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Radiation Transport Modeling of Beam-Target Experiments for the AAA Project: Quaterly Report

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Quarterly Report

AAA/UNLV University Participation Program

Title:

Radiation Transport Modeling of Beam-Target Experiments for the AAA Project

2362-254-504M

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1. Project Description

The national development of technology to transmute nuclear waste depends upon the generation of high energy neutrons produced by proton spallation. Proton accelerators, such as LANSCE at the Los Alamos National Laboratory, are capable of producing 800 MeV protons. By bombarding a lead/bismuth target, each proton may generate 500 or more neutrons that can activate fission products or induce the fission of transuranic isotopes.

The Monte Carlo radiation transport code MCNPX developed at LANL is an important tool in the design of transmuter technology. It must be validated, however, for the neutron energy that will be employed. Experiments are being conducted at LANSCE to test the ability of MCNPX to accurately predict neutron production and leakage rates from lead/bismuth targets. Students at UNLV are being educated in the use of MCNPX to analyze the results of these tests and to use the software to in the development of future experimental studies.

2. Review of Tasks

The development of new systems for the transmutation of nuclear waste will depend upon computational tools that can provide an accurate assessment of the system performance. MCNPX, a Monte Carlo neutron transport code, will be used by UNLV students to support AAA experimental work at LANSCE. The tasks listed in the proposal are outline in the table below. The work conducted in the first quarter is highlighted in this report.

	Year 1											
Task	9/01	10/01	11/01	12/01	1/02	2/02	3/02	4/02	\5/02	6/02	7/02	8/02
Neutron Leakage Experiments												
MCNPX Training												
LANL/LANSCE Visits and Work												
Postanalysis of neutron data												
Sodium Activation Experiments												
MCNPX Training												
MCNPX (and other codes) modeling												
LANL/LANSCE Visit												
Analysis of Data												
Actinide Fission Measurements												
Neutron Multiplicity Measurements												
MCNPX Simulations												
LANSCE Site Visit												

The first quarter report covers work completed to mid December.

Tasks

- Acquire MCNPX for use on student workstations and provide for the adequate training of the student researchers.

- Work with Drs. Beller, Klann, Pitcher, and Wender along with other researchers at LANL and ANL to model the integral experiment at LANSCE.

- Conduct MCNPX simulations of the preliminary design of an integral experiment to estimate the neutron leakage from lead/bismuth targets of varying radii. Provide similar computational support for proton activation experiments in sodium coolant.

3. Progress in the First Quarter

- Student Training

The initial phase of the project involved hiring students to work on the project and providing them with the tools to assist in the MCNPX simulations. Computers were ordered for the students and software was installed to conduct the studies.

Several students have been employed on the project. During the first quarter of this project, the students were trained in the use of software that will be employed on both this project and a second AAA project titled: "Nuclear Criticality Analyses of Separations Processes for the Transmutation Fuel Cycle." During the second quarter, they will be assigned individually to each project. The students include:

* Jason Viggato - doctoral student in mechanical engineering.
* Daniel Lowe – sophomore in mechanical engineering.
* Elizabeth Bakker – senior in mechanical engineering.
* Maurice Moore – masters student in mechanical engineering. Mr. Moore is an officer at Nellis AFB and is not receiving financial support from this project.
* Suresh Sadenini – masters student in mechanical engineering. Mr. Sadenini is on a teaching assistantship this semester and is not receiving financial support from this project. He is working on his M.S. project in neutron spallation.

Acquisition of MCNPX

With the assistance of Dr. Beller, we have been added to the MCNPX beta test team. This has allowed us access to the most recent version of MCNPX. Two new workstations were acquired for student use on the project. Both machines have 500 MB of RAM and 1.8 GHz processors.

The beta versions of MCNPX are available for computers employing the UNIX and Linux operating systems. An additional 800 MHz machine with 384 MB of RAM and a 30 GB hard disk has been installed with Redhat Linux version 7.2. The most recent version of MCNPX was installed on this multiuser machine and accounts are being added for student access. This computer is connected to the internet and Redhat's security prevents unauthorized usage of the system.

Dr. Laurie Waters at LANL is scheduled to offer an MCNPX course at UNLV in January 2002. The students employed on this project will be signed up for the course.

Visits to Laboratory Sites

- ANL

Mr. Viggato, Mr. Lowe, Ms. Bakker, and Dr. Culbreth visited the Argonne National Laboratory to discuss research with Dr. Klann in December. The neutron spallation tests conducted at LANSCE in early December were discussed.

- IAC

Mr. Sadenini was not funded from the project during the first semester, but he is pursuing a thesis on radiation transport simulations for neutron spallation. In mid-December, he and Dr. Culbreth visited Dr. Frank Harmon at the Idaho Accelerator Center to discuss a test that they will be conducting during the summer of 2002. Dr. Harmon and his staff will use an electron accelerator to bombard a lead target. Neutrons produced by spallation will be measured and compared with MCNPX runs to verify that the code accurately predicts neutron leakage rates from the target.

Dr. Harmon has invited Mr. Sadenini to work at IAC during the summer to help with the experiment, to provide MCNPX simulations, and to analyze data. Mr. Sadenini will be supported by the IAC during the summer. This work at IAC nicely complements the work that we are doing on the LANSCE experiments.

American Nuclear Society Conference

Mr. Viggato, Mr. Lowe, Ms. Bakker, and Dr. Culbreth attended the American Nuclear Society Conference in November 2001 held in Reno, Nevada. Each student presented a paper on their work on the AAA project. Their work was also presented in poster form. Each student's paper discussed both this project and their initial work on the criticality project. Ms. Bakker's paper discussed the work in progress on radiation transport modeling. A copy of her Powerpoint presentation is included with this report as Appendix A.

4. Work Scheduled for Second Quarter

During the second quarter, students will receive training on the use of MCNPX by Dr. Laurie Waters and her staff from LANL. This week-long course will be taught at UNLV. The students visited the Argonne National Laboratory to meet with Dr. Klann in early December and Suresh Sadenini is schedule to visit with Dr. Frank Harmon at the Idaho Accelerator Center over the winter break. Based on the preliminary report on the results obtained from the neutron spallation target tests conducted at LANSCE in early December, MCNPX runs will be made to validate the ability of the software to replicate the measure neutron flux measured at various sensors around the target.

Appendix A

Student Presentation
at the
American Nuclear Society Conference
in Reno, Nevada
November, 2001

"Radiation Transport Simulations in Support of Accelerator-Based Transmutation"

Slide 1

Radiation Transport Simulations

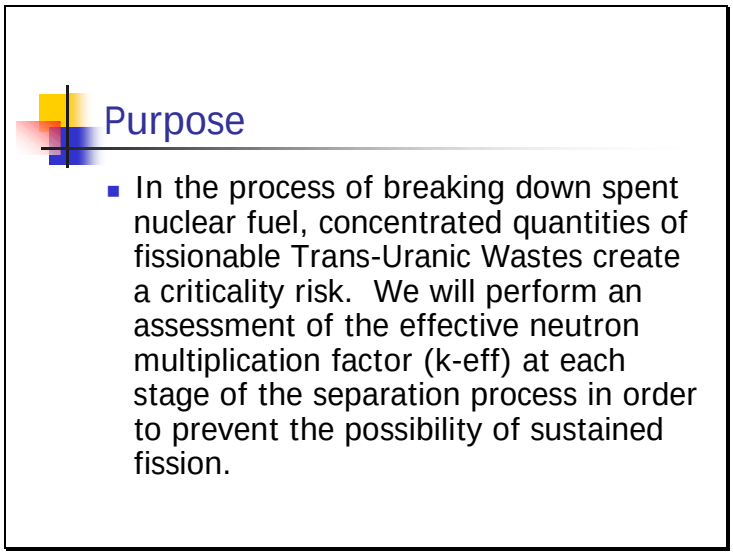
In Support of Accelerator-Based Transmutation

Elizabeth Bakker UNLV student of Mechanical Engineering

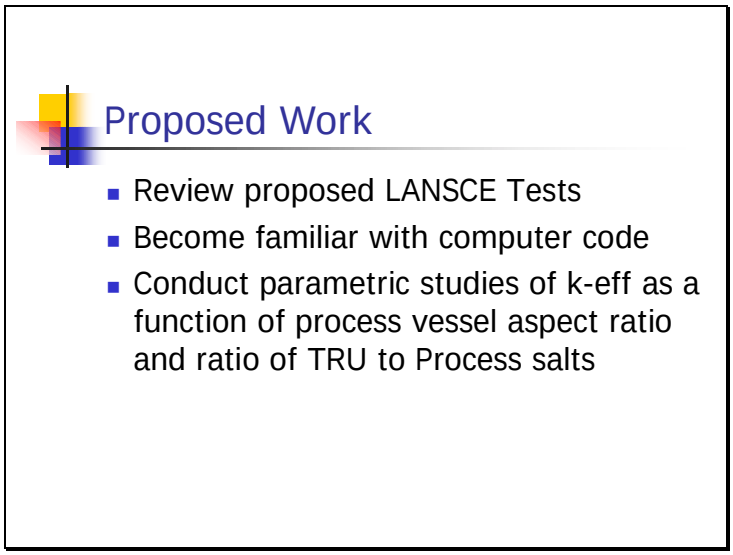
Dr. William Culbreth UNLV Professor of Mechanical Engineering

ANS Conference November 10 – 15 2001

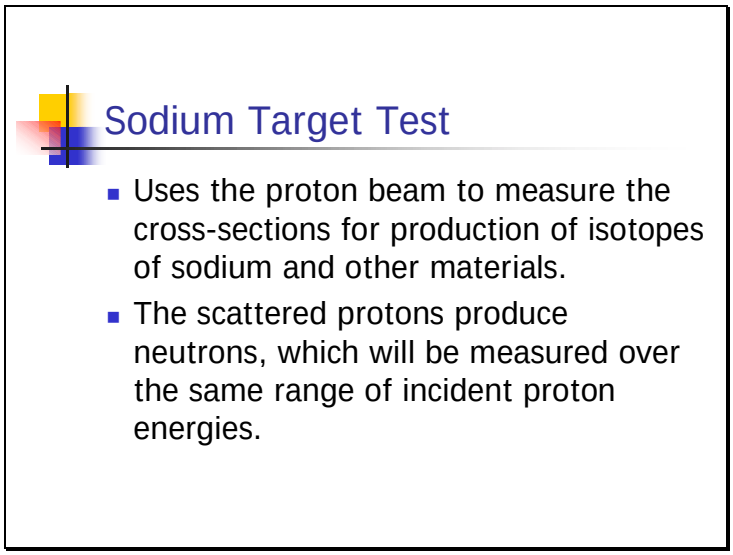
Slide 2


Purpose
In the process of breaking down spent nuclear fuel, concentrated quantities of fissionable Trans-Uranic Wastes create a criticality risk. We will perform an assessment of the effective neutron multiplication factor (k-eff) at each stage of the separation process in order to prevent the possibility of sustained fission.

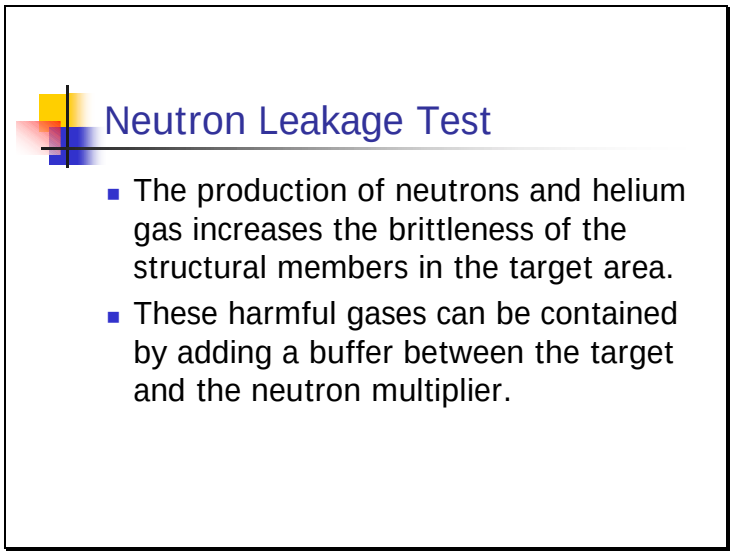
Slide 3


Proposed Work
Review proposed LANSCE Tests
Become familiar with computer code
Conduct parametric studies of k-eff as a function of process vessel aspect ratio and ratio of TRU to Process salts

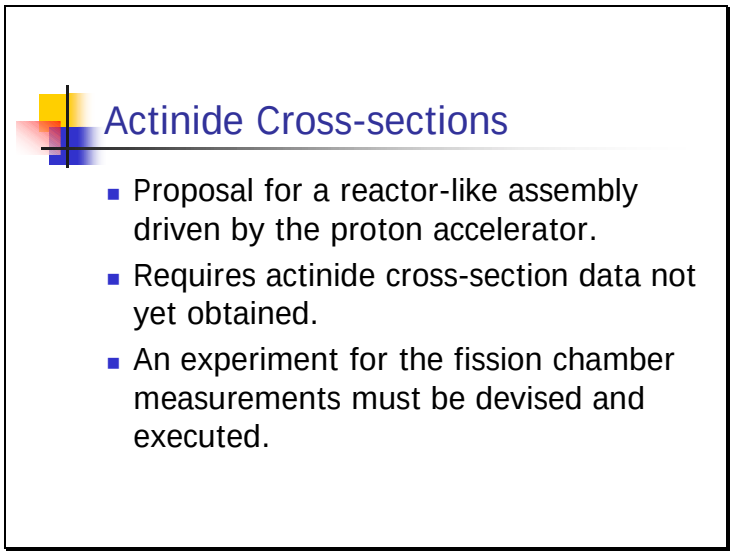
Slide 4


Sodium Target Test
Uses the proton beam to measure the cross-sections for production of isotopes of sodium and other materials.
The scattered protons produce neutrons, which will be measured over the same range of incident proton energies.

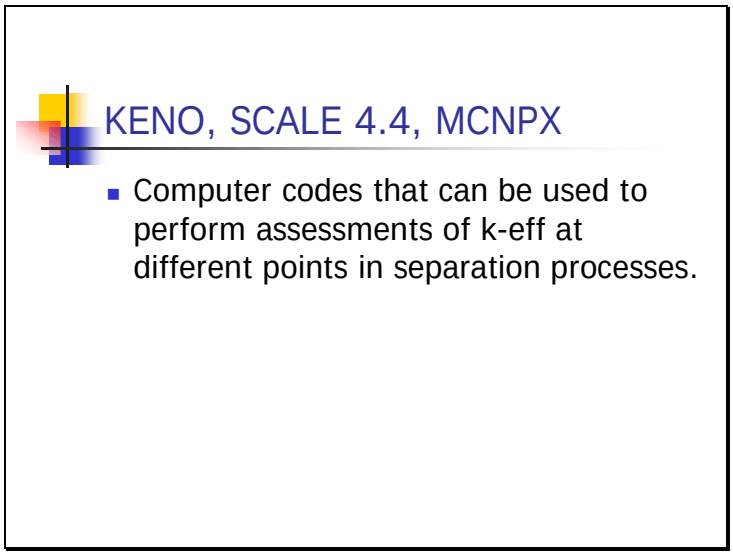
Slide 5


Neutron Leakage Test
The production of neutrons and helium gas increases the brittleness of the structural members in the target area.
These harmful gases can be contained by adding a buffer between the target and the neutron multiplier.

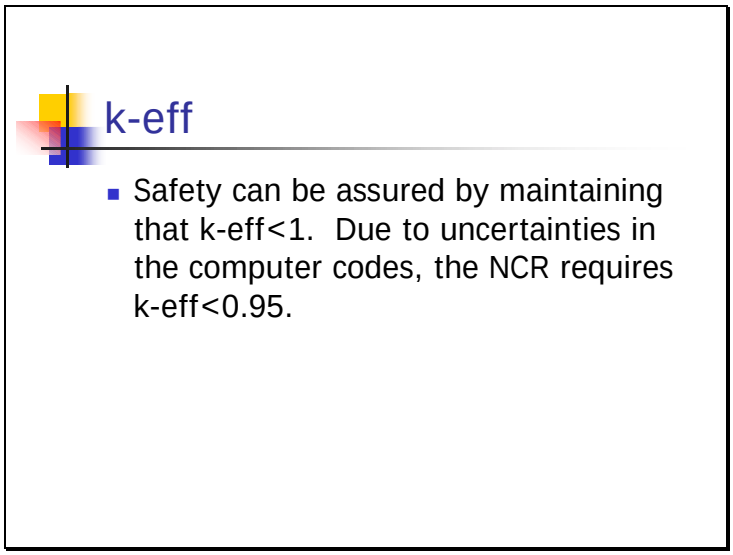
Slide 6


Actinide Cross-sections
Proposal for a reactor-like assembly driven by the proton accelerator.
Requires actinide cross-section data not yet obtained.
An experiment for the fission chamber measurements must be devised and executed.

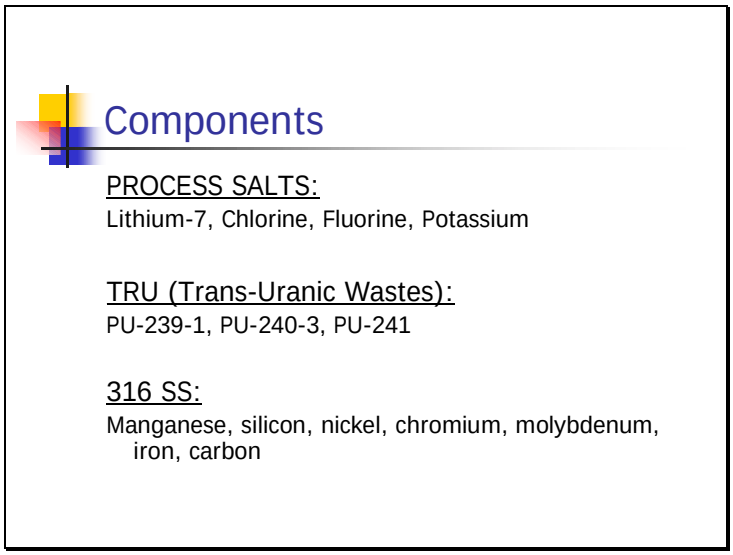
Slide 7


KENO, SCALE 4.4, MCNPX
Computer codes that can be used to perform assessments of k-eff at different points in separation processes.

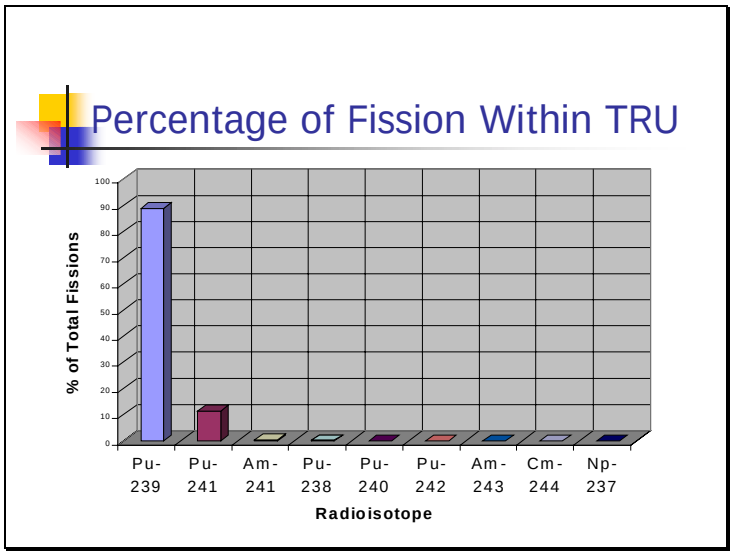
Slide 8


k-eff
Safety can be assured by maintaining that k-eff<1. Due to uncertainties in the computer codes, the NCR requires k-eff<0.95.

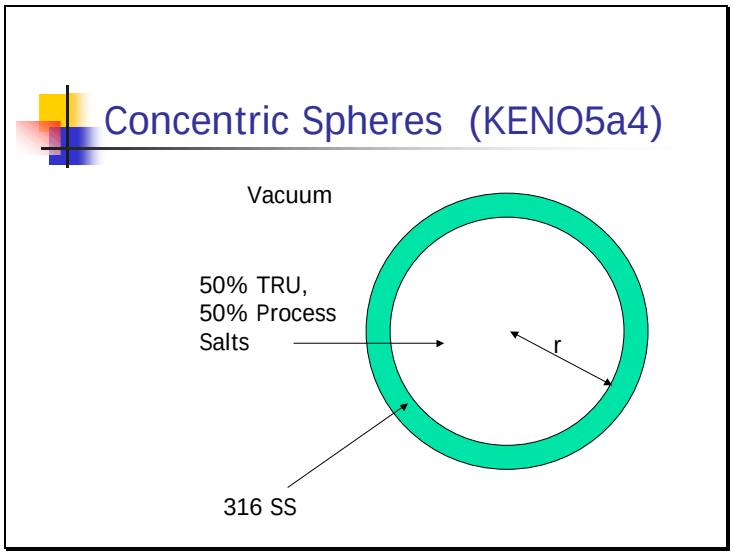
Slide 9


Components
PROCESS SALTS:
Lithium-7, Chlorine, Fluorine, Potassium
TRU (Trans-Uranic Wastes):
PU-239-1, PU-240-3, PU-241
316 SS:
Manganese, silicon, nickel, chromium, molybdenum, iron, carbon

Slide 10

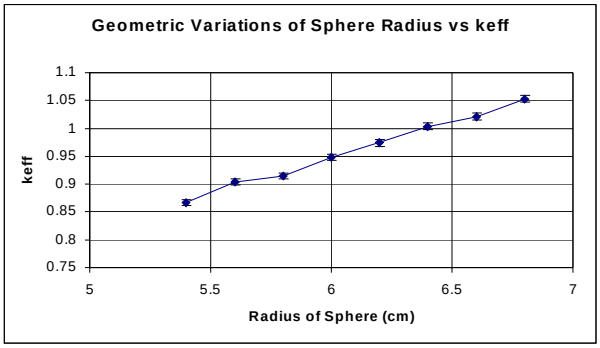

Percentage of Fission Within TRU
% of Total Fissions
100
90
80
70
60
50
40
30
20
10
0
Pu-239
Pu-241
Am-241
Pu-238
Pu-240
Pu-242
Am-243
Cm-244
Np-237
Radioisotope

Slide 11

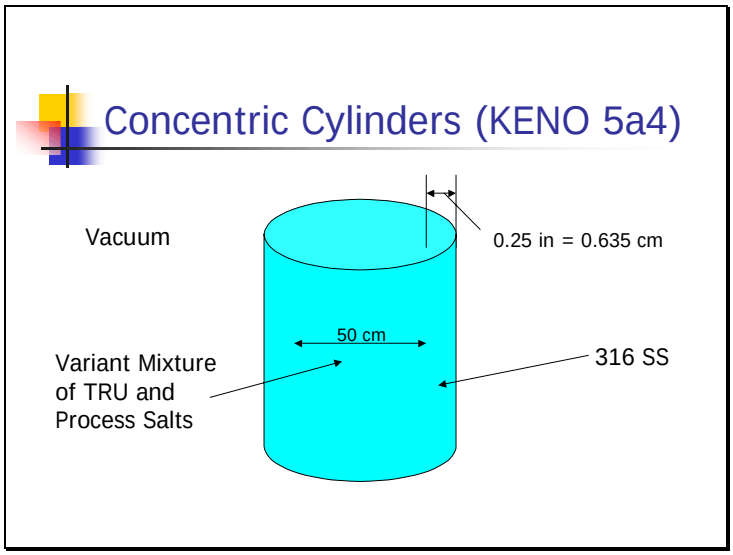

Concentric Spheres (KENO5a4)
Vacuum
50% TRU,
50% Process
Salts
r
316 SS

Slide 12

Results For Concentric Spheres

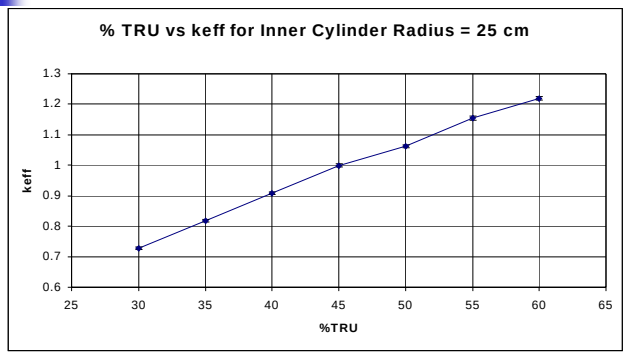


Slide 13

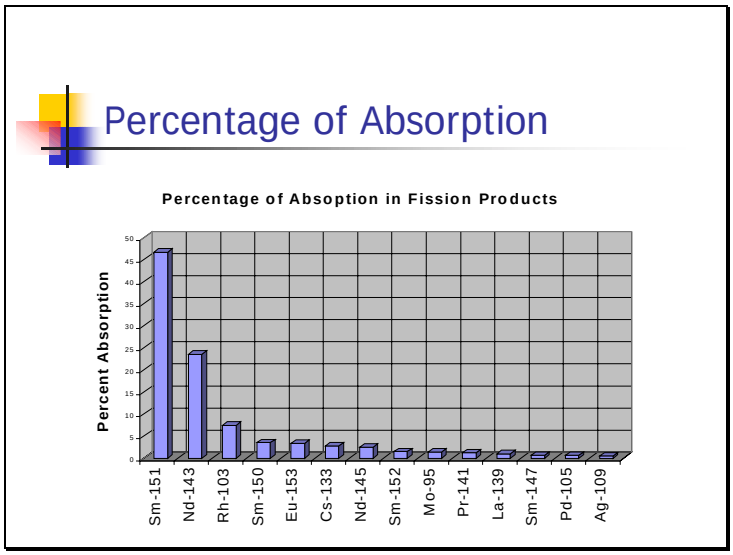

Concentric Cylinders (KENO 5a4)
Vacuum
0.25 in = 0.635 cm
50 cm
Variant Mixture
of TRU and
Process Salts
316 SS

Slide 14

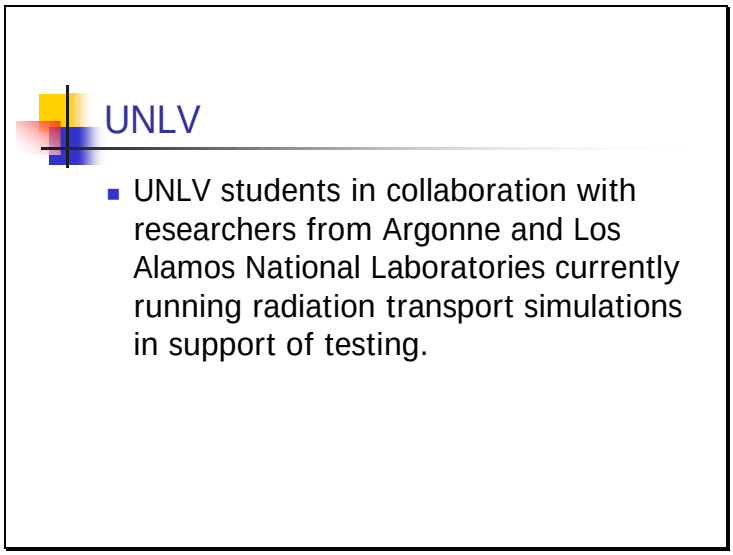
Results For Concentric Cylinders



Slide 15


Percentage of Absorption
Percentage of Absoption in Fission Products
Percent Absorption
0
5
10
15
20
25
30
35
40
45
50
Sm-151
Nd-143
Rh-103
Sm-150
Eu-153
Cs-133
Nd-145
Sm-152
Mo-95
Pr-141
La-139
Sm-147
Pd-105
Ag-109

Slide 16


UNLV
UNLV students in collaboration with researchers from Argonne and Los Alamos National Laboratories currently running radiation transport simulations in support of testing.