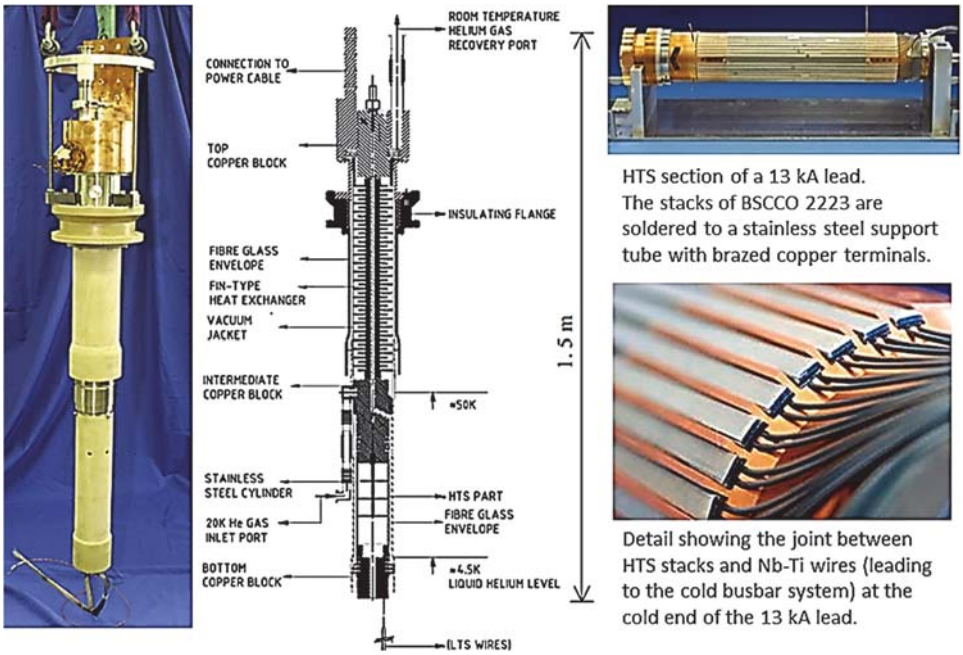

Fig. 8.13. 13 kA HTS current lead for the LHC

8.5 A Pumping Vacuum Chamber: Ultimate Simplicity

Cristoforo Benvenuti

The successful performance of Non Evaporable Getter (NEG) pumping for LEP (Chapter 7) was a strong motivation to envisage also applying a similar solution to the LHC warm sectors. But the LHC warm chambers were too small to host the LEP getter pump. The obvious solution would be to coat the chamber walls with a thin NEG film [36], all the more because such a solution could also be adopted for the chambers in the experimental areas.

It was clear that a thin film NEG coating, if this could be done, would be more effective than the LEP NEG pump for the following reasons: (i) the NEG surface would be much larger, resulting in a lower pressure, and (ii) the coating would inhibit the degassing of the underlying chamber, the major gas source in the accelerator. In addition, the NEG coating pump would be intrinsically safe (no moving parts, no risk of electric short circuits) and simpler (no power supplies, no electric feedthroughs required). To cope with the machine gas load a coating thickness of 1–2 μm would be sufficient using typical getters. However, heating the film for NEG activation implies heating the chamber, therefore activation should be feasible at a temperature that also the Aluminium chambers in the

experimental areas can withstand (≤ 200°C). This temperature was too low for the activation of the available getters, so a suitable NEG alloy had to be found.

The coating process envisaged (cylindrical magnetron sputtering) brought another problem. The coating is obtained by ion bombardment of a cathode. These ions are produced by triggering a discharge in argon or krypton gas (at a pressure of about 10^{-1} Pa), obtained by applying a negative bias voltage of 400 V to the cathode, a rod a few mm in diameter, placed at the centre of the chamber (Fig. 8.14). Producing such cathodes of the different alloys to be explored has a cost and takes time. Furthermore, some of the alloys of the usual getter elements, such as Ti or Zr, are not ductile and the production of the cathode is problematic. To overcome this difficulty, cathodes were made by twisting together wires of pure metals, readily available from industry, as shown in the figure. The atoms extracted by sputtering from the different wires recombine on the chamber walls to provide the desired alloy. In this way the elemental composition of the alloy may be varied and, in addition, for a given choice of metals the relative composition may be changed by changing the diameter of the wires. A smaller wire results in a lower content of the corresponding metal in the final alloy. In this way about 20 different alloys were tested until finally a Ti-Zr-V alloy was found to offer an activation temperature of 180°C, low enough for LHC. For this final choice wires of equal diameter were used, resulting in the same atomic content of these metals [37]. As this technology was not available in industry, the ~ 6 km of room temperature LHC chambers were coated at CERN. Some coated chambers were tested under different conditions showing that extremely low pressures could be achieved (below 10^{-10} Pa). Furthermore, the degassing induced by synchrotron radiation was much lower than for uncoated chambers. Finally, the secondary emission of electrons was reduced by the coating to such a level that the electron cloud was no longer a problem.

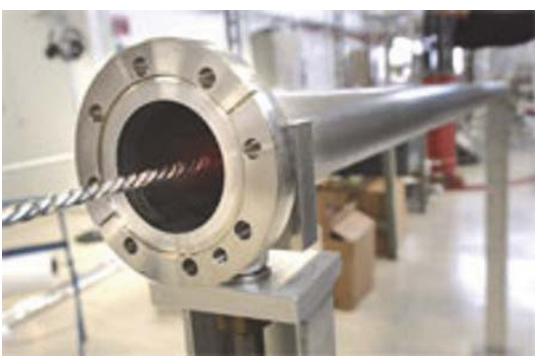

Fig. 8.14. Sputtering configuration with a cathode consisting of twisted wires.