Assessing the noise level of quantum-limited parametric amplifiers

A. Alocco[1,2], M. Borghesi[3,4,5], A. Celotto[1,2], P. Durandetto[2], E. Enrico[2,6], M. Faverzani[3,4,5], L. Fasolo[2], E. Ferri[4], A. Giachero[3,4,5], A. Nucciotti[3,4,5], L. Oberto[2,6]

[1]*Politecnico di Torino*, Torino, Italy; [2]*Istituto Nazionale di Ricerca Metrologica (INRiM)*, Torino, Italy;
[3]*University of Milano - Bicocca*, Milan, Italy; [4]*INFN Milano - Bicocca*, Milan, Italy; [5]*Bicocca Quantum Technologies (BiQuTe) Centre*, Milan, Italy;
[6]*INFN - Trento Institute for Fundamental Physics and Applications (TIFPA)*, Trento, Italy

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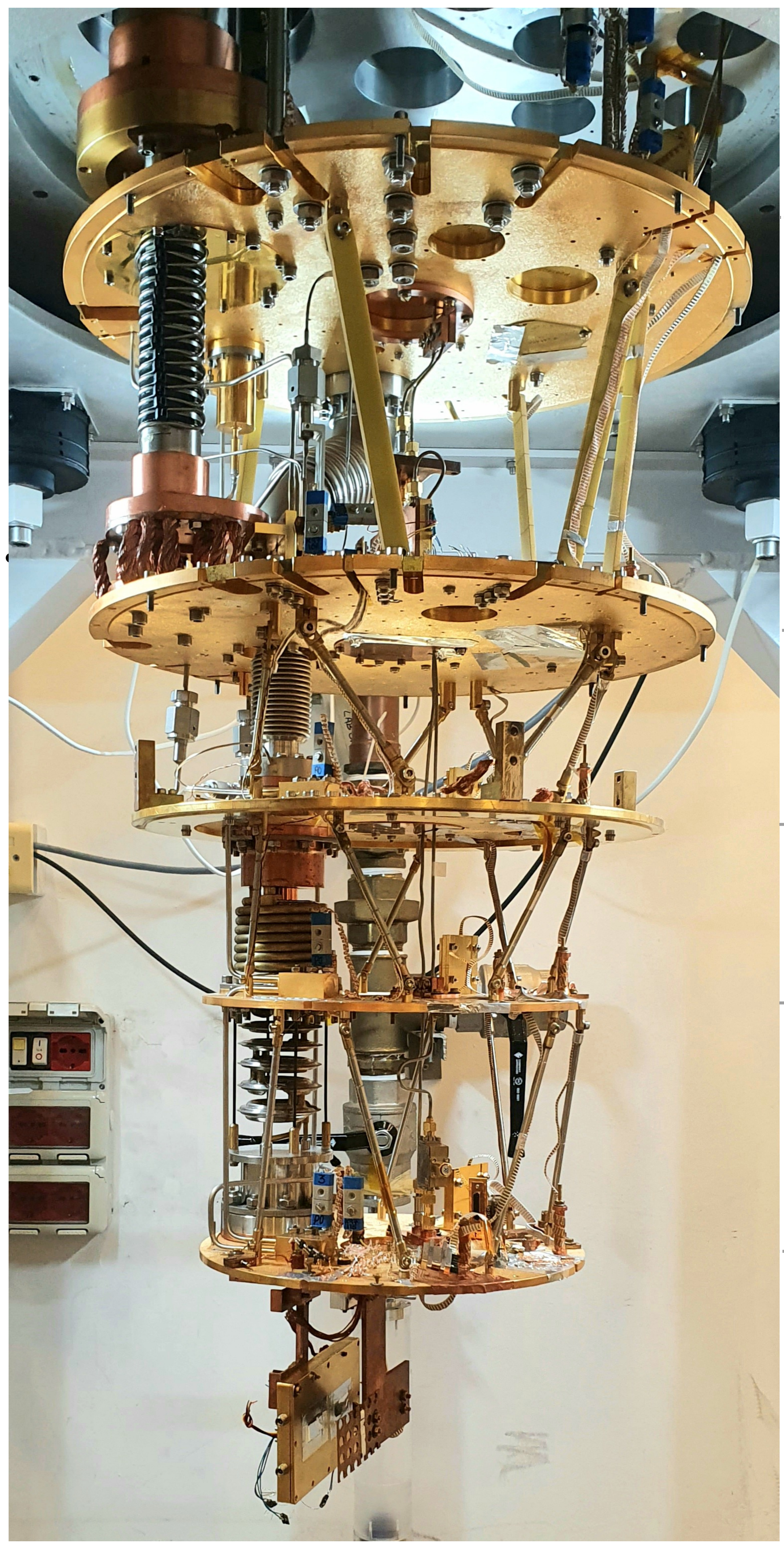
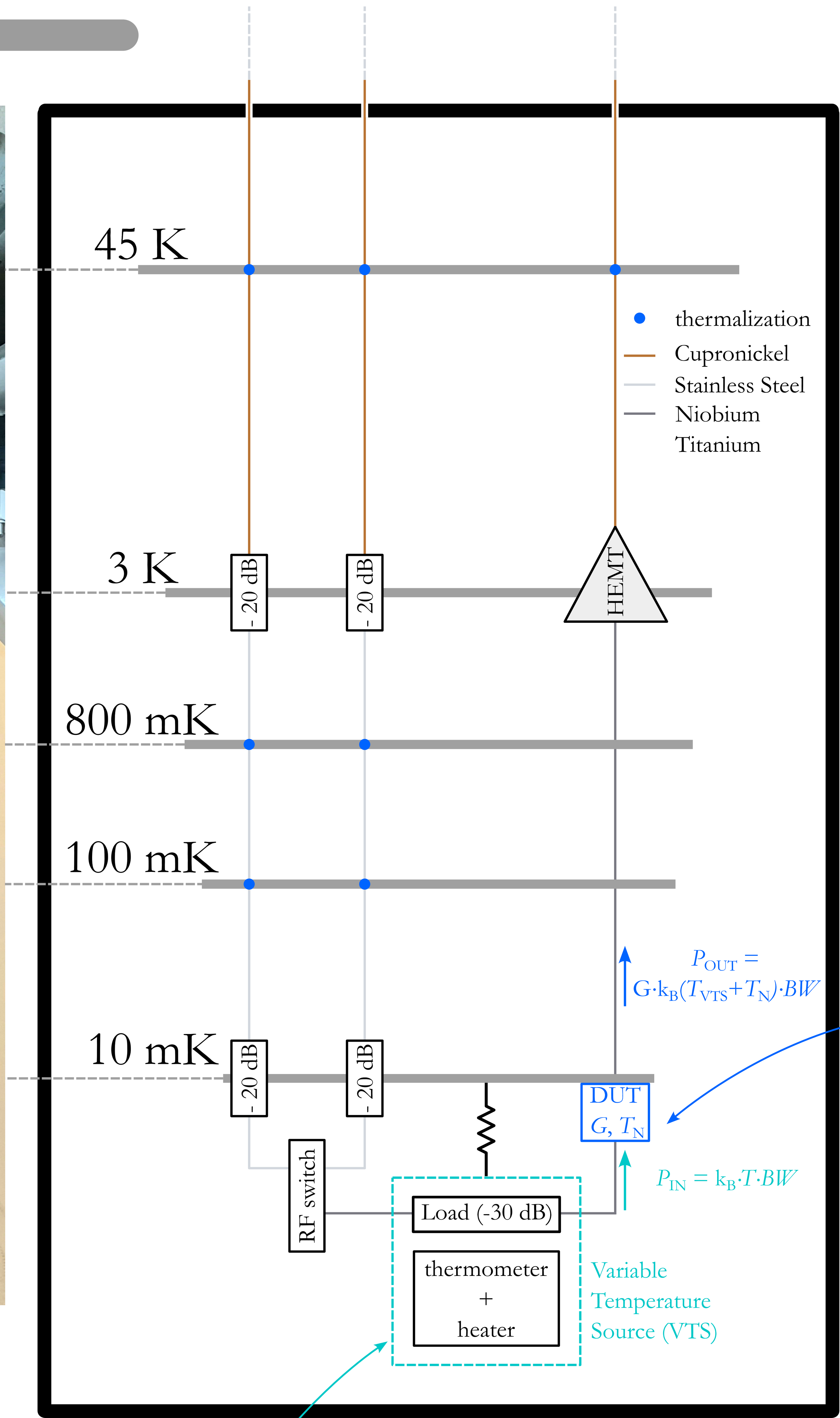
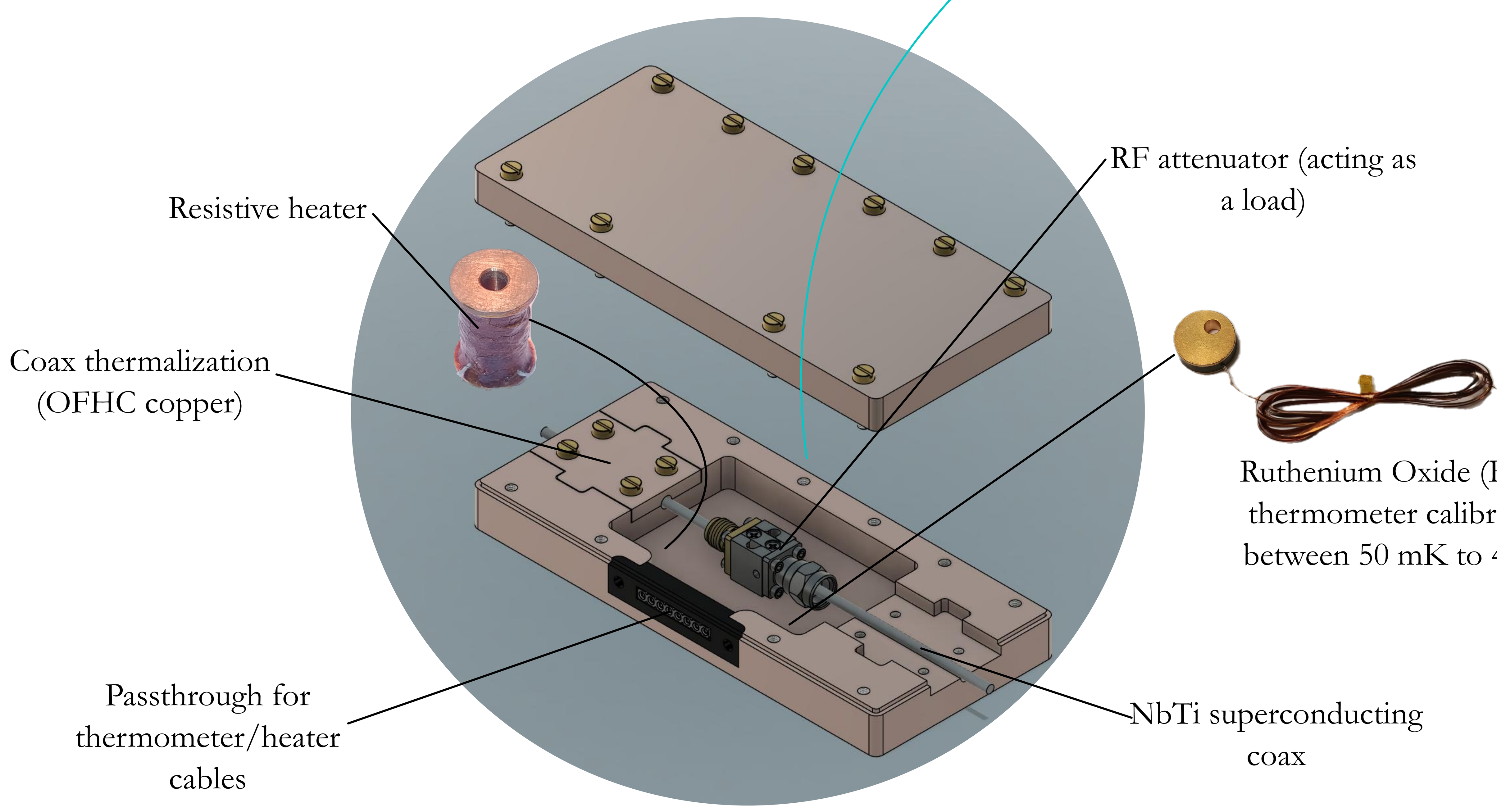
Cryogenic microwave technology is a rapidly growing field of business, driven by the boom of Quantum Computing (QC) and other Quantum Technologies (QT), but also with wide applications in reading out cryogenic particle detectors. Superconducting parametric amplifiers play a relevant role in reading out both superconducting qubits and low temperature particle detectors. These devices offer the incredible opportunity to amplify feeble microwave signals while adding noise at the minimum level allowed by quantum mechanics. In order to characterize this fundamental property of these amplifiers, a proper custom setup needs to be designed and realized. One of the goals of the project CalQuStates, carried out in collaboration between INRiM and Università di Milano – Bicocca, aims to develop a testbed to measure the noise of superconducting parametric amplifiers in a cryogenic environment. The setup which is being developed by the unit of Milano – Bicocca consists in a 50 Ohm load to be linked to the coldest stage of a dilution refrigerator. While the latter is required to remain at its base temperature around a few millikelvin, the load needs to span temperatures up to 1 K with high thermal stability, posing a technical challenge. This development will allow to perform the noise measurement of low temperature amplifiers exploiting the Y-factor method.

Cryogenic Setup





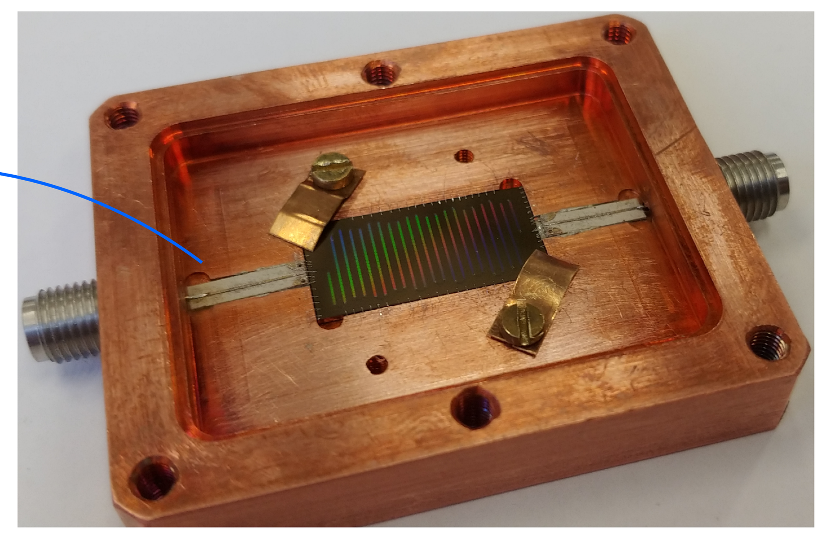


Noise measurement: concept

a resistance R placed at a temperature T is a generator of white noise (Johnson-Nyquist noise):

$$N_{in}^{Johnson} = \frac{1}{e^{h\nu/k_B T} - 1} + \frac{1}{2} = \frac{1}{2}\coth\left(\frac{h\nu}{2k_B T}\right) \xrightarrow[h\nu \ll k_B T]{} \frac{k_B T}{h\nu}$$

the DUT is a low-temperature, low-noise amplifier, such as Traveling Wave Parametric Amplifiers (TWPA), such as the ones developed within DARTWARS (**see A. Giachero's talk on Thursday 9:10 a.m.**)



- to measure the noise with the **Y-factor method** in principle only two temperatures are required
- several temperatures used to increase the reliability of the measurement
- temperature stability ensured by a Resistance Bridge with temperature controller
- the first measurement will involve the measurement of the noise of the HEMT amplifier, which is characterized at the factory