EBIS Injector Linac

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MAC Review
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- LEBT
- RFQ
- MEBT
- LINAC
- Injection into the Booster

Acknowledgments

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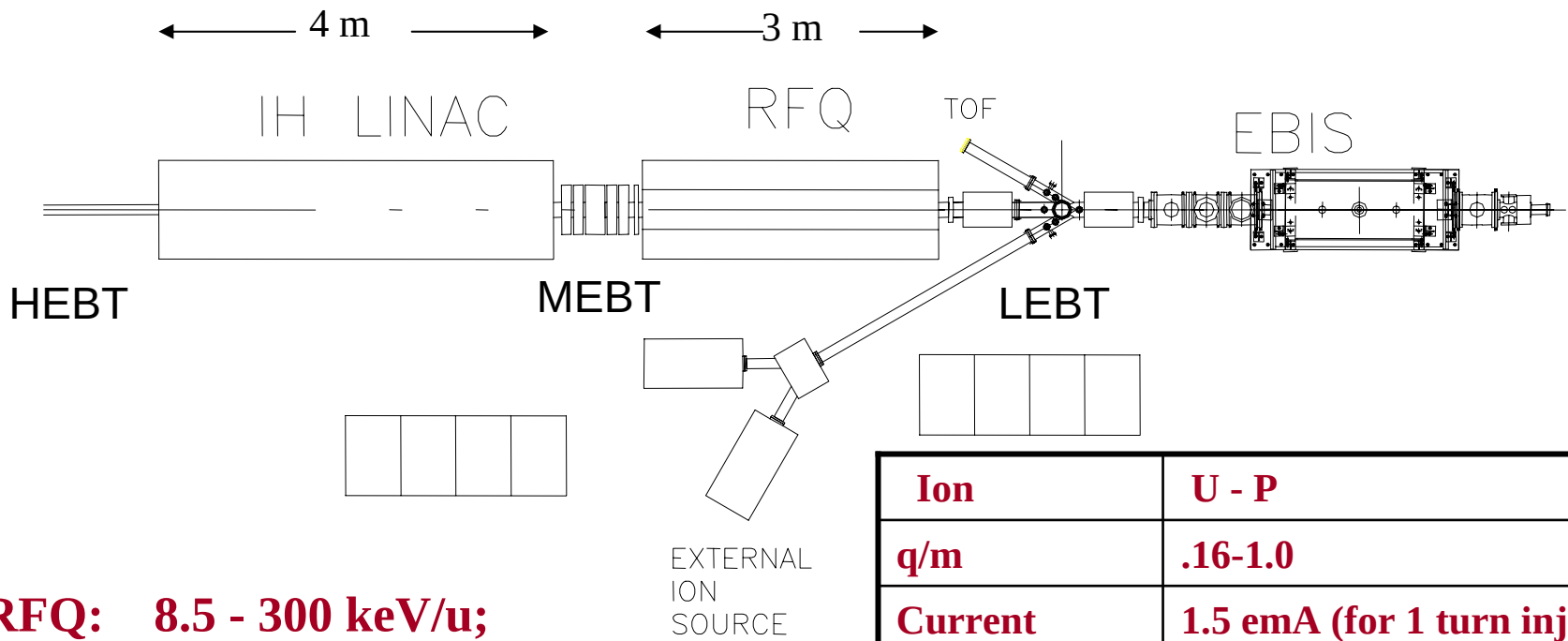
Proposed Linac –Based RHIC Preinjector



RFQ: 8.5 - 300 keV/u; 100 MHz

IH Linac: 0.3 - 2.0 MeV/u; 100 MHz

Ion	U - P
q/m	.16-1.0
Current	1.5 emA (for 1 turn inj)
Pulse Length Rep. Rate Duty Factor	10 μs 5 Hz 0.005 %
Emittance	0.7 π mm rad (nor, 90%)
Energy Spread	0.7 keV/amu

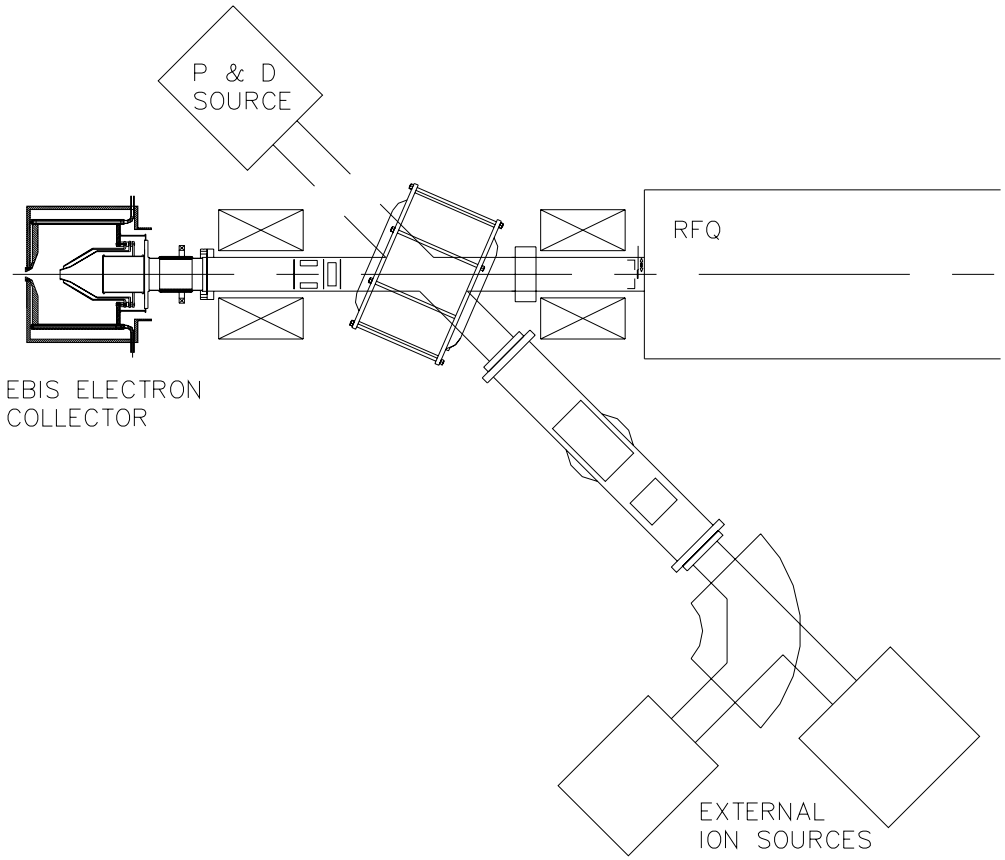
LEBT Requirements

-Inject singly-charged ions into EBIS
-Extract highly charged ions from EBIS
-Diagnostics: Emittance Monitor, Current Monitor(2), TOF
-Matching into RFQ

Twiss parameters at beginning and end of the LEBT

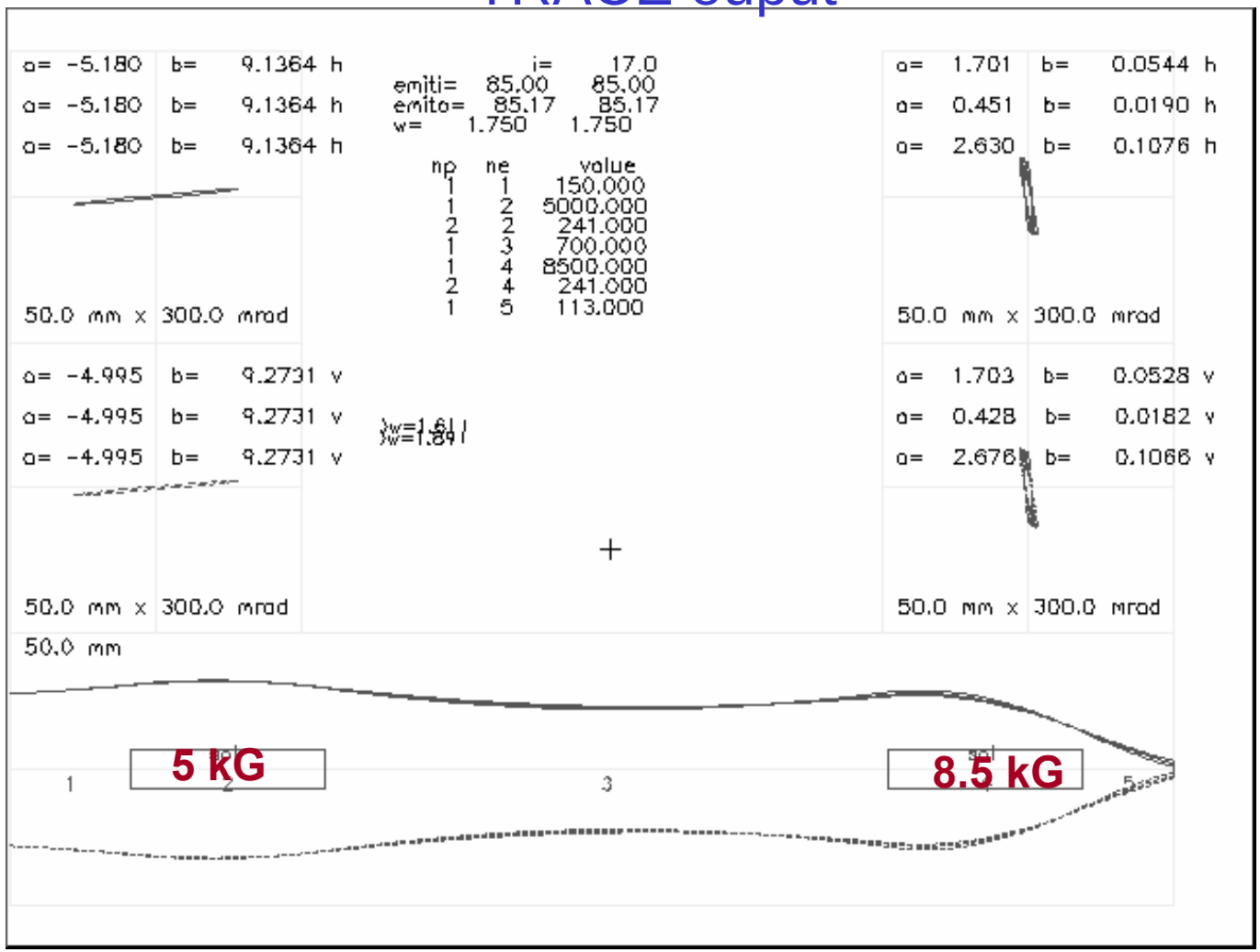
Parameters	Begin. of LEBT	End of LEBT	Units
α_X	-5.180	2.630	
β_X	9.136	0.1076	mm/mrad
ε_X (4* rms,unnorm)	85.00	85.17	π mm mrad
α_Y	-5.180	2.630	
β_Y	9.136	0.1076	mm/mrad
ε_Y (4* rms,unnorm)	85.00	85.17	π mm mrad

LEBT with magnetic solenoid focusing is shown as the baseline. Designs with electrostatic focusing are also being considered.



LEBT Optics (Solenoid focusing)

TRACE ouput

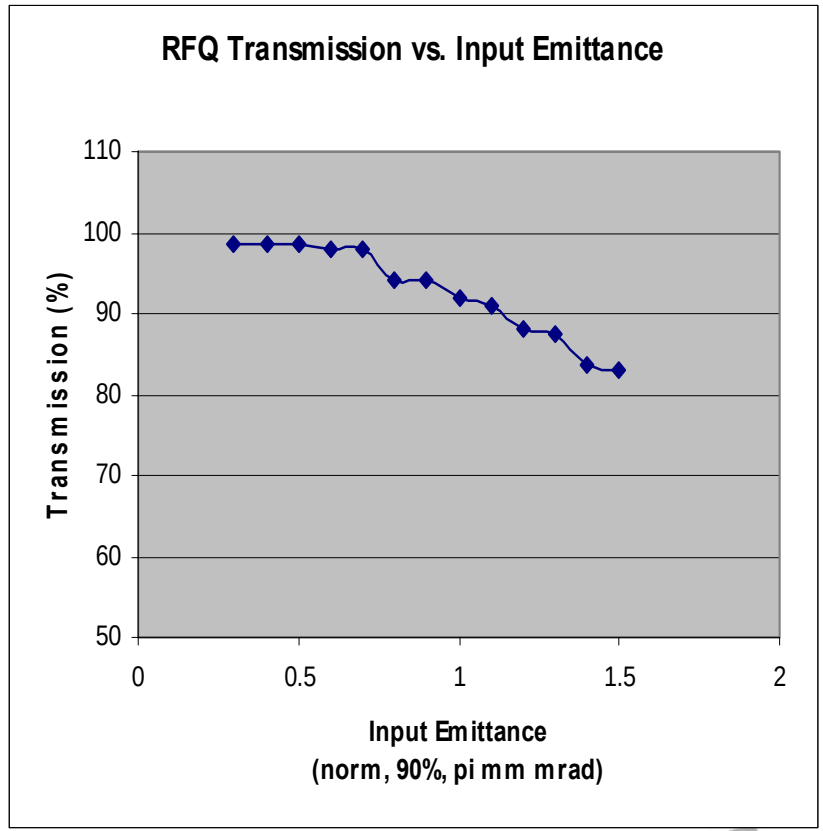


RFQ Parameters

-Proven technology, No risks
-Could accelerate P - U

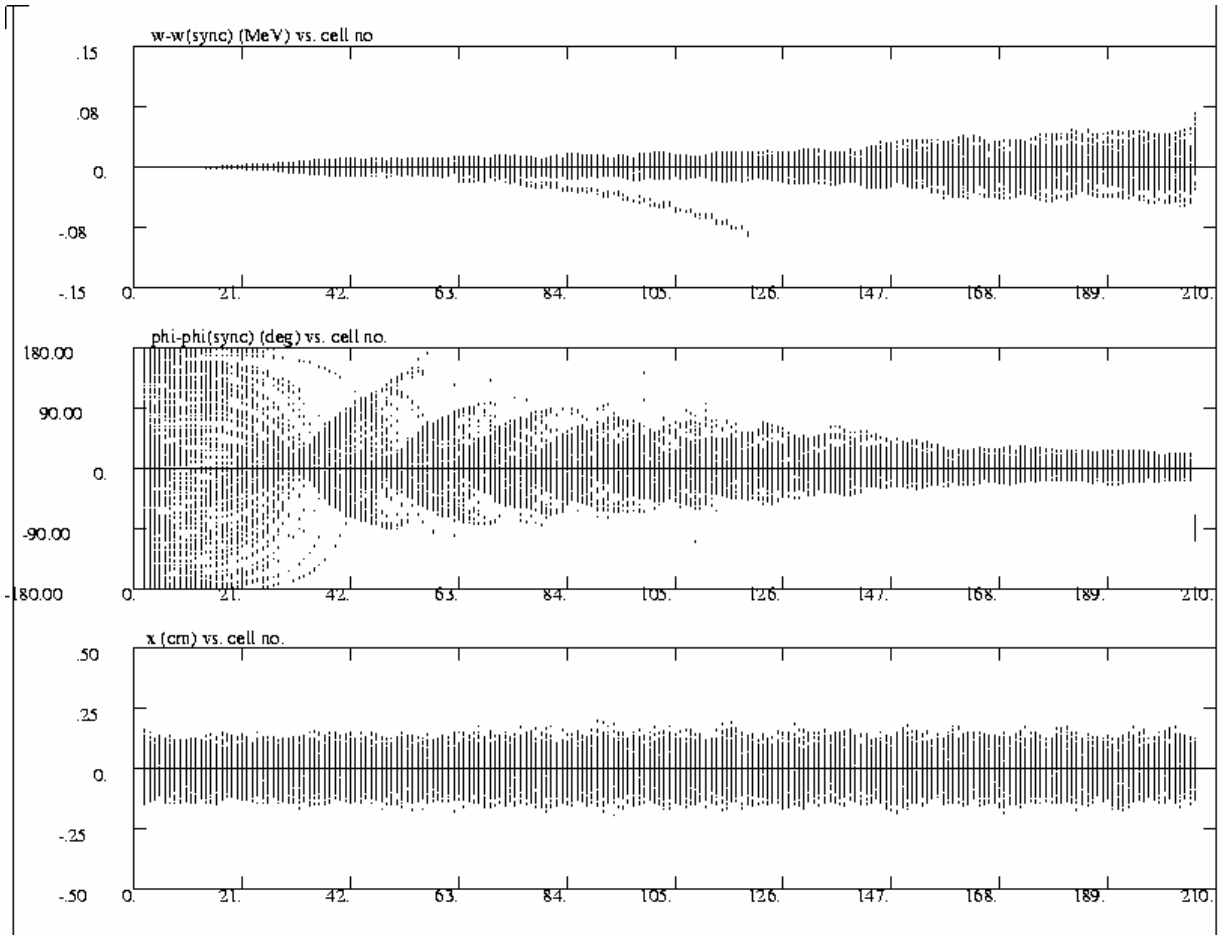
(Present thinking – collaboration with Frankfurt on a 4-rod RFQ)

Parameters	BNL	CERN	Units
Type	4-rod	4-rod	
Q/m	0.16-1.0	0.12	
Energy in	8.5	2.5	keV/amu
Energy out	300	250	keV/amu
Frequency	101.28	101.28	MHz
Max rep rate	10	10	Hz
Length	2.96	2.5	Meters
# of cells	236		
Aperture	0.006	.0045	Meters
Voltage	92	70	kV
E (surface)	20.8	≤ 23	MV/m
RF Power	< 350	< 350	kW
Acceptance	1.7	> 0.8	π mm mrad (nor)
Input Emit.	0.35		π mm mrad, nor, 90%
Output Emit. (trans)	0.375		π mm mrad, nor, 90%
Output Emit. (longit)	0.75		π MeV deg
Transmission	97	93	%
Bravery factor	1.8	≤ 2	Kilpatrick



RFQ Beam Dynamics Design

PARMTEQ



Transmission:

Au^{35+} 97% (2 mA)

$^{3}He^{2+}$ 88 % (2 mA)

P 65 % (2 mA)

Requirements for MEBT

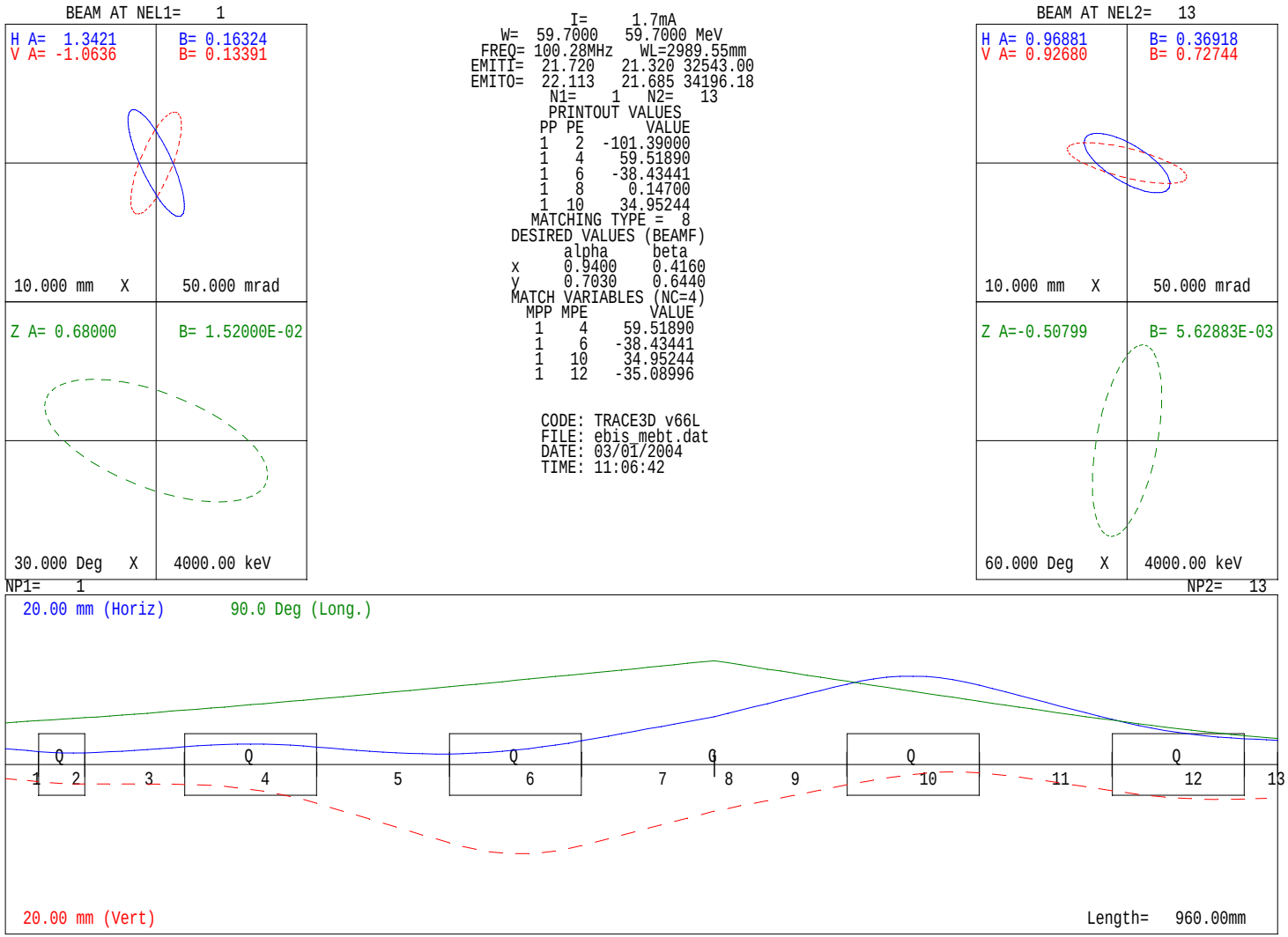
-Matching from FODO (RFQ) to axial symmetric IH structure with triplets
-Diagnostics: Current monitor(2) , Emittance

Twiss parameters at beginning and end of the MEBT

Parameters	End of RFQ	Entrance of IH	Units
α_X	1.34	0.94	
β_X	0.163	0.416	mm/mrad
ε_X (5* rms,unnorm)	21.72	21.72	π mm mrad
α_Y	-1.06	0.703	
β_Y	0.134	0.644	
ε_Y (5* rms,unnorm)	21.72	21.72	π mm mrad
α_Z	0.6800	-0.50806	
β_Z	0.0152	0.0056	deg/keV
ε_Z (5* rms,unnorm)	32543	32543	π deg keV

Transport from RFQ to Linac

(5 quads, 1 buncher)



IH Linac

An IH Linac very similar to the first tank of the CERN Pb linac, is our baseline:

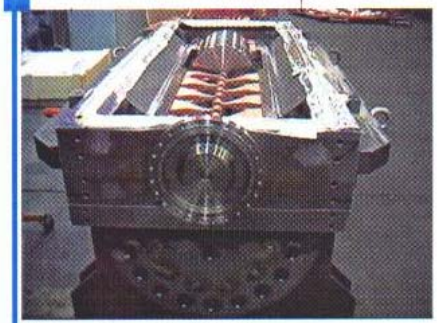
Main parameters of the IH linac

Parameters	BNL	CERN Tank 1	Units
Q/m	0.16-1.0	0.12	
Input energy	0.300	0.250	MeV/amu
Output Energy	2.0	1.87	MeV/amu
Frequency	101.28	101.28	Mhz
Max rep rate	10	10	Hz
length	4.0	3.57	Meters
Input emittamce	0.55		pi mm mrad, norm,90%
Output emittance	0.61		pi mm mrad, norm,90%
Output energy spread	20.0		keV/amu
transmission	100		%

(Present thinking – collaboration with GSI on an IH Linac)

NTG
NEUE TECHNOLOGIEN

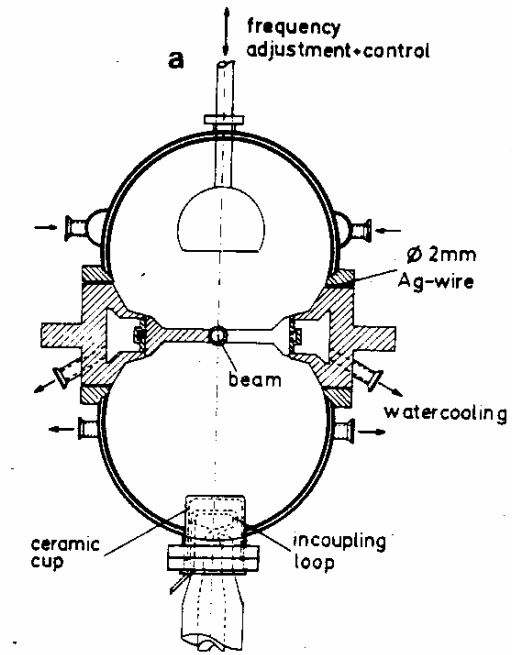
IH-Resonator for the REX-ISOLDE Project



Mid section with drift tubes

Section with drift tubes during measurement of the resonance frequency

Watercooled top section of the IH-Resonator



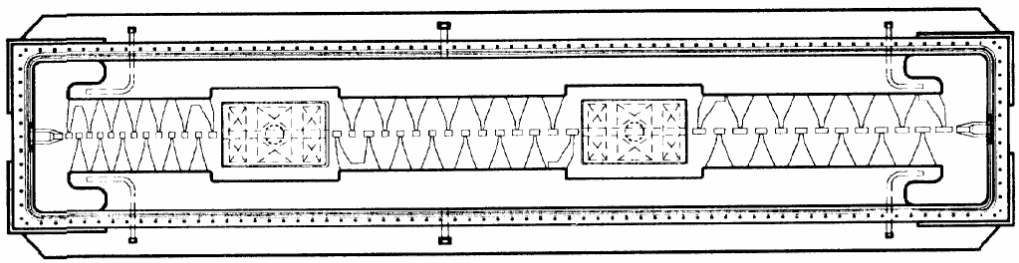
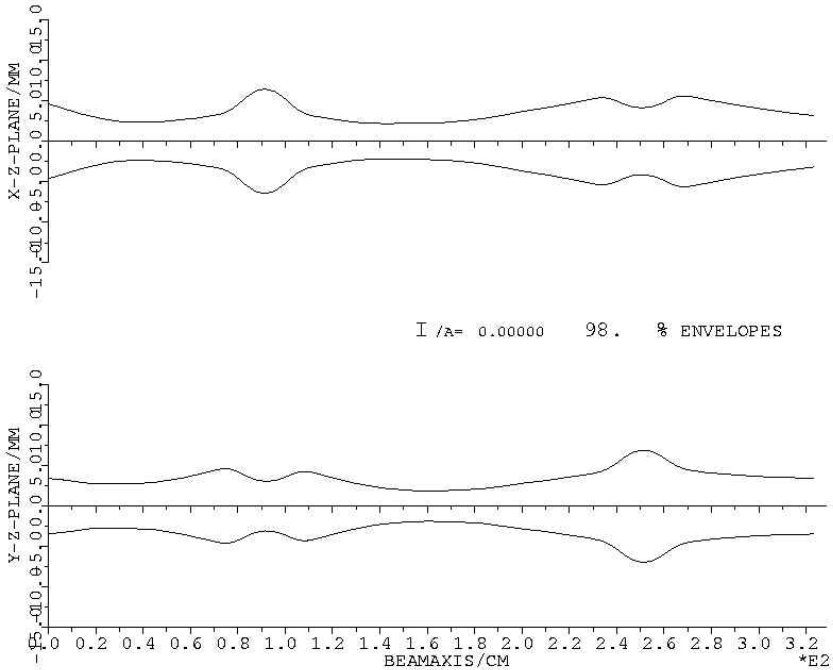


Fig. 3b) Top view on the middle part of the GSI-cavity.

IH linac optics codes LORAS used in this preliminary design



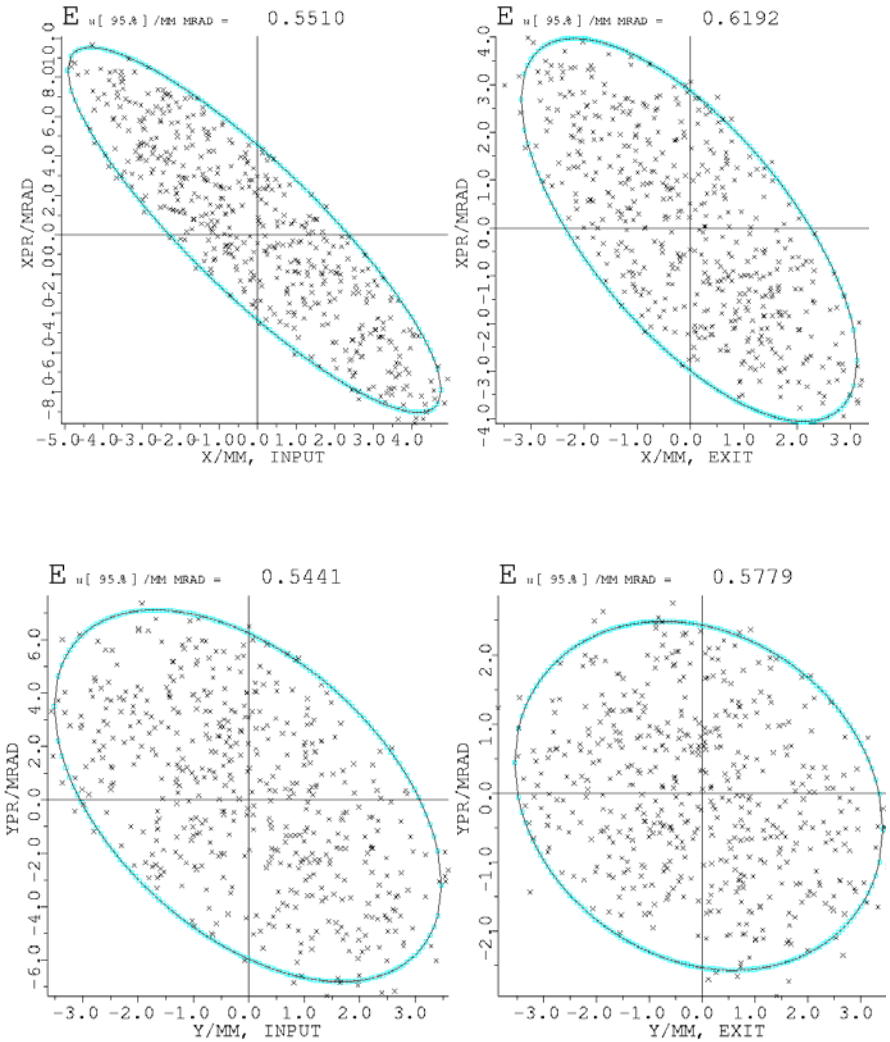
Transmission:

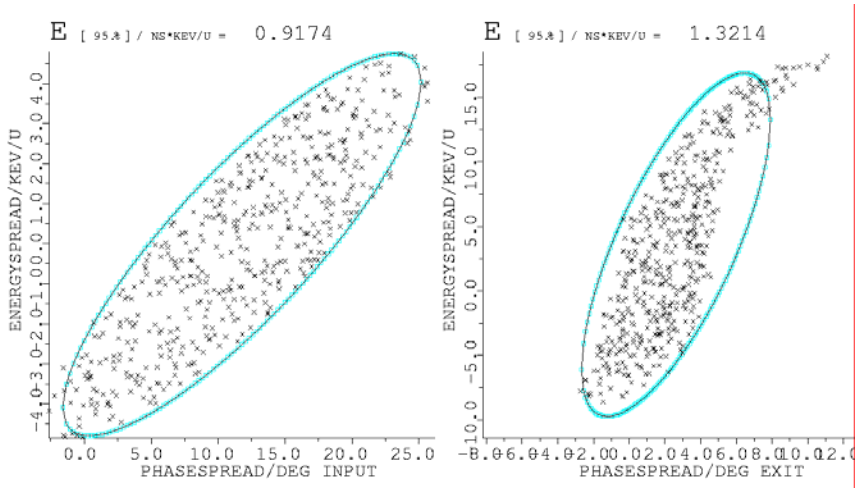
Au^{35+} 100% (2 mA)
$^{3}He^{2+}$ 100% (2 mA)

Longitudinal profiles in the IH linac

Transverse profiles in the IH linac

IH Linac Input and Output Emittances

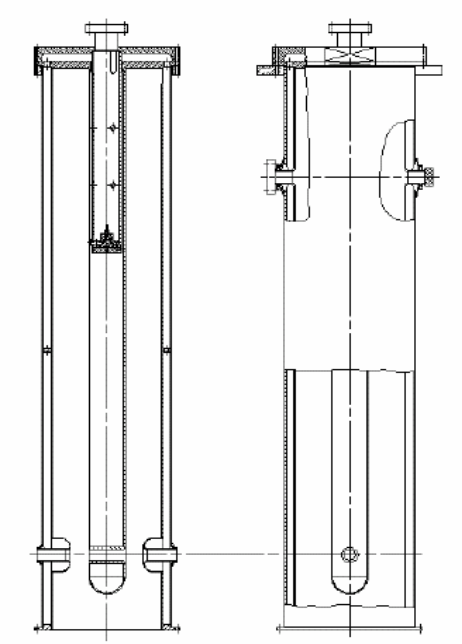




SCL Option

-Allows acceleration to higher energies for higher q/m ions (> 6MeV/u for q/m=0.5)
-Based on ATLAS, ALPI, ISAC-II and RIA technology
-Two type of cavity β ~0.04(14) and 0.08 (10)

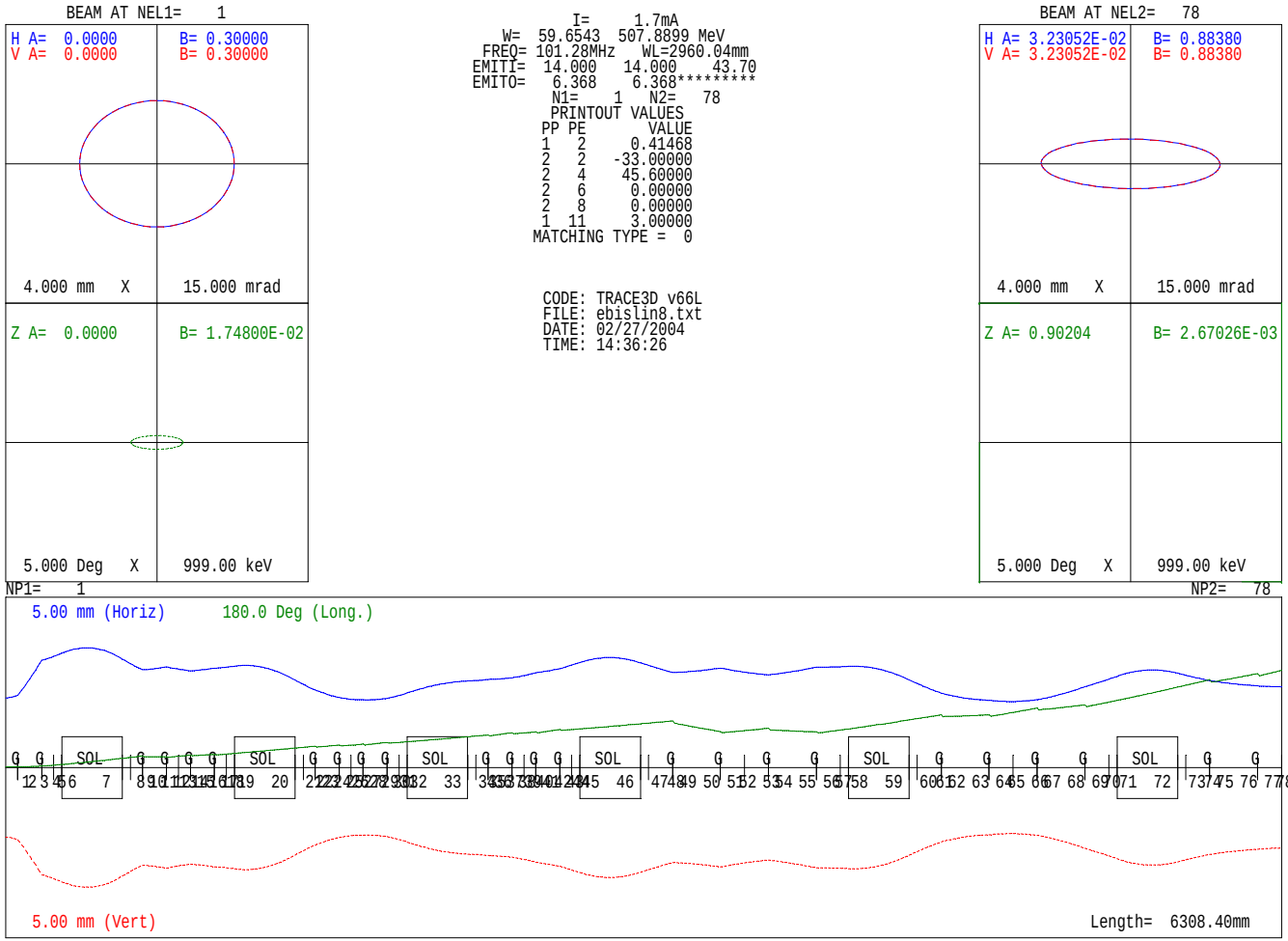
Parameter	Values	Units
Q/m	0.16-1.0	
Input energy	0.300	MeV/amu
Output Energy	2-7.5	MeV/amu
Frequency	101.28	MHz
Max rep rate	5	Hz
Input emittance	0.55	π mm mrad, norm,90%
Output emittance	~ 0.6	π mm mrad, norm,90%
Transmission	100	%



The ALPI resonator

-Accelerating Gradient 7MV/m
-Energy gain 5MeV/charge/cryostat
-Three cryostats to produce 15 MeV for the SCL

TRACE Simulation for SCL (Au)



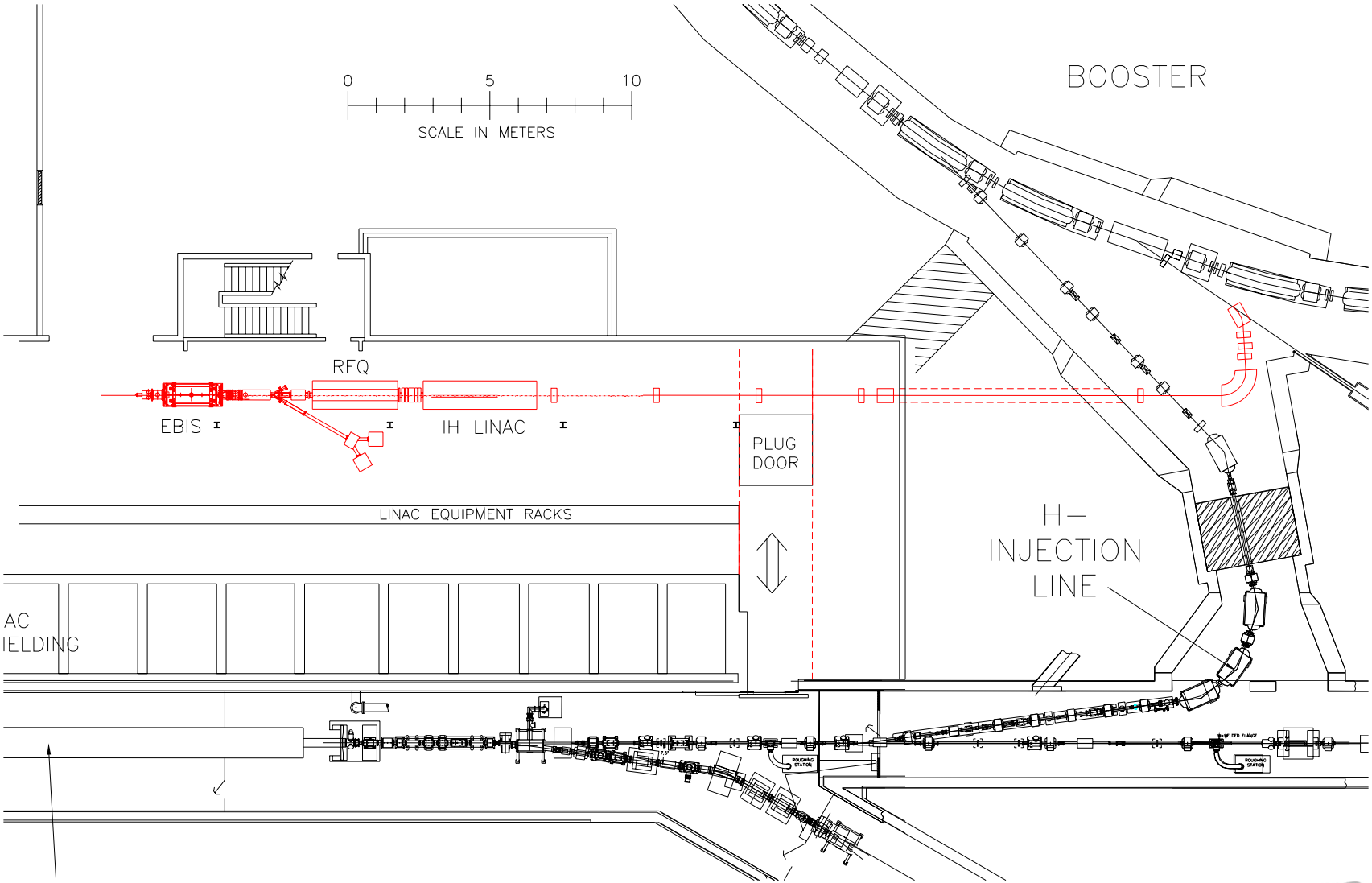
Requirements for HEBT

-Match beam transversely to Booster injection
-Minimize energy spread at injection, dp/p = ±0.05%,
-Provide ion charge state discrimination
-Diagnostics: Current monitor (2), Multiwire/Faraday cup (3), Fast Faraday cup

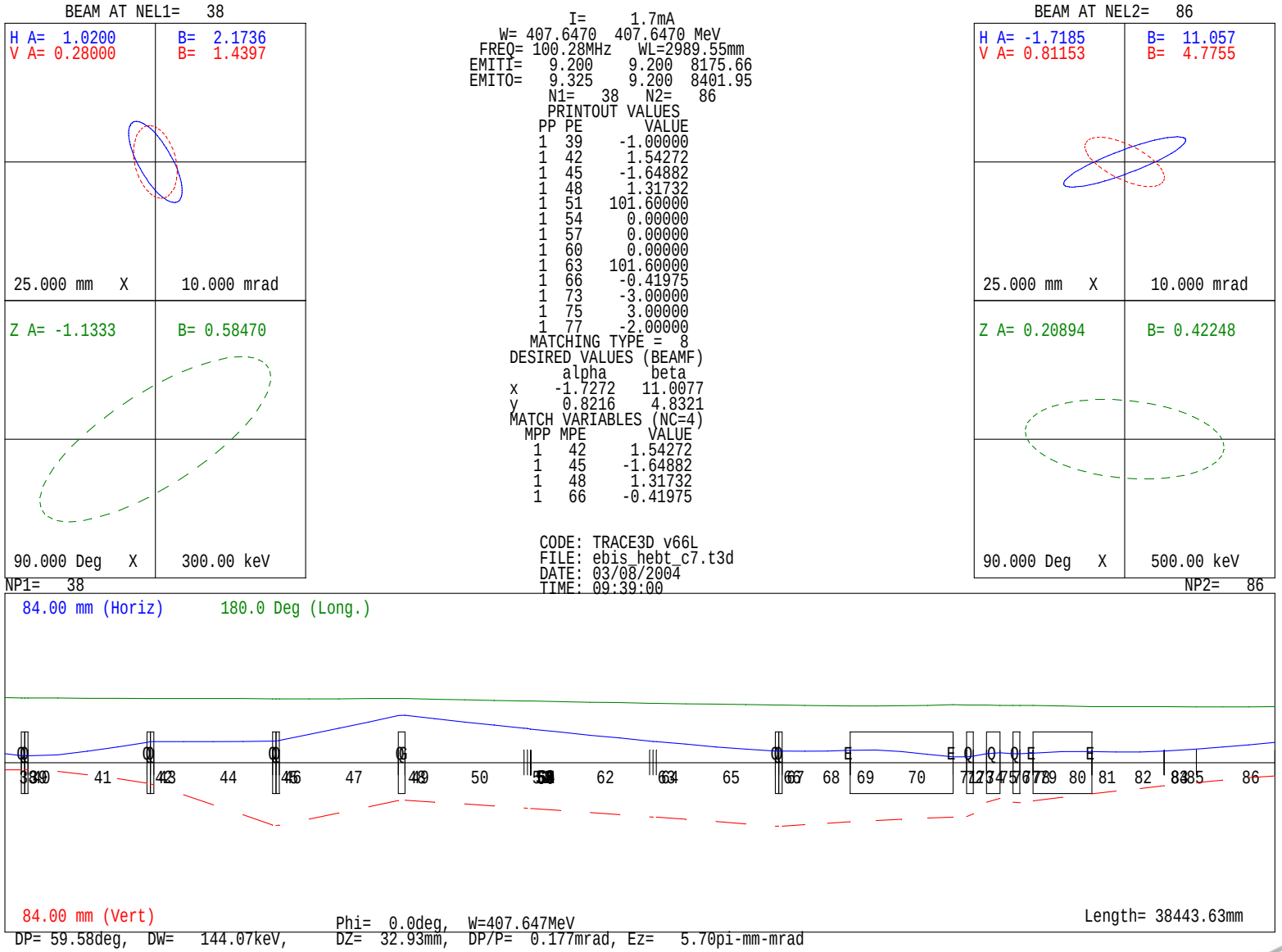
Twiss parameters at beginning and end of the HEBT

Parameters	End of IH Linac	Entrance of Booster	Units
α_X	1.200	-1.7277	
β_X	2.1736	11.008	mm/mrad
ε_X (5* rms,unnorm)	9.2	9.2	π mm mrad
α_Y	0.28	0.82163	
β_Y	1.4397	4.8321	mm/mrad
ε_Y (5* rms,unnorm)	9.2	9.2	π mm mrad
ΔE (for 5* rms ε_Z)	±180	± 145	keV

Layout in the Linac Lower Equipment Bay



Optics of the Transport line to the Booster



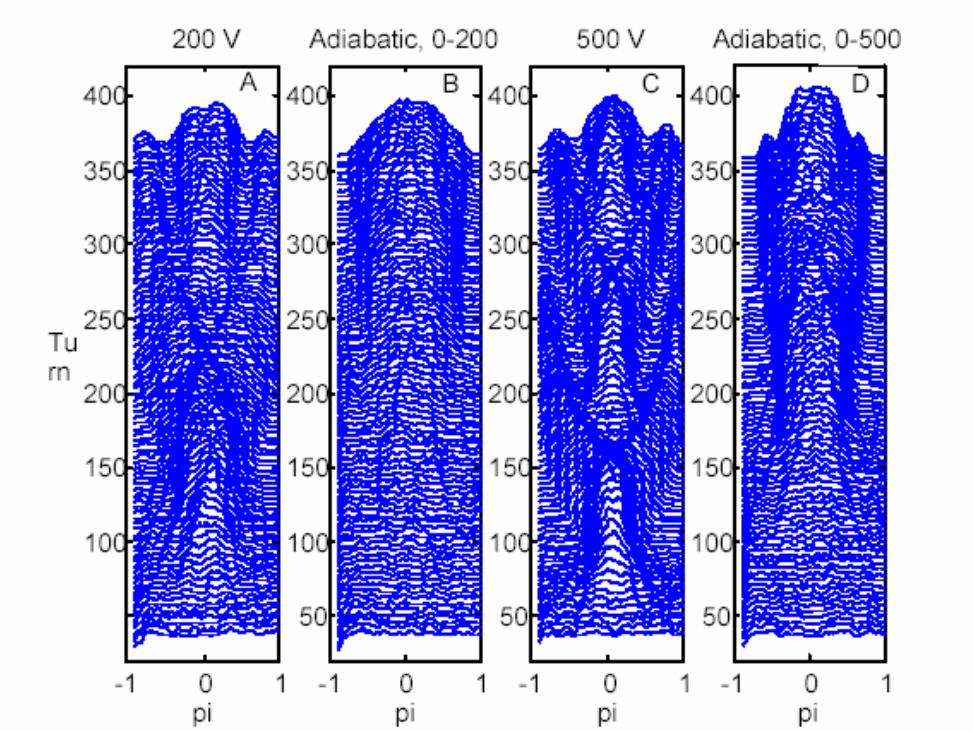
Booster Injection

-**Transverse:** -1-4 turn injection emittance in Booster is about 5.0 π mm mrad, and incoherent tune spread is 0.08

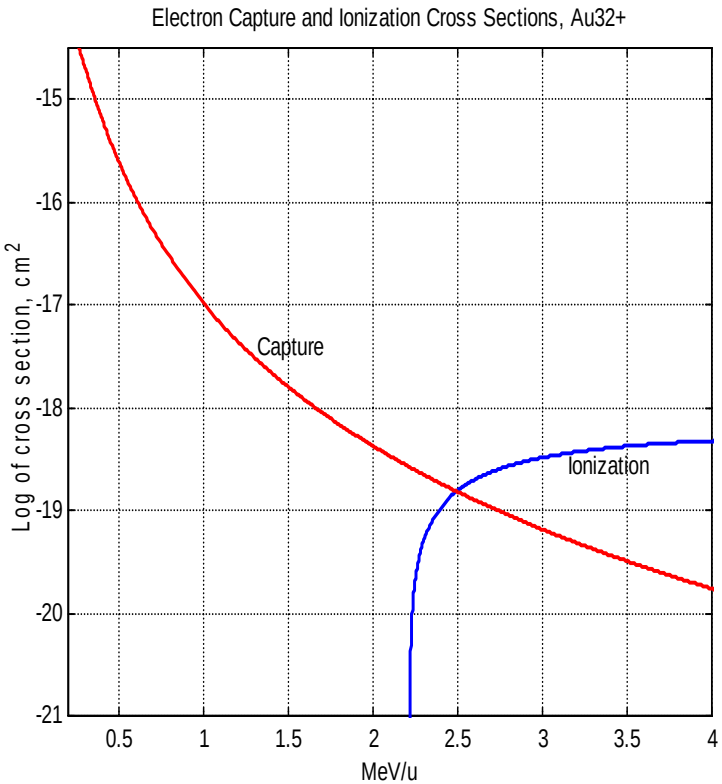
-**Longitudinal:** -Simulation result shows EBIS injected will have emittance of ≤ 0.05 eV-s/u (present 0.05 eV-s/u)

-Longitudinal microwave instability: Keil-Schnell criteria requires dp/p >0.0012% which is satisfied by EBIS beam (dp/p = ±0.05%,)

Booster Injection



Mountain range of 4 EBIS capture schemes



At 2 MeV/u, capture cross section reduced by factor of 40 relative to Tandem.

Emittance Budget for Linac

	Energy (keV/u)	Current* (mA)	ε_T (90%,,nor) (π mm mrad)	Comments
EBIS	**8.5**	**1.75**	**0.35**	
RFQ	**300**	**1.7**	**0.5**	
IH	**2000**	**1.7**	**0.7**	**ΔE = ±1 keV/u**
Booster Injection	**2000**	**1.7**	**0.7**	**ΔE = ±0 .7 keV/u**

* Current required for single turn injection into the Booster.

CONCLUSION

Will use proven technologies for RFQ and IH (SC ?) structures.

This linac will satisfy all (transverse and longitudinal) requirements for Booster injection.