Geometry Testing

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Contents

- Testing coverage status of geometry features
- Validation of shapes

Testing Coverage

- Geant4 geometry modeler testing coverage summarised in traceability matrix document
  - http://cern.ch/geant4/collaboration/working_groups/geometry/docs/traceability_matrix.pdf
  - Matching: use-case <> design document <> unit test <> system test
- Examples and tests define the system testing suite
  - Geometry features exercised in essentially any system test in direct or indirect way
  - Specific tests aimed to cover geometry features (solids & volumes types):
    - test01 – raytracing test (geantino) for CSG shapes, placed, replicated volumes & assembly
    - test10 – random optical photons reflection on any available shape types
  - Examples aimed to demonstrate and test modeler features
  - Executed daily in Continuous and Nightly builds
- Unit tests for class-level functionalities and interfaces
  - For shapes, volumes, navigation, structures, voxels, etc..
  - Interactive or batch tests
  - Executed by the developers for any specific update

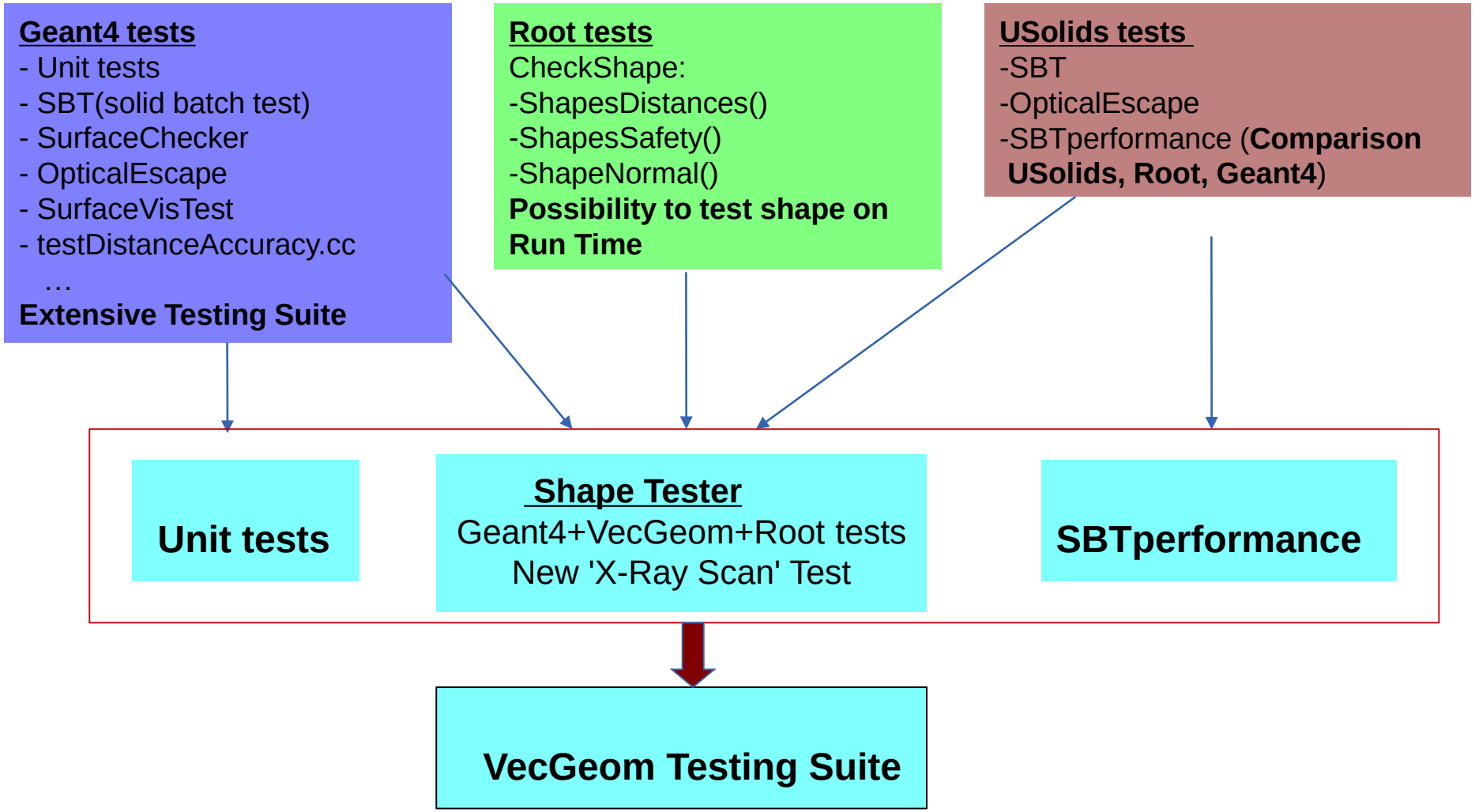
SOLIDS & VOLUMES

UR	Design	Implementation	Use case	Unit test	System test
3.1	geom.mdl	Classes in: solids/CSG solids/specific	**3.1.1** – Construction of a box (G4Box) **3.1.2** – Construction of a cone (G4Cons) + section **3.1.3** – Construction of a tube (G4Tubs) + section **3.1.4** – Construction of a shell-sphere (G4Sphere) + section **3.1.5** – Construction of a full-sphere (G4Orb/G4Sphere) + section **3.1.6** – Construction of a generic trapezoid (G4Trap) **3.1.7** – Construction of a trapezoid along Z (G4Trd) **3.1.8** – Construction of a parallelepiped (G4Para) **3.1.9** – Construction of a torus (G4Torus) + section **3.1.10** – Construction of a polyhedron (G4Polyhedra) + section **3.1.11** – Construction of a polycone (G4Polycone) + section **3.1.12** – Construction of an hyperbolic tube (G4Hype) **3.1.13** – Construction of an elliptical tube (G4EllipticalTube) **3.1.14** – Construction of a twisted tube (G4TwistedTube) **3.1.15** – Construction of a twisted trapezoid (G4TwistedTrap) **3.1.16** – Combination of cases above with major functionalities (see additional use-cases table T.3.1 in Appendix) **3.1.17** – Visualization of above shapes (3.1.1 to 3.1.15)	Tests in: CSG/test specific/test See Appendix.	test10
3.4	geom..mdl	G4BooleanSolid and derivatives	**3.4.1** – Union of a combination of CGS/specific solids **3.4.2** – Intersection of a combination of CSG/specific solids **3.4.3** – Subtraction of a combination of CSG/specific solids **3.4.4** – Combination of cases above with major functionalities (see additional use-cases table T.3.4) **3.4.5** – Visualization of Boolean solids with/without shared surfaces	Tests in Boolean/test	test10
3.5	geom.mdl	G4LogicalVolume	**3.5.1** – See cases in 1.2	Any test	Any test
3.6	geom..mdl	G4PVReplica	**3.6.1** – Replication along single axis (Cartesian, phi, rho) for major CSG and specific solids (box, cone, tube, sphere, trap/trd, polycone, polyhedron, torus)	testG4ReplicaNavigation replicaCal	basic/B2,3,4

Benchmarks

- Navigation features and wide variety of shapes and volumes combinations tested nightly/monthly in benchmarks
  - Simplified calorimeter derived from LHC experiments:
    - CMS hadronic calorimeter
    - ATLAS barrel
  - Full CMS geometry
- Geometry imported from GDML files
  - Alice, CMS, LHCb, ATLAS

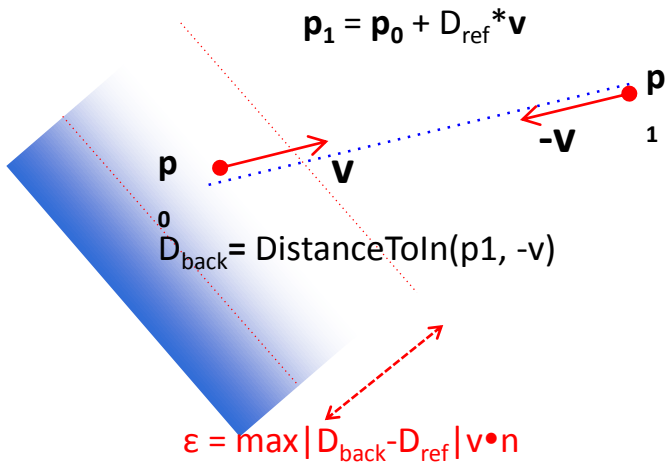
VecGeom testing suite for shapes



Example:

Checking boundary precision in ShapeTester

- Loop points on boundary and compute normal in these points
- Generate ***nsamples*** random directions outwards and propagate with known reference distance
- Compute distance back to boundary and compare with reference
- Store maximum error with respect to many reference distances



Systematic check in Shape Tester for each shape

Coverage extension

- One shape for each different topology
  - Sections, shells, …
  - Degenerated configurations
  - Pathological cases
- Shapes selection from a DB
  - DB generated from imported LHC experiments geometries
- Random generation of shapes
  - Per type, dimension and position in space
- Geantino tracking comparisons on realistic geometries
  - CMS, LHCb, ATLAS, …
- *Batch or interactive mode*

Summary

- Geometry testing suite: a combination of interactive and batch tests
  - Variety of setups and combinations exercised daily automatically
  - Enhanced suite for shape testing introduced with USolids and VecGeom
- Extensions to increase coverage ongoing
  - More shape topologies
  - Realistic geometry setups
- Traceability matrix matching use-cases