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Cornell Laboratory for
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HOM Measurements with Beam at the Cornell Injector Cryomodule

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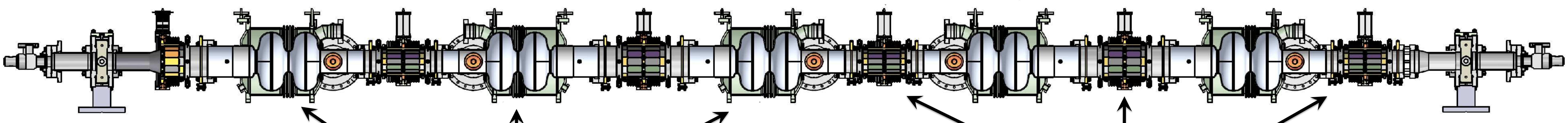
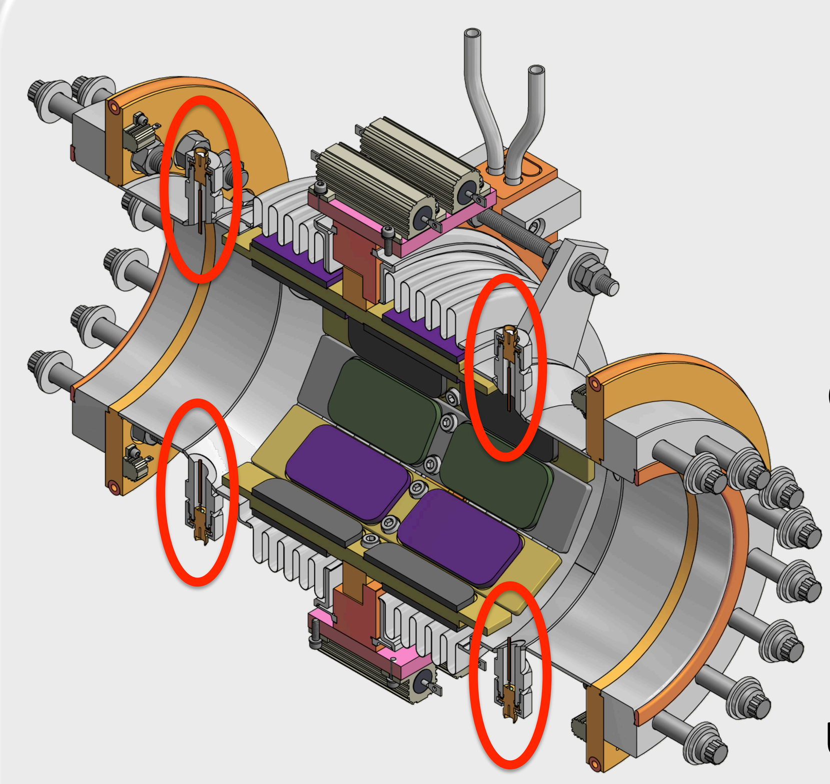


Introduction

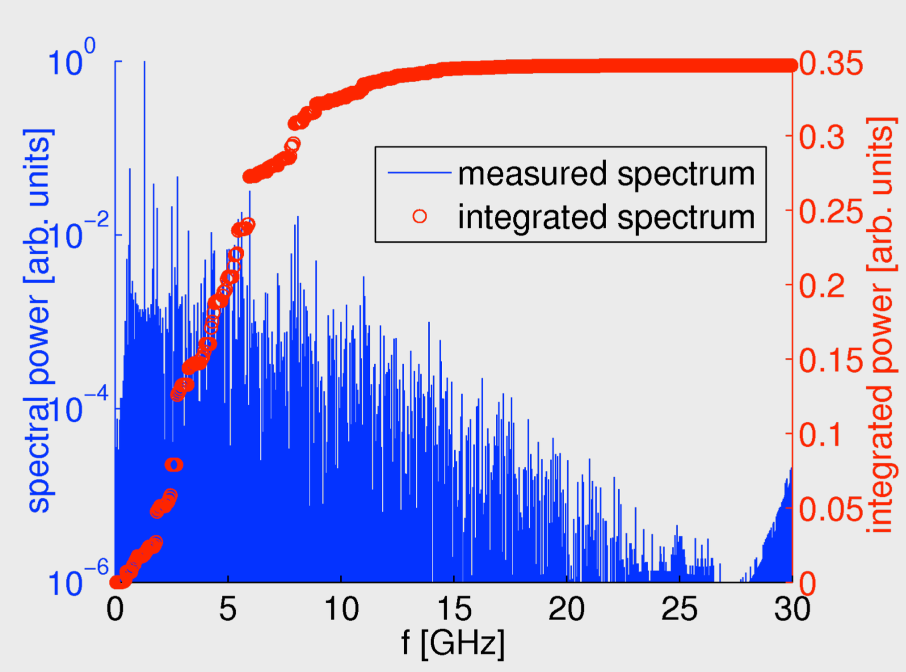
The Cornell ERL injector prototype is undergoing commissioning and testing for running unprecedented currents in an electron cw injector. The main acceleration stage is the injector cryomodule, which contains five two-cell 1.3 GHz superconducting cavities operating at 5-15 MV/m. The short bunch length (<1 mm) and high current (up to 100 mA) generate significant power in undesirable higher order modes (HOMs) up to tens of GHz, which is intercepted in HOM beam line absorbers located between the SRF cavities.

Measurement



The HOM loads absorb power in RF-lossy absorber tiles. HOM spectra were obtained by connecting a spectrum analyzer to one of 8 RF pickups and measuring incident power over frequencies from 0-50 GHz. A typical scan requires several minutes of uniform beam and has a resolution of approximately 50 kHz.

Shown here is a typical HOM spectrum, plotted with the integrated spectrum. There are no very strong lines present which would indicate resonant excitation of an HOM with higher Q. This shows excellent damping of all monopole HOMs in the beam line up to 30 GHz with typical Q's in the few 1000 range.

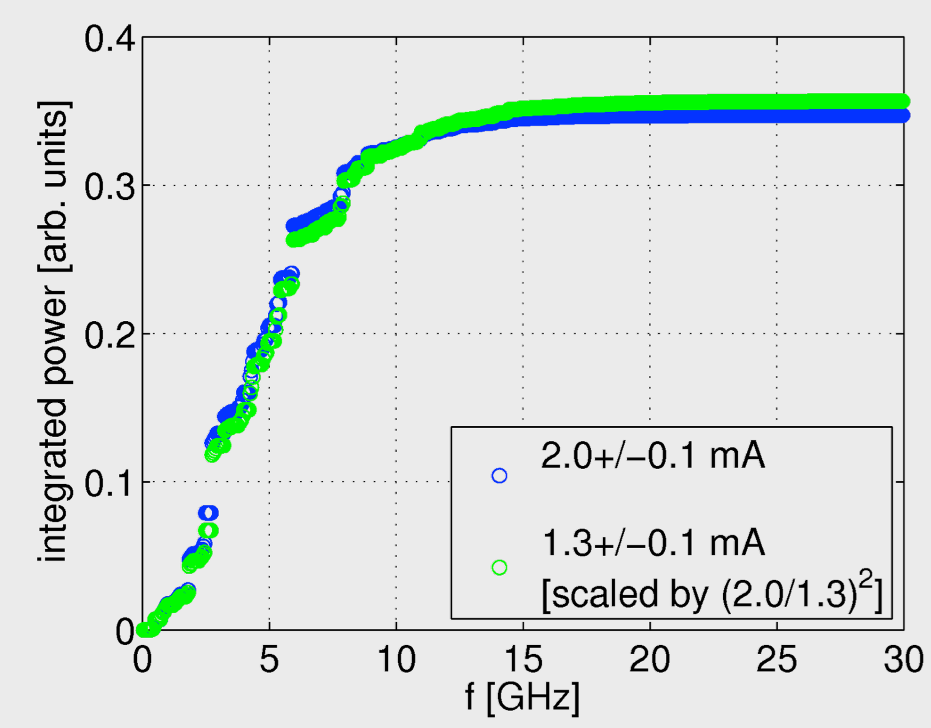


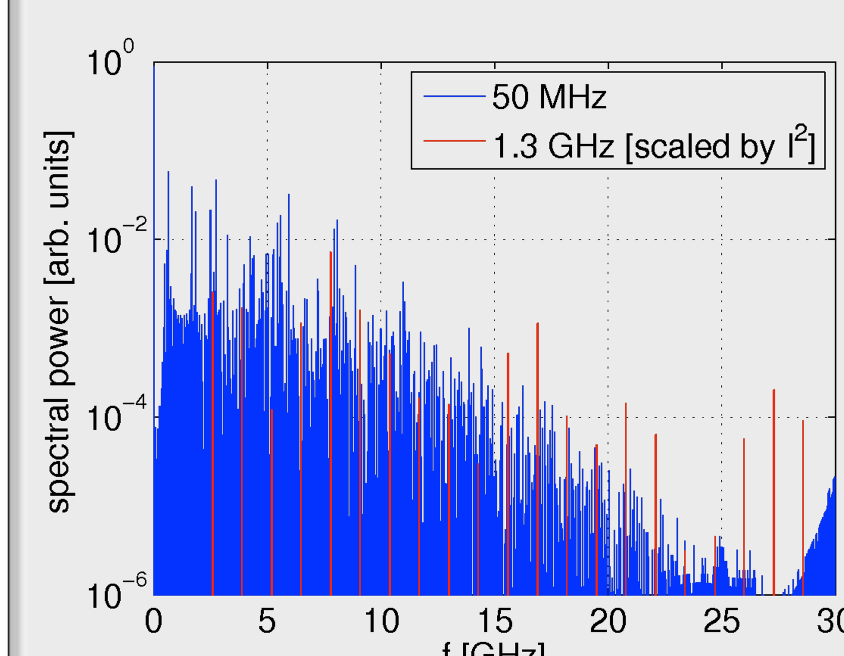
Varying Beam Parameters

The single bunch loss spectrum is given by

$$\frac{dP}{d\omega} = \frac{dk_{\parallel}}{d\omega} qI = \frac{dk_{\parallel}}{d\omega} \frac{I^2}{f_{rep}}$$

When only the current I is changed, the integrated HOM spectra should vary with I^2. This was confirmed experimentally.





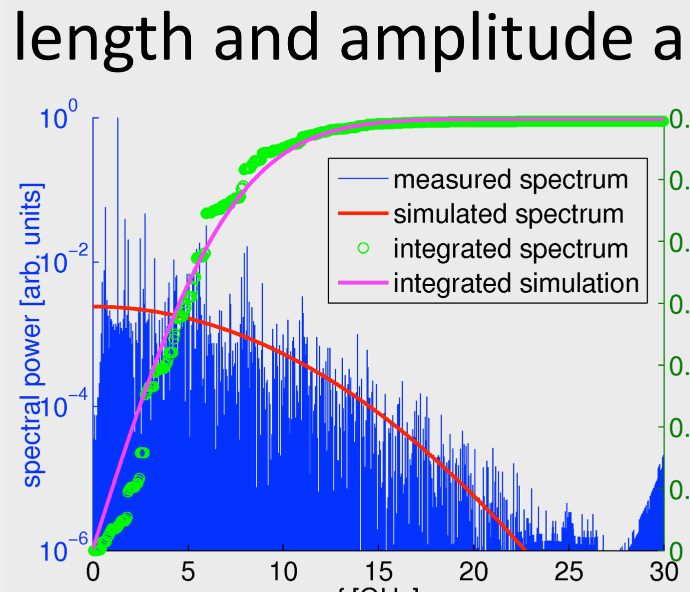
When the bunch repetition rate f_{rep} is also changed, the HOM spectra should vary with I^2/f_{rep}. At high frequencies, the f_{rep}=1.3 GHz spectrum has strong spectral lines out much further. This suggests that the bunch length decreased in the weeks between the 50 MHz measurement and the 1.3 GHz measurement.

HOM Heating

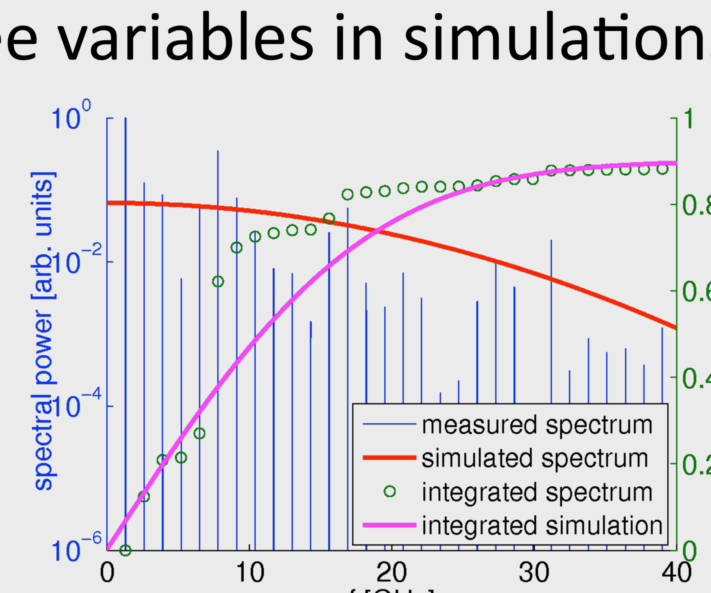
At I=20 mA, thermometers on the HOM loads measured a temperature increase of ~0.15 K. Using heaters on the loads as calibrated power signals, the absorbed HOM power was calculated to be 0.5 W per load. This gave an estimate of $k_{||}$=19 V/pC, which from simulation corresponds to a bunch length of order 1 mm, as expected.

Comparison to Simulation

The measured HOM spectra are compared to ABCI simulations of $dk_{||}/d\omega$ (should be proportional). Bunch length and amplitude are free variables in simulations.



f_{rep}=50 MHz



f_{rep}=1.3 GHz

Conclusions

- HOM spectra show expected behavior with varying current and repetition rate
- There are no weakly damped resonant modes excited by the beam
- HOM spectra provide non-destructive measure of bunch length at high currents
- ΔT of HOM loads small at 20 mA. Loads should easily handle operation at 100 mA.

LEPP, the Cornell University Laboratory for Elementary-Particle Physics, and CHESS resources have merged and a new lab, (CLASSE), has formed. CLASSE develops and operates facilities and provides infrastructure for the study of beams and accelerators, photon science, particle physics and the early universe, serving students, the public and scientists from Cornell and elsewhere. LEPP's primary source of support is the National Science Foundation.