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Introduction

The 35 1.3 GHz cryomodules for the Linac Coherent Light Source II (LCLS-II) at SLAC National Accelerator Laboratory are assembled and tested at Fermi National Accelerator Laboratory and Thomas Jefferson National Accelerator Facility.

Following the transport to SLAC, the cryomodules undergo several incoming inspection steps before ultimately being moved to the tunnel for installation in the linac. The RF part of the incoming inspection covers measurements of a number of parameters like cavity frequency spectrum, notch filter frequency of the higher order mode couplers and external quality factor Q_{ext} of the input coupler. The inspection results are compared to measurements at the partner labs prior to shipping and the nominal values in order to verify that the cryomodules have not been damaged during the transport and are ready for installation.

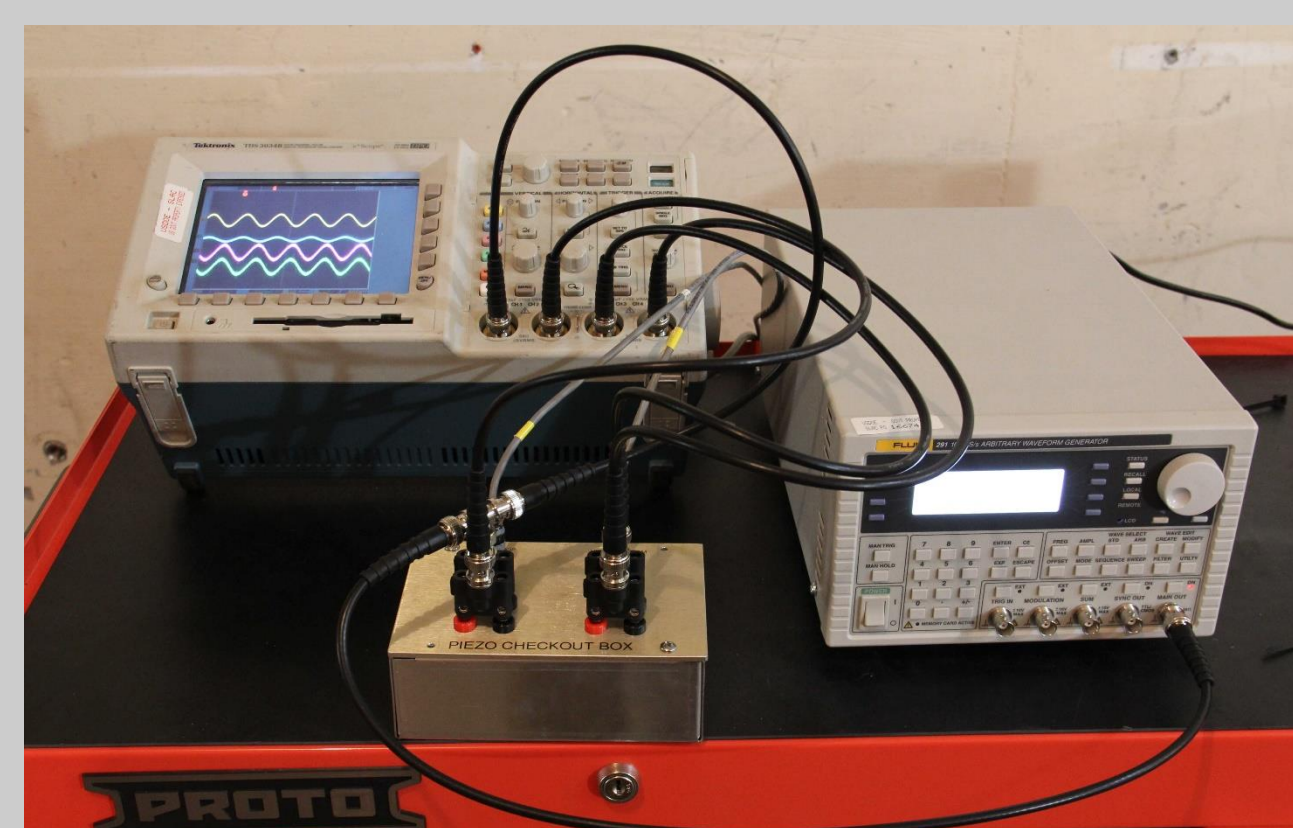
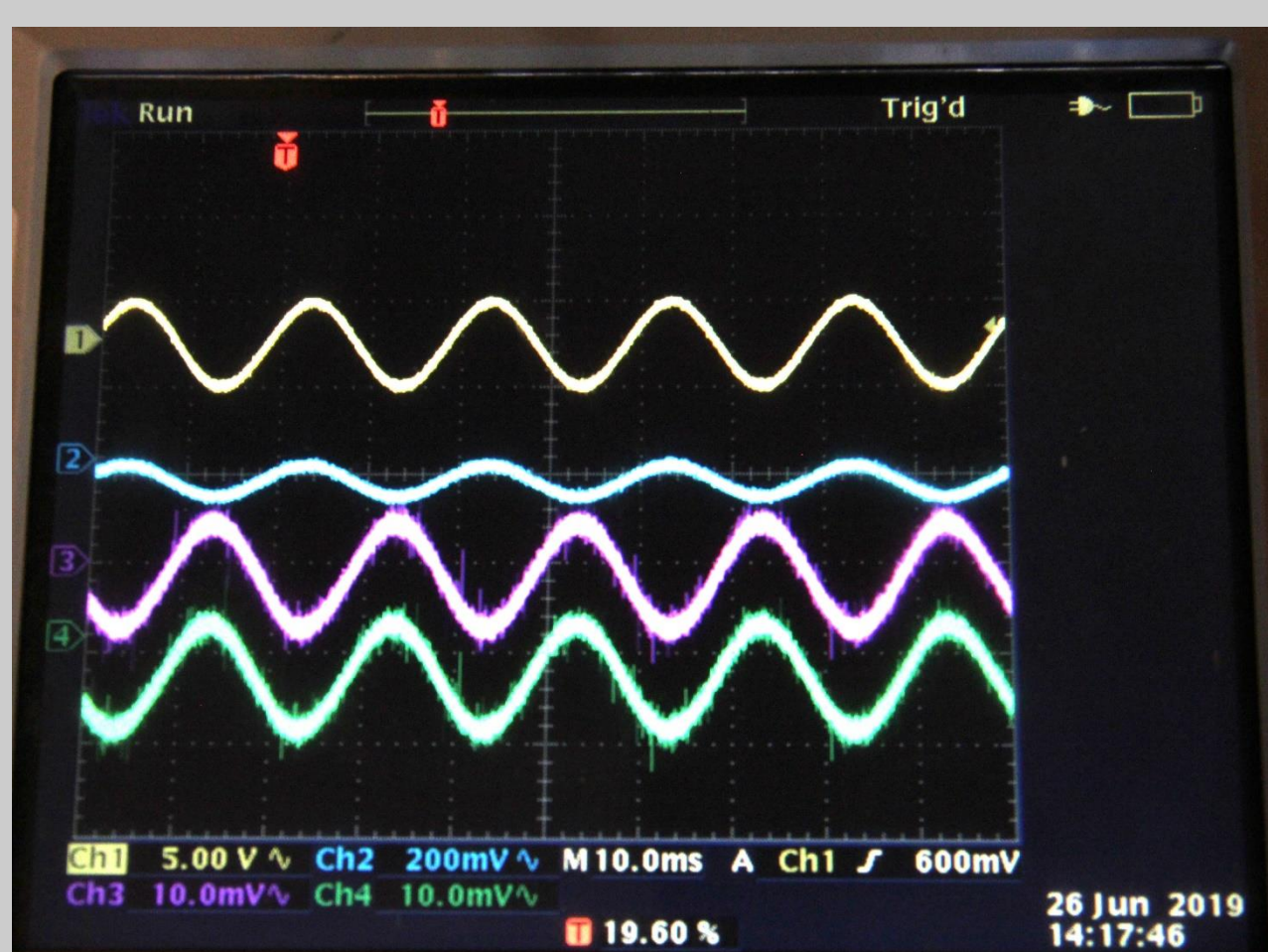
Cryomodule receiving

- RF incoming inspection completed for 14 cryomodules
- Inspection in S10 adit on alignment stands or in “meatlocker”
- Typically done after metrology/alignment checks
- For some CMs with coupler transport fixture “M-mounts” before/after removal



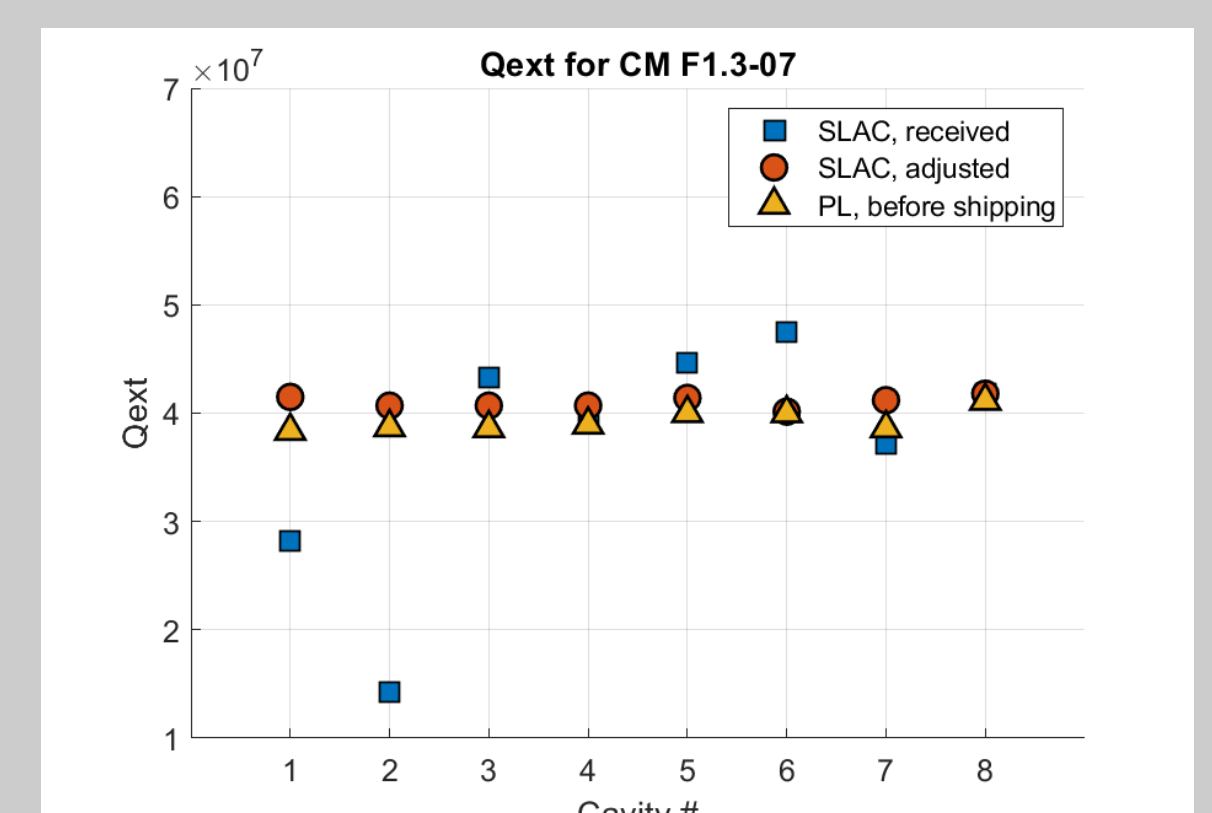
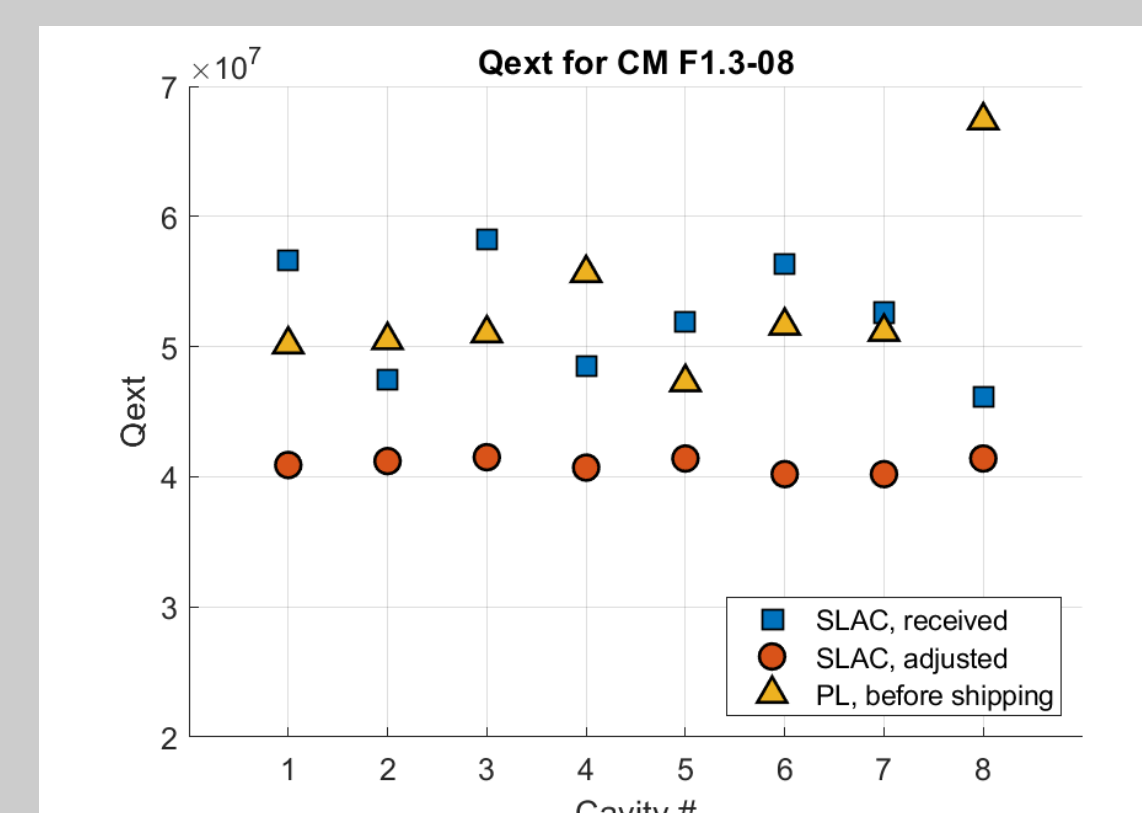
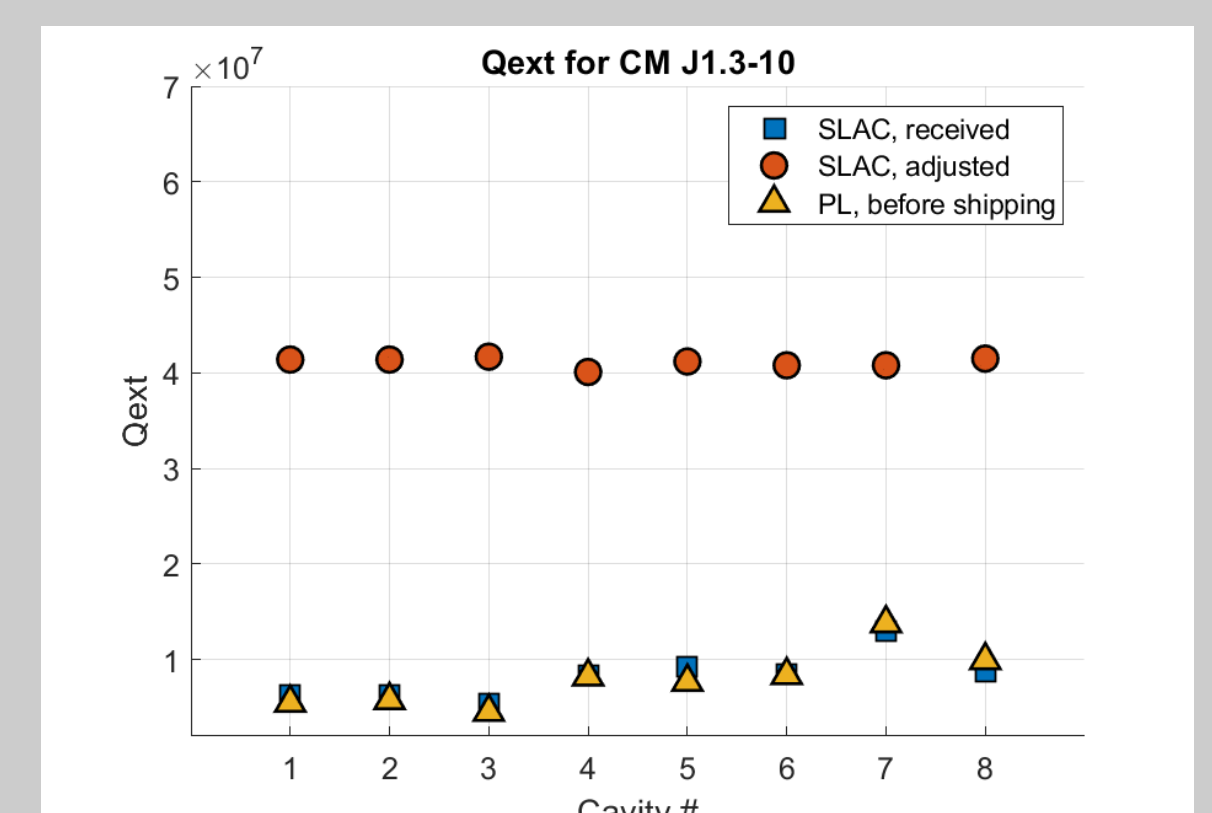
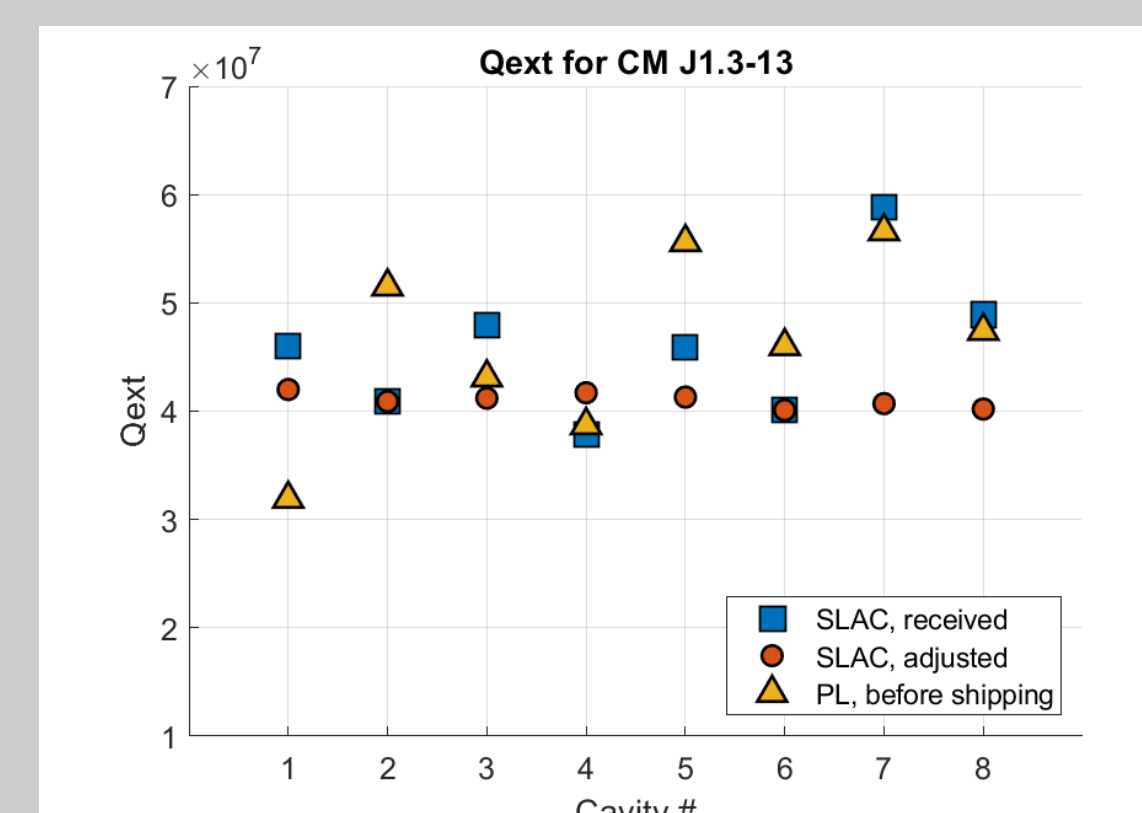
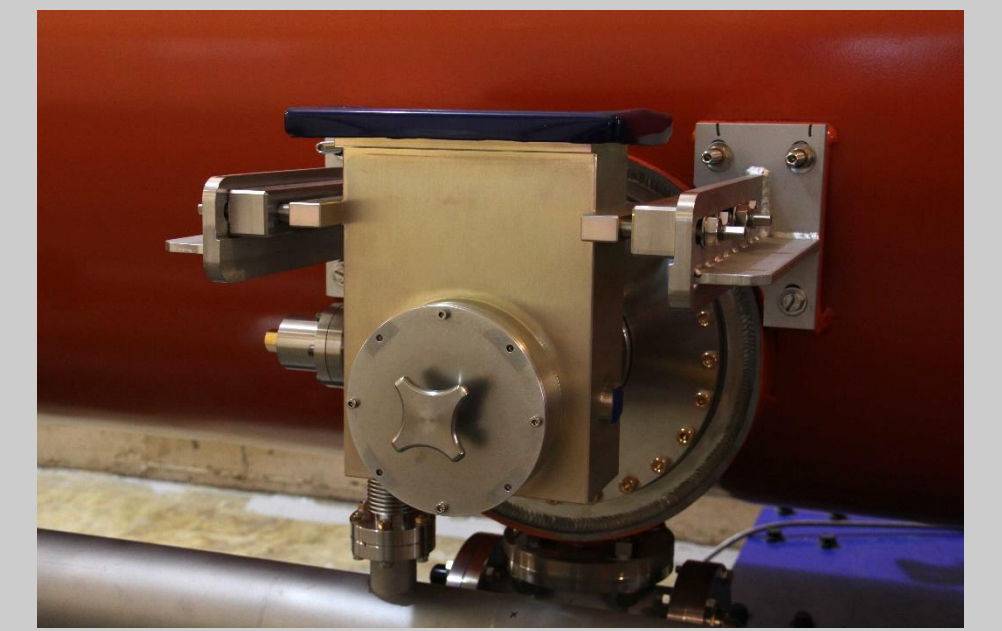
Tuner and Piezos

- Verify that slow tuner (stepper motor) and fast tuner (piezos) work
- Move stepper motor set amount of steps and observe frequency change of cavity
- Check that piezo is working and engaged
- First setup used LCLS-II production style resonance control chassis
- Complex infrastructure needed (control through EPICS, connection to cabled network)
- Switched to system developed at Fermilab (breakout boxes, LabVIEW control of stepper motor)
- Several cavities in early CMs needed significant number of steps for frequency change/piezo engagement
- Adding check for piezo engagement at JLab significantly sped up inspection process at SLAC
- Used tuner access ports in few cases to verify that stepper motor is actually moving and piezos loose but getting tighter



Power coupler Q_{ext}

- Q_{ext} of fundamental power coupler is adjustable
- Adjust to (cold) design value of $Q_{\text{ext}} = 4.1 \times 10^7$
- Spot checks after move into final tunnel position
- no significant change of Q_{ext}

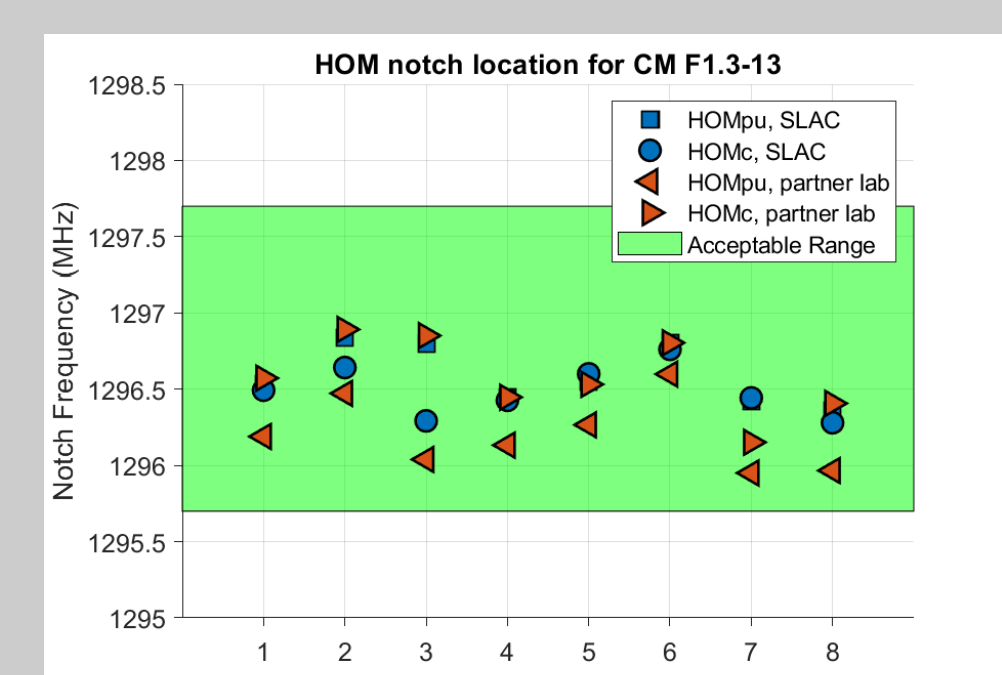
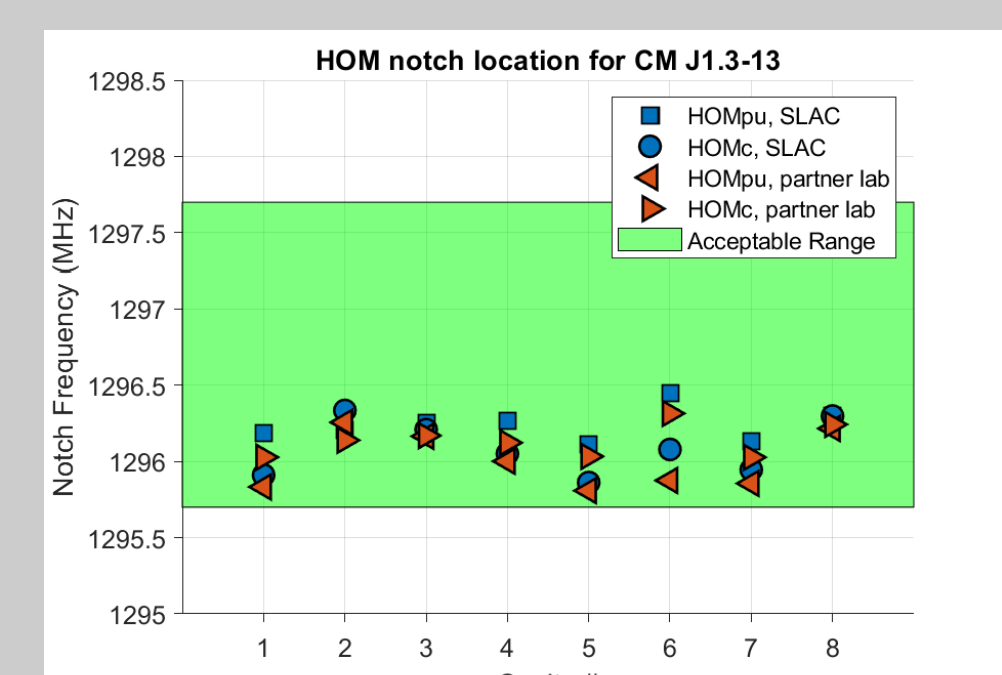
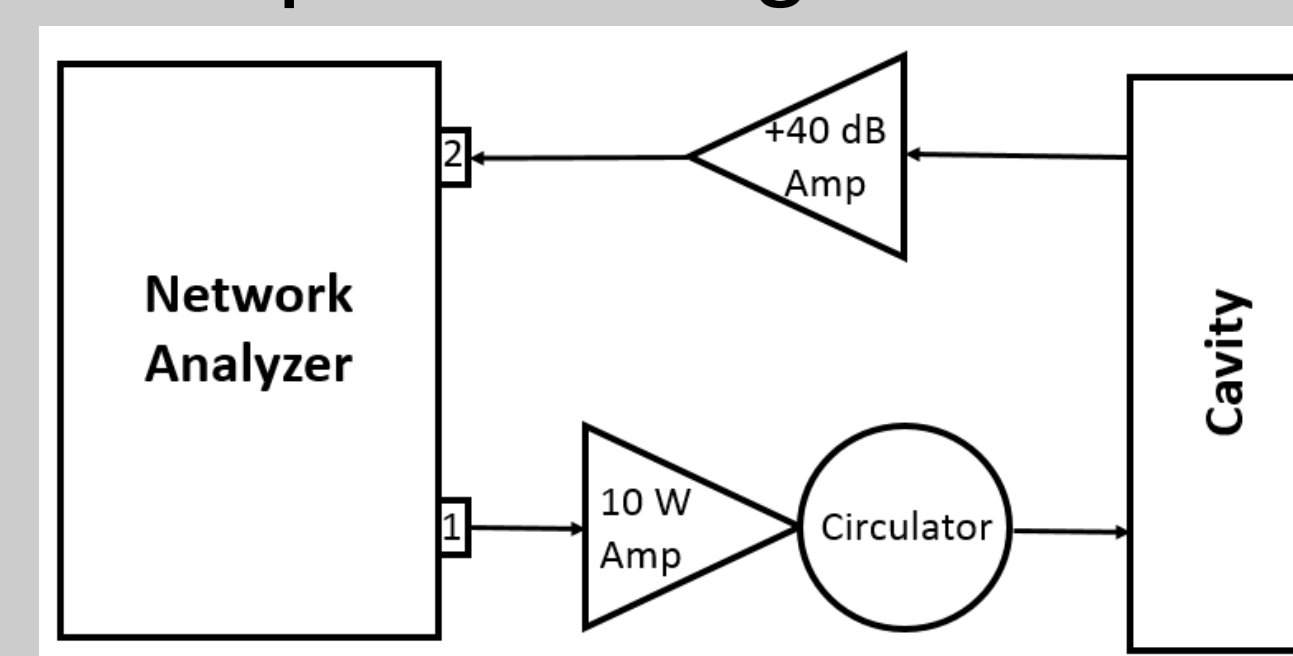


Beam Position Monitor

- 4 BPM electrodes (top, bottom, left, right)
- Measure S11, S12, S21 and S22 between all possible pairwise combinations over the range of 200MHz to 2.8 GHz

HOM Notch Frequency

- Extract location of HOM notch frequency from measuring S21 over 9 modes of fundamental passband between FPC and pickup, FPC and $\text{HOM}_{\text{pickup}}$ and $\text{HOM}_{\text{coupler}}$ to pickup
- No significant detuning out of acceptable range observed



Cavity spectrum

- “R-parameter” characterizes changes in the cavity spectrum
- $R_{\text{cavity}} = \text{RMS}(R_i)_{i=1 \dots 9}$
- $R_i = \frac{f(\frac{i}{9}\pi \text{ mode})_{\text{SLAC}} - f(\pi \text{ mode})_{\text{SLAC}}}{f(\frac{i}{9}\pi \text{ mode})_{\text{PL}} - f(\pi \text{ mode})_{\text{PL}}}$
- $R < 10$ kHz is generally deemed acceptable
- Very few cavities exceed spec and were accepted as is after expert review

