11.6 Calibration and Monitoring

11.6.1 Introduction

In order to maintain proper performance of the SCT, all critical characteristics of the system will be tracked. This monitoring operation can be described by three types of operations:

1. Monitoring of all parametric characteristics of the SCT, such as voltages, currents and temperatures
2. Periodic calibration of the detectors and readout electronics
3. Monitoring of the quality of data being collected by SCT and passed to the Trigger/DAQ. System.

The first operation listed above will be under the supervision of the SCT-DCS while the other two will be under the supervision of the SCT Off-detector and Control System.

11.6.2 Monitoring of SCT Operating Parameters

The monitoring of the SCT detector is split on several nodes of the DCS. Most monitoring can be done in a rather friendly environment outside the SCT detector where the services are generated. For monitoring in high radiation environment inside the SCT thermal insulation the aim is to have as few complex active elements as possible but the choice of technique also has to take into account the amount of material which will be introduced into the tracker. The sampling frequency of the monitoring is not foreseen to exceed 1 Hz for a full set of parameters. In the event of a power failure the monitoring will continue to run on uninterruptable power supplies. The following parameters will be monitored by the SCT DCS:

- the low voltage and current,
- the high voltage and current,
- the temperature of the modules, the SCT environment and cable bundles passing the TRT,
- the humidity inside SCT,
- the barometric pressure inside the SCT,
- the radiation inside the SCT, and
- the status of the cooling system

The monitoring of voltages and currents is made at the power supplies. It is believed that the voltages at the module can be known to a precision better than 2.5% of nominal value even without remote sensing. The monitoring of the power supplies is connected to the LCS (Local Control Station) through an industrial standard interface such as CAN bus.

Temperature monitoring is done within the high radiation environment. Thermal platinum resistor sensors will be used giving a relative precision better than 0.2 ˚C and the corresponding absolute precision will be better than 0.5 ˚C. The power cables have leads for bringing the signals of the probes to readout boards outside the high radiation environment. A temperature monitoring crate has 10 readout boards with 32 input channels each giving 320 channels/crate. In total about 4000 temperature monitoring channels will be needed or 125 readout boards. The

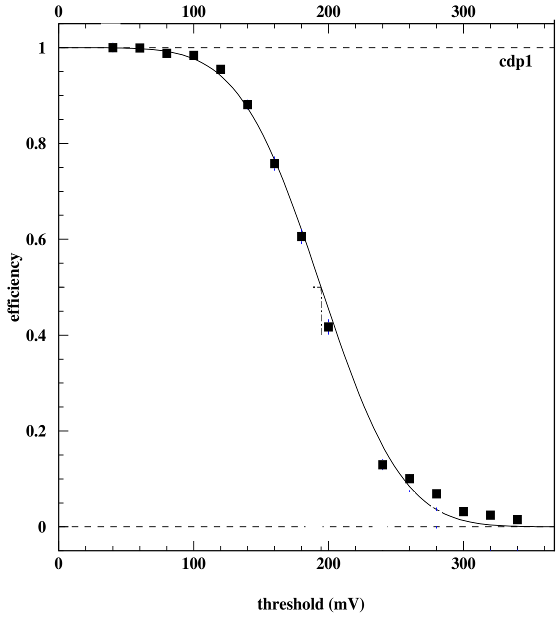

Figure 11-77 Typical S-curve calibration data for a one-channel threshold variation (mV) for fixed input charge.

crates are connected to the LCS through an industrial standard interface. The monitoring crate will be placed close to the power supply crates and the patch panel.

Methods of reducing the number of sensor wires are under investigation. One possible reduction can be achieved by converting the parallel readout to serial form before transferring the data outside the tracker with one analogue radiation hard multiplexer per local support in the barrel and with a similar segmentation in the forward direction.

The barometric pressure and humidity are monitored inside the thermal shield. The environment data is needed for the alignment system. The barometric pressure will be monitored with a precision of 1mbar. The SCT will be flushed with dry nitrogen inside the thermal shield. Ideally there is no humidity but in the events of leaks there may be humidity and the refractive index of air will change. The monitoring system must sense small amounts of water vapour.

Only a few monitoring points are needed both for humidity and barometric pressure. The SCT will be installed in 5 sections, each having a thermal shield. Every section will have two monitoring points of humidity and barometric pressure.

Commercially available monolithic pressure sensors are being irradiated in order to check that they fulfil the radiation tolerance needed in the SCT. A method of monitoring the humidity without active elements inside the high radiation environment is under investigation. The method is based on the absorption of light in water vapour.

11.6.3 Calibration of Detectors and Readout Electronics

The front-end electronics will have a built-in calibration facility which allows charge pulses to be injected into the front end of the amplification stage upon request from the SCT Off-detector and Control System. The quantity of charge, the timing of the charge pulse and the sub-set of channels pulsed can be controlled by commands to the front-end chips. The details of how this calibration function is implemented is discussed in Section 11.4.4.

With the binary readout architecture, the principal calibration procedure is to either vary the amplitude of the injected charge with fixed threshold or to vary the threshold with fixed amounts of injected charge. For each calibration pulse, the resulting status of the comparator (either hit or no-hit) is recorded. Figure 11-77 shows the result of one of these scans plotting detection efficiency as a function of threshold for a fixed input charge. The “S” curve response is typical showing 100% efficiency at low threshold and falling away to 0% efficiency at very high threshold. The point where this response crosses 50% locates the mean value of the injected charge distribution. The width of the transition region (from 100% to 0%) measures the width of the distribution of charge measured at the comparator. For the case of calibration pulses of fixed amplitude, this distribution is, in fact, the composite noise of the readout system.

A quick scan of each channel provides a easy measure of the overall gain of the analogue section (i.e. the 50% point) and the noise. Since the charge is injected at the very front of the readout stage and propagated through the entire chain (including pipeline, data compressor, data transmission and ROD), these calibration procedures provide an excellent diagnostic for the entire readout system.

The full calibration procedure as controlled by the off-detector system will scan the threshold for a series of calibration pulses on each channel and collect the data as shown in Figure 11-77. A quick fit of an error function to the “S” curve for each channel will produce the mean pulse amplitude and the standard deviation of the noise for that channel. These two values will then be stored in the historical trend charts for each channel and compared against allowed statistical limits.

The operation of this calibration procedure for the whole of SCT will simultaneously pulse 64 channels on each module and read out the “hit” data. The repetition rate will be approximately 10 kHz so that 5,000 points can be accumulated for an “S” curve in 0.5 s. To complete this procedure for all the channels will take 24 such sequences or 12 seconds. Since each module has a completely independent readout chain, the entire SCT can be thus calibrated in 12 seconds. The 10 kHz rate can be handled easily by the available bandwidth and the 5,000 points will provide sufficient accuracy in determining the mean and standard deviation of the distributions for historical monitoring.

This calibration procedure is intended to spot slow drifts in the SCT performance. Dramatic changes in operation resulting from, for example, a dead channel, will be most likely spotted by monitors of the Data Quality discussed in Section 11.6.4. Therefore, this calibration procedure needs only to be run once every few days and this can be accommodated during run changes or other non-data taking periods so as not to introduce dead time into the experiment.

11.6.4 Monitoring of Data Quality

As described in Section 11.4.3, the Read Out Driver (ROD) will have the capability to supply samples of event data to the Readout Controllers for the monitoring of data quality. The occupancy of each channel or strip will be accumulated and filtered. Sampling of the Level 1 triggered data will be random at a rate determined by the processing power of the Readout Controller (estimated to be ~100 Hz). Given the expected 1% occupancy of each channel, statistics for these occupancy measurements will accumulate very quickly and deviations from the norm will be immediately reported. Occupancies averaged over periods of approximately one hour will be recorded in a short term data base with longer averages held in permanent storage.

It will be possible to collect statistics on other aspects of the event data as specified by filters given to the Readout Controller. This may be used to look for more subtle correlations in the data. The possibility of using fitted tracks to measure real channel efficiencies using a 3 out of 4 point requirement is also being investigated. The ability to do this will only be limited by the available processing power for these on-line monitors.