Simplification of the ATLAS CAD geometry for Geant4 simulation

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https://indico.cern.ch/event/1287543/

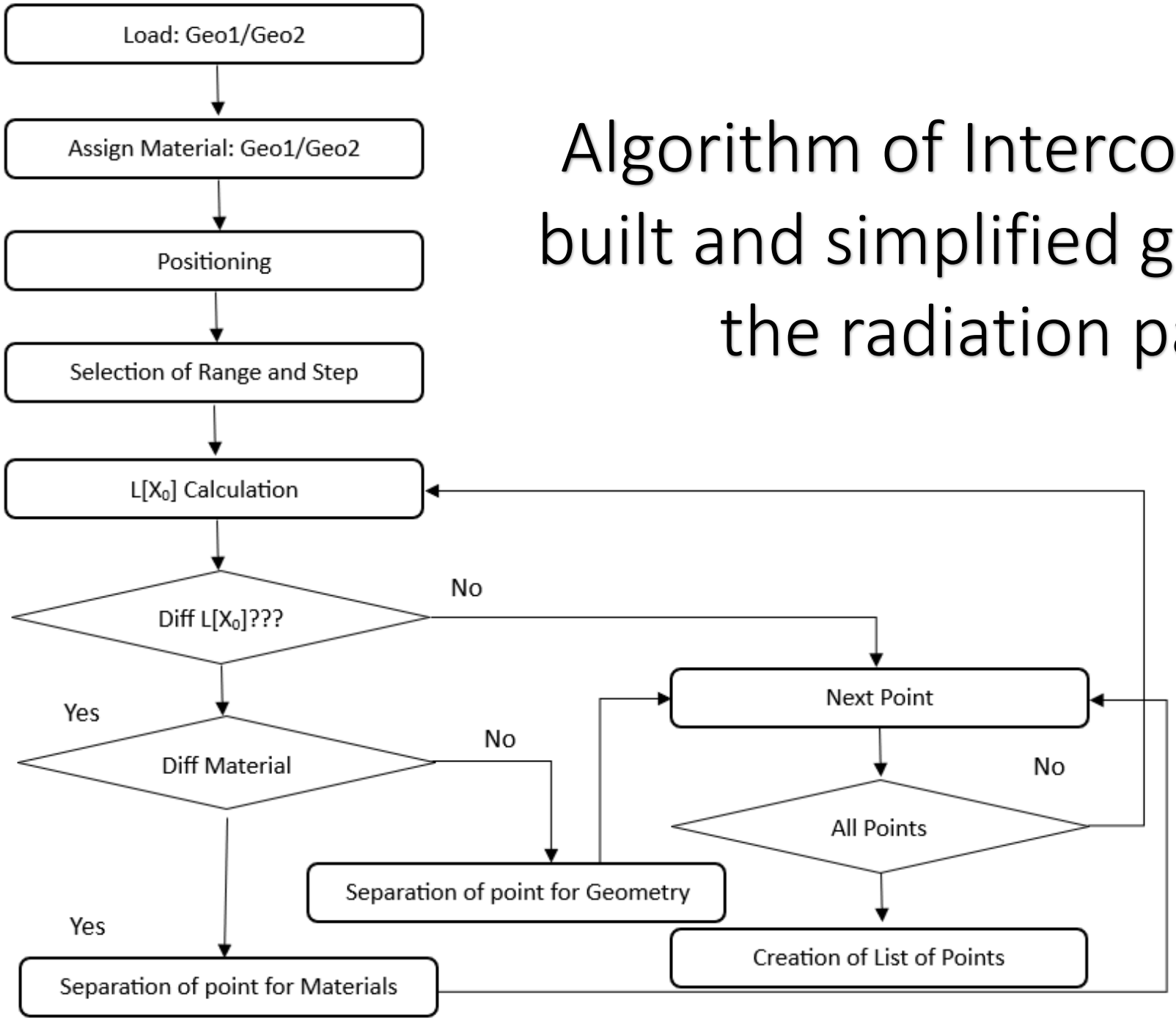
Detector Description Session During S&C Workshop

Objectives:

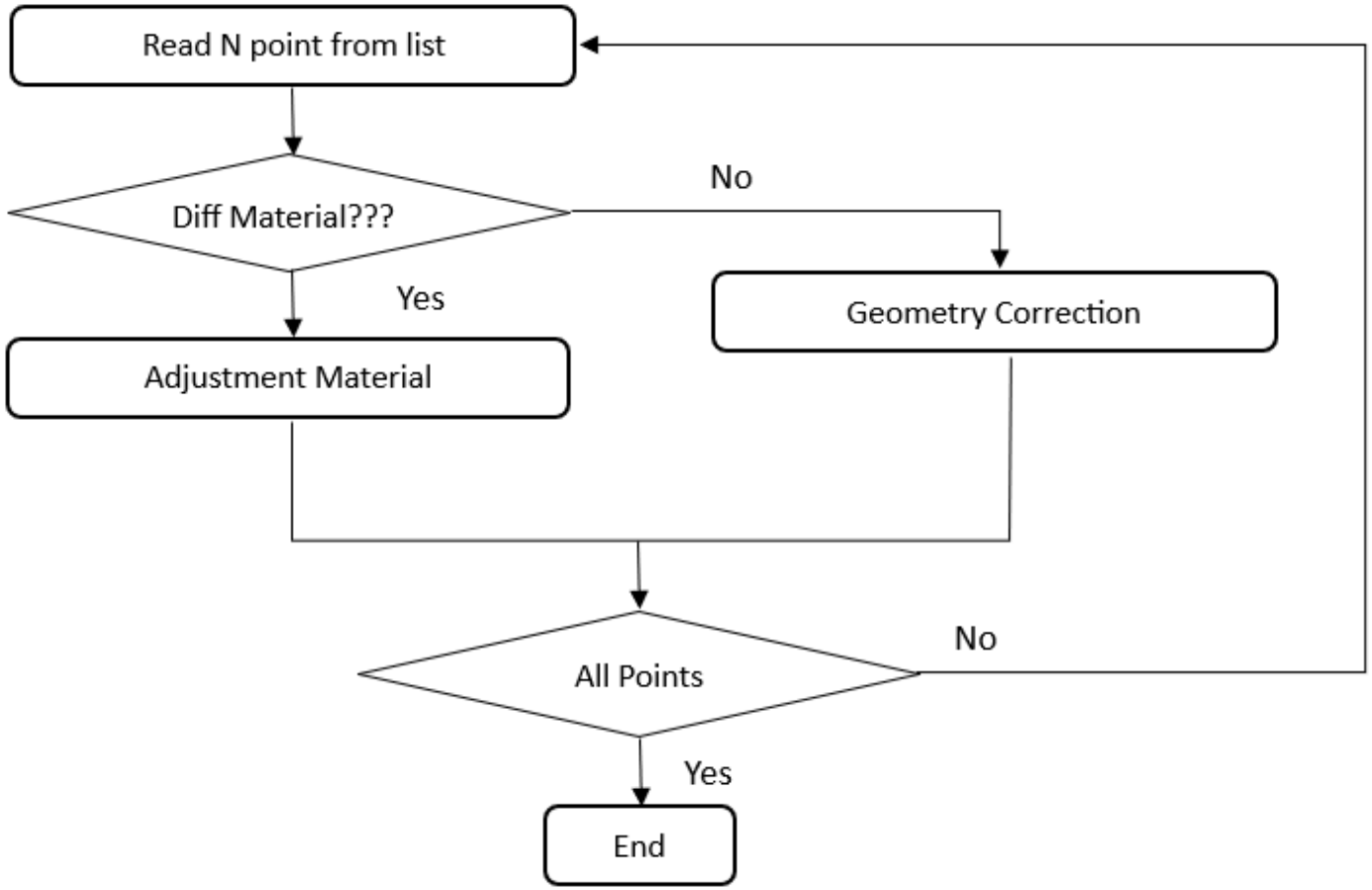
1. Simplification is needed to simplified As-build geometry because it cannot be used in a simulation like it is.
2. The best representation of as-built geometry of the detector components is CAD 3D Models
3. Therefore, simplification method and tools should be developed for CAD platforms which will enable make simplification on the early stage of geometry development for simulation
4. The proposed method should ensure the same mass and radiation properties of as-built geometry descriptions in the simplified ones
5. This report represents the method of geometry simplification for the CATIA platform and the results of its implementation

I. Concept

Algorithm of Intercomparison of As-built and simplified geometries using the radiation parameters

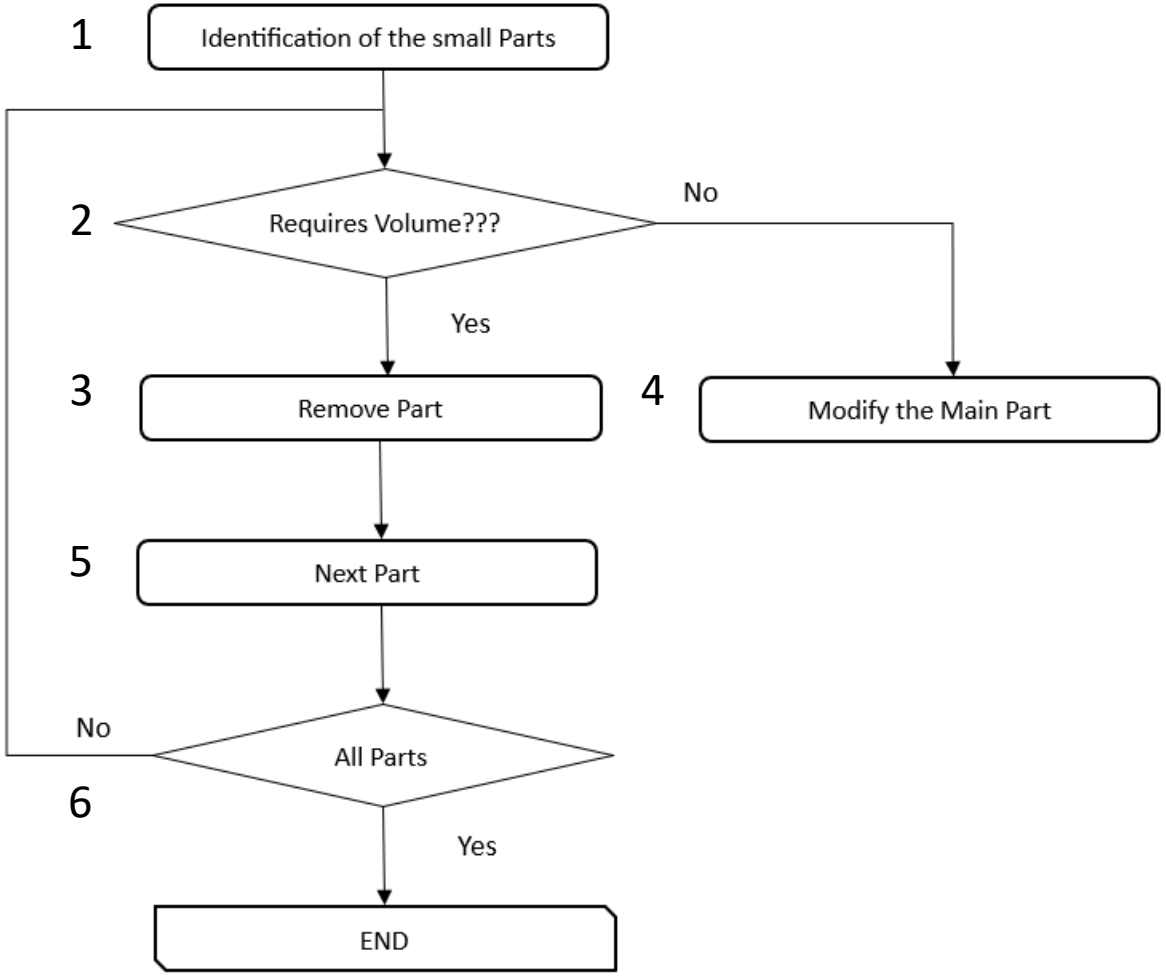


Algorithm for the modification of simplified geometry description



Geometry correction algorithm

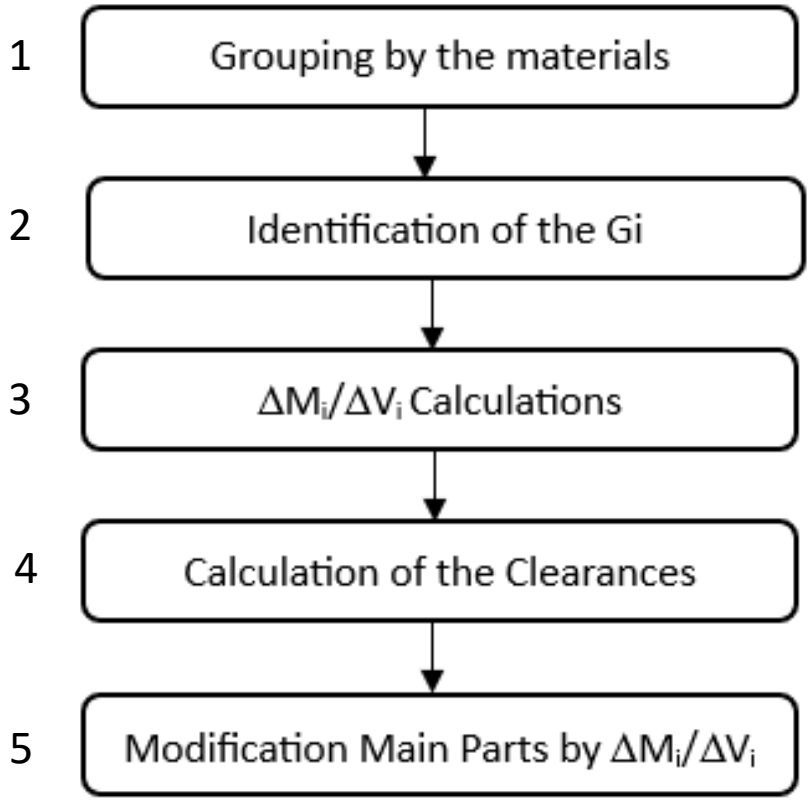
Π_1 Transformation: Removal of the components



- In the first step, parts with small volumes compared to the central part must be identified (block#1)
- In the next step, it has to be checked whether the considered candidate part can be integrated into the central part using the polygon methods or not. It should be removed if it is impossible and the candidate part requires a separate volume in the description. Otherwise, the description of the main volume has to be modified (block#4)

Geometry correction algorithm

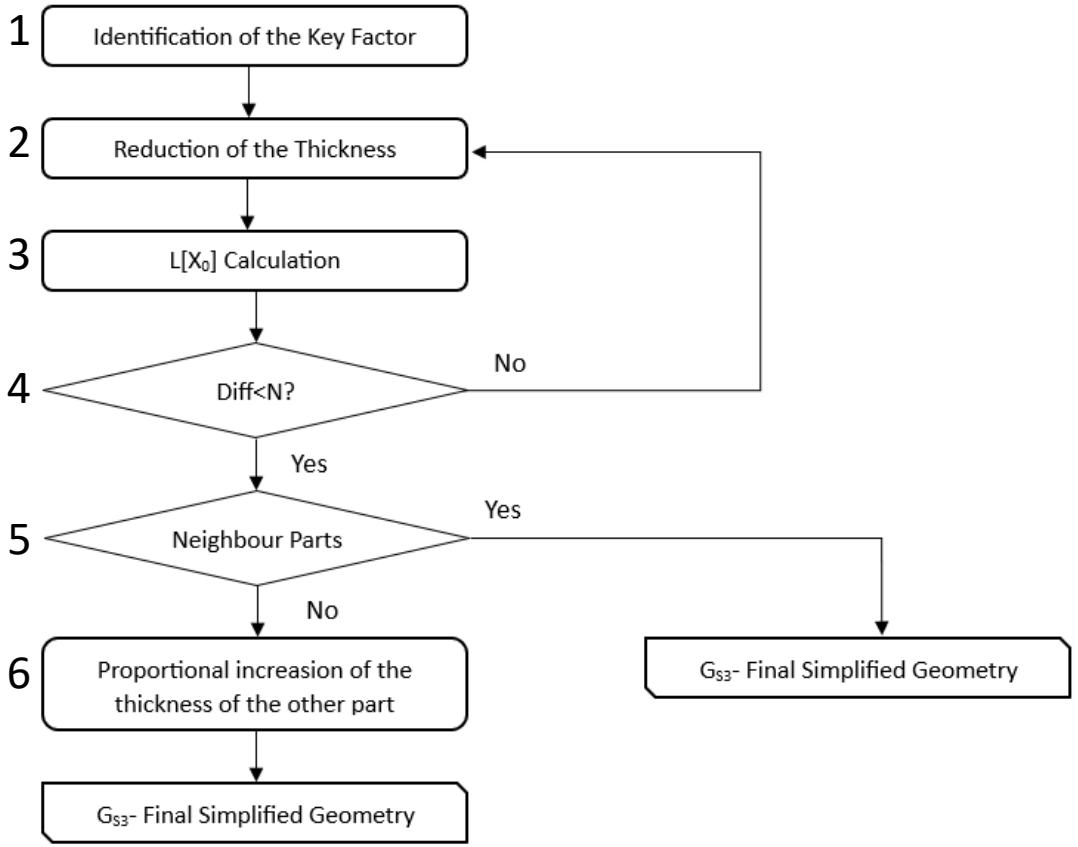
Π2 Transformation: reproduction of Mass properties



- In the firs step all parts in the as-built geometry must be grouped according to materials and functional subassemblies (block#1)
- After the identification of removed parts inside the group it is possible to calculate the overall weight and volume of remove materials from the group (block#3)
- It is necessary to know clearances around and inside of simplified geometry. For that purpose the simplified geometry should be loaded together the other descriptions and must identify the clearance(block#4)
- The main parts in each group have to modified by $\Delta M_i/\Delta V_i$ and clearance (block#5)

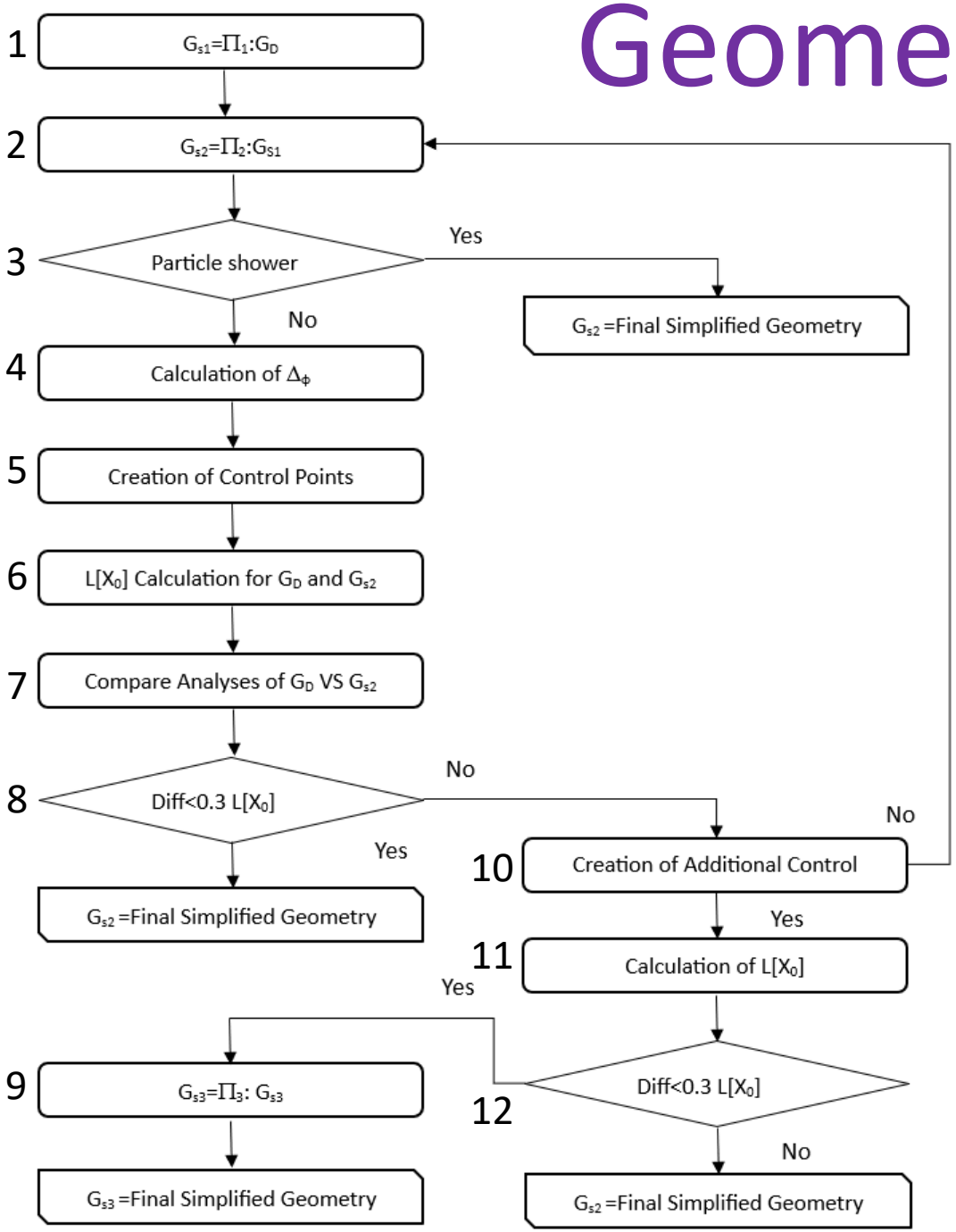
Geometry correction algorithm

Π_3 Transformation: Reproduction of the radiation parameters



- The purpose is a modification of simplified geometry in the way to reduced radiation length changes below the allowable value and generate new simplified description
- After redaction of thickness radiation length is calculated and checked if it is below the allowable value (blocks#2,#3,#4)
- However, thickness reduction causes material loss, which has to be compensated by the proportional increase of thickness in other places, that can causes changes in the L[Xo] radiation length above the allowable value N
- (blocks#5, #6) insure the necessary modifications of the geometry

Geometry correction algorithm

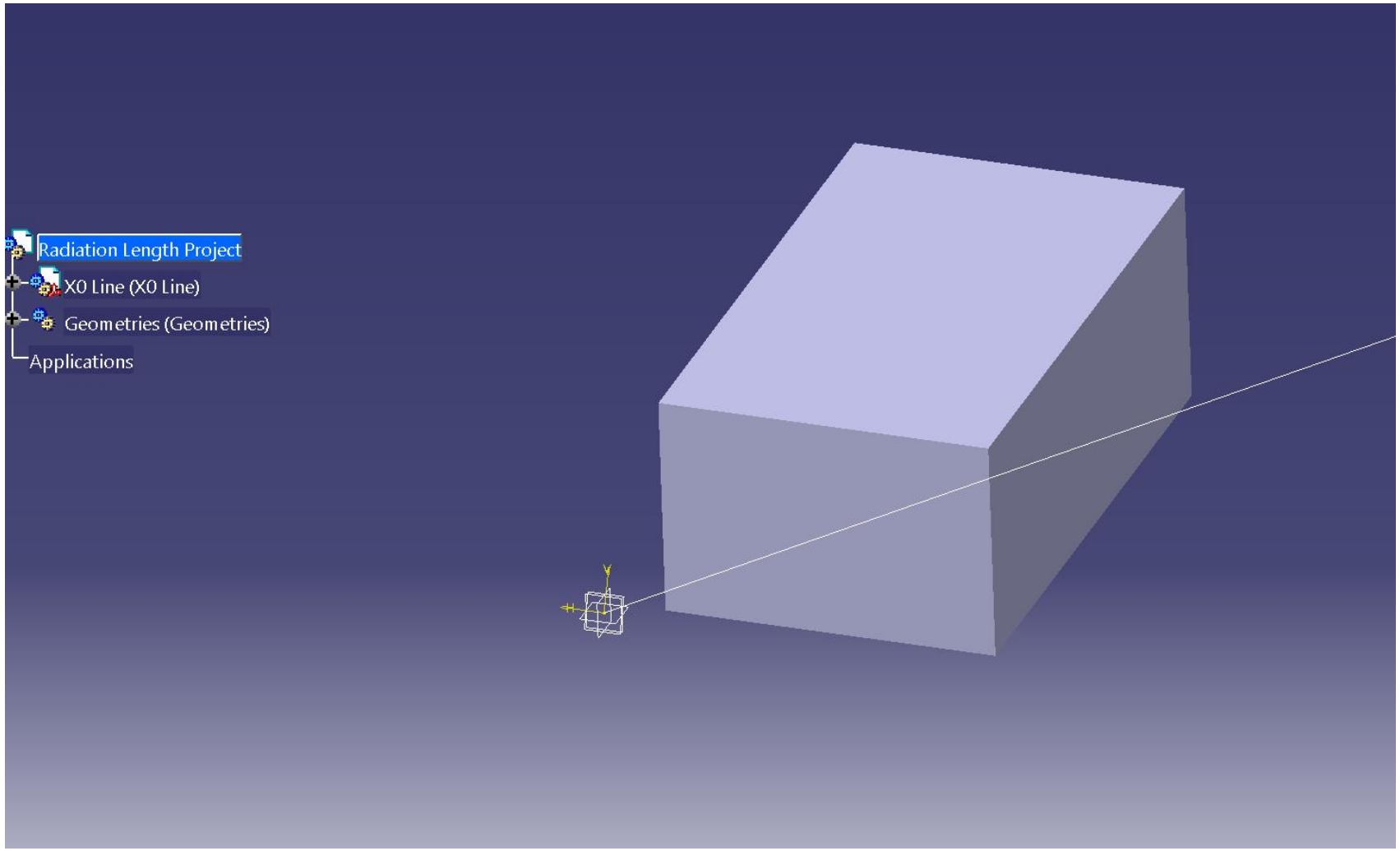


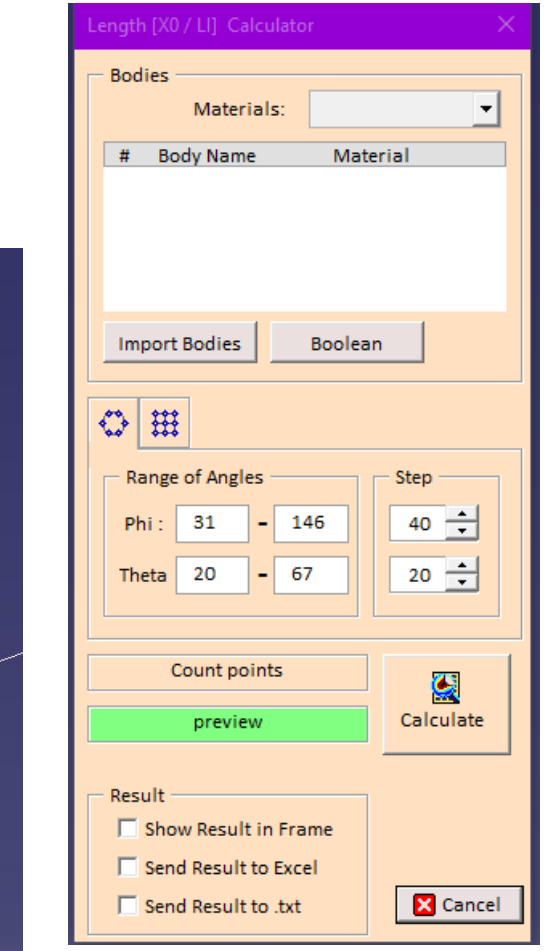
General steps of the geometry simplification

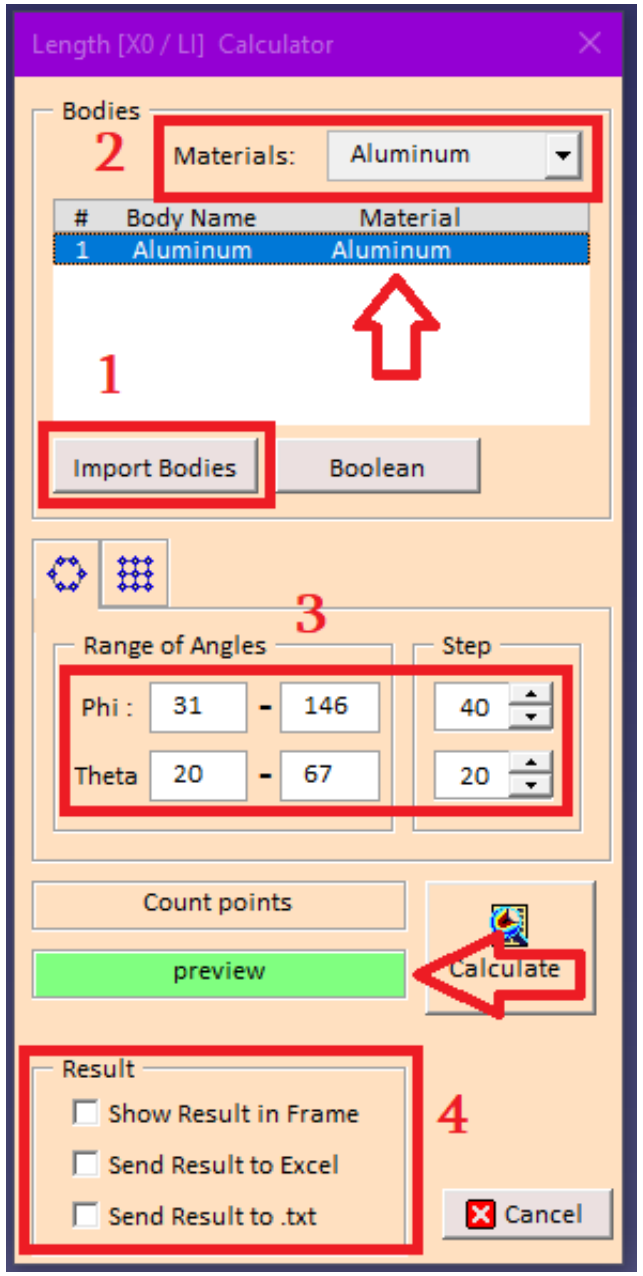
- First two blocks make simplification according to Π_1/Π_2
- For the particle showers there is no need for further simplification
- For the single particles L[X0]/L[λ] analysis is needed (blocks #4, #5, #6, #7). If the difference L[X0]/L[λ] is more then allowable value (block#8) then additional calculations in neighbor points take place to understand if detected difference has systematical character or occurs just in one point (blocks #10, #11, #12)
- In case of systematical character the Π_3 transaction is needed to receive the final simplified geometry (block#9)

II.CATIA Tools

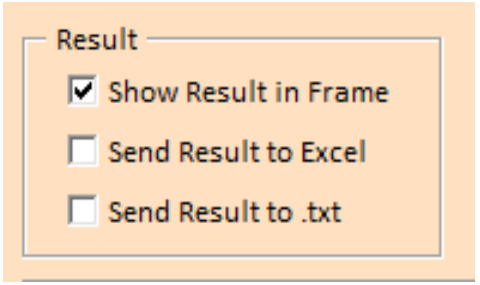
The CATIA Tool for the Simplification



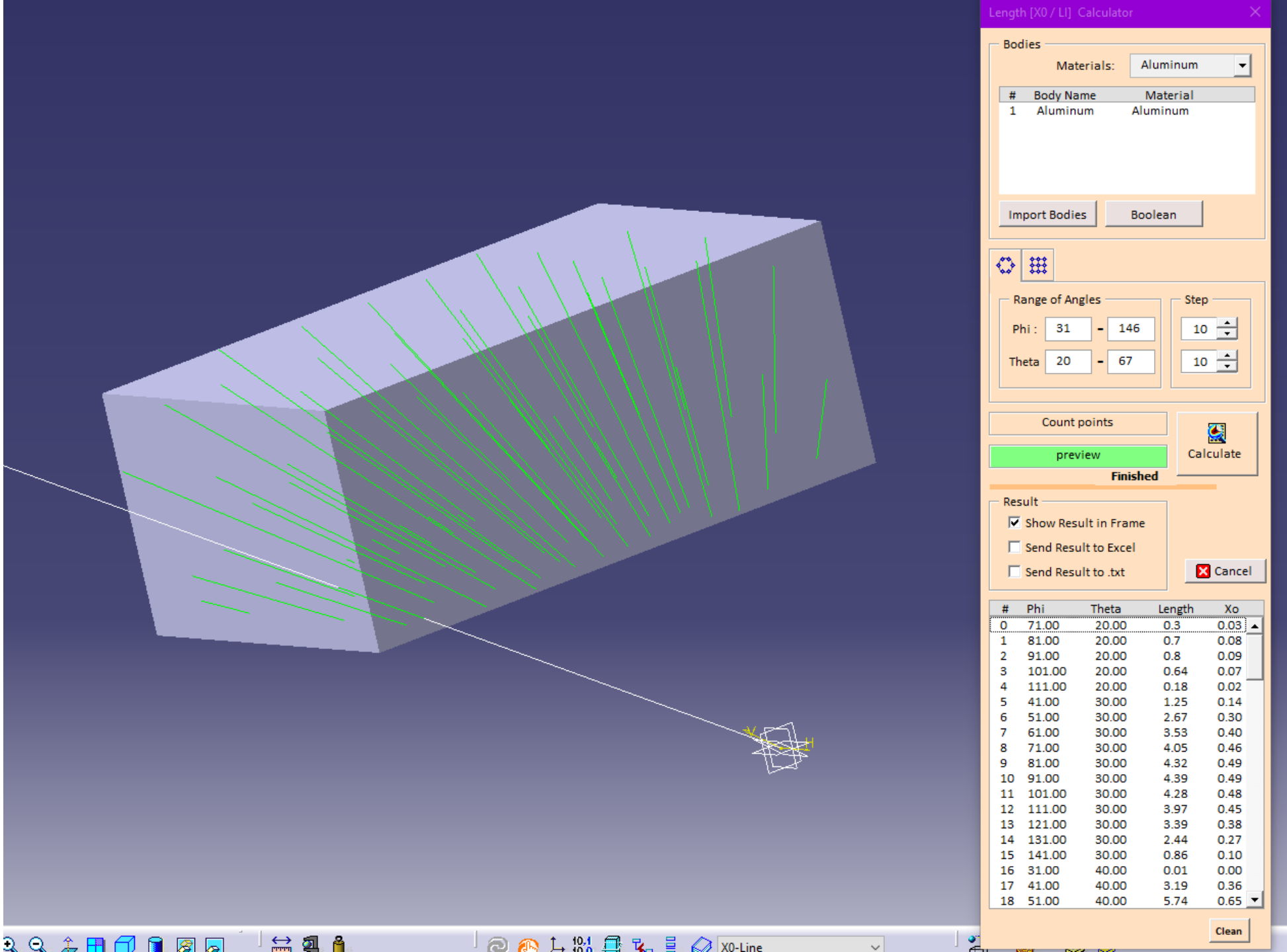




Userform tools description



Result

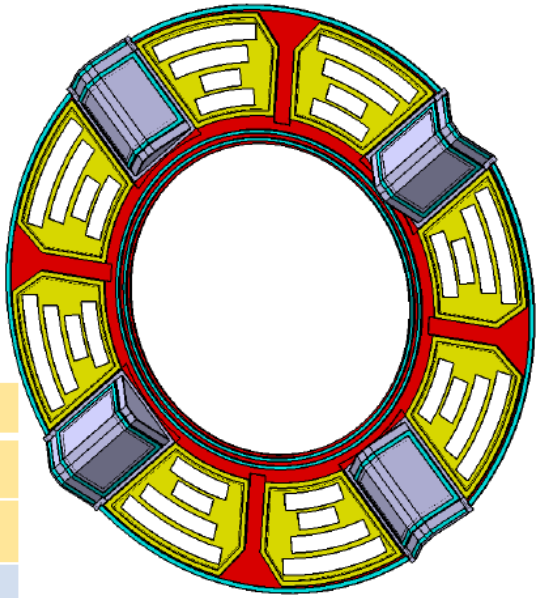

Length [X0 / Li] Calculator
Bodies
Materials:
Aluminum
Body Name Material
1 Aluminum Aluminum
Import Bodies
Boolean
Range of Angles
Phi : 31 - 146
Theta 20 - 67
Step
10
10
Count points
preview
Finished
Calculate
Result
Show Result in Frame
Send Result to Excel
Send Result to .txt
Cancel
Phi Theta Length Xo
0 71.00 20.00 0.3 0.03
1 81.00 20.00 0.7 0.08
2 91.00 20.00 0.8 0.09
3 101.00 20.00 0.64 0.07
4 111.00 20.00 0.18 0.02
5 41.00 30.00 1.25 0.14
6 51.00 30.00 2.67 0.30
7 61.00 30.00 3.53 0.40
8 71.00 30.00 4.05 0.46
9 81.00 30.00 4.32 0.49
10 91.00 30.00 4.39 0.49
11 101.00 30.00 4.28 0.48
12 111.00 30.00 3.97 0.45
13 121.00 30.00 3.39 0.38
14 131.00 30.00 2.44 0.27
15 141.00 30.00 0.86 0.10
16 31.00 40.00 0.01 0.00
17 41.00 40.00 3.19 0.36
18 51.00 40.00 5.74 0.65
Clean
X0-Line

III. Implementation

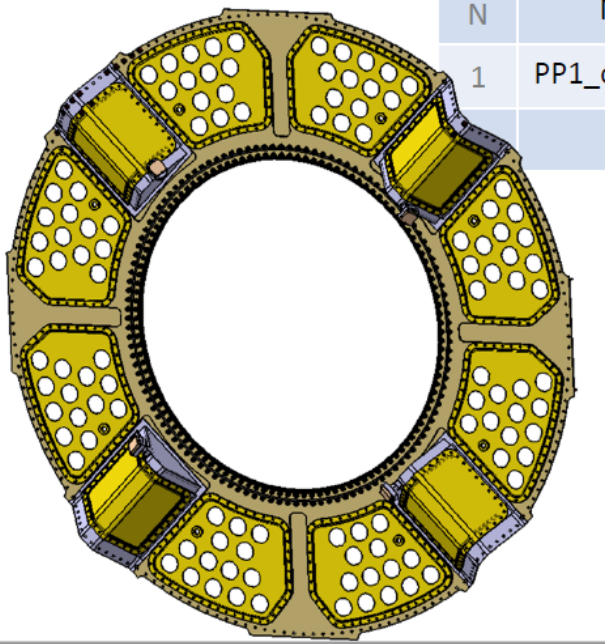
ITk Detector PP1-outerwall simplification

Simplification – Final Results

Simplified Geometry



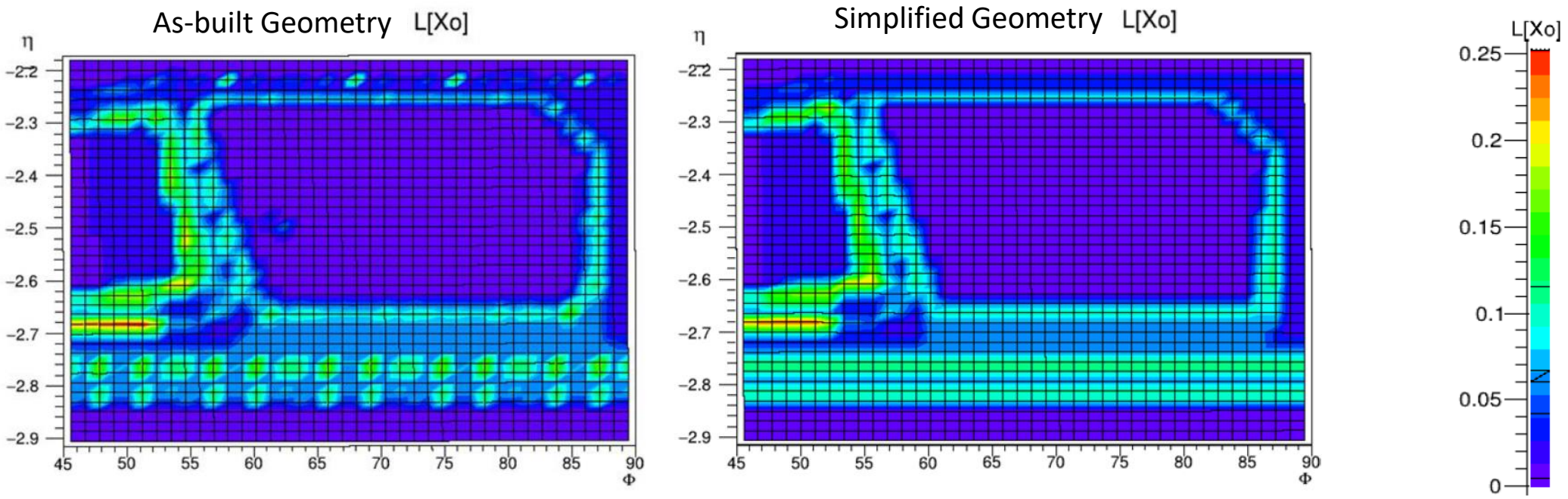
As-build geometry



		Detailed Model		Simplified Model	
N	Name	Volume (m^3)	Weight (kg)	Volume (m^3)	Weight (kg)
1	PP1_outerwall	0.00383	10.3	0.00383	10.3
		Total:	**10.3**		**10.3**

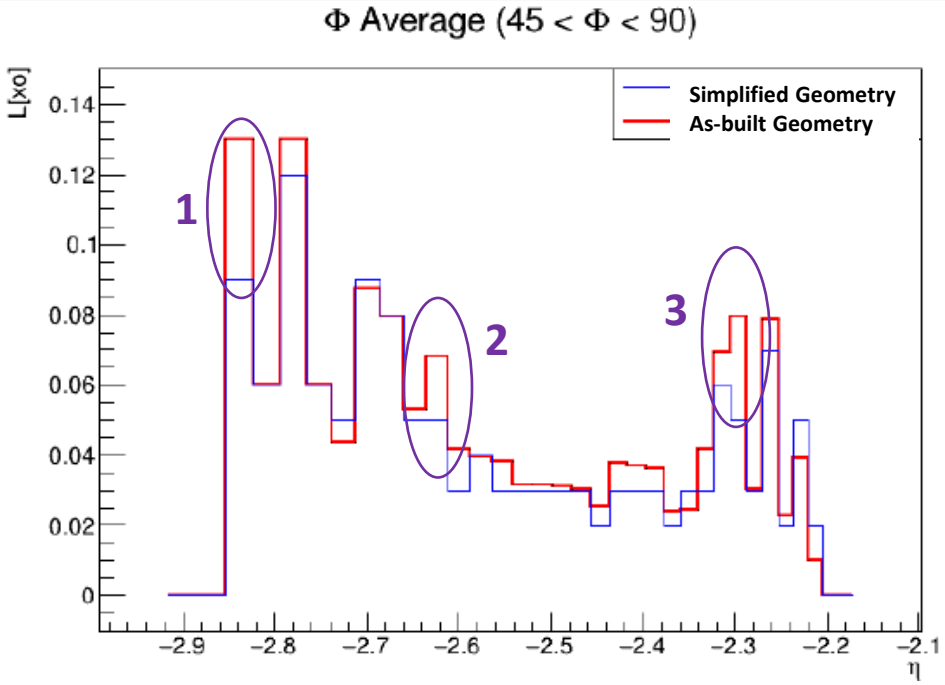
Diff. 0 kg

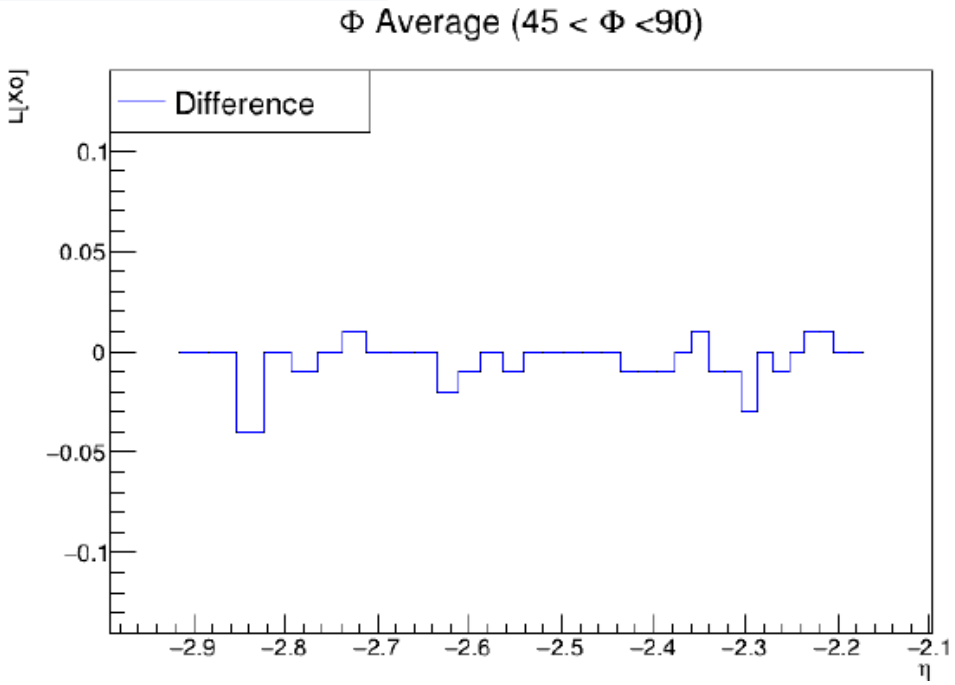
PP1-outerwall Radiation Length



As-built Geometry vs Simplified Geometry

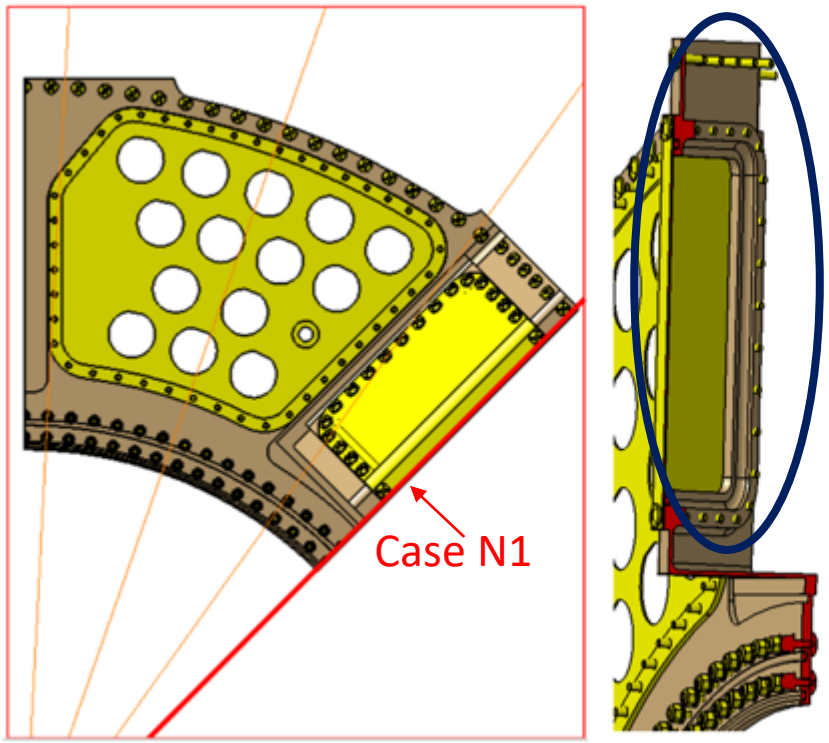
Compare Analyses – Radiation Length (Average Values)



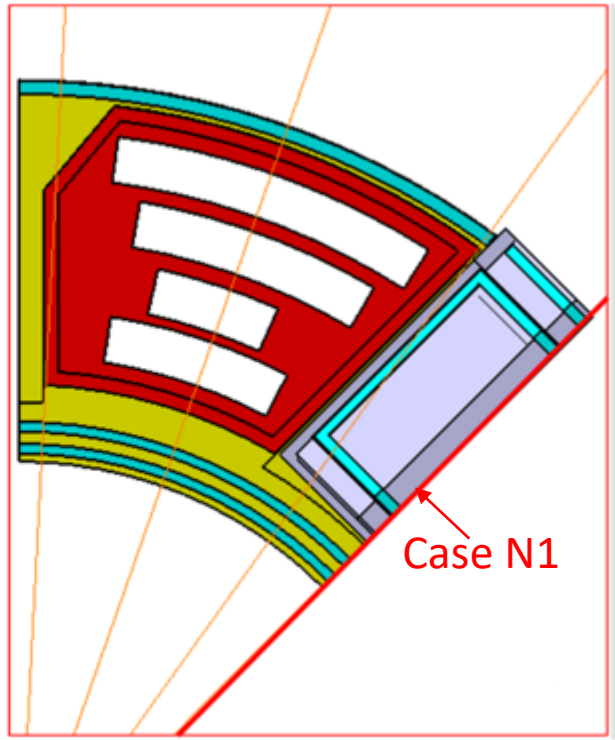


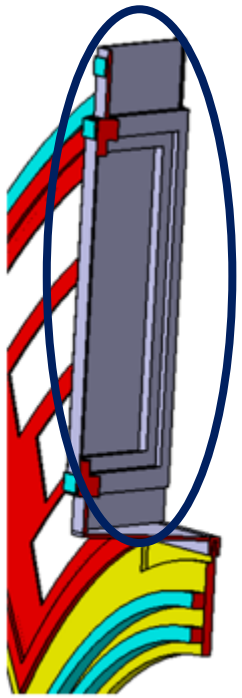
Critical Case N1

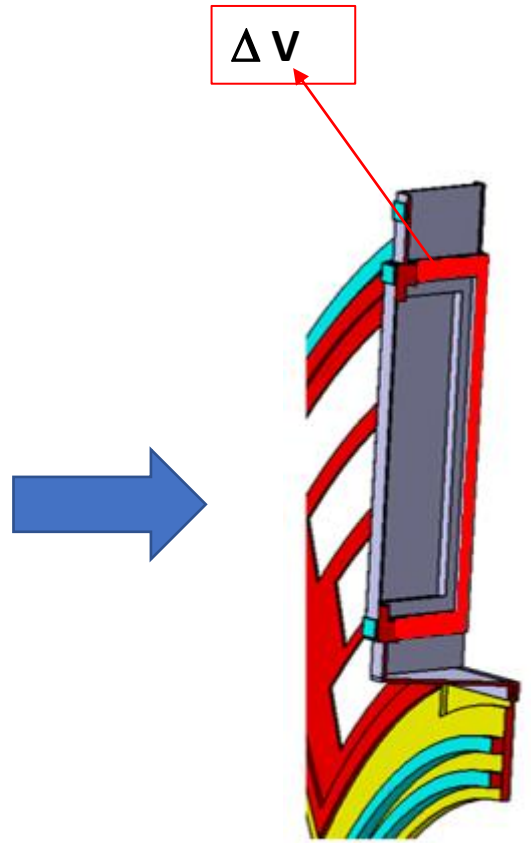
As-built geometry



Simplified Geometry

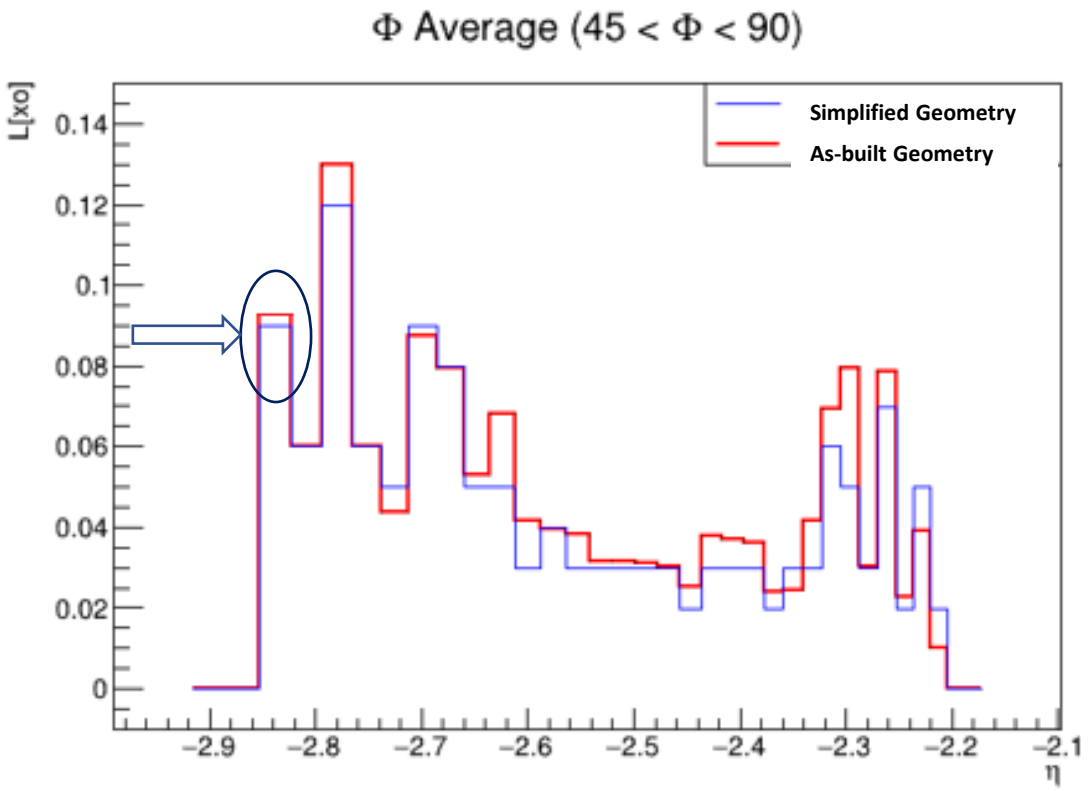


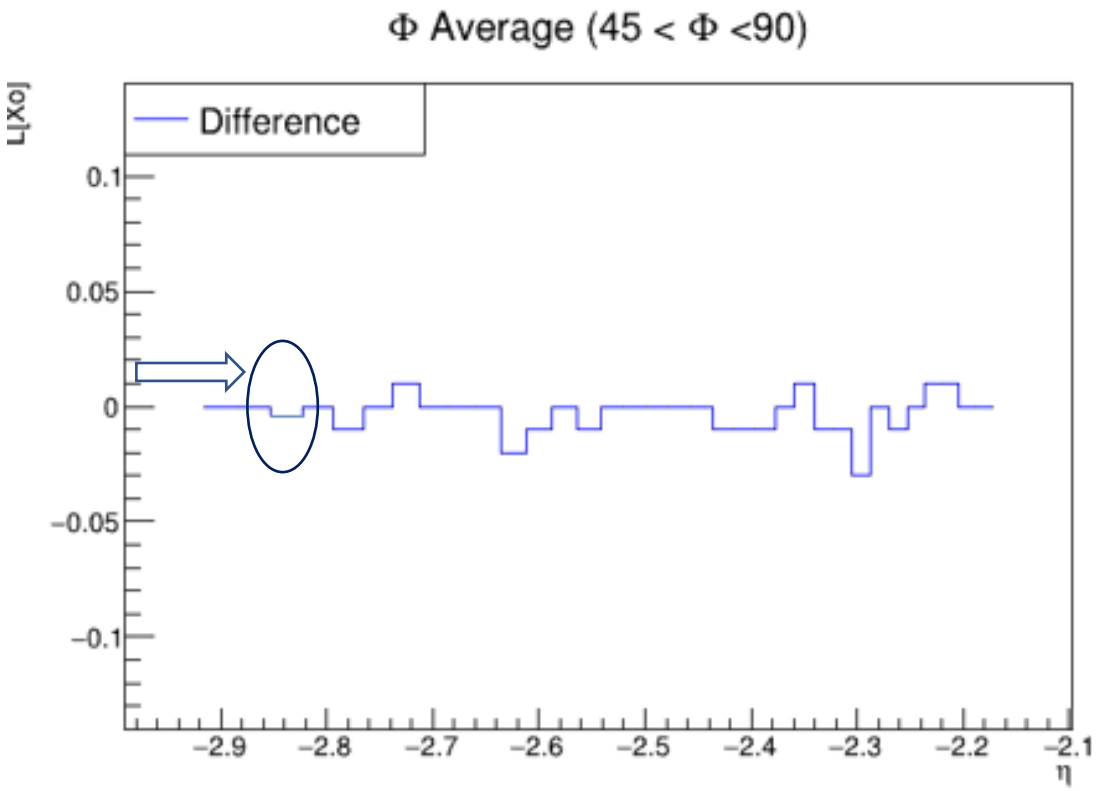




New simplified geometry

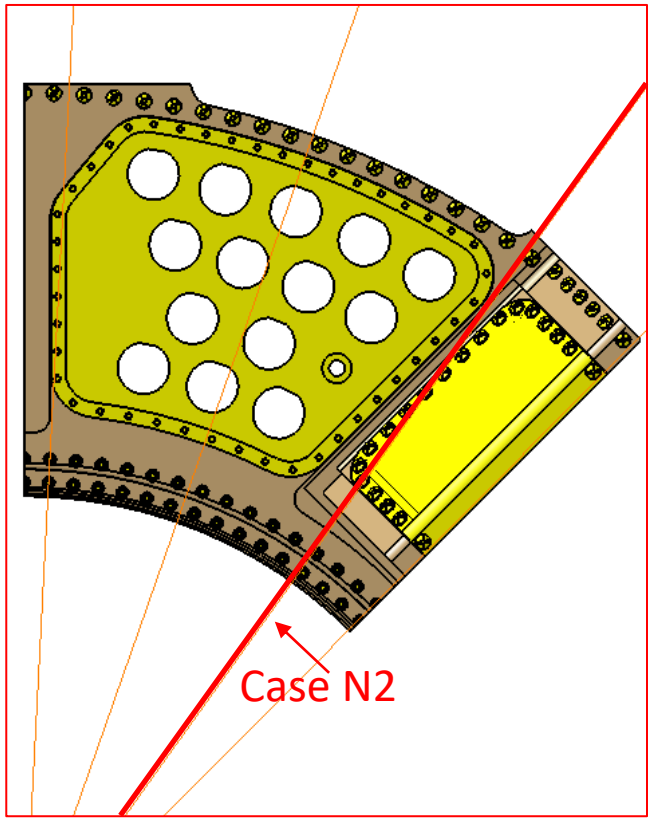
Radiation length after geometry correction case N1

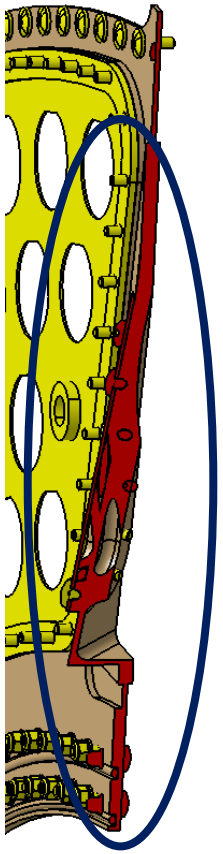




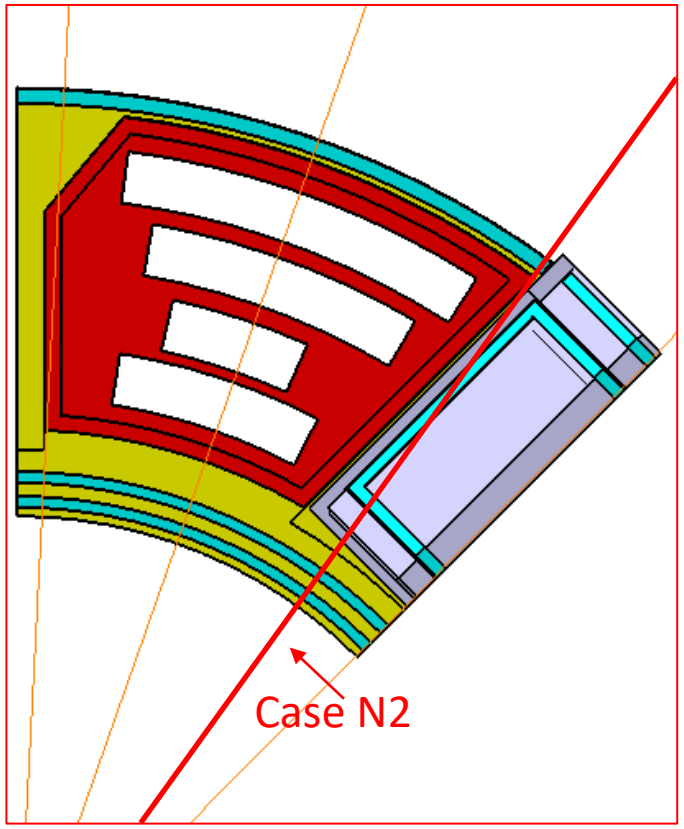
Critical Case N2

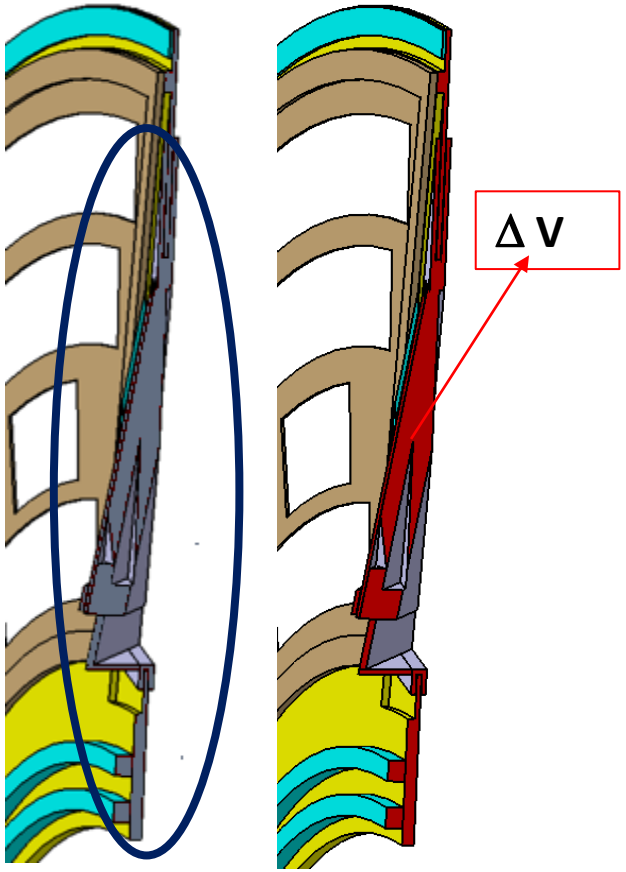
As-built geometry



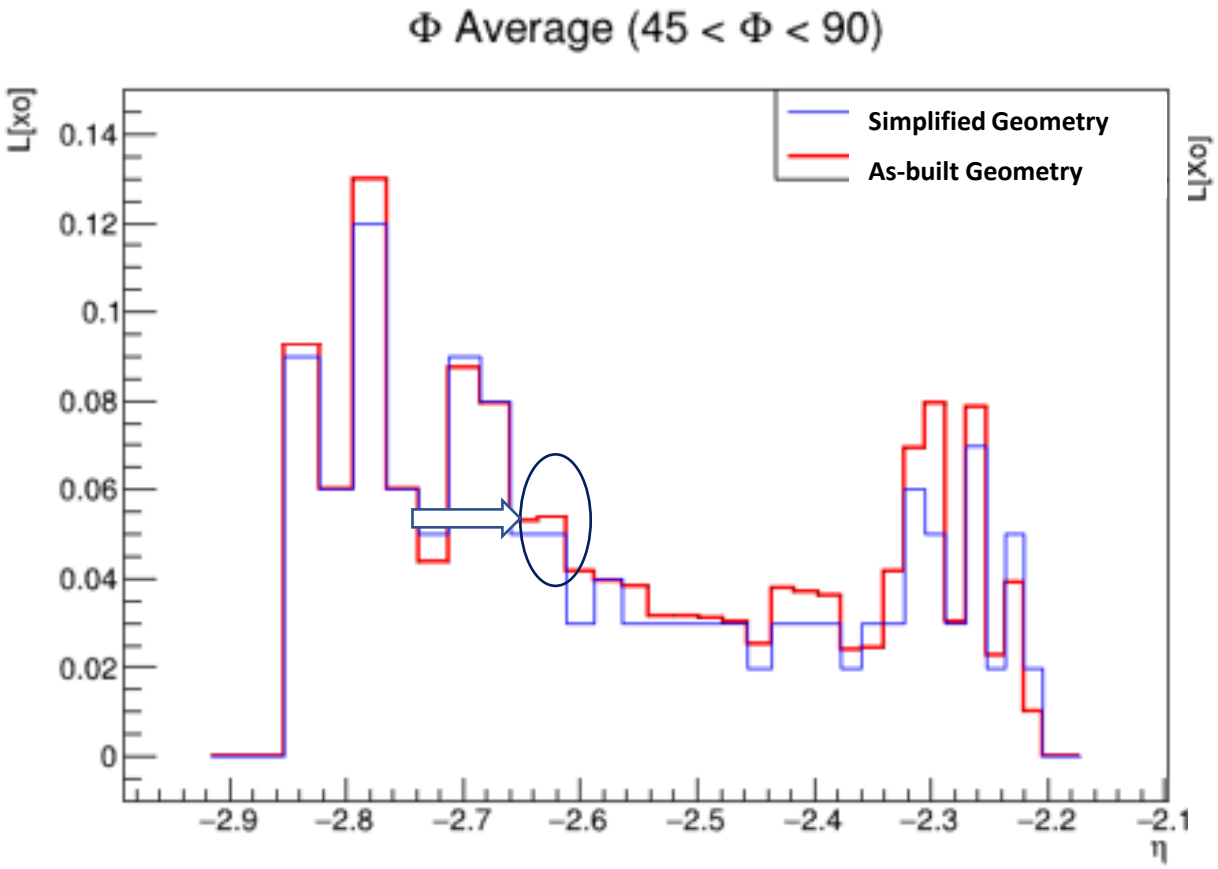


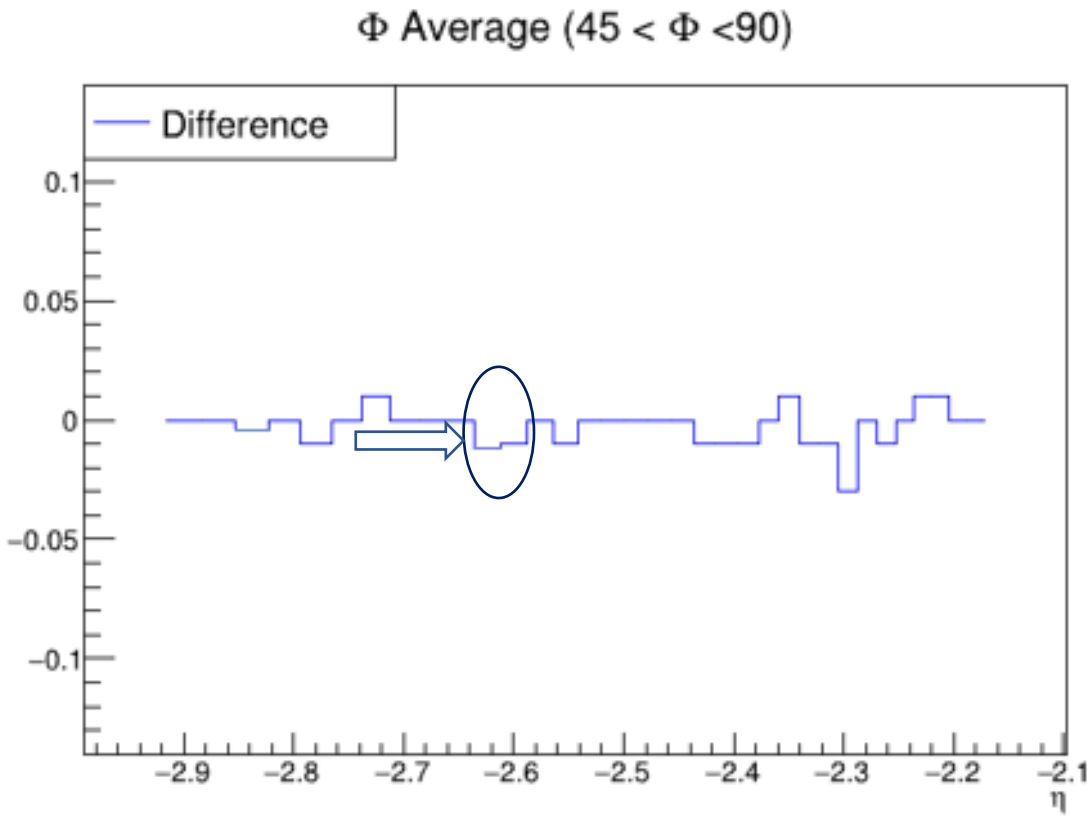
Simplified Geometry





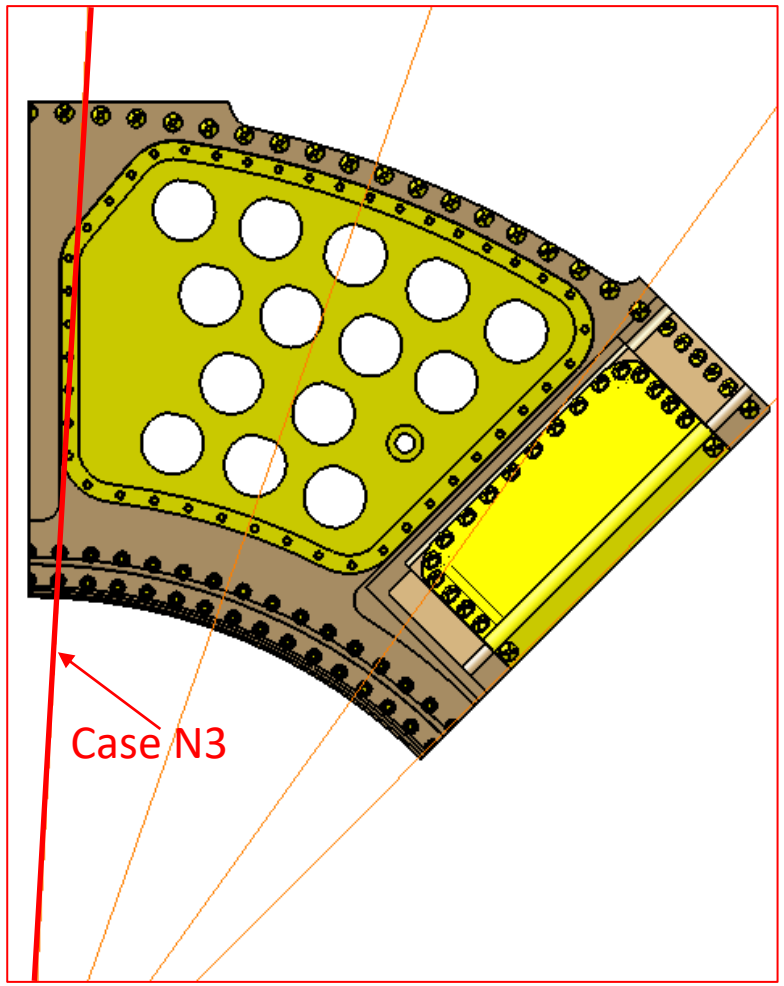
Radiation length after geometry correction case N2

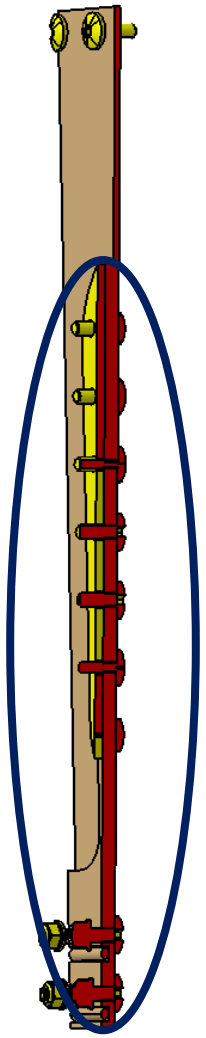




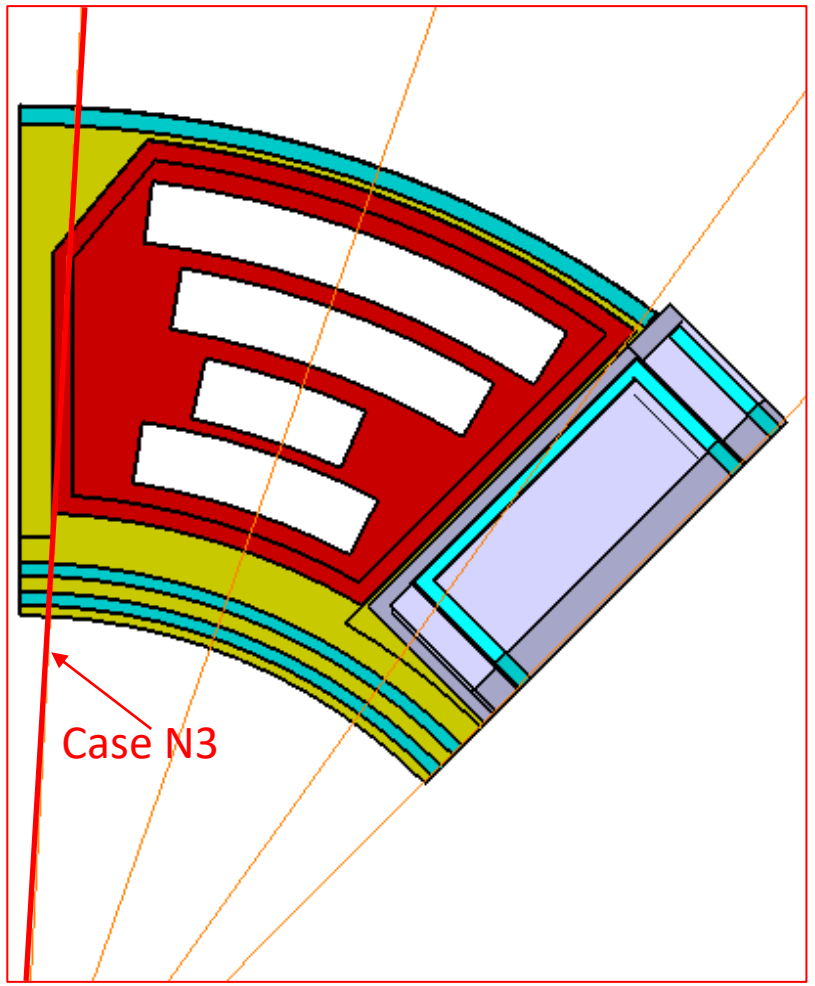
Critical Case N3

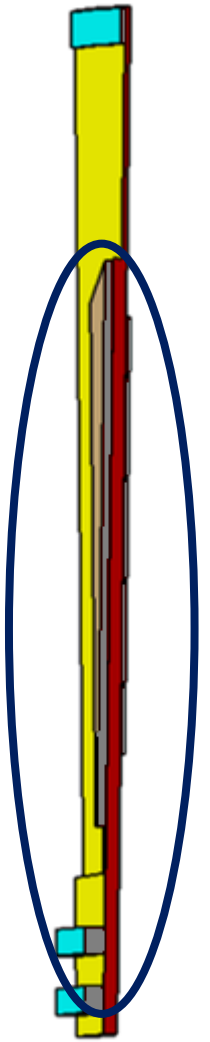
As-built geometry

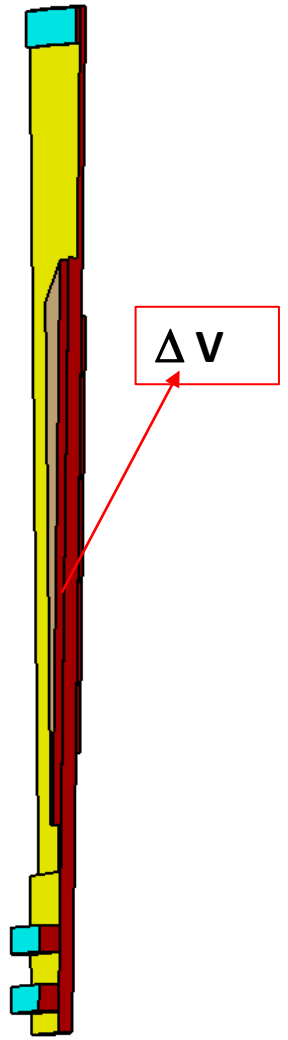




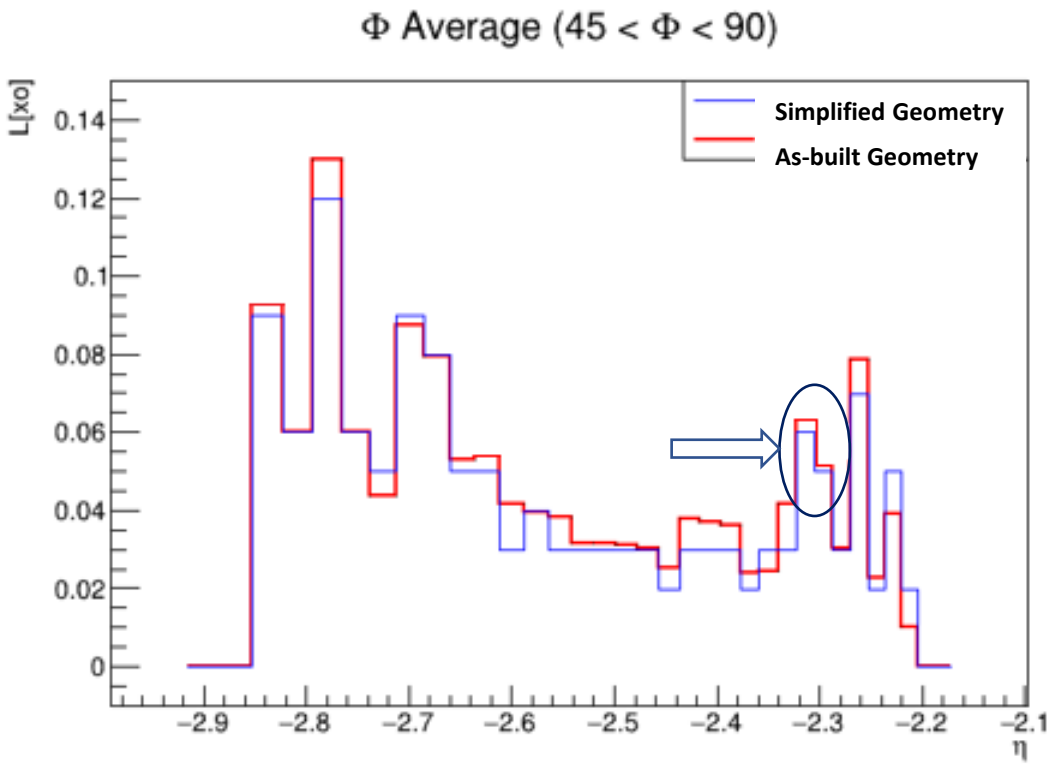
Simplified Geometry

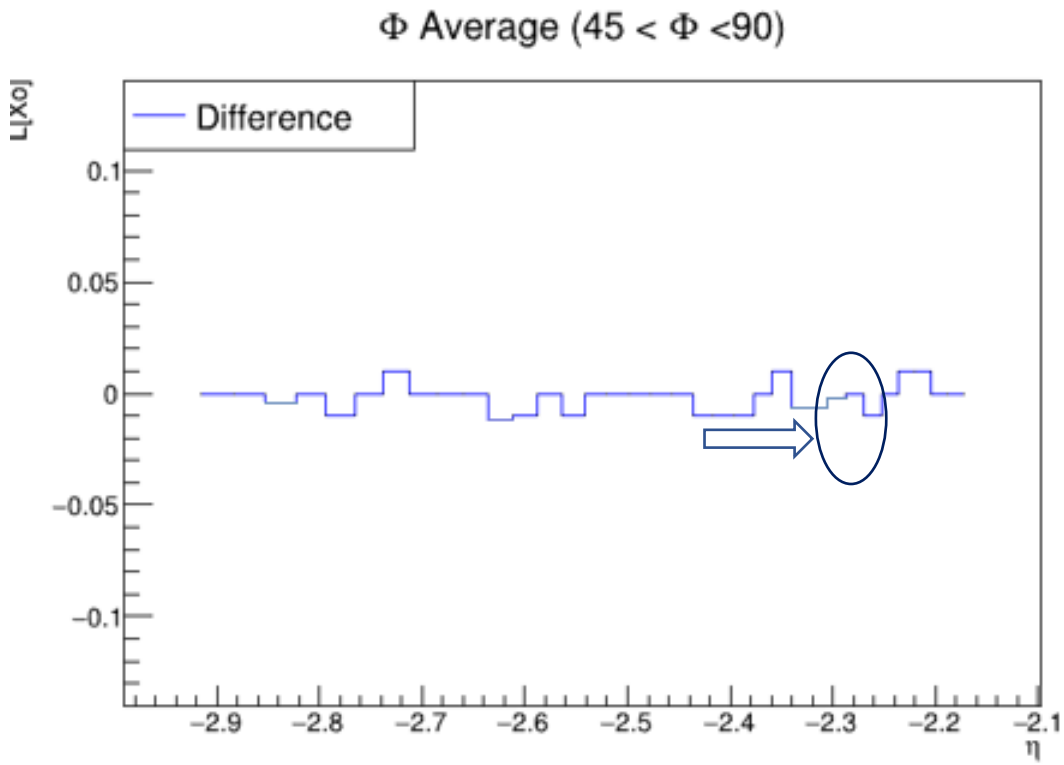






Radiation length after geometry correction case N3





Conclusion

1. An efficient method of simplification of the geometry based on the radiation analysis in the CATIA was developed

2. This method permits to identify critical fragments on the geometry where the difference in radiation length between the as-built and simplified geometries exceed the allowable values and make geometry simplification in correct way

3. The method and CATIA tools have been tested on current projects for development of ITK simulation geometry and demonstrated its effectiveness

4. This method and application are used in the ongoing TAI agreement between the ATLAS collaboration and the Georgian Technical University.

Thank You!