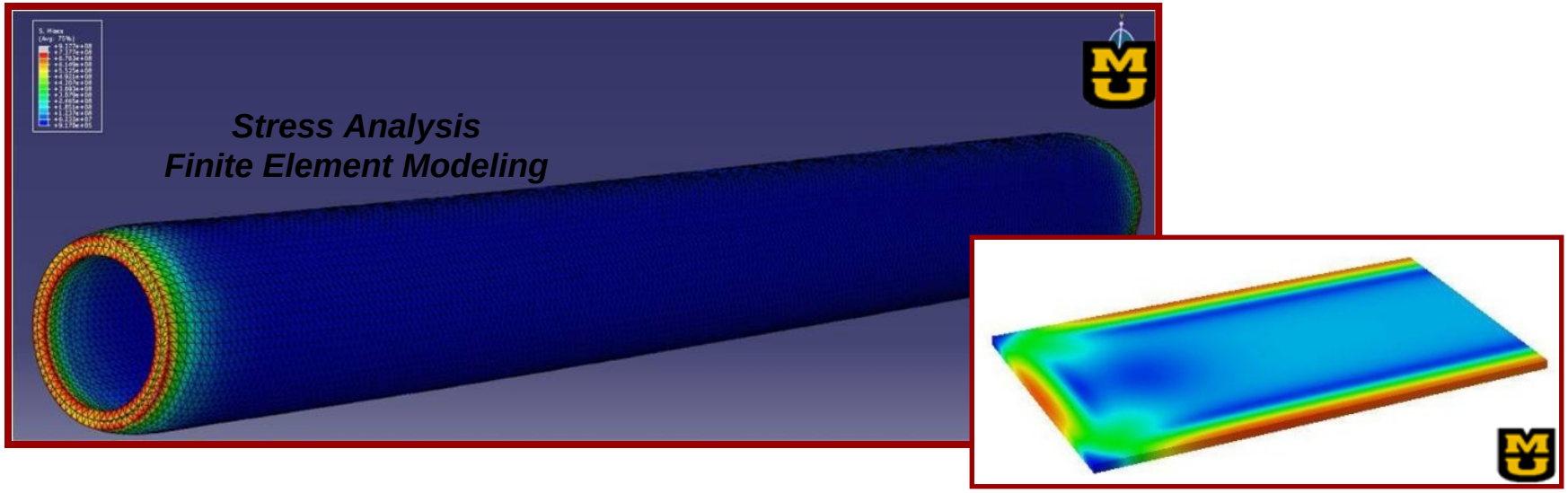
Equivalent Fission Mo-99 Target without Highly Enriched Uranium



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Y-12 National Security Complex
and
Charlie Allen and Gary L. Solbrekken
University of Missouri

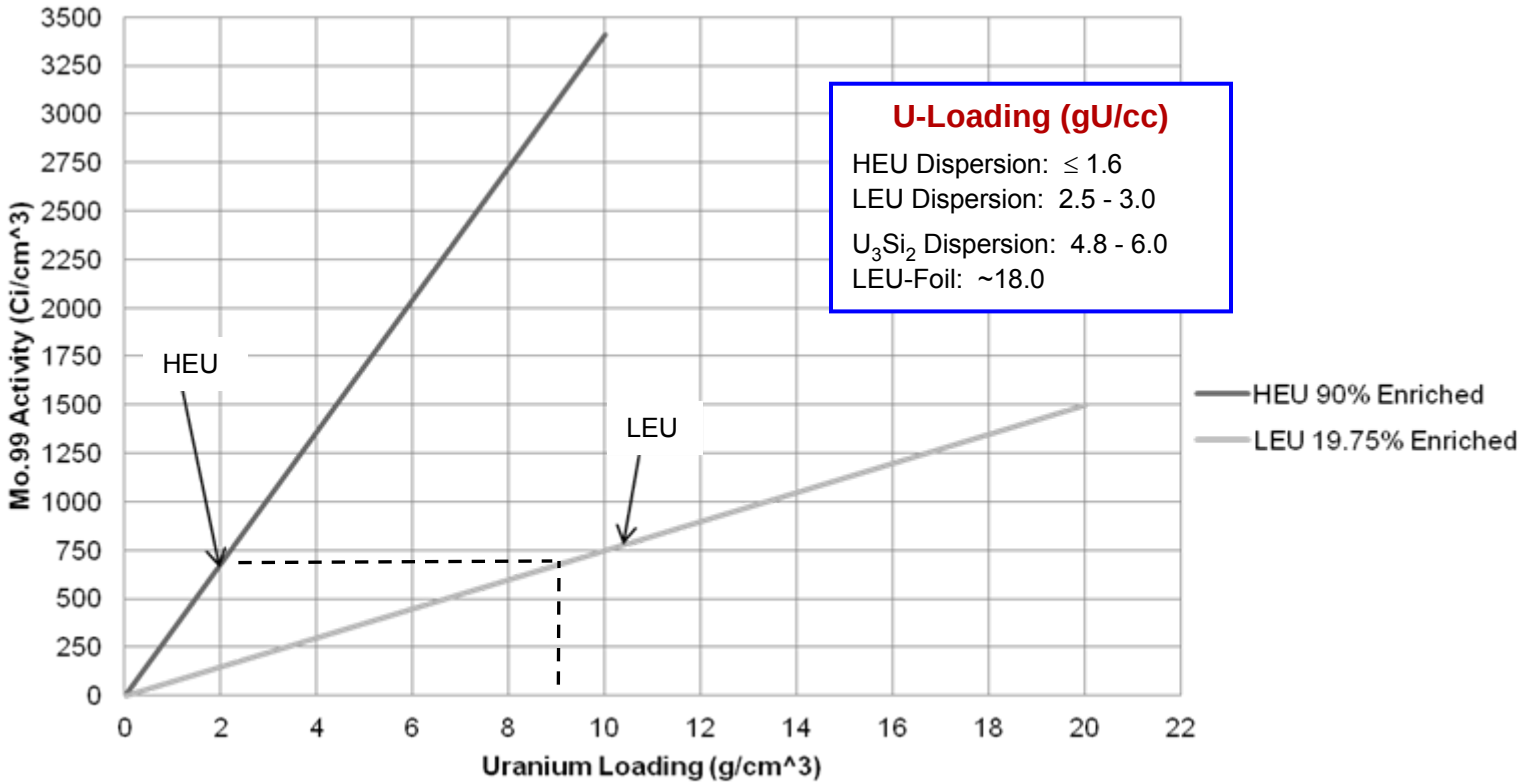
Mo-99 Topical Meeting
4-7 December 2011
Santa Fe, NM

. UAl_x Dispersion vs. LEU-Foil Annular

- UALx Dispersion Plate Targets
  - Manufactured to Materials & Test Reactor (MTR) fuel specifications and Quality Control Program requirements
  - Long history - - - > 10,000 safely irradiated and processed to date
  - U-density of HEU targets currently in use is upwards to 1.6 gU/cc
  - U-density of LEU targets now used by CNEA, ANSTO, and NECSA is in the range of 2.5 – 3.0 gU/cc [8 - 9 gU/cc needed for HEU equivalency]
  - Disassembly not required for process dissolution step
- LEU-Foil Targets
  - Not currently manufactured to Quality Control Program requirements
  - Minimal history - - - < 30 safely irradiated and processed to date
  - Not currently manufactured / qualified to an industry accepted standard. They are <u>not</u> a qualified reactor fuel type as are dispersion type targets
  - U-density of LEU-Foil targets is ~18 gU/cc
  - Potential to disassemble to remove foil for dissolution process step

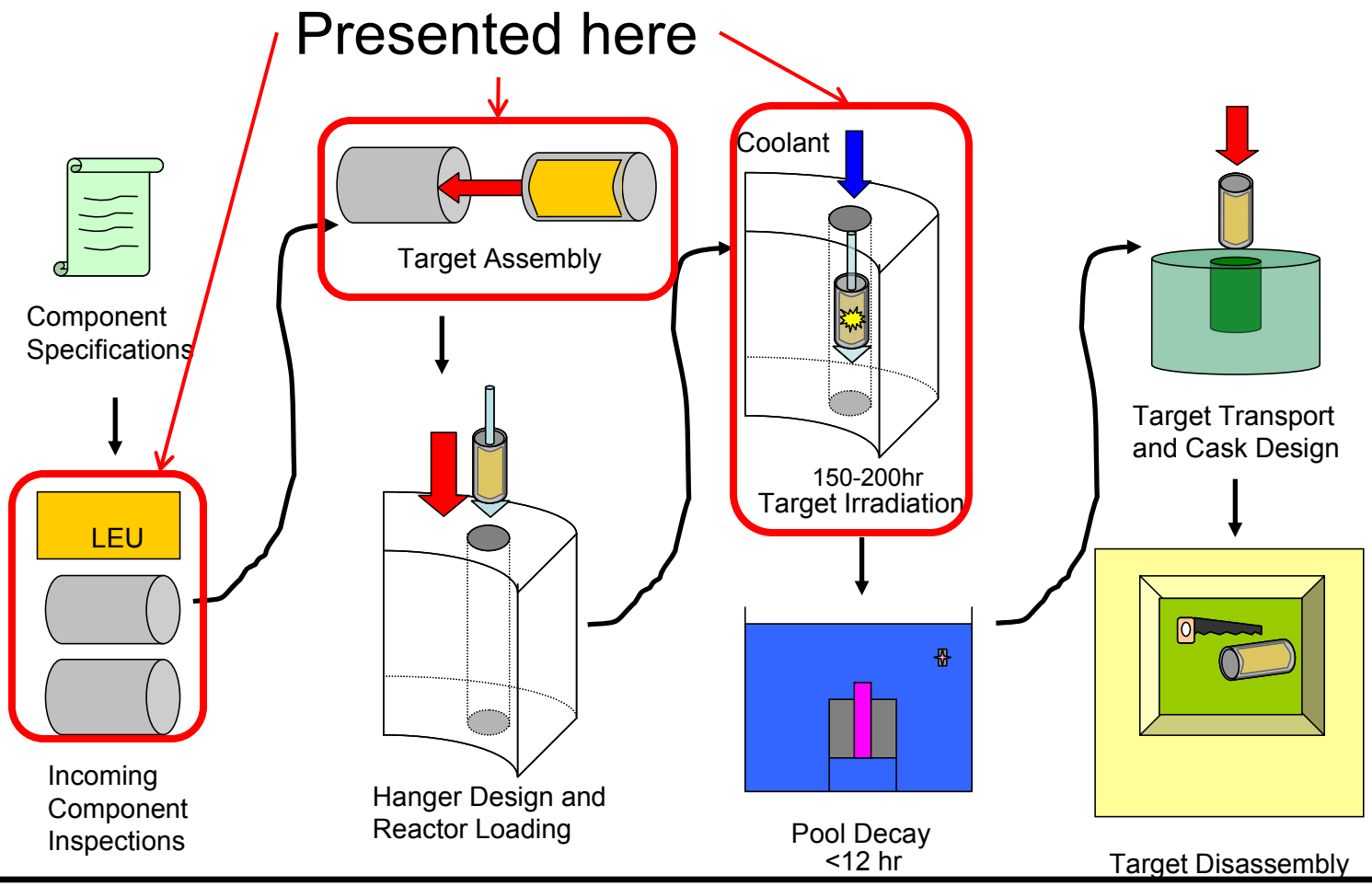
Motivation: Uranium Loading

- **LEU-Foil Approach**
  - Direct conversion from HEU to LEU on a gram-for-gram basis significantly reduces Mo-99 yield
  - Allowable uranium loading (g/cc) limited by site specific target heat removal capability

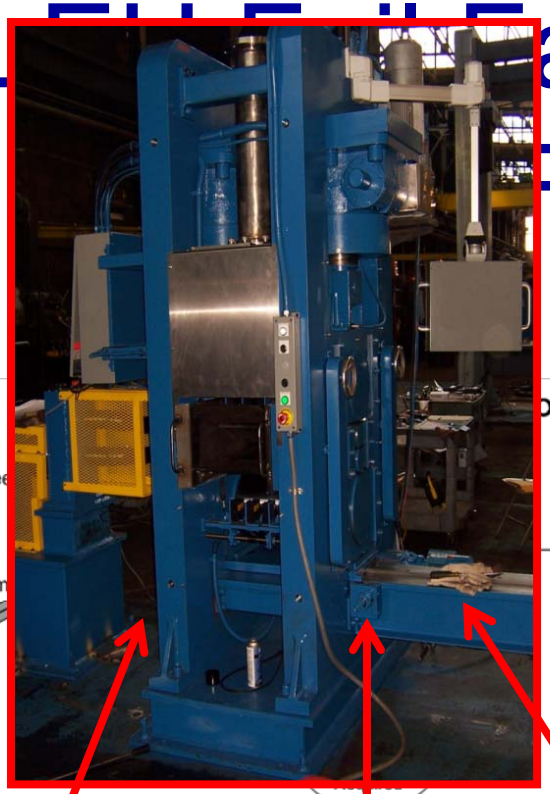


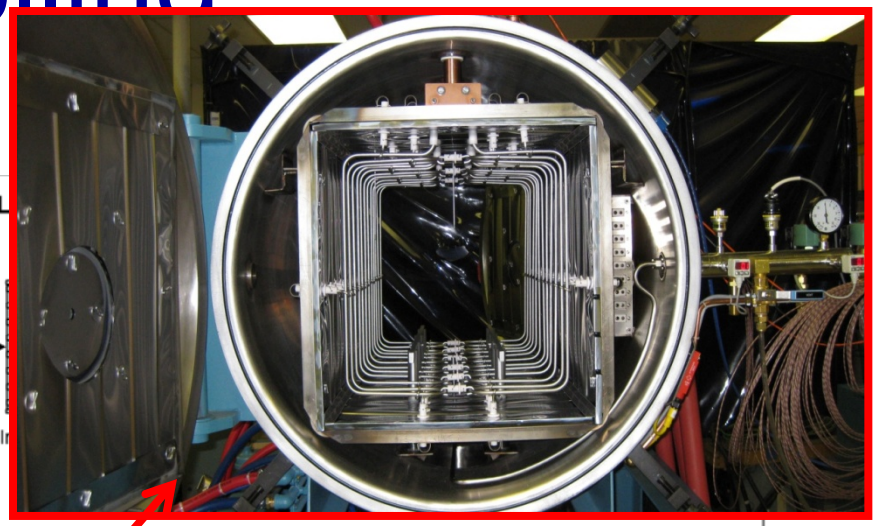
Assumed flux: 2E14 n/s*m^2

Process Flow for Target Life (outline)

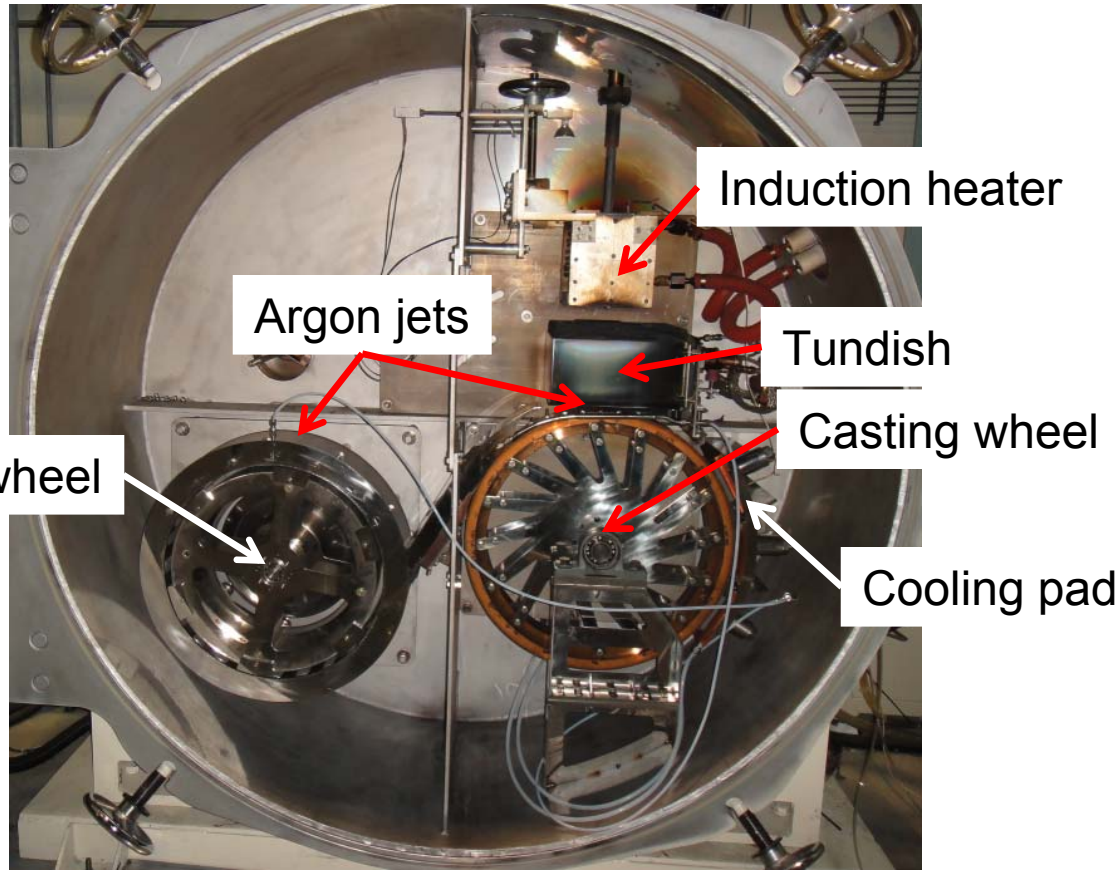


LEU Foil Fabrication – Y-12 Rolling





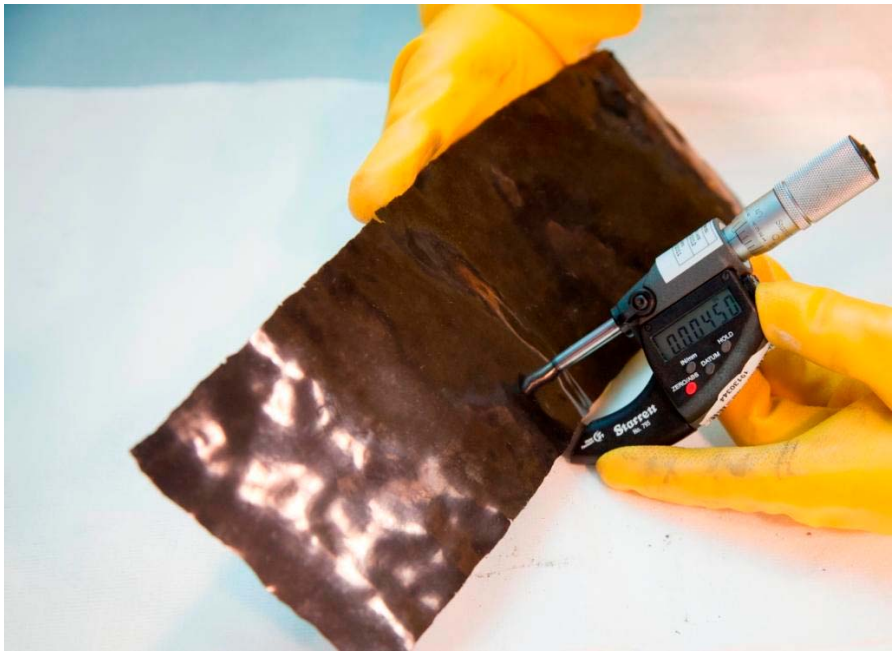
LEU Foil Fabrication – KAERI Roll Cast



Modified Roll Caster at KAERI

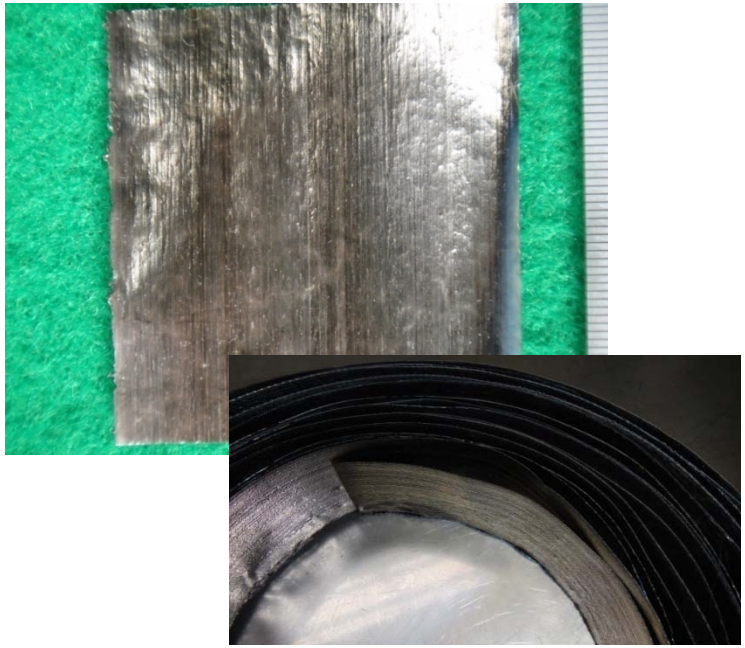
Foil Comparison

Y-12 Rolled Foil
114 μm thick (4.5 mils)



Low Rate Initial Production
(160-200 25g foils/week)

KAERI Roll Cast Foil
Average 139 μm thick (5.5 mils)



15 m long foil in 2 days

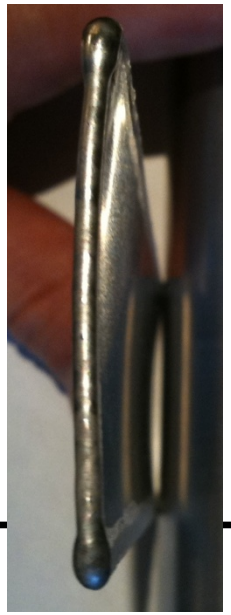
Thermal/Mechanical Design Analysis

- Assess risk/margin to failure
  - Temperature and stress are metrics
- Use combination of analytic, numeric, and experimental tools to support
  - Analytic: simple models allowing quick, parametric studies
  - Numeric: complex geometric studies, results in color plots
  - Experimental: model validation

Annular

Plate

Curved Plate



Annular Geometry Modeling

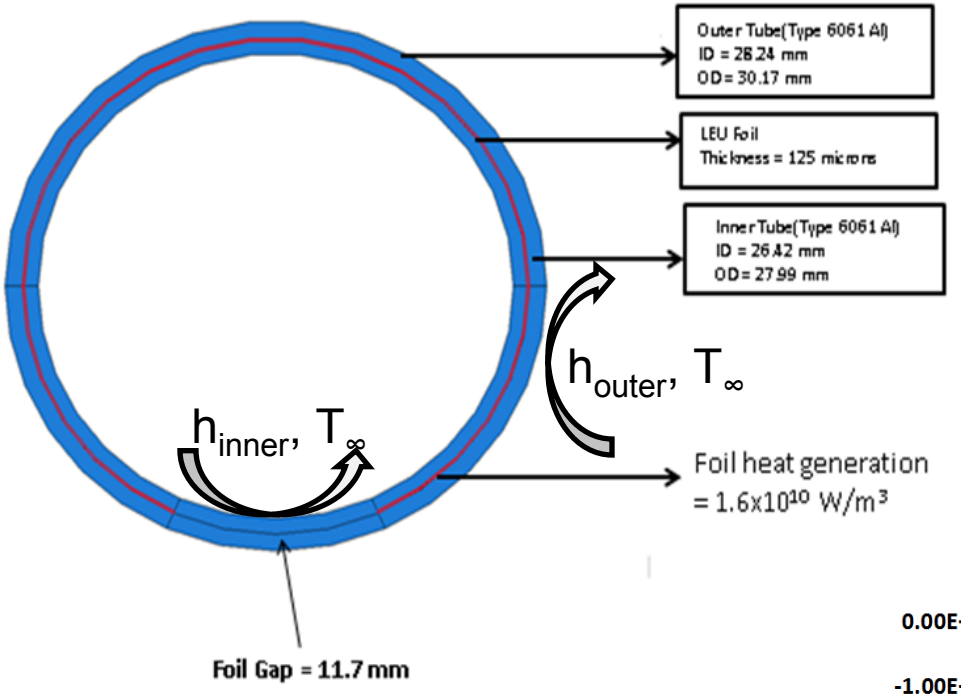
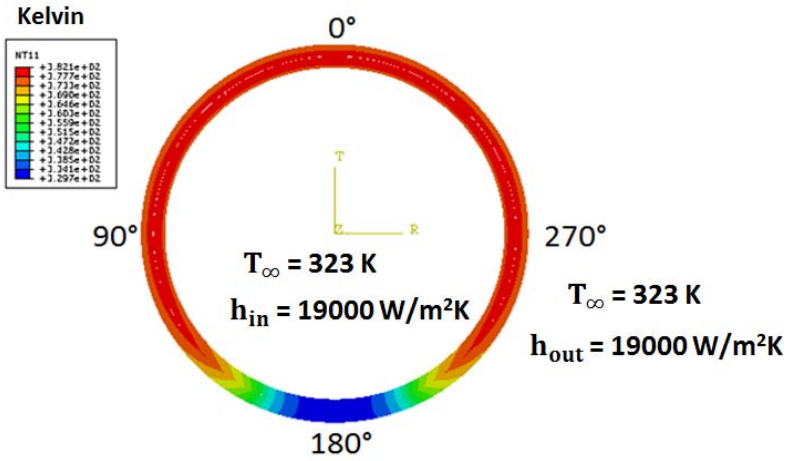
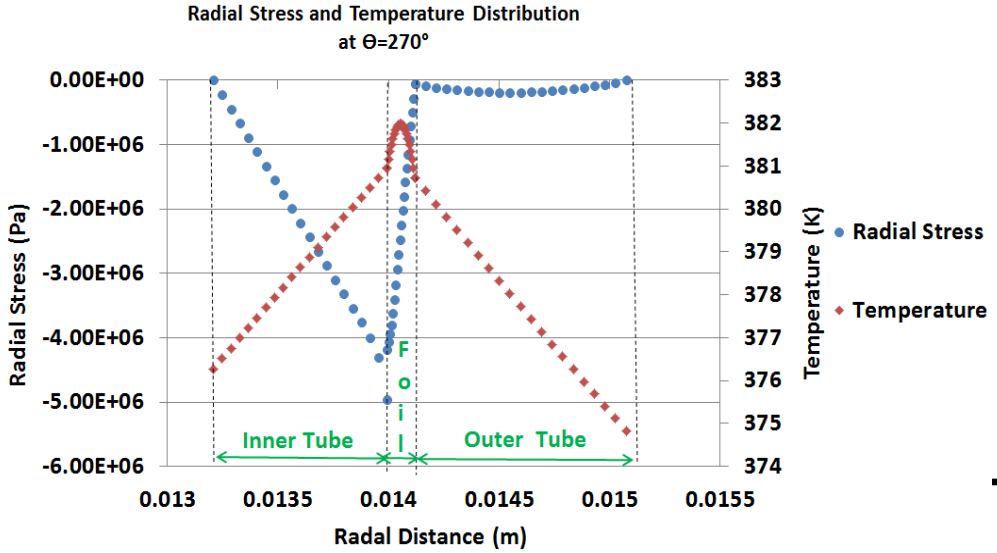


Fig.1 . Problem Setup





Assumes no assembly residual stress

Separation between the foil and the tubes

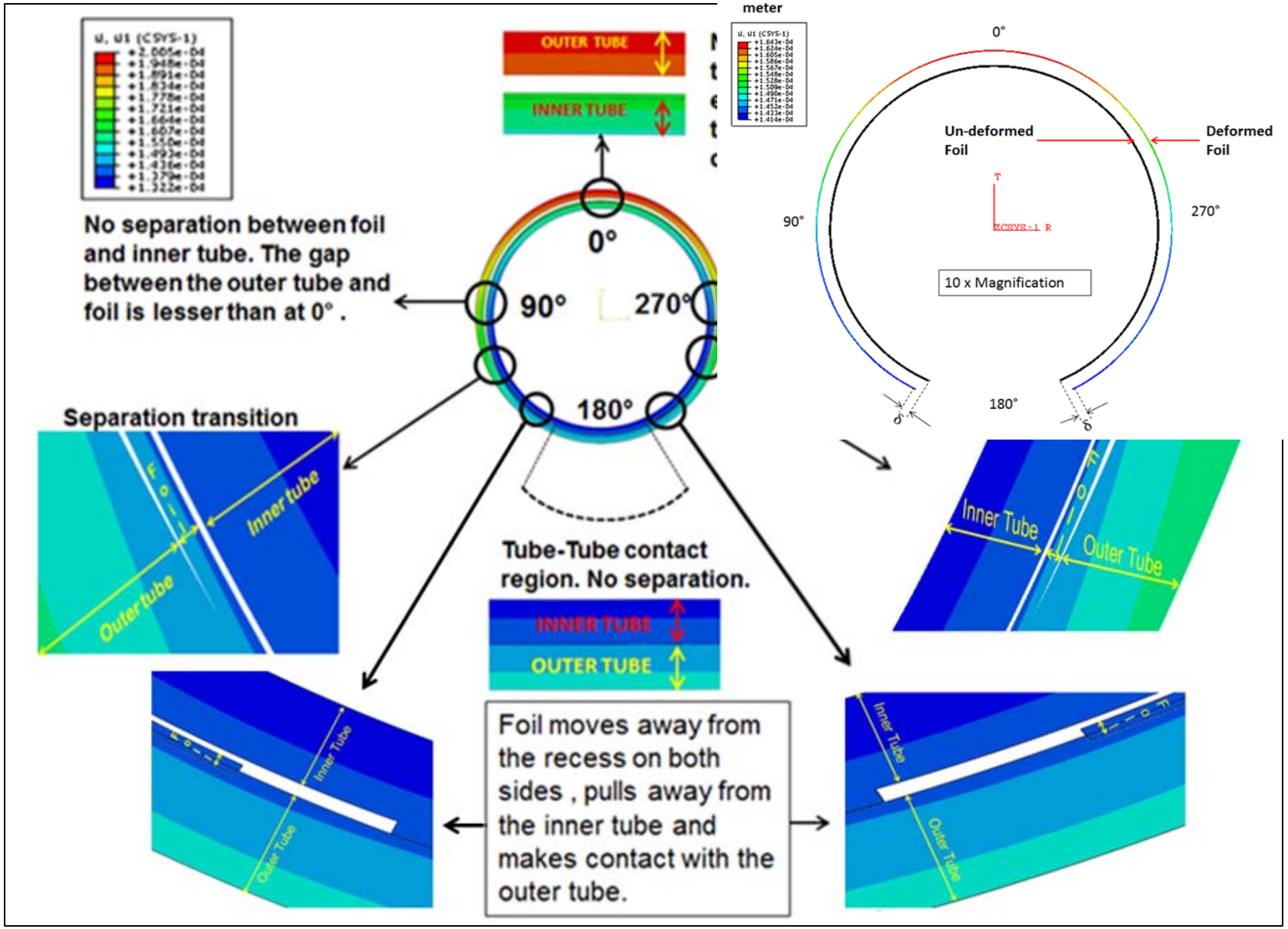
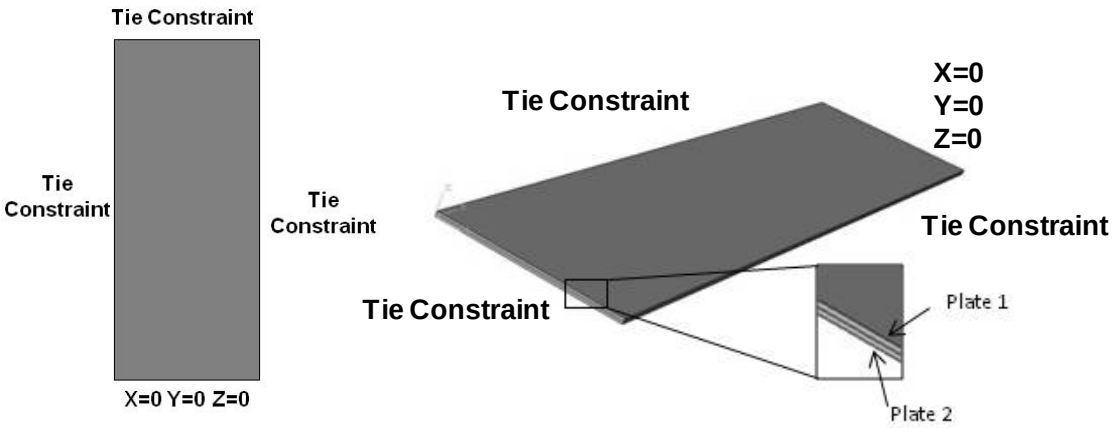
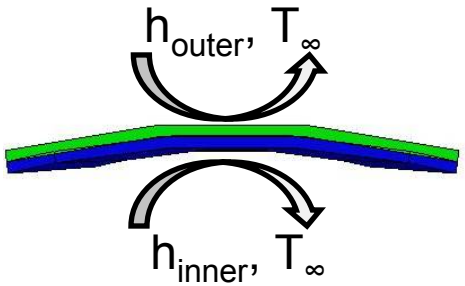


Plate Geometry

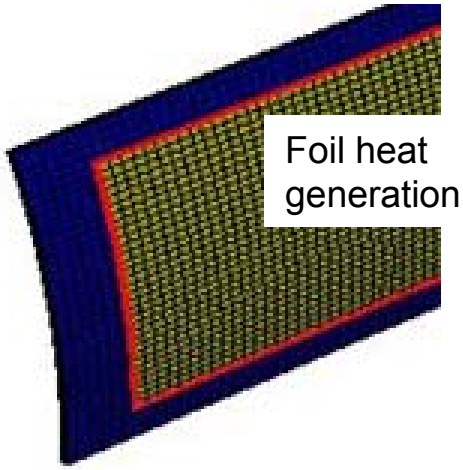
- 'Tie Constraint' simulates weld
- Curved analysis ongoing



Mechanical Boundary Conditions



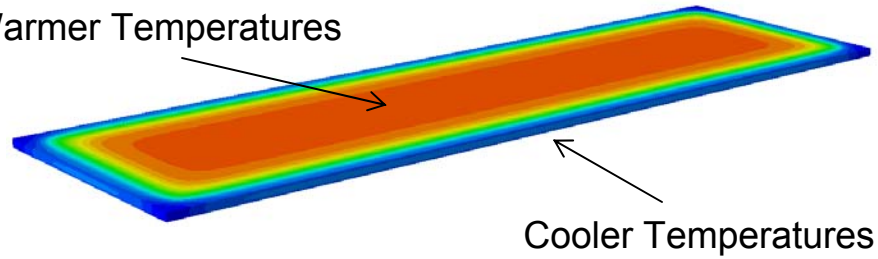
Thermal Boundary Conditions



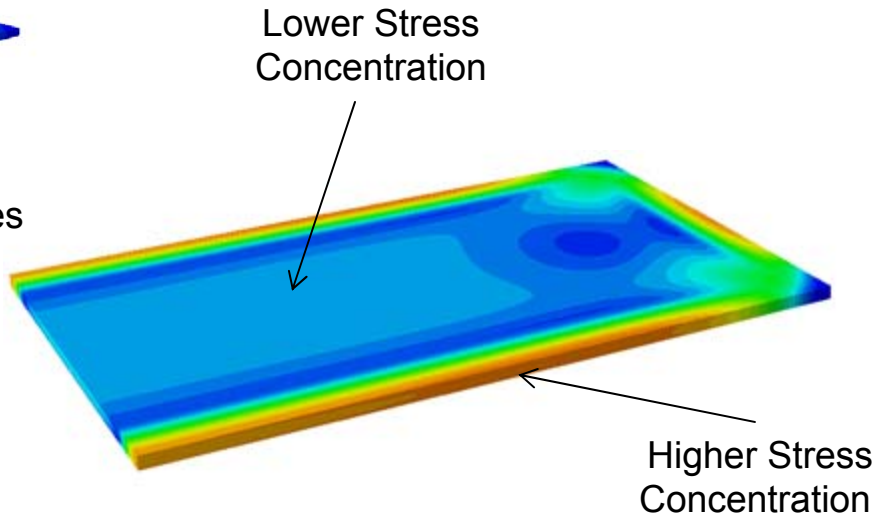
Assumes no assembly residual stress

LEU Foil Plate Target: Results

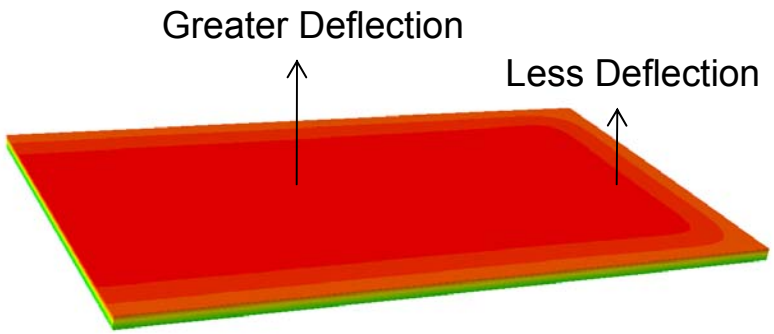
- Results
  - Higher temperatures and deflections at center of target
  - Higher stresses seen at edges of the target (weld)



Temperature Profile

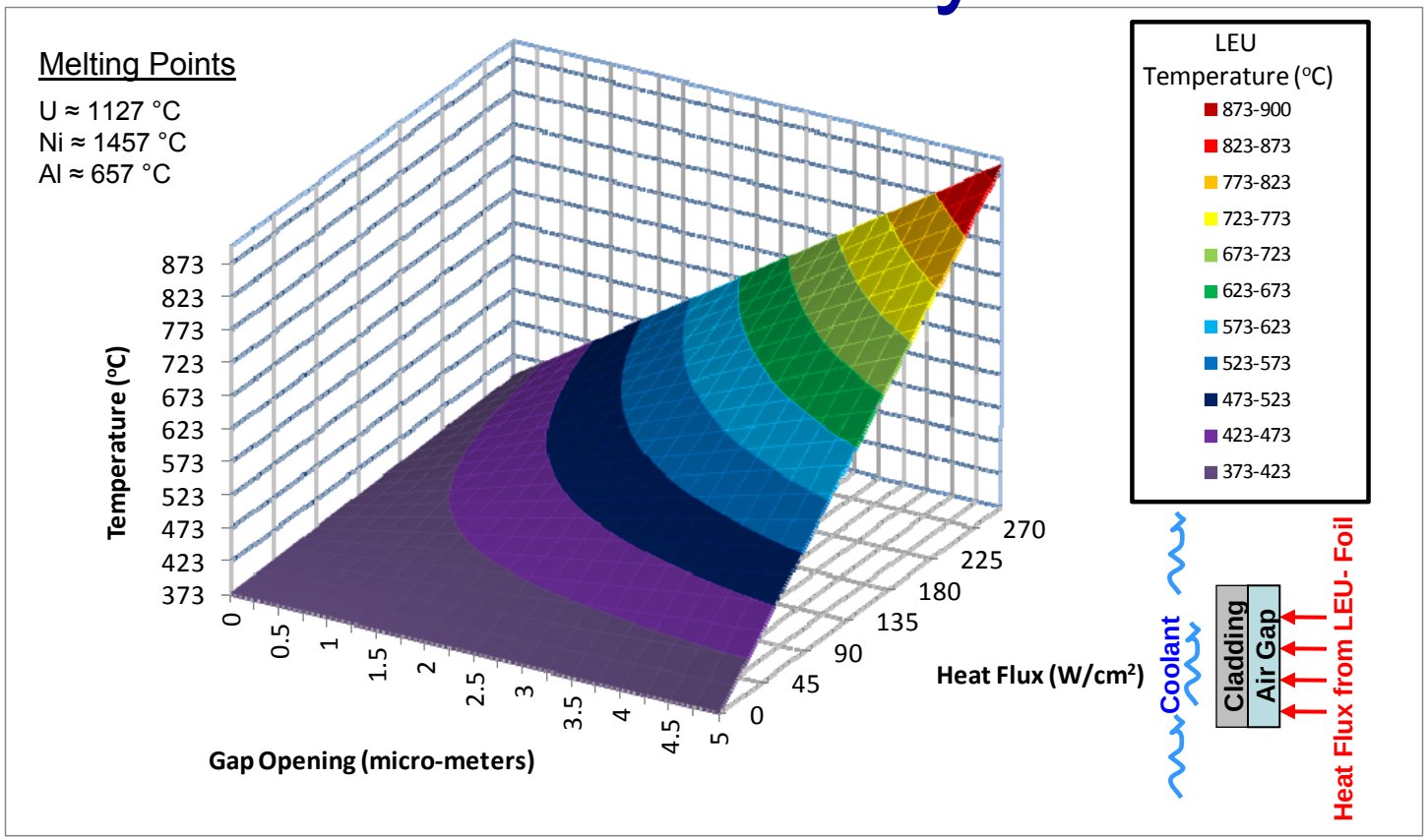


Von Mises Stress Profile



Deflection Profile

Interfacial Thermal Resistance Gap Analysis



Heat flux
~heat generation
~Mo-99 production

For a given production rate (heat flux) the temperature increases with gap opening

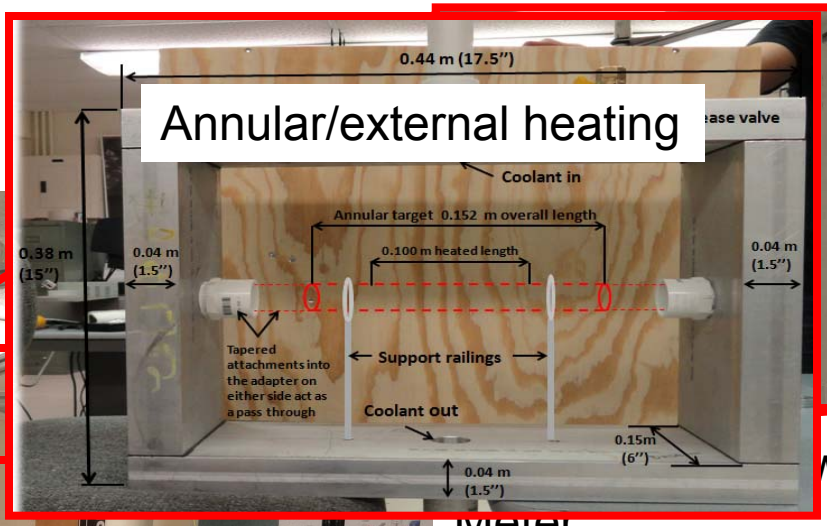
Coolant/outer cladding assumed to be 100 °C

-Small gaps can be tolerated
-Periodic contact needs to be evaluated
-Required residual stress to close larger gaps needs to be established
-Experimental validation needed

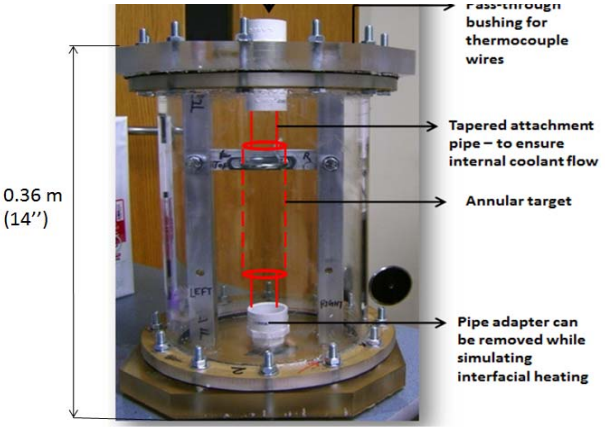
al Analysis

Plate/interfacial heating

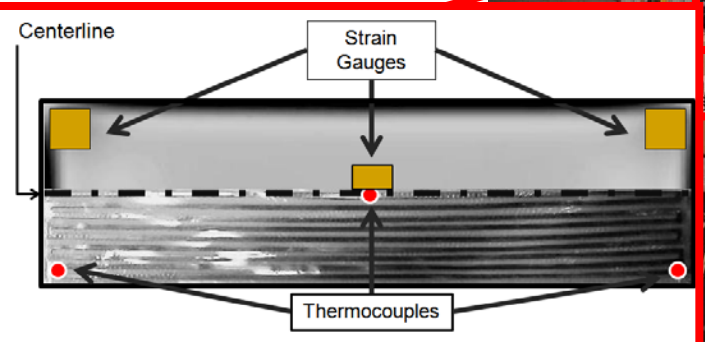
Annular/external heating



Annular/internal heating



Lase
Disp
Measurement
Test Section
Location



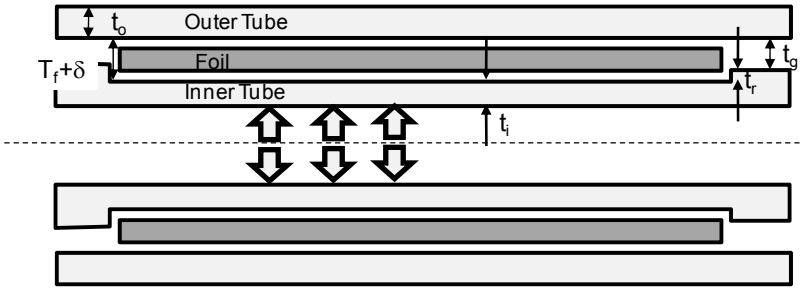
Meter

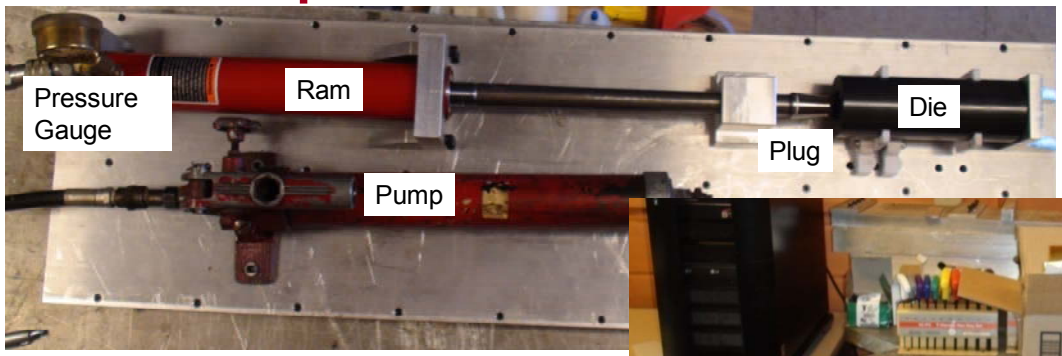
Control Valve

ata Acquisition

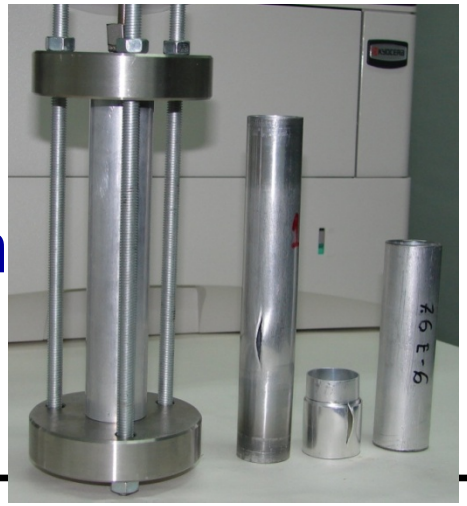
Target Assembly

- Inner tube needs to be expanded to hold LEU foil
  - Draw plug



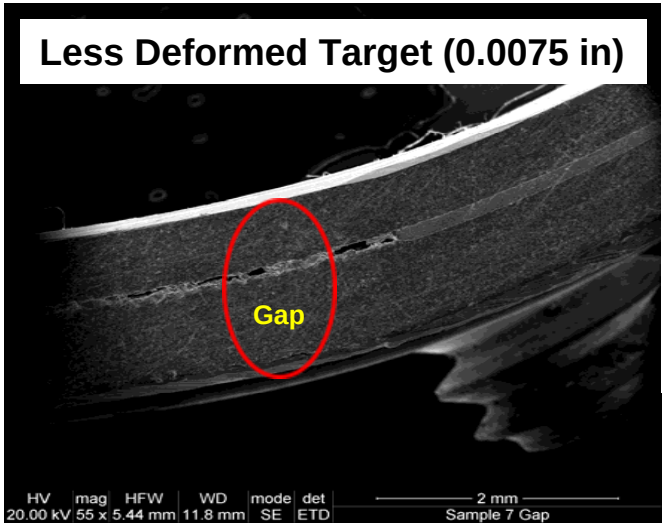


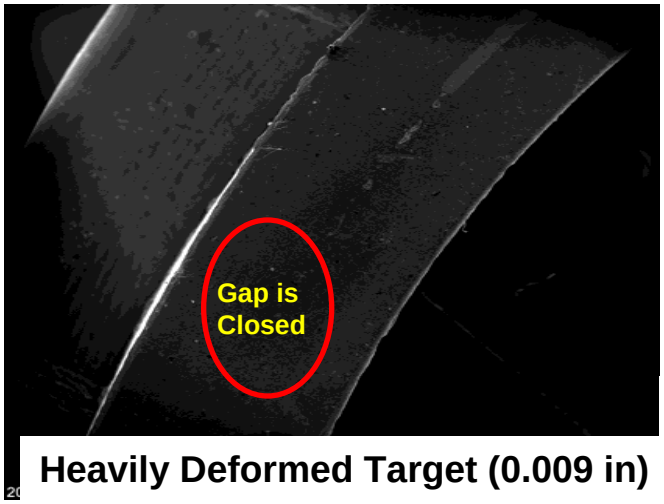
  - Hydraulic expansion



Draw Plug Assembly

- Experiment underway to understand tolerances
  - Tolerances can be relaxed to facilitate assembly
    - 5 minute assembly demonstrated
- Residual stress analysis needed to ensure potential gap openings eliminated

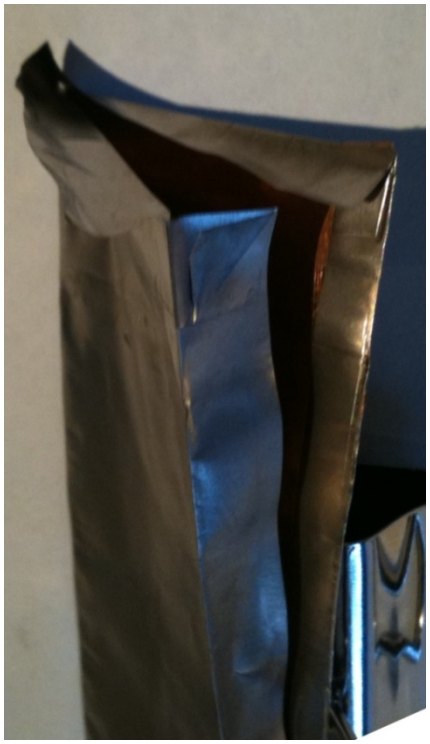




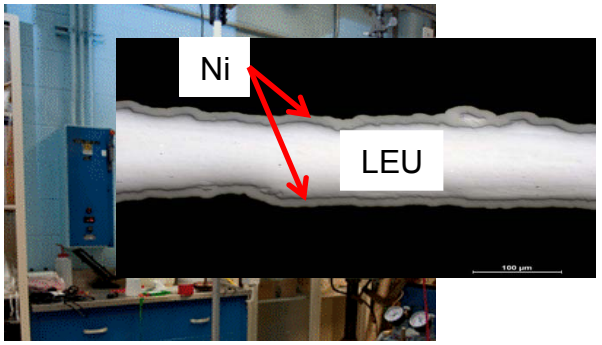
Ni Fission Recoil Barrier

- LEU will weld to Al cladding during irradiation
- To allow for disassembly, need recoil barrier

Wrapping Option



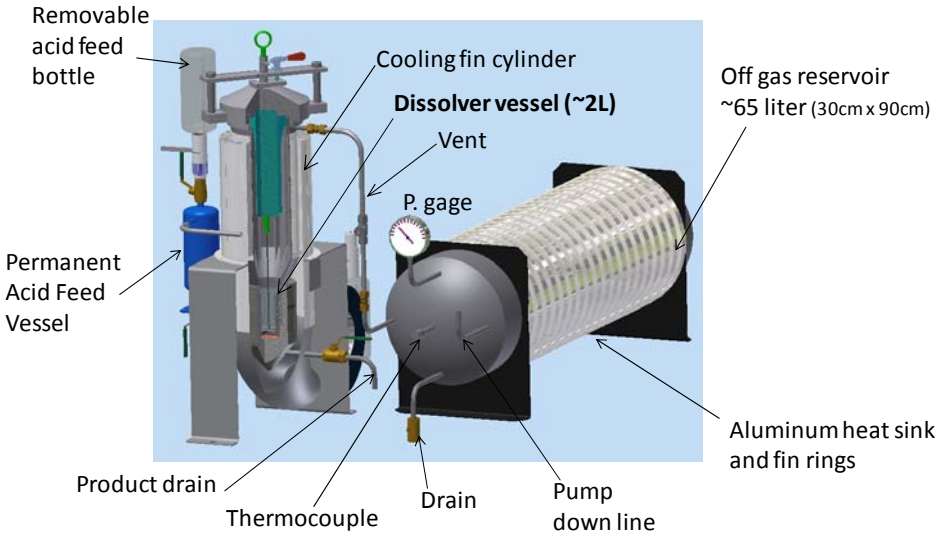
Electroplating Option



Electroplating Bath

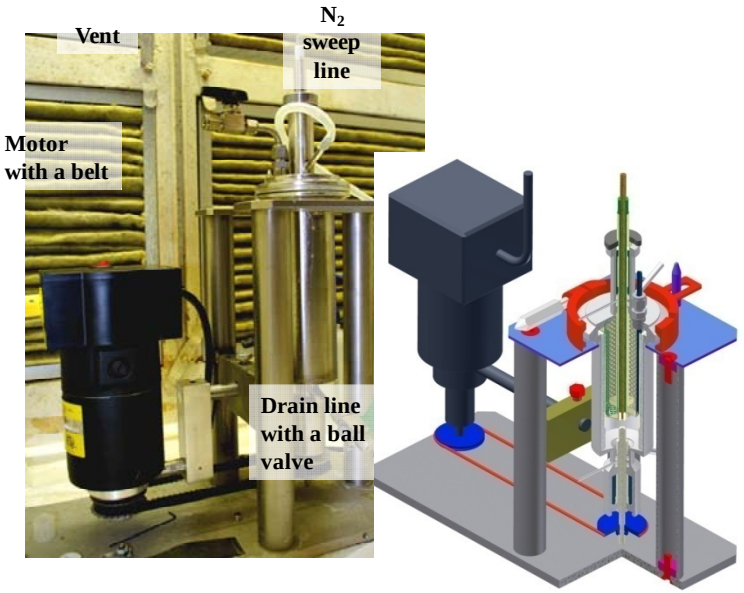
Chemical Processing Options

Acid Dissolution



Front end for:
- LEU-Modified Cintichem
- Current alkaline processes
  -Ni fission recoil barrier

Electro-chemical Dissolution



Front end for:
- Current alkaline processes
  -Al fission recoil barrier

Conclusions

- Foil targets provide high LEU-density
- Thin LEU foils can be fabricated in significant quantities
- Thermal/mechanical analysis tools in place for annular and plate geometries
- Assembly study ongoing to relax tolerances
- Chemical processes in development for foil targets

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