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A Study of the Effects of Source Sampling Methods on ARIES-RS NWL Profiles

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ARIES Pathways Project
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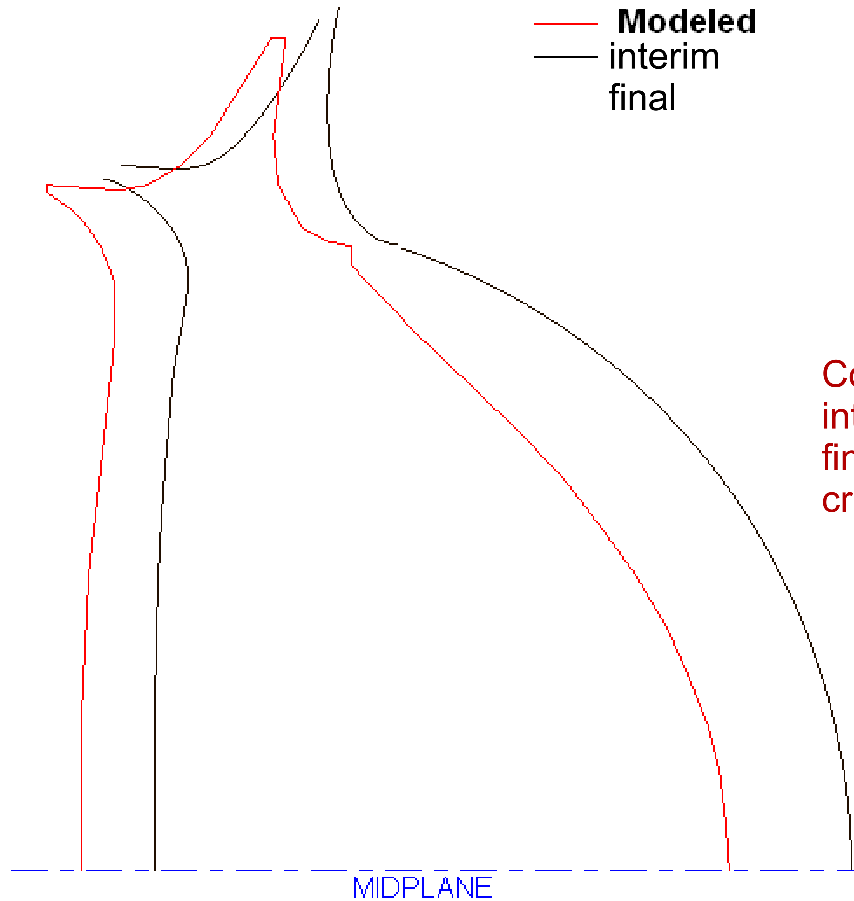
Outline

- Introduction
- Past NWL Work (in 1996) with approximate neutron source distribution
- Present Work with exact neutron source distribution
- Comparison with DAGMC
- Results
- Recommendations
- Publications

Introduction

- Using 3-D MCNP code, El-Guebaly* determined neutron wall loading (NWL) distribution for interim design
- Final design was later determined



Comparison of interim and final design cross sections

Parameter	Interim (Jan '96)	Final (Aug '96)
Power	1881.5 MW	2167 MW
Major Radius	5.12 m	5.52 m
Minor Radius	1.28 m	1.38 m
Magnetic Shift	55 cm	33 cm
Peak NWL (midplane)	5.3 MW/m^2	5.6 MW/m^2 (from ACS)

*El-Guebaly, L.A., The ARIES Team. "Overview of ARIES-RS neutronics and radiation shielding: key issues and main conclusions." *Fusion Engineering and Design* 38. (1997) : 139-158

Introduction

- We reexamined the NWL for ARIES-RS
- Different source sampling methods were used
  - Effect on NWL distribution is analyzed
- FW segmented vertically (every 10-20 cm) to improve accuracy

ARIES-RS cross section view with structural detail

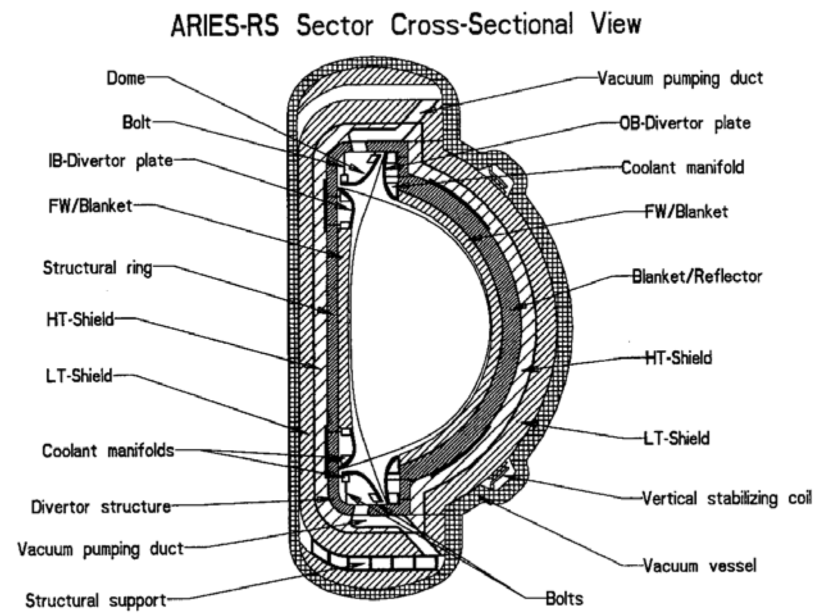


Fig. 1. Vertical cut through ARIES-RS showing the latest divertor configuration.

ARIES-RS cross section view with wall segmenting and 3 source regions shown

Past Work

- Used standard MCNP source definition
- 3 regions were created in the plasma zone
- They were weighted to represent the actual source distribution, provided by C. Bathke
- Each region was sampled uniformly
- Angular distribution was isotropic

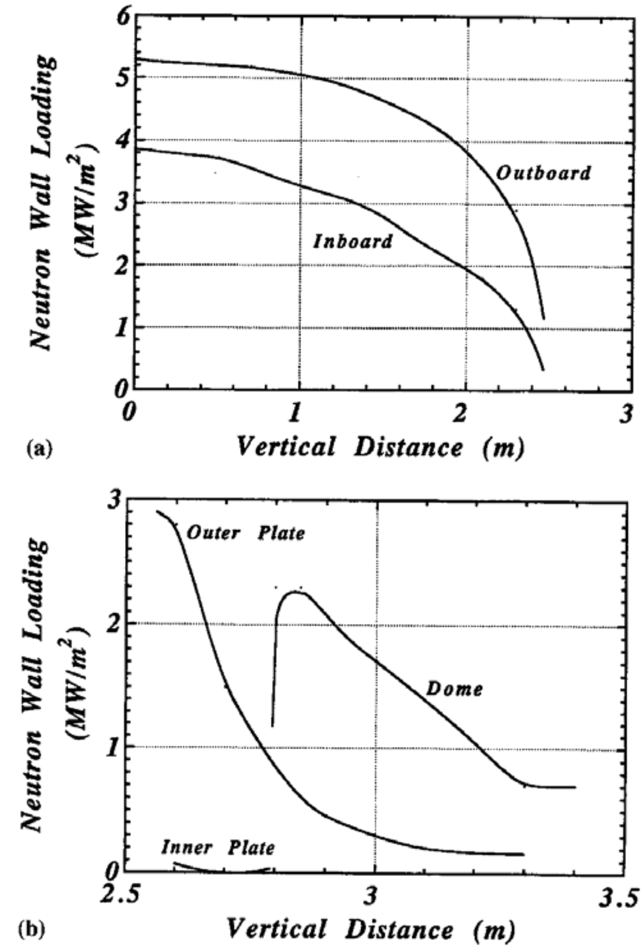


Fig. 2. Poloidal variation of neutron wall loading.

NWL results from 1997 report

Present Work

- For interim ARIES-RS design, NWL was computed using 3 source distributions:
  - one uniformly sampled region (basic)
  - 3 uniformly sampled regions (this is what was done before)
  - Sampling of actual source distribution provided by C. Kessel
- These results will be compared to assess the accuracy of each method.

Present Work (cont.)

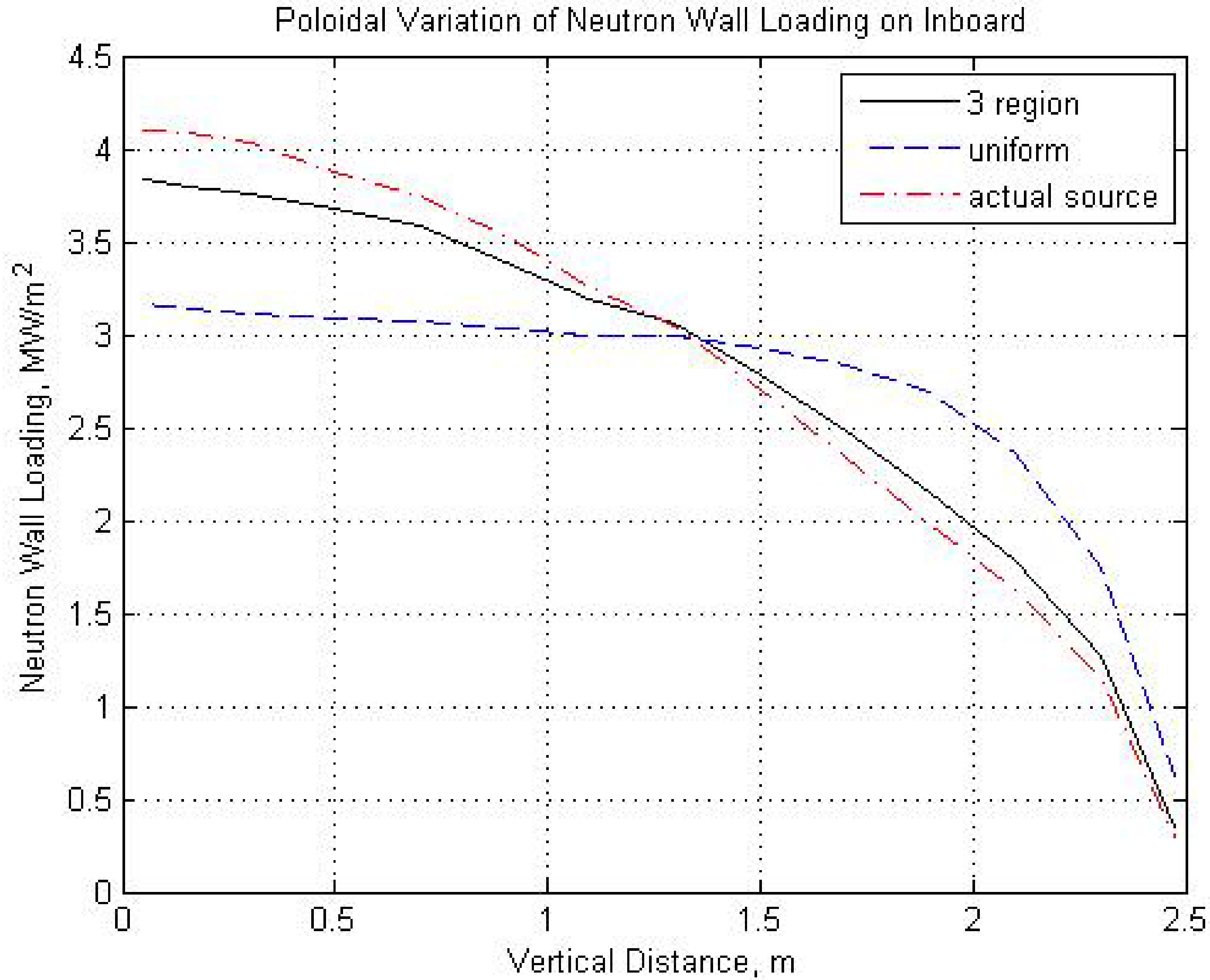
- Plasma parameters provided by C. Kessel
  - Provided on R-Z grid in standard output format from plasma physics simulation
- Generate a source density distribution on R-Z grid, S(R,Z)
- Source probability density function (PDF) derived by volume weighting
  - PDF = $2\pi R*dR*dZ*S(R,Z)$
- Cumulative distribution function is created by summing over R and Z

Present Work (cont.)

- Source mesh cell is selected by:
  - Linear search through Z from distribution function
  - Linear search through R from distribution function
  - Toroidal angle is sampled randomly from a uniform distribution
- The source mesh cell is then sampled uniformly in volume; the size is obtained from the R-Z grid
- The source is emitted isotropically

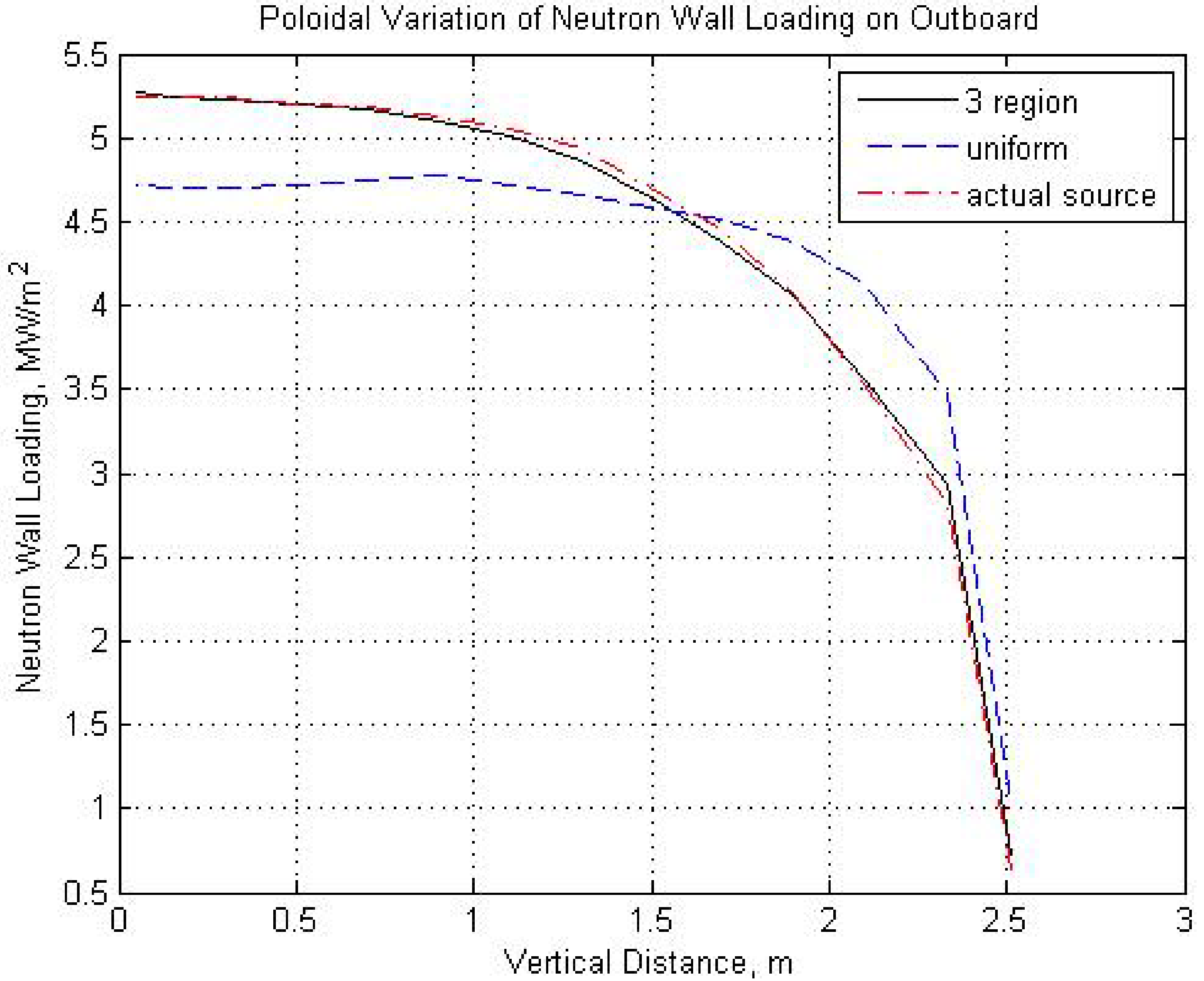
Results

Comparison of Inboard NWL results by source, native geometry



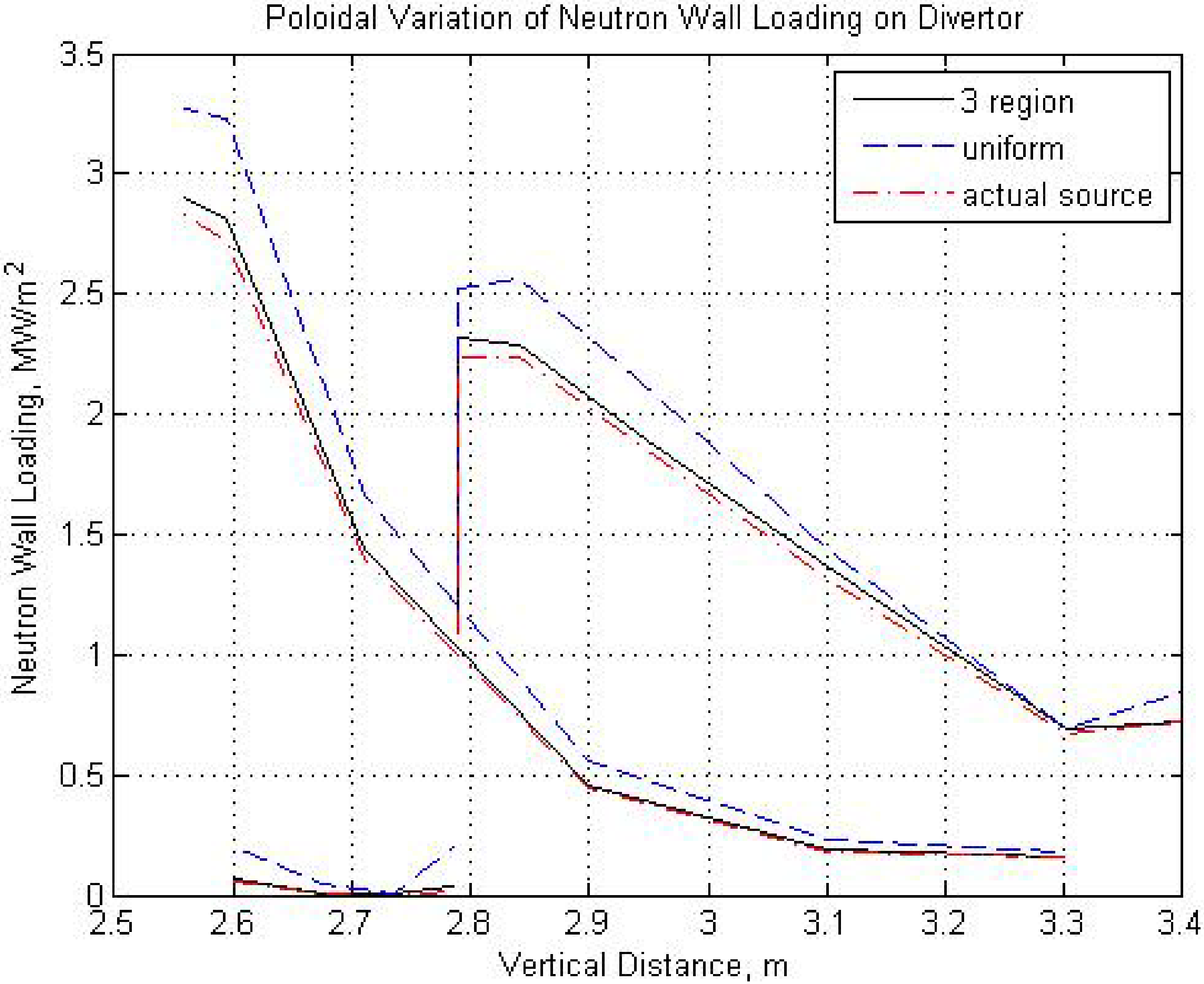
Results

Comparison of Outboard NWL results by source, native geometry



Results

Comparison of Divertor NWL results by source, native geometry

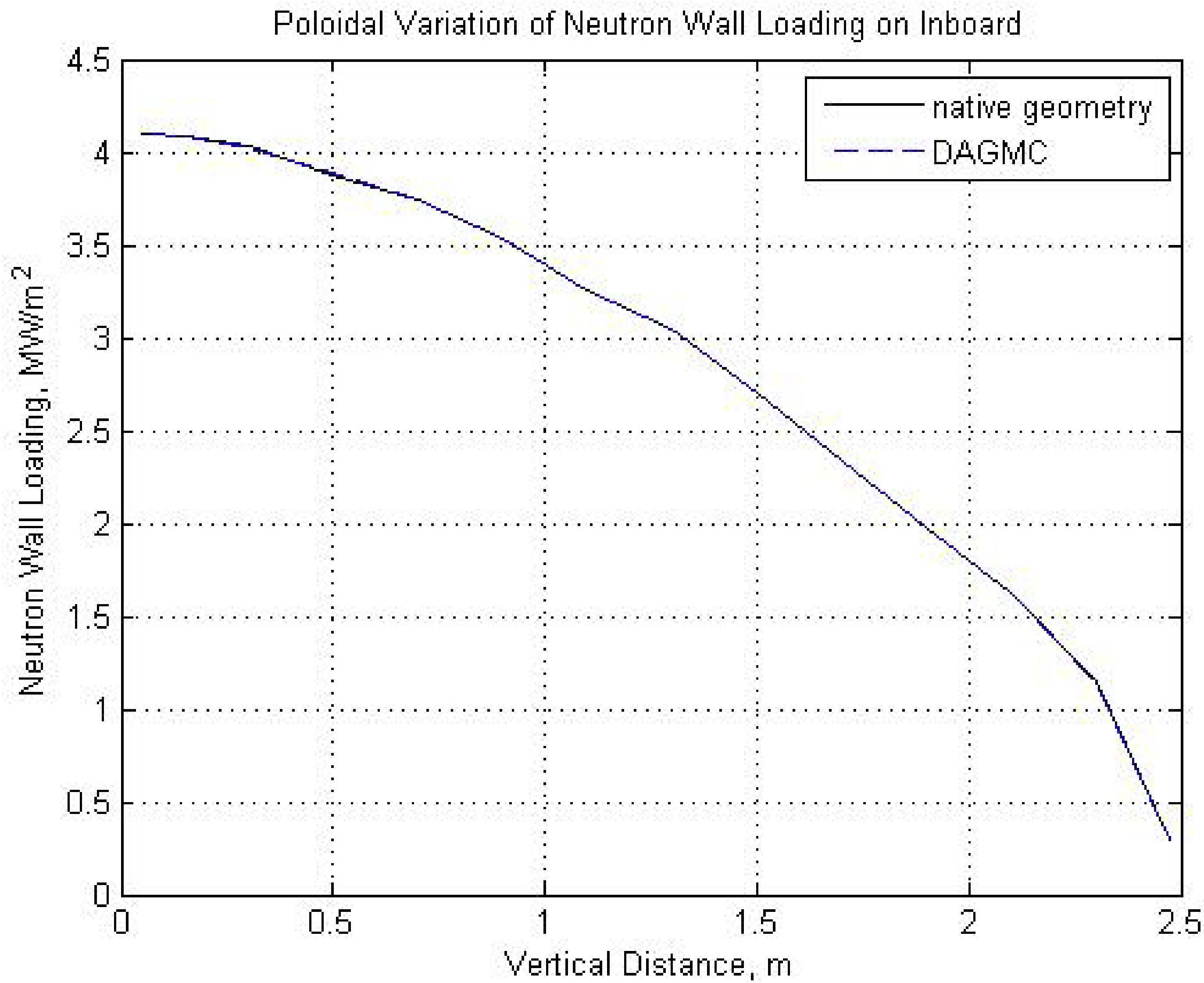


Comparison to DAGMCNPX

- Calculations repeated with DAGMCNPX
  - Previous results used “native” MCNP geometry
- DAGMCNPX was developed at UW and performs transport directly on the CAD geometry file
- The results from the native and DAGMCNPX geometries will be compared

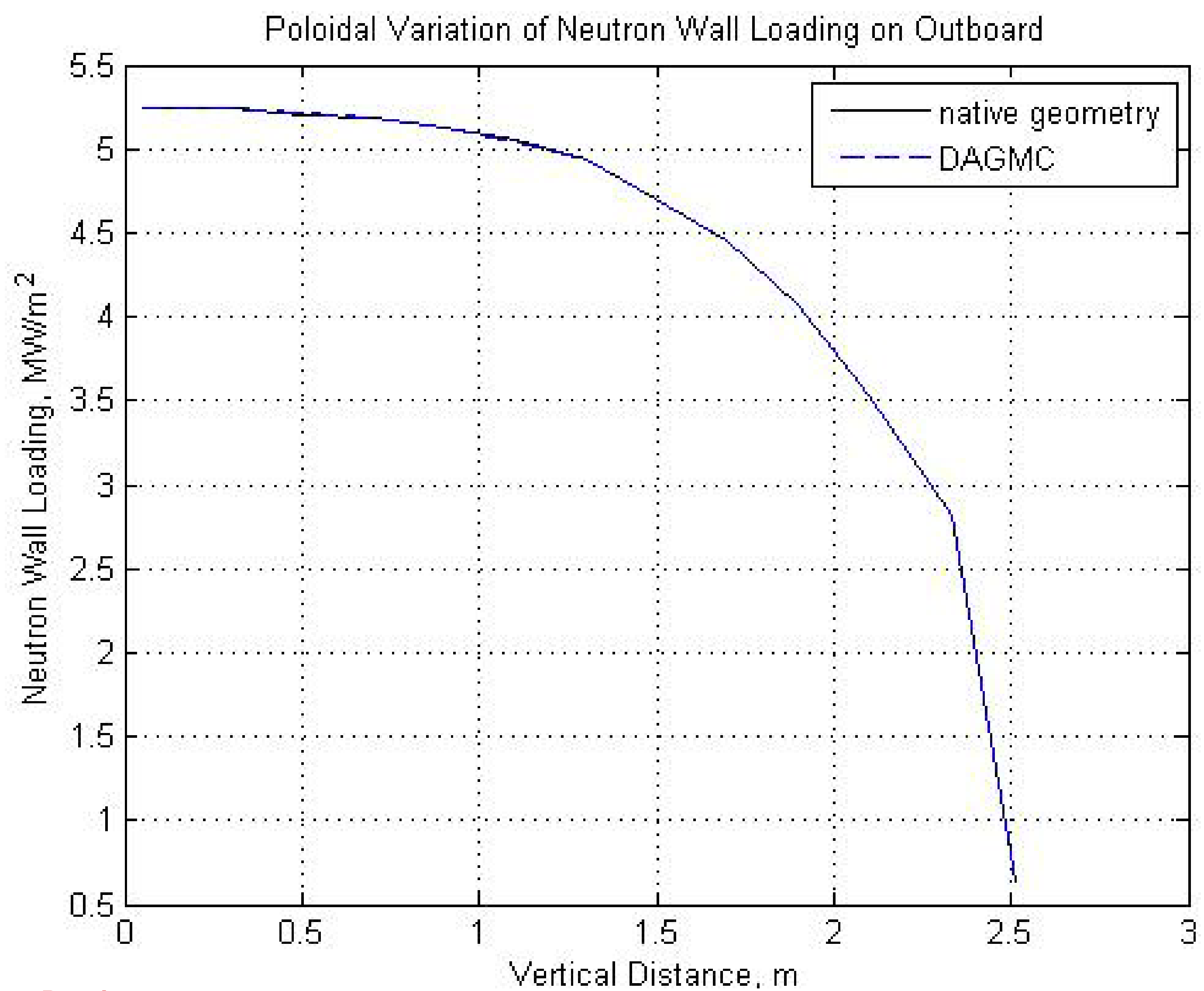
Results

Comparison of DAGMC and native geometry for Inboard NWL , actual source



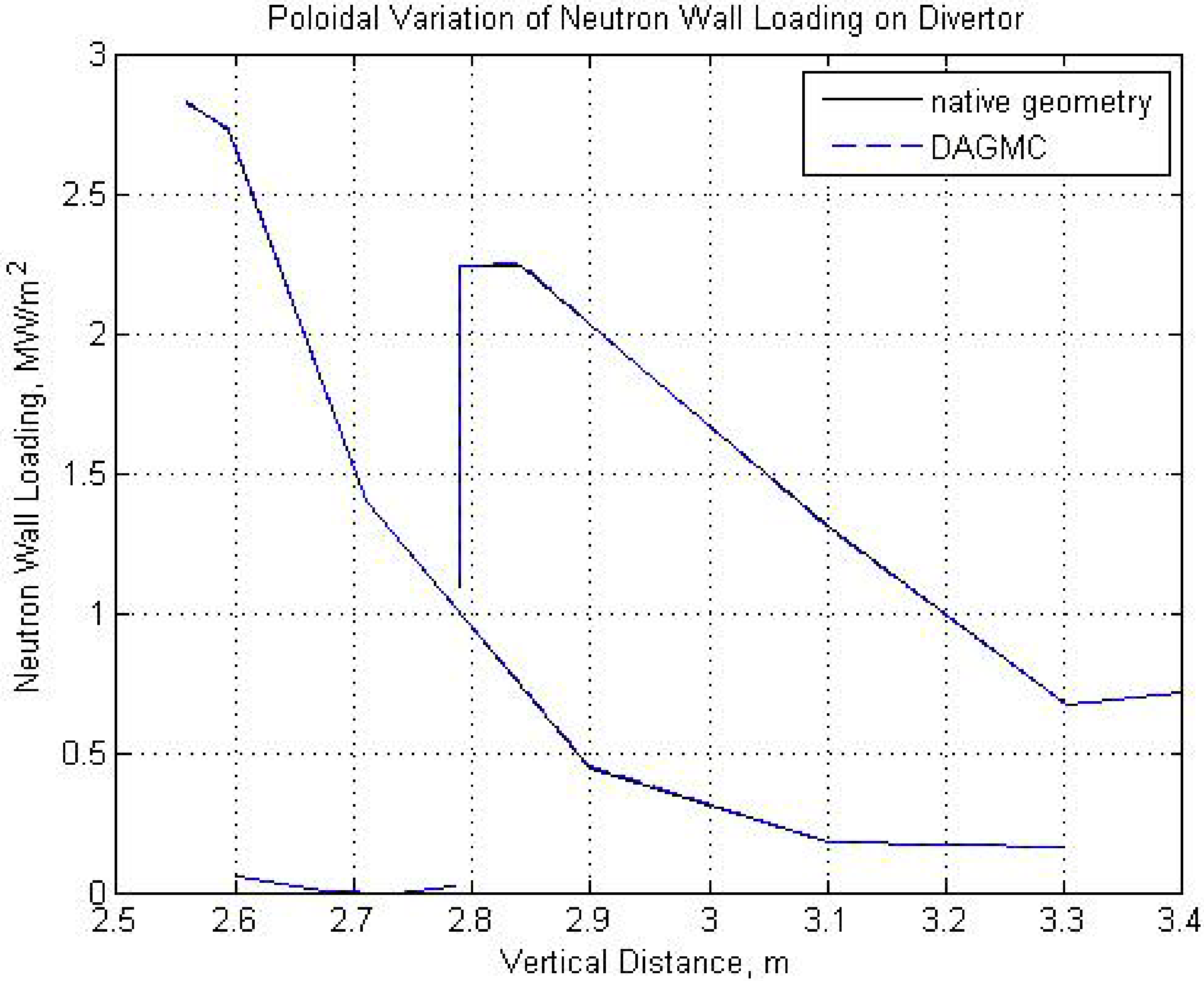
Results

Comparison of DAGMC and native geometry for Outboard NWL , actual source



Results

Comparison of DAGMC and native geometry for Divertor NWL , actual source



Results

	one uniform region	3 uniform regions	actual distribution
Peak Inboard Γ	3.2 MW/m^2	3.8 MW/m^2	4.1 MW/m^2
Peak Outboard Γ	4.8 MW/m^2	5.3 MW/m^2	5.3 MW/m^2
Average* Γ	3.1 MW/m^2	3.1 MW/m^2	3.1 MW/m^2

	Native Geometry (actual source)	DAGMC (actual soruce)
Peak Inboard Γ	4.1 MW/m^2	4.1 MW/m^2
Peak Outboard Γ	5.3 MW/m^2	5.3 MW/m^2
Average* Γ	3.1 MW/m^2	3.1 MW/m^2

* Average Γ = Neutron Power / FW area including divertor

Results

- Source Comparison:
  - Outboard and divertor cases:
    - the 3 region source matched the actual quite well
  - Inboard case, the 3 region source was
    - ~8% lower at the midplane
    - shallower curvature, and
    - >10% higher near the top/bottom

- DAGMC comparison:
  - For the actual source, all results within 4%
    - For 3/45 cases with >1% discrepancy had a statistical error of the same magnitude
  - Ssimilar results for both other source types

Recommendations

- The 3 region source captures many of the effects of the real source
- However, due to the slight disagreement for the inboard results (+/- 10%), the actual source should be used
- DAGMC is also an appropriate choice for these kinds of calculations
- Sensitivity to actual source resolution should be studied

Publications

- UWFDM Report: A Study of Effects of Source Sampling Methods on ARIES-RS NWL Profile. R. N. Slaybaugh, E. P. Marriott, P. P. H. Wilson, L. El-Guebaly

- SOFT 2008: R.N. Slaybaugh, P.P.H. Wilson, L. El-Guebaly, E.P. Marriott "A Monte Carlo Sampling Method for an Arbitrary Toroidal Source"