Czech Nuclear Society

ČNS – Expert's View on MELCOR Code Applicability

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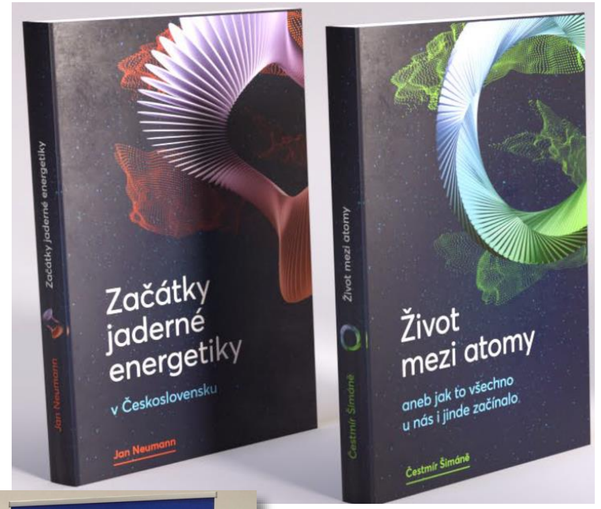
EMUG 2025 – European MELCOR Users Group Meeting

Outline

- Czech Nuclear Society
- MELCOR Code History
- EMUG
- User’s Errors
- Conclusions

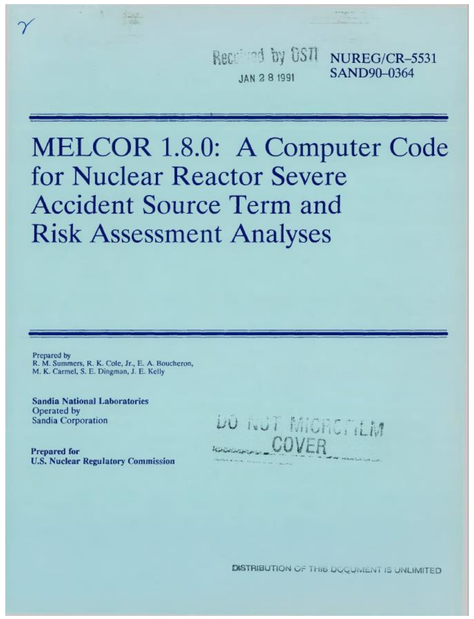
Czech Nuclear Society

- **The main goal is to connect the Czech nuclear community, carry out awareness-raising activities, assist in educating the public in the field of nuclear energy and disseminate objective information in the field of peaceful use of nuclear energy**
  - Founded 1990, Member of European Nuclear Society
  - Individual and Corporate membership
  - Publication activities, Promotion of civil Nuclear applications
  - Organization of conferences and workshops
  - Consulting and independent professional support
  - Awarding of student’s activities
  - Cooperation with partner societies



MELCOR Code History

Sandia National Laboratories



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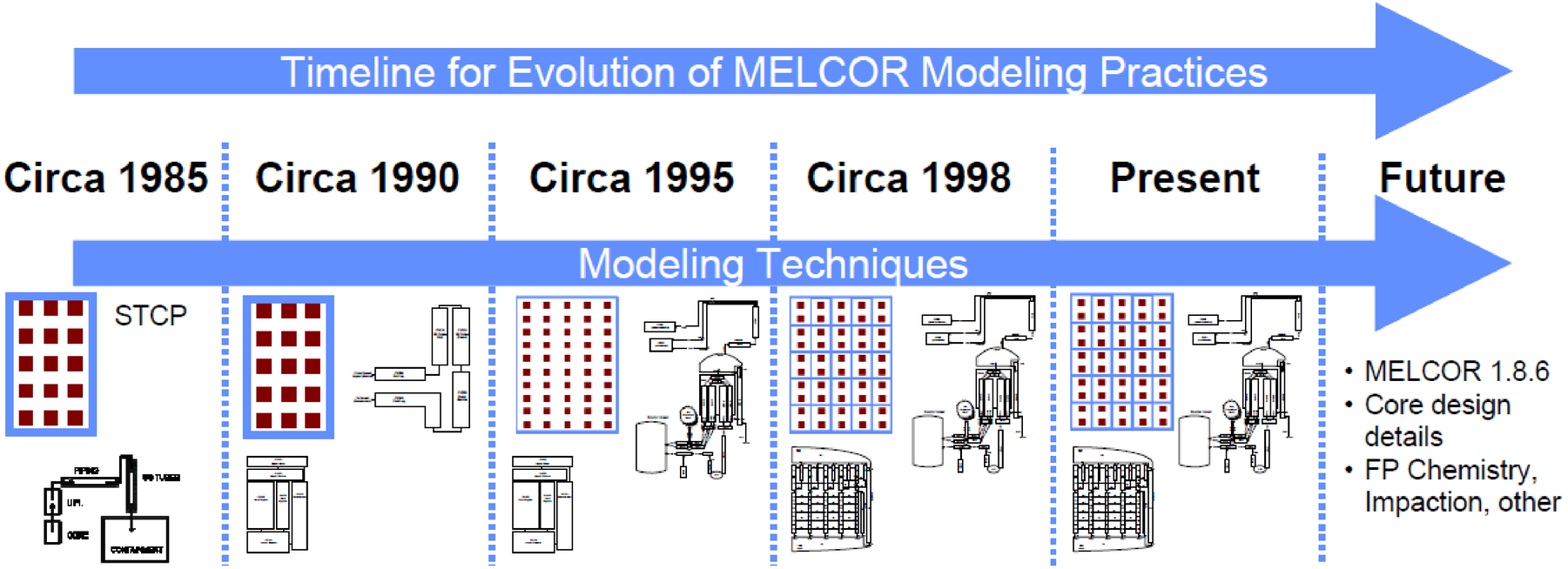
- **MELCOR code has been developing since 1982**
  - First release in USA MELCOR 1.6.0 (Oct ’86)
  - First international release (CSARP) MELCOR 1.8.0 (Mar ‘89)
- **Main objective - integration**
  - Replacement of individual modules coupled into package (STCP)
  - Elimination of hand preparation of interfaces between modules ⇦ **Source of user’s errors**
  - Direct feed back
    - Coupling of temperatures, releases, and decay heat
    - Transport of heat sources, including FP deposition

- **Since that time**
  - Several new generations of HW (started at Unix stations, later in 90’ PC, then Linux)
    - HDD 200 MB - plotfile ~30÷40 MB in middle of 90’ ⇦ very simple nodalization (like 2 CVs in Cntn)
  - Understanding of physical phenomena significantly improved
  - M182 and M183 – only one Other Structure in COR node – later distinguished SS and NS,
    - CF numbers only 001 – 999 (since M185 8-digit number, i.e. 10 millions of CFs)

MELCOR Code History

- **MELCOR code has significant progress in modelling approach – best practices**



Scott G. Ashbaugh: Best Prectices in Modeling Severe Accident Progression in Nuclear Power Plants, MCAP Meeting, Sept 23, 2005

EMUG History

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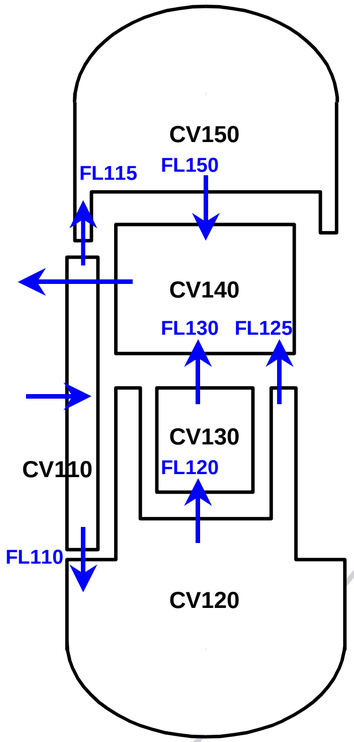
- **The first EMUG organized by PSI in Villigen in Dec 2008**
  - **Original idea of Dr. Salih Guentay, based on previously organized AMUG**
    - **Support from NRC H. Esmailli and SNL L. Humphries + European users J. Birchley, T. Haste, M. Sonnekalb, and others**
  - **Aims of EMUG (S. Guentay's presentation at the 1st EMUG 2008)**
    - **To provide a forum for the presentation and discussion of the experience gained by:**
      - MELCOR assessment using integral and separate-effect tests leading to presentation of performance of models and related issues including sensitivity to selected model parameters and model uncertainties,
      - Model development efforts
      - Application of MELCOR for plant safety studies, including L2 PSA, which demonstrates weaknesses and strengths of MELCOR models in reproducing the individual severe accident phenomena and interplay between them occurring in the nuclear and balance of plant systems and the effect of operator actions on the accident progression through user input as introduced in the code input models,
      - Use of code with different compilers and operating systems
    - **Prioritization of user error correction and model development needs, to be transmitted to the code developers and the NRC**
    - **To minimize the efforts required to obtain an adequate knowledge of optimum use of the MELCOR, through sharing of experience**
    - **To support the gaining of MELCOR knowledge and experience, particularly concerning the younger and less experienced users**

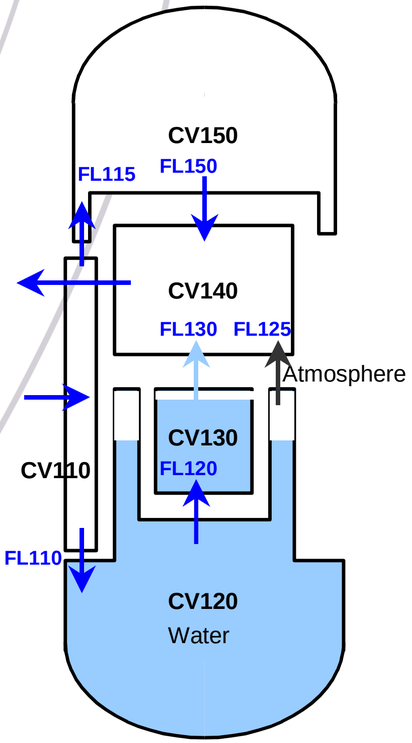
17 years of EMUG history confirmed this idea as really correct

User's Errors

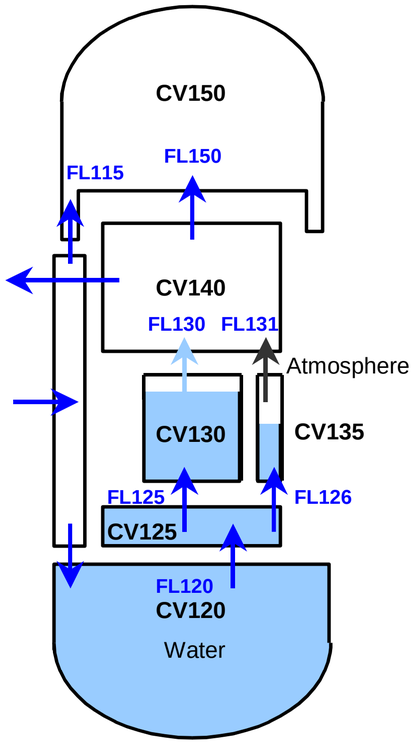
- **Slides in this section originally presented at MCAP 2008**
  - Based on my experience from support of MELCOR input conversion from 183 to 185 for plant input developed for IAEA Vienna
  - RPV Nodalization



Original



Partly uncovered

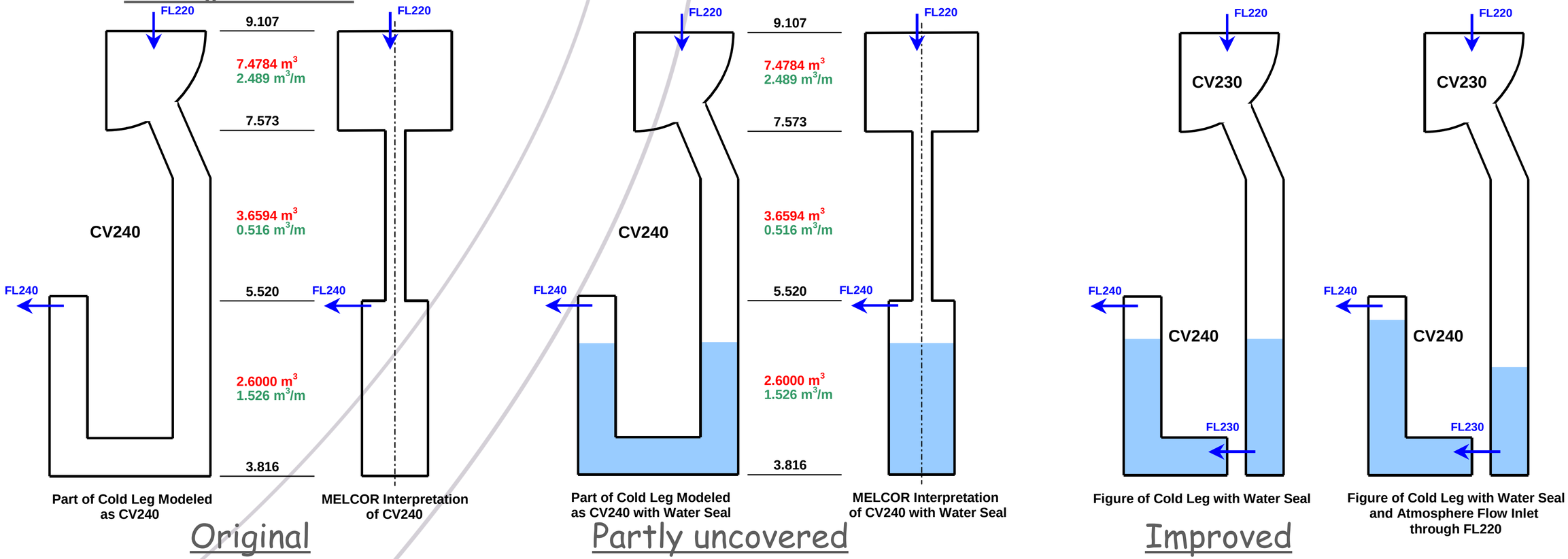


Improved

  - Water in core is boiling, in bypass is collapsed
  - Steam coming through FL110 is added into ATM in „bypass" and its interaction with water in CV120 is bypassed (SPARC model switched off in all FLs by default – in M183 as well as in M2.2 – parameters IBUBF and IBUBT)

User's Errors

- **Slides in this section originally presented at MCAP 2008**
  - Based on my experience from support of MELCOR input conversion from 183 to 185 for plant input developed for IAEA Vienna
  - Cold Leg Nodalization



- Steam coming through FL220 is added into common ATM of CV240 and this common atmosphere escapes CV240 via FL240

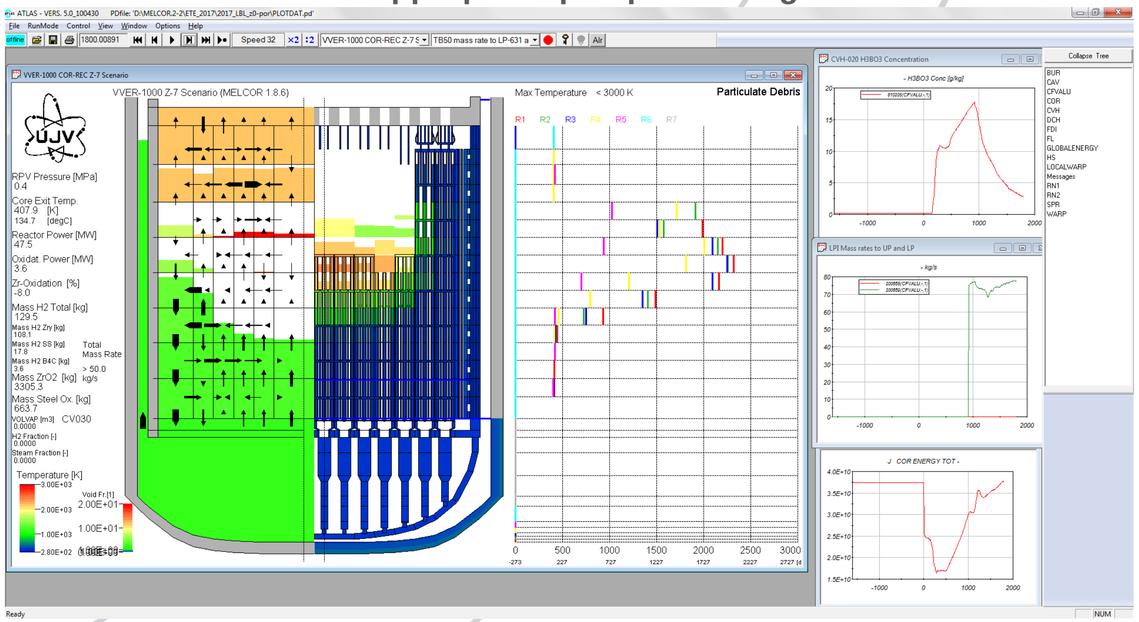
  Water seal is bypasses in original nodalization regardless of definitions of ZFM and ZTO parameters (Altitudes)

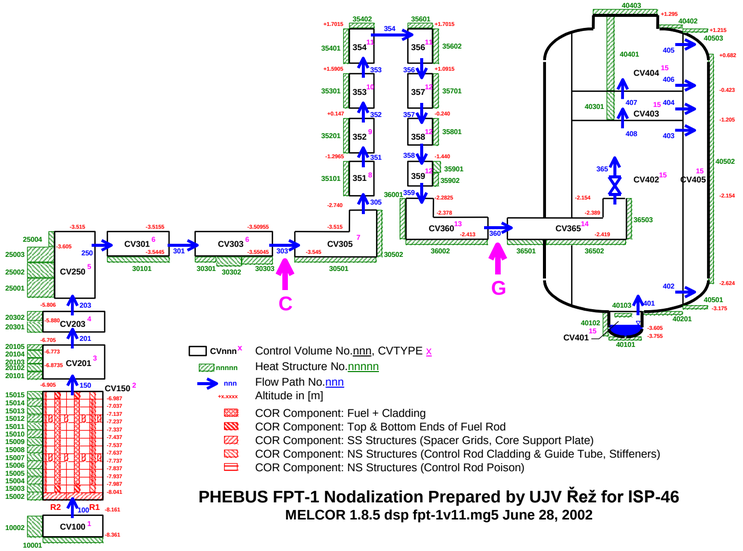
User's Errors

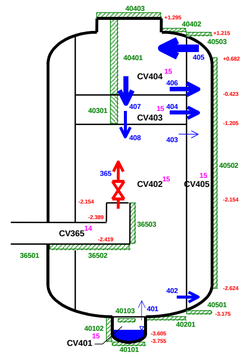
- **Slides in this section originally presented at MCAP 2008**
  - **Based on my experience from support of MELCOR input conversion from 183 to 185 for plant input developed for IAEA Vienna**
  - **<u>Other user's errors</u>**
    - **Reactor pressure vessel (misunderstanding of COR and CV-FL-HS roles)**
      - Duplicity of modeling of internals and lower head
        - Modeled as Other Structure in COR Package and also as Heat Structure
      - Absence of structures
        - Only part of upper plenum internals modeled – underestimation of surfaces for FP retention
    - **Primary circuit**
      - Absence of structures
        - Only part of primary pipes modeled as HS – underestimation of surfaces for FP retention and underestimation of heat losses to containment
        - All primary and secondary HS connected to Cntn had adiabatic condition on outer surface
    - **Absence of important FL**
      - During the calculation of SBO scenario, primary circuit pressure started increasing after secondary water boiled off ⇨ run aborted due to condition of pressure over 20 MPa
      - Pressurizer valves modeled using two FLs to bubble tank CV (30 m^3), but this is not connected with any other CV (containment) - user was happy with model (valves correctly opened at beginning of pressurization), but **the MELCOR code was denoted as "wrong"!!!**
    - **SBO timing differences observed (comparison to RELAP5 model of the same NPP, much longer in MELCOR)**
      - My identifications - steady state mass of water in SG secondary and decay power differ (more than 20 % in DCH), and wrong control of FW termination resulted in overfilling of secondary side ⇨ time to SG boil off much longer in MELCOR
    - **Absence of real steady state calculation**
      - Only 10 s calculated for initiation and "fitting" of important values (pressure, temperature) within uncertainty range (1000 s steady state calculation resulted in reactor SCRAM!!!)

Conclusions

- **Only reading of manuals (all three volumes) is not sufficient to be expert in MELCOR**
- **To become real expert, you have**
  - To check input file interpretation by MELCOR in MEGOUT output ⇦ important during new model development mainly
  - To prepare baby-cases to confirm correct modelling of simulated phenomena or to demonstrate observed errors
  - To perform validation against experiments – from SET to integral ones
  - To perform validation against real accidents (TMI or Fukushima) or code-to-code comparison
  - To perform deep result evaluation and interpretation ⇦ to take into account simplifications of models in the code and in input
    - Error progression in integral simulation
  - To use appropriate postprocessing tools – visualization of more output parameters together (time evolutions of parameters are insufficient)







Integral model of FPT-1 experiment

stand-alone Cntn

Acknowledgement
Presented MELCOR activities were gained within more than three decades of author's employment in ÚJV Řež, a. s.

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Thank you for your attention