Axial ADFs for High Conversions BWRs

E. Fridman[1], S. Duerigen[1], Y. Bilodid[1], D. Kotlyar[2], E. Shwageraus[2]

[1]HZDR
[2]Ben-Gurion University

HZDR

HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

Outline

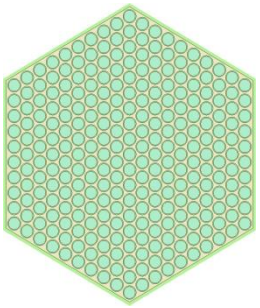
- Background
- Modeling challenges (neutronics)
- Generation of axial ADFs
- Numerical example
- Summary

Why HC LWRs?

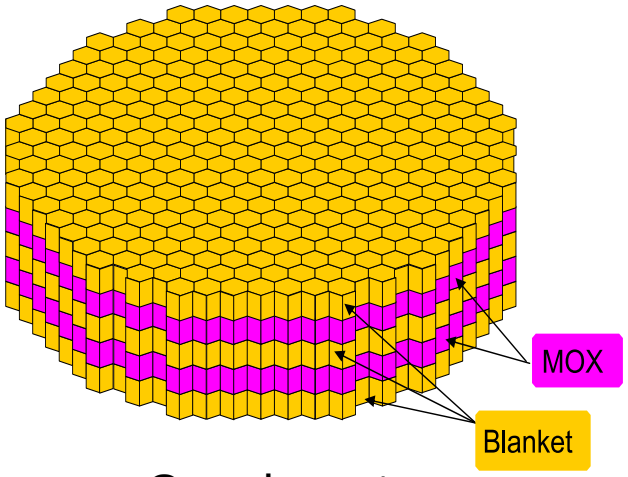
- GEN-IV goals using LWR technology
- Actinides recycling
- Fissile material breeding
- No immediate need for fast reactors

Hitachi Resource-Renewable BWR (RBWR)

- Tight lattice
- High void fraction
- Hard spectrum
- Internal axial blankets
  - to get CR > 1.0



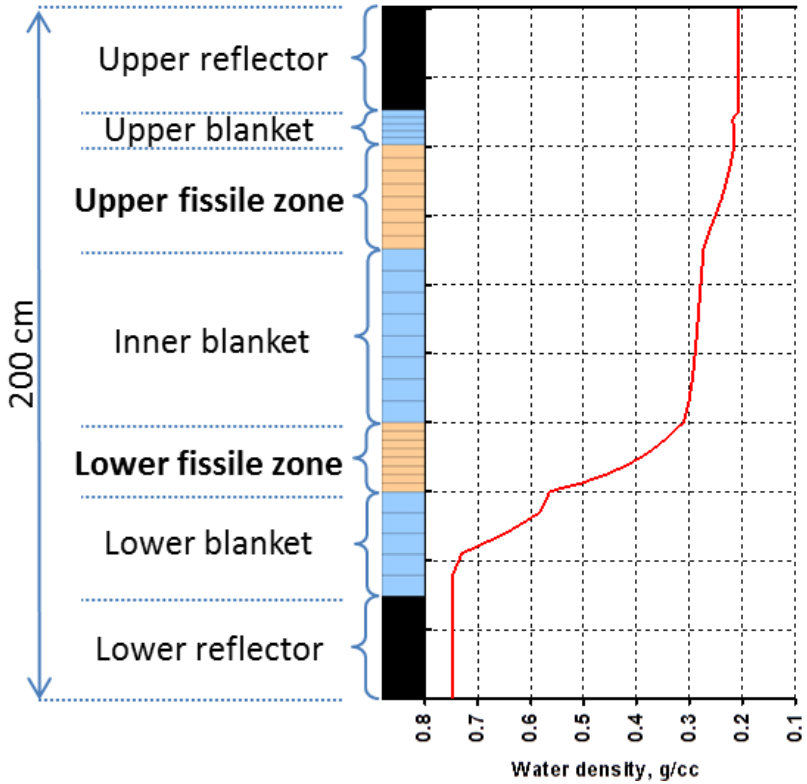
Fuel assembly layout

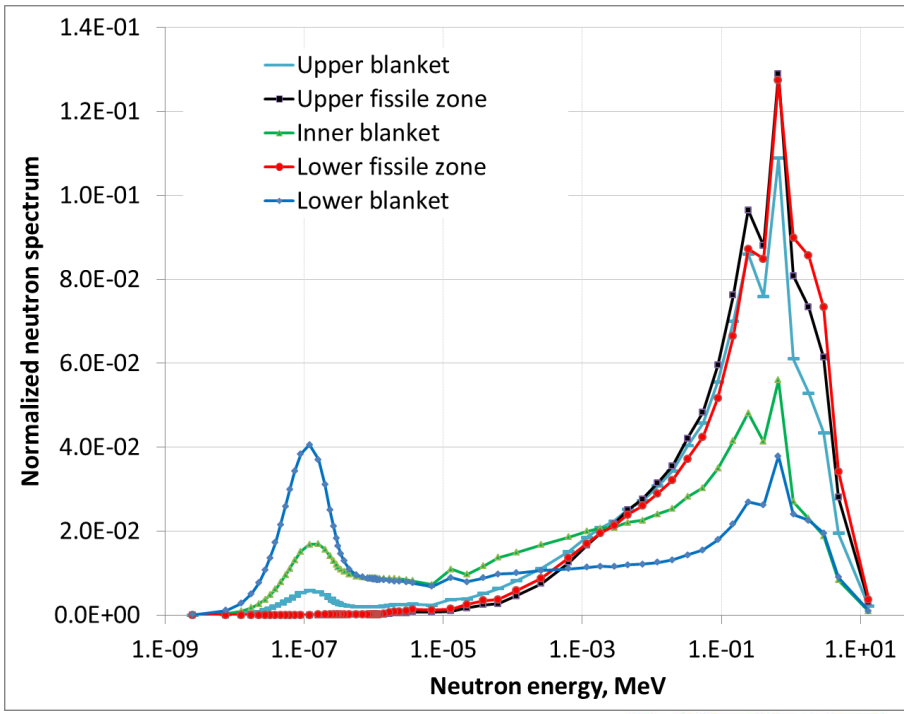


Core layout

Modeling challenges

- Very heterogeneous
  - Sharp differences in the material properties
  - Large changes in coolant density
  - Strong spectral transitions
  - No distinct spectral zones for XS generation





Addressing the challenges

- 3D XS generation
  - By Serpent
  - Using full assembly model

- Introduction of axial discontinuity factors (ADF)
  - To preserve nodal net leakage rates
  - Recently implemented in DYN3D

ADF generation methodology

- Split fuel assembly into axial nodes
  - Generate XS for every axial node
  - Calculate incoming and outgoing partial currents at every nodal interface

- Calculate net surface currents and heterogeneous surface fluxes:

$$J_{s,g}^{Net} = J_{s,g}^{+} - J_{s,g}^{-} \quad \text{and} \quad \phi_{s,g}^{i,het} = 2\left(J_{s,g}^{i,+} + J_{s,g}^{i,-}\right)$$

- Solve 1D fixed-source diffusion equation for every axial node
  - Using net currents as a boundary condition
  - To get diffusion surface fluxes

$$-D_g \frac{d^2\phi_g^{hom}}{dz^2} + \Sigma_{t,g}\phi_g^{hom} = \sum_{h=1}^{G} \Sigma_s^{h\to g}\phi_h^{hom} + \frac{1}{k_{eff}} \chi_g \sum_{h=1}^{G} \nu\Sigma_{f,h}\phi_h^{hom}$$

- Calculate ADF as:

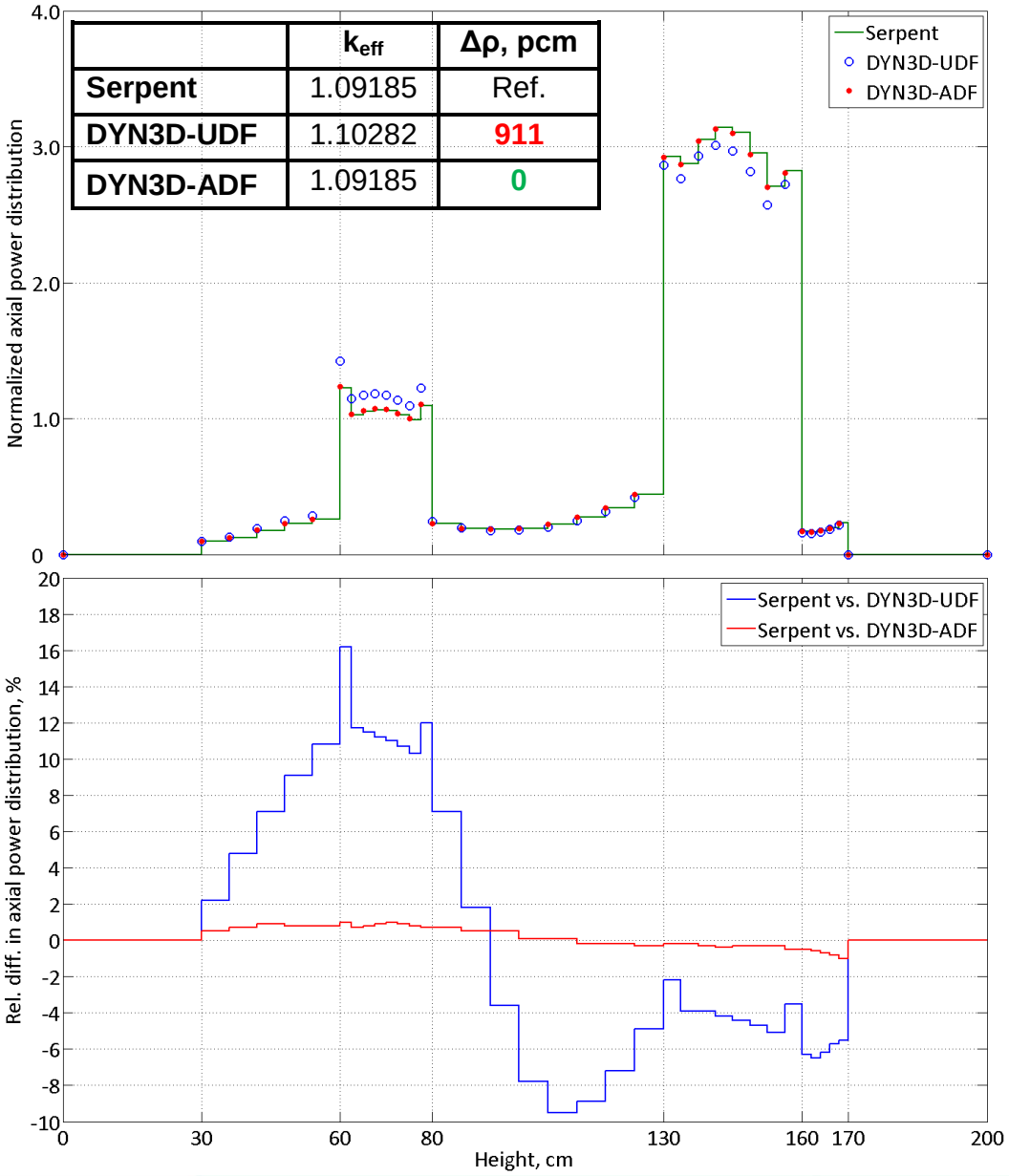
$$f_{s,g}^{i} = \frac{\phi_{s,g}^{i,het}}{\phi_{s,g}^{i,hom}}$$

DYN3D analysis of a single RBWR assembly

- Consider a single 3D RBWR-MOX assembly
- Generate two-group XSs and ADFs
  - for every axial node
- Perform DYN3D calculations
  - with and without ADF
- Compare with the reference Serpent solution

K-eff and axial power, Serpent vs. DYN3D

	k_{eff}	Δρ, pcm
Serpent	1.09185	Ref.
DYN3D-UDF	1.10282	**911**
DYN3D-ADF	1.09185	**0**



Summary

- Modeling of HC BWR is challenging
  - Axial heterogeneity
- Possible solution
  - 3D XS generation + use of axial ADFs
  - yields good nodal results for a single 3D assembly
- Future work (probably in progress at UCB and Michigan)
  - Optimization of few-group energy structure
  - Radial ADFs
  - Branching calculations
  - Full core tests

Thank you for your attention!