DC Beam Collimation in the mu2e 8-GeV beam Line

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Table 1: Particle loss along beam line for the beam with zero momentum spread.

path length	loss	loss	Aperture		length	name
			hor.	ver.		
m	W/m	GeV/Po			m	
19.753	0.328E+03	40162.4974	16.00	16.00	1.0000	DUMP1
20.277	0.206E+00	13.2413	60.00	60.00	0.5240	COLH
21.801	0.566E+00	105.7526	60.00	60.00	1.5240	COLH
22.801	0.501E+00	61.4019	60.00	60.00	1.0000	DMT1
23.262	0.537E+00	30.3570	60.00	60.00	0.4613	MUQ16
24.262	0.535E+00	65.6322	60.00	60.00	1.0000	DMT1
24.723	0.344E+00	19.4527	60.00	60.00	0.4613	MUQ17
27.723	0.285E+00	104.9794	60.00	60.00	3.0000	DM51
28.185	0.458E-01	2.5930	60.00	60.00	0.4613	MUQ18
30.185	0.290E+00	71.2192	60.00	60.00	2.0000	DMT
30.415	0.152E+00	4.2952	60.00	60.00	0.2306	MUQ19
30.646	0.125E+00	3.5489	60.00	60.00	0.2306	MUQ19
32.646	0.224E+00	54.8900	60.00	60.00	2.0000	DMT
33.107	0.266E+00	15.0412	60.00	60.00	0.4613	MUQ18
36.107	0.963E-01	35.4176	60.00	60.00	3.0000	DM51
44.539	0.145E-01	1.7738	60.00	60.00	1.0000	DMT1
48.000	0.244E-02	0.8964	60.00	60.00	3.0000	DM51
60.306	0.118E+00	14.3986	16.00	16.00	1.0000	DUMP2
65.277	0.158E-01	0.8938	60.00	60.00	0.4613	MUQ17
68.277	0.138E-01	5.0632	60.00	60.00	3.0000	DM51
70.738	0.362E-02	0.8867	60.00	60.00	2.0000	DMT
73.200	0.640E-02	1.5706	60.00	60.00	2.0000	DMT
73.661	0.473E-01	2.6725	60.00	60.00	0.4613	MUQ18
76.661	0.729E-02	2.6818	60.00	60.00	3.0000	DM51
81.107	0.673E-01	12.5703	18.00	18.00	1.5240	KICK2

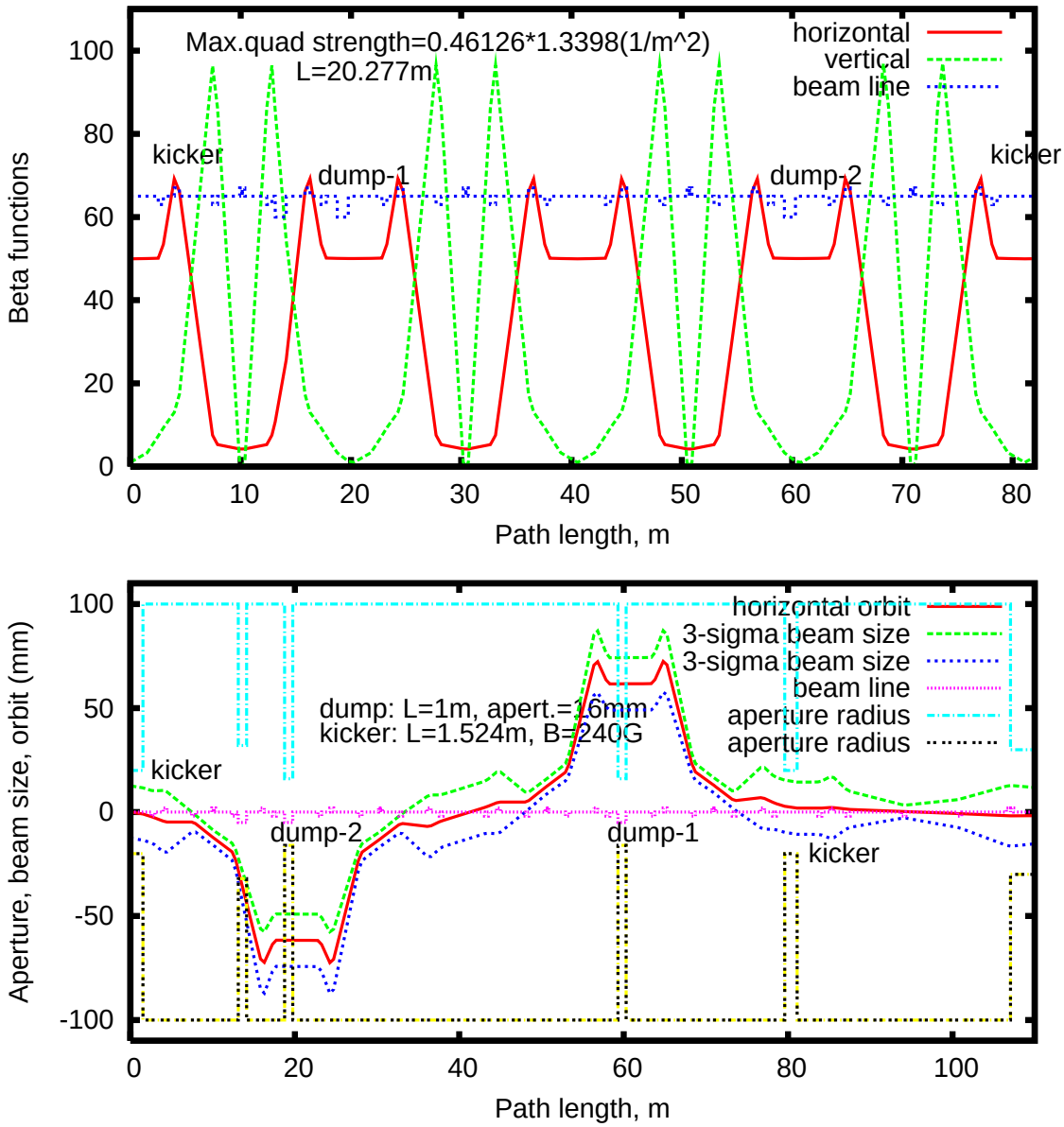

Figure 1: A part of Mu2e 8-GeV beam line, used for DC beam collimation, consists of a 90° identical periods. Two horizontal kicker-magnets, located at 2π phase advance, are used to dump DC beam populated between the main bunches to two beam Dumps, placed at π phase advance between them. The sinusoidal wave of magnetic field is used with main bunches located at zero and π phases of the kicker wave. The DC beam located between the main bunches is moved to Dump jaws by nonzero kicker field. The 3σ envelope of emittance $\varepsilon_{95\%} = 20\pi mm - mrad$ beam is shown on the bottom.

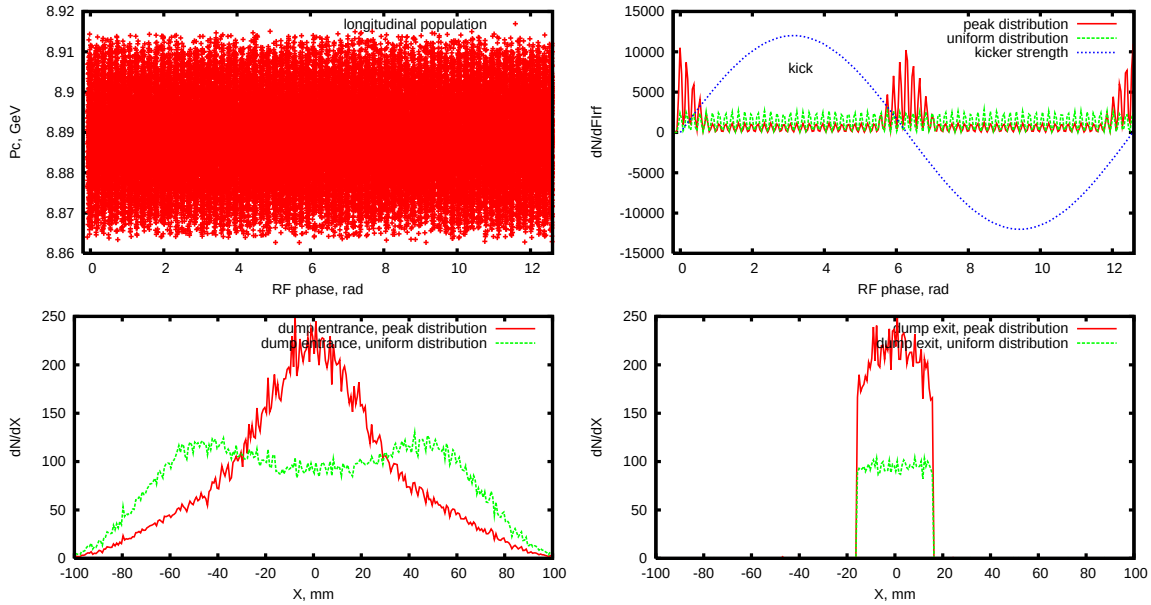

Figure 2: DC beam collimation in the Mu2e 8-GeV beam line. Longitudinal population (top, left) and distribution (top, right) of particles between the main bunches are shown. Transverse distribution of particles upstream of the Dump1 entrance and distribution of particles at the Dump1 exit are presented on the bottom for uniform distribution of DC beam and for distribution with increased number of particles in a vicinity of the main bunches (peak distribution). Total number of particles is the same in both distributions.

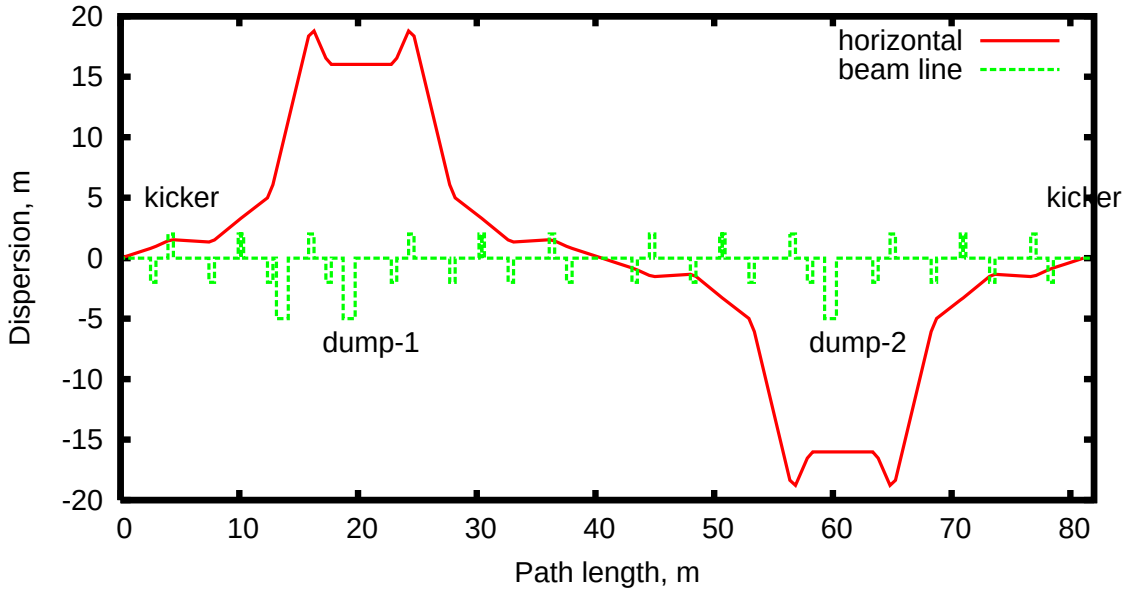

Figure 3: Horizontal dispersion in the beam line at maximum kicker strength.

Table 2: Particle loss along beam line for the beam with dP/P=0.0001 momentum spread.

path length	loss	loss	Aperture		length	name
			hor.	ver.		
m	W/m	GeV/Po			m	
15.830	0.147E-01	5.4005	60.00	60.00	3.0000	DM51
16.292	0.143E+00	8.1012	60.00	60.00	0.4613	MUQ17
19.753	0.321E+03	39368.7064	16.00	16.00	1.0000	DUMP1
20.277	0.180E+00	11.5917	60.00	60.00	0.5240	COLH
21.801	0.515E+00	96.2374	60.00	60.00	1.5240	COLH
22.801	0.642E+00	78.6726	60.00	60.00	1.0000	DMT1
23.262	0.735E+00	41.5926	60.00	60.00	0.4613	MUQ16
24.262	0.471E+00	57.8014	60.00	60.00	1.0000	DMT1
24.723	0.532E+00	30.1163	60.00	60.00	0.4613	MUQ17
27.723	0.282E+00	103.7800	60.00	60.00	3.0000	DM51
28.185	0.124E+00	6.9952	60.00	60.00	0.4613	MUQ18
30.185	0.279E+00	68.4764	60.00	60.00	2.0000	DMT
30.415	0.339E+00	9.5998	60.00	60.00	0.2306	MUQ19
30.646	0.376E+00	10.6265	60.00	60.00	0.2306	MUQ19
32.646	0.235E+00	57.5748	60.00	60.00	2.0000	DMT
33.107	0.282E+00	15.9411	60.00	60.00	0.4613	MUQ18
36.107	0.101E+00	37.2479	60.00	60.00	3.0000	DM51
36.568	0.314E-01	1.7746	60.00	60.00	0.4613	MUQ1
44.539	0.714E-02	0.8755	60.00	60.00	1.0000	DMT1
60.306	0.169E+00	20.6981	16.00	16.00	1.0000	DUMP2
64.816	0.145E-01	1.7777	60.00	60.00	1.0000	DMT1
68.277	0.242E-02	0.8888	60.00	60.00	3.0000	DM51
70.738	0.355E-02	0.8718	60.00	60.00	2.0000	DMT
71.200	0.311E-01	0.8807	60.00	60.00	0.2306	MUQ19
73.200	0.144E-01	3.5327	60.00	60.00	2.0000	DMT
76.661	0.239E-02	0.8797	60.00	60.00	3.0000	DM51
81.107	0.672E-01	12.5633	18.00	18.00	1.5240	KICK2

Table 3: Particle loss along beam line for the beam with dP/P=0.001 momentum spread.

path length	loss	loss	Aperture		length	name
			hor.	ver.		
m	W/m	GeV/Po			m	
12.830	0.345E+01	195.2577	60.00	60.00	0.4613	MUQ18
15.830	0.682E+02	25091.3365	60.00	60.00	3.0000	DM51
16.292	0.125E+02	708.2791	60.00	60.00	0.4613	MUQ17
19.753	0.201E+03	24705.0069	16.00	16.00	1.0000	DUMP1
20.277	0.258E+00	16.5886	60.00	60.00	0.5240	COLH
21.801	0.216E+00	40.3944	60.00	60.00	1.5240	COLH
22.801	0.362E+00	44.4333	60.00	60.00	1.0000	DMT1
23.262	0.345E+00	19.5296	60.00	60.00	0.4613	MUQ16
24.262	0.260E+00	31.9332	60.00	60.00	1.0000	DMT1
24.723	0.303E+00	17.1656	60.00	60.00	0.4613	MUQ17
27.723	0.125E+00	45.8708	60.00	60.00	3.0000	DM51
28.185	0.454E-01	2.5660	60.00	60.00	0.4613	MUQ18
30.185	0.145E+00	35.5122	60.00	60.00	2.0000	DMT
30.415	0.125E+00	3.5270	60.00	60.00	0.2306	MUQ19
30.646	0.218E+00	6.1596	60.00	60.00	0.2306	MUQ19
32.646	0.927E-01	22.7337	60.00	60.00	2.0000	DMT
33.107	0.201E+00	11.3566	60.00	60.00	0.4613	MUQ18
36.107	0.458E-01	16.8444	60.00	60.00	3.0000	DM51
48.000	0.483E-02	1.7773	60.00	60.00	3.0000	DM51
60.306	0.132E+00	16.1802	16.00	16.00	1.0000	DUMP2
64.816	0.713E-02	0.8738	60.00	60.00	1.0000	DMT1
68.277	0.238E-02	0.8764	60.00	60.00	3.0000	DM51
76.661	0.732E-02	2.6915	60.00	60.00	3.0000	DM51
81.107	0.289E-01	5.3922	18.00	18.00	1.5240	KICK2

Table 4: Particle loss along beam line with additional DUMP3 for the beam with dP/P=0.001 momentum spread.

path length	loss	loss	Aperture		length	name
			hor.	ver.		
m	W/m	GeV/Po			m	
12.830	0.328E+01	185.4149	60.00	60.00	0.4613	MUQ18
13.130	0.319E+02	1171.7512	60.00	60.00	0.3000	DM51
14.130	0.213E+03	26131.6062	32.00	32.00	1.0000	DUMP3
15.830	0.319E+01	665.0019	60.00	60.00	1.7000	DM51
16.292	0.255E+01	144.2930	60.00	60.00	0.4613	MUQ17
17.292	0.647E+00	79.2904	60.00	60.00	1.0000	DMT1
17.753	0.494E+00	27.9399	60.00	60.00	0.4613	MUQ16
18.753	0.534E+00	65.4440	60.00	60.00	1.0000	DMT1
19.753	0.178E+03	21854.0031	16.00	16.00	1.0000	DUMP1
20.277	0.169E+00	10.8361	60.00	60.00	0.5240	COLH
21.801	0.238E+00	44.5397	60.00	60.00	1.5240	COLH
22.801	0.231E+00	28.3618	60.00	60.00	1.0000	DMT1
23.262	0.504E+00	28.5077	60.00	60.00	0.4613	MUQ16
24.262	0.377E+00	46.2714	60.00	60.00	1.0000	DMT1
24.723	0.144E+00	8.1303	60.00	60.00	0.4613	MUQ17
27.723	0.112E+00	41.0300	60.00	60.00	3.0000	DM51
28.185	0.453E-01	2.5614	60.00	60.00	0.4613	MUQ18
30.185	0.139E+00	33.9922	60.00	60.00	2.0000	DMT
30.415	0.152E+00	4.3062	60.00	60.00	0.2306	MUQ19
30.646	0.123E+00	3.4702	60.00	60.00	0.2306	MUQ19
32.646	0.117E+00	28.7733	60.00	60.00	2.0000	DMT
33.107	0.773E-01	4.3698	60.00	60.00	0.4613	MUQ18
36.107	0.508E-01	18.6720	60.00	60.00	3.0000	DM51
60.306	0.808E-01	9.9023	16.00	16.00	1.0000	DUMP2
68.277	0.717E-02	2.6385	60.00	60.00	3.0000	DM51
73.200	0.364E-02	0.8918	60.00	60.00	2.0000	DMT
73.661	0.473E-01	2.6767	60.00	60.00	0.4613	MUQ18
76.661	0.487E-02	1.7920	60.00	60.00	3.0000	DM51
81.107	0.481E-01	8.9805	18.00	18.00	1.5240	KICK2

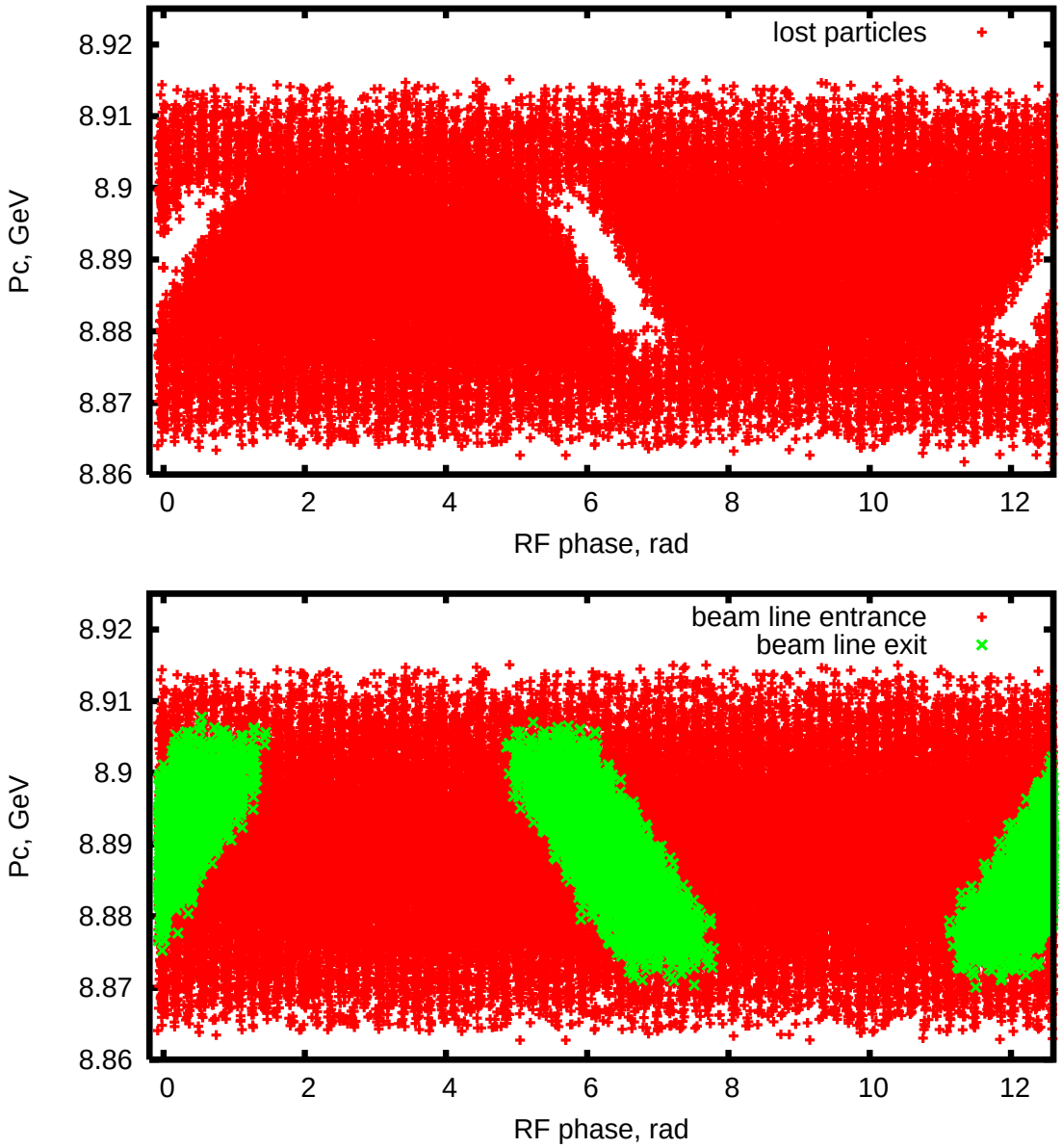

Figure 4: Lost particles of DC beam longitudinal phase plane (top), and initial particles at beam line entrance and survived particles after collimation (bottom).

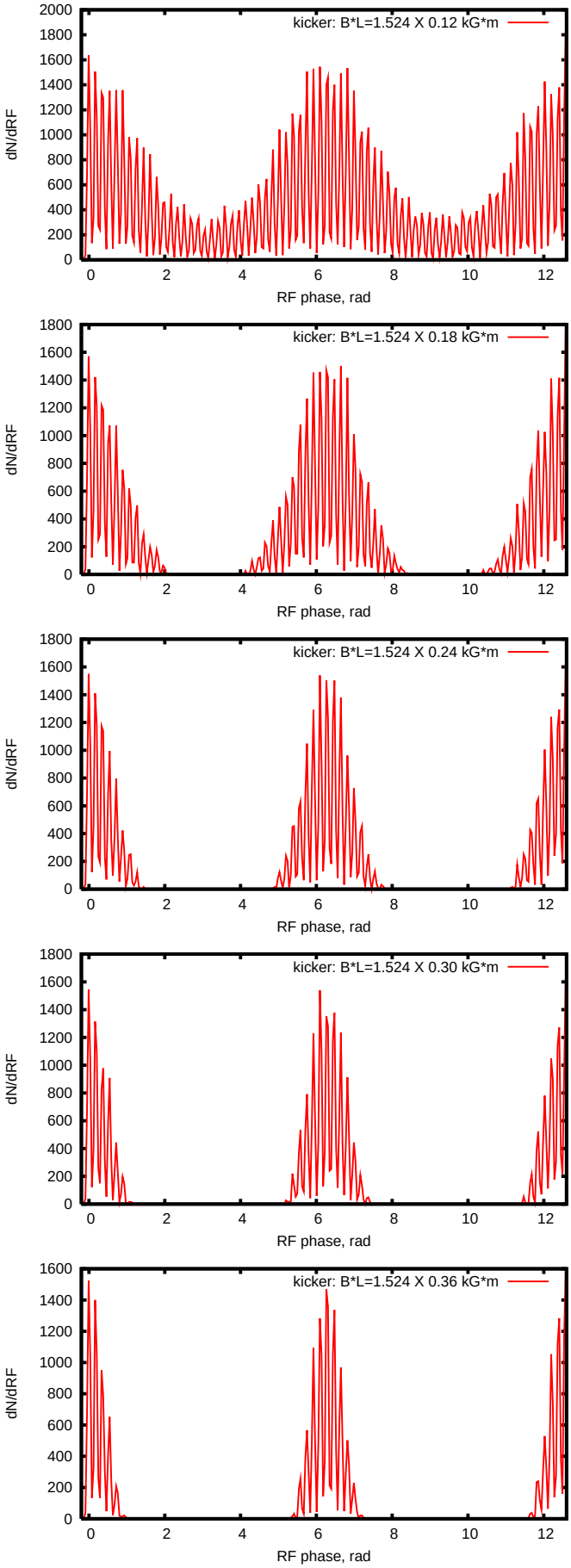

Figure 5: Survived particles of DC beam distribution for different strength of kicker.