OVERVIEW OF MELCOR ACTIVITIES IN CIEMAT (2011)

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Scenarios Addressed

- **Plant analysis.**

  BWR3 (Spanish CSN) → MELCOR 1.8.6 YV 3084

- **Fuel degradation in the presence of air.**

  SFP (OECD-SFP project) → MELCOR 1.8.6 YV 3084 SFP

- **Containment thermal-hydraulic and aerosol behavior.**

  SFR (CP-ESFR project) → MELCOR 1.8.6 YV 3084

  LWR (Phebus-FP project) → MELCOR 1.8.6 YV 3084

Inputs updating

- Plant analysis BWR

184 ✓ → *185* ✓**COR** ✓**Converter** → *186* ✘ **On it** → *2.1* ✘ **SNAP**

- SFR-ABCOVE

186 ✓ → *2.1.1576*

- Phebus FPT3

✓ **SNAP running**
✘ **SNAP post pro**

Further work and final remarks

- OECD-SFP project: extension to PWR fuel assemblies
- Phebus-FPT3 Benchmark (Sarnet 2)
- Extension of validation against SFR available data (source term)

- Analysis of SGTR scenarios

✓ *Stress the need of a SNAP course, not easy to handle*

THANK YOU FOR YOUR ATTENTION

Inputs updating:

v2.1.1576

(Unoptimized)

Melgen OK!
ERROR-melcor

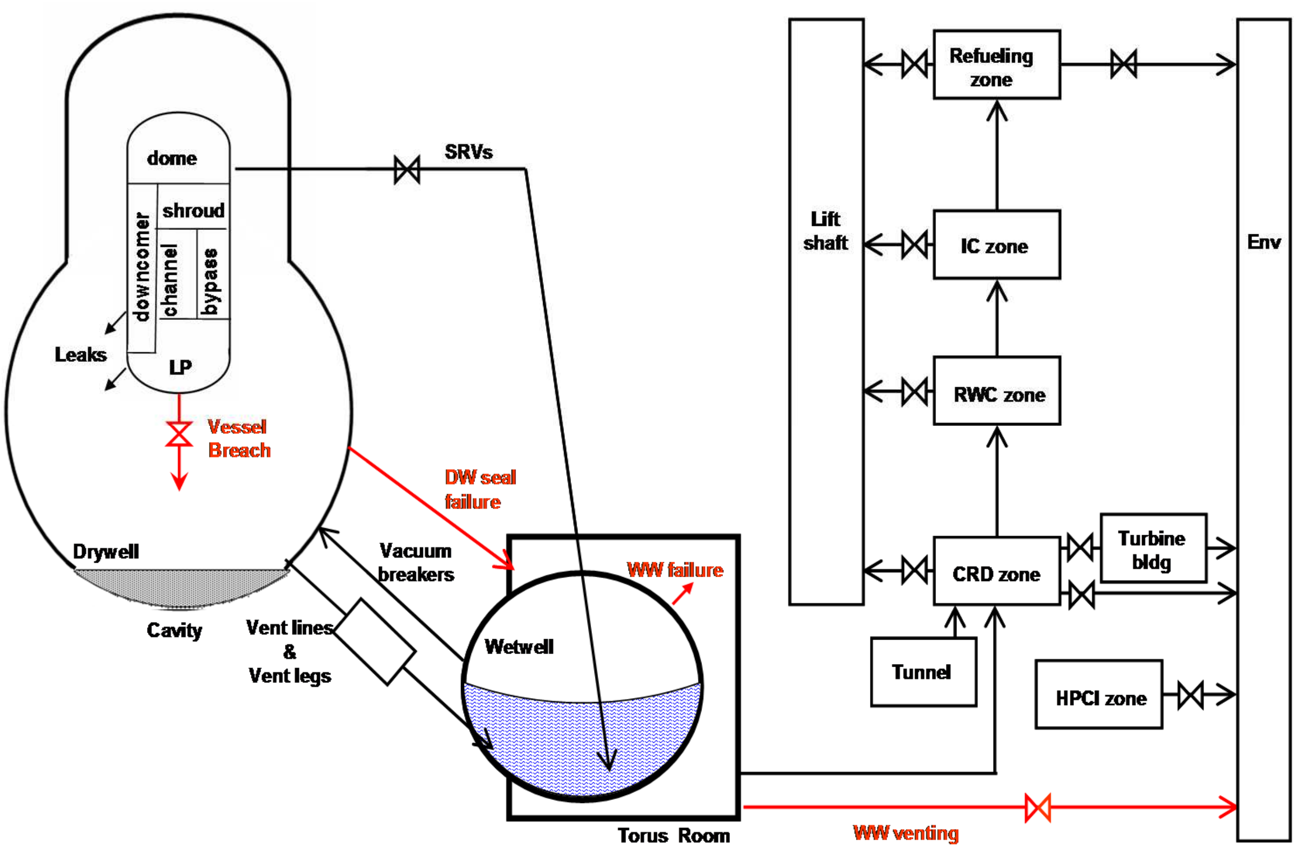
<Diagnostic Message> Time= 3.6644E+04 Dt= 9.4609E-01 Cycle= 36593 (CVH)
Attempted cycle advancement was unsuccessful - DT reduced to = 4.4202E-01

v2.1.4206

ERROR-melgen

WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Diagnostics during input processing TF package:
NO errors during input processing TF package
WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Diagnostics during input processing COR package:

1. BWR3-Mark I



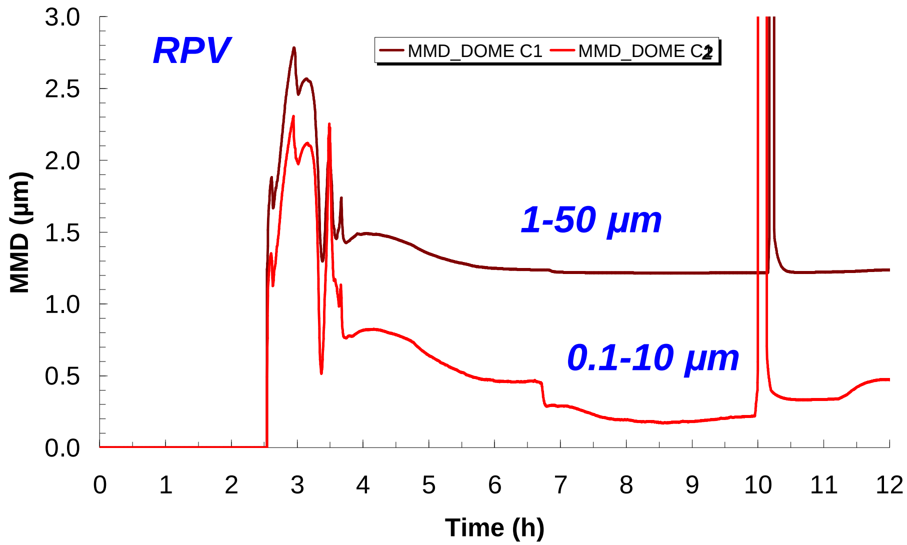
Accident Sequence

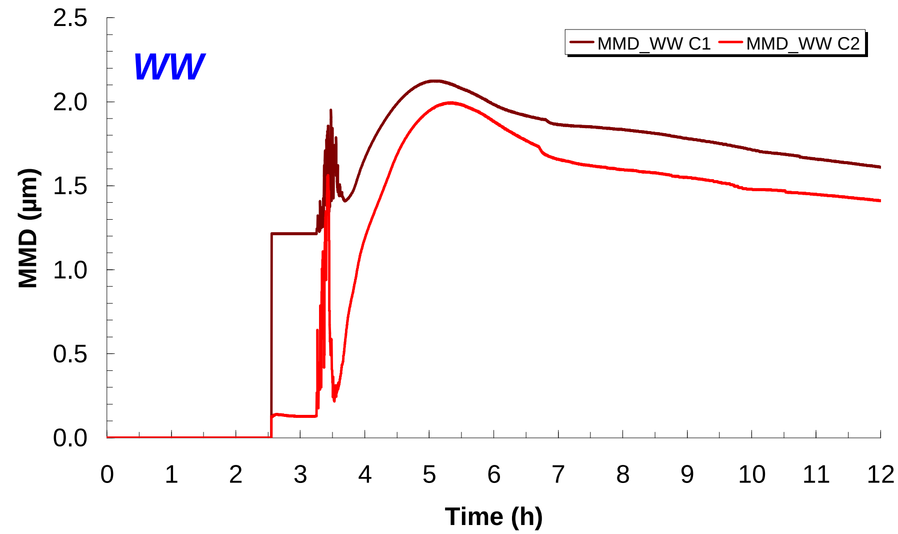
- ***SBO***
- ***High pressure (~75 bar)***
- ***6 SRVs available***
- ***High pressure ECCS and IC unavailable***

1. BWR3-Mark I

- ✓ *Updating with the MELCOR BMP (Nureg/CR-7008)*
- ✓ *Revision of the aerosol characterization:*

  Range of size, shape factors, sticking coefficient…..





1. BWR3-Mark I

**	TIME	DTMAX	DTMIN	DTEDIT	DTPLOT	DTREST
TIME8	7500.0	1.0	1.0E-6	5.0E3	400.0	5.0E3
TIME9	8500.0	1.0	1.0E-6	5.0E3	400.0	5.0E3
TIME10	10000.0	2.0	1.0E-6	5.0E3	400.0	5.0E3
TIME11	25000.0	3.0	1.0E-7	5.0E3	400.0	5.0E3

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TIME8	7500.0	1.0	1.0E-6	5.0E3	400	5.0E3
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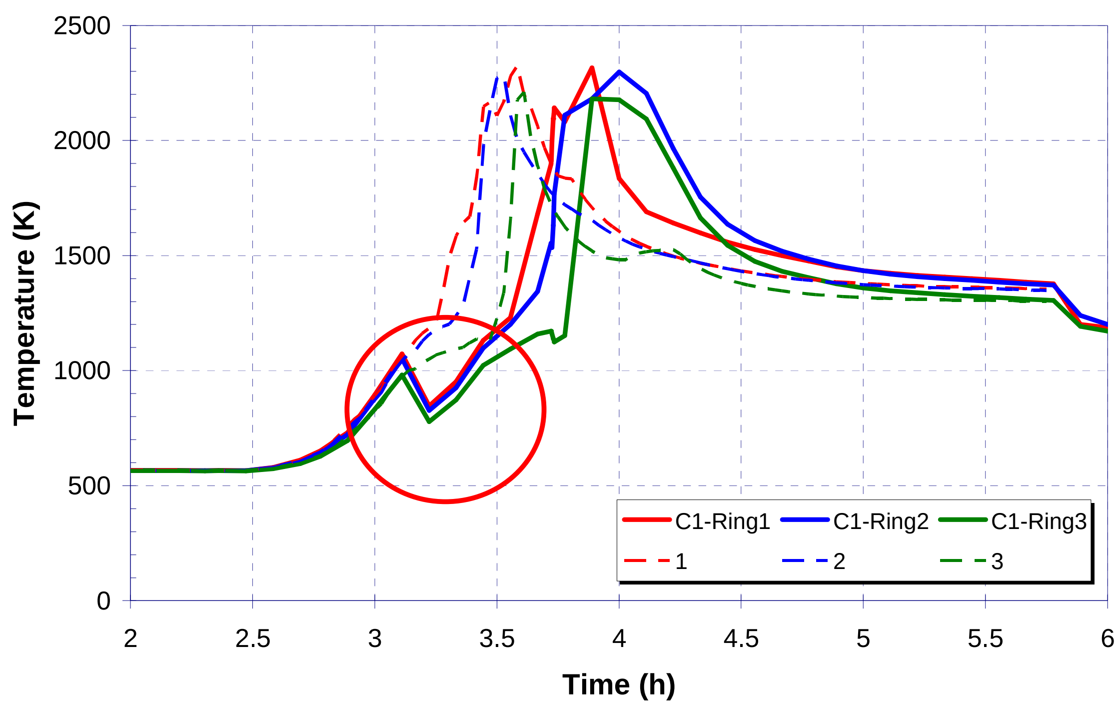
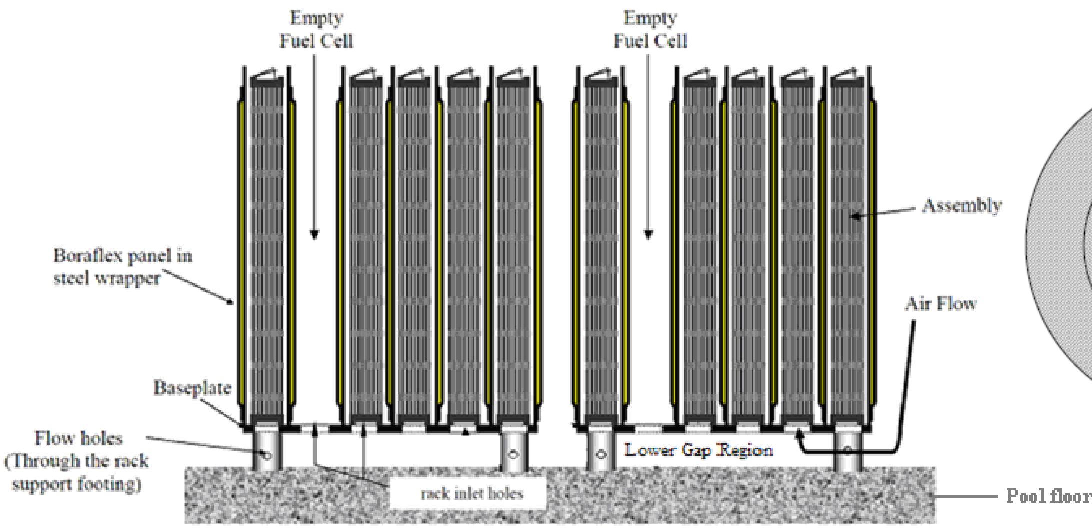
TIME11	25000.0	3.0	1.0E-7	5.0E3	400	5.0E3

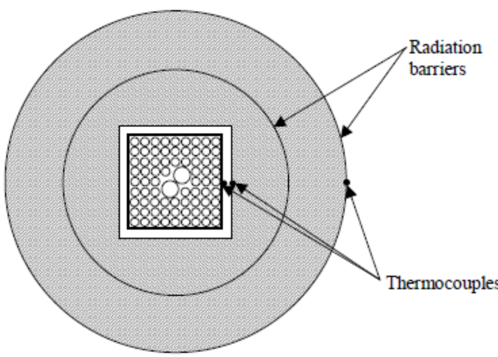


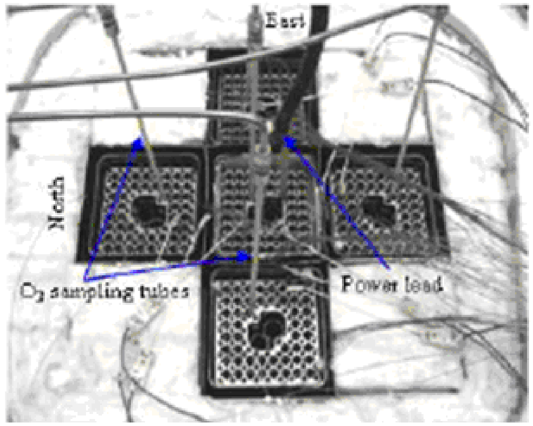
- ✓ *DTmax, DTplot*

2. SFP

- *Zr air oxidation leading to cladding ignition*
- *Prototypic BWR FAs (electrically heated with MgO fuel substitute) in prototypic SFP racks (SS walls with neutron absorber layer - Boraflex)*
- *Assemblies arrangements*
  - *1x1: "hot-neighbor" situation → ignition axial propagation*
  - *1x4: "cold-neighbor" situation → ignition radial propagation*







2. SFP: Modeling studies

Base Case

- **Hydraulic model**
  - S_{lam}
  - k

  $$k^{*} = k + \frac{S_{LAM} \cdot L}{\mathrm{Re} \cdot D_H}\left(\frac{F \cdot A}{A_S}\right)$$

- **CVH nodalization**
  - Coarse: $n = 6$
  - Fine: $n = 13$

  Base Case, n=10

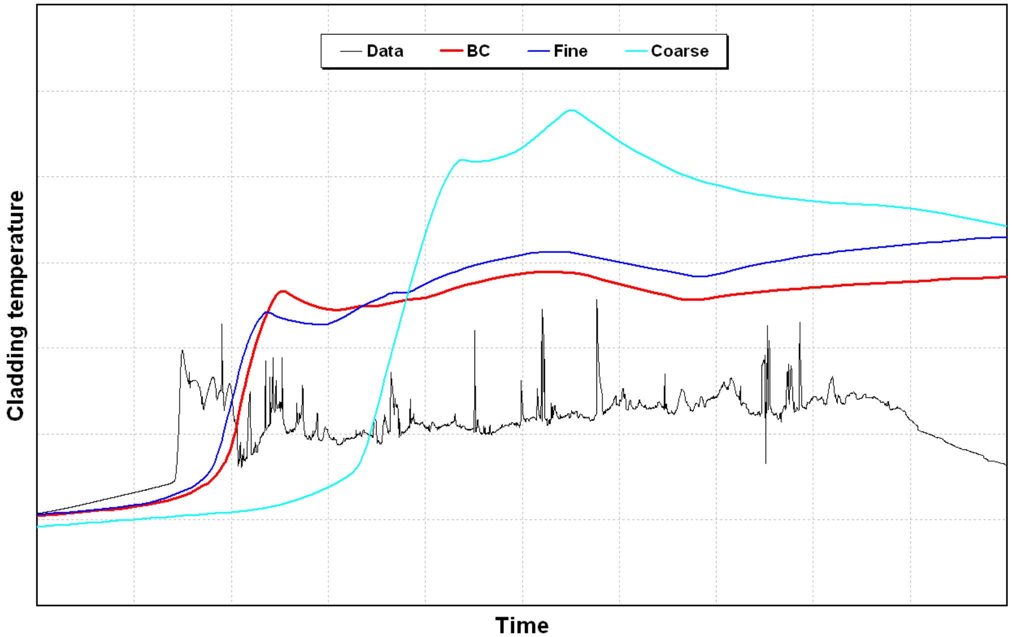
- **Oxidation model**
  - Breakaway Transition
    - LF
    - τ
  - Pre- rate
    - $k_{ox\text{-}air}$

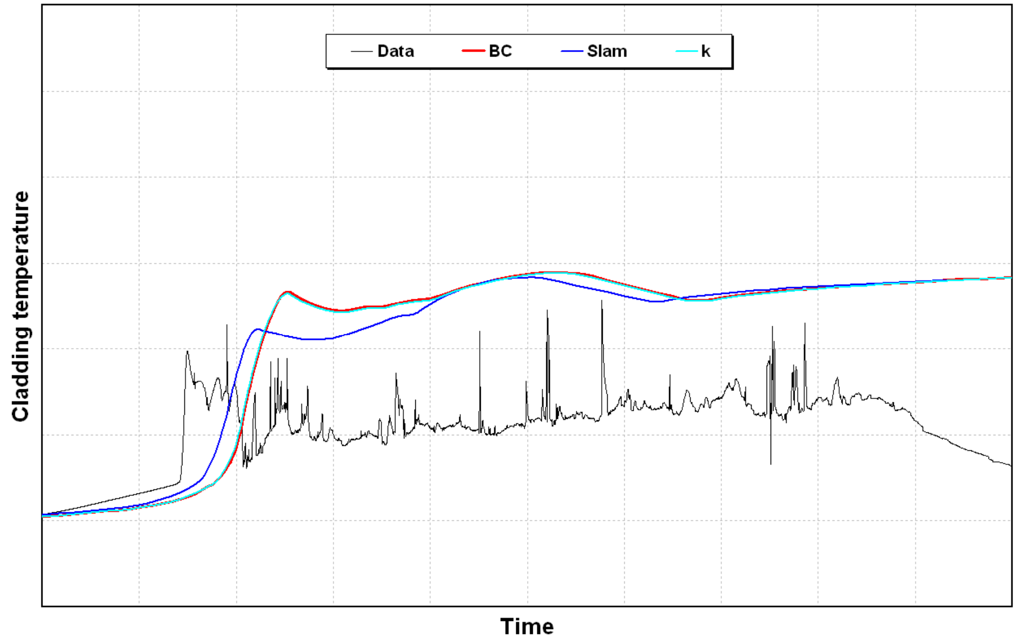
  $$k_{Trans} = \alpha \cdot k_{pre} + (1-\alpha) \cdot k_{post}$$

  $$\alpha = \frac{LF_{max} - LF}{LF_{max} - 1.0}$$

  $$LF = \int_0^t \frac{t'}{\tau} dt' \qquad \tau \cong \frac{10^{42.04}}{T^{12.58}}$$

2. SFP: CVH nodalization and hydraulic model

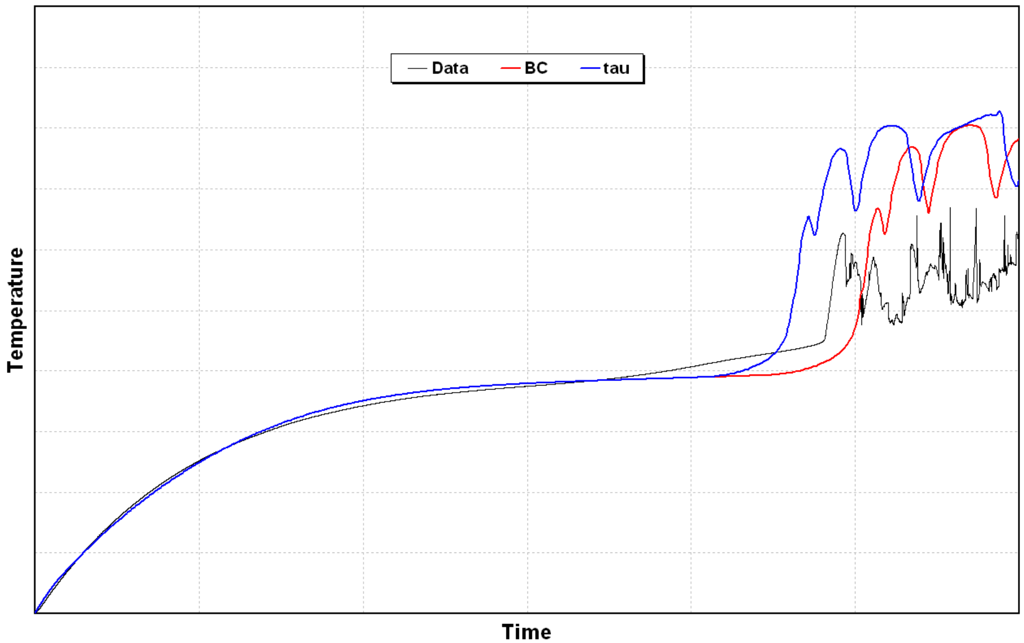


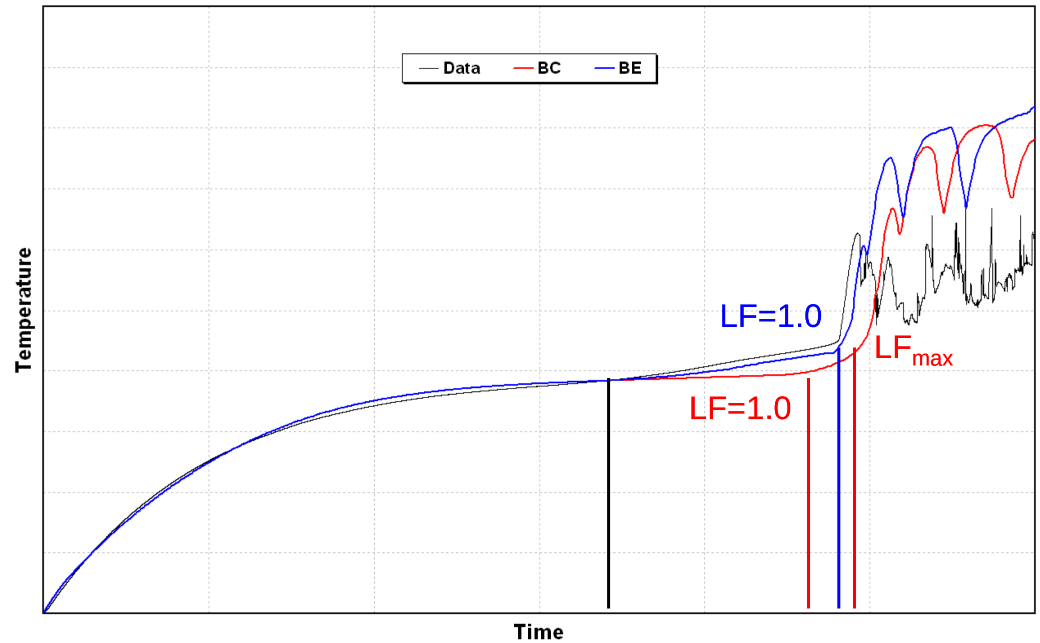


BWR 1x1

The coarse nodalization leads to different results in spite of preserving total hydraulic losses
The variation of S_{LAM} in the range of the experimental uncertainty sligthly affects the results
The variation of k in the range of the experimental uncertainty hardly affects the results

2. SFP: Zr air oxidation model





BWR 1x4

Heavily parametrized (slight variation of τ correlation)
The BC does not seem to represent the actual oxidation phenomena
Best estimate is achieved by accelerating pre-breakaway kinetics and making abrupt transition

3. SFR

CSTF Facility

Project: EU-ESFR (SP3 - Safety)

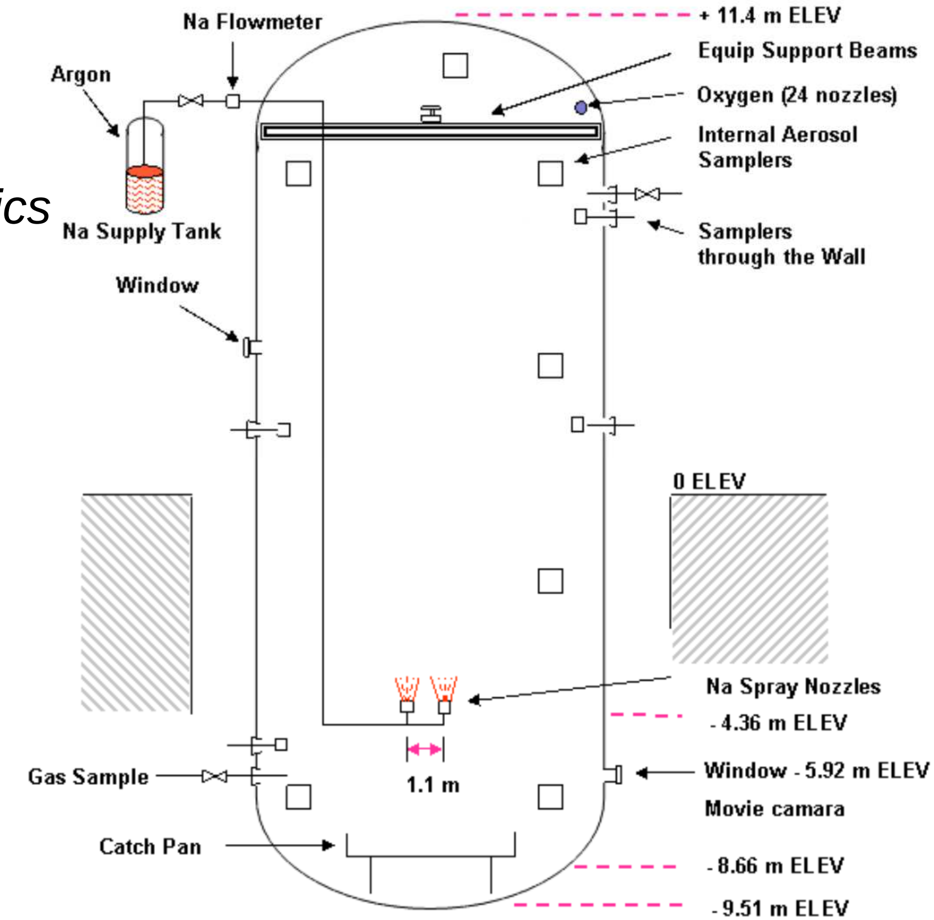
Focus: In-containment Aerosol dynamics

Scenario: ABCOVE Program

AB5 Na spray fire

AB6 NaI + Na spray fire

AB7 Na pool fire – NaI injection



3. SFR: modeling challenges

CB

$Q_{ch} + Q_s$ → **100% atm**

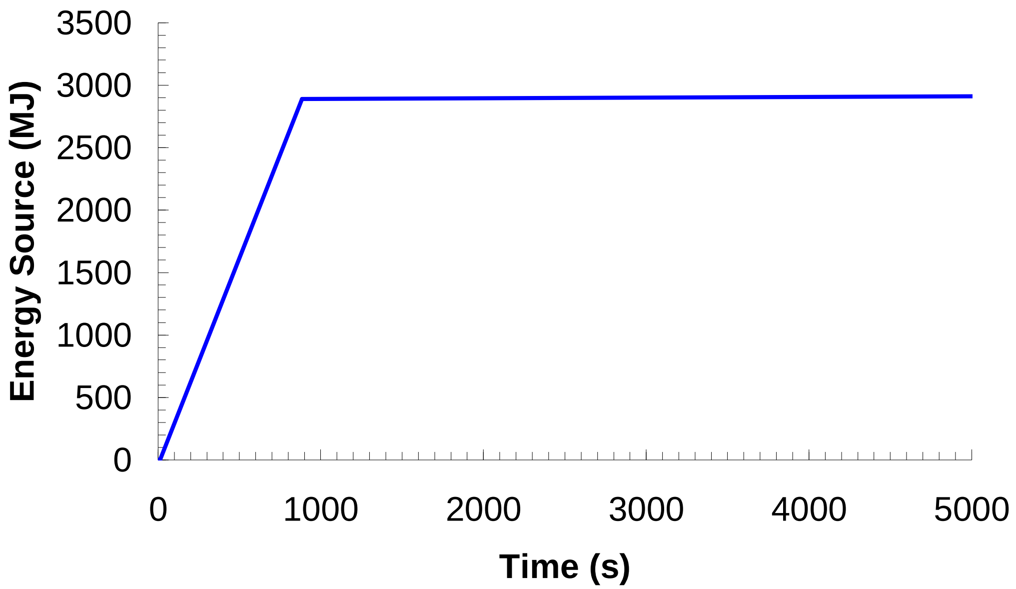
TF

Q_{ch}

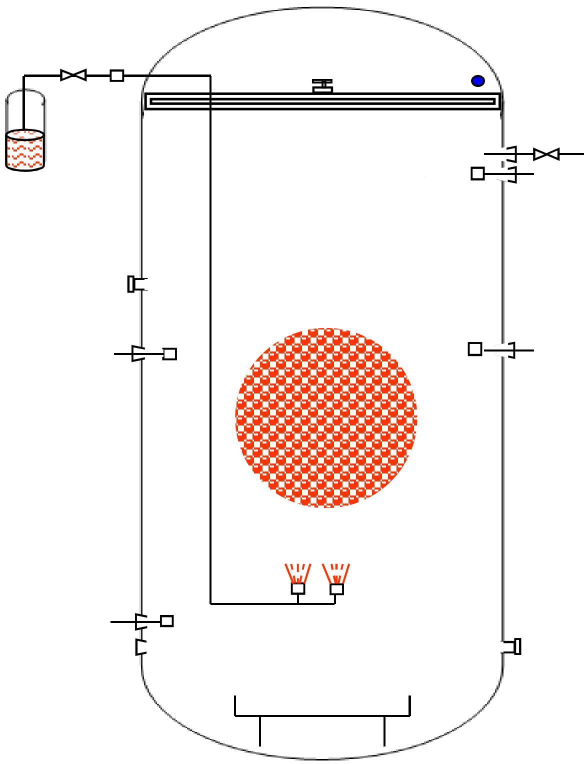
$$2Na + O_2 \rightarrow Na_2O_2 \quad \Delta H = -124 kcal/mol$$

$$HOH + Na_2O_2 \rightarrow 2NaOH + \frac{1}{2}O_2 \quad \Delta H = -85 kcal/mol$$

Q_s *To account for the ΔT between the aerosols and the atmosphere*



3. SFR: modeling challenges



CIEMAT

Q_{ch} → **50% atm + 50% 'Fire ball'**

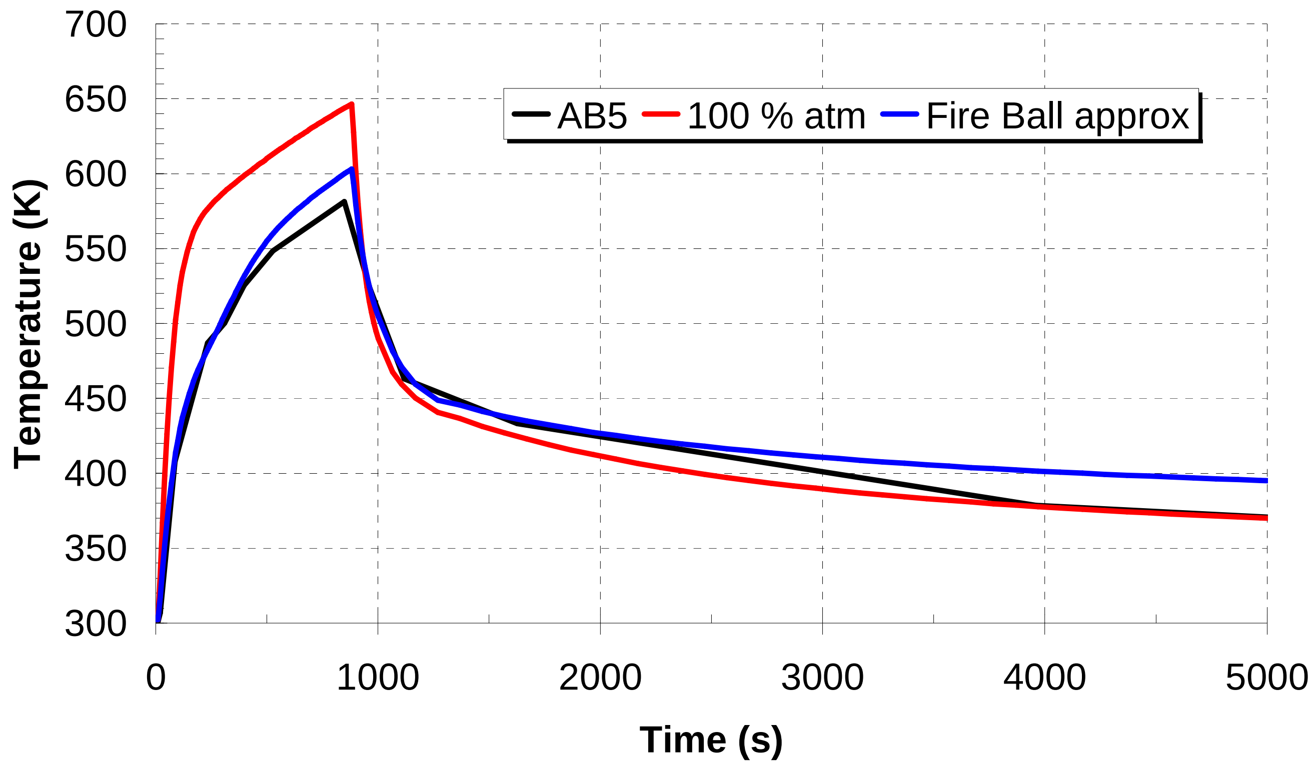
(TF) (HS)

Fire ball hypothesis (HS rectangular, vertical)

- *Shielding effect*
- *HS surface*
- *HS thickness*
- *HS density*
- *HS Cp*

→ *A dense & compact mass to preserve the thermal capacity and thermal inertia of the hot aerosols cloud*

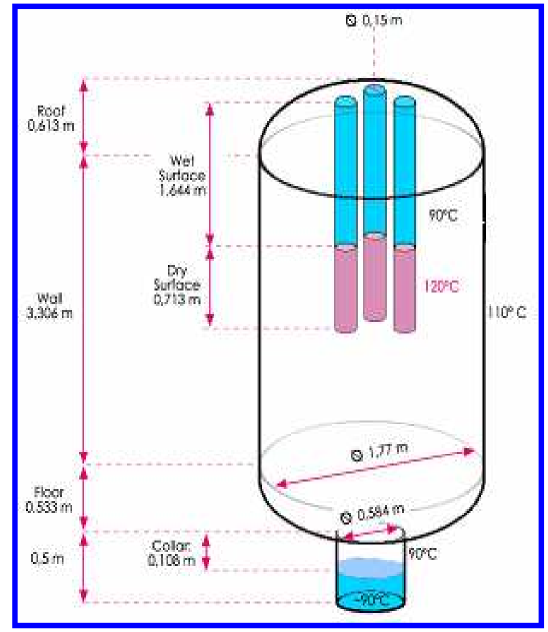
3. SFR: modeling challenges



4. Phebus-FPT3

FPT3 test:

Flow	Fuel	Containment
Steam poor (steam starvation)	BR3 24.5 GWd/tU B_4C control rods	Evaporating acidic sump Recombiners



Objective

- Uncertainty analysis to the Th's and aerosol modeling of FPT3

Th's: 24 var

- *Rh_o*
- *$T_{wet\text{-}cond}$*

Aerosols

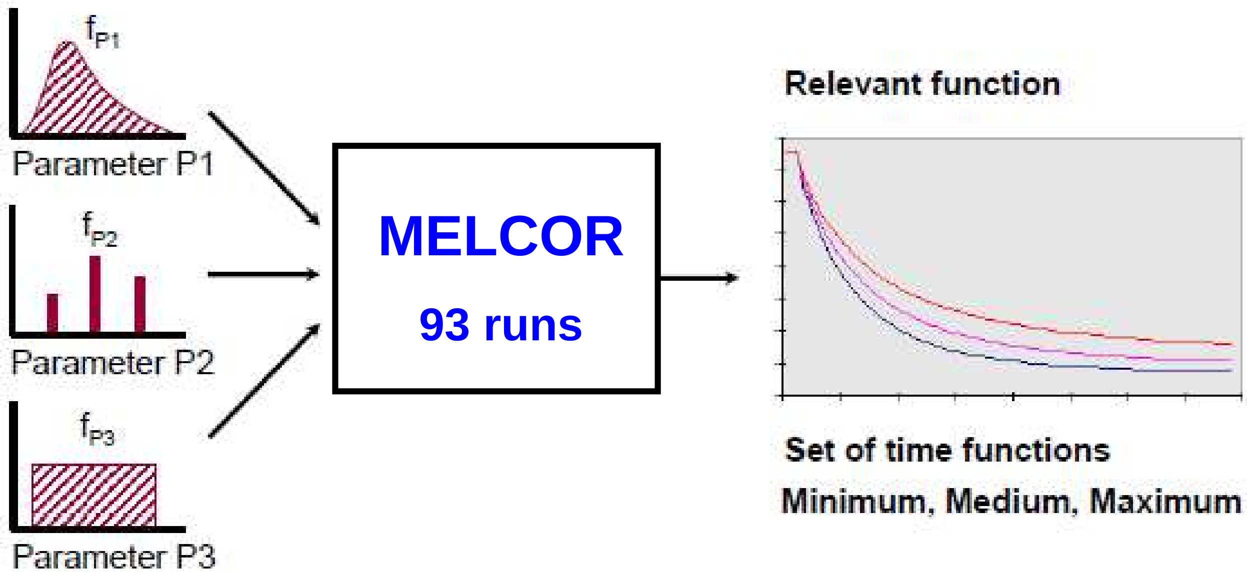
- *Iodine source*
- *Particle size*
- *Density*

Uncertainty

4. Phebus-FPT3: User tool kit for uncertainty analysis

Stochastic approach: Wilks Theory

"93 samplings determine a 95% of the CI with a 95% of CL"

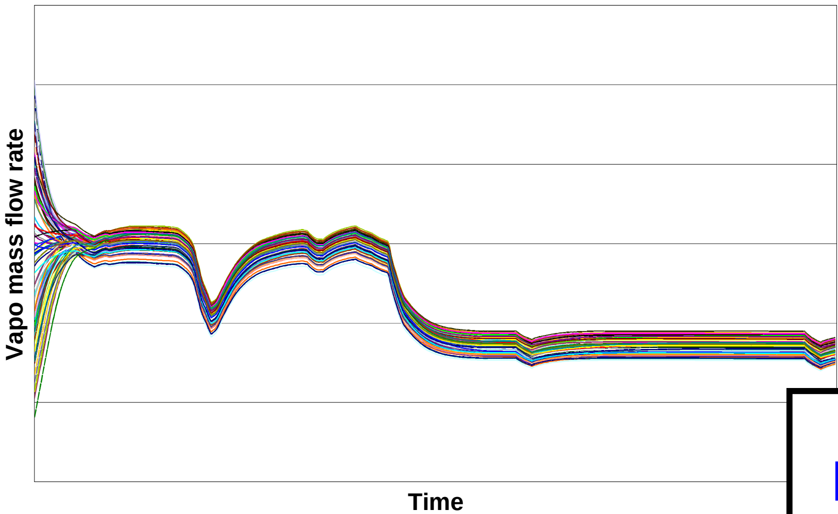


Fortran Applications: → ***Specific for Phebus-FPT3***

n inputs:
- ***n samples***
- ***Different distributions***
- ***Time dependent profiles BC***

Postprocessing:
- ***n output files***
- ***Defined output variables***

4. Phebus-FPT3: On going analysis



MELCOR

93 runs