Experience of LCLS-II Cavities * Radial Tuning at DESY.

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Abstract

Radial tuning (rolling) was applied to three LCLS-II cavities to prevent that their lengths exceed the technical limits. The cavities have a reduced frequency due to additional material removal during cavity treatment well beyond the baseline recipe. The mechanical condition of the cavities was relatively soft because of the thermal history and the niobium manufacture requirement of an optimal flux expulsion. The niobium was highly recrystallized by 3 hours annealing at 900°C and 975°C respectively. Each cavity received an inner surface treatment of 200 µm electro-polishing (EP) and an external 30 µm buffered chemical polishing (BCP) as part of the baseline recipe. Each cavity received an addition ~100 µm of chemical removal along with a second annealing treatment before the radial tuning process. Detailed information about the accuracy and homogeneity of LCLS-II cavities rolling is presented as well as results of field distribution analysis for TM011 zero-mode with a comparison to standard cavities.

Cavity characteristics

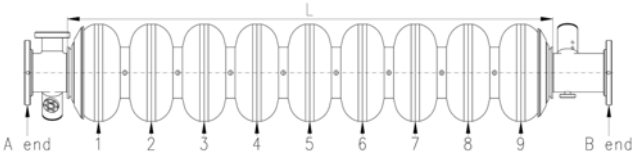

Figure 1: Length (L) of 9 cells LCLS-II cavity

Table 1: cavity characteristics before rolling

cavity	L, mm	F, MHz	ΔL, mm	ΔR, µm
EZ-1	1063.7	1297.90	2.9	5
RI-1	1063.6	1297.89	2.8	8
RI-2	1064.0	1297.96	3.0	0

Table 2: cavity characteristics after rolling

cavity	L, mm	F, MHz	ΔL, mm	ΔR, µm
EZ-1	1064.0	1298.63	0.8	112
RI-1	1063.0	1298.98	-1.4	220
RI-2	1063.2	1299.14	-1.7	237

(!) **Before rolling: cavity lengths achieved their upper technical limit (ΔL ≈ 3 mm).**

(!) **Additional electropolishing treatment after radial tuning (100 µm for EZ and 200 µm for RI cavities) can be provided keeping cavity lengths in tolerance.**

Target cavity length:

L_T = 1061 mm.

Maximal cavity length deviation:

ΔL_T = ± 3.0 mm.

Target cavity frequency at room temperature during standard tuning:

F_T = 1297.96 MHz.

Cavity length deviation after tuning:

$\Delta L = (L - L_T) - (F - F_T) / (dF/dL)$.

Maximal value of additional EP treatment:

$\Delta R = (\Delta L - |\Delta L_T|) (dF/dL) / (dF/dR)_{EP}$,

where sensitivity of pi-mode frequency (F) to deviations of cavity length (during standard tuning) and inner contour radii (during electropolishing process):

dF/dL = 300 kHz/mm,
$(dF/dR)_{EP}$ = - 6 kHz/µm.

Eigenfrequencies of cavity cells

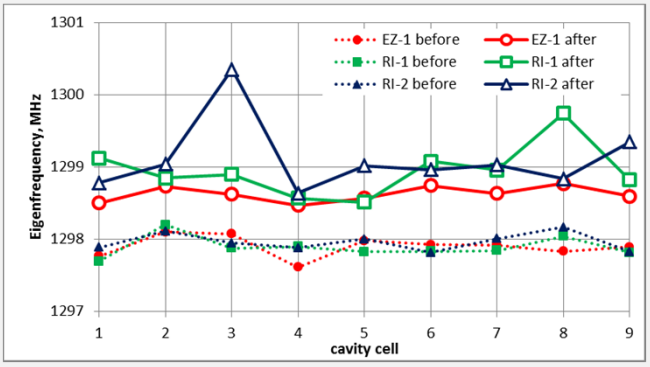

Figure 2: Cavity cells eigenfrequencies before and after rolling

Higher Order Modes

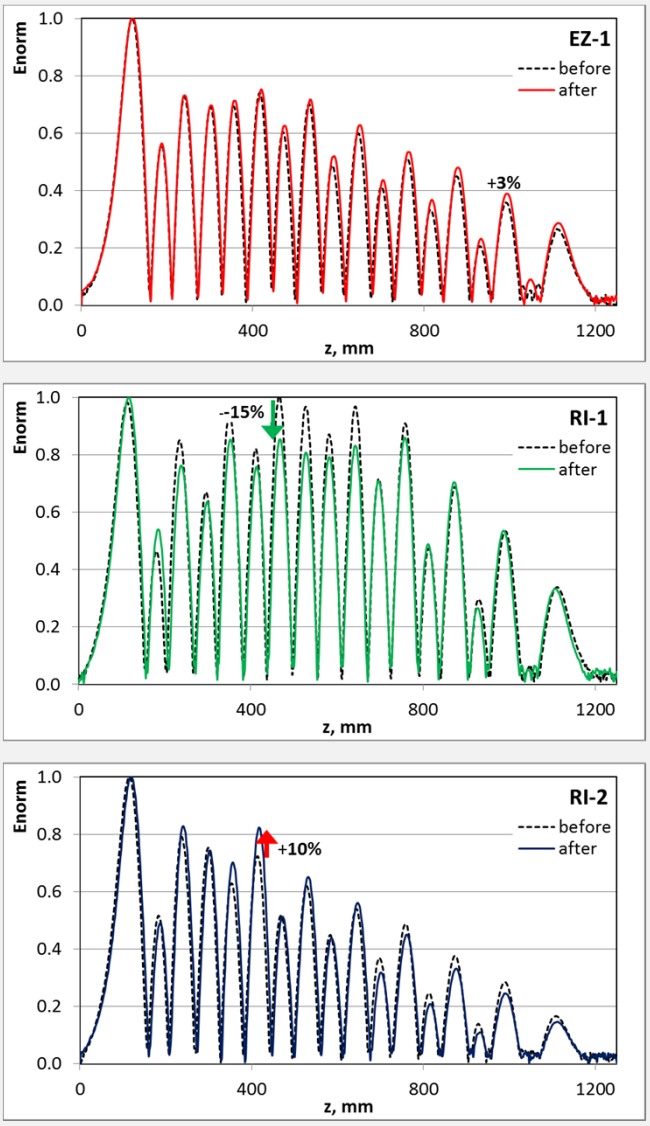

Figure 3: Normalized field distribution |E(r=0,z)| on cavity axis for second monopole mode TM011

Summary

Based on our experience with LCLS-II cavities, we can come to the following conclusions:

- **radial tuning at DESY allowed to decrease the cavities lengths about 2 mm for EZ-1 and over 3 mm for RI-1,2 or/and provide the possibility of an additional chemical treatment (over 100 µm EP);**
- **the most accurate (homogeneous) deformations of all 9 cells were provided for cavity EZ-1 (see Fig. 2). The reasons of deviations in some cells for RI-1, 2 can be explained by different hardness of cavity material and limited accuracy of radial deformations process;**
- **deviation of field distribution for TM011 zero-mode relative to standard cavities is less then between the cavities before rolling. So the radial tuning inaccuracy brings no significant impact to HOM suppression efficiency.**

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