

# Recommendation on studies regarding the installation of HOM couplers

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The current statement in the CDR is that HOM couplers should be installed on the SC elliptical cavities, however more in-depth studies of their effect may alter this decision. If these studies show that the effect of the HOMs is below the prescribed limits, then the decision to install couplers will be reversed.

Such studies would need to be comprised of the following:

**Beam dynamics** Studies similar to those in [1] should be performed using details of the preferred ESS lattice, and full details of the HOM spectrum ( $R/Q$ ,  $Q$ , etc.).

In the first place, these should include a full macro-pulse where each proton bunch is modelled as a point particle. These will be used to excite multiple HOMs in each cavities, where the excitation of the HOMs is calculated using the expected  $R/Q$  of the modes, as well as their central frequency and decay times. These fields will then act back on subsequent pulses, altering their 6D position, so that the errors accumulate along the length of the linac.

The HOM parameters should be randomly varied (a Monte Carlo type simulation) across a reasonable range for each of the individual cavities in order to explore the effects of this variation.

These studies should then be repeated using a more realistic model of the bunch than simple point-like macroparticles.

The figure of merit for these calculations is the increase in the emittance due to the excitation of HOMs. If this is shown to be greater than, for example, the emittance increase due to allowable RF errors, then it should be concluded that HOM power is a problem from the point of view of the beam quality.

**Cryoload** Since the energy generated in the HOMs must be deposited somewhere, there is a risk that it may be dumped into the cryogenic system, thus increasing its load, and significantly raising the cost of its operation. Studies similar to those mentioned above should calculate the likely generation of HOM power in order to estimate this increase.

Note that it is expected that the cryoload is likely to provide a stronger motivation for the installation of HOM couplers, as previous studies on different machines have shown that it is unlikely that beam dynamics will provide problems for the bunch structure planned for ESS.

The figure of merit for this set of calculations is the increased load on the cryogenic system, and a reasonable limit on this should be acquired from discussions with the cryogenic group.

## References

- [1] M. Schuh, et al, “Influence of Higher Order Modes on the Beam Stability in the High Power Superconducting Proton Linac”, *Phys.Rev.ST Accel.Beams* 14, 051001 (2011).