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Cryocooler-based conduction cooling technology development for 1.3 GHz Nb3Sn superconducting radio frequency cavity

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Superconducting radio frequency (SRF) cavities are, along with superconducting magnets, indispensable technologies for modern particle
accelerators. The current cooling method for SRF cavities is immersion in liquid helium, which is ideal in terms of cooling because the entire outer surface of the cavity is maintained at liquid helium temperature.
On the other hand, while superconducting magnets such as MRIs have been converted from immersion cooling with liquid helium to conduction cooling with cryocoolers to reduce costs and difficulties related liquid helium, conduction cooling for SRF cavities are still in the development stage. In particular, considering the recent rise in the price of helium, the conduction-cooled SRF cavity technology with cryocoolers will obviously be essentially important in the future.
In order to operate SRF cavities with conduction cooling by 4K cryocoolers, it is desirable to adopt Nb3Sn (Tc˜18.3 K) cavities instead of conventional Nb (Tc˜9.2 K) cavities. This is to lower the BCS resistance and reduce heating when RF power is applied. Also, a cryocooler with a large cooling capacity and high electrical efficiency is desirable. In KEK, conduction cooling of Nb3Sn cavities has been performed using two types of cryocoolers, GM (1.8-2W at 4.2K) and new GM-JT (9-10W at 4.2K) cryocoolers developed by Sumitomo Heavy Industries, Ltd. In this presentation, the current status of cryocooler-based conduction cooling technology development in KEK will be reported.

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