LA-UR-16-28655
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Title:	Measuring the Multiplication of Spent Fuel Assemblies – It's easier than you think!
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Intended for:	8 slides for advertising how easy it can be to measure the multiplication of a spent fuel assembly
Issued:	2016-11-09

Measuring the Multiplication of Spent Fuel Assemblies – It's easier than you think!

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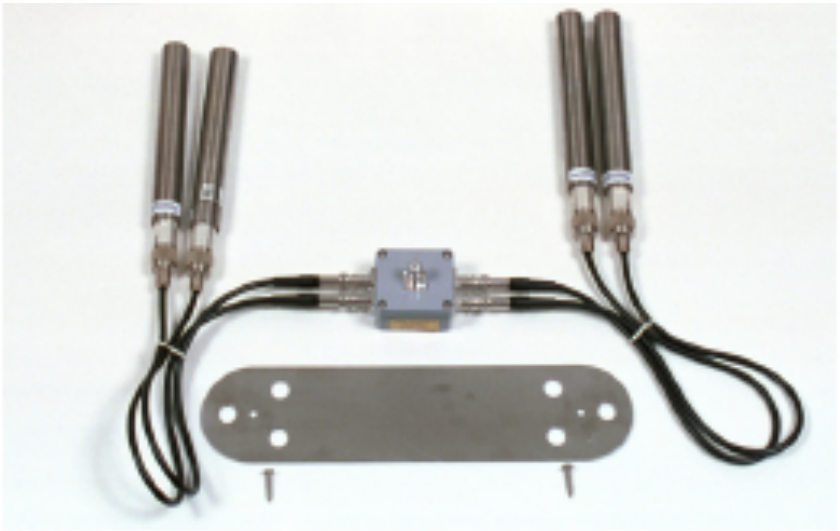
All that is Needed is (1) a Standard Fuel Rack and (2) the Hardware Indicated below



Four fission chambers, one m^3 of one mm thick Cd, one m^3 of one mm thick steel and data acquisition

Some Technical Details

The Nondestructive Assay Technique used is Passive Neutron Albedo Reactivity (PNAR)

- The suggested implementation works by measuring the assembly twice, once in a high multiplying vertical section of the individual rack opening and once in a low multiplying section of the same rack opening
  - The low multiplying section is created by wrapping a ~0.75 m vertical section of the rack with 1 mm of Cd
  - The high multiplying section is created doing nothing to the rack
  - Two fission chambers are position on opposite side of the fuel in both the high and low multiplying sections of the rack
  - The fuel is moved within the rack ~1 meter so that the section of interest, often the mid-plane, is measured in each section
  - Total count time for both measurements generally less than 15 minutes and can be much faster if ^{3}He tubes are used

Benefits of Measuring Multiplication to the Facility

Superior to the state-of-the-practice “burnup credit” approach

… Which involves measuring photons from fission fragments?

… So that you can infer the burnup?

… So that you can infer if there is a criticality concern

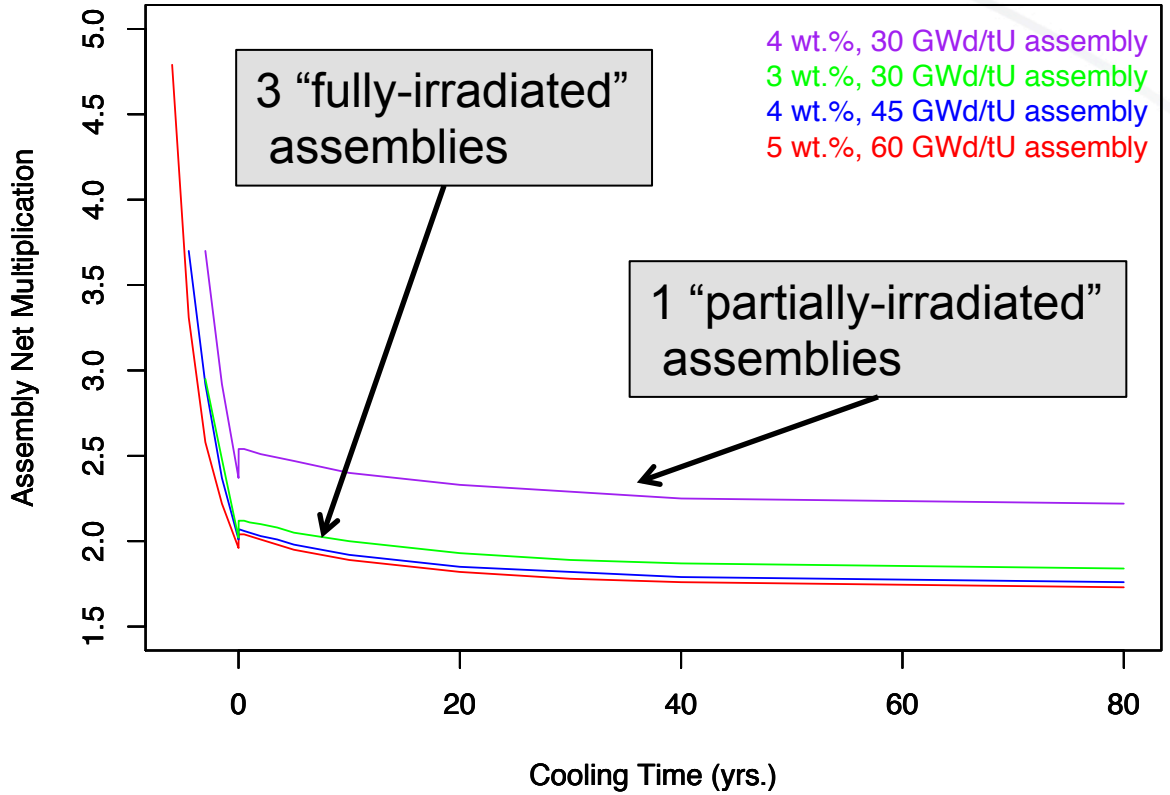
Why not directly measure the neutron reactivity/multiplication?

Such a measurement is easy, robust and accurate and can be built into a storage rack.

Benefits of Measuring Multiplication to the IAEA

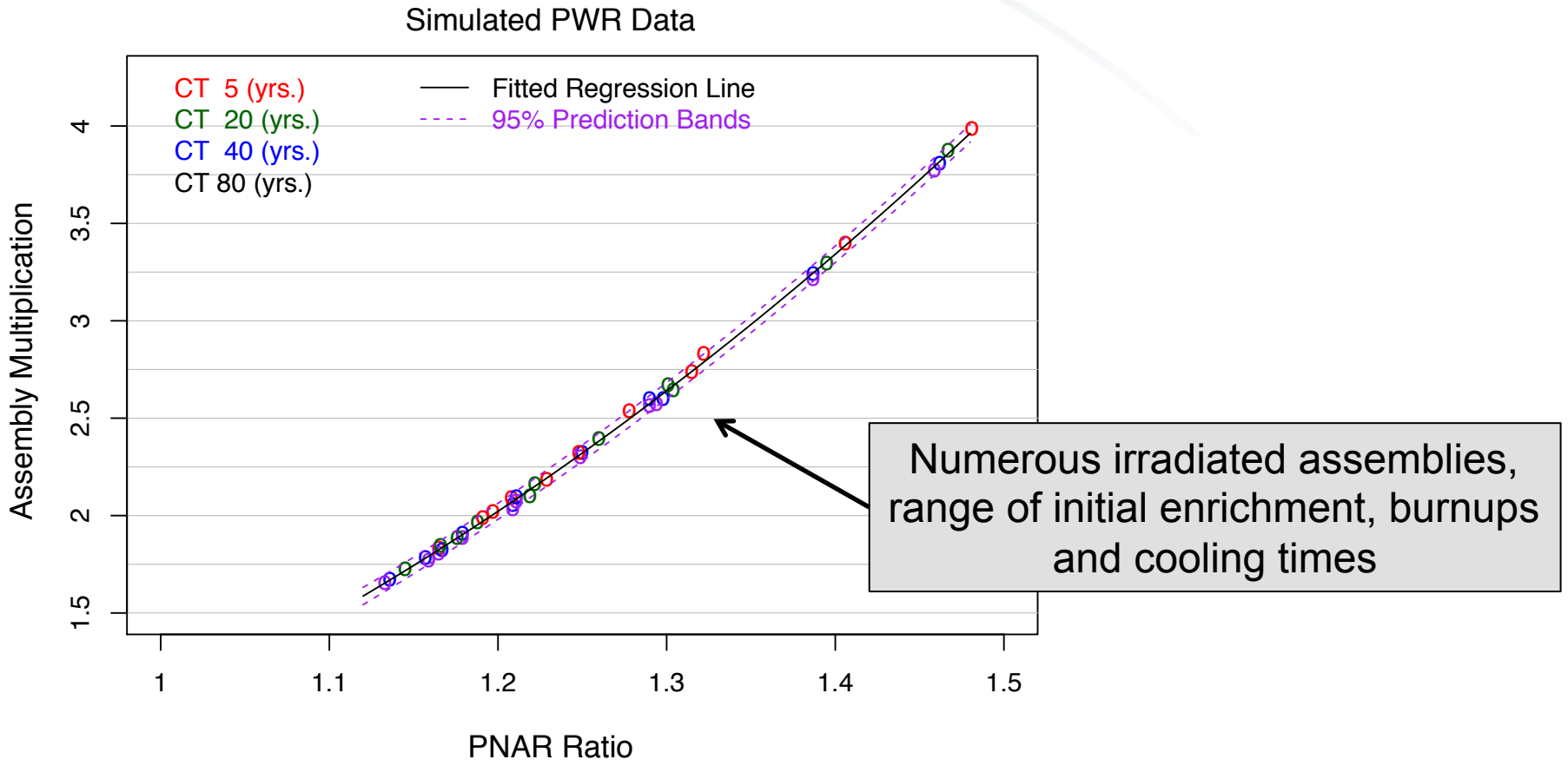
1. Multiplication indicates that fissile material is present
2. Multiplication does not vary much after discharged. From 10 years to 80 years:
   - Multiplication changes by ~8%
   - The intensity of ^{137}Cs gamma or the passive neutron count rate change by more than 200% for the same time interval
3. Multiplication is not significantly impacted by large breaks in reactor operating cycles as reactor operators strive to optimally extract energy
4. The neutron signals used to measure multiplication penetrate the entire assembly

Note the Change in Multiplication with Time



Simulated change in assembly net multiplication from fresh to 80 years post-irradiation

Simulated PNAR Ratio as a Function of Assembly Multiplication



Conclusion

A robust (fission chambers), rapid (under 15 minutes), direct (multiplication is measured, not photons from fission fragments) measurement of multiplication is possible