

# CENTRAL DETECTOR SUB-SYSTEMS FOR INTERACTION POINT 6

## 1.5 TESLA REFERENCE DETECTOR

### OVERVIEW AND ASSUMPTIONS

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#### Overview

In order to simplify the development and adaptation of central detector models for the Electron Ion Collider project, a collection of drop-in dynamic components has been developed. These components, which are based on Trimble Sketchup, are dramatically simplified representations of the engineering models and have user configurable settings that allow their dimensions, position and other parameters to be easily altered. For several of the expected configurations, an initial model has been created that contains all of the components in their default configuration. This document provides a list of the components in the 1.5-Tesla model for Interaction Point 6, along with all of their initial parameters. Using this document, in conjunction with the [Detector Menagerie](#) of dynamic components, any user should be able to reconstruct this model and then make alterations to suit their preferred configurations.

A separate document will be available that provides a description of each of the components, their configuration options and how they can be best used. As these dynamic components continue to be developed, automatic volume calculations and other features will be added to assist in using them for weight and material calculations.

**Keep in mind that these objects are for conceptual design only. While they are very effective for facilitating the exchange of ideas, they do not constitute an engineering design.**

#### Assumptions

The following are design assumptions related to the 1.5 T BABAR Magnet in IP-6. These assumptions governed the construction of the initial model and the component parameters that are included in this document.

- Because of interference with the RCS beamline, the maximum outer radius of the detector cannot exceed 3.2 meters.
- The maximum length of the detector cannot exceed 9.5 meters (4.5 meters in the lepton direction, and 5 meters in the hadron direction.)
- The crossing angle at IP-6 is fixed at 25 mrad, with 8 mrad in the electron beam and 17 mrad in the hadron beam.
- The axis of the solenoid must be aligned with the electron beam, thus the central detector is rotated by 8 mrad.
- As much as possible will be reused from the IP-6 infrastructure; i.e. rail systems, cradle, platform components, etc.
- To be able to reuse the STAR cradle, we offset the 1.5 Tesla magnet by 20 cm in the forward (hadron direction) side. *(This alteration also makes it possible to move this magnet through the doorway of IP-8 once the end caps have been removed.)*
- The hadron calorimeter endcap on the lepton side will remain in the collider hall during maintenance.
- The hadron calorimeter endcap and the electromagnetic calorimeter on the hadron side will remain in the hall during maintenance.

- The cryo-can will be in a fixed position in the collider hall and will be connected to the solenoid cryostat using a flexible cryo-line.
- Based on preliminary engineering designs by Roland Wimmer, we assume that the support structure for the barrel EMCal will be 7.62 cm thick and will be installed between the solenoid cryostat and the barrel EMCal.
- Based on another adaptation of Wimmer's engineering design, we assume a universal support structure for the DIRC that will be 16 cm thick. This may be more substantial than needed in some configurations, but will allow the DIRC support to be used to also support other heavier components within the barrel.

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**IP-6 FIXED CARRIAGE**

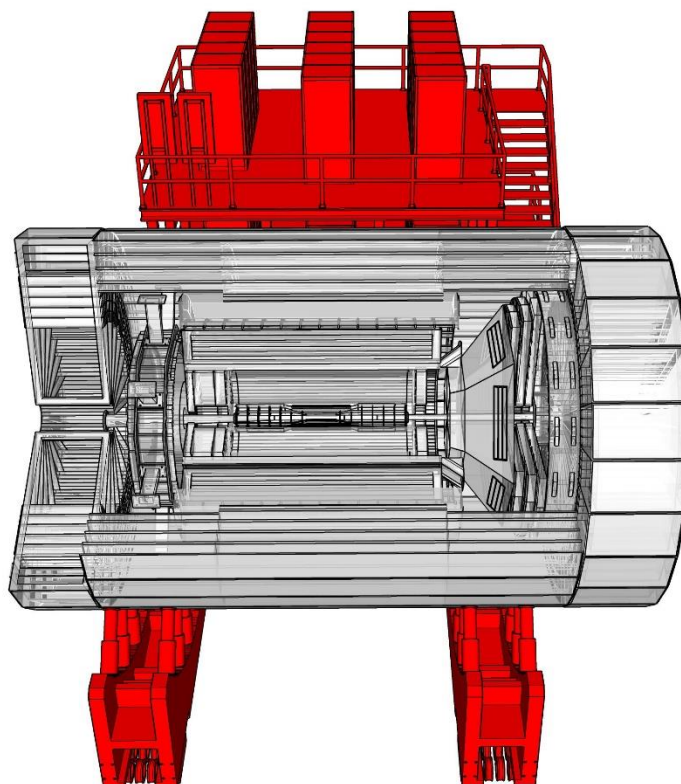


Figure 1: IP-6 Fixed Carriage

**Dimensions/Location**

N/A

**Weight Estimates**

<i>Element</i>	<i>Basis</i>	<i>Weight</i>
Carriage (5.92 m <sup>3</sup> Steel)	7850 kg/m <sup>3</sup>	46,452 kg
STAR Cradles (6.88 m <sup>3</sup> Steel)	7850 kg/m <sup>3</sup>	54,046 kg
Danfysik Power Supplies	2 @ 850kg	1,700 kg
Computing Racks	39 @ 227kg	8,845 kg
Transformers	4 @ 231kg	925 kg
Total:		111,968 kg

**Power Requirements**

<i>Component</i>	<i>Source/Voltage</i>	<i>Amps</i>
Data Not Collected		

**Heat Dissipation**

<i>Removal Mechanism/Medium</i>	<i>BTUs</i>
Data Not Collected	

**Communications/Signal**

<i>Element</i>	<i>Cables/Connections</i>
Data Not Collected	

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**BARREL HADRON CALORIMETER**

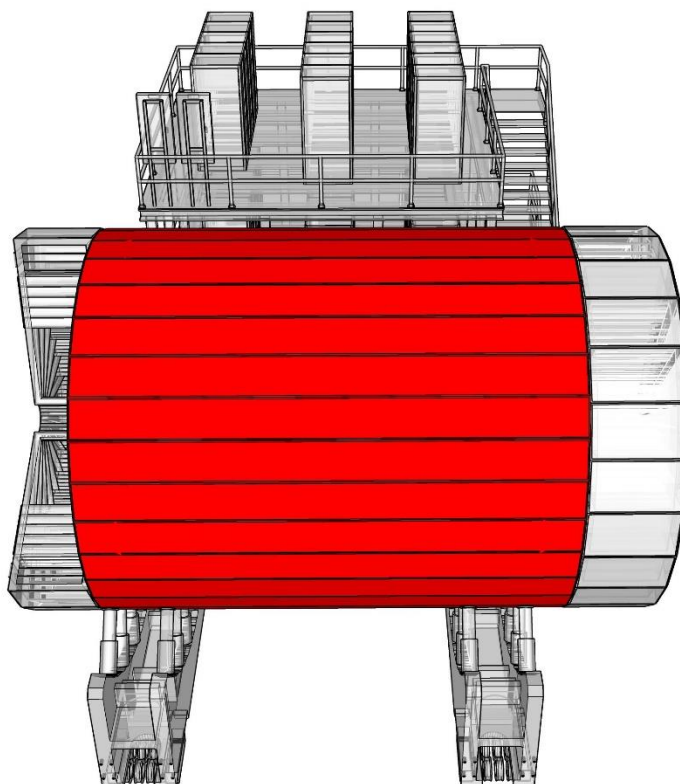


Figure 2: Barrel Hadron Calorimeter

**Dimensions/Location**

Overall Length	640 cm
Lepton Direction Section Length	170 cm
Center Section Length	300 cm
Hadron Direction Section Length	170 cm
Lepton Direction Bore	194 cm
Center Bore	180 cm
Hadron Direction Bore	194 cm
Radius	267 cm
Offset	20 cm in Lepton Direction
Total Volume	72.60 m <sup>3</sup>

**Weight Estimates**

Element	Basis	Weight
57.4 m <sup>3</sup> of Iron	7,847 kg/m <sup>3</sup>	450,046 kg
15.2 m <sup>3</sup> of Plastic	970 kg/m <sup>3</sup>	14,788 kg
Cabling		
Total:		464,834 kg

**Power Requirements**

Component	Source/Voltage	Amps
Data Not Collected		

**Heat Dissipation**

Removal Mechanism/Medium	BTUs
Data Not Collected	

**Communications/Signal**

Element	Cables/Connections
Data Not Collected	

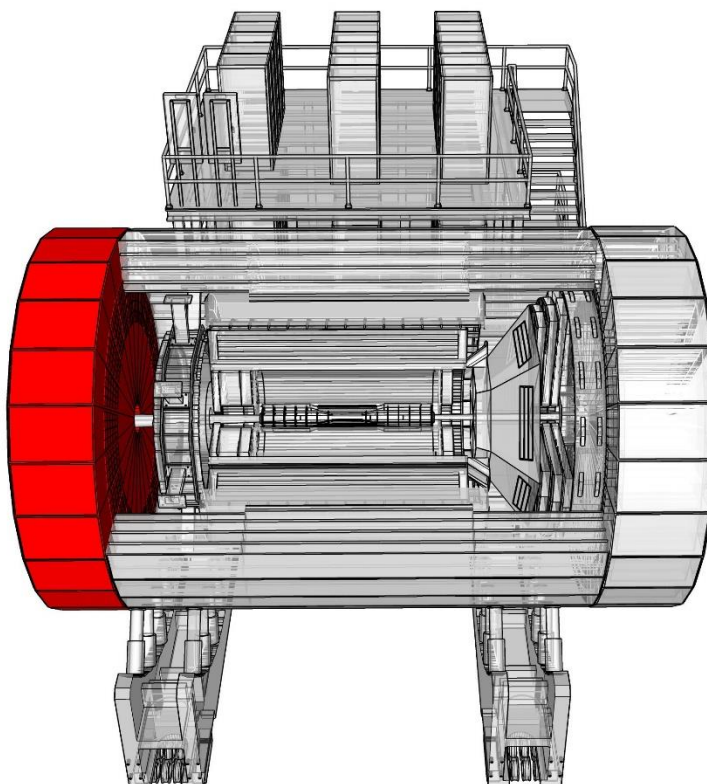
**LEPTON DIRECTION HADRON CALORIMETER ENDCAP**


Figure 3: Lepton Direction Endcap

**Dimensions/Location**

<i>Overall Length</i>	105 cm
<i>Bore</i>	22 cm
<i>Radius</i>	267 cm
<i>Offset</i>	300 cm in Lepton Direction
<i>Total Volume</i>	23.36 m <sup>3</sup>

**Weight Estimates**

<i>Element</i>	<i>Basis</i>	<i>Weight</i>
18.5 m <sup>3</sup> of Iron	7,847 kg/m <sup>3</sup>	144,788 kg
4.9 m <sup>3</sup> of Plastic	970 kg/m <sup>3</sup>	4,758 kg
Cabling		
	Total:	149,546 kg

**Power Requirements**

<i>Component</i>	<i>Source/Voltage</i>	<i>Amps</i>
Data Not Collected		

**Heat Dissipation**

<i>Removal Mechanism/Medium</i>	<i>BTUs</i>
Data Not Collected	

**Communications/Signal**

<i>Element</i>	<i>Cables/Connections</i>
Data Not Collected	

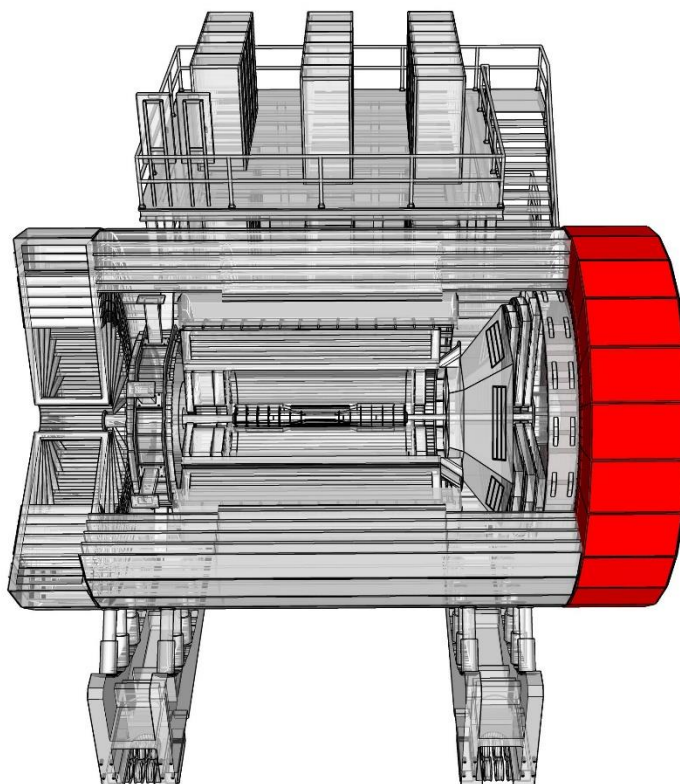
**HADRON DIRECTION HADRON CALORIMETER ENDCAP**


Figure 4: Hadron Direction Endcap

**Dimensions/Location**

<i>Overall Length</i>	120 cm
<i>Bore</i>	30 cm
<i>Radius</i>	267 cm
<i>Offset</i>	340 cm in Hadron Direction
<i>Total Volume</i>	26.54 m <sup>3</sup>

**Weight Estimates**

<i>Element</i>	<i>Basis</i>	<i>Weight</i>
21. m <sup>3</sup> of Iron	7,847 kg/m <sup>3</sup>	164,500 kg
5.6 m <sup>3</sup> of Plastic	970 kg/m <sup>3</sup>	5,405 kg
Cabling		
Total:		169,906 kg

**Power Requirements**

<i>Component</i>	<i>Source/Voltage</i>	<i>Amps</i>
Data Not Collected		

**Heat Dissipation**

<i>Removal Mechanism/Medium</i>	<i>BTUs</i>
Data Not Collected	

**Communications/Signal**

<i>Element</i>	<i>Cables/Connections</i>
Data Not Collected	

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**SOLENOID CRYOSTAT**

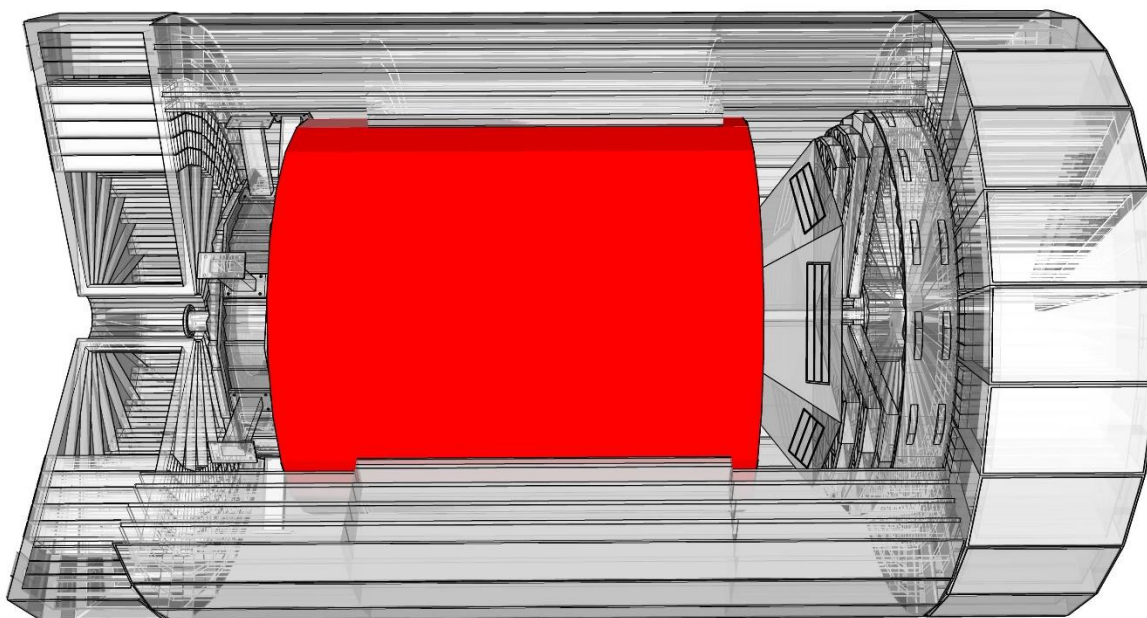


Figure 5: Solenoid Cryostat

**Dimensions/Location**

Overall Length	384 cm
Bore	142 cm
Radius	177 cm
Offset	0 cm
Total Volume	13.47 m <sup>3</sup>

**Weight Estimates**

Element	Basis	Weight
Volume Coeff (CLEO II)	3,412 kg/m <sup>3</sup>	45,956 kg
Cabling		
Total:		45,956 kg

**Power Requirements**

Component	Source/Voltage	Amps
Data Not Collected		

**Heat Dissipation**

Removal Mechanism/Medium	BTUs
Data Not Collected	

**Communications/Signal**

Element	Cables/Connections
Data Not Collected	



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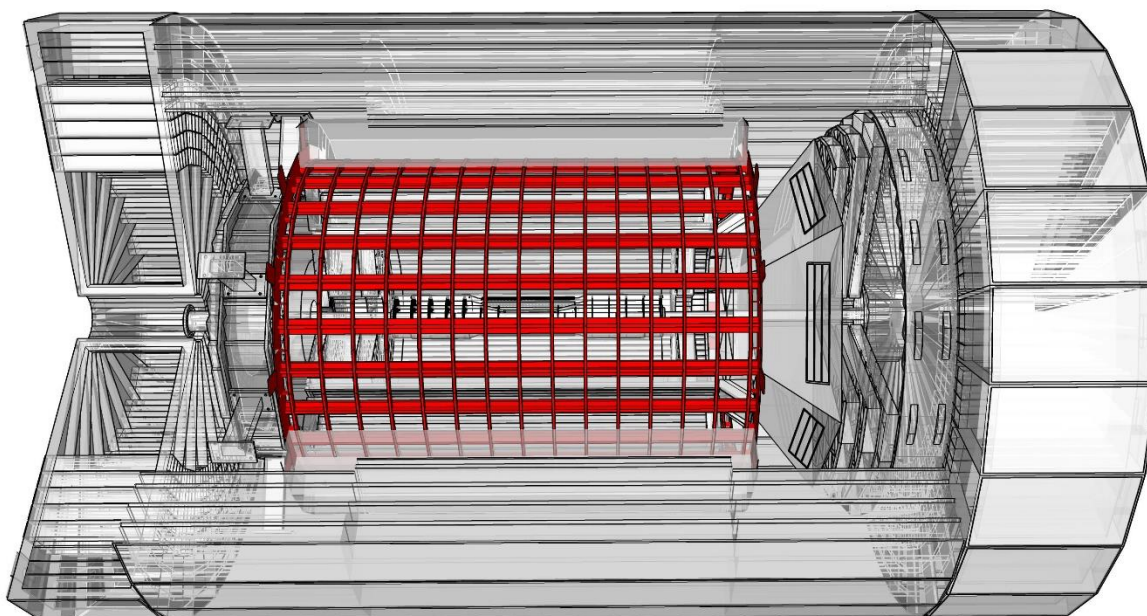


Figure 6: Barrel Support

**Dimensions/Location**

Structure Length	385 cm
Radius	142 cm
Support Radius	220 cm
Offset	0 cm

**Weight Estimates**

Element	Basis	Weight
Data Not Collected		
Total:		lbs
		tons



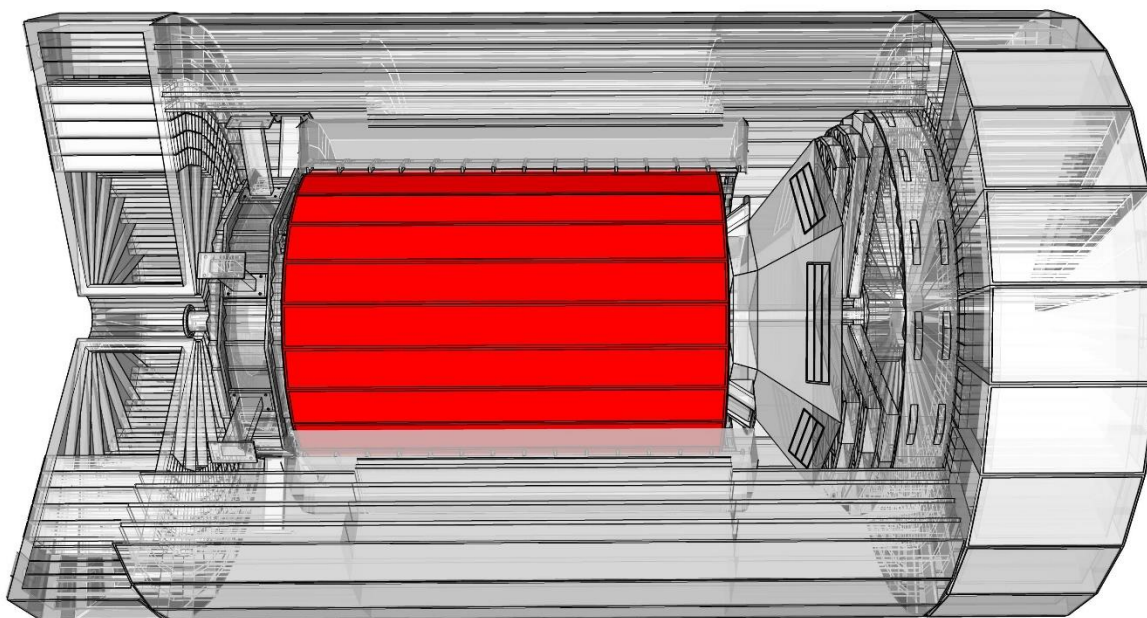
**1.5**  
TESLA**BARREL ELECTROMAGNETIC CALORIMETER**

Figure 7: Barrel Electromagnetic Calorimeter

**Dimensions/Location**

<i>Overall Length</i>		360 cm
<i>Bore</i>		84 cm
<i>Radius</i>		134 cm
<i>Offset</i>	11 cm in Lepton Direction	
<i>Total Volume</i>		12.33 m <sup>3</sup>

**Weight Estimates**

<i>Element</i>	<i>Basis</i>	<i>Weight</i>
Volume Coeff (CMS)	3,508 kg/m <sup>3</sup>	43,246 kg
Cabling		
	Total:	43,246 kg

**Power Requirements**

<i>Component</i>	<i>Source/Voltage</i>	<i>Amps</i>
Data Not Collected		

**Heat Dissipation**

<i>Removal Mechanism/Medium</i>	<i>BTUs</i>
Data Not Collected	

**Communications/Signal**

<i>Element</i>	<i>Cables/Connections</i>
Data Not Collected	

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## DIRC (DETECTION OF INTERNALLY REFLECTED CHERENKOV LIGHT) DETECTOR

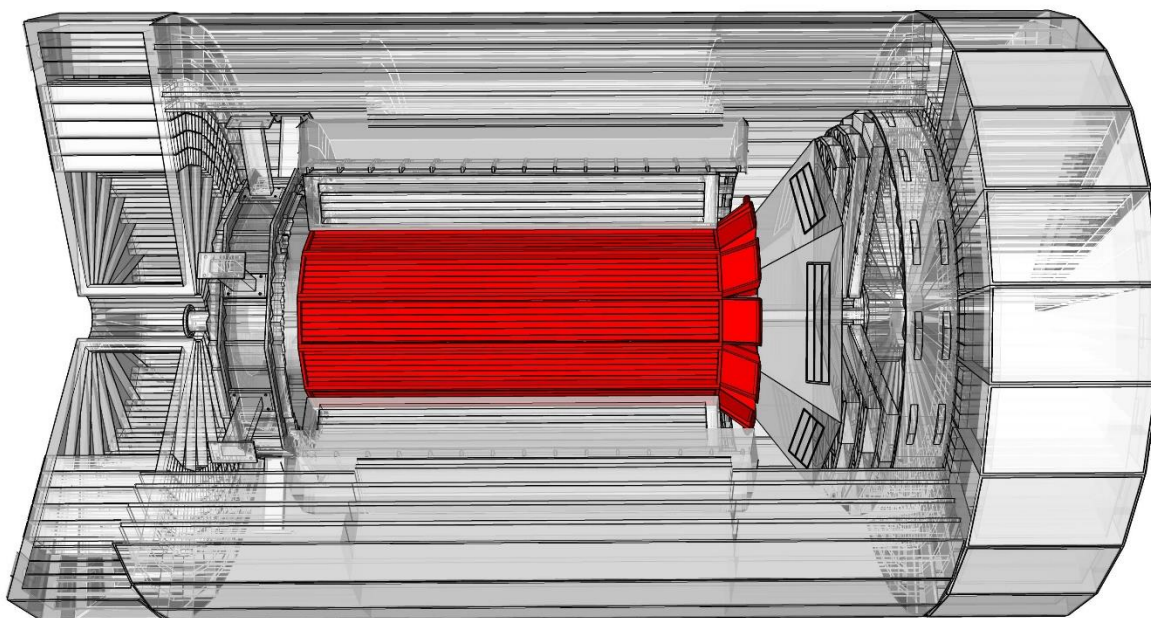


Figure 8: DIRC Detector

### Dimensions/Location

<i>DIRC Bar Length</i>		360 cm
<i>DIRC Segment Count</i>		12
<i>Bore</i>		N/A
<i>Radius</i>		81 cm
<i>Offset</i>	169 cm in Hadron Direction	
<i>Total Volume</i>		0.78 m <sup>3</sup>

### Weight Estimates

<i>Element</i>	<i>Basis</i>	<i>Weight</i>
0.15 m <sup>3</sup> of Steel	7,850 kg/m <sup>3</sup>	1,193 kg
0.63 m <sup>3</sup> of Quartz	2,320 kg/m <sup>3</sup>	1,452 kg
Cabling		
	Total:	2,645 kg

### Power Requirements

<i>Component</i>	<i>Source/Voltage</i>	<i>Amps</i>
Data Not Collected		

### Heat Dissipation

<i>Removal Mechanism/Medium</i>	<i>BTUs</i>
Data Not Collected	

### Communications/Signal

<i>Element</i>	<i>Cables/Connections</i>
Data Not Collected	

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**LEPTON DIRECTION ELECTROMAGNETIC CALORIMETER**



Figure 9: Lepton Direction Electromagnetic Calorimeter

**Dimensions/Location**

Overall Length	60 cm
Bore	15 cm
Radius	110 cm
Support Radius	194 cm
Offset	195 cm in Lepton Direction
Total Volume	2.64 m <sup>3</sup>

**Weight Estimates**

Element	Basis	Weight
2.2 m <sup>3</sup> of Lead Glass	6,220 kg/m <sup>3</sup>	13,910 kg
0.4 m <sup>3</sup> of Steel	7,850 kg/m <sup>3</sup>	3,199 kg
Cabling		
	Total:	17,110 kg

**Power Requirements**

Component	Source/Voltage	Amps
Data Not Collected		

**Heat Dissipation**

Removal Mechanism/Medium	BTUs
Data Not Collected	

**Communications/Signal**

Element	Cables/Connections
Data Not Collected	

**LEPTON DIRECTION TIME OF FLIGHT DETECTOR**

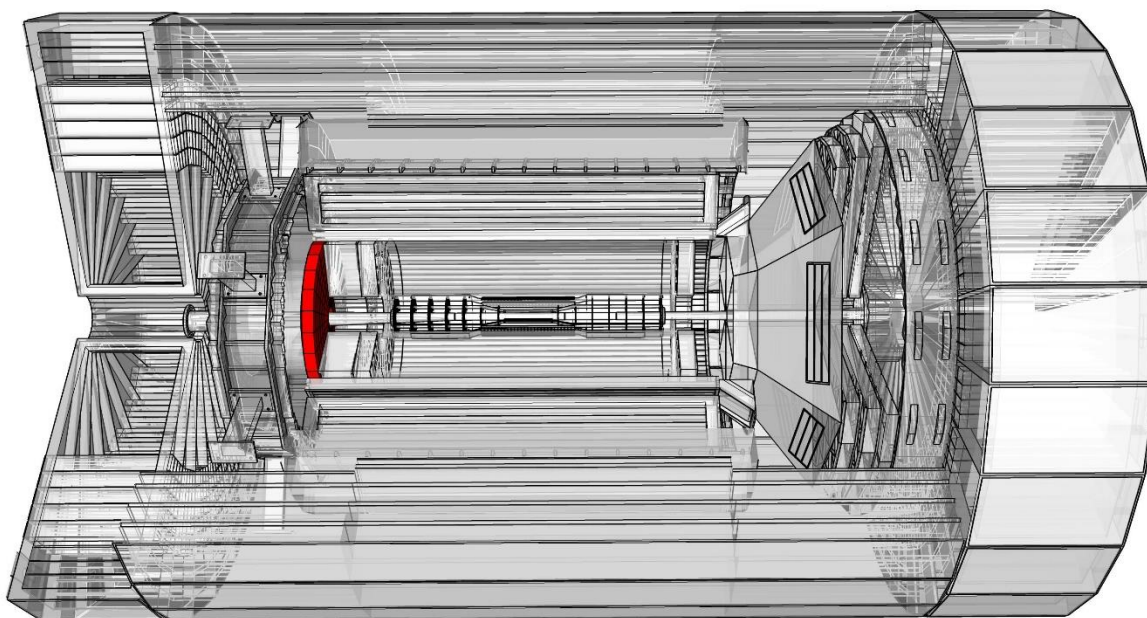


Figure 10: Lepton Direction Time of Flight Detector

**Dimensions/Location**

Overall Length	10 cm
Bore	10 cm
Radius	71 cm
Offset	180 cm in Lepton Direction
Total Volume	0.16 m <sup>3</sup>

**Weight Estimates**

Element	Basis	Weight
Volume Coeff (PANDA)	605 kg/m <sup>3</sup>	94 kg
Cabling		
Total:		94 kg

**Power Requirements**

Component	Source/Voltage	Amps
Data Not Collected		

**Heat Dissipation**

Removal Mechanism/Medium	BTUs
Data Not Collected	

**Communications/Signal**

Element	Cables/Connections
Data Not Collected	



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**CHERENKOV COUNTER**

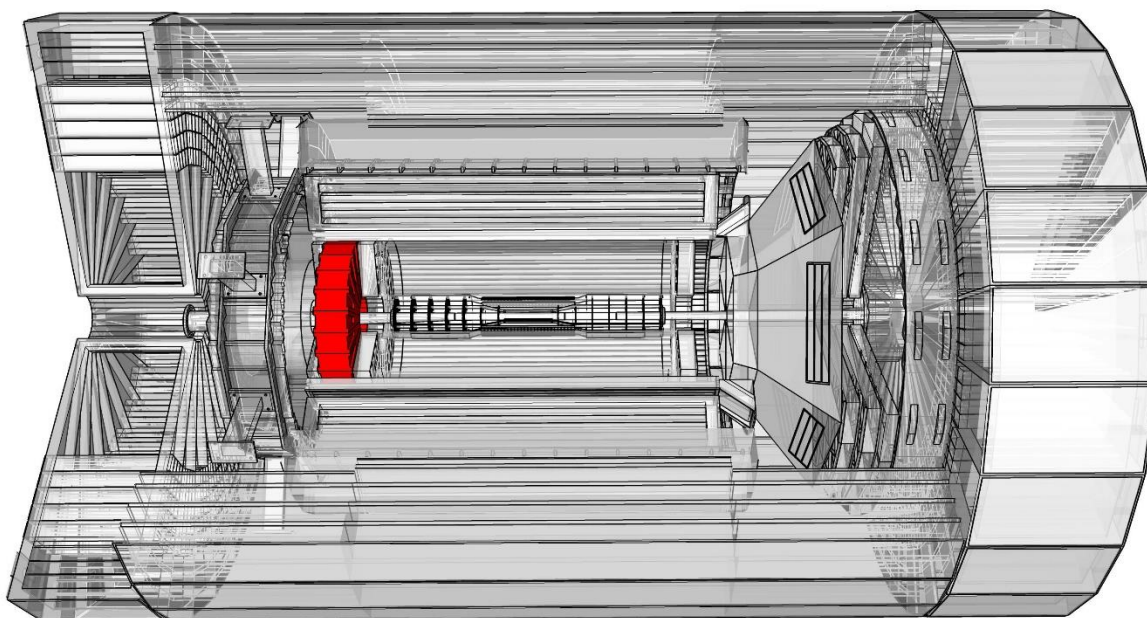


Figure 11: Cherenkov Counter

**Dimensions/Location**

Overall Length	30 cm
Bore	20 cm
Radius	71 cm
Offset	150 cm in Lepton Direction
Total Volume	0.44 m <sup>3</sup>

**Weight Estimates**

Element	Basis	Weight
Volume Coeff (CLAS LTCC)	186 kg/m <sup>3</sup>	81 kg
Cabling		
Total:		81 kg

**Power Requirements**

Component	Source/Voltage	Amps
Data Not Collected		

**Heat Dissipation**

Removal Mechanism/Medium	BTUs
Data Not Collected	

**Communications/Signal**

Element	Cables/Connections
Data Not Collected	

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**LEPTON DIRECTION MICRO-PATTERN GAS DETECTOR**

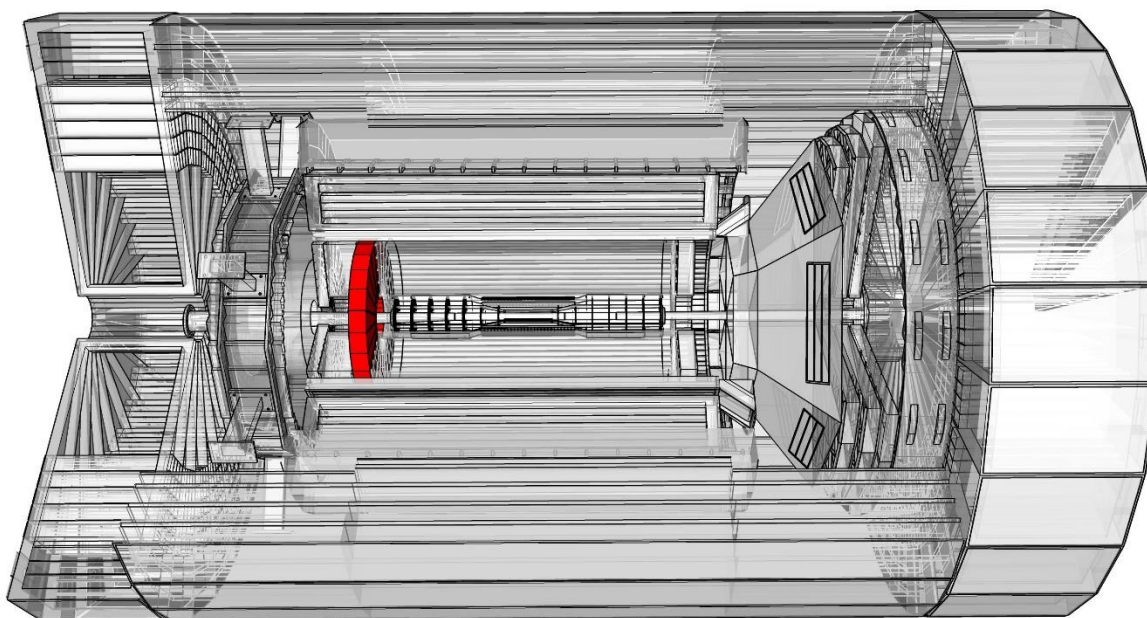


Figure 12: Lepton Direction Micro-Pattern Gas Detector

**Dimensions/Location**

Overall Length	15 cm
Bore	20 cm
Radius	71 cm
Offset	135 cm in Lepton Direction
Total Volume	0.22 m <sup>3</sup>

**Weight Estimates**

Element	Basis	Weight
Volume Coeff (SBS GEM)	200 kg/m <sup>3</sup>	44 kg
Cabling		
	Total:	44 kg

**Power Requirements**

Component	Source/Voltage	Amps
Data Not Collected		

**Heat Dissipation**

Removal Mechanism/Medium	BTUs
Data Not Collected	

**Communications/Signal**

Element	Cables/Connections
Data Not Collected	



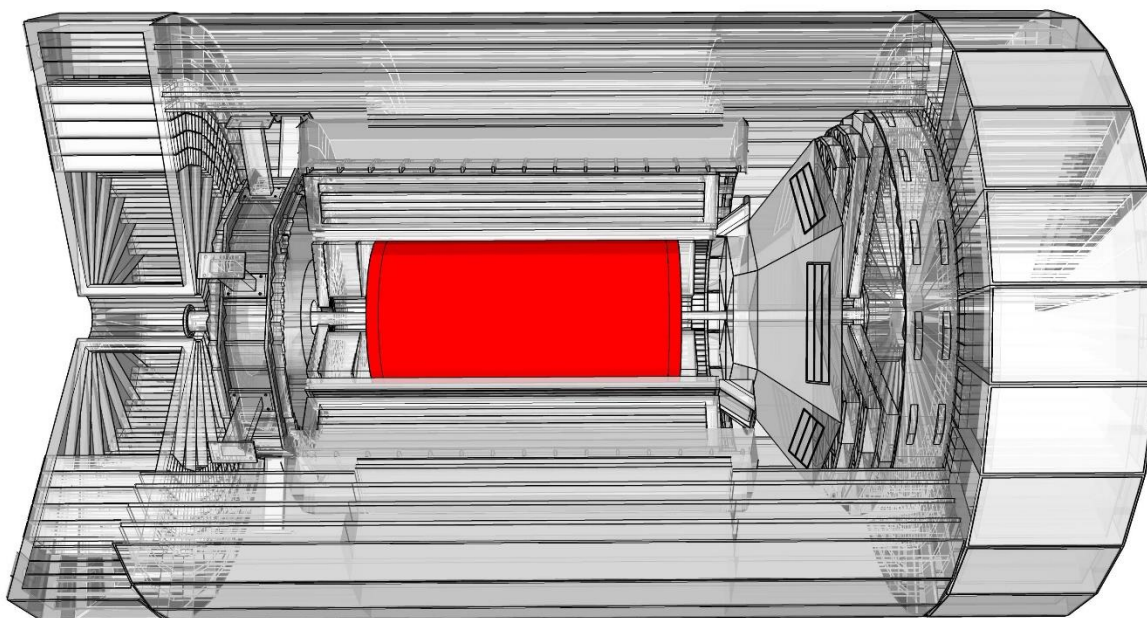
**OUTER TRACKING**


Figure 13: Outer Tracking

**Dimensions/Location**

<i>Overall Length</i>	270 cm
<i>Bore</i>	20 cm
<i>Radius</i>	71 cm
<i>Offset</i>	0 cm
<i>Total Volume</i>	3.94 m <sup>3</sup>

**Weight Estimates**

<i>Element</i>	<i>Basis</i>	<i>Weight</i>
Volume Coeff (sPHENIX TPC)	99 kg/m <sup>3</sup>	390 kg
Cabling		
	Total:	390 kg

**Power Requirements**

<i>Component</i>	<i>Source/Voltage</i>	<i>Amps</i>
Data Not Collected		

**Heat Dissipation**

<i>Removal Mechanism/Medium</i>	<i>BTUs</i>
Data Not Collected	

**Communications/Signal**

<i>Element</i>	<i>Cables/Connections</i>
Data Not Collected	

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**HADRON DIRECTION MICRO-PATTERN GAS DETECTOR**

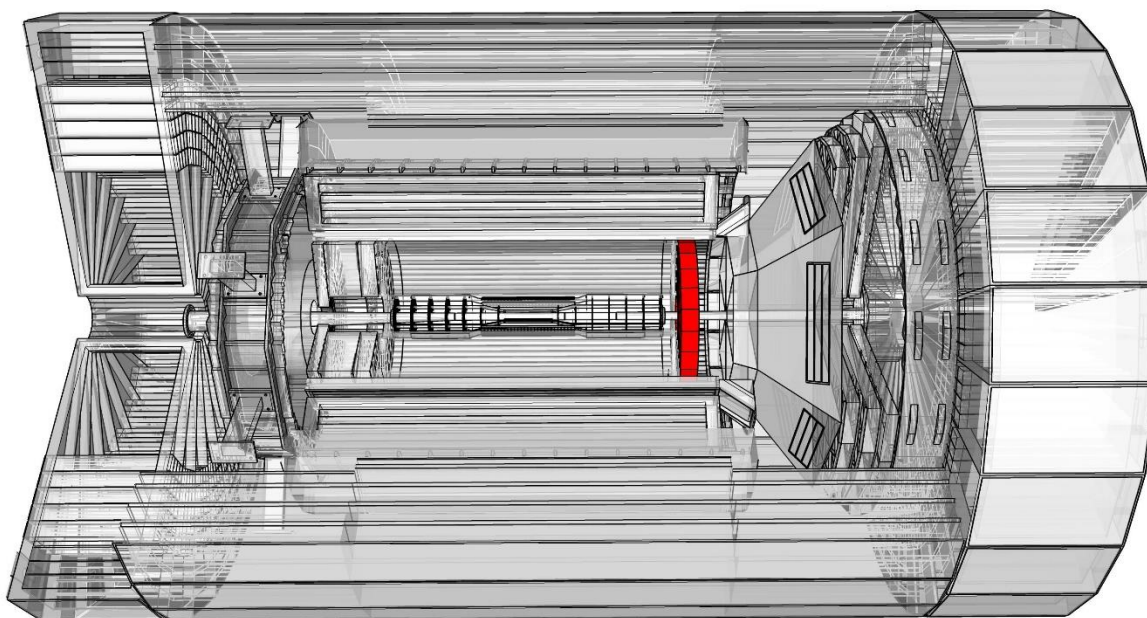


Figure 14: Hadron Direction Micro-Pattern Gas Detector

**Dimensions/Location**

Overall Length	15 cm
Bore	20 cm
Radius	71 cm
Offset	135 cm in Hadron Direction
Total Volume	0.22 m <sup>3</sup>

**Weight Estimates**

Element	Basis	Weight
Volume Coeff (SBS GEM)	200 kg/m <sup>3</sup>	44 kg
Cabling		
Total:		44 kg

**Power Requirements**

Component	Source/Voltage	Amps
Data Not Collected		

**Heat Dissipation**

Removal Mechanism/Medium	BTUs
Data Not Collected	

**Communications/Signal**

Element	Cables/Connections
Data Not Collected	

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**RICH (RING IMAGING CHERENKOV) DETECTOR**

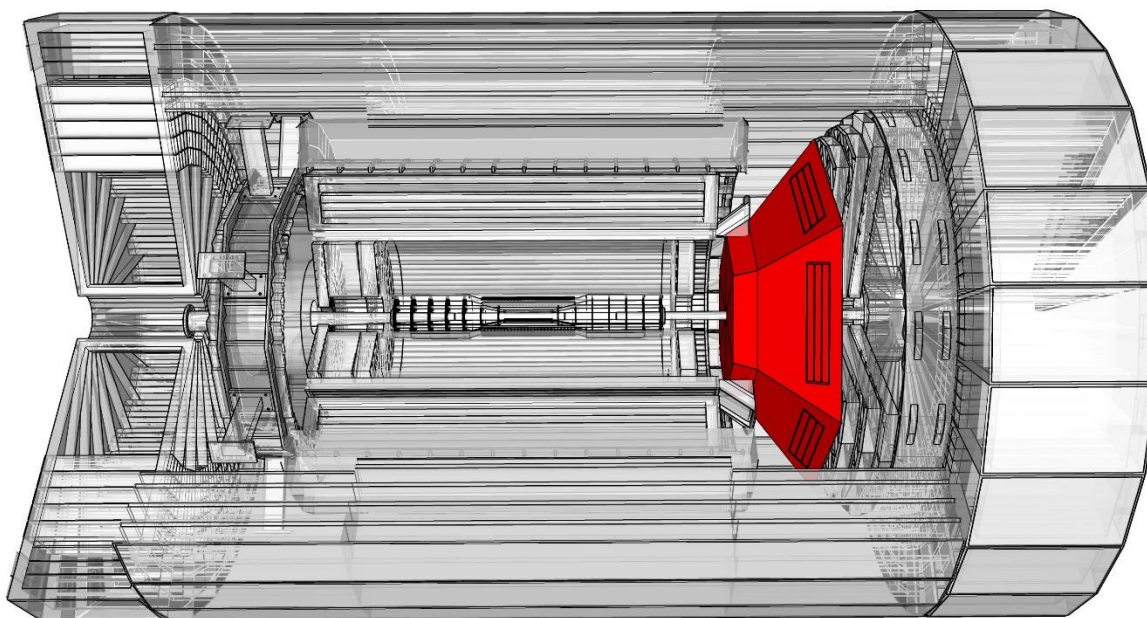


Figure 15: RICH Detector

**Dimensions/Location**

Overall Length	80 cm
Aerogel Length	20 cm
Aerogel Radius	75 cm
Detector Length	60 cm
Bore	10 cm
E1 (Far) Radius	160 cm
E2 (Near) Radius	85 cm
Offset	260 cm in Hadron Direction
Segment Count	6
Total Volume	3.32 m <sup>3</sup>

**Weight Estimates**

Element	Basis	Weight
Volume Coeff (CLAS LTCC)	185.81 kg/m <sup>3</sup>	617 kg
Cabling		
	Total:	617 kg

**Power Requirements**

Component	Source/Voltage	Amps
Data Not Collected		

**Heat Dissipation**

Removal Mechanism/Medium	BTUs
Data Not Collected	

**Communications/Signal**

Element	Cables/Connections
Data Not Collected	

**HADRON DIRECTION TRANSITION RADIATION DETECTOR 2**

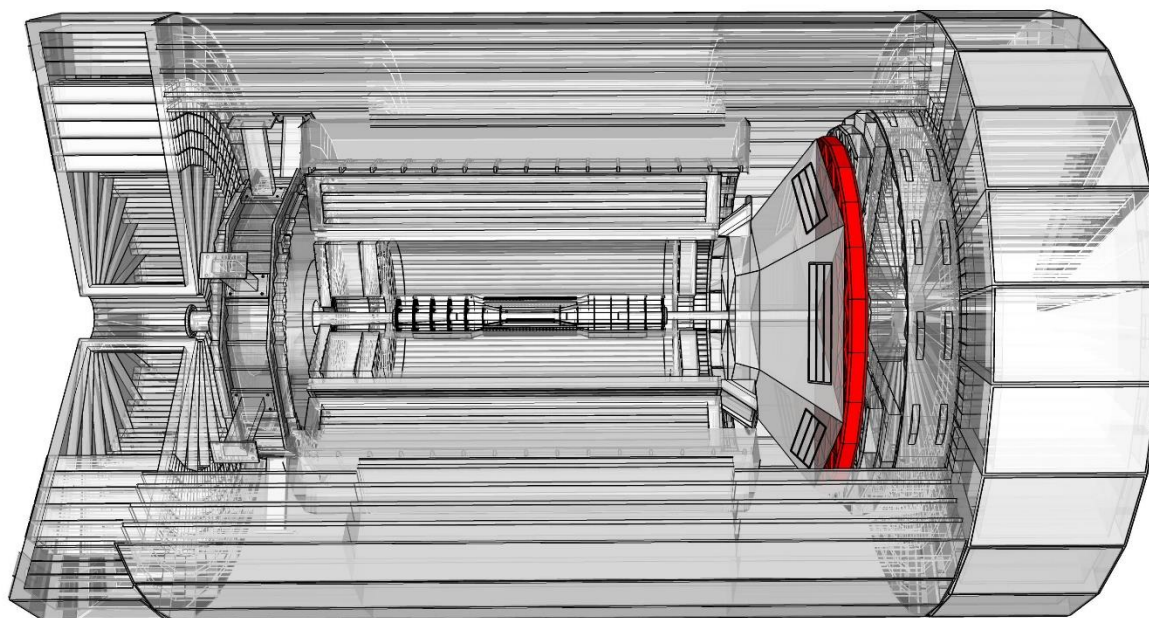


Figure 16: Hadron Direction Transition Radiation Detector 2

**Dimensions/Location**

Overall Length	15 cm
Bore	20 cm
Radius	160 cm
Offset	260 cm in Hadron Direction
Total Volume	1.19 m <sup>3</sup>

**Weight Estimates**

Element	Basis	Weight
Volume Coeff (SBS GEM)	239 kg/m <sup>3</sup>	283 kg
Cabling		
Total:		283 kg

**Power Requirements**

Component	Source/Voltage	Amps
Data Not Collected		

**Heat Dissipation**

Removal Mechanism/Medium	BTUs
Data Not Collected	

**Communications/Signal**

Element	Cables/Connections
Data Not Collected	



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**HADRON DIRECTION TRANSITION RADIATION DETECTOR 1**

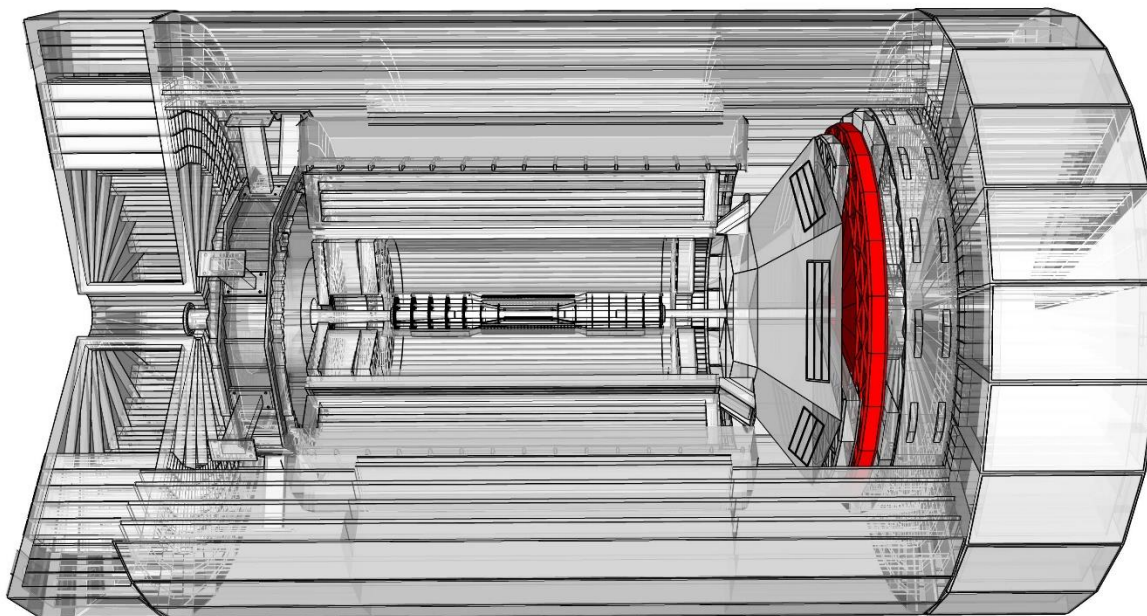


Figure 17: Hadron Direction Transition Radiation Detector 1

**Dimensions/Location**

Overall Length	15 cm
Bore	20 cm
Radius	170 cm
Offset	275 cm in Hadron Direction
Total Volume	1.34 m <sup>3</sup>

**Weight Estimates**

Element	Basis	Weight
Volume Coeff (SBS GEM)	239 kg/m <sup>3</sup>	321 kg
Cabling		
Total:		321 kg

**Power Requirements**

Component	Source/Voltage	Amps
Data Not Collected		

**Heat Dissipation**

Removal Mechanism/Medium	BTUs
Data Not Collected	

**Communications/Signal**

Element	Cables/Connections
Data Not Collected	

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**HADRON DIRECTION TIME OF FLIGHT DETECTOR**

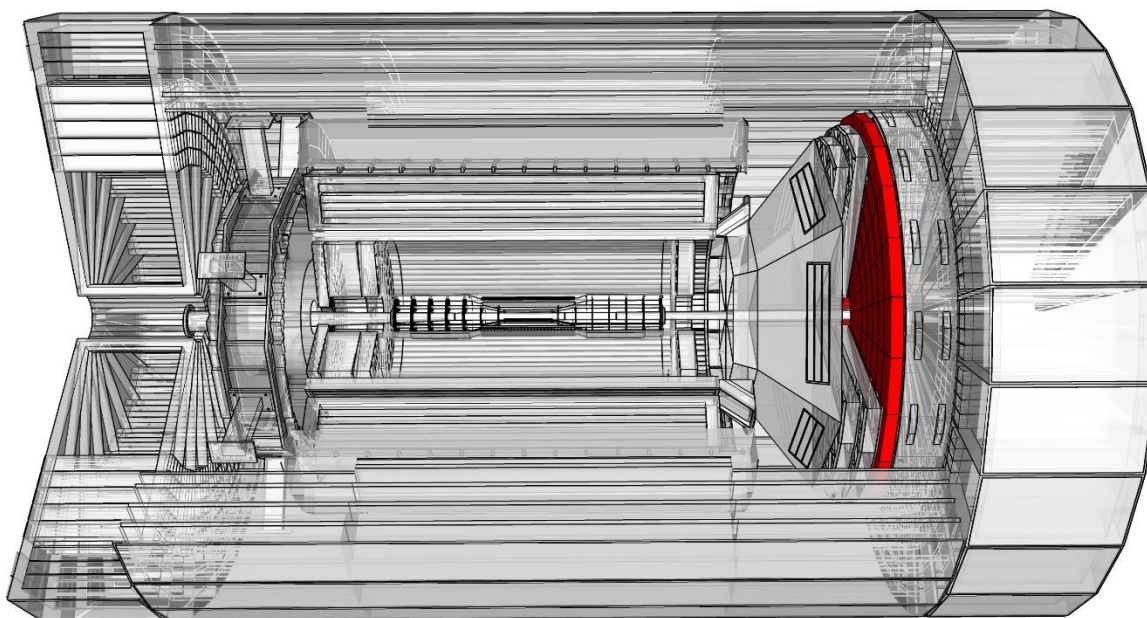


Figure 18: Hadron Direction Time of Flight Detector

**Dimensions/Location**

Overall Length	10 cm
Bore	20 cm
Radius	180 cm
Offset	290 cm in Hadron Direction
Total Volume	1.01 m <sup>3</sup>

**Weight Estimates**

Element	Basis	Weight
Volume Coeff (PANDA)	605 kg/m <sup>3</sup>	609 kg
Cabling		
Total:		609 kg

**Power Requirements**

Component	Source/Voltage	Amps
Data Not Collected		

**Heat Dissipation**

Removal Mechanism/Medium	BTUs
Data Not Collected	

**Communications/Signal**

Element	Cables/Connections
Data Not Collected	



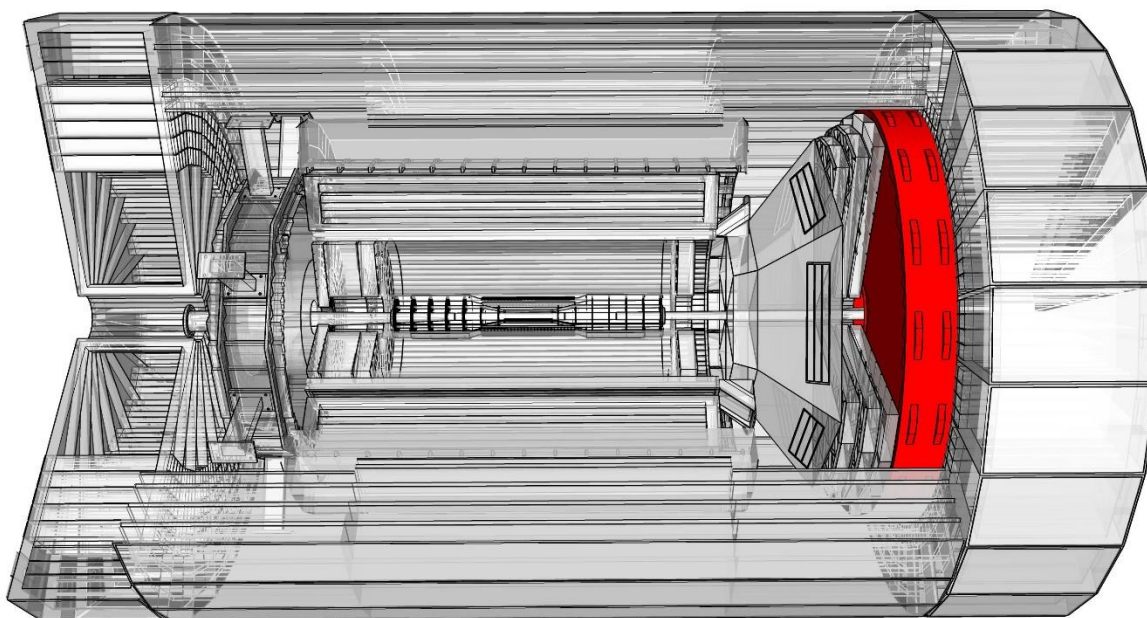
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Figure 19: Hadron Direction Electromagnetic Calorimeter

**Dimensions/Location**

<i>Overall Length</i>	40 cm
<i>Bore</i>	30 cm
<i>Radius</i>	190 cm
<i>Offset</i>	300 cm in Hadron Direction
<i>Total Volume</i>	4.42 m <sup>3</sup>

**Weight Estimates**

<i>Element</i>	<i>Basis</i>	<i>Weight</i>
4.3 m <sup>3</sup> of Lead Glass	6,220 kg/m <sup>3</sup>	26,764 kg
0.12 m <sup>3</sup> of Steel	7,850 kg/m <sup>3</sup>	946 kg
Cabling		
Total:		27,710 kg

**Power Requirements**

<i>Component</i>	<i>Source/Voltage</i>	<i>Amps</i>
Data Not Collected		

**Heat Dissipation**

<i>Removal Mechanism/Medium</i>	<i>BTUs</i>
Data Not Collected	

**Communications/Signal**

<i>Element</i>	<i>Cables/Connections</i>
Data Not Collected	

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## SILICON VERTEX DETECTOR

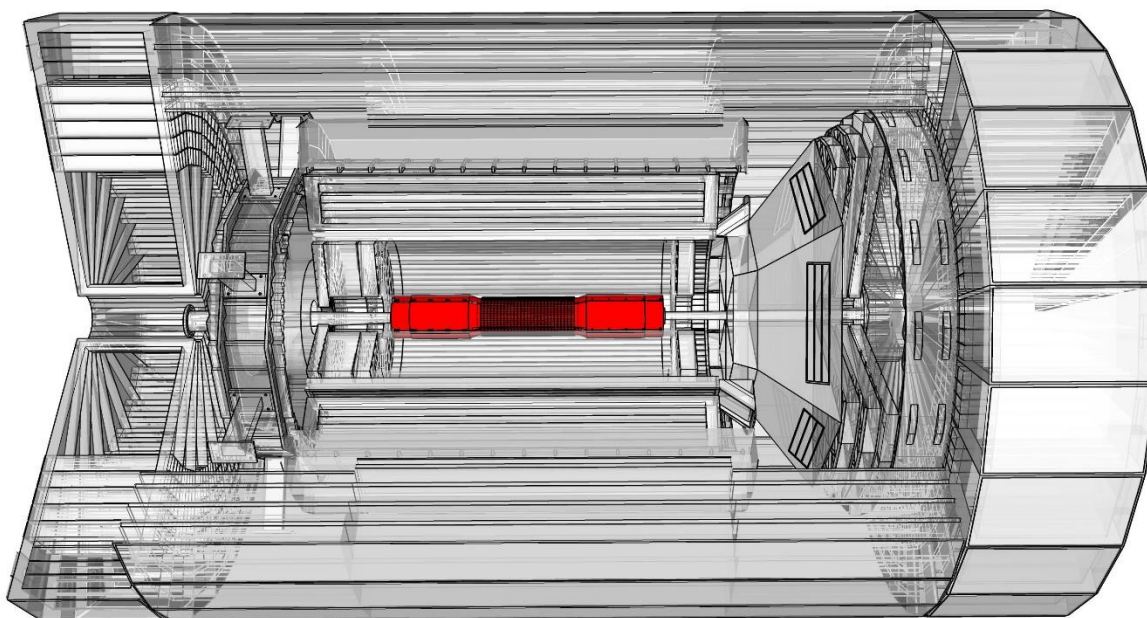


Figure 20: Silicon Vertex Detector

### Dimensions/Location

Overall Length	244 cm
Bore	0 cm
Radius	19.8 cm
Offset	0 cm
Total Volume	0.30 m <sup>3</sup>

### Weight Estimates

Element	Basis	Weight
0.009 m <sup>3</sup> of Aluminum	2,710 kg/m <sup>3</sup>	24 kg
0.009 m <sup>3</sup> of Silicon	2,330 kg/m <sup>3</sup>	21 kg
Cabling		
Total:		45 kg

### Power Requirements

Component	Source/Voltage	Amps
Data Not Collected		

### Heat Dissipation

Removal Mechanism/Medium	BTUs
Data Not Collected	

### Communications/Signal

Element	Cables/Connections
Data Not Collected	

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**VACUUM CHAMBER**

Note that this vacuum chamber is specific to IP-6. An alternate design will be produced for IP-8.



Figure 21: Vacuum Chamber (Top View)

**Dimensions/Location**

<i>Overall Length</i>	645.28 cm
<i>Beryllium Length</i>	146.05 cm
<i>Interior Section Length</i>	243.90 cm
<i>Lepton Section Length</i>	Not Available
<i>Hadron Section Length</i>	Not Available

**Weight Estimates**

<i>Element</i>	<i>Basis</i>	<i>Weight</i>
Data Not Collected		
Total:		lbs
		tons

**Power Requirements**

<i>Component</i>	<i>Source/Voltage</i>	<i>Amps</i>
Data Not Collected		

**Heat Dissipation**

<i>Removal Mechanism/Medium</i>	<i>BTUs</i>
Data Not Collected	

**Communications/Signal**

<i>Element</i>	<i>Cables/Connections</i>
Data Not Collected	