**Pneumatic Tuner Control**

The HWRs use pneumatic tuners in comparison to the stepper tuner used by the quarter wave resonators (QWRs). The control design for the pneumatic tuner has evolved a lot in the past few years based on new findings. Current implementation contains two nonlinear sections to map the tuner error to the valve control voltage. One is to deal with the valve deadzone, the other deals with phase curve nonlinearity.

**Automatic Multi-pacting Conditioning**

The HWRs have multi-pacting (MP) barriers at different field levels. The high barrier occurs at around 3 MV/m. Once the high barrier is excited and conditioned, the middle barrier at around 0.1 MV/m is usually observed. A low barrier less than 0.01 MV/m happens in some cases. But the low barrier can be jumped over relatively easy and usually does not need to be conditioned. The MP conditioning is time consuming and labor intensive, which motivate us to automate the process. It was tested during LS3 SRF commissioning:
- Check for X-ray level while increasing power
- Condition both high barrier and middle barrier
- Rescan to confirm
- Take 20 ~ 50 minutes depending on cavities

**Bias Tee and Spark Detector for HWR**

The FRIB fundamental power coupler (FPC) for the HWRs was designed to minimize the effect of multi-pacting. But the MP can still occur in certain situations. To reliably suppress the MP in the FPC, a bias tee with high DC bias voltage (~3 kV) was designed in collaboration with an industrial partner.

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**Phase Jump Issue on All LS2 β=0.29 HWRs**

During the ARRO5 beam commissioning in October 2020, it was noticed that some of the β=0.29 HWRs tripped fast protection system (FPS) at the same time due to phase error exceeding +/- 1 degree. Later it was confirmed that all β=0.29 HWRs (LS2 CC) had phase jumps at the same time, while other parts (β=0.53 HWRs and QWRs) of the Linac were not affected.

After almost two months of extensive data collection, cross checking and debugging. The issue was finally resolved in December 2020. The culprit turns out to be a bad connection at the six-way splitter for the reference clock distribution.