

New Geometry of Muon Walls in October 1997 Tilecal Beam Test

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Abstract

Computer controlled positioning system of muon walls is described. Suitable setting for the leakage detection during the extended barrel module 0 beam test is explained in details.

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1 Introduction

The muon walls [1] were newly equipped with a motor movement and a remote control for Tilecal 1997 beam test of two extended barrel modules 0, the lower one BCN and the upper one ANL, see Fig. 1.

This paper concerns only the October test beam period, the first part of the 1997 beam test is described in another note.

The back wall slides parallel to the modules' girders and the side wall slides perpendicular to them. Both muon walls can together fully cover leaking particles for η around -1.1 , when the beam axis passes through the corner of the extended barrel. The back wall, see Fig. 2, is composed of 3 rows of 5 pieces of scintillator detectors, the so called 'Prague' counters [2] with the total active area $94 \times 106 \text{ cm}^2$. The active area in this position can detect leak from the ANL module, the BCN module is covered only partially.

The side muon wall, see Fig. 3, consists of 5 Michigan State University (MSU) scintillator pairs [3] used in the April 1996 combined beam test as MidSamplers and in the September 1996 beam test as a part of the back muon wall. The MSU counters are fixed with 2 cm overlaps and their active area $90 \times 102 \text{ cm}^2$ has no dead zones. The horizontal axis of the wall is parallel to the middle plane of the BCN module, its geometrical centre is 14 cm above this plane, the side muon wall covers both BCN and ANL extended barrel modules.

A group of three scintillator pairs of the side wall can be folded to allow the drawer insertion into the girder.

The muon walls cabling and the data acquisition labels are summarised in Table 1.

The walls are moved with the use of engines and their position is electronically read. The walls positioning may be operated either remotely from the control room by PC or locally on the scanning table as explained in Section 2. The recommended positions for different test beam geometries are summarised in Section 3. The standard ntuple variables describing muon walls counters are the same as for September 1996 data [1] and their description is in Appendix A.

2 Remote control of muon walls

2.1 Description

The walls are moved by 220V engines. Each wall has its own steering electronics box fixed respectively directly on the back wall or just under the side wall. The box contains display that shows the position in some local relative units and knobs for display operation. The box further contains main switch ON/OFF and a toggle REMOTE/LOCAL. An operation box with a yellow light and 2 green push buttons for manual wall movement in respective directions is located close to the steering box. Manual operation can be used only in the toggle position LOCAL. For a remote control the toggle must be in the REMOTE position.

The back wall is moved by DC 220V engine over a chain fixed to the scanning table floor. The engine is controlled with the help of relay. The relay is steered

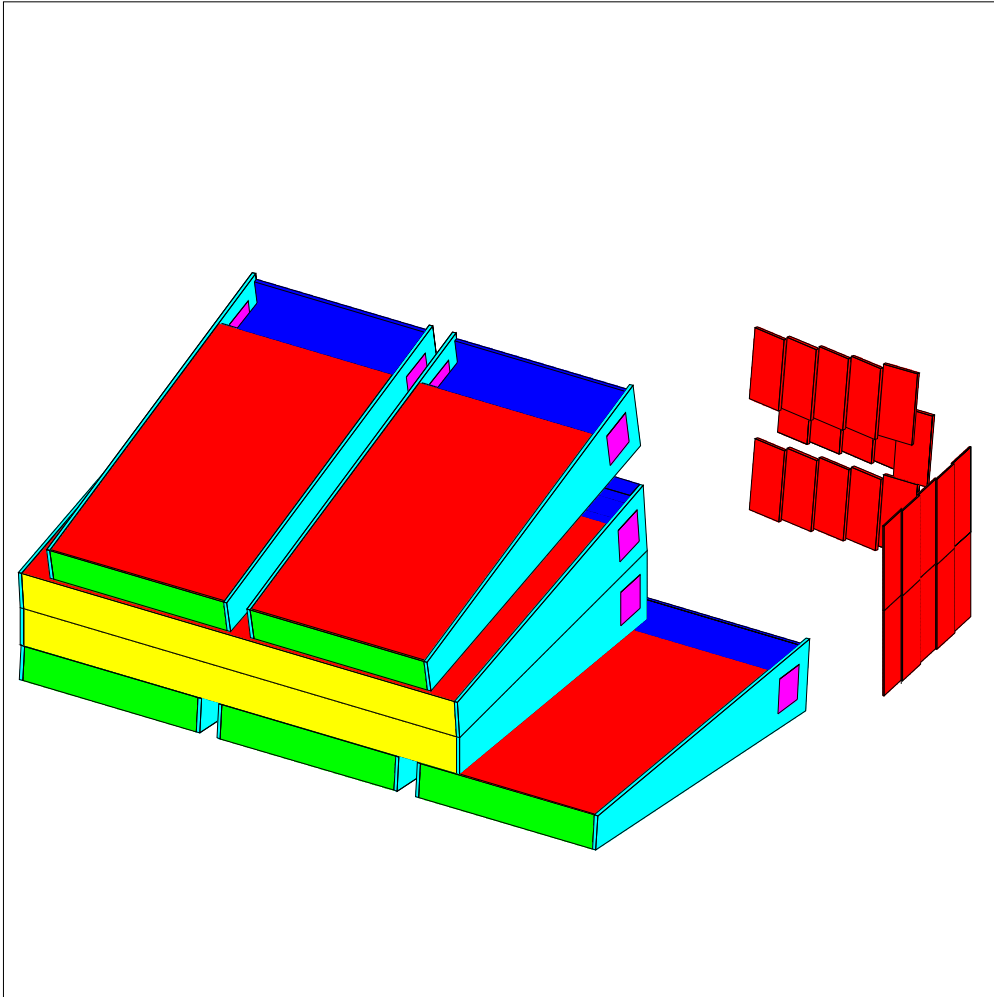


Figure 1: The October 1997 beam test setup with the automatically movable remotely controlled muon walls. The walls are in the position for the pseudo-rapidity scan at $\eta = -1.07$.

BACK MUON WALL
 =====

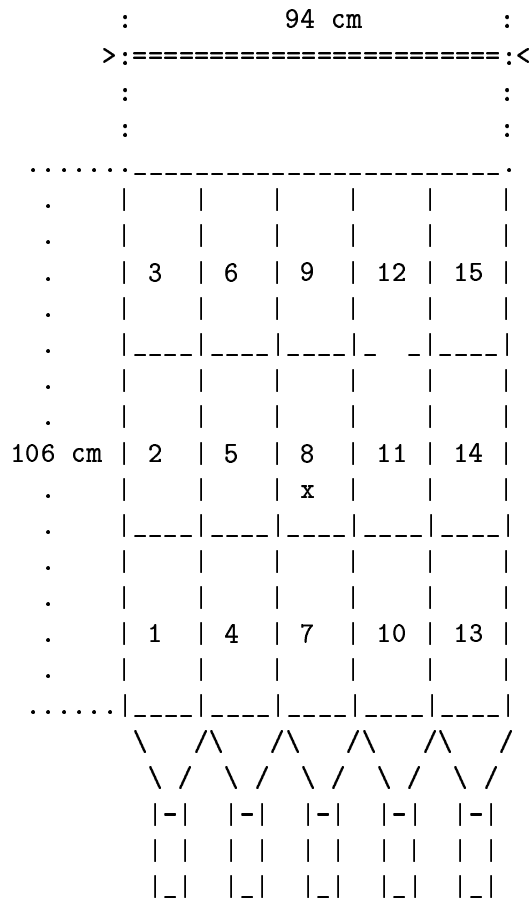


Figure 2: The back muon wall for the beam test of extended barrel module 0 in October 1997. The beam entrance for pseudorapidity scan of ANL module at $\eta = -1.0$ is marked by x.

SIDE MUON WALL
 =====

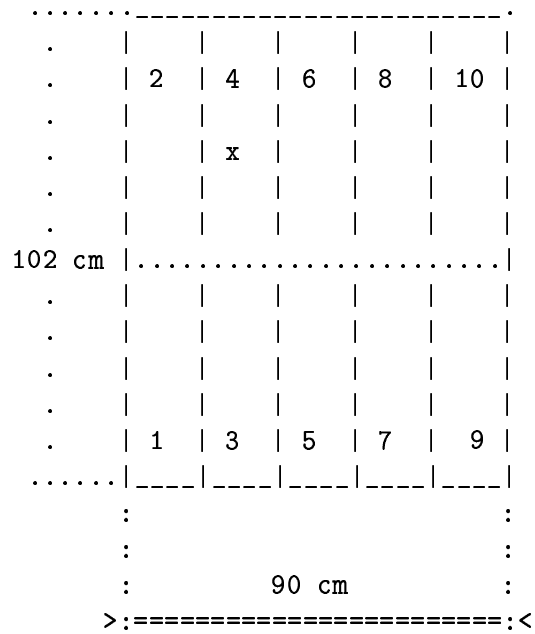


Figure 3: The side muon wall for the October 1997 beam test as seen by the beam at $\theta = -90$ deg. Beam entrance is marked by x for the test of tile number 10 of the ANL module.

# counter see Fig.2,3		HV cable	Signal cable	ADC channel	#DET	#PMT case	HV [V]	CAEN Crate 04 channel	# PM in DATA- BASE	Comment
	1	214	228	228	20	374	1550	35	1	Prague
	2	801	245	250	13	4294	1850	33	6	Prague
	3	211	246	225	1	4279	1850	19	11	Prague
B	4	212	226	226	2	4315	1790	20	2	Prague
A	5	213	227	227	3	4316	1820	21	7	Prague
C	6	215	229	248	7	4262	1850	23	12	Prague
K	7	216	230	230	8	4282	1850	24	3	Prague
	8	217	231	249	10	4289	1730	25	8	Prague
W	9	218	232	232	11	4290	1770	26	13	Prague
A	10	219	233	233	12	4277	1830	27	4	Prague
L	11	220	234	234	14	4385	1820	28	9	Prague
L	12	221	235	235	15	4261	1750	29	14	Prague
	13	222	236	236	16	4311	1740	30	5	Prague
	14	223	240	240	17	4317	1830	31	10	Prague
	15	224	242	242	18	4293	1750	32	15	Prague
S	1	201	215	215	1down	1	1650	08	16	Michigan
I	2	206	220	220	1up	6	1450	13	21	Michigan
D	3	202	216	216	2down	2	1548	09	17	Michigan
E	4	207	221	221	2up	7	1497	14	22	Michigan
	5	203	217	217	3down	3	1648	10	18	Michigan
W	6	208	222	222	3up	8	1675	15	23	Michigan
A	7	204	218	218	4down	4	1625	11	19	Michigan
L	8	209	223	223	4up	9	1646	16	24	Michigan
L	9	205	219	219	5down	5	1575	12	20	Michigan
	10	210	224	224	5up	10	1649	18	25	Michigan

Table 1: The muon walls and DAQ labels for the October 1997 beam test. The second column contains the counter logical numbers for the back and the side walls as marked in Fig. 2 and Fig. 3. The sixth and seventh columns give the production serial numbers of Prague counters and PMT's, respectively. For the Michigan State University PMT's, the number in the seventh column is the label attached to the PMT-case.

via simple diodes logic directly by pushing green knobs on the steering box. For the remote control the relay is operated by steering electronics. The position is measured by an IRC element. The element precision is 0.05 mm, the wall positioning precision due to gear box and chain and steering system is on the level of 15 mm.

The side wall is moved by AC asynchronous 220V engine over long screw. The control is practically the same as for the back wall. The position is measured by the IRC method, but the element is realised by mechanical switches. The positioning precision is similar to the back wall.

Remote control personal computer located in the control room sets two target position values for each wall. The steering electronics will start the engine motion in correct direction to move the wall between the set target positions. The target position values are sent from the personal computer over serial line RS422 (2x twisted pair). One cable connects both walls, because each wall has its own address. C-language program resides on PC and sends the target position values, computed from requested η values for projective scan or from θ and z values for non-projective scan. It is also possible to set directly the walls positions in Atlas coordinates. The final walls positions can be displayed on the PC.

Each wall has two sets of end switches. First switch stops the wall movement in current direction and enables to move it in the opposite one. The second end switch is an emergency switch that switches off the engine but the relay logic still remains operational. A technical intervention is required when the second emergency end switch is activated. Both walls have manual emergency switches that switch off the whole wall. They may be used for emergency stop of the walls and complete electronics switch off. Moreover, one emergency switch stopping and switching off both walls is located on the fence of the experimental zone close to the control room entrance.

2.2 Operation

Remote control is provided by PC-Olivetti placed in the control room of H8 test beam with the program 'muonwall.exe' placed in directory `C:\muonwall`. The values of parameters necessary for program initialisation are read from the file 'muonwall.ini'. All distances are given in Atlas reference system coordinates in cm.

The control electronics system of muon walls has to be initialised in the beginning by means of steering and operation boxes:

- Release the red emergency stop buttons.
- Flip main switch to 'ON' position.
- Flip toggle to 'REMOTE' position. Remark: The wall may automatically begin to move to some previously set position!
- Start the program muonwall.exe.

- Send the command "o" to origin the positions of both walls. The walls start to move and each wall will automatically stop in its limit position. The Back wall is moved in the direction of side wall (to the highest Atlas z) and the side wall in the direction of back wall (to the highest Atlas r).
- Press the red emergency stop to switch off both walls.
- After few seconds release this emergency stop to switch on. Both displays will be set to 0.
- Now the walls are ready to be set to desired positions.

The program is operated from the keyboard by single character commands with the following meanings (see also a hint inside the program window on the screen):

- g** GO - both walls start to move to positions which can be set by 'e','s','b' or 't'+ 'z' commands
- q** QUIT the program
- e** ETA - set a value of pseudorapidity. Type 'enter' after delivering η value. Program will calculate positions of walls. Then you can press button 'g' and walls start to move to computed positions. You can check the position of walls by pressing 'r'.
- r** READ - the program will continuously read the positions of the walls. To stop reading press any key.
- s** SIDE - set the position of the sidewall separately. After typing a number press 'enter'.
- b** BACK - set the position of the back wall separately. After typing a number press 'enter'.
- t** THETA - set the angle theta for non-projective scan. After typing a number press 'enter'.
- z** ZETA - set z-coordinate for non-projective scan (Atlas z-coordinate of the beam entrance into the extended barrel 0). After typing a number press 'enter'.

Pseudorapidity of test beam	η_{min}	η_{centre}	η_{max}	z_{min} [cm]	z_{centre} [cm]	z_{max} [cm]
-0.8	-0.73	-0.80	-0.87	416.	463.	510.
-0.9	-0.84	-0.90	-0.96	488.	535.	582.
-1.0	-0.94	-1.00	-1.06	565.	612.	659.
-1.1	-1.03	-1.09	-1.14	640.	687.	734.
-1.2	-1.03	-1.09	-1.14	640.	687.	734.
-1.3	-1.03	-1.09	-1.14	640.	687.	734.
-1.4	-1.03	-1.09	-1.14	640.	687.	734.
-1.5	-1.03	-1.09	-1.14	640.	687.	734.

Table 2: The correspondence between the beam test pseudorapidities and the η and z values of the edges and centre of the BACK MUON WALL for the η scan values. The table is applicable to both modules but BCN extended barrel module is covered only partly.

3 Muon wall positioning

The active surface centre of either wall is normally positioned against the beam spot. If it is not possible respective wall remains in its limit position.

3.1 Pseudorapidity scan

For extended barrel 0 beam test the back muon wall can detect secondary particles with Atlas pseudorapidities from -1.14 to -0.7 . The side muon wall covers range -1.5 to -1.14 . More exactly, the values depend on module under test. For the lower BCN module the beam enters the centre of the module at an angle of ≈ 8.2 deg to the scanning table surface while for the upper ANL module the angle is ≈ 13.9 deg and the counters of back muon wall are in larger distance from back plate of extended barrel module 0 because the back muon wall is perpendicular to the scanning table surface.

Tabs. 2 and 3 show the real coverage possibilities of either wall by means of the three values of pseudorapidities corresponding to the edges (η_{max} and η_{min}) and to the centre (η_{centre}) of the wall for several pseudorapidities planned for the test beam. Further they show position of wall edges and centres in the Atlas coordinates z and r for back and side muon walls, respectively.

3.2 Scan at $\theta = -90$ deg

During the scan at $\theta = -90$ degrees by electron beams the side muon wall must be outside the beam trajectory. This can be simply achieved by the same wall position as for rapidity scan with $\eta = -1.21$. (Side wall will be in the position closest to the back muon wall).

The side muon wall can detect muon and pion beams only for the test of tiles number 10 and 11 if it is positioned to its limit upstream position. Alternatively,

Pseudorapidity of test beam	η_{min}	η_{centre}	η_{max}	r_{min} [cm]	r_{centre} [cm]	r_{max} [cm]
-0.8	-1.29	-1.21	-1.14	440.	485.	530.
-0.9	-1.29	-1.21	-1.14	440.	485.	530.
-1.0	-1.29	-1.21	-1.14	440.	485.	530.
-1.1	-1.29	-1.21	-1.14	440.	485.	530.
-1.2	-1.29	-1.21	-1.14	440.	485.	530.
-1.3	-1.40	-1.30	-1.22	391.	436.	481.
-1.4	-1.50	-1.39	-1.29	349.	394.	439.
-1.5	-1.50	-1.39	-1.29	349.	394.	439.

Table 3: The correspondence between the test beam pseudorapidities and the η and r values of the edges and centre of the SIDE MUON WALL for the η scan values. This table is applicable for both ANL and BCN extended barrel modules.

a) BCN module				b) ANL module			
θ [deg]	z_{in} [cm]	z_{centre} [cm]	r_{centre} [cm]	θ [deg]	z_{in} [cm]	z_{centre} [cm]	r_{centre} [cm]
10.	380.	450.	485.	10.	380.	450.	485.
10.	500.	552.	485.	10.	500.	553.	485.
10.	520.	572.	485.	10.	520.	573.	485.
20.	380.	487.	485.	20.	380.	490.	485.
20.	500.	607.	485.	20.	500.	610.	485.
20.	520.	627.	485.	20.	520.	630.	485.

Table 4: The setting of the muon walls for the non-projective scan defined by the beam input θ angle and the z_{in} input point. The z_{centre} describes the position of the back muon wall centre and the r_{centre} describes the position of the side muon wall centre.

for a fine scan, the desired side wall position may be set by 's' SIDE command.

3.3 Non-projective scan

The non-projective scan is defined by two variables θ and z_{in} (on computer display marked as 'z'). The z_{in} is Atlas z coordinate of the beam entrance to the extended barrel module 0 face and θ is an angle between this face normal and the beam axis. Table 4 shows the corresponding muon walls centres setting for specified beams.

3.4 Manual positioning

As a backup solution the walls can be moved manually (the toggle on steering box in 'LOCAL' position). The position labels are marked on the scanning table

along the muon walls rails. Tables 5 and 6 show the correspondence between the position labels and η , z , r values of muon wall centres in the Atlas coordinates.

Position label	z_{centre} [cm]	η_{centre} beam to BCN	η_{centre} beam to ANL
1	450.	-0.78	-0.77
2	490.	-0.84	-0.83
3	530.	-0.89	-0.88
4	570.	-0.95	-0.93
5	608.	-0.99	-0.98
6	648.	-1.04	-1.03
7	687.	-1.09	-1.08

Table 5: Manual positioning the back muon wall. The correspondence between the position labels and z and η values of muon wall centre in the Atlas coordinates.

4 Response to the muons

The response of the muon wall scintillation counters to charged particles was tested using muon beams and using selected events with muon contamination of pions beams. Energy losses in the scintillator correspond to the Landau theory and were fit by the convolution of Landau and Gaussian distribution [4] to determine a peak position. A slight dependence of the muon response peak position on the distance of the muon beam from the light guide edge, 0.88 % per cm, was measured for 'Prague' counters.

Peak positions for all counters of both muon walls are summarised in the Table 7.

Upper row of scintillator counters in the back muon wall is unreachable by the test beam therefore its values of peak positions were extrapolated from previous usage of these counters.

Position label	r_{centre} [cm]	η_{centre}
1	394.	-1.39
2	417.	-1.34
3	440.	-1.29
4	462.	-1.25
5	485.	-1.21

Table 6: Manual positioning the side muon wall. The correspondence between the position labels and r and η values of muon wall centre in the Atlas coordinates. This table is applicable for both ANL and BCN extended barrel modules.

Backward wall				Side wall	
'Prague' counters				'MSU' counters	
# det	Peak_position	# det	Peak_position	# det	Peak_position
1	93	11	202	1	33.4
2	284	12	224	2	25.6
3	155	13	406	3	18.7
4	220	14	249	4	48.9
5	270	15	284	5	25.5
6	284			6	18.0
7	273			7	32.4
8	247			8	22.4
9	120			9	38.0
10	242			10	43.9

Table 7: The peak position of the muon response for all counters

These values are used for the standard ntuple production in the following manner : We define that the counter was hit by at least one charged particle if the signal obeys the relation

$$ADC > 0.7 \times \text{Peak_position} \quad (1)$$

The number of counters with charged particle hits is given for the back and side muon walls separately. The sum of the normalised signals from all counters is also calculated for the back and side muon walls separately using the formulae

$$MuBackSum = \sum_{i=1}^{15} MuBack(i)/Peak_position(i) \quad (2)$$

$$MuSideSum = \sum_{i=1}^{10} MuSide(i)/Peak_position(i) \quad (3)$$

5 Summary

The muon wall scintillation counters and their correspondence to the DAQ system is described for the October 97 extended barrel module 0 beam test period in Table 1.

The remote control is explained and the suitable positions of the movable muon walls for the beam test of the Tilecal extended barrel module 0 are given in Tabs. 2,3.

The response of muon wall counters to the muon beam is listed in Table 7.

6 Acknowledgements

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References

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A Muon wall data in the standard NTUPLES

The Muwall information in the standard N–tuple has the following structure:

```

*      1  * R*4  *      *      * MUWALL  * MuBackSum
*      2  * R*4  *      *      * MUWALL  * MuBackHit
*      3  * R*4  *      *      * MUWALL  * MuSideSum
*      4  * R*4  *      *      * MUWALL  * MuSideHit
*      5  * R*4  *      *      * MUWALL  * dummy
*      6  * R*4  *      *      * MUWALL  * MuBack(15)
*      7  * R*4  *      *      * MUWALL  * MuSide(10)

```

- MuBackSum contains the normalised sum of the 15 counters of the back muon wall.
- MuBackHit is the number of counters detecting at least one charged particle (m.i.p.) in the back muon wall.
- MuSideSum and MuSideHit are equivalent values for the side muon wall.
- The muon walls are described by 4 words and two vectors MuBack(15) and MuSide(10). The vectors contain ADC output for each counter (the

vector sequence numbers correspond to the logical numbers shown in the Figs. 1,2).

For the 'Prague' counters the values given are **NON-AMPLIFIED ADC** counts, for the 'MSU' counters the values are **AMPLIFIED ADC** counts.