TUPPO031

Microphonics in the ATLAS Upgrade Cryomodule

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ABSTRACT

Microphonics measurements have been performed on the recently commissioned ATLAS upgrade cryomodule which holds seven new β=0.145 quarter-wave cavities operating at 109 MHz. Tests have been performed at the full operational fields with an average gradient E_{ACC}=8.3 MV/m and V_{ACC}=2.1 MV/cavity, a record for cavities in this range of beta. In the commissioning run of the cryomodule with cavities at full gradient, RMS frequency jitter ranged from 1-2 Hz RMS. With a VCX fast tuner on each cavity configured for a tuning window of 40 Hz there is essentially no "out-of-lock" due to microphonics. Measurements were performed with the cryostat attached to the ATLAS 4.5 Kelvin liquid helium refrigeration system. The quarter-wave cavities themselves are equipped with a passive mechanical vibration damper so that low-lying intrinsic mechanical modes which couple to the cavity RF fields contribute little to the total microphonics. Rather, at useful accelerating fields most of the modest frequency jitter is due to relatively low frequency pressure oscillations in the helium bath due to pool boiling. Future plans for fast tuning on the next ATLAS upgrade cryomodule are discussed.

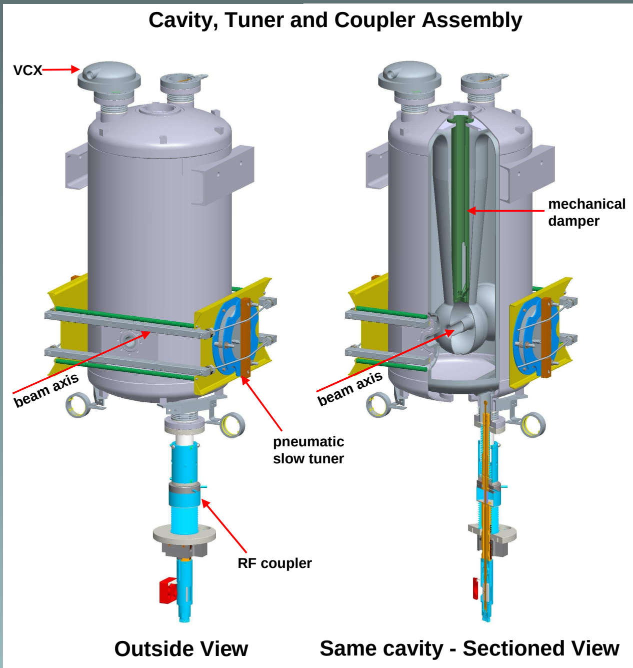

Figure 1. Cavity and tuning system for the ATLAS 109 MHz quarter-wave resonator (left) and a sectioned view (right). Visible are the coupler, pneumatic slow tuner and VCX fast tuner. A mechanical vibration damper located inside the center conductor is visible in the sectioned view. This robust system with 30-40 kHz slow tuner window, 40 Hz fast tuning window, mechanical vibration damping and low helium pressure sensitivity provides a good tuning margin with respect to online cavity microphonics and frequency drifts.

Figure 2. The complete ATLAS upgrade cavity string shown just prior to installation into the box cryomodule. Major components visible from top to bottom are the cryostat lid, the 80 K copper shield, the horizontal cylindrical helium manifold, and the cavity string mounted on the long rectangular aluminum 'strong back'.

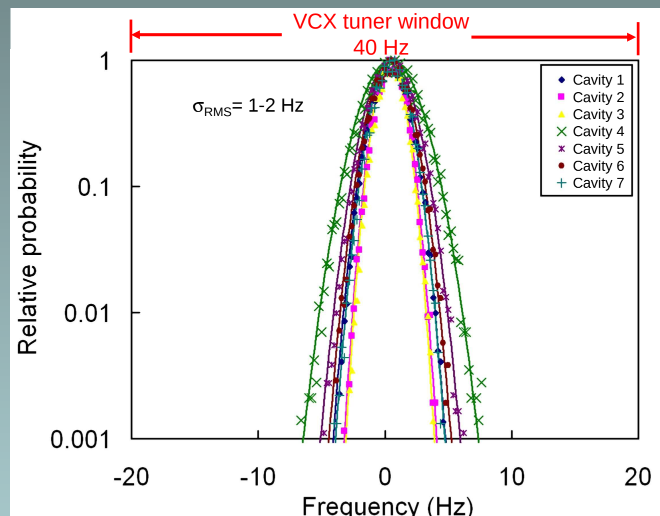

Figure 3. Measured cavity microphonics shown as a probability density for the seven ATLAS upgrade cavities operating simultaneously, here with an average of E_{ACC}=8.1 MV/m (2 MV/cavity). Data points are for 10 seconds of operation per cavity and were collected sequentially over the course of about 1 hour. Solid lines are Gaussian fits. The RMS frequency vibration for each cavity is σ_{RMS}=1-2 Hz and the full width of the distribution lies well within the VCX fast tuner window of 40 Hz. During the commissioning run of the cryomodule at full energy similar long term stability was observed and 'out-of-lock' due to microphonics was practically nonexistent.

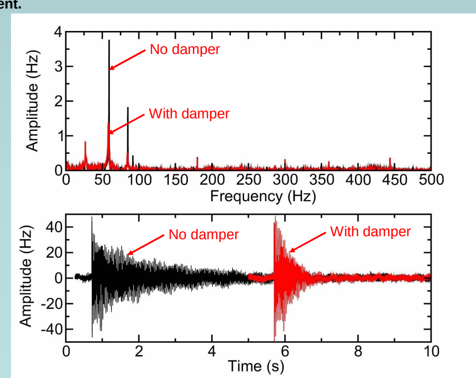

Figure 4. 'Hammer' test performed at room temperature showing the microphonic damping with (red) and without (black) the mechanical fast damper.

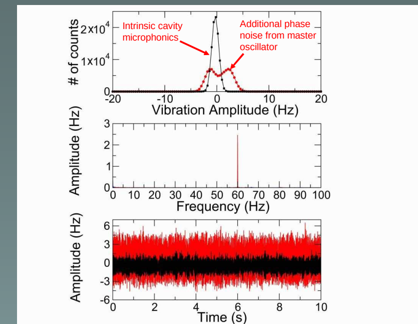

Figure 5. Error signal for one of the seven ATLAS upgrade quarter-wave cavities when locked to the ATLAS master rf oscillator (red) and when locked to a low noise external signal generator (black). In this case more than half of the frequency jitter is due to 60 cycles FM (*i.e.* not real microphonics) superimposed on the 109 MHz master oscillator signal. A lower phase noise master oscillator is planned for ATLAS.

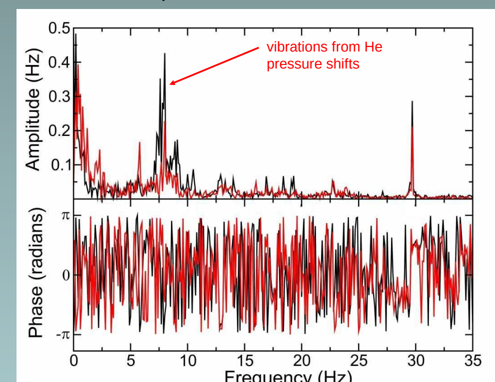

Figure 6. Fourier amplitudes and phases of the frequency error signal for two adjacent cavities in the ATLAS upgrade cryomodule. The peak near 30 Hz appear to be phase and amplitude correlated, however, the remainder of both spectra are mostly uncorrelated. This indicates that, in this case, the microphonics are not driven by 'global' pressure fluctuations in the ATLAS refrigeration system, but by local changes specific to the individual cavities.

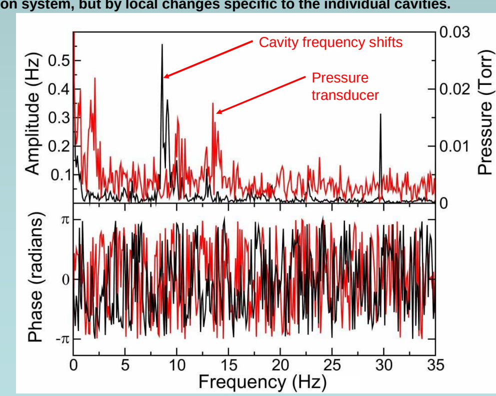

Figure 7. An attempt was made to correlate pressure fluctuations in the cryomodule liquid helium bath to eigenfrequency excursions of the cavities. Above are the Fourier amplitudes and phases for a cavity compared with data collected at the same time using a pressure transducer mounted on cryomodule helium system near the large manifold (see Fig. 2). Unlike earlier observations in the single cavity test cryostat, no clear correlations between cavity microphonics and the helium pressure in the main storage manifold were observed.