



**Current Engineering and Design Activities
at Los Alamos National Laboratory
Supporting Commercial U.S. Production of
99Mo without the Use of HEU**

Gregory E. Dale

Mo-99 Topical Meeting

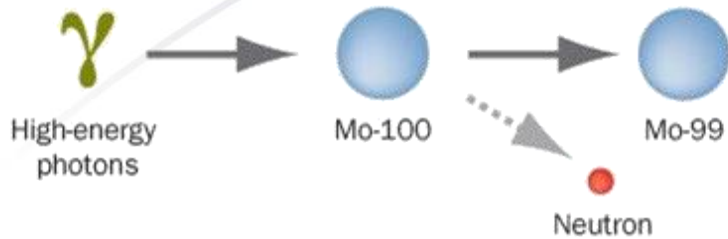
June 26, 2014



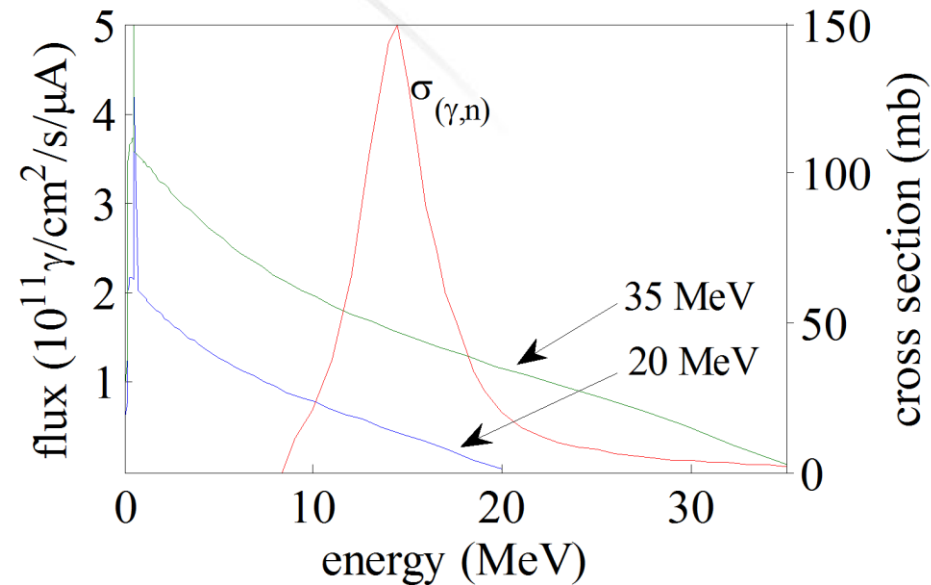
Outline

- LANL is supporting GTRI and commercial partners in the development of reliable, domestic, commercial production of ^{99}Mo that does not require the use of HEU.
- As part of the GTRI Program, we are supporting:
 - NorthStar Medical Radioisotopes with the electron accelerator production of ^{99}Mo from $^{100}\text{Mo}(\gamma, n)^{99}\text{Mo}$.
 - Shine Medical Technologies with the production of fission product ^{99}Mo from a DT accelerator driven subcritical uranium salt solution.

NorthStar Electron Accelerator Production



- The NorthStar process uses an electron accelerator to create a high flux of bremsstrahlung photons in enriched ^{100}Mo targets to create ^{99}Mo through the photonuclear reaction $^{100}\text{Mo}(\gamma, n)^{99}\text{Mo}$.
 - Reaction threshold is 9 MeV.
 - Peak cross section is 150 mb at 14.5 MeV.
- We are exploring electron beams in the 35-42 MeV range.

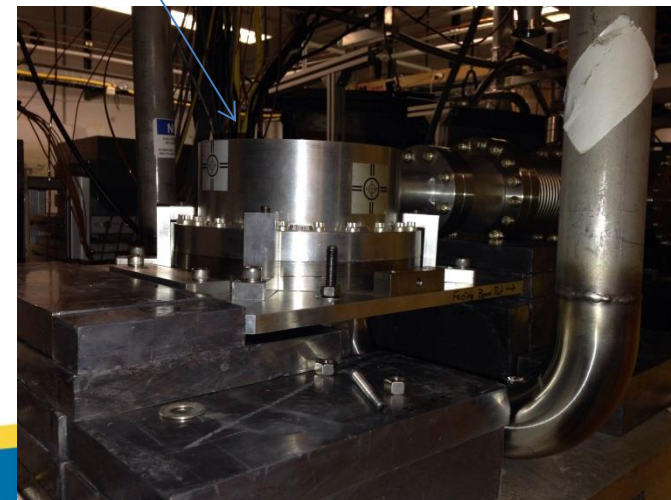
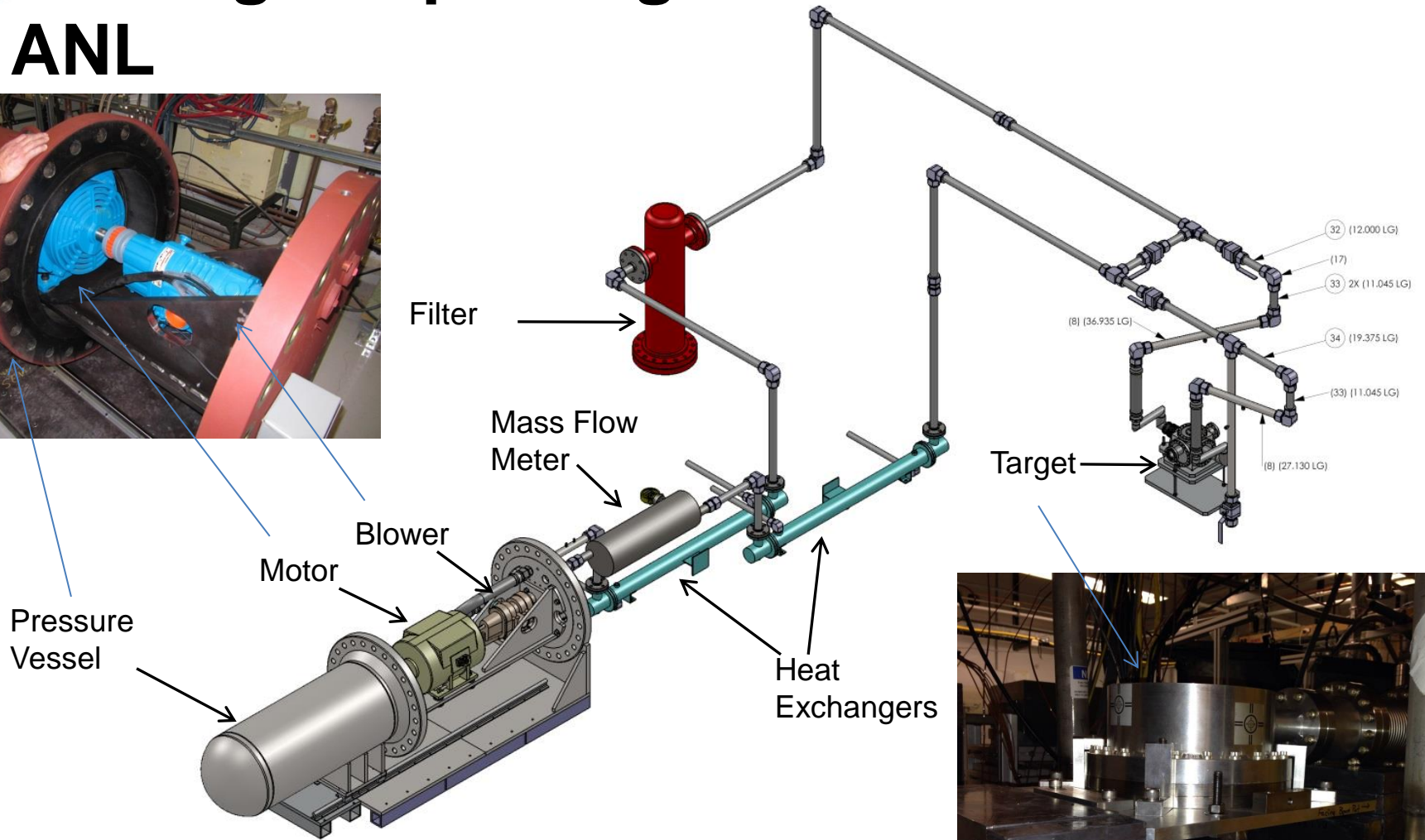
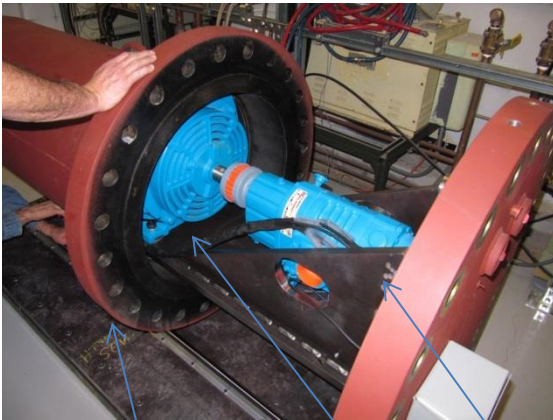


Average bremsstrahlung photon spectra produced with 20- and 35-MeV electron beams in a Mo target compared to the photonuclear cross section of ^{100}Mo .

NorthStar Support Focus Areas

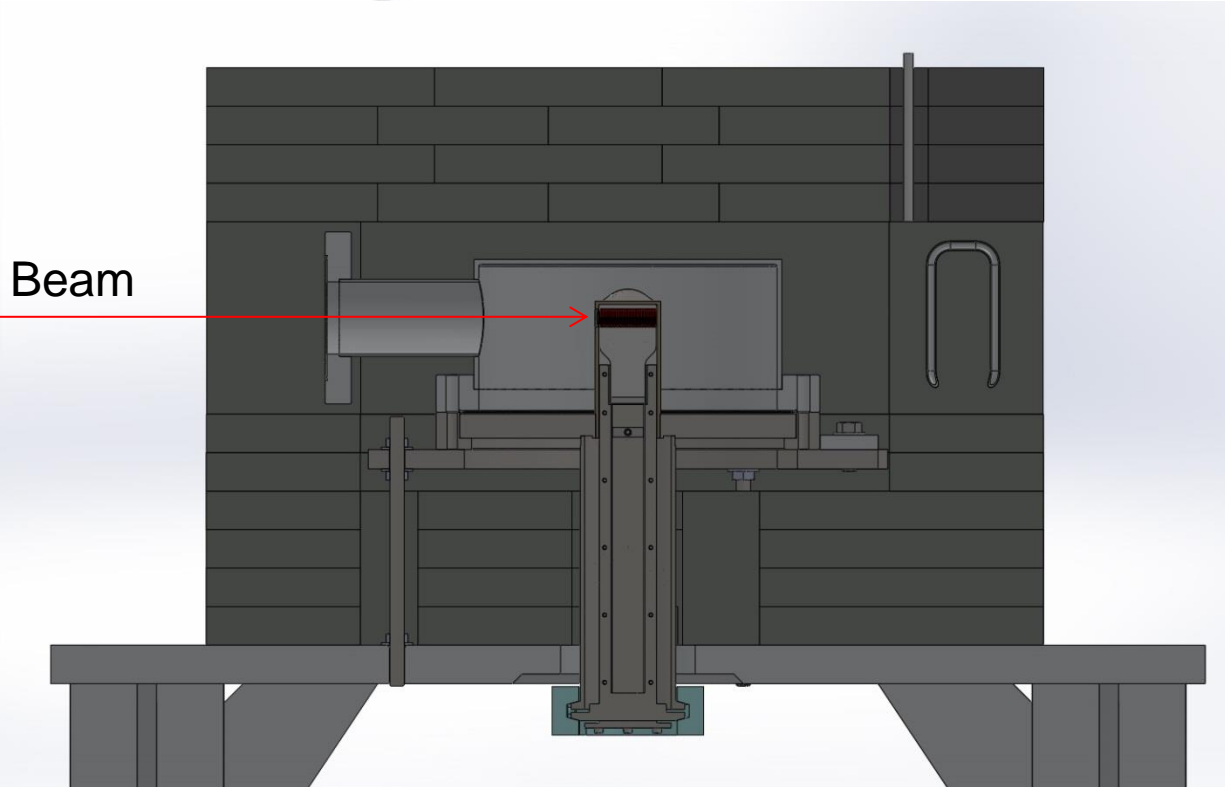
- Production and Thermal Tests at ANL
- Target Design and Testing
 - Target thermal performance
 - Production and radionuclide inventory
- Subsystem Development and Testing
 - Beam diagnostics
 - Target cooling system
 - Control systems
- Production Facility Design Support
 - Local target shielding
 - Beam line design
 - Target removal and conveyance

NorthStar Target and Helium Cooling Loop Design Installed at ANL



NorthStar Target Testing at ANL

Target Side View



Collaborating with ORNL on target disk design and production

For More on the NorthStar target design, please see Keith Woloshun's poster presentation this afternoon titled "Mo-100 to Mo-99 Production Target: Design, Analysis, and Test Results"

Backlighting Target Window

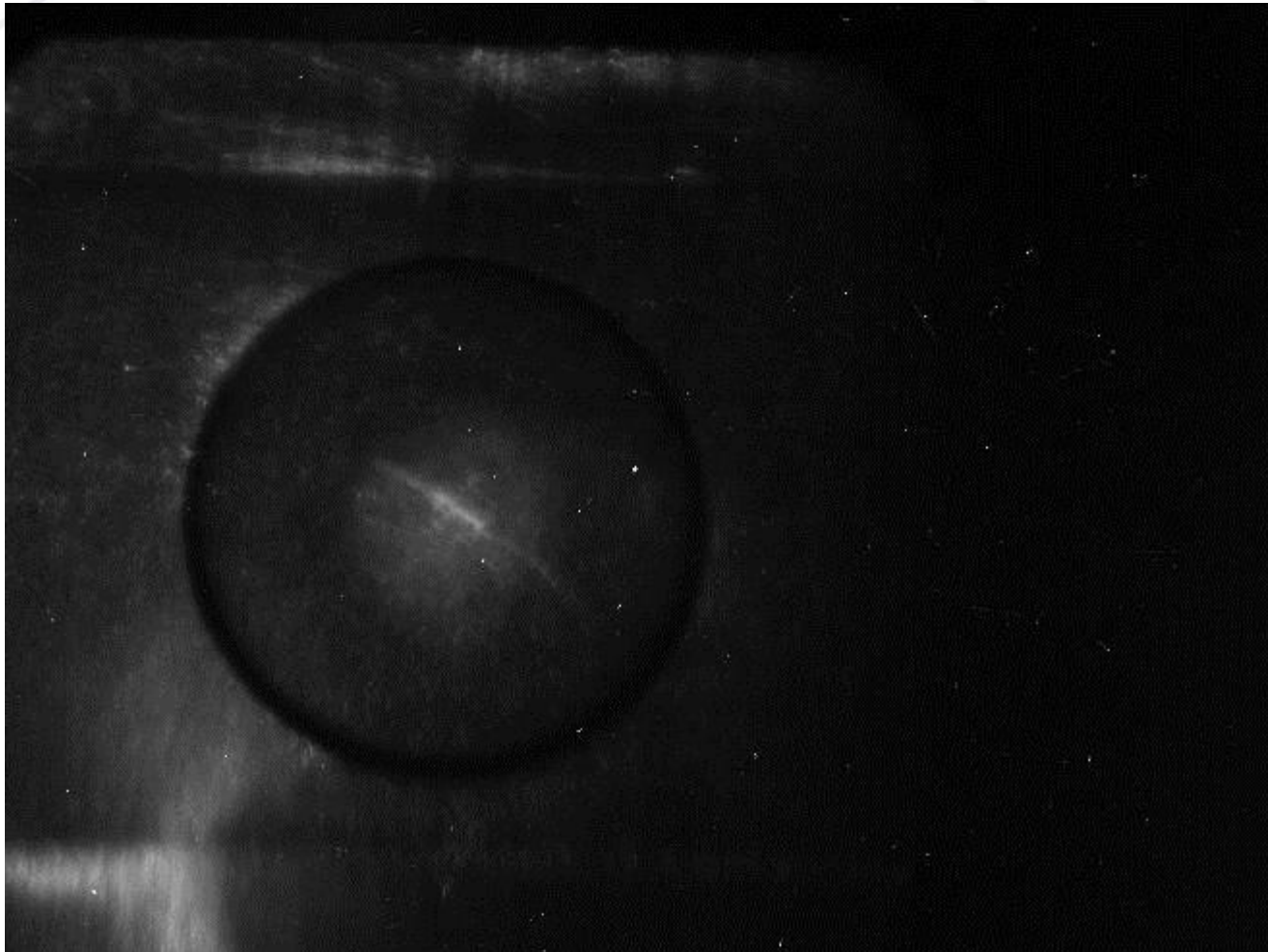
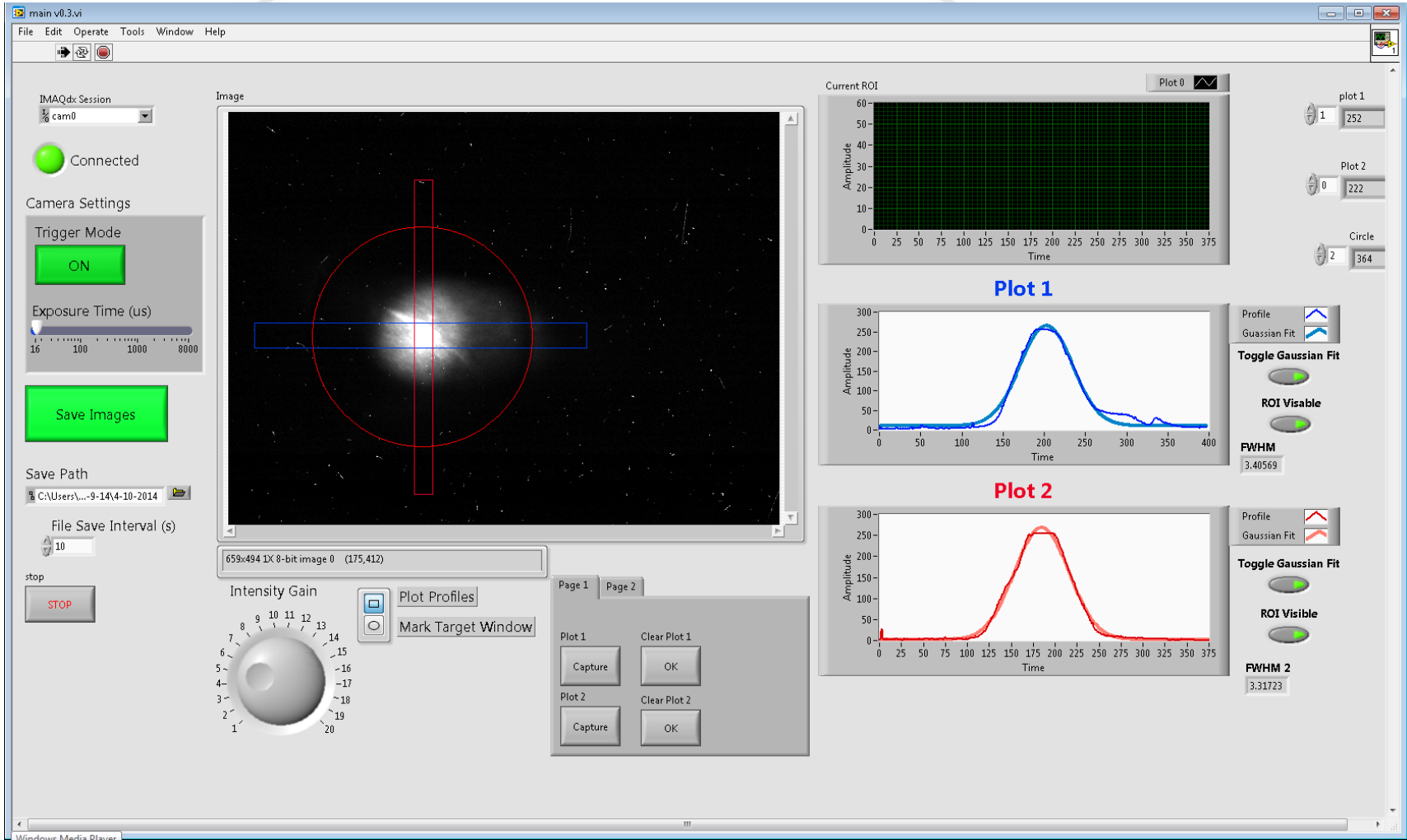


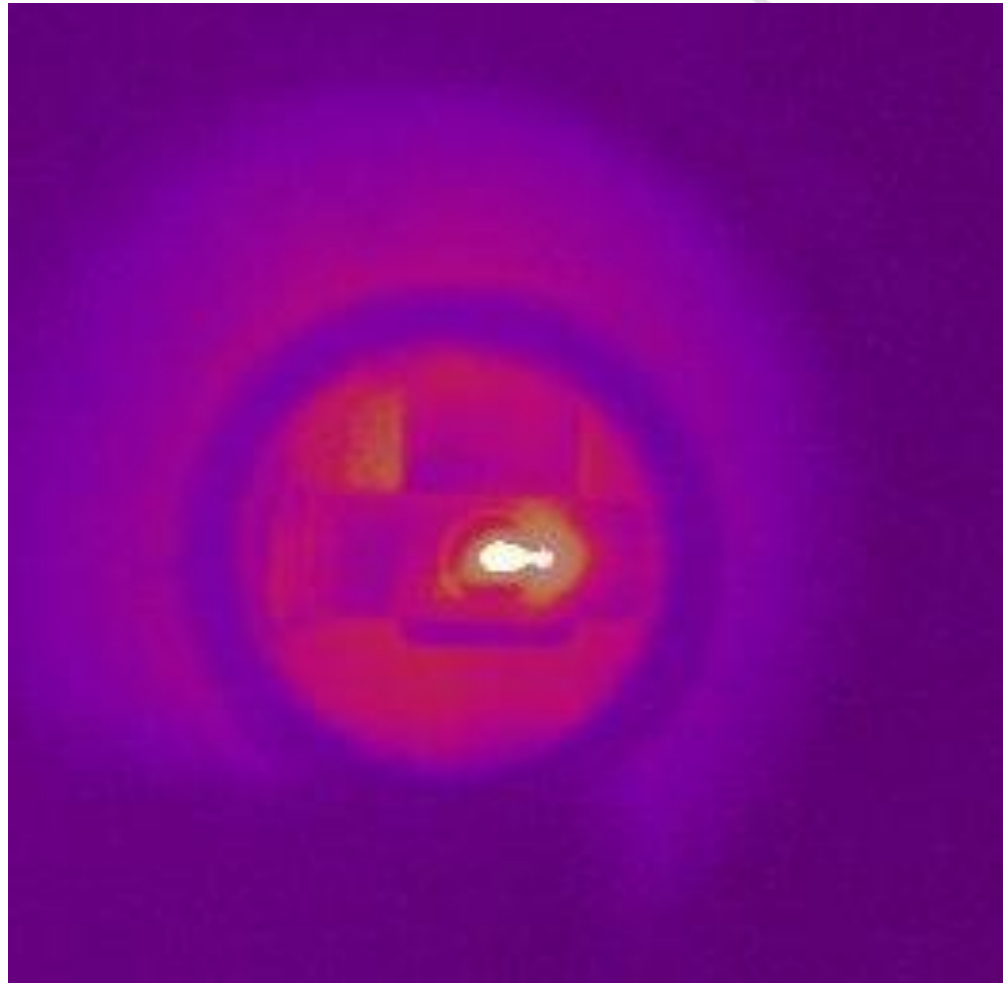
Image of Optical Transition Radiation off of the Target Window



Optical Transition Radiation Position and Profile Software

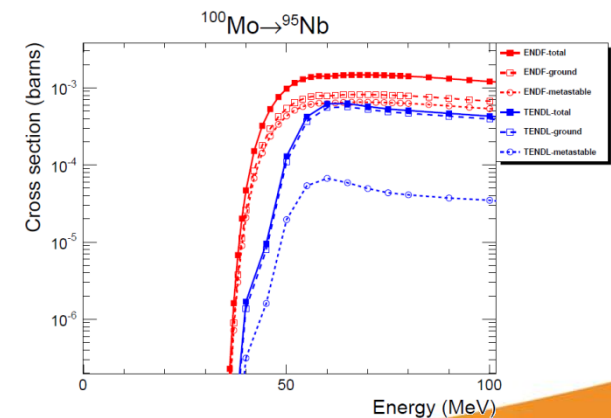
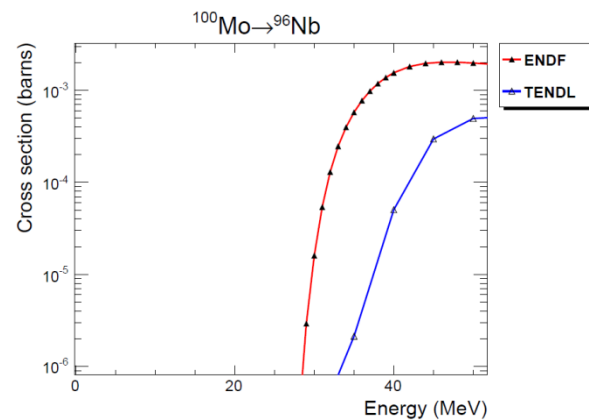
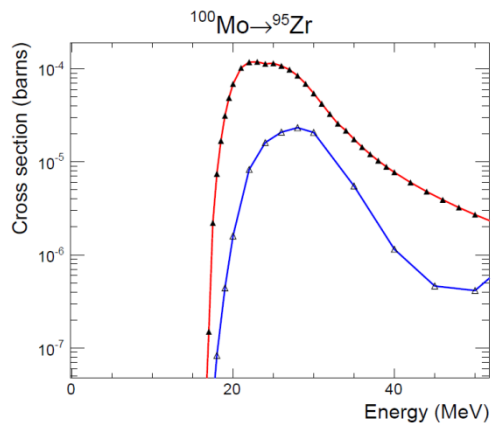


IR Camera Image



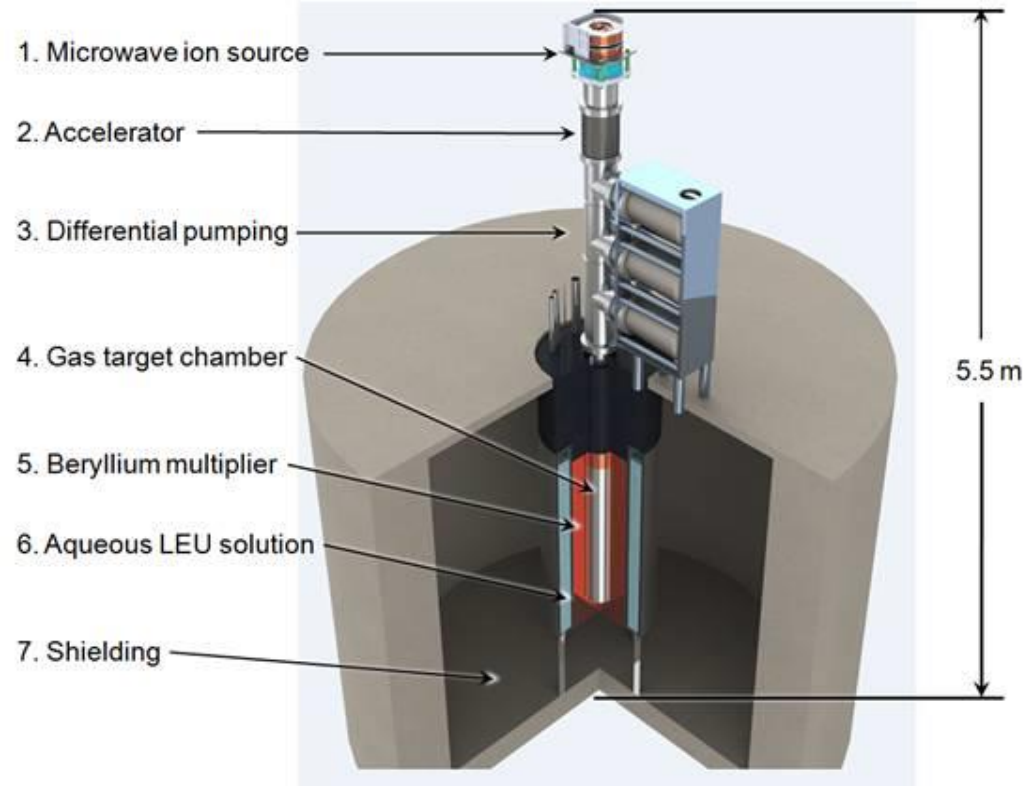
Libraries and Side Reactions

- ENDF/B-VII and TENDL-2012 libraries
 - ENDF: 163 targets and 4335 reactions
 - TENDL: 2400 targets and 301,565 reactions
- TENDL cross sections are generally lower than ENDF
- More side reaction and impurity activation analysis in future
- Half-lives: Zr-95 64 d, Nb-96 23 h, Nb-95 35 d, Nb-95m 3.6 d



LANL Support for SHINE Medical Technologies

- SHINE Medical Technologies will produce fission product ^{99}Mo in a subcritical accelerator driven low enriched uranium salt solution

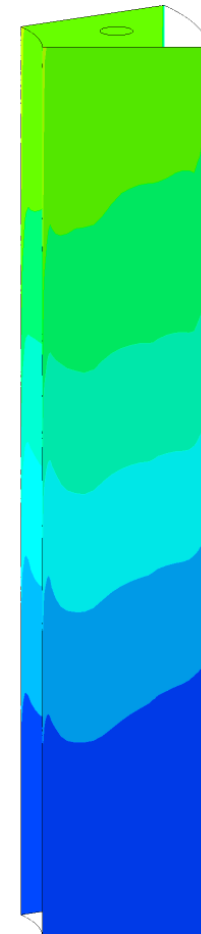
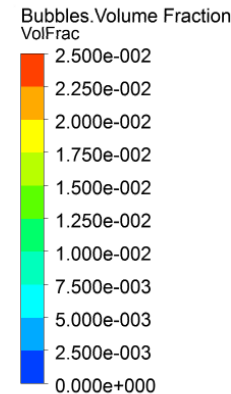


SHINE Support Activities

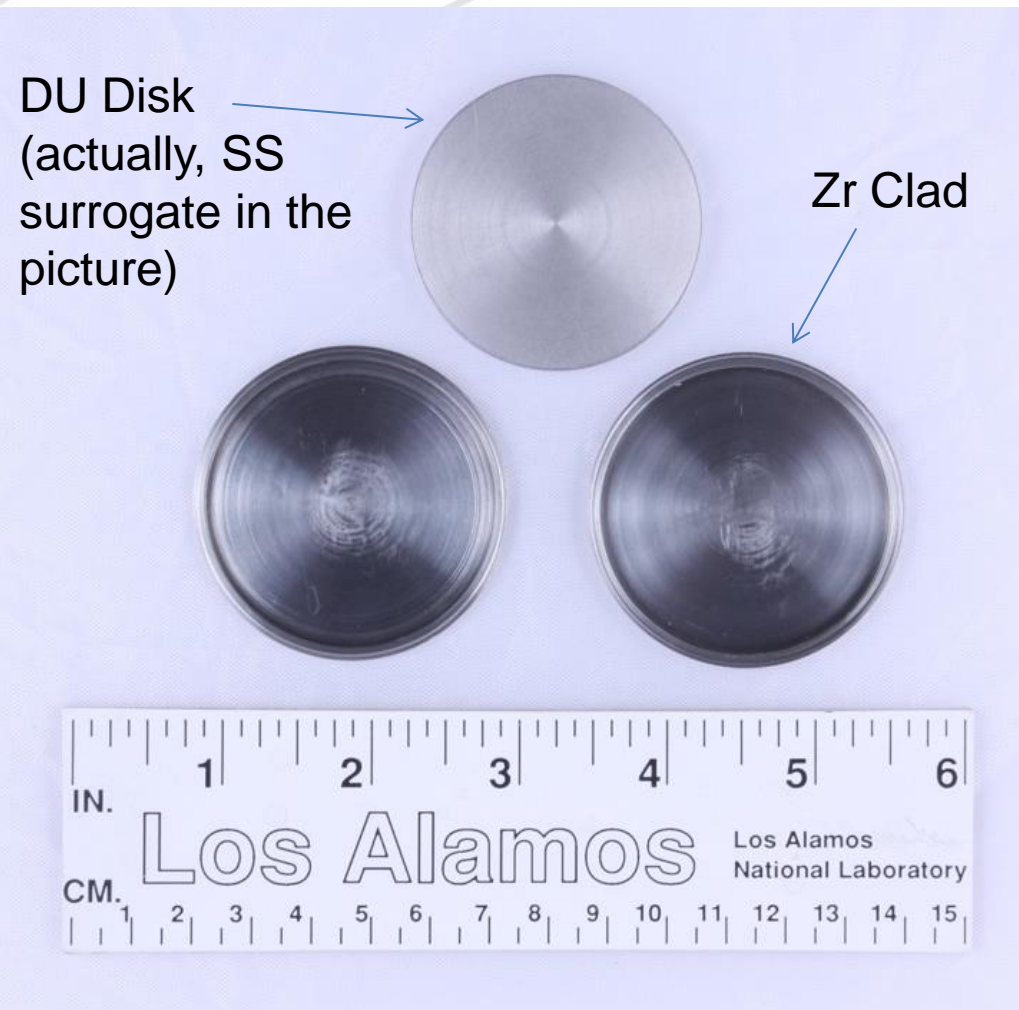
- System Modeling & Design Support
 - System dynamics and reactivity modeling
 - Thermal hydraulics modeling
 - Gas nozzle design for the accelerator target.
- Irradiations and Separations Chemistry
 - Measurement and control of the total uranium concentration
- Evaluation of the Tritium Recycle Loop and Associated Systems (in partnership with SRNL)
- Zr Clad DU Target Fabrication
 - For the ANL photoneutron target for the mini-SHINE experiment.

Thermal Hydraulic Modeling for SHINE

- Using the Fluent CFD Code to help SHINE and the University of Wisconsin model the thermal performance of the SHINE Target Solution Vessel (TSV)
- Modeling the combined effects of natural convection and radiolytic gas bubble dynamics.



Fabrication of Zr clad DU Disks



Completed thick disks

Other LANL LEU Solution Presentations

- Steve Klein, “Dynamic System Simulation of Fissile Solution Systems”
 - Friday 8:30 AM Session
 - Second Presentation
- Iain May, “Low Enriched Uranium Control Applicable to a Range of Potential Mo-99 Production Processes”
 - Friday 10:30 AM Session
 - Second Presentation

Summary

- LANL is partnering closely with NNSA and the other national laboratories to help the commercial domestic production of ^{99}Mo without the use of HEU.
- Under the GTRI ^{99}Mo Program, we are currently supporting NorthStar Medical Radioisotopes and SHINE Medical Technologies.
- Leveraging the unique capabilities of the National Laboratories to increase the production of ^{99}Mo .