MEDSI 2016 — Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation

THERMO-FLUID NUMERICAL SIMULATION OF THE UPC RACE-TRACK MICROTRON COOLING SYSTEM

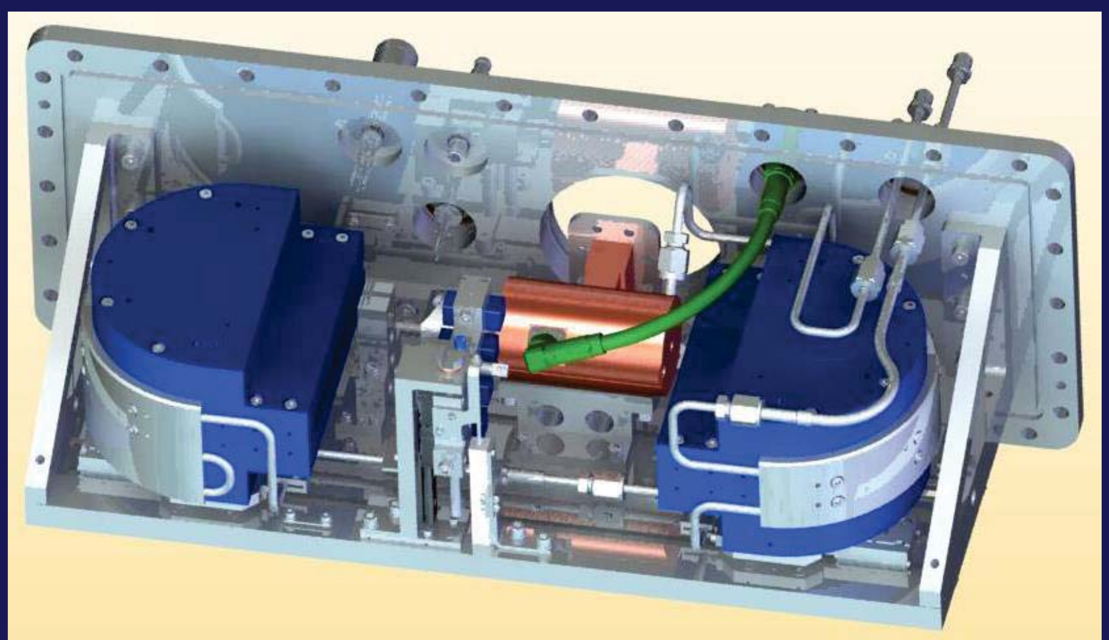
X. Escaler, Yu.A.Kubyshin, V. Blasco, J.A. Romero, A. Sánchez, M. Prieto, Technical University of Catalonia, Barcelona, Spain

V.I. Shvedunov, SINP MSU, Moscow, Russia

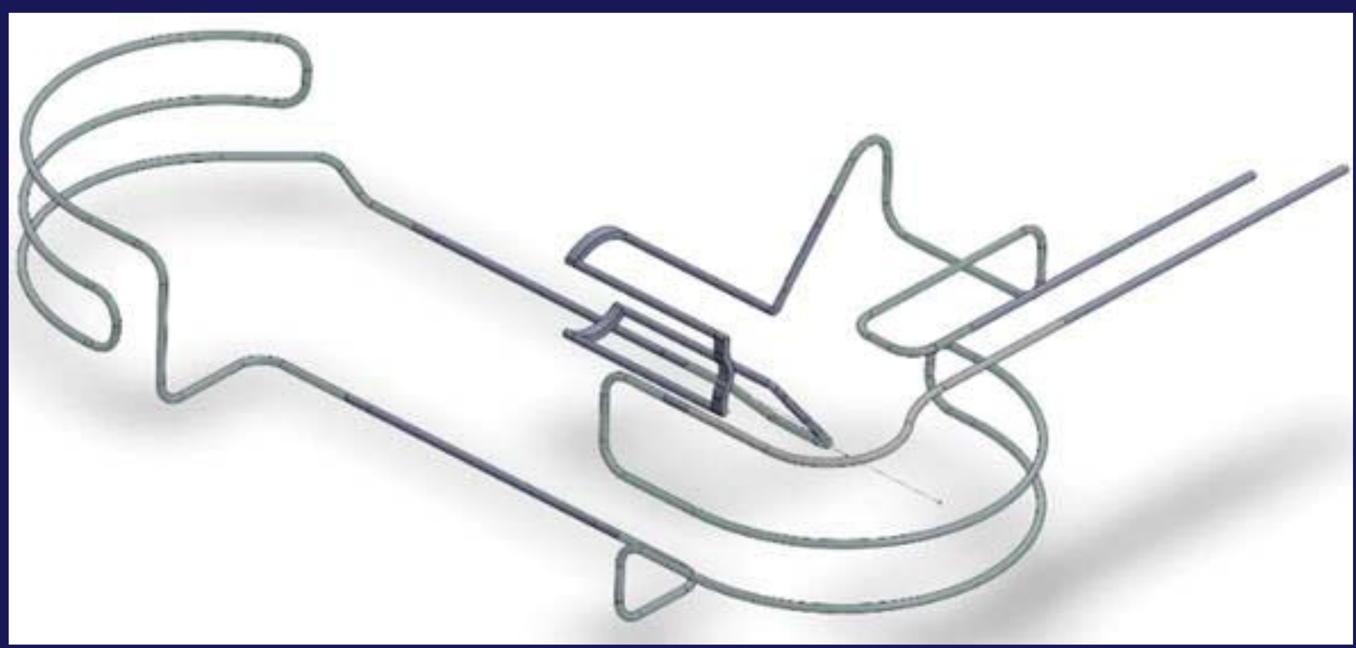
E-mail: iouri.koubychine@upc.edu

INTRODUCTION

The cooling system of the RTM end magnets and linac has been simulated by means of a Computational Fluid Dynamics (CFD) software at the Center for Industrial Diagnostics and Fluid Dynamics (CDIF) of the UPC. The main function of the RTM cooling system is to provide a safe and stable operation by ensuring temperature stability. Moreover, the chiller pump must be powerful enough to provide the required flow rate to extract the generated heat. The hydraulic and thermal performance of the system has been studied for various operation conditions.



RTM components inside the vacuum chamber



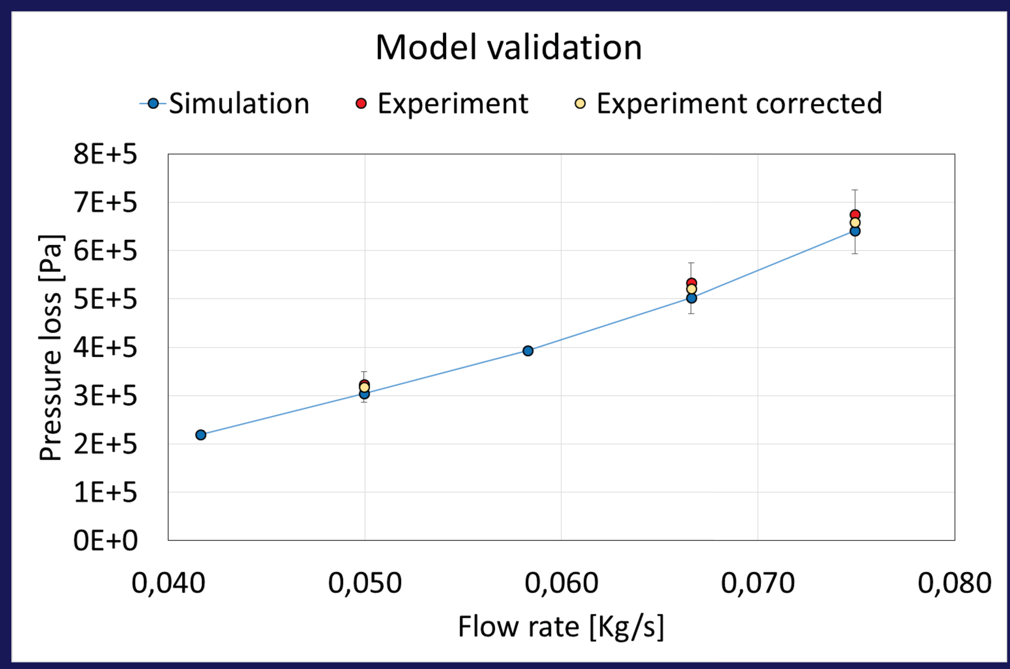
Fluid domain representing the water conduits

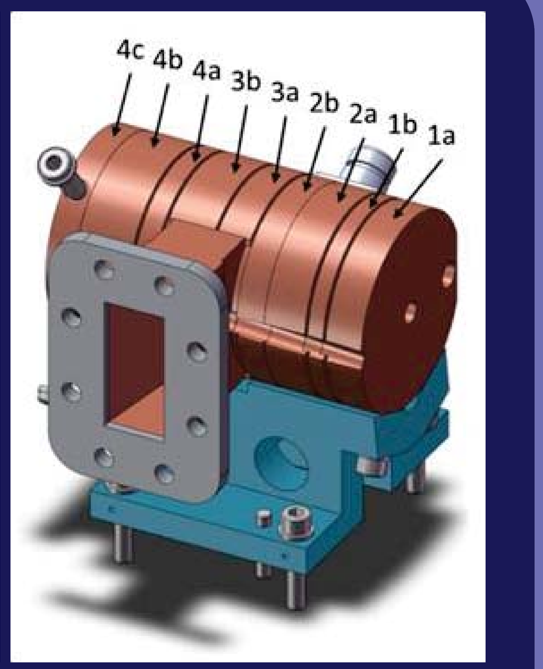
Chiller flow conditions

Mass flow rate (Kg/s)	Reynolds (-)
0.0416	10137
0.0499	12165
0.0583	14192
0.0666	16220
0.0749	18247

MODEL EXPERIMENTAL VALIDATION AND HYDRAULIC BEHAVIOUR

- To validate the model ANSYS® CFX 14.5, a series of experimental measurements with the cooling system of the RTM vacuum chamber have been carried out at the INTE.
- The signals from two pressure sensors (model PT5404 from ifm®) and a flowmeter (model PF3W520-F03-1-R from SCM®) have been registered with a 10 bits Arduino® Ethernet board.
- The pressure loss measured at three different flow rates has been compared with the numerical results and good agreement has been observed.





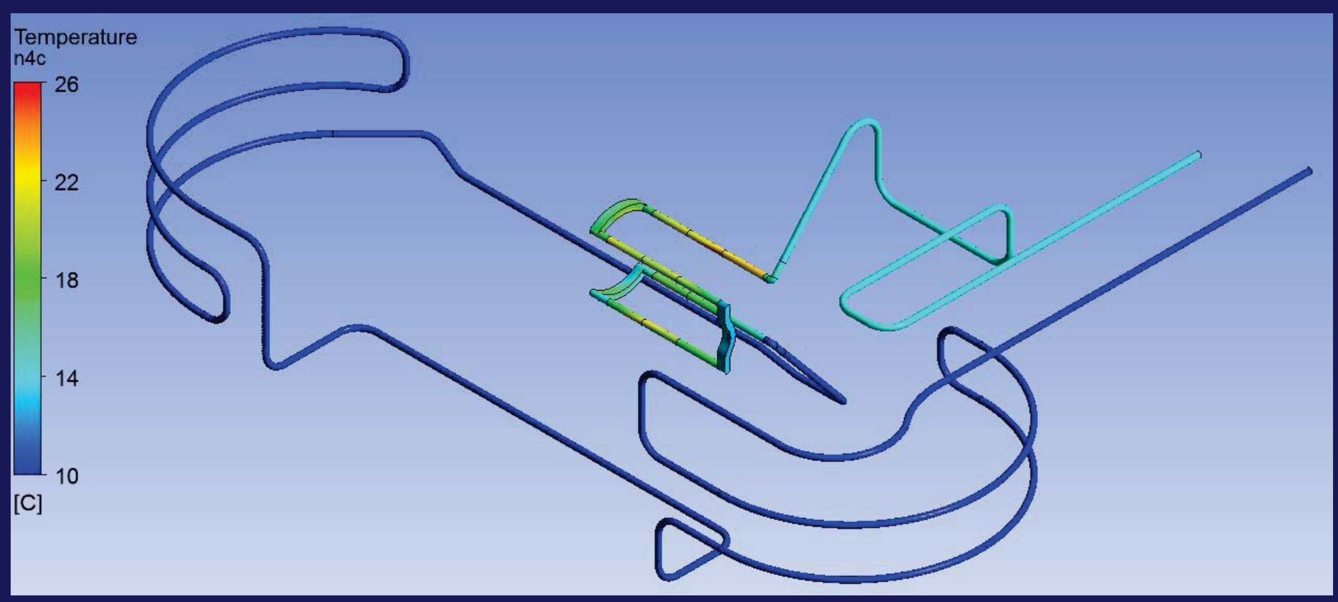
POWER LOSSES IN THE CAVITY WALLS OF THE LINAC AND END MAGNETS

- According to results obtained in the PhD Thesis by David carrillo (CIEMAT) the RF power dissipated in the linac 1st (1a+1b), 2nd (2a+2b), 3rd (3a+3b) and 4th (4a+4b) acceleration cells and 4c segment corresponds to 18%, 26%, 26%, 25% and 5% of the 1000 W total dissipated power, respectively. The total dissipated power at the end magnets is 10 W.

THERMAL BEHAVIOUR OF THE COOLING SYSTEM

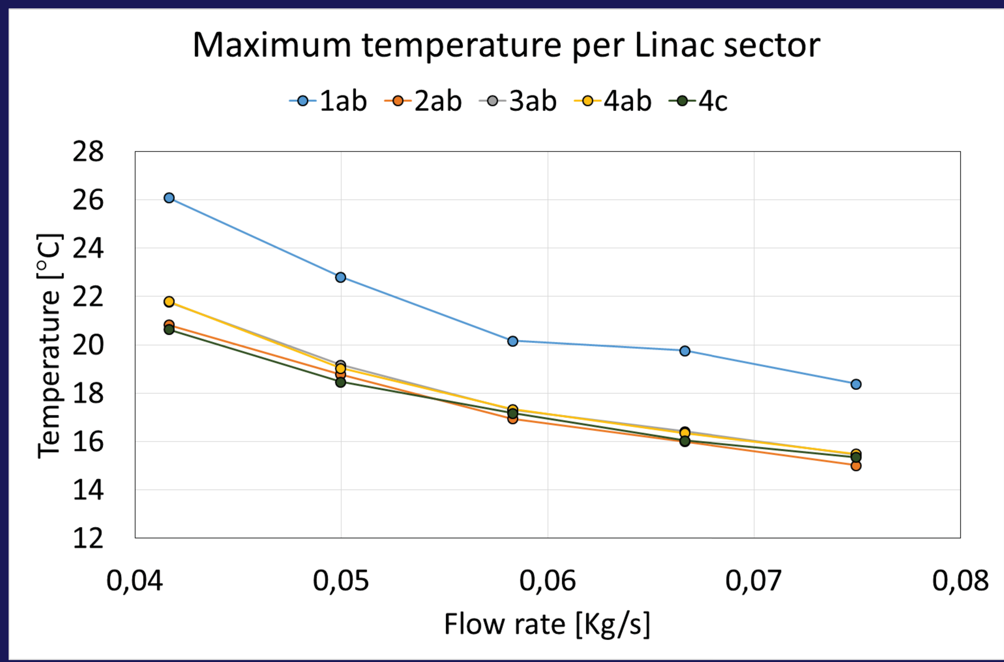
- The outlet water temperature, the maximum wall temperature and the maximum and average wall heat transfer coefficients have been estimated for all the flow rates given an inlet temperature of 10°C.

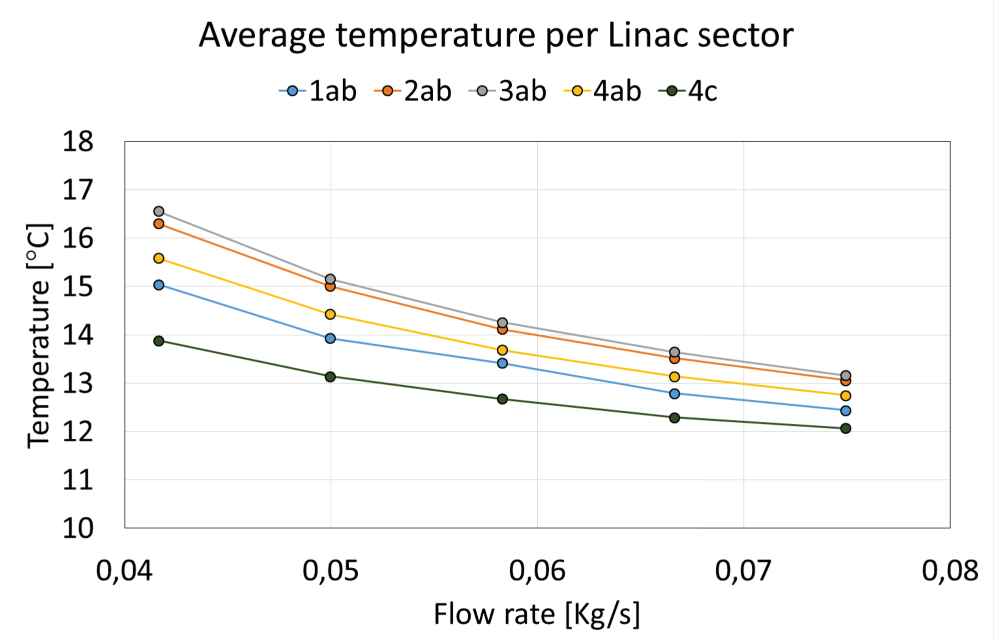
[kg/s]	T_{out} [°C]	T_{max} [°C]	h_{max} [W/(m²K)]	h_{ave} [W/(m²K)]
0.0416	15.8	26.1	35519	5832
0.0499	14.8	22.3	40030	6711
0.0583	14.2	20.1	44127	7556
0.0666	13.6	19.8	48597	8392
0.0749	13.3	18.4	52285	9129

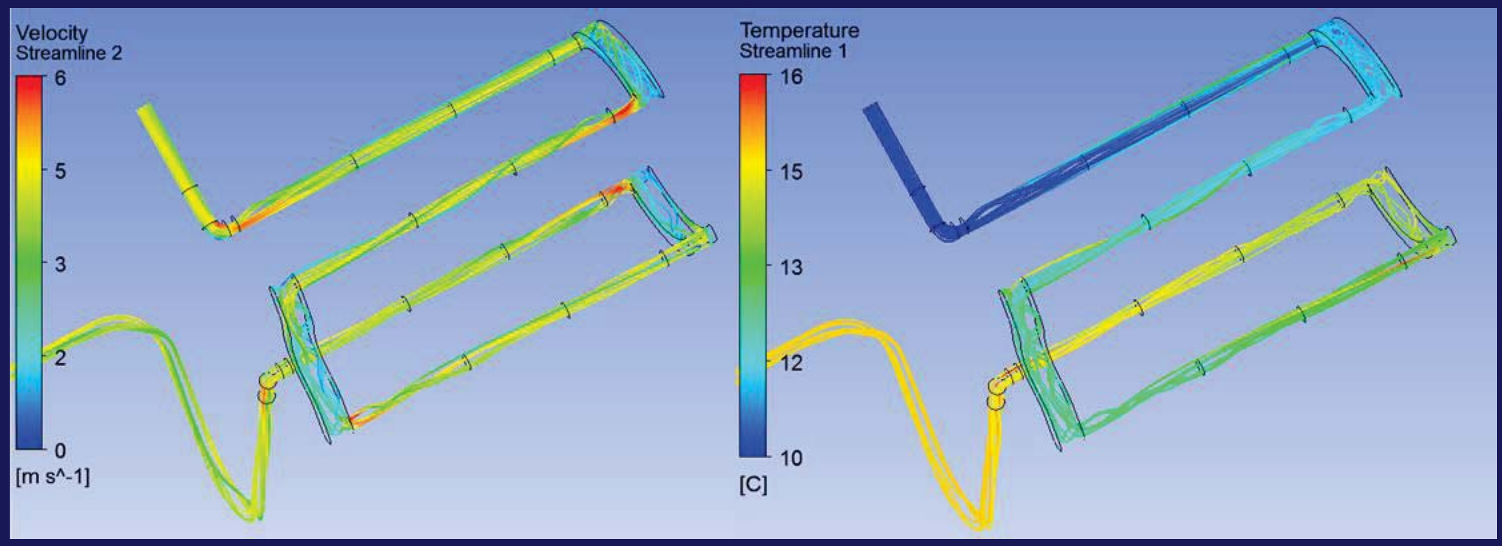


Pipe wall temperature for 0.05 kg/s

- The local maximum and average wall temperatures have been estimated for each of the linac segments.
- The maximum wall temperatures are always in the segment 1a+1b, and the maximum average temperatures are always in the segment 3a+3b.







Linac flow streamlines colored as a function of the velocity (left) and the temperature (right)

CONCLUSIONS

- ✓ Water flow streamlines show boundary layer detachments resulting in regions with stagnant water and very low velocities that reduce significantly the convective heat transfer and provoke high wall temperatures. To avoid this the tube geometry must be optimized by rounding the bends.
- ✓ For low mass flow rates the temperature difference between the linac segments may lead to unwanted consequences preventing its correct operation. The flow rate must about 0.075 kg/s or higher.

http://inte.upc.edu

MEDSI, 11-16 September 2016, Barcelona, Spain