CLAS-NOTE 2003-013
CVS: docs/clas_notes/tof_mask
Original: Feb 12, 2003
Updated: August 21, 2003
Version: 2.0

Mask Calibration of the TOF Laser System

Kiho Chu, Kijun Park, Serguei Pozdniakov, Byongwook Shin, Elton S. Smith, and Wooyoung Kim

1 Background

The laser calibration system for CLAS is used to measure the time-walk correction functions for the time measurements using leading edge discriminators. Descriptions of the hardware are given in previous documents [1, 2]. The parameterization of the functions themselves was studied for the e1-6 run period [3]. All data to date has been obtained by simultaneously illuminating all fiber bundles attached to one laser. For the forward carriage laser, this procedure is adequate. However, especially for the "coupled-paddles" in the backward direction, this procedure produces data where both scintillators of the pair fire simultaneously and the calibration data is suspect. Good calibrations could only be obtained by turning off the high voltage to one of the scintillators in each pair.

The calibration system includes a metal sheet ("mask") with hole patterns which can be placed in front of the fiber array to selectively illuminate predefined bundles. The mask hardware and motors to control its motion have been installed for sometime. The motors are identical to those used to change the neutral density filter settings. However, due to the difficulty in aligning the mask in front of the fiber array, this feature has not been used. This note describes the calibration of the mask system, which will allow the systematic selection of fiber bundles to be illuminated during a calibration procedure.

2 Description

2.1 The Mask

The mask is a metal sheet with hole patterns. It can be used to selectively illuminate optical fiber bundles with a single laser beam. The mask pattern is shown in Fig. 1.

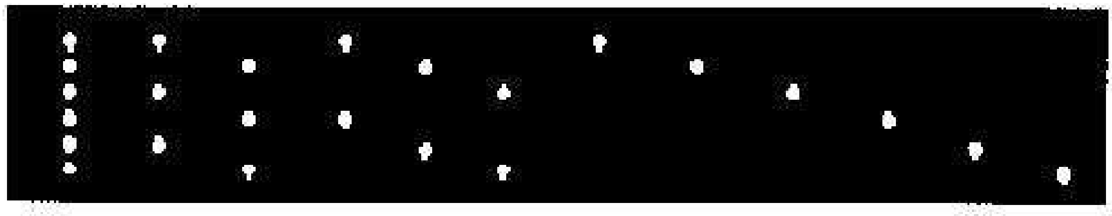

Figure 1: Hole pattern of Mask

The patterns were chosen to illuminate every fourth bundle (six at a time), every eight bundle (three at a time), every twelfth bundle (two at a time), and every sixteenth (one at a time). Each hole is matched to the size of a fiber bundle that carries seven fibers, nominally one fiber to each sector plus a spare. By positioning the mask in front of the array of fiber bundles, one can select which set of fibers is illuminated at any given time. This allows the mask to be used to study cross-talk anywhere in the entire chain of electronics and/or to block from scintillators which might fire simultaneously as in the case of the coupled paddles.

2.2 Mask motor control

The mask is moved horizontally using a Velmex motor, which is in turn controlled by Velmex motor controller. The Velmex motor is a stepping motor which has 400 steps per revolution with 0.9^o step angle resolution. The mask is fixed in its vertical position, and the motor only moves the mask either left or right. Velmex stepping motor controller connected to VME via new serial board VMIC 6016.

3 Moving the mask

3.1 Low level library

The motor low level library written in C language. The detail description of this library can be found in "New Operating Software Package for the TOF Laser Calibration System" [4]. Library is downloaded in VME controller during the booting process. The library code for Velmex motor with full path is:

$CLON_VXWORKS/code/motor_ppc.o

and the source is:

$CLON_SOURCE/vxworks/laser/motor.c

This library is downloaded to both VME crates: 'camac3' and 'sc-laser1'. Below is the list of some essential low level routines:

```
int  open_port          (int channel)
int  close_port         (int channel)
int  nullify_motors     (int channel)
int  set_mask_speed     (int channel, int speed)
int  get_mask_position  (int channel)
int  move_mask          (int channel, int step)
```

First two are necessary to open and close serial port channels. Now electronics configuration has two VME crates and uses four serial port channels for four Velmex motor controllers on different support structure:

```
CAMAC3    has only channel#1 (Forward carriage)

SC-LASER1 has      channel#2 (North Clam Shell)
                   channel#3 (South Clam Shell)
                   channel#4 (Space Frame)
```

Last four routines control mask motor. They are necessary to nullify index of mask motor, to set speed of mask motor, to move mask and to get mask position. Next Section describes how to control mask remotely from UNIX side.

3.2 UNIX scripts to operate mask

Now it is not necessary to go directly into VME controller and to execute library routines from VxWorks prompt. It is not convenient and reliable, very frequently it leads to blocking VxWorks operating system and necessity to reboot VME crate. New TOF laser Software Package [4] includes set of UNIX scripts which were used during mask calibration and can be used for TOF laser calibration. Most useful for mask calibration were the next scripts:

```
TOF_laser_on           - correct turn lasers on
TOF_laser_off          - correct turn lasers off
TOF_laser_enable       - enable lasers (if they are ready)
TOF_laser_disable      - disable lasers
TOF_laser_status       - get lasers statuses
TOF_move_mask          - move mask for specified laser
TOF_get_mask_position  - get mask position for specified laser
```

All scripts can be executable from any CLON clusters. They can have input parameters, options 'h', '-h' or 'help' will give the synopsis of the script. Their sources are in '$CLON_SOURCE/laser/sc/scripts' directory and their executable codes are in '$CLON_BIN' directory.

3.3 How to take the data

In order to acquire the laser data using the mask system, perform the following tasks:

1. Set the DAQ system on clon10 machine. Choose proper CODA configuration, TOF_LASER.

2. Download run configuration file 'tof_laser.cfg', it is almost the same as for usual TOF laser calibration runs except that several lines should be commented (for this type of file all comments should be between '<!– ' and ' –>'):

```
<prestart>
<!-- TOF_laser_on -->
</prestart>

<go>
<!-- TOF_laser_start -->
</go>

<end>
<!-- TOF_laser_off -->
</end>
```

   The run configuration file is located at '$CLON_PARMS/trigger/config/calib'. Check that DAQ system has completed the 'Download' without any errors.

3. Turn ON the laser mask of which will be calibrated. From any CLON cluster activate the scripts:

```
TOF_laser_on ni
```

   where ni is a laser number.

4. Wait until laser will be ready. It could take about 5 minutes. Check laser status time to time:

```
TOF_laser_status ni
```

5. Enable the laser:

   ```
   TOF_laser_enable ni
   ```

6. Move the mask to certain position using the script:

   ```
   TOF_move_mask ni step
   ```

   Mask should be moved on 'step' steps from current position To check new position of the mask use:

   ```
   TOF_get_mask_position ni
   ```

7. Press 'Prestart', fill run-sheet (enter some comments about upcoming run) then click 'OK'.

8. Start the run (click 'Go' on DAQ system GUI) to take data through DAQ program.

9. Get enough statistics and end the run, click 'End'.

10. Do the (6)-(9) steps again with different mask position.

11. After all positions will be tested turn OFF the laser:

    ```
    TOF_laser_off ni
    ```

12. Analyze the laser data.

13. Find the relation between mask position and step.

4 Procedure and results

The hardware of laser systems in the space frame, north and south clam shell are identical. This includes motors, controllers, and the mask itself. Rough calibrations for all three systems indicate that this is indeed the case. The forward-carriage laser system, however, was assembled early on and used as a prototype for the other systems. Although they are similar in the software programing, the hardware and calibrations are different. During the maintenance period, we were only able to obtain laser data for the forward carriage, since the detector was openned and the large-angle scintillators were uncabled.

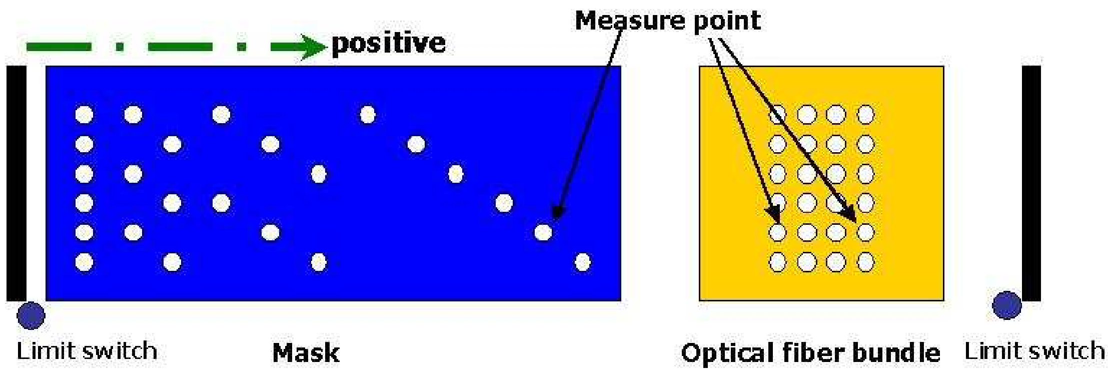

Figure 2: Mask moving and measuring point

4.1 Rough Calibration

The procedure was broken down into two steps. First a rough calibration was obtained by moving the motor and measuring the movement of the mask with rulers and determining the position of the mask alignment relative to the fiber bundles by eye. This rough calibration yielded the following approximate calibrations for the forward carriage:

$$\text{position (forward)} = -22mm + 0.12mm/step \times (\text{motor step}) \tag{1}$$

The same rough procedure yielded a calibration for the space frame, north, and south clam shells:

$$\text{position (others)} = \text{A} + 0.0127mm/step \times (\text{motor step}), \tag{2}$$

where A was not determined. However, the slope was determined with fairly good accuracy.

This procedure yielded an approximate calibration which was then used to take a series of data runs in fine steps and plot the response of the illuminated fibers. Figs. 3-6 show the response of one fiber bundle which was illuminted as a function of the number of steps moved by the motor. One bundle contains fibers distributed to scintillator in different sectors, and we can see that the agreement between all scintillators and both right and left pmts is very consistent. We note that the location of each fiber within the bundle is arbitrary, which means that the position relative to the mask will be somewhat different for each sector. However, the mask cleanly illuminates the bundle and produces sharp response as it moves across the array. The pulse height in each sector varies due to significant differences in coupling between the fibers and the scintillator.

4.2 Fine Scans

Fine scans of the mask system were taken for the first row (number 17) and last row (number 20) of the fiber array of the forward carriage. Using the average of the data for all pmts at each location the data could be fit to determine the position of the mask relative to the fiber array (see Fig. 7). A straight line fit to these to points yields the following calibration

$$\text{position (forward)} = -34.50 + 0.1287 mm/step \times \text{(motor step)}, \tag{3}$$

This is in good agreement with the rough calibration obtained earlier, but directly determines the position of the fiber bundles in terms of the commands given to the motor that controls the mask.

A second set of fine scans was taken on the first row (number 24 and 36) and the last row (number 31 and 41b) [1] of the south clam shell. Using the average as for the forward carriage, we obtain a straight line fit as shown in Fig 12 :

$$\text{position (southclam)} = -214.392 + 0.0131926 mm/step \times \text{(motor step)} \tag{4}$$

References

[1] E.S. Smith, K. Loukachine, J. Santoro, S. Taylor, M. Huertas, D. Tedeschi, "CLAS TOF Online Manual", CLAS-NOTE 2001-019, Oct 29, 2001.

[2] K. Giovanetti, K. Kim, W. Kim, E.S. Smith, "Operation of the TOF Laser Calibration System", CLAS-NOTE 2001-004, Feb 22, 2001.

[3] E.S. Smith and R. Nasseripour, "Systematic Study of Time-walk Corrections for the TOF Counters", CLAS-NOTE 2002-007, May 6, 2002.

[4] S. Pozdniakov, "New Operating Software Package for the TOF Laser Calibration System", CLAS-NOTE 2003-014, August 22, 2003.

[1] The second row was scanned instead of the first, because fiber 39 was not operational.

A Fiber Array Labeling

Table 1: Labeling for Full Fiber Array TOP (Forward Carriage)

	Column 1	Column 2	Column 3	Column 4
Row 1	SC S0 F1	SC S0 F2	SC S0 F3	SC S0 F4
	SC S1 F1	SC S1 F2	SC S1 F3	SC S1 F4
	SC S2 F1	SC S2 F2	SC S2 F3	SC S2 F4
	SC S3 F1	SC S3 F2	SC S3 F3	SC S3 F4
	SC S4 F1	SC S4 F2	SC S4 F3	SC S4 F4
	SC S5 F1	SC S5 F2	SC S5 F3	SC S5 F4
	SC S5 F1	SC S6 F2	SC S6 F3	SC S6 F4
Row 2	SC S0 F5	SC S0 F6	SC S0 F7	SC S0 F8
	SC S1 F5	SC S1 F6	SC S1 F7	SC S1 F8
	SC S2 F5	SC S2 F6	SC S2 F7	SC S2 F8
	SC S3 F5	SC S3 F6	SC S3 F7	SC S3 F8
	SC S4 F5	SC S4 F6	SC S4 F7	SC S4 F8
	SC S5 F5	SC S5 F6	SC S5 F7	SC S5 F8
	SC S5 F5	SC S6 F6	SC S6 F7	SC S6 F8
Row 3	SC S0 F9	SC S0 F10	SC S0 F11	SC S0 F12
	SC S1 F9	SC S1 F10	SC S1 F11	SC S1 F12
	SC S2 F9	SC S2 F10	SC S2 F11	SC S2 F12
	SC S3 F9	SC S3 F10	SC S3 F11	SC S3 F12
	SC S4 F9	SC S4 F10	SC S4 F11	SC S4 F12
	SC S5 F9	SC S5 F10	SC S5 F11	SC S5 F12
	SC S5 F9	SC S6 F10	SC S6 F11	SC S6 F12

Table 2: Labeling for Full Fiber Array BOTTOM (Forward Carriage)

	Column 1	Column 2	Column 3	Column 4
Row 4	SC S0 F13	SC S0 F14	SC S0 F15	SC S0 F16
	SC S1 F13	SC S1 F14	SC S1 F15	SC S1 F16
	SC S2 F13	SC S2 F14	SC S2 F15	SC S2 F16
	SC S3 F13	SC S3 F14	SC S3 F15	SC S3 F16
	SC S4 F13	SC S4 F14	SC S4 F15	SC S4 F16
	SC S5 F13	SC S5 F14	SC S5 F15	SC S5 F16
	SC S5 F13	SC S6 F14	SC S6 F15	SC S6 F16
Row 5	SC S0 F17	SC S0 F18	SC S0 F19	SC S0 F20
	SC S1 F17	SC S1 F18	SC S1 F19	SC S1 F20
	SC S2 F17	SC S2 F18	SC S2 F19	SC S2 F20
	SC S3 F17	SC S3 F18	SC S3 F19	SC S3 F20
	SC S4 F17	SC S4 F18	SC S4 F19	SC S4 F20
	SC S5 F17	SC S5 F18	SC S5 F19	SC S5 F20
	SC S5 F17	SC S6 F18	SC S6 F19	SC S6 F20
Row 6	SC S0 F21	SC S0 F22	SC S0 F23	spare
	SC S1 F21	SC S1 F22	SC S1 F23	spare
	SC S2 F21	SC S2 F22	SC S2 F23	spare
	SC S3 F21	SC S3 F22	SC S3 F23	spare
	SC S4 F21	SC S4 F22	SC S4 F23	spare
	SC S5 F21	SC S5 F22	SC S5 F23	spare
	SC S5 F21	SC S6 F22	SC S6 F23	spare

Table 3: Labeling for Half Array (Clam Shell, South)

	Column 1	Column 2	Column 3	Column 4
Row 1	SC S0 F24	SC S0 F25	SC S0 F26	SC S0 F27
	SC S1 F24	SC S1 F25	SC S1 F26	SC S1 F27
	SC S2 F24	SC S2 F25	SC S2 F26	SC S2 F27
	SC S6 F24	SC S6 F25	SC S6 F26	SC S6 F27
	SC S1 F36	SC S1 F37	SC S1 F38	SC S1 F39
	SC S2 F36	SC S2 F37	SC S2 F38	SC S2 F39
	SC S6 F36	SC S6 F37	SC S6 F38	SC S6 F39
Row 2	SC S0 F28	SC S0 F29	SC S0 F30	SC S0 F31
	SC S1 F28	SC S1 F29	SC S1 F30	SC S1 F31
	SC S2 F28	SC S2 F29	SC S2 F30	SC S2 F31
	SC S6 F28	SC S6 F29	SC S6 F30	SC S6 F31
	SC S1 F40a	SC S1 F40b	SC S1 F41a	SC S1 F41b
	SC S2 F40a	SC S2 F40b	SC S2 F41a	SC S2 F41b
	SC S6 F40a	SC S6 F40b	SC S6 F41a	SC S6 F41b
Row 3	SC S0 F32	SC S0 F33	SC S0 F34	SC S0 F35
	SC S1 F32	SC S1 F33	SC S1 F34	SC S1 F35
	SC S2 F32	SC S2 F33	SC S2 F34	SC S2 F35
	SC S6 F32	SC S6 F33	SC S6 F34	SC S6 F35
	SC S1 F42a	SC S1 F42b	spare	spare
	SC S2 F42a	SC S2 F42b	spare	spare
	SC S6 F42a	SC S6 F42b	spare	spare

Table 4: Labeling for Half Array (Clam Shell, North)

	Column 1	Column 2	Column 3	Column 4
Row 1	SC S0 F24	SC S0 F25	SC S0 F26	SC S0 F27
	SC S3 F24	SC S3 F25	SC S3 F26	SC S3 F27
	SC S4 F24	SC S4 F25	SC S4 F26	SC S4 F27
	SC S5 F24	SC S5 F25	SC S5 F26	SC S5 F27
	SC S3 F36	SC S3 F37	SC S3 F38	SC S3 F39
	SC S4 F36	SC S4 F37	SC S4 F38	SC S4 F39
	SC S5 F36	SC S5 F37	SC S5 F38	SC S5 F39
Row 2	SC S0 F28	SC S0 F29	SC S0 F30	SC S0 F31
	SC S3 F28	SC S3 F29	SC S3 F30	SC S3 F31
	SC S4 F28	SC S4 F29	SC S4 F30	SC S4 F31
	SC S5 F28	SC S5 F29	SC S5 F30	SC S5 F31
	SC S3 F40a	SC S3 F40b	SC S3 F41a	SC S3 F41b
	SC S4 F40a	SC S4 F40b	SC S4 F41a	SC S4 F41b
	SC S5 F40a	SC S5 F40b	SC S5 F41a	SC S5 F41b
Row 3	SC S0 F32	SC S0 F33	SC S0 F34	SC S0 F35
	SC S3 F32	SC S3 F33	SC S3 F34	SC S3 F35
	SC S4 F32	SC S4 F33	SC S4 F34	SC S4 F35
	SC S5 F32	SC S5 F33	SC S5 F34	SC S5 F35
	SC S3 F42a	SC S3 F42b	spare	spare
	SC S4 F42a	SC S4 F42b	spare	spare
	SC S5 F42a	SC S5 F42b	spare	spare

Table 5: Labeling Scheme for Half Array (Space Frame)

	Column 1	Column 2	Column 3	Column 4
Row 1	SC S0 F43a	SC S0 F44a	SC S0 F45a	SC S0 F46a
	SC S1 F43a	SC S1 F44a	SC S1 F45a	SC S1 F46a
	SC S2 F43a	SC S2 F44a	SC S2 F45a	SC S2 F46a
	SC S3 F43a	SC S3 F44a	SC S3 F45a	SC S3 F46a
	SC S4 F43a	SC S4 F44a	SC S4 F45a	SC S4 F46a
	SC S5 F43a	SC S5 F44a	SC S5 F45a	SC S5 F46a
	SC S5 F43a	SC S6 F44a	SC S6 F45a	SC S6 F46a
Row 2	SC S0 F47a	SC S0 F48a	SC S0 F43b	SC S0 F44b
	SC S1 F47a	SC S1 F48a	SC S1 F43b	SC S1 F44b
	SC S2 F47a	SC S2 F48a	SC S2 F43b	SC S2 F44b
	SC S3 F47a	SC S3 F48a	SC S3 F43b	SC S3 F44b
	SC S4 F47a	SC S4 F48a	SC S4 F43b	SC S4 F44b
	SC S5 F47a	SC S5 F48a	SC S5 F43b	SC S5 F44b
	SC S5 F47a	SC S6 F48a	SC S6 F43b	SC S6 F44b
Row 3	SC S0 F45b	SC S0 F46b	SC S0 F47b	SC S0 F48b
	SC S1 F45b	SC S1 F46b	SC S1 F47b	SC S1 F48b
	SC S2 F45b	SC S2 F46b	SC S2 F47b	SC S2 F48b
	SC S3 F45b	SC S3 F46b	SC S3 F47b	SC S3 F48b
	SC S4 F45b	SC S4 F46b	SC S4 F47b	SC S4 F48b
	SC S5 F45b	SC S5 F46b	SC S5 F47b	SC S5 F48b
	SC S5 F45b	SC S6 F46b	SC S6 F47b	SC S6 F48b

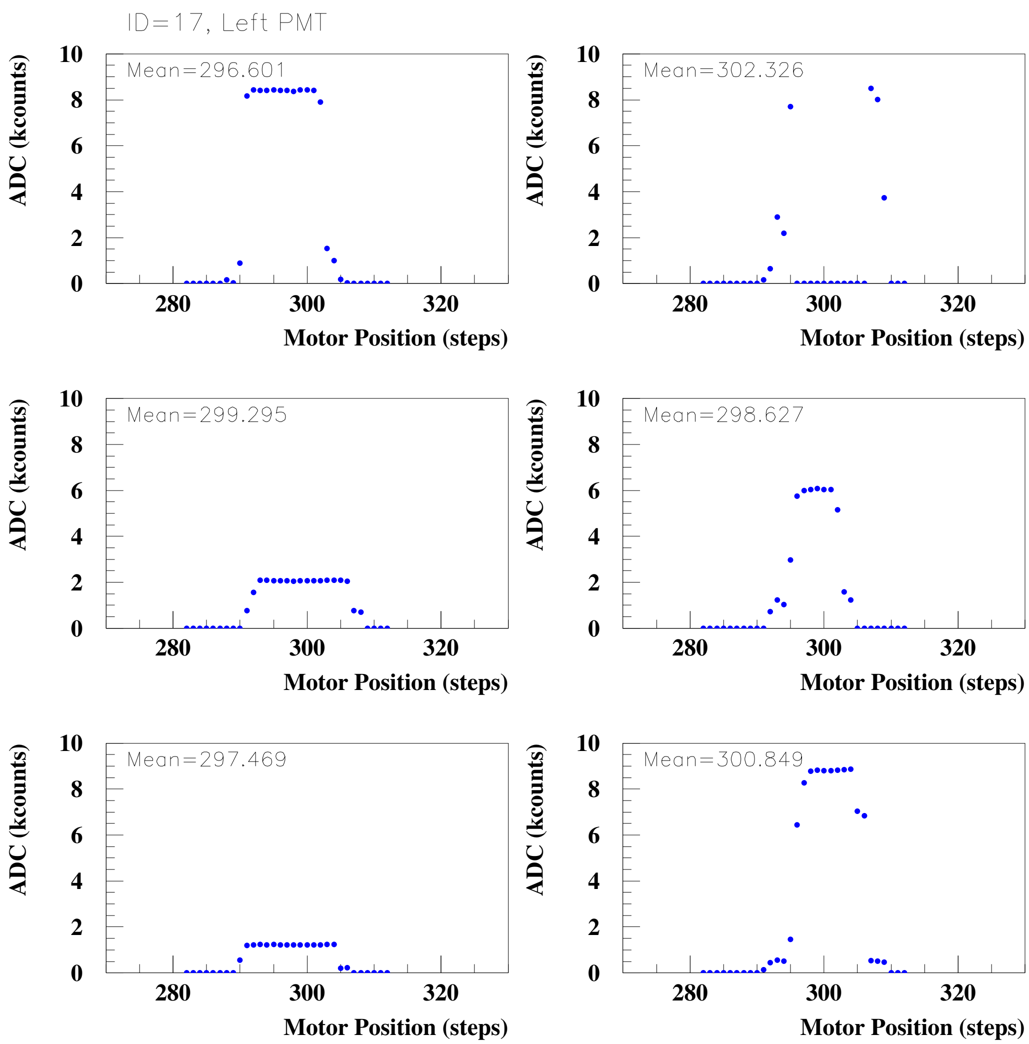

Figure 3: Pulse height recorded in scintillator 17 (left) for all six sectors as the mask was scanned across the fiber bundle. When the pulse heights in sector 2 overflow the ADC, they are plotted as zeros.

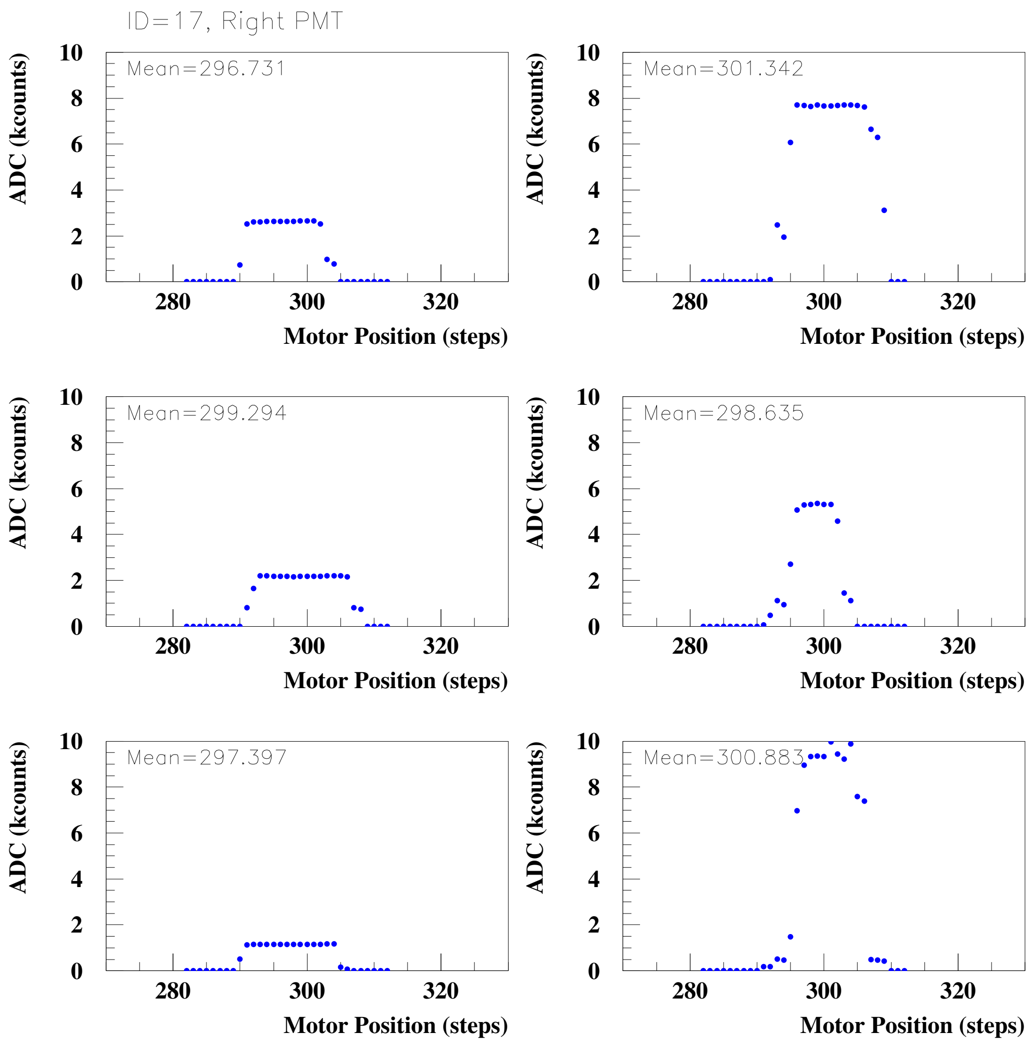

Figure 4: Pulse height recorded in scintillator 17 (right) for all six sectors as the mask was scanned across the fiber bundle.

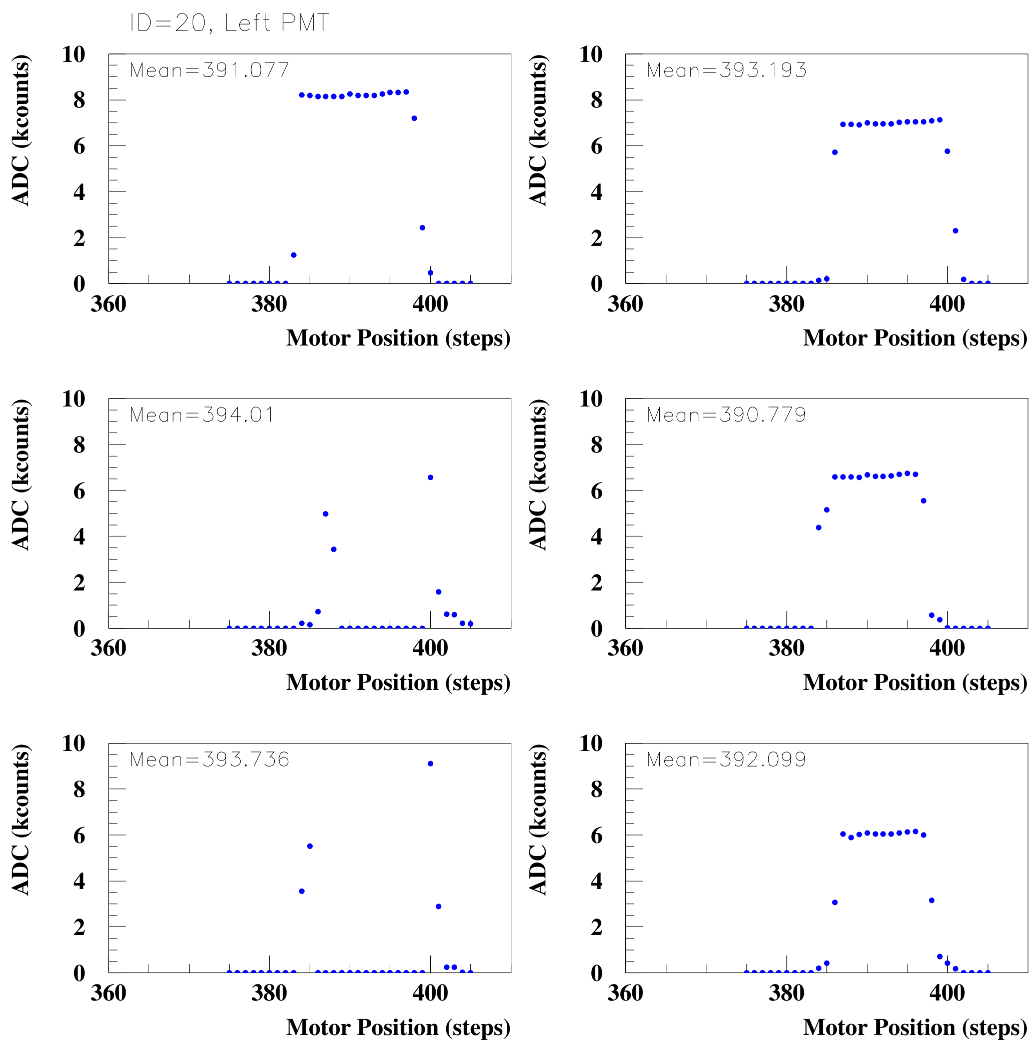

Figure 5: Pulse height recorded in scintillator 20 (left) for all six sectors as the mask was scanned across the fiber bundle. When the pulse heights in sectors 3 and 5 overflow the ADC, they are plotted as zeros.

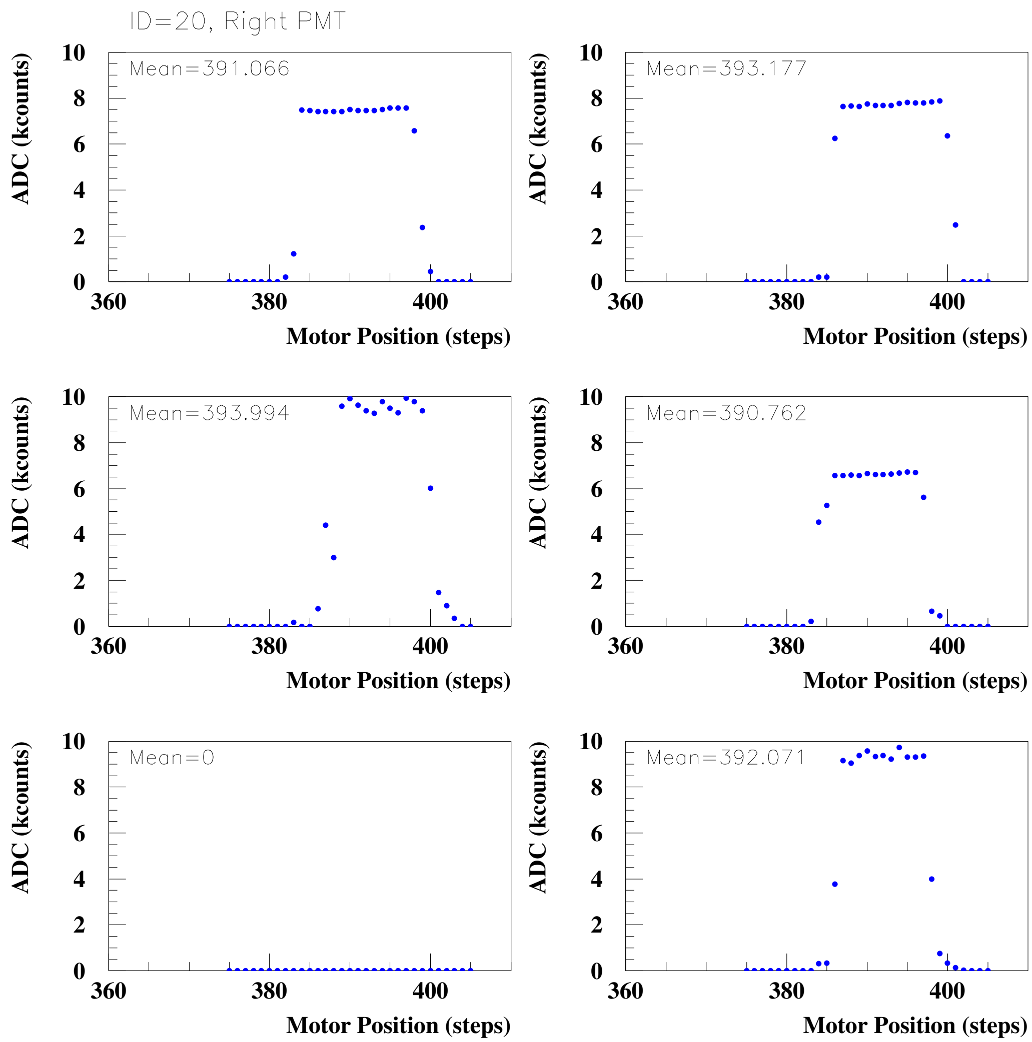

Figure 6: Pulse height recorded in scintillator 20 (right) for all six sectors as the mask was scanned across the fiber bundle. Scintillator 20R in sector 5 was dead.

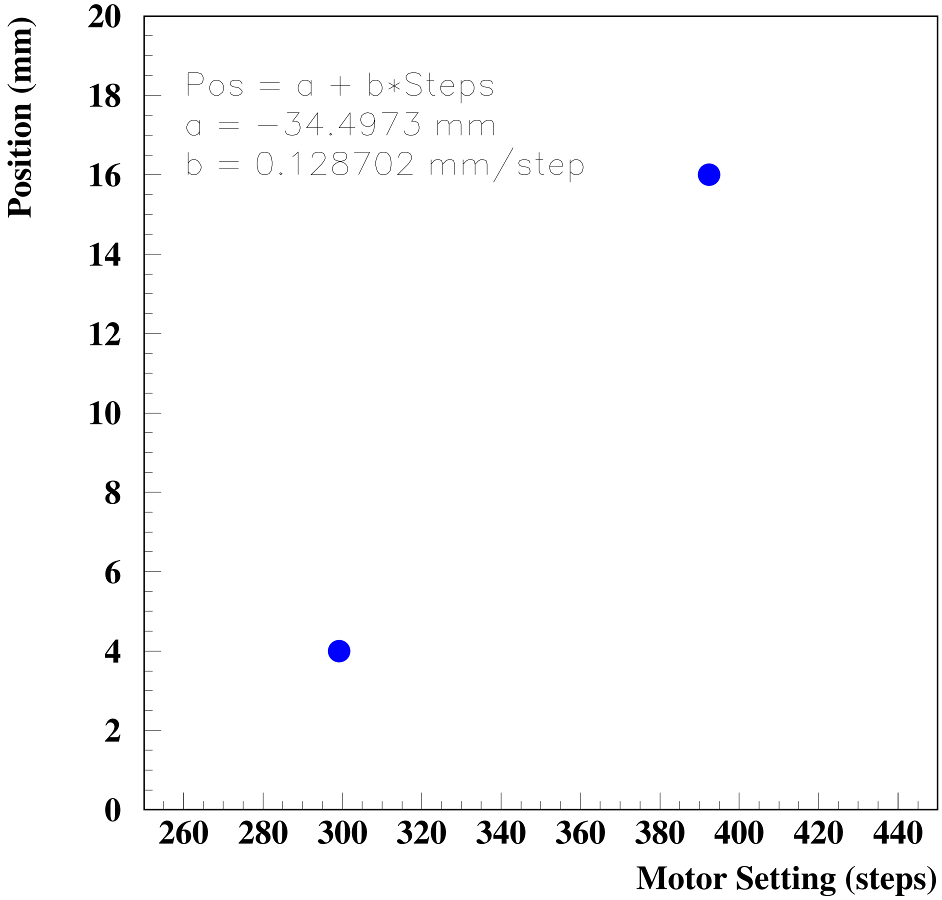

Figure 7: The average stepping moter counter for all sectors is plotted against the known location of the fiber bundle. The linear fit is also given to convert the motor steps into the position.

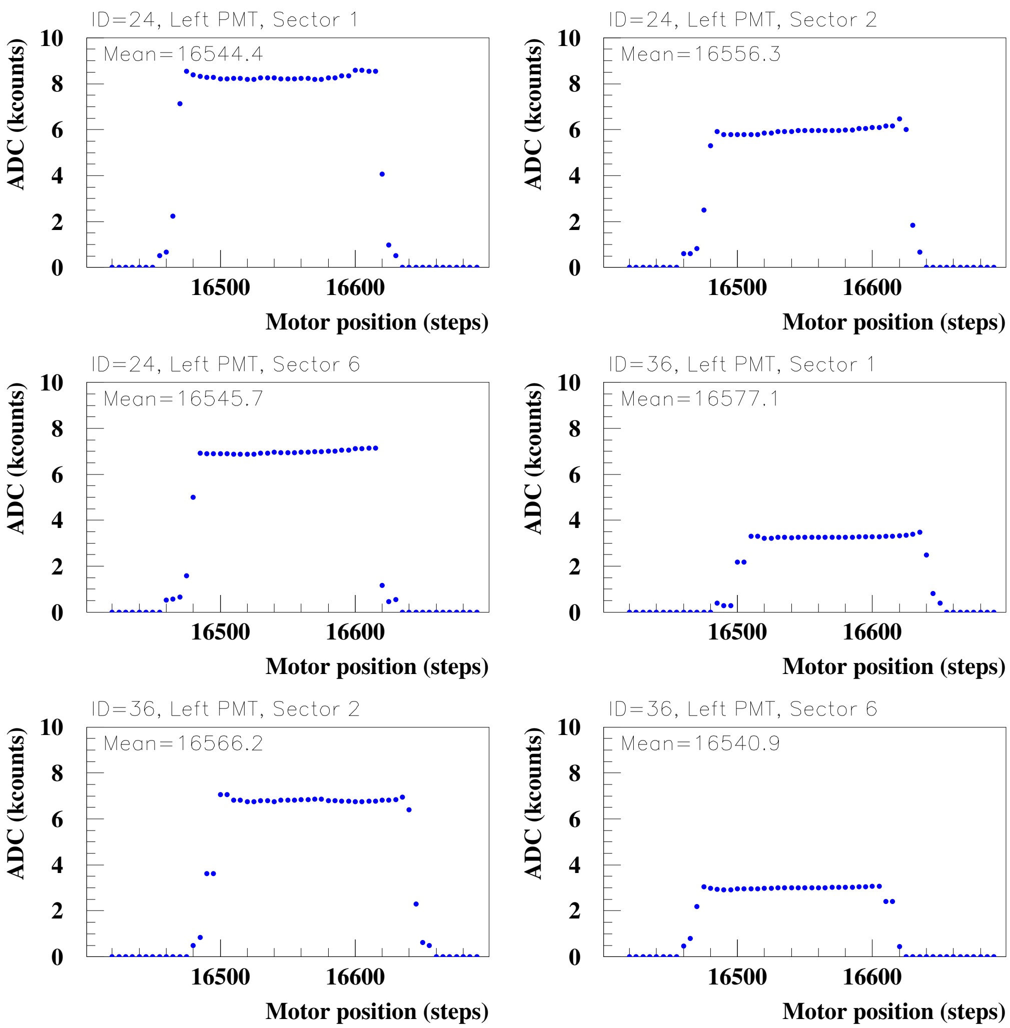

Figure 8: Pulse height recorded in scintillator 24 (left) and 36 (left) for sector 1 2 and 6 as the mask scanned across the fiber bundle.

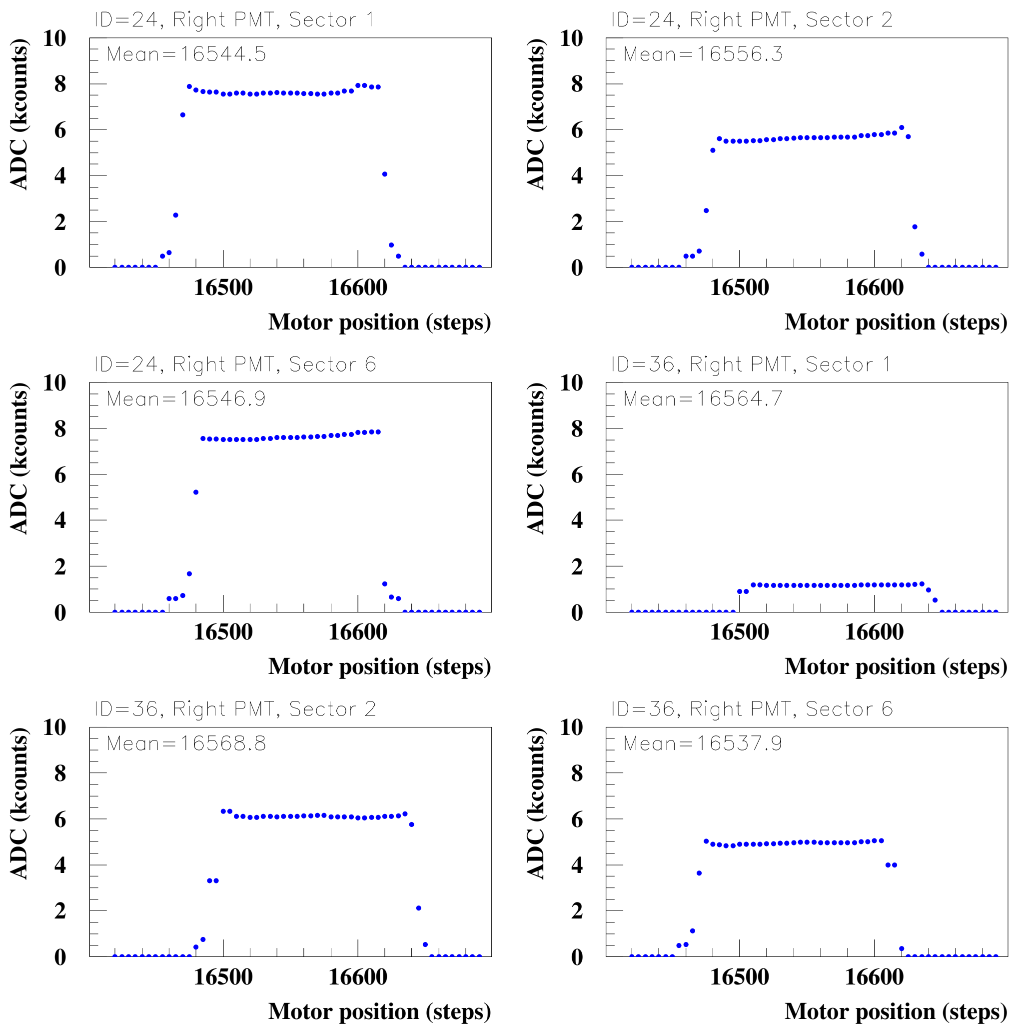

Figure 9: Pulse height recorded in scintillator 24 (right) and 36 (right) for sector 1 2 and 6 as the mask scanned across the fiber bundle.

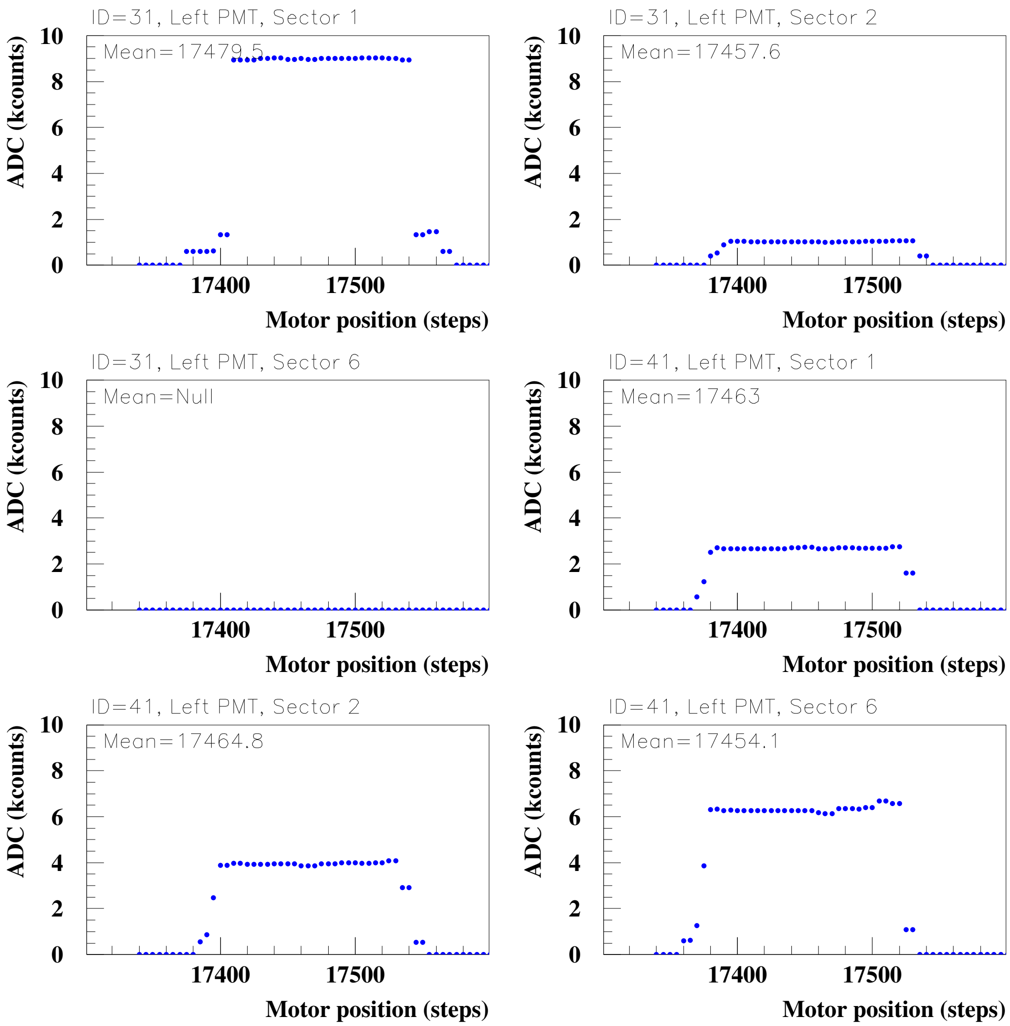

Figure 10: Pulse height recorded in scintillator 31 (left) and 41 (left) for sector 1 2 and 6 as the mask scanned across the fiber bundle. Scintillator 31L in sector 6 was dead.

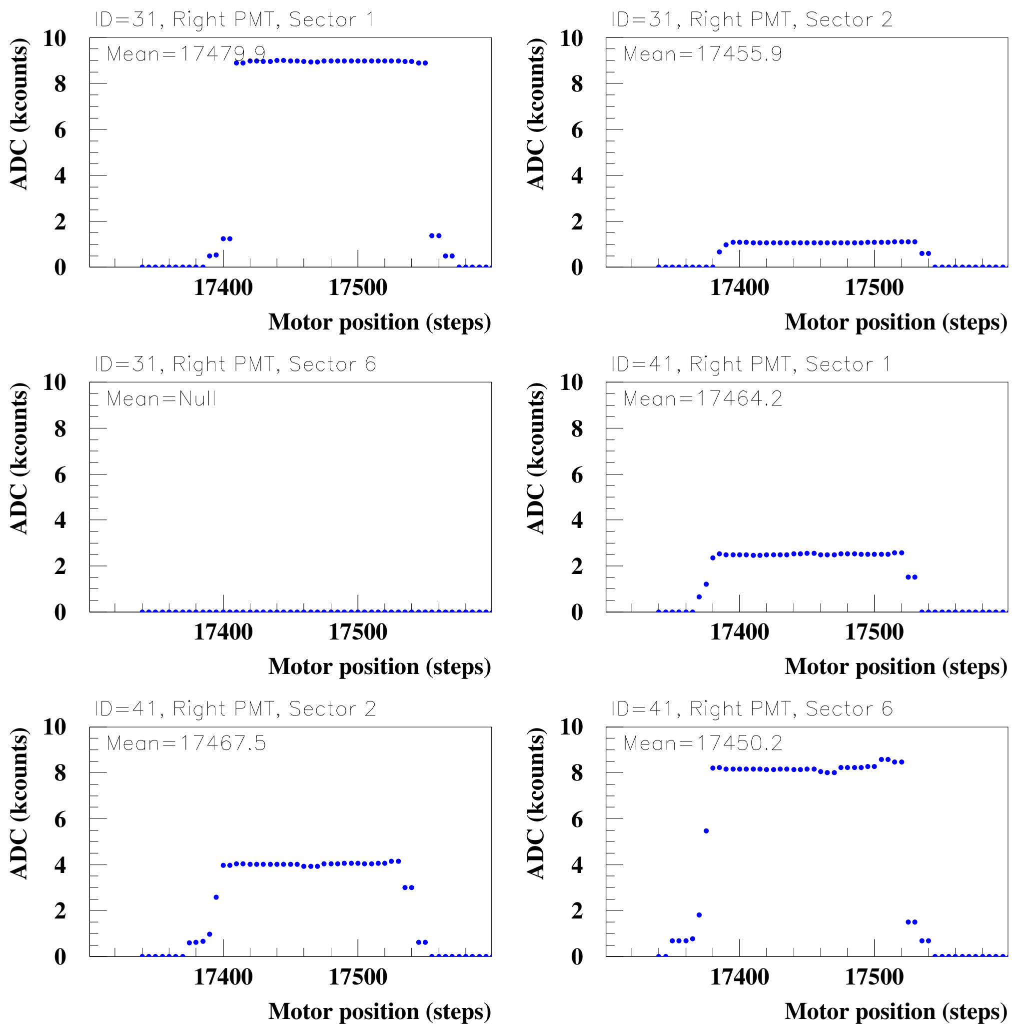

Figure 11: Pulse height recorded in scintillator 31 (right) and 41 (right) for sector 1 2 and 6 as the mask scanned across the fiber bundle. Scintillator 31R in sector 6 was dead.

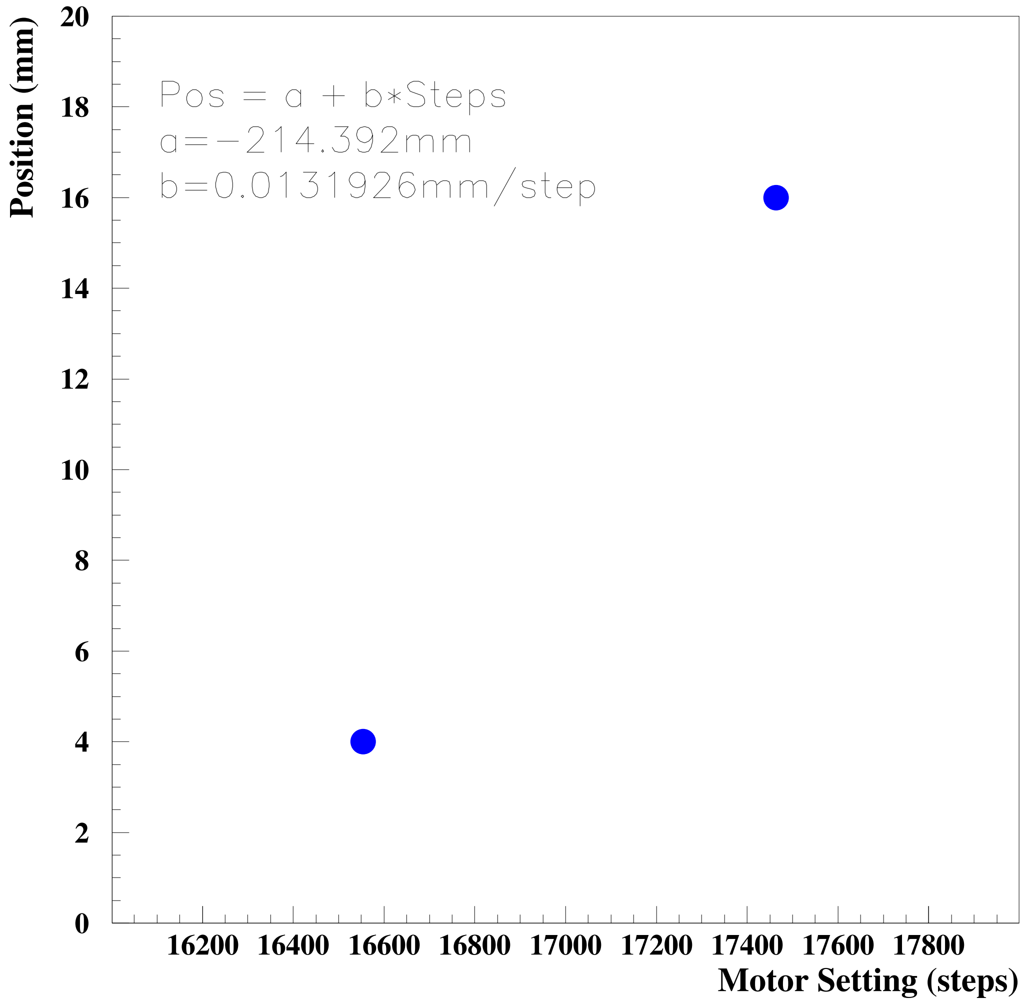

Figure 12: The average stepping moter counter for all sectors is plotted against the known location of the fiber bundle. The linear fit is also given to convert the motor steps into the position.