

IRSN

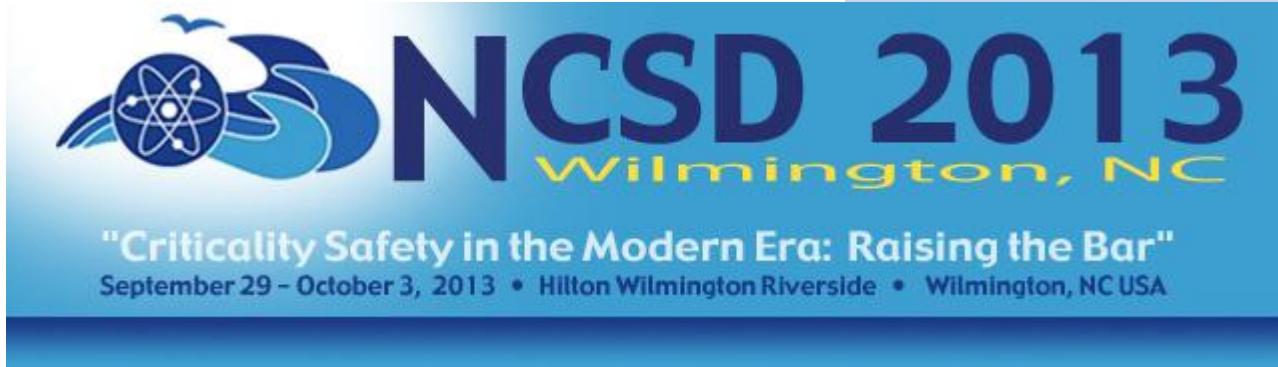
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

ON THE ASSUMPTION OF THE MAXIMUM VOID FRACTION IN BURNUP CREDIT IMPLEMENTATION FOR BWR FUEL

L. JUTIER, S. EVO, G. CAPLIN
IRSN (France)

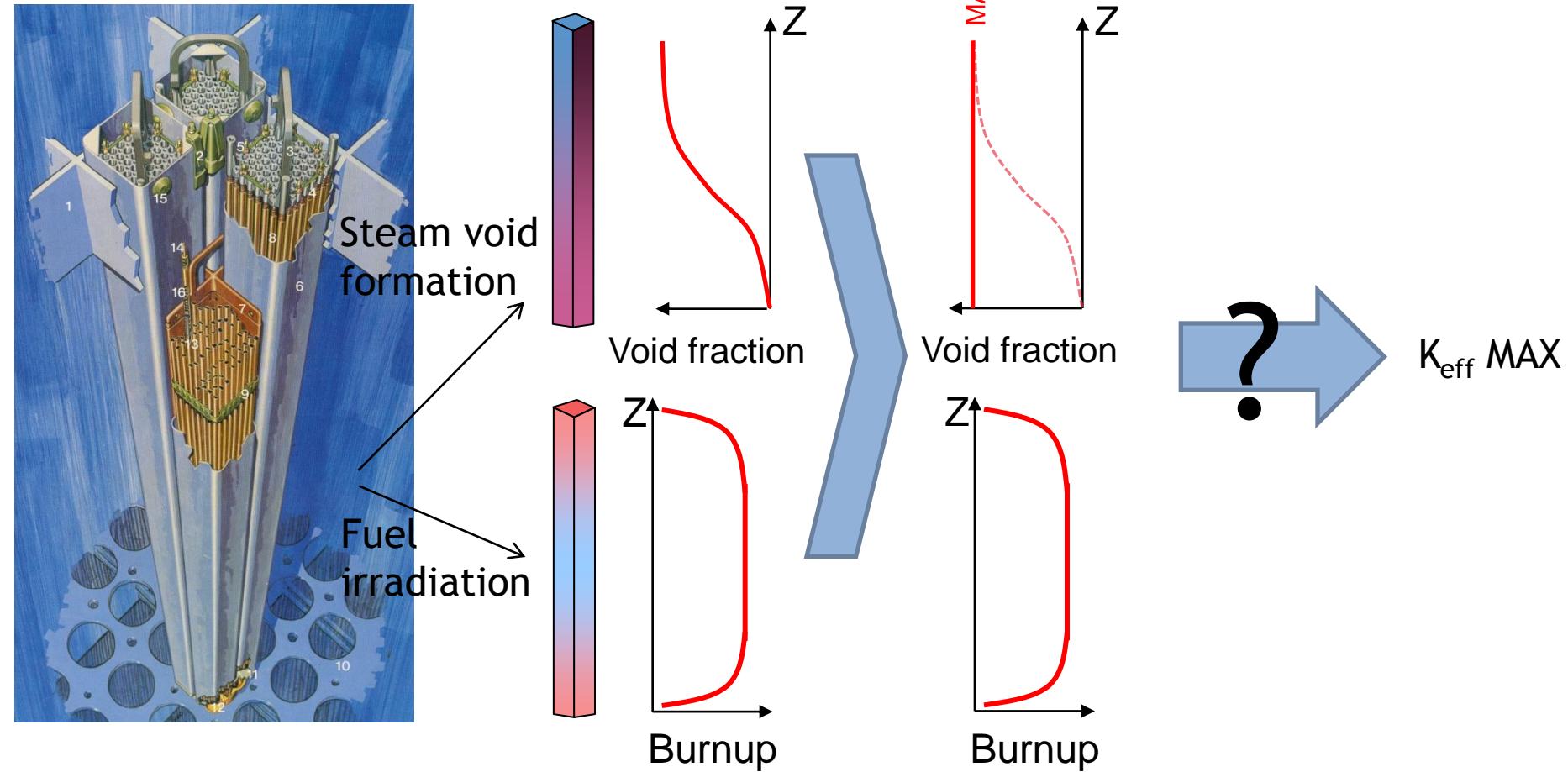
G. GRASSI
AREVA (France)



OVERVIEW

- | Introduction
- | Models
- | Calculation method
- | Depletion of gadolinium rods
- | Influence of an axial profile of the burnup and void fraction
- | Conclusion

Introduction



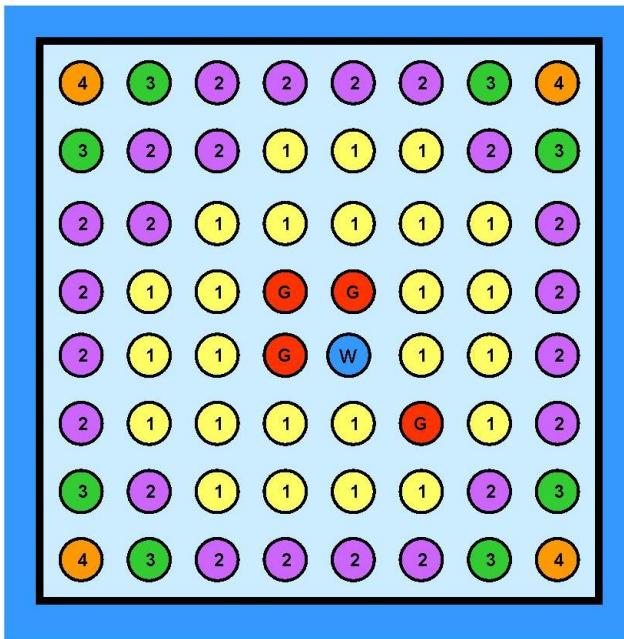
↗ Goal = improve the comprehension of the combined influences of an axial profile of the burnup and void fraction



Models

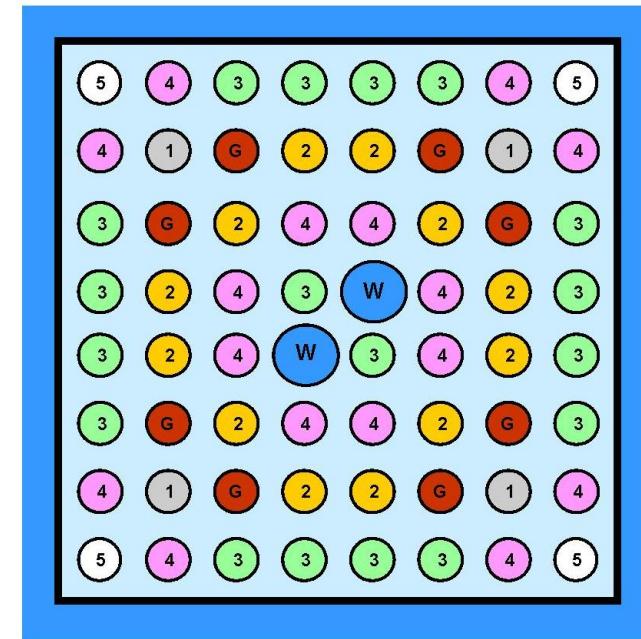
↗ Assemblies

REB2008

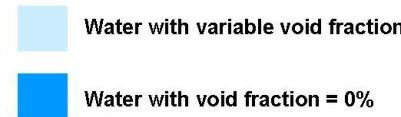


$E_{moy} = 2.43 \%$
 $E_{min} = 1.57 \%$
 $E_{max} = 2.96 \%$
 $Gd_2O_3 \rightarrow 2 \%$

REB2012

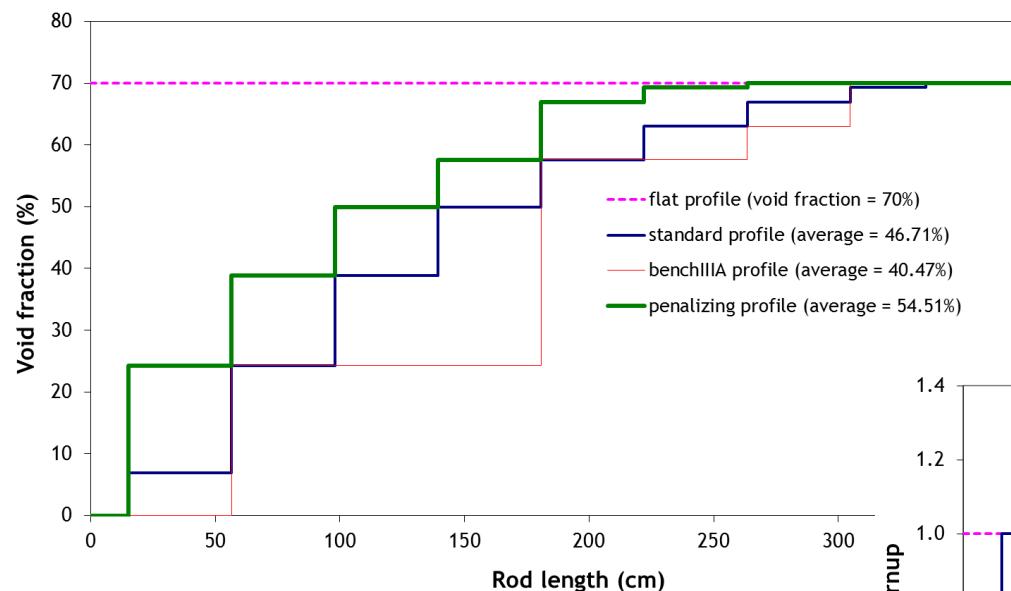


$E_{moy} = 3.31 \%$
 $E_{min} = 2.09 \%$
 $E_{max} = 3.91 \%$
 $Gd_2O_3 \rightarrow 4.5 \%$

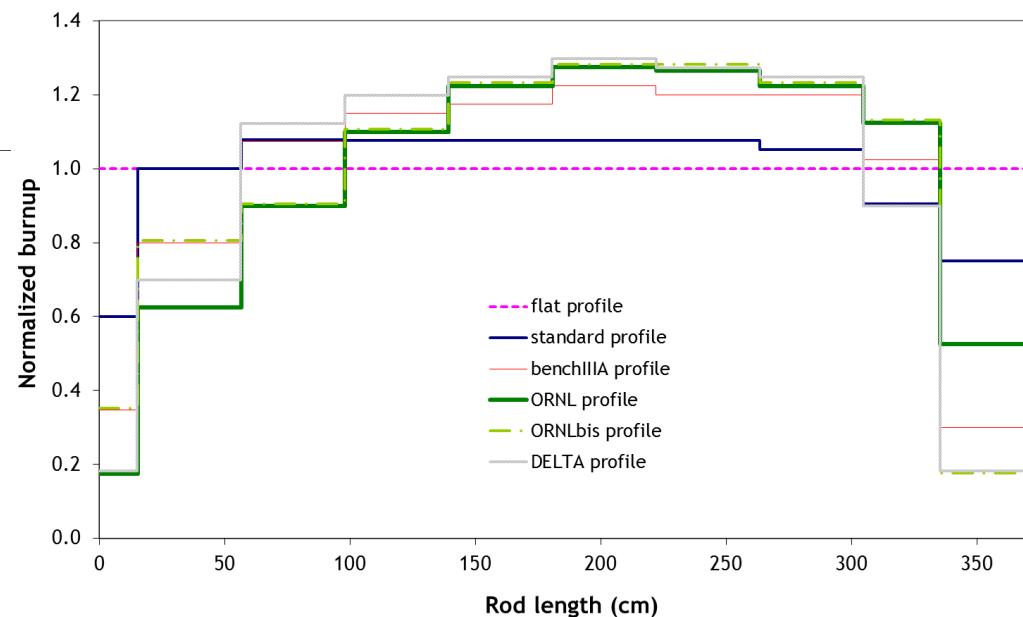


Models

↗ Axial profiles of void fraction



↗ Axial profiles of burnup



Calculation method

REB2008
REB2012

VF = 0 - 70 %
Total BU = 40 Gwd/t

↗ Depletion calculation

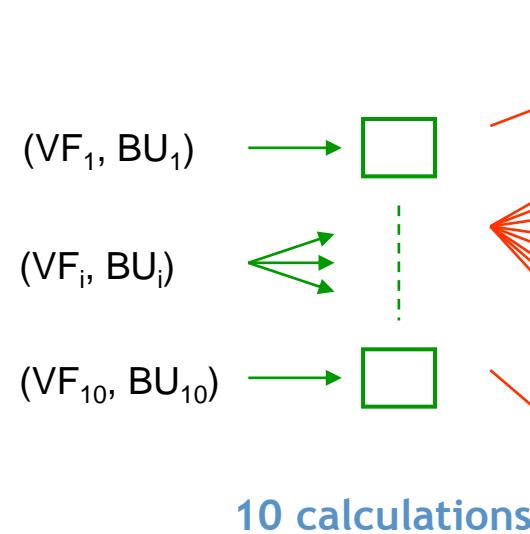
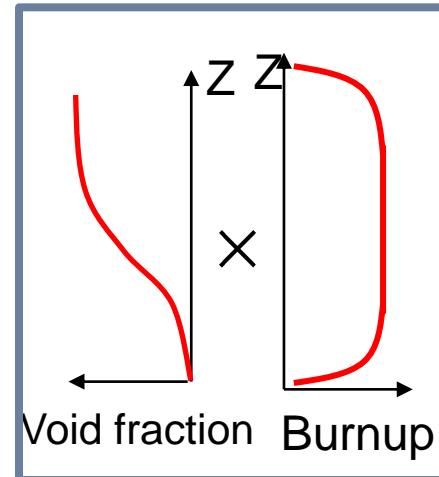


↗ Criticality calculation



Actinides (16): ^{234}U , ^{235}U , ^{236}U ,
 ^{238}U , ^{238}Pu , ^{239}Pu , ^{240}Pu , ^{241}Pu ,
 ^{242}Pu , ^{237}Np , ^{241}Am , ^{242m}Am ,
 ^{243}Am , ^{243}Cm , ^{244}Cm , ^{245}Cm

Fission products (15): ^{95}Mo , ^{99}Tc ,
 ^{101}Ru , ^{103}Rh , ^{109}Ag , ^{133}Cs , ^{143}Nd ,
 ^{145}Nd , ^{147}Sm , ^{149}Sm , ^{150}Sm ,
 ^{151}Sm , ^{152}Sm , ^{153}Eu , ^{155}Gd

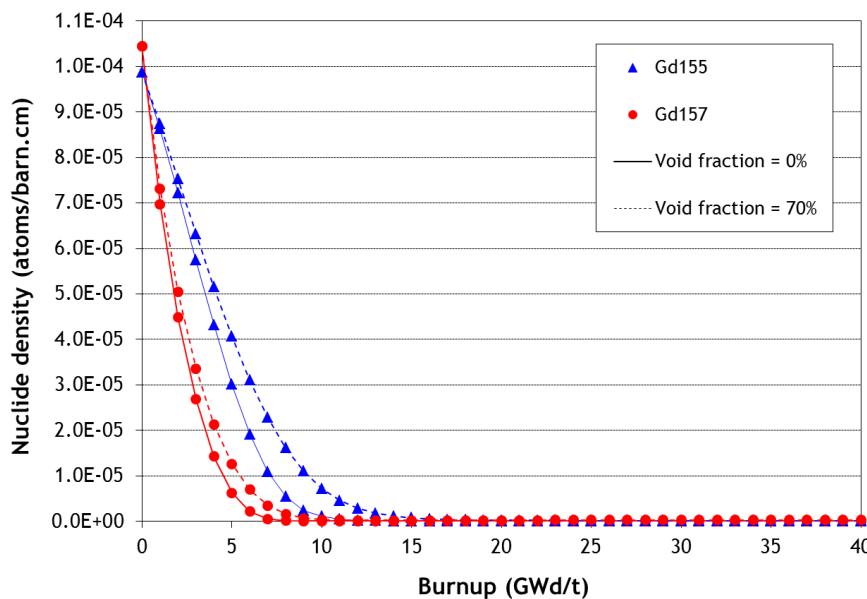


Depletion of gadolinium rods

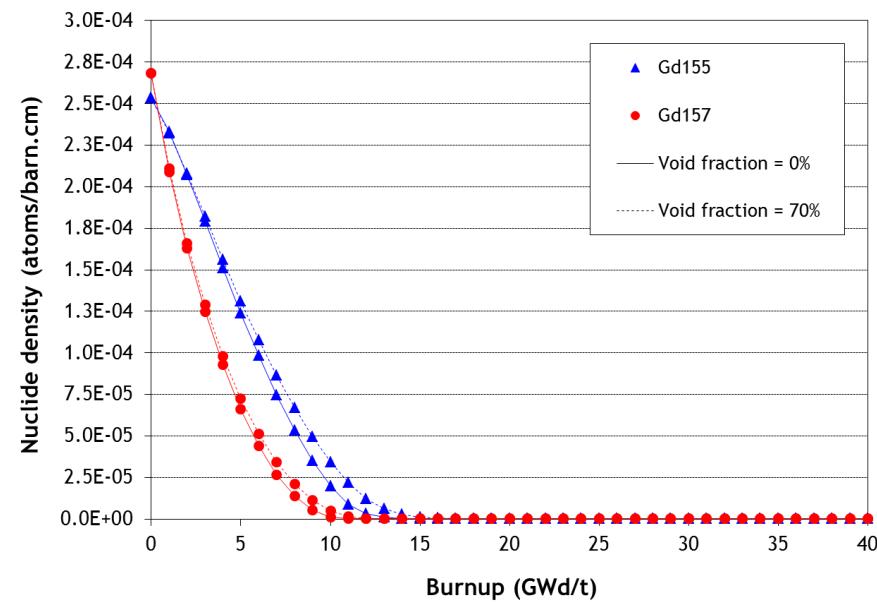
↗ Depletion of gadolinium (Gd155, Gd157) as a function of burnup and void fraction



REB2008



REB2012

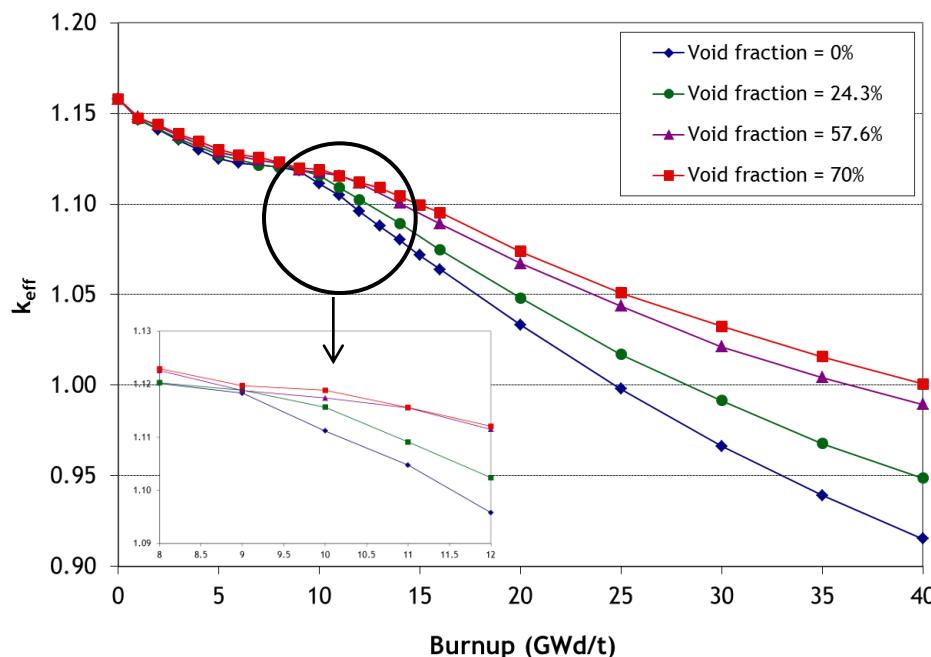


Influence of an axial profile of BU and VF

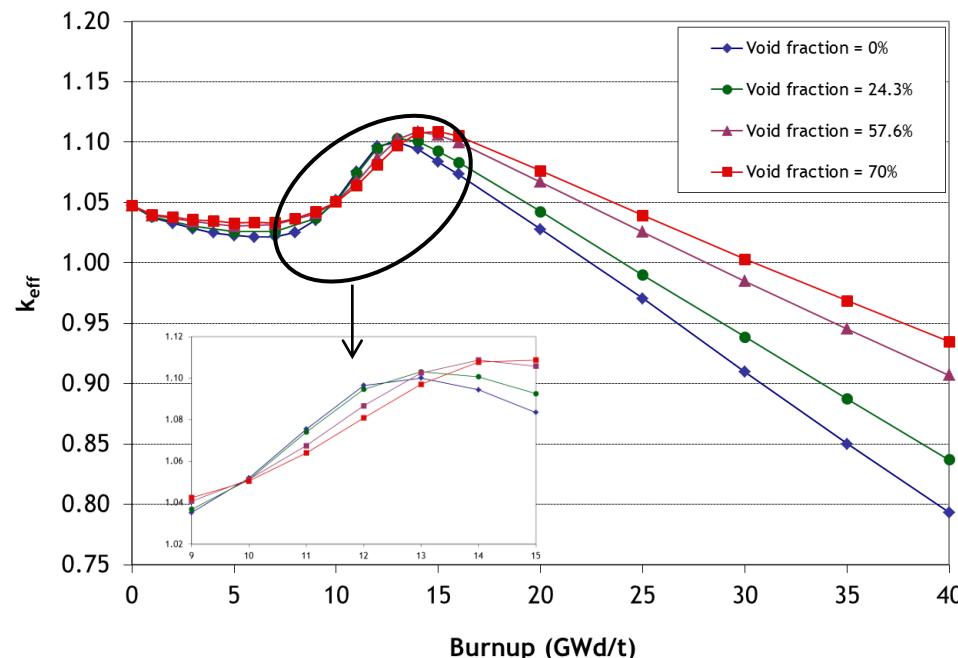
↗ Parametric study of the reactivity as a function of BU and VF



REB2008



REB2012

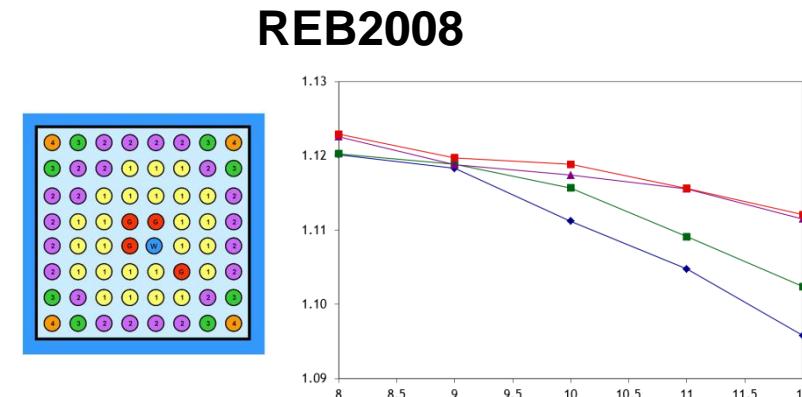


Influence of an axial profile of BU and VF

↗ Combined influence on the reactivity of axial profiles ...

$$\Delta k (\text{pcm}) = [k_{\text{eff}}(\text{VF}=70\%) - k_{\text{eff}}(\text{VF profile})] \times 10^5$$

Average BU = 40GWd/t		VF profiles		
BU profiles	flat profile	standard profile	benchIII A profile	penalizing profile
	911	1268	327	
	316	620	73	
	-76	-26	-95	
	2431	2409	2252	
	-97	-91	-109	
	33	170	53	



Average BU = 10GWd/t		VF profiles		
BU profiles	flat profile	standard profile	benchIII A profile	penalizing profile
	42	236	90	
	162	236	189	
	329	376	147	
	342	427	131	
	193	375	181	
	309	414	213	

↗ Void Fraction = MAX
↓
 $k_{\text{eff}} \underset{\forall \text{ } BU}{\text{MAX}}$

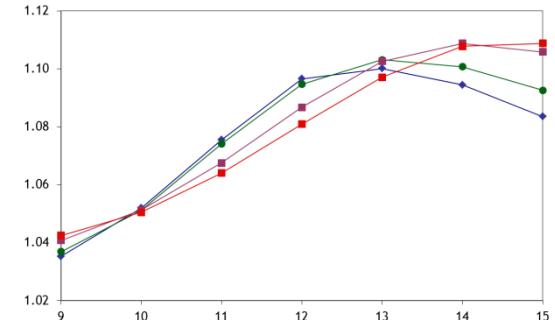
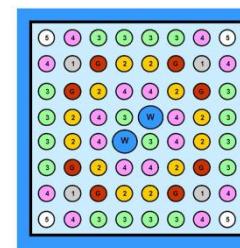
Influence of an axial profile of BU and VF

↗ Combined influence on the reactivity of axial profiles ...

$$\Delta k \text{ (pcm)} = [k_{\text{eff}}(\text{VF}=70\%) - k_{\text{eff}}(\text{VF profile})] \times 10^5$$

Average BU = 40Gwd/t		VF profiles standard profile
BU profiles	flat profile	
	benchIIIa profile	
	ORNL bis profile	
	DELTA profile	
		1487
		53
		2155
		687

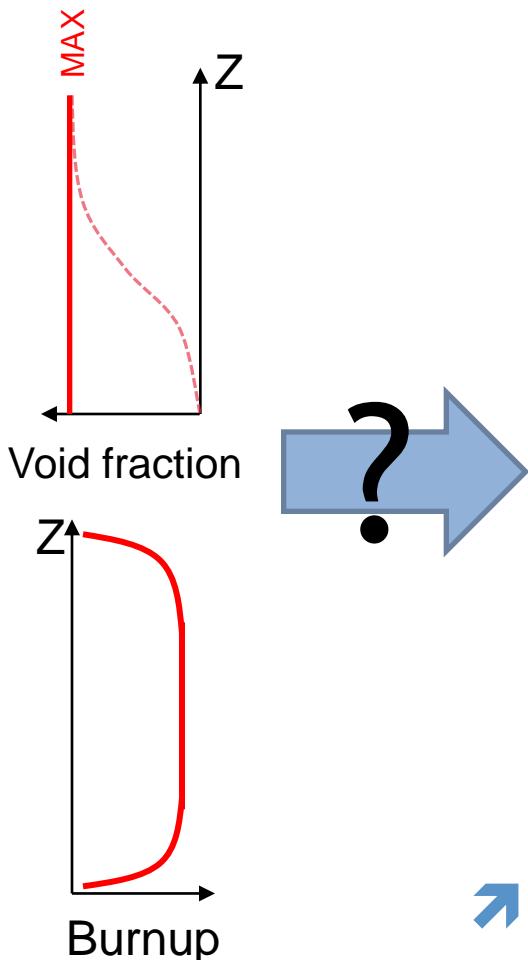
REB2012



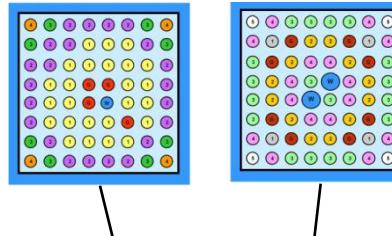
Average BU = 10Gwd/t		VF profiles standard profile
BU profiles	flat profile	
	benchIIIa profile	
	ORNL bis profile	
	DELTA profile	
		-118
		-192
		-394
		-481

↗ Void Fraction = MAX ~~MAX~~ k_{eff} MAX
when $\overline{BU} = 10 \text{ Gwd/t}$.

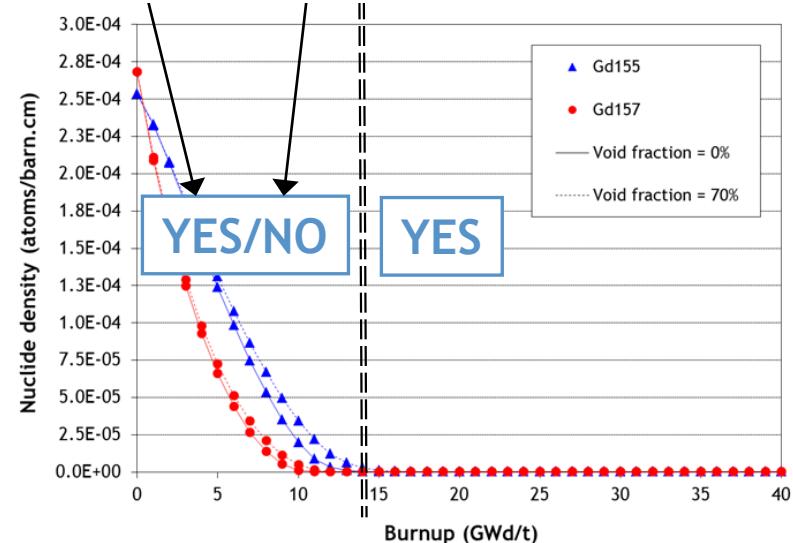
Conclusion



Not a matter of axial burnup profile
→ gadolinium rods



Differential consumption of the gadolinium according to the void fraction



↗ YES if Gd not taken into account
or if irradiation > 1 cycle