#

TECHNICAL UNIVERSITY OF GEORGIA

DISSERTATION

Master’s Degree

Development of Geometrical Descriptions of Magnet System of ATLAS Detector for the Simulation and Reconstruction Software Packages

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RESUME

Nowadays high energy physics research carries ambitious goals, which are fastidious challenges for engineering society to handle its capacities, design and construction of facilities, machines and detectors.

High energy physics aims are vast, but on this stage main objectives are to determine and explore ‘The Big Bang theory’ with its associate questions as: existence of other dimensional life, phenomena of black holes, etc. having a scientific response to those global questions of our existence requires specific and unique facilities and machines.

At this stage, proudly can be underlined several projects/experiments in HEP:

1) LHC (Large Hardron Collider) constructed in Geneva, Switzerland.
2) ITER (International Thermonuclear Experimental Reactor), Cadarache, France.
3) FAIR (Facility for Antiproton and Ion Research), GSI, Darmstadt, Germany.

An important part of LHC project is presented by ATLAS collaboration, which conducts construction and exploitation of world’s largest and complex detector. ATLAS detector is 46m long, 25m diameter and 7000 tones device, buried 100m underground of Geneva, Switzerland. Whole Collaboration unifies 169 partners from 37 countries with 2500 scientists and engineers.

Dissertation work is based on ATLAS computing in reconstruction and modeling sectors, objective: to have explicit detector components and to improve its quality and precision. Specific method has been invented based on usage of CAD software package CATIA to produce precise cad models. Below, is given actual result of ATLAS detector magnetic axis creation life cycle.

IN THE 1ST CHAPTER are introduced HEP research topics and descriptions of LHC, ITER and FAIR projects. links between HEP and technology in general which itself engender new innovative engineering technologies as Radiation sensors, solar panels, electro connectors and IT technologies to support HEP projects. Modern WWW internet standard, which

has been invented at CERN and new global web GRID are bright examples of impact of HEP on technology.

IN 2ND CHAPTER is presented definition of ATLAS detector. Examined a connection between physics research and detector shape, which itself consists of 4 main sub detectors: Inner detector, Tile Calorimeter, Muon Spectrometer, Magnetic system. Each sub system definition, composition and geometric configuration is given.

IN 3RD CHAPTER is presented engineering challenges of ATLAS experiment. With its construction objectives which can be interpreted in three major steps as: planning/design, procurement and installation.
Detector associated IT goals are divided in 4 types: 1) data collection; 2) organization of Database; 3) reconstruction; 4) modeling;

In same chapter are described three types of trigger system, which operates online and filters imported data from detector and determines final data stream with inlet stream of 23PByte/sec and outlet 100MByte/sec. Explored and discussed the following aspects: structure of database (built in Oracle), reconstruction problems, types, data streams and physical modeling definition and its role, IT maintenance, Geant4/C++ programming resources.

Chapter 3 provides brief description of 4 layer structure of ATLAS detector in Geant4, with detailed definition of each layer composition and links between, as well methods of geometrical model development in Geant4.

CHAPTER 4: ATLAS detector magnetic axis geometry and mass property analysis: At the 1st stage, magnetic axis has been imported from CERN SMARTEAM database, where all CAD models are situated. According to the information retrieved from additional 225 drawing, reproduction of magnetic axis has been made in CATIA, where final result of axis was segmented into 21 individual components, volume and mass has been determined for each. Afterwards, import of magnetic axis from Geant4 to CATIA was implemented. Compare analysis between reproduced model of axis and ancient one has revealed ~13% difference in volume:

$\Delta_m = \Delta_{Catia} - \Delta_{G4}$ = 92 130 kg – 80 449.1 kg = 11 680.9 kg

and ~12% in mass:

$\Delta_V = \Delta_{Catia} - \Delta_{G4} = 24.75\ m^3 – 21.85\ m^3 = 2.9\ m^3$

As a result, axis in Geant4 has been modified.

CHAPTER 5: presented simplification of magnetic axis and Geant4/C++ programming objectives. To remain high performance of reconstruction and design it is essential to simplify geometry of magnetic axis , by replacing original objects with basic solid shapes (cylinder, prism), but keeping original volume and mass, as well consolidating certain parts into one solid, which, in general can pose difference of mass and volume between reproduced and simplified versions. After conducting the analysis in CATIA, minimum difference in mass of 15kg and volume of 0.05m has been detected. In order to develop Geant4/C++ code, magnetic axis was divided into geometrical models. Process of object programming in Geant4/C++ is conducted in Z0. For that reason it is essential to replace and revolve for final positioning of components, which itself might cause shifting of parts. Therefore while code development in Geant4/C++ following integration conflicts might occur, as: Overlap–when two object cross each other; Gap–when two objects are separated. To solve the above mentioned problem, special method has been invented in CATIA to verify and detect conflicts in Geant4/C++. It foresees two step exports of Facet data from Geant4 to CATIA. To improve above mentioned method multiple cycle work has been done in order to reduce the clearance. Final result ensures 0.03 mm clearance.

Each segment of magnetic axis has been described and analyzed with above mentioned method on Geant4/C++ programming language in CATIA. In result the code of magnetic axis of ATLAS Detector was developed.