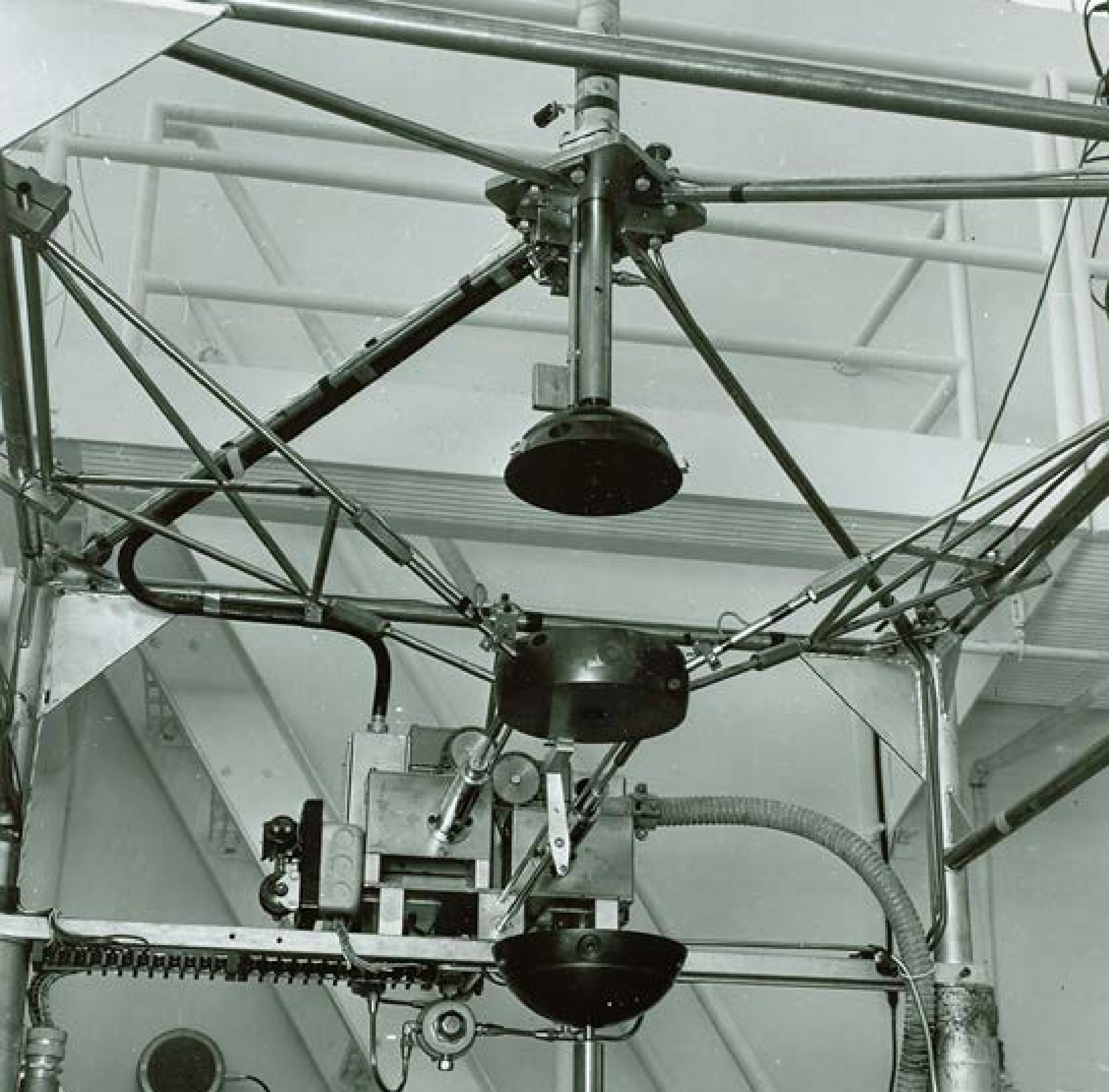

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LA-UR-17-29495

Neptunium Subcritical Observation (NeSO) Integral Benchmark Experiment Design

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Winter 2017

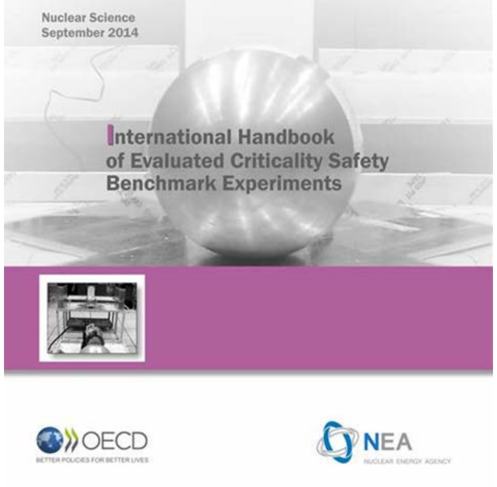
Background and Motivation

Design/Conduct/Analyze Subcritical Validation Experiments

- **Nuclear Data**
  - Fill integral experiment database deficiencies through new measurements
  - Find differential nuclear data library deficiencies through new measurements covering different:
    - Energy Ranges (Thermal, Intermediate, Fast)
    - Multiplication Ranges (Low, Medium, High)
    - Materials (Fissile, Moderator, Reflector)
    - Neutron Reactions
- **Transport Codes Validation**
- **Uncertainty quantification methodology development**

Recent Advances in Subcritical Experiments

- **We have come a long way since the first subcritical measurements at CP-1 in 1942.**
- **Many organizations (LANL, LLNL, SNL, IAEA, IRSN, CEA, universities, and others) have pursued subcritical experiments and/or simulations in recent years.**
- **The BeRP ball reflected by nickel benchmark evaluation was published in the 2014 edition of the ICSBEP handbook.**
- **This benchmark was the first:**
    - Published benchmark evaluation of measurements performed at DAF.
    - Benchmark evaluation using new MCNP capabilities for subcritical systems (the MCNP list-mode patch and MCNP6 list-mode capabilities).
    - Benchmark using the Feynman Variance-to-Mean method.
    - LANL-led subcritical experiment in the ICSBEP handbook.
- **This benchmark was the culmination of several years of subcritical experiment research.**
- **Additional benchmarks:**
    - BeRP-tungsten
    - BeRP-copper

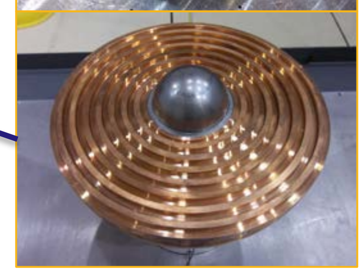


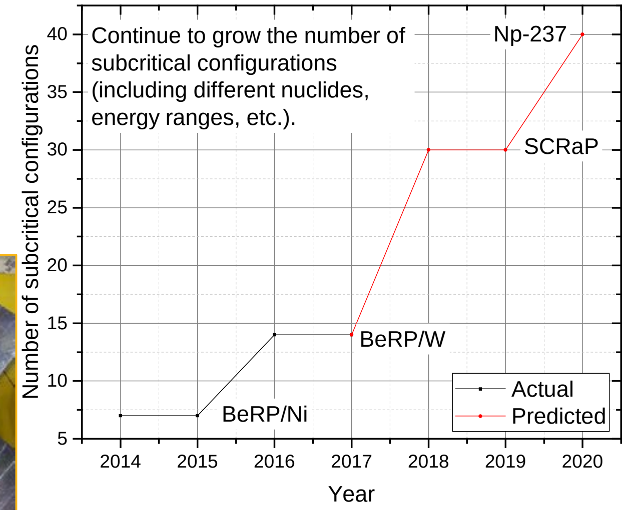
Validating Codes and Data with Subcritical Experiments

- **Growing dataset of neutron multiplication benchmarks experiments/evaluations**
  - Culmination of several years of sub-critical experiment research
  - Goal is to validate nuclear data and computational methods

Chronology: 2012 - Present

- **BeRP-Ni (published in 2014)**
  - Executed in 2012, ICSBEP evaluation published in 2014
- **BeRP-W (published in 2016)**
  - Sub-critical tungsten-reflected α-phase Pu
  - Executed in 2012, ICSBEP evaluation published in 2016
- **SCRαP (to be published in 2018?)**
  - Sub-critical copper/poly-reflected α-phase Pu
  - Executed in 2016, ICSBEP evaluation published in 2018
- **Neptunium (to be published in 2020?)**
  - Sub-critical Neptunium w/various reflectors, in design phase





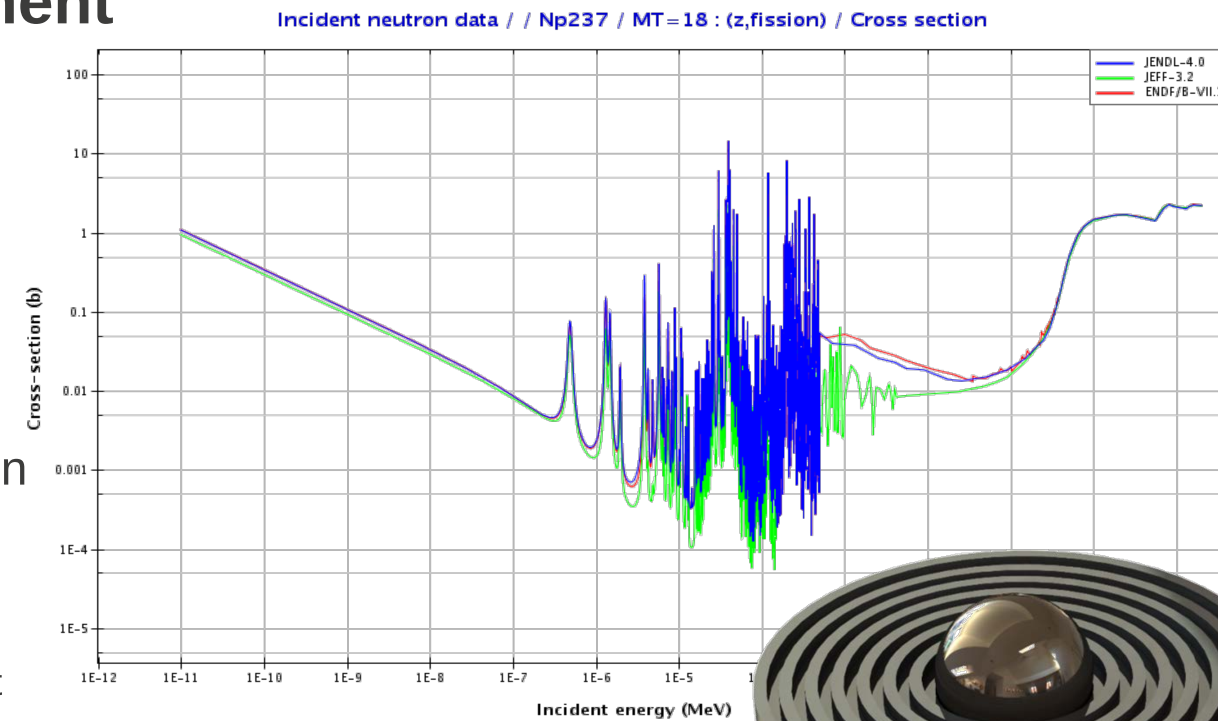
Preliminary Design of the NeSO Integral Experiment

Neptunium Subcritical Observation (NeSO) Integral Experiment

- **NeSO Preliminary Design (w/ MCNP®6)**
  - o Neptunium Sphere
  - o High-purity nested metal shells
    - Varied thicknesses considered
    - Varied materials considered

Neptunium Subcritical Observation (NeSO) Integral Experiment

- **Neptunium**
  - o 6.07 kg sphere, 98.8% ^{237}Np
    - Manufactured at Los Alamos in 2001
  - o Cross-section variations based on data library
    - Np is a threshold fissioner so low-Z moderators were not considered



Previous Experiments with the Np Sphere

- **Critical Experiments**
  - o Documented in the ICSBEP
    - Np sphere reflected by HEU (SPEC-MET-FAST-008)
    - Np sphere reflected by HEU and Steel (SPEC-MET-FAST-014)
    - Np sphere reflected by HEU and Polyethylene (SPEC-MET-FAST-011)

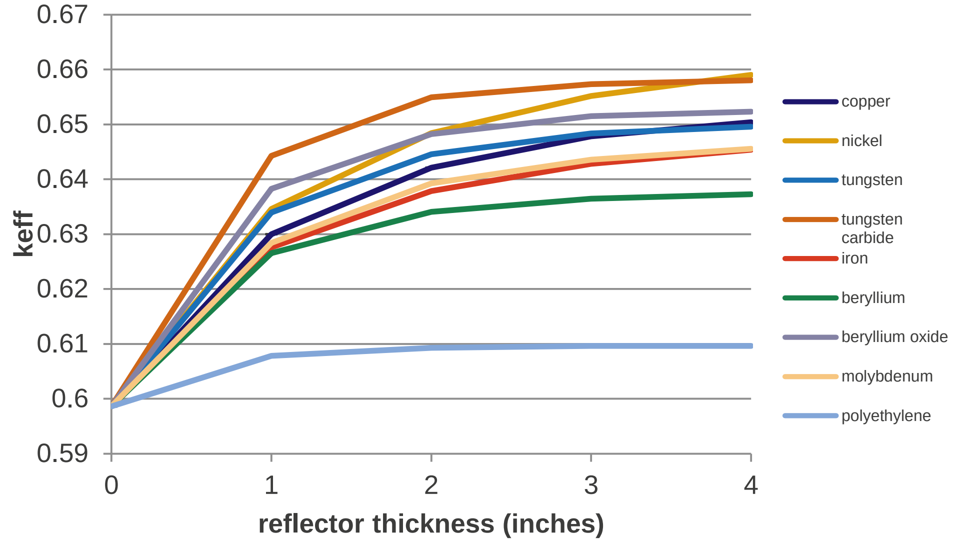
Neptunium Subcritical Observation (NeSO) Integral Experiment

- **NeSO Preliminary Design (w/ MCNP®6)**
  - o Np Sphere
  - o High-purity metal nested hemishells (0 - 4” thick)

- **Reflector considerations:**
  - Range of their k-eff
  - ^{237}Np fission cross section sensitivity
  - Average neutron energy causing fission

Preliminary Keff Results with MCNP®6

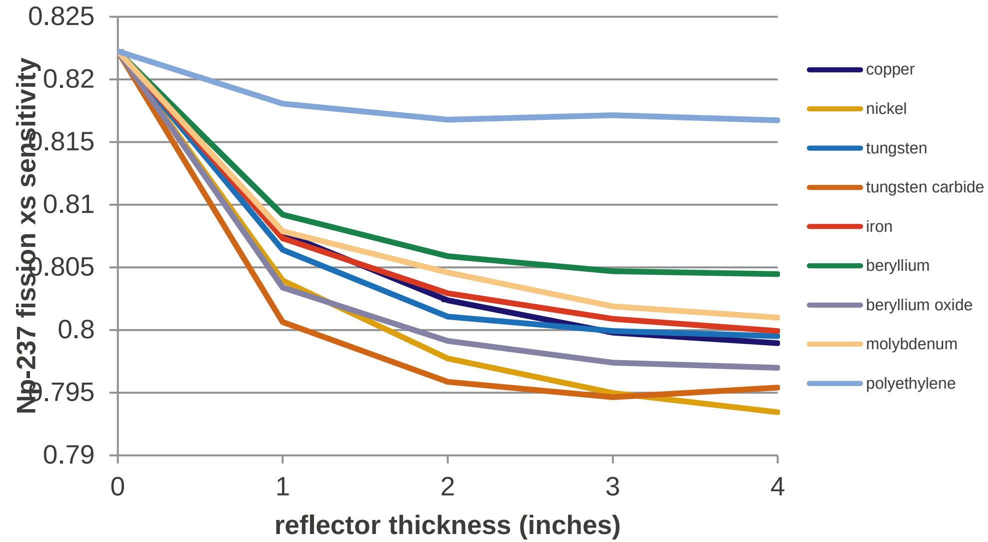
- **0 [bare] to 4 in. thick reflector**
- **Planned measurement will likely go up to 4.0” thickness of total reflector:**
  - o Previous subcritical benchmark sensitivity
  - o Beyond 4.0”, assembly weight becomes more problematic for handling.
  - o Cost prohibitive for high purity metals beyond 4” thick
- **Ni shows greatest variability in keff over all thicknesses**



Preliminary Sensitivity Results with MCNP®6

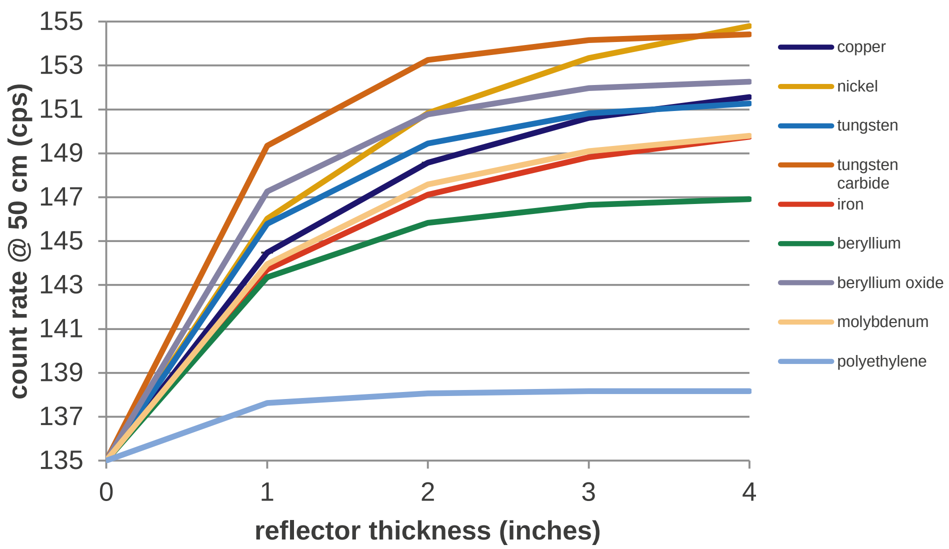
- **0 [bare] to 4 in. thick reflector**

- **Comparison to current ICSBEP benchmarks for ^{237}Np**
  - o ^{237}Np is the primary isotope of interest
  - o According to DICE, only 4 critical configurations have ^{237}Np
  - o Max sensitivity for NeSO configurations is 0.82
    - 4x any currently existing ICSBEP benchmarks



Preliminary Countrate Approximations with MCNP®6

- **Np sphere measured with a LANL multiplicity detector [NPOD] in 2008**
    - o 135 cps @ 50 cm from center of Np sphere
- **Leakage multiplication for various configurations approximated using MCNP k-eff**
- **Known efficiency for the NPOD (~1%)**



Conclusions

- Nickel reflected only
- NoMAD neutron multiplicity detectors, as was used in SCRaP experiment in 2016
- Analyze uncertainty associated with countrate predicted by isotopics compared to preliminary measurements

What's next?

- **Final Design**
  - Continuous-energy nuclear data sensitivity analysis will be provided.
  - Final design simulations will incorporate the detectors that will be used for the subcritical measurements.
  - Determine measurement times for Np sphere and Cf-252 for each configuration using new approach which determines measurement uncertainties as a function of counting time

This work was supported by the DOE Nuclear Criticality Safety Program, funded and managed by the National Nuclear Security Administration for the Department of Energy.

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