SDC-93-499
ANL-HEP-TR-93-36

SDC
SOLENOIDAL DETECTOR NOTES

Measurement of Source Tube Radial Position in Cast EMC Testbeam Module

D. Jankowski and R. Stanek
High Energy Physics Division
Argonne National Laboratory, Argonne, Illinois 60439

05 May 1993

SDC–93–499
ANL–HEP–TR–93–36

Measurement of Source Tube Radial Position in Cast EMC Testbeam Module

D. Jankowski and R. Stanek
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, IL 60439

1. Abstract

Using a ^{137}Cs source we have determined the position of two of the source tubes embedded in the Pb absorber in the cast EMC module used in the Fermilab test beam. Two scintillator tiles placed in the gaps on both sides of an absorber containing a source tube were readout into independent phototubes. The difference in scintillator response was measured in two towers at two different source tube layers. We find the source tube to be displaced towards the (radial) front of the EMC by about 1.6 mm in both measurements.

Work is proceeding now to check other source tubes in other locations.

2. Introduction

In the ANL design for the cast Pb . MC of the BCAL[1], the source tubes are embedded in the Pb absorber, and are constrained between towers at the bulkheads. If a low energy source such as ^{137}Cs is used to measure the response of a scintillator tile, the tolerance of the source tube placement in the Pb perpendicular to the scintillator, becomes an important issue due to varying amounts of Pb between the scintillator and source.

We have previously measured[2] the effect of Pb and air absorber thickness on ^{137}Cs signals and found that if the sum of the scintillators on either side of a source tube are used for calibration, we estimate a source tube displacement of ±450μ will cause an error in the PMT outputs by 1%. Furthermore, a displacement of 1 mm causes a 5% error.

[1]SDC Technical Proposal, SDC-92-201.
[2]SDC Note SDC-92-350.

* This work supported by the U.S. Department of Energy, Division of High Energy Physics, Contract W-31-109-ENG-38.

In order to try to determine the actual position of the source tube within the Pb absorber, we ran the ^{137}Cs sou... into a source tube and looked at the difference in response of scintillator tiles placed on either side of the Pb absorber. From this measurement and our previous results, we can deduce the position of the source tube in the lead transverse to the scintillators.

3. *Description of Measurement*

Figure 1A shows a picture of the EMC test module and fig. 1B is a diagram of the test setup incorporating Fig. 1A. Empty scintillator slots in towers 4 and 5 and adjacent to source tube numbers 1 and 2 respectively of casting #1 were fitted with 10 cm × 10 cm × 2.5 mm Kuraray SCSN-81 plastic scintillator tiles coupled in the standard fashion with Y7 waveshifter to two Hamamatsu R580 phototubes. A 2 mCi ^{137}Cs source was driven through a source tube in the absorber between the two scintillators. The output of the PMTs were coupled into a CAMAC multiplexed ADC and the current integrated for 20 msec and read out by an IBM XT.

Scintillators A and B were initially positioned such that A was in the upstream pocket, and B in the downstream pocket (Run 1). The high voltage was then set such that the current from tile A, I_A, was about equal that of tile B, I_B. Source scans were then made in this configuration, then tiles A and B were interchanged (Run 2). A second source scan was done, and the resulting current differences used to determine the source tube locations.

4. *Results*

Figures 2A and 2C show the PMT currents for the A and B pair in towers 4 and 5, respectively. These figures are shown for A in the upstream position and B in the downstream position. Figures 2B and 2D show the A and B currents in towers 4 and 5 again, but with the A and B tiles interchanged such that B is upstream and A is downstream. Table 1 summarizes the changes in signals after interchanging scintillators A and B between Runs 1 and 2.

Table 1

Run	*Scintillator A (ADC Counts)*	*Scintillator B (ADC Counts)*
1	448	444
2	1100	175
Ratio Run 1/Run 2	0.407	2.537
Run		
3	400	385
4	950	158
Ratio Run 3/Run 4	0.421	2.437

From Eq. 1 and Eq. 2 of the appendix, we can calculate the displacement of the source tube using either the signal change of scintillator A or scintillator B. The results are summarized in Table 2.

Table 2

	δx	
	A	B
Tower 4	-1.6 mm	-1.7 mm
Tower 5	-1.6 mm	-1.7 mm

By returning the scintillators to the original configuration after interchange (Run 2 configuration → Run 1 configuration), we can estimate possible systematic errors by remeasuring the signals from the A and B tiles. We estimate the error in our measurements to be ~ 1%.

Conclusion

There seems to be a systematic shift of the source tubes within the Pb absorbers by the order of 1.5 mm. Calibration using pairs of tiles should be insensitive to this displacement.

The misplacement of the tubes is seen as due to a lack of precise keying of the frame inside the mold. A few more pockets will be checked to see in fact if this is really a systematic effect throughout the module.

Appendix

Referring to Figure 3 as reference:

$$I = I_o(1 + 0.25\delta x)$$

(see SDC-92-350 - 25% change in intensity per mm displacement)

Run 1

$$I_{1A} = g_A \cdot I_o \cdot (1 + 0.25\,\delta x)$$
$$I_{1B} = g_B \cdot I_o \cdot (1 - 0.25\,\delta x)$$

Run 2

$$I_{2A} = g_A \cdot I_o \cdot (1 - 0.25\,\delta x)$$
$$I_{2B} = g_B \cdot I_o \cdot (1 + 0.25\,\delta x)$$

g(A,B) = PM tube gain

Note: δx positive in direction of "A" originally.

$$\frac{I_{1A}}{I_{2A}} = \frac{1 + 0.25\delta x}{1 - 0.25\delta x} = R_A$$

$$\frac{I_{2A}}{I_{2B}} = \frac{1 - 0.25\delta x}{1 + 0.25\delta x} = R_B$$

Therefore:

$$1 + \frac{1}{4}\delta x = R_A - \frac{1}{4}R_A\delta x$$

$$\frac{1}{4}\delta x + \frac{1}{4}R_A\delta x = R_A - 1$$

$$\frac{1}{4}\delta x(1 + R_A) = R_A - 1$$

$$\therefore \quad \delta x = 4\frac{R_A - 1}{R_A + 1} \qquad \text{Eq. (1)}$$

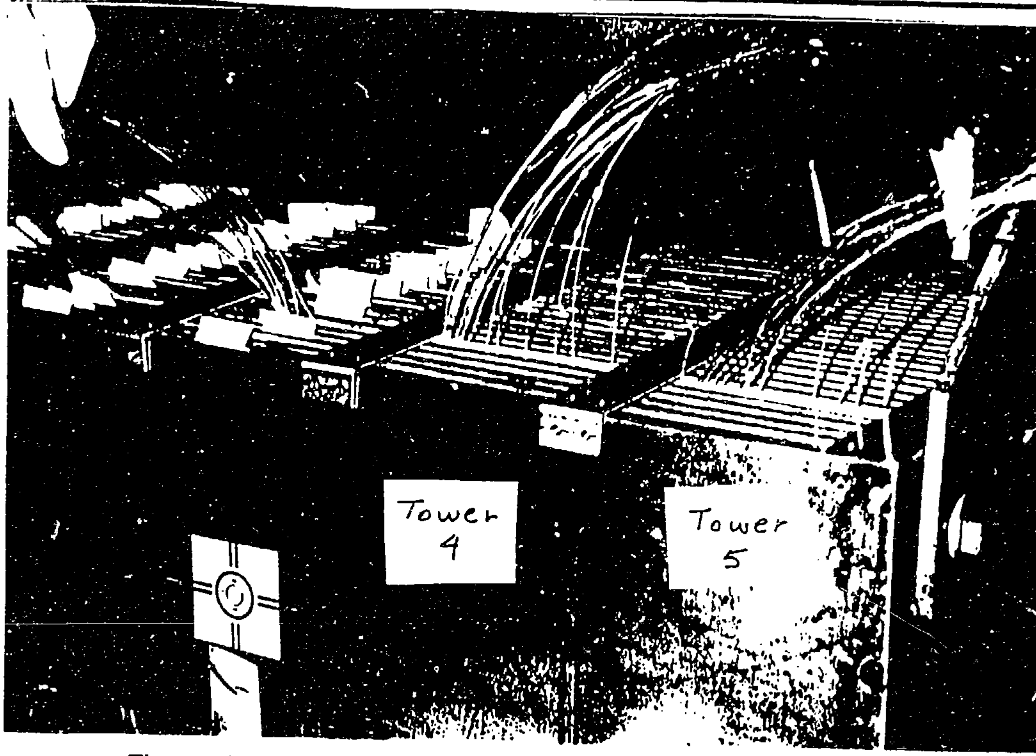
and

$$1 - \frac{1}{4}\delta x = R_B + \frac{1}{4}R_B\delta x$$

$$1 - R_B = \frac{1}{4}R_B\delta x + \frac{1}{4}\delta x$$

$$1 - R_B = \frac{1}{4}\delta x(R_B + 1)$$

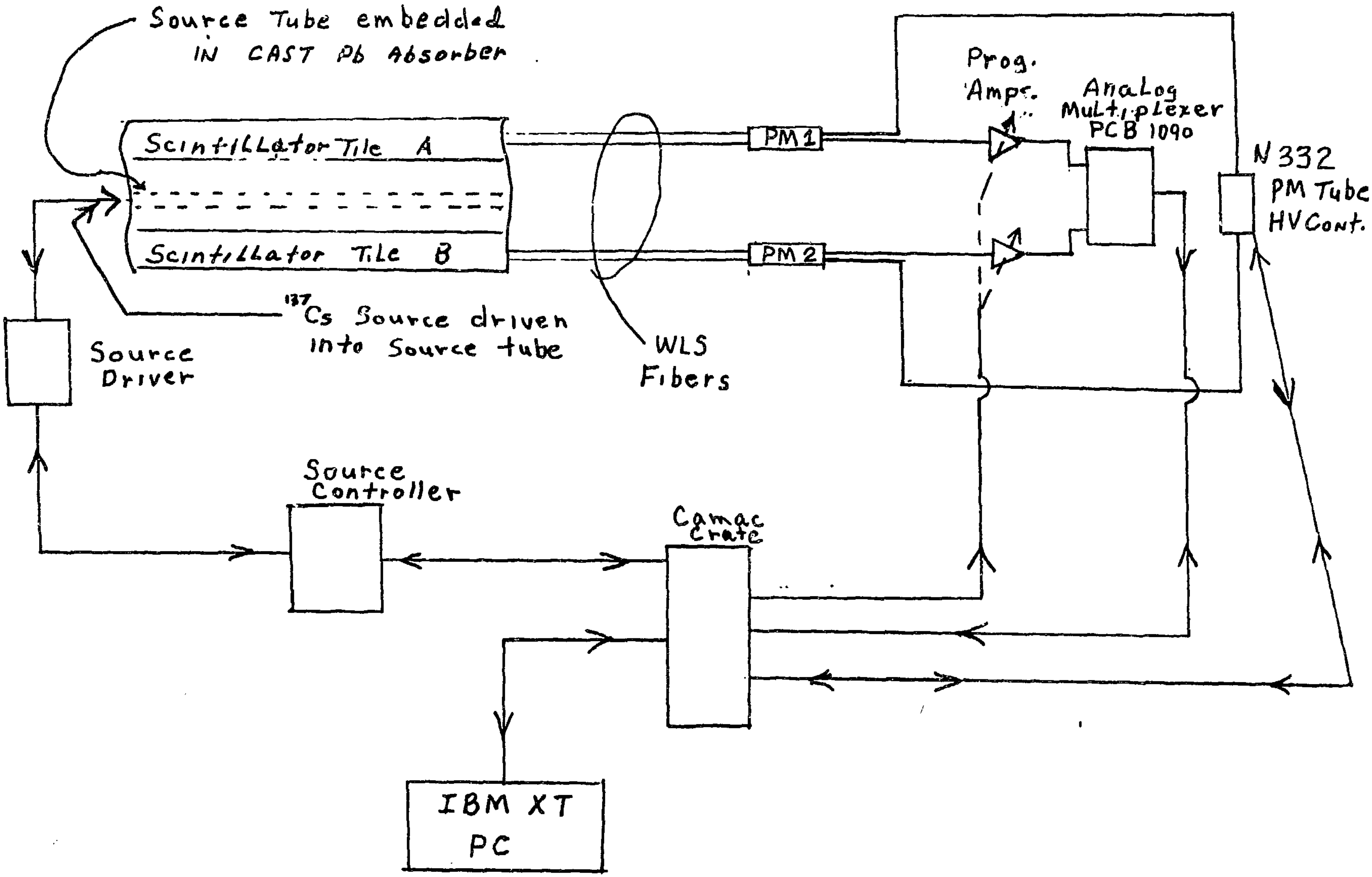
$$\therefore \quad \delta x = 4\left(\frac{1 - R_B}{1 + R_B}\right) \qquad \text{Eq. (2)}$$



The test beam casting with the SMD tiles and fibers being installed.

EMC TEST MODULE

- SCSN-38 Scintillator were inserted into the empty spaces of towers 4 & 5 for these measurements



Source Tube embedded
IN CAST Pb Absorber
Scintillator Tile A
Scintillator Tile B
^{137}Cs Source driven
into Source tube
WLS
Fibers
PM 1
PM 2
Prog.
Amps.
Analog
Multiplexer
PCB 1090
N 332
PM Tube
HV Cont.
Source
Driver
Source
Controller
Camac
Crate
IBM XT
PC

Figure 1B

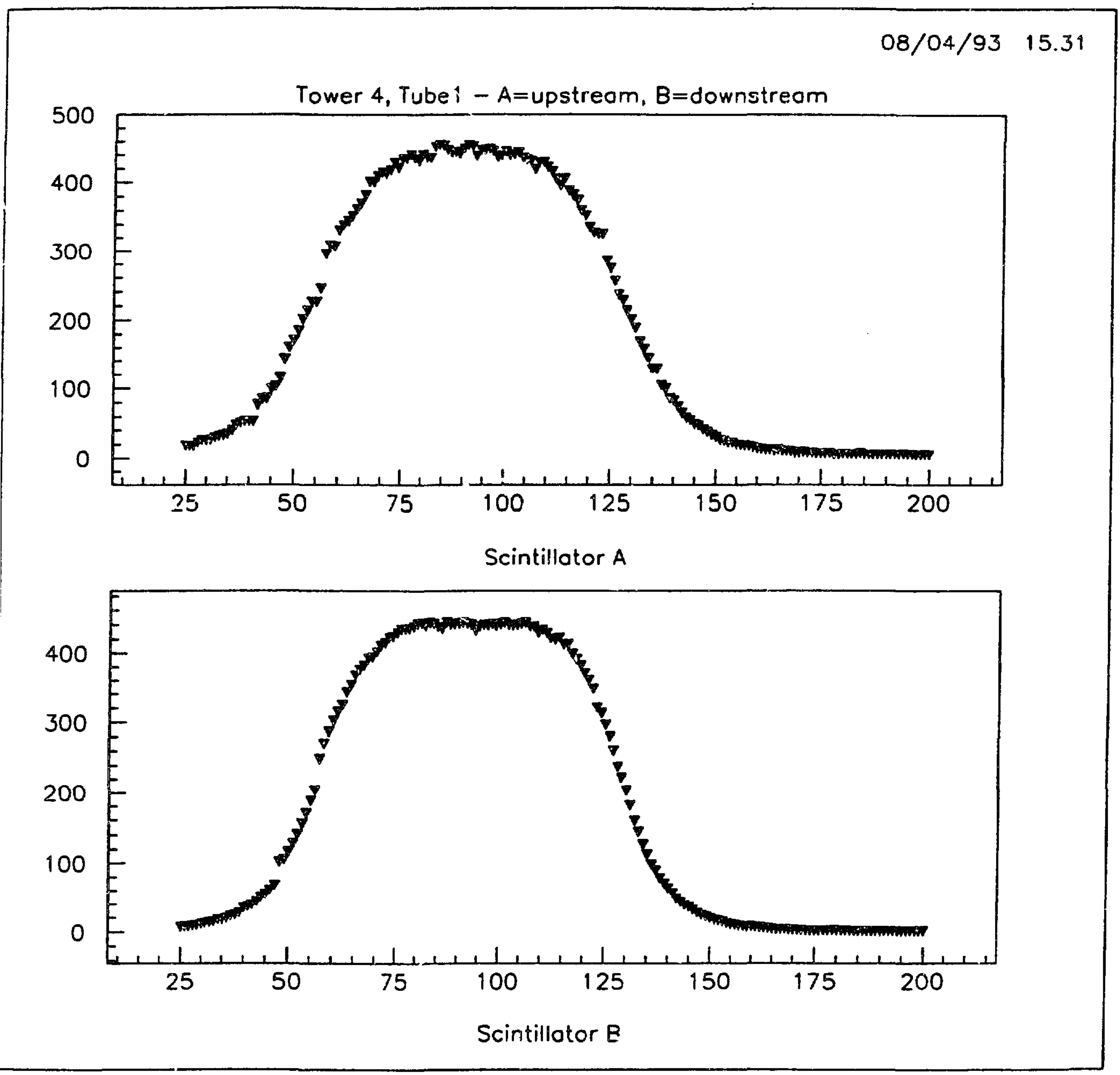

08/04/93 15.31
Tower 4, Tube1 – A=upstream, B=downstream
500
400
300
200
100
0
25
50
75
100
125
150
175
200
Scintillator A
400
300
200
100
0
25
50
75
100
125
150
175
200
Scintillator B

Figure 2A

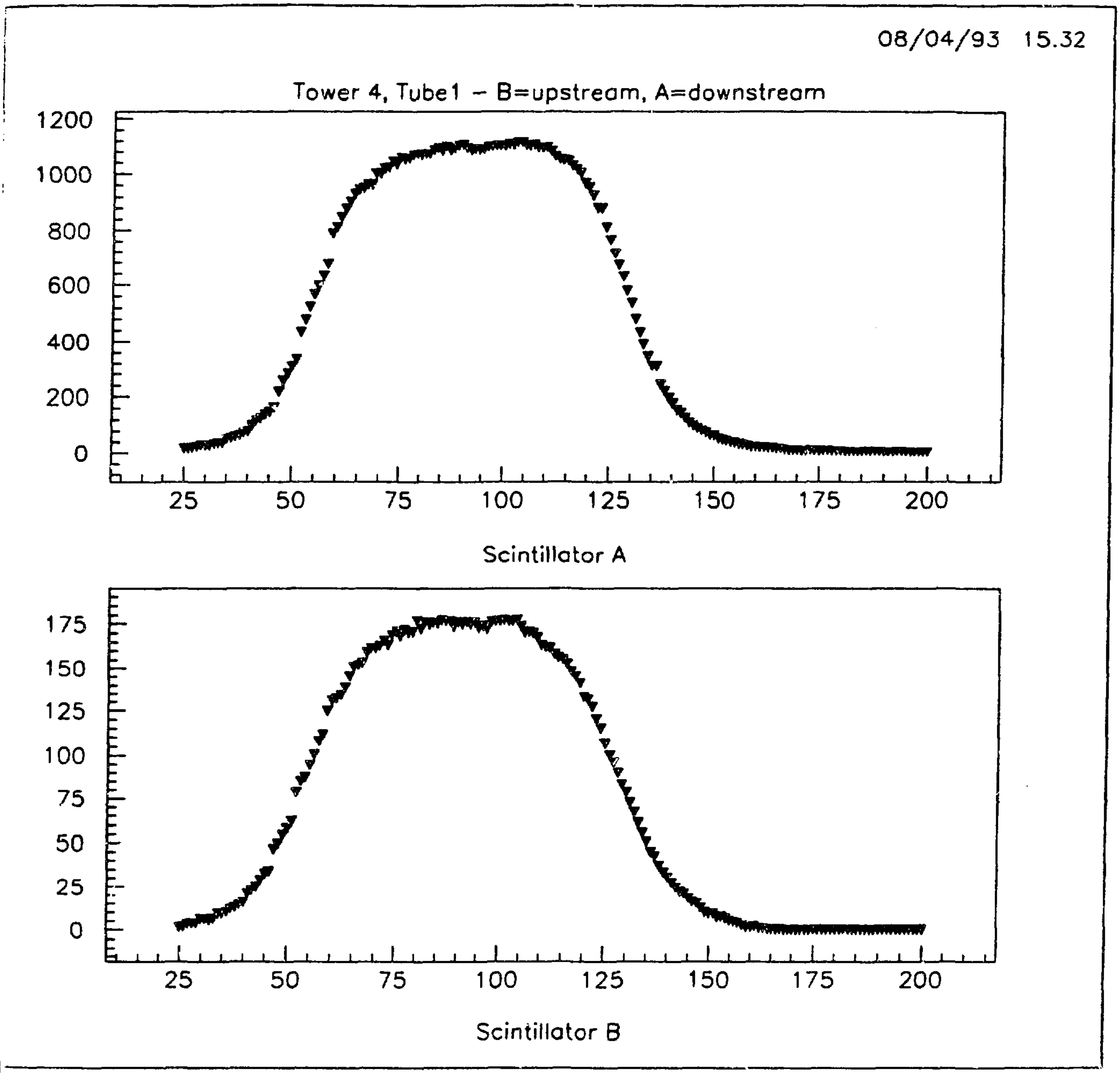

08/04/93 15.32
Tower 4, Tube1 – B=upstream, A=downstream
1200
1000
800
600
400
200
0
25
50
75
100
125
150
175
200
Scintillator A
175
150
125
100
75
50
25
0
25
50
75
100
125
150
175
200
Scintillator B

Figure 2B

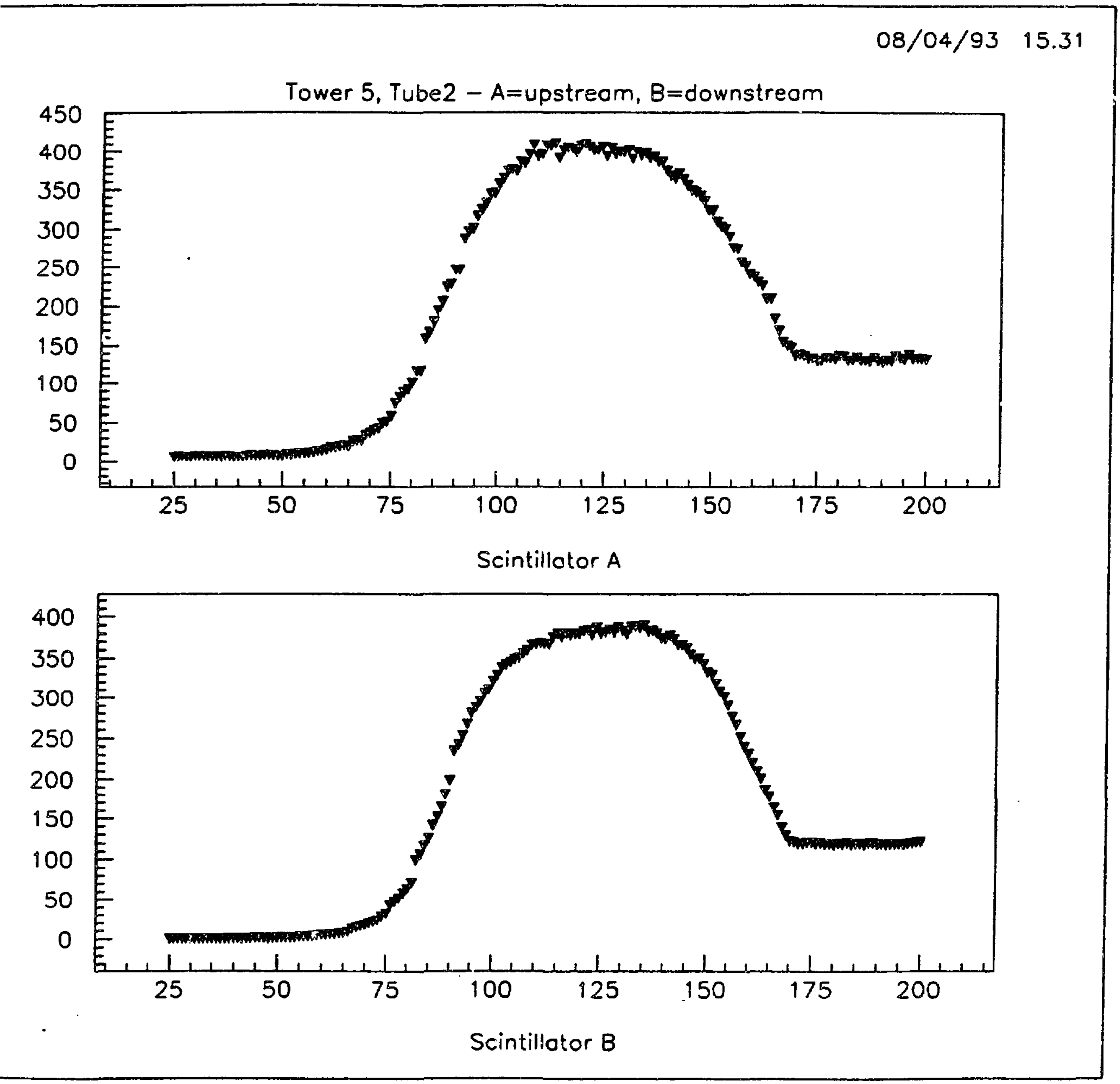
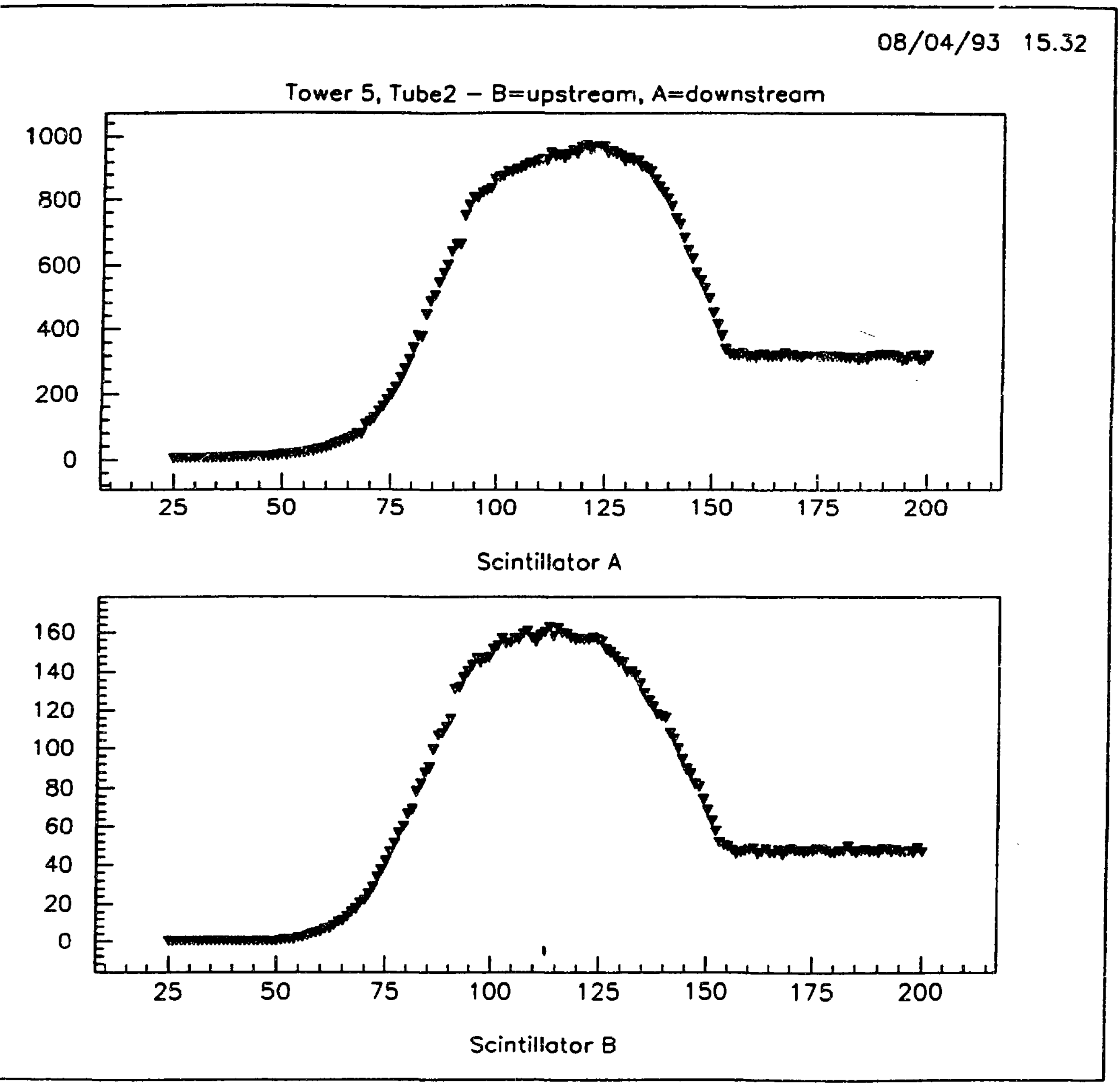
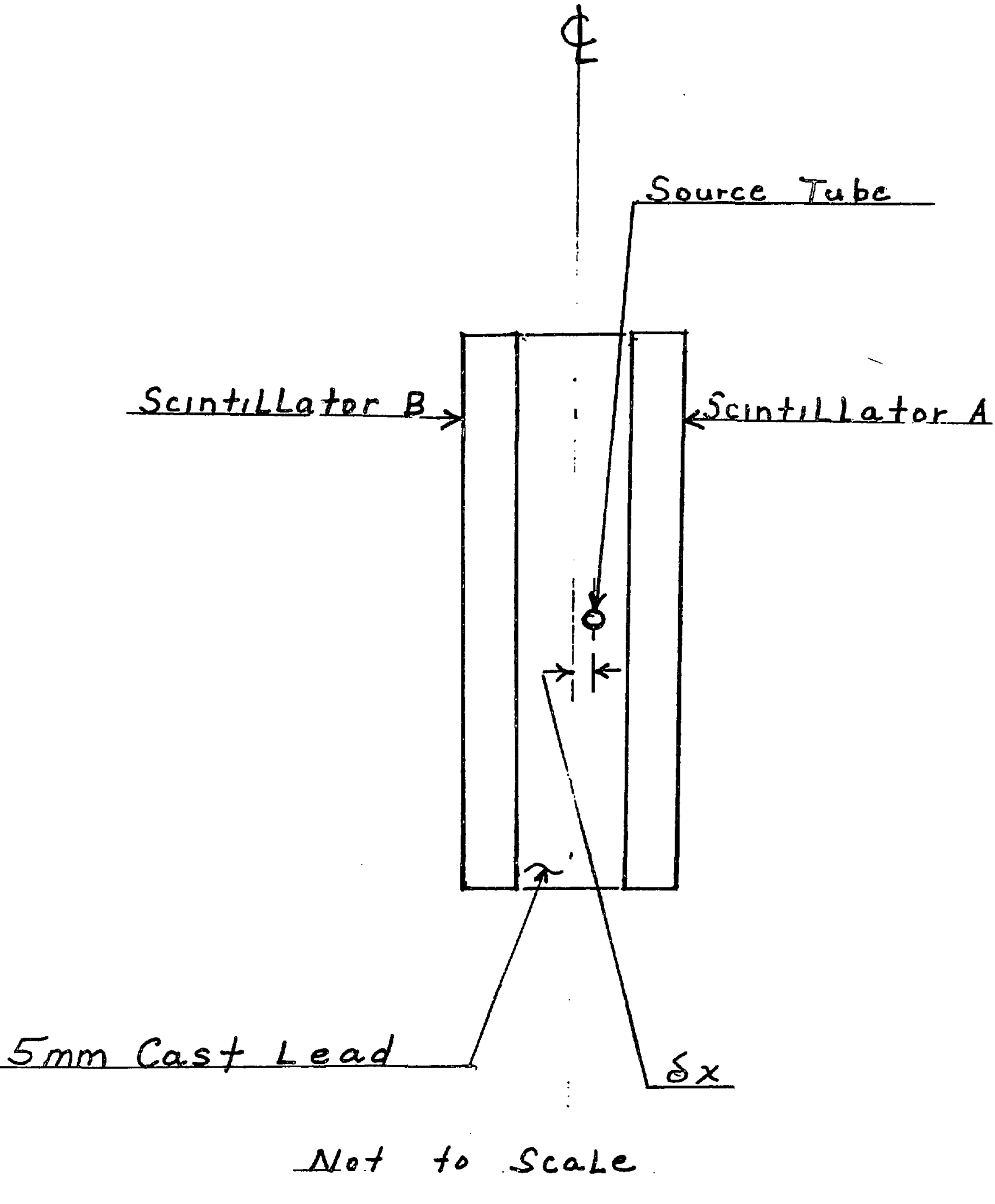

08/04/93 15.31
Tower 5, Tube2 – A=upstream, B=downstream
450
400
350
300
250
200
150
100
50
0
25
50
75
100
125
150
175
200
Scintillator A
400
350
300
250
200
150
100
50
0
25
50
75
100
125
150
175
200
Scintillator B

Figure 2C



08/04/93 15.32
Tower 5, Tube2 – B=upstream, A=downstream
1000
800
600
400
200
0
25
50
75
100
125
150
175
200
Scintillator A
160
140
120
100
80
60
40
20
0
25
50
75
100
125
150
175
200
Scintillator B

Figure 2D



℄
Source Tube
Scintillator B
Scintillator A
5mm Cast Lead
δx
Not to Scale

Figure 3