

LA-UR-18-22929

Approved for public release; distribution is unlimited.

Title: Reactivity Simulation for Criticality Safety Training and Future

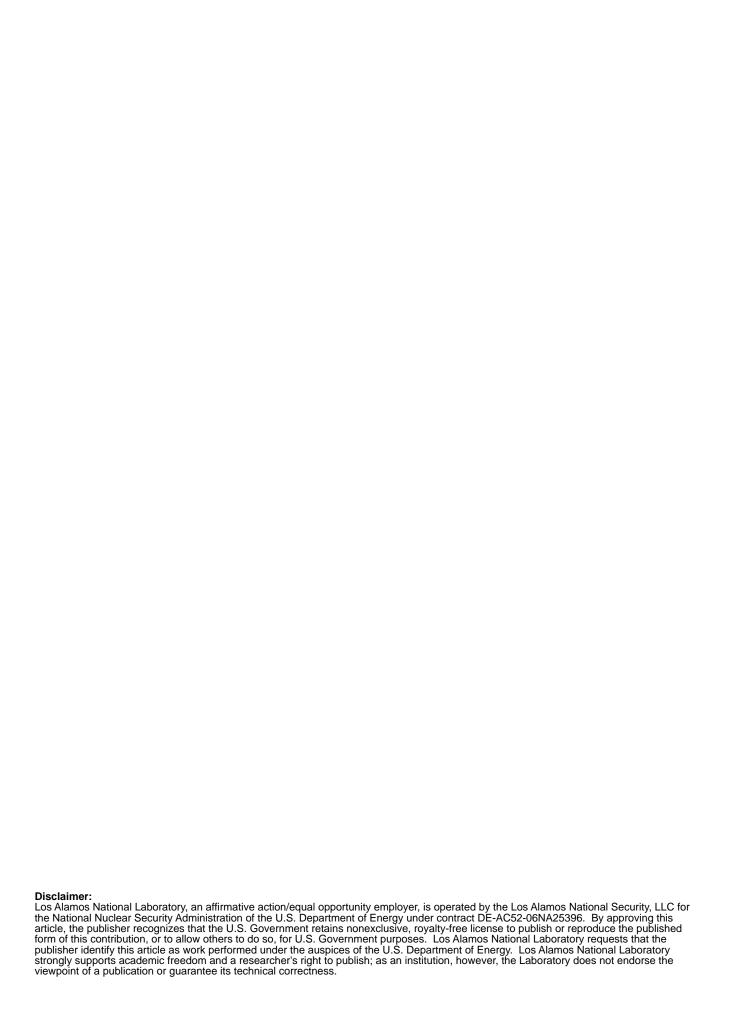
Projects at LANL

Author(s): McCallum, Jacob Bryan

Intended for: 2018 Annual ANS Meeting, 2018-06-17/2018-06-21 (Philadelphia,

Pennsylvania, United States)

Issued: 2018-04-05







Delivering science and technology to protect our nation and promote world stability



Reactivity Simulation for Criticality Safety Training and Future Projects at LANL

ANS Annual Meeting, Philadelphia, 2018



Jacob B. McCallum



TABLE OF CONTENTS

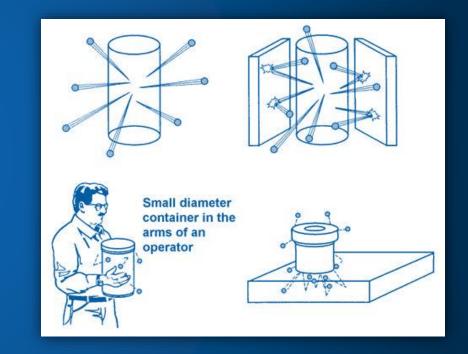
Philadelphia, PA



- Purpose for a Reactivity Simulator
 - Comparison to Actual Pu Core
- How it Works
- Intended Use for Training
- Future Simulation Projects
 - Changes in Reactivity Due to Interaction of Multiple Units
 - Recreation of 1978 Siberian Pu Ingot Accident
 - Recreation of 1946 Slotin Accident
- Final Thoughts/References

PURPOSE FOR A REACTIVITY SIMULATOR

- Incidental reflection
 - Well known-concept for those with a nuclear background
 - Not as well known by operators at a nuclear facility
- Reflection effects from the human body play a major role
 - In particular, hand reflection from handling material
- Device/Poster will provide insight into neutronics involved
- Device is a tungsten ball
 - Similar in size/weight to sphere of 239 Pu with a $k_{eff} \sim 0.95$



Comparison to Actual Pu Core

Demonstration of increased reactivity on LANL reactivity simulator



Official recreation of Slotin accident with the "demon core"



Similar in size/weight to sphere of 239 Pu with a $k_{eff} \sim 0.95$

HOW IT WORKS



Theremin technology

- Musical instrument utilizing the performer's body as an electrical control
- Performers hand acts as a grounded plate of a capacitor, manipulated based on proximity
- Oscillator frequency is varied producing an audible tone

Reactivity simulator

- The user's hands manipulate capacitance about the tungsten ball
- Calibrated to produce clicking sound, increasing as the operator moves hands closer
 - Simulates detector response from an increase in reactivity

INTENDED USE FOR TRAINING

- Fissionable Material Handler (FMH) training at LANL includes criticality safety
 - Reactivity simulator provides a hands-on interactive aid
- Fissionable Material Operation (FMO) adjacent tasks introduce potential for added reflection
- Poster/Simulator aim to increase knowledge of all audiences
 - Individuals that may passively or inadvertently interact with fissionable material
 - RCTs
 - Engineers
 - Craft workers
 - General worker knowledge of criticality safety at TA-55 and site wide

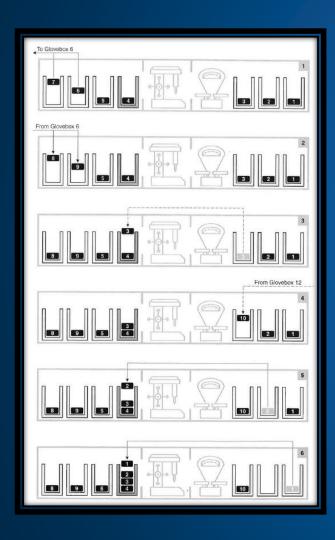
FUTURE SIMULATION PROJECTS

Changes in Reactivity Due to Interaction of Multiple Units

- Goal to increase understanding of interaction principles
 - Introduce 2-3 ²³⁹Pu units into a system and examine audible click rate from their interaction
- How it works
 - 2-D light curtain to identify location
 - Click-rate will be calibrated to match units' proximity to each other
 - Potentially add a third dimension



Recreation of 1978 Siberian Pu Ingot Accident



- Accident involved fundamental breakdown in con-ops
 - Administrative limit of 1 ingot/container
 - Only 1 operator allowed per operation per shift
 - Deviated by having 2 operators
 - No communication on hand-off back to original operator
 - Both operators placed 2 ingots into a container (total mass = 10.68 kg)
 - Criticality and ejection occurred upon addition of 4th ingot

Operator suffered an amputation of both arms up to the elbow

Recreation of 1978 Siberian Pu Ingot Accident

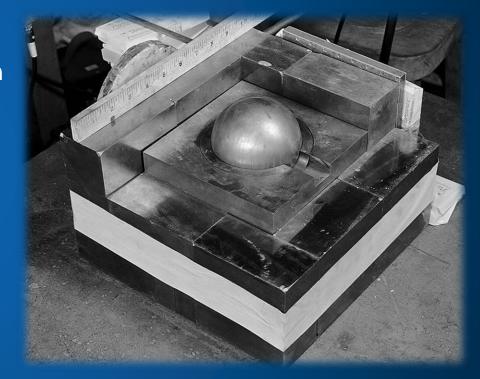
How it works

- Set up a demonstration where the addition of a fourth ingot simulates a criticality event
- Blue flash
- Ejection mechanism rigged to simultaneously go off at the moment of contact with the previously stacked third ingot.

Goal to help FMHs comprehend the effects of over-massing

Recreation of 1946 LANL Slotin Accident; The "Demon core"

- Accident caused by loss of geometry and hand reflection
 - Dhaglian accident with same core 9 months prior
 - Early experiment; done remotely now
 - Concentric Be hemi-shells separated by screwdriver
 - Screwdriver slipped sending assembly prompt-critical
 - Recreation of accident, performed remotely, not critical
 - Likely due to lack of added reflection from hand/thumb



Recreation of 1946 LANL Slotin Accident; The "Demon core"



How it works

- Sensors located near edge of upper hemishell
- Hemishell will be lowered over the core
- Increased click-rate will simulate increased reactivity
- Thumb mechanism
- Blue flash upon contact of the hemishells

Goal to stress importance of leakage and reflection in a system

Los Alamos National Laboratory 4/5/2018

Final Thoughts/References

- Reactivity Simulator is an interactive tool to provide hands-on criticality safety training
 - Ultimate goal to improve FMHs knowledge of incidental reflection
- Simulator & Poster will be used to improve criticality safety knowledge at TA-55 and beyond
- Future projects will help us learn from mistakes, and incorporate a stronger understanding of factors that contribute to criticality safety
 - MAGIC MERV

REFERENCES

McLaughlin, Monahan, Pruvost, Frolov, Ryazanov, Sviridov. "A Review of Criticality Accidents." LA-13638. Los Alamos National Laboratory (2000).

QUESTIONS?