
# Updates on Development of CAD Interface to Detector Simulation

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April 21st, 2021

# Motivation and key work items



- Motivation
  - Because of the complexity of the detector - accelerator integration we need to convert the output of the CAD program to Geant4-readable geometry.
  - We need to do this for full 3D design drawings with parametric surfaces, not some simple EIC IR toy models of CSG shapes, that is not good enough for detailed simulation.

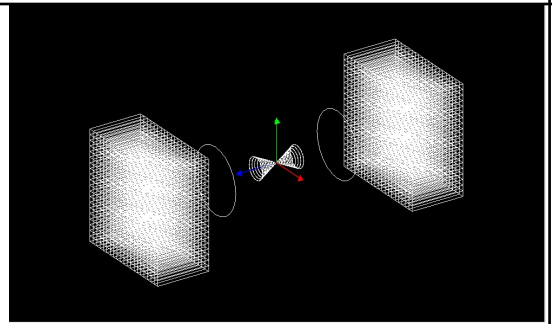
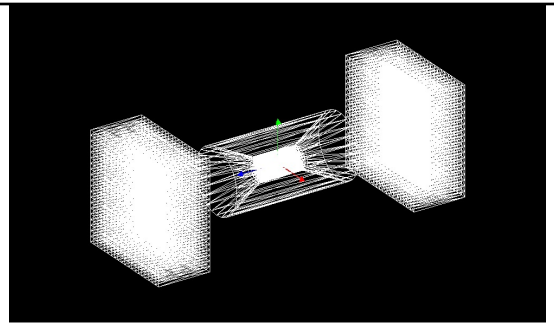
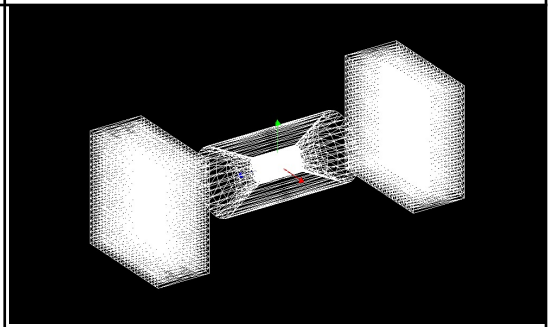
- Key work items
  1. Conversion of CAD STEP file to GDML file
  2. Material composition
  3. Vacuum volume

- We launched the effort
  - Starting with the work item #1
  - Studying items #2 and #3 in parallel

# Conversion of CAD STEP file to GDML file

- We need to develop an automated way to convert CAD file to GDML.
- CAD file format : STEP (STL, PLY)
  - Available for most, if not all, of CAD tools used for EIC accelerator design studies
- STEP to GDML conversion tool
  - Most promising : **MRADSIM**
    - http://mc-infn.lns.infn.it/?action=Geant4/MRADSIM_Converter
    - New free tool developed by INFN Perugia. Need evaluation.
  - Alternative : CADMesh
    - Converting one solid at a time – known volume overlap issue if two solids are touching to each other with their curved surfaces.
  - There are some commercial tools to evaluate as a backup
- Is tessellation good enough?? Or, too good???
  - NURBS can be converted to Tessellated solid. If tessellated solid is good enough, we want to avoid using NURBS in simulation geometry.
    - NURBS is more accurate, but harder to deal with.
      - Not fully convertible to GDML. Manual conversion to some Geant4-native solids, including Extruded solid, may be required.
  - Granularity of facets may need to be optimized.

# Sample GDML for preliminary benchmarking

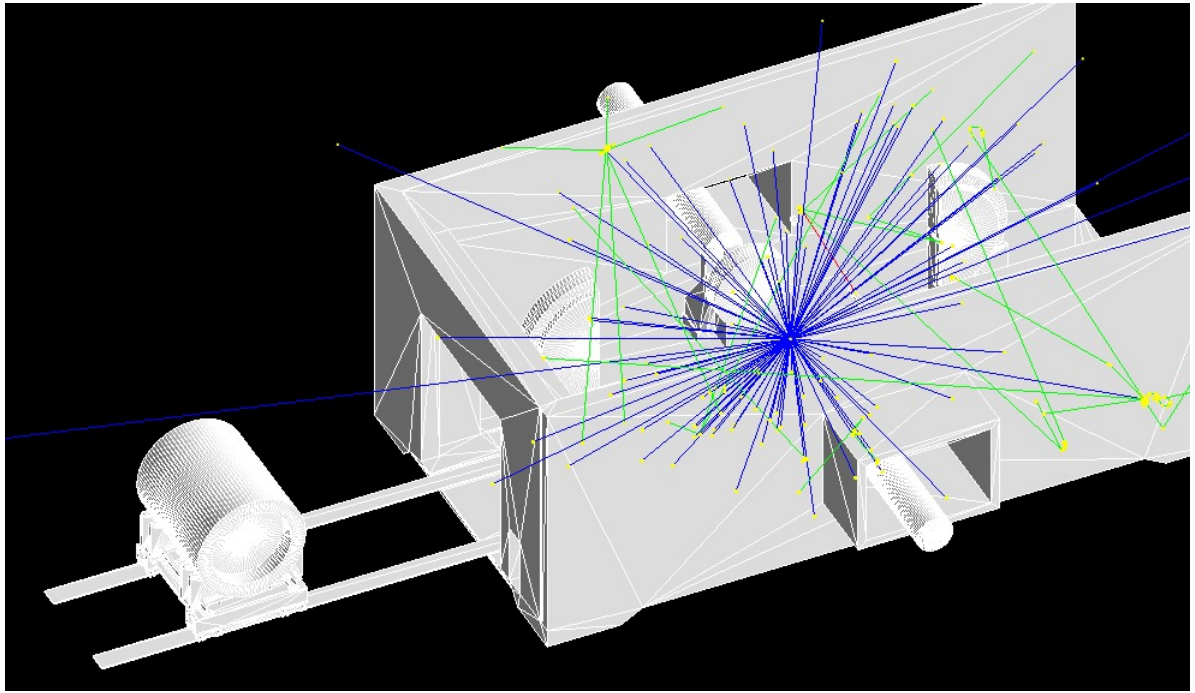
| File | CSG (hand-written) | Tessellated solids (Commercial converter) | Tessellated solids (MRADSIM converter) |
|---|---|---|---|
| |  |  |  |
| File size | 2,423 Byte | 2,575,524 Byte | 3,427,771 Byte |
| 200,000 geantino's 12 threads | | | Many warning messages from GDML Parser |
| Total time (within event loop) | User=9.120000s Real=0.822846s Sys=0.060000s [Cpu=1115.6%] | User=44.090000s Real=3.821735s Sys=0.120000s [Cpu=1156.8%] | User=47.060000s Real=4.059320s Sys=0.110000s [Cpu=1162.0%] |
| Total memory | 120 MB | 107 MB | 122 MB |

# Conversion of CAD STEP file to GDML file



- MRADSIM is very promising
  - Developer team is very responsive!
  - Few issues identified and reported to the developers. Some of them have already been addressed.
- As a backup solution, a commercial tool is confirmed.
- Thanks, Elke, for sample STEP files.

- As a preliminary measurement, navigating tessellated solid is ~5 times slower than simple CSGs
  - With physics interactions, difference should be much smaller.
  - Further study is required with tuning granularity of facets.



EIC_model.gdml converted by a commercial tool and simulated by Geant4-based application

Backup

# Material composition

- CAD file often specifies the material just by name.
  - Sometimes there is no material description at all.
- Geant4 simulation (in particular, hadronic physics models) requires isotope-level material composition.
- A material composition table (database) is required.
  - Mapping volume name and material name to isotope-level composition
  - Additional GDML file or another format?
- Need to develop a tool
  - To modify the input GDML file,
  - Or, to set materials after reading GDML into Geant4

# Vacuum volume



- CAD usually defines volumes that are to be crafted, e.g. beam pipe, but does not describe vacancy, e.g. vacuum inside the beam pipe.
- Geant4 requires solid to represent a material. Thus, we need a dedicated volume for vacuum.
  - If the beam pipe is a simple tube, we can easily define a cylinder that touches to the inner surface of the beam pipe tube.
  - But now our beam pipe is complicated tessellated solid. Each facet is not obviously representing inner or outer surface.
- We need to develop (hopefully) an automated mechanism to create a vacuum volume. Some ideas to study/evaluate.
  - Generating an envelope mother volume.
    - Envelope is filled by vacuum, placing the actual beam pipe in it.
    - Envelope is filled by vacuum and placed in a parallel world.
  - Create some voxels, fill them with vacuum and place in a parallel world.
  - Create some simplified volumes with CSG, fill them with vacuum and place in a parallel world. Manual creation needed.