# Review Charge Statement

The review committee is charged to evaluate the LCLS-II-HE tuner for off-frequency operation (OFO) by responding to the following questions:

1. If we increase the length of the arms by 7mm, what other tuner/cryomodule parts need to be modified?

Brief description of the mechanical design of the LCLS-II tuner was presented. Proposed changes to the LCLS-II tuner were presented and include the increase of the length of the tuner arms by 7 mm. 3D model of the LCLS-II-HE Cavity with the proposed new design is F10146648. According to the 3D model a total of 5 components need to be modified:

1. F10146870 – Motor Side Arm
2. F10146871 – Tuner Support Arm
3. F10146893 – Stop Rod
4. F10146894 – Top Lever Plate
5. F10146895 – Bottom Lever Plate

These components have been already modified to accommodate the new increased length of the arms by 7 mm.

No additional component appears to need modification to allow an increased length of the tuner arms. No major interferences with the cavity and with the coldmass components were detected during the presentation of the new 3D model.

1. Based on LCLS-II statistics, with the 7mm increase in the length of arms, what percentage of cavities can be tuned to -465kHz with the current installation procedure?
2. Based on LCLS-II statistics, with the 5mm increase in the length of arms, what percentage of cavities can be tuned to -465kHz with the current installation procedure?
3. Based on LCLS-II statistics, what percentage of cavities can be tuned to -465kHz with the current extended range design and installation procedure?
4. Based on LCLS-II statistics, what percentage of cavities can be tuned to -465kHz with the current extended design and updated installation procedure modified with different preload and to take into account individual cavity warm frequency?

From the data presented it appears that:

1. changing the lever ratio to 1:16
2. increasing the preload on the piezo by 50 kHz (100 kHz total)
3. assembling the tuner with the cavity under vacuum (additional 60 kHz of compression)

would result in approximately 20-21 over 160 cavities not tuned to the -465 kHz requirement using all the stroke of the motor (34 mm). This corresponds to roughly the 13% of the total cavities used for the LCLS-II project.

During the presentations it was stated that the project requires 5/8 of the total cavities to be tuned off-frequency.

In the current situation, implementing the modifications a, b and c mentioned above and considering the nominal model, even if the tuner arms are not extended by any measurable length, it appears that the project requirements would be satisfied.

However, this analysis is to be considered simplistic not taking into account that:

1. Cavities can be longer than the nominal length
2. Magnetic shield assembled position can differ from the nominal position

It is therefore impossible for the review committee to reliably predict the total number of cavities that can be tuned off-frequency implementing the modifications a, b and c mentioned above.

After a careful analysis of the data presented and discussed during the review and the additional material that was send the committee recommends the following modification to be implemented on the LCLS-II-HE tuner:

1. Increase length of the arms of at least 7 mm, changing the lever ratio to 1:16, increasing the preload on the piezo by 50 kHz (100 kHz total) and assembling the tuner with the cavity under vacuum (additional 60 kHz of compression)
2. Precision positioning of tuner components during installation procedure leads to the conclusion that an increased length of the motor shaft by 5mm is necessary. The length of the arms should be corrected as necessary to exclude interference of the TUNER levels with parts of the magnetic shielding.
3. Investigate possibility to install the modified TUNER on cavity #1 with minimum modifications of support components of the end valve. This increase a chance to qualify the cavity for off-frequency operation. Is it possible to combine F10077286 and F10077179?
4. Because the presented analysis is based on the statistic of LCLS-II cavity data we recommend estimating possible effects of LCLS-II-HE cavity treatment on its tuning. Different processing of the cavities could affect the overall cavity internal volume and therefore cavity length due to additional tuning shall be considered.

Moreover, the statistic presented regarding the LCLS-II cavities shows a noticeable trend. It appears the variance of the cavity landing frequency at 2K decreases going from cavity 1 to cavity 160. This raises another issue: is the project expecting to see a further decrease of the variance on the landing frequency for the cavities that will be built in the future?