ENDF/B-VIII.1 Performance for RPV Fluence and Reactor Dosimetry Applications

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Introduction

- This presentation contains preliminary comparisons of calculated reaction rates for reactor dosimetry sensors based on the latest nuclear data to current methods

- Calculations are performed with two-dimensional deterministic (S_N) methods
  - P_5 anisotropic scattering
  - S_{16} quadrature

Data Description

- The "current" data:
  - Transport cross sections: 47n20g BUGLE-96 (released in 1996)
    - Based on ENDF/B-VI.3
    - "Fine" 199n42g library processed by AMPX
    - "Broad" 47n20g library collapsed from 199n42g using spectra from a 1D calculation
  - Dosimetry cross sections: SNLRML (released in 1993)

Data Description

- The "latest" data:
  - Transport cross sections: 45n20g
  - Based on ENDF/B-VIII.1
  - "Fine" 200n47g library processed by NJOY and TRANSX
  - "Broad" 45n20g library collapsed from 200n47g using spectra from a 2D calculation
    - Added a few groups > 0.1 MeV; subtracted several < 0.1 MeV
- Dosimetry cross sections: ~~IRDFF-II~~ SNLRML

Sensors

- Westinghouse maintains a large database of measurements from reactor dosimetry sensors placed outside the reactor vessel at operating LWRs.

Table 1-1 Dosimeter Neutron Reactions

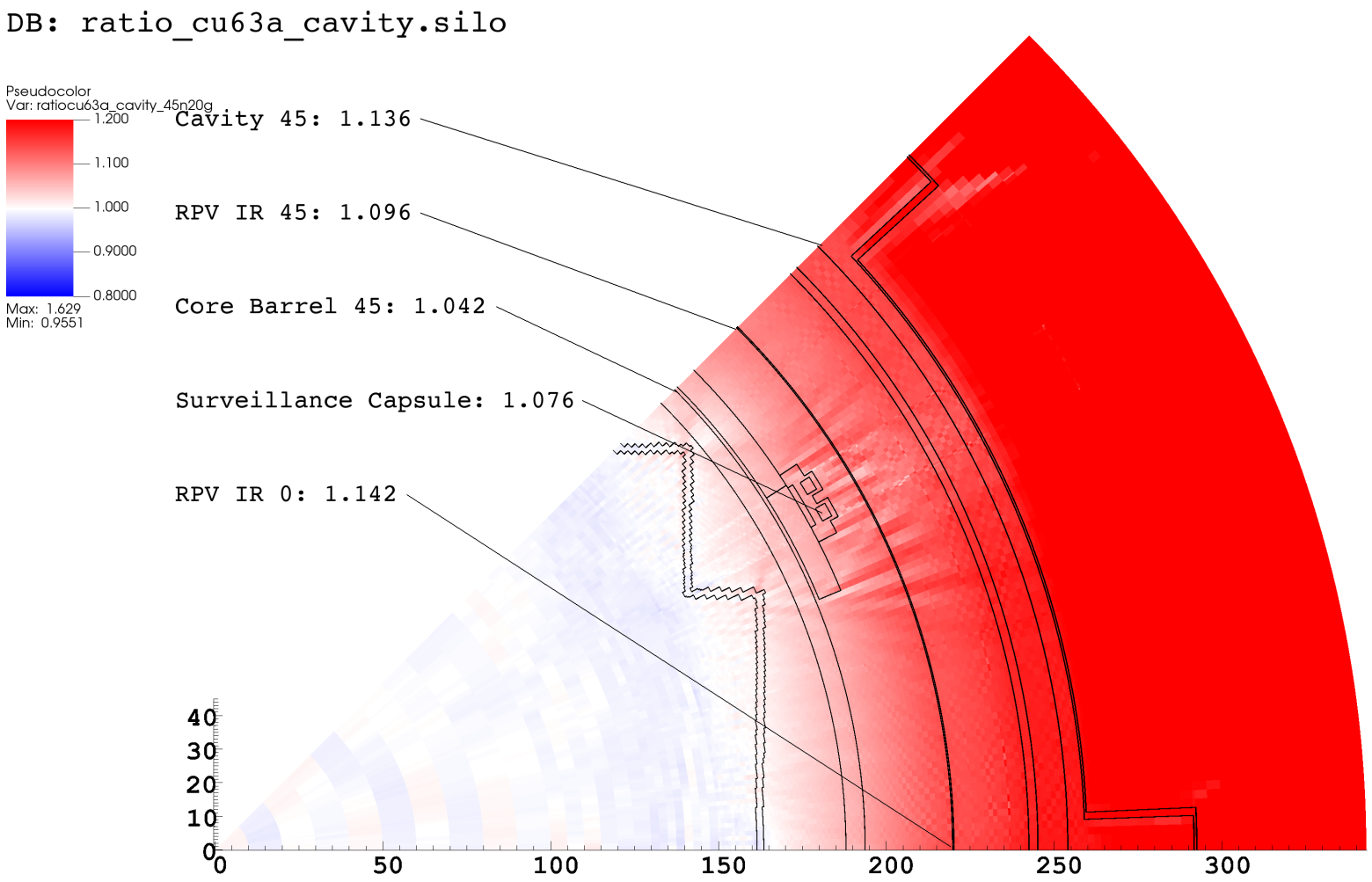
Material	Reaction of Interest	Neutron Energy Response[1]	Product Half-Life	Dosimeter Capsule Position[2]	Gradient Chain[3]
Copper	$^{63}Cu(n,\alpha)^{60}Co$	4.53-11.0 MeV	5.271 y	2-Cd	No
Titanium	$^{46}Ti(n,p)^{46}Sc$	3.70-9.43 MeV	83.788 d	2-Cd	No
Iron	$^{54}Fe(n,p)^{54}Mn$	2.27-7.54 MeV	312.13 d	1-B & 2-Cd	Yes
Nickel	$^{58}Ni(n,p)^{58}Co$	1.98-7.51 MeV	70.86 d	2-Cd	Yes
^{238}U[4]	$^{238}U(n,f)^{137}Cs$	1.44-6.69 MeV	30.05 y	3-Cd	No
Niobium	$^{93}Nb(n,n')^{93m}Nb$	0.95-5.79 MeV	16.13 y	3-Cd	No
^{237}Np[4]	$^{237}Np(n,f)^{137}Cs$	0.68-5.61 MeV	30.05 y	3-Cd	No
Cobalt-Al	$^{59}Co(n,\gamma)^{60}Co$	Thermal	5.271 y	1-B & 2-Cd	Yes

Notes:
1. Energies between which 90% of activity is produced (^{235}U fission spectrum). [12]
2. B denotes bare and Cd denotes cadmium-shielded.
3. Determined with additional radiochemical analysis.
4. Vanadium-encapsulated ^{238}U and ^{239}Np fission monitors are currently unavailable.

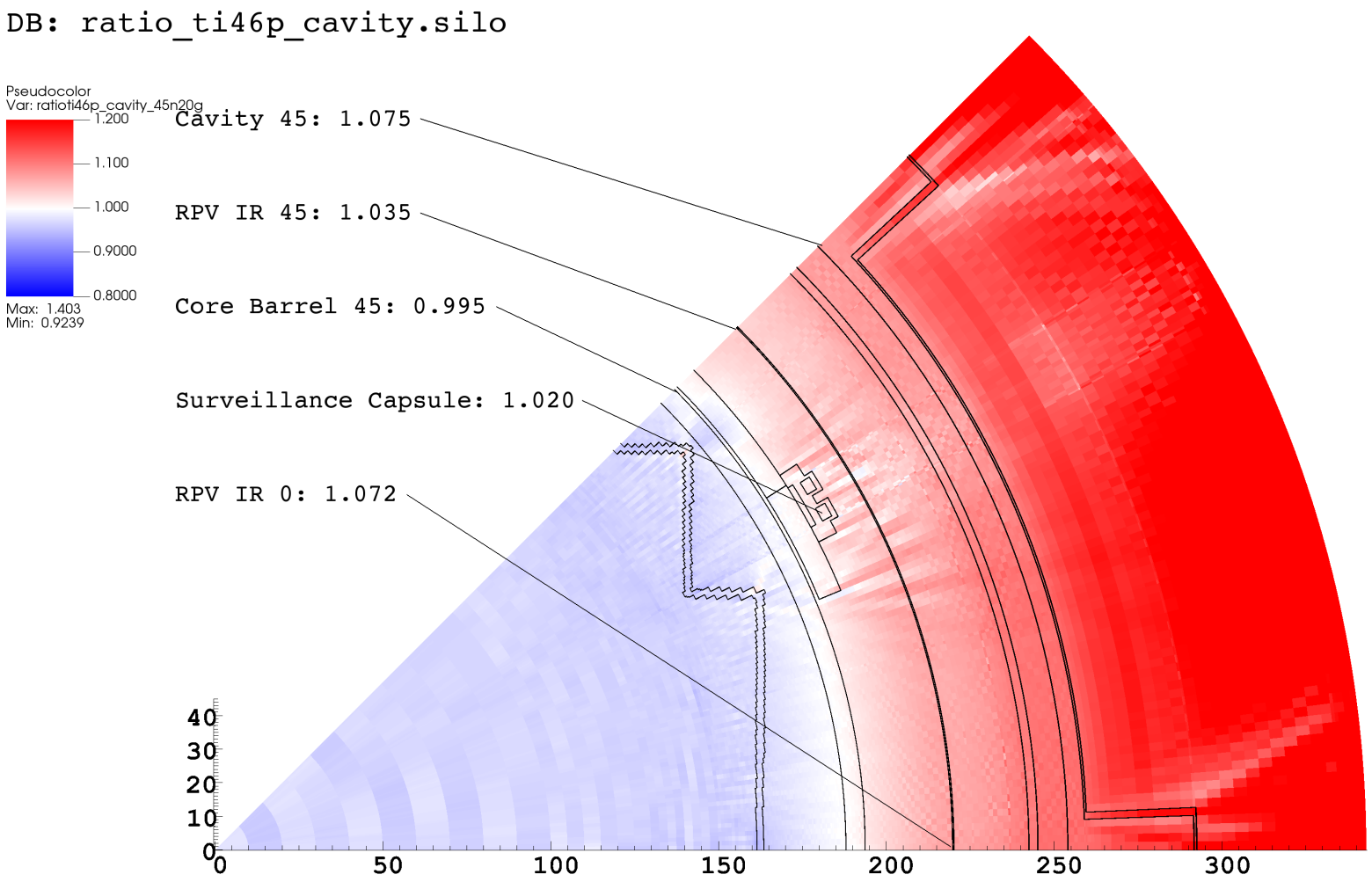
Comparisons

- Comparisons that follow show computed reaction rates
  - ("latest" / "current")

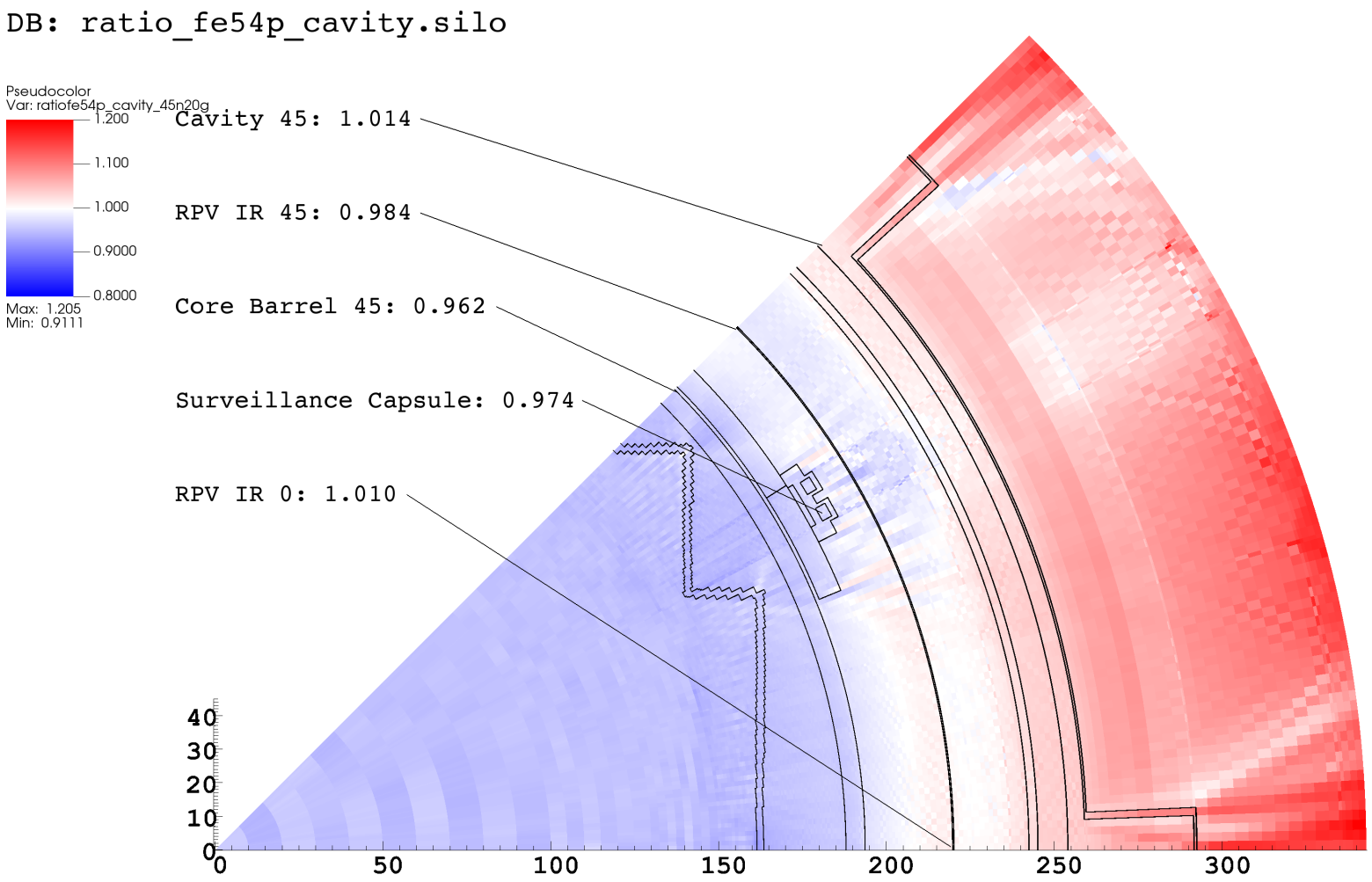
Comparisons



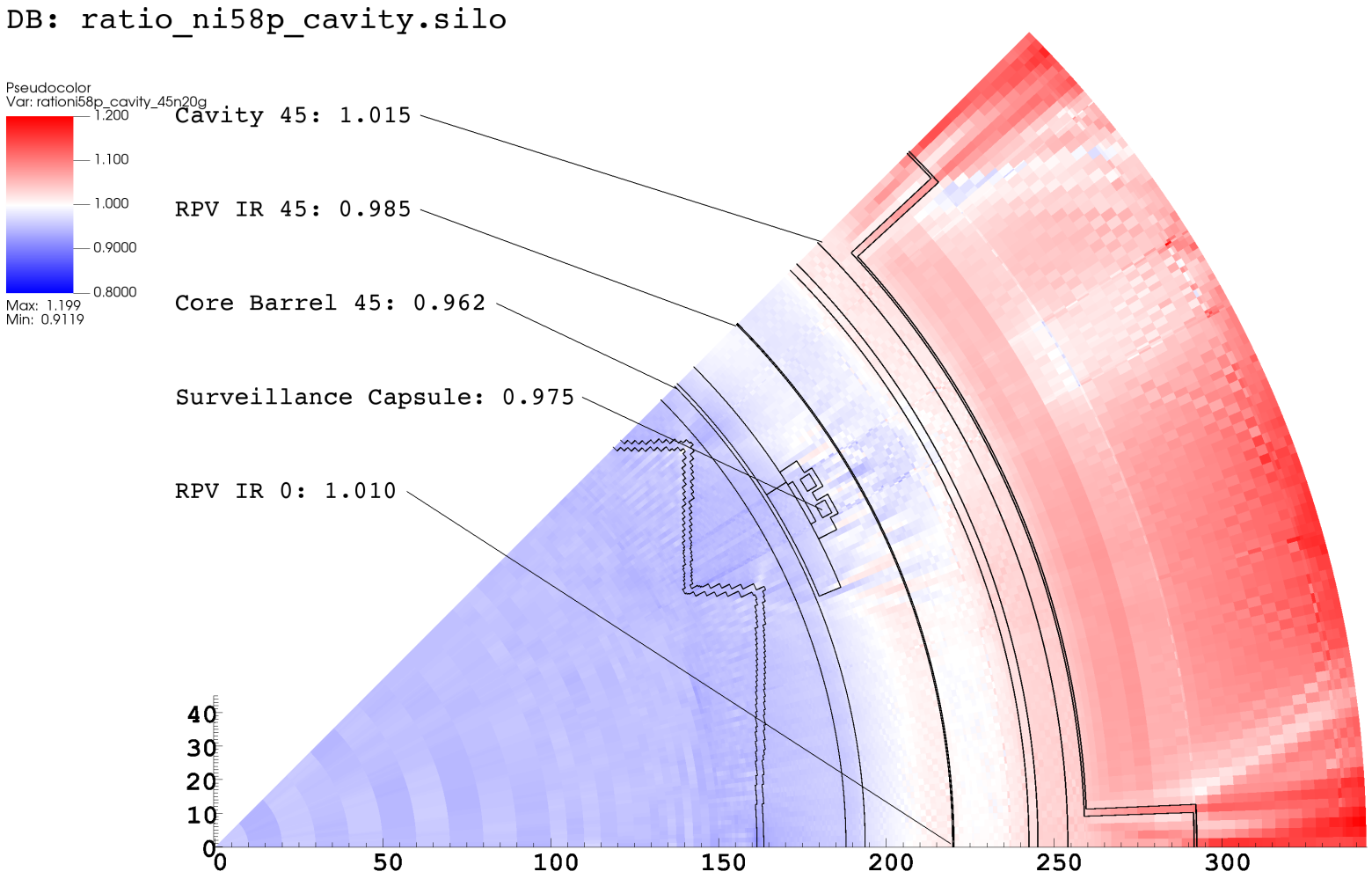
Comparisons



Comparisons



Comparisons



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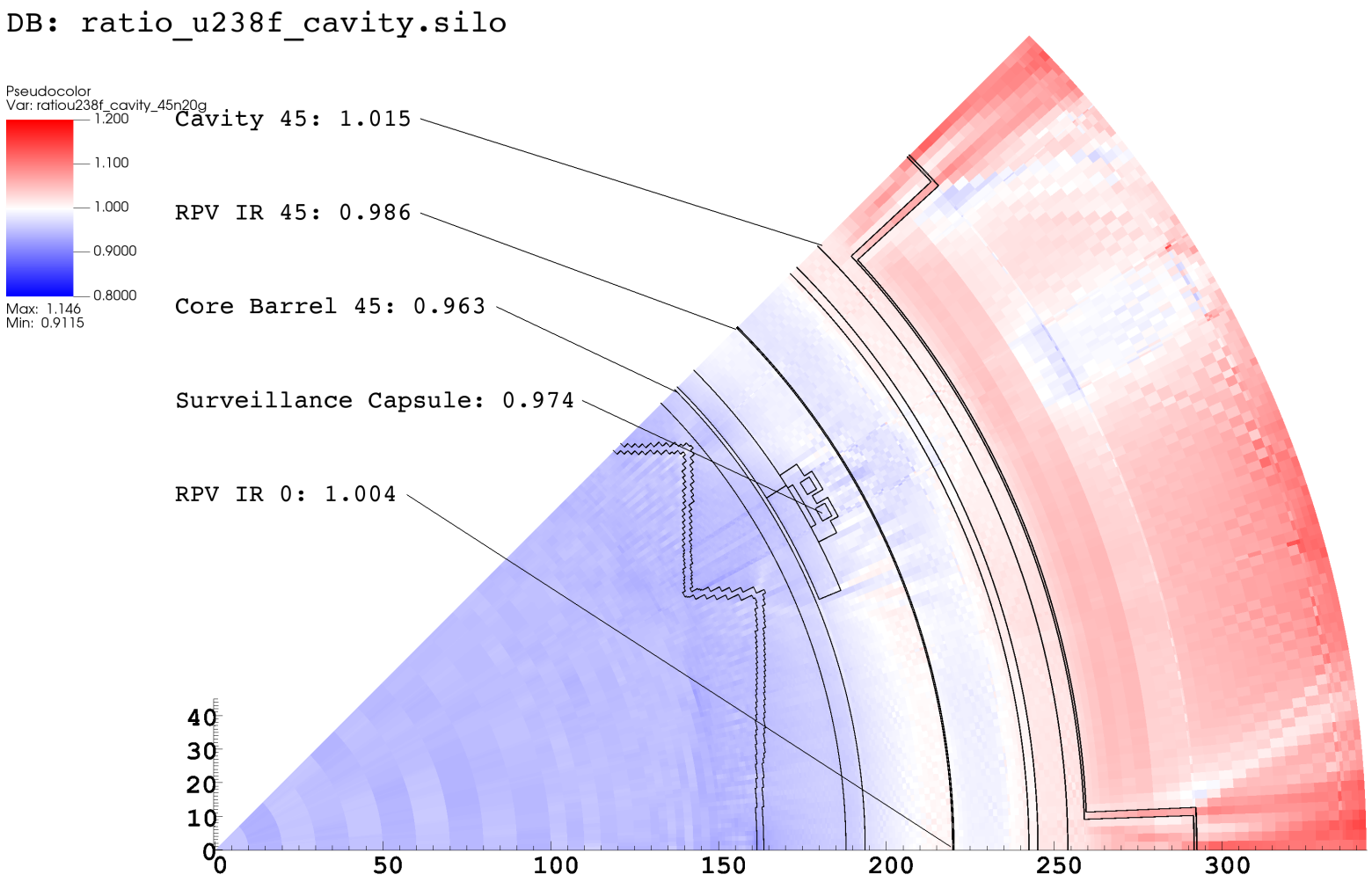

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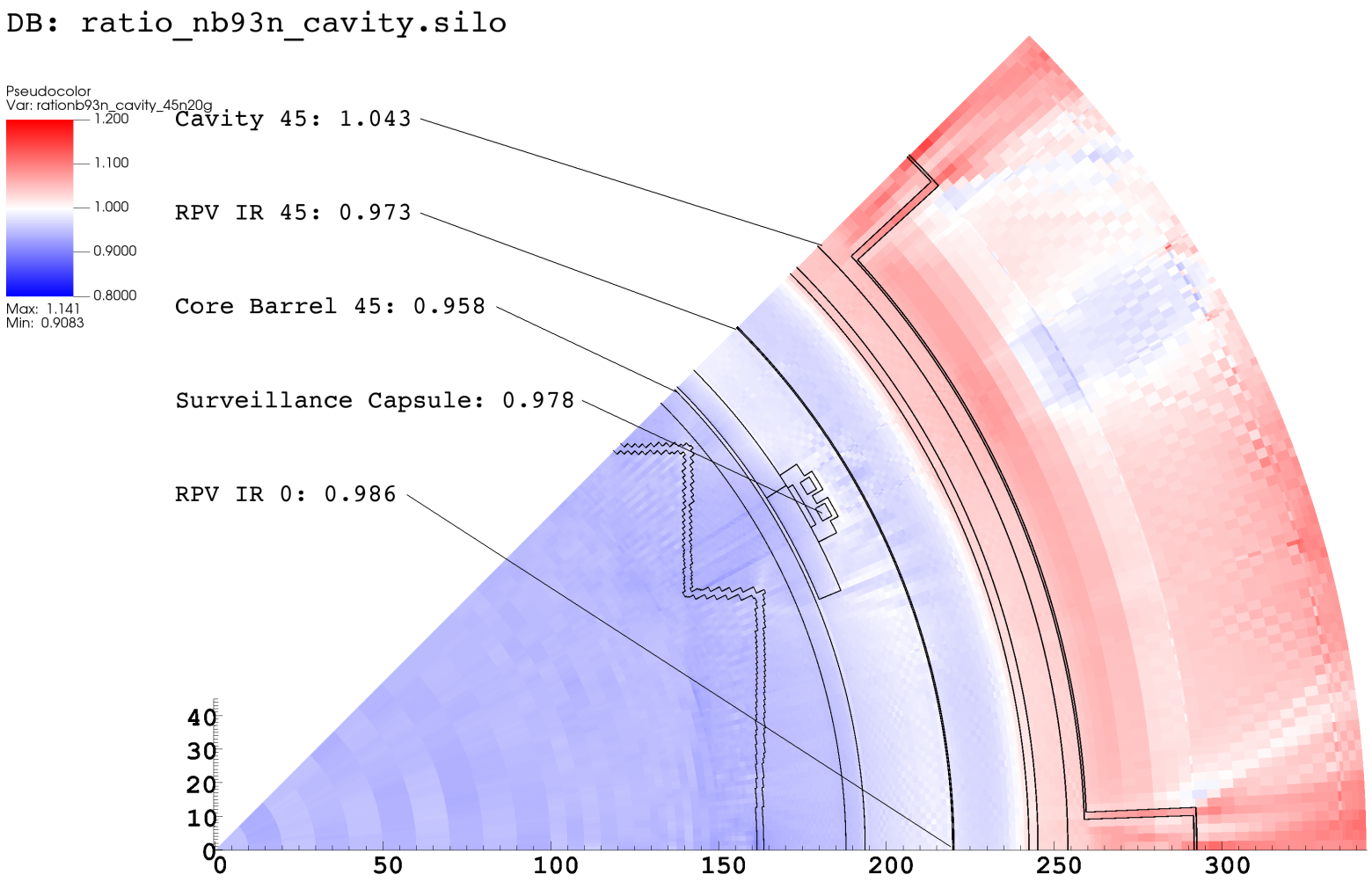

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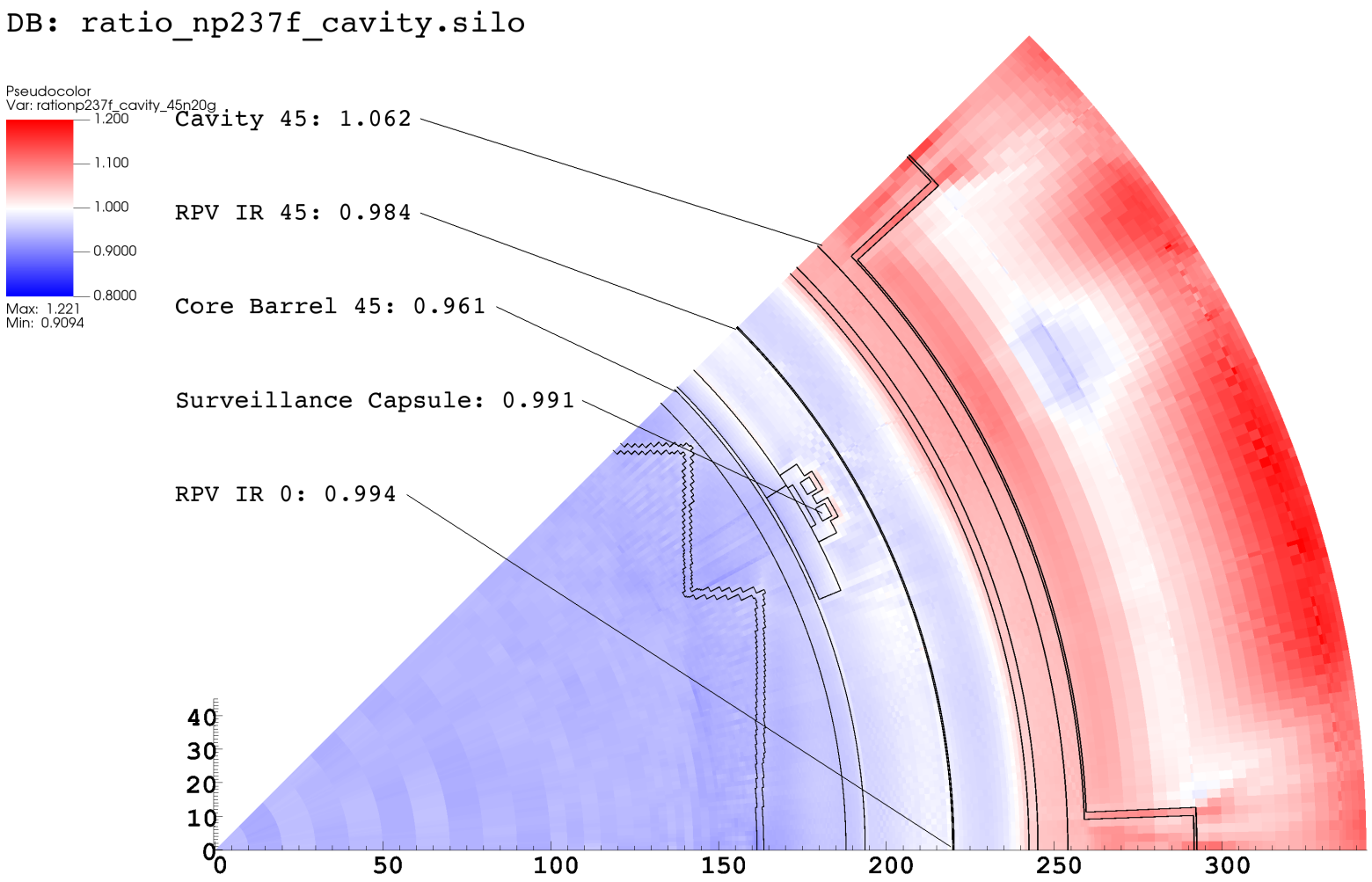
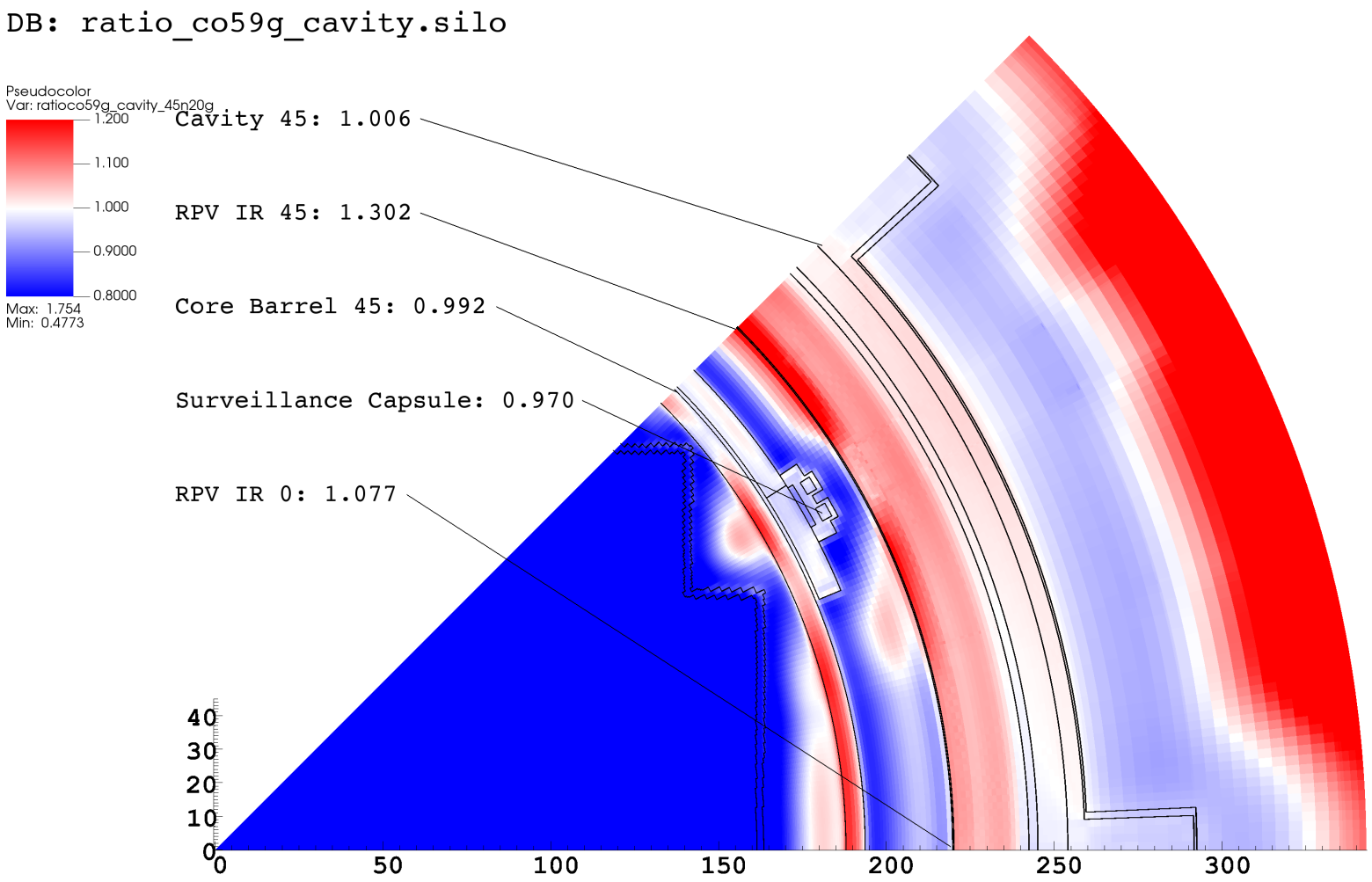


Comparisons



Measurement Database

- The Westinghouse database of ex-vessel dosimetry measurements has:

Reaction	Individual Sensor Reaction Rate			
	Average M/C	% Std Dev	Samples	Reactors
Cu-63 (n,α) Co-60	0.90	11.9	363	37
Ti-46 (n,p) Sc-46	0.93	11.0	338	36
Fe-54 (n,p) Mn-54	0.92	12.1	366	37
Ni-58 (n,p) Co-58	0.88	11.6	358	37
U-238 (n,f) FP (Cd)	0.93	11.5	146	15
Nb-93 (n,n') Nb-93m (Cd)	0.97	13.3	218	31
Np-237 (n,f) FP (Cd)	1.02	14.1	99	14
Total	0.92	12.7	1888	37

Conclusions

- In ENDF/B-VIII.1, lower energy (< 4 MeV) neutrons exhibit performance that seems consistent with current transport data.

- High energy (> 4 MeV) neutron attenuation through water with ENDF/B-VIII.1 seems to result in higher reaction rates.
  - This appears to be contrary to what we see in our database of measurement data.