ÚJV Řež, a.s.

GFR modeling in Melcor 1.8.6 experience, troubles, solutions

Petr Vácha

petr.vacha@ujv.cz

7th EMUG, Brussels, March 17-18, 2015

CONTENT

- GFR ALLEGRO
- MELCOR model of ALLEGRO
- Troubles and (sometimes) solutions
- Results

GFR ALLEGRO - R&D

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

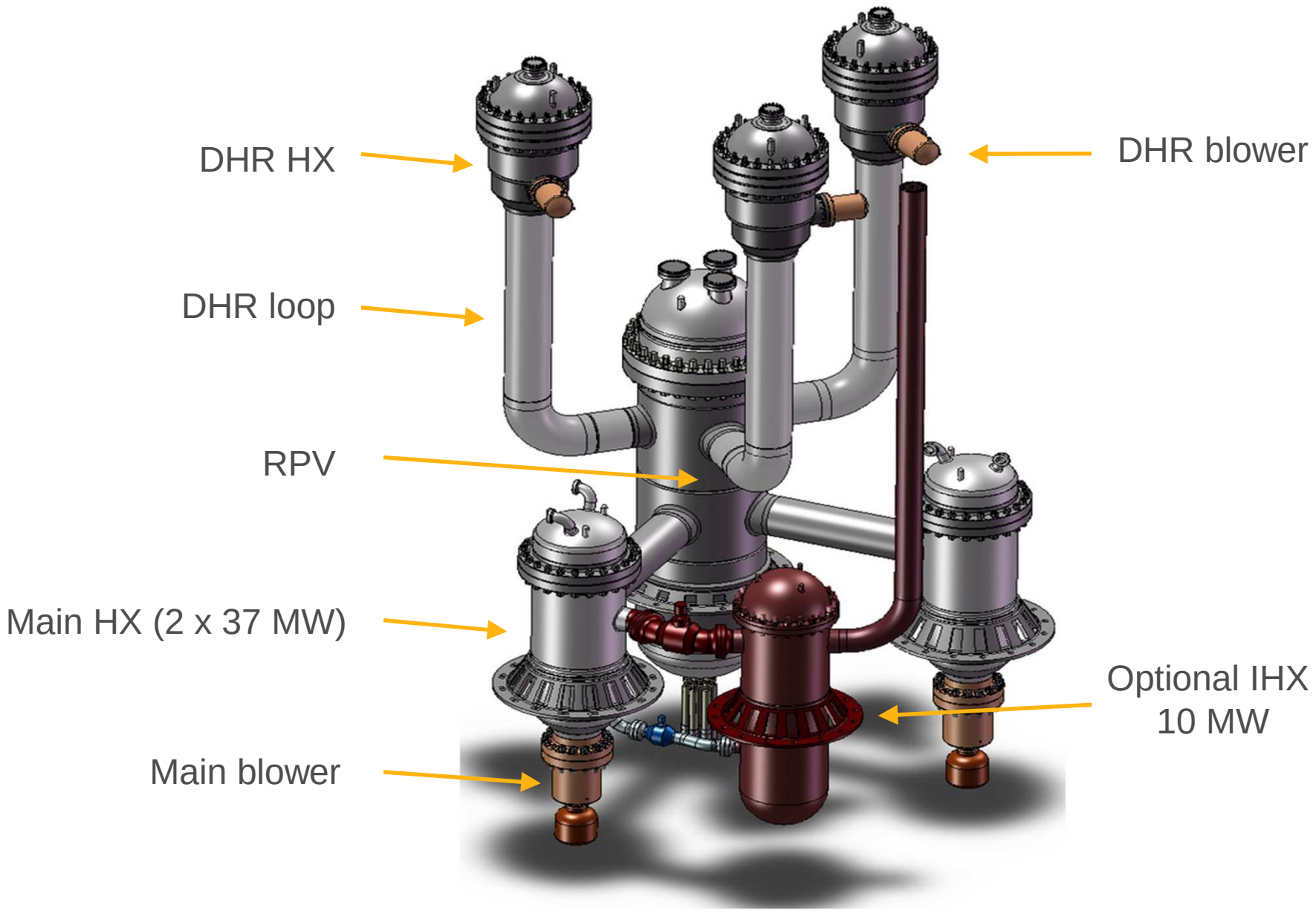
- **Legal frame: Association „V4G4 Centre of Excellence“**
  - Registered in August 2013 in Slovakia
  - **VUJE** (general. designer): Design & Safety (with ÚJV assistance)
  - **ÚJV Řež:** **R&D and exp. support (He technology, …)**
  - **MTAEK** Budapest: Fuel
  - **NCBJ** Swierk: Materials

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

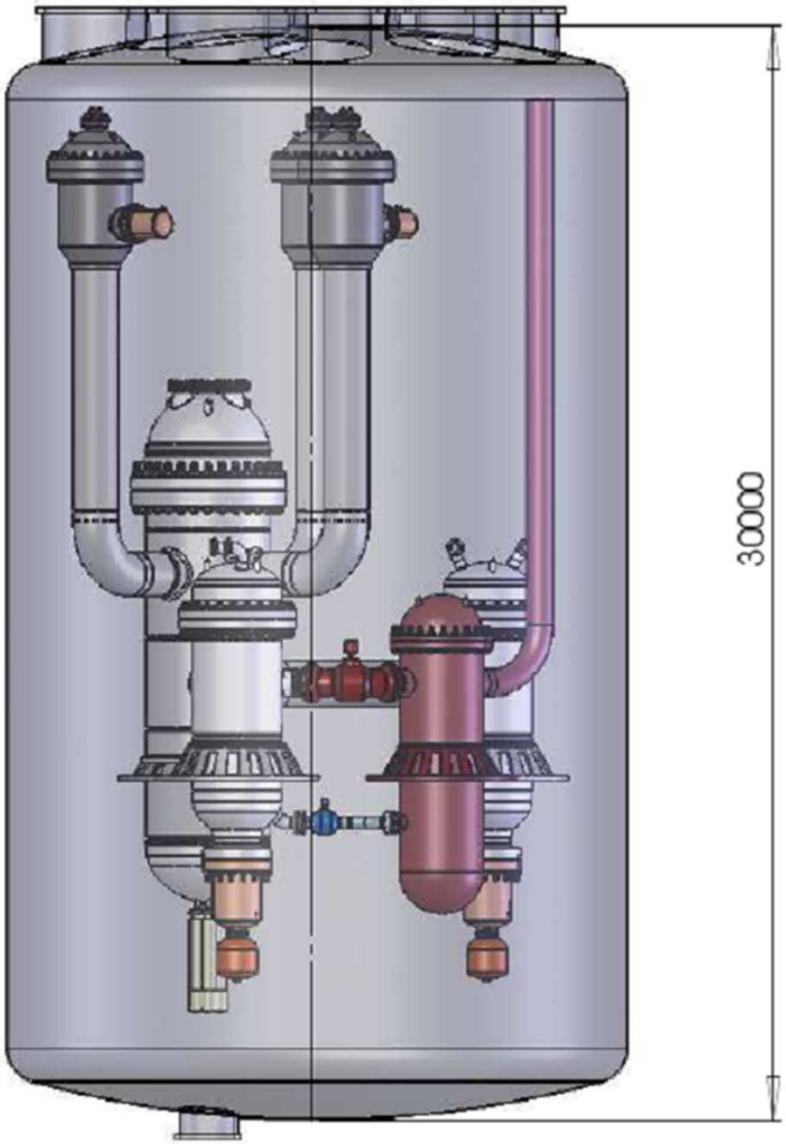
GFR ALLEGRO - specifications

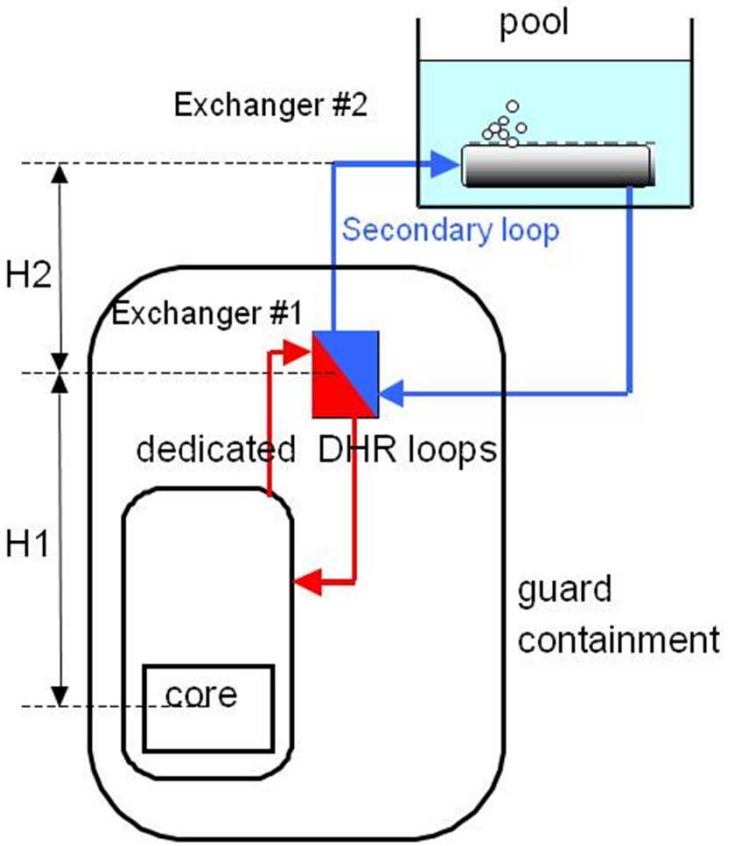
- **CEA ALLEGRO (2009) concept:**
  - Reactor unit size: **75** MWt
  - Core power density: **100** MWt/m^3
  - Coolant: **He**
  - Nominal pressure: **7** MPa
  - Fuel forms: **MOX pin-type** (starting core)
    Ceramic pin-type (refractory core)
  - Core outlet temperature: **530**°C (starting)
    750°C (refractory)

CEA ALLEGRO 2009 (75 MWt)

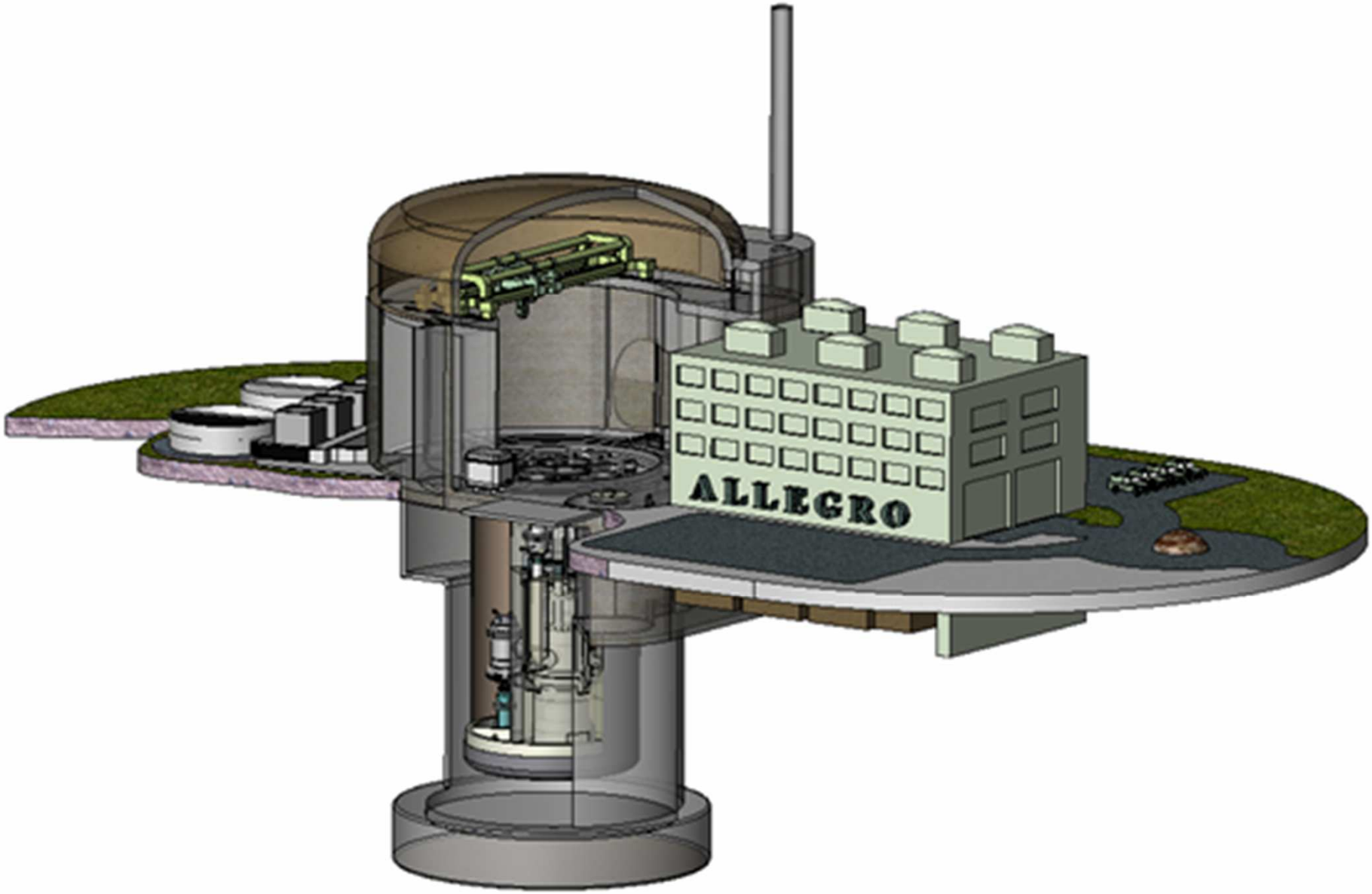


CEA ALLEGRO 2009 (75 MWth)

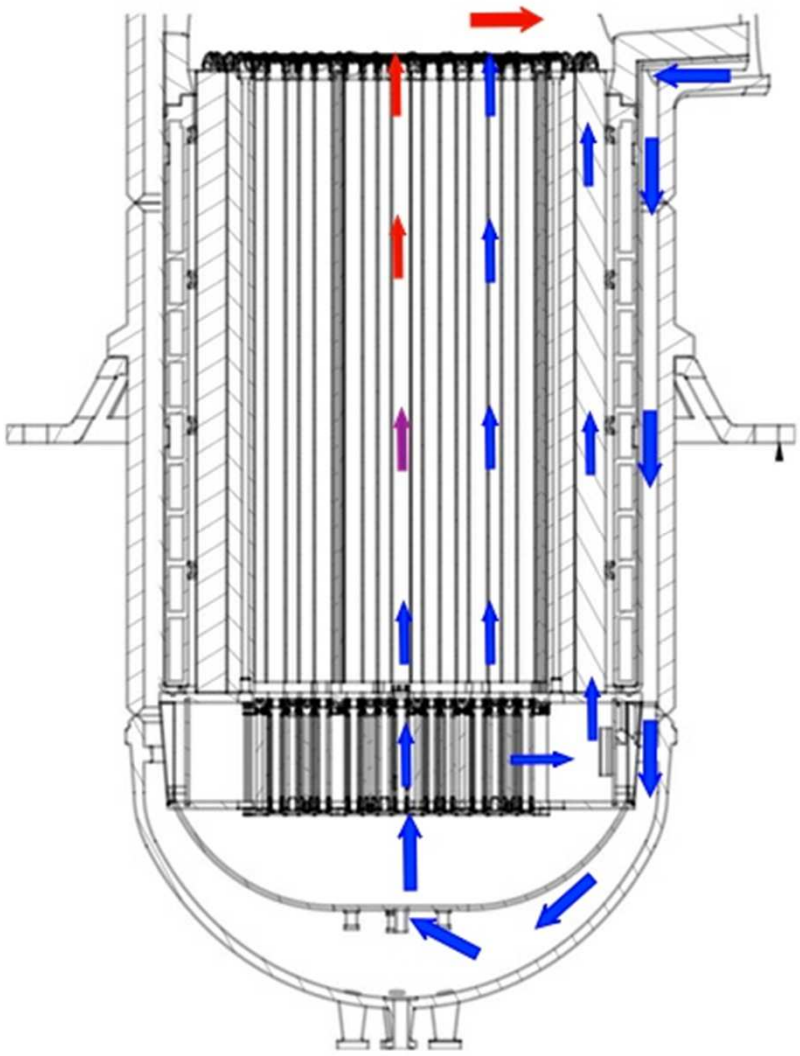


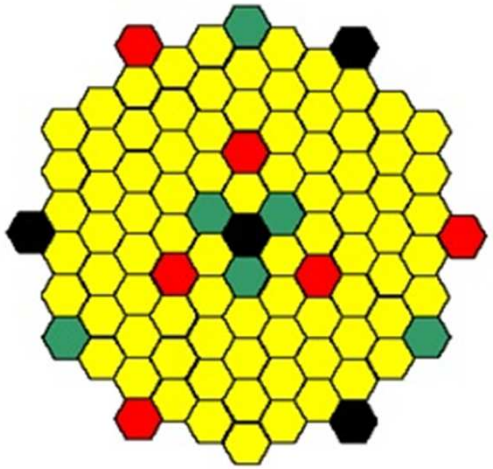


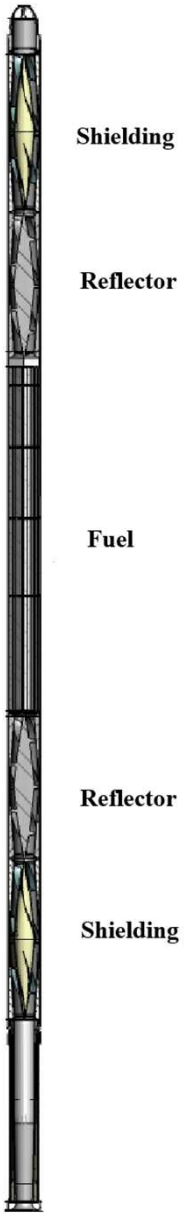
ALLEGRO – global facility



ALLEGRO - MOX Core

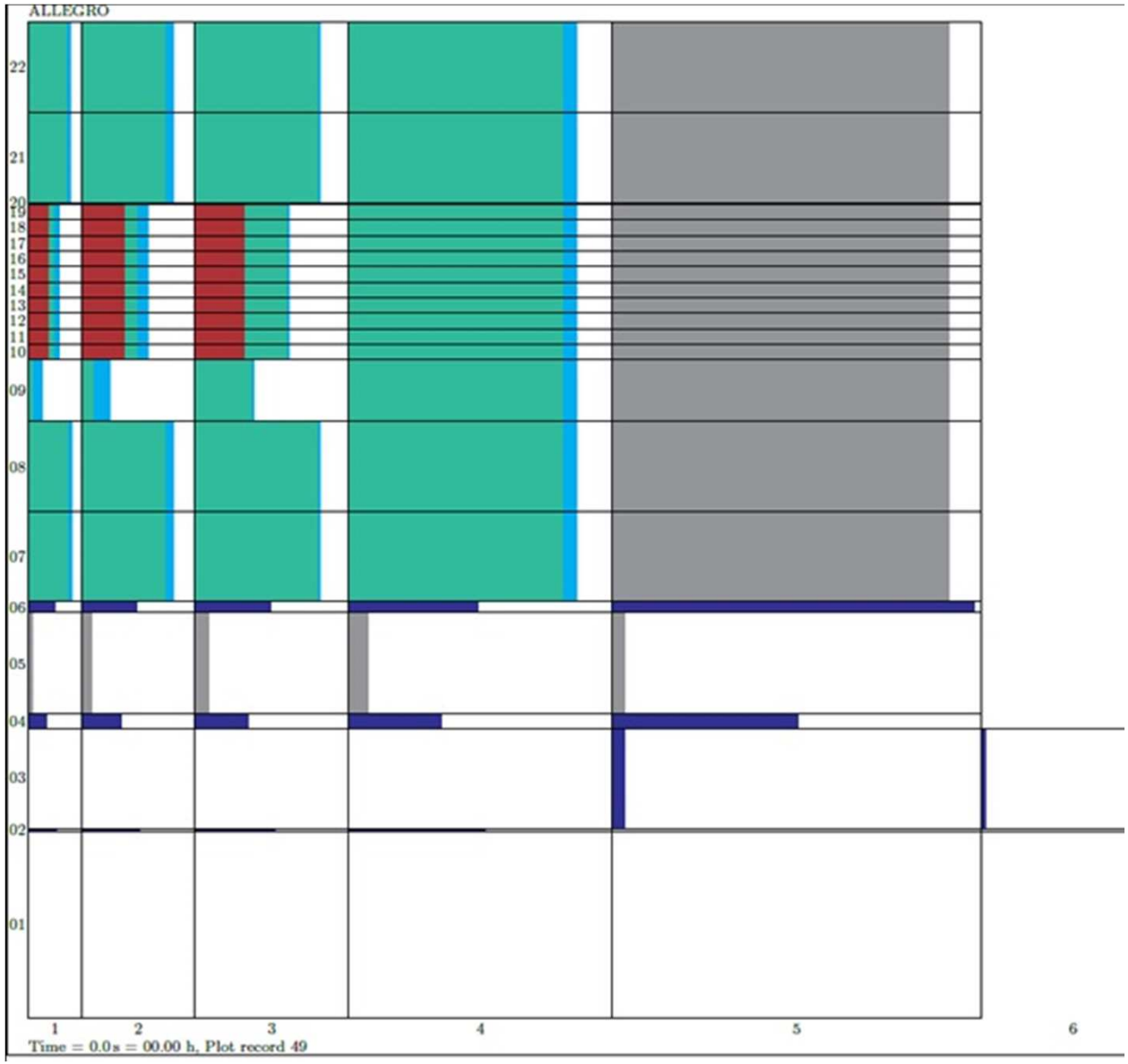






ALLEGRO COR model

- **Core includes bypass** – BWR model used
- **BWR model puts NS to bypass** – NS modeled as cladding in regions with bypass

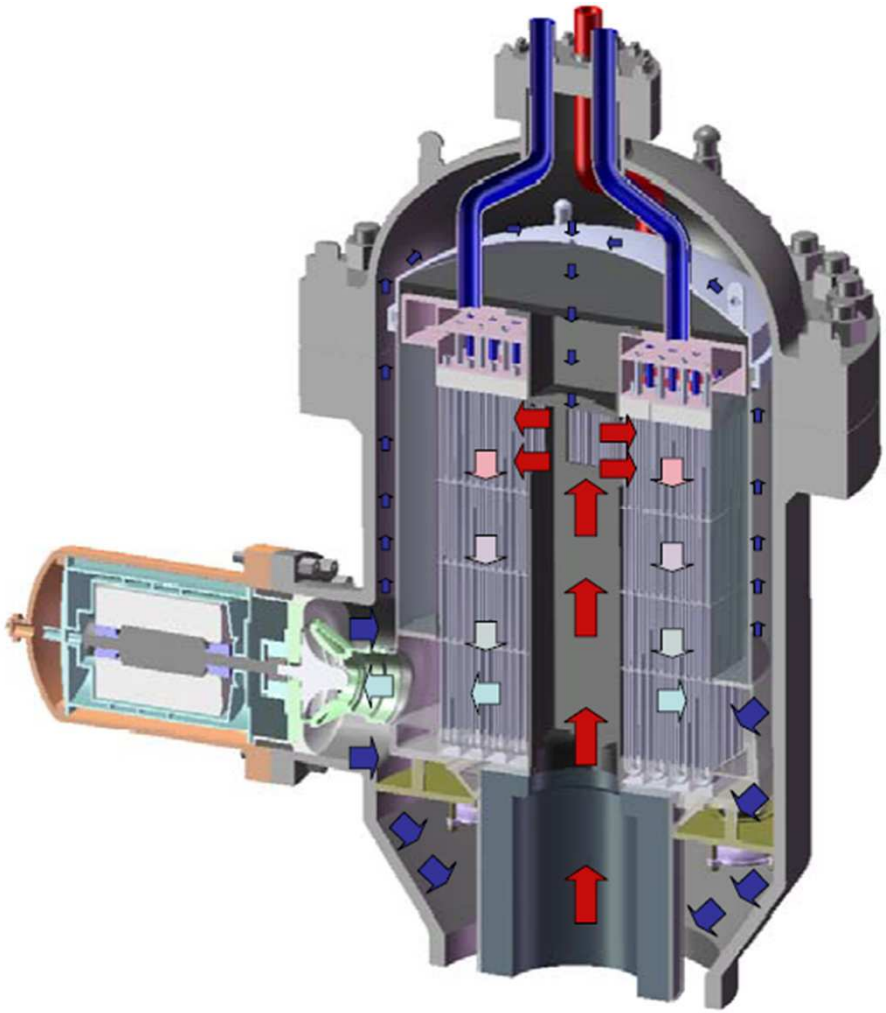


Color key: fu cl cn ns ss helium

DHR system model

- **DHR system model**
  - Very complicated shape and flow path
  - Blower and intermediate circuit pump on –OK
  - SBO – natural convection mode in both DHR exhanger and i.c.

- **DHR blower model**
  - SBO – no problem
  - LOCA scenarios – homologous model under developement

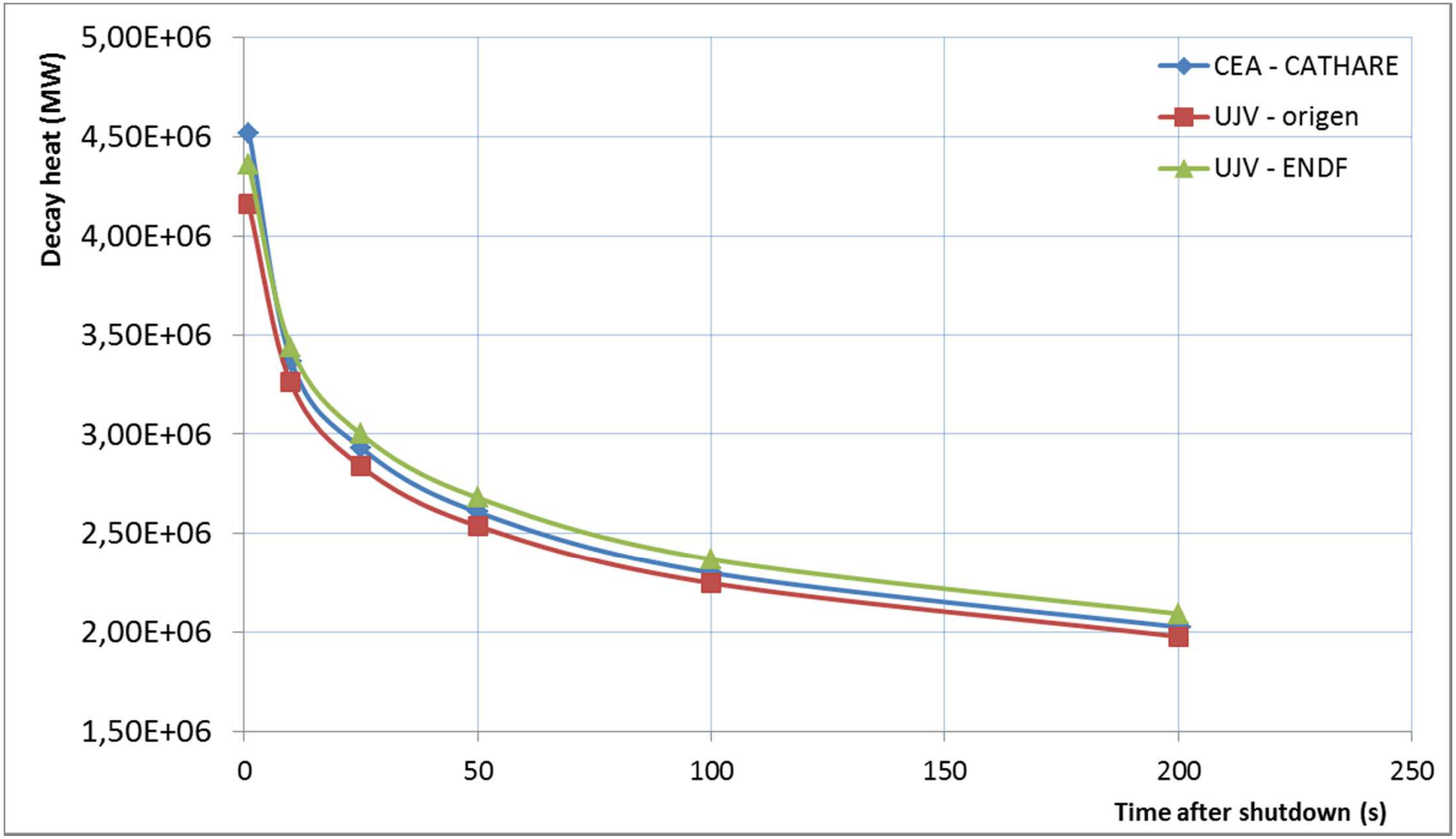


Unsolved issues

- **MELCOR 1.8.6 calculations**
  - 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. has no problem using the same input.

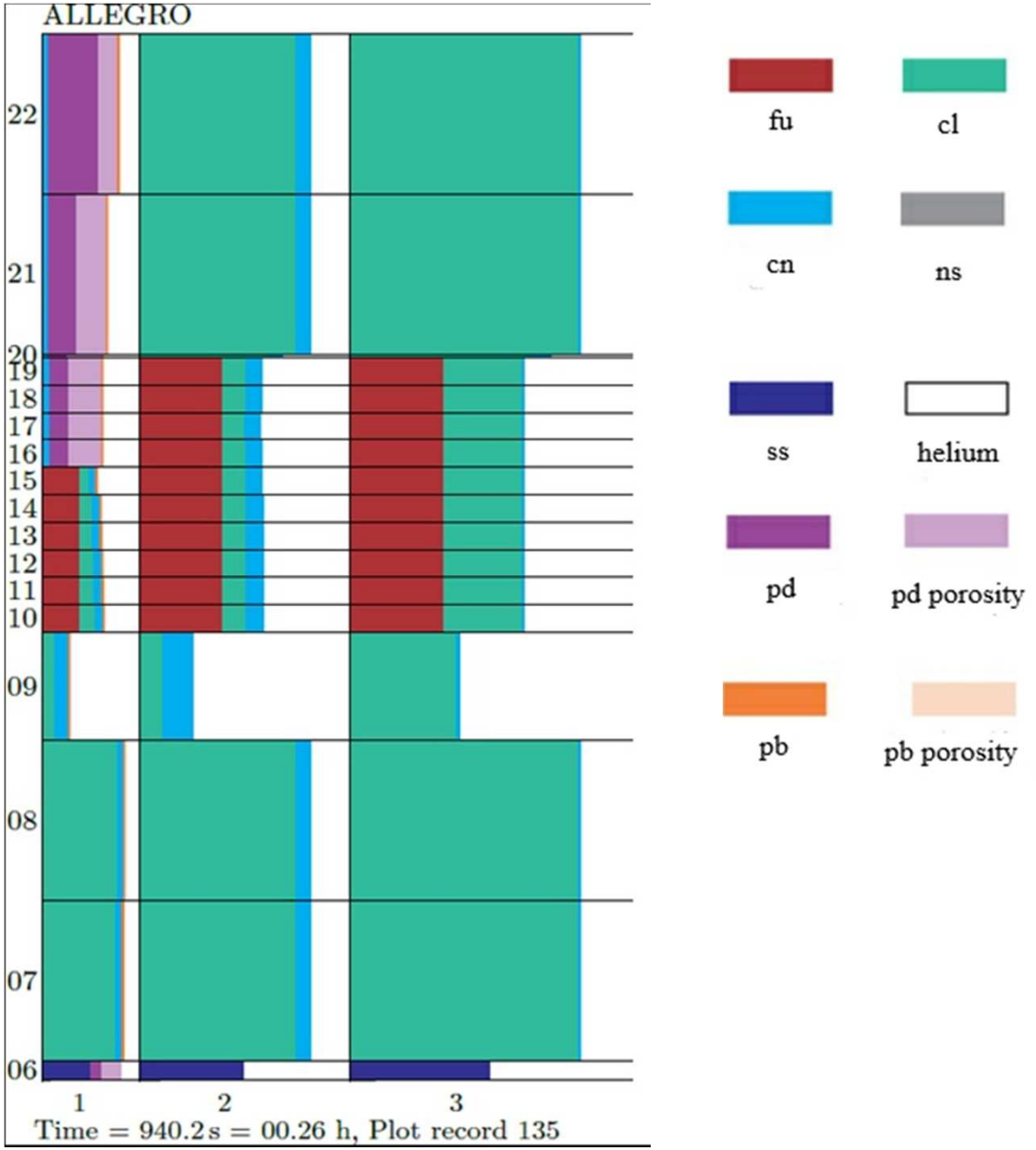
Decay heat


Decay heat (MW)
5,00E+06
4,50E+06
4,00E+06
3,50E+06
3,00E+06
2,50E+06
2,00E+06
1,50E+06
0
50
100
150
200
250
Time after shutdown (s)
CEA - CATHARE
UJV - origen
UJV - ENDF

SBO results

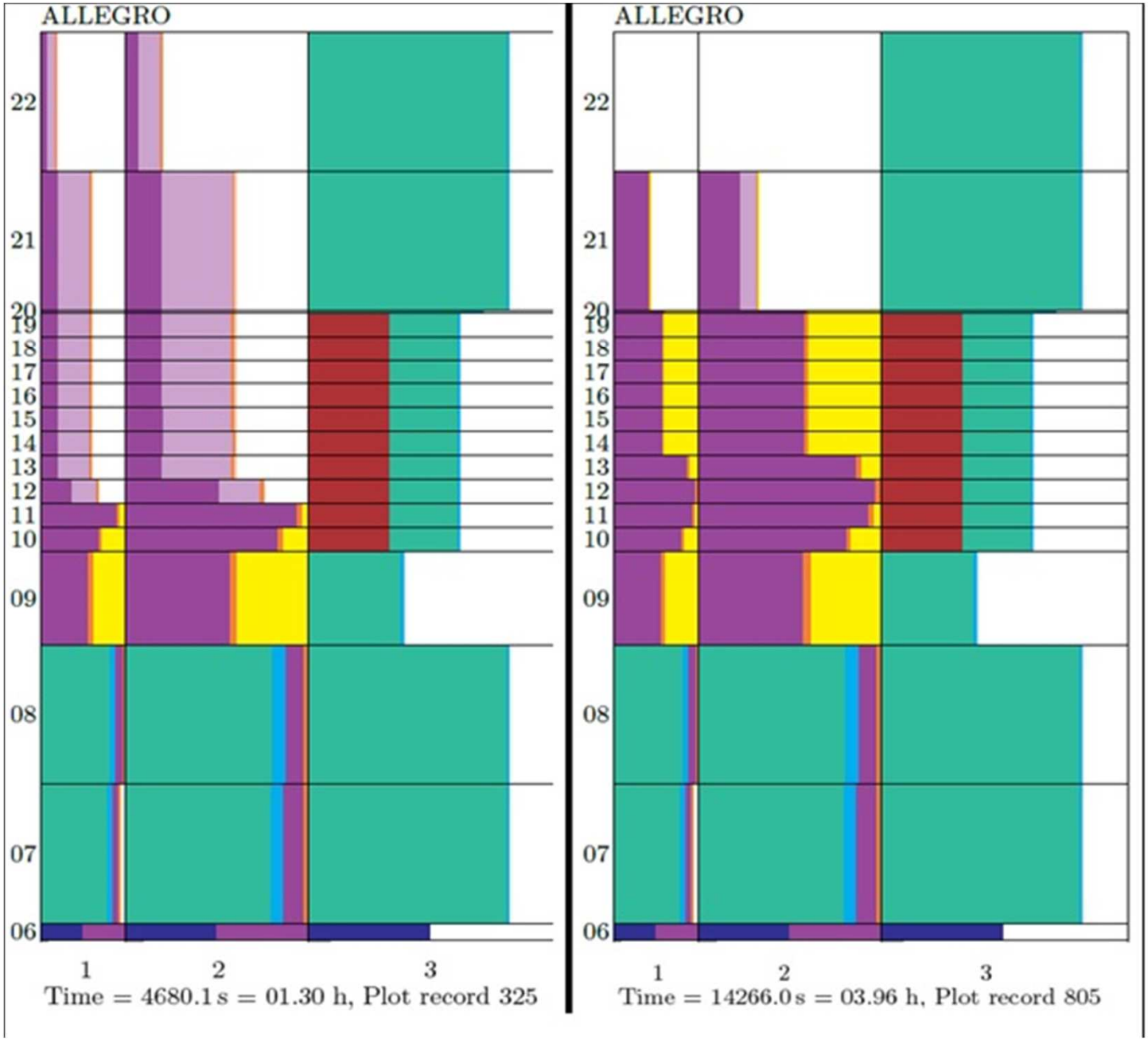
- **main check valves close + DHR check valves do not open –** worst possible scenario

- **Result is total loss of cooling and core overheating** – melting of cladding in less than **16 minutes**



Blackout results

49 min.

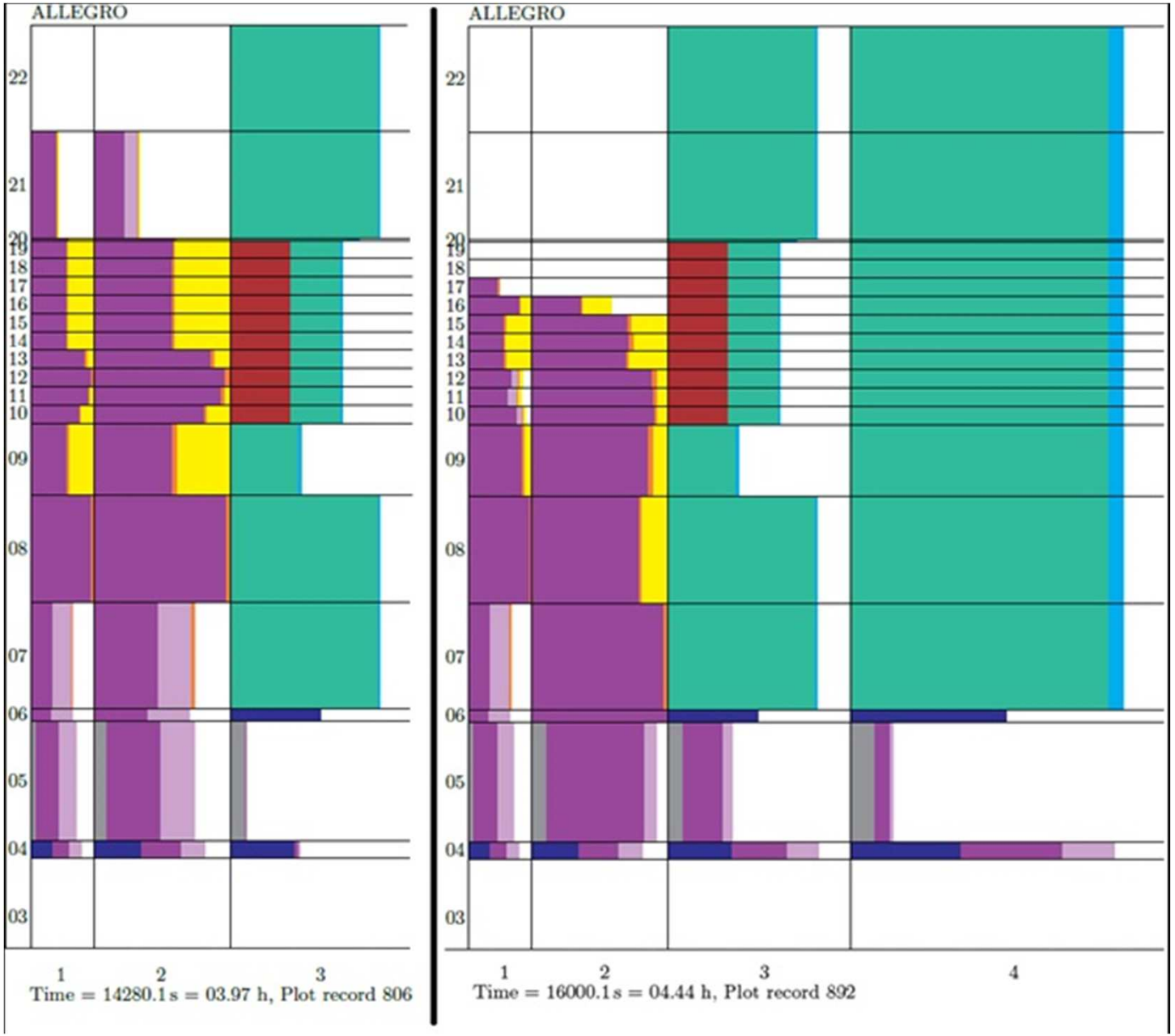


3 hrs

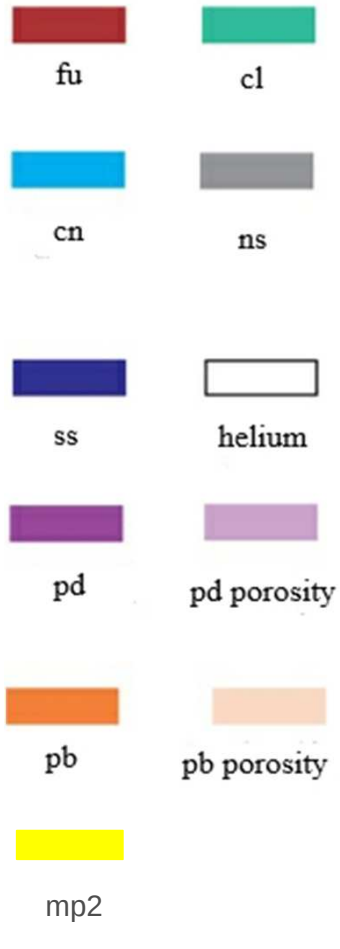
fu
cl
cn
ns
ss
helium
pd
pd porosity
pb
pb porosity
mp2

Blackout results

4 hrs



4 hrs 40 min.



SBO results

- Fast propagation – cladding failure after only 16 minutes
- No fuel melting occurs until relocation to lower head – lack of oxidic molten pool
- third ring remains almost untouched – probably due to fast „dissapearance“ of fuel from first two rings?
- Lot of steel remains in the core region – does not participate in heat dissipation after relocation (internal core catcher? Liner?)

Conclusion

- ALLEGRO is still in (pre)conceptual phase – lot of changes in design expected
- Modeling of GFR in MELCOR is complicated but possible
- Results of severe accident calculations will help to further develop the safety systems of ALLEGRO