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Integral Experiment Request 226 CED-1 Summary Report Horizontal Split-Table Critical Assembly Conceptual Design for Sandia Critical Experiments

Critical and Subcritical Experiment Design Team (C_EdT)

Allison D. Miller (SNL), C_EdT Experiment Member
Gary A. Harms (SNL), C_EdT Lead and Publication Member
Michael E. Dunn (ORNL), C_EdT NDAG Member
Thomas M. Miller (ORNL), C_EdT Methods Member
David P. Heinrichs (LLNL), C_EdT Member

National Nuclear Security Administration

Oak Ridge National Laboratory

U.S. Department of Energy

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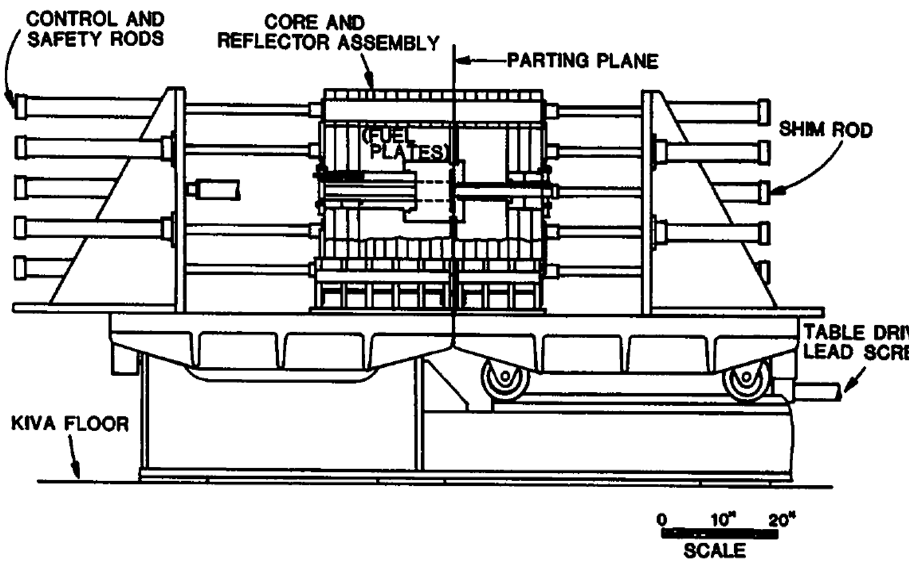
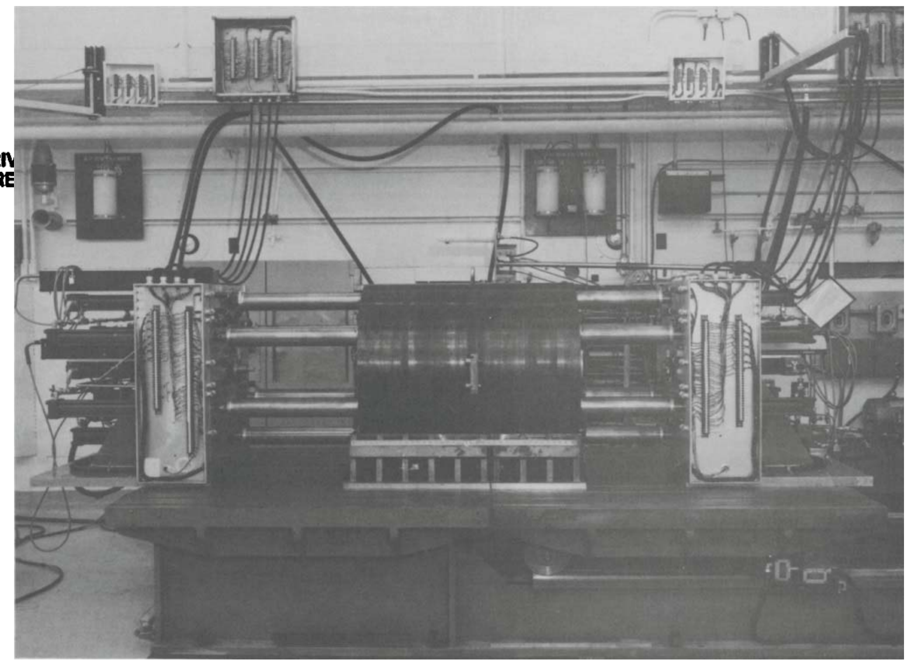
Conceptual Design

- Historical Research
  - LANL, Rocky Flats, ORNL, Argonne
- Split-Table Sensitivities
- Horizontal Split-Table Machine
- Shutdown Mechanisms
- Critical Experiment Feasibility

Survey of Past Split-Table Machines

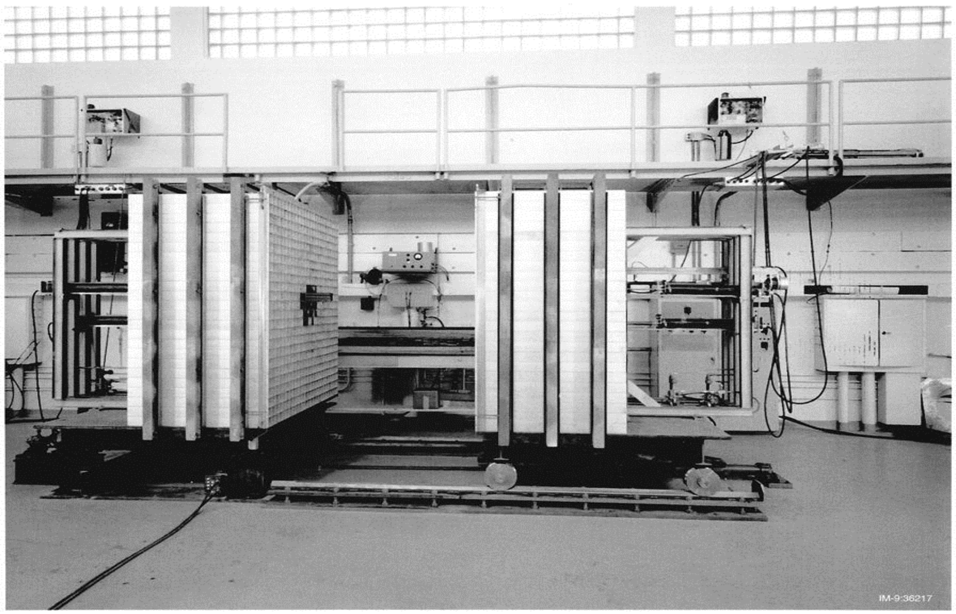
- Big-Ten – Los Alamos National Laboratory





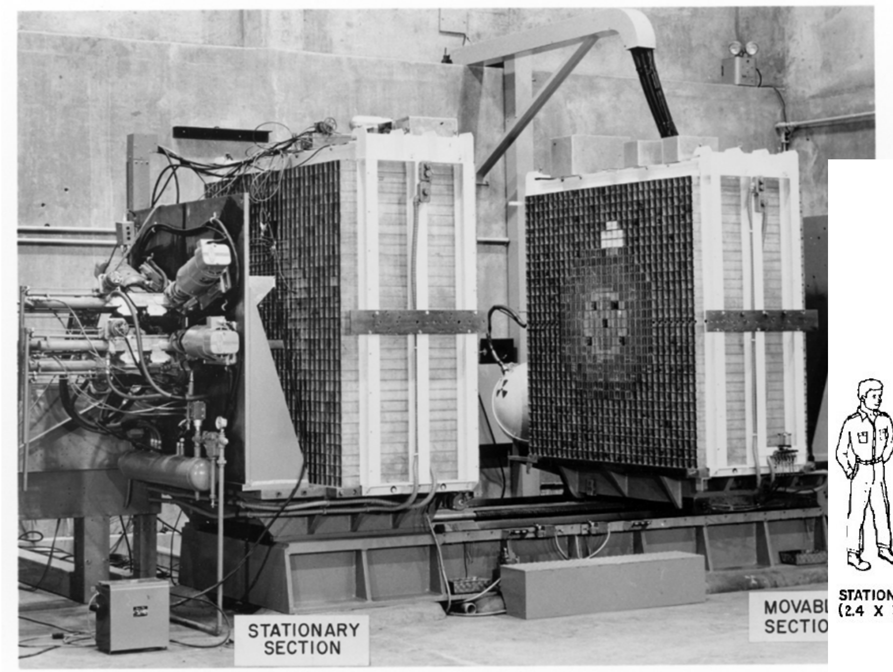
Survey of Past Split-Table Machines

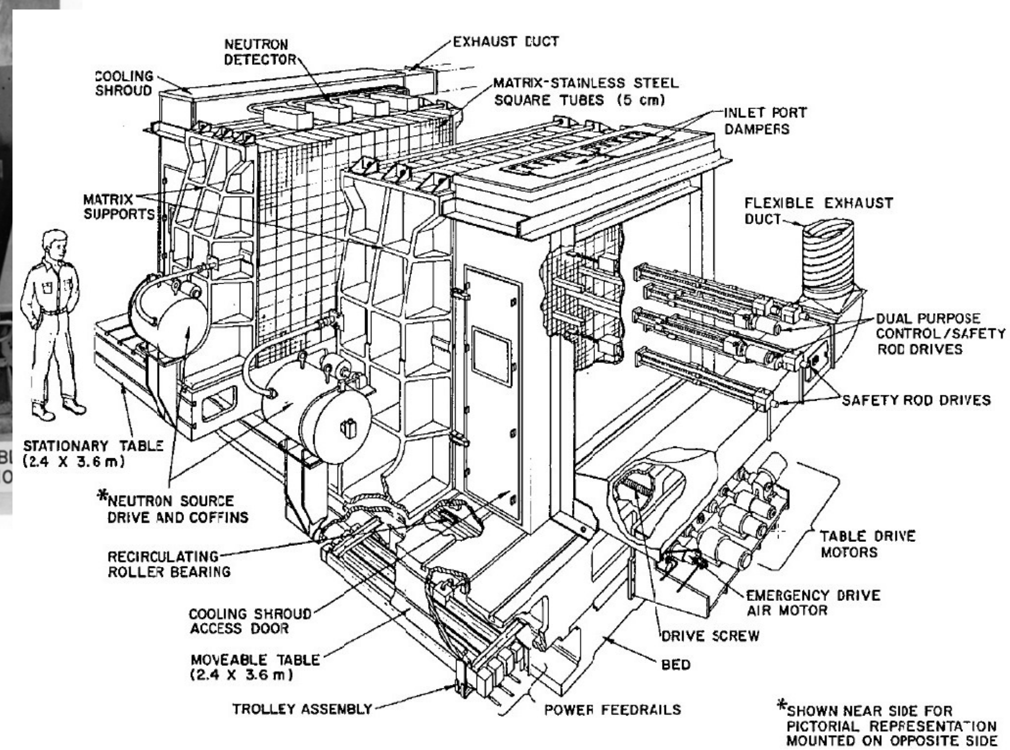
- Honeycomb – Los Alamos National Laboratory

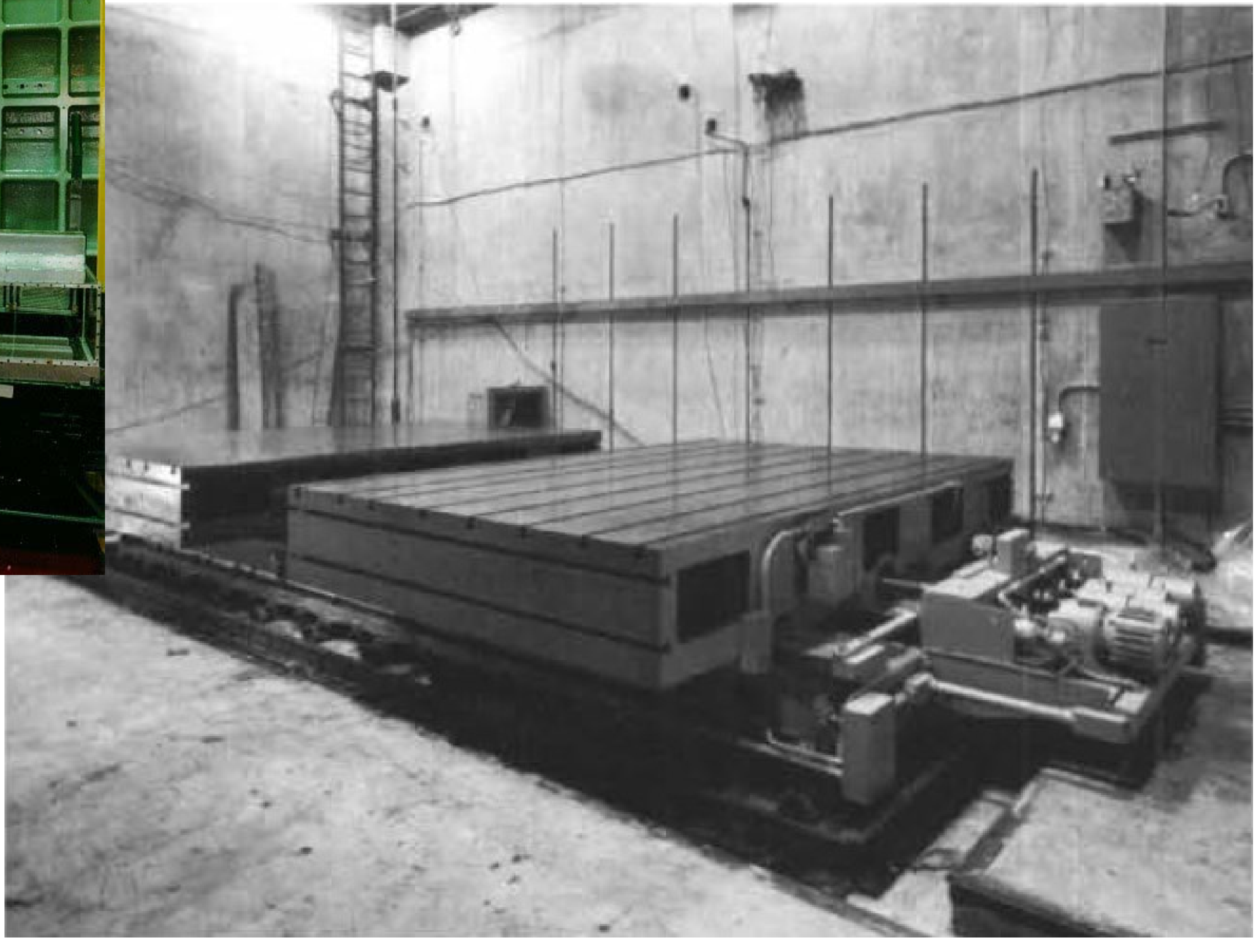


Survey of Past Split-Table Machines

- ZPR, ZPPR – Argonne National Laboratory







Survey of Past Split-Table Machines

- Horizontal Split-Table Critical Assembly – Oak Ridge National Laboratory

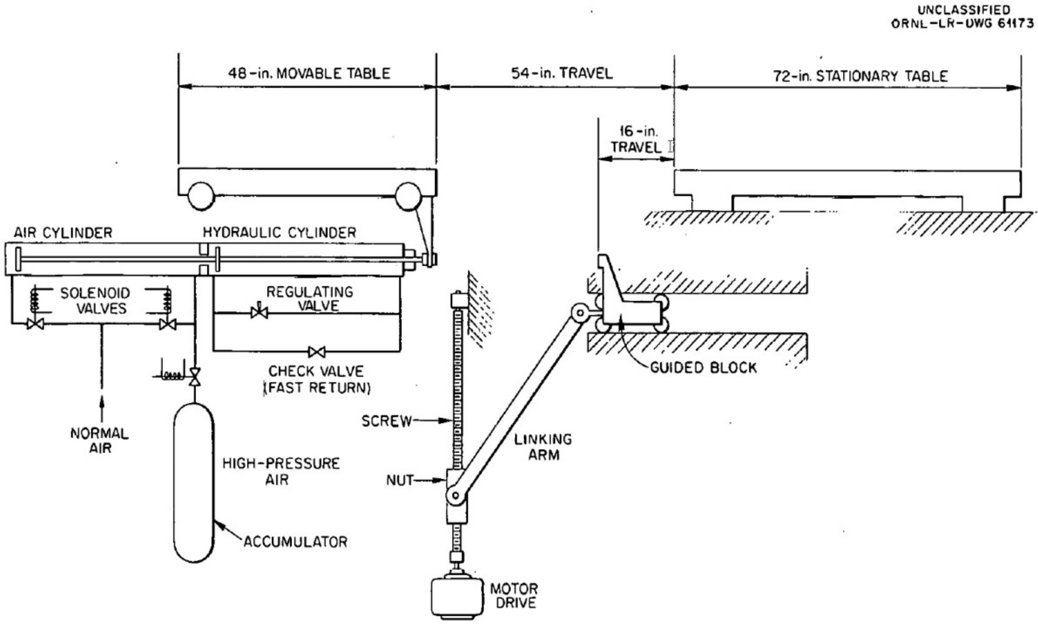
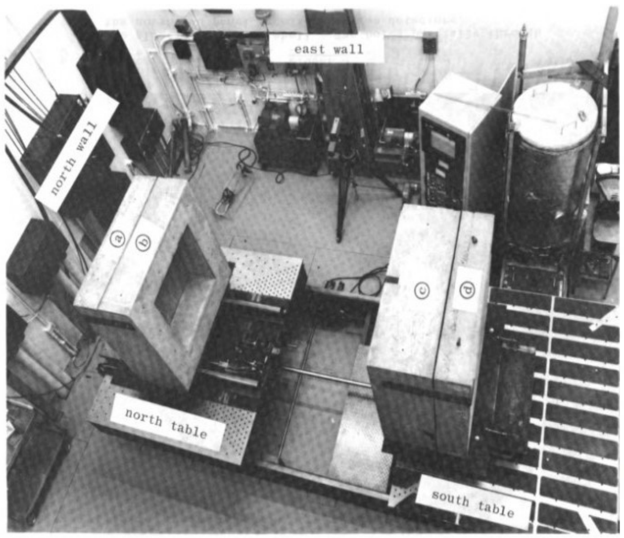
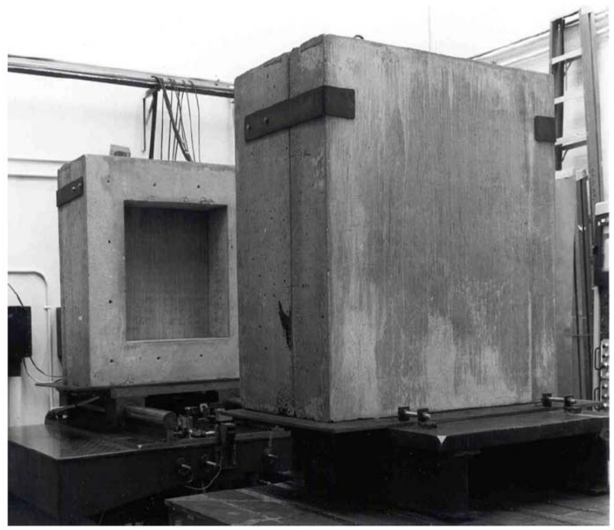


Fig. 3.6.3. Schematic of Drive Arrangement for Split-Table Machine.

Survey of Past Split-Table Machines

- Horizontal Split-Table Critical Assembly – Rocky Flats



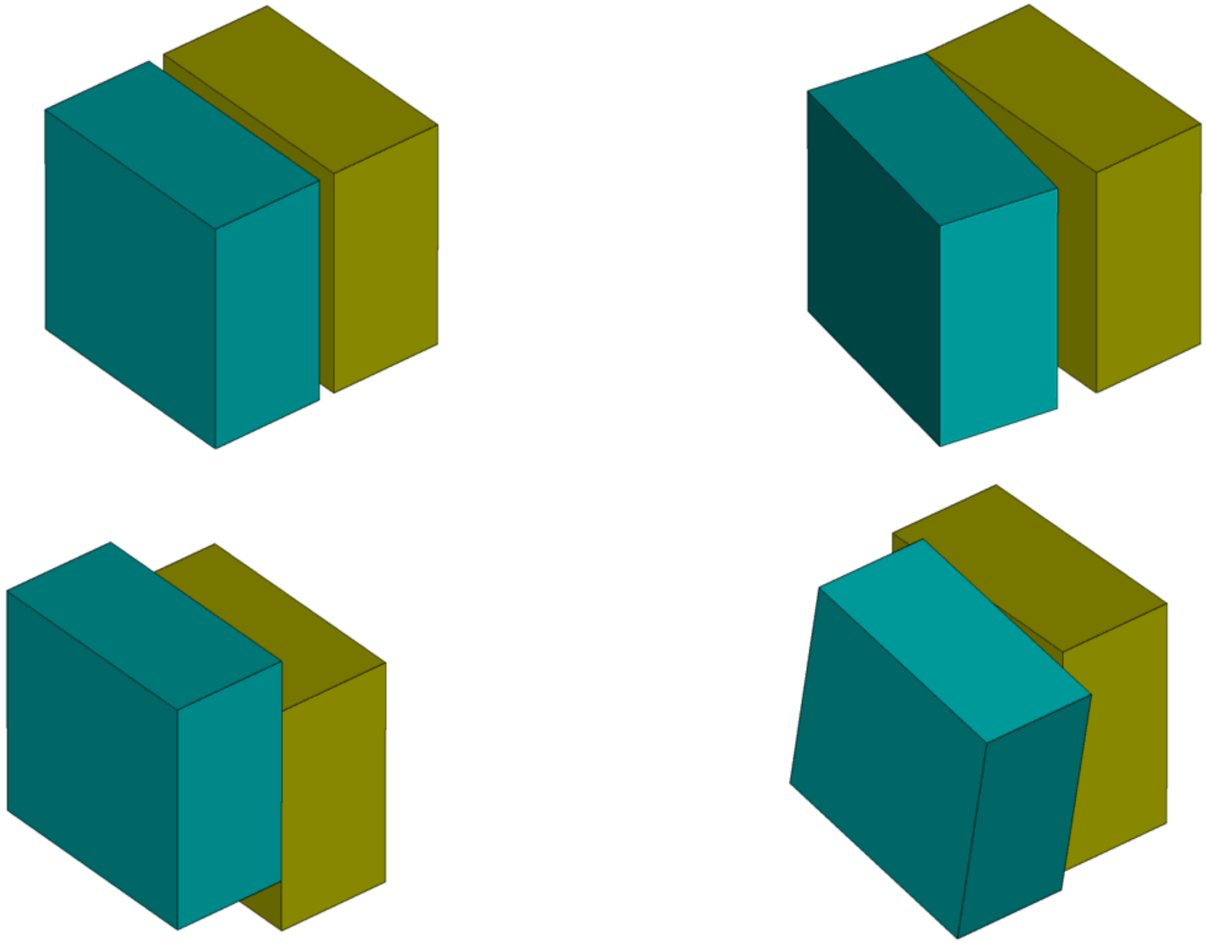



What We Learned

- How past designs were designed and operated
- Two Major core-supporting structures
- Very large in dimensions and mass
- Commonalities to Current Critical Assemblies
  - A fast-acting fail-safe safety system;
  - A plant-protection system to back the operators up in unplanned events;
  - A control system for fine reactivity adjustment

Split-Table Sensitivities

- Possible Geometric Inaccuracies



Notional Critical Experiments

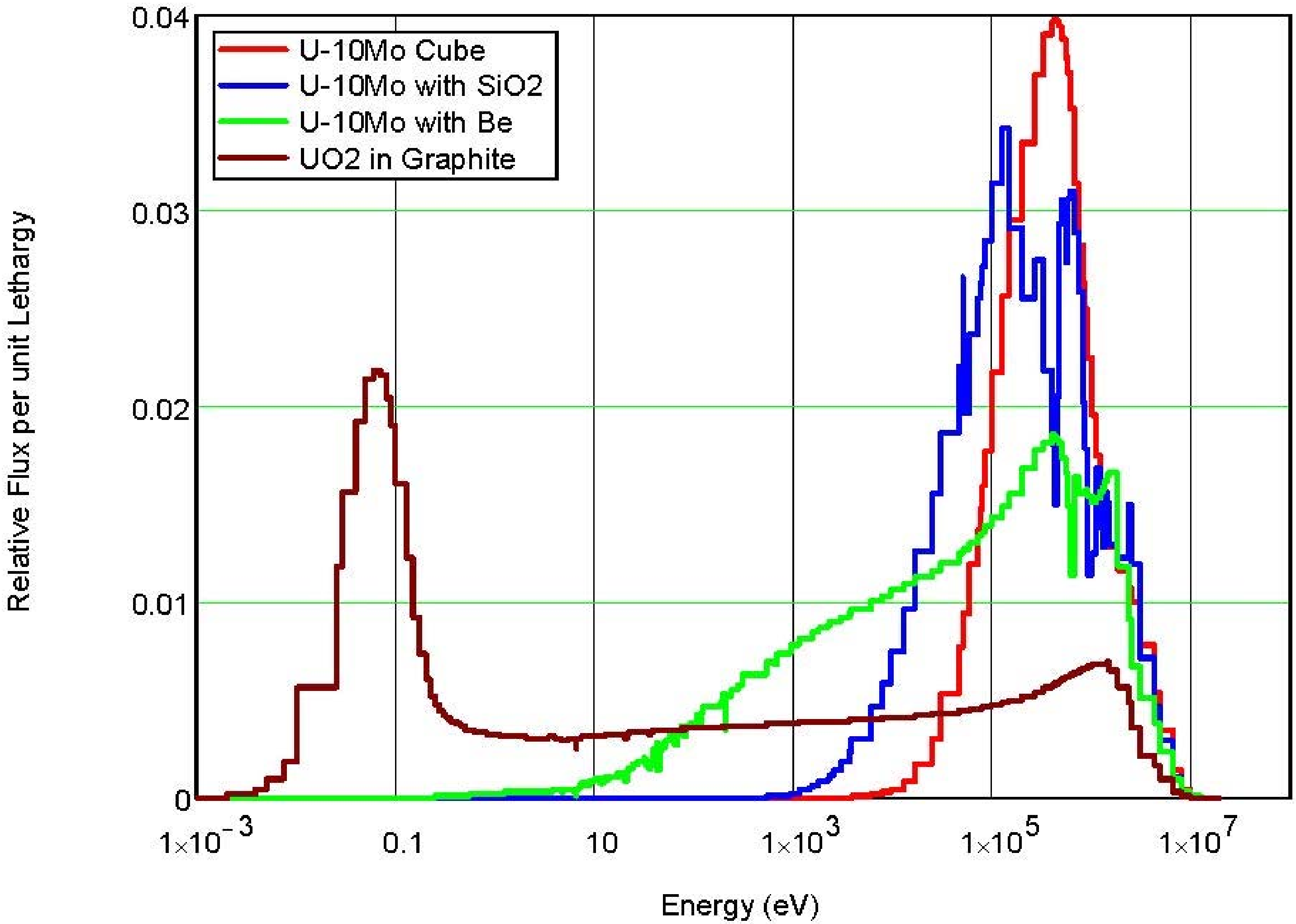
- U-10Mo Cube
- U-10Mo with SiO_2
- U-10Mo with Beryllium
- UO_2 mixed with and reflected by graphite

Table 2-2. Characteristics of Four Critical Assemblies Used in Study

	U-10Mo Cube	U-10Mo with SiO_2	U-10Mo with Be	UO_2 with Graphite
Fuel	U-10Mo	U-10Mo	U-10Mo	UO_2
Fuel Intrinsic Density (g/cm^3)	16.86	16.86	16.86	10.97
Diluent	None	SiO_2	Beryllium Metal	Graphite
Diluent Intrinsic Density	-	2.648	1.848	1.70
Diluent Volume Fraction (%)[1]	-	64	87	99.816
Void Fraction in the Core (%)	0	10	10	10
Fueled Volume Side Length (cm)	43.78	100	100	100
Fuel Mass (kg)	1,415	5,463	1,973	18.2
Reflector	None	None	None	Graphite
Reflector Thickness (cm)	-	-	-	50

1. Fraction of the non-void core volume that is occupied by the diluent.

Neutron Spectra of Four Critical Assemblies



Conceptual Design of the Horizontal Split-Table Critical Assembly

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Experiment:

- Platform position(s) must be established, maintained, and controlled along a 3-axis reference datum to within approximately 0.0005-inch or better (intent to report in the 4th decimal).
- Platforms are to be flat and parallel (intent to establish these tolerances in the 4th decimal).
- Metal platform, structurally sound to control and maintain position relative to datum tolerances throughout all ranges of motion up to maximum payload.
- Fixed table and movable table must come together and touch.
- Position reporting in three (3) axis is preferred.

Control:

- Platform separates using a simple remote command/control approach with the capability to start, stop, and change direction at the desire of the operator.
- Provision for monitoring and reporting system response will be required for travel speed, direction, and position.
- Safety interlocks will be required to control unintended or inadvertent system response.
- Translation axis must move and be controlled, however, there is no rate of motion (movable table speed) requirements.
- No interface between the split-table control system and the reactor control system (i.e., any SCRAM feature would be performed by the reactor control system).
- Capability to control the split-table locally as well as from a remote control room shall be provided.

Conceptual Design of the Horizontal Split-Table Critical Assembly

Regulatory:

- Under a graded approach, a quality program will be instituted to address the criteria established within 10 CFR 830, Subpart A.

Mechanical:

- Payload Capacity: Six (6) metric tons.
- Payload Support Area: 6 ft. x 6 ft.
- Platform horizontally separates approximately in half along one axis (each half capable of supporting three [3] metric tons with a payload support area of approximately 3 ft. × 6 ft.). Separation distance to be approximately 3 ft. to 8 ft.

Design Assumptions:

- Specify suitable materials for use with a research reactor with intent to avoid generation of RCRA and mixed wastes.
- Provision to locate and secure the experiment to the table surface will be required.
- Look at industry for similar applications and functional use. An example includes large milling and machining platforms used to support manufacture of large heavy machine components and hardware (aircraft engines, diesel engines, etc.).
- Prefer commercial off-the-shelf (COTS) to minimize customization of components and control system.
- Design and selection of components and hardware to include reference to relevant industry standards for equipment that performs a similar function.
- Overall footprint of split-table must fit within existing building.

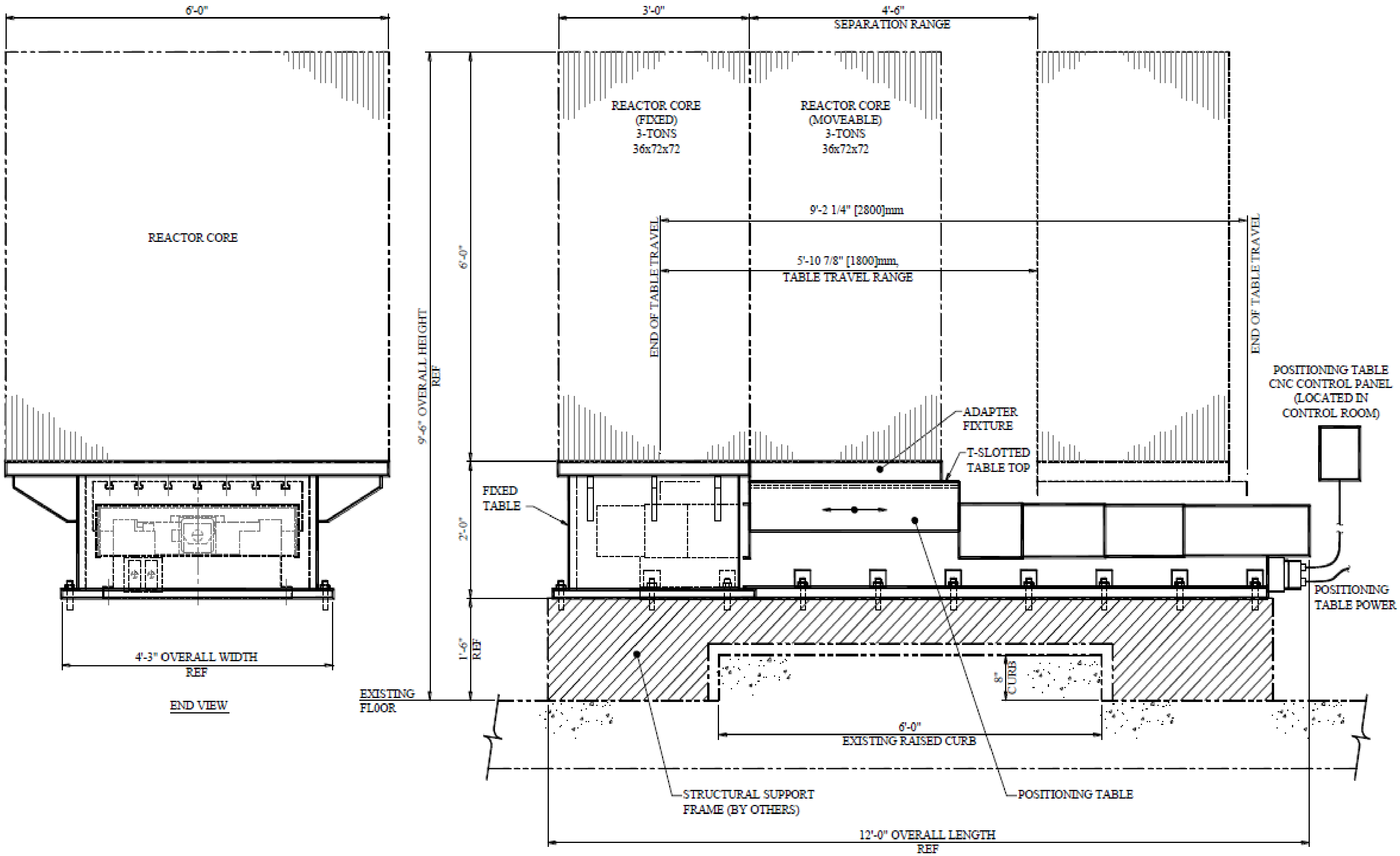
Shutdown Mechanisms

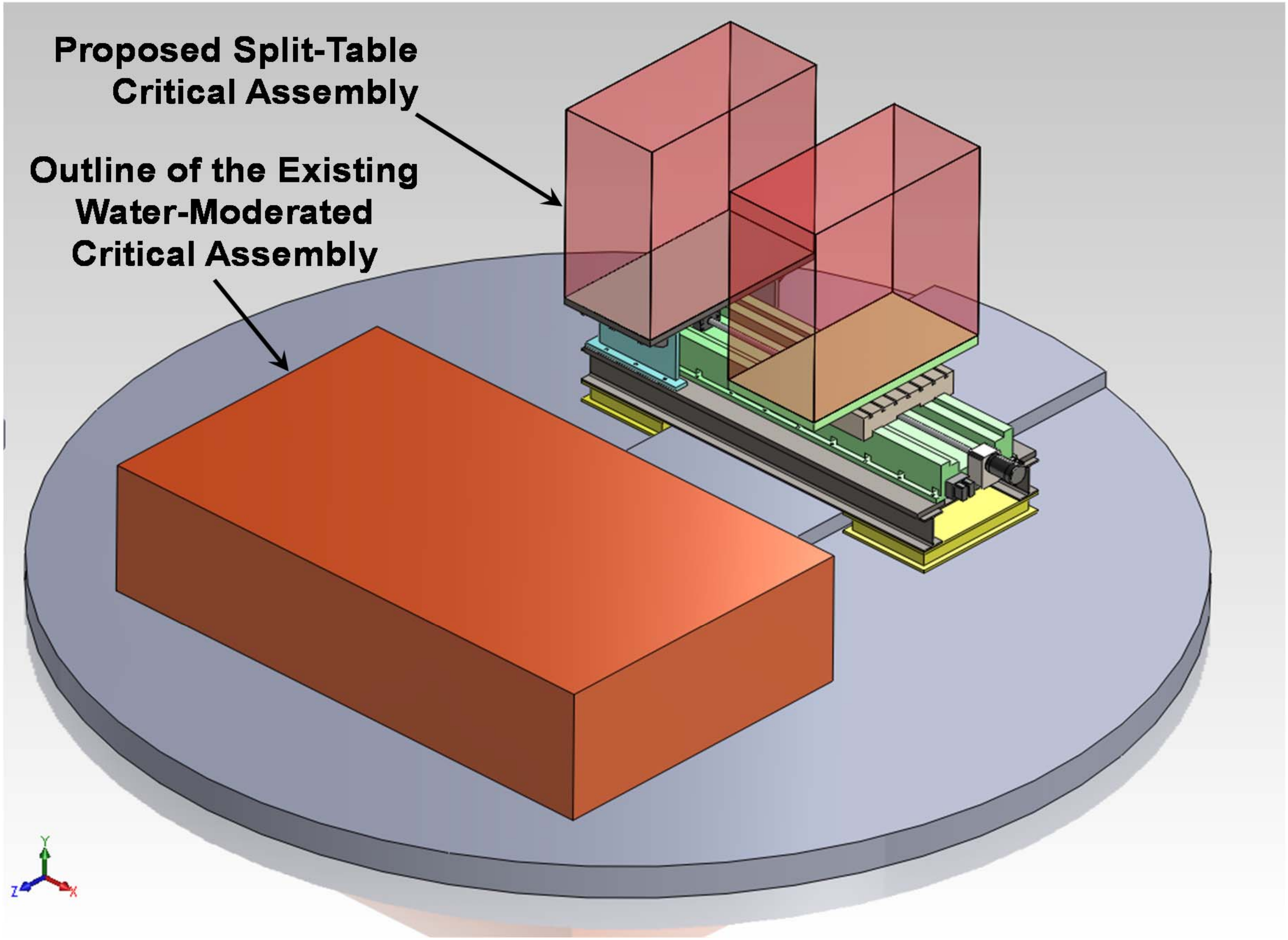
- Experiment Dependent
- Separation of Two Halves
  - Primary or Secondary Shutdown
  - SCRAM Initiated
- Insertion of Absorber Rods
  - Most Worth for Thermal Systems
- Reflector Control
  - Most Worth for Hard (Fast) Spectrum Experiments
- In-Core Control Mechanisms

Design Options

- Build the split-table assembly from scratch;
- Build the split-table assembly from a large commercial off-the-shelf (COTS) boring/milling machine modified to include a fixed table;

Split-Table Design Concept - Elevation View




Proposed Split-Table
Critical Assembly
Outline of the Existing
Water-Moderated
Critical Assembly

Critical Assembly Feasibility

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- Systems Using Fuel Currently Available at the SCX
  - 7uPCX and BUCCX Fuel with Polyethylene
  - 7uPCX Fuel with Graphite Moderator
  - Harder Neutron Spectra with Existing Fuel
- Systems with New Fuel
  - Uranium Metal with 10 Weight Percent Molybdenum (U-10Mo)
  - Homogeneous Systems with U-10Mo Fuel
  - System with U-10Mo Plates Interleaved with Graphite

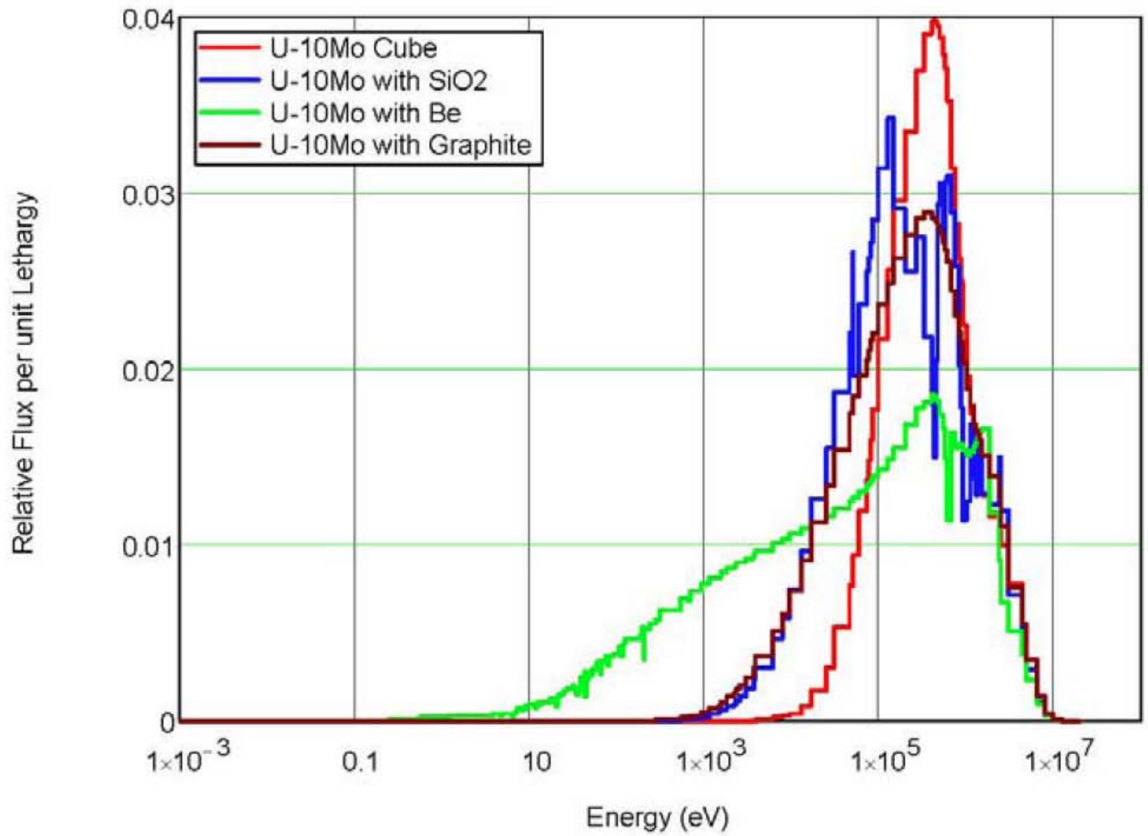

Figure 5-4 Comparison of Neutron Spectra in Four U-10Mo Fueled Systems

Conclusion

- Reviewed Past Split Table Designs
  - LANL, Argonne, ORNL and Rocky Flats Plant
- Sensitivities of Notional Critical Experiments
- Possible Shutdown Mechanisms
- Experiment Feasibility with Existing Fuel and New Fuel