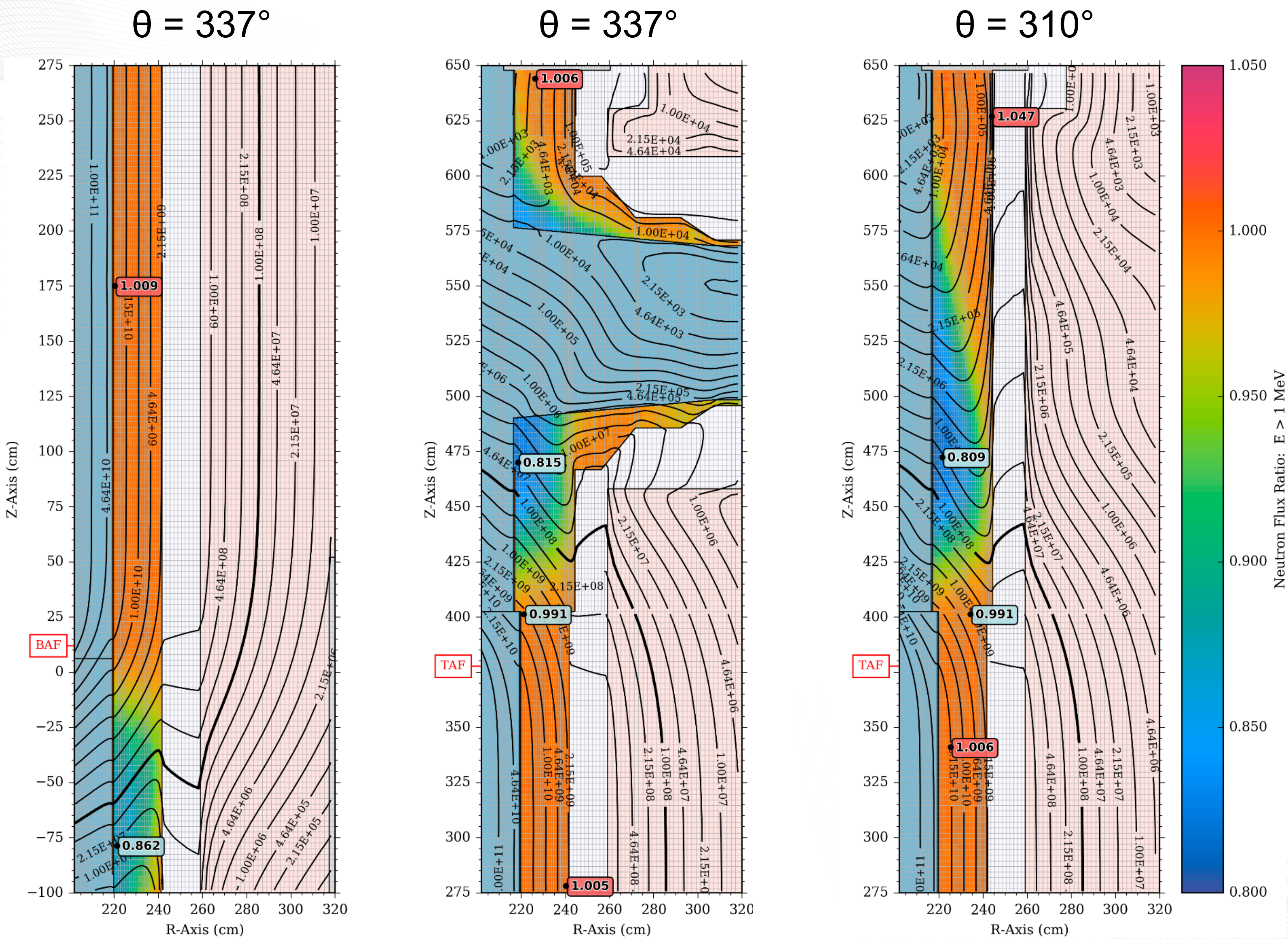
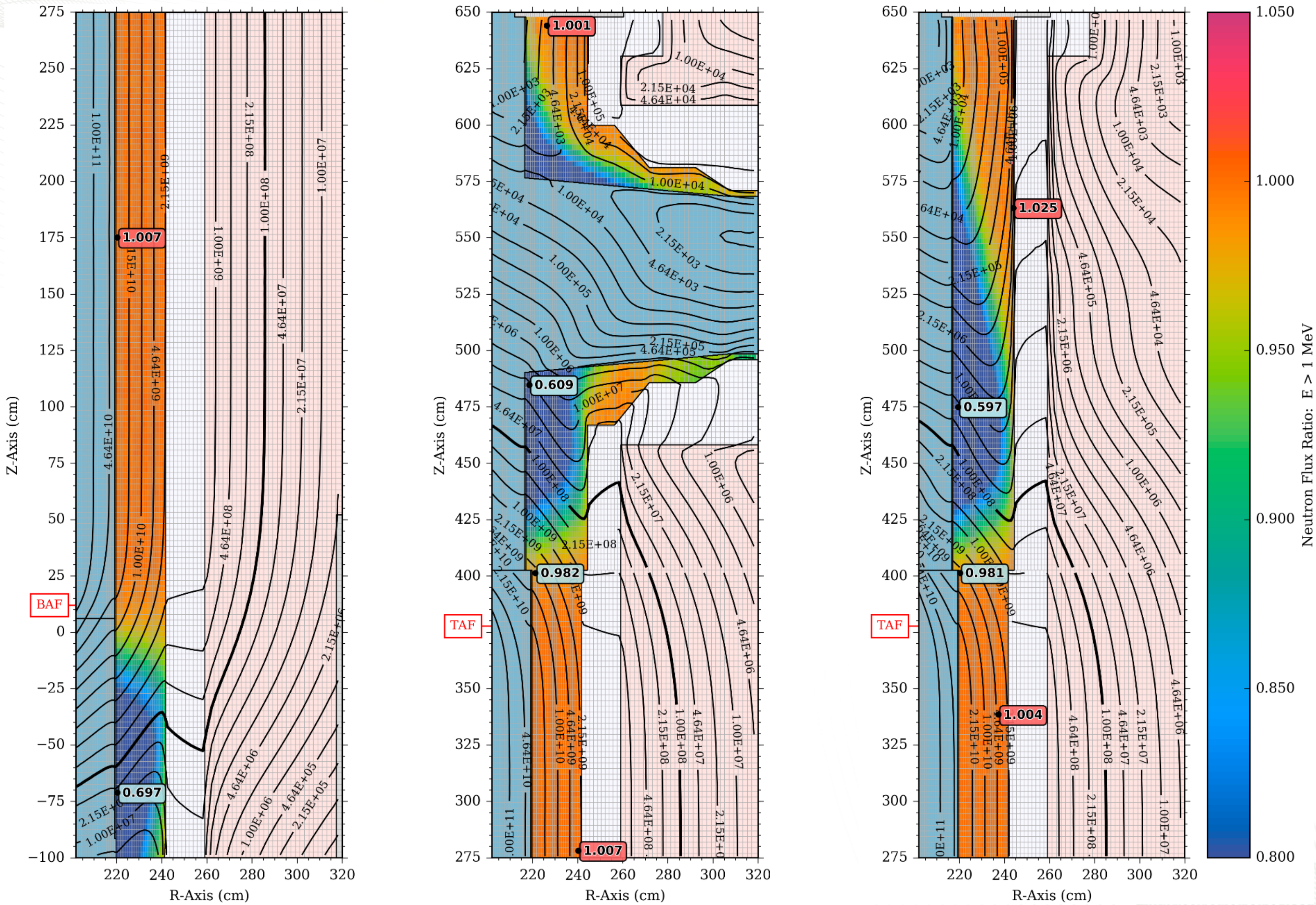
Increasing the M/W Density by 10%: Fast Flux Ratio

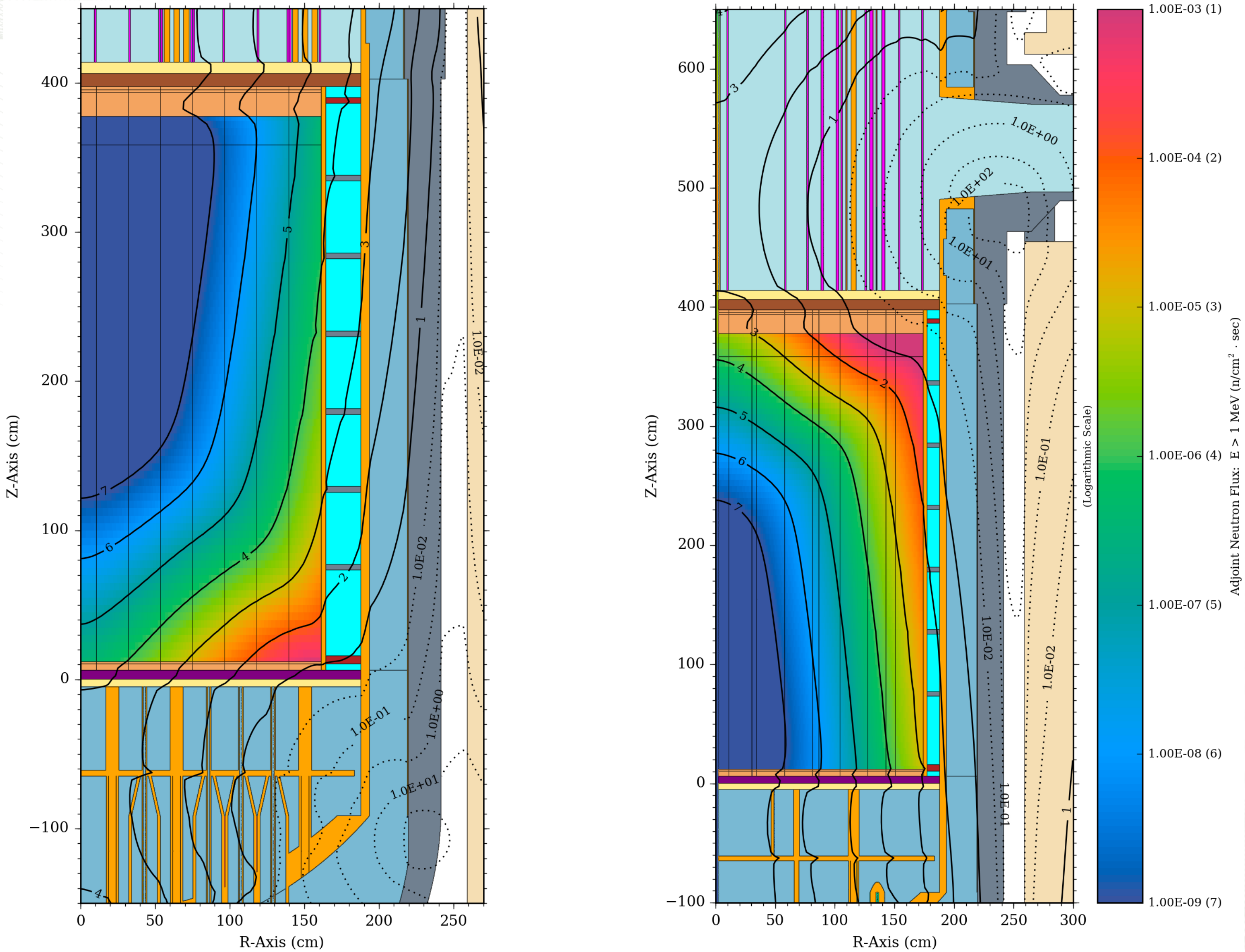


Increasing the M/W Density by 25%: Fast Flux Ratio

θ = 337°   θ = 337°   θ = 310°

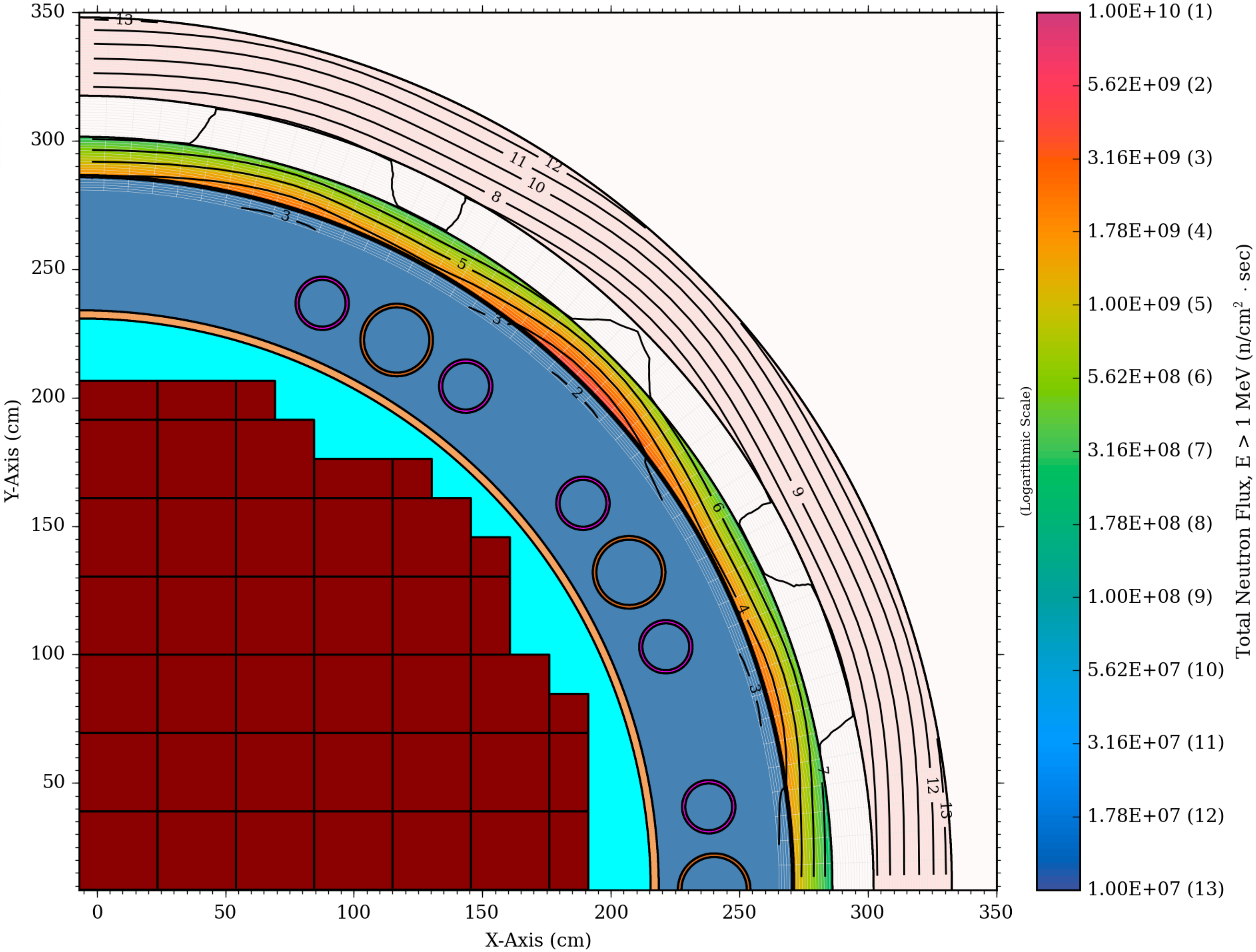


Deterministic Adjoint Calculations for the Lower Portion of the Vessel and the Lower Portion of the Outlet Nozzle

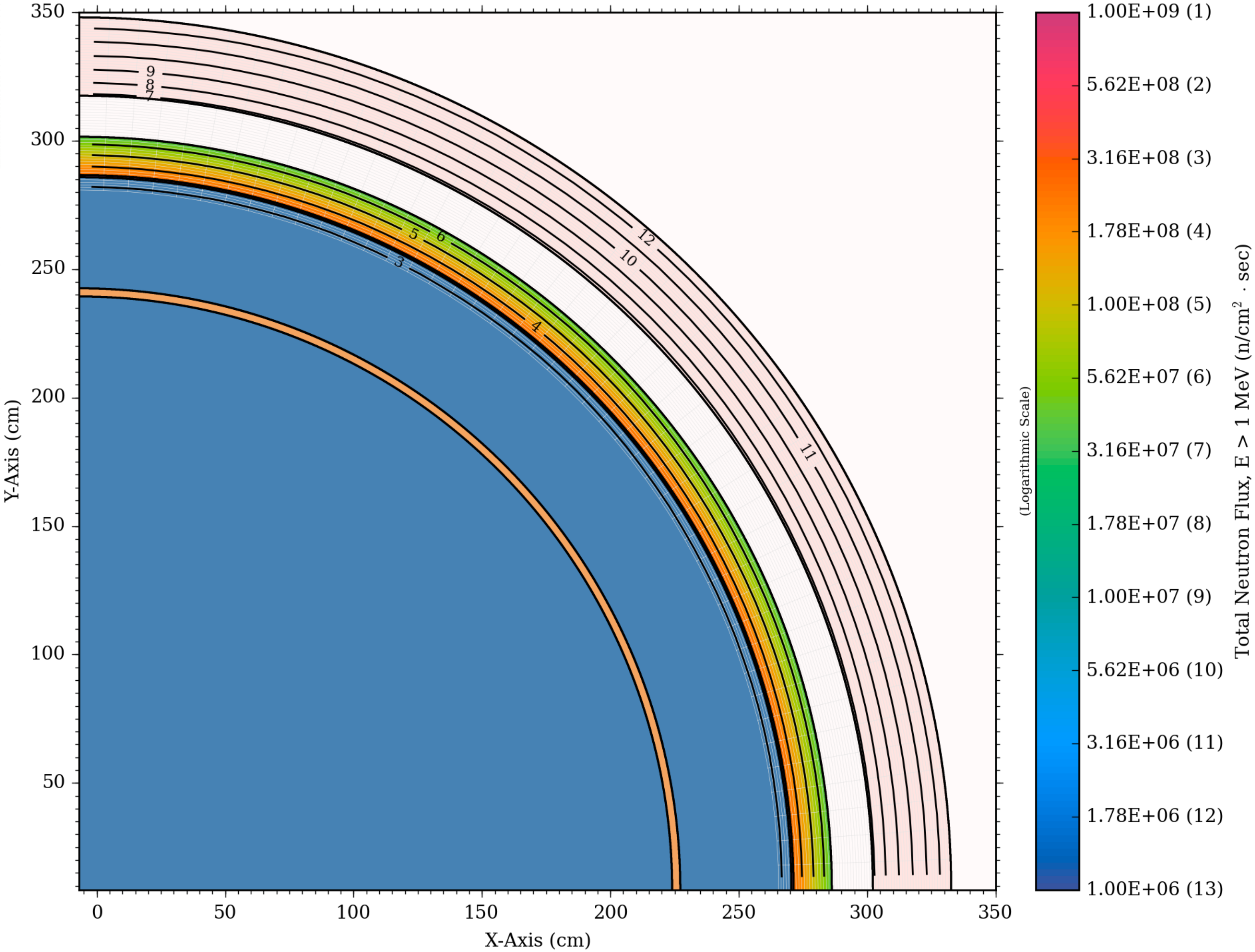


Fast Flux Levels for the BWR Model

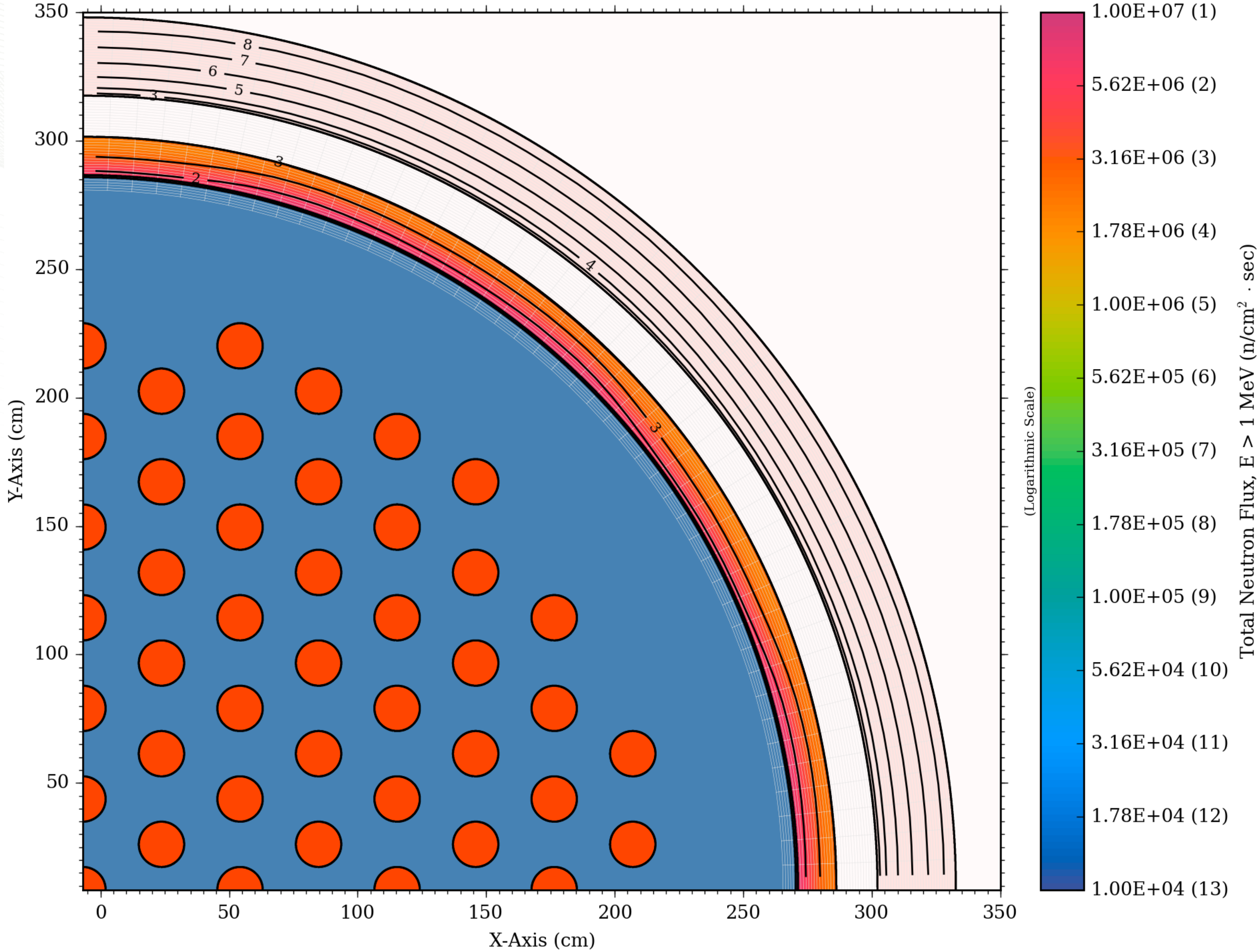
- The next four slides illustrate the fast flux levels in a BWR model of Hatch Unit 2. In this case we use a homogenized core representation with a BOL source distribution. These few slides simply illustrate the variation in the fast flux at a few elevations and the ability to obtain well-converged Monte Carlo fluxes using a mesh tally.



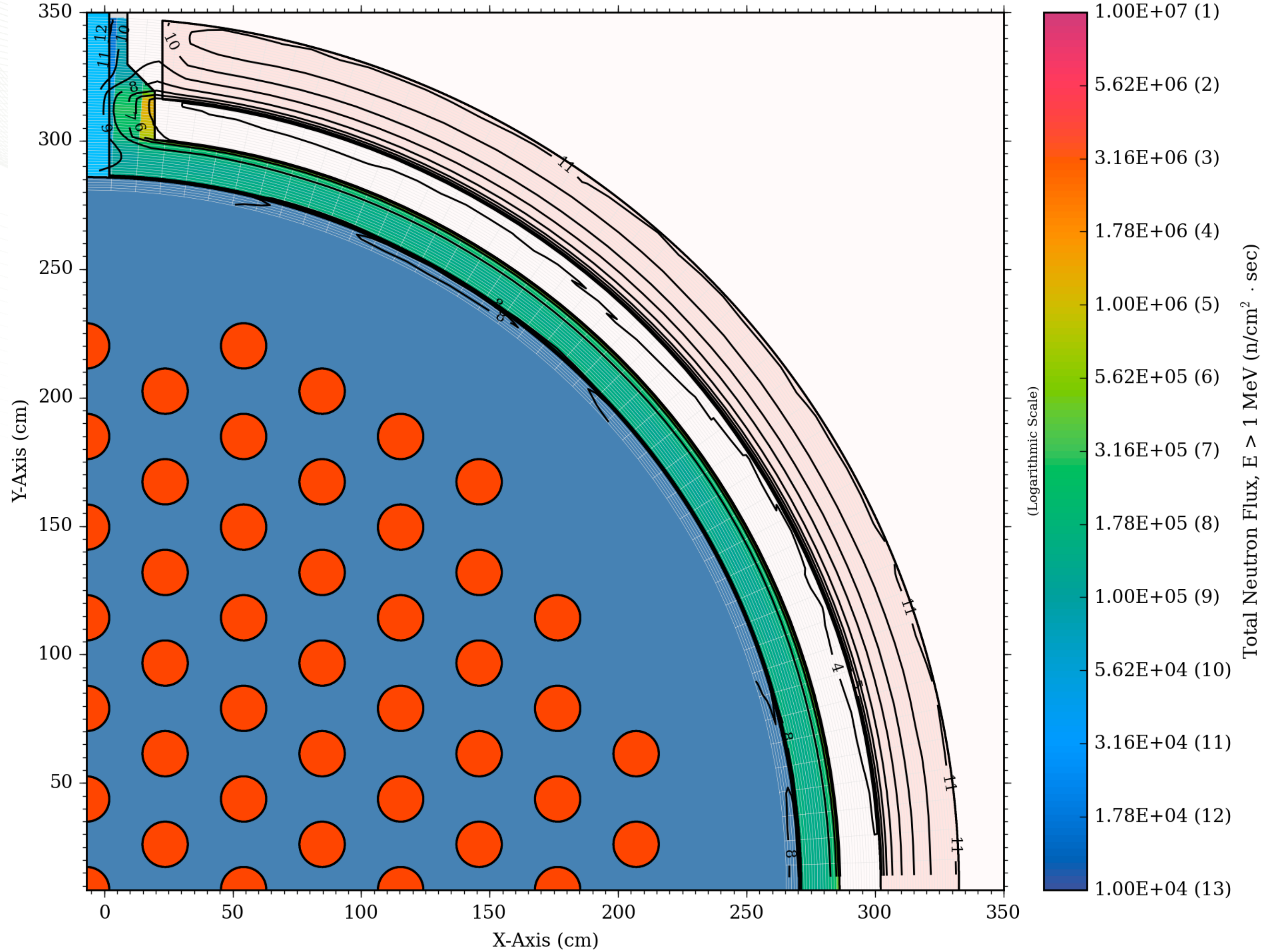
Fast neutron flux (E > 1 MeV) at Z = 0 cm (the core midplane elevation) for the BWR reference model.



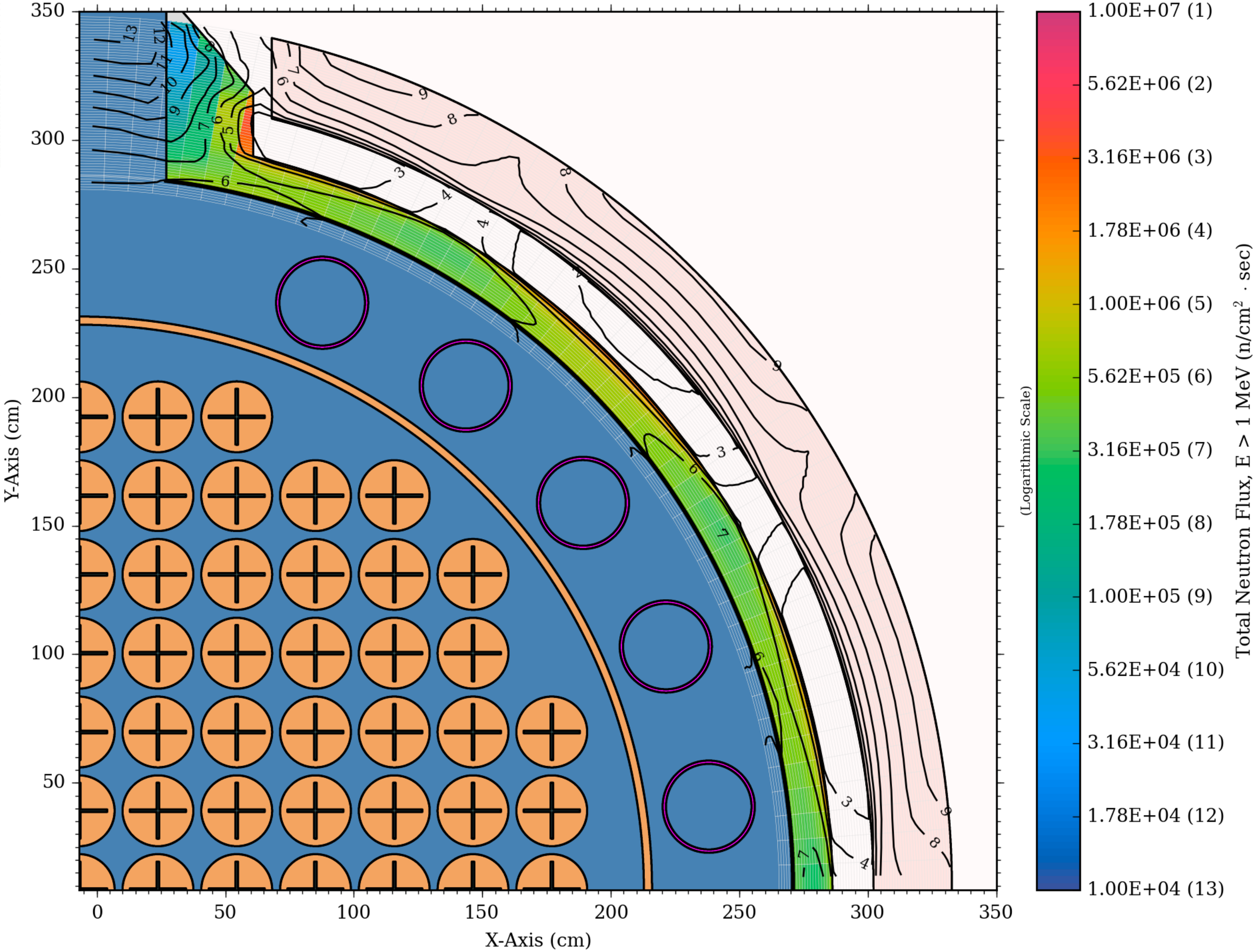
Fast neutron flux (E > 1 MeV) at Z = 300 cm for the BWR reference model.



Fast neutron flux (E > 1 MeV) at Z = 400 cm for the BWR reference model (steam separator standing pipes).



Fast neutron flux (E > 1 MeV) at Z = 468.5 cm for the BWR reference model (core spray nozzle elevation).

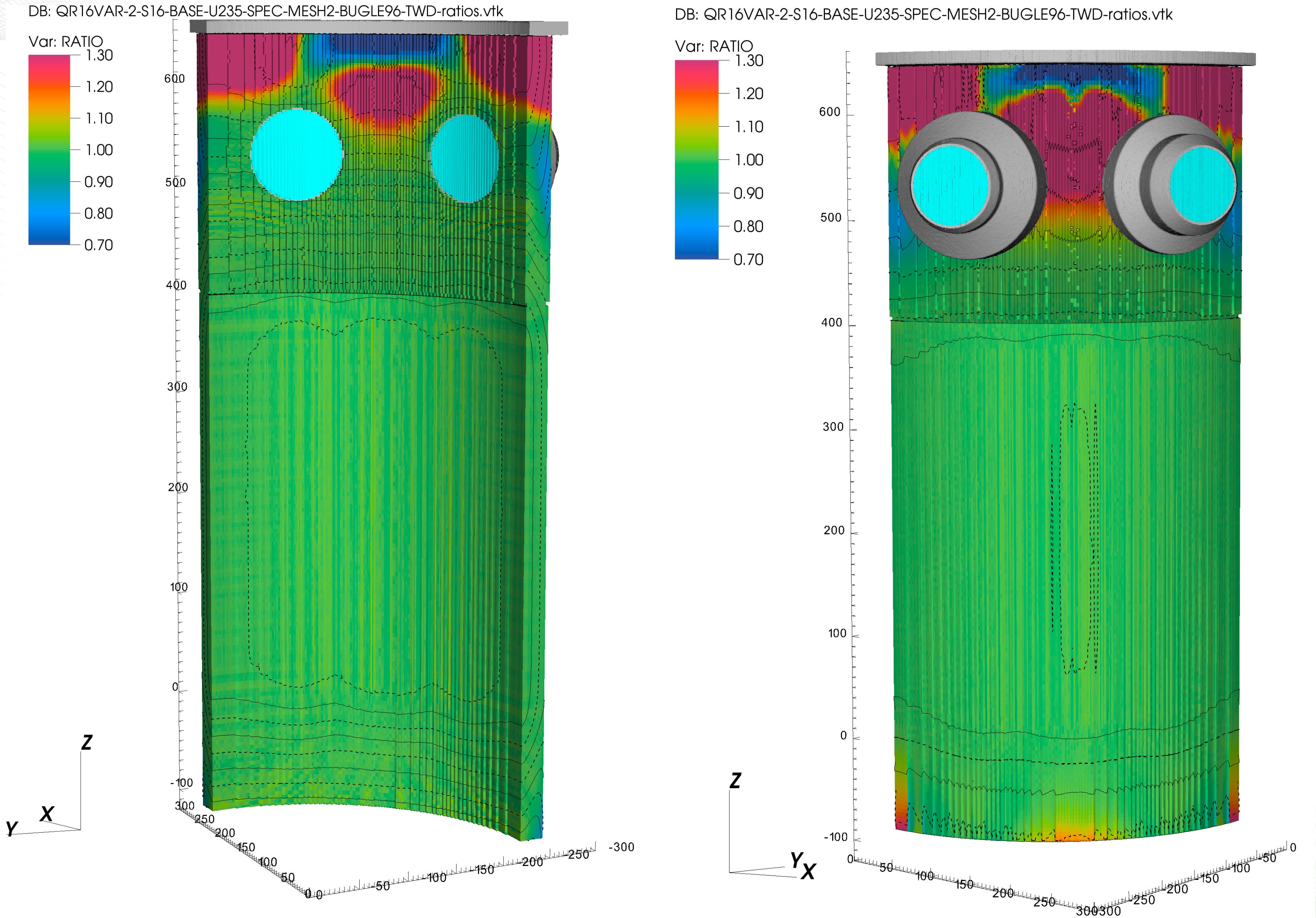


Fast neutron flux (E > 1 MeV) at Z = -302.4 cm for the BWR reference model (recirculation nozzle elevation).

Discretization Effects with Deterministic Calculations

- The effects of discretization (space, energy, and angle) will be addressed in an upcoming presentation. Here we show one such comparison illustrating the impact of angular discretization on the calculation of flux levels outside the beltline region.
- The ‘baseline’ solution in this case is a discrete ordinates solution (using the ORNL Denovo code) with the widely used S16 level symmetric quadrature. The second solution simply changes the quadrature set from S16 to a QR16 (Quadruple Range) quadrature with the same number of total angles.
- QR quadratures have been shown to be superior for many problems that involve streaming and/or material discontinuities near the coordinate axes. In this case we see a significant difference in the calculated flux levels in the vicinity of the nozzles.

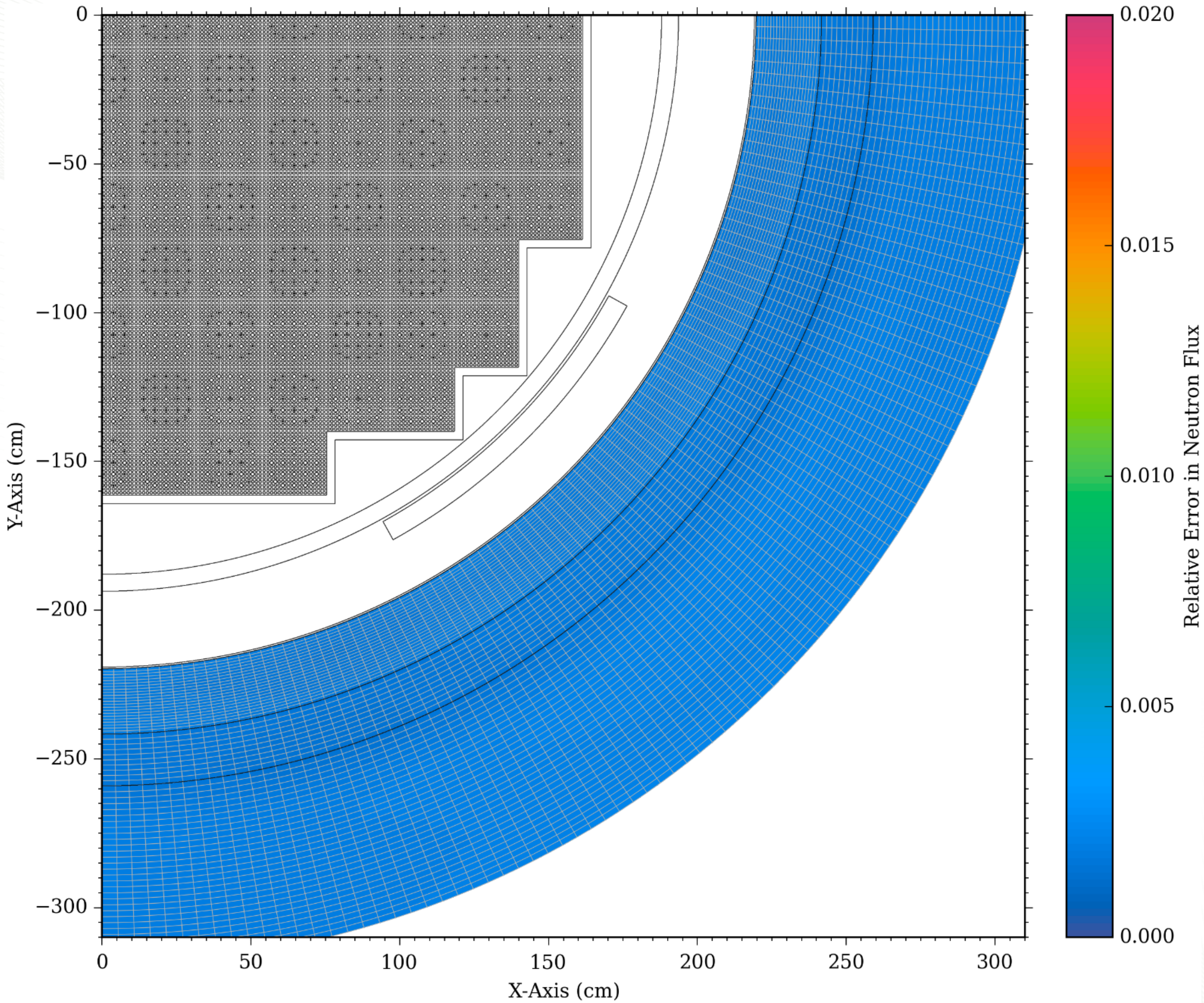
PWR Model with QR16 Quadrature/S16 Quadrature



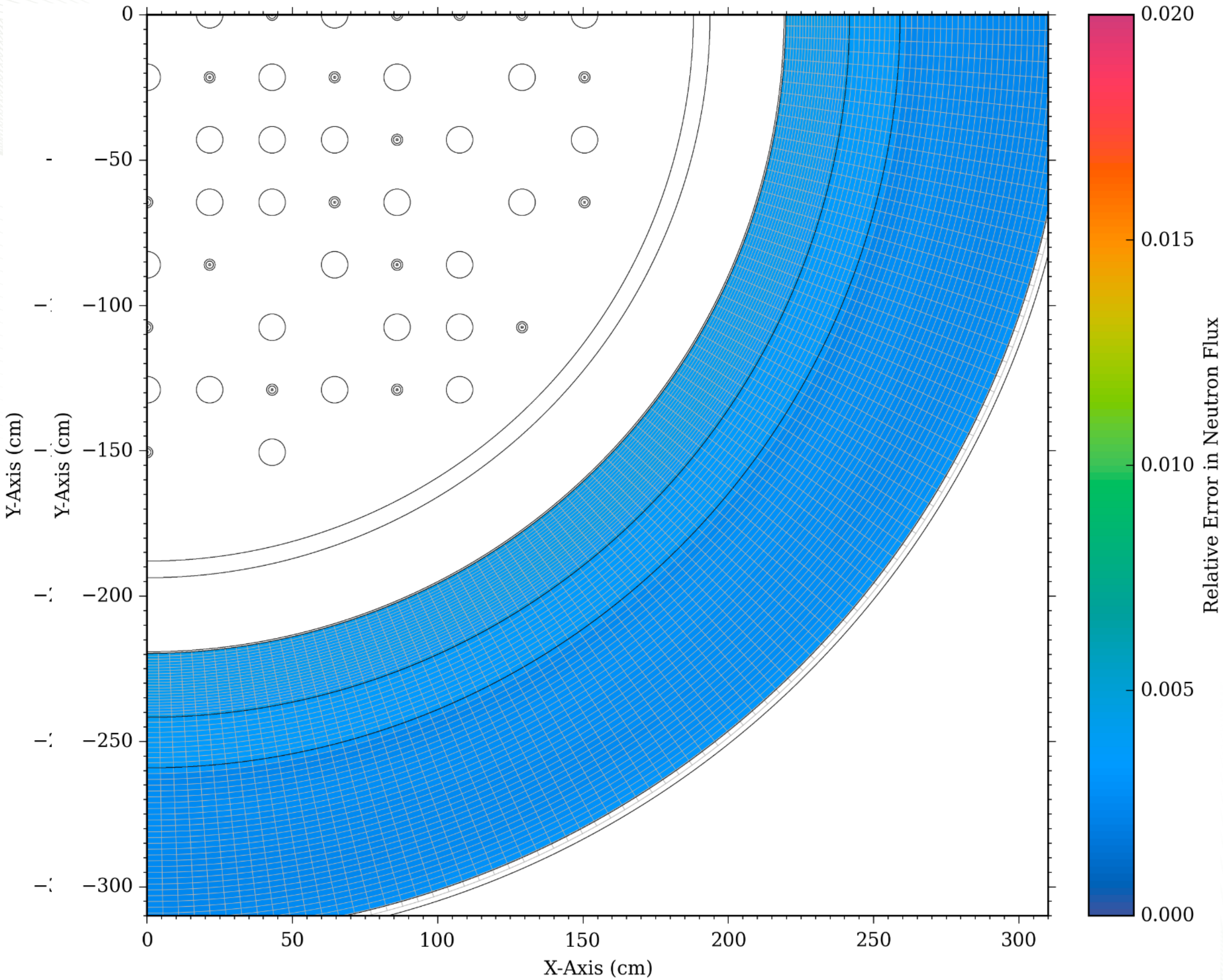
Summary

- Calculation of RPV fluxes outside the beltline region is subject to effects that are not significant within the beltline region.
- Accurate calculation of RPV fluence levels outside the beltline region will likely require some methodology revisions for discrete ordinates calculations (e.g., quadrature sets, multigroup cross-section libraries).
- The use of hybrid deterministic/Monte Carlo methods provides the capability to obtain well-converged ‘global’ Monte Carlo solutions. In addition, this method provides the potential to streamline the analysis process by reducing the need for multiple parametric studies that may be required for discretization effects in deterministic calculations.

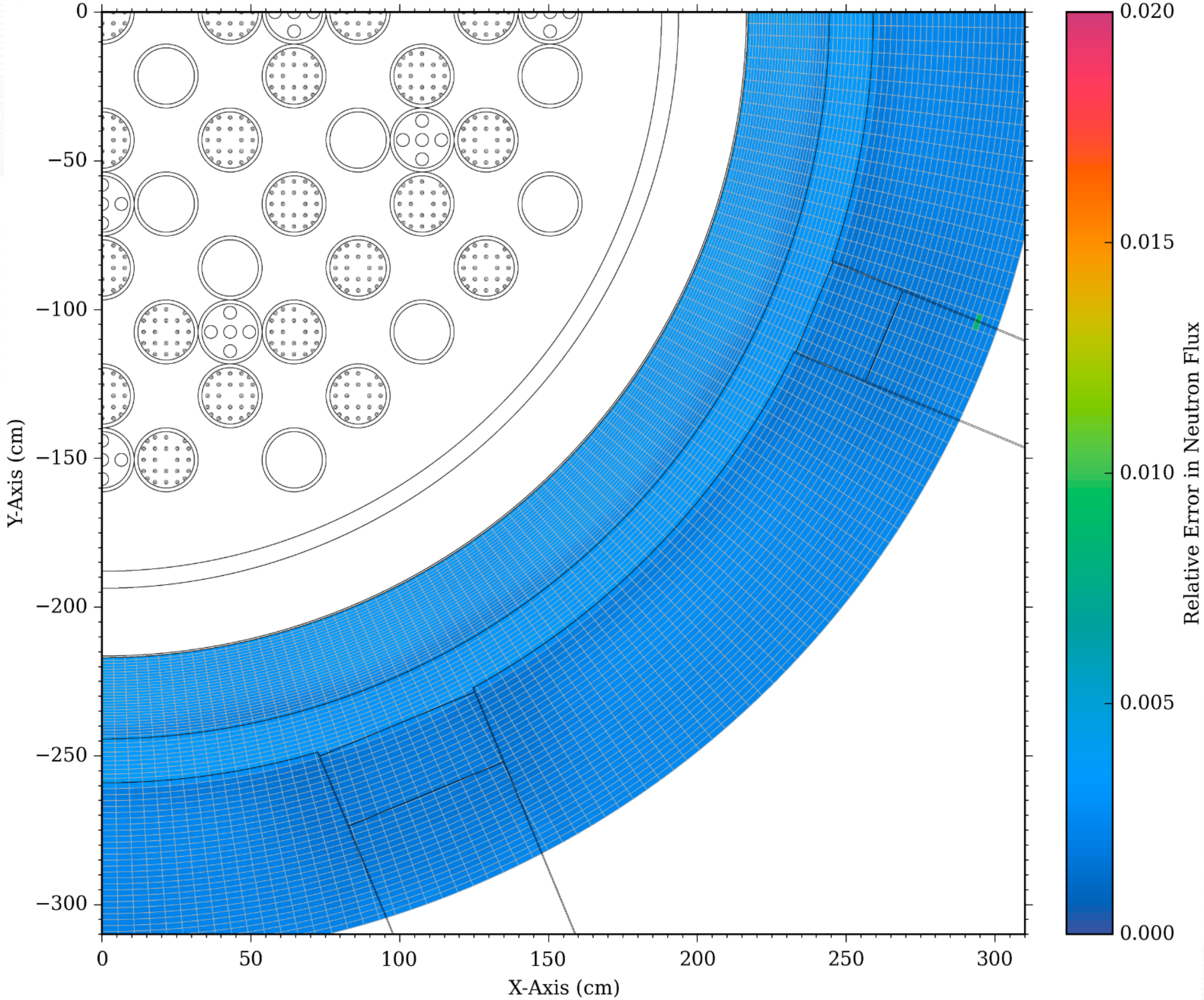
Supplementary Slides – Relative Error Plots



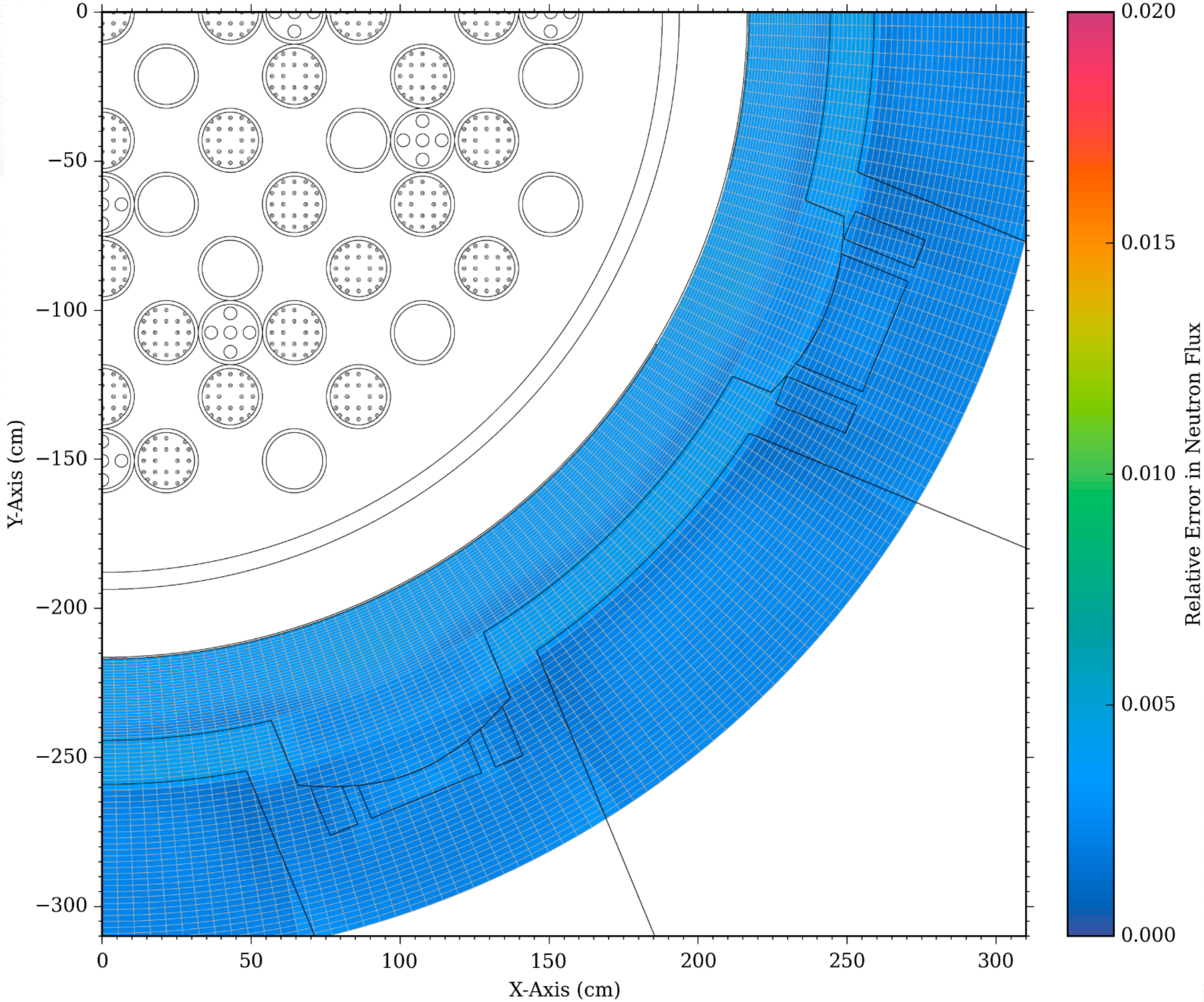
Relative error in fast neutron flux at Z = 200 cm



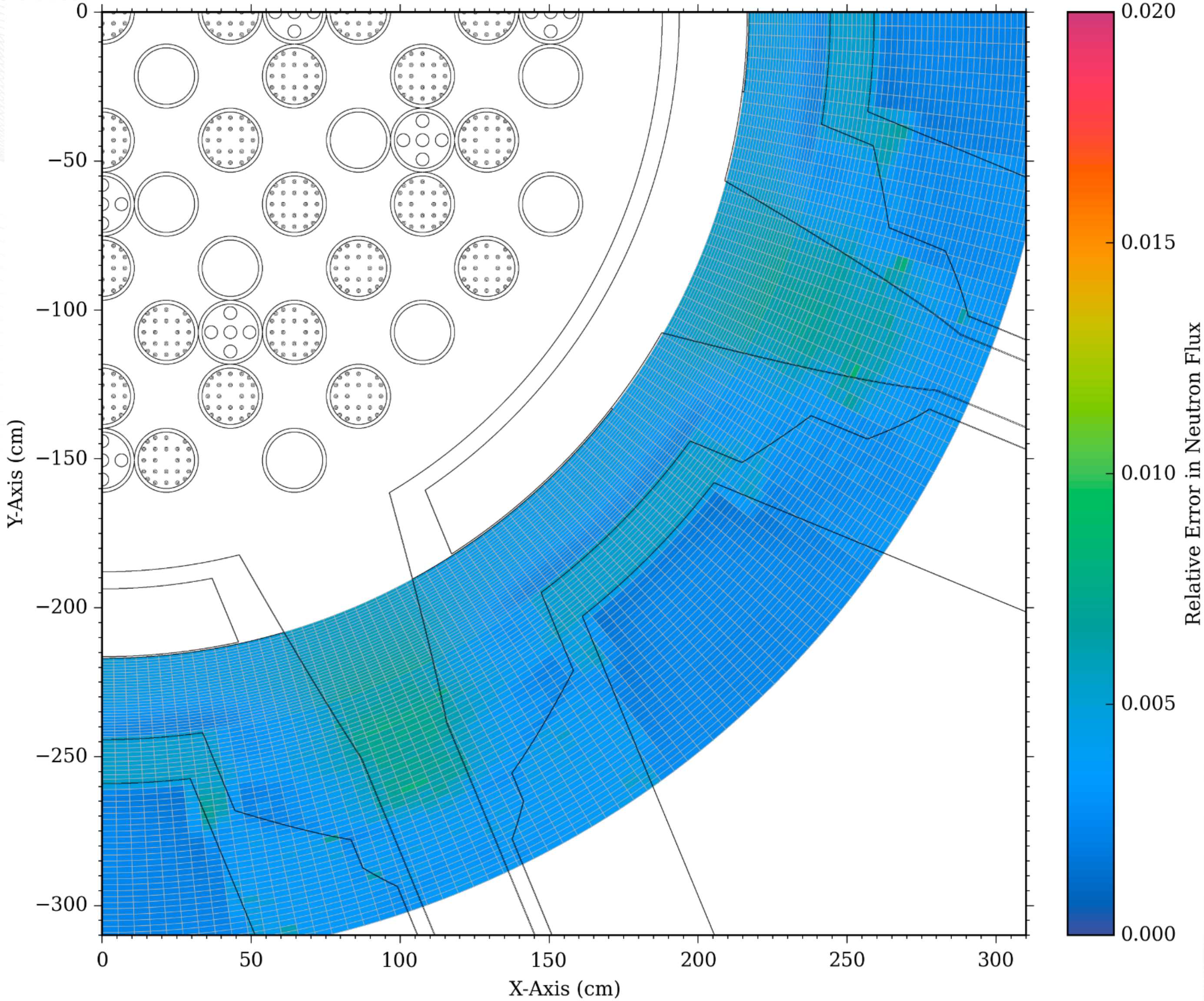
Relative error in fast neutron flux at Z = -60 cm



Relative error in fast neutron flux at Z = 460 cm

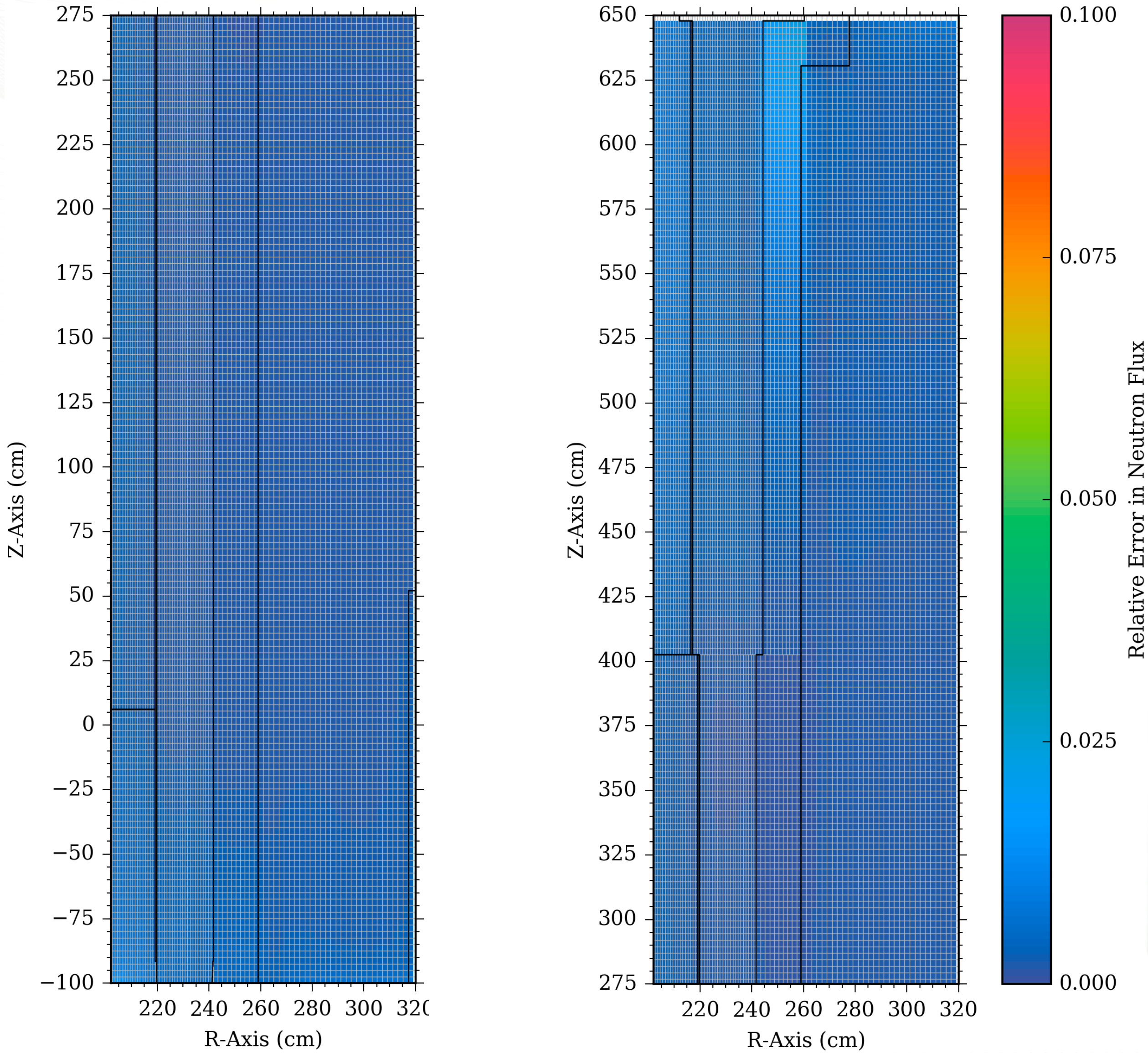


Relative error in fast neutron flux at Z = 475 cm



Relative error in fast neutron flux at Z = 500 cm

Axial Flux Profile at Theta = 270.5° for the PWR Reference Model With a Spatially Uniform U-235 fission Source



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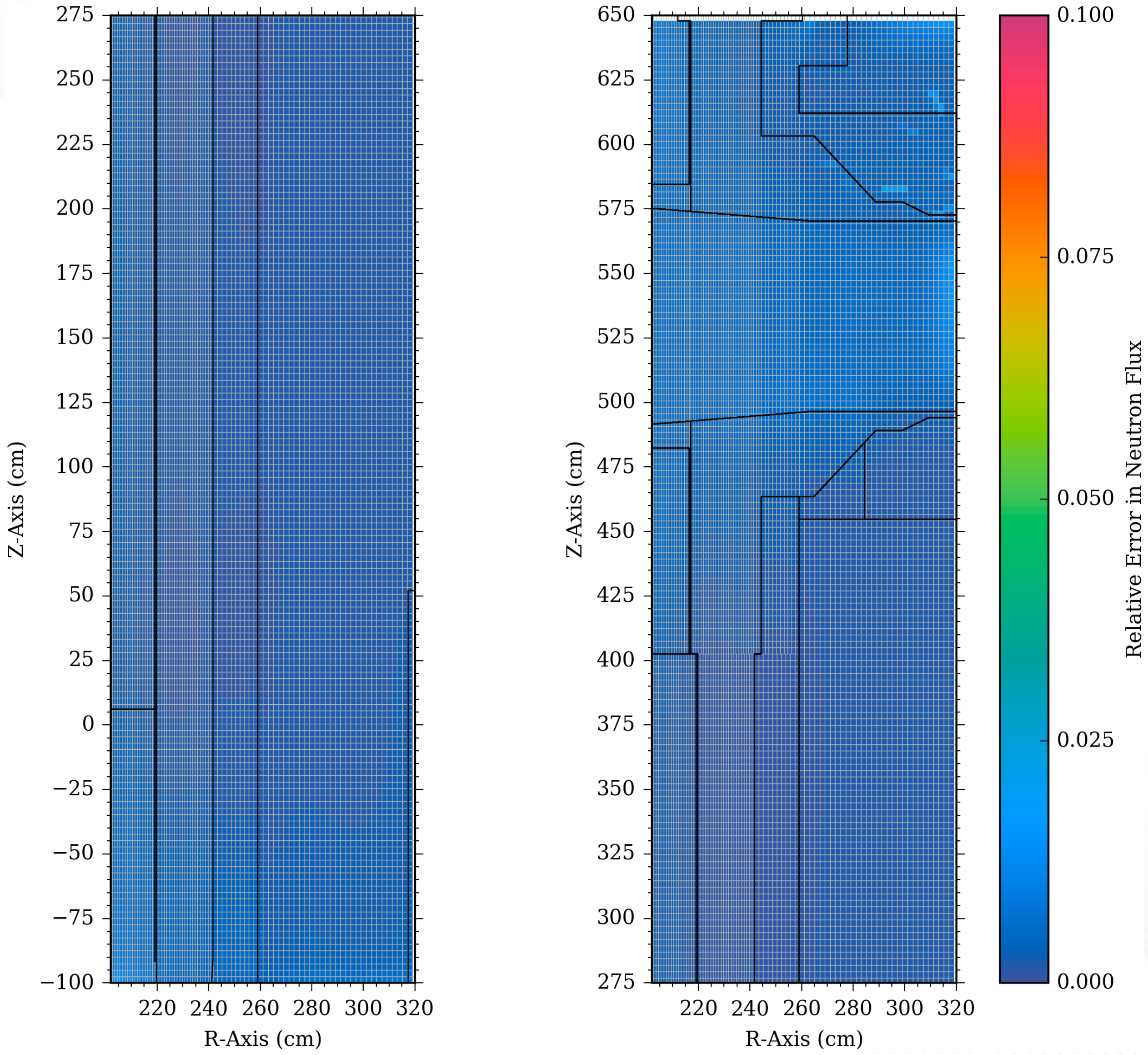
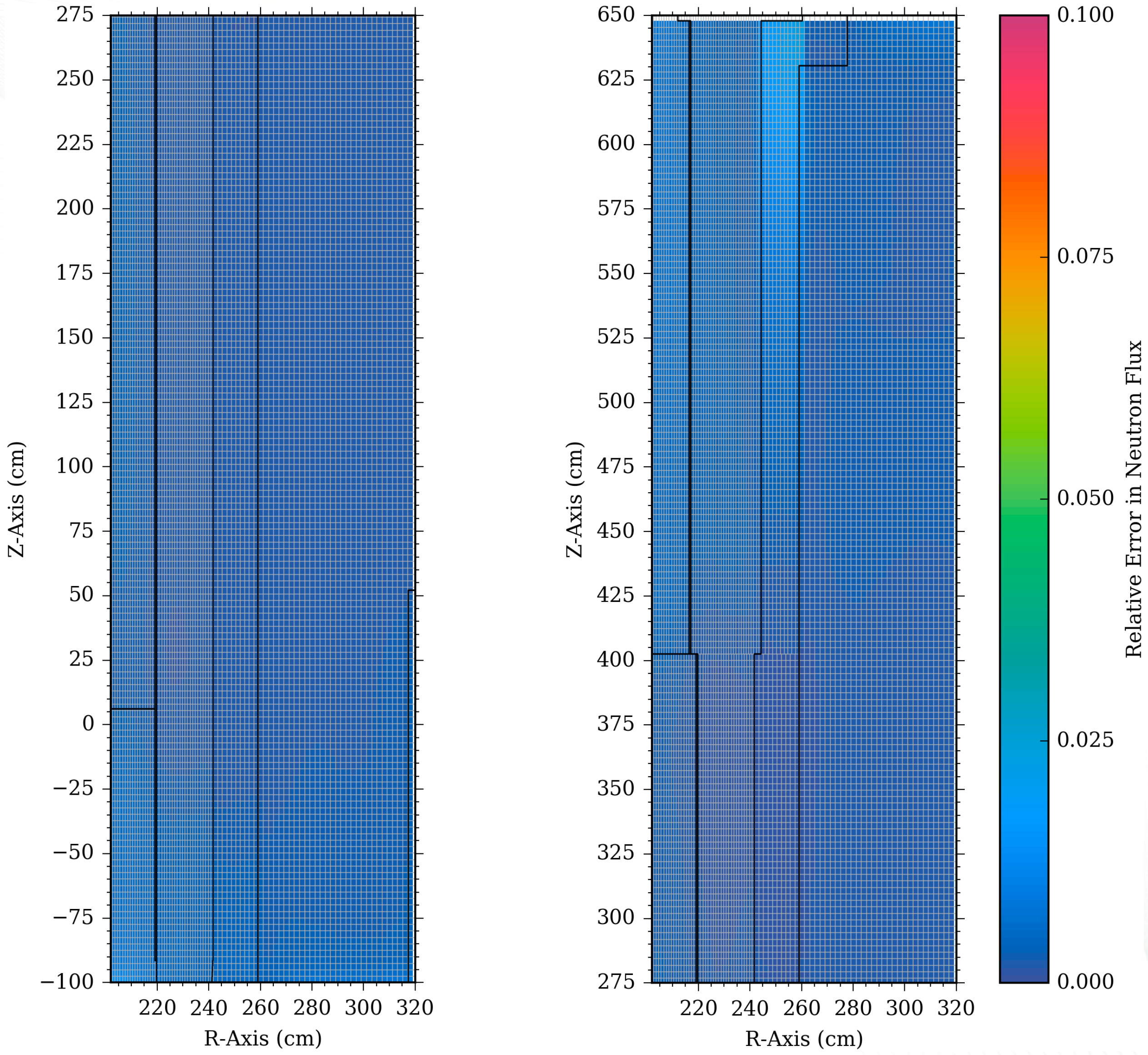
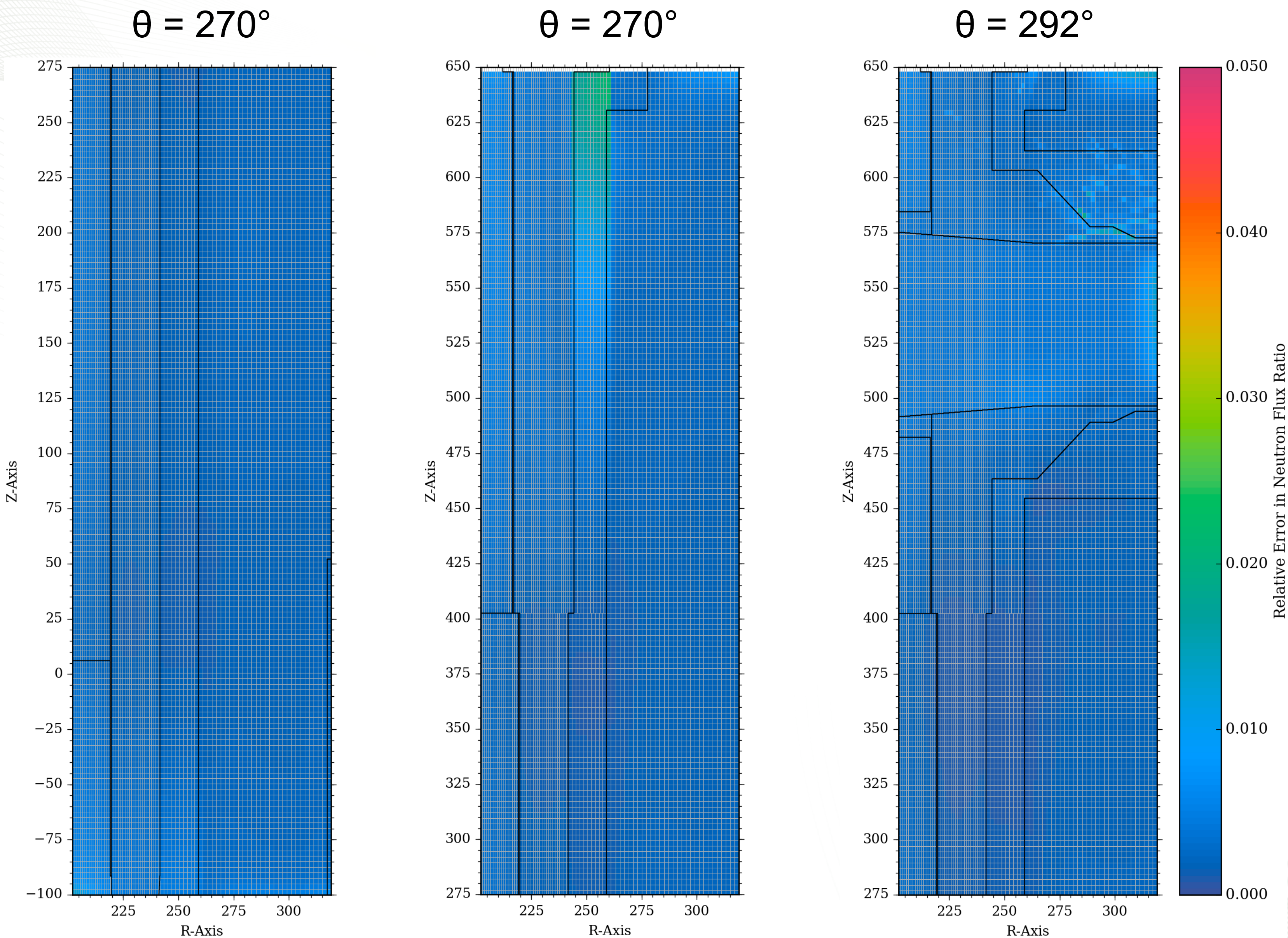
Axial Flux Profile at Theta = 292.5° for the PWR Reference Model With a Spatially Uniform U-235 fission Source



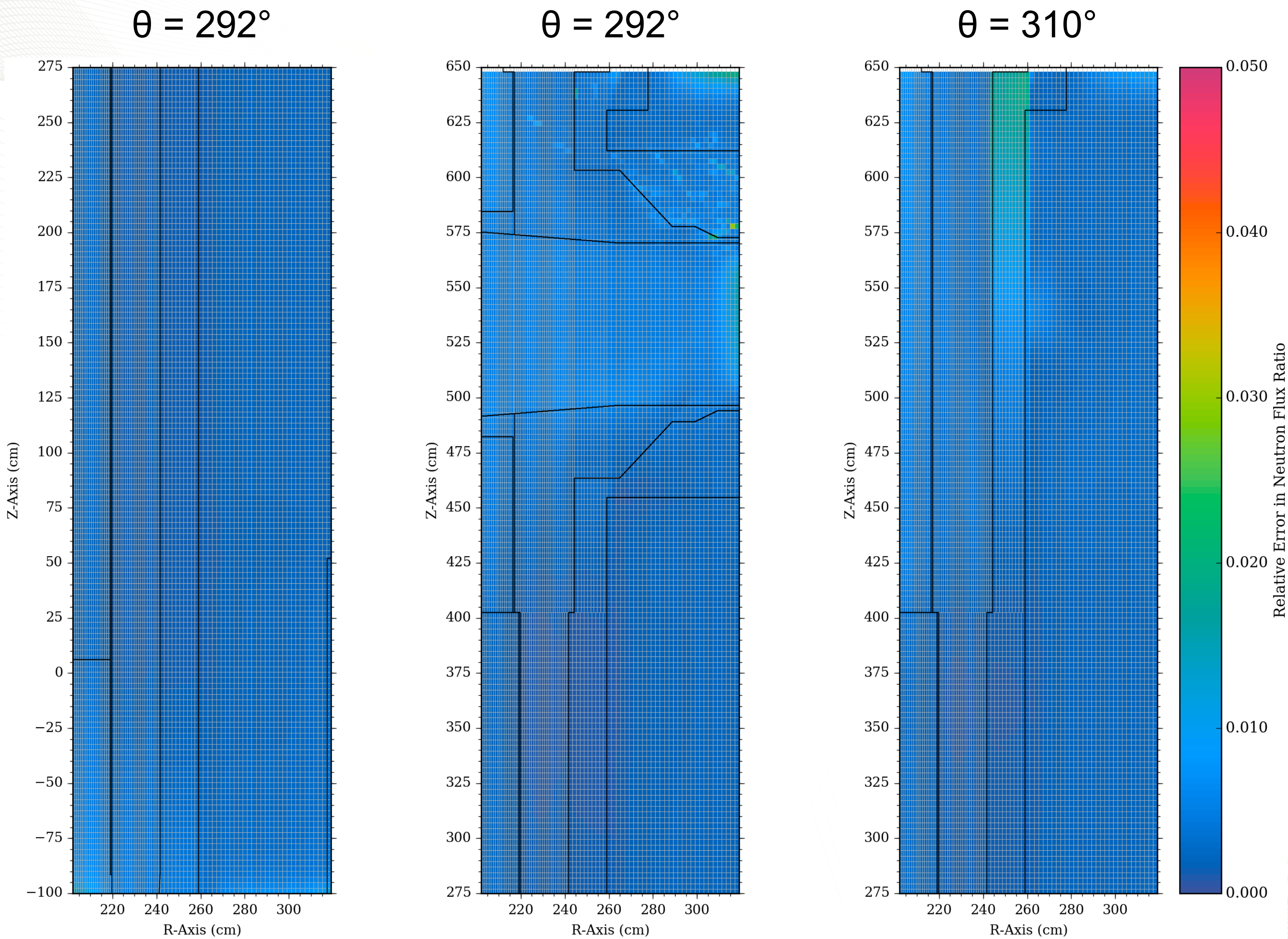
Axial Flux Profile at Theta = 315.5° for the PWR Reference Model With a Spatially Uniform U-235 fission Source



Pu-239/U-235 Fast Flux Ratio at θ = 270° and 292°



NBS-03 / NBS-04 at θ = 292° and 310°



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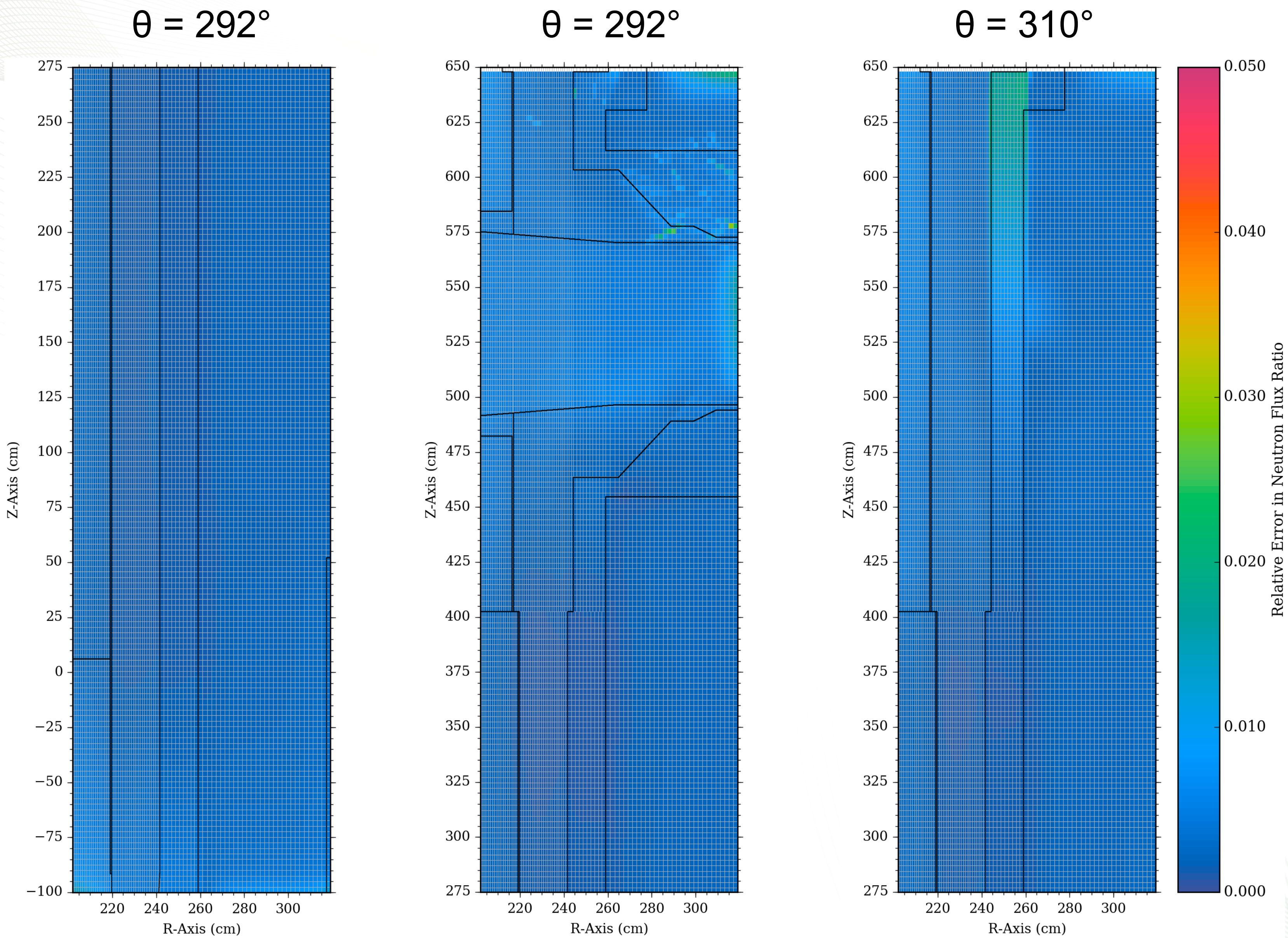
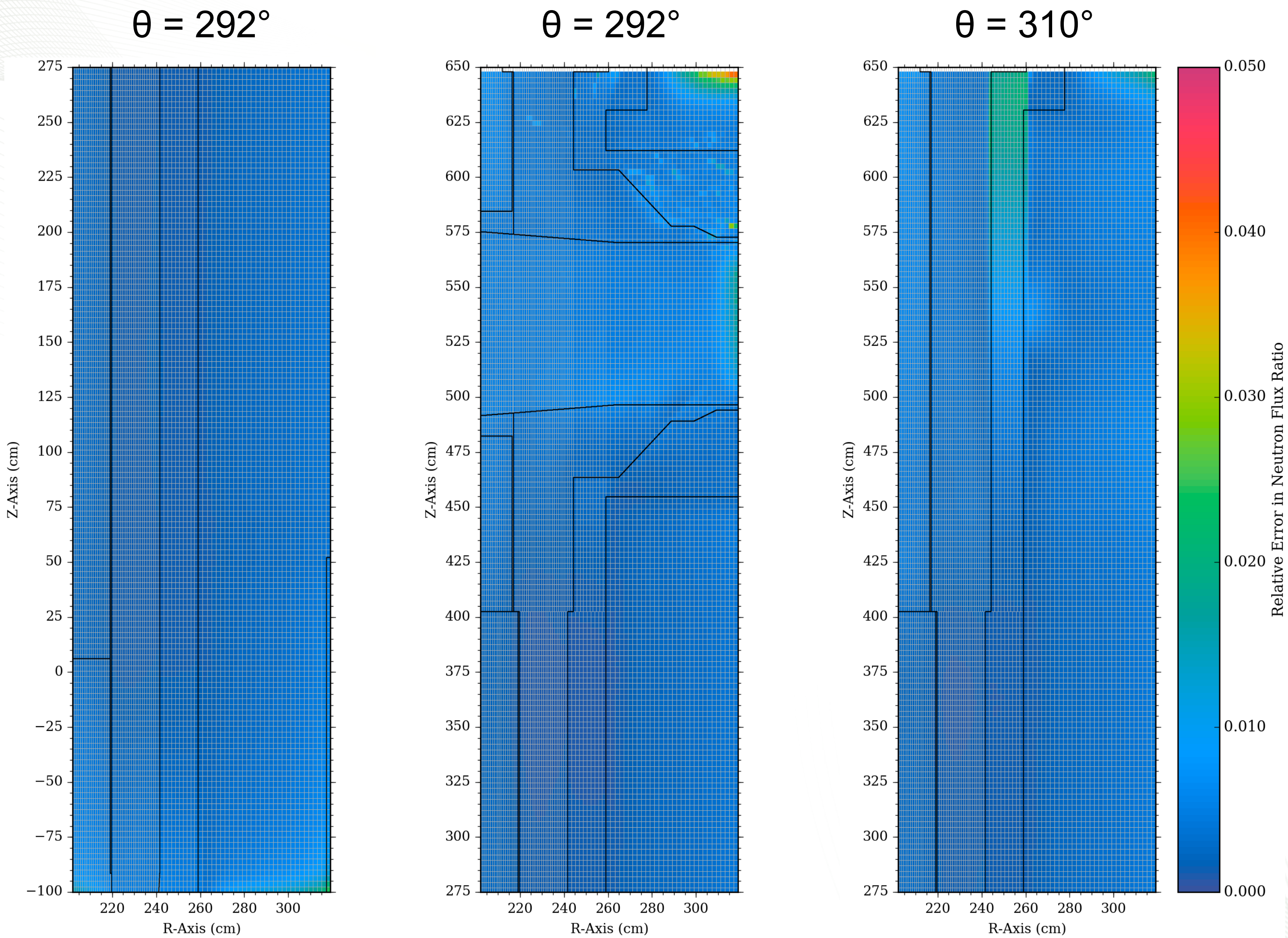
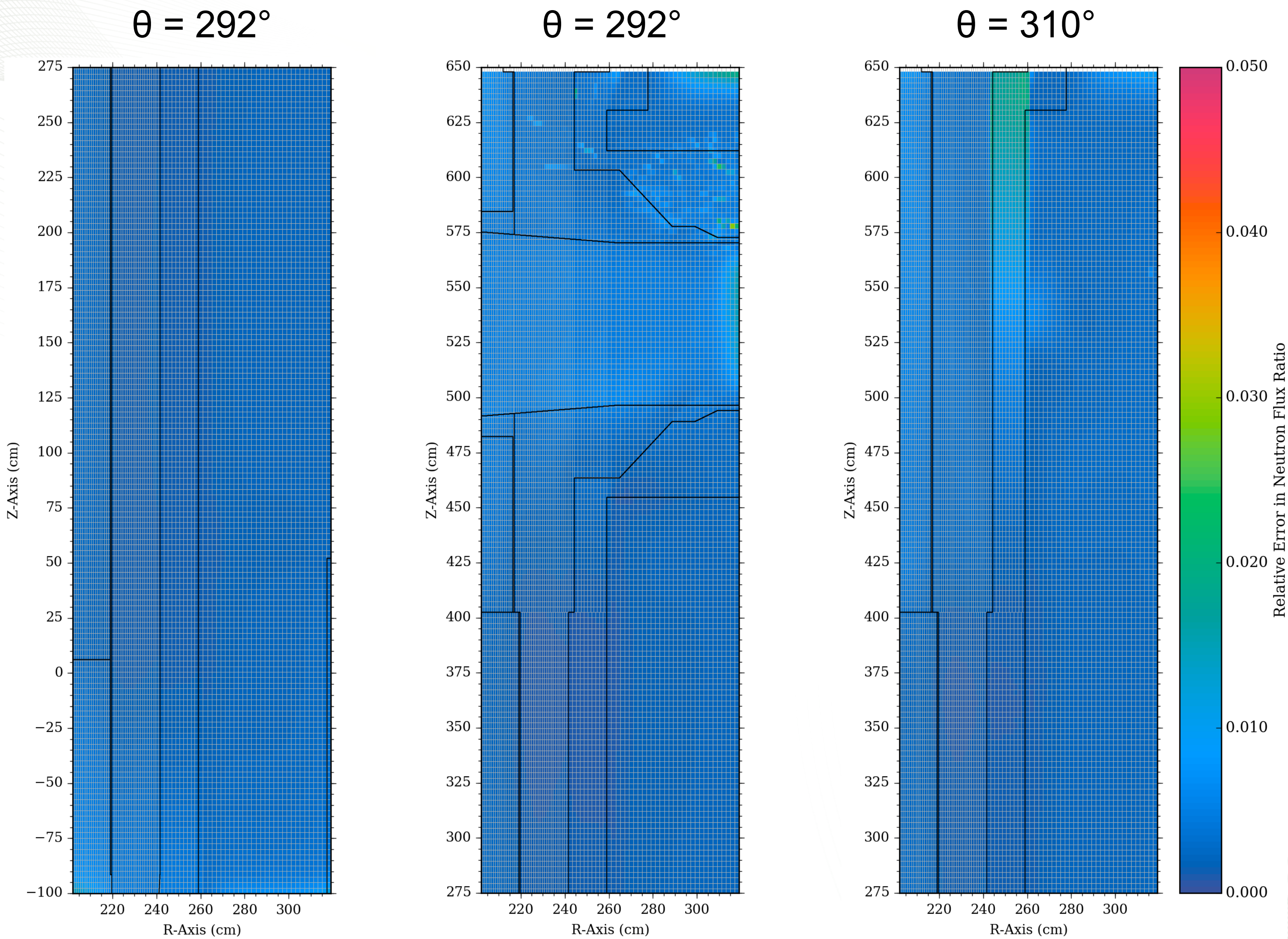
“Regulatory” / NBS-04 at θ = 292° and 310°



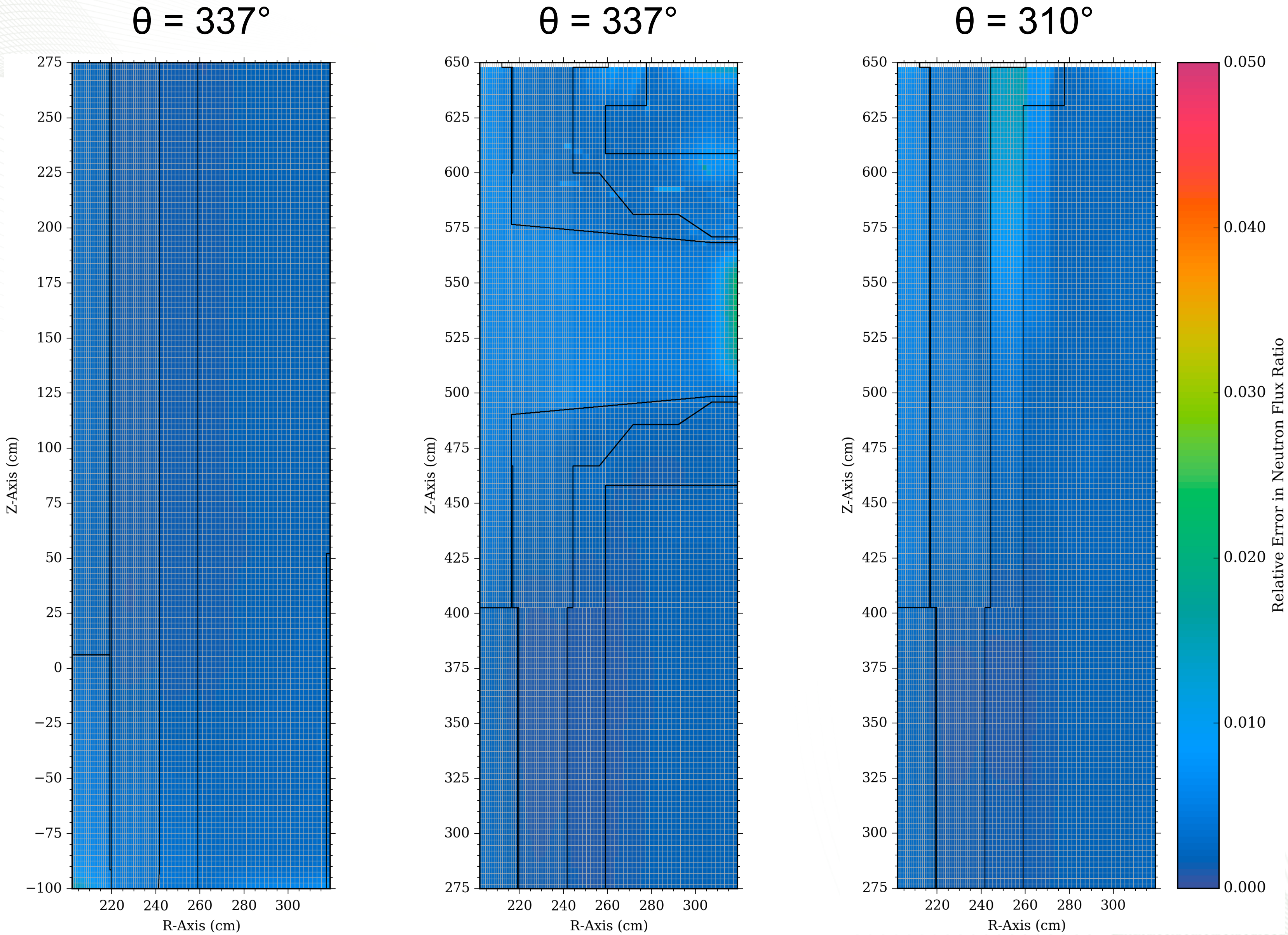
PNNL “Ordinary” / NBS-04 at θ = 292° and 310°



PNNL "Ordinary" with Reduced H / NBS-04 at θ = 292° and 310°



Increasing the Cavity Gap by 10 cm



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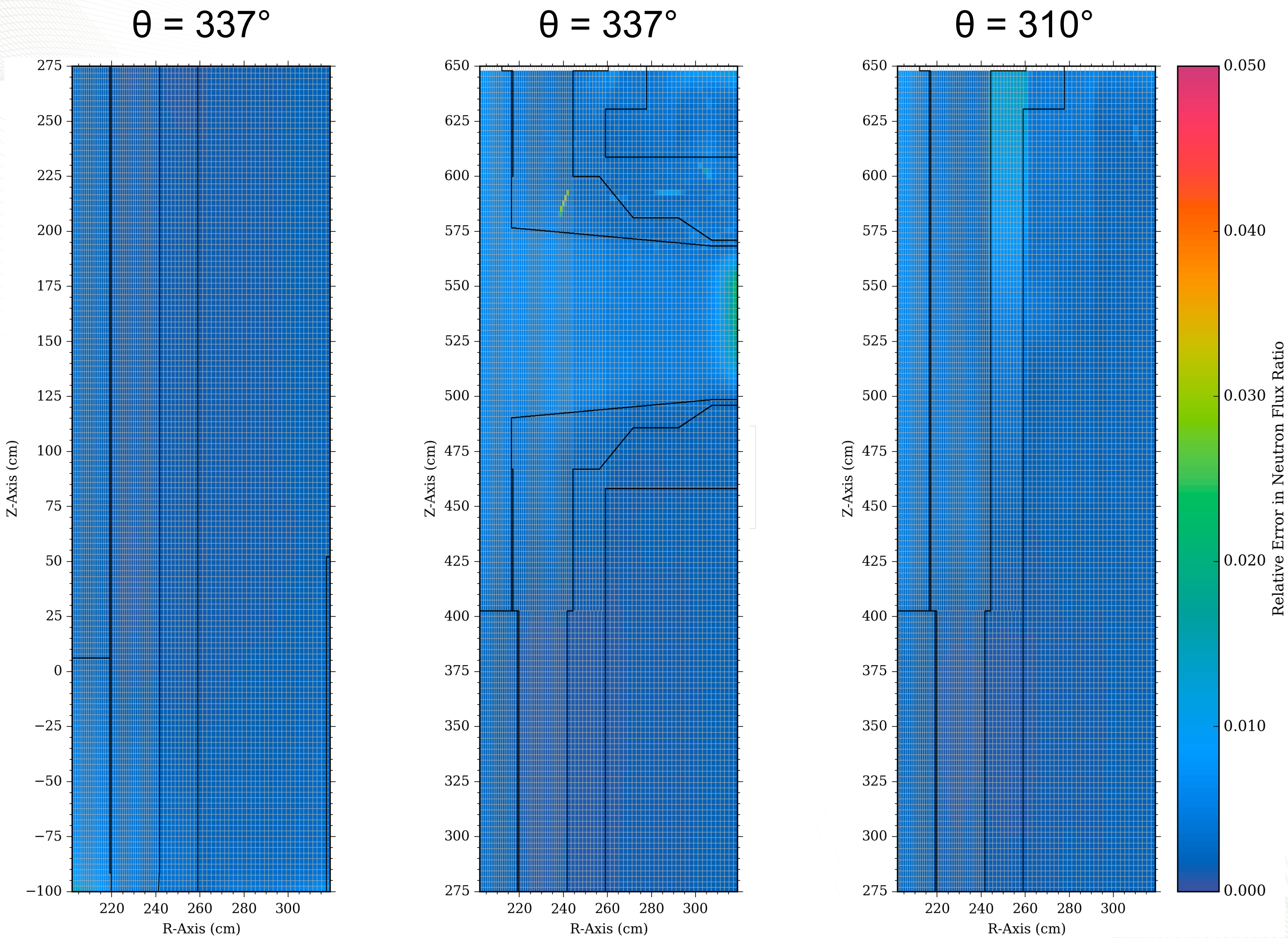
Increasing the Cavity Gap by 30 cm



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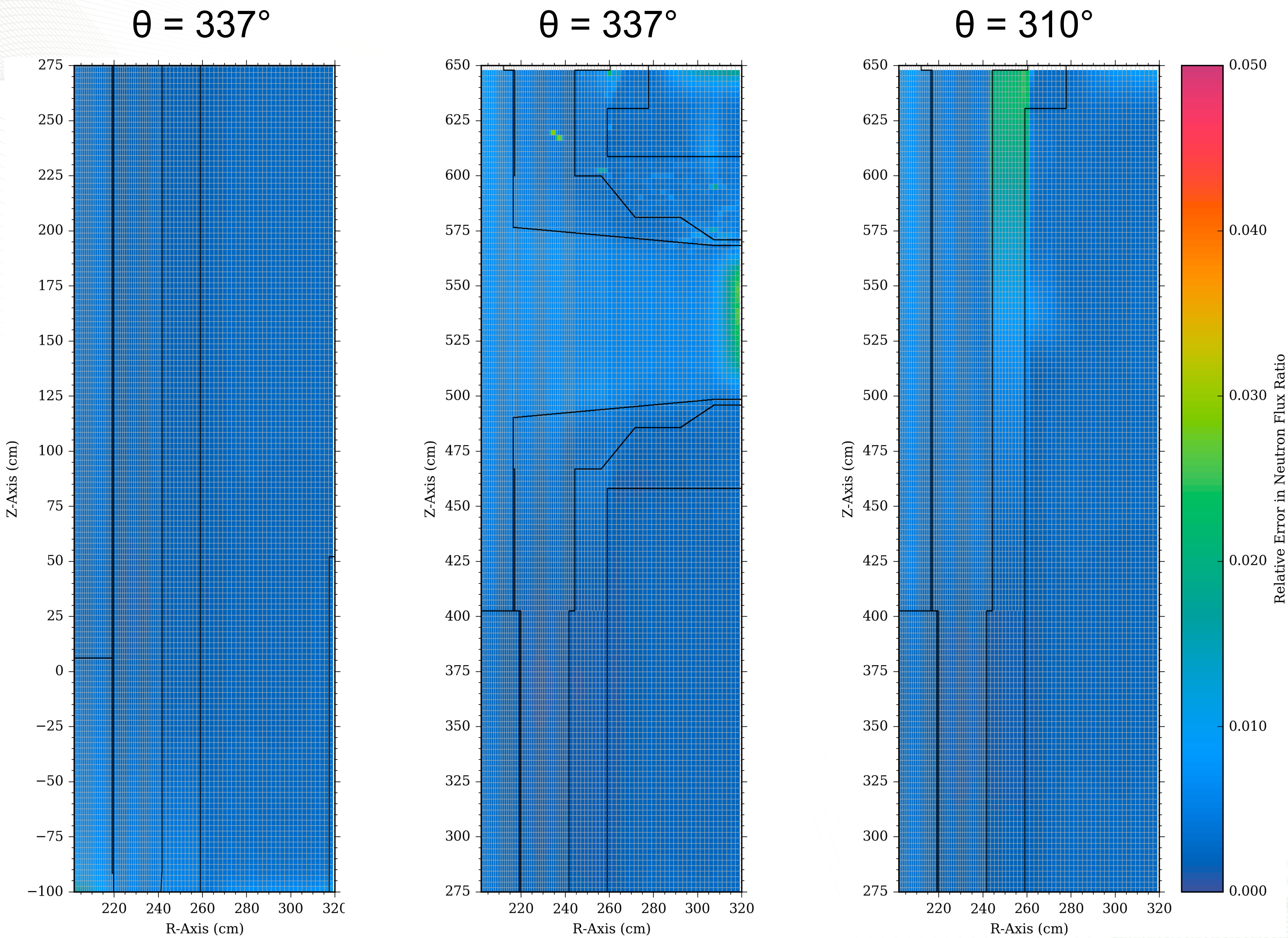
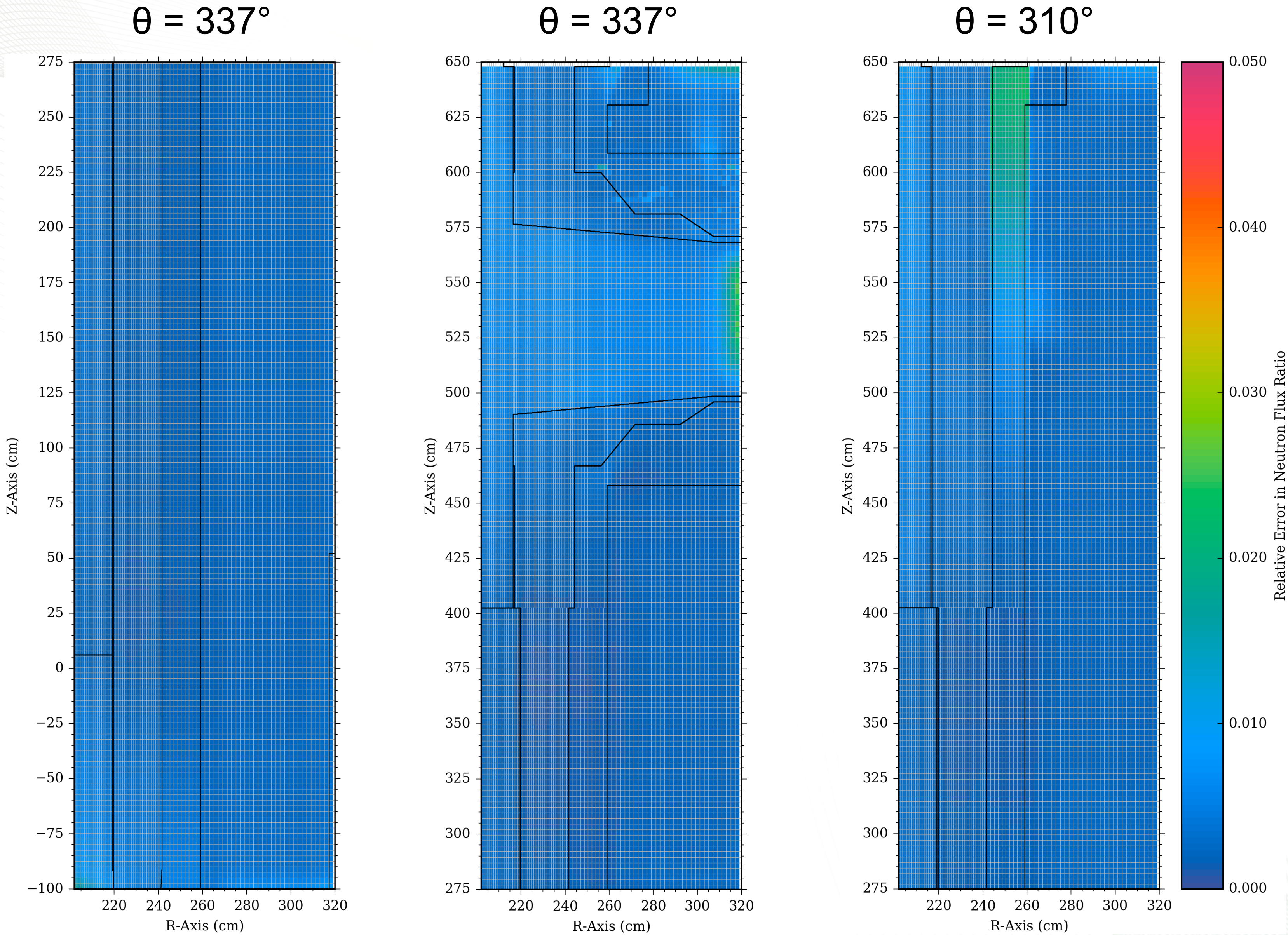
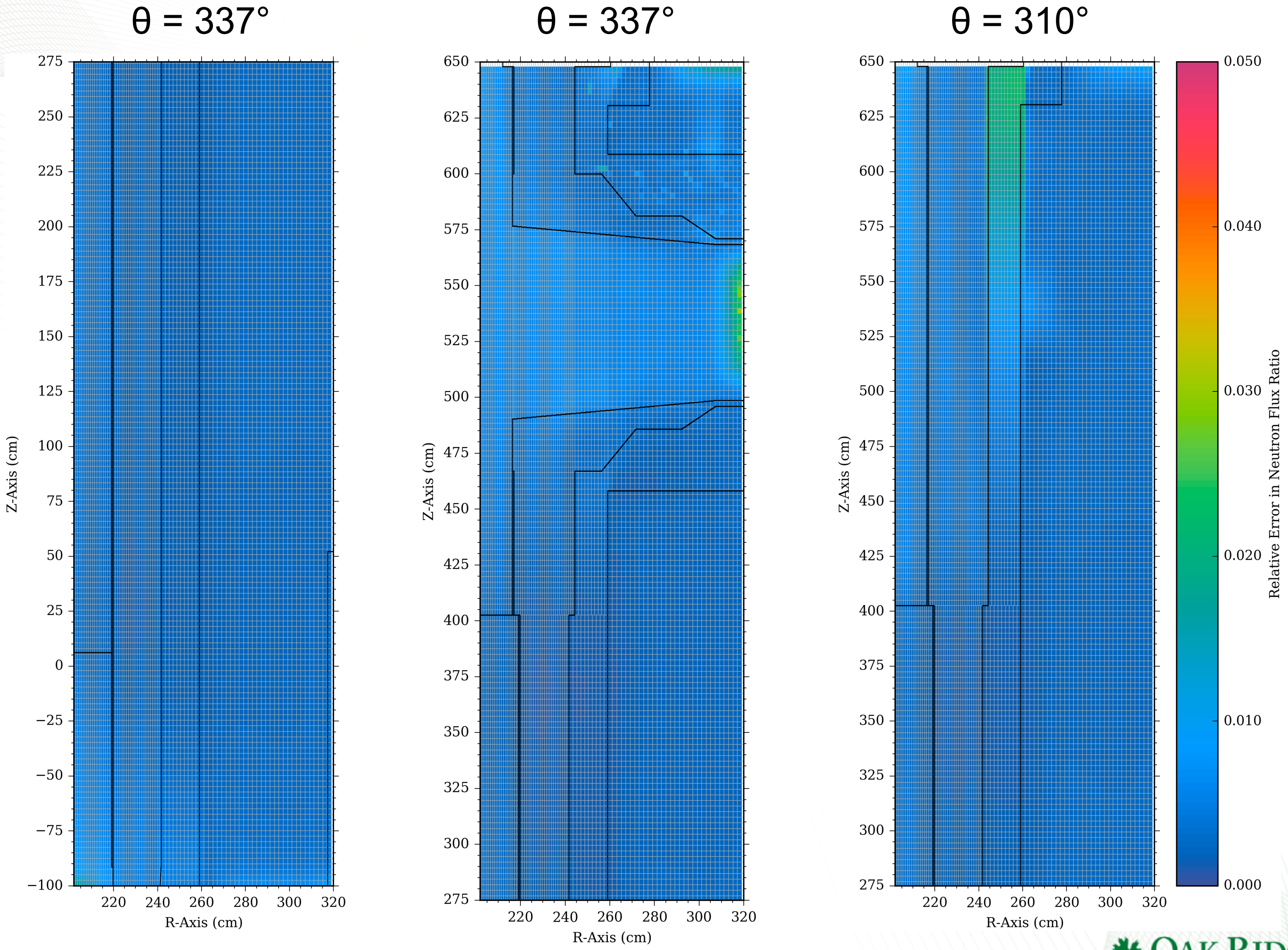
Decreasing the M/W Density by 10%



Decreasing the M/W Density by 25%



Increasing the M/W Density by 10%



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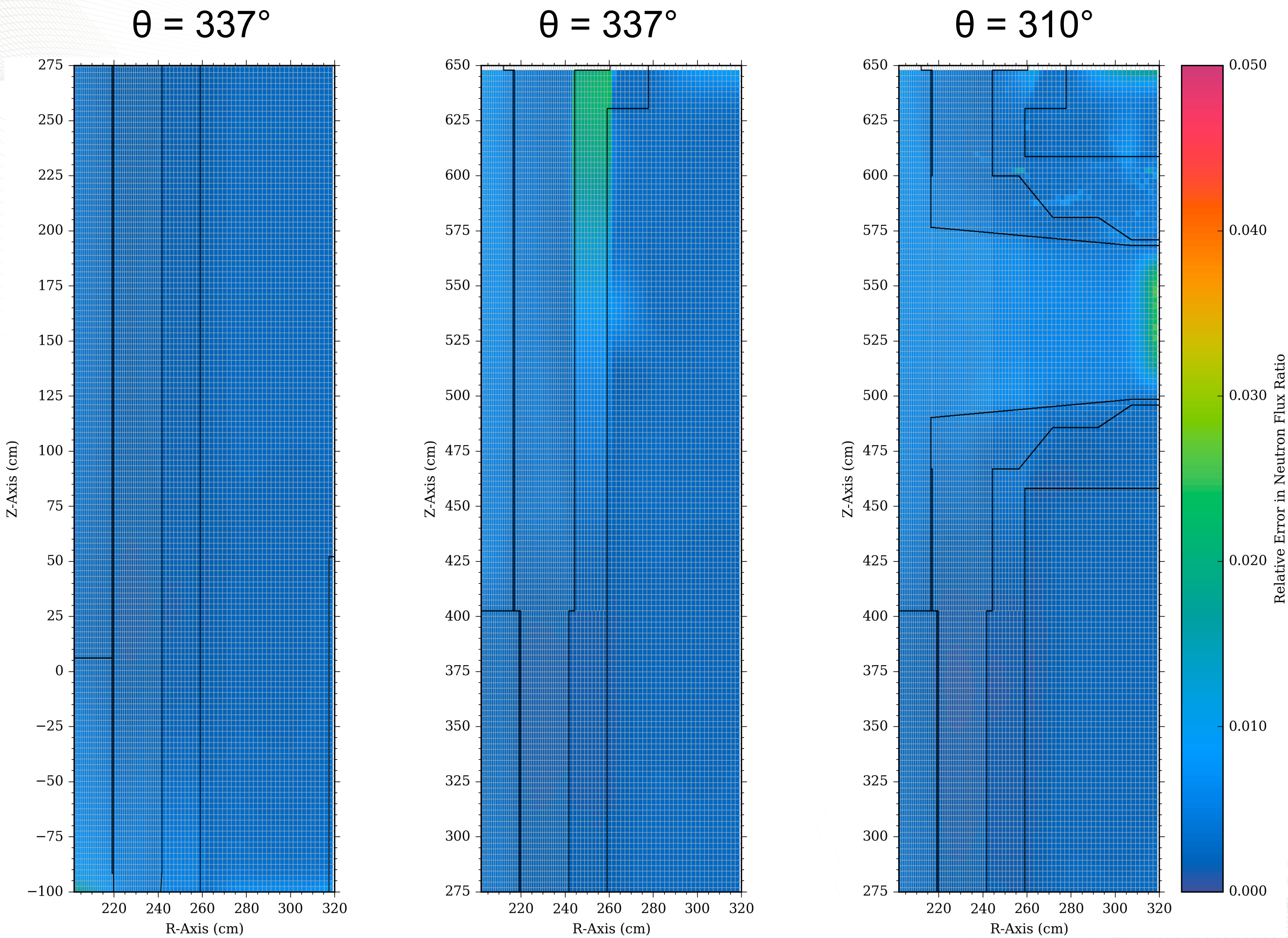
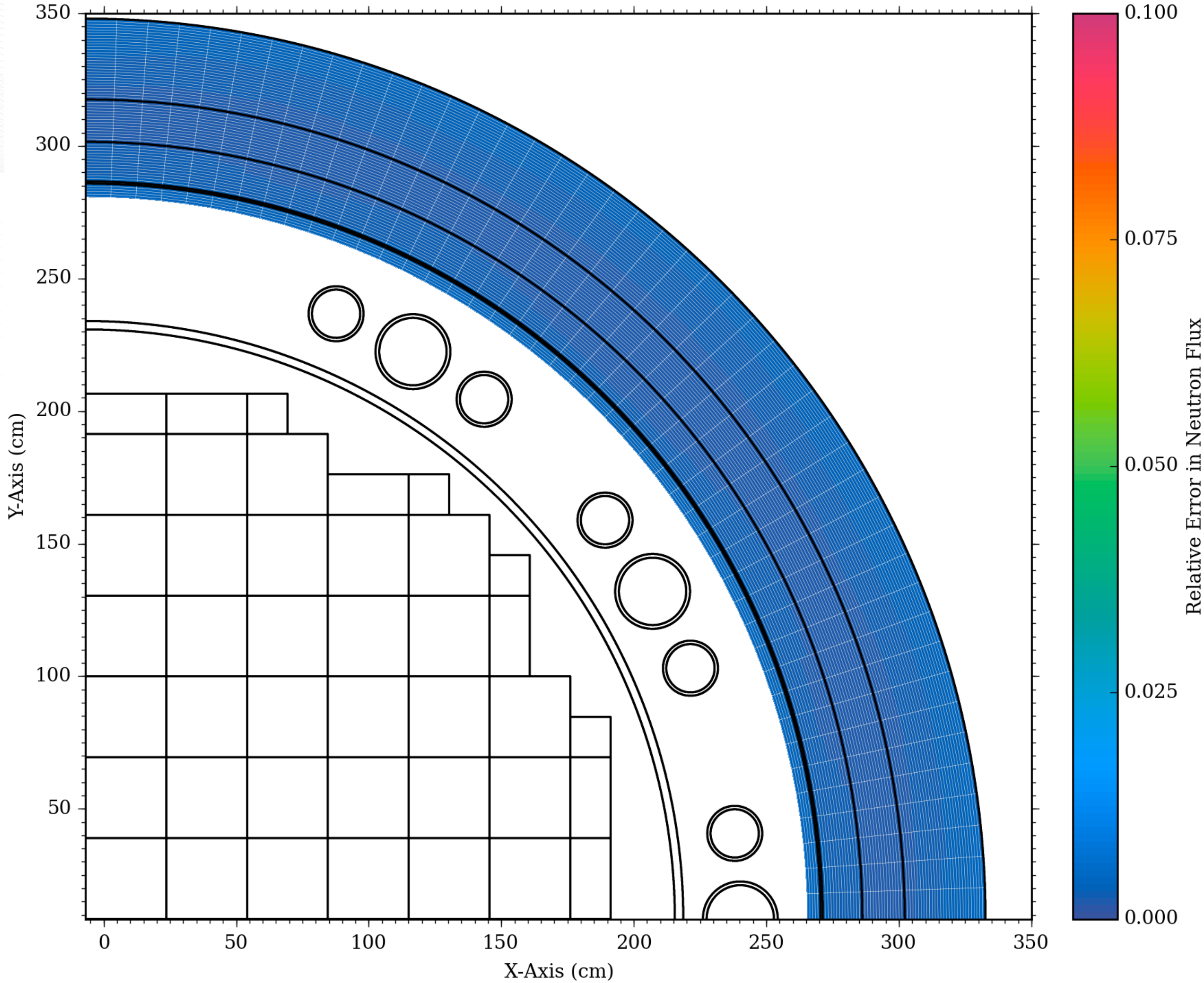
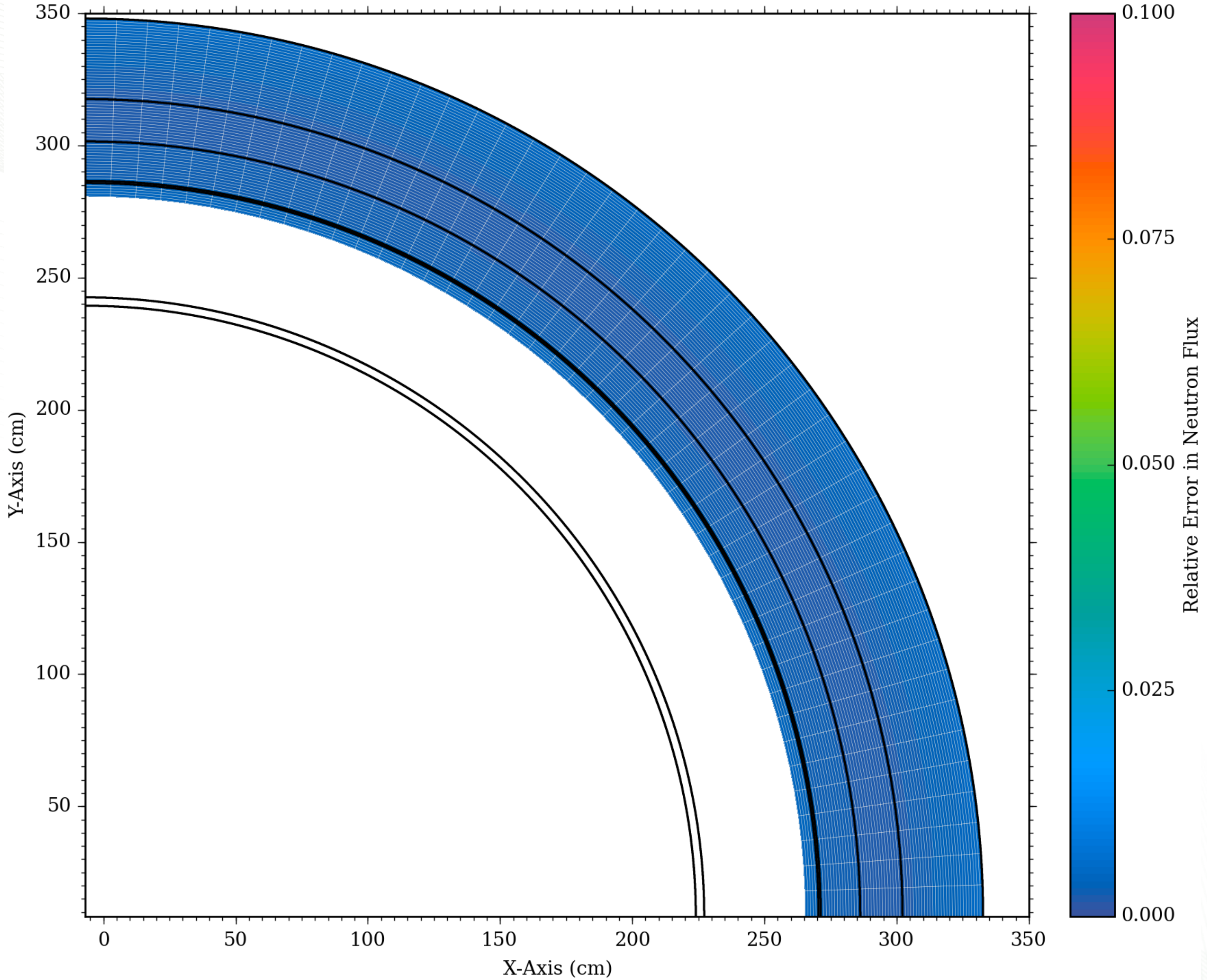
Increasing the M/W Density by 25%

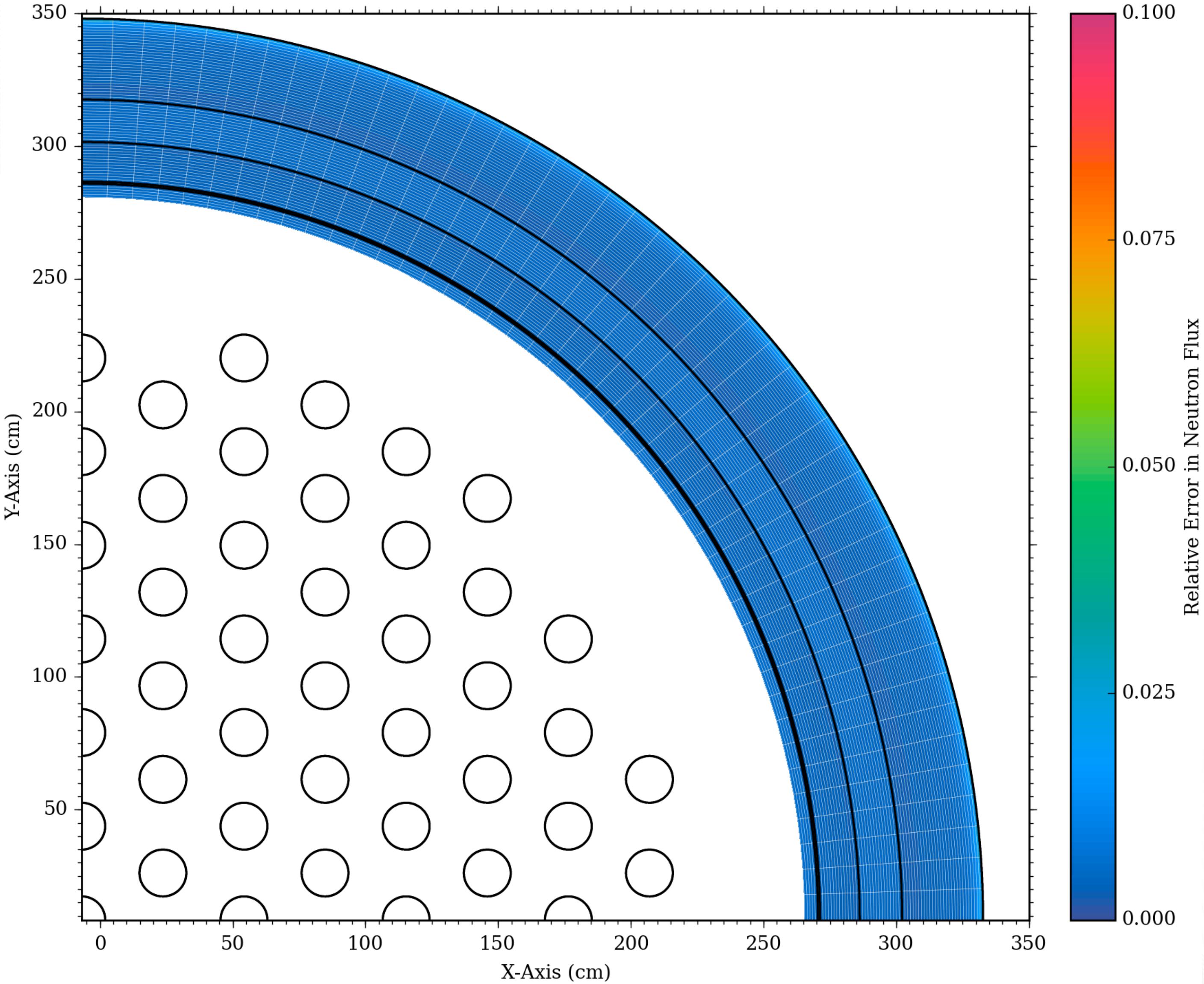




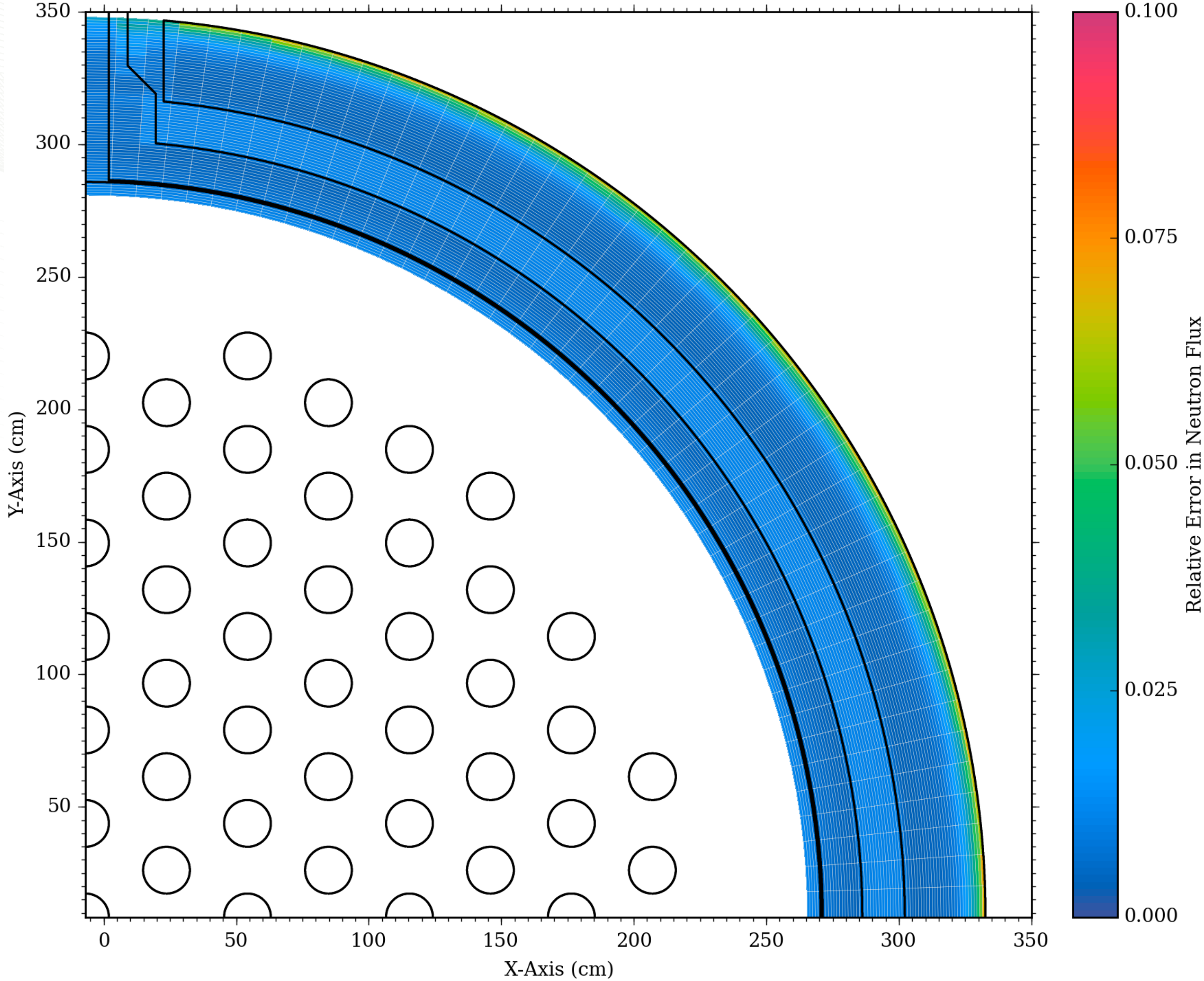
Fast neutron flux (E > 1 MeV) at Z = 0 cm (the core midplane elevation) for the BWR reference model.



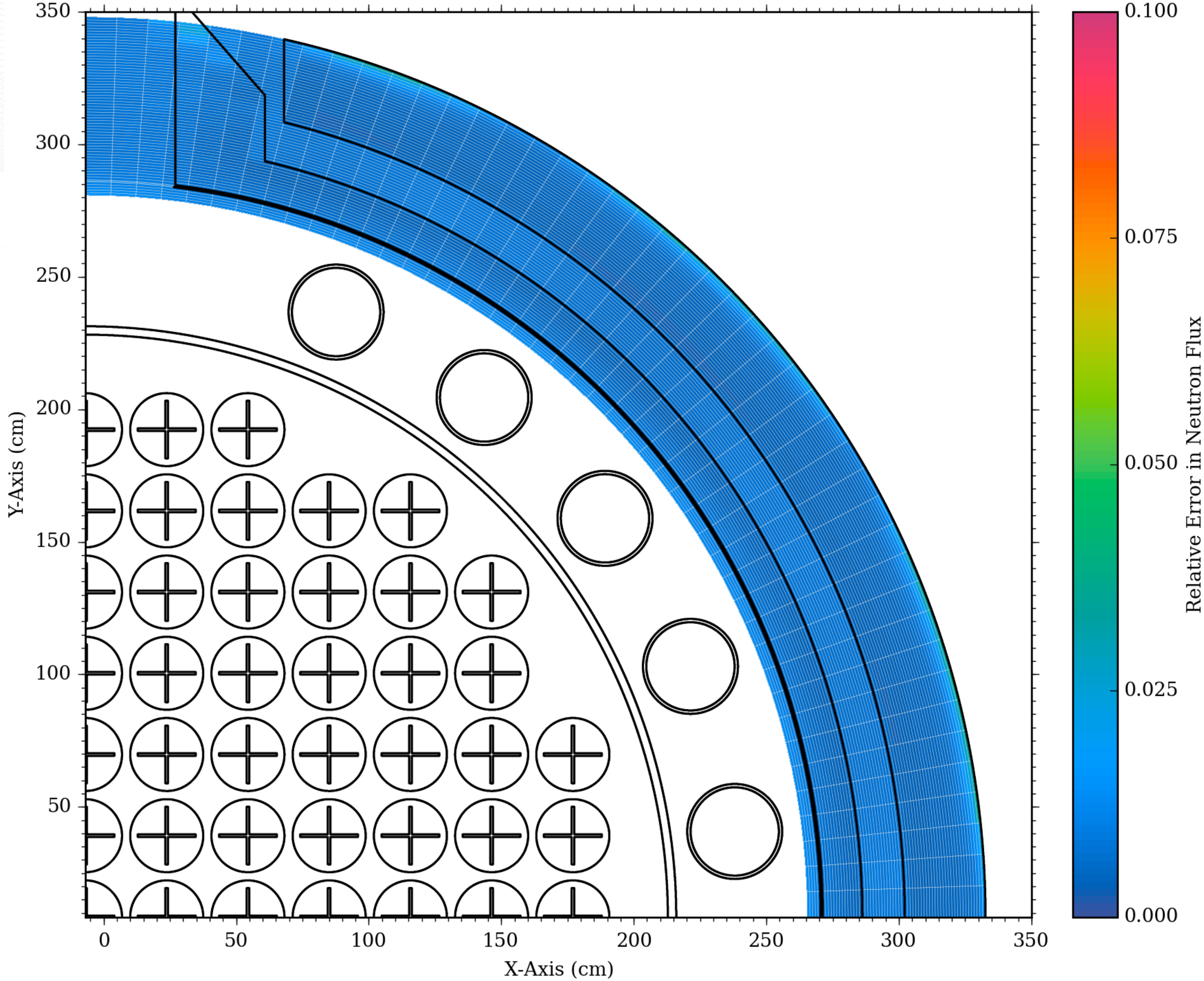
Fast neutron flux (E > 1 MeV) at Z = 300 cm for the BWR reference model.



Fast neutron flux (E > 1 MeV) at Z = 400 cm for the BWR reference model (steam separator standing pipes).

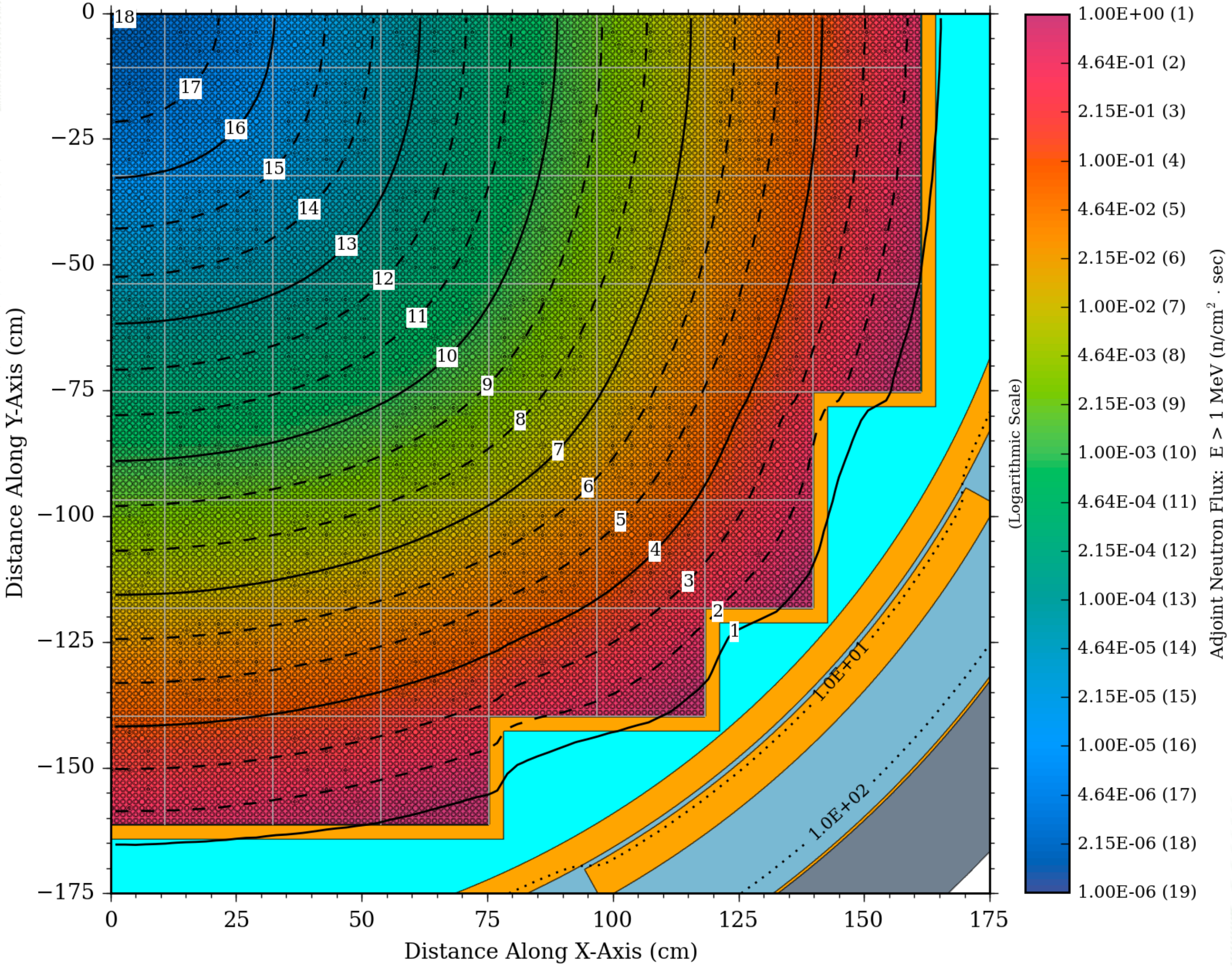


Fast neutron flux (E > 1 MeV) at Z = 468.5 cm for the BWR reference model (core spray nozzle elevation).

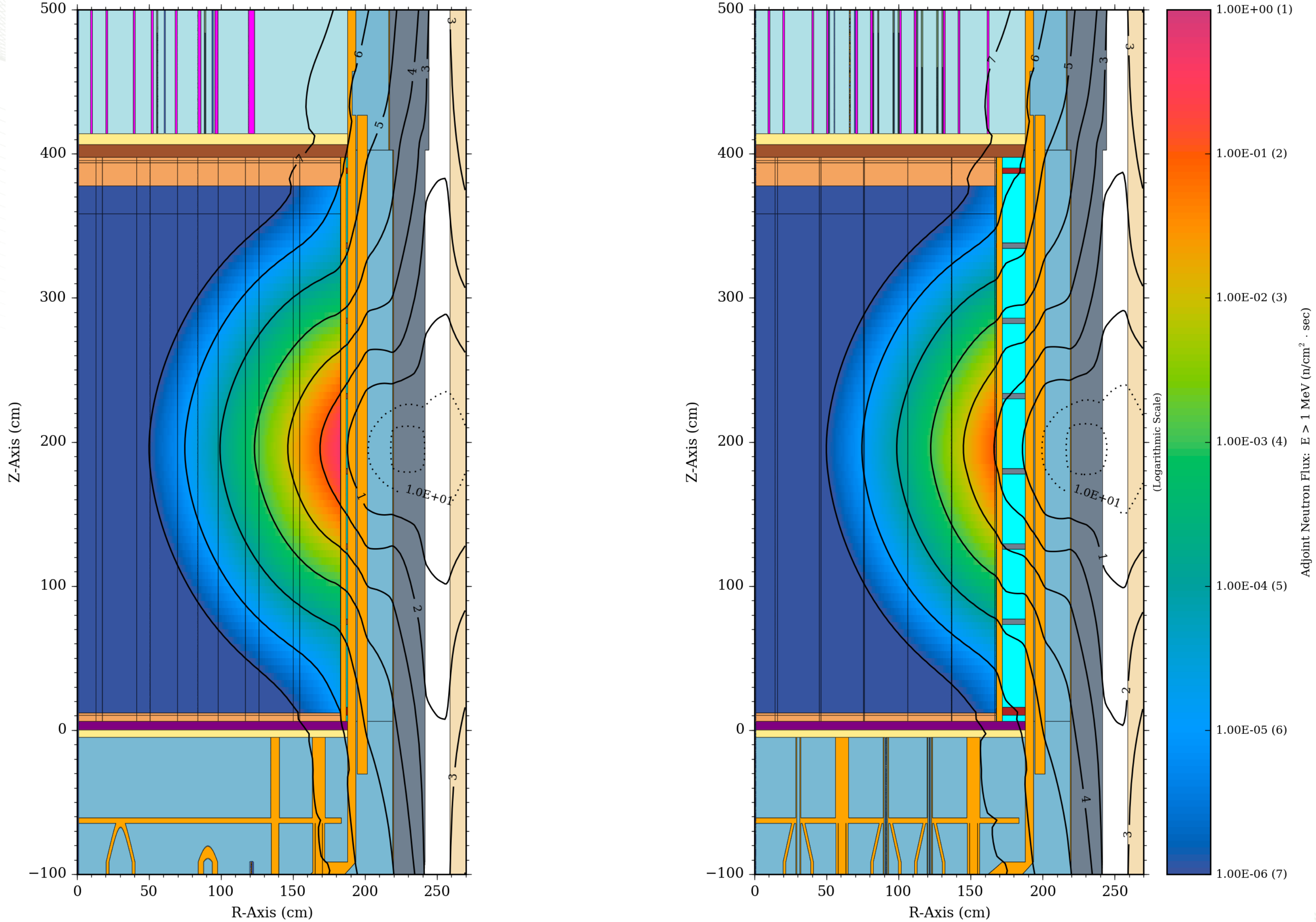


Fast neutron flux (E > 1 MeV) at Z = -302.4 cm for the BWR reference model (recirculation nozzle elevation).

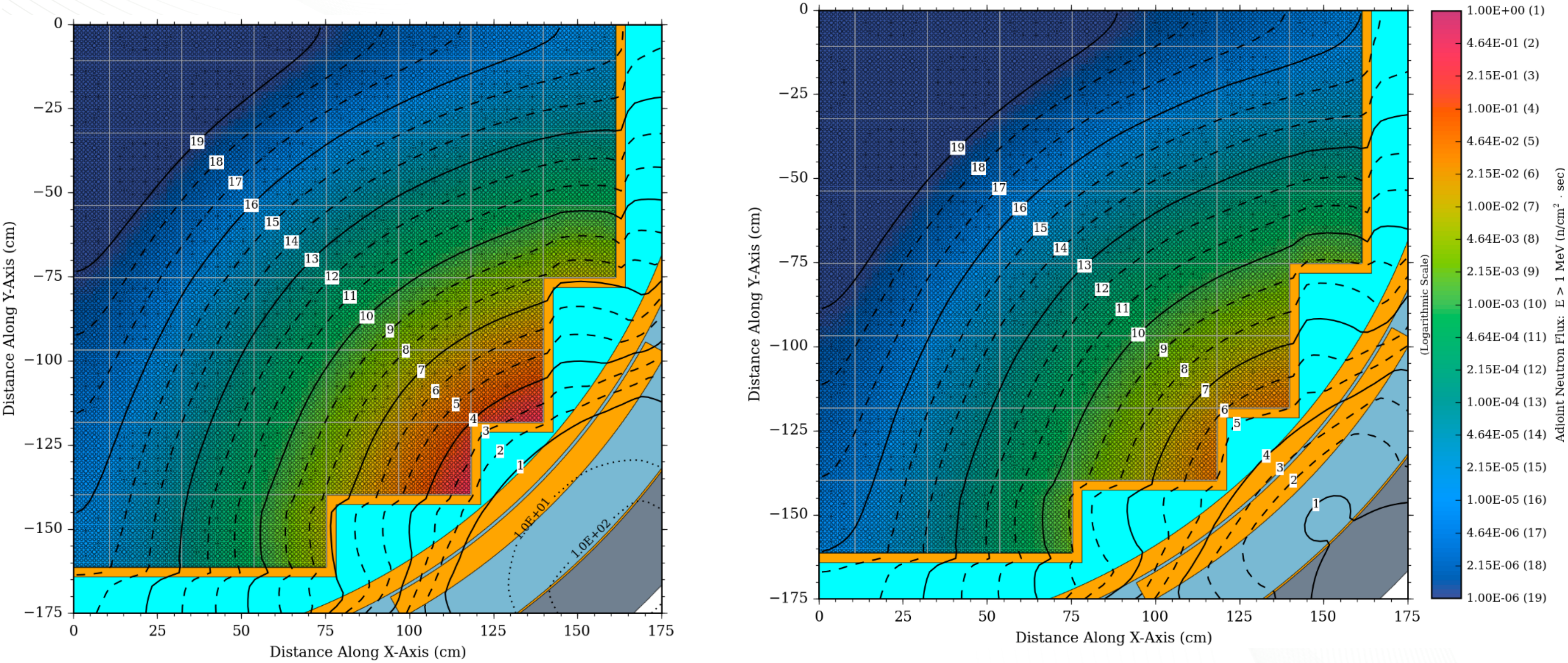
Supplementary Slides - Adjoint Neutron Flux Calculations

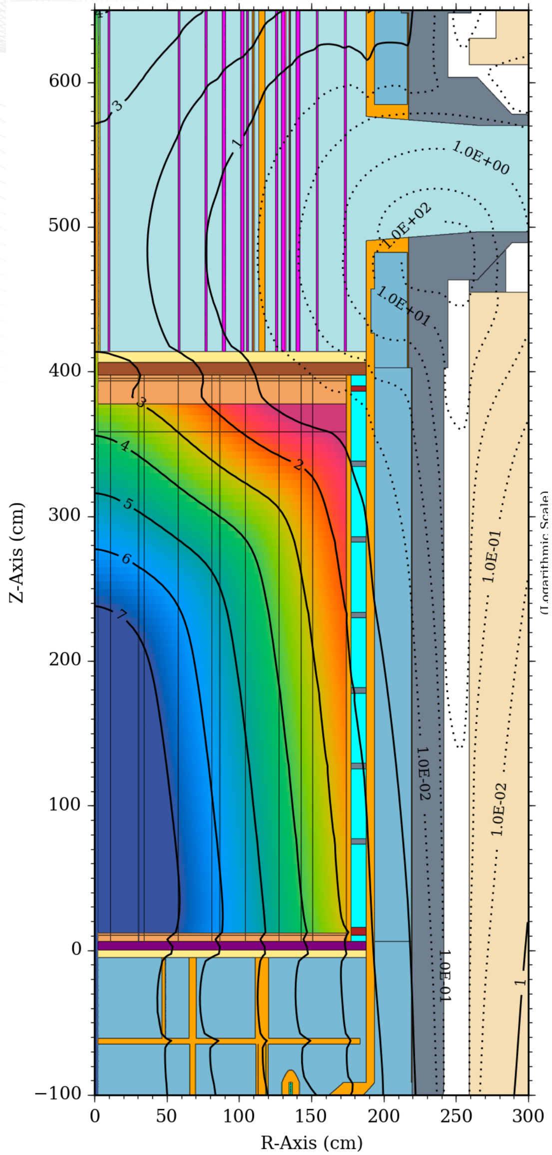


Distance Along Y-Axis (cm)
Distance Along X-Axis (cm)
0
−25
−50
−75
−100
−125
−150
−175
0
25
50
75
100
125
150
175
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1.0E+01
1.0E+02
(Logarithmic Scale)
Adjoint Neutron Flux: E > 1 MeV (n/cm² · sec)
1.00E+00 (1)
4.64E-01 (2)
2.15E-01 (3)
1.00E-01 (4)
4.64E-02 (5)
2.15E-02 (6)
1.00E-02 (7)
4.64E-03 (8)
2.15E-03 (9)
1.00E-03 (10)
4.64E-04 (11)
2.15E-04 (12)
1.00E-04 (13)
4.64E-05 (14)
2.15E-05 (15)
1.00E-05 (16)
4.64E-06 (17)
2.15E-06 (18)
1.00E-06 (19)

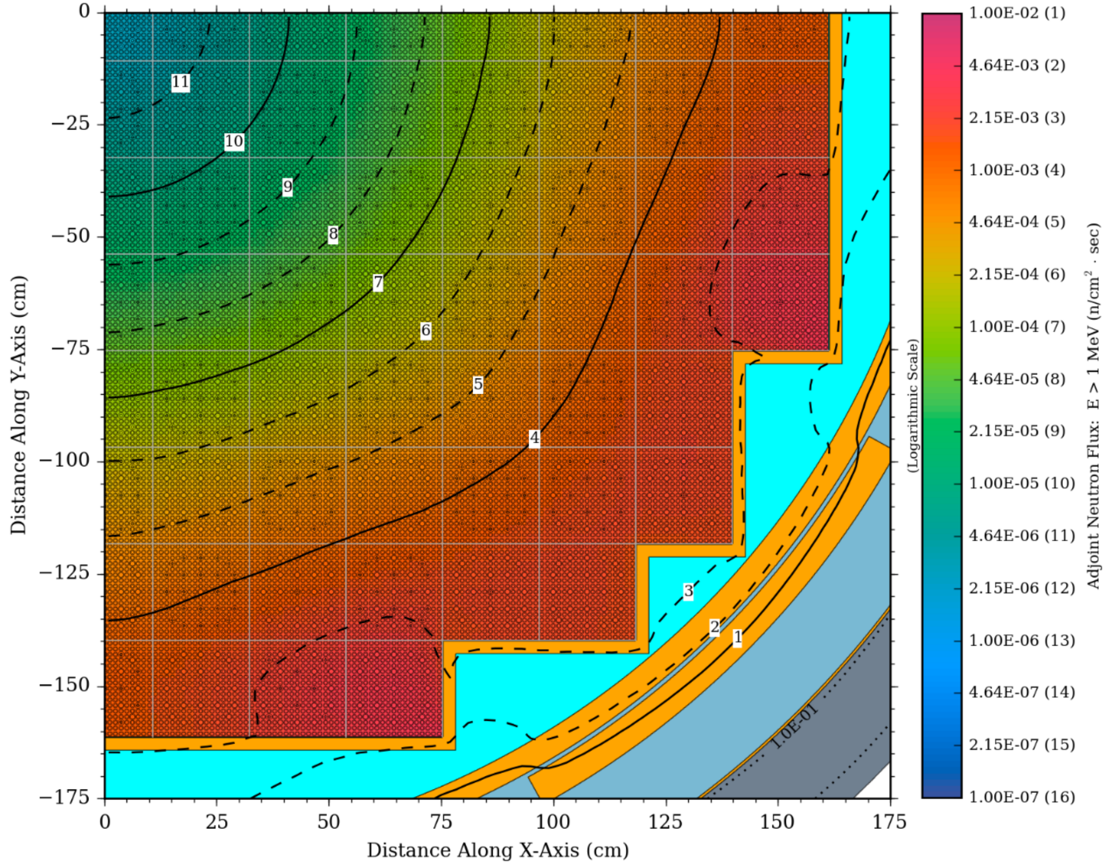


Z-Axis (cm)
R-Axis (cm)
1.0E+01
(Logarithmic Scale)
Adjoint Neutron Flux: E > 1 MeV (n/cm² · sec)
1.00E+00 (1)
1.00E-01 (2)
1.00E-02 (3)
1.00E-03 (4)
1.00E-04 (5)
1.00E-05 (6)
1.00E-06 (7)

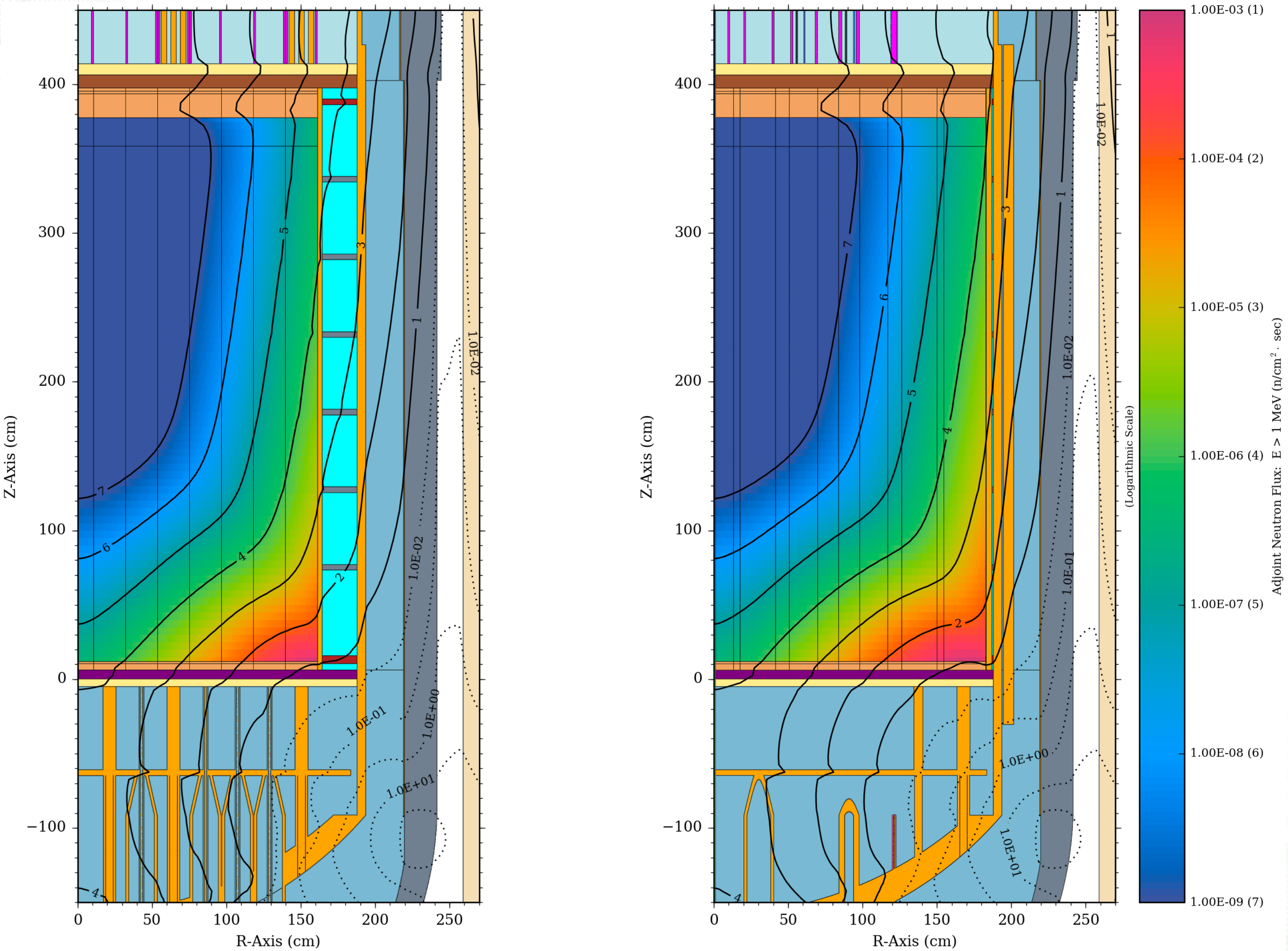

Distance Along Y-Axis (cm)
Distance Along X-Axis (cm)
1.0E+01
1.0E+02
1.00E+00 (1)
4.64E-01 (2)
2.15E-01 (3)
1.00E-01 (4)
4.64E-02 (5)
2.15E-02 (6)
1.00E-02 (7)
4.64E-03 (8)
2.15E-03 (9)
1.00E-03 (10)
4.64E-04 (11)
2.15E-04 (12)
1.00E-04 (13)
4.64E-05 (14)
2.15E-05 (15)
1.00E-05 (16)
4.64E-06 (17)
2.15E-06 (18)
1.00E-06 (19)
(Logarithmic Scale)
Adjoint Neutron Flux: E > 1 MeV (n/cm² · sec)



Z-Axis (cm)
R-Axis (cm)
1.0E+00
1.0E+02
1.0E+01
1.0E-01
1.0E-02
(Logarithmic Scale)



Distance Along Y-Axis (cm)
Distance Along X-Axis (cm)
(Logarithmic Scale)
Adjoint Neutron Flux: E > 1 MeV (n/cm² · sec)
1.00E-02 (1)
4.64E-03 (2)
2.15E-03 (3)
1.00E-03 (4)
4.64E-04 (5)
2.15E-04 (6)
1.00E-04 (7)
4.64E-05 (8)
2.15E-05 (9)
1.00E-05 (10)
4.64E-06 (11)
2.15E-06 (12)
1.00E-06 (13)
4.64E-07 (14)
2.15E-07 (15)
1.00E-07 (16)



Z-Axis (cm)
R-Axis (cm)
1.0E-02
1.0E-01
1.0E+00
1.0E+01
(Logarithmic Scale)
Adjoint Neutron Flux: E > 1 MeV (n/cm^2 · sec)
1.00E-03 (1)
1.00E-04 (2)
1.00E-05 (3)
1.00E-06 (4)
1.00E-07 (5)
1.00E-08 (6)
1.00E-09 (7)