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Advanced European Infrastructures for Detectors at Accelerators

Milestone Report

Running prototype for Geant4 based simulation toolkit

Cosmo, G. (CERN)

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Advanced European Infrastructures for Detectors at Accelerators

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MILESTONE REPORT

RUNNING PROTOTYPE FOR GEANT4 BASED SIMULATION TOOLKIT

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Abstract:

The USolids package [1] now available within VecGeom [2], provides an extended set of geometrical primitives with also vector signatures, which can be exercised through the Geant4 simulation toolkit [3]. In this document, we briefly report on the testing performed within Geant4 and the design behind the interface bridging Geant4 with the VecGeom package, such that original Geant4 primitives can be fully replaced in their functionalities with VecGom/USolids ones.

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Delivery Slip

	Name	**Partner**	**Date**
Authored by	G. Cosmo [Task coordinator]	CERN	13/01/17
Edited by	G. Cosmo [Task coordinator]	CERN	13/01/17
Reviewed by	W. Pokorski [WP coordinator] F. Sefkow	CERN DESY	23/01/17
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Executive summary

The Geant4 simulation toolkit [3] can now make use of VecGeom [2] primitives, by replacing in full the functionalities provided by the original Geant4 shapes and running in scalar mode. The latest Geant4 release 10.3 has been tested against VecGeom v00.03.00 for a limited set of shapes passing most of the available unit/integration tests. Validation has also been performed on realistic detector setups like the CMS or the LHCb full geometries, imported from GDML [4].

1. INTRODUCTION

The latest release of the Geant4 simulation toolkit, Geant4 10.3, has been tested and validated against the geometrical primitives included in VecGeom v00.03.00. VecGeom primitives can replace the original Geant4 shapes by simply specify the proper configuration option at the time Geant4 gets installed. Primitives from VecGeom v00.03.00 which can be used for replacement are: Box, Orb, Trapezoid (Trap), Simple Trapezoid (Trd), Sphere (+ spherical section), Tube (+ cylindrical section), Cone (+ conical section), Generic Trapezoid (Arb8), Polycone, Polyhedron, Paraboloid and Torus (+ toroidal section).

2. DESIGN AND IMPLEMENTATION

The Geant4 simulation toolkit includes now the possibility to adopt primitives available in VecGeom, replacing the corresponding original shapes implemented in the toolkit. This can be achieved when configuring the Geant4 installation, allowing for the possibility to either replace the whole set of available shapes, or, in order to facilitate validation and debugging, specify individually which shape to replace. The original type names and interfaces are preserved, thanks to the adoption of dedicated wrapper classes redirecting all functionalities to the VecGeom core implementation and acting as "bridges" to the VecGeom package, as depicted in the design diagram in Fig. 1.

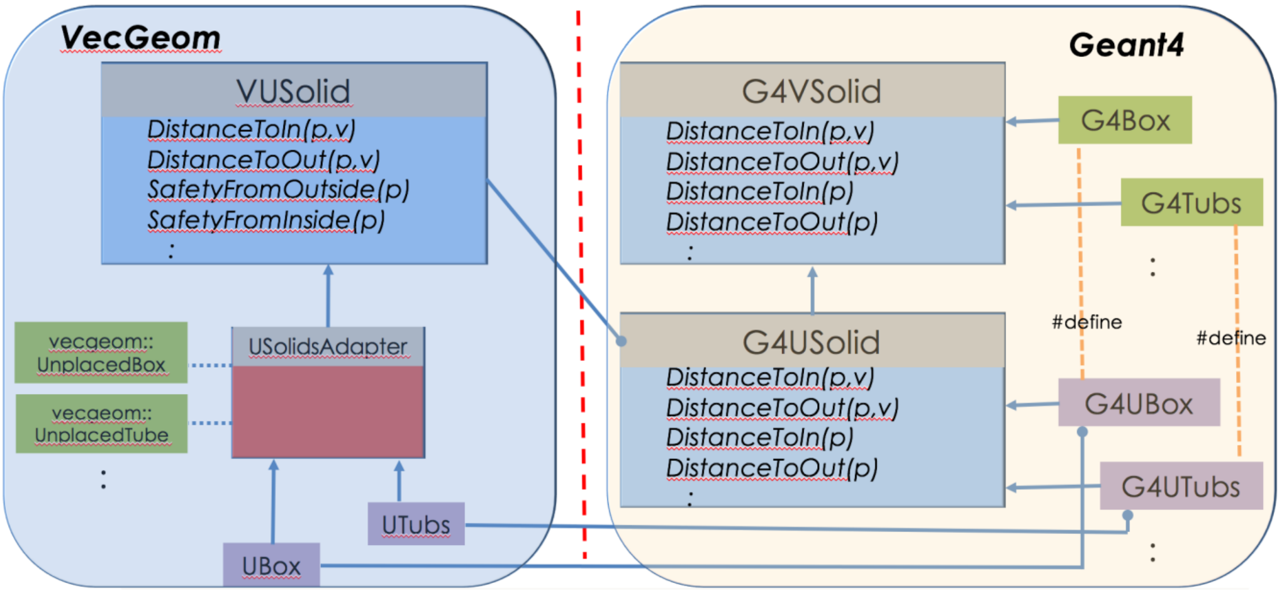

Figure 1: Diagram illustrating the design pattern used in Geant4 for bridging shapes functionalities to VecGeom/USolids. Original type names are preserved thanks to wrappers (G4U classes) defined in Geant4, redirecting all functionalities to specific adapters in VecGeom.*

VecGeom primitives are being regularly tested as part of the nightly testing suite in Geant4, therefore being exposed to almost 300 tests/configurations and applications with real physics applied (see example in Fig.2) and being stress-tested in jobs with different statistics. Part of the validation includes also adoption of VecGeom primitives on dedicated benchmarks for realistic detector setups, like simplified calorimeters or complete geometry descriptions of the CMS and the LHCb detectors, imported from GDML. For most shapes, all tests are successfully reproducing the expected results in tracking. Investigations are going on few shapes, where performance/correctness is still not satisfactory.

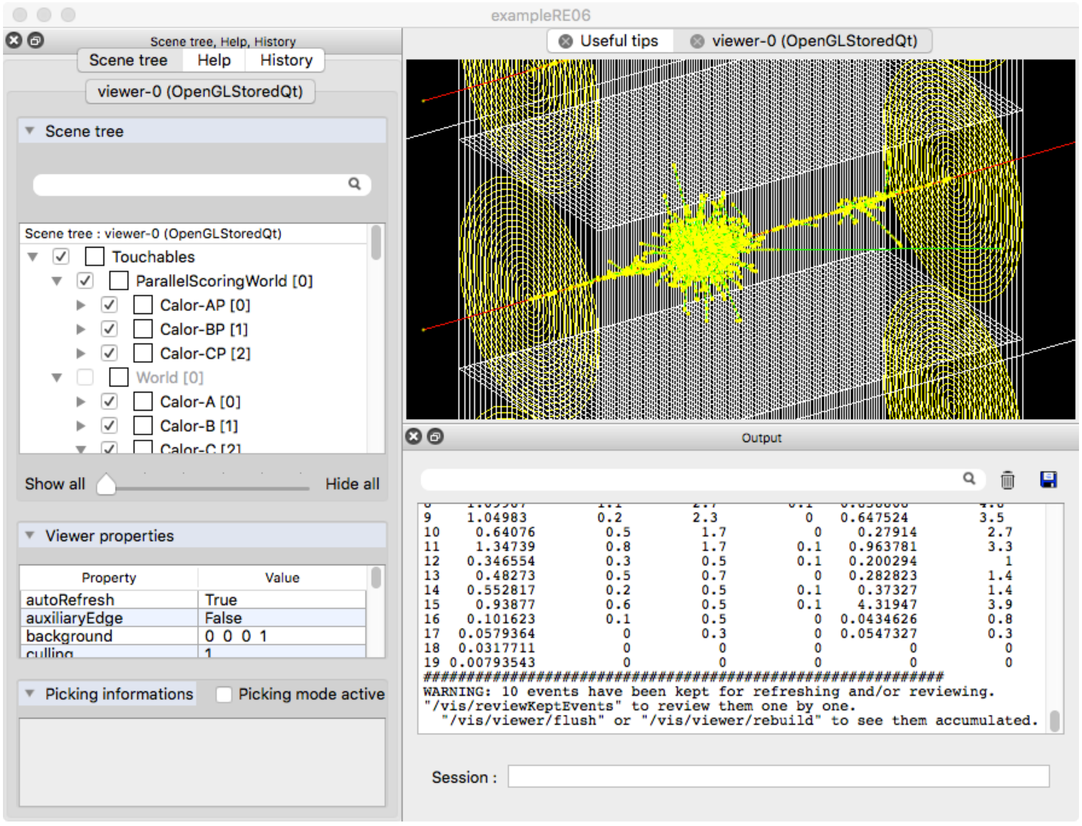

Figure 2: Screenshot of a Geant4 application using VecGeom primitives, part of the standard set of advanced examples in the toolkit, implementing most of the functionalities the Geant4 geometry modeler provides, i.e. scoring fluxes on parallel geometries, and adopting navigation in parameterized and replicated volumes.

3. CONCLUSIONS

The USolids primitives, now included in the VecGeom package can be used in the latest releases of the Geant4 simulation toolkit to replace the original primitives implemented in Geant4. Further testing is still going on to resolve issues detected for some of the shapes and related to performance and correctness. The testing suite is still being gradually extended to increase coverage for all possible topologies of shapes and compositions.

4. REFERENCES

1. M. Gayer et al., "New software library of geometrical primitives for modeling of solids used in Monte Carlo detector simulations", Journal of Physics: Conference Series **396** (2012) 052035.
2. J. Apostolakis et al., "Towards a high performance geometry library for particle-detector simulations", Journal of Physics: Conference Series **608** (2015) 012023.
3. S.Agostinelli et al., "Geant4 – a simulation toolkit", Nuclear Instruments and Methods in Physics Research A **506** (2003) 250-303.
4. R. Chytracek et al., "Geometry Description Markup Language for Physics Simulation and Analysis Applications", IEEE Transactions on Nuclear Science **53** (2006) 2892-2896 ISSN 0018-9499.

ANNEX: GLOSSARY

Acronym	Definition
GDML	Geometry Description Markup Language
USolids	Unified Solids