Freq [GHz]	Q_0	R/Q [Ω]	±Voltage [kV]
2.07224	18786	2.34	0.22
2.08329	15573	0.51	0.04
2.09903	21937	9.72	4.04
3.02310	18102	114.0	1.43
3.27113	7432	39.1	0.12
4.71641	26127	13.0	0.02
4.71714	22706	1.64	0.19
4.77059	29309	28.8	0.36
dp/p: ±2.92e-3		Sum	6.46

Sum with fine structure: 5.84
Without beating: 0.57

1.875” beam pipe
Longitudinal cut-off: 4.822GHz (TM01)

Reference:
Requirement: ±7e-4 peak to peak

1.925” beam pipe
Longitudinal cut-off: 4.697GHz (TM01)

Freq [GHz]	Q_0	R/Q [Ω]	±Voltage [kV]
2.07332	19955.7	1.82	0.18
2.09904	22092.7	9.58	3.97
3.02416	18264.7	112.39	1.43
3.28181	13718.6	43. 10	0.50
3.51672	7157.2	0.20	0.03
dp/p: ±2.57e-3		Total	6.14

Sum with fine structure: 5.14
Without beating: 0.55

To suppress the SOMs, we further reduce the end cell length to λ/2. (beam pipe 1.925”)

Freq [GHz]	Q_0	R/Q [Ω]	Voltage [kV]
3.2574	15882	10.5	0.12
3.2808	17602	73.8	1.1
3.3034	15265	34.6	0.36
dp/p: ±7.9e-4		Total	1.64

Sum with fine structure: 1.57

Without beating: 0.24

SOMs		
Freq [GHz]	Q_0	R/Q [Ω]
2.0719	14313	0.035
2.0976	19919	0.071

Shift the 3.2808 GHz mode 0.5 MHz away from the harmonic of the 9.14 MHz gives 0.57 kV total fluctuation, corresponding to ±2.9e-4 dp/p.

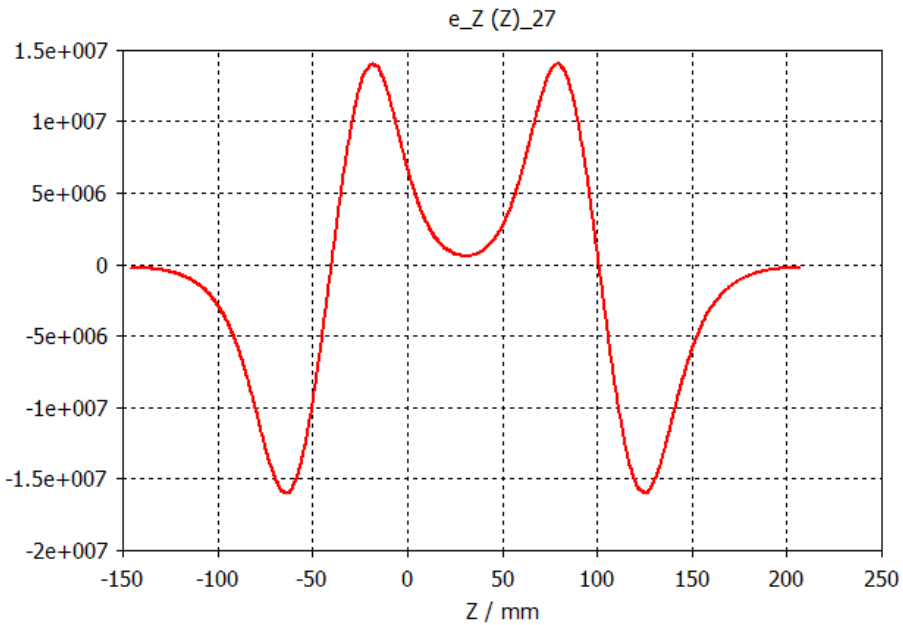
Model	with slot	1.875” λ/2+10	1.925” λ/2	1.925” λ/2+10
$k_{//}$ [V/pc]	2.74	2.5	1.82	1.85
$k_{//}$ 2.11G [V/pc]	1.62	1.04	1.16	1.04
$k_{//}$ SHOM [V/pc]	1.12	1.46	0.66	0.81

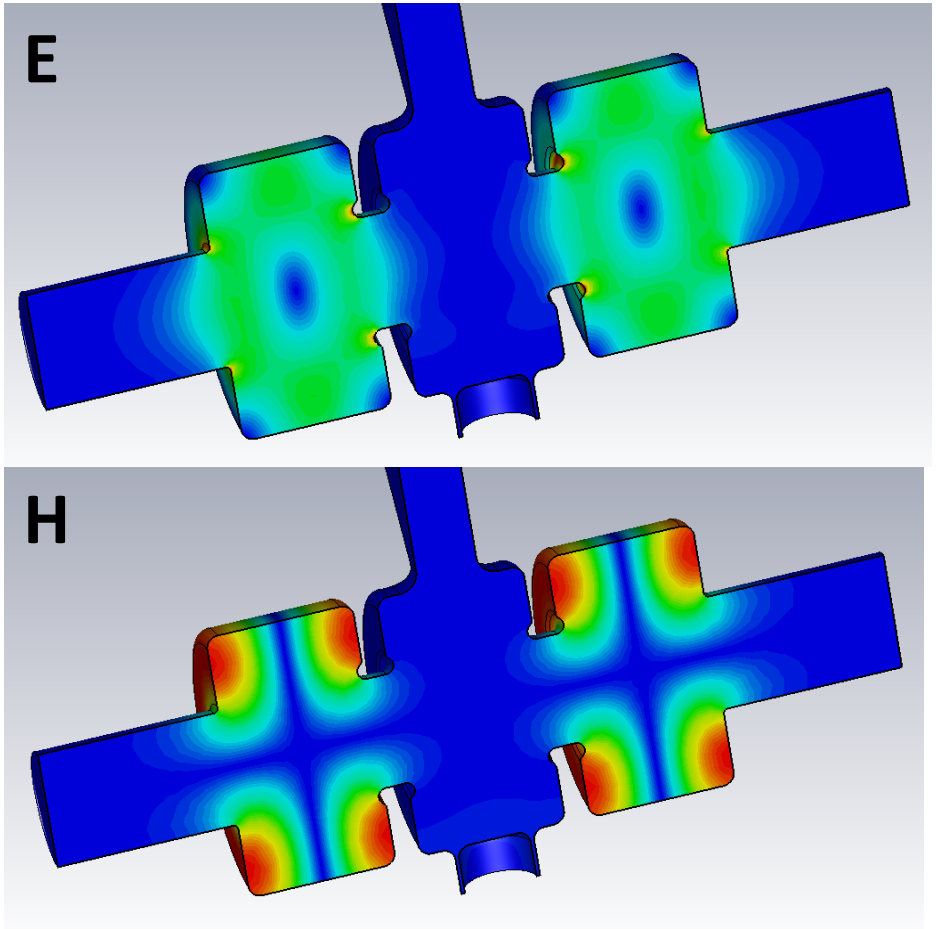
If we use 30 bunches instead of 31 bunches, the voltage from 3.2808 GHz mode changes to 0.47 kV, and the sum with fine structure changes to 0.55 kV, without beating it changes to 0.16kV.

If we use 30 bunches and 31 bunches alternatively in the train, the voltage fluctuation will be (1.57+0.55)/2=1.06kV.

If we shift the 3.2808 GHz mode 0.5 MHz away from the harmonic of the 9.14 MHz, the 30-bunch configuration gives 0.32 kV fluctuation, and the alternating configuration gives 0.45 kV fluctuation. They are both less than the 31-bunch configuration.

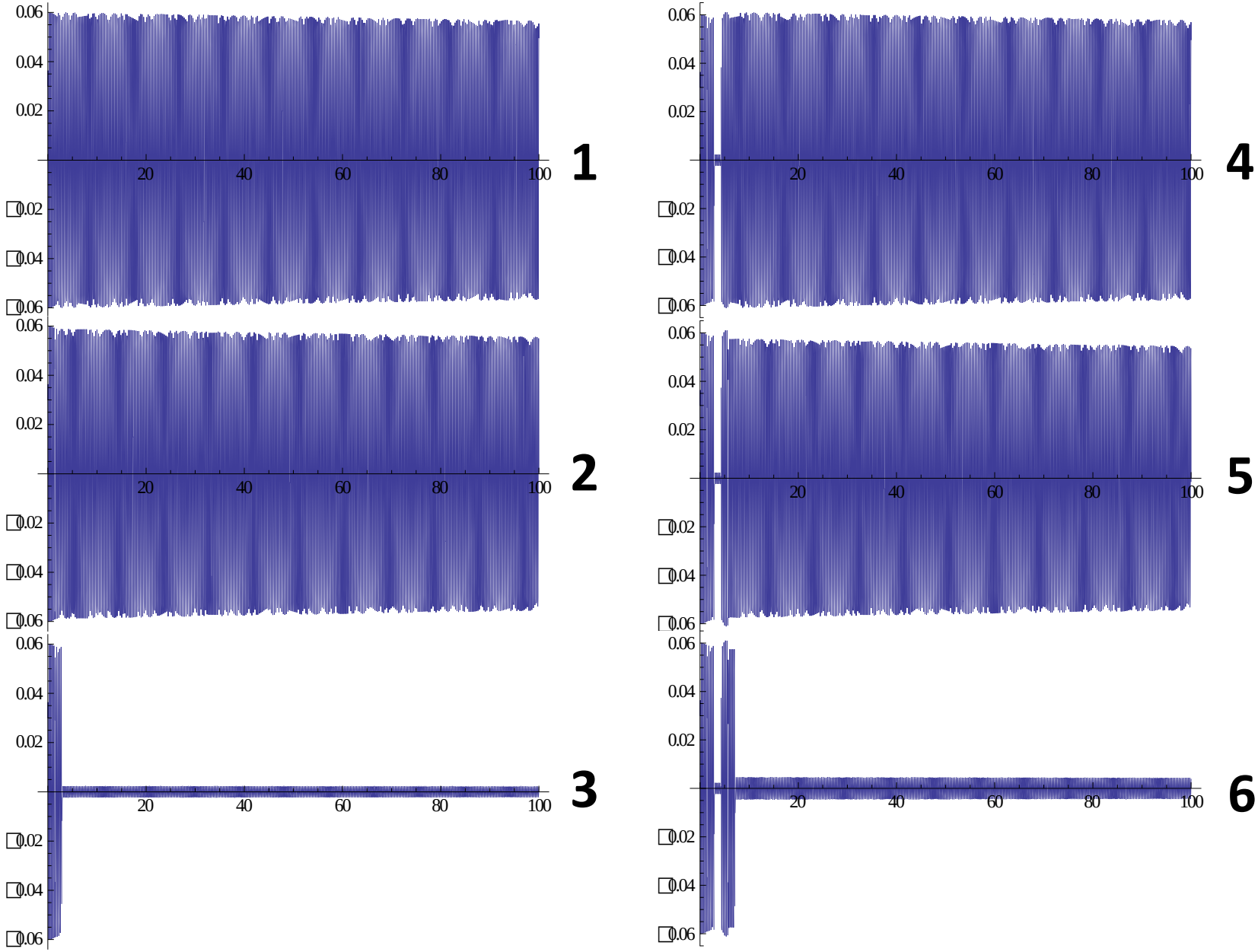
3.2808 GHz HOM



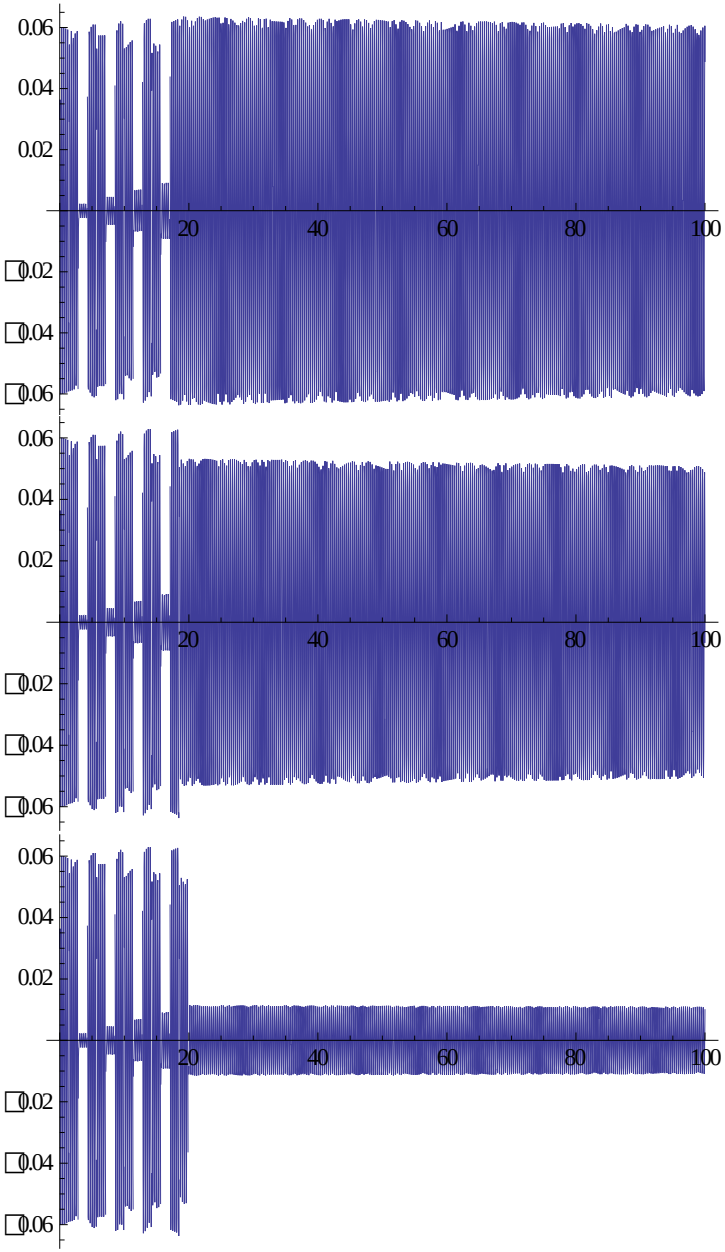


Why 30-bunch configuration and 31-bunch configuration are different?

Voltage with n bunches



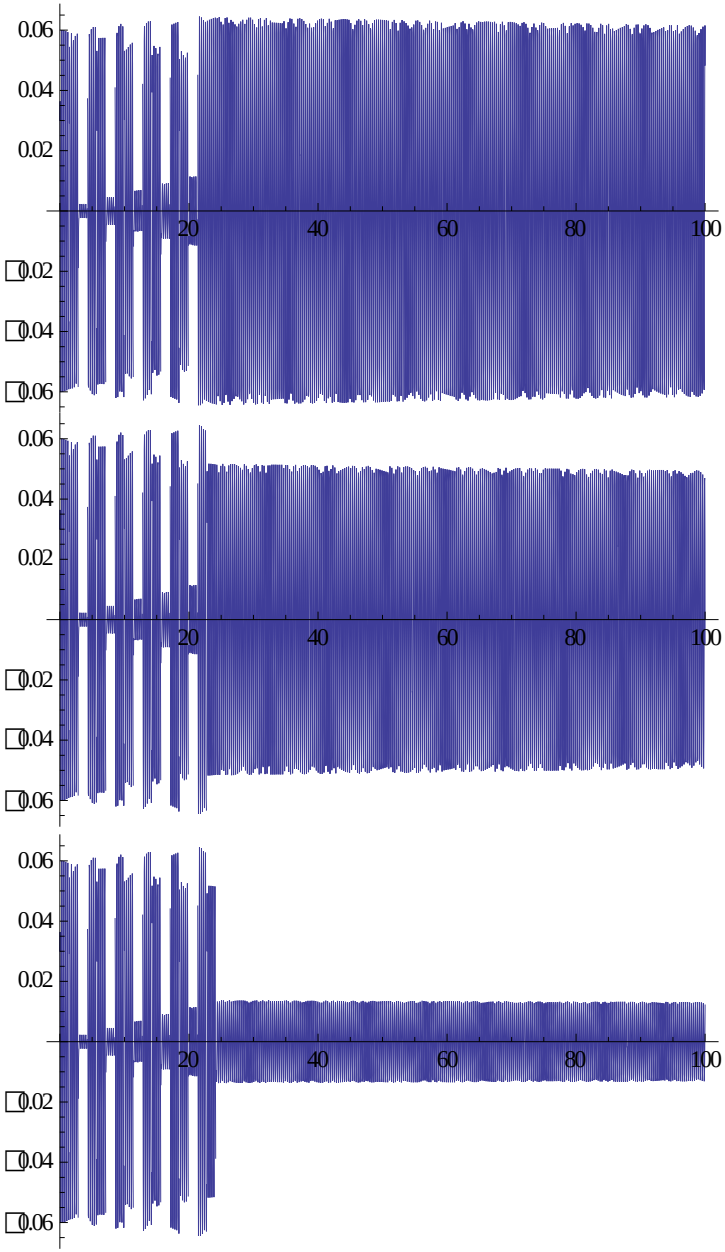
Voltage with n bunches



13

14

15

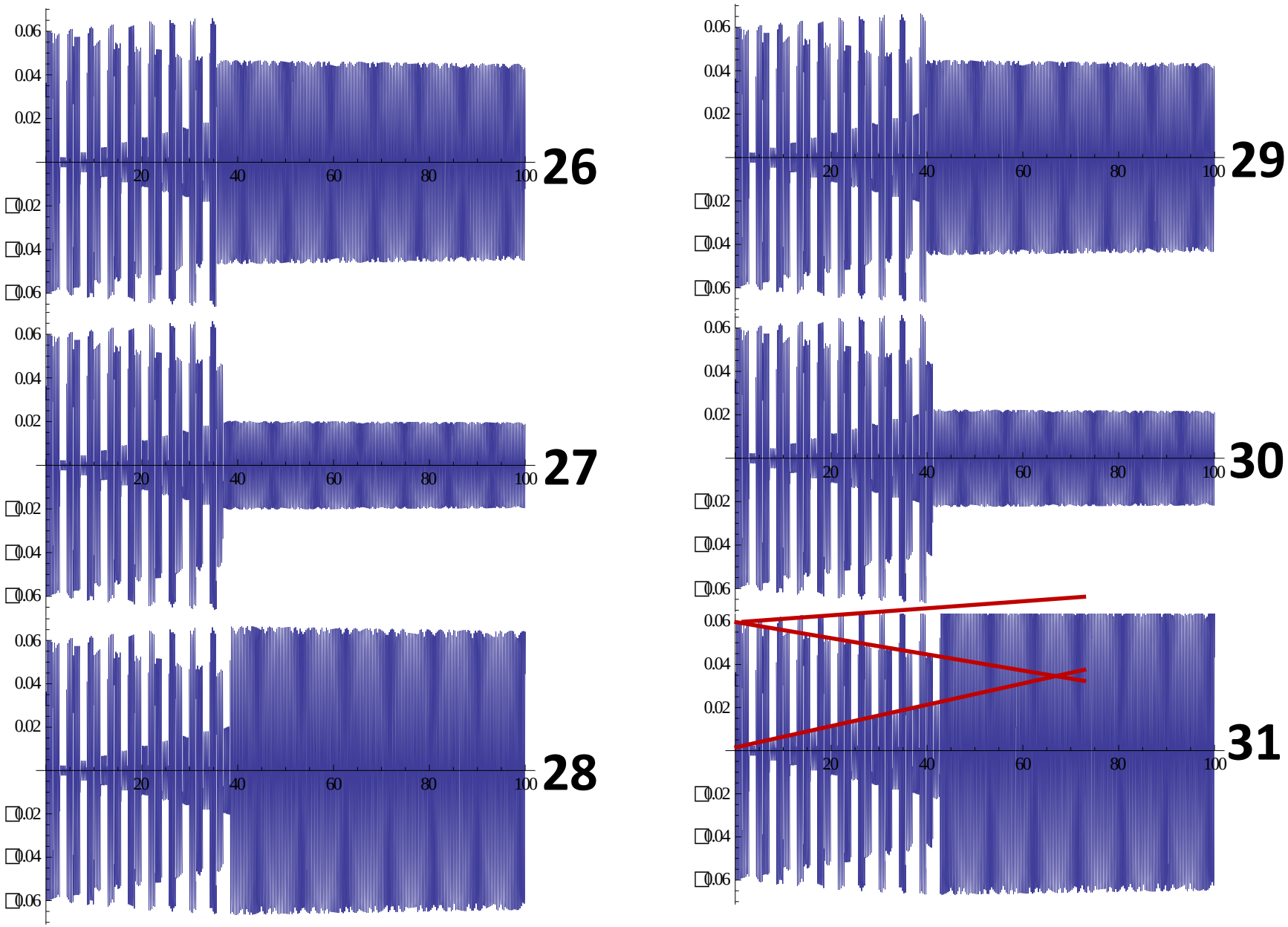


16

17

18

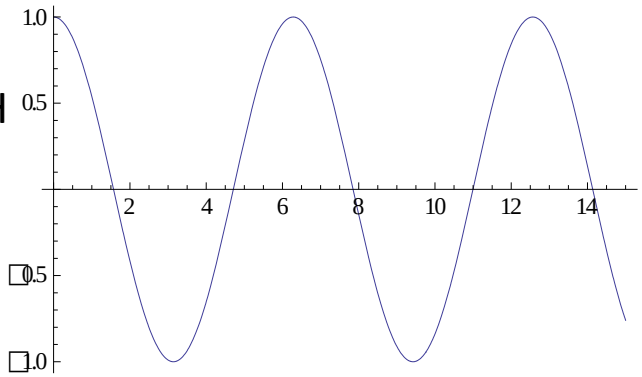
Voltage with n bunches



The reason is that 3.2808 GHz is 4.663 times of the 704 MH

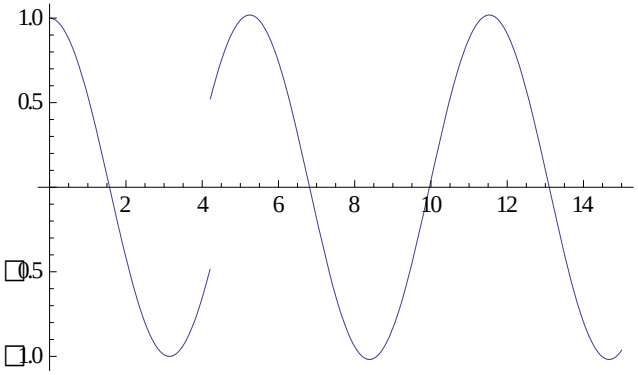
If we consider a mode 0.67 times of the fundamental.

A single bunch gives Cos[τ] voltage fluctuation:



Two bunches give

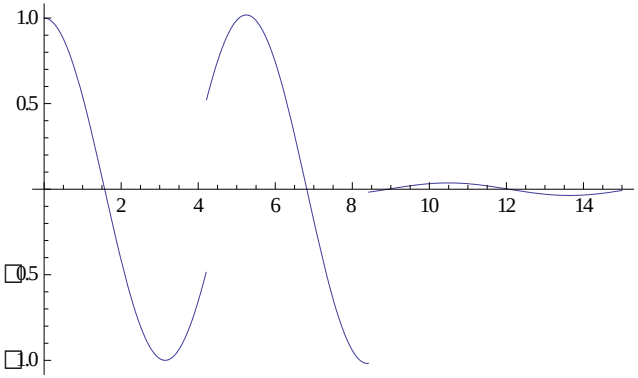
Cos[τ]+Cos[τ-0.67*2π]*UnitStep[τ-0.67*2π]



And three bunches give

Cos[τ]+Cos[τ-0.67*2π]*UnitStep[τ-0.67*2π]

+Cos[τ-0.67*2*2π]*UnitStep[τ-0.67*2*2π]



The voltage fluctuation from this mode will get cancelled every three bunches.

Due to the 0.004 times slip, It will not fully get cancelled every three bunches.

Backup slides

(31 bunches, beam pipe 1.925” for all models)

To suppress the SOMs, we further reduce the end cell length to λ/2.

Freq [GHz]	Q_0	R/Q [Ω]	Voltage [kV]
3.2574	15882	10.5	0.12
3.2808	17602	73.8	1.1
3.3034	15265	34.6	0.36
dp/p: ±7.9e-4		Total	1.64

Sum with fine structure: 1.57
Without beating: 0.24

SOMs		
Freq [GHz]	Q_0	R/Q [Ω]
2.0719	14313	0.035
2.0976	19919	0.071

Slightly change the end cell length to λ/2+2.

Freq [GHz]	Q_0	R/Q [Ω]	Voltage [kV]
2.0721	20017	0.16	0.02
2.0977	21185	0.49	0.20
3.2214	17817	81.5	0.42
3.2879	14150	44.7	0.13
4.6766	28304	3.74	0.03
dp/p: ±3.7e-4		Total	0.81

Sum with fine structure: 0.73
Without beating: 0.08

Shifting this mode 0.5MHz away changes the voltage to 0.41 kV
dp/p: ±2.1e-4

Slightly change the end cell length to λ/2-2.

Freq [GHz]	Q0	R/Q [Ω]	Voltage [kV]
2.0970	20499	0.36	0.05
3.2727	14430	30.4	0.16
3.3447	17392	66.3	1.09
3.3521	16721	15.3	0.20
4.6732	28756	3.94	0.06
dp/p: ±7.0e-4		Total	1.57

Sum with fine structure: 1.40
Without beating: 0.25

Model	with slot	1.875” λ/2+10	1.925” λ/2	1.925” λ/2-2	1.925” λ/2+2	1.925” λ/2+8	1.925” λ/2+10	1.925” λ/2+12
$k_{//}$ [V/pc]	2.74	2.5	1.82	1.80	1.95	1.86	1.85	2.09
$k_{//}$ 2.11G [V/pc]	1.62	1.04	1.16	1.18	1.15	1.00	1.04	1.00
$k_{//}$ SHOM [V/pc]	1.12	1.46	0.66	0.62	0.80	0.86	0.81	1.09

Model	Freq [GHz]	Q_0	R/Q [Ω]	Voltage [kV]
λ/2	3.2808	17602	73.8	1.1
λ/2-2	3.2727	14430	30.4	0.16
λ/2+2	3.2879	14150	44.7	0.13

3.3447	17392	66.3	1.09
3.2214	17817	81.5	0.42