He3JET update in IR4

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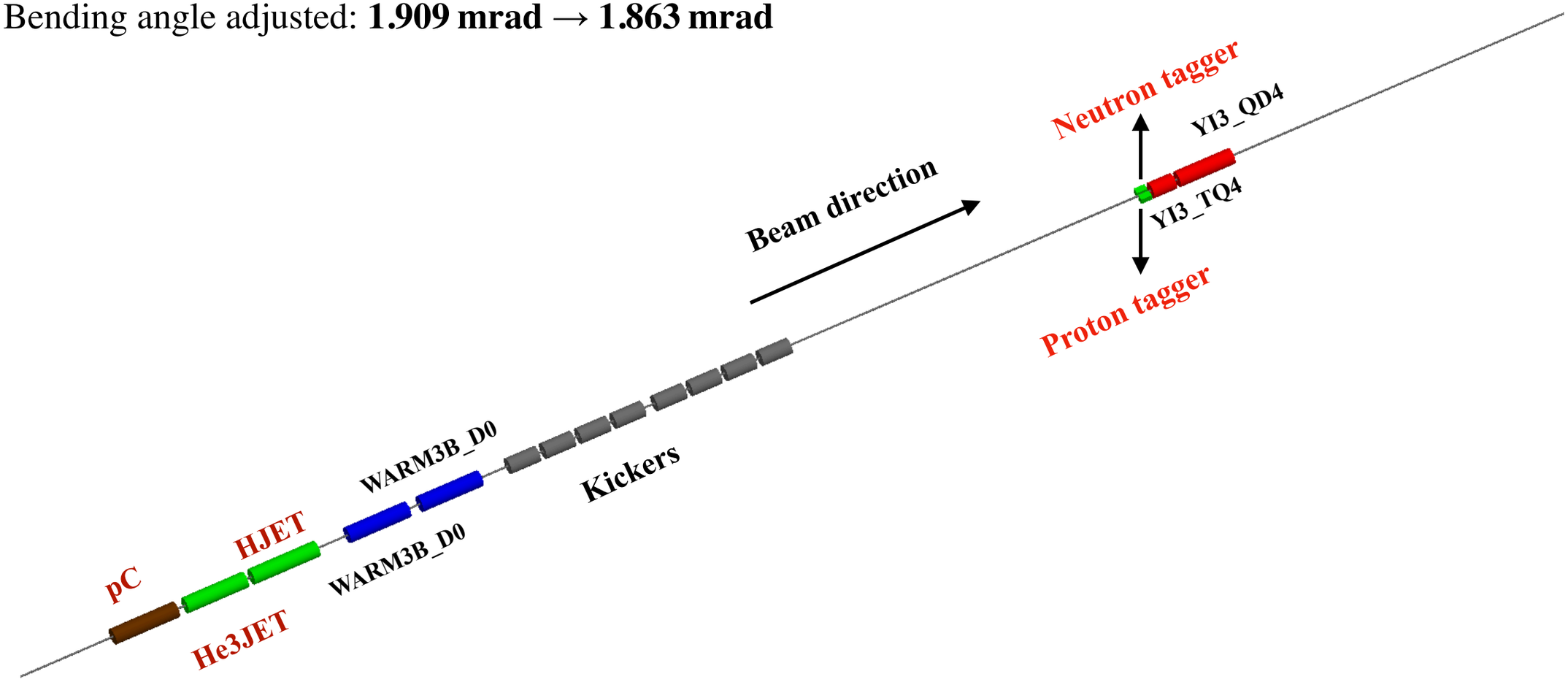
The layout of the HJET in IR4

April 2025 layout update:

- Warm dipole length reduced: **2.032 m → 2.000 m**
- Bending angle adjusted: **1.909 mrad → 1.863 mrad**



The layout of the HJET in IR4

- **Energy Threshold for Tagging**: Only events with deposited energy > 5 GeV at the tagger are triggered.
- Tagging efficiency comparable to previous setup (slight improvement at 166 GeV, few percent improvement at 110 GeV).

166GeV	Now	Before
Aluminum (1mm) ⌀ 7cm	92.7%	91.9%
Cooper (1mm) ⌀ 7cm	90.0%	86.1%
Stainless Steel (1mm) ⌀ 7cm	90.8%	87.5%
Aluminum (1mm) ⌀ 6cm	95.2%	93.4%
Aluminum (1mm) ⌀ 5cm	96.1%	94.9%

110GeV	Now	Before
Aluminum (1mm) ⌀ 7cm	90.2%	84%
Aluminum (1mm) ⌀ 6cm	92.9%	87.1%
Aluminum (1mm) ⌀ 5cm	94.0%	89.2%

Discussion of Techniques

Most of our simulations are based on the Geant4 Monte Carlo simulation framework. For simple geometries, it is relatively straightforward to describe them using **Constructive Solid Geometry (CSG)** models. However, this approach becomes impractical for more complex geometries.

Advantages of Using FreeCAD for Geometry Construction

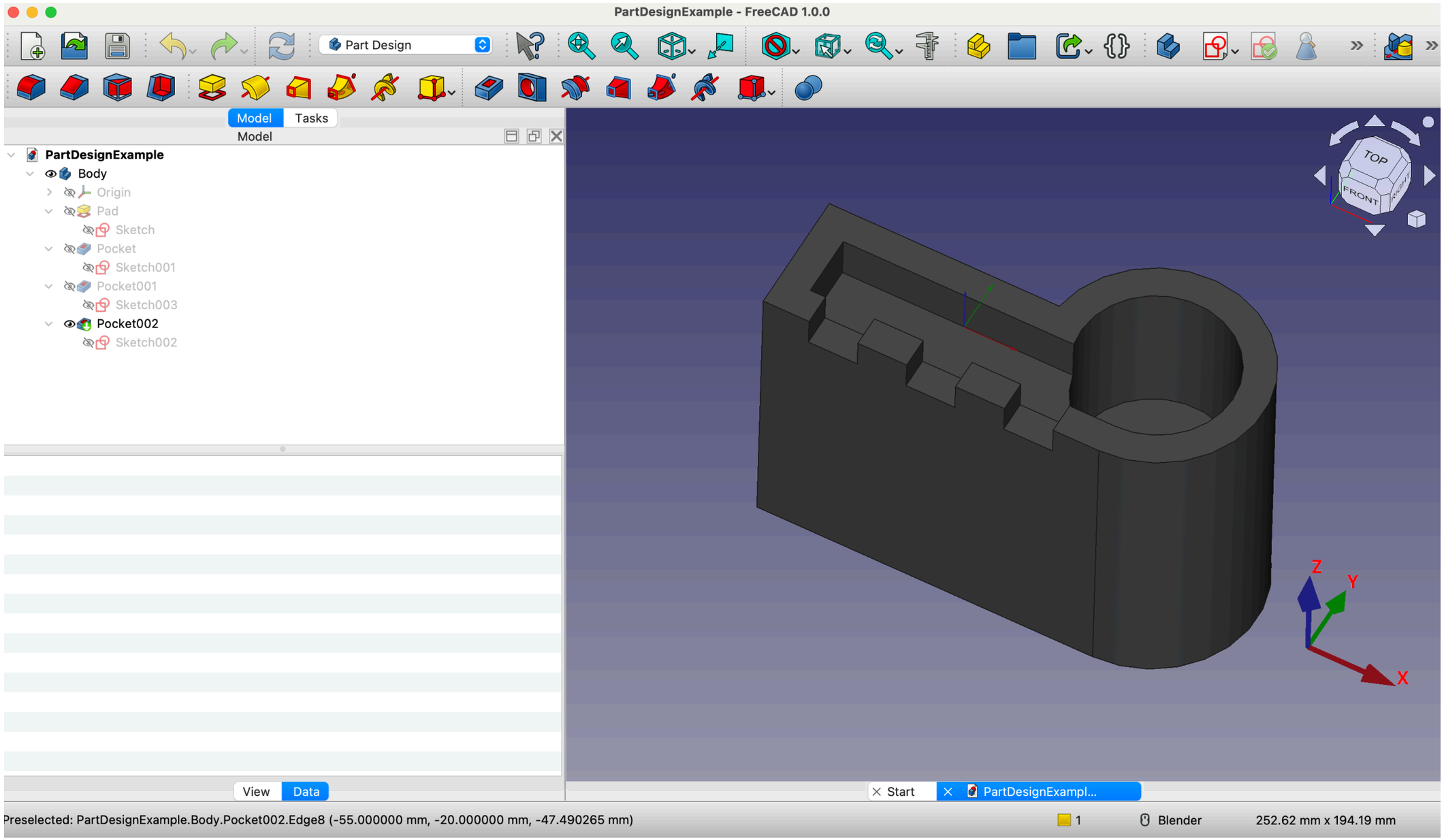
- **Sketch-Based Design:** Intuitive 2D sketching tools allow precise control of shapes and constraints.
- **Boolean Operations:** Robust tools for combining, subtracting, and intersecting complex solids.
- **Extensive Workbenches:** Includes a variety of design and modeling tools to streamline geometry creation.
- **Visual Debugging:** Easy to build, visualize, and verify complex geometries before exporting.

However, FreeCAD uses Boundary Representation (BRep), which defines geometry using surfaces and edges. This format is not directly compatible with Geant4, which relies on Constructive Solid Geometry (CSG). Additionally, FreeCAD does not natively support the material definitions used in Geant4, requiring extra steps for material integration.

Although Geant4's GDML format can be easily converted to the CAD-friendly STEP format, converting STEP back to GDML is difficult. It often results in loss of detail and many tessellated solids, which can slow simulations.

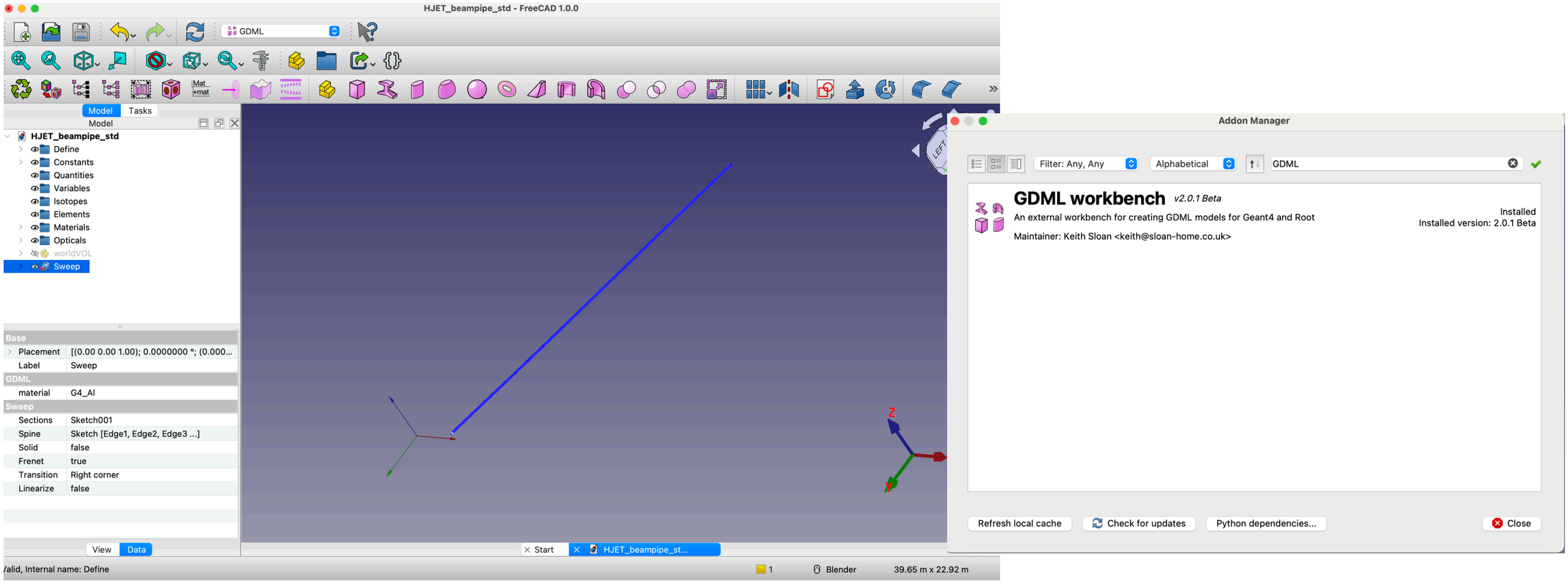
To address this, the GDML workbench for FreeCAD—developed by Keith Sloan and Both Keith and other—offers a promising solution (not perfect) for exporting FreeCAD models to Geant4-compatible GDML.

FreeCAD



Version: 1.0.0 (latest).

GDML Workbench



https://github.com/KeithSloan/GDML

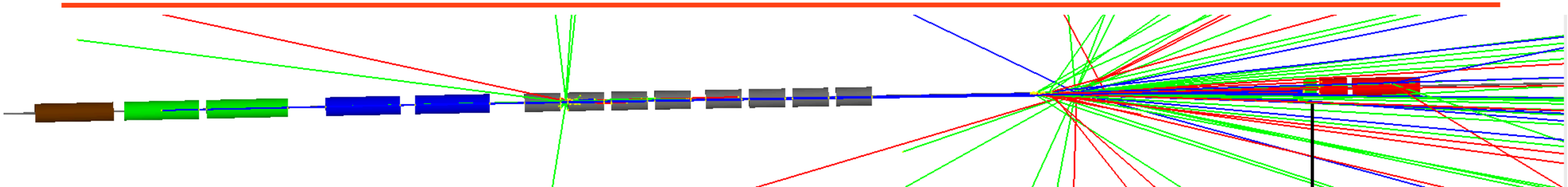
Installation:

- FreeCAD (https://freecad.org/)
- lxml
- gmsh python library

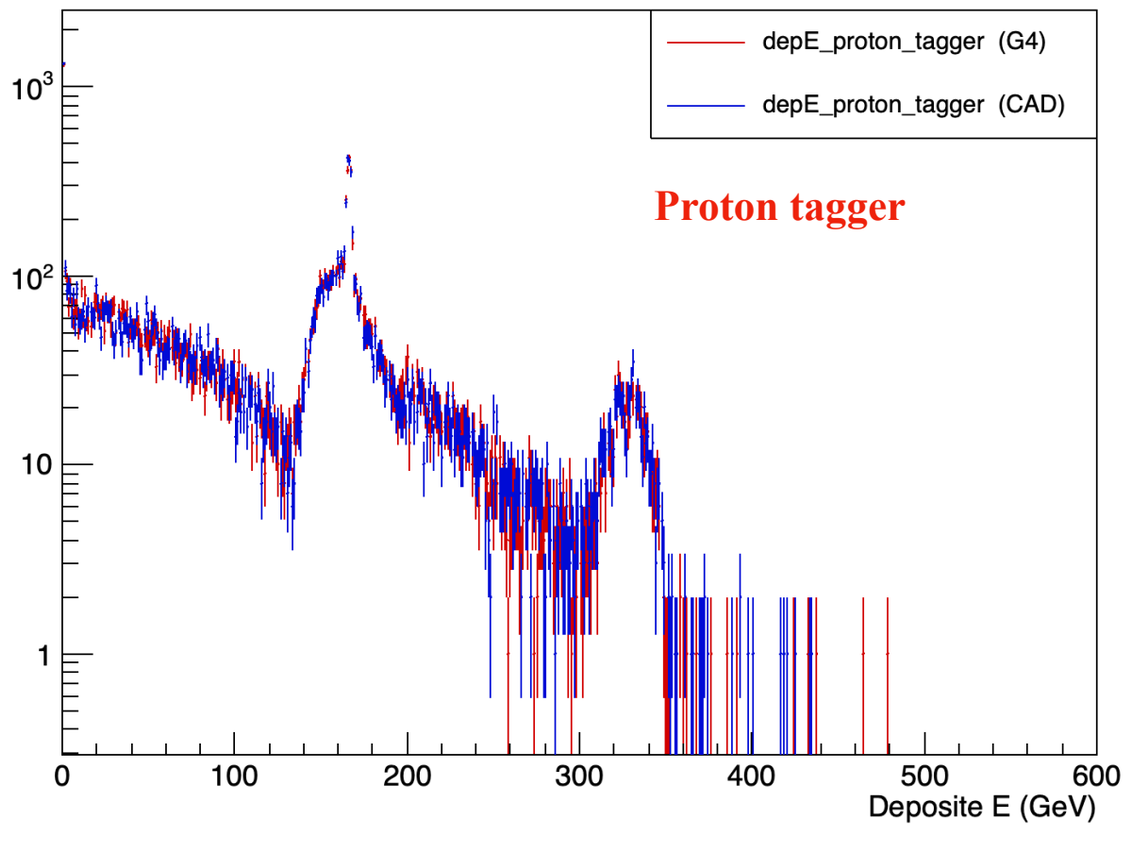
Validate GDML Workbench

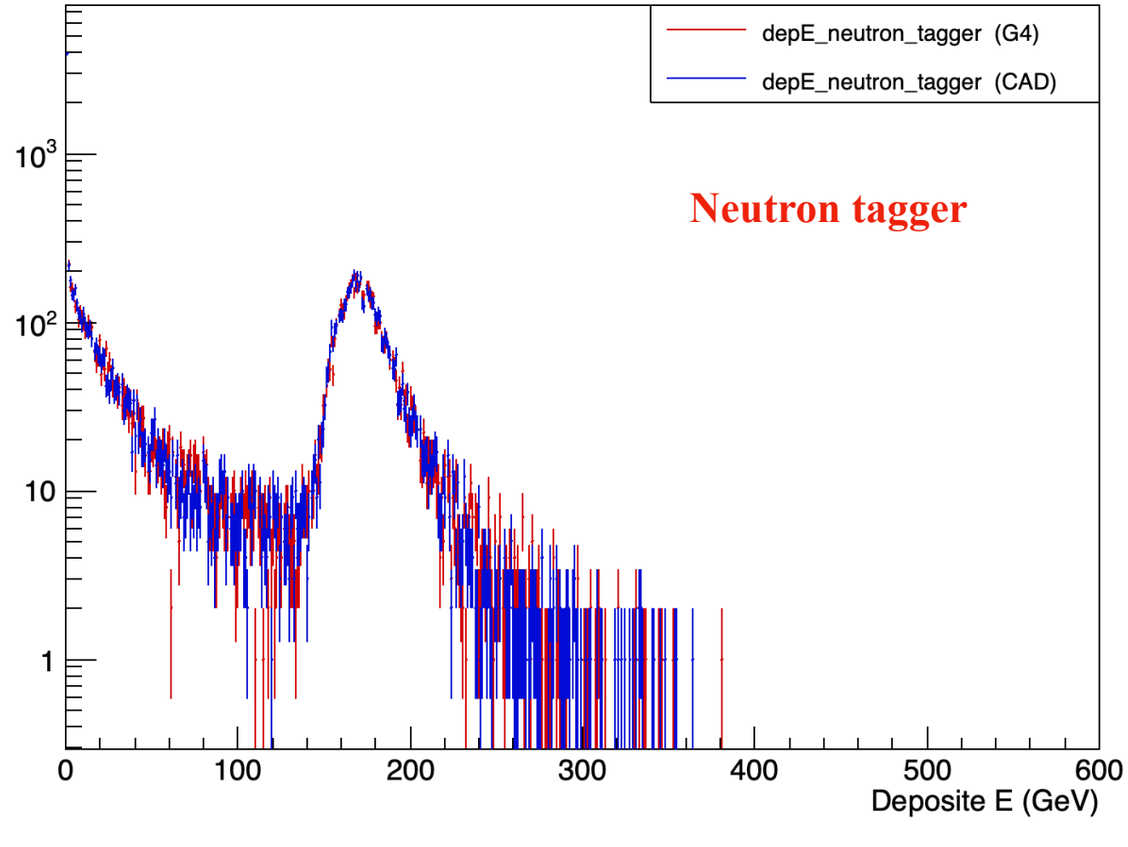
1. Learn basic FreeCAD operations
2. Build a simple beam pipe geometry in FreeCAD
    - Model a tube for the HJET layout using the GDML Workbench
    - Assign material and export the GDML file
    - Import into Geant4 and compare with beam pipe built directly in Geant4
3. Test more complex geometries

Validate GDML Workbench

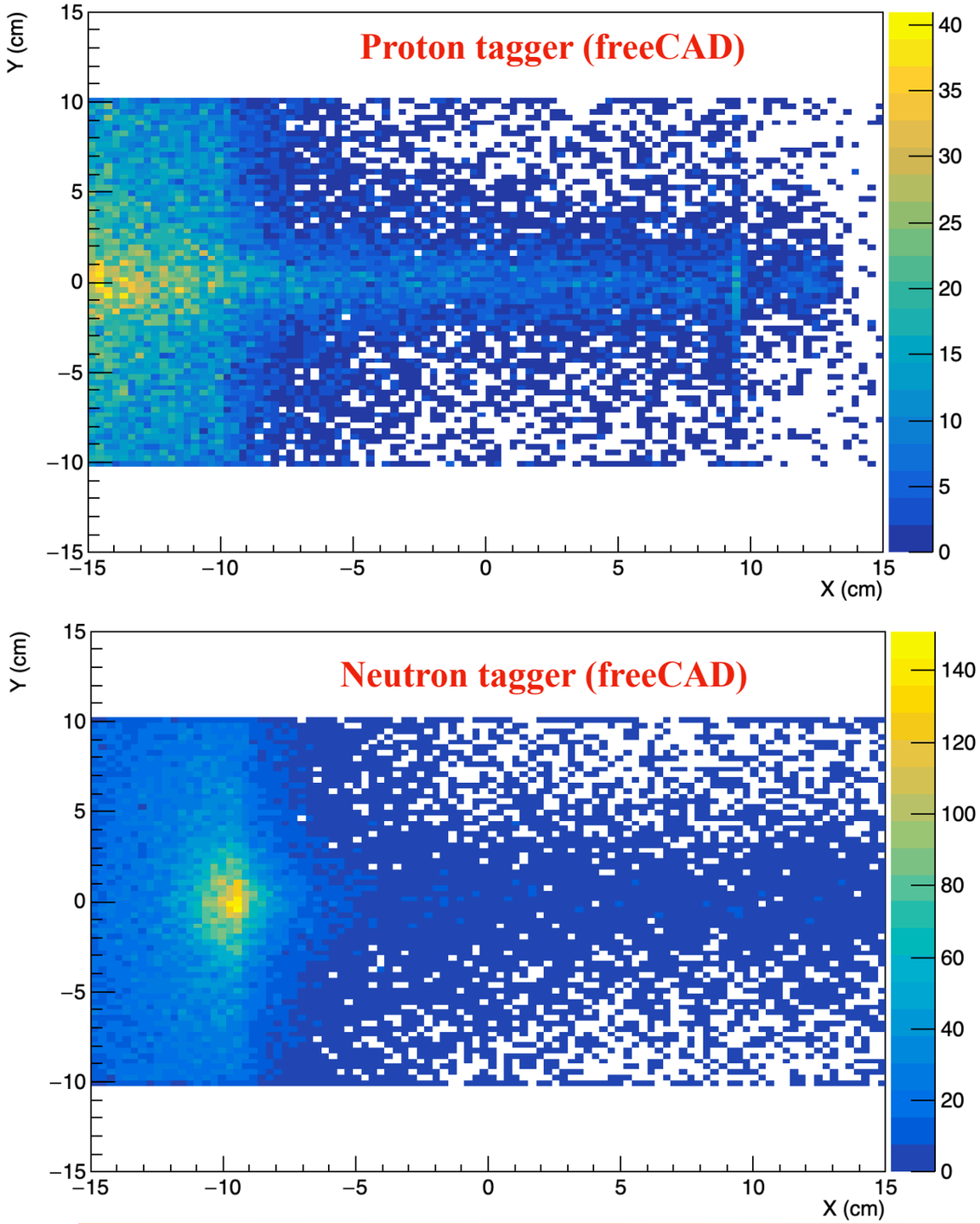


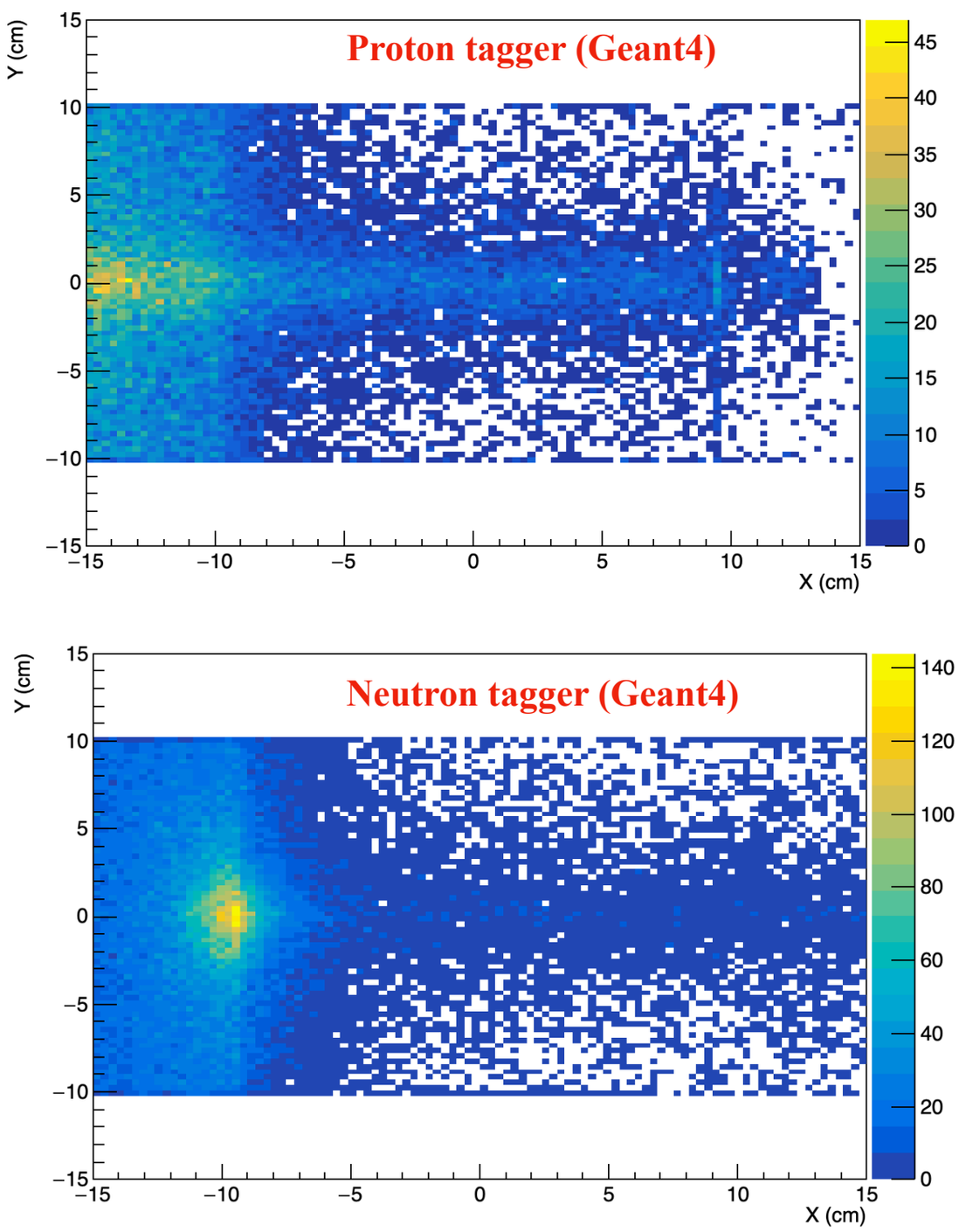
PhysicsList: FTFP_BERT
Material: Aluminum (1mm)





Validate GDML Workbench





Test more complex geometries


Extrude

Extrudes a solid object from a selected sketch. **It worked!**


Revolve

Creates a solid by revolving another object (not solid) around an axis. **It worked!**


Sweep

Sweeps one or more profiles along a path. **Not Working!**


Thickness

Missing.


Arc

FreeCAD appears to have a bug preventing arcs over 1000 m radius. A possible workaround is scaling, though untested.

A group of tools in the GDML workbench is available for converting STEP shapes to GDML, though I haven't tested them yet.

Other approaches

Not yet tested.

- G4CAD - A FreeCAD workbench for converting CAD files to GDML.
- Other tools like GUIMesh for converting CAD files to GDML.
- A native STEP reader for Geant4 has been discussed on the Geant4 forum, but it has not been developed yet.

Thanks!