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Topic: definition of RF parameters for collaboration with Cockroft institute

pictures on layout: https://edms.cern.ch/file/869889/1/Lacroix.pdf

Workpackage description for the SPL high-power RF distribution network

Distribution of RF power from one 5-6 MW klystron (704 MHz) to 4/8 and, if possible, up to 16 cavities with the capability of adjusting/controlling the amplitude and phase of each cavity individually. The phase/amplitude control of the single cavity fields will have to reach a precision of -+ 0.5% and -+ 0.5 deg. The following conditions apply:

- The input power couplers will be matched for an average current of 40 mA, yielding a maximum power per cavity of ~1 MW,
- Operation at 20 mA is foreseen using the same input power couplers, yielding a reflected power from the couplers of ~11%, and yielding a peak power per cavity of up to ~0.5 MW (+ reflected power),
- A power budget of 30% is foreseen to compensate cavity detuning caused by Lorentz Forces,
- The system must be designed for 50 Hz and a maximum RF pulse length of 2 ms,
- Due to space restrictions in the klystron tunnel the RF splitting has to be done in the accelerator tunnel.
- We assume a single RF output from the klystron. If it becomes apparent during the R&D phase that one output is not feasible due to restrictions on the window or due to a high risk of sparking 2 klystron outputs will be considered.

The distribution system has to aim for the following goals:

- possibility to adjust for different gradients and phases (via mechanical phase shifters) in the cavities of one string without a large overhead of reflected power, this implies the use of variable splitters, which can be adjusted mechanically,
- Ideally there should be a possibility to “remove” a single cavity from the RF distribution in case of technical problems. This could be done by either detuning the cavity and/or adjusting the variable splitters to minimise the reflected power.
- “fast” phase/amplitude shifters should be used to compensate for transient effects such as Lorentz force detuning. These units should have a bandwidth in the 10 kHz range with approximately 50 us rise time, providing a phase/amplitude adjustment of -+60 deg/12 db.
- Space is a major concern, which means that the RF distribution system should be as compact as possible.
- It is desirable to be able to operate a string of cavities, even if one cavity of the string cannot be used. In such a case that RF distribution system should still allow the operation of the remaining cavities of the string.

The RF distribution can be inspired by the XFEL power distribution system, which has very similar requirements as mentioned above, and has much tighter needs in terms of phase and amplitude control. The XFEL system is based on binary cells consisting of 2 circulators connected to a shunt tee with an integrated phase shifter. Multiple binary cells are fed via asymmetric mechanically tunable shunt tees. The RF power for each pair of RF cavities can thus be adjusted. In the case of XFEL the power of one 10 MW klystron at 1300 MHz is distributed to 32 cavities. The preliminary tunnel integration study has assumed an RF distribution as it is used for XFEL, without going into the detailed design of the single components. Information on the XFEL system is available in:

"Compact Waveguide Distribution with Asymmetric Shunt Tees for the European XFEL", V. Katalev, S. Choroba, PAC'07
"Design and Status of the XFEL RF System", S. Choroba, PAC'07

References on high-power phase shifters:

"High-Power 325 MHz Vector Modulators for the Fermilab High Intensity Neutrino Source (HINS)", R.L. Madrak, D. Wildman, LINAC'08
"First Results with a Fast Phase and Amplitude Modulator for High Power RF Applications", H. Frischholz, J. Tückmantel, D. Valuch, C. Weil, EPAC'04
"High CW Power, Phase and Amplitude Modulator Realized with fast Ferrite Phase-Shifters", D. Valuch, CERN-THESIS-2005-021