Karlsruhe Institute of Technology
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A New Geant4 Modeling Solution Based on CAD and Unstructured Mesh Geometries

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Free for download!

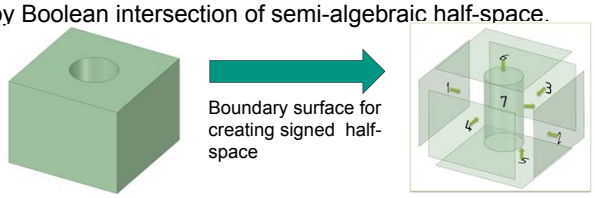
McCad *: https://github.com/inr-kit/McCad-Salome-Binaries*
Halfspace solid*: https://github.com/Derek-yfqiu/Geant4-Halfspace-solid*

Achievements

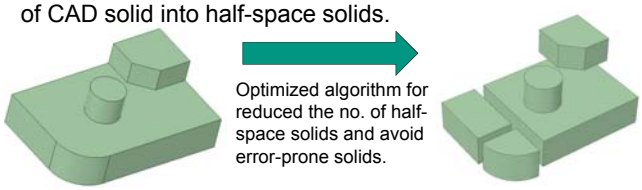
- **CAD to CSG conversion**: allow directly converting complex CAD model to a new Geant4 CSG solid called **half-space solid**, which enable fast and accurate MC simulation of complex detector geometry;
- **CAD to unstructured mesh**: allow obtaining three-dimensional physical distributions with **unstructured mesh scoring** on the parallel world detector geometry.

CAD to CSG conversion

- **Half-space solid**: a new Geant4 CSG solid type constructed by Boolean intersection of semi-algebraic half-space.



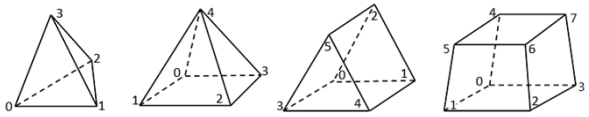
- **CAD to CSG conversion**: Automatic intelligent decomposition of CAD solid into half-space solids.



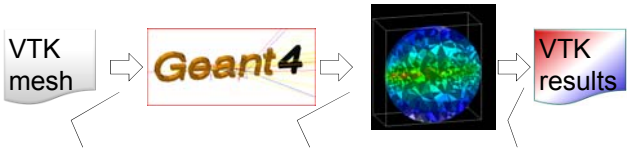
- **A modeling system**: Modeling, conversion, interfacing and simulation as a whole ; **support tessellated solid** as well.

Unstructured mesh

- **Unstructured mesh element**: new Geant4 solid types of first- order element.



- **Unstructured mesh scoring**: a superimposed scoring approach developed based on the Geant4 score mesh.



Use general mesh format, simple read using command line.

Scoring any physical quantities supported by Geant4 multifunctional detector

Output in VTK format for fast visualization.

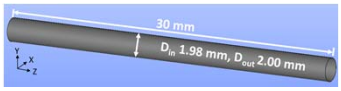
Test and verifications

- Comparison with 14 type of Geant4 primitive CSG solids.

	Volume (%)	Relative position	Surface normal	Distance to enter	Safety outside	Distance to exit	Safety inside	Skin (mm)
Half-space solid								
Box	0.001	Pass	0	5.68×10^{-14}	1.00×10^{-09}	5.68×10^{-14}	0	5.5
Sphere	0.023	Pass	2.77×10^{-32}	2.64×10^{-12}	N/A	2.47×10^{-13}	0	2.6
Cylinder	0.012	Pass	2.47×10^{-32}	6.39×10^{-13}	N/A	1.17×10^{-13}	0	4.4
Cone	0.156	Pass	7.43×10^{-23}	8.33×10^{-12}	N/A	1.69×10^{-11}	8.88×10^{-15}	2.4
Torus	0.163	Pass	1.20×10^{-29}	6.17×10^{-09}	N/A	1.20×10^{-10}	N/A	0.9
Trapezoid	0.014	Pass	1.08×10^{-25}	3.12×10^{-08}	N/A	1.32×10^{-07}	3.80×10^{-10}	4.9
Tube	0.133	Pass	2.47×10^{-32}	1.90×10^{-12}	N/A	3.48×10^{-13}	9.17×10^{-16}	2.3
Cut Tube	0.099	Pass	2.47×10^{-32}	1.48×10^{-12}	N/A	1.85×10^{-12}	8.46×10^{-09}	1.4
Cone section	0.123	Pass	1.63×10^{-31}	1.56×10^{-12}	N/A	2.78×10^{-12}	7.33×10^{-15}	1.4
Ellipsoid	0.002	Pass	1.73×10^{-31}	9.35×10^{-12}	N/A	9.18×10^{-14}	N/A	2.4
Torus section	0.175	Pass	1.92×10^{-29}	1.88×10^{-10}	N/A	2.24×10^{-11}	N/A	0.8
Unstructured mesh element								
Box	0	Pass	1.71×10^{-13}	1.14×10^{-13}	N/A	0	0	1.6
Trapezoid	0	Pass	4.93×10^{-32}	4.26×10^{-13}	N/A	8.24×10^{-13}	N/A	1.4
Wedge	0.012	Pass	6.16×10^{-32}	2.64×10^{-12}	N/A	6.82×10^{-13}	N/A	0.4
Pyramid	N/A	Pass	1.54×10^{-23}	5.09×10^{-08}	N/A	4.76×10^{-10}	N/A	1.3
Tetrahedron	0	Pass	0	0	0	0	0	1.2

Good agreement!

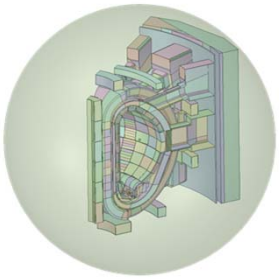
- Comparison on a cylinder tube model.



		Track length	CPU time
Primitive		1	1
Half-space Solid		1.0000	1.47
Tessellated solid	200 facets	1.0152	2.29
	448 facets	1.0068	2.46
	1440 facets	1.0060	3.29

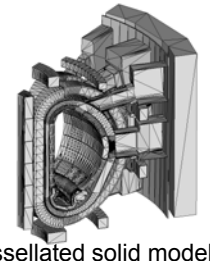
Fair acceleration!

- Comparison on the **ITER** (International Thermonuclear Experimental Reactor) Benchmark model with **3049 solids**.



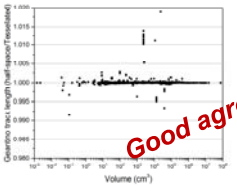
Half-space solid model

V.S.



Tessellated solid model

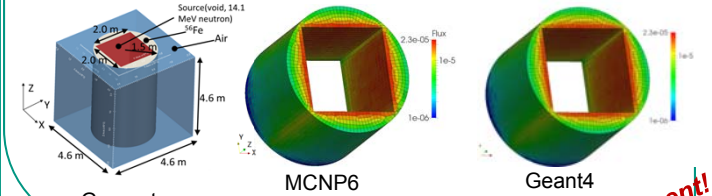
	CPU time (1 x3.4 GHz)	Lost particles
Half-space solid	~ 4 hours	$5/10^7$
Tessellated solid	~ 6 hours	$90/10^7$



Good agreement!

Track length comparison

- Comparison on a tube model for the unstructured mesh scoring.



Normalized neutron flux results

Spatial agreement!