Updating the Godiva-IV Benchmark

Victoria Hagopian[1,2], Joetta Goda[1], Jesson Hutchinson[1], Geordie McKenzie[1]

[1]Los Alamos National Laboratory

NEN – Nuclear Engineering & Nonproliferation

NEN-2: Advanced Nuclear Technology

[2]Penn State University

Outline

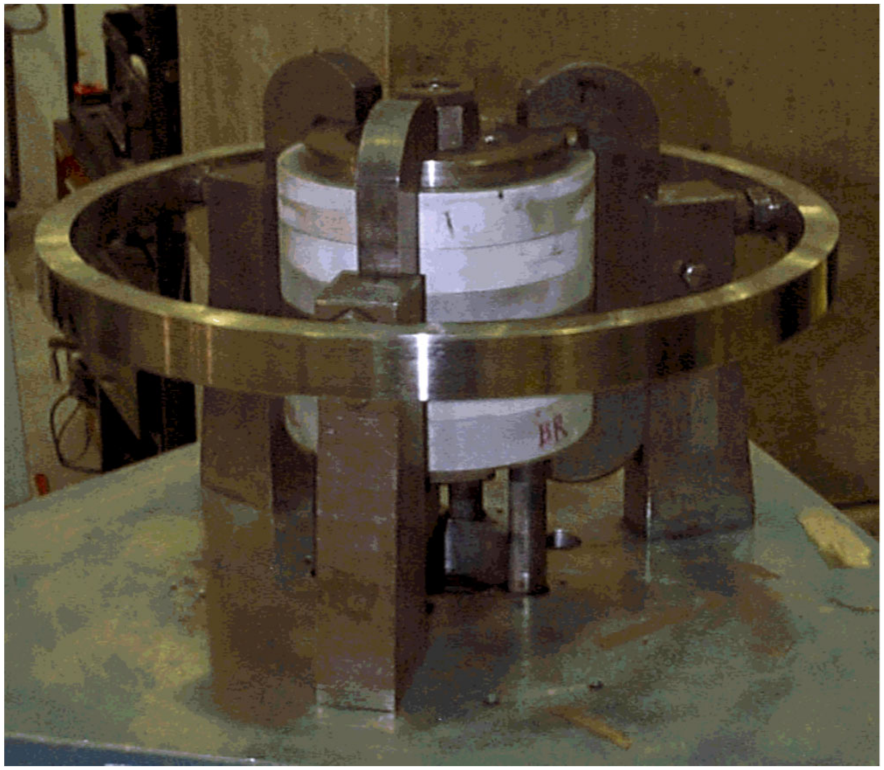
- **Description of device**
  - Overview of uses and applications
- **Purpose behind work**
- **Creating user friendly interface for operators**
- **Comparison between ENDF/B-VII.1 and ENDF/B-VIII.0 Libraries**
- **Comparison to Benchmark Case 4**
- **Current work on detailed model**
- **Future/continued work**

History – Lady Godiva to Now

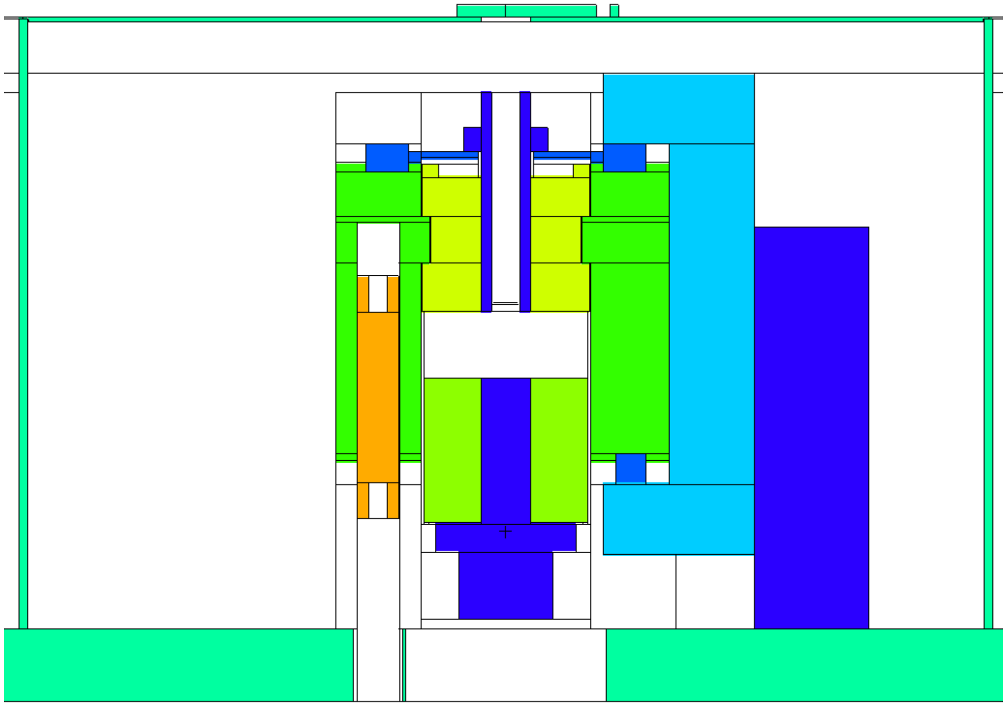
- **Built in 1950s**
- **Unshielded, spherical pulsed reactor**
- **Used to produce neutron and gamma ray bursts for sample irradiation**
- **Description of Assembly**
  – Diameter: ~12 inches
  – Mass: 52.65 kg
  – Enrichment: 93.71 wt% U-235

Godiva-IV Assembly Description

- **Supercritical fast-burst assembly**
  - Experimental regimes: subcritical, delayed-critical, prompt-critical
- **Fourth in series**
  - Built in 1960’s
  - First version, Lady Godiva was a sphere
- **Description of Assembly**
  - Height: ~6 inches
  - Diameter: ~7 inches
  - Mass: 65 kg
  - Enrichment: 93.5 wt% U-235
- **Applications:**
  - Sample reactivity worth studies
  - Reactor kinetics benchmark studies
  - Dosimetry measurements
  - Criticality alarm testing
  - Sample neutron activation studies

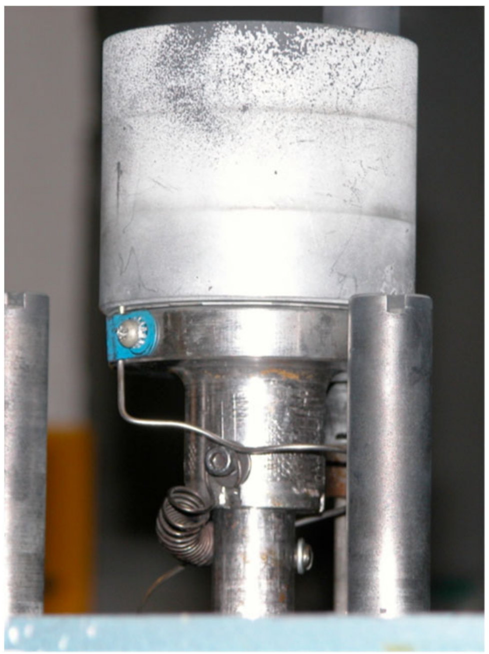


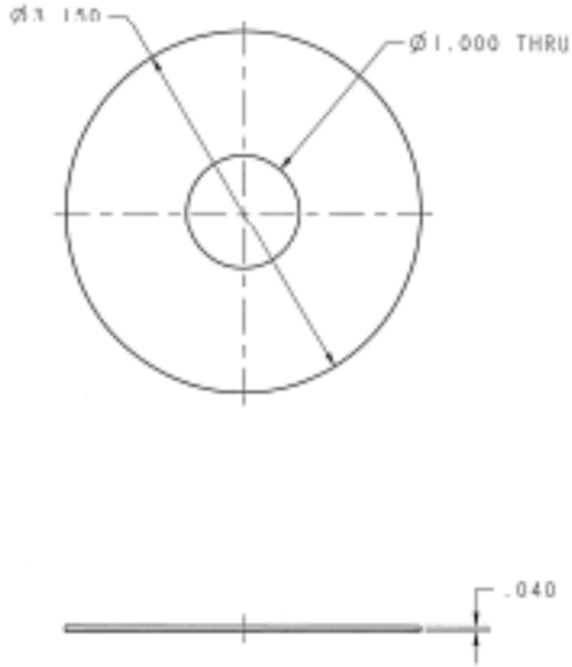
Breakdown of Work

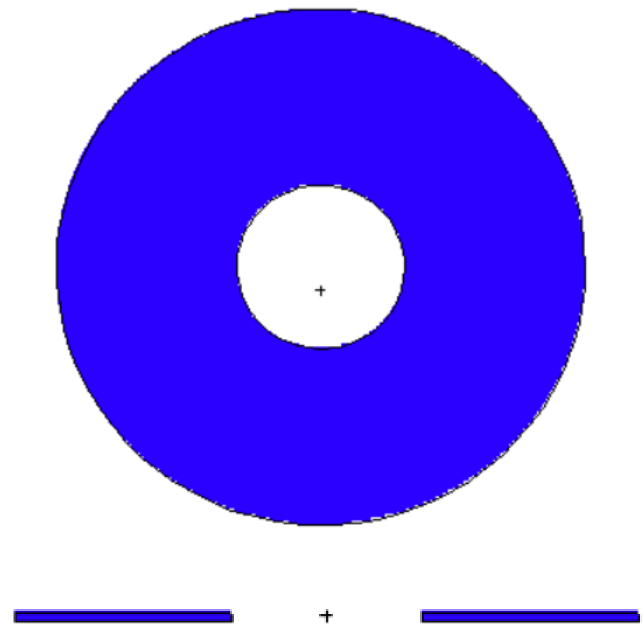


- **From the disassembly…**
  - Updated spindle dimensions
  - Updated glory-hole dimensions
  - Addition of shim
- **New top hat**
- **New cross-section libraries**
  - Comparison between ENDF/B-VII.1 and ENDF/B-VIII.0
- **TR Cards**
- **Updates have significantly changed computational result**
  - Closer to the expected value from the experiment

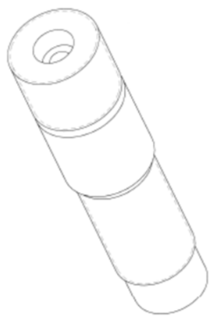
Safety Block Shim



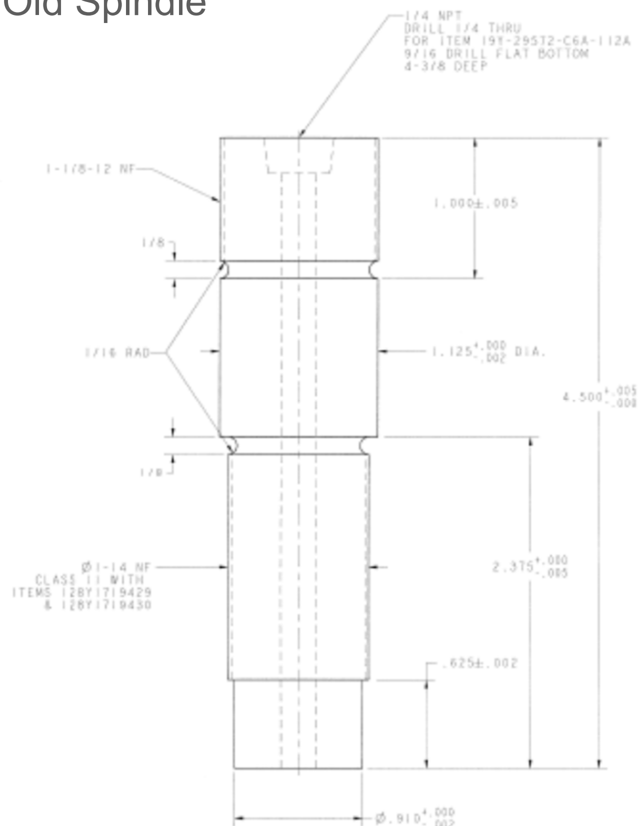


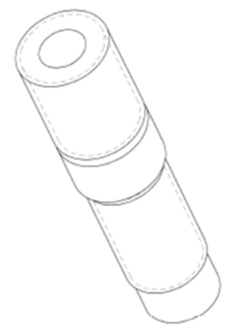


Spindle

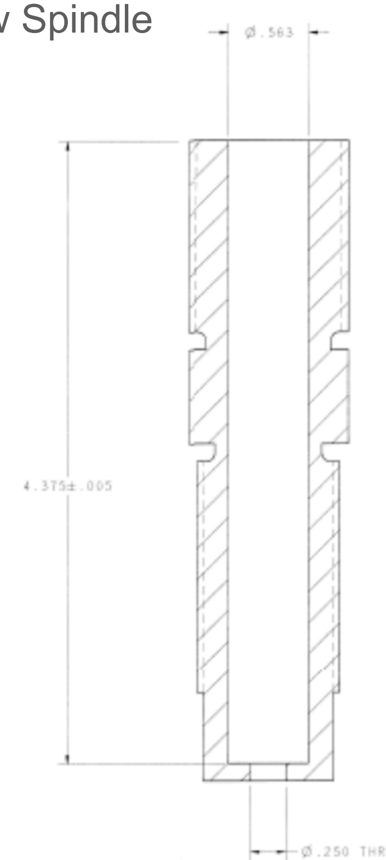


Old Spindle



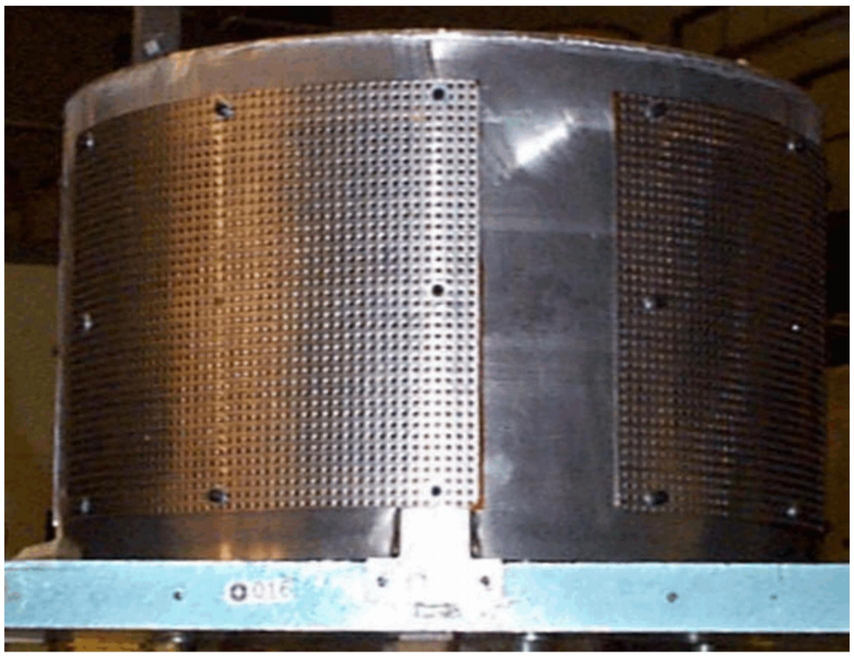


New Spindle

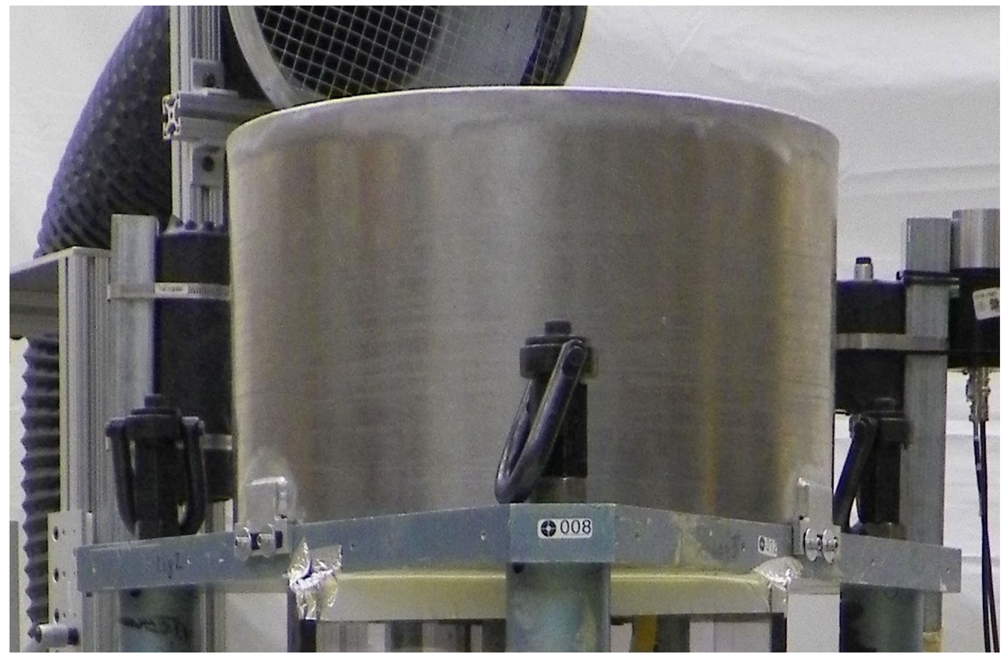


Top Hat

Old Top Hat



New Top Hat



TR Cards

```
c ~~~~~~~~ Translation Cards ~~~~~~~~
c To move the Safety Block to one of the Control System positions, change the z value of TR1 to a value of the line:
c      y = -2.54*x-0.4207
c Where y is the z value in TR1 in MCNP and x is the Control System Position in inches.
c Equation is bounded between -0.150 and 7.844 inches.
TR1 0 0 0
c
c To move Control Rod 1 to one of the Control System positions, change the z value of TR2 to a value of the line:
c      y = -2.54*x+0.8204
c Where y is the z value in TR2 in MCNP and x is the Control System Position in inches.
c Equation is bounded between -0.160 and 4.000 inches.
TR2 0 0 0
c
c To move Control Rod 2 to one of the Control System positions, change the z value of TR3 to a value of the line:
c      y = -2.54*x+0.3175
c Where y is the z value in TR3 in MCNP and x is the Control System Position in inches.
c Equation is bounded between -0.250 and 4.000 inches.
TR3 0 0 0
c
c To move the Burst Rod to one of the Control System positions, change the z value of TR4 to:
c
c Control System Position | z Value of TR4
c          Full-In        |     7.51050
c          Full-Out       |     0.00000
TR4 0 0 0
c
```

ENDF/B-VII.1 vs ENDF/B-VIII.0

ENDF/B-VII.1 Cross Section Results

Case: Top Hat	Present	Removed
$\mathbf{k_{eff}}$	0.99810 ± 0.00027	0.99710 ± 0.00026
Average Energy of Neutrons Causing Fission $(\mathbf{MeV})$	1.4251	1.4268
Average Number of Neutrons Produced per Fission $(\bar{\nu})$	2.595	2.595
Percentage of Fission Caused by Neutrons		
Thermal $(< \mathbf{0.625\ eV})$	0.00%	0.00%
Intermediate $(\mathbf{0.625\ eV - 100\ keV})$	5.54%	5.50%
Fast $(> \mathbf{100\ keV})$	94.46%	94.50%

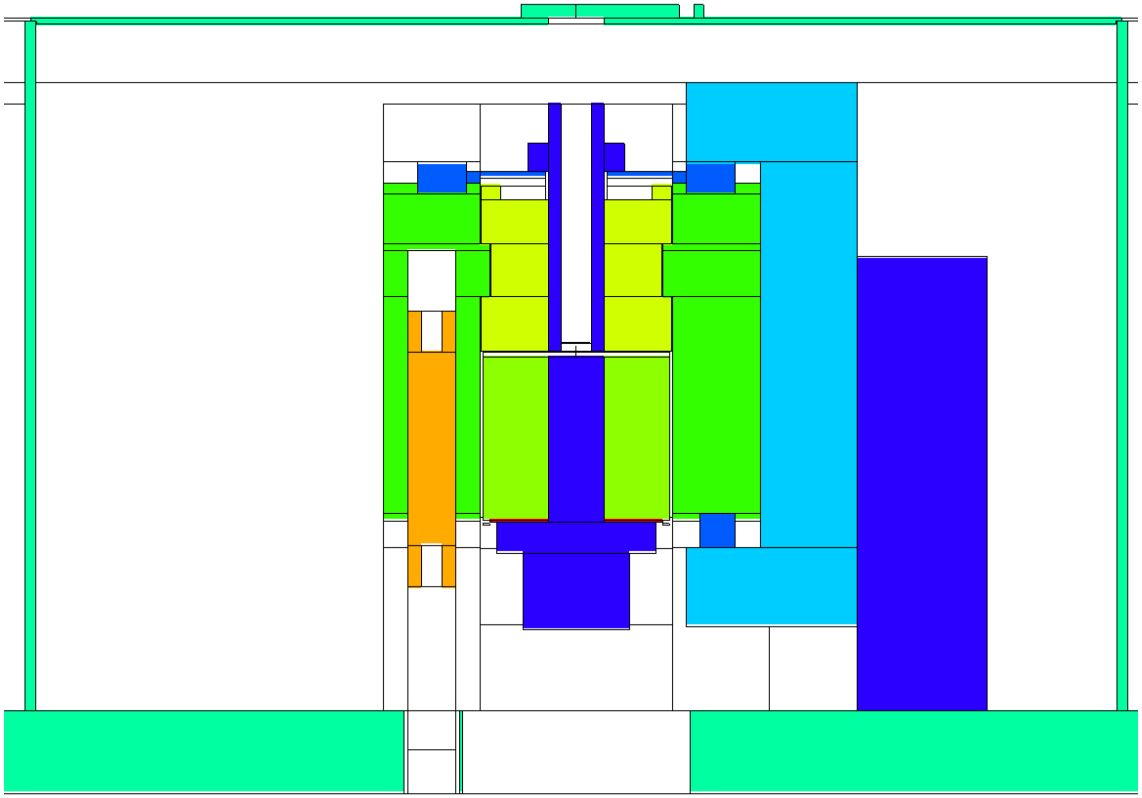
ENDF/B-VIII.0 Cross Section Results

Case: Top Hat	Present	Removed
$\mathbf{k_{eff}}$	0.99773 ± 0.00028	0.99633 ± 0.00026
Average Energy of Neutrons Causing Fission $(\mathbf{MeV})$	1.4227	1.4243
Average Number of Neutrons Produced per Fission $(\bar{\nu})$	2.592	2.592
Percentage of Fission Caused by Neutrons		
Thermal $(< \mathbf{0.625\ eV})$	0.00%	0.00%
Intermediate $(\mathbf{0.625\ eV - 100\ keV})$	5.04%	5.01%
Fast $(> \mathbf{100\ keV})$	94.96%	94.99%

Benchmark Case 4

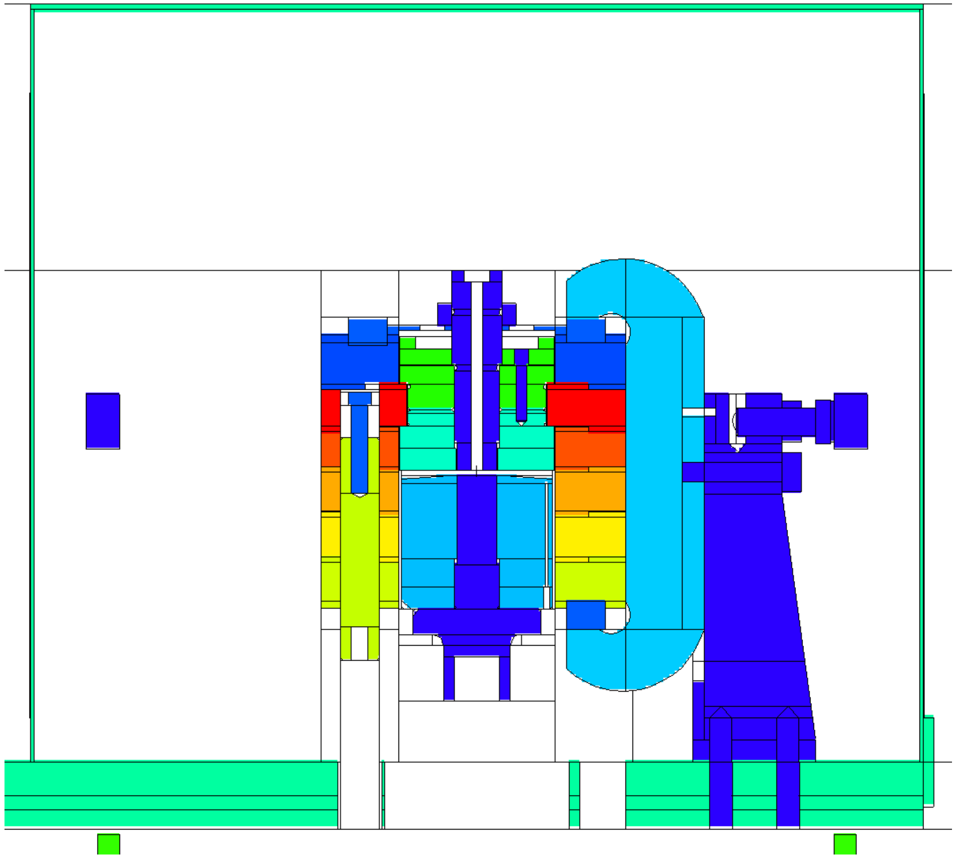
Benchmark Case 4 Results

Model:	Case 4
$\mathrm{k_{eff}}$ - ENDF/B-VI	0.9897 ± 0.0003
$\mathrm{k_{eff}}$ - ENDF/B-VII.1	0.9907 ± 0.0003
Average Number of Neutrons Produced per Fission ($\bar{\nu}$)	2.593
Percentage of Fission Caused by Neutrons	
Thermal (< 0.625 eV)	0.00%
Intermediate (0.625 eV $- 100$ keV)	5.57%
Fast (> 100 keV)	94.43%



Current Work – Detailed Model

- Detailed modelling of each individual piece
- Need to complete all clamps
- Almost ready to begin sensitivity study



Current Work - KSEN

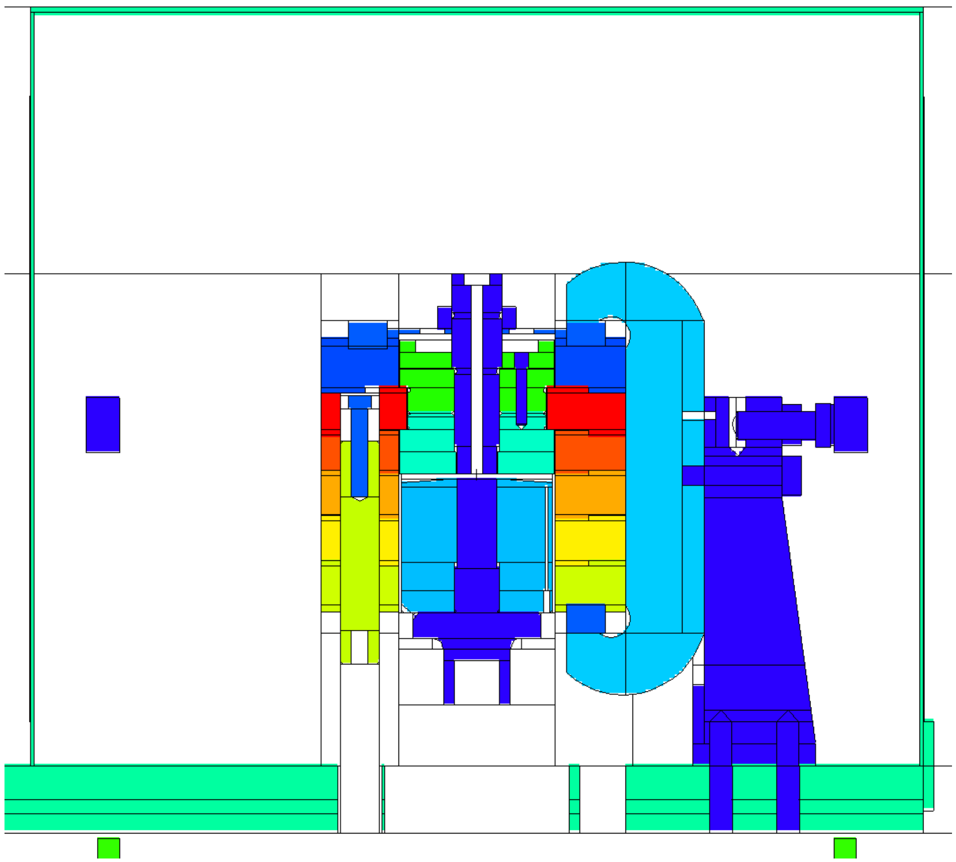
- Plan to use KSEN card in MCNP to perform sensitivity study
- Novel because this functionality is fairly new to MCNP and very new to benchmark community
- The change in k with a respect to a change in component density is shown the right
- KSEN is able to directly calculate the unconstrained sensitivity (S) using a single input deck
- Similar techniques can be used to calculate compositional uncertainties

$$u_k = k_0 \sqrt{\left(S_{k,\rho} \frac{u_\rho}{\rho_0}\right)^2}$$

```
c ~~~~~~~~ Data Cards ~~~~~~~~
mode n
kcode 100000 1.0 50 100
ksrc 0.0 2.5 1.27 0.0 -2.5 1.27
ksen1 xs cell = 700 MT=-1
ksen2 xs cell = 701 MT=-1
```

Future Work

- **Continue sensitivity analysis**
- **Update the benchmark document**
  - New figures
  - New tables
  - New components to discuss
  - Ensure sensitivities are still adequate
- **Continue development of detailed model**
- **Add pstudy for moving components**
- **Hope to include updates to next edition of ICSBeP**



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