Advances in the Coreform Cubit DAGMC workflow

Agenda

- Understanding DAGMC workflows with Coreform Cubit
- How DAGMC enables CAD-based geometry in Monte Carlo simulation
- Maximizing the value of converting existing MCNP models to CAD in Coreform Cubit
  - Visualization
  - Multiphysics
  - Benchmarking DAGMC
- Preparing CAD for DAGMC simulations in Coreform Cubit
  - manually assigning metadata (see previous webinar)
  - **working with imported MCNP models and metadata**

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Coreform LLC

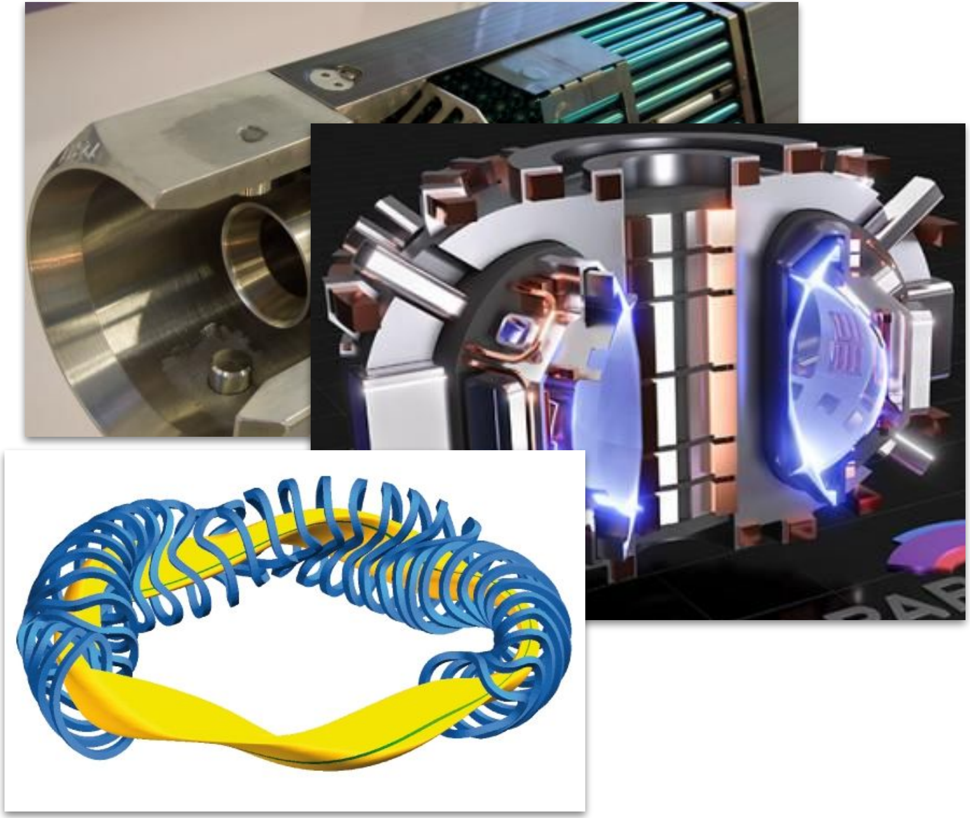
Trends in Neutronics Analysis

Streamlined Neutronics

- Neutronics only
- Multiphysics

Motivated by

- Fission: advanced reactor designs
- Fusion: startup ecosystem
- Advanced manufacturing

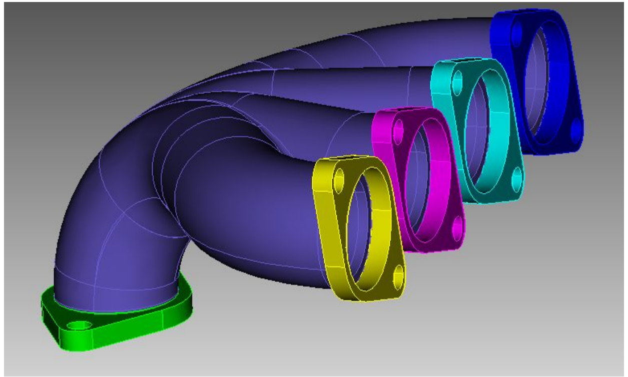


Direct Accelerated Monte Carlo: DAGMC

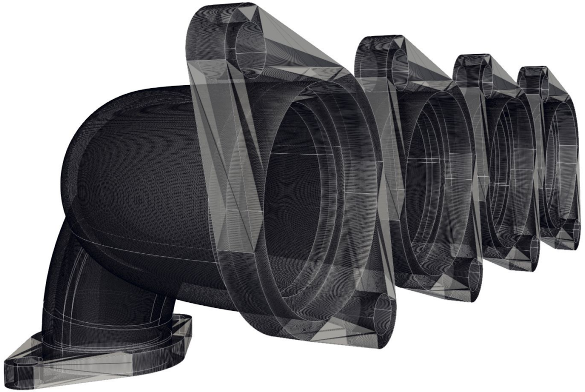
Project began at UW – Madison around 2009

A surface mesh representation for Monte Carlo neutronics

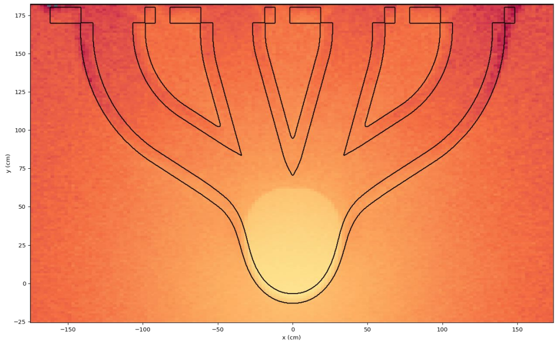
- triangle surface tessellations
- *embedded topology*



Build or Import



Mesh & Export



Simulate

Trends in (Fusion) Neutronics Analysis

Monte Carlo Neutronics

OpenMC

Geant4 — A simulation toolkit

MCNP® — MONTE CARLO N-PARTICLE

Geometry/Mesh

coreform

DAGMC

Multiphysics

MOOSE

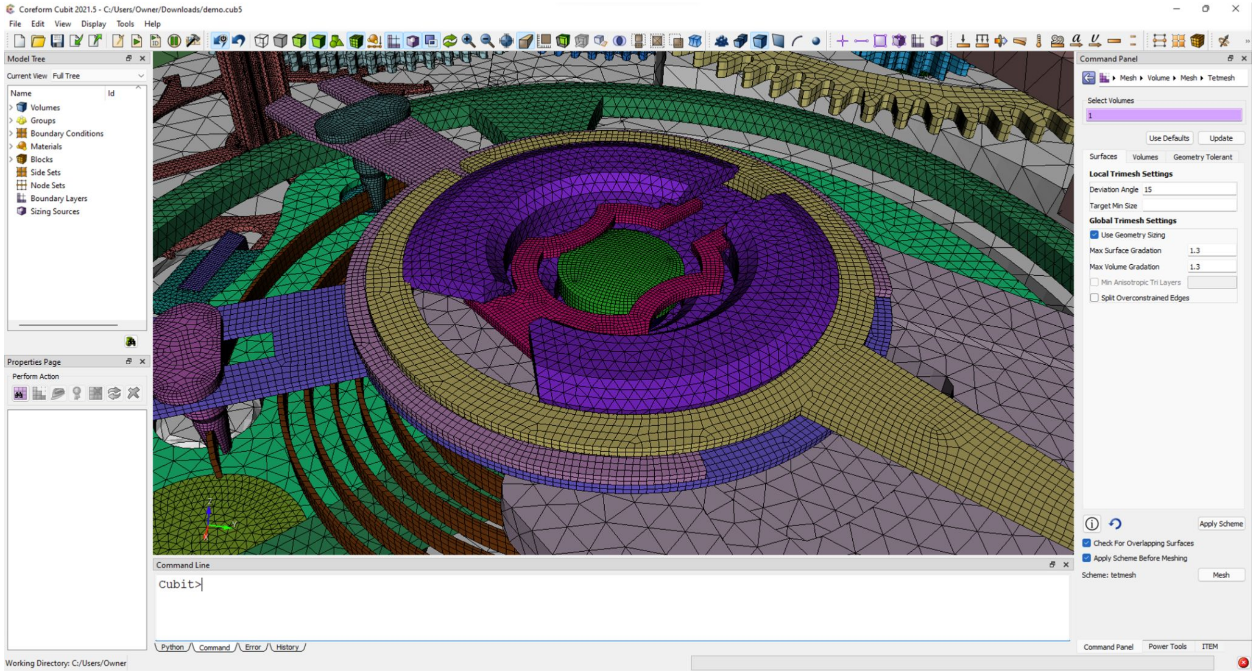
preCICE.org

MFEM

Coreform Cubit

Advanced meshing for challenging simulations

- CAD import and clean-up
- Semi-automated hex meshing
- Maximum control of mesh properties and quality
- *Python and scripting*
- *Integrated DAGMC workflow*



DAGMC Integration in Coreform

Coreform Cubit

- Dedicated surface meshing parameters
- Meshes are inherently watertight
- Surface mesh visualization
- Integrated export capability in Cubit
- *Integrated MCNP input import capability**

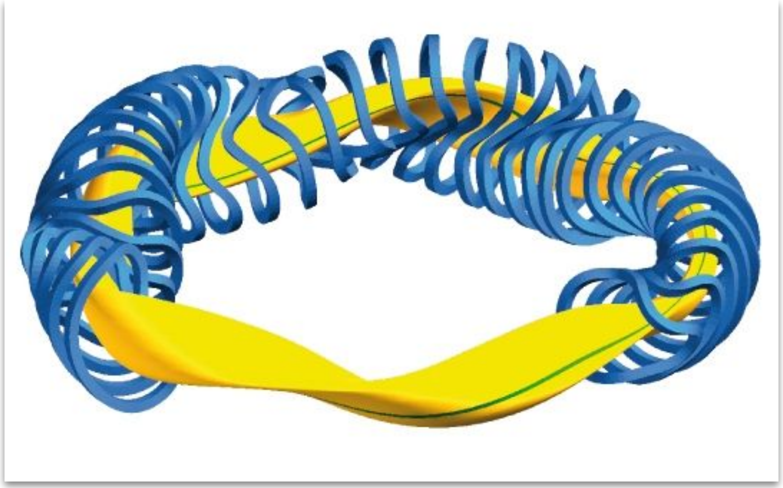
DAGMC Ecosystem

- Updated DAGMC Documentation
- DAGMC 2.0 library (🚧)
    - Support for multiple mesh libraries::
        - MOAB, libMesh, MFEM
    - Volumetric mesh particle tracking and tally support
    - Quads/Hexes

*depends on the mcnp2cad project at UW – Madison

DAGMC Model Origins

1. Built in CAD (Solidworks, Cattia, etc.)
    - import as ACIS, STEP, IGES, etc.



2. CSG to CAD Conversion

```
81900 8 -0.99565 -61900 tmp=2.61235E-08
81800 8 -0.99565 -61800 tmp=2.61235E-08
81700 8 -0.99565 (-61700 90997 61701):(90995 -11700 -90997) tmp=2.61235E-08
81600 8 -0.99565 (-61600 90997 61601):(90995 -11600 -90997) tmp=2.61235E-08
81500 8 -0.99565 (-61500 90997 61501):(90995 -11500 -90997) tmp=2.61235E-08
81400 8 -0.99565 (-61400 90997 61401):(90995 -11400 -90997) tmp=2.61235E-08
81300 8 -0.99565 (-61300 9
81200 8 -0.99565 -61200 612
81100 8 -0.99565 -61100 tmp
c
82900 8 -0.99565 -62900 tmp
82800 8 -0.99565 -62800 tmp
82700 8 -0.99565 (-62700 9
82600 8 -0.98804 (-62600 12
        tmp=2.78469E-08
82500 8 -0.98804 (-62500 12
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82200 8 -0.99565 -62200 622
82100 8 -0.99565 -62100 621
c
83900 8 -0.99565 -63900 tmp
83800 8 -0.99565 -63800 tmp
83700 8 -0.98804 (-63700 13
        tmp=2.78469E-08
83600 8 -0.98804 (-63600 13
        tmp=2.78469E-08
83500 8 -0.98804 (-63500 13
        tmp=2.78469E-08
83400 8 -0.98804 (-63400 13
        tmp=2.78469E-08
83300 8 -0.98804 (-63300 13
        tmp=2.78469E-08
83200 8 -0.99565 -63200 tmp
83100 8 -0.99565 -63100 631
c
```
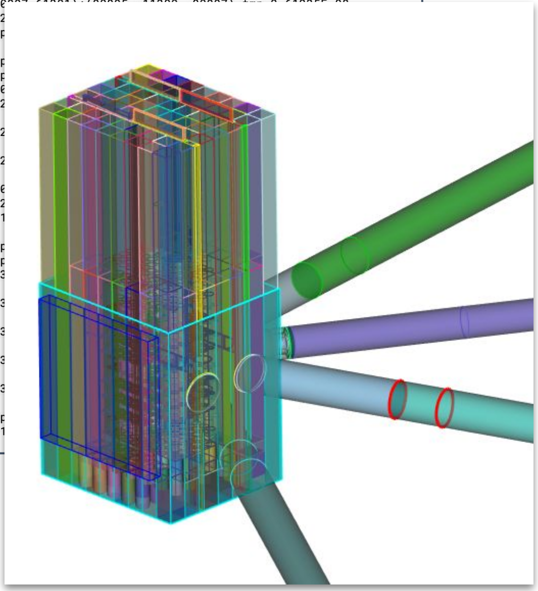



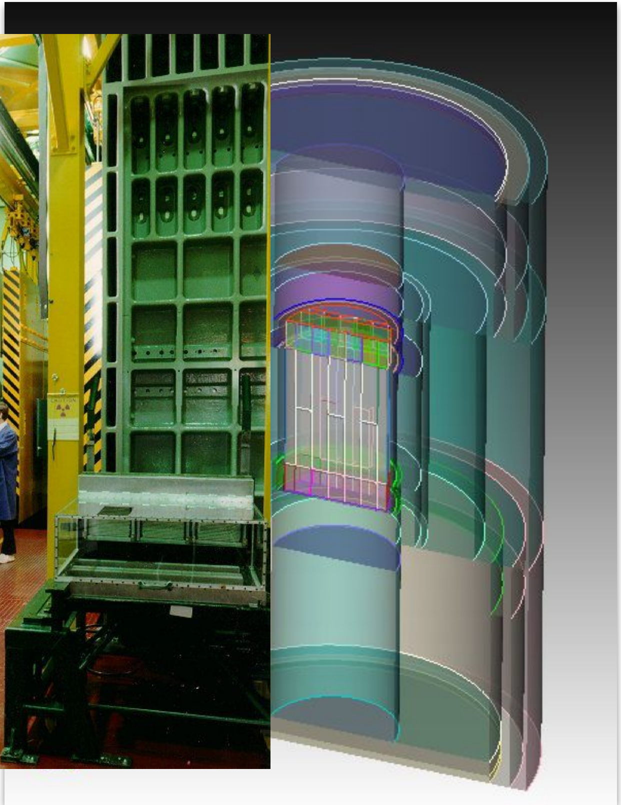
DAGMC Demonstration

ICSBEP[1] Model: SUB-HEU-MET-FAST-001

Zero Power Physics Reactor (ZPPR-20E)

Subcritical assembly built at INL in 1969

- HE Uranium Nitride
- Lithium
- Beryllium Oxide
- Niobium
- Rhenium
- Zirconium
- Stainless Steel
- Lithium (coolant)

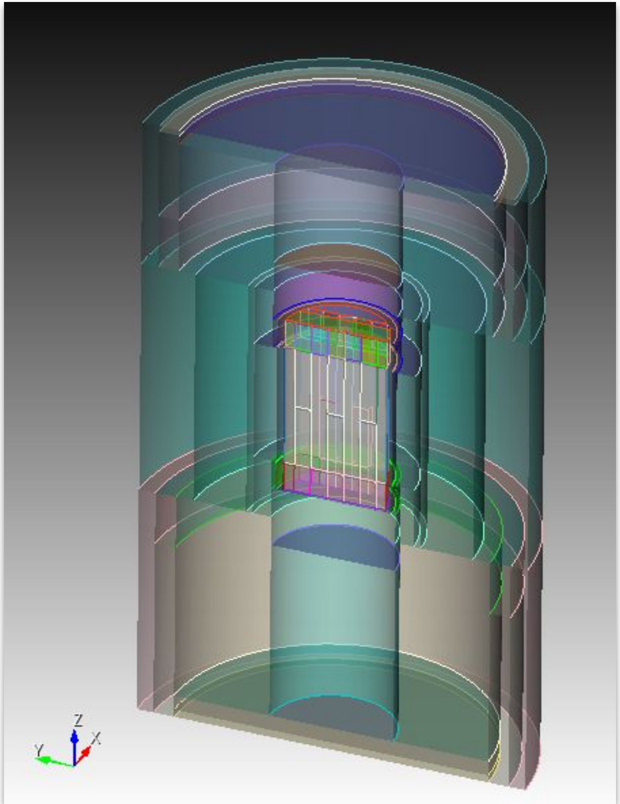


1- International Handbook of Evaluated Criticality Safety Benchmark Experiments / Nuclear Energy Agency. - Paris: OECD Nuclear Energy Agency, 2016. (NEA;7328)

DAGMC Demonstration

ICSBEP[1] Model: SUB-HEU-MET-FAST-001

1. Model import
2. Metadata prep (w/ scripting)
3. Mesh
4. Export a DAGMC model
5. Execute a run with OpenMC
    a. DAGMC Universe
       Docs & Example



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MCNP Imports (Expectations & Optimizations)

- CSG consists of regions defined by the Boolean combinations of halfspaces of analytic surfaces

- Conversion to CAD requires the creation of these halfspaces as volumes in Cubit and Boolean combinations of the resulting volumes

- Every operation requires an update of user-facing information in the GUI

  (visualization and rendering)

- Geometries with repeated features can be particularly onerous to convert

Some optimizations:

1. Apply the following settings in the console

```
echo off
undo off
warning off
set default autosize off
journal off
graphics off
info off
```

2. Import models through the Python module

```
import cubit
cubit.init('')
cubit.cmd('import mcnp "path/to/mcnp/input.i"')
cubit.cmd('save cub5 "input.cub5"')
```

Links and References

Cubit

- Update the group names of an old DAGMC Model
- Transfer group metadata to Cubit materials and block assignments
- Compute surface mesh accuracy*

DAGMC

- PyDAGMC - a Python API for modifying DAGMC models
- New Docs

OpenMC

- MCNP adapter tool for OpenMC
- Mixed CSG and DAGMC geometry example

*courtesy of Greg Vernon

Questions?

To try this workflow:

Request a free trial of Coreform Cubit to test out the DAGMC workflow

Ask questions at forum.coreform.com