CIEMAT's MELCOR Modeling Activities during 2014

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Contents: 1. **Background & recent activities**

2. **Modeling Core**

3. **Modeling PCV**

4. **Numerical items**

1. Background and recent activities:

		LWR	SFR
M.1.8.6	In-containment source-term and thermal-hydraulics	Phebus-FP project FPT1 FPT2 tests	CP-ESFR ABCOVE tests
	Fuel degradation in the presence of air	OECD-SFP project	**ASTEC**

M.1.8.6 M.2.1	Input updating Sequence analysis	BWR (CSN) PWR (CSN) ← → **MAAP**

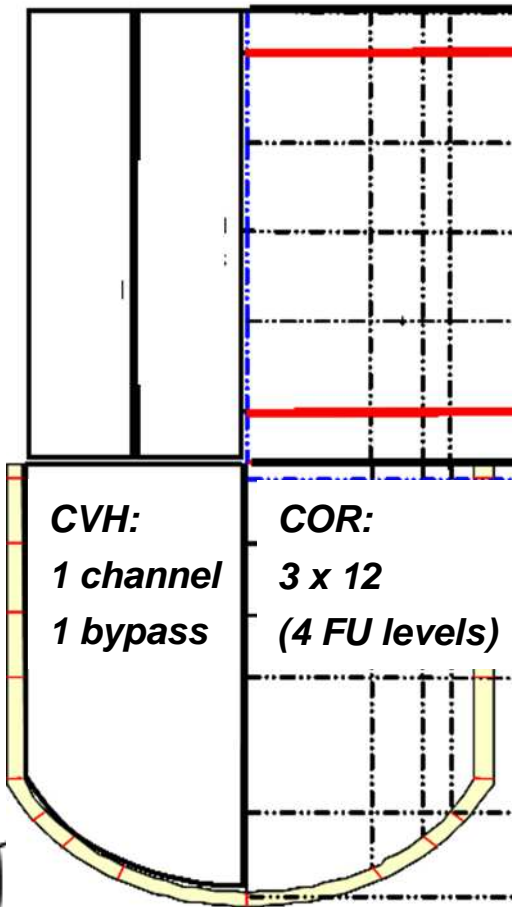| **M.2.1**	Plant modeling Sequence analysis Validation	BSAF project (CSN) 1F1; 1F2; 1F3

- Starting point: Spanish BWR NPP → **M.2.1.4803**
  - ✓ Detailed plant model
  - ✓ MELCOR Best Modeling Practices (SOARCA, NUREG/CR-7008, 2014)

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2. CORE modeling: OECD-BSAF project (CSN)

MELCOR 1.8.4.

MELCOR 2.1.4803

1F1
1F2
1F3

	CORE & LP	RPV
COR	53	-
CVs	33	5
FLs	40	6

CVH:
1 channel
1 bypass

COR:
3 x 12
(4 FU levels)

CVH:
28 channel
4 bypass

COR:
4 x 13
(7 FU levels)
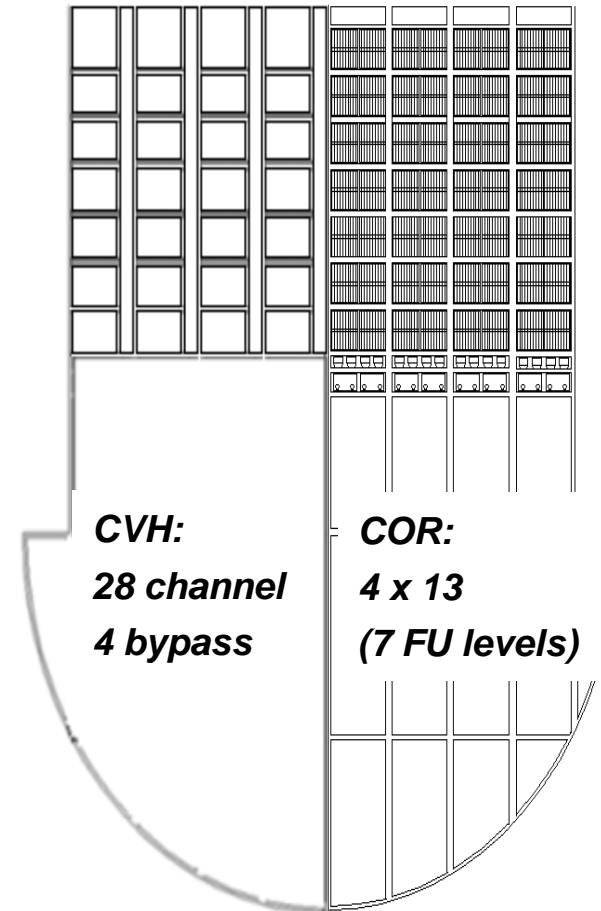
2. CORE modeling: BWR

MELCOR 2.1.4803

Parametric Analyses:

I.   **Eutectic effect**

II.   **Fuel rod damage effect**

III. **Horizontal flow effect**

IV. **Channels effect**

CVH:
28 channel
4 bypass

COR:
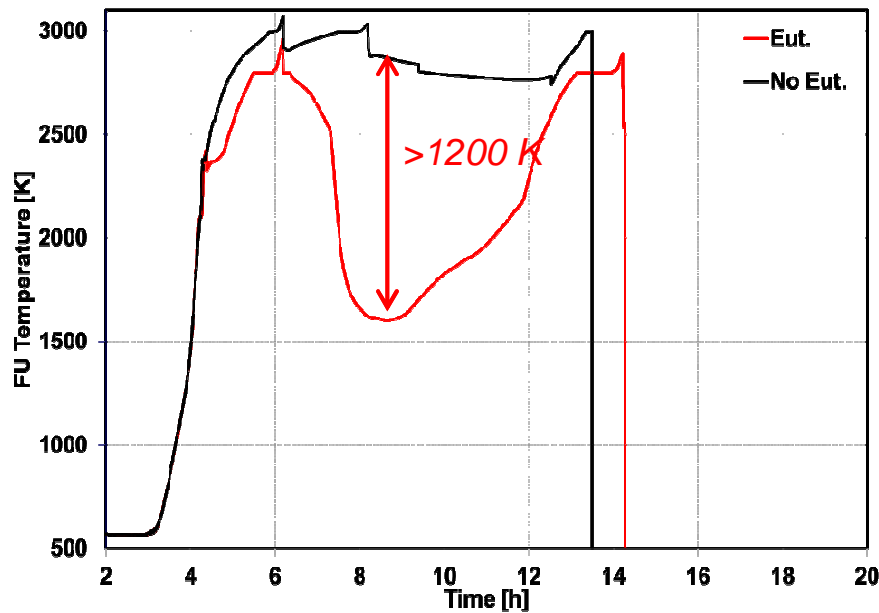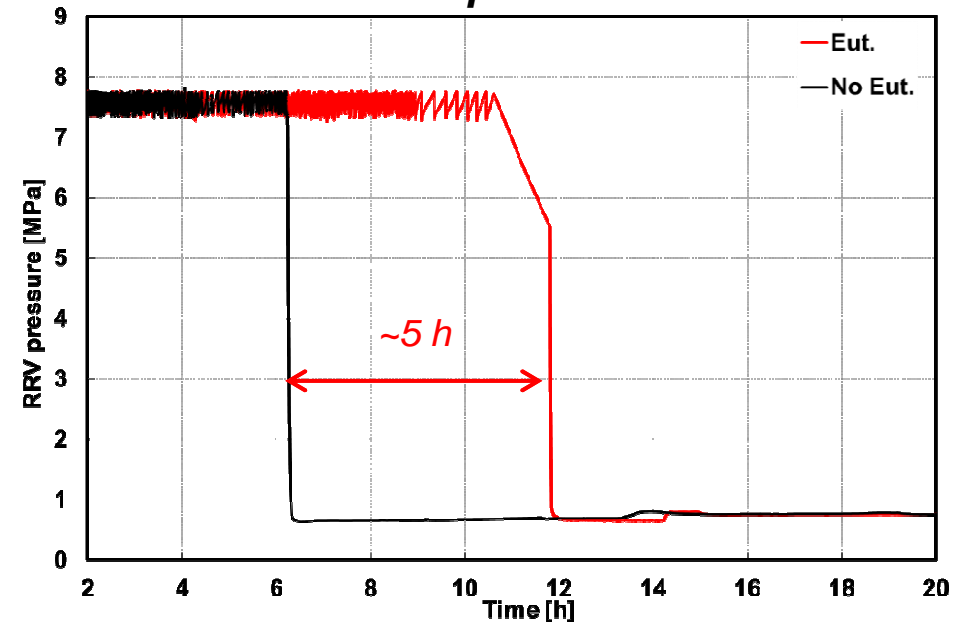*4 x 13*
(7 FU levels)
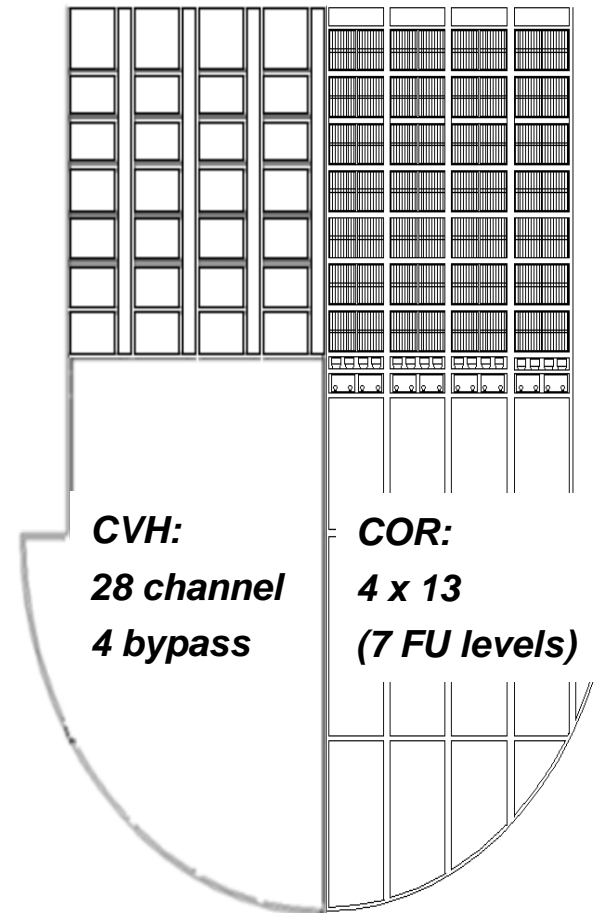
I. Eutectic effect

No eutectic model → Parametric model: new materials UO$_2$-INT, ZrO$_2$-INT & B$_4$C-INT
(↓ melting point)

Maximum fuel temperature

RPV pressure

- *Lower maximum temperature*
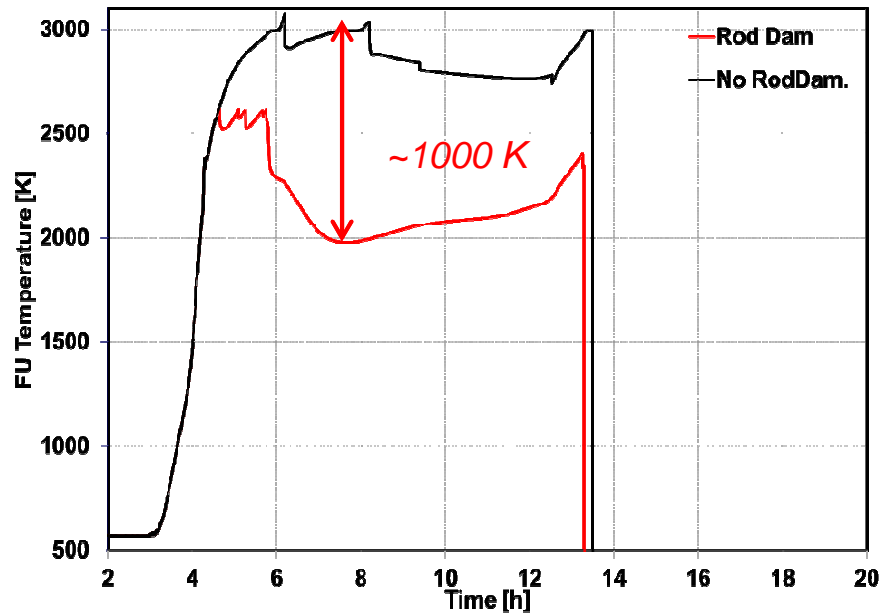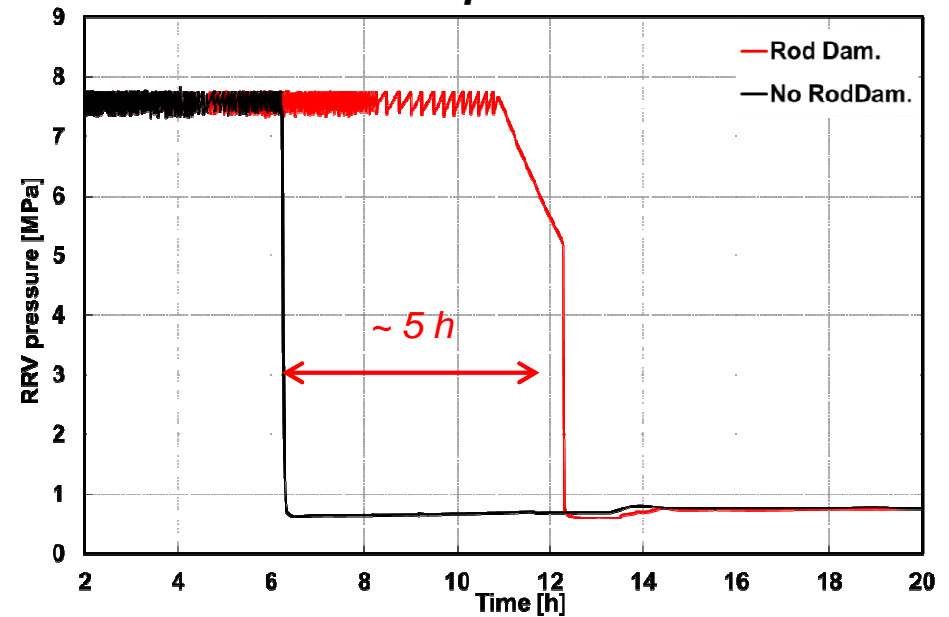- *Delayed RPV breach*

II. Fuel Rod damage effect

MELCOR BPG SOARCA, 2014→ Thermal-mechanical weakening of the fuel rod
(COR_ROD, TF)

Maximum fuel temperature

RPV pressure
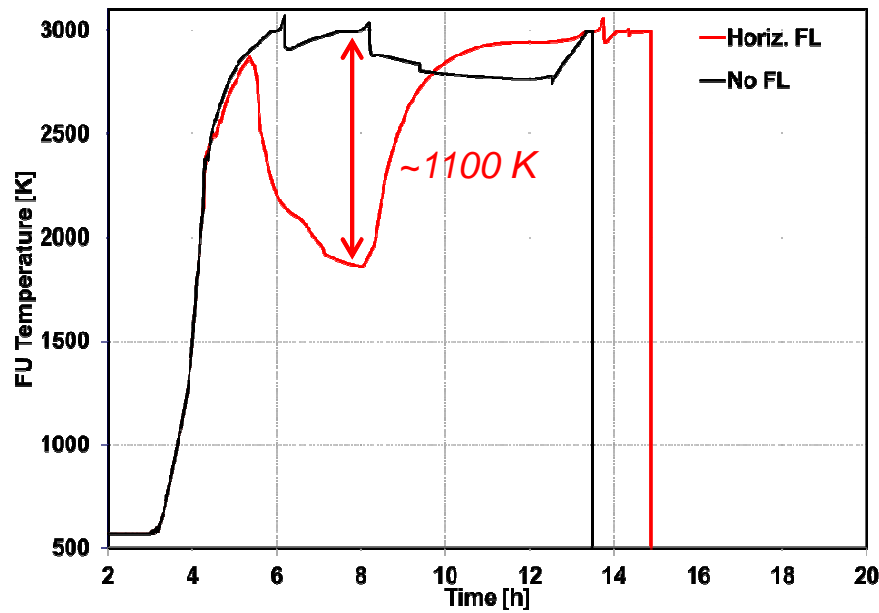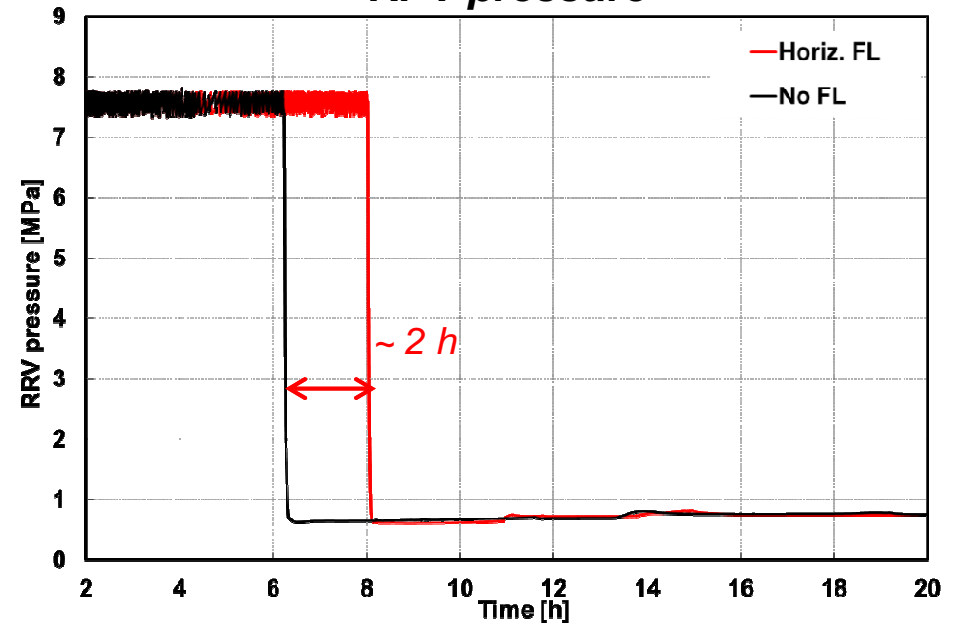

- *Lower maximum temperature*
- *Delayed RPV breach*

III. Horizontal Flow effect

Channel – Bypass connection by the channel box failure   (FL_BLK channel-box)
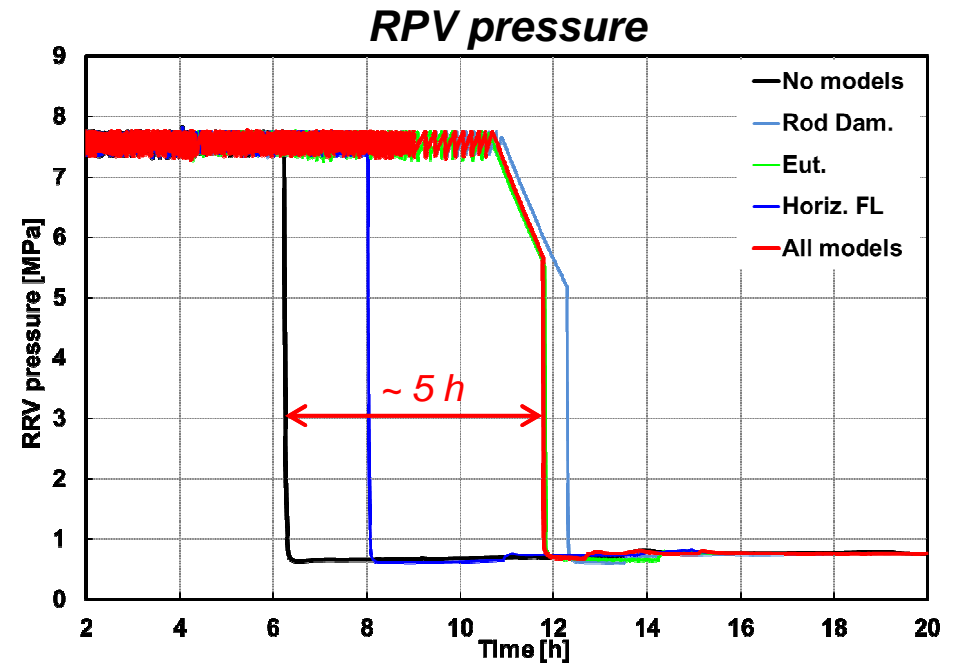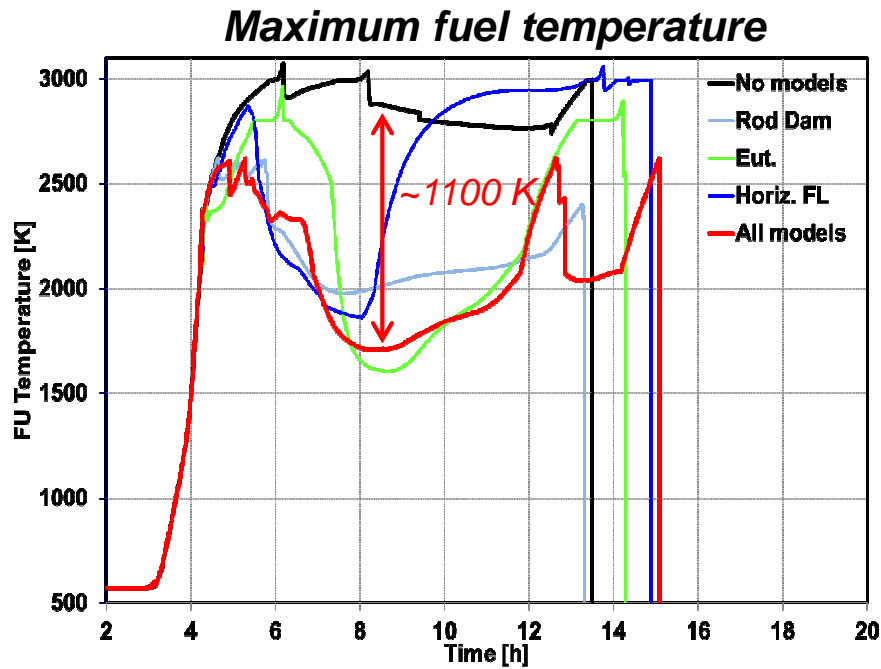
Maximum fuel temperature

~1100 K

Horiz. FL
No FL

RPV pressure

~ 2 h

Horiz. FL
No FL

- *Lower temperature*
- *Delayed RPV breach*

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→ *Cumulative effect*

Maximum fuel temperature

RPV pressure

- *No cumulative effect*
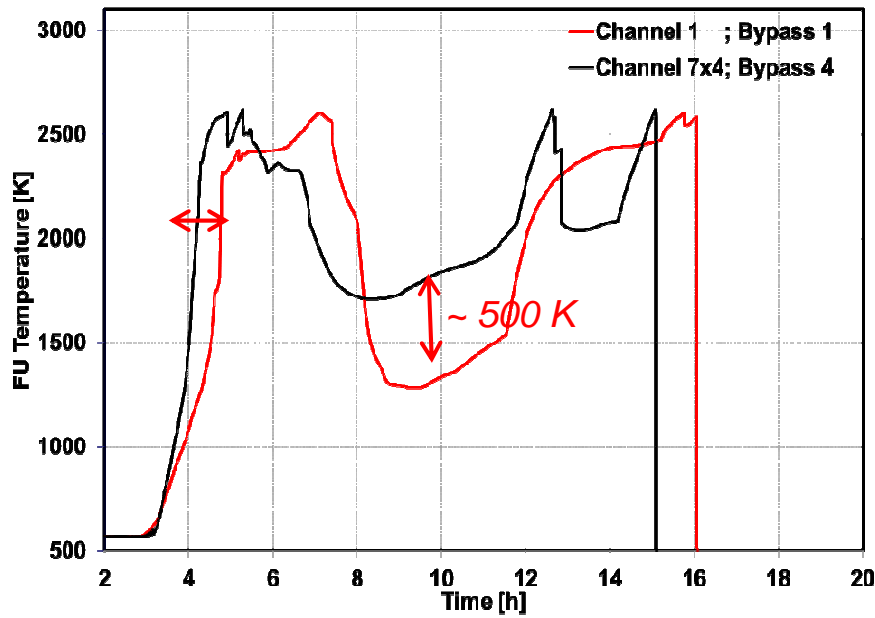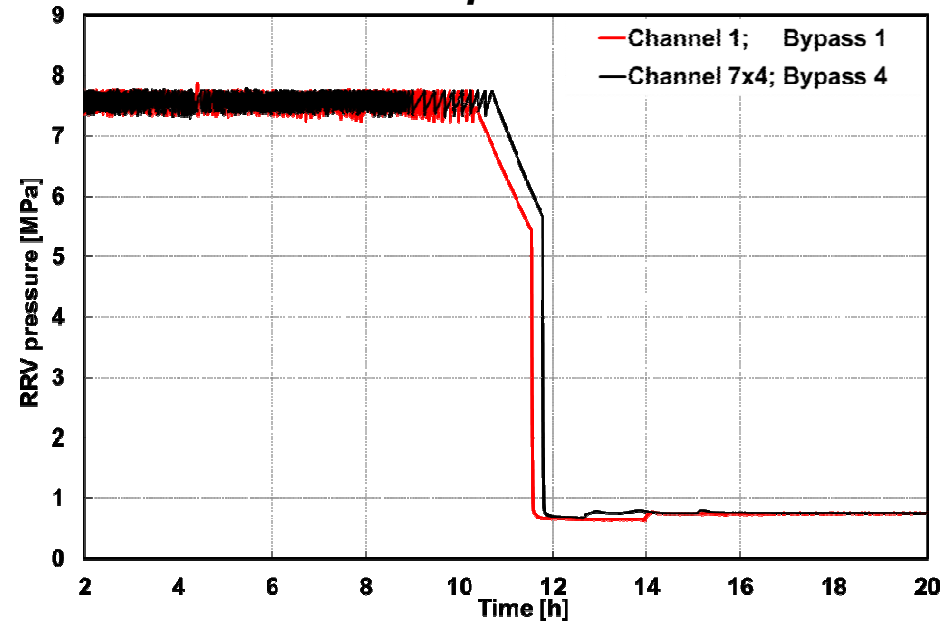- *Local differences in fuel degradation*

IV. Channel's effect

Increasing detail in hydrodynamic core description
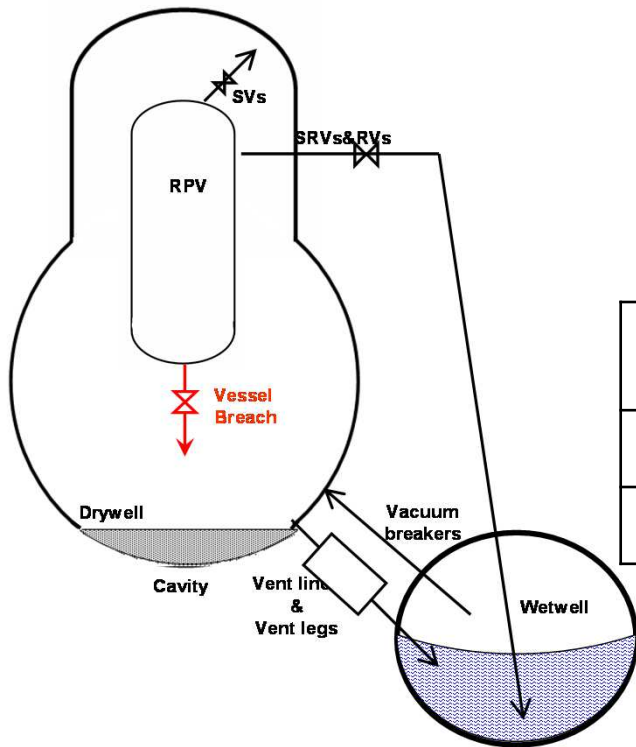
Maximum fuel temperature

RPV pressure

- Similar behavior
- Delayed temperature profile
- No effect on RPV breach

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3. PCV modeling: OECD-BSAF project (CSN)

Single-CV approach

Multiple-CV approach

1F1
1F2
1F3

	DW	WW	Vents
CVs	9	8	8
FLs	16	8	8

DW

WW

Modeling cavity

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Modeling Cavity

- CAV 1: In-pedestal

- CAV 2: Out-pedestal

- Material transfer: → CF

  $h_{cav1} > 10$ cm $+ h_{cav2};$ $T \geq 1650$ K $\Rightarrow X = 1.0$

  $T \leq 1360$ K $\Rightarrow X = 0.0$

- Melt spreading velocity (Cav 2):

  0.22 cm/s

- Liner failure:

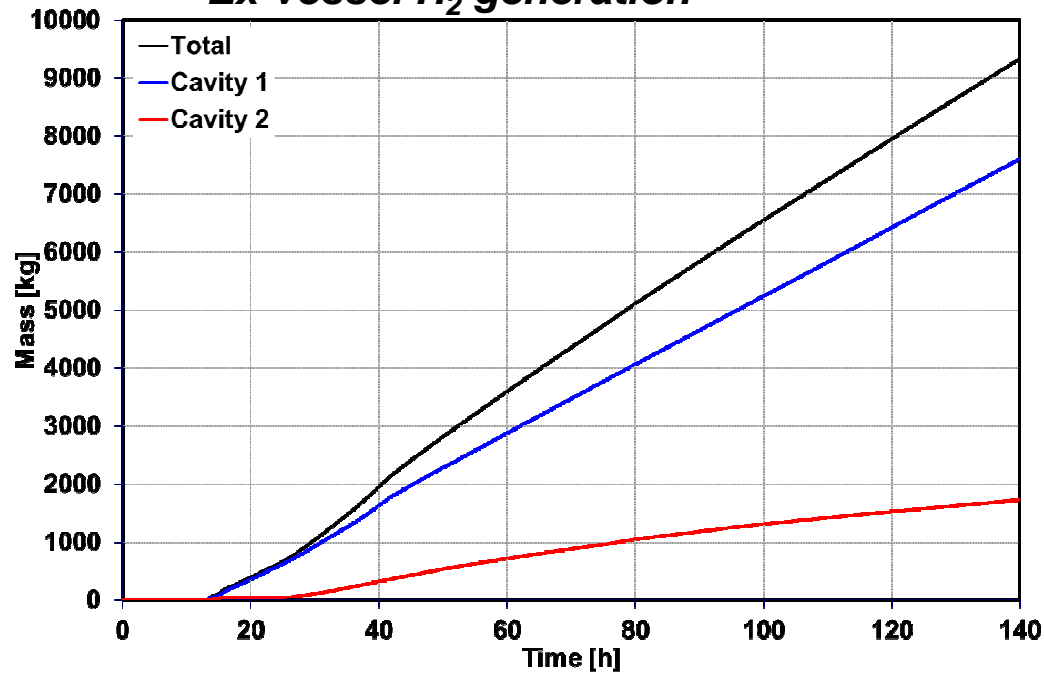 $T > 1810$ K $t \geq 5$ min
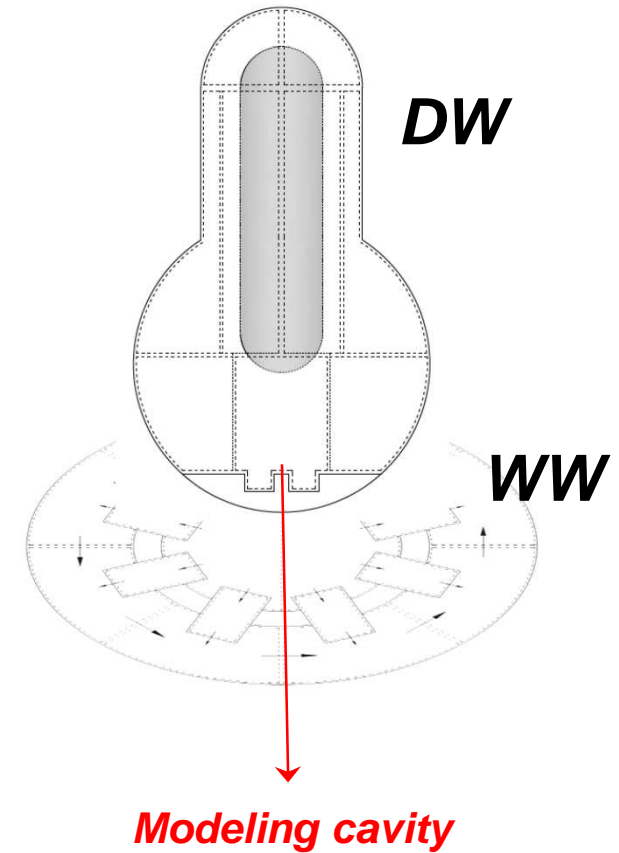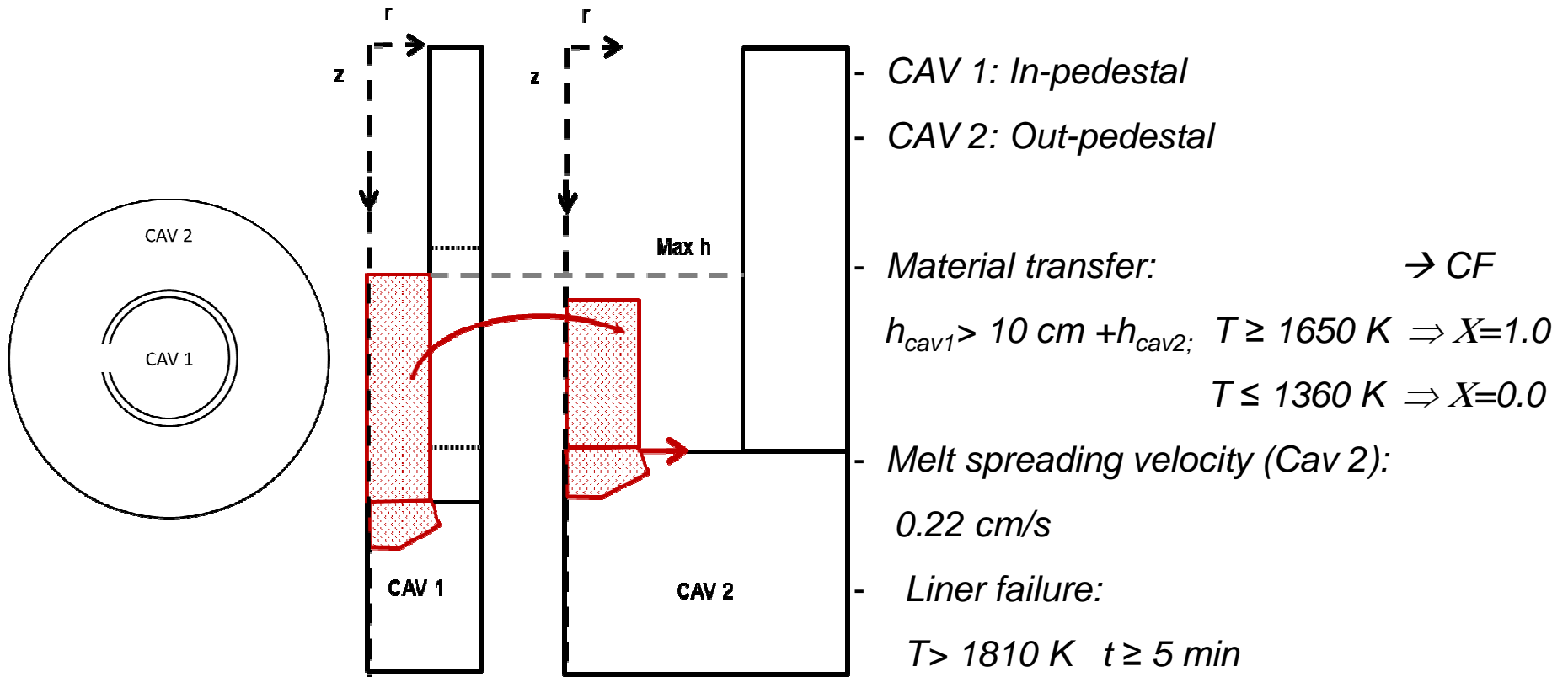
(BPG SOARCA, 2014)

Modeling Cavity

Ex-vessel H$_2$ generation

~ 9.5 ton H$_2$

Source from RPV:

- Available metal:

Zr (13 ton) + SS (23.7 ton)

→ *1.5 ton of H$_2$*

Source from Concrete:

- No re-bar
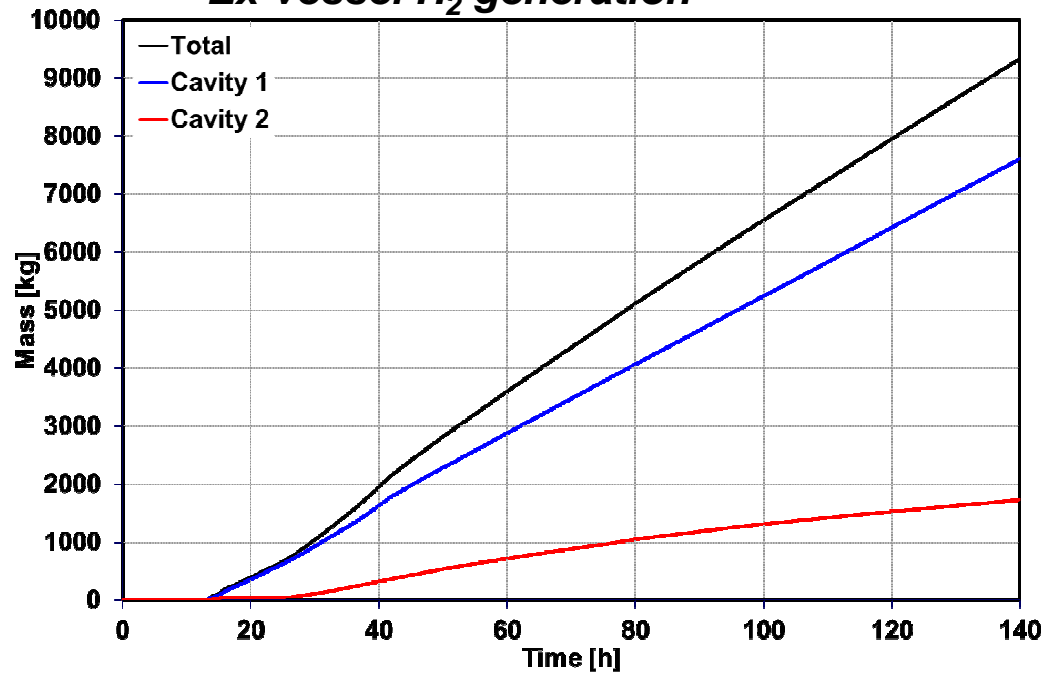
- Reduction concrete oxides
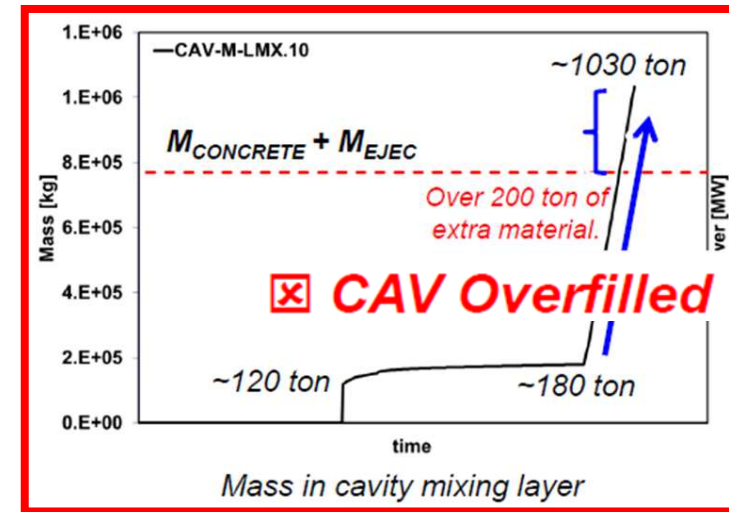
→ *2.5 ton of H$_2$*

→ *Source for 5.5 ton of H$_2$?*

Modeling Cavity

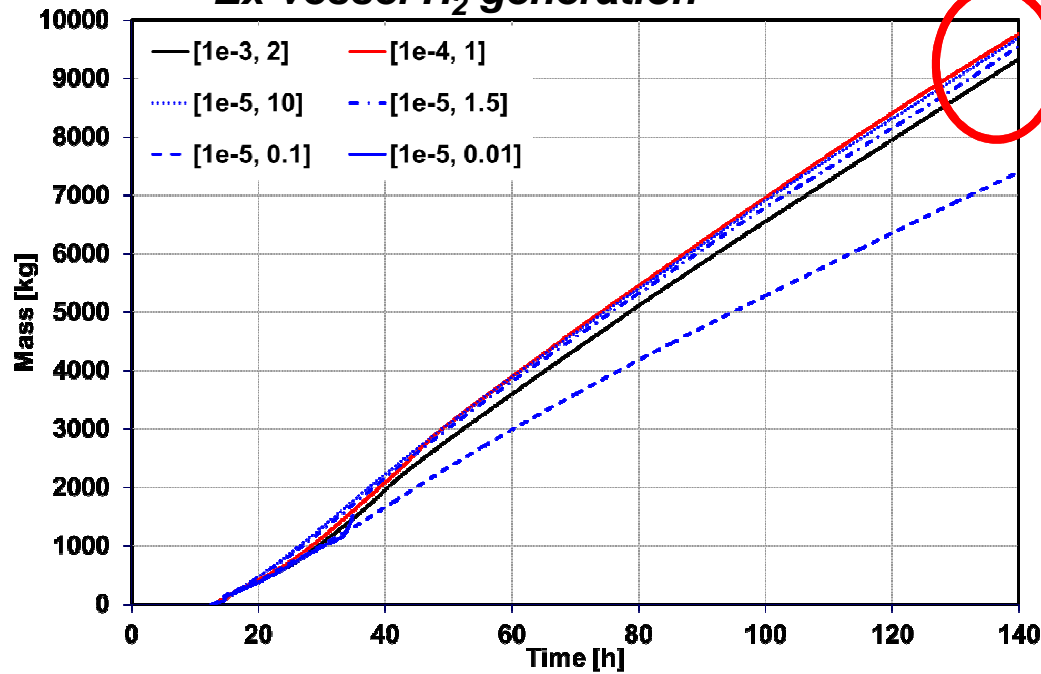### Ex-vessel H₂ generation

→ **Extra material into cavity?**

EMUG, 2014:

Mass in cavity mixing layer

→ *Source for 5.5 ton of H₂?*

Modeling Cavity

Ex-vessel H₂ generation

9886 kg ± 307 kg H₂

Legend:
- [1e-3, 2]
- [1e-4, 1]
- [1e-5, 10]
- [1e-5, 1.5]
- [1e-5, 0.1]
- [1e-5, 0.01]

Step time (s):

t_{min}	10^{-3}	10^{-4}	10^{-5}
t_{max}	2	1	10
			1.5
			0.1
			0.01

→ *Numerical error?*

4. Numerical items: Time interval definition

Maximum fuel temperature
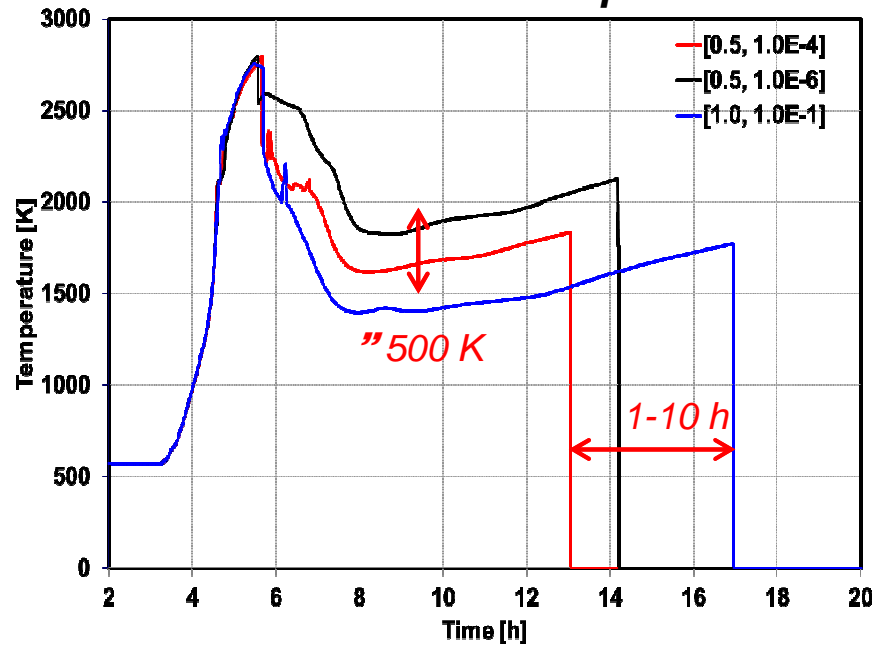
PCV pressure
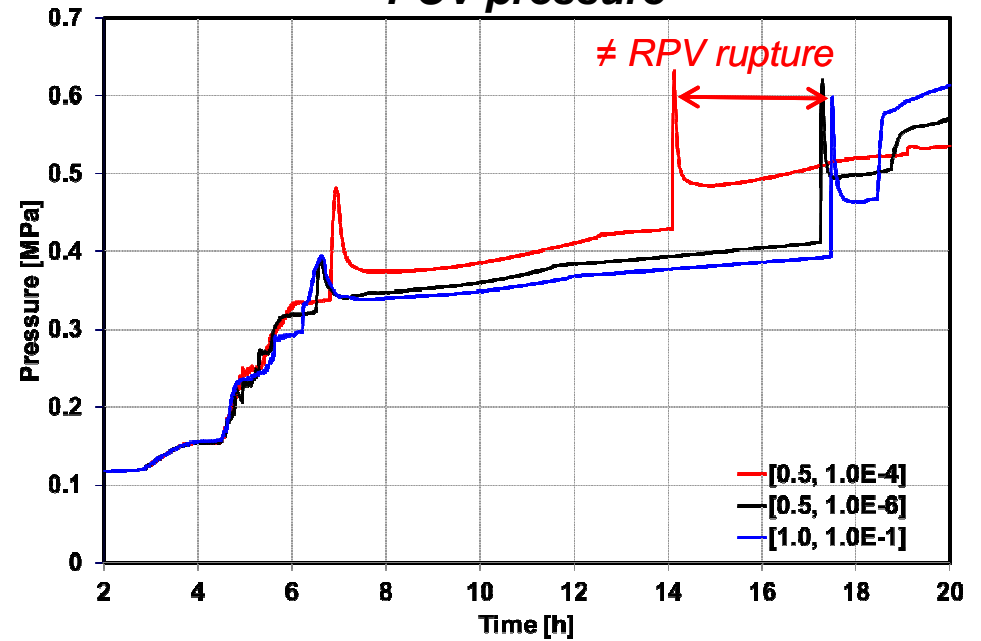
Thank you all for your attention!

Thank you SNL for your support!