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Experience with MELCOR applications to the VVER-440 reactor equipped with IVR

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UJV Group
PEOPLE | INNOVATION | TECHNOLOGY

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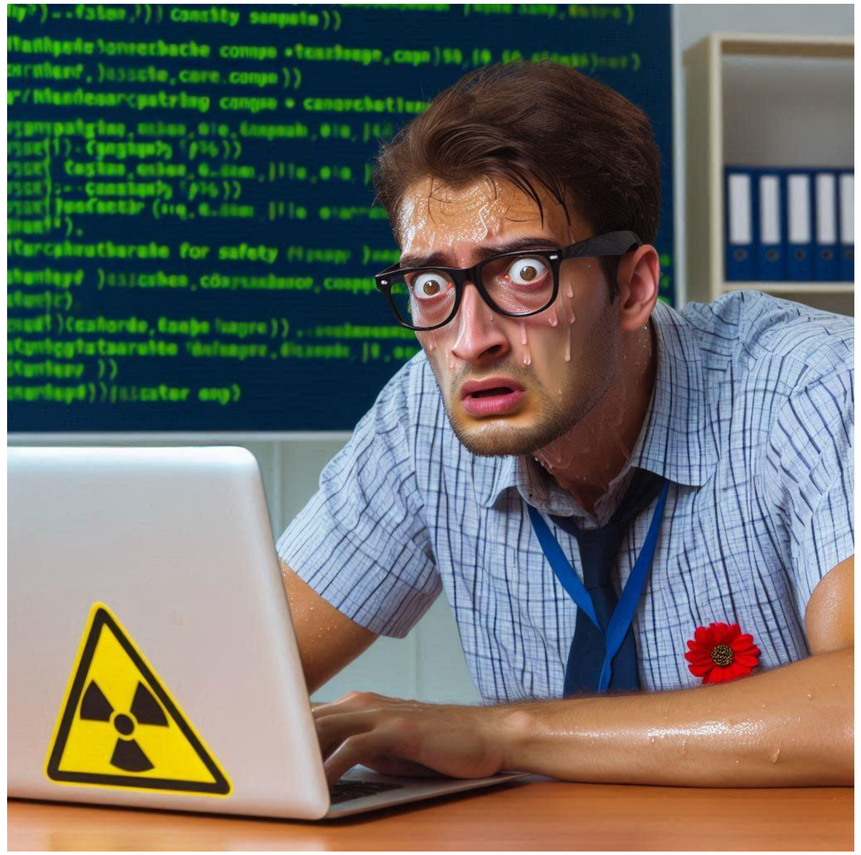
CONTENT

- **Overview of the VVER 440 geometry**
- **Approaches to modeling the system**
- **IVMR in Melcor**
  - **How can it be incorporated**
  - **Challanges**
  - **Approaches**
  - **Question marks**
  - **Discussion**

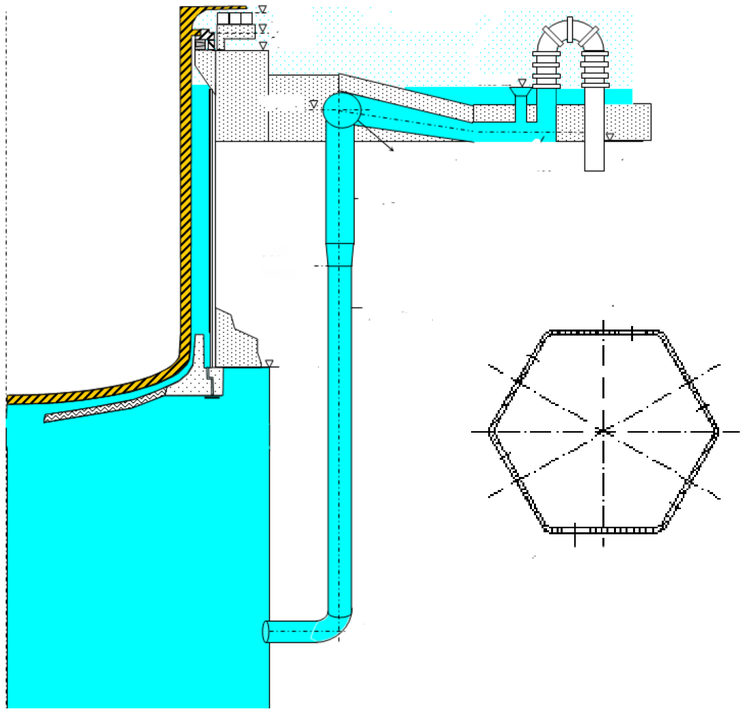
GOALS FOR THE MODEL

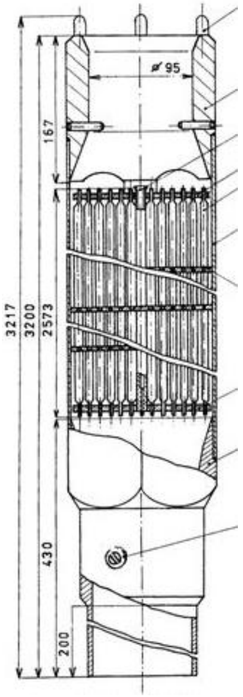
- **Source term analyses**
- **Simple but still accurate model (COR)**
- **Detailed containment**
- **Quick runtimes**
- **Sensitivity study ready**
- **Universal for every possible SA case**
- **Postulate IVMR not model it**
- **Have it yesterday**

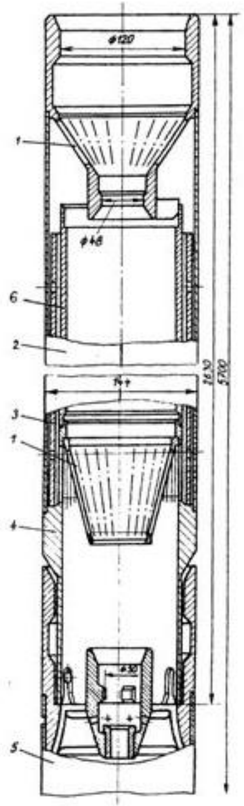


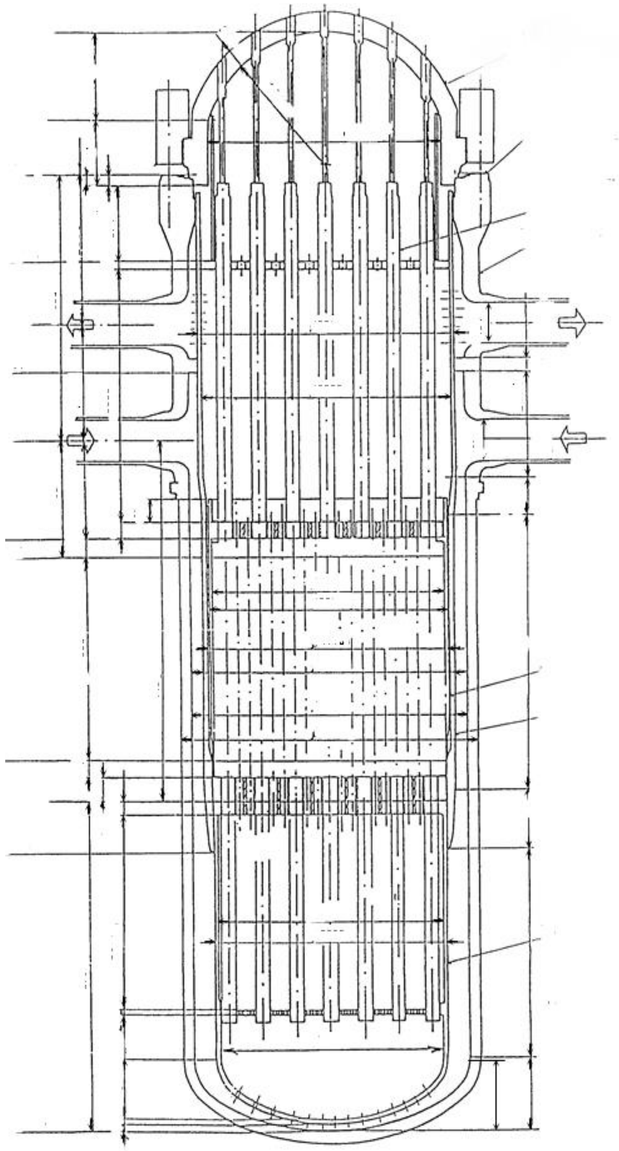
VVER 440 GENERAL GEOMETRY

- **Almost flat elliptical lower head**
- **Control „HRK“ assemblies under the core**



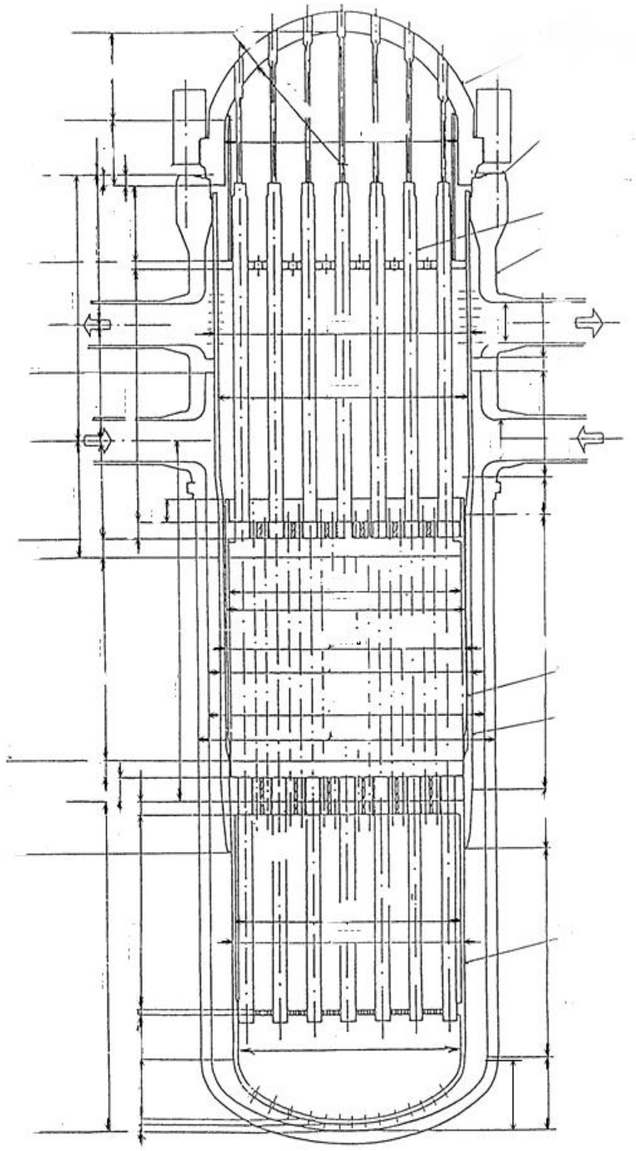






APPROACHES TO A MODEL

- There has been at least 3 different models in the **UJV Group**.
- **PWR vs BWR**
  - Channel vs Bypass between the fuel
  - NS vs CN for fuel envelopes
- **Where should the core end?**
  - HRK assemblies should be up vs down
  - What is best for power distribution/ IVMR/ thermal hydraulics
- **How to model the cavity?**
  - concentric CVH rings vs 2 CVH vs 1 CVH



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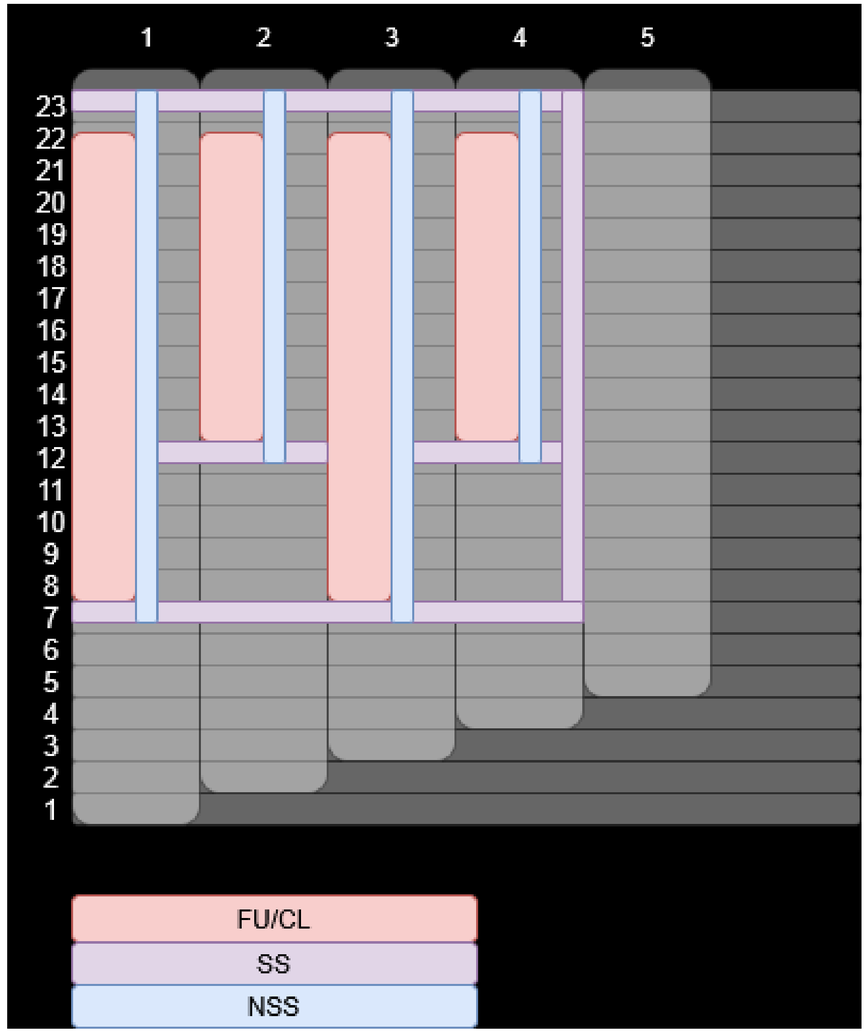
MODEL STATE FROM THE END OF 2024

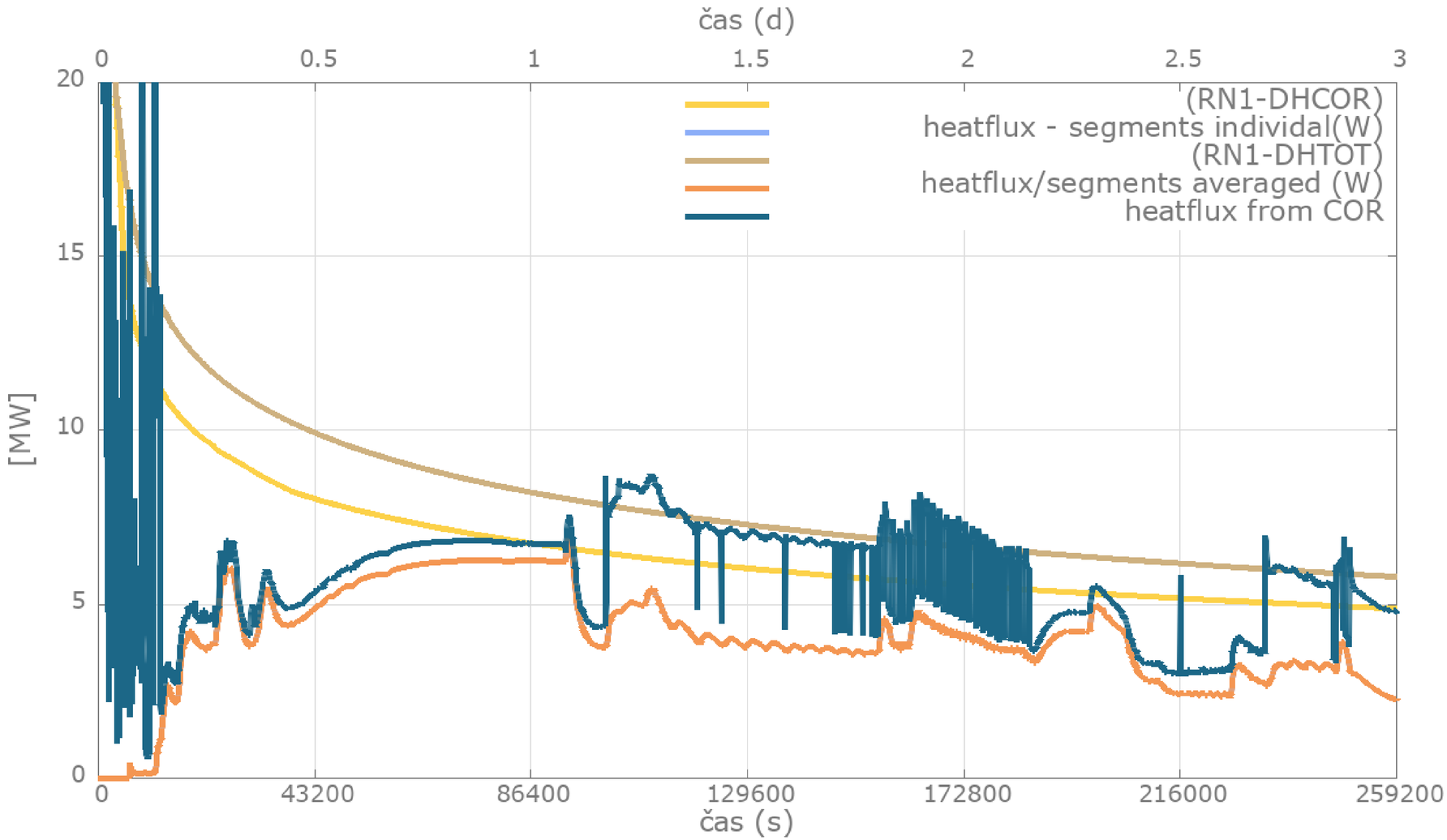
- PWR without bypass (runtimes)
- Fuel envelopes as NSS
- Core all the way down
- Fallen control assemblies
- 1 CVH cavity under the RPV



HOW TO POSTULATE IVMR (1)

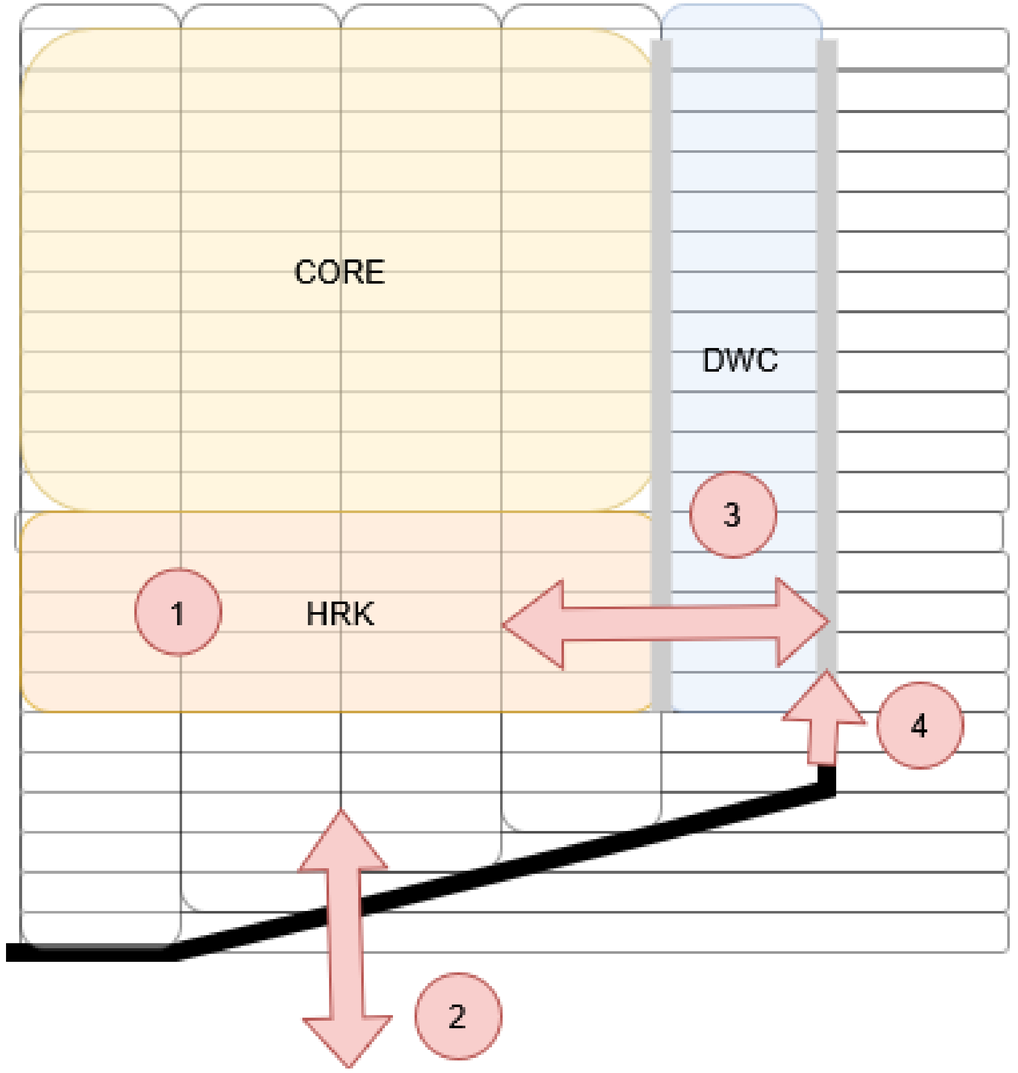
- 1 CVH cavity under the RPV
- No critical heat flux
- No Larsson-Miller creep failure
- No “MODEL” for alpha from MP1/MP2/PD
- Tune the alpha as CF that are connected to the decay heat
- Gave significant results when tuned only for PD (it is cooled off from melt at the bottom of the RPV)

HOW TO POSTULATE IVMR (2)

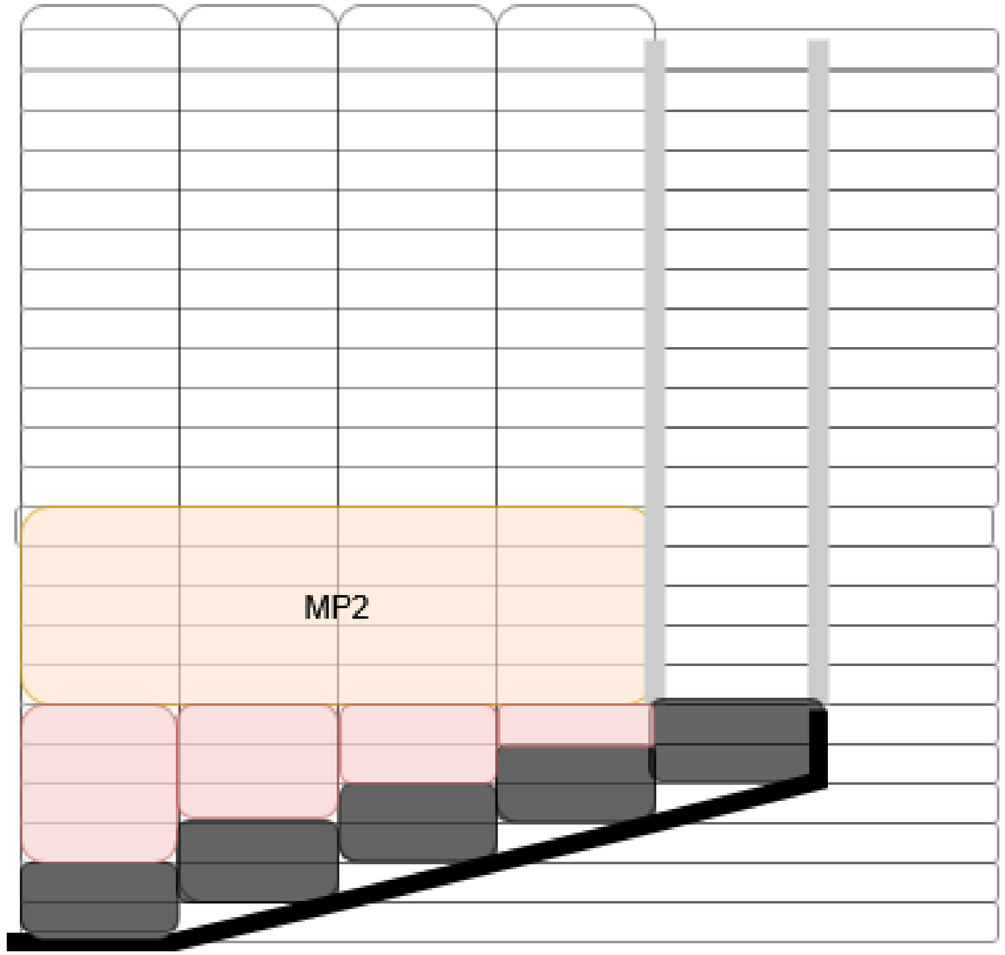


CHALLENGES OF THE CURRENT APPROACH

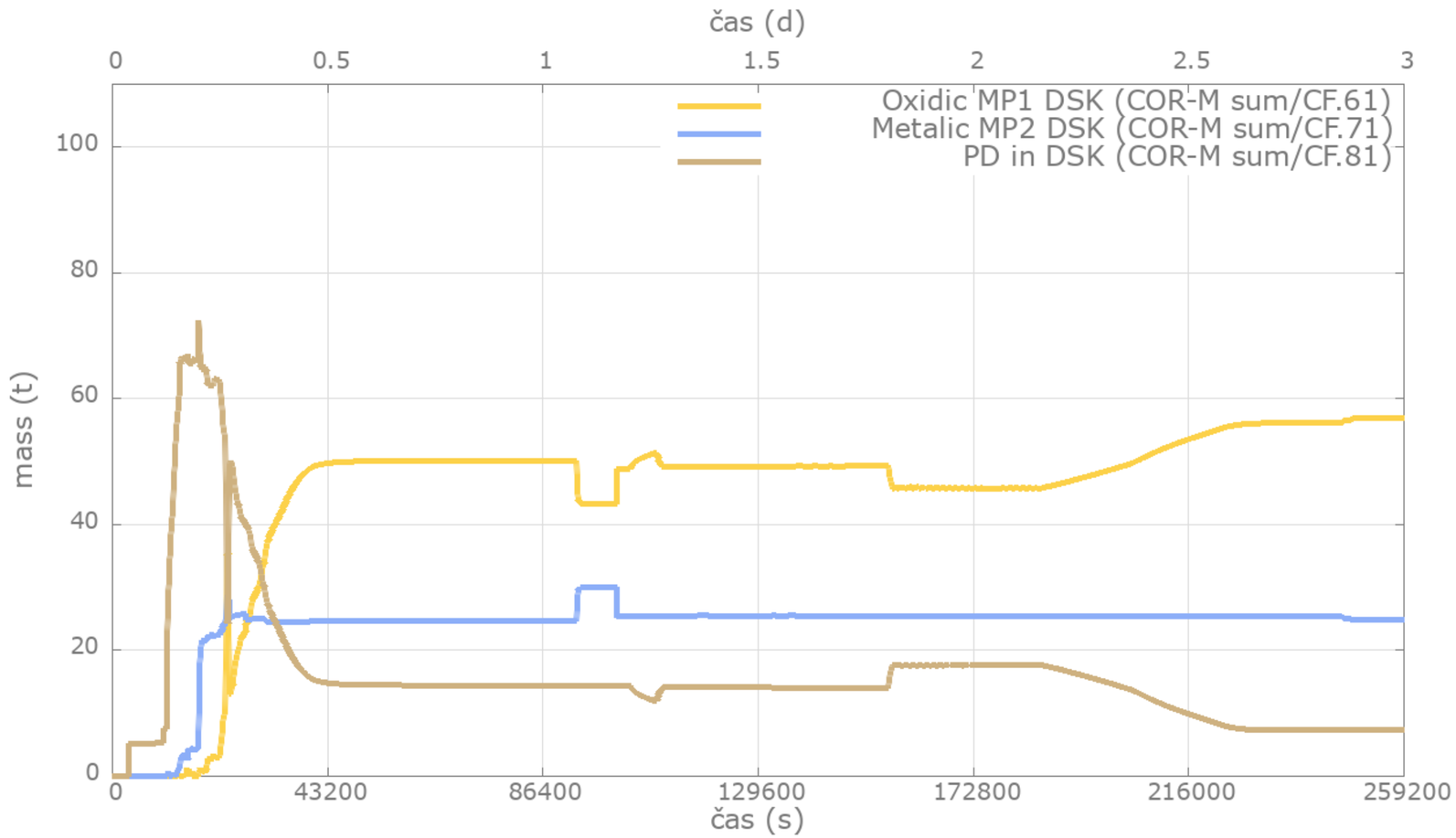
- 1 – Lower head is full
- 2 – Heat through the LH/melting
- 3 – Core barrel radiation
- 4 – RPV/LH axial heat conduction



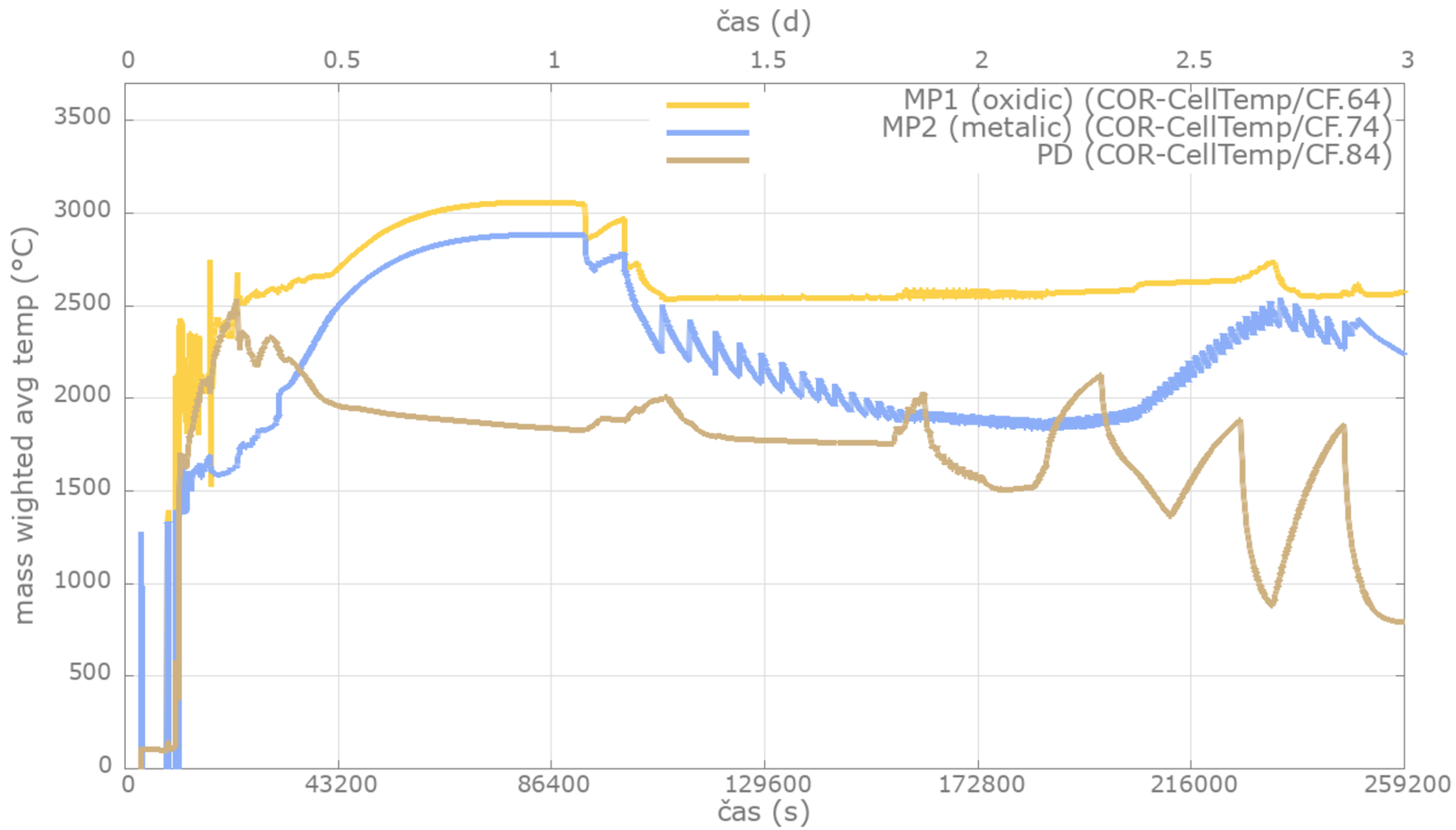
HOW MELCOR SEES OUR IVMR



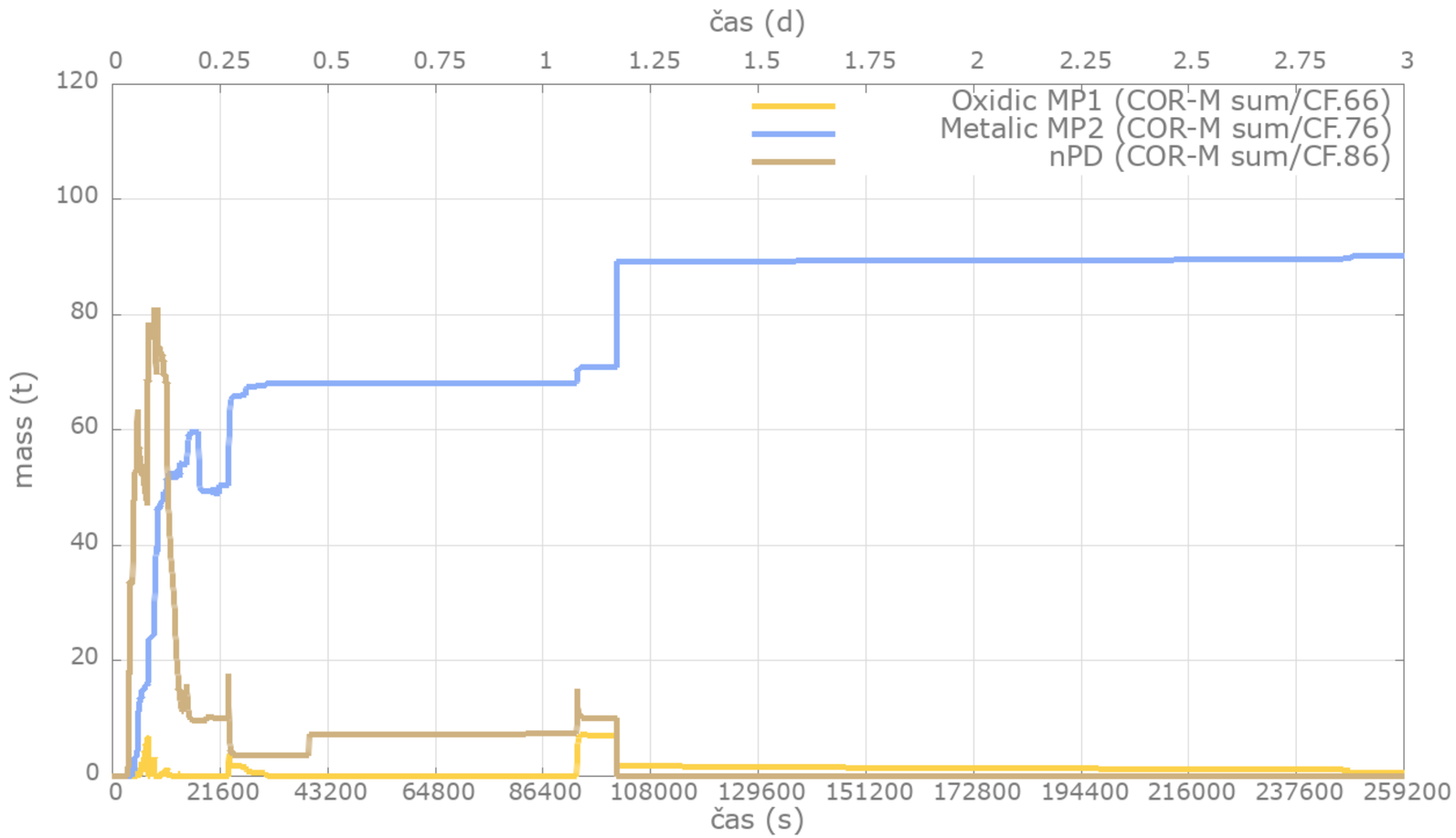
1 – MP1/MP2/PD IN THE LOWER HEAD (1)



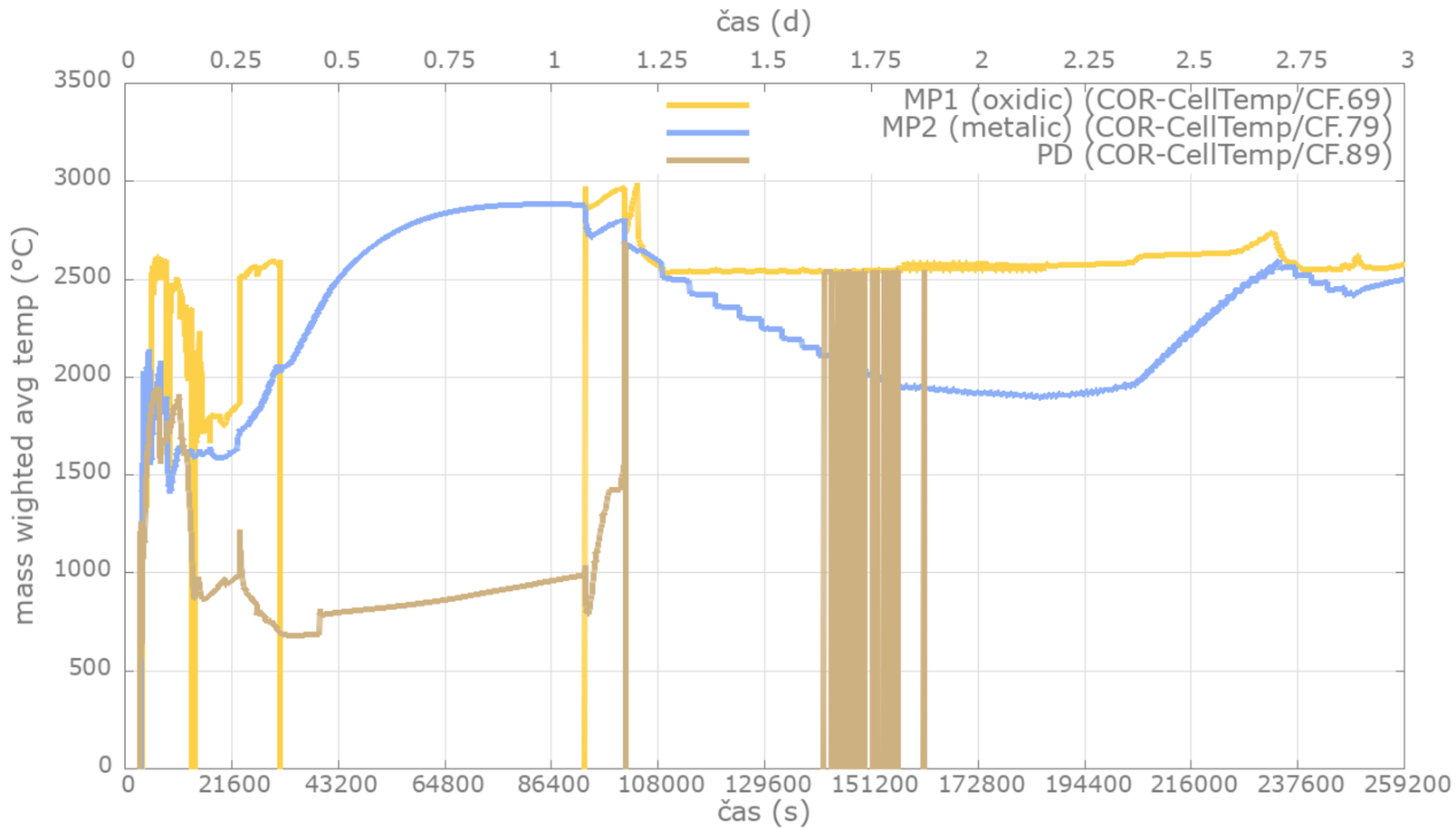
1 – MP1/MP2/PD IN THE LOWER HEAD (2)



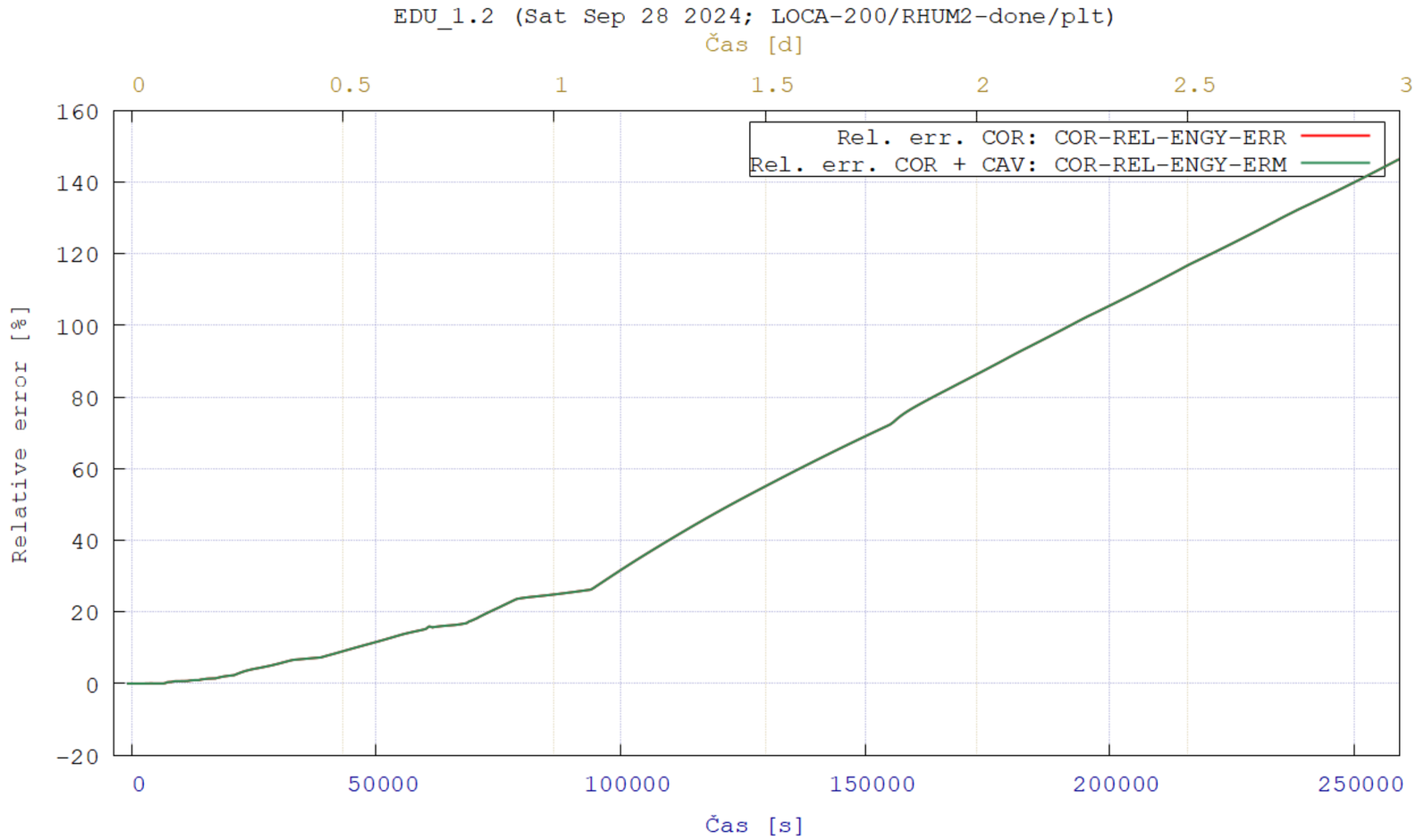
1 – MP1/MP2/PD ABOVE THE LOWER HEAD (1)



1 – MP1/MP2/PD ABOVE THE LOWER HEAD (2)



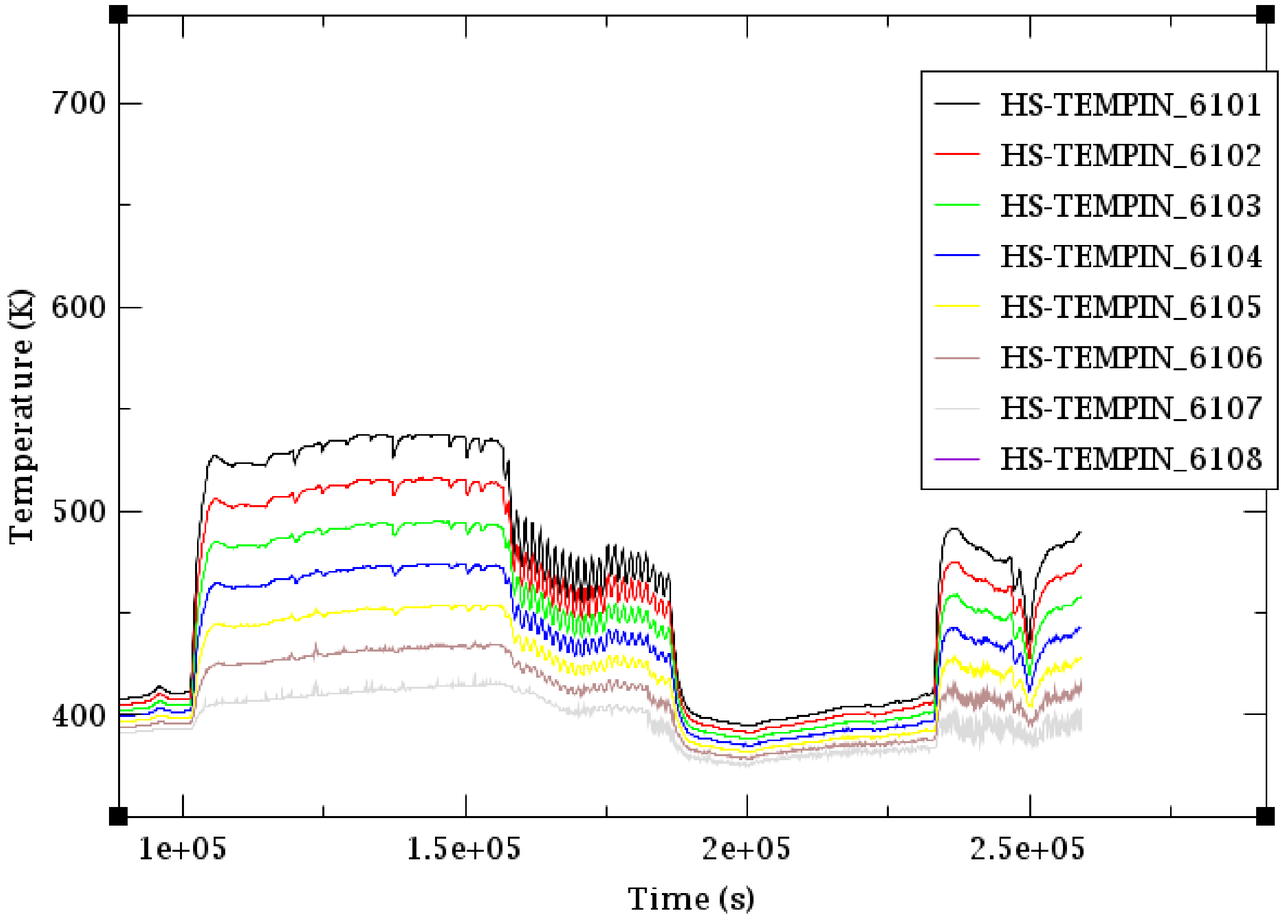
2 – LH MELTING AND ENERGY ERRORS



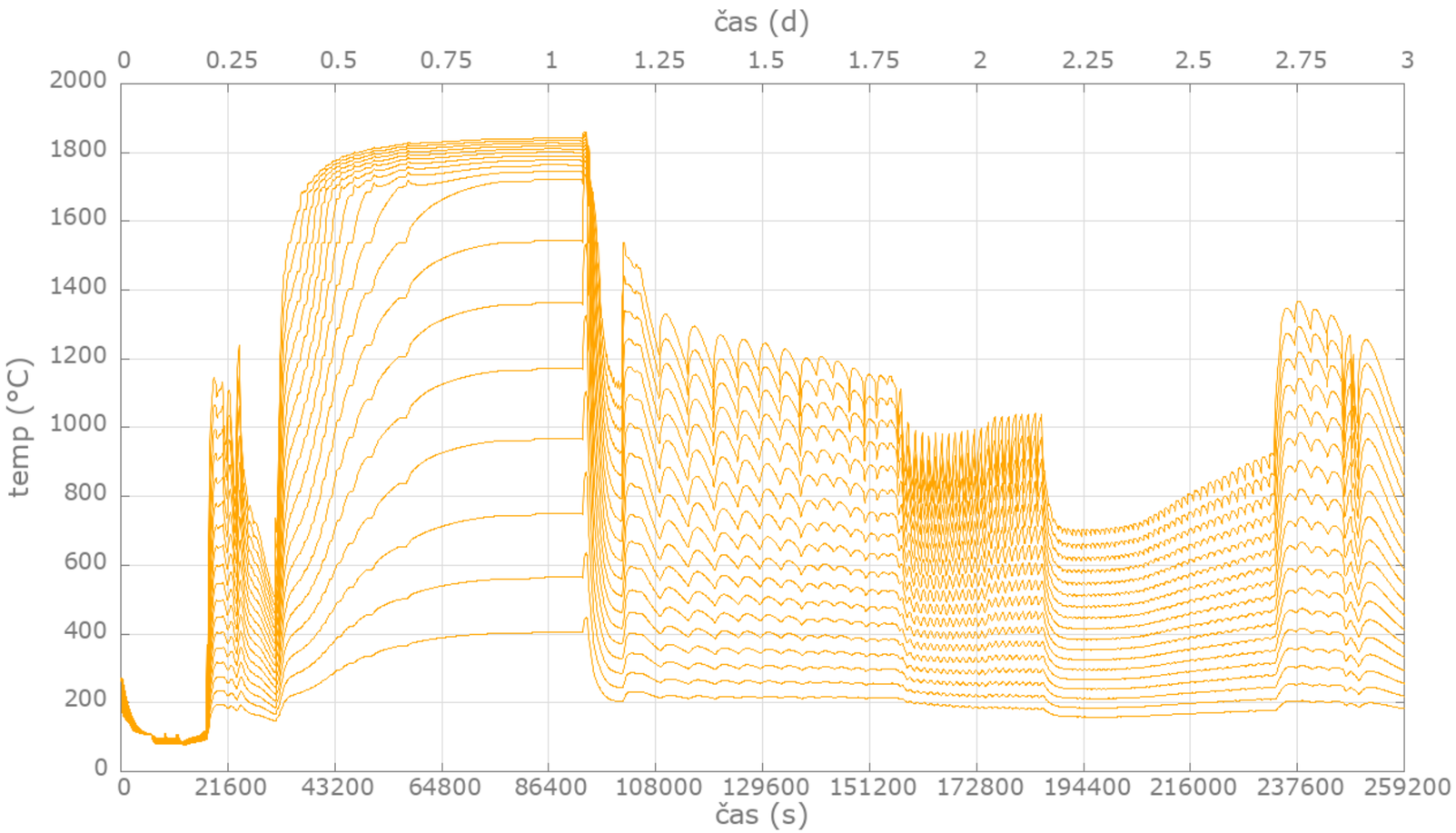
CHALLENGES CONCLUSIONS 1-2

- The lower head is full of debris that is created by IVMR cooling and in a way “insulates” the MP1/MP2 system -- > for postulation only alpha from debris matters for the heat transfer through the LH
- Enabling the critical heat flux and creep was destroying the vessel
- It might be worthwhile to have cavity as 2 CVH for separate CV_ARE input for internal velocity in the CVH which heavily impacts the convection
- The model with control assemblies up and very high LH should be considered -- > possible drawbacks in power distribution, thermal-hydraulics for any state where core is not completely melted

3/4 – TEMPERATURE PROFILE IN RPV



3/4 – TEMPERATURE PROFILE IN 7TH SEGMENT



CHALLENGES CONCLUSIONS 3-4

- The current best approach for the downcomer region when considering the low LH approach is to not have degassing and melting for boundary HS so it has radiation heat transfer to the RPV (via HS_RD – not in these graphs

- We did not know about the option of user defined heat transfer between the COR components and HS, mentioned by Larry yesterday during his presentation (I am afraid of how much data it would take to justify such user definition)

- The RPV is not in COR so any way of solving axial heat transfer would be highly arbitrary and require a ton of data/experiments to be properly implemented by user

MELCOR “WISHLIST”

- **CF vectors addressable from outside the CF package (can be worked around)**
- **Possibility to have a lower head region, that could be extended during the accident (can be worked around)**
- **Possibility to have a lower head region nodalization even more free from core nodalization (might be irrelevant without the rework of the melt behaviour, possibly not necessary)**
- **Better way to model heat transfer through RPV for IVMR without rigging it significantly – even simple set up that would enable user to transfer the RN1-DHCOR exactly as a way to postulate would be at this moment better than a mechanistic approach with how LH and CVH work**
- **Axial pairing of the upmost LH segment to the RPV HS for conduction**
- **Solved the inside of LH melting without energy error (thanks!)**
- **Resuspension of RN from the pool is crucial for IVMR**

Thank you for attention!

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