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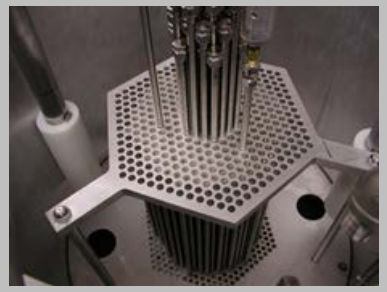


IER-451 Titanium Sleeve Experiments in the BUCCX

David Ames, SNL

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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Sandia Critical Experiments Facility

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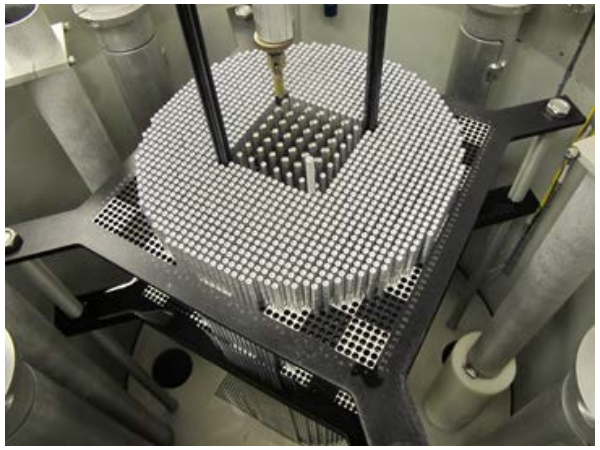
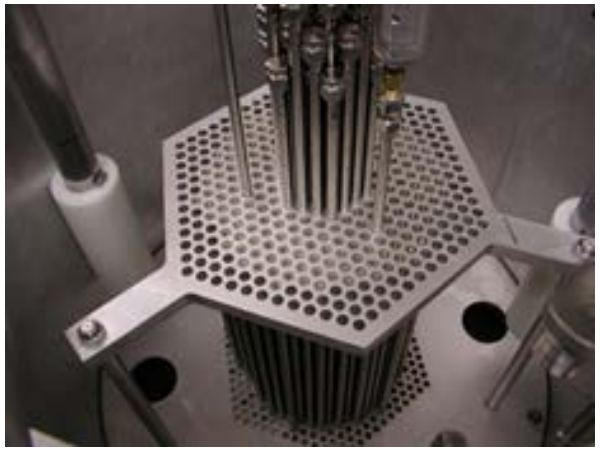
The Seven Percent Critical Experiment (7uPCX)

- UO_2 fuel (6.9%)
- 45x45 Square array (pitch 0.8 cm)
- Fuel diameter 0.526 cm



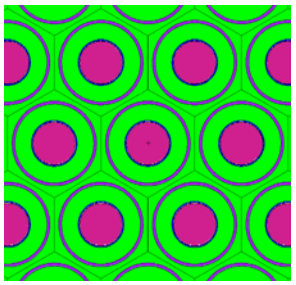
The Burnup Credit Critical Experiment (BUCCX)

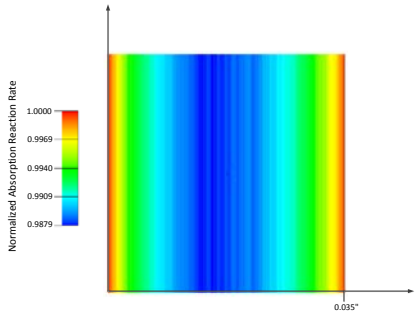
- UO_2 fuel (4.3%)
- Triangular pitch (2.0 and 2.8 cm)
- Fuel diameter 1.265 cm

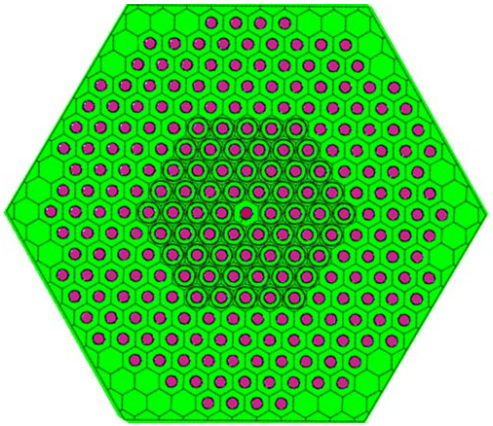


BUCCX Titanium Sleeve Experiment Design

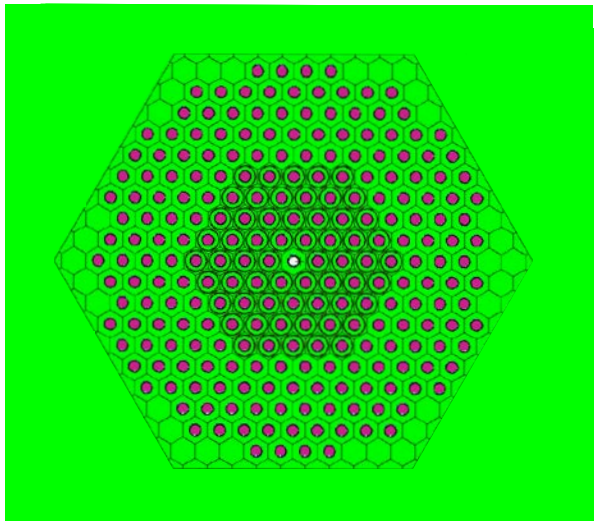
- Option for two sets of grid plates (2.0 or 2.8 cm triangular pitch)
  - 2.8 cm near optimum moderation (slightly undermoderated)
    - Less sensitive to uncertainties to amount of water in array
    - Softer spectrum
- Titanium sleeves
  - Purity (commercially pure: grades 1-5, and alloys)
    - Grade 2 (price and availability)
  - Outer diameter (range of 0.55” - 1.10”)
    - 1.0” (configuration, price, and availability)
  - Wall thickness
    - 0.035” (self shielding, availability and price)
  - Length
    - 19.60” (space between grid plates)
  - Configuration
    - Interstitial (Centered around fuel rods)
  - Amount
    - 61 sleeves (symmetric , max for critical configuration)
    - 241 fuel rods
- Aluminum Sleeves

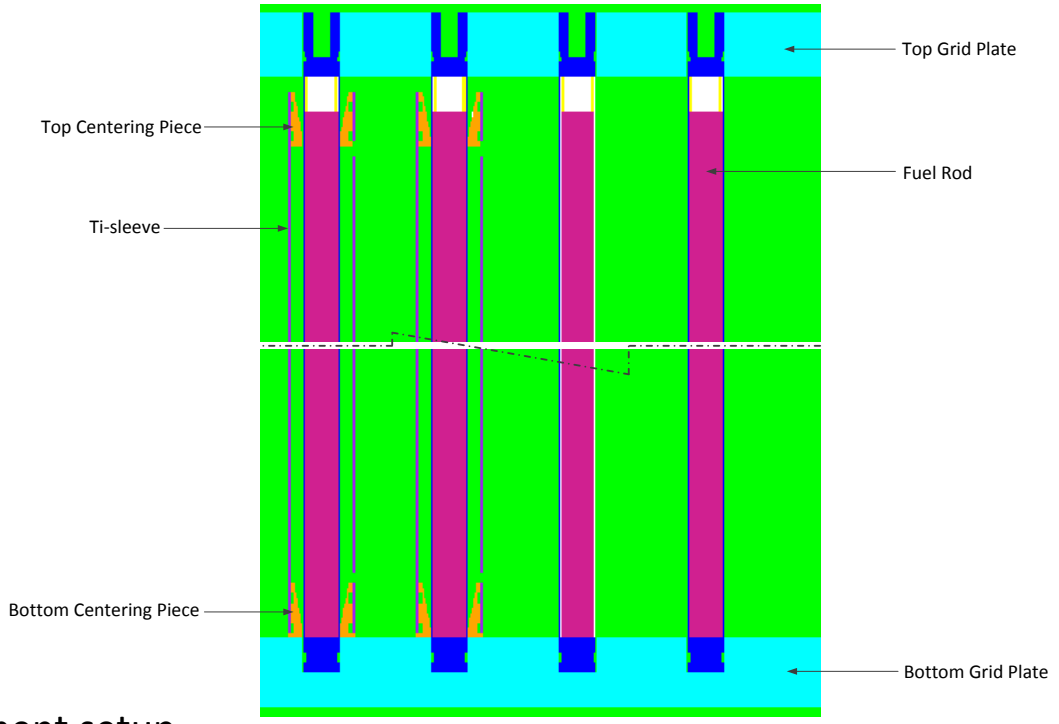






BUCCX Titanium Sleeve Experiment Design





Experiment setup

- Operationally functional
- Configuration (ensure sleeves are centered and positioned correctly)
- Allow water inside sleeves

Sleeve centering

- Top and bottom centering pieces
- Dimensions and material (fabrication, neutronics, installation, environment)

BUCCX Titanium Sleeve Experiment Design

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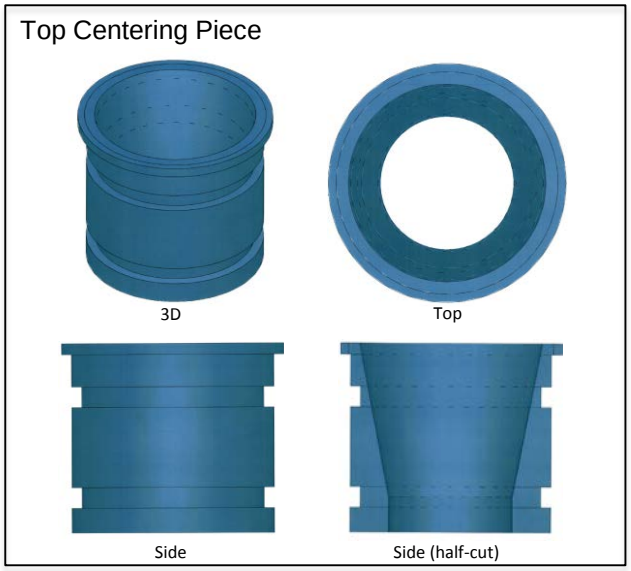
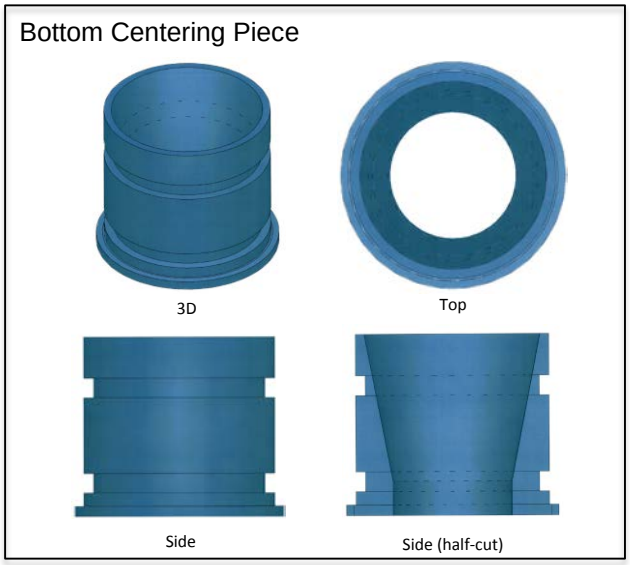
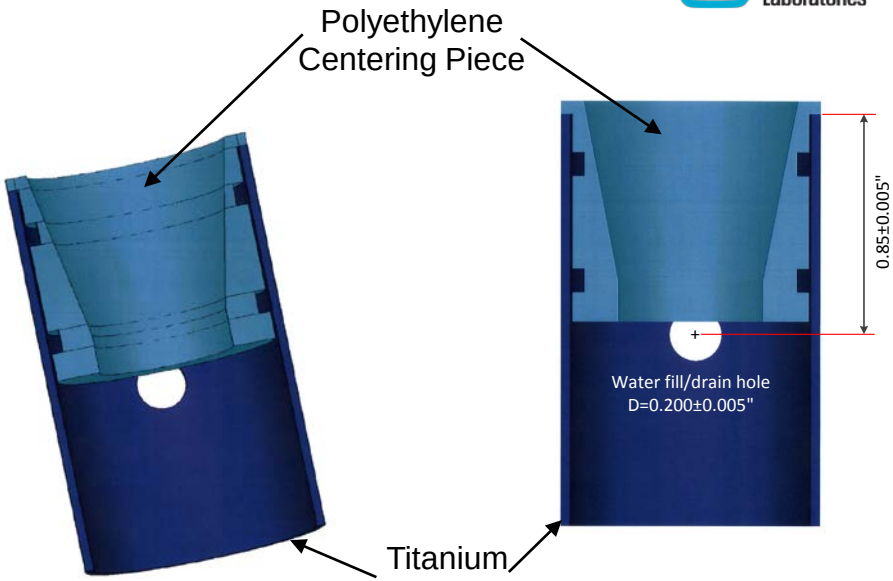
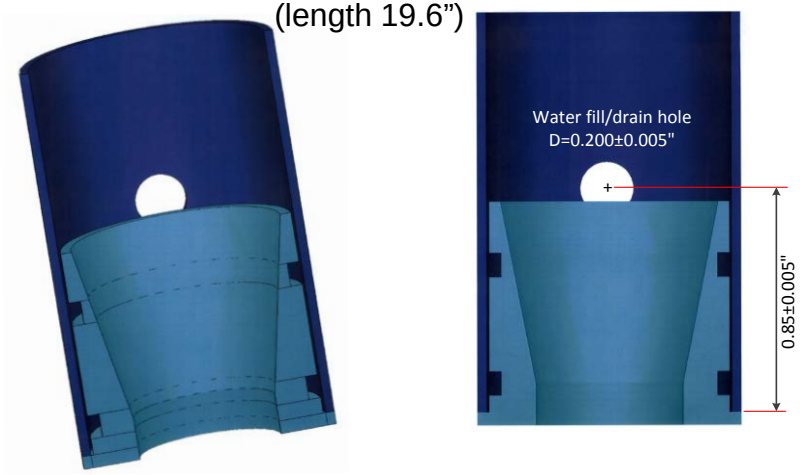






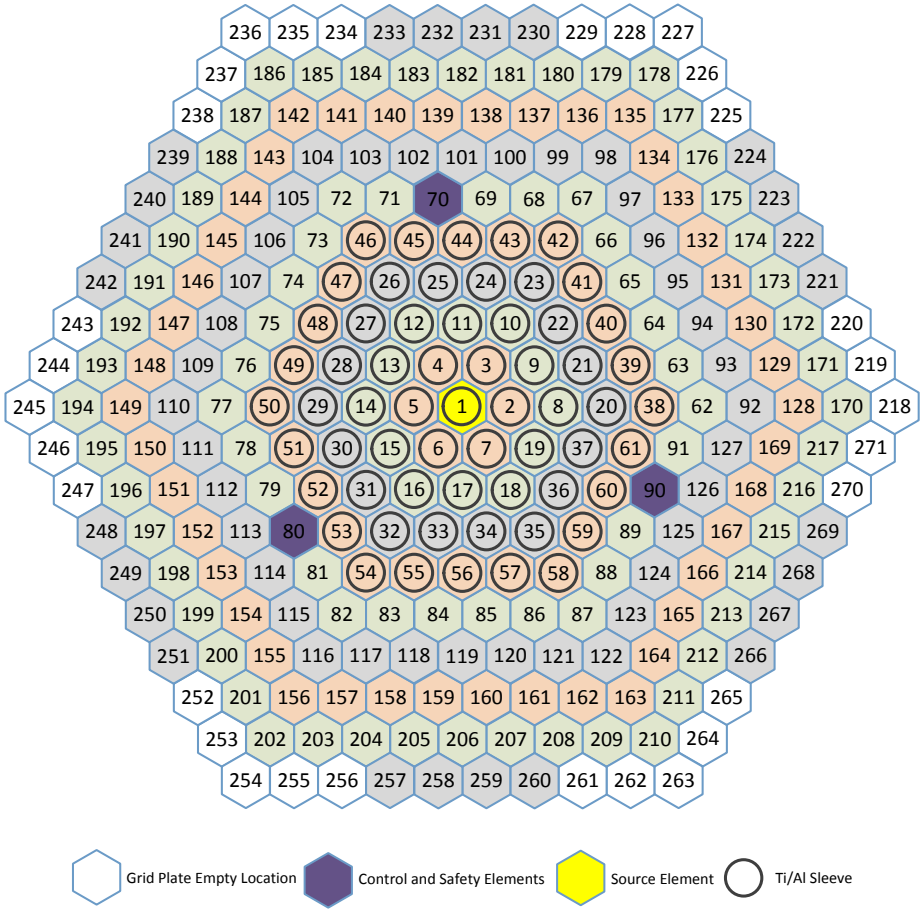


Standard size O-rings
AS-568 No. -019

BUCCX Titanium Sleeve Experiment Method

- Measure the effects of titanium and aluminum sleeves in the fuel array on the critical array size.
  - All titanium experiments will have corresponding aluminum experiments
    - Configuration of the sleeves (titanium and aluminum) the same for each case
    - Number of fuel rods in the array will differ due to the effects of titanium and aluminum
- Critical array size for each configuration shall be determined by an approach-to-critical experiment
  - Array fully reflected by water
  - Approach parameter is the number of fuel rods
    - Load from center toward the outside while maintaining a roughly cylindrical cross section of the array
    - Inverse count rate as function of number of fuel rods extrapolated to zero to obtain critical array size
  - Initial two arrays for each configuration determined by calculations
    - 1^{st} array: $k_{eff} = 0.90$
    - 2^{nd} array: $k_{eff} = 0.95$
  - Subsequent measurements guided by count rate results
    - Loading order guided by fuel element incremental worth calculations

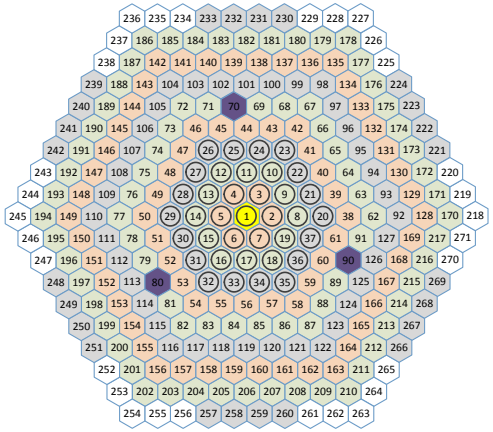
BUCCX Titanium Sleeve Experiment



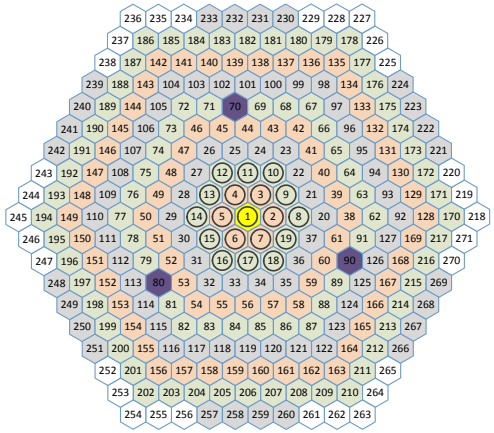
- 271 total fuel rod locations
  - 1 source element
  - 3 control and safety elements
- 61 titanium sleeves
  - WT = 0.035”
  - OD = 1.0”
  - Length = 19.60”
- 241 fuel rods
- MCNP calculations
  - k_{eff} = 0.99917
  - EALF = 0.121 eV
  - Titanium Δk 9.9%
    - Void titanium

Titanium/Aluminum Sleeve Configurations

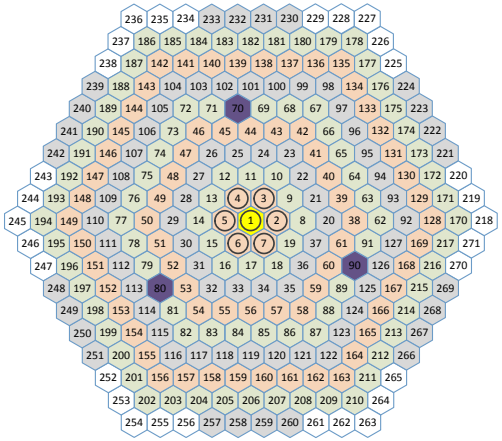
37 sleeves

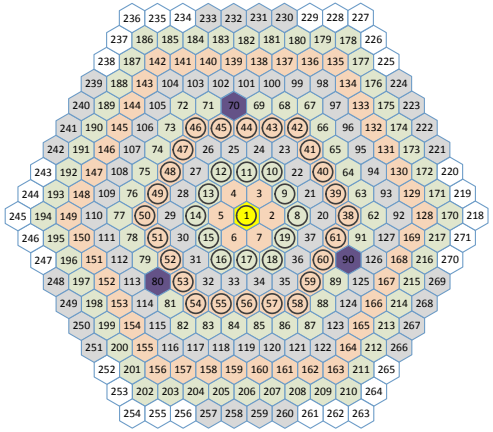


19 sleeves

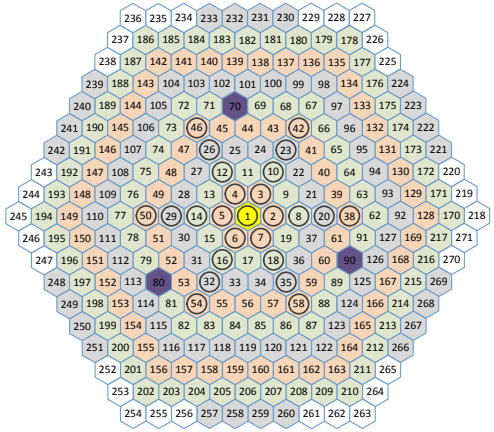


7 sleeves

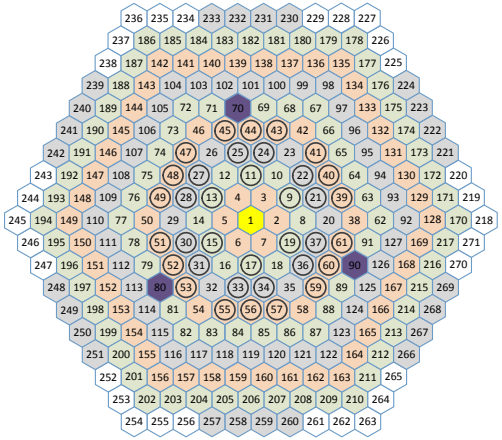




37 sleeves

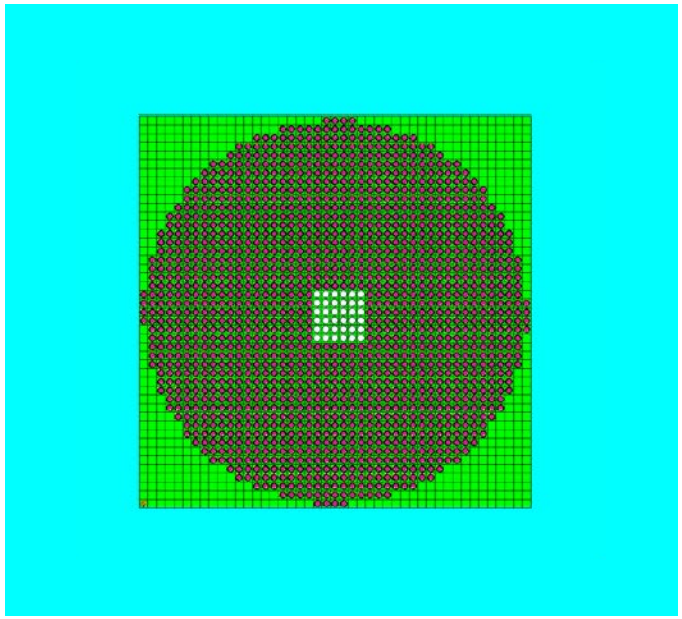


25 sleeves

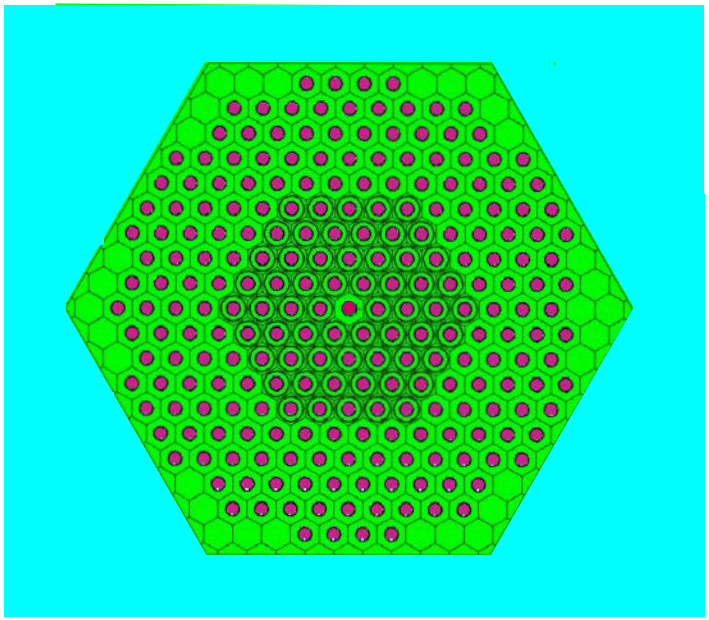


36 sleeves

7uPCX and BUCCX Titanium Experiments

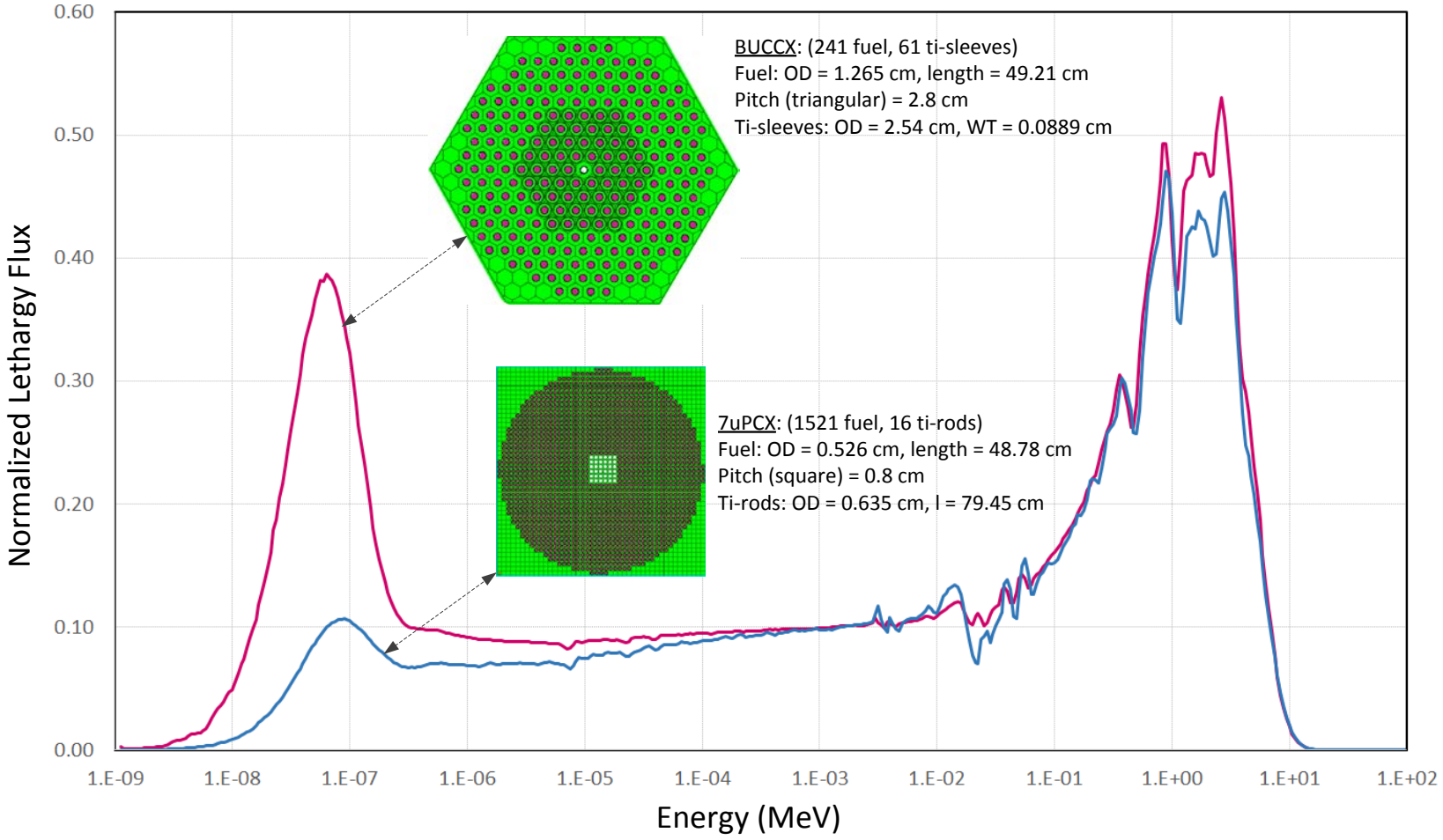


- 4 – 36 titanium rods
  - Diameter 0.25”
  - Multiple configurations
- Fuel rods
  - 6.9% enrichment
  - Diameter = 0.207”
  - Pitch (square) = 0.315”



- Up to 61 titanium sleeves
  - OD = 1.0”
  - WT = 0.035”
- Fuel rods
  - 3.8% enrichment
  - Diameter = 0.498”
  - Pitch (triangular) = 1.102”

7uPCX and BUCCX Titanium Experiments



Conclusions

- Titanium sleeve experiments in the BUCCX planned to start next month.
- Results to be submitted for review at the 2017 Annual ICSBEP working group meeting

Acknowledgements

The critical experiments performed at Sandia are supported by the DOE Nuclear Criticality Safety Program. Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Security Administration under contract DE-AC04-94AL85000.