The authors would like to thank the reviewers for their constructive and helpful feedback. We believe the paper is in a much better state thanks to the suggested changes.

**Response 1**

1. P. 2, Last paragraph in RESULTS  
   It was discussed that in recoated cavity, a large increase in x-ray emission, figure 1, may be caused by heating due to multipacting. Meanwhile, we can't see any increase in x-ray emission in the initial cavity. Why can we see the increase in x-ray emission only in the recoated cavity? Can you give some comments in the text? Is it some influence of cracks?

This particular cavity has experienced x-ray emissions in the past, so we do not think it is due to the cracks or the recoating procedure. We have explained this point in the final paragraph of the results section.

**Response 2**

1. [Reference]  
    References should be numbered in the order in which they appear in the text.

The references have been fixed.

1. [Introduction, line 6]  
    "Nb3Sn make,however" --> add space before "however"

Fixed.

1. [Results, line 2 and 9]  
    "Maximum Q of 1 x 10^10 at 4K" as the explanation of fig 1. B) and C) in the text. From figures, maximum Q seems to be 2 x 10^10 or close to that rather than 1 x 10^10.  
    Could you please check the correct numbers?

Yes, the max Q is 2 x 10^10. This error has been fixed.

1. [Results, last 5 lines]  
    You mention that the additional hot spot closer to iris appears with accompanied by x-ray emissions and this is caused by multipacting.  
    But multipacting at around 20 MV/m for 1.3 GHz cavity is two-points muptipacting occurring at equator region. Normally we do not have signal at iris region.  
    Do you have some scenario or evidence of multipacting at iris region?  
    It is more natural for me to understand that such hot spot is caused by Field emission, if you have x-ray radiation.

After reviewing the data, we concluded that there is not enough information to say whether the x-ray emissions are caused by multipacting or field emission. We have thus removed the statement that the quench was caused by multipacting.

1. [Fig. 1 C)]  
    4K data showing 2 lines. Higher Q and lower Q lines.  
    Could you explain in the text why you have two lines?  
    Are upper/lower lines before/after quench, respectively?  
   Is the Q-degradation due to flux trapping during quench or multipacting (or field emission)?  
    Is red star in fig. 1 C) correct? Isn't it on the lower Q line?  
    Why 2K data does not have 2 lines behavior of Q-E curves?  
    Could you explain in the text about this point, difference between 4K and 2K results?  
    Was 2K data taken just after 4K data?  
   - if degradation is due to multipacting or F.E. -> Was that processed?  
   - if degradation is due to trapped field by quench -> Was there any warming-up process between 4K and 2K measurement? Or was 2K measurement before 4K?

The upper and lower Q lines in figure 1C are caused by a quench at 16MV/m which resulted in trapped flux. We have labelled figure 3 to indicate which lines correspond to pre-quench and post-quench data. In the 2K test the cavity did not quench until reaching the maximum gradient, so there is no trapped flux in this test. This information has been added to paragraph 2 of the results section.

We have included more information on the VTS test and T-map procedure in the experimental section of the paper. The 4K test was performed first and the cavity was heated up above its superconducting transition temperature and cooled back down to 2K to remove any trapped flux resulting from the quench. The T-map is calibrated at 4K and then measured at 2K, so the red star in figure 1, C is correct. We have added this information to the caption of figure 2.

1. [Results, last line]  
    I can't understand well what was happened on cavity from this sentence.  
    What you say is no increase of T-map temperature and no x-ray (and no Q-drop)?

This sentence was removed.

1. [Fig. 2]  
    Please add explanation of plot about where is equator and where is iris. I want to know the relation between sensor numbers and cavity position.

We have added more information on the sensor positions in the caption of figure 2. The sensors 1 and 16 are near the iris and sensor 8 is on the equator.

1. [Discussion]  
    Could you give some comments about Fig. 1 C)? Why does Q-value of 2K become low? Is this the effect of "recoating"?

We have added a discussion of the VTS results in paragraph 1 of the discussion section.

**Response 3**

1. "Degradation" of Nb3Sn has several subtleties. Elastic strain modifies the electronic density of states and electron-phonon coupling, resulting in property changes that are recoverable upon removal of elastic stress. Mismatch in the coefficient of thermal expansion is one known source of reversible degradation. The authors should note that elastic sources are not plausible for their cavity because (a) the niobium body has nearly the same contraction as the film upon cooling, and (b) many Nb3Sn cavities have been tested with thermal cycling and show no degradation.

It is important to distinguish between degradation caused by elastic deformation of the Nb3Sn caused by thermal expansion and cracks. We have noted this difference in paragraph 2 of the experimental section.

1. The authors tacitly confine their discussion to irreversible degradation, where properties are not recoverable after a strain event. As the paper points out, cracks are the common source of irreversible degradation. Triggers of irreversible degradation include plastic deformation of the cavity as pointed out in the paper, but can also arise from local stress concentrations due to foreign particles or impurities, especially if they occur between the Nb and the Nb3Sn coating. Past literature has identified variations in the Nb3Sn coating caused by impurities on the Nb surface, so the authors should give some consideration that a local stress event caused cracks to form.

We have included the possibility of foreign particles causing the cracks to form in paragraph 2 of the experimental section.

1. Having mentioned cracks, the paper would be much stronger if a cavity section could be removed and examined microscopically showing the cracks. I realize this is very costly and that substitution of coupon experiments might not be sufficient verification, but I think it is essential to know what type of cracks are forming before discussing what healing mechanisms might be occurring upon later exposure to tin at high temperature.

We agree that a microscopic examination of this cavity would greatly reinforce our claims in this paper. Unfortunately, we cannot cut out a section from this cavity since this cavity is still highly valuable for performing more studies on Nb3Sn surface treatments such as recoating and mechanical polishing.

1. The paper then speculates that cracks become healed in some way during the high-temperature application of tin to restore a degree of performance. Two mechanisms are proposed: (a) some tin fills the cracks, followed by Nb diffusion into the crack (from the grains? upward from the base metal?) and then a reaction occurs to form Nb3Sn between the grains. Or, (b) some tin fills cracks which penetrate entirely through the Nb3Sn coating, reaching the base Nb metal and forming more thickness beneath the original Nb3Sn layer like a patch, resulting in an electrical bridge for the RF behavior. While these are plausible, I find these speculations to be inappropriate for APL without validation from microscopy studies verifying what happens after different processing steps. Again, cavity cut-outs and perhaps coupon studies could add convincing information. Importantly, in either case the authors present a case that the re-growth of Nb3Sn makes the grain-to-grain connection "good as new", suggesting that an optimization of healing could restore Nb3Sn to its intrinsic physical limitations.

We strongly acknowledge the need for more microscopic evidence of crack healing as pointed out by this comment and we have put in a lot of effort to provide more evidence for this mechanism. In lieu of analyzing the cavity itself, we have performed a new sample study using Nb3Sn coated wires to obtain microscopic evidence of crack healing. Nb wires were coated with Nb3Sn using Sn vapor diffusion. The wires were then elongated to produce cracks in the film and then recoated with the same recipe as the cavity. We analyze the cracks before and after recoating using SEM and EDS. The cracks formed on these samples are representative of an extreme case of crack formation in Nb3Sn cavities, since the wires are deformed much more than a typical cavity. We find that in this worst case scenario our recoating process can partially heal the cracks and even completely heal the cracks in some areas. We feel that this evidence is strong enough to support our claim that the recoating procedure can heal cracks in Nb3Sn cavities thereby recovering their performance after degradation has occurred.

We also find evidence to support our initial speculation about the crack healing mechanism. It appears that both of the originally proposed mechanisms are occurring during the recoating. We saw the creation of new Nb3Sn both at the base of the cracks in the Nb substrate as well as within the crack itself as shown in the new figures 3 and 4. Using EDS, we were able to determine that the newly deposited material is Nb3Sn and there does not appear to be excess Sn in the new material. While there are still more studies needed to deeply understand the healing process, such as using TEM-EDS to more accurately measure the stoichiometry of the deposited Nb3Sn, we believe that this evidence is sufficient to support our proposed healing mechanism.

1. There are several alternative mechanisms that are not explored. Some possibilities suggest that Nb3Sn might never be restored to its intrinsic physical capacity, which is an important distinction needed for publication in APL: First, it is plausible that a coating of tin forms an electromagnetic bridge between grains via proximity effect. The data in Fig. 1 suggests that the lossy features in the degraded cavity are retained in the recoated cavity, just displaced to higher E and lower Q, which is consistent with coupling via proximity effect. No dissolution of the Nb3Sn grains or long-distance diffusion of Nb is needed for this possibility. This mechanism has important physics implications for the eventual loss of Q, where surface magnetic field would always decouple grains below their intrinsic limit. Second, liquid tin can dissolve Nb3Sn above 910 C, leading to the possibility of dissolution and re-solidification along the crack as well as introduction of other non-superconducting Nb-Sn intermetallics (Nb6Sn5, NbSn2). Past literature has shown that large Nb-Sn intermetallic inclusions form hot spots, which is not the case here, but it is unknown how small inclusions might affect temperature mapping. Small inclusions such as hydrides always result in high-field Q slope in Nb cavities and prevent them from attaining ideal performance due to generation of local losses.

In light of this new study on crack healing, there does not seem to be any fundamental limitation to restoring the intrinsic capacity of the Nb3Sn. The material deposited in the cracks does not appear to be metallic Sn but instead mostly Nb3Sn. The low Q seen in the recoated cavity is due to trapped flux caused by a quench at 16 MV/m whereas the low Q seen in the degraded cavity is intrinsic to the cavity. We have clarified this information in figure 1 and in the results section.

The dissolution of Nb3Sn into the Sn liquid layer could explain the rapid diffusion of Nb into the newly deposited material. However, there is no evidence of Sn rich intermetallics forming in the cracks. We acknowledge that SEM-EDS may not have the spatial resolution to resolve small inclusions of Sn rich intermetallics and more studies are required. From our VTS data we have shown that, if they do exist, these inclusions do not cause significant dissipation. We discuss the possibility of non-superconducting phases in paragraph 3 of the discussion section.