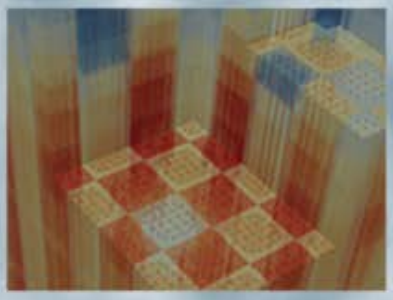
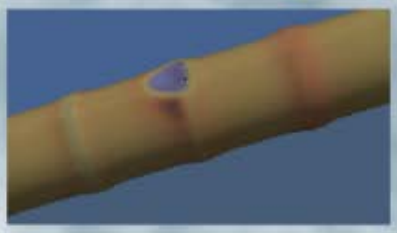
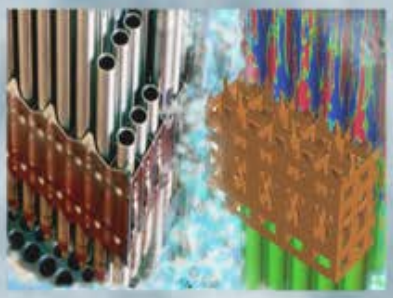
CASL-U-2015-0123-000

Discussion of Pin-Resolved Validation







Tom Downar
University of Michigan

April 19, 2015

U.S. DEPARTMENT OF ENERGY | Nuclear Energy

CASL-U-2015-0123-000

Discussion of Pin-Resolved Validation

Tom Downar

INERI Meeting
April 19th , 2015

CASL-U-2015-0123-000

MPACT Verification / Validation Plan

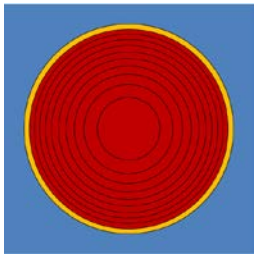
The V&V plan includes two principal components:

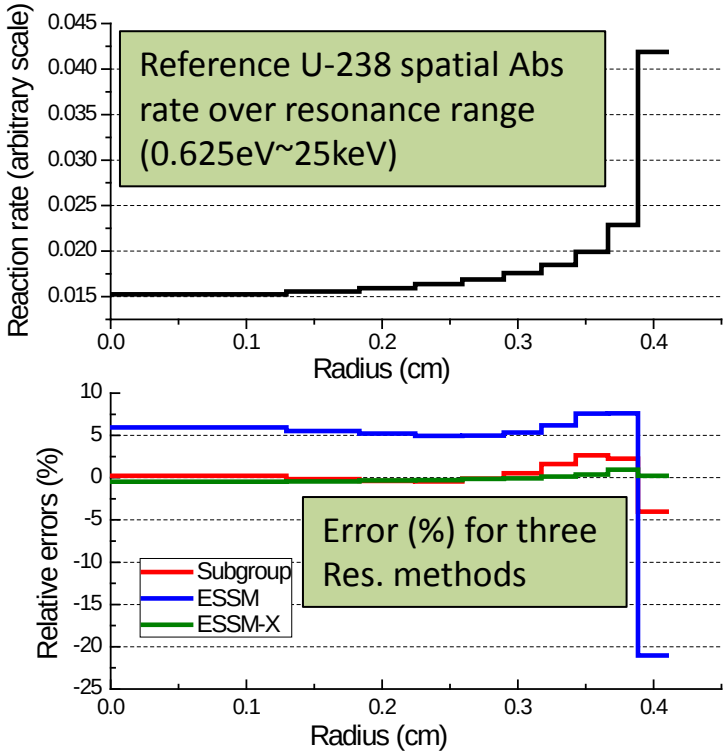
- **Verification**:
  - **Unit testing** (Brendan Kochunas / Dan Jabaay)
  - **Regression testing** (Ben Collins: L3RTM.PRT.P10.04 MPACT Regression Test Harness)
  - **Solution verification** (Wang/Martin/Collins): Manufactured Solutions)
- **Validation:**
  - Largely driven by Andrew Godfrey's "VERA-CS Validation Plan" CASL-U-2014-0185-000:
    - **Operating plant data** (e.g. BEAVRS/Watts Bar Collins/Godrey)
    - **Critical experiments** (e.g. B&W criticals Shane Stimpson (ORNL) / Joel Kalusza (UM)
    - **Depletion**
    - **CE Monte Carlo** (overlaps with solution verification)
  - Additional Validation for "pin resolved" or within pin reaction rates?
    - CE Monte Carlo w/ pin resolved tallies (Liu/Martin)
    - "Within Pin" code/code temp/isotopics ocmparisons INERI?
    - PSI PROTEUS coiled wire / SPECT Experiments ?

Self-shielding: Radial Effect (Y. Liu)

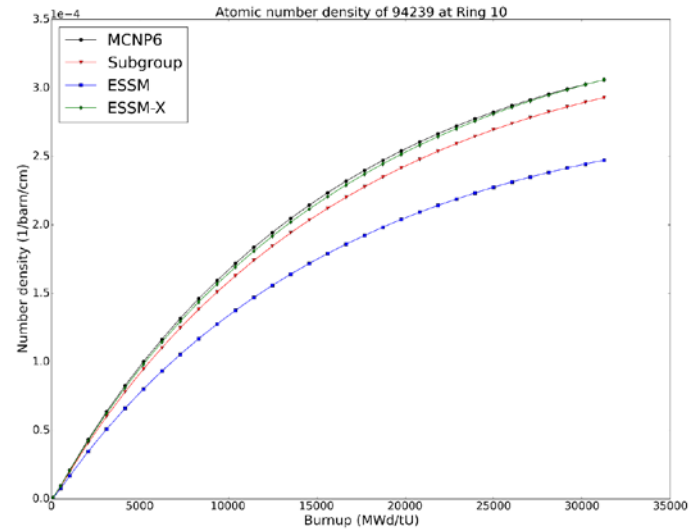
Calculation model:

- Infinite pin cell
- 10 rings of fuel region
- MCNP vs DeCART (subgroup, ESSM and ESSM-X)

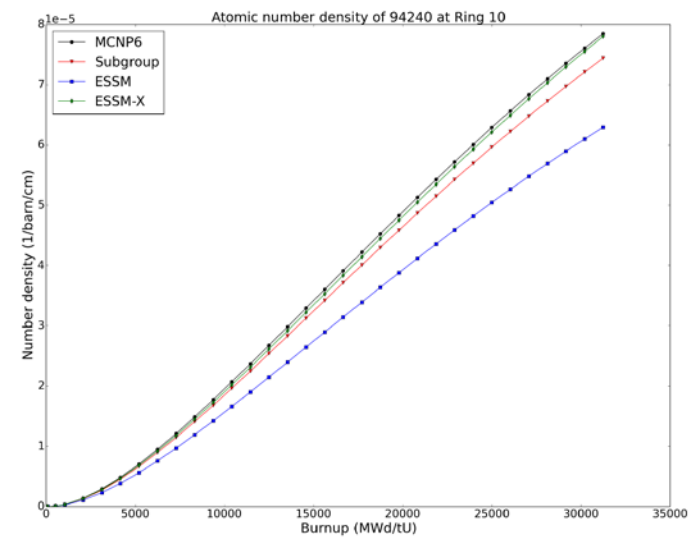




U-238 radially dependent absorption rates compared to MCNP reference (BOC)



Pu-239 content in the rim zone vs. burnup

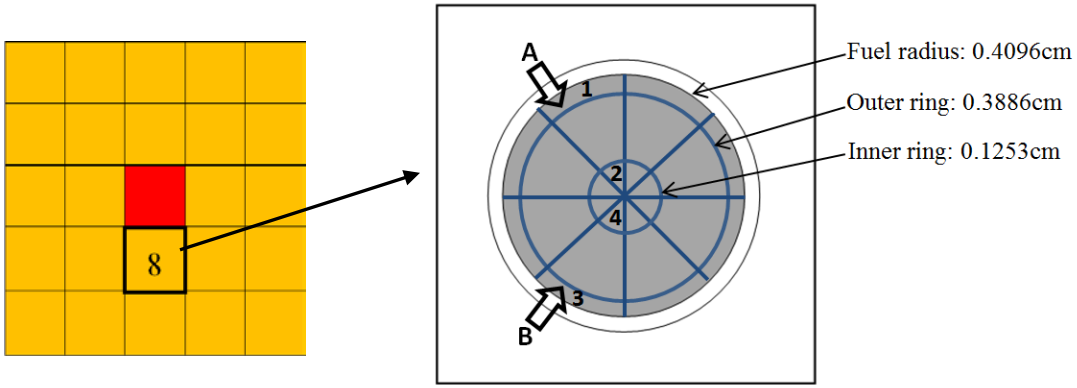


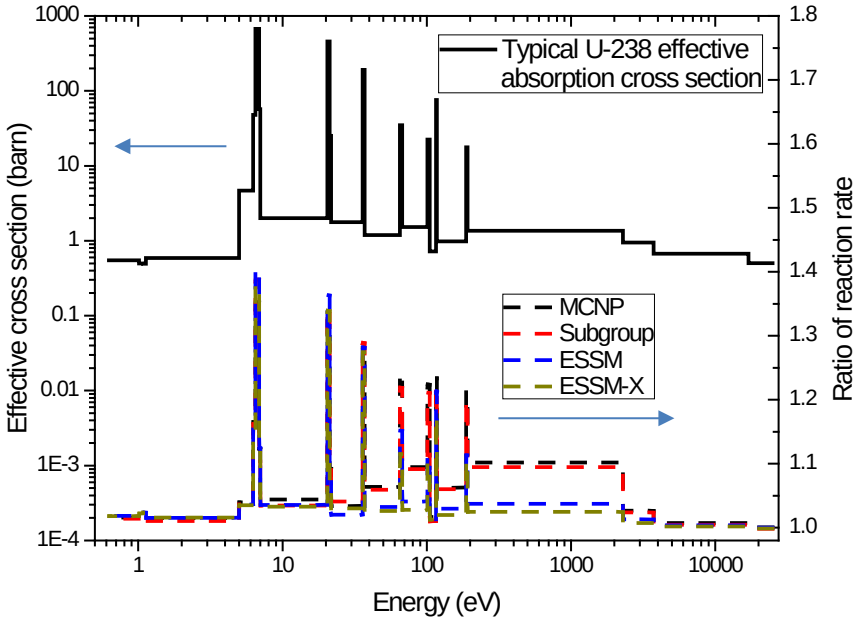
Pu-240 content in the rim zone vs. burnup

Self-shielding: Azimuthal Effect (Y. Liu)

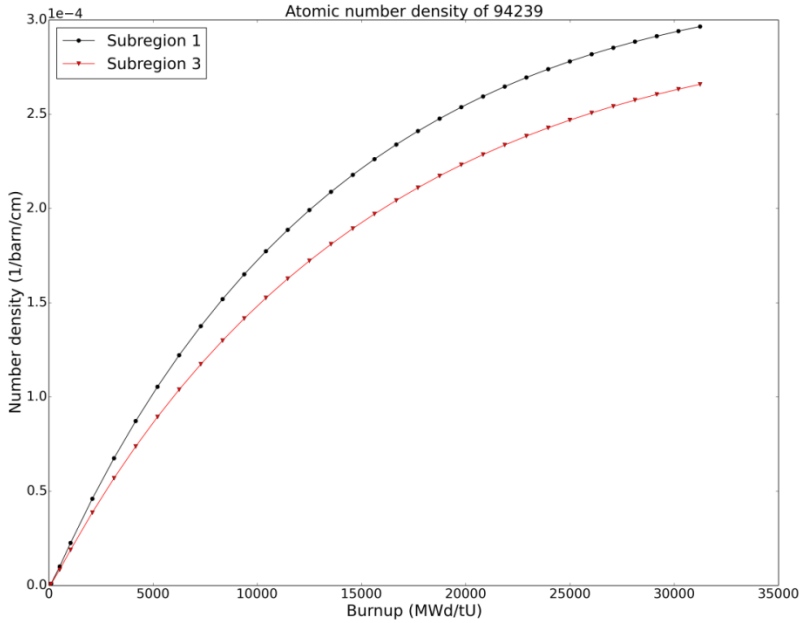
Calculation model:

- 5 by 5 pins
  - Yellow: UO2
  - Red: water hole
- Investigate pin 8: radial and azimuthal subdivision
- MCNP vs DeCART (subgroup, ESSM and ESSM-X)





U-238 Abs rate ratio of subregion 1 and 3, (subgroup gives good agreements with MCNP)



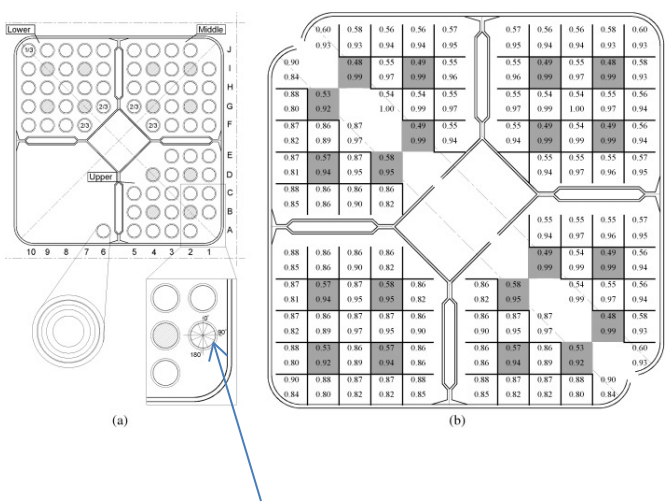
Pu-239 content of subregions 1 and 3 (10%-20% difference)

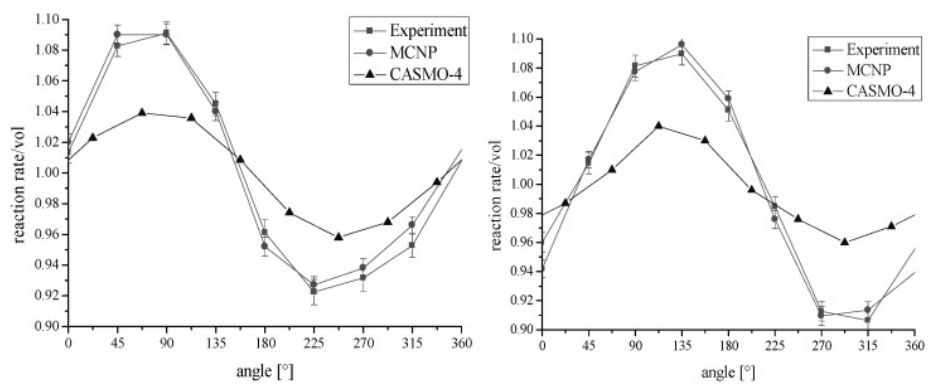
Pin Resolved Experiments (I)

Radial and Azimuthal 235U Fission and 238U Capture Distributions in BWR UO2 Pins: CASMO-4 and MCNP4C Versus Activation Foil Measurements

PSI / NSE: **155**, 96–101 2007

Abstract– *In the context of the LWR-PROTEUS program,* ***radial and azimuthal 235U fission (F5) and 238U capture (C8)*** *rate distributions have been calculated for zero-burnup pins of a* ***Westinghouse SVEA-96 Optima2*** *boiling water reactor fuel assembly using the stochastic* ***MCNP4C*** *and the deterministic* ***CASMO-4*** *codes. The within-pin F5 distributions predicted by the two codes are in very good agreement; the C8 distributions are more pronounced, and there are significant discrepancies between the codes, both azimuthally and radially. The calculations have been compared with experimental results obtained from* ***activation foil measurements in two pins*** *of the assembly irradiated in the center of the PROTEUS test zone. The measurements confirm that the two codes can accurately predict the radial and azimuthal F5 distributions but that* ***MCNP4C within-pin C8 distributions are much more accurate than those of CASMO-4.***



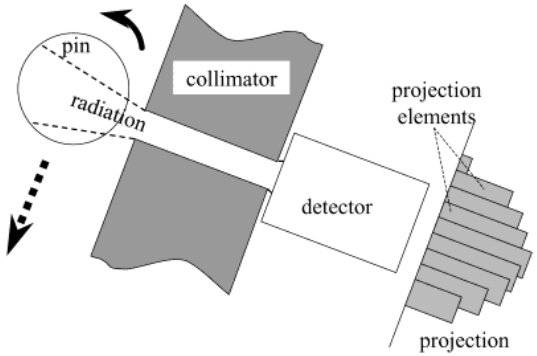
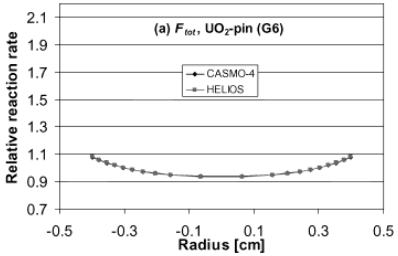
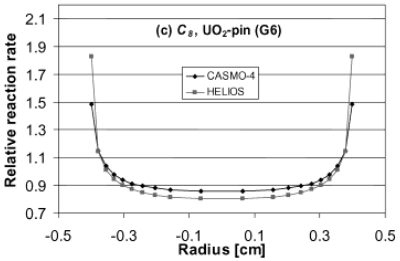


(a) C_8, lower part of pin B1

(b) C_8, middle part of pin B1

Pin Resolved Experiments (II)

Within-Pin Reaction Rate Distributions: CASMO-4 and HELIOS Compared Against Tomographic Measurements at the PROTEUS Reactor

PSI / NSE: **150**, 27–36 2005

Abstract–*In the framework of the **LWR-PROTEUS** project—an extended validation program for advanced light water reactor core analysis tools conducted at the Paul Scherrer Institute—the radial, internal variations of the total fission rate (Ftot) and the capture rate in 238U (C8) have been calculated for zero-burnup pins of a **Westinghouse SVEA-961 boiling water reactor** fuel assembly using two codes, namely, **CASMO-4** and **HELIOS**. While Ftot distributions predicted by CASMO-4 and HELIOS are in good agreement, **C8 distributions show significant inconsistencies (20 to 30%).** The calculations are compared with experimental results obtained using **single photon emission computerized tomography** for several SVEA-961 pins irradiated in the zero-power reactor PROTEUS. The comparisons confirm the predicted shape of the Ftot distributions within UO2 pins and clearly indicate that HELIOS within-pin predictions for C8 are more reliable than CASMO-4 results. This is important for the derivation of gamma-ray selfabsorption corrections when pin-integrated reaction rates are to be determined using the gamma-scanning technique. Thus, the use of CASMO-4–type within-pin distributions would lead to 3 to 4% discrepancies in the absolute, self-absorption–corrected pin-integrated values deduced for C8 and hence for C8 /Ftot. For relative C8 distributions, the discrepancy would be much smaller, namely, up to ;1% if pins containing a burnable absorber are involved.*