LA-UR-18-28060
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Title: Criticality Accident Alarm System (CAAS) CSG-UM Hybrid Example

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Intended for: ANS Radiation Protection and Shielding Division Topical Meeting, 2018-08-26 (Santa Fe, New Mexico, United States)

Issued: 2018-08-23

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

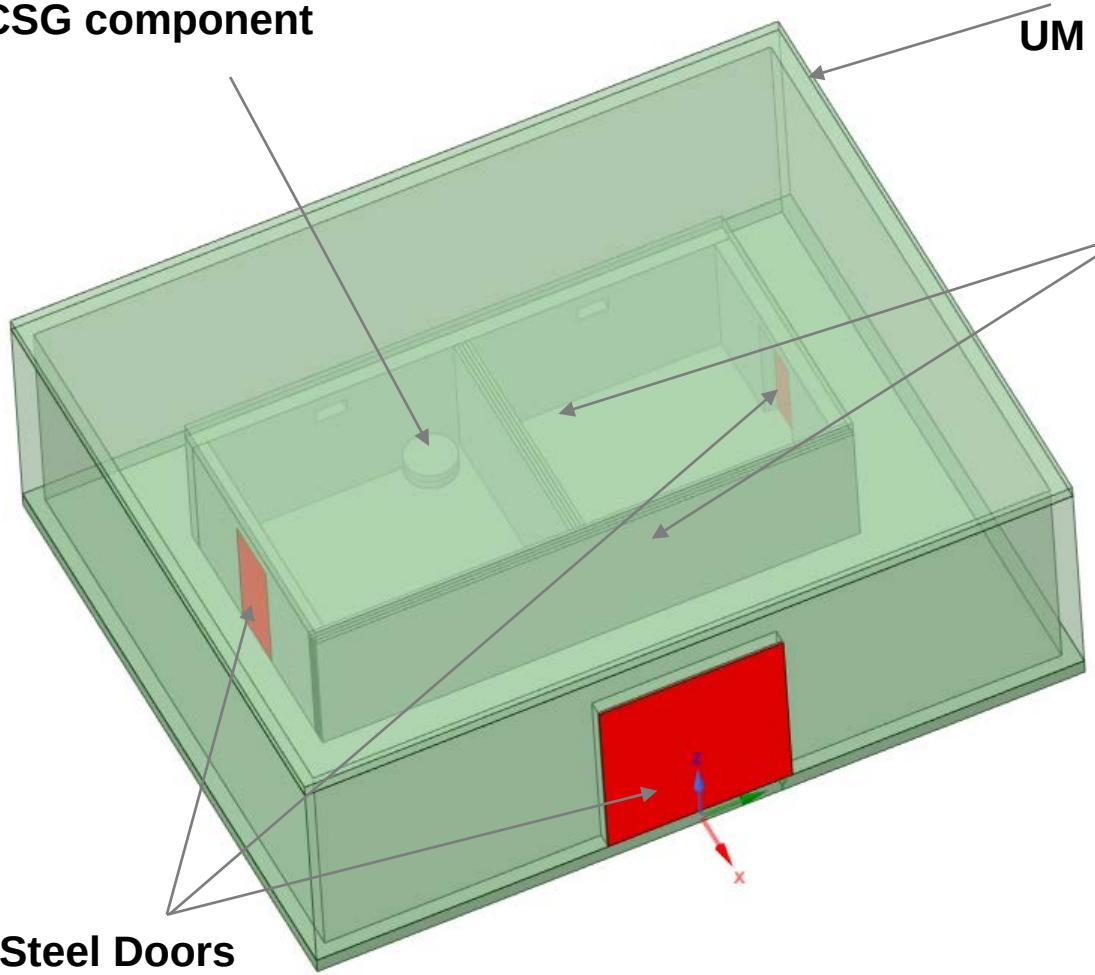
- Import solid geometry, generate mesh, create calculation in Attila4MC and create MCNP6.2 UM file
- Insert CSG cells for criticality tank and detectors into MCNP6.2 UM file
- Run MCNP6.2 KCODE calculation ensuring convergence and generate source
- Define tallies for energy deposition to detectors and 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

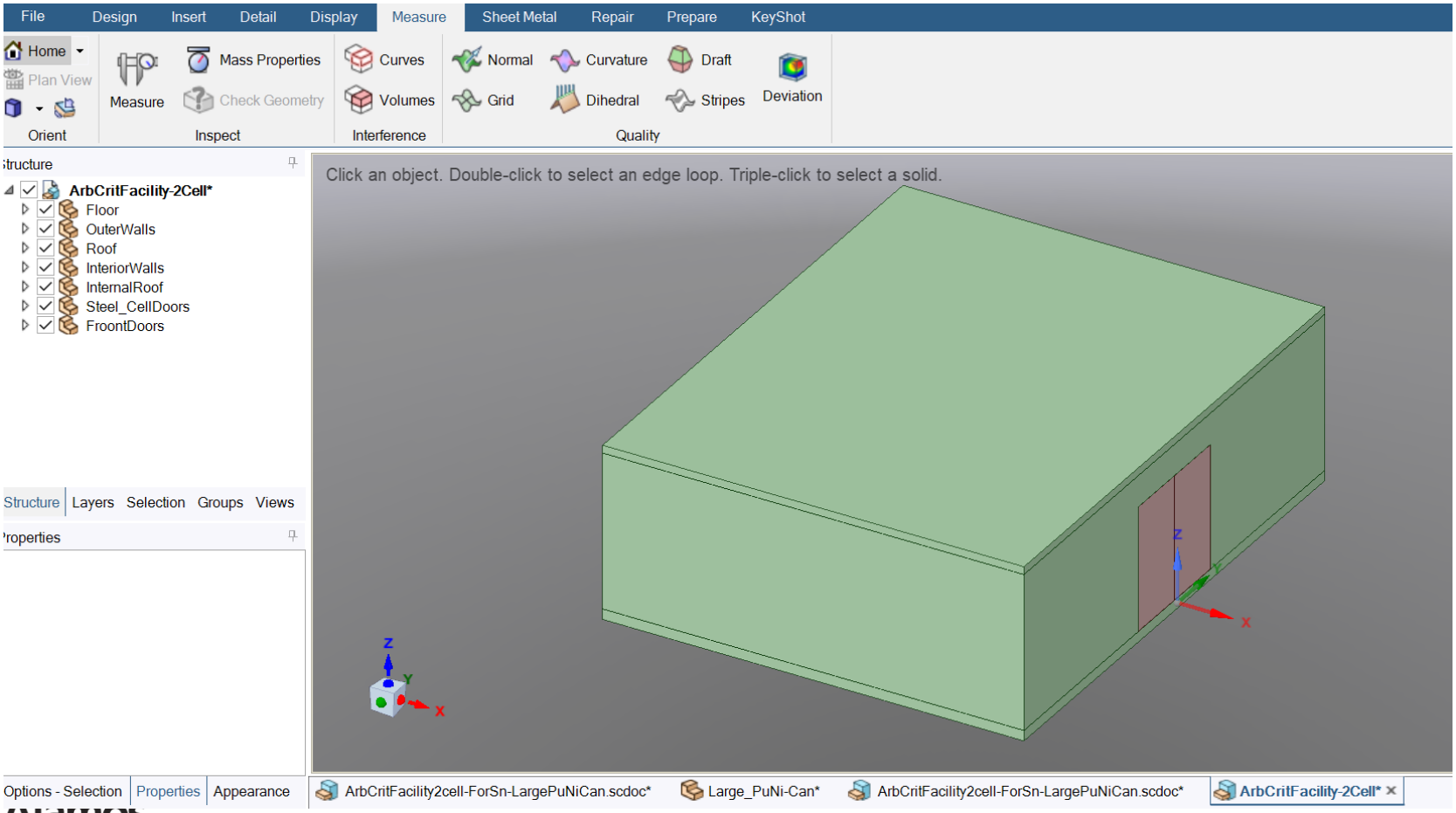


Steel Doors UM components

CAAS UM-CSG Example

Solid geometry import into Attila4MC

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



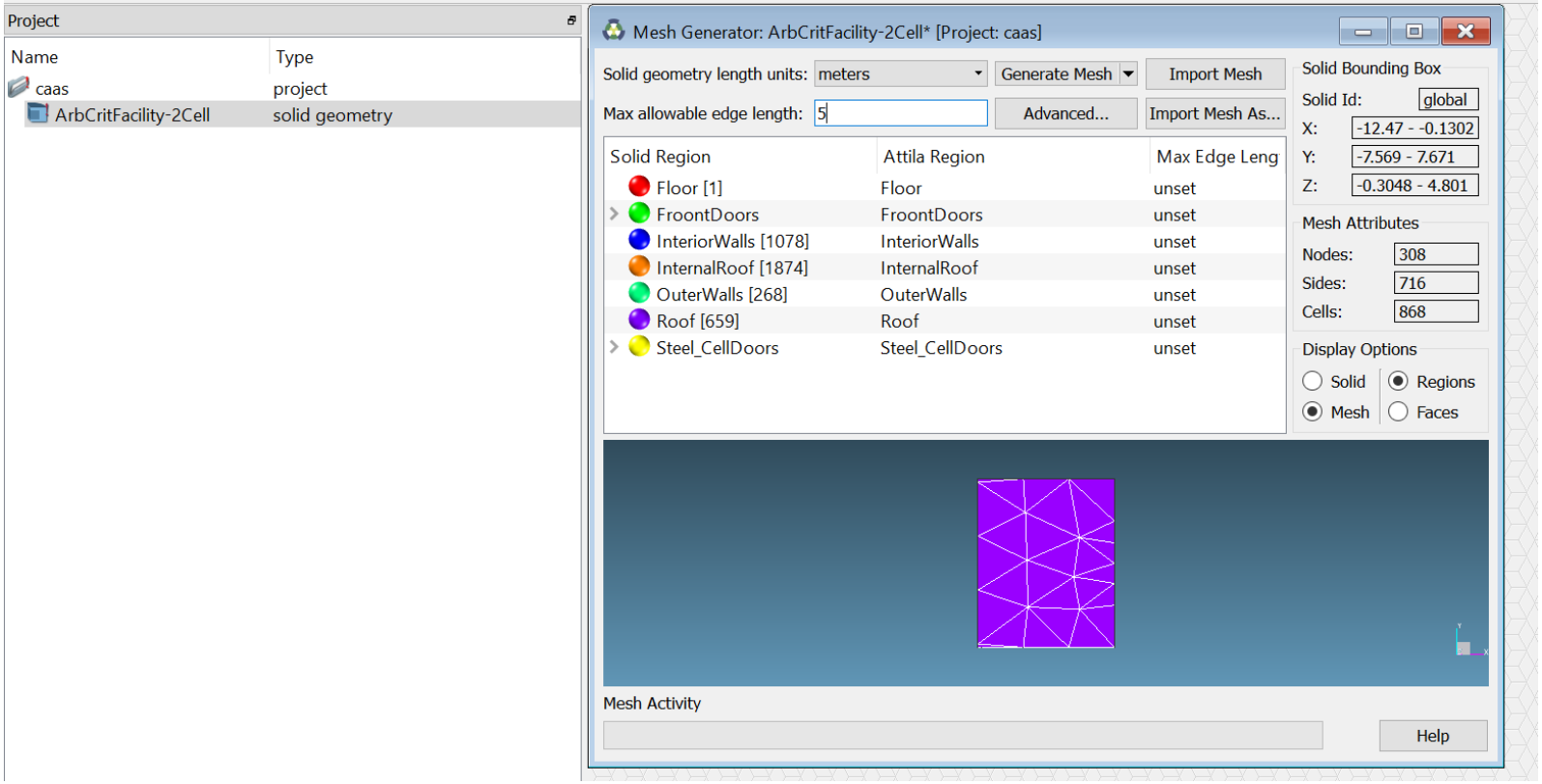
CAAS UM-CSG Example

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**

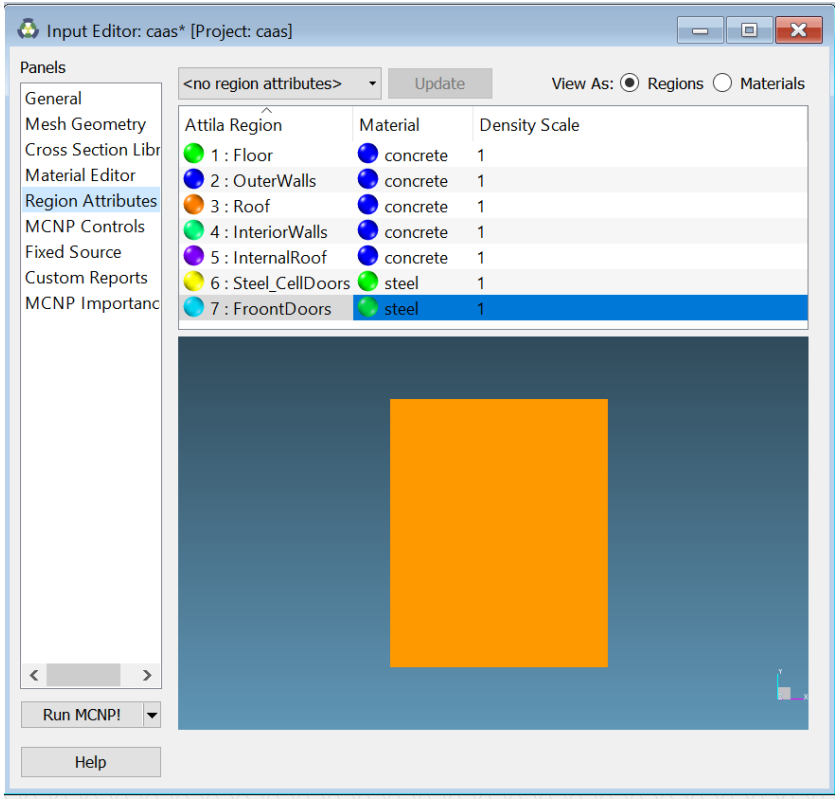


CAAS UM-CSG Example

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 Crititicality 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
```

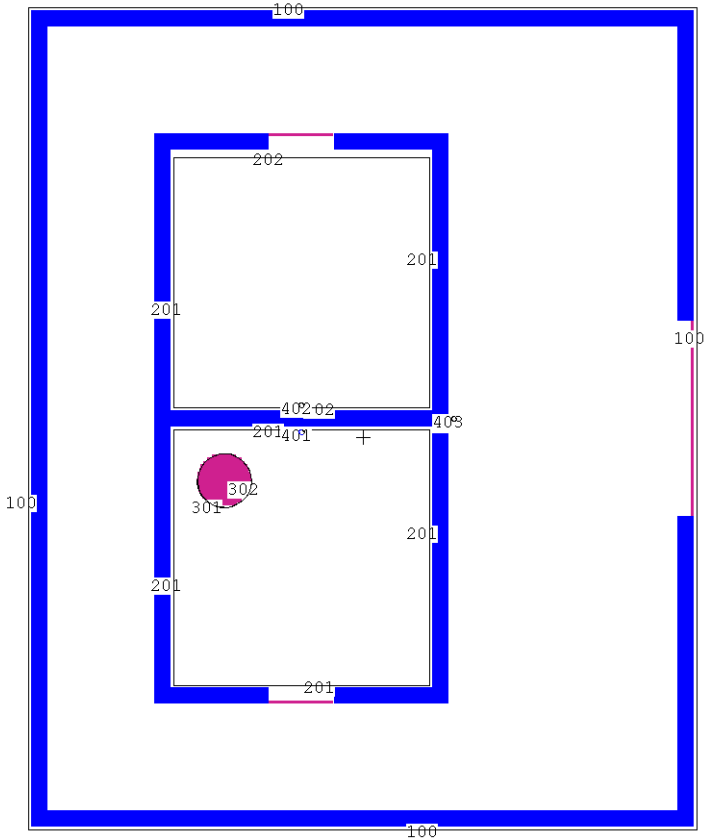
CAAS UM-CSG Example

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)



lue for cel 21

in Cell 21

= -629.65, -29.75, 100.00

RSOR	Restore	Cellline
etScript	ROTATE	
LOR	SCALES 0	LEVEL
	YZ	ZX
ABELS	L1 sur	L2 off
CDI on	PRESH	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

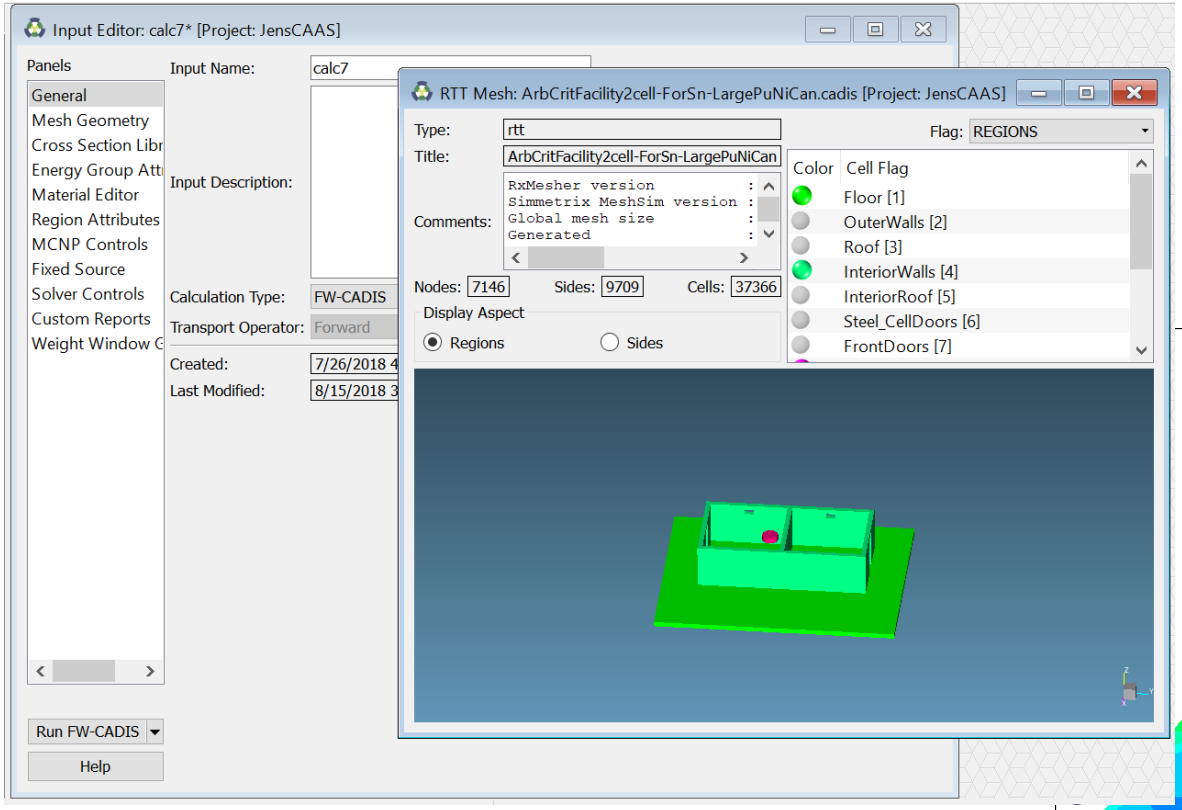
CAAS UM-CSG Example

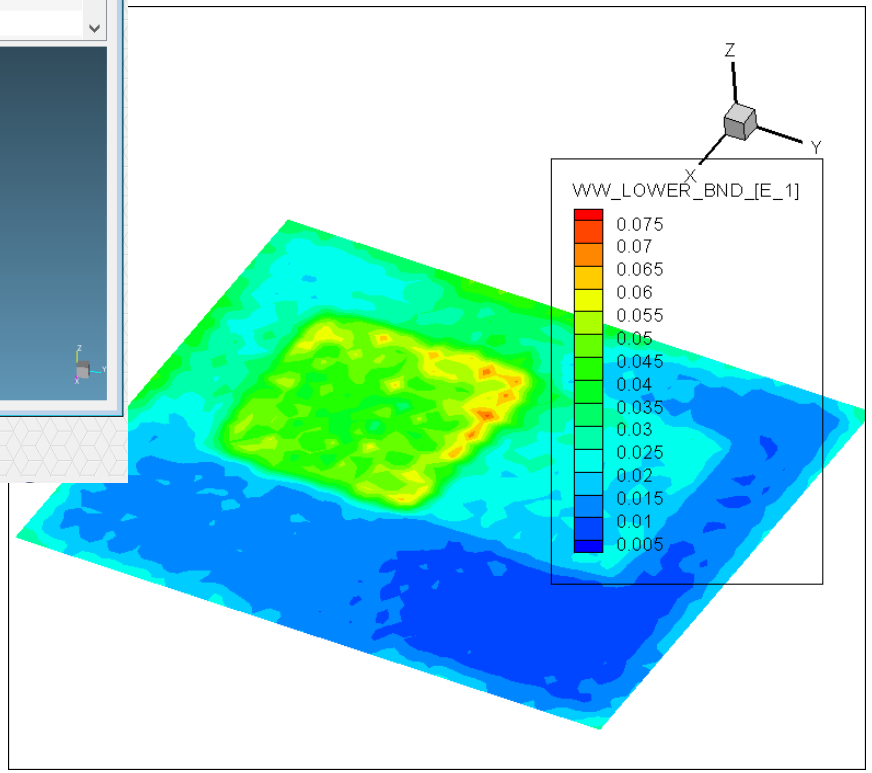
MCNP6.2 Neutron Energy Deposition Results

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

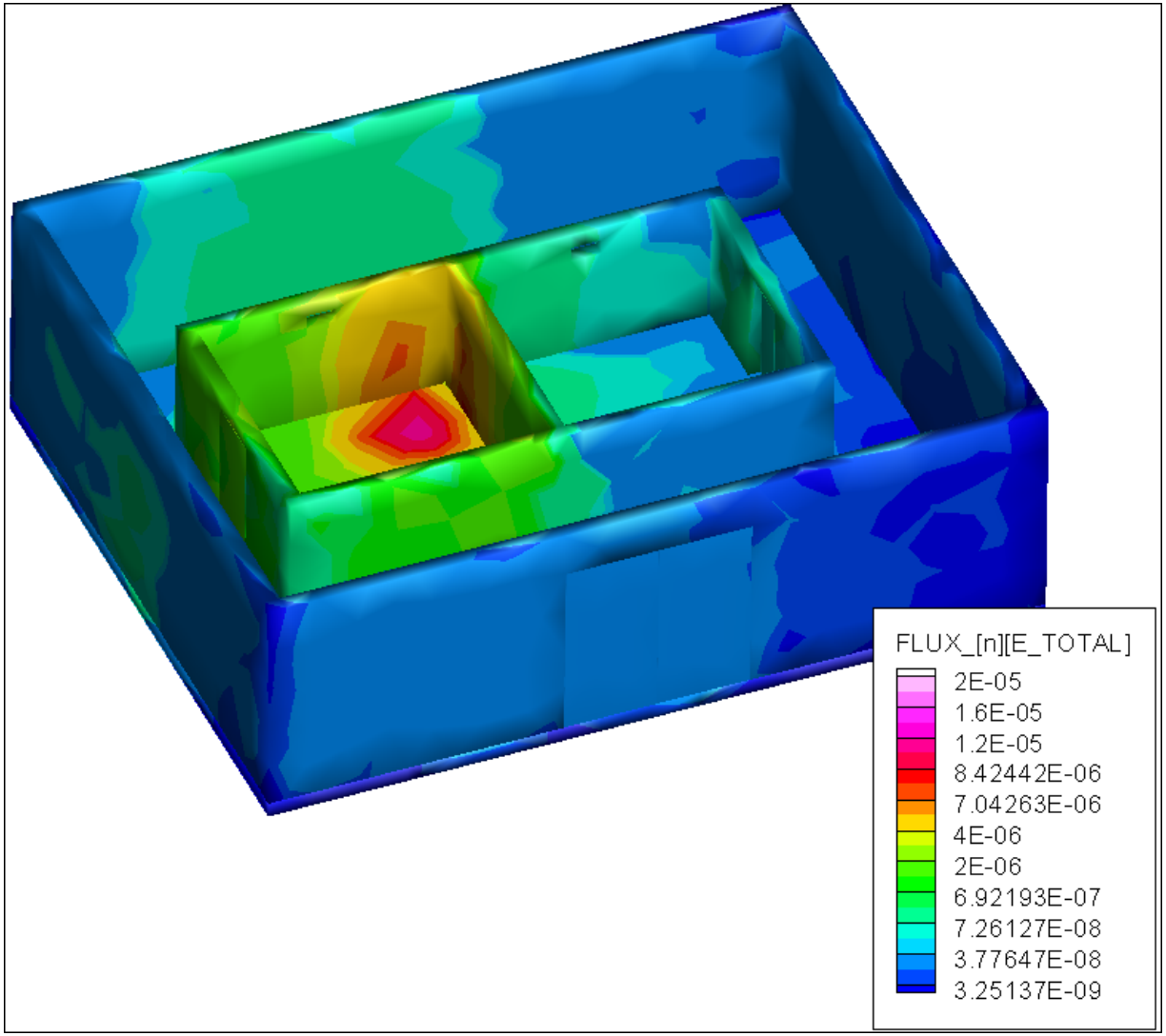
Attila FW-CADIS



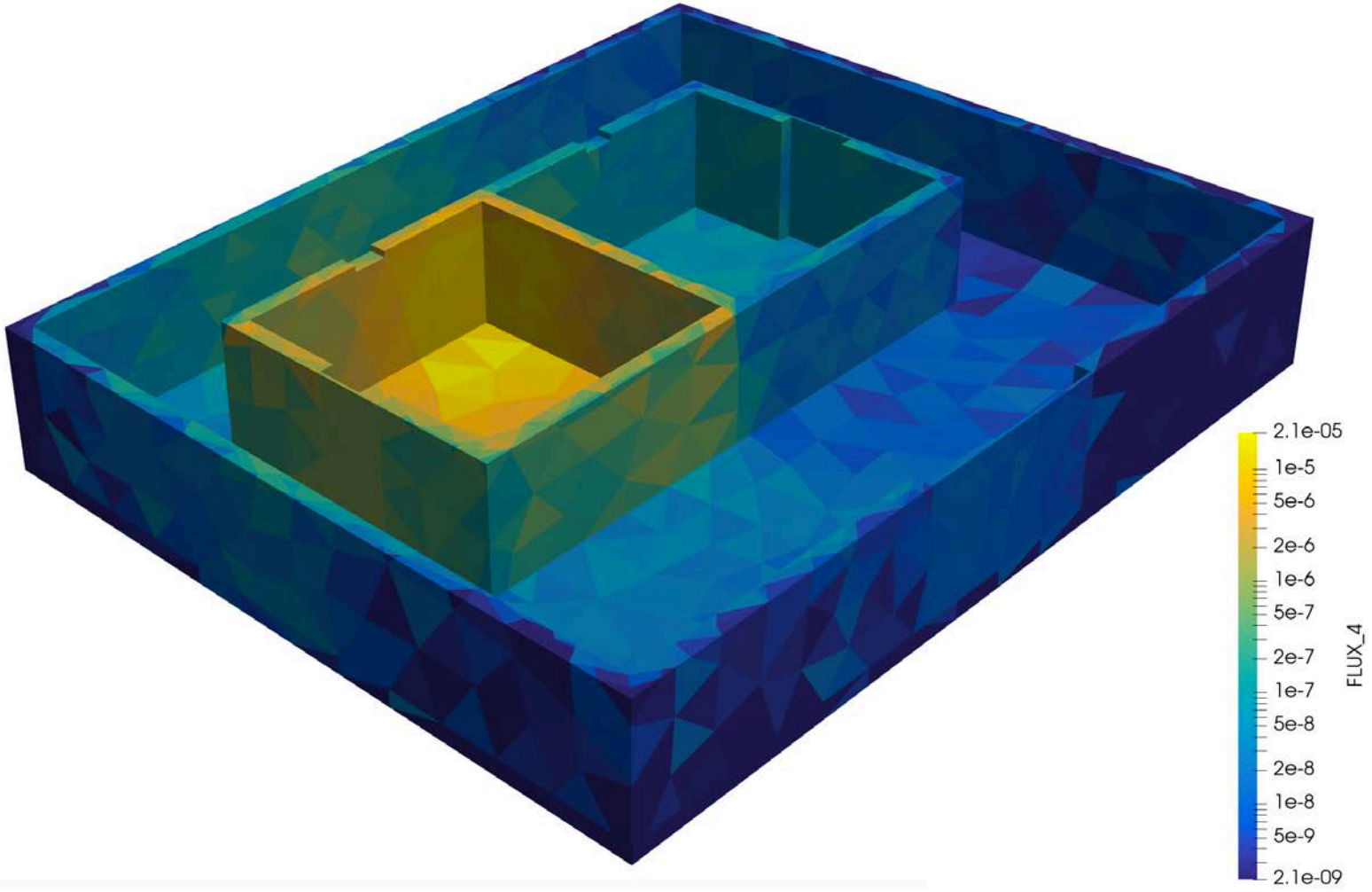


CAAS UM-CSG Example

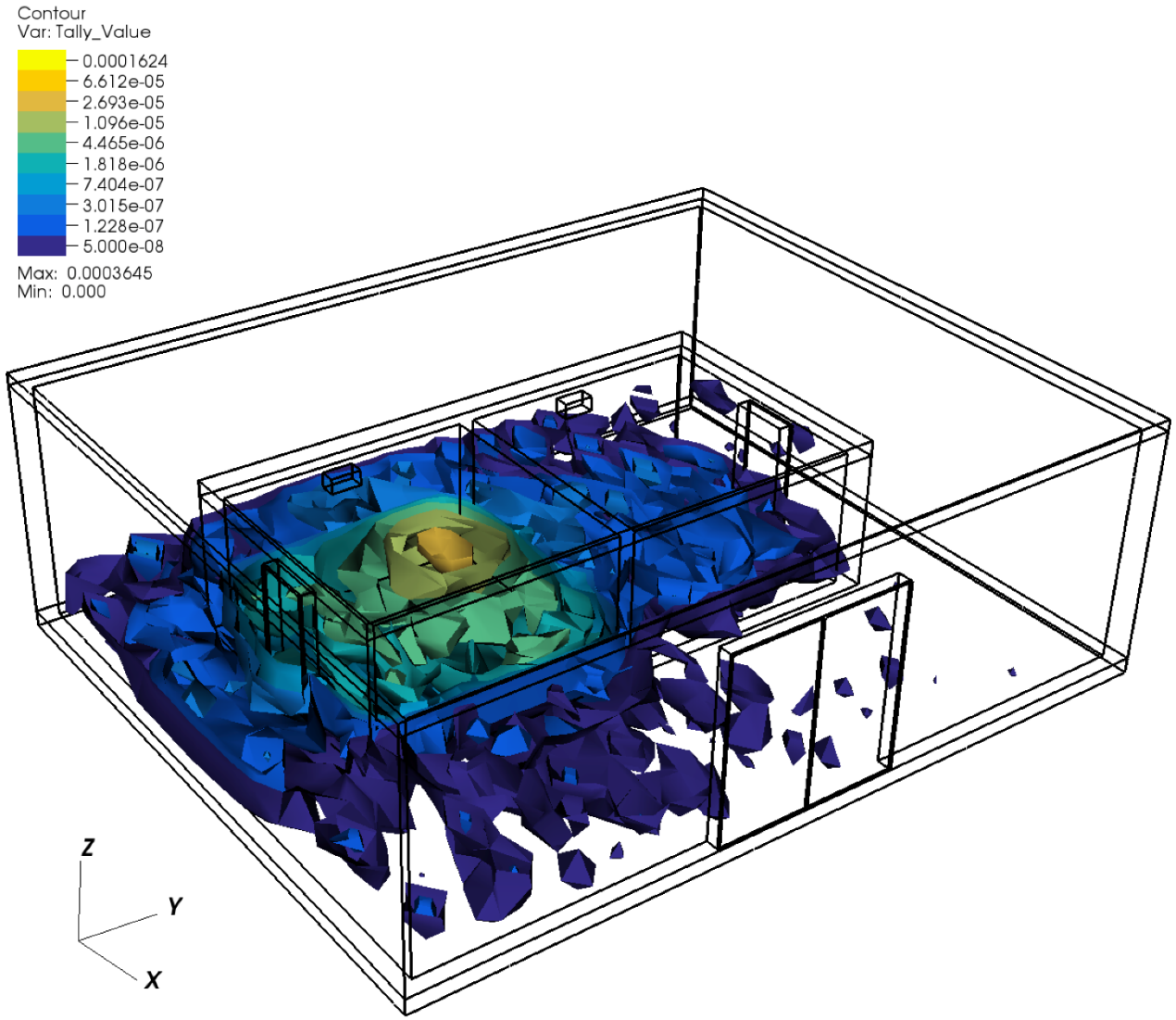
Tecplot from MCPN6.2 eeout file



CAAS UM-CSG Example



CAAS UM-CSG Example



CAAS UM-CSG Example

Acknowledgements:

Gregory Failla and Dan Oranski – Varex Imaging:

- Thanks for assistance with mesh, CADIS and FW-CADIS and providing Attila

Joel Kulesza – LANL:

- Thanks for assistance with visualization Visit and