Assessment of control rod release models of MELCOR 1.8.6

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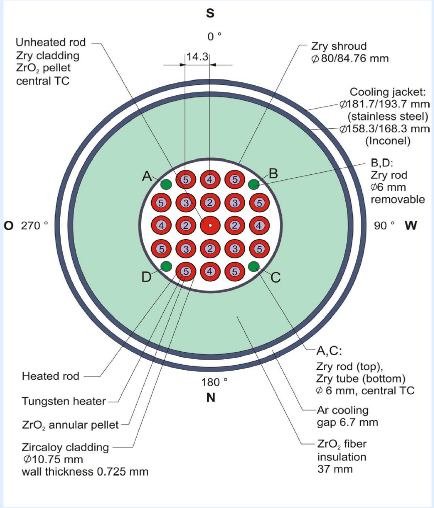
PSI

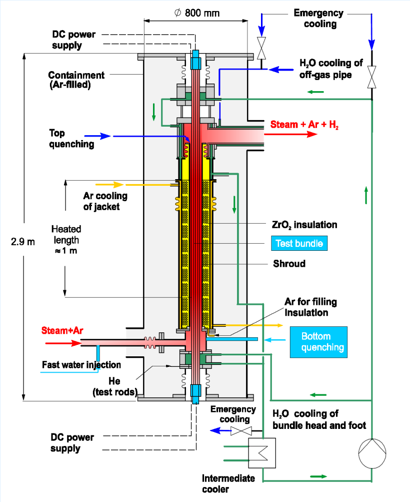
Outline

- Introduction
- Conversion of Quench Input Deck (ISP45)
- Implementation of Control Rod Models
- Assessment studies
  - QUENCH-07 (B_4C)
  - QUENCH-13 (SIC)
- Conclusions

QUENCH simulations

- Pre- and post-test analyses of all QUENCH experiments
  - MELCOR used in tandem with SCDAP/RELAP5 to provide
    - confirmatory pre-test analyses
    - assessment of MELCOR 1.8.6 and non-regression relative to 1.8.5
    - aerosol and gas release from control rod (not modelled by SCDAP/RELAP5)
- Selected results
  - bundle temperature (QUENCH-07,13)
  - hydrogen generation (QUENCH-07)
  - carbon gases (QUENCH-07)
  - SIC release (QUENCH-13)





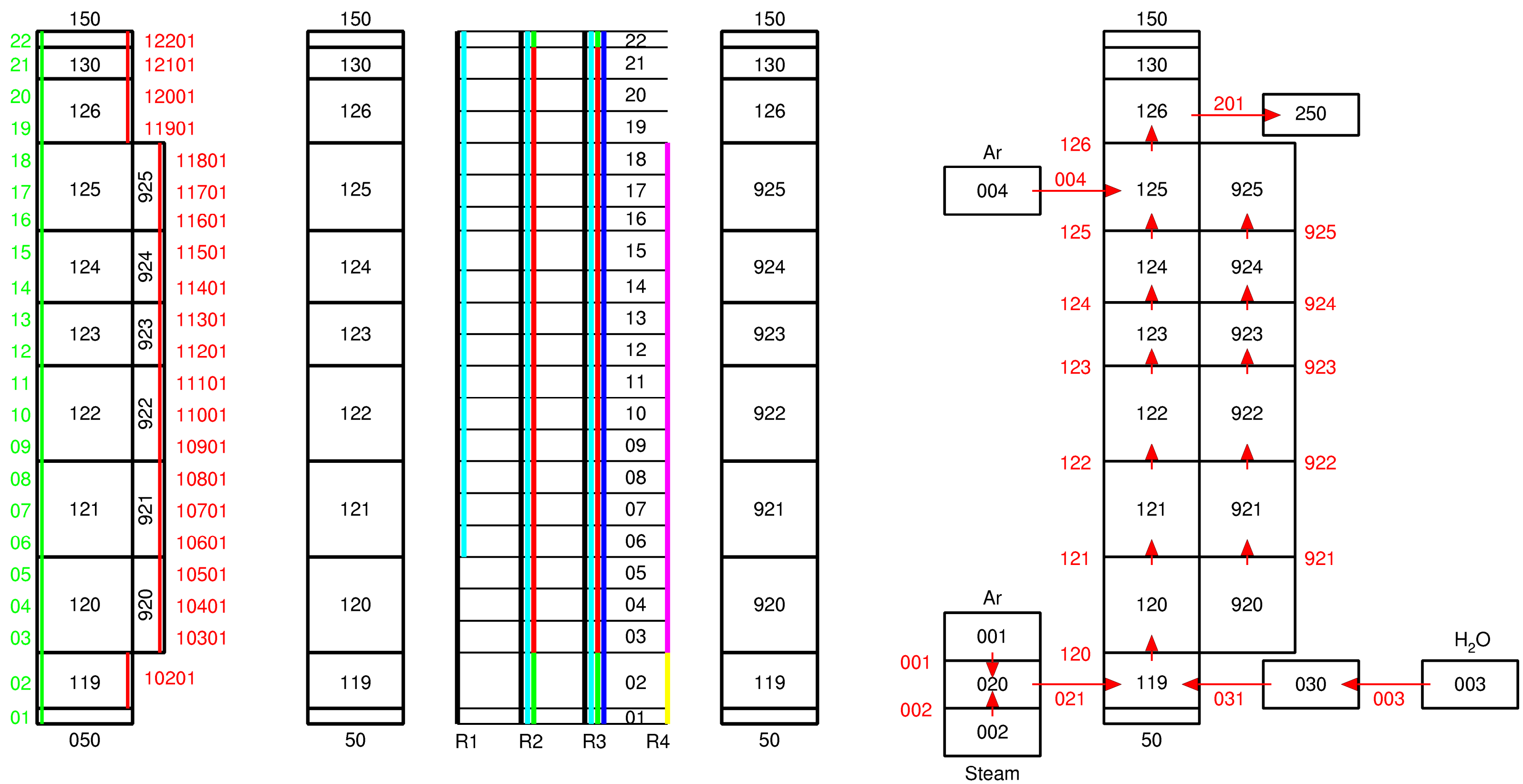
Quench-06 Nodalization

CORE COMPONENTS

VOLUMES

- ZrO_2
- Cladding
- SS
- Copper
- CN
- NS
- Tungsten

FLOW PATHS



Input Deck Conversion

- 'Lower head' conversion was problematic
- 'Upper dome', boundary conditions had to be changed

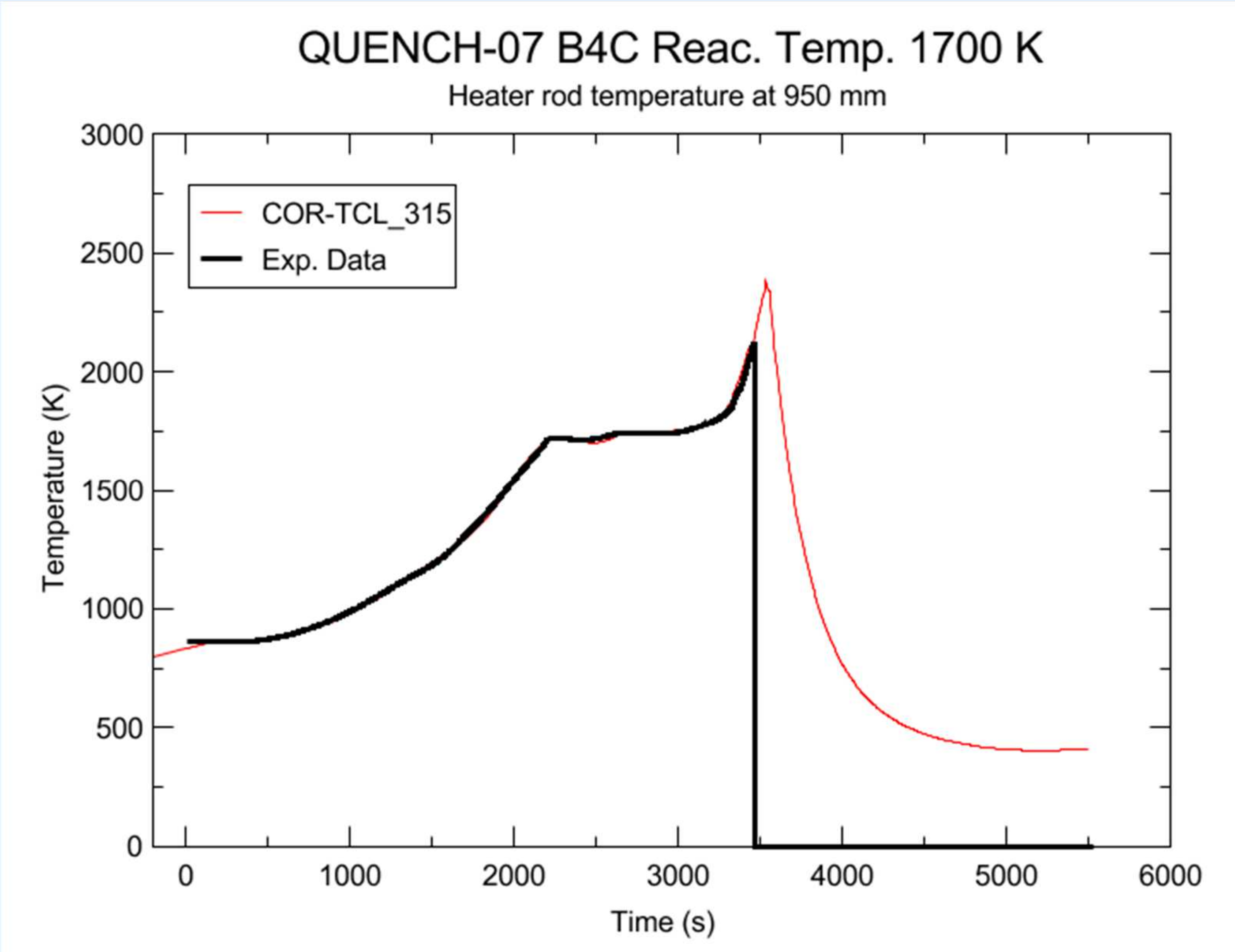
- Comparison of results showed:

- Argon material properties have changed
- Additional changes in heat conductivity models (not described in UG or RM)

Implementation of B_4C Control Rod Model

- MELCOR accommodates only a limited number of core materials
  - not enough for all the actual materials
  - copper was modeled as stainless steel (so that B_4C could be modeled with the correct properties)
- Control Rod was completely modeled as non-supporting structure (KNS card)
  - Needed to avoid problems of premature collaps to debris and burning
- BORON-CARBIDE and B_4C-INT models were used for comparison

ASSESSMENT USING QUENCH-07



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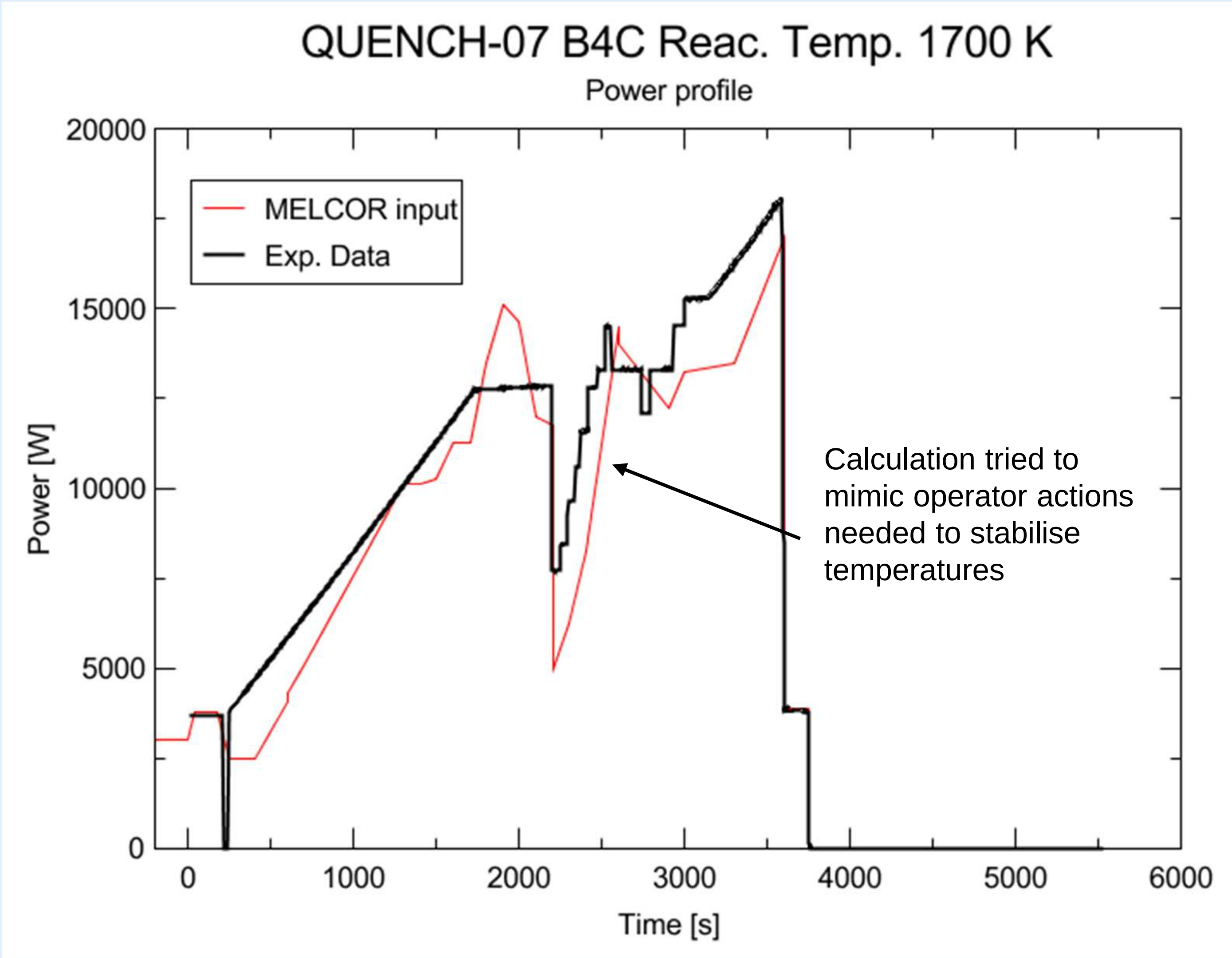

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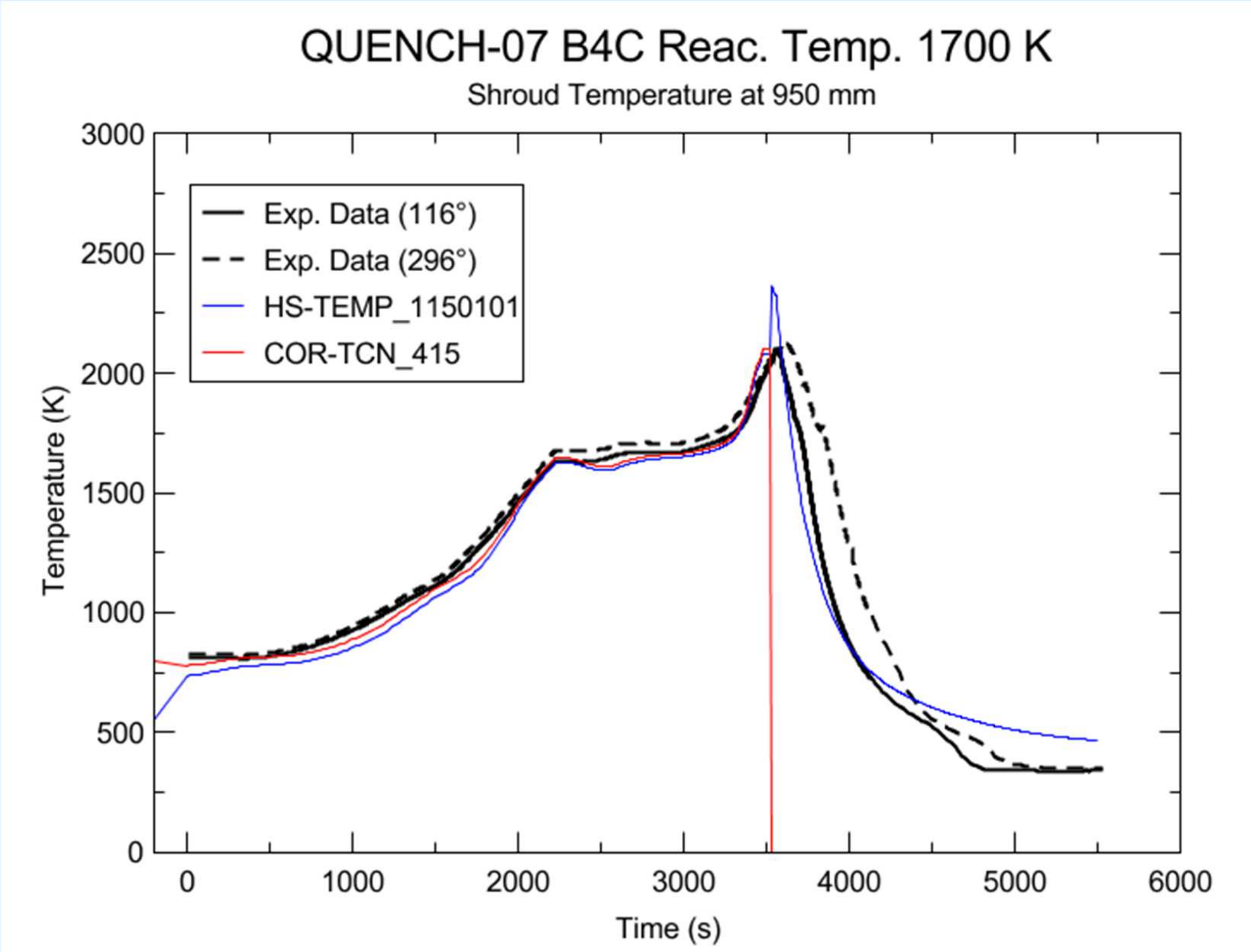
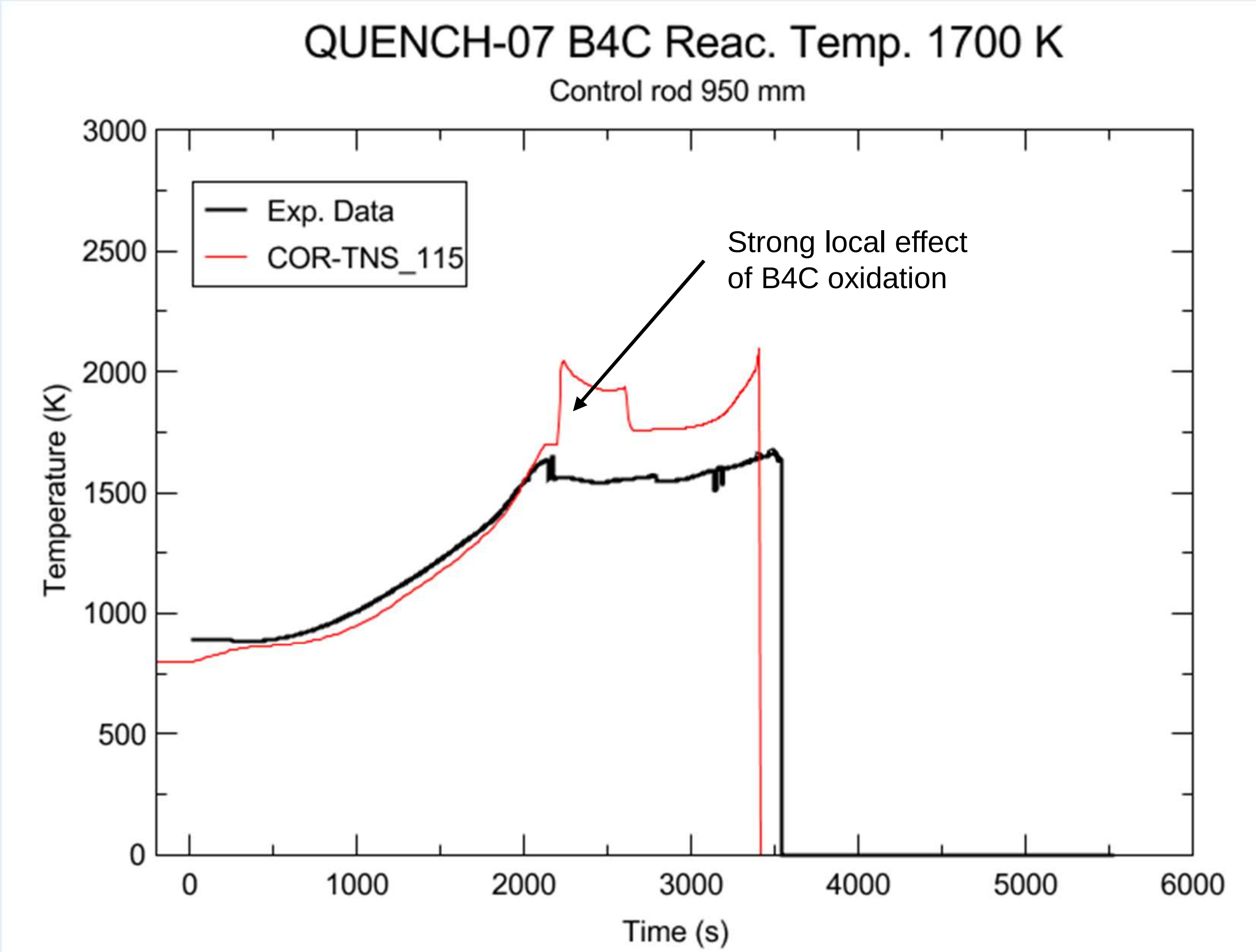
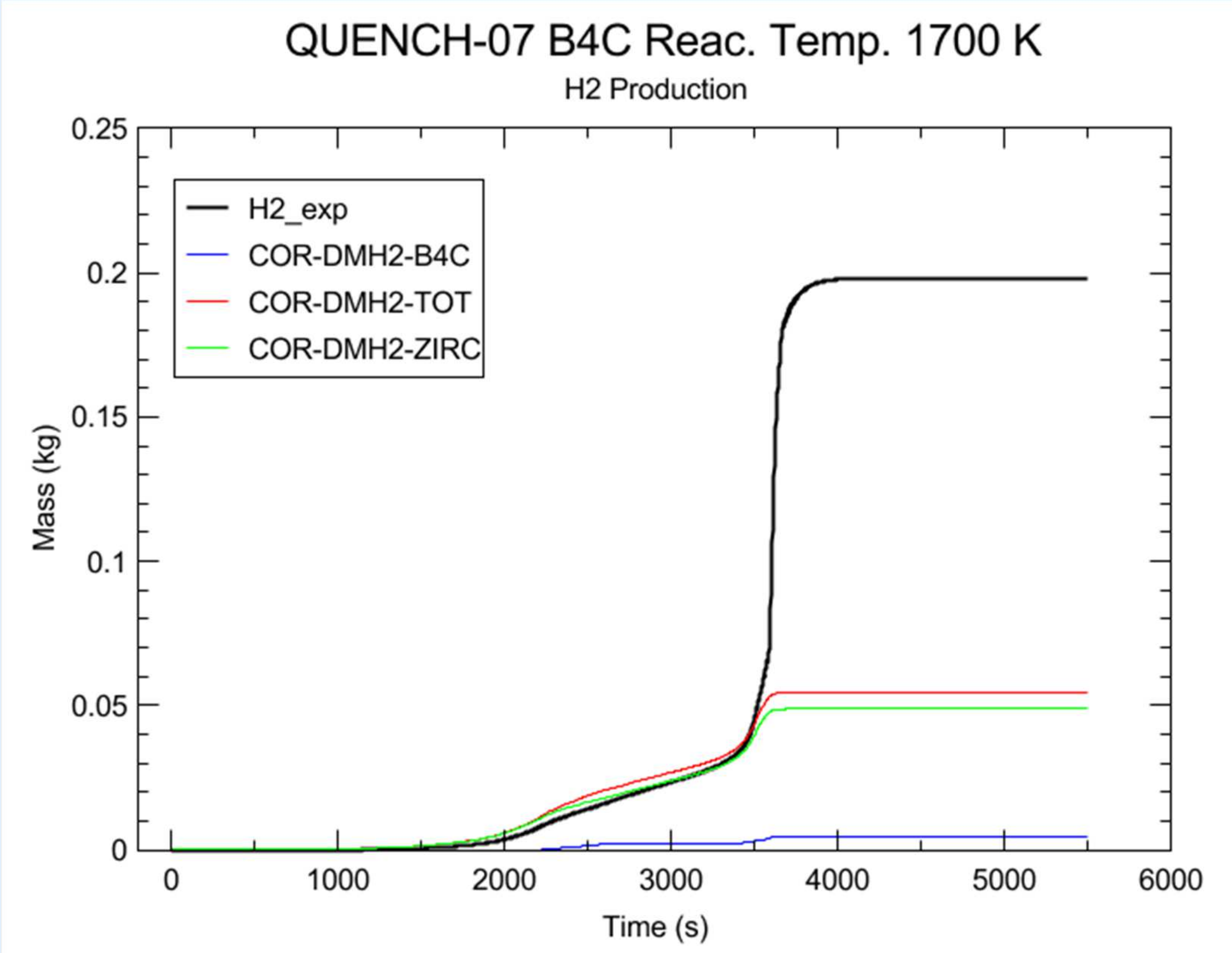


ASSESSMENT USING QUENCH-07



ASSESSMENT USING QUENCH-07



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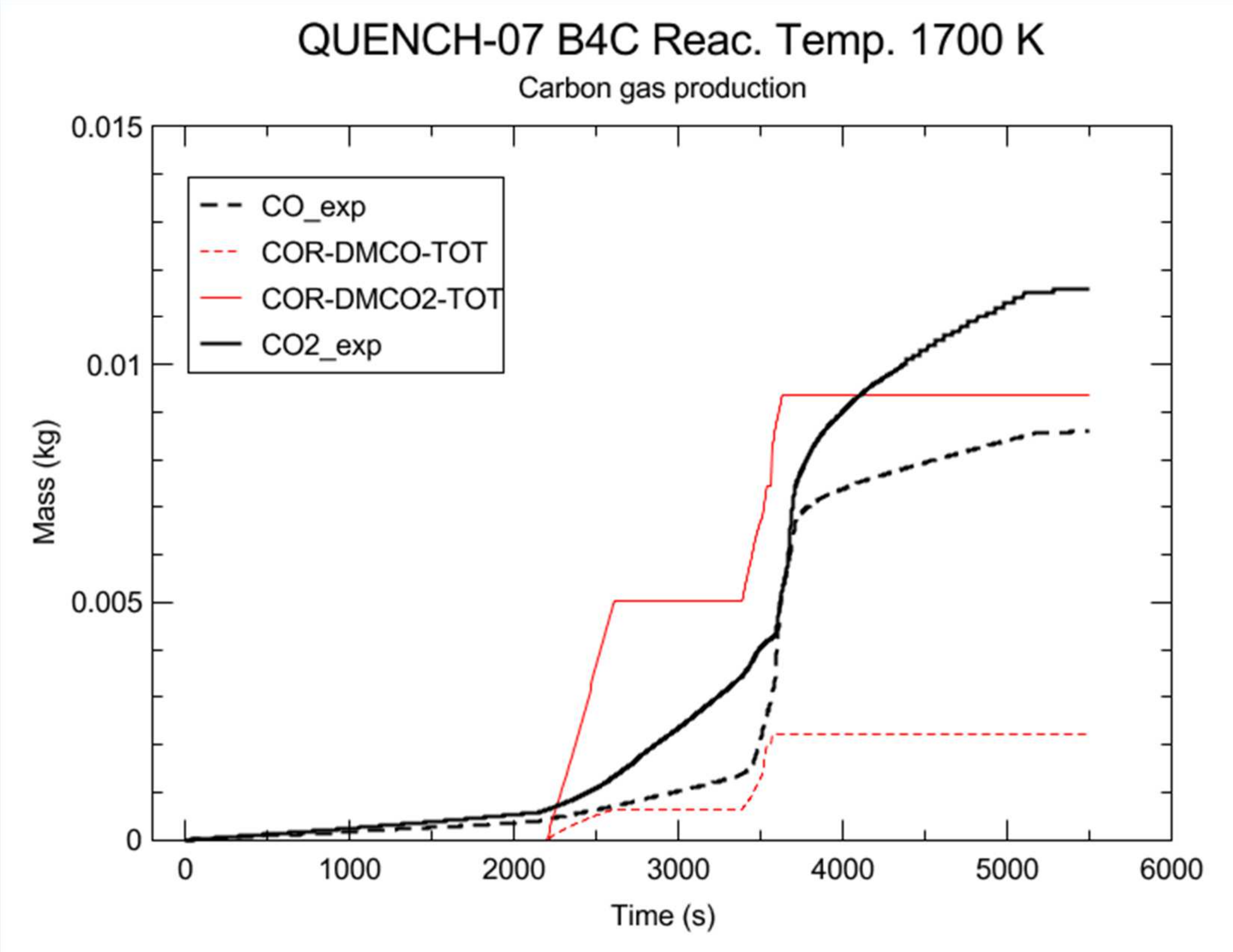


Summary of QUENCH-07 analysis

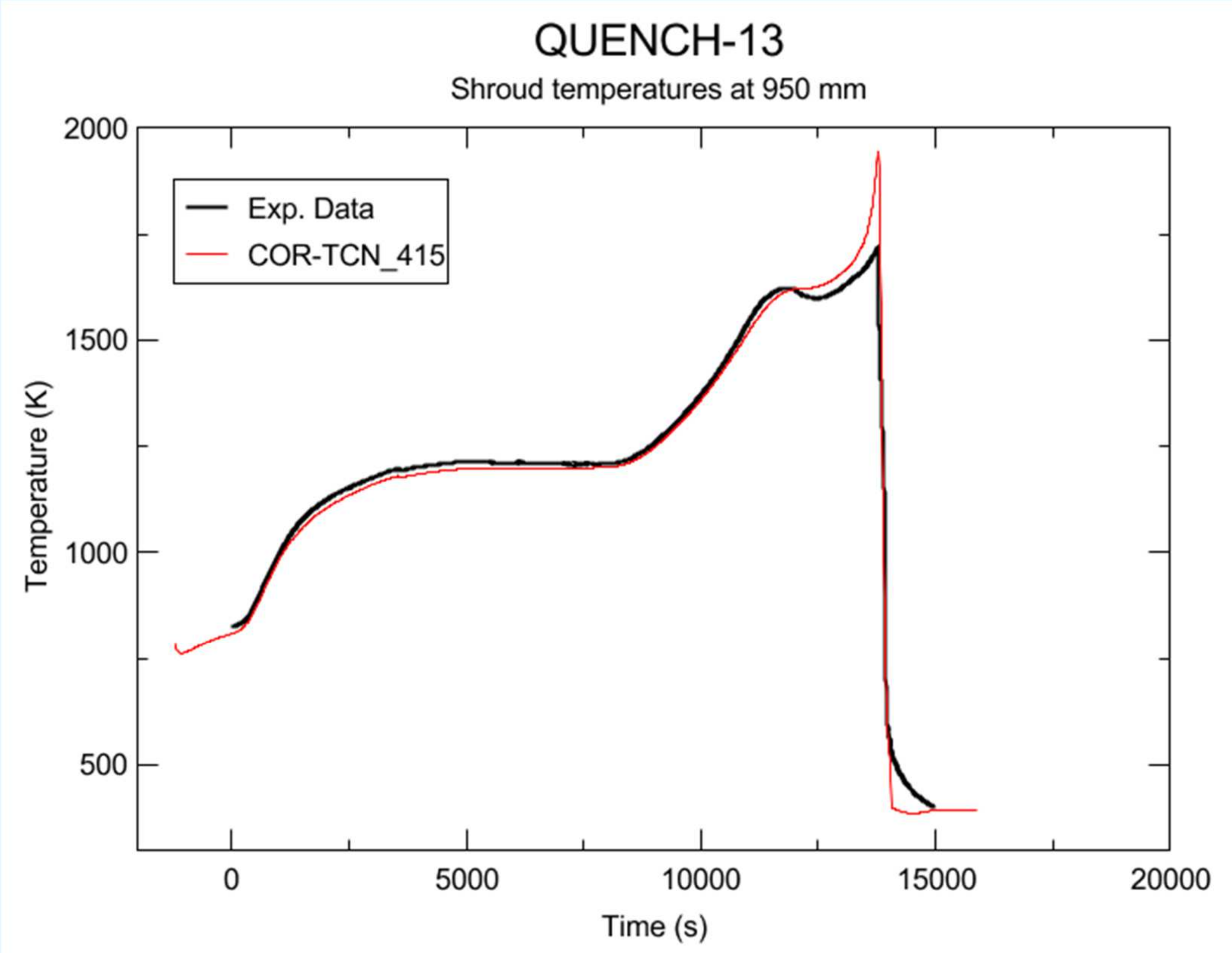
- Onset and total CO_2 production well calculated
- CO is small in calculation but almost the same as CO_2 in the experiment
- H_2 production is underestimated in quench phase
  - evidence of strong oxidation of molten metallic in experiment
- Oxidation of steel/B_4C mixture and molten B_4C not included in model

- Temperature criterion instead of cladding failure used for start of B_4C reaction
- B4C-INT model: reaction switches off at liquefaction of B_4C

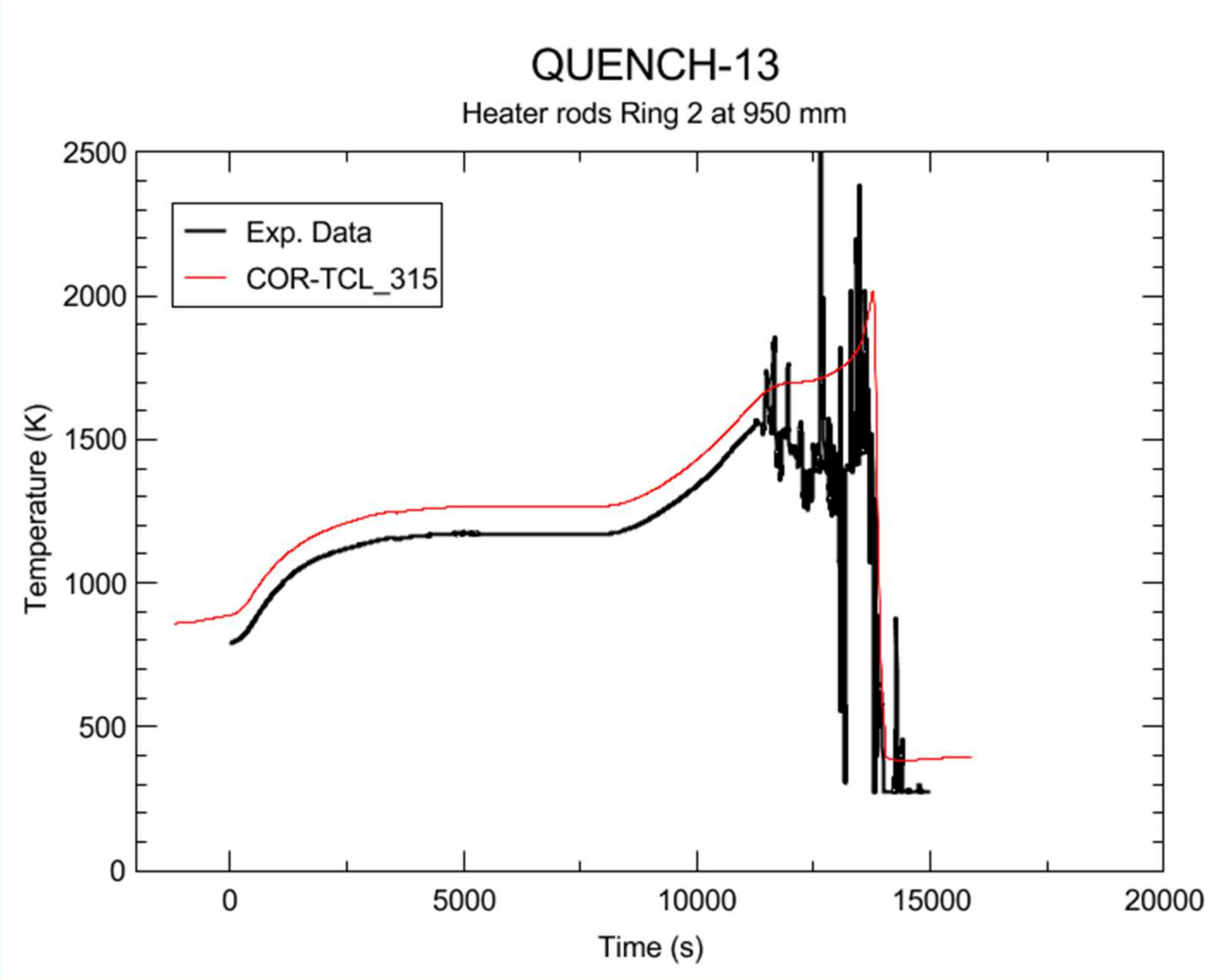
Modeling of SIC control rod

- Structure of input model similar to QUENCH-07
- Implementation of CR-release groups (AG-CR, IN-CR, CD-CR) in RN package
- Definition of vapor pressure, diffusion coefficients and molecular mass of CR materials with SC
- Addition of horizontal heat structures for aerosol sedimentation
- Definition of sedimentation paths
- Using measured power history

ASSESSMENT USING QUENCH-13



ASSESSMENT USING QUENCH-13



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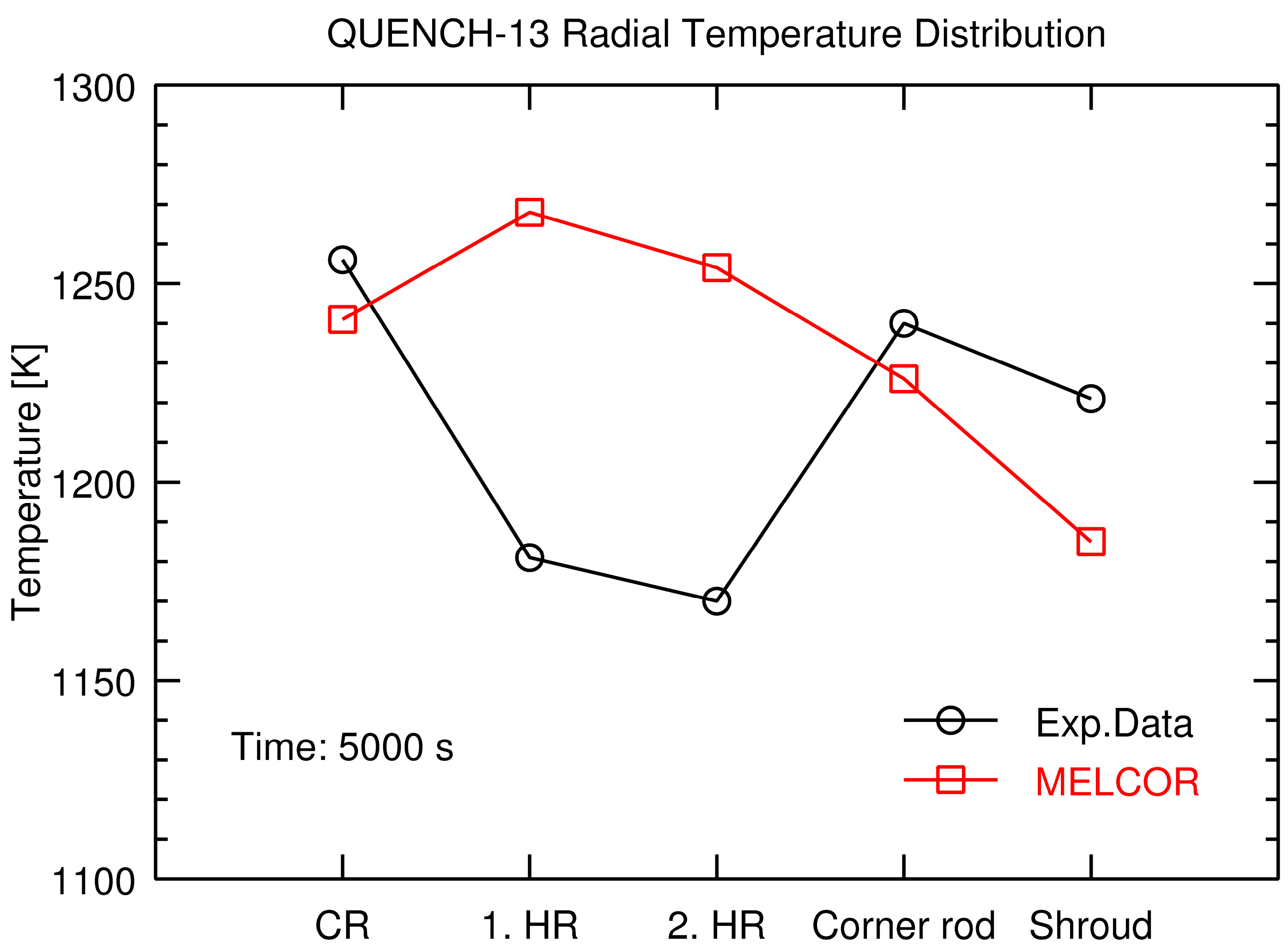
ASSESSMENT USING QUENCH-13



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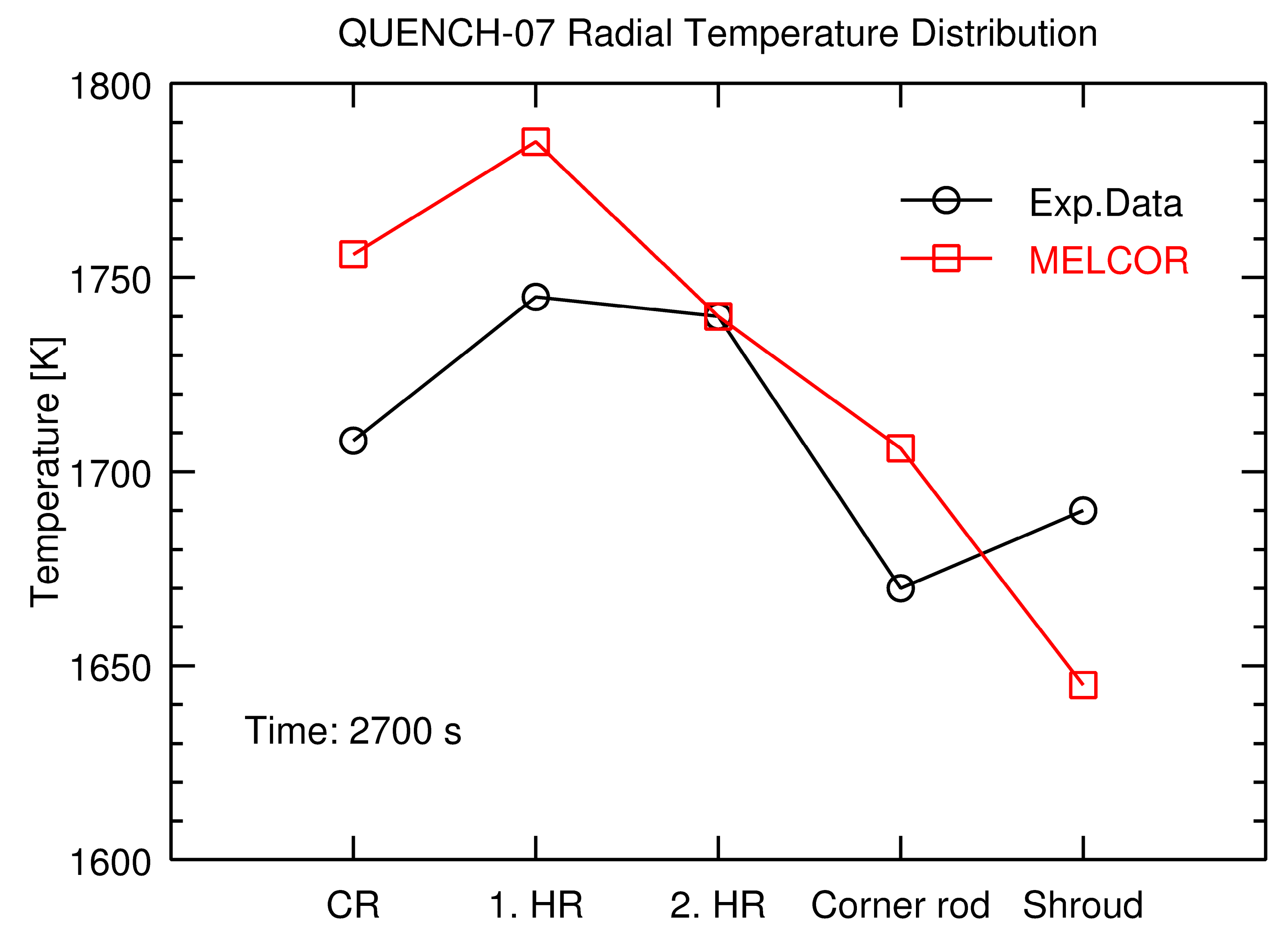

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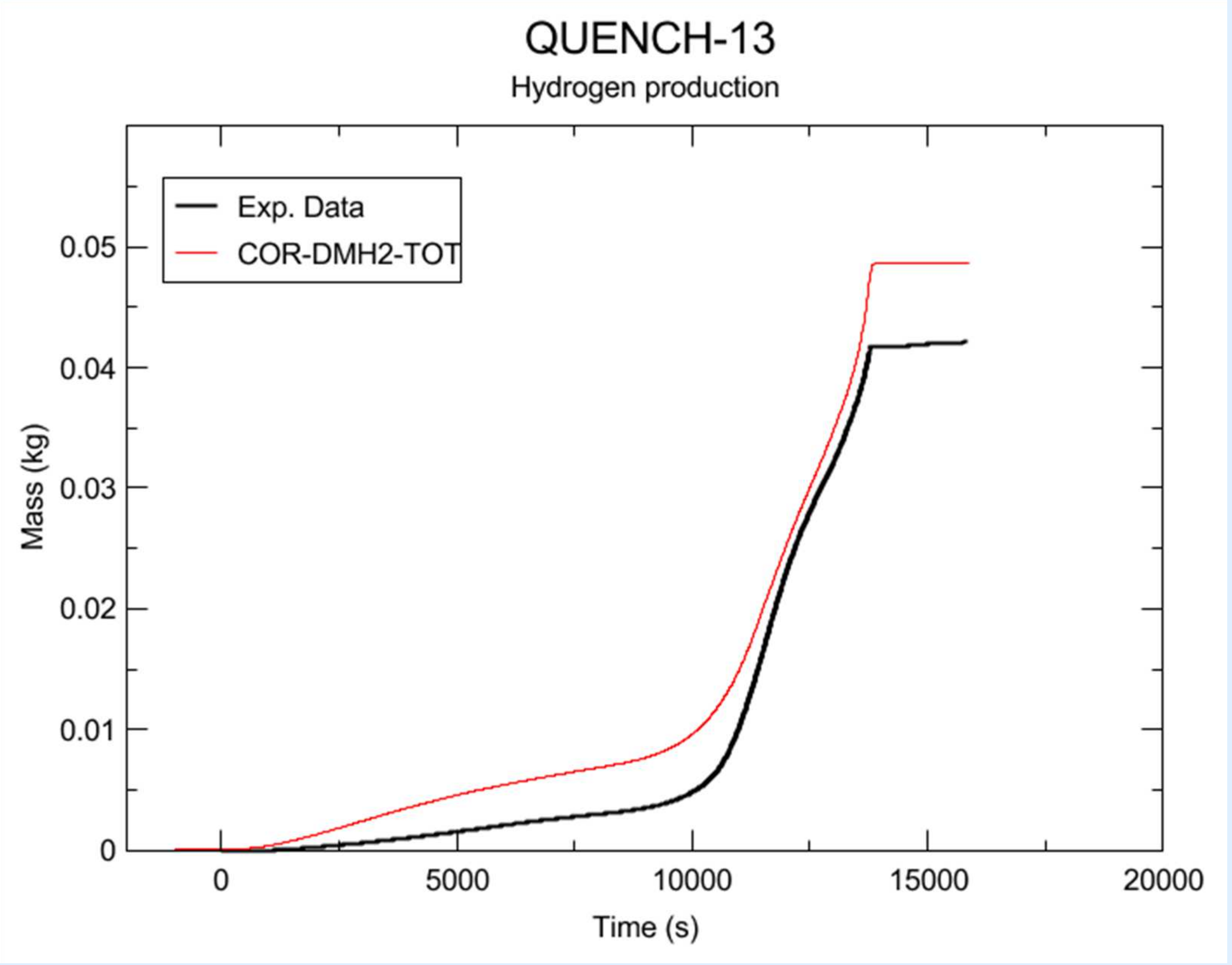

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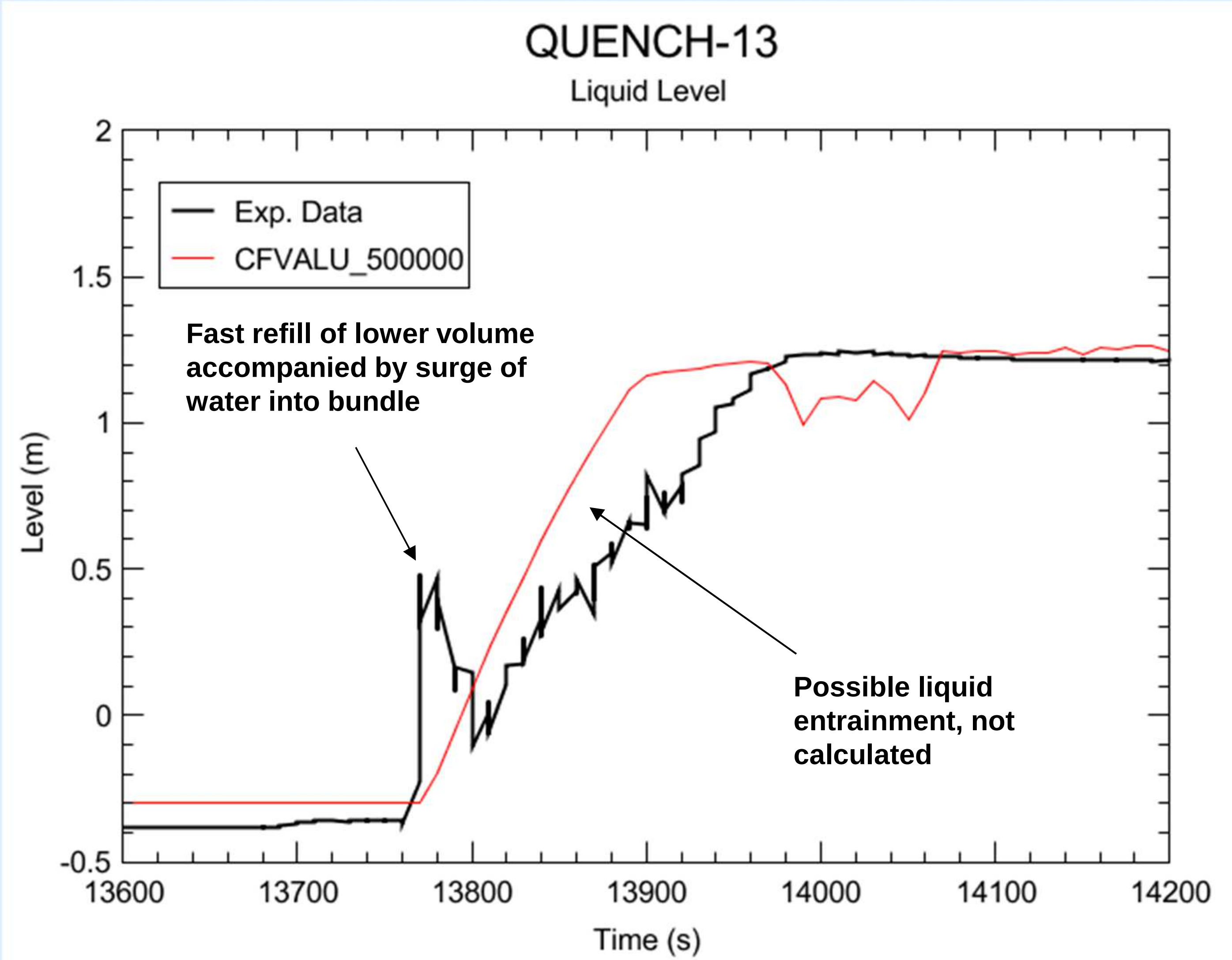


Control rod release

Aerosol composition

Exptl Estimate*   **MELCOR**

after CR failure:

Ag: 3% 55%

In: 48% 10%

Cd: 49% 35%

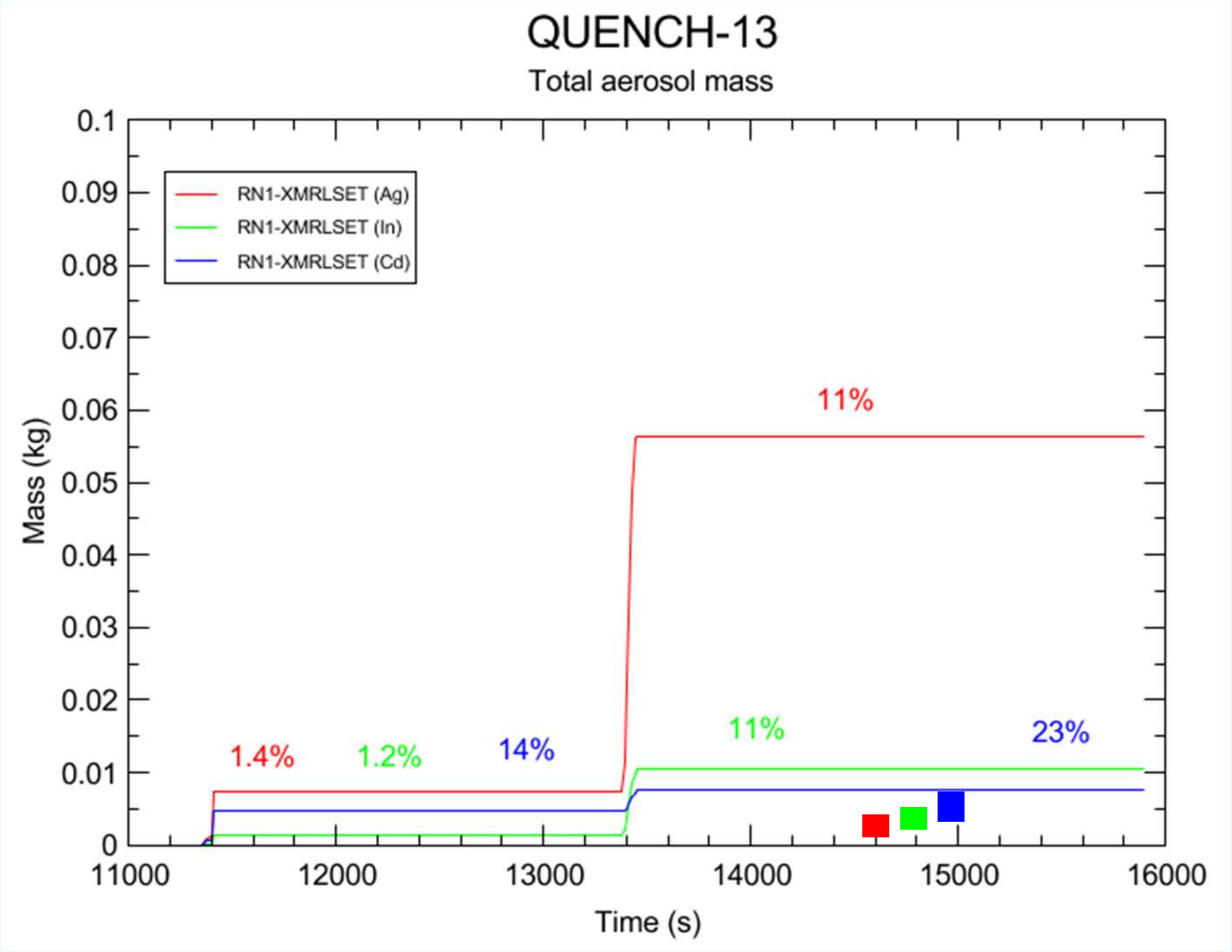
Before quench phase:

Ag: 11% 80%

In: 43% 15%

Cd: 46% 5%

***very approximate**



Summary of Quench-13 analysis

- Release of droplets into RN classes is not modeled
- Only failed COR nodes are allowed to release CR materials, therefore discrete release steps are calculated
- Only one CR material can be released from COR package into RN package
- 3 runs necessary to calculate Ag, In and Cd release
  - Cd release in agreement with experimental data
  - In release overestimated by a factor of 3
  - Ag release strongly overestimated
- Model to calculate also release from reheated conglomerate, reduces overall release???

Conclusions

- Conversion of QUENCH input files from 1.8.5 to 1.8.6 is not straight forward
- Differences of MELCOR 1.8.5 and MELCOR 1.8.6 results can not be explained completely
  - minor differences between YK, YR and YT releases
- Control rod release models of MELCOR 1.8.6 are incomplete
  - no separate treatment of Ag, In and Cd
- Total B_4C oxidation is in fair agreement but deficiencies remain
  - start of reaction should be coupled with cladding failure
  - using of B4C-INT is unclear
  - oxidation of molten B_4C or B_4C-steel mixture needed
- Calculation on different computer platforms gave same results
- No compiler or optimization dependencies were observed

Thank you for your Attention