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## An innovative cryogenic block for dilution refrigerators to face the challenges of quantum computing scale-up

The ultra-low temperature cryogenics industry faces many challenges, such as the emergence of new players and the rise of quantum computing, which is now the focus of industrial and policy concerns. With the development of quantum computing, the most complex problems could be solved much faster because quantum computing will offer an unprecedented level of computing power.

In order to meet this major challenge, we have developed a higher power dilution refrigeration module. Many such units can be inserted in a large size cryostat to provide high cooling power, they can be easily removed for maintenance and are interchangeable. It therefore enables to serve both the needs of regular-size fridges for research purposes, to the extra-large cryostats needed for quantum computing.

Each dilution core is able to provide either 10 or 15 $\mu$ W of cooling power @20mK. It gathers all the essential components:

- A 300K adaptor which contains the He3 pumping line, normal and fast injection lines, pulse tube head. This block is designed to be inserted in a standard way within a larger 300K flange in order to build a cryostat with several dilution blocks.
- A dynamic sleeve. This sleeve is the interface between the pulse tube head and the cryostat. This sleeve provides a gas exchange which offers a lower level of vibration, a faster cool-down time and easier maintenance of the pulse tube head compared with copper braids.
- The dilution unit is an industrialized unit from Joule Thomson to the mixing chamber. In particular, there is no tin solder in contact with the internal vacuum of the cryostat, enabling better reliability.
- The pumping line is in parallel with the dilution unit. Once pre-cooling is over, the circuit is reversed: the sleeve is used for pumping and the injection line (with impedance) is used to inject the mixture.

This technology presents many advantages such as:

- Modular

The cryogenic block is able to reach up to 30 $\mu$ W@20mK by using two dilution cores in one cryostat. The pulse tube numbers can be adjusted based on the need for cooling power at higher temperatures.

- Reliable

The dilution core is fully standardized, without tin solders and with leak tests at every step of the manufacturing.

- Easy maintenance

In case of maintenance, the dilution core can be taken out easily and replaced by another standard unit.

- Upgradable

In case of an evolutive experiment, the system can be upgraded by changing the plates, OVC and 300K flange, no need to change the dilution core.

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