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Feature Article: SQUID Application
- Progress in Spinal Cord Diagnostic Systems Employing LTS-SQUID

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The author and his research group have advanced the development of magnetospinogram (MSG), a technique that utilizes a SQUID magnetometer array placed at the body surface to detect feeble magnetic fields accompanying neural activity[1)], thereby allowing non-invasive assessment of spinal cord lesions. The MSG system is able to visualize spinal neural activity and provide useful and accurate diagnosis in spinal degeneration due to paralysis and/or numbness of hands and feet. A prototype MSG system is being continuously used at the Department of Orthopaedic Surgery of Tokyo Medical and Dental University, and progressively demonstrates the effectiveness in the diagnosis of spinal cord lesions.

The high operational costs of MSG prevent it from being widely introduced at hospitals since the need to utilize liquid helium, similar to other SQUID-based biomagnetic measurement systems such as magneto-encephalogram and magneto-cardiogram. The author and his research group have performed experiments to minimize the evaporation of liquid helium, employing a pulse-tube cryocooler to cool the thermal radiation shield inside the low temperature vessel using helium gas [2)].

Typically, cryocooler oscillations and magnetic noise significantly impact biomagnetic measurements. However, the magnetic frequency signals associated with the spinal cord range between several 100 Hz to several kHz, and thus the frequency bands do not overlap with the cryocooler noise of less than 10 Hz. Even so, a high-pass filter can be utilized to reduce noise and thus minimize the effects to any measurements.

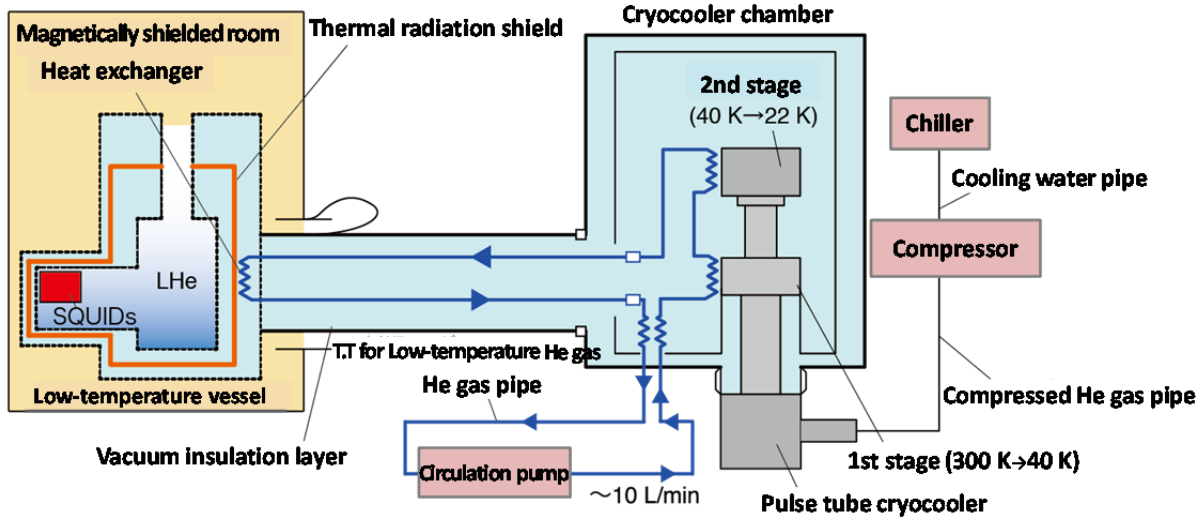

Fig. 1 System configuration of the experiments undertaken to reduce helium evaporation with the use of a cryocooler

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Figure 1 shows the experimental system configuration. A pulse-tube cryocooler with a cooling capacity of 0.5W@4K was employed (Iwatani Corporation, CryoMini PDX05/CW701). The system achieved a 46 % reduction in helium evaporation. As shown in Figure 2, the measured spinal magnetic signals were equivalent to a system equipped without a cryocooler and yet the pulse-tube cryocooler was placed 1.5 m away from the wall of a shielded room.

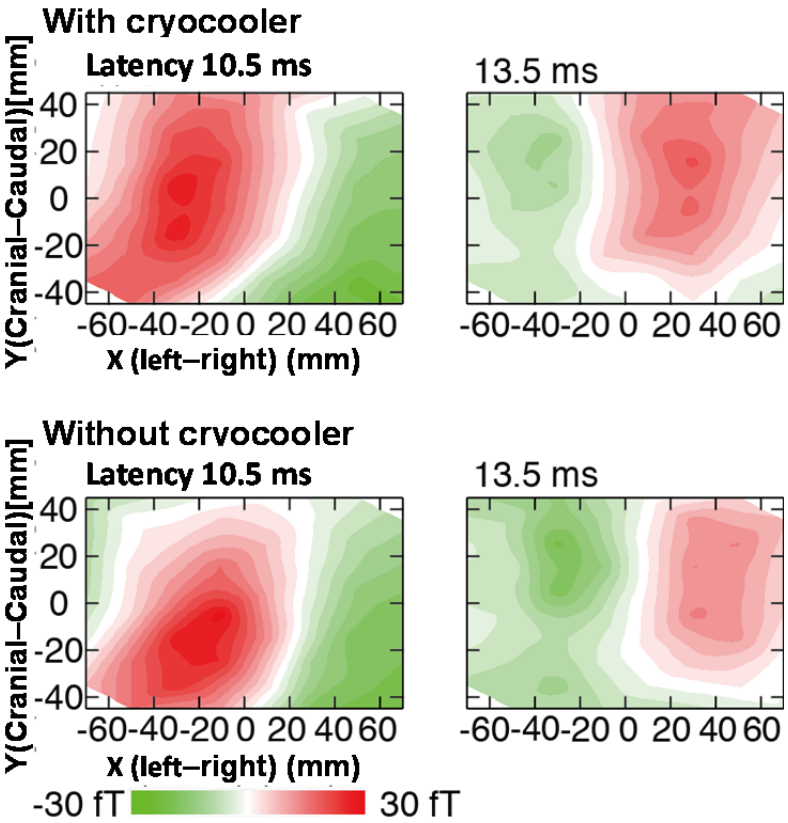

Fig. 2 Comparisons of the cervical spinal cord evoked magnetic fields produced by median nerve stimulation given in left wrist, using a magnetospinography equipped with/without a cryocooler

Reference:
1) Y Adachi *et al*., "Magnetospinography: Instruments and Application to Functional Imaging of Spinal Cords", IEICE Trans Electron, E96-C, 326–333, 2013.
2) Y Adachi *et al*, "Spinal Cord Evoked Magnetic Field Measurement Using a Magnetospinography System Equipped with a Cryocooler", Engineering in Medicine and Biology Society (EMBC), 35th Annual International Conference of the IEEE, 4426–4429, 2013.

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