

Tessellated Shapes, CAD Volumes and new Developments in DD4hep

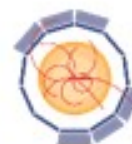
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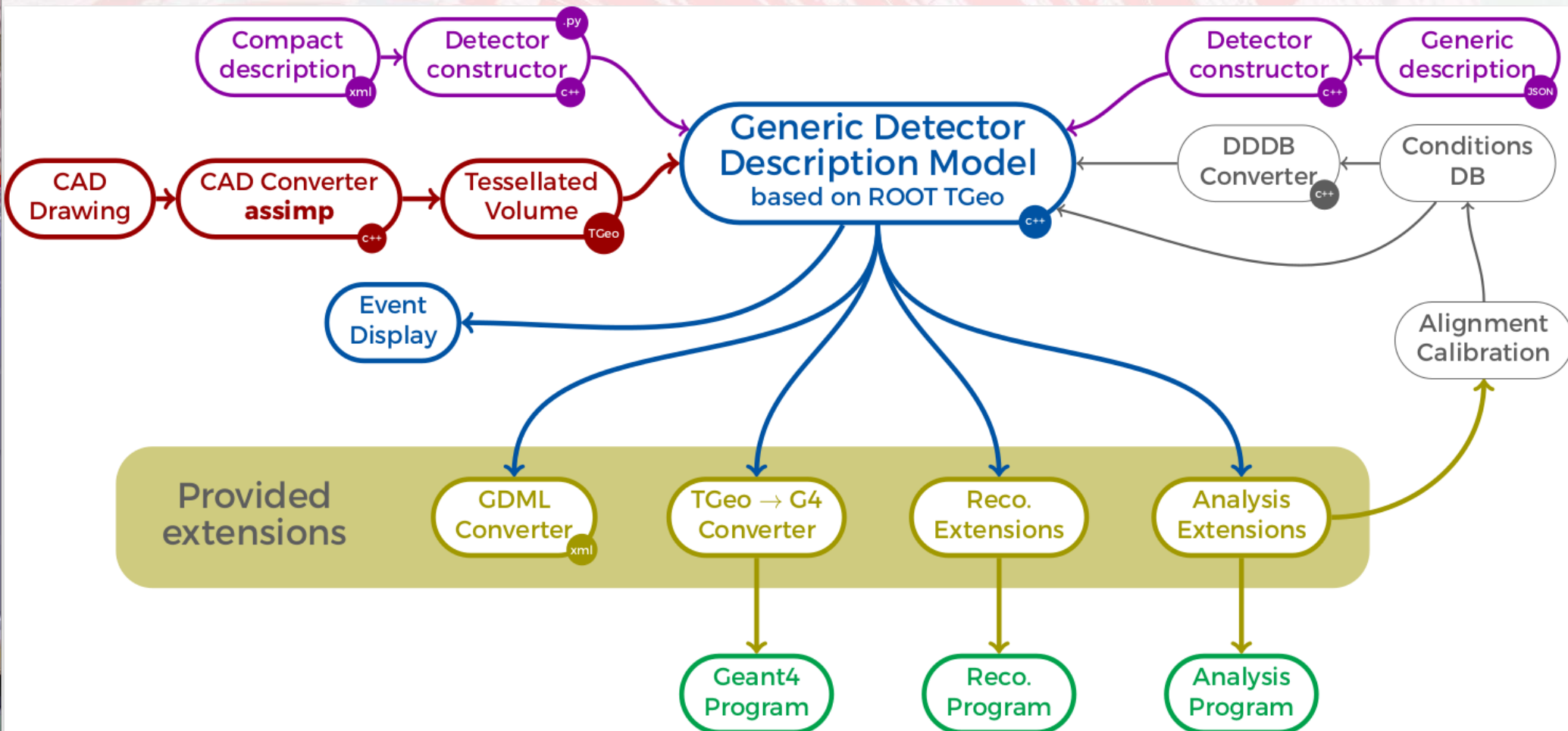
This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement no. 654168.



AIDA²⁰²⁰

- **Short introduction**
- **Support for import of shapes and volumes from Computer Aided Design (CAD) tools (ROOT version $\geq 6.21.02$)**
- **Support for Geant4 units in TGeo/DD4hep (ROOT version $\geq 6.22.00 / 07$)**
- **Support for writing DD4hep simulation output using EDM4hep**

DD4Hep - The Big Picture



Tessellated Shapes and CAD

- **We have now tessellated shapes in TGeo thanks to Andrei Gheata: TGeoTessellated**
- **Only one step further from tessellated shapes to shapes read from CAD drawings**
 - **Dream of physicists to simplify detector geometries**
- **Libassimp: Open Asset Importer Library**
 - **Creates standardized meshes from multiple CAD input formats**
See <http://assimp.org>
- **Import of shapes and volumes**
- **Export of shapes and volumes**
- **A few words about round-trip engineering**

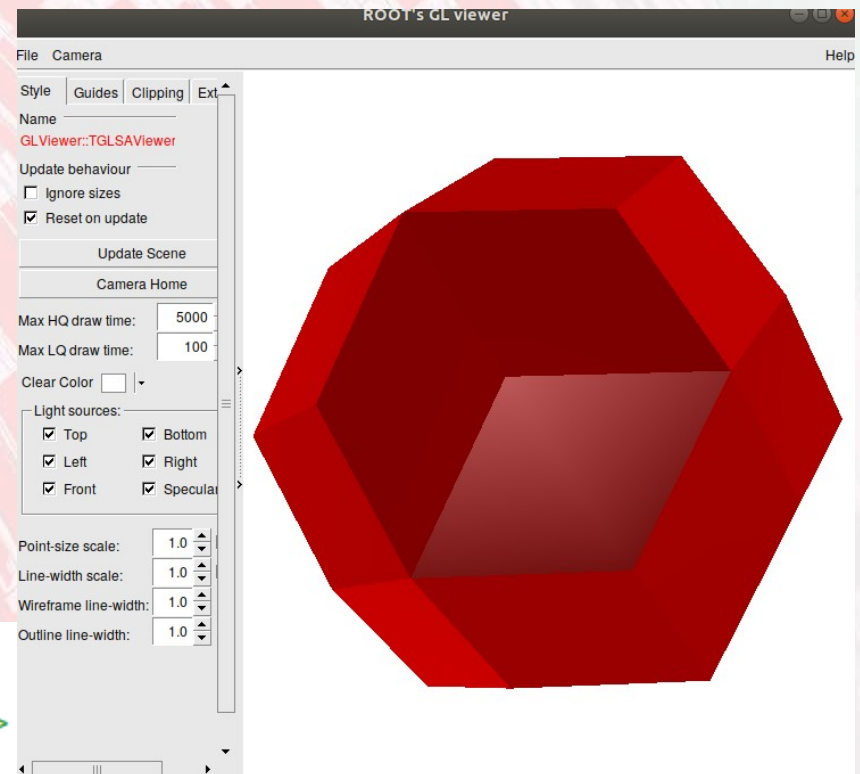
What is a Tessellated Shape ?

- Shapes with a closed surface composed of a mesh of tri- or quadri- linear facets
 - Define a set of vertices
 - Define the mesh of triangles
 - Radial shapes can only be approximated

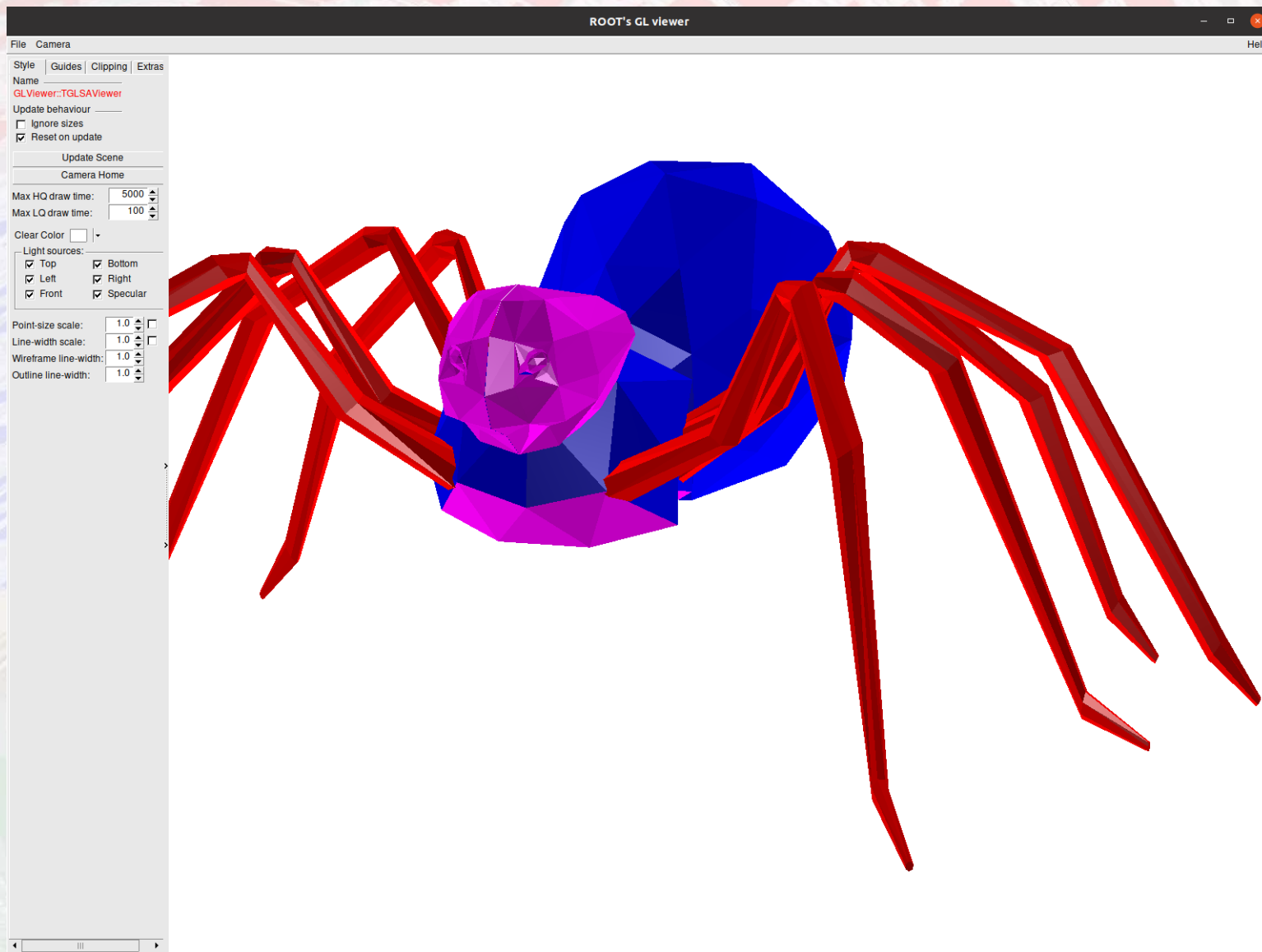
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<vertex x="0.5 * (1 + sqrt5)" y="-1" z="0"/>
<vertex x="0.5 * (-1 + sqrt5)" y="0.5 * (-1 - sqrt5)" z="0"/>
<vertex x="0" y="0.5 * (-1 - sqrt5)" z="-1"/>

<vertex x="0.5 * (1 + sqrt5)" y="-1" z="0"/>
<vertex x="1" y="-1" z="1"/>
<vertex x="0" y="0.5 * (-1 - sqrt5)" z="1"/>
<vertex x="0.5 * (-1 + sqrt5)" y="0.5 * (-1 - sqrt5)" z="0"/>

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<facet v0="4" v1="7" v2="6" v3="5"/>
<facet v0="8" v1="9" v2="10" v3="11"/>
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```



Combine Multiple Tessellated Meshes



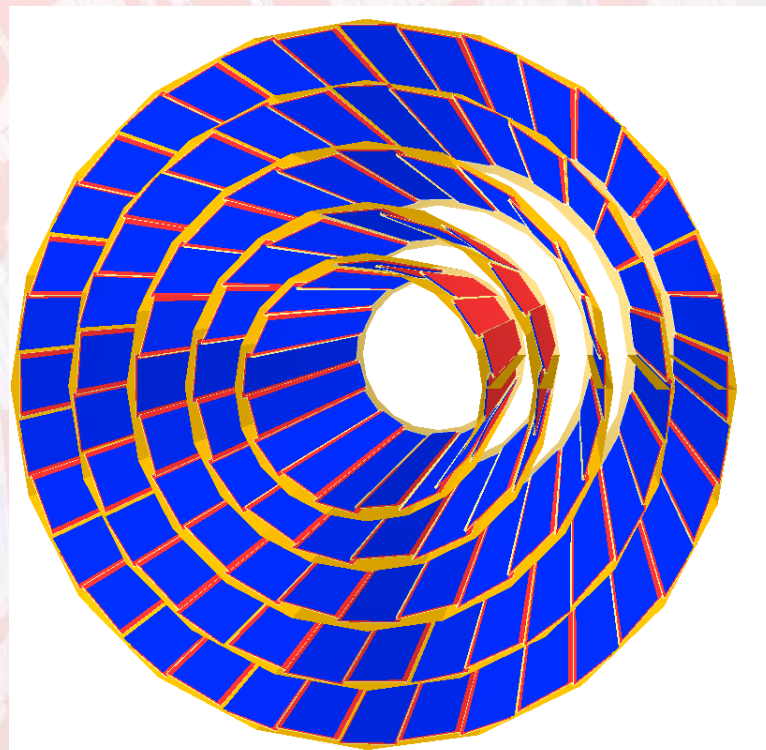
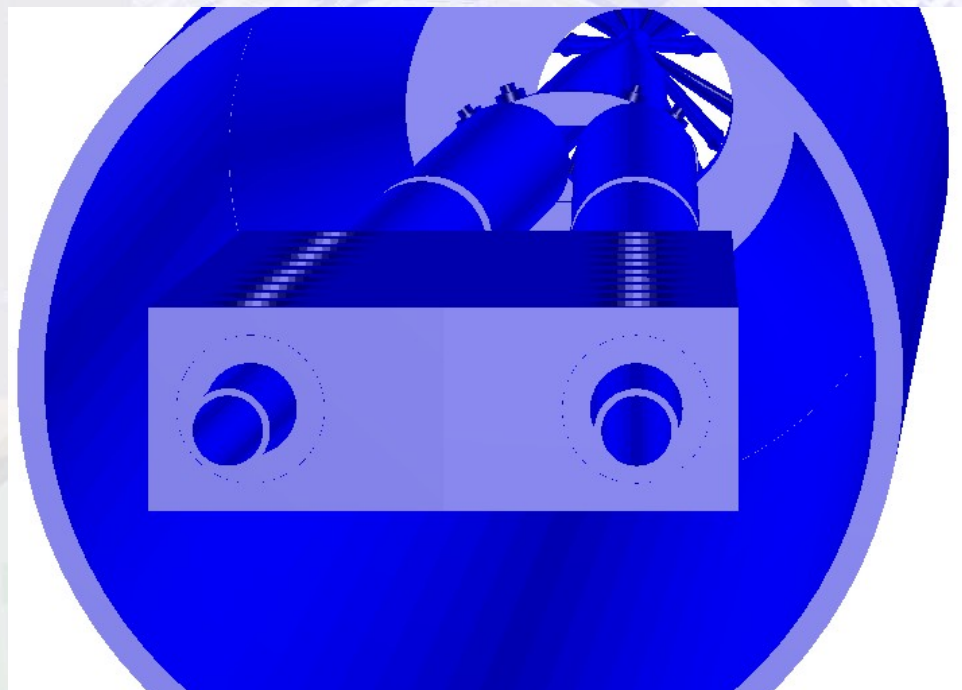
CAD Import, Export and Round-Trips

- If supported by Assimp, DD4hep supports
 - Import of shapes/volumes defined in CAD files into DD4hep
 - Export of partial geometries to CAD format

Import from CAD (STL)

Round-trip:

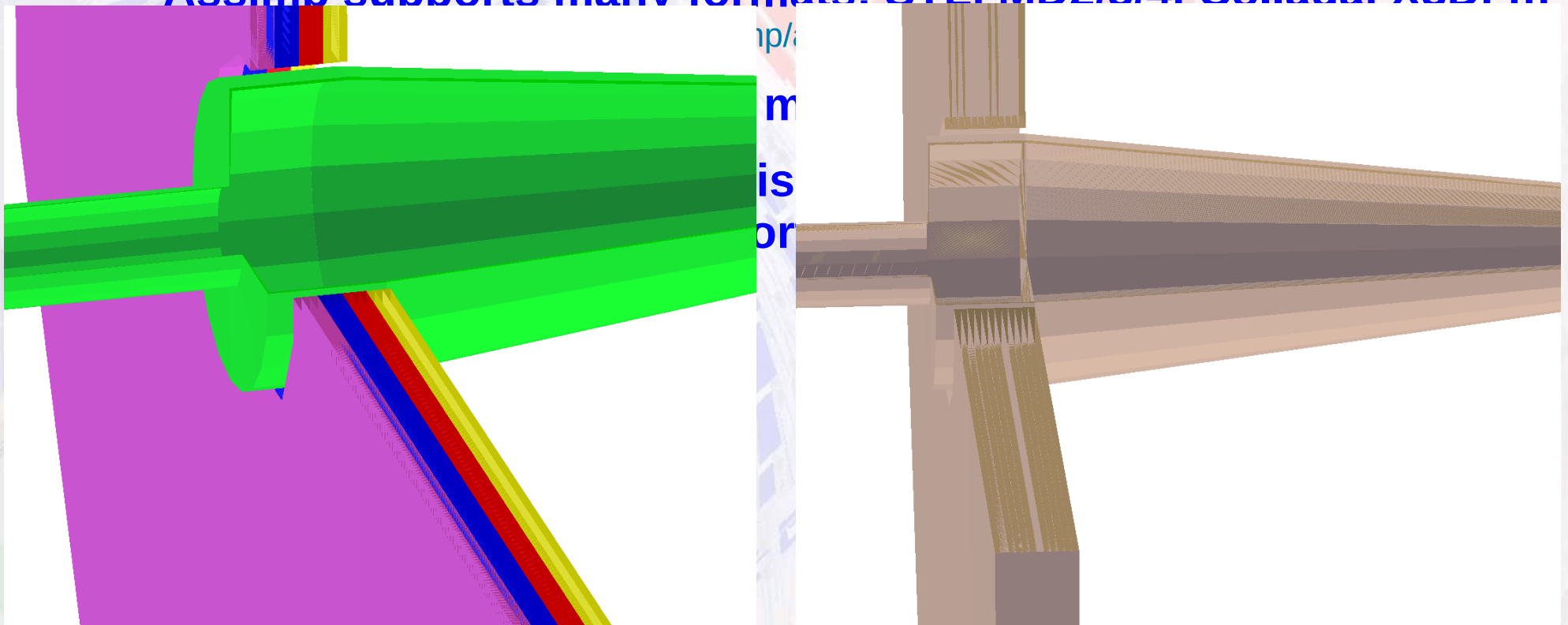
DD4hep / TGeo => CAD => TGeo



- **CAD Meshes are complex**
 - Limitation of the total number of manageable vertices / facets
 - Analytical shapes are simpler than tessellated shapes and likely far better performing for tracking
- **CAD comes in many dialects**
 - **Assimp supports many formats: STL, MD2/3/4, Collada, X3D, ...**
For details see: <https://github.com/assimp/assimp/tree/master/code/AssetLib>
 - **Single mesh CAD formats, multiple mesh CAD formats**
 - **Not all support materials, visualization attributes etc.**
Need to be injected by import mechanism
 - **Need to choose optimal format**

CAD: Limitations and Remarks

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Need to be injected by import mechanism
- **Round-trips are not unambiguously reversible**
 - **Example: Tube => Tessellated cannot be converted back**
- **Can use round-trips for views in CAD tools**
- **Shape/Volume creation uses DD4hep plugin mechanism**

Support For Geant4 Units

- TGeo is agnostic to unit-lengths
- Unit system of TGeo is based on: cm, second, GeV
- Unit system Geant4 is based on: mm, nanosecond, MeV
 - Unit system used by most experiment frameworks
- Problems arise with the use of materials
 - Radiation length, interaction are dependent, computed values
- All quantities needed re-normalization
 - Example: `length * CLHEP::cm / dd4hep::cm`
 - Big pain for users
- Injected a patch to ROOT / TGeo to support Geant4 units at run-time
 - Units system to be defined before creating elements / materials

Support for EDM4hep in DDG4

- **DDG4 is the DD4hep toolkit to support Geant4**
 - Automatic geometry conversion
 - Plugin based, flexible programming of all user callbacks
- **DDG4 supports intrinsically output to ROOT files, LCIO and now EDM4hep**
 - **New event model developed by Key4hep team, part of HSF**
Independent talks at this conference elaborate the issue
See Andre's talk: Key4hep: Status and Plans, <https://indi.to/HNBpp>
See Thomas talk: EDM4hep and podio - The event data model...., <https://indi.to/MbMcJ>
- **Ensures the interoperability of the full DDG4 functionality in the key4hep framework**
- **Support for EDM4hep based experiment specific digitization and reconstruction programs**

- **Some important items on our shopping list are resolved**
 - Thanks to CMS and FCC for pushing for the new developments and testing new stuff
- **We are proud to have solved CAD issue**
 - Thanks to G4 and TGeo for support of tessellated shapes
 - We only glued things together
 - Was on the client wish list for decades
- **The units should help to simplify the life of users**
- **The integration with EDM4hep shows that DD4hep is in active use also for detector studies**

Questions and Discussion