Capture ^{99}Mo ORNL Research Update

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Oak Ridge National Laboratory
In Support of GE-Hitachi

Mo-99 Topical Meeting
Santa Fe, NM

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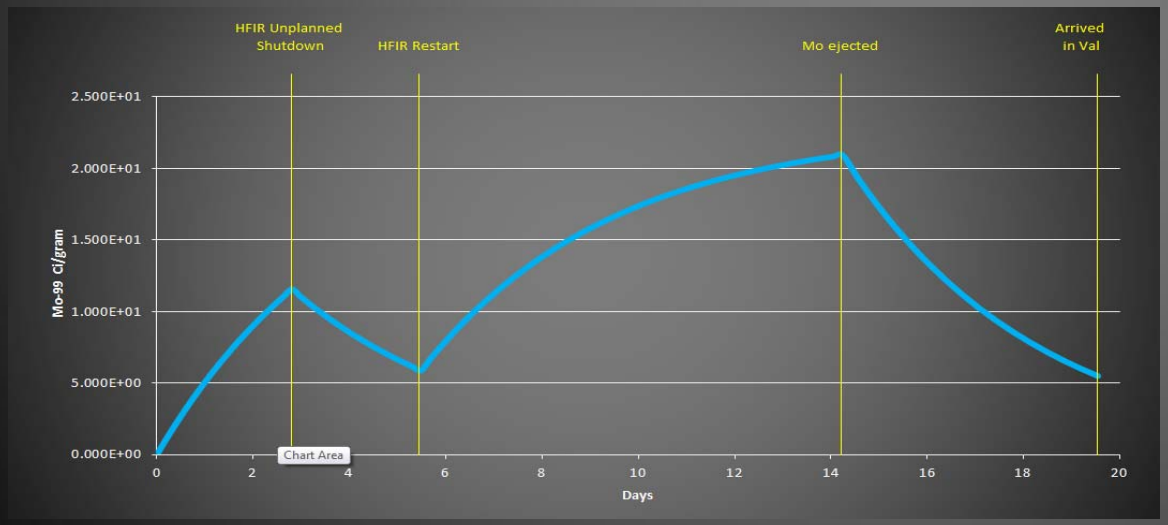
FY11 Support Areas

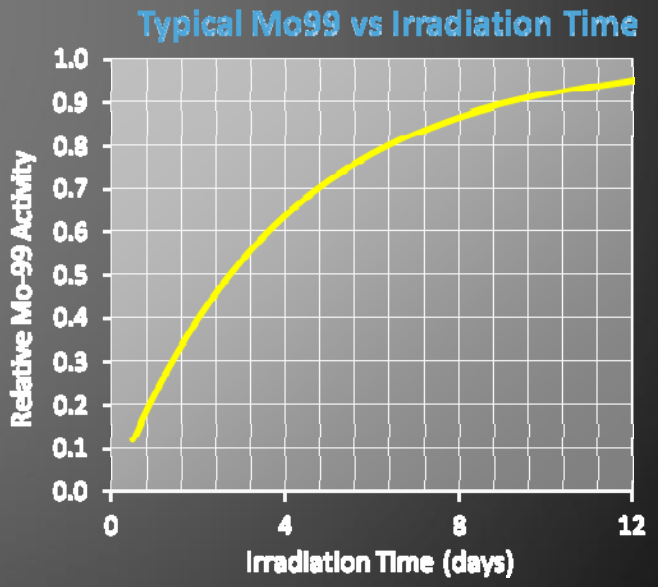
Irradiations and shipping of research quantities of ^{99}Mo to GE-Hitachi

Molybdenum metal characterization research

July 2011 Irradiation Summary

- Irradiation in 7 capsules in the hydraulic tube facility.
- Two hollow sleeves plus a foil disc in an aluminum housing
- Total molybdenum mass irradiated was 91 g
- Irradiation time was split due to an unplanned reactor shutdown
  - First part was 67 hours (2.8 days)
  - Then 65 hour shutdown (2.7 days)
  - Then 210 hour irradiation (8.8 days)





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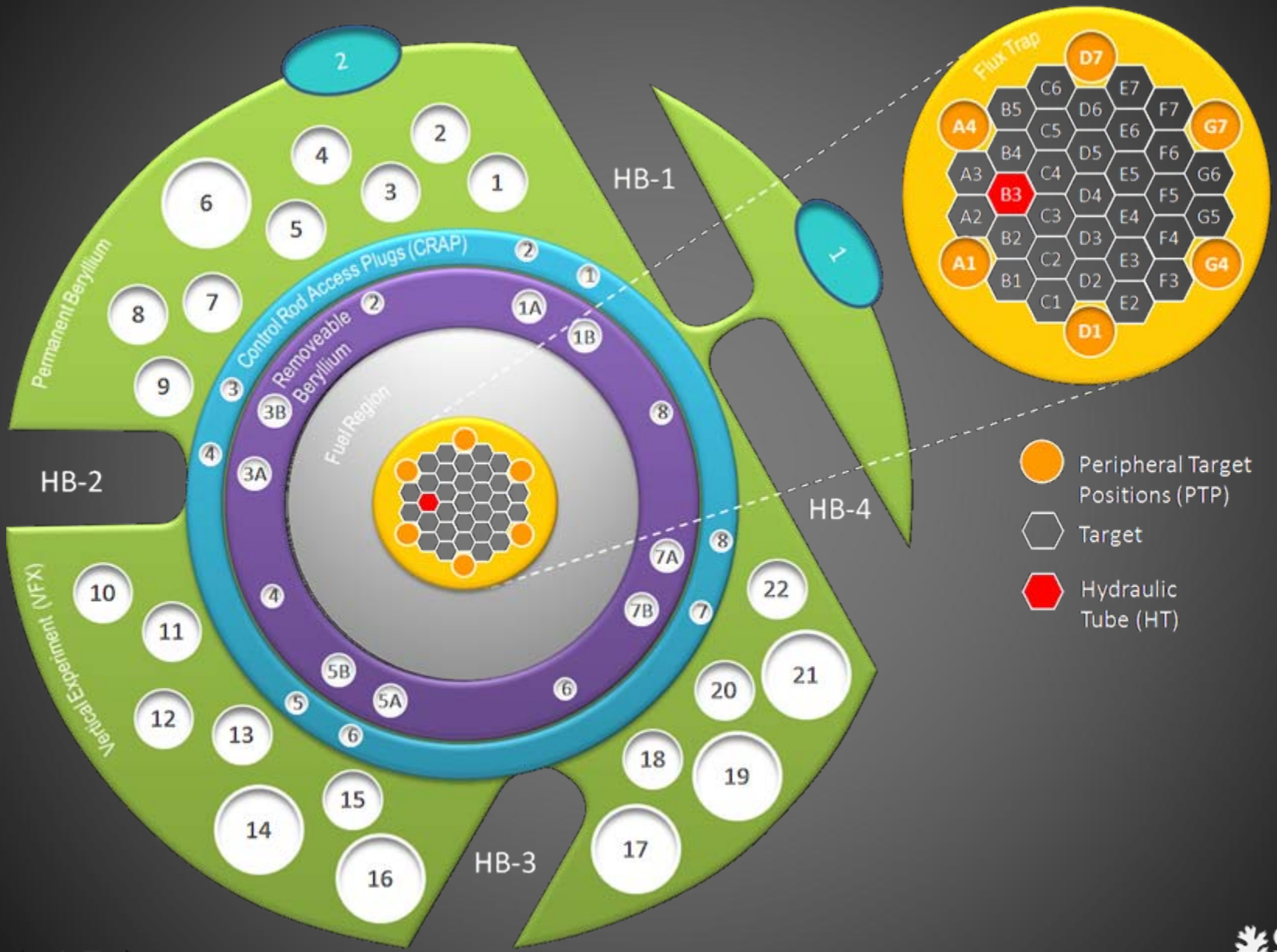
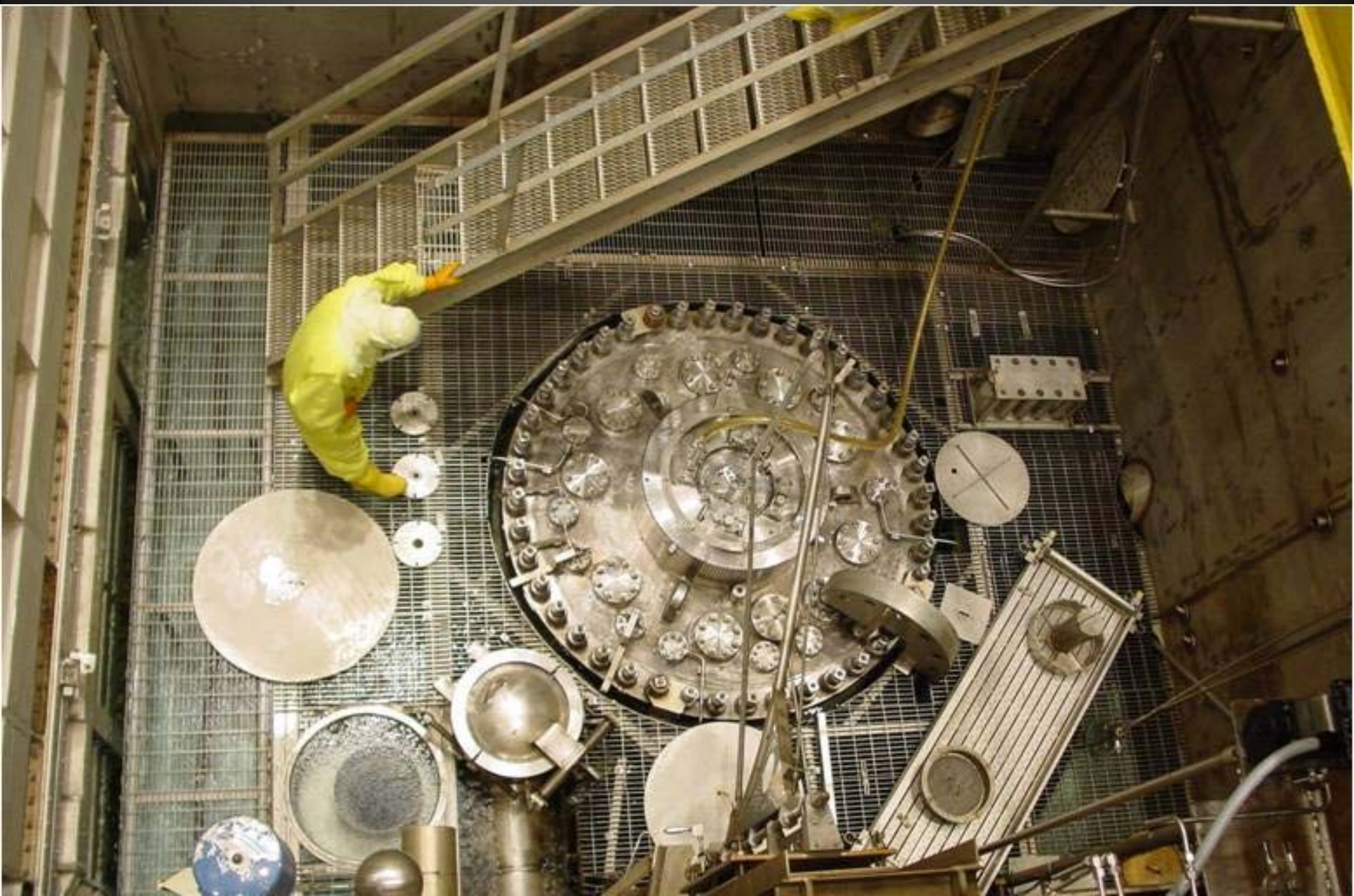
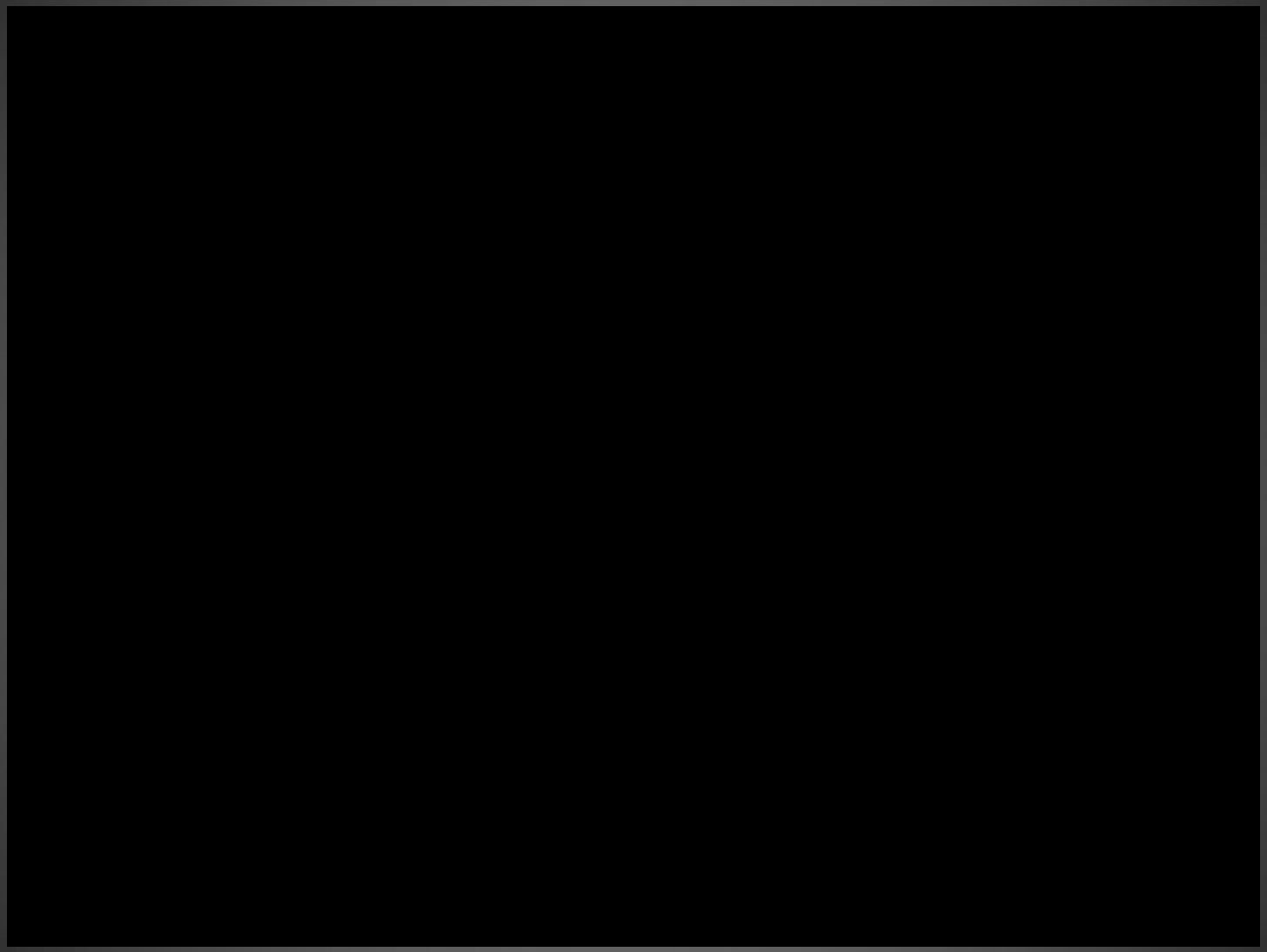
Map showing the HFIR Core



HFIR reactor pool with the water down



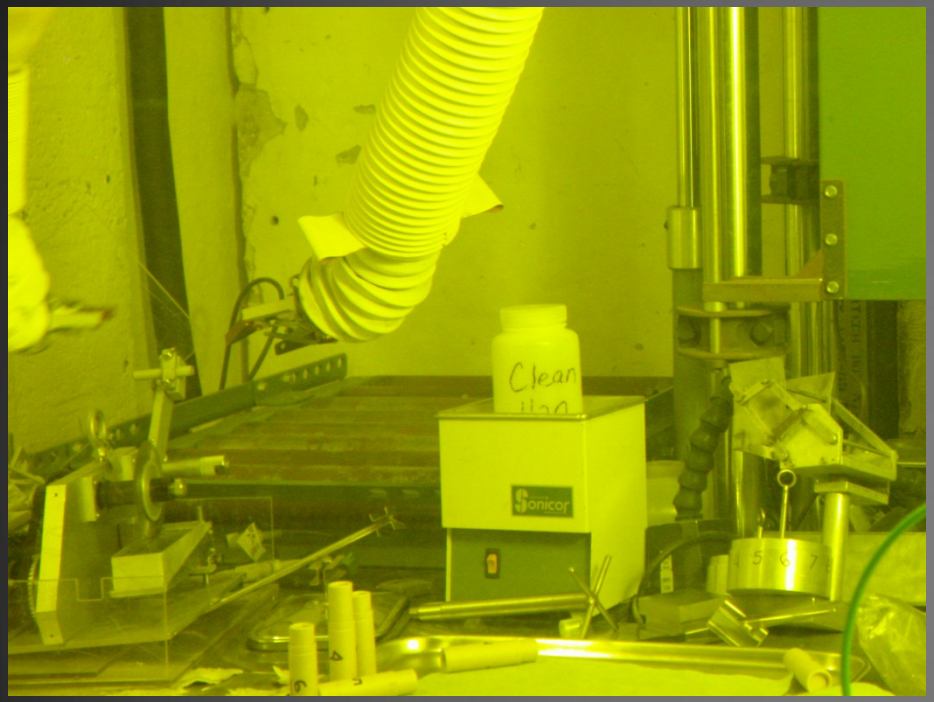
Video of capsules (rabbits) coming out of HFIR

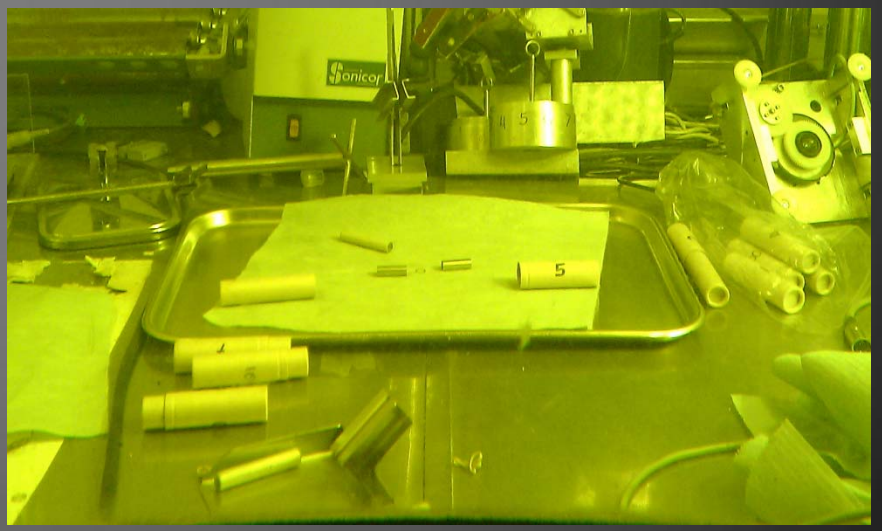


Shipping from HFIR to the hot cells

Sugarman Cask – wet loaded in the HFIR pool

In-cell cutting and wrapping in paper sleeves





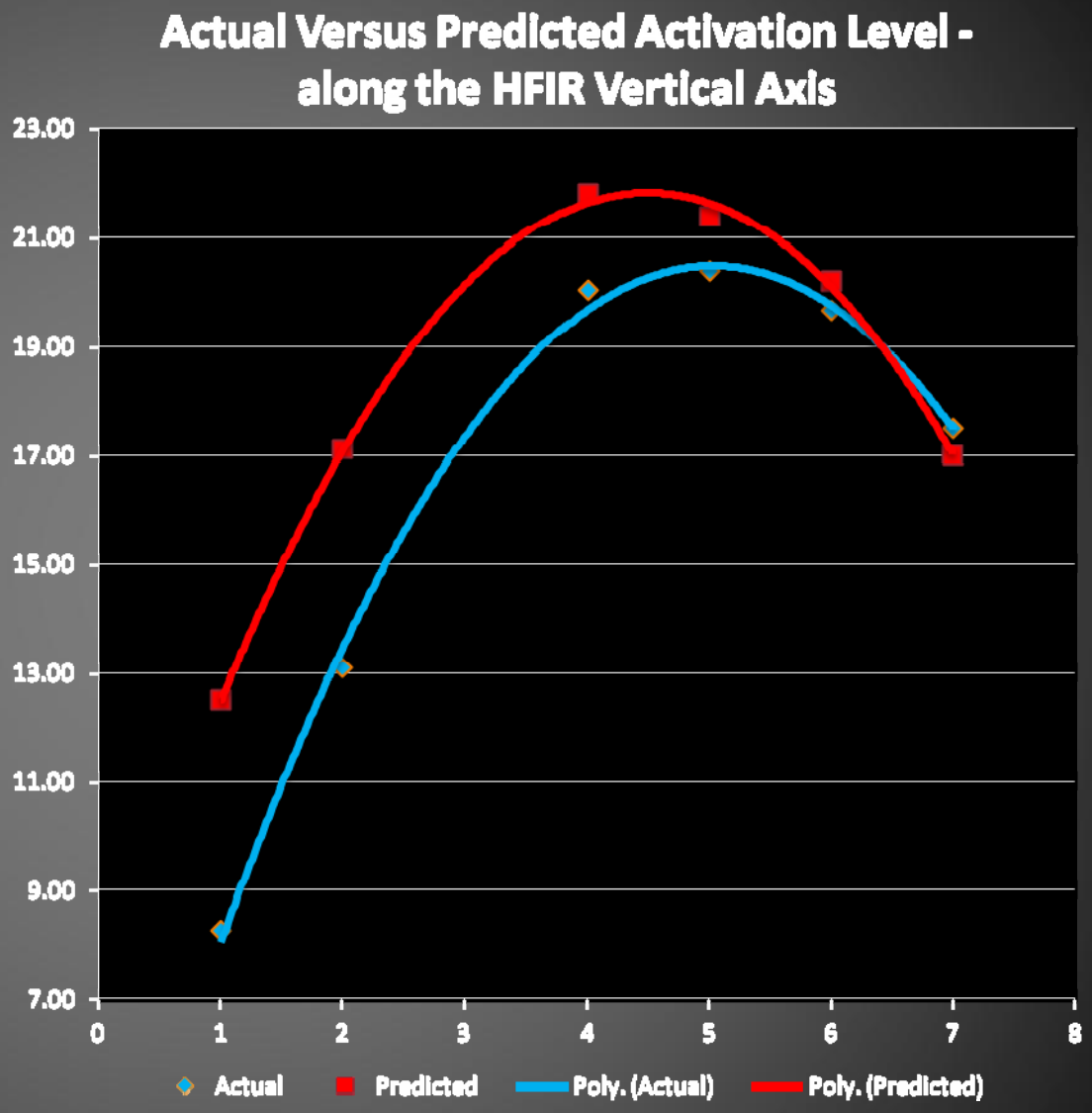
Placing the loaded sleeves into the GE100

GE100

Insert for moly sleeves

HT Irradiations axial profile

- Several Methods were used to predict activation levels of ^{99}Mo. MCNP results matched our data fairly well
- Measurements indicate peak specific activity just over 20 Ci/g at ejection



Material characterization research

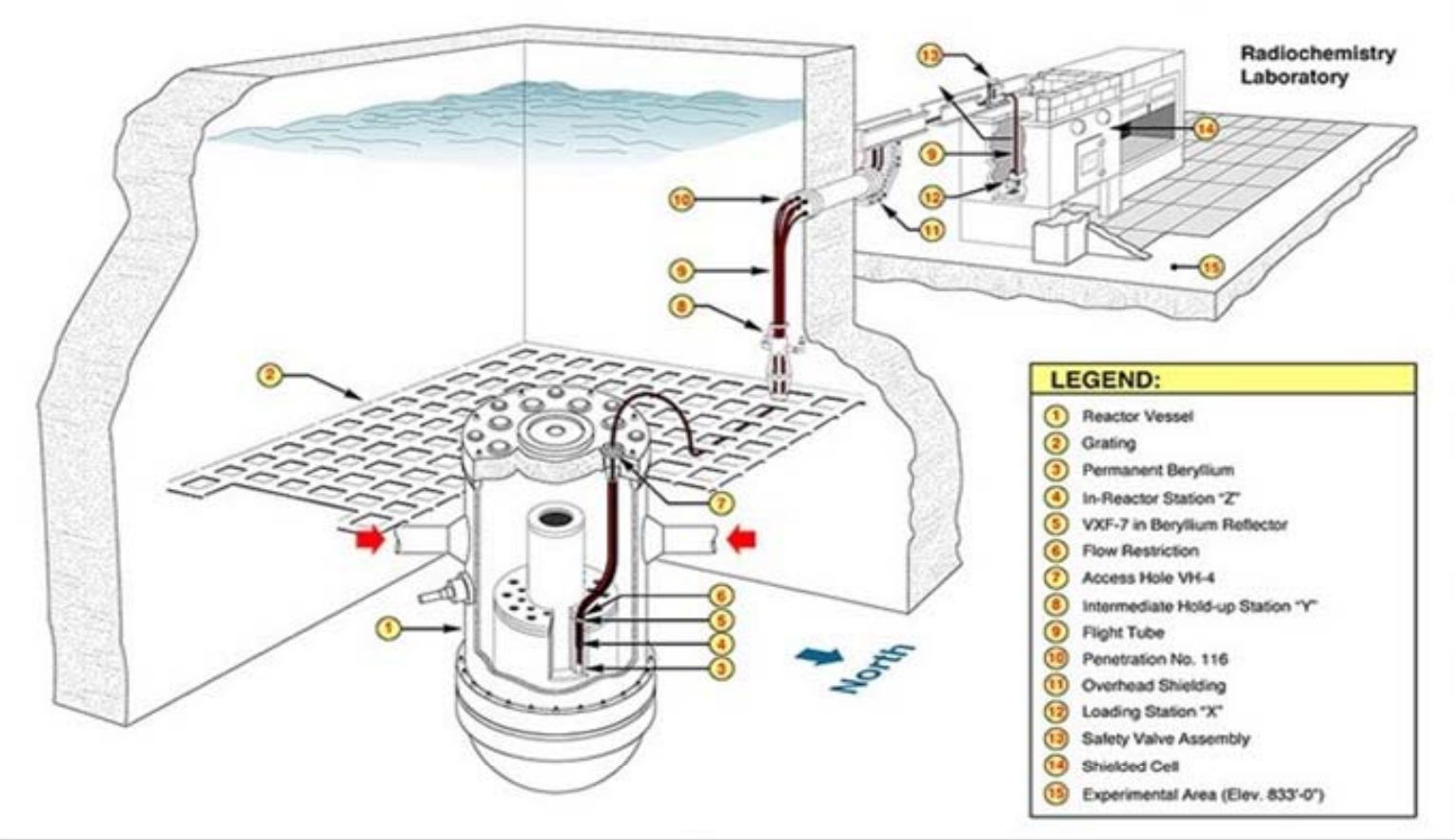
Natural molybdenum material research

- Impurities verification for several vendor samples
- Oxidation thresholds

NAA Impurities Assessment

Irradiation in PT-1

Neutron activation analysis



Natural Molybdenum Properties

Some major impurities in both samples	
Element	Concentration, %
Molybdenum (all isotopes)	98%
Niobium	8.6 ppm
Antimony	0.63 %
Iridium	121 ppm
Copper	1.13 %

Typical Isotopic Make-up	
^{92}Mo	14.2172%
^{94}Mo	9.0547%
^{95}Mo	15.7498%
^{96}Mo	16.6756%
^{97}Mo	9.6470%
^{98}Mo	24.6267%
^{100}Mo	10.0290%

^{140}La present in significant quantities

Supplier 1
(12.7 mm diameter ball)

Supplier 2
(25 mm diameter disk)

BWR TIP tube environment dictates that we understand the mechanisms for potential oxidation of molybdenum metal.

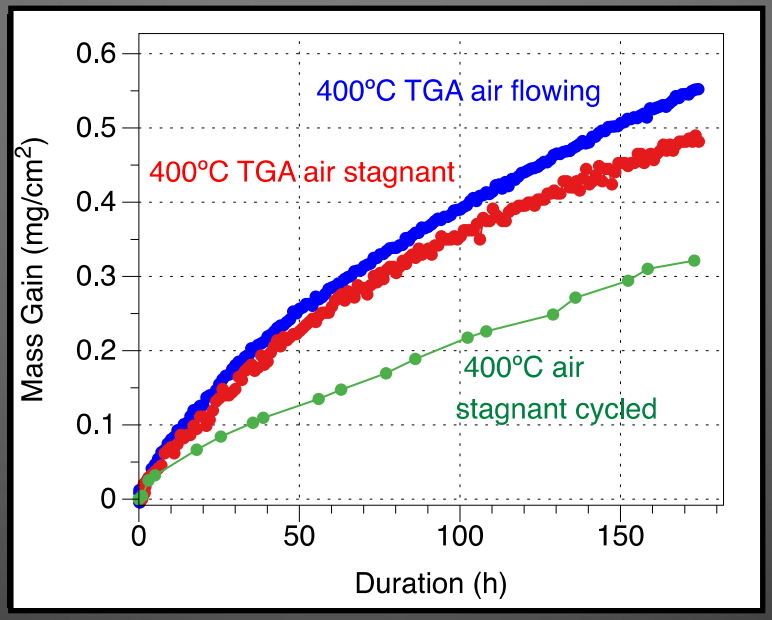
- Oxidation will occur in any O_2 environment, but what thermal/environmental conditions pose issues for molybdenum?
  - Oxidation will follow standard diffusion models.
- Additionally, sublimation of molybdenum-(tri)oxide at high temperatures is a recognized phenomenon.
  - Technetium will sublimate first, likely as Tc_2O_7, followed by the Molybdenum.
  - Sublimation varies by oxygen levels, temperature, surface area.

Oxidation questions prior to determining our test methods

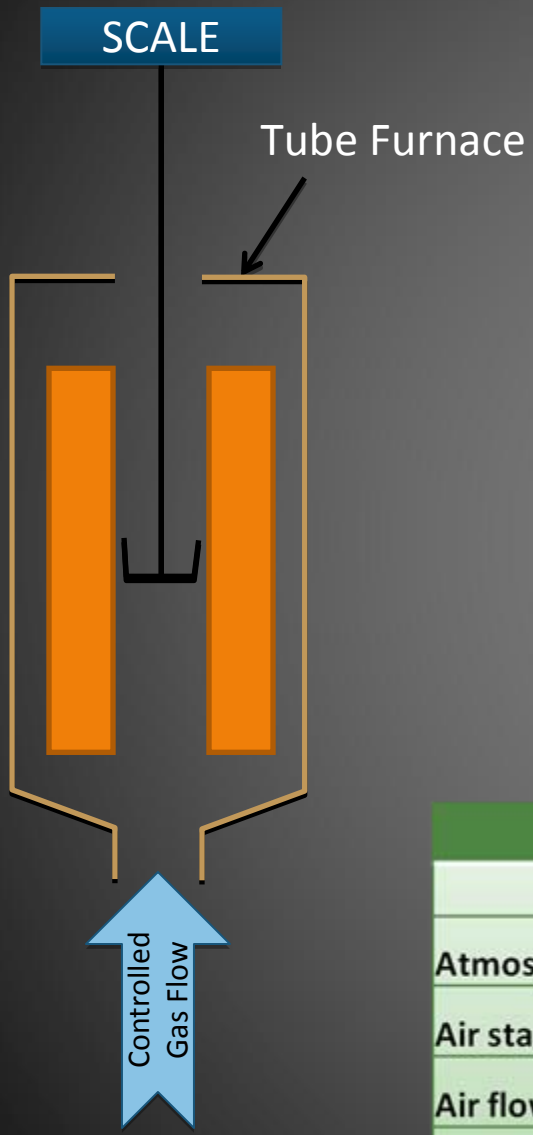
Needed to answer several questions about testing the oxidation properties of molybdenum metal.

1. **What is the effect of stagnant versus flowing air?**
   Effects appear to be minor.

2. **What is the effect of periodic removal of the sample for weighing (thermal cycling)?**
   Thermal cycling causes local spallation and more significant mass loss.

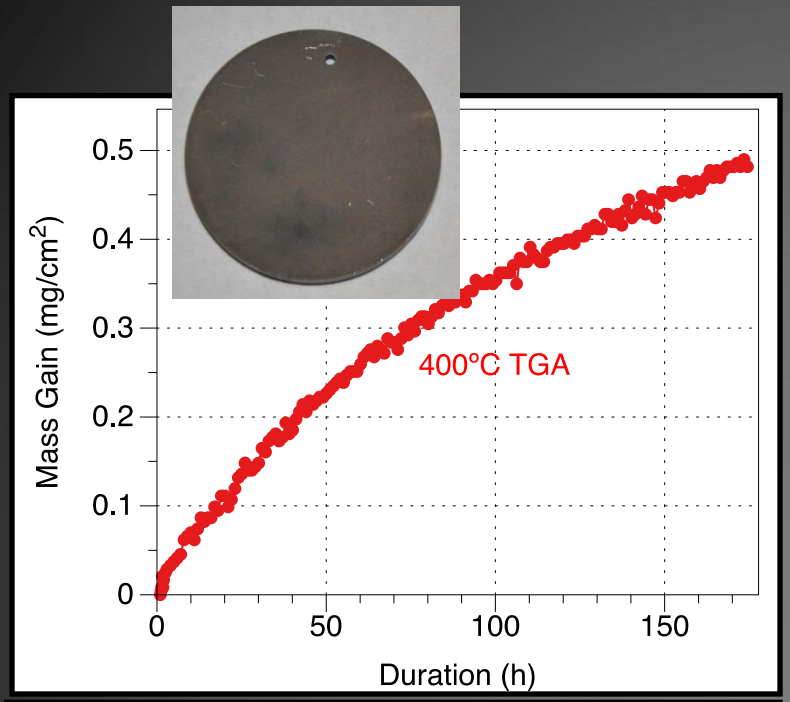


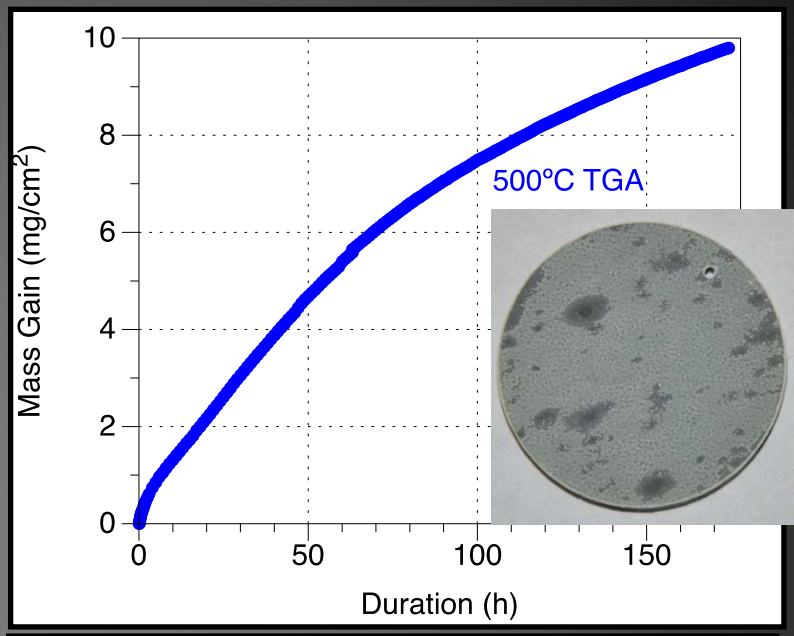
Test setup

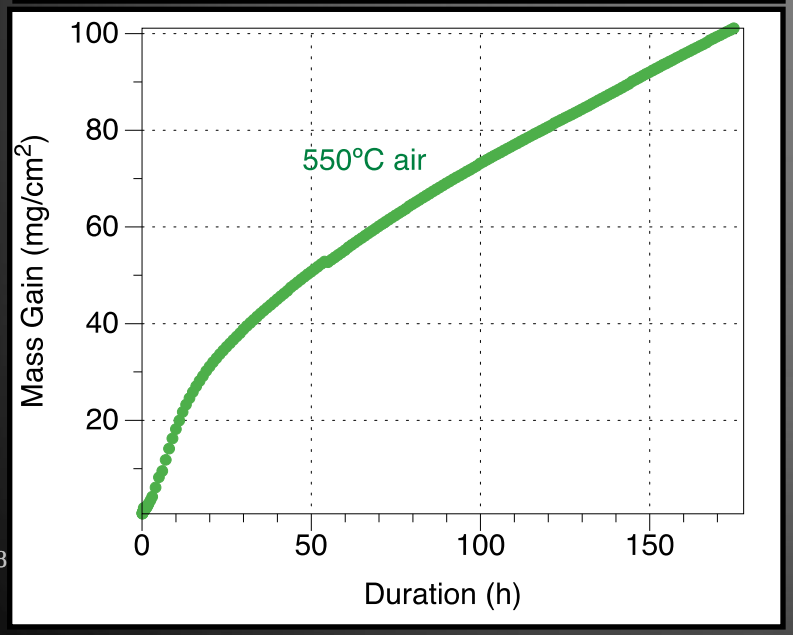


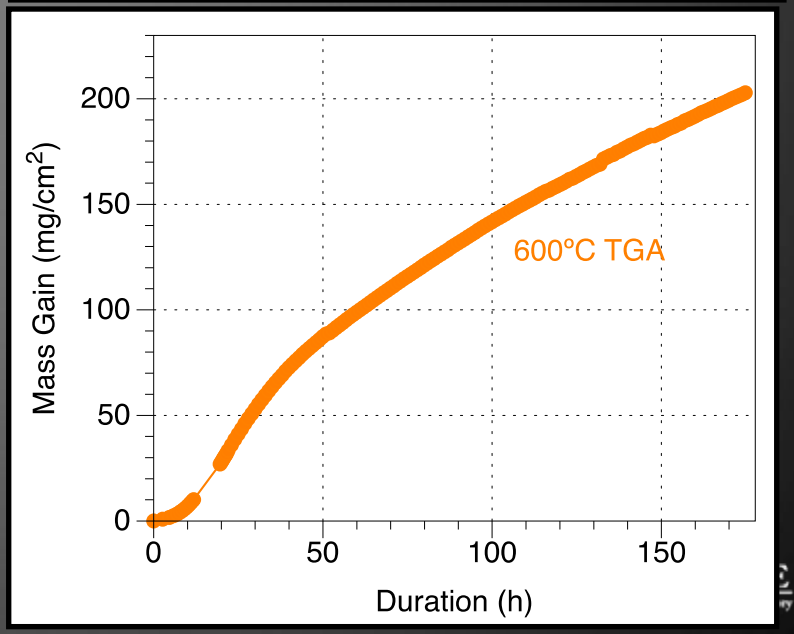
Test Matrix					
	Temperature (ºC)				
Atmosphere	400	450	500	550	600
Air stagnant	X		IP	X	X
Air flowing	X		X		
5% O2 + 95% He flowing			X	IP	

Oxidation in air ranging from 400°C to 600°C









Next Steps

- Continue oxidation matrix
- Perform PIE on irradiation “test string”
- Possibly irradiate additional molybdenum for GEH chemistry work.