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SDC
SOLENOIDAL DETECTOR NOTES

SDC MUON MEASURMENT SYSTEM
ENGINEERING MODEL

October 1992

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SOLENOIDAL DETECTOR COLLABORATION

SUPERCONDUCTING SUPERCOLLIDER LABORATORY

Final Report for Contract Number: SSC 91-Z-11116

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INTRODUCTION

A computer model of the muon measurement system portion of the SSC Solenoidal Detector has been developed at Draper Laboratory in order to support management of the engineering and design of the muon system. The model incorporates the algorithms needed to define the locations of all the measurement components of the SDC muon system and provides a means of tracking changes to the detector configuration, as well as disseminating configuration details. A detector configuration tracking system has been implemented, and a connection has been made between the Draper model and Intergraph, the SSCL CAD system.

This model was designed and built as part of Contract SSC 91-Z-1116.

Purpose

The purpose of this model is to provide an analytical tool to support the following:

- trade-off studies as a result of configuration changes,
- a database describing the envelopes of the components of the muon system that can be used by members of the collaboration in whatever formats they need,
- tracking and archiving of muon system configurations,
- checking and analysis of drift tube placement algorithms,
- provision of inputs for cost and scheduling.

Overview

The model has been built using the programs Microsoft Excel and Matlab, and runs on a Macintosh computer. The Excel portion can function as a standalone model, and can be used to calculate the envelopes and positions of the muon measurement system components. Matlab is used to generate the tube positions, provide some simple drawing capabilities, and perform analysis of detector configurations and tube placements. Figure 1 shows a simple drawing, generated in Matlab, of the upper right quadrant of the detector based on the model.

Inputs to the model are gathered from the SDC central database and stored in Excel worksheets. The worksheet, Parameter Definitions, contains the parameters defined by the muon group which are the driving parameters used in determining the detector configuration. The functional relationships between elements of the detector have been defined, based upon discussions with the muon system community. These functional relationships are contained in a set of worksheets corresponding to regions of the detector. From these worksheets, a Matlab readable database is generated (Model_out.matlab) to provide an automatic link between the Excel portion of the model and Matlab. Figure 2 shows the overall structure of the model and how information is distributed. A set of Matlab routines are called which calculate the tube positions and related information, as a function of the chamber envelopes and positions.

A set of Excel readable data is produced by Matlab, and is stored in a separate, Excel worksheet (Data_from_matlab). From the Excel model, and from the Matlab output, various summary worksheets can be generated. These worksheets are custom designed to the specifications desired by the user. Examples of existing summary worksheets have been included in the Appendix 2.

The model can be used for parameter lookup and for configuration studies. It should be noted that a solid familiarity with Excel is advised if dealing with the model directly, especially for modifications of the configuration. Instructions on using the model are given below.

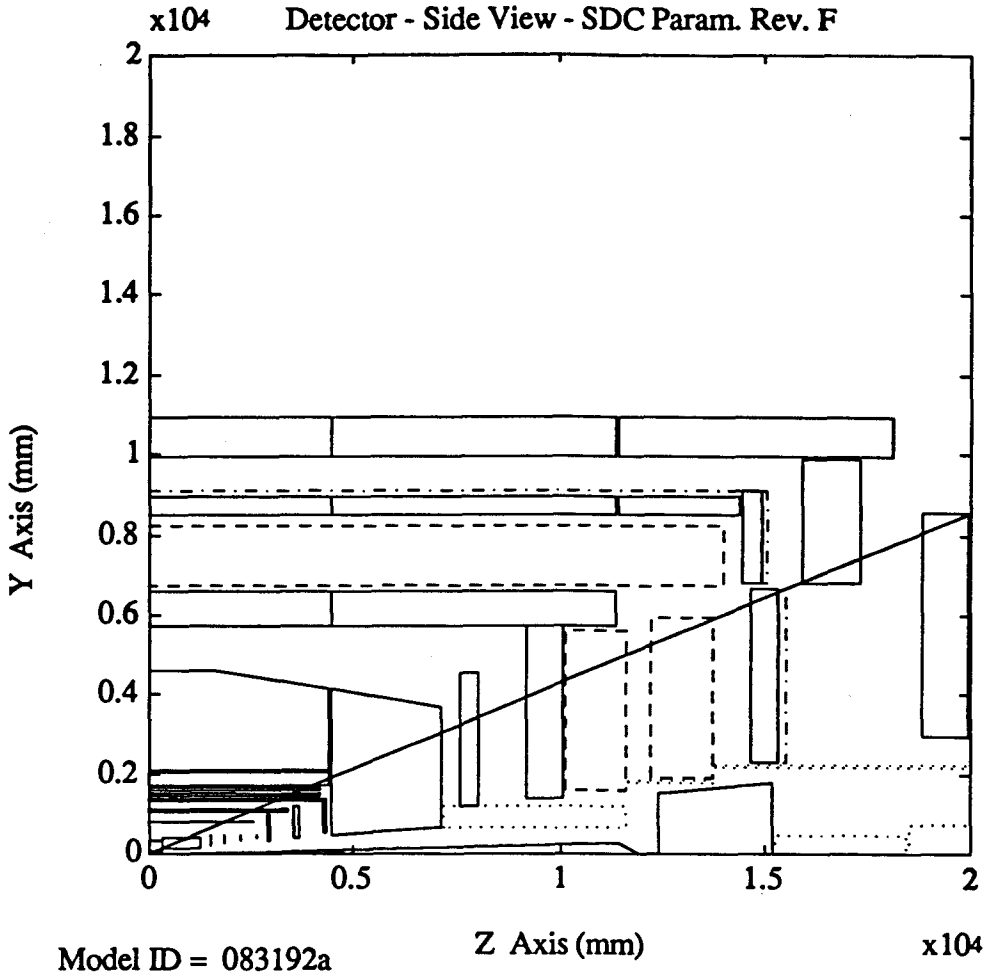


Figure 1
Drawing generated by Matlab, based on the muon system model.

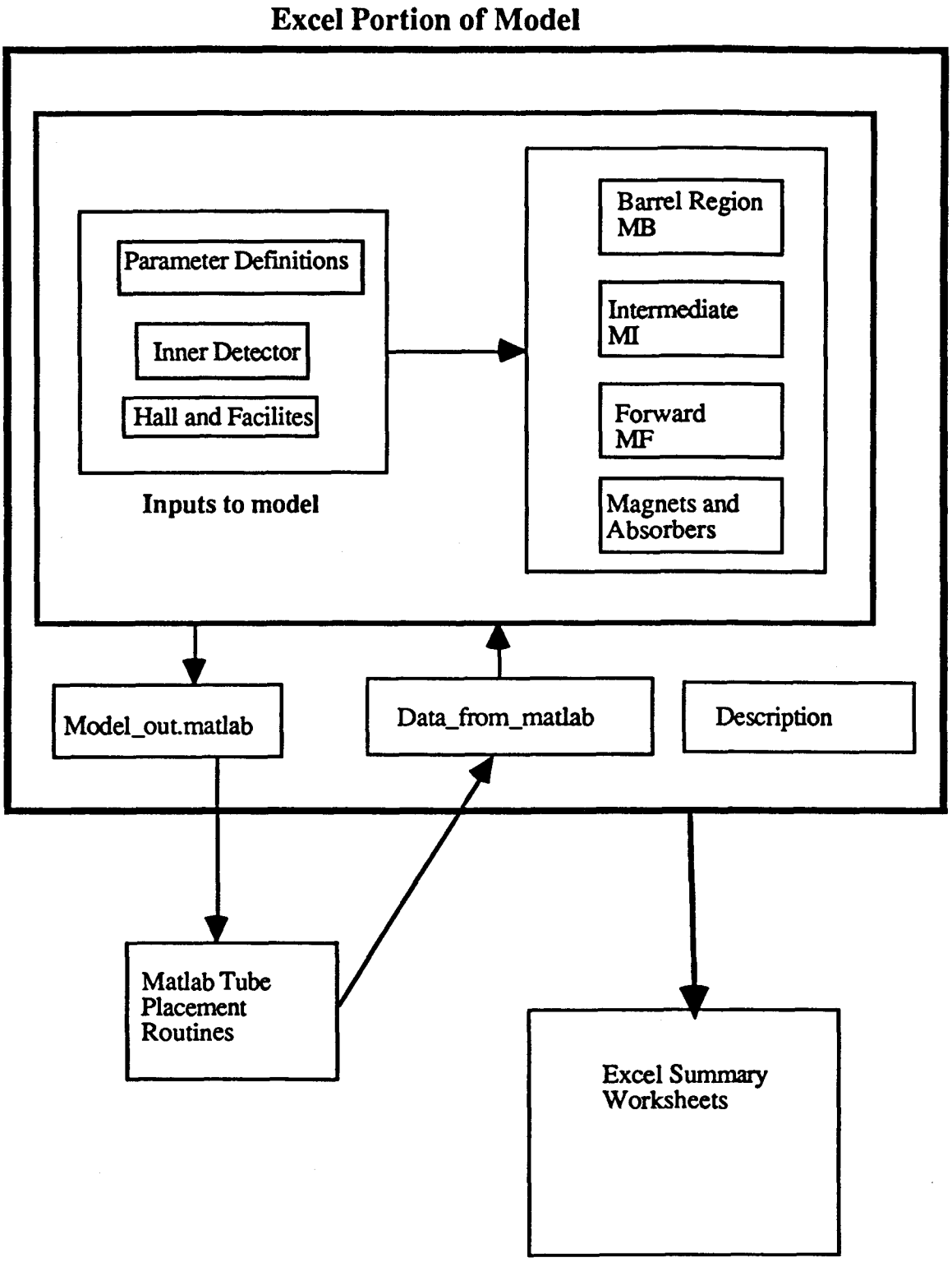


Figure 2 - Structural layout of Model

Model Description and Use

Description of model

The Excel portion of the model is comprised of a set of linked worksheets corresponding to the regional breakdown of the detector, a description of the model, and input to and output from Matlab. These files are all kept in a single directory. The directory "Model" contains the working version of the model. The directory "Saved Models" contains a set of sub-directories, each containing a stored version of the model (see Figure 6). A summary worksheet can be linked to the working model or to any previously saved version. A naming convention and model identification number has been incorporated in order to make archiving and version tracking easier. When summary worksheets are requested, they are based on the version of the model consistent with the latest version of the SDC Parameters Book unless otherwise specified. A snapshot of the model can be taken at any time, so that configurations can be archived with their full functionality. This will be discussed in more detail in the Configuration Tracking section of this document. Appendix 1 contains a printout of all the worksheets that make up the model and Appendix 4 contains a discussion of the algorithms and definitions used.

Below is a brief description of each of the worksheets comprising the model.

Parameter Definitions (PD) - This worksheet contains a list of the parameters that drive the algorithms used in determining the envelopes and positions of the muon system components. Included are such items as: tube diameters, access space dimensions, gap sizes between components, plate and rail thicknesses, etc.

Barrel Region (MB) -
Intermediate Region (MI) -
Forward Region (MF) -
Magnets and Absorbers (M_A) - These worksheets contain the functionality of the model and generate the dimensions of the components of the muon system. They also contain details about components such as: drift tube orientation, tube centerlines, and channel counts.

Inner Detector (ID) -
Hall and Facilities (HF) - These worksheets contain the dimensions of the components in the inner detector and the relevant hall and facilities measurements. The values are collected from the central SDC database and are used as inputs to the muon system calculation where appropriate.

Model_out.matlab - This worksheet generates the main database used by MatLab to calculate tube placements and produce drawings. The worksheet contains envelope information from the other worksheets, as well as a list of parameters used within Matlab. A copy of Model_out.matlab is saved as a text file named "muon_data.m" which can be accessed by Matlab directly.

Data_from_matlab - This worksheet contains all the data generated by Matlab that is used by the model and/or summary sheets. This sheet was created in order to minimize the problems of passing data from Matlab to Excel. It also allows the freezing of the Matlab data with a specific model configuration.

Description - This worksheet describes the main features of the model and details the changes from the previous baseline version.

functions - The functions worksheet contains a set of algorithms used by the model, which are too complicated to be placed in the normal formula box in Excel. This worksheet should always be open when working with other worksheets in the model.

Macros - The Macros worksheet contains a set of Excel macros that make it easier to move around in and manage the model. These include: updating links, taking a snapshot of the model, hiding and unhiding worksheets, etc.

The structure of the model has been designed to support functionality, not necessarily information lookup. There is an easy to follow basic structure, but if your are interested in specific summary information, especially information derived from model data, a worksheet should be constructed for that purpose (see Appendix 2 for examples of currently existing summary worksheets).

The Matlab portion of the model includes a set of routines that place the wire drift tubes in the chambers (Due to the complexity and size of the tube placement algorithm, Excel is not suited for this task.). Each chamber has its own Matlab script that handles specific details (first tube placement, whether to sparsify, etc.). These scripts then call a set of placement and sparsification routines (a sample script has been included in Appendix 3). An array containing results from these calculations is generated for each chamber. These arrays can be read by Excel, and the format is shown below:

	MBW13	MBW14
Theta Tube Data		
number of theta tubes	359.0	200.0
y coord of tube center for max theta	6402.3	6210.9
z coord of tube for max theta	-4268.0	4576.1
y coord of tube center for min theta	6498.0	6498.0
z coord of tube center for min theta	4274.6	11255.4
Total length of theta tubes (m)	1824.6	1029.0
Max theta angle coverage - tube pair	-56.0	53.9
Min theta angle coverage - tube pair	56.4	29.5
Phi Tube Data		
Number of phi tubes	194	194

Figure 3
Output from Matlab Tube Placement Routines

Also, for each chamber, an array of tube positions is generated. The arrays consists of the y and z coordinates of the theta tube centers and angular orientations for each of the chambers, as well as for the phi tubes in the barrel region (a sample from BW2.5 has been included in Appendix 3). These arrays can be passed to the Intergraph workstation as text files and used to generate a 2d, EMS drawing of the theta tubes placed and oriented correctly in the appropriate chambers (see Appendix 6 for the PPL file that does this).

A driver has been built in Matlab that automatically loads the database from the Excel portion of the model and generates the tube placement data for all the chambers, placing the output in the appropriate directory (see Figure 4 below).

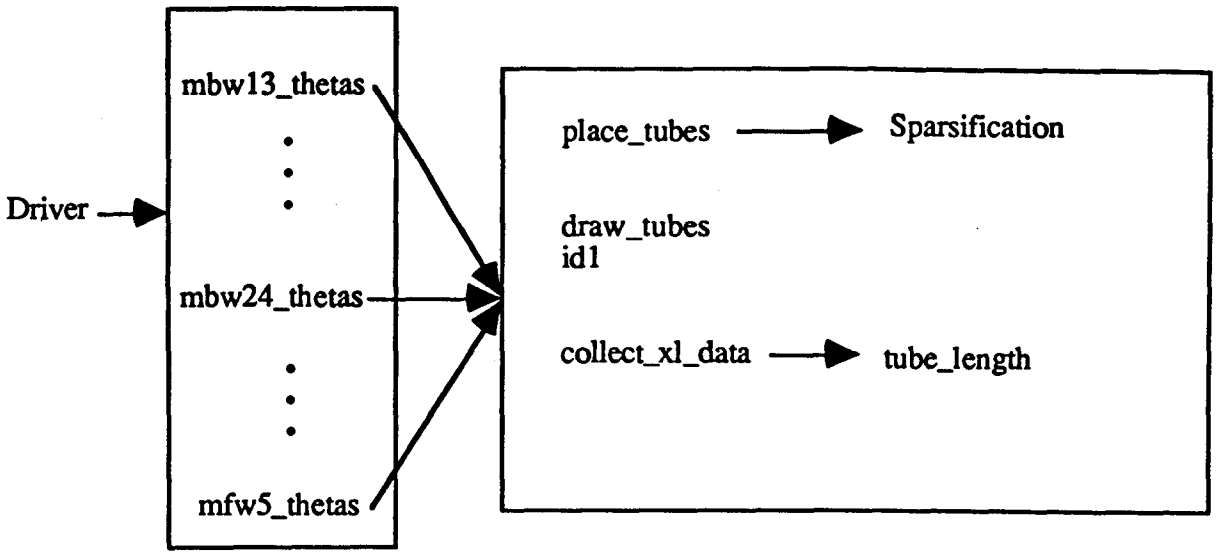


Figure 4
Overview of Tube Placement Scripts in Matlab

Several other capabilities have been developed in Matlab to support the engineering effort. These include simple drawing capabilities to illustrate various portions of the detector, both 2d and 3d, sketches showing tube placements within the chambers, plots showing the number of tubes that an infinite momentum muon will pass through as a function of the angle theta, and plots of the distances between tubes within a chamber.

Appendix 5 contains a set of plots used in analyzing the placements of tubes in the chambers. (A more detailed discussion of the tube placement algorithms and analysis will be contained in a memo to follow.) The Matlab scripts containing the sparsification algorithm used in placing tubes in the first row (Sparsification), and the algorithm for placing the other tubes, based on projections (place_tubes), have been included in Appendix 3.

Whenever possible, each of these Matlab scripts have been designed with an object oriented structure, in order to facilitate using and/or modifying them. Calls to subroutines can be easily turned on or off, and routines containing key algorithms, such as the sparsification algorithm, can be modified globally without having to make changes to many specific scripts. Some Matlab scripts have been included in Appendix 3, along with some of the graphics output.

Using the Model

There are two basic ways to use the model. The first is as a database defining a specific detector configuration. The second is as an actual model used to explore different detector configuration options and their implications. Using the model as a database is fairly straightforward. Using the model to alter the detector configuration requires good familiarity with the model and a strong grasp of Excel. If one is not careful, it is possible to come up with incorrect results, as linking between the various worksheets can easily become corrupted.

Everything needed to use the model for data lookup is contained in a single folder, with a model identification number in the folder name. All the worksheets within the folder will have the same model identifier as a suffix. Worksheets will come up in a read-only mode by default. This allows playing with the model without altering the original. Changes will have to be saved under a new name if they are to be kept for later review. The outline feature of Excel has been used to provide easy navigation of worksheets within the model. The overall structure is illustrated in Figure 2, showing the relationships of the worksheets to each other.

For general look up, the worksheets MB.mod_id_#, MI.mod_id_#, and MF.mod_id_# contain the most information. They all have basically the same structure, naming conventions, and format. The Muon Barrel worksheet is shown below in "Outline" format illustrating the basic organizational structure. If one sets the outline option to level 2, the worksheets will be laid out in a way that is easy to navigate. Details can be readily accessed by clicking on the outline button next to the appropriate heading.

The worksheet "functions" should be opened and "hidden" when using the model, even for parameter lookup. If it is not, error messages will appear in some of the worksheets as they try to access functions defined within the function worksheet. To make understanding the functionality of the model easier, variable names have been used extensively in the equations defining the functional relationships.

Summary worksheets should be checked to insure that all the links are to the desired model configuration. In the "Macros" worksheet, are some macros that will make this task easier.

In exploring configuration changes to the detector, the Parameter Definitions worksheet is meant to be a driver for the model. An attempt was made to include those parameters that are most likely to be modified in this worksheet. Changes made here will automatically propagate through all the appropriate worksheets that are open. In general, the model will only work properly if all the included worksheets are open. It is suggested that most of the worksheets be "hidden" when possible to avoid cluttering up the screen. The functionality is usually defined by the formula in the relevant cell, except in cases where it is too complicated to fit, in which case it is defined in the functions worksheet. Changes to the functionality of the model must be carried out within the worksheet for the region of interest. It should be noted that most of the formulas defining the functionality include variables from other worksheets. This can result in unwanted propagation of effects, if one is not careful when modifying formulas. Complex changes to the model should be done carefully, off-line, in order to insure valid results. Again, it should be emphasized that due to the complexity of the model, a solid understanding of Excel is advised.

If one is interested in the effects of configuration changes on tube placements and related information, or they would like a simple sketch showing the new configuration, the worksheet Model_out.matlab, should be saved as a text file called muon_data.m, where it can be accessed by Matlab. This will provide Matlab with all the parameters representing the new configuration. A new drawing can be generated by typing "sideview" in Matlab (if the scripts are available).

MB - OVERALL	
MBW1	
Overall Dimensions	
MBW1.N.N.DT.00.YY.00	
MBW1.2	
MBW1.3	
MBW1.4	
Total Number of channels	
MBW2	
Overall Dimensions	
MBW2.N.N.DT.00.YY.00	
MBW2.1	
MBW2.2	
MBW2.3	
MBW2.4	
MBW2.5	
Total Number of channels	
MBW3	
Overall Dimensions	
MBW3.N.N.DT.00.YY.00	
MBW3.1	
MBW3.2	
MBW3.3	
MBW3.4	
MBW3.5	
Total Number of channels	
SUPERTOWERS	
MBW0.1	
MBW0.2	
MBS2	
Overall Dimensions	
Envelope -	

Figure 5
Outline of Muon Barrel Region Worksheet

Configuration Tracking

In order to track changes in the configuration of the detector, an archiving scheme has been implemented. A "snapshot" of the model is taken and stored in its own sub-directory within a directory called "Saved Models". Each of the worksheets is renamed with a model identifier added to its existing name (see Figure 6). The model identifier is also passed to the Matlab database and all summary worksheets so that particular summaries and drawings can be easily referenced to specific model configurations. A directory containing a complete snapshot can be used as a standalone model, and can be run on an individual's Mac (assuming they have Excel). It contains the complete functionality of the model at that time. Included with this snapshot is a worksheet containing a description of particular characteristics of the saved configuration. Also, the Excel readable database generated by Matlab is included in order to provide summary information on tube counts and related calculations. The archived models are saved as read only, but can be saved under new names if a user wants to explore modifications to a particular configuration. Summary worksheets can be linked to the desired model version when appropriate.

<u>Saved Models</u>
- Base.040692
- Base.042192
- Base.061592
- Model.083192a
  - Data Matlab.083192a
  - Description.083192a
  - functions.083192a
  - HF.083192a
  - ID.083192a
  - Intergraph Data.083192a
  - Macros
  - MB.083192a
  - MF.083192a
  - MI.083192a
  - Mod_out.mat.083192a
  - M_A.083192a
  - PD.083192a
- Model.083192f
- Model.083192g
- Model.090192a
- Model.090292a
- SDC Param Rev E inputs

Figure 6

An Excel macro has been designed to automate the snapshot procedure. A model identifier is automatically generated with the format mmddyyx, where: mmddyy are two digit numbers for the month, day, and year respectively, and x is a letter starting with a, that is incremented if more than one snapshot is taken on a given day. This identifier is incorporated into the directory name, appended to each worksheet being saved, and is inserted into the worksheets where appropriate. If one wishes to generate drawings or carry out analysis in Matlab based on a particular configuration, they should save the file "Mod_out.mat.mod_id_#" as a text file "muon_data.m" where Matlab can access it. By calling "muon_data" in Matlab the database will be loaded into Matlab and all routines will use this data in their calculations. The model identification number will be placed in the lower left corner of drawings generated.

The plan is to have a saved configuration corresponding to each approved baseline release. At this point, a formal baseline change and approval process is still being developed within the SDC. The muon system model will be consistent with this when it has been agreed upon by the community.

Interface with Intergraph

Currently, both Excel data and Matlab data are being passed to the Intergraph Engineering Modeling System (EMS). The envelope dimensions of the measurement portions of the detector are passed to EMS with the appropriate names (the text file generated for this is included in Appendix 6). A Parametric Programming Language (PPL) script translates and loads this data into an EMS file template (the PPL file is included in Appendix 6 as well). The result is a one octant drawing of the muon system portion of the detector, in three dimensions, with the various parts of the detector assigned to layering consistent with the main SDC configuration model at SSCL.

The procedure for generating this drawing is the following:

1. Open the file "template" in EMS
2. Type on the command line - <esc>ci
3. Type mu
4. when it asks for the file name, enter the name of the text file with the dimensions (i.e., xl_model_out.txt)
5. Save as new file

The beginning of a directory structure on Zambia (the Harvard Intergraph workstation) has been laid out to archive these files. The intent is to give those needing access to this data an easy to use archiving scheme. Included with the PPL generated drawing will be a dimensions file and other detector drawings as desired.

Layer Assignments are listed in the table below. Items in **boldface** type are elements of the muon system.

Layer Number	Layer Name
900	dimensions
1	Si Tracker
2	Barrel tracker
3	Internal Tracker
4	Coil
5	Barrel Calorimeter
6	end caps
7	**FW1**
8	**FW2**
9	**FWD Toroid 1**
10	**FWD Toroid 2**
11	**FW4**
12	**FS4**
13	**FW5**
14	**FS5**
15	**BW1**
16	**Barrel Toroid**
17	**BW2**
18	**BS2**
19	**BW3**
20	**IW2**

21	IS2
22	IW3
23	Absorber
24	FWD Calorimeter
500	vis edge iso

Described above are the arrays of theta tube centers and orientations for each chamber produced by Matlab. These arrays can be passed to the Intergraph workstation as text files and can be used to generate a 2d, EMS drawing of the theta tubes placed and oriented correctly in the appropriate chambers (the script is included in Appendix 6 as place_thetas.u). This still needs to be expanded to include the phi and stereo tubes and full 3 dimensional capability. The procedure for using place_thetas.u is basically the same as described above for generating the 3d drawing.

A method to collect the dimensional data from the non-muon portions of the detector, either from the main SDC EMS configuration model, or from some sort of data base, is being explored.

APPENDICES

Appendix 1 Model Worksheets

Appendix 2 Model Outputs

Appendix 3 Matlab Outputs and Files

Appendix 4 Detailed discussion of the functionality

Appendix 5 Tube Analysis plots

Appendix 6 Intergraph files

APPENDIX 1 EXCEL MODEL WORKSHEETS

This snapshot contains tube count updates based on inputs from S. Lusin and use of more complete placement algorithims.

Below are the descriptions of the changes from the previous baseline that were incorporated into the model. The resulting model outputs were used as inputs to the SDC Detector Parameters Rev F.

changed forward chamber thickness calculation to include extra intersitital plates

updated on Parameter Definitions sheet the magnet gap that MBWn.4/5 will key on

changed the names of the FT coil gaps in the PD change variable names
also changed postion of FW4_z1 (added 840 access gap)

moved MFS4 to be attached MFW4
MBS2 half length now = MBW2 half length

MIW2_y2 = MBS2_y2 : MIW2 now extends to the top of the scintillators on MBW2
MIW2_y1 = MIW3_y1 : MIW2 bottom

MFS4_y2 now = MFW4_y2

BW2_y1 now with 250 mm gap

The bottom of MIW3 (IW3_y1) and the top of MFW5 (MFW5_y2) are determined based on infinite momnteum projections from MFW4 to the bottom and top most tubes of the respective chamber.

GENERAL

092392a
Reference:

Momentum (GeV)	?	
Resolution @90° (%)	?	
Level 1 trigger threshold (min pt - GeV/c)		
No. of Sectors	8	

TRACKING SYSTEM

Required Alignment relative to the Muon System		
r*phi (μm)	100	TDR 4/92 - pg. 4-2
in z (mm)	2	TDR 4/92 - pg. 4-2
Tracking Dimensions Used for Defining Forward Region		
Outer Radius - y2 (mm)	1619	either 1618.8 or 1345.9 - j pile 5/7
Half Length - z (mm)	4020	

Wire Drift Tube Chamber Specifications

MBW Drift Tube OD (mm)	93.6	Value used by C. Daly in e-mail 3/27/92
MBW Drift Tube Wall Thickness (mm)	1.6	TDR 5/1/92
MBW Drift Tube Active Width (mm)	88	value used by C. Daly from disc. 4/29
MBW Drift Tube Active Height (mm)	20	estimated from drawing in TDR
Tube End Dead Zone	50	C. Daly's 6/8/92 present.
Gap between Tubes (mm)	0.50	
Interstitial Plate Thickness (mm)	1.6	
MBW/MIW tube layer offset (mm)	40.0	
MFW1&2 Drift Tube OD (mm)	45	
MFW1&2 Drift Tube Active Width (mm)		
MFW4&5 Drift Tube OD (mm)	60	
MFW4&5 Drift Tube Active Width (mm)		

MBW End Rail Thickness	25	
MBW Top/Bottom Side Rail Thickness	25	
MBW Top/Bottom Side Rail Width	160	guess from TDR drawing
MBW Cover Plate Thickness	6	
Tube End Side Plate Thickness	19	
Tube End End Plate Thickness	19	
MBW Outer Plate Thickness	19	email, C. Daly 9/4/92
MIW End Rail Thickness	25	
MIW Side Rail Thickness		
MIW Cover Plate Thickness	6	
MFW End Rail Thickness		
MFW Side Rail Thickness		
MFW Cover Plate Thickness	6	
MBW End Inactive Region (mm)	90	Value used by C. Daly in e-mail 3/27/92
MBW Side Inactive Region	50	Value used by C. Daly in e-mail 3/27/92
Average Density of Chambers (kg/m^3)	230.0	Discussion w/ Feysi 4/30
Interstitial plates Density (kg/m^3)	2700	Density of aluminum
BARREL		
Multiple Scatter (μm) [avg. theta]	?	
Minimum Theta (°)	?	
Gap between Chambers (mm)	20	
Gap between MBW1 and MBT1 (mm)	180	SDC Detector Params 3/24/92
BW2 Magnet gap	250	per colin daly
BW3 Access gap	840	new value from c.g. 6/2/92
BW1 Multiple Scattering (mrad)	10	from Bensinger
BW3 Multiple Scattering (mrad)	80	from C Daly 6/9 fax to cg
INTERMEDIATE		
Distance from end of MBT1 to MIW2 (mm)	500	SDC Detector Params 3/24/92
IW Access gap	840	new value from c.g. 6/2/92
MBW2 - MIW2 gap	100	
FORWARD		
Multiple Scatter (μm) [avg. theta]	?	
1st endcap Muon layer (mm)	?	
Last endcap Muon Layer	?	
Resolution @ minimum theta (%)	?	

Resolution @ 5.7°(eta=3.0) (%)	?	
eta used to define FT and FW bottoms	2.5	
Distance from eta=2.5 to For. Toroids (mm)	100	
Top FT Coil gap (mm)	120	
Side FT Coil gap (mm)	90	
FW Support Thickness (mm)	50	
Support to Chamber distance (mm)	10	
FT2 Access gap	840	SDC Detector Params 3/24/92
Space between FW1 and CEO for PMTs	442	
FW4 Space due to moment arm (mm)	58	

CALORIMETERS

Calorimeter Support OR (mm - y)	4631	
Calorimeter half length (mm - z) - CBO+CEO	7095	
Maximum Eta	2.5	
CEO min. theta	9.4	

Forward Calorimeter

MAGNETS

BT1 gap for MBWn4 to key on	11453	old value10612
	13	either 11172 or 10612
Block Boundary which MBWn.4/5 will key on	11388	
Alignment hole size in z (mm)	130	
Alignment hole size in phi (mm)	150	

MB - OVERALL		
Octant:	**1**	**Description:**
Wire Tube Diameter - OD (mm)	93.6	from Param. Def.
MBW End Inactive Region (mm)	90	from Param. Def.
MBW Side Inactive Region	50	from Param. Def.
MBW End Rail Thickness	25	from Param. Def.
Chamber Gap (mm)	20	from Param. Def.
Interstitial Plate Thickness	1.6	Parameter Definitions
Gap Between Tubes (mm)	0.5	from Param. Def.
MBW1		
Overall Dimensions		
Envelope -		
Inside half width - x1 (mm)	2373	BW1_y1*TAN(22.5)-BW_gap/2/COS(22.5)
Outside half width - x2 (mm)	2711	f(y2,gap)
Inner radius - y1 (mm)	5756	y2 - thickness
Thickness (mm)	814	f(# of layers, tube OD, plate thickness)
Outer radius - y2 (mm)	6570	(BT1 iner radius) - (BW1_BT1_gap)
Half length - z (mm)	11443	PD!BT1_gap1-BW_gap/2
Weight (metric tonnes)	21.8	avg. density * vol.
		includes results of sparsification calcs.
Minimum theta - active - theta tubes (deg)		min of: atan(y4/z4max) and atan(y3/z3max)
Minimum theta - active - phi tubes (deg)		atan(y4/(z_env-MBW_end_inact)
Maximum phi - active - theta tubes (deg)		atan(y4/(x_env-MBW_end_inact)
Maximum phi - active - phi tubes (deg)		max of: atan(y4/x4max) and atan(y3/x3max)

MBW1.N.N.DT.00.YY.00		
1	phi	
y - center line	5828	BW1_y1+mbw_end_rail+(tube_OD + tube_gap)/2
2	phi	
y - center line	5924	MBW1_dt_y1 + tube_OD + tube_gap + Interst_Plate
3	phi	
y - center line	6019	
4	phi	
y - center line	6115	
5	theta	
y - center line	6211	
6	theta	
y - center line	6307	
7	theta	
y - center line	6402	
8	theta	
y - center line	6498	
MBW1.2		
Z1 - envelope	-11443	BW1 half length
Z2 - envelope	-4439	CBO_half_length + (CBO_CEO_gap/2)+BW_gap/2
Number of theta tubes	202	same as MBW1.4
MBW1.3		
Z1 - envelope	-4419	
Z2 - envelope	4419	CBO_half_length + (CBO_CEO_gap/2) - BW_gap/2
Number of theta tubes	357	from sparsification results
MBW1.4		
Z1 - envelope	4439	CBO_half_length + (CBO_CEO_gap/2)+BW_gap/2
Z2 - envelope	11443	
Number of theta tubes	202	from sparsification results
Total Number of channels		
Number of phi tubes per chamber	194	from placement results
theta	761	sum of above values
phi	582	3* result from one chamber
stereo	0	
Total	1343	
Total for 8 Octants	10744	

MBW2		
Overall Dimensions		
Envelope -		
Inside half width - x1 (mm)	3510	BW2_y1*TAN(22.5)-BW_gap/2/COS(22.5)
Outside half width - x2 (mm)	3689	f(y2,gap)
Inner radius - y1 (mm)	**8500**	BT1_out_rad + BW2_Rail_Space
Thickness (mm)	**431**	f(# of layers, tube OD, plate thickness)
Outer radius - y2 (mm)	8931	BW2_y1 + BW2_thick
Half length - z (mm)	14416	MIW2_z1-100
Weight (metric tonnes)	**20.6**	avg. density * vol.
Minimum theta - active - theta tubes (deg)		min of: atan(y4/z4max) and atan(y3/z3max)
Maximum phi - active - theta tubes (deg)	68.1	atan(y4/(x_env-MBW_end_inact)
MBW2.N.N.DT.00.YY.00		
1	theta	
y - center line	8572	
2	theta	
y - center line	8668	
3	theta	
y - center line	8763	
4	theta	
y - center line	8859	

MBW2.1		
Z1 - envelope	-14416	BW2_half_len (= MIW2_z2)
Z2 - envelope	-11463	BW1 half length - gap
Number of theta tubes	79	same as MBW2.5
MBW2.2		
Z1 - envelope	-11443	BW1 half length
Z2 - envelope	-4439	MBW1.2 _z2
Number of theta tubes	253	same as MBW2.4
MBW2.3		
Z1 - envelope	-4419	MBW1.3 _z1
Z2 - envelope	4419	
Number of theta tubes	358	from sparsification results
MBW2.4		
Z1 - envelope	4439	
Z2 - envelope	11443	
Number of theta tubes	253	from sparsification results
MBW2.5		
Z1 - envelope	11463	
Z2 - envelope	14416	
Number of theta tubes	79	from sparsification results
Total Number of channels		
theta	1022	Sum of above
phi	0	
stereo	0	
Total	1022	
Total for 8 Octants	8176	

MBW3		
Overall Dimensions		
Envelope -		
Inside half width - x1 (mm)	4099	BW3_y1*TAN(22.5)-BW_gap/2/COS(22.5)
Outside half width - x2 (mm)	4515	
Inner radius - y1 (mm)	**9921**	BW2_y2 + BS2_thick + BW3_Truss
Thickness (mm)	1005	
Outer radius - y2 (mm)	10927	BW3_in_rad + BW3_thick
Half length - z (mm)	18124	projective from top tube in IW3, layer 3 to last tube in layer 9, includes scattering of 80 mrad from center of layer 1 tube in IW3
		(MBW3_dt_y9-IW3_lay1_top_tube)/tan(theta- ms) + IW3_dt_z1 +mechanics +(tube_od+.5)/2
		17325
Weight (metric tonnes)	**72.2**	
Minimum theta - active - theta tubes (deg)		
Minimum theta - active - phi tubes (deg)	29.7	atan(y4/(z_env-MBW_end_inact)
Maximum phi - active - theta tubes (deg)	68.0	atan(y4/(x_env-MBW_end_inact)
Maximum phi - active - phi tubes (deg)		max of: atan(y4/x4max) and atan(y3/x3max)

MBW3.N.N.DT.00.YY.00		
1	phi	
y - center line	9993	BW3_y1 + Top_Plate + (tube_OD+ gap)/2
2	phi	
y - center line	10089	
3	phi	
y - center line	10185	
4	phi	
y - center line	10280	
5	stereo(phi)	
y - center line	10376	
proposed stereo angle (± mrad)	?	
6	stereo(theta)	
y - center line	10472	
proposed stereo angle (± mrad)	?	
7	theta	
y - center line	10567	
8	theta	
y - center line	10663	
9	theta	
y - center line	10759	
10	theta	
y - center line	10855	

SDC Parameters RevF + tube count modifications: Barrel Region

MBW3.1		
Z1 - envelope	-18124	MIW3_z2
Z2 - envelope	-11463	BW1_half_len-BW_gap
Number of theta tubes	198	same as MBW3.5
MBW3.2		
Z1 - envelope	-11443	BW1_half_len
Z2 - envelope	-4439	
Number of theta tubes	269	same as MBW3.4
MBW3.3		
Z1 - envelope	-4419	
Z2 - envelope	4419	CBO_half_length + CBO_CEO_gap/2-BW_gap/2
Number of theta tubes	358	from sparsification results
MBW3.4		
Z1 - envelope	4439	CBO_half_length + CBO_CEO_gap/2+BW_gap/2
Z2 - envelope	11443	
Number of theta tubes	269	from sparsification results
MBW3.5		
Z1 - envelope	11463	
Z2 - envelope	18124	
Number of theta tubes	198	from sparsification results
Total Number of channels		
Number of phi tubes per chamber	340	from tube placement results
theta	1292	sum of above
phi	1700	5* number from sparsification for one chamber
stereo(phi)	425	phi/4
stereo(theta)	323	thetas/4
Total	3740	
Total for 8 Octants	29920	

SUPERTOWERS		
MBW0.1		
Components	BW2,BW3	
Weight (metric tonnes)		
c.g. - x		
c.g. - y		
c.g. - z		
envelope		
attachment		
MBW0.2		
Weight (metric tonnes)		
c.g. - x		
c.g. - y		
c.g. - z		

MBS2		
Overall Dimensions		
Envelope -		
Half width - MBS_x (mm)	3689	BW2_x2
Inner radius - y1 (mm)	8931	BW2_y2
Layer Thickness (mm)	150	
Outer radius - y2 (mm)	9081	
Thickness (panel - mm)	10	
Half Length (mm)	14416	MBW2_Z2
Panel Volume (approx m^3)	17.2	
Segmentation in theta	58	
Segmentation in phi	32	
MBS2.1		
Z1 - envelope	14416	IW2_z2 + IS2_thick
Z2 - envelope	-11463	BW21_z2
MBS2.2		
Z1 - envelope	-11443	BW22_z1
Z2 - envelope	-4439	BW22_z2
MBS2.3		
Z1 - envelope	-4419	MBW23_z1
Z2 - envelope	4419	MBW23_z2
MBS2.4		
Z1 - envelope	4439	MBW24_z1
Z2 - envelope	11443	MBW24_z2
MBS2.5		
Z1 - envelope	11463	MBW23_z1
Z2 - envelope	14416	IW2_z2 + IS2_thick
No. of counters	1856	
No. of channels (PMT)	3712	
Counter Width (mm)	500	
Counter Length (mm)	1850	
scintillator width difference		

MI - OVERALL		
Octant:	**1**	**Description:**
Wire Tube Diameter - OD (mm)	93.6	Parameter Definitions
MIW Chamber End Inactive Region (mm)	90	Parameter Definitions
MIW Chamber Side Inactive Region	50	Parameter Definitions
MIW End Rail	25	Parameter Definitions
Chamber Gap (mm)	20	Parameter Definitions
Interstitial Plate Thickness	1.6	Parameter Definitions
Gap between Tubes (mm)	0.5	Parameter Definitions
Gap from bot. of MBW2 to top of MIW2	100	Parameter Definitions
MIW2		
Overall Dimensions		
Envelope -		
Inside half width - x1 (mm)	2796	IW2_y1*TAN(22.5)-gap/2/COS(22.5)
Outside half width - x2 (mm)	3751	
Inner radius - y1 (mm)	6777	IW2_Z2*FW4_Y2/FW4_Z2 (old value 6417)
delta y (mm)	2304	
Outer radius - y2 (mm)	9081	MBW2_y1 - BW2_IW2_gap
Z position - z1 (mm)	14516	BT1_half + BT1_IW2_gap
Thickness (mm)	431	f(# of layers, tube OD, tube gaps, Intersititial)
Outer Z - z2 (mm)	14947	IW2_z1 + thickness
Weight (metric tonnes)	1.5	avg. density * vol.
Minimum theta - full coverage		
Maximum theta - full coverage		

MIW2.0.1.DT.00.00.ZZ		
1	theta	
z - centerline	14588	IW2_z1+Top_Plate+(tube_OD+ tube_gap)/2
2	theta	
z - centerline	14684	MIW2_dt_z1+tube_OD+tube_gap+Interst_Plate
3	theta	
z - centerline	14779	
4	theta	
z - centerline	14875	
Number of channels		
Number per Chamber - theta	84	
Totals for both ends, 8 octants		
theta	1344	
phi	0	
stereo	0	
Total	1344	

MIW3		
Overall Dimensions		
Envelope -		
Inside half width - x1 (mm)	2796	
Outside half width - x2 (mm)	4090	
Inner radius - y1 (mm)	6777	IW3_z2*IW2_y1/IW2_z2 (old value7420)
delta y (mm)	3124	
Outer radius - y2 (mm)	9901	*BW3_y1 - BW_gap*
Z position - z1 (mm)	15937	IS2_z2 + PD!IW_Acc_gap
Thickness (mm)	1388	
Outer Z - z2 (mm)	17325	IW3_z1 + thickness
Weight (metric tonnes)	6.9	avg. density * vol.
Minimum theta - full coverage		
Maximum theta - full coverage		
MIW3.0.1.DT.00.00.ZZ		
1	theta	
z - centerline	16009	IW3_z1+Top_Plate+(tube_OD tube_gap)/2
2	theta	
z - centerline	16105	
3	theta	
z - centerline	16201	
4	theta	
z - centerline	16296	
5	stereo	
z - centerline	16392	
proposed stereo angle (± mrad)	100	
6	stereo	
z - centerline	16488	
proposed stereo angle (± mrad)	100	
7	phi	
z - centerline	16583	
8	phi	
z - centerline	16679	
9	phi	
z - centerline	16775	

10	phi	
z - centerline	16871	
11	phi	
z - centerline	16966	
12	phi	
z - centerline	17062	
13	phi	
z - centerline	17158	
14	phi	
z - centerline	17253	
Number of channels		
Number per Chamber - theta	120	
Number per Chamber - phi	346	Lusin 9/16
Number per Chamber - stereo	43	Lusin 9/16
Totals for both ends, 8 octants		
theta	1920	
phi	5536	
stereo	688	estimated to be same as theta count for now
Total	8144	

MIS2		
Overall Dimensions		
Half width - x1 (mm)	2796	IW2_x1
Upper halfwidth - x2 (mm)	3751	
Inner radius - y1 (mm)	6777	IW2_y1
Outer radius - y2 (mm)	9081	IW2_Y2
Inner Z position (mm)	14947	IW2_z2
Layer Thickness (mm)	150	
Outer Z (outline)	15097	IS2_z1+ 150
Thickness (panel)	10	
Panel Volume (approx. m^3)	2.4	
Segmentation in theta	10	
No. of counters	320	
No. of channels (PMT)	640	
Counter Width (mm)	500	
Counter Length (mm)	1850	

MF - OVERALL		9/23/92
		Description:
MFW End Inactive Region (mm)		
MFW Side Inactive Region		
MFW Cover Plate Thickness	6	Parameter Definitions
Chamber Gap (mm)	20	Parameter Definitions
Interstitial Plate Thickness	1.6	Parameter Definitions
Gap between Tubes (mm)	0.5	Parameter Definitions
FW Support Thickness (mm)	50	Parameter Definitions
Support to Chamber distance (mm)	10	Parameter Definitions
Extra FW2 Plates (mm)	25	Parameter Definitions
FW4 Space	58	Parameter Definitions
eta: used in defining bottoms of chambers	2.5	Parameter Def.
Equivalent theta (deg)	9.39	
MFW1		
Overall Dimensions		
Envelope -		
Inside half width - x1 (mm)	495	
Outside half width - x2 (mm)	1874	
Inner radius - y1 (mm)	1220	*FW1_z1*TAN(theta_MF)-100*
Thickness - delta y (mm)	3331	
Outer radius - y2 (mm)	4551	FW1_z2*FW2_y2/FW2_z2
Inner Z position (mm)	7537	CEO_z2_env+ FW1_PMT_space
Thickness (mm)	450	2*no_lay*(Fdt_od+gap)+2*Interst*(no_lay-1) +2*Sup_gap+Sup_Thick
Outer Z (mm)	7987	
Weight (metric tonnes)	0.8	
Minimum theta - active (deg)	9.37	
Maximum theta - full coverage	29.83	
Chamber Details		
Wire Tube Diameter - OD (mm)	45	
Chamber Gap (mm)	20	

MFW1.N.1.DT.00.00.ZZ		
1	theta	
z - centerline	7566	FW1_z1+Cover_Plate+(tube_OD+ tube_gap)/2
2	theta	
z - centerline	7613	MFW1_dt_z1+tube_OD+tube_gap+Interst_Plate
3	theta	
z - centerline	7660	
4	theta	
z - centerline	7707	
No. of channels per chamber	272	from tube placement algorithm
No. of channels (both ends)	4352	

MFW2		
Overall Dimensions		
Envelope -		
Inside half width - x1 (mm)	577	
Outside half width - x2 (mm)	2365	
Inner radius - y1 (mm)	1419	FW2_z1*TAN(theta_MF*PI()/180)-100
Thickness - delta y (mm)	4317	
Outer radius - y2 (mm)	5736	BW1_y1 - SM_gap
Inner Z position (mm)	9189	
Thickness (mm)	877	sames as FW1 + 2*FW2_plates
Outer Z (mm)	10066	
Weight (metric tonnes)	2.3	
Minimum theta - active (deg)	8.96	
Maximum theta - full coverage	30.34	
Chamber Details		
Wire Tube Diameter - OD (mm)	45	
Chamber Gap (mm)	20	

MFW2.N.1.DT.00.00.ZZ		
1	theta	
z - centerline	9243	
2	theta	
z - centerline	9290	
3	stereo	
z - centerline	9337	
4	stereo	
z - centerline	9384	
5	theta	
z - centerline	9431	
6	theta	
z - centerline	9478	
7	stereo	
z - centerline	9526	
8	stereo	
z - centerline	9573	
No. of channels per chamber - theta	352	from tube placement algorithm
No. of channels per chamber - stereo	352	estimatated to = thetas for now
No. of channels (both ends)	11264	

MFW3		
Overall Dimensions		
Envelope -		
Inside half width - x1 (mm)	752	
Outside half width - x2 (mm)	2437	
Inner radius - y1 (mm)	1841	
Thickness - delta y (mm)	4069	
Outer radius - y2 (mm)	5910	
Inner Z position (mm)	11746	
Thickness (mm)	443.6	
Outer Z (mm)	12190	
Weight (metric tonnes)	1.3	
Minimum theta projection (deg)	8.75	
Minimum theta - active (deg)	9.21	
Maximum theta projection	26.28	
Maximum theta - full coverage	25.90	
Chamber Details		
Wire Tube Diameter - OD (mm)	45	
Chamber Gap (mm)	20	
MFW3.N.1.DT.00.00.ZZ		
1	theta	
z - centerline	11752	
2	theta	
z - centerline	11799	
3	theta	
z - centerline	11846	
4	theta	
z - centerline	11893	
No. of channels (both ends)		

MFW4		
Overall Dimensions		
Envelope -		
Inside half width - x1 (mm)	954	
Outside half width - x2 (mm)	2735	
Inner radius - y1 (mm)	2329	FW4_z1*TAN(theta_MF*PI()/180)-FT_eta25_gap
delta y (mm)	4299	
Outer radius - y2 (mm)	6628	proj. from ft2 thru cntr of top tube, l3, outside
Inner Z position (mm)	14696	****was M_A!FT2_z2+PD!FT1_FW2_gap
Thickness (mm)	686	same as FW1 + 2*FW1_space
Outer Z (mm)	15382	FW4_z1+FW4_thick
		15382
Weight (metric tonnes)	2.5	
Minimum theta projection (deg)	8.80	
Minimum theta - active (deg)	9.17	
Maximum theta projection	23.79	
Maximum theta - full coverage	23.47	
Chamber Details		
Wire Tube Diameter - OD (mm)	60	
Chamber Gap (mm)	20	
MFW4.N.1.DT.00.00.ZZ		
1	theta	
z - centerline	14732	
2	theta	
z - centerline	14794	
3	theta	
z - centerline	14914	FW4_dt_z2+FW4_dt_od+tube_gap+Interst_Plate+FW4_space
4	theta	
z - centerline	14977	
No. of channels per chamber	264	from tube placement algorithm
No. of channels (both ends)	4224	

MFW5		
Overall Dimensions		
Envelope -		
Inside half width - x1 (mm)	1236	
Outside half width - x2 (mm)	3544	
Inner radius - y1 (mm)	3010	
Delta y (mm)	5572	
Outer radius - y2 (mm)	8582	proj. from fw4 w/ scatter
Inner Z position (mm)	18816	
Thickness (mm)	1117	
Outer Z (mm)	19933	FW5_z1+FW5_thick
Weight (metric tonnes)	6.8	
Minimum theta - active (deg)	9.26	
Maximum theta - full coverage	23.64	
Chamber Details		
Wire Tube Diameter - OD (mm)	60	
Chamber Gap (mm)	20	

MFW5.N.1.DT.00.00.ZZ		
1	theta	
z - centerline	18877	
2	theta	
z - centerline	18939	
3	stereo	
z - centerline	19001	
4	stereo	
z - centerline	19064	
5	theta	
z - centerline	19126	
6	theta	
z - centerline	19188	
7	stereo	
z - centerline	19250	
8	stereo	
z - centerline	19312	
No. of channels per chamber	348	from tube placement algorithm
No. of channels (both ends)	11136	2* thetas to include stereos

MFS4		
Half width - x1 (mm)	954	
Upper halfwidth - x2 (mm)	2735	
Inner radius - y1 (mm)	2329	FS4_z1*TAN(theta_MF)-FT_eta25_gap
Outer radius - y2 (mm)	6628	6661 - FS4_z2*FW4_y2/FW4_z2
Inner Z position (mm)	15382	attached to FW4
Layer Thickness (mm)	150	
Outer Z (outline)	15532	
Thickness (panel)	10	
Panel Volume (m^3)	2.6	
Segmentation in theta	33	
No. of counters	1120	
No. of channels (PMT)	1120	
MFS5		
Half width - x1 (mm)	1236	
Upper halfwidth - x2 (mm)	3544	
Inner radius - y1 (mm)	3010	FW5_y1
Outer radius - y2 (mm)	8582.2	FW5_y2
Inner Z position (mm)	19933	FW5_z2
Layer Thickness (mm)	150	
Outer Z (outline)	20083	
Thickness (panel)	10	
Panel Volume (m^3)	4.3	
Segmentation in theta	33	
No. of counters	1136	
No. of channels (PMT)	1136	why not 2* No. of counters?
Cerenkov		
No. of modules	16	
Inner Z position (mm)	15716	
Thickness (mm)	2000	
Outer Z (mm)	17716	
Inner radius (mm)	2498	
Outer radius (mm)	5982	
Volume (m^3)	3468.8	
No. of channels (both ends)	400	
No. of mirrors (both ends)	1600	

eta: used in defining bottoms of chambers	2.5				
Equivalent theta (deg)	9.39				
MBT1					
Inner Radius	6750				
Thickness (mm)	1500				
Outer Radius (mm)	8250				
Half Length (mm)	14016				
Total Volume (m^3)	2090				
Total Weight (tonnes)	16406				
B field (tesla)	1.8				
Field orientation	phi				
Number of Coils	16				
Support Segmentation in Z	19				
N° of Jacks	76				
Inner radius of space truss	8950				
Outer radius of space truss	10050				
Inner radius of tieplate	11510				
Outer radius of tieplate	12010				
Radius at base plate	13950				
Width of girder/jack assembly	3000				
Height of girder/jack assembly	2700				
Total width of base	12800				
Thickness of inclined plates	300				
MFT1					
Inner radius - y1 (mm)	1579	FT1_z1*tan(9.39)			
Delta y (mm)	4057				
Outer radius to flat - y2 (mm)	5636	BW1_y1-!FT_Coil_gap		(old value 5600)	
Inner Z position - z1 (mm)	10156				
Thickness (mm)	1500				
Outer Z - z2 (mm)	11656				
Total Volume (m^3)	291				
Weight (both ends) (metric tonnes)	2284				
B field (tesla)	1.8				
Field Orientation	phi				
Number of Coils	16				
Support Segmentation in Z	2				
N° of Jacks	16				
Inner radius of base	5636				
Outer radius of base	?				
Radius at slab (rails)	6750				
Width of jack assembly	750				
Total width of base	4900				
Height of base	1114				

MFT2					
Inner radius - y1 (mm)	1927	FT2_z1*tan(9.39)			
Delta y	3983				
Outer radius to flat - y2 (mm)	5910		FT2_z2*ID!Brl_Trk_Rad/ID!Brl_trk_half_len		
Inner Z position - z1 (mm)	12266				
Thickness (mm)	1500				
Outer Z - z2 (mm)	13766				
Total Volume (m^3)	310.3				
Weight (both ends) (metric tonnes)	2474				
B field (tesla)	1.8				
Field Orientation	phi				
Number of Coils	16				
Support Segmentation in Z	2				
N° of Jacks	16				
Inner radius of base	5910				
Outer radius of base	?				
Radius at slab (rails)	6750				
Width of jack assembly	750				
Total width of base	4900				
Height of base	840				
ABSORBERS					
	AB1	**AB3**	**AB4**		
Z inner postion (mm)	7145	13816	15276		
Z outer position (mm)	11656	19933	18450		
Inner Radius - y1 (mm)	710	2179	25		
Thickness (mm)	500	100			
Outer radius - y2 (mm)	1210	2279	500		
Quad Shield & Cryo					
Z inner postion (mm)	18500				
Z outer position (mm)	20000				
Inner Radius (mm)	25				
Outer radius (mm)	750				
SSC Quad					
Z inner postion (mm)	200000				
Z outer position (mm)	300000				
Inner Radius (mm)	25				
Outer radius (mm)	750				

					9/23/92
BEAM PIPE					
Central Section					
Length (mm)	2200				
Diameter (mm)	50				
Conical Sections	**Inner**	**Outer**			
Inner z position	2200	11500			
Length (mm)	10400	500			
Outer Z position (mm)	11500	12000			
Min Diam. (mm)	50	50			
Max Diam. (mm)	500	500			
Outboard Sections					
Inner z position	12000				
Length (mm)	8500				
Outer z position (mm)	20500				
Diameter (mm)	50				
TRACKING SYSTEM					
Silicon Tracker					
SI Tracker half length (mm)	2580				
SI Tracking outer radius (mm)	466				
Inner theta projection (deg)					
SI Tracker cylinders combined					
Half length - Z (mm)	300				
Inner radius (mm)	90				
Outer radius (mm)	360				
SI Disks	**SID1_9**	**SID10**	**SID11**	**SID12**	**SID13**
Z - Position - inside	330	1460	1820	2180	2580
Z Position - outiside (mm)	1220	1460	1820	2180	2580
Inner radius (mm)	150	225	285	345	405
Outer radius (mm)	390	465	465	465	465
Theta projection (deg)	24.44395	8.76091	8.89986	8.9929	8.9213
Inner Theta Projection (deg)	8.76				
Barrel Tracker					
Barrel Tracker Radius (mm)	1619		1675		
Half Length (mm)	4020		4348		
Tracker Space	25				
Super Layer	**C1**	**C2**	**C3**	**C4**	**C5**

Mean Radius	816	1103	1351	1488	1632
Inner radius	798	1083	1333	1468	1614
Thickness (mm)	37	40	37	40	37
Outer radius (mm)	835	1123	1370	1508	1651
Total half length (mm) - Includes electronics	2530	3401	4153	4153	4153
Active half length (mm)	2410	3281	4033	4033	4033
No. of modules	92	124	152	168	184
Straws//layer/half	1219	1643	2041	2226	2438
Layers/superlayer	8	6	8	6	8
Channel count	19504	19716	32224	26712	390008
Stereo Angle	0	3	0	-3	0
Minimum Theta (deg)	5.70				
Intermediate Tracker	**IT1**	**IT2**	**IT3**		
Mean z (mm)	2910	3585	4260		
Inner z	2870	3545	4220		
Thickness	80	80	80		
Outer z	2950	3625	4300		
Inner radius (mm)	350	432	515		
Outer radius (mm)	978	1201	1425		
No. of eta segments	4	4	4		
Number of layers	4	4	4		
Orientations					
radial	2	2	2		
stereo	2	2	2		
No. of anodes					
SUPERCONDUCTING SOLENOID					
B field - Selenoid (T)	2.00				
Inner Radius (mm)	1700				
Coil Thickness	350				
Outer Radius (mm)	2050				
Coil Half Length (mm)	4363				
Coil - CBO Seperation (mm)	50				
Chimney Diameter (mm)	305				
Chimney Envelope					

CALORIMETERS					
Calorimeter Envelope space - (mm)	**412**				
CBO		**Plus Env.**			
CBO Inner radius (mm)	2100				
Calorim. Barrel Thicknes (mm)	2119				
CBO Outer radius (mm) at Z=0	4219	4631			
CBO outer radius at end (mm)	3757	4169			
CBO half length - cylinder region (mm)	1525				
CBO half length (mm) - overall	4389				
		4429			
CBO - CEO gap along Z (mm)	80				
CEO					
CEO Inner radius at inner z (mm)	466				
CEO Outer radius at inner z (mm)	3745	4157			
CEO Inner radius at outer z (mm)	708				
CEO Outer radius at outer z (mm)	3306	3718			
CEO length (mm)	2371	2625			
CEO back edge - z (mm)	4469				
CEO forward edge (mm)	6840	7095	was+254		
Calorimeter half length (mm - z) - CBO+CEO	7095				
CEO Min. theta (deg)	**5.7**				
Elec./Sevice Acc. space delta R (mm)	1089				
Forward Calorimter					
Z position (mm)	12476				
Length (mm)	2750				
Z outer (mm)	15226				
Inner radius (mm)	50				
Outer radius at inner z (mm)	1500				
Outer radius at outer z (mm)	1769.757				
Weight (both ends - tonnes)	300				

HALL PARAMETERS	
Depth of floor (m)	**63.4**
Height from floor (m):	
Shelf	**7.3**
IP	**13.9**
Ceiling	**40**
Width (in x, m)	**29**
Length (+z -> S , m)	**105**
Pit Length (in z, m)	**50**
IP from North wall (z)	50
Hall projections in IP frame (mm)	
Side walls x = ±	14500
Pit floor: y =	-13900
Shelf floor: y =	-6600
Ceiling: y =	26100
North wall: z =	-50000
South wall: z =	55000
North pit wall: z=	-25000
South pit wall: z =	25000

MBW12		
2373	5756	-11443
2711	6570	-4439
MBW13		
2373	5756	-4419
2711	6570	4419
MBW14		
2373	5756	4439
2711	6570	11443
MBW21		
3510	8500	-14416
3689	8931	-11463
MBW22		
3510	8500	-11443
3689	8931	-4439
MBW23		
3510	8500	-4419
3689	8931	4419
MBW24		
3510	8500	4439
3689	8931	11443
MBW25		
3510	8500	11463
3689	8931	14416
MBW31		
4099	9921	-18124
4515	10927	-11463
MBW32		
4099	9921	-11443
4515	10927	-4439
MBW33		
4099	9921	-4419
4515	10927	4419
MBW34		
4099	9921	4439

4515	10927	11443
MBW35		
4099	9921	11463
4515	10927	18124
MIW2		
2796	6777	14516
3751	9081	14947
MIW3		
2796	6777	15937
4090	9901	17325
MFW1		
495	1220	7537
1874	4551	7987
MFW2		
577	1419	9189
2365	5736	10066
MFW4		
954	2329	14696
2735	6628	15382
MFW5		
1236	3010	18816
3544	8582	19933
MFS4		
954	2329	15382
2735	6628	15532
MFS5		
1236	3010	19933
3544	8582	20083
MIS2		
2796	6777	14947
3751	9081	15097
MBS21		
3689	8931	-14416
3689	9081	-11463

MBS22		
3689	8931	-11443
3689	9081	-4439
MBS23		
3689	8931	-4419
3689	9081	4419
MBS24		
3689	8931	4439
3689	9081	11443
MBS25		
3689	8931	11463
3689	9081	14416
MIW2		
2796	6777	-14516
3751	9081	-14947
MIW3		
2796	6777	-15937
4090	9901	-17325
MFW1		
495	1220	-7537
1874	4551	-7987
MFW2		
577	1419	-9189
2365	5736	-10066
MFW4		
954	2329	-14696
2735	6628	-15382
MFW5		
1236	3010	-18816
3544	8582	-19933
MFS4		
954	2329	-15382
2735	6628	-15532
MFS5		
1236	3010	-19933

3544	8582	-20083
MIS2		
2796	6777	-14947
3751	9081	-15097
MBT1		
2796	6750	-14016
3417	8250	14016
MFT1		
654	1579	10156
2335	5636	11656
MFT1		
654	1579	-10156
2335	5636	-11656
MFT2		
798	1927	12266
2448	5910	13766
MFT2		
798	1927	-12266
2448	5910	-13766

APPENDIX 2 SAMPLE EXCEL MODEL OUTPUTS

Tube_Data.083192a

Tube Data Summary
Model ID = 083192a

MBW1	Tube Count	Total Length(m)
theta	761	4709
phi	582	4327
stereo	0	
Total for one octant	1343	9037
Total for 8 Octants	10744	72293

MBW2	Tube Count	Total Length(m)
theta	1022	7849
phi	0	0
stereo	0	0
Total for one octant	1022	7849
Total for 8 Octants	8176	62790

MBW3	Tube Count	Total Length(m)
theta	1292	7849
phi	1700	11991
stereo - phi	425	2998
stereo - theta	323	2770
Total for one octant	3740	25608
Total for 8 Octants	29920	204860

BW2+BW3 for 7 Octants	Tube Count	Total Length(m)
theta	16198	109883
phi	11900	83939
stereo - phi	2975	20985
stereo - theta	2261	19387
Total for 7 octants	33334	234194
MBW Totals	48840	339944

Tube_Data.083192a (cont.)

MIW2

	Tube Count	Total Length(m)
per Chamber:		
theta	84	529
phi	0	0
stereo	0	
Total for one octant	84	529
Total for both ends, 16 Octants	1344	8469

MIW3	Tube Count	Total Length(m)
per Chamber:		
theta	120	796
phi	392	1154
stereo	120	796
Total for one octant	632	2745
Total for both ends, 16 Octants	10112	43923
MIW Totals	11456	52392

Tube_Data.083192a (cont.)

MFW1	Tube Count	Total Length(m)
per Chamber:		
theta	272	573
phi	0	0
stereo	0	
Total for one octant	272	573
Total for both ends, 16 Octants	4352	9170

MFW2	Tube Count	Total Length(m)
per Chamber:		
theta	352	943
phi	0	0
stereo	352	472
Total for one octant	704	1415
Total for both ends, 16 Octants	11264	22633

MFW4	Tube Count	Total Length(m)
per Chamber:		
theta	264	907
phi	0	0
stereo	0	
Total for one octant	264	907
Total for both ends, 16 Octants	4224	14509

MFW5	Tube Count	Total Length(m)
per Chamber:		
theta	348	1570
phi	0	0
stereo	348	785
Total for one octant	696	2355
Total for both ends, 16 Octants	11136	37680

MFW Totals	30976	83993

Angular_Coverage

Angular Coverage in MBW for Two_Tube Tracks				
083192a				
These calculations are for tracks that pass				
through the outermost pair of tubes in each chamber				
These angles are with respect to the vertical (i.e. 90-theta) in order to be c				
with C. Daly				
	Overall angular coverage of chamber (deg)	Percent actually covered		
Theta tube Coverage in theta directi				
MBW1	60.47	95.97		
MBW2	58.33	95.57		
MBW3	59.08	95.86		
Theta tube Coverage in phi direction				
MBW1	42.59	94.65		
MBW2	43.30	96.22		
MBW3	43.59	96.87		
Phi tube Coverage in theta direction				
MBW1	61.96	96.29		
MBW3	60.48	95.64		

Tube Data Comparisons

	A	B	G	K	L	M
1	Summary of Configuration Changes					
2						
3		Active link to Matlab results	C. Daly's numbers 7/7/92	Discrete spars., z-gap = 10162 7/24	delta counts G - K	Tube counts with the gaps filled in the corners. Uses new z gap 8/25/92
4	TUBE COUNTS					
5	phi tubes					
6	MBW1n	194	192	194	- 2	194
7	MBW3n	340	340	340	0	340
8	Total phi tubes/octant					
9						
10	theta tubes					
11	MBW12	200	193	180	13	202
12	MBW13	359	357	359	- 2	359
13	MBW14	200	193	180	13	202
14	MBW21	76	116	102	14	79
15	MBW22	250	234	224	10	253
16	MBW23	360	362	360	2	360
17	MBW24	250	234	224	10	253
18	MBW25	76	116	102	14	79
19	MBW31	192	232	222	10	198
20	MBW32	267	241	237	4	269
21	MBW33	360	358	360	- 2	360
22	MBW34	267	241	237	4	269
23	MBW35	192	232	222	10	198
24						
25						
26	MBW1 Tubes/Octant	1341	1319	1301	18	1345
27	MBW2 Tubes/Octant	1012	1062	1012	50	1024
28	MBW3 Tubes/Octant	2978	3004	2978	26	2994
29						
30						

Behrends

Below are a list of parameters requested by Steve Behrends			
Model ID=	083192a		
	X	Y	Z
MBW13_center =	0.0	6163.0	0.0
MBW13_del_x1 =	4746.8		
MBW13_del_x2 =	5421.1		
MBW13_del_y=	814.0		
MBW13_del_z=	8838.0		
MBW14_center =	0.0	6163.0	7941.0
MBW14_del_x1 =	4746.8		
MBW14_del_x2 =	5421.1		
MBW14_del_y=	814.0		
MBW14_del_z=	7004.0		
MBW23_center =	0.0	8715.6	0.0
MBW23_del_x1 =	7020.0		
MBW23_del_x2 =	7377.2		
MBW23_del_y=	431.2		
MBW23_del_z=	8838.0		
MBW24_center =	0.0	8715.6	7941.0
MBW24_del_x1 =	7020.0		
MBW24_del_x2 =	7377.2		
MBW24_del_y=	431.2		
MBW24_del_z=	7004.0		
MBW25_center =	0.0	8715.6	12939.5
MBW25_del_x1 =	7020.0		
MBW25_del_x2 =	7377.2		
MBW25_del_y=	431.2		
MBW25_del_z=	2953.0		

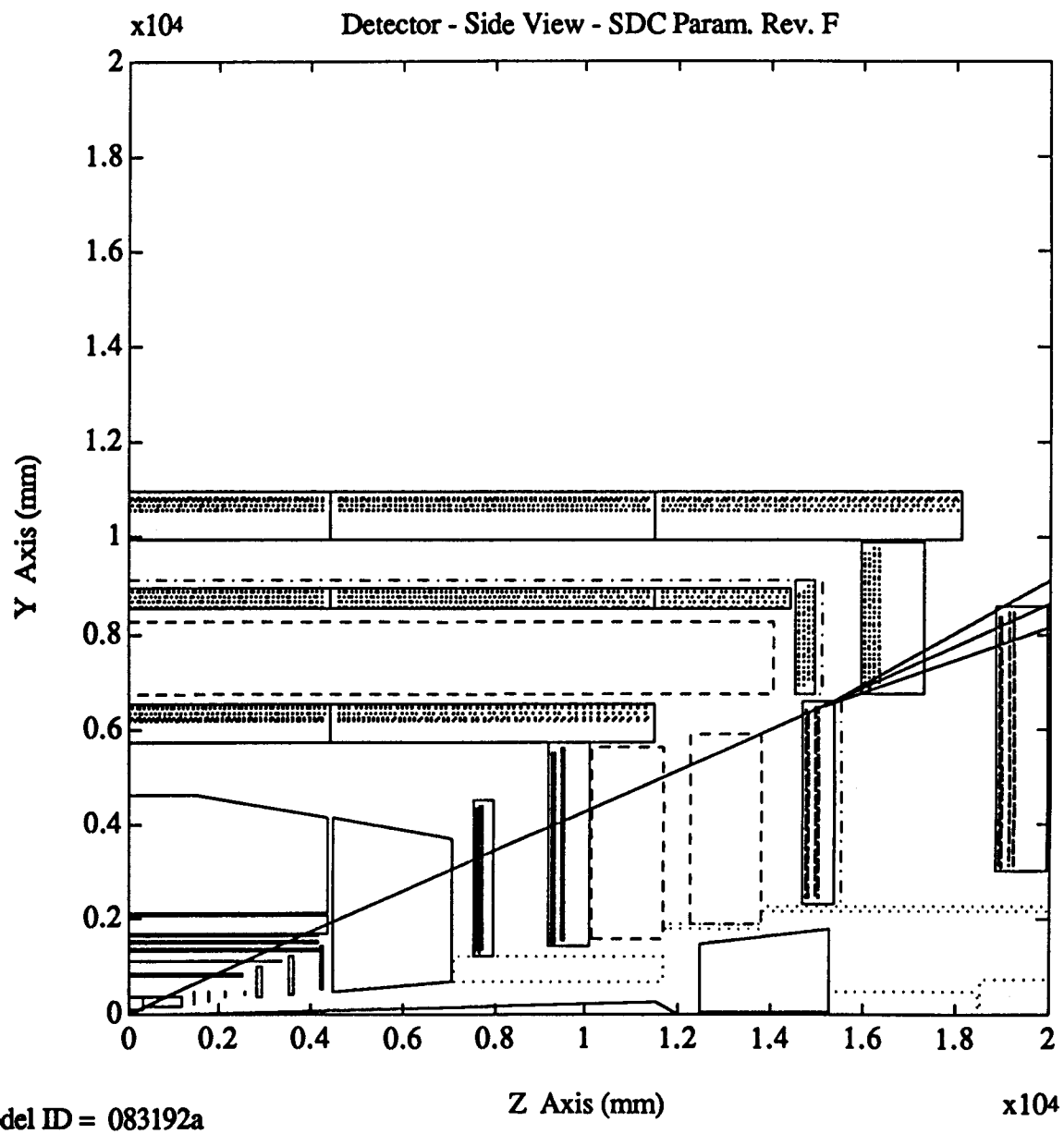
Behrends (cont.)

MBW33_center =	0.0	10423.9	0.0
MBW33_del_x1 =	8197.3		
MBW33_del_x2 =	9030.2		
MBW33_del_y=	1005.4		
MBW33_del_z=	8838.0		
MBW34_center =	0.0	10423.9	7941.0
MBW34_del_x1 =	8197.3		
MBW34_del_x2 =	9030.2		
MBW34_del_y=	1005.4		
MBW34_del_z=	7004.0		
MBW35_center =	0.0	10423.9	14793.7
MBW35_del_x1 =	8197.3		
MBW35_del_x2 =	9030.2		
MBW35_del_y=	1005.4		
MBW35_del_z=	6661.3		
MIW2_center =	0.0	7929.2	14731.6
MIW2_del_x1 =	5592.7		
MIW2_del_x2 =	7501.5		
MIW2_del_y=	2304.1		
MIW2_del_z=	431.2		
MIW3_center =	0.0	8339.2	16631.3
MIW3_del_x1 =	5592.7		
MIW3_del_x2 =	8180.8		
MIW3_del_y=	3124.1		
MIW3_del_z=	1388.2		

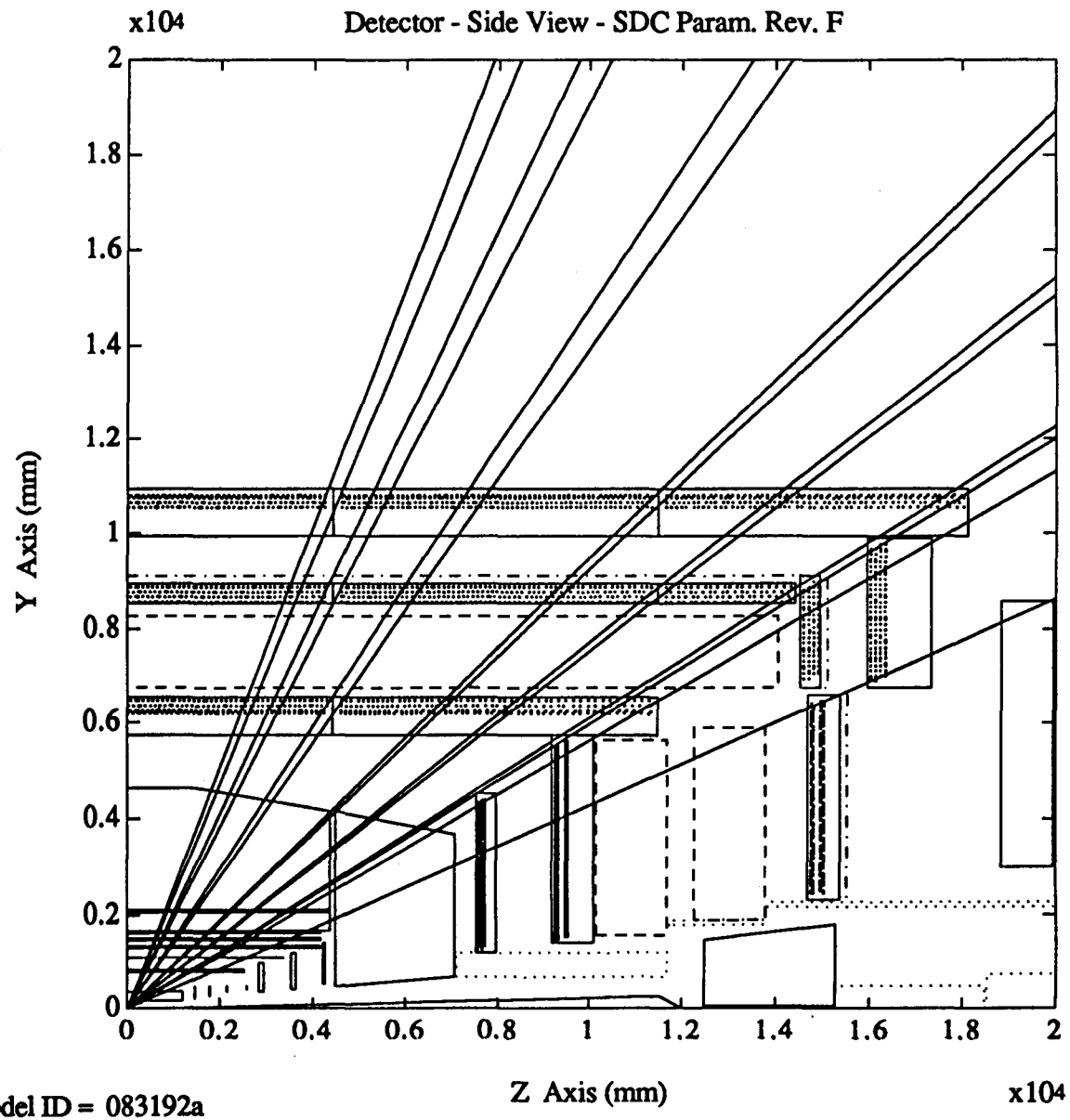
Behrends (cont.)

MFW1_center =	0.0	2885.7	7762.0
MFW1_del_x1 =	989.1		
MFW1_del_x2 =	3748.8		
MFW1_del_y=	3331.2		
MFW1_del_z=	450.0		
MFW2_center =	0.0	3577.4	9627.6
MFW2_del_x1 =	1153.7		
MFW2_del_x2 =	4730.2		
MFW2_del_y=	4317.2		
MFW2_del_z=	876.8		
MFW3_center =	0.0	3875.5	11967.8
MFW3_del_x1 =	1503.5		
MFW3_del_x2 =	4874.4		
MFW3_del_y=	4069.0		
MFW3_del_z=	443.6		
MFW4_center =	0.0	4478.7	15039.0
MFW4_del_x1 =	1907.8		
MFW4_del_x2 =	5469.6		
MFW4_del_y=	4299.5		
MFW4_del_z=	686.0		
MFW5_center =	0.0	5796.1	19374.4
MFW5_del_x1 =	2471.9		
MFW5_del_x2 =	7088.1		
MFW5_del_y=	5572.2		
MFW5_del_z=	1116.8		

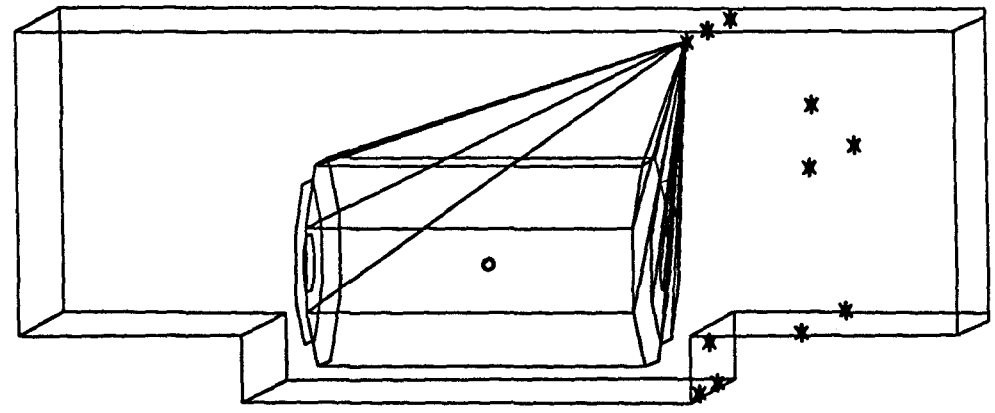
APPENDIX 3 MATLAB OUPUTS



Model ID = 083192a

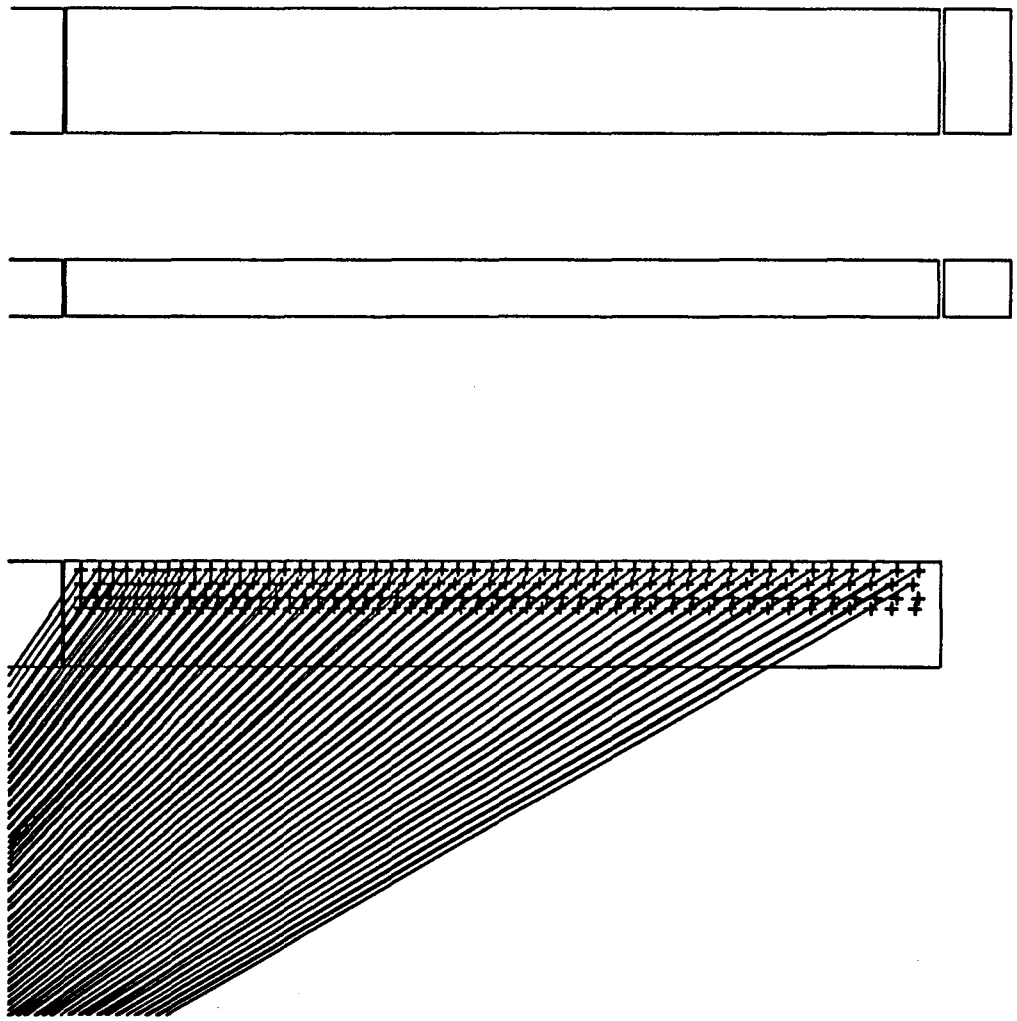


Model ID = 083192a



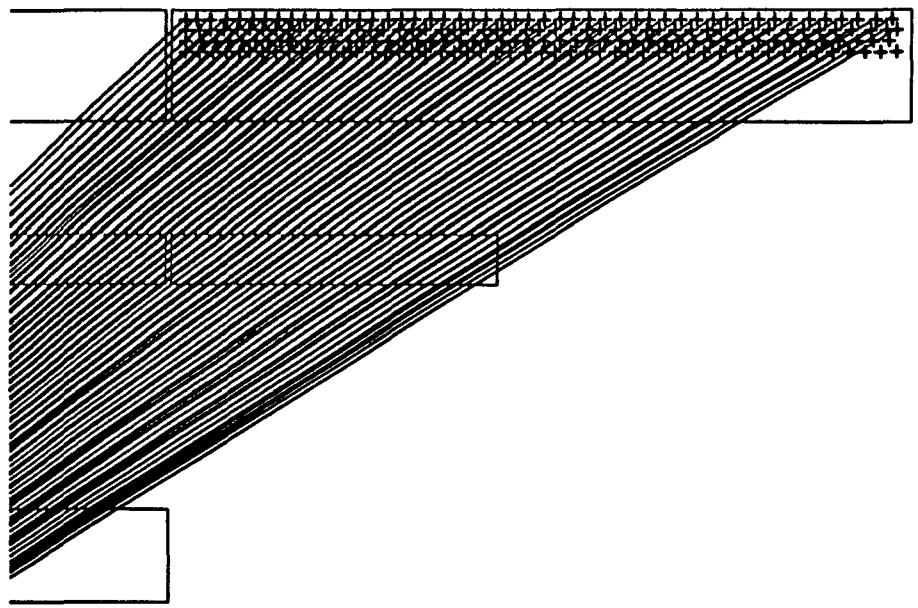
Model ID = 083192a

MBW14 Theta Tube Placements



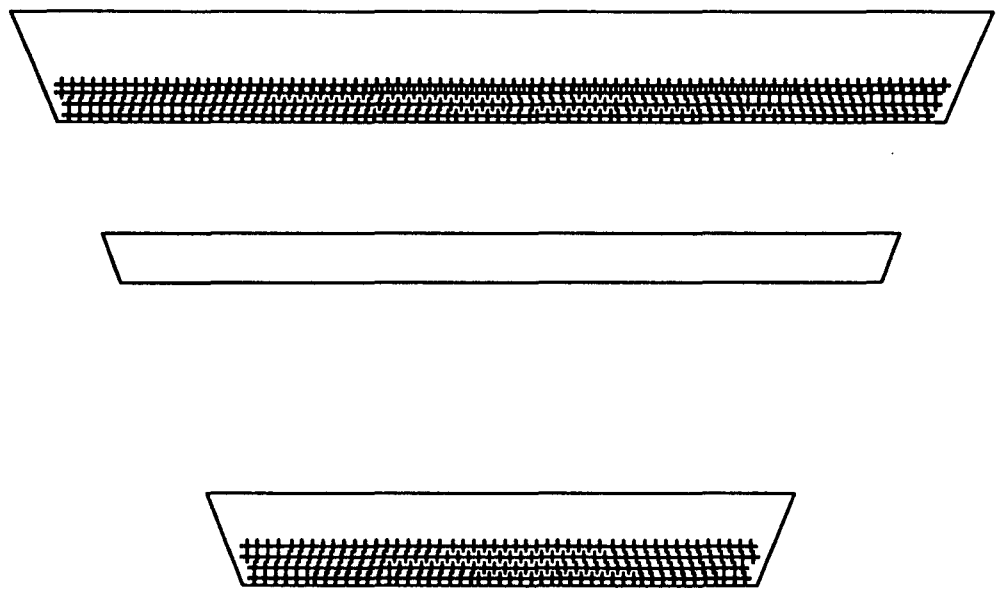
Model ID = 083192a

MBW35 Theta Tube Placements



Model ID = 083192a

MBW Phi Tube Placements



Model ID = 083192a

Sample array of tube positions and oreintation from mbw25

% spars_mbw25

8.5720500e+03	1.1600050e+04	3.6463165e+01
8.5720500e+03	1.1724150e+04	3.6172206e+01
8.5720500e+03	1.1858250e+04	3.5862281e+01
8.5720500e+03	1.1992350e+04	3.5556926e+01
8.5720500e+03	1.2126450e+04	3.5256057e+01
8.5720500e+03	1.2260550e+04	3.4959593e+01
8.5720500e+03	1.2394650e+04	3.4667453e+01
8.5720500e+03	1.2528750e+04	3.4379558e+01
8.5720500e+03	1.2662850e+04	3.4095830e+01
8.5720500e+03	1.2796950e+04	3.3816193e+01
8.5720500e+03	1.2931050e+04	3.3540573e+01
8.5720500e+03	1.3065150e+04	3.3268896e+01
8.5720500e+03	1.3199250e+04	3.3001089e+01
8.5720500e+03	1.3343350e+04	3.2717546e+01
8.5720500e+03	1.3487450e+04	3.2438305e+01
8.5720500e+03	1.3631550e+04	3.2163282e+01
8.5720500e+03	1.3775650e+04	3.1892394e+01
8.5720500e+03	1.3919750e+04	3.1625561e+01
8.5720500e+03	1.4063850e+04	3.1362704e+01
8.5720500e+03	1.4207950e+04	3.1103745e+01
8.6677500e+03	1.1600050e+04	3.6767696e+01
8.6677500e+03	1.1769555e+04	3.6369981e+01
8.6677500e+03	1.1895041e+04	3.6080301e+01
8.6677500e+03	1.2030638e+04	3.5771733e+01
8.6677500e+03	1.2166235e+04	3.5467709e+01
8.6677500e+03	1.2301832e+04	3.5168148e+01
8.6677500e+03	1.2437429e+04	3.4872968e+01
8.6677500e+03	1.2573026e+04	3.4582088e+01
8.6677500e+03	1.2708623e+04	3.4295431e+01
8.6677500e+03	1.2844220e+04	3.4012918e+01
8.6677500e+03	1.2979818e+04	3.3734474e+01
8.6677500e+03	1.3115415e+04	3.3460024e+01
8.6677500e+03	1.3251012e+04	3.3189496e+01
8.6677500e+03	1.3386609e+04	3.2922818e+01
8.6677500e+03	1.3532318e+04	3.2640464e+01
8.6677500e+03	1.3678026e+04	3.2362389e+01
8.6677500e+03	1.3823735e+04	3.2088509e+01
8.6677500e+03	1.3969444e+04	3.1818743e+01
8.6677500e+03	1.4115153e+04	3.1553009e+01
8.6677500e+03	1.4260862e+04	3.1291229e+01
8.7634500e+03	1.1600050e+04	3.7069828e+01
8.7634500e+03	1.1724820e+04	3.6775441e+01
8.7634500e+03	1.1859060e+04	3.6463165e+01
8.7634500e+03	1.1985931e+04	3.6172206e+01
8.7634500e+03	1.2123026e+04	3.5862281e+01
8.7634500e+03	1.2260120e+04	3.5556926e+01
8.7634500e+03	1.2397214e+04	3.5256057e+01
8.7634500e+03	1.2534308e+04	3.4959593e+01
8.7634500e+03	1.2671402e+04	3.4667453e+01
8.7634500e+03	1.2808497e+04	3.4379558e+01

8.7634500e+03	1.2945591e+04	3.4095830e+01
8.7634500e+03	1.3082685e+04	3.3816193e+01
8.7634500e+03	1.3219779e+04	3.3540573e+01
8.7634500e+03	1.3356874e+04	3.3268896e+01
8.7634500e+03	1.3493968e+04	3.3001089e+01
8.7634500e+03	1.3641285e+04	3.2717546e+01
8.7634500e+03	1.3788603e+04	3.2438305e+01
8.7634500e+03	1.3935920e+04	3.2163282e+01
8.7634500e+03	1.4083238e+04	3.1892394e+01
8.7634500e+03	1.4230555e+04	3.1625561e+01
8.8591500e+03	1.1600050e+04	3.7369571e+01
8.8591500e+03	1.1725155e+04	3.7073522e+01
8.8591500e+03	1.1856201e+04	3.6767696e+01
8.8591500e+03	1.2029449e+04	3.6369981e+01
8.8591500e+03	1.2157705e+04	3.6080301e+01
8.8591500e+03	1.2296297e+04	3.5771733e+01
8.8591500e+03	1.2434888e+04	3.5467709e+01
8.8591500e+03	1.2573479e+04	3.5168148e+01
8.8591500e+03	1.2712071e+04	3.4872968e+01
8.8591500e+03	1.2850662e+04	3.4582088e+01
8.8591500e+03	1.2989253e+04	3.4295431e+01
8.8591500e+03	1.3127845e+04	3.4012918e+01
8.8591500e+03	1.3266436e+04	3.3734474e+01
8.8591500e+03	1.3405027e+04	3.3460024e+01
8.8591500e+03	1.3543619e+04	3.3189496e+01
8.8591500e+03	1.3682210e+04	3.2922818e+01
8.8591500e+03	1.3831136e+04	3.2640464e+01
8.8591500e+03	1.3980063e+04	3.2362389e+01
8.8591500e+03	1.4128989e+04	3.2088509e+01
8.8591500e+03	1.4277915e+04	3.1818743e+01

Sample Matlab srcipt that places the tubes in the chamber mbw14.

```
%sparsification- for MBW14
%first tube in lower left hand corner
tube_OD =BW_tube_OD;
%act=88;
act=tube_active ; % 88
gap=BW_tube_gap;
side_plate=side_mech;
offset=40/tube_OD;  % second layer tube offset 40 mm
chamber='MBW14';
z1_env=MBW141(2,3);
z2_env=MBW141(3,3);
zlength= z2_env-z1_env-2*side_plate;
z_max=z2_env-side_plate-(tube_OD+gap)/2;


alpha_ms=ms_bw1 ;  % value from PD

% row number corresponds to layer number

mbw1=MBW1_DT_cls(5:8,1);
mbw2=MBW2_DT_cls([1:4],1); % centerlines from muon_data
mbw3=MBW3_DT_cls(7:10,1);
clines=mbw1;

cl1=clines(1,1);
cl2=clines(2,1);
cl3=clines(3,1);
cl4=clines(4,1);
hold off
q=[4000 12000 3000 11000];
%q=[4300 5300 5700 6700];
clear spars_array
clear lines
%row 1****************

ntubes1=150;  % pick a large number for looping

spars_array(1,1)=cl1;   %y1
tube21=z1_env + side_plate +(tube_OD+gap)/2; % second row first tube
%spars_array(1,2)= (tube21*cl1/cl2)+(1-offset)*tube_OD;
spars_array(1,2)=z1_env + side_plate +(tube_OD+gap)/2;  % z1

%************************************

place_tubes
%*************************************************************
ntubes=ntubes1+ntubes2+ntubes3+ntubes4;  %

spars_array(:,3)=(180/pi)*atan(spars_array(:,1)./spars_array(:,2));
%*****************Draw Plots
if draw==1,
```

```
draw_tubes
end

% Get XL data ******************************
if save_files==1,

collect_xl_data_b

save MBW14_tube_data xl_theta_data /ascii
save spars_mbw14 spars_array /ascii

end
```

The Matlab script place_tubes, used to positions the tubes as a function of projections. Calls Sparsifiaction for first row positions.

```
%place_tubes
z_min=z1_env+side_plate+(tube_OD+gap)/2;
z_max=z2_env-side_plate-(tube_OD+gap)/2;
spacer=10;  %tube spacer for first layer
n_sp=1 ;  % number of spacers
for i=2:100,
  spars_array(i,1)=cl1;
  spars_array(i,2)=spars_array(i-1,2)+tube_OD+gap;
 %********Sparsification

 if sparsify==1,

 Sparsification;
  end

  if spars_array(i,2)> z_max,

    %see if a tube will fit with a smaller gap,
    % and if so, place an extra tube against edge
     if z_max-spars_array(i-1,2) > tube_OD+gap,
       spars_array(i,2)=z_max;
       ntubes1=i;
      else,
       ntubes1=i-1;
     end
    break
   end

end


%row 2 ************************************
ntubes2=ntubes1+5;
spars_array(ntubes1+1,1)=cl2;
spars_array(ntubes1+1,2)=tube21;
a12= cl2/cl1;

k=0;

for i=(ntubes1+2):(ntubes1+ntubes2),
     k=k+1;
     spars_array(i,1)=cl2;  % yi
     spars_array(i,2)=a12*spars_array(i-ntubes1-1,2)+offset*tube_OD;

   if spars_array(i,2)> z_max,

     %see if a tube will fit with a smaller gap,
     % and if so, place an extra tube against edge
      if z_max-spars_array(i-1,2) > tube_OD+gap,
        spars_array(i,2)=z_max;
        ntubes2=k+1
```

```
        else,
          ntubes2=k;
         end
       break
    end

 end

%row3 *********************
ntubes3=ntubes1;
ntubes4= ntubes2;
nsum=ntubes1+ntubes2;
a13=cl3/cl1;
k=0;

% fill in space between wall before going on
 %***** find number of tubes that can fit in gap
 nn1=fix((a13*spars_array(1,2)-z_min)/(tube_OD+gap));
  %*****find space left over
 gap1=rem((a13*spars_array(1,2)-z_min),(tube_OD+gap));
  %*****smallest discrete spacer size
 zsp= 10*cl3/cl1;
  n_sp=fix(gap1/zsp/2);
%**** put in extra tubes
for i=(nsum+1):(nsum+nn1),
   spars_array(i,1)=cl3;
   spars_array(i,2)=z_min+(i-nsum-1)*(zsp*n_sp+tube_OD+gap);
   k=k+1;
  end
%*****put in projected tubes
for i=(nsum+1+nn1):(nsum+ntubes3),
   spars_array(i,1)=cl3;
   spars_array(i,2)=a13*spars_array(i-nsum-nn1,2);

   k=k+1;
  if spars_array(i,2)> z_max,
    %see if a tube will fit with a smaller gap,
     % and if so, place an extra tube against edge

       if z_max-spars_array(i-1,2) > tube_OD+gap,
         spars_array(i,2)=z_max;
         ntubes3=k;
        else,
      yz3max=spars_array(i-1,1:2);
      ntubes3=k-1;
     end
      break
    end

 end


%row 4  ****************************************
```

```
a14=cl4/cl2;
k=0;
% fill in space between wall before going on
 %***** find number of tubes that can fit in gap
 nn1=fix((a14*spars_array(1,2)-z_min)/(tube_OD+gap));
  %*****find space left over
 gap1=rem((a14*tube21-z_min),(tube_OD+gap));
  %*****smallest discrete spacer size
 zsp= 10*cl4/cl1;
  n_sp=fix(gap1/zsp/2);
%**** put in extra tubes

for i=(nsum+ntubes3+1):(nsum+ntubes3+nn1),
   spars_array(i,1)=cl4;
   spars_array(i,2)=z_min+(i-nsum-ntubes3-1)*(zsp*n_sp+tube_OD+gap);
    k=k+1;

  end
  itemp=i;
for i=(itemp+1):(nsum+ntubes3+ntubes4),
   k=k+1;
   spars_array(i,1)=cl4;
   spars_array(i,2)=a14*spars_array(i-ntubes3-ntubes2-nn1,2);
 if spars_array(i,2)> z_max,
     %see if a tube will fit with a smaller gap,
      % and if so, place an extra tube against edge

       if z_max-spars_array(i-1,2) > tube_OD+gap,
         spars_array(i,2)=z_max;
         ntubes4=k;
        else,
      ntubes4=k-1;
      spars_array(i,2)=spars_array(i-1,2)  ; % fix last tube overrun
      end
       %yz4max=spars_array(i-1,1:2);
      break
   end

end
ntubes=length(spars_array)-1;
```

The Matlab script Sparsifiaction which is called by place_tubes

```
%Sparsification
% called by place_tubes
% will put in discretizaton
% places row one tubes, then goes back to place_tubes

  y1=spars_array(i-1,1);  % get y component of previous tube
 z1=spars_array(i-1,2);  % get z component of previous tube
  y2=spars_array(i,1);    % get y of guess from place_tubes
  z2=spars_array(i,2);

    theta1=atan(y1/z1); % y(i-1)/z(i-1);
     y1p=y1- (act/2)*cos(theta1);  % y comonent of edge of active region
     z1p=z1+ (act/2)*sin(theta1);  % z compoent

     theta2=atan(y2/z2); %
     y2p=y2+ (act/2)*cos(theta2);
     z2p=z2- (act/2)*sin(theta2);

    a1=tan(atan(y1p/z1p)+alpha_ms);  %  tan(theta' + alpha_ms)

    z1p_ms=z1p+abs(y2p-y1p)/a1; % project ms out to y2p

   if (z2p+1*spacer) < z1p_ms,

      z1pp_ms=z1p+abs(cl1-y1p)/a1;


     %spars_array(i,2)=z1pp_ms+(act/2)/sin(atan(cl1/z1pp_ms));
     nn=fix((z1p_ms-z2p)/spacer) ;  % determine correct number of spacers
     spars_array(i,2)=spars_array(i-1,2)+(nn-0)*spacer+tube_OD+gap;


    %check to make sure overlap is ok

     y2=spars_array(i,1);
     z2=spars_array(i,2);
     theta2=atan(y2/z2); %
     y2p=y2+ (act/2)*cos(theta2);
     z2p=z2- (act/2)*sin(theta2);
    z1p_ms=z1p+abs(y2p-y1p)/a1;

  if z2p > z1p_ms,
     spars_array(i,2)=spars_array(i-1,2)+(nn-1)*spacer+tube_OD+gap;

    end
end
```

Matlab script that draws a 2d sideview of the detector

%sideview - draws a sideview (y - z plane) of the detector. Various components %of the detector can be selected by removing comment marks ("%") in front of the %appropriate component. The axis can be changed to provide different points of %view, but the image cannot be rotated. Output from the sparsification routines %can be overlaid on this if desired. This routine required the file "muon_data" %that is generated by excel as its database for the drawing. Once muon_data has %been run, it can be commented out to save a few seconds of run time.

```
% database based plotting file for SDC


muon_data   % loads database

xmax= 20000;
xmin= 00000;
ymax = xmax-xmin;
clg
hold off

q=[xmin xmax 000 ymax+000];  % sets the boundaries for the drawing
%q=[10000 18000 4000 12000]; % standard upper right quadrant view
%q=[13000 19000 5500 11500];
axis(q);
axis('square');

MBWside  % calls the routine for plotting the barrel wire chambers
hold on
MIWside
MFWside

Scint_side
Inner_side
mags_n_abs

orig=[0 0];
x=[xmin 21000];
x1=[0 21000];
y=[0 ymax];
plot(x,orig,'w')
plot(orig,y,'w')
yangle=[0 21000*FT2r(2)/FT2z(3)];
plot(x1,yangle,'g')

title('Detector - Side View - SDC Param. Rev. F')
%date1
id1
xlabel('Z  Axis (mm)')
ylabel('Y  Axis (mm)')
if side_text==1,
text(1000,18000,' - Model output showing detector configuration.')
text(1000,17000,' - Multiple scattering has been included in the postioning')
text(1000,16000,' - of the chambers.     Z gap =10612')
end
```

APPENDIX 4 - Configuration Definitions

Mechanical envelope - the nominal boundary surface of each supermodule which completely contains all mechaical parts(except attachment hardware).

Mechanical enclosure dimensions - the space allotted to the local support structure which when removed from the nominal mechanical envelope yeilds the available volume for drift tubes. The current baseline is 50mm for the slanted sides and 90mm for the vertical sides.

Active tube end gap - the longitudinal distance from the outer surface of the tube endcaps to the point on the wire where full function is attained(threshold?). This is a summation of the endcap dimension plus the E field disturbance effects at the tube end. Current baseline is the endcap dimension plus the drift gap waist dimension =38 + 20mm respectively.

Active tube width - the width of the fully functioning drift cell. This is the ID of the tube less any distance before the field nonuniformities disappear(threshold?). Current baseline is 88mm for the 93.6mm OD tubes.

Active region - the limits of coverage within each supermodule by fully functioning drift cells forming complete tube pairs for the L1 trigger. The maximum number of tube pairs are placed in the volume remained after subtracting the mechanical enclosure dimensions from the mechnaical envelope.

Module Thickness - Derived frrom the sum of all mechanical parts(and their tolerances) including tubes, interstitial plates and cover plates. In addition, the forward system modules are two octants deep with a support structure and clearance gap between.

Envelope definitions:

Barrel

BT1 Y	BT1 y1 is a basic parameter = 6750	Basic parameter
	BT1 thickness is a basic parameter = 1500mm	Basic parameter
	BT1 y2 = BT1 y1 + thickness	
BT1 Z	The half length of BT1 is a basic parameter = 14016	Basic parameter

APPENDIX 4 - Configuration Definitions

BWN X	The mechanical envelope is always derived from the module symmetry plane at 22.5° at the given Y location less a gap(at the same angle). Current baseline for this gap to centerline is 20/2mm.	Mod gap=20
BW1 Y	BW1 y2 = BT1 inner radius less a fixed gap for attachment mechanics. Current baseline is 6750-180 respectively.	BW1 BT1 gap=180
	BW1 thickness is the sum of all mechanical parts plus tolerances.	BW1 thickness=814
	BW1 y1 = BW1 y2 - BW1 thickness	
BW2 Y	BW2 y1 = BT1 outer radius plus a fixed gap for attachment mechanics. Current baseline is 8250+250 respectively.	BW2 BT1 gap=250
	BW2 thickness = is the sum of all mechanical parts plus tolerances. = 431	
	BW2 y2 = BW2 y1 + BW2 thickness	
BW3 Y	BW3 y1 = Outer surface of BW2 plus the scintillator envelope, BS2, plus a gap for access. Current baseline is BW2 y2 + 150 + 840 respectively.	BW3 Acc gap=840
	BW3 thickness = is the sum of all mechanical parts plus tolerances.	
	BW3 y2 = BW3 y1 + BW3 thickness	

BWN.3 Z	**The mechanical envelope for the barrel supertower centered on the detector Y axis is fixed from the gap between the CB0 and CE0 for the reason of alignment LOS access to the Tracker. The location of this gap is fixed by the calorimeter group.** **Another concern is to line-up with the block boundaries in BT1 such that the required 200 alignment access hole is such that it begins at the boundary and goes all into one block to minimize extra machining costs. Boundaries are at 876mm intervals in Z from the BT1 centerline.** **The current baseline has the CB0/CE0 boundary center at Z= 4427.5 and the closest block boundary at 4380mm. The integration group has determined that the calorimeter concerns over-ride in this situation. The Z envelope for BW0.3 is therefore the CB0/CE0 gap centerline less half the clearance gap between supermodules. Current baseline is BW0.3 Z=±(4389+80/2-20/2) respectively.**	**Set by: Cal gap Z=4389+80/2**
BWN.2/4 Z	BWN.2 and 4 z1 - The limits in Z of the mechanical envelope for the barrel supertowers 2+4 closest to BWN.3 is set by the BWN.3(which itself is defined by the CB0/CE0 gap) plus a clearance gap. The current baseline is (BWN.3 Z)+20.	Set by BWN.3 Z
	BWN.2 and 4 z2 - The limits in Z of the mechanical envelope for the barrel supertowers 2+4 closest to BWN.1/5 is set by the BW1 supermodules. The BW1 envelope is in turn set to be alinged along the block boundary in BT1 plus half of the alignment space. The current baseline is 11388+130/2-20/2	BT1 Z is one of the base parameters NOTE: 11162≠11072 TDR
BW2.1/5 Z	BW2.1 and 5 z1 = outside edge of BW2.2 and 4 plus 20 mm gap	
	BW2.1 and 5 z2 = IW2 z1 - 100	

BW3.1/5 Z	BW3.1 and 5 z1 = outside edge of BW3.2 and 4 plus 20 mm gap
	BW3.1 and 5 z2 - align outermost possible active tube pair active region with top pair active region of IW3, and then add mechanics.
BS2 X	X values = the BW2 X values at BW2 y2
BS2 Y	BS2 y1 is defined as = BW2 y2
	BS2 thickness of mechanical envelope is 150mm
	BS2 y2 = BS2 y1 + envelope thickness
BS2 Z	Z values currently follow BW2

INTERMEDIATE

IWN X	The mechanical envelope is always derived from the module symmetry plane at 22.5° at the given Y location less a gap(at the same angle). Current baseline for this gap to centerline is 20/2mm.
IW2 Y	**IW2 y1 - same as bottom of IW3**
	IW2 y2 = lines up with the top of BS2
IW3 Y	IW3 y1 - projective from the top of the active region of the top tube of FW4.

IW3 y2 lines up with the bottom of BW3 less the standard module gap. The current baseline is IW3 y2 = BW3 y1 - 20mm.

IW2 Z	IW2 z1 = BT1 surface plus a fixed gap for attachment mechanics. Current baseline is 14016+500 respectively. IW2 thickness = is the sum of all mechanical parts plus tolerances. IW2 z2 = IW2 z1 + IW2 thickness	BT1 IW2 gap = 500mm
IW3 Z	IW3 z1 = Outer surface of IW2 plus the scintillator envelope plus a gap for access. Current baseline is IW2 z2+150+840 respectively. IW3 thickness = is the sum of all mechanical parts plus tolerances. IW3 z2 = IW3 z1 + IW3 thickness	IW Acc gap = 840
IS2 X	X values = the IW2 X values	
IS2 Y	Y values = the IW2 Y values	
IS2 Z	The scintillator is mounted on the surface of IW2 therefore IS2 z1 = IW2 z2 IS2 thickness of mechanical envelope is 150mm IS2 z2 = IS2 z1 + envelope thickness	

Forward

FT1 Y	**FT1 y1 is defined as being 100mm below the eta = 2.5 line at the FT1 z1 face.**	Why 100mm???
	FT1 y2 = BW1 y1 - a gap required for the coils which is 120mm in the current baseline	FT coil gap is 120mm NOTE: ≠5600 fixed TDR
FT1 Z	FT1 z1 is a basic parameter = 10156mm	Needs definition per lever arm of FW1/2
	FT1 thickness is a basic parameter = 1500mm	
	FT1 z2 = FT1 z1 + thickness	
FT2 Y	**FT2 y1 is defined as being 100mm below the eta = 2.5 line at the FT2 z1 face.**	Why 100mm???
	FT2 y2 = BT1 y1 - a gap required for access inside the detector which is 840mm in the current baseline	Needs standards from safety etc.
FT2 Z	FT2 z1 is a basic parameter = 12266mm	Needs definition per foreseen FW3 thickness and standard module gap either side added to FT1 z2
	FT2 thickness is a basic parameter = 1500mm	
	FT2 z2 = FT2 z1 + thickness	

APPENDIX 4 - Configuration Definitions

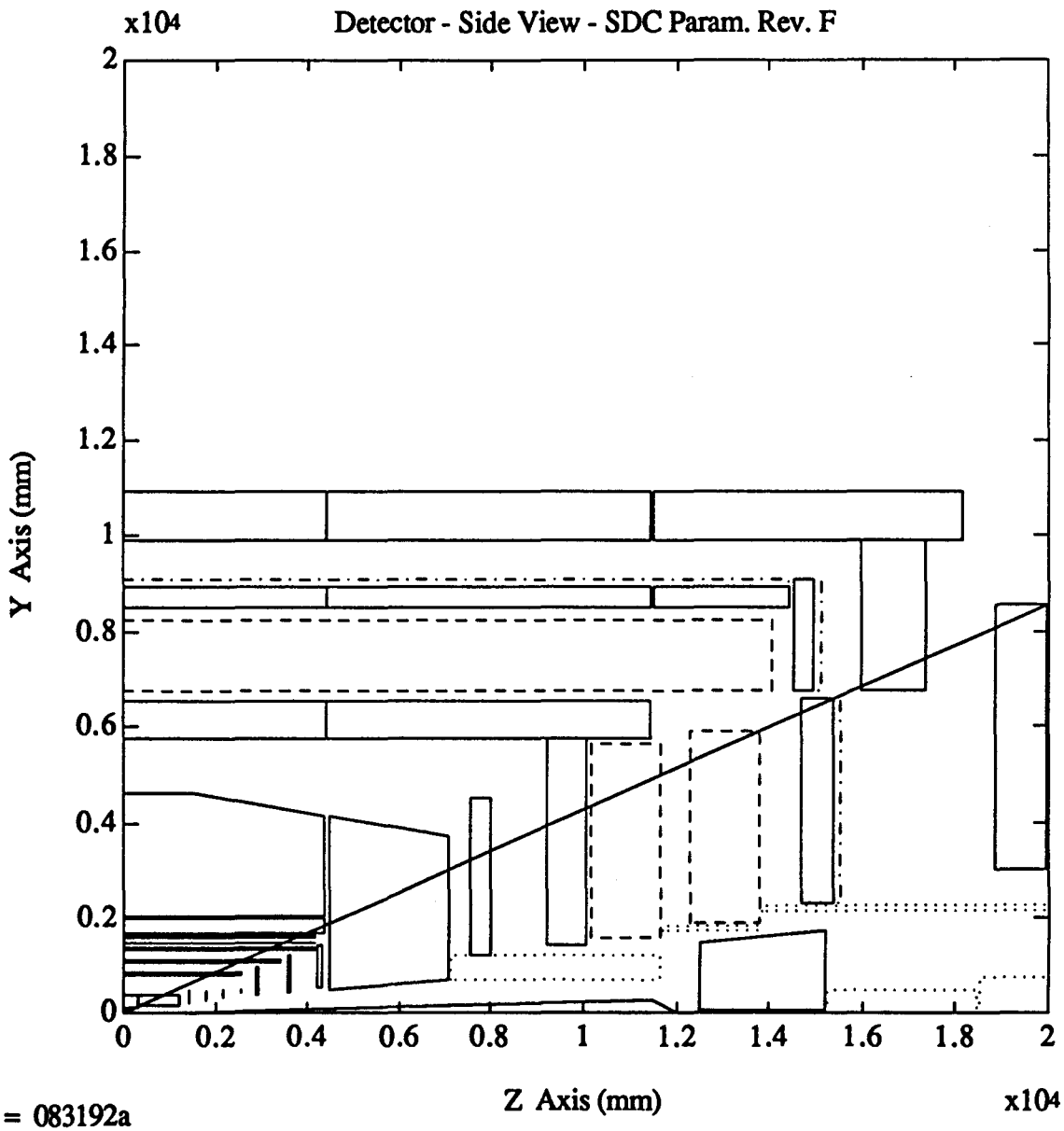
FWN X	Later.	
FW1 Y	**FW1 y1 is defined as being 100mm below the eta = 2.5 line at the FW1 z1 face.**	Absorber needed as logical choice and needs MS term
	FW1 y2 is defined so that the (z2, y2) corners of FW1 and FW2 are projective. Therefore FW1 y2 = (FW1 z2) X ((FW2 y2)/(FW2 z2)	
FW2 Y	FW2 y1 is defined as being 100mm below the eta = 2.5 line at the FW2 z1 face.	Needs MS from cal term
	FW2 y2 is defined by the BW1 y1 surface less the standard module gap = BW1 y1 - 20	≠ flush with FT1 TDR
FW3 Y	Later.	
FW4 Y	FW4 y1 is defined as being 100mm below the eta = 2.5 line at the FW4 z1 face.	Needs Pt bend and MS term plus real active gap
	FW4 y2 is defined by the projection from the forward toroid y2,z2 corner.	Link to Tracker(Fiber Barrel) NOTE: XX≠YY TDR
FW5 Y	FW5 y1 is defined as being 100mm below the eta = 2.5 line at the FW5 z1 face.	Needs Pt bend and MS term plus real active gap

	FW5 y2 is defined for the (y2, z2) corner to project from the corresponding point of FW4. FW5 y2 = (FW5 z2) X ((FW4 y2)/(FW4 z2)).	NOTE: XX≠YY TDR
FW1 Z	FW1 z1 is defined as standing off the CE0 by 442mm to leave space for the PMTs	CE0 PMT gap = 442mm
	FW1 thickness is the sum of all mechanical parts plus tolerances.	
	FW1 z2 = FW1 z1 + the module thickness	
FW2 Z	FW2 z1 = FW2 z2 - the module thickness	
	FW1 thickness is the sum of all mechanical parts plus tolerances.	NOTE: XX≠YY TDR
	FW2 z2 is defined as standing off the FT1 by a gap of 90mm for the coils	
FW3 Z	Later.	
FW4 Z	FW4 z1 is defined as standing off the FT2 by a gap of 90mm for the coils + an access gap of 840	
	FW4 thickness is the sum of all mechanical parts plus tolerances.	NOTE: XX≠YY TDR
	FW4 z2 = FW4 z1 + the module thickness	

APPENDIX 4 - Contiguration Definitions

FW5 Z	Is a given value of 18816 (FW5 z1 is defined by a required lever arm from FW4 for momentum resolution which in the current baseline is 3150mm)	should be theta to theta layer gap
	FW5 thickness is the sum of all mechanical parts plus tolerances.	NOTE: XX≠YY TDR
	FW5 z2 = FW5 z1 + the module thickness	
FS4 X	=FW4 x	
FS4 Y	= FW4 y	
FS4 Z	FS4 z1 = FW4 z2	
	FS4 thickness of mechanical envelope is 150mm	
	FS4 z2 = FS4 z1+ thickness	
FS5 X	= FW5 X	
FS5 Y	Y values = the FW5 Y values	
FS5 Z	The scintillator is mounted on the surface of FW5 therefore FS5 z1 = FW5 z2	
	FS5 thickness of mechanical envelope is 150mm	
	FS5 z2 = FS5 z1 + envelope thickness	

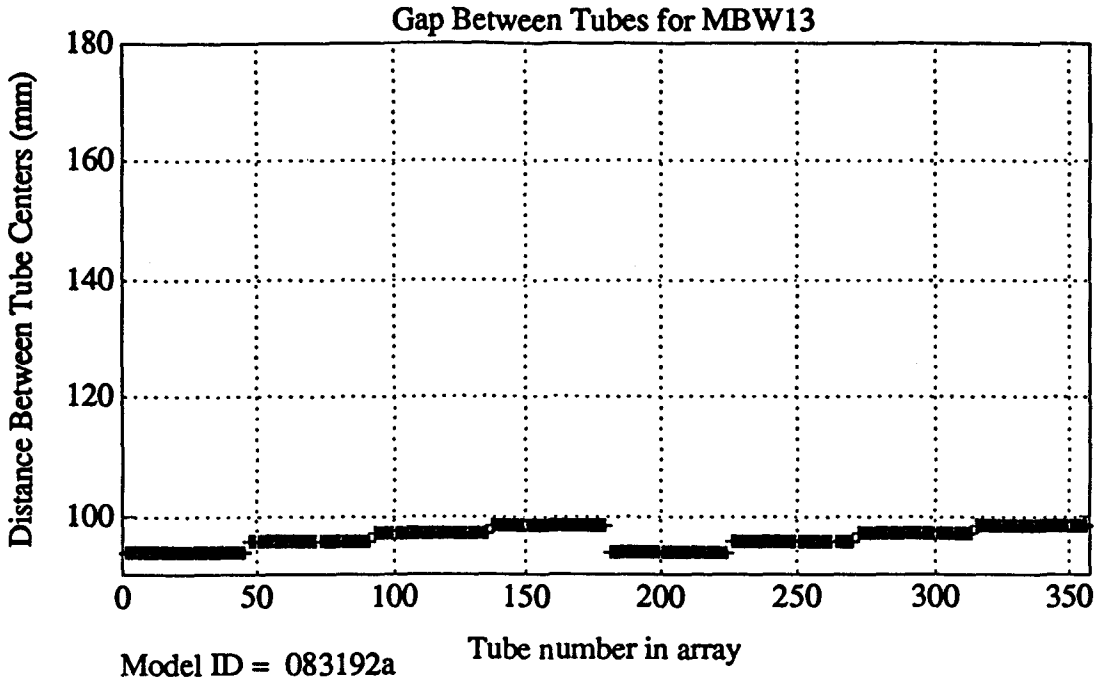
APPENDIX 4 - Configuration Definitions

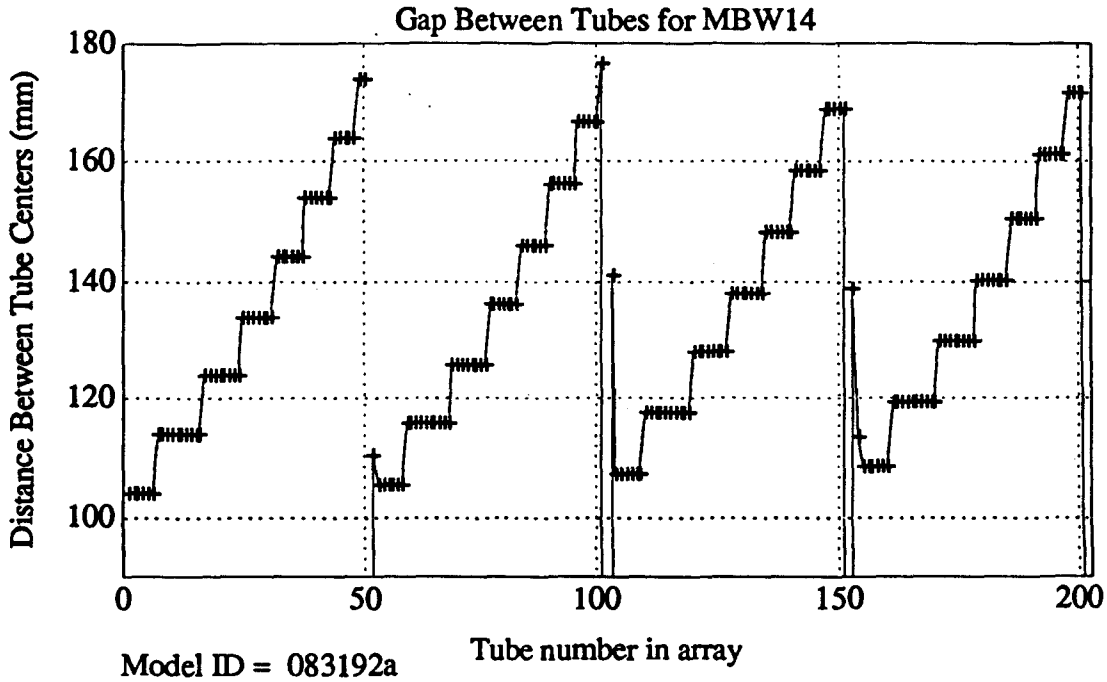


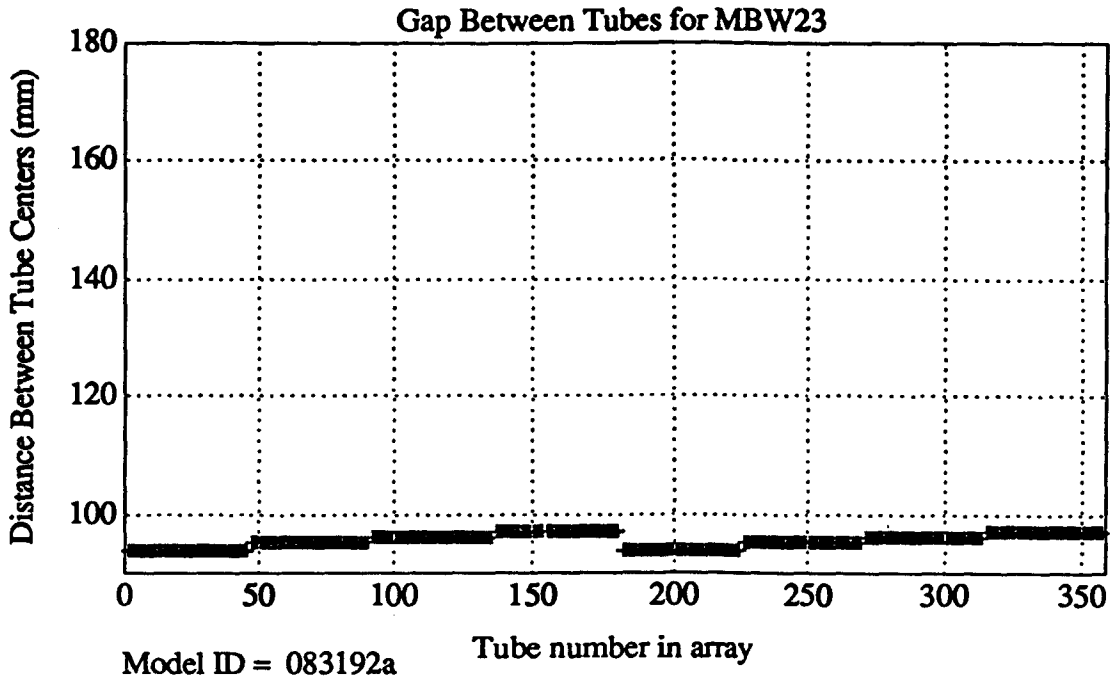
Model ID = 083192a

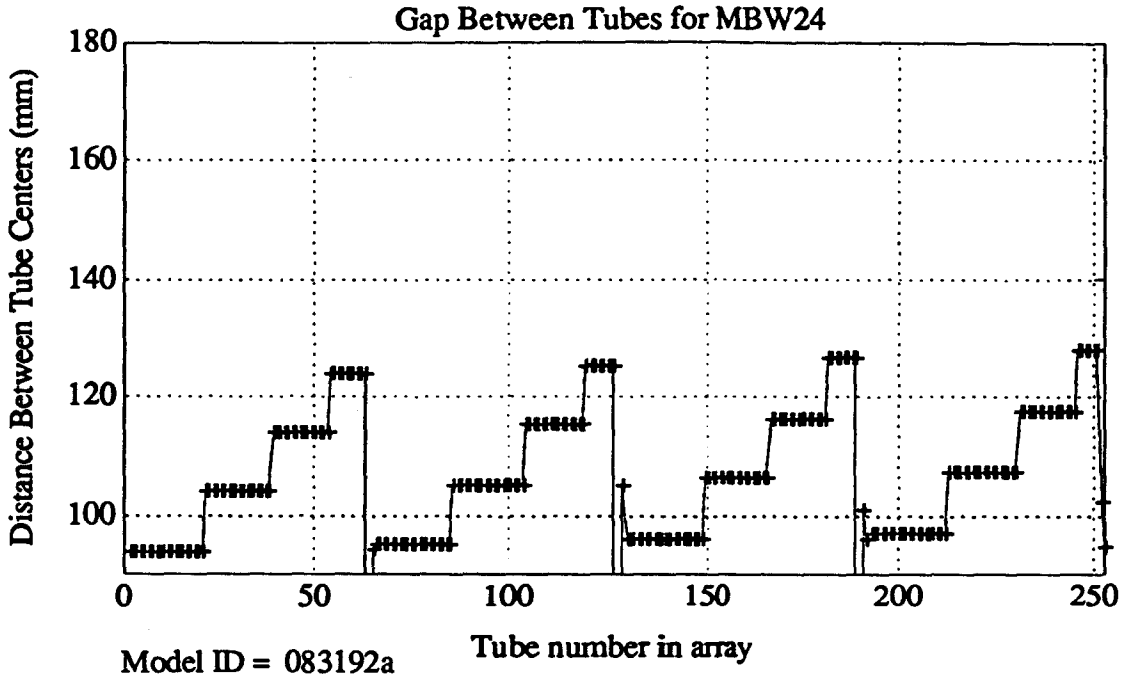
APPENDIX 5 - TUBE PLACEMENT ANALYSIS PLOTS

Appendix 5 contains samples of plots used for evlaulting tube placement algorithms.

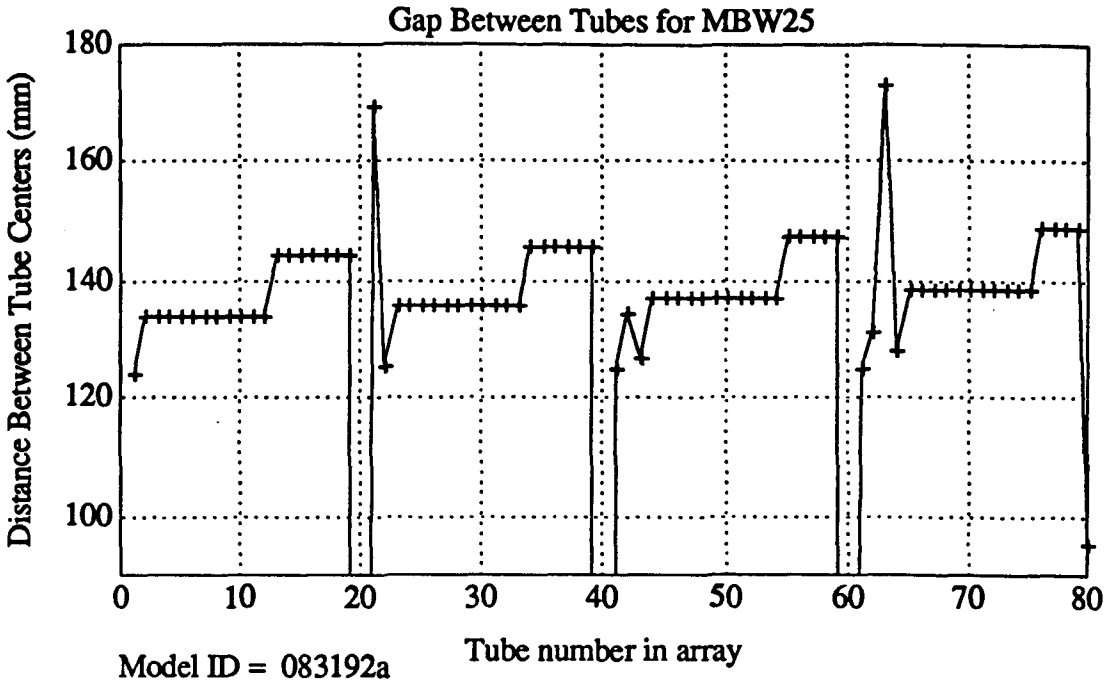


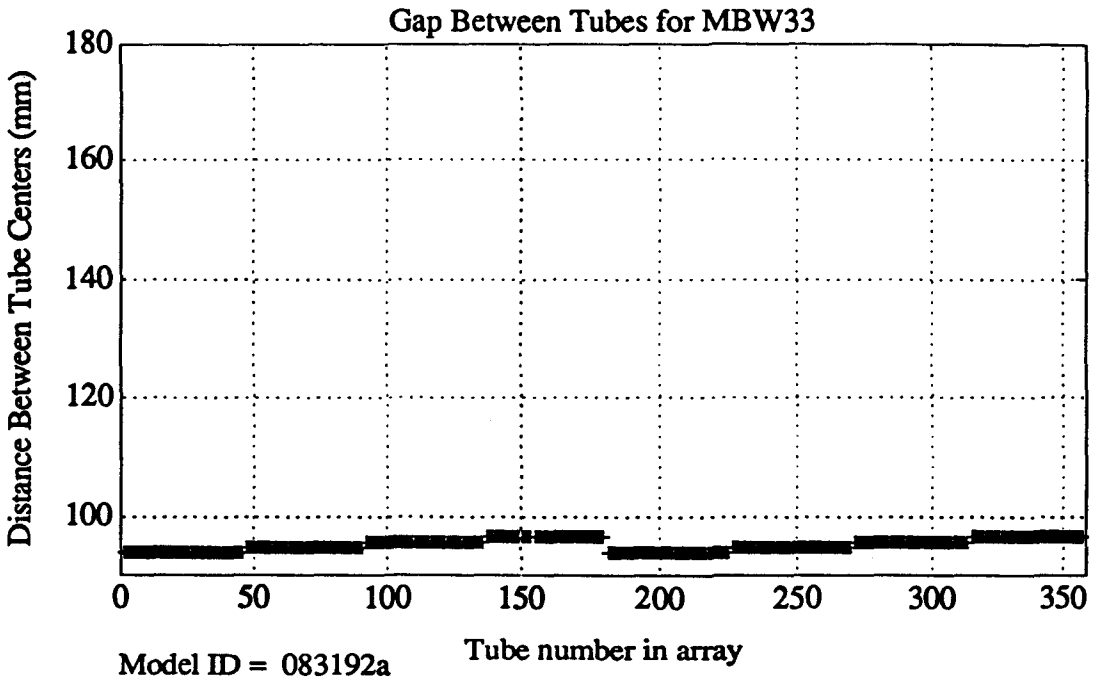


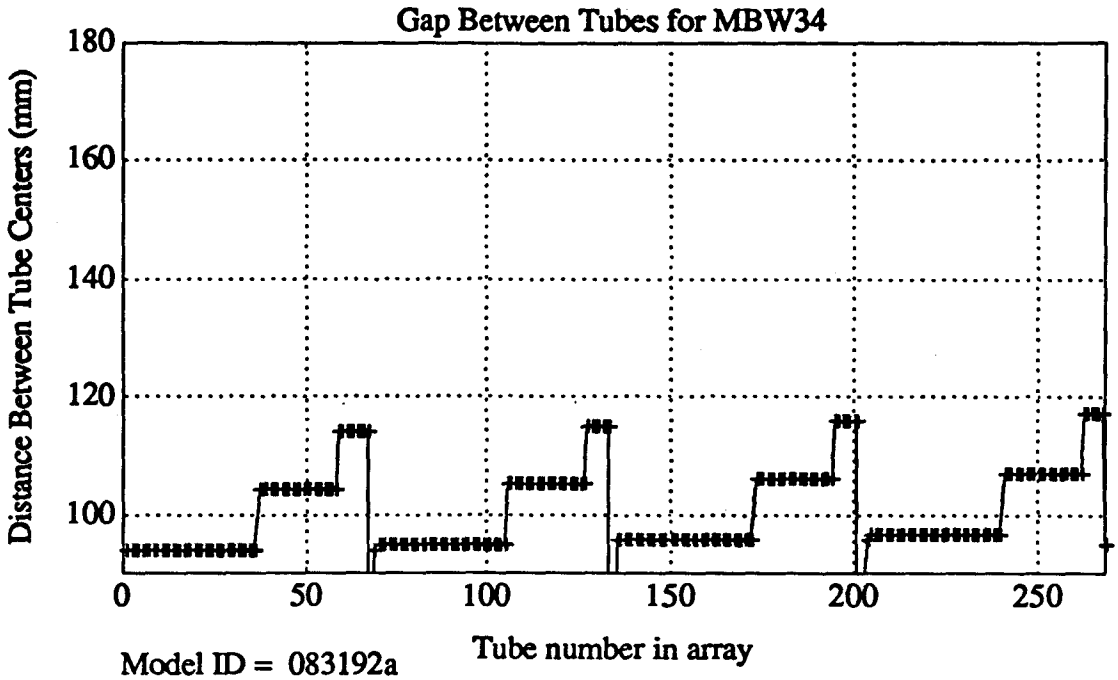

Gap Between Tubes for MBW23
Distance Between Tube Centers (mm)
180
160
140
120
100
0
50
100
150
200
250
300
350
Tube number in array
Model ID = 083192a

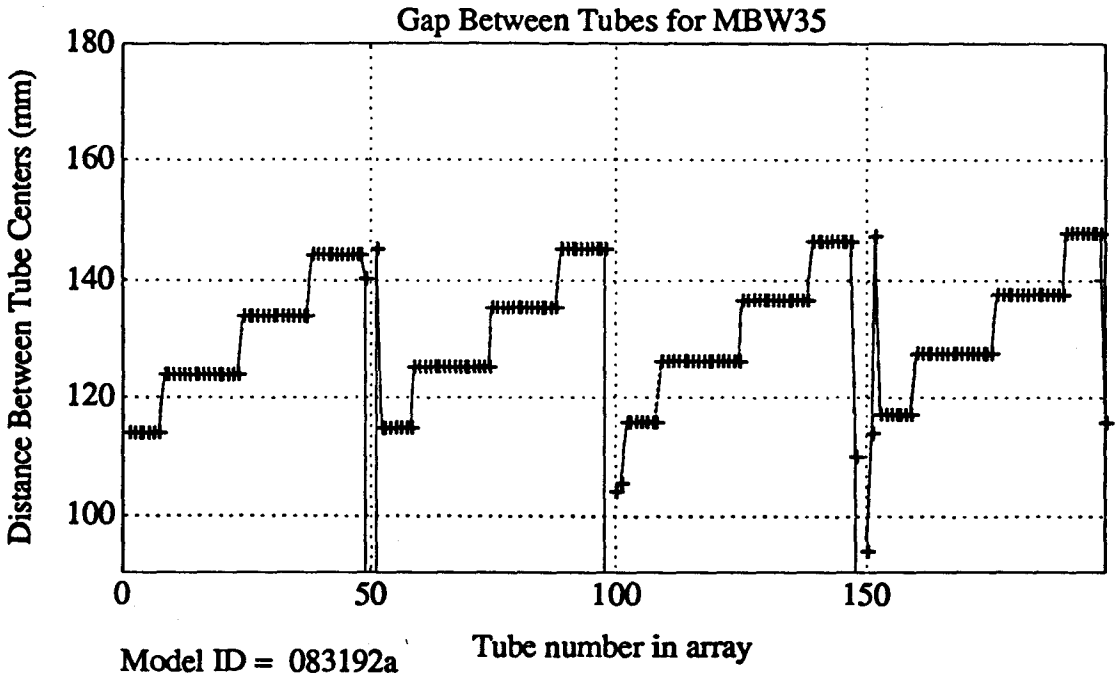

Gap Between Tubes for MBW24
Distance Between Tube Centers (mm)
180
160
140
120
100
0
50
100
150
200
250
Tube number in array
Model ID = 083192a

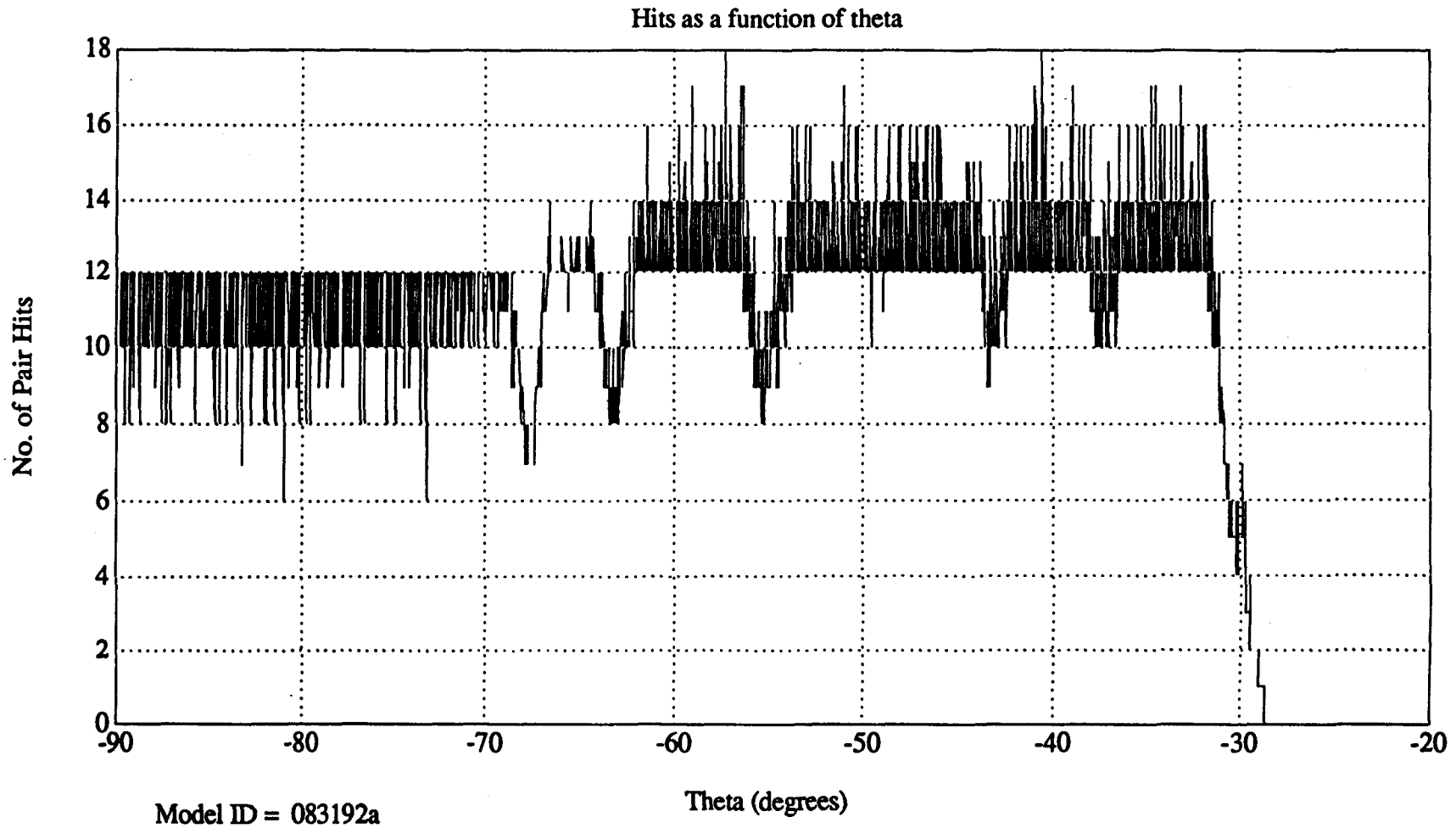
APPENDIX 5 - TUBE PLACEMENT ANALYSIS PLOTS

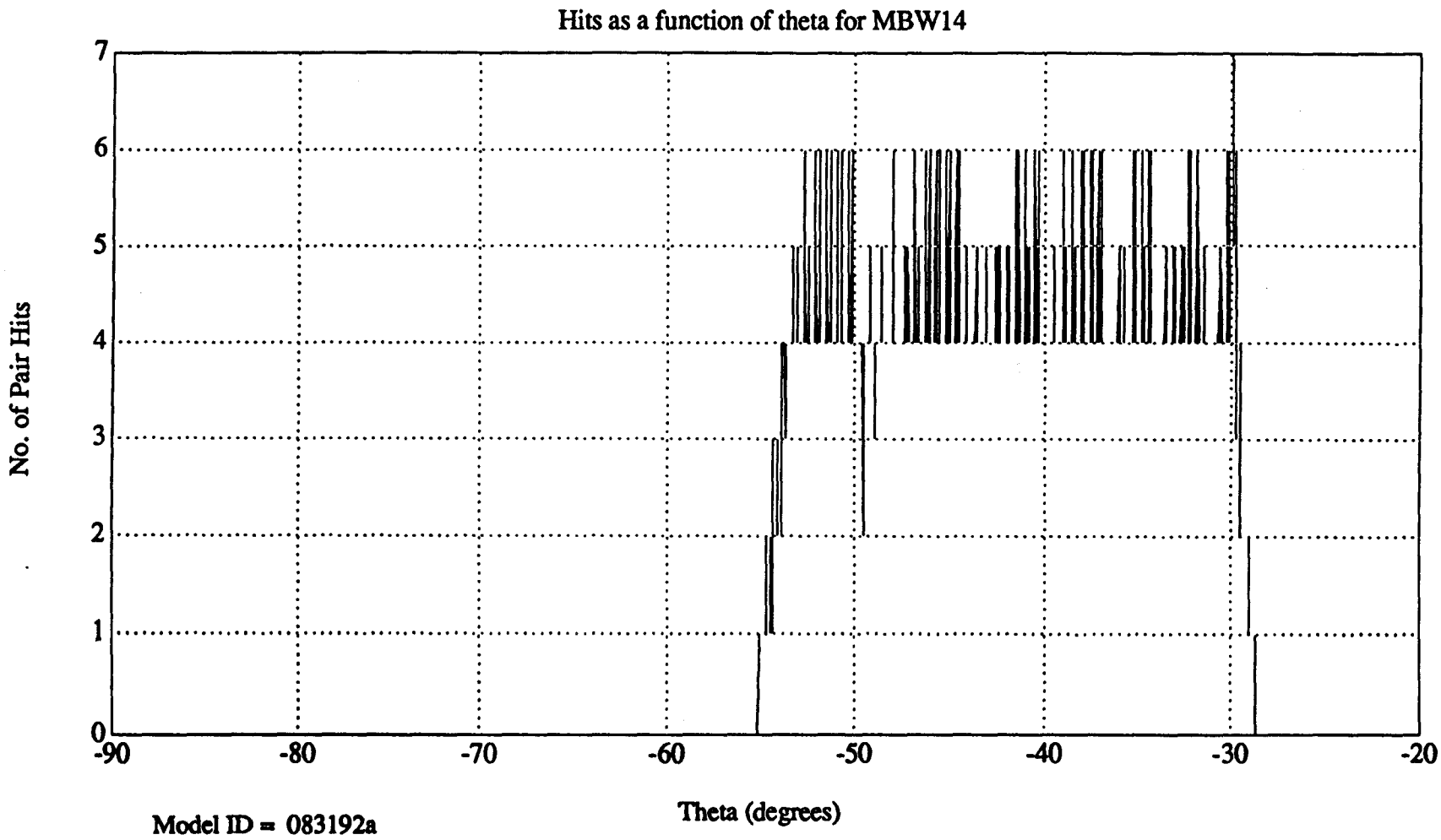


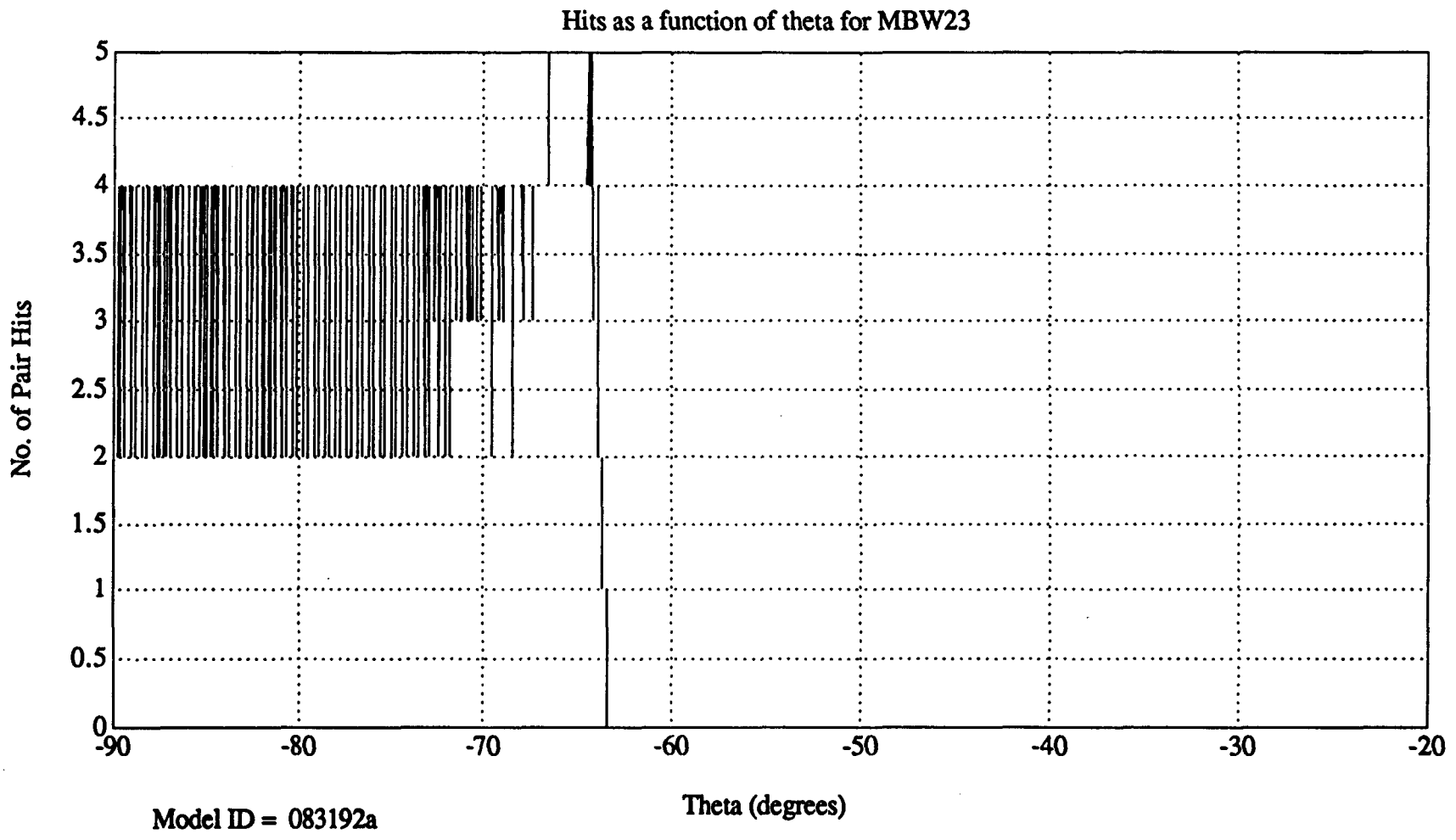


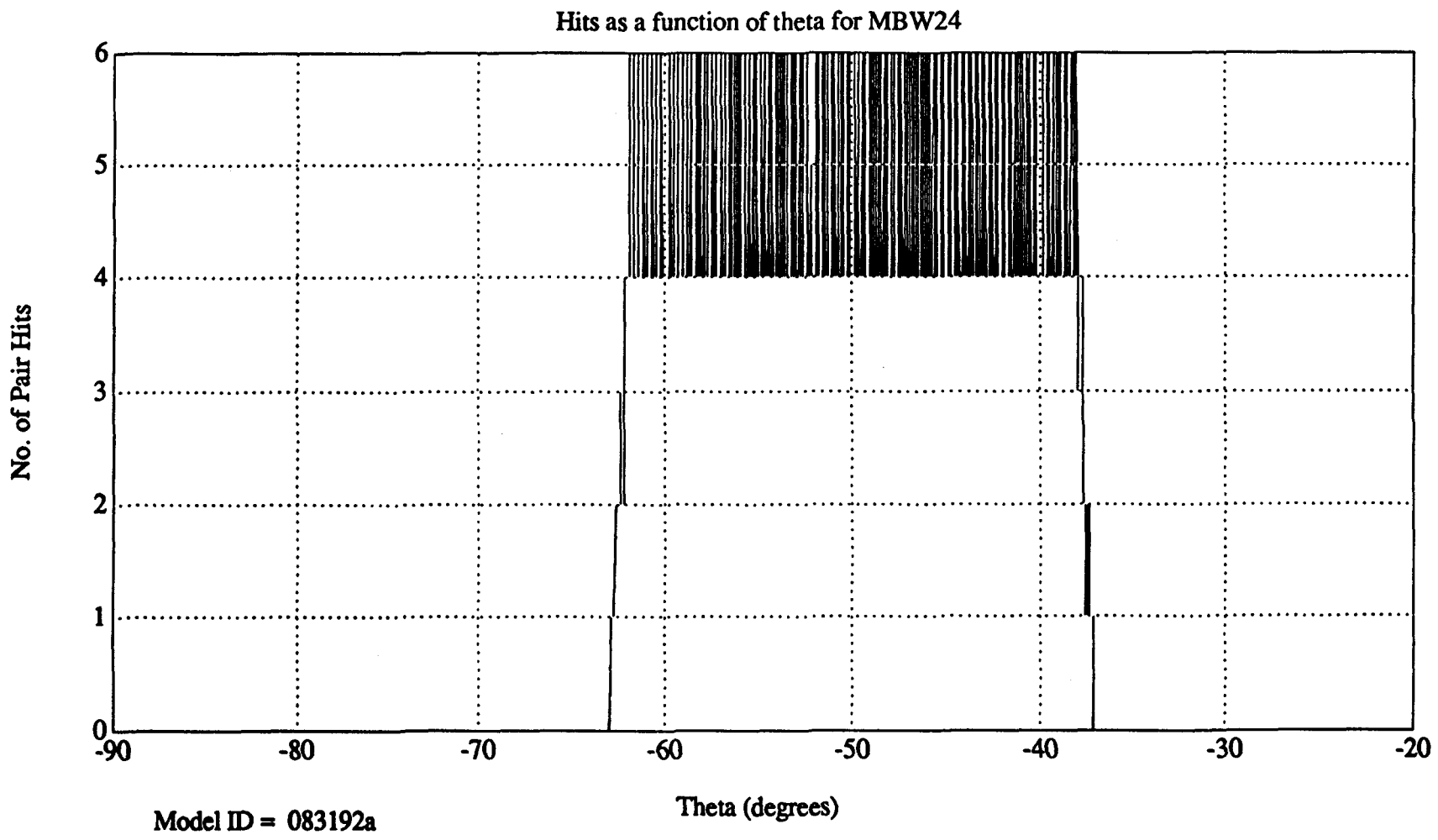

Gap Between Tubes for MBW34
Distance Between Tube Centers (mm)
180
160
140
120
100
0
50
100
150
200
250
Tube number in array
Model ID = 083192a

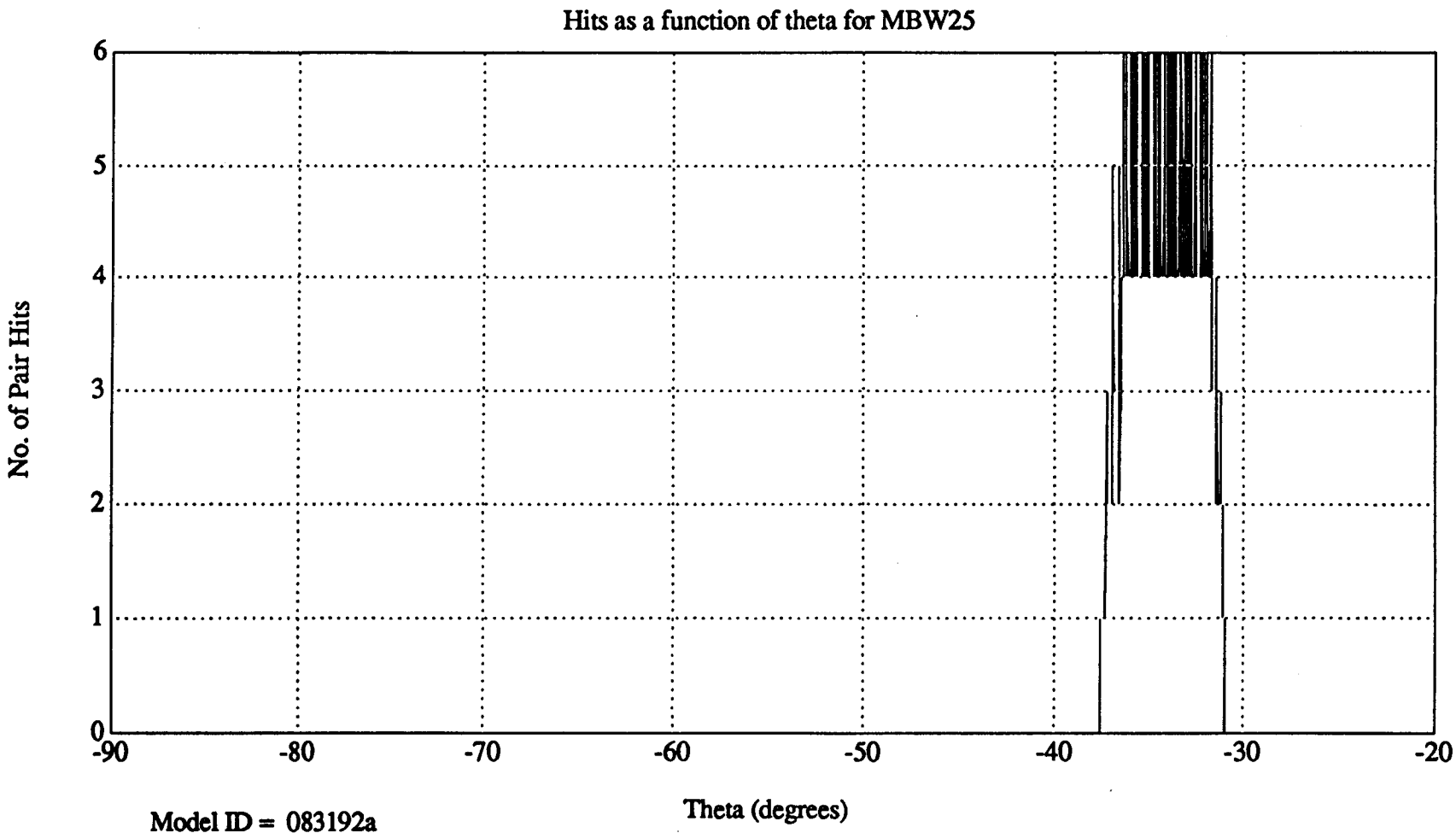

Gap Between Tubes for MBW35
Distance Between Tube Centers (mm)
180
160
140
120
100
0
50
100
150
Tube number in array
Model ID = 083192a

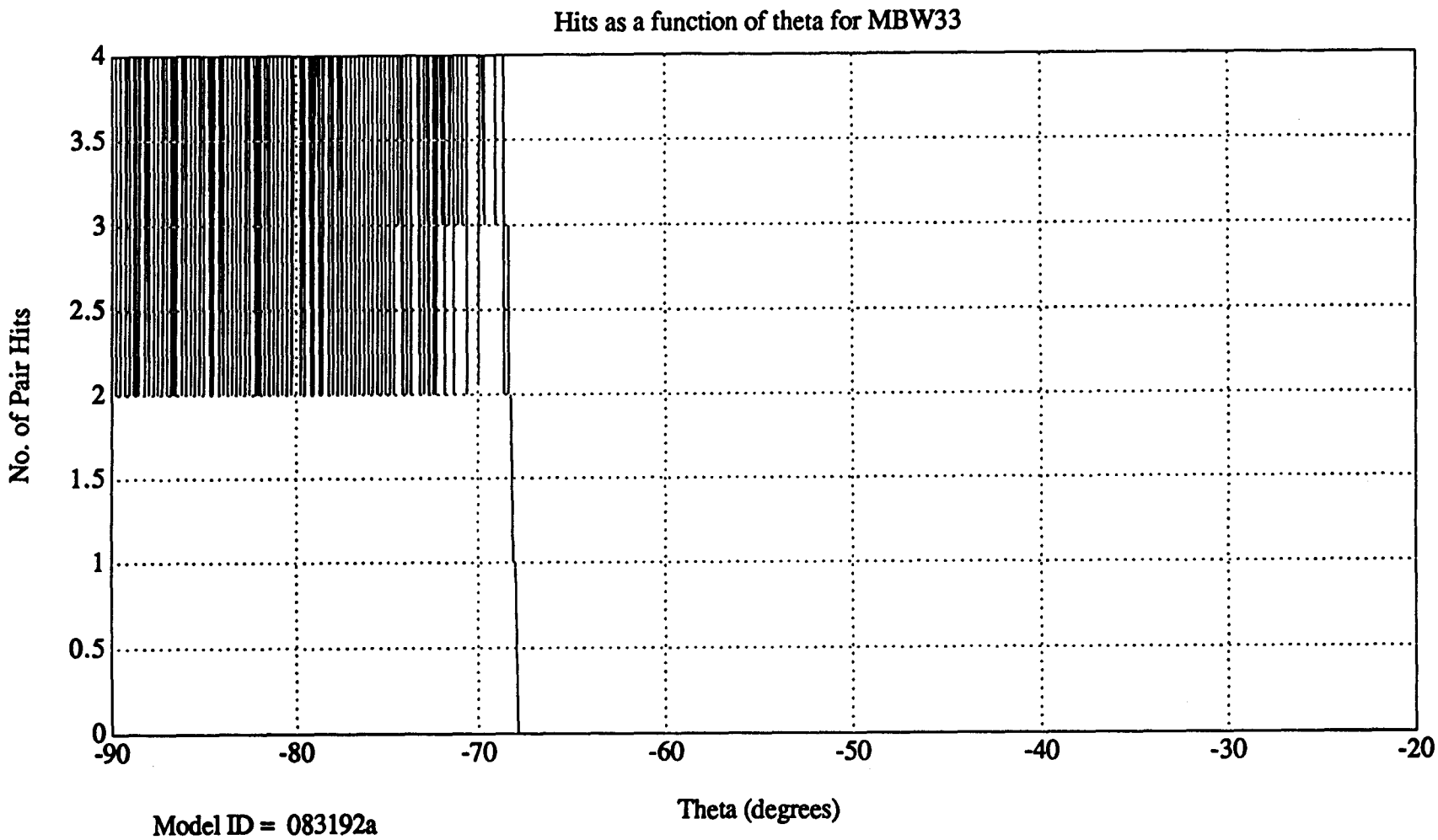

Hits as a function of theta
No. of Pair Hits
18
16
14
12
10
8
6
4
2
0
-90
-80
-70
-60
-50
-40
-30
-20
Theta (degrees)
Model ID = 083192a

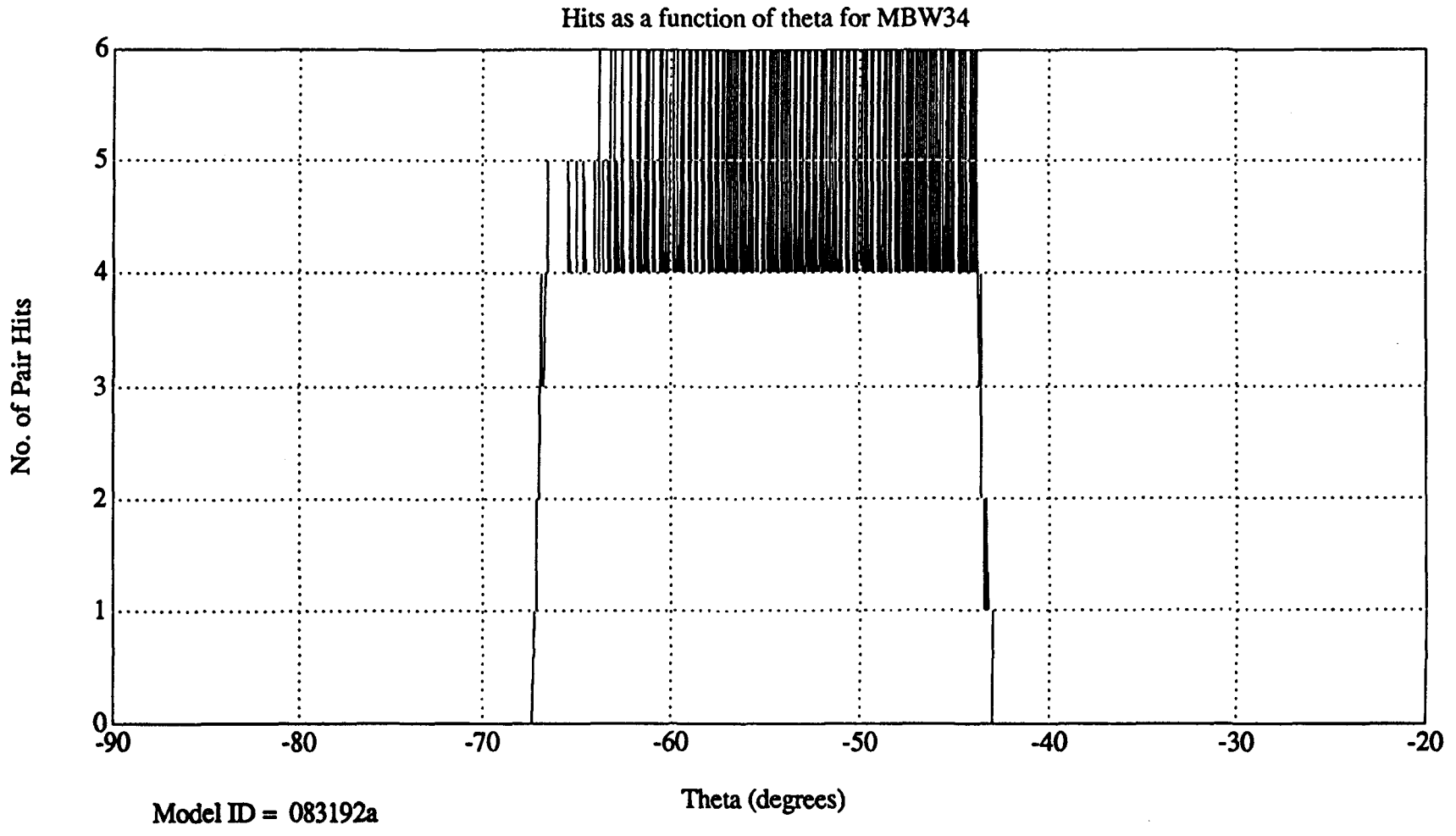

Hits as a function of theta for MBW14
No. of Pair Hits
0
1
2
3
4
5
6
7
-90
-80
-70
-60
-50
-40
-30
-20
Theta (degrees)
Model ID = 083192a

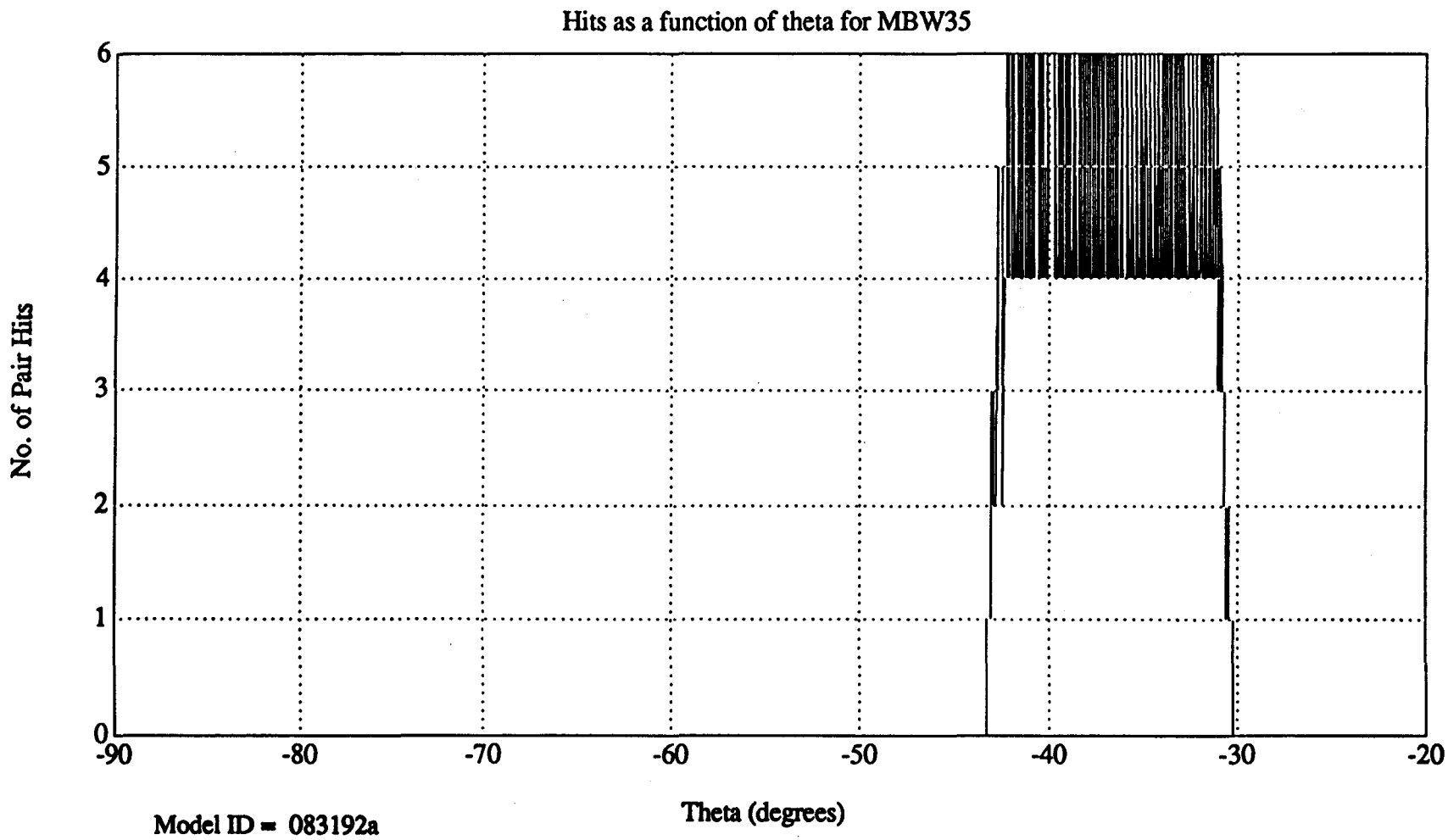

Hits as a function of theta for MBW23
No. of Pair Hits
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-90
-80
-70
-60
-50
-40
-30
-20
Theta (degrees)
Model ID = 083192a


Hits as a function of theta for MBW24
No. of Pair Hits
0
1
2
3
4
5
6
-90
-80
-70
-60
-50
-40
-30
-20
Theta (degrees)
Model ID = 083192a


Hits as a function of theta for MBW25
No. of Pair Hits
0
1
2
3
4
5
6
-90
-80
-70
-60
-50
-40
-30
-20
Theta (degrees)
Model ID = 083192a


Hits as a function of theta for MBW33
No. of Pair Hits
4
3.5
3
2.5
2
1.5
1
0.5
0
-90
-80
-70
-60
-50
-40
-30
-20
Theta (degrees)
Model ID = 083192a


Hits as a function of theta for MBW34
No. of Pair Hits
0
1
2
3
4
5
6
-90
-80
-70
-60
-50
-40
-30
-20
Theta (degrees)
Model ID = 083192a


Hits as a function of theta for MBW35
No. of Pair Hits
0
1
2
3
4
5
6
-90
-80
-70
-60
-50
-40
-30
-20
Theta (degrees)
Model ID = 083192a

Included in Appndix 6 are samples of the files used to link the Excel model on the Macintosh with the CAD package EMS, running on the Intergraph workstation at Harvard.

Below is the text file generated by the Excel model, that is ftp'd to zambia and used as the inputs to EMS.

xl_model_out.txt

```
MBW12
2373    5756   -11443
2711    6570   -4439

MBW13
2373    5756   -4419
2711    6570   4419

MBW14
2373    5756   4439
2711    6570   11443

MBW21
3510    8500   -14416
3689    8931   -11463

MBW22
3510    8500   -11443
3689    8931   -4439

MBW23
3510    8500   -4419
3689    8931   4419

MBW24
3510    8500   4439
3689    8931   11443

MBW25
3510    8500   11463
3689    8931   14416

MBW31
4099    9921   -18124
4515    10927  -11463

MBW32
4099    9921   -11443
4515    10927  -4439

MBW33
4099    9921   -4419
4515    10927  4419
```

xl_model_out.txt (cont.)

MBW34
4099 9921 4439
4515 10927 11443

MBW35
4099 9921 11463
4515 10927 18124

MIW2
2796 6777 14516
3751 9081 14947

MIW3
2796 6777 15937
4090 9901 17325

MFW1
495 1220 7537
1874 4551 7987

MFW2
577 1419 9189
2365 5736 10066

MFW4
954 2329 14696
2735 6628 15382

MFW5
1236 3010 18816
3544 8582 19933

MFS4
954 2329 15382
2735 6628 15532

MFS5
1236 3010 19933
3544 8582 20083

MIS2
2796 6777 14947
3751 9081 15097

xl_model_out.txt (cont.)

```
MBS21
3689    8931   -14416
3689    9081   -11463

MBS22
3689    8931   -11443
3689    9081   -4439

MBS23
3689    8931   -4419
3689    9081   4419

MBS24
3689    8931   4439
3689    9081   11443

MBS25
3689    8931   11463
3689    9081   14416

MIW2
2796    6777   -14516
3751    9081   -14947

MIW3
2796    6777   -15937
4090    9901   -17325

MFW1
495     1220   -7537
1874    4551   -7987

MFW2
577     1419   -9189
2365    5736   -10066

MFW4
954     2329   -14696
2735    6628   -15382

MFW5
1236    3010   -18816
3544    8582   -19933

MFS4
954     2329   -15382
2735    6628   -15532
```

xl_model_out.txt (cont.)

```
MFS5
1236    3010   -19933
3544    8582   -20083

MIS2
2796    6777   -14947
3751    9081   -15097

MBT1
2796    6750   -14016
3417    8250   14016

MFT1
654     1579   10156
2335    5636   11656

MFT1
654     1579   -10156
2335    5636   -11656

MFT2
798     1927   12266
2448    5910   13766

MFT2
798     1927   -12266
2448    5910   -13766
```

The following file is the ppl file mu.u, used to create a three dimesIonal drawing based on the text file above.

```
/* PPL code to generate solids from file
   mjleblanc august 1992
   c.s. draper labs
*/

#include <stdio.h>
/*
#include "ci_wire.h"
#include "ci_surface.h"
#include "ci_solid.h"
*/

#include "ciminimum.h"
#include "cimacros.h"

#include "grlastele.h"
#include "grmacros.h"

extern int printf(), fscanf();

struct hdPoint{
        double x;
        double y;
        double z;
      };


hdSetPoint(thePoint, x, y, z)
  struct hdPoint *thePoint;
  double x,y,z;{


  thePoint->x = x;
  thePoint->y = y;
  thePoint->z = z;

}/* end hdSetPoint */


hdClickXYZ(x,y,z,window) /* clicks @ specified point */
  double x,y,z;        /* the point */
  char *window;{       /* window to point in */

  double point[3];
/*
  do local-to-world conversions here, while putting points
  into the PPL array format
*/

  point[0] = z;  /* lcl(z) --> wld(x) */
  point[1] = x;  /* lcl(x) --> wld(y) */
```

```
 point[2] = y;  /* lcl(y) --> wld(z) */

 ci$put(point = point, window_name = window);
}/* end hdClickXYZ */


hdClickPoint(pt,window) /* clicks @ specified point */
 struct hdPoint *pt;   /* the point */
 char *window;{        /* window to point in */

 double point[3];

 point[0] = pt->x;   /* strip struct into silly array */
 point[1] = pt->y;   /* format for PPL */
 point[2] = pt->z;

 ci$put(point = point, window_name = window);
}/* end hdClickPoint */



hdGenerateSolid(pt1,pt2,objName)
 struct hdPoint *pt1;
 struct hdPoint *pt2;
 char *objName;{

 double x1,y1,z1,x2,y2,z2;
 struct GRid solidID;
 int nr;
 long errcode;

 x1 = pt1->x;
 y1 = pt1->y;
 z1 = pt1->z;

 x2 = pt2->x;
 y2 = pt2->y;
 z2 = pt2->z;

 begincmd_key("EMPS16Fc8V");
   hdClickXYZ(x1, y1, z1,"top");
   hdClickXYZ(-x1, y1, z1, "top");
   hdClickXYZ(-x1, y1, z2, "top");
   hdClickXYZ(x1, y1, z2, "top");

   hdClickXYZ(x2,y2,z1, "top");
   hdClickXYZ(-x2,y2,z1, "top");
   hdClickXYZ(-x2,y2,z2,"top");
   hdClickXYZ(x2,y2,z2,"top");

   ci$put(response = TERMINATE);
 endcmd();

 /* get GRid of the thing just drawn */
```

```
 ci$get_module_info(md_os = &solidID.osnum);

 gr$last_elements(parents = 1,/* want the solid, not the lines */
            pobj = &solidID.objid,
            nb_wanted = 1,
            nb_read = &nr);


 /* now name the thing DOESN'T WORK !!!*/
/*  gr$put_name(msg = &errcode, object_id = &solidID,name=objName);/**/

 printf("generated solid %s\n",objName);

}/* end hgGenerateSolid */


hdSetColor(objName)
char *objName;{

 int colr;


 if(objName[2]=="W")
  colr=1;  /* green */

 if(objName[2]=="T")
  colr=2; /* red */

 if(objName[2]=="S")
  colr=3; /* blue */

 begincmd_key("GRSCl");
  ci$put(value=colr);
 endcmd();
}/* end SetColor */

SetLayer(objName)
 char *objName;{

 int lyr;
 char nm[5];

 nm[0]=objName[1];  /* copy unique chars */
 nm[1]=objName[2];
 nm[2]=objName[3];
 nm[3]=0;

 lyr=999;

 if(strcmp(nm,"BW1")==0)
  lyr=15;

 if(strcmp(nm,"BW2")==0)
  lyr=17;
```

```
if(strcmp(nm,"BW3")==0)
  lyr=19;

if(strcmp(nm,"IW2")==0)
  lyr=20;

if(strcmp(nm,"IW3")==0)
  lyr=22;

if(strcmp(nm,"FW1")==0)
  lyr=7;

if(strcmp(nm,"FW2")==0)
  lyr=8;

if(strcmp(nm,"FW4")==0)
  lyr=11;

if(strcmp(nm,"FW5")==0)
  lyr=13;

if(strcmp(nm,"FS4")==0)
  lyr=12;

if(strcmp(nm,"FS5")==0)
  lyr=14;

if(strcmp(nm,"IS2")==0)
  lyr=21;

if(strcmp(nm,"BS2")==0)
  lyr=18;

if(strcmp(nm,"BT1")==0)
  lyr=16;

if(strcmp(nm,"FT1")==0)
  lyr=9;

if(strcmp(nm,"FT2")==0)
  lyr=10;

if(lyr==999){
  printf("LAYER ERROR  ");
  printf("%s",nm);
 }

 begincmd_key("GRSLy");
  ci$put(value=lyr);
 endcmd();

}/* end SetLayer */
```

```
main(){

 char  buffer[255];
 char  objName[255];

 struct hdPoint pt1;
 struct hdPoint pt2;

 double x,y,z;
 FILE *fp;

 begincmd_key("GRSDsMsUn");  /* set units to mm */
  ci$put(string = "mm");
 endcmd();

/* open the file */
 ci$get(string=buffer,prompt="input file name?:");
 fp=fopen(buffer,"r");
 if(fp==NULL){
  printf("FILE ERROR");
  exit;
 }

 while(fgets(buffer,256,fp)!=NULL){/* get name */
  strcpy(objName,buffer);
  objName[strlen(objName)-1] = (char)0; /* kill newline */

  /* now get the two listed points */
  fgets(buffer,256,fp);
  sscanf(buffer,"%lf %lf %lf",&x, &y, &z);
  hdSetPoint(&pt1,x/25.4,y/25.4,z/25.4);

  fgets(buffer,256,fp);
  sscanf(buffer,"%lf %lf %lf",&x,&y,&z);
  hdSetPoint(&pt2,x/25.4,y/25.4,z/25.4);

/* now generate the solid */
  hdSetColor(objName);
  SetLayer(objName);
  hdGenerateSolid(&pt1,&pt2,objName);

/* dummy read to kill the newlines */
  fgets(buffer,256,fp);
 }/* end while */
}/* end main */
```

The following file is the ppl file "place_thetas.u". It is used to generate 2d drawing of the theta tube positions.

```
/*  place_thetas.u

PPL file for placing 2d tube in chamber outlines. It uses a library object
tube4, which is an end view of the tube with a simplified representation of the tubes.
An array of the tube centers and orintations is passed to this script, i.e. spars_mbw35.
The first colum is y, second column is z, and the third is theta for that tube.

G. Holden
 */



#include "ciminimum.h"
#include "cievent.h"
#include "stdio.h"
#include "pl_cell.h"



#define   MAXSTRING        256
#define MAXCELL            32

FILE            *pfile;

extern FILE     *fopen();
extern char     *fgets();
extern int      fclose(),
          strlen(),
          printf(),
          strncmp();

delete ()
{
  if (pfile != (FILE *) 0)
          (void) fclose(pfile);
}

main(argc, argv)
int       argc;
char      **argv;
{
  int             i,nr;

  char            file[MAXSTRING+1],
                  line[MAXSTRING+1],
                  cell[MAXCELL];
```

```
double                  pos[3],
                xy_angle,
                yz_angle;

pfile = (FILE *) 0;
xy_angle=0;
yz_angle=0;
nr=1;

if (argc > 1)
        (void) strcpy(file, argv[1]);
else
        ci$get(string=file, prompt="Key in file name to read");

if ((pfile = fopen(file, "r")) == (FILE *) 0)
{
        (void) printf("ERROR: OPENING FILE %s\n", file);
        goto Exit;
}



while(fgets(line, sizeof line, pfile))
{
        if (sscanf (line, "%lf %lf %lf ",
                        pos+1, pos+2, &xy_angle) != 3)
        {
                (void) printf ("ERROR: Not enough data");
                goto Exit;
        }

      pos[2]=pos[2]/25.4;
      pos[1]=pos[1]/25.4;


        origin[0] = 0 ;
        origin[1] = pos[1];
        origin[2] = pos[2] ;

         xy_angle =-PI/180*(xy_angle );

        strcpy(cell,"tube4") ;



        get_vtl(yz_angle,0.0,xy_angle,rotation);

        put_cell(cell);



        nr=nr+1;
  }
Exit:
```