End-Cap Alignment Cables

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Introduction

The existing design of the ATLAS end-cap muon detector alignment system specifies shielded halogen-free CAT-5 cables for its data acquisition. The MDT production sites plan to install the alignment DAQ cables as they assemble future chambers. In this report we present the results of our most recent investigation into the generation of false MDT hits by alignment system cables on an MDT chamber. Earlier this year, we wrote a similar report [2], in which we presented the results of another noise test. In the earlier test, we observed false hits when we used shielded cables, and an intolerable number of false hits when we used unshielded cables. As a result of these observations, we decided that we had no choice but to use shielded cables on the chambers. As we reported at the time, however, our results were inconsistent, and we suspected that the faraday cage of the chamber was ineffective. Since then, Harvard has built its own test chamber, with a new faraday cage and the latest MDT electronics. With the help of John Oliver (HUHEPL) and Michelle Dolinski (HUHEPL), we returned to Harvard last week and repeated our noise tests with this new chamber.

Apparatus

The Harvard test chamber is trapezoidal, and approximately two meters across its diagonal. During our experiment, the tubes contained argon under pressure, but we applied no high-voltage to the wires. Michelle connected the top-right set of twenty-four MDT channels to a computer. To simulate alignment data acquisition, we brought with us from Brandeis a stand-alone version of our Long-Wire Data Acquisition System (LWDAQ) Driver [1] that retrieves pixels continuously from an image sensor at 2 M Pixels/s, or

flashes an 80-mA light source at 25 kHz, depending upon switch settings on the board. We provided power to the LWDAQ Driver by plugging it into an available VME crate.

We divided our experiment into eleven tests. Our measurement for each test is a table of the number of hits counted during ten thousand 2-μs intervals (a total of 20 ms of counting time) for each of the twenty-four active MDT channels and at a range of MDT channel threshold voltages. Each channel has associated with it a threshold voltage, a hysteresis voltage, and a dead time. We set up the channels to measure 'time over threshold', in which state their hysteresis and dead time are disabled.

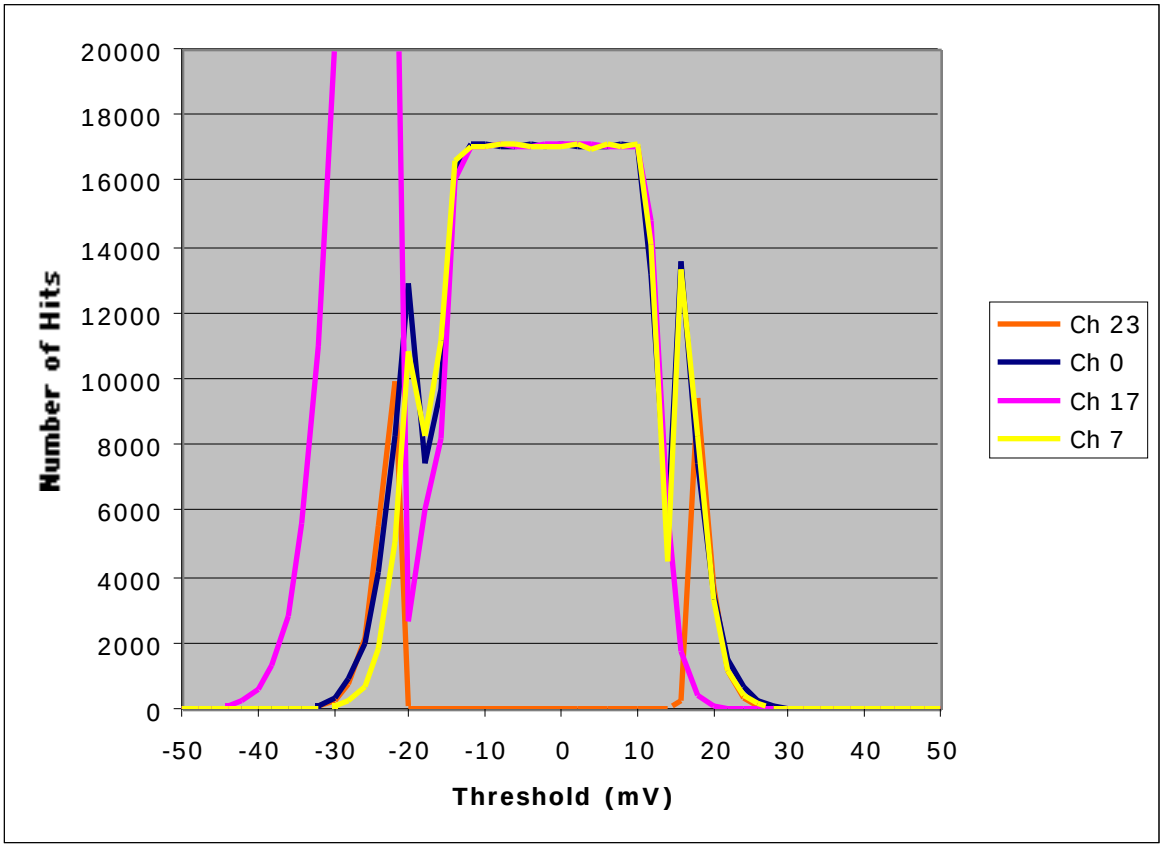

Figure 1: Number of hits verses threshold voltage during the control test for four channels selected out of the twenty-four active channels.

Our first test we performed with the LWDAQ turned off, to measure the background hit rate at our range of threshold voltages. Figure 1 shows the background hit rates verses threshold for four channels taken from the twenty-four available channels. One of the channels appears to suffer from excessive self-generated hits. Table 1 shows the number of hits obtained at a particular threshold voltage, 30 mV, for the first five channels, all of which appear to be well-behaved.

Test	Channel Number				
	0	1	2	3	4
1	34	2	46	60	16
2	34	4	20	73	22
3	63	3	30	87	21
4	47	4	52	80	20
5	55	5	25	80	40
6	48	0	36	48	30
7	28	7	28	78	7
8	16	0	0	24	3
9	32	0	36	51	40
10	16	0	24	71	24
11	36	0	28	80	8

Table 1: Number of hits recorded over 10,000 2-μs intervals for threshold +30 mV in first five channels for all eleven cable arrangements.

Our second test we performed with the LWDAQ plugged in and capturing images, but with the image sensor and cables sitting on the floor nearby the chamber. As we can see from Table 1, there is no statistically significant change in the number of hits recorded by the MDT channels. The same is true for all other tests we performed, no matter how aggressive we were with the cable arrangements. Neither unshielded cable nor multiple-passes across the top of the faraday cage caused any significant change in the number of hits generated at any value of threshold voltage. Figure 2 shows our various cable arrangements.

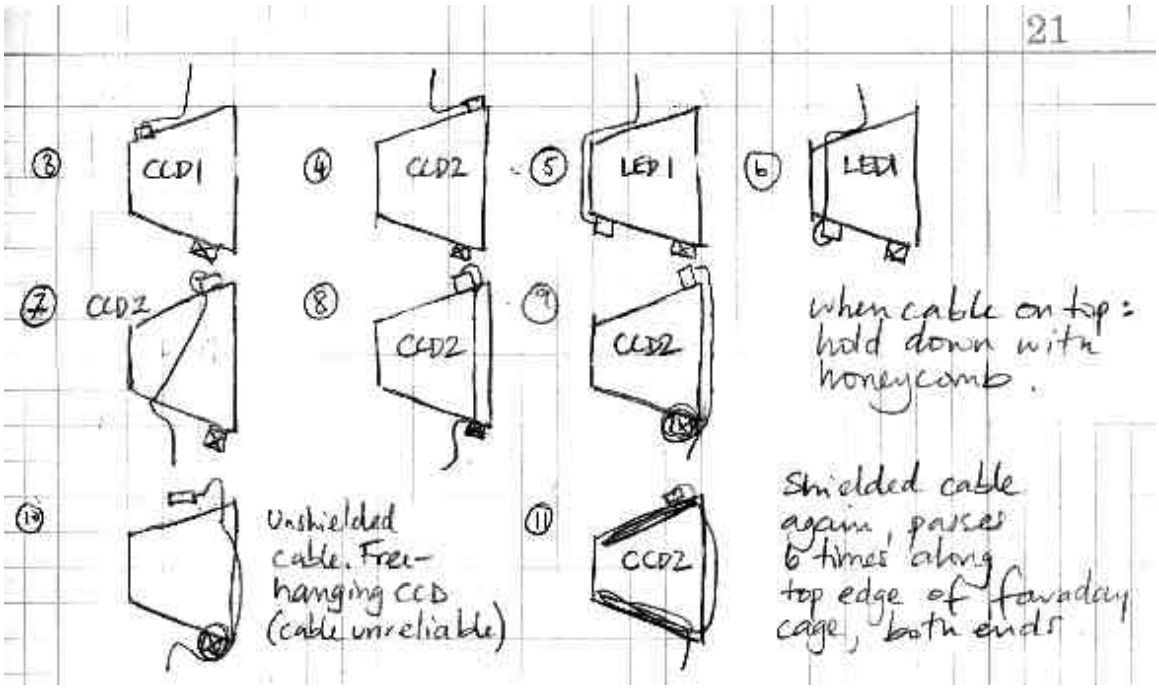

Figure 2: Cable arrangements for tests 3 to 11, scanned from notes taken during the test. The trapezoid is the chamber, with tubes running vertically in the drawing. The square with the cross in the middle, on the

lower right corner, is the active front-end readout electronics. The other squares indicate either inplane image sensors, inplane masks, or, in test 10, a free-hanging inplane sensor board.

LWDAQ Chamber Cables

We intend to supply chamber-production sites with rolls of halogen-free shielded cable, together with shielded connectors, crimp tools, and detailed instructions on how to assemble shielded CAT-5 cables for the LWDAQ. The halogen-free shielded cable we have chosen is made by Quabbin Wire and Cable Company. Its wires are stranded, and the shield is made of foil. The stranded wires make the cable more flexible, but they reduce the maximum length of cable that will operate with the LWDAQ from 100 m to 20 m. None of the chamber cables will be longer than 10 m, so we anticipate no problems.

The connector pin-out for LWDAQ cables is as follows.

Pin	Signal	Wire Color	Description
1	T+	Brown	LVDS Transmit Positive from Driver
2	T–	Brown and White	LVDS Transmit Negative from Driver
3	R+	Orange	LVDS Receive Positive from Device
4	R–	Orange and White	LVDS Receive Negative from Device
5	+5V	Green	5 V Power
6	0V	Green and White	0 V Return
7	+15V	Blue	+15 V Power
8	–15V	Blue and White	–15 V Power

Table 1: Long-Wire Plug and Socket pin-out

For a description of the LWDAQ architecture and grounding policies, please consult the LWDAQ Specification [1]. To ensure that signals and power propagate with the minimum of noise transmission and reception, we ask that cable-makers adhere to the color-code allocation specified in the table.

Conclusion

The chamber-makers can route the alignment cables around and across their chambers in any way they choose. The alignment system will cause no disturbance to the MDT readout. Even with unshielded cable wrapped around the MDT readout electronics,

we see no increase in the MDT background hit rate when we capture images. Previously, we were keen to use unshielded cable instead of shielded cable because we were concerned about the additional labor required to apply a shielded connector. But we have since studied the shielded connector problem more carefully, and we find that it takes no more than five minutes to put a shielded connector on a CAT-5 cable when you have the right connector and a good crimp toll. Furthermore, the entire procedure is simple enough to be described over the telephone. Therefore, we have decided to adhere to our original specification for shielded cables on the chambers. The shielded cable we have selected has stranded wires, making it more flexible and easier to route around the corners of a chamber.

References

[1] Long-Wire DAQ Specification, Kevan Hashemi
[2] End-Cap Alignment Cables (May 2002), Kevan Hashemi