ÚJV Řež, a.s.

Using MELCOR 2.1 as a thermal-hydraulics analysis code (GFR)

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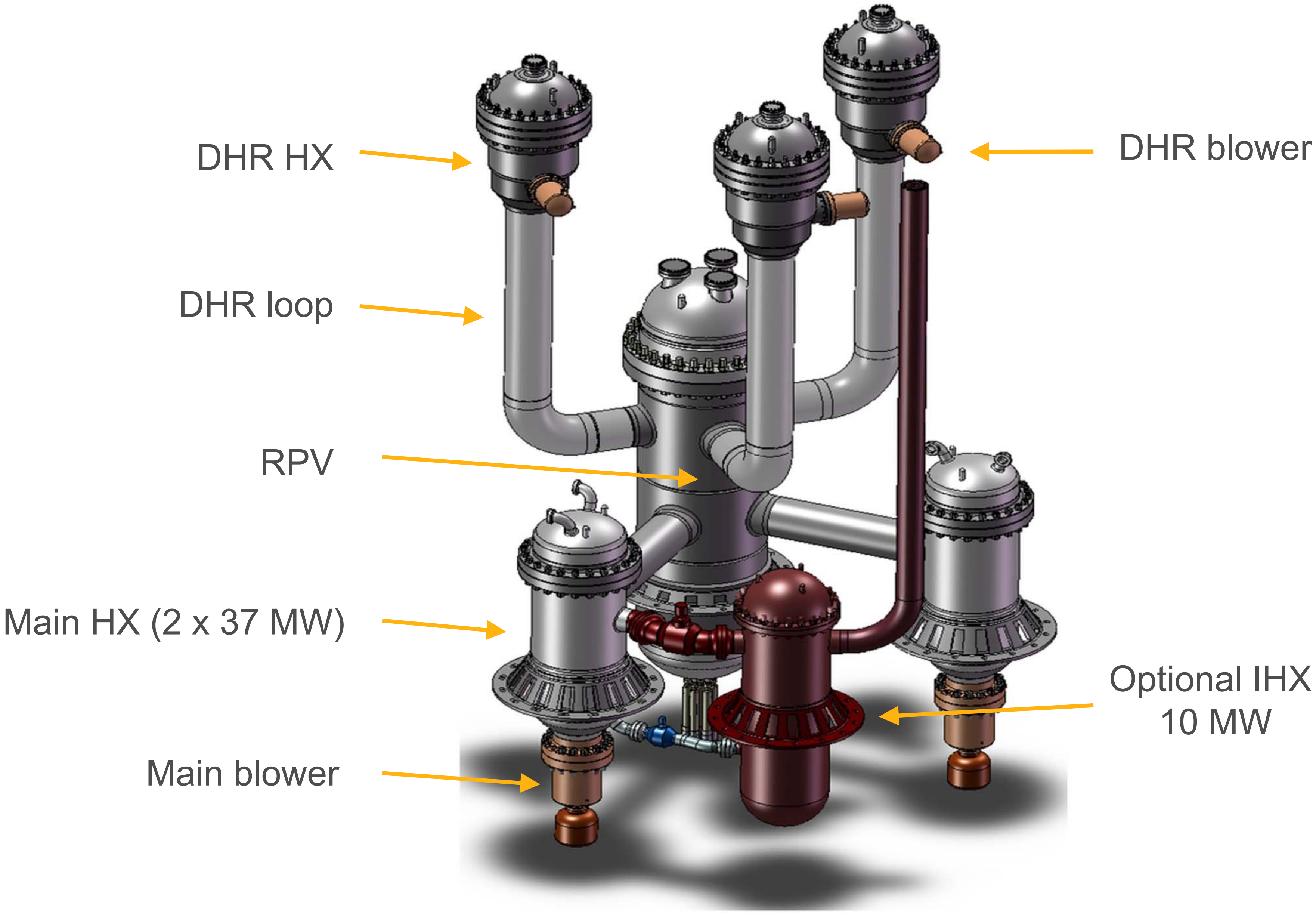
- Code-to-code TH benchmark
- Preliminary results
- Future outlook

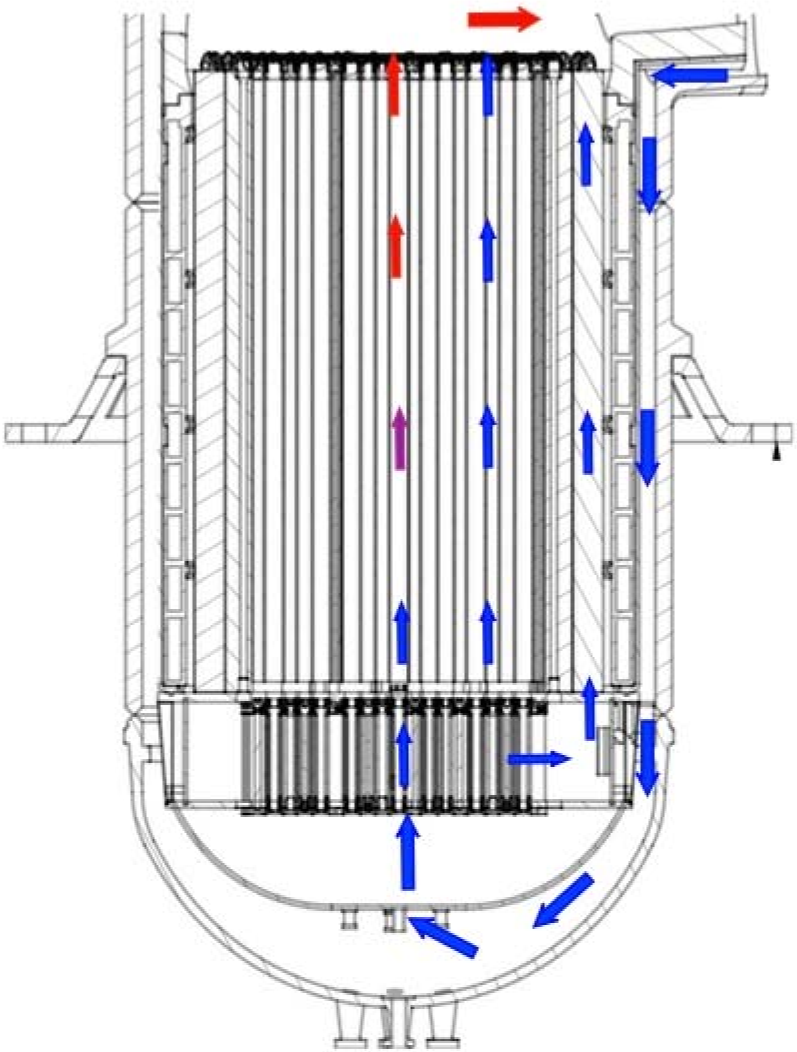
GFR ALLEGRO - specifications

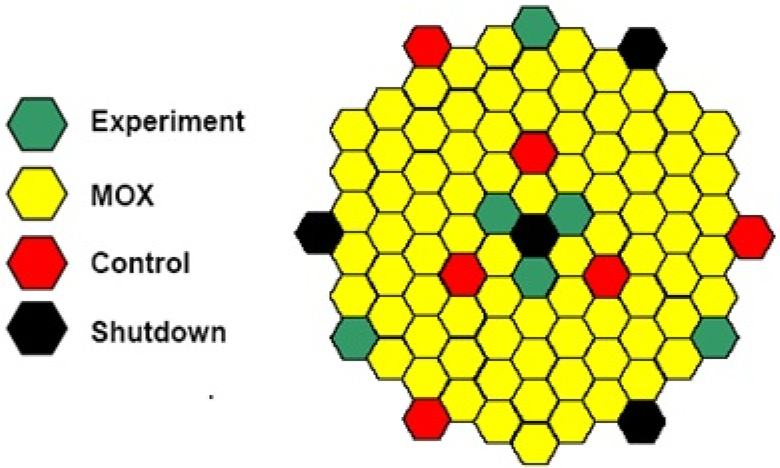
- **ALLEGRO concept:**
  - Reactor unit size: **75** MWt
  - Core power density: **100** MWt/m^3
  - Coolant: **He**
  - Nominal pressure: **7** MPa
  - Fuel forms: **MOX pin-type** (starting core)
    Ceramic pin-type (refractory core)
  - Core outlet temperature: **530**°C (starting)
    850°C (refractory)

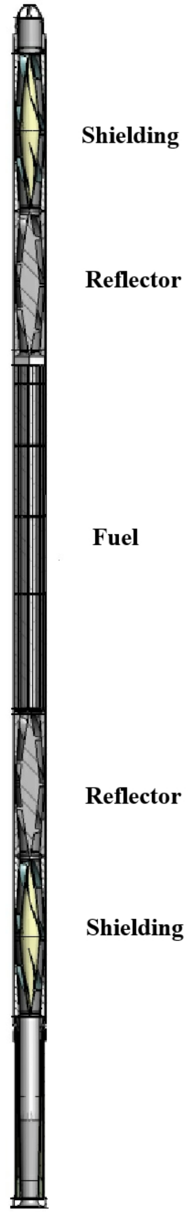
ALLEGRO 75 MWt



ALLEGRO - MOX Core







ALLEGRO TH code-to-code Benchmark (1/3)

- **Purpose**
  - unifying (and improving) input decks, comparing results

- **Codes**
  - RELAP5 (VUJE),
  - CATHARE2 (MTA-EK, NCBJ, UJV),
  - MELCOR 2.1 (UJV)

- **Schedule**
  - 2016 – preparation of Database and Benchmark specs.
  - 03/2017 – Steady state qualification
  - 06/2017 – Transient calculations comparison

- **Why MELCOR (SA code) in TH bench?**

ALLEGRO TH Benchmark (2/3)

- **2 Transients selected for the transient calculation comparison**
  - LOCA on main cold duct
  - SBO

- **Compared results**
  - Over 60 compared values for the steady state
  - Over 40 compared values for the transients (Temperatures, pressures, mass flow ratess, etc.)

ALLEGRO TH Benchmark (3/3)

Property	Refference value	MELCOR value	Acceptable error (%)	MELCOR error (%)
Core inlet temperature (°C)	260.0	259.1	0.5	0.35
Core outlet temperature (°C)	516.0	513.88	0.5	0.41
Core inlet pressure (MPa)	7.0	6.99	0.1 (?)	0.13
Core mass flow rate (kg/s)	56.45	56.79	2.0	0.6
Core pressure drop (kPa)	84.0	84.8	10.0	0.95
MHX pressure drop (kPa)	20.0	11.4	10.0	43.0 (!)

Issues with using MELCOR as a TH code

- **MELCOR related**
  - Lack of details in some areas – temperature profiles inside cladding/fuel

- **Modeling related**
  - Hot channel definition (power distribution)
  - Core modelling

- **Possibly my own lack of skill**
  - HX model – works well in the steady state, osciallations and instability in transients. Any experience?
  - Homologous pump model – any experience?

Preliminary comparison CATHARE-MELCOR

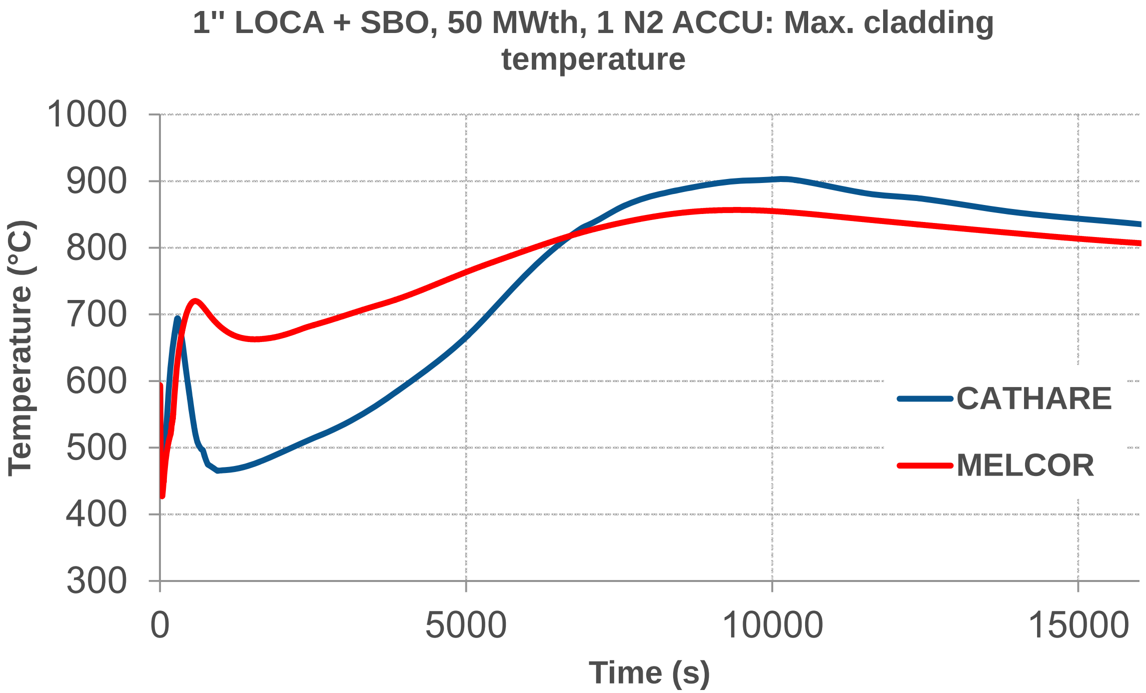
- **Transient: LOCA 1“ on one cold leg + SBO, 1 N2 accumulator available, 2 DHR loops available (+ 2“ and 3“ LOCA)**

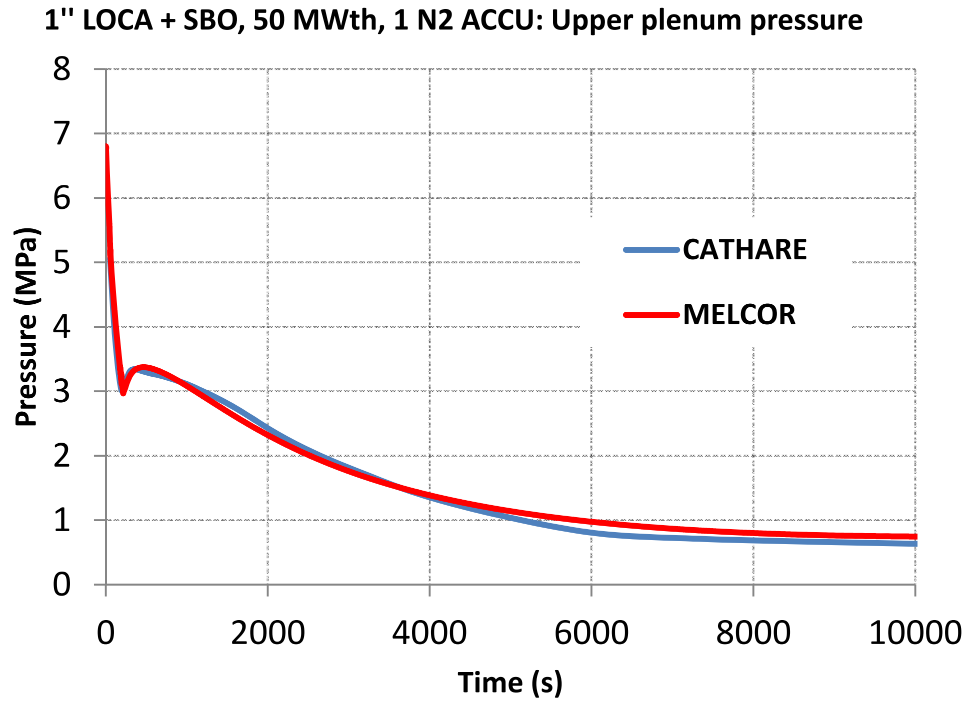
- **Synchronized initial and boundary conditions:**
  - Nominal conditions in PC (Pressure in lower/upper plenum, core mass flow rate, power, blowers performance, conditions in GV)
  - Fission and decay power over time
  - Size of the N2 accumulator, initial pressure and temperature of N2 in it, conditions for opening the accumulator (PC pressure below 3 MPa)
  - Initial mass flow rate of N2 from the accumulator
  - Rate of PC depressurization (for 1“ breach only)
  - Timing of main and DHR valves closure/opening

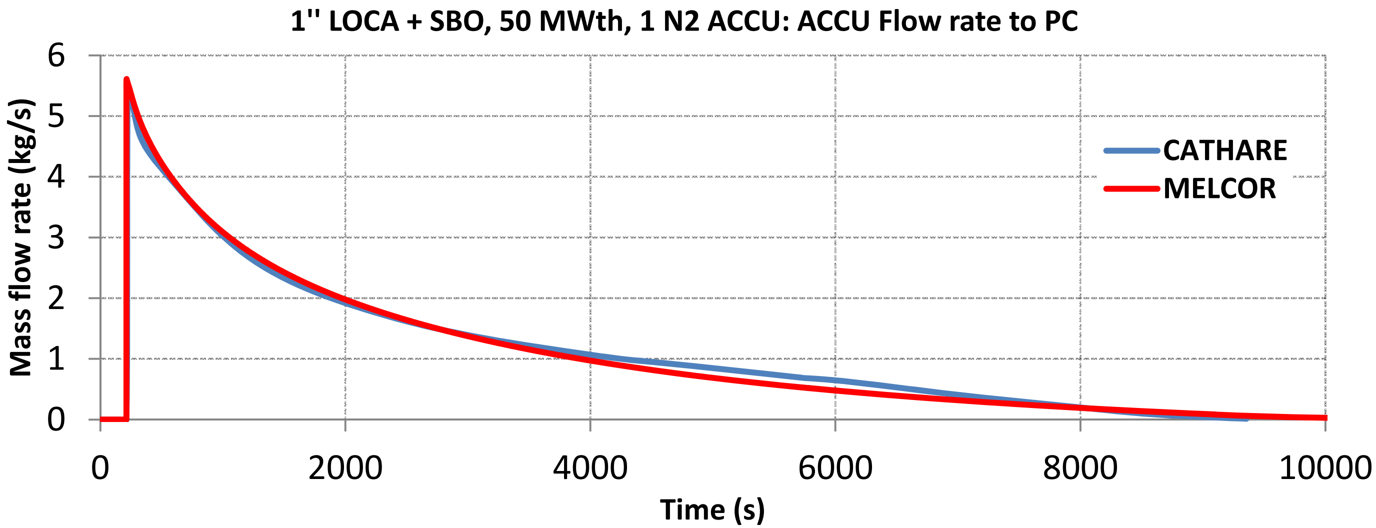
Major differences between the models

- Heat capacity of the core (absence of non-fuel SAs, adiabatic hot channel)
- Differences in DHR system (different boundary conditions and volumes)
- General differences in volumes and areas

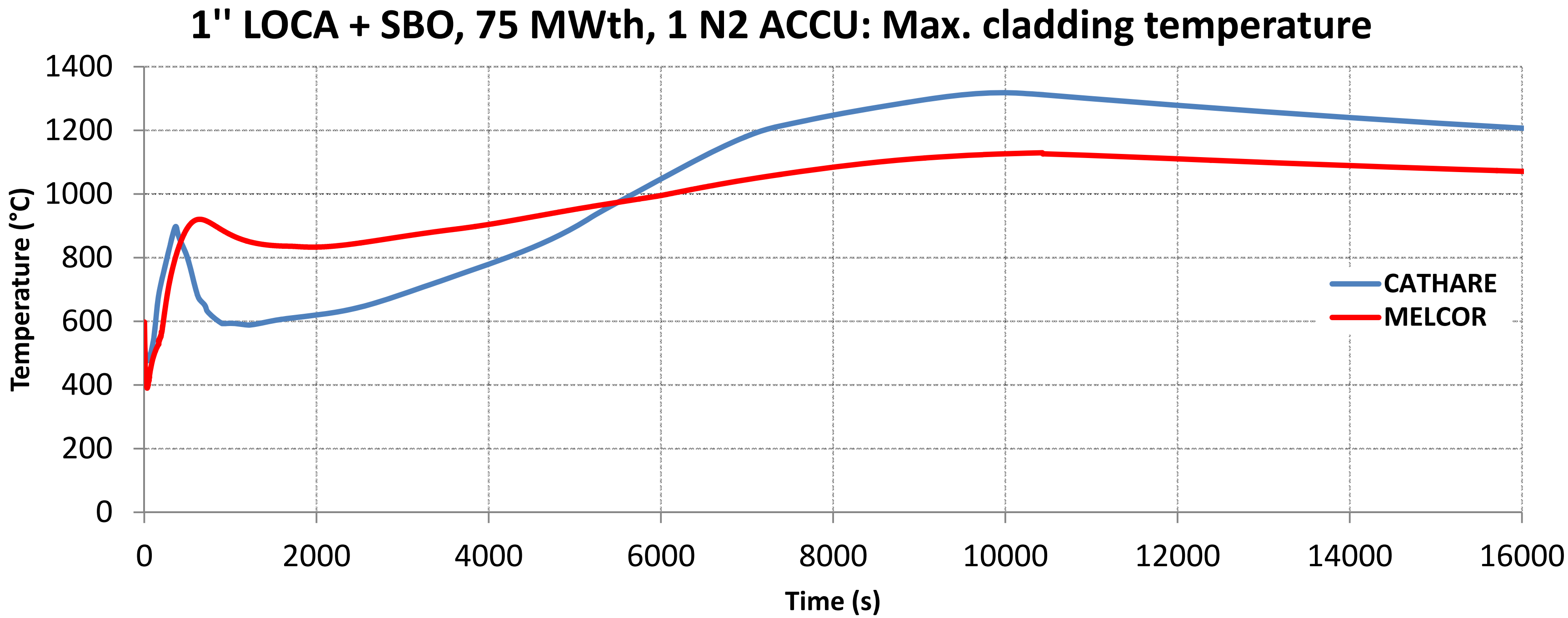
Results (1/4) – 1“ LOCA 50 MW

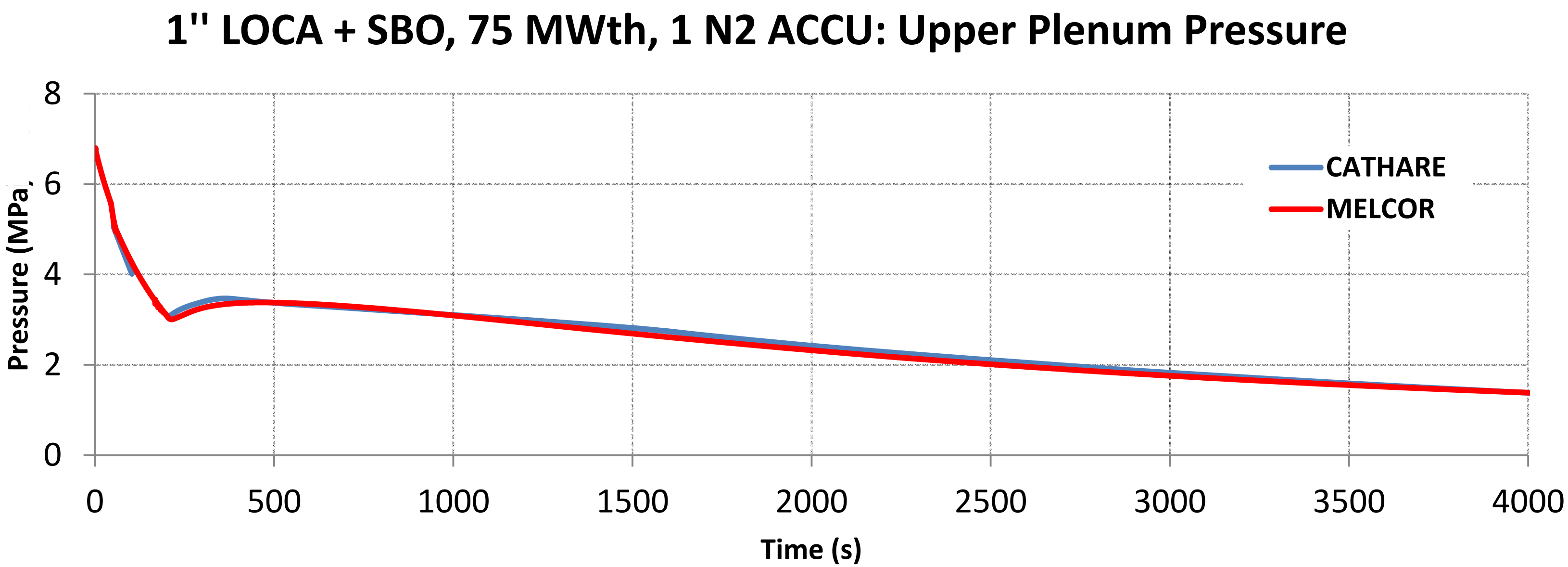




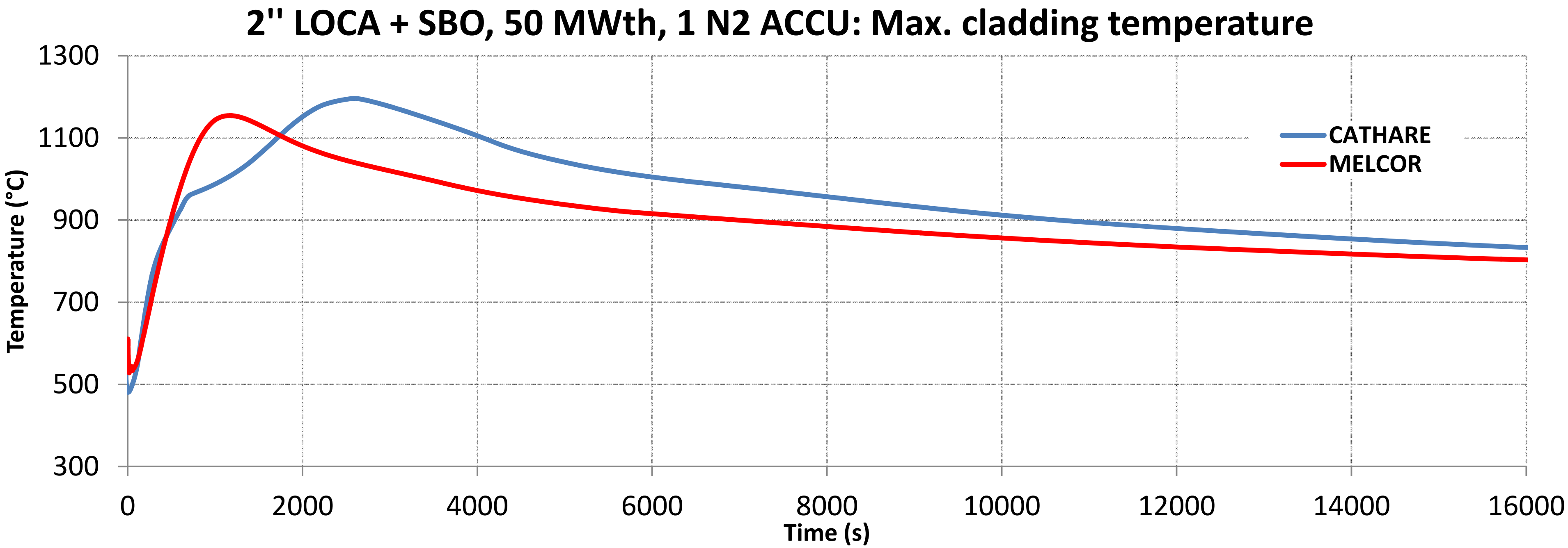


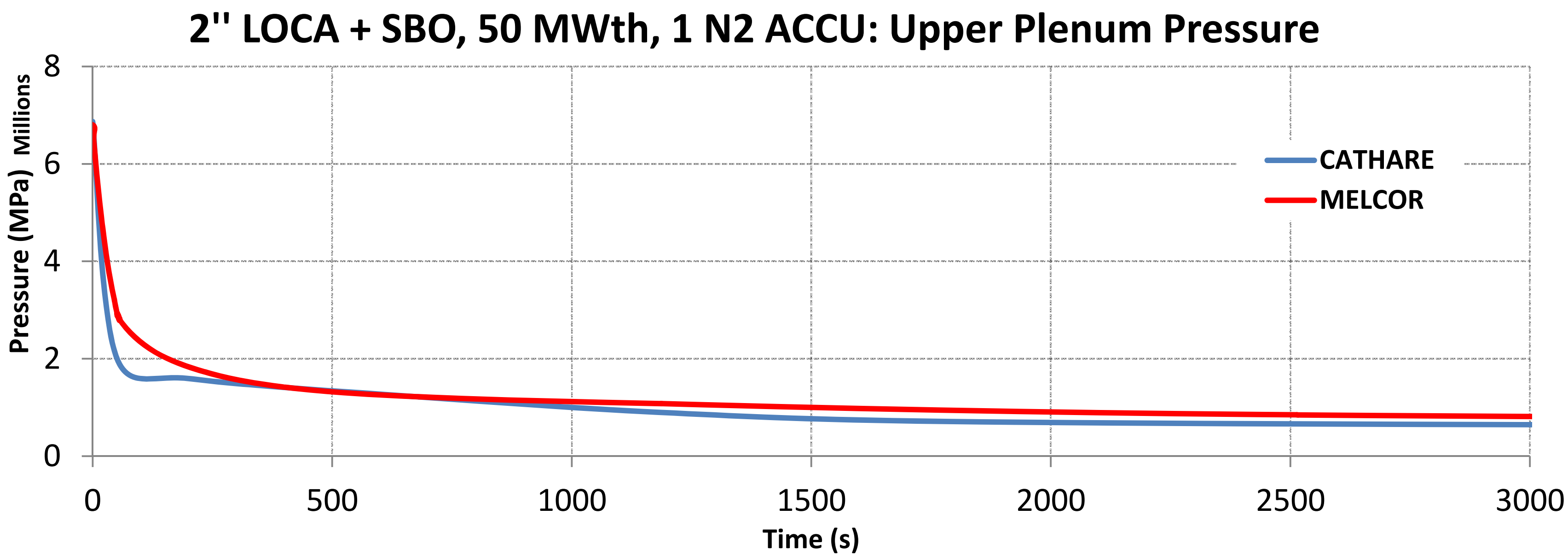
Results (2/4) – 1“ LOCA 75 MW



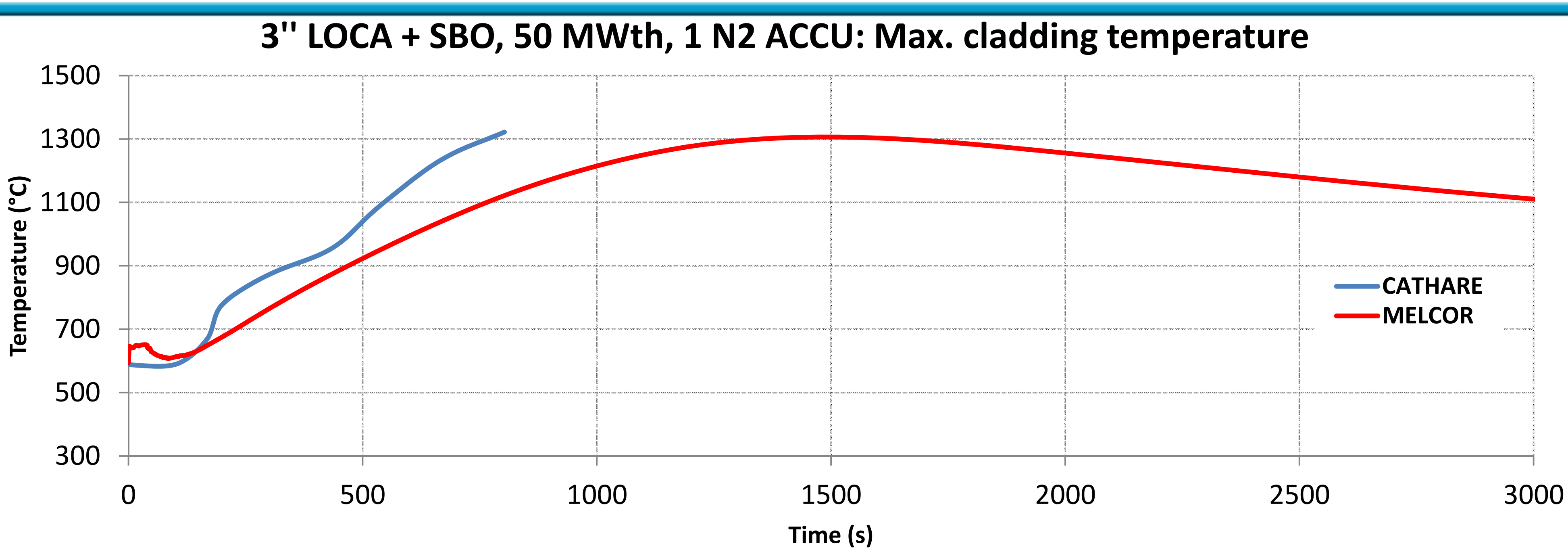


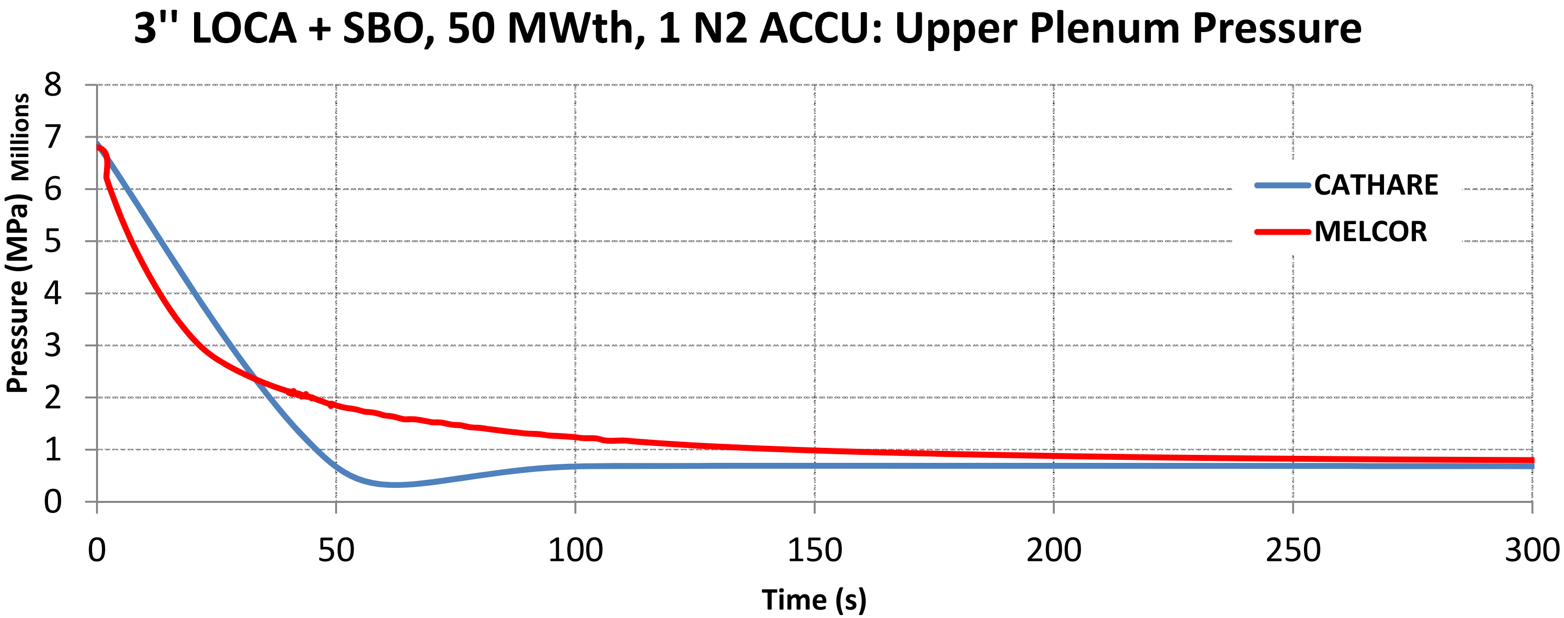
Results (3/4) – 2“ LOCA 50 MW





Results (4/4) – 3“ LOCA 50 MW





Plans for the future

- **2018-2020 Code-to-experiment benchmark (TH)**
  - S-ALLEGRO and STU loops
  - The loops will contribute to the reactor development, too

- **SA assesment**
  - All the already calculated results need to be evaluated and put into one document (2017-2018)
  - Unprotected transients calculations (point kinetics model applicable to fast reactors?)
  - Crucial tasks – complete concpetual design of Guard Vessel internals – core catcher concept (2016 – 2018)

- **GFR oriented SA research**
  - Big safety-oriented research project (ALFA) rejected by the EU -> delay
  - Several new projects (national and international) under evaluation/in the preparation phase

Conclusions

- Detailed ALLEGRO TH benchmark has been prepared, comparing 3 codes and 5 users
- Qualitatively, MELCOR is capable to calculate the transients in ALLEGRO in the same way as CATHARE
- Quantitatively, differences in results are in in correspondence with the differences in models.
- Comparison of critical flow models in LOCA breaches should be done