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Title: MCNP6 Hybrid Geometry: Overview (U)

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MCNP6 Hybrid Geometry

Overview

ABSTRACT

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This presentation provides an overview of the new hybrid geometry capability in MCNP6. The modeling paradigm, some implementation, and user requirements are discussed. The new MCNP input cards are presented. A simple example is shown to illustrate some of the relevant ABAQUS® features. Recent accomplishments and near term goals are mentioned.

Outline

- Overview of the capability
- A quick view of the new MCNP Input Cards
- Concrete cylinder example / sample results from ABAQUS
- Recent accomplishments
- Near term goals

Capability Overview

Objectives of these next slides:

- **Provide the user with a basic understanding of**
  - the modeling paradigm used in this hybrid approach
  - some implementation & user requirements

Embedded mesh

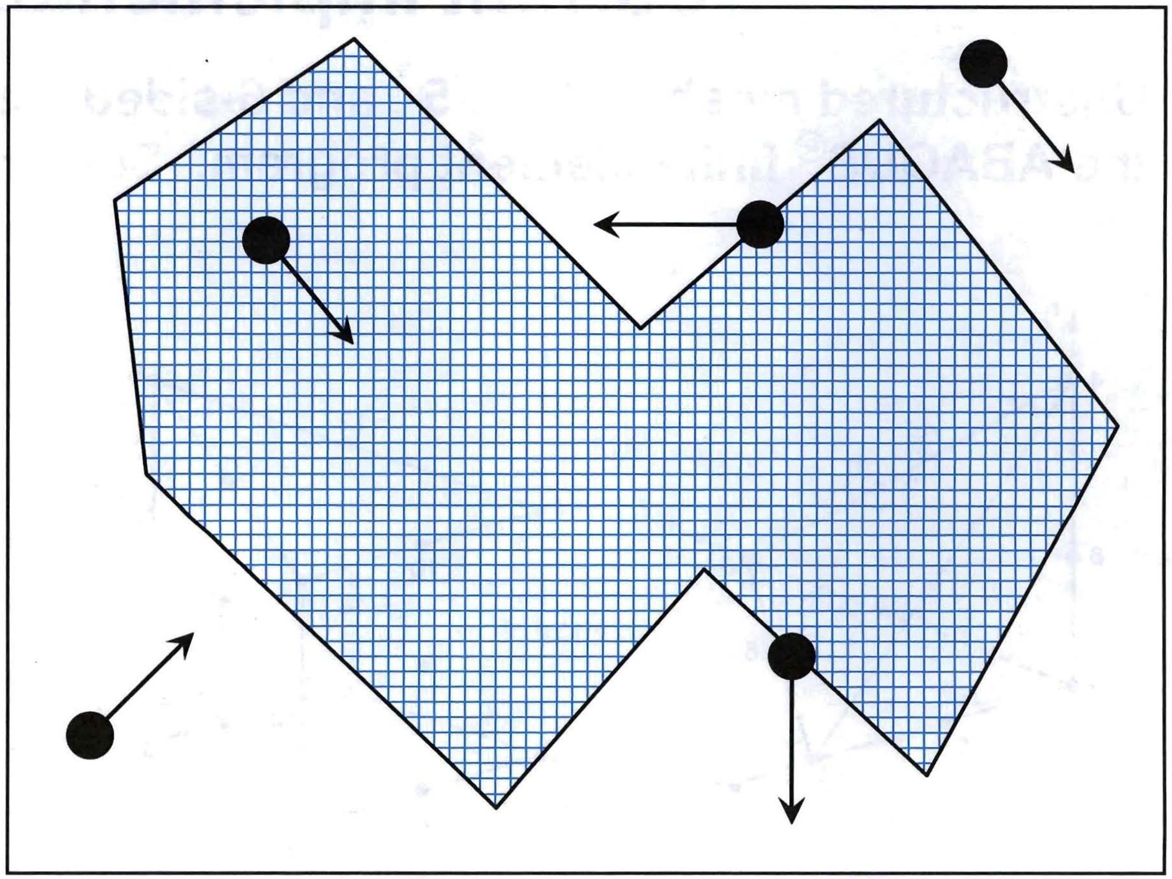
- **Mesh geometry co-exists with MCNP cell-based geometry.**
  - read from separate input file
- **Implemented as a universe.**
- **Ultimately, "many" instances of the same mesh or instances of "several" different mesh.**

Some Geometry Requirements

Irregular mesh body

Tracking considerations:

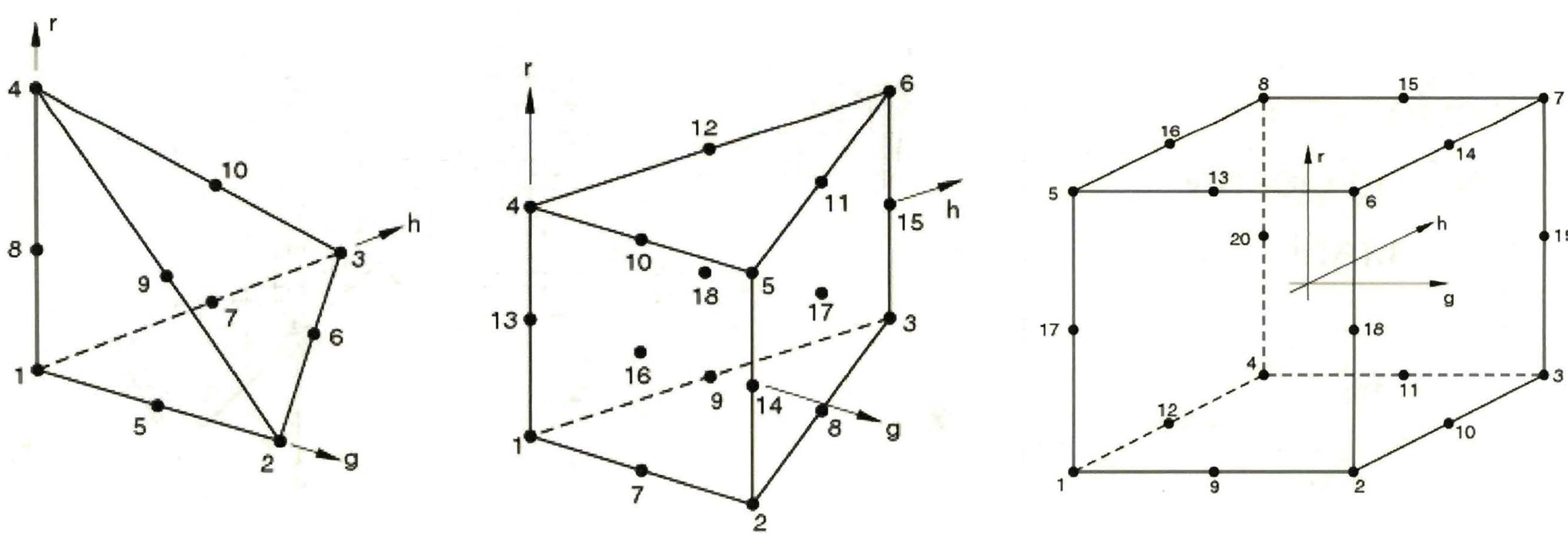
1. Outside hitting
2. Outside missing
3. Inside
4. Leaving cleanly
5. Re-entrant



mesh universe / fill cell

Current Implementation

Unstructured mesh with 4-, 5-, and 6-sided elements generated by the ABAQUS® finite element program. Surfaces may be bilinear.



Currently, no mid-point nodes permitted.

Example Geometry

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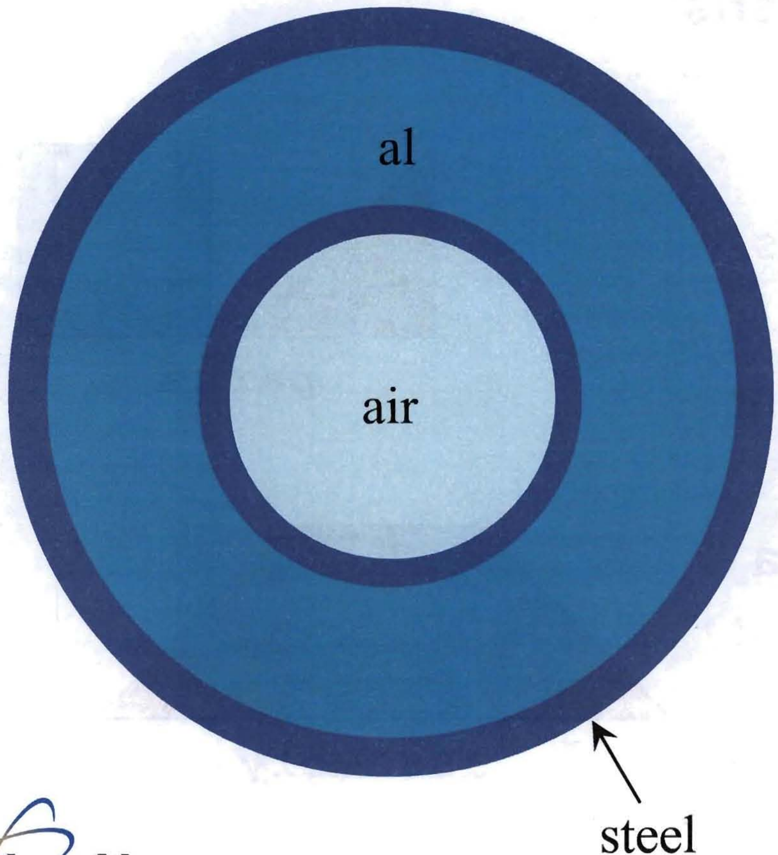
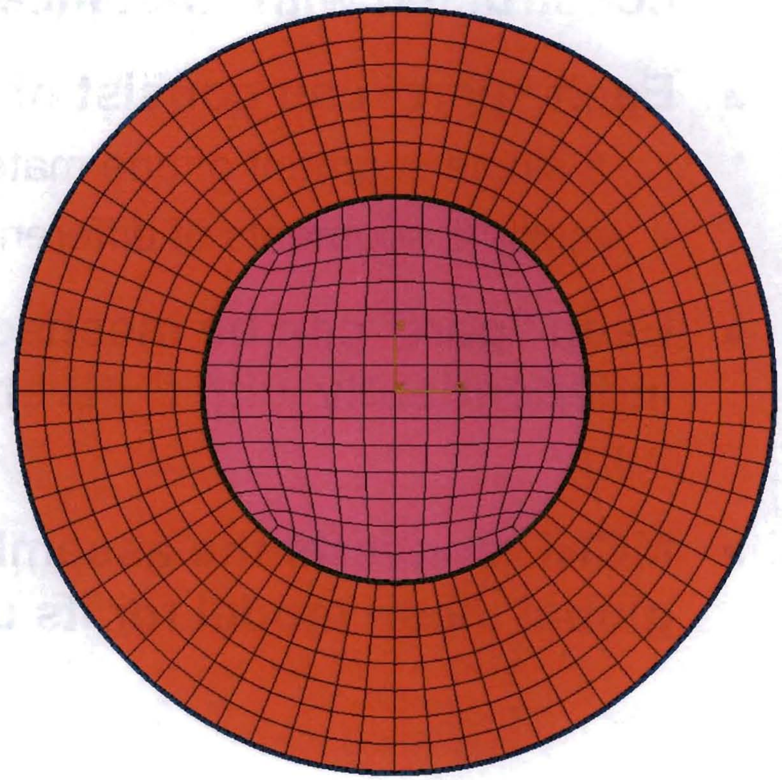
Osaka Aluminum Sphere Benchmark Problem

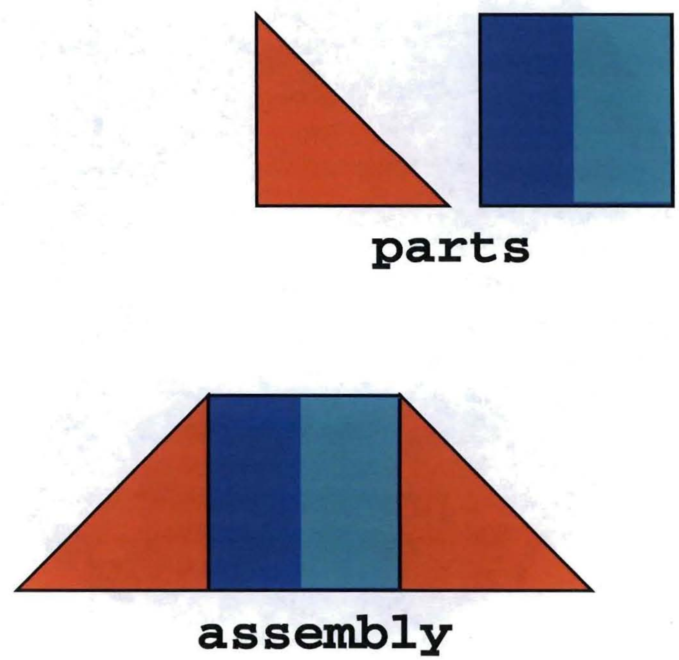




Background: Constructing A Mesh Geometry

Created with ABAQUS

- **The final model is an "assembly" constructed with "instances" of "parts"**
- **Each "part" can consist of**
  - a single segment of one material
  - multiple segments of different materials
- **Each "part" can be meshed independently with different element types**
- **MCNP converts the assembly into a global mesh model for its use**



Background: Constructing A Mesh Geometry

- How to map the material descriptions to the mesh?
- How to take advantage of MCNP's cell-base machinery?

Background: Constructing A Mesh Geometry

Created with ABAQUS

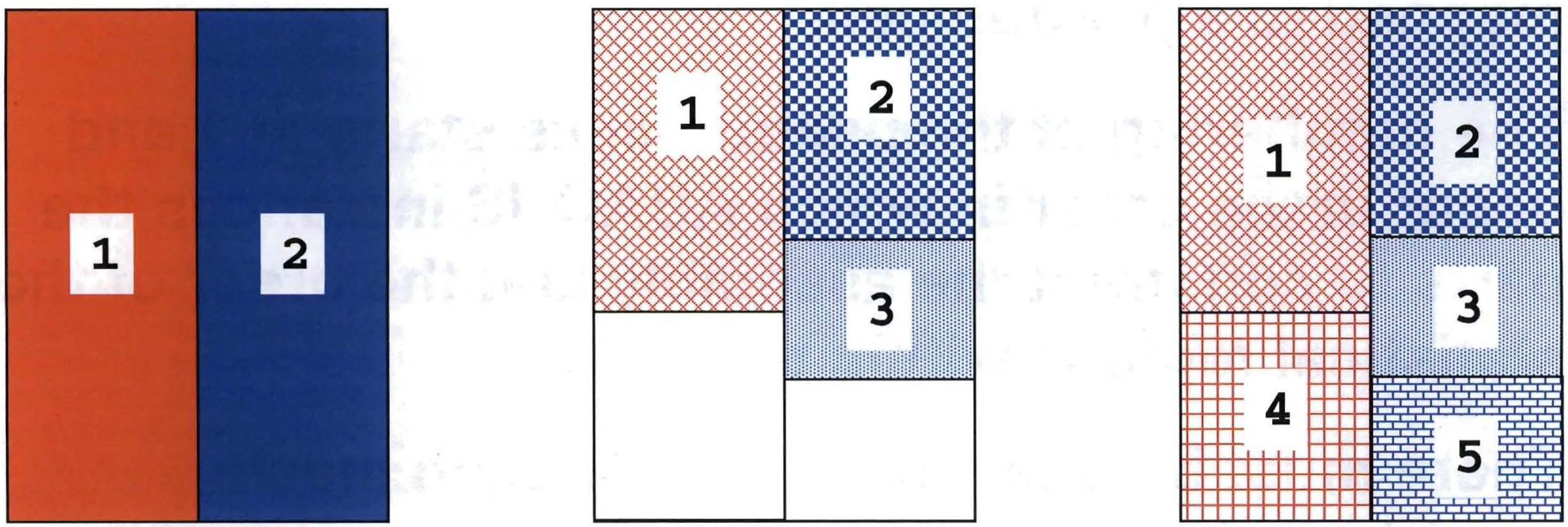
- **Each part must contain three element sets (elsets) of data for:**
  - materials
  - statistics
    - Can not encompass multiple materials
    - Used for cell-based tallies
  - exterior surfaces

Pseudo-Cells

- Each part--material--statistic region is automatically mapped to a pseudo-cell.
- The numbering of the pseudo-cells starts at 1 and occur in the order in which ABAQUS instances the parts to construct the assembly and the order of the statistical regions within the part.
- There must be one MCNP cell for each mesh pseudo-cell.
- The MCNP cell must contain the correct material definition for the pseudo-cell.

Background: Constructing A Mesh Geometry

Pseudo-Cell Example



1 part with 2 materials

3 defined & 2 undefined statistical regions

5 pseudo-cells (always consecutively numbered from 1)

Contact Pair

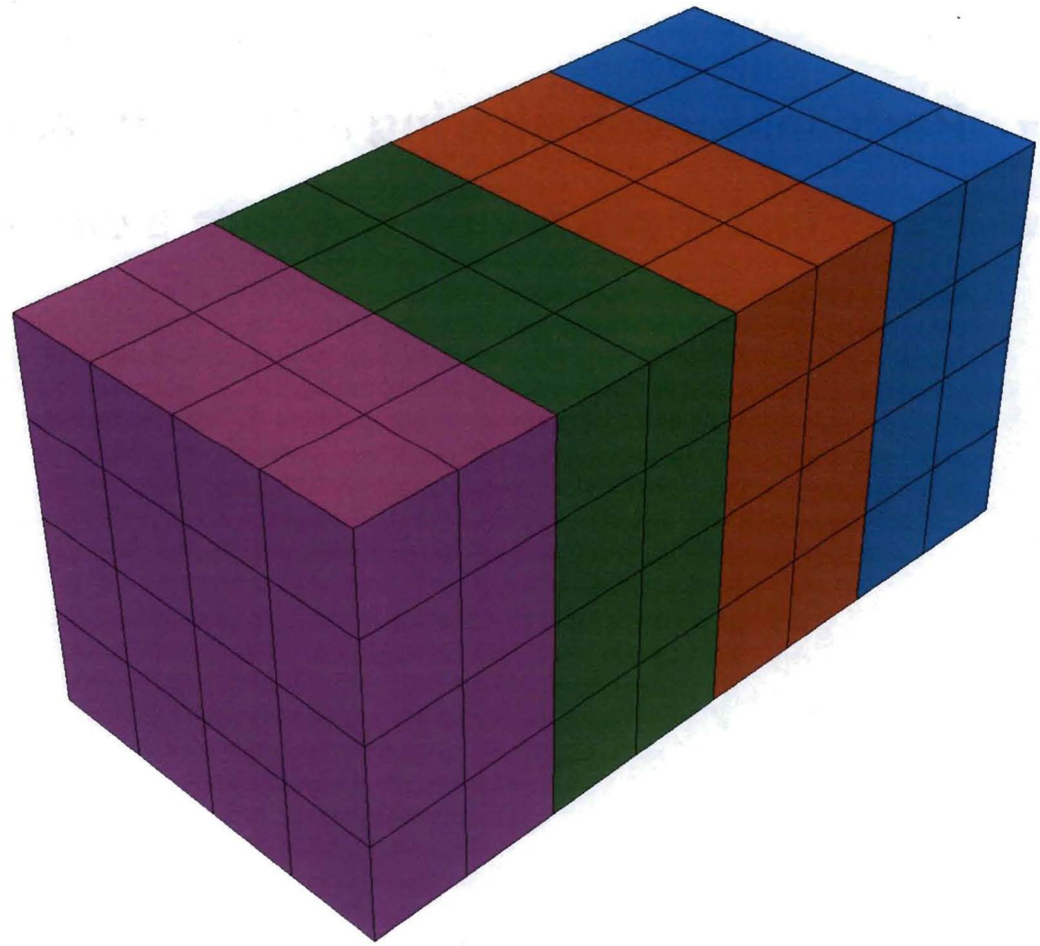
- **Parts/Instances sharing a (flat) surface but not nodes.**
- **Parts/Instances trying to share a curved surface, resulting in overlaps and gaps.**

Modeling Considerations

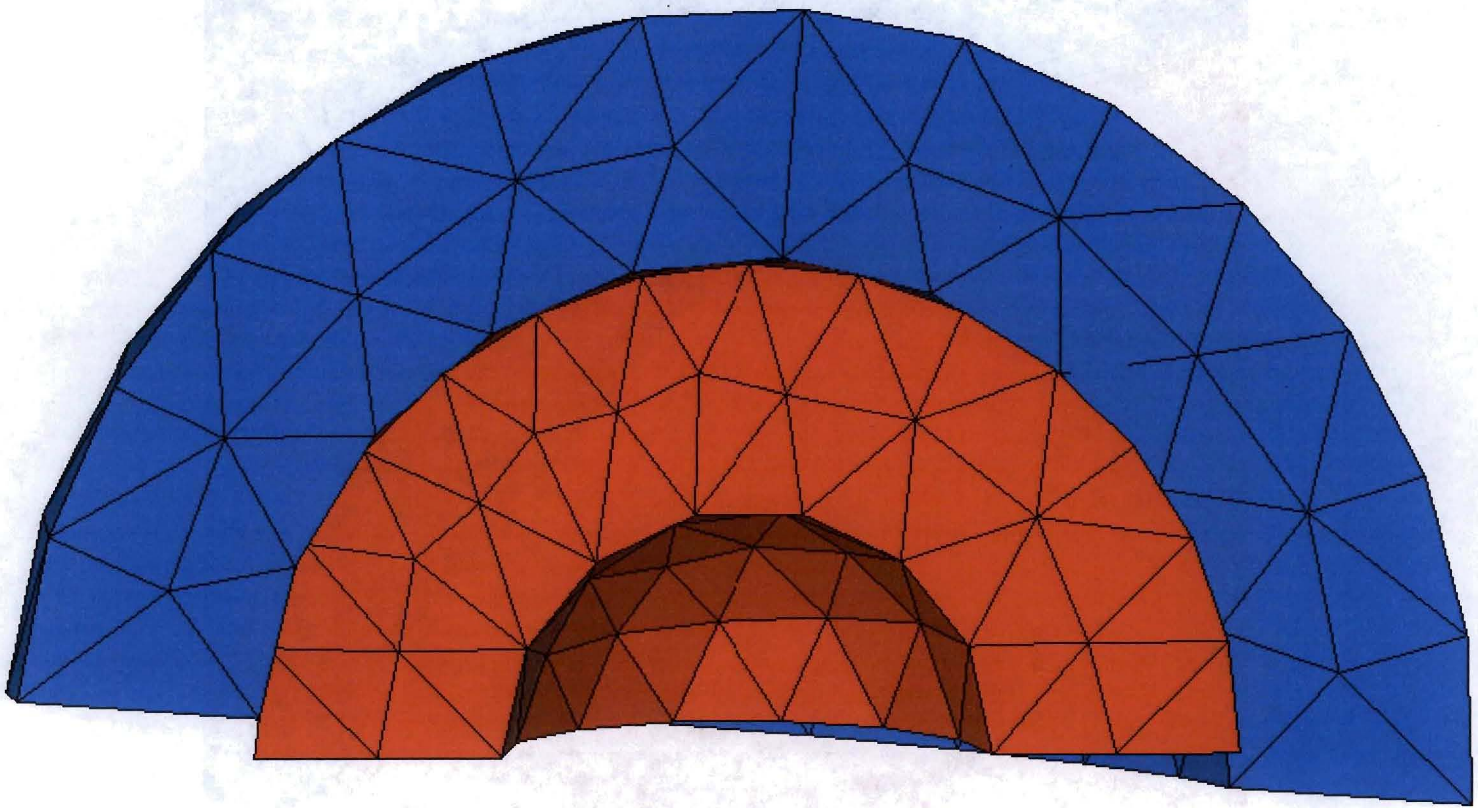
4 Parts

3 Contact Pair Surfaces

Redundant nodes on each contact pair surface

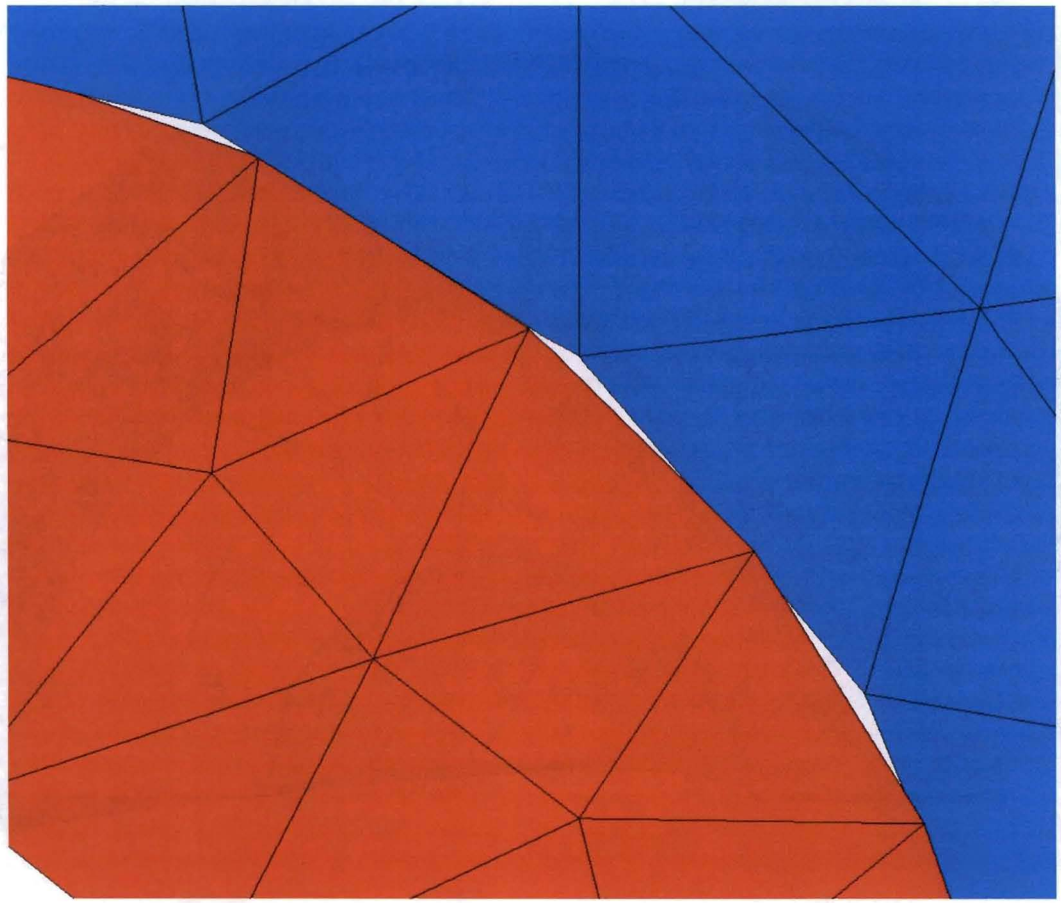


Two Parts On A Curved Surface



Modeling Considerations

Gaps & Overlaps



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Modeling Considerations or "Style" Dictate Tracking Implementation

- **One part model with possibly many material sections**
  - quickest when tracking from element to element (use nearest neighbor search)
- **Multi-part model with contact pairs**
  - more work required to find the next element on the other side of the contact pair surface
- **Multi-part model with overlaps and gaps / re-entrant surfaces**
  - most work required; may need to look at all elements

User has control over the model

Additional Requirements

- **Path length estimates of flux, energy deposition, and/or fission energy by mesh element**
  - Referred to as "elemental edits"
  - NO statistical uncertainties on results
  - Results output (including mesh geometry) in a special file
  - Dictates tracking implementation
    - Path length estimation (like MCNP) produces result in each mesh element through which the particle tracks.
    - Surface-to-surface "fast" tracking is not efficient in producing results in the mesh, but is desirable for transport speed up where edits aren't needed.

Current Restrictions

- Neutral particles only
- Charged particle tracking to be added later

Input Cards

Embedded Mesh Universe

- **Geometry mesh are embedded as the lowest level universe.**
- **Cell card requirements:**
  - At least one cell card with an embedded universe parameter "embu" along with the "u" parameter is needed to embed the mesh universe.
  - "embu" value must coordinate with the number on the "embed" data card.
  - One cell card with "embu" parameter for each mesh "pseudo-cell".
  - All cell cards with the "embu" parameter must appear first.
  - Immediately following the "embu" parameter cards must be a cell card with the "fill" parameter.

```
c     *** Cell cards ***
11      2  -7.8240  -8      embu=1 u=2
12      1  -1.2230  -8      embu=1 u=2
13      2  -7.8240  -8      embu=1 u=2
10      3  -0.0012  -8      embu=1 u=2
20      3  -0.0012  -8      fill=2
 6      3  -0.0012   8  -7
 7      0            7
```

Embedded Mesh Control Card

```
EMBEDn  meshgeo=  mgeoin=  meeout=  meein= length=
```

`n`	embedded mesh universe number (only one card currently permitted)
`meshgeo`	mesh geometry type Current permitted values: abaqus
`mgeoin`	mesh input file name
`meeout`	elemental edits output file name
`meein`	elemental edits input file name (valid only in continuation runs)
`length`	conversion factor to centimeters for all mesh dimensions in input and output

Elemental Edits Control Card

`EMBEEn:<pl>   embed=   length=   energy=   time=`

`n`	elemental edit number ending in 4, 6, or 7 follows tally convention current maximum of 4 cards
`<pl>`	particle designator from particle list current valid entrees: n or p
`embed`	embedded mesh universe number must correspond to a valid embed card #
`energy`	conversion factor from MeV/gm or jerks/gm for all energy related output
`time`	conversion factor from shakes for all time related output

Embedded Mesh Data Cards

Elemental Edit Energy Bins & Multipliers

EMBEBn B_1 B_2 ... B_k

n elemental edit number; 0 is not valid.

B_i monotonically increasing upper energy of the *i'th* bin.

EMBEMn M_1 M_2 ... M_k

n elemental edit number; 0 is not valid.

M_i monotonically increasing upper energy of the *i'th* bin.

Embedded Mesh Data Cards

Elemental Edit Time Bins & Multipliers

EMBTBn B_1 B_2 ... B_k

n elemental edit number; 0 is not valid.

B_i monotonically increasing upper time of the *i'th* bin. values in units of shakes (1 shake = 10^{-8} s)

EMBTMn M_1 M_2 ... M_k

n elemental edit number; 0 is not valid.

M_i monotonically increasing upper energy of the *i'th* bin.

Concrete Cylinder Example

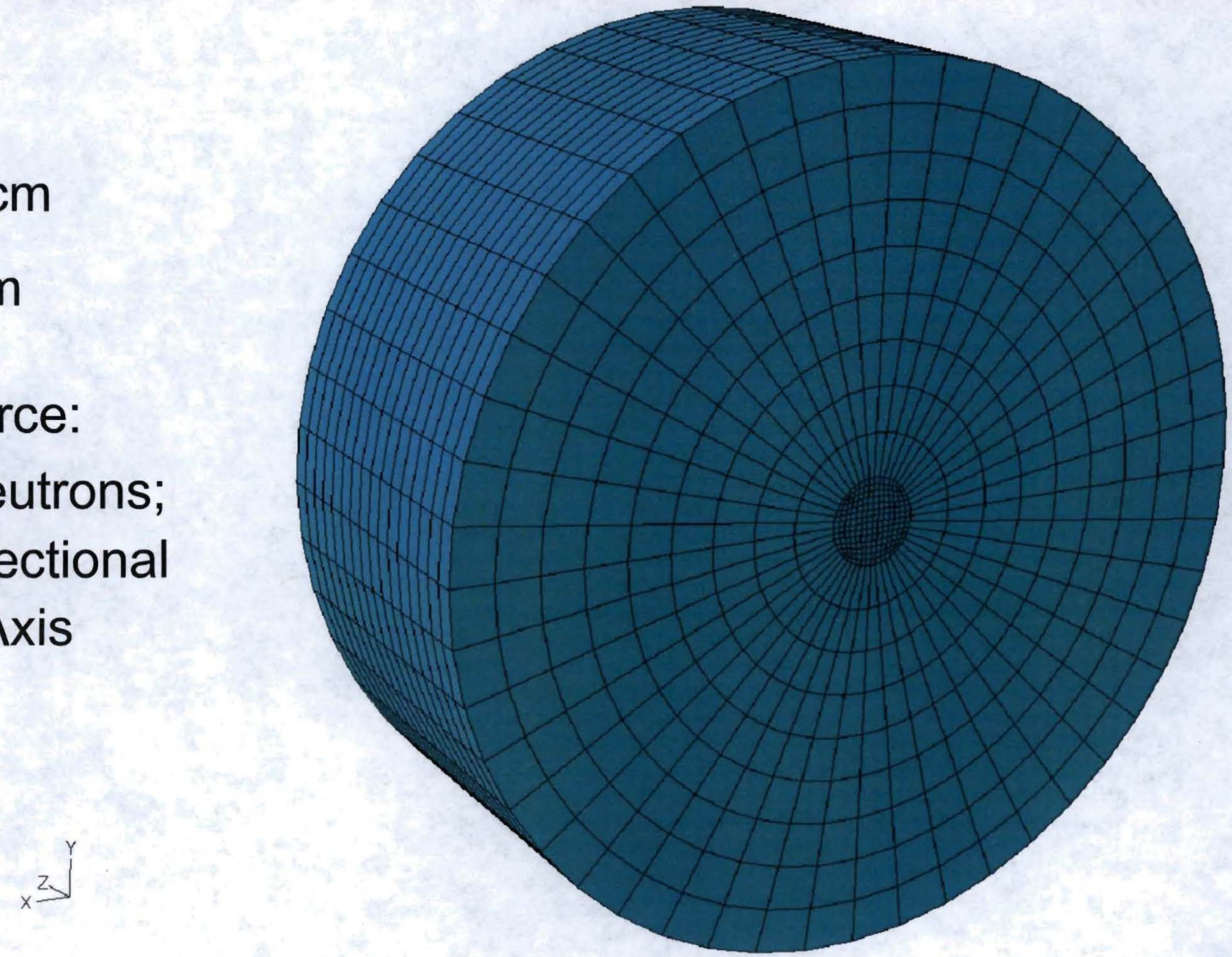
Concrete Cylinder Geometry

R = 100 cm

H = 80 cm

Source:

2 MeV neutrons; mono-directional along Z-Axis



Concrete Cylinder: 1 Part / 2 Mesh Zones

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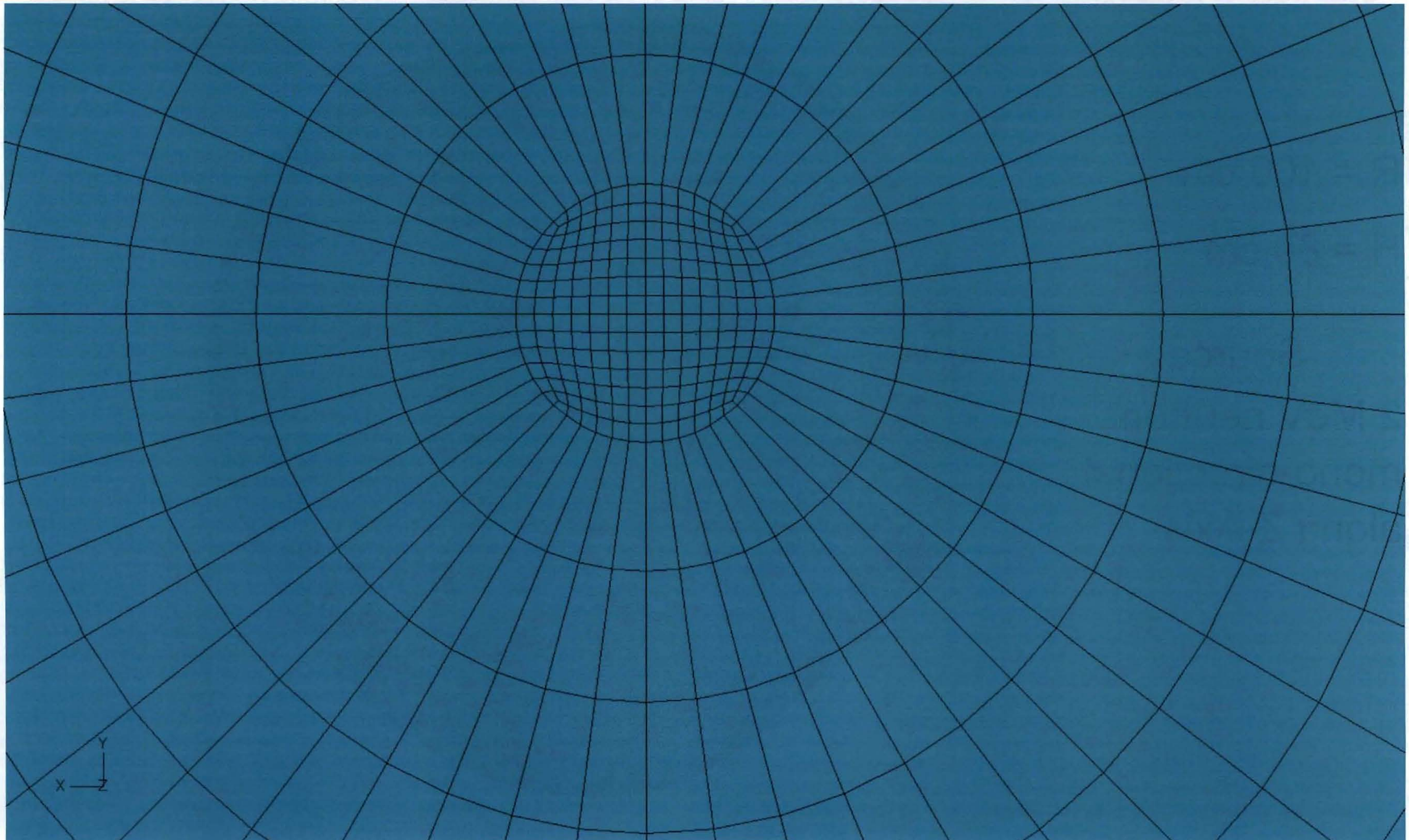
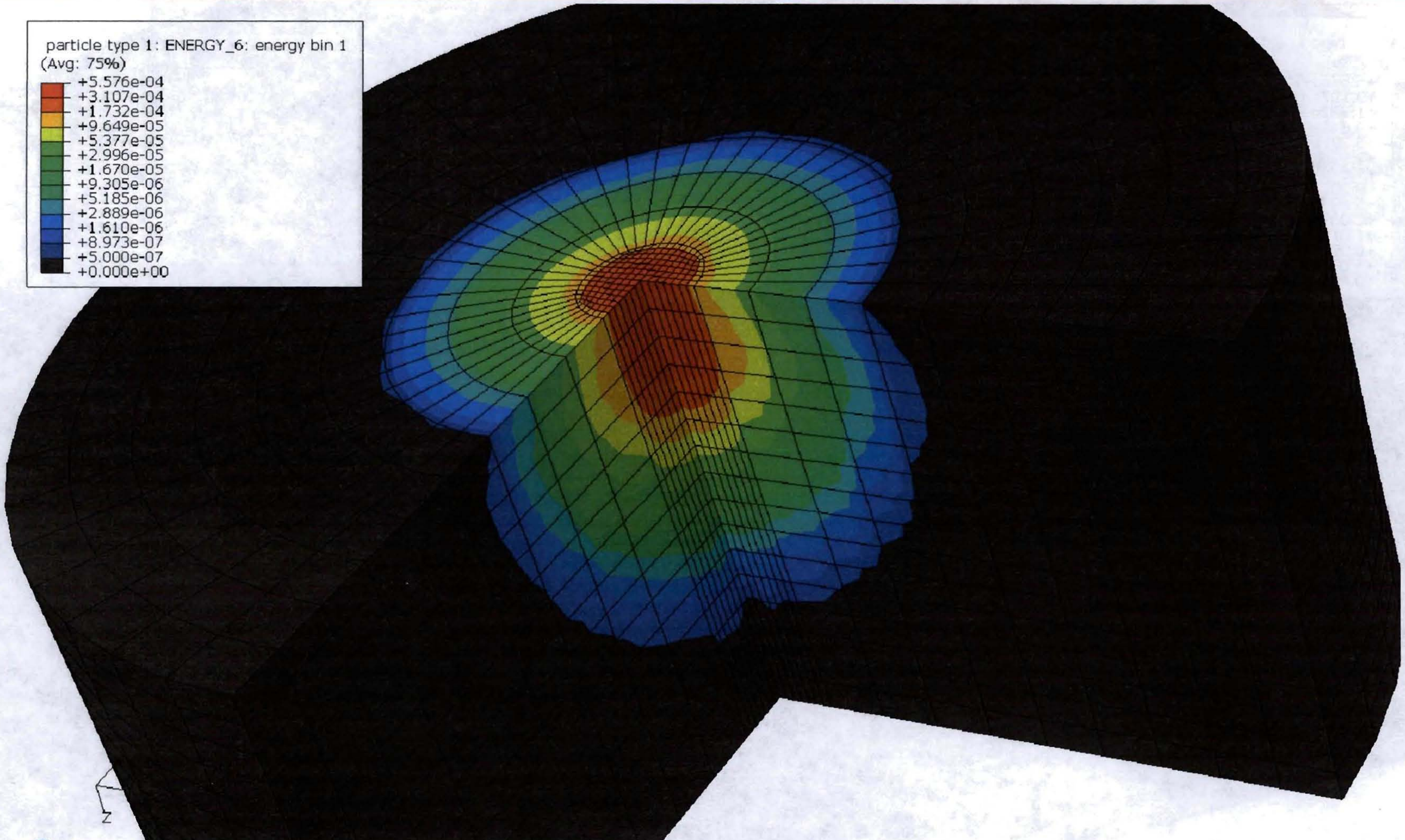


Total Energy Deposition: 3-D View With ¾ Geometry



Total Energy Deposition: 3-D View With Half Geometry

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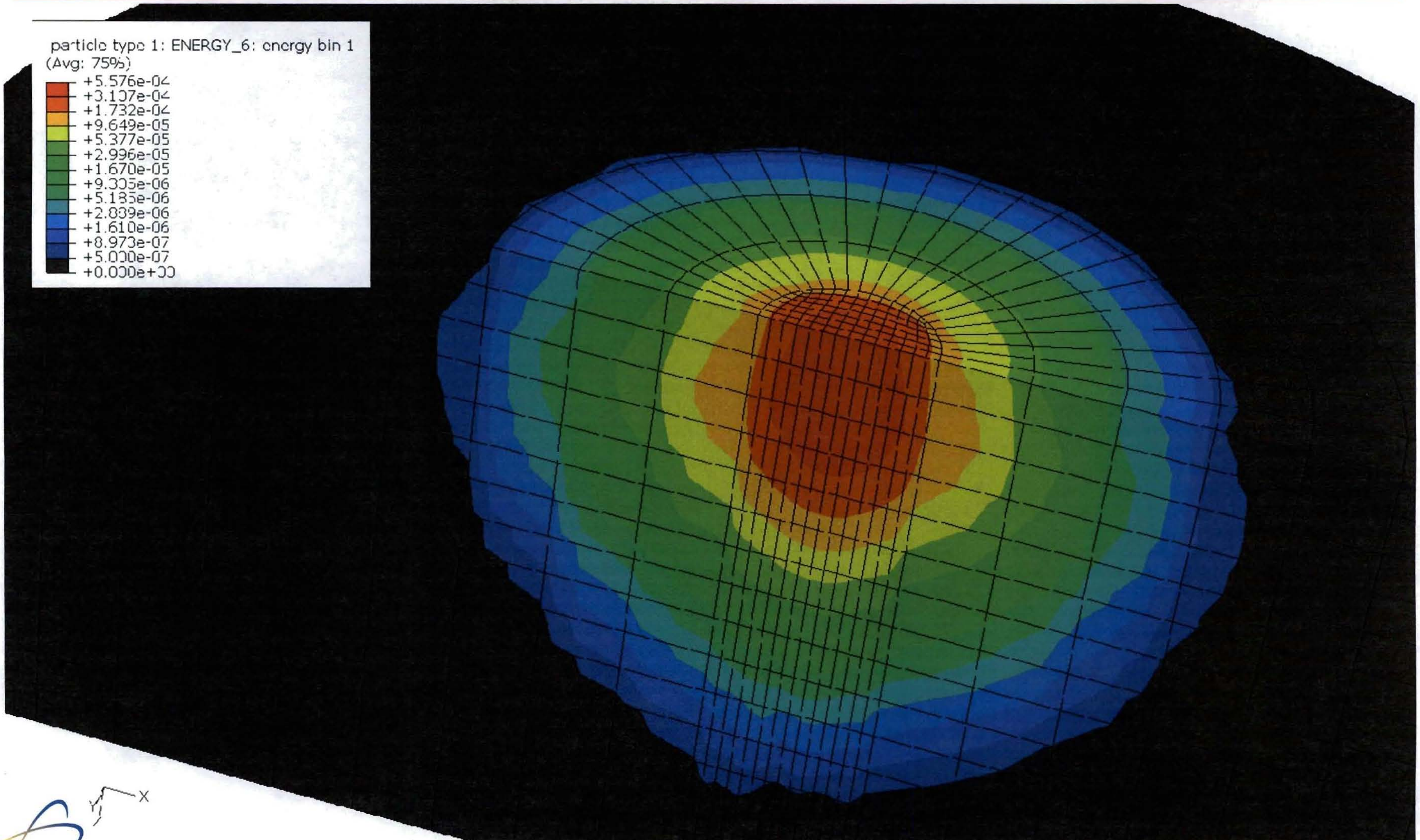

Total Energy Deposition: 2-D View

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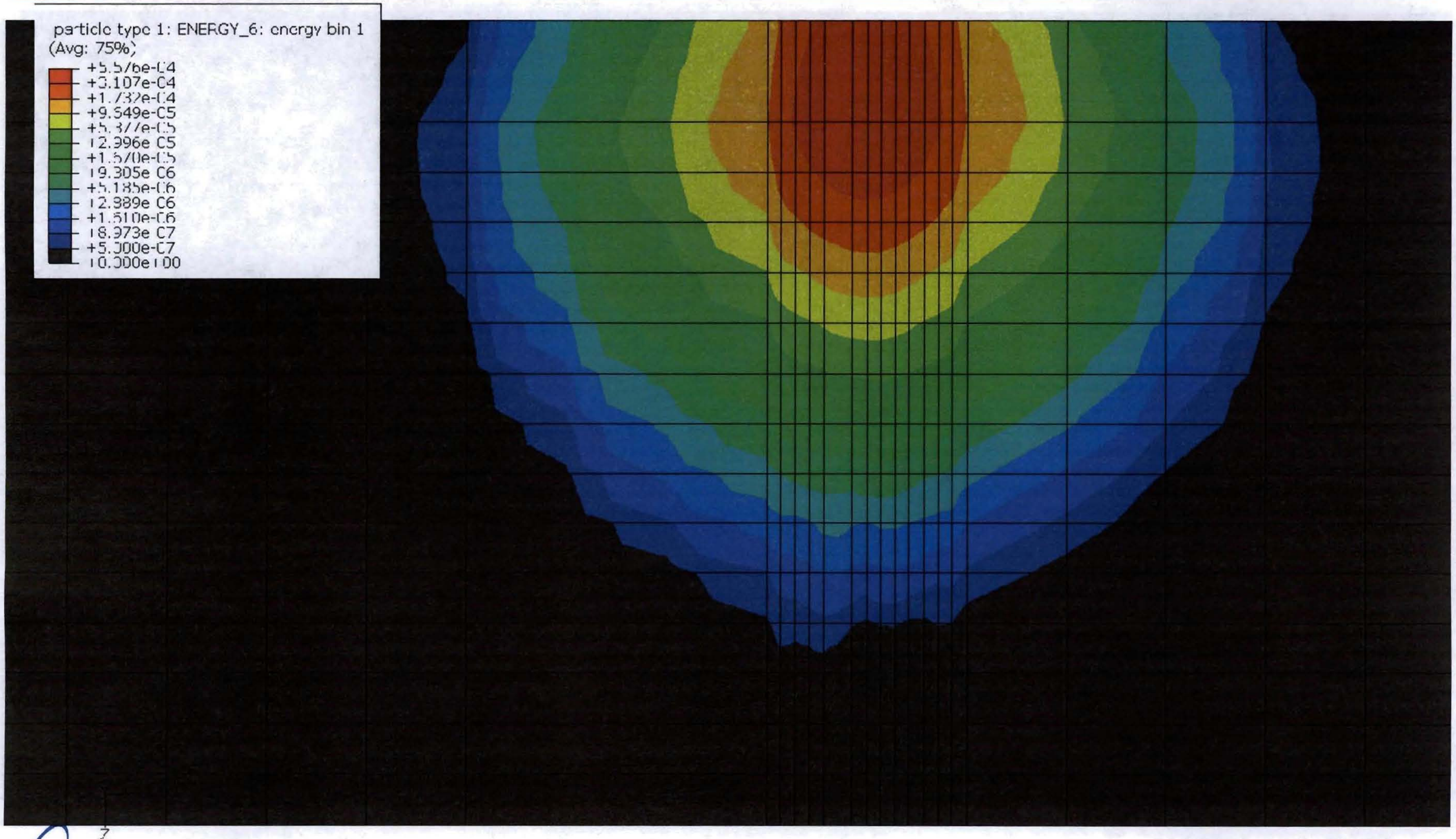

Concrete Cylinder: total neutron flux movie

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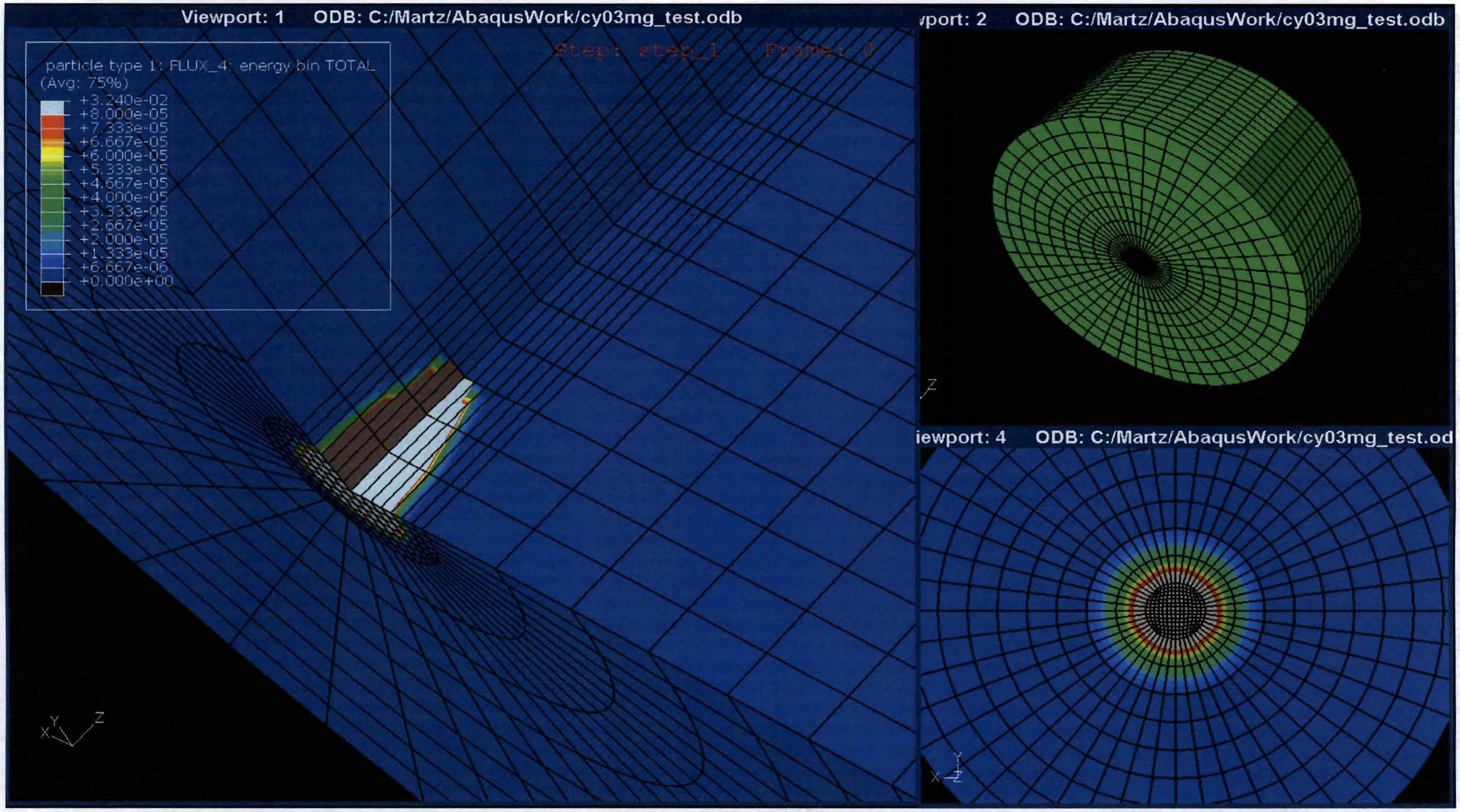

Concrete Cylinder: total neutron flux movie

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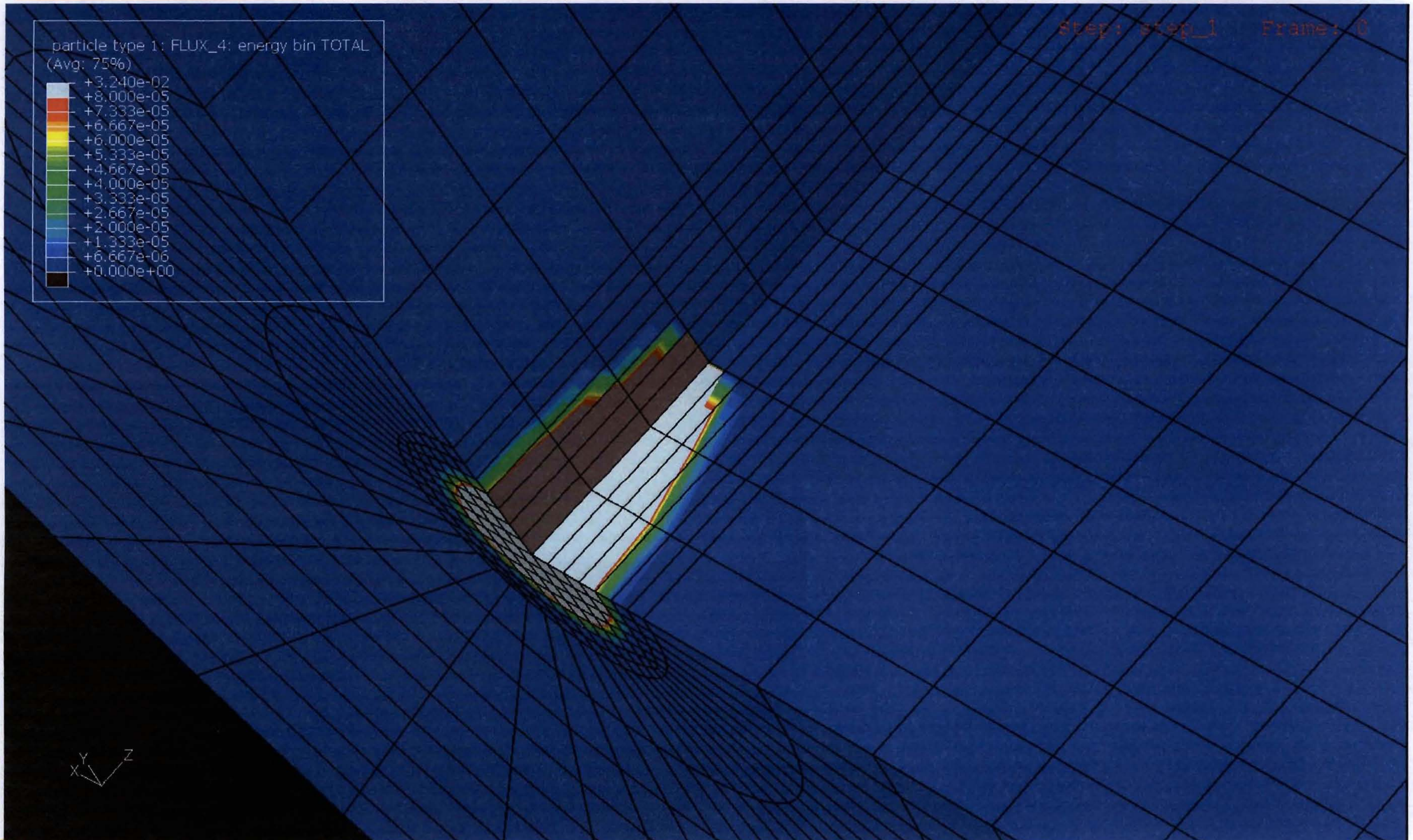

Concrete Cylinder With Penetration (5 cm radius)

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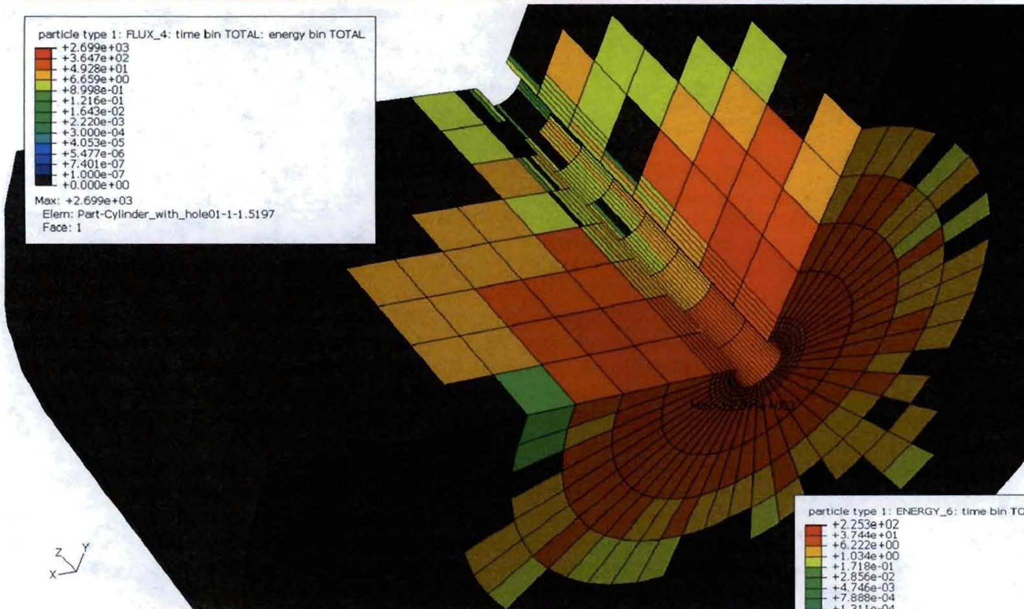
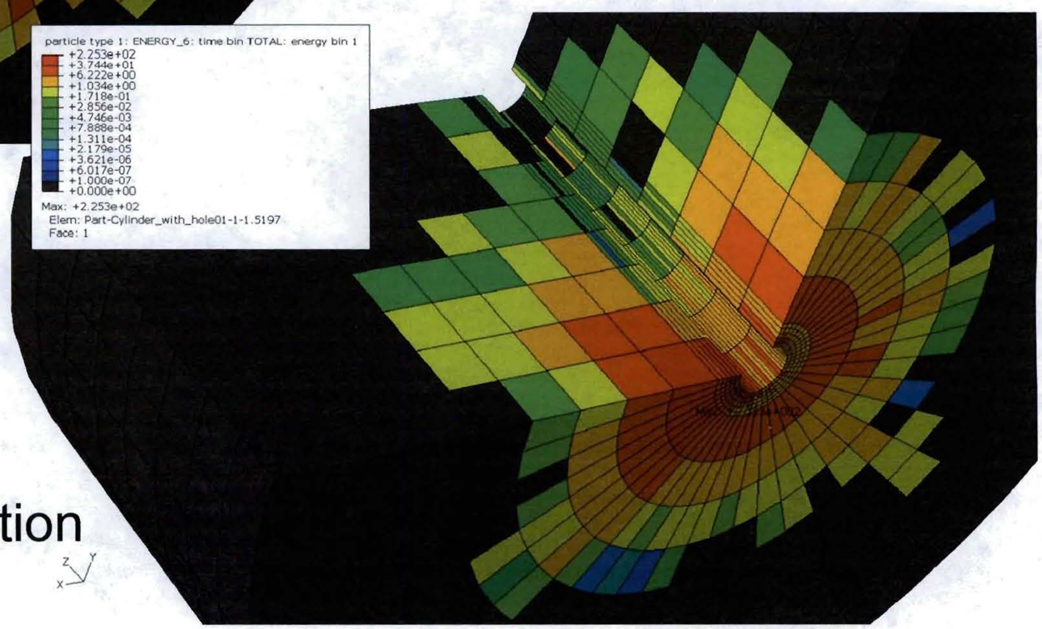


Total neutron flux



Total neutron energy deposition

Accomplishments

Important Development Milestones To Date:

1. **Methods for "working with" unstructured mesh researched and programmed.**
   - Implemented with planar and bilinear surfaces for intersection & containment
   - skd-tree for searching mesh
   - Contact pairs, re-entrant particles, gaps / overlaps
2. **ABAQUS input parser**
3. **Mesh edit results file & visualization**
4. **Serial, omp, and mpi versions of the code are being tested.**
5. **Presented some preliminary results at the ANS RPSD08 meeting**

Near Term Goals

Near Term Goals

Next 6 Months

1. Continue testing & "bug" fixing
2. Resolve integration issues
3. Present user interface to MCNP Change Control Board
4. Implement surface-to-surface fast tracking
5. Implement quadratic surfaces
6. Technical society presentations
7. Documentation
8. Interest others in using these tools or fund further development