

Progress in use of CATIA interface to describe material in MS

Alexander SHARMAZANASHVILI

Georgian Team

www.cadcam.ge

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Participants from Georgian Team:

SURMAVA Archil

KEKELIA Besik

TSUTSKIRIDZE Nikoloz



Structure of Presentation:

1. Preface
2. Consideration of CATIA Geometry of Coil
3. Compare Analysis of CATIA $\Leftrightarrow$ FLUGG;
CATIA $\Leftrightarrow$ G4 volumes
4. Simplification of CATIA volumes for G4/FLUGG

I. Preface

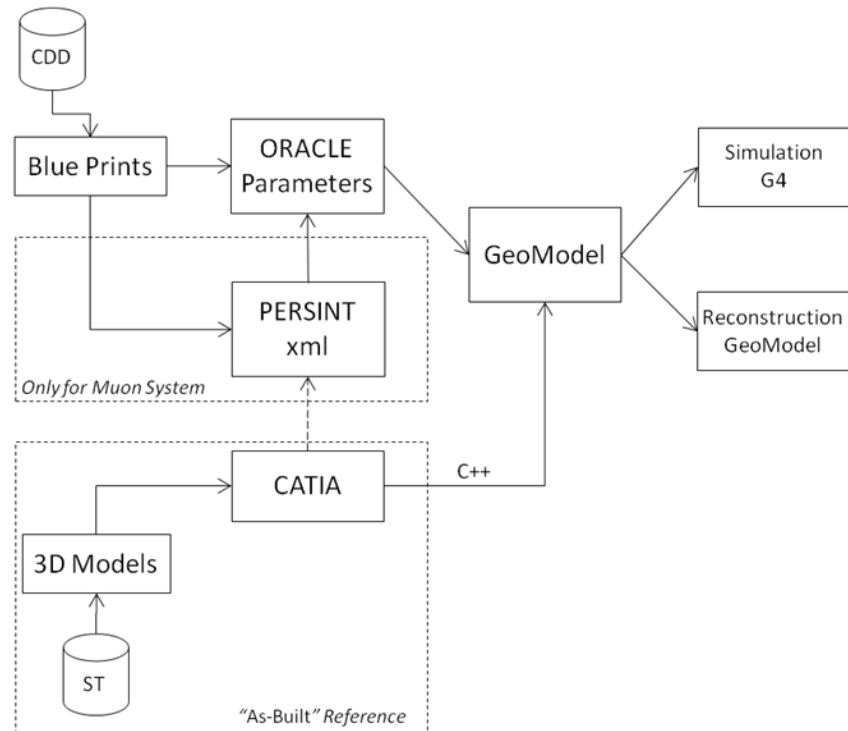
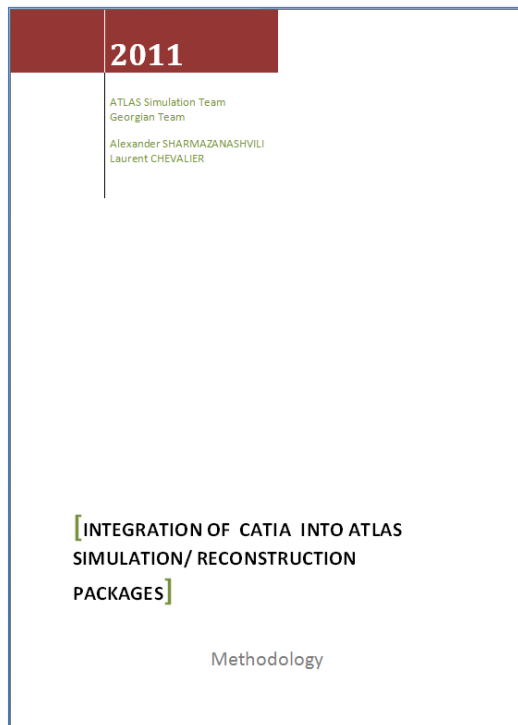
I. Preface

CATIA Tool is the combination of Software and data:

- Software – CATIA package (Dassault Systems Co.) for Engineering design and product modeling
- Data – Set of 3D models on SmarTeam database of ATLAS detector used by TCn for construction and installation work

I. Preface

In 2011 Alexander and Laurent developed methodology about how to integrate CATIA Tool for the improvement of geometry descriptions in Simulation and Reconstruction packages



II. CATIA Geometry of Coil

II. Development of CATIA Geometry

Source geometry has been taken from SmarTeam Engineering Database:

Path : ATLAS2009/Detector System/Magnets ATLAS/Toroid Magnets
ATLAS/Barrel Toroid Magnet ATLAS/TB coils

Model: **ST0301587 TB COIL SEC2 (id: CAD000323373)**

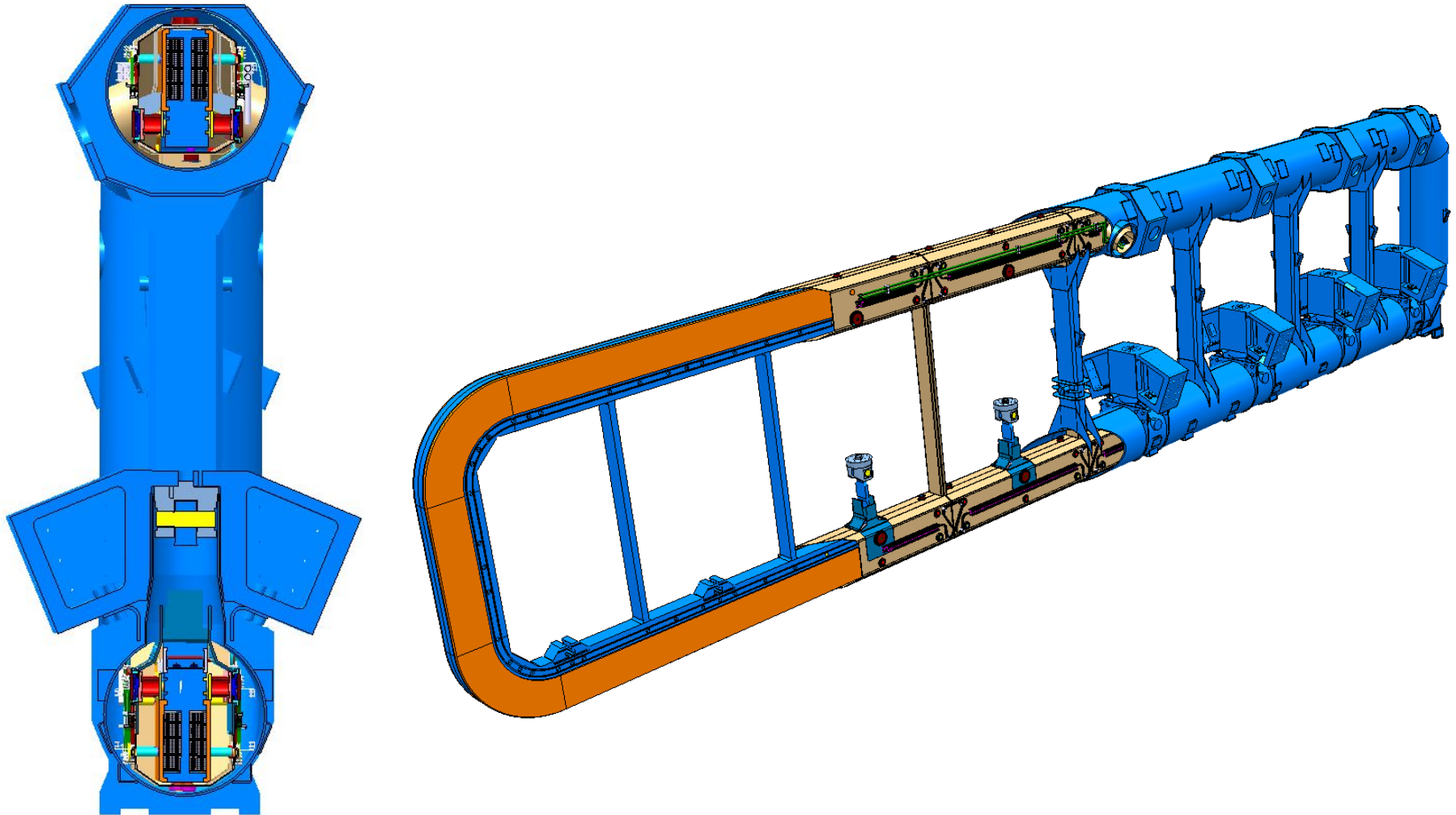
Date : 01/11/2011

However internal part of Coil never presented on Smarteam. So Georgian Team started reproduction of 3D model from CDD manufacturing drawings

225 manufacturing drawings have been founded on CDD and missing parts was added to primary Smarteam geometry

II. Development of CATIA Geometry

As a result entire 3D model of Coil has been created



II. Development of CATIA Geometry

Then entire geometry has been divided into 21 individual volumes according to materials and position

For each of them material was identified, volume and weight have been calculated

92348 kg	Total Weight	= 10088 kg	Vol.1	+ 1344 kg	Vol.2,4,6,8	+ 2704 kg	Vol.3,7	+11368 kg	Vol.5
		+ 12344.4 kg	Vol.9	+ 5336 kg	Vol.10	+ 4824 kg	Vol.11	+ 2020 kg	Vol.12
		+ 2928 kg	Vol.13	+ 18579 kg	Vol.14	+ 4963.6 kg	Vol.15	+ 11572.5 kg	Vol.16
		+ 253 kg	Vol.17	+ 538 kg	Vol.18	+ 1117 kg	Vol.19	+276 kg	Vol.20
		+ 1873 kg	Vol.21						

24.75 m³ Total Volume	= 1.261 m³ Vol.1	+ 0.168 m³ Vol.2,4,6,8	+ 0.338 m³ Vol.3,7	+ 1.421 m³ Vol.5
	+ 4.416 m³ Vol.9	+ 0.667 m³ Vol.10	+ 0.603 m³ Vol.11	+ 0.7373 m³ Vol.12
	+ 0.391 m³ Vol.13	+ 6.959 m³ Vol.14	+ 1.866 m³ Vol.15	+ 4.367 m³ Vol.16
	+ 0.074 m³ Vol.17	+ 0.21 m³ Vol.18	+ 0.293 m³ Vol.19	+ 0.0144 m³ Vol.20
	+ 0.101 m³ Vol.21			

Total

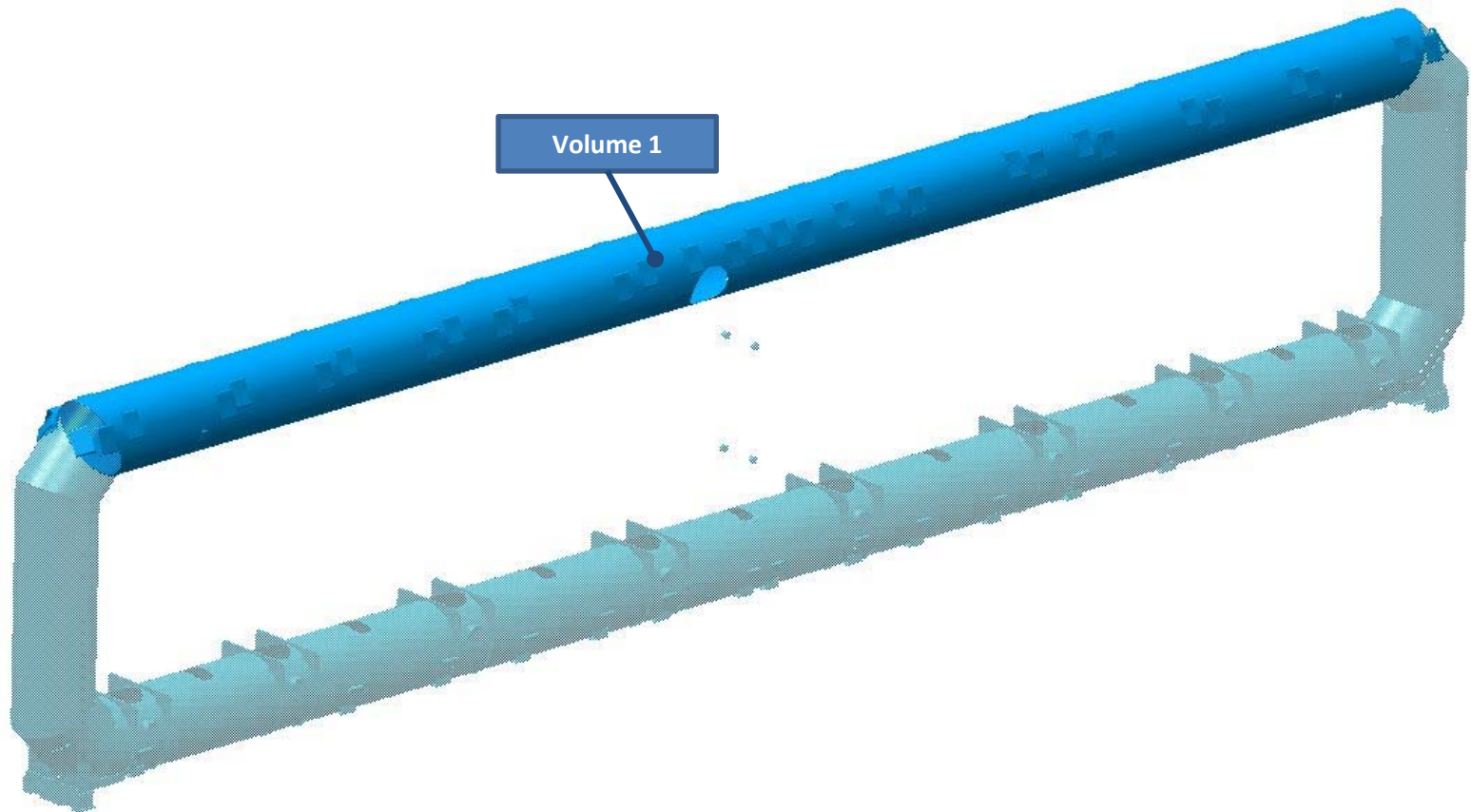
24.75
Volume (m3)

92130
Weight(kg)

II. Development of CATIA Geometry

Volume 1 Cryostat Long (Top)

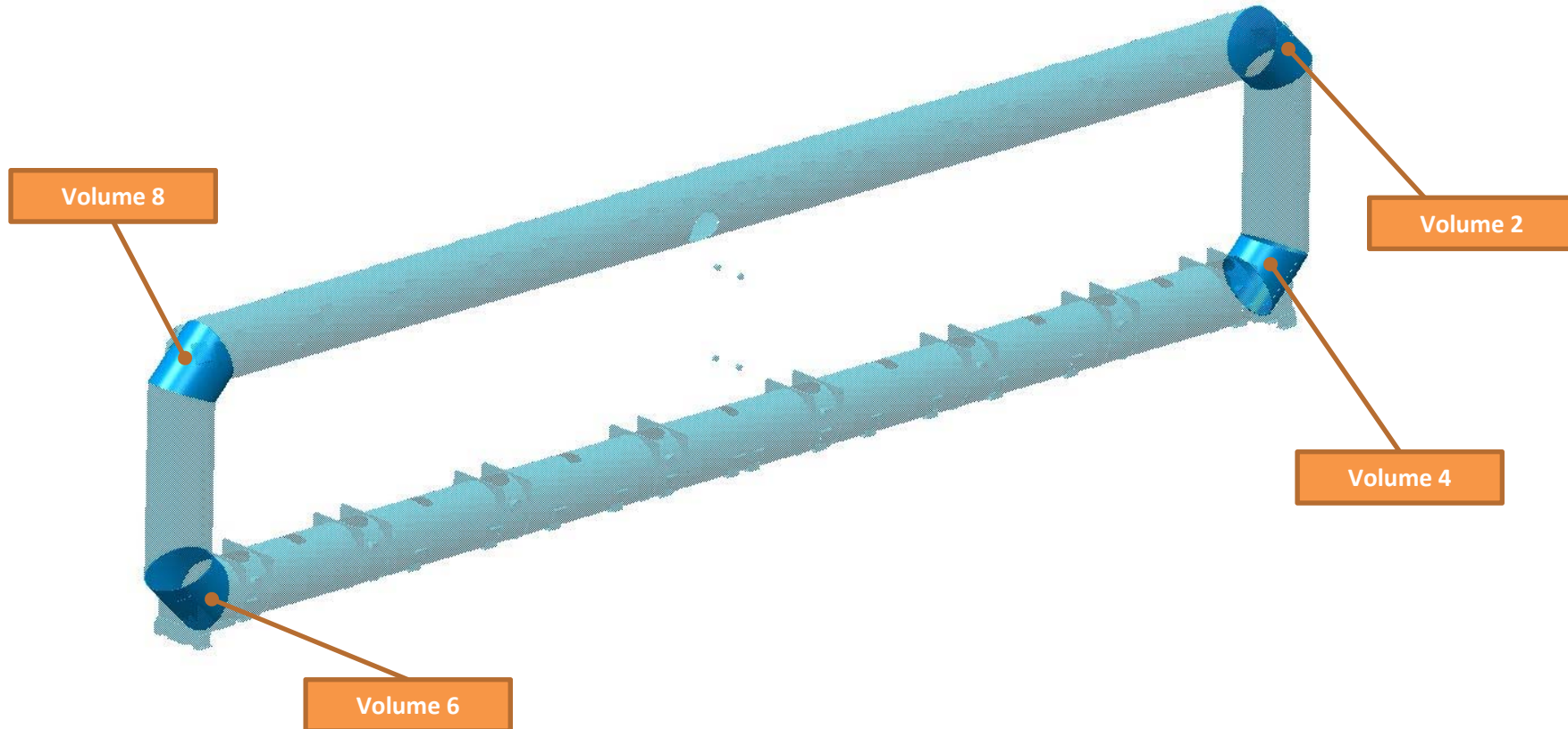
Volume 1	Number of Items	Part Name		Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	1	Cryostat Long (Top)	Assembly	Stainless Steel 304L	8000	1.261	1.261	10088
							Total Mass (kg): 10088	



II. Development of CATIA Geometry

Volume 2, 4, 6, 8 Cryostat Corner

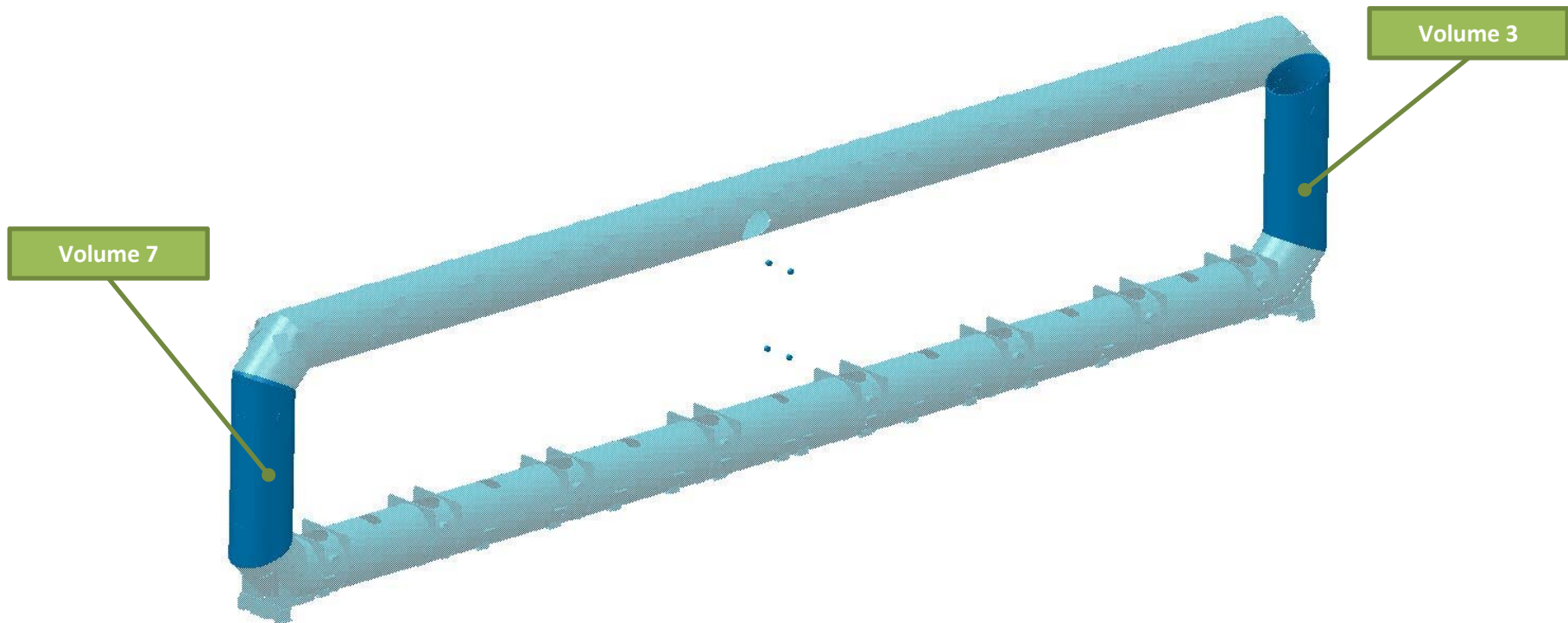
Volume 2,4,6,8	Number of Items	Part Name		Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	4	Cryostat Corner	Assembly	Stainless Steel 304L	8000	0.042	0.168	1344
Total Mass (kg): 1344								



II. Development of CATIA Geometry

Volume 3, 7 Cryostat Short

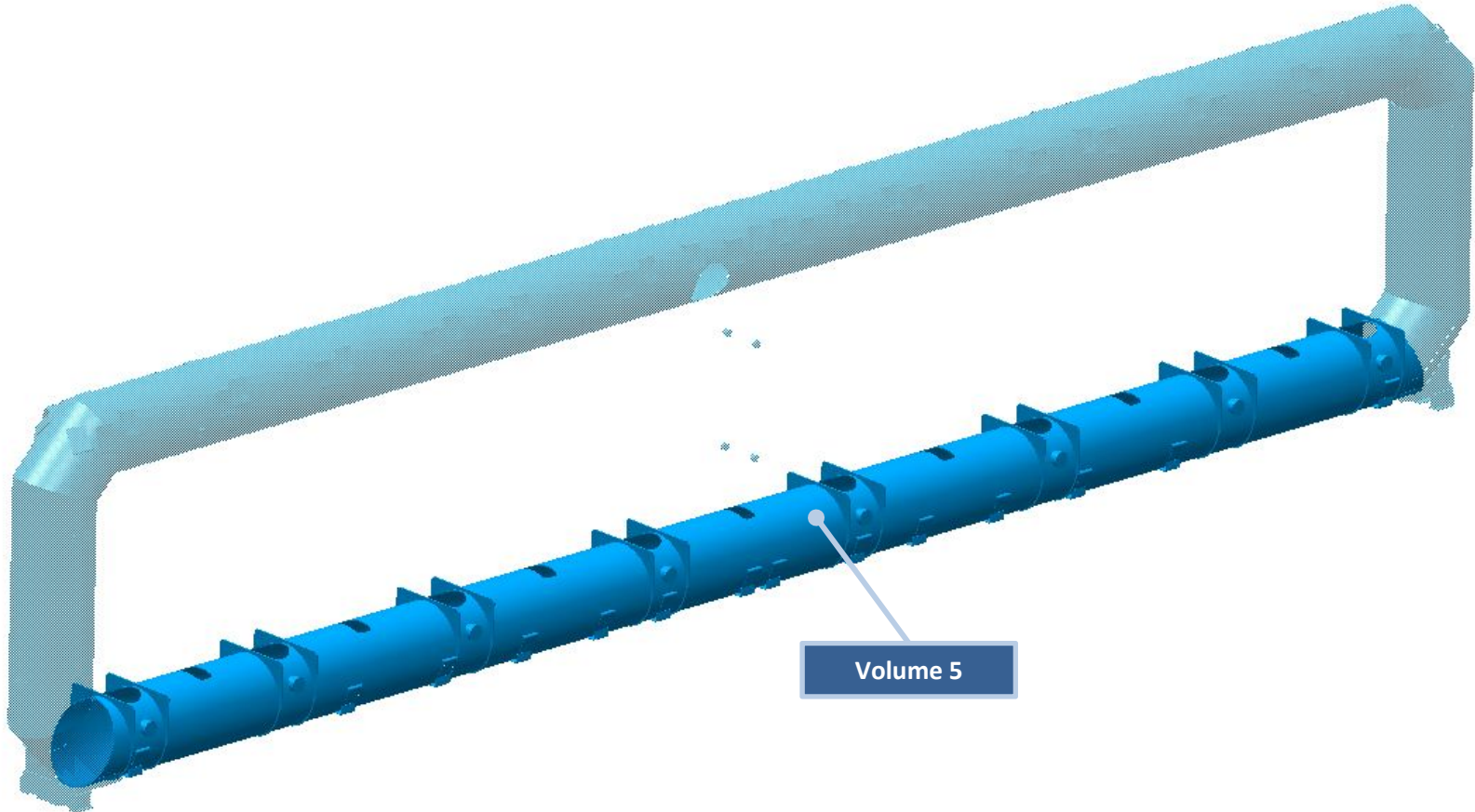
Volume 3,7	Number of Items	Part Name		Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	2	Cryostat Short	Assembly	Stainless Steel 304L	8000	0.169	0.338	2704
							Total Mass (kg): 2704	



II. Development of CATIA Geometry

Volume 5 Cryostat Long (bottom)

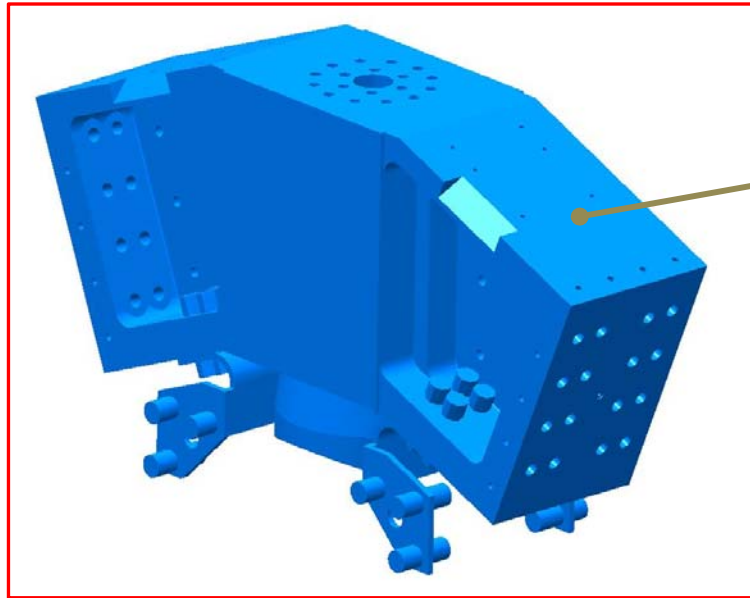
Volume 5	Number of Items	Part Name		Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	1	Cryostat Long (bottom)	Assembly	Stainless Steel 304L	8000	1.421	1.421	11368
							Total Mass (kg): 11368	



II. Development of CATIA Geometry

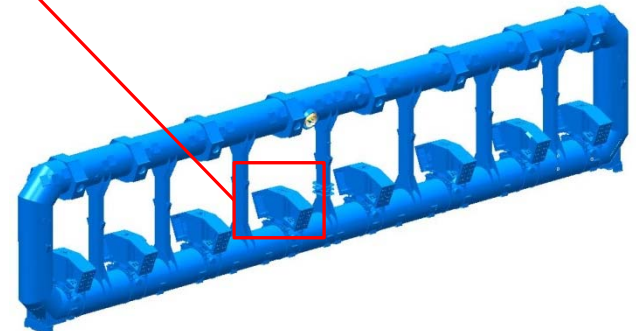
Volume 9 Voussoirs

Volume 9	Number of Items	Part Name		Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	8	Voussoirs	Assembly	Aluminum/Stainless Steel 304L	2650/8000	0.552	4.416	12344.4
Total Mass (kg): 12344.4*								* +680 -0



Volume 9

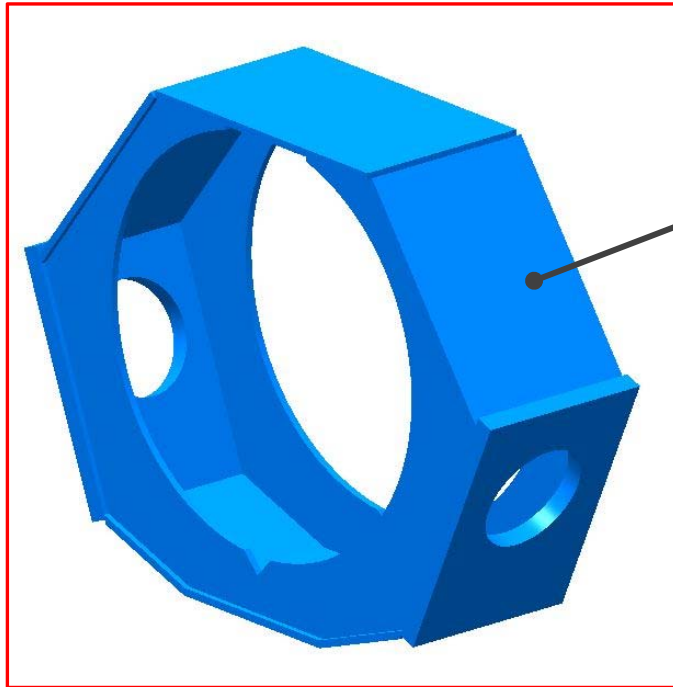
8 x Voussoirs



II. Development of CATIA Geometry

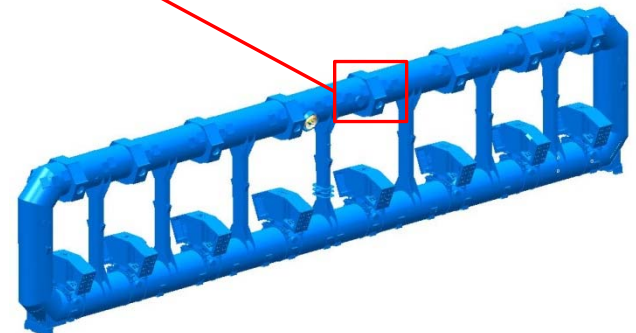
Volume 10 STEFFENERS

Volume 10	Number of Items	Part Name		Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	8	STEFFENER	Assembly	Stainless Steel 304L	8000	0.083	0.667	5336
							Total Mass (kg): 5336.0	



Volume 10

8 x Stiffener

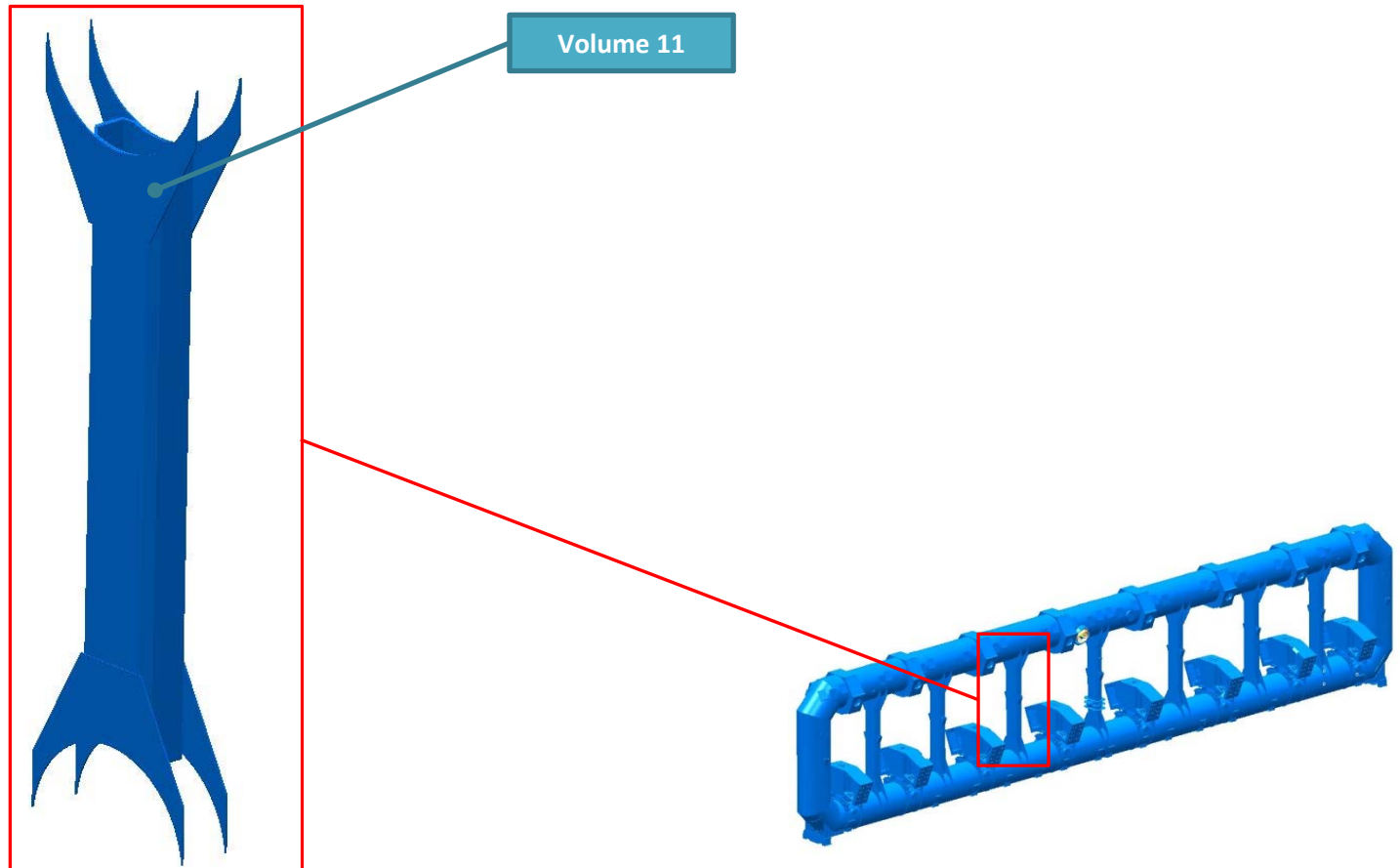


II. Development of CATIA Geometry

Volume 11 Ribs

Volume 11	Number of Items	Part Name	Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	7	Rib	Assembly	Stainless Steel 304L	8000	0.086	0.603
							Total Mass (kg): 4824.0

7 x Rib



II. Development of CATIA Geometry

Volume 12 Thermal Shielding

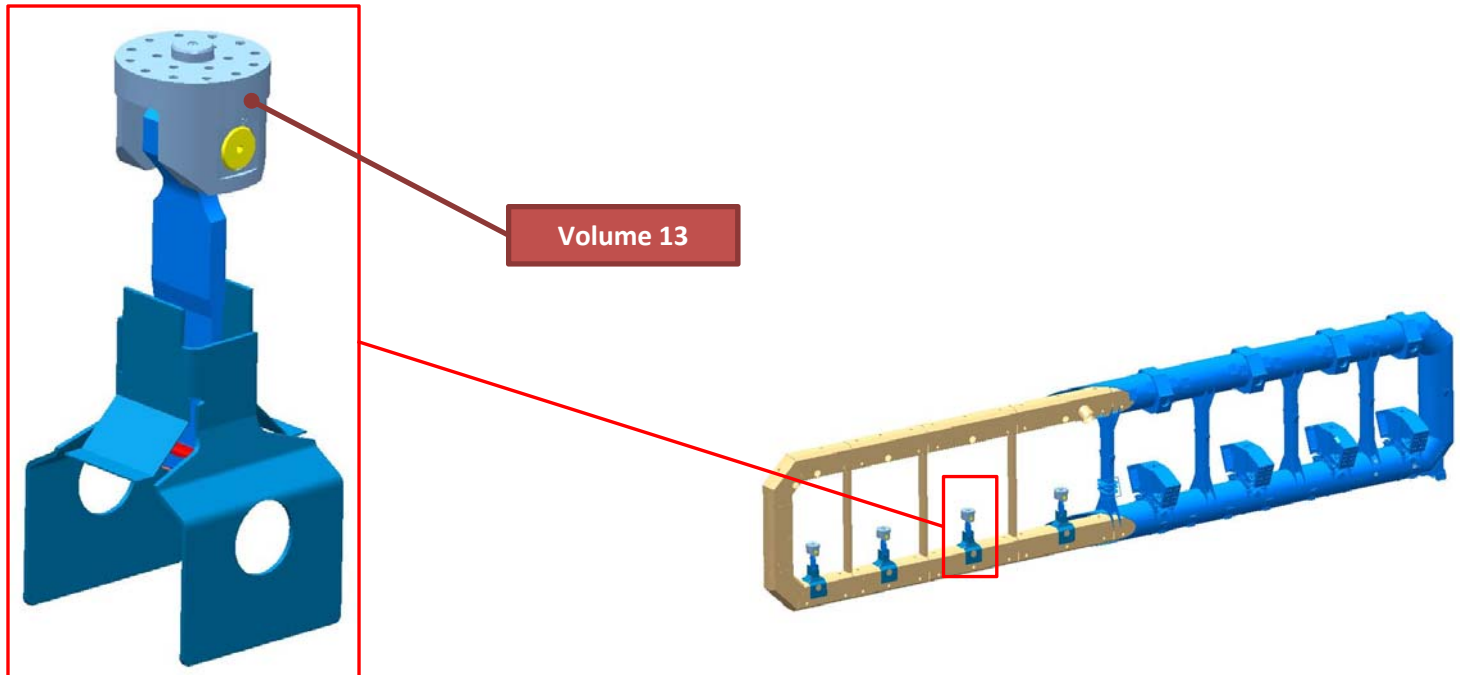
Volume 12	Number of Items	Part Name		Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	1	Thermal Shielding	Part	Aluminum 3003.H22	2740	0.7373	0.7373	2020
								Total Mass (kg): 2020



II. Development of CATIA Geometry

Volume 13 Tie Rod

Volume 13	Number of Items	Part Name		Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	8	Tie rod	Part	Titan TA5E-ELI	4480	0.016	0.1280	573.44
	8	Lug (Tie rod)	Part	Stainless Steel Z3 CN18-10	8000	0.028	0.2240	1792.0
	8	Shouldered axis (Tie rod)	Part	Titan TA5E-ELI	4480	0.005	0.0400	179.2
	8	Small bar support (Tie rod)	Part	Stainless Steel Z3 CN18-10	8000	0.0002946	0.0024	18.9
	16	Piston (Tie rod)	Part	Stainless Steel Z3 CN18-10	8000	0.00007062	0.0011	9.0
	16	Convex bar (Tie rod)	Part	Stainless Steel Z3 CND 17-12 Az	8000	0.00008187	0.0013	10.5
	16	Concave bar (Tie rod)	Part	Stainless Steel Z3 CND 17-12 Az	8000	0.0001569	0.0025	20.1
	8	Tie-Rod Therm. Plate	Part	Al uminum 1050 H22	2705	0.015	0.12	324.6
Total Mass (kg): 2928								

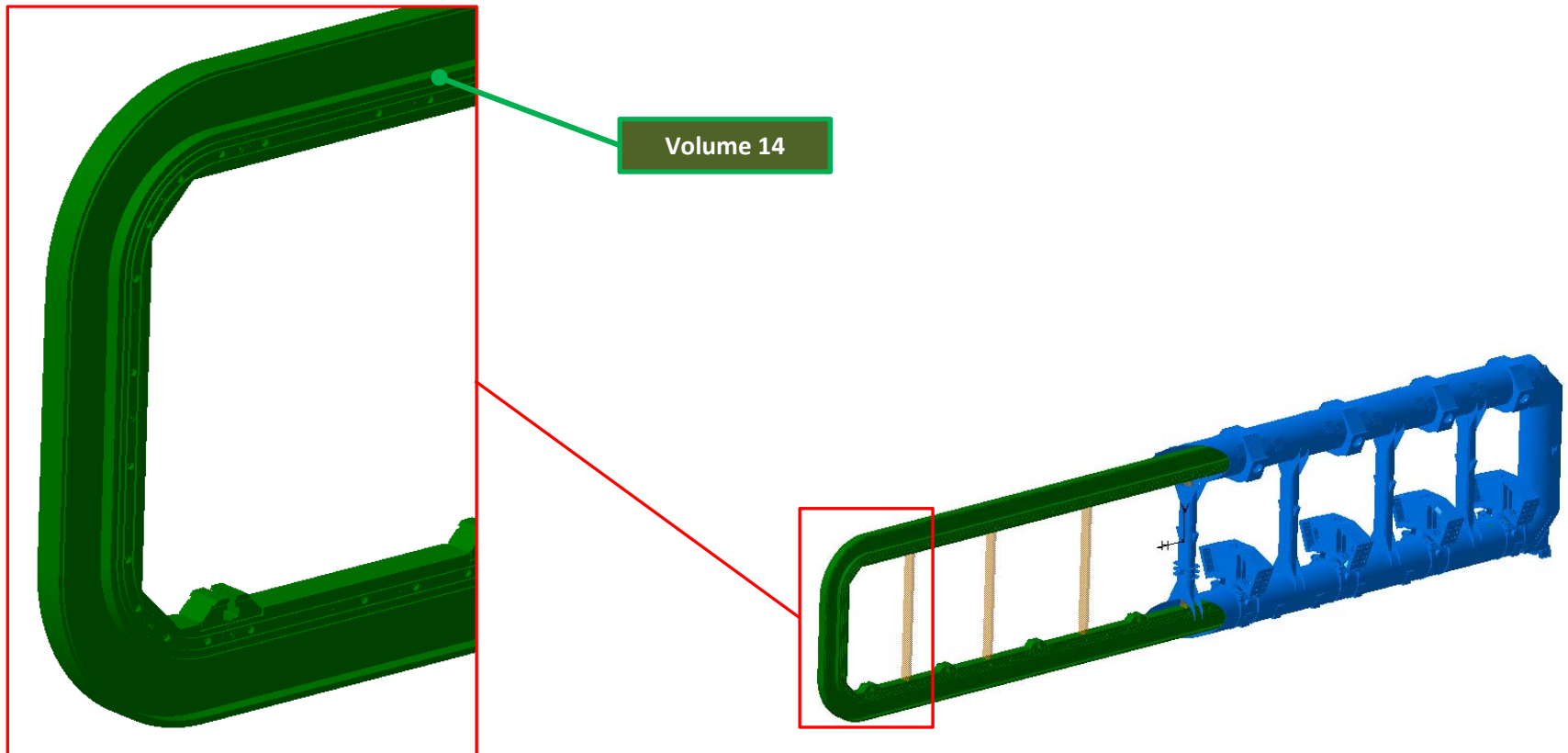


8 x Tie Rod

II. Development of CATIA Geometry

Volume 14 Coil casing

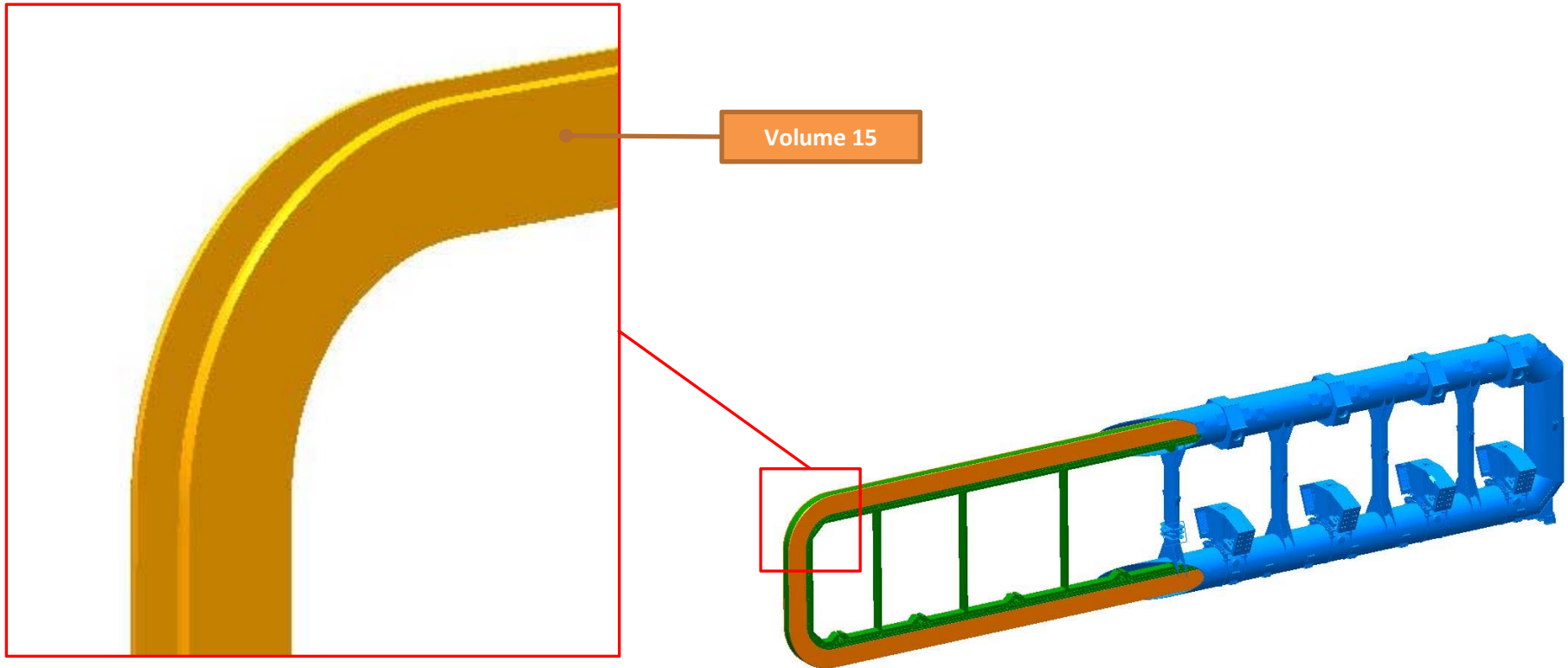
Volume 14	Number of Items		Part Name		Material	Density (kg/m³)	Volume (m³)	Total Volume (m³)	Total Weight (kg)
	1	Coil casing	Part	Aluminum 5083	2650	6.959	6.959	18440.82	
	86		Part	Aluminum 7075 T73	2810	0.00022	0.0189	53.1	
	16		Part	Aluminum 5083	2650	0.0002	0.032	84.8	
								Total Mass (kg): 18578.7	



II. Development of CATIA Geometry

Volume 15 Coil casing part

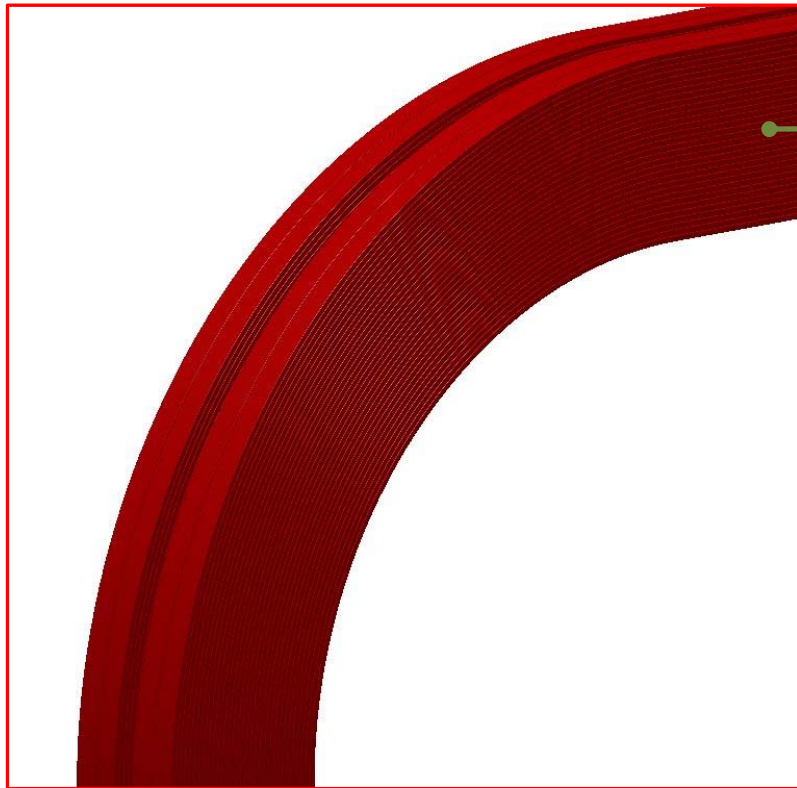
Volume 15	Number of Items	Part Name		Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	1	Coil casing part	Part	Aluminum 5083 h112	2660	1.866	1.866	4963.6
							Total Mass (kg): 4963.6	



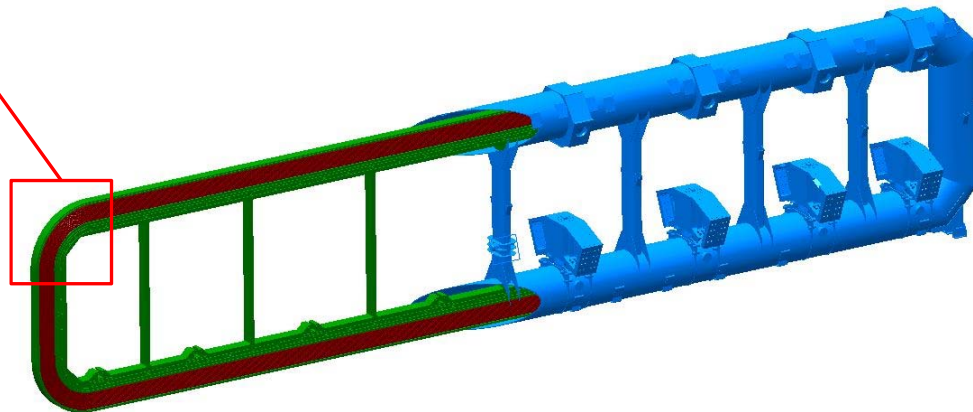
II. Development of CATIA Geometry

Volume 16

Volume 16	Number of Items	Part Name	Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	1	Part	Aluminum	2650	4.367	4.367	11572.55
Total Mass (kg): 11572.55*							*+700



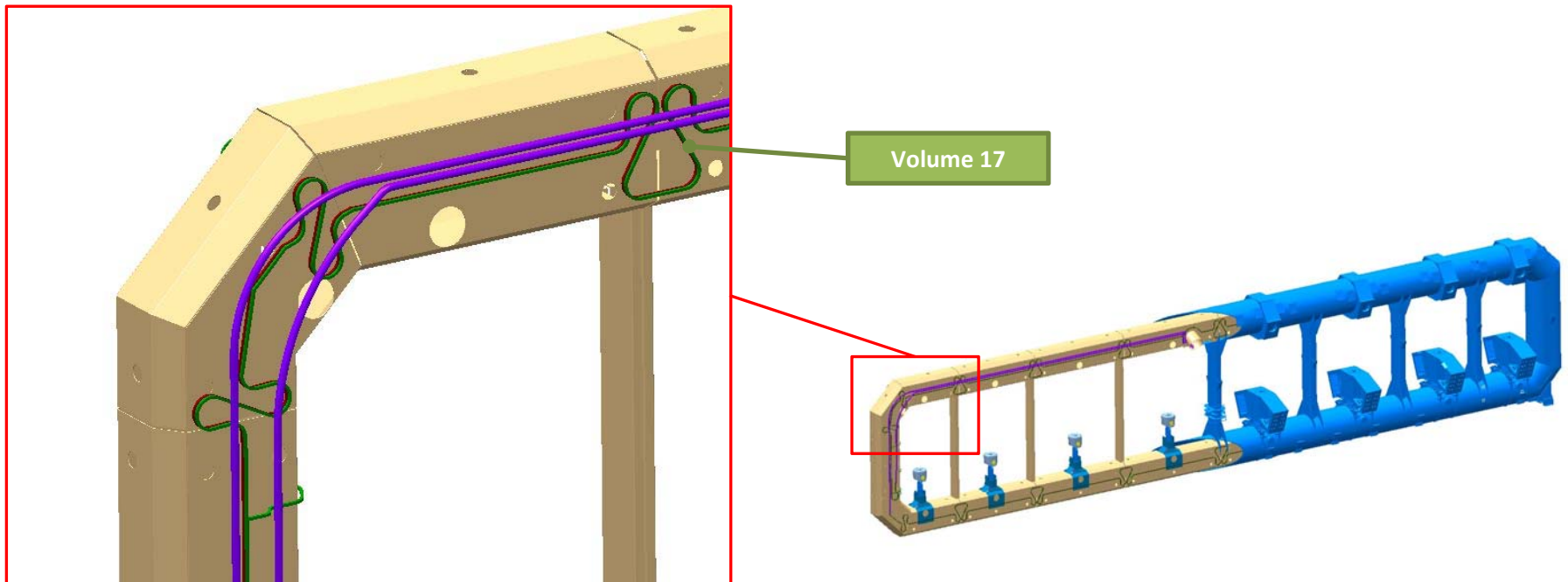
Volume 16



II. Development of CATIA Geometry

Volume 17 Services

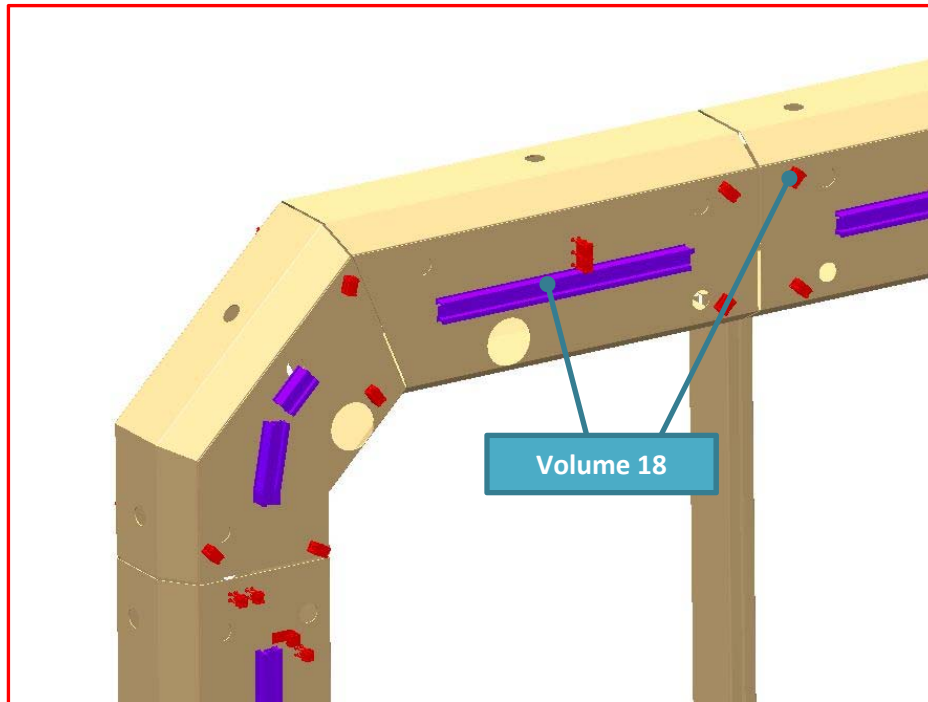
Volume 17	Number of Items	Part Name		Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	1	Pipes	Part	Aluminum 1050	2705	0.0640	0.0640	173.1
	1	Part5	Part	Stainless Steel 304L	8000	0.0040	0.0040	32.0
	1	Part2	Part	Stainless Steel 304L	8000	0.0040	0.0040	32.0
	1	atltbyr_0036	Part	Stainless Steel 304L	8000	0.0006	0.0006	4.6
	2	atltbyr_0035	Part	Stainless Steel 304L	8000	0.0003	0.0005	4.1
	1	atltbyr_0034	Part	Stainless Steel 304L	8000	0.0005	0.0005	4.1
	1	atltbyr_0033	Part	Stainless Steel 304L	8000	0.0004	0.0004	3.2
							Total Mass (kg): 253	



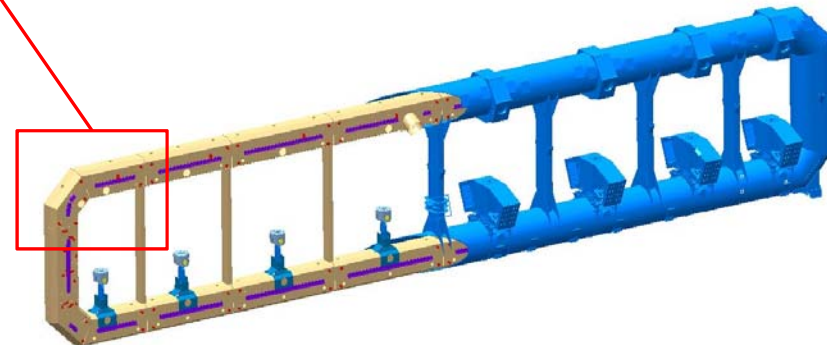
II. Development of CATIA Geometry

Volume 18 Supports of Services

Volume 18	Number of Items	Part Name		Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	139	S3	Part	Multiple*		0.000085	0.01	31.72
	81	Parts	Part	Multiple*		0.00018	0.01479	22.1
	1	Pipes	Part	Aluminum 1050	2705	0.179	0.179	484.2
Total Mass (kg): 538.0								

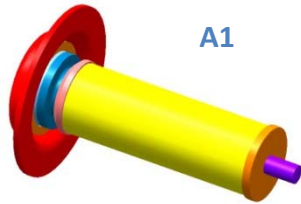


Multiple *	Density - (kg/m ³)
SSTEEL (304, 304L, 304H)	8000
Aluminum 7075 T73	2810
Aluminum mg 3	2670
Aluminum 5083 H111	2650
Aluminum 3003	2700
Aluminum 1050	2705
fibra de vetro	2600

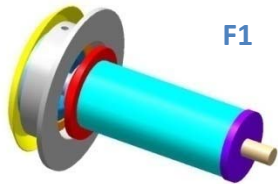


II. Development of CATIA Geometry

Volume 19 Supports of Coil



A1



F1



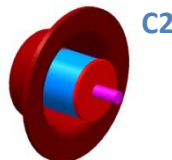
A3



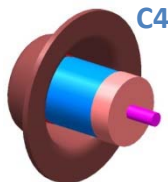
E-EST



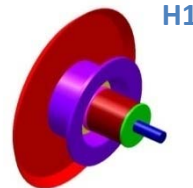
C1



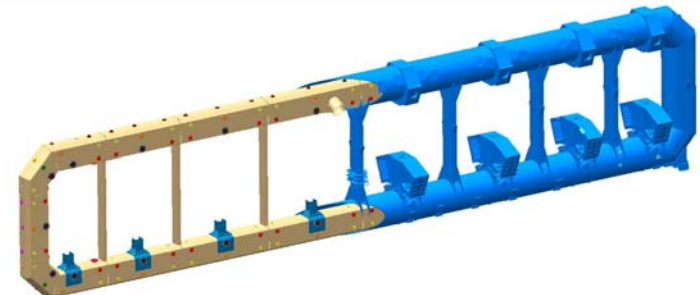
C2



C4



H1



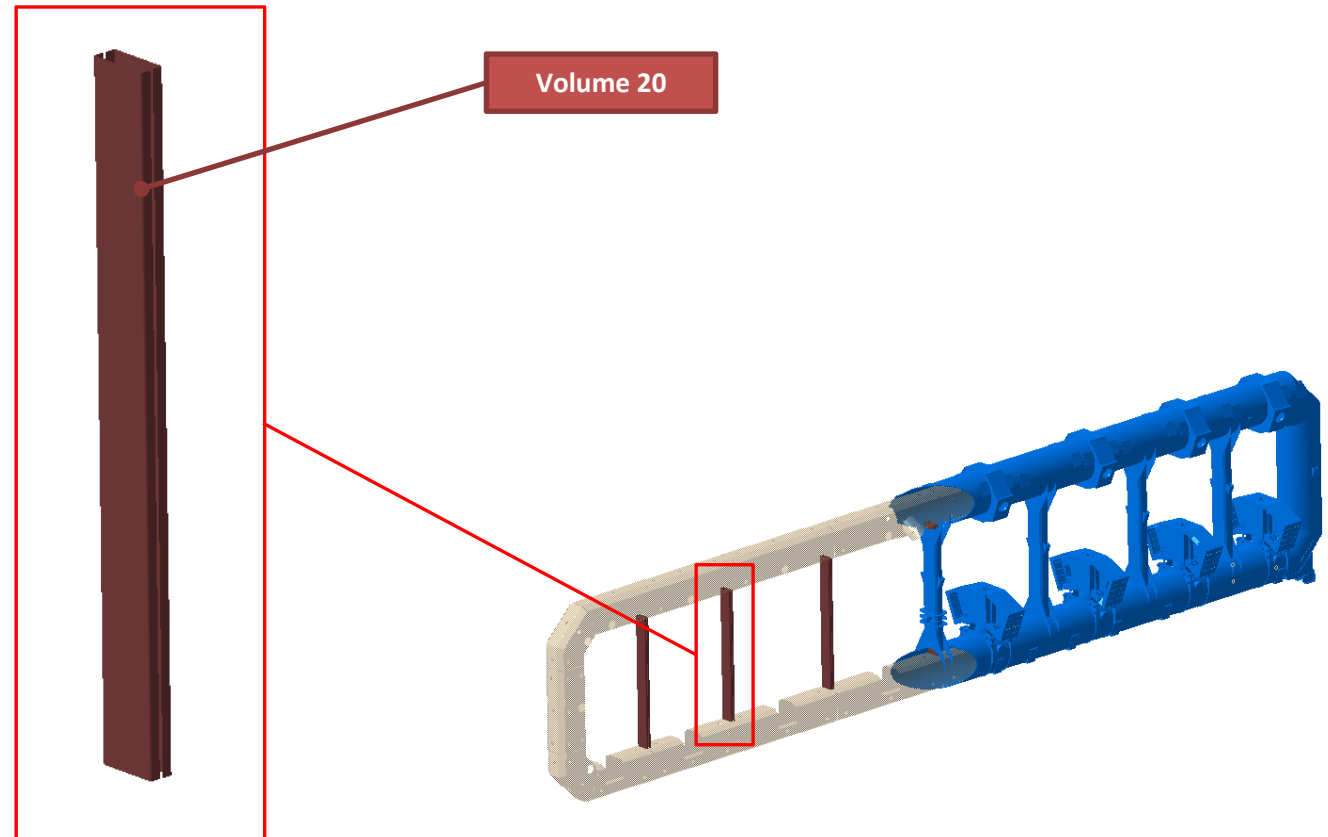
Volume 19				Number of	Part Name	Material	Density	Volume	Total Volume	Total Weight
				Items			(kg/m ³)	(m ³)	(m ³)	(kg)
	108	Support A1.1	Part	Aluminum 5083 F	2660	0.0001048	0.0113184	30.1		
	108	Support A1.5	Part	Stainless Steel 304L	8000	0.00004723	0.00510084	40.8		
	108	Support A1.6	Part	Stainless Steel 304L	8000	0.00006412	0.00692496	55.4		
	100	Support A1.8	Part	Stainless steel AISI 304 L	8000	0.00002734	0.002734	21.9		
	52	Support C1.2	Part	Aluminum 5083 F	2660	0.0001228	0.0063856	17.0		
	58	Support C1.7	Part	Stainless Steel 304L/316L	8000	0.0000223	0.0012934	10.3		
	58	Support C1.8	Part	Stainless Steel 304L/316L	8000	0.00002888	0.00167504	13.4		
	28	Support D1.1	Part	Stainless Steel 304L/316L	8000	0.00005369	0.00150332	12.0		
	28	Support D1.5	Part	Aluminum 2024 T3	2780	0.0001857	0.0051996	14.5		
	44	E EST_2	Part	Stainless Steel AISI 304 L	8000	0.0004261	0.0187484	150.0		
	44	E EST_3	Part	PERMAGLAS TE630	1850	0.0005058	0.0222552	41.2		
	44	E EST_4	Part	Aluminum	2700	0.0007714	0.0339416	91.6		
	44	E EST_5	Part	Aluminum	2700	0.0005786	0.0254584	68.7		
	44	E EST_6	Part	Aluminum	2700	0.0006777	0.0298188	80.5		
	44	E EST_7	Part	Aluminum	2700	0.0001206	0.0053064	14.3		
	44	E EST_9	Part	Aluminum	2700	0.0005685	0.025014	67.5		
	72	Support F1.1	Part	Stainless Steel 304L/316L	8000	0.00008567	0.00616824	49.3		
	72	Support F1.3	Part	Aluminum 2024 T3	2780	0.0001163	0.0083736	23.3		
	72	Support F1.5	Part	Stainless Steel 304L/316L	8000	0.00003998	0.00287856	23.0		
	72	Support F1.6	Part	Stainless Steel 304L/316L	8000	0.00009161	0.00659592	52.8		
	72	Support F1.8	Part	Stainless Steel AISI 304L	8000	0.00002725	0.001962	15.7		
	72	Support F1.13	Part	PERMAGLAS TE630	1850	0.00007735	0.0055692	10.3		
	4454	other parts					0.0591	213.4		
									Total Mass (kg): 1117.1	

II. Development of CATIA Geometry

Volume 20 Ribs of Thermal Shielding

Volume 20	Number of Items	Part Name		Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	7	Ribs of Thermal Shielding	Part	Aluminum 3003.H22	2740	0.0144	0.101	276
							Total Mass (kg): 276	

7 X Rib of Thermal
Shielding

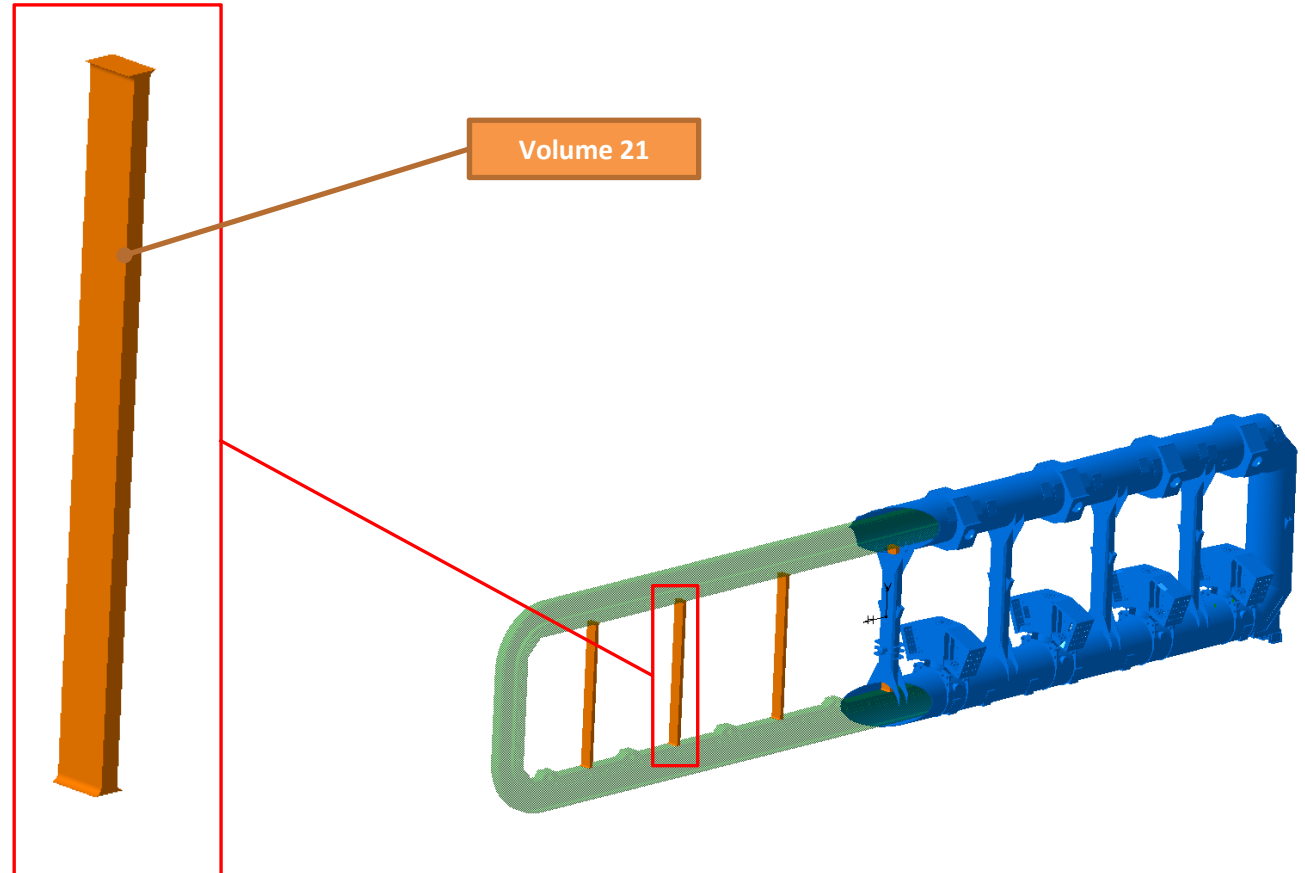


II. Development of CATIA Geometry

Volume 21 Ribs of Coil casing

Volume 21	Number of Items	Part Name		Material	Density (kg/m ³)	Volume (m ³)	Total Volume (m ³)	Total Weight (kg)
	7	Ribs of Coil casing	Part	Aluminum 5083	2650	0.101	0.707	1873.02
								Total Mass (kg): 1873

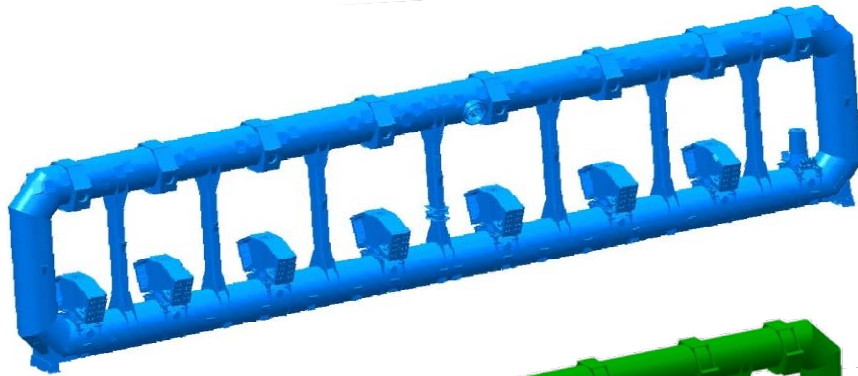
7 x Rib of Coil
casing



III. Compare Analysis of CATIA ↔ FLUGG / CATIA ↔ G4

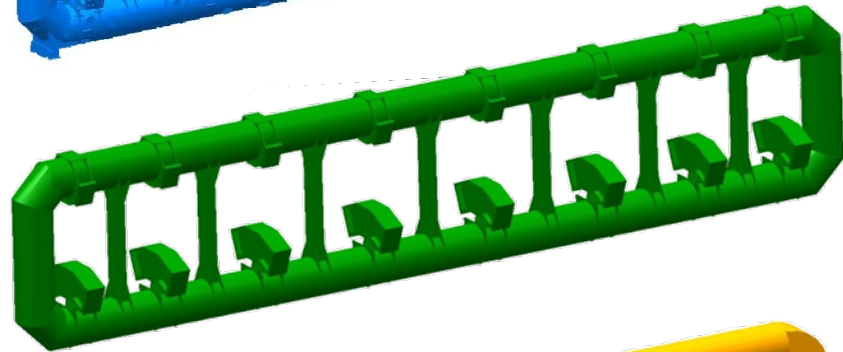
III. Compare Analysis

Sources:



CATIA - 21/12/2011

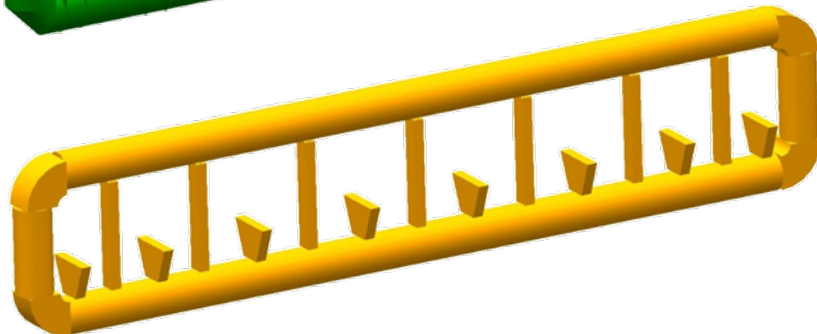
Georgian Team



G4 - 16/12/2011

Tag: ATLAS-GEO-18-01-00

VP1 Release-4 on Lxplus



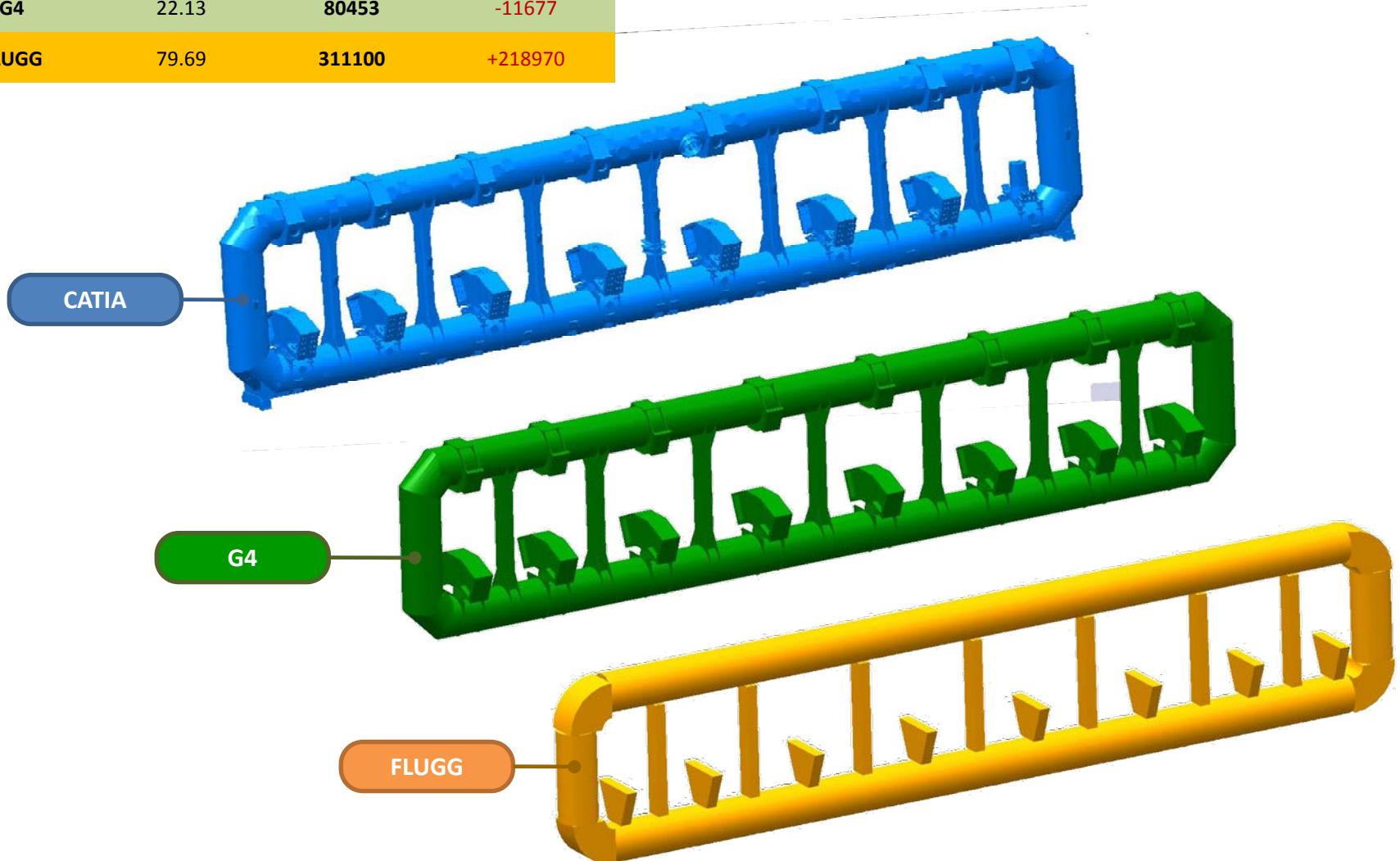
FLUGG - 30/09/2011

<http://www.slac.stanford.edu/~tkoi/G4Apps.rv2.tar.gz>

Sender: Tatsumi Koi

III. Compare Analysis

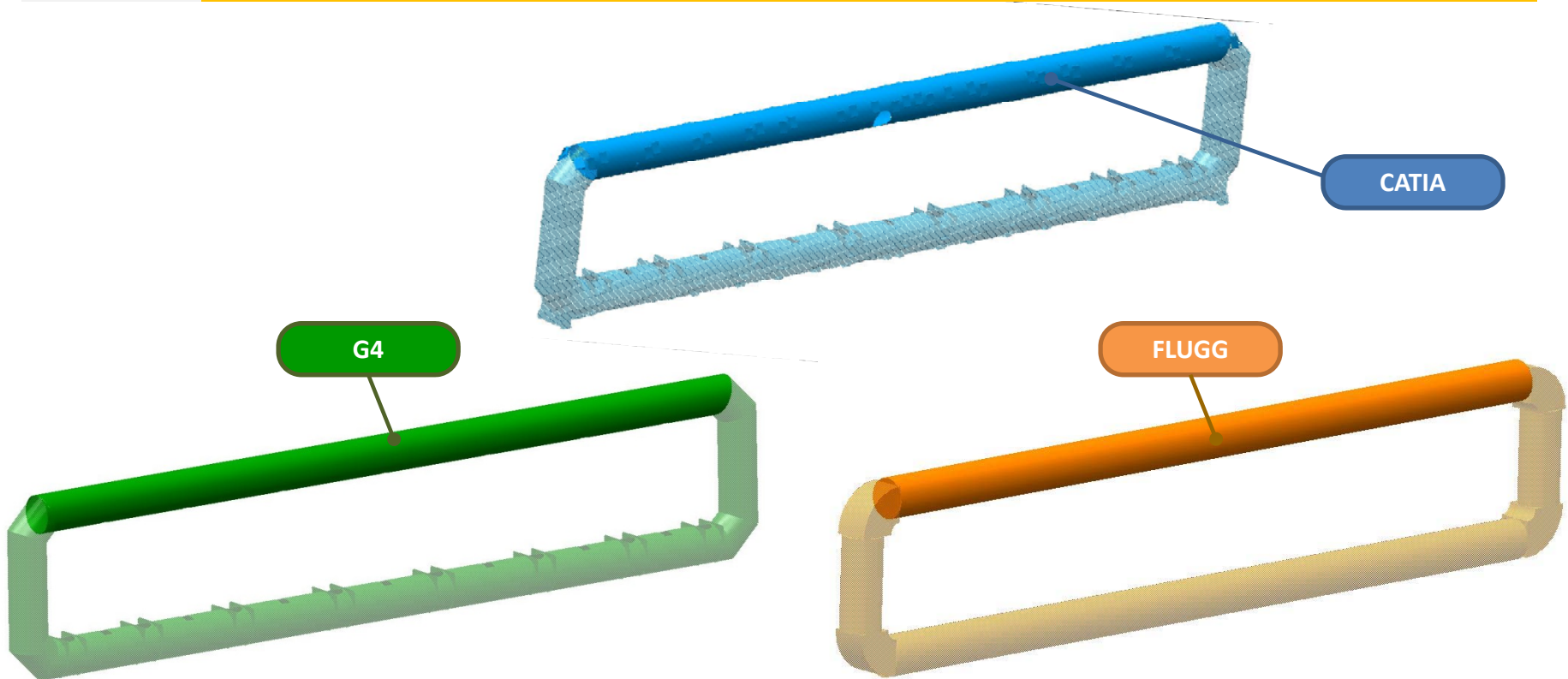
Model	Volume (m3)	Weight (kg)	Difference (kg)
CATIA	24.75	92130	
G4	22.13	80453	-11677
FLUGG	79.69	311100	+218970



III. Compare Analysis

Volume 1 Cryostat Long (Top)

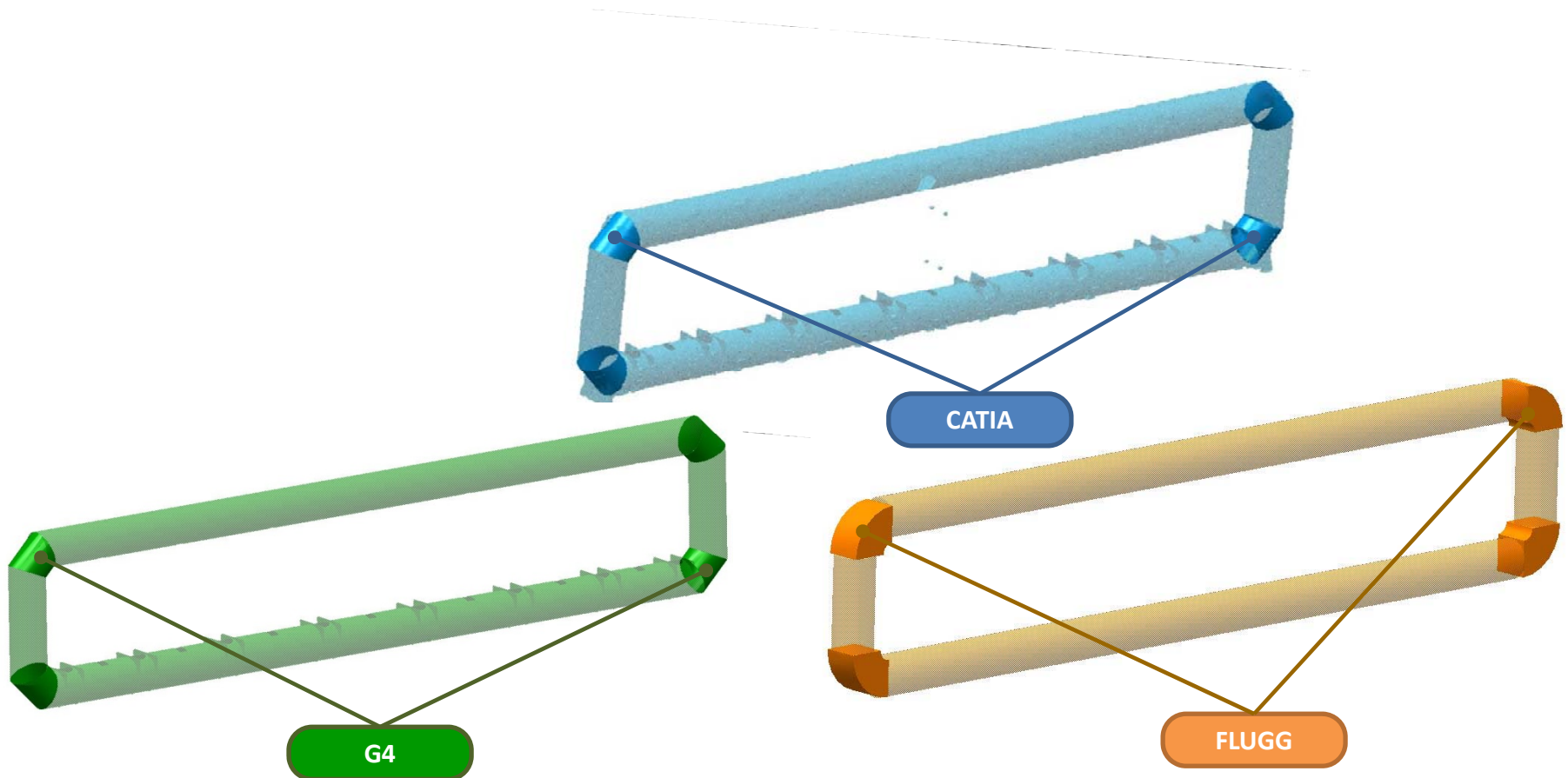
Volume 1	Cryostat Long (Top)	Model	Material	Density (kg/m3)	Volume (m3)	Weight (kg)	Difference (kg)
		CATIA	SSteel 304L	8000	1.261	10088	
		G4	Iron	7870	1.137	8950	-1138
		FLUGG	SSteel	7870	10.6815	84065	+73977



III. Compare Analysis

Volume 2, 4, 6, 8 Cryostat Corner

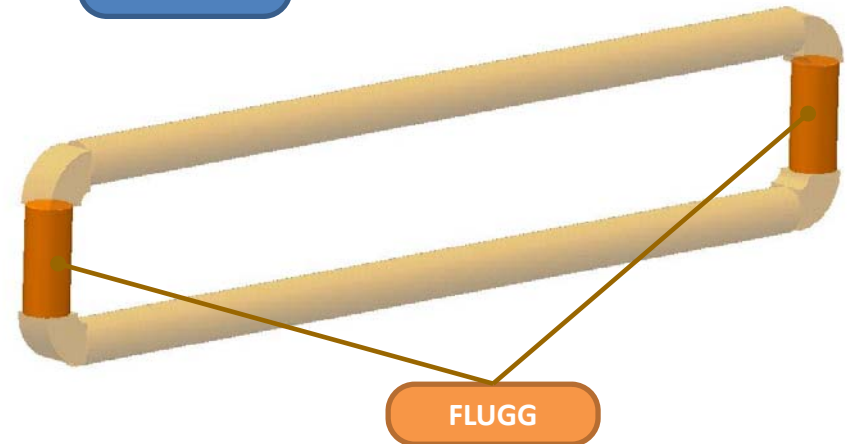
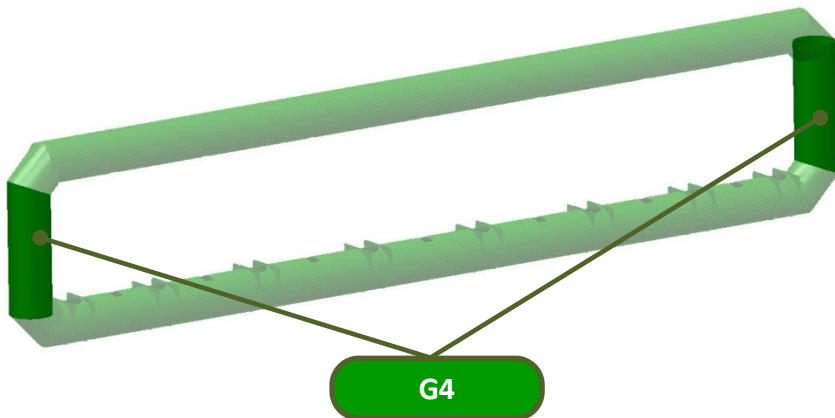
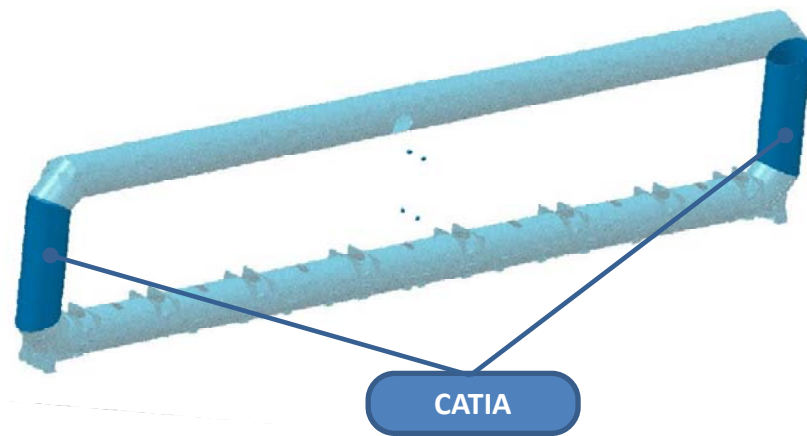
Volume 2,4,6,8	Cryostat Corner	Model	Material	Density (kg/m3)	Volume (m3)	Weight (kg)	Difference (kg)
		CATIA	SSteel 304L	8000	0.168	1344	
		G4	Iron	7870	0.169	1330	-14
		FLUGG	SSteel	7870	4.59	36120	+34776



III. Compare Analysis

Volume 3, 7 Cryostat Short

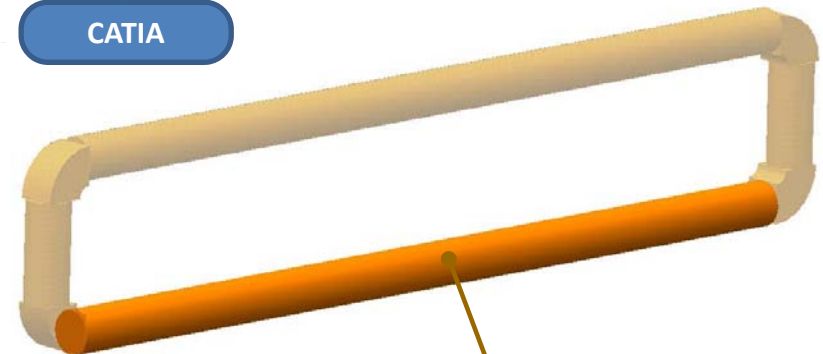
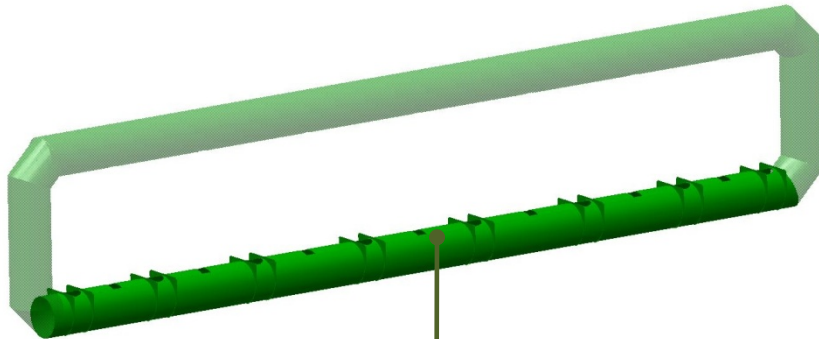
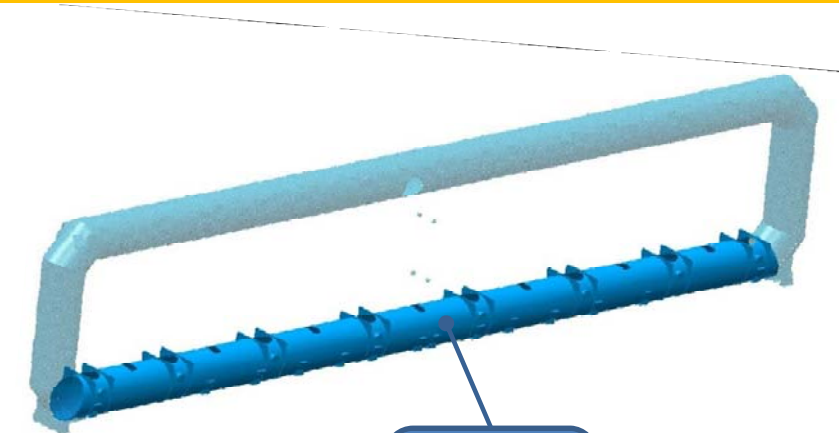
Volume 3,7	Cryostat Short	Model	Material	Density (kg/m ³)	Volume (m ³)	Weight (kg)	Difference (kg)
		CATIA	SSteel 304L	8000	0.338	2704	
		G4	Iron	7870	0.162	2546	-158
		FLUGG	SSteel	7870	2.41	18990	+16286



III. Compare Analysis

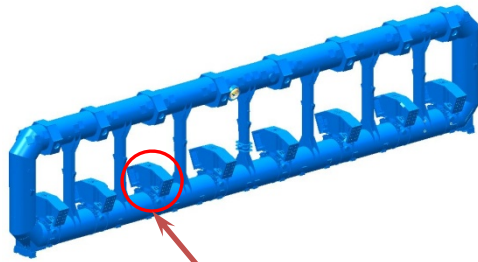
Volume 5 Cryostat Long (Bottom)

Volume 5	Cryostat Long (Bottom)	Model	Material	Density (kg/m3)	Volume (m3)	Weight (kg)	Difference (kg)
		CATIA	SSteel 304L	8000	1.421	11368	
		G4	Iron	7870	1.223	9630	-1738
		FLUGG	SSteel	7870	10.6815	84065	+72697

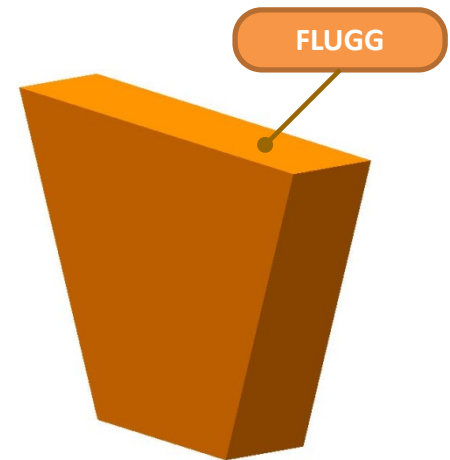
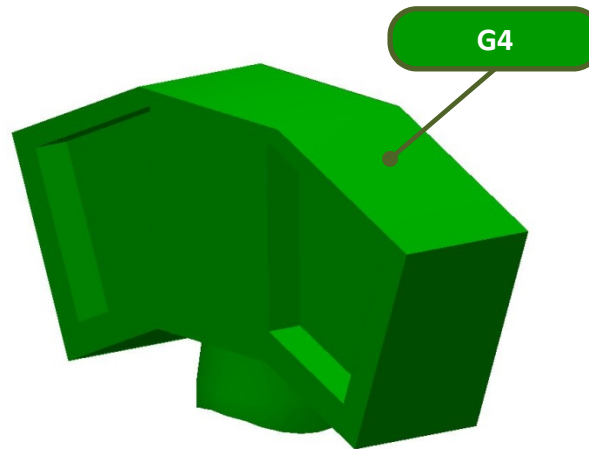
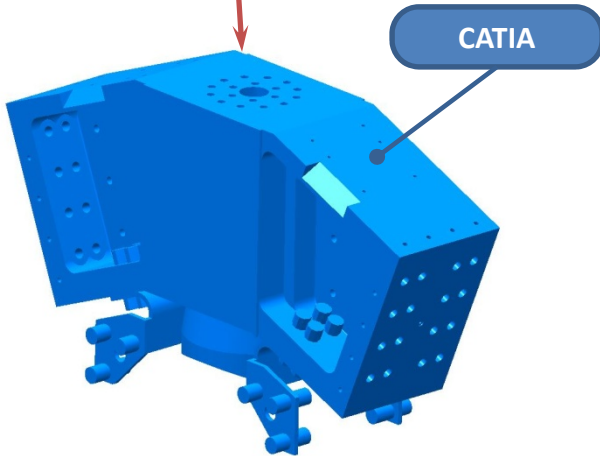


III. Compare Analysis

Volume 9 Voussoirs



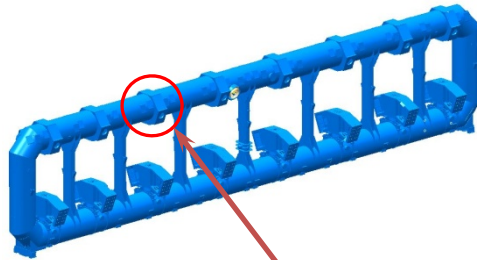
8 x Voussoirs



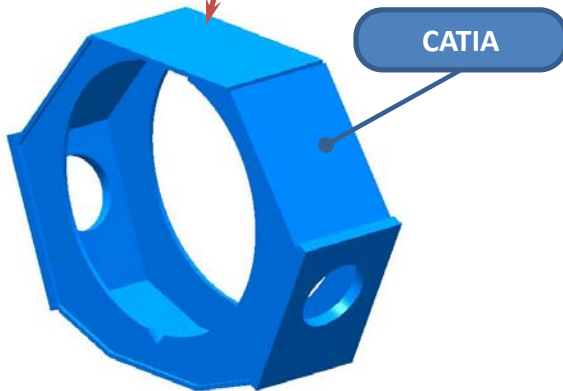
Volume 9	Voussoirs	Model	Material	Density (kg/m ³)	Volume (m ³)	Weight (kg)	Difference (kg)
		CATIA	Ssteel 304L/Al	8000/2650	4.416	12344	
		G4	Iron/Al	7870/2700	4.573	13255	+911
		FLUGG	SSteel	7870	2.71	21350	+9006

III. Compare Analysis

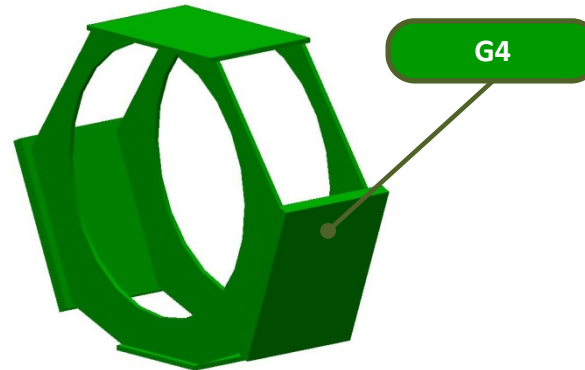
Volume 10 Steffiner



8 x Stiffener



CATIA



G4

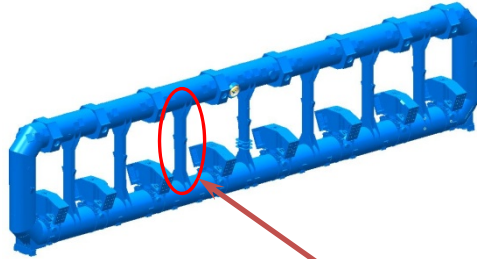
FLUGG

This volume has
not included in
FLUGG geometry

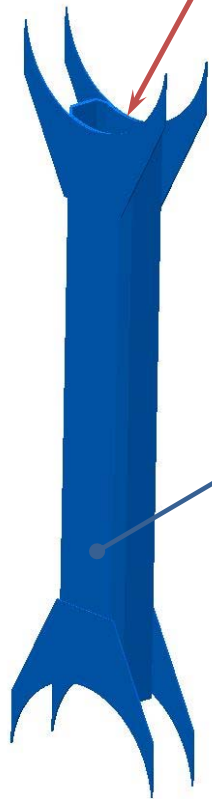
Volume 10	Stiffener	Model	Material	Density (kg/m3)	Volume (m3)	Weight (kg)	Difference (kg)
		CATIA	Ssteel 304L	8000	0.667	5336	
		G4	Iron	7870	0.579	4558	-778
		FLUGG					-5336

III. Compare Analysis

Volume 11 Rib

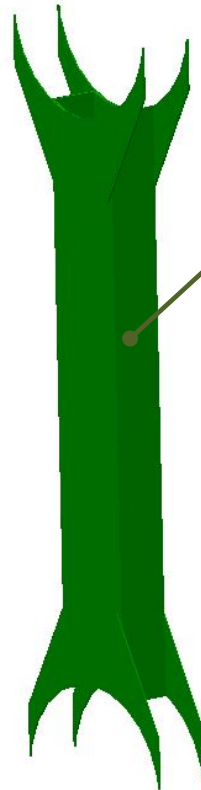


7 x Rib

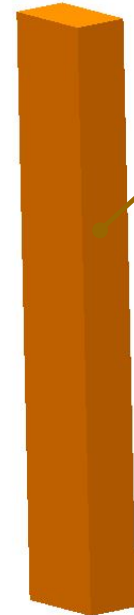


CATIA

Volume 11	Rib	Model	Material	Density (kg/m ³)	Volume (m ³)	Weight (kg)	Difference (kg)
		CATIA	Ssteel 304L	8000	0.603	4824	
		G4	Iron	7870	0.454	3576	-1248
		FLUGG	Ssteel	7870	3.28	25780	+20956



G4



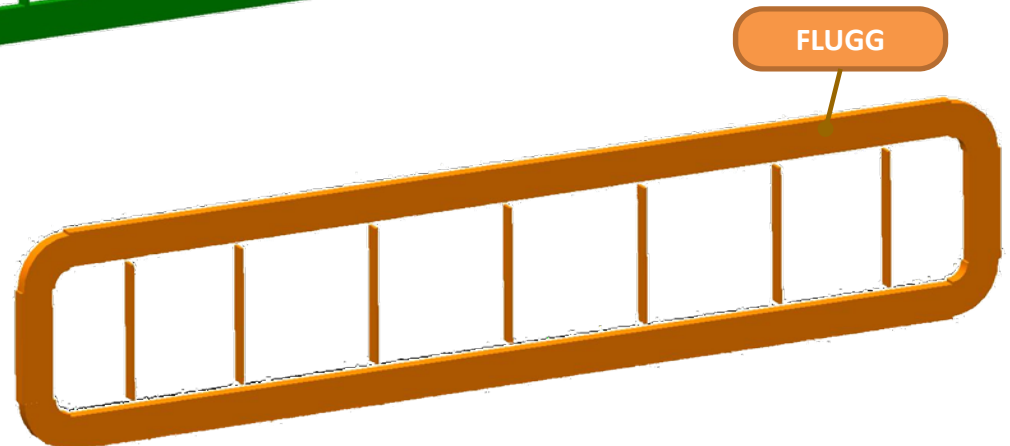
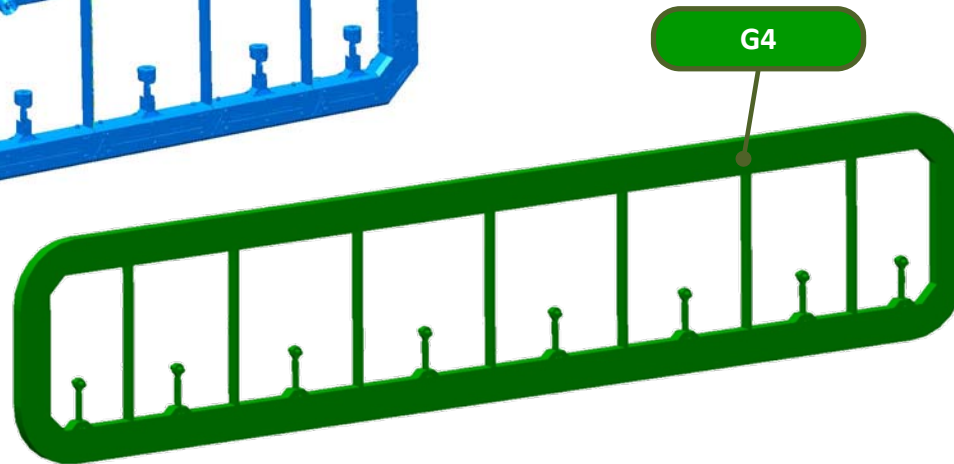
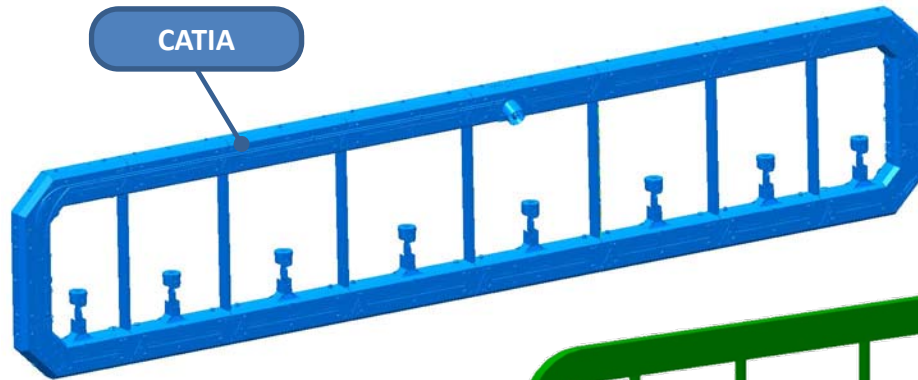
FLUGG

III. Compare Analysis

Volume 12 Inside of Coil

Volume 12 Inside of Coil	Model	Material	Density (kg/m3)	Volume (m3)	Weight (kg)	Difference (kg)
	CATIA	Materials*		15.885	44122	
	G4	Aluminum	2700	13.558	36607	-7515
	FLUGG	Aluminum	2700	15.08	40720	-3402

* Materials	Density
Ssteel 304L	8000
Ssteel 316L	8000
Al 5083F	2660
Al 2024 T3	2780
Al 1050 H22	2705
Al 5083 H111	2650
Al 5083 H112	2660
Al 7075 T73	2810
TA5E-ELI	4480
Al 3003 H22	2740
Al MG 3	2740
Permaglas TE630	1850



CATIA Volume 12 Inside of Coil	Volume	Part name	Volume (m3)	Weight (kg)
	Volume 12	Thermal Shielding	0.838	2296
	Volume 13	Tie Rod	0.52	2928
	Volume 14	Coil casing	7.717	20453
	Volume 15	Coil casing part	1.866	4964
	Volume 16	Babine double pancake	4.367	11572
	Volume 17	Services	0.074	253
	Volume 18	Supports of Services	0.21	538
	Volume 19	Supports of Coil	0.293	1117
Total:			15.885	44340

IV. Simplification of CATIA volumes

IV. Simplification of CATIA volumes

Simplification of CATIA volumes foresee steps as follow:

- 1st iteration Adding volumes with similar materials into one
- 1st iteration Simplification of shape – removing all details, holes, lugs, etc. and creation simple cylinders, tubes etc. keeping initial volume and weight
- 2nd iteration of Adding and Simplification of shapes
- Modification of shapes to avoid possible overlaps with other volumes

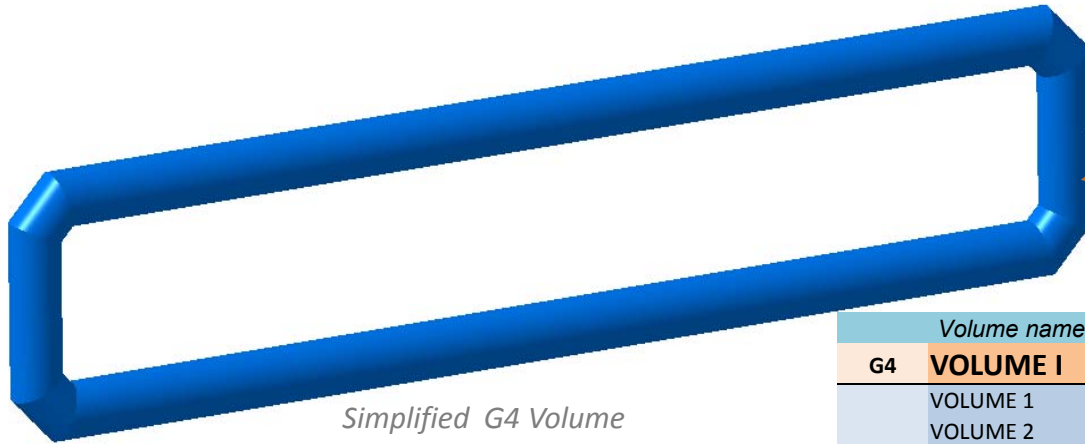
9 simplified volumes have been created from 21 CATIA volumes

IV. Simplification of CATIA volumes

VOLUME I (External Part)

VOLUME I has been created by adding 9 CATIA volumes and simplification of shapes. Received difference in weight after simplification is 0.3kg

VOLUME I = Volume_1 + Volume_2 + Volume_3 + Volume_4 + Volume_5 + Volume_6 + Volume_7 + Volume_8 + Volume_10

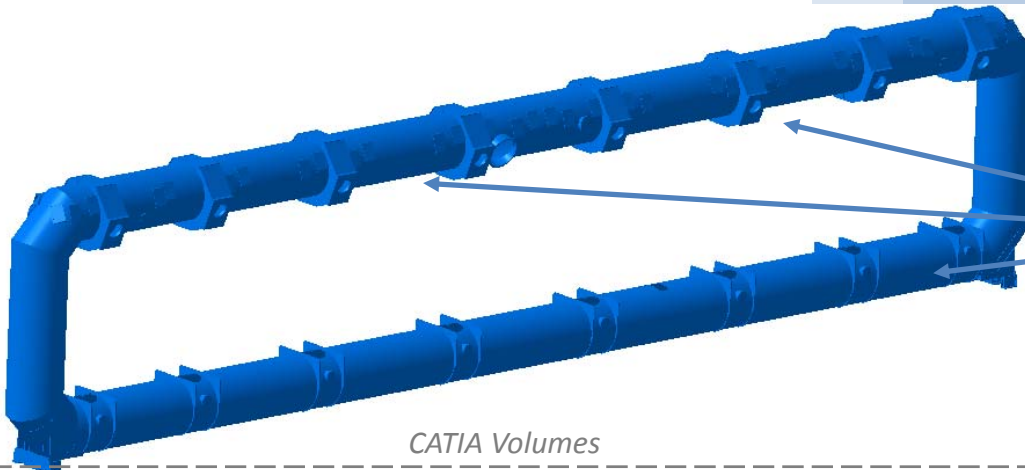


Simplified G4 Volume

VOLUME I

Material :Stainless
Steel
Density: 8000
Mass: 30840 kg

	Volume name	Volume (m ³)	Material	Density (kg/m ³)	Weight (kg)	Diff (kg)
G4	VOLUME I	3.85496	SSTEEL	8000	30839.7	-0.3
CATIA	VOLUME 1	1.261	SSTEEL	8000	10088	
	VOLUME 2	0.042	SSTEEL	8000	336	
	VOLUME 3	0.169	SSTEEL	8000	1352	
	VOLUME 4	0.042	SSTEEL	8000	336	
	VOLUME 5	1.421	SSTEEL	8000	11368	
	VOLUME 6	0.042	SSTEEL	8000	336	
	VOLUME 7	0.169	SSTEEL	8000	1352	
	VOLUME 8	0.042	SSTEEL	8000	336	
	VOLUME 10	0.083	SSTEEL	8000	664	



CATIA Volumes

VOLUME 1
VOLUME 2
VOLUME 3
VOLUME 4
VOLUME 5
VOLUME 6
VOLUME 7
VOLUME 8
VOLUME 10

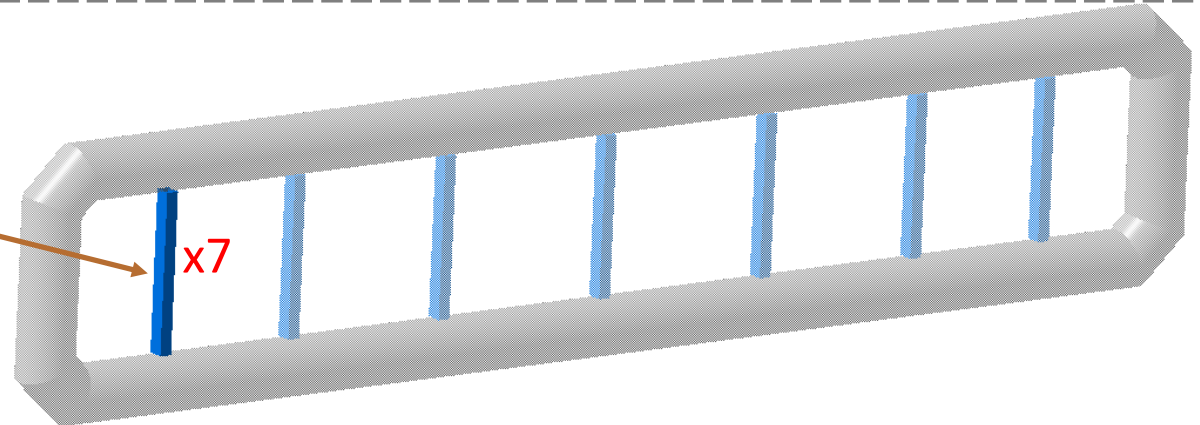
IV. Simplification of CATIA volumes

7 x VOLUME II (External Part)

VOLUME II has been created by simplification of shape of CATIA Volume 11.

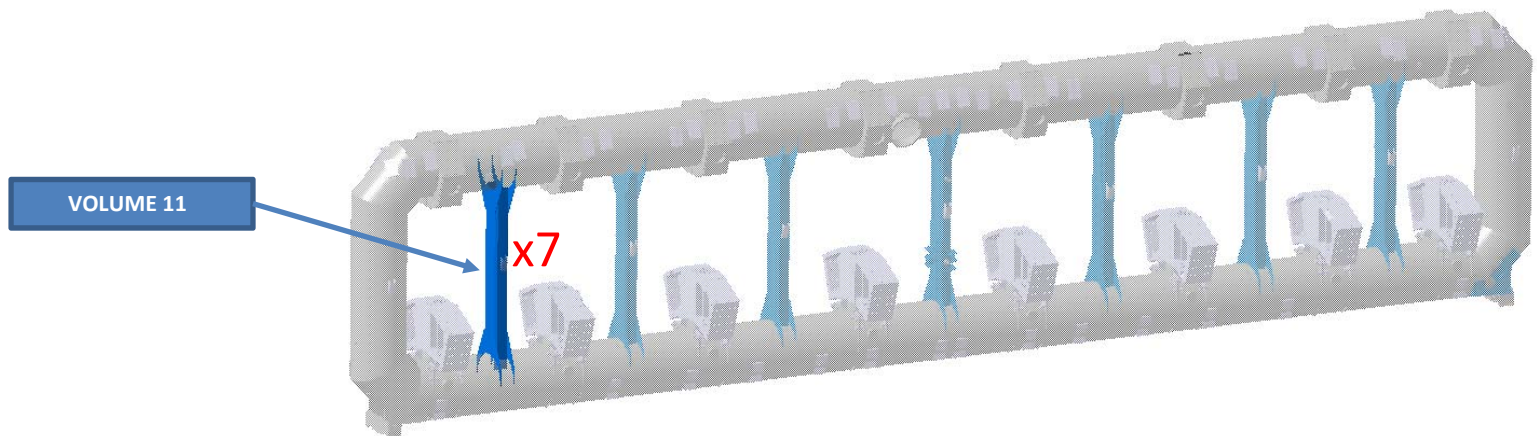
VOLUME II = Volume_11

VOLUME II
Material :Stainless Steel
Density: 8000
Mass: 688 kg



Simplified G4 Volume

	Volume name	Volume (m ³)	Material	Density (kg/m ³)	Weight (kg)	Diff (kg)
G4	VOLUME II	0.086	SSTEEL	8000	688	0
CATIA	VOLUME 11	0.086	SSTEEL	8000	688	

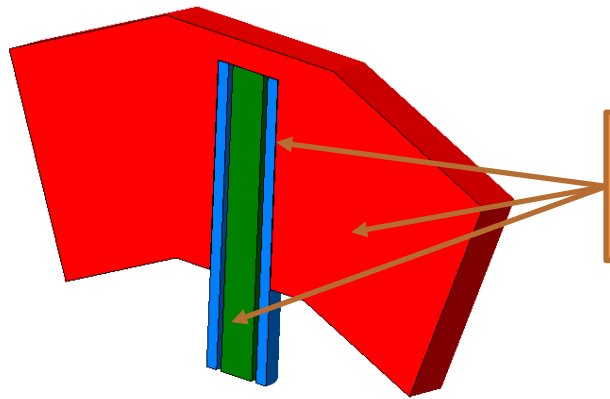


CATIA Volume

IV. Simplification of CATIA volumes

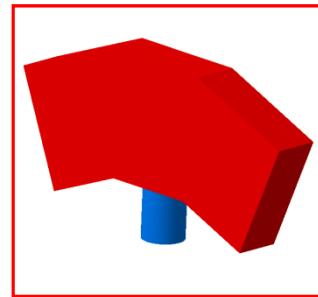
8 x VOLUME III, IV, V (External Part)

VOLUME's III, IV, and V have been created in 2 steps of synthesis described on slides below

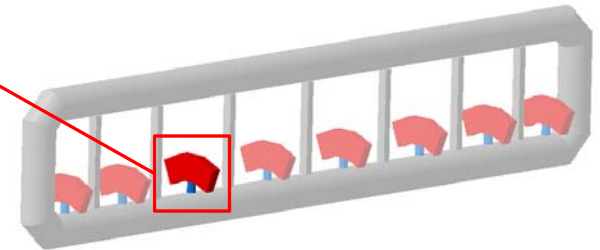


VOLUME III
VOLUME IV
VOLUME V

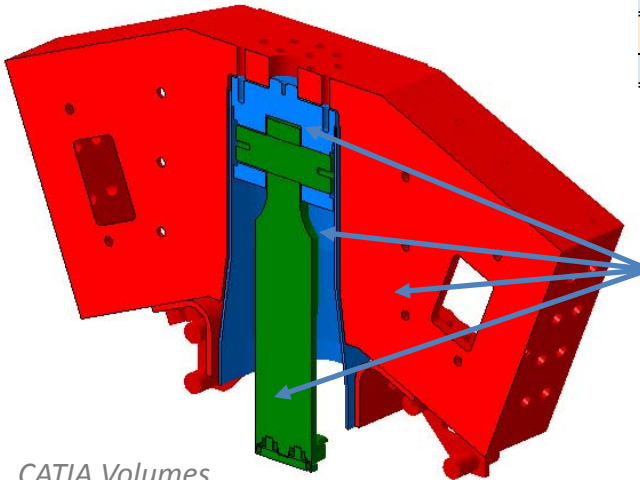
Simplified G4 Volume



x8

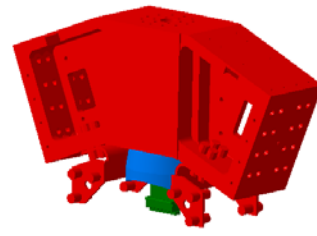


	Volume name	Volume (m³)	Material	Density (kg/m³)	Weight (kg)	Diff (kg) $\Delta = \Delta_1 + \Delta_2$
G4	VOLUME III	0.0439	SSTEEL	8000	351.0	0
CATIA	VOLUME 9.2	0.015	SSTEEL	8000	120.0	
	VOLUME 13.3	0.0286	SSTEEL	8000	229.0	
G4	VOLUME IV	0.537	Aluminum	2650	1423.0	0
CATIA	VOLUME 9.1	0.537	Aluminum	2650	1423.0	
G4	VOLUME V	0.021	TITAN	4480	94.0	0
CATIA	VOLUME 13.2			4480	94.0	

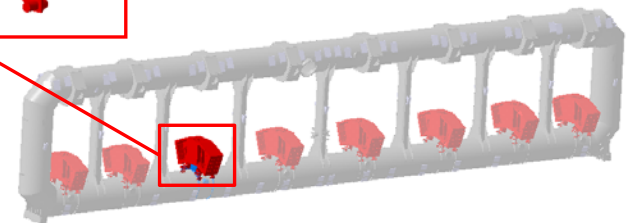


VOLUME 9.2
VOLUME 13.3
VOLUME 9.1
VOLUME 13.2

CATIA Volumes



x8

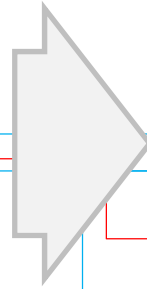


IV. Simplification of CATIA volumes

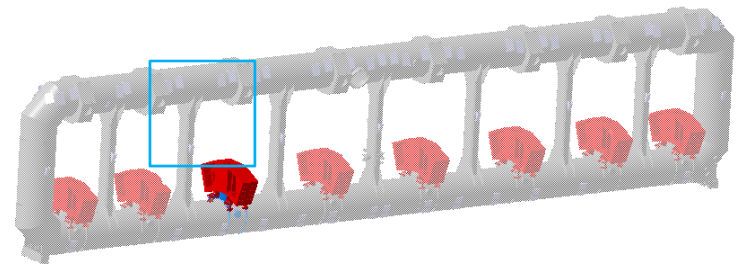
VOLUME III, IV, V (External Part) / 1st Step of synthesis

On the 1st step of synthesis CATIA volumes have been grouped by materials. Than for each grouped volume shape has been simplified

CATIA Volumes					
	Part Name	Material	Density	Volume (kg/m3)	Weight (kg)
Volume 9	Vossuoir	Aluminum	2650	0.537	1423
	Vossuoir	SSTEEL	8000	0.015	120
Volume 13	Tie rod	TA5E-ELI	4480	0.0160	72
	Lug (Tie rod)	Z3 CN18-10	8000	0.0280	224
	Shouldered axis	TA5E-ELI	4480	0.0050	22
	Small bar support	Z3 CN18-10	8000	0.0003	2
	Piston (Tie rod)	Z3 CN18-10	8000	0.0001	1
	Convex bar (Tie rod)	Z3 CND 17-12 Az	8000	0.0001	1
	Concave bar (Tie rod)	Z3 CND 17-12 Az	8000	0.0002	1
	Tie-Rod Therm. Plate	Al 1050 H22	2705	0.0150	41

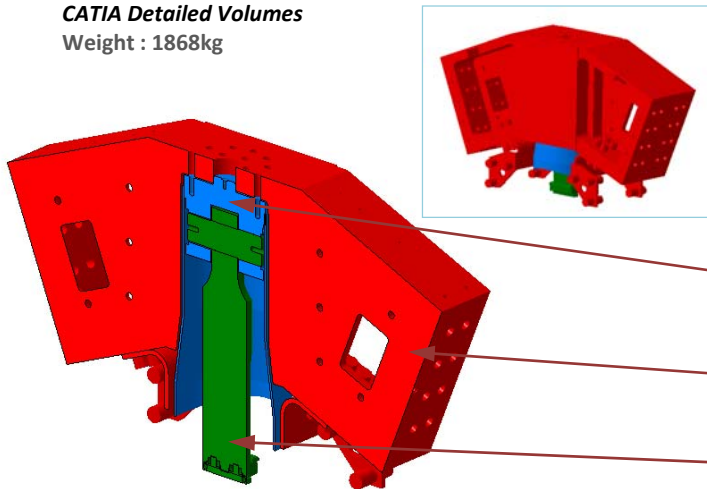


Volumes after grouping and simplification of shape				
Volume name	Material	Density (kg/m ³)	Volume (m ³)	Weight (kg)
VOLUME 9.2	SSteel	8000	0.015	120
VOLUME 13.3	SSteel	8000	0.0286	229
VOLUME 9.1	Aluminum	2650	0.537	1423
VOLUME 13.2	TITAN	4480	0.021	94.1



$$\Delta_1 = 1868\text{kg} - 1868\text{kg} = 0\text{kg}$$

CATIA Detailed Volumes
Weight : 1868kg

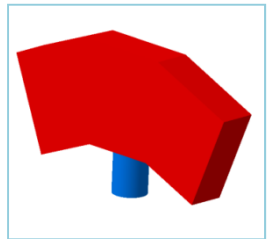
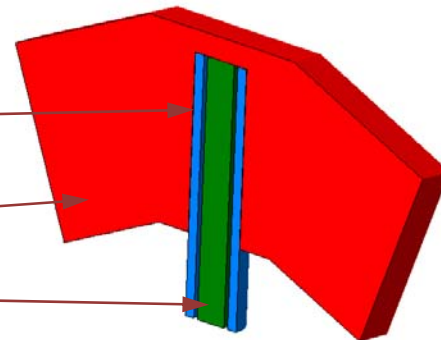


VOLUME 9.2
VOLUME 13.3

VOLUME 9.1

VOLUME 13.2

Volumes after grouping and simplification of geometry
Weight : 1868kg



IV. Simplification of CATIA volumes

VOLUME III, IV, V (External Part) / 2nd Step of synthesis

On the 2nd step of synthesis simplified volumes have been joined in one entire volume and shape again modified to avoid overlaps with other existing volumes

Volumes after 1 st Step of Synthesis				
Volume name	Material	Density (kg/m ³)	Volume (m ³)	Weight (kg)
VOLUME 9.2	SSteel	8000	0.015	120
VOLUME 13.3	SSteel	8000	0.0286	229
VOLUME 9.1	Aluminum	2650	0.015	1423
VOLUME 13.2	TITAN	4480	0.021	94

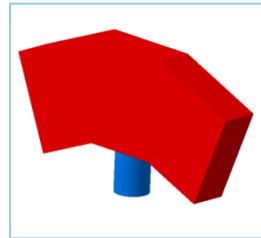
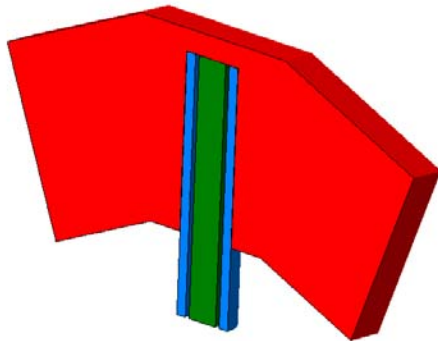


Volumes after joining and again modification of shape				
Volume name	Material	Density (kg/m ³)	Volume (m ³)	Weight (kg)
VOLUME III	Ssteel	8000	0.0436	349
VOLUME IV	Aluminum	2650	0.015	1423
VOLUME V	Titan	4480	0.021	94

$$\Delta_2 = 1868\text{kg} - 1868\text{kg} = 0\text{kg}$$

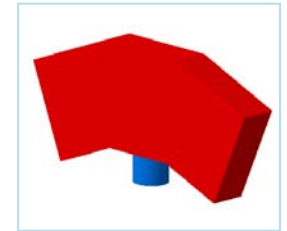
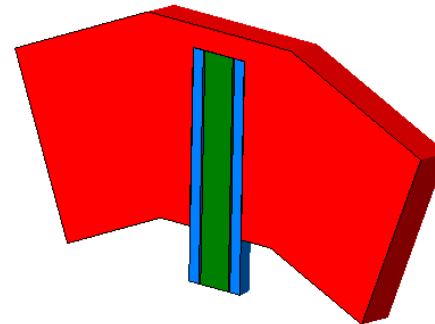
Volumes after grouping and simplification of geometry

Weight : 1868kg



Volumes after joining and again simplification

Weight : 1868kg



IV. Simplification of CATIA volumes

VOLUME VI (Internal Part)

VOLUME VI has been created in 2 steps of synthesis described on slides below

VOLUME VI

Material : Aluminum
Density: 2740
Mass: 2997 kg

Simplified G4 Volume

CATIA Volumes

Multiple *	Density (kg/m ³)
Aluminum 7075 T73	2810
Aluminum mg 3	2670
Aluminum 5083 H111	2650
Aluminum 3003	2700
Aluminum 1050	2705
fibra de vetro	2600

	Volume name	Volume (m ³)	Material	Density (kg/m ³)	Weight (kg)	Diff (kg) $\Delta=\Delta^1+\Delta^2$
G4	VOLUME VI	1.09384	Aluminum	2740	2997	+12
CATIA	VOLUME 12	0.7373	Aluminum	2740	2020	
	VOLUME 13.1	0.015	Aluminum	2705	41	
	VOLUME 17.1	0.064	Aluminum	2705	173	
	VOLUME 19.1	0.172448	Multiple *		467	

VOLUME 12
VOLUME 13.1
VOLUME 17.1
VOLUME 19.1

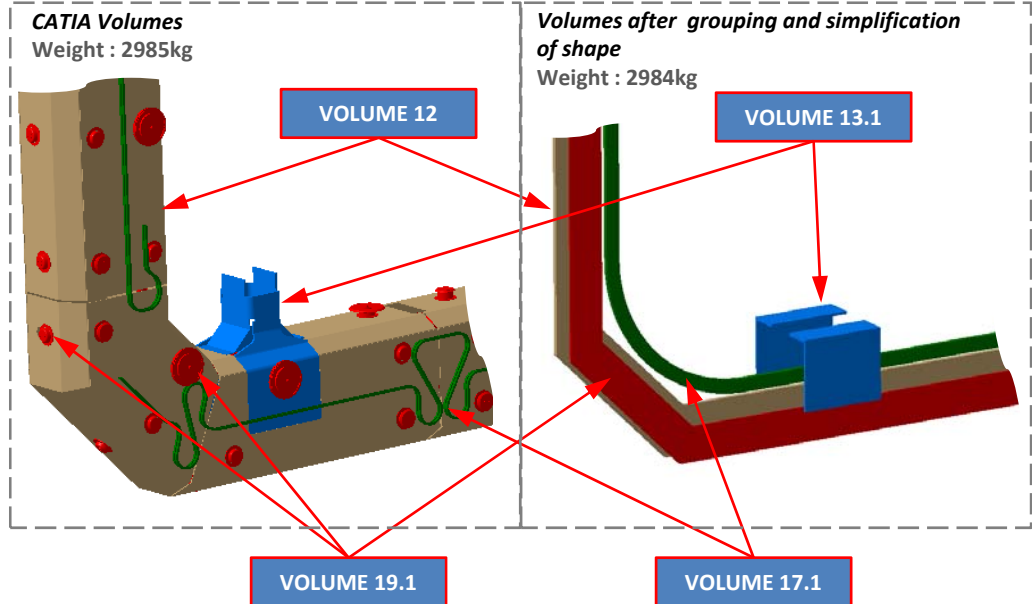
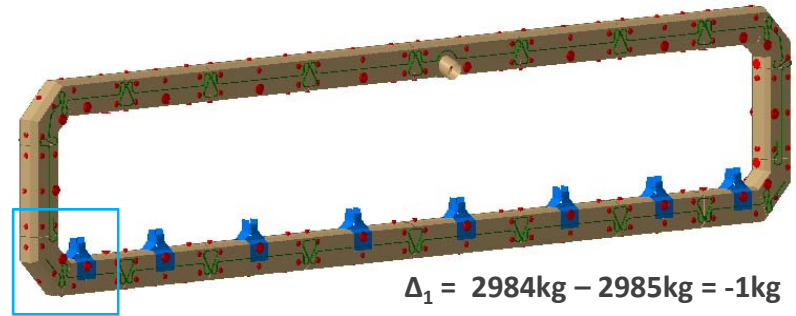
IV. Simplification of CATIA volumes

VOLUME VI (Internal Part) / 1st Step of synthesis

On the 1st step of synthesis CATIA volumes have been grouped by materials. Than for each grouped volume shape has been simplified

	Part Name	Material	Density	Volume	Weight
Volume 12	Thermal Shielding	3003.H22	2740	0.7373	2020
Volume 13	Tie rod	TA5E-ELI	4480	0.1280	573
	Lug (Tie rod)	Z3 CN18-10	8000	0.2240	1792
	Shouldered axis	TA5E-ELI	4480	0.0400	179
	Small bar support	Z3 CN18-10	8000	0.0024	19
	Piston (Tie rod)	Z3 CN18-10	8000	0.0011	9
	Convex bar (Tie rod)	Z3 CND 17-12 Az	8000	0.0013	10
	Concave bar (Tie rod)	Z3 CND 17-12 Az	8000	0.0025	20
Volume 17	Tie-Rod Therm. Plate	Al 1050 H22	2705	0.1200	325
	Pipes	Al 1050	2705	0.0640	173
	Part5	304L	8000	0.0040	32
	Part2	304L	8000	0.0040	32
	atltbyr_0036	304L	8000	0.0006	5
	atltbyr_0035	304L	8000	0.0005	4
	atltbyr_0034	304L	8000	0.0005	4
Volume 19	atltbyr_0033	304L	8000	0.0004	3
	Support A1.1	Al 5083 F	2660	0.0113	30
	Support A1.5	304 L o 316L	8000	0.0051	41
	Support A1.6	304 L o 316L	8000	0.0069	55
	Support A1.8	AISI 304 L	8000	0.0027	22
	Support C1.2	Al 5083 F	2660	0.0064	17
	Support C1.7	304 L/316L	8000	0.0013	10
	Support C1.8	304 L/316L	8000	0.0017	13
	Support D1.1	304 L/316L	8000	0.0015	12
	Support D1.5	AL 2024 T3	2780	0.0052	14
	E EST_2	AISI 304 L	8000	0.0187	150
	E EST_3	PR.GLAS TE630	1850	0.0223	41
	E EST_4		2700	0.0339	92
	E EST_5		2700	0.0255	69
	E EST_6		2700	0.0298	81
	E EST_7		2700	0.0053	14
	E EST_9		2700	0.0250	68
	Support F1.1	304 L/316L	8000	0.0062	49
	Support F1.3	Al 2024 T3	2780	0.0084	23
	Support F1.5	304 L/316L	8000	0.0029	23
	Support F1.6	304 L/316L	8000	0.0066	53
	Support F1.8	AISI 304L	8000	0.0020	16
	Support F1.13	Pr.GLAS TE630	1850	0.0056	10
	other small parts			0.0591	213

Volumes after grouping and simplification of shape				
Volume name	Volume (m ³)	Material	Density (kg/m ³)	Weight (kg)
VOLUME 12	0.7373	Aluminum	2740	2020
VOLUME 13.1	0.12	Aluminum	2705	325
VOLUME 17.1	0.064	Aluminum	2705	173
VOLUME 19.1	0.172448	Multiple *		467



IV. Simplification of CATIA volumes

VOLUME VI (Internal Part) / 2nd Step of synthesis

On the 2nd step of synthesis simplified volumes have been joined in one entire volume; average density has been assigned and shape again simplified

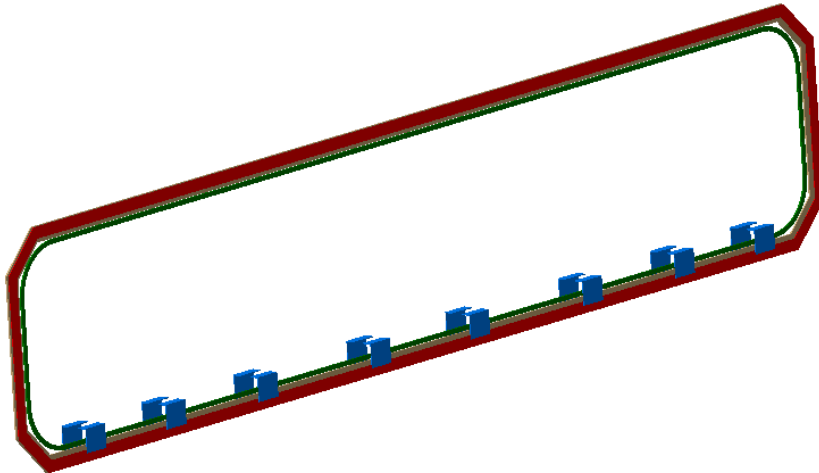
Volumes after 1 st Step of synthesis				
Volume name	Volume (m ³)	Material	Density (kg/m ³)	Weight (kg)
VOLUME 12	0.7373	Aluminum	2740	2020
VOLUME 13.1	0.12	Aluminum	2705	325
VOLUME 17.1	0.064	Aluminum	2705	173
VOLUME 19.1	0.172448	Multiple *		467



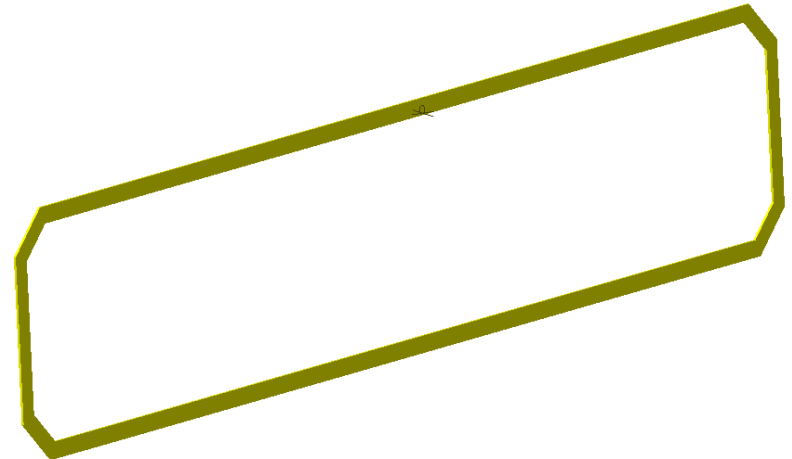
Volumes after joining and again simplification				
Volume name	Volume (m ³)	Material	Density (kg/m ³)	Weight (kg)
VOLUME VI	1.09384	Aluminum	2740	2997

$$\Delta_2 = 2997\text{kg} - 2984\text{kg} = +13\text{kg}$$

Volumes after 1st Step of synthesis
Weight : 2984kg



Volumes after joining and again simplification of shape
Weight : 2997kg



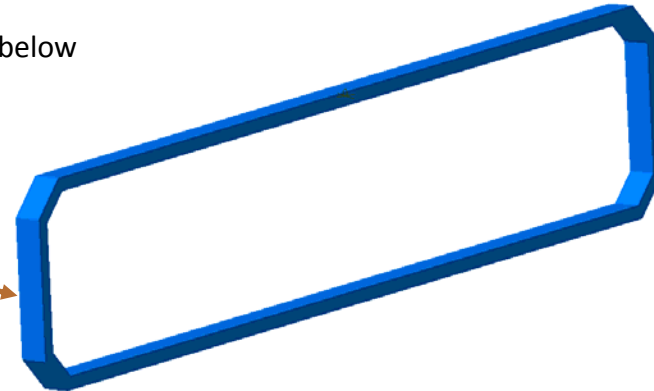
IV. Simplification of CATIA volumes

VOLUME VII (Internal Part)

VOLUME VII has been created in 2 steps of synthesis described on slides below

VOLUME VII

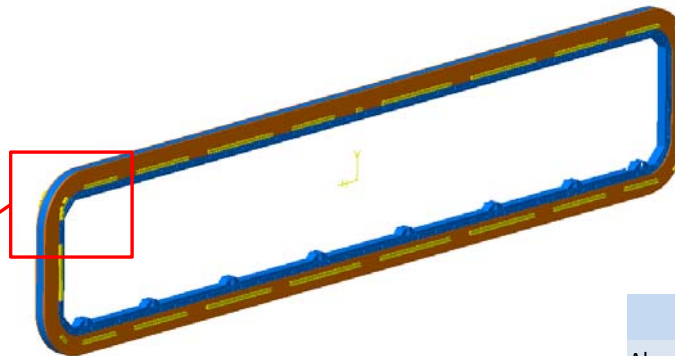
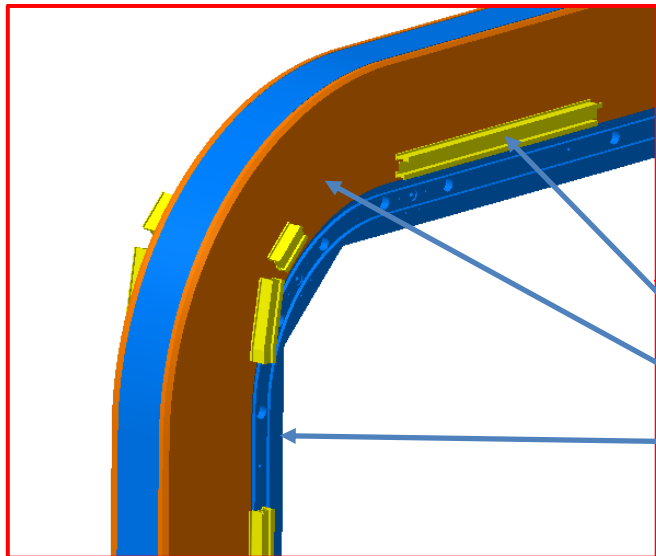
Material :Aluminum
Density: 2650
Mass: 35637 kg



G4 Volume

	Volume name	Volume (m ³)	Material	Density (kg/m ³)	Weight (kg)	Diff (kg) $\Delta=\Delta_1+\Delta_2$
G4	VOLUME VII	13.448	Aluminum	2650	35637	-14
	VOLUME 14	7.01	Aluminum	2650/2810	18579	
	VOLUME 15	1.866	Aluminum	2660	4964	
	VOLUME 16	4.367	Aluminum	2650	11572	
	VOLUME 18	0.2056	Multiple *		538	

CATIA Volume



VOLUME 14
VOLUME 15
VOLUME 16
VOLUME 18

Multiple *	Density (kg/m ³)
Aluminum 7075 T73	2810
Aluminum mg 3	2670
Aluminum 5083 H111	2650
Aluminum 3003	2700
Aluminum 1050	2705
fibra de vetro	2600

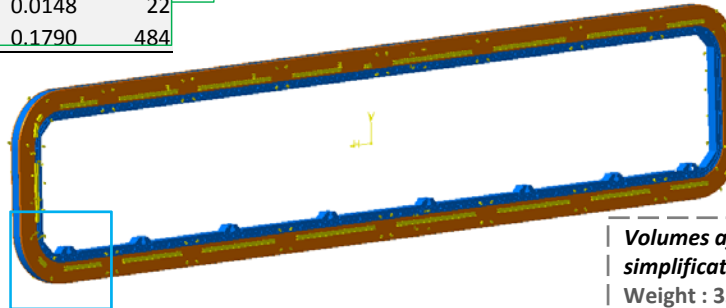
IV. Simplification of CATIA volumes

VOLUME VII (Internal Part) / 1st Step of synthesis

On the 1st step of synthesis CATIA volumes have been grouped by materials. Then for each grouped volume shape has been simplified

CATIA Volumes					
	Part Name	Material	Density (kg/m ³)	Volume (kg/m3)	Weight (kg)
Volume 14	Coil casing	Aluminum 5083	2650	6.9588	18441
		Aluminum 7075	2810	0.0189	53
		Aluminum 5083	2650	0.0320	85
Volume 15	Coil part	Aluminum 5083	2660	1.8660	4964
Volume 16		Aluminum	2650	4.3670	11572
Volume 18	S3			0.0118	32
	Small Parts			0.0148	22
	Pipes	Al 1050	2705	0.1790	484

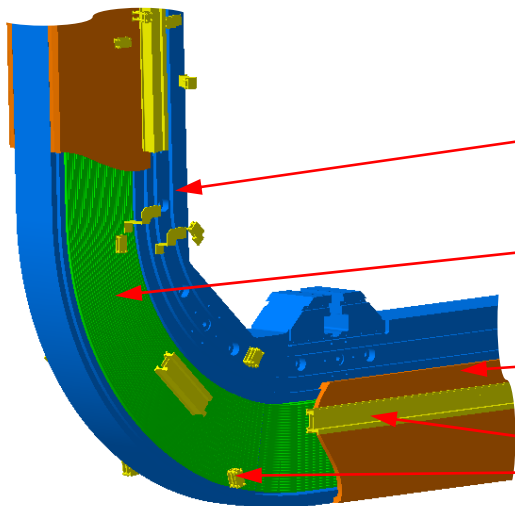
Volumes after grouping and simplification of shape				
Volume name	Material	Density (kg/m ³)	Volume (m ³)	Weight (kg)
VOLUME 14	Aluminum	2650	0.7373	18576
VOLUME 15	Aluminum	2660	0.015	4964
VOLUME 16	Aluminum	2650	0.064	11572
VOLUME 18	Aluminum	2650	0.172448	543



$$\Delta_1 = 35656\text{kg} - 35652\text{kg} = +4\text{kg}$$

CATIA Detailed Volumes

Weight : 35652kg



VOLUME 14

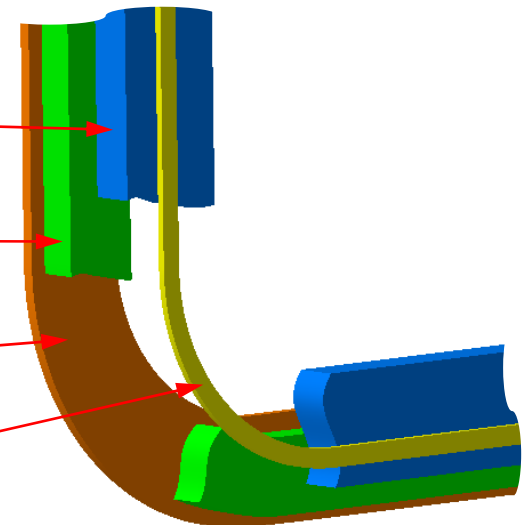
VOLUME 16

VOLUME 15

VOLUME 18

Volumes after grouping and simplification of geometry

Weight : 35656kg



IV. Simplification of CATIA volumes

VOLUME VII (Internal Part) / 2nd Step of synthesis

On the 2nd step of synthesis simplified volumes have been joined in one entire volume; average density has been assigned and shape again simplified

Volumes after 1st Step of synthesis

Volume name	Material	Density (kg/m ³)	Volume (m ³)	Weight (kg)
VOLUME 14	Aluminum	2650	0.7373	18576
VOLUME 15	Aluminum	2660	0.015	4964
VOLUME 16	Aluminum	2650	0.064	11572
VOLUME 18	Aluminum	2650	0.172448	543



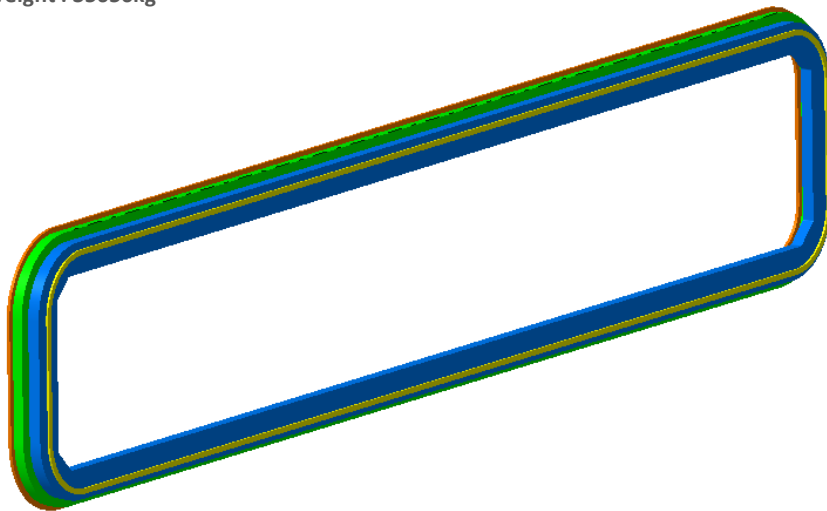
Volumes after joining and again simplification

Volume name	Material	Density (kg/m ³)	Volume (m ³)	Weight (kg)
VOLUME VII	Aluminum	2650	13.448	35637

$$\Delta_2 = 35637\text{kg} - 35656\text{kg} = -19\text{kg}$$

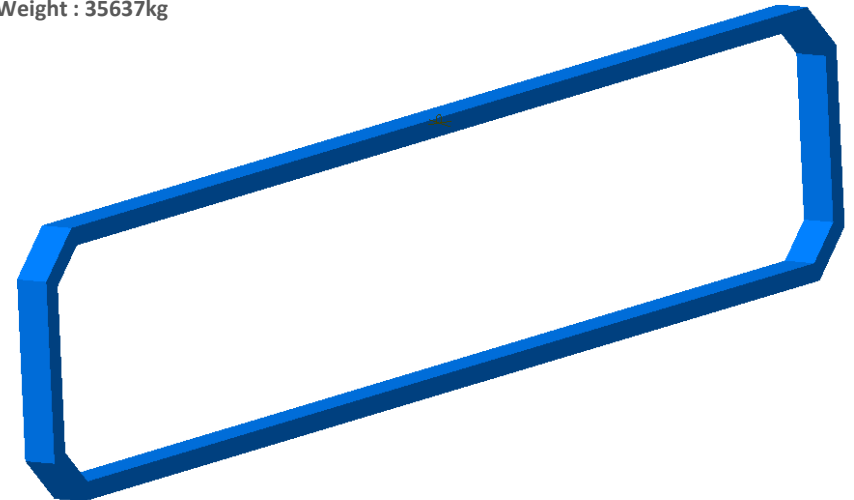
Volumes after grouping and simplification of geometry

Weight : 35656kg



Volumes after joining and again simplification

Weight : 35637kg



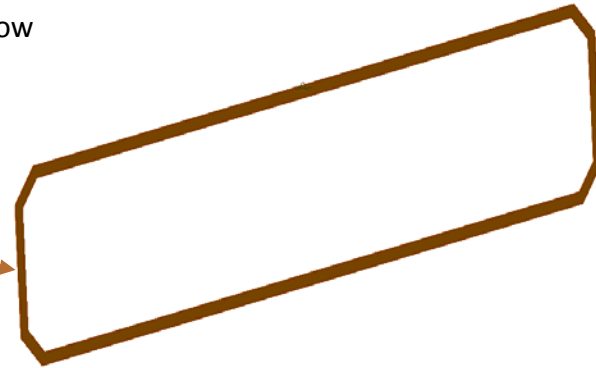
IV. Simplification of CATIA volumes

VOLUME VIII (Internal Part)

VOLUME VIII has been created in 2 steps of synthesis described on slides below

VOLUME VIII

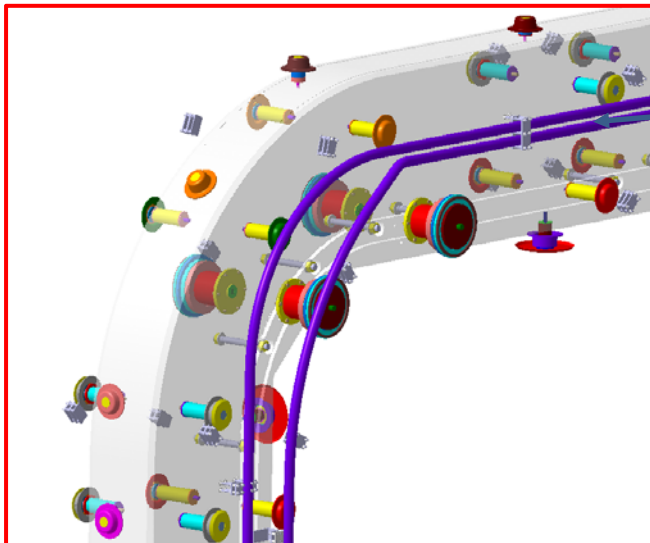
Material :Stainless
Steel
Density: 8000
Mass: 632 kg



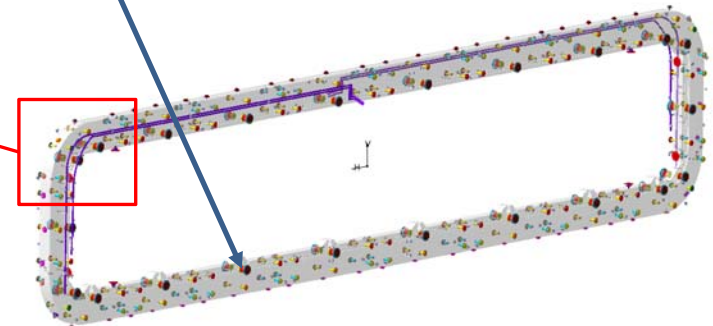
G4 Volume

CATIA Volumes

	Volume name	Volume (m³)	Material	Density (kg/m³)	Weight (kg)	Diff (kg) $\Delta = \Delta^1 + \Delta^2$
G4	VOLUME VIII	0.079	SSTEEL	8000	632	-2
CATIA	VOLUME 17.2	0.01	SSTEEL	8000	80	
	VOLUME 19.2	0.069	Multiple *		554	



VOLUME 19.2
VOLUME 17.2

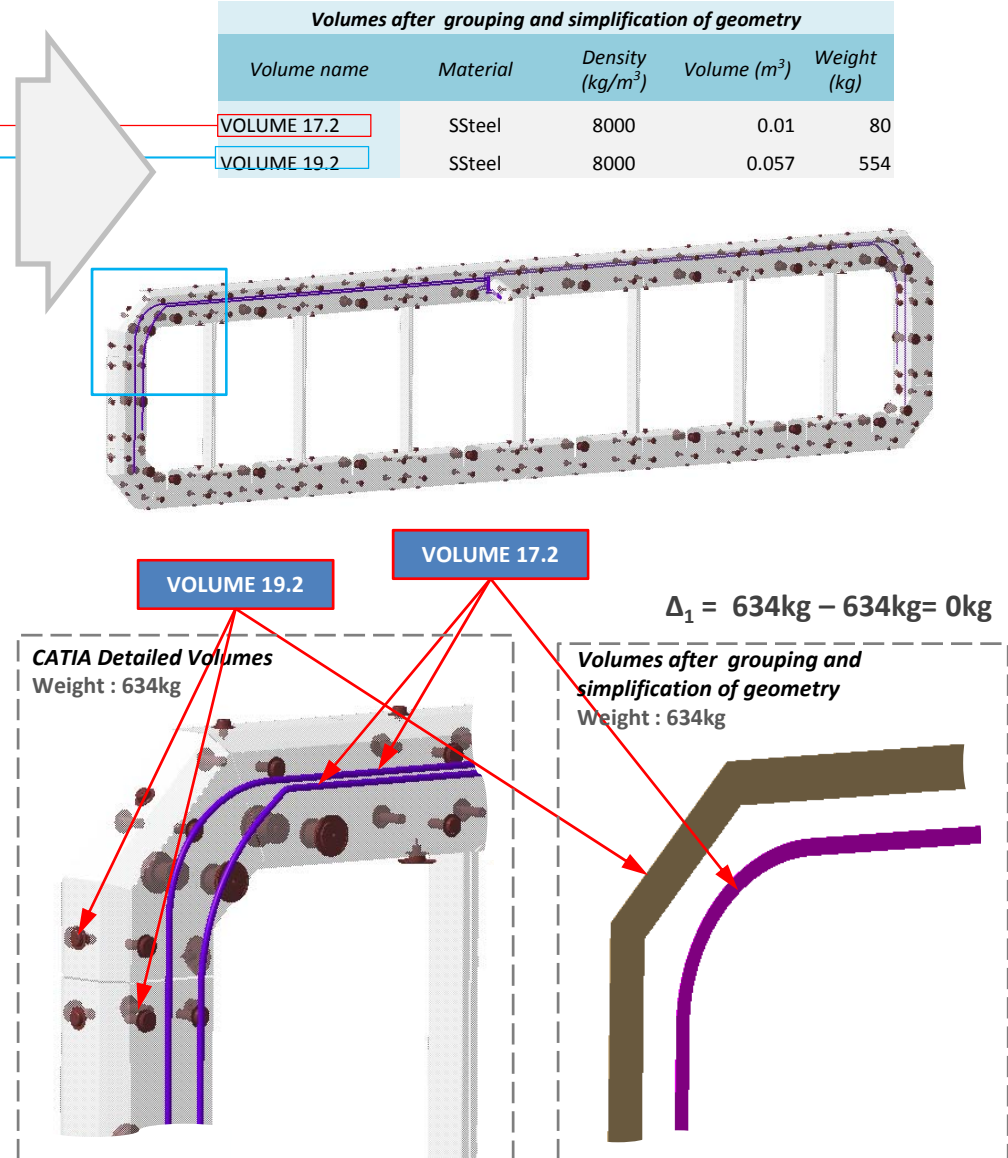


IV. Simplification of CATIA volumes

VOLUME VIII (Internal Part) / 1st Step of synthesis

On the 1st step of synthesis CATIA volumes have been grouped by materials. Then for each grouped volume shape has been simplified

CATIA Volumes					
	Part Name	Material	Density	Volume (kg/m3)	Weight (kg)
Volume 17	Pipes	Al 1050	2705	0.0640	173
	Part5	304L	8000	0.0040	32
	Part2	304L	8000	0.0040	32
	atltbyr_0036	304L	8000	0.0006	5
	atltbyr_0035	304L	8000	0.0005	4
	atltbyr_0034	304L	8000	0.0005	4
	atltbyr_0033	304L	8000	0.0004	3
Volume 19	Support A1.1	Al 5083 F	2660	0.0113	30
	Support A1.5	304 L o 316L	8000	0.0051	41
	Support A1.6	304 L o 316L	8000	0.0069	55
	Support A1.8	AISI 304 L	8000	0.0027	22
	Support C1.2	Al 5083 F	2660	0.0064	17
	Support C1.7	304 L/316L	8000	0.0013	10
	Support C1.8	304 L/316L	8000	0.0017	13
	Support D1.1	304 L/316L	8000	0.0015	12
	Support D1.5	AL 2024 T3	2780	0.0052	14
	E EST_2	AISI 304 L	8000	0.0187	150
	E EST_3	PERMAGLAS TE630	1850	0.0223	41
	E EST_4		2700	0.0339	92
	E EST_5		2700	0.0255	69
	E EST_6		2700	0.0298	81
	E EST_7		2700	0.0053	14
	E EST_9		2700	0.0250	68
	Support F1.1	304 L/316L	8000	0.0062	49
	Support F1.3	Al 2024 T3	2780	0.0084	23
	Support F1.5	304 L/316L	8000	0.0029	23
	Support F1.6	304 L/316L	8000	0.0066	53
	Support F1.8	AISI 304L	8000	0.0020	16
	Support F1.13	PERMAGLAS TE630	1850	0.0056	10
	other small parts			0.0591	213



IV. Simplification of CATIA volumes

VOLUME VIII (Internal Part) / 2nd Step of synthesis

On the 2nd step of synthesis simplified volumes have been joined in one entire volume; average density has been assigned and geometry again simplified

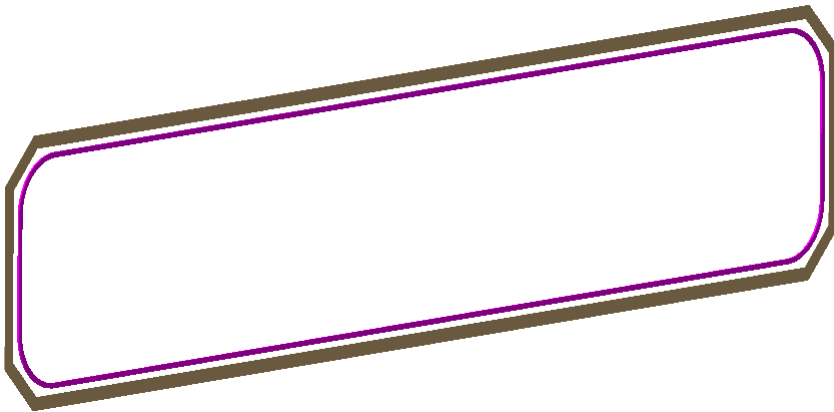
Volumes after grouping and simplification of geometry				
Volume name	Material	Density (kg/m ³)	Volume (m ³)	Weight (kg)
VOLUME 17.2	SSteel	8000	0.01	80
VOLUME 19.2	SSteel	8000	0.057	554



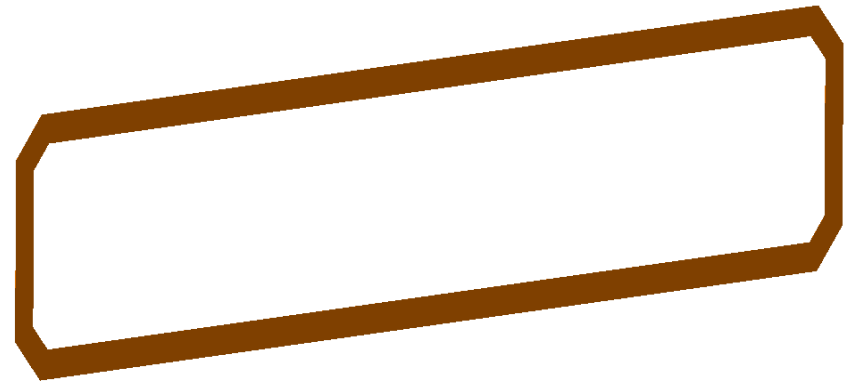
Volumes after joining and again simplification				
Volume name	Material	Density (kg/m ³)	Volume (m ³)	Weight (kg)
VOLUME VIII	SSteel	8000	0.0335	632

$$\Delta_2 = 632\text{kg} - 634\text{kg} = -2\text{kg}$$

Volumes after grouping and simplification of geometry
Weight: 634kg



Volumes after joining and again simplification
Weight: 632kg



IV. Simplification of CATIA volumes

7 x **VOLUME IX** (Internal Part)

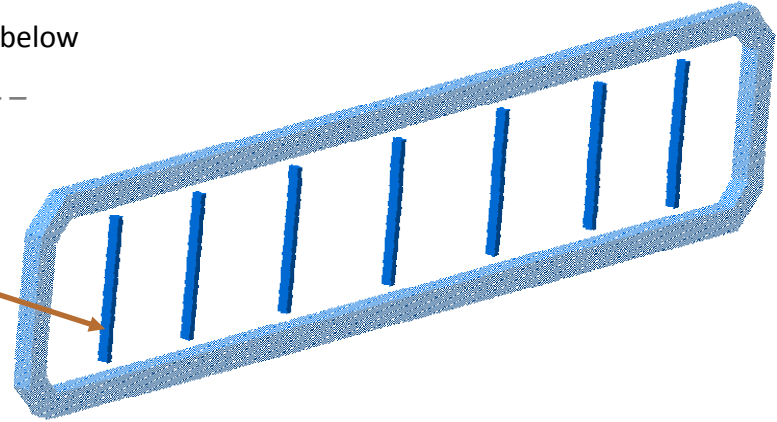
VOLUME IX has been created in 2 steps of synthesis described on slides below

VOLUME IX = Volume_20 + Volume_21

G4 Volume

VOLUME IX

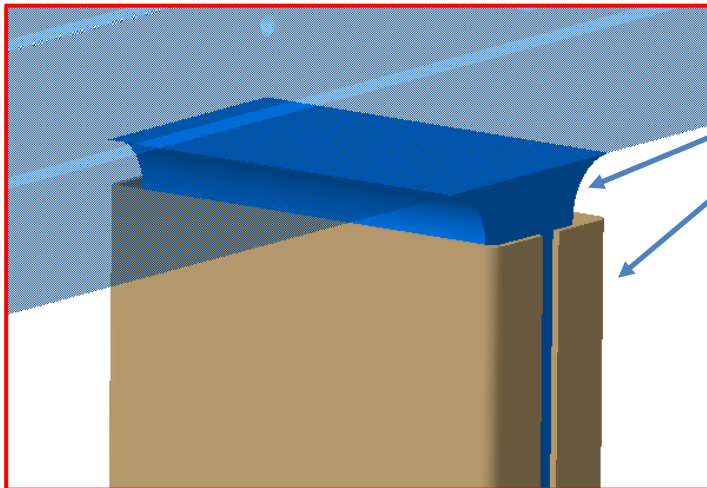
Material :Aluminum
Density: 2650
Mass: 306 kg



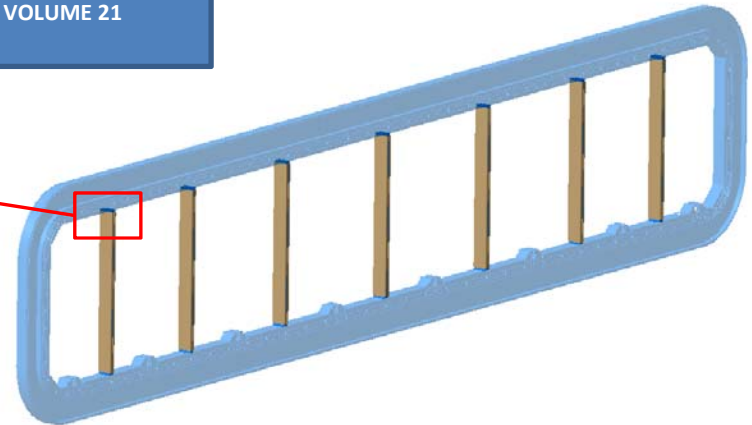
CATIA Volume

	Volume name	Volume (m³)	Material	Density (kg/m³)	Weight (kg)	Diff (kg) $\Delta = \Delta^1 + \Delta^2$
Simplified	VOLUME IX	0.8075	Aluminum	2650	2141	-8
Detail	VOLUME 20	0.1007	Aluminum	2740	276	
	VOLUME 21	0.7068	Aluminum	2650	1873	

7 x



VOLUME 20
VOLUME 21



IV. Simplification of CATIA volumes

VOLUME IX (Internal Part) / 1st Step of synthesis

On the 1st step of synthesis CATIA volumes have been grouped by materials. Than for each grouped volume geometry has been simplified

CATIA Detailed Volumes (see Coil Weight Analysis V3.2.pdf)

	Part Name	Material	Density	Volume (kg/m3)	Weight (kg)
Volume 20	Thermal Shielding	3003.H22	2740	0.1007	276
Volume 21	Coil casing (Rib)	Aluminum 5083	2650	0.7068	1873

Volumes after grouping and simplification of geometry

Volume name	Material	Density (kg/m ³)	Volume (m ³)	Weight (kg)
VOLUME 20	Aluminum	2740	0.1007	276
VOLUME 21	Aluminum	2650	0.7068	1873

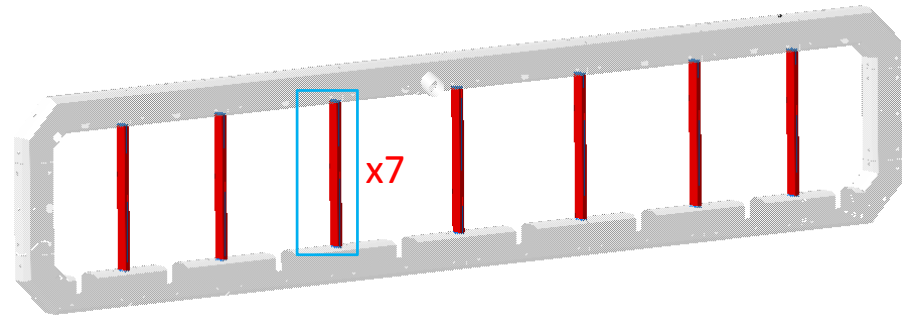
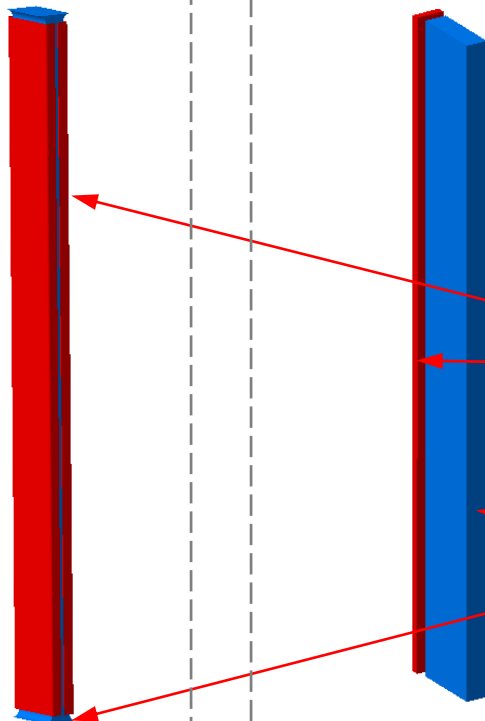
$$\Delta_1 = 2149\text{kg} - 2149\text{kg} = 0\text{kg}$$

CATIA Detailed Volumes

Mass: 2149kg

Volumes after grouping and simplification of geometry

Mass: 2149kg



IV. Simplification of CATIA volumes

VOLUME IX (Internal Part) / 2nd Step of synthesis

On the 2nd step of synthesis CATIA volumes have been joined in one entire volume; average density has been assigned and shape again simplified

Volumes after grouping and simplification of geometry				
Volume name	Material	Density (kg/m ³)	Volume (m ³)	Weight (kg)
VOLUME 20	Aluminum	2740	0.1007	276
VOLUME 21	Aluminum	2650	0.7068	1873

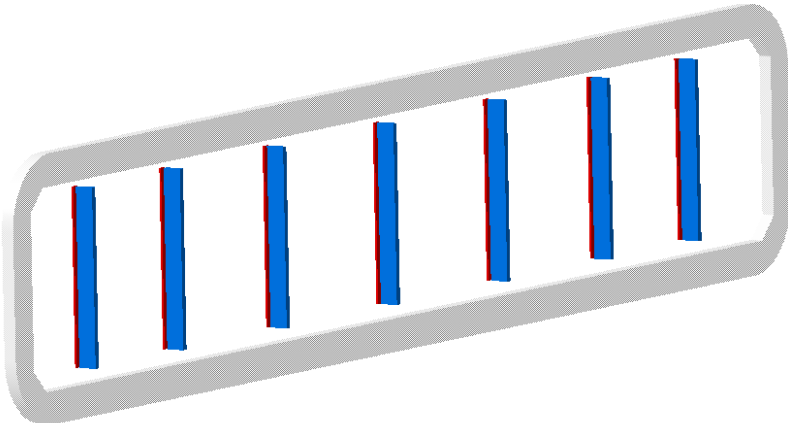


Volumes after joining and again simplification				
Volume name	Material	Density (kg/m ³)	Volume (m ³)	Weight (kg)
VOLUME IX	Aluminum	2740	0.807	2141

$$\Delta_2 = 2141\text{kg} - 2149\text{kg} = -8\text{kg}$$

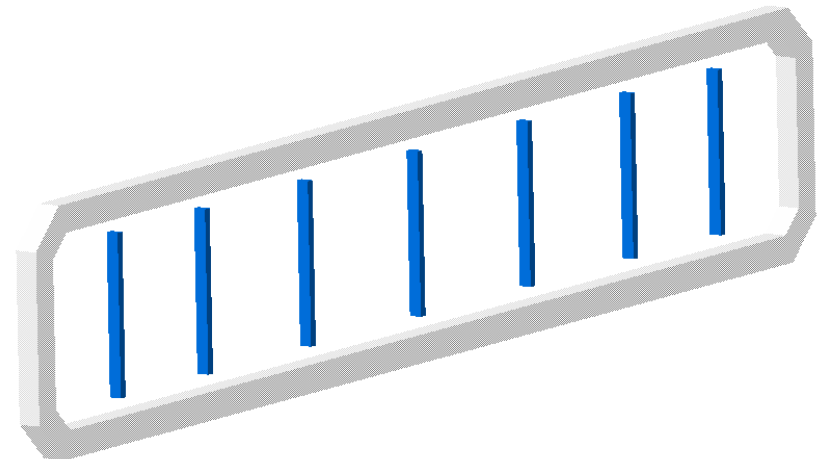
Volumes after grouping and simplification of geometry

Weight : 2149kg



Volumes after joining and again simplification

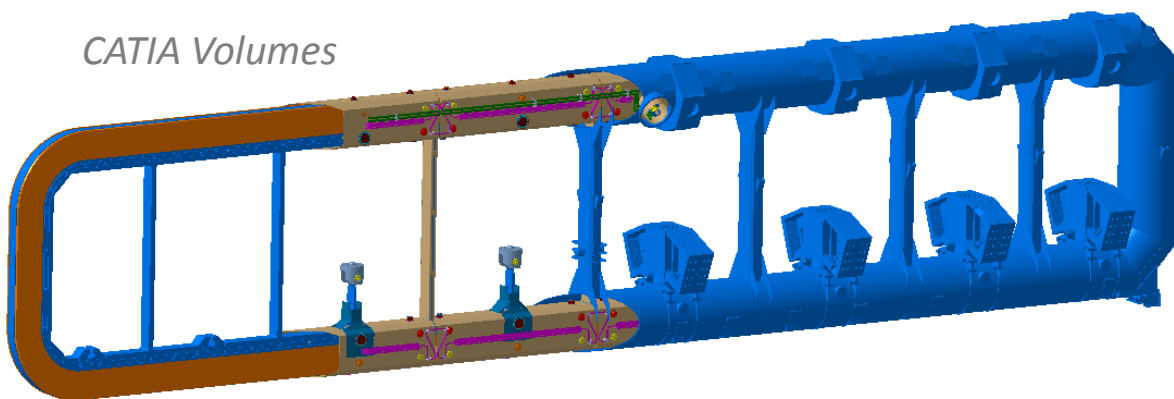
Weight : 2141kg



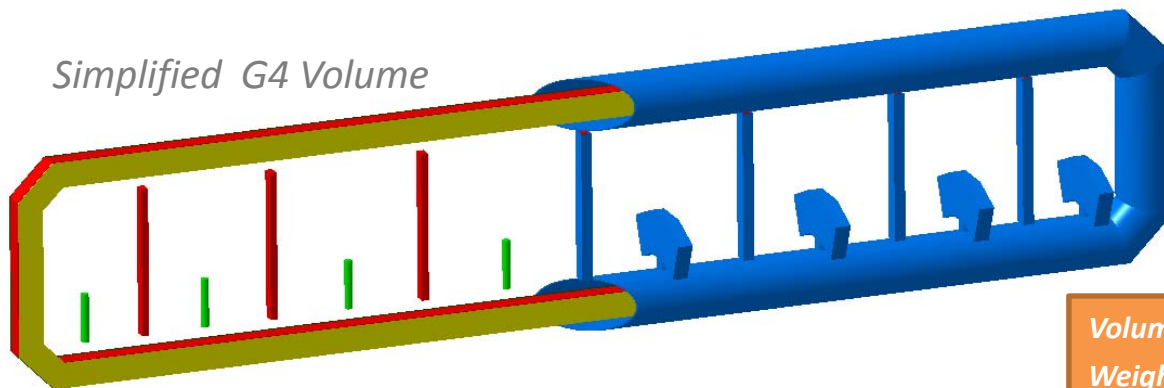
IV. Simplification of CATIA volumes

Final Results of Simplification:

CATIA Volumes



Simplified G4 Volume



Volume: 24.7 m³

Weight : 92031kg

Volume: 24.75 m³

Weight : 92130kg

Difference:

Volume: 0.05 m³

Weight : 99kg

Future Steps to be done:

1. Generation C++ codes for G4/FLUGG
2. Migration C++ geometry into CATIA and make comparison to estimate possible discrepancies coming from geometrical transactions
3. Generation of report
4. Uploading all materials on SVN and creation of tags