ONE DESIGN OF HEAVY ION LINAC INJECTOR FOR CSRm

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Abstract

The design of heavy ion linac as one new injector of the main Cooling Storage Ring (CSRm) has been discussed. The linac design is based on interdigital H mode drift tube with KONUS (Kombinierte Null Grad Struktur). A high acceleration rate with zero degree synchronous particle phase acceleration reduces the length of IH-KONUS linac and the cost in comparison with conventional linac based on Alvarez structure. To reduce the effect of emittance growth, he RFQ structure is used in front of the IH-KONUS linac. In this linac, the design particle $^{238}U^{28+}$ will be accelerated to 7 AMeV, and the transmission of Uranium beam can reach up to 80%. In this report, the initial physics design of the main linac is presented.

INTRODUCTION

HIRFL-CSR (Heavy Ion research Facility in Lanzhou-Cooling storage Ring) has been built and supplied 7000 hours operation time. As the user number increasing and the experimental requirement improved, the injection linac is proposed, which will make the operation time to improve by 2000 hours. The whole HIRFL-CSR Layout with CSR-LINAC injector is shown in figure.1.

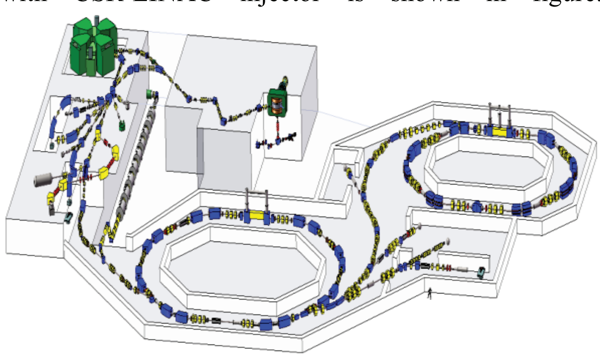

Figure 1: The whole HIRFL-CSR Layout with CSR-LINAC injector.

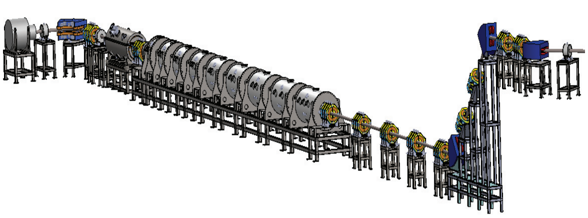

Figure 2: The 3-Dimensional Map of the heavy ion linac for CSRm.

The new linac injector will accelerate $^{238}U^{28+}$ to 7AMeV and the operation frequency is chosen to 108.48 MHz [1] [2]. The main parameters are summarized in table.1. The heavy ion linac consists of electron cyclotron resonance ion source, low energy beam transport, radio frequency quadrupole linac, medium energy beam transport and drift tube linac. The 3-Dimensional Map of the heavy ion linac injector for CSRm is shown in figure.2.

Table 1: Heavy Ion Injection Linac Main Parameters

Ion source	parameter
Particles	C, Ar, Xe, Pb, U
Superconducting ECRIS	$^{208}Pb^{35+}$, $^{238}U^{28+}$
Beam current (emA)	0.05-0.15 (pulsed)
Emittance (pi.mm.mrad)	0.4 (normalized, 90%)
Voltage（KV）	25-40
RFQ	parameter
Input energy (AkeV)	4
Exact energy (AkeV)	300
q/A	1/8.5
Frequency (MHz)	108.48
maximum power (kW)	250
Duration (ms)	10
Repetition (Hz)	10
Duty factor	2%
Transmission (design)	>90%
emittance (pi.mm.mrad)	<0.8 (normalized, 90%)
IH-DTL	Parameter
Input energy (AkeV)	300
Exact energy (AMeV)	7
q/A	1/8.5
Frequency (MHz)	108.48/216.96
Duration (ms)	10
Repetition (Hz)	10
Duty factor	2%
emittance (pi.mm.mrad)	0.8 (normalized, 90%)
Output momentum spread	< ±0.15%
Transmission (design)	> 90%

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RFQ BEAM DYNAMICS DESIGN

Because of the transverse focusing and longitudinal bunching simultaneously, Radio Frequency Quadrupole is greatly important in linear accelerator. In this scheme, 4-rod structure is adopted in order to high impedance and good electric field stability at 108.48MHz. The energy acceleration range is from 4AkeV to 300AkeV and the pole length is 202 cm [3]. the 0 mA and 3 mA simulation is done and the comparison is shown table.2.

Table 2: 0mA and 3mA RFQ Main Parameter Comparison

Beam	$^{238}U^{28+}$	$^{238}U^{28+}$	
structure	4rod	4rod	
Frequency	108.48	108.48	MHz
Duty cycle	2	2	%
Beam current	0	3	mA
Input energy	4	4	AkeV
Output energy	300	300	AkeV
Vane Length	202	202	Cm
Voltage	80	80	KV
Transmission	98	94	%
Power losses	100	100	KW
Impedance	130	130	KΩ/m
RF power	100	108	KW
Cell number	157	157	
Modulation	2.5	2.5	
Min. aperture	2.7	2.7	Mm
Ein_total	200	200	Pi.mm.mrad
Ein_norm	0.1	0.1	Pi.mm.mrad
Eout_norm	0.1	0.1	Pi.mm.mrad
TiwssP_in	-0.47 0.03 40.7	-0.47 0.03 40.7	— mm/mrad mrad/mm
TiwssP_out,x	-1.39 0.22 13.3	-1.56 0.25 13.89	— mm/mrad mrad/mm
TiwssP_out,y	1.67 0.285 12.1	1.77 0.3 13.8	— mm/mrad mrad/mm
TiwssP_out,z	0 0.087 11.4	- 0.1450. 125 8.17	— ns/AkeV AkeV/ns

DTL DESIGN

The IH-KONUS structure is used in the main acceleration section. The frequency is 108.48MHz until the particle energy reaches 1.4AMeV and in the post acceleration section 217.96MHz is applied until the particle energy reach 7AMeV. The total length is 19.96 m, including 10 cavities. The main parameter is shown in table.3.

LORASR code is applied for the IH-KONUS drift tube linac design, which is dedicated for KONUS structure. In case of the minimum emittance growth, the initial physics design is finished [4]. Figure.3 shows the x and y transverse envelope along the linac. Figure.4 shows the energy and phase spread along the linac. Figure.5 exhibits the phase space distribution at the entrance and exit of the DTL section. Figure.6 exhibits the relative emittance along the linac.

Table 3: The Main Acceleration Section Parameters

Particle	$^{238}U^{28+}$	
Current	0	mA
A/q	8.5	
Frequency	108.48/216.96	MHz
No. of Tank	10	
No. of Gaps	217	
Energy range	0.3-7	AMeV
Total length	1996.1	Cm
Transmission	100	%
Pulse cycle	2	%
TwissP_out,x	1.8588 3.0821 1.4454	— mm/mrad mrad/mm
TwissP_out,y	1.3666 2.8722 0.9984	— mm/mrad mrad/mm
TwissP_out,z	0.8435 0.0061 281.314	— ns/AkeV AkeV/ns
Emittance_x (Norm, 90%)	0.15718	Pi.mm.mrad
Emittance_y (Norm, 90%)	0.14135	Pi.mm.mrad
Emittance_z (Norm, 90%)	0.62009	AkeV*ns

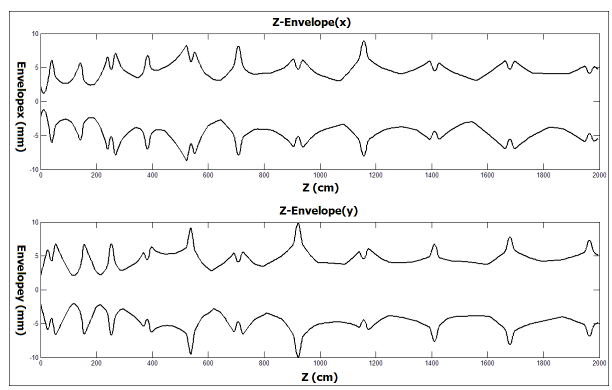

Figure 3: The x and y transverse envelope along the linac.

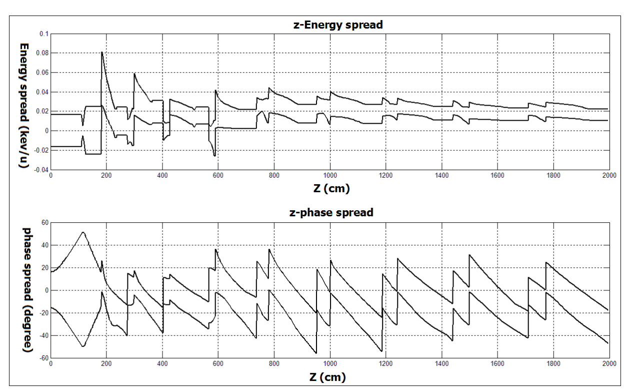

Figure 4: The energy and phase spread along the linac

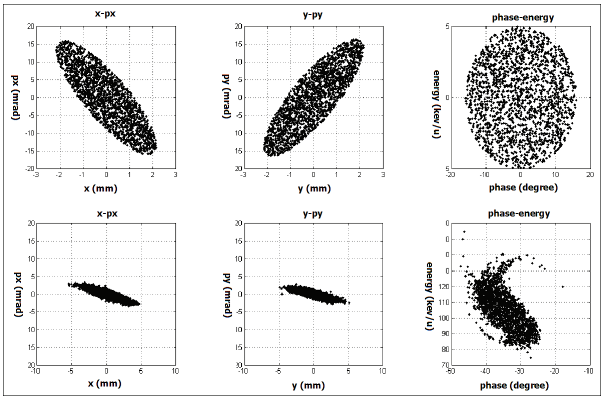

Figure 5: The phase space distribution at the entrance and exit of the DTL section.

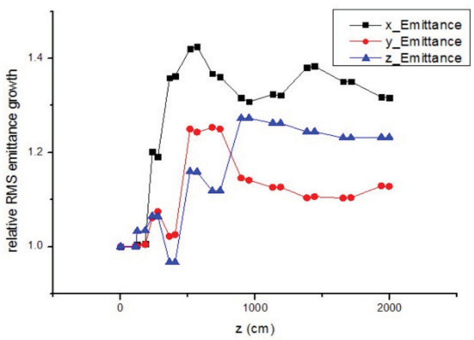

Figure 6: The relative emittance growth along the linac.

CONCLUSIONS

The heavy ion linac injector is very important for staring more comprehensive physical experiments and improving operation efficiency. Compared with the cyclotron injector, the linear accelerator can supply higher current and smaller emittance beam. Moreover, the Linac has larger beam acceptance and higher transmission [5].

LORASR and Beampath code will be applied for the whole physical design and optimization process. Beampath code will be well used for the end-to-end simulation and optimization, besides error analysis.

However, much more work will be done in the future.

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