Atlas Geometry Validation – Tools and Case Study

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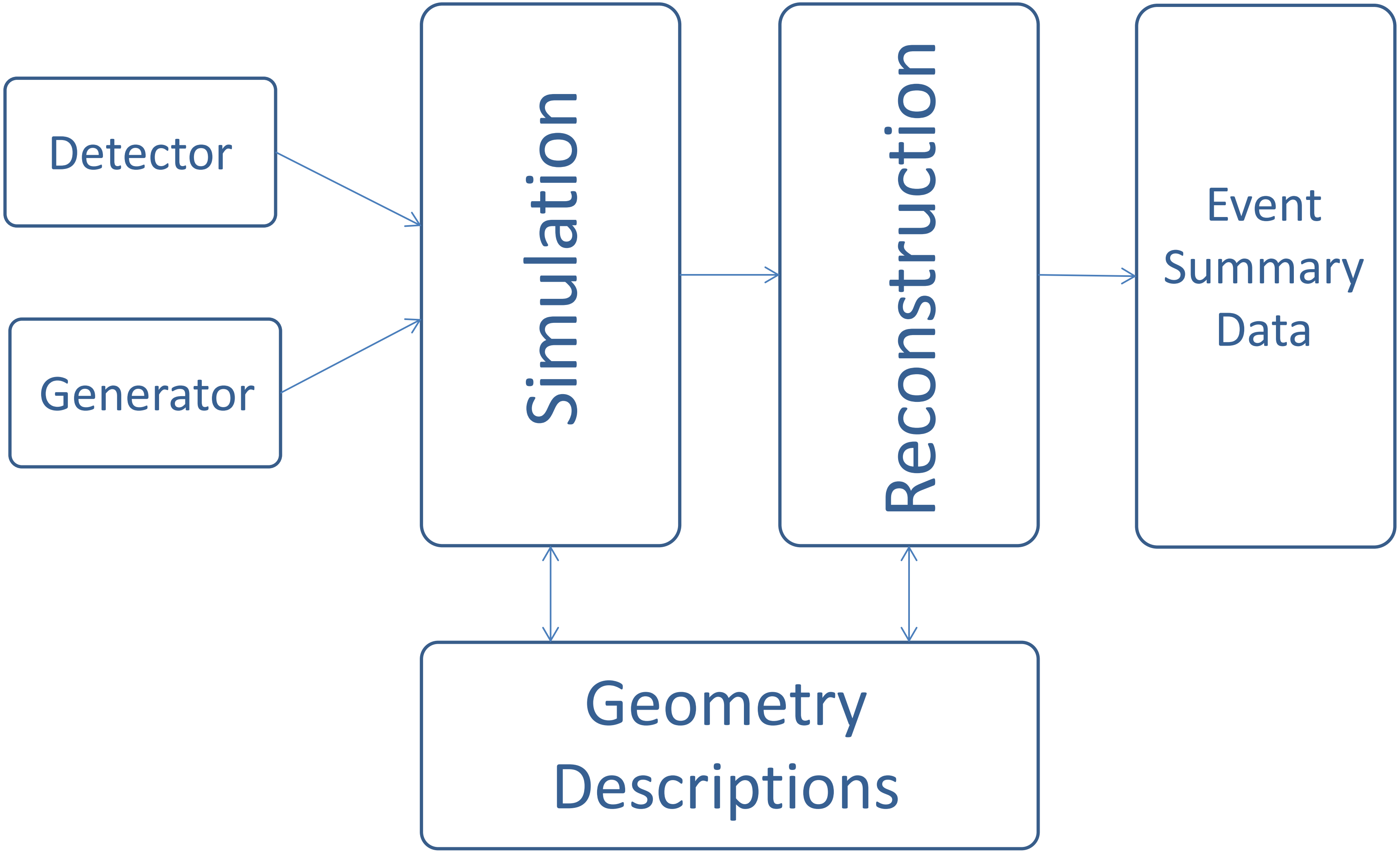
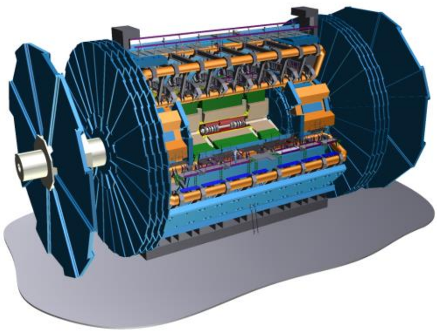
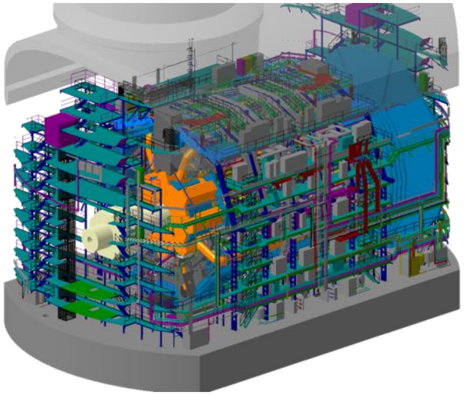
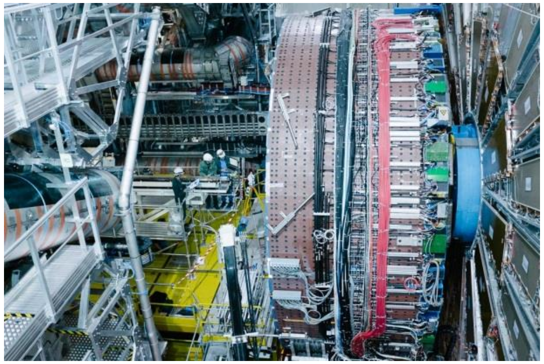
ATLAS Geometry Study



ATLAS Geometry Study

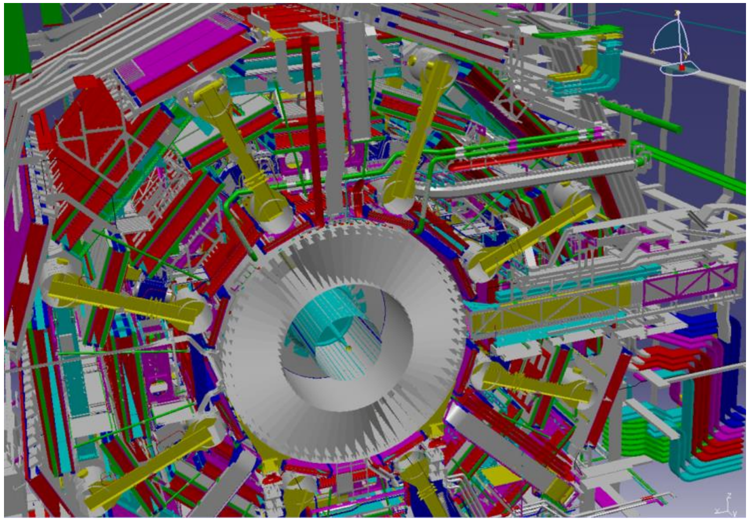






ATLAS Detector is Complex Engineering Construction:

- 3’700 big Assemblies
- 62Gb data for 3D models
- 10’000’000 mechanical nodes

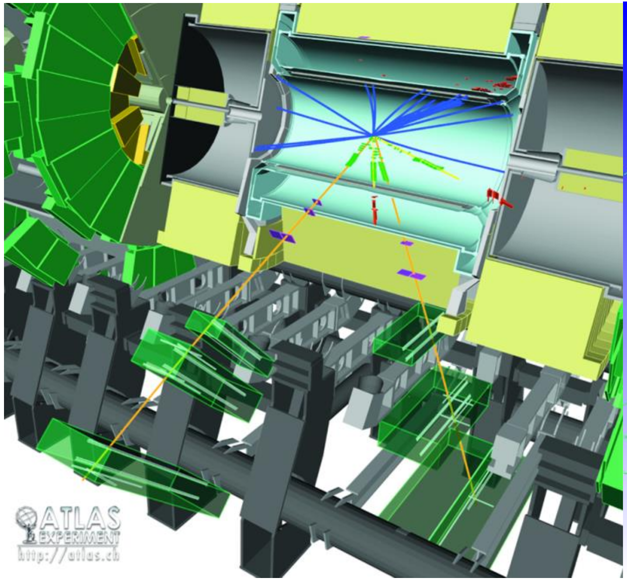


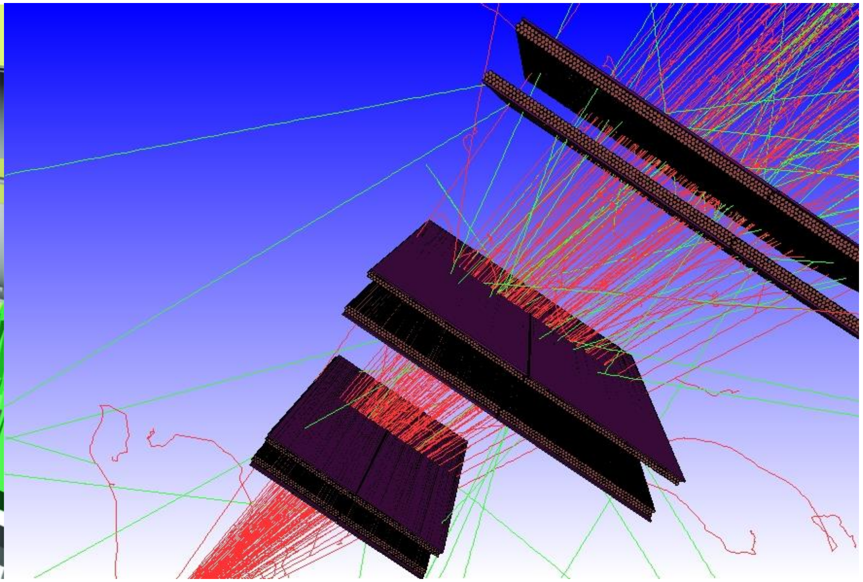
Detector crosssecsion in Z0

It is really very complex!

ATLAS Geometry Study

In Simulation/Reconstruction software packages Geometry Objects are using for tracking





So Geometry Objects should be:

1. Simplified to ensure high performance of tools
2. Precisely represent volume, weight and position

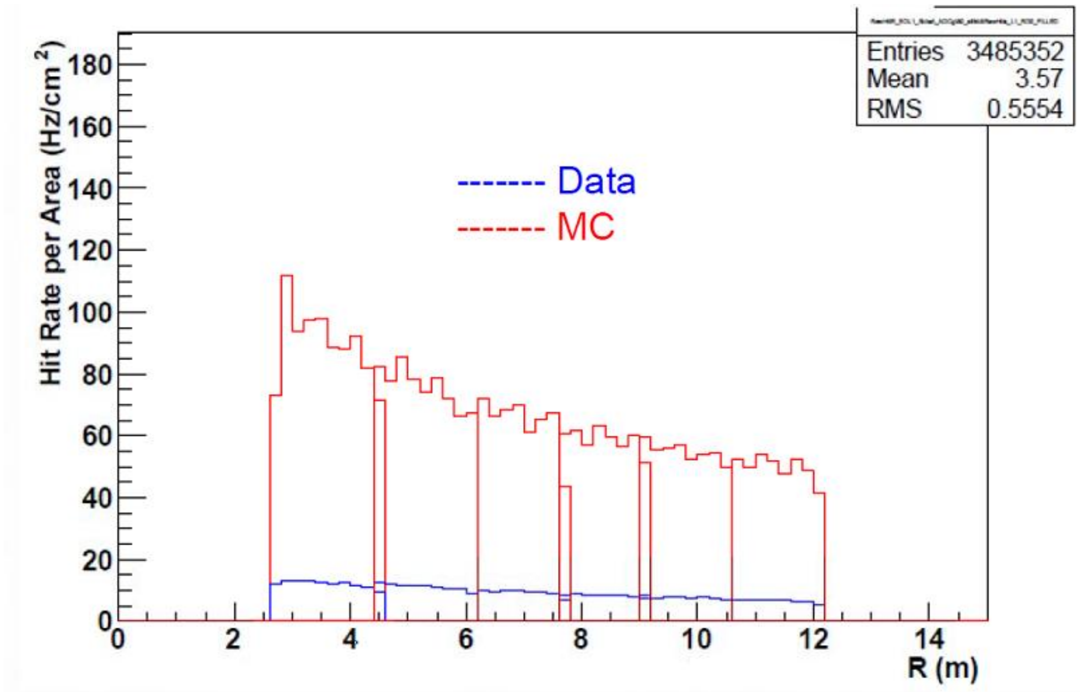
ATLAS Geometry Study

There are 2 reasons why Geometry studies are timeless actual for Simulation/Reconstruction tasks:

1. Detector upgrades
2. Needs of Comparison to check consistency with as-built geometry

ATLAS Geometry Study

Need of Comparison is coming from the problem of Data/Montecarlo discrepancies



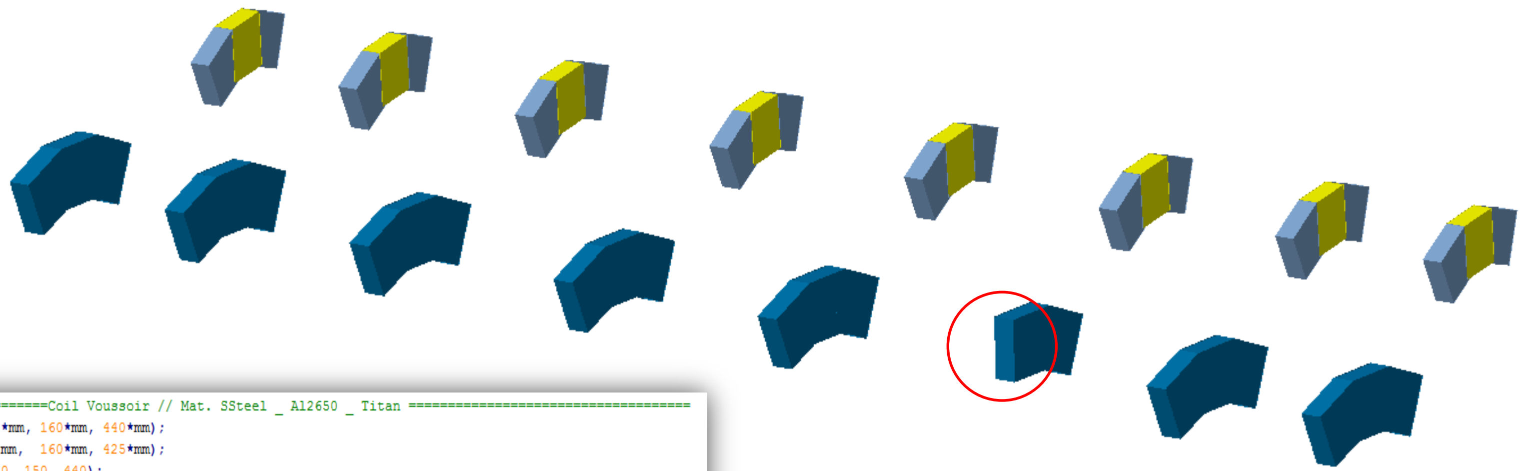
1[st] step of investigation here is to make sure that discrepancies are not due by the inconsistancy of described geometry with as-built geometry

ATLAS Geometry Study

Why Geometry can be inconsistence with real detector geometry ?

1. Geometry descriptions in Simulation/Reconstruction packages created by physicists and not engineers who are involved in detector construction work
2. Geometry created on the base of blue prints which in most of the cases doesn't represent latest updates
3. Tools implemented during geometry creation have limited functionalities and never permits to consider many details of mechanical parts
4. Simulation/Reconstruction tools adding inaccuracies during geometry transactions

Geant-4 Boolean Processor Fault



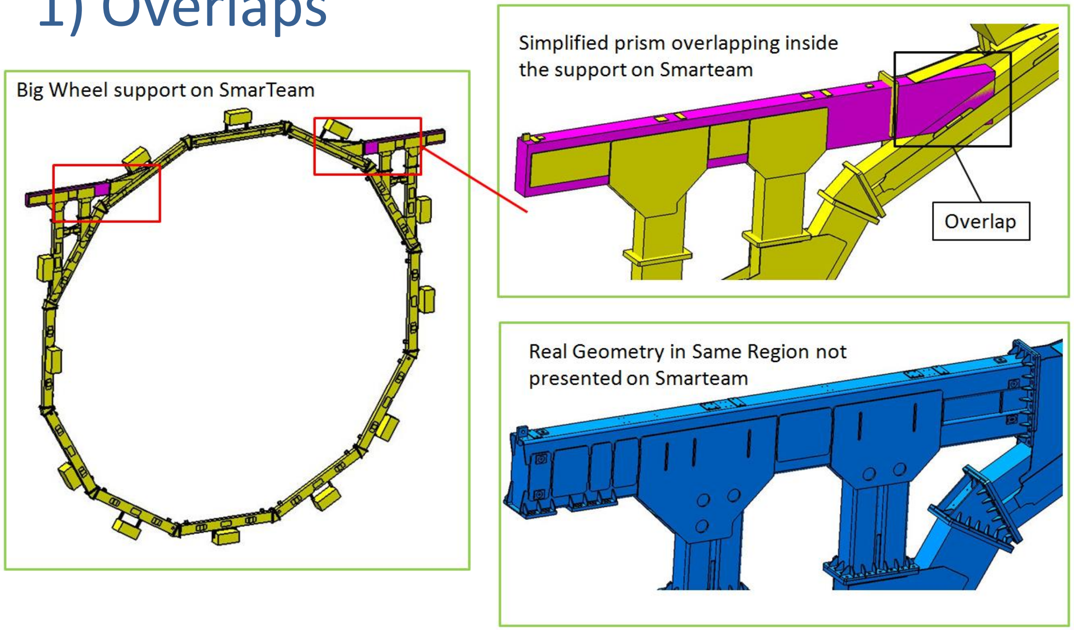
```
//===========================================Coil Voussoir // Mat. SSteel _ Al2650 _ Titan ====================================
 GeoBox* Voussoir_mdl = new GeoBox(417*mm, 160*mm, 440*mm);
 GeoBox* Voussoir_rl = new GeoBox(415*mm,  160*mm, 425*mm);
 GeoTube* Voussoir_Tube = new GeoTube(0, 150, 440);
 HepTransform3D VR_L1 = HepTranslate3D( 637.77*mm,  0*mm, -111.462*mm) * HepRotateY3D(0.392699);
 HepTransform3D VR_L2 = HepTranslate3D(-637.77*mm,  0*mm, -111.462*mm) * HepRotateY3D(-0.392699);
 HepTransform3D VR_L3 = HepTranslate3D(0*mm, 0*mm, -100*mm);
 const GeoShape& Voussoir_Sub = Voussoir_mdl->add((*Voussoir_rl)<<VR_L2).
                                              add((*Voussoir_rl)<<VR_L1).
                                              subtract((*Voussoir_Tube)<<VR_L3);
 GeoLogVol* Voussoir_log = new GeoLogVol("Voussoir_log",&Voussoir_Sub, AL2650);
 GeoPhysVol* Voussoir_phy = new GeoPhysVol(Voussoir_log_11);
//----------------------------------------------------------------------------
 for ( int i = 0; i < 8; i++ )
 {
  int rotZ = i*45;

  for (int k = 0; k < 8; k++)
   {
    world->add(tag);
    world->add(new GeoTransform( HepRotateZ3D(rotZ*degree) * HepTranslate3D(2491.6
                                 HepRotate3D(2.86481, HepVector3D(-0.139281*mm,0.7
```

Voussoir created by 1 solid with use of union

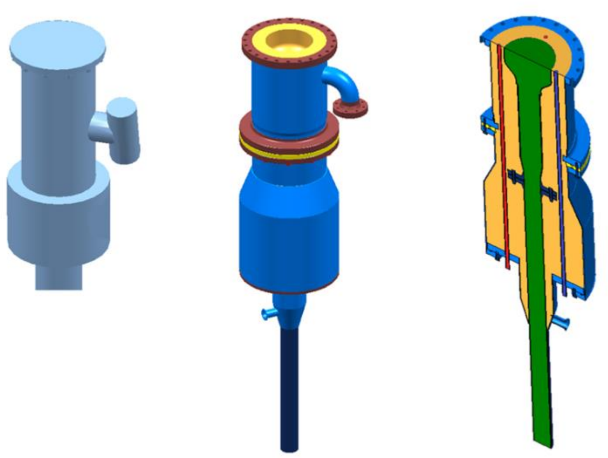
```
//===========================================Coil Voussoir // Mat. SSteel _ Al2650 _ Titan ====================================
 GeoBox* Voussoir_mdlp = new GeoBox(417*mm, 160*mm, 440*mm);
 GeoBox* Voussoir_mdlc = new GeoBox(417*mm, 170*mm, 440*mm);
 GeoBox* Voussoir_rl = new GeoBox(415*mm,  160*mm, 425*mm);
 GeoTube* Voussoir_Tube = new GeoTube(0, 150, 440);
 HepTransform3D VR_L1 = HepTranslate3D(-631.877*mm,  0*mm, 141.086*mm) * HepRotateY3D(0.392699);
 HepTransform3D VR_L2 = HepTranslate3D(631.877*mm,  0*mm, 141.086*mm) * HepRotateY3D(-0.392699);
 HepTransform3D VR_L3 = HepTranslate3D(0*mm, 0*mm, -100*mm);
 const GeoShape& Voussoir_mdl = Voussoir_mdlp->subtract((*Voussoir_Tube)<<VR_L3);
 const GeoShape& Voussoir_r = Voussoir_rl->subtract((*Voussoir_mdlc)<<VR_L1);
 const GeoShape& Voussoir_l = Voussoir_rl->subtract((*Voussoir_mdlc)<<VR_L2);
 GeoLogVol* Voussoir_mdl_log = new GeoLogVol("Voussoir_mdl_log",&Voussoir_mdl, AL2650);
 GeoPhysVol* Voussoir_mdl_phy = new GeoPhysVol(Voussoir_mdl_log);
 GeoLogVol* Voussoir_r_log = new GeoLogVol("Voussoir_r_log",&Voussoir_r, AL2650);
 GeoPhysVol* Voussoir_r_phy = new GeoPhysVol(Voussoir_r_log);
 GeoLogVol* Voussoir_l_log = new GeoLogVol("Voussoir_l_log",&Voussoir_l, AL2650);
 GeoPhysVol* Voussoir_l_phy = new GeoPhysVol(Voussoir_l_log);
//----------------------------------------------------------------------------
 for ( int i = 0; i < 8; i++ )
 {
  int rotZ = i*45;
  for (int k = 0; k < 8; k++)
   {
    world->add(tag);
```

Smarteam Database Problems

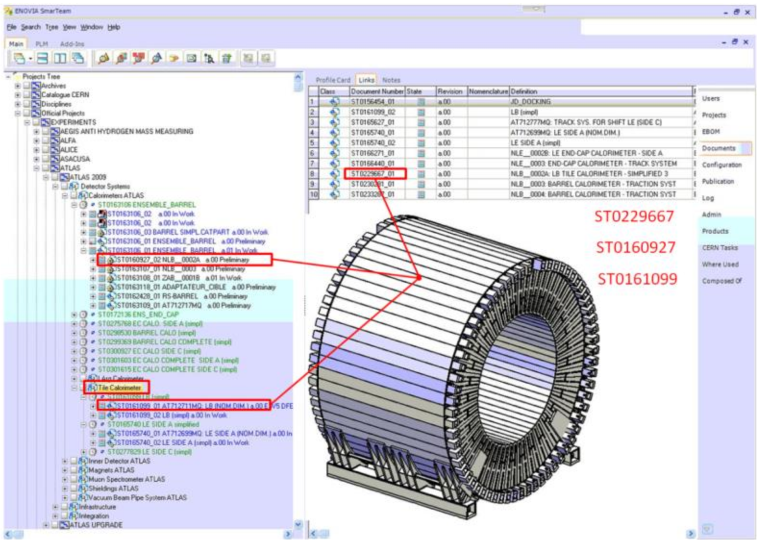
1) Overlaps



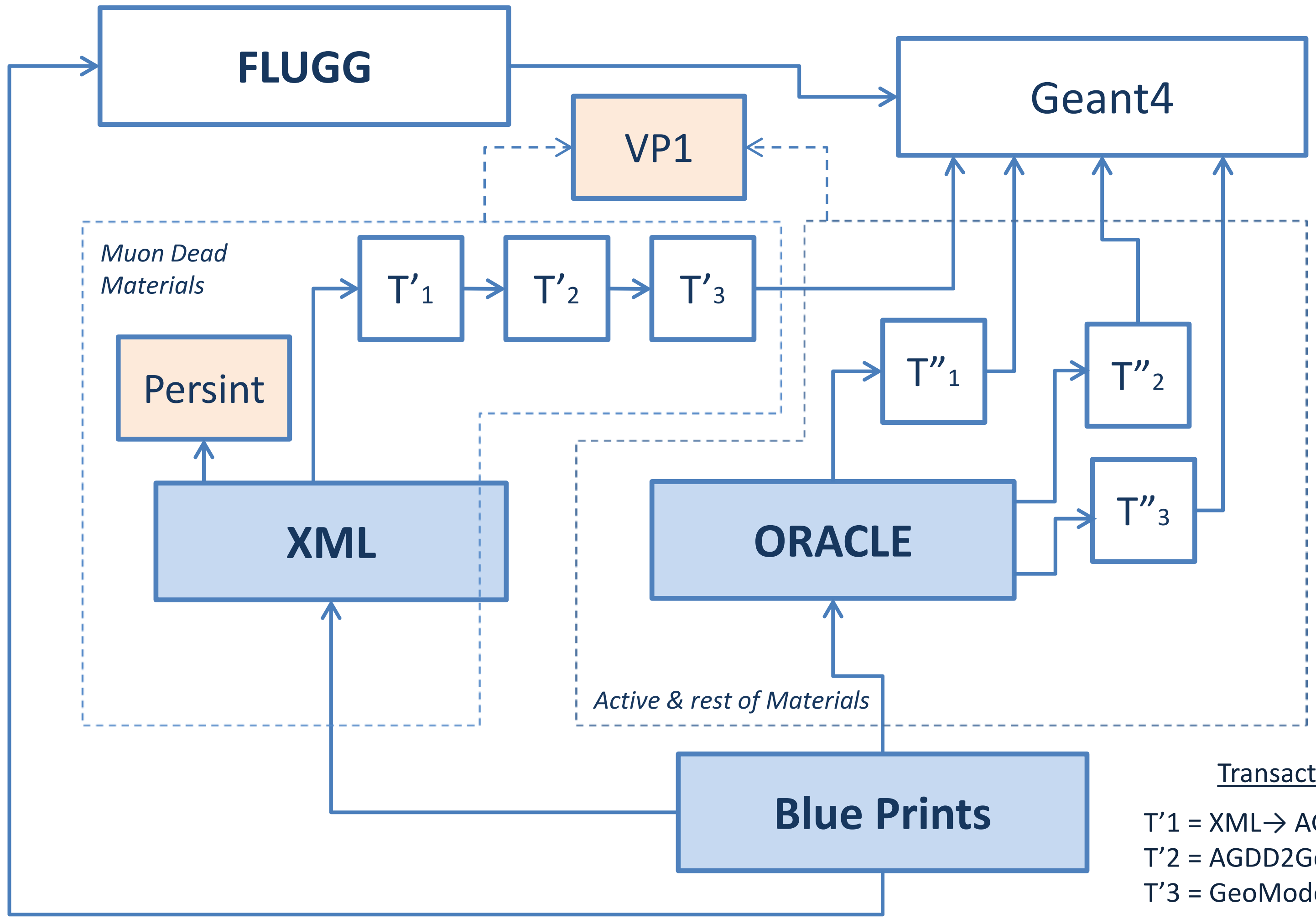
2) Simplified Envelops



3) Multiple Representation



Simulation Loop



<u>Transactions:</u>

T'1 = XML→ AGDD2Geo
T'2 = AGDD2Geo → GeoModel
T'3 = GeoModel → Geo2G4

T"1 = Oracle → MuonGeoModel
T"2 = Oracle → CaloGeoModel
T"3 = Oracle → ID GeoModel

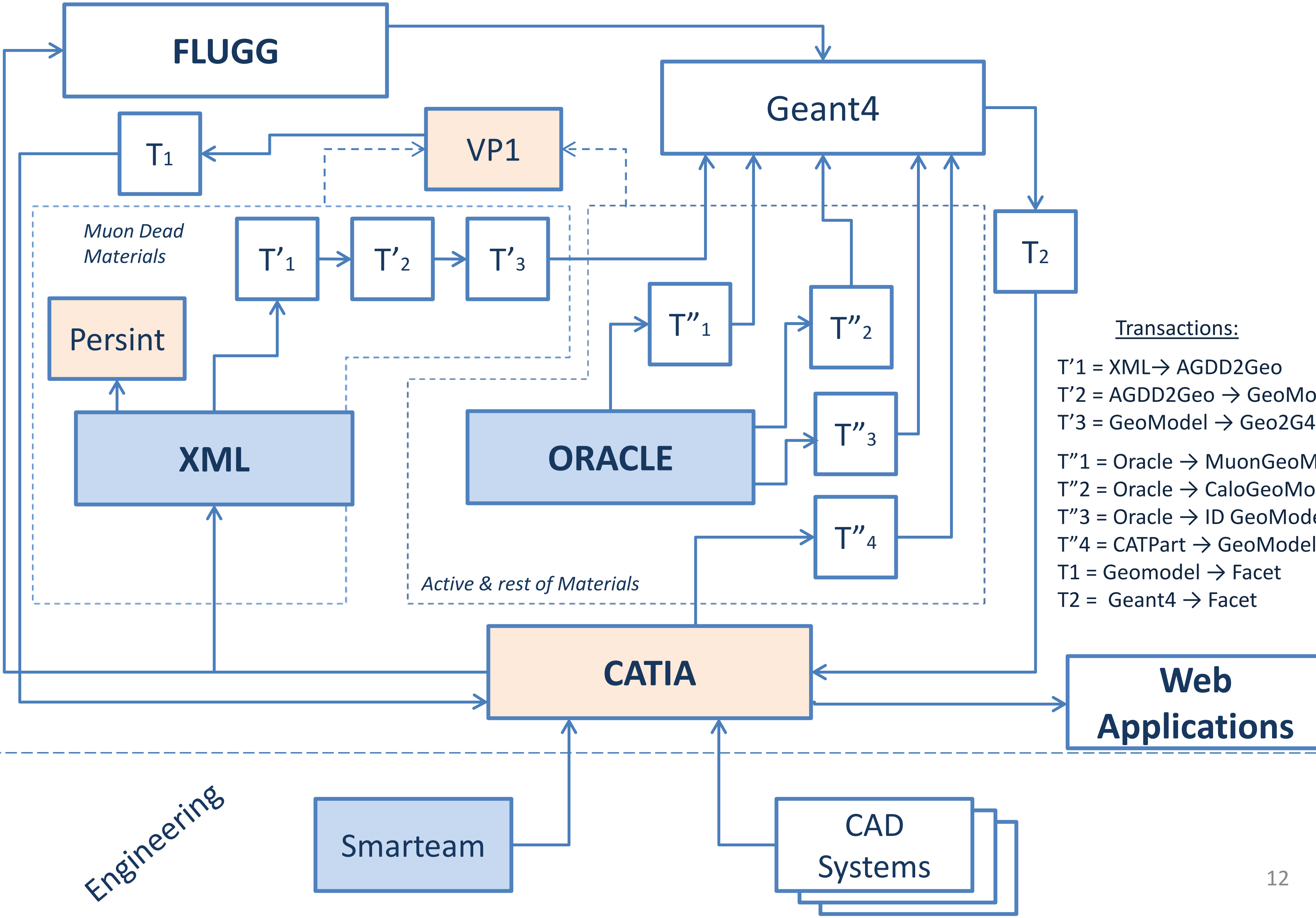
Simulation Loop

Georgian Team create so call Geometry hub on the base of CATIA software

It was built following interfaces:

- CATIA_to_XML
- GeoModel_to_CATIA
- CATIA_to_GeoModel
- Geant4_to_CATIA
- CATIA_to_FLUGG
- FLUGG_to_CATIA
- CATIA_to_3D-PDF

Simulation Loop



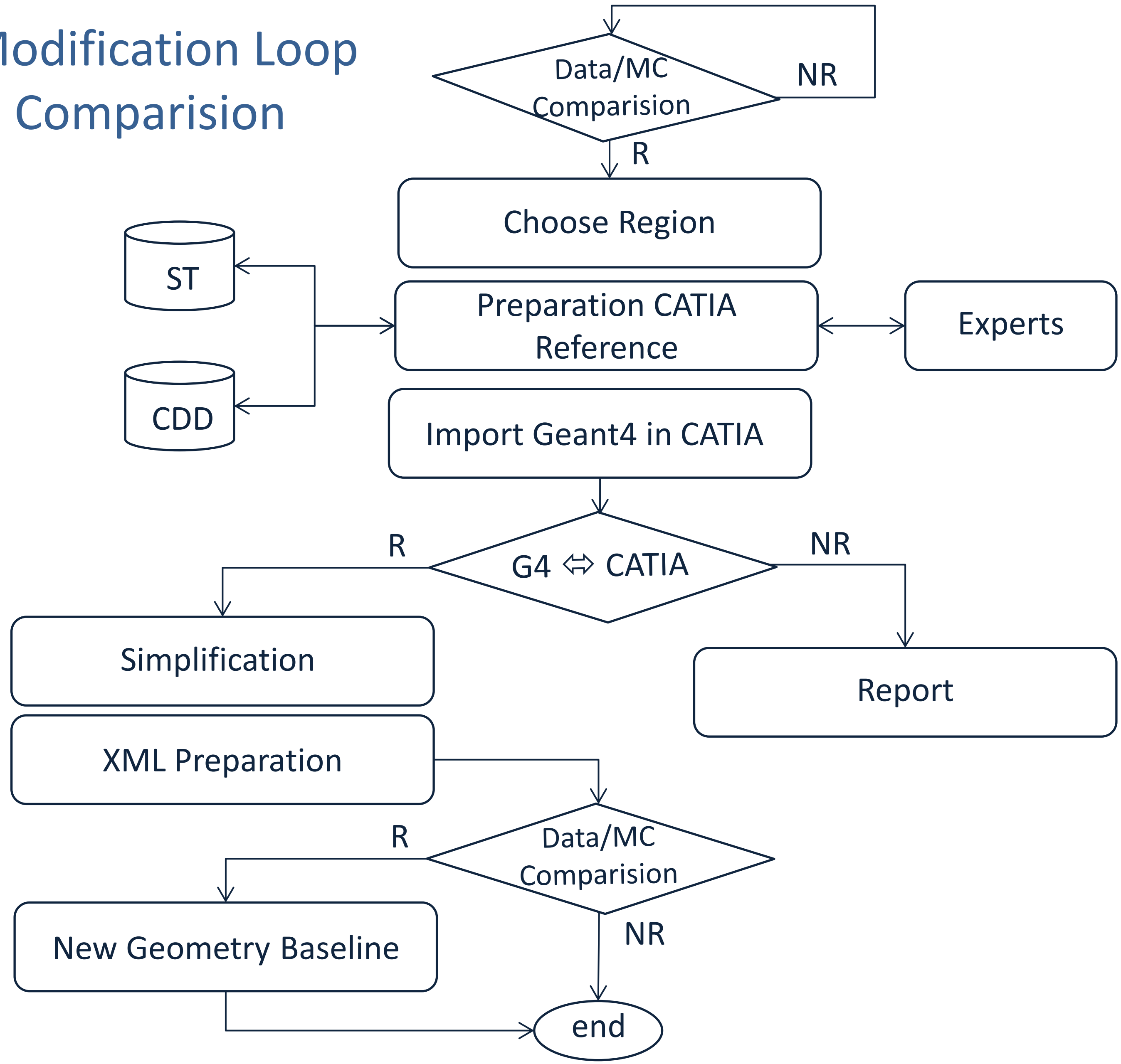
Transactions:

T'1 = XML→ AGDD2Geo
T'2 = AGDD2Geo → GeoModel
T'3 = GeoModel → Geo2G4

T"1 = Oracle → MuonGeoModel
T"2 = Oracle → CaloGeoModel
T"3 = Oracle → ID GeoModel
T"4 = CATPart → GeoModel
T1 = Geomodel → Facet
T2 = Geant4 → Facet

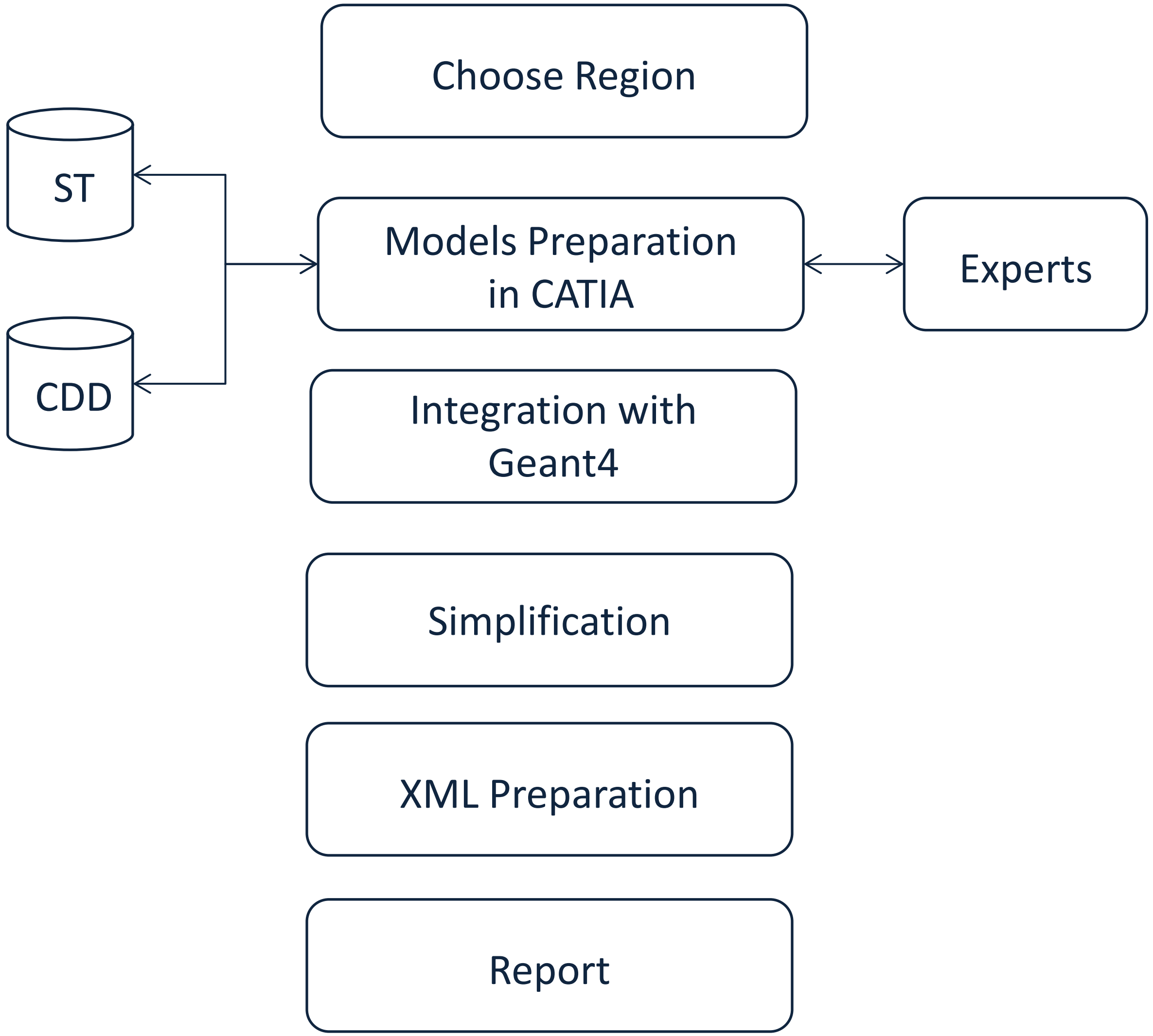
Working Methodology

Geometry Modification Loop according to Comparision



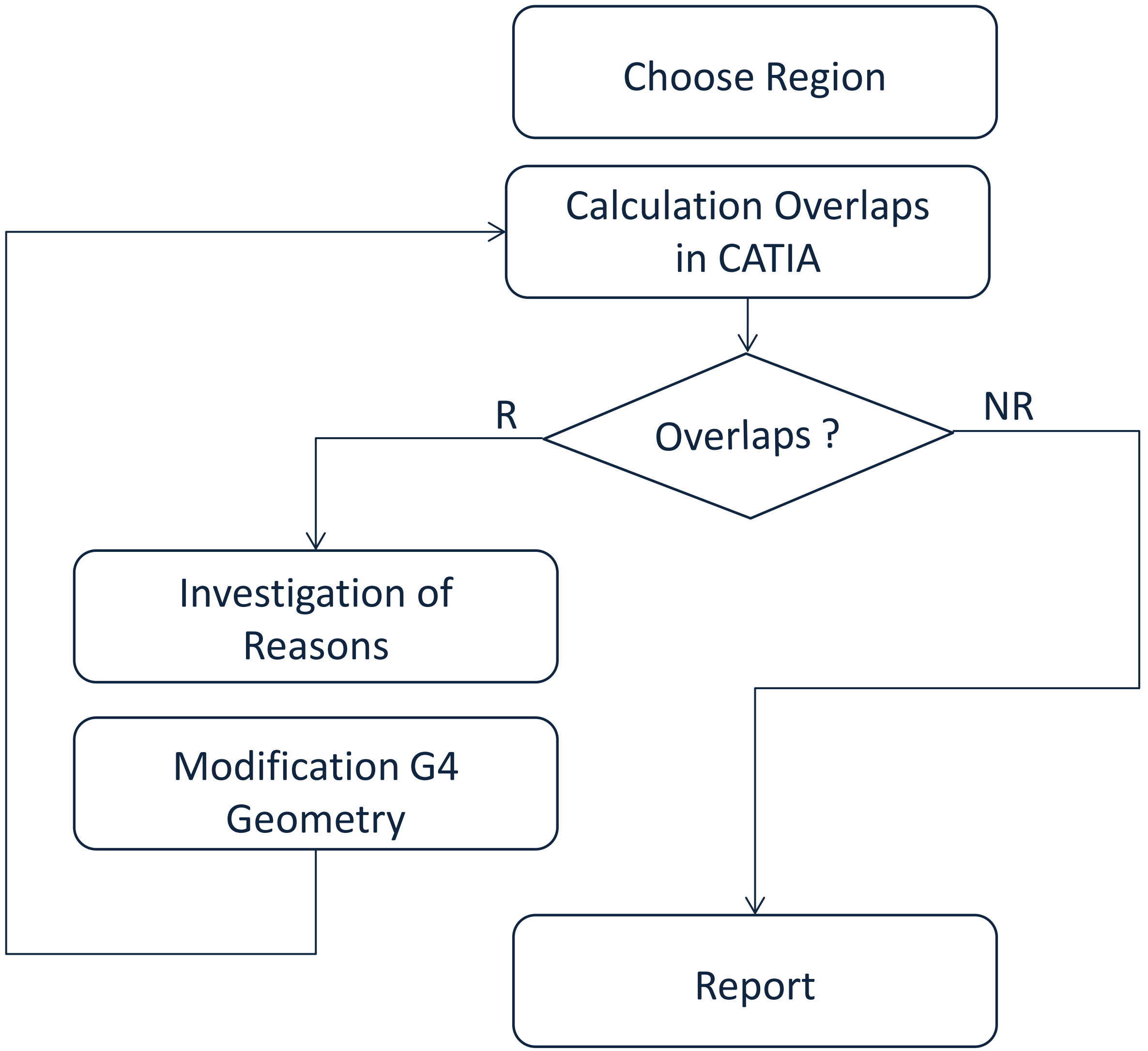
Working Methodology

New Geometry Adding Loop



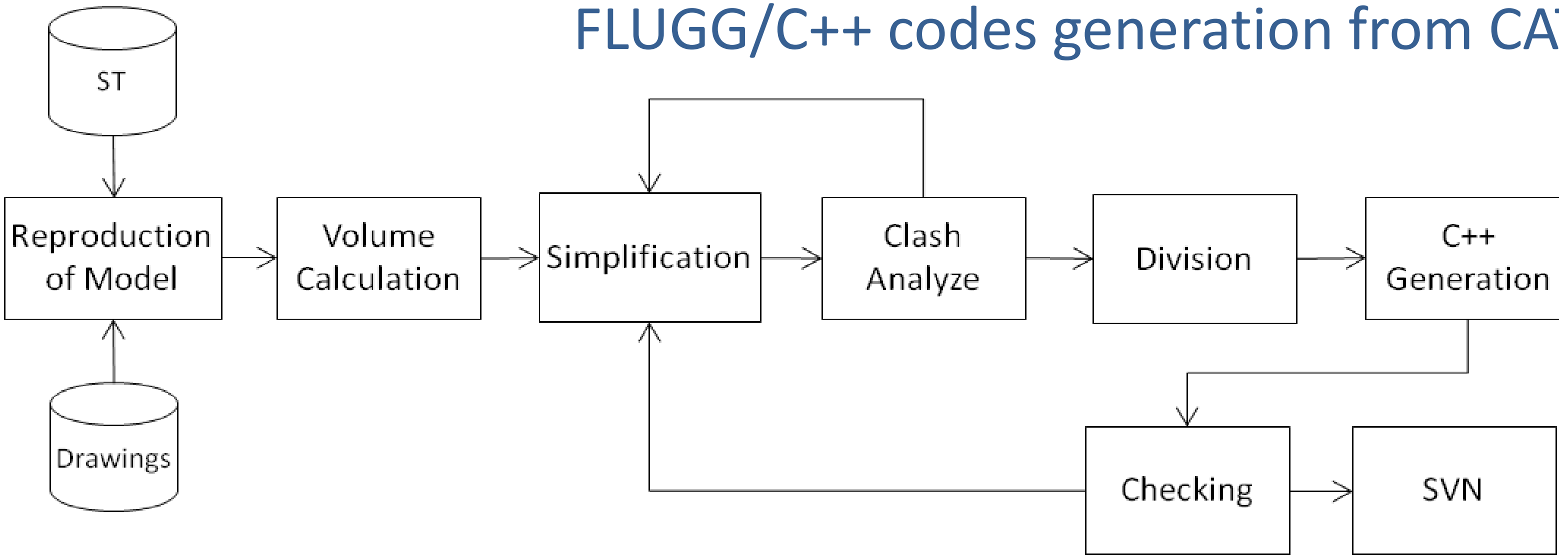
Working Methodology

Overlaps Checking Loop



Working Methodology

FLUGG/C++ codes generation from CATIA



- Downloading volumes (.so files) from SVN into local folder
- Make registration of local folder into Athena environment parameters
  `Export GCCECGEOMODELLIB=`*<path, folder_name>*
- Start Athena with modified Athena.py file
- Georgian team has added codes to existing
  `16.0.3/AtlasCore/16.0.3/Instal/Area.share.bin.athena.py`

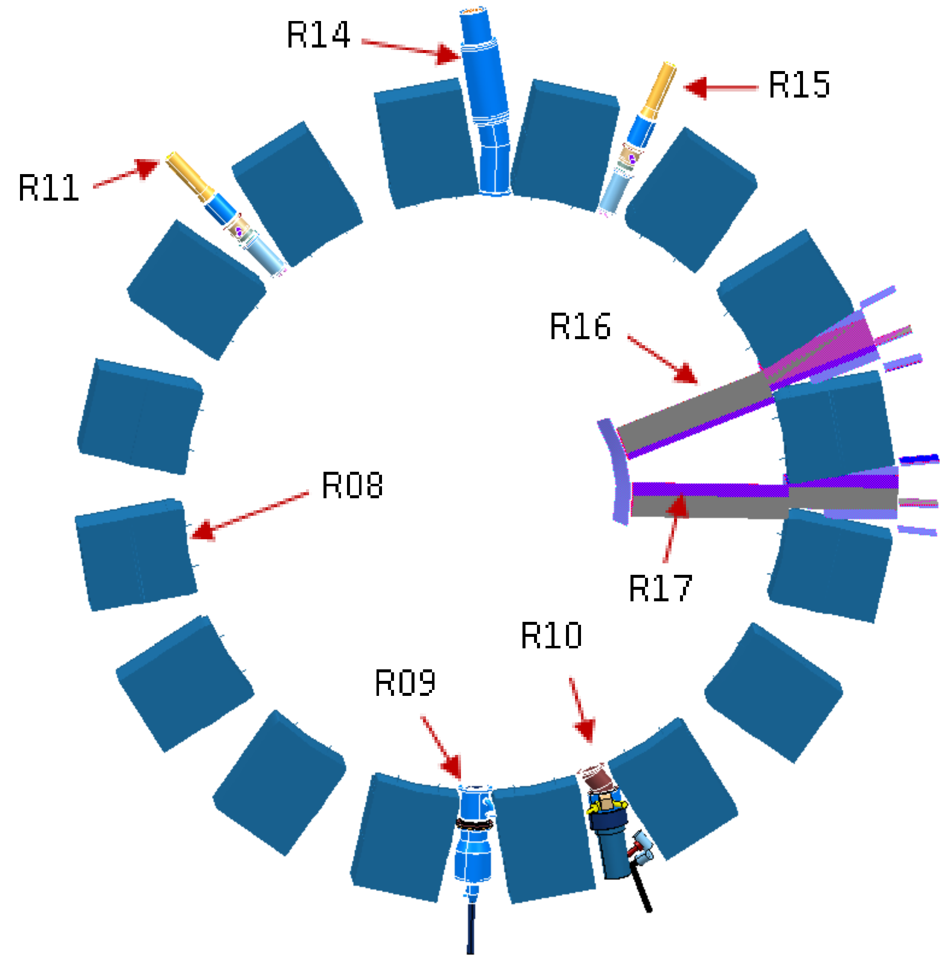
  Code contains reference on `GCCECGEOMODELLIB=`*<path, folder_name>* local folder and definition of key word `-gccecgeo` for startup CMD

```
#GCCECGEOMODELLIB
GCCECGEOALTERNATE=0
r=0
for A in $@
do
    if [ $A = "--gccecgeo" ]; then
        GCCECGEOALTERNATE=1
        echo 'Activating GCCEC ALTERNATE GEOMODEL'
        echo $LD_LIBRARY_PATH | grep "$GCCECGEOMODELLIB"
        if [ $? -eq 0 ]; then
            echo "GEOMODELGCCEC Already activated"
        else
            echo "Setting GEOMODELGCCEC lib path"
            export LD_LIBRARY_PATH=$GCCECGEOMODELLIB:$LD_LIBRARY_PATH
        fi
    fi
done
```

- Finally, for using CATIA volumes in simulation, Athena should be started with following CMD:
  `> Athena.py –gccecgeo` *<JobOption_Number> <other_parameters>*

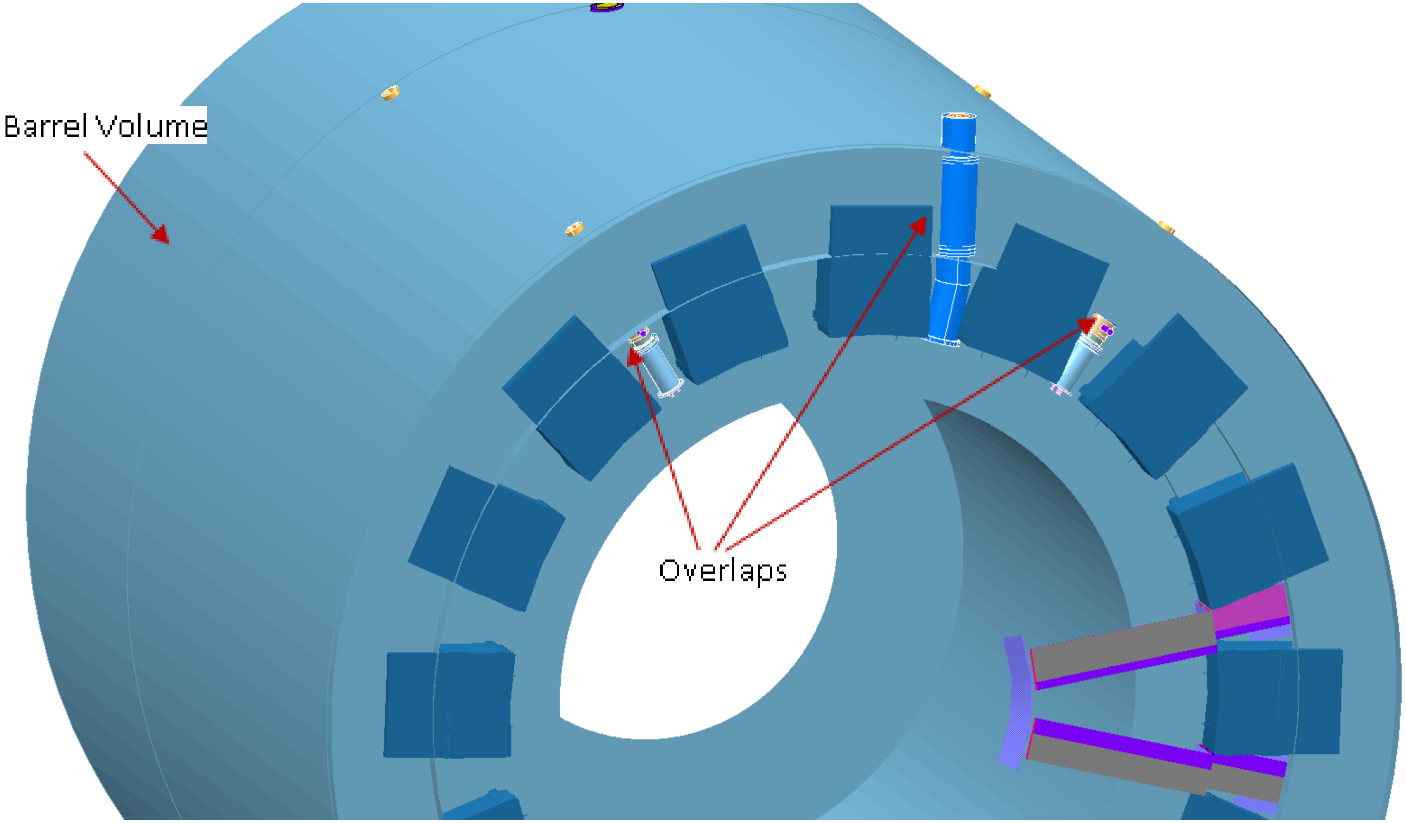
Adding New Volumes for FLUGG Geometry

R08 – Electronic Boxes
R09- LA Drain Line
R10 – LA Pump
R11 – By Pass Tube
R13 – Cryostat LN2 GN2 Lines
R14 – Cryostat Safety Line
R15 – Solenoid Line
R16 – ID SGM01 Supports
R17 – ID SGM01 Cables
R18 – ID SGM01 Pipes



Adding New Volumes for FLUGG Geometry

Overlaps of GAP Services with GeoModel Barrel



Adding New Volumes for FLUGG Geometry

Overlaps of GAP Services with GeoModel Barrel

C++ code

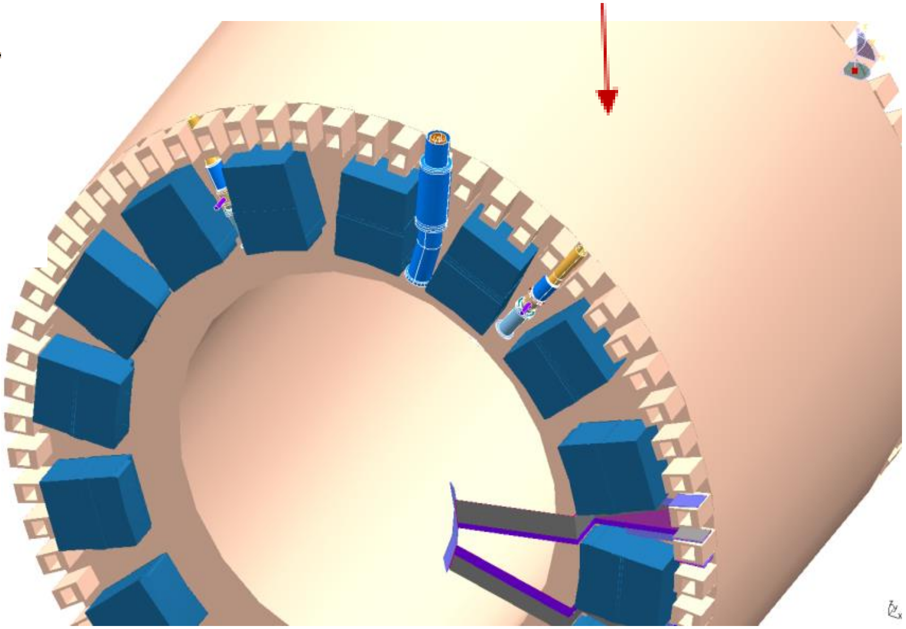
```
//-------------------------------------------------------------------------------------------//
///////////////////////////////////  Calorimeter  ////////////////////////////////
//-------------------------------------------------------------------------------------------//
//Barrel
 GeoTube* Barrel = new GeoTube(2290.708*mm, 4235.048*mm, 2820*mm);
//Barrel Hole
 GeoBox* Barrel_Hole= new GeoBox(79*mm,79*mm,2830*mm);
 HepTransform3D TR1(HepRotateZ3D(2.8025*degree) *HepTranslate3D(0*mm, 4062*mm, 0*mm));
 GeoShapeSubtraction* Barel_Sub = new GeoShapeSubtraction(Barrel, &(*Barrel_Hole << TR1));
for(int i=1; i<64; i++){
 HepTransform3D TR1(HepRotateZ3D(2.8025*degree+i*5.625*degree) *HepTranslate3D(0*mm, 4062*mm, 0'
  Barel_Sub= new GeoShapeSubtraction(Barel_Sub, &(*Barrel_Hole << TR1));
}
 GeoLogVol* Barrel_sub_log = new GeoLogVol("Barrel_sub",Barel_Sub,SSTEEL);
 GeoPhysVol* Barrel_sub_phy = new GeoPhysVol(Barrel_sub_log);
for(int i=0; i<63; i++){
//Fingers Side C
 GeoBox* FingerC= new GeoBox(110*mm,175*mm,187.5*mm);
//Fingers Hole
 GeoBox* FingerC_Hole= new GeoBox(79*mm,79*mm,195*mm);
 const GeoShapeSubtraction& FingerC_Sub = FingerC->subtract((*FingerC_Hole));
 GeoLogVol* FingerC_sub_log = new GeoLogVol("FingerC_sub",&FingerC_Sub,SSTEEL);
 GeoPhysVol* FingerC_sub_phy = new GeoPhysVol(FingerC_sub_log);
 world->add(tag);
 world->add(new GeoTransform(HepRotateZ3D(194.0525*degree+i*5.625*degree)));
 world->add(new GeoTransform(HepTranslate3D(0*mm, 4052*mm, -3010.5*mm)));
 world->add(FingerC_sub_phy);
}
for(int i=0; i<63; i++){
//Fingers Side A
 GeoBox* FingerA= new GeoBox(110*mm,175*mm,187.5*mm);
//Fingers Hole
 GeoBox* Finger_HoleA= new GeoBox(79*mm,79*mm,195*mm);
 const GeoShapeSubtraction& FingerA_Sub = FingerA->subtract((*Finger_HoleA));
 GeoLogVol* FingerA_sub_log = new GeoLogVol("FingerA_sub",&FingerA_Sub,SSTEEL);
 GeoPhysVol* FingerA_sub_phy = new GeoPhysVol(FingerA_sub_log);
 world->add(tag);
 world->add(new GeoTransform(HepRotateZ3D(177.1775*degree+i*5.625*degree)));
 world->add(new GeoTransform(HepTranslate3D(0*mm, 4052*mm, 3010.5*mm)));
 world->add(FingerA_sub_phy);
}
 world->add(tag);
 world->add(Barrel_sub_phy);
```

Material Description

Geometry Description

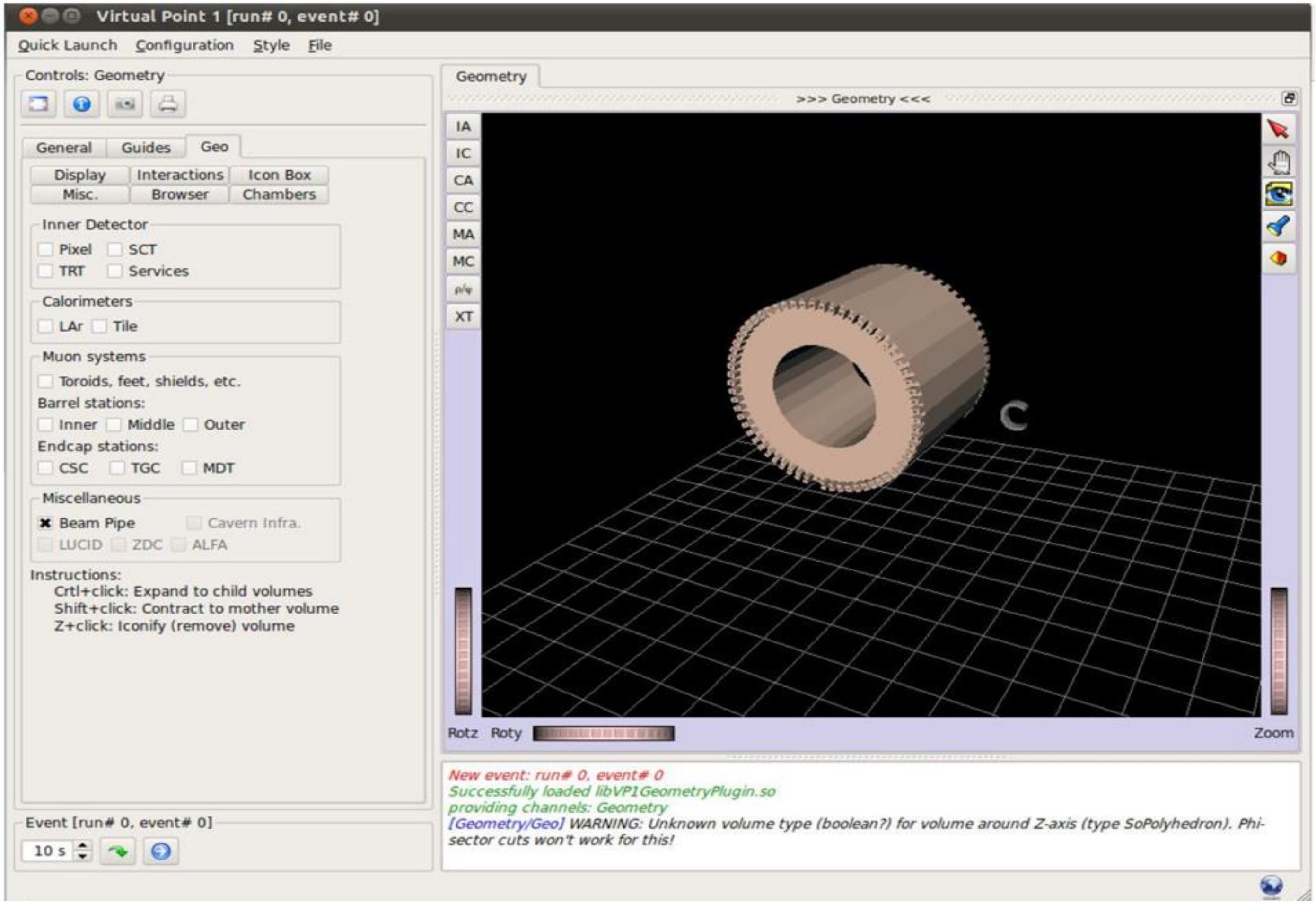
Transactions

New Barrel Volume



Adding New Volumes for FLUGG Geometry

VP1 Screenshot with new Barrel Geometry



XML Geometry Studies

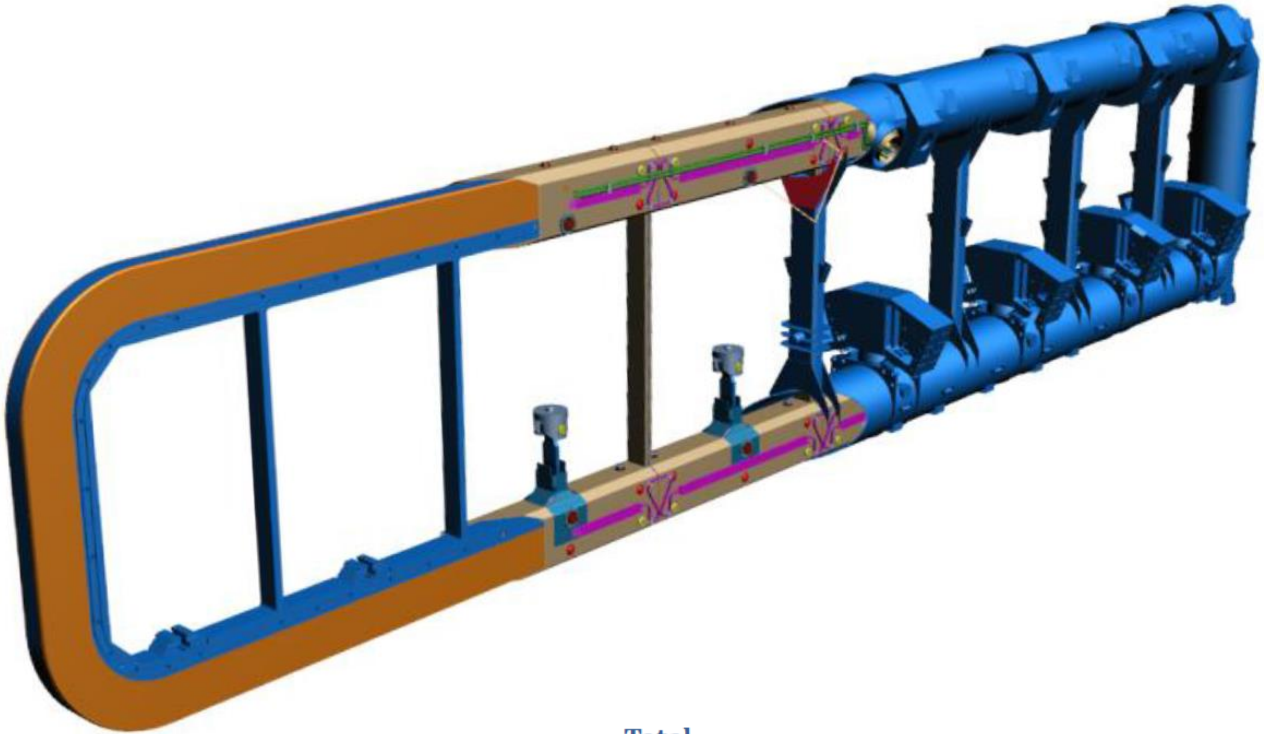
Georgian Team has done several projects of Compare Analysis and Adding of New Geometries:

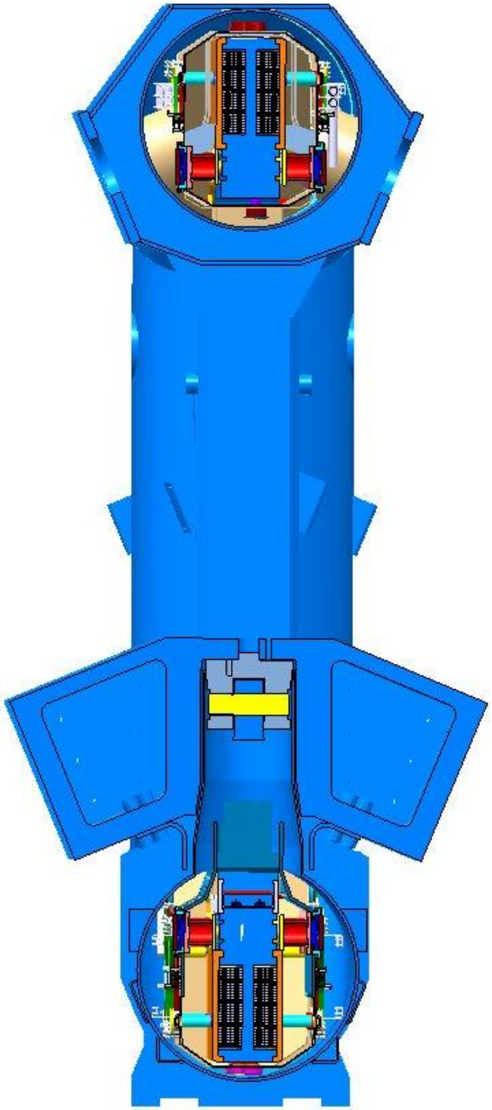
1. ATLAS Coils
2. TGC Structures
3. MDT Structures
4. Feets
5. End-Cap Toroid
6. New Small Wheel Geometry updates

Also several projects of Integration Conflicts Checking have been done:

1. Coils Analysis
2. End-Cap Toroid Analysis
3. Warm Structure Analysis

Coil Geometry Studies





	Volume (m^3)	Weight (kg)
Total	24.75	92348

Reproduction As-Built model in CATIA

Coil Geometry Studies

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

Coil Geometry Studies

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

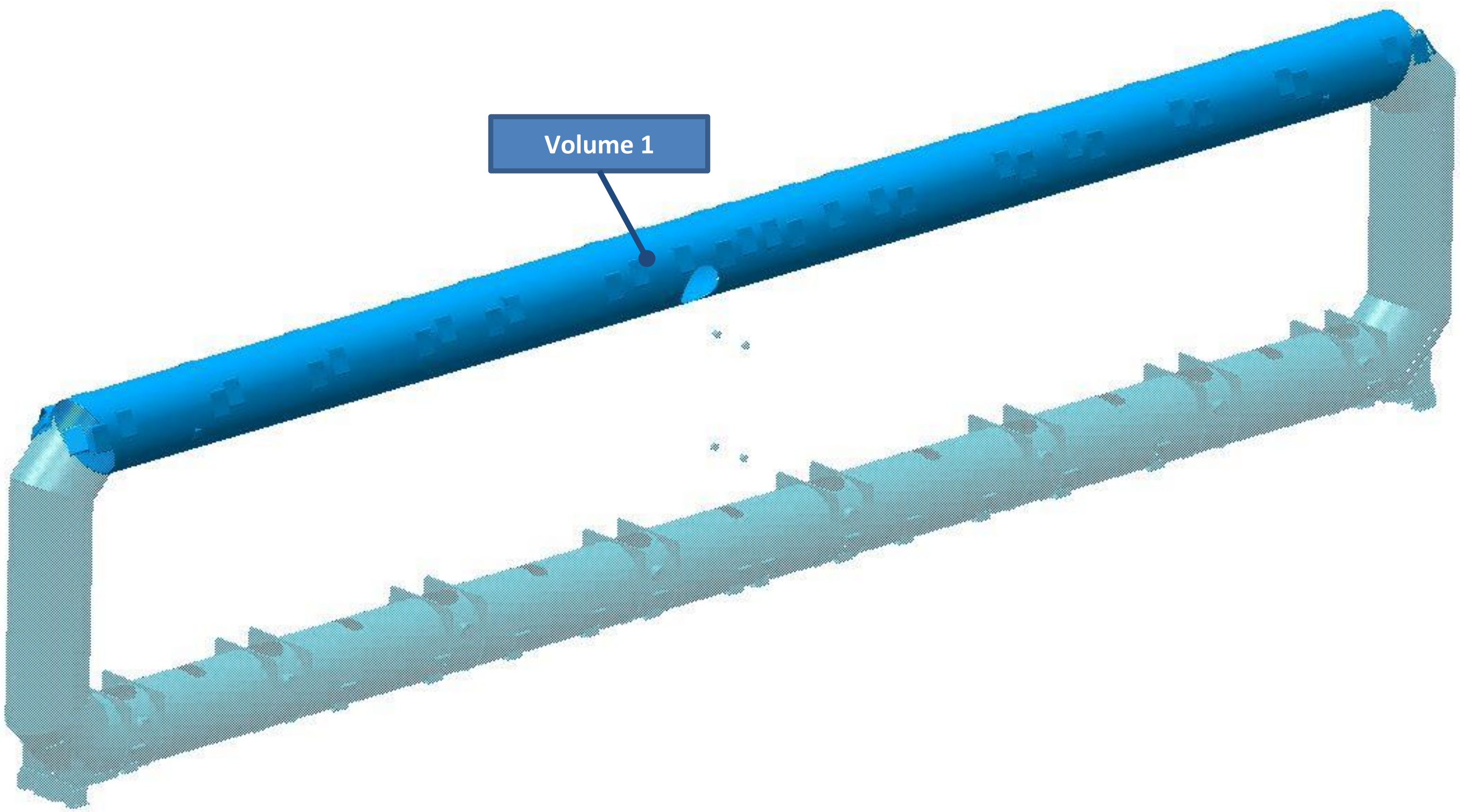
24.75 m^3 $|_{\text{Total Volume}}$ = 1.261 m^3 $|_{\text{Vol.1}}$ + 0.168 m^3 $|_{\text{Vol.2,4,6,8}}$ + 0.338 m^3 $|_{\text{Vol.3,7}}$ + 1.421 m^3 $|_{\text{Vol.5}}$
+ 4.416 m^3 $|_{\text{Vol.9}}$ + 0.667 m^3 $|_{\text{Vol.10}}$ + 0.603 m^3 $|_{\text{Vol.11}}$ + 0.7373 m^3 $|_{\text{Vol.12}}$
+ 0.391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

Total	**24.75** Volume (m3)	**92130** Weight(kg)

Coil Geometry Studies

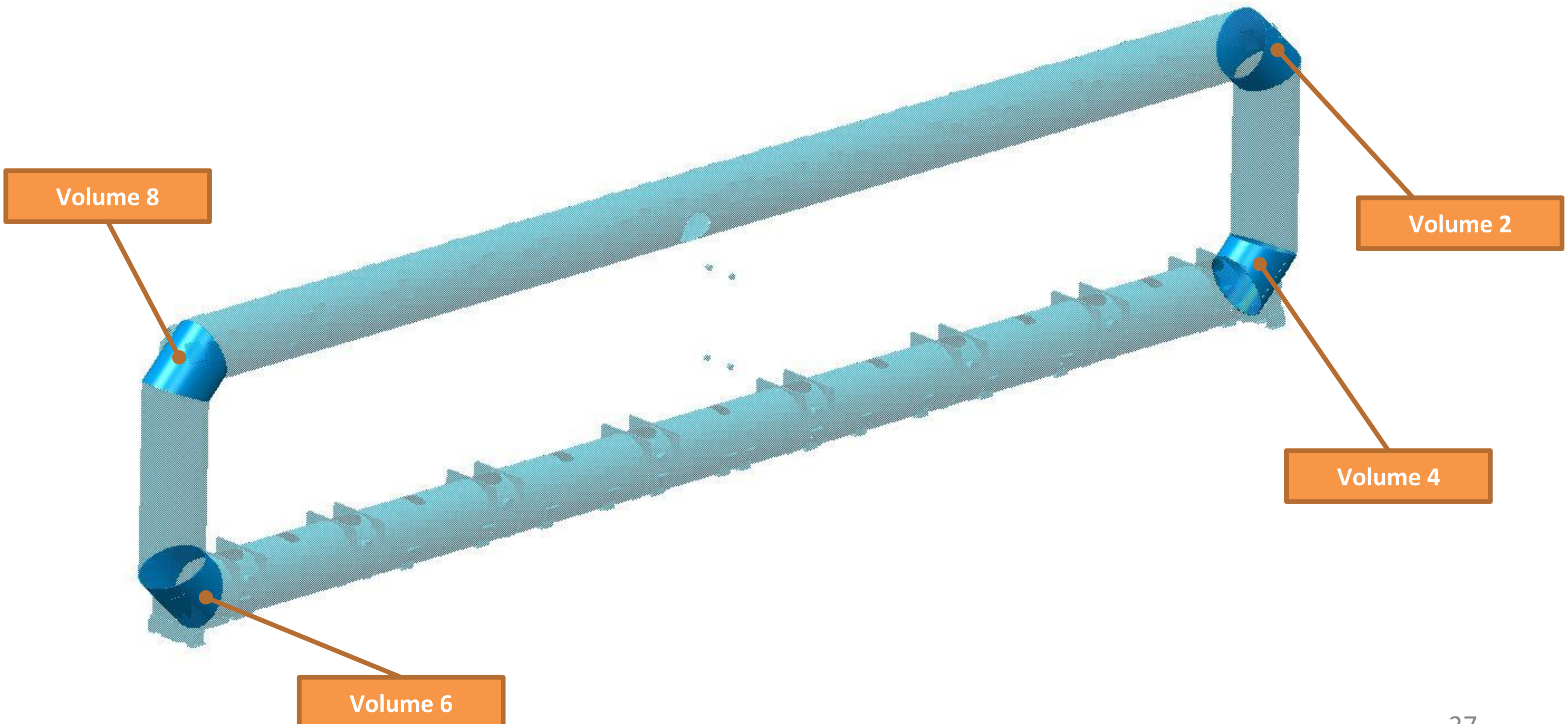
Volume 1 Cryostat Long (Top)

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**



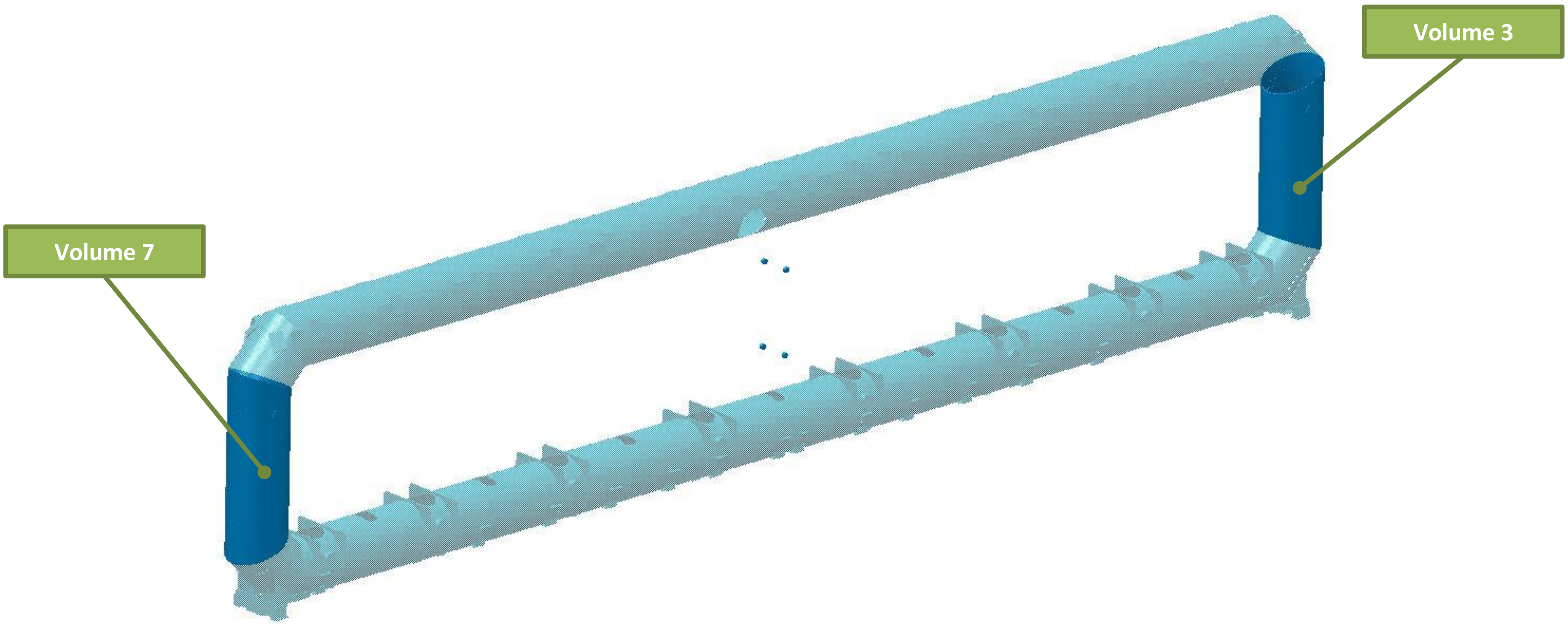
Volume 2, 4, 6, 8 Cryostat Corner

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**



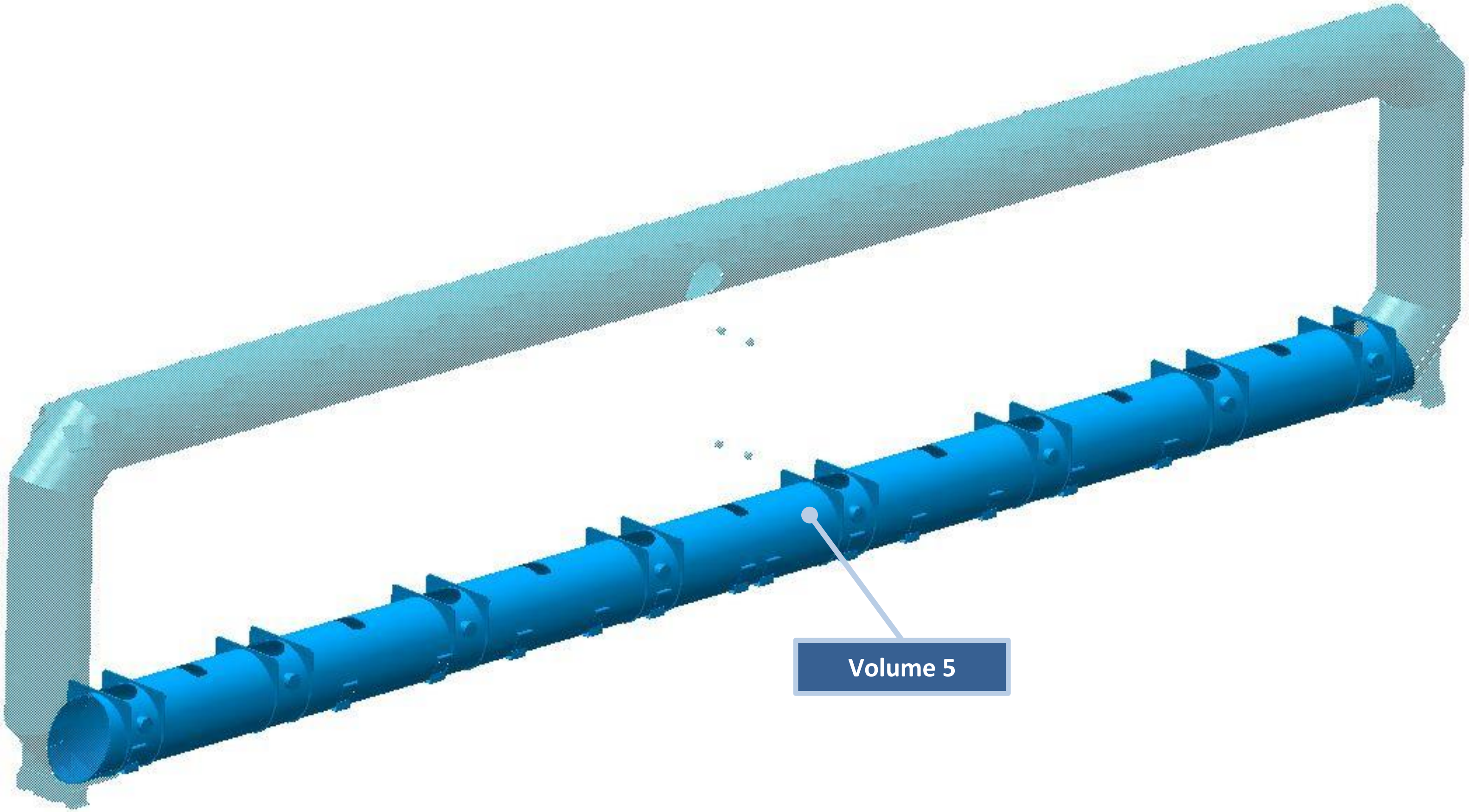
Volume 3, 7 Cryostat Short

Volume 3,7	Number of Items	Part Name		Material	Density (kg/m³)	Volume (m³)	Total Volume (m³)	Total Weight (kg)
	2	Cryostat Short	Assembly	Stainless Steel 304L	8000	0.169	0.338	2704
							Total Mass (kg): **2704**	



Volume 5 Cryostat Long (bottom)

Volume 5	Number of Items	Part Name		Material	Density (kg/m³)	Volume (m³)	Total Volume (m³)	Total Weight (kg)
	1	Cryostat Long (bottom)	Assembly	Stainless Steel 304L	8000	1.421	1.421	11368
							Total Mass (kg):	**11368**

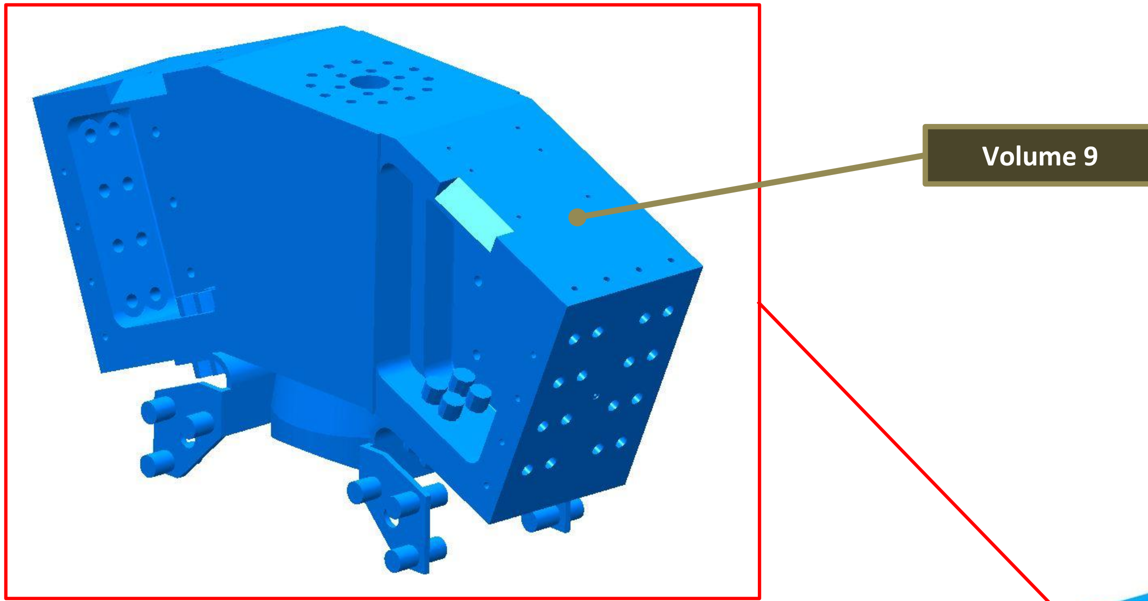


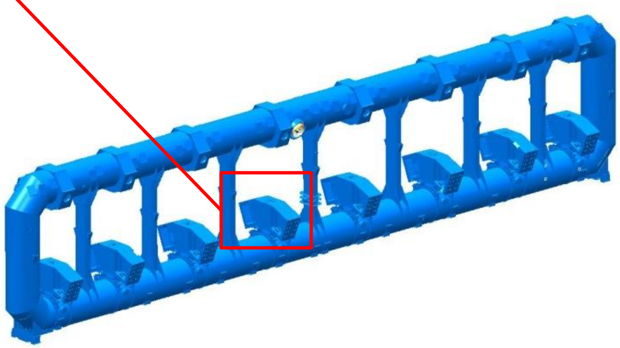
Coil Geometry Studies

Volume 9 Voussoirs

Volume 9	Number of Items	Part Name		Material	Density (kg/m³)	Volume (m³)	Total Volume (m³)	Total Weight (kg)
	8	Voussoirs	Assembly	Aluminum/Stainless Steel 304L	2650/8000	0.552	4.416	12344.4
							Total Mass (kg):	**12344.4***

$* {}^{+680}_{-0}$



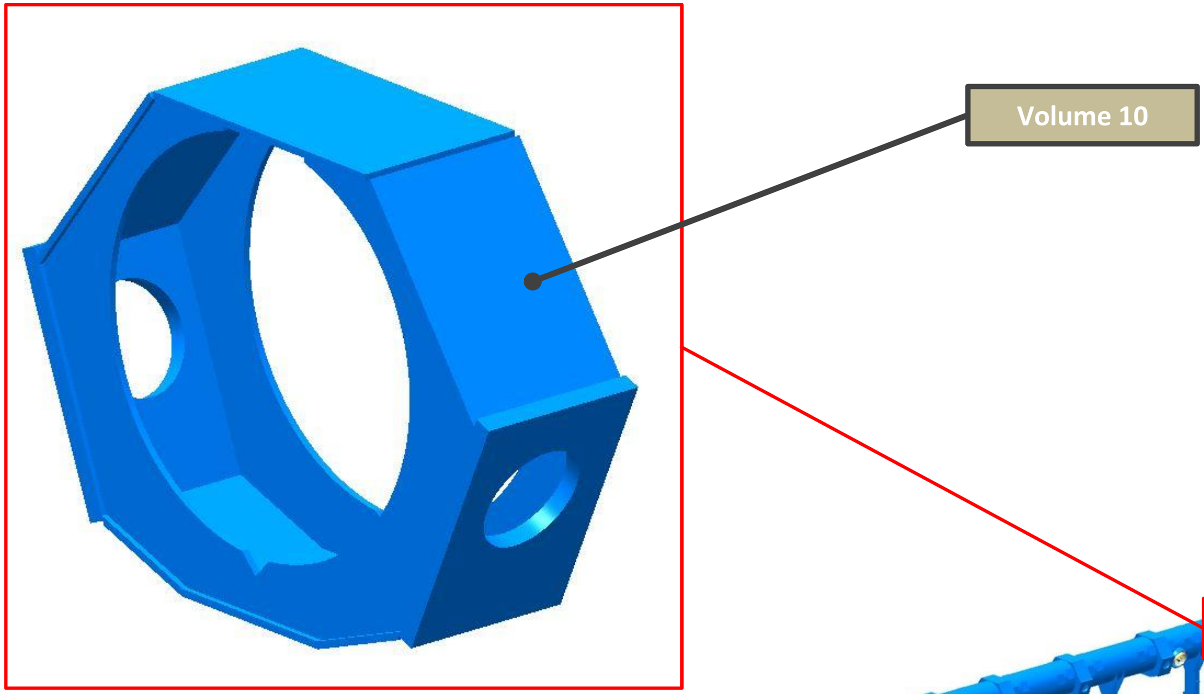


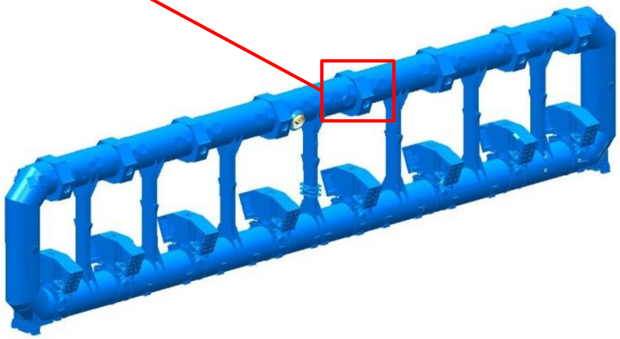
8 x Voussoirs

Coil Geometry Studies

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**	



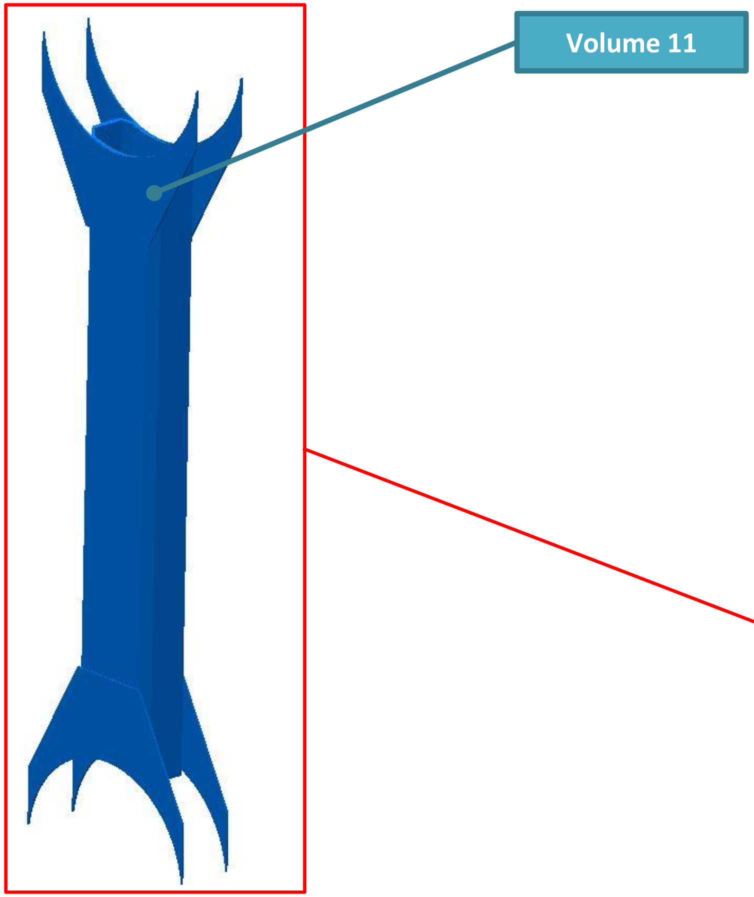


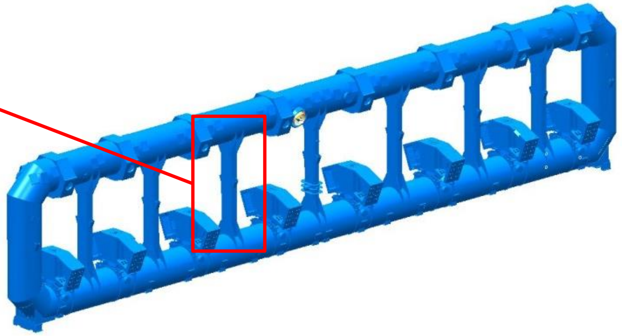
8 x Stiffener

Coil Geometry Studies

Volume 11 Ribs

Volume 11	Number of Items	Part Name		Material	Density (kg/m³)	Volume (m³)	Total Volume (m³)	Total Weight (kg)
	7	Rib	Assembly	Stainless Steel 304L	8000	0.086	0.603	4824
							Total Mass (kg):	**4824.0**

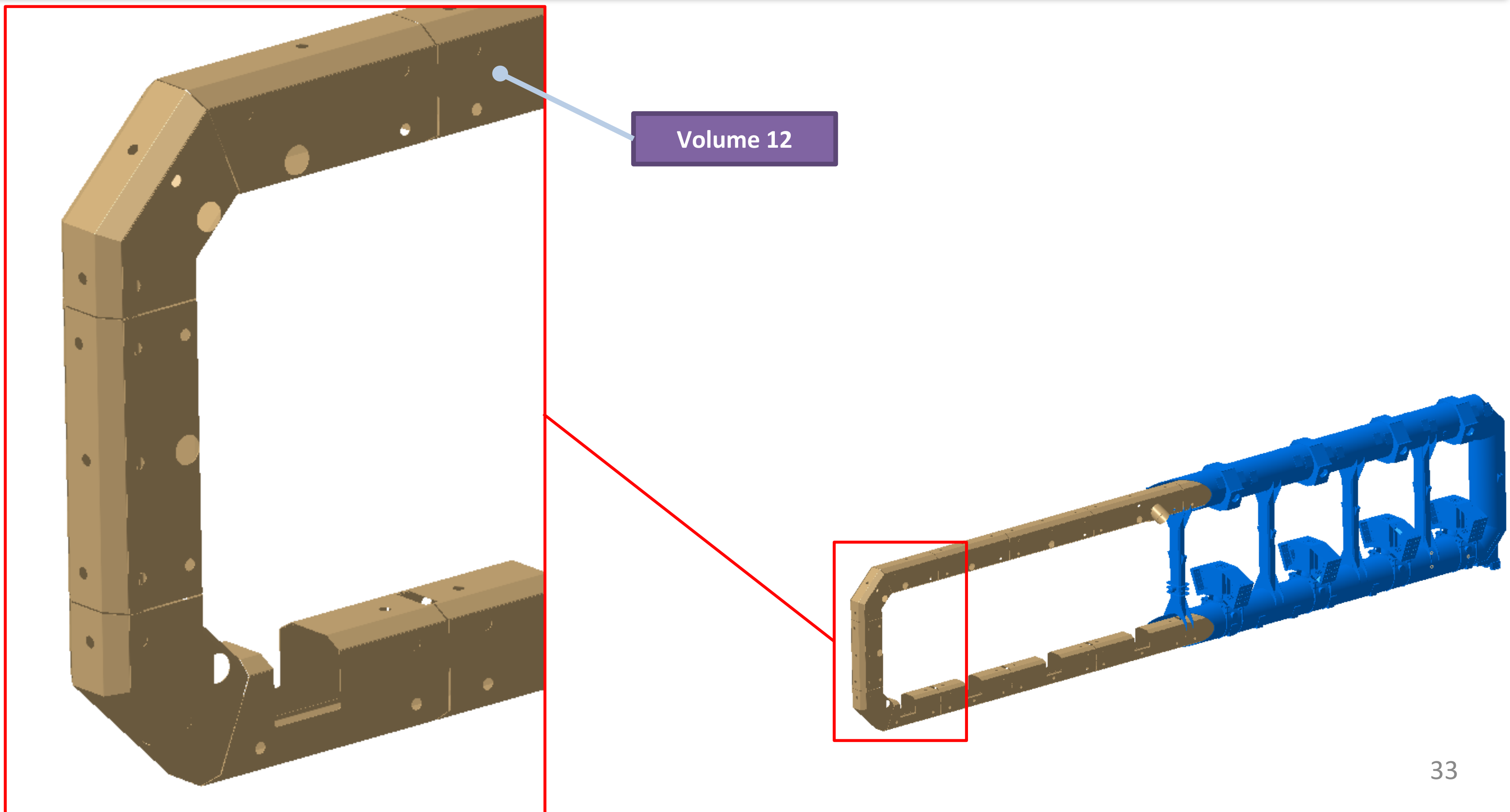




7 x Rib

Volume 12 Thermal Shielding

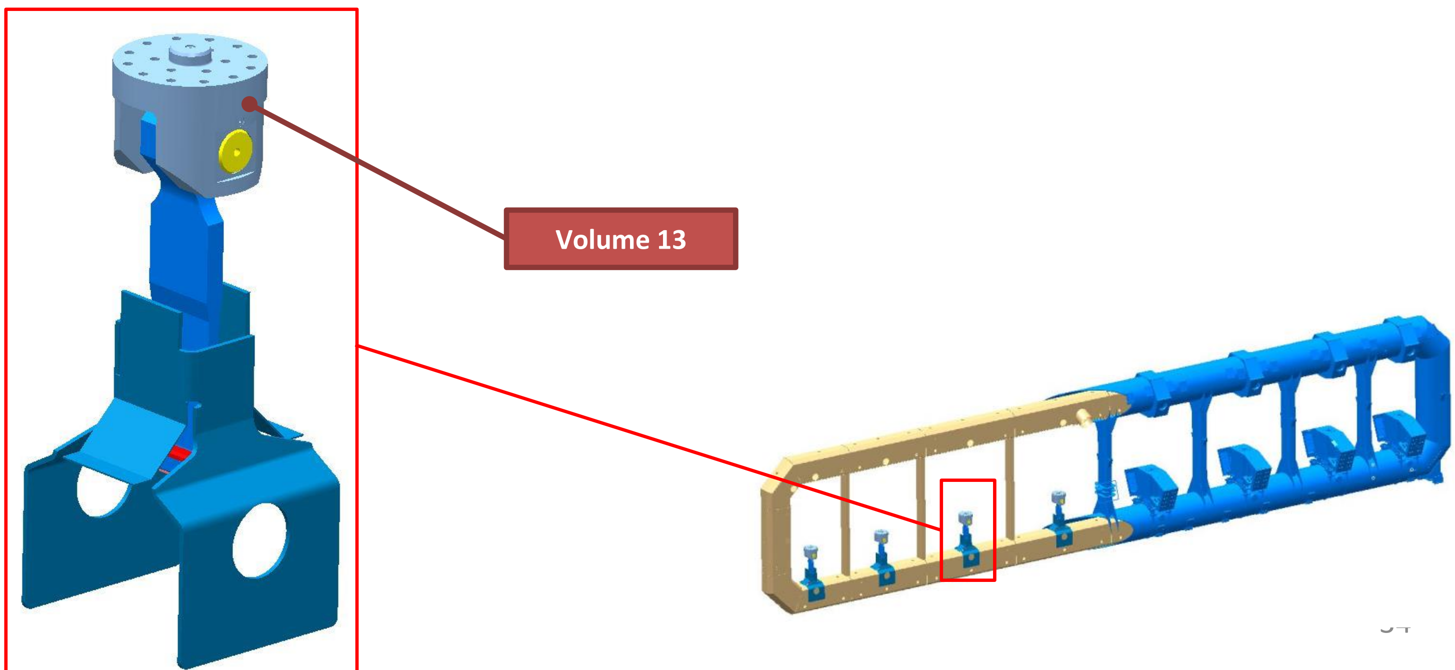
	Number of Items	Part Name		Material	Density (kg/m^3)	Volume (m^3)	Total Volume (m^3)	Total Weight (kg)
Volume 12	1	Thermal Shielding	Part	Aluminum 3003.H22	2740	0.7373	0.7373	2020
							Total Mass (kg):	**2020**



Coil Geometry Studies

Volume 13 Tie Rod

	Number of Items	Part Name		Material	Density (kg/m³)	Volume (m³)	Total Volume (m³)	Total Weight (kg)
Volume 13	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**	

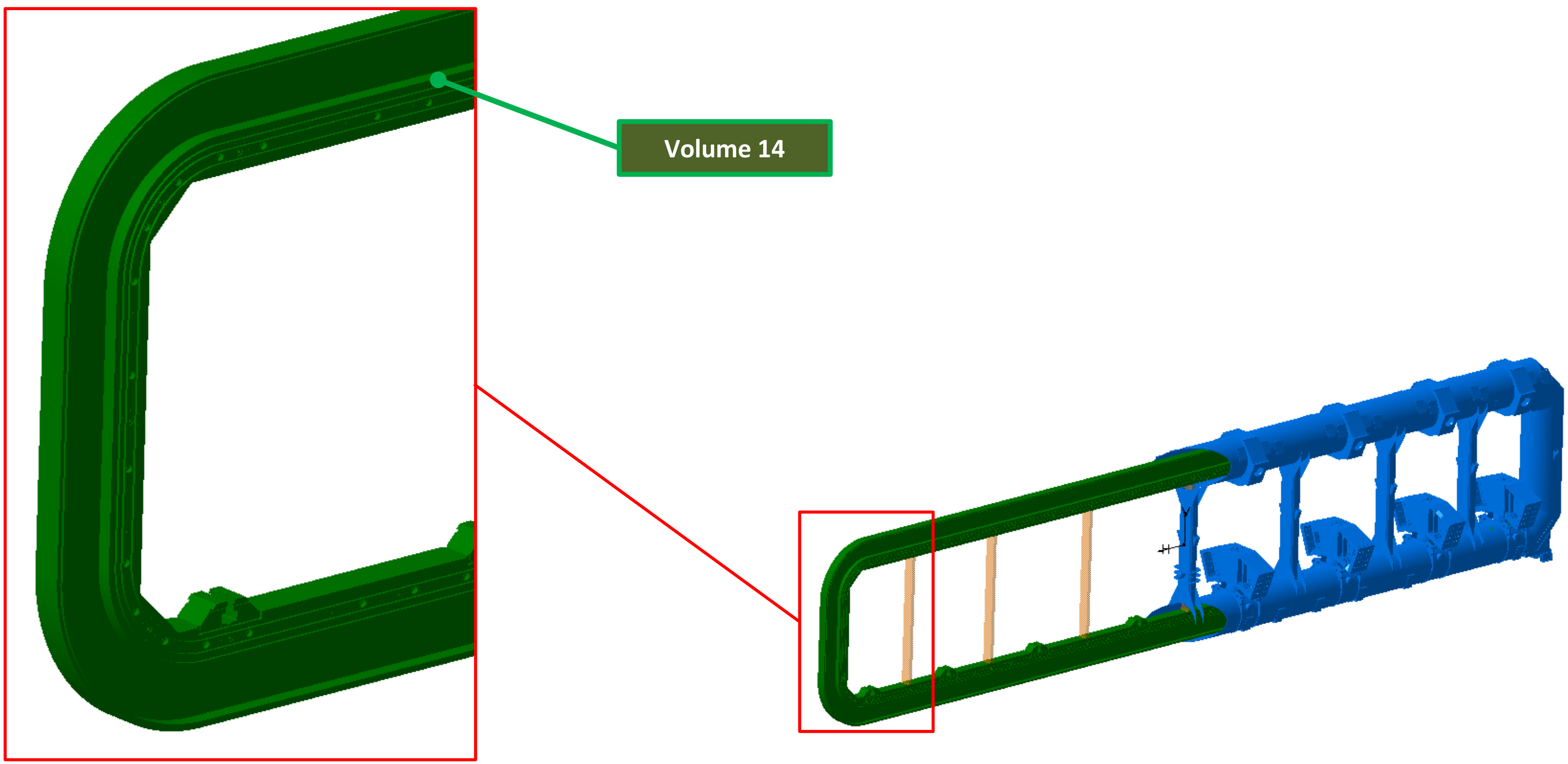


8 x Tie Rod

Coil Geometry Studies

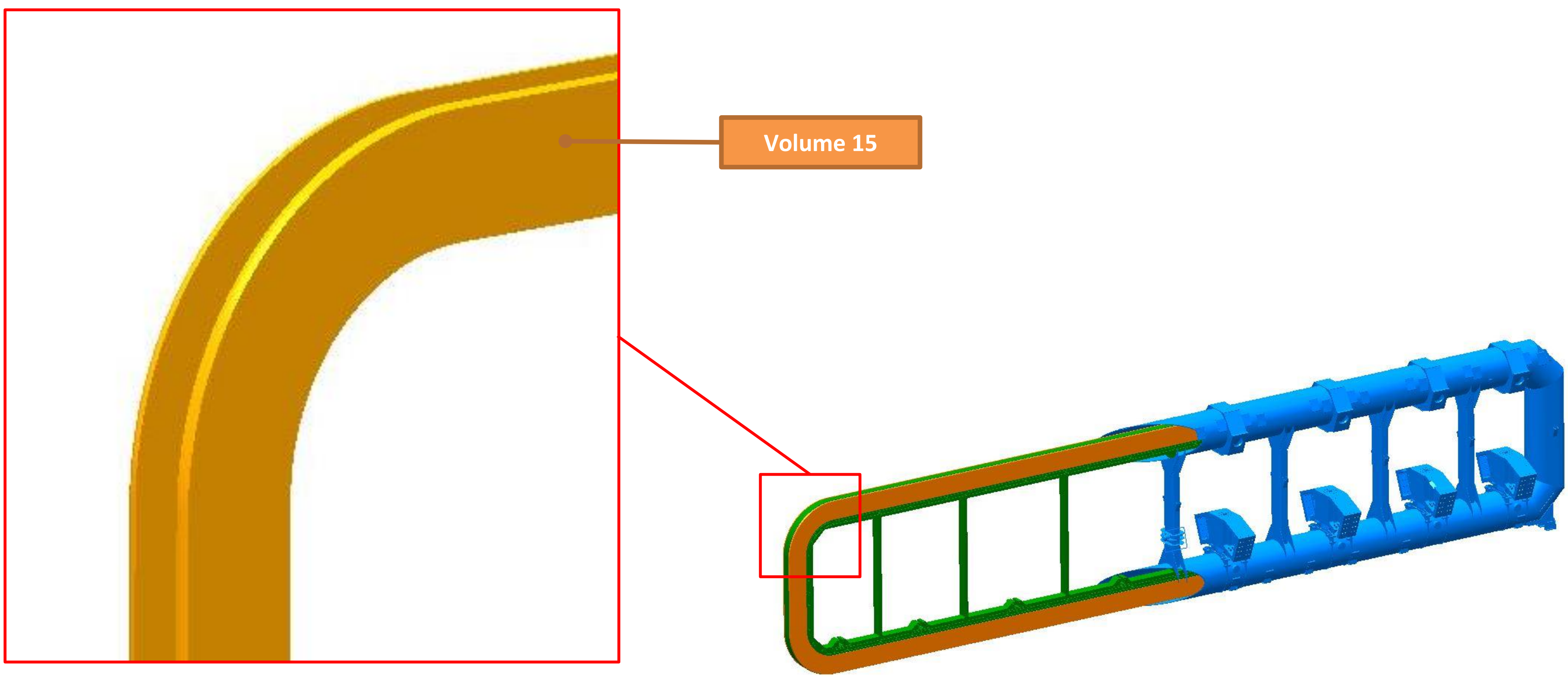
Volume 14 Coil casing

Volume 14	Number of Items	Part Name		Material	Density (kg/m^3)	Volume (m^3)	Total Volume (m^3)	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**



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**

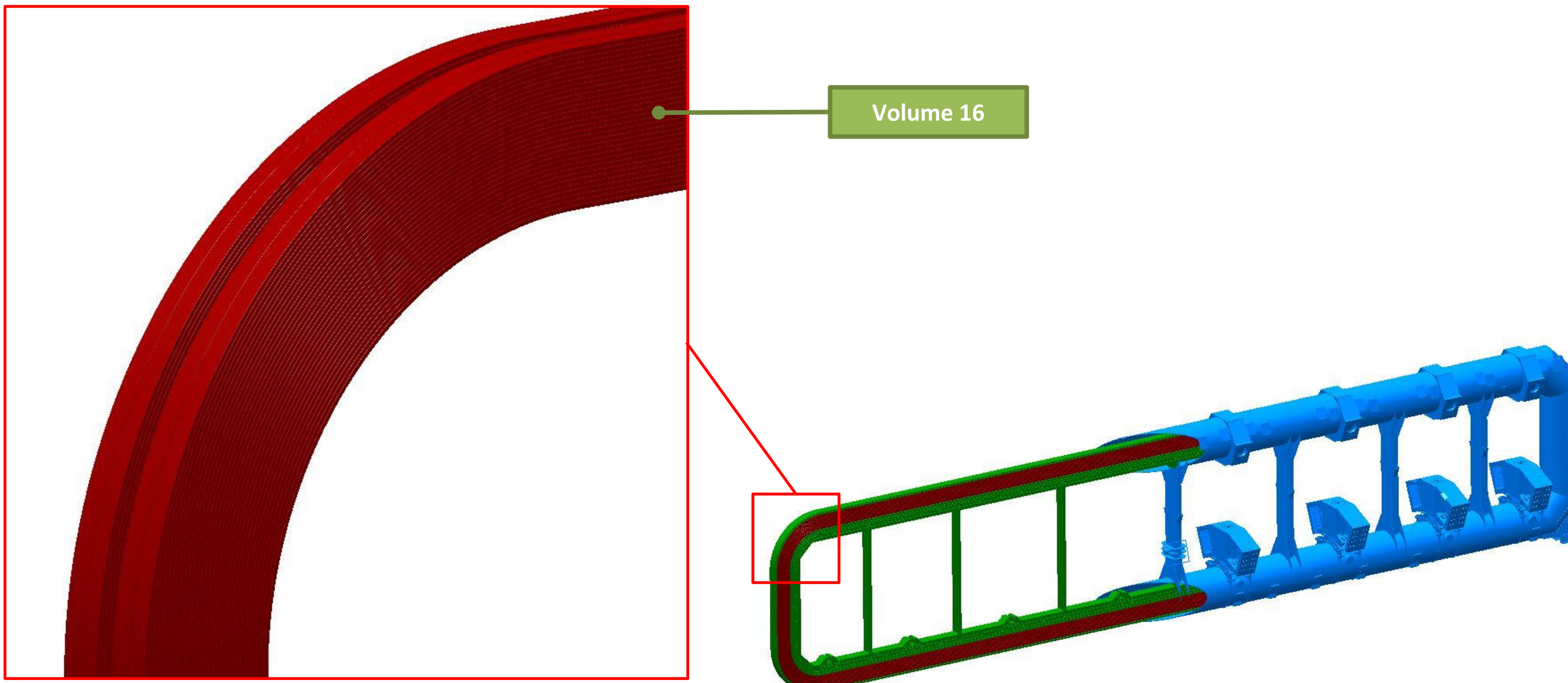


Coil Geometry Studies

Volume 16

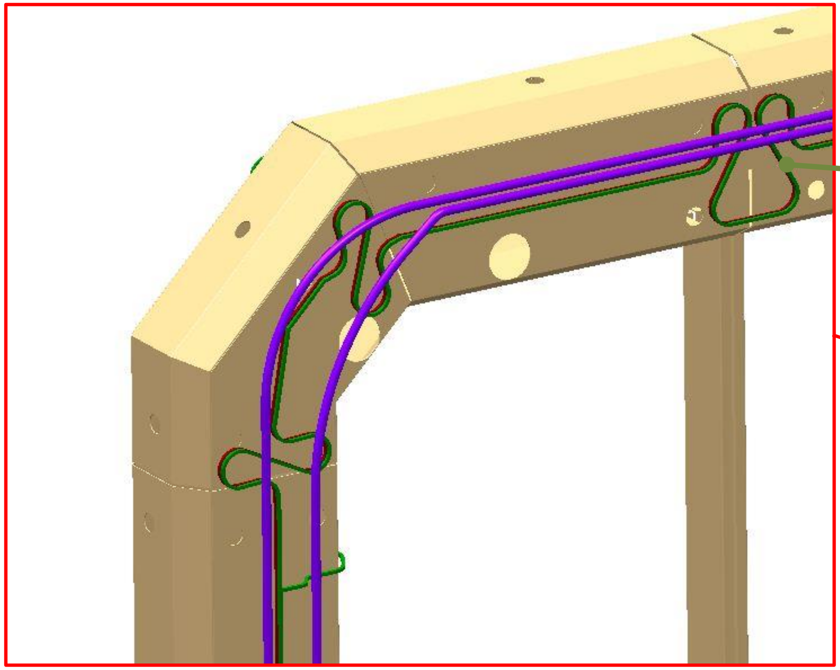
Volume 16	Number of Items	Part Name	Material	Density (kg/m^3)	Volume (m^3)	Total Volume (m^3)	Total Weight (kg)
	1	Part	Aluminum	2650	4.367	4.367	11572.55
						Total Mass (kg):	11572.55*

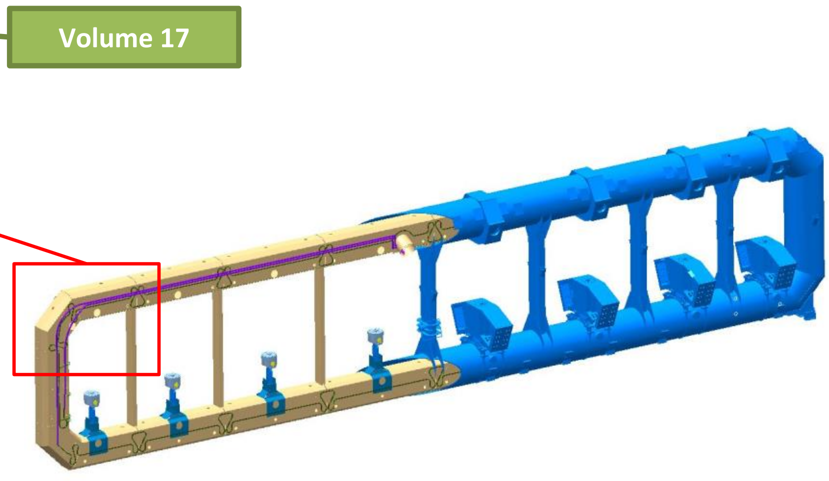
*+700



Volume 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**	

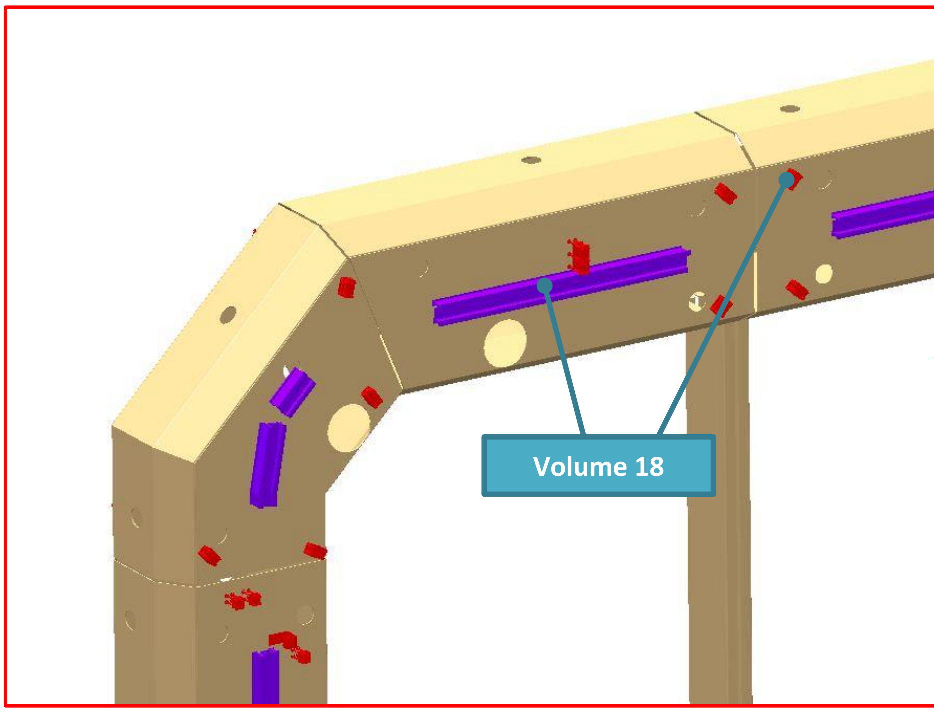




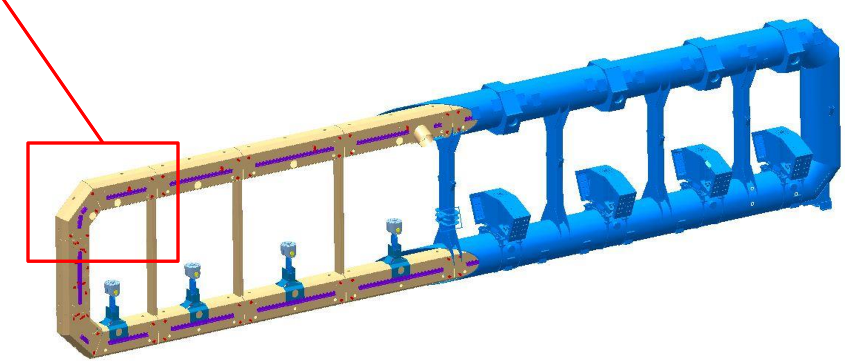
Coil Geometry Studies

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**

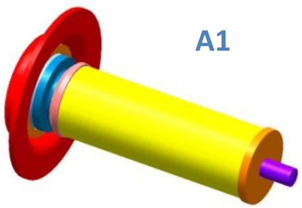


Multiple *	Density - (kg/m^3)
SSTEEL (304, 304L, 304H)	8000
Aluminum 7075 T73	2810
Aluminum mg 3	2670
Aluminum 5083 H111	2650
Aluminum 3003	2700
Aluminum 1050	2705
fibra de vetro	2600

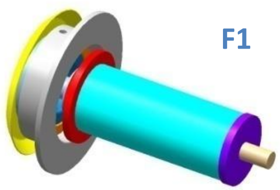


Coil Geometry Studies

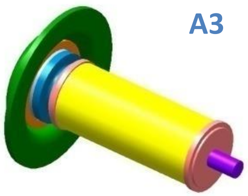
Volume 19 Supports of Coil



A1

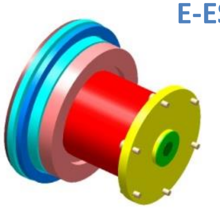


F1

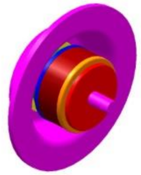


A3

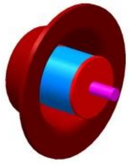
	Number of Items	Part Name		Material	Density (kg/m^3)	Volume (m^3)	Total Volume (m^3)	Total Weight (kg)
Volume 19	108	Support A1.1	Part	Aluminum 5083 F	2660	0.0001048	0.0113184	30.1
	108	Support A1.5	Part	Stainless Steel 304L	8000	0.00004723	0.00510084	40.8
	108	Support A1.6	Part	Stainless Steel 304L	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**



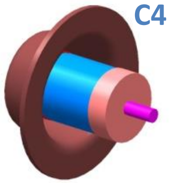
E-EST



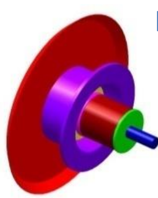
C1



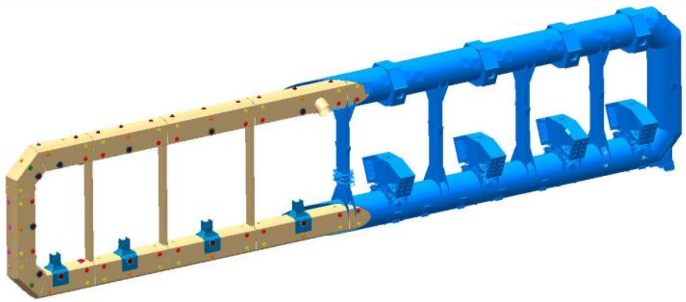
C2



C4



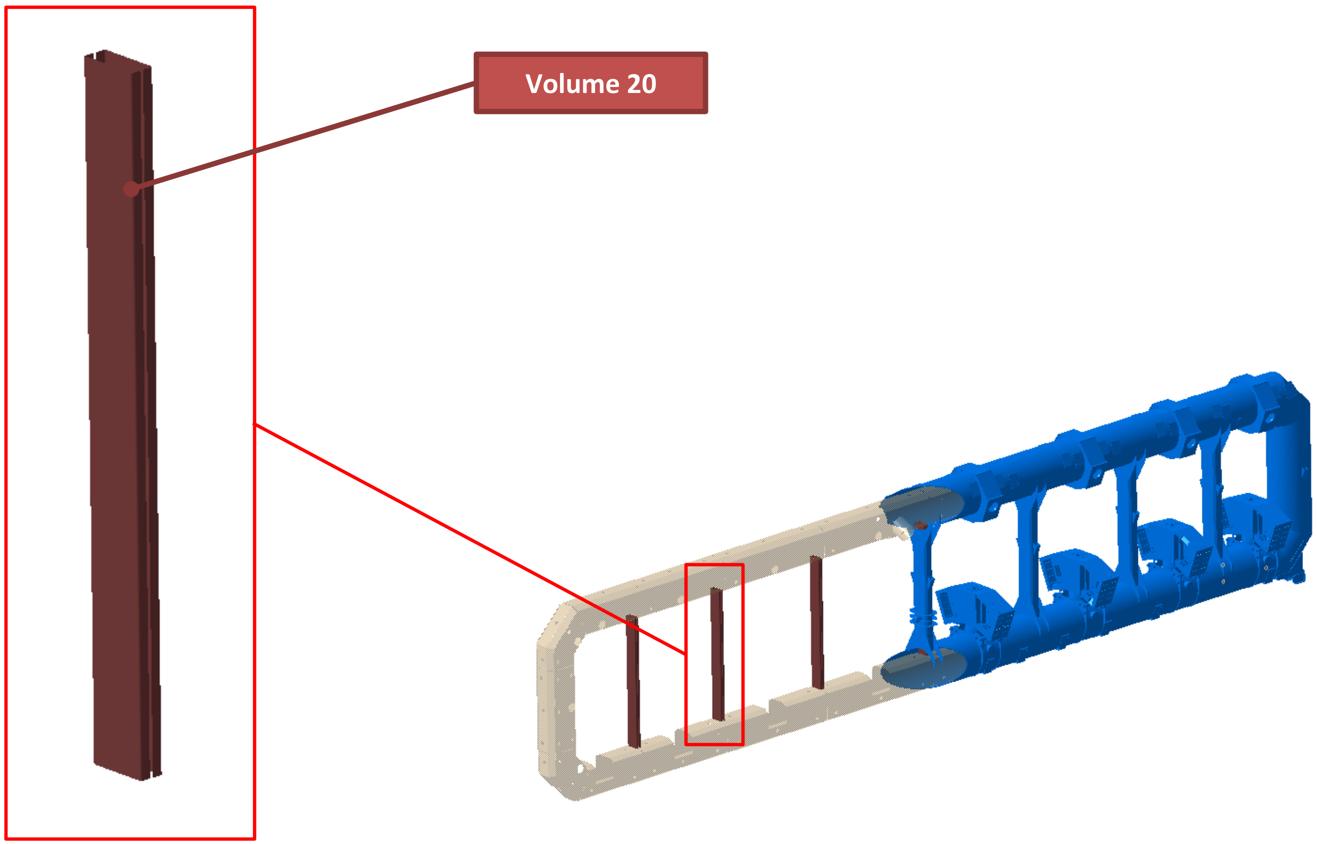
H1



Coil Geometry Studies

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**	

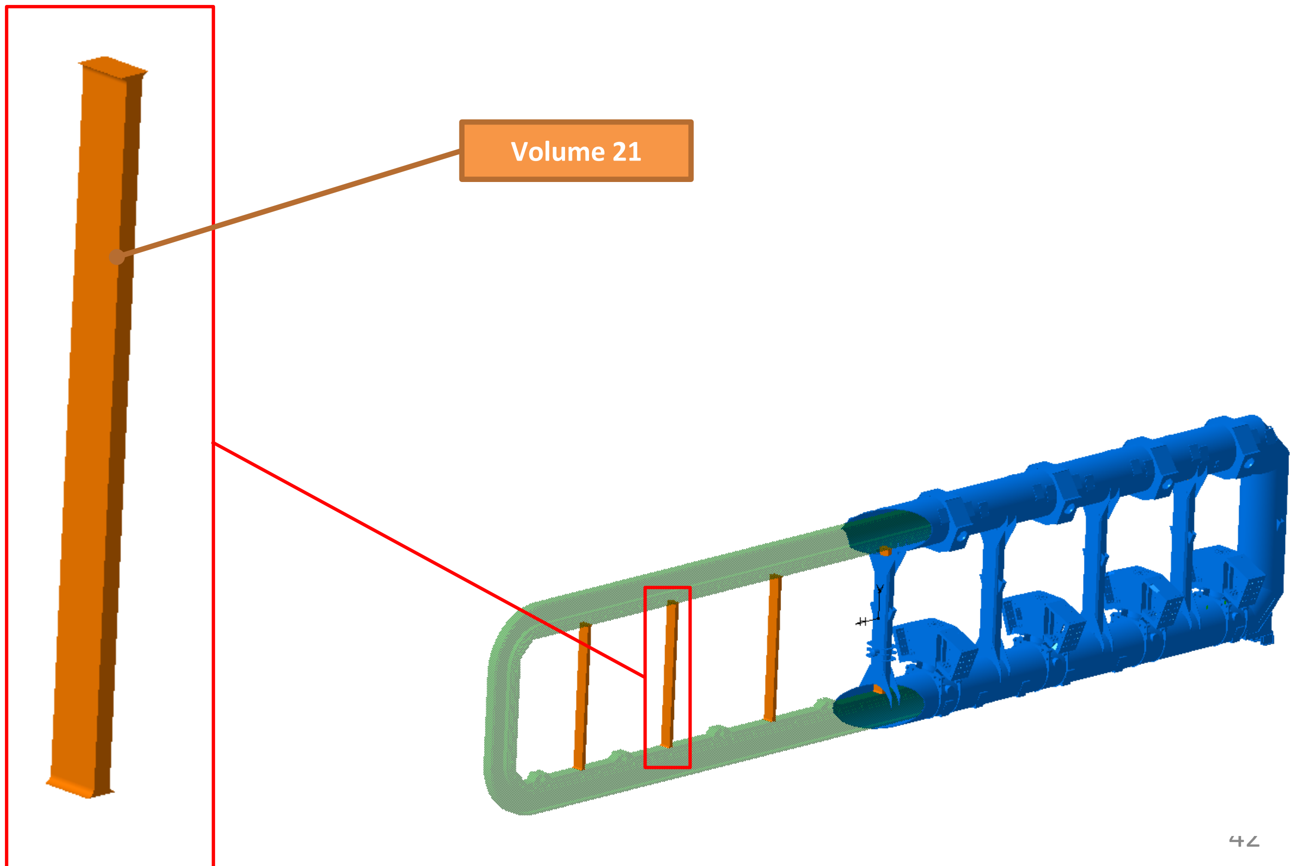


7 x Rib of Thermal Shielding

Coil Geometry Studies

Volume 21 Ribs of Coil casing

Volume 21	Number of Items	Part Name		Material	Density (kg/m³)	Volume (m³)	Total Volume (m³)	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

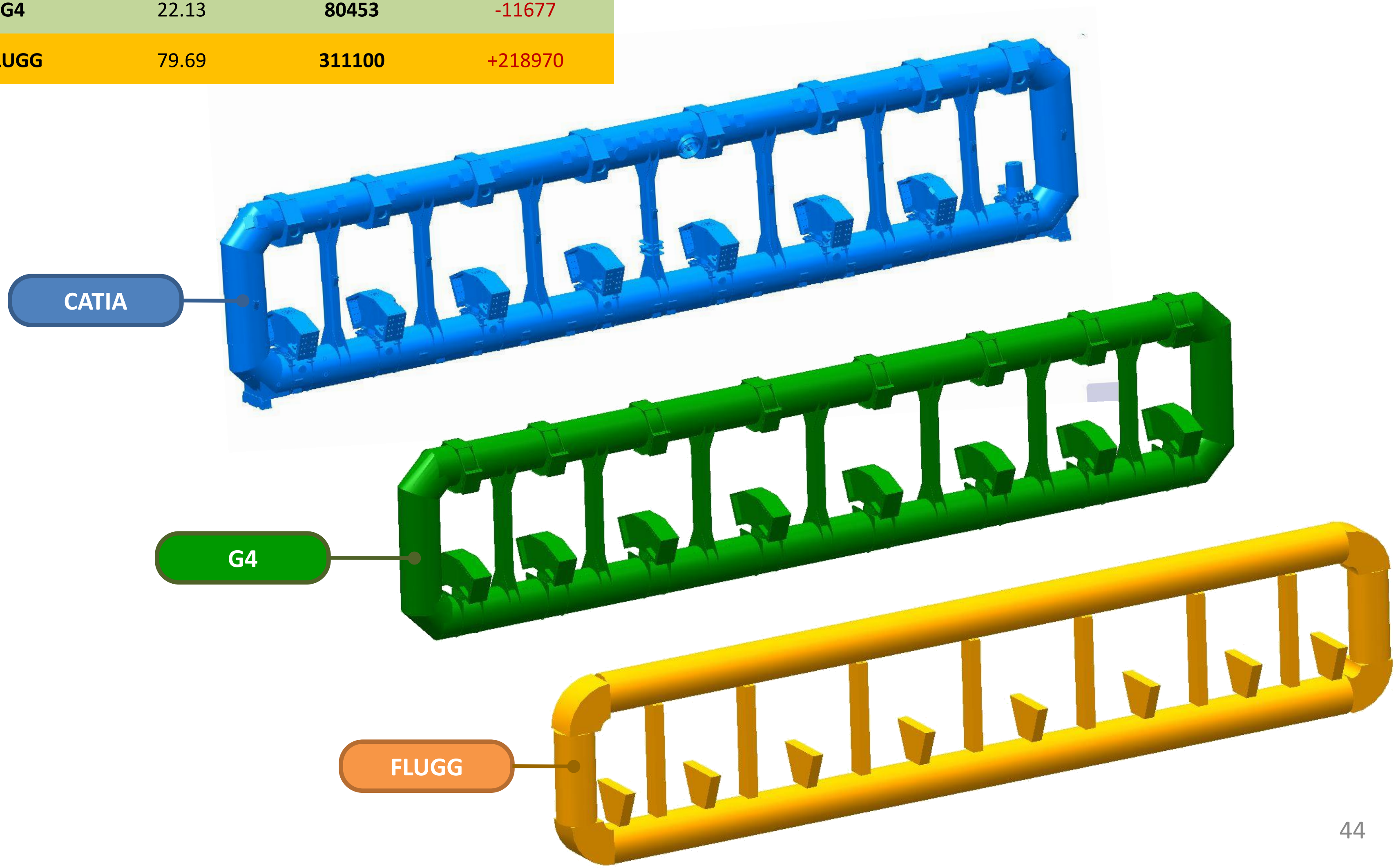
Coil Geometry Studies

Compare Analysis of

CATIA⇔FLUGG / CATIA⇔G4

Coil Geometry Studies

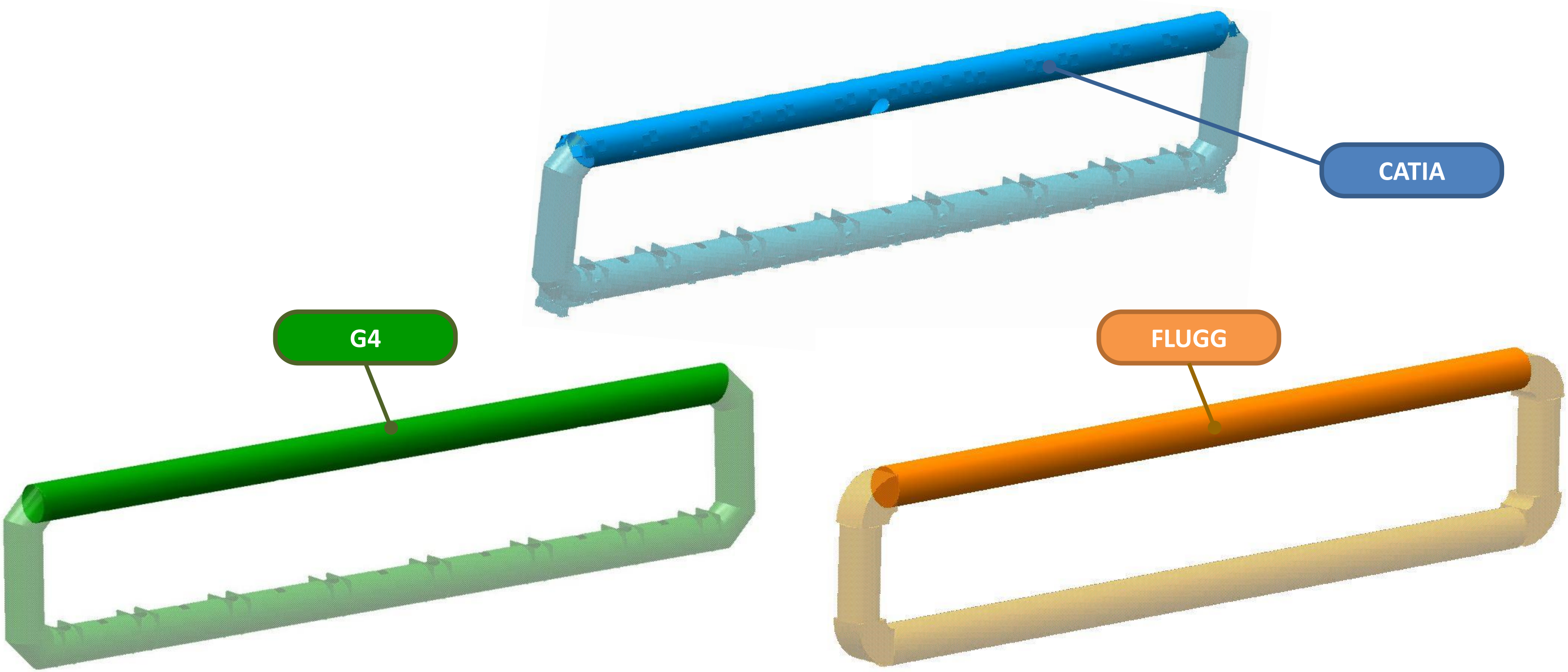
Model	Volume (m3)	**Weight (kg)**	Difference (kg)
CATIA	24.75	**92130**	
G4	22.13	**80453**	-11677
FLUGG	79.69	**311100**	+218970



Coil Geometry Studies

Volume 1 Cryostat Long (Top)

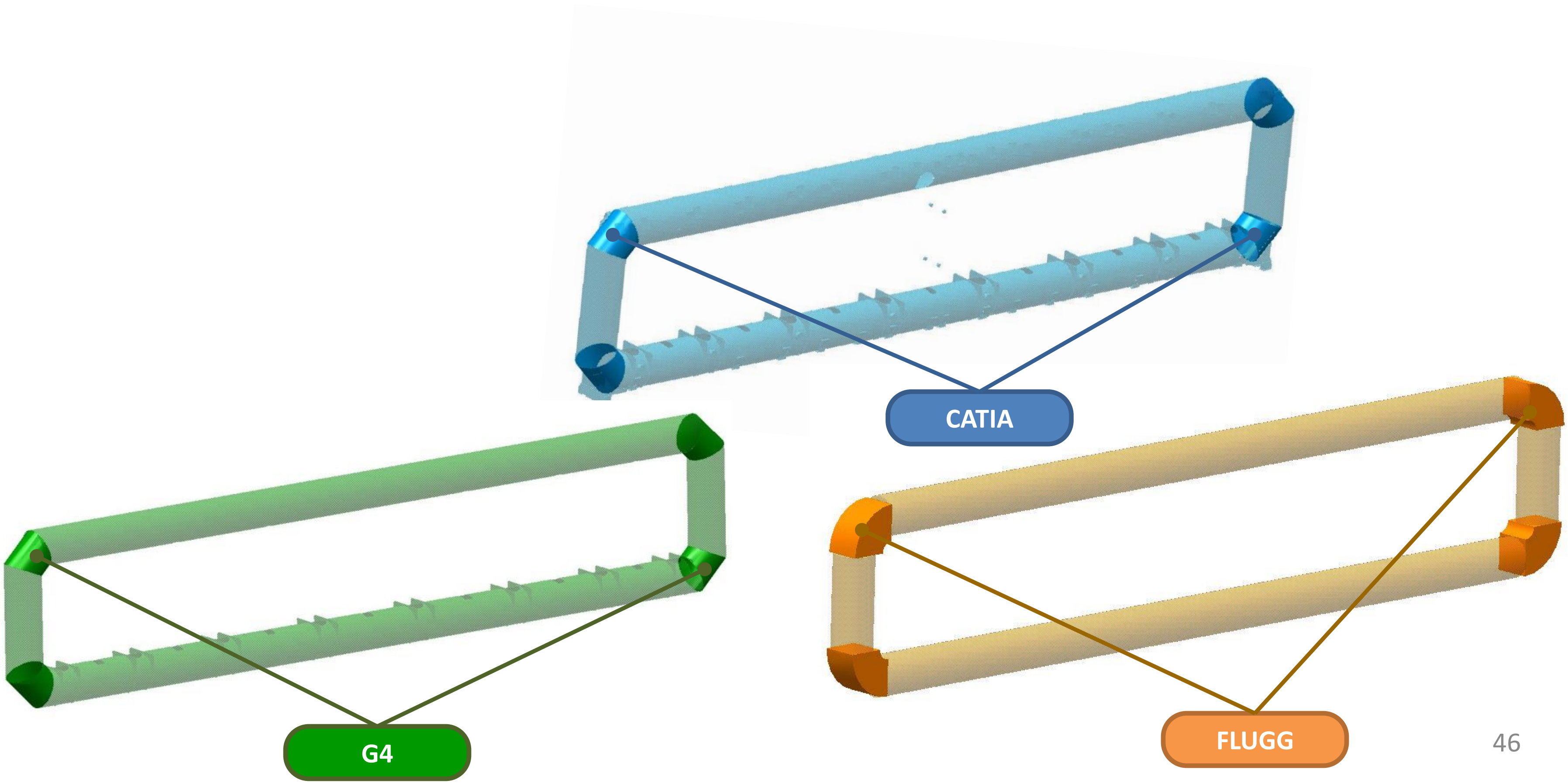
		Model	Material	Density (kg/m3)	Volume (m3)	Weight (kg)	Difference (kg)
Volume 1	*Cryostat Long (Top)*	**CATIA**	SSteel 304L	8000	1.261	**10088**	
		G4	Iron	7870	1.137	**8950**	-1138
		FLUGG	SSteel	7870	10.6815	**84065**	+73977



Coil Geometry Studies

Volume 2, 4, 6, 8 Cryostat Corner

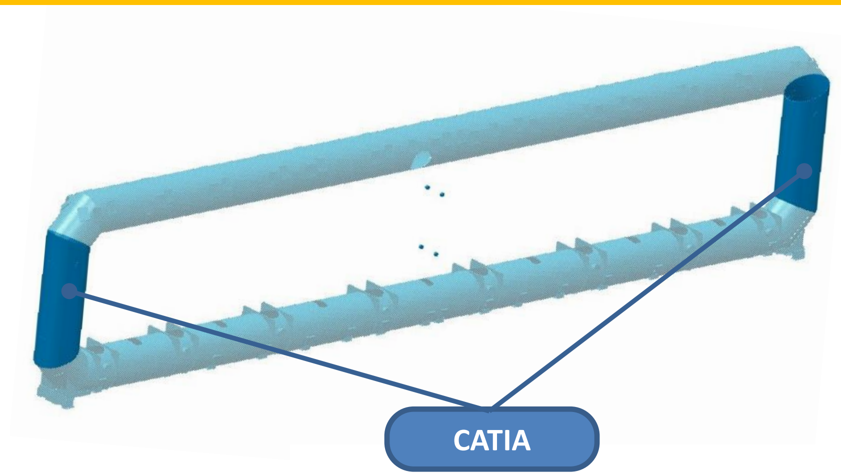
		Model	Material	Density (kg/m3)	Volume (m3)	Weight (kg)	Difference (kg)
Volume 2,4,6,8	*Cryostat Corner*	**CATIA**	SSteel 304L	8000	0.168	**1344**	
		G4	Iron	7870	0.169	**1330**	-14
		FLUGG	SSteel	7870	4.59	**36120**	+34776

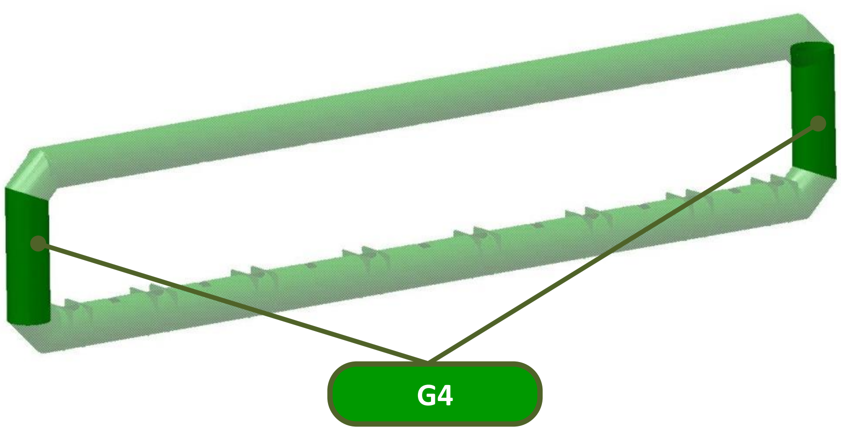


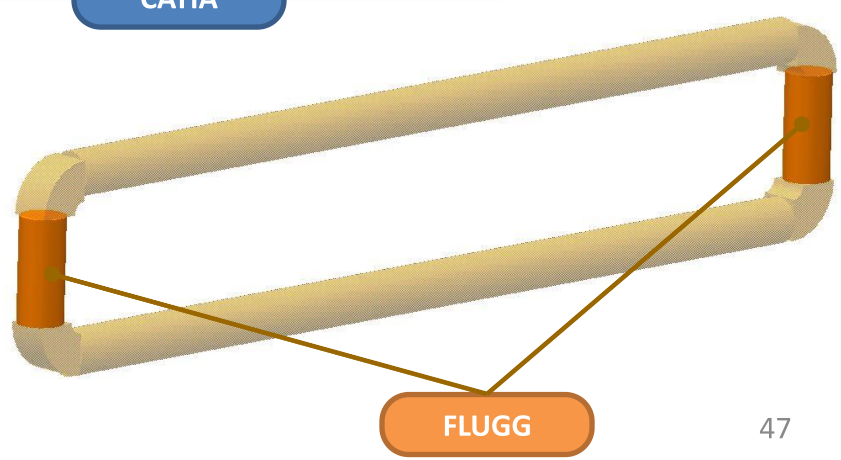
Coil Geometry Studies

Volume 3, 7 Cryostat Short

		Model	Material	Density (kg/m3)	Volume (m3)	**Weight (kg)**	Difference (kg)
Volume 3,7	*Cryostat Short*	**CATIA**	SSteel 304L	8000	0.338	**2704**	
		G4	Iron	7870	0.162	**2546**	-158
		FLUGG	SSteel	7870	2.41	**18990**	+16286



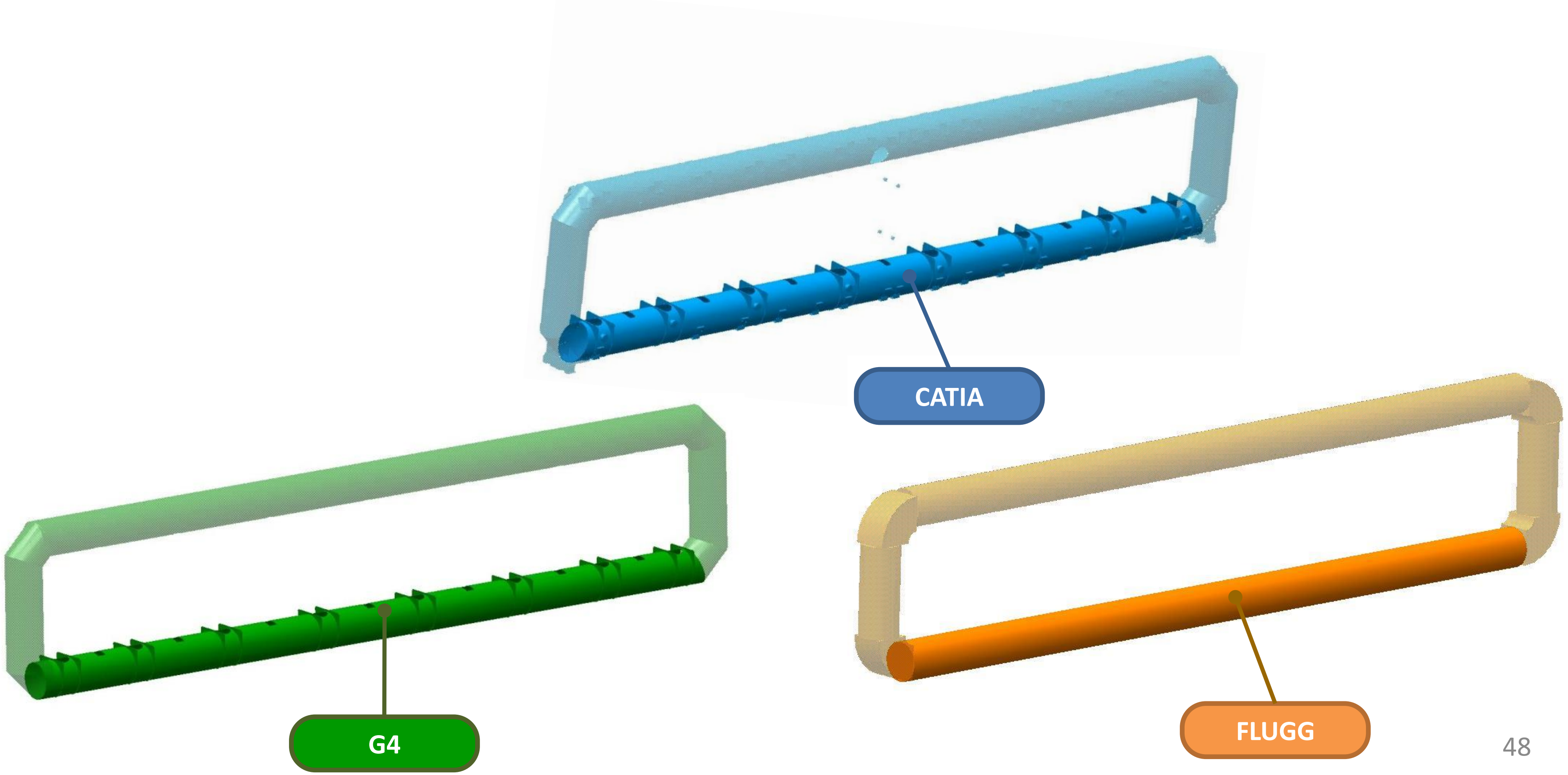




Coil Geometry Studies

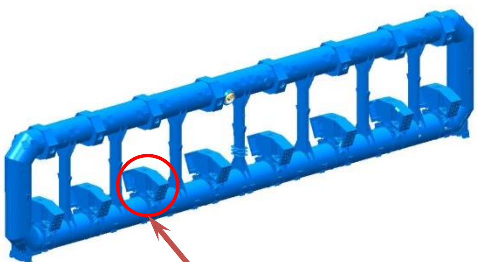
Volume 5 Cryostat Long (Bottom)

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

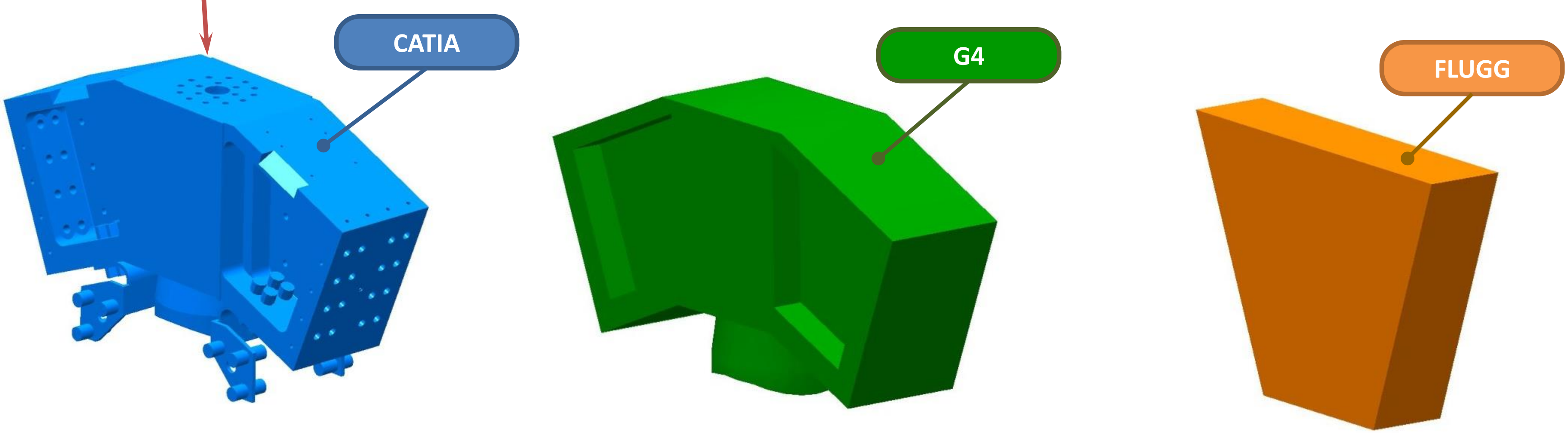


Volume 9 Voussoirs

		Model	Material	Density (kg/m3)	Volume (m3)	**Weight (kg)**	Difference (kg)
Volume 9	*Voussoirs*	**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



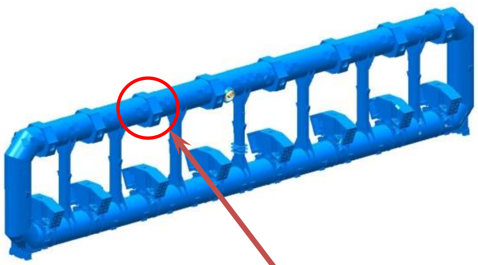
8 x Voussoirs

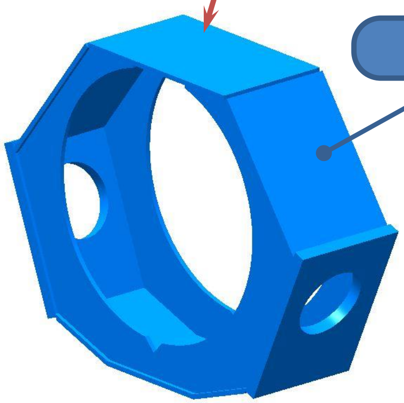


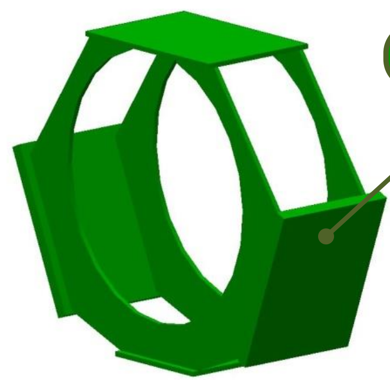
Coil Geometry Studies

<u>Volume 10</u> Steffiner

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





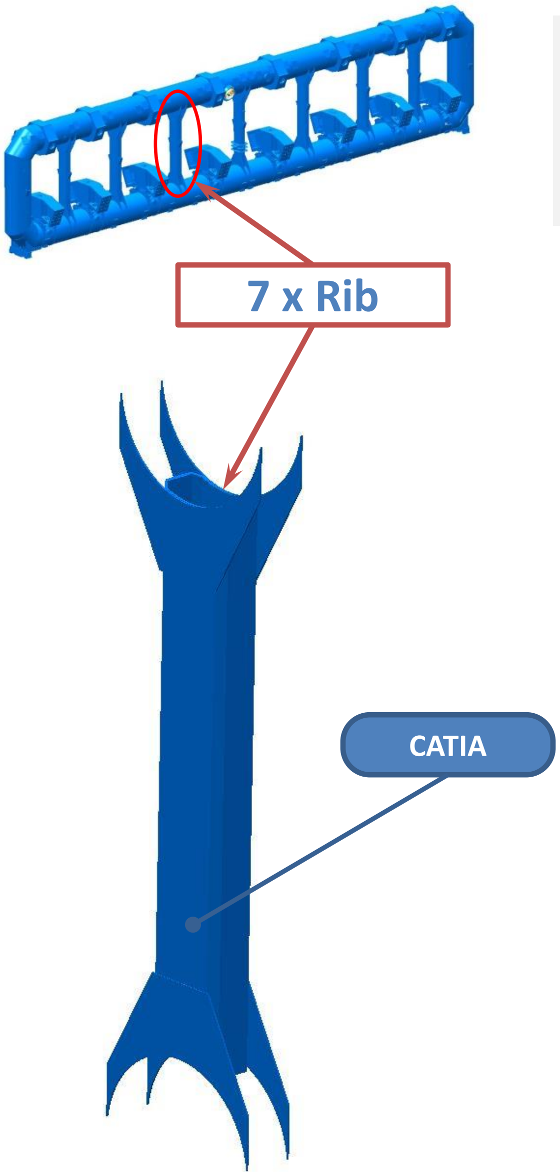


FLUGG

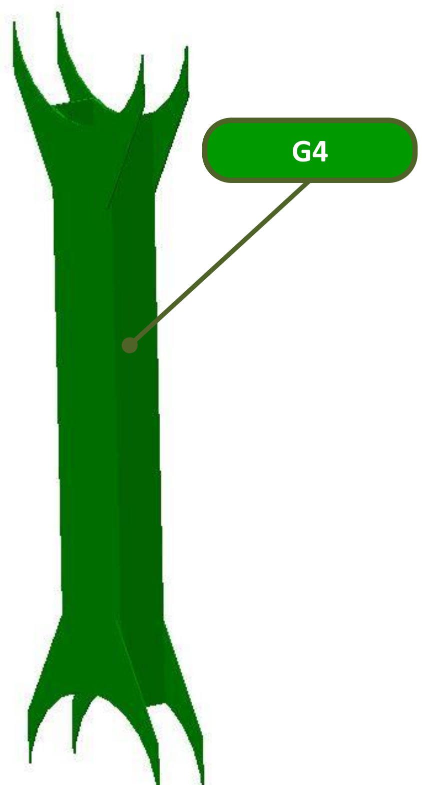
This volume has not included in FLUGG geometry

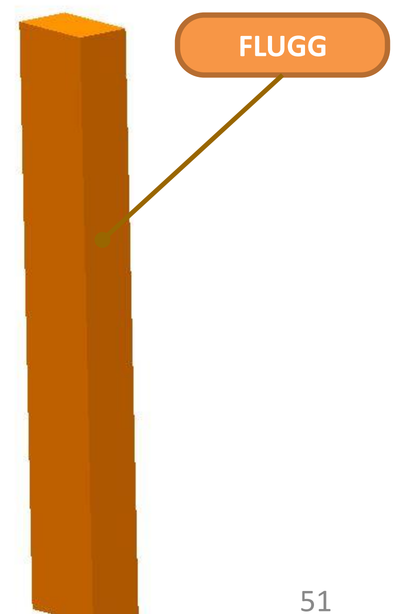
Coil Geometry Studies

<u>Volume 11</u> Rib



		Model	Material	Density (kg/m3)	Volume (m3)	**Weight (kg)**	Difference (kg)
Volume 11	*Rib*	**CATIA**	Ssteel 304L	8000	0.603	**4824**	
		G4	Iron	7870	0.454	**3576**	-1248
		FLUGG	Ssteel	7870	3.28	**25780**	+20956



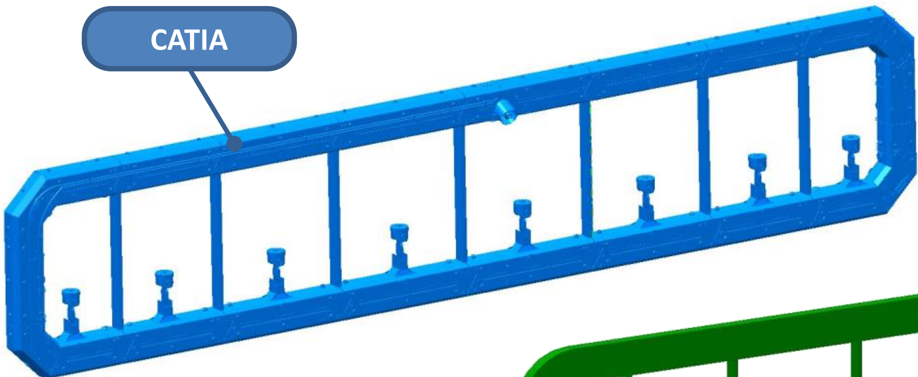


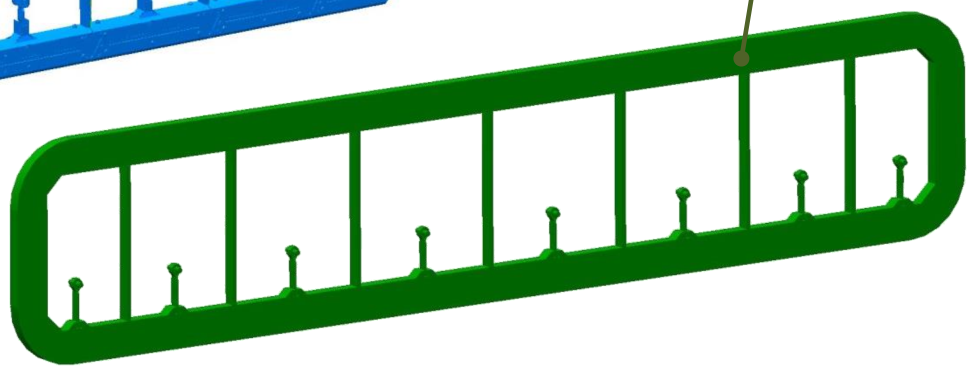
Coil Geometry Studies

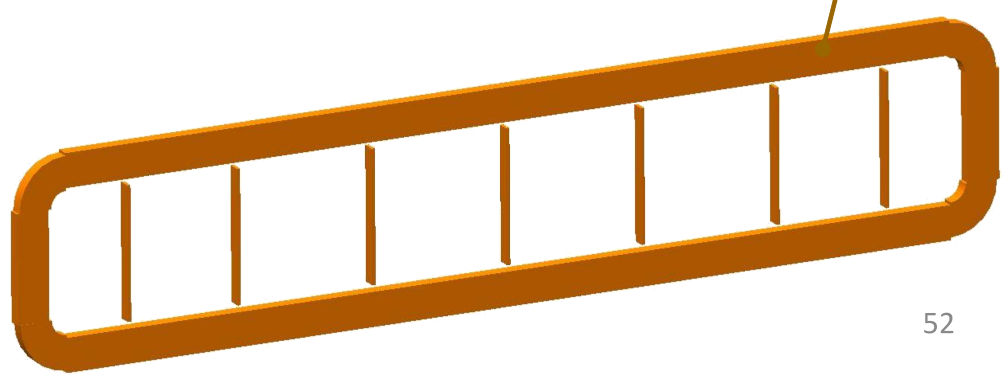
Volume 12 Inside of Coil

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

Simplification of CATIA volumes

Coil Geometry Studies

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

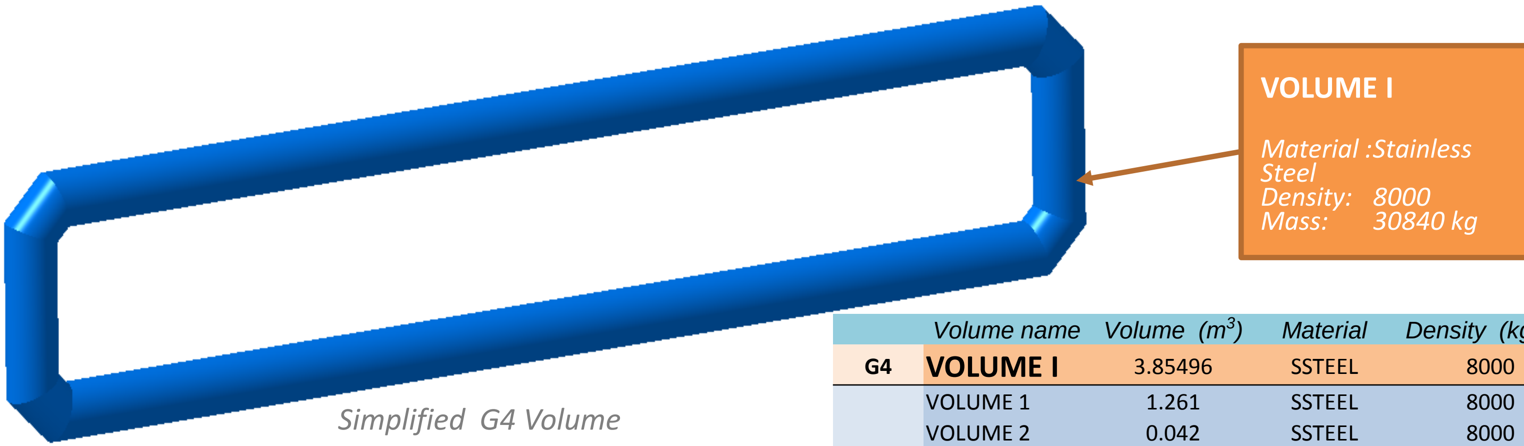
9 simplified volumes have been created from 21 CATIA volumes

Coil Geometry Studies

VOLUME I (External Part)

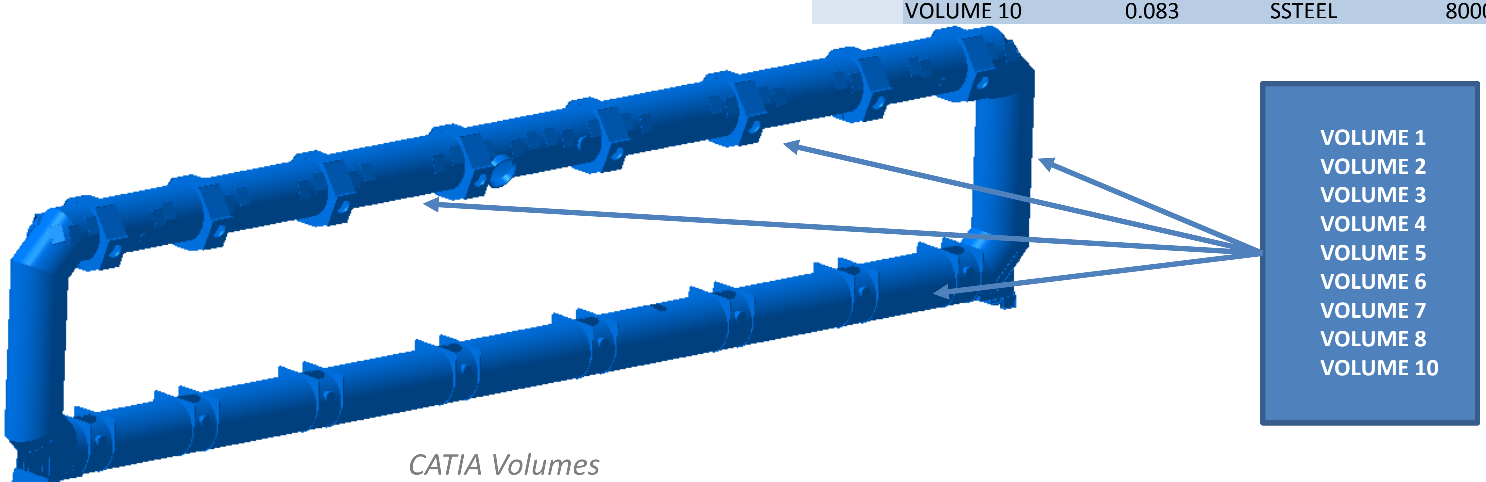
VOLUME I has been created by adding 9 CATIA volumes and simplification of shapes. Received difference in weight after simplification is 0.3kg

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



Simplified G4 Volume

	Volume name	Volume (m³)	Material	Density (kg/m³)	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	



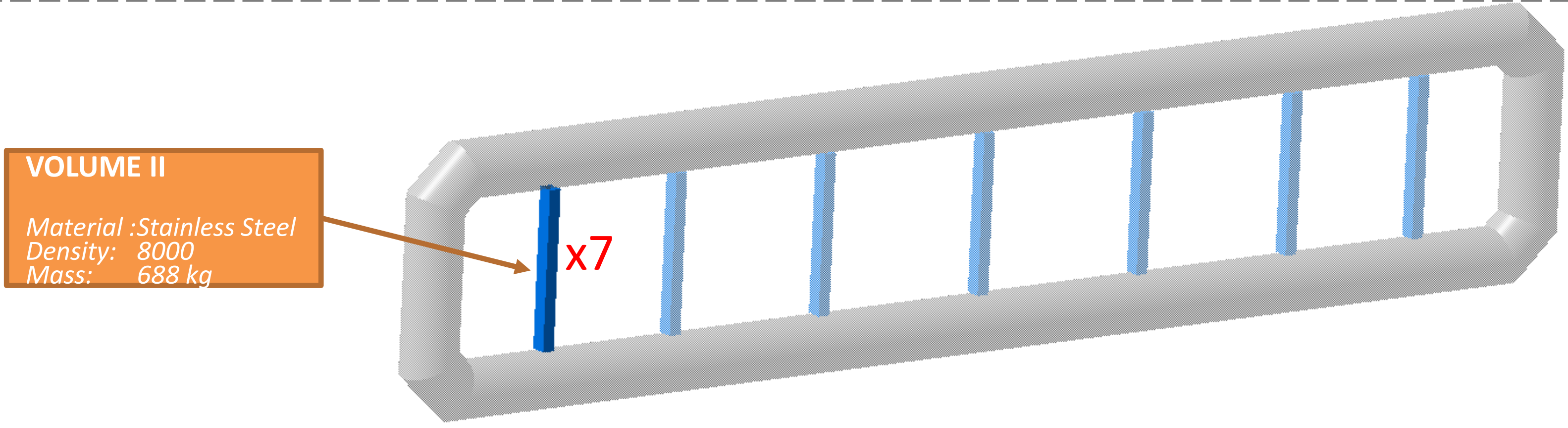
CATIA Volumes

Coil Geometry Studies

7 x VOLUME II (External Part)

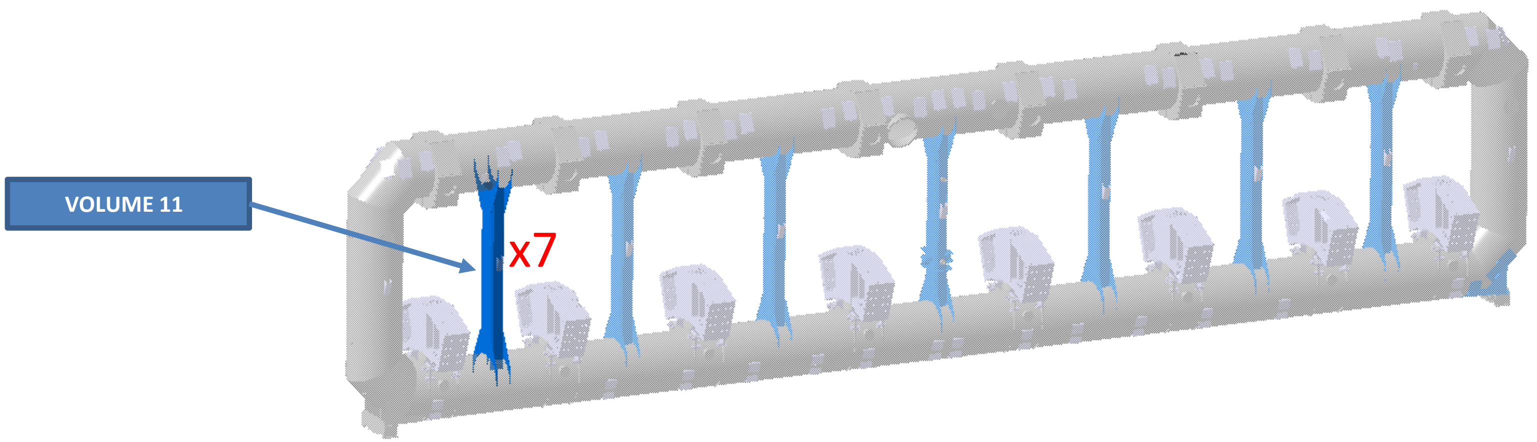
VOLUME II has been created by simplification of shape of CATIA Volume 11.

VOLUME II = Volume_11



Simplified G4 Volume

	Volume name	Volume (m³)	Material	Density (kg/m³)	Weight (kg)	Diff (kg)
G4	**VOLUME II**	0.086	SSTEEL	8000	688	0
CATIA	VOLUME 11	0.086	SSTEEL	8000	688	

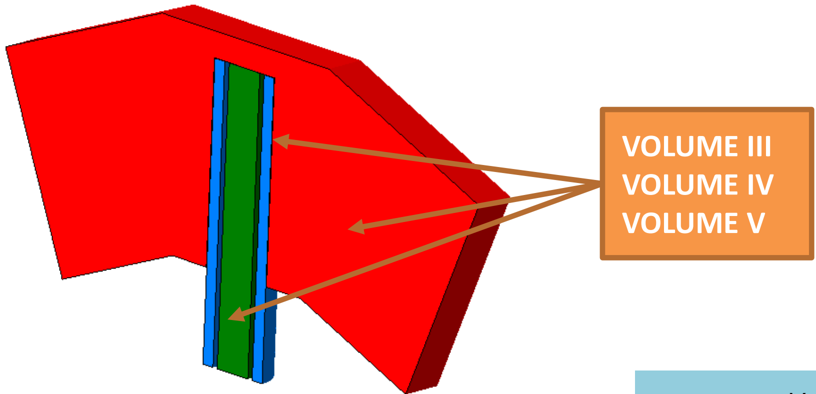


CATIA Volume

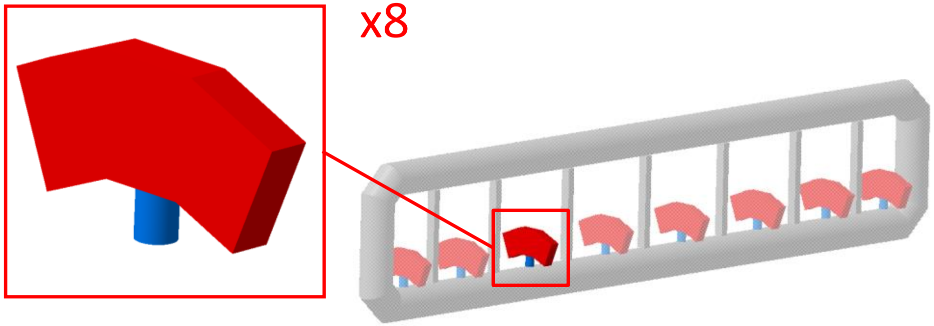
Coil Geometry Studies

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

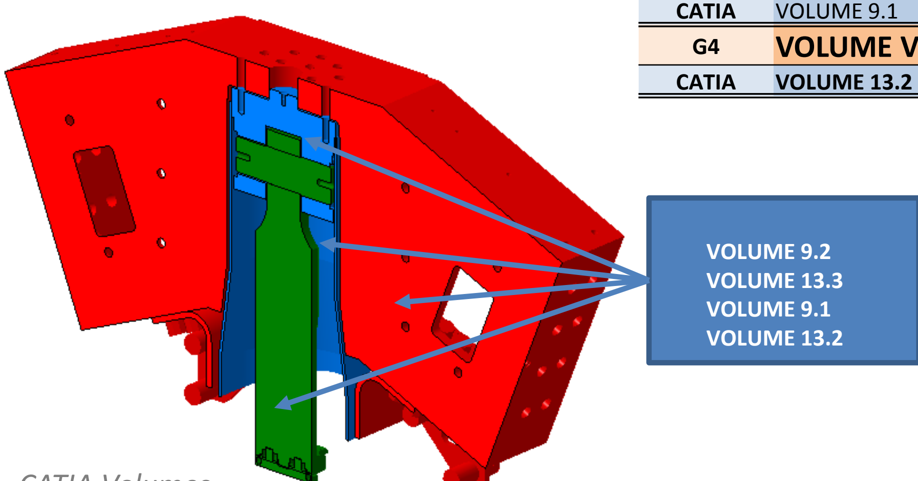
VOLUME's III, IV, and V have been created in 2 steps of synthesis described on slides below



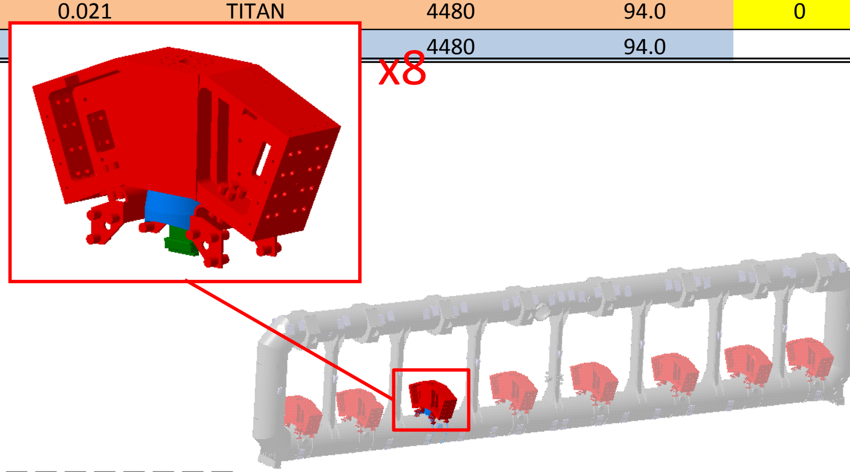
Simplified G4 Volume



	Volume name	Volume (m³)	Material	Density (kg/m³)	Weight (kg)	Diff (kg) Δ=Δ1 +Δ2
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**	[illegible]	[illegible]	4480	94.0	



CATIA Volumes



Coil Geometry Studies

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

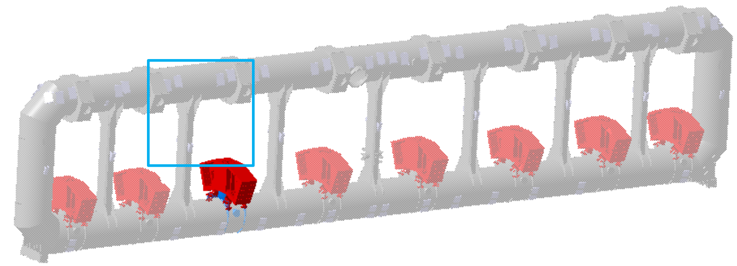
On the 1st step of synthesis CATIA volumes have been grouped by materials. Than for each grouped volume shape has been simplified

CATIA Volumes

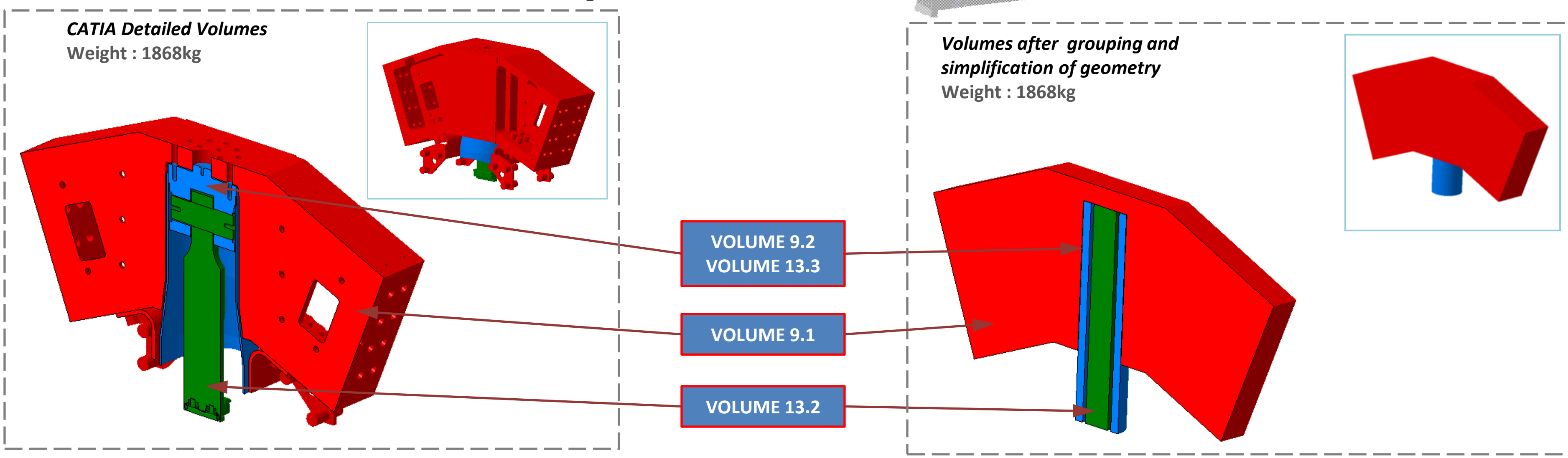
	Part Name	Material	Density	Volume (kg/m3)	*Weight (kg)*
Volume 9	Vossuoir	Aluminum	2650	0.537	1423
	Vossuoir	SSTEEL	8000	0.015	120
Volume 13	Tie rod	TA5E-ELI	4480	0.0160	72
	Lug (Tie rod)	Z3 CN18-10	8000	0.0280	224
	Shouldered axis	TA5E-ELI	4480	0.0050	22
	Small bar support	Z3 CN18-10	8000	0.0003	2
	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



Δ_1 = 1868kg – 1868kg = 0kg



Coil Geometry Studies

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

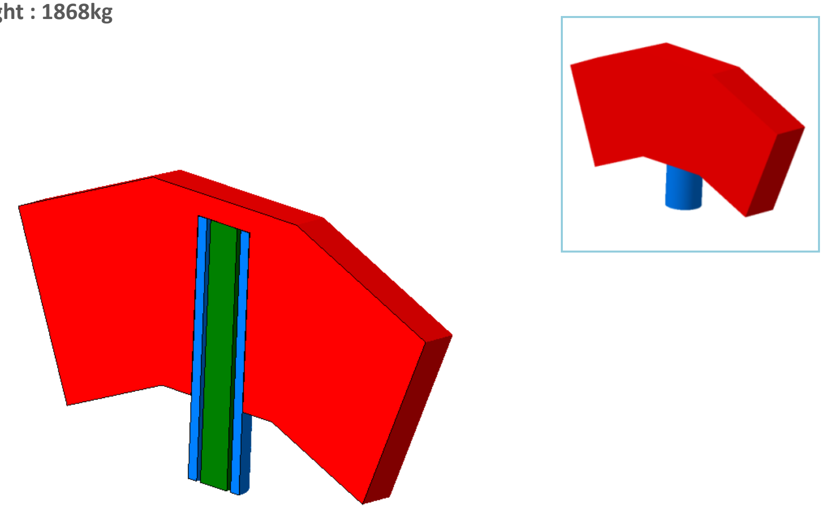
On the 2nd step of synthesis simplified volumes have been joined in one entire volume and shape again modified to avoid <u>overlaps</u> with other existing volumes

Volumes after 1st Step of Synthesis				
Volume name	*Material*	*Density (kg/m³)*	*Volume (m³)*	*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

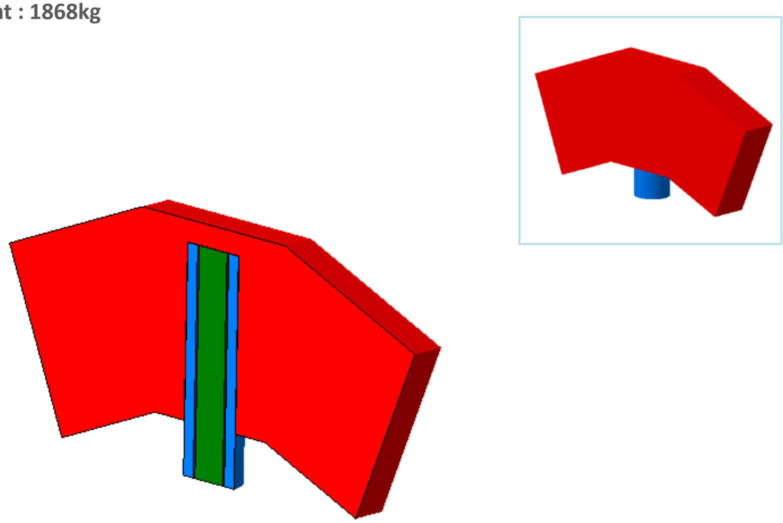
Volumes after joining and again modification of shape				
Volume name	*Material*	*Density (kg/m³)*	*Volume (m³)*	*Weight (kg)*
VOLUME III	Ssteel	8000	0.0436	349
VOLUME IV	Aluminum	2650	0.015	1423
VOLUME V	Titan	4480	0.021	94

Δ_2 = 1868kg – 1868kg = 0kg

Volumes after grouping and simplification of geometry
Weight : 1868kg



Volumes after joining and again simplification
Weight : 1868kg

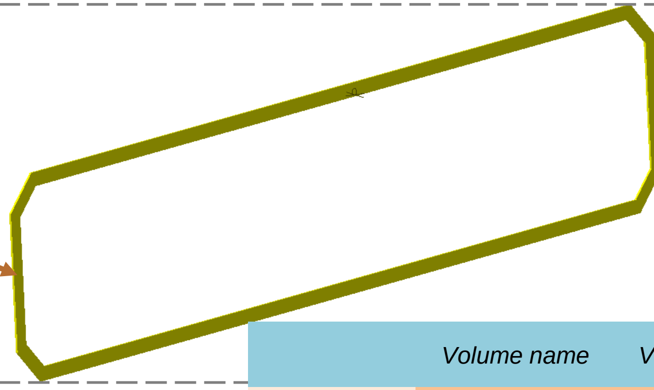


VOLUME VI (Internal Part)

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

VOLUME VI

Material :Aluminum
Density: 2740
Mass: 2997 kg

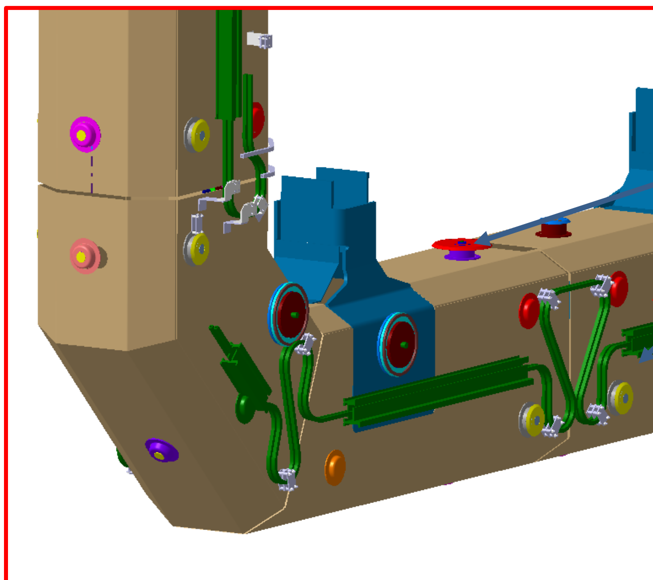


Simplified G4 Volume

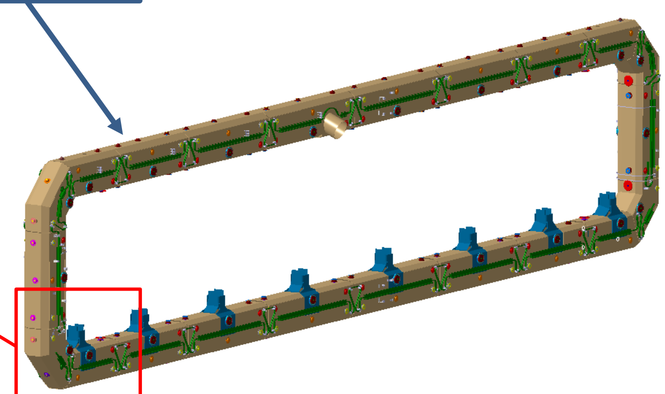
Multiple *	Density (kg/m^3)
Aluminum 7075 T73	2810
Aluminum mg 3	2670
Aluminum 5083 H111	2650
Aluminum 3003	2700
Aluminum 1050	2705
fibra de vetro	2600

	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	

CATIA Volumes



VOLUME 12
VOLUME 13.1
VOLUME 17.1
VOLUME 19.1



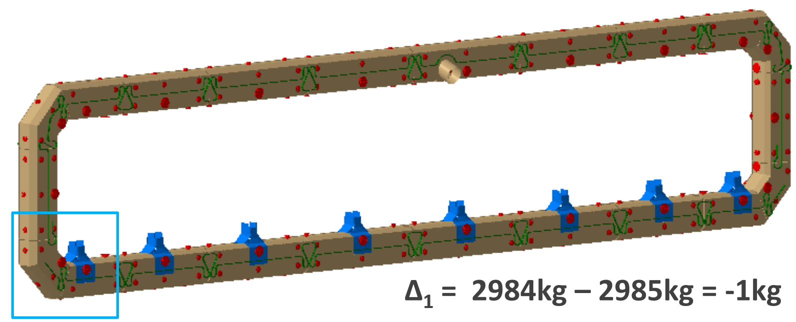
VOLUME VI (Internal Part) / 1st Step of synthesis

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

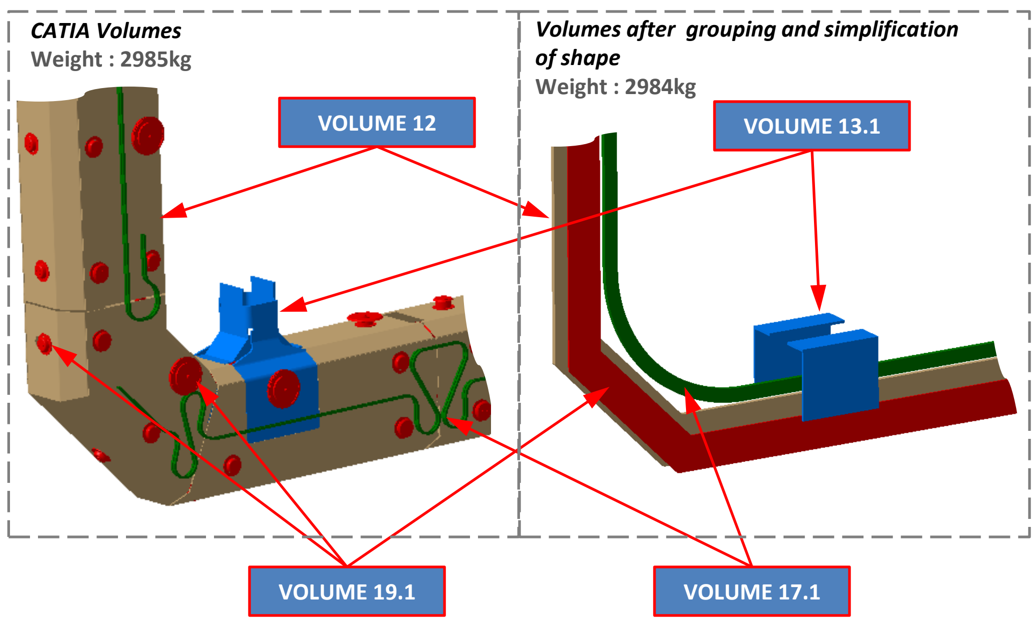
	Part Name	*Material*	*Density*	*Volume*	*Weight*
Volume 12	Thermal Shielding	3003.H22	2740	0.7373	2020
Volume 13	Tie rod	TA5E-ELI	4480	0.1280	573
	Lug (Tie rod)	Z3 CN18-10	8000	0.2240	1792
	Shouldered axis	TA5E-ELI	4480	0.0400	179
	Small bar support	Z3 CN18-10	8000	0.0024	19
	Piston (Tie rod)	Z3 CN18-10	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
	Tie-Rod Therm. Plate	Al 1050 H22	2705	0.1200	325
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	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



Δ_1 = 2984kg – 2985kg = -1kg



Coil Geometry Studies

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

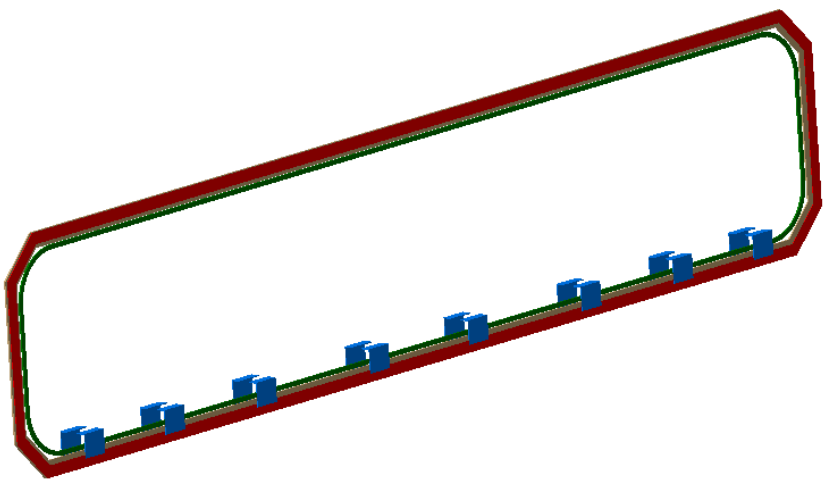
On the 2nd step of synthesis simplified volumes have been joined in one entire volume; average density has been assigned and shape again simplified

Volumes after 1st 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

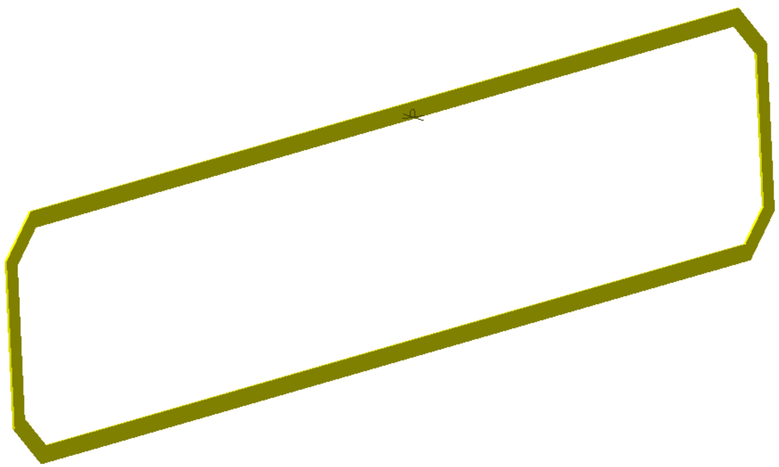
Volumes after joining and again simplification				
Volume name	*Volume (m^3)*	*Material*	*Density (kg/m^3)*	*Weight (kg)*
VOLUME VI	1.09384	Aluminum	2740	2997

$$\Delta_2 = 2997kg - 2984kg = +13kg$$

Volumes after 1st Step of synthesis
Weight : 2984kg



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

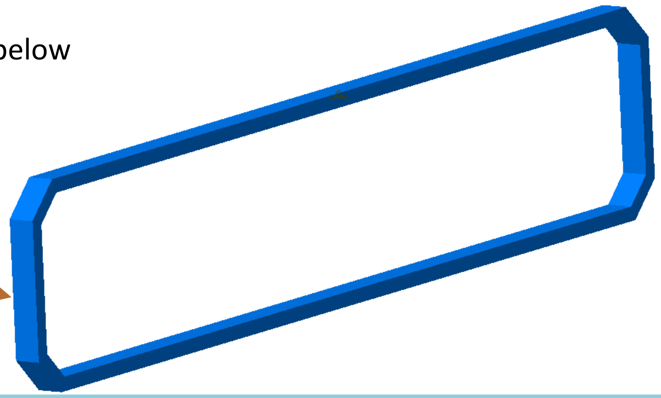


VOLUME VII (Internal Part)

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

VOLUME VII

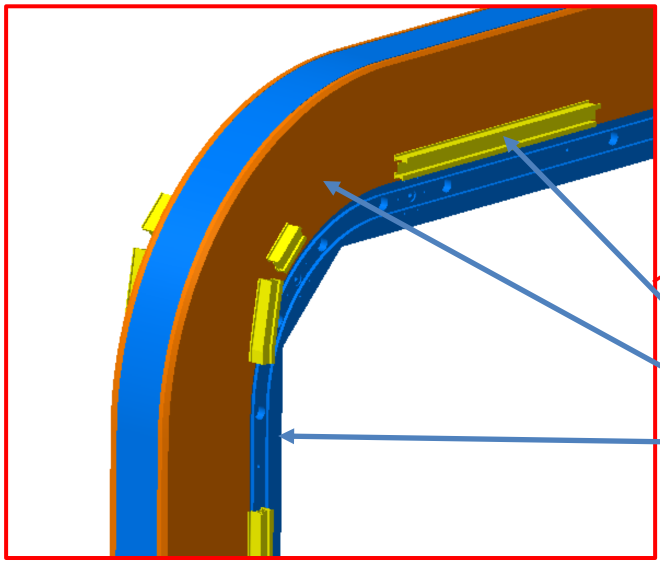
Material :Aluminum
Density: 2650
Mass: 35637 kg

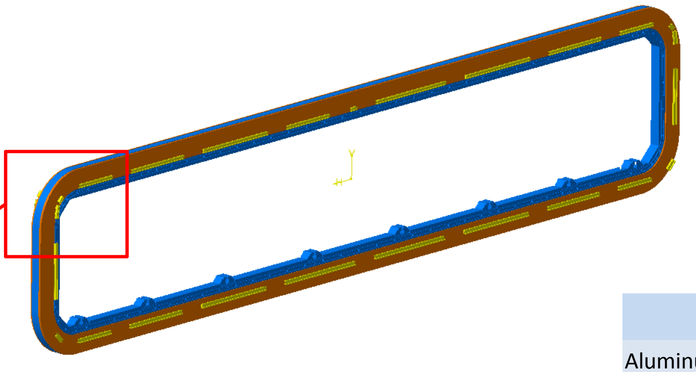


G4 Volume

CATIA Volume

	Volume name	*Volume (m³)*	*Material*	*Density (kg/m³)*	*Weight (kg)*	*Diff (kg) Δ=Δ1 +Δ2*
G4	**VOLUME VII**	13.448	Aluminum	2650	35637	-14
CATIA	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	





VOLUME 14
VOLUME 15
VOLUME 16
VOLUME 18

Multiple *	Density (kg/m³)
Aluminum 7075 T73	2810
Aluminum mg 3	2670
Aluminum 5083 H111	2650
Aluminum 3003	2700
Aluminum 1050	2705
fibra de vetro	2600

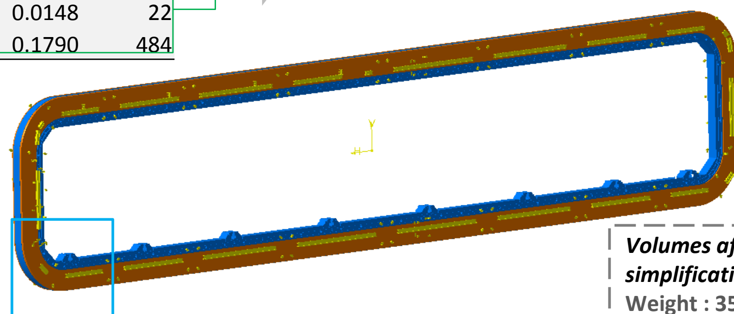
Coil Geometry Studies

VOLUME VII (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

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



Δ_1 = **35656kg – 35652kg = +4kg**

CATIA Detailed Volumes
Weight : 35652kg

Volumes after grouping and simplification of geometry
Weight : 35656kg

Coil Geometry Studies

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

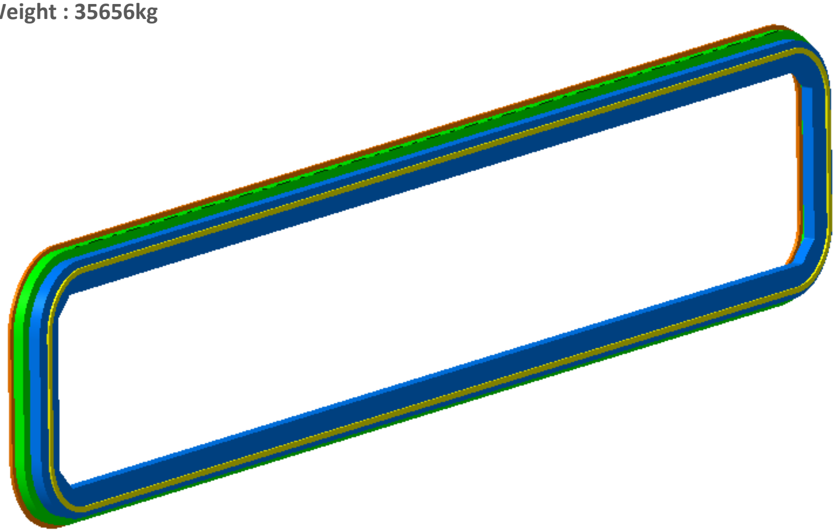
Volumes after 1st Step of synthesis				
Volume name	*Material*	*Density (kg/m^3)*	*Volume (m^3)*	*Weight (kg)*
VOLUME 14	Aluminum	2650	0.7373	18576
VOLUME 15	Aluminum	2660	0.015	4964
VOLUME 16	Aluminum	2650	0.064	11572
VOLUME 18	Aluminum	2650	0.172448	543

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

Δ_2 = 35637kg – 35656kg = -19kg

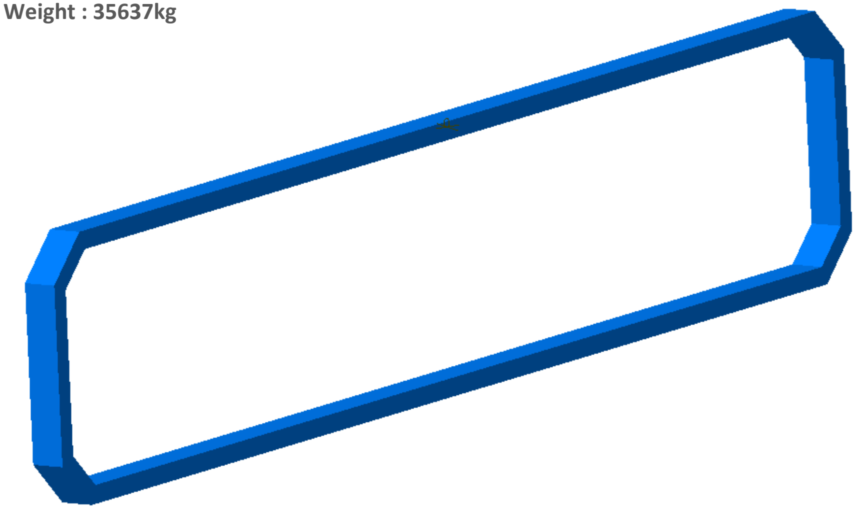
Volumes after grouping and simplification of geometry

Weight : 35656kg



Volumes after joining and again simplification

Weight : 35637kg



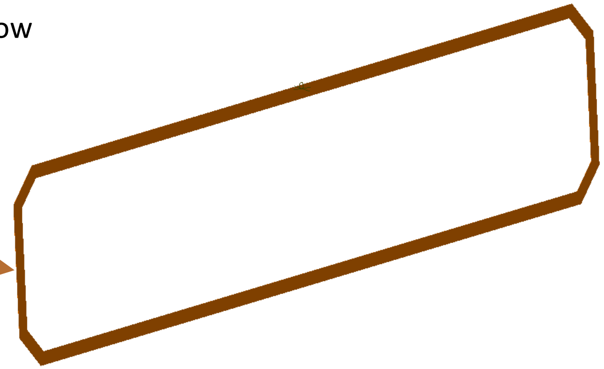
Coil Geometry Studies

VOLUME VIII (Internal Part)

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

VOLUME VIII

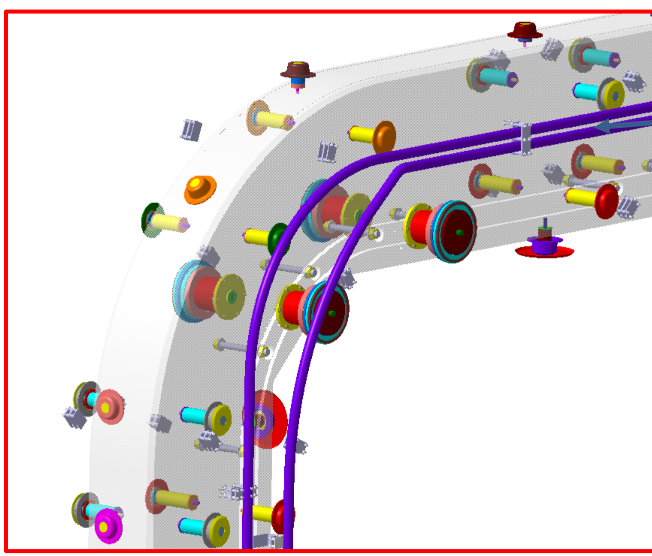
Material :Stainless Steel
Density: 8000
Mass: 632 kg



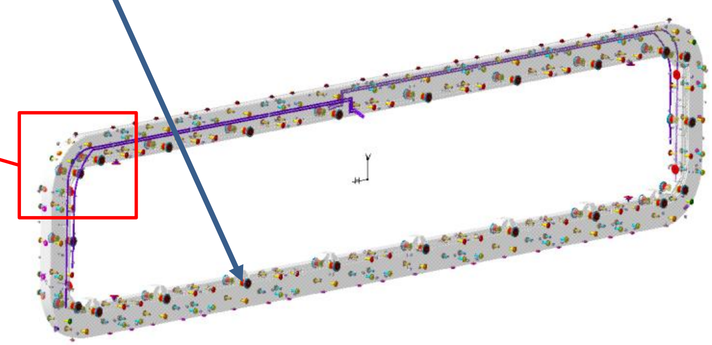
G4 Volume

CATIA Volumes

	Volume name	*Volume (m^3)*	*Material*	*Density (kg/m^3)*	*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



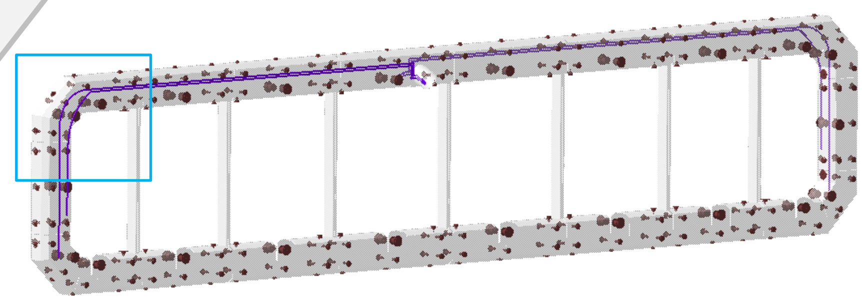
Coil Geometry Studies

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

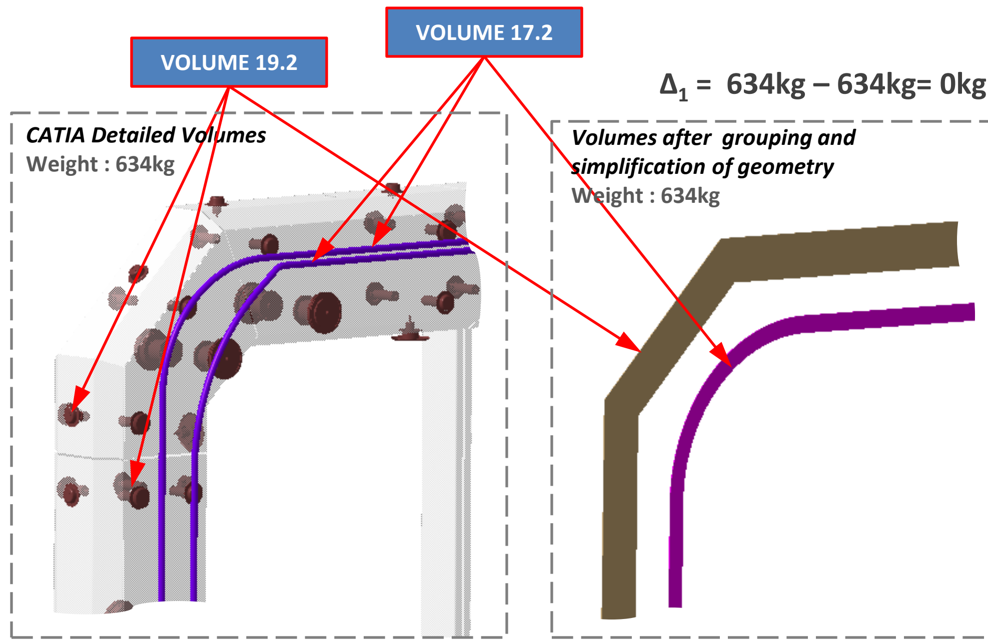
On the 1st step of synthesis CATIA volumes have been grouped by materials. Than for each grouped volume shape has been simplified

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

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



Δ_1 = 634kg – 634kg= 0kg



Coil Geometry Studies

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

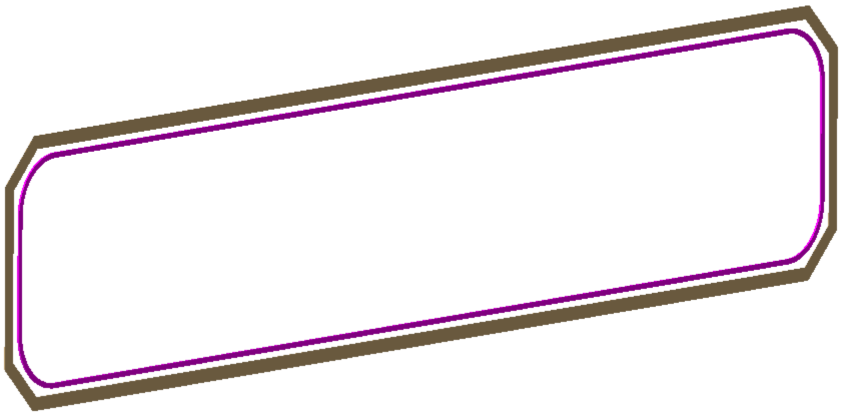
On the 2nd step of synthesis simplified volumes have been joined in one entire volume; average density has been assigned and geometry again simplified

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

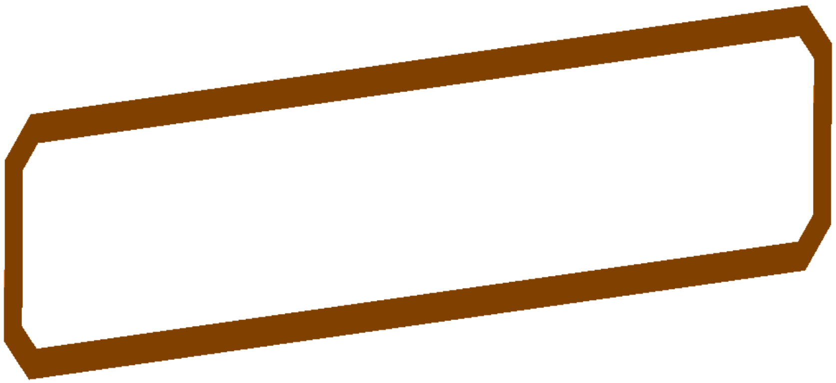
Volumes after joining and again simplification				
Volume name	*Material*	*Density (kg/m^3)*	*Volume (m^3)*	*Weight (kg)*
VOLUME VIII	SSteel	8000	0.0335	632

Δ_2 = 632kg – 634kg = -2kg

Volumes after grouping and simplification of geometry
Weight: 634kg



Volumes after joining and again simplification
Weight: 632kg



Coil Geometry Studies

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

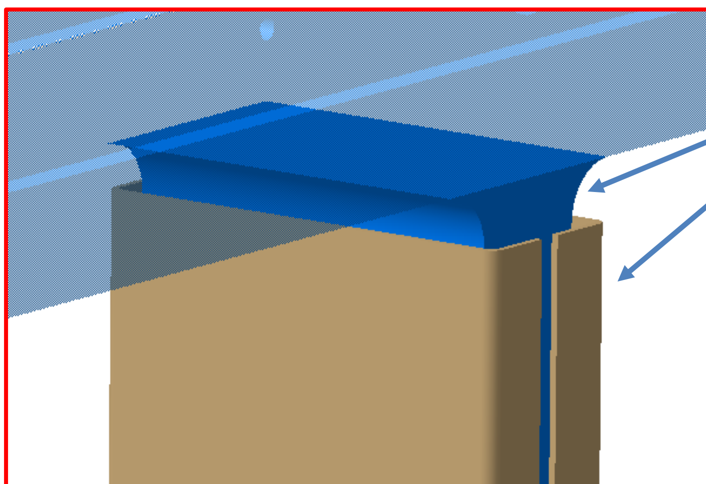
G4 Volume

VOLUME IX

Material :Aluminum
Density: 2650
Mass: 306 kg

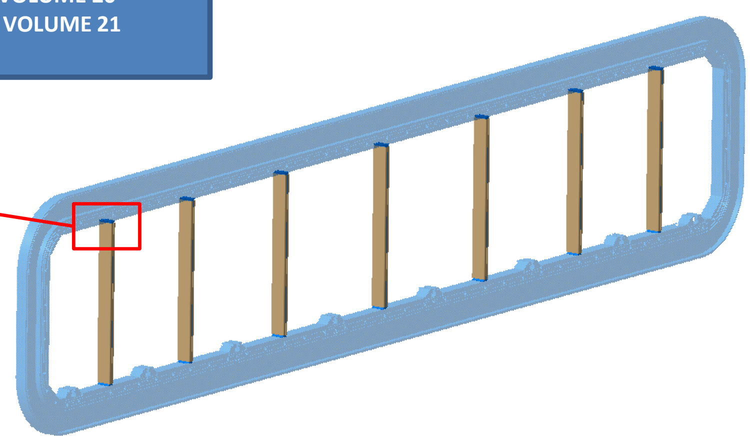
	Volume name	*Volume (m^3)*	*Material*	*Density (kg/m^3)*	*Weight (kg)*	*Diff (kg) $\Delta = \Delta_1 + \Delta_2$*
Simplified	**VOLUME IX**	0.8075	Aluminum	2650	2141	-8
Detail	VOLUME 20	0.1007	Aluminum	2740	276	
	VOLUME 21	0.7068	Aluminum	2650	1873	

CATIA Volume



7 x

VOLUME 20
VOLUME 21



Coil Geometry Studies

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

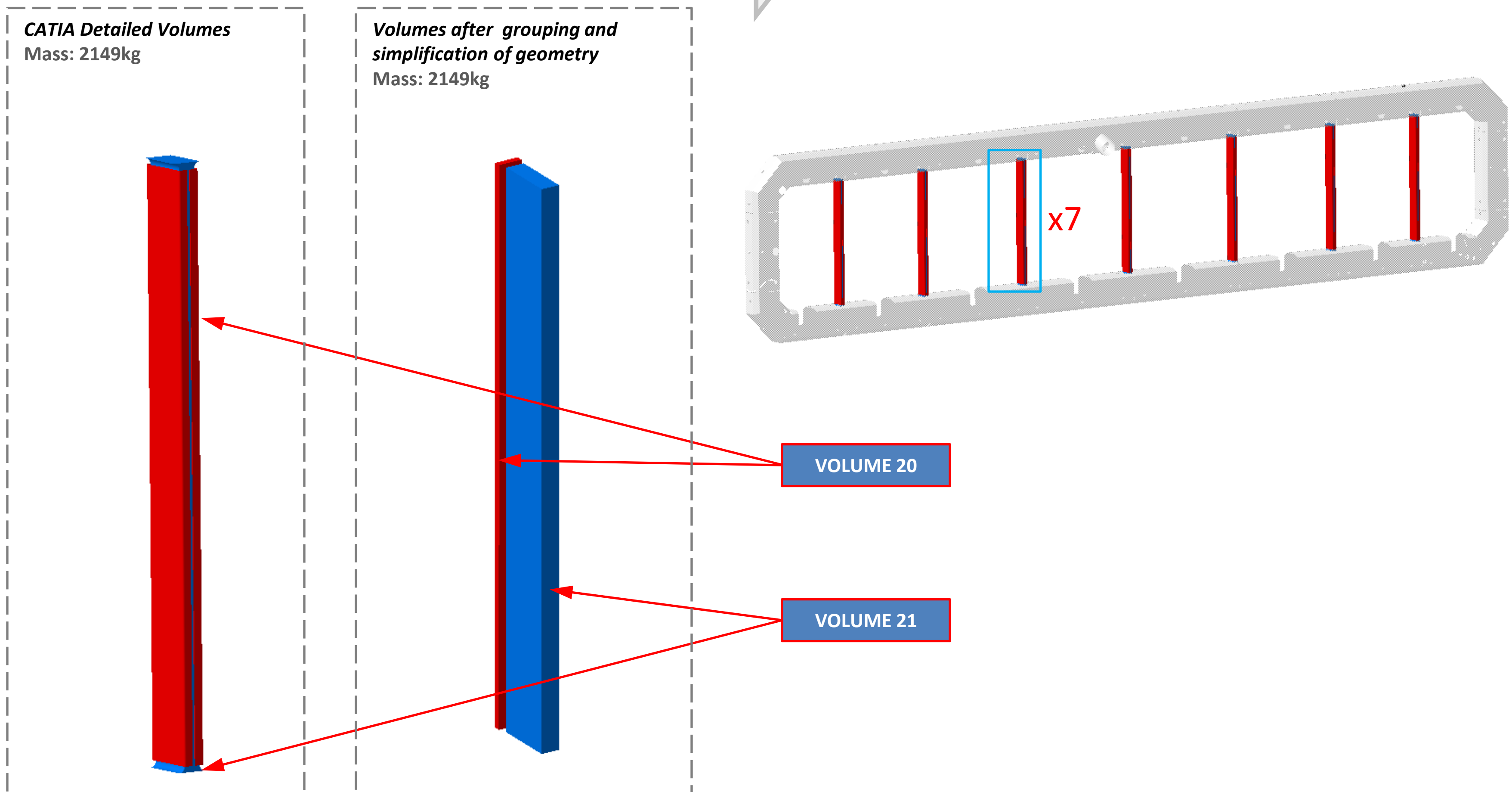
CATIA Detailed Volumes (see Coil Weight Analysis V3.2.pdf)

	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

Δ_1 = 2149kg – 2149kg = 0kg



Coil Geometry Studies

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

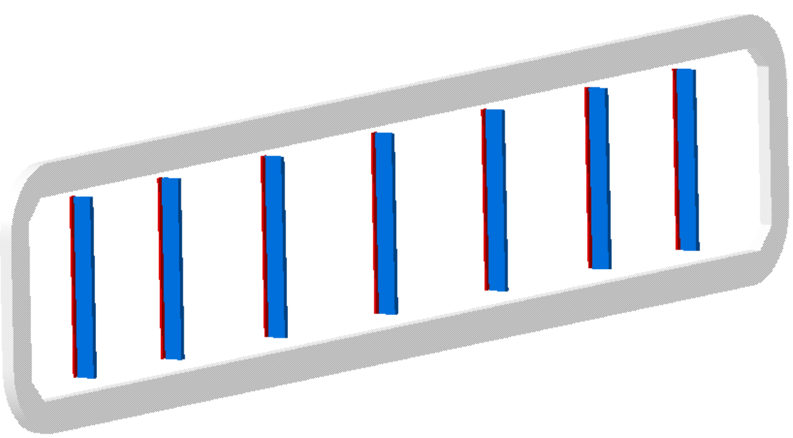
On the 2nd step of synthesis CATIA volumes have been joined in one entire volume; average density has been assigned and shape again simplified

Volumes after grouping and simplification of geometry				
Volume name	*Material*	*Density (kg/m³)*	*Volume (m³)*	*Weight (kg)*
VOLUME 20	Aluminum	2740	0.1007	276
VOLUME 21	Aluminum	2650	0.7068	1873

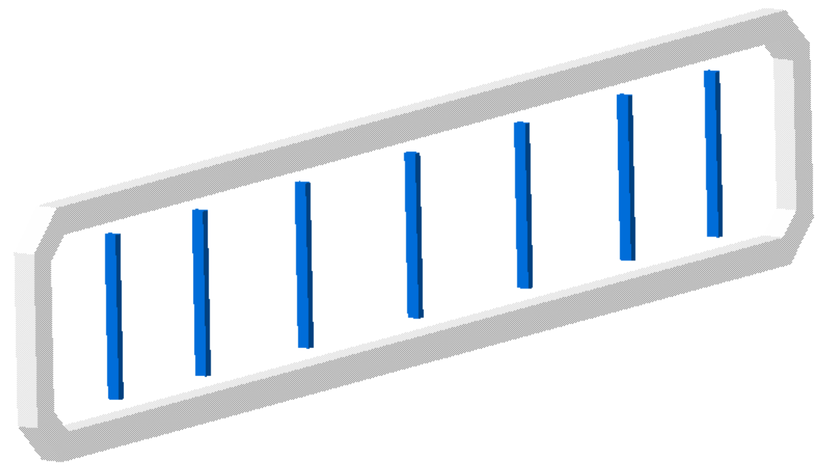
Volumes after joining and again simplification				
Volume name	*Material*	*Density (kg/m³)*	*Volume (m³)*	*Weight (kg)*
VOLUME IX	Aluminum	2740	0.807	2141

Δ_2 = 2141kg – 2149kg = -8kg

Volumes after grouping and simplification of geometry
Weight : 2149kg



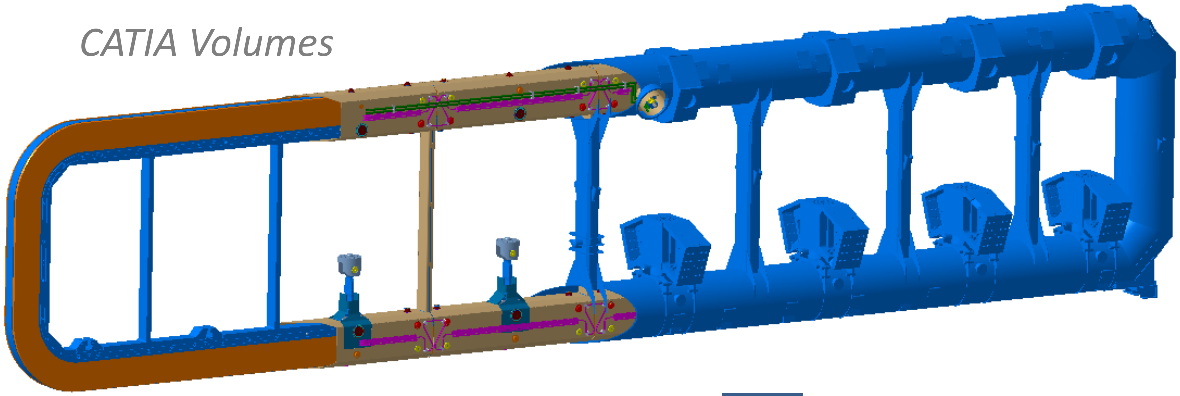
Volumes after joining and again simplification
Weight : 2141kg



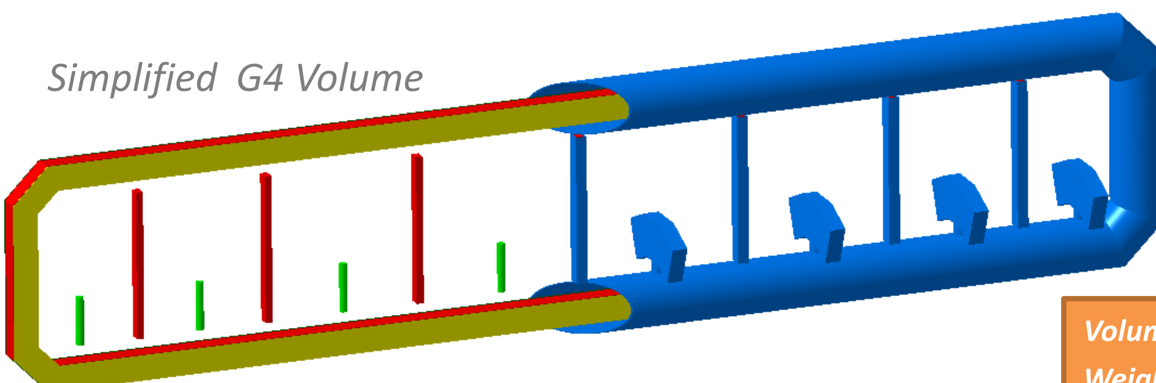
Coil Geometry Studies

Final Results of Simplification:

CATIA Volumes



Simplified G4 Volume



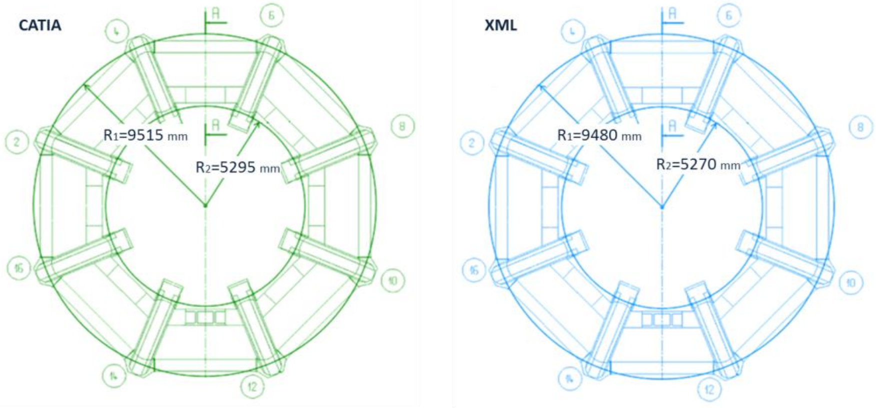
Volume:	***24.7 m3***	
Weight :	***92031kg***	
Volume:	***24.75 m3***	
Weight :	***92130kg***	

Difference:

Volume: ***0.05 m3***
Weight : ***99kg***

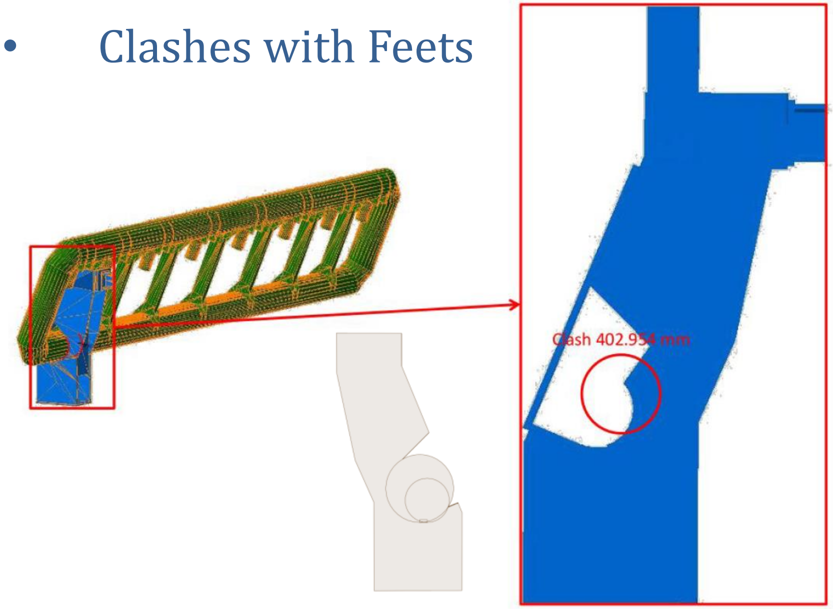
Integration Conflicts Checking

- COIL's + Warm Structure Displacement

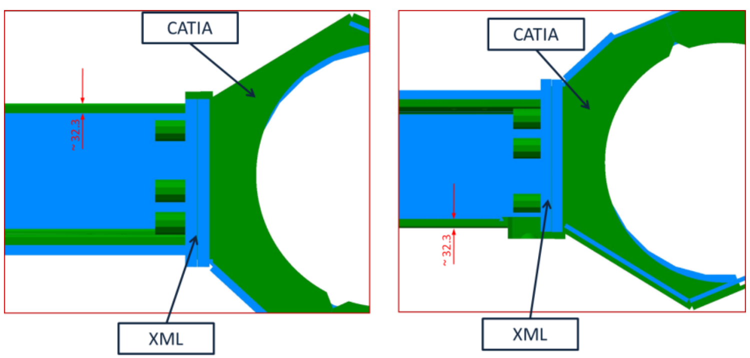


$\Delta_{R1} = R1|_{CATIA} - R1|_{XML} = 9515\ mm - 9480\ mm = 35\ mm$
$\Delta_{R1} = R2|_{CATIA} - R2|_{XML} = 5295\ mm - 5270\ mm = 25\ mm$

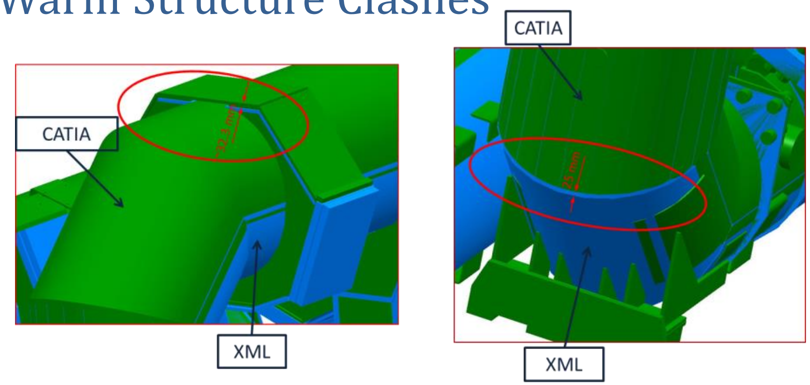
- Clashes with Feets



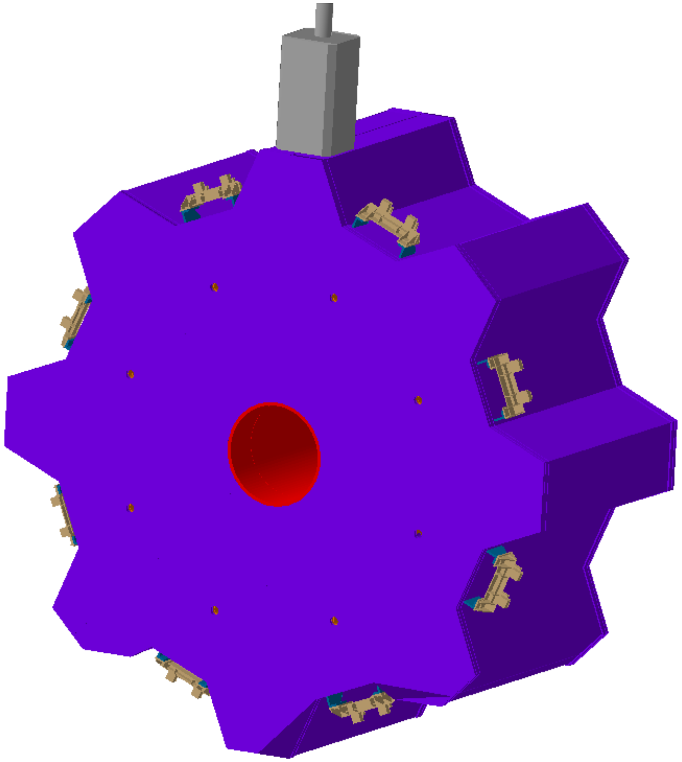
- Warm Structure Clashes



- Warm Structure Clashes



Integration Conflicts Checking

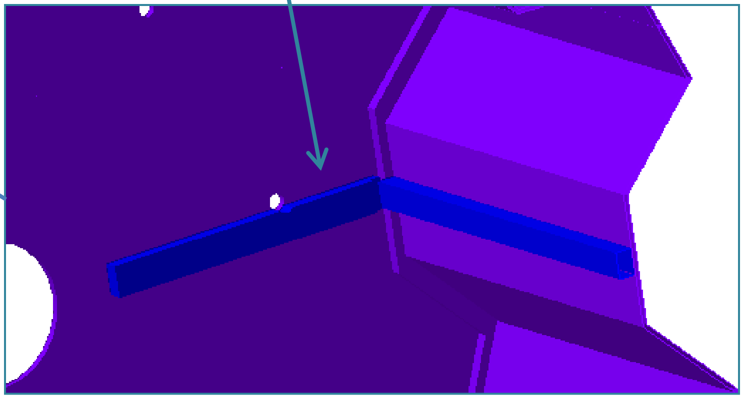


	Geometry I	Geometry II	Type	Value (mm)
1	Attachment	EV_AlignTube	Contact	0
2	Attachment	EV_Envelop	Contact	0
3	Attachment	Ring	Clash	-94.3
4	Cryo_Stop_Inside	EV_Envelop	Clash	-4.7
5	Cryo_Stop_Outside	EV_Envelop	Clash	-2.44
6	ECT_ColdMass	TS_CentralTub	Clash	-0.42
7	EV_AlignTube	EV_Envelop	Contact	0
8	EV_CentralTube	EV_Envelop	Clash	-7.98
9	EV_CentralTube	Ring	Contact	0
10	EV_Envelop	ServTur	Clash	-0.11
11	ServiTower	ServTur	Contact	0

Integration Conflicts Checking

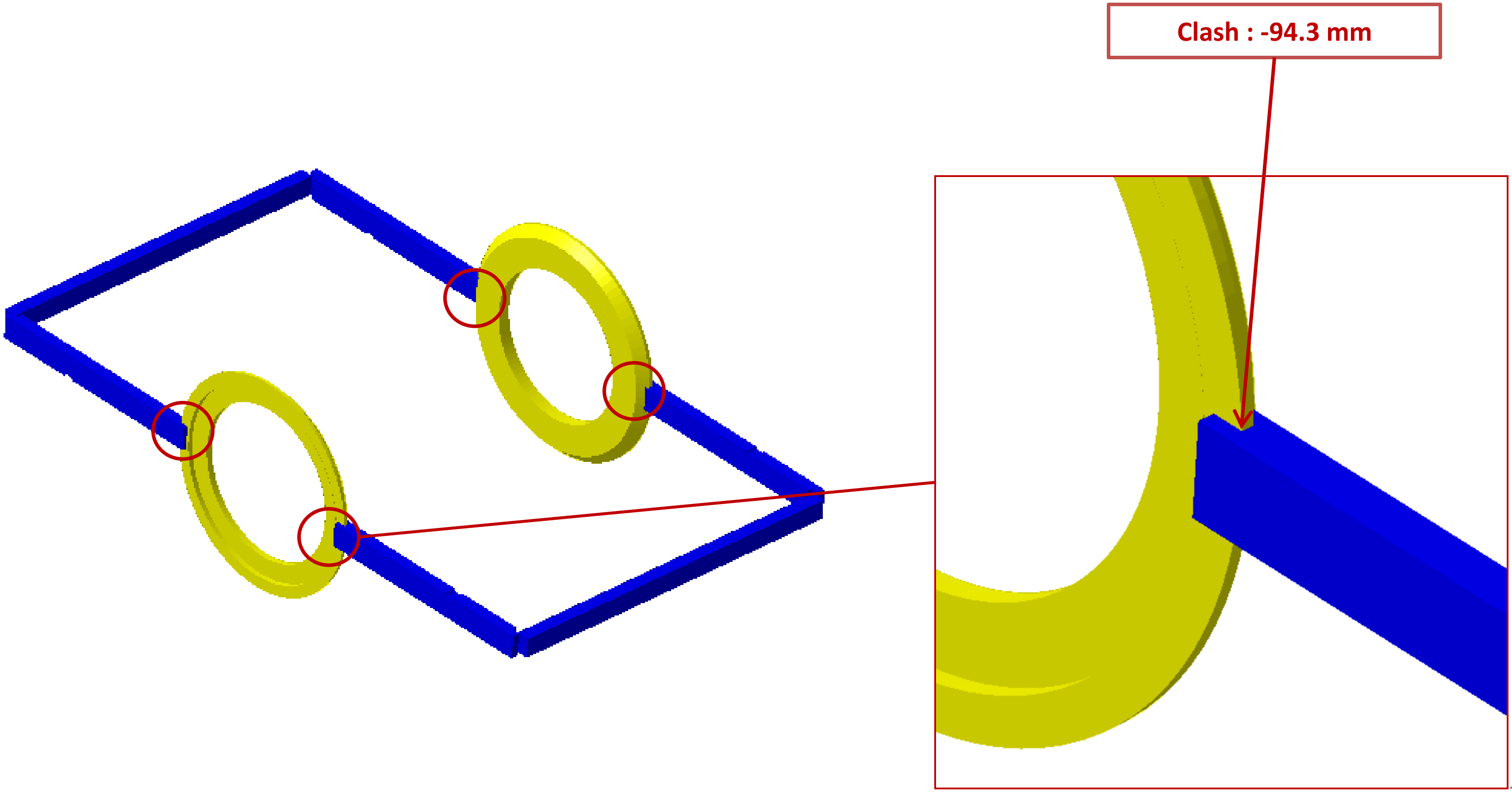
	Geometry I	Geometry II	Type	Value (mm)
2	Attachment	EV_Envelop	Contact	0

Contact



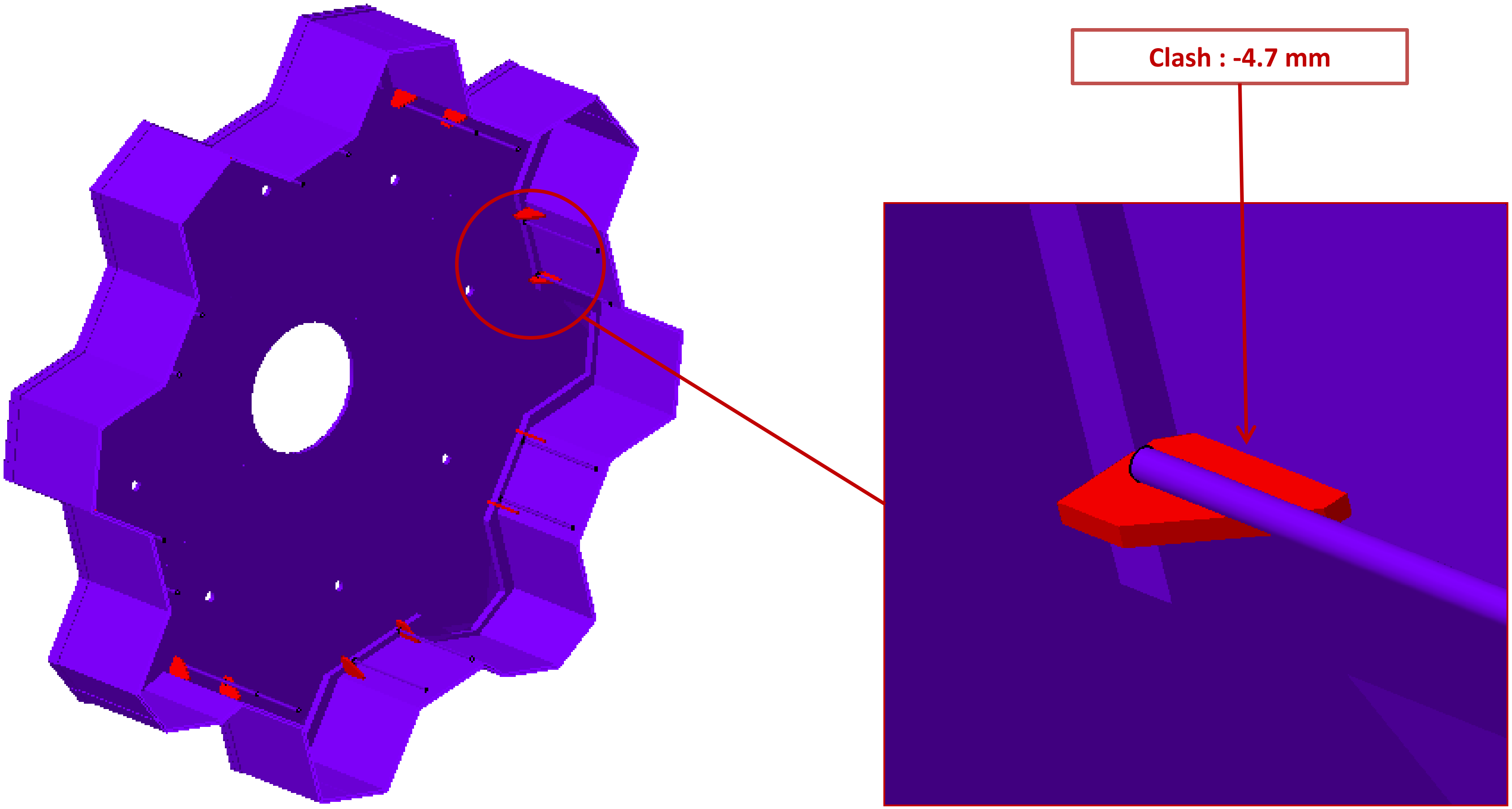
Integration Conflicts Checking

	Geometry I	Geometry II	Type	Value (mm)
3	Attachment	Ring	**Clash**	**-94.3**



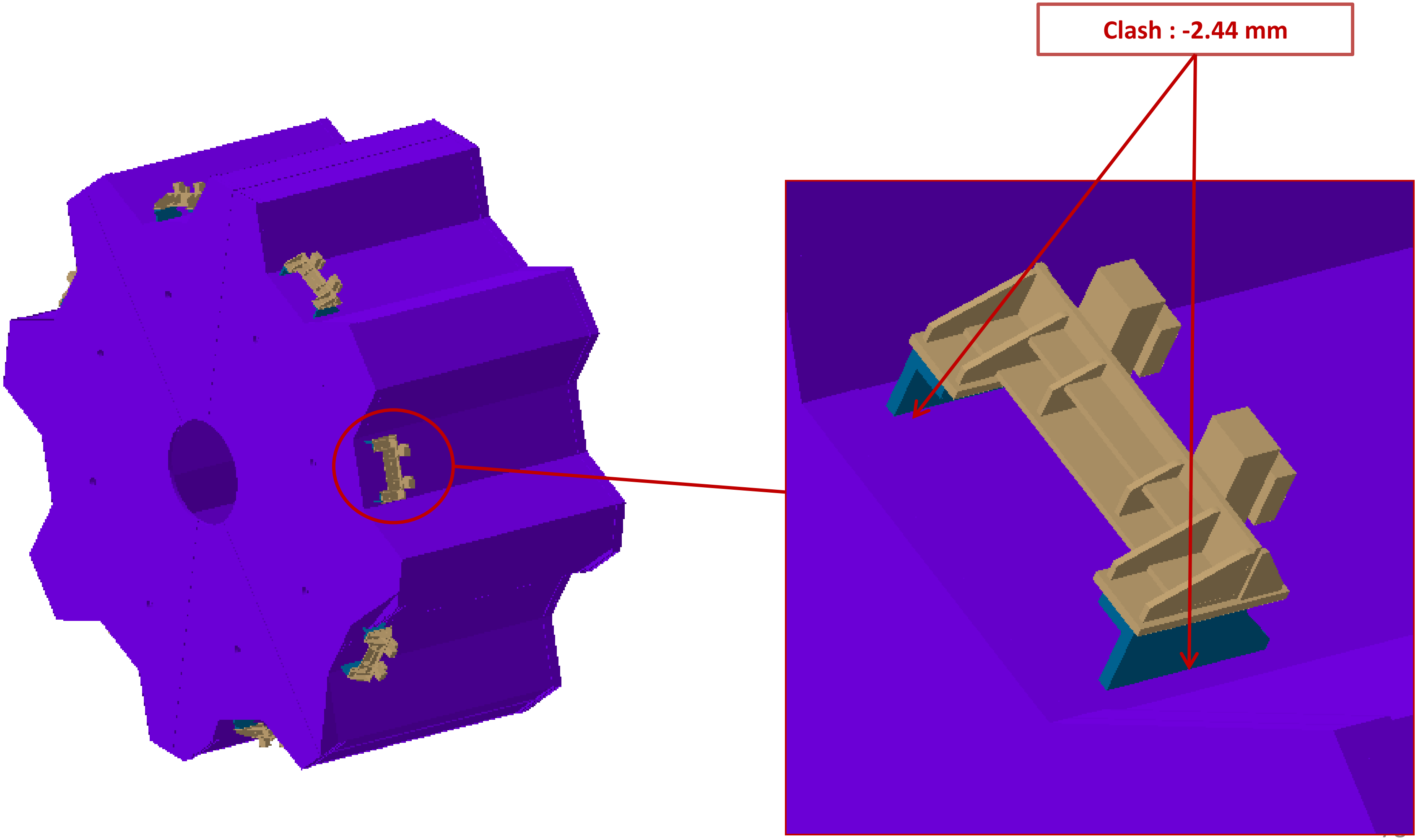
Integration Conflicts Checking

	Geometry I	Geometry II	Type	Value (mm)
4	Cryo_Stop_Inside	EV_Envelop	**Clash**	**-4.7**



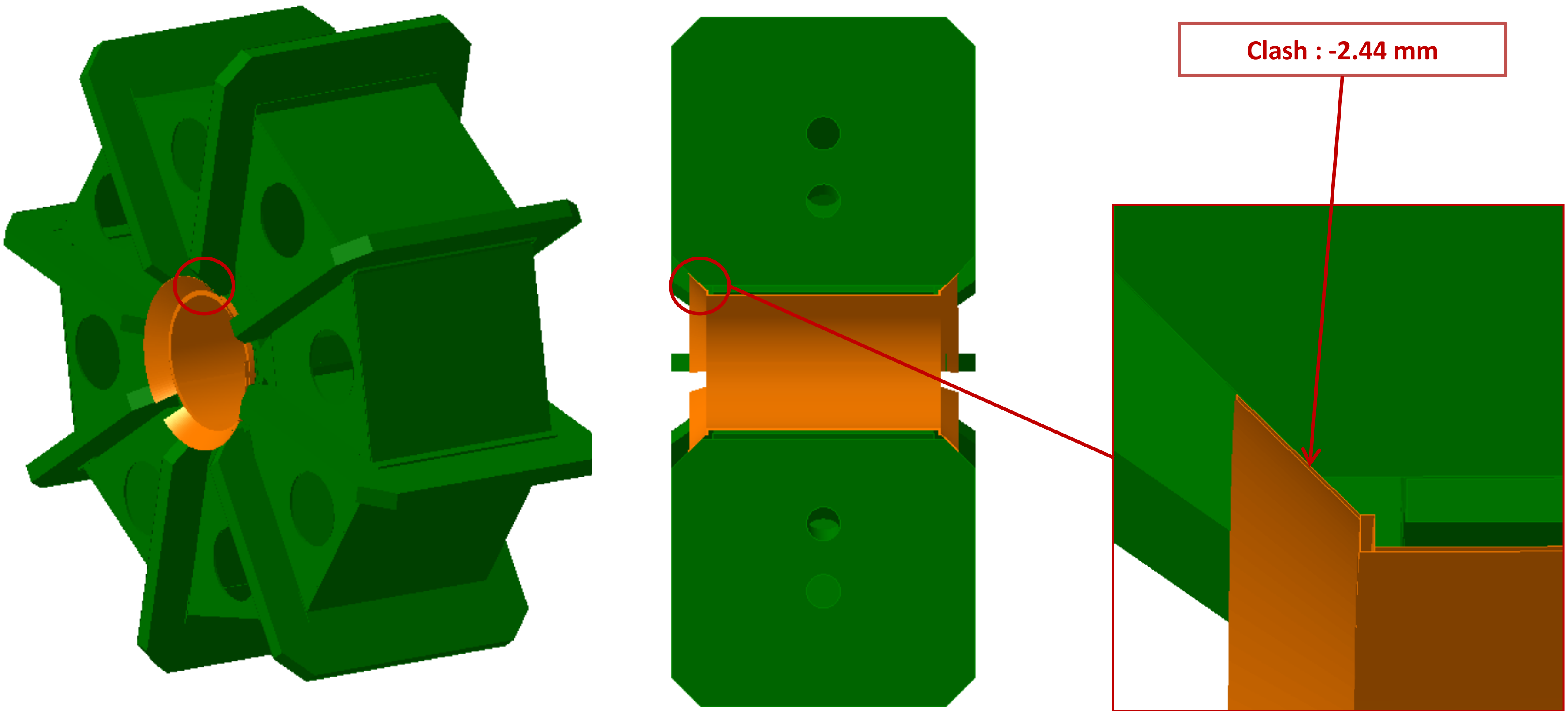
Integration Conflicts Checking

	Geometry I	Geometry II	Type	Value (mm)
5	Cryo_Stop_Outside	EV_Envelop	**Clash**	**-2.44**



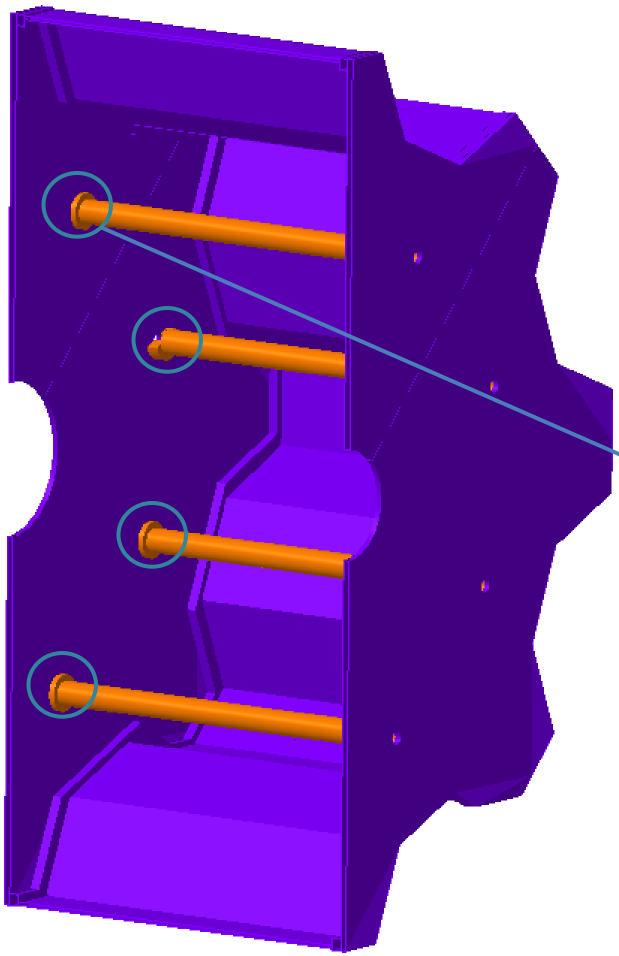
Integration Conflicts Checking

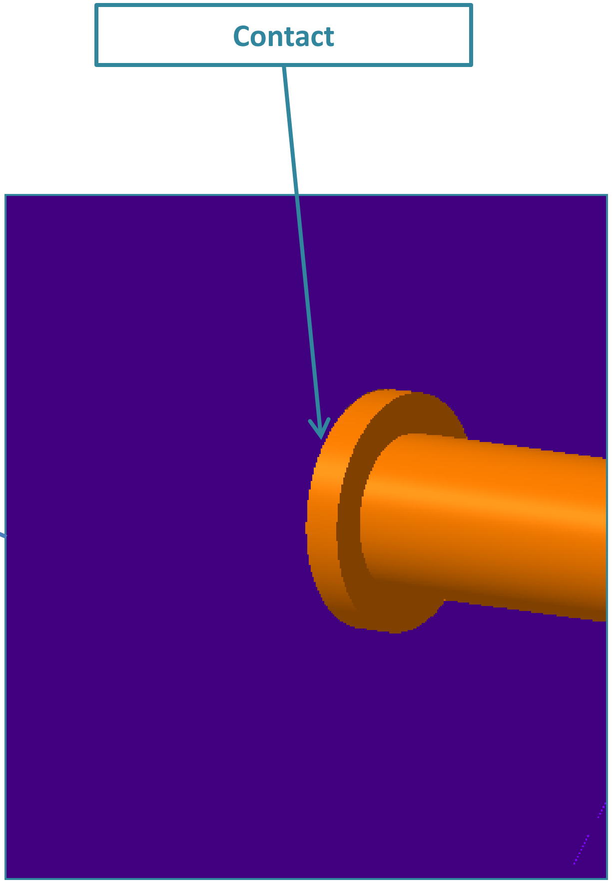
	Geometry I	Geometry II	Type	Value (mm)
6	ECT_ColdMass	TS_CentralTub	**Clash**	**-0.42**



Integration Conflicts Checking

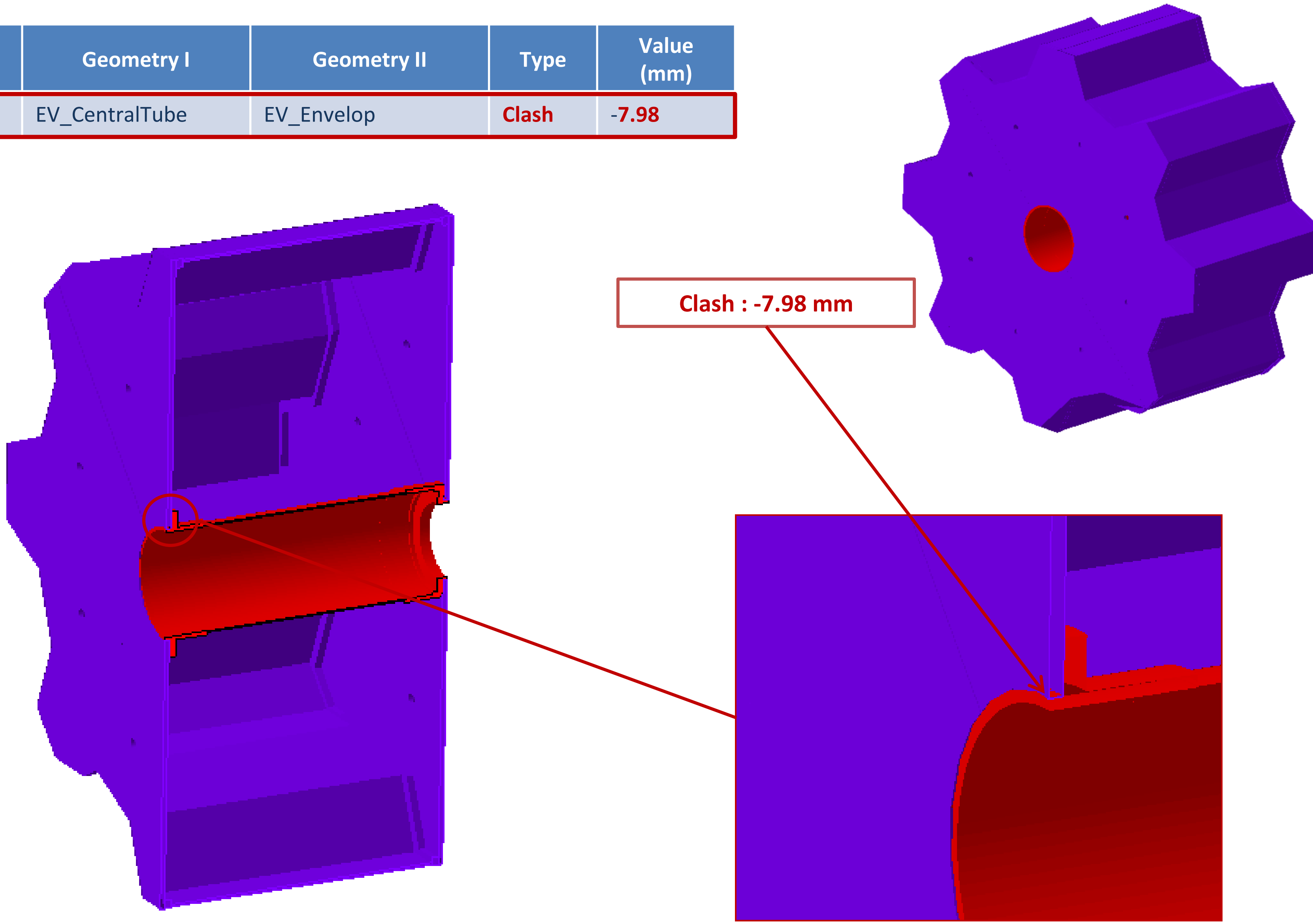
	Geometry I	Geometry II	Type	Value (mm)
7	EV_AlignTube	EV_Envelop	Contact	0





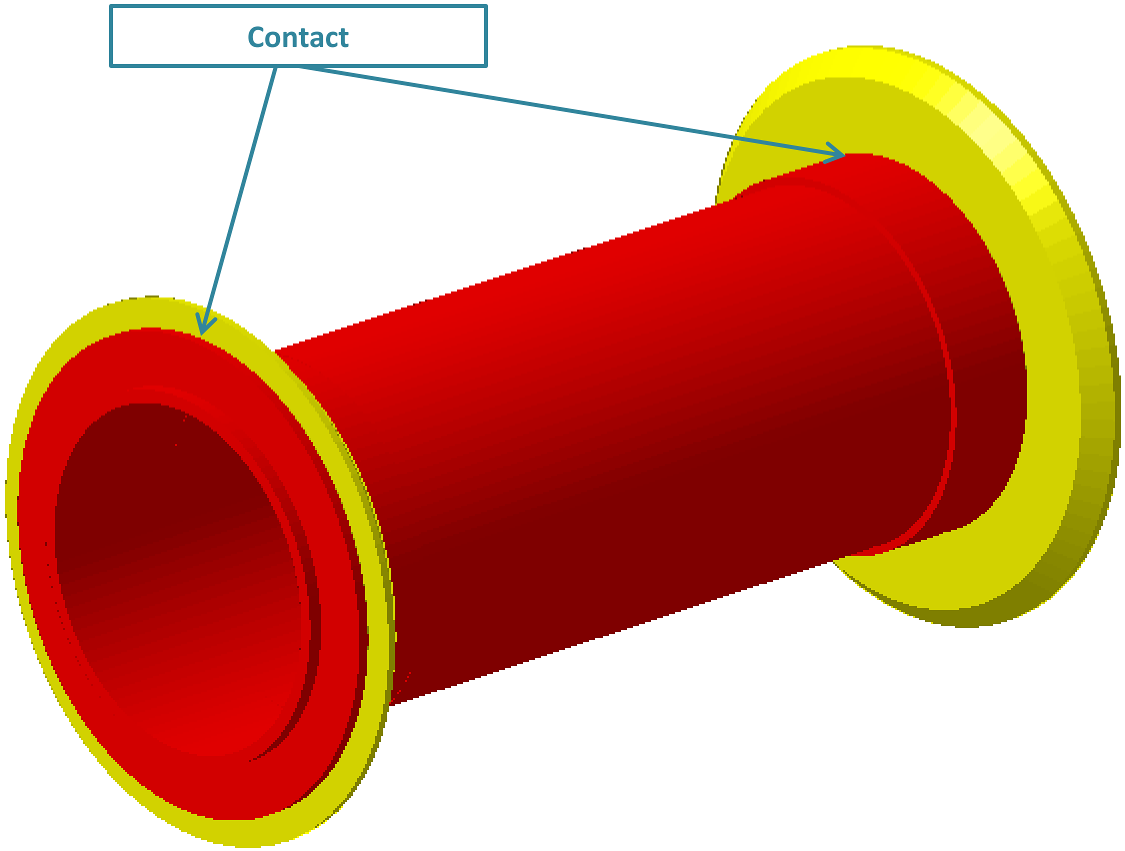
Integration Conflicts Checking

	Geometry I	Geometry II	Type	Value (mm)
8	EV_CentralTube	EV_Envelop	**Clash**	**-7.98**



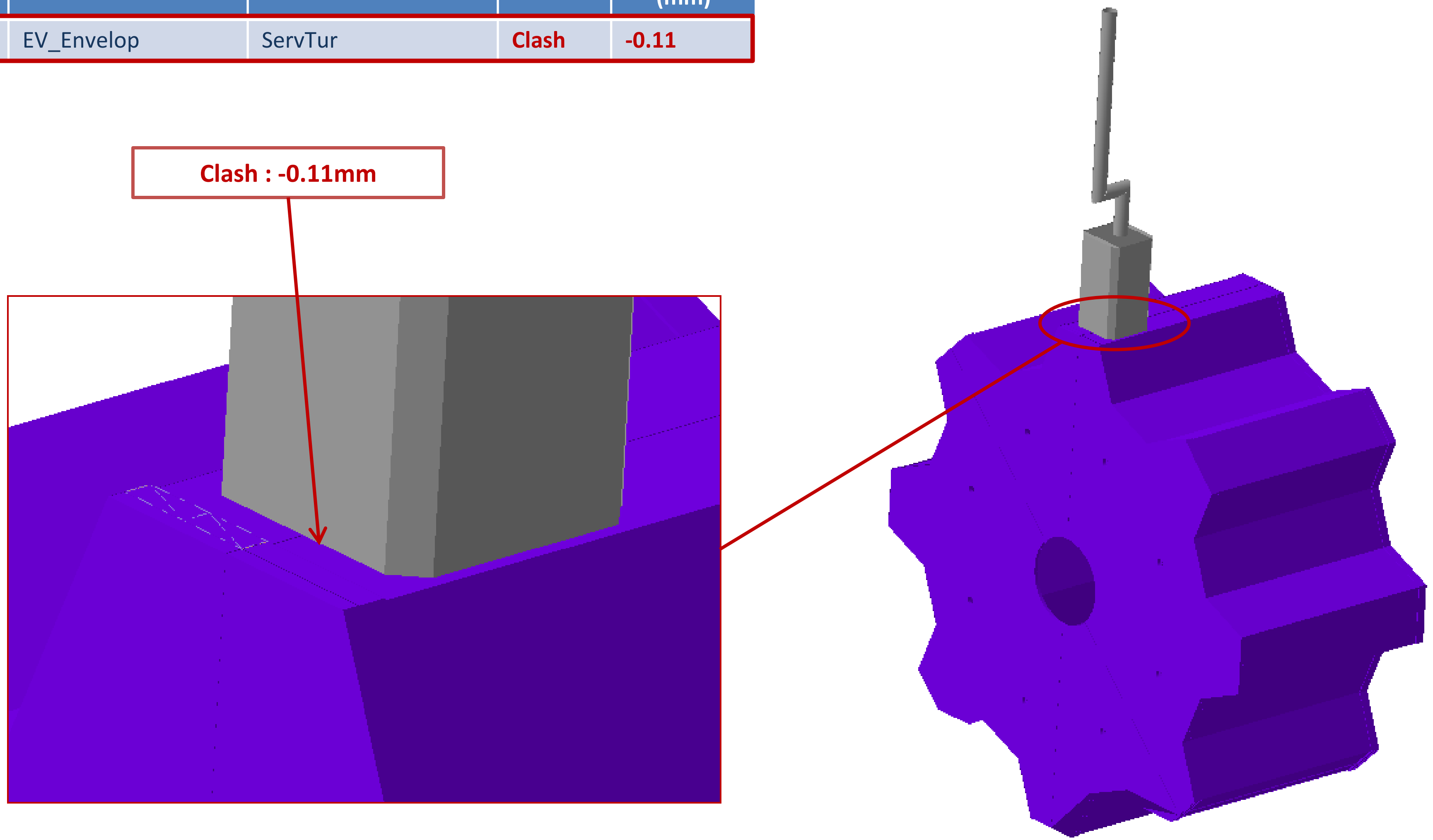
Integration Conflicts Checking

	Geometry I	Geometry II	Type	Value (mm)
9	EV_CentralTube	Ring	Contact	0



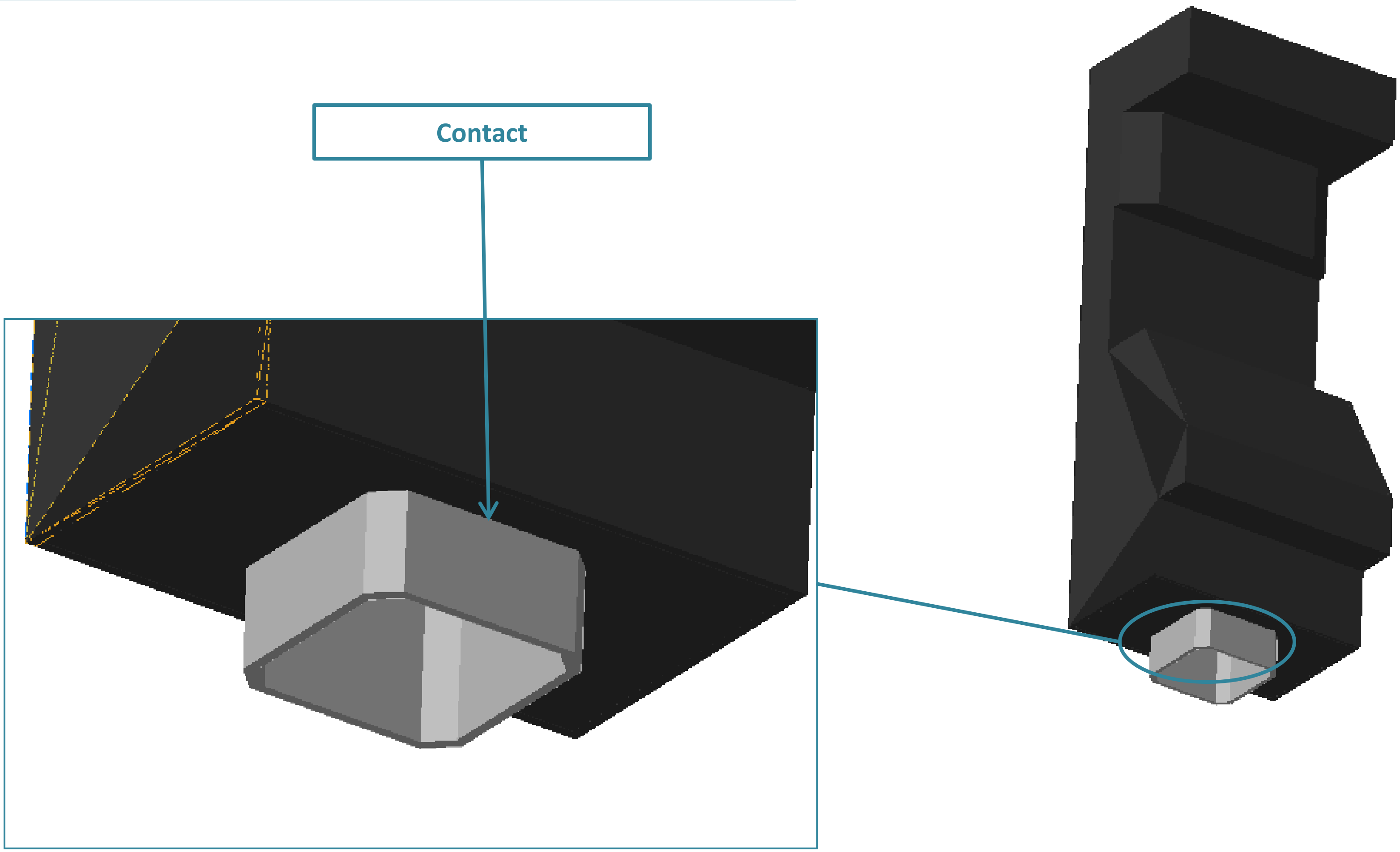
Integration Conflicts Checking

	Geometry I	Geometry II	Type	Value (mm)
10	EV_Envelop	ServTur	**Clash**	**-0.11**



Integration Conflicts Checking

	Geometry I	Geometry II	Type	Value (mm)
11	ServiTower	ServTur	**Contact**	0



About Georgian Engineering Team

Visitors from CERN

www.cadcam.ge

Thanks!