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MODIFICATIONS TO BASELINE ISL DESIGN DUE TO THE LARGE RANGE OF (q/A)

JOHN EDIGHOFFER

Center for Beam Physics, Lawrence Berkeley Laboratory, Berkeley, California, CA 91720, USA

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The ISL baseline post-accelerator design as described in the ISL concept document[1] cannot match the velocity profile of RFQ1 and RFQ2 over the full charge to mass ratios required without some modification. The minimum modification needed is to add an rf accelerating module between RFQ1 and RFQ2. At this workshop for the purpose of minimizing the longitudinal phase space growth, a prebuncher/chopper system was added in front of RFQ1. This allows the added rf acceleration module to be placed in front of RFQ1, allowing RFQ1 to be at ground potential. This is a nice solution if the buncher/chopper system can handle the width range of energy per nucleon. This solution provides for a constant velocity profile past the rf acceleration module for all species of ions.

KEY WORDS: RQF, emittance, bunching

Figure 1 shows the ISL baseline post accelerator and Table 1 shows the operational parameters as a function of charge to mass. First, RFQ1 would have to have a variable velocity profile, impossible over the range required. Second, for q/A between 1/6 and 1/8, the ions exiting RFQ1 would have to have a negative energy in order to have the right energy by the time they reach RFQ2; of course they would simply be lost.

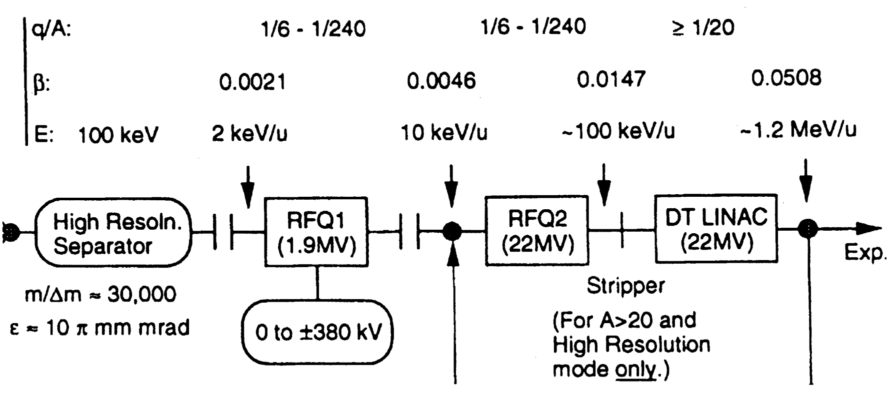

FIGURE 1: Baseline ISL Post Accelerator Concept

TABLE 1: Baseline ISL Concept

q/A	Voltage at Output of High Resolution Separator (KeV/u)	DC Voltage Applied to RFQ1 Housing to get 2 Kev/u at the Entrance (KeV)	Voltage at Output of RFQ1 so that the Input to RFQ2 is 10 KeV/u (KeV/u)	Acceleration due to RFQ1 (KeV)	Acceleration due to RFQ1 (KeV/u)	Voltage at Input of RFQ2 (KeV/u)	Voltage at Output of RFQ2 (KeV/u)
1/6	16.67	88	**-4.67**	-40	**-6.67**	10	100
1/7	14.29	86	**-2.29**	-30	**-4.29**	10	100
1/8	12.50	84	**-0.50**	-20	**-2.50**	10	100
1/9	11.11	82	**0.89**	-10	**-1.11**	10	100
1/12	8.33	76	**3.67**	20	**1.67**	10	100
1/18	5.56	64	**6.44**	80	**4.44**	10	100
1/24	4.17	52	**7.83**	140	**5.83**	10	100
1/32	3.13	36	**8.88**	220	**6.88**	10	100
1/48	2.08	4	**9.92**	380	**7.92**	10	100
1/72	1.39	-44	**10.61**	620	**8.61**	10	100
1/96	1.04	-92	**10.96**	860	**8.96**	10	100
1/120	0.83	-140	**11.17**	1100	**9.17**	10	100
1/180	0.56	-260	**11.44**	1700	**9.44**	10	100
1/240	0.42	-380	**11.58**	2300	**9.58**	10	100

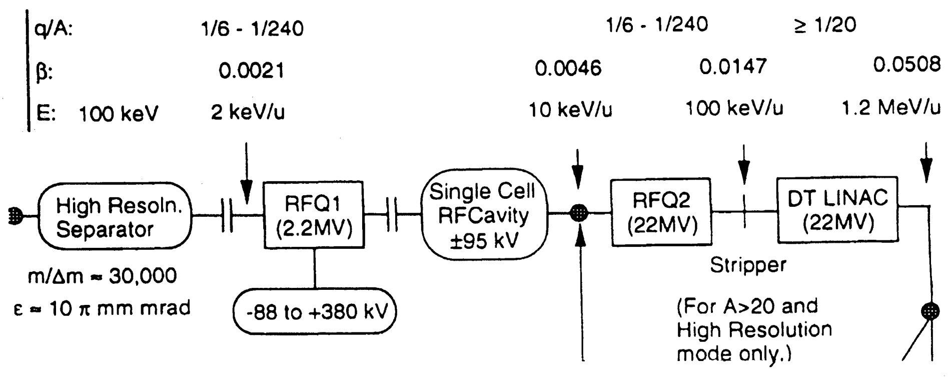

FIGURE 2: Modified ISL Post Accelerator Concept with RF Module after RFQ1

Figure 2 shows the first possible modification to the ISL baseline, that of adding a accelerating module after the DC accelerating between RFQ1 and RFQ2. This is also shown in the updated ISL document.[2] Table 2 shows the resulting operating parameters as a function of q/A. The output energy per nucleon has been optimized so as to minimize the acceleration required by the rf acceleration module. RFQ1 can now have a fixed velocity profile. There is no longer a problem of particles going through zero energy for an ion. The rf acceleration is low enough that a single rf cavity would be sufficient.

TABLE 2: Modified ISL Concept with Rf Acceleration after RFQ1

q/A	Voltage at Output of High Resolution Separator (KeV/u)	DC Voltage Applied to RFQ1 to get 2 Kev/u at the Entrance (KeV)	Voltage at Output of RFQ1 so that the Input to RFQ2 is 10 KeV/u (KeV/u)	Acceleration due to RFQ1 (KeV)	Acceleration due to RFQ1 (set to 9.19) (KeV/u)	Voltage at Entrance to Single Cell (KeV)	Acceleration due to Rf Module (KeV)	Voltage at Input of RFQ2 (KeV/u)	Voltage at Output of RFQ2 (KeV/u)
1/6	16.67	88	11.19	55.14	9.19	155.14	-95.14	10	100
1/7	14.29	86	11.19	64.33	9.19	164.33	-94.33	10	100
1/8	12.50	84	11.19	73.52	9.19	173.52	-93.52	10	100
1/9	11.11	82	11.19	82.71	9.19	182.71	-92.71	10	100
1/12	8.33	76	11.19	110.28	9.19	210.28	-90.28	10	100
1/18	5.56	64	11.19	165.42	9.19	265.42	-85.42	10	100
1/24	4.17	52	11.19	220.56	9.19	320.56	-80.56	10	100
1/32	3.13	36	11.19	294.08	9.19	394.08	-74.08	10	100
1/48	2.08	4	11.19	441.12	9.19	541.12	-61.12	10	100
1/72	1.39	-44	11.19	661.68	9.19	761.68	-41.68	10	100
1/96	1.04	-92	11.19	882.24	9.19	982.24	-22.24	10	100
1/120	0.83	-140	11.19	1102.8	9.19	1202.80	-2.80	10	100
1/180	0.56	-260	11.19	1654.2	9.19	1754.20	45.80	10	100
1/240	0.42	-380	11.19	2205.6	9.19	2305.60	94.40	10	100

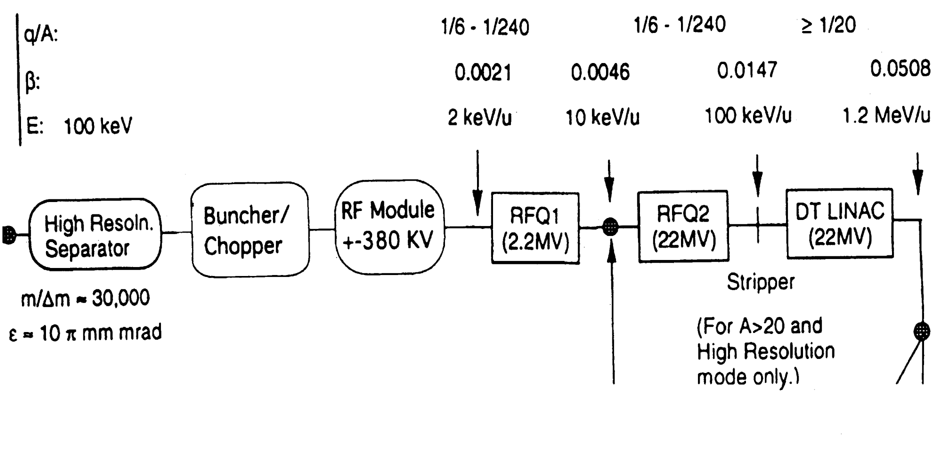

FIGURE 3: Modified ISL Post Accelerator Concept with RF Module before RFQ1 and RFQ1 Grounded

Figure 3 shows the second possible modification, allowed by the decision to add a prebuncher/chopper in front of RFQ1. That is the adding of the rf acceleration module in front of RFQ1 instead of after it. This allows the removal of the HV DC acceleration into and out of RFQ1. Table 3 shows the operating parameters for this case. This modification also provides a constant velocity profile after the rf acceleration module. This is a very nice solution if the buncher/chopper proves practical over the full charge to mass ratio. The rf acceleration module requires more acceleration capability (380 KeV vs. 95 KeV) and is

TABLE 3: Modifield ISL Concept with Rf Acceleration before RFQ1 (RFQ1 is at Ground).

q/A	Energy at Output of High Resolution Separator (KeV/u) (100 KeV)	Energy at Output of Buncher (KeV/u)	RF Acceleration Before RFQ1 So that the energy is 2 Kev/u at Entrance (KeV)	Energy at Input of RFQ1 (KeV/u)	Energy at Output of RFQ1 (KeV/u)	Acceleration due to RFQ1 (KeV)	Energy at Input of RFQ2 (KeV/u)
1/6	16.67	16.67	-88	2.00	10.00	48	10
1/7	14.29	14.29	-86	2.00	10.00	56	10
1/8	12.50	12.50	-84	2.00	10.00	64	10
1/9	11.11	11.11	-82	2.00	10.00	72	10
1/12	8.33	8.33	-76	2.00	10.00	96	10
1/18	5.56	5.56	-64	2.00	10.00	144	10
1/24	4.17	4.17	-52	2.00	10.00	192	10
1/32	3.13	3.13	-36	2.00	10.00	256	10
1/48	2.08	2.08	-4	2.00	10.00	384	10
1/72	1.39	1.39	44	2.00	10.00	576	10
1/96	1.04	1.04	92	2.00	10.00	768	10
1/120	0.83	0.83	140	2.00	10.00	960	10
1/180	0.56	0.56	260	2.00	10.00	1440	10
1/240	0.42	0.42	380	2.00	10.00	1920	10

therefore probably more than a single cell. The actual design acceleration may well be higher due to the need to help with the bunching/debunching as part of the total buncher/chopper system.

Conclusion: Either modification will over come the problem of matching the energy into and out of the first two RFQ's. The second solution is highly preferred, but contingent on developing a buncher/chopper design that can be flexible enough to handle the full range of ions. The rf acceleration module is part of the buncher/chopper system design, that is the buncher/chopper system design must include the rf acceleration module.

REFERENCES

1. "The IsoSpin Laboratory (ISL) Research Opportunities with Radioactive Nuclear Beams", LALP 91-51, 1991.
2. Nitschke, "Future Propects for Radioactive Nuclear Beams in North America", LBL-34239, Proc. of the International School Seminar on Heavy Ion Physics, May 1993, Dubna, Russia.