MANTRA Experiment and the INL Experiment Design Process

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Introduction

Measurement of Actinide Neutronic Transmutation RAtes

- MANTRA is an NSUF Experiment that was awarded in 2010
- Description and Status of the MANTRA Experiment
- Explanation of the the INL design process

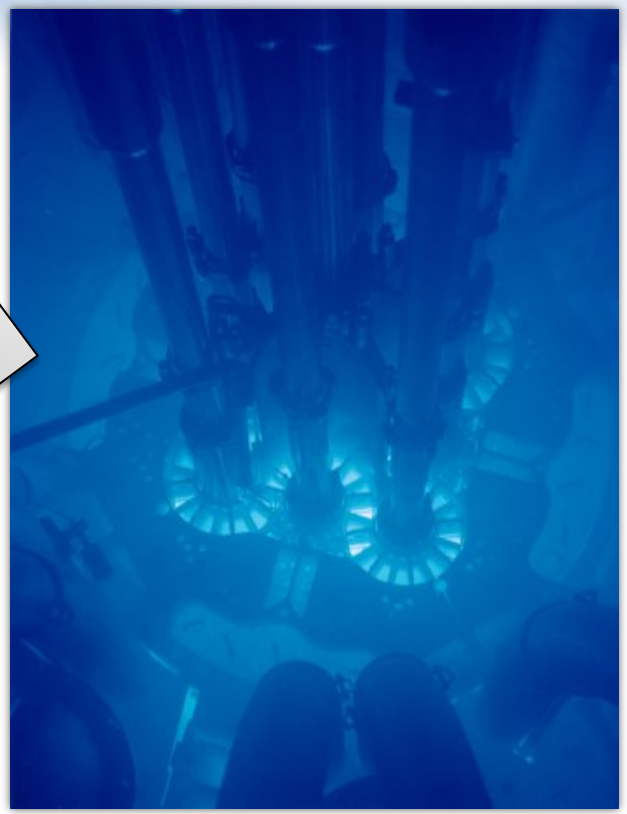
Proposal — Objective

- Infer effective neutron capture cross-sections of actinides of interest for reactor physics in fast and epithermal spectra (a few fission products are also considered)

- Consistency of the fast and epithermal data (i.e. same samples, same fabrication protocols, same PIE protocols, same experimentalists, etc…)

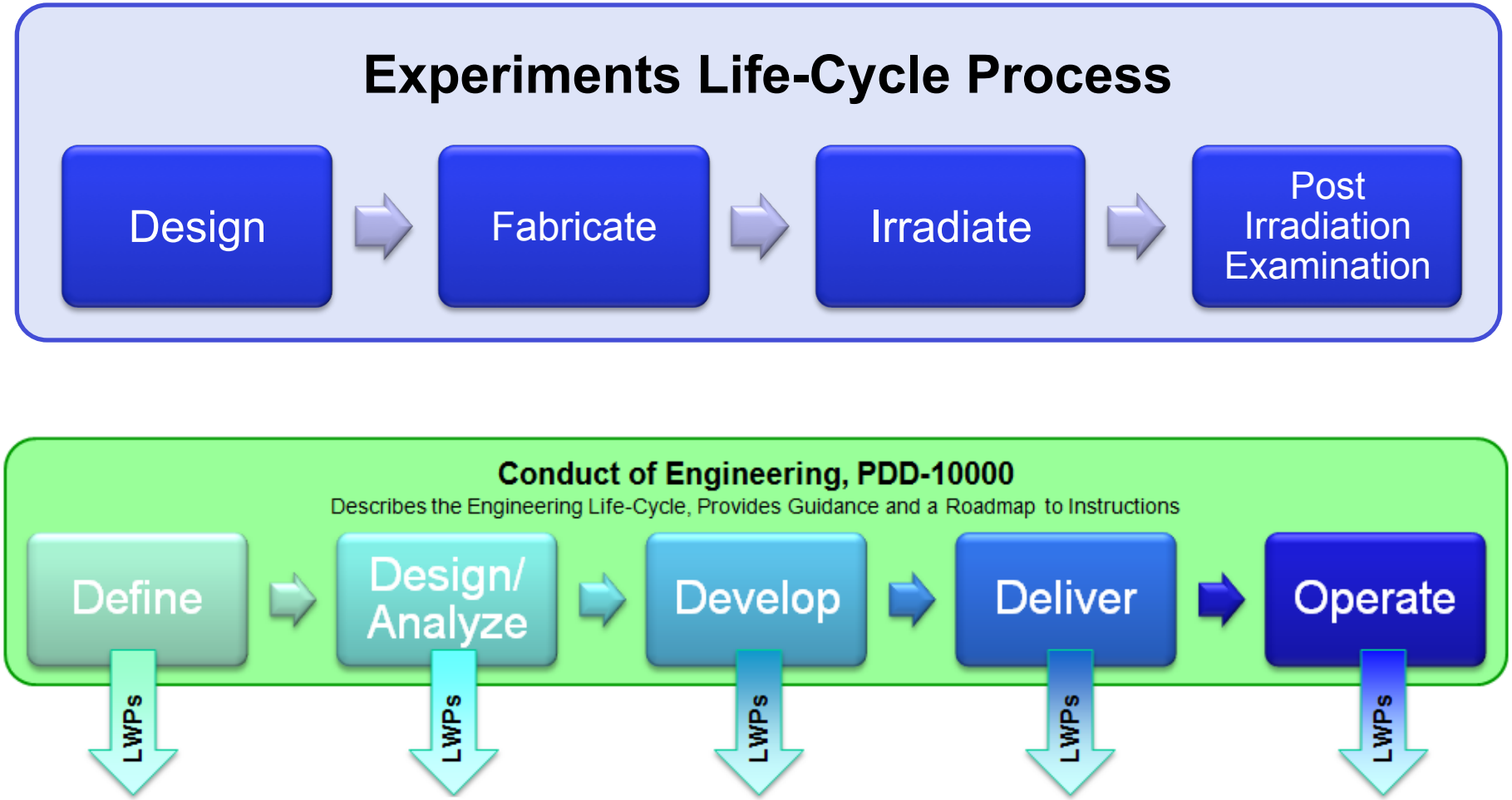
Proposal — Facilities

Irradiate Isotopes in ATR
(Advanced Test Reactor)



Measure daughter products at ATLAS
(Argonne Tandem Linear Accelerator)

INL Processes

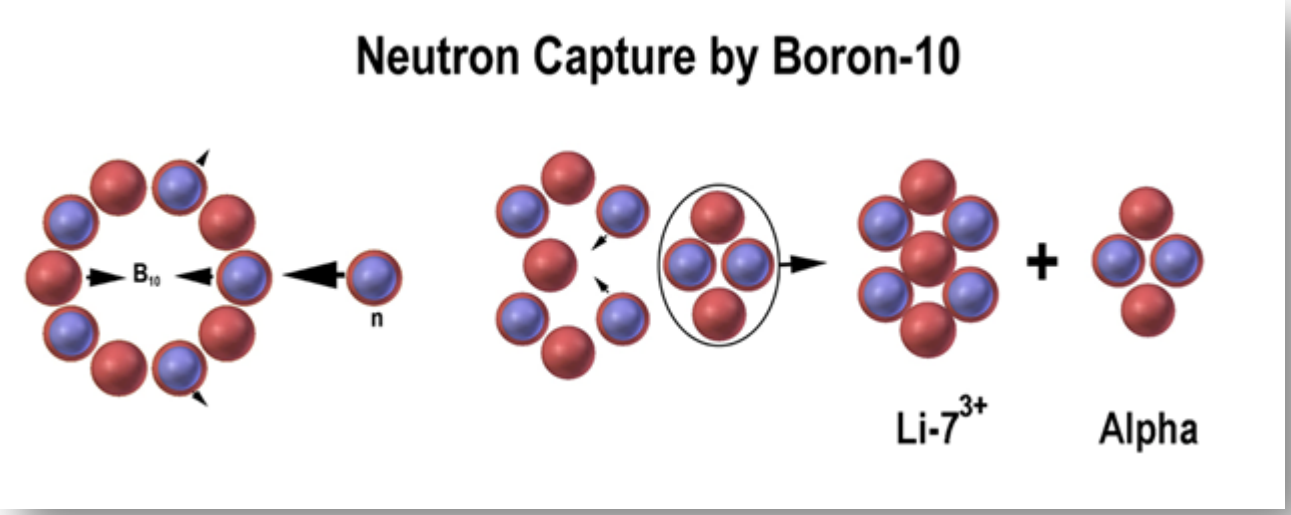


Design

- Isotope will be contained in an aluminum vial
- Each vial is placed in a stainless steel rodlet
- 78 rodlets total
  - 21 to 24 isotopes per capsule
  - 4 rodlets with flux wires
    - U-235, Co, Ni, Ti, Cu, Fe
- 3 capsules
  - 25 rodlets in boron filtered capsules
  - 28 rodlets in cadmium filtered capsules
- 3 different neutron filter baskets
  - Thin Boron filter
  - Thick Boron filter
  - Cadmium filter

Design — Boron Filters

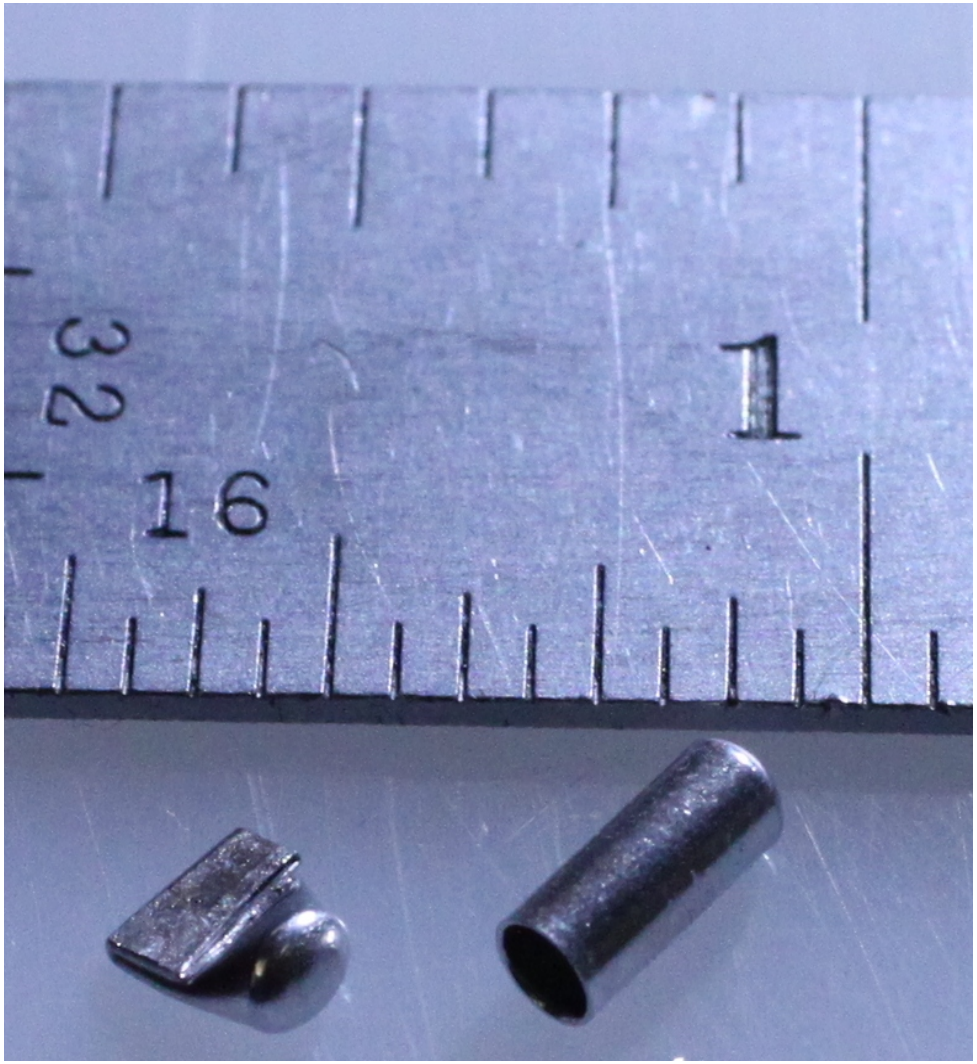
- Ceradyne was contracted to make Boron Carbide pellets
  - Enriched to 70% B-10
  - Boron had to be precision ground to size
  - 6 month lead time
- Boron pellets arrived about 16 months after order was placed.
- He pressurizes the basket making structural analysis much more difficult.



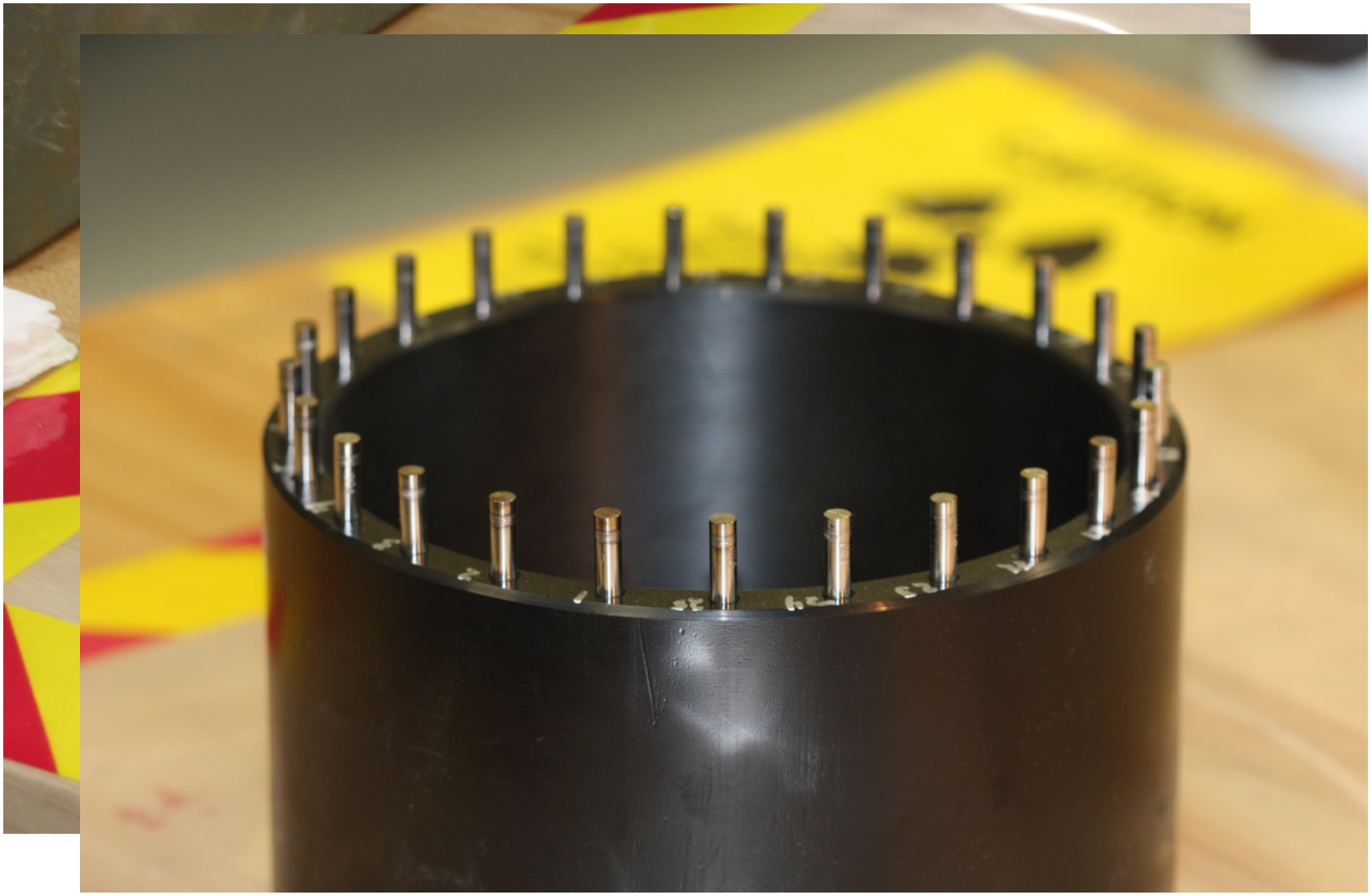
Fabrication — Specimens

- The INL Analytical Laboratory purified the samples.
- Impurities were measured using ICP-MS

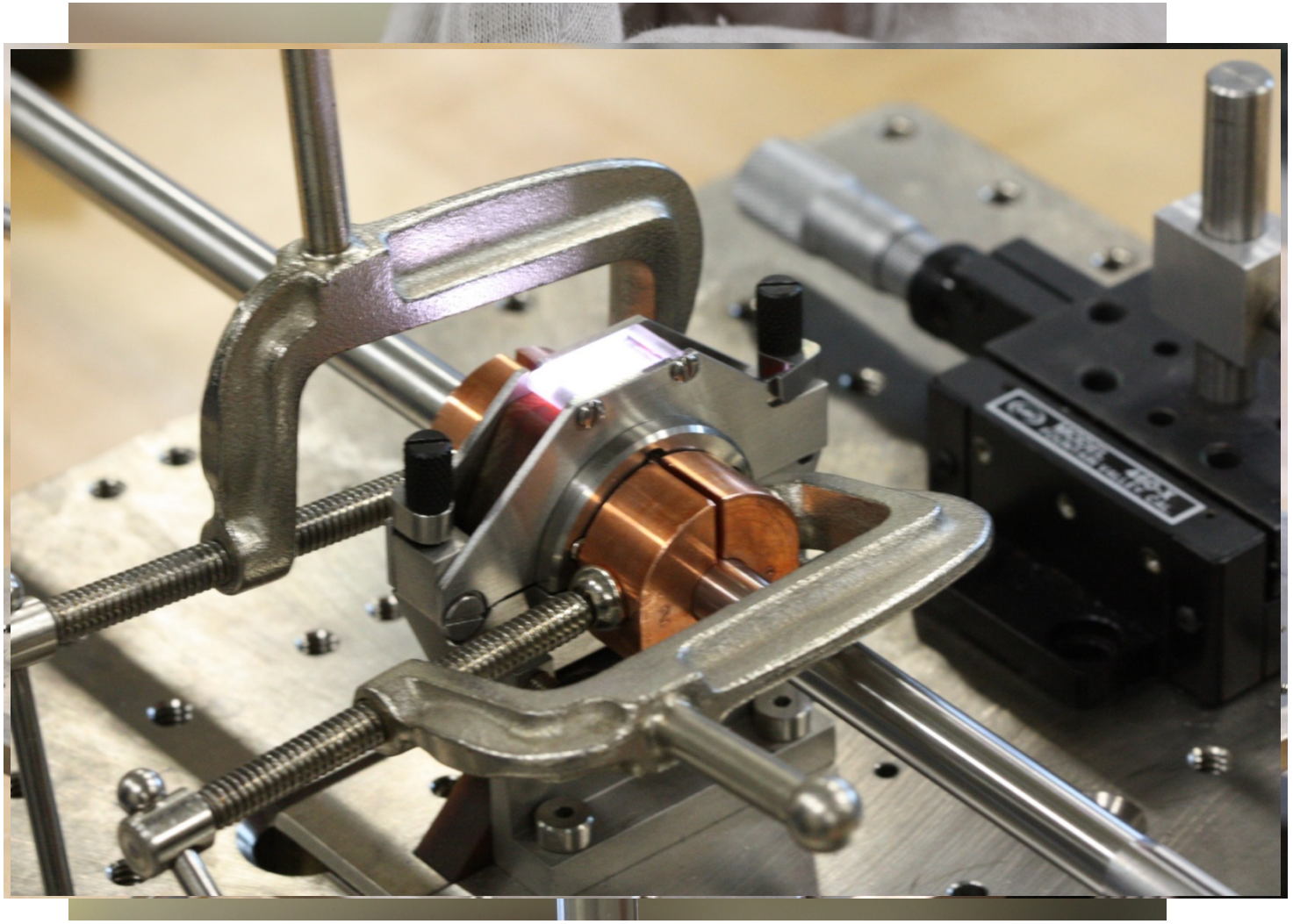
Isotopes		
Ru-101	Th-232	Pu-241
Rh-103	U-233	Pu-242
Pd-105	U-235	Pu-244
Cs-133	U-236	Am-241
Nd-143	U-238	Am-243
Nd-145	Np-237	Cm-244
Sm-149	Pu-239	Cm-248
Eu-153	Pu-240	



Fabrication — Rodlets

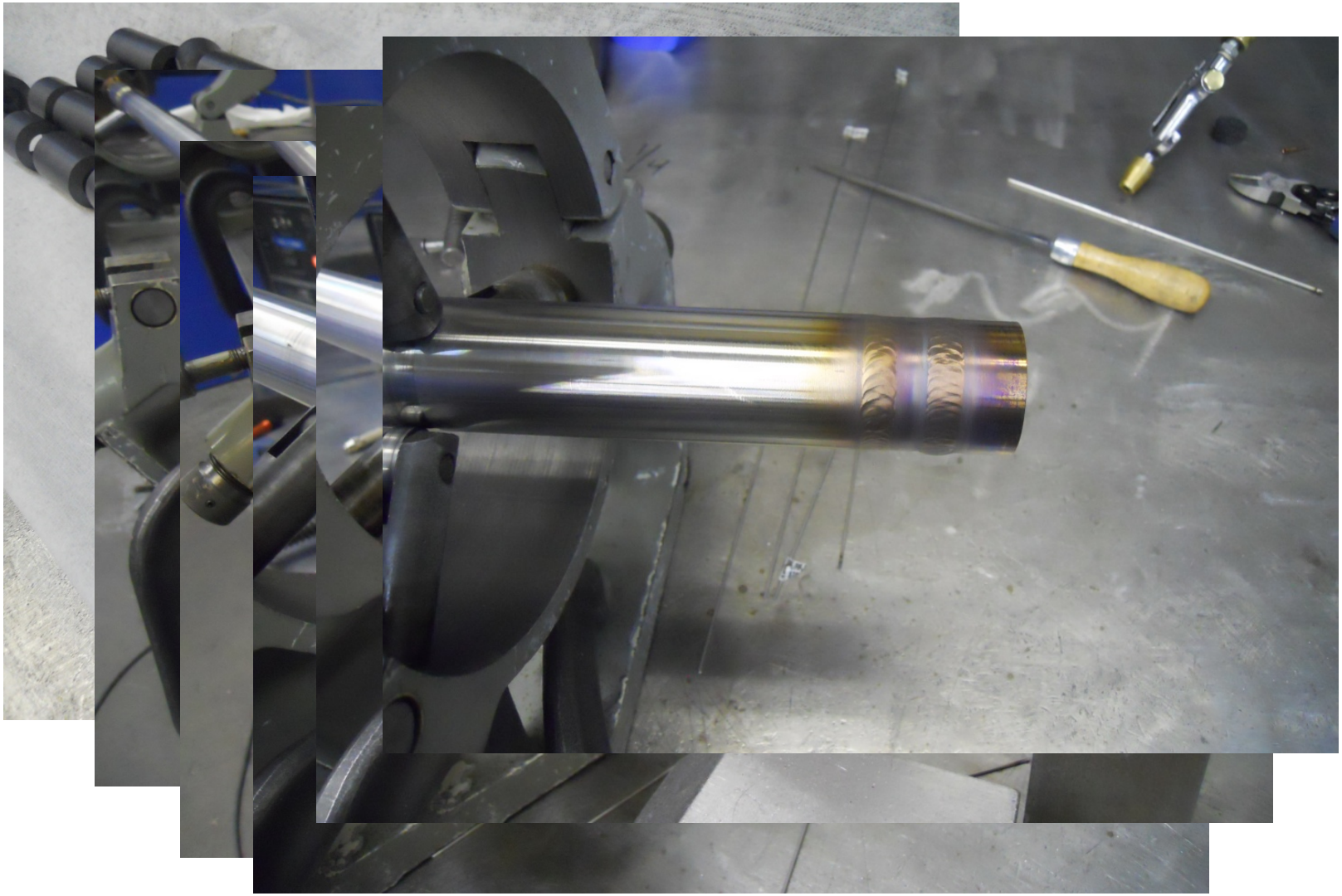


Fabrication — Capsules



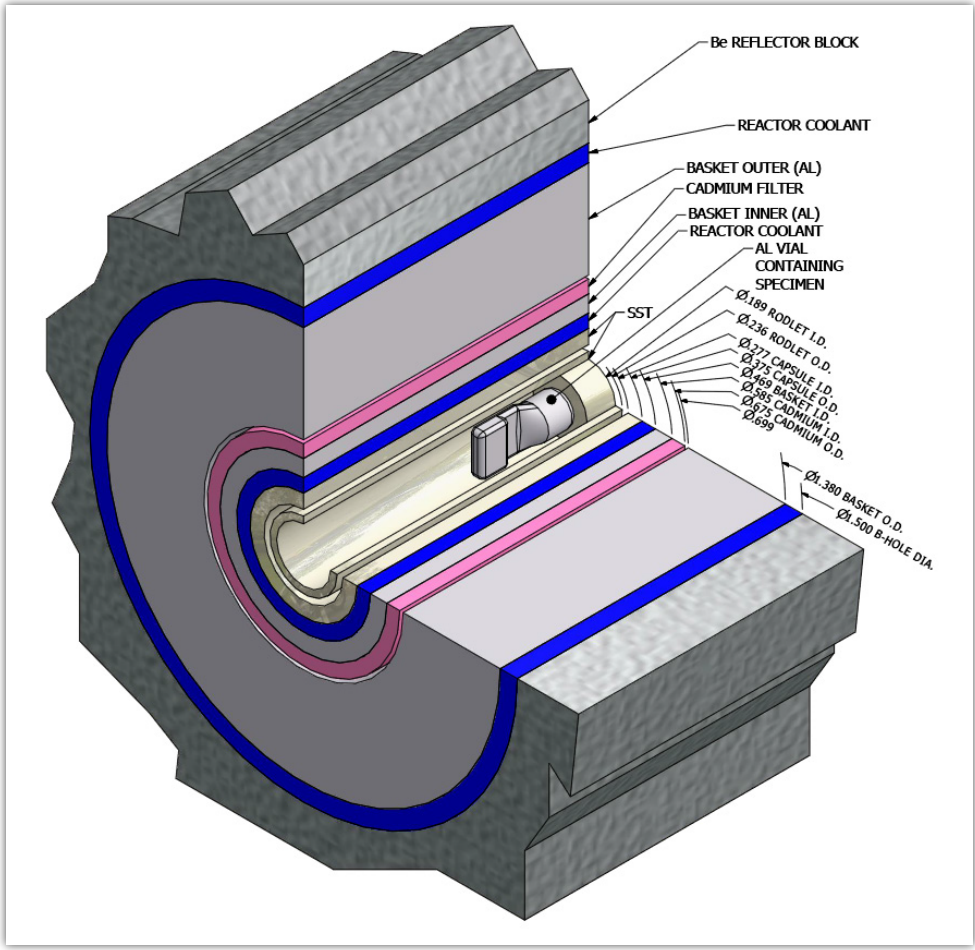
Sm149	1
Np237	2
flux wires	3
Am243	4
U233	5
U235	6
Cm248	7
Pu242	8
Pu244	9
flux wires	10
Pu240	11
Th232	12
Am241	13
Np237	14
Pu244	15
Cm248	16
flux wires	17
U238	18
Am243	19
Pu239	20
U236	21
Pu242	22
flux wires	23
Am241	24
Eu-Cs-Rh	25

Fabrication — Neutron Filters



Experiment Assembly

- Isotope
- Vial
- Rodlet
- Capsule
- Basket
- Beryllium Reflector



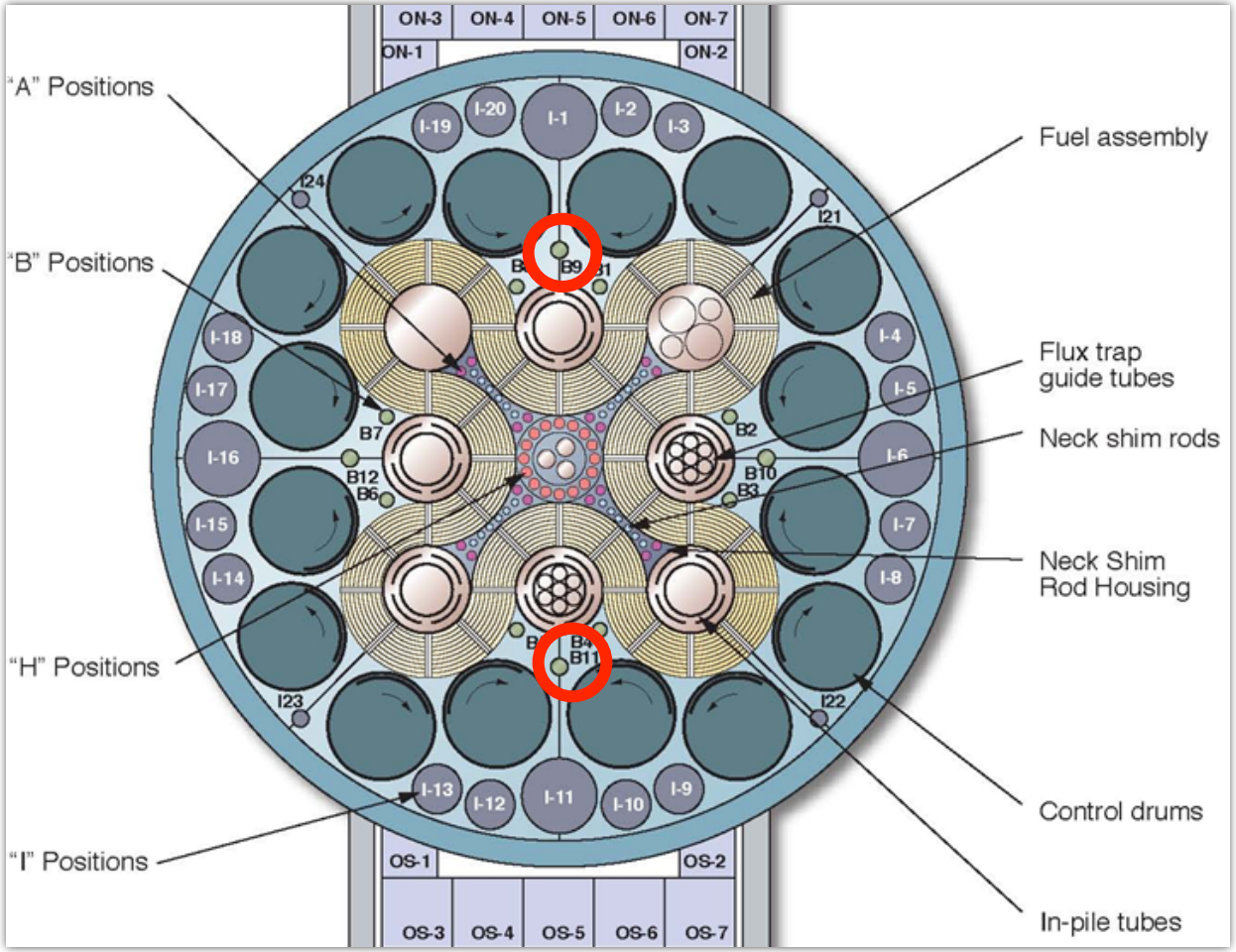
Irradiation

Before Insertion

- Engineering Safety Assurance Packagae (ESAP)
- Safety Oversight Review Committee (SORC Review)

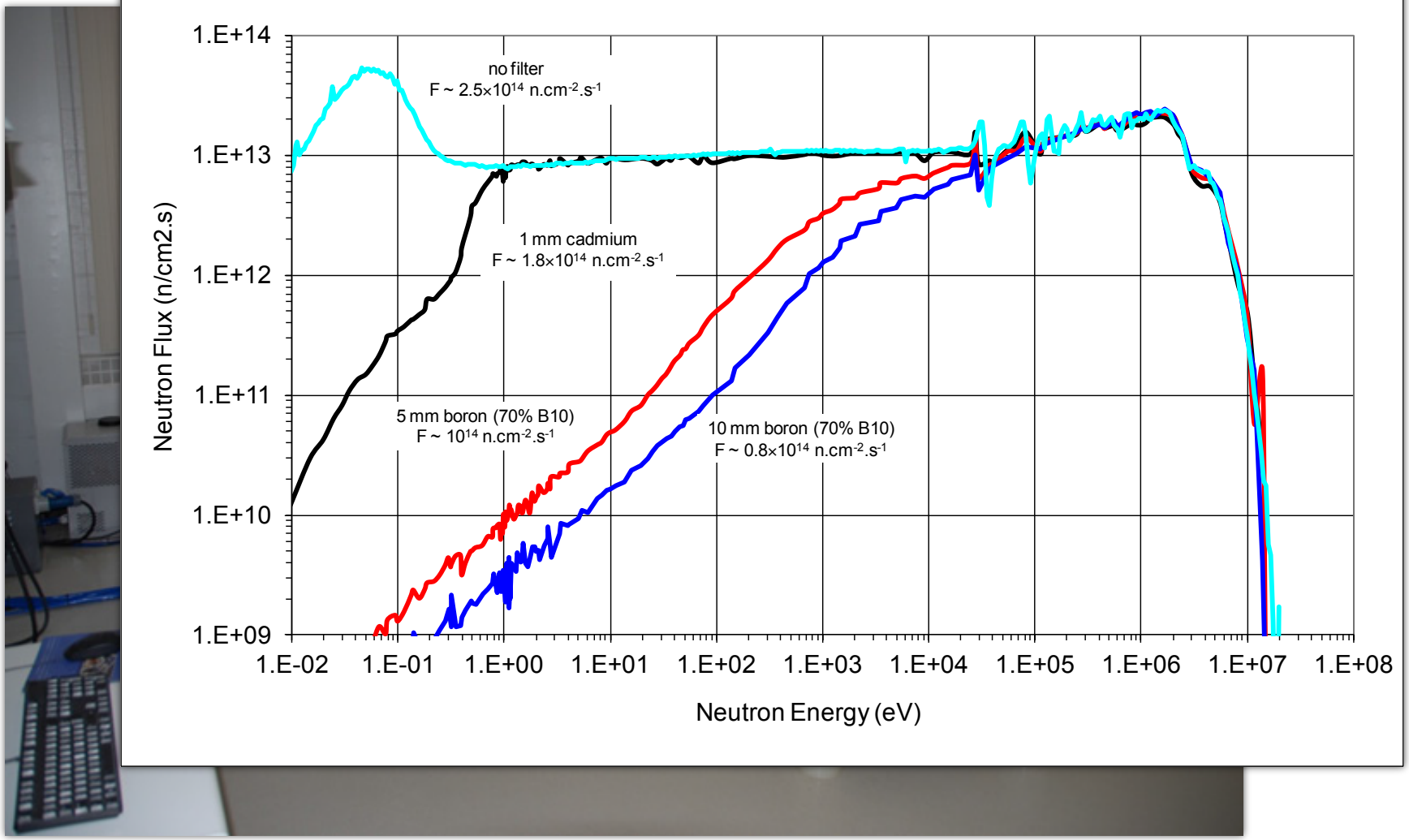
After Insertion

- Transfer experiment to canal to decay
- Prepare experiment for shipping



Shipping Irradiated Capsules to MFC

Results


1.E+14
1.E+13
1.E+12
1.E+11
1.E+10
1.E+09
Neutron Flux (n/cm2.s)
no filter
F ~ 2.5×10¹⁴ n.cm⁻².s⁻¹
1 mm cadmium
F ~ 1.8×10¹⁴ n.cm⁻².s⁻¹
5 mm boron (70% B10)
F ~ 10¹⁴ n.cm⁻².s⁻¹
10 mm boron (70% B10)
F ~ 0.8×10¹⁴ n.cm⁻².s⁻¹
1.E-02
1.E-01
1.E+00
1.E+01
1.E+02
1.E+03
1.E+04
1.E+05
1.E+06
1.E+07
1.E+08
Neutron Energy (eV)

What's Next?

- Dissolve specimens from last capsule
- Perform MC-ICPMS measurements at INL
- Ship specimens to ATLAS
- Measure transmutation products and calculate cross sections