
ÚJV Řež, a.s.

# Modeling a Gas Cooled Fast Reactor in MELCOR 2.1

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8th EMUG, London, April 6-7, 2016

EMUG

# CONTENT

- **Wraped-up:**


Source: https://cdn.meme.am/instances/37508219.jpg

**Detailed:**

**GFR ALLEGRO**

**MELCOR model of ALLEGRO**

**Troubles and solutions**

**Results**

# GFR ALLEGRO - project

- **A concept of prototypic GENIV GFR**
  - Originally developed by CEA (2001-2011), continues in Central Europe since 2013
  - Goal: to test GFR-related technology, qualify a new type of refractory fuel, demonstrate viability of the GFR concept

- **Legal frame: Association „V4G4 Centre of Excellence“**
  - Registered in August 2013 in Slovakia
  - **VUJE** (general. designer): Design & Safety (with ÚJV assistance)
  - **ÚJV Řež:** **R&D and exp. support (He technology, …)**
  - **MTAEK** Budapest: Fuel
  - **NCBJ** Swierk: Materials

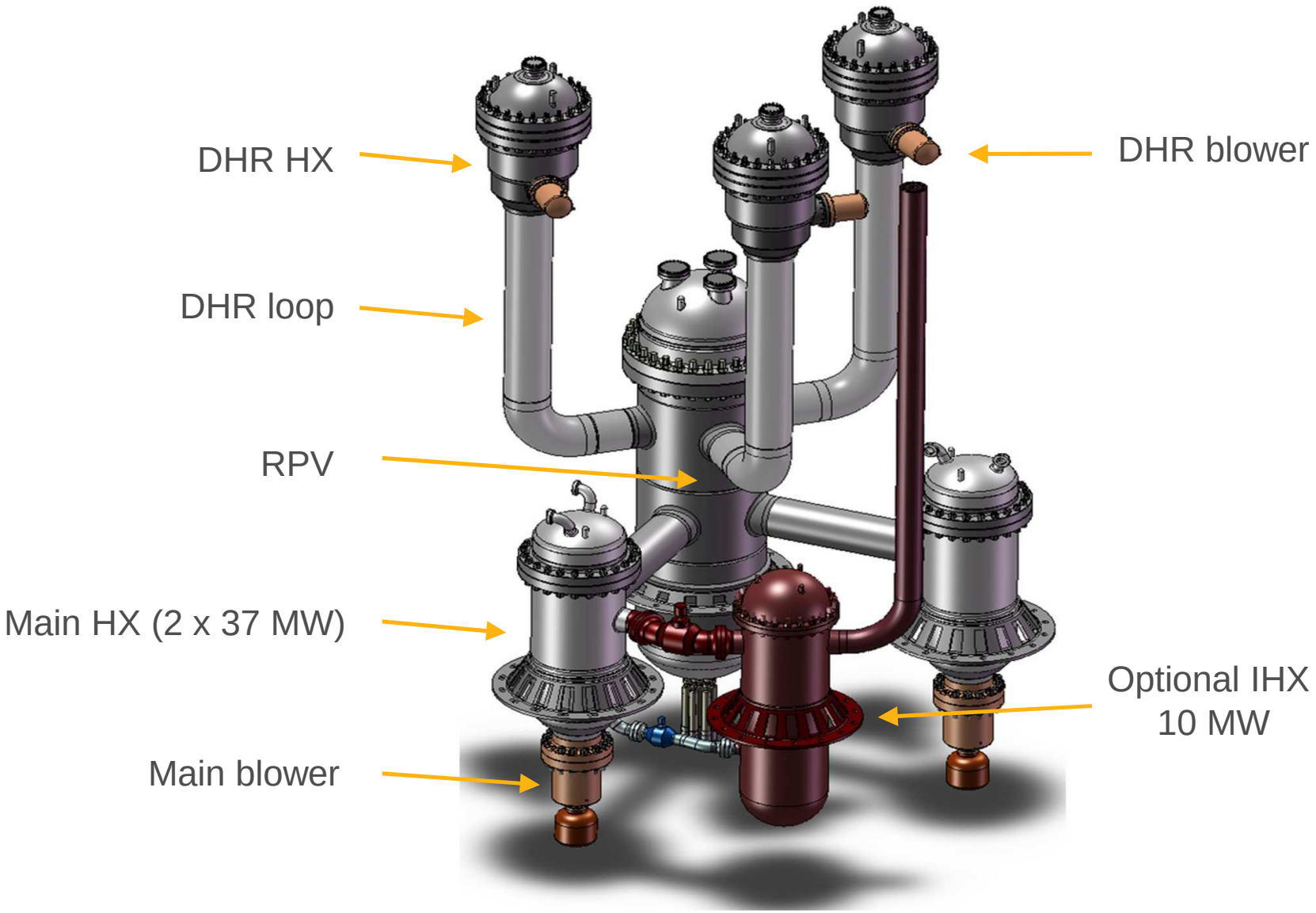
  CEA plans to become associated member (observer to support V4G4)

# GFR ALLEGRO - specifications

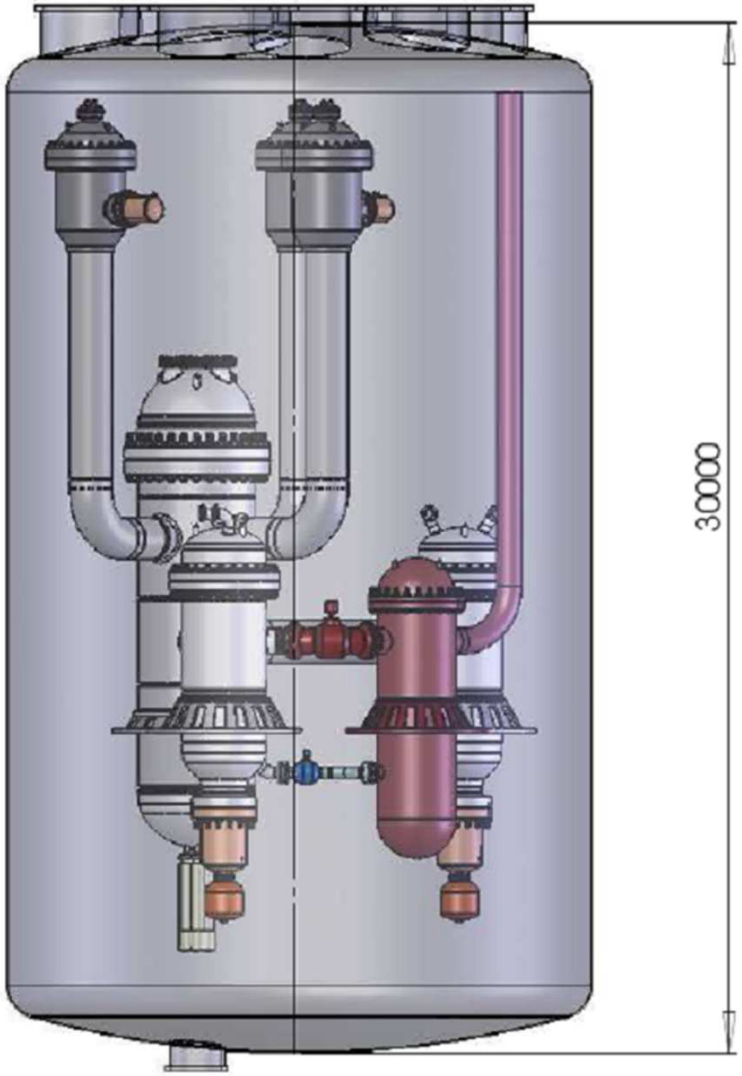
- **ALLEGRO concept:**
  - Reactor unit size: **75** MWt
  - Core power density: **100** MWt/m$^3$
  - Coolant: **He**
  - Nominal pressure: **7** MPa
  - Fuel forms: **MOX or UOX pin-type** (starting core)
    **Carbidic pin-type** (refractory core)
  - Core outlet temperature: **530**°C (starting)
    **750-850**°C (refractory)

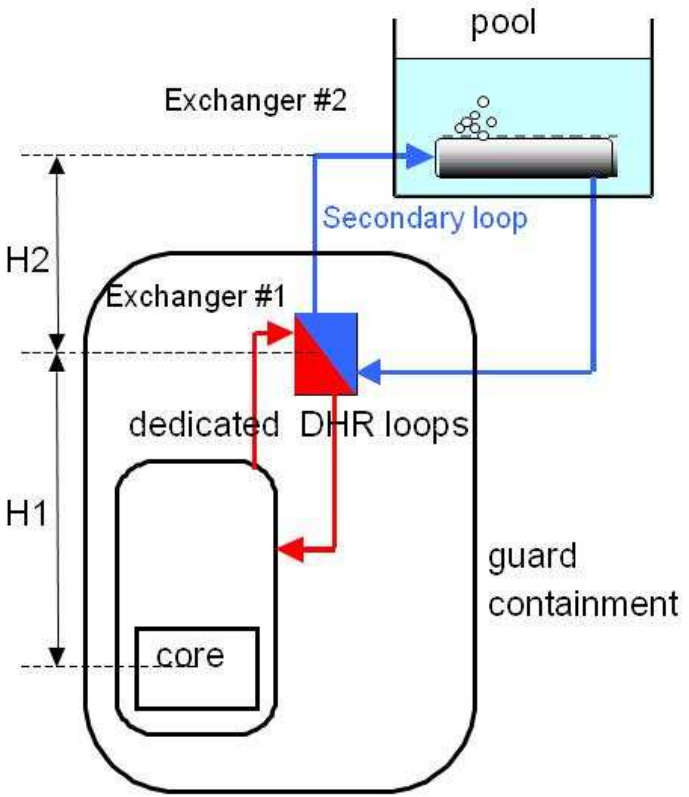
- **SAs in ALLEGRO:**
  - One of the chapters in ALLEGRO development roadmap
  - SA analyses as a basis for core catcher design and SAM development

# CEA ALLEGRO 2009 (75 MWt)

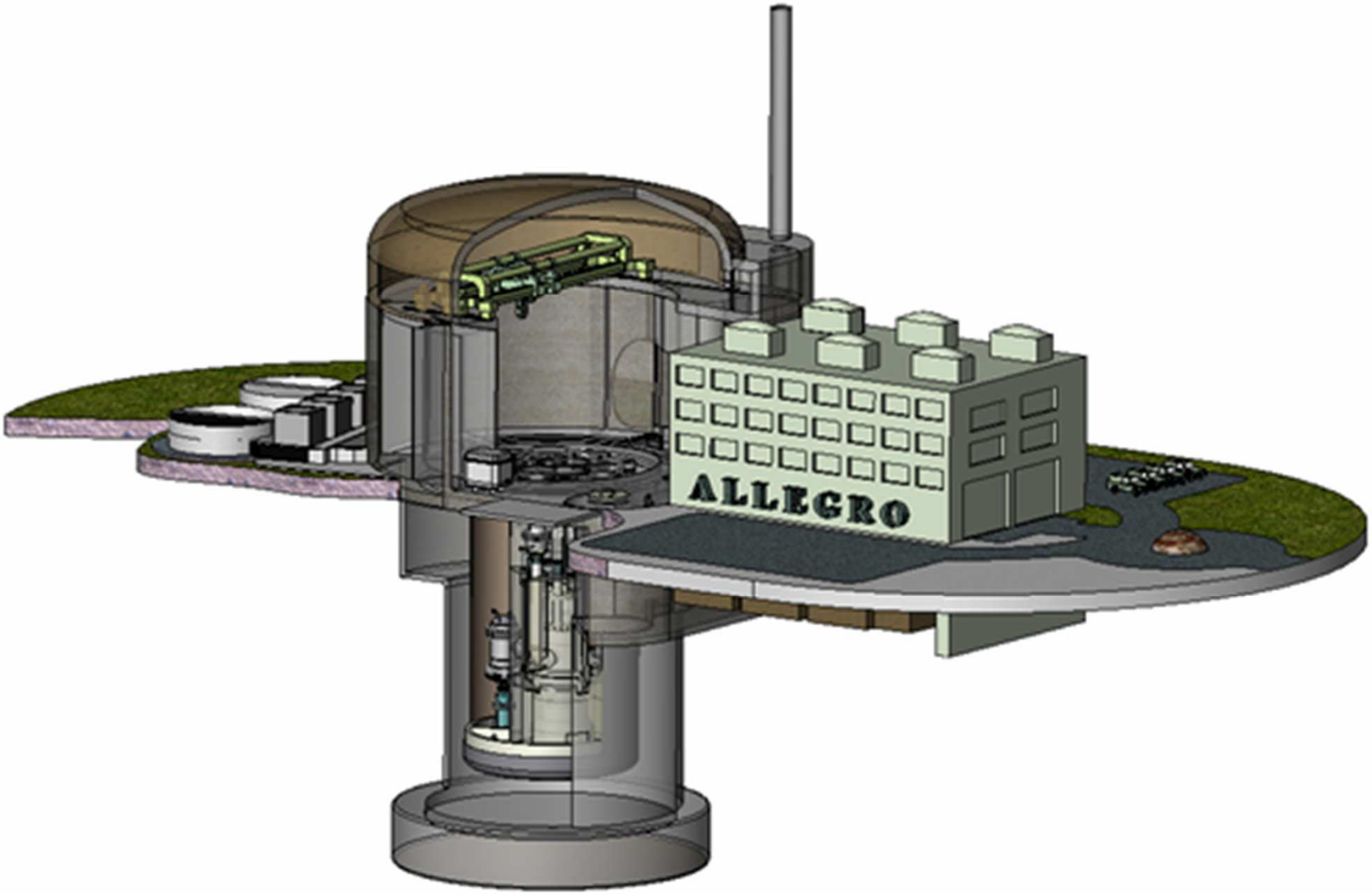


# ALLEGRO close containment

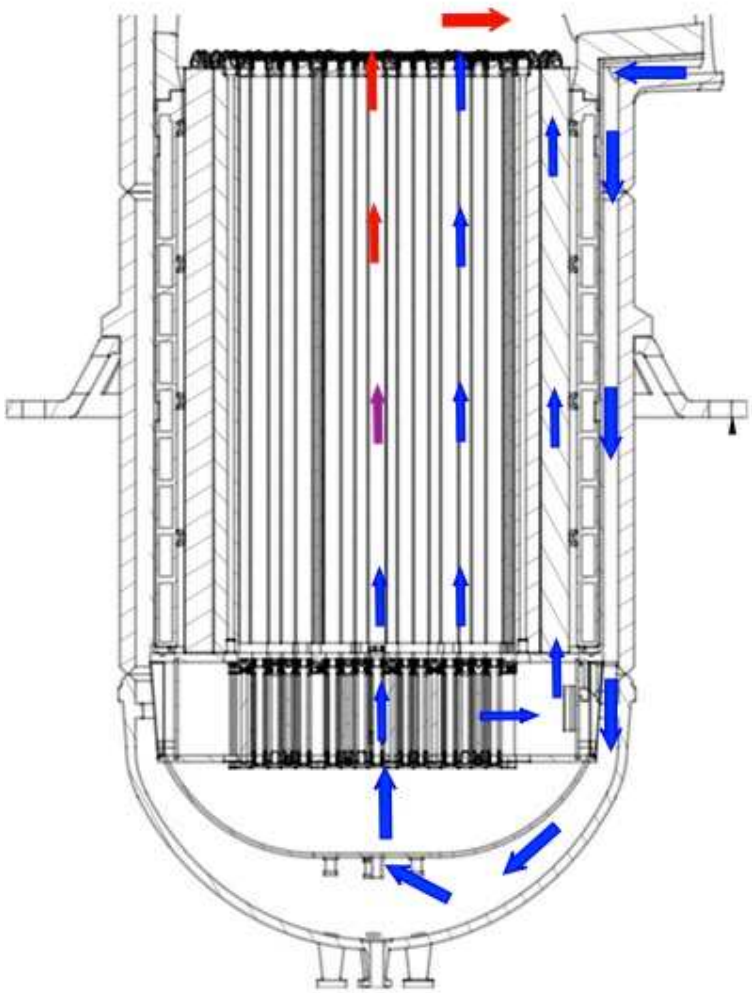


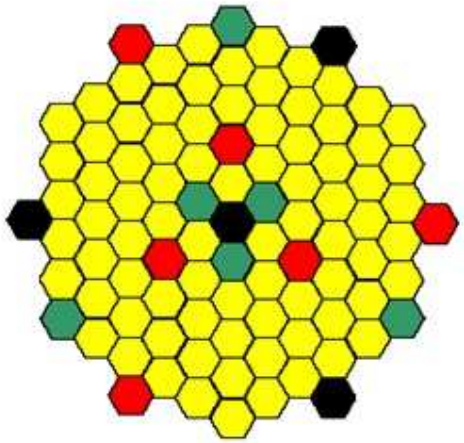



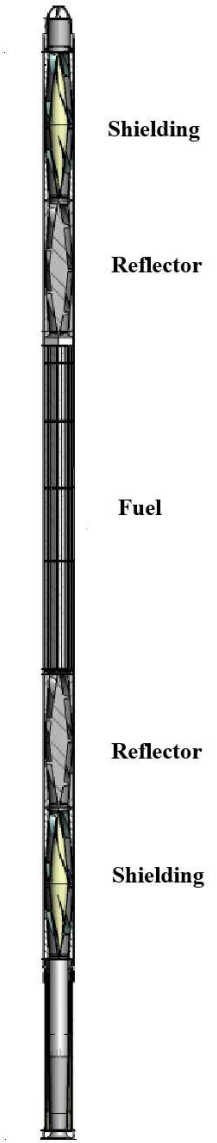
# ALLEGRO – global facility



# ALLEGRO - MOX Core





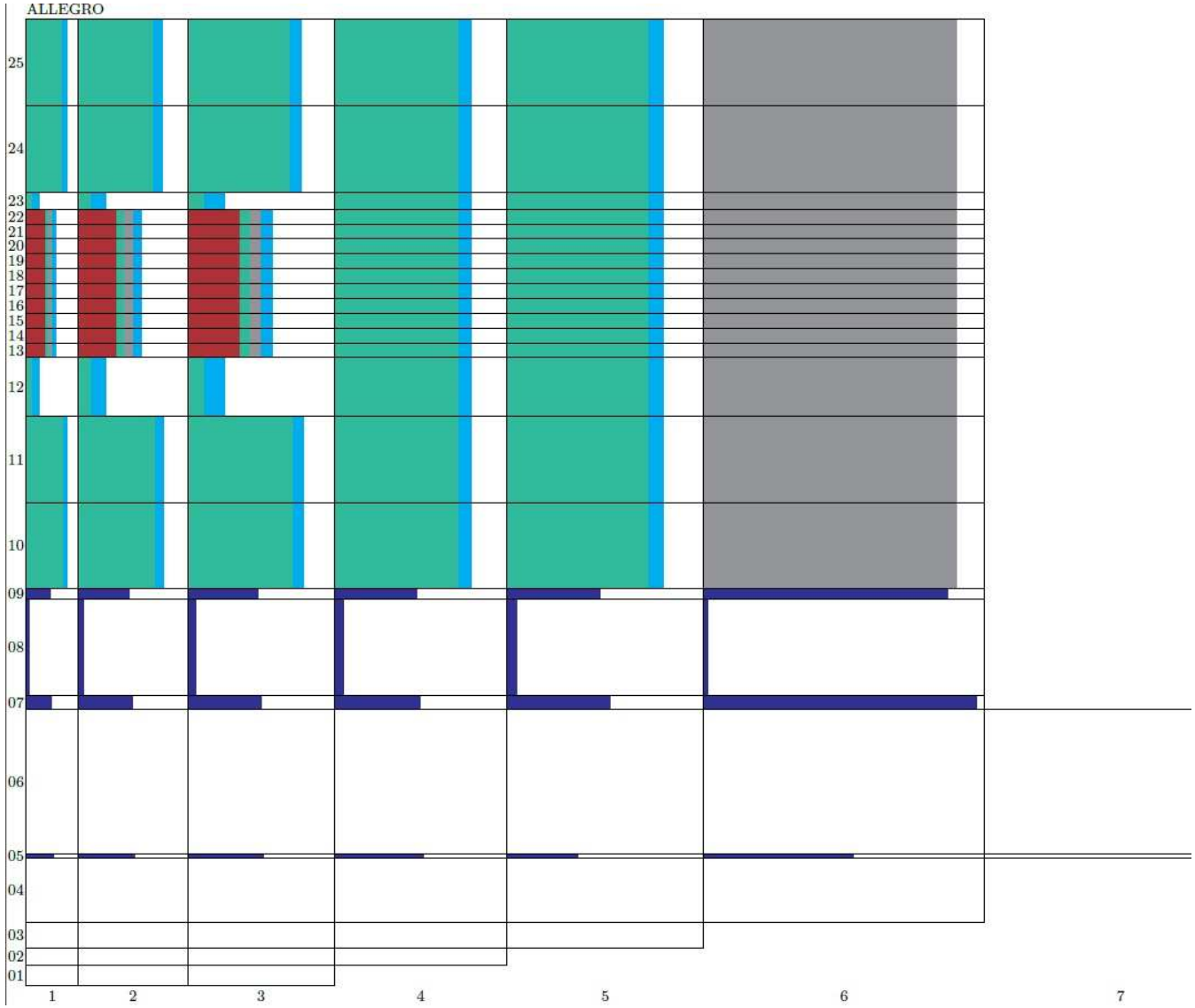
# ALLEGRO COR model

- **Core featuring  a bypass**

–> BWR model used

- **BWR model puts NS to bypass**

– NS modeled as cladding in regions with bypass



# (Un)solved issues

- **MELCOR 1.8.6 calculations** **abandoned**
  - RN package off – no problem
  - RN package on – calculations fail each time after the first „gap release“ message by „math error“, no output is written in the diagnostic files.

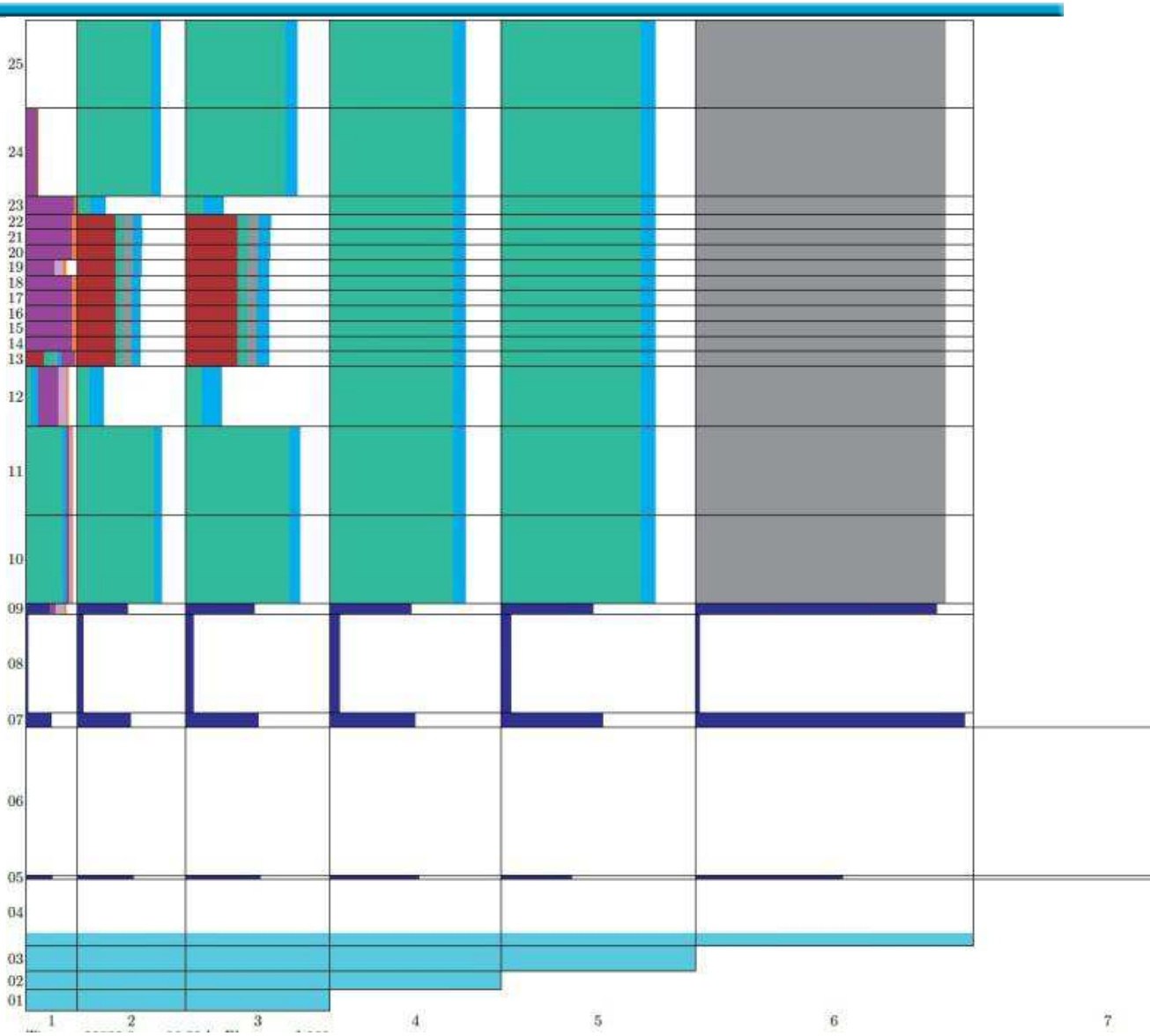
- **MELCOR 2.1 calculations**
  - Numerical instabilities leading to crashes in case of natural convection mode in the DHR system during blackout. 1.8.6. had no problem using the same input. **Solved (by developers)**
  - Natural circulation calculations – still some problems, but propably caused by limitations of the code itself
  - Absence of aditional materials and material interaction models – limiting the usage of MELCOR to the first (oxidic) core only

# Analyses performed so far (and leading to a SA)

- **Pressurized scenarios**
  - SBO + LOHS
  - SBO + Water ingress from DHR system
- **Depressurized scenarios**
  - LB-LOCA with failure of 1 DHR compressor
  - Total cross-section break of one primary loop
  - SBO + SB-LOCA
- **„Promising“ scenarios to be analyzed**
  - Internal break (hot leg)
  - RPV breach
  - LOCA + failure of close containment

# SBO + Water ingress

- Water from one DHR HX penetrates the PC
- Cannot be isolated (coaxial pipings)
- No reactor depressurization (natural convection) -> steam condensation in RPV and liquid pool in lower head
- Partial core degradation due to steel oxidation

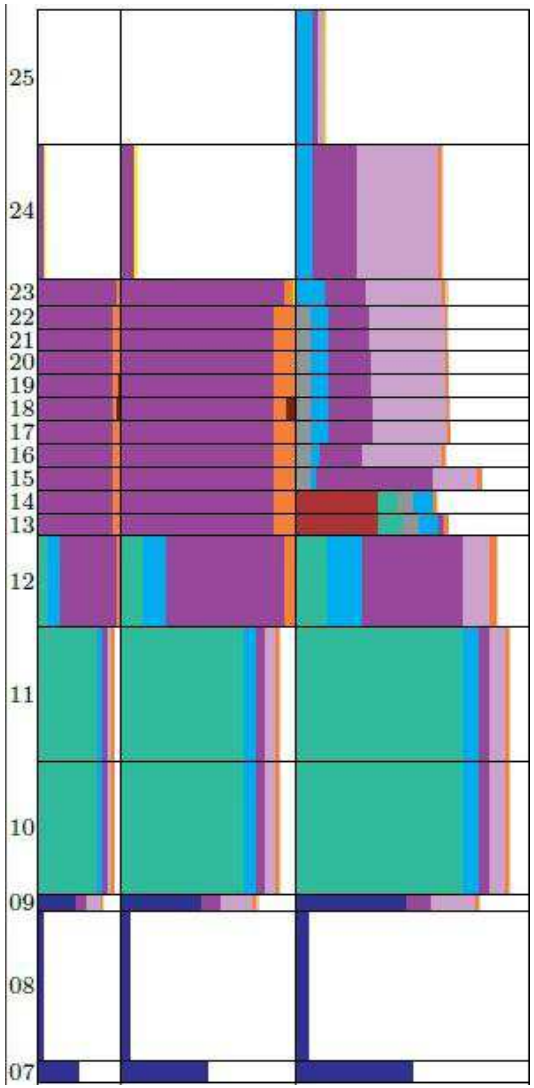


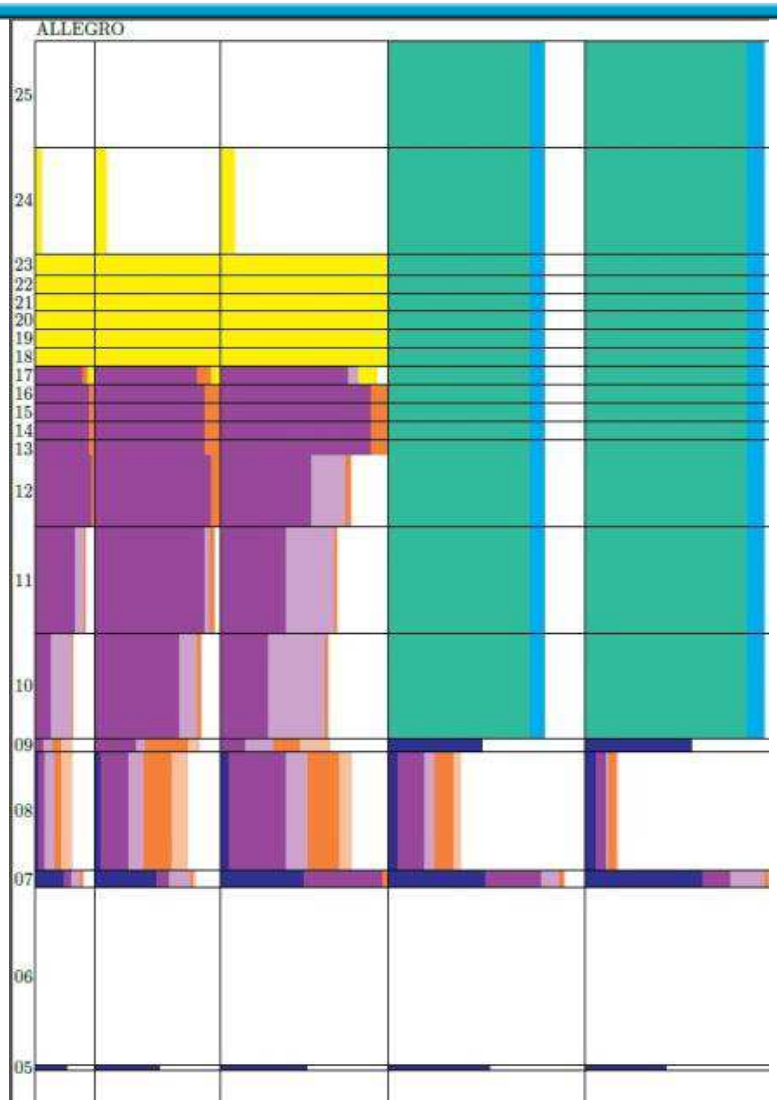
# SBO + SB-LOCA

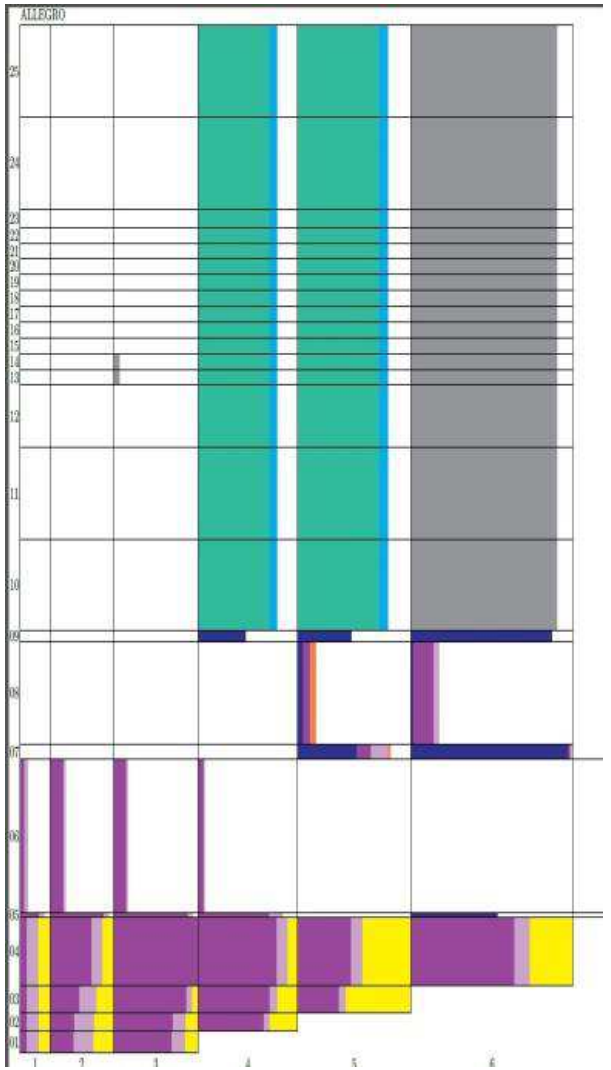
- Fast propagation – melting in 11 minutes
- Passive cooling of the core not effective enough
- Most severe kind of scenarios so far analyzed
- Design of the passive safety systems has to be updated

| Event | Time |
|---|---|
| First fuel pin rupture (gap release) | 212 s |
| First melting of cladding | 11 min. |
| No intact fuel in the core | 6.5 h |
| Upper support plate failure | 18.0 h |
| Lower support plate failure | 20.9 h |
| Lower head failure | 26.3 h |

# SBO + SB-LOCA





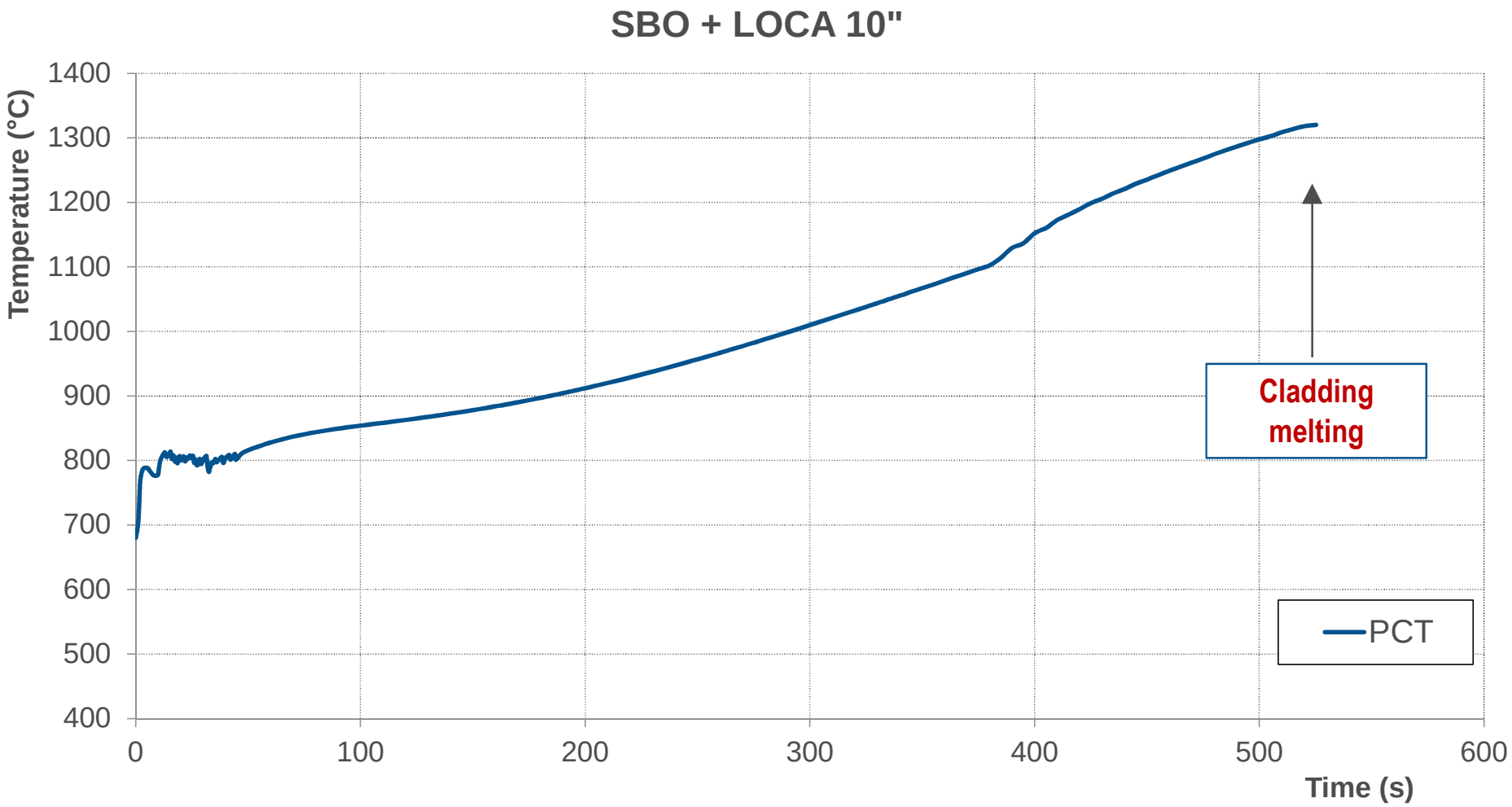



a) t = 4 h

b) t = 18 h

c) t = 23 h

# SBO + LB-LOCA = even more „fun“



# Future work (this and next year)

- Analyses of the remaining interesting scenarios
- ALLEGRO thermal-hydraulic benchmark (CATHARE2, RELAP3D, MELCOR 2.1)
- Unprotected transients calculations – ERANOS-MELCOR coupling
- Validation of MELCOR 2.1 using data from HTHL2  helium loop

# Conclusions

- ALLEGRO is still in (pre)conceptual phase – lot of changes in design expected
- Modelling of GFR in MELCOR is complicated but possible
- Passive systems still not able to handle the most challenging scenarios
- First actual changes in design based on MELCOR calculations being implemented

# Acknowledgement


- This work was co-financed by the Technology Agency of Czech Republic, project TACR-CANUT