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Title: MCNP6 Unstructured Mesh (UM) for Criticality Accident Alarm System (CAAS) Analysis

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MCNP6 Unstructured Mesh (UM) for Criticality Accident Alarm System (CAAS) Analysis

ANS 20th Topical Meeting of the RPSD 2018

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Monte Carlo Methods, Codes, and Applications (XCP-3)

CAAS UM-CSG Example

Criticality Accident Alarm Systems

- criticality and shielding calculation methods.

UM for facility details

- import of existing facility drawings.

CSG used for criticality and detector cells

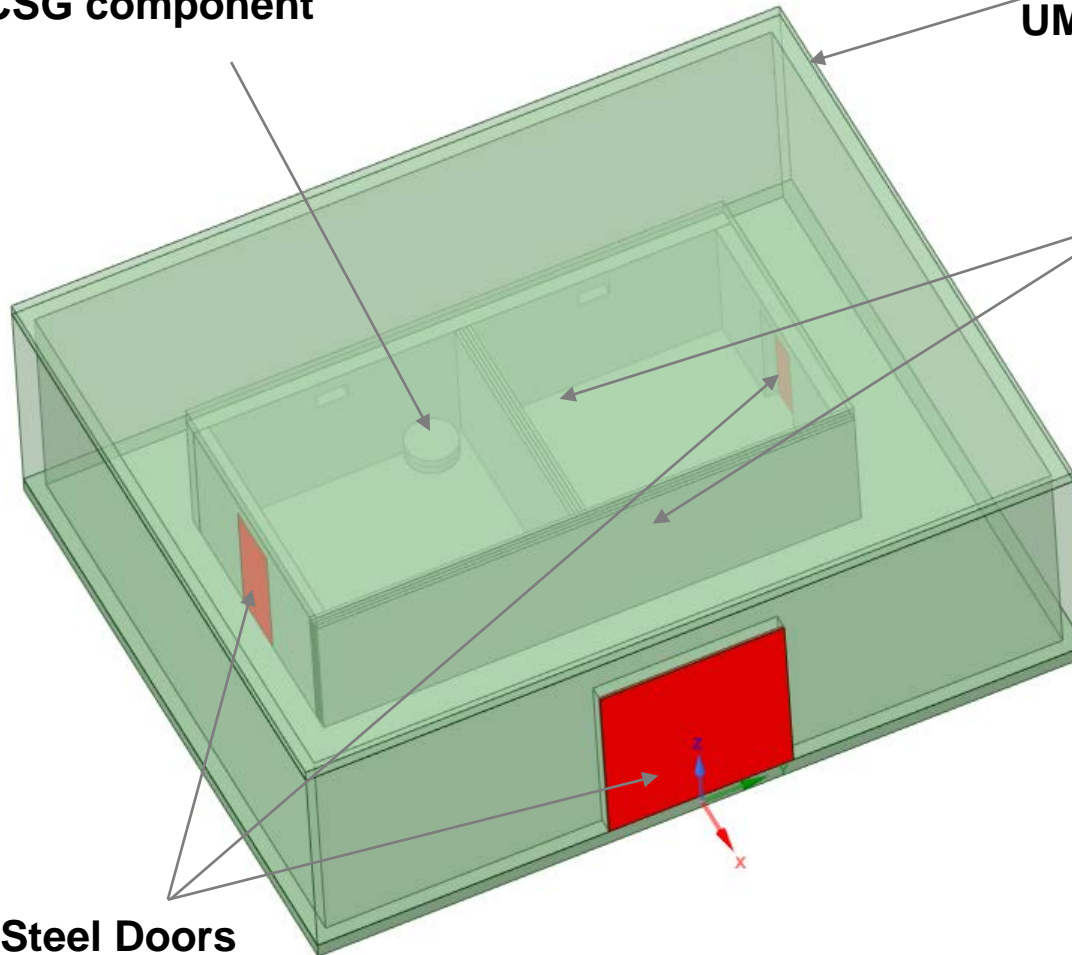
- place criticality/detector cells in multiple locations
 - conserve mass/volume geometry for criticality cells
-
- Import solid geometry, generate mesh, create calculation in Attila4MC and create MCNP6.2 UM file
 - Insert CSG cells for criticality tank and detectors into MCNP6.2 UM file
 - MCNP6.2 KCODE calculation, ensure convergence & generate source
 - Tallies for detector energy deposition, MCNP6.2 fixed source calculation
 - MCNP6.2 and Attila variance reduction techniques for reliable tally results
-
- Weight windows – stochastic and deterministic, DXTRAN

CAAS UM-CSG Example

Critical assembly modeled as CSG component

Concrete Walls and Roof UM components

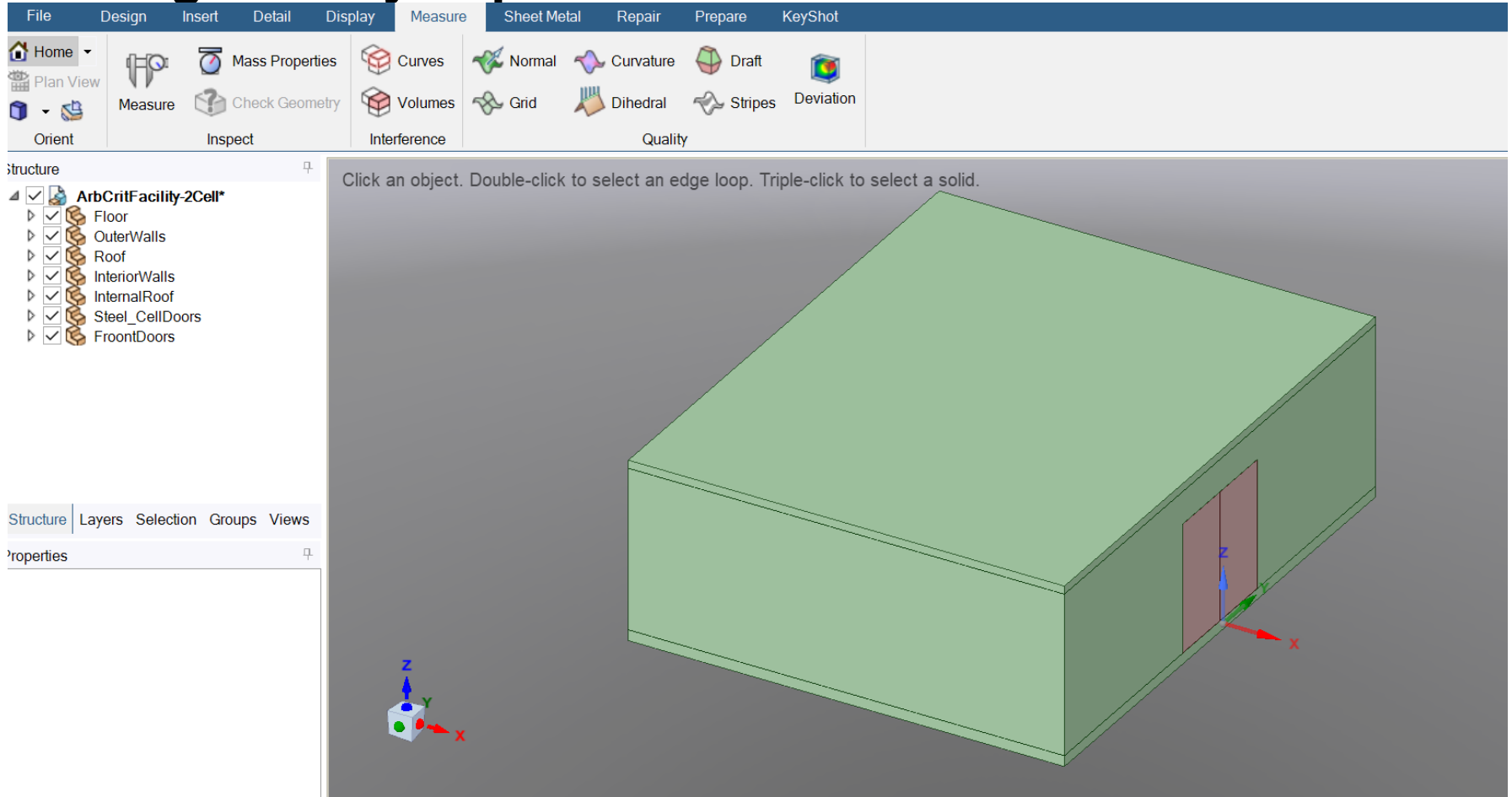
Spheres represent detectors modeled as CSG components



Steel Doors
UM components

CAAS UM-CSG Example

Solid geometry import into Attila4MC



CAAS UM-CSG Example

Cell Cards Showing only UM Geometry

```

c ----- Cell Cards ----- 80
1  2  -2.3   0                u=1
2  2  -2.3   0                u=1
3  2  -2.3   0                u=1
4  2  -2.3   0                u=1
5  2  -2.3   0                u=1
6  1  0.08636  0                u=1
7  1  0.08636  0                u=1
8  0          0                u=1 $ background
9  0          100 -101 102 -103 104 -105 fill=1 $ fill cell
10 0          (-100:101:-102:103:-104:105)
c ----- End Cell Cards ----- 80
  
```

Cell Cards Showing only UM-CSG Geometry

```

c ----- Cell Cards ----- 80
1  2  -2.3   0                imp:n=1    u=1
2  2  -2.3   0                imp:n=1    u=1
3  2  -2.3   0                imp:n=1    u=1
4  2  -2.3   0                imp:n=1    u=1
5  2  -2.3   0                imp:n=1    u=1
6  1  0.08636  0                imp:n=1    u=1
7  1  0.08636  0                imp:n=1    u=1
8  0          0                imp:n=1    u=1 $ background
9  0          -100 201 202 203 fill=1 imp:n=1 $ fill cell
c
c Criticality Cells CSG
21 0          -201 #30 #31 #32 #40 imp:n=1
22 0          -202 #41                imp:n=1
23 0          -203 #42                imp:n=1
c
c Pu Nitrate solution in cell 1
30 94 9.9270e-2  -301 -303  imp:n=1
31 0          -301 303  imp:n=1
32 1  0.08636  -302 301  imp:n=1
c
c Detector Spheres
40 96 -0.92 -401 imp:n=1
41 96 -0.92 -402 imp:n=1
42 96 -0.92 -403 imp:n=1
c
c outside world
99 0          100 imp:n=0
c ----- End Cell Cards ----- 80
  
```

CAAS UM-CSG Example

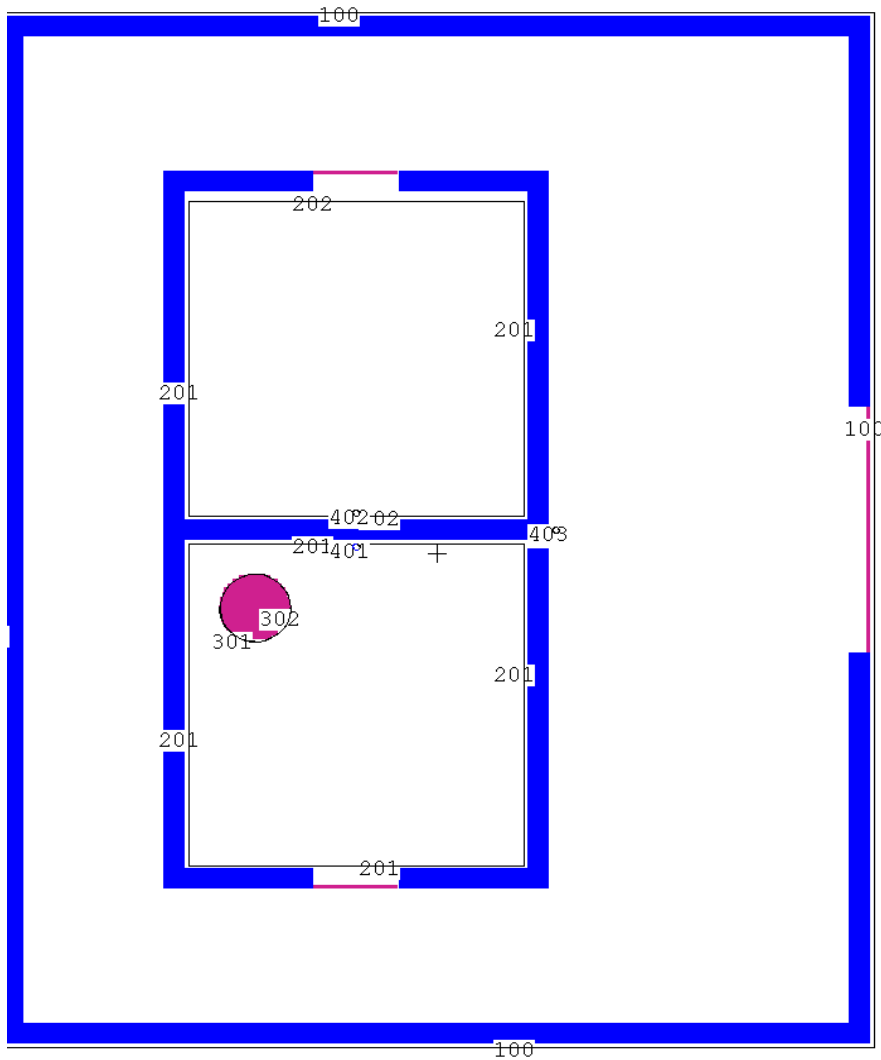
Cell Cards Showing only UM-CSG Geometry

c ----- Surface Cards ----- 80
c
100 px -2304.02
101 px -8.0175
102 py -761.92
103 py 772.08
104 pz -35.48
105 pz 485.06
c ----- End Surface Cards ----- 80

Cell Cards Showing only UM-CSG Geometry

c ----- Surface Cards ----- 80
c
c 100 px -1252.46
c 101 px -8.0175
c 102 py -761.92
c 103 py 772.08
c 104 pz -35.48
c 105 pz 485.06
100 RPP -1252.46 -8.0175 -761.92 772.08 -35.48 485.06
c
c Criticality Storage Cells with 5cm buffer to UM walls
201 RPP -983.38 -505.7 -492.83 -15.15 5.0 269.32
202 RPP -983.38 -505.7 25.15 492.83 5.0 269.32
203 SPH -460.2175 5.085 100 7
c
c Plutonium-Nitrate Container in inside corner of cell 1
301 RCC -888.38 -110.15 100.0 0.0 131.7 50
302 RCC -888.38 -110.15 99.0 0.0 132.7 50.5
303 pz 117.0
c
c Detector Sphere in inside corner of cell 2
401 sph -744.5375 -20.1549 100.0 5
402 sph -744.5375 30.3251 100.0 5
403 sph -460.2175 5.085 100.0 5
c ----- End Surface Cards ----- 80

CAAS UM-CSG Example: MCNP6 Geometry, fmesh plots



CAAS UM-CSG Example

MCNP6.2 Neutron Energy Deposition Results

Run	Detector 1 Mean Estimate (Gy)	Relative Error Estimate	Detector 2 Mean Estimate (Gy)	Relative Error Estimate	Detector 3 Mean Estimate (Gy)	Relative Error Estimate
1: UM-CSG using FW-CADIS	2.2870E-02	0.0397	6.3406E-04	0.0367	1.0857E-04	0.0512
2: UM-CSG using DXT, ESPLT	2.3486E-02	0.0374	6.3958E-04	0.0345	9.7151E-05	0.0710
3: CSG using DXT, ESPLT	2.2815E-02	0.0131	6.2337E-04	0.0128	1.0838E-04	0.0305
Difference 1-2	-2.69%		-0.87%		10.52%	
Difference 1-3	0.24%		1.69%		0.18%	

CAAS UM-CSG Example

Attila FW-CADIS

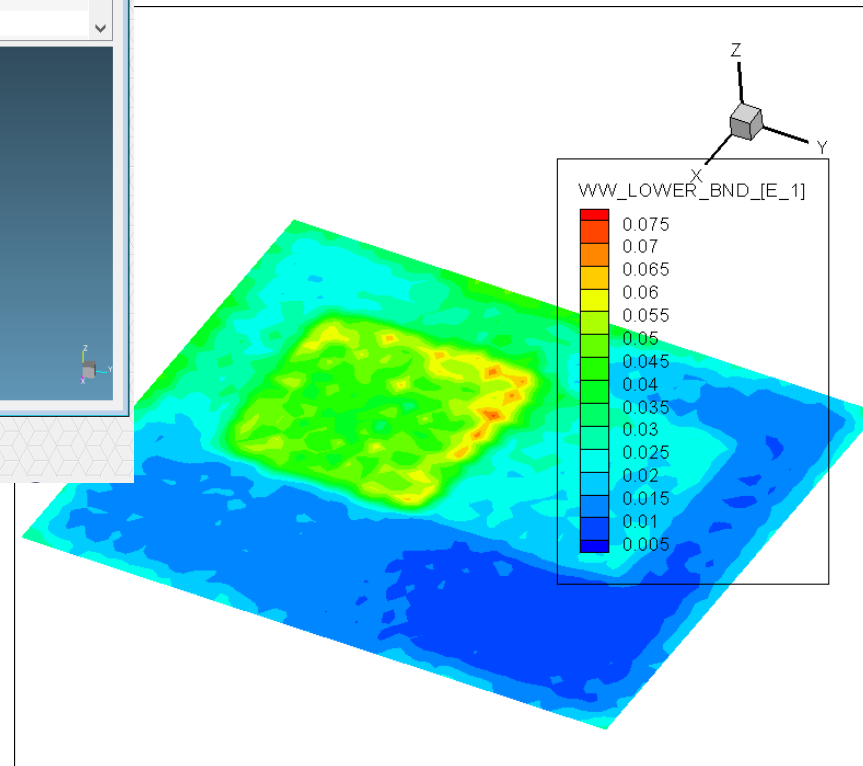
The screenshot displays the CAAS software interface. The main window is titled "Input Editor: calc7* [Project: JensCAAS]". On the left, a "Panels" list includes: General, Mesh Geometry, Cross Section Libr, Energy Group Att, Material Editor, Region Attributes, MCNP Controls, Fixed Source, Solver Controls, Custom Reports, and Weight Window C. The "Input Name" is "calc7". The "Input Description" field is empty. The "Calculation Type" is "FW-CADIS", and the "Transport Operator" is "Forward". The "Created" date is "7/26/2018 4" and the "Last Modified" date is "8/15/2018 3".

The "RTT Mesh: ArbCritFacility2cell-ForSn-LargePuNiCan.cadis [Project: JensCAAS]" panel is open, showing the following details:

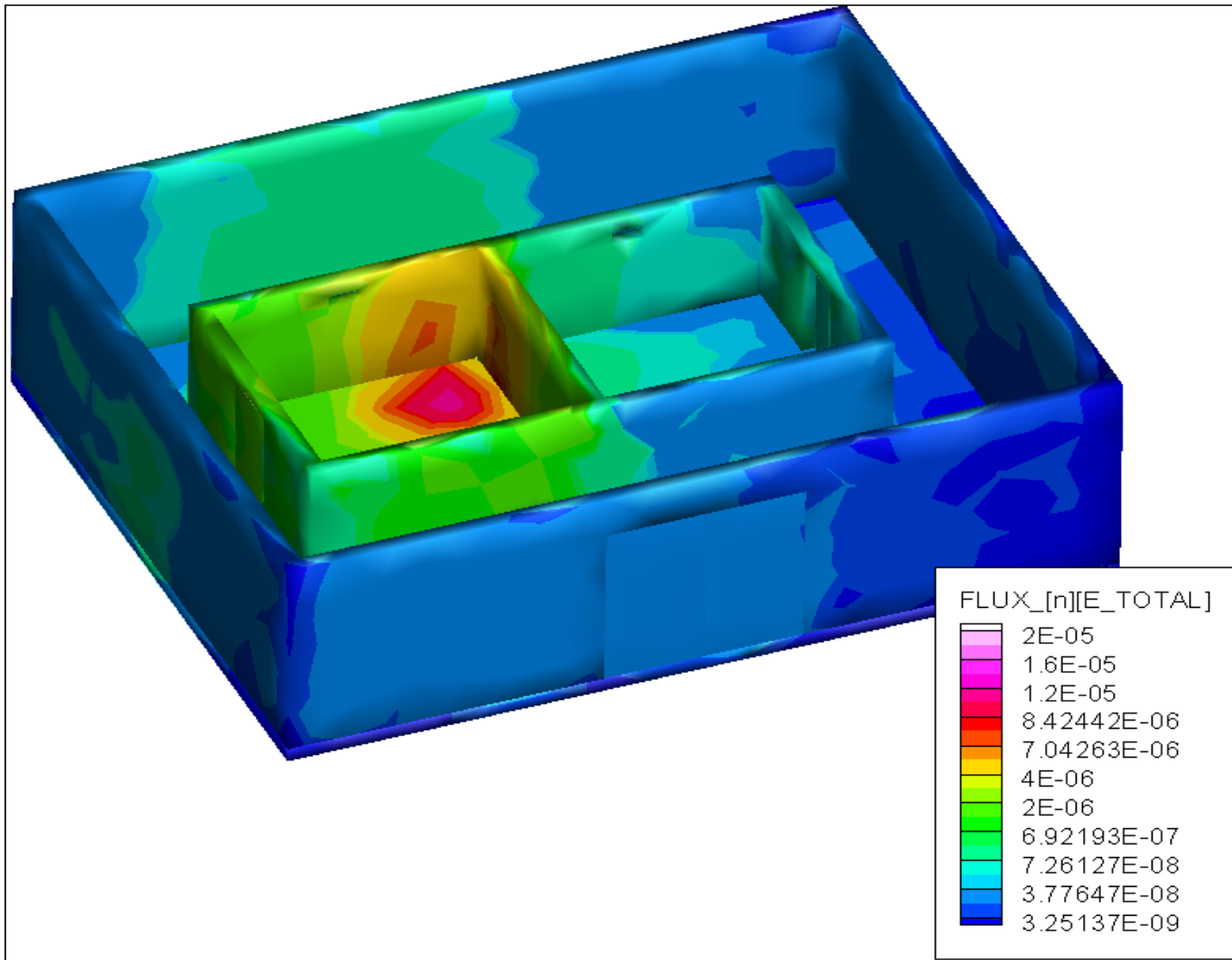
- Type: rtt
- Title: ArbCritFacility2cell-ForSn-LargePuNiCan
- Comments: RxMesher version : ^, Simmetrix MeshSim version : ^, Global mesh size : ^, Generated
- Nodes: 7146, Sides: 9709, Cells: 37366
- Display Aspect: Regions, Sides
- Flag: REGIONS
- Color Cell Flag table:

Color	Cell Flag
●	Floor [1]
●	OuterWalls [2]
●	Roof [3]
●	InteriorWalls [4]
●	InteriorRoof [5]
●	Steel_CellDoors [6]
●	FrontDoors [7]

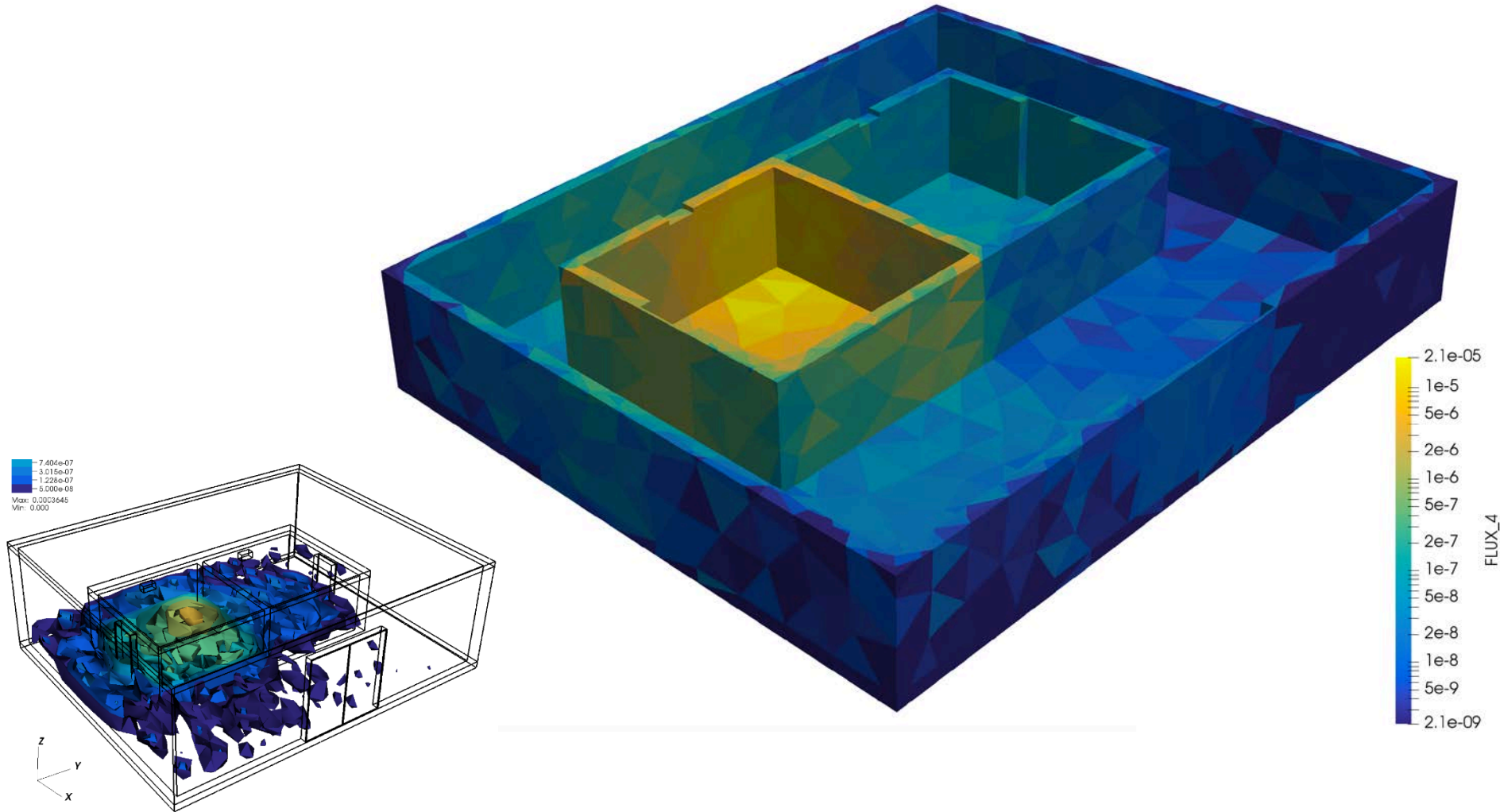
The main 3D view shows a green rectangular structure with a red dot on top, representing the meshed geometry.



CAAS UM-CSG Example: MCNP6.2 eeout → Tecplot



CAAS UM-CSG Example- MCNP6 Meshtal → Paraview



CAAS UM-CSG Example

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- Attila & Attila4MC, meshing, and CADIS/FW-CADIS

Joel Kulesza – LANL:

- Assistance with Paraview visualization