Adding electronics noise and pedestals to the CALICE simulation

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The effects of pedestals and noise were added to the CALICE simulation, using values determined from the CALICE electromagnetic calorimeter prototype readout electronics. No significant worsening in energy resolution was observed over a range of RMS noises, pedestals and threshold cuts.

1 Introduction

A program was written to add electronics noise effects to the CALICE electromagnetic calorimeter (ECAL) simulation output. The pedestals and noise were varied around measurements from the first prototype and the threshold cut per channel was also varied. The ECAL's energy resolution was calculated in order to assess the impact of the noise on the calorimeter's performance.

2 Modelling the DAQ and Readout Electronics

The CALICE ECAL comprises layers of silicon wafers interspersed with tungsten. Each wafer contains 36 pads [1]. The signal from each pad is separately shaped, amplified, multiplexed and digitised before the data are recorded.

The 16 bit ADC range (65536 ADC counts) corresponds to a maximum readout of 200 MeV or 1000 minimum ionising particles (m.i.p.s). The pedestals and RMS noise were generated from Gaussian distributions and saturation effects from multiple hits at the same pad were accounted for. The signals were digitised and a threshold cut on the energy read out per pad was applied.

3 Results and Discussion

The first tests of the ECAL prototype electronics measured the pedestals at around 32750 ADC counts and the RMS noise at around 10 ADC counts. This pedestal value corresponds to a maximum readout of 500 m.i.p.s.

To calculate the ECAL energy resolution for different noise values, 10,000 electrons at 5, 10, 15 and 20 GeV were generated with the CALICE simulation. To these data different noise scenarios were applied. These scenarios, "design", "present", "hopeful" and "worst", had pedestals at 500, 32750, 500 and 32750 ADC counts and RMS noise values of 16, 10, 10 and 25 ADC counts respectively. The measured prototype readout values correspond to the "present" scenario. For each scenario, the average energy recorded per electron was plotted against the actual electron energy and a linear fit was applied. This fit, along with the width of the measured energy distributions, was used to calculate the energy resolution as a function of electron energy.

The left-hand plot in Figure 1 shows that as the noise increases from 0 to 15 ADC counts, the accuracy to which the energy can be measured stays roughly constant up to 10 ADC counts and then worsens only slightly. The right-hand plot shows that reducing the amount of data read out with a threshold cut has negligible effect on the energy resolution. Comparing the different scenarios, there is negligible difference between the energy resolutions except for the worst case, which has a rather pessimistic noise value of 25 ADC counts.

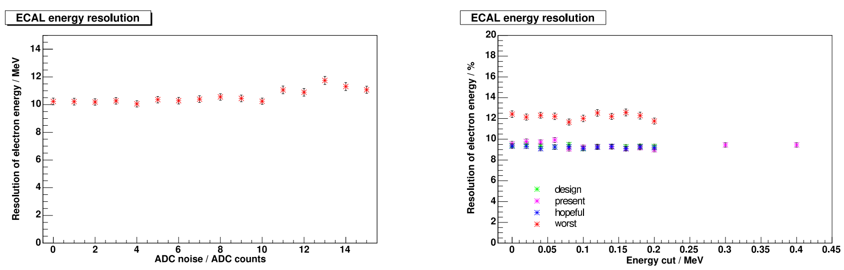

Figure 1: Left: The width of the measured energy distribution against ADC noise for 6 GeV electrons with no threshold cut and a pedestal of 32750 ADC counts. Right: The energy resolution for 6 GeV electrons against threshold cut per pad for the four scenarios, "design", "present", "hopeful" and "worst", described in Section 3.

4 Conclusion

These results look quite promising, showing that the ECAL suffers no significant degradation in energy resolution over a realistic range of RMS noise and pedestal values and threshold cuts. The effects from other electronics effects such as crosstalk and common mode fluctuations have not yet been included.

References

1. CALICE Collaboration, Conference Contribution, IEEE04, *Silicon-Tungsten Electromagnetic Calorimeter for experiments on the future e^+e^- linear collider*, 2004.