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PATTERN RECOGNITION IN A SILICON AND SCINTILLATING FIBER SDC TRACKING SYSTEM

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Abstract

The proposed SDC silicon and scintillating fiber tracking system has been simulated and tracks reconstructed for a 300 GeV Higgs producing four leptons. The process has been simulated with and without the background expected at SSC design luminosity. Results are presented for occupancies, track reconstruction efficiencies and resolutions for the parameters characterizing the reconstructed leptons.

Introduction

The design of the central tracking system for the SDC detector is a major unresolved issue within the collaboration. Here we report results of simulation and pattern recognition studies carried out with the presently envisioned silicon and scintillating fiber detectors.

Detector

This study makes use of two of the subsystems in the SDC design: the silicon inner tracker and the scintillating fiber outer tracker. The design of the silicon tracker is similar to that in the LOI [1]. Most relevant to us is the barrel which covers +/-45 deg, i.e., -0.9 < eta < 0.9. There are eight double-sided layers with the innermost at a radius of 9 cm and the outermost at 36 cm. The geometry was taken from the SDCSIM v03 file st_descope3.kumac distributed with that version of the program.

The scifi system is that described in the corresponding CDR [2] and shown in figure 1. Three inner barrels cover |eta| < 2.0 and two additional barrels also provide information for |eta| < 1.6. Three disks on either end extend the coverage to |eta| of 2.5. All barrels have four axial layers (fibers parallel to the beam axis) with relative fiber offsets of 0.0, 0.5, 0.25 and 0.75 fibers. These quarter-fiber offsets provide optimal resolution. The outer layer also has two pairs of stereo layers with half-fiber offsets. The stereo angles are opposite in direction and have a magnitude of 15 degrees.

The scifi disks include four layers: two pairs of half-fiber offset spiral layers. All fibers run from the inner to outer radius beginning in the radial direction and then wrapping around the beam axis so as to remain close-packed. We do not make use of the disks in our present reconstruction. It is worthwhile to note that the fiber count is determined by the inner radius and that a detector made up of purely radial wedges with the same spacing at the inner radius would have the same channel count and occupancy.

Simulation

The simulation and reconstruction were carried out in the framework of the SDC simulation package SDCSIM (the "shell") [3] version v03. Minor changes were made to incorporate the most recent versions of the the packages SF and TR. We provided some additional code, mostly the filling of ntuples, through the standard user interface package US. The analysis was carried out in three stages where each of the latter stages used the SDC data structure output from the previous stage as input. In the first stage events were generated using the SE package, in the second they were tracked through the detector and digitized using SG and in the last the tracks were reconstructed using TR. Each of these steps is described in separate sections below. The user is referred to the SDCSIM documentation [3] for information about the various packages. We generally did runs of 100 events.

The work described here was carried out on IBM RS6000 machines at Rice. There are two model 530's and one 320 for a total of about 100 MIPS with about 1 Gbyte of available disk space. This system was adequate for studies of single events and events at design luminosity but did not allow us to go to significantly higher luminosities. We have begun to carry out studies at the SSCL computer ranch pdsf but note that one user's "fair" share may not exceed that already available to us. Studies at higher luminosity will require some combination of filtering the generated events, improvements in SDCSIM and increased CPU power and disk space.

Event Generation

We generated Higgs with mass 300 GeV/c using Isajet and required that the Higgs decay into two Z's and that each of the Z's decay into electrons or muons. We also did some runs with a Higgs' mass of 800 GeV and found similar occupancies. The event vertex was fixed to be the origin (r=0, z=0) to provide a uniform geometrical acceptance. Background was generated by using Pythia to generate QCD inelastic events (MSEL = 1). Background at design luminosity was simulated by including 1.6 events/crossing in each of buckets -4 through +2 in accordance with the conventions of the SDC tracking group. We did runs without background and with this background and three times this background. Disk space and CPU limitations prevented us from tracking runs at the higher luminosity. The SE input files used to generate the Higgs and background events are included as appendices.

Most of the results discussed here are based on two runs: number 90 including Higgs alone and number 94 with the Higgs plus design luminosity (10**33 /cm**2/sec) background. Each run consists of 100 events but the last nine events of the run with background were lost during the GEANT tracking so only 91 of those events are used. The Higgs alone required 4 CPU-sec/event for generation and the Higgs at design luminosity required 14 CPU-sec/event.

GEANT tracking

Events are tracked through the detector using GEANT interfaced to SDCSIM through the package SG. The subpackages ST and SF were used to define the geometry and evaluate the response of the the silicon and scintillating fiber tracking systems. SG provides a description of the beam pipe (1 mm thick beryllium at a radius of 4 cm) and the solenoid. All tracks were stopped when they reached a radius of 180 cm or $|z|$ of 450 cm to save CPU time. The exact details of the geometry and other adjustable constants may be found in the initialization files st_descope3a.kumac for ST and sf_optc5.dat for SF. These are included as appendices to this paper. All 100 events of run 90 and the first 91 events of run 94 were successfully passed through this stage at rates of 10 and 31 CPU-minutes/event.

Track Reconstruction

We reconstructed the tracks in the event using the track reconstruction package TRF which is contained in the SDCSIM package TR. Calls to TRDEFK, TRINIT and TREVNT were added to the corresponding routines in US. Also an optional call to SGINIT was added to USINIT so that the geometry could be set up without calling SG each event. It is expected that SDCSIM will soon be capable of including geometry data structures as part of the overall saved data structure so that this last addition will not be neccessary.

TRF uses a programmable road-following technique to find the tracks. The user provides instructions in an ascii file often called trf.dat. The user chooses a layer in which to start tracks and then extends the tracks to each of the others in the order he chooses. Each time a hit is added to the track, it is refit and the user may delete tracks based on the number of hits or chi-square.

For this study, we reconstructed tracks by starting in the outer layer of the silicon and moving in. In some runs, we then stopped and did a final fit with a vertex constraint or varied the vertex and fit at the distance of closest approach. In other runs we added the scifi layers moving outwards after fitting the silicon and then closed tracks in the same way. We only made use of the barrel layers because the disk-fitting routines are not yet debugged. This restricts our eta range to $-0.9 < eta < 0.9$. We only searched for tracks with $pT > 5$ GeV/c to decrease the execution time. We rejected tracks with chi-square above 50 in the silicon or 100 in the combined system.

Each of the two runs was reconstructed four times -- with and without the scifi and with and without the radial vertex constraint. One of the map files is included as an appendix. The longest runs required 2 CPU-min/event for the events without background and 3 min/event for those at design luminosity.

At the end of the reconstruction, each of the reconstructed tracks is compared with the each of the Monte Carlo tracks and the nearest Monte Carlo track is assigned to that reconstructed track. The nearness of tracks is measured in terms of a match chi-square obtained by squaring the difference between the Monte Carlo and reconstructed track vectors weighted by the inverse of the error matrix. Each Monte Carlo track is only assigned to no more than one reconstructed track.

Results

We present results for occupancies, track-finding and reconstruction efficiency and resolution. The data were reduced to two ntuples from which these values were extracted. The first ntuple is filled once for each layer each event and contains the number of channels, digitizations and coordinates. It was used to calculate occupancies. The second ntuple is filled for each charged Monte Carlo track with pT > 2 GeV/c and for each unmatched reconstructed track (i.e., each one without a Monte Carlo track assigned to it). The ntuple contains the Monte Carlo and reconstructed track vectors and is used to calculate efficiencies and resolutions.

Occupancies

Occupancies in the scintillating fiber system were obtained by dividing the number of digitized fibers by the total number of fibers in each superlayer. The silicon values were obtained in a similar way. Results are give in tables 1-3 for the Higgs events with and without the 10**33 background. The silcon occupancies are always well under a percent and the highest scifi occupancy is 3% in the innermost layer.

Efficiencies

Efficiencies were calculated using electrons and muons with pT > 5 GeV/c. There are 60 to 80 of each of these onstructed tracks.e track-finding efficiency is defined as the fraction of these tracks which are assigned to one of the reconstructed tracks. This efficiency was 99 or 100% for the silicon alone for both electrons and muons. The track-finding efficiency for muons remains at 99% when the scintillating fibers are added but drops to 92% for the electrons.

The track-finding efficiency does not include any measure of how well the reconstructed tracks match up with the Monte Carlo tracks so we define a reconstruction efficiency for which we require the match chi-square to be less than 100. The match chi-square was defined in the reconstruction section.

With this addition, there is a small decrease in the muon efficiencies which still remain above 95% while the electron efficiencies drop significantly. We assume that the electron inefficiencies are due to bremsstrahlung and expect that much of the loss can be recovered by fitting with a special electron algorithm. This is justified because the electron track-finding efficiency for silicon alone is 99%.

Both track-finding and reconstruction efficiencies are presented in table 4. The efficiencies were not significantly different for the run with 10**33 background and these values are an average of the two. The number of false tracks, i.e. those not assigned to any Monte Carlo track varied from 0 to 2 in the different runs implying giving a false/true ratio of less than 0.01 above our track-finding momentum threshold of 5 GeV/c.

Resolutions

We have evaluated the resolution for various tracking parameters by looking at the difference between their reconstructed and Monte Carlo values. The event sample used for these includes all found leptons that passed the match chi-square criterion used to define the reconstruction efficiency. The resolutions quoted are the RMS deviations from zero for these differences. The mean values of the differences were always small compared to the resolution.

Resolutions for all following are given in table 5. The transverse momentum resolution dpT/pT**2 is calculated from the curvature. The xy direction of motion phi0 is measured at the origin or point of closest approach. The impact parameter r0 is the distance of closest approach in the r-phi plane. The dip angle tan(lambda) = dz/dsxy is approximately dz/dr for stiff tracks. The resolution for the z-position of the vertex (z0) is also given. In addition to these parameters which are taken directly from the track vectors, we use the tan(lambda) resolution to estimate the z-resolution at the shower-max and muon systems. This is done by assuming

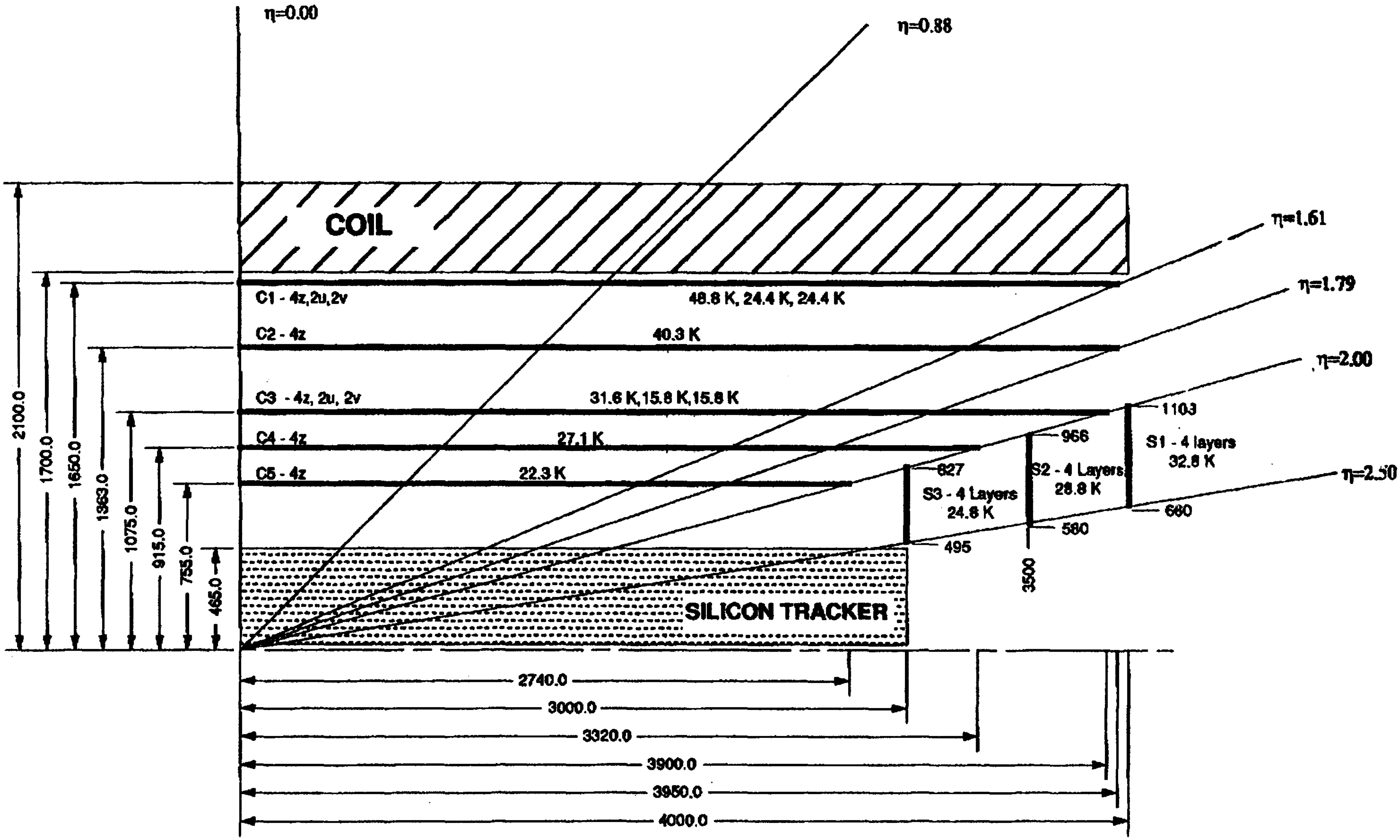
dz' = (r - rtmax) dtan(lambda)

where r is the radius of the shower-max or muon system (taken to be 250 and 600 cm, respectively) and rtmax is the outer radius of the tracking system taken to be 35 cm for the silicon alone and 165 for the combined system.

We note that the leptons used in this study have a spectrum that peaks around pT = 50 GeV/c with 30% of the tracks below the peak value. Consequently, multiple scattering still plays a significant role and the resolutions can be expected to improve for muons with higher momenta. For example, we find that the momentum resolution for single 4 TeV muons is 1.2 Tev/c corresponding to dpT/pT**2 = 0.08 -- a factor of two better than for the muons here.

Conclusions

We find that the proposed design for the silicon and scintillating fiber tracking systems is very efficient and easily meets the design requirements for the SDC at design luminosity over the rapidity range studied here. We plan to extend these studies to higher luminosities (3 and 10 times design) in the near future. We also expect to implement disk track-finding in TRF so that the full range of rapidity can be covered.



250.5 K Channels per End - Barrel (501 Total)

86.4 K Channels per End - Intermediate (172.8 K Total)

Total Channel Count 673.8 K

SCINTILLATING FIBER CENTRAL TRACKER

ornl
RML
10/25/91

Fig. 1

layer	radius (cm)	z max (cm)	eta max	# chan /side	occupancy L = 0	10**33
1	9.0	15.0	1.3	58000	.00024	.00032
2	12.0	15.0	1.0	77000	.00032	.00044
3	18.0	18.0	0.9	69000	.00047	.00066
4	21.0	21.0	0.9	81000	.00053	.00073
5	24.0	24.0	0.9	122000	.00077	.00105
6	27.0	27.0	0.9	138000	.00085	.00107
7	33.0	33.0	0.9	211000	.00085	.00115
8	36.0	36.0	0.9	276000	.00132	.00180

Table 1. Silicon barrel geometry and occupancies. The dimensions of each barrel and the number of readout channels on each side of each barrel are listed. The occupancy is calculth Z --> e e, e muhe number of digitizations by the number of channels. The occupancy is for H --> ZZ with Z --> e e, e mu or mu mu and a Higg's mass of 300 GeV. Occupancies are given for these events alone and these events superimposed on a minimum bias background at design luminosity (10**33 /cm**2/sec).

super layer	radius (cm)	z max (cm)	eta max	# fibers /layer	total	occupancy L = 0	10**33
1	165.2	395.	1.6	11952	188000	.0028	.0045
2	135.3	395.	1.8	9792	78000	.0055	.0085
3	107.4	395.	2.0	7776	62000	.0097	.0159
4	91.5	390.	2.0	6624	53000	.0122	.0216
5	75.5	274.	2.0	5472	44000	.0166	.0295

Table 2. Scifi barrel geometry and occupancies. The number of fibers in an axial layer and the total number in the superlayer (two ends and four or eight layers) are given. Occupancies are calculated as the number of hit fibers divided by the number of fibers in a superlayer. The events used are the same as in table 1.

super layer	z (cm)	r (cm) min	max	eta min	max	# fibers /layer	total	occupancy L = 0	10**33
1	400.0	66.0	110.3	2.0	2.5	4767	38000	.0038	.0068
2	350.0	58.0	96.6	2.0	2.5	4189	34000	.0041	.0084
3	300.0	49.5	82.7	2.0	2.5	3575	29000	.0038	.0093

Table 3. Scifi intermediate geometry and occupancies. The number of fibers in a layer and the total number in the disks on both ends are given. The occupancies are calculated in the same way as table 2 and the events are those described in table 1.

	Track-finding		Reconstruction	
	e	mu	e	mu
Si alone	0.99	1.00	0.94	1.00
Si + Scifi	0.92	0.99	0.70	0.97

Table 4. Track finding and track reconstruction efficiencies for electrons and muons in the silicon alone and silicon with scintillating fibers.

			Resolution	
		particle	Si	Si + Scifi
dpT/pt**2 (/TeV/c)	w/rvc	e	1.1	0.35
		mu	0.8	0.16
	w/o rvc	e	2.3	0.41
		mu	1.6	0.16
phi0 (rad)	w/rvc	e	0.00007	0.00005
		mu	0.00006	0.00003
	w/o rvc	e	0.00027	0.00009
		mu	0.00021	0.00007
r0 (mm)	w/o rvc	e	0.027	0.013
		mu	0.022	0.012
tan(lambda)		both	0.011	0.0007
z0 (mm)		both	2.6	1.1
z-showermax (mm)		both	24.	1.
z-muon (mm)		both	62.	3.

Table 5. Resolutions for various track parameters calculated as the RMS difference between reconstructed and Monte Carlo values. Momenta are evaluated with and without a radial vertex constraint (rvc). The last two parameters (z-showermax and z-muon) are not evaluated directly but are estimated from tan(lambda). See the text for details.

References
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1. Letter of Intent by the Solenoidal Detector Collaboration, SSCL, Nov 1990.

2. Outer Tracker Conceptual Design Scintillating Fiber Option, Nov 1991.

3. SHELL_USERS_GUIDE.DOC in the SDCSIM documentation area presently in SSCVX1::USER5:[SDCSHELL.V03.DOC].

Appendices

A. Higgs event generation file used with SE/Isajet

B. Background event generation file used with SE/Pythia

C. ST geometry description file st_descope3a.kumac

D. SF geometry description file sf_optc5.dat

Appendix A

```
----------
HIGGS DECAY TO Z PAIRS
40000,1000,0,0/
HIGGS
HMASS
300/
QMH
250,400/
JETTYPE1
'Z0'/
JETTYPE2
'Z0'/
WMODE1
'E+','E-'/
WMODE2
'MU+','MU-'/
PT
50,20000,50,20000/
END
STOP
```

Appendix B

```
----------
*-------------------------------------------------------------
*         == PYTHIA Control Input Data ==
*      Set P-P collider mode with Ecm = 40 TeV
*-------------------------------------------------------------
*
LULIST = 1           ! Number of events to list by LULIST
*
FRAME = CMS          ! Frame is center-of-mass (Collider)
BEAM  = P            ! Beam is proton
TARGET= P            ! Target is proton
WIN   = 40000.       ! incident energy Ecm=2*Ebeam is 4 TeV
*
LUGIVE:MDCY(C111,1)=0   ! make pi0      stable
LUGIVE:MDCY(C310,1)=0   ! make Ks       stable
LUGIVE:MDCY(C3112,1)=0  ! make sigma+   stable
LUGIVE:MDCY(C3122,1)=0  ! make sigma-   stable
LUGIVE:MDCY(C3222,1)=0  ! make lambda0  stable
LUGIVE:MDCY(C3312,1)=0  ! make xi0      stable
LUGIVE:MDCY(C3322,1)=0  ! make xi-      stable
LUGIVE:MDCY(C3334,1)=0  ! make omega0   stable
*
LUGIVE:PMAS(6,1)=150.   ! Set top quark mass to 150 GeV
LUGIVE:PMAS(25,1)=400.  ! Set Higgs mass     to 400 GeV
*
PYGIVE:MSEL=1           ! Set event type by MSEL to QCD inelastic
*PYGIVE:MSEL=16          ! Set event type by MSEL to Higgs production
*
END
```

```
*
message "ST_DESCOPE3.KUMAC."
*
* Setup silicon system geometry
*
* Module parameters specified on ST/GEOM/MODULE command:
* ====================================================
* Module number
* Number of layers
* Detector type (unused, always 1)
* Material # of support structure (6 for carbon)
* Thickness of silicon wafers (cm)
* Dead region at ends of wafers (cm)
* Dead region at sides of wafers (cm)
* Density factor for silicon (normally 1.0)
* Tilt angle (compensates for Lorentz angle) (radians, barrel only)
*
* Layer parameters specified on ST/GEOM/LAYER command:
* =======================================================
* Layer number
* Number of z wafers (barrel) or rings (forward)
* Position (r:barrel, z:forward, cm)
* Minimum extent (z:barrel, r:forward, cm)
* Maximum extent (z:barrel, r:forward, cm)
* Layer thickness (cm, including support material)
* Strip pitch (cm)
* Stereo angle (radians)
* Radiation lengths of support material
* Energy threshold for digitization (GeV)
*
* Wafer parameters specified on ST/GEOM/WAFER command:
* ==================================================
* Wafer number
* Minimum extent (in Z for barrel, r for forward) (cm)
* Maximum extent (in Z for barrel, r for forward) (cm)
* Number of phi wafers
* Phi offset of phi wafer 1 (radians)
* Wafer width (cm for barrel, radians for forward)
* Wafer type (see document; 1:readout at low Z or r, 2:readout at high Z or r)
* Position offset of odd phi wafers (r for barrel, Z for forward) (cm)
* Position offset of even phi wafers (r for barrel, Z for forward) (cm)
*
* Barrel module parameters (module 1):
* =================================
*
ST/GEOM/MODULE 1 8 1 6 .03 .05 .05 1. .1309
*
ST/GEOM/LAYER 1 5  9. -15.  15.   1.  .005   .005  .005 .00003
*
ST/GEOM/WAFER 1  -15.  -9. 18   0.   3.3  1 0. 0.
ST/GEOM/WAFER 2   -9.  -3. 18   0.   3.3  1 0. 0.
ST/GEOM/WAFER 3   -3.   3. 18   0.   3.3  1 0. 0.
ST/GEOM/WAFER 4    3.   9. 18   0.   3.3  1 0. 0.
ST/GEOM/WAFER 5    9.  15. 18   0.   3.3  1 0. 0.
*
ST/GEOM/LAYER 2 5 12. -15.  15.   1.  .005  -.005  .005 .00003
*
ST/GEOM/WAFER 1  -15.  -9. 24   0.   3.3  1 0. 0.
ST/GEOM/WAFER 2   -9.  -3. 24   0.   3.3  1 0. 0.
ST/GEOM/WAFER 3   -3.   3. 24   0.   3.3  1 0. 0.
ST/GEOM/WAFER 4    3.   9. 24   0.   3.3  1 0. 0.
ST/GEOM/WAFER 5    9.  15. 24   0.   3.3  1 0. 0.
*
ST/GEOM/LAYER 3 6 18. -18.  18.   1.  .005   .005  .005 .00003
*
ST/GEOM/WAFER 1  -18. -12. 36   0.   3.3  -2 0. 0.
ST/GEOM/WAFER 2  -12.  -6. 36   0.   3.3  -1 0. 0.
ST/GEOM/WAFER 3   -6.   0. 36   0.   3.3   1 0. 0.
ST/GEOM/WAFER 4    0.   6. 36   0.   3.3   2 0. 0.
ST/GEOM/WAFER 5    6.  12. 36   0.   3.3  -2 0. 0.
```



```
ST/GEOM/WAFER 6   12.  18. 36   0.   3.3  -1 0. 0.
*
ST/GEOM/LAYER 4 6 21. -21.  21.   1.  .005  -.005  .005 .00003
*
ST/GEOM/WAFER 1  -21.  -13.5 42   0.   3.3 -2 0. 0.
ST/GEOM/WAFER 2  -13.5  -6.  42   0.   3.3 -1 0. 0.
ST/GEOM/WAFER 3   -6.    0.  42   0.   3.3  1 0. 0.
ST/GEOM/WAFER 4    0.    6.  42   0.   3.3  2 0. 0.
ST/GEOM/WAFER 5    6.   13.5 42   0.   3.3 -2 0. 0.
ST/GEOM/WAFER 6   13.5  21.  42   0.   3.3 -1 0. 0.
*
ST/GEOM/LAYER 5 8  24. -24.  24.   1.  .005   .005  .005 .00003
*
ST/GEOM/WAFER 1  -24. -18. 48   0.   3.3   1 0. 0.
ST/GEOM/WAFER 2  -18. -12. 48   0.   3.3   2 0. 0.
ST/GEOM/WAFER 3  -12.  -6. 48   0.   3.3  -2 0. 0.
ST/GEOM/WAFER 4   -6.   0. 48   0.   3.3  -1 0. 0.
ST/GEOM/WAFER 5    0.   6. 48   0.   3.3   1 0. 0.
ST/GEOM/WAFER 6    6.  12. 48   0.   3.3   2 0. 0.
ST/GEOM/WAFER 7   12.  18. 48   0.   3.3  -2 0. 0.
ST/GEOM/WAFER 8   18.  24. 48   0.   3.3  -1 0. 0.
*
ST/GEOM/LAYER 6 8  27. -27.  27.   1.  .005  -.005  .005 .00003
*
ST/GEOM/WAFER 1  -27.  -19.5 54   0.   3.3  1 0. 0.
ST/GEOM/WAFER 2  -19.5 -12.  54   0.   3.3  2 0. 0.
ST/GEOM/WAFER 3  -12.   -6.  54   0.   3.3 -2 0. 0.
ST/GEOM/WAFER 4   -6.    0.  54   0.   3.3 -1 0. 0.
ST/GEOM/WAFER 5    0.    6.  54   0.   3.3  1 0. 0.
ST/GEOM/WAFER 6    6.   12.  54   0.   3.3  2 0. 0.
ST/GEOM/WAFER 7   12.   19.5 54   0.   3.3 -2 0. 0.
ST/GEOM/WAFER 8   19.5  27.  54   0.   3.3 -1 0. 0.
*
ST/GEOM/LAYER 7 10  33. -33.  33.   1.  .005  .005  .005 .00003
*
ST/GEOM/WAFER  1  -33.  -25.5 66   0.   3.3  1 0. 0.
ST/GEOM/WAFER  2  -25.5 -18.  66   0.   3.3  2 0. 0.
ST/GEOM/WAFER  3  -18.  -12.  66   0.   3.3 -2 0. 0.
ST/GEOM/WAFER  4  -12.   -6.  66   0.   3.3 -1 0. 0.
ST/GEOM/WAFER  5   -6.    0.  66   0.   3.3  1 0. 0.
ST/GEOM/WAFER  6    0.    6.  66   0.   3.3  2 0. 0.
ST/GEOM/WAFER  7    6.   12.  66   0.   3.3 -2 0. 0.
ST/GEOM/WAFER  8   12.   18.  66   0.   3.3 -1 0. 0.
ST/GEOM/WAFER  9   18.   25.5 66   0.   3.3  1 0. 0.
ST/GEOM/WAFER 10   25.5  33.  66   0.   3.3  2 0. 0.
*
ST/GEOM/LAYER 8 12  36. -36.  36.   1.  .005  -.005  .005 .00003
*
ST/GEOM/WAFER  1  -36. -30. 72   0.   3.3  1 0. 0.
ST/GEOM/WAFER  2  -30. -24. 72   0.   3.3  2 0. 0.
ST/GEOM/WAFER  3  -24. -18. 72   0.   3.3 -2 0. 0.
ST/GEOM/WAFER  4  -18. -12. 72   0.   3.3 -1 0. 0.
ST/GEOM/WAFER  5  -12.  -6. 72   0.   3.3  1 0. 0.
ST/GEOM/WAFER  6   -6.   0. 72   0.   3.3  2 0. 0.
ST/GEOM/WAFER  7    0.   6. 72   0.   3.3 -2 0. 0.
ST/GEOM/WAFER  8    6.  12. 72   0.   3.3 -1 0. 0.
ST/GEOM/WAFER  9   12.  18. 72   0.   3.3  1 0. 0.
ST/GEOM/WAFER 10   18.  24. 72   0.   3.3  2 0. 0.
ST/GEOM/WAFER 11   24.  30. 72   0.   3.3 -2 0. 0.
ST/GEOM/WAFER 12   30.  36. 72   0.   3.3 -1 0. 0.
*
*
* Forward module parameters (module 3 assumed to be same as module 2)
* ===================================================================
*
ST/GEOM/MODULE 3  16  1  6 .03    .05   .05    1.
*
ST/GEOM/LAYER  1  1   16.5   9. 16.5  1.  .005  -.005  .005 .00003
ST/GEOM/WAFER  1  9.  16.5   30  0.    0.219394   -1  0. 0.1
*
```

Appendix C

```
ST/GEOM/LAYER  2  2   19.5   9. 19.5  1.  .005   .005  .005 .00003
ST/GEOM/WAFER  1  9.  14.5   36  0.    0.165641   -2  0. 0.1
ST/GEOM/WAFER  2 14.5 19.5   36  0.    0.165641   -1  0. 0.1
*
ST/GEOM/LAYER  3  3   25.5   9. 25.5  1.  .005  -.005  .005 .00003
ST/GEOM/WAFER  1  9.  16.5   30  0.    0.219394   -1 -.2 -.1
ST/GEOM/WAFER  2 16.5 21.5   48  0.    0.141961   -2  0.  0.1
ST/GEOM/WAFER  3 21.5 25.5   48  0.    0.141961   -1  0.  0.1
*
ST/GEOM/LAYER  4  4   31.5   9. 31.5  1.  .005   .005  .005 .00003
ST/GEOM/WAFER  1  9.  14.5   36  0.    0.165641   -2 -.2 -.1
ST/GEOM/WAFER  2 14.5 19.5   36  0.    0.165641   -1 -.2 -.1
ST/GEOM/WAFER  3 19.5 25.5   60  0.    0.114921   -2  0. 0.1
ST/GEOM/WAFER  4 25.5 31.5   60  0.    0.114921   -1  0. 0.1
*
* slight edge gap wafers 1,2
*
ST/GEOM/LAYER  5 4    39.0  15. 39.0  1.  .005  -.005  .005 .00003
ST/GEOM/WAFER  1 15.   21.0  48  0.   0.1340741   -2 -.2 -.1
ST/GEOM/WAFER  2 21.   27.0  48  0.   0.1340741   -1 -.2 -.1
ST/GEOM/WAFER  3 27.   33.0  72  0.   0.0928205   -2  0. 0.1
ST/GEOM/WAFER  4 33.   39.0  72  0.   0.0928205   -1  0. 0.1
*
ST/GEOM/LAYER  6 4    46.0  15. 39.0  1.  .005   .005  .005 .00003
ST/GEOM/WAFER  1 15.   21.0  48  0.   0.1340741   -2 -.2 -.1
ST/GEOM/WAFER  2 21.   27.0  48  0.   0.1340741   -1 -.2 -.1
ST/GEOM/WAFER  3 27.   33.0  72  0.   0.0928205   -2 0. 0.1
ST/GEOM/WAFER  4 33.   39.0  72  0.   0.0928205   -1 0. 0.1
*
ST/GEOM/LAYER  7 4    55.0  15. 39.0  1.  .005   -.005  .005 .00003
ST/GEOM/WAFER  1 15.   21.0  48  0.   0.1340741   -2 -.2 -.1
ST/GEOM/WAFER  2 21.   27.0  48  0.   0.1340741   -1 -.2 -.1
ST/GEOM/WAFER  3 27.   33.0  72  0.   0.0928205   -2 0. 0.1
ST/GEOM/WAFER  4 33.   39.0  72  0.   0.0928205   -1 0. 0.1
*
ST/GEOM/LAYER  8 4    65.0  15. 39.0  1.  .005   .005  .005 .00003
ST/GEOM/WAFER  1 15.   21.0  48  0.   0.1340741   -2 -.2 -.1
ST/GEOM/WAFER  2 21.   27.0  48  0.   0.1340741   -1 -.2 -.1
ST/GEOM/WAFER  3 27.   33.0  72  0.   0.0928205   -2 0. 0.1
ST/GEOM/WAFER  4 33.   39.0  72  0.   0.0928205   -1 0. 0.1
*
ST/GEOM/LAYER  9 4    77.0  15. 39.0  1.  .005   -.005  .005 .00003
ST/GEOM/WAFER  1 15.   21.0  48  0.   0.1340741   -2 -.2 -.1
ST/GEOM/WAFER  2 21.   27.0  48  0.   0.1340741   -1 -.2 -.1
ST/GEOM/WAFER  3 27.   33.0  72  0.   0.0928205   -2 0. 0.1
ST/GEOM/WAFER  4 33.   39.0  72  0.   0.0928205   -1 0. 0.1
*
ST/GEOM/LAYER  10 4    91.0  15. 39.0  1.  .005   .005  .005 .00003
ST/GEOM/WAFER  1 15.   21.0  48  0.   0.1340741   -2 -.2 -.1
ST/GEOM/WAFER  2 21.   27.0  48  0.   0.1340741   -1 -.2 -.1
ST/GEOM/WAFER  3 27.   33.0  72  0.   0.0928205   -2 0. 0.1
ST/GEOM/WAFER  4 33.   39.0  72  0.   0.0928205   -1 0. 0.1
*
ST/GEOM/LAYER  11 4   110.0  15. 39.0  1.  .005   -.005  .005 .00003
ST/GEOM/WAFER  1 15.   21.0  48  0.   0.1340741   -2 -.2 -.1
ST/GEOM/WAFER  2 21.   27.0  48  0.   0.1340741   -1 -.2 -.1
ST/GEOM/WAFER  3 27.   33.0  72  0.   0.0928205   -2 0. 0.1
ST/GEOM/WAFER  4 33.   39.0  72  0.   0.0928205   -1 0. 0.1
*
ST/GEOM/LAYER  12 4   136.0  22.5 46.5  1.  .005   .005  .005 .00003
ST/GEOM/WAFER  1 22.5 28.5  66  0.   0.1049275   -2 -.2 -.1
ST/GEOM/WAFER  2 28.5 34.5  66  0.   0.1049275   -1 -.2 -.1
ST/GEOM/WAFER  3 34.5 40.5  84  0.   0.0778495   -2 0. 0.1
ST/GEOM/WAFER  4 40.5 46.5  84  0.   0.0778495   -1 0. 0.1
*
ST/GEOM/LAYER  13 4  168.0  22.5 46.5  1.  .005   -.005  .005 .00003
ST/GEOM/WAFER  1 22.5 28.5  36  0.   0.1049275   -2 -.2 -.1
ST/GEOM/WAFER  2 28.5 34.5  36  0.   0.1049275   -1 -.2 -.1
ST/GEOM/WAFER  3 34.5 40.5  48  0.   0.0778495   -2  0. 0.1
ST/GEOM/WAFER  4 40.5 46.5  48  0.   0.0778495   -1  0. 0.1
```



```
*
ST/GEOM/LAYER  14 2  208.0  34.5 46.5  1.  .005   .005  .005 .00003
ST/GEOM/WAFER  1 34.5 40.5  48  0.    0.0778495   -2 0. 0.1
ST/GEOM/WAFER  2 40.5 46.5  48  0.    0.0778495   -1 0. 0.1
*
ST/GEOM/LAYER  15 2  255.0  34.5 46.5  1.  .005   -.005  .005 .00003
ST/GEOM/WAFER  1 34.5 40.5  48  0.    0.0778495   -2 0. 0.1
ST/GEOM/WAFER  2 40.5 46.5  48  0.    0.0778495   -1 0. 0.1
```

```
;                                       SF.DAT
;
; 02NOV91 dla - The previous version of this file was bad.  A mistake in the
;               light propagation speed ==> no fiber digitizations.
; 31OCT91 dla - modify digitization parameters -- I decreased the light output
;               and fixed the timing so that we no longer lose 0.5 ns on the
;               fast end
; 31OCT91 dla - fix fiber spacing in C2 to be 0.087 instead of 0.089
; Created 28 OCT 91 dla.
;
;      Describes FTG option C as circulated by D. Koltick.  See figure in
; DLA log II-43.  Layer spacings are on II-34.
;      Modified to reflect new drawings circulated 30OCT91.  See drawing and
; layer positions on II-46.
;
;      Contains a description of a scintillating fiber tracking detector for
; use with SSC simulations.  A series of volumes are defined by giving a name
; for the shape and then the size, position and orientation.
; The units are cm and radians.
;
; The line beginning with 'digit' is followed with two lines setting the
; parameters used in the digitization:
; NDGTIM  DGDTIM  DGTOFF  DGTWID
; PHOGEV  FINTER  ATTLEN  ATTOPT  QUANEF  VSIG
; The signal is DGDWID ns wide and is sampled NDGTIM times at intervals of
; DGDTIM ns starting at time DGTOFF.   The other parameters are:
; PHOGEV = # photons produced in one cm of fiber per GeV of energy deposit
; FINTER = fraction of photons internally reflected = 1 - cos(thtint)
; ATTLEN = attenuation length in the scintillating fiber
; ATTOPT = attenuation in optical fiber and couplings
; QUANEF = quantum efficiency of the photodetector
; VSIG = speed of the signal in the fiber (cm/s)
; Defaults are provided if these lines are missing; they are:
; 1        16.0     29.0     16.0
; 1.e7     0.030    1000.0  0.5      0.6      20.e9
; The following parameters give 10.2 photons at the near end of a fiber and
; 4.5 at 4 meters.  The timing is set to accept all prompt particles and has
; 5 ns of slop on the slow end.
digitization parameters
  1        16.0     31.0     22.0                   ; see log II-48
 0.50e7    0.030    500.0   0.5      0.8      20.0E9  ; see II-49
;
mother                     ; description of mother volume
170.0, 420.0               ; outer radius and half-length
;
; ************* C1 *************
;
cylinder                      ; volume shape
165.24 166.16 395.              ; min radius, max radius, length (cm)
0.  0. -197.5                 ; location of center of cylinder
8                             ; number of fiber layers
1, -1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
165.49, 165.49, 0.00, 0.00000        ; r0 , r, offset, stereo slope (rad/cm)
1, -1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
165.49, 165.57, 0.50, 0.00000        ; r0 , r, offset, stereo slope (rad/cm)
1, -1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
165.49, 165.67, 0.25, 0.00000        ; r0 , r, offset, stereo slope (rad/cm)
1, -1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
165.49, 165.75, 0.75, 0.00000        ; r0 , r, offset, stereo slope (rad/cm)
1, -1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
165.85, 165.85, 0.00, 0.00161        ; r0 , r, offset, stereo slope (rad/cm)
1, -1                              ; fiber shape, readout
0.087, 0.083,                        ; fiber spacing (cm), width (cm), not used
165.85, 165.9          , 0.00161     ; r0 , r, offset, stereo slope (rad/cm)
1, -1                              ; fiber shape, readout
```



```
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
166.03, 166.03, 0.00,-0.00161        ; r0 , r, offset, stereo slope (rad/cm)
1, -1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
166.03, 166.11, 0.50,-0.00161        ; r0 , r, offset, stereo slope (rad/cm)
;
;
cylinder                      ; volume shape
165.24 166.16 395.              ; min radius, max radius, length (cm)
0.  0.  197.5                 ; location of center of cylinder
8                             ; number of fiber layers
1,  1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
165.49, 165.49, 0.00, 0.00000        ; r0 , r, offset, stereo slope (rad/cm)
1,  1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
165.49, 165.57, 0.50, 0.00000        ; r0 , r, offset, stereo slope (rad/cm)
1,  1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
165.49, 165.67, 0.25, 0.00000        ; r0 , r, offset, stereo slope (rad/cm)
1,  1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
165.49, 165.75, 0.75, 0.00000        ; r0 , r, offset, stereo slope (rad/cm)
1,  1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
165.85, 165.85, 0.00, 0.00161        ; r0 , r, offset, stereo slope (rad/cm)
1,  1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
165.85, 165.93, 0.50, 0.00161        ; r0 , r, offset, stereo slope (rad/cm)
1,  1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
166.03, 166.03, 0.00,-0.00161        ; r0 , r, offset, stereo slope (rad/cm)
1,  1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
166.03, 166.11, 0.50,-0.00161        ; r0 , r, offset, stereo slope (rad/cm)
;
; **************** C2 **************
;
cylinder                      ; volume shape
135.34 135.90 395.              ; min radius, max radius, length (cm)
0.  0. -197.5                 ; location of center of cylinder
4                             ; number of fiber layers
1, -1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
135.59, 135.59, 0.00, 0.00000        ; r0 , r, offset, stereo slope (rad/cm)
1, -1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
135.59, 135.67, 0.50, 0.00000        ; r0 , r, offset, stereo slope (rad/cm)
1, -1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
135.59, 135.77, 0.25, 0.00000        ; r0 , r, offset, stereo slope (rad/cm)
1, -1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
135.59, 135.85, 0.75, 0.00000        ; r0 , r, offset, stereo slope (rad/cm)
;
cylinder                      ; volume shape
135.34 135.90 395.              ; min radius, max radius, length (cm)
0.  0.  197.5                 ; location of center of cylinder
4                             ; number of fiber layers
1,  1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
135.59, 135.59, 0.00, 0.00000        ; r0 , r, offset, stereo slope (rad/cm)
1,  1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (cm), not used
135.59, 135.67, 0.50, 0.00000        ; r0 , r, offset, stereo slope (rad/cm)
1,  1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width (     not used
135.59, 135.77, 0.25, 0.00000        ; r0 , r, offset, stereo slo     'cm)
1,  1                              ; fiber shape, readout
0.087, 0.083, 0.0                    ; fiber spacing (cm), width        not used
```

Appendix D

```
135.59, 135.86, Ø.75, Ø.00000    ; rØ , r, offset, stereo slope (rad/cm)
;
; ***************** C3 *****************
;
cylinder                        ; volume shape
107.42 107.98 390.                ; min radius, max radius, length (cm)
Ø.  Ø. -190.Ø                   ; location of center of cylinder
4                               ; number of fiber layers
1, -1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
107.67, 107.67, Ø.ØØ, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1, -1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
107.67, 107.75, Ø.5Ø, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1, -1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
107.67, 107.86, Ø.25, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1, -1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
107.67, 107.93, Ø.75, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
;
cylinder                        ; volume shape
107.42 107.98 390.                ; min radius, max radius, length (cm)
Ø.  Ø.  190.Ø                   ; location of center of cylinder
4                               ; number of fiber layers
1,  1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
107.67, 107.67, Ø.ØØ, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1,  1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
107.67, 107.75, Ø.5Ø, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1,  1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
107.67, 107.86, Ø.25, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1,  1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
107.67, 107.93, Ø.75, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
;
; **************** C4 ******************
;
cylinder                        ; volume shape
 91.47,  92.03, 332.Ø              ; min radius, max radius, length (cm)
Ø.  Ø. -166.Ø                   ; location of center of cylinder
4                               ; number of fiber layers
1, -1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 91.72,  91.72, Ø.ØØ, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1, -1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 91.72,  91.80, Ø.5Ø, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1, -1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 91.72,  91.90, Ø.25, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1, -1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 91.72,  91.98, Ø.75, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
;
cylinder                        ; volume shape
 91.47,  92.03, 332.Ø              ; min radius, max radius, length (cm)
Ø.  Ø.  166.Ø                   ; location of center of cylinder
4                               ; number of fiber layers
1,  1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 91.72,  91.72, Ø.ØØ, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1,  1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 91.72,  91.80, Ø.5Ø, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1,  1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 91.72,  91.90, Ø.25, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
```



```
1,  1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 91.72,  91.98, Ø.75, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
;
; ****************** C5 ********************
;
cylinder                        ; volume shape
 75.52,  76.08, 274.Ø              ; min radius, max radius, length (cm)
Ø.  Ø. -137.Ø                   ; location of center of cylinder
4                               ; number of fiber layers
1, -1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 75.77,  75.77, Ø.ØØ, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1, -1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 75.77,  75.85, Ø.5Ø, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1, -1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 75.77,  75.95, Ø.25, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1, -1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 75.77,  76.03, Ø.75, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
;
cylinder                        ; volume shape
 75.52,  76.08, 274.Ø              ; min radius, max radius, length (cm)
Ø.  Ø.  137.Ø                   ; location of center of cylinder
4                               ; number of fiber layers
1,  1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 75.77,  75.77, Ø.ØØ, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1,  1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 75.77,  75.85, Ø.5Ø, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1,  1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 75.77,  75.95, Ø.25, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
1,  1                                ; fiber shape, readout
Ø.087, Ø.083, Ø.Ø                     ; fiber spacing (cm), width (cm), not used
 75.77,  76.03, Ø.75, Ø.00000         ; rØ , r, offset, stereo slope (rad/cm)
;
; ******************* S1 ****************
;
spiral
 66.ØØ  11Ø.3  Ø.44             ; inner, outer radii, thickness
Ø.Ø Ø.Ø -400.ØØ                  ; xØ, yØ, zØ
4                               ; number of layers
1 1                             ; fiber shape and readout
Ø.087, Ø.083, Ø.Ø                ; fiber spacing, width, not used
-Ø.17, Ø.Ø,  66.ØØ,  1           ; z, offset, rØ, parity
1 1                             ; fiber shape and readout
Ø.087, Ø.083, Ø.Ø                ; fiber spacing, width, not used
-Ø.Ø9, Ø.5,  66.ØØ,  1           ; z, offset, rØ, parity
1 1                             ; fiber shape and readout
Ø.087, Ø.083, Ø.Ø                ; fiber spacing, width, not used
 Ø.Ø1, Ø.Ø,  66.ØØ,  1           ; z, offset, rØ, parity
1 1                             ; fiber shape and readout
Ø.087, Ø.083, Ø.Ø                ; fiber spacing, width, not used
 Ø.Ø9, Ø.5,  66.ØØ,  1           ; z, offset, rØ, parity
;
spiral
 66.ØØ  11Ø.3  Ø.44             ; inner, outer radii, thickness
Ø.Ø Ø.Ø  400.ØØ                  ; xØ, yØ, zØ
4                               ; number of layers
1 1                             ; fiber shape and readout
Ø.087, Ø.083, Ø.Ø                ; fiber spacing, width, not used
-Ø.17, Ø.Ø,  66.ØØ,  1           ; z, offset, rØ, parity
1 1                             ; fiber shape and readout
Ø.087, Ø.083, Ø.Ø                ; fiber spacing, width, not used
-Ø.Ø9, Ø.5,  66.ØØ,  1           ; z, offset, rØ, parity
1 1                             ; fiber shape and readout
```

```
0.087, 0.083, 0.0           ; fiber spacing, width, not used
 0.01, 0.0,  66.00,  1      ; z, offset, r0, parity
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
 0.09, 0.5,  66.00,  1      ; z, offset, r0, parity
;
; **************** S2 ****************
;
spiral
 58.00   96.6  0.44         ; inner, outer radii, thickness
0.0 0.0 -350.00             ; x0, y0, z0
4                           ; number of layers
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
-0.17, 0.0,  57.80,  1      ; z, offset, r0, parity
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
-0.09, 0.5,  57.80,  1      ; z, offset, r0, parity
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
 0.01, 0.0,  57.80,  1      ; z, offset, r0, parity
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
 0.09, 0.5,  57.80,  1      ; z, offset, r0, parity
;
spiral
 58.00   96.6  0.44         ; inner, outer radii, thickness
0.0 0.0  350.00             ; x0, y0, z0
4                           ; number of layers
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
-0.17, 0.0,  57.80,  1      ; z, offset, r0, parity
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
-0.09, 0.5,  57.80,  1      ; z, offset, r0, parity
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
 0.01, 0.0,  57.80,  1      ; z, offset, r0, parity
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
 0.09, 0.5,  57.80,  1      ; z, offset, r0, parity
;
; **************** S3 ****************
;
spiral
 49.50   82.7  0.44         ; inner, outer radii, thickness
0.0 0.0 -300.00             ; x0, y0, z0
4                           ; number of layers
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
-0.17, 0.0,  49.50,  1      ; z, offset, r0, parity
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
-0.09, 0.5,  49.50,  1      ; z, offset, r0, parity
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
 0.01, 0.0,  49.50,  1      ; z, offset, r0, parity
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
 0.09, 0.5,  49.50,  1      ; z, offset, r0, parity
;
spiral
 49.50   82.7  0.44         ; inner, outer radii, thickness
0.0 0.0  300.00             ; x0, y0, z0
4                           ; number of layers
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
-0.17, 0.0,  49.50,  1      ; z, offset, r0, parity
1                           ; fiber shape and readout
       9.083, 0.0           ; fiber spacing, width, not used
```



```
-0.09, 0.5,  49.50,  1      ; z, offset, r0, parity
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
 0.01, 0.0,  49.50,  1      ; z, offset, r0, parity
1 1                         ; fiber shape and readout
0.087, 0.083, 0.0           ; fiber spacing, width, not used
 0.09, 0.5,  49.50,  1      ; z, offset, r0, parity
;
```