

As-Built Model of Plutonium-Aluminum Zero Power Physics Reactor (ZPPR) Fuel for TEX

Presented at the Nuclear Criticality Safety Program (NCSP) Technical Program Review
March 26-27, 2014 at Los Alamos National Laboratory

Catherine Percher
Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory, P.O. Box 808, L-186, Livermore, CA 94551-0808

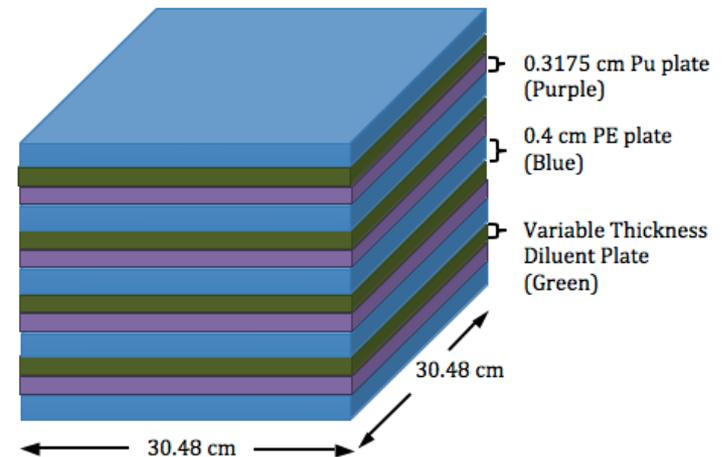
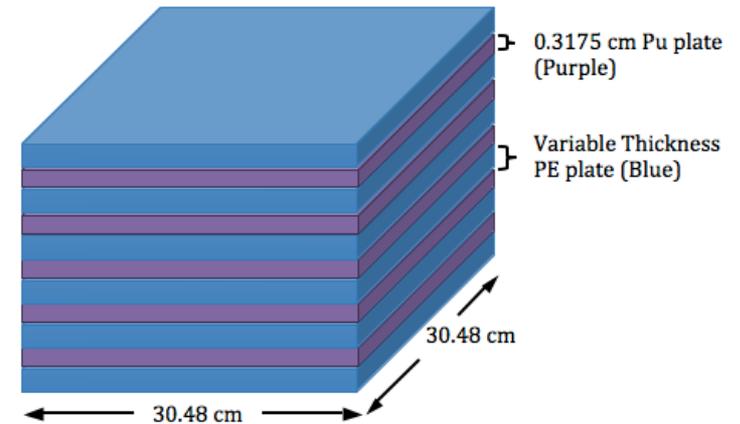
This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

IER 184: Thermal/Epithermal eXperiments (TEX)

- TEX Feasibility Meeting
 - July 2011 at Sandia National Laboratories, Albuquerque, NM
 - Representatives from US, UK, and France
- Intermediate spectrum experiments needed
 - Limited Data (2.1% of ICSBEP Benchmarks)
 - Consensus prioritization of nuclear data needs (in order):
 - ^{239}Pu , ^{240}Pu , ^{238}U , ^{235}U , Temperature variations, Water density variations, Steel, Lead (reflection), Hafnium, Tantalum, Tungsten, Nickel, Molybdenum, Chromium, Manganese, Copper, Vanadium, Titanium, and Concrete (reflection, characterization, and water content)
- CED-1 (FY12) showed feasibility for three different fissile systems to create intermediate energy assemblies with various diluent materials
 - Downselect to ZPPR Pu assemblies moderated by polyethylene with tantalum diluents for CED-2

TEX ZPPR Preliminary Design

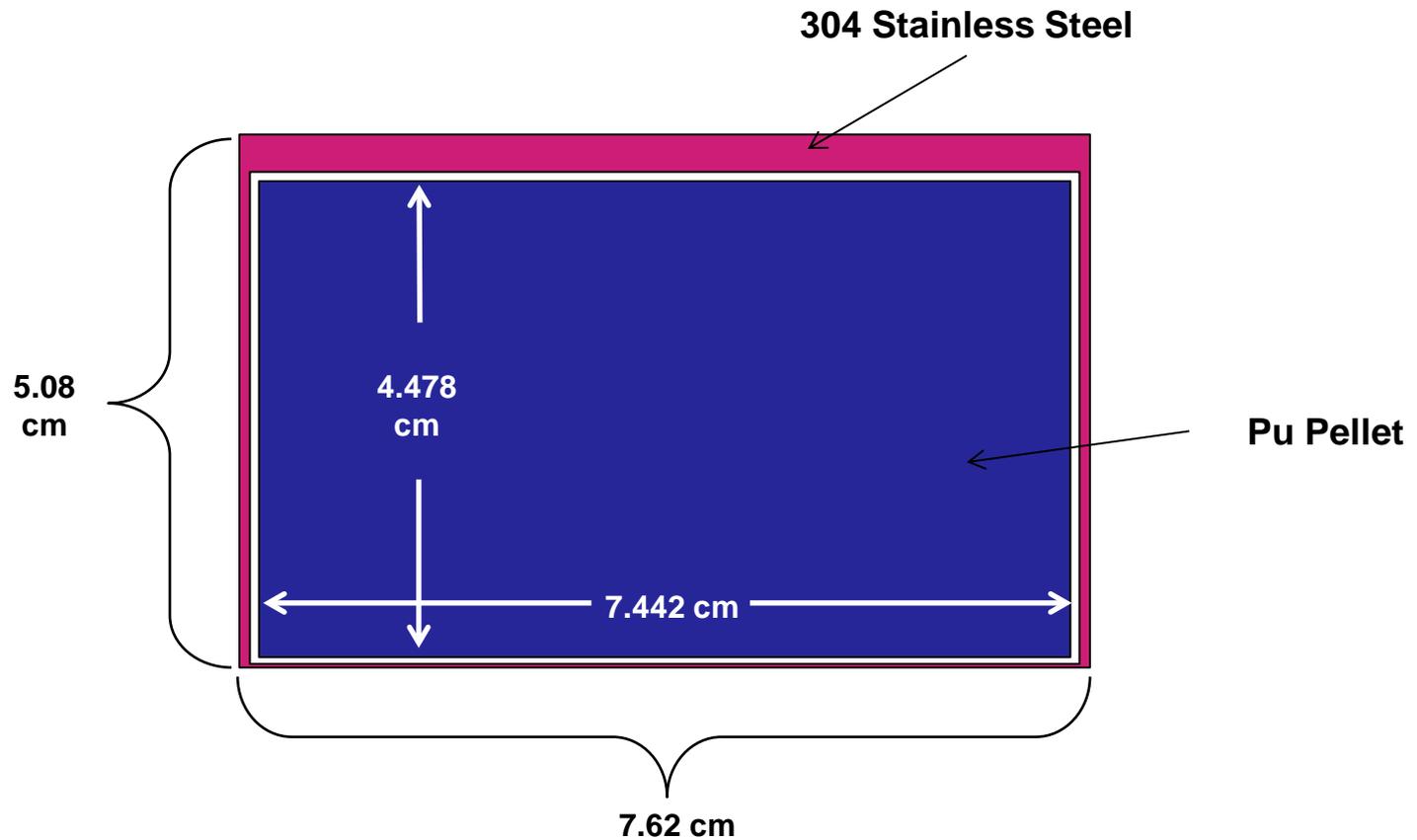
- Pu/Al (δ Pu stabilized with 1% Al) ZPPR plates (PANN) have approximate dimensions of 2" by 3" by 1/8"
- Experiment design arranges PANN plates in 12" square layers, 24 plates per layer, with varying levels of interspersed polyethylene and diluent materials
- The Pu, Al, and 304 stainless steel cladding were homogenized over the entire plate
 - Simplify calculations
 - Unknowns about plate construction



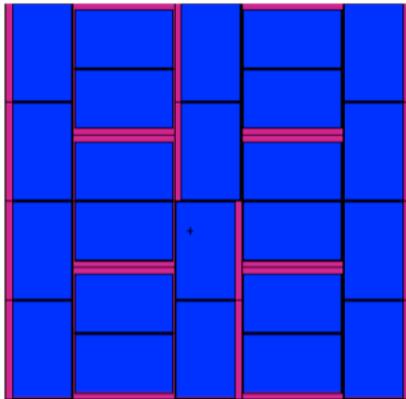
Does Homogeneity Effect the Results?

- Pu/Al ZPPR plates have been used in ICSBEP benchmarks, but detailed plate descriptions were not included
- From benchmarks and ANL documents, we knew:
 - **Pu “Pellet”**- known fairly well
 - Pu mass
 - Major isotopics, including Al content, but no impurity info
 - Dimensions of pellet
 - **304 Stainless Steel Cladding**- more unknowns
 - Average SS mass per plate
 - Major isotopics
 - 12 mil steel sheet used for construction
 - Nominal outer dimensions
 - Written description describes a “flat plug” of SS being “welded into the bottom” of the SS jacket
 - Written description of a “flat spring” being placed in one end of the jacket to hold the Pu flush against one side of the cladding

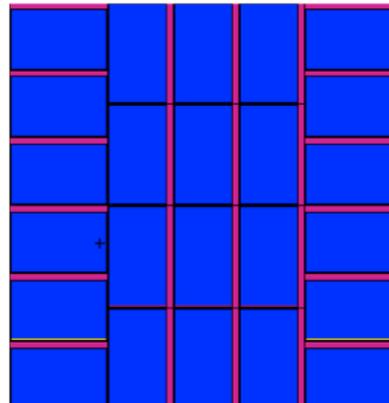
Initial Plate Model to Test Homogeneity Effects



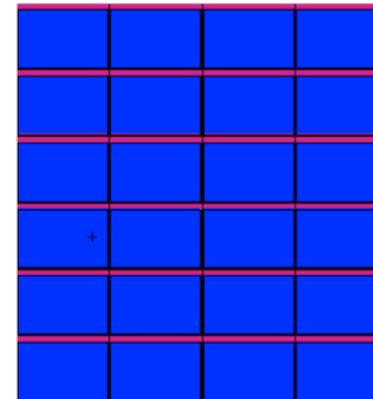
Layout Matters



Array 1



Array 2



Array 3

Thickness of Polyethylene Plates (cm)	Number of Critical Pu Layers			
	Keno V.A Homogenous	Array 1	Array 2	Array 3
0 (no PE)	31	31	31	32
0.25	23	23	23	24
0.4	19	19	20	20
0.5	17	17	18	18
0.75	13	13	14	14
1.0	11	11	12	12
2.0	6	7	8	7

Detailed Plate Design Information Required

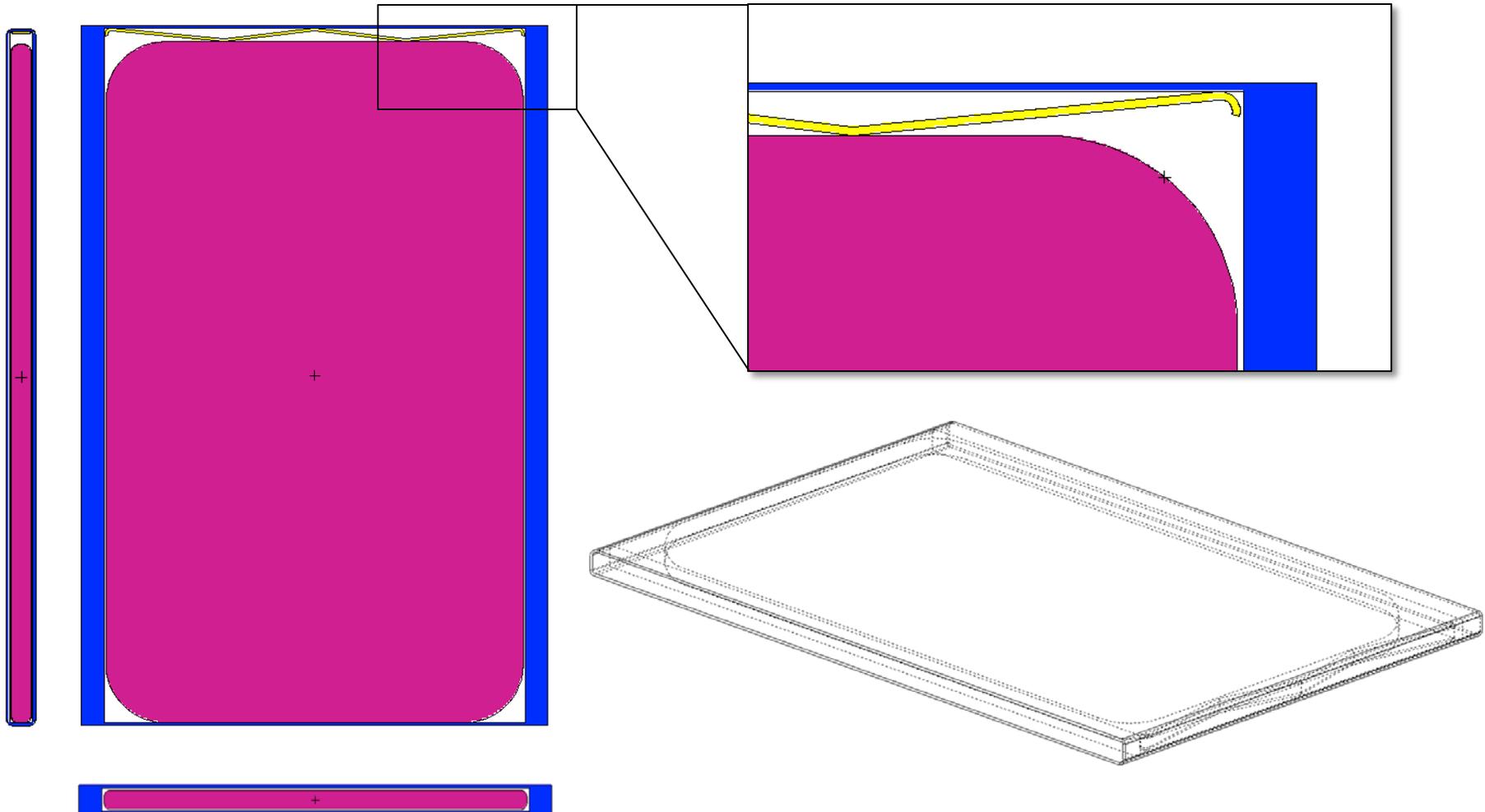
- PANN plates were made for reactor development experimental campaigns- drawings and specifications **must** have once existed
- At Argonne, information about the plates only existed in the ADEN database, which was used to create VIM decks
- With the lack of mission for ZPPR and Argonne-West transferring to INL, all relevant information was “sent to the INL archives”



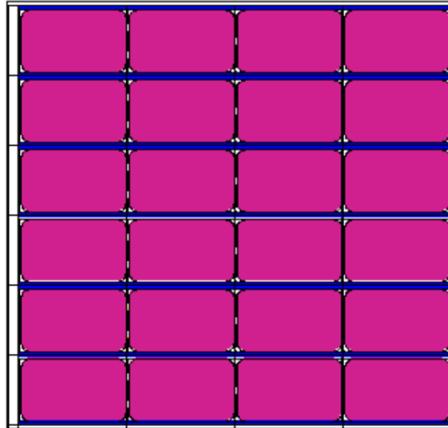
INL Archives Provided a Wealth of Information

- Identified 15 boxes of interest through INL Archives Database
- First box- “Ark of the Covenant”
 - Original drawing for PANN 3-inch plate (Drawing PF-1303)
 - Original specification for PANN plates, including fabrication details
 - Original letters between Dow Chemical (Rocky Flats) and Argonne hashing out details of plate fabrication
 - Including one dated Nov. 29, 1960 stating that the PANN plates had to be fabricated with declassified Pu, explaining enrichment differences from spec
 - Notes from radiography of every single 3” PANN plate detailing pellet irregularities, broken springs, springs on wrong side, etc.
 - Unfortunately, no specific information on impurities
 - Based on information found, impurity level is ~600 ppm (0.0654 g unknown out of a 105.383 g pellet)
- Other boxes- information about diluent plates
 - Impurity tests

Improved PANN As-Built Model



As-Built Calculations in Support of Final Design



Thickness of Polyethylene Plates (cm)	Number of Critical Pu Layers		As-Built Critical Mass (kg ²³⁹ Pu)	As-Built Stack Height (cm)
	Keno V.A Homogenous	As Built		
0 (no PE)	31	31	77.6	9.5
0.25	23	22	55.1	12.5
0.4	19	18	45.1	13.1
0.5	17	16	40.1	13.4
0.75	13	13	32.5	14.5
1.0	11	11	27.5	15.4
2.0	6	7	17.5	18.1

Current Work (FY2014) for TEX

- Final design (CED-2) for PANN plates and tantalum assemblies
- Experimental fixturing for use with Planet
 - Machined prototype tray and surrogate plates
- Engagement of AB to discuss DSA impacts

Acknowledgements

- I would like to thank the late, great Dick McKnight for all his comments on my CED-1 report and his help in pointing me toward the treasure trove of Argonne ZPPR documents in the INL archives.
- I express my undying gratitude toward Jason Andrus and Reese Gannon, both of INL, who spent many hours lobbying on my behalf to obtain entry into the INL archives and cheerfully spent many more hours and braved many paper cuts to assist me in examining boxes of paper files.
- I would also like to acknowledge my summer students, Crystal Greene and Una Stephens, who quickly mastered nested universes in MCNP and completed things so quickly I was challenged to provide them with adequate tasks.
- Allan Krass developed the as-built PANN plate MCNP model as only he could. His prowess with CAD and knowledge of all things mechanical is unrivaled. Soon Kim is also to be credited with the majority of the calculations in this presentation.