Requirements for CeC systems

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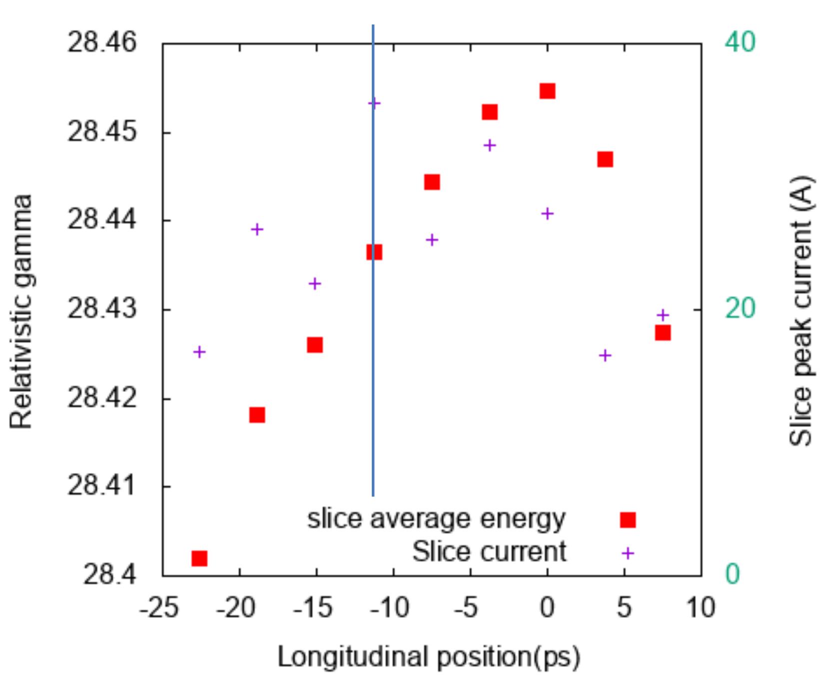
for the CeC team
8.16.2021

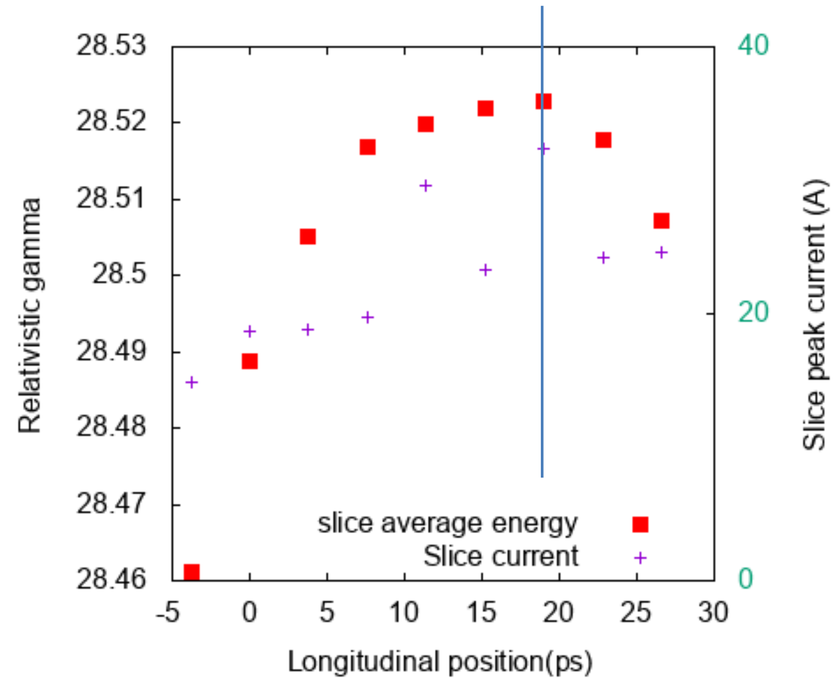
Outline

- Laser
- Magnet power supplies
- RFs
- Summary

Laser time jitter



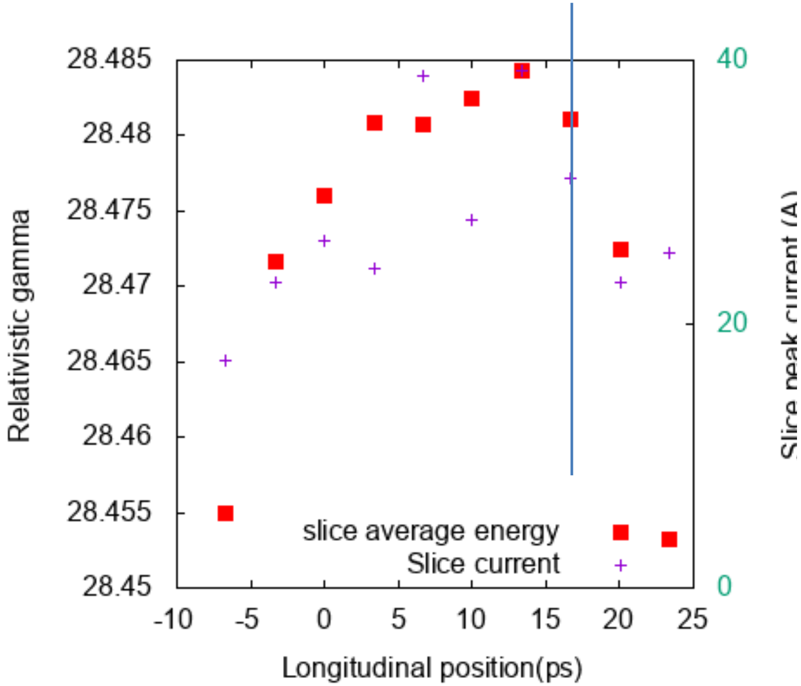
- 40 ps



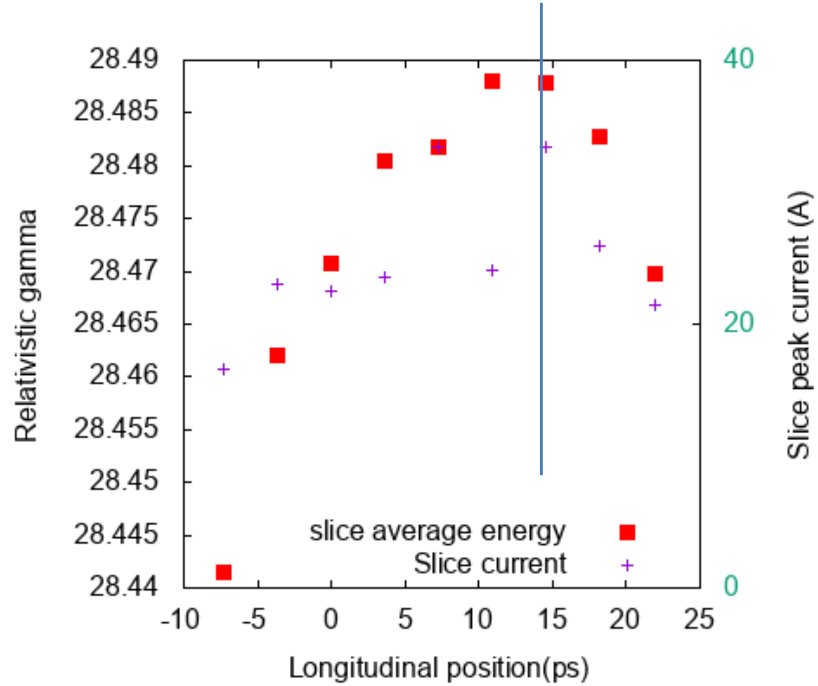
+ 40 ps

- Laser jitter affects the average slice energy significantly.
- A jitter in Laser time (+/- 40 ps) changes slice energy from +0.14%/-0.16% w.r.t. the designed value. Verified in experiments.
- Thus for a rms 2e-4 energy jitter required for cooling, the rms laser jitter needs to be < 5 ps.

Laser intensity jitter



- 10% Laser Intensity

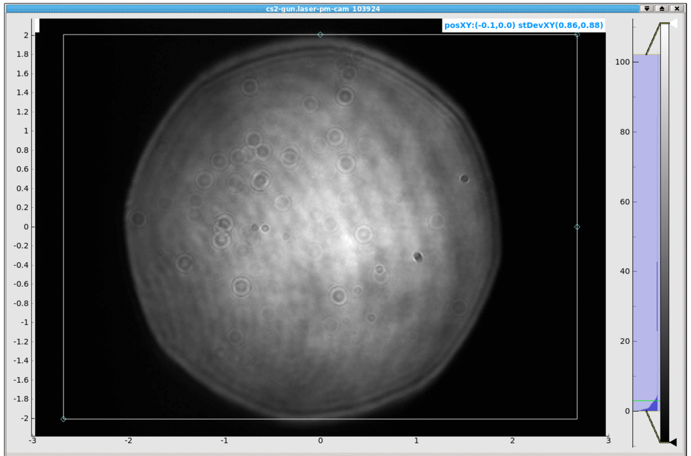


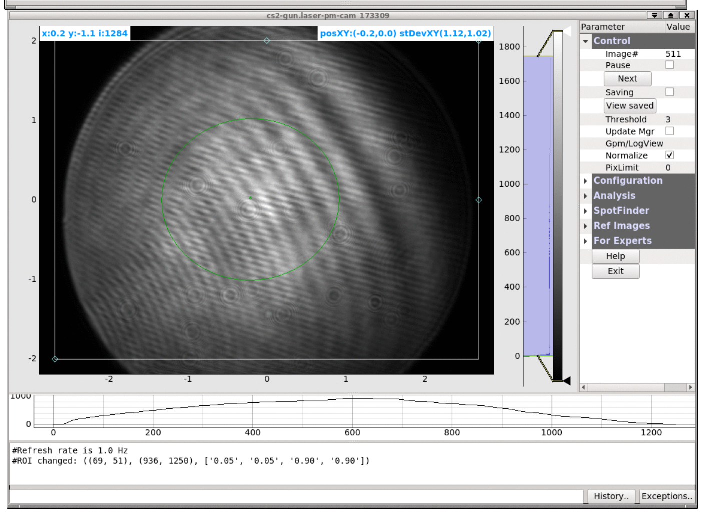
+ 10% Laser Intensity

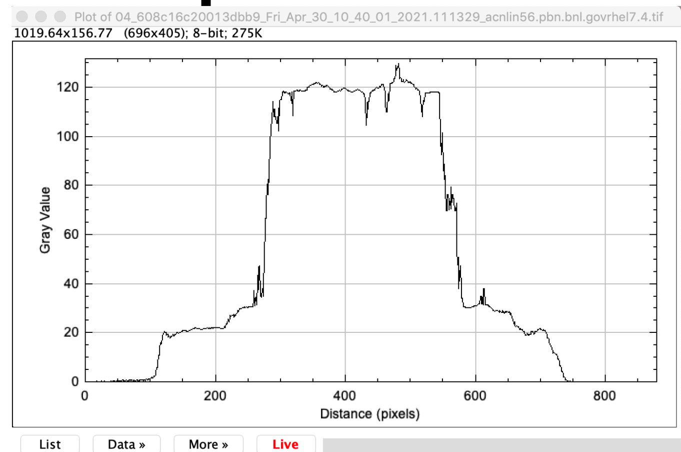
➢Laser intensity jitter does NOT affect the average slice energy much.

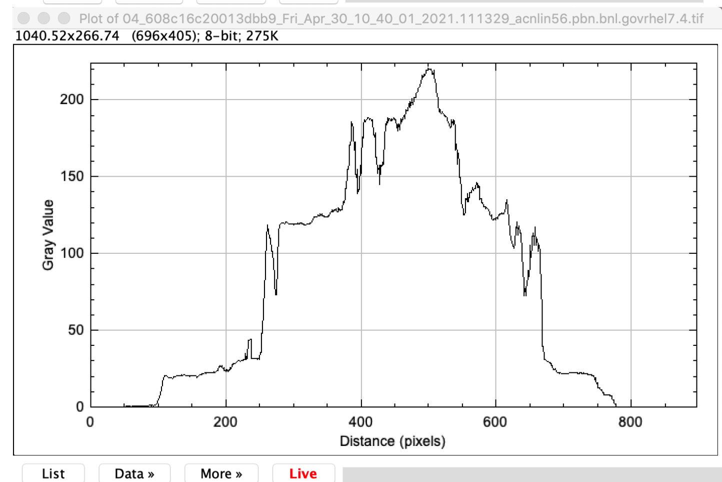
➢A jitter in Laser intensity, i.e., bunch charge variation (+/- 10%) changes slice energy less than 1e-4 (peak to peak) w.r.t. the designed value.

Laser transverse profile









- ➢Laser is not uniform transversely.
- ➢Transverse position vibration needs to be improved by at least 3-4 fold, center of gravity variation should be < 100 um.

Power supply stability

	inj.tv1	inj.th1	inj.tv2	inj.th2	inj.tv3	inj.th3	inj.tv4	inj.th4	inj.tv5	inj.th5
inj.bb0 x	0.0549	-0.5216	-1.1281	-0.0697	0.0207	0.0048	0.0781	-0.0098	-0.1438	0.0841
inj.bb0 y	-0.2167	-0.0253	-0.7484	-0.0495	0.0555	0.0180	0.0848	0.0246	-0.3172	0.0801
inj.bb1 x	-5.8766	17.8352	-39.0242	25.4470	-0.1451	4.0867	0.1105	-0.0125	0.0169	0.0245
inj.bb1 y	14.4986	7.2877	87.8109	9.8005	5.1037	0.0671	0.1833	0.0029	-0.3641	0.1019
inj.bb2 x	5.4753	-15.0073	51.5578	-32.4255	1.0912	-16.9831	-0.4189	1.4029	-7.8548	10.8008
inj.bb2 y	-13.3752	-7.7249	-117.7992	-15.5008	-22.2405	-1.3497	2.0847	-0.0142	14.9316	6.0229
acc.bb x	7.0968	-18.8932	37.8562	-21.8625	-0.7584	2.1057	-5.6408	32.6526	-18.8698	24.8459
acc.bb y	-8.7859	-5.9353	-48.1961	-7.5257	-0.8410	-0.1785	20.5444	2.6579	17.3516	7.9769
dgl.bb x	-2.8766	12.9335	-12.5344	14.6867	1.4306	-1.8357	0.8500	-20.9854	9.3441	-17.0470
dgl.bb y	-39.0604	-22.3430	-232.3023	-30.8307	-12.1616	-1.6680	76.6470	5.3316	72.3577	28.1752
mod.bb1 x	5.7834	-14.6473	36.0977	-20.1173	-0.1074	-2.1598	-3.7542	20.0405	-13.5675	17.3216
mod.bb1 y	34.3707	21.1305	200.7273	28.2269	9.3700	1.2092	-71.2555	-6.8823	-64.8328	-27.1523
mod.bb2 x	28.8797	-5.3276	175.1312	-9.5616	5.8713	-4.1732	-48.0791	18.0144	-56.5759	3.8478
mod.bb2 y	41.1993	35.7795	238.9047	49.2082	12.7216	3.9178	-89.0530	-18.8253	-75.8438	-44.4351
amp.bb1 x	13.5360	-16.6315	87.1852	-27.2636	1.5005	-7.5842	-15.8327	19.7605	-27.3044	16.8852
amp.bb1 y	52.7194	35.4687	309.3430	48.2924	15.8517	2.9635	-108.5767	-13.1598	-97.7105	-44.7060
amp.bb2 x	-5.9285	2.6967	-32.0070	1.3005	-0.6979	-2.5730	10.3170	-10.4639	13.4488	-4.5462
amp.bb2 y	-3.3071	-0.3930	-18.3734	-0.0248	0.0112	0.5241	7.9489	-0.6764	7.3489	1.1284
amp.bb3 x	-24.2095	5.3049	-146.4789	7.6048	-4.9739	1.7716	40.8011	-18.9214	48.7672	-5.2312
amp.bb3 y	-30.5147	-26.4500	-178.6062	-35.1823	-9.5649	-2.0160	66.3441	14.8484	56.4986	33.1961
kck.bb1 x	-14.2131	16.7297	-92.8375	24.8976	-2.3042	5.3716	16.6316	-23.5314	29.5602	-18.2156
kck.bb1 y	-48.1783	-31.8745	-283.3180	-42.5438	-14.5214	-2.2293	99.3027	11.5507	90.0583	40.2389
kck.bb2 x	-28.7308	2.4317	-177.6805	5.9792	-7.1158	4.9083	48.2977	-13.2424	55.2906	0.2184
kck.bb2 y	-35.4825	-34.4695	-206.2773	-48.0158	-11.7848	-5.1358	77.3456	18.5338	64.9616	41.7472
dmp.bb x	20.4227	-2.1326	125.6656	-5.0518	5.2937	-3.9775	-33.9456	9.1307	-38.9394	0.2209
dmp.bb y	18.0555	14.5910	108.0937	18.4565	5.3404	-0.7514	-39.3622	-10.0478	-33.4850	-19.7637

- Upstream trims in LEBT have greater effect in orbit in common section (can exceed 200 mm/A). If 10 um rms orbit stability is required, 5e-5 A rms jitter in power supply needs to be satisfied.
- In Run 21, we observed common section orbit variation is on the order of few tens of um rms.

Figure 1 <@cscompute01.pbn.bnl.gov>

File Edit View Insert Tools Desktop Window Help

CeC BPMs Averaging

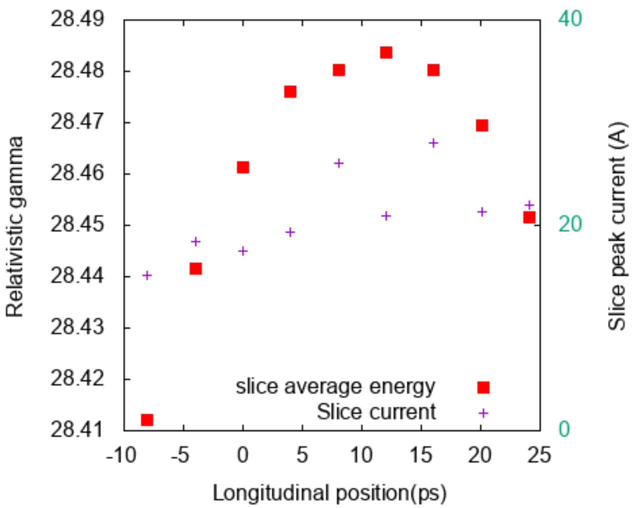
N average	Counter
64	64

Acquire

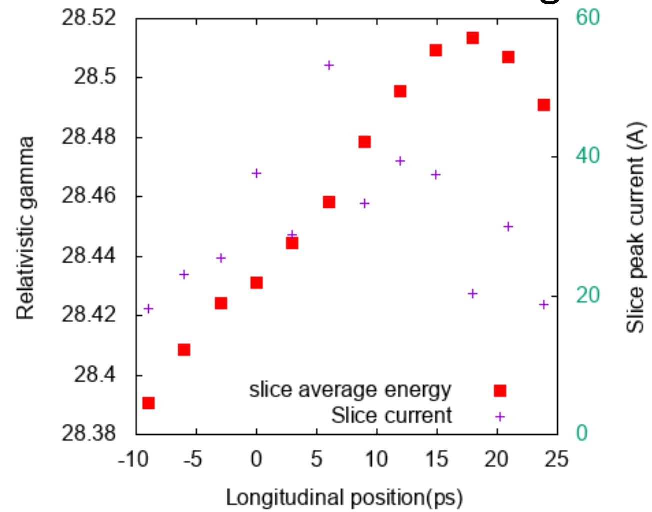
	<X>, mm	<Y>, mm	sigmaX, mm	sigmaY, mm
Buncher BPM	-0.0043	-0.2846	0.0312	0.0290
1st LEBT BPM	0.2195	-0.2828	0.0215	0.0271
2nd LEBT BPM	-0.4596	-2.2054	0.0069	0.0146
Triplet BPM	-2.2587	0.1371	0.0319	0.0217
Dogleg BPM	-0.9267	2.1732	0.0282	0.0817
1st Modulator BPM	0.7195	0.5117	0.0244	0.0148
2nd Modulator BPM	0.3930	-0.0316	0.0322	0.0414
1st amplifier BPM	0.5720	-0.1319	0.0062	0.0241
2nd amplifier BPM	0.5143	-0.2760	0.0249	0.0206
3rd amplifier BPM	0.5507	-0.3718	0.0302	0.0258
1st Kicker BPM	0.3139	0.4085	0.0733	0.0430
2nd Kicker BPM	0.1172	-0.1110	0.0379	0.0185
HP Dump BPM	2.8264	-0.3502	0.0499	0.0301
1st modulator hBPM	1.2369	1.1230	0.3693	0.3558
2nd amplifier hBPM	-0.3288	0.1107	0.0624	0.0483
2nd kicker hBPM	-0.8752	0.6328	0.0683	0.0616

Gun requirements

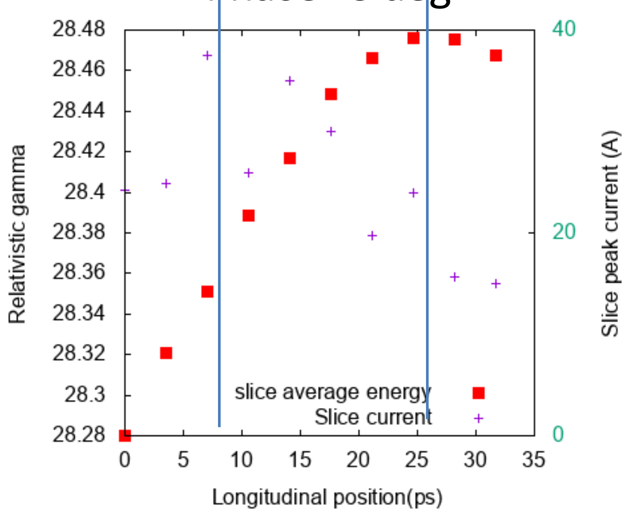
Huge chirp, 2.5 kV/ps



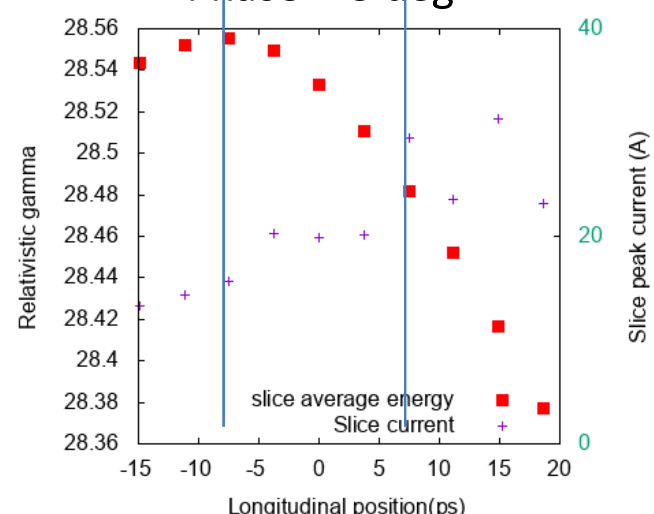
Phase -3 deg



Phase + 3 deg



Voltage -10 kV

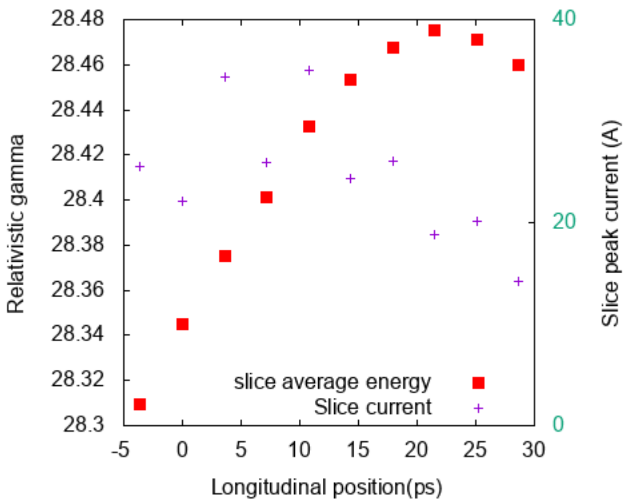


Voltage + 10 kV

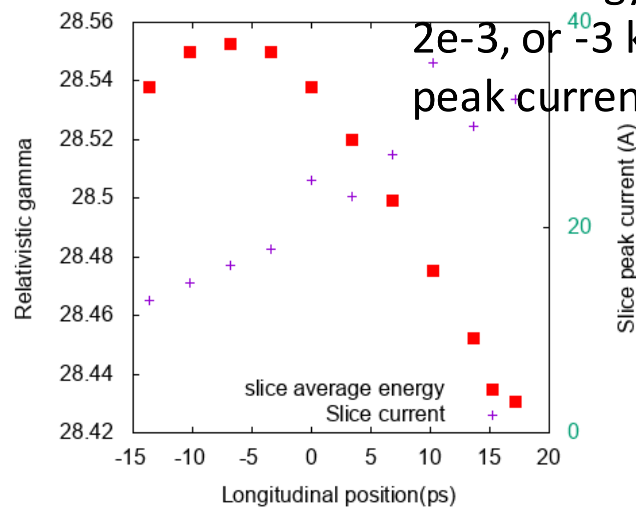
Peak current and energy slices miss each other!

Buncher requirements

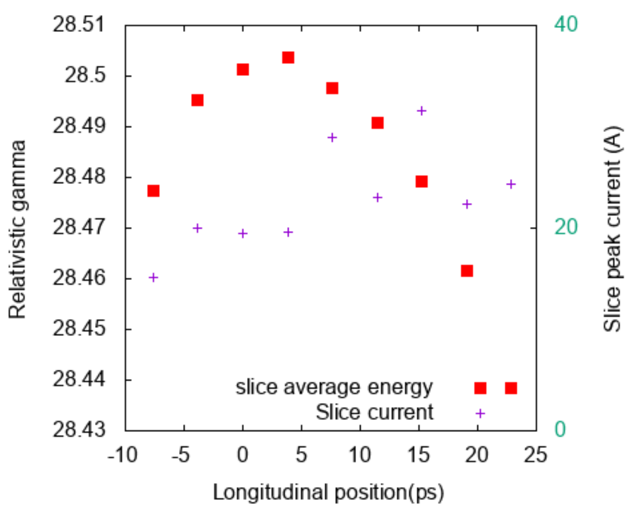
Peak energy changed by 2e-3, or -3 kV/ps chirp for peak current slice



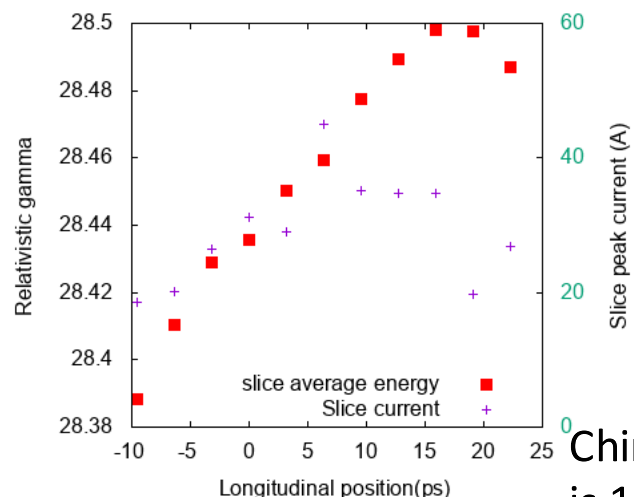
Phase -3 deg



Phase + 3 deg



Voltage -10 kV



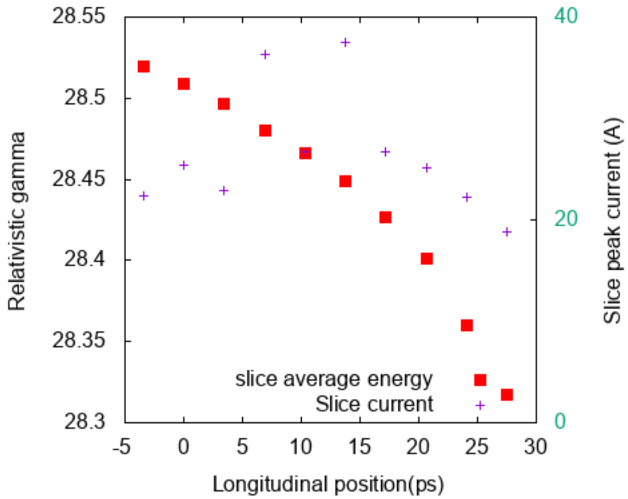
Voltage + 10 kV

Chirp for core is 1.5 kV/ps

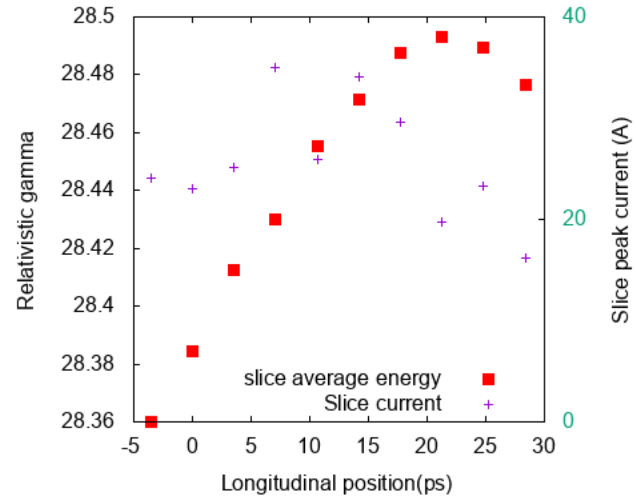
Buncher is very sensitive as it affects the arrival time into linac

Linac requirements

Large chirp +5 kV/ps for core



Phase -2 deg



Phase + 2 deg

- Linac phase needs to be very stable to maintain desirable chirp, 2 deg change in linac phase can cause 25 times larger chirp than tolerable.
- Linac voltage jitter needs to be < 2.5 kV rms to satisfy required energy jitter for cooling (2e-4).
- Orbit jitter into linac should be less than 50 um, detailed study needs further simulation.

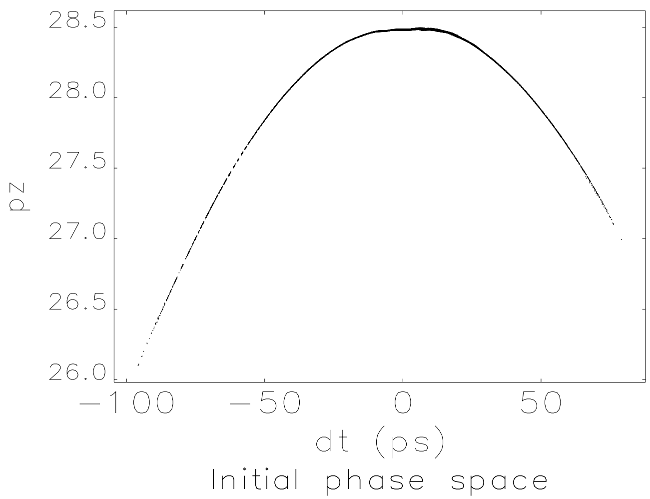
Summary

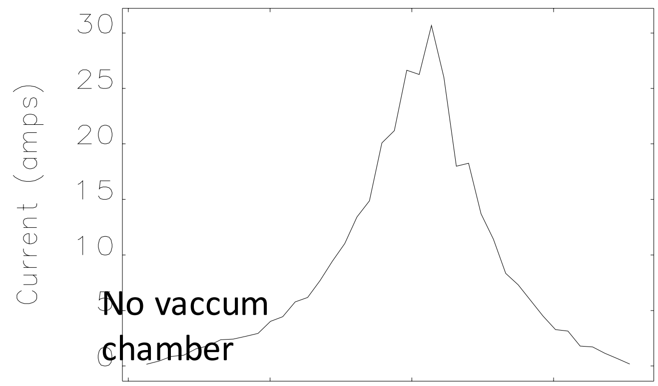
- CeC cooling requires good stability in beam energy (rms 2e-4), proper energy chirp and orbit (rms 10 um) in common section.

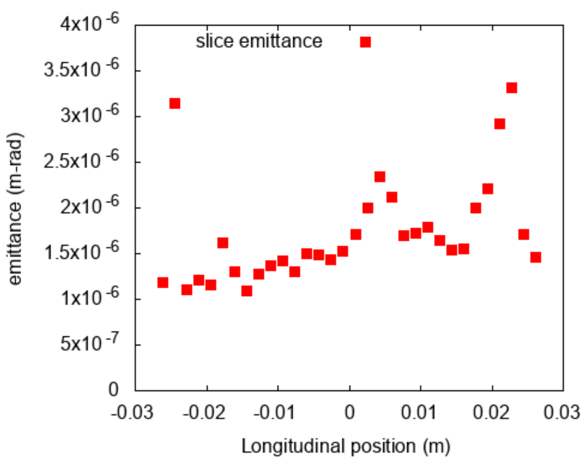
Items	requirements	Beam parameter effect
Laser jitter (ps, rms)	5	2e-4 energy jitter
Laser intensity (rms)	1%, transverse uniformity needs improvement	Peak current variation
Trim PS (A, rms)	5e-5	10 um orbit jitter in common section
Gun phase (deg, rms)	< 0.1	<0.2 kV/ps energy chirp jitter for core
Gun voltage (kV, rms)	< 0.5 kV	< 1 ps separation between peak current and energy
buncher phase (deg, rms)	0.2	Energy jitter < 2e-4, chirp jitter < 0.2 kV/ps
buncher voltage (kV, rms)	1.4	Chirp jitter < 0.2 kV/ps
Linac phase (deg, rms)	< 0.05	Chirp jitter < 0.2 kV/ps
Linac voltage (kV, rms)	2.5	Energy jitter < 2e-4

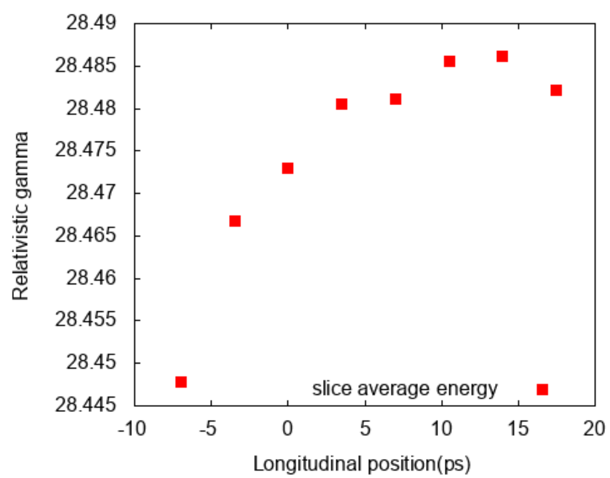
Additional slides

Base line



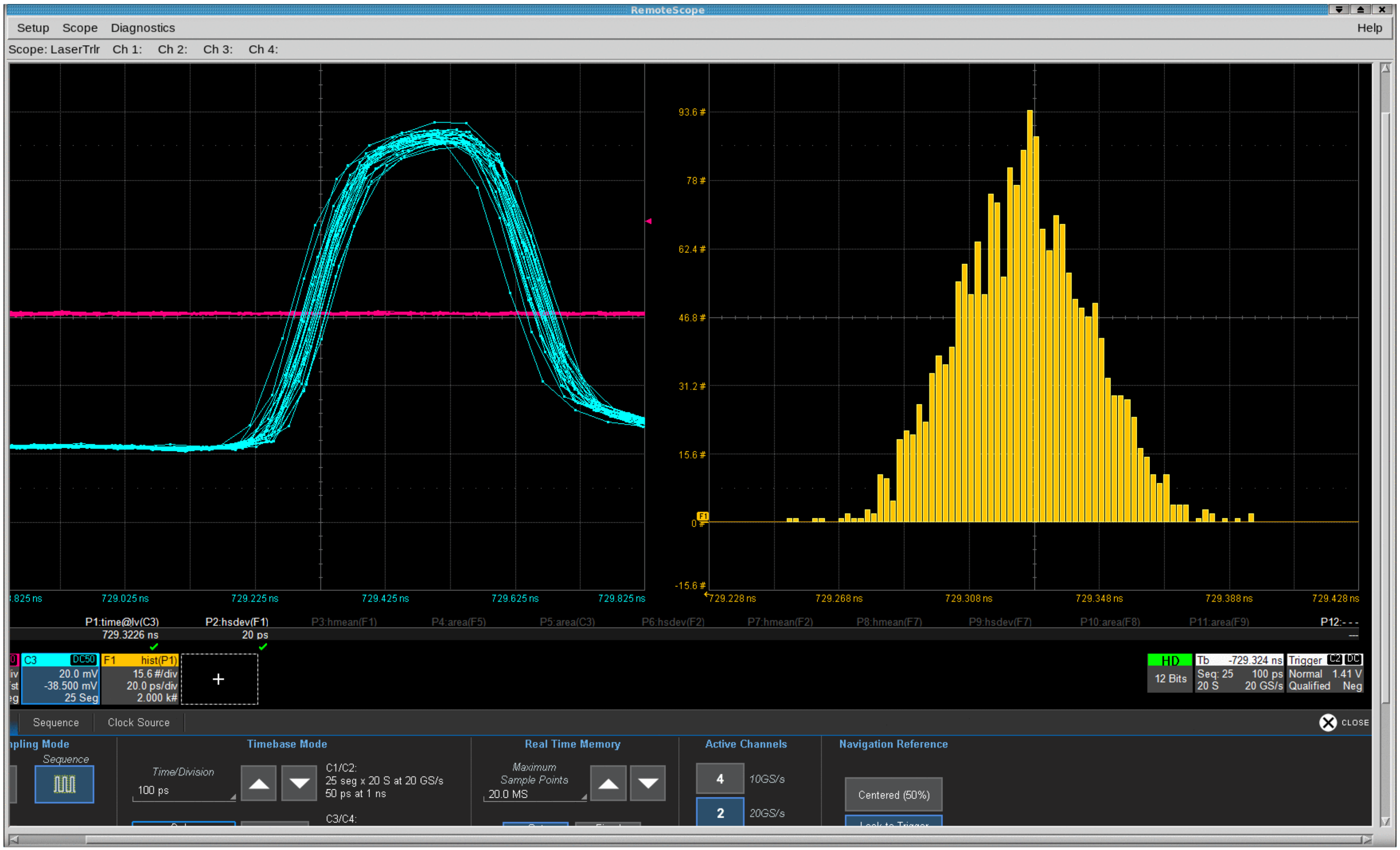




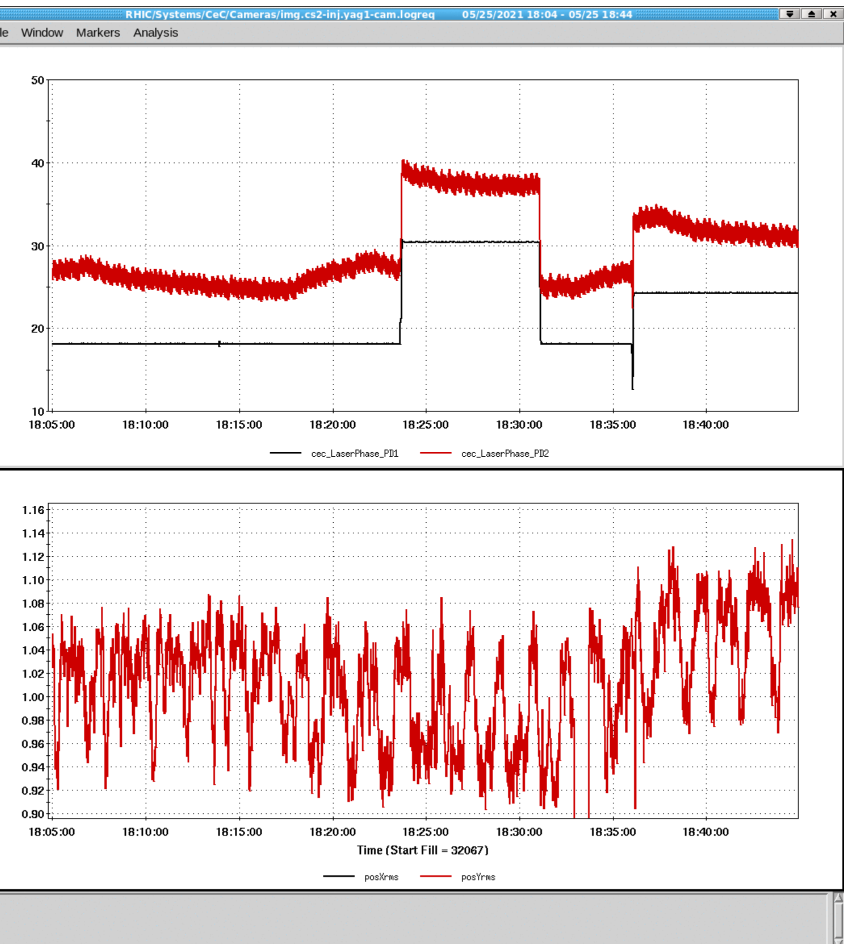


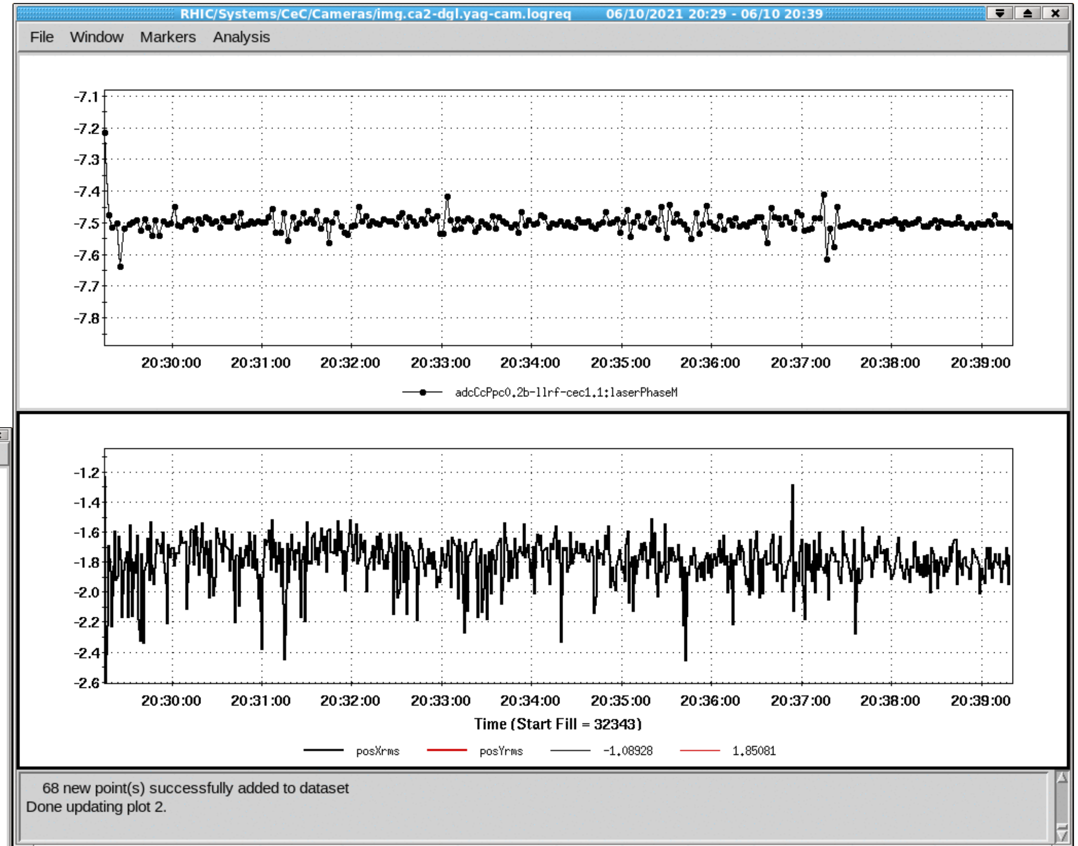
Slice emit < 1.5 for higher current slices.

Measured jitters



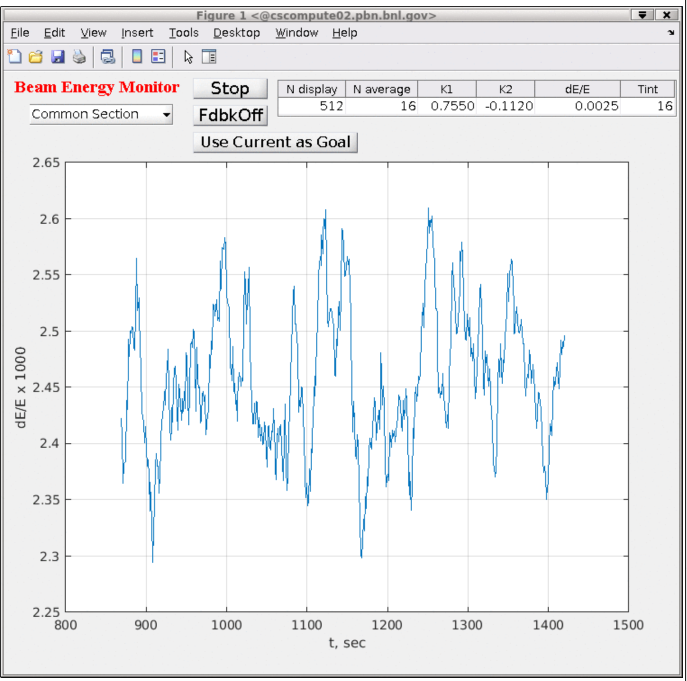
Peak to peak 100 ps

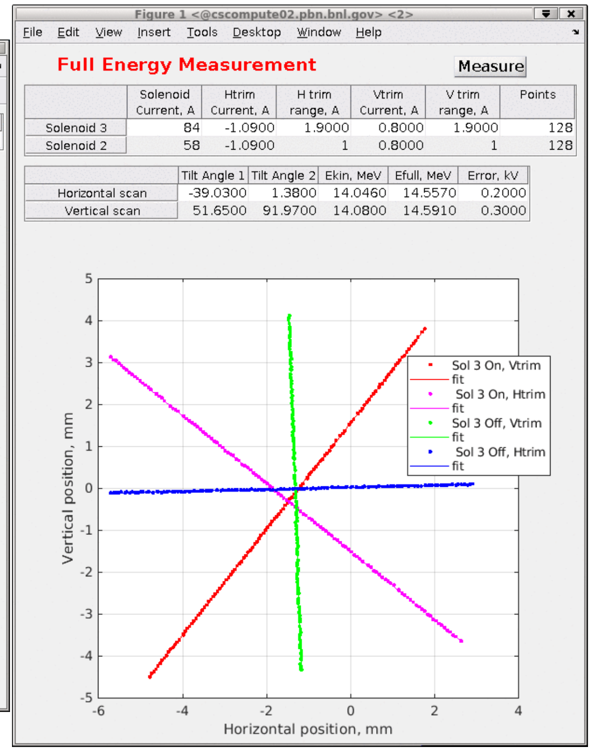


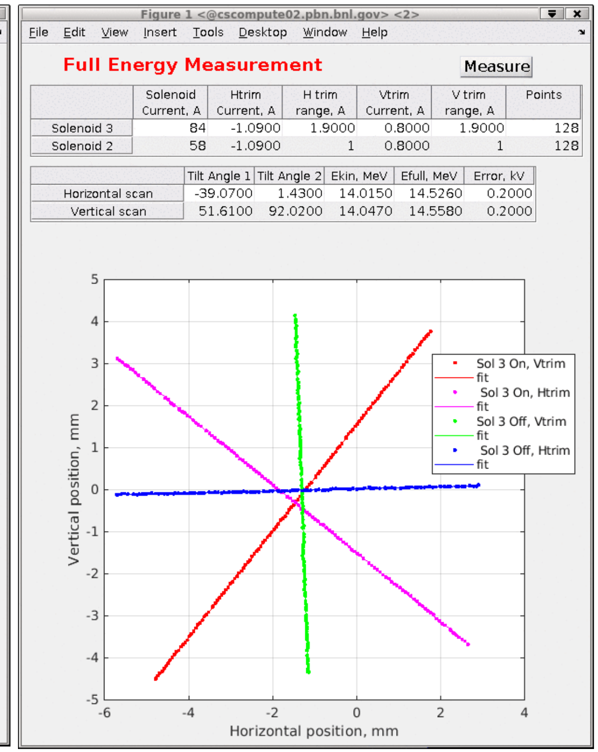


Laser jitter causing serious beam jumps in orbit in LEBT and dogleg

Energy change







Energy change by 2.6e-3 over time