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VELO Module Production - Cable Testing

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Abstract

This note describes in detail the procedures used in the reception, handling, testing and storage of HT and LT cables for the LHCb VELO detector modules.

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1. Introduction

This note describes in detail the procedures used in the reception, handling, testing and storage of "short kapton" HT and LT cables for the LHCb VELO detector modules. The procedures have been evolved over the last few years and this version was finalised for the Mid Term Review of the production process after 12 production modules had been made and transported to CERN for installation.

For the 2006/2007 the short kaptons were produced by Flexible Technology Ltd, and by Stevenage Circuits. No distinction in drawn in this document between the two.

The first part of the document is a description of the reception and testing procedures for the cables. The metrology of the hybrids is also described. The final section (Section 6) contains a summary of the results for the 2006 production.

2. Reception Procedure

2.1. Reception

The flow process for the production of the cables [1] is shown in Figure 1.

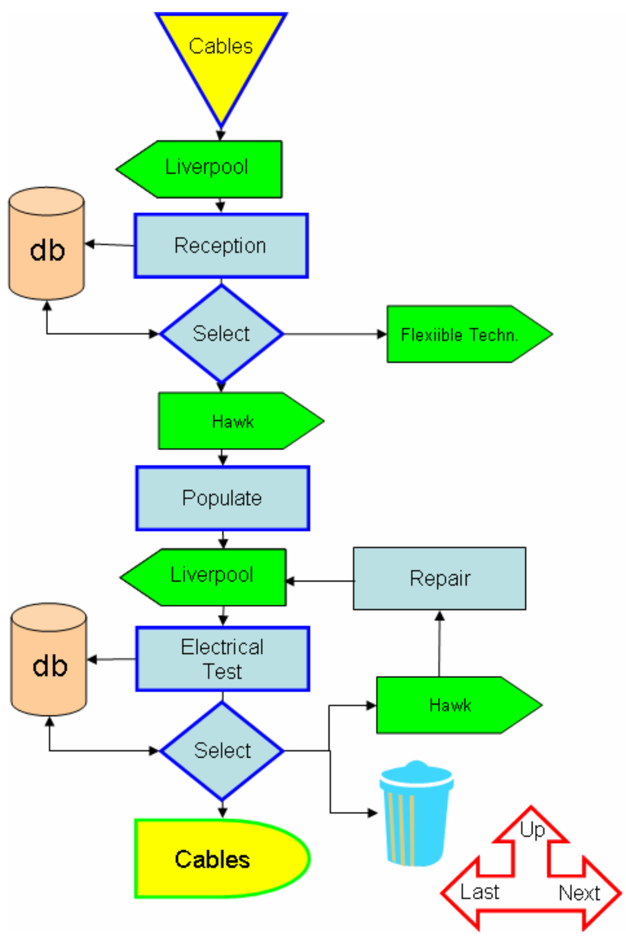


Figure 1: Flow Chart for production of cables. (From reference [1].)

Upon reception the cables from the manufacturer the cables are not equipped with connectors. They are first inspected by eye to ensure that there are no obvious signs of discolouration, folds or evidence of delamination. The cables are also inspected to look for signs of damage to the cable itself or to the pads to which connectors will be connected. The pads are further inspected, under a microscope, to ensure that there are not obvious short or faults.

2.2. Data Entry

The cables are numbered and then logged in the database [2]. Faulty cables are sent back to the manufacturer.

3. Electrical Testing

The electrical testing of the cables is performed in two parts. Firstly the resistance of all the cable traces is measured on an automated setup which allows a quantitative assessment of the cable manufacturing quality and identifies anomalies but is unable to detect short circuits between traces. The second test setup allows testing for shorts between trace pairs and between traces to power and ground plus it is able to give a quick visual indication of intermittent opens or shorts caused by cable or connector flexing and dry solder joints.

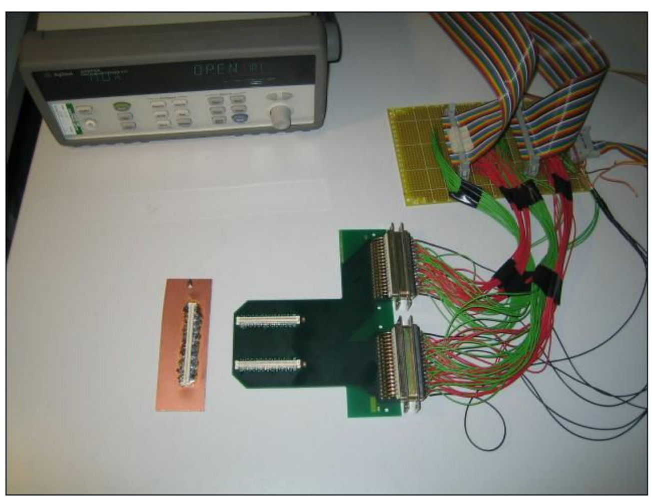
3.1. Detect Open Circuits and Anomalous Resistances

3.1.1. Equipment

Basic Set-up.

The Equipment set-up consists of 4 main components;

1) The Agilent 34970A Data Acquisition Unit
2) The IDE to 50-way Cannon Unit
3) The 50-way Cannon to Short Tail Unit (Dummy Board)
4) The Ground Socket

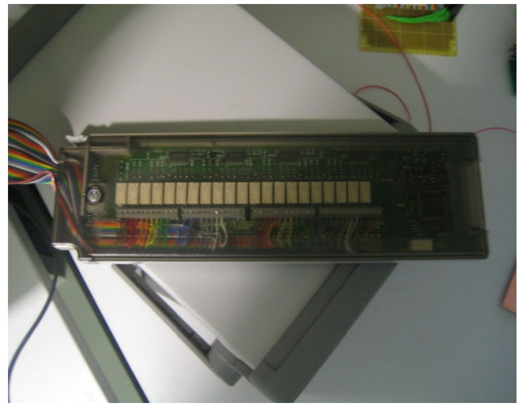


1. The Agilent 34970A Data Acquisition Unit.

This device is used to measure the resistance of the strips within the cable. It has 3x 40-channel multiplexers, allowing it to measure up to 120 channels.

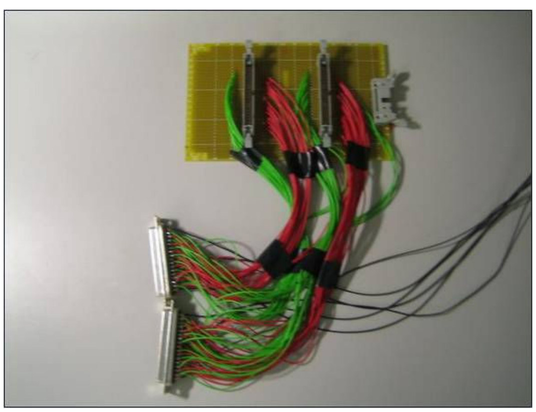
For a Short Tail, only 88 of these channels are measured for an LT cable, and 79 for an HT cable.

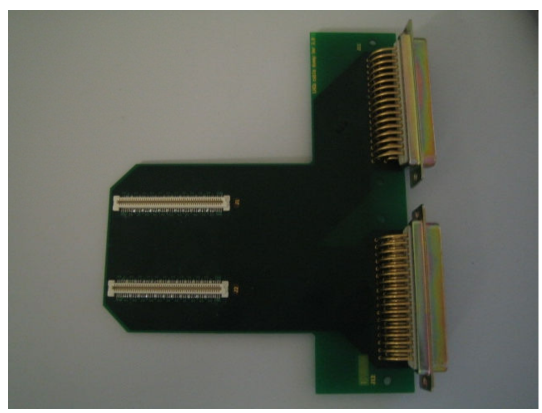
To measure Short Tail strip resistances, one of each of the multiplexer channels are connected to the individual strips, via the 'IDE to 50-way Cannon Unit' and the '50-way Cannon to Short Tail Unit', and the strips are then earthed to a common ground with the multiplexers.



2. The IDE to 50-way Cannon Unit.

This unit divides the multiplexer channels between the two legs of the Short Tails'. Essentially, it takes IDE's from the 3 multiplexers and converts to 2x 50-way Cannon connectors such that the first 44 channels attach to the first leg of a Short Tail, and the second 44 attach to the second leg. The black wires connect to the multiplexer ground wires.





3. The 50-way Cannon to Short Tail Unit (Dummy Board).

The Dummy board is the interface between the Short Tail cables and the Multiplexers. It converts the 50-way cannon connectors into the smaller 100-pin connectors on the Short Tails.

4. The Ground Socket.

The Ground Socket is the final component and is used to connect all of the strips within a Short Tail to a common ground with the multiplexers. It connects every strip within the cable to the cables' ground pins.

The common ground of the multiplexers is then connected to the cable ground through the 50-way Cannon connectors on the Dummy Board.

Cable Differences.

There are two different types of Short Tail Cables, LT and HT. The cables are very similar in layout, with the exception of a region on the HT cable, where there are no strips connected to the pins.

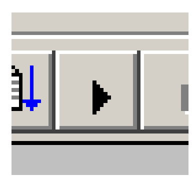
To accommodate this, two set-ups, for the Agilent Data Acquisition Unit, have been written. The first set-up, "LT test", tests every strip on the LT cable. The second set-up, "HT test", does exactly the same scan, except it doesn't make measurements of the missing strips.

For an LT cable, 88 strips are measured, whereas for an HT cable, only 79 strips are tested.

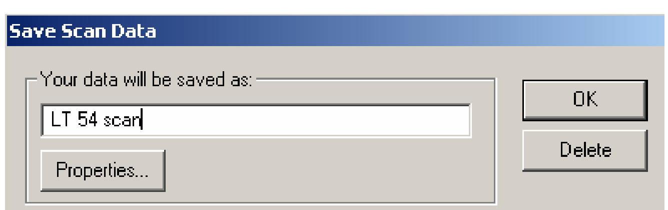
3.1.2. Measurements

Instructions

1) On the Desktop, click on the "LMT_test" icon
2) Choose the "Open existing set-up" option and click OK
3) For LT cables choose the "LT cable test" set-up, and for HT cables choose the "HT cable test" set-up
4) Attach the cable to the Interface



5) Click on the "Start Scan" icon at the top of the screen.
   Note that when you open the set-up, the first scan will download to the Agilent (taking approx 1 min); scans after this do not download again.
6) When the Scan is complete (5 secs – 1 min), a window will pop-up, allowing you to save the data.

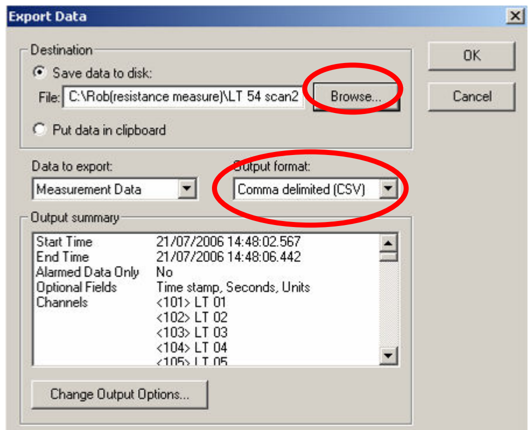


3.1.3. Exporting data to a .csv or .txt file:

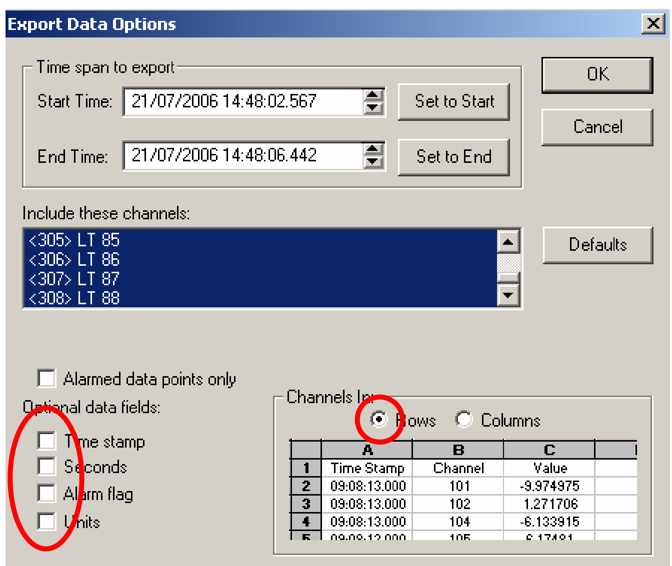
Once you have scanned a cable, you can export the resistance data to look at in another program.

1) In the "LMT_test" window, in the "file" tab, click "Export Data"

2) Choose a location to save the data to via the Browse button, and choose .csv or .txt from the "Output format" dropdown menu.



3) Before exporting the data, some of the output options require changing. Click the "Change Output Options" button. All of the "optional data fields" should be unchecked and the "Rows" option should be selected.



4) Click OK, and OK again.

3.1.4. Results Spreadsheet

The results exported from the cable test program can be calibrated and stored in a spreadsheet called “Short Tail Resistance Tests” located on the desktop. This spreadsheet contains graphs and statistics about the cables that have been measured.

<u>Using the Spreadsheet</u>

- To open the spreadsheet, click on the “Short Tail Resistance Tests” Icon

- The spreadsheet contains a number of different sheets, showing different data, these can be selected via the tabs at the bottom of the screen.

Raw data: Imported data from cable test program

Calibration data: Imported data from calibration spreadsheet (see calibration)

Calibrated data: Calculates the actual resistance of the strips, anomalous cables are highlighted by coloured rows (the anomalous point is the value in the row that is not coloured), averages and resistance widths of individual strips are also shown at the end of the sheet.

Graphs: Resistances of each strip for each cable are shown on graphs (5 per graph)

Strip Graphs: Numerical distributions of several different strip numbers are graphed

LT Graph: All LT cable resistances are shown on a single graph

HT Graph: All HT cable resistances are shown on a single graph

Names Key LT: List of names for individual LT strips

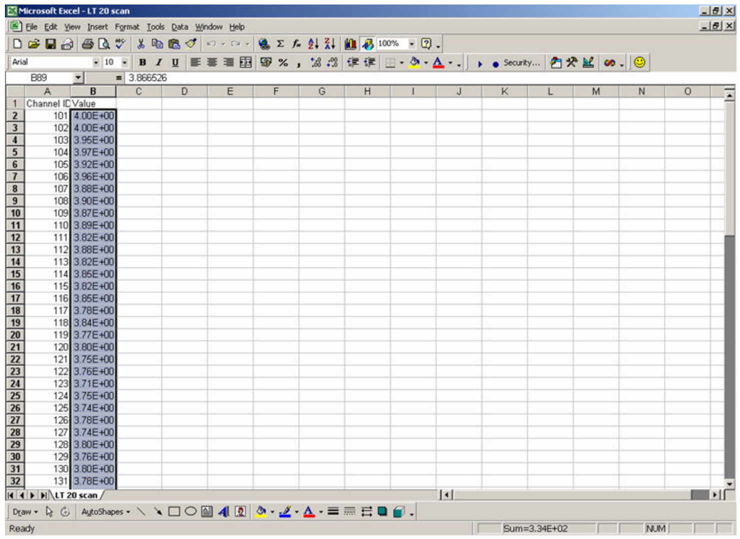
Names Key HT: List of names for individual HT strips

Summary: Average values are shown, anomalous points given in detail and missing cables are shown

- To view all the data in the sheet, use the scroll bars move through the data, LT cables are generally listed at the top of the sheet and HT cables are generally shown underneath.

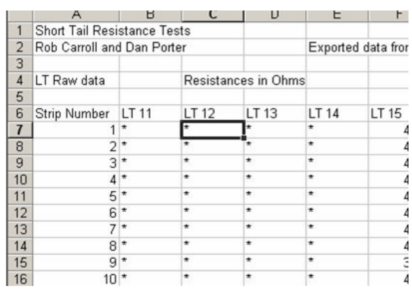
Importing Data

- Open the data that has been exported from the cable test program using excel.
- Select and Copy the resistance values (under the heading Value) for all 88 (or 79 for HT) channels.



Channel ID	Value
101	4.00E+00
102	4.00E+00
103	3.95E+00
104	3.97E+00
105	3.92E+00
106	3.96E+00
107	3.88E+00
108	3.90E+00
109	3.87E+00
110	3.89E+00
111	3.82E+00
112	3.88E+00
113	3.82E+00
114	3.85E+00
115	3.82E+00
116	3.85E+00
117	3.78E+00
118	3.84E+00
119	3.77E+00
120	3.80E+00
121	3.75E+00
122	3.76E+00
123	3.71E+00
124	3.75E+00
125	3.74E+00
126	3.78E+00
127	3.74E+00
128	3.80E+00
129	3.76E+00
130	3.80E+00
131	3.78E+00

- Go to the "Raw Data" sheet in the Short Tail Resistance tests spreadsheet and find the cable number that you are importing data for (LT cables are at the top of the sheet, and HT cables are at the bottom).



	A	B	C	D	E	F
1	Short Tail Resistance Tests					
2	Rob Carroll and Dan Porter				Exported data fror	
3						
4	LT Raw data		Resistances in Ohms			
5						
6	Strip Number	LT 11	LT 12	LT 13	LT 14	LT 15
7	1	*	*	*	*	4
8	2	*	*	*	*	4
9	3	*	*	*	*	4
10	4	*	*	*	*	4
11	5	*	*	*	*	4
12	6	*	*	*	*	4
13	7	*	*	*	*	4
14	8	*	*	*	*	4
15	9	*	*	*	*	3
16	10	*	*	*	*	4

- Select the cell directly under the cable name and paste the resistance values into the cells.
- You can check the data for anomalous points in either the "Calibrated Data" sheet or the "Graphs" Sheet. If you find any anomalous points, go to the anomalies section.

3.1.5. Anomalies

Anomalies can be found in the results taken in the form of high resistance values. These are usually best seen on the "Graphs" Sheet in the "Short Tail Resistance tests" spreadsheet, where a single reading will not follow the trend of the other readings.

An anomaly can be anything from a fraction of an ohm away from the trend (in which case it is usually merely a faulty connection) to an infinite value, which is a break (shown in excel as 9.90E+34). Note that HT cables always have 3 points which do not follow the trend of the rest of the points, these are at pins 64, 65 and 66 and they are not anomalies, to check their values, compare them to other HT cables.

Anomalous values are most commonly caused via a bad connection from the cable to either the dummy board or more generally the ground socket, if an anomaly is found; follow this procedure, scanning each time to check whether the anomaly has gone.

- Make sure that all components are fitted together properly. SCAN
- Remove the cable from the apparatus; make sure there is nothing blocking any of the pins and replace. SCAN (if the value has changed but not become normal, try another time before moving on).
- Remove the cable from the apparatus, then using a scalpel (with great care!) and the pin diagrams, find the pin that is causing the anomaly and carefully flick it out a bit (this is quite tricky but you will find that you can nicely get the back of the blade behind the pin to nudge it out a little). Do this first on the ground socket (140 pin connector) and SCAN the cable, then try the dummy board (100 pin connector) if it did not work. SCAN
- If this has not worked it is likely that the problem is with the cable itself, therefore it is a good idea to take the cable and manually test the pins to find out whether it is giving an accurate reading.

3.1.6. Calibration

Due to the equipment between the Agilent unit and the cable, there is a certain resistance found in the measurements that accounts for the resistance of the wires and so forth in this equipment.

In order to calibrate the measurements so that this extra resistance is taken away, a spreadsheet is used that can find the resistance of the equipment, so that these values can then be used in the main “Short Tail Resistance Tests” spreadsheet to calibrate the readings.

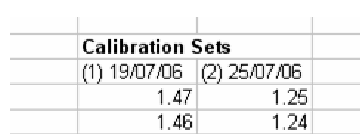
To calibrate the devise, 3 standard cables (LT 39, LT 48, and LT 25) are tested using the “Cable test” program. This data is entered into the spreadsheet and the spreadsheet will subtract the resistance of these cables (found manually) to find the remaining resistance of the equipment.

<u>Instructions for LT cables</u>

- Using the “LT Cable test” program set-up, take measurements of LT cables 39, 48 and 25 and export the data.
- In the “Short tail resistance tests” folder on the desktop, open the “Calibration Numbers LT” file
- Click on the “Multiplex Resistance” tab at the bottom of the sheet

- Open the exported data you saved before for the 3 cables and copy and paste the resistance values into the 3 columns (Marked Value (LT39), Value (LT 48), Value (LT25)) and check to make sure there are no anomalous values.
- Click on the “Calibration” Tab at the bottom of the sheet

- Scroll along the sheet to find the column marked “System Resistance Mean” and copy the 88 resistances in this column.
- You can now paste these values into the “Calibration Data” sheet in the “Short Tail Resistance tests” spreadsheet.
- It is useful first paste this value at the end of the “Calibration Data” sheet next to the previous calibrations, with the date the calibration was taken at the top.



Calibration Sets	
(1) 19/07/06	(2) 25/07/06
1.47	1.25
1.46	1.24

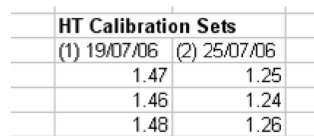
- You can then copy data from this column to the column containing the cable number you have tested.

Instructions for HT cables

- Using the "HT Cable test" program set-up, measure the LT cables 39, 48 and 25 and export the data, also measure HT Cables 41, 36 and 56 and export the data.
- In the "Short tail resistance tests" folder on the desktop, open the "Calibration Numbers HT" file
- Click on the "Multiplex Resistance" tab at the bottom of the sheet

- Open the exported data you saved before for the 6 cables then copy and paste the resistance values of the 3 LT cables into the 3 columns (Marked Value (LT39 + HT41), Value (LT 48 + HT36) and Value (LT25 + HT56)) and check to make sure there are no anomalous values.
- Now copy only channels 224, 225 and 226 from the 3 HT cable files and paste these into the corresponding channels in the "Multiplex resistance" sheet.
- Click on the "Calibration" Tab at the bottom of the sheet

- Scroll along the sheet to find the column marked "System Resistance Mean" and copy the 79 resistances in this column.
- You can now paste these values into the "Calibration Data" sheet in the "Short Tail Resistance tests" spreadsheet.
- It is useful first paste this value at the end of the "Calibration Data" sheet next to the previous calibrations, with the date the calibration was taken at the top.



HT Calibration Sets	
(1) 19/07/06	(2) 25/07/06
1.47	1.25
1.46	1.24
1.48	1.26

- You can then copy data from this column to the column containing the cable number you have tested.
- NOTE: If for either calibration, you cannot find the required calibration cables, it will be required that you find 3 working cables and manually test the resistances of all 88 pins on the LT cables and strips 64, 65 and 66 on the HT cables. Then paste the values into the calibration sheet in the Calibration sheet in the "Resistances" columns. For the HT strips, copy and paste the manually taken values over the LT values for the same strips, also remember to remove the values from strips 45, 46, 63, 67, 68, 69, 70, 87 and 88.

3.1.7. LT Cable Names Key

Strip Number	Channel ID	100 pin Number	140 pin Number	50 pin Number	Name
1	101	13	133	26	COMPCLKN
2	102	15	134	10	COMPCLK
3	103	21	131	43	ANA0-0N
4	104	23	132	27	ANA0-0
5	105	29	127	11	ANA0-1N
6	106	31	128	44	ANA0-1
7	107	37	125	28	ANA0-2N
8	108	39	126	12	ANA0-2
9	109	45	121	45	ANA0-3N
10	110	47	122	29	ANA0-3
11	111	53	119	13	ANA1-0N
12	112	55	120	46	ANA1-0
13	113	61	115	30	ANA1-1N
14	114	63	116	14	ANA1-1
15	115	69	113	47	ANA1-2N
16	116	71	114	31	ANA1-2
17	117	77	109	15	ANA1-3N
18	118	79	110	48	ANA1-3
19	119	85	107	32	SDARET
20	120	87	108	16	SDA
21	121	97	103	49	sense0-
22	122	99	104	33	sense0+
23	123	92	101	18	TRIGGERN
24	124	90	102	2	TRIGGER
25	125	84	97	35	CLOCKN
26	126	82	98	19	CLOCK
27	127	76	95	3	ANA2-0N
28	128	74	96	36	ANA2-0
29	129	68	91	20	ANA2-1N
30	130	66	92	4	ANA2-1
31	131	60	89	37	ANA2-2N
32	132	58	90	21	ANA2-2
33	133	52	85	5	ANA2-3N
34	134	50	86	38	ANA2-3
35	135	44	83	22	ANA3-0N
36	136	42	84	6	ANA3-0
37	137	36	79	39	ANA3-1N
38	138	34	80	23	ANA3-1
39	139	28	77	7	ANA3-2N
40	140	26	78	40	ANA3-2
41	201	20	73	24	ANA3-3N
42	202	18	74	8	ANA3-3
43	203	12	71	41	SCL-RET
44	204	10	72	25	SCL
45	205	13	67	26	RADMONB
46	206	15	68	10	RADMONA
47	207	21	65	43	ANA4-0N
48	208	23	66	27	ANA4-0
49	209	29	61	11	ANA4-1N
50	210	31	62	44	ANA4-1
51	211	37	59	28	ANA4-2N
52	212	39	60	12	ANA4-2
53	213	45	55	45	ANA4-3N
54	214	47	56	29	ANA4-3
55	215	53	53	13	ANA5-0N
56	216	55	54	46	ANA5-0
57	217	61	49	30	ANA5-1N
58	218	63	50	14	ANA5-1
59	219	69	47	47	ANA5-2N
60	220	71	48	31	ANA5-2
61	221	77	43	15	ANA5-3N
62	222	79	44	48	ANA5-3
63	223	85	41	32	NTCB2
64	224	87	42	16	NTCA2

Strip Number	Channel ID	100 pin Number	140 pin Number	50 pin Number	Name
65	225	97	37	49	NTCA
66	226	99	38	33	NTCB
67	227	92	35	18	sensel-
68	228	90	36	2	sensel+
69	229	84	31	35	TEMPRIGHT
70	230	82	32	19	TEMPMID
71	231	76	29	3	ANA6-0N
72	232	74	30	36	ANA6-0
73	233	68	25	20	ANA6-1N
74	234	66	26	4	ANA6-1
75	235	60	23	37	ANA6-2N
76	236	58	24	21	ANA6-2
77	237	52	19	5	ANA6-3N
78	238	50	20	38	ANA6-3
79	239	44	17	22	ANA7-0N
80	240	42	18	6	ANA7-0
81	301	36	13	39	ANA7-1N
82	302	34	14	23	ANA7-1
83	303	28	11	7	ANA7-2N
84	304	26	12	40	ANA7-2
85	305	20	7	24	ANA7-3N
86	306	18	8	8	ANA7-3
87	307	12	5	41	TEMPLEFT
88	308	10	6	25	TEMPU+

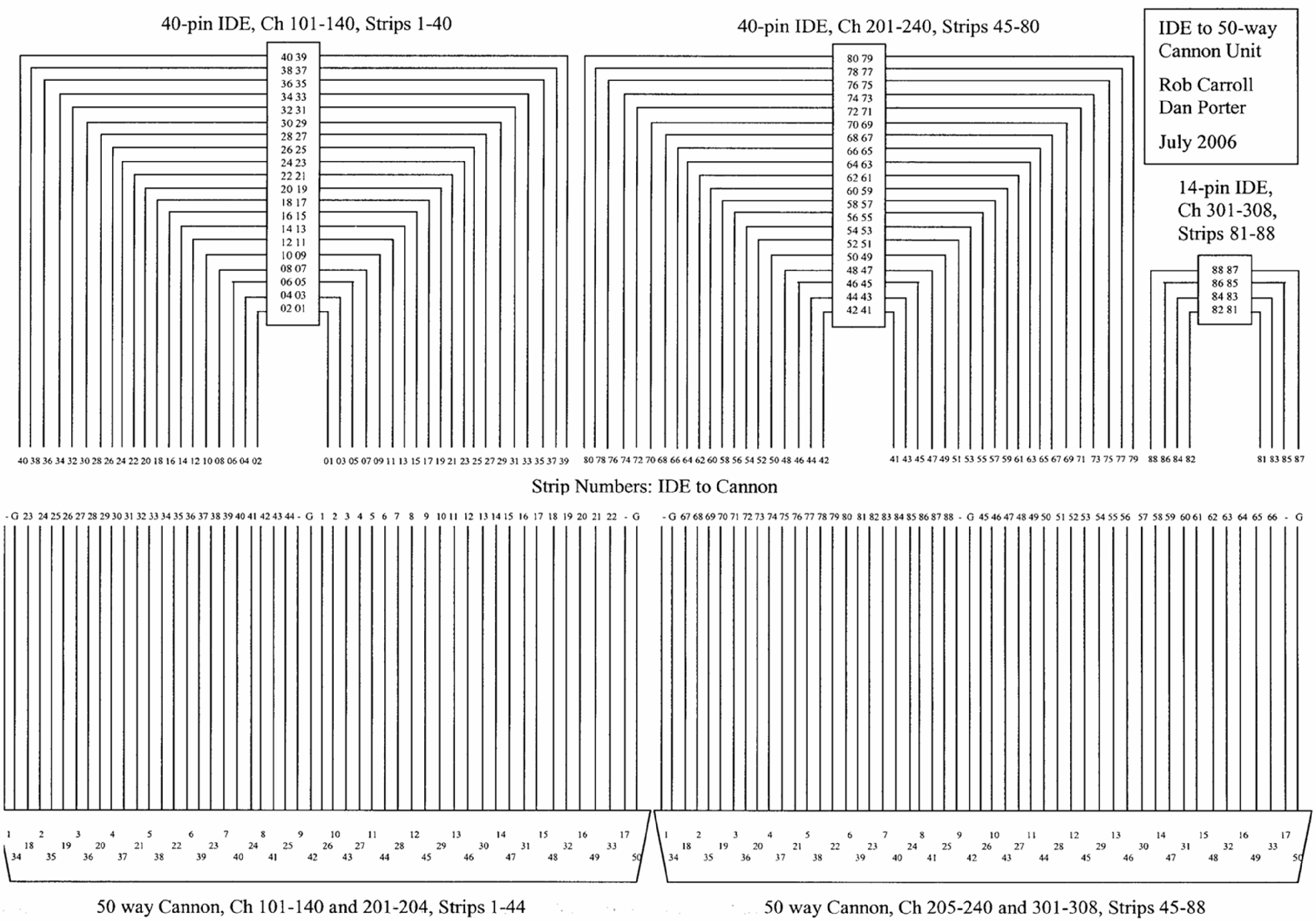
Table 1: Key for LT Cable names

3.1.8. HT Cable Names Key

Strip Number	Channel ID	100 pin Number	140 pin Number	50 pin Number	Name
1	101	13	133	26	sense2-
2	102	15	134	10	sense2+
3	103	21	131	43	ANA8-0N
4	104	23	132	27	ANA8-0
5	105	29	127	11	ANA8-1N
6	106	31	128	44	ANA8-1
7	107	37	125	28	ANA8-2N
8	108	39	126	12	ANA8-2
9	109	45	121	45	ANA8-3N
10	110	47	122	29	ANA8-3
11	111	53	119	13	ANA9-0N
12	112	55	120	46	ANA9-0
13	113	61	115	30	ANA9-1N
14	114	63	116	14	ANA9-1
15	115	69	113	47	ANA9-2N
16	116	71	114	31	ANA9-2
17	117	77	109	15	ANA9-3N
18	118	79	110	48	ANA9-3
19	119	85	107	32	TP
20	120	87	108	16	TPN
21	121	97	103	49	RESET
22	122	99	104	33	RESETN
23	123	92	101	18	PORRET
24	124	90	102	2	POR
25	125	84	97	35	ENEDCRET
26	126	82	98	19	ENEDC
27	127	76	95	3	ANA10-0N
28	128	74	96	36	ANA10-0
29	129	68	91	20	ANA10-1N
30	130	66	92	4	ANA10-1
31	131	60	89	37	ANA10-2N
32	132	58	90	21	ANA10-2
33	133	52	85	5	ANA10-3N
34	134	50	86	38	ANA10-3
35	135	44	83	22	ANA11-0N

Strip Number	Channel ID	100 pin Number	140 pin Number	50 pin Number	Name
36	136	42	84	6	ANA11-0
37	137	36	79	39	ANA11-1N
38	138	34	80	23	ANA11-1
39	139	28	77	7	ANA11-2N
40	140	26	78	40	ANA11-2
41	201	20	73	24	ANA11-3N
42	202	18	74	8	ANA11-3
43	203	12	71	41	sense3-
44	204	10	72	25	sense3+
47	207	21	67	43	ANA12-0N
48	208	23	68	27	ANA12-0
49	209	29	65	11	ANA12-1N
50	210	31	66	44	ANA12-1
51	211	37	61	28	ANA12-2N
52	212	39	62	12	ANA12-2
53	213	45	59	45	ANA12-3N
54	214	47	60	29	ANA12-3
55	215	53	55	13	ANA13-0N
56	216	55	56	46	ANA13-0
57	217	61	53	30	ANA13-1N
58	218	63	54	14	ANA13-1
59	219	69	49	47	ANA13-2N
60	220	71	50	31	ANA13-2
61	221	77	47	15	ANA13-3N
62	222	79	48	48	ANA13-3
64	224	87	30	16	HT RETURN
65	225	97	35, 39	49	GUARD
66	226	99	37	33	BIAS or HT
71	231	76	26	3	ANA14-0N
72	232	74	25	36	ANA14-0
73	233	68	23	20	ANA14-1N
74	234	66	24	4	ANA14-1
75	235	60	19	37	ANA14-2N
76	236	58	20	21	ANA14-2
77	237	52	17	5	ANA14-3N
78	238	50	18	38	ANA14-3
79	239	44	13	22	ANA15-0N
80	240	42	14	6	ANA15-0
81	301	36	11	39	ANA15-1N
82	302	34	12	23	ANA15-1
83	303	28	7	7	ANA15-2N
84	304	26	8	40	ANA15-2
85	305	20	5	24	ANA15-3N
86	306	18	6	8	ANA15-3

Table 2: Key for HT cable names


40-pin IDE, Ch 101-140, Strips 1-40
40-pin IDE, Ch 201-240, Strips 45-80
IDE to 50-way Cannon Unit
Rob Carroll
Dan Porter
July 2006
14-pin IDE, Ch 301-308, Strips 81-88
Strip Numbers: IDE to Cannon
50 way Cannon, Ch 101-140 and 201-204, Strips 1-44
50 way Cannon, Ch 205-240 and 301-308, Strips 45-88

3.2. Detect Shorts and Intermittent Breaks

Two PCBs, CABTESTA and CABTESTB were produced to facilitate this test and are used as a pair with the cables connected between them. CABTESTA allows a voltage to be applied to each of the pins of the connector at one end of the cable and CABTESTB provides an LED to receive the applied voltage on each of the pins at the other end of the cable. Although switches are provided for the isolation of any individual trace they will normally be closed. Instead of laboriously testing individual lines many lines are tested at the same time. The topology of the cables lends itself to this approach as it is possible to apply a voltage to one side of all of the trace pairs simultaneously and to check that none of the LEDs associated with the other side of the pair lights. This is a very quick way to test for shorts between pairs. In addition the other most likely shorts to occur are between any trace and ground and power and again these can be quickly identified. One other use for this setup is to be able to quickly identify intermittent connections due to connector pin alignment or defective solder joints by deforming the cable slightly or applying a gentle rocking motion to each of the connectors and observing any LEDs that may dim or extinguish completely.

3.2.1. Test Schedule for LHCB Cables

Two different types of cable have to be tested.

The HT cable can be identified by the Connectors: - PL13, PL4 and PL3. It also has a group of missing pins observed on the cable side of connector PL13, on the left hand side.

The LT cable can be identified by the Connector: - PL11, PL2, and PL1.

The following description assumes that the CABTESTA board is positioned such that the large connector is nearest the Operator and the slide switches are furthest away.

The Slide Switches on the CABTESTA printed circuit board are identified left to right as follows:-

HT / VCC / GND / Unmarked horizontal Slide Switch / PAIRS

If the unmarked horizontal slide switch is in the left position, the Vcc and GND tests are active; the right position selects the data PAIRS test. This switch is referred to as the "Selector Switch".

The Vcc, GND and PAIRS switches are ON if they are in the position nearest the operator.

Prior to testing a cable, check that connectors PL13, PL4, PL3, PL11, PL2, PL1 are mounted the correct way round.

Before installing or removing a cable, ensure that the VCC, GND and PAIRS switches are off.

3.2.2. Testing the LT Cable using CABTESTA & CABTESTB.

Connect cable connector PL11 to the socket on the CABTESTA printed circuit board.

Cable connectors PL1 and PL2 are placed in sockets on the CABTESTB printed circuit board.

Switch on the mains AC – DC Adaptor.

Move the Selector Switch to the PAIRS switches position.

Move the Left Hand PAIRS switch to OFF and the Right Hand PAIRS switch to ON.

All the Green leds in the centre two columns on both sides of CABTESTB will light.

Check that only the selected leds are lit. If any green leds are not lit try re-seating the cable connectors.

Move the Right Hand PAIRS switch to OFF and the Left Hand PAIRS switch to ON.

All the Red leds in the centre two columns on both sides of the CABTESTB board will light.

Move the Selector Switch to the VCC/GND switches position.

Move the VCC switch to OFF and the GND switch to ON, all the red leds in the outer columns on both sides of the CABTESTB board will light.

Move the GND switch to OFF and the VCC switch to ON, all the yellow leds will light.

Final Test.

Move the GND, VCC and both PAIRS switches to ON.

Move the Selector switch between its two positions; check that all the leds light.

3.2.3. Testing the HT Cable

(Refer to led note below).

Connect cable connector PL13 to the socket on the CABTESTA printed circuit board.

Cable connectors PL3 and PL4 are placed in sockets on the CABTESTB printed circuit board.

Move the Selector Switch to the PAIRS switches position.

Move the Left Hand PAIRS switch to OFF and the Right Hand PAIRS switch to ON.

All the Green leds in the centre two columns on the right hand side of CABTESTB will light and the Red leds in the centre two columns on the left hand side of CABTESTB will light. (Please note the exceptions list below).

Move the Right Hand PAIRS switch to OFF and the Left Hand PAIRS switch to ON.

All the Red leds in the centre two columns on the right hand side of CABTESTB will light.

The Green leds in the centre two columns and 87 red on the left hand side of CABTESTB will light. (Please note the exceptions list below).

Move the Selector Switch to the VCC/GND switches position.

Move the VCC switch to OFF and the GND switch to ON.

The red leds in the outer columns on both sides of the CABTESTB board will light.

Move the GND switch to OFF and the VCC switch to ON.

All the yellow leds will light.

HT cable leds on the left hand side of the CABTESTB board which do not operate.

Leds that do not light (In Boxed Area):- 10, 12, 13, 15, 82, 84, 85, 90, 92.

Other leds that do not light: - 89, 91, 93, 94, 95, 96, 98, 100.

Note that led 97 on the left hand side of CABTESTB is lit for both the right hand PAIRS and GND tests.

Cable Faults

Check for any leds which do not light or are dim, indicating either an open circuit or a bad connection or solder joint. Check also that only the correct LEDS light I.E. that only RED leds or green leds. If a LED of the other colour lights then this indicates a short either to the adjacent trace or to power or ground. Individual cable tracks can then be isolated by switching the relevant DIL switch on CABTESTA to off, for further investigation with a multimeter and visually.

4. Cable Preparation for Clamps

On the connector side, measure 180mm from the outer edge of PL13 (HT cable) and PL11 (LT cable).

Lightly abrade the varnish over the width of the cable for an area of +/- 10mm from the 180mm mark

The cable is now ready for cleaning.

5. Cable cleaning & Storage

Working in a fume-cupboard, carefully wipe both sides of each cable using Prozone on a clean Room cloth,

Dampen a second cloth with de-ionised water and remove traces of Prozone from the cables. Be careful to keep Prozone and de-ionised water away from the connectors.

Dry the cables with nitrogen.

Place the cables in a clean bag for storage

.

6. Cable Testing Results

The following Table lists the total sets of cables produced and the current (Sept 2007) list of attachments to modules. In total 126 cable pairs were produced and approximately 90 mounted onto modules.

Cable-Pair	HT Module	LT Module	Comment
1			
2			
3		56-p	Prototype(FTL)
4	75-r	75-r	Prototype(FTL)
5	64-r		
6	75-p	75-p	Prototype(FTL)
7		72-r	Prototype(FTL)
8			
9			
10	18-r	18-r	Prototype(FTL)
11	54-p	18-p	
12	61-r	61-r	
13			
14	20-r	20-r	
15	28-r	28-r	
16	20-p	20-p	
17			
18	54-r	54-r	
19	26-p	26-p	
20	28-p	28-p	
21	21-r	21-r	
22	61-p	61-p	
23			
24	23-r	23-r	
25	21-p	21-p	
26	29-r	29-r	
27			
28	26-r	26-r	
29	56-p	54-p	
30		64-r	

Cable-Pair	HT Module	LT Module	Comment
31	29-p	29-p	
32	24-r	24-r	
33	27-r	27-r	
34	27-p	27-p	
35	37-r	37-r	
36	25-r	25-r	
37	25-p	25-p	
38	30-r	30-r	
39	23-p	23-p	
40	30-p	30-p	
41	24-p	24-p	
42	31-r	31-r	
43	31-p	31-p	
44	33-r		
45	32-r	32-r	
46	32-p	32-p	
47	33-p	33-p	
48	35-r	35-r	
49	35-p	35-p	
50	36-r	36-r	
51	36-p	36-p	
52	37-p	37-p	
53	58-r	33-r	
54	72-r		
55			
56		56-r	
57	73-r	73-r	
58	48-r		
59	44-r	44-r	
60	38-r	38-r	
61	38-p	38-p	
62	55-r	55-r	
63	55-p	55-p	

Cable-Pair	HT Module	LT Module	Comment
64	42-r	42-r	
65	42-p	42-p	
66	44-p	44-p	
67	45-r	45-r	
68	45-p	45-p	
69			
70	50-r	50-r	
71	50-p	50-p	
72	51-r	51-r	
73	52-r	52-r	
74	58-p		
75	56-r		
76	52-p	52-p	
77	49-r	49-r	
78		72-p	
79	72-p		
80	49-p	49-p	
81	53-r	53-r	
82	53-p	53-p	
83		48-r	
84	48-p	48-p	
85	47-r	47-r	
86	47-p	47-p	
87	51-p	51-p	
88	5-r	5-r	
89	59-r	71-r	
90	62-r	59-r	
91	5-p	59-p	
92		5-p	
93	59-p	71-p	
94	62-p	60-r	
95	7-r	60-p	
96	73-p	62-r	

Cable-Pair	HT Module	LT Module	Comment
97		58-r	
98	74-r	58-p	
99	7-p	73-p	
100			
101	60-r	62-p	
102		63-p	
103			
104	60-p	7-r	
105	74-p	74-p	
106			
107	63-r	63-r	
108	63-p	7-p	
109	64-p	74-r	
110			
111	71-r		
112		64-p	
113	71-p	4-r	
114		4-p	
115	4-r		
116	4-p		
117			
118			
119			
120			
121			
122			
123			
124			
125			
126			

Table 3: List of cable pairs and their assignment to modules.

The cables were all tested as to the procedures described above. The raw HT and LT cable data, for *cables that ended on production modules only*, are shown below in Figure 2 and Figure 3. Both show anomalous features labeled in capitals (**A, B**…) for the HT cables and lower case (**a, b**…) for the LT cables. Features **A** and **b** correspond to sequential trace number 40. A fault in the testing equipment meant that only "opens" could be tested for this trace.

For the HT cables **B, C**, and **D** correspond to high value traces not rejected by the QA procedures above. In two cases these are HT return lines. These faults will be discussed in the summary.

For the LT cables feature **a** is a low resistance cable but was not rejected. The feature **c** was not large enough to be rejected by the original QA.

The average cable resistance for the HT and LT cables is plotted in Figure 4 and Figure 5. The Cable resistance is seen to drop during the production. The low resistance LT cable (a) is clearly indicated. These distributions are plotted as histograms in Figure 6 and Figure 7. The low resistance cable (**a**) is ~ 3σ from nominal ~ 3.6Ω.

Scaling all the cable resistances to the nominal allows us to directly compare individual cable traces within the cohort of cables, see Figure 8 and Figure 9. An additional feature **d** is visible in the LT cables and **c** is more prominent. The average cable trace distributions are also shown in Figure 10 to Figure 13. Figure 14 and Figure 15 show the resistances are distributed approximately normally about the means i.e. there is no unexpected systematic effects.

Table 4 contains the list of all anomalous cables.

Two cables with LT-32 and LT-52 with open traces in the cable data were in the data. The open on LT-32 is not important as it is not read out and LT-52 is marked as having been fixed in the db prior to mounting. The remaining problems on the LT cables are either on unused RADMON lines or on analog lines but are <1Ω over nominal.

On the HT cables one potentially serious fault is indicated on HT-24 – an HV return line – which was not picked up by the original QA. This should be investigated to ensure that the sensor remains operable. The same cable also has a significantly over resistance trace: ANA15-3N which could give rise to ½ gain channel output.

We also note that 5 cables, although checked and passed, have data files with corrupted or missing information; thus the cable trace resistance cannot be reanalyzed. All cables test had the "testing" problem on channel 40 meaning that ANA3-2 and ANA11-02 on all cables were not fully qualified.

7. Summary

The cable testing data procedure and data has been presented. A reanalysis of the data allows an increased sensitivity to bad traces. Of approximately 8000 cable traces investigated one trace was found that could compromise the functioning of a sensor.

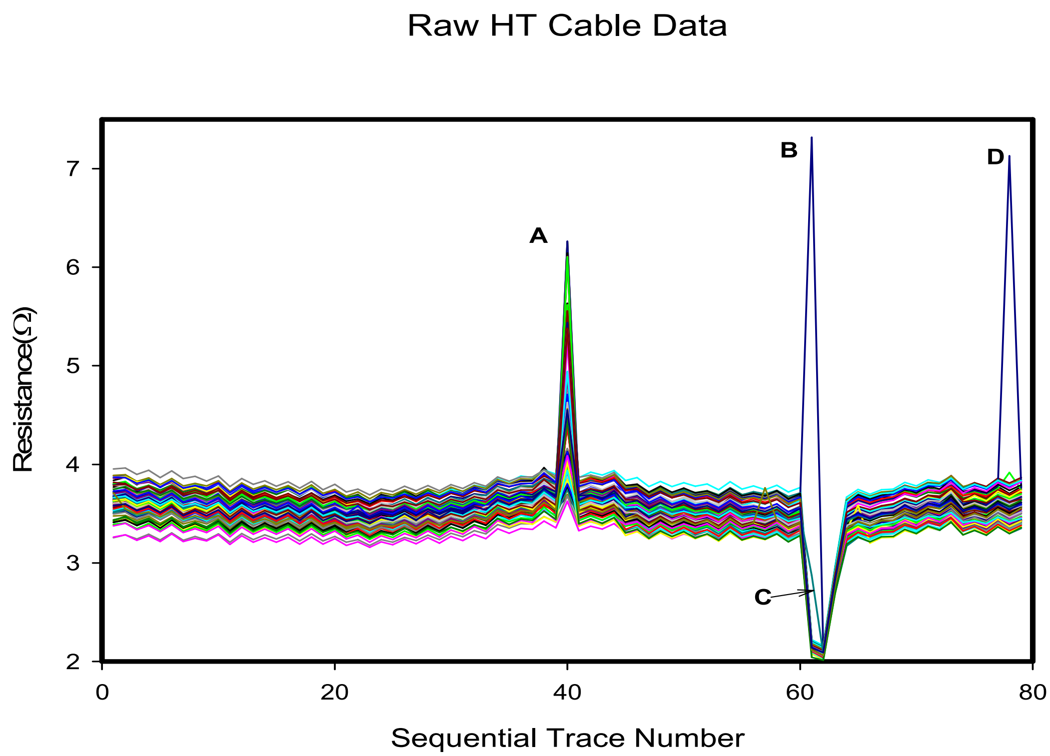


Figure 2: All the HT cable trace resistances as a function of sequential trace number.

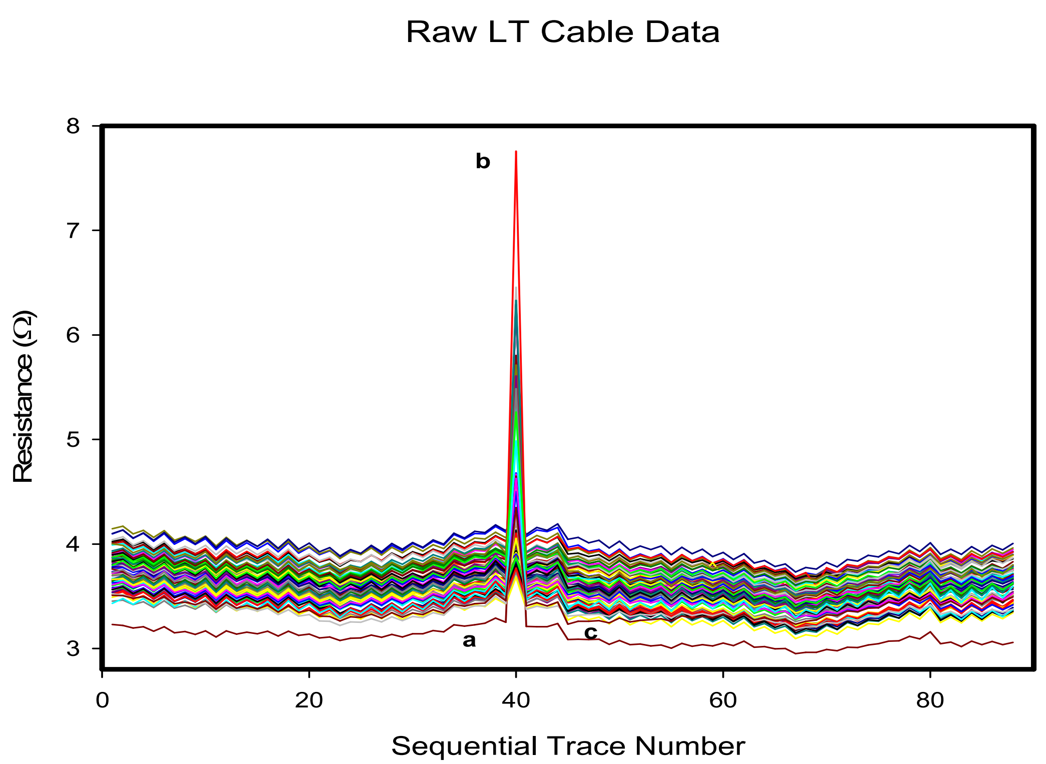


Figure 3 All the LT cable trace resistances as a function of sequential trace number

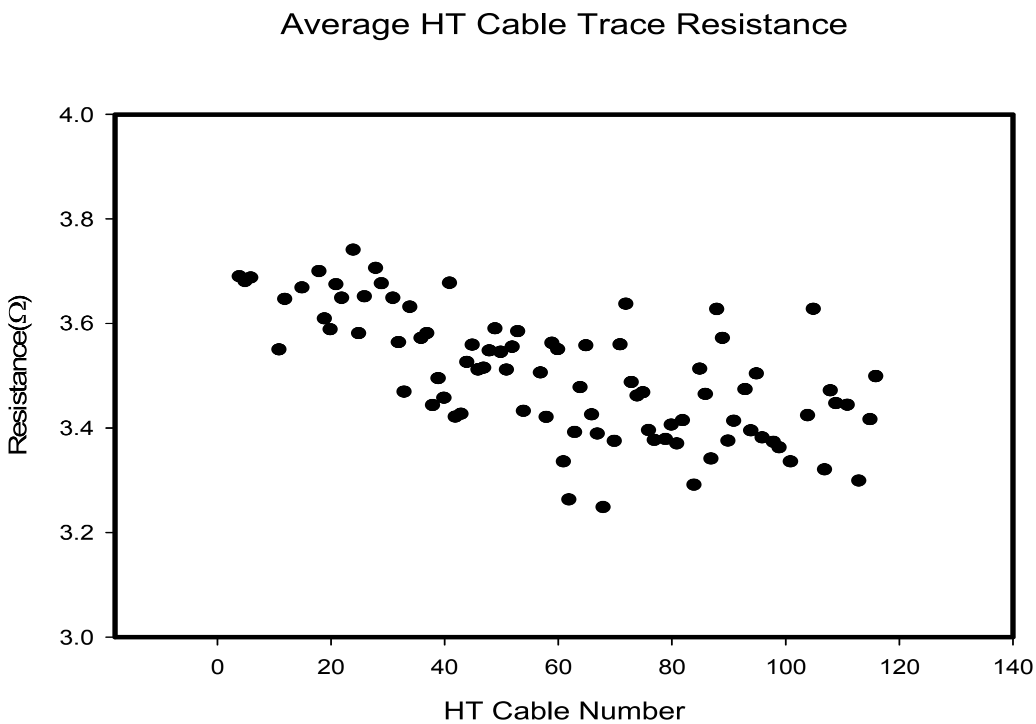


Figure 4: Average HT Cable trace resistance per cable as a function of sequential trace number

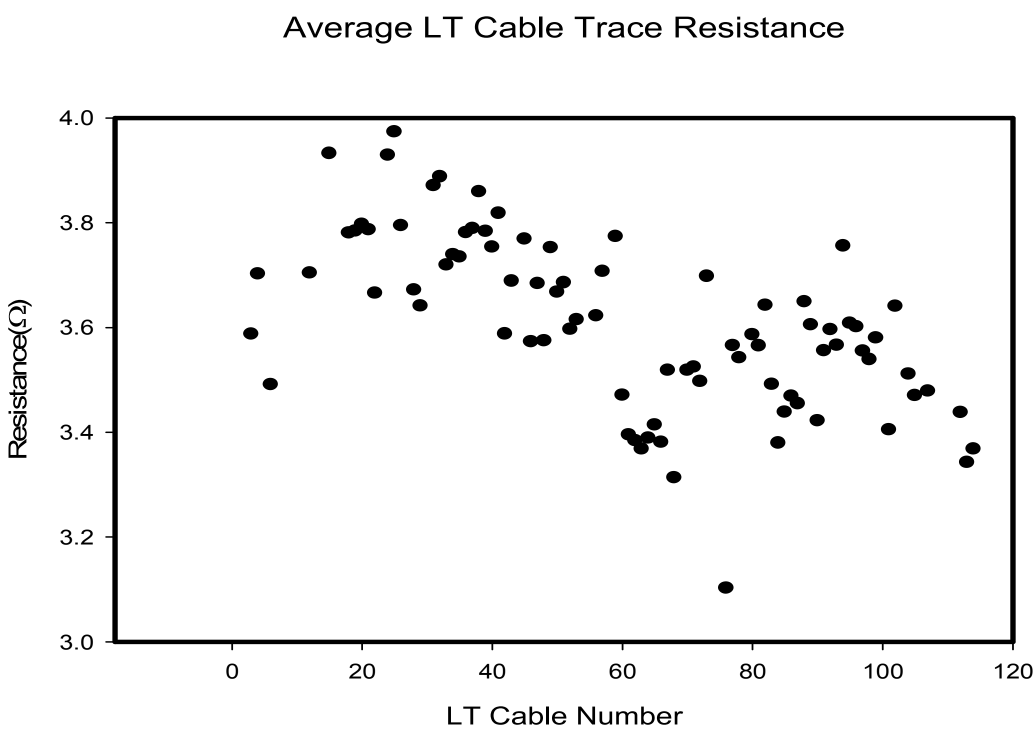


Figure 5: Average LT Cable trace resistance per cable as a function of sequential trace number

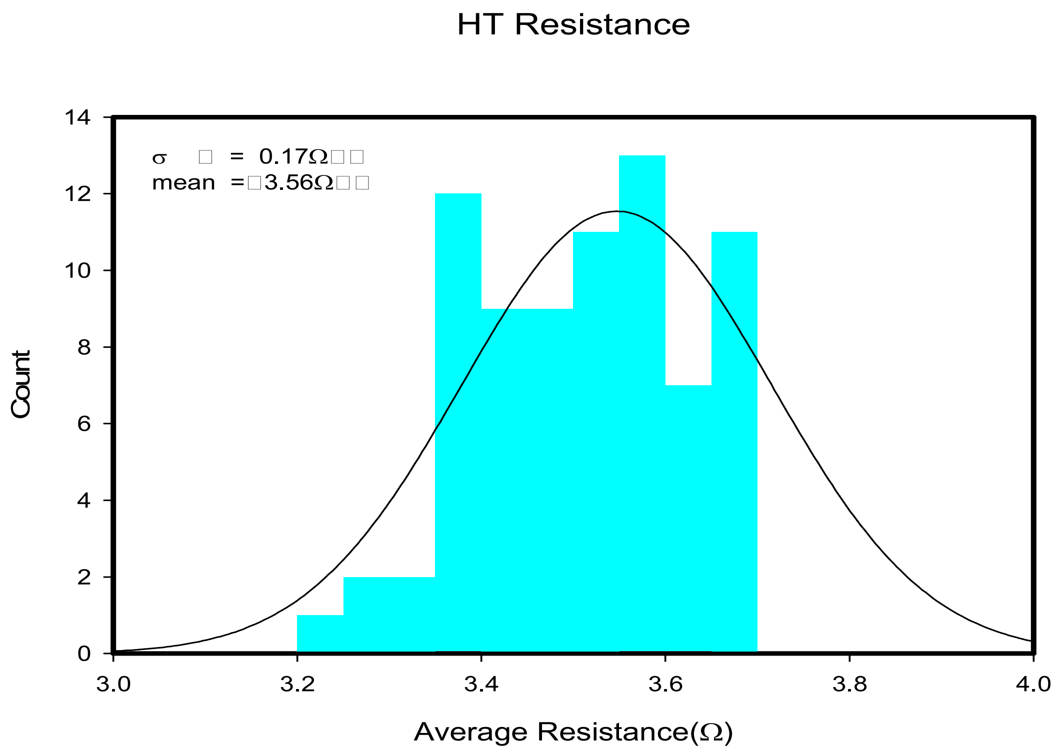


Figure 6: Histogram of the resistance of the HT cables

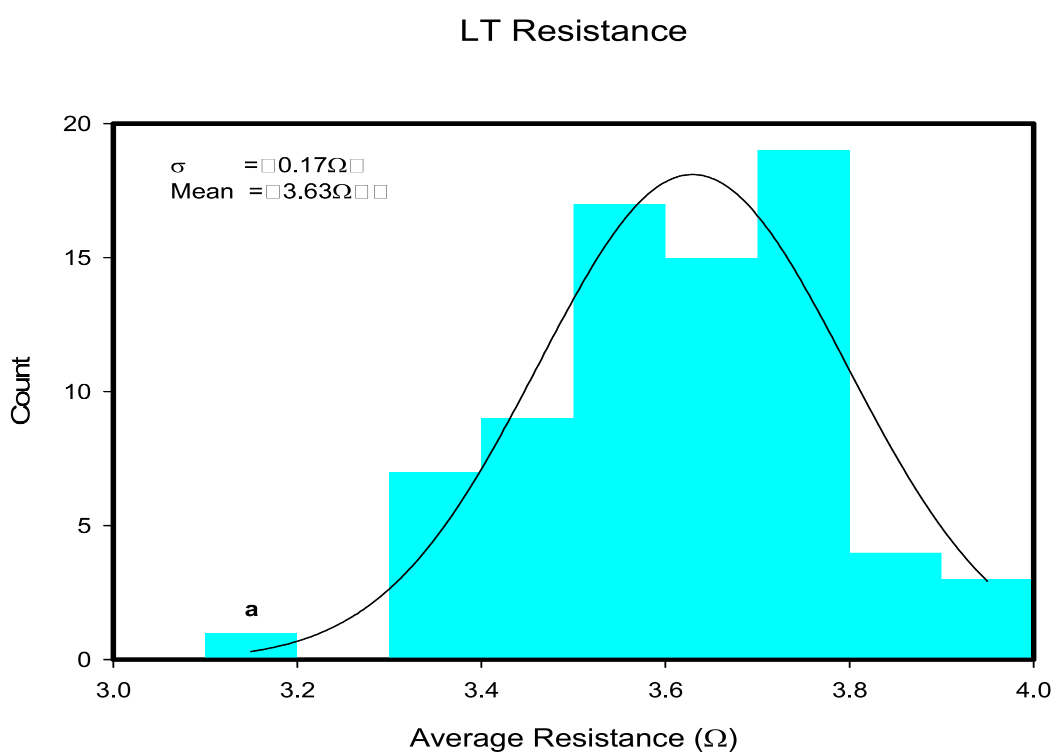


Figure 7: Histogram of the resistance of the LT cable

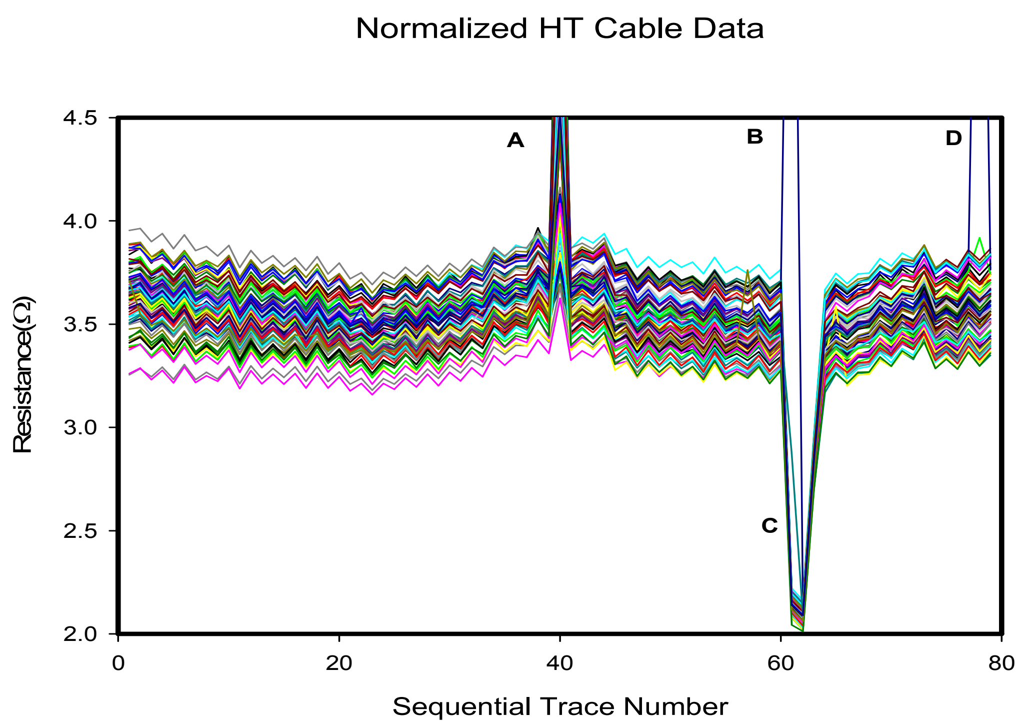


Figure 8: Distribution of trace resistances for HT cables. Each cable has been scaled to have an average resistance of 3.6 ohms.

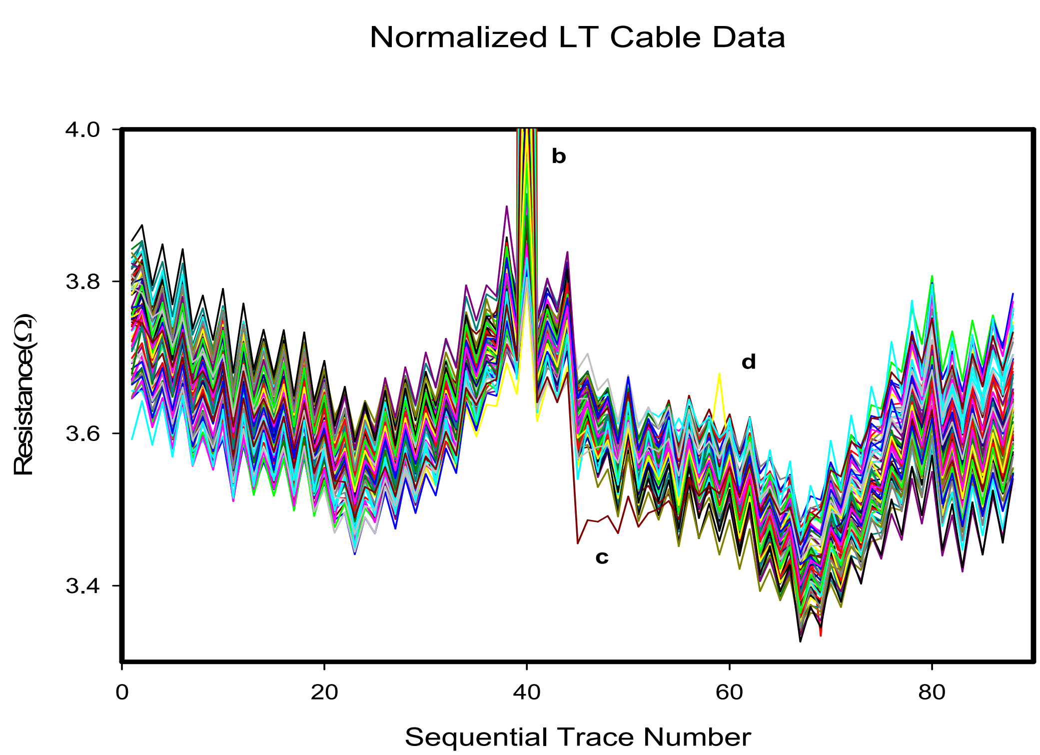


Figure 9 : Distribution of trace resistances for LT cables. Each cable has been scaled to have an average resistance of 3.6 ohms.

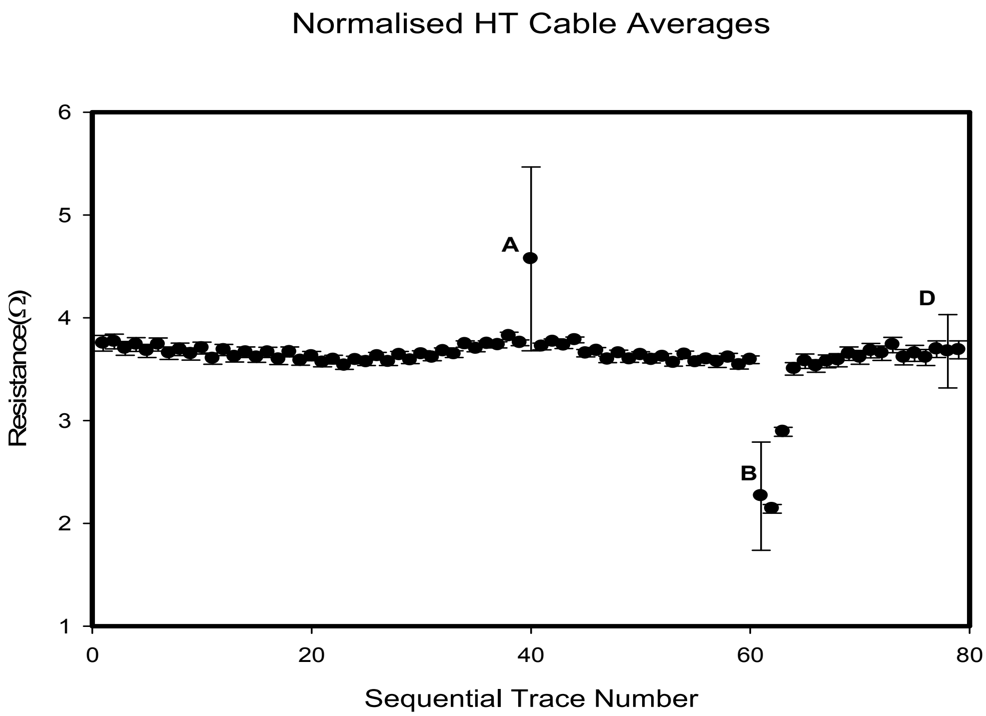


Figure 10: Average HT resistance per trace – all cable resistances have been normalized to 3.6Ω.

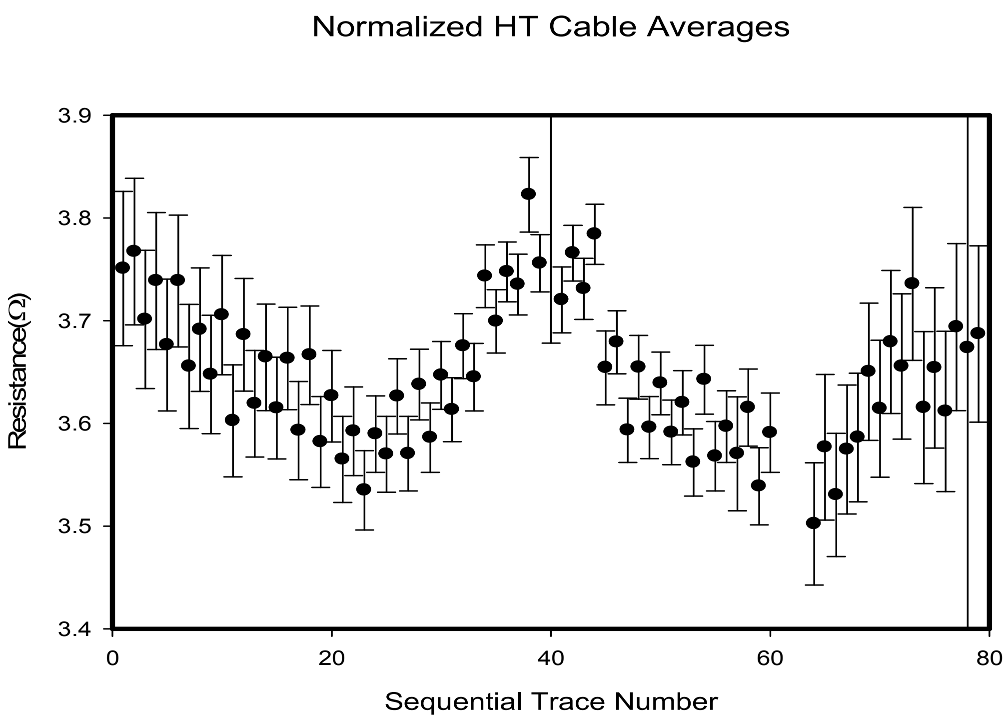


Figure 11: Average HT resistance per trace – all cable resistances have been normalized to 3.6Ω, large scale diagram showing trace structure.

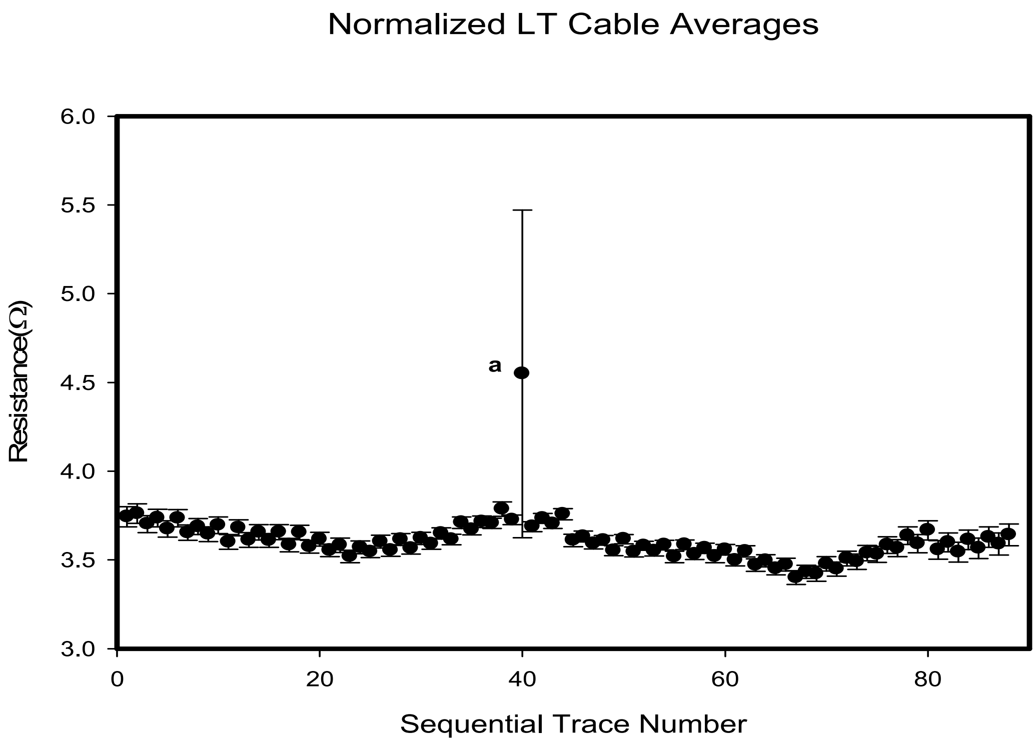


Figure 12 : Average HT resistance per trace – all cable resistances have been normalized to 3.6Ω.

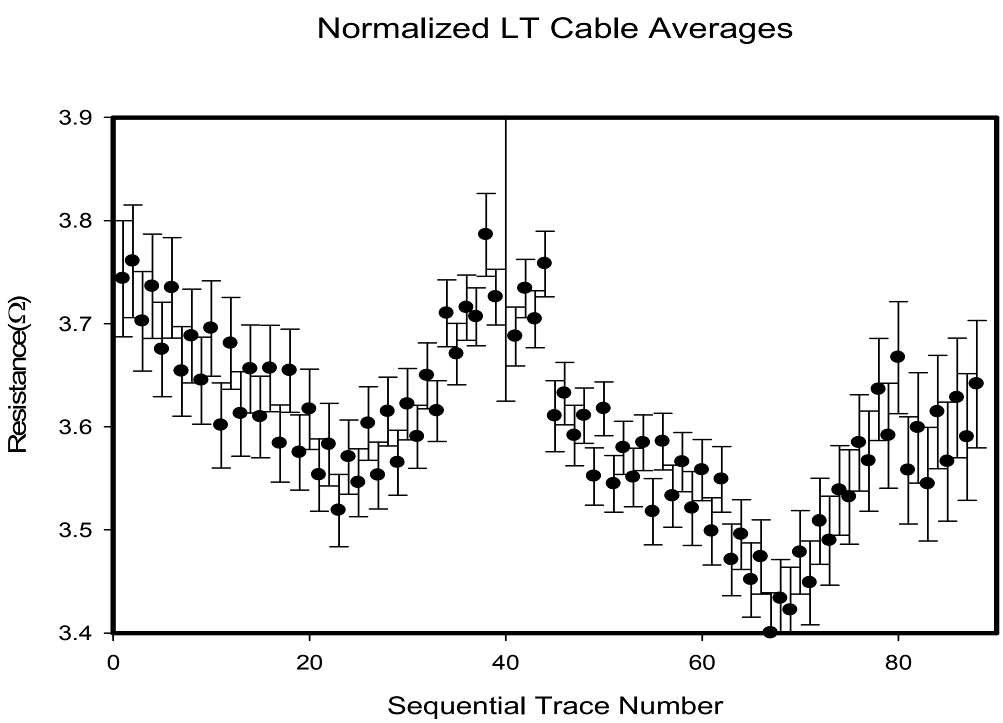


Figure 13: Average HT resistance per trace – all cable resistances have been normalized to 3.6Ω large scale diagram showing trace structure.

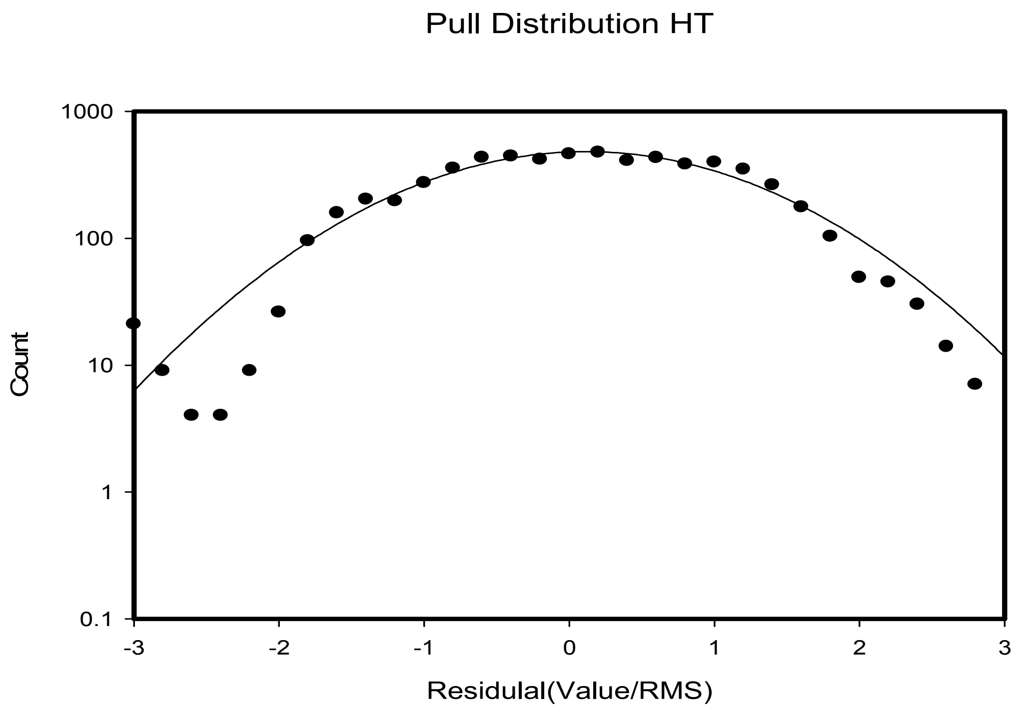


Figure 14: “Pull distribution of HT cable trace resistances”. The fit is a Gaussian of width 1.

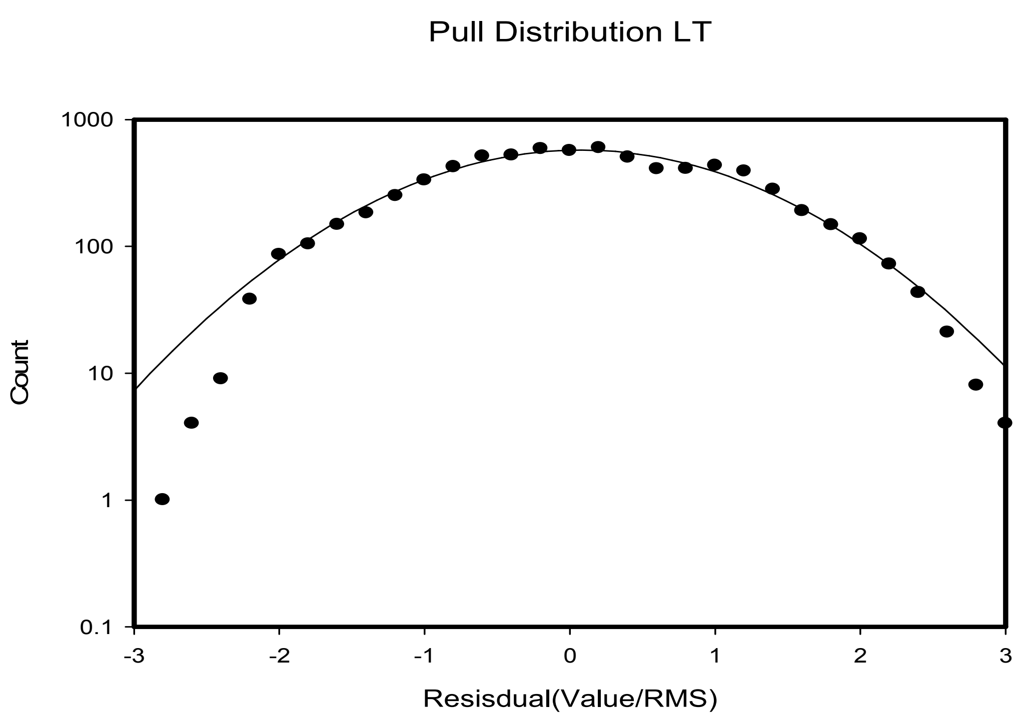


Figure 15: “Pull distribution of LT cable trace resistances”. The fit is a Gaussian of width 1.

Cables with Anomalous Individual Trace Resistance								
Cable	Cable	Feature	ModuleN	Sequenti	Trace Number	Trace Name	Meas Res	
LT	32	Not shown	24-r	69	229	TEMP- R	∞	
LT	52	Not shown	37-p	55	215	ANA5-0N	∞	*Fixed* db
LT	34	d	27-p	59	219	ANA5-2N	3.82	
LT	114	c	4-p	45	205	RADMONB	3.23	
LT	114	c	4-p	46	206	RADMONA	3.26	
LT	114	c	4-p	47	208	ANA4-0	3.25	
HT	24	B	23-r	61	224	HT-return	7.32	
HT	24	D	23-r	78	305	ANA15-3N	7.13	
HT	95	C	7-r	61	224	HT-return	2.87	
Cables with Anomalous Average Trace Resistance								
LT	76	a	52-p	all	all		<3.10>	
Data Not Available (information only)								
LT	7		72-r				n/a	
LT	30		64-r				n/a	
LT	108		7-p				n/a	
LT	109		74-r				n/a	
HT	35		37-r				n/a	
For all Cables original testing ONLY tested for opens only								
LT	A		all		140	ANA3-2		
HT	all		all		140	ANA11-02		

Table 4: Summary of all anomalous cable resistances in production cables

8. References

1. *Cable production flowchart*, http://hep.ph.liv.ac.uk/lhcb/html/cables3.html

2. *LHCb VELO production database*, http://hep.ph.liv.ac.uk/lhcb/html/database.html