Bunch Merging in the Helical Channel

We are on the edge of a proof of principle helical channel design that merges 13 bunches exiting a first HCC, which fits the acceptance of a second HCC that cools the merged bunch.

"Proof of Principle" Design

- 40m of "bunch preparation" that puts different bunches at different energies.
  - V'_{max} = 1 MV/m, 204.17 MHz < f < 271.84 MHz
  - η = 0.43
- 60m of drift in the same helical channel w/o RF.
  - η = 0.43
- ~5m RF capture into a single bunch
  - V'max = 10 MV/m, f = 200 MHz
  - η = 0.43

General HCC parameters:

- λ = longitudinal spatial period = 1 m
- r_{ref} = 16 cm, κ = pitch = 1, η = 0.43, Bsol(z-axis) = 5.7 T

Boundary Conditions

(HCC reported by Katsuya at the 2011 Winter MAP Meeting @ JLAB)

Parameter list

	Z	b	b'	bz	v	E	κ	λ	ε_μ	ε_T	ε_L	ε_{6D}
unit	m	T	T/m	T	GHz	MV/m		m		mm rad	mm	mm^3
	Channel length	@ ref	@ ref	@ ref	RF		$p_\perp/p_z$		Trans-mission	RMS normalized		
0									1.0	21	23	8900
1	100	1.2	-0.21	-4.2	0.2	16	1.0	1.0	0.75	1.9	4.3	9.4
2	91	1.8	-0.42	-6.0	0.4	16	1.0	0.7	0.62	0.86	1.8	0.99
3	86	3.1	-1.29	-10.7	0.8	16	1.0	0.4	0.41	0.32	1.0	0.08
4	24	4.2	-2.29	-14.0	0.8	16	1.0	0.3	0.38	0.34	1.1	0.07

end of merger

start of merger

Boundary Conditions

(HCC reported by Katsuya at the 2011 Winter MAP Meeting @ JLAB)

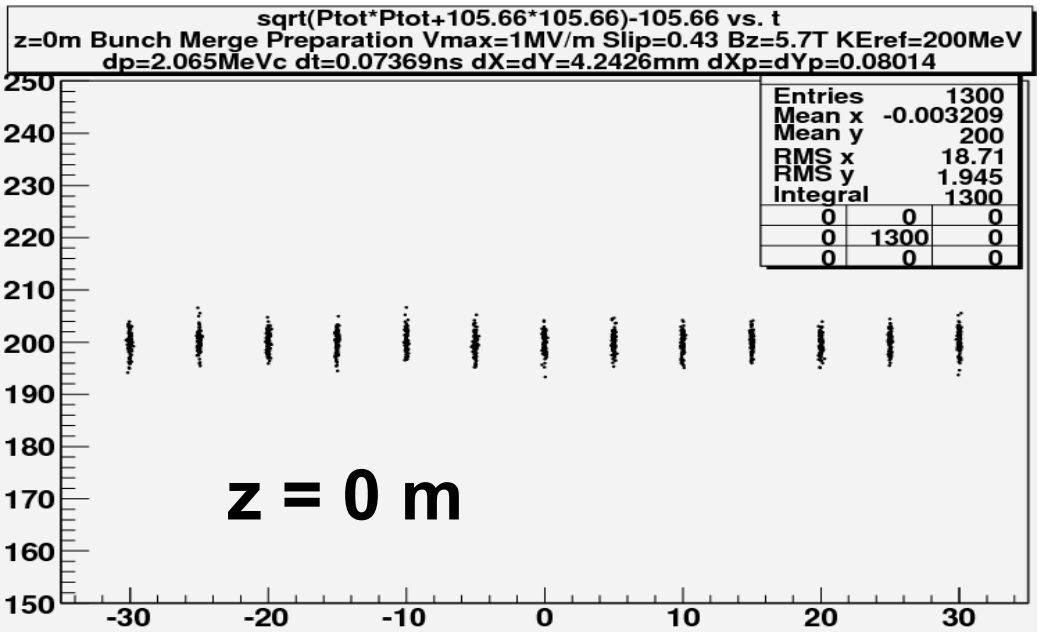
Parameter list

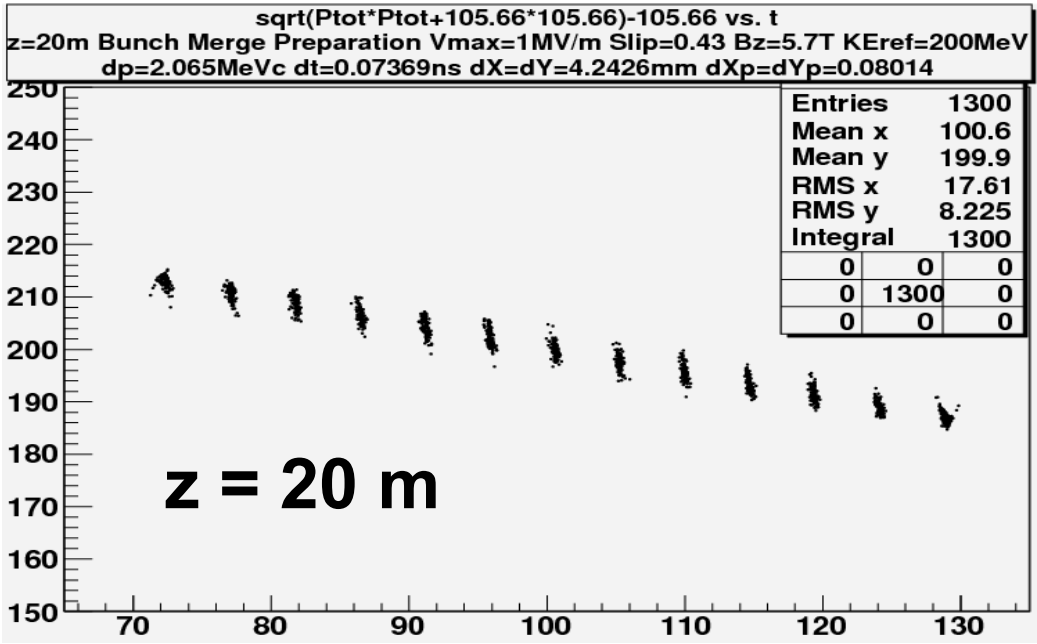
	Z	±Δr	±Δp/p	b	b'	bz	v	κ	λ	N_μ	ε_T	ε_L	ε_{6D}
unit	m	cm	%	T	T/m	T	GHz		m		mm rad	mm	mm^3
	Channel length	Full Width	Full width	@ ref	@ ref	@ ref	RF				end of merger		
1	0	15	22	1.3	-0.5	-4.2	0.325	1.0	1.0	388	20.4	42.8	12900
2	40	8	10	1.3	-0.5	-4.2	0.325	1.0	1.0	375	5.97	19.7	415.9
3	49	7	10	1.4	-0.6	-4.8	0.325	1.0	0.9	354	4.01	15.0	10.8
4	129	3	2.5	1.7	-0.8	-5.2	0.325	1.0	0.8	327	1.02	4.8	2.0
5	219	1.7	1.8	2.6	-2.0	-8.5	0.65	1.0	0.5	327	0.58	2.1	3.2
6	243	1.6	1.3	3.2	-3.1	-9.8	0.65	1.0	0.4	327	0.42	1.3	0.14
7	273	1.3	1.3	4.3	-5.6	-14.1	0.65	1.0	0.3	327	0.32	1.0	0.08
8	303	1.2	1.1	4.3	-5.6	-14.1	1.3	1.0	0.3	327	0.34	1.1	0.07

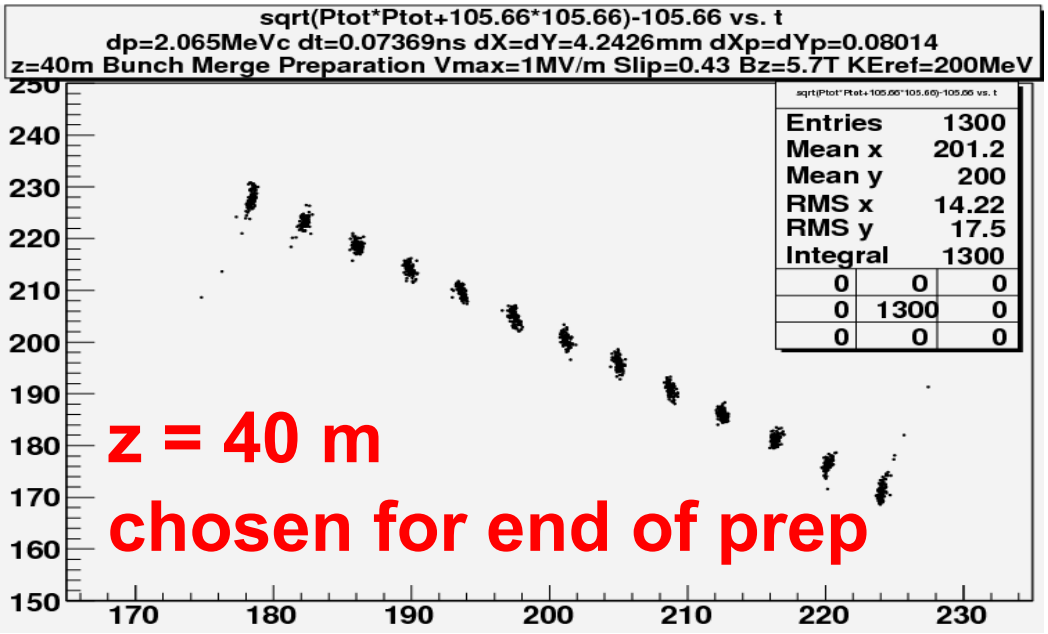
start of merger

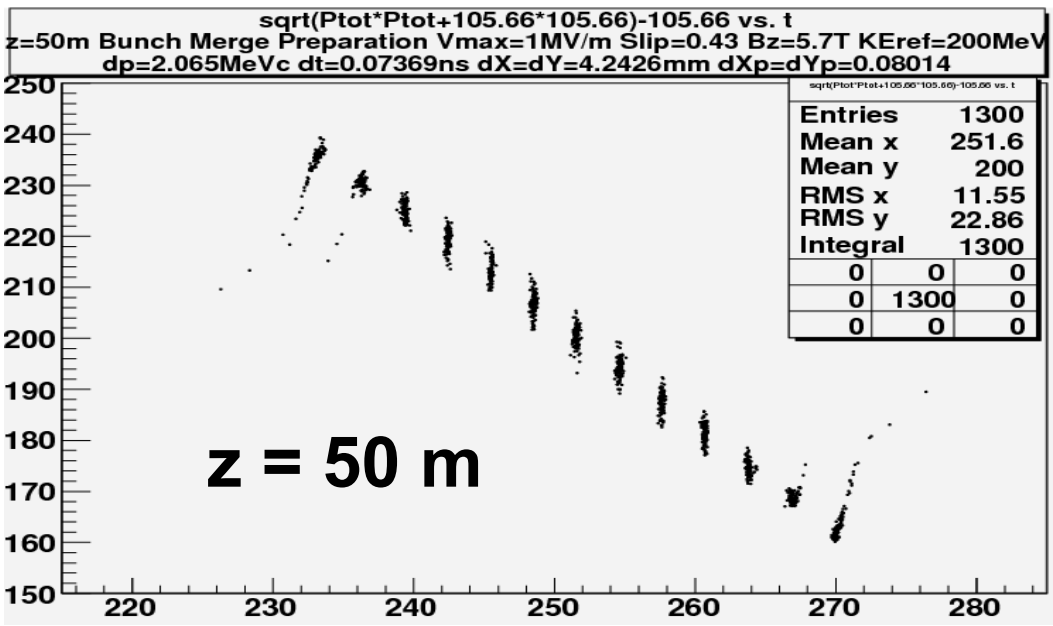
Energy of reference is scaled/accelerated from ~120 MeV out of Katsuya's HCC to 200 MeV for bunch merging, but emittances are assumed conserved in the acceleration.

Bunch Preparation

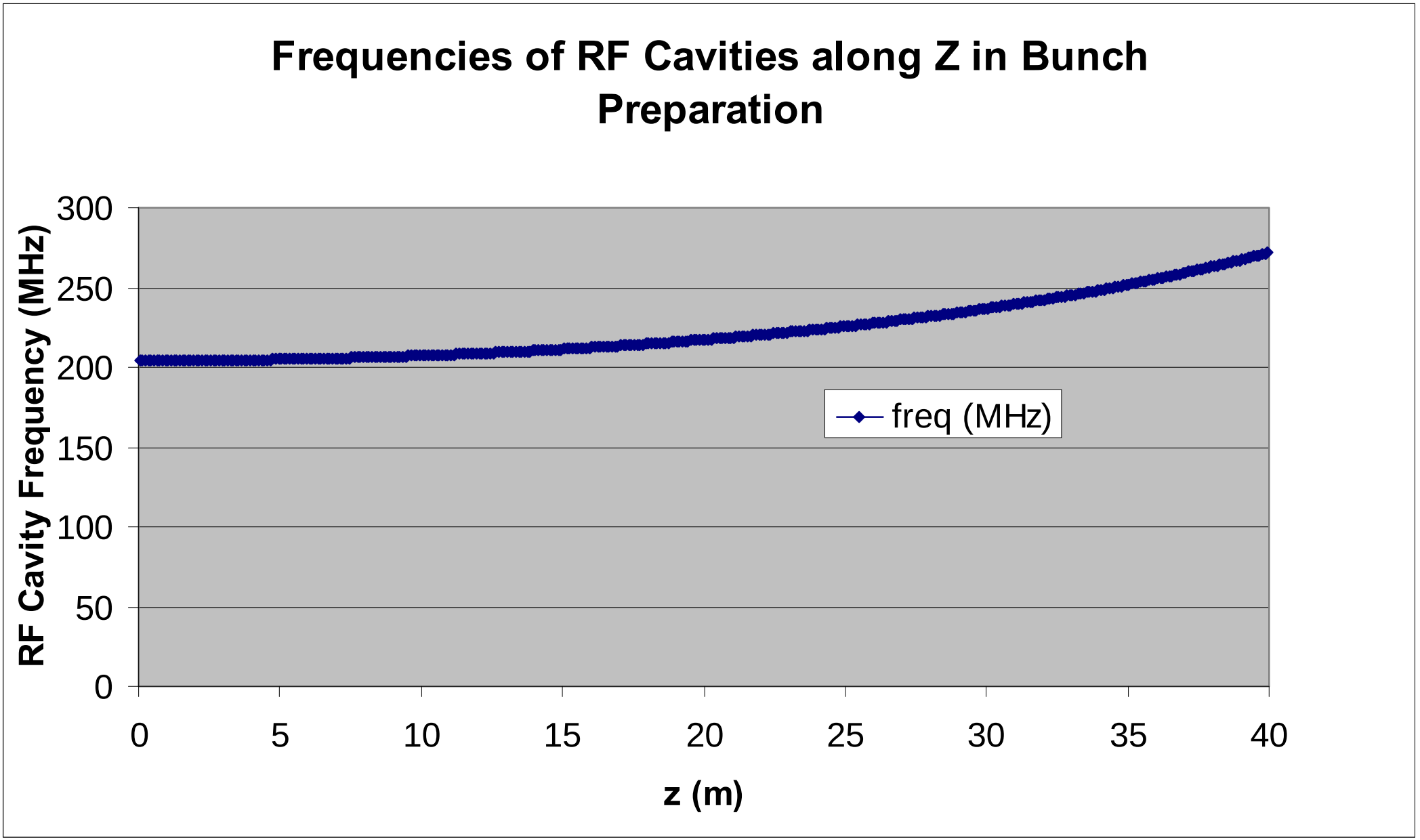




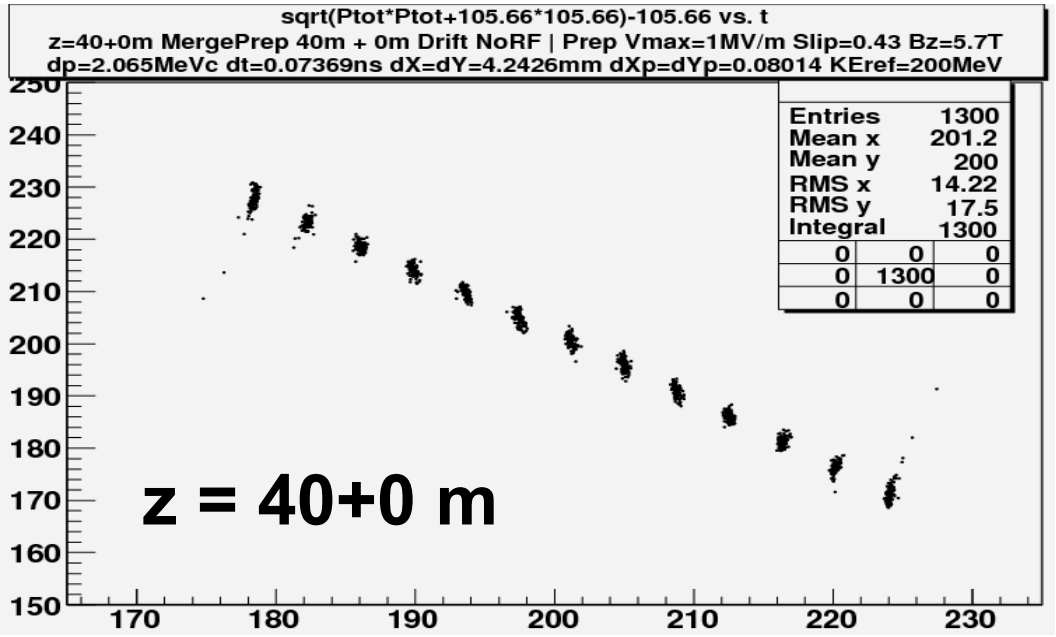


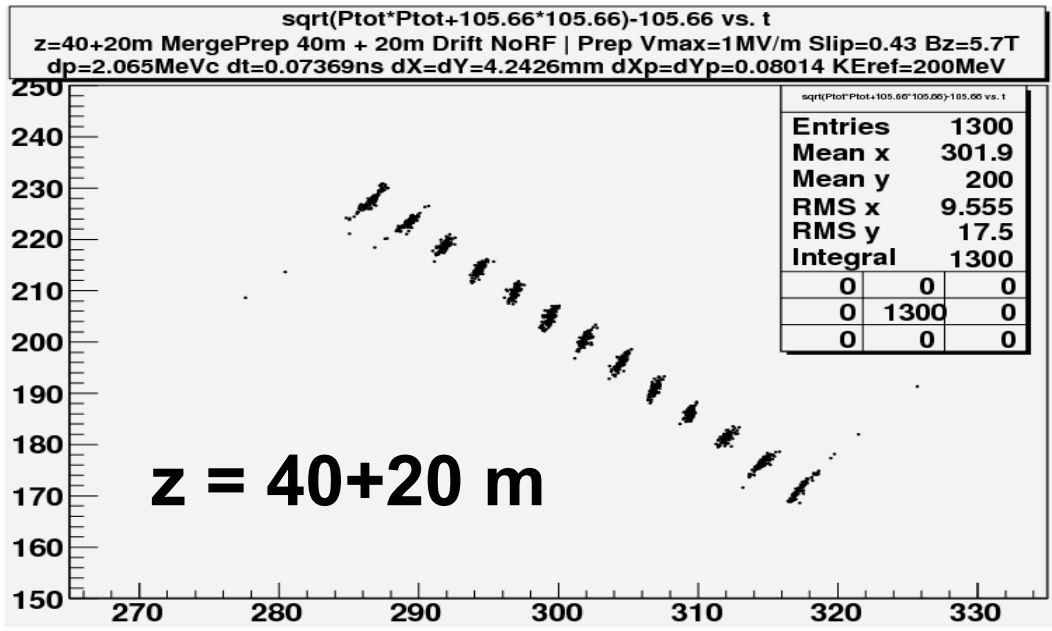


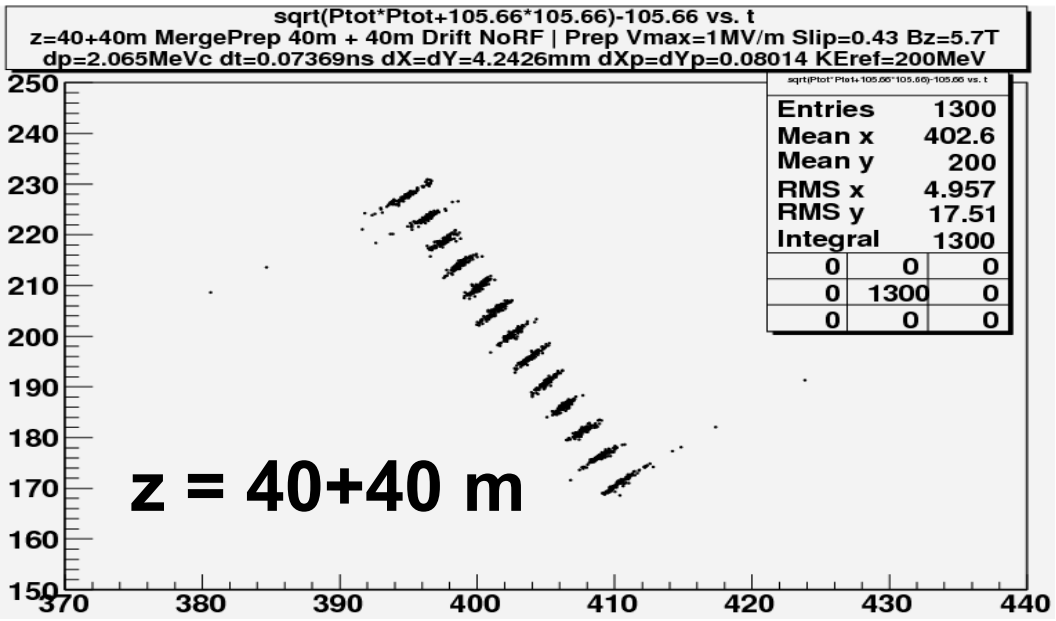
Bunch Preparation

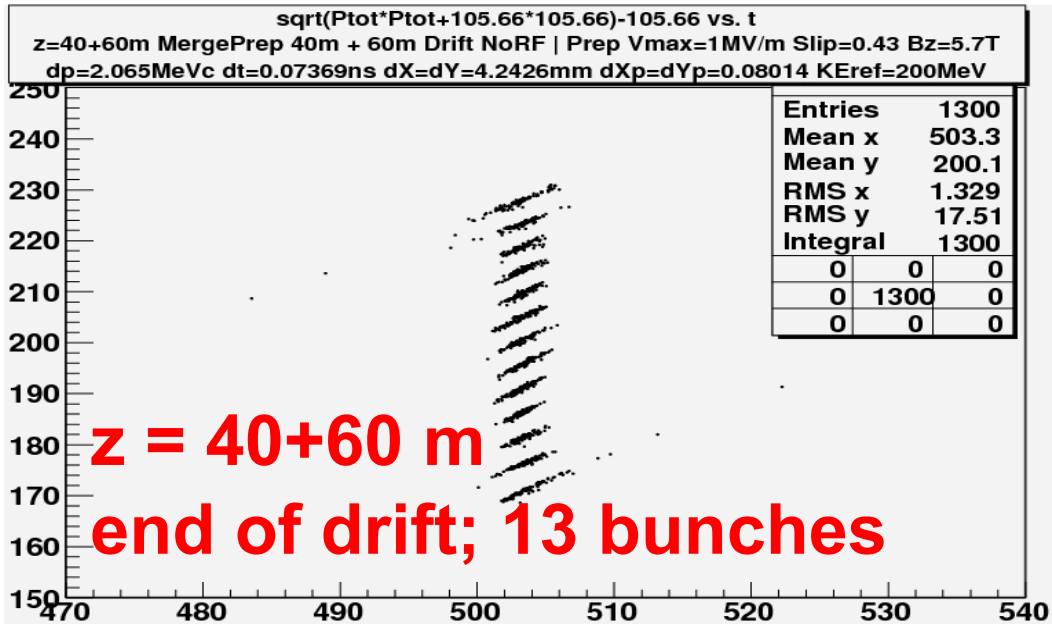


Drift w/o RF for Bunch Merge









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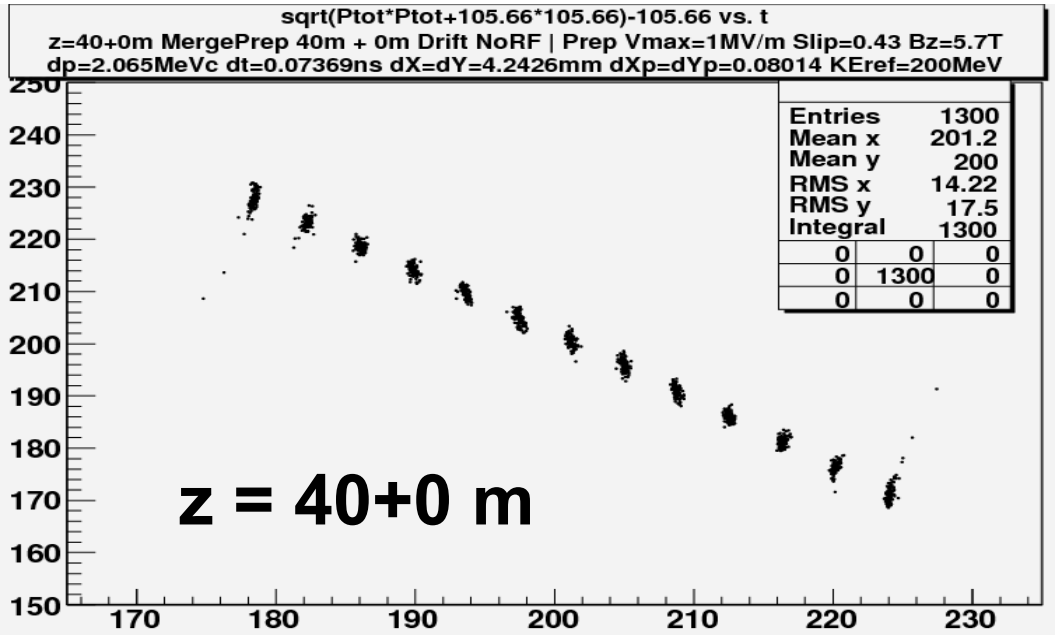
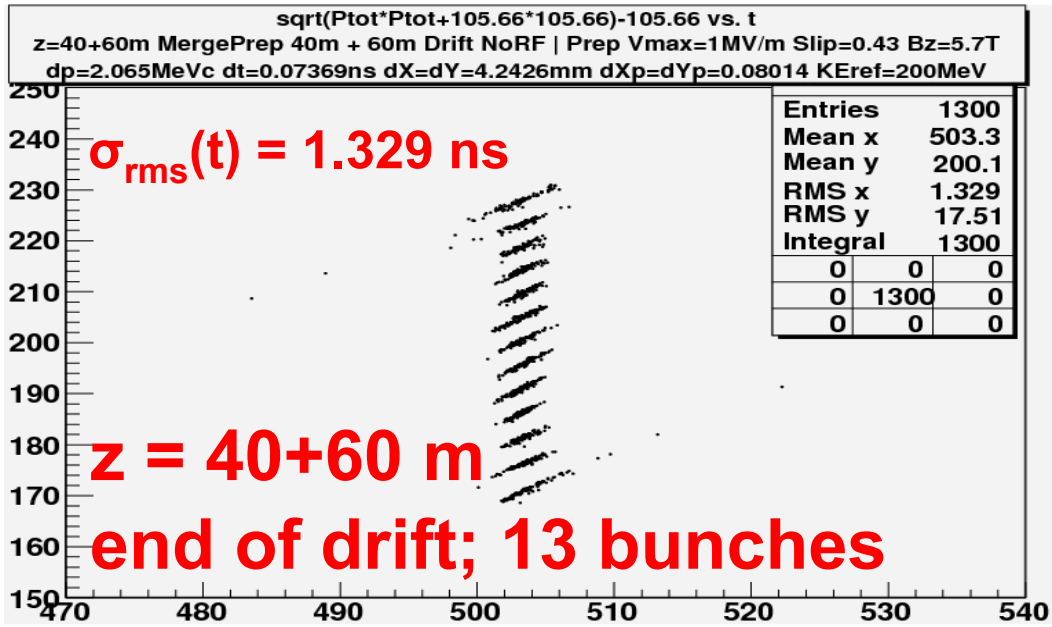
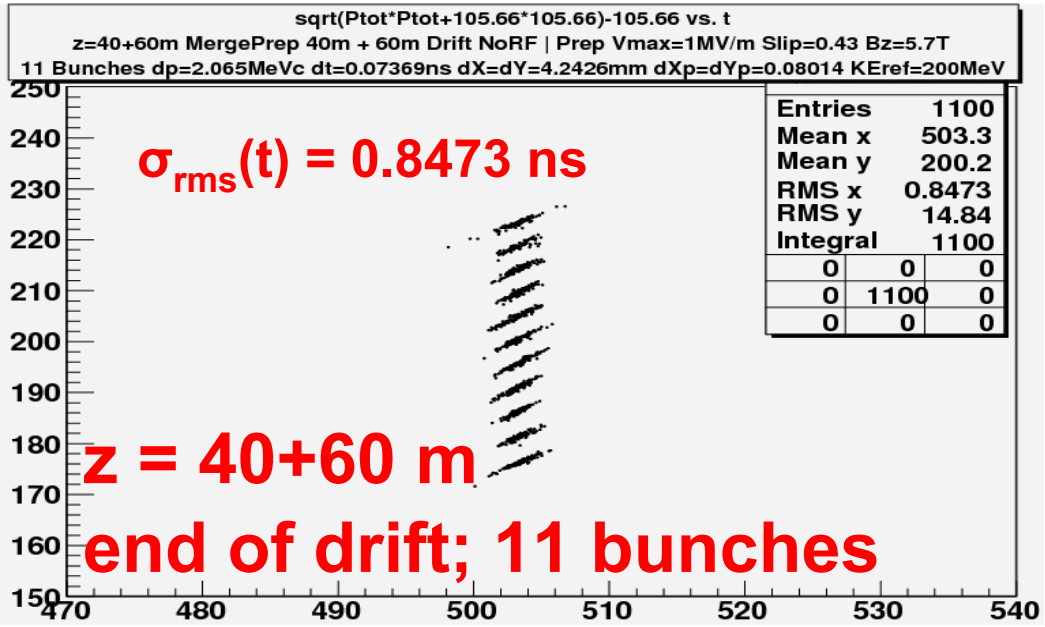
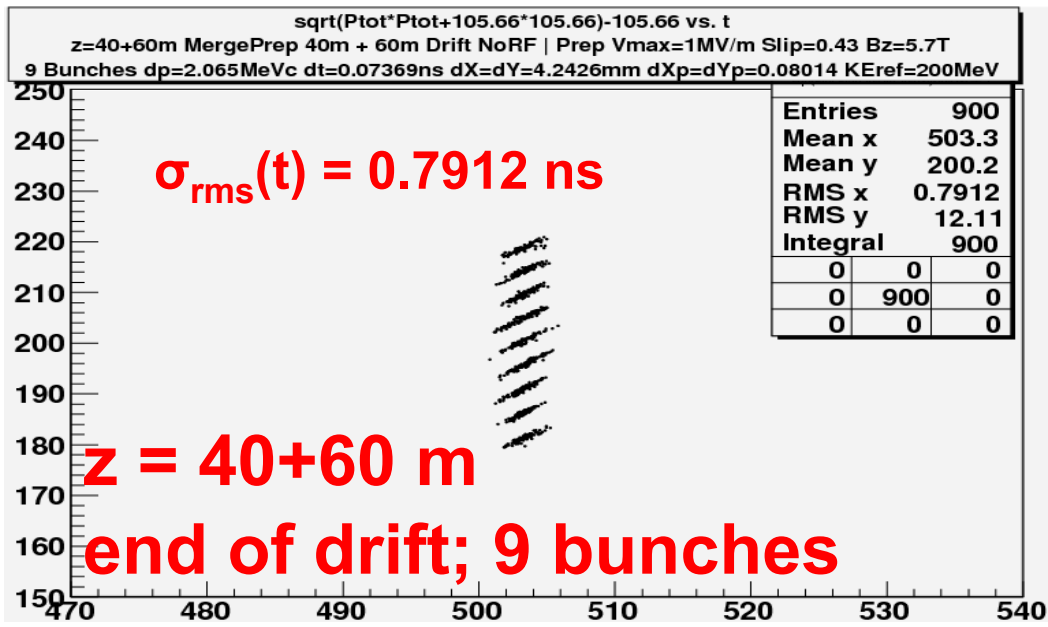
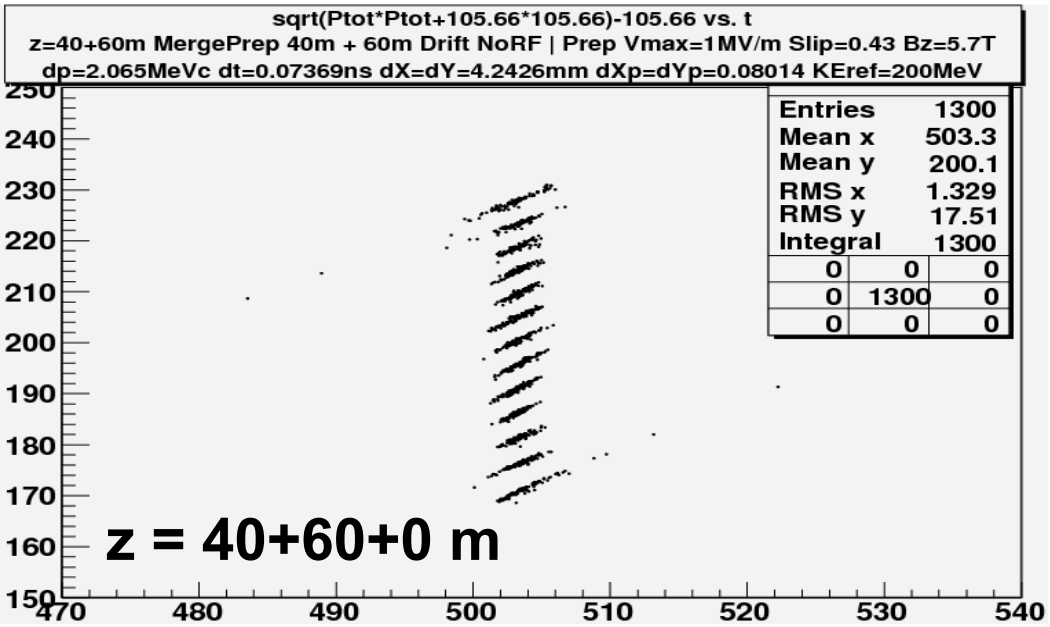


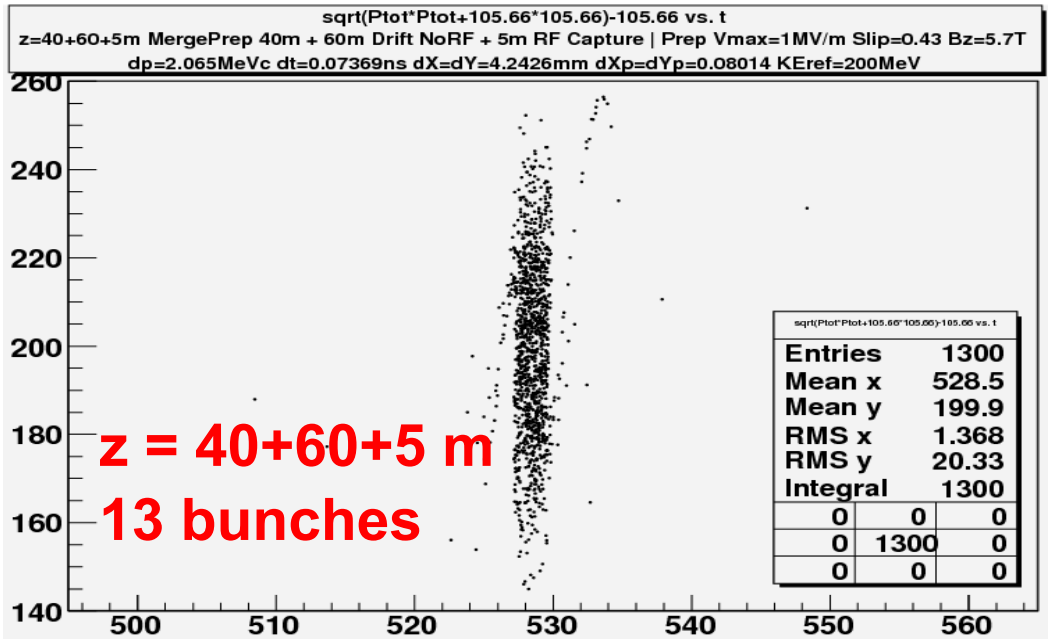


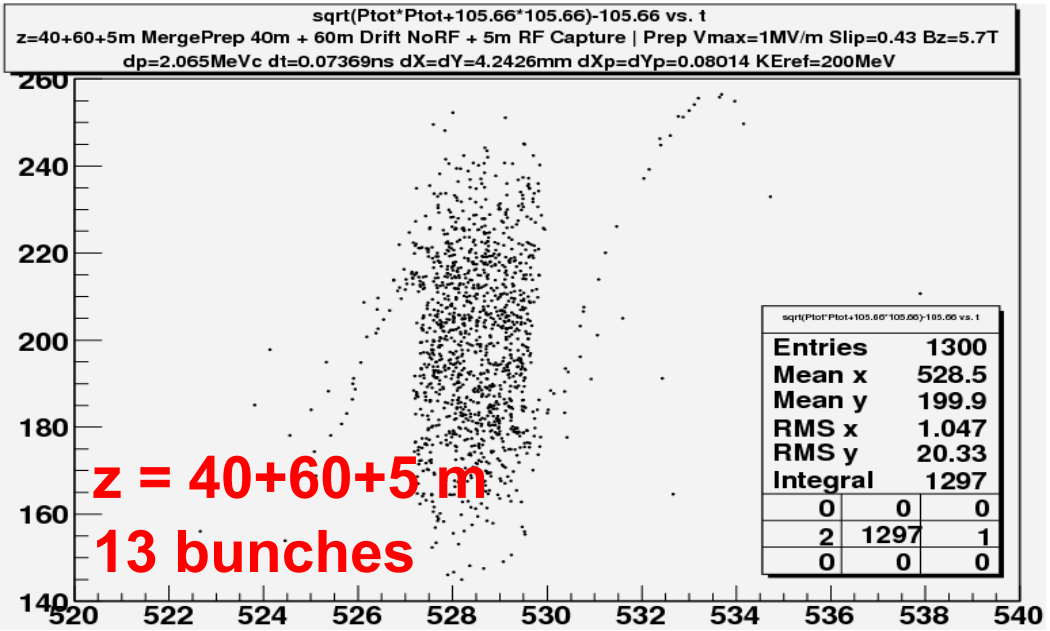




Capture of 13 Bunches into a Single RF Bucket





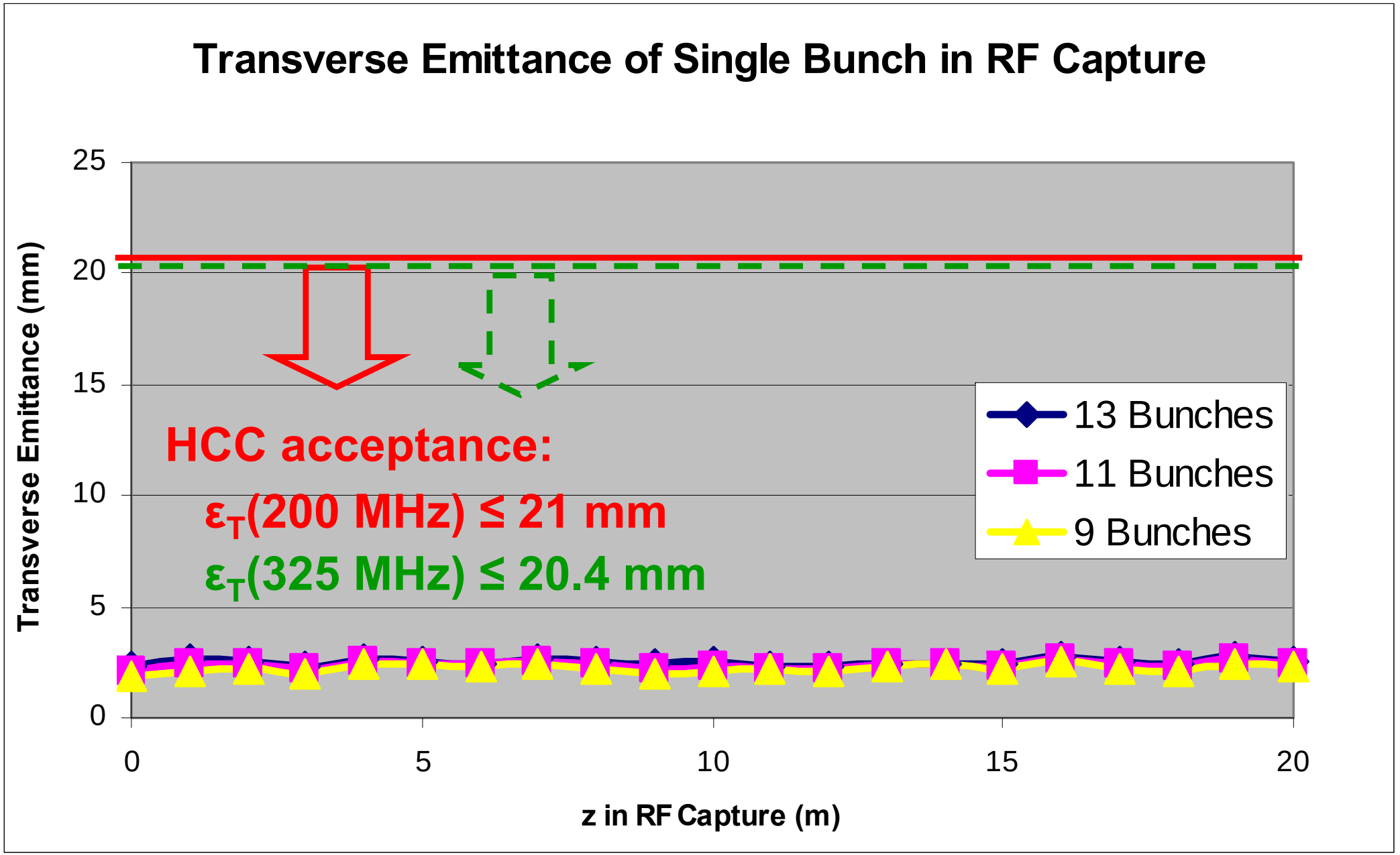


V'_{max} = 10 MV/m

f = 200 MHz in vacuum

Note that this capture sits just upstream of the 2nd HCC, so incorporating gas to increase V'max is possible (desired). May also use cylindrical wedges to increase longitudinal cooling as well.

Capture of Bunches into a Single RF Bucket



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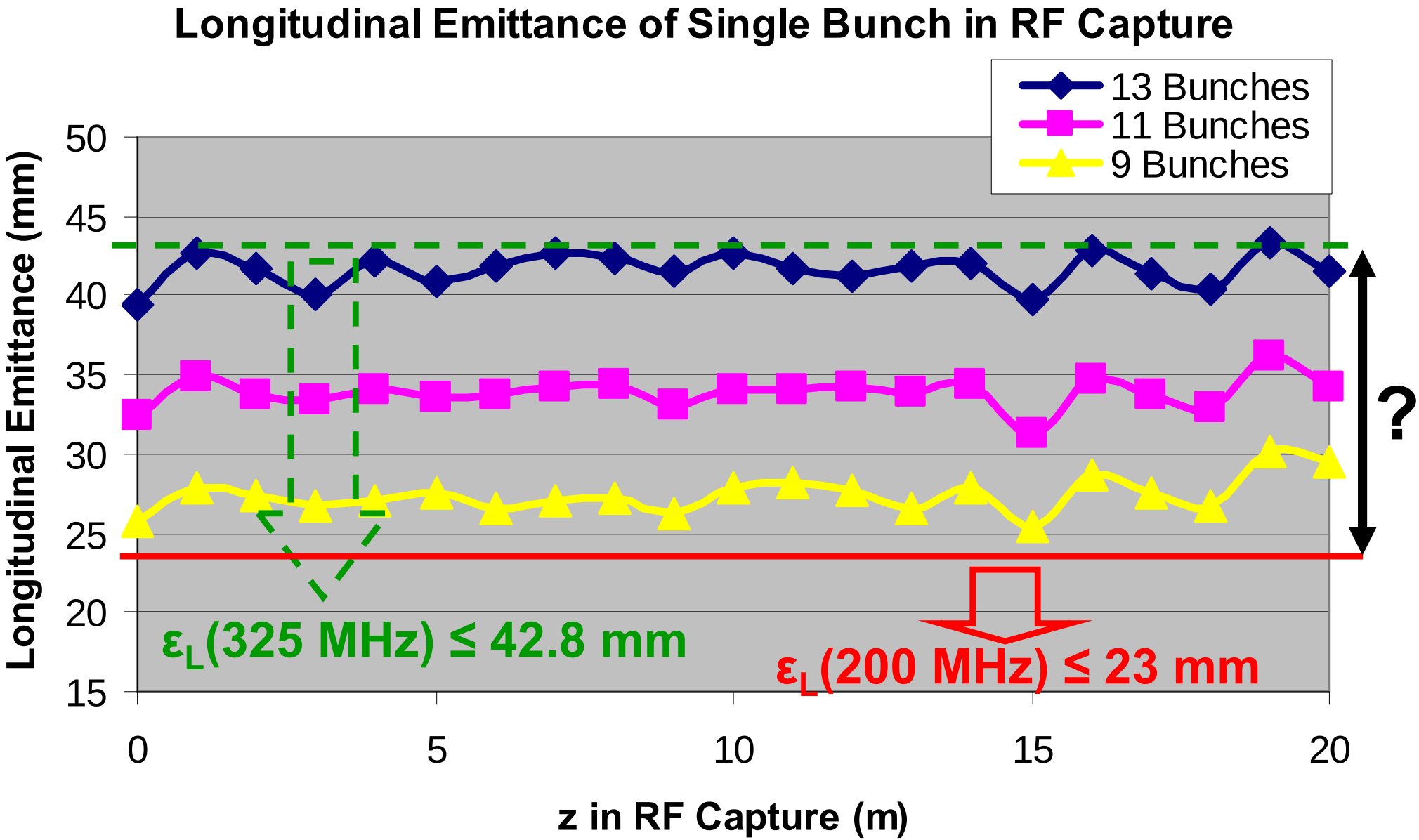

Conclusions and Future

- **We are on the edge of a proof of principle helical channel design that merges 13 bunches exiting a first HCC, which fits the acceptance of a second HCC that cools the merged bunch.**
- **The discrepancy where 200 MHz has a smaller ε_L acceptance than the 325 MHz case needs to be understood/rectified. Both used 16 MV/m.**
- **Future (assuming HCC ε_L for 200 MHz case can be made to accept 9/more bunches):**
  - **Consolidate frequencies in preparation portion to produce a more practical design.**
  - **Think about enhanced longitudinal cooling at RF capture (upstream of second HCC).**
    - **Incorporating cylindrical wedges? (Use lessons learned from "maximal use of wedges" in Quasi studies a few months ago?)**
  - **???**