RF SUPERCONDUCTIVITY AT DESY

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Abstract After the successful prototype program 16 superconducting cavities including the nessessery cryostats, RF- and cryogenic infrastructure are under industrial production. The wohle system will be installed in HERA before summer 1990 to increase the e^- energy up to 33.5 GeV. We report about the status of these activities as well as about parallel research on superconductivity (pipe cooling, Nb- sputtered Cu-cavities and HT_c-RF measurements).

INTRODUCTION

At DESY a development programme had been started to produce 500 MHz superconducting cavities for HERA. The general layout and detailed design is described in [1] and [2]. Three 4-cell cavities and two cryostats were fabricated by industrial firms (DORNIER, INTERATOM, NTG). A series of RF- and cryogenic measurements and a storage ring test in PETRA were carried out. After the prototype programme a pilot project of 16 cavities and 8 cryostats was approved. These resonators will increase the HERA e^- energy up to 33 GeV [2] and we will gain operating experience for a possible further upgrading with superconducting cavities. Cavities and cryostats will be delivered in the time from August 89 to March 90. The installation in the tunnel is scheduled until summer 90.

PRINCIPLE LAYOUT

Fig. 1 shows the complete module installed in PETRA during the last beam test. The cryostat has a length of 4.5 m and contains two 500 MHz 4-cell cavities. The design values for the cavities are an accelerating gradient of 5 MV/m and a quality factor of 2 x 10^9 at 4.2 K. The high design current of HERA implies that the operating gradient will be limited by the power rating of the input window rather than by the cavity properties. At 100 kW RF power for each input coupler and a beam current of 30 mA the gradient is limited to 4 MV/m. Each cavity is equipped with three higher order mode couplers. These two stub coaxial HOM couplers reduce the Q for the longitudinal modes to values around 1,000 and for the transverse modes to values lower than 10,000. All niobium parts like the HOM coupler and the main coupler are welded by EB to the cavity. The liquid helium vessel is sealed to the cavity without any flanges by brazing connections between stainless steel and niobium and contains less than 100 l of LHe. More details are given [1,2].

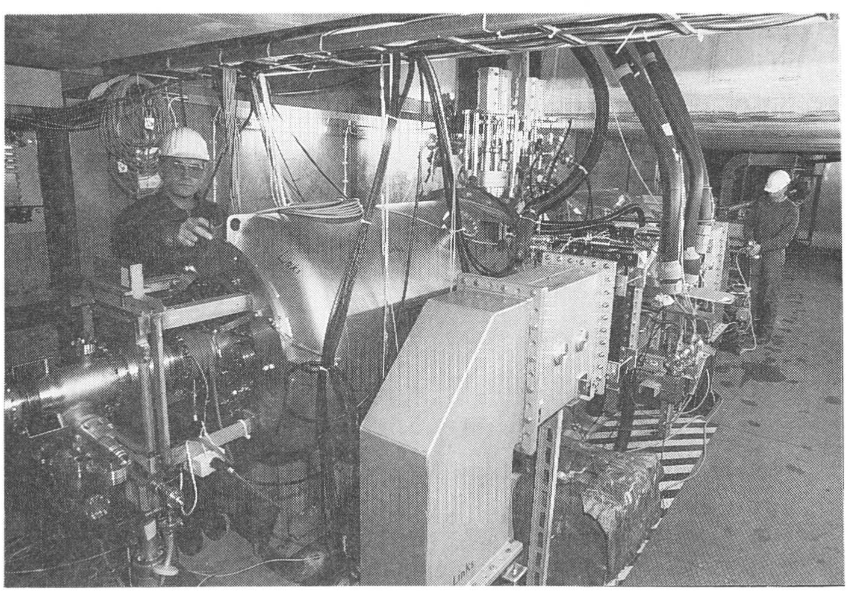

FIGURE 1 Superconducting cavity module installed in the PETRA tunnel

EXPERIENCE WITH THE PROTOTYPE AND RESULTING IMPROVEMENTS

Originally the prototype cryostat showed stand by losses of 30 W at 4.2 K and 245 W at the shield circuit (40-80 K). The major heat leaks (fixed point construction, heat exchanger, quench detector leads etc.) have been analysed and could be reduced by a factor of about two. The safety of the LHe circuit is a severe problem because cavities cannot withstand high pressure. We reduced the amount of LHe to less than 100 l per cavity and designed a large (63 mm diameter) safety line with a low pressure (2 bar) burst disc. For moderate pressure increase two Kautsky valves [3] releave at 1.5 bar. At four Helium accidences (three refrigerator failures, one klystron interlock mistake) we lost all our LHe in less than 1 minute. The cryostat and the cavity itself remained undamaged which proved our safety concept.

The sixteen cavities are delivered cleaned and ready for cryostat installation. For quick acceptance test they will be cooled down and measured in a simplified horizontal cryostat (see Fig. 2).

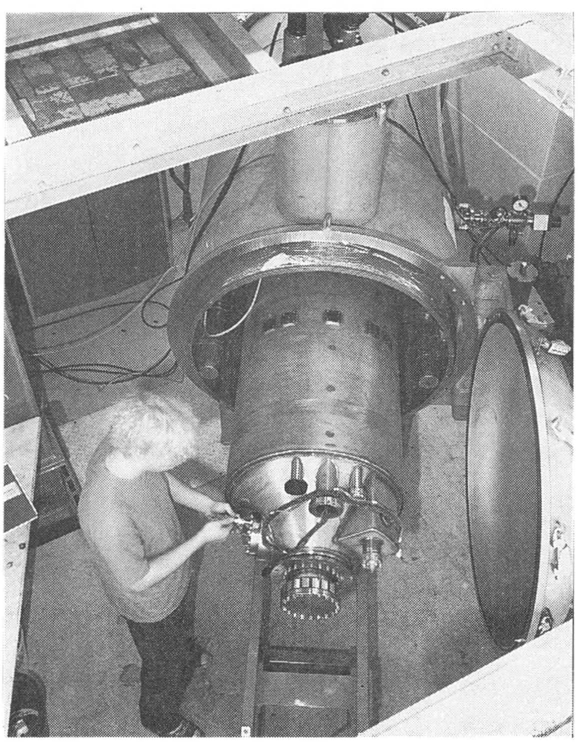

FIGURE 2
Testcryostat with opened door and a 4-cell cavity on rails for easy assembly

Assembly, cool down and warm up can be done within two days. According to the prototype experience the assembly of two cavities in the accelerator cryostat takes 2.5 weeks including all accessary equipment.
The experience with the prototype module showed that the high power input coupler had to be trained carefully to avoid sparking at the ceramic Al_2O_3 window. A high power input window conditioning facility was built (see Fig. 3) to investigate the training behaviour [4]. In addition couplers will be processed here before cavity assembly. Recently two couplers have been operated up to a level of 300 kW forward power [4]. This power level enables to accelerate the maximum e^- HERA current of 60 mA at a gradient of 5 MV/m.

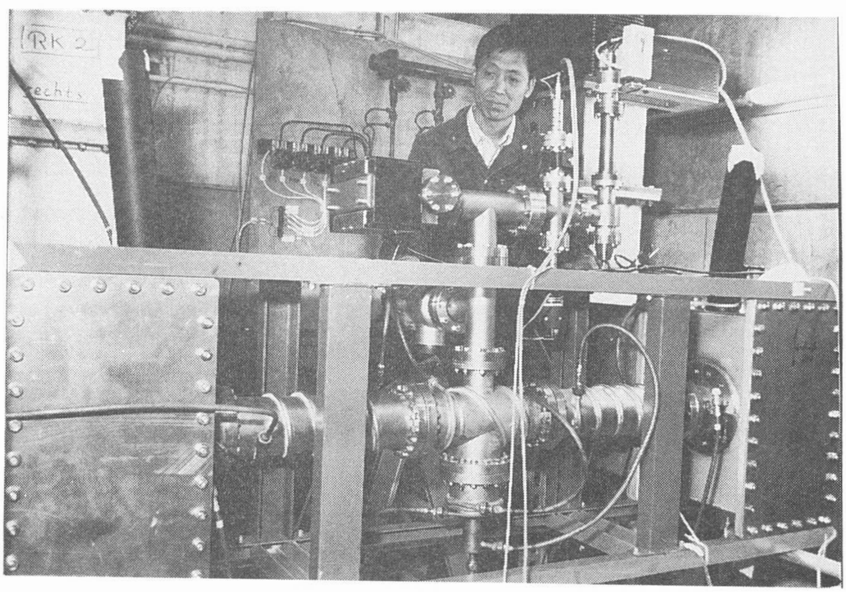

FIGURE 3 High power input window conditioning facility

A three stub variable input transformer has been developed to match the klystron-cavity system for different beam currents [5]. This device allows a transformer ratio from 0.2 to 5 and additional independent phase adjustment. An early version of two stubs has been successfully used at a PETRA beam test to match the different performances of two cavities to the same klystron.

The higher order mode impedance of the superconducting cavity alone should allow to store 50 mA multibunch current in PETRA. This prediction will be tested in the coming beam test (September 1989). Here all normalconducting cavities are bypassed so that only the superconducting cavity provides the necessary circumferencial voltage.

HERA INSTALLATION

Fig. 4 shows the HERA tunnel cross section with the superconducting RF-module, the LHe distribution box and the RF-waveguides. Because of limited space in the tunnel the radial dimensions of the 8 cryostats had to be reduced as compared to the prototype. One 0.8 MW klystron station is installed and all waveguide components have been ordered. Production of the LHe distribution line and the valve boxes will start in September 1989. The complete installation is scheduled in the HERA summer shut down 1990.

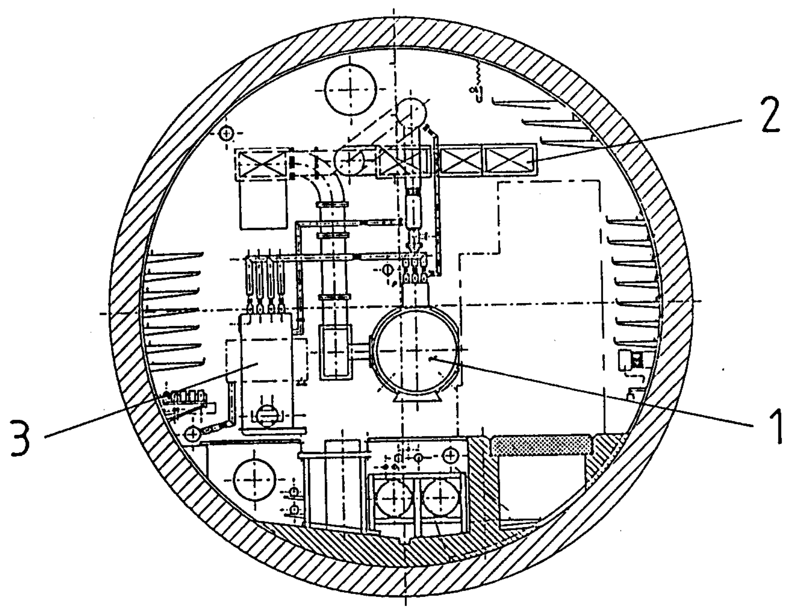

FIGURE 4 HERA tunnel cross section
1 superconducting RF module, 2 waveguides,
3 valve box with He distribution system

PIPE COOLING DEVELOPMENTS

The advantages of pipe cooling as compared to bath cooling are the reduced safety problems, the simplified LHe distribution system and the easier operating procedure. We developed this cooling technique to have an alternative design for a possible next generation of HERA super-conducting cavities. A second single cell pipe cooled cavity was produced by explosively bonded niobium/copper sheets [6]. This cavity reached a field of 9 MV/m but showed a degradation of the quality factor after each quench. Most likely this is caused by the magnetic field of thermo currents because the original data could be restored after a temperature circle above transition temperatur. The good results of sputtered cavities at CERN offer an interesting way to realize pipe cooling. Therefore we have recently started a Nb sputter programme at DESY [7]. So far two copper cavities with integrated cooling channels (see Fig. 5) were fabricated and are used to adjust cleaning and sputter parameters.

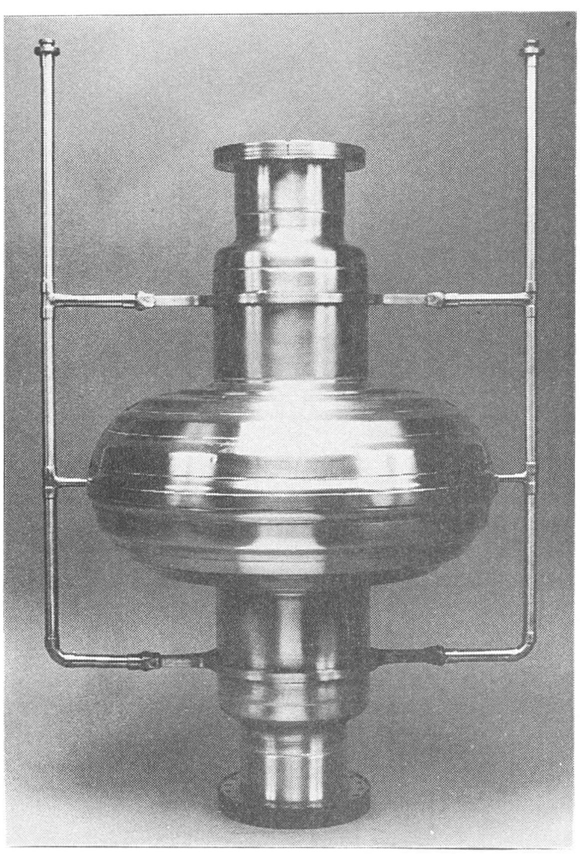

FIGURE 5
Copper cavity with integrated cooling channels

A sputter apparatus is designed to sputteretch, sputter and transfer the cavity to the cryogenic environment without opening the cavity (Fig. 6).

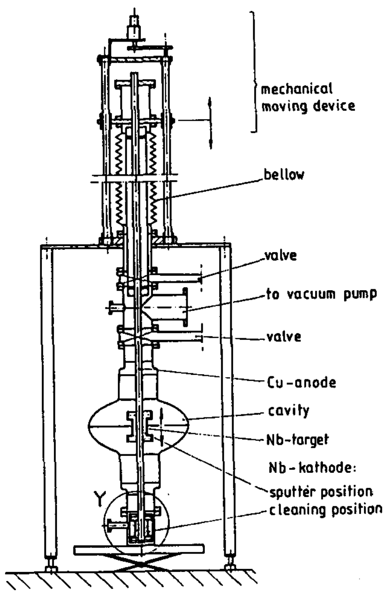

FIGURE 6
Design of our planned sputter apparatus

MESUREMENT OF THE SURFACE RESISTENT OF YBCO [8]

The inner conductor of a 500 MHz coaxial resonator is made from solid silver and covered by YBCO (see Fig. 7). Painting as well as electrophoretic depositioning are used as plating technique. So far a surface resistance of 1 mOhm is measured at 500 MHz and 77K. Figure 8 shows the frequency dependency of YBCO from 500 MHz to 2 GHz. The moderat value of the surface resistance is most likely due to the temperature inhomogenity of the furnice ($\Delta t=30°C$) and a not long enough sintering time (20-30 h).

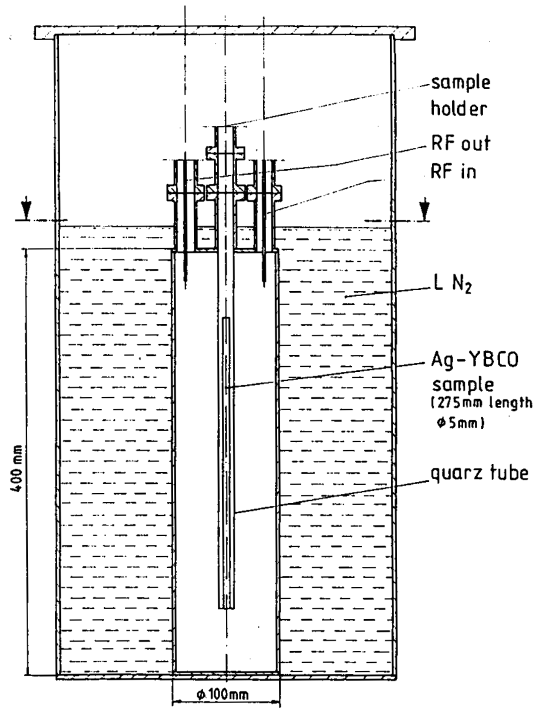

FIGURE 7
Cross section of the 500 MHz coaxial resonator. The inner conductor is fabricated from solid silver and covered with YBCO ($40\ cm^2$)

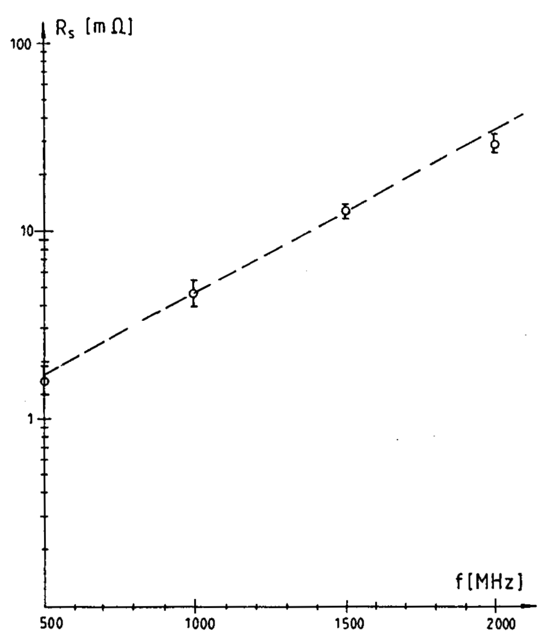

FIGURE 8
Measured frequency dependancy of the surface resistance of YBCO. The dashed line corresponds to a quadratic increase.

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