Evaluation of the X/X0 of the stave in the IBL layout

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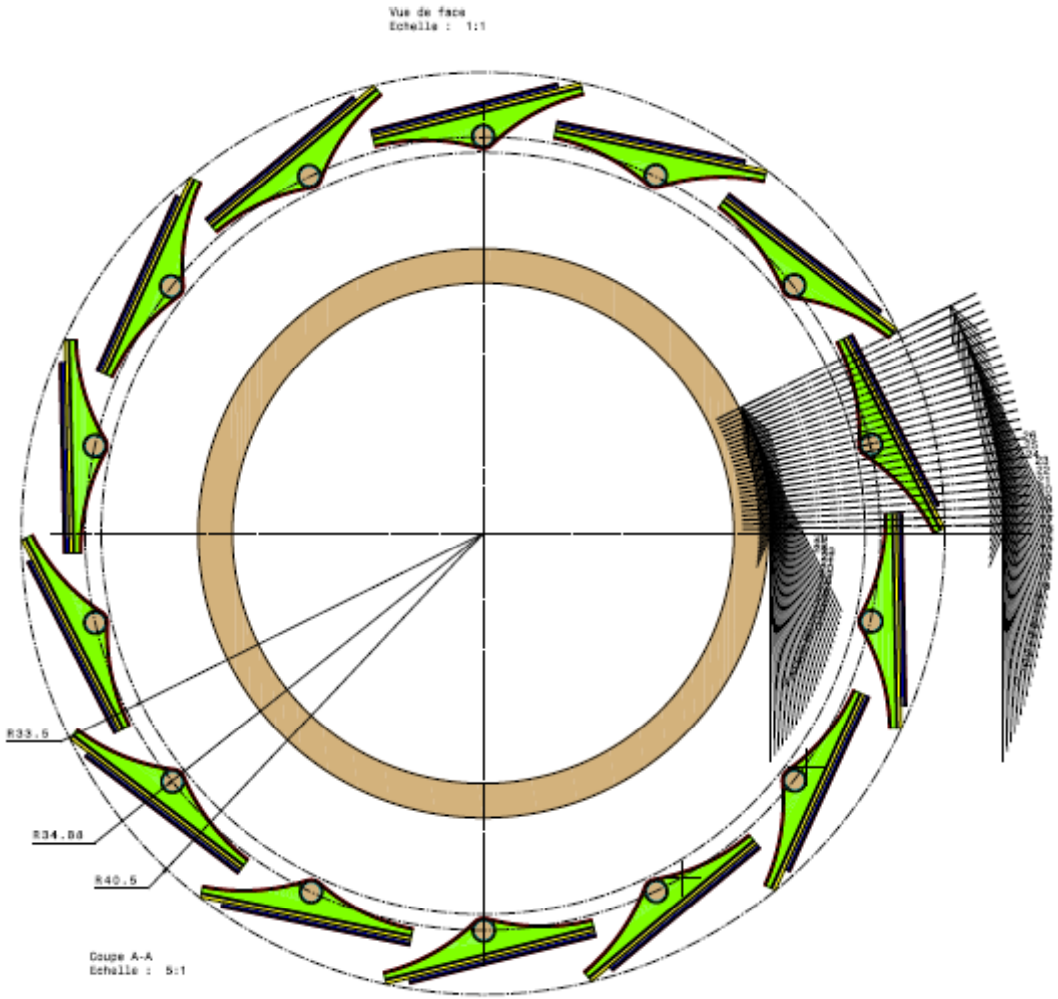
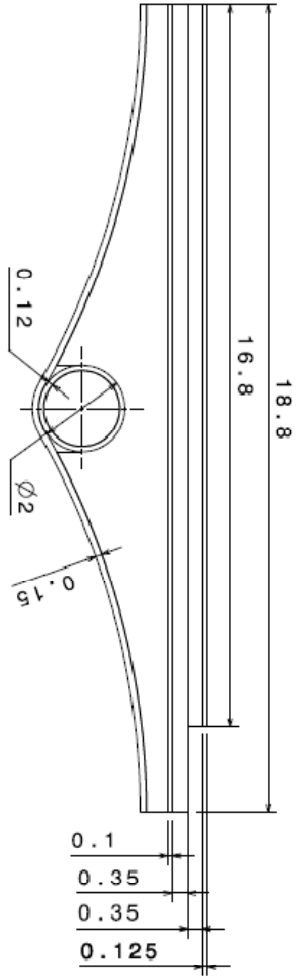
Geometry of IBL desin





14 staves
R=32 mm
Cooling pipe
OD=3 mm

Materials used

OMEGA		Type	E [Gpa]	ρ [g/cm3]	CTE [ppm/K]	K [W m-1K-1]	Fiber Vol. Ratio
Option A1	Fiber	YS-80A	785,00	2,15	-1,50	320,00	
	Resin System	Epoxy	4,5	1,2	70	0,2	60%
Thickness=150um	Lay-up	(0/90/0)					
Option A2	Fiber	YS-80A	785,00	2,15	-1,50	320,00	
	Resin System	Epoxy	4,5	1,2	70	0,2	60%
Thickness=300um	Lay-up	(0/60/-60)S2					
Option A3	Fiber	YS-80A	785,00	2,15	-1,50	320,00	
	Resin System	EX-1515	3	1,3	70	0,3	60%
Thickness=150um	Lay-up	(0/90/0)					
Option A4	Fiber	YS-80A	785,00	2,15	-1,50	320,00	
	Resin System	EX-1515	3	1,3	70	0,3	60%
Thickness=300um	Lay-up	(0/60/-60)S2					
Option A5	Fiber	YS-80A	785,00	2,15	-1,50	320,00	
	Resin System	EX-1515	3	1,3	70	0,3	60%
Thickness=150um	Lay-up	(0/60/-60)S1					

CARBON FOAM		Type	E [Gpa]	ρ [g/cm3]	CTE [ppm/K]	K [W m-1K-1]	Heat Capacity	Compression Strength [Mpa]
Option B1	POCO	Low Density	0,373	0,55	-0.7/+0.6	135/45	0,7	
Option B2	Poppers KFOAM	L1 250	0,894	0,245	-0.7/+0.6	40/??		

CARBON PIPE		Type	E [Gpa]	ρ [g/cm3]	CTE [ppm/K]	K [W m-1K-1]	Fiber Vol. Ratio
Option C1	Fiber	T-300	231,00	1,76	-1,50	8.5/5 [≡/⊥]	
	Resin System	Epoxy	4,5	1,2	70	0,2	
Thickness=300um	Lay-up	(-54.7/+54.7)					
Option C2	Fiber	T-300	231,00	1,76	-1,50	8.5/5 [≡/⊥]	50%
	Resin System	Epoxy	4,5	1,2	70	0,2	
Thickness=300um	Lay-up	(-45/+45)					

Materials used

Raw materials

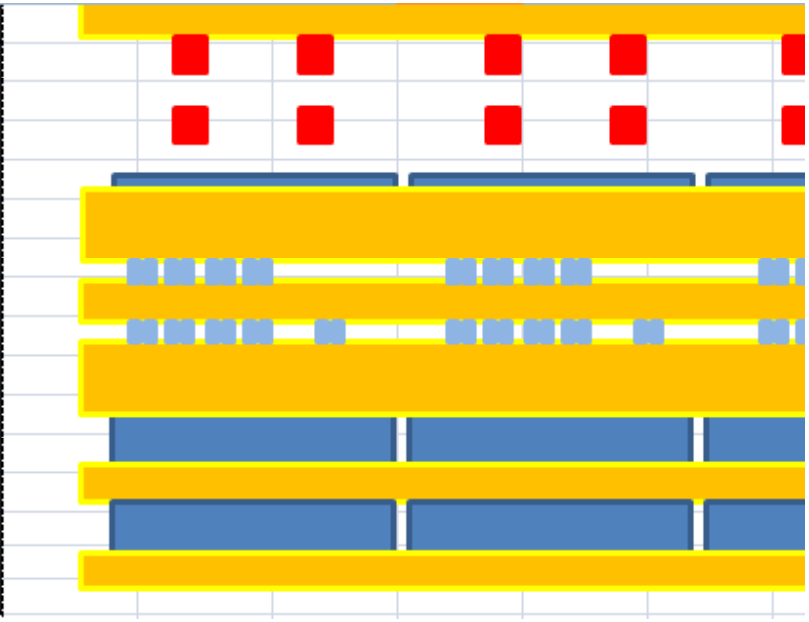
Material	Density	Composition	X0 (g cm^{-2})	X0 (mm)	Lambda (g cm^{-2})	Lambda (mm)	Source for X0	Source for Lambda
Detector/readout chips	2,3290	Si	21,82	93,7	107,2	465,2	PDG	PDG
Plate glass	2,4	Assume PDG plate g	25,660	106,9	99,6	415	PDG	PDG
Titanium	4,54	Ti	16,16	35,6	126,2	278	PDG	PDG
Epoxy Resin (C18 H20 O3)	1,15	C18H20O3	41,9	364	47,553	413,5	Gilchriese	calculation
Carbon	2,21	C	42,7	193,2	85,8	429	PDG	PDG
Copper	8,96	Cu	12,86	14,36	137,3	153,2	PDG	PDG
Aluminum	2,7	Al	24,01	88,97	107,2	397	PDG	PDG
Kapton (polyimide)	1,42	(C22H10N2O5)n	40,58	285,7	85,5	602	PDG	PDG
Freon-12	1,12	(CF2Cl2)	23,65	211,1	105,8	944,6	PDG	PDG
Freon-12-B2	1,8	CF2Br2)	13,6	75,56	129,9	721,6	PDG	PDG
C3F8	1,601	C3F8	34,44	215,25	94,942	593,4	calculation	calculation
C4F10	1,594	C4F10	34,08	214,36	94,816	596,4	calculation	calculation
Fluor	1,51	F	32,93	218,5	97,4	646,4	PDG	PDG
Carbon dioxyde	1,842	CO2	36,2	196,7	88,9	483,2	PDG	PDG

Actual IBL ingredients

Material	Density	Composition	X0 (g cm^{-2})	X0 (mm)	Lambda (g cm^{-2})	Lambda (mm)	Source for X0	Source for Lambda
A1	1,77	0.728 C+0.272 epoxy	42,498	240,1	70,398	397,7	calculation	calculation
A2	1,77	0.728 C+0.272 epoxy	42,498	240,1	70,398	397,7	calculation	calculation
A3	1,81	0.713 C +0.287 epox	42,5	234,8	69,707	385,1	calculation	calculation
A4	1,81	0.713 C +0.287 epox	42,5	234,8	69,707	385,1	calculation	calculation
A5	1,81	0.713 C +0.287 epox	42,5	234,8	69,707	385,1	calculation	calculation
B1	carbon foam	0.55/2.21=0.249C	42,7	776,3	85,8	1560	calculation	calculation
B2	carbon foam	0.245/2.21=0.1108C	42,7	1742,7	85,8	3502	calculation	calculation
C1	1,48	0.595 Cfiber+0.405 e	42,39	286,42	64,717	437,3	calculation	calculation
C2	1,48	0.595 Cfiber+0.405 e	42,39	286,42	64,716	437,3	calculation	calculation

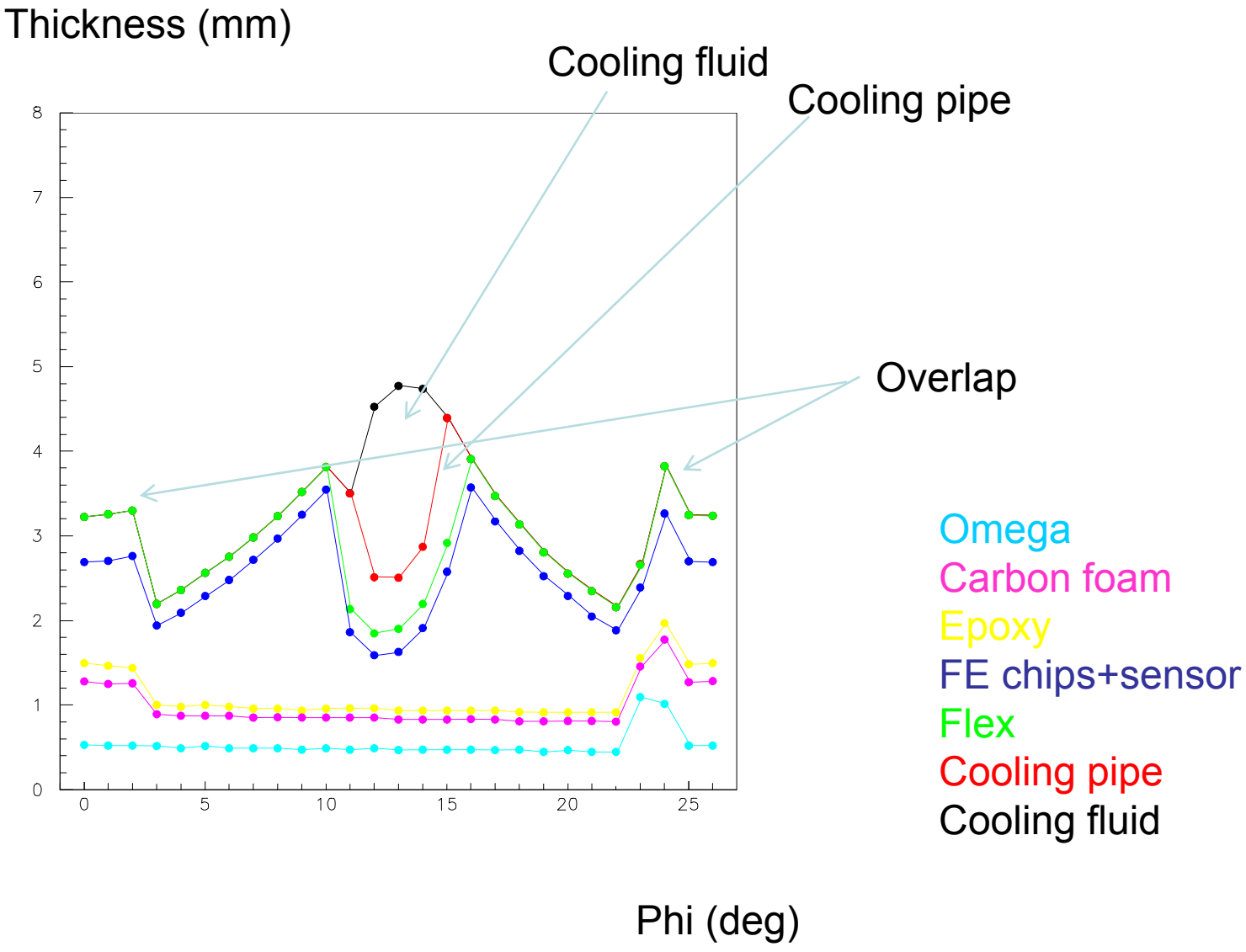
Estimate of flex contribution

Layer Name	Type	Material	Thickness (um)	Width (um)	Spacing (um)
	Dielectric	Apical	20		
TOP	Conductor	Copper	15	250	1000
	Dielectric	Apical	20		
HV ret	Conductor	Copper	15	250	1000
	Dielectric	Apical	20		
GND1	Plane	Copper	5		
	Dielectric	Apical	55		
LVDS2	Conductor	Copper	5	76	127
	Dielectric	Apical	30		
LVDS1	Conductor	Copper	5	76	127
	Dielectric	Apical	55		
GND	Plane	Aluminium	25		
	Dielectric	Apical	20		
Bottom	Plane	Aluminium	25		
	Dielectric	Apical	20		



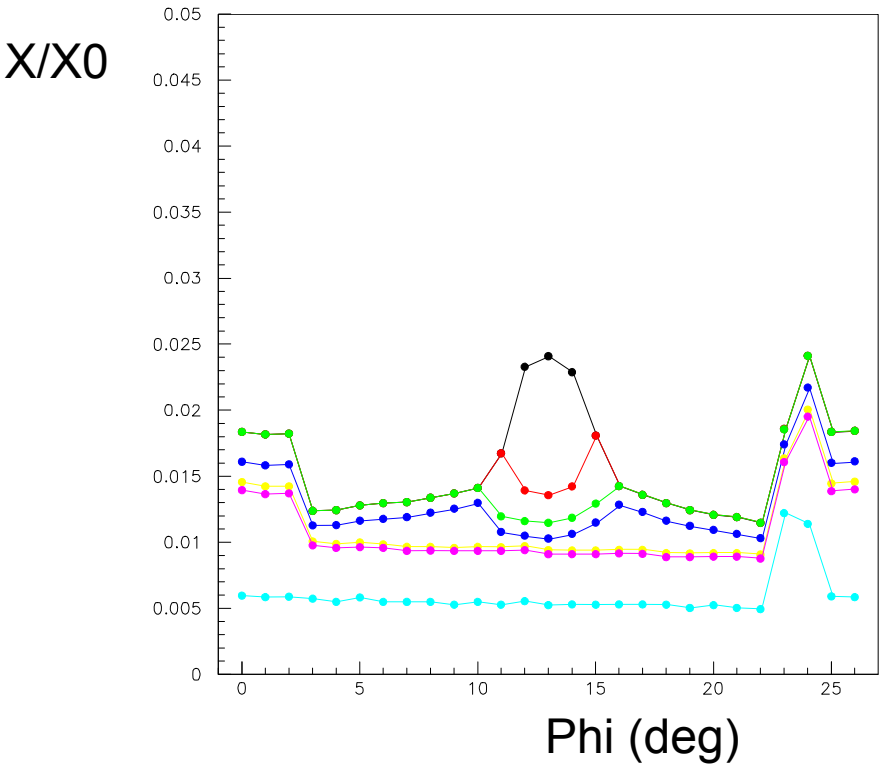
X0 contribution goes from 0.00176 up to 0.00209
(depends upon number of copper/aluminum lines)
Use average value of 175.32 mm X0 length for flex material

Absolute thickness profile



Present design X/X0 option 1

Omega
Carbon foam
Epoxy
FE chips+sensor
Flex
Cooling pipe
Cooling fluid



Flex	0.00192
Sensor	0.00418
R/O chips	0.00479
Epoxy glue	0.00035
Carbon foam	0.00184
Omega	0.00145
Cooling pipe	0.00100
Cooling fluid (C3F8,100%)	0.00091
General total (50% fluid)	0.01599
Structure	0.00464
Structure+50%fluid	0.00510

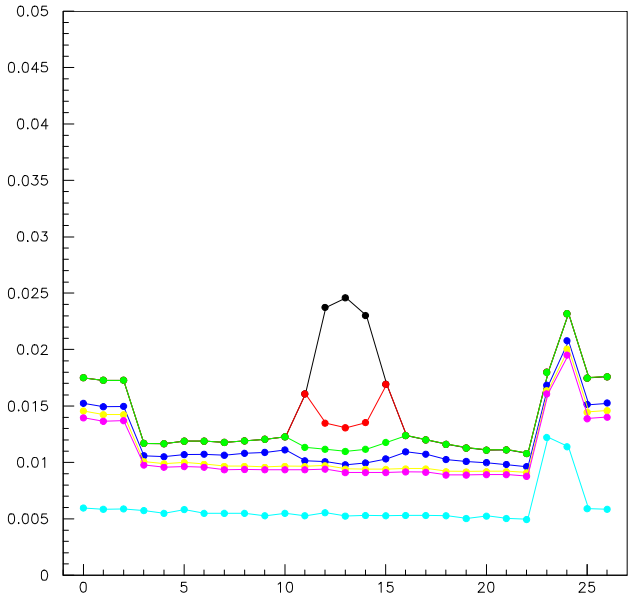
Hypotheses :
CF pipe OD=3mm, wall 250 µ
Light (150 µ) omega,
Heavy foam
C3F8 cooling

Present design X/X0 option 2

Omega
Carbon foam
Epoxy
FE chips+sensor
Flex
Cooling pipe
Cooling fluid

Flex	0.00192
Sensor	0.00418
R/O chips	0.00479
Epoxy glue	0.00035
Carbon foam	0.00082
Omega	0.00145
Cooling pipe	0.00100
Cooling fluid (CO2,100%)	0.00100
General total (50% fluid)	0.01501
Structure	0.00362
Structure+50%fluid	0.00412

X/X0



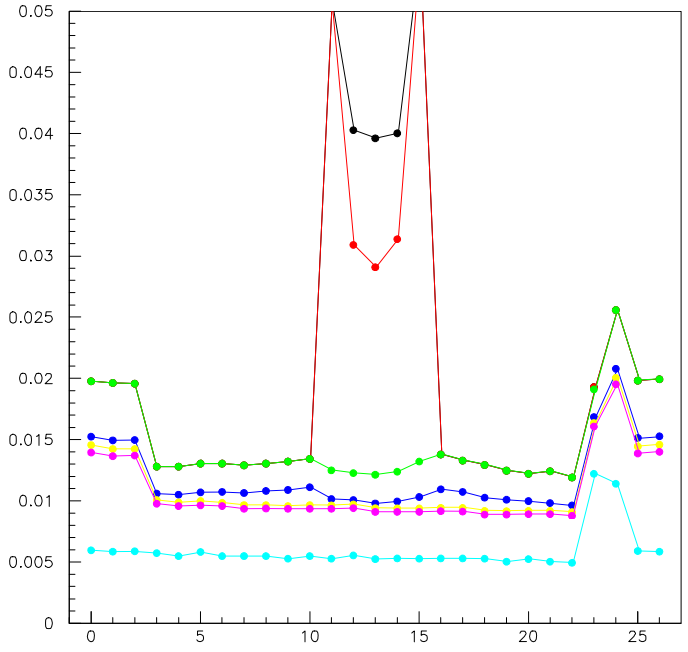
Phi (deg)

Hypotheses :
CF pipe OD=3mm, wall 250 µ
Light (150 µ) omega,
Light foam
CO2 cooling

Present design X/X0 option 3

Omega
Carbon foam
Epoxy
FE chips+sensor
Flex
Cooling pipe
Cooling fluid

X/X0



Phi (deg)

Flex	0.00192
Sensor	0.00418
R/O chips	0.00479
Epoxy glue	0.00035
Carbon foam	0.00082
Omega	0.00290
Cooling pipe	0.00430
Cooling fluid (C3F8,100%)	0.00091
General total (50% fluid)	0.01972
Structure	0.00837
Structure+50%fluid	0.00883

Hypotheses :
Ti pipe OD=3mm, wall 120 μ
Thick (300 μ) omega,
Light foam
C3F8 cooling

Present design X/X0 option 4

Omega
Carbon foam
Epoxy
FE chips+sensor
Flex
Cooling pipe
Cooling fluid

Flex	0.00192
Sensor	0.00418
R/O chips	0.00479
Epoxy glue	0.00035
Carbon foam	0.00089
Omega	0.00290
Cooling pipe	0.00134
Cooling fluid (CO2,100%)	0.00046
General total (50% fluid)	0.01660
Structure	0.00548
Structure+50%fluid	0.00571

Hypotheses :
Ti pipe OD=2mm, wall 120 μ
Thick (300 μ) omega,
Light foam
CO2 cooling

IST contribution

- Same material as stave omega

OMEGA		Type	E [Gpa]	ρ [g/cm3]	CTE [ppm/K]	K [W m-1K-1]	Fiber Vol. Ratio
Option A1	Fiber	YS-80A	785,00	2,15	-1,50	320,00	60%
	Resin System	Epoxy	4,5	1,2	70	0,2	
Thickness=150um	Lay-up	(0/90/0)					

Actual IBL ingredients

Material	Density	Composition	X0 (g cm^{-2})	X0 (mm)	Lambda (g cm^{-2})	Lambda (mm)	Source for X0	Source for Lambda
A1	1,77	0.728 C+0.272 epoxy	42,498	240,1	70,398	397,7	calculation	calculation

Thickness : 0.5 mm → X/X0 contributio of 0.0020

Summary

Option 1

Flex	0.00192
Sensor	0.00418
R/O chips	0.00479
Epoxy glue	0.00035
C.foam	0.00184
Omega	0.00145
Cool. pipe	0.00100
C. fluid (C3F8,100%)	0.00091
Gen. total (50% fluid)	0.01599
Structure	0.00464
Structure+50%fluid	0.00510

CF pipe OD=3mm,
wall thickness 250 µ
Light (150 µ) omega,
Heavy foam
C3F8 cooling

Option 2

Flex	0.00192
Sensor	0.00418
R/O chips	0.00479
Epoxy glue	0.00035
Carbon foam	0.00082
Omega	0.00145
Cool.pipe	0.00100
C. fluid (CO2,100%)	0.00100
Gen. total (50% fluid)	0.01501
Structure	0.00362
Structure+50%fluid	0.00412

CF pipe OD=3mm,
wall thickness 250 µ
Light (150 µ) omega,
Light foam
CO2 cooling

Best !

Option 3

Flex	0.00192
Sensor	0.00418
R/O chips	0.00479
Epoxy glue	0.00035
Carbon foam	0.00082
Omega	0.00290
Cool. pipe	0.00430
C. fluid (C3F8,100%)	0.00091
Gen.total (50% fluid)	0.01972
Structure	0.00837
Structure+50%fluid	0.00883

Ti pipe OD=3mm,
wall thickness 120µ
Thick(300 µ) omega,
Light foam
C3F8 cooling

Option 4

Flex	0.00192
Sensor	0.00418
R/O chips	0.00479
Epoxy glue	0.00035
Carbon foam	0.00089
Omega	0.00290
Cool. pipe	0.00134
C. fluid (CO2,100%)	0.00046
Gen.total (50% fluid)	0.01660
Structure	0.00548
Structure+50%fluid	0.00571

Ti pipe OD=2mm,
wall thickness 120 µ
Thick(300 µ) omega,
Light foam
CO2 cooling