General Discussion on RF-design led by Ken Shepard and Jean Delayen

The general discussion session continued with details of the ladder design. Shepard pointed out that these spoke resonator designs always have to do a trade-off between making the structure ”floppy” for tunability and making it stiff enough so that microphonics e.g. due to variations in the helium bath pressure do not become a major issue. He asked if for the boxy ladder structure these issues have been studied, as this geometry is more susceptible to pressure variations. Bisoffi answered that mechanical studies have just begun and did not go beyond the basic mechanical modes of the structure, yet.

Schrage asked about the cost issues due to the use of the huge niobium flanges as the sidewalls that allow access to the interior of the cavity. Bisoffi answered that similarly sized flanges have been used for their superconducting RFQ. They worked well and were reasonably priced. Some cost and complexity reduction comes from the use of a combination of niobium and titanium. Titanium is used for parts of the flange that do not carry any RF current.

Zaplatin stated that from his comparisons between ladder and cross-bar structures the cross-bars were superior in terms of peak surface fields for low-β structures. For higher-β structures that have a larger volume these structures could be a more interesting option. He thinks that their major benefit is the potential to better clean the inside due to the large sidewall port. This should increase the achievable gradient in these structures. He also mentioned that the locations of flat surfaces that tend to deform more due to helium pressure changes are in lower field areas that should have less effect on the frequency changes in the cavity.

Addressing the fine tuning of resonator geometries to lower peak fields and thus increase achievable gradients, Rusnak asked if anybody ever considered non-symmetric gaps in multigap resonators, making the first one shortest and gradually increase succeeding ones. He was curious if an increase in transit time factor could be expected. Shepard pointed out that these structures are anyhow used over a wider energy range and thus internal tweaking should have little additional benefit. Rusnak pointed out that there still might be an effect as particles are faster after each gap thus making larger gaps later inside a structure better matched to the particle velocity. Bisoffi added that this non-symmetric design could be used to lower the peak fields in the endcells and thus allow a higher gradient than a constant structure.

Delayen made some comments on the general design procedure for 2-gap spoke resonators. His experience showed that gapcenter-to-gapcenter distances of $\beta\lambda/2.2$ gave the lowest peak surface fields, if the design procedure adjusted the overall active length of the resonator to maintain this distance, even when the spoke thickness is modified. For this approach he always found optimum solutions, where the spoke thickness consumed half of the active cavity length. As an additional argument for this approach he reminded us that besides the frequency, the structure-β is the most important RF-structure parameter provided by the beam-dynamics and that this parameter should be maintained. Pagani commented that the important

feature for the beam-dynamics simulations are the actual fields and their oscillations. In this scheme the definition of β is purely arbitrary. He agreed however that the definition of β needs to be consistent among designs. He also pointed out that the definition of β should be tied to the length of a accelerating structure. He added furthermore that the "β-label" of a transit time factor curve is meaningless as these curves are also influenced by other quantities, like the aperture and length of a structure.

Shepard made a few more remarks on the proper comparison of structures. He mentioned that in the end the performance of a structure counts and that probably the peak surface fields for a specific voltage gain are useful numbers to compare. He also suggested to resolve the discrepancy between his and Delayen's optimal spoke thickness of $L_{cav}/2$ compared with the Orsay result of $L_{cav}/3$.

The discussion on optimization strategies next focused on the quantities that were kept invariable during a design. There was a general agreement of the fixing of the β for any optimization. Pagani then pointed out that also the optimization criteria for a structure vary. While in Europe generally peak magnetic fields of 50 mT are seen as a fixed upper field level criterium, a lot of US-designs focus more on the peak electric field. Here the recent SNS number of 27.5 MV/m is becoming a standard for the upper limit for achievable field levels. For these designs sometimes peak magnetic fields of 60 mT or more would be reached. These criteria add more obstacles to comparing structures.

Shepard responded that a constant maximum peak surface field independent of the structure is not sufficient. He believes that from a better understanding of the mechanism behind field emission a peak surface field criterium should include the surface area of the structure. He asked for volunteers to collect and interpret the data for this information to get better peak surface field criteria for different structures. He agreed to Pagani's remark that better HPR reduced the importance of field emission to a certain degree.

Krawczyk started a discussion on the ports attached to the spoke resonators. Orsay and LANL are the only designs that use huge coupler ports due to the potential requirement of accelerating beam currents in the range of 100 mA. He asked if the much smaller ports on other designs are matched to the expected beam current operation of their accelerators or if they are solely for prototyping purposes. Shepard answered that the ports on RIA are matched to the expected operation. They have a preliminary coupler design whose thermal management for the nominal operation with 2 kW of transmitted power and also for up to 20 kW of overcoupled operation for microphonics compensation is reasonably well understood.