GEANT4 GEOMETRY

Traceability matrix

Status: Draft

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DETECTOR CONSTRUCTION

UR	Design	Implementation	Use case	Unit test	System test
1.1	geom.mdl	geometry/solids/* classes	**1.1.1** – Specific construction of solids, through one or more constructors (see 3.1 and 3.2 for specific cases)	testG4* tests	test01 test10 Any test
			1.1.2 – Explicit deletion of solids from a dynamic geometry setup		
1.2	geom.mdl	G4LogicalVolume G4VPhysicalVolume & subclasses	**1.2.1** – Specific construction of physical volumes through constructors or successive *set* methods	testG4Volumes testG4Parameterised/Solid1/Material	Placement: any Replicas: basic/B2,4; biasing/B01,2,3
			1.2.2 – Setting of material to logical volume (LV)		
			1.2.3 – Setting of sensitive detector to LV		
			1.2.4 – Setting of region to LV		
			1.2.5 – Setting of visualization attributes to LV		
			1.2.6 – Setting of field manager to LV		
			1.2.6 – Setting of parameterization to LV		
			1.2.7 – Setting of importance biasing to LV		
			1.2.8 – Dynamic modification of geometry (switching and/or explicit deletion)		
1.3	geom.mdl	navigation/G4GeomTestVolume, G4GeometryMessenger DAVID graphics tool	**1.3.1** – UI verification through recursive check	UI commands	UI commands
			1.3.4 – UI verification through non recursive mode		
			1.3.5 – UI verification with limited recursion		
			1.3.6 – UI verification with high/low resolution		
			1.3.7 – UI verification with higher/lower tolerance		
			1.3.8 – Verification overlap mother-daughter		
			1.3.9 – Verification overlap (partial and totally overlapping) daughter-daughter		
1.4	geom.mdl CutsPerRegion.mdl	G4Region, G4RegionStore	**1.4.1** – Disjoint root regions definition	none	runAndEvent/RE06 test34,36,46,52
			1.4.2 – Nested root regions definition		
			1.4.3 – Deletion of regions (disjoint and/or nested)		
1.5	geom.mdl	G4LogicalVolume	**1.5.1** – See cases from 1.2.2 to 1.2.7	Any test	Any test

1.6	GDML web page	persistency/gdml classes	**1.6.1** – Import of persistent geometry (details for shapes from 3.1 and 3.2) from file together with material definitions and attributes	none	gdml
			1.6.2 – Export of transient geometry (details for shapes from 3.1 and 3.2) to file together with material definitions and attributes		
			1.6.3 – Import/export of a CAD geometry (details for shapes from 3.1 and 3.2)		
A.1	geom.mdl	CSG solids specific solids	**A.1.1** – See case 1.6.3	CSG tests, specific tests	CSG: any test specific: any test
A.2	geom.mdl	G4VPhysicalVolume G4PVPlacement G4PVReplica, G4PVParameterised	**A.2.1** – Placement of a volume in a mother when a replica is placed already	none	Not applicable
			A.2.2 – Replica NOT filling a mother volume		
			A.2.3 – Not applicable replications or parameterizations		
			A.2.4 – Not allowed axis for division of a volume		
			A.2.5 – Degenerated solids: trap/prism, disjoint polyhedrons/polycones		
			A.2.6 – Invalid Boolean constructions (disjoint constituent solids, subtraction/intersections of solids with shared surfaces)		
A.3	geom.mdl	Navigation/G4GeomTestVolume	**A.3.1** – See case 1.3.5	UI commands	UI commands

ELECTROMAGNETIC FIELD

UR	Design	Implementation	Use case	Unit test	System test
2.1	geom.mdl field.mdl	G4Field and derivatives G4FieldManager	**2.1.1** – Definition of a uniform magnetic field **2.1.2** – Definition of a non-uniform magnetic field **2.1.3** – Definition of an electric field **2.1.4** – Combination of fields according to a map	???	???
2.2	field.mdl	G4EquationOfMotion G4Mag*Driver, G4Mag*Stepper	**2.2.1** – Definition of a generic equation of motion	magneticfield/test/*	basic/B2,4 field01 field02 field03
2.3	field.mdl	G4ChordFinder G4FieldManager	**2.3.1** - …	???	???
2.4	field.mdl	G4Mag*Stepper G4Field and derivatives	**2.4.1** – Runge-Kutta stepper **2.4.2** - …	OtherFields, NTST, ???	field01 ???
2.5	field..mdl	G4FieldTrack G4FieldManager	**2.5.1** - …	???	???
2.6	geom..mdl field.mdl	G4Field and derivates	**2.6.1** – See 2.1.1 and 2.1.2	???	Non uniform: field03
2.7	field.mdl	G4ElectricField	**2.7.1** – See 2.1.3	???	field02
B.1	geom.mdl	G4EquationOfMotion G4FieldManager	**B.1.1** - …	???	See 2.2
B.2	field..mdl	G4Mag_EqRhs G4Mag_SpinEqRhs	**B.2.1** - …	testProPerpSpin	none
B.3	geom..mdl	G4FieldManager G4LogicalVolume	**B.3.1** - …	???	field03
B.4	geom..mdl	G4FieldManager	**B.4.1** – Definition of sub-detectors with no field associated	???	none
B.5	geom.mdl	magneticfield classes	**B.5.1** – Looping mouns **B.5.2** - …	???	???

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

			3.6.2 – Replications along multiple axes or replication containing replications		
			3.6.3 – Visualization of replicated volumes		
3.7	geom..mdl	G4PVParameterised G4VPVParameterisation	**3.7.1** – Parameterization by dimension and/or position for major CSG and specific solids (box, cone, tube, sphere, trap/trd, polycone, polyhedron)	testG4Parameterised testG4ParameterisedMaterial testG4ParameterisedSolid1	basic/B2,4
			3.7.2 – Parameterization by solid shape		
			3.7.3 – Parameterization by material		
			3.7.4 – Visualization of parameterized volumes		
3.8	none	Classes in: geometry/divisions	**3.8.1** – Division along specified Cartesian/phi/rho axis for major CSG and specific solids (box, cone, tube, sphere, trap/trd, polycone, polyhedron)	testG4PVDivision ExDivisions	none
			3.8.2 – Definition of offsets in divisions		
			3.8.3 – Visualization of divided volumes		
3.9	geom..mdl	G4ReflectedSolid G4ReflectionFactory	**3.9.1** – Reflection of a single volume of hierarchy of volumes (only placements)	testG4ReflectedSolid	none
			3.9.2 – Reflection of a hierarchy of volumes including replicas		
			3.9.3 – Reflection of a hierarchy of volumes including parameterizations or divided volumes		
			3.9.4 – Reflection of attributes of a logical volume and daughters		
			3.9.5 – Visualization of reflected volumes		
3.10	geom.mdl	G4ReflectionFactory	**3.10.1** – Retrieval of a pointer to the reflected volume	none	none
			3.10.2 – Retrieval/customization of the name/ID associated to a reflected volume		
3.11	geom..mdl	G4AssemblyVolume G4AssemblyTriplet	**3.11.1** – Composition of major CSG solids (box, tube, cone, sphere, trap/trd) into an assembly	TestAssemblyVolume	test01
			3.11.2 – Retrieval/customization of the name/ID associated to an assembly component		
			3.11.3 – Automatic handling of allocated objects in the assembly		
3.12	geom..mdl	G4LogicalVolume	**3.12.1** – Definition of a volume hierarchy with partial optimization	none	none
3.13	geom.mdl	G4LogicalVolume	**3.13.1** – Computation of volume mass or density of a generic hierarchy of volumes (including replicas/parameterized/divided volumes) with	none	none

			different materials associated		
C.1	geom..mdl	G4DisplacedSolid	**C.1.1** – Definition of Boolean solids (union, intersection, subtraction) with defined displacement (translation, rotation)	testG4DisplacedSolid	none
C.2	geom..mdl	Classes in: solids/CSG solids/specific	**C.2.1** – See cases in 3.1	Tests in: CSG/test Specific/test	test10
C.3	geom..mdl	G4PVReplica G4ReplicaNavigation G4ParameterisedNavigation G4SmartVoxelHeader and related	**C.3.1** – Replication/parameterization of many volumes compared to normal placements, with/without optimization	CPU benchmarks: replicaCal Memory benchmarks: none	none
C.4	geom.mdl	G4SmartVoxelHeader and related	**C.4.1** – Verification of optimization for generic hierarchies including different parameterizations/replications along different axes	testG4SmartVoxelProxy testG4SmartVoxels testG4VoxelLimits TestDrawVox	basic/B4

NAVIGATION & TRANSPORTATION

UR	Design	Implementation	Use case	Unit test	System test
4.1	geom.mdl	G4Navigator	**4.1.1** – Define customized navigator with slightly different behavior from the default	testG4Navigator*	none
D.1	geom..mdl	G4Navigator and related G4SmartVoxelHeader and related G4VTouchable and subclasses	**D.1.1** – Definition of a flat geometry structure with more or less "dense" areas of placements **D.1.2** – Definition of a reasonably complex structured geometry **D.1.3** – See cases C.3.1 and C.4.1	See C.4 testG4AffineTransform testG4Touchables testG4NavigationHistory testG4BlockingList calorimeter	Any test
D.2	geom..mdl	G4TouchableHistory G4NavigationHistory and related	**D.2.1** – Location of points in geometry structure with multiple placements, replicas/parameterized volumes, divisions. Identification of the copy-number	TestG4NavigationHistory	B2,3,4 Others in tests and extended…
D.3	geom..mdl field.mdl	G4Transportation G4PropagationInField	**D.3.1** – Transportation of charged-geantinos in a geometry structure with mixed field setups	none	Any test

BIASING

UR	Design	Implementation	Use case	Unit test	System test
5.1	biasing.mdl	Classes in: geometry/biasing processes/transportation	**5.1.1** – Importance biasing and scoring of particles in the real tracking geometry	none	extended/biasing/* test33,34 extended/runAndEvent/*
			5.1.2 – Importance biasing and scoring of particles in a parallel simplified geometry		

GENERAL

UR	Design	Implementation	Use case	Unit test	System test
E.1	geom..mdl	G4VPhysicalVolume G4SmartVoxelHeader and related	**E.1.1** – Definition of reasonably complex structured geometry and measurement of memory consumption with/without optimization (see also D.1.2)	calorimeter G3 comparison tests	Any advanced test
E.2	geom..mdl	G4SmartVoxelHeader and related	**E.2.1** – Definition of a tracker setup without field	See E.1	Any advanced test
			E.2.2 – Definition of a tracker setup with field		
E.3	geom..mdl	Classes in 'g3tog4' module	**E.3.1** – Import a structured/not-structured geometry setup with placements, replicas, parameterized volumes, divisions, reflections	none	clGeometry cltog4
			E.3.2 – Import a geometry setup with materials assigned		
			E.3.3 – Import a geometry setup with field-map assigned		
			E.3.4 – Import a setup with sensitive readout areas		
			E.3.5 – Import a setup with a variety of G3 solids		
E.4	geom..mdl	G4SolidStore G4RegionStore G4LogicalVolumeStore G4PhysicalVolumeStore	**E.4.1** – Switch of the geometry setup at run-time	none	basic/B3 TestEm1/2/3/6/7/9 Field01/2/3 underground_physics
			E.4.2 – Replacement (with deletion) of whole or part of the geometry setup at run-time (see also 1.2.8)		
			E.4.3 – Explicit deletion of solids and/or volumes (see also 1.1.2)		

APPENDIX

TABLE T.3.1 – CSG Solids

Solid	Function	Unit test	System test
G4Box	DistanceToOut / DistanceToIn / Inside	testG4Box	Any test
	SurfaceNormal	SolidsChecker	test10
G4Cons	DistanceToOut / DistanceToIn / Inside	testG4Cons1, testG4Cons2	Any test
	SurfaceNormal	SolidsChecker	test10
G4Tubs	DistanceToOut / DistanceToIn / Inside	testG4Tubs	Any test
	SurfaceNormal	SolidsChecker	test10
G4Sphere	DistanceToOut / DistanceToIn / Inside	testG4Sphere, testG4Sphere2	test10
	SurfaceNormal	SolidsChecker	test10
G4Orb	DistanceToOut / DistanceToIn / Inside	testG4Orb	test10
	SurfaceNormal	SolidsChecker	test10
G4Trap	DistanceToOut / DistanceToIn / Inside	testG4Trap	test10
	SurfaceNormal	SolidsChecke	test10
G4Trd	DistanceToOut / DistanceToIn / Inside	testG4Trd	test10
	SurfaceNormal	SolidsChecker	test10
G4Para	DistanceToOut / DistanceToIn / Inside	testG4Para1, testG4Para2	test10
	SurfaceNormal	SolidsChecker	test10

G4Torus	DistanceToOut / DistanceToIn / Inside	testG4Torus	test10
	SurfaceNormal	SolidsChecker	test10
G4Polyhedra	DistanceToOut / DistanceToIn / Inside	testG4Polyhedra	test10
	SurfaceNormal	SolidsChecker	test10
G4Polycone	DistanceToOut / DistanceToIn / Inside	testG4Polycone	test10
	SurfaceNormal	SolidsChecker	test10
G4Hype	DistanceToOut / DistanceToIn / Inside	testG4Hype	test10
	SurfaceNormal	SolidsChecker	test10
G4EllipticalTube	DistanceToOut / DistanceToIn / Inside	testEllipticalTube	test10
	SurfaceNormal	SolidsChecker	test10
G4TwistedTube	DistanceToOut / DistanceToIn / Inside	testG4TwistedTubs	test10
	SurfaceNormal	SolidsChecker	test10
G4TwistedTrap	DistanceToOut / DistanceToIn / Inside	testG4TwistedTrap	test10
	SurfaceNormal	SolidsChecker	test10

TABLE T.3.4 – Boolean Solids

Solid	Function	Unit test	System test
G4UnionSolid	DistanceToOut / DistanceToIn / Inside	testG4UnionSolid	test10
	SurfaceNormal	testG4UnionSolid	test10
G4Intersection Solid	DistanceToOut / DistanceToIn / Inside	testG4IntersectionSolid	test10
	SurfaceNormal	testG4IntersectionSolid	test10
G4Subtraction Solid	DistanceToOut / DistanceToIn / Inside	testG4SubtractionSolid	test10
	SurfaceNormal	testG4SubtractionSolid	test10