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Title: Criticality Accident Alarm System (CAAS) CSG-UM Hybrid Example

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Criticality Accident Alarm System (CAAS) CSG-UM Hybrid Example

ANS 20th Topical Meeting of the RPSD 2018
Workshop: Attila4MC for simplifying MCNP,
Including CAD integrated CADIS and FW-CADIS

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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

Objective: Demonstrate a hybrid method using UM for facility and CSG for criticality & detector cells

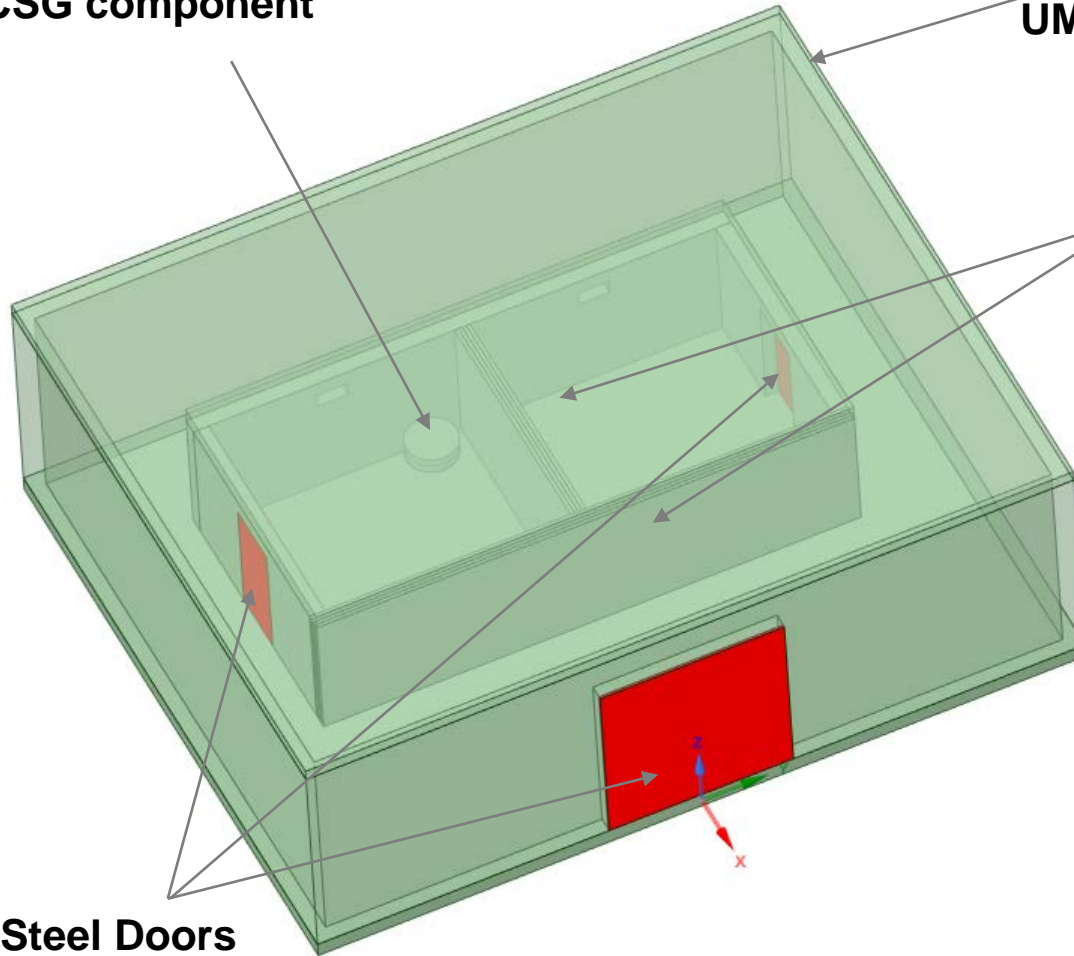
- Import solid geometry, generate mesh, create calculation in Attila4MC and create MCNP6.2 UM file
- Insert CSG cells for criticality tank and detectors into MCNP6.2 UM file
- Run MCNP6.2 KCODE calculation ensuring convergence and generate source
- Define tallies for energy deposition to detectors and run MCNP6.2 fixed source calculation
- Employ MCNP6.2 and Attila variance reduction techniques for reliable tally results

CAAS UM-CSG Example

Critical assembly modeled as CSG component

Concrete Walls and Roof UM components

Spheres represent detectors modeled as CSG components

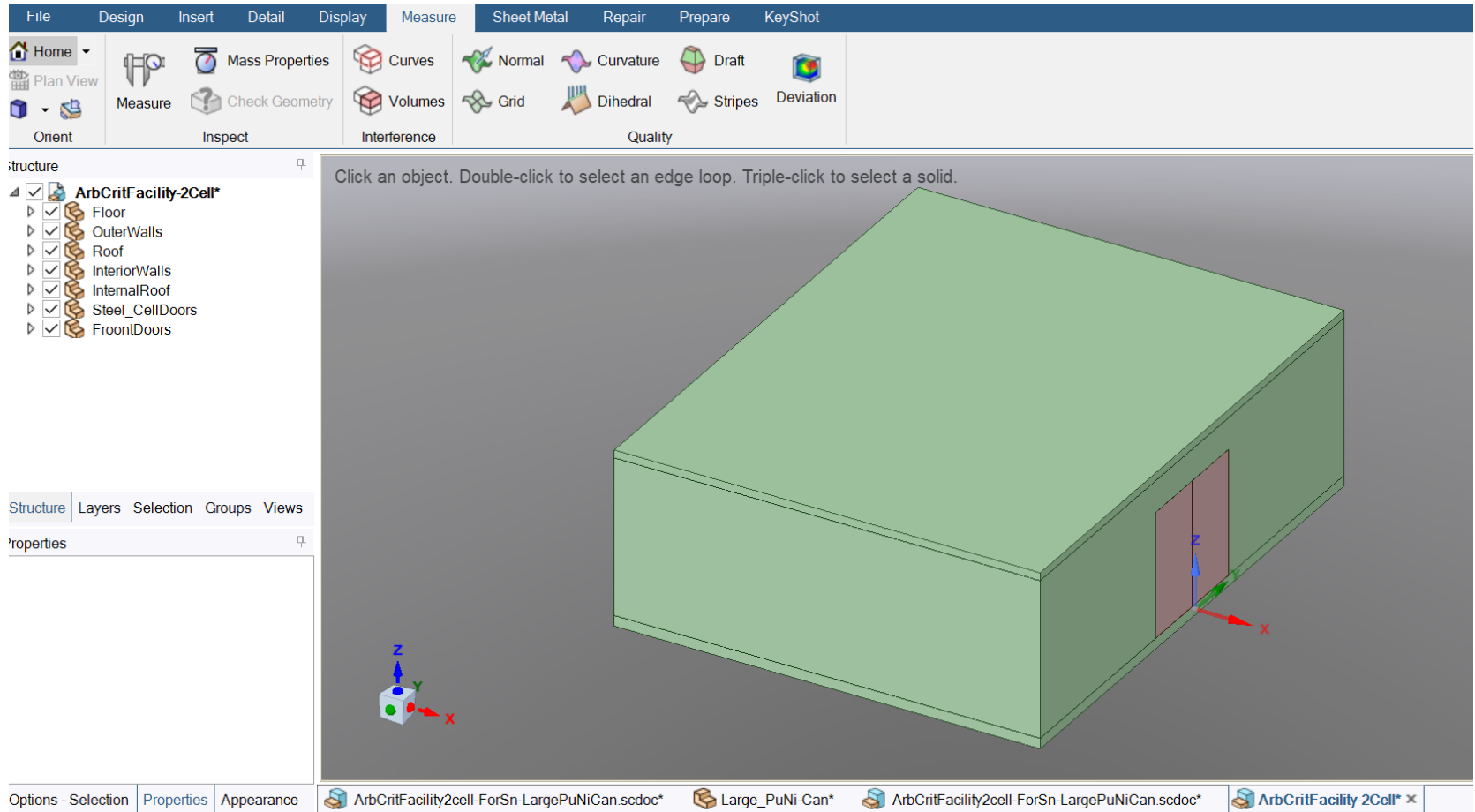


Steel Doors UM components

CAAS UM-CSG Example

Solid geometry import into Attila4MC

ArbCritFacility-2Cell.x_t -- view parasolid file in Spaceclaim → import into Attila4MC



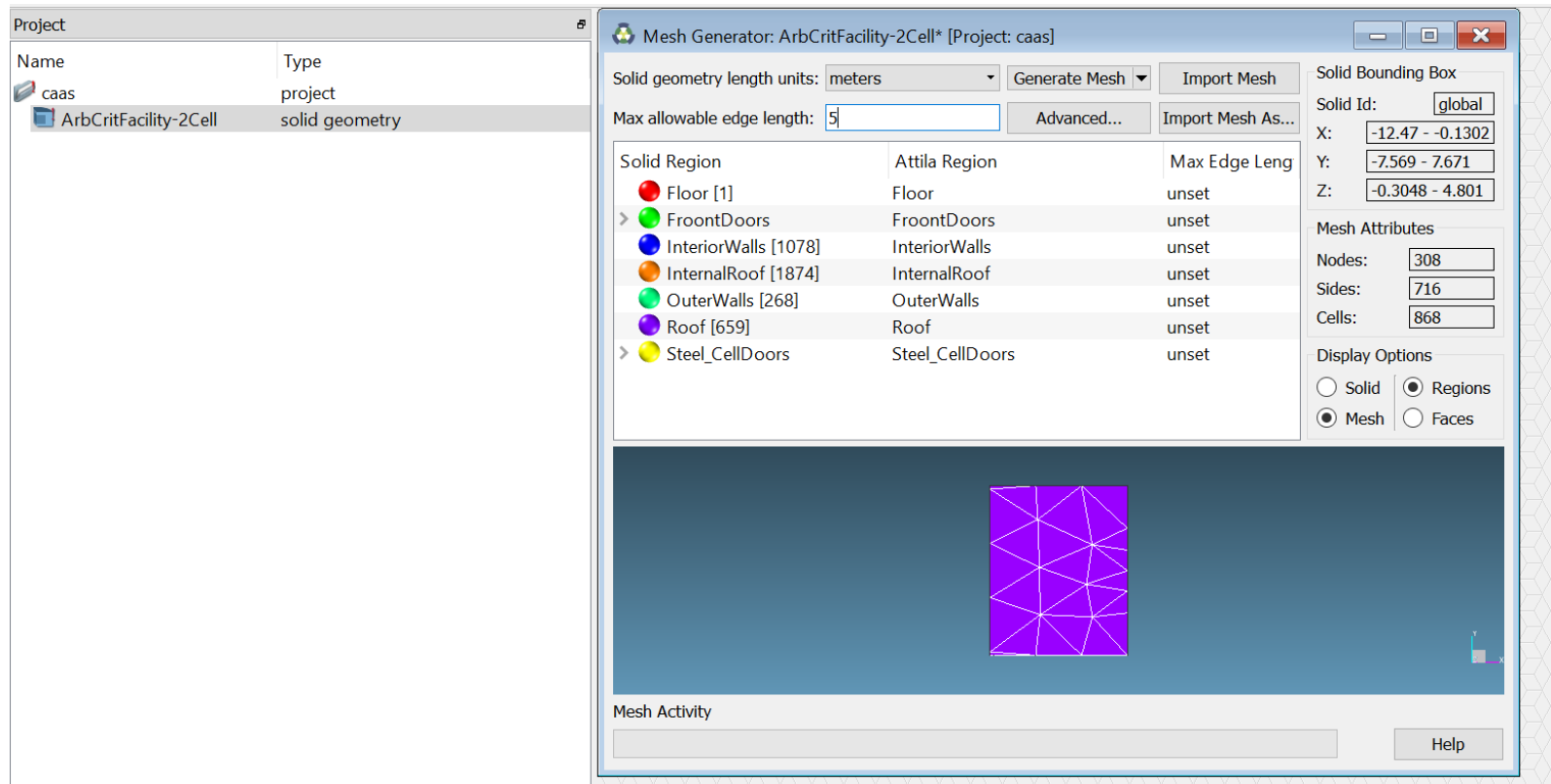
CAAS UM-CSG Example

Generate Mesh in Attila4MC:

File: New: Project: caas

Project: Import file: Solid Geometry: **ArbCritFacility-2Cell.x_t**

Generate Mesh (unclick Identify Empty Regions) → **ArbCritFacility-2cell.mesh.inp**



The screenshot shows the 'Mesh Generator: ArbCritFacility-2Cell* [Project: caas]' window. On the left, a 'Project' tree lists 'caas' (project) and 'ArbCritFacility-2Cell' (solid geometry). The main panel displays a table of regions and their meshing parameters:

Solid Region	Attila Region	Max Edge Leng
Floor [1]	Floor	unset
FroontDoors	FroontDoors	unset
InteriorWalls [1078]	InteriorWalls	unset
InternalRoof [1874]	InternalRoof	unset
OuterWalls [268]	OuterWalls	unset
Roof [659]	Roof	unset
Steel_CellDoors	Steel_CellDoors	unset

Additional settings include 'Solid geometry length units: meters', 'Max allowable edge length: 5', and 'Solid Bounding Box' coordinates (X: -12.47 to -0.1302, Y: -7.569 to 7.671, Z: -0.3048 to 4.801). Mesh statistics show 308 Nodes, 716 Sides, and 868 Cells. Display options are set to 'Regions' and 'Mesh'. A 3D preview window shows a purple mesh of the facility structure.

CAAS UM-CSG Example

Create calculation in Attila4MC and pack for MCNP

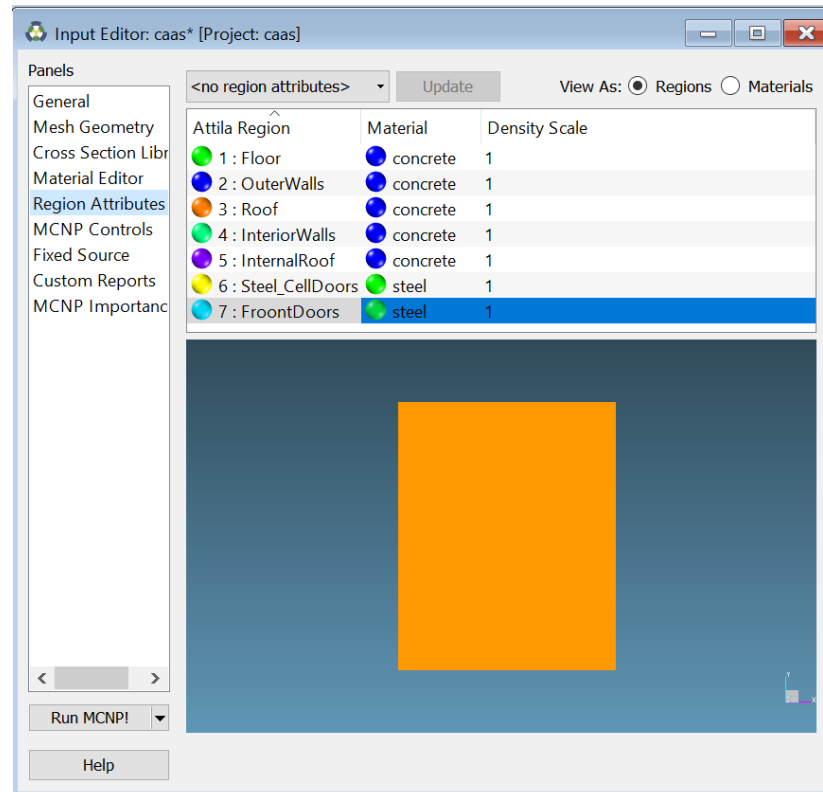
Project: Create Object > Calculation

Library Name: **MCNP_Isotopes_Lib.xs.aux.inp** (must have cross sections imported)

Material – choose material for each Attila region

Project: Import MCNP Attributes...**arb_crit_facility-CSG.mcnp.i**

Calculation> Pack for MCNP
arbcritfacility-2cell.mcnp.i
arbcritfacility-2cell.abaq



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

MCNP6.2 Geometry Plot of UM-CSG cells

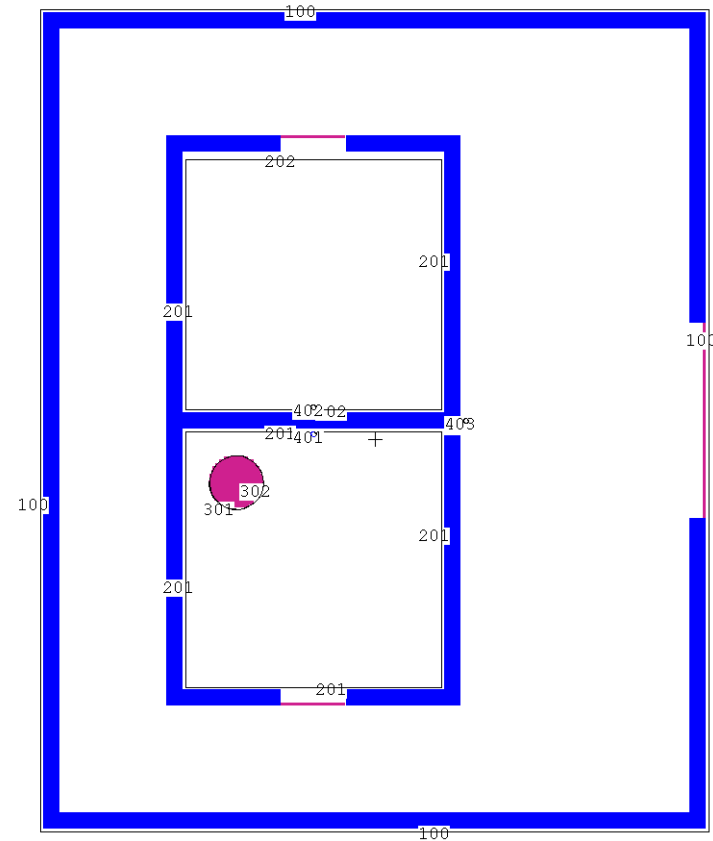
```
05/11/18 11:48:14
Caas Hybrid CSG-UM
```

UP	RT	DN	LF	Origin	.1	.2	Zoom	5.	10
----	----	----	----	--------	----	----	------	----	----

```
>probid = 05/11/18 11:47:54
>basis: XY
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
>origin:
( -629.65, -29.75, 100.00)
>extent = ( 956.25, 956.25)
```

```
Use for cell 21
in Cell 21
x = -629.65, -29.75, 100.00
```

RSOR	Restore	CellLine
wtScript	ROTATE	
VLOR	SCALES 0	LEVEL
r	YZ	ZX
UNLS	L1 on	L2 off
NOY on	FRESH	LEGEND off



CAAS UM-CSG Example

- **MCNP6.2 KCODE calculation with SSW**
- **Generated with the SSW or “Surface Source Write” card.**
- **Form: SSW CEL = C1 C2 ...**
 - CEL keyword lists cells to store fission source points from KCODE calculation.
 - Produces a file with default name **wssa**.
 - The source file may be used as the source from a criticality accident.

```
...
KCODE 20000 1.0 50 150
KSRC -888.38 -110.15 108.5
ssw cel=30
...
```

```
mcnp6 i = caas1.txt o = caas1o.txt wssa = source
```

- Note: This will generate 2 million source points and will take a long time.
- Examine results, verify run was successful and Shannon entropy check confirms source convergence

CAAS UM-CSG Example

- **MCNP6.2 fixed source calculation with SSR**
- **Form: SSR CEL = C1 C2 ... WGT = W PSC = P**
 - CEL lists cells to use from the surface source file.
 - W is the intensity of the source (neutrons released from the burst).
 - PSC is the probability of scattering cosine. From fission this is isotropic and 0.5. This is needed for F5 tallies and DXTRAN.
- **Since fission was already treated in the KCODE calculation, it must be treated as capture.**
- **Form: NONU N1 N2 ... N(NCEL)**
 - Specifies a list of cells where fission is treated as capture
 - = 0, do not perform fission (treat as capture)
 - = 1, perform fission
- **The neutron energy deposited in a cell may be obtained with an F6 tally.**
- **Form: F6:n C1 C2 ...**
 - Computes energy deposition for each cell listed on the card in MeV/gram.

CAAS UM-CSG Example

MCNP6.2 KCODE

```

.....
kcode 20000 1.0 50 150
KSRC -888.38 -110.15 108.5
ssw cel=30
.....

```

MCNP6.2 fixed source

```

.....
c Source Definition
ssr cel=30 wgt=2.9e15 psc=0.5
nonu 0 18r
c
c Histories (or Computer Time Cutoff)
nps 1e6
c
c Tallies or embee cards
fmesh4:n ORIGIN=-1255. -750. 0.
      IMESH=0. IINTS=184
      JMESH=750. JINTS=124
      KMESH=450. KINTS=36
c
f16:n 40
fm16 1.6022e-10 $1.602e-10 convert MeV/gram to J/kg
fc16 Criticality Accident Dose at Detector 1 in Gy

```

mcnp6 i = caas3.txt o = caas3o.txt rssa = source

CAAS UM-CSG Example

MCNP6.2 Fmesh results

fmesh tally in input file:

```
fmesh4:n ORIGIN=-1255. -750. 0.
  IMESH=0. IINTS=184
  JMESH=750. JINTS=124
  KMESH=450. KINTS=36
```

After successful run, plot fmesh tally:

```
mcnp6 z r=caas3.r
```



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

Input Editor: calc7* [Project: JensCAAS]

Input Name: calc7

Input Description:

Calculation Type: FW-CADIS

Transport Operator: Forward

Created: 7/26/2018 4

Last Modified: 8/15/2018 3

RTT Mesh: ArbCritFacility2cell-ForSn-LargePuNiCan.cadis [Project: JensCAAS]

Type: rtt

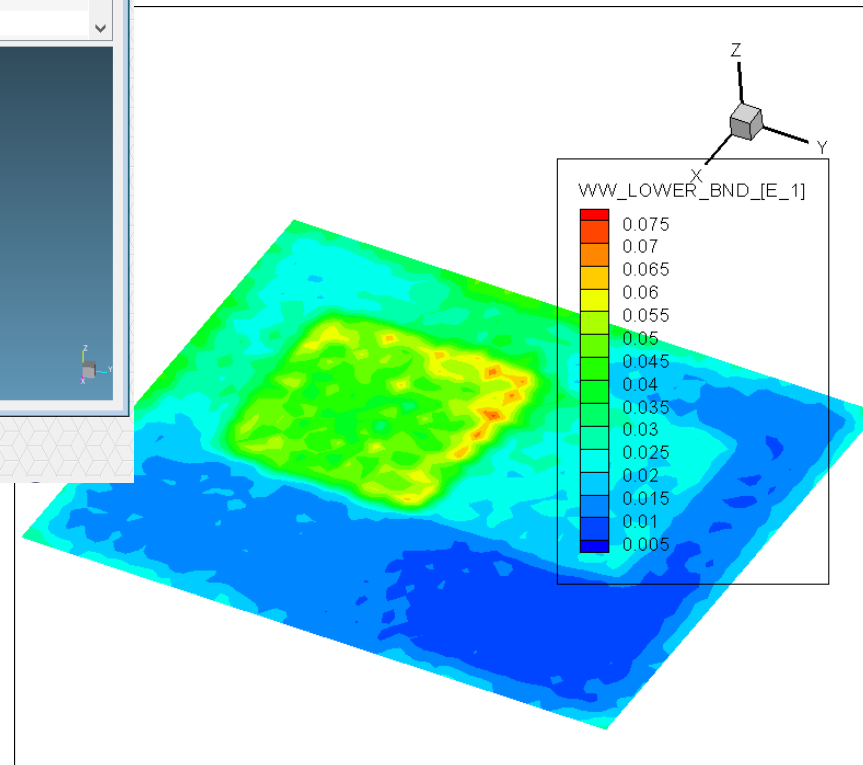
Title: ArbCritFacility2cell-ForSn-LargePuNiCan

Comments: RxMesher version : ^, Simmetrix MeshSim version : ^, Global mesh size : ^, Generated

Nodes: 7146, Sides: 9709, Cells: 37366

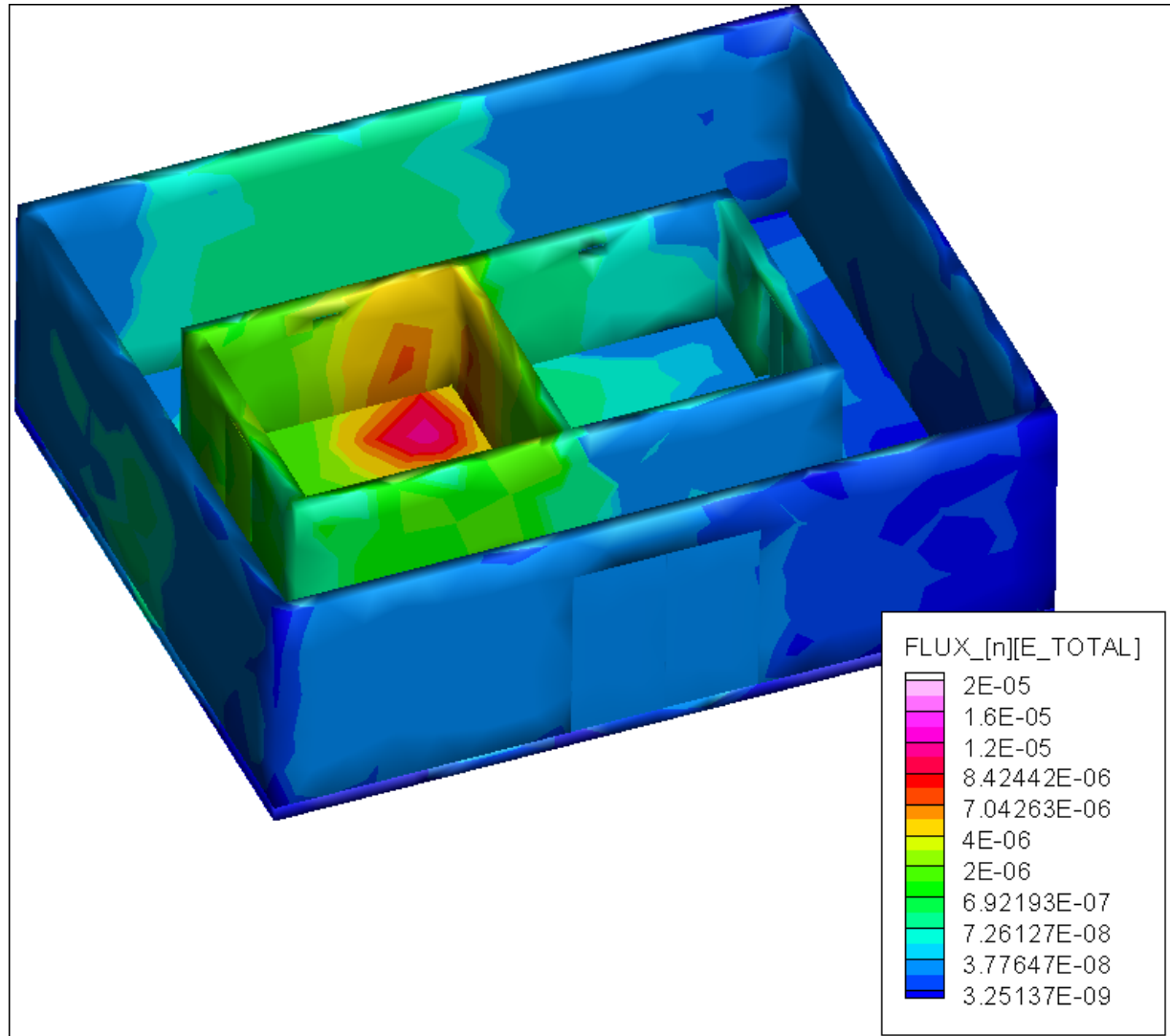
Display Aspect: Regions, Sides

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

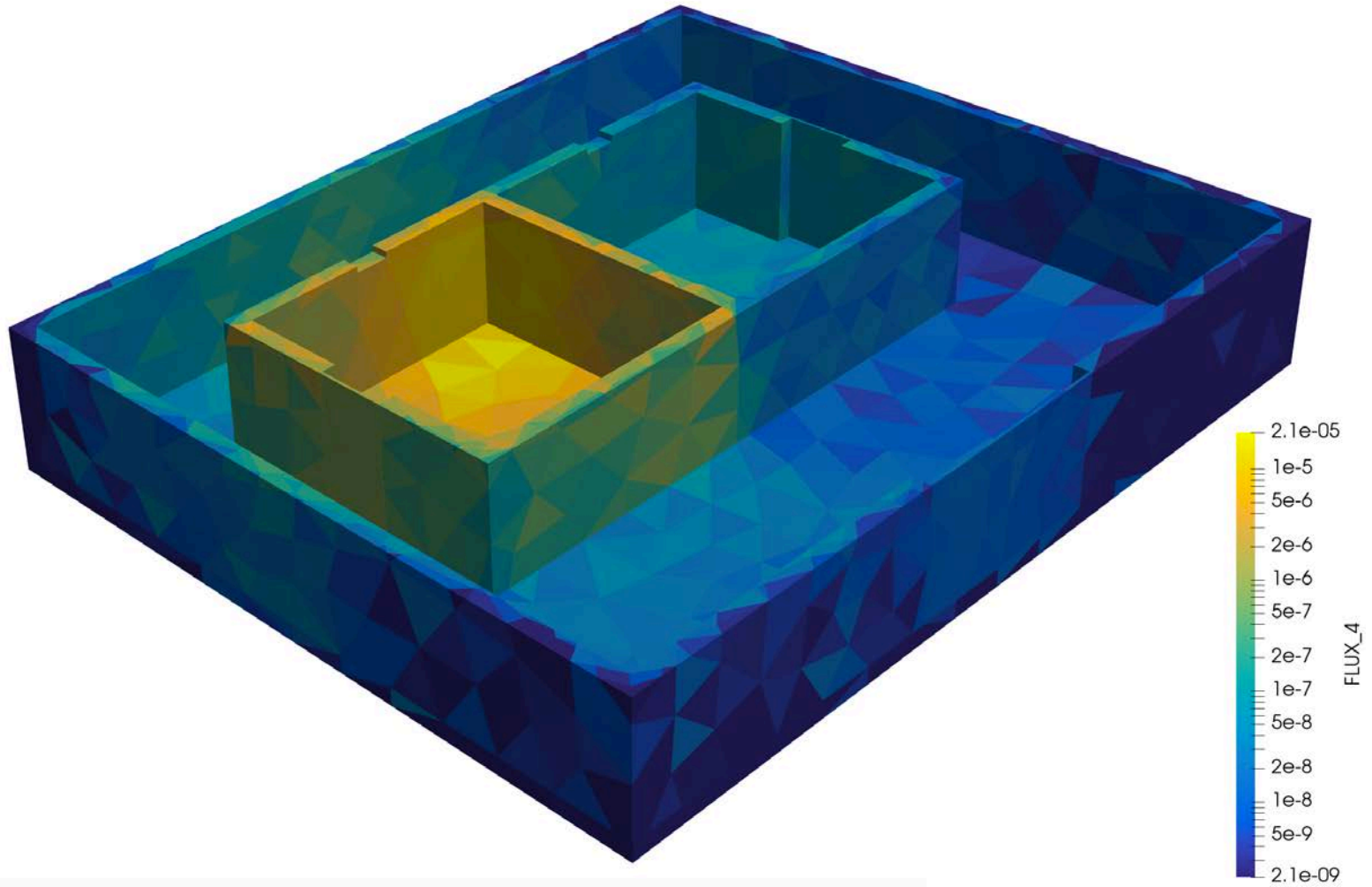


CAAS UM-CSG Example

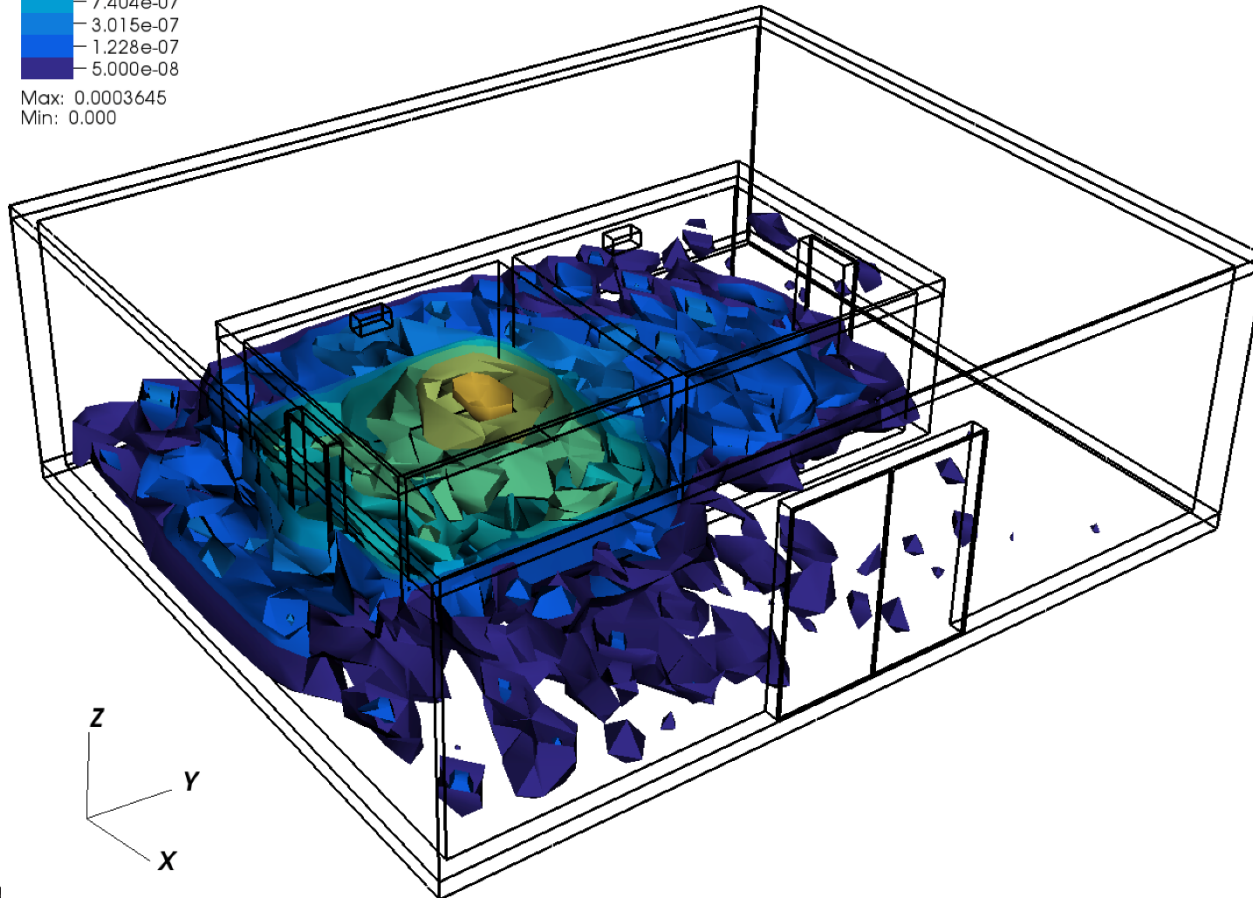
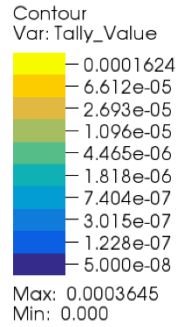
Tecplot from
MCPN6.2 eeout file



CAAS UM-CSG Example



CAAS UM-CSG Example



CAAS UM-CSG Example

Acknowledgements:

Gregory Failla and Dan Oranski – Varex Imaging:

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Joel Kulesza – LANL:

- Thanks for assistance with visualization Visit and