FERMILAB-LU-155

400 MeV Upgrade Linac Parameter Tables

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LU - 155

Abstract

This note consists entirely of parameter tables for the 400 MeV SCL for the linac upgrade. The tables are based on the properties of the structure with the nose cone shape documented in the memo "Linac Upgrade Cavity Parameters" (T. Jurgens, 11 September 1989). The cell lengths have been kept at the values used for the earlier version of these tables (15 May 1989), but the gradients have been adjusted to attain the same exit energies of each section at the same synchronous phase as before. The most noticeable result of the new parameters is the slightly higher power consumption resulting from the increase of gradients to compensate for the slightly lower transit time factors and the intended lower peak surface fields. Included are a Summary Parameter Table, a table of Principal Mechanical Dimensions, a table of Kinematic and Dynamic Quantities, an RF Power Budget, and a table of Numbers Derived from Energy and $\bar{\beta}$. All of these tables are dated 6 December 1989 and should be used in place of earlier or undated versions. Any further revisions will be dated and distributed by means of a Linac Upgrade note (LU - nnn) similar to this.

400 MeV Linac – Summary Parameter Table

6 December 1989

Module /Sect.	Grad. [MV/m]	KE_{out} [MeV]	L_{rf} [m]	L_{sep} [m]	Devices (upstream)	D_Q [m]	P_{Cu} [MW]	P_{beam} [MW]	$\Delta\psi_{x,y}$ [deg]	$\Delta\psi_z$ [deg]
0										
1	2.40	116.5	0.8508	0.3653	Q′/2 B V S	0.3653	0.10	0.00		
2	1.90	116.5	0.4254	0.7227	Q B S W C′	0.6497	0.03	0.00		
			0.0000	1.4218	Q B S W C′ T V B S	0.8560				
			1.2762	2.5098			0.13	0.00		
			3.7859				0.13			
1	8.07									
1		125.1	1.3814	0.1418	Q W C	0.1418	1.75	0.43		
2		133.8	1.4215	0.2628	T Q W	0.1460	1.88	0.44	77	109
3		142.8	1.4606	0.2703	B Q S	0.1501	1.93	0.45		
4		152.1	1.4987	0.2775	B Q S	0.1542	1.91	0.46	78	106
			5.7622	0.9524			7.47	1.78		
			6.7146				9.25			
2	7.85									
1		161.2	1.5353	0.2846	V Q W C	0.1581	1.72	0.46		
2		170.6	1.5704	0.2912	T Q W	0.1618	1.85	0.47	80	103
3		180.2	1.6047	0.2977	B Q 7S/6	0.1654	1.88	0.48		
4		190.0	1.6380	0.3041	B Q 7S/6	0.1689	1.88	0.49	80	101
			6.3484	1.1776			7.33	1.90		
			7.5260				9.23			
3	7.66									
1		199.7	1.6700	0.3102	V Q W C	0.1723	1.70	0.48		
2		209.5	1.7009	0.3161	T Q W	0.1756	1.82	0.49	81	98
3		219.6	1.7309	0.3218	B Q 7S/6	0.1787	1.86	0.50		
4		229.8	1.7600	0.3273	B Q 7S/6	0.1818	1.85	0.51	81	96
			6.8618	1.2754			7.23	1.98		
			8.1372				9.21			
4	7.48									
1		239.9	1.7881	0.3327	V Q W C	0.1848	1.68	0.51		
2		250.1	1.8151	0.3379	T Q W	0.1877	1.79	0.51	81	94
3		260.5	1.8414	0.3428	B Q 4S/3	0.1905	1.84	0.52		
4		271.1	1.8670	0.3477	B Q 4S/3	0.1932	1.83	0.53	80	92
			7.3116	1.3611			7.14	2.07		
			8.6728				9.21			
5	7.34									
1		281.5	1.8917	0.3524	V Q W C	0.1958	1.67	0.52		
2		292.1	1.9155	0.3570	T Q W	0.1983	1.78	0.53	80	90
3		302.8	1.9387	0.3614	B Q 4S/3	0.2007	1.83	0.53		
4		313.6	1.9613	0.3657	B Q 4S/3	0.2031	1.81	0.54	79	89
			7.7072	1.4365			7.09	2.12		
			9.1436				9.21			
6	7.20									
1		324.4	1.9830	0.3698	V Q W C	0.2054	1.66	0.54		
2		335.2	2.0039	0.3738	T Q W	0.2077	1.77	0.54	79	87
3		346.1	2.0244	0.3777	B Q 3S/2	0.2098	1.81	0.55		
4		357.1	2.0443	0.3815	B Q 3S/2	0.2119	1.79	0.55	78	85
			8.0555	1.5028			7.03	2.18		
			9.5583				9.21			
7	7.09									
1		368.1	2.0635	0.3852	V Q W C	0.2140	1.65	0.55		
2		379.1	2.0821	0.3887	T Q W	0.2159	1.76	0.55	77	84
3		390.2	2.1002	0.3921	B Q 3S/2	0.2178	1.80	0.56		
4		401.5	2.1179	0.3955	B Q 3S/2	0.2197	1.78	0.56	76	82
			8.3637	1.5614			6.99	2.22		
			9.9251				9.21			
Grand			51.6866	11.7770			50.27	14.25		
Total			63.4637				64.66			

Symbol	Device	Length [cm]
B	beam position monitor	3.00
C	current pickup	1.00
C′	bunch length monitor	30.00
Q	standard quadrupole	8.60
Q′	DTL quadrupole	16.76
S	steering trim magnet	6.00
T	toroid current monitor	3.10
V	vacuum gate valve	4.90
W	wire scanner	5.00

Note: Available for devices $3\beta\lambda/2$ – 9.92 cm.

400 MeV Linac Upgrade - Principal Mechanical Dimensions

Module /Sect.	KE_{out} [MeV]	L_{rf} [m]	L_{sep} [m]	L_{cum} [m]	Devices (upstream)	D_Q [m]	L_{device} [m]	L_{cell} [m]	L_{gap} [m]
0									
1	116.5	0.85078	0.36526	1.21604	Q'/2 B V S	0.36526	0.2228	0.08508	0.03717
2	116.5	0.42539	0.72270	2.36414	Q B S W C'	0.64970	0.4830	0.08508	0.03717
		0.00000	1.42180	3.78594	Q B S T C' V B S Q/2	0.85602	0.6890		
		1.27618	2.50976						
1									
1	125.1	1.38139	0.14178	5.30911	Q/2 W C	0.14178	0.0920	0.08634	0.03782
2	133.8	1.42149	0.26285	6.99345	T Q W	0.14601	0.1560	0.08884	0.03911
3	142.8	1.46059	0.27027	8.72431	B Q S	0.15013	0.1760	0.09129	0.04038
4	152.1	1.49870	0.27751	10.50051	B Q S	0.15416	0.1760	0.09367	0.04162
		5.76217	0.95241						
2									
1	161.2	1.53531	0.28456	12.32038	V Q W C	0.15807	0.1740	0.09596	0.04282
2	170.6	1.57045	0.29123	14.18207	T Q W	0.16178	0.1560	0.09815	0.04397
3	180.2	1.60468	0.29774	16.08448	B Q 7S/6	0.16539	0.1860	0.10029	0.04509
4	190.0	1.63801	0.30407	18.02656	B Q 7S/6	0.16891	0.1860	0.10238	0.04619
		6.34845	1.17760						
3									
1	199.7	1.67006	0.31023	20.00685	V Q W C	0.17233	0.1740	0.10438	0.04725
2	209.5	1.70085	0.31608	22.02378	T Q W	0.17558	0.1560	0.10630	0.04827
3	219.6	1.73088	0.32178	24.07644	B Q 7S/6	0.17875	0.1860	0.10818	0.04927
4	229.8	1.76002	0.32733	26.16379	B Q 7S/6	0.18183	0.1860	0.11000	0.05024
		6.86181	1.27542						
4									
1	239.9	1.78810	0.33272	28.28461	V Q W C	0.18483	0.1740	0.11176	0.05118
2	250.1	1.81512	0.33786	30.43758	T Q W	0.18768	0.1560	0.11344	0.05209
3	260.5	1.84141	0.34285	32.62185	B Q 4S/3	0.19045	0.1960	0.11509	0.05297
4	271.1	1.86702	0.34772	34.83658	B Q 4S/3	0.19316	0.1960	0.11669	0.05384
		7.31164	1.36115						
5									
1	281.5	1.89170	0.35245	37.08073	V Q W C	0.19579	0.1740	0.11823	0.05467
2	292.1	1.91549	0.35697	39.35319	T Q W	0.19830	0.1560	0.11972	0.05547
3	302.8	1.93866	0.36137	41.65322	B Q 4S/3	0.20074	0.1960	0.12117	0.05626
4	313.6	1.96134	0.36566	43.98022	B Q 4S/3	0.20312	0.1960	0.12258	0.05703
		7.70719	1.43645						
6									
1	324.4	1.98297	0.36983	46.33301	V Q W C	0.20544	0.1740	0.12394	0.05777
2	335.2	2.00394	0.37381	48.71076	T Q W	0.20765	0.1560	0.12525	0.05848
3	346.1	2.02437	0.37769	51.11282	B Q 3S/2	0.20981	0.2060	0.12652	0.05918
4	357.1	2.04426	0.38147	53.53856	B Q 3S/2	0.21191	0.2060	0.12777	0.05986
		8.05553	1.50281						
7									
1	368.1	2.06350	0.38516	55.98721	V Q W C	0.21395	0.1740	0.12897	0.06052
2	379.1	2.08209	0.38869	58.45799	T Q W	0.21592	0.1560	0.13013	0.06116
3	390.2	2.10021	0.39213	60.95033	B Q 3S/2	0.21783	0.2060	0.13126	0.06178
4	401.5	2.11787	0.39548	63.46368	B Q 3S/2	0.21969	0.2060	0.13237	0.06239
		8.36367	1.56145						

Devices Needed in Inter-tank Spaces

Symbol	Device	Length [cm]
B	beam position monitor	3.00
C	current pickup	1.00
C'	bunch width monitor	30.00
Q	standard quadrupole	8.00
Q'	DTL quadrupole	16.76
S	steering trim magnet	6.00
T	toroid current monitor	3.10
V	vacuum gate valve	4.90
W	wire scanner	3.90

Note: Available for devices $3\beta\lambda/2 - 9.92$ cm.

400 MeV Linac Upgrade - Kinematic and Dynamic Quantities

Module /Sect.	KE_{out} [MeV]	L_{rf} [m]	γ	β	$\bar{\beta}$	$\beta\gamma$	$\Delta\psi_{x,y}$ [deg]	$\Delta\psi_z$ [deg]	$\hat{\beta}$ [m]	$\check{\beta}$ [m]	β_φ [deg/keV]
0									4.72	2.65	0.0601
1	116.54	0.8508	1.12421	0.456904	0.456904	0.513655					
2	116.54	0.4254	1.12421	0.456904	0.456904	0.513655					
1									8.65	1.06	0.0131
1	125.06	1.3814	1.13329	0.470527	0.463663	0.533244					
2	133.83	1.4215	1.14264	0.483816	0.477121	0.552826	77	109	8.11	0.98	0.0127
3	142.84	1.4606	1.15223	0.469773	0.490245	0.572398					
4	152.07	1.4987	1.16207	0.509398	0.503034	0.591957	78	106	8.33	1.03	0.0116
2											
1	161.25	1.5353	1.17186	0.521344	0.515325	0.610941					
2	170.63	1.5704	1.18186	0.532984	0.527119	0.629912	80	103	8.49	1.07	0.0109
3	180.21	1.6047	1.19207	0.544320	0.538609	0.648867					
4	189.98	1.6380	1.20248	0.555356	0.549796	0.667807	80	101	8.66	1.13	0.0101
3											
1	199.69	1.6701	1.21282	0.565829	0.560552	0.686251					
2	209.56	1.7009	1.22335	0.576027	0.570889	0.704680	81	98	8.78	1.18	0.0095
3	219.60	1.7309	1.23404	0.585954	0.580969	0.723093					
4	229.79	1.7600	1.24491	0.595616	0.590748	0.741490	81	96	8.92	1.24	0.0089
4											
1	239.91	1.7881	1.25569	0.604804	0.600174	0.759446					
2	250.17	1.8151	1.26662	0.613749	0.609241	0.777388	81	94	9.02	1.29	0.0085
3	260.56	1.8414	1.27770	0.622457	0.618069	0.795315					
4	271.09	1.8670	1.28893	0.630932	0.626662	0.813227	80	92	9.13	1.36	0.0080
5											
1	281.55	1.8917	1.30007	0.639024	0.634946	0.830779					
2	292.13	1.9155	1.31135	0.646903	0.642932	0.848317	80	90	9.22	1.42	0.0077
3	302.83	1.9387	1.32276	0.654574	0.650708	0.865842					
4	313.65	1.9613	1.33428	0.662044	0.658322	0.883354	79	89	9.31	1.49	0.0073
6											
1	324.36	1.9830	1.34570	0.669174	0.665580	0.900510					
2	335.18	2.0039	1.35724	0.676120	0.672619	0.917655	79	87	9.38	1.55	0.0071
3	346.11	2.0244	1.36888	0.682886	0.679476	0.934789					
4	357.13	2.0443	1.38063	0.689477	0.686155	0.951911	78	85	9.47	1.63	0.0068
7											
1	368.08	2.0635	1.39230	0.695797	0.692611	0.968755					
2	379.12	2.0821	1.40406	0.701957	0.698852	0.985590	77	84	9.53	1.69	0.0066
3	390.25	2.1002	1.41592	0.707959	0.704933	1.002414					
4	401.46	2.1179	1.42788	0.713809	0.710860	1.019230	76	82	9.62	1.79	0.0063

400 MeV Upgrade Linac - RF Power Budget

Module /Sect.	Grad. [MV/m]	KE_{out} [MeV]	L_{rf} [m]	P_{acc} [MW]	P_{bridge} [MW]	P_{beam} [MW]	P_{total} [MW]
0							
1	2.40	116.5	0.8508	0.10	0.00	0.00	0.10
2	1.90	116.5	0.4254	0.03	0.00	0.00	0.03
				0.13	0.00	0.00	0.13
1	8.07						
1		125.1	1.3814	1.75	0.00	0.43	2.18
2		133.8	1.4215	1.77	0.11	0.44	2.32
3		142.8	1.4606	1.79	0.14	0.45	2.38
4		152.1	1.4987	1.80	0.11	0.46	2.37
				7.10	0.36	1.78	9.25
2	7.85						
1		161.2	1.5353	1.72	0.00	0.46	2.18
2		170.6	1.5704	1.74	0.11	0.47	2.32
3		180.2	1.6047	1.75	0.13	0.48	2.36
4		190.0	1.6380	1.77	0.11	0.49	2.37
				6.98	0.35	1.90	9.23
3	7.66						
1		199.7	1.6701	1.70	0.00	0.48	2.18
2		209.6	1.7009	1.71	0.11	0.49	2.31
3		219.6	1.7309	1.73	0.13	0.50	2.36
4		229.8	1.7600	1.74	0.11	0.51	2.36
				6.88	0.35	1.98	9.21
4	7.48						
1		239.9	1.7881	1.68	0.00	0.51	2.19
2		250.2	1.8151	1.69	0.10	0.51	2.30
3		260.6	1.8414	1.71	0.13	0.52	2.36
4		271.1	1.8670	1.72	0.11	0.53	2.36
				6.80	0.34	2.07	9.21
5	7.34						
1		281.6	1.8917	1.67	0.00	0.52	2.19
2		292.1	1.9155	1.68	0.10	0.53	2.31
3		302.8	1.9387	1.70	0.13	0.53	2.36
4		313.6	1.9612	1.71	0.10	0.54	2.35
				6.76	0.33	2.12	9.21
6	7.20						
1		324.4	1.9830	1.66	0.00	0.54	2.20
2		335.2	2.0039	1.67	0.10	0.54	2.31
3		346.1	2.0244	1.68	0.13	0.55	2.36
4		357.1	2.0443	1.69	0.10	0.55	2.34
				6.70	0.33	2.18	9.21
7	7.09						
1		368.1	2.0635	1.65	0.00	0.55	2.20
2		379.1	2.0821	1.66	0.10	0.55	2.31
3		390.2	2.1002	1.67	0.13	0.56	2.36
4		401.5	2.1179	1.68	0.10	0.56	2.34
				6.66	0.33	2.22	9.21
Grand Total				48.02	2.39	14.25	64.66

400 MeV Linac - Numbers derived from Energy and $\bar{\beta}$ 6 Dec. 89

W [MeV]	β	γ	$\beta \times \gamma$	$\bar{\beta}$	L_{rf} [m]	L_{sep} [m]	L_{sec} [m]	L_{cum} [m]	D_Q [m]	L_{cell} [cm]	L_{gap} [cm]	T	ZT^2 [MΩ/m]	E_{max} (E_o = 1 MeV)
116.540	0.4569042	1.1242070	0.5136549	0.4569042	0.0000000	0.0000000	0.0000000	3.7859380	0.0000000	8.50785	3.71685	0.84288	36.028	4.485
125.064	0.4705271	1.1332915	0.5332444	0.4636630	1.3813930	0.1417834	1.5231763	5.3091145	0.1417834	8.63371	3.78171	0.84405	36.511	4.497
133.831	0.4838164	1.1426358	0.5528260	0.4771208	1.4214878	0.2628456	1.6843334	6.9934478	0.1460107	8.88430	3.91123	0.84623	37.440	4.522
142.835	0.4967732	1.1522324	0.5723981	0.4092452	1.4605894	0.2702693	1.7308587	8.7243061	0.1501346	9.12868	4.03801	0.84816	38.302	4.545
152.068	0.5093977	1.1620729	0.5919573	0.5030373	1.4987009	0.2775072	1.7762080	10.5005140	0.1541552	9.36688	4.16204	0.84987	39.101	4.566
					5.7621713	0.9524055	6.7145762							
161.249	0.5213445	1.1718572	0.6109414	0.5153251	1.5353101	0.2845595	1.8198696	12.3203840	0.1580728	9.59569	4.28159	0.85137	39.833	4.586
170.633	0.5329843	1.1818583	0.6299120	0.5271194	1.5704489	0.2912332	1.8616821	14.1820660	0.1617800	9.81531	4.39673	0.85268	40.501	4.604
180.213	0.5443201	1.1920691	0.6488671	0.5386087	1.6046789	0.2977354	1.9024143	16.0844803	0.1653920	10.02924	4.50925	0.85385	41.121	4.622
189.984	0.5553564	1.2024832	0.6678067	0.5497959	1.6380091	0.3040678	1.9420769	18.0265579	0.1689087	10.23756	4.61916	0.85489	41.697	4.639
					6.3484473	1.1775960	7.5260434							
199.686	0.5658294	1.2128234	0.6862511	0.5605521	1.6700550	0.3102329	1.9802879	20.0068455	0.1723344	10.43784	4.72516	0.85580	42.223	4.656
209.559	0.5760269	1.2233453	0.7046798	0.5708887	1.7008508	0.3160833	2.0169342	22.0237789	0.1755843	10.63032	4.82732	0.85660	42.706	4.672
219.596	0.5859540	1.2340434	0.7230927	0.5809689	1.7308829	0.3217798	2.0526628	24.0764427	0.1787487	10.81802	4.92722	0.85732	43.154	4.688
229.794	0.5956159	1.2449124	0.7414896	0.5907477	1.7600169	0.3273253	2.0873423	26.1637859	0.1818292	11.00011	5.02440	0.85796	43.568	4.703
					6.8618059	1.2754214	8.1372280							
239.907	0.6048038	1.2556906	0.7594464	0.6001737	1.7880999	0.3327226	2.1208224	28.2846088	0.1848274	11.17562	5.11831	0.85853	43.948	4.719
250.165	0.6137490	1.2666225	0.7773883	0.6092413	1.8151150	0.3378552	2.1529701	30.4375782	0.1876785	11.34447	5.20889	0.85904	44.297	4.734
260.561	0.6224568	1.2777035	0.7953152	0.6180689	1.8414149	0.3428522	2.1842670	32.6218452	0.1904544	11.50884	5.29728	0.85951	44.621	4.749
271.094	0.6309325	1.2889293	0.8132274	0.6266615	1.8670150	0.3477165	2.2147315	34.8365784	0.1931565	11.66884	5.38352	0.85993	44.921	4.764
					7.3116450	1.3611465	8.6727915							
281.552	0.6390242	1.3000746	0.8307791	0.6349463	1.8916979	0.3524512	2.2441490	37.0807266	0.1957866	11.82311	5.46687	0.86031	45.197	4.779
292.132	0.6469032	1.3113513	0.8483174	0.6429324	1.9154910	0.3569714	2.2724624	39.3531876	0.1982976	11.97182	5.54738	0.86066	45.450	4.793
302.833	0.6545745	1.3227557	0.8658422	0.6507084	1.9386580	0.3613727	2.3000307	41.6532173	0.2007425	12.11661	5.62594	0.86098	45.685	4.808
313.650	0.6620435	1.3342844	0.8833544	0.6583221	1.9613415	0.3656581	2.3269997	43.9802170	0.2031230	12.25838	5.70302	0.86129	45.904	4.823
					7.7071886	1.4364533	9.1436424							
324.365	0.6691743	1.3457040	0.9005105	0.6655803	1.9829658	0.3698304	2.3527963	46.3330116	0.2054408	12.39354	5.77665	0.86157	46.103	4.838
335.185	0.6761203	1.3572365	0.9176551	0.6726194	2.0039375	0.3738138	2.3777514	48.7107620	0.2076536	12.52461	5.84820	0.86183	46.287	4.853
346.109	0.6828862	1.3688791	0.9347887	0.6794760	2.0243654	0.3776940	2.4020593	51.1128197	0.2098090	12.65228	5.91802	0.86208	46.458	4.868
357.133	0.6894767	1.3806283	0.9519110	0.6861549	2.0442638	0.3814736	2.4257374	53.5385590	0.2119086	12.77665	5.98615	0.86232	46.616	4.883
					8.0555334	1.5028118	9.5583448							
368.080	0.6957971	1.3922955	0.9687552	0.6926112	2.0634992	0.3851551	2.4486544	55.9872131	0.2139537	12.89687	6.05212	0.86255	46.762	4.898
379.119	0.7019565	1.4040607	0.9855895	0.6988517	2.0820916	0.3886859	2.4707775	58.4579926	0.2159150	13.01307	6.11600	0.86278	46.896	4.913
390.248	0.7079588	1.4159217	1.0024141	0.7049331	2.1002100	0.3921265	2.4923365	60.9503288	0.2178263	13.12631	6.17835	0.86299	47.020	4.927
401.464	0.7138085	1.4278760	1.0192300	0.7108598	2.1178672	0.3954796	2.5133469	63.4636765	0.2196889	13.23667	6.23921	0.86321	47.135	4.942
					8.3636684	1.5614470	9.9251156							