mesh2gdml
From CAD to Geant4

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Importing Tesselated Volumes into Geant4

The automatic conversion of CAD-generated geometrical models into Geant4 volumes is an often-requested feature. One major impediment is the lack of a standard way to describe geometric volumes. Another is the proprietary nature of many commercial file formats. We discuss a solution which targets tesselated volumes in simple file formats and produces Geant4 geometries in GDML format. This solution suffers from a number of shortcomings, but may be useful in certain cases.

Geant4 "Primitives" vs Tesselations

- Geant4 Primitives
  - \+ Geant4 provides a very rich library of basic geometrical shapes plus the ability to define complex compound geometries via boolean operations.
  - \+ Analytic, or optimized geometric calculations of "inside" or distance to boundary, with reasonable CPU performance.
  - \+ Parameterizations also available, reducing memory footprint.
  - \- Cumbersome to define irregular shapes
  - \- Labor-intensive manual intervention to implement CAD designs
- Tesselations
  - \+ Complex (CAD) geometries with minimal human intervention.
  - \+ Support for irregular shapes, e.g. biological phantoms
  - \- Complex geometrical calculations increase CPU
  - \- Large number of vertices and facets increase memory

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CAD to Geant4?

- Often requested from user community, despite recognized limitations of:
  - difficulty accessing proprietary formats
  - mismatch between level of detail, approaches to parent-child relationships, material definitions
  - performance issues
- Most existing solutions target recognized interchange formats such as STEP and IGES, but even these can have problems
  - complicated file format, usually not open source
  - possible loss of hierarchy or material association
  - little or no mapping to primitives

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STL: Lowest Common Denominator

- \+ Simple format : list of three dimensional corner point coordinates (vertex) and flat triangles (facet).
- \+ Ubiquitous as an export format for CAD and other 3D software.
- \- No topological information about the mesh.
- \- No guarantee of correctness
  - single facets, holes, overlaps, etc.
- \- No material or other attributes
- \- Format is verbose, making file sizes large and subject to error from roundoff precision
  - e.g. shared vertices are listed explicitly n times.
- \- Overlap problems can arise when combining STL files from different software packages, or exported with different tolerances.

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STL to GDML

- \+ Adopted a solution requiring no modifications to any Geant4 code by converting STL to GDML
- \+ Convert STL facets directly to G4TriangularFacet and create G4TessellatedSolid.
- \+ Assign material at creation time, e.g.

  > java StlToGdml model.stl model.gdml Aluminum
- \+ Can either create world volume from bounding box to use standalone, or leave as individual volume to aggregate or incorporate into a common world volume later.
- \- Wrote code to identify topologically distinct elements in the file, but cannot assign different materials.
- \- No checking of geometry integrity.
  - Assume that input STL file is valid!

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Plans

- Finalize mesh conversion code, communicate with experts on optimization, perform code review, release.
- Work in progress on GUI to aid translation process, allowing user to select volume and:
  - Delete unwanted volumes
  - Assign material
    - by name (prone to mistake, e.g. Aluminum vs Aluminium)
    - from drop-down list (predefined, e.g. NIST or G4_*)
    - from material editor
  - Create hierarchy and place volumes into it.
- Collaborate with other interested parties.

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File Format Future: STL → AMF

- ASTM F2915 defines a standard specification for Additive Manufacturing File Format (AMF)
- Takes STL format for vertices and facets and adds support for:
  - **<object>** Defines a volume associated with a material ID for printing.
  - **<material>** Optional element defines one or more materials for printing.
  - **<texture>** Optional element defines images or textures for color or texture mapping.
  - **<constellation>** Optional element provides hierarchy support.
  - **<metadata>** Optional element contains additional information
- Just recently approved (May, 2011) but expect CAD vendors to add support.
- Solves most of the problems associated with STL.

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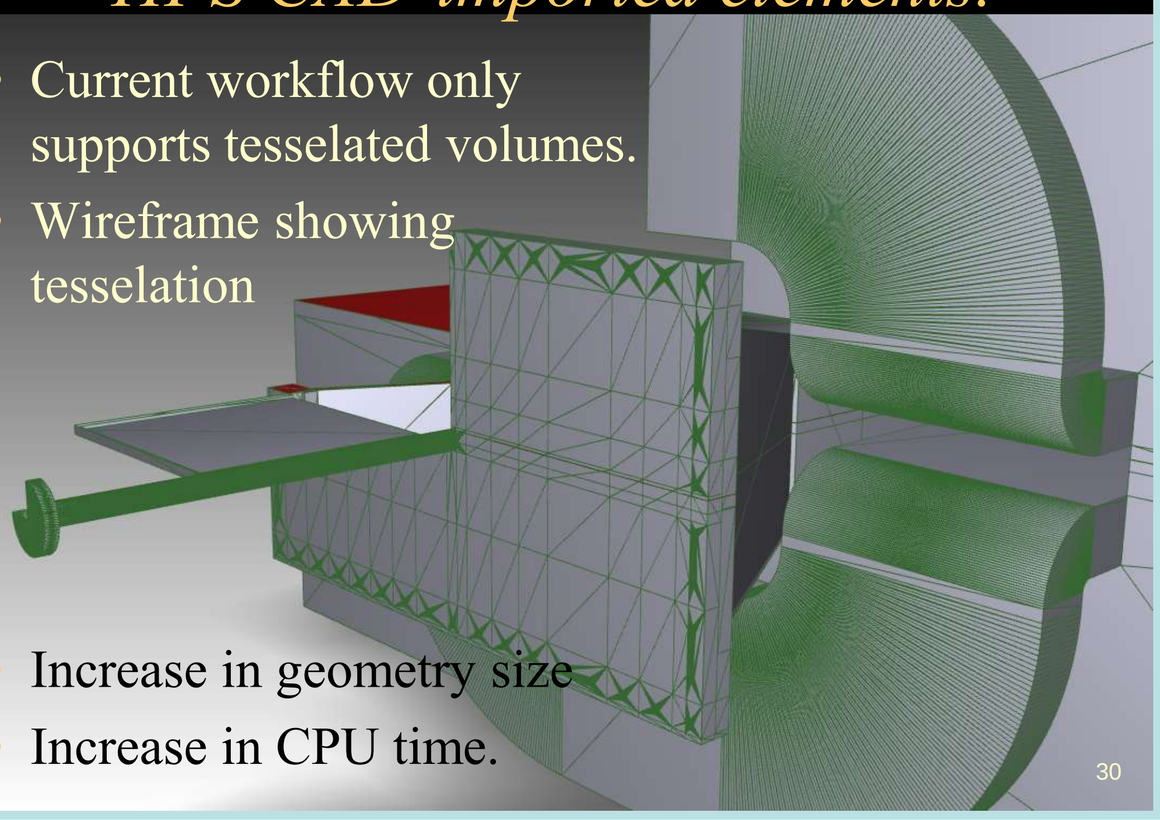
Test Applications

HPS CAD-imported elements.

- Current workflow only supports tesselated volumes.
- Wireframe showing tesselation



- Increase in geometry size
- Increase in CPU time.

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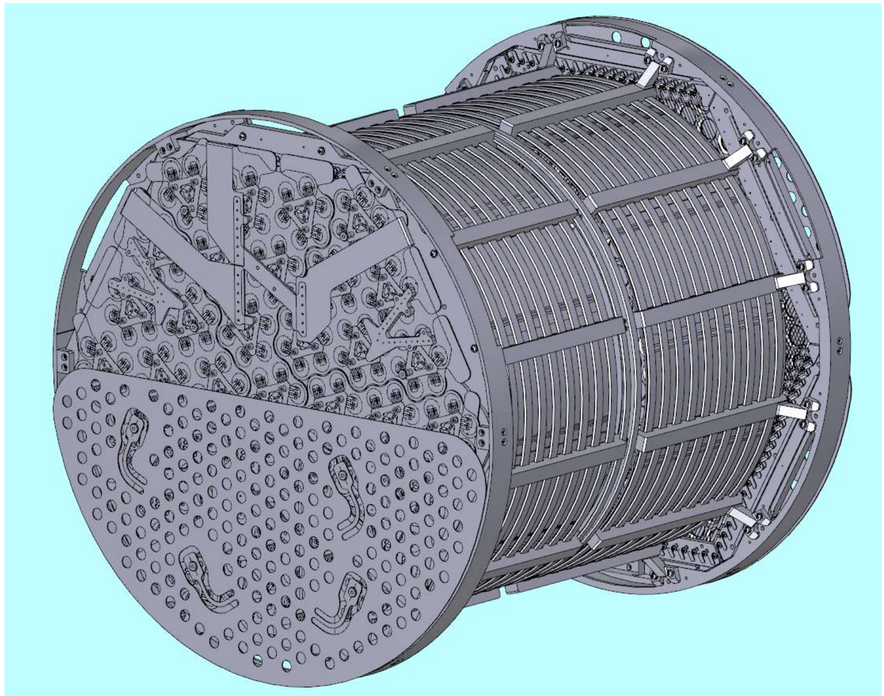
EXO liquid Xe TPC, 7000+ elements



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