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Beam dynamics study of a 400 kW D^+ linear accelerator to generate fusion-like neutrons for breeding blanket tests in Korea

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Abstract

- D+T Fusion generates neutrons at 14.1 MeV
- Tritium breeding blanket : Self-sufficient tritium fuel source (Gap technology between ITER and DEMO)

➢ Korea Fusion Engineering Advanced Test Complex (KFEAT)
→ Main R&D task : Tritium Breeding Unit (TBU) test

Goal

- 400 kW (40 MeV, maximum 10 mA) : ~1/10 of IFMIF-DONES
- CW D^+ beam
- A dedicated linear accelerator for fusion-like neutrons
- CW beam operation → Long-term continuous neutron yield

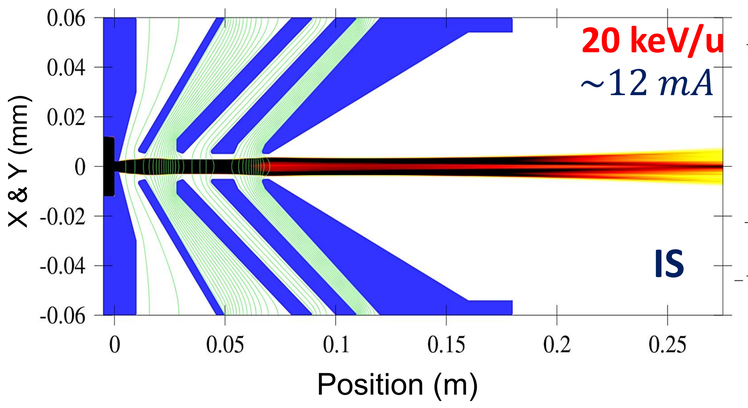
Layout of 40 MeV D+ linear accelerator for fusion-like neutron sources in Korea

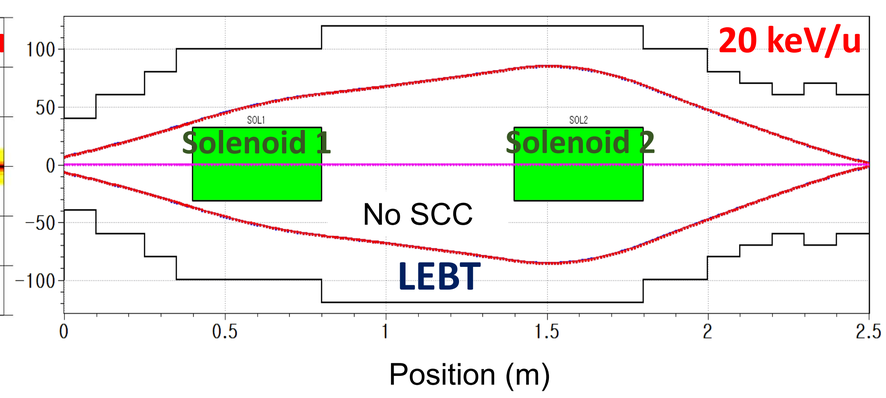
Tot : ~56 m

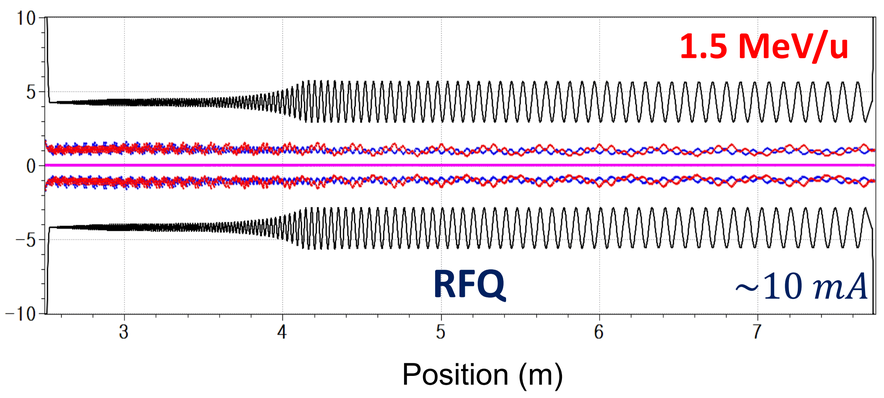
Ion source	LEBT	RFQ	MEBT	SRF Linac		HEBT	Target Cell
ECR IS (NC) 2.45 GHz	Matching between IS and RFQ	4-vane 176 MHz –bunching & acceleration	Matching between RFQ and SCL ❖Space charge effect is important	HWR (SC) 176 MHz (2 cryomodules) $\beta_{opt} = 0.091$	HWR (SC) 176 MHz (2 cryomodules) $\beta_{opt} = 0.181$	2 Octupoles (For making rectangular shaped, uniform beam)	(Solid Be 20 cm x 20 cm)
D^+ CW ~12 mA 20 keV/u	2 Solenoids 20 keV/u	172.3 kW Max 10 mA 1.5 MeV/u	7 Quads + 2 Rebunchers 1.5 MeV/u	1.5 MeV/u -> 6 MeV/u	6 MeV/u -> 20 MeV/u	Two 30° Dipoles (Achromatic)	Expected neutron flux : $\sim 10^{17}$ n/m^2/s
				Solenoid (SC) L_{eff} = 250 mm		Beam diagnostics	Beam Dump

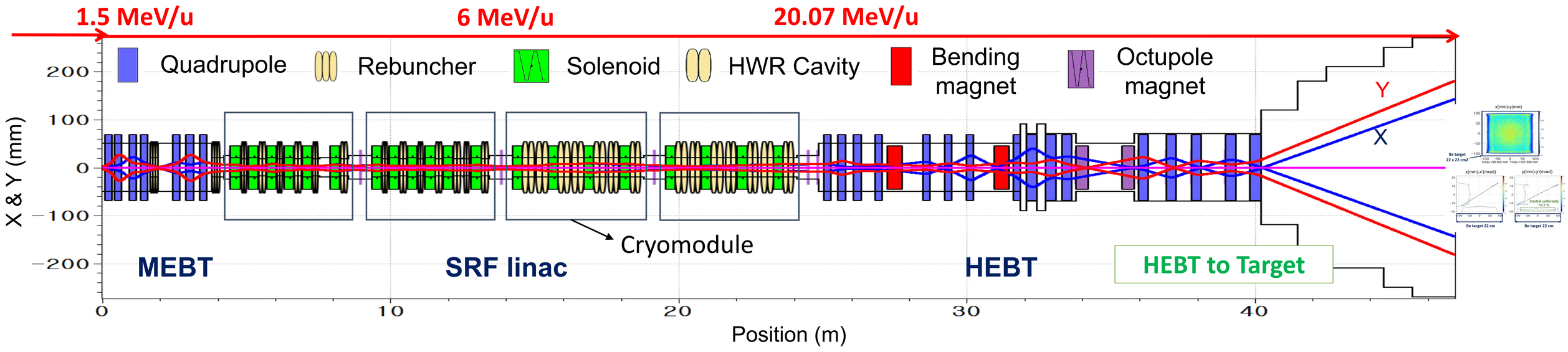
- Benchmark : SARAF-PHASE2 accelerator (D+ CW, 40 MeV, 5 mA → 200 kW)
- Deuteron dedicated accelerator & CW 400 kW – Superconducting RF linac : HWR cavity + solenoid focusing
- Fusion research target beam : Rectangular shaped, uniform density beam – Octupole (non-linear) magnets & quadrupoles

Start-to-end simulation



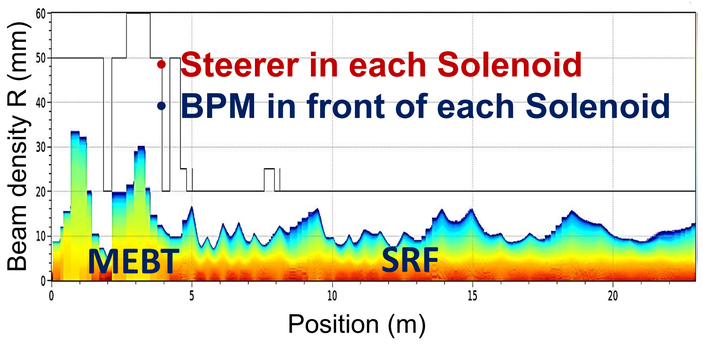


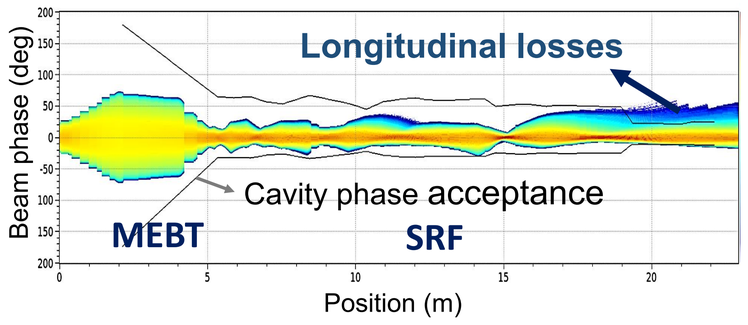


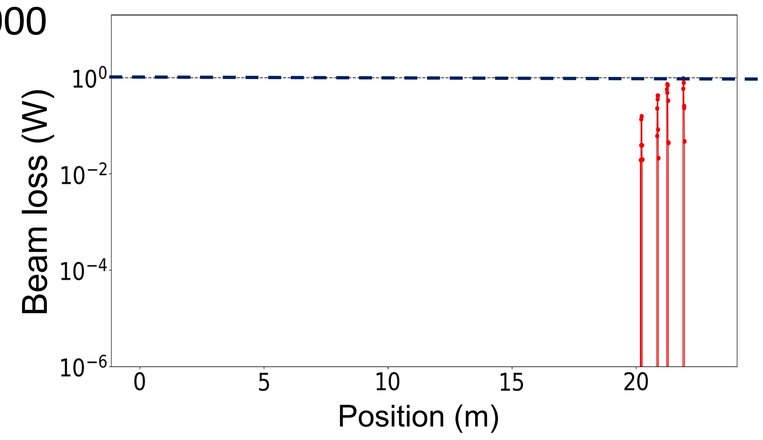


Error study of MEBT + SRF Linac

macro-particle = 1,000,000
Linac : 1000







➢**Nominal beam loss limitation : < 1 W/m**

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