THE DETECTOR MENAGERIE

A COLLECTION OF DROP-IN DYNAMIC COMPONENTS
FOR MODELING THE ELECTRON-ION COLLIDER

CENTRAL DETECTOR COMPONENTS

CTR

IP-6 Fixed Carriage

Overview

The ***IP-6 fixed carriage model*** is a proposed design that makes several assumptions. First, it assumes that the STAR cradles will be re-used and will be fitted with *inserts* that allow them to accommodate a variety of HCAL radii. Adjustable carriage jacks are included in this model to simulate the supports that may need to be added to accommodate different HCALs.

A second assumption is that the supporting infrastructure for the detector will be installed on a service carriage. While this is expected to reduce the length of service/communications lines, it also allows the detector to be moved in and out of the collider hall, while disturbing a minimum number of connections.

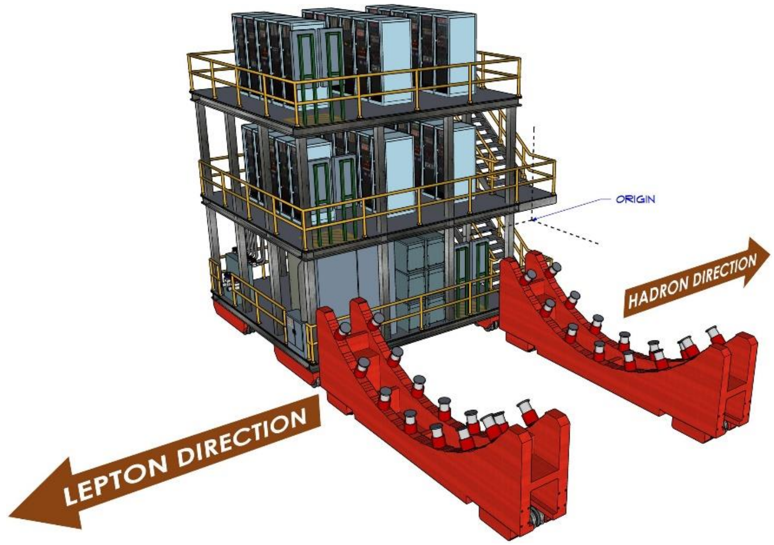

Figure 1: *IP-6 Fixed Carriage*

Component Options

X	Position of the object's origin relative to the red axis (horizontal axis orthogonal to the beamline).
Y	Position of the object's origin relative to the green axis (horizontal axis parallel to the beamline).
Z	Position of the object's origin relative to the blue axis (vertical axis orthogonal to the beamline).
Carriage Jack Length	Length of the carriage jacks. This parameter allows the jack length to be adjusted to support a variety of HCAL radii.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The total weight of this carriage design can be estimated using a parametric approach. The following volumes and material weights may be adapted for use.

Item	*Basis*	*Weight*
Carriage (5.9 m³)	Steel (7850 kg/m³)	46,451.91 kg
Cradles (2@3.44 m³)	Steel (7850 kg/m³)	54,044.96 kg
Power Supplies (2)	850.03 kg each	1,700.06 kg
Computing Racks (39)	226.80 kg each	8,845.04 kg
Transformers (4)	231.33 kg each	925.33 kg
	Total	111,967.31 kg

This is a preliminary list for planning purposes only. As new components are added to the service carriage, their weights should be included in the table.

CTR IP-8 Fixed Carriage

Overview

The ***IP-8 fixed carriage model*** is derived from the sPHENIX carriage. The user should note that the proposed placement of this carriage will result in an interference between the carriage and the door when the detector is moved from the detector hall to the assembly area. Actual use of this carriage will require some modification.

Unlike the IP-6 carriage, the door between the detector hall and assembly hall is sufficiently high that the electronics and supporting infrastructure can be installed above the detector. This results in a more compact design, but does limit the amount of equipment that may be installed. Other alternative designs consider adding a service carriage toward the interior of the detector hall, but this may have other implications – particularly if a turntable is used to rotate the carriage.

Component Options

X	Position of the object's origin relative to the red axis (horizontal axis orthogonal to the beamline).
Y	Position of the object's origin relative to the green axis (horizontal axis parallel to the beamline).
Z	Position of the object's origin relative to the blue axis (vertical axis orthogonal to the beamline).

All component dimensions are specified as centimeters unless otherwise stated.

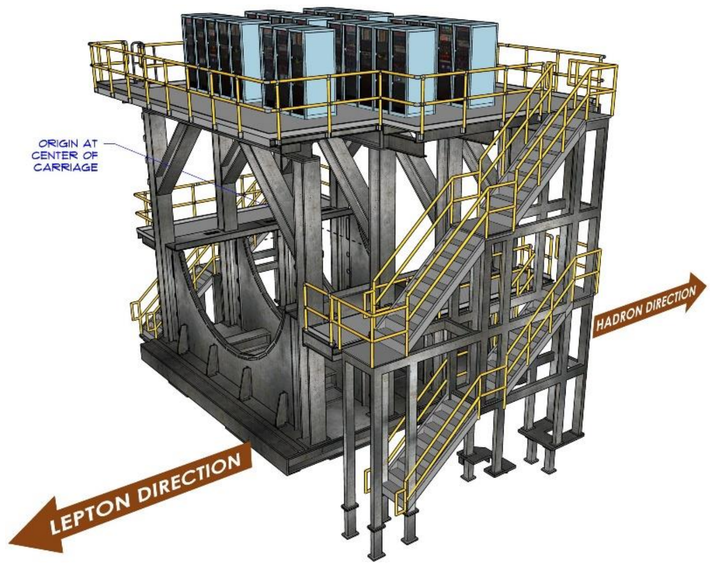

Figure 2: *IP-8 Fixed Carriage*

Methods for Weight Estimation

Jonathan Hock of Brookhaven National Lab estimates the total weight of this carriage to be 110 tons or 99,790 kg. This weight includes the four cradles and the base. The following table of values may be used to compute weight changes based on alternations in what is installed.

Item	*Basis*
Power Supplies	850.03 kg each
Computing Racks	226.80 kg each
Transformers	231.33 kg each

As new components (and component types) are added to the service carriage, their weights should be included in the table.

CTR Barrel Hadron Calorimeter (1 Part)

Overview

The barrel hadron calorimeter is the outer most detector and its radius governs the maximum radius of the central detector. For this collection of models, there are currently three types of HCALs. They have one, two and three part barrels respectively, along the radius to vary along the length of the detector. This component has a one part barrel, meaning that it has a continuous bore radius across its entire length.

In the interest of consistency, this component is constructed from 24 radial segments. As a central detector, its origin is located in the exact center of the object and its *offset* parameter can be used to move it along the beamline.

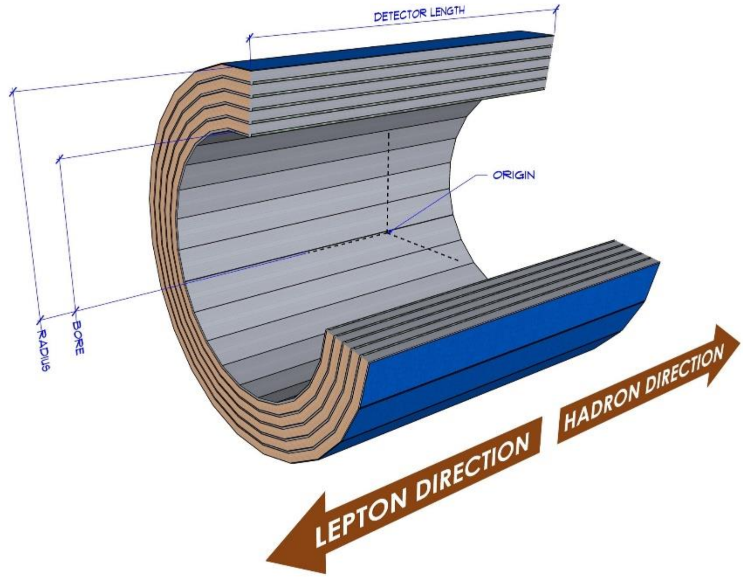

Figure 3: *Barrel Hadron Calorimeter (1 Part)*

Component Options

The barrel hadron calorimeter has the following options.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

One method of weight estimation for the barrel hadron calorimeter has been developed using the specifications from the CMS Hadron Calorimeter at CERN. The CMS HB HCAL is constructed from brass and plastic scintillator (CERN, Detector | CMS Experiment, 2021), and consist of 36 segments weighing 26 tons each, totaling 936 tons (849,125 kg) (CERN, 2021). The HB HCAL has a total volume of 109.5732 cubic meters (Abdullin, 2007).

Using the densities of brass (8,730 kg/m³) and scintillator plastics (1,023 kg/m³) in conjunction with the other parameters, it can be determined that this hadron calorimeter consist of 87.2763% brass and 12.7237% plastic. Instead of brass, this project will be using iron for the hadron calorimeter which has a density of 7,874 kg/m³.

Therefore, the following formula can be used to estimate the weight of a similarly constructed hadron calorimeter with a volume given in m³.

*weight = (0.872763*7874+0.127237*1023)*volume*

*weight = 7002.3 * volume*

where volume is given in cubic meters and the density is provided as kg/m³.

CTR

Barrel Hadron Calorimeter (2 Part)

Overview

This is a two-part barrel hadron calorimeter. The component consists of a lepton direction and hadron direction section, each of which have independently configurable radii.

As with other central detector components, the origin is in the center of the object and its position along the beamline is adjusted using the offset parameter. Positive offset values move the component in the lepton direction, while negative values move the component in the hadron direction.

In order to be consistent with the other components in the collection, this object is constructed using 24 radial segments. For simplicity, though, the volume of the component is computed using cylindrical volumes, which should be adequate for estimating weights.

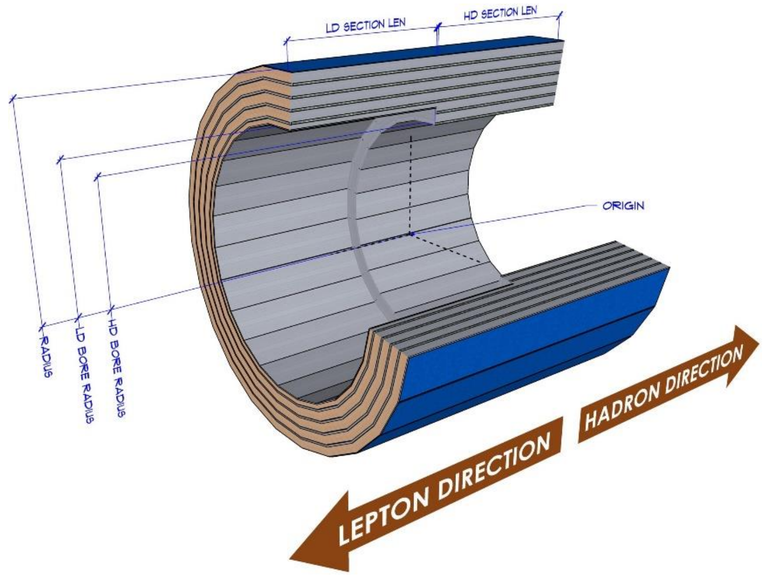

Figure 4: *Barrel Hadron Calorimeter (2 Part)*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line *(read-only)*.
LD Section Len	Length of the lepton direction section.
HD Section Len	Length of the hadron direction section.
LD Bore Radius	Radius from the origin to the inside of the lepton direction section of the detector.
HD Bore Radius	Radius from the origin to the inside of the hadron direction section of the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

Weight estimates for this object are also based on the CMS HB Hadron Calorimeter as described earlier. Using this approach, the weight can be calculated by applying a coefficient to the volume measured in m^3, where:

*weight = volume * 7002.3*

where volume is given in cubic meters and the density is provided as kg/m³.

*See the section describing the **one-part barrel hadron calorimeter** for details.*

CTR Barrel Hadron Calorimeter (3 Part)

Overview

This is a three-part barrel hadron calorimeter. The component consists of a lepton direction, center and hadron direction section, each of which have independently configurable radii.

As with other central detector components, the origin is in the center of the object and its position along the beamline is adjusted using the offset parameter. Positive offset values move the component in the lepton direction, while negative values move the component in the hadron direction.

In order to be consistent with the other components in the collection, this object is constructed using 24 radial segments. For simplicity, though, the volume of the component is computed using cylindrical volumes, which should be adequate for estimating weights.

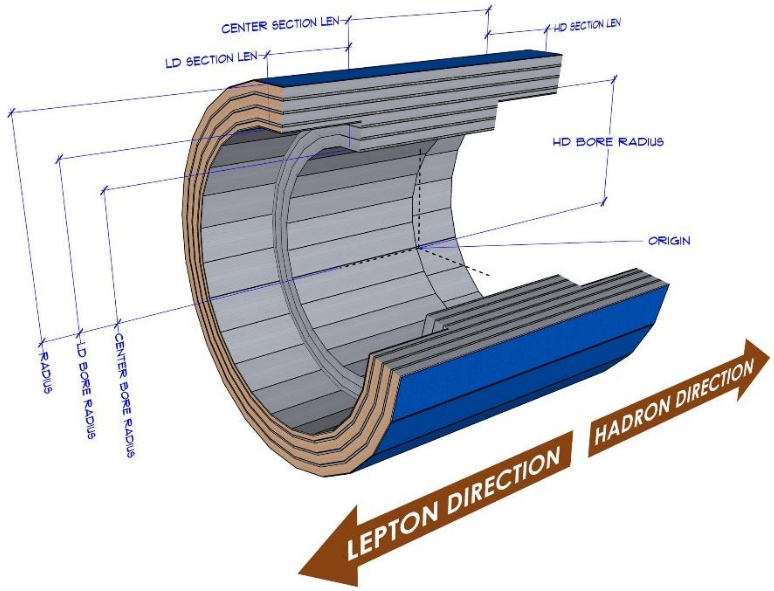

Figure 5: *Barrel Hadron Calorimeter (3 Part)*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line *(read-only)*.
LD Section Len	Length of the lepton direction section.
Center Section Len	Length of the center section.
HD Section Len	Length of the hadron direction section.
LD Bore Radius	Radius from the origin to the inside of the lepton direction section.
Center Bore Radius	Radius from the origin to the inside of the center section.
HD Bore Radius	Radius from the origin to the inside of the hadron direction section.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

Weight estimates for this object are also based on the CMS HB Hadron Calorimeter as described earlier. Using this approach, the weight can be calculated by applying a coefficient to the volume measured in m³, where:

*weight = volume * 7002.3*

where volume is given in cubic meters and the density is provided as kg/m³.

*See the section describing the **one-part barrel hadron calorimeter** for details.*

CTR Barrel Hadron Calorimeter with Spacers

Overview

This hadron calorimeter was designed specifically for the ATHENA proto-collaboration's detector design. It has 32 segments that are separated with spacers in order to increase its radius while still using existing components.

This is a three-part barrel hadron calorimeter. The component consists of lepton direction, center and hadron direction sections, each of which have independently configurable radii and lengths. If fewer than three sections are required, a section can be hidden by setting its *Section Length* to 0.0 cm.

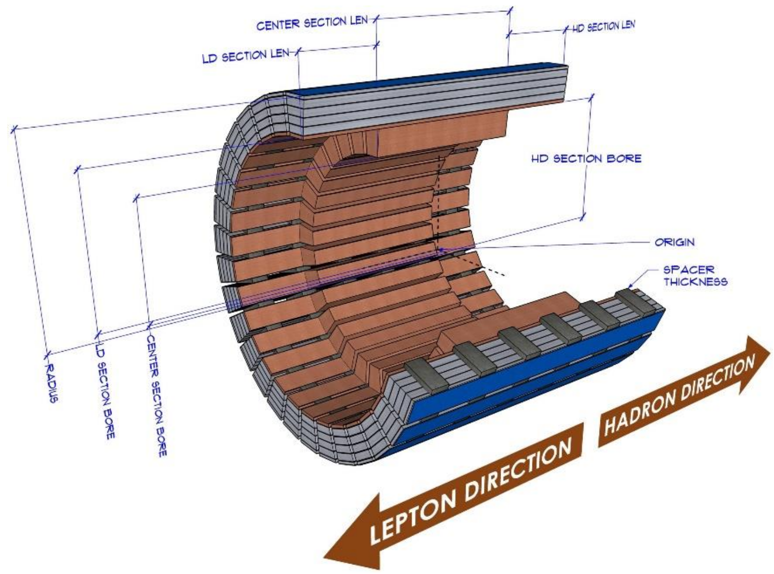

Figure 6: *Barrel Hadron Calorimeter with Spacers*

As with other central detector components, the origin is in the center of the object and its position along the beamline is adjusted using the offset parameter. Positive offset values move the component in the lepton direction, while negative values move the component in the hadron direction.

The volume of the component is computed using cylindrical volumes, which should be adequate for estimating weights.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line *(read-only)*.
LD Section Len	Length of the lepton direction section.
Center Section Len	Length of the center section.
HD Section Len	Length of the hadron direction section.
LD Section Bore	Radius from the origin to the inside of the lepton direction section.
Center Section Bore	Radius from the origin to the inside of the center section.
HD Section Bore	Radius from the origin to the inside of the hadron direction section.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Spacer Thickness	The thickness of the spacer blocks that are installed between each of the HCAL sectors.
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

Weight estimates for this object are also based on the CMS HB Hadron Calorimeter as described earlier. Using this approach, the weight can be calculated by applying a coefficient to the volume measured in m³, where:

*weight = volume * 7002.3*

where volume is given in cubic meters and the density is provided as kg/m³.

*See the section describing the **one-part barrel hadron calorimeter** for details.*

CTR Solenoid Cryostat

Overview

This component represents the cryostat for the solenoid magnet within the detector. It has a configurable length, radius and bore. The origin of this object is at its center, and its position along the beamline is adjusted using the offset parameter.

Because the objects in this collection are simplified to make them lightweight and easy to use, this cryostat does not show the connections that lead to the cryogenic system. Still, the final design will need to consider the entry point for cryogenic services and how they will be routed through the rest of the system.

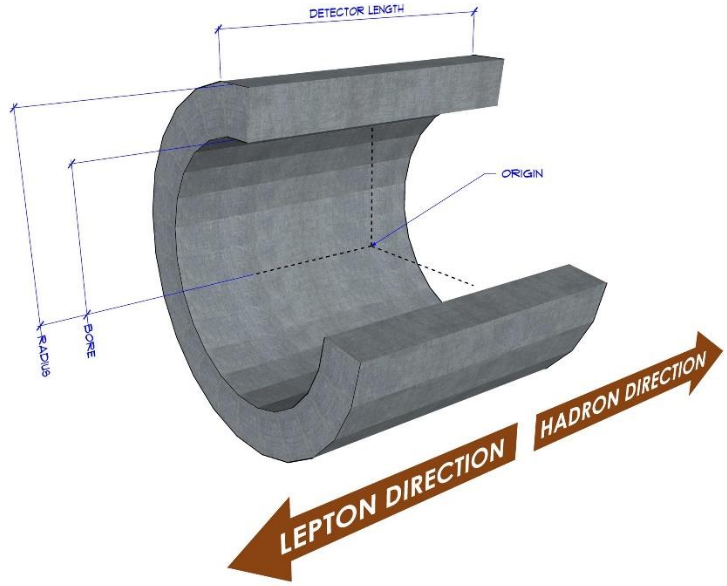

Figure 7: *Solenoid Cryostat*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Cryostat Length	Total length of the cryostat along the beam line.
Bore	Radius from the origin to the inside of the cryostat.
Radius	Radius from the origin to the outside of the cryostat.
Offset from Center	Distance along the beamline that the cryostat's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The weight of this component may be computed using the known weight and volume of the CLEO II cryostat as a parametric basis. The CLEO II cryostat has a total weight of 22,000 kg and a volume of 11.3021 cubic meters (Kubota, 1992). Therefore, the weight of any similar cryostat can be estimated using a coefficient in conjunction with the volume measured in m^3, where:

*weight = volume * 1,946.54*

CTR Barrel Support

Overview

The barrel support component is a simplification of the barrel calorimeter support design developed by Roland Wimmer at Brookhaven National Laboratory. The role of this component is to support the barrel electromagnetic calorimeter within the solenoid cryostat. It has extension arms that transfer the weight of it and its contents to the bore of the barrel hadron calorimeter.

The supporting walls of this component are 7.62 cm thick, therefore that space must be included between the bore of the cryostat and the exterior radius of the barrel electromagnetic calorimeter. This object will be constructed from non-magnetic stainless steel.

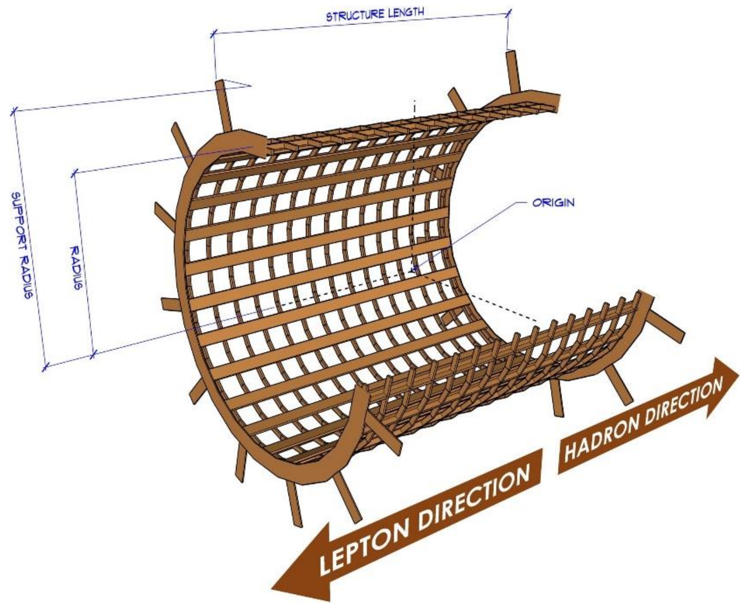

Figure 8: *Barrel Support*

Component Options

The following options are available for configuring the barrel support.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Structure Length	Total length of the structure along the beam line.
Bore	The radius from the origin to the inside of the structure.
Radius	The radius from the origin to the outside of the structure *(should be equal to the bore of the parent detector).*
Support Radius	The radius from the origin to the supporting structure to which this assembly attaches.
Offset from Center	The distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

Because the barrel support will be custom built based on the dimensions of surrounding objects, it is difficult to provide an exact method for computing the weight without constructing a CAD model. However, using a density of 7,480 kg/m³ for stainless steel, it is possible to produce a rough estimate based on the radius and length of the barrel support in current models.

The formula for producing this rough weight estimate is:

*weight = PI * radius^2 * length * 157.6 kg*

Therefore, a barrel support with a radius of 1.60 m and a length of 3.84 m can be estimated to weigh 4,867 kg.

CTR Inhomogeneous Barrel Electromagnetic Calorimeter

Overview

The inhomogeneous barrel electromagnetic calorimeter is another of the central detector components. Its general dimensions are specified by providing a detector length, radius and bore. The origin of this component is at the center, and its position along the beamline is altered by changing the offset parameter.

This object is constructed from 24 radial segment like many of the other components in the collection. For simplicity, the volume is computed by subtracting the cylindrical volume of the bore from the cylindrical volume of the radius.

The "inhomogeneous" barrel electro-magnetic calorimeter has crystals that run the length of the detector.

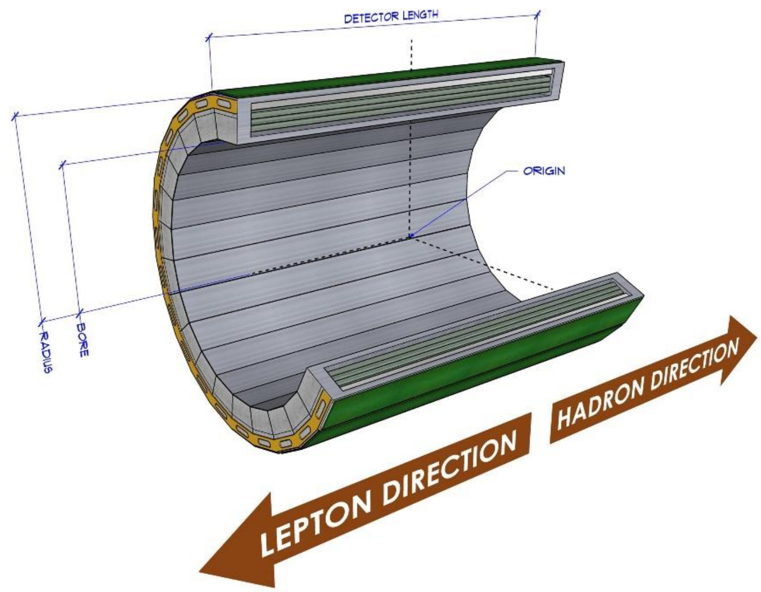

Figure 9: *Inhomogeneous Barrel Electromagnetic Calorimeter*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

Weight estimates for the barrel electromagnetic calorimeter are dependent on the technology and the construction material. For this document, the CMS electromagnetic calorimeter was used to create a parametric estimate. The cylindrical barrel of the CMS ECAL-EB detector consists of 61,200 crystals formed into 36 "supermodules", each weighing around three tons and containing 1700 crystals, for a total weight of 97,976 kg (CERN, 2021). Based on reference documents, the volume of the ECAL-EB is 27.94 m³ (Abdullin, 2007).

Further, the ECAL-EB is constructed of 61,200 lead tungstate crystals measuring 2.2cm x 2.2cm x 23cm with a density of 8.3 g/cm³ (CERN, 2021). Therefore, 58% of the weight of this detector is represented by lead tungstate glass, while 42% of the detector is represented by other materials. Using this information, a general, volume-based estimate for the weight of the barrel calorimeter is given by:

*weight = volume * 3,506.66*

where volume is the total volume of the barrel calorimeter given in cubic meters.

If crystals will be used with a different density, then the weight can be estimated as:

*weight = density*volume*0.2438 + volume*1482.82*

where density is the density of the crystals given in kg/m³ and volume is the total volume of the barrel calorimeter given in cubic meters.

CTR Homogeneous Barrel Electromagnetic Calorimeter

Overview

The homogeneous barrel electromagnetic calorimeter is another of the central detector components. Its general dimensions are specified by providing a detector length, radius and bore. The origin of this component is at the center, and its position along the beamline is altered by changing the offset parameter.

This object is constructed from 24 radial segment like many of the other components in the collection. For simplicity, the volume is computed by subtracting the cylindrical volume of the bore from the cylindrical volume of the radius.

The "homogeneous" barrel electromagnetic calorimeter has crystals that are positioned orthogonal to the beamline.

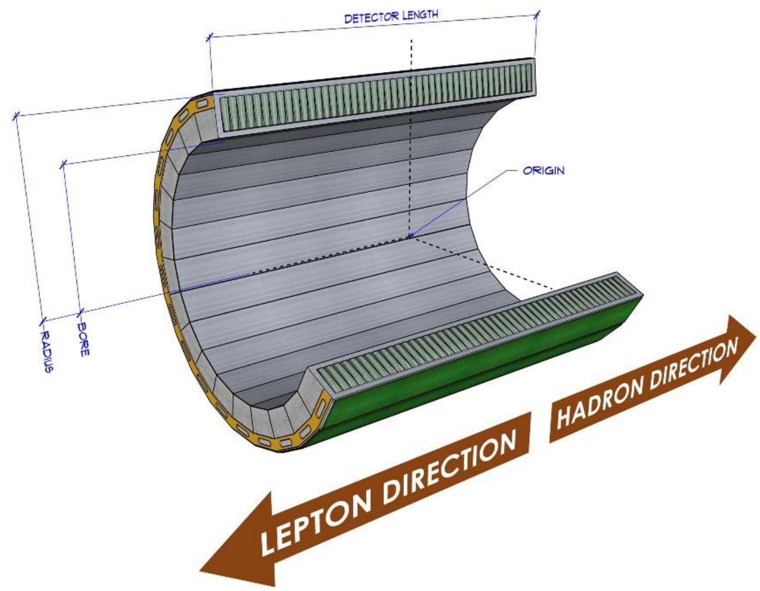

Figure 10: *Homogeneous Barrel Electromagnetic Calorimeter*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

Weight estimates for the barrel electromagnetic calorimeter are based on the CMS electromagnetic calorimeter described earlier. Using this approach, a general, volume-based estimate for the weight of the barrel calorimeter is given by:

*weight = volume * 3,506.66*

where volume is the total volume of the barrel calorimeter given in cubic meters.

If crystals will be used with a different density, then the weight can be estimated as:

*weight = density*volume*0.2438 + volume*1482.82*

where density is the density of the crystals given in kg/m³ and volume is the total volume of the barrel calorimeter given in cubic meters.

CTR Homogeneous-Projective Barrel Electromagnetic Calorimeter

Overview

The homogeneous-projective barrel electromagnetic calorimeter is another of the central detector components, and has crystals that are positioned radially around the interaction point. Its general dimensions are specified by providing a detector length, radius and bore. The origin of this component is at the center, and its position along the beamline is altered by changing the offset parameter.

This is a complex component with many parts. For simplicity, the volume is computed by subtracting the cylindrical volume of the bore from the cylindrical volume of the radius.

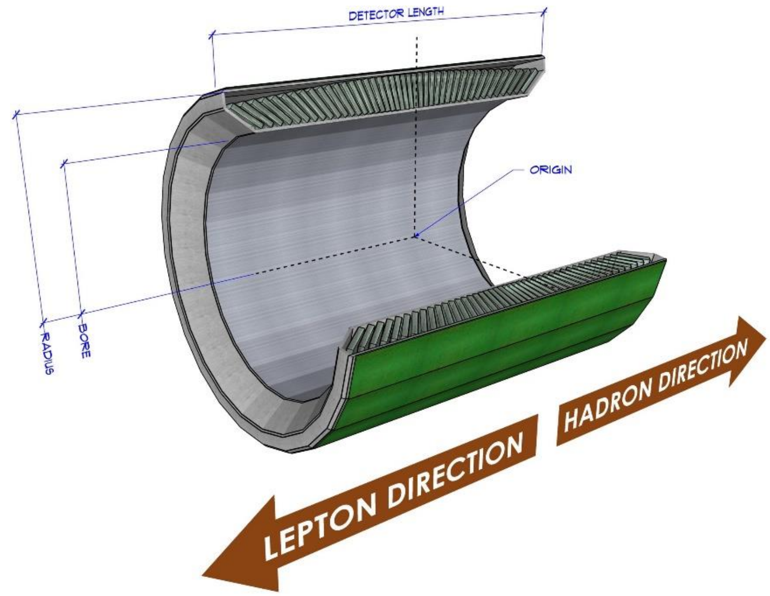

Figure 11: *Homogeneous-Projective Barrel Electromagnetic Calorimeter*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Wall Thickness	The thickness of the walls of the cylinder surrounding the crystals.
Minimum Inter-Crystal Gap	The minimum space between crystals in the detector.
Hadron Crystal Thickness	The thickness (across the beam line) of the crystals installed on the hadron direction side. Use -1 to make them maximum width.
Hadron Crystal Length	The length of the crystals on the hadron direction side. Use -1 to make them maximum length.
Hadron Crystal Width	The width (along the beam line) of the crystals on the hadron direction side.
Lepton Crystal Thickness	The thickness (across the beam line) of the crystals installed on the lepton direction side. Use -1 for maximum width.
Lepton Crystal Length	The length of the crystals on the lepton direction side. Use -1 for maximum length.
Lepton Crystal Width	The width (along the beam line) of the crystals on the lepton direction side.
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

Weight estimates for the barrel electromagnetic calorimeter are based on the CMS electromagnetic calorimeter described earlier. Using this approach, a general, volume-based estimate for the weight of the barrel calorimeter is given by:

*weight = volume * 3,506.66*

where volume is the total volume of the barrel calorimeter given in cubic meters.

If crystals will be used with a different density, then the weight can be estimated as:

*weight = density*volume*0.2438 + volume*1482.82*

where density is the density of the crystals given in kg/m³ and volume is the total volume of the barrel calorimeter given in cubic meters.

CTR AC-Coupled Low-Gas Avalanche Detector

Overview

The AC-coupled low-gas avalanche detector homogeneous (AC-LGAD) is a proposed component of the central detector. Because this is a new configuration for this type of detector, most of the modeling information contained here is speculative, as is the physical design of the component. Like the other detectors, its general dimensions are specified by providing a detector length, radius and bore. The origin of this component is at the center, and its position along the beamline is altered by changing the offset parameter.

This object is constructed from 24 radial segment like many of the other components in the collection. For simplicity, the volume is computed by subtracting the cylindrical volume of the bore from the cylindrical volume of the radius.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

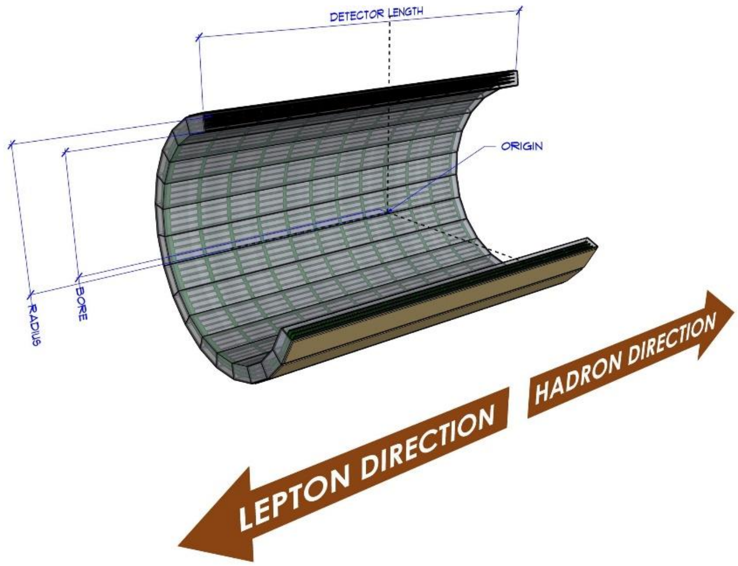

Figure 12: *Barrel Electromagnetic Calorimeter*

Methods for Weight Estimation

Because the design of this component is speculative, the weight estimate is also somewhat vague. For the purpose of this calculation it is assumed that the device has a metallic covering (14 gauge stainless steel at 15.93 kg/m²) and the volume is filled with 50% silicon and 50% air (or gas).

$$\text{covering weight} = 0.001593 * \pi * ((2 * \text{radius} * \text{len}) + (2 * \text{bore} * \text{len}) + (\text{radius}^2 - \text{bore}^2))$$

$$\text{silicon weight} = 2330 * \text{volume}/2$$

where the total weight is the sum of the covering weight and the silicon weight.

CTR Lepton Direction DIRC

Overview

This is the first of two DIRC detector components. The supports are based on a design by Roland Wimmer. In this configuration, the DIRC's readouts are facing in the lepton direction and the DIRC bars extend toward the center in the hadron direction.

The origin of the DIRC is not in the center of the component, but rather, immediately behind the readout – where the DIRC bars begin. Additionally, because the DIRC segments are a fixed size, the number of segments increase as the radius increases, in order to maximize coverage. The number of DIRC segments is computed using the radius and the DIRC bar width.

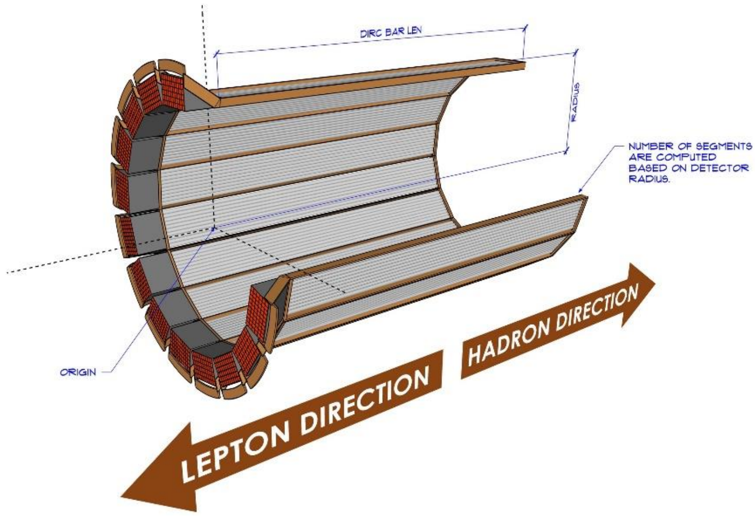

Figure 13: *Lepton Direction DIRC*

Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Segment Count	The number of DIRC assemblies that can be installed in the specified radius.
Support Thickness	The thickness of the support structure holding the quartz DIRC bars.
Detector Volume	Volume in cubic meters of the detector bars and readouts *(read-only)*.
Support Volume	Volume in cubic meters of the support structure *(read-only)*.

All component dimensions are specified as centimeters unless otherwise stated.

The bore size is automatically computed based on the size of the support structure and the radius of the overall detector. This value is calculated within the model to make it easier to specify the size of sub-components within the DIRC.

To simplify weight calculations, the component automatically provides estimates for the volume of the detector (the DIRC bars and readouts) and the volume of the support structure.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
DIRC Bar Len	Length of the quartz bars of the DIRC detector *(all other elements have a fixed length)*.
DIRC Bar Thickness	The thickness of the quartz bars of the DIRC detector.
DIRC Bar Width	The width of the quartz bars in a single DIRC segment.
Bore	The computed radius from the origin to the inside of the detector based on the overall radius and number of segments *(read-only)*.

Methods for Weight Estimation

The weight of the detector may be estimated by summing the detector volume multiplied by the density of its primary material (quartz = 2,320 kg/m^3) and the support volume multiplied by the density of its primary material (stainless steel = 7,480 kg/m^3).

*weight = detector volume * 2320 + support volume * 7480*

where volumes are given in cubic meters and densities are provided as kg/m^3.

CTR Hadron Direction DIRC

Overview

This is the second of the DIRC detector components. In this configuration, the DIRC's readouts are facing in the hadron direction and the DIRC bars extend toward the center in the lepton direction.

As before, the origin of the DIRC is not in the center of the component, but rather, immediately behind the readout – where the DIRC bars begin. Additionally, because the DIRC segments are a fixed size, the number of segments increase as the radius increases, in order to maximize coverage. The number of DIRC segments is computed using the radius and the DIRC bar width.

The bore size is automatically computed based on the size of the support structure and the radius of the overall detector. This value is calculated within the model to make it easier to specify the size of sub-components within the DIRC.

To simplify weight calculations, the component automatically provides estimates for the volume of the detector (the DIRC bars and readouts) and the volume of the support structure.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
DIRC Bar Len	Length of the quartz bars of the DIRC detector *(all other elements have a fixed length).*
DIRC Bar Thickness	The thickness of the quartz bars of the DIRC detector.
DIRC Bar Width	The width of the quartz bars in a single DIRC segment.
Bore	The computed radius from the origin to the inside of the detector based on the overall radius and number of segments *(read-only)*.
Radius	Radius from the origin to the outside of the detector.

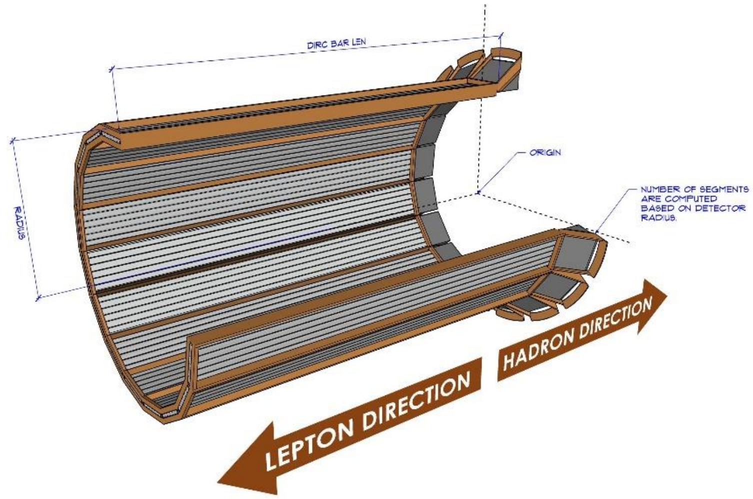

Figure 14: *Hadron Direction DIRC*

Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Segment Count	The number of DIRC assemblies that can be installed in the specified radius.
Support Thickness	The thickness of the support structure holding the quartz DIRC bars.
Detector Volume	Volume in cubic meters of the detector bars and readouts *(read-only)*.
Support Volume	Volume in cubic meters of the support structure *(read-only).*

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The weight of the detector may be estimated by summing the detector volume multiplied by the density of its primary material (quartz = 2,320 kg/m^3) and the support volume multiplied by the density of its primary material (stainless steel = 7,480 kg/m^3).

*weight = detector volume * 2320 + support volume * 7480*

where volumes are given in cubic meters and densities are provided as kg/m^3.

CTR

Block EMCal

Overview

This is a version of the electromagnetic calorimeter that is designed to fit anywhere within the central detector. It features inner and outer blocks, each of which can be set to specific lengths.

As this detector moves along the beamline, its origin shifts. This is important, because the crystals are aligned on the side of the detector that is facing the interaction point. As a result, if the detector is positioned on the lepton side of the interaction point, its placement will be calculated from the inner most face (the hadron side). Likewise, if the detector is positioned on the hadron side, its placement will be calculated from the face on the lepton side.

The block count is calculated with the assumption that the interior blocks are 2x2 cm, and that the outer blocks are 4x4 cm. The volume of this object represents the volumes of the crystals and the structural supports.

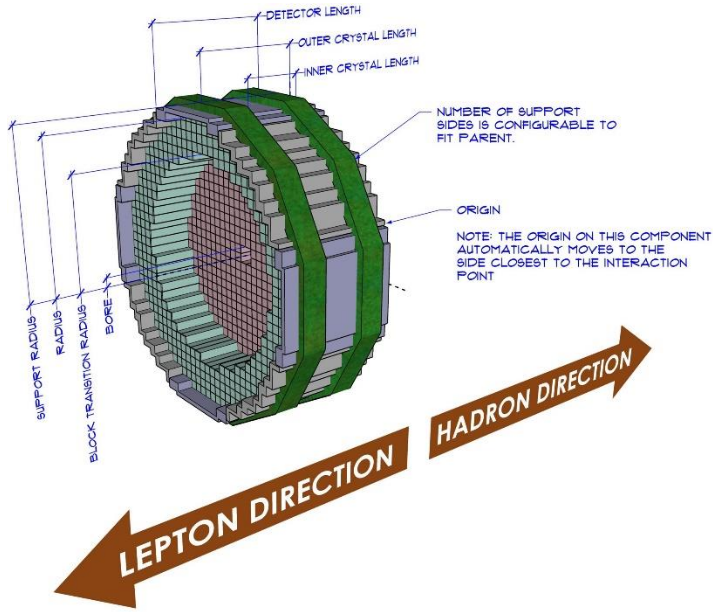

Figure 15: *Block Electromagnetic Calorimeter*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Inner Block Count	Estimated number of 2x2 cm blocks that will fit in the interior radial volume.
Outer Block Count	Estimated number of 4x4 cm blocks that will fit in the exterior radial volume.
Detector Length	Total length of the detector along the beam line.
Block Transition Radius	The radius at which the blocks change from the inner blocks to the outer blocks.
Bore	Radius from the origin to the inside of the detector.
Inner Crystal Length	The length of the inner most crystals in the detector.
Outer Crystal Length	The length of the outer most crystals in the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Support Sides	Number of sides on the supporting structure *(typically matches the number of sides on the parent detector)*.
Support Radius	Radius from the origin to the supporting structure to which this assembly attaches *(typically, the parent's bore radius)*.
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The volume parameter of this detector includes the volume of the lead glass and the support structure. A weight estimate for this object can be generated by multiplying the volume of the glass by the density of lead glass and the balance of the volume by the density of steel. For a more precise calculation, the user may independently compute the volumes of lead glass and lead tungstate glass, as their density differs. A simple weight estimate is given by:

$$glass = ((PI * radius^2)-(PI * bore^2))*length$$

$$steel = ((PI * supportRadius^2)-(PI * radius^2))*length$$

$$weight = glass*6220\ kg/m^3 + steel*7850\ kg/m^3$$

CTR AC-Coupled Low-Gas Avalanche Disk Detector

Overview

The AC-Coupled Low-Gas Avalanche Detector uses the standard set of parameters that are available in the other detector components. This component has a dynamic origin, which means the positioning point for the object will always be located on the side that is nearest to the interaction point, allowing it to be used on either side of the detector.

As with other components, the object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the *offset* parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

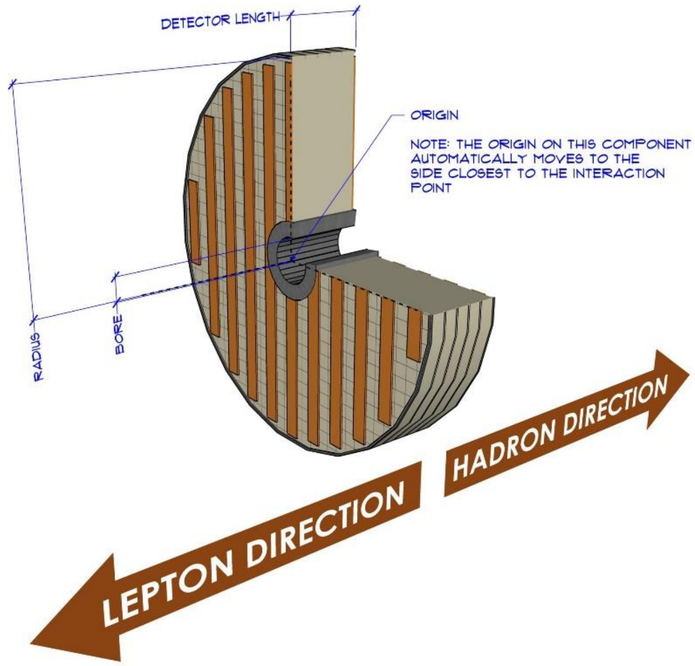

Figure 16: *AC-Coupled Low-Gas Avalanche Disk Detector*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

Because the design of this component is speculative, the weight estimate is also somewhat vague. For the purpose of this calculation it is assumed that the device has a metallic covering (14 gauge stainless steel at 15.93 kg/m²) and the volume is filled with 50% silicon and 50% air (or gas).

*covering weight = 0.001593 * π * ((2 * radius * len) + (2 * bore * len) + (radius² - bore²))*

*silicon weight = 2330*volume/2*

where the total weight is the sum of the covering weight and the silicon weight.

CTR GEM Chamber Disk Detector

Overview

The GEM detector uses the standard set of parameters that are available in the other detector components. This component has a dynamic origin, which means the positioning point for the object will always be located on the side that is nearest to the interaction point, allowing it to be used on either side of the detector.

As with other components, the object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the *offset* parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Readout Card Length	This is the length of the readout cards that are located along the perimeter of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders).*

All component dimensions are specified as centimeters unless otherwise stated.

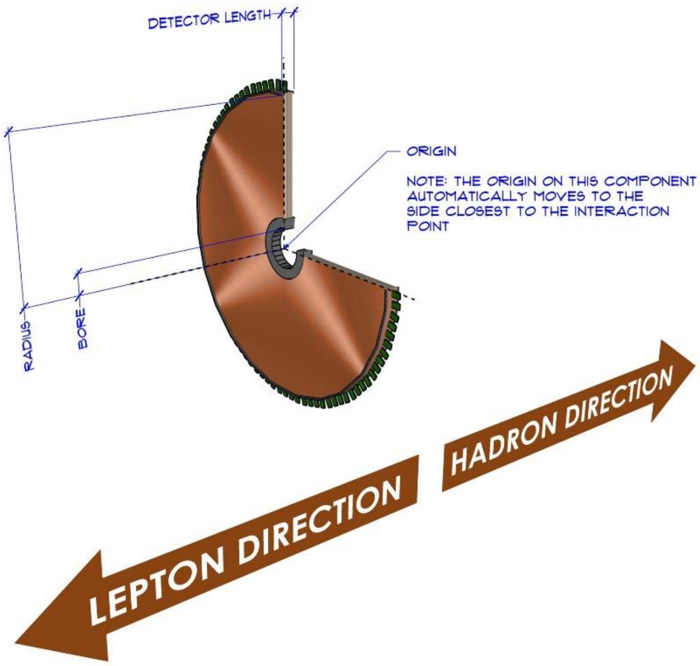

Figure 17: *GEM Chamber Disk Detector*

Methods for Weight Estimation

The weight of the GEM detector may be estimated based on the parameters from the Super BigBite GEM trackers (Liyanage, 2013). In this design, each chamber weighed 5 kg and was 50cm x 50cm x 10cm, providing the following formula:

*weight = volume * 200*

where volume is given in cubic meters and the density is provided as kg/m³.

CTR GEM Chamber Barrel Detector

Overview

The GEM detector uses the standard set of parameters that are available in the other detector components. The origin of this component is at the center, and its position along the beamline is altered by changing the offset parameter.

As with other components, the object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the *offset* parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

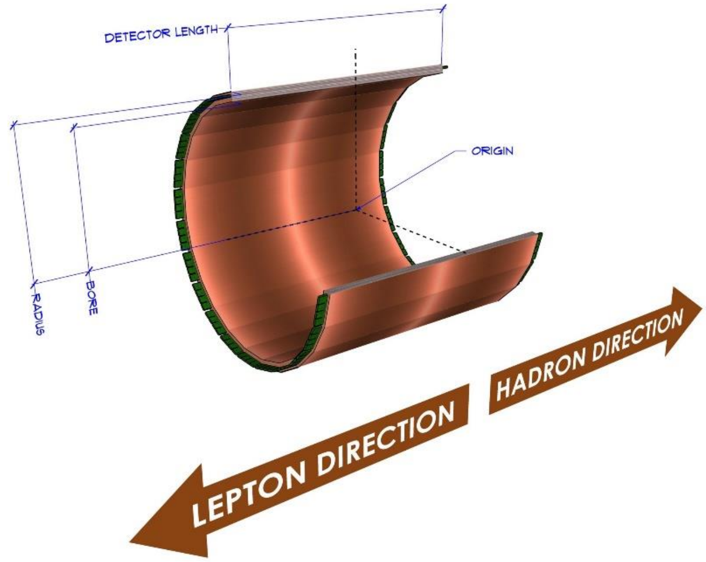

Figure 18: *GEM Chamber Barrel Detector*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Readout Card Length	This is the length of the readout cards that are located along the perimeter of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The weight of the GEM detector may be estimated based on the parameters from the Super BigBite GEM trackers (Liyanage, 2013). In this design, each chamber weighed 5 kg and was 50cm x 50cm x 10cm, providing the following formula:

*weight = volume * 200*

where volume is given in cubic meters and the density is provided as kg/m³.

CTR Time of Flight Detector

Overview

The Time of Flight detector uses the standard set of parameters that are available in the other detector components. This component has a dynamic origin, which means the positioning point for the object will always be located on the side that is nearest to the interaction point, allowing it to be used on either side of the detector.

As with other components, the object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the *offset* parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

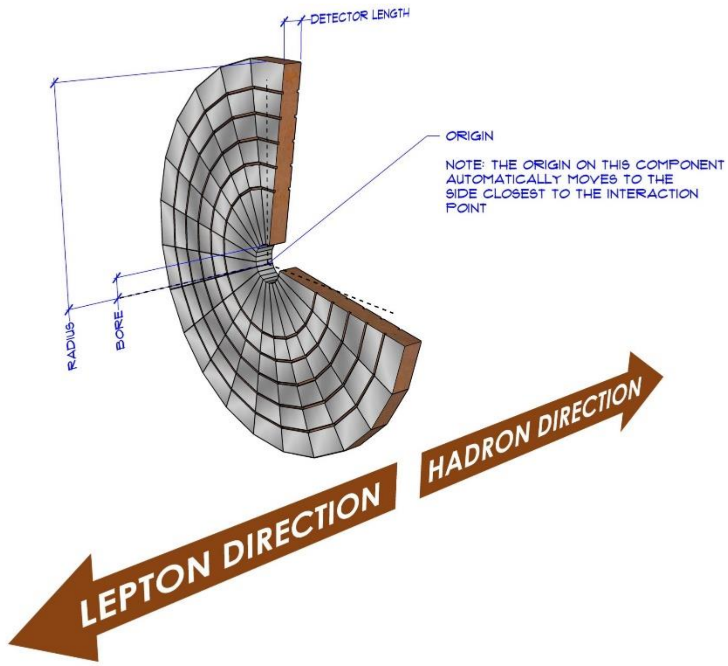

Figure 19: *Time of Flight Detector*

Methods for Weight Estimation

A parametric approach for weight estimation has been developed based on the PANDA forward time of flight detector (PANDA Collaboration, 2018). The weight of the PANDA detector together with the supporting frame, the wheels and the rail is estimated to be 800 kg, and it has a volume of 1,320,000 cm^3. Therefore, using the volume parameter of the dynamic component, the weight can be estimated as follows:

*weight = volume * 606.1*

where volume is given in cubic meters and the density is provided as kg/m^3.

CTR Cherenkov Counter

Overview

The Cherenkov Counter uses the standard set of parameters that are available in the other detector components. This component has a dynamic origin, which means the positioning point for the object will always be located on the side that is nearest to the interaction point, allowing it to be used on either side of the detector.

As with other components, the object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the *offset* parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

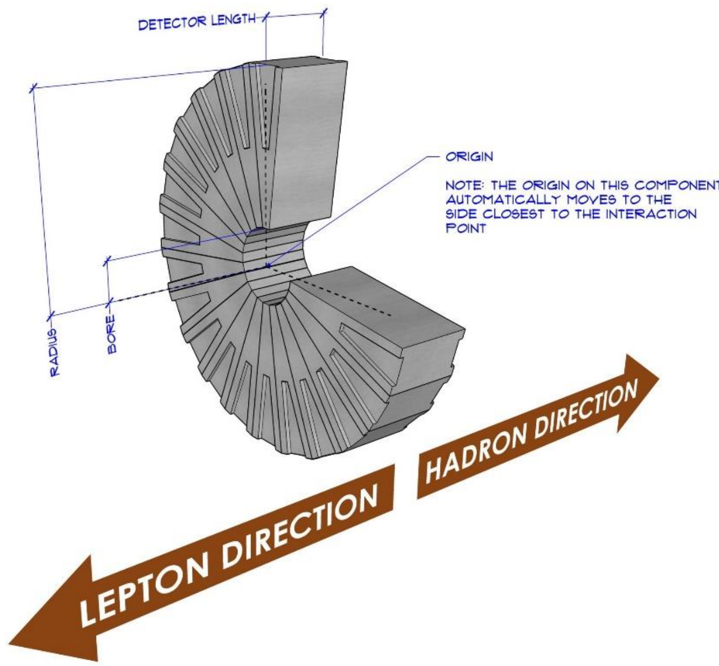

Figure 20: *Cherenkov Counter*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The weight of the RICH detector can be estimated using the parameters from the CLAS12 RICH detector (CLAS Collaboration, 2013). As noted in their technical design report, each RICH sector weighs 1300 kg, and the modeled volume of a RICH sector is 7.011 m³. This allows the volume to be used to compute the weight as follows:

*weight = volume * 185.42*

where volume is given in cubic meters and the density is provided as kg/m³.

CTR Micro-Pattern Gas Detector

Overview

The micro-pattern gas detector uses the standard set of parameters that are available in the other detector components. This component has a dynamic origin, which means the positioning point for the object will always be located on the side that is nearest to the interaction point, allowing it to be used on either side of the detector.

As with other components, the object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the *offset* parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

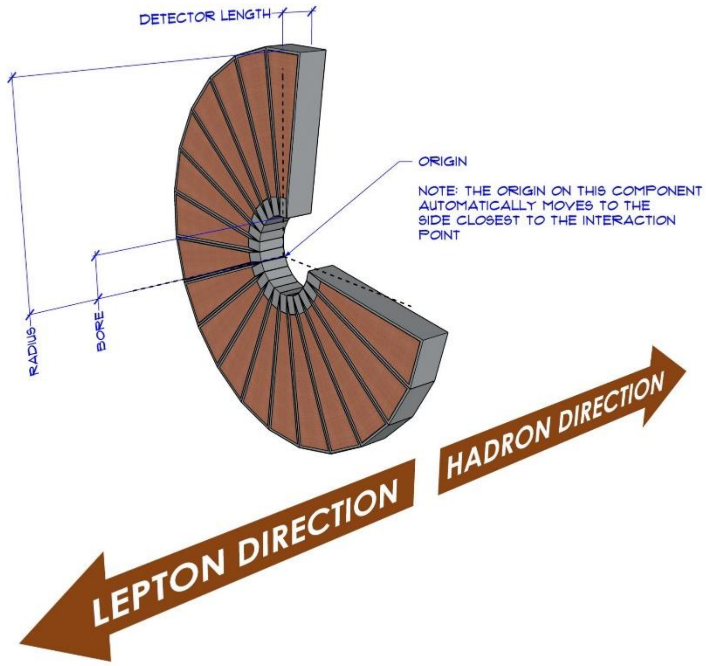

Figure 21: *Micro-Pattern Gas Detector*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The weight of the micro-pattern gas detector may be estimated based on the parameters from the Super BigBite GEM trackers (Liyanage, 2013). In this design, each chamber weighed 5 kg and was 50cm x 50cm x 10cm, providing the following formula:

*weight = volume * 200*

where volume is given in cubic meters and the density is provided as kg/m³.

CTR Outer Tracking

Overview

The outer tracking component is currently a placeholder that could represent a variety of tracking systems, such as a time projection chamber. As the design process continues, additional components will be introduced that better represent the exact technology being used and the options that are available.

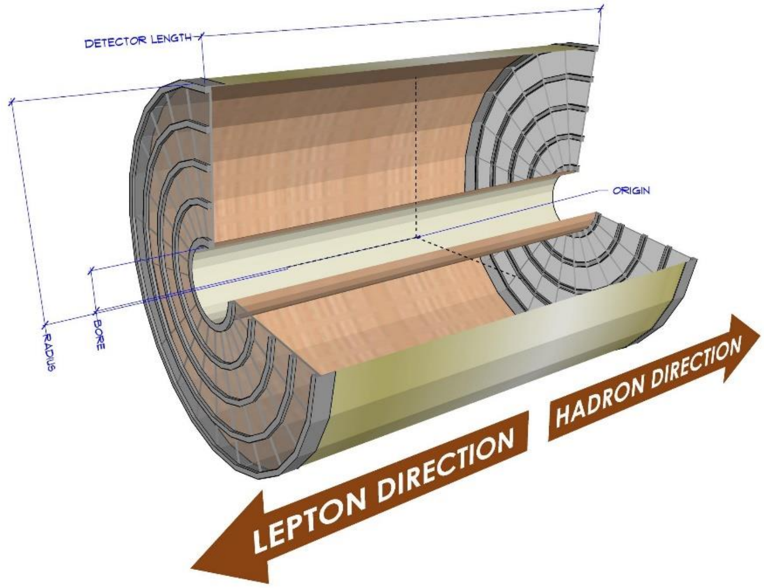

Figure 22: *Outer Tracking*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

Because the exact technology being used for the outer tracking system has not been defined, an exact approach for estimating weight cannot be provided. Still, a preliminary estimate can be computed using the sPHENIX time project chamber as a basis.

The sPHENIX TPC is 200 cm long, with an exterior radius of 80 cm and a bore of 40 cm (Brookhaven National Laboratory, 2015) , giving it a volume of 3.02 m³. This assembly has a total weight of 295.7 kg (Hemmick, 2019). Therefore, a parametric estimate for an outer tracking system using a time projection chamber is given as:

*weight = volume * 98.06*

where volume is given in cubic meters and the density is provided as kg/m³.

CTR Silicon Detector

Overview

The silicon detector is installed at the core of the central detector and is expected to be constructed with the inner most section of the beamline included. This is a preliminary model of the silicon detector which is based on engineering models created by James Fast and Brian Eng of Jefferson Lab. Revised models are in development that will allow the user to specify the size of sensors being used, and the number and dimensions of the staves.

As with other central detector components, the origin of this component is at its center and its position along the beamline is adjusted using the *offset* parameter.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector *(this is an advisory value and is currently used only for computing volume)*.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

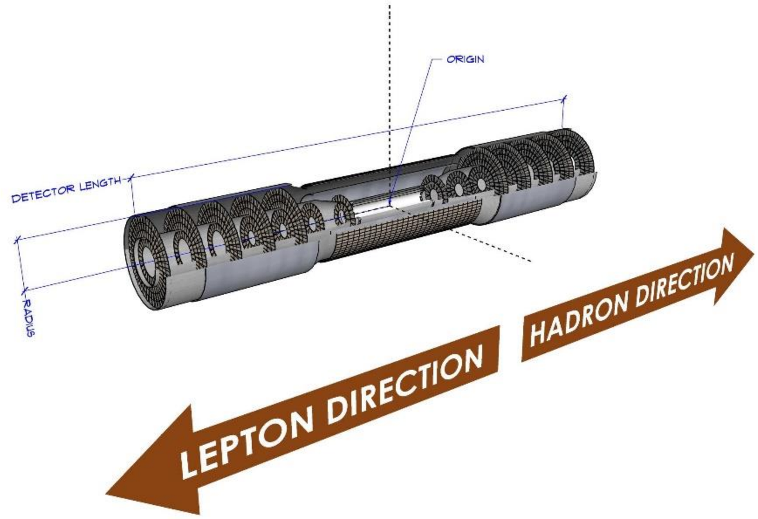

Figure 23: *Silicon Detector*

Methods for Weight Estimation

A preliminary weight estimation can be derived by using the dimensions and materials shown in the design from Fast and Eng. In this model, the cylindrical volume of the detector is 0.30 m³. The volume of the detector that is represented by copper conductor and tubing is 0.002433 m³, the volume represented by aluminum is 0.0001573, and the volume represented by silicon is 0.002390 m³. The balance of the volume is considered to be inert gas. Using the standard densities of copper, aluminum and silicon, the formula for computing the weight of the silicon detector is given as follows:

*weight = volume * 92.31*

where volume is given in cubic meters and the density is provided as kg/m³.

CTR ECCE Silicon Detector

Overview

This version of the Silicon Detector was designed specifically for the ECCE proto-collaboration. It has only positioning parameters (X, Y, and Z). All other parameters are fixed.

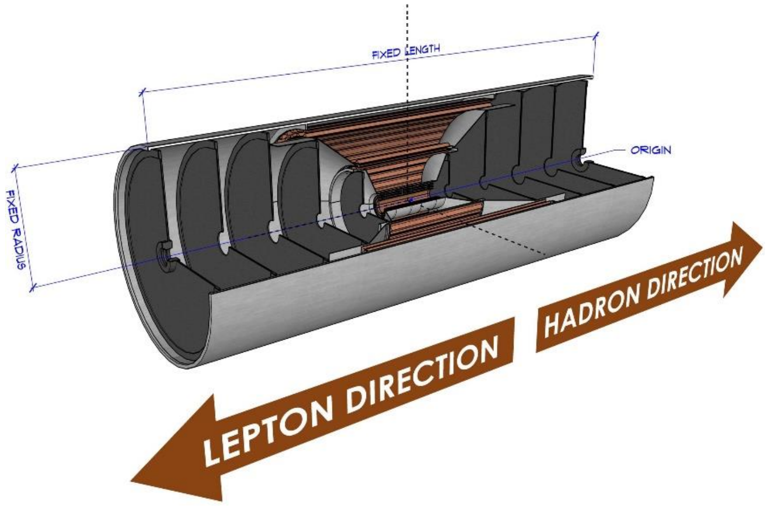

Figure 24: *Silicon Detector*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

A preliminary weight estimation can be derived by using the dimensions and materials shown in the design from Fast and Eng. In this model, the cylindrical volume of the detector is 0.30 m^3. The volume of the detector that is represented by copper conductor and tubing is 0.002433 m^3, the volume represented by aluminum is 0.0001573, and the volume represented by silicon is 0.002390 m^3. The balance of the volume is considered to be inert gas. Using the standard densities of copper, aluminum and silicon, the formula for computing the weight of the silicon detector is given as follows:

> *weight = volume * 92.31*
>
> *where volume is given in cubic meters and the density is provided as kg/m³.*

CTR ATHENA Silicon Detector

Overview

This version of the Silicon Detector was designed specifically for the ATHENA proto-collaboration. It has only positioning parameters (X, Y, and Z). All other parameters are fixed.

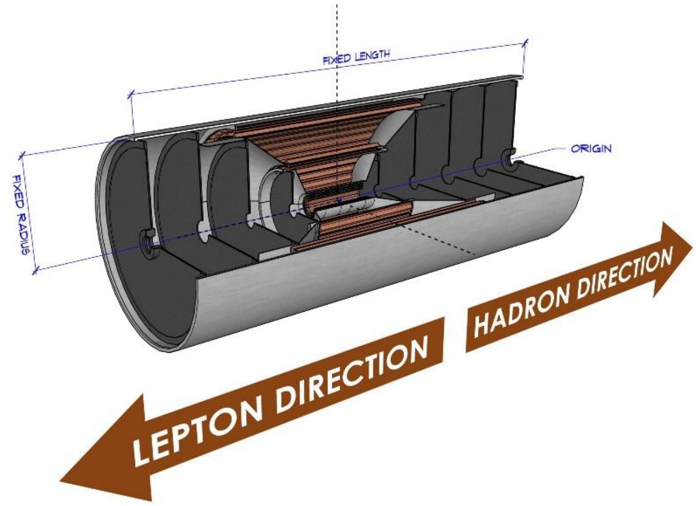

Figure 25: *ATHENA Silicon Detector*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

A preliminary weight estimation can be derived by using the dimensions and materials shown in the design from Fast and Eng. In this model, the cylindrical volume of the detector is 0.30 m³. The volume of the detector that is represented by copper conductor and tubing is 0.002433 m³, the volume represented by aluminum is 0.0001573, and the volume represented by silicon is 0.002390 m³. The balance of the volume is considered to be inert gas. Using the standard densities of copper, aluminum and silicon, the formula for computing the weight of the silicon detector is given as follows:

*weight = volume * 92.31*

where volume is given in cubic meters and the density is provided as kg/m³.

CTR Generic Silicon Detector

Overview

This version of the silicon detector was designed to provide a flexible replacement for the existing, proto-collaboration specific detectors described earlier. This component includes up to 12 silicon disks, each of which has a configurable position, bore, radius and disk thickness.

The offset parameter is not provided in this component, because it's disks are positioned explicitly and the body of the detector will extend from the first silicon disk until the last. The disks are positioned along the beamline, with positive positions extending in the lepton direction and negative positions going toward the hadron direction.

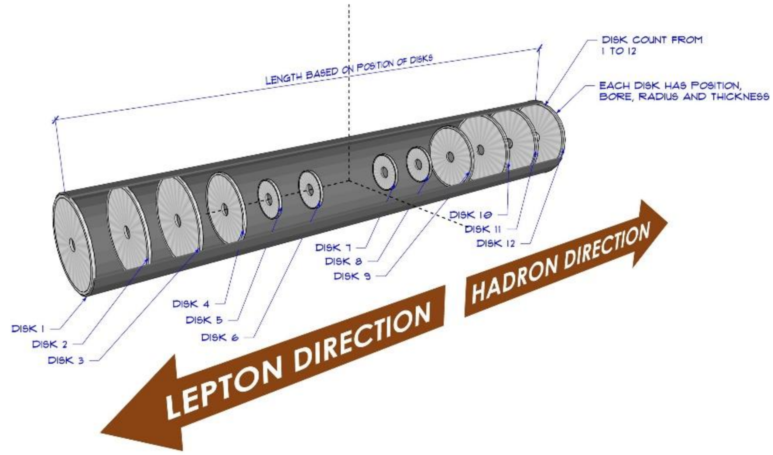

Figure 26: *Silicon Detector*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Outer Wall Thickness	The thickness of the outer casing that is surrounding the silicon disks.
Disk Cnt	The number of silicon disks in the detector (from 1 to 12).
Bore 01 to 12	The bore radius of each disk.
Disk Position 01 to 12	The position of the center of each silicon disk along the beamline.
Radius 01 to 12	The radius of each disk.
Disk Thickness 01 to 12	The thickness of each disk.
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

A preliminary weight estimation can be derived by using the dimensions and materials shown in the design from Fast and Eng. In this model, the cylindrical volume of the detector is 0.30 m^3. The volume of the detector that is represented by copper conductor and tubing is 0.002433 m^3, the volume represented by aluminum is 0.0001573, and the volume represented by silicon is 0.002390 m^3. The balance of the volume is considered to be inert gas. Using the standard densities of copper, aluminum and silicon, the formula for computing the weight of the silicon detector is given as follows:

*weight = volume * 92.31*

where volume is given in cubic meters and the density is provided as kg/m

CTR Micromega Cylinder – Single Layer

Overview

The micromega cylinders are typically distributed within the structure of the silicon detector. The Detector Menagerie contains several types of micromegas that can be combined to create a layered detector using multiple components.

This version of the micromega has a single layer of detectors that are positioned around the outside of the cylinder. The component has the standard set of parameters that are available in the other detector components. The origin of this component is at the center, and its position along the beamline is altered by changing the offset parameter.

As with other components, the object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the *offset* parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector *(this is an advisory value and is currently used only for computing volume)*.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

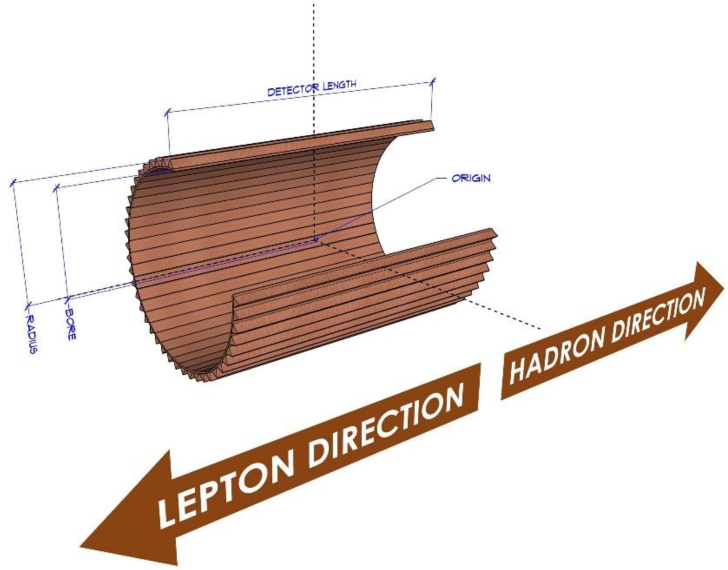

Figure 27: *Micromega Cylinder - Single Layer*

Methods for Weight Estimation

For the purpose of estimation, it can be assumed that the volume of each detector consists of 50% silicon and 50% air. Thus, each cubic meter should weight half of a cubic meter of silicon.

*weight = volume * 1165*

where volume is given in cubic meters and the density is provided as kg/m.

CTR Micromega Cylinder – Two Layer, Interior

Overview

This version of the micromega has two layers of detectors that are positioned on the interior faces of a cylinder. The component has the standard set of parameters that are available in the other detector components. The origin of this component is at the center, and its position along the beamline is altered by changing the offset parameter.

As with other components, the object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the *offset* parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

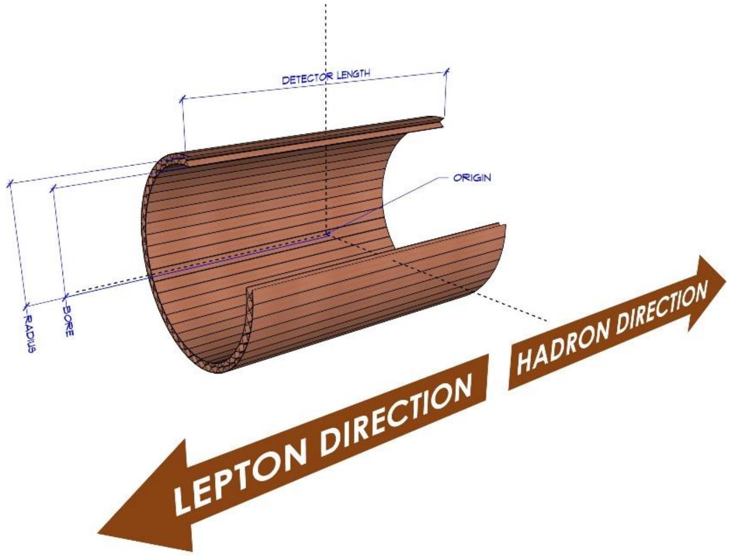

Figure 28: *Micromega Cylinder - Two Layer, Interior*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector *(this is an advisory value and is currently used only for computing volume)*.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

For the purpose of estimation, it can be assumed that the volume of each detector consists of 50% silicon and 50% air. Thus, each cubic meter should weight half of a cubic meter of silicon.

*weight = volume * 1165*

where volume is given in cubic meters and the density is provided as kg/m.

CTR Micromega Cylinder – Two Layer, Exterior

Overview

This version of the micromega has two layers of detectors that are positioned on the exterior faces of a cylinder. The component has the standard set of parameters that are available in the other detector components. The origin of this component is at the center, and its position along the beamline is altered by changing the offset parameter.

As with other components, the object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the *offset* parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

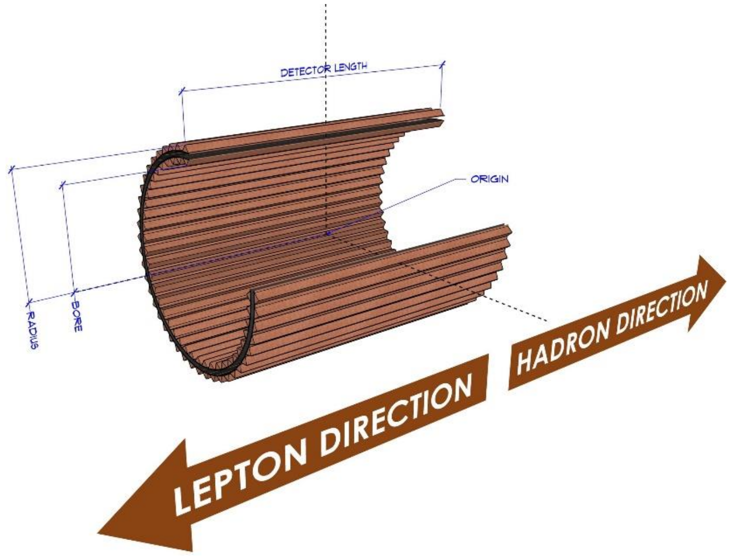

Figure 29: *Micromega Cylinder - Two Layer, Exterior*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector *(this is an advisory value and is currently used only for computing volume)*.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

For the purpose of estimation, it can be assumed that the volume of each detector consists of 50% silicon and 50% air. Thus, each cubic meter should weight half of a cubic meter of silicon.

*weight = volume * 1165*

where volume is given in cubic meters and the density is provided as kg/m.

CTR IP-6 Detector Chamber

Overview

The IP-6 detector chamber is the vacuum beam pipe that runs through the center of the detector. The detector chamber has a beryllium section at its center, where the hadron and lepton beam pipes converge.

The design of this component continues to evolve, as the placement of flanges and connectors are entirely dependent on the configuration of the other detector components.

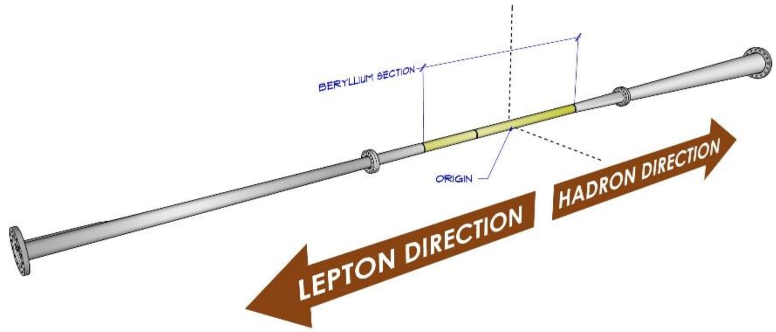

Figure 30: *IP-6 Detector Chamber*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The design of the detector chamber is preliminary and a parametric formula for weight estimation has not been developed.

LEPTON DIRECTION COMPONENTS

LD Lepton Direction Hadron Calorimeter Endcap

Overview

The lepton direction endcap is the first of the components on the outgoing lepton side of the detector. Unlike components in the center of the detector, the origin of lepton direction components are at the center of the inner most face of the object, as shown in the figure at right.

As with other components, the object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the offset parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

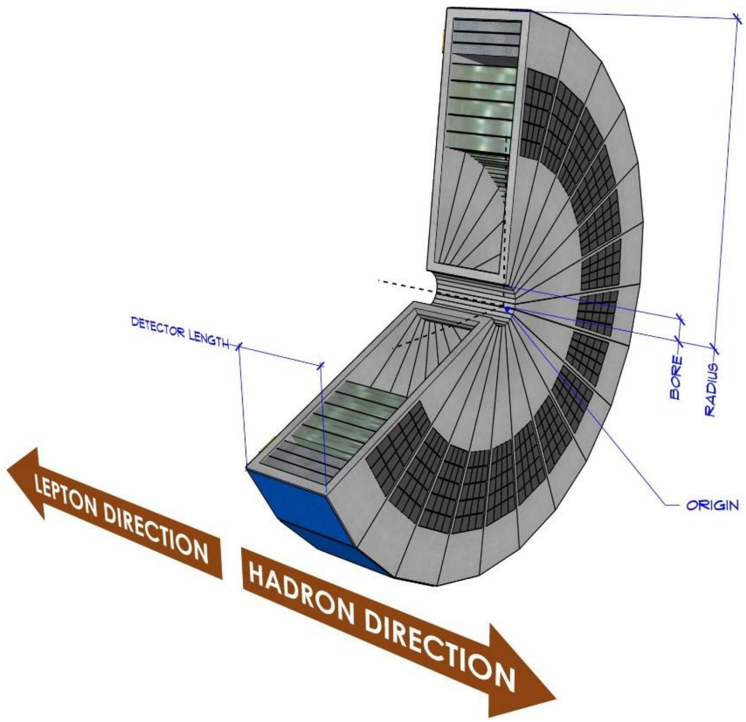

Figure 31: *LD Hadron Calorimeter Endcap*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

Weight estimates for this object are also based on the CMS HB Hadron Calorimeter as described earlier. Using this approach, the weight can be calculated by applying a density coefficient to the volume, such that:

*weight = volume * 7002.3*

where volume is given in cubic meters and the density is provided as kg/m³.

See the section describing the ***one-part barrel hadron calorimeter*** for details.

LD Lepton Direction Iron HCal Endcap

Overview

This version of the lepton direction hadron calorimeter endcap is constructed from iron blocks. This component is provided in three versions. The first is a full endcap, the second is the "A" half of the endcap (which is located nearest to the assembly hall), and finally the "B" half of the endcap.

The endcap halves are provided to allow the modeler to illustrate how the endcap will be split in order to facilitate movement.

The origin of all these objects is at the center of the bore on the side closest to the interaction point *(hadron side).* The object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the offset parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

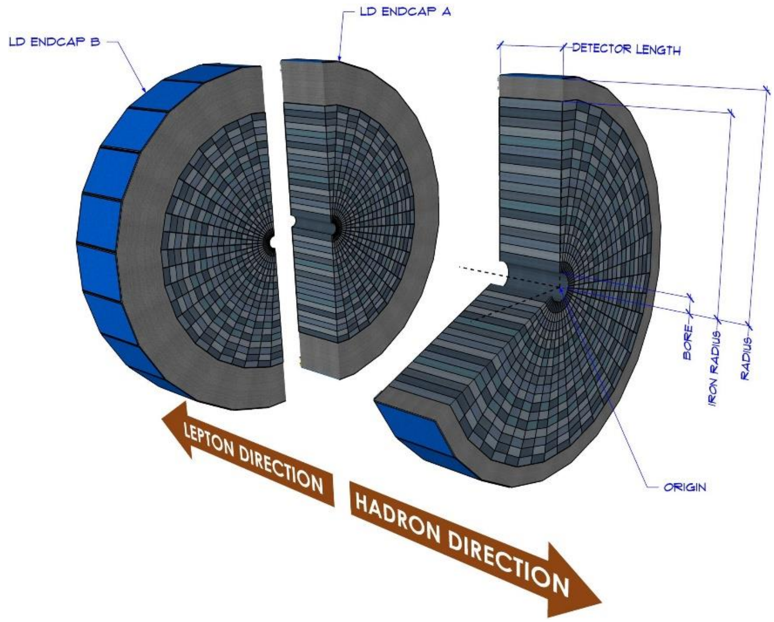

Figure 32: *LD Iron HCAL Endcap*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the first row of iron blocks.
Iron Radius	Radius from the origin to the last row of iron blocks.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The weight of this component assumes that it is constructed entirely of iron. Therefore:

weight = volume 7873*

where volume is given in cubic meters and the density is provided as kg/m³.

LD Lepton Direction Iron HCal Endcap for ATHENA

Overview

This version of the lepton direction hadron calorimeter endcap was designed specifically for the ATHENA proto-collaboration. It is composed of 32 segments and is constructed of iron.

This component is provided in three versions. The first is a full endcap, the second is the "A" half of the endcap (which is located nearest to the assembly hall), and finally the "B" half of the endcap.

The endcap halves are provided to allow the modeler to illustrate how the endcap will be split in order to facilitate movement.

The origin of all these objects is at the center of the bore on the side closest to the interaction point *(hadron side).* The object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the offset parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the first row of iron blocks.
Iron Radius	Radius from the origin to the last row of iron blocks.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

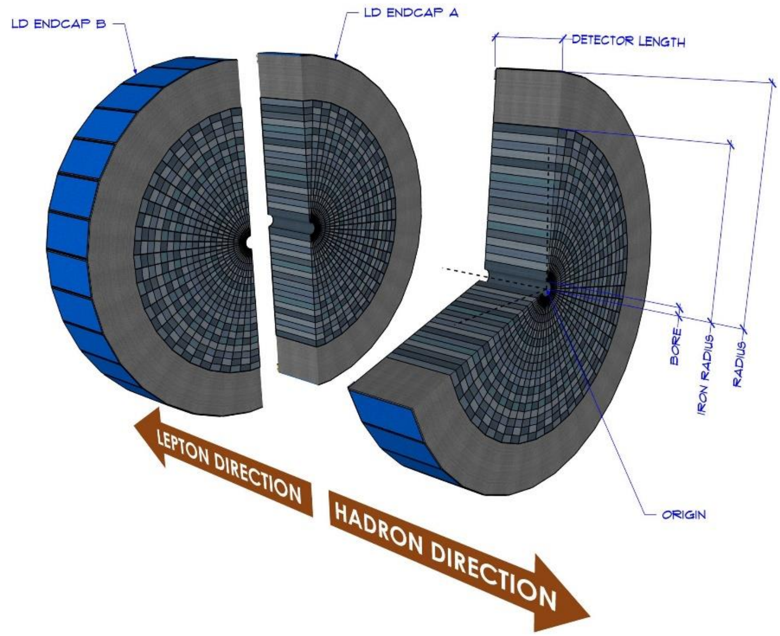

Figure 33: *LD Iron HCAL Endcap for ATHENA*

Methods for Weight Estimation

The weight of this component assumes that it is constructed entirely of iron. Therefore:

weight = volume 7873*

where volume is given in cubic meters and the density is provided as kg/m³.

LD Lepton Direction HCal Gate Endcap

Overview

This version of the lepton direction hadron calorimeter endcap was designed specifically for the ECCE collaboration. This component is provided as two halves. The "A" half of the endcap is located nearest to the assembly hall, and the "B" half is located toward the rear of the experimental hall.

The endcap halves are provided to allow the modeler to illustrate how the endcap will be split in order to facilitate movement.

The origin of all these objects is at the center of the bore on the side closest to the interaction point *(hadron side).* The object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the offset parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Overall Thickness	The thickness of the radial portion of the endcap – the cylinder.
Bore	Radius from the origin to bore of the cylinder.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Floor to Center	The distance that the gate wall extends from the origin toward the floor.
Wall Height	The overall height of the gate wall.
Wall Offset from Center	The offset of the gate wall relative to the center of the cylinder.
Wall Thickness	The thickness of the gate wall.
Volume (estimated)	For simplicity, the approximate volume is calculated from the volume of the cylinder, plus half the volume of the wall.

All component dimensions are specified as centimeters unless otherwise stated.

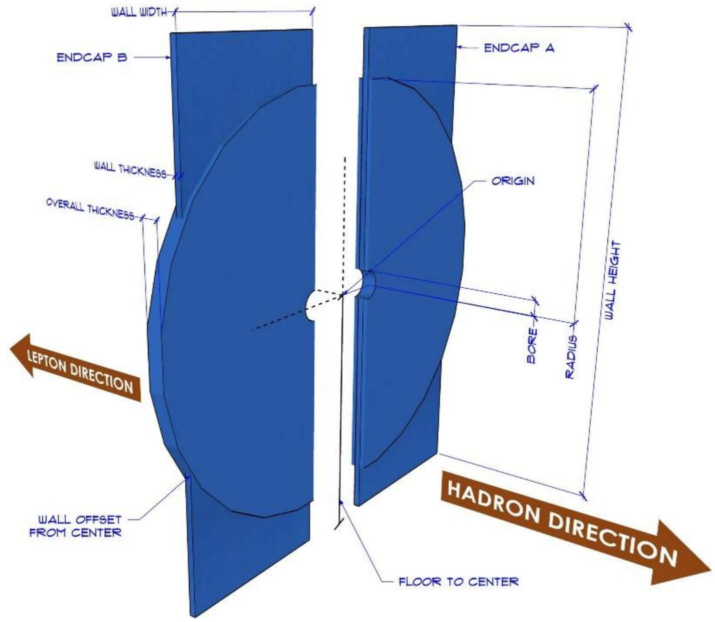

Figure 34: *LD HCAL Gate Endcap*

Methods for Weight Estimation

The weight of this component assumes that it is constructed entirely of iron. Therefore:

weight = volume 7873*

where volume is given in cubic meters and the density is provided as kg/m³.

LD Lepton Direction Electromagnetic Calorimeter

Overview

Because the configuration of the electromagnetic calorimeter can vary significantly depending on factors such as the orientation of the DIRC, several versions of this dynamic component are provided. The following three versions are based on a design produced by Joshua Crafts and has several configurable parameters.

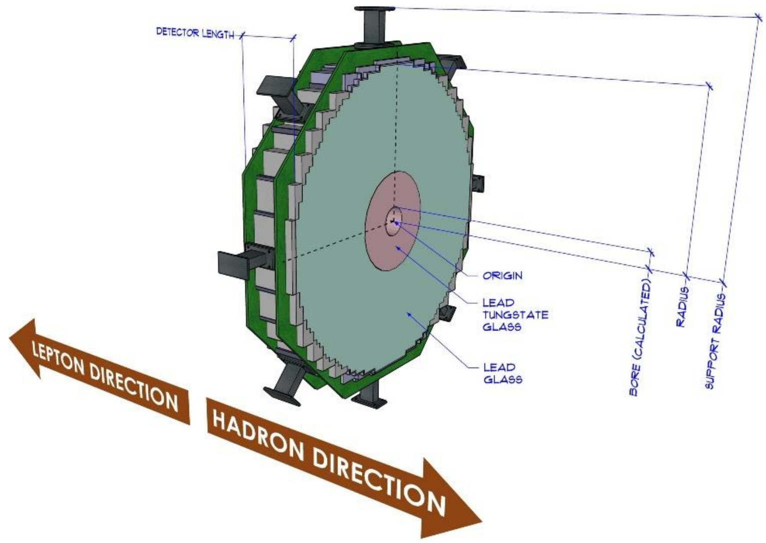

Figure 35: *LD Electromagnetic Calorimeter*

The *radius* parameter represents the external radius at the perimeter of the outer blocks. Supporting structure for the glass blocks extends an additional ~12% beyond the specified radius. Structural members extend from glass supports to the perimeter specified by the *support radius* parameter. These members allow the electromagnetic calorimeters weight to be transferred to an external structure, such as the barrel hadron calorimeter.

The bore radius and inner block radius are automatically calculated based on the calorimeter's distance from the origin. The bore is at a 4.5 degree radius from the origin and the inner blocks are at a 15 degree radius from the origin. The inner block count and outer block count parameter contain an estimate of the number of glass blocks that will fit within each of the volumes.

As with other lepton direction components, the origin is positioned at the center of the inner face and the offset is used to position the object along the beamline.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Inner Block Count	Estimated number of 2x2 cm blocks that will fit in the interior radial volume.
Outer Block Count	Estimated number of 4x4 cm blocks that will fit in the exterior radial volume.
Detector Length	Total length of the detector along the beam line.

Bore	Computed radius from the origin to the inside of the detector *(4.5 degree radius from the origin / read-only)*.
Radius	Radius from the origin to the outside of the detector.
Support Radius	Radius from the origin to the supporting structure to which this assembly attaches.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The volume parameter of this detector includes the volume of the lead glass and the support structure. A weight estimate for this object can be generated by multiplying the volume of the glass by the density of lead glass and the balance of the volume by the density of steel. For a more precise calculation, the user may independently compute the volumes of lead glass and lead tungstate glass, as their density differs. A simple weight estimate is given by:

*glass = ((PI * radius²)-(PI * bore²))*length*

steel = volume – glass

*weight = glass*6220 kg/m³ + steel*7850 kg/m³*

LD Lepton Direction Electromagnetic Calorimeter (PWO)

Overview

This version of the electromagnetic calorimeter is designed to fit within the bore of the DIRC and it consists entirely of lead tungstate glass. As with the previous electromagnetic calorimeter, it has a radius parameter which specifies the radius to the perimeter of the lead tungstate glass, and a support radius which represents the distance from the center to the bore of the external supporting component.

In order to make this component fit properly with the component that is supporting it, the number of support sides may be specified. The size of the bore is based on the component's distance from the interaction point and is at a 4.5 degree radius from the origin. The number of blocks is the estimated number of 2x2cm blocks that will fit within the glass surface of the detector.

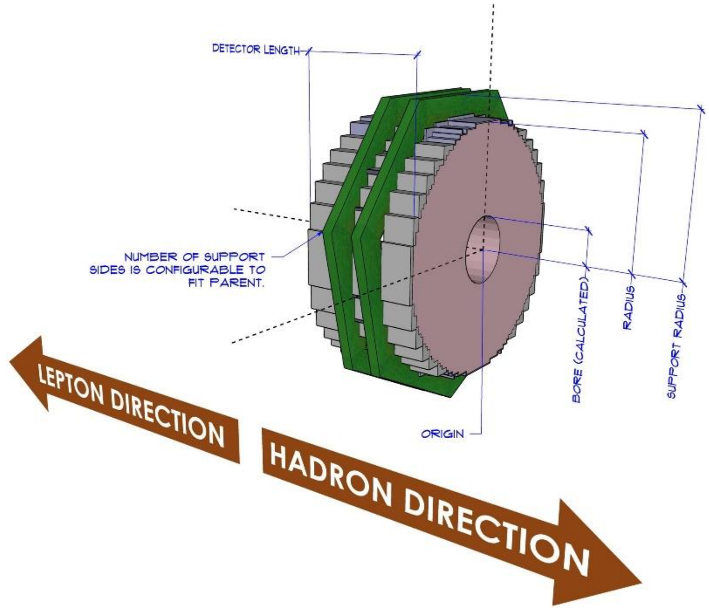

Figure 36: *LD Electromagnetic Calorimeter (PWO)*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Block Count	Estimated number of 2x2 cm blocks that will fit in the detector's radial volume.
Detector Length	Total length of the detector along the beam line.
Bore	Computed radius from the origin to the inside of the detector *(4.5 degree radius from the origin / read-only)*.
Radius	Radius from the origin to the outside of the detector.
Support Sides	Number of sides on the supporting structure *(typically matches the number of sides on the parent detector)*.
Support Radius	Radius from the origin to the supporting structure to which this assembly attaches *(typically, the parent's bore radius)*.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The method for estimating weight for this object is similar to that used for the previous electromagnetic calorimeter, except that the density of lead tungstate glass is used for the entire glass volume. Therefore:

*glass = ((PI * radius^2)-(PI * bore^2))*length*

steel = volume – glass

*weight = glass*8300 kg/m³ + steel*7850 kg/m³*

LD Lepton Direction Electromagnetic Calorimeter (Compact)

Overview

This compact electromagnetic calorimeter is also designed to fit within the bore of the DIRC detector. In this case, the calorimeter consists of both lead glass and lead tungstate blocks. The radius parameter specifies the outer most perimeter of glass on the detector. The size of the bore and the perimeter of the lead tungstate glass are computed based on the object's distance from the origin. The number of blocks that will fit within both the inner and outer glass perimeters are calculated based on the glass volumes.

The *support radius* specifies the distance from the center to the bore of the supporting structure. Since the number of DIRC segments may vary, the *support sides* parameter allows the user to specify the number of sides on the electromagnetic calorimeter so that it matches the DIRC.

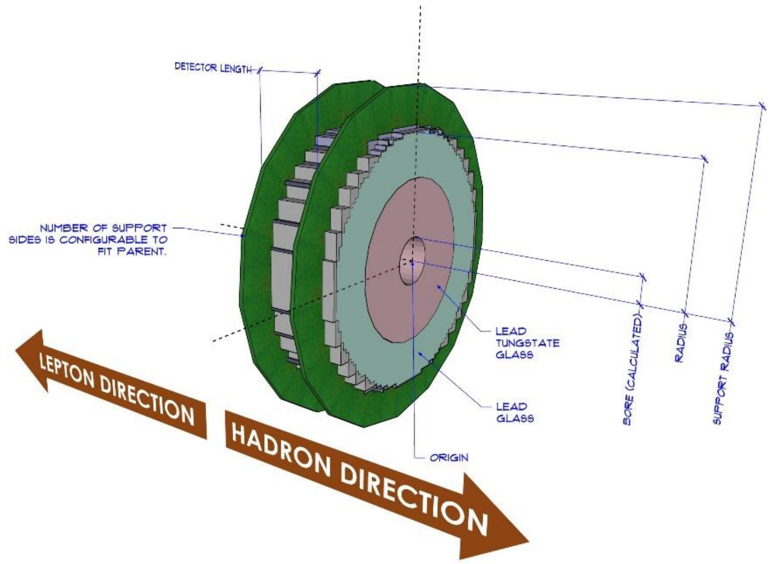

Figure 37: *LD Electromagnetic Calorimeter (Compact)*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Inner Block Count	Estimated number of 2x2 cm blocks that will fit in the interior radial volume.
Outer Block Count	Estimated number of 4x4 cm blocks that will fit in the exterior radial volume.
Detector Length	Total length of the detector along the beam line.
Bore	Computed radius from the origin to the inside of the detector *(4.5 degree radius from the origin / read-only)*.
Radius	Radius from the origin to the outside of the detector.
Support Sides	Number of sides on the supporting structure *(typically matches the number of sides on the parent detector)*.
Support Radius	Radius from the origin to the supporting structure to which this assembly attaches *(typically, the parent's bore radius)*.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The volume parameter of this detector includes the volume of the lead glass and the support structure. A weight estimate for this object can be generated by multiplying the volume of the glass by the density of lead glass and the balance of the volume by the density of steel. For a more precise calculation, the user may independently compute the volumes of lead glass and lead tungstate glass, as their density differs. A simple weight estimate is given by:

$$glass = ((PI * radius^2)-(PI * bore^2))*length$$

$$steel = volume - glass$$

$$weight = glass*6220\ kg/m^3 + steel*7850\ kg/m^3$$

LD Lepton Direction Compound Electromagnetic Calorimeter

Overview

This electromagnetic calorimeter was proposed by Elke Aschenauer to ease system disassembly. The outer calorimeter is permanently assembled and can fit over the beamline for easy removal. The smaller, interior sub-calorimeter captures particles missed by the larger calorimeter and can be easily disassembled/reassembled for removal.

The size of the bore and the radius at which the glass blocks transition from lead tungstate to glass are explicitly specified in this component. The *support radius* specifies the distance from the origin to the exterior of the supporting structure. Since the number of DIRC segments may vary, the *support sides* parameter allows the user to specify the number of sides on the electromagnetic calorimeter so that it matches the DIRC.

Note: The support structure is hidden if the support radius is less than the radius.

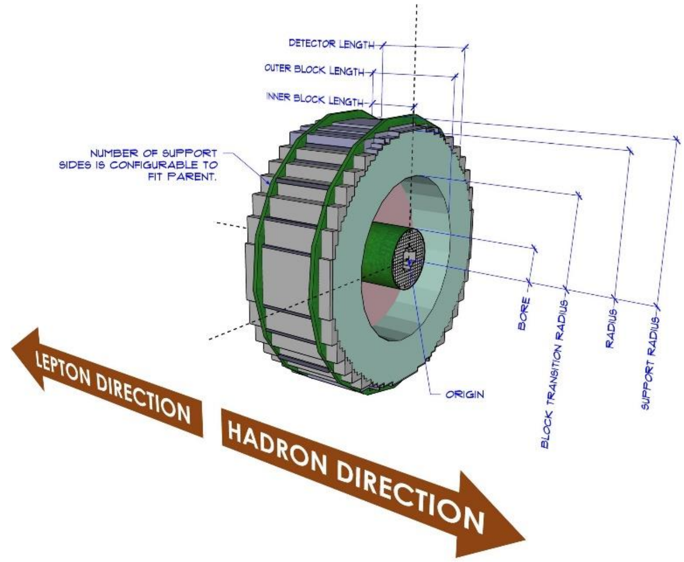

Figure 38: *LD Electromagnetic Calorimeter (Compact)*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Inner Block Count	Estimated number of 2x2 cm blocks that will fit in the interior radial volume.
Outer Block Count	Estimated number of 4x4 cm blocks that will fit in the exterior radial volume.
Detector Length	Total length of the detector along the beam line.
Inner Block Length	The length of the lead tungstate blocks at the interior of the detector.
Outer Block Length	The length of the lead glass blocks at the exterior of the detector.
Bore	Computed radius from the origin to the inside of the detector *(4.5 degree radius from the origin / read-only)*.
Block Transition Radius	The radius at which the blocks change from the inner blocks to the outer blocks.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Support Sides	Number of sides on the supporting structure *(typically matches the number of sides on the parent detector)*.
Support Radius	Radius from the origin to the supporting structure to which this assembly attaches *(typically, the parent's bore radius)*.
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The volume parameter of this detector includes the volume of the lead glass and the support structure. Assuming that the interior glass (innerVol) is constructed from lead tungstate glass, the outer glass (outerVol) is constructed from lead glass, and the support is made from steel, a weight estimate is created as follows:

innerVol =	*((PI * transRadius^2)-(PI * bore^2))*innerBlockLength*
outerVol =	*((PI * radius^2)-(PI * transRadius^2))*outerBlockLength*
supportVol =	*((PI * supportRadius^2)-(PI * radius^2))*detectorLength*
weight =	*innerVol*8300 + outerVol*6200 + supportVol*7850*

LD Lepton Direction Electromagnetic Calorimeter Sub-Detector

Overview

This is the sub-detector that is used in the LD Compound EMCal that is illustrated in the preceding figure. It is included as a separate dynamic component so that it can be used to construct other types of compound EMCals. When resized, the number of blocks remains fixed and the bore increases proportionately.

This component has a dynamic origin, which means the positioning point for the object will always be located on the side that is nearest to the interaction point, allowing it to be used on either side of the detector.

As with other components, the object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the *offset* parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Inner Block Count	Estimated number of 2x2 cm blocks that will fit in the interior radial volume.
Detector Length	Total length of the detector along the beam line.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

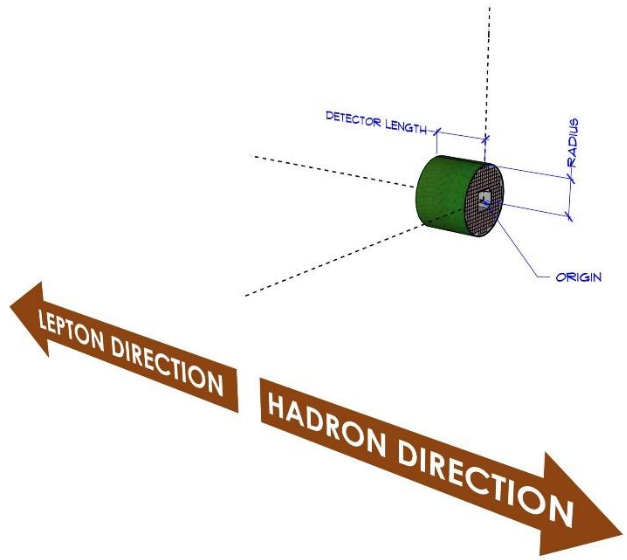

Figure 39: *LD Electromagnetic Calorimeter (Compact)*

Methods for Weight Estimation

Because of its relatively small size and that the bulk of this component is made from lead tungstate glass, its weight can be estimated as follows:

*weight = volume * 8300 kg/m³*

HADRON DIRECTION COMPONENTS

HD RICH (Ring Image Cherenkov) Detector

Overview

The RICH Detector is the first of the hadron direction detectors, however, its unusual configuration causes its origin to be at the center of the outside face. The RICH detector has a number of parameters that are not available in other detectors. Specifically, its shape is governed by three distinct radii; the aerogel radius represents the face farthest to the lepton direction, the LD radius is near the middle of the detector, and the HD radius is at the far hadron side of the detector. The length of the aerogel section and the detector section are also independently configurable.

Because the number of RICH segments that will be used has not been determined, the *segment count* parameter can be used to increase or decrease the number of sectors. Current guidance from Beni Zihlman of Jefferson Lab is that the RICH detector will be limited to six sectors.

Although the detector is faceted, its volume is estimated using cylindrical formulas, which should be adequate for weight calculations.

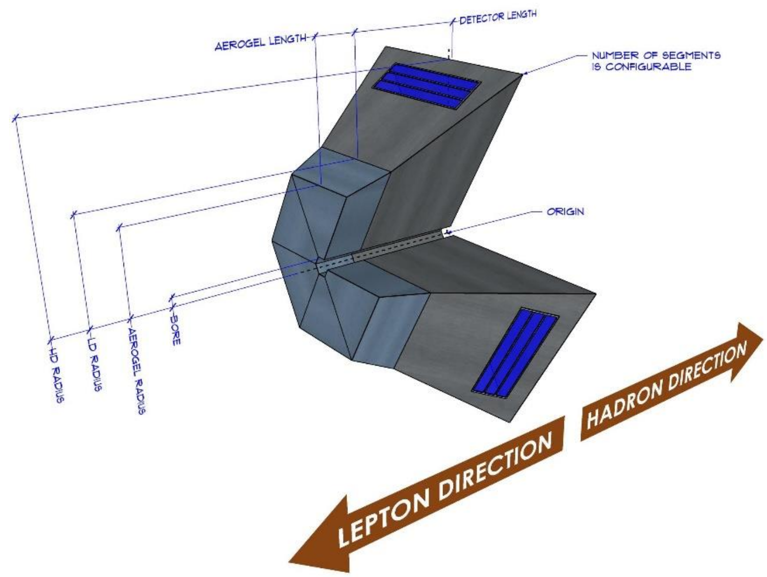

Figure 40: *RICH Detector*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Aerogel Length	Length of the aerogel section of the detector.
Aerogel Radius	Radius of the **front** of the aerogel section of the detector.
Detector Length	Length *(along the beamline)* of the detector portion of the RICH.
Bore	Radius from the origin to the inside of the detector.
HD Radius	Radius from the origin to the outside of the detector on the hadron direction end.
LD Radius	Radius from the origin to the outside of the detector on the lepton direction end.
Segment Count	The number of RICH segments that are installed in the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The weight of the RICH detector can be estimated using the parameters from the CLAS12 RICH detector (CLAS Collaboration, 2013). As noted in their technical design report, each RICH sector weighs 1300 kg, and the modeled volume of a RICH sector is 7.011 m³. This allows the volume to be used to compute the weight as follows:

*weight = volume * 185.42*

where volume is given in cubic meters and the density is provided as kg/m³.

HD RICH (Ring Image Cherenkov) Cylindrical Detector

Overview

This version of the RICH detector has a cylindrical detector body and the origin is located at the interior face of the detector, just behind the aerogel. The RICH detector has a number of parameters that are not available in other detectors. The *aerogel radius* refers to the radius of the aerogel section on the lepton side of the detector, the LD radius is the radius of the aerogel section on the opposite side, and the HD radius refers to the radius of the overall detector.

Note: while these parameter names may seem inconsistent, they were used to maintain compatibility with the existing RICH component.

While the detector is cylindrical, the aerogel section is faceted, and the *segment count* refers to the number of segments in the aerogel section.

Although the detector is faceted, its volume is estimated using cylindrical formulas, which should be adequate for weight calculations.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Aerogel Length	Length of the aerogel section of the detector.
Aerogel Radius	Radius of the **front** of the aerogel section of the detector.
Detector Length	Length *(along the beamline)* of the detector portion of the RICH.
Bore	Radius from the origin to the inside of the detector.
HD Radius	Radius from the origin to the outside of the detector on the hadron direction end.
LD Radius	Radius of the **back** of the aerogel section of the detector.

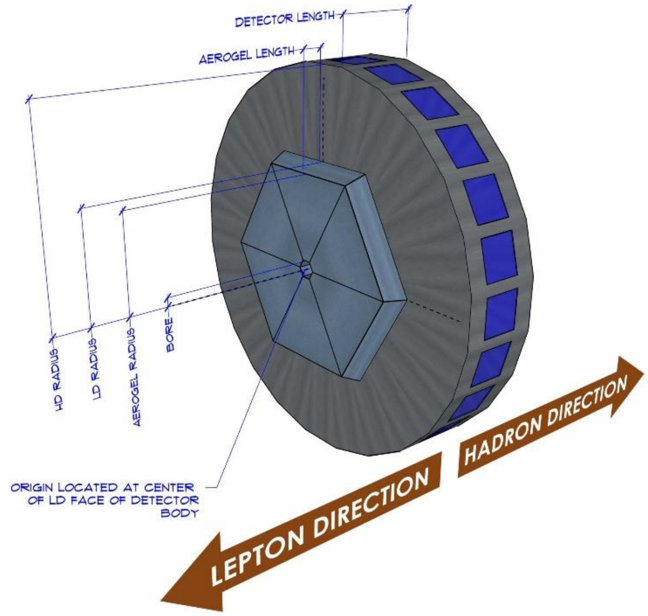

Figure 41: *RICH Detector*

Segment Count	The number of segments in the aerogel section..
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The weight of the RICH detector can be estimated using the parameters from the CLAS12 RICH detector (CLAS Collaboration, 2013). As noted in their technical design report, each RICH sector weighs 1300 kg, and the modeled volume of a RICH sector is 7.011 m³. This allows the volume to be used to compute the weight as follows:

*weight = volume * 185.42*

where volume is given in cubic meters and the density is provided as kg/m³.

HD Hadron Direction Electromagnetic Calorimeter

Overview

Unlike the lepton direction electromagnetic calorimeter, this component is a more primitive placeholder that will be enhanced in future versions. This object scales proportionately with changes in the radius and length, meaning that the visual size of the bore may not be consistent with its actual size. For computational purposes (and to accommodate future versions) a bore parameter is provided and is used for calculating the component's volume.

The origin of this component is at the center of the inside face. As with other components, this object should be centered at the origin and positioned along the beamline using the *offset* parameter.

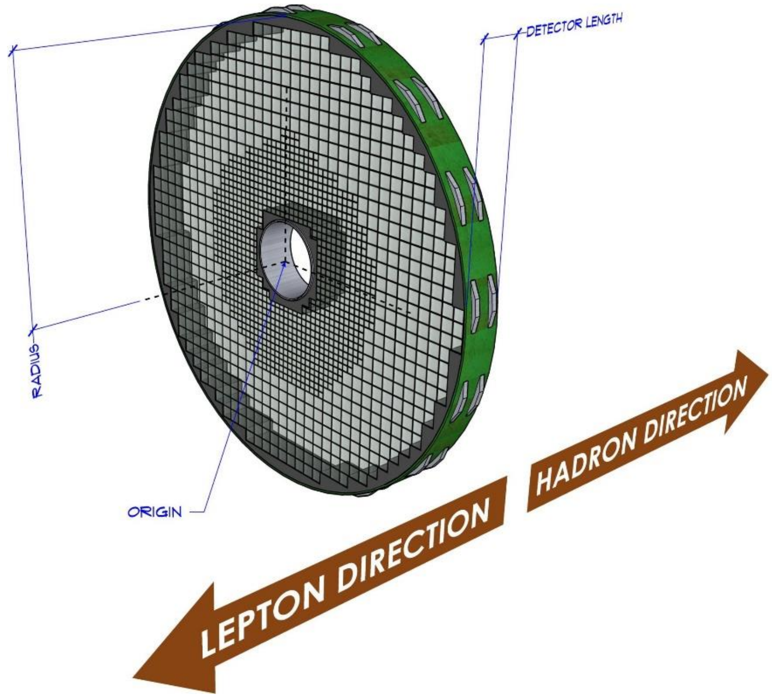

Figure 42: *HD Electromagnetic Calorimeter*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector *(this is an advisory value and is currently used only for computing volume)*.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

Because the design of this electromagnetic calorimeter is not fully defined, its weight is estimated as the product of its computed volume and the density of lead glass. This provides the following formula:

*weight = volume * 6220*

where volume is given in cubic meters and the density is provided as kg/m³.

HD Hadron Direction Hadron Calorimeter Endcap

Overview

The hadron direction endcap is the outer most component on the outgoing hadron side of the detector. Unlike components in the center of the detector, the origin of hadron direction components are at the center of the inner most face of the object, as shown in the figure at right.

As with other components, the object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the *offset* parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

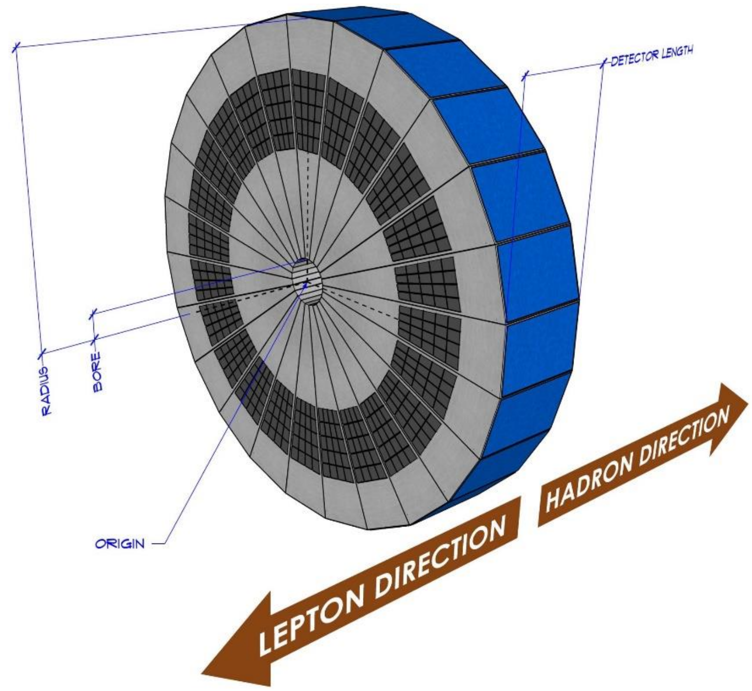

Figure 43: *HD Hadron Calorimeter Endcap*

Methods for Weight Estimation

Weight estimates for this object are also based on the CMS HB Hadron Calorimeter as described earlier. Using this approach, the weight can be calculated by applying a density coefficient to the volume, such that:

*weight = 7002.3 * volume*

where volume is given in cubic meters and the density is provided as kg/m³.

*See the section describing the **one-part barrel hadron calorimeter** for details.*

HD Hadron Direction Compound Calorimeter Endcap (ATHENA)

Overview

This version of the hadron direction endcap was designed specifically for the ATHENA proto-collaboration. It is composed of 32 segments and is constructed of lead glass surrounded by an iron band.

This component is provided in three versions. The first is a full endcap, the second is the "A" half of the endcap (which is located nearest to the assembly hall), and finally the "B" half of the endcap.

The endcap halves are provided to allow the modeler to illustrate how the endcap will be split in order to facilitate movement.

The origin of all these objects is at the center of the bore on the side closest to the interaction point *(lepton side).* The object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the offset parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

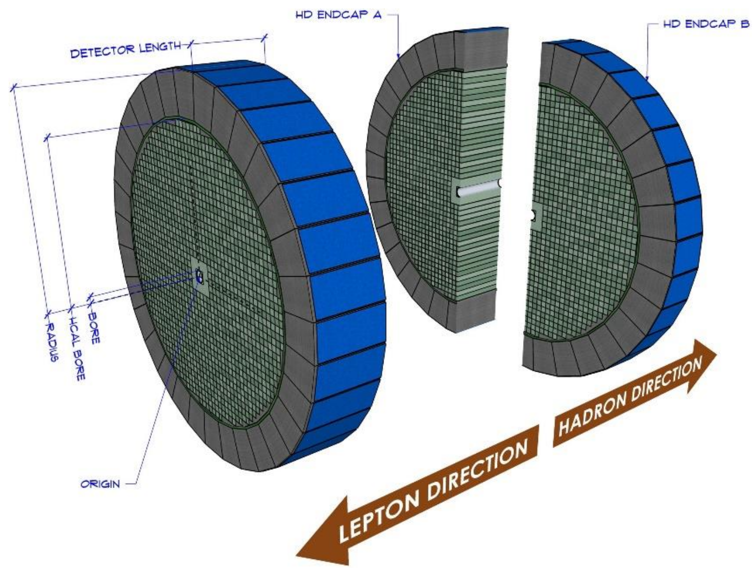

Figure 44: *HD Hadron Calorimeter Endcap*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
HCAL Bore	The radius at which the EMCal ends and the HCal begins.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The volume parameter of this detector includes the volume of the EMCal and the HCAL. Assuming that the EMCal *(glass)* is constructed from lead glass, and the HCal *(steel)* is made from steel, a weight estimate is created as follows:

glass = $((PI * HCalBore^2)-(PI * bore^2)) * detectorLength$

steel = $((PI * radius^2)-(PI * HCalBore^2)) * detectorLength$

*weight = glass*6200 + steel*7850*

where volume is given in cubic meters and the density is provided as kg/m³.

HD Hadron Direction Compound Calorimeter Endcap (ECCE)

Overview

This version of the hadron direction endcap was designed specifically for the ECCE proto-collaboration and features an embedded electromagnetic calorimeter that extends beyond the surrounding hadron calorimeter.

This component is provided in three versions. The first is a full endcap, the second is the "A" half of the endcap (which is located nearest to the assembly hall), and finally the "B" half of the endcap.

The endcap halves are provided to allow the modeler to illustrate how the endcap will be split in order to facilitate movement.

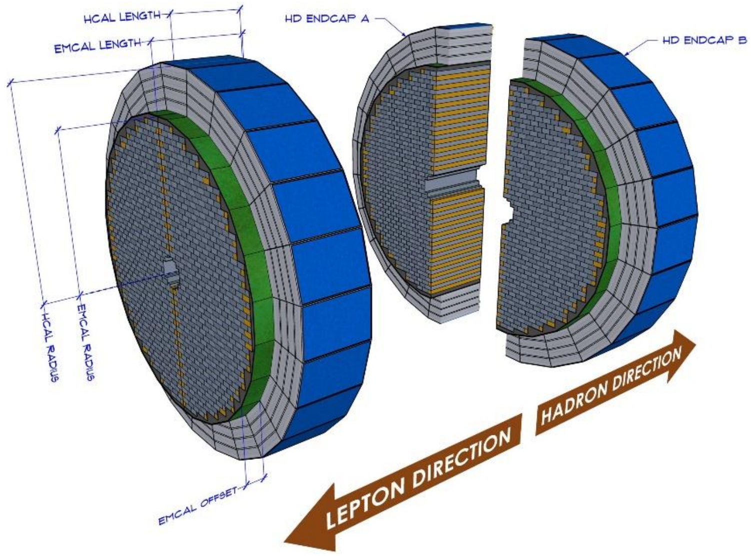

Figure 45: *HD Hadron Calorimeter Endcap*

The origin of all these objects is at the center of the bore on the side closest to the interaction point *(lepton side).* The object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the offset parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Hadron Cal. Length	The length of the hadron calorimeter portion of this detector.
Bore	Radius from the origin to the inside of the detector.
EM Cal. Length	The length of the electromagnetic calorimeter section of the detector.
EM Cal. Offset	The offset of the interior face of the EMCal relative to the interior face of the HCal.
EM Cal. Radius	The radius of the electromagnetic calorimeter.
Hadron Cal. Radius	Radius from the origin to the outside of the hadron calorimeter.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The volume parameter of this detector includes the volume of the EMCal and the HCAL. Assuming that the EMCal *(glass)* is constructed from lead glass, and the HCal *(steel)* is made from steel, a weight estimate is created as follows:

$$glass = ((PI * HCalBore^2)-(PI * bore^2)) *detectorLength$$

$$steel = ((PI * radius^2)-(PI * HCalBore^2)) *detectorLength$$

$$weight = glass*6200 + steel*7850$$

where volume is given in cubic meters and the density is provided as kg/m³.

HD Hadron Direction Hadron Calorimeter Endcap (ATHENA)

Overview

This version of the lepton direction hadron calorimeter endcap was designed specifically for the ATHENA proto-collaboration. It is composed of 32 segments and is constructed of iron.

This component is provided in three versions. The first is a full endcap, the second is the "A" half of the endcap (which is located nearest to the assembly hall), and finally the "B" half of the endcap.

The endcap halves are provided to allow the modeler to illustrate how the endcap will be split in order to facilitate movement.

The origin of all these objects is at the center of the bore on the side closest to the interaction point *(lepton side).* The object's origin is placed at the interaction point, and then its position is adjusted along the beamline using the offset parameter. Negative offset values move the object in the hadron direction and positive values move it in the lepton direction.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Detector Length	Total length of the detector along the beam line.
Bore	Radius from the origin to the inside of the detector.
Radius	Radius from the origin to the outside of the detector.
Offset from Center	Distance along the beamline that the detector's origin is offset from the interaction point. *(HD is negative and LD is positive)*
Volume	Volume in cubic meters of the detector *(read-only, computed as cylinders)*.

All component dimensions are specified as centimeters unless otherwise stated.

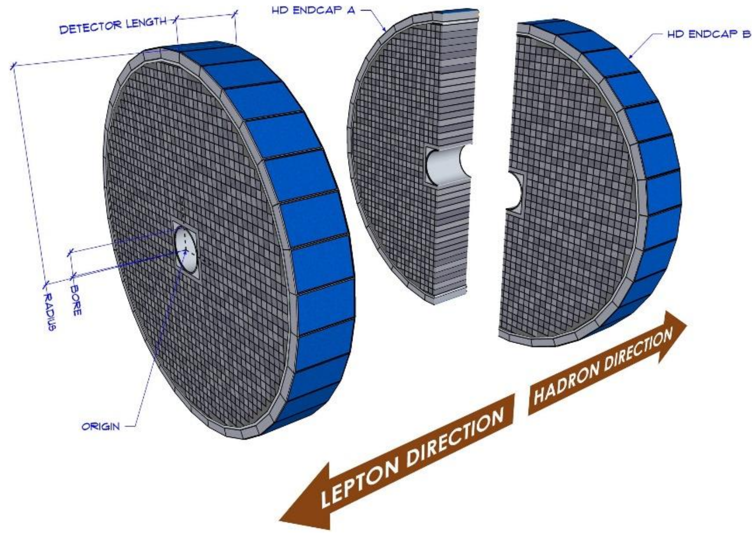

Figure 46: *HD Hadron Calorimeter Endcap*

Methods for Weight Estimation

The weight of this component assumes that it is constructed entirely of iron. Therefore:

weight = volume 7873*

where volume is given in cubic meters and the density is provided as kg/m³.

EXTERNAL COMPONENTS AND SYSTEMS

EXT Accelerator Superconducting Magnet Body

Overview

The accelerator superconducting magnet body component is used to create preliminary models that show the placement of beamline magnets outside of the detector. This particular component may be used in conjunction with the accelerator superconducting magnet to illustrate a larger cryostat that contains multiple accelerator magnets.

The magnet body is significantly simpler than most components and its primary attributes are limited to length and radius. For positioning purposes, the component also has an option that allows the user to specify the distance from the floor to the center of the magnet. This becomes pertinent when it is combined with the accelerator SC magnet, which uses the "floor to center" attribute to draw the support structure.

Unlike other objects, this component's origin is the center of the magnet. The Y parameter is altered to move it along the beamline.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Magnet Length	Total length of the magnet along the beam line.
Radius	Radius from the origin to the outside of the magnet.
Floor to Center	Distance from an arbitrarily located floor to the center of the magnet.

All component dimensions are specified as centimeters unless otherwise stated.

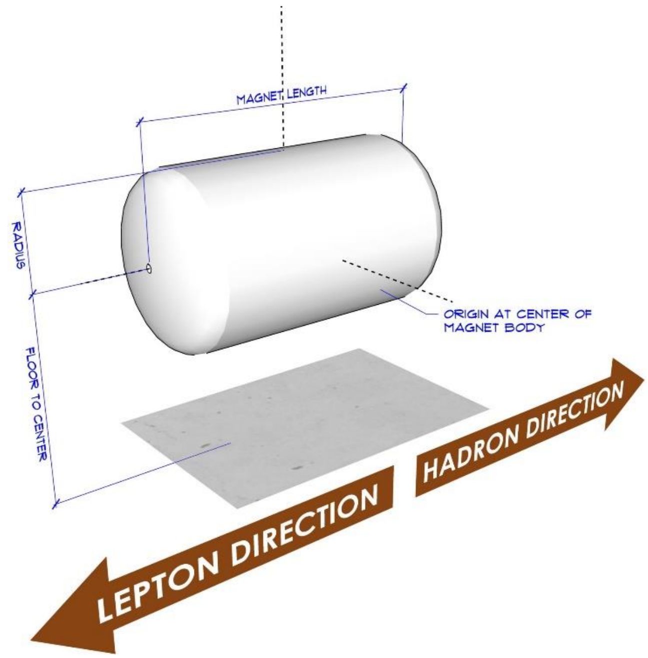

Figure 47: *Accelerator Superconducting Magnet Body*

Methods for Weight Estimation

Because this component is permanently affixed and is not relocated as part of the detector package, a weight estimation formula is not provided.

EXT Accelerator Superconducting Magnet

Overview

The accelerator superconducting magnet component is similar to the magnet body described earlier, with some supplemental features. This component has an extensible base that expands and lengthens as the size of the magnet is altered. For compound magnets (those with multiple magnets within a single cryostat), this object can be combined with two or more embedded magnet bodies to produce a visualization.

The magnet body is significantly simpler than most components and its primary attributes are limited to length and radius. For positioning purposes, the component also has an option that allows the user to specify the distance from the floor to the center of the magnet. This attribute is used to draw the support structure.

Unlike other objects, this component's origin is the center of the magnet. The Y parameter is altered to move it along the beamline.

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.
Magnet Length	Total length of the magnet along the beam line.
Radius	Radius from the origin to the outside of the magnet.
Floor to Center	Distance from an arbitrarily located floor to the center of the magnet.

All component dimensions are specified as centimeters unless otherwise stated.

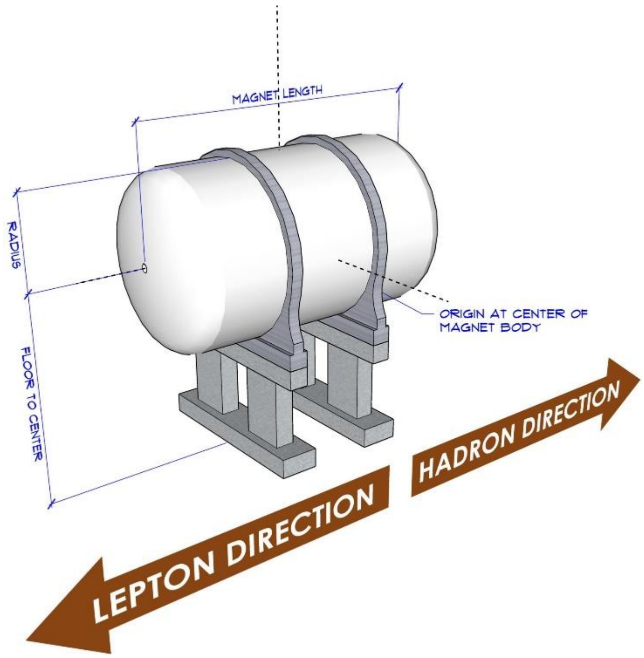

Figure 48: *Accelerator Superconducting Magnet*

Methods for Weight Estimation

Because this component is permanently affixed and is not relocated as part of the detector package, a weight estimation formula is not provided.

EXT IP-8 Muon Shield

Overview

The IP-8 muon shield component represents the muon shields that are currently installed in the IP-8 experimental hall. Prior to installing the new detector, these shields will need to be removed or altered to facilitate the new system.

Because this is a static system, it has very few user configurable options.

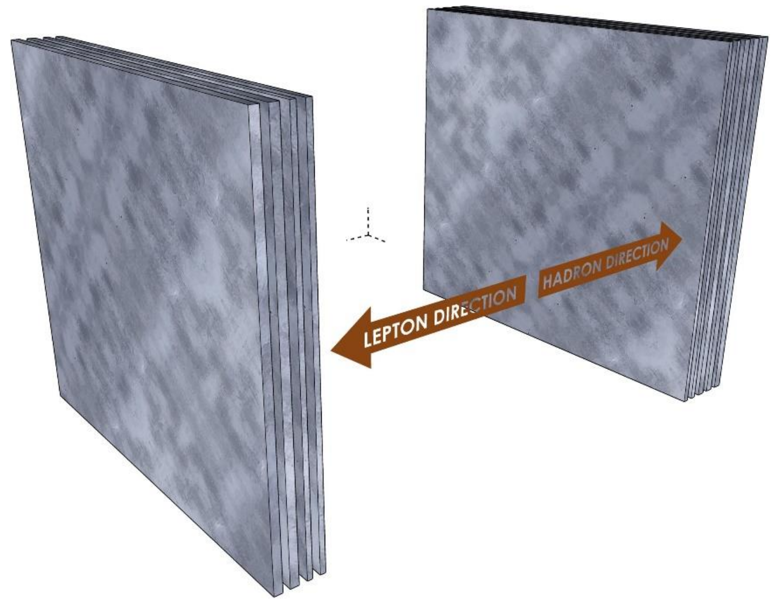

Figure 49: *Accelerator Superconducting Magnet Body*

Component Options

The following options are available for configuring this component.

X, Y, Z	Position of the object's origin relative to the red, green and blue axes respectively.

All component dimensions are specified as centimeters unless otherwise stated.

Methods for Weight Estimation

The muon chambers are made of iron and have a modeled volume of 276 cubic meters and have a total estimated weight of 2,172,948 kilograms.

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