DESIGN OF THE MEBT FOR THE JAEA-ADS PROJECT

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Abstract

The Medium Energy Beam Transport (MEBT) will transport a cw proton beam with a current of 20mA and energy of 2.5 MeV from the exit of the normal conducting Radiofrequency Quadrupole (RFQ) to the superconducting Half-Wave resonator (HWR) section. The MEBT must provide a good matching between the RFQ and HWR, effective control of the emittance growth and the halo formation, enough space for all the beam diagnostics devices, among others. This work reports the first lattice design and the beam dynamics studies for the MEBT of the JAEA-ADS.

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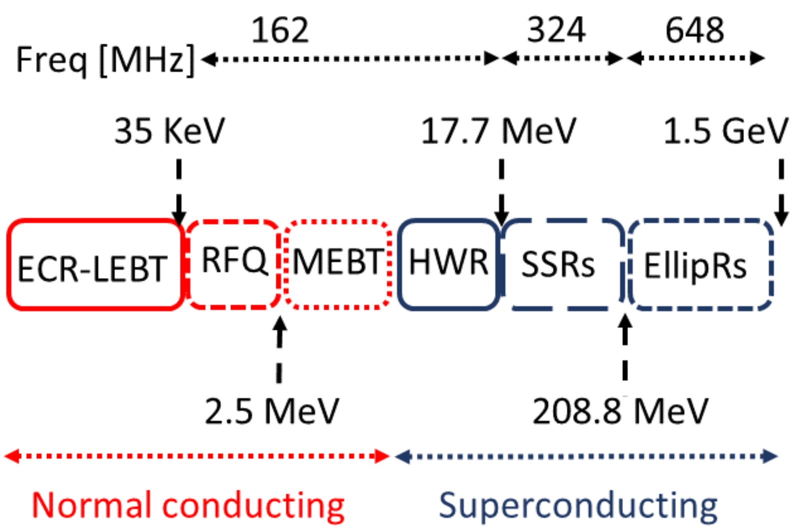
Introduction

The Japan Atomic Energy Agency (JAEA) is designing a 30 MW cw proton linac for the accelerator-driven subcritical system (ADS) project.



ECR= Electron Cyclotron Resonance
LEBT= Low Energy Beam Transport
RFQ= Radiofrequency Quadrupole
MEBT= Medium energy Beam transport
HWR= Half-Wave Resonator
SSR = Single Spoke Resonator
EllipR= Five-cell Elliptical Resonators

Figure 1: Schematic design of the JAEA-ADS linac.

Table 1: Parameters for the JAEA-ADS MEBT design.

Parameter	**Value**
Energy MeV	2.5
Beam current mA	20
RFQ output $\varepsilon_{norm,rms,x}$ (π mm mrad)	0.20
RFQ output $\varepsilon_{norm,rms,y}$ (π mm mrad)	0.21
RFQ output $\varepsilon_{norm,rms,z}$ (π mm mrad)	0.37
Ideal HWR input $\varepsilon_{norm,rms,x/y}$ (π mm mrad)	0.23
Ideal HWR input $\varepsilon_{norm,rms,z}$ (π mm mrad)	0.38
Ideal HWR input $\alpha_{x/y}$	0.64
Ideal HWR input $\beta_{x/y}$ (mm/πmrad)	0.76
Ideal HWR input α_z	2.05
Ideal HWR input β_z (mm/π mrad)	2.43

MEBT lattice design

The MEBT design was created following the next constraints:

- Beam power lost < 1 W/m
- $\varepsilon_{norm,rms}$ growth < 20% .
- Transverse rms size < 10mm and Max. transverse beam size < MEBT aperture.
- Mismatch factor < 0.1.
- MEBT length < 3 m.

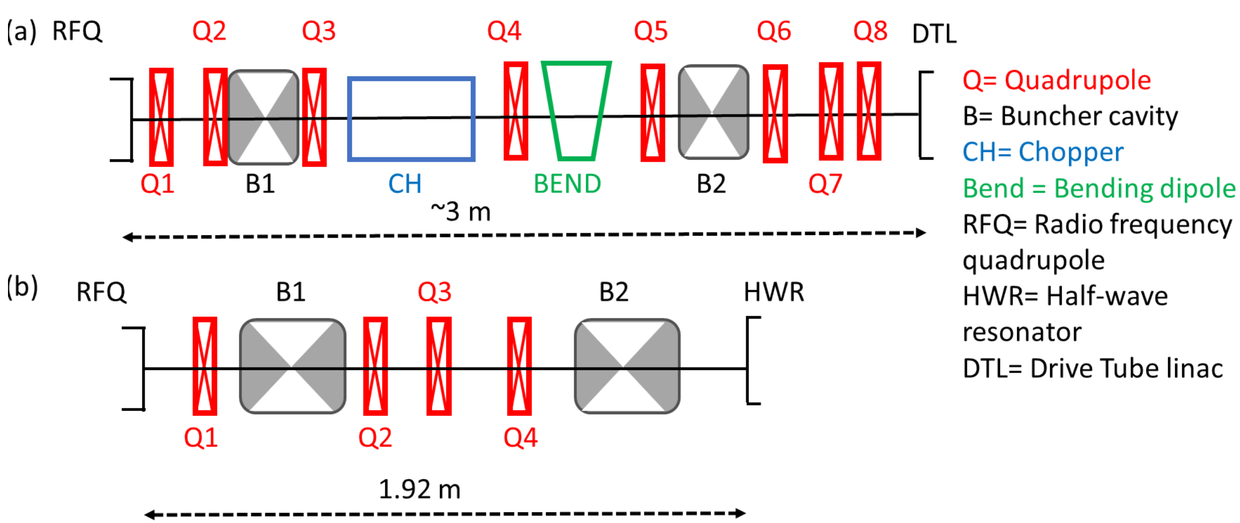


Figure 2: MEBT lattice design for the J-PARC linac (a) and the JAEA-ADS (b).

Table 2: Parameters of the MEBT elements. D stands for drift, Q for quadrupole and B for buncher cavity. The positive sign of Q gradients means that the beam is focusing on the x plane.

Element	Length (mm)	Aperture (mm)	Gradient (T/m) / Voltage (kV)
D1	180	40	
Q1	60	70	7.6
D2	105	40	
B1	300	40	64.5
D3	68.9	70	
Q2	60	70	-14.1
D4	156.7	70	
Q3	60	70	18.1
D4	179.6	70	
Q4	60	70	-11.1
D5	193.5	70	
B2	300	40	114.7
D6	200	40	

Multiparticle tracking studies

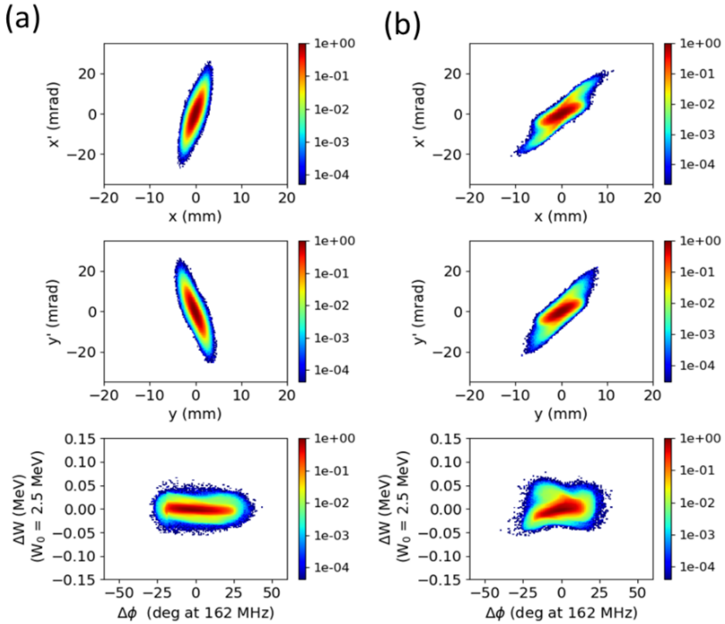


Figure 3: Phase space distribution at the entrance (a) and at the end (b) of the MEBT.

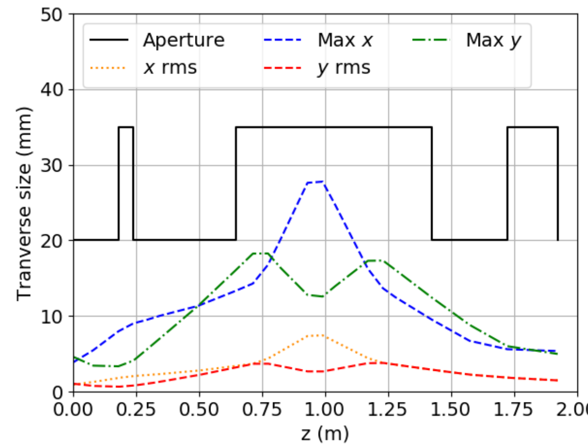


Figure 4 :Maximum and rms beam size on the transverse plane in the MEBT. The aperture is the physical radius of the elements that composed the MEBT.

Table 3: Design goals valued obtained from multiparticle and envelope simulations in TraceWin. The ε values are at the end of the MEBT. The mismatch is concerning the ideal twiss parameters presented in Table 1.

Parameter	Value x / y / z
Beam power lost W/m	0
Length m	1.92
$\varepsilon_{norm,rms}$ growth (%)	17 / 9 / 3
$\varepsilon_{norm,rms,x}$ (π mm mrad)	0.24 / 0.23 / 0.39
Maximum transverse rms size (mm)	7.4 / 3.7
Maximum transverse size (mm)	27.7 / 18.2
Mismatch	0.09 / 0.06 / 0.03

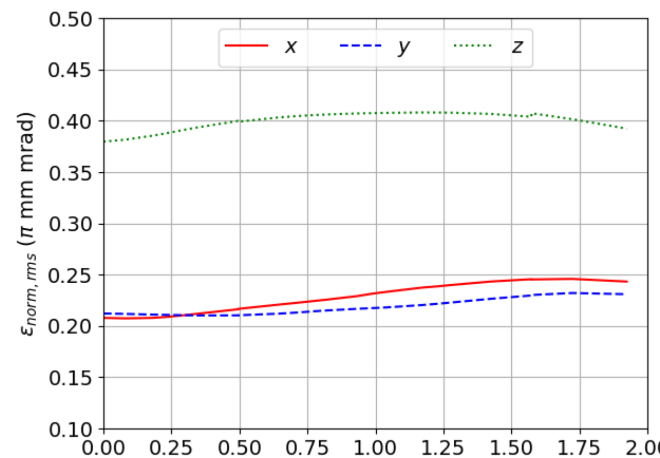
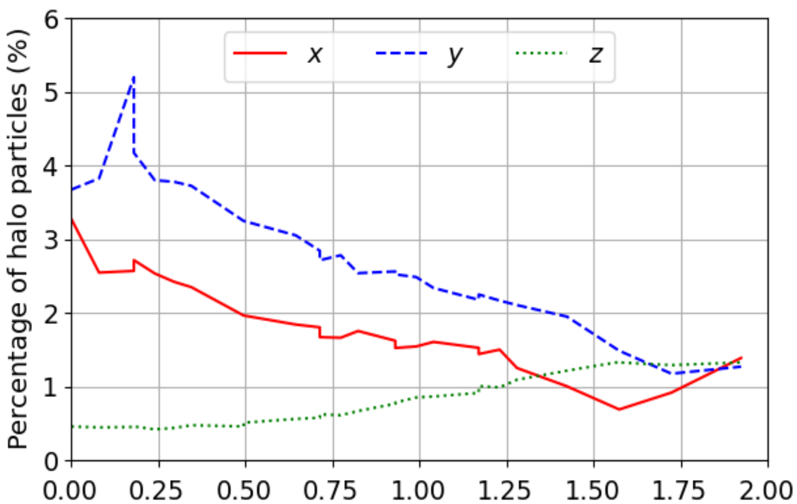


Figure 5 :Normalized rms emittance along the MEBT.

Halos



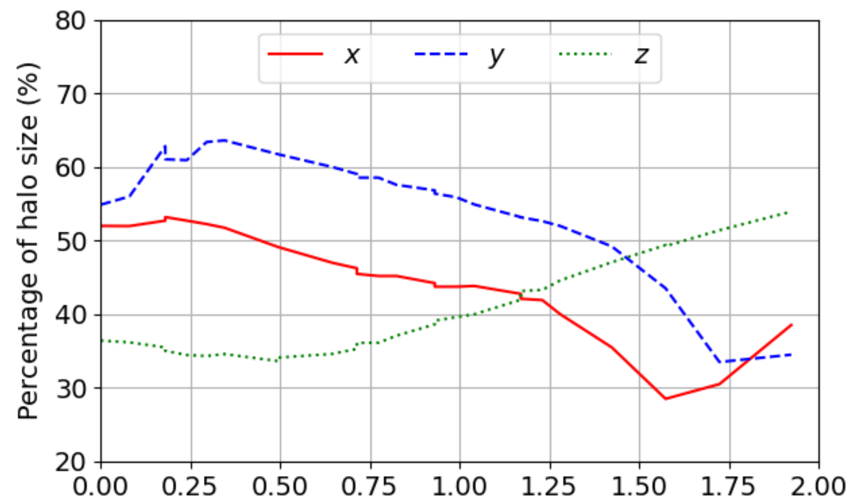


Figure 6 :Percentage of the halo with respect to the total beam (left) and percentage of the halo size to the total beam size (right).

Conclusions

- JAEA-ADS MEBT is a compact transport line that fulfills the beam optics goals of beam matching, power lost, emittance, and beam halo.