sid02

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This is the version of the Silicon Detector modelled for the Letter of Intent (LOI) exercise.
The compact description of this detector in xml format can be found at http://www.lcsim.org/detectors/sid02.zip.

What follows is a plain text description of the file compact.xml found in this zip file.

Where a material is listed as xx% coverage, the density of the material has been reduced to xx% of its nominal value to mimic the effect of cutouts in the material.

The tracking region is defined to be a cylinder with radius 126.5cm and z extent +/- 167.9cm.

Beampipe:

The beampipe consists of a cylindrical central tube and forward/backward conical sections. The 0.040cm thick Beryllium central tube has an inner radius of 1.2cm and extends to |z|<6.25cm. The conical sections have a cone half-angle of 43.4mrad with an inner radius that flares from 1.2 cm at 6.25cm to 8.218cm at |z|=167.9cm. The conical sections are 0.0875cm thick Be for 6.25cm<|z|<37.5cm, where they transition to steel. The thickness of the steel section flares from 0.0875cm at |z|=37.5cm to 0.1992cm at |z|=167.9cm. A titanium liner on the inner surface of the beam pipe consists of a 0.0025cm thick cylinder and 0.0075cm thick conical sections.

Vertex Detector:

The vertex detector is composed of a central barrel system with five layers and forward systems composed of four disks.

Barrels

The barrels are composed of .0113cm thick Silicon, of which the outer .002cm is sensitive, with the following inner radii and |z| extents:

Layer	Inner Radius	|z| Extent
1	1.46cm	6.25cm
2	2.26cm	6.25cm
3	3.54cm	6.25cm
4	4.80cm	6.25cm
5	6.04cm	6.25cm

Sensors are supported by cylinders made of 0.026cm thick carbon fiber with 25% coverage.

Layer	Inner Radius	|z| Extent
1	1.43cm	6.27cm
2	2.23cm	6.27cm
3	3.51cm	6.27cm
4	4.77cm	6.27cm
5	6.01cm	6.27cm

The cylinders attach to 0.026cm thick carbon fiber (25% coverage) bulkheads that span 1.44cm<r<7.16cm and have an inner |z| of 6.27cm. The vertex detector is attached to the support tube by 0.026cm thick carbon fiber (25% coverage) support disks that span 1.44cm<r<16.87cm and have an inner |z| of 6.30cm.

Disks

There are four forward disks on either end, composed of a total of .0113cm of silicon, of which the inner .002cm is sensitive. The radial extent and inner |z| for the disks are:

Layer	Inner Radius	Outer Radius	Inner |z|
1	1.4cm	7.1cm	7.18cm
2	1.6cm	7.1cm	9.02cm
3	1.8cm	7.1cm	12.16cm
4	2.0cm	7.1cm	17.00cm

The forward disk supports are 0.026cm thick carbon fiber (25% coverage) disks located as follows:

Layer	Inner Radius	Outer Radius	Inner |z|
1	1.395cm	16.87cm	7.21cm
2	1.595cm	16.87cm	9.05cm
3	1.795cm	16.87cm	12.19cm
4	1.995cm	16.87cm	17.03cm

Readout Electronics and Cables

For the barrel, readout electronics are modeled as G10 rings that are currently located outside the support membrances:

Layer	Inner Radius	Outer Radius	Inner |z|	Thickness
1	1.46cm	1.66cm	6.4cm	0.5cm
2	2.26cm	2.46cm	6.4cm	0.5cm
3	3.54cm	3.74cm	6.4cm	0.5cm
4	4.80cm	5.00cm	6.4cm	0.5cm
5	6.04cm	6.24cm	6.4cm	0.5cm

Forward disk readout electronics are modeled as inner and outer rings, both made of G10:

Layer	Inner Radius	Outer Radius	Inner |z|	Thickness
1-in	1.3cm	1.4cm	6.98cm	0.2cm
2-in	1.5cm	1.6cm	8.82cm	0.2cm
3-in	1.7cm	1.8cm	11.96cm	0.2cm
4-in	1.9cm	2.0cm	16.80cm	0.2cm
1-out	7.1cm	7.6cm	6.98cm	0.2cm
2-out	7.1cm	7.6cm	8.82cm	0.2cm
3-out	7.1cm	7.6cm	11.96cm	0.2cm
4-out	7.1cm	7.6cm	16.80cm	0.2cm

Barrel cables first are brought radially down to the beam pipe. These radial cables are modeled as Cu disks:

Inner Radius	Outer Radius	Inner |z|	Thickness
1.32cm	2.26cm	6.90cm	0.0057cm
2.26cm	3.54cm	6.90cm	0.0031cm
3.54cm	4.80cm	6.90cm	0.0016cm
4.80cm	6.04cm	6.90cm	0.0007cm

The remaining cable and service materials are located along the beam pipe. Inner cables are 0.012cm thick copper and run conically from an inner radius of 1.32cm at |z|=6.9cm to a radius of 1.455cm at |z|=10.0cm. Service material is 0.3cm thick G10 that runs conically from an inner radius of 1.455cm at |z|=10cm to 1.542cm at |z|=12cm. Outer cables are modeled as copper that flares from a thickness of 0.010cm with an inner radius of 1.542cm at |z|=12cm to a thickness of 0.004cm with an inner radius of 8.310cm at |z|=167.9cm.

Support Tube

The entire vertex detector is enclosed within a double walled carbon fiber support tube. The support tube walls are 0.05cm thick carbon fiber with inner radii of 16.87cm and 18.42cm and a |z| extent of |z|<89.48cm. The ends of the support tube double-walled disks of 0.05cm thick carbon fiber disks located as follows:

Wall	Inner Radius	Outer Radius	Inner |z|
Inner	4.80cm	16.87cm	86.88cm
Outer	4.91cm	16.87cm	89.43cm

Tracker:

The tracker is composed of five cylindrical barrels with four disk-shaped endplanes. The z extent of the barrels increases with radius and the endplane for each extends beyond its cylinder in radius to provide overlap. The sensitive medium is silicon, assembled into carbon-fiber/Rohacell/PEEK modules and read out via a bump-bonded chip and Kapton/Copper cables. These modules are supported by carbon-fiber/Rohacell/carbon-fiber barrels or disks. Each barrel cylinder is supported from the next barrel out by an annular carbon fiber-ring. Outside each of these support rings in z, G10/Copper printed circuit boards are mounted for power and readout distribution to all silicon modules in a layer.

Barrels:

The radii and |z| extents of the barrel silicon layers are:

Layer	Inner Radius	|z| Extent
1	21.8cm	55.8cm
2	46.8cm	82.5cm
3	71.8cm	108.3cm
4	96.8cm	134.7cm
5	121.8cm	160.6cm

The estimated material thickness for modules, silicon, readout, and cables are averaged over the barrel and are given by:

Material	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5
PEEK	0.02cm	0.02cm	0.02cm	0.02cm	0.02cm
Rohacell31 (50% coverage)	0.28cm	0.28cm	0.28cm	0.28cm	0.28cm
Epoxy	0.0175cm	0.0175cm	0.0175cm	0.0175cm	0.0175cm
Carbon Fiber	0.016cm	0.016cm	0.016cm	0.016cm	0.016cm
Silicon (active)	0.03cm	0.03cm	0.03cm	0.03cm	0.03cm
Silicon (dead)	0.00048cm	0.00048cm	0.00048cm	0.00048cm	0.00048cm
Kapton	0.0038cm	0.0051cm	0.0064cm	0.0078cm	0.0091cm
Copper	0.00038cm	0.00052cm	0.00065cm	0.00079cm	0.00093cm

The barrel support cylinders are composed of .05cm CarbonFiber, 0.80cm of Rohacell31 (15% coverage) and 0.05cm CarbonFiber. The inner radii and |z| extent are given by:

Layer	Inner Radius	|z| Extent
1	20.6cm	57.7cm
2	45.6cm	84.3cm
3	70.6cm	110.2cm
4	95.6cm	136.6cm
5	120.6cm	162.4cm

The barrels are supported by 0.05cm thick carbon fiber (15% coverage) rings:

Layer	Inner Radius	Outer Radius	Inner |z|
1	21.5cm	45.6cm	57.0cm
2	46.5cm	70.6cm	83.6cm
3	71.5cm	95.6cm	109.5cm
4	96.5cm	120.6cm	135.9cm
5	121.5cm	126.5cm	161.7cm

Endcap:

Each layer is composed of two sensor modules to measure coordinates in two stereo (u-v) views. The table below shows the radial extent of the disks and the inner |z| position for the "A" and "B" sensor planes.

Layer	Inner Radius	Outer Radius	|z| for A Plane	|z| for B Plane
1	20.7cm	49.4cm	85.5cm	85.9cm
2	20.7cm	74.7cm	111.4cm	111.8cm

3	20.7cm	99.9cm	137.8cm	138.2cm
4	20.7cm	125.0cm	163.6cm	164.0cm

Each A plane has the following material thicknesses:

Material	Layer 1	Layer 2	Layer 3	Layer 4
Silicon (active)	0.03cm	0.03cm	0.03cm	0.03cm
Silicon (dead)	0.00048 cm	0.00048 cm	0.00048 cm	0.00048 cm
Kapton	0.0051cm	0.0064cm	0.0078cm	0.0091cm
Copper	0.00052 cm	0.00065 cm	0.00079 cm	0.00093 cm
PEEK	0.02cm	0.02cm	0.02cm	0.02cm
Rohacell31 (50% coverage)	0.3cm	0.3cm	0.3cm	0.3cm
Epoxy	0.0175cm	0.0175cm	0.0175cm	0.0175cm
Carbon Fiber	0.016cm	0.016cm	0.016cm	0.016cm

Each B plane has the following material thicknesses:

Material	Layer 1	Layer 2	Layer 3	Layer 4
Silicon (active)	0.03cm	0.03cm	0.03cm	0.03cm
Silicon (dead)	0.00048 cm	0.00048 cm	0.00048 cm	0.00048 cm
Kapton	0.0051cm	0.0064cm	0.0078cm	0.0091cm
Copper	0.00052 cm	0.00065 cm	0.00079 cm	0.00093 cm

The endcap supports are disks made of two 0.05cm thick Carbon Fiber planes separated by a 0.63cm thick layer of Rohacell31 (15% coverage). The radial span and inner z coordinate are:

Layer	Inner Radius	Outer Radius	Inner |z|
1	20.5cm	51.0cm	84.5cm
2	20.5cm	76.3cm	110.3cm
3	20.5cm	101.3cm	136.7cm
4	20.5cm	126.3cm	162.6cm

Services

The readout and power distribution boards are mounted on the outside surfaces of the barrel support rings. The regions occupied by these boards and the average thickness of the material they represent are given by:

Layer	Inner Radius	Outer Radius	Inner |z|	G10 Thickness	Copper Thickness
1	25.7cm	45.6cm	57.1cm	0.057cm	0.0038cm
2	51.0cm	70.6cm	83.7cm	0.102cm	0.0068cm
3	76.3cm	95.6cm	109.6cm	0.108cm	0.0072cm
4	101.3cm	120.6cm	136.0cm	0.186cm	0.0124cm
5	101.3cm	120.6cm	167.0cm	0.246cm	0.0164cm

Note that in layer five, due to the constraints of the calorimeter, the readout boards are not mounted on this annular ring, but rather at smaller radius.

Forward Disks

There are also three forward disks at small angles composed of pixel sensor modules. The table below shows the radial extent of the disks and the inner |z| positions for the sensor planes.

Layer	Inner Radius	Outer Radius	|z|
1	2.78cm	16.67cm	20.40 cm
2	7.51cm	16.67cm	53.85 cm

3	11.65cm	16.67cm	82.95 cm

Each sensor plane has the following material thicknesses:

Material	Thickness
Silicon (active)	0.002cm
Silicon (dead)	0.028cm
Carbon Fiber (25%)	0.026cm

An x-y quarter view of the sid02 tracking detectors can be found at sid02_Tracker_QuarterView.eps
A plot of the material, expressed in percentage of a radiation length (X/X_0), as a function of the polar angle, can be found at sid02TrackerMaterialScan.eps

Calorimeters:

Electromagnetic Calorimeter:

This element sets the basic size and aspect ratio for the rest of the detector. The inner radius for the barrel is 127cm. The aspect ratio is set to cos(theta) =0.8, meaning the inner z of the endcap EM calorimeter is at z of 168cm.

The EM calorimeter is a sampling calorimeter composed of 20 layers of

material	thickness
Tungsten	.250cm
Silicon	.032cm
Copper	.005cm
Kapton	.030cm
Air	.033cm

followed by ten layers of

material	thickness
Tungsten	.50cm
Silicon	.032cm
Copper	.005cm
Kapton	.030cm
Air	.033cm

There is a sensitive silicon layer before the first layer of Tungsten to provide additional electron/photon discrimination, giving a total of 31 layers of silicon readout.
The Tungsten alloy being used is TungstenDen24 (93% W, 6.1% Ni, .9% Fe) with a density of 17.8 g/cm^3.
The endcap plug sits inside the barrel cylinder, so the barrel z extent is +/- 182.0cm.
The endcap starts at an inner radius of 20cm and extends out to 126.5cm.

Segmentation

The readout is 3.5mm x 3.5mm square cells.

Hadron calorimeter:

The hadron calorimeter is a sampling calorimeter composed of 40 layers of

material	thickness
Steel	2.0cm
PyrexGlass	0.11cm
RPCGas	0.12cm
PyrexGlass	0.11cm
G10	0.3cm
Air	0.16cm

It begins immediately outside of the EM calorimeters, with the endcap plug sitting inside the barrel.

The barrel inner radius is 141.0 with a z extent of +/- 294cm.
The endcap extends from an inner radius of 20.0cm to an outer radius of 140.75, inner z of 182.0.

Segmentation

The readout is 1cm x 1cm squares.

Solenoid:

The solenoid is modelled as a cylinder with an inner radius of 255cm. This is larger than the outer radius of the hadron calorimeter since we will not be building a cylindrical detector, but a polygonal one (current thinking is dodecagonal). The barrel composition is as follows:

material	thickness	z
Steel	6.0cm	271.0 cm
Air	8.5cm	271.0 cm
Aluminum	39.3cm	262.5 cm
Steel	6.0cm	262.5 cm
Air	20.0cm	271.0 cm
Steel	3.0cm	271.0 cm

This is capped with disk endplates of 6cm steel from r=250cm to 332.8cm

The field is solenoidal, constant 5 Tesla along z up to half the coil thickness and -0.6 outside.

Muon System:

The muon system is composed of 11 layers of 20cm thick Iron plates interspersed with double RPC readout.
The barrel inner radius is 338.8cm with z extent of +/- 294cm.
The endcap sits outside the barrel at an inner z of 303.3cm and radius from 20.0cm to 608.2cm

Segmentation

The readout is 3cm x 3cm squares.

An x-y quarter view of the sid02 calorimeters and solenoid can be found at sid02_Calorimeters_QuarterView.eps

Masks and Far Forward Detectors

The far forward region is designed for the 14mr beam crossing solution so has separate incoming (inner radius 1.0cm) and outgoing (inner radius 1.5cm) beampipes. The far forward plug is designed to fit within a radius of 20cm. It starts with an electromagnetic calorimeter (LumiCal) with the same composition as the endcap calorimeter, extending from 6.0cm out to 19.5cm.

The calorimeter is backed up by a conically tapered tungsten mask, inner radius 8.0cm at z of 182cm, tapering to 16cm at z of 313.5cm. The outer radius is constant at 15.5cm.

There is a far forward low-Z shield (12.39cm thick Borated polyethylene) at z of 282cm.

This is followed by a 50 layer silicon-tungsten calorimeter (BeamCal)at z of 295cm.

Segmentation

All the far forward electromagnetic calorimeters have 3.5mm x 3.5 mm square readout.

An x-y quarter view of the sid02 far forward region (also referred to as the machine-detector interface, or MDI) can be found at sid02_MDI_Cut.eps

For additional details, please see the xml file.