

Simulation Loop Between Cad Systems, GEANT-4 and GeoModel: Implementation and Results¹

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Abstract—Compare analysis of simulation and as-built geometry descriptions of detector is important field of study for data_vs_Monte-Carlo discrepancies. Shapes consistency and detalization is not important while adequateness of volumes and weights of detector components are essential for tracking. There are 2 main reasons of faults of geometry descriptions in simulation: (1) Difference between simulated and as-built geometry descriptions; (2) Internal inaccuracies of geometry transformations added by simulation software infrastructure itself. Georgian Engineering team developed hub on the base of CATIA platform and several tools enabling to read in CATIA different descriptions used by simulation packages, like XML->CATIA; VP1->CATIA; Geo-Model->CATIA; Geant4->CATIA. As a result it becomes possible to compare different descriptions with each other using the full power of CATIA and investigate both classes of reasons of faults of geometry descriptions. Paper represents results of case studies of ATLAS Coils and End-Cap toroid structures.

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1. INTRODUCTION

ATLAS simulation is implemented for deep and wide range investigation of physics processes from the event generator in a format which is identical to the output of the ATLAS detector data acquisition system. Simulation chain combines as a single job – generated events and decays, detector model and physics interactions, digitized energy deposited into voltages and currents for comparison to the detector outputs [1]. Both the simulated data and detector outputs are running through the same trigger and reconstruction packages. However R1 data analyses for some region of detector shows discrepancies of simulated and real data. Several reasons can cause above mentioned discrepancies. In several cases they caused by inaccuracies of detector geometry descriptions using in simulation. Plot on Fig. 1 shows example how adequate description of detector geometry will fit closer results of MC simulation and data [3]. Black dots are correspond to data from Run-2 and shows that discrepancy for modified geometry of Pixel detector is less than for default geometry. Most visible it is for IBL structure where default geometry missing surface mount device at around $r = 32$ mm. Updated geometry which includes missed materials significantly improves the agreement between data and MC.

Geometry description analyse includes 2 studies:

1. Consistency study of simulation geometry descriptions with as-built geometry descriptions of detector
2. Study of inaccurateness of geometry transactions doing by simulation software infrastructure itself.

2. ATLAS DETECTOR GEOMETRY FOR SIMULATION

ATLAS detector is one of the most complex engineering facility worldwide. Detector geometry consists of simple parts like prisms, cylinders, tubes, etc. hav-

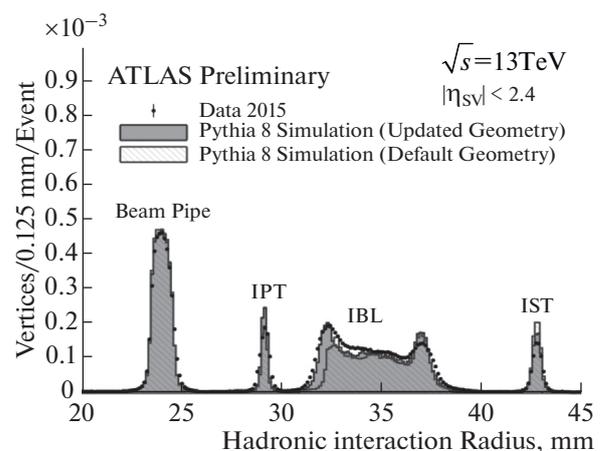


Fig. 1. Data/MC discrepancy.

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	CATIA	XML	Difference	%
1. Cold Mass	116740 kgs	123012 kgs	6272 kgs	5.4%
2. Thermal Shielding	15988 kgs	15957 kgs	-31 kgs	0.2%
3. Cover	57966 kgs	57185 kgs	-781 kgs	1.3%
4. Bare Tube	13433 kgs	10208 kgs	-3225 kgs	24.0%
5. Yoke	1820 kgs	1338 kgs	-483 kgs	26.5%
6. Stay Tube	2028 kgs	2214 kgs	186 kgs	9.2%
7. JTV Shielding	4161 kgs	4510 kgs	349 kgs	8.4%
8. Turret	2476 kgs	1512 kgs	-964 kgs	38.9%
9. Tie Rod	3077 kgs	1268 kgs	-1809 kgs	58.8%
10. Bolts/	2965 kgs		-2965 kgs	100%
11. Services	869 kgs		-869 kgs	100%

Fig. 4. Weight differences between CATIA and XML description.

		Material	Density kg/m ³	Volume m ³	Weight tonnes	Difference tonnes
XML	Outside Assembly	Steel	7870	3887	30.6	5.1
CATIA		Steel	8000	4458	35.7	
XML	Voussoir Structures	Aluminum Steel	2700/7870	4.56	13.2	-0.9
CATIA		Aluminum Steel	2650/8000	4.416	12.3	
XML	Tie Road	Aluminum	2700	0.42	1.1	1.8
CATIA		Steel/Titan Aluminum	8000/4480/ 2705	0.5193	2.9	
XML	Thermal Shielding	Aluminum	2700	13.138	35.5	5.6
CATIA	Coil Casing	Aluminum	2740	0.7517	2.3	
	Coil Covers	Aluminum	2650	12.033	31.9	
	Services	Aluminum Steel	2660/2650 8000/8000/ 2650	1898	5	
					Difference:	11.6

Fig. 5. Weight differences between CATIA and XML of Coils.

as-built 3D models are stored. As a result CATIA platform can be considered as a hub for collection of geometry descriptions from various platforms and proceed different studies of detector geometry descriptions.

4. ATLS End-CAP TOROID STUDY

End-Cap Toroid (ECT) is one of the biggest and heaviest (250 tonnes) part of ATLAS detector. According to muon team estimations of simulation performance of muon system, current sagitta resolution of all the End-Cap sectors (Fig. 3) expected to become better after improvement of ECT geometry description [7]. Thus ECT geometry has been investigated. On the 1st stage engineering descriptions on Smarteam have been analysed. Several 3D models compared and most detailed one was chosen. After comparison with several assembly drawings and pho-

tos it was concluded necessity in 3D model reproduction in CATIA, because of lot of missing descriptions.

Manufacturing drawings for reproduction were downloaded from CDD (CERN Drawing Database). As a result detailed ECT geometry was reproduced in CATIA from 902 manufacturing drawings. On the 2nd stage full ECT description was split into 11th volumes by mechanical structure and materials and for each volume weights were calculated. On the 3rd stage 11th identical volumes have been extracted from XML geometry and calculated their weights. Compare analyse of CATIA vs XML (Fig. 4) shows >20% difference in volume and weight for majority of components. The grouping of volumes in the two geometry systems may differ somewhat, but the distribution of mass in the detector still shows significant differences.

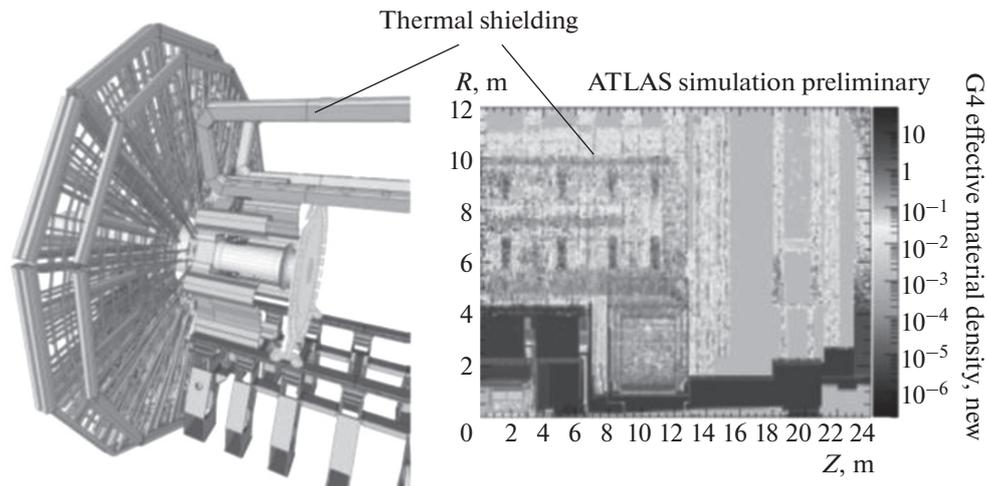


Fig. 6. Simulation results with updated geometry of coils.

Most big discrepancies were detected for BoreTube assembly – 3 tonnes; TieRod assembly – 2 tonnes and Turret assembly – 960 kg. It was decided to update existing XML geometry of ECT. Therefore, on the next stage detailed CATIA geometry was simplified by keeping volume and weight of each component. Maximum scattering of volume and weight after simplification was 0.01 m^3 and 27 kg accordingly. On the final stage baseline geometry was updated by generation of new XML descriptions from the simplified geometry.

5. ATLAS COIL STUDY

ATLAS detector have 8 identical coils. Coil is complex engineering facility which consists of lots of various parts inside and outside. Initial analyse of Smarteam model on completeness shows necessity for model reproduction in CATIA. 255 CDD drawings have been considered and added as a 3D parts to Smarteam model of coil. After, coil assembly was split into 7 volumes according to mechanical structure and materials [6]. Then weight for each of volume were calculated. On the next stage identical 7 volumes were extracting from XML geometry and also weights were calculated.

Compare analyse shows big differences in volume and weight between CATIA and XML descriptions (Fig. 5).

Therefore XML baseline geometry were updated by simulation team. Figure 6 illustrates different simulation results by adding thermal shielding to XML description.

6. CONCLUSIONS

1. Creation geometry hub on the base of CATIA brings unique possibilities for several geometry cross-

checking and investigation of simulation software infrastructure.

2. ATLAS End-CAP Toroid geometry study shows difference (11t missed /6.7t added) of weight between XML and as-built geometry volumes.

3. ATLAS Coils geometry study shows 11.6 tones missed materials in XML baseline geometry.

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