PAUL SCHERRER INSTITUT PSI	Project **SLS-2**
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1 Proposal for a Detachable, Drop-in Cold-Head

Interfacing the cold-head of the SLS 2.0 6 T superbend to the rest of cryogenic system: thermal shield, current leads and 4 K helium re-condenser is the most critical issue towards achieving the expected, calculated magnet performance. Contact resistance at the first and second stage if to large will result in too high temperatures on the top of HTS current leads and a too high operating temperature of the superconducting coils with a reduced operating temperature margin.

During the maintenance of the cryocooler if the contacts at the first and second stage is fixed, the whole magnet must be warmed-up in order to remove the cryocooler. After the maintenance, the magnet must be re-cooled back to 4 K. The maintenance can be scheduled in one of the long shut-down periods of the ring but even then, disassembling the cryocooler from the magnet is not a simple operation. Existing good thermal contacts (indium shims) are destroyed and the new ones are not simply to be redone. The result can be seen only after the cool-down. Some times it is necessary to warm-up the magnet again and to replace the bad contacts hopping in better ones.

In view of these facts, it is desirable to use drop-in coolers in the SLS 2.0 superbends i.e. a solution where the cryocoolers can be easily changed without the need to completely warm-up the magnets.

A possible solution to this problem is presented in Fig.1.

The magnet cryostat is provided wit an insertion tube provided with two copper sleeves and two bellows. The cryocooler should have tapered copper plugs at the first and second stage which mate with the corresponding receptacles in the sleeves. Good thermal contact is achieved by having the second stage receptacle float between stainless-steel bellows above and below it. The dimensions are chosen such that the second stage engages first when the cryocooler is inserted and moves down until the first stage plug is also seated.

Heat is transferred at the couplings primarily by conduction through the gas enclosed between the mating surfaces and also by mechanical contact. It is important to have a helium atmosphere

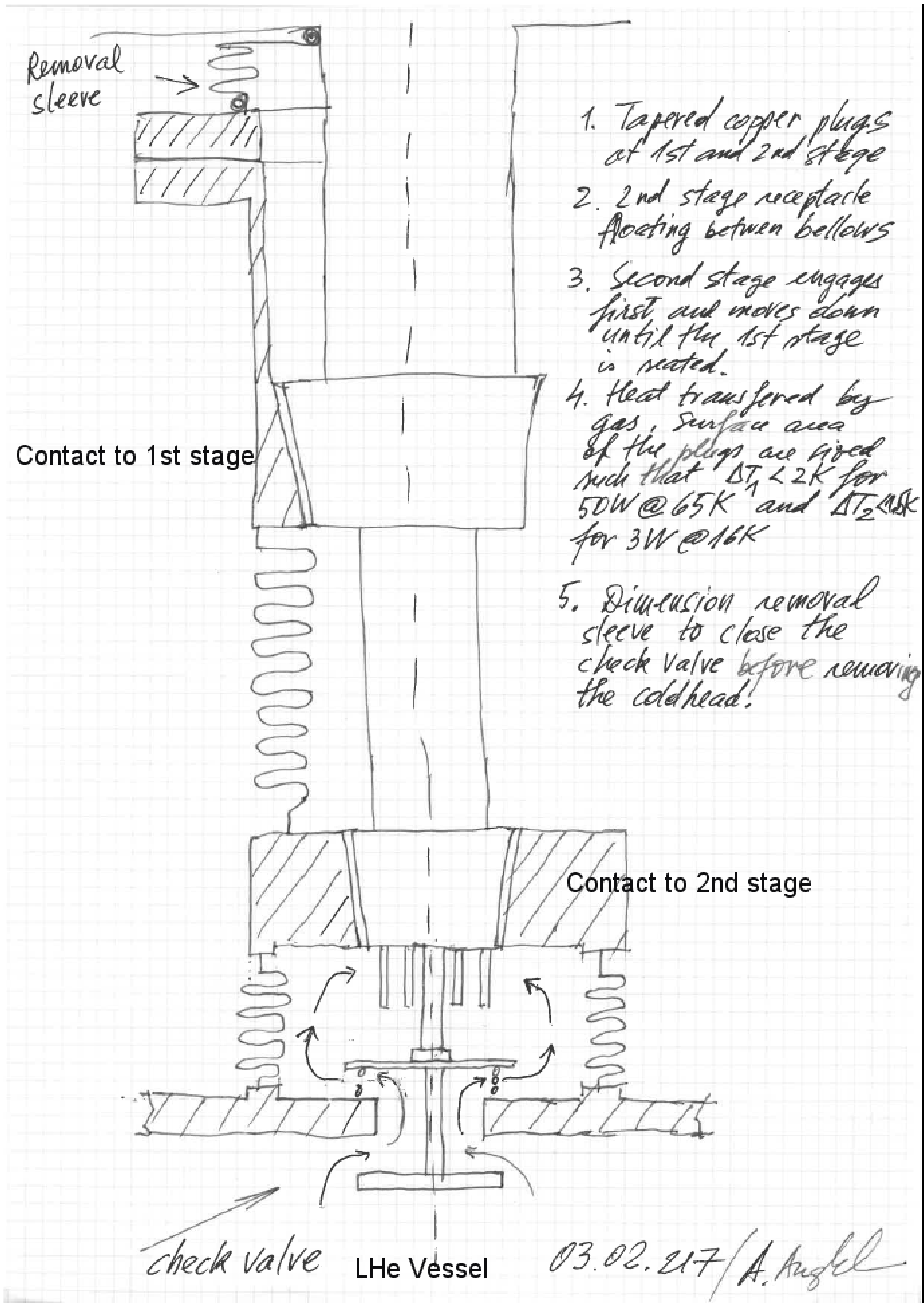

Figure 1: Drop-in solution for cryocooler with condensing unit on 2nd stage

in the insertion tube after the installation of the cryocooler. The heat transfer is almost independent of force or at least there is no need of a high bolt-down force when installing.

In our sketch, at the bottom of the insert tube, a check valve is mounted which is opened by an extension stick on the re-condensing unit. When the cryocooler is removed, this valve closes and stops the helium expansion to atmosphere. The reverse happens when the cryocooler is installed. The stick pushes down the valve and a gap opens for helium vapor and liquid circulation.

If the re-condensing unit is inside the liquid helium vessel as in the actual design of the SLS 2.0 superbend, this device is not needed. The second stage is in direct contact to the re-condensing heat exchanger through a cantilever plate outside the liquid helium vessel. The design for this case is shown in Fig.2.

The dimensions of the two bellows must be chosen according to the principle shown in Fig.3. The contact force on the firat stage is

$$F_1 = k_e \Delta l + k_c \Delta l = (k_e + k_c) \Delta l \tag{1}$$

because B_1 is in extension (elastic contant k_e) and B_2 in compression (elastic constant k_c).

The force applyed to the cantilevered second stage contact is

$$F_2 = k_c \Delta l \tag{2}$$

as a result of the compressed state of the bellow B_2. The deformation Δl includes the deformation of the o-ring of vacuum seal on the top.

Finally, the cryocooler should have a collar at the warm end for attachment to a flexible sleeve, which typically would be purged with helium as the cryocooler is being removed or installed when the magnet is cold.

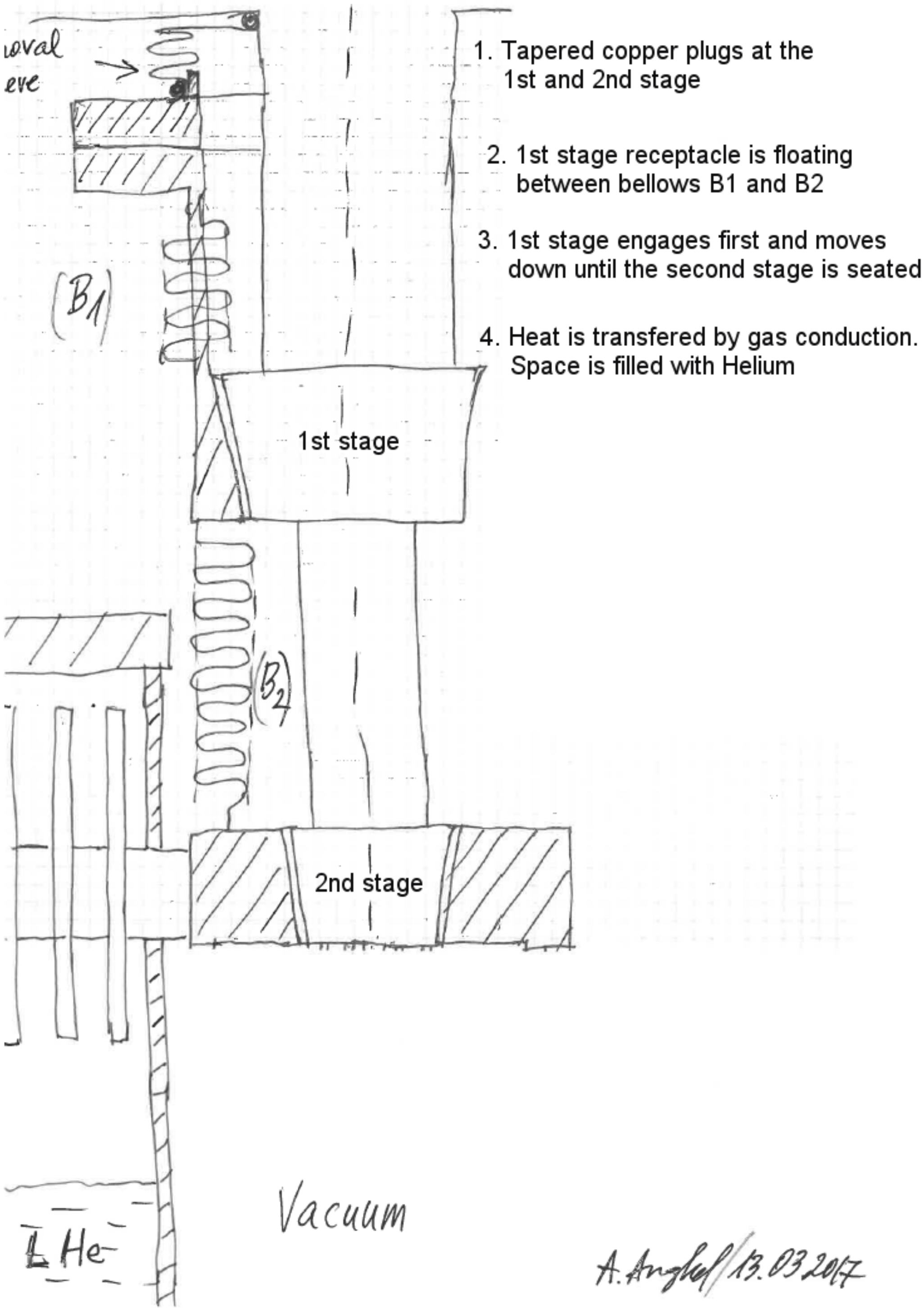

Figure 2: Drop-in solution for cryocooler with internal condensing unit

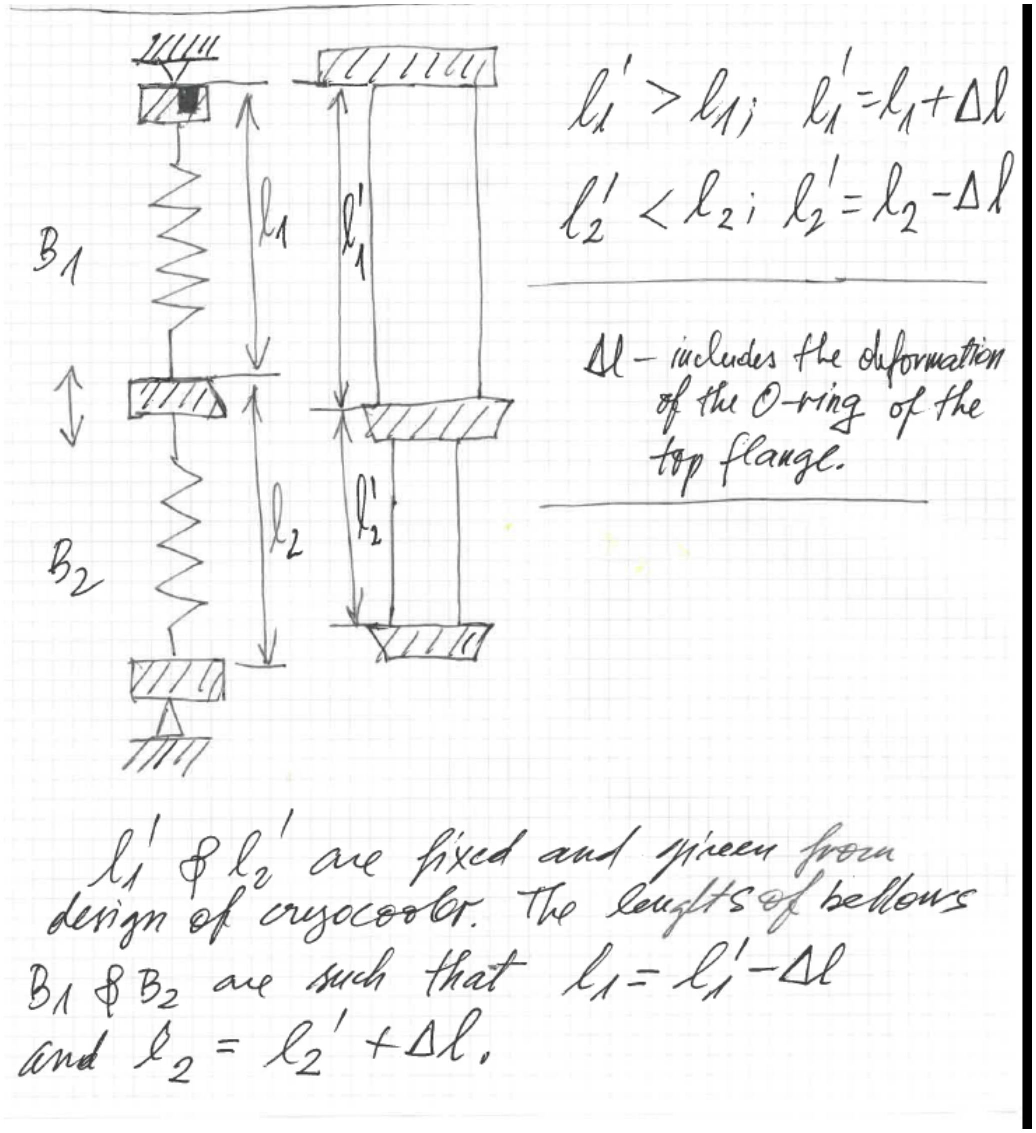

Figure 3: The relation between the cryocooler dimensions and bellows lengths.