CHAPTER 3
TEST CALIBRATION & EFFICIENCY
CHAPTER-3
TEST, CALIBRATION AND EFFICIENCY

Linearity of the analog channels B, C & D was observed using pulse generator, from input to digitized output. A sample calibration curve is shown in fig. 3.1. The pulse amplitude measurements from $\frac{dE}{dx}$ and E detectors should be converted into energy deposited by charged particle, by knowing the equivalent pulse heights. The charged particle telescope has been tested and individual counters calibrated for energy using various radio active Beta particle and Gamma-ray sources. These are described in following sections.

3.1 Radioactive Source Test: For testing individual counters the radioactive sources are most convenient. Advantage being in the small size of the sources. Even when the counters have been mounted in telescope their performance could be independently checked. For testing plastic scintillators and Cerenkov detectors we have chosen Sr$^{90}$Beta emitting source, having $E_{\text{max}} = 0.54$ MeV, which is above the detection threshold of Cerenkov detector for
Fig. 3.1 ADC calibration Curve for D.ADC.

Input was given at the input of Preamplifier, where PMT output is also fed.
electron (0.2 MeV) and sufficiently high to give good signal in Plastic scintillator.

To test & calibrate the NaI (Tl) total energy (E) detector $^{137}$Cs and $^{60}$Co Gamma-ray sources were used. The $^{60}$Co was selected for two reasons. First it has two gamma-ray lines having larger energies compared to $E_{\text{max}}$ of Sr$^{90}$. The two peaks in $^{60}$Co correspond to 1.17 and 1.33 MeV respectively. Secondly, the stopping power & conversion efficiency of NaI (Tl) is high enough to stop the penetrating gamma-rays & convert it into photoelectrons of total energy almost equal to the gamma ray energy. $^{137}$Cs gamma-ray source ($E_{\text{peak}} = 660$ KeV) was used to calibrate the lower energy region. The radioactive source is being used to confirm the proper working of any counter, by monitoring the pulse height output from a detector which must not vary—for a fixed high voltage supply of Photomultiplier throughout the experiment. The individual discriminator levels of all counters are selected based upon the energy deposited in detector by high energy ground level muons. These discriminator levels are also verified dynamically by radioactive sources and pulse generator.

High-voltages, Source Count-rates and background count-rates of all the counters have been
termed as Control (or standard) parameters. Periodic verification of the control parameters helps in maintaining the standard working condition of telescope. A typical control parameter list is given in table 3.1.

3.2 Cosmic Ray Muon Test: It is a well established fact that the energy spectrum of Cosmic ray produced secondary muons at sea level is fairly constant. Most of the measurements have confirmed a spectrum with a broad peak at around 100 MeV energy region. Muons deposit a fixed amount of energy in a detector corresponding to minimum ionization which can be used as a standard for calibration by monitoring the energy deposited by muons in different counters. Since these muons are mostly relativistic and penetrating, the variation of $\frac{dE}{dx}$ are small, thus producing a peak in $\frac{dE}{dx}$ as well as total Energy detector, the magnitude of the energy deposited is accurately calculated from standard energy loss data tables. The various parameters of detectors evaluated using cosmic-ray muons are discussed below:

(1) The Penetrating muons deposit a fixed amount of energy in each detector, corresponding to minimum ionization energy loss. This can be used to test the various counters and calibrate both
Table 3.1

Control Parameters for Charged Particle Telescope

<table>
<thead>
<tr>
<th>Date</th>
<th>Detector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold</td>
<td></td>
</tr>
<tr>
<td>Calibration</td>
<td></td>
</tr>
<tr>
<td>High Voltage</td>
<td></td>
</tr>
</tbody>
</table>

Singles Rates:

|                     | Without Source | With Source |
|---------------------|----------------|
| Standard Count Rate |                |
| Before Run          |                |
| After Run           |                |

Muon Run:

<table>
<thead>
<tr>
<th></th>
<th>Peak</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Coincidence Rates:

Up : Muon
     Electron

Down : Muon
      Electron
Fig. 3.2 A typical muon pulse height distribution in one of the Energy loss Detectors.
COSMIC RAY MUONS IN $dE/dx$ DETECTOR

PEAK - 62 CH.
FWHM - 21%
(ii) Muon peak also gives an indicating of the energy resolution and uniformity of response of the scintillator. A muon peak for detector B in coincidence with detectors A' & C is presented in fig. 3.2.

(iii) To achieve effective discriminator level settings, the muon peak was utilized. The discriminator levels were so chosen so as to allow the signals well above the noise level & still select most of the penetrating muons. This is illustrated in fig. 3.3.

3.3 The Electron Beam Calibration: Various counters of the charged particle telescope were calibrated by a 8 MeV low intensity electron beam from a Race track microtron at the University of Poona. The beam intensity was reduced to a level so that the saturation in detectors did not occur. This was also necessary since the data handling subsystem had a dead time of about 20 ms. required for Analog Digital Conversion and Serialization of data.

3.4 Efficiency of Cerenkov Counter: For a good electron muon discrimination, it is quite important that the velocity threshold Cerenkov counter has
Fig. 3.3 Pulse height distributions in all the counters of CPT for Muons and Sr$^{90}$ Beta Source (Co$^{60}$ for C detector). The Setting of Discriminator threshold is decided by noise level in that detector.
the best detection efficiency. The Cerenkov efficiency even at the lowest energy near threshold was determined using three different radiations viz.

i) Radioactive Beta Sources

ii) Cosmic ray muons at ground level

iii) 8 MeV electron beam from microtron

These tests show that the efficiency of Cerenkov detector near 0.5 MeV was 99% and it improves at electron energy of 8 MeV.