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Group 5 - Structures Group

Working Group Chairmen - E. Haebel, J Kirchgessner

Working Group Summary, 5B -Mechanical Considerations and Costs

Presented by J. Kirchgessner

The chairmen wish to thank all the members of the Group 5 Working Group for participating in and contributing to these sessions. Those assigned to the group were as follows:

Bernard	CERN
Beroud	SICN Direction General
Cavallari	CERN
Durand	SICN Direction General
Ferrario	INFN Frascati
Haebel *	CERN
Harfoush	Fermilab
Hartung	CERN
Hurand	CERCA
Kirchgessner*	Cornell university
Kneisel	CEBAF
Maccioni	CERCA
Marziali	Stanford University
Mosnier	CEN Saclay
Parodi	INFN Genova
Peiniger	Interatom GmbH
Porcellato	INFN di Legnaro
Rietdorf	TH Darmstadt
Schardt	TH Darmstadt
Sekutowicz	DESY
Spalek	Los Alamos National Laboratory
Spamer	TH Darmstadt
Takeuchi	JAERI
Trinks	TU Muenchen
Tueckmantel	CERN
Vogel	Interatom GmbH

We wish to apologize for omissions from this list and we wish to thank those individuals who have helped in these efforts.

The nine cell DESY-TESLA design along with the accompanying parameter set was assumed as a framework for the discussions.

The items to be considered by the Structures Group were as follows: cavity design, trapped modes, mechanical stability, couplers, tuning, ...

Arbitrarily the Group 5 sessions and reporting were divided into two parts: 5A which includes Electromagnetic and coupling considerations, and 5B which includes Mechanical considerations and costs.

A summary of the sessions dedicated to mechanical considerations and costs is presented.

MECHANICAL CONSIDERATIONS

• The plan is to brace the 9 cell units with braces from the equator of cell 1 to the equator of cell 9. This requires that all of the required tuning deformation must be taken up by the two end 1/2 cells. This must be done within the elastic range of these end cells.

• Calculations should be made of all the electrical resonances, all of the mechanical resonances and all of the mechanical and thermomechanical stresses in the cavity structure. The codes exist now for doing all of these calculations and all of these calculations must be done to determine the final parameters of the cavity structure / tuner / mechanical resonance system.

• Niobium hydroformed bellows could be used between 9 cell structures. The required stroke and the wakefield loss (Volts/picocoulomb) must be considered in this design. In any case, it is possible to manufacture from niobium any bellows that could be made from stainless steel. The properties of the niobium version would be very close to the properties of the stainless.

• In order to minimize the mechanical resonance problem, an effort should be made to make the cavity structure as stiff as possible from equator 1 to equator 9. To achieve this the braces should be welded to each cell along the way. Such a braced structure must be accomplished in an inexpensive manner considering both material and welding/fabrication costs. This rigid body should then be loosely hung at the 1/3 points from the rigid cryostat beam, with damping if possible in this support. In this effort we must keep in mind the alignment tolerance for the cavities which is of the order of 0.1 mm.

• The helium vessel should be designed in such a way, that with proper bellows placement, the pressure variations in the helium bath will be decoupled from the cavity. That is, these pressure variations will exert no axial tuning force on the cavity.

• The proposed tuner mechanism with 3 cold stepping motors and gear trains at helium temperatures are possible. Very careful attention must be paid, however, to cost effectiveness and reliability. There might be a better yet to be invented solution.

COST CONSIDERATIONS

• Niobium costs should be lower. 1/3 of the present European cost would be a reasonable goal. A proof that this contention might be reasonable is that the present cost of niobium in the US today is about 1/2 the European cost for the same items. It would seem that the solution lies in the area of adequate competition.

• Can material be saved by making the cavity material thinner? Of course, the cavity must still be strong enough to withstand the required strains without permanent deformation. The problem is calculatable and it should be possible to arrive at a cost minimum considering all of the input parameters.

• Machining of the niobium cups should be minimized. This probably indicates that there should be no weld steps at the equators. Many cavities have been successfully made in this manner. Uniform weld material thickness can easily be assured this way.

• Deep drawing, stamping, and other high production techniques should be used to decrease the number of parts, the amount of required machining, and the number and complexity of the welds.

• Mass production techniques should be used wherever possible in order to operate at the cost minimum considering the tooling, jig and fixture costs as well as the production costs. Unfortunately we are not really in the realm of true mass production with only 10,000 units.

• Niobium sputtered on hydroformed copper has the ultimate potential for saving considerable money in several areas. The high field operation of such cavities must, of course, be as good or better than that of the niobium cavities.

• It is very necessary that the detailed design of all components and systems be cost driven. With the present state of scientific technology in our laboratories, this is becoming more and more difficult.

Electromagnetic Considerations

- **1. Cell Geometry** Computer studies done at Saclay, Cornell and Los Alamos allow the conclusion, that combining an elliptical iris with a spherical equator results in more satisfactory parameter sets than the combinations elliptical-elliptical, spherical-elliptical and spherical-spherical.

  A recent Saclay study gathered information on the question of the optimal iris diameter. A lower limit is 6 cm since below one finds no further worthwhile reduction of the E_{peak}/E_{acc} ratio. An upper limit is 9 cm since above fundamental mode fields penetrate too far into the beamtubes. The comparative table below illustrates strong and weak points in attributing stars.

parameter	6cm diameter	9cm diameter	remarks
E_{peak}/E_{acc}	* * *		44% gain
H_{peak}/E_{acc}	* *		20% gain
$(R/Q)_{fundam}$	* *		40% gain
$(R/Q)_{hom}$		* *	
inter cell coupling		*	
admissible tolerances		*	

  The most important advantage of the small iris diameter case is its small E_{peak}/E_{acc} ratio of 1.8 combined with a high fundamental mode (R/Q). But this implies higher (R/Q) values also for the hom, with the consequence of a correspondingly bigger hom energy deposition than for the large aperture case.

  Before a choice is made the question to be answered is then which percentage of the hom power can be dissipated outside of the 1.8 K bath. No quantitative calculation methods are available. But the argument has been put forward that the long time available between bunch trains should assure a high extraction efficiency of say 90% . Then a small aperture geometry will not only provide 40% higher gradients but also produce a given gradient at 40% less cooling power.

- **2. Trapped Modes.** These are modes which, nominally propagating, excite only small field amplitudes in the beamtubes. This entails the risk that neither beamtube couplers nor absorption in the beamtube walls assures their sufficient damping.

  For the 9-cell cavities studied, URMEL predicts such modes in the fifth dipol and monopol passband and some of the monopoles have sizeable coupling impedance. Computer simulations assuming cavities without fabrication tolerances indicate that beamtube couplers can provide external Q's of 10^5 to 10^6 for these momnopoles if the technique of tuned beamtube diameter reductions is applied. Without reductions simulations become doubtful because URMEL needs closed boundaries. Model measurements are needed to assess this simpler solution, attractive since it reduces the short range wake and improves the chances to extract high frequency hom power towards the ends of a 8 cavity module where absorbers could be placed at 66 K.

  For all these trapped modes the field profile along the cavity is strongly parabolic i. e. the central cell is maximally excited. It is therefore proposed to try a central cell trapped mode compensation with the aim to enhance the excitation of the end cells.

We are concerned about these modes since they could cause cumulative beam break up. Its threshold depends on both, damping and frequency spread. So far simulations have only considered the natural spread by fabrication tolerances. But the manufacture of cavities with slightly different geometries and stagger tuned polarization directions of dipol modes can be envisaged with little additional cost. Future studies of beam stability should consider this possibility of artificial spread in view of easing the hom damping requirements.

- **3. The Input Coupler.** In principle of coaxial construction it couples via a probe with the electric cavity fields in the beam tube and has to contain a flexible element to take up differential thermal contractions between Helium container and vacuum vessel. This element could be a piece of waveguide, flexible in beam direction, at the intermediate temperature of the radiation shield and communicating via appropriate transitions with the coaxial section of 4 cm diameter leading to the beamtube and a second of 8 cm leading out of the vacuum vessel. Within this waveguide a first vacuum window of generous dimensions could be housed. A second at room temperature in the 8 cm diameter section. We are confident that lines of the chosen dimensions can handle (200-300) kW with the envisaged duty cycle. but how much more power will be needed for pulsed high power processing?

- **4. HOM Couplers.** The main point of concern is whether cooling only by solid conduction is really feasible. Only experimental work can give the answer.