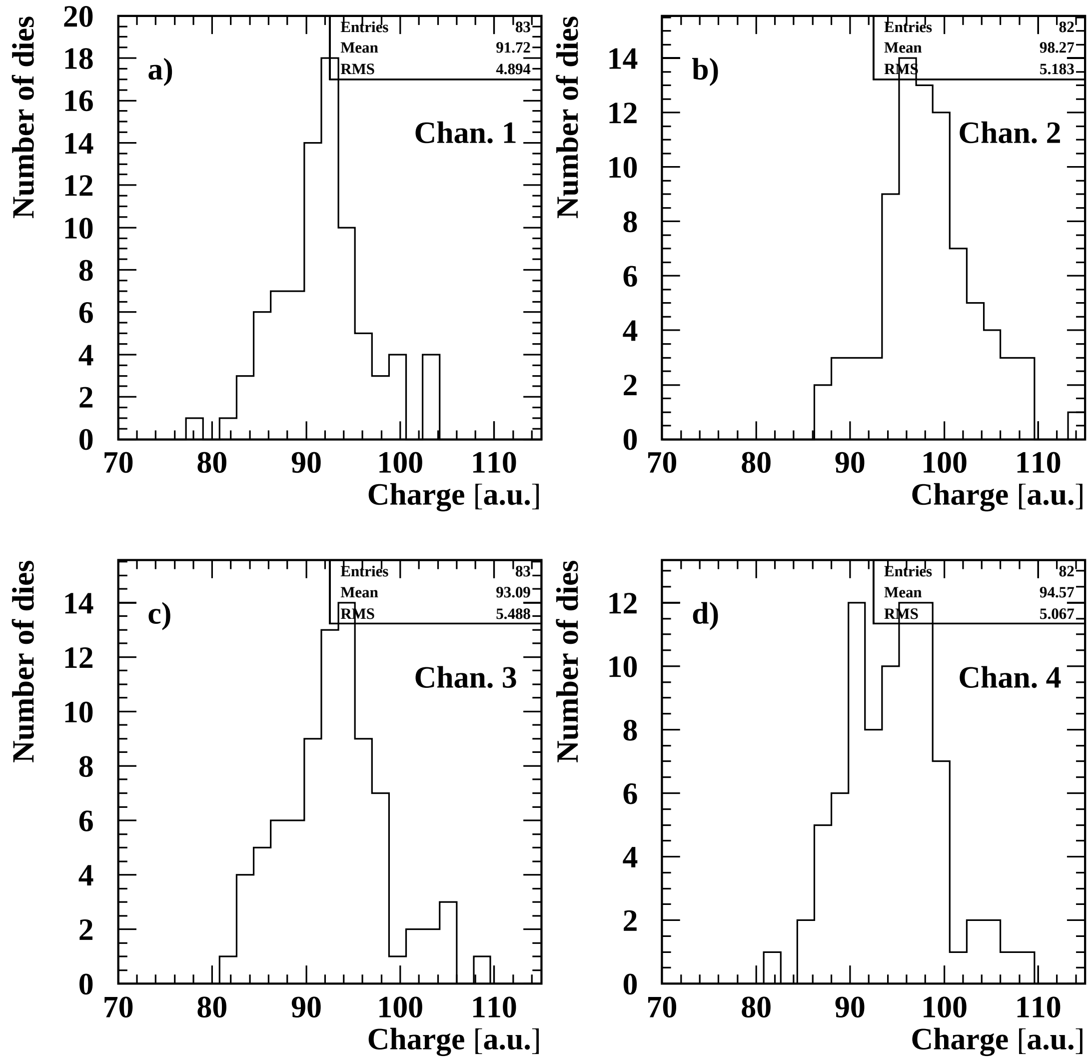

Figure 5: The distributions of charge at the preamplifier output for different channels in silicon die.

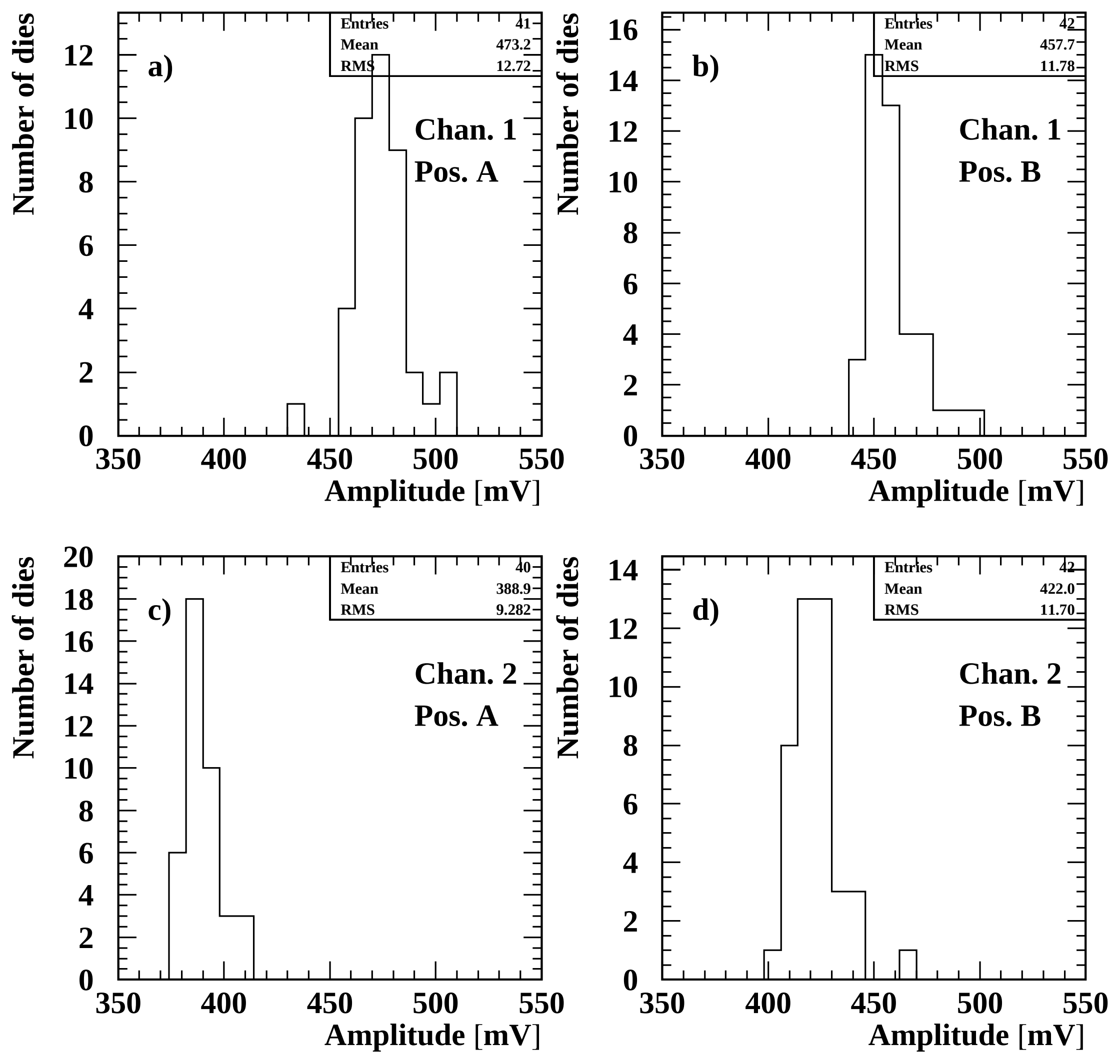

Figure 6: ad) The distributions of amplitude of the pulse at the preamplifier output for different channels in silicon die and the position of die on a TAB slide.

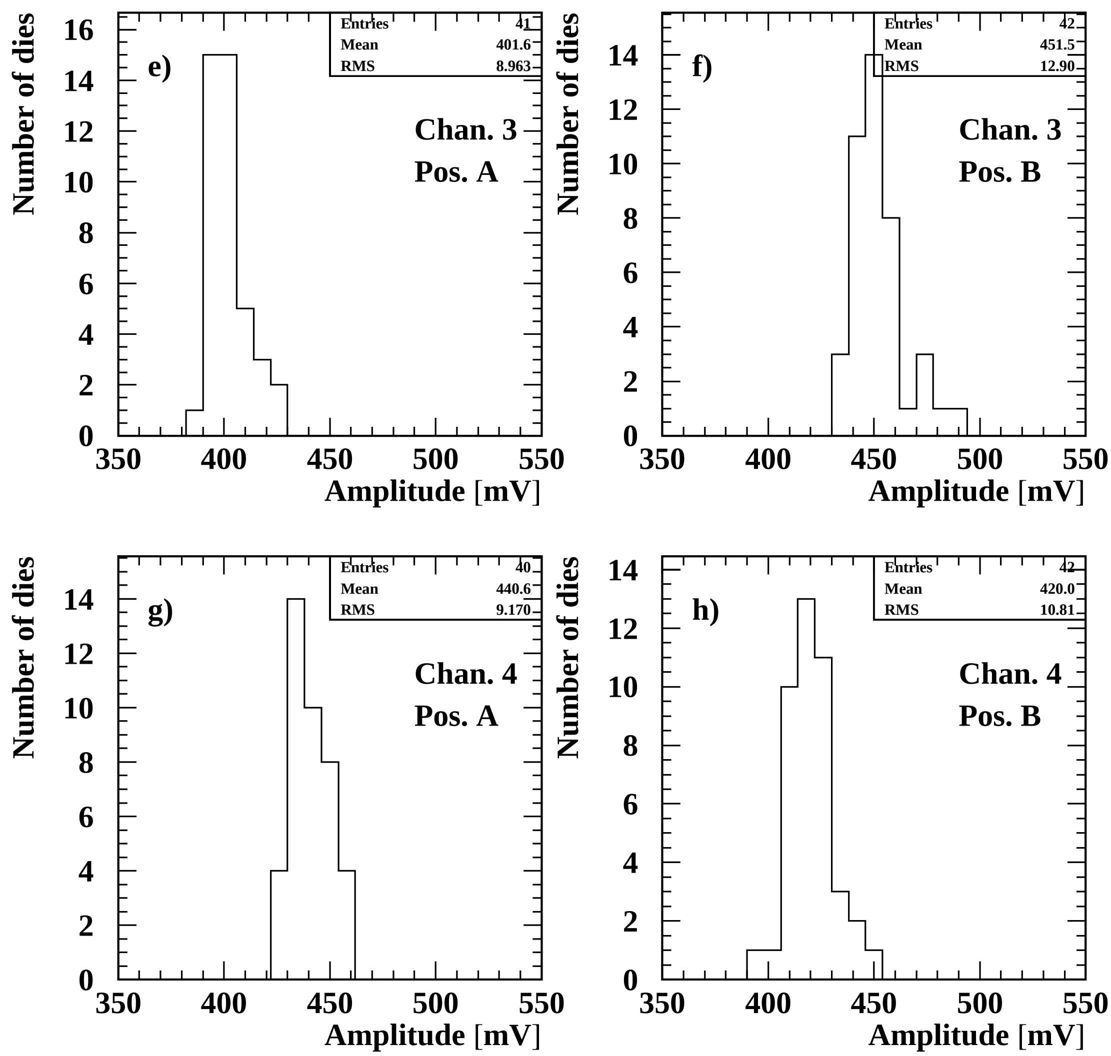

Figure 6: eh) The distributions of amplitude of the pulse at the preamplifier output for different channels in silicon die and the position of die on TAB slide.

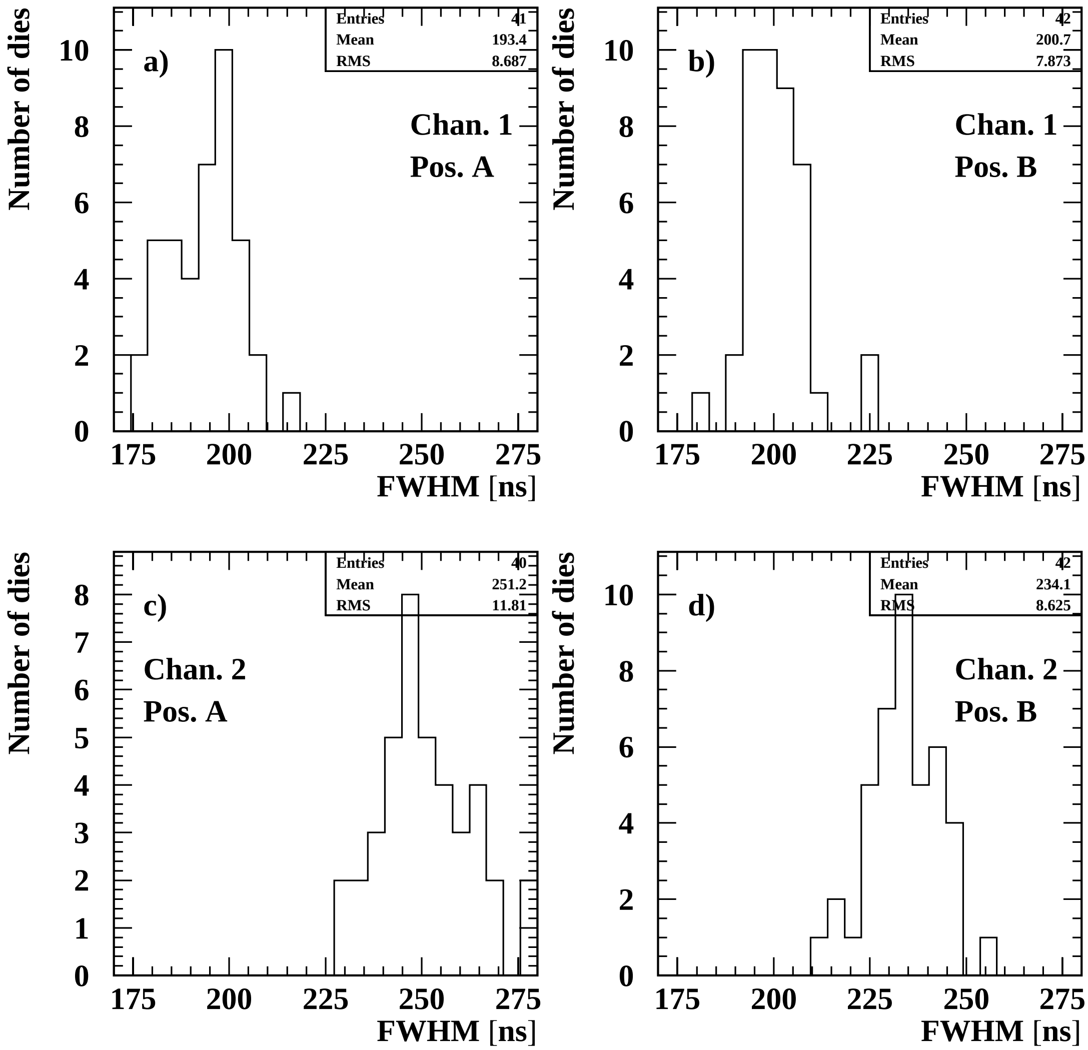

Figure 7: ad) The distributions of FWHM of the pulse at the preamplifier output for different channels in silicon die and the position of die on a TAB slide.

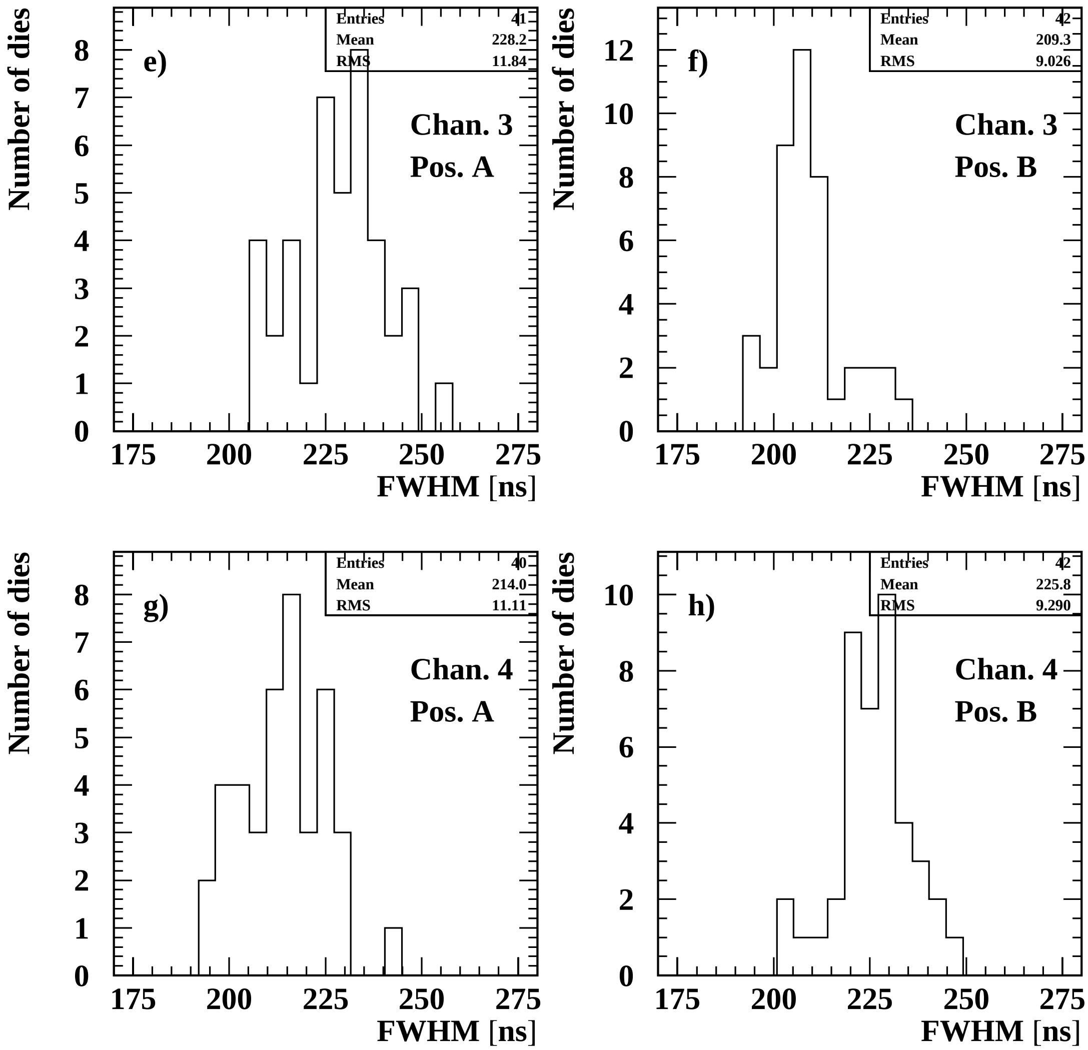

Figure 7: eh) The distributions of FWHM of the pulse at the preamplifier output for different channels in silicon die and the position of die on a TAB slide.

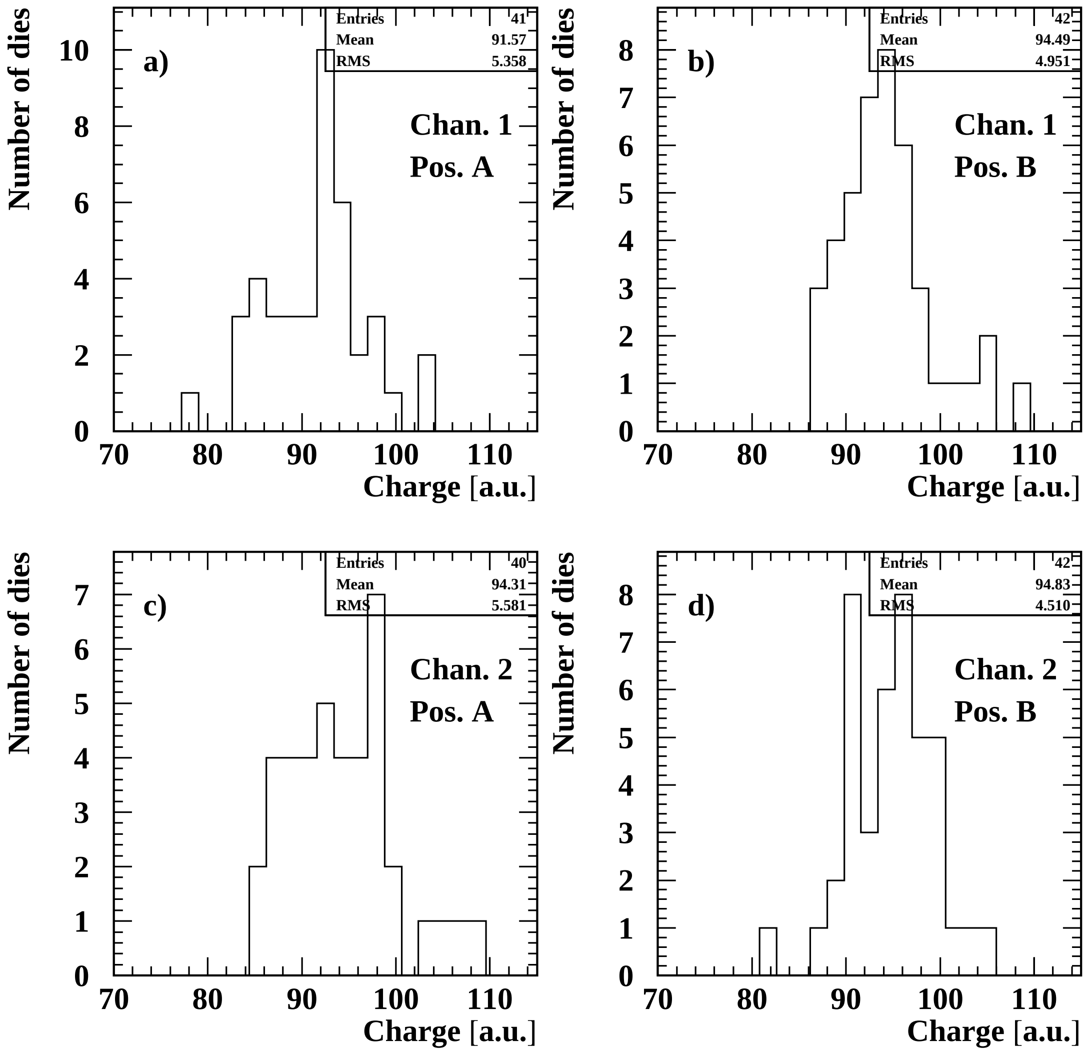

Figure 8: ad) The distributions of charge at the preamplifier output for different channels in silicon die and the position of die on a TAB slide.

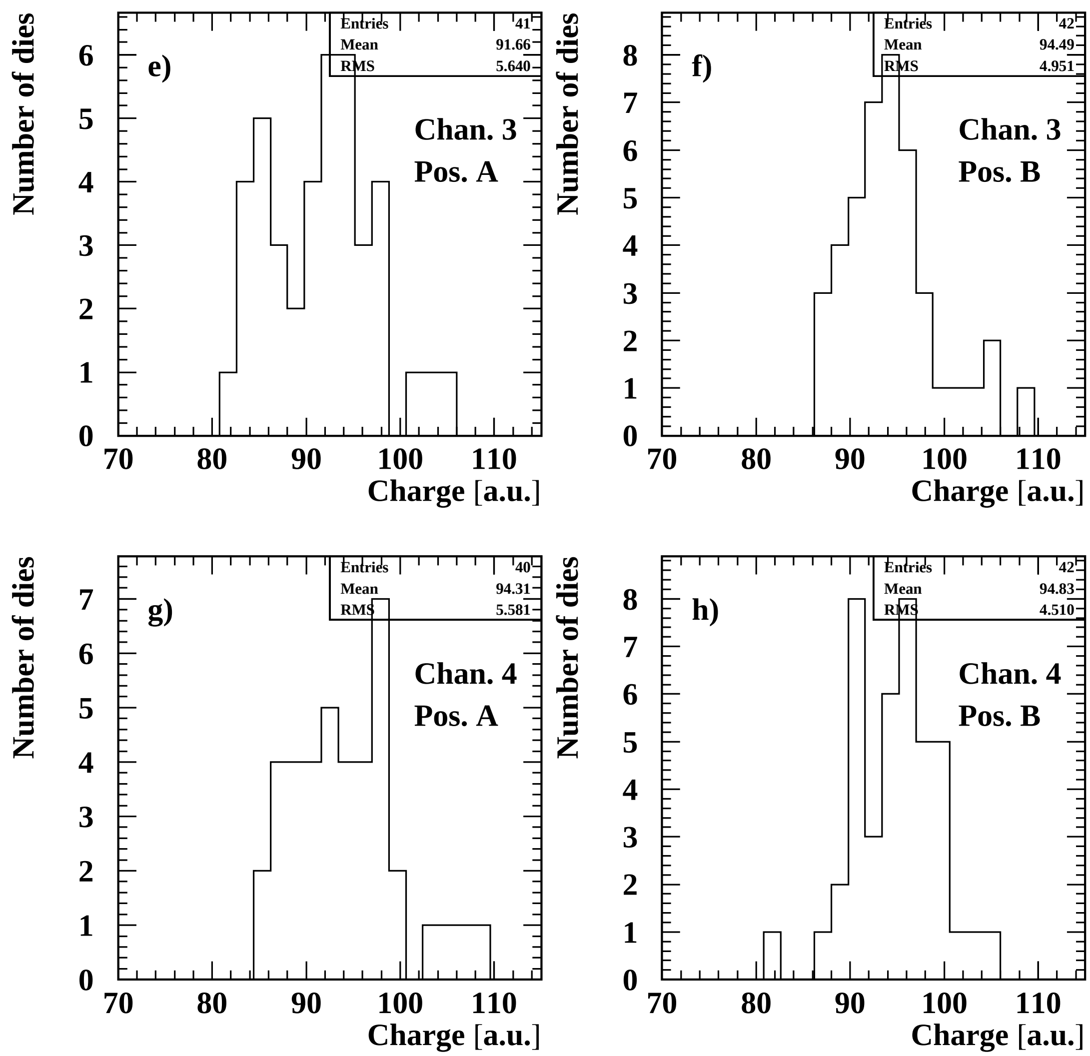

Figure 8: eh) The distributions of charge at the preamplifier output for different channels in silicon die and the position of die on a TAB slide.