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 Title:
 MCNP6 Hybrid Geometry: Overview (U)

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MCNP6 Hybrid Geometry

**Overview** 



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### 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<sup>®</sup> features. Recent accomplishments and near term goals are mentioned.



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### **This Talk**

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### 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



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### **Capability Overview**



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### **Hybrid Geometry**

### **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



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#### **New Capability For MCNP6**

### 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.



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### **Some Geometry Requirements**

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# Irregular mesh body Tracking considerations: Outside hitting **Outside missing** Inside Leaving cleanly **Re-entrant**

#### mesh universe / fill cell



1.

2.

3.

4.

5.

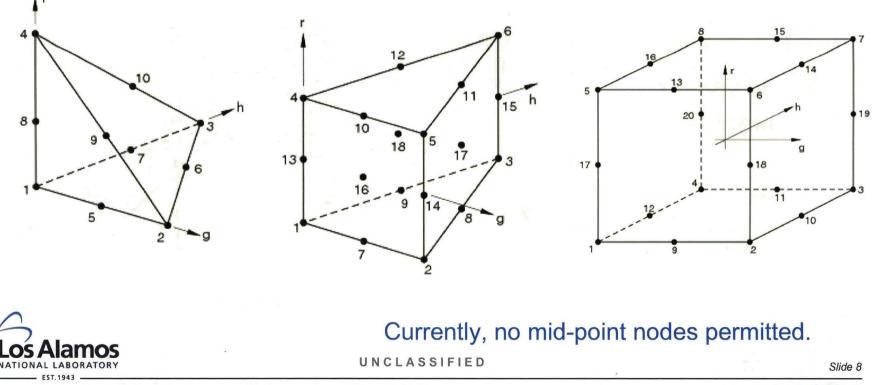
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### **Current Implementation**

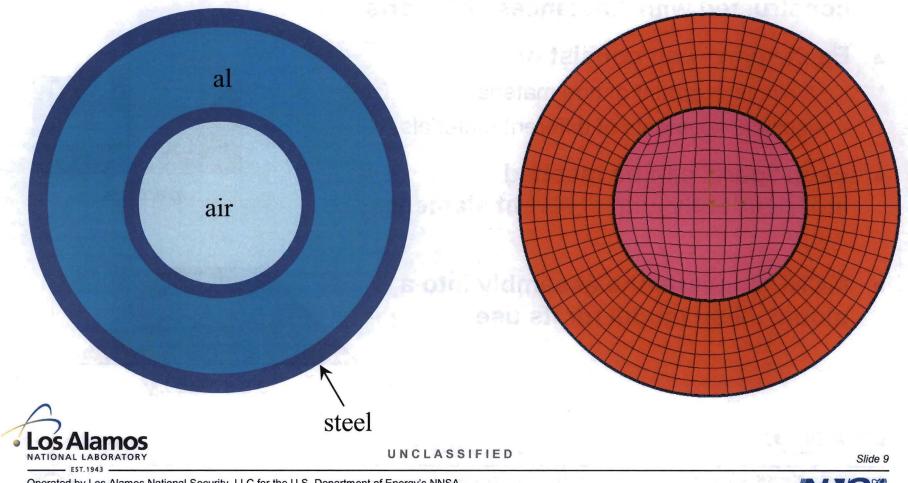
Unstructured mesh with 4-, 5-, and 6-sided elements generated by the ABAQUS<sup>®</sup> finite element program. Surfaces may be bilinear.





### Example Geometry

### **Osaka Aluminum Sphere** Benchmark Problem

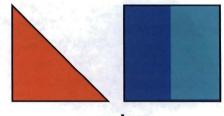




### **Background: Constructing A Mesh Geometry**

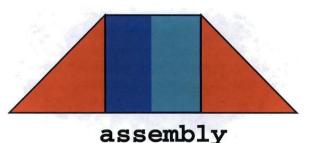
### **Created with ABAQUS**

- 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



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parts





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### **Background: Constructing A Mesh Geometry**

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



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### Background: Constructing A Mesh Geometry LA-UR-09- уууу

### **Created with ABAQUS**

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



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### Background: Constructing A Mesh Geometry

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### **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.



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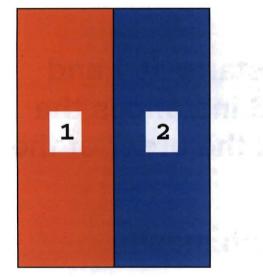


### **Background: Constructing A Mesh Geometry**

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#### **Pseudo-Cell Example**

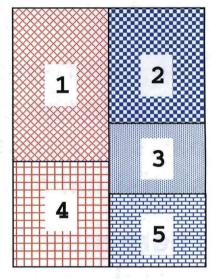
1



1 part with 2 materials

3 defined & 2 undefined statistical regions

3



5 pseudo-cells (always consecutively numbered from 1)



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### **Contact Pair**

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



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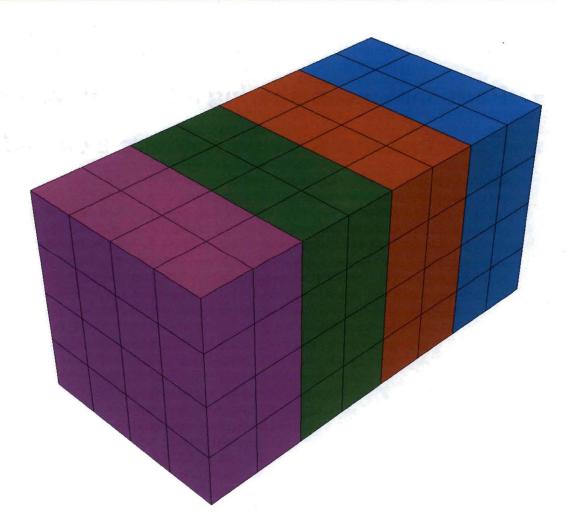


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4 Parts

### 3 Contact Pair Surfaces

Redundant nodes on each contact pair surface





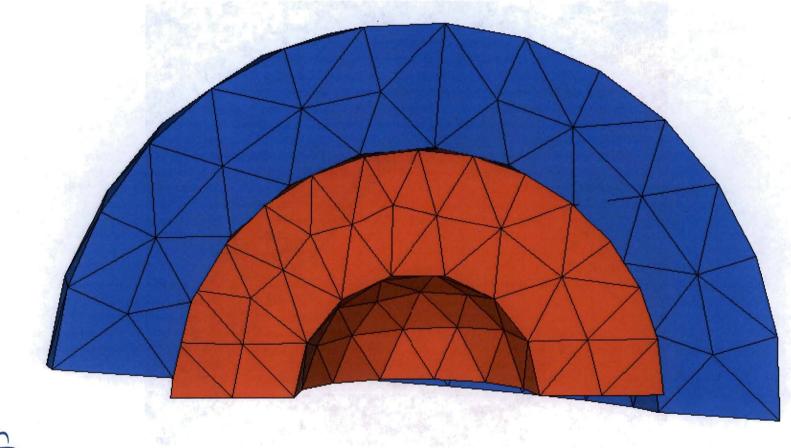
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### **Two Parts On A Curved Surface**





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### Gaps & Overlaps





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### Some Implementation Drivers

### 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



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### **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.



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### **Current Restrictions**

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



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### **Input Cards**



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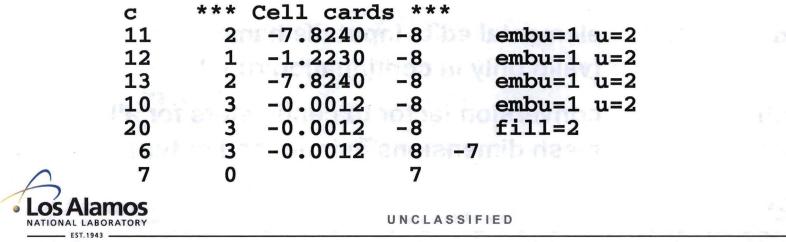


### Embedded Mesh Universe

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.



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### **Embedded Mesh Data Cards**

#### **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				



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Embedded Mesh Data Cards

### Elemental Edits Control Card

EMBEEn: <pl></pl>	embed=	length=	energy= time=			
n And destand	elemental edit number ending in 4, 6, or 7 follows tally convention current maximum of 4 cards					
<pl></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	energy conversion factor from MeV/gm or jerks/g for all energy related output					
time	e conversion factor from shakes for all time related output					
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### **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** $M_1 M_2 \dots M_k$

- n elemental edit number; 0 is not valid.
- $M_i$  monotonically increasing upper energy of the *i* '*th* bin.



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#### **Embedded Mesh Data Cards**

### **Elemental Edit Time Bins & Multipliers**

**EMBTBN**  $B_1 B_2 \dots B_k$ 

- n elemental edit number; 0 is not valid.
- Bi monotonically increasing upper time of the *i'th* bin.
   values in units of shakes (1 shake = 10<sup>-8</sup> s)

### **EMBTMn** $M_1 M_2 \dots M_k$

- n elemental edit number; 0 is not valid.
- $M_i$  monotonically increasing upper energy of the *i* '*th* bin.



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### **Concrete Cylinder Example**



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#### Concrete Cylinder Geometry

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R = 100 cm H = 80 cm Source:

2 MeV neutrons; mono-directional along Z-Axis

Z

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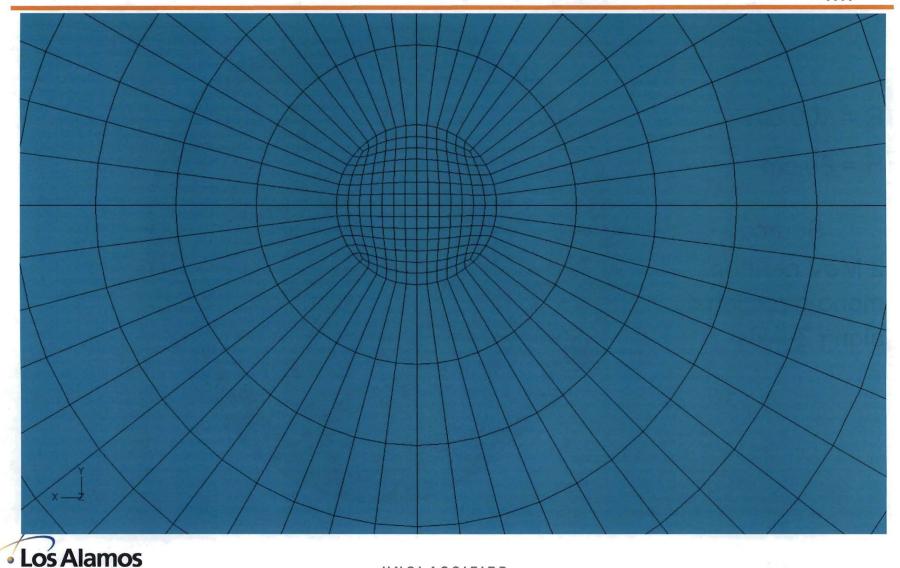
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### **Concrete Cylinder: 1 Part / 2 Mesh Zones**

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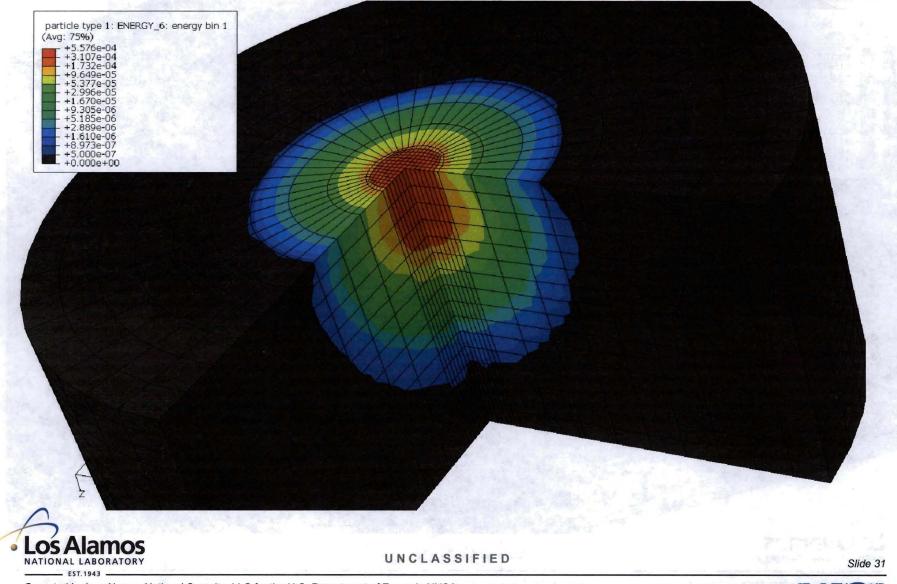
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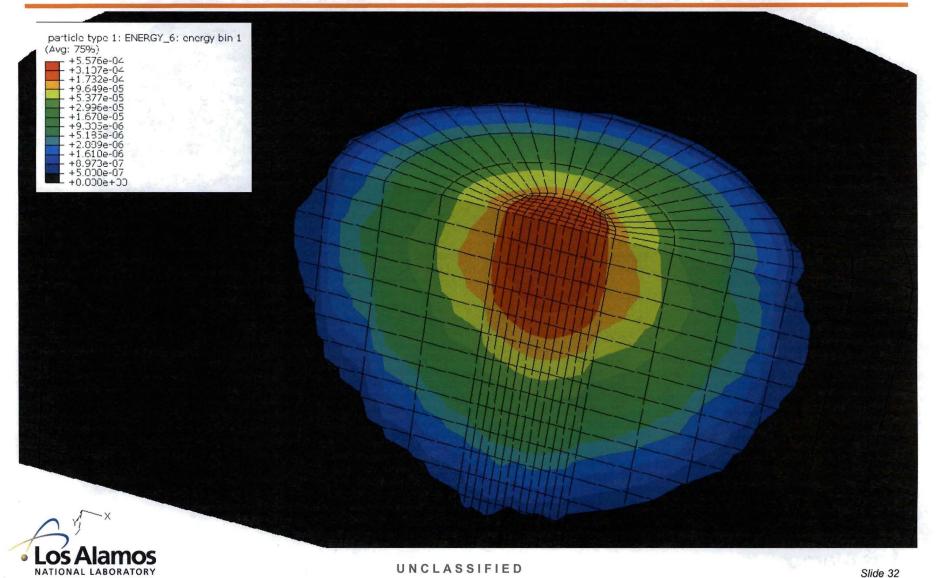
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### Total Energy Deposition: 3-D View With <sup>3</sup>/<sub>4</sub> Geometry 9-yyyy





### Total Energy Deposition: 3-D View With Half Geometry,



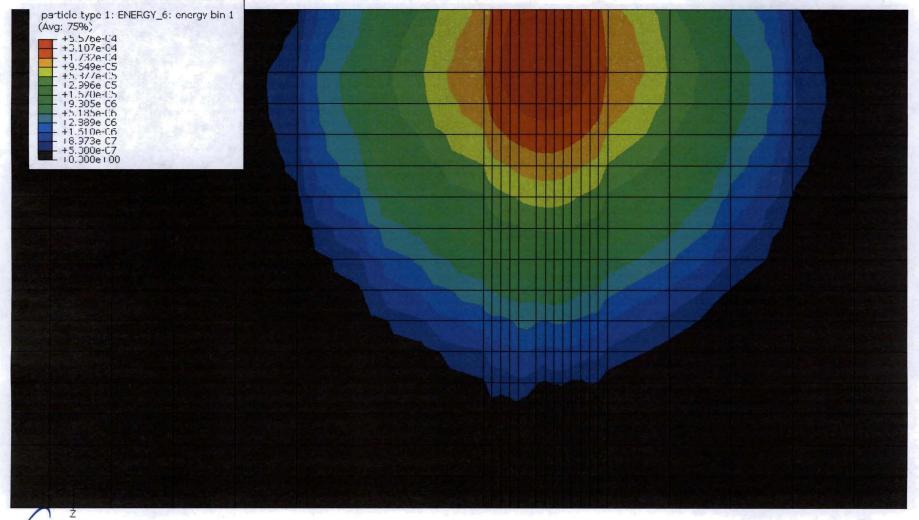
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### **Total Energy Deposition: 2-D View**

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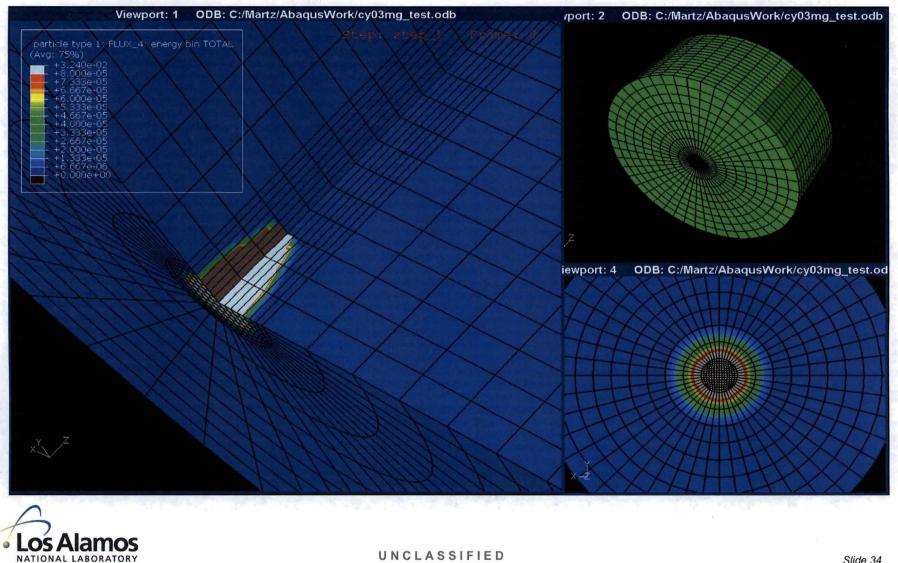
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### **Concrete Cylinder: total neutron flux movie**

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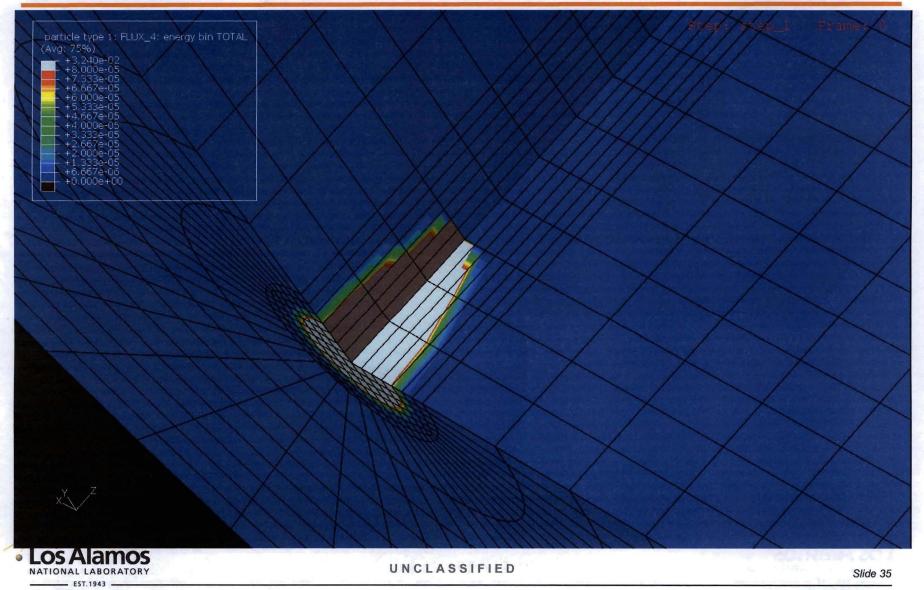
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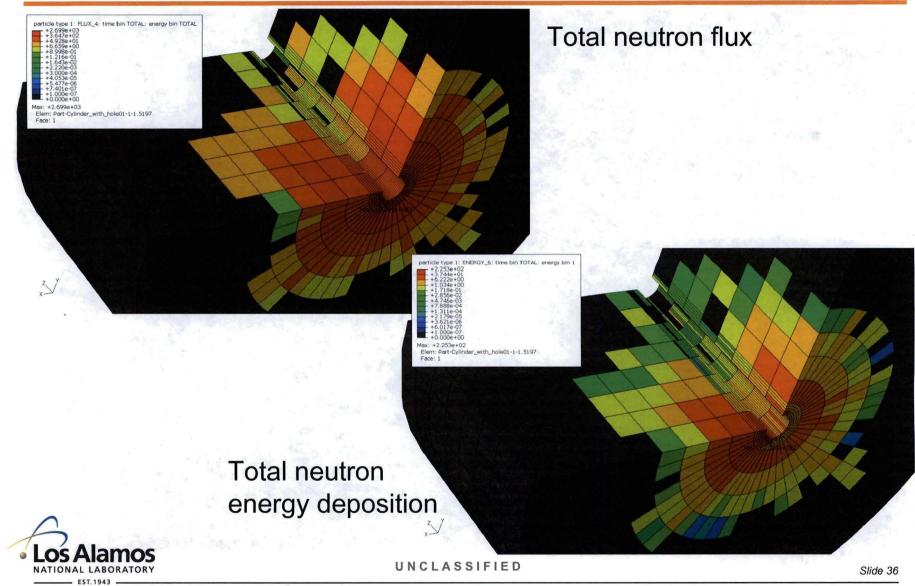
### **Concrete Cylinder: total neutron flux movie**

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### Concrete Cylinder With Penetration (5 cm radius) A-UR-09-yyyy





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## Accomplishments

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- Structure A. M. C. Structure and any constraint of the control of the Merican of the second of the s



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### 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



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#### Next 9 Morths

- Concrete resting a "bright fixing" fixing
  - sense en la gotei dés sel

### Near Term Goals

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  - Implement oundhail surrace
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#### **Near Term Goals**

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### **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



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