Measuring the Seebeck Coefficient at Cryogenic Temperatures for LCLS-II-HE Project

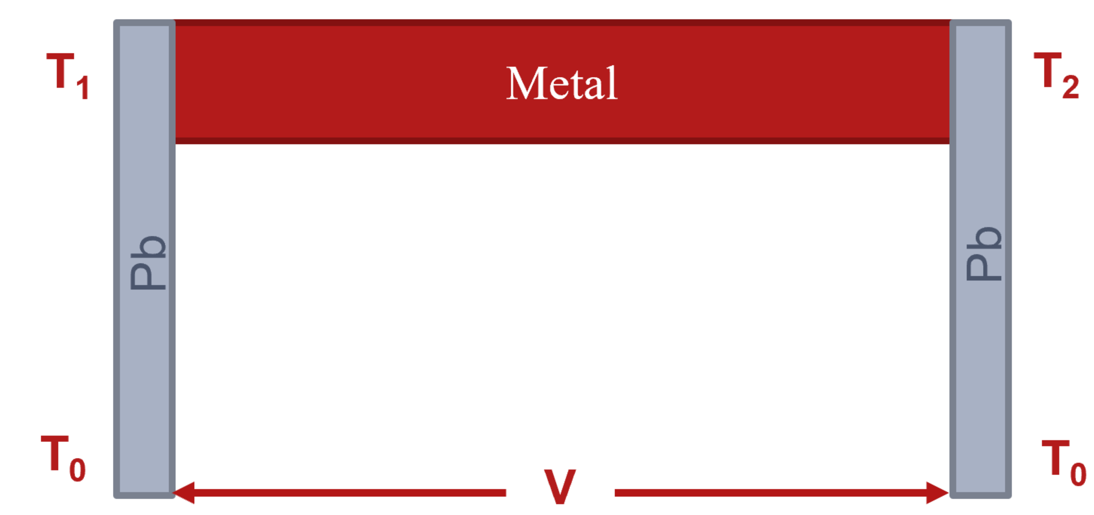
Paper ID: **THPOGE015**

L. Shpani*, M. Ge, A. Holic, M. Liepe, J. Sears, N. Verboncoeur
Cornell University, Ithaca, NY 14850, USA

Thermoelectric currents in cryomodules influence the performance of RF cavities. We present Seebeck coefficient measurements at **cryogenic** temperatures for materials commonly used in cryomodules, namely Nb, Ti, Nb-Ti, stainless steel (316L and 316LN) and silicon bronze.

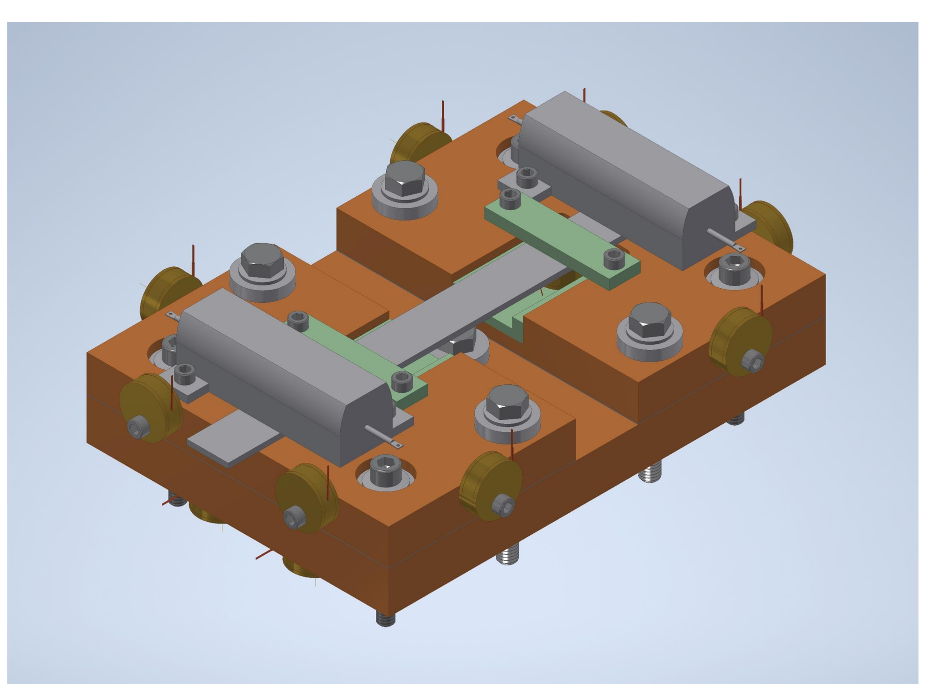
Measurement Method and Setup

The Seebeck effect describes the electric potential emergent across a conductor within a thermal gradient. The Seebeck coefficient is a temperature-dependent material property. The Seebeck coefficient is calculated using the formula $S_{ab} = \lim_{\Delta T \to 0} \frac{\Delta V_{ab}}{\Delta T}$.

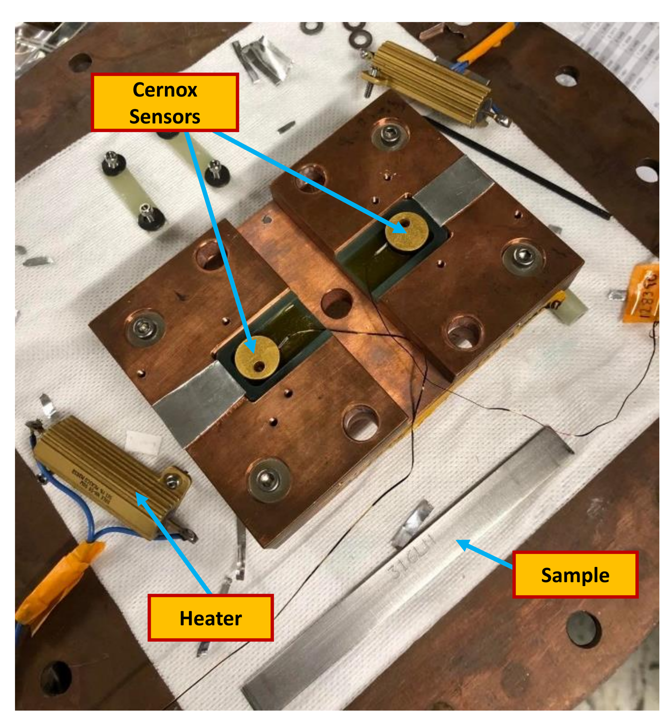


Measurement was done using the differential method (small ΔT). We **simultaneously** measure the temperature on each side of the sample and the induced potential difference.

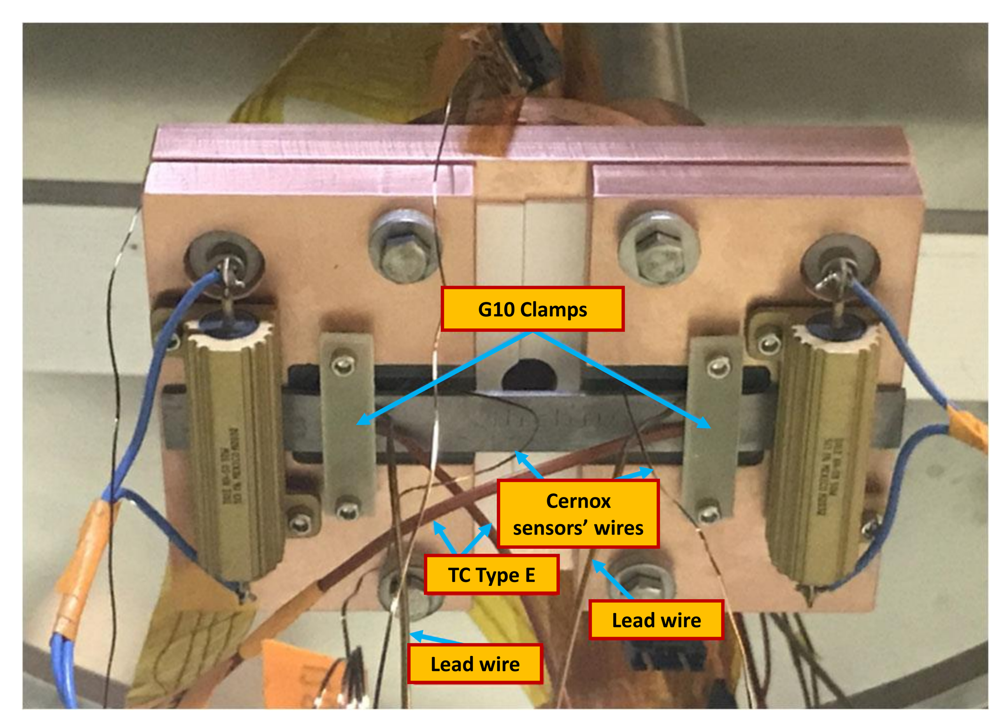
The measured Seebeck coefficient requires the correction of the Pb wires: $S_a(T_{ave}) = -\frac{V}{\Delta T} + S_b(T_{ave})$.



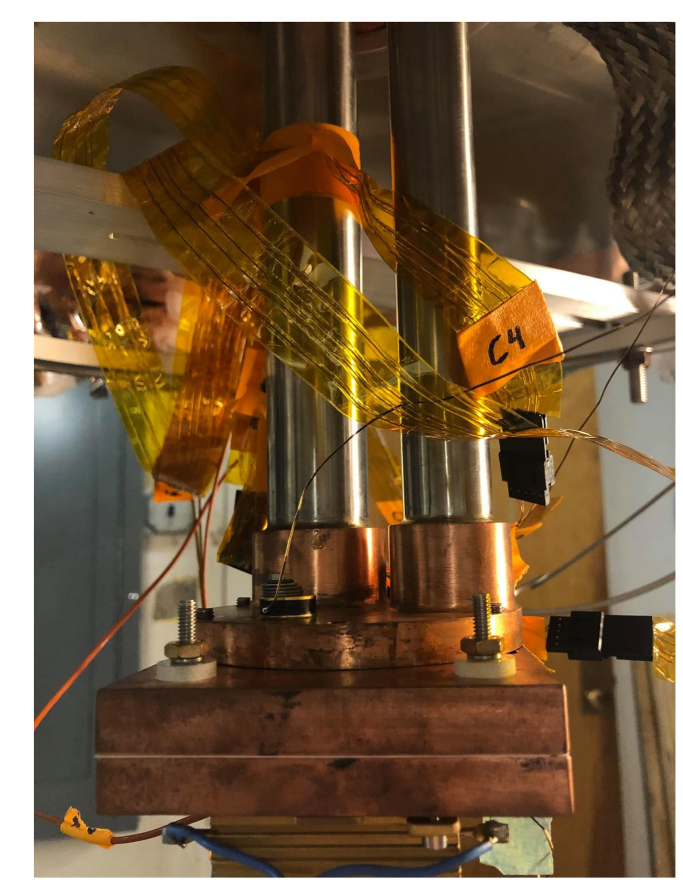
3D model



Disassembled

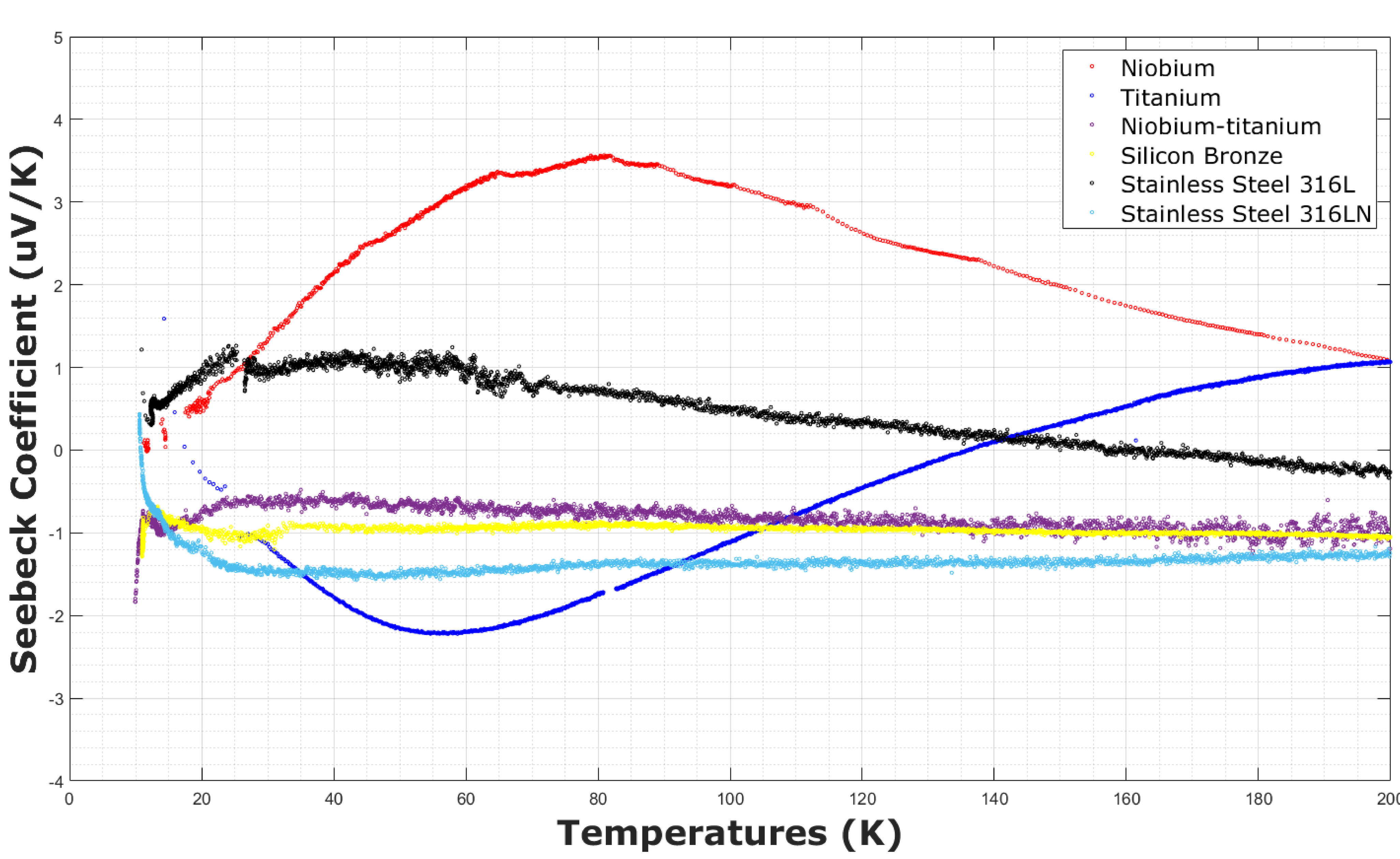


Assembled



Cryocooler Cold Head

Results



Conclusions

We have optimized and commissioned a system to measure Seebeck coefficients at cryogenic temperatures.

Measurements of niobium and titanium are consistent with literature. Note that our measurements are continuous in contrast to the literature curves which are fitted.

We present **first-ever data** for the **cryogenic Seebeck coefficient** for Nb-Ti, stainless steel, and silicon bronze, materials commonly used in cryomodules. This data is useful to compare the impact of these materials on generating thermoelectric currents.

Abstract

The Seebeck effect plays a crucial role during the cooldown procedure in SRF based accelerators, like LCLS-II at SLAC. The temperature-dependent Seebeck coefficient quantitatively measures the strength of electric potential induced by thermal gradients in metals. This effect is present in cryomodules and drives thermoelectric currents generating magnetic fields. These fields can get trapped in cavities and cause additional dissipation in RF fields. We have therefore designed and commissioned an experimental setup that does continuous measurements of the Seebeck coefficient for cryogenic temperatures ranging from 200K down to below 10K. We present results of the measurements of this coefficient for materials commonly used in cryomodules, such as niobium, titanium, niobium-titanium, silicon bronze, and stainless steel.

*ls936@cornell.edu
This work is supported by the DOE LCLS-II HE Project.