FEST EXPERIMENTAL PLATFORM

Fluids Experiments and Simulations in Temperature

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and the technical teams of the LPSC Laboratory

Past work : Loop with forced continuous flow (FFFER)

- ✓ Glove box experiments
- ✓ Loop with forced discontinuous flow (SWATH)

with fluoride salts

Future loop planned in the PIA - ISAC project with chloride salts

Small experiments for space propulsion project

Targets for neutron field generation

Molten Salt

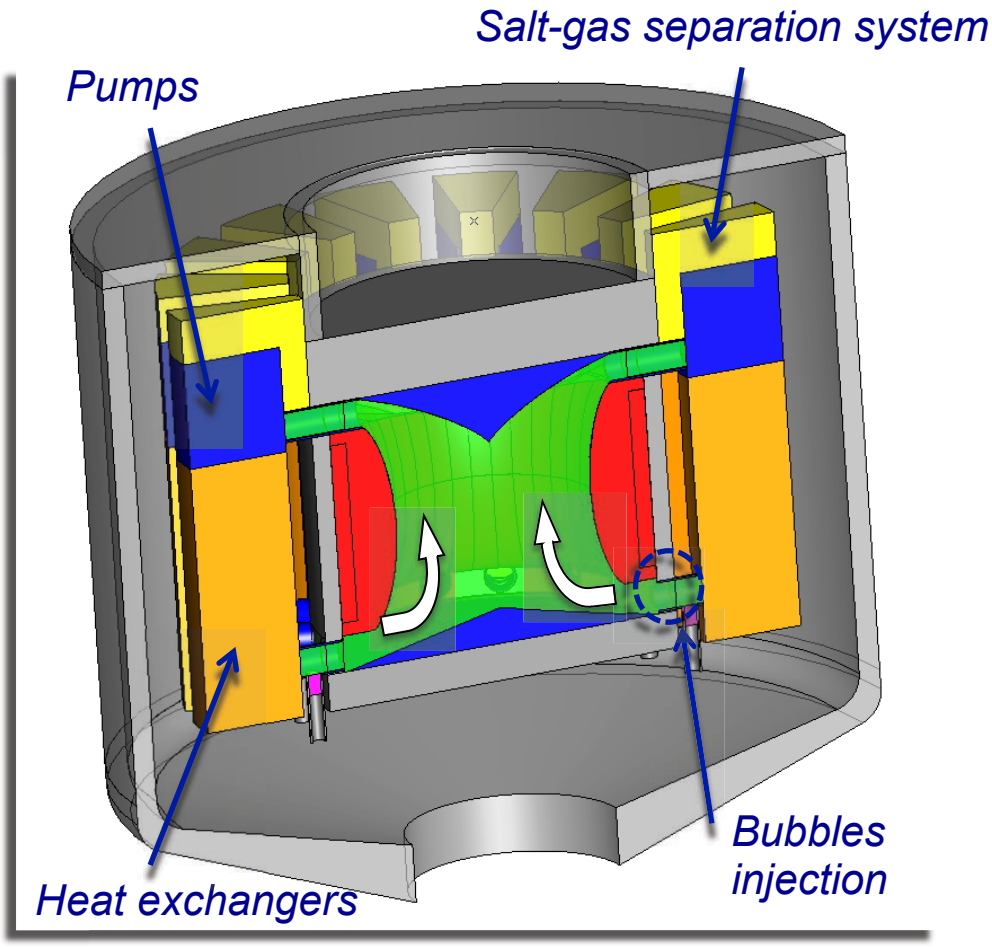
Liquid Lithium (Thin Be layer)

Water models

Numerical simulations

Starting Point of the story for us:

Questions regarding the possibility of in-line bubbling in the MSFR as a salt cleaning process in the MSFR Concept



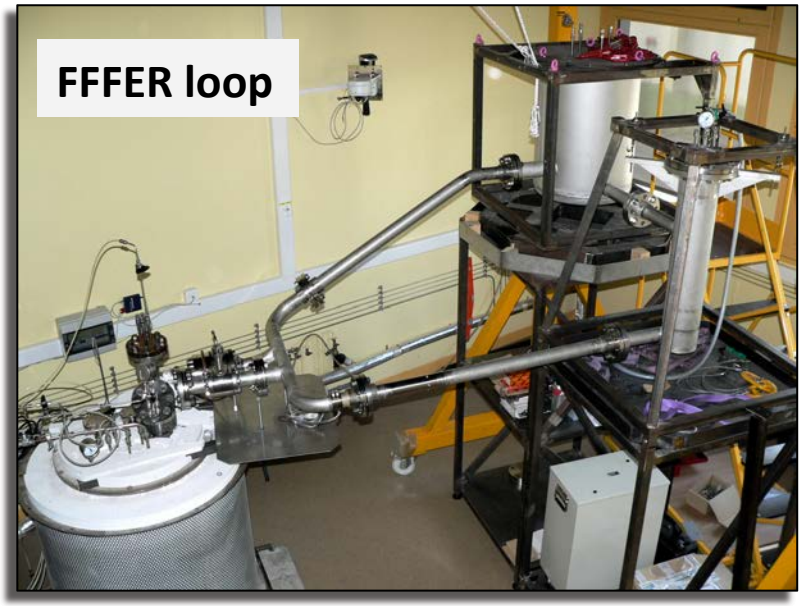
Objectives were:

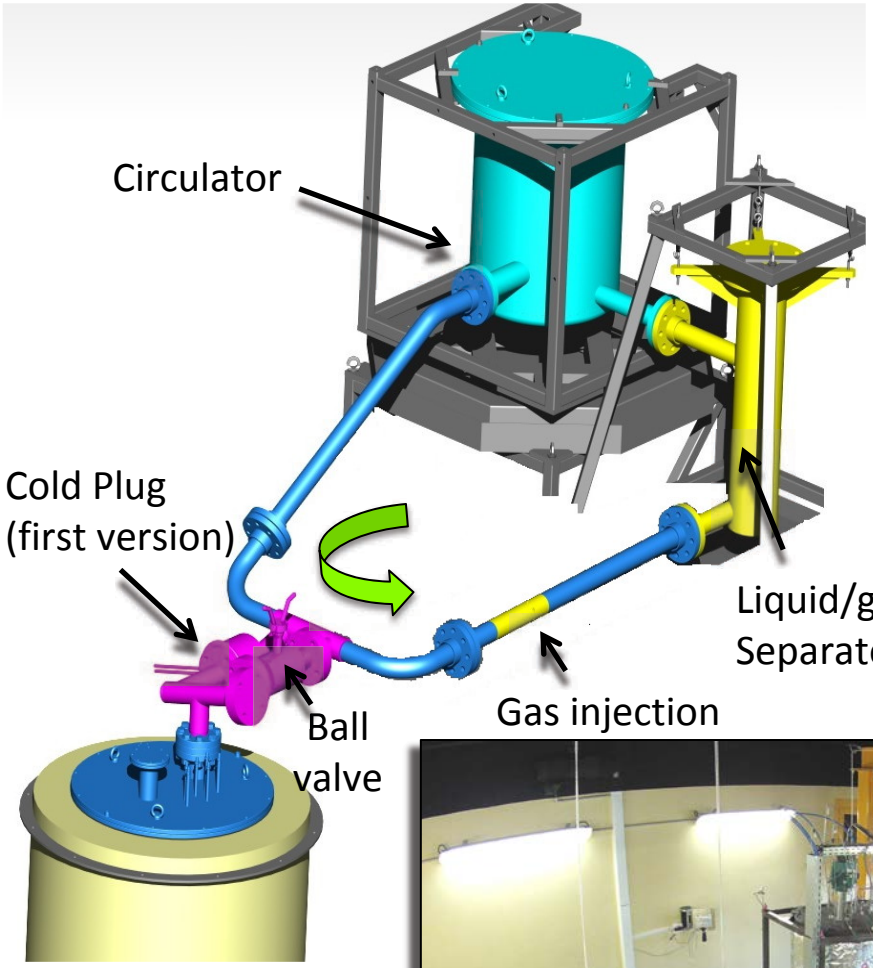
- Partial removal of dissolved gaseous species
- Limitation of particles in suspension or sticking on walls
- Creation of know-how

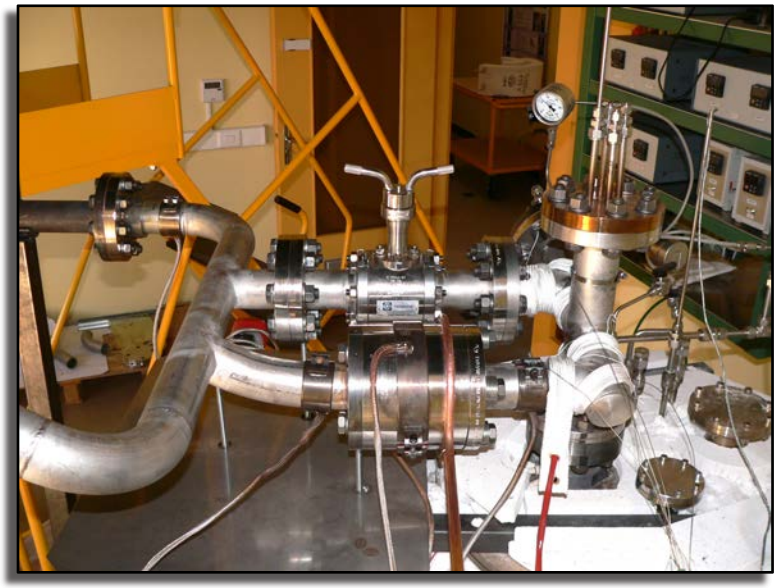
FFFER project

Forced **F**luoride **F**low for **E**xperimental **R**esearch

Forced Fluoride Flow for Experimental Research



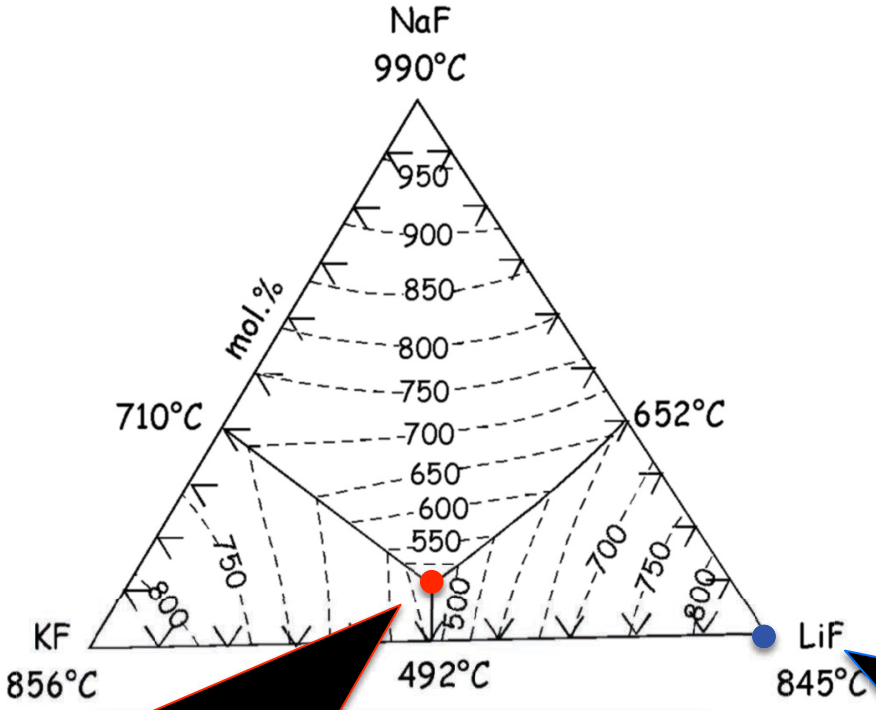




Forced Fluoride Flow
for Experimental Research

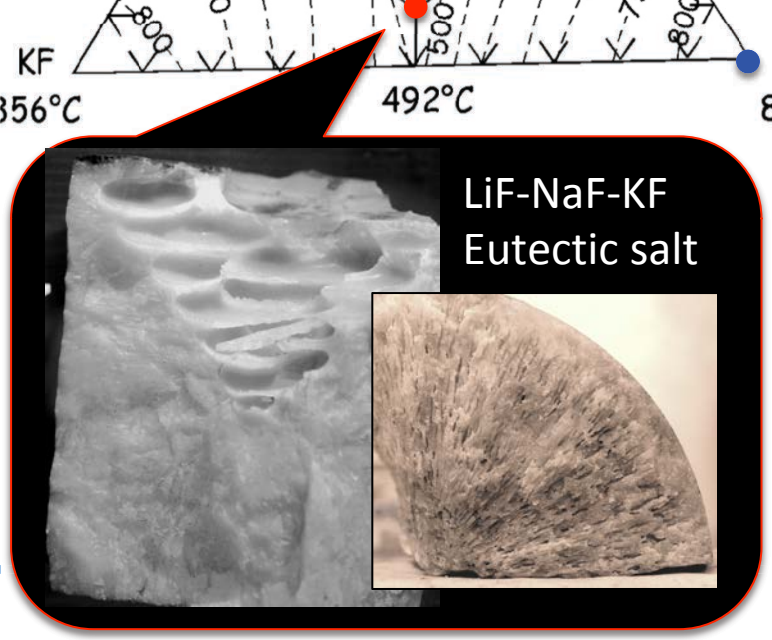
Last tests carried out in 2017

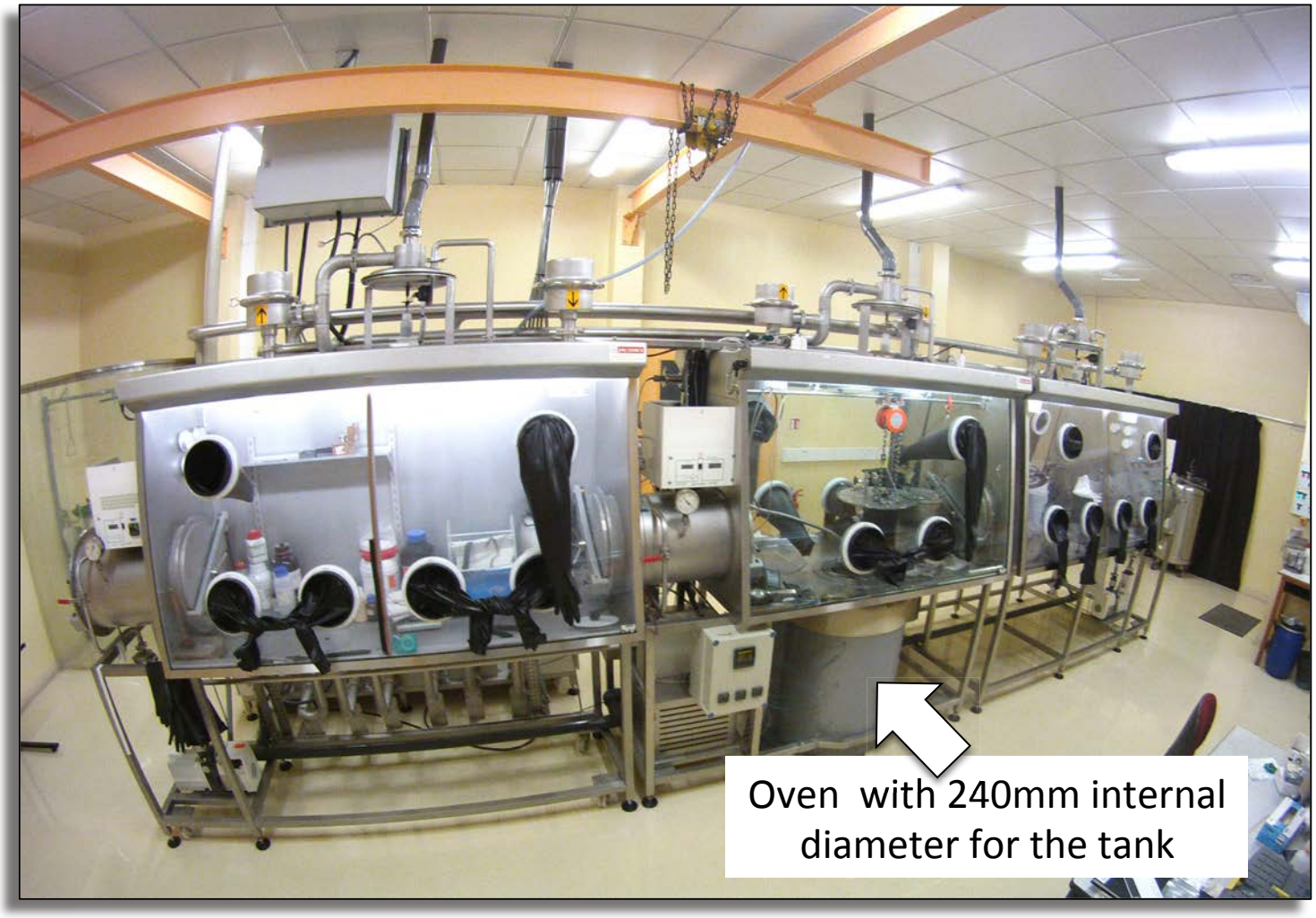
Model salt used for fluorides studies:



LiF-ThF4		Flinak	
T °C	Prandtl	T °C	Prandtl
600	21,0	475	24,0
700	16,0	500	20,0
800	12,8	525	16,8
900	10,6	550	14,3
1000	9,1	575	12,3
1100	7,9	600	10,7
1200	7,1	625	9,3
1300	6,4	650	8,2
1100	7,9	675	7,2
1200	7,1	700	6,5
1300	6,4		

Possible similarity with normal conditions and accidental conditions





Basic infrastructure: a set of glove boxes to make salt for experiments and also capable of receiving small experiments in the central oven

The following experimental work is then carried out in the framework of the European Euratom H2020 SAMOFAR Project **SAMOFAR** (2015-2019) strongly coordinated with **Multiphysics numerical modeling (Cf. Pablo Rubiolo)**.

A new experimental facility called **SWATH**

Salt at WAll: Thermal excHanges

has been built at the LPSC and used during SAMOFAR and SAMOSAFER (2019-2023) H2020 European projects to study some of the thermal-hydraulics challenges created by the use of fluoride molten salts.

Validation of Key Models

PIRT DEFINITION

Phenomena Identification and Ranking Table

Numerical model Development

- RANS Turbulence
- Phase change
- Thermal radiation
- Porous medium
- Internal heat sources

Experiments Design

Experimental facility:
- Flow control system
- Instrumentation

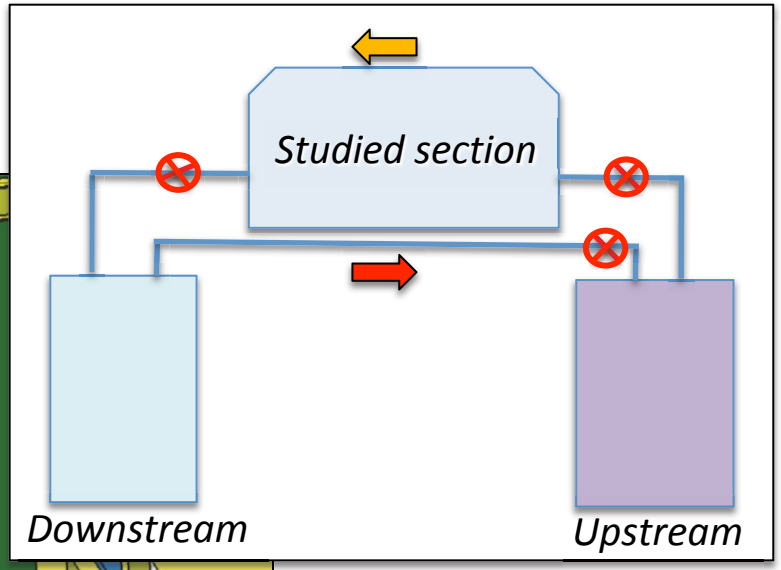
Test section:
- Phenomena
- Instrumentation

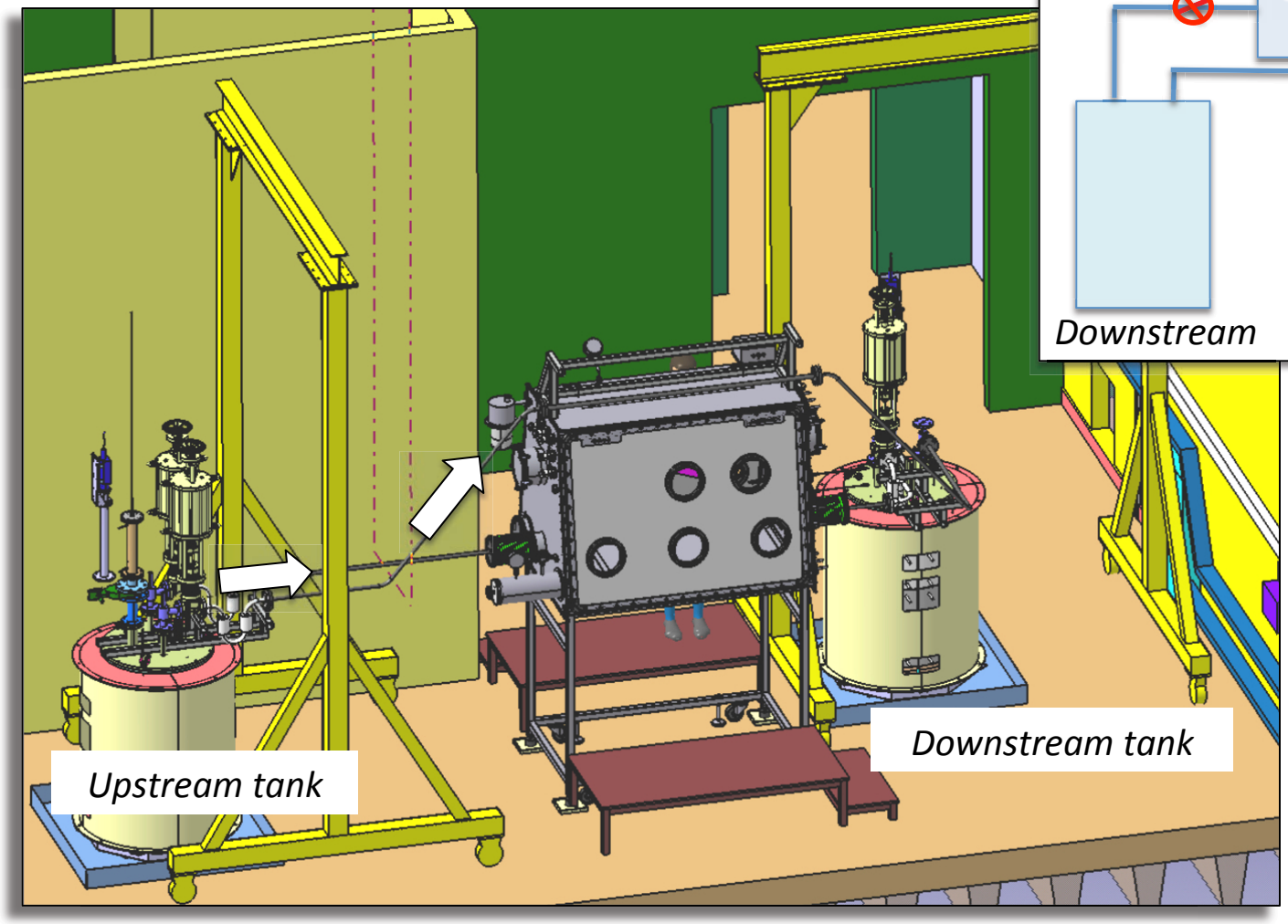
Comparison between model and experimental data

Key point: decrease as much as possible experimental uncertainties

The SWATH experimental installation :

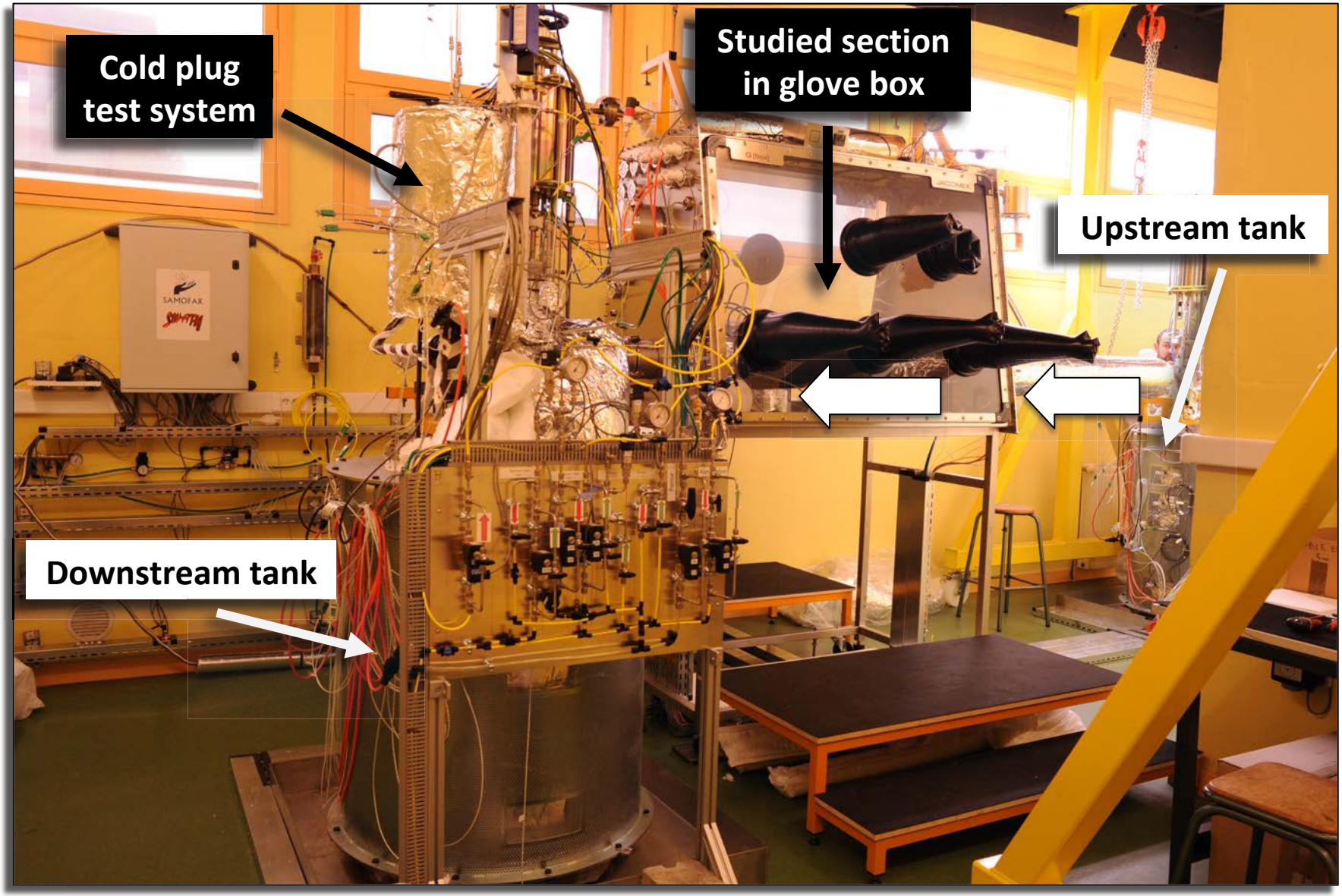
A discontinuous operating mode →





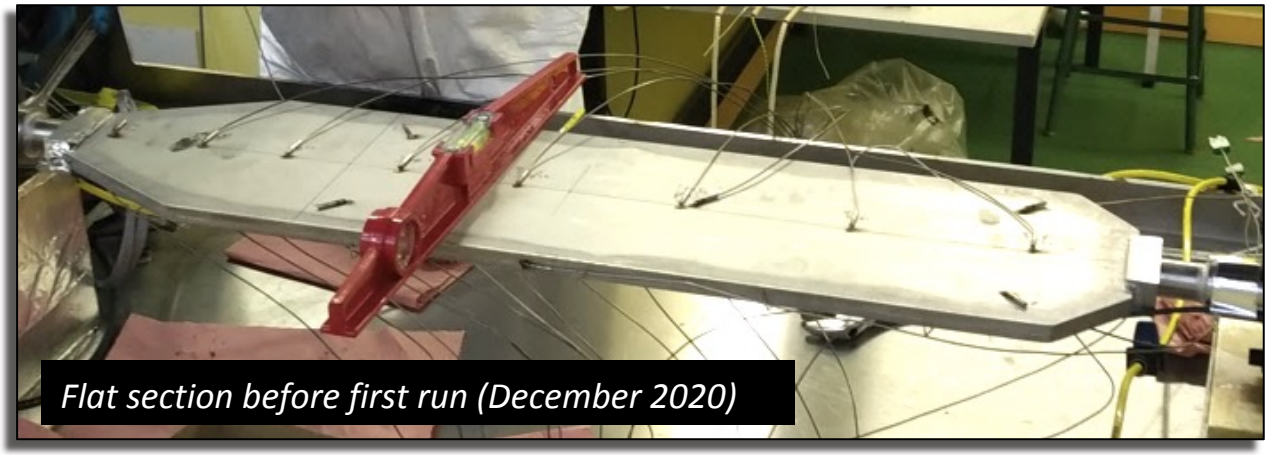
The duration of the tests is limited by the chosen flow rate but the installation does not include a pump.

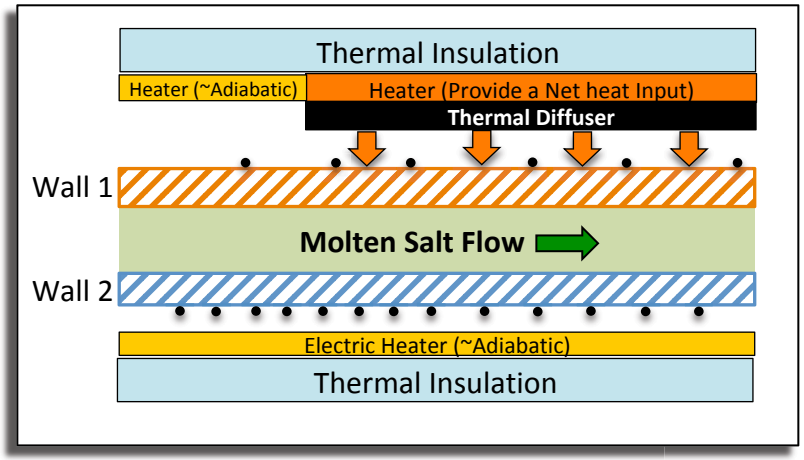
The flows are managed by the control of the pressure in the tanks.

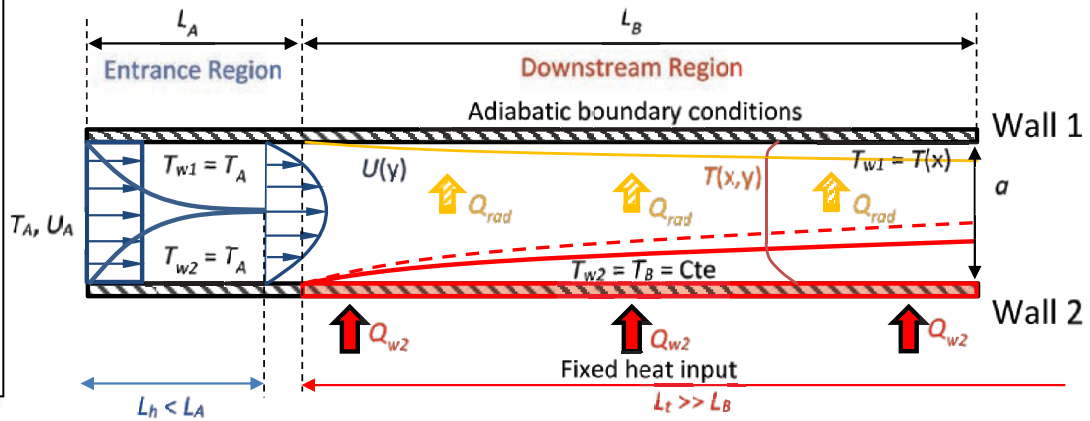


SWATH facility (FlinaK salt)

The flat channel section:



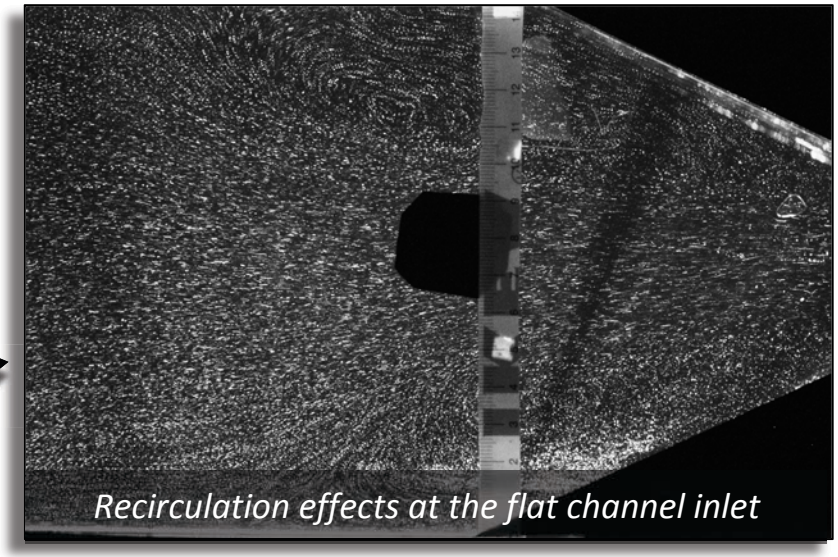




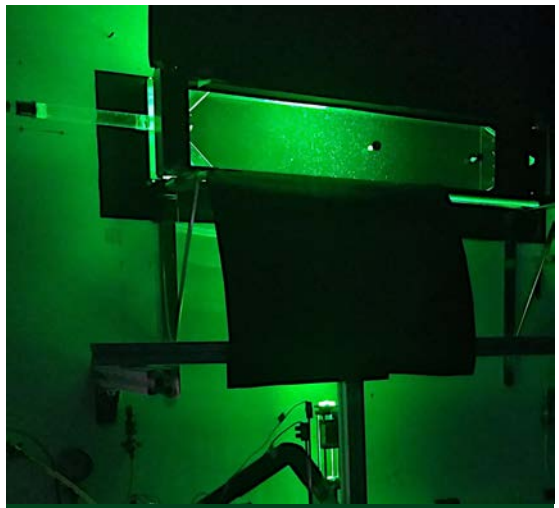
Thermal boundary layer development is used as working principle for the investigation of radiation heat transfer in the experiment:

By changing the molten salt flow inlet temperature and mass rate, the development length of the thermal boundary layer and the relative importance between radiation and convective heat transfers can be modified without changing the geometry.

Hydraulic geometry validation on water model:

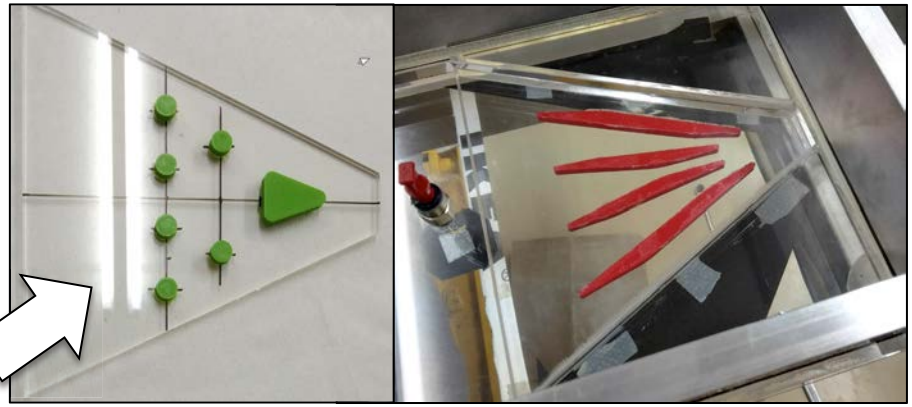


Recirculation effects at the flat channel inlet

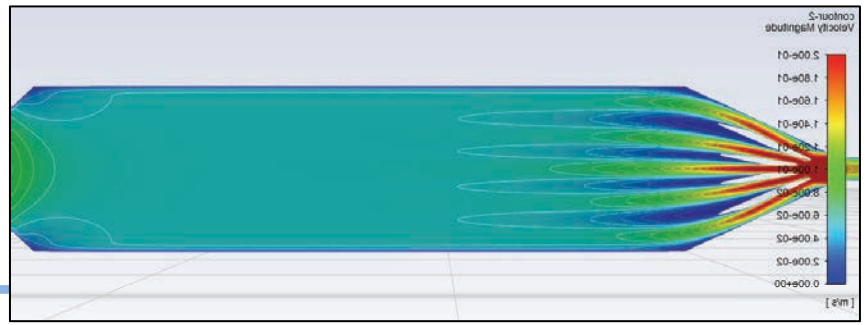


→ Flow Field acquisitions with PIV (Particles Image Velocimetry) experiments

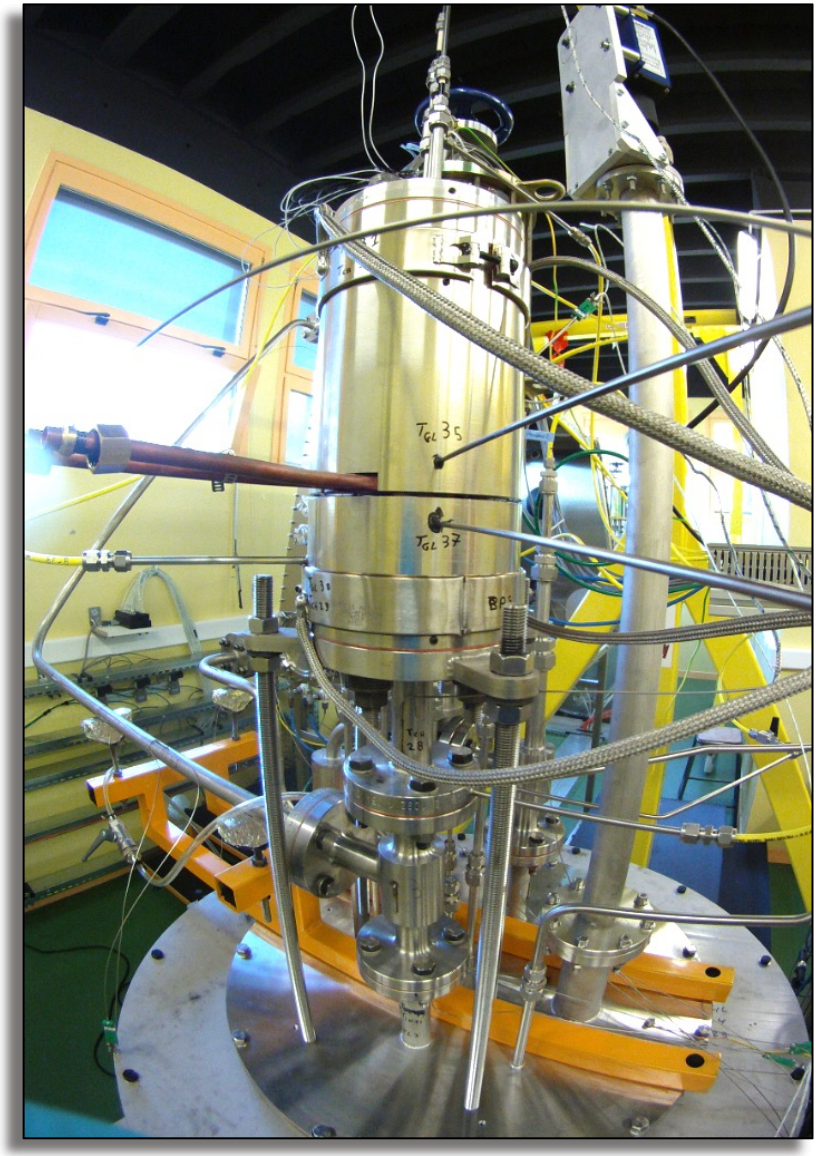
Studies of several diffuser shapes to suppress or minimize flow disturbances:

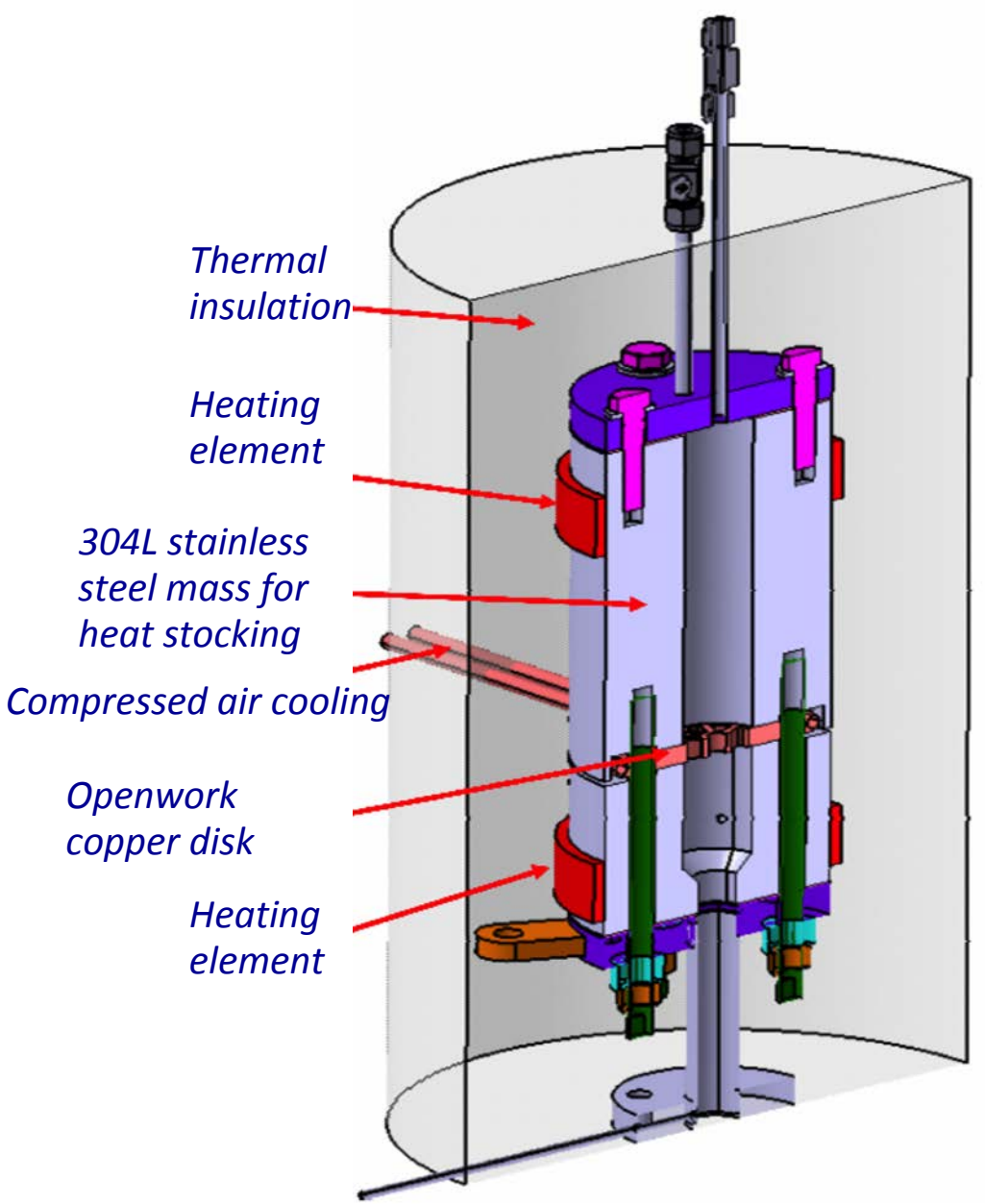


Configuration used in the metallic flat section

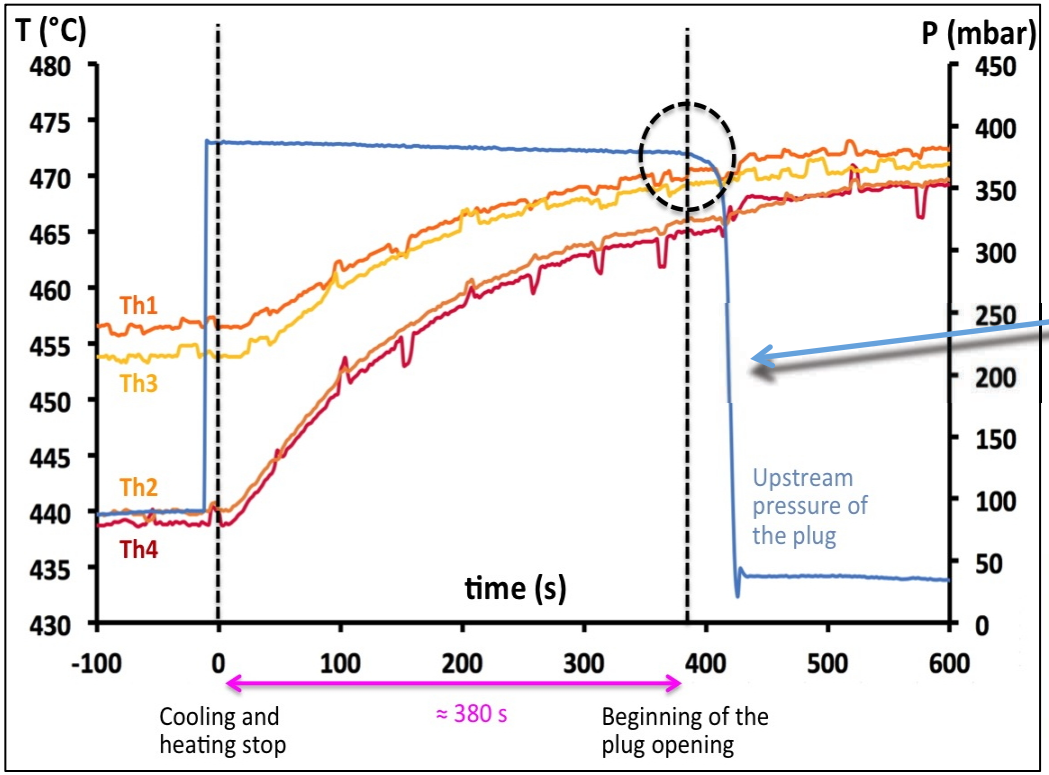


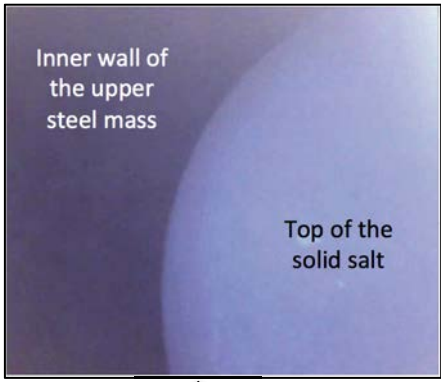
*J. Giraud, EPJ-Nuclear Sci. Technol. **5**, 9 (2019)*





Cold plug study mounted on the downstream tank

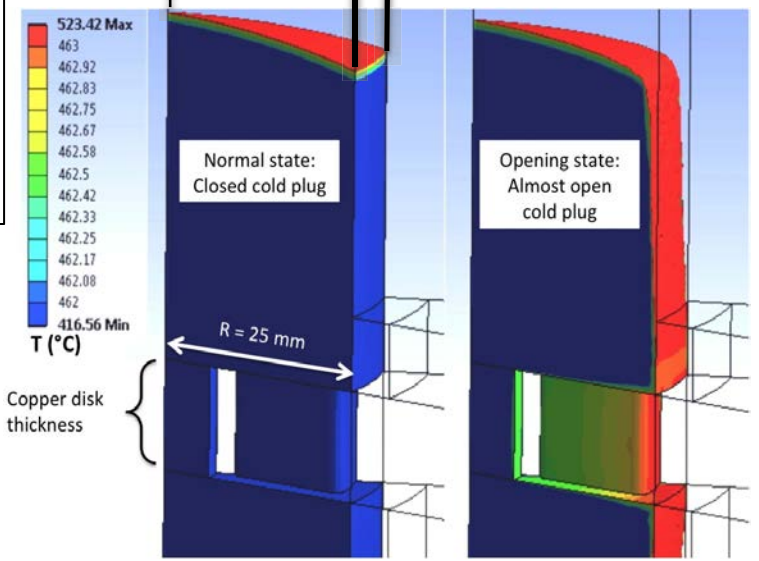




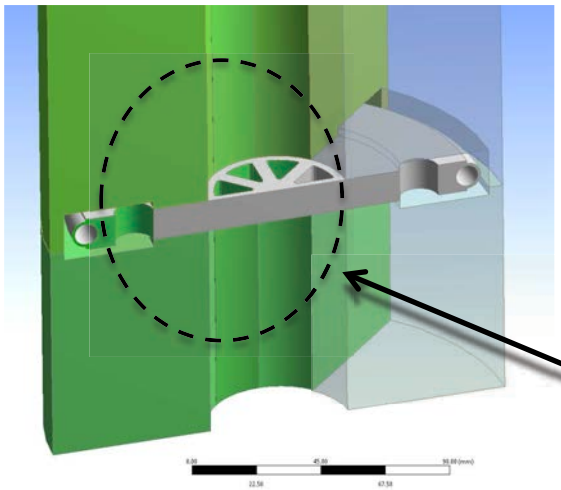
Upstream pressure

Liquid salt

After the upstream liquid has run down



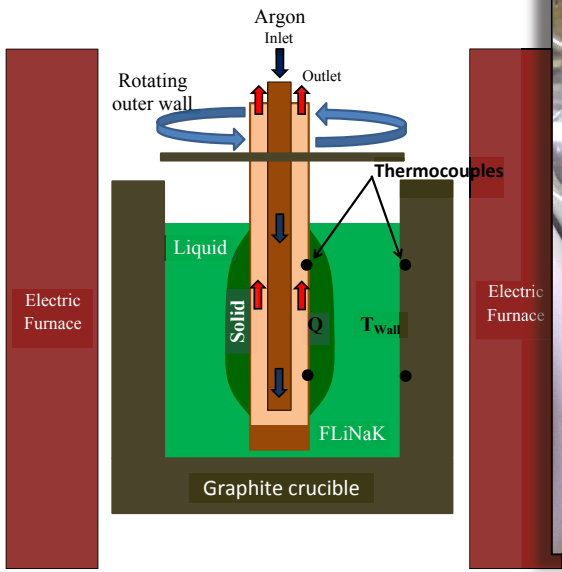
The opening time and the height of the plug are in agreement with the numerical simulation

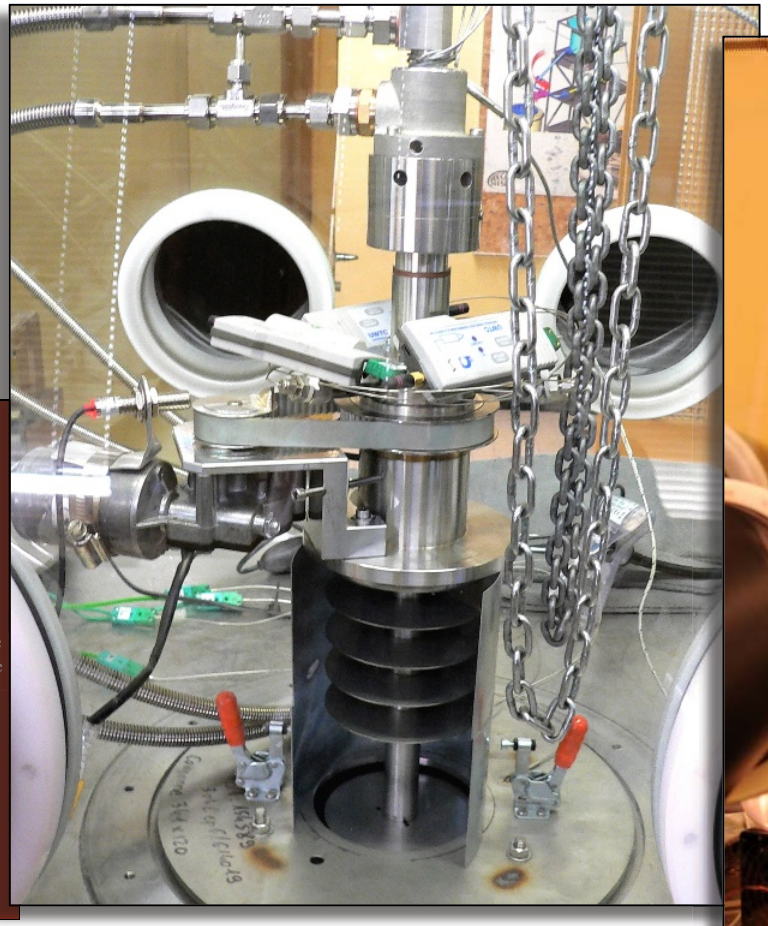


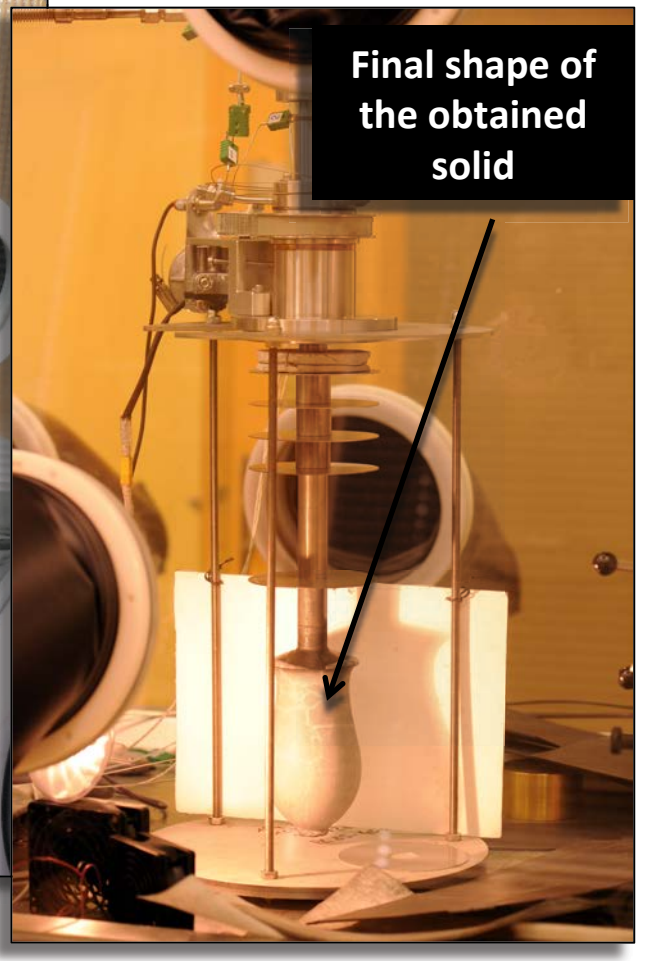
Location of the plug

Solidification experiments under controlled convection conditions:

These experiments employ a rotating tube inside an annular cavity filled with molten salt.







The rotating tube contains an inner tube that allows for the circulation of a gas coolant (argon) to decrease the temperature of the external wall of the outer tube below the salt melting point and thus initiating the solidification process.

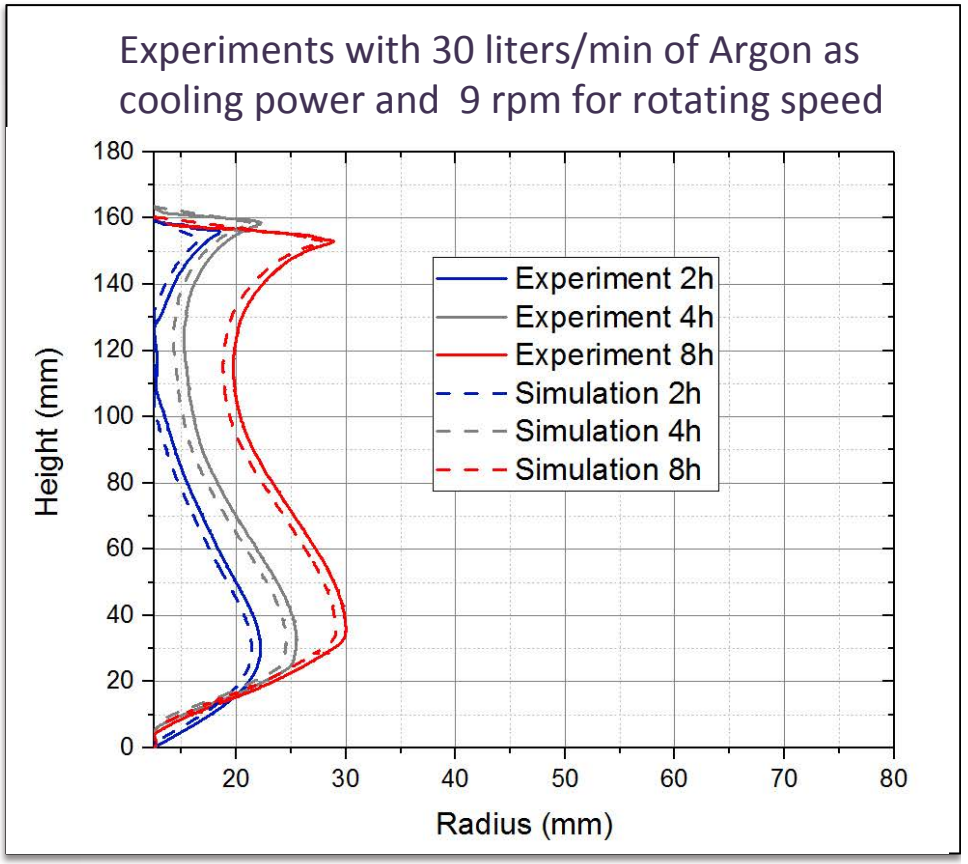
The tube rotation generates a relative simple forced convection velocity field in the fluid or not if fixed.

Examples of solid profile obtained:

Ar 30 litres/min
No rotation
4 hours

Ar 30 litres/min
9 rpm
8 hours

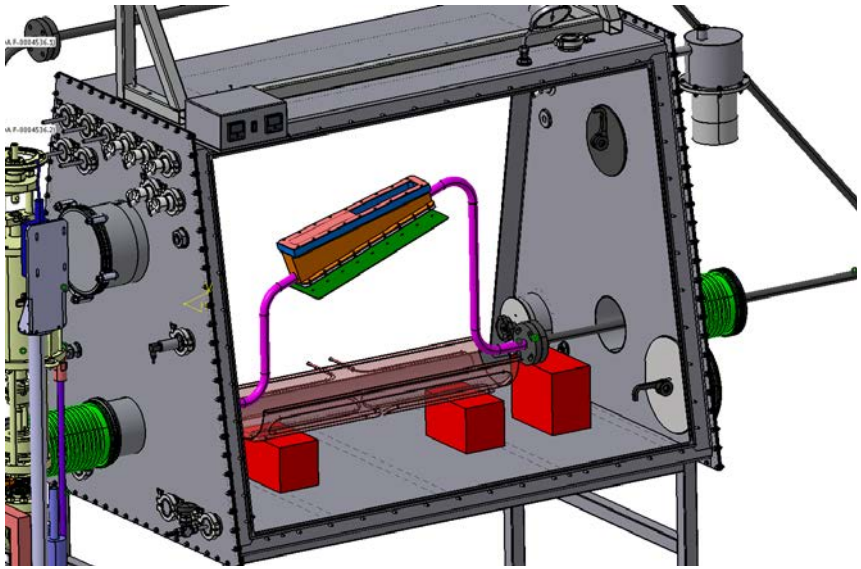
✓ Notable differences are observable according to the conditions of natural or forced convection



✓ Good agreement between the solid profiles obtained and those provided by the numerical simulation

Further technical developments are planned (2022- 2026):

- Test of an **open channel already designed and for which water tests are now beginning**
- Design and test of a small experiment for comparison with natural convection numerical simulation (PhD of Jonas Narvaez)
- Design and test of small experiment in relation with the space propulsion reactor (PhD Franco Quinteros)



- Implementation of the PIA-ISAC French project, which will run from 2022 to 2026. This project is based on chloride salt reactor studies. The planned work will consist of building a new loop, smaller than FFFER, and partly included in a glove box to study in line bubbling and some components.