LIEBE project:

WP3 – Construction and tests

Project coordination meeting – 30/01/2015

M. Delonca on behalf of the WP3 contributors

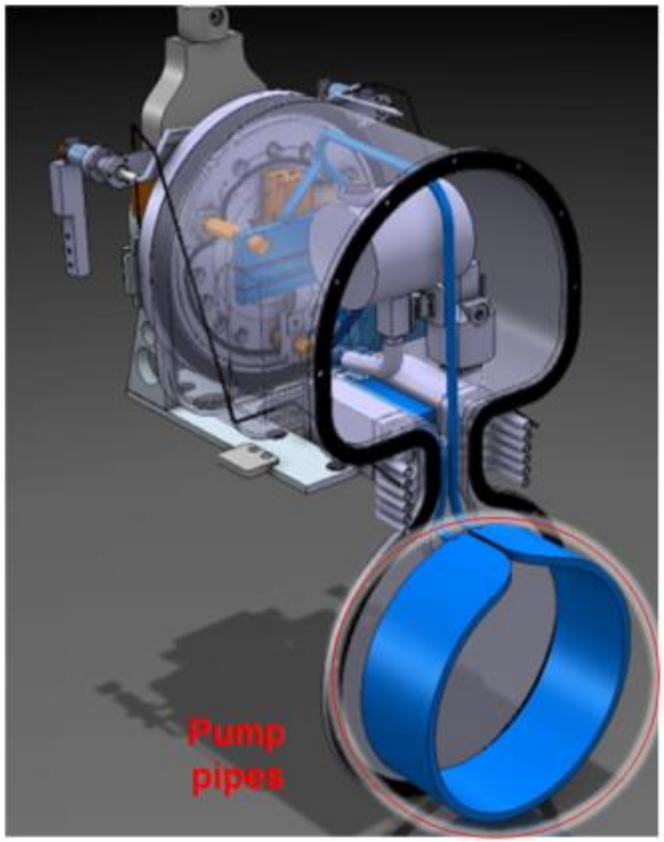
Outline

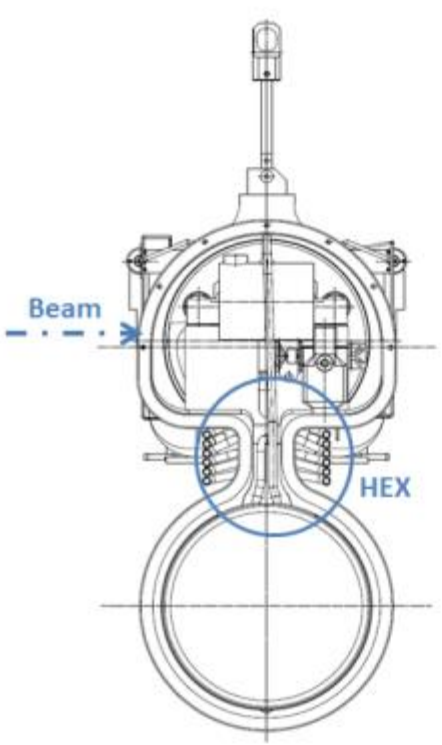
- Design:
  - Modifications since the Design Study report
  - Remaining open points
- Prototyping:
  - LBE shower tests – results
  - HEX test – plan
  - Other prototype to be planned
- Open points/conclusion

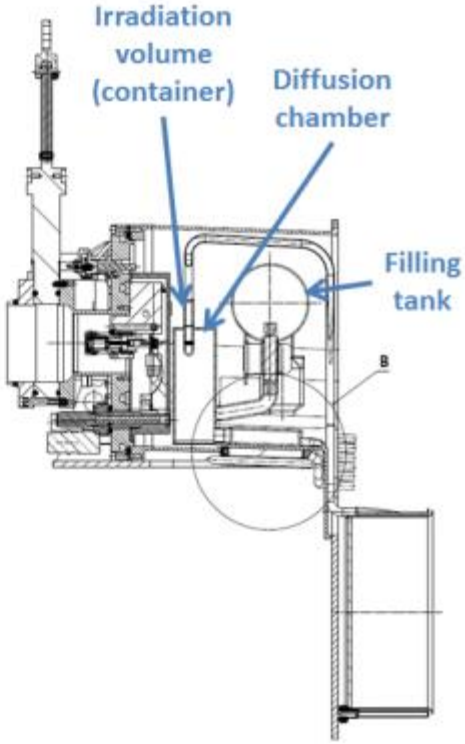
Design…

… modifications since the Design Study report and open points

Proposed design – at the review

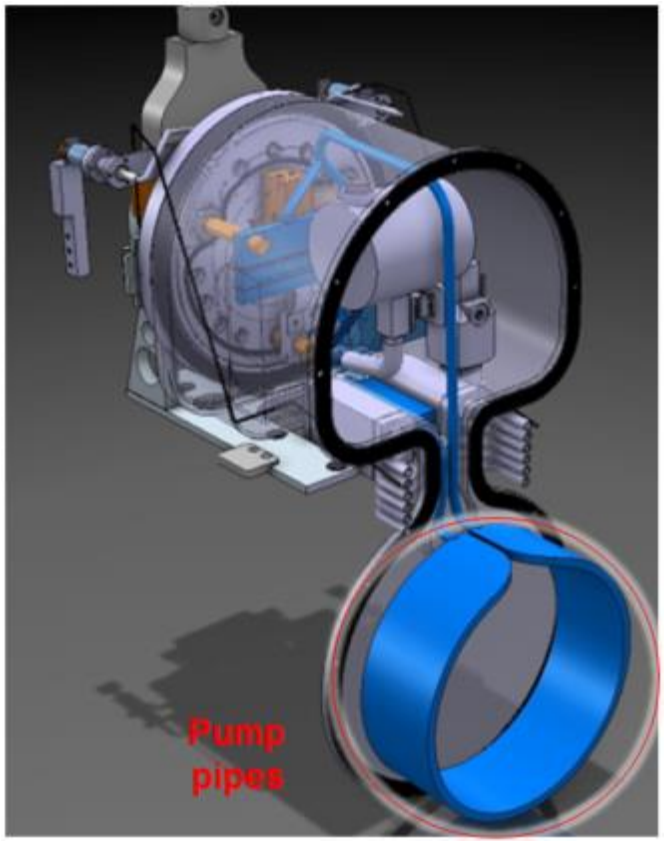


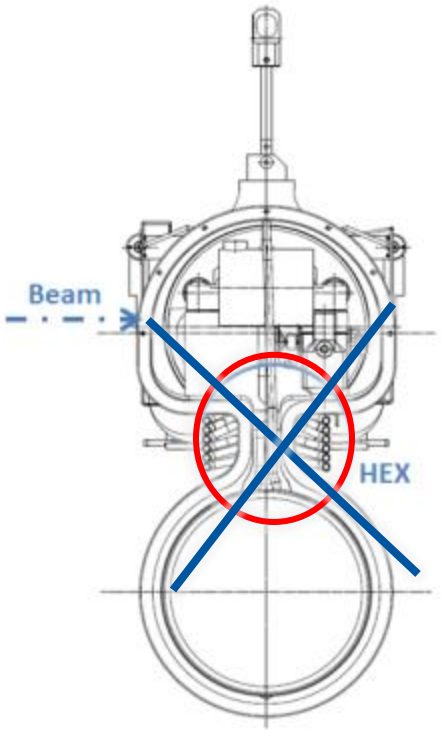




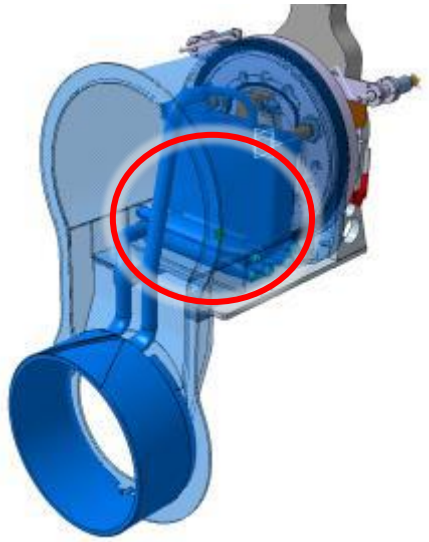
Proposed design – modifications (1)

- HEX



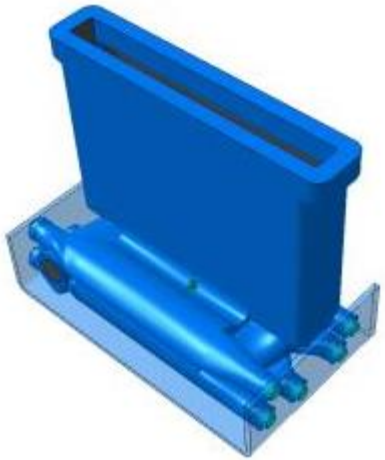


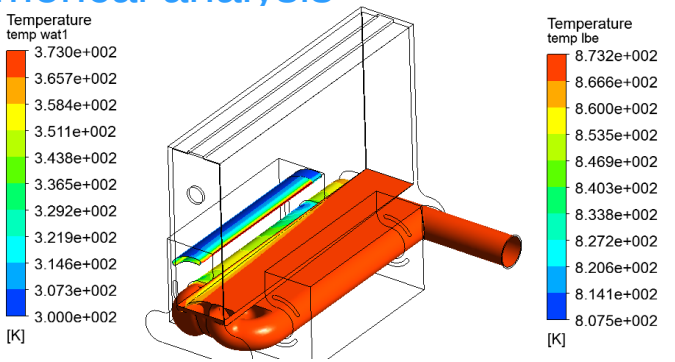
Weight too high: an important part comes from the LBE in the diff chamber and in the HEX.



Proposed design – modifications (2)

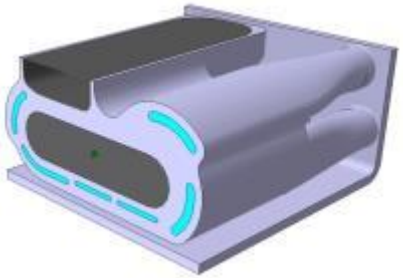
- HEX – detailed design – design validated by numerical analysis



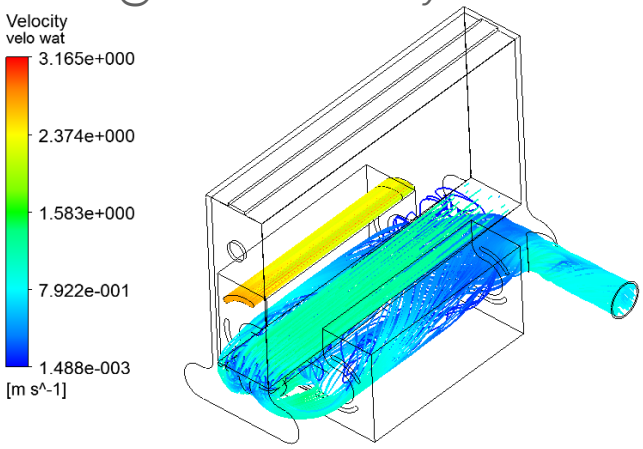


Temperatures repartitions foo LBE and water @ 600 ˚C – CFX analysis

No double confinement anymore!



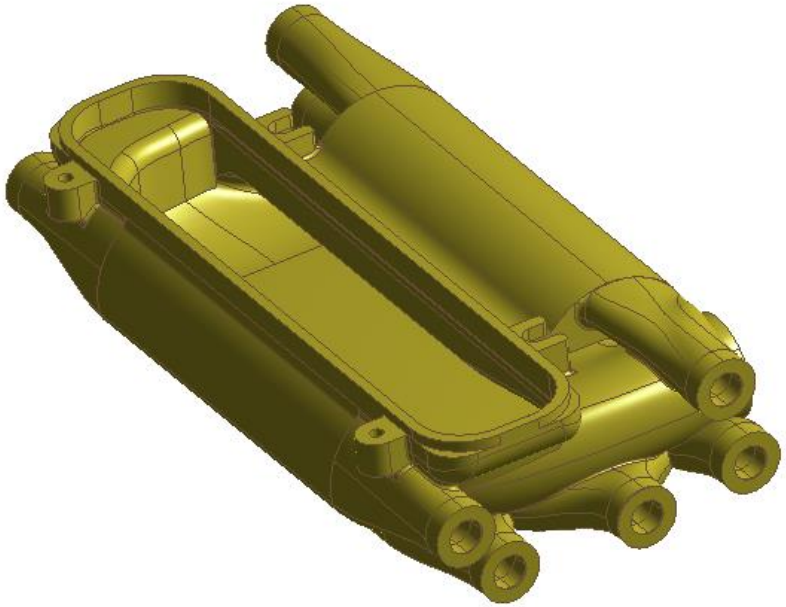
Part built by additive manufacturing!



Velocity streamlines fro LBE and water @ 600 ˚C CFX analysis

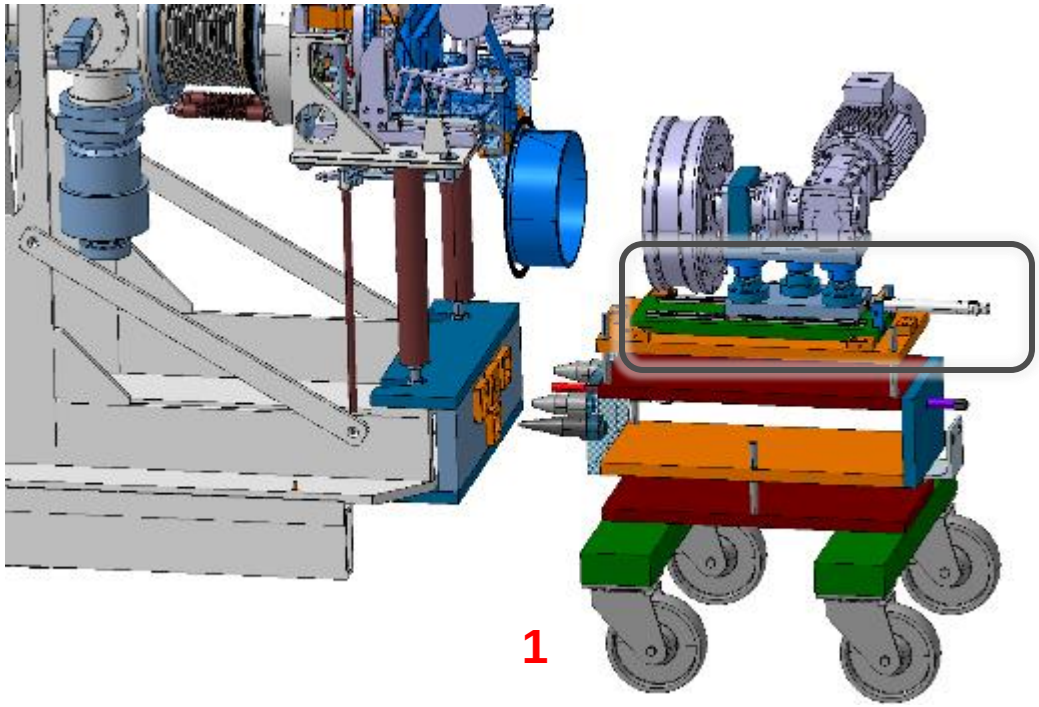
Proposed design – updates (3)

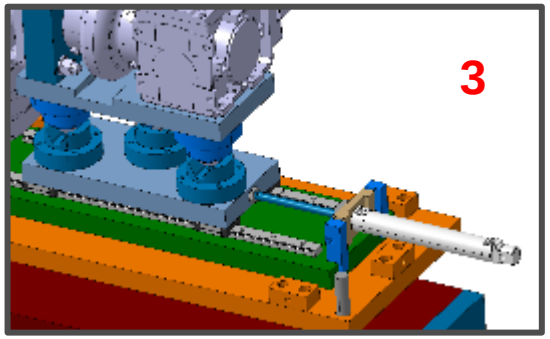
- HEX – part already ordered for test – should be received next week
  - Part tested at 16 bars by the company
  - X-ray analysis provided as well
  - Chemical treatment for finer roughness inside the channel



Proposed design – updates (4)

- Coupling of the pump part and the main loop part – system proposed
  1. positioning of the trolley regarding to the front end,
  2. coupling of the trolley thanks to pre-guiding and guiding system,
  3. translation of the engine/magnets part thanks to an actuator and sliding guide.





Proposed design – updates (5)

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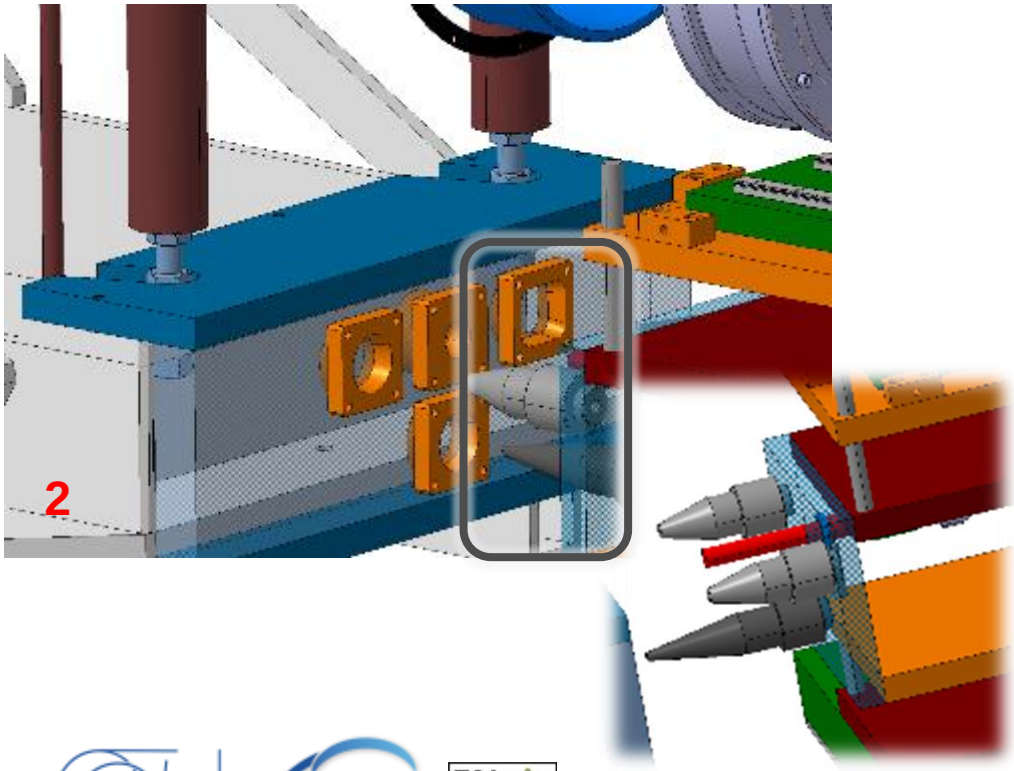
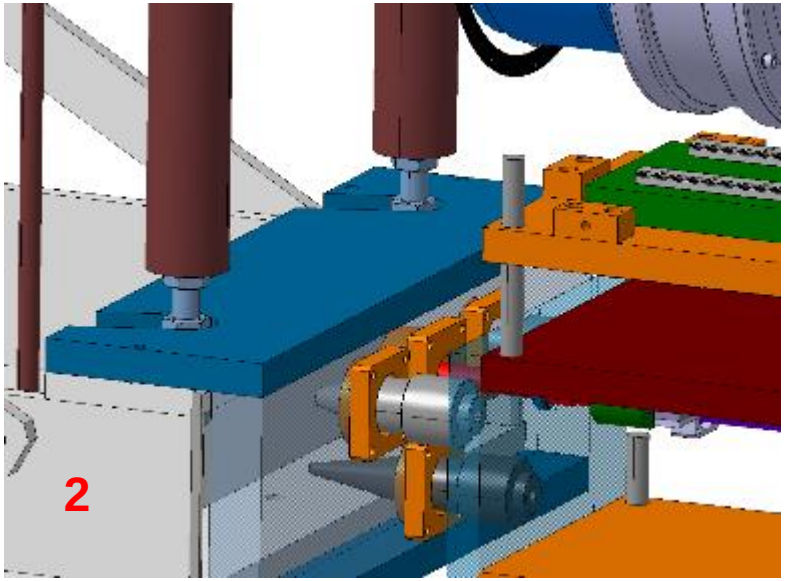
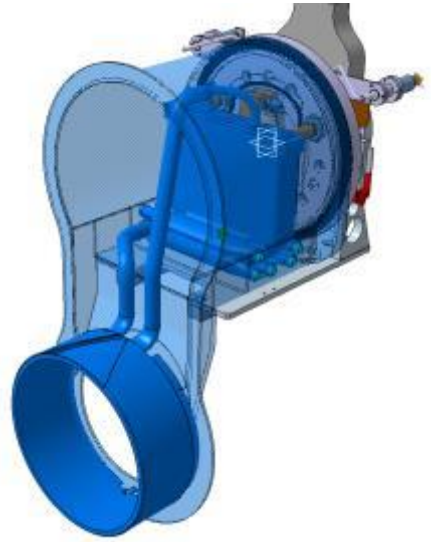




Proposed design – open points

- Open points on the design:
  - Monitoring elements to be implemented,
  - filling procedure,
  - emptying procedure,
  - coupling to the Front end
- Simulations remaining:
  - Shock waves coupled with flow (?),
  - Casserole integrity,

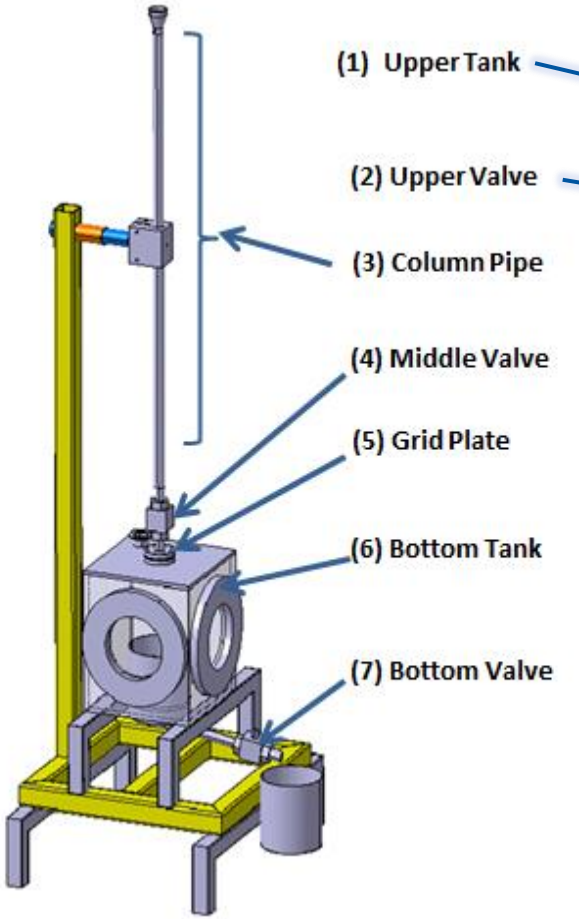


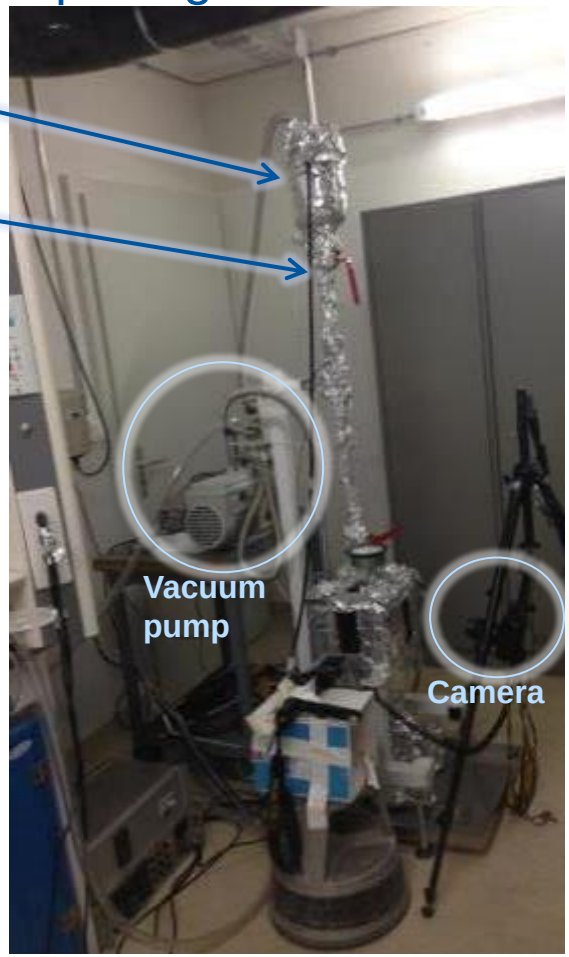
And validation of proposed design with prototype!

Prototyping…
… LBE shower test - results

Prototypes – LBE shower test (1)

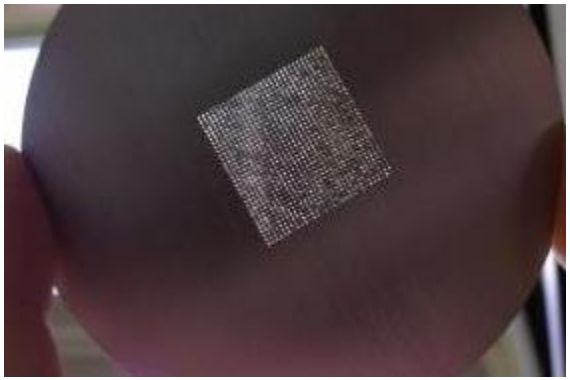
- What is the proper spacing with LBE?





- **Volume of LBE** per shower known (between the upper and middle valve)
- **4 grids** to be tested (different spacing from 1 mm up to 0.4 mm), holes diameter of 0.1 mm.
- **5 showers** per grids (repeatability)
- **Camera** to take picture (3 per second)

Grid samples



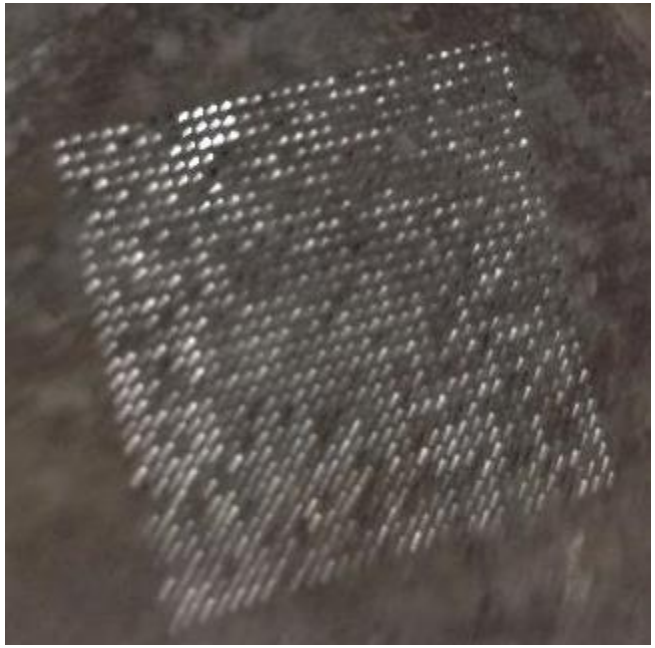
Courtesy D. Grenier & T.M. Mendonca, CERN

Prototypes – LBE shower test (2)

- Observations:

Shower at start.

Shower at the end.

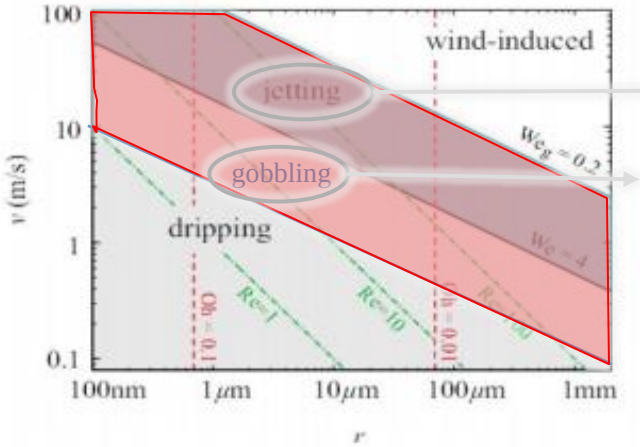


After the serie of shower
Clogging visible

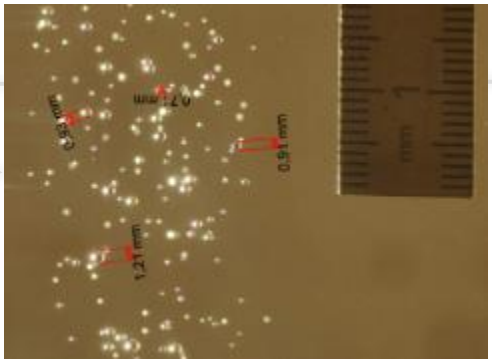
- Shower feasibility proven: smallest spacing between holes of **0,5 mm** for 0,1 mm holes
- Oxidation prevent a proper operation of the grid (analysis of the grid foreseen)
- Size of droplets vary between the start and the end of the shower

Prototypes – LBE shower test (3)

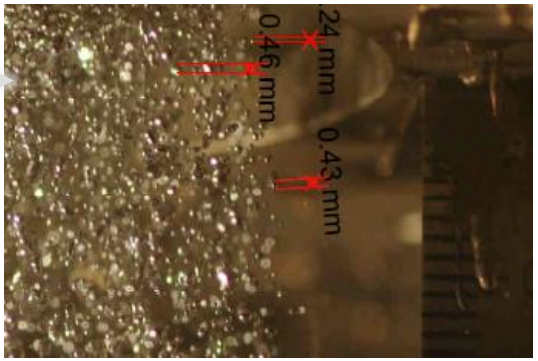
Classification of droplet formation regimes



Impact on the **dimension of the droplets** created



Gobbling



Jetting

Hoeve et al. (2010) and C.Clasen et al (2008)

Limit velocity between the two regimes: $v^* = \sqrt{\frac{\gamma}{\rho r}} = 0{,}62\,\frac{m}{s}$

with γ the surface tension of the liquid (N/m), ρ the liquid density (kg/m^3) and r the nozzle radius (m)

Regime	Velocity	Calculated droplet diameter	Average droplet diameter - test
Gobbling	0 to 0,62 m/s	~ 1,2 mm	~ 1 mm
Jetting	> 0,62 m/s	~ 0,4 mm	~ 0,4 mm

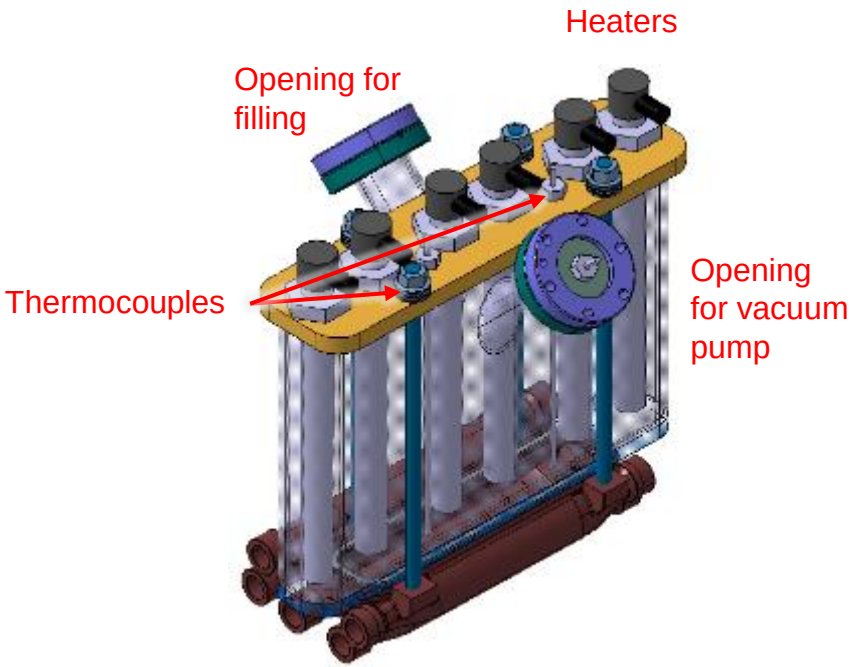
Good agreement between theory and experimental data (considering the measurements and post processing errors).

To obtain smaller droplets, the outlet velocity should be **> 0,62 m/s** (jetting regime).

Prototyping…
… HEX test - plan

Prototypes – HEX (1)

- HEX – test proposal – *from Sevan Kelpentidjian*
- *Ecal mobil unit will be borrowed from CV department*



HEX bloc with diffusion chamber, heating elements, feedthrough for thermocouples and openings.

On the ECAL unit:

- Pump up to 7,2 m^3/h and 4 bars
- HEX up to 7 kW
- Control of inlet and outlet temperature
- Demineralized water

ISOLDE cooling circuit:

- 0,8 m^3/h
- 10 bars

Prototypes – HEX (2)

Dimensioning of an HEX:

$$P = H * S * \Delta T_{lm}$$

$$with\ \Delta T_{lm} = \frac{\Delta T_2 - \Delta T_1}{\ln\left(\frac{\Delta T_2}{\Delta T_1}\right)} \quad and\ H = \frac{1}{\frac{1}{h_1} + \frac{1}{h_2}}$$

- Planned tests:
  - *Test of the HEX bloc at 16 bar with air @ CERN*
  - *Test of circulation of water inside the HEX channels, without LBE*
  - *Test with LBE at various T and under vacuum*

- *Expected results:*
  - *Control of inlet and outlet water temperature to estimate the power extracted*
  - *Verification of mechanical integrity of the HEX bloc*

$$P = \dot{m} * Cv * (T_2 - T_1)$$

	$T_{in}water$	$T_{out}water$	$\Delta T_{test}water$	P_{test}	ΔT_{simu}	P_{simu}	difference temp (%)	difference P (%)
200	test	test	#VALUE!	calcul	4,2	3636	#VALUE!	#VALUE!
300	test	test	#VALUE!	calcul	3,6	3221	#VALUE!	#VALUE!
400	test	test	#VALUE!	calcul	3,7	3139	#VALUE!	#VALUE!
500	test	test	#VALUE!	calcul	3,4	2930	#VALUE!	#VALUE!
600	test	test	#VALUE!	calcul	3,0	2562	#VALUE!	#VALUE!

Since there is no circulation of LBE, the velocity of water must be lower than for the LIEBE target to be in the same cooling condition for the water.
Might be difficult to assess with precision the power extracted!

Prototyping…

… other prototypes to be planned

Prototypes – tests to be planned before the full loop test

- Prototyping of coupling procedure for the main loop target and the pump/engine one – **CERN**
- Prototyping for the coupling of the target with the front end (including the coupling of the monitoring elements and water for the HEX) – **CERN**
- Prototyping to assess the behavior of the pipes if the LBE freeze inside (open point from the panel review) - **?**
- Testing of the pump (care to be put on cavitation issue) – **IPUL**
- Testing of the robot compatibility in all situation (even in case of break up of the main loop) – **CERN**
- Testing of the leak tightness system – **CERN**
- Testing of the stability of LBE flow in Y-divider - **?**

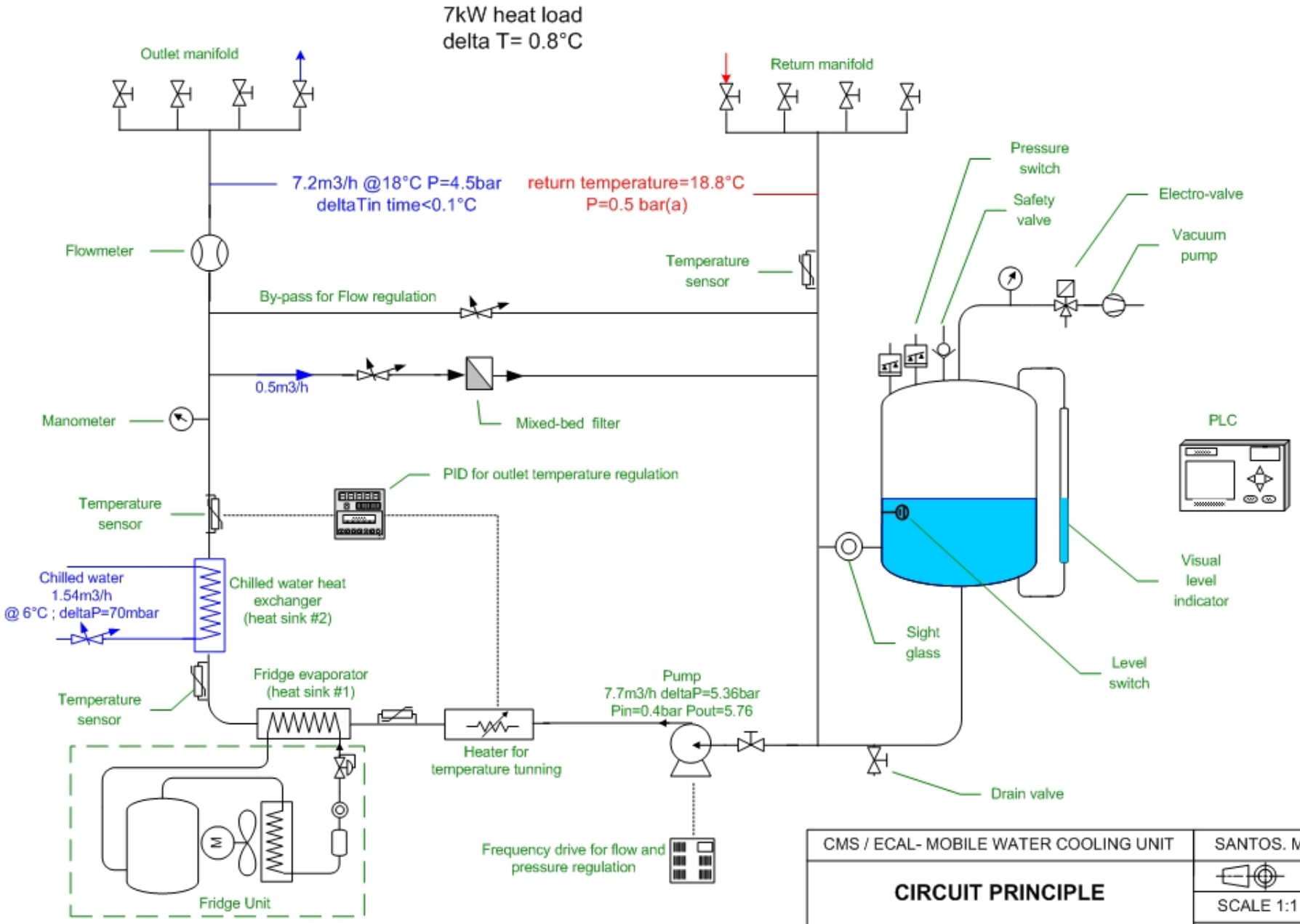
Open points - conclusion

Open points - conclusion

- Design still requires some finalization,
- Many prototypes to do,
- 17 recommendations have been given by the panel review: to be discussed today,
- Other points?

Thank you for your attention!

Back up slides…



Power to be removed either by fridge unit or chilled water =(19-18)x4184(J/Kg.K) x 2(Kg/s)=8368W
Heater Power=12kW

CMS / ECAL- MOBILE WATER COOLING UNIT	SANTOS. M
CIRCUIT PRINCIPLE	SCALE 1:1
	18/09/2002
CERN/ST/CV	127.42.01