Cornell University
Laboratory for Elementary-Particle Physics

Bug Found and Fixed in BMAD Calculations of Orbit Distortions Induced by Cavity Offsets

--

Example of HOM Kicks Distorting Orbit in the CERL 8.2 Lattice and Effectiveness of Orbit Correction

J.A. Crittenden, Georg Hoffstaetter, Chris Mayes and David Sagan

Cornell Laboratory for Accelerator-Based Sciences and Education

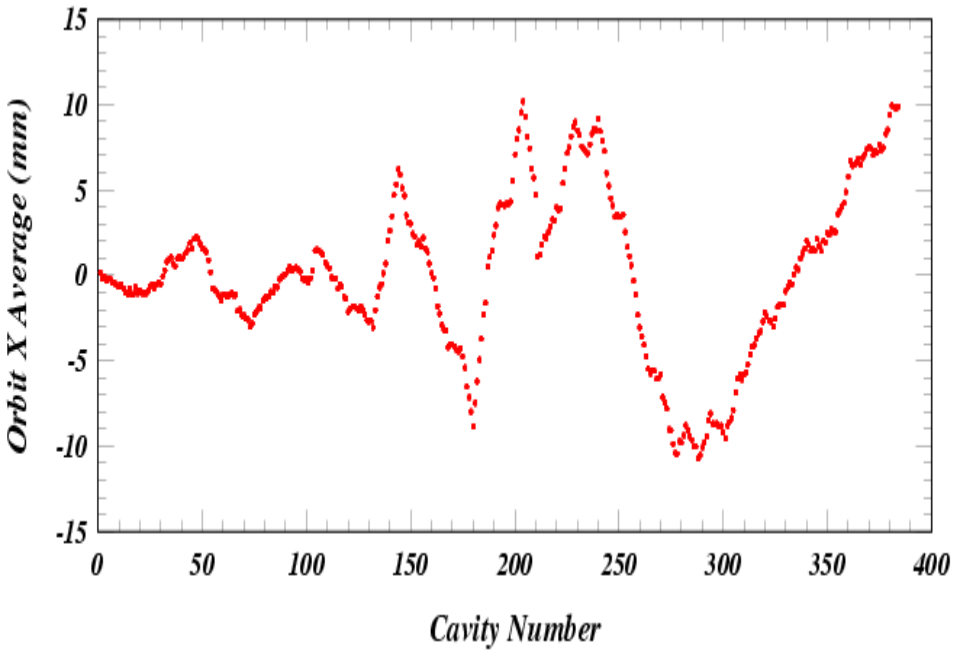
ERL@CESR Meeting

18 November 2010

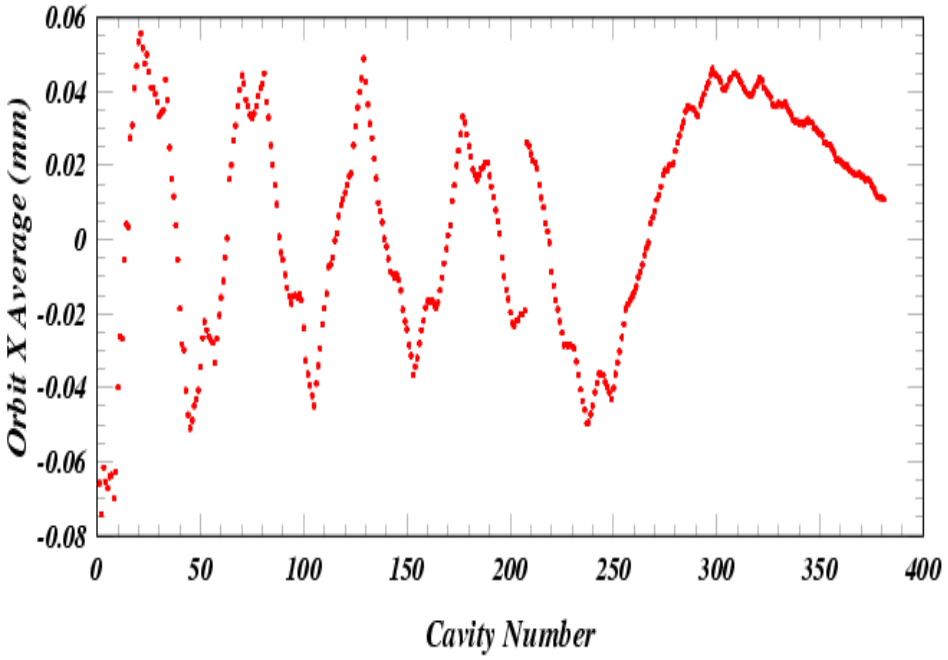
Effect of bug on full CERL8.2 equilibrium orbit calculation with 5 HOMS in all cavities and 0.3 mm rms offsets

Calculated orbit distortion before fix

(see talk of 23 September 2010)



After fix



This bug affected ONLY cases of HOM elements in RF cavities with position offsets.

CERL 8.2 calculation with 0.3 mm randomized cavity offsets

5 HOMs (MUL 2009) in each of 384 cavities

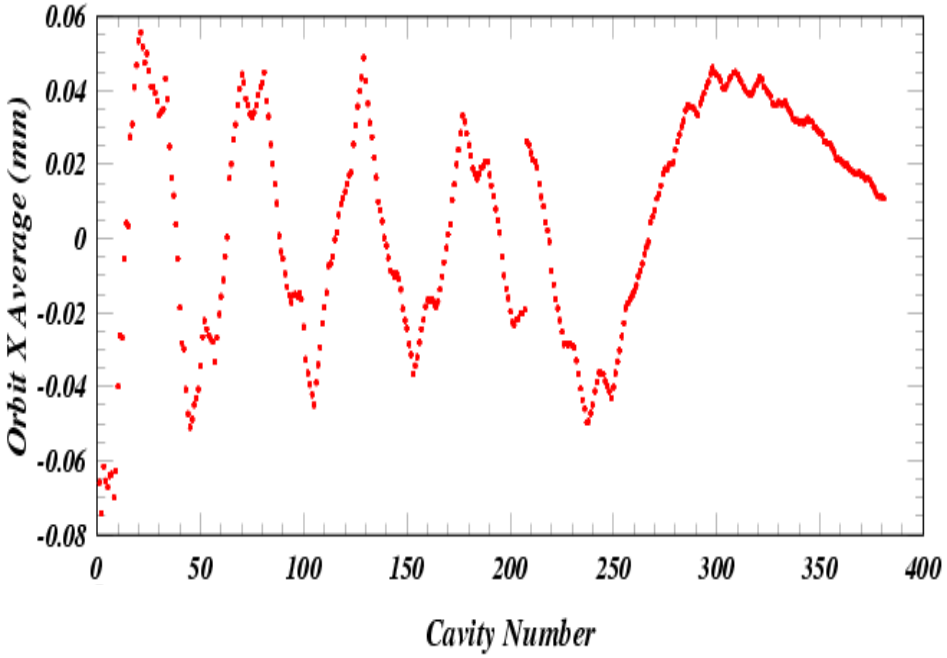
	Frequency [Hz]	R/Q [Ohm/m^(2n)]	Q	n	Polarization_Angle [Radians/2pi]
&long_range_modes					
lr(1) =	2.512896E+009	21180	8867	1	0.00
lr(2) =	2.513556E+009	76777	1472	1	0.00
lr(3) =	2.514671E+009	81083	8557	1	0.00
lr(4) =	3.068192E+009	632	186198	1	0.00
lr(5) =	3.073245E+009	3971	64567	1	0.00

The frequency spread is 0.4%, i.e. 10-12 Mhz.

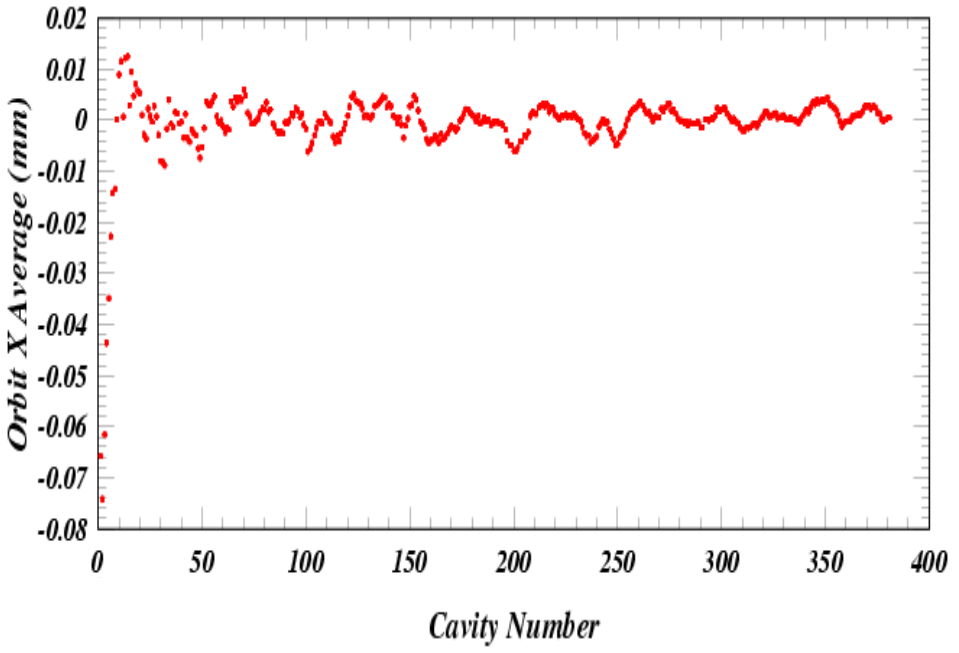
The randomization of the HOM frequencies is limited to +- $3\sigma_f$

Orbit correction in CERL 8.2 with 5 HOMS in all cavities and 0.3 mm rms offsets

Before orbit correction



After orbit correction

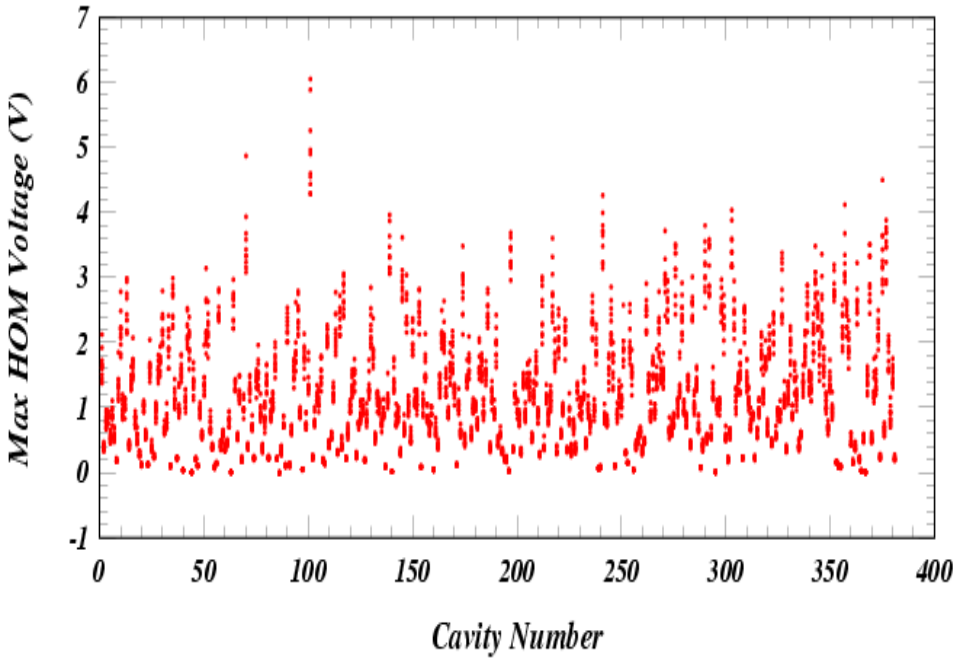


Correction only possible downstream of kickers.

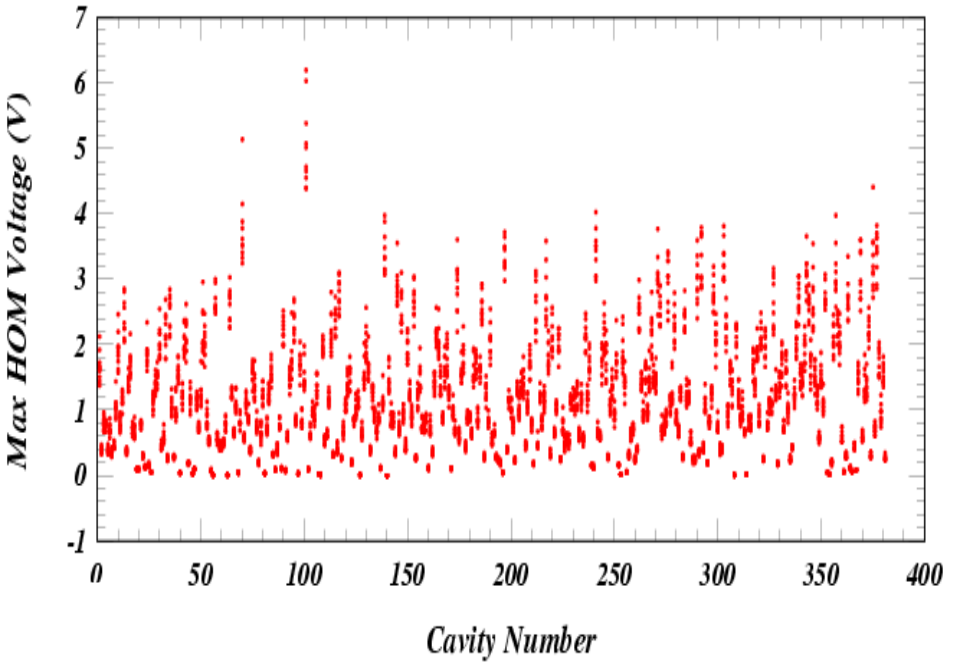
NB: Orbit distortion is much smaller than the cavity offsets.

Equilibrium HOM kicks with and without orbit correction

Before orbit correction



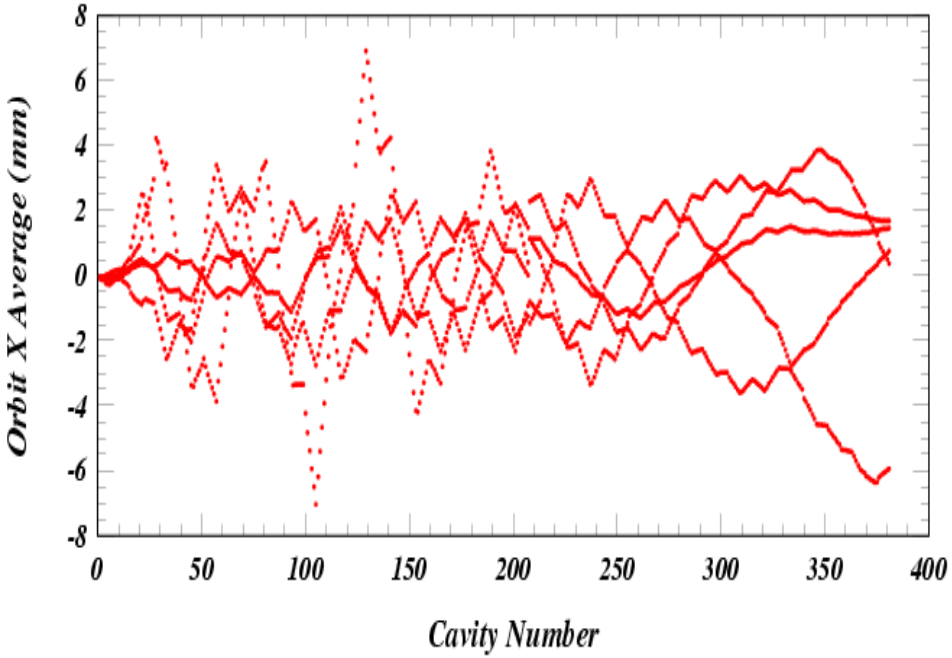
After orbit correction



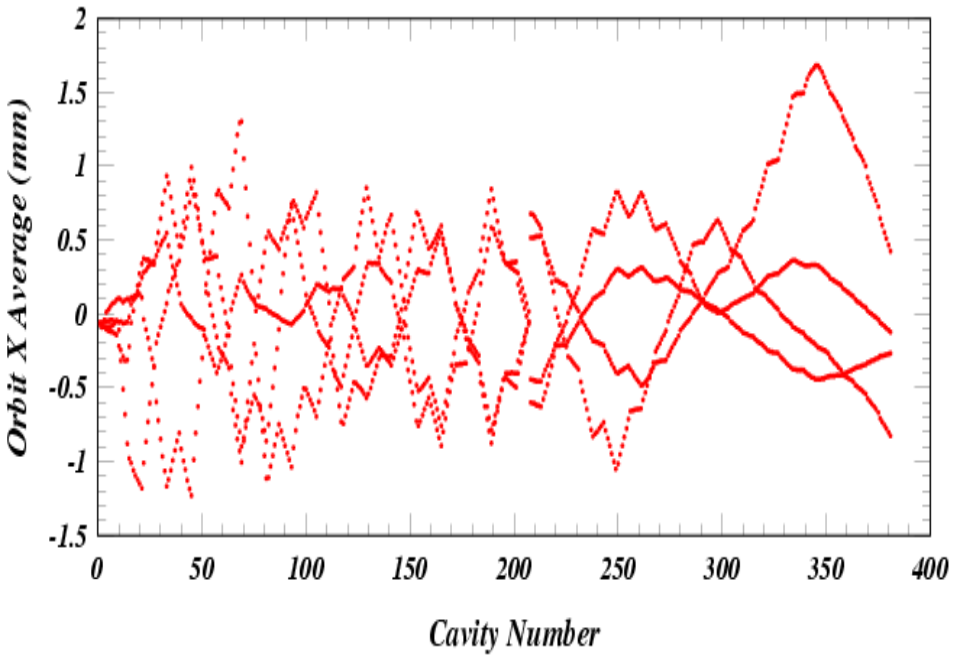
The effect of the orbit correction is negligible, because the cavity offsets are much larger.
Let's apply unrealistically large HOM kicks to see their effect and the effect of the orbit correction.

Resonant HOM: 2.6 GHz with R/Q raised factor 200 to 4e6 ohm/m^2 with and without orbit correction

Before orbit correction



After orbit correction

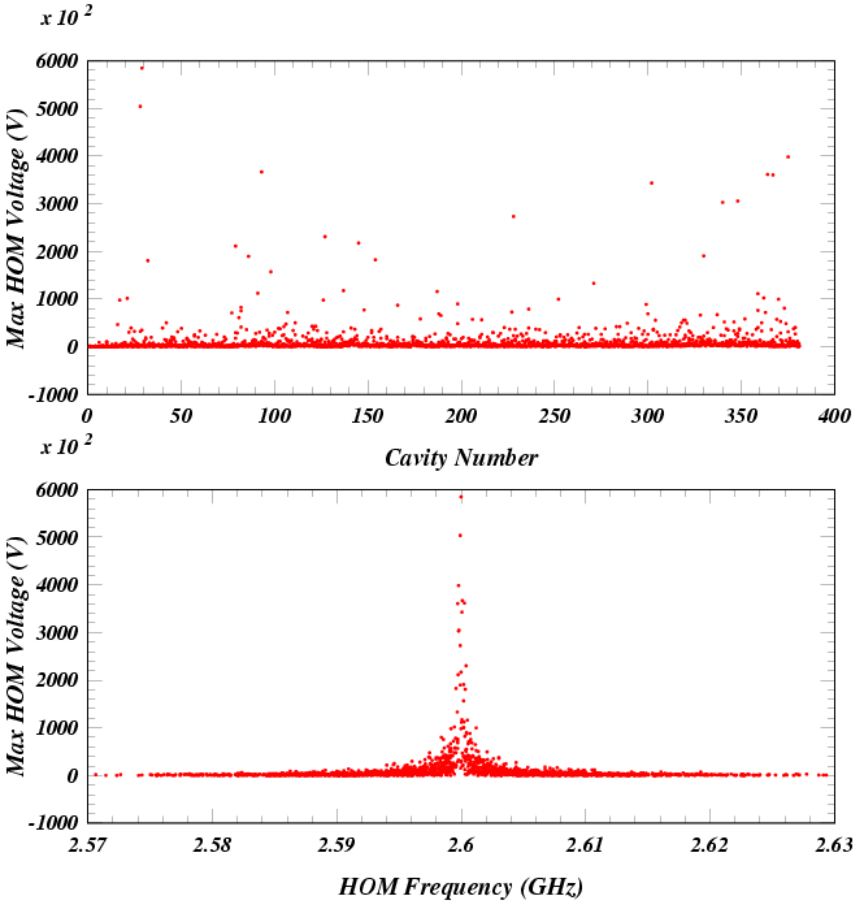


The orbit correction works well, despite the randomized HOM frequencies.

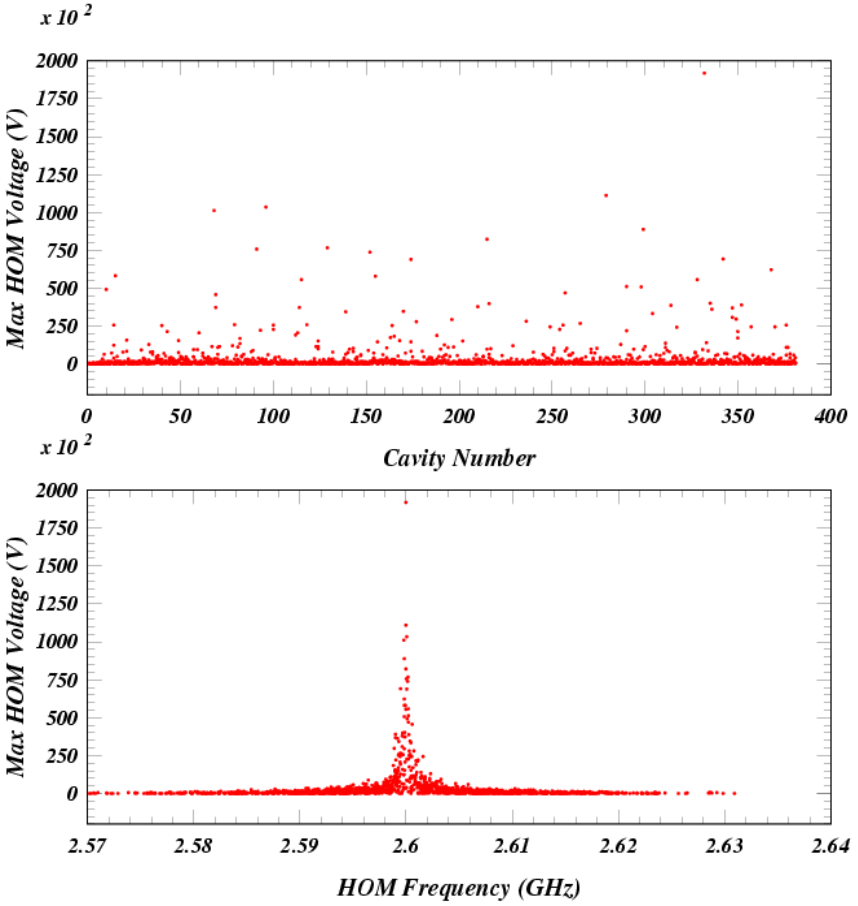
NB: The offsets are random, but the same in each cavity for the ten cases plotted here.

Resonant HOM: 2.6 GHz with R/Q raised factor 200 to 4e6 ohm/m^2 with and without orbit correction

Before orbit correction



After orbit correction



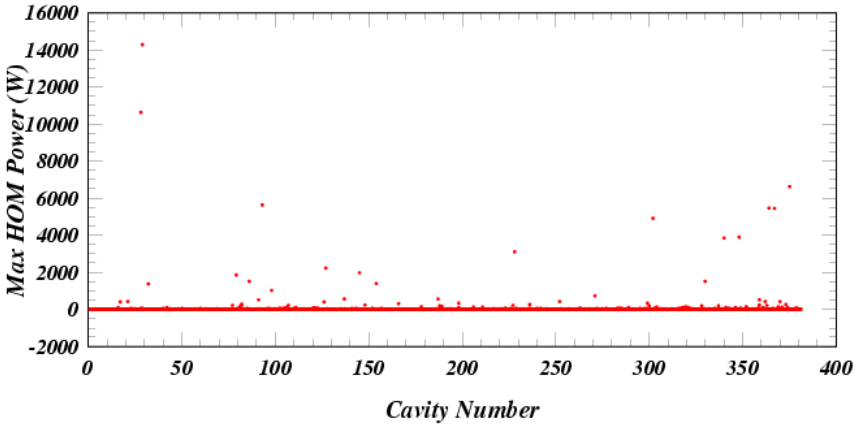
The HOM kicks are now as high as 600 kV.

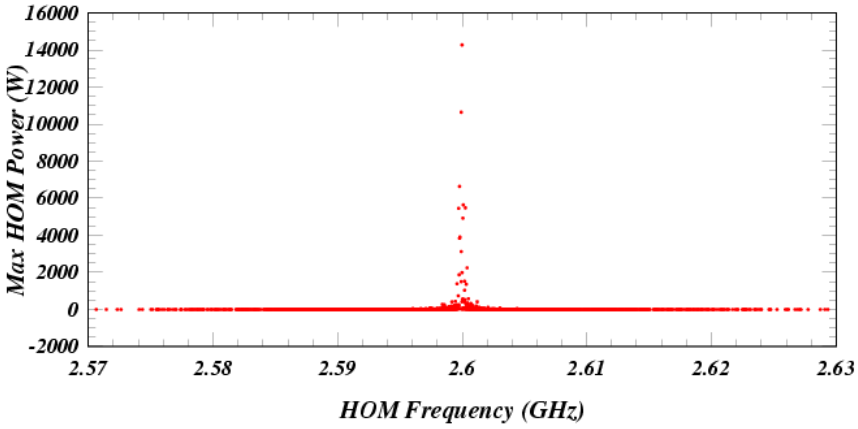
The orbit correction now works well, since the orbit distortions are larger than the offsets.

Analysis now includes calculation of HOM power

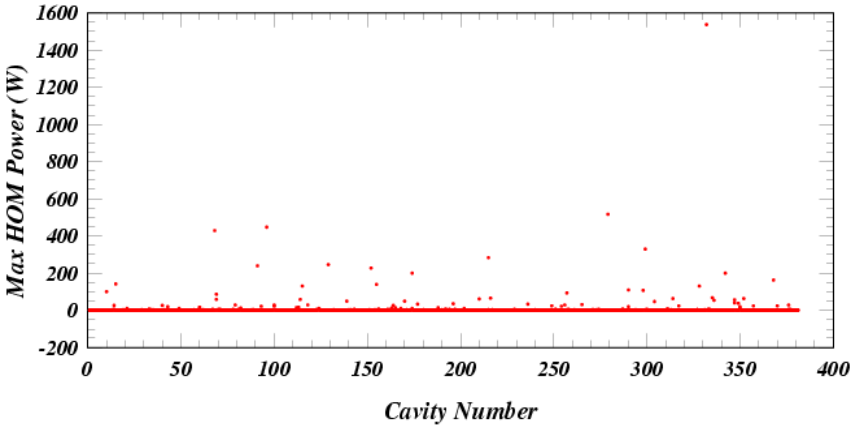
$$dU/dt = V_T^2 \, \omega_\lambda^2 / (Q \, (R/Q) \, c^2)$$

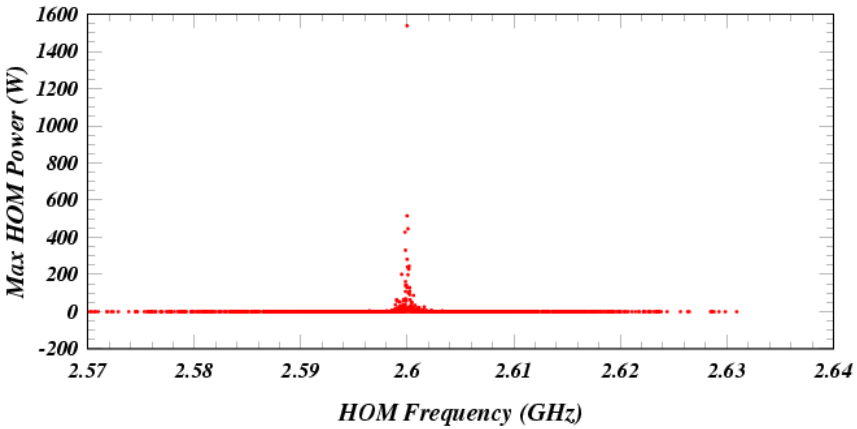
Before orbit correction





After orbit correction





HOM kicks of 600 kV correspond to power values of 16 kW in this exaggerated example.
The orbit correction reduces the power by an order of magnitude.
The nominal value for (R/Q) of 2e4 Ω/m² reduces the stored HOM power to 8 W,
which is within the specification of 20 W, even in this resonant case $\omega_\lambda = 2\omega_0$.