CALICE ECAL Readout Electronics: Data Acquisition Requirements

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1 Introduction

The readout electronics must interface to a data acquisition system and allow the ECAL channels to be read out. In principle, zero suppression could be done in hardware, although there must be some ability to read out the raw values for pedestal and noise calculations. The proposed system reads out all raw data for every event.

The system must also be flexible to allow for the uncertainties of the HCAL, trigger and beam monitoring readout, none of which are well-defined at this stage.

2 Event numbers

The main aim of the project is to get precise data on hadronic interactions to compare with simulation. The precision achievable obviously depends on the number of events taken. If it is assumed that a 5% accuracy is needed for a 3σ tail (0.13% of the total) of a distribution, then 400 events are needed in this region. This corresponds to a total of 3×10^5 events.

This number of events is needed for each of several experimental configurations. The quantities varying between the setups are:

- The particle type; at least electrons and pions will be needed, and possibly muons also. Assume 2 variations.
- The beam energy; energies between 1 and 10 GeV are needed, ideally data with 3 or 4 different energies would be taken. Assume 4 variations.
- The HCAL; data with both the tile and two digital HCAL options are needed. Assume 3 variations.
- Entrance angle; normal and 45° incidence angles are wanted. Assume 4 variations.
- Preshower; material will be included in front of the ECAL for some data. Assume 2 variations.

Although not all combinations are particularly meaningful, the simple calculation of doing all would give a total of $2 \times 4 \times 3 \times 4 \times 2 = 192$ variations. This would imply a total data sample of around 6×10^7 events.

3 Event rates

Most beam lines operate with the particles arriving in bunches, typically with roughly a 10% duty factor. A sustained rate of around 100Hz is required, so that the peak rate achievable within a bunch should be around 1kHz.

At this rate, the time to acquire the 300k events needed for each experimental configuration is 3000 s, or around 1 hour. Even allowing for significant setup time for each configuration, it seems feasible to complete the beam test within a couple of months.

4 Data rates and volumes

The ECAL data will be around 19 kBytes per event. The tile HCAL option has up to 1500 channels, each reading 16 bits, and so corresponds to around 3 kBytes. Both the digital HCAL options will have 10k channels in each of up to 38 layers, with each channel corresponding to one bit. This gives a total of around 4×10^5 bits or 50 kBytes without any zero suppression. With the expected suppression, around 2 kBytes per event on average are expected at the highest energies. Some beam monitoring and trigger data need to be included also, which should be 1 kByte or less.

Assuming the event sizes are around 25 kBytes, then the realistic VME backplane speed of around 20 MBytes/s will limit the event rate to around 800 Hz maximum, which is close to, but not quite at, the 1 kHz requirement.

With an average data size of 25 kBytes per event, then the total data sample of 6×10^7 events will be 1.5 TBytes. Calibration and cosmics runs are assumed to be comparatively small and have not been included in this estimate.

To avoid problems with large file sizes ($>$ 2 GBytes for standard Linux), then the number of events per file (assumed to be a run) would need to be restricted to around 80k events, which would imply a run would last around 800s or 13 minutes. A single configuration sample would be four runs and the total sample would be around 800 runs.