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Reactivity Simulation for Criticality Safety Training and Future Projects at LANL

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Operated by Los Alamos National Security, LLC for the U.S. Department of Energy's NNSA

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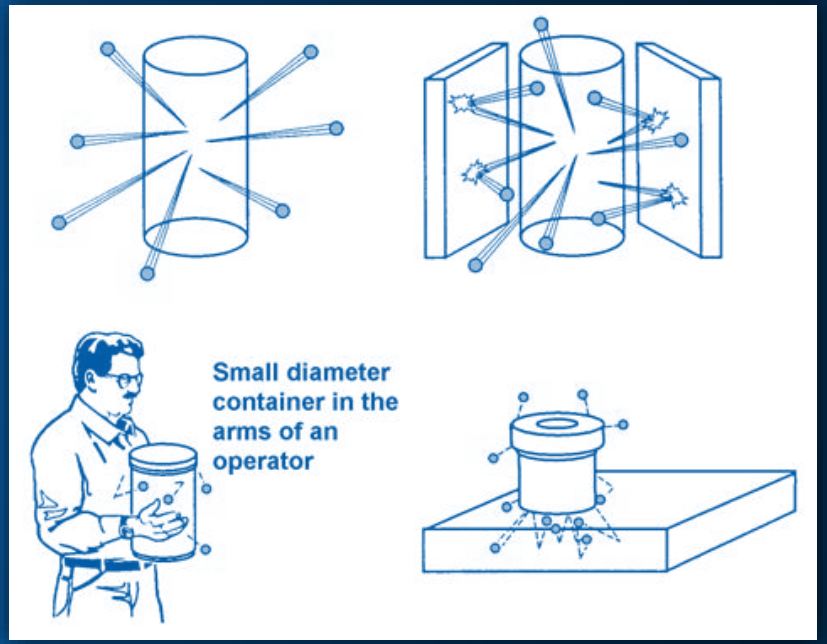
Philadelphia, PA

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

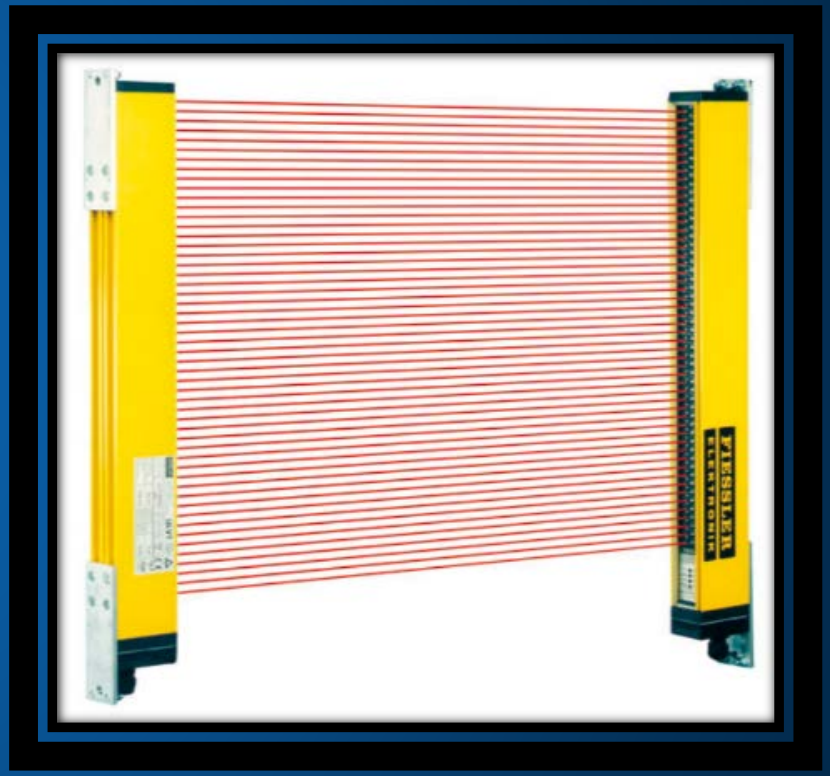
INTENDED USE FOR TRAINING

- **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

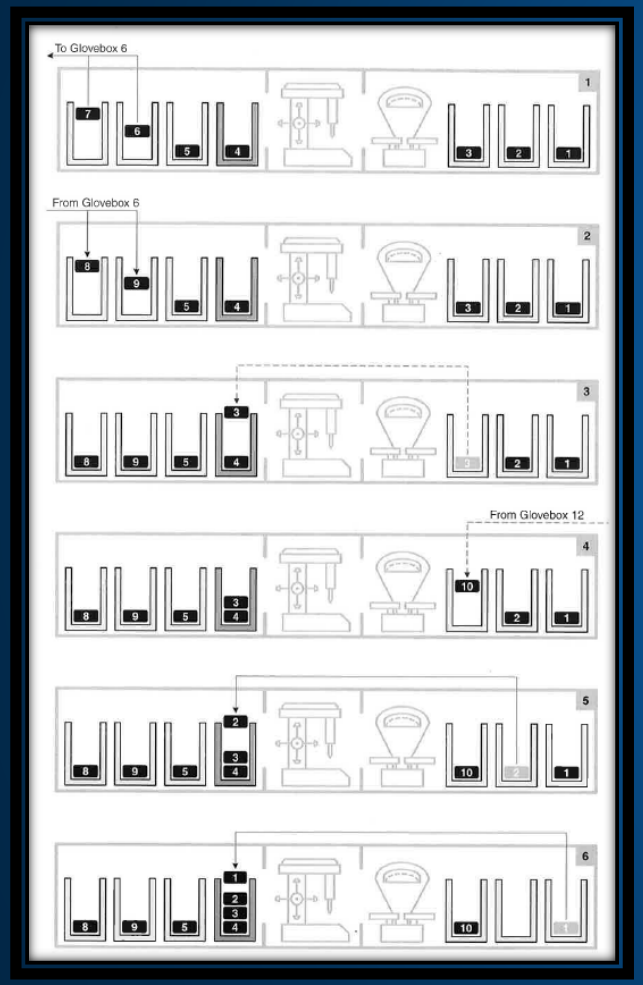
FUTURE SIMULATION PROJECTS

Changes in Reactivity Due to Interaction of Multiple Units

- **Goal to increase understanding of interaction principles**
  - Introduce 2-3 ^{239}Pu 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**

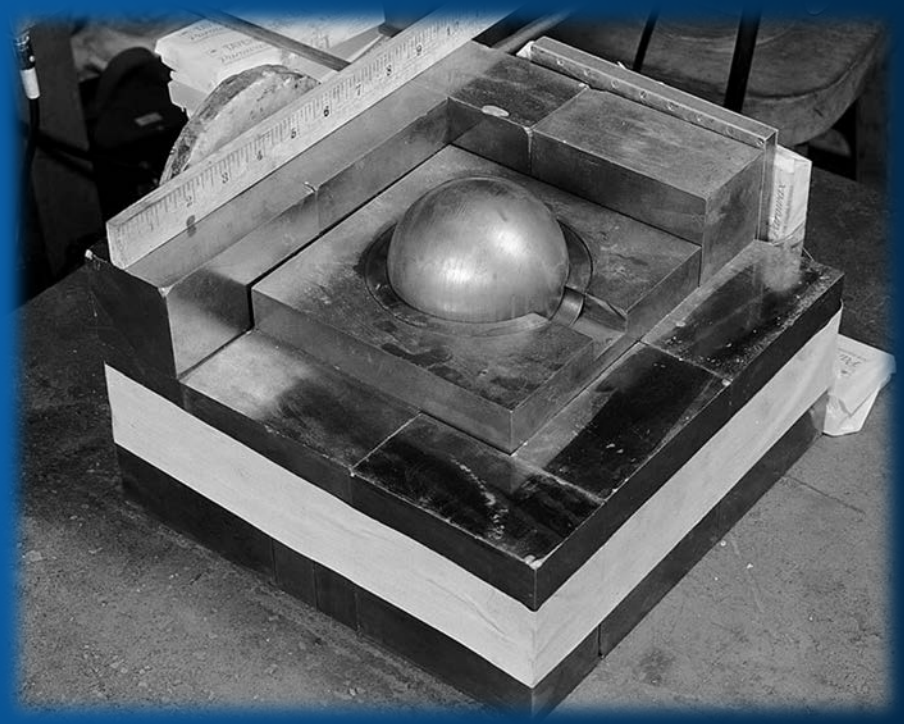
Recreation of 1978 Siberian Pu Ingot Accident

- **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

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?