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Abstract

Based on existing sources, I compile parameters for the RF systems for a neutrino factory which accelerates to 10 GeV.

Table 1: RF parameters for the buncher (Table X in [1], with some rounding where appropriate). f_{RF} is the the cavity RF frequency, G_{RF} is the RF gradient for cavities of that frequency, L_{textRF} is the length of cavities with that RF frequency, n_{cav} is the number of cavities with that frequency, V_{tot} is the total voltage of all cavities with that frequency, and P_{tot} is the total peak power required for all cavities with that frequency.

f_{RF} MHz	G_{RF} MV/m	L_{cav} m	n_{cav}	V_{tot} MV	P_{tot} MW
319.63	3.42	0.40	1	1.37	0.2
305.56	4.89	0.40	2	3.92	0.6
293.93	4.17	0.45	2	3.34	0.5
285.46	5.34	0.45	2	4.80	1.0
278.59	6.36	0.45	2	5.72	1.3
272.05	4.94	0.45	3	6.66	1.5
265.80	5.61	0.45	3	7.57	1.5
259.83	6.30	0.45	3	8.48	2.0
254.13	6.97	0.45	3	9.41	2.3
248.67	7.65	0.45	4	10.33	2.3
243.44	8.31	0.45	4	11.23	2.5
238.42	9.01	0.45	4	12.16	3.0
233.61	9.71	0.45	4	13.11	3.5
			37	98.10	22.2

Table 2: RF parameters for the phase rotation (Table XI in [1]). See Table 1 for column definitions. P_{RF} is the peak RF power required *per cavity*, in contrast to Table 1. All cavities are 0.5 m long. The total peak RF power is 144.8 MW.

f_{RF} MHz	G_{RF} MV/m	P_{RF} MW	n_{cav}	V_{tot} MV
230.19	13.0	2.2	3	19.5
226.13	13.0	2.2	3	19.5
222.59	13.0	2.3	3	19.5
219.48	13.0	2.4	3	19.5
216.76	13.0	2.4	3	19.5
214.37	13.0	2.5	3	19.5
212.48	13.0	2.5	3	19.5
210.46	13.0	2.6	3	19.5
208.64	13.0	2.6	4	26.0
206.90	13.0	2.7	4	26.0
205.49	13.0	2.7	4	26.0
204.25	13.0	2.7	5	32.5
203.26	13.0	2.8	5	32.5
202.63	13.0	2.8	5	32.5
202.33	13.0	2.8	5	32.5
			56	364.0

1. Front End

I describe the RF systems for the front end that is given in the Interim Design Report of the International Design Study for the Neutrino Factory [1].

The front end consists of three subsystems: buncher, phase rotation, and cooling. The buncher creates a train of bunches, each having a different average energy. The phase rotation makes the energies of the bunch trains the same. The cooling then reduces the transverse emittance of the bunches. The buncher begins with a low gradient and an RF frequency higher than the desired period of the bunch train. As one goes down the beamline, the RF frequency decreases and the gradient increases. The RF parameters for the buncher are given in Table 1. Once in the phase rotation, the RF frequency continues to decrease down the beamline from its final value in the buncher down to the desired frequency for the bunch train. The RF gradient stays at a constant high value in the phase rotation. The RF parameters for the phase rotation are given in Table 2. In the cooling, all cavities have the same gradient (16 MV/m) and an RF frequency (201.25 MHz) matching the desired bunch train frequency. There are 130 cavities, each with a length of 0.5 m, a gradient of 16 MV/m, and requiring a peak RF power of 4.3 MW. The total installed voltage in the cooling is 880 MV. From Study II [2], the pulse length from the power source is 125 μs.

The totals for the front end sections are summarized in

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Table 3: Summary of RF totals for the front end.

	Count	Voltage	Power
Buncher	37	98.10 MV	22.2 MW
Rotation	56	364.0 MV	144.8 MW
Cooling	130	880 MV	559 MW

Table 4: Parameters for the RF cavities and their power supplies, taken from [2]. The single cell cavity's parameters are derived from the double cell cavity parameters by cutting appropriate values in half.

RF frequency (MHz)	201.25	201.25	201.25
Aperture diameter (mm)	300	460	460
Cells per cavity	2	1	2
Energy gain/cavity (MeV)	25.5	11.25	22.5
Stored energy/cavity (J)	2008	966	1932
Input power/cavity (kW)	1016	490	980
RF on time (ms)	3	3	3
Loaded Q	10^6	10^6	10^6

Table 3.

2. Acceleration

The acceleration systems consist of a linac, an RLA, and an FFAG. For the purposes of this paper, the linac will accelerate to 1.2 GeV, the RLA will accelerate to 5 GeV in 4.5 turns, and the FFAG will accelerate to 10 GeV in about 6.5 turns.

There are two types of superconducting cavities described in [2] which we will consider, the parameters for which are given in Table 4.

The linac design has been modified from [1] to consist entirely of cells with either one single-cell 460 mm aperture cavity or one double-cell 460 mm aperture cavity [3]. We take the design in [3] and add cells with on-crest acceleration to the end to accelerate the beam to 1.2 GeV total energy. The resulting linac has 24 single-cell 460 mm aperture cavities and 32 double-cell 460 mm aperture cavities.

For the first RLA, I scale up the amount of linac required from the design in [3], but using two-cell 460 mm aperture cavities. Conservatively, I believe 42 such cavities will be required.

For the FFAG, a preliminary design has 38 two-cell 300 mm aperture cavities.

The cavities used in the acceleration are summarized in Table 5.

[1] R. J. Abrams *et al.*, "Interim Design Report," arXiv:1112.2853 (2011).

[2] S. Ozaki, R. Palmer, M. Zisman, and J. Gallardo, eds., "Feasibility Study-II of a Muon-Based Neutrino Source," BNL-52623 (2001).

[3] S. A. Bogacz, V. S. Morozov, Y. R. Roblin, K. B. Beard, A. Kurup, M. Aslaninejad, C. Bontoiu, and J. K. Pozimski, "Recent Progress Toward a Muon Recirculating Linear Accelerator," in *Proceedings of IPAC2012, New Orleans, Louisiana, USA* (IEEE, 2012) 1422.

Table 5: Summary of cavities used in acceleration.

	Diameter	Cells	Count
Linac	460 mm	1	24
Linac	460 mm	2	32
RLA	460 mm	2	42
FFAG	300 mm	2	38