Constrains and needs for the dRICH envelope

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Introductory remarks

dRICH is a complex detector

Principle

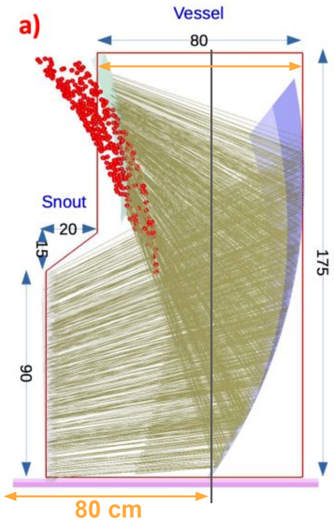
- low-n (gas) radiator @ high-energy
    - long path for light yield
- resolution vs emission point
    - proper light focalization

Consequence

- extensive volume and not trivial geometry
- bending inside the magnetic field

Performance is strictly related to the Detector-1 global layout
dRICH cannot be made arbitrarily small to guarantee required performance for physics at EIC

Need to maximise the length of gas radiator



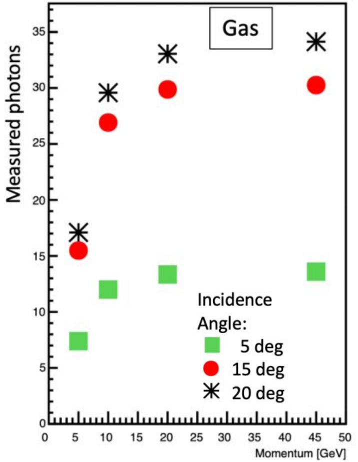
current total dimension of longitudinal envelope in Detector 1: 100 cm
https://physdiv.jlab.org/EIC/Menagerie/docs/DetectorParameterTable.pdf

from total envelope one has to remove

- vessel walls: assume to be negligible
- aerogel and related items: 5 cm
- space between mirror and back of vessel: ~ 15 cm
  - maybe even more than 30 cm in ECCE design

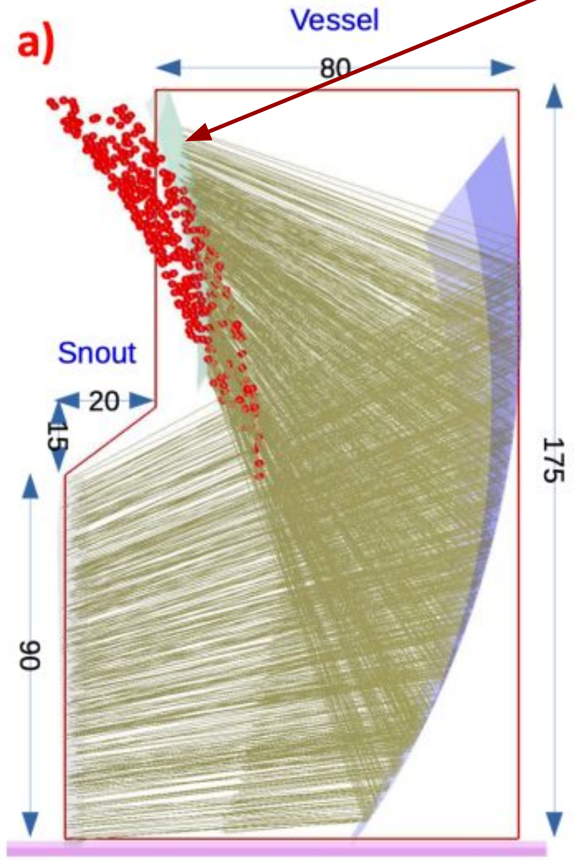
gas available for Cherenkov emission in ECCE design is very limited:
→ at very forward rapidity (eta ~ 0) is less than 70 cm

~ half of the photons emitted by the gas of dRICH in the Yellow Report reference detector
assuming tracking contribution is negligible, angular resolution / momentum reach improve with $\sqrt{N_{ph}}$



- significantly shorter than Yellow Report reference detector design
  - 160 cm envelope → 140 cm gas → 75% more photons → 30% better resolution
- significantly shorter than dRICH envelope in ATHENA proposal
  - 140 cm envelope → 120 cm gas → 50% more photons → 20% better resolution
- significantly shorter than current dRICH prototype
  - 150 cm envelope → 120 cm gas

Space for servicing the readout plane



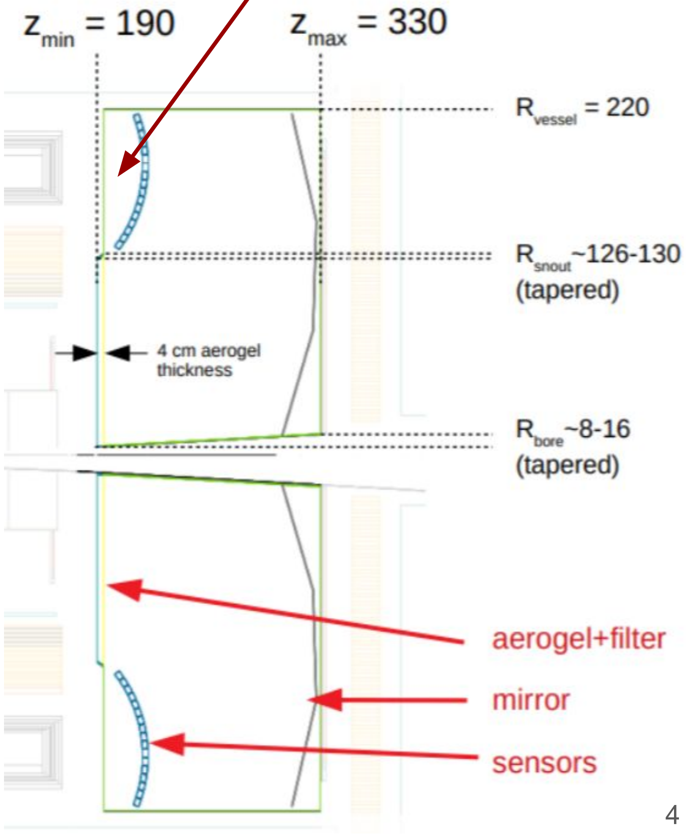
there is not enough space between the sensor plane and the limits of the dRICH envelope

it must be possible to put the needed services for the sensors

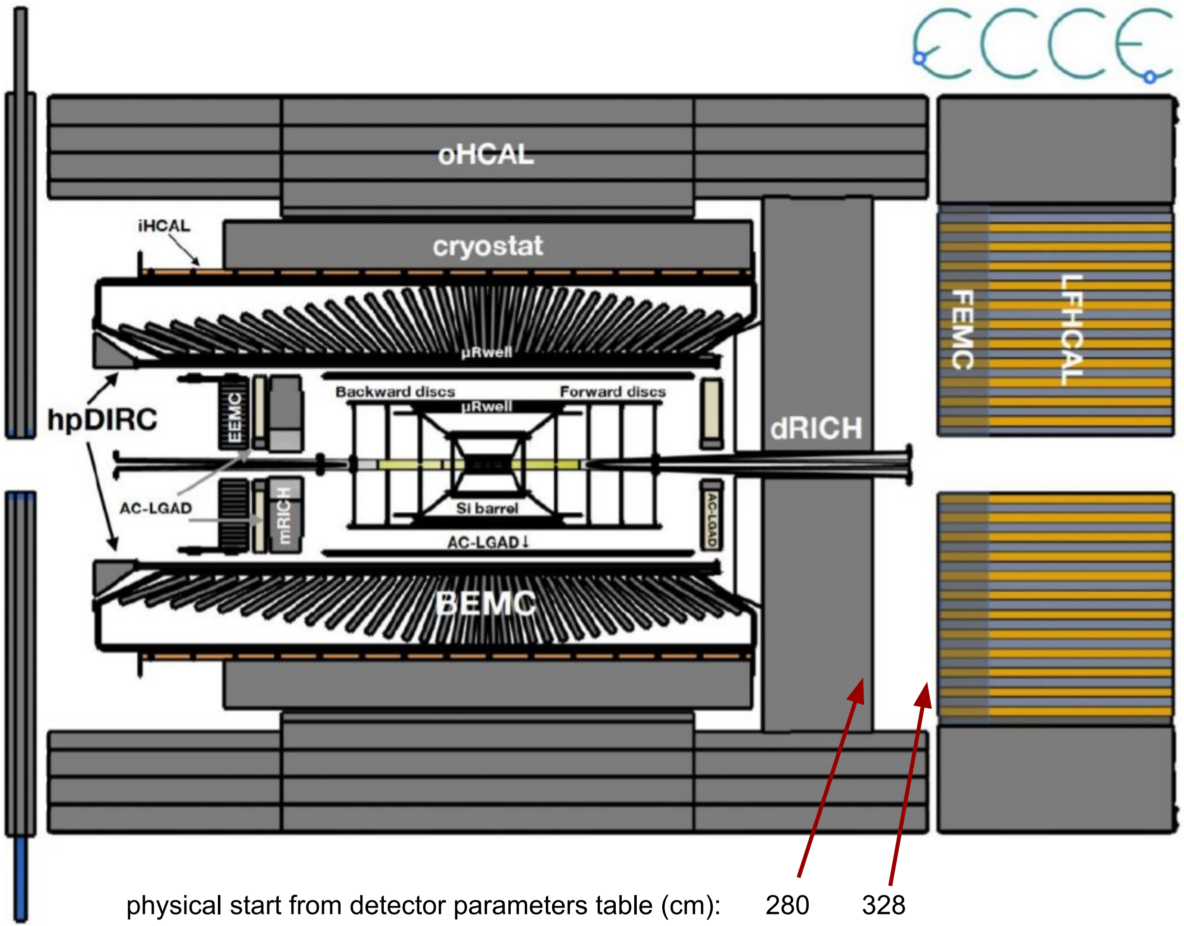
- front-end electronics
- cables
- cooling plates for SiPM
- cooling pipes for front-end
- ….

a larger longitudinal envelope is needed to accommodate those services

room for sensor services in ATHENA dRICH layout



Increase length of dRICH envelope within constraints



physical start from detector parameters table (cm): 280 328

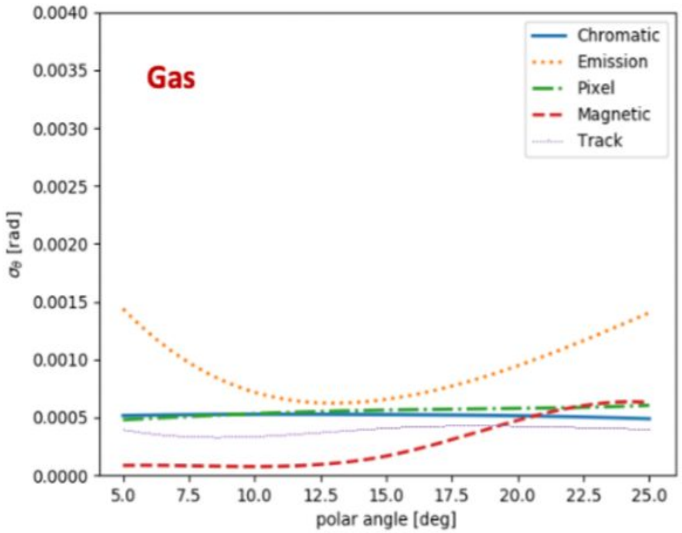
there are 48 cm of empty space between dRICH and ECAL

is there any constraints that avoid the assignment of a fraction that space to dRICH envelope?

<u>proposal to evaluate:</u>
assign 30 cm more to dRICH
leave 10 cm for tracker behind RICH and 8 cm of contingency space
(4 cm between each piece of equipment)

of course one should review and revisit the dRICH layout of optics for optimal focus on sensor plane, but in principle those might be still achievable goals
(see for example dual mirror concept of ATHENA proposal, double reflection as in LHCb, …)

The need for tracking behind dRICH



difference of K/π Cherenkov angle emission
at 50 GeV/c momentum in C_2F_6 gas: 1.15 mrad

3σ separation requires total (tracking included)
angular resolution better than 0.4 mrad

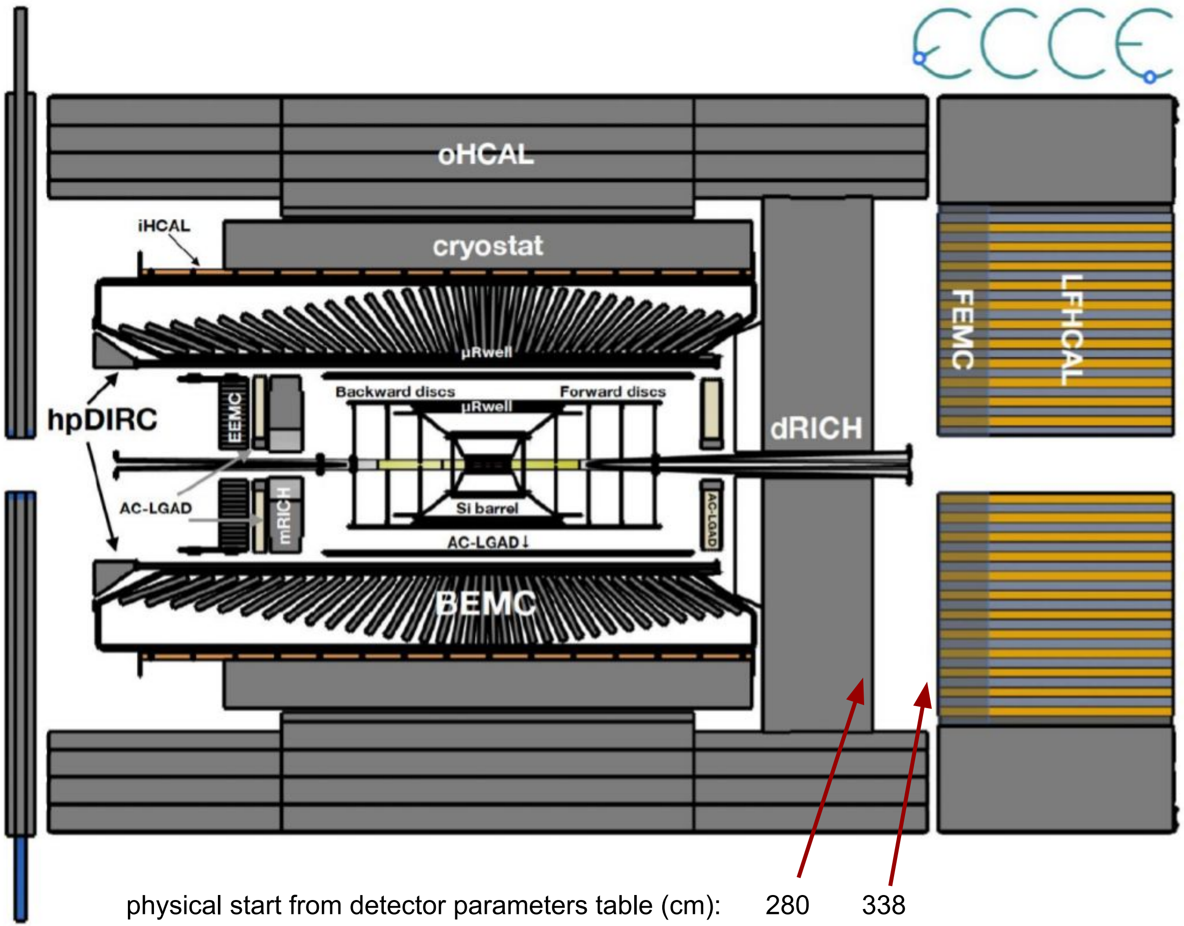
is the track direction in the middle of the dRICH volume known better than 0.4 mrad?

- last tracking point is on forward TOF LGAD sensors
  - hadron TOF is 155 cm from IP
  - dRICH midpoint of vessel is 230 cm from IP
  - there are 75 cm of flight path with no tracking information
- scattering in material between LGAD and dRICH gas
  - LGAD electronics and services
  - dRICH vessel (pressure!)
  - cause of unmeasured angular deflections

Due to the large lever arm and possible scattering internal to the detector itself (entrance window in the high pressure version), it is likely wise to supplement the tracking prior to the dRICH with a detector that provides an additional space point beyond the radiation volume [Yellow Report].

Need to understand from tracking group **what is the resolution of the track direction at the middle of the dRICH gas volume** with and without a tracking (GEM) detector behind the dRICH

Increase length of dRICH envelope within constraints



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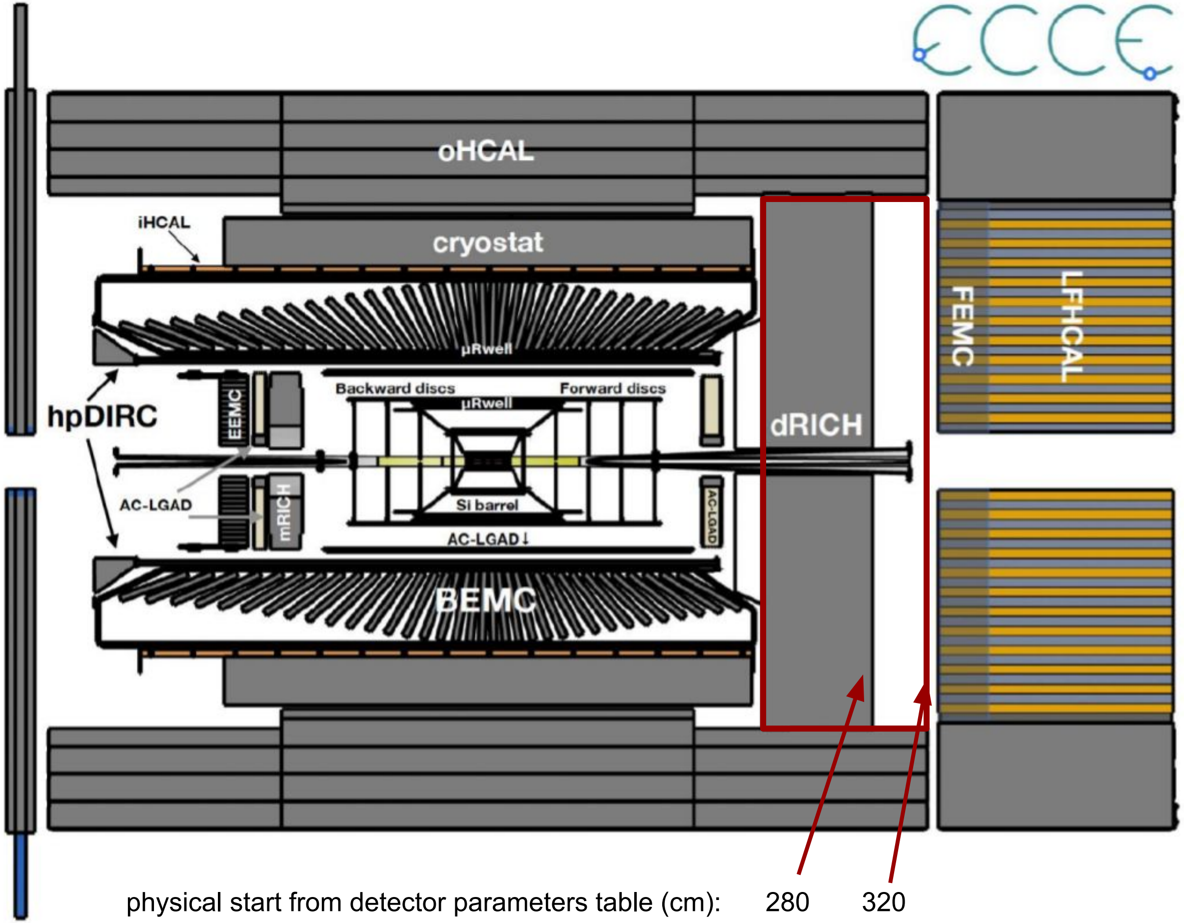
there are ideas to sacrifice dRICH photons to better define track angle without tracker behind.

I do not know the details of this method, which might be valuable but has to be proven to work.

if it works, one could perhaps drop the tracker, but still if some PID photons have to be sacrificed for particle tracking, more gas is needed

in the end not much changes: assign 40 cm more to dRICH system, which might include or not a tracker

Increase length of dRICH envelope within constraints



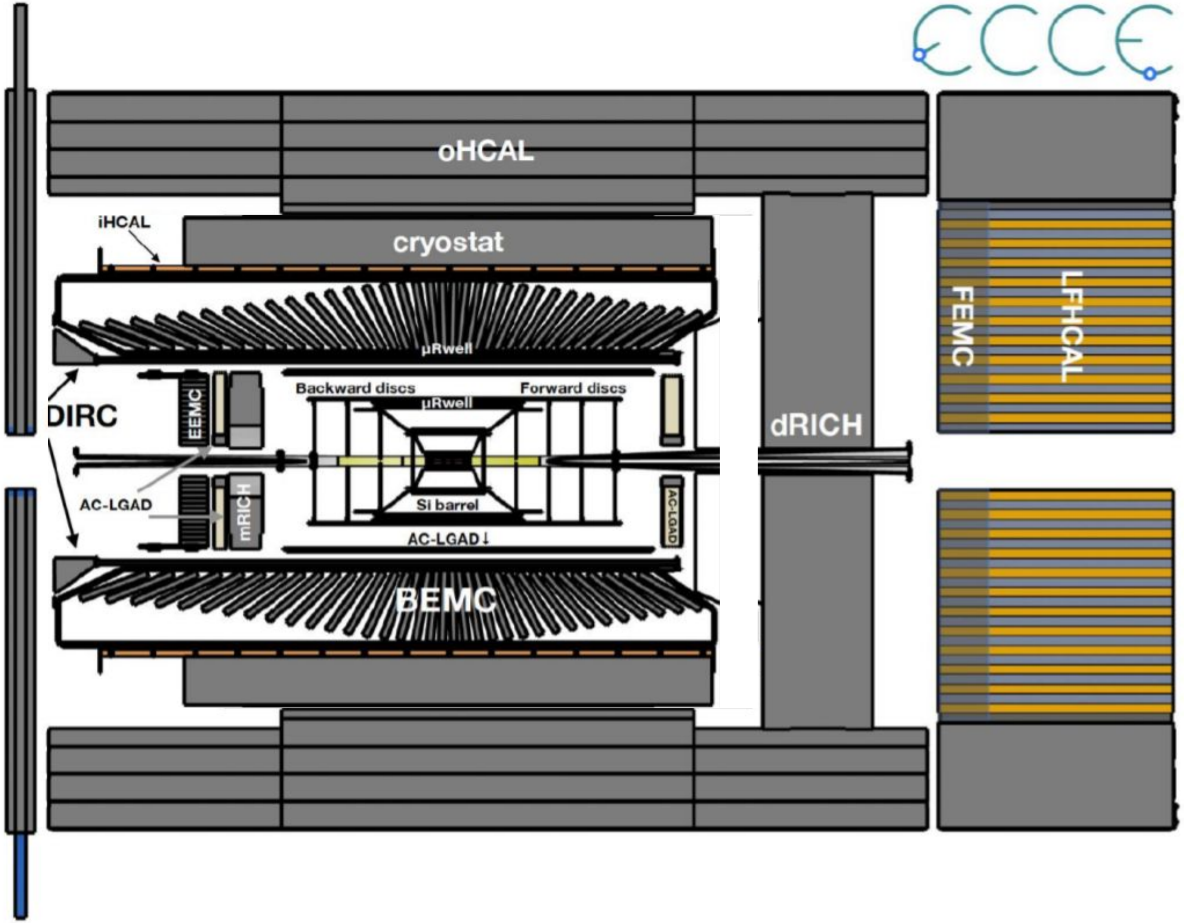
physical start from detector parameters table (cm): 280 320

possible minimal requirement: extend dRICH envelope to match HCAL border: from 280 to 320 cm

→ would gain 40 cm, good for
- more photons for PID
- room for services

dRICH system envelope might include or not a GEM tracker, according to studies of track direction resolution at dRICH point of interest

Increase length of dRICH envelope within constraints



find more space with more exotic solution

there seems to be space on the far end of the electron-side
move all the barrel detectors by 10-20 cm and increase the dRICH envelope even further

the end

Region	Component	Sub-Component	WBS	Length (cm)	Inner Radius (cm)	Outer Radius (cm)	Offset from Center (cm)	Physical Start (cm)	Physical End (cm)	Volume (m³)	Weight (kg)	Technology	Notes
HADRON DIRECTION END CAP	**Hadron Calorimeter**		6.10.06	171	30	267	328	499	328	33.611645	215,210	FeSc, WSc last segment	Tower size: 5cm x 5cm x 140cm, 20cm readout Offset: measured from face nearest to interaction point Volume: calculated as cylindrical volume minus the volume of the embedded ECAL Weight: estimated as 79% iron and 21% plastic
	Electromagnetic Calorimeter		6.10.05	38	30	190	328	366	328	4.2021943	27,165	Pb/Sc	Tower size: 1cm (1.65cm) x 1cm(1.65cm) x 37.5cm, 5cm readout Offset: measured from face nearest to interaction point Weight: estimated as 85% lead glass and 15% steel
	Service Gap			8			320	328	320				Offset: measured from location nearest to interaction point
CENTRAL DETECTOR	**Barrel Hadron Calorimeter**		6.10.06	640		267	0	320	-320	72.60	464,834	FeSc	Offset: measured from center of detector Volume: calculated as sum of the sub-sections Weight: estimated as 79% iron and 21% plastic
		HD Section		*170*	*194*	*267*	*150*	*320*	*150*	*17.97*			*Offset: measured from face nearest to interaction point*
		Central Section		*300*	*180*	*267*	*0*	*150*	*-150*	*36.65*			*Offset: measured from center of detector*
		LD Section		*170*	*194*	*267*	*-150*	*-150*	*-320*	*17.97*			*Offset: measured from face nearest to interaction point*
	Dual RICH		6.10.04	100	10		180	280	180	10.29	1,911	Aerogel/Gas	Offset: measured from face nearest to interaction point Volume: calculated as sum of the sub-sections Weight: based on parametric estimate from CLAS LTCC
		Detector Section		*80*	*10*	*195*	*200*	*280*	*200*	*9.53*			*Offset: measured from face nearest to interaction point*
		Aerogel Section		*20*	*10*	*110*	*180*	*200*	*180*	*0.75*			*Offset: measured from face nearest to interaction point*
	Solenoid Magnet		6.10.07	384	142	177	0	192	-192	13.47	45,956	Solenoid	Weight: based on parametric estimate from CLEO II
	EMCal Outer Support			445	134	140	-30	192.5	-252.5	2.30	3,608	Steel, Instrumented	Weight: calculated as 20% of total volume as steel (balance is air)
	EMCal Electronics			480	125.5	134	-45	195	-285	3.33	1,938	Near eta=0	Weight: calculated as 25% silicon (balance is air)
	Barrel EMCal		6.10.05	480	80	125.5	-45	195	-285	14.10	49,463	Sci Glass	Weight: based on parametric estimate from CMS EMCal
	EMCal Inner Support			480	79.5	80	-45	195	-285	0.12	944	Steel	Weight: calculated as 100% steel
	Barrel Gem Tracker		6.10.03	340	77	79.5	-5	165	-175	0.42	84	muRWell (plane type)	Weight: based on parametric estimate from SBS Gem
	DIRC Support			455	65	77	-257	168	-287	2.60	1,019	Steel	Offset: measured from point where DIRC bar connects to the readout Volume: calculated as sum of sub-sections Weight: estimated as 5% of total volume as steel (balance is air & detector)
		Bar Support		*425*	*65*	*77*	*-257*	*168*	*-257*	*2.28*			
		Readout Support		*30*	*65*	*105*	*-257*	*-257*	*-287*	*0.32*			*Readout support is triangular frame, therefore volume is halved.*
	DIRC Detector		6.10.04		71.5	76.6	-257	168	-287	1.28	893	Fused silica bars	Detector is totally enclosed by DIRC Support. Weight: calculated as sum of sub-components
		DIRC Bar		*425*	*71.5*	*76.6*	*-257*	*168*	*-257*	*1.01*	*702*		*Weight: calculated as 30% quartz (balance is air & support system)*
		DIRC Readout		*30*	*71.5*	*104.4*	*-257*	*-257*	*-287*	*0.27*	*191*		*Readout is triangular, therefore volume is halved.* *Weight: Calculated as 30% silicon(balance is air & support system)*
	Barrel Time of Flight/Tracker		6.10.03	270	63	65	15	150	-120	0.22	43	AC/LGAD	Weight: based on parametric estimate from SBS Gem
	HD Time of Flight/Tracker		6.10.03	15	12	62	155.5	170.5	155.5	0.17	35	AC/LGAD	Offset: measured from face nearest to interaction point Weight: based on parametric estimate from SBS Gem
	Silicon Tracker		6.10.03	228	3	45.9	0	126	-102	1.50	227	MAPS	Weight: calculated as 3% aluminum and 3% silicon (balance is air)
	Modular RICH		6.10.04	25	10	64	-135	-135	-160	0.31	58	Aerogel	Offset: measured from face nearest to interaction point Weight: based on parametric estimate from CLAS LTCC
	LD Time of Flight/Tracker		6.10.03	10	12	64	-161	-161	-171	0.12	25	AC/LGAD	Offset: measured from face nearest to interaction point Weight: based on parametric estimate from SBS Gem
	LD EMCal		6.10.05	60	9	63	-175	-175	-235	0.73	4,738	PbWO4	Offset: measured from face nearest to interaction point Weight: estimated as 85% lead glass and 15% steel
	Service Gap			10			-320	-320	-330	0.00			Offset: measured from location nearest to interaction point
LEPTON DIRECTION ENDCAP	**Backward Field Return**		6.10.06	20.32			-330	-330	-350.32	5.18	40,649	Iron	Offset: measured from face nearest to interaction point Weight: calculated as 100% iron.
		Return Cylinder		*20.32*	*20*	*270*	*-330*	*-330*	*-350.32*	*4.63*			
		Support Panel		*7.62*	*454*	*664*	*-336.35*	*-336.35*	*-343.97*	*0.55*			*Height: specified in outer radius* *Width: specified in inner radius*