Design and Testing of a New Cooling System using Solid Nitrogen for Pulsed Field Magnetization and Characterization of HTS Bulks

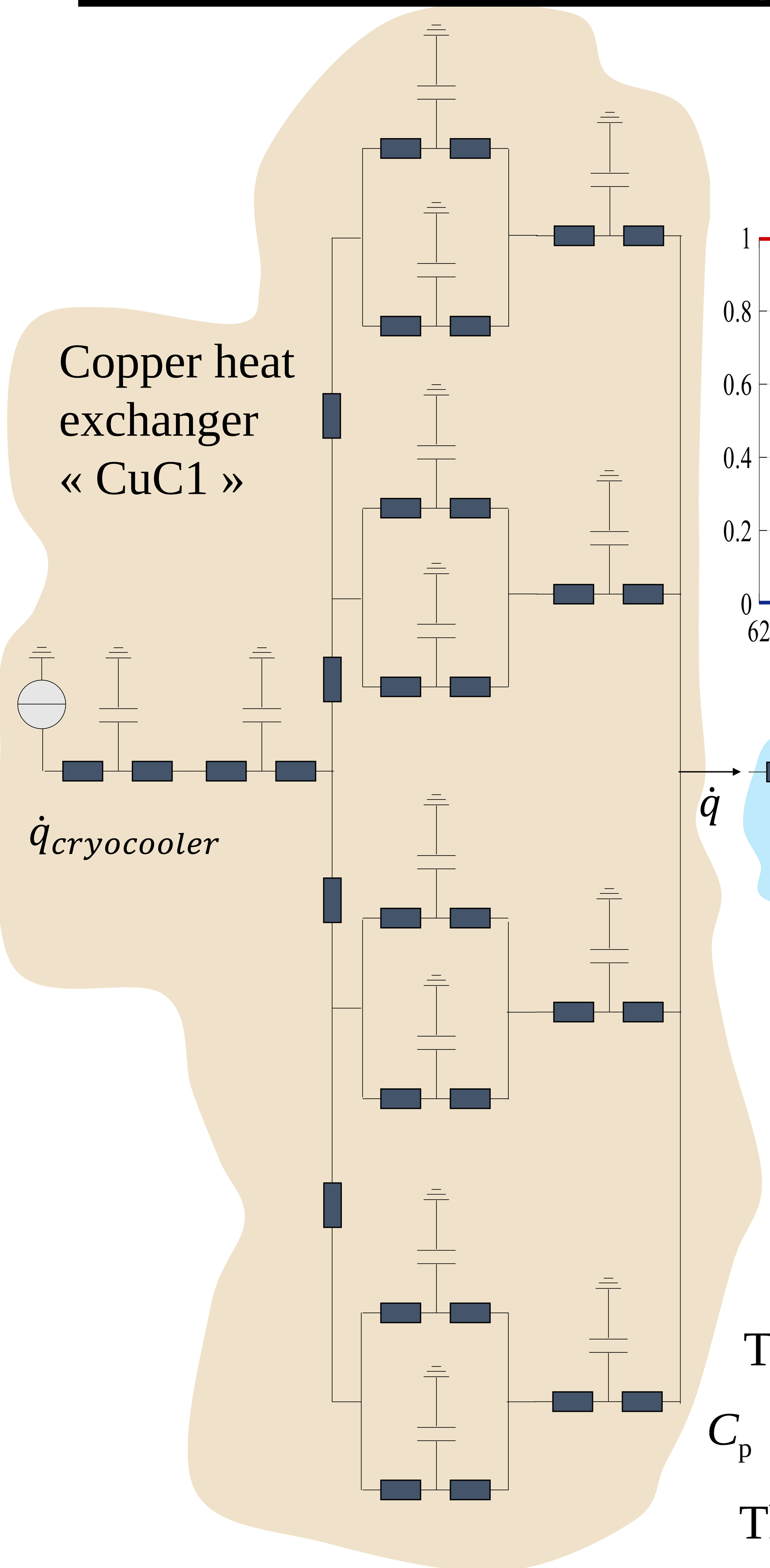
Ghazi Hajiri[1], Kévin Berger[1] and Jean Lévêque[1]

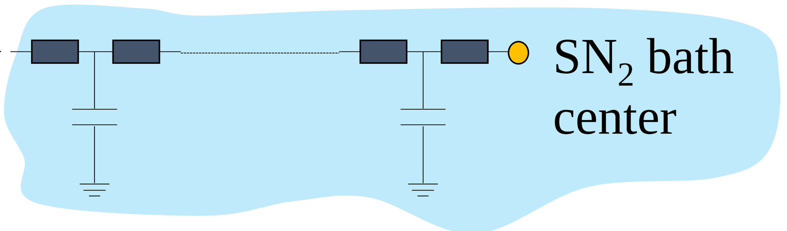
1 – Groupe de Recherche en Energie Electrique de Nancy, University of Lorraine, France

Abstract

Solid Nitrogen (SN2) can provide a uniform and stable cryogenic environment for High Temperature Superconducting (HTS) systems such as bulk samples during their magnetization and/or characterization. In this paper, we are studying a SN2 cooling system consisting of a cryocooler Sumitomo CH-110 and an exchanger in a Liquid Nitrogen (LN2) bath. In order to design this cooling system, an analytical model based on a nodal method coupled to a formulation of the thermal capacity (NMCTC) was realized. The model considers the thermal parameters variation as well as the phase change of the Nitrogen. In order to compare our results, we performed a 3D simulation on COMSOL Multiphysics. The performance of the cooling system was evaluated and we estimates that 50 L of LN2 can be cooled down to 20 K in 50 hours.

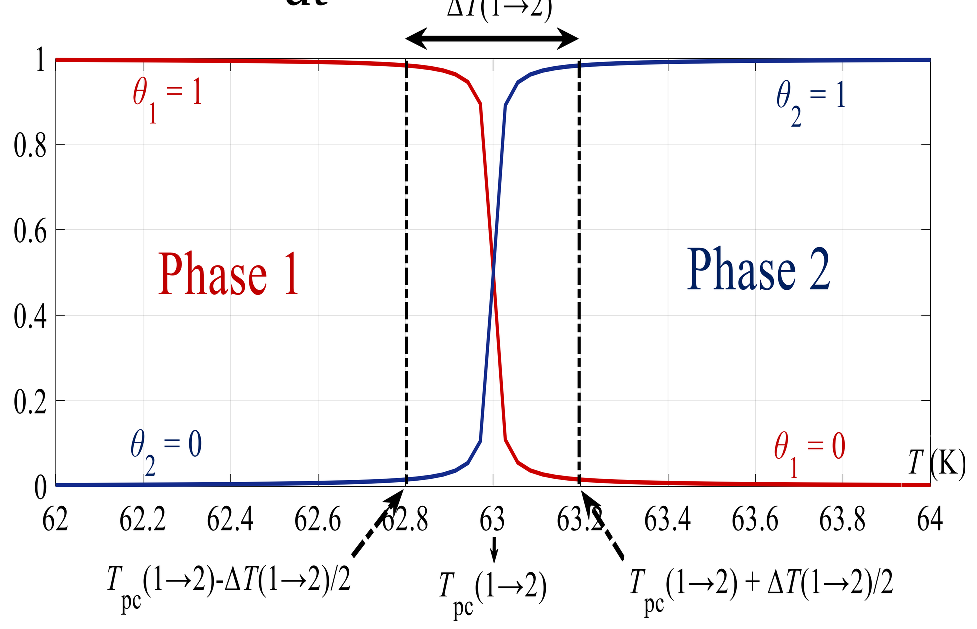
Governing Equations





The heat diffusion equation :

$$\rho C_p \frac{dT}{dt} = P_v + \mathrm{div}\left(k \cdot \overrightarrow{\mathrm{grad}}\, T\right)$$



The thermal conductivity k :

$$k = \theta_1 k_{ph1} + \theta_2 k_{ph2}$$

The specific enthalpy H :

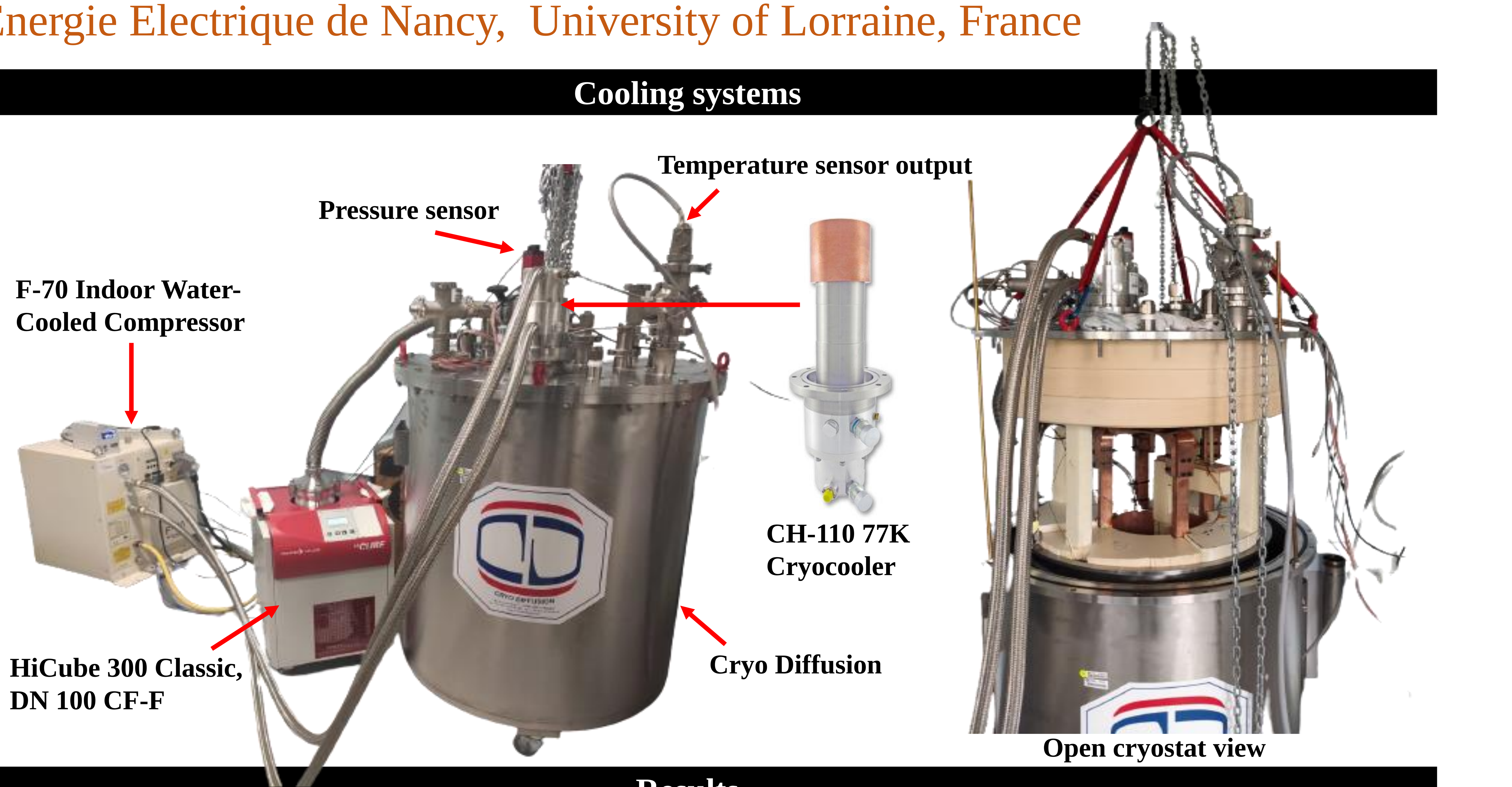
$$H = \theta H_{ph1} + (1-\theta) H_{ph2}$$

The specific heat capacity C_p :

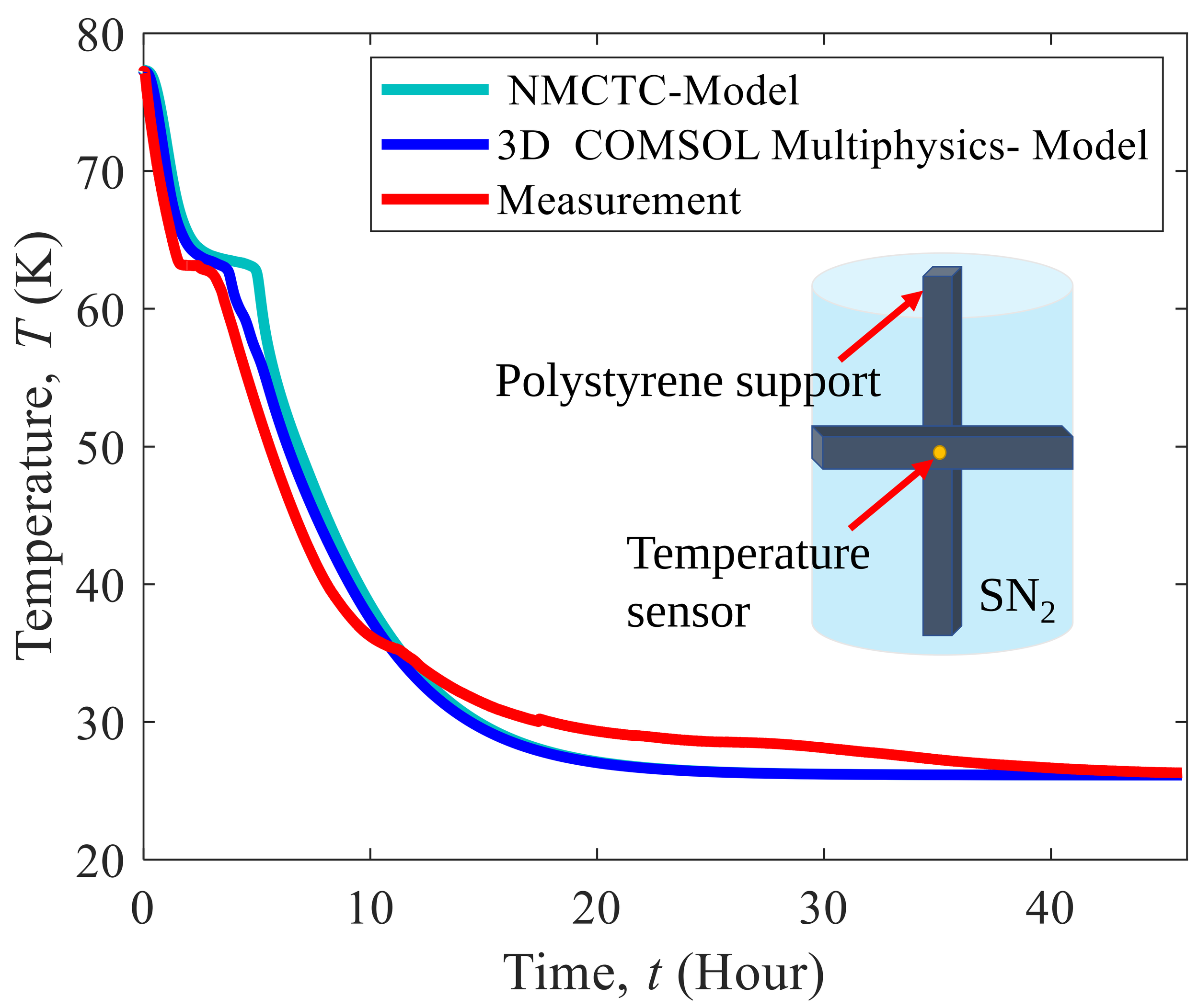
$$C_p = \left(\theta_1 C_{p,\,ph1} + \theta_2 C_{p,\,ph2}\right) + \left(H_{ph2} - H_{ph1}\right)\frac{d\beta_m}{dT}$$

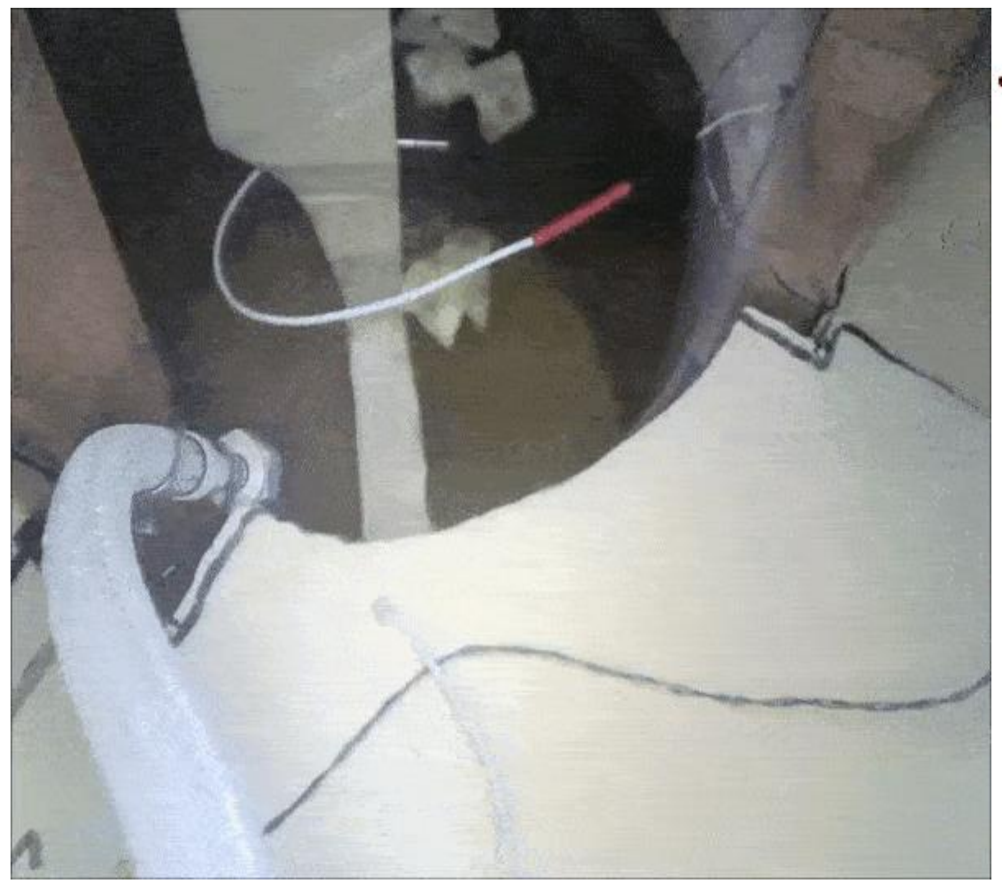
The Dirac pulse : $\beta_m = \frac{1}{2}(\theta_2 - \theta_1)$

Cooling systems

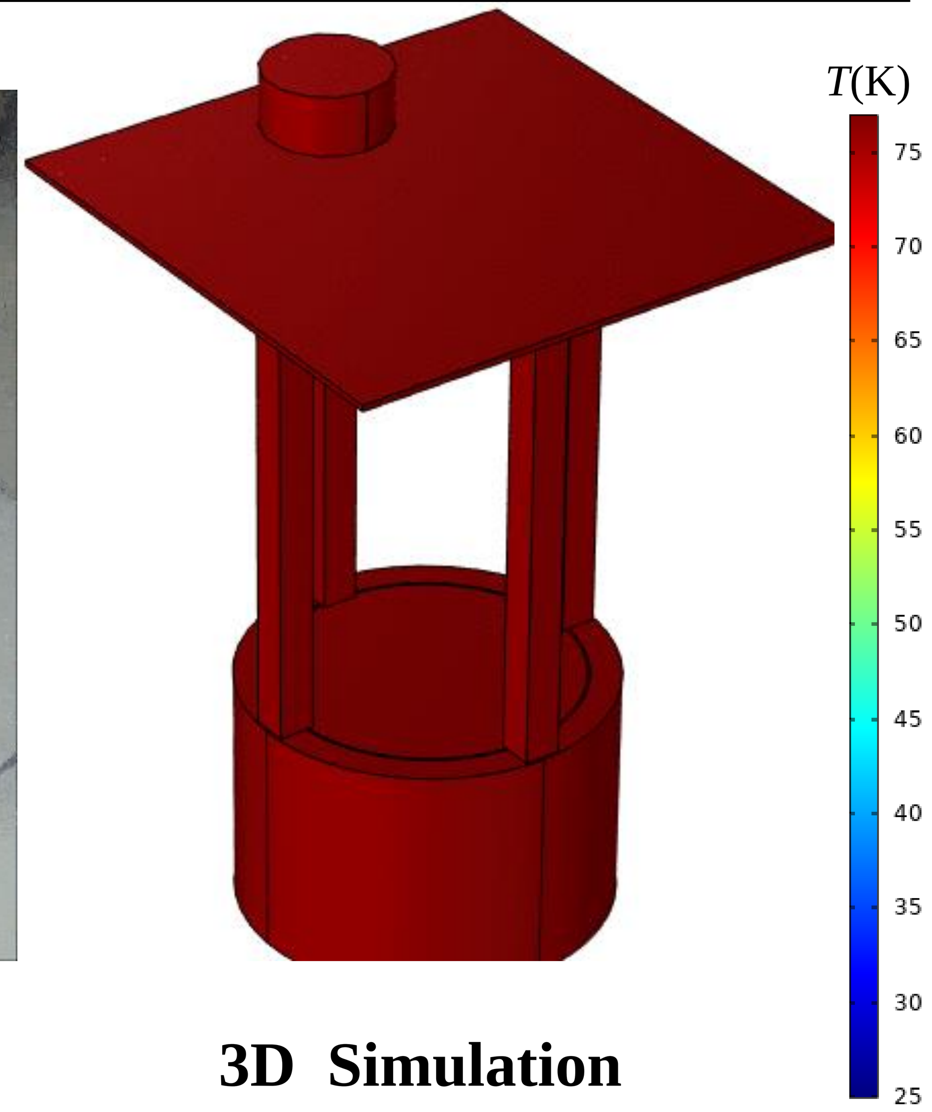


Results





Reality



3D Simulation

Conclusion

- ✓ The analytical model based on a nodal method coupled with a heat capacity formulation and the 3D simulation in COMSOL were validated with experimental measurements.
- ✓ Pulsed field magnetization tests and characterization of HTS bulbs are planned soon.