DEVELOPMENT OF THE TRITRON CAVITIES

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Abstract:

For the TRITRON (see contribution of U.Trinks) we need 6 wedge shaped cavities for simultaneous acceleration of 20 neighbouring beams. Some data: length 1.2 m, height 0.7 m, width_{max} 0.7 m, frequency 170 MHz, frequency variation (by mechanical deformation) ±3%, the superconductor is lead on 6mm copper.

As a first step a rotational symmetric reentrant cavity (Ø 44 cm, $f(TM_{010})$ =490 MHz, $f(TE_{111})$ =1 GHz, gap = 10 cm) with smooth curved shape was manufactured from 6 mm copper sheets and elektroplated with lead. Without suitable surface treatment Q-values of $5 \cdot 10^7$ (2.5% of theoretical maximum) in the TM_{010}-mode and $1.5 \cdot 10^8$ in the TE_{111}-mode were measured. A maximum voltage of U = 440kV was achieved, limited by the RF-power supply (14 W). Meanwhile the facilities for advanced surface treatments are under construction.

The development of the Munich superconducting seperated orbit cyclotron TRITRON as post accelerator for the 13 MV Tandem for heavy ions has started.

The rf system consists of 6 wedge shaped cavities (with a length of 1.2 m and maximum height of 0.7 m) of reentrant typ (driven in the TE_{101} mode) with a frequency of 170 MHz. The accelerating gap has a slit length of 0.8 m in radial direction for simultaneous acceleration of 20 neighbouring beams (see fig.1). These cavities are positioned in the (stray) field free intermediate sectors between two superconducting magnet sectors. In order to get the turn separation of Δr=4 cm a maximum rf voltage of 3 MV per turn corresponding to 500 kV per cavity is needed..

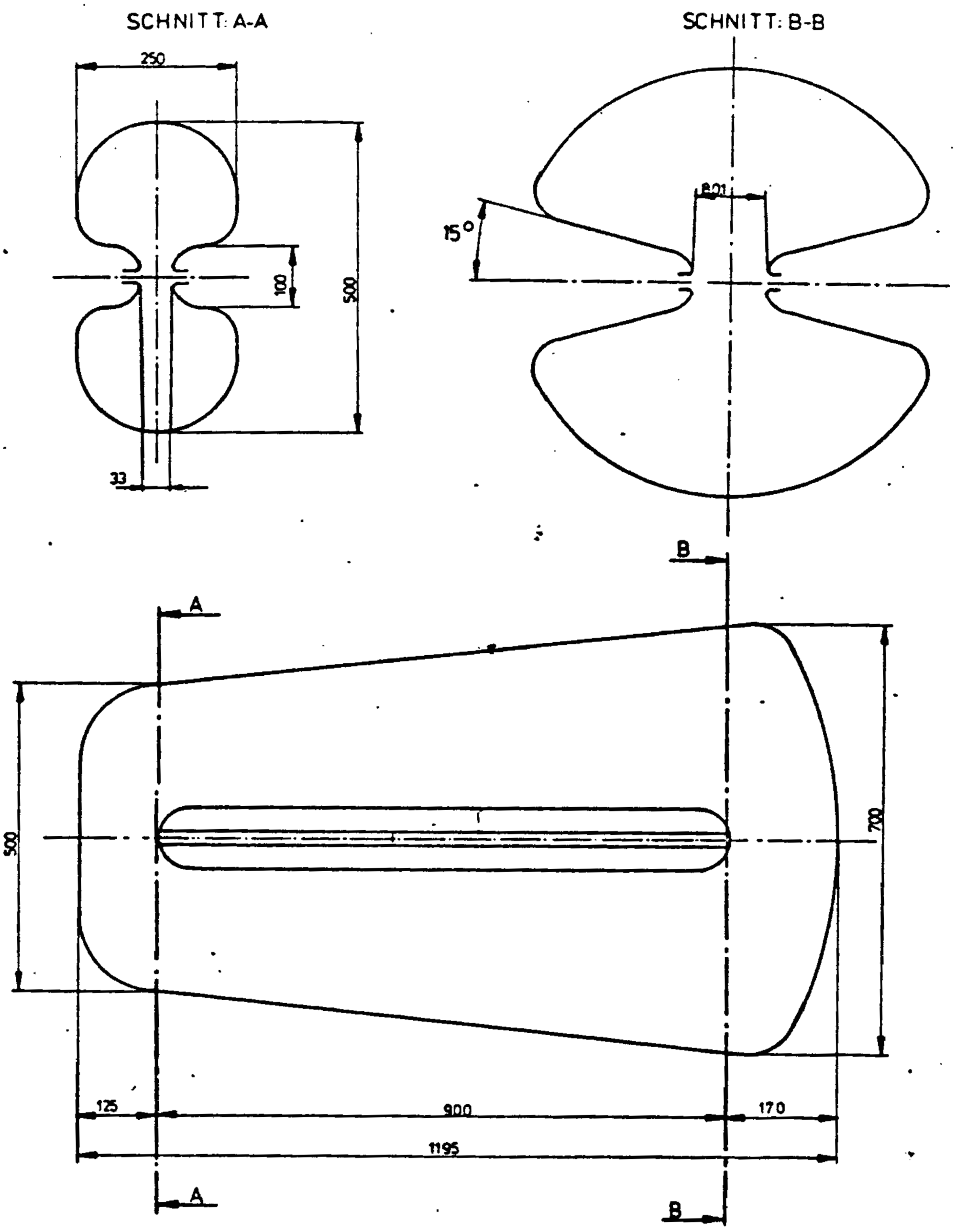

fig.1: Shape of the TRITRON cavity

In case of conventional cavities the power dissipation would exceed 300 kW. To avoid this power dissipation in the close neighbourhood of the cold magnets, superconducting cavities are favourable. We use a curved contour of the outer wall to suppress multipacting. The cavity in fig.1 was calculated by means of a computer code for three dimensional cavities /1/.

The shunt impedance for normal conducting copper is 4 MΩ. The final design will reduce the peak electric and magnetic surface fields at the expense of shunt impedance. The revolution frequency of the ions is changing with the specific charge state and injection energy, hence we need a resonance frequency variation of ±3% . This variation could be done without sliding contacts by mechanical deformation of the cavity, verified by tests with a 1:5 model. It is planned to build the TRITRON cavity with copper using the electroforming technique. This treatment results in a very smooth copper surface (roughness less than 0.2 μm), which is necessery for successful electroplating with lead. This Cu-Pb composite has in comparision to Nb considerable advantages for the TRITRON cavity, as there is the easy manufactoring without any welding and soldering. The comparably large surface demands a good stability against thermomagnetic breakdown, because the probability of normal conducting spots is proportional to the amount of the surface. This stability is guarantied by the excellent thermal conductivity of the composite. The somewhat higher rf-losses of Pb are not important in our case. The low peak magnetic surface rf field (nearly 80 Gauß at the required accelerating voltage) does not demand the higher critical data of Nb.

In a first step we have built a more simple test cavity to solve technological problems under realistic conditions. Mainly the manufactoring and improvement of the superconducting surface is studied to yield lower residual losses. Furthermore we want to learn something about mechanical stability, joints and fine tuning. We have chosen for the test cavity a torodial symmetric reentrant shape with a diameter of 44 cm (see fig.2). Similar to the TRITRON cavity the gap width is 10 cm, the outer wall is curved and the peak electric and magnetic surface fields are kept low. The ratio of the maximum surface electric field to the electric field on symmetry axis is 1.4, the peak magnetic surface field, normalized to an accelerating voltage of U_{acc}=500 kV is 72 Gauß.

The frequency of TM_{010} mode is 490 MHz. The test cavity is able to accelerate beams with $\beta \gtrsim 0.4$ and is therefore no low-β structure. Consequently tests with our heavy ion beams are not intended.

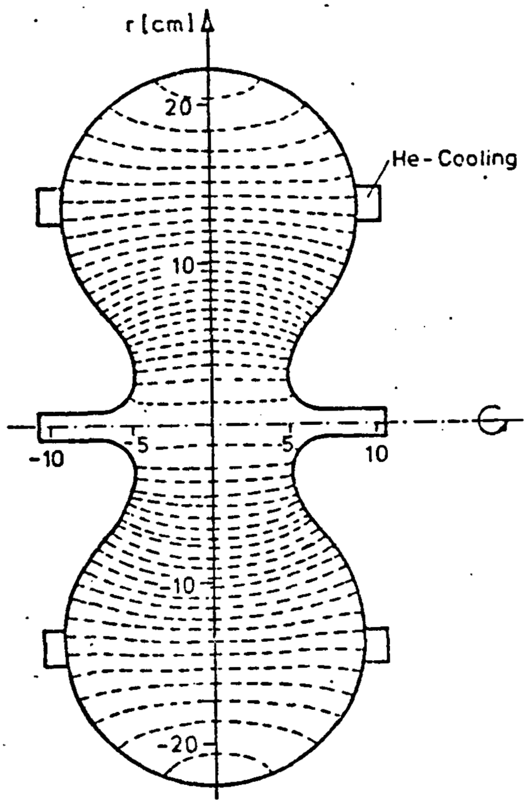

fig.2: The test cavity with electric field lines

The cavity is built up of two shells connected by joints along the equator (at r=22 cm). The shells are pressed of 6 mm OFHC copper sheets and connected with cooling pipes for 4.2 K liquid helium cooling. After mechanical and electropolishing treatment in the TM_{010} mode a Q-value of 34000 was measured in the normal conducting state corresponding to the theoretical value calculated by the SUPERFISH code /2/.

In a first crude experiment the cavity was electroplated without using suitable facilities. In the superconducting state a Q-value of $5 \cdot 10^7$ (theoretical maximum is $2 \cdot 10^9$) and an accelarating voltage U_{acc} of 440 kV were measured in the TM_{010} mode. The voltage was limited by the rf-power supply (14 W power consumption in the cavity). Even during slow increase of the field amplitude there was no multipacting observed. In the TE_{111} mode (f=1 GHz) a Q-value of $1.5 \cdot 10^8$ was measured. Both Q-values correspond to a high surface resistance of about $2 \cdot 10^{-6} \Omega$ caused by the imperfect surface. Although the rf joints have been slightly distorted, they did not show a significant loss mechanism.

To get better residual losses, we tested several surface treatments. Applied on small samples we got good results with the following methods:

1) The well known chemical polishing procedure /3/
2) Elektropolishing (acetic acid plus sodium acetate)
3) Vapour exposition

In addition we developed an electrolyte for electroplating that leads to better surfaces than the usual lead fluoborate. The so attained surfaces resist to oxidation and keep their mirror like appearance. It may be possible that this surfaces need no further treatement.
Meanwhile we have installed facilities to apply these techniques on our test cavity. With this progress we hope that we can present lower residual losses after the next tests.

References:

/1/ W.Wilhelm, Part.Accel. 12, 139 (1982)
/2/ J.Halbach,R.F.Holsinger, Part.Accel. 7, 213 (1976)
/3/ G.J.Dick et. al. IEEE NS 24 pp.1130-1132 (1977)