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PROGRESS ON SRF LINAC DEVELOPMENT FOR THE ACCELERATOR-DRIVEN SUBCRITICAL SYSTEM AT JAEA*

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Abstract

To overcome the nuclear waste problem, the Japan Atomic Energy Agency (JAEA) has been developing an accelerator-driven subcritical system (ADS) since the late 1980s. In the JAEA-ADS proposal, an 800 MWth subcritical reactor is driven by a 30 MW cw proton linear accelerator (linac). The biggest challenges for the ADS machines are the high reliability and availability required for their operations. To this end, the present JAEA-ADS linac was redesigned by adopting the current developments in Superconducting Radio-Frequency (SRF) technology. Additionally, we developed a robust lattice to control the beam loss and implemented a fault-tolerance scheme for the fast recovery of SRF cavity failures. This work presents the latest results of the R&D of the JAEA-ADS superconducting linac.

Introduction

The Japan Atomic Energy Agency (JAEA) is designing an Accelerator Driven Subcritical System (ADS) to deal with nuclear waste by transmuting minor actinides.

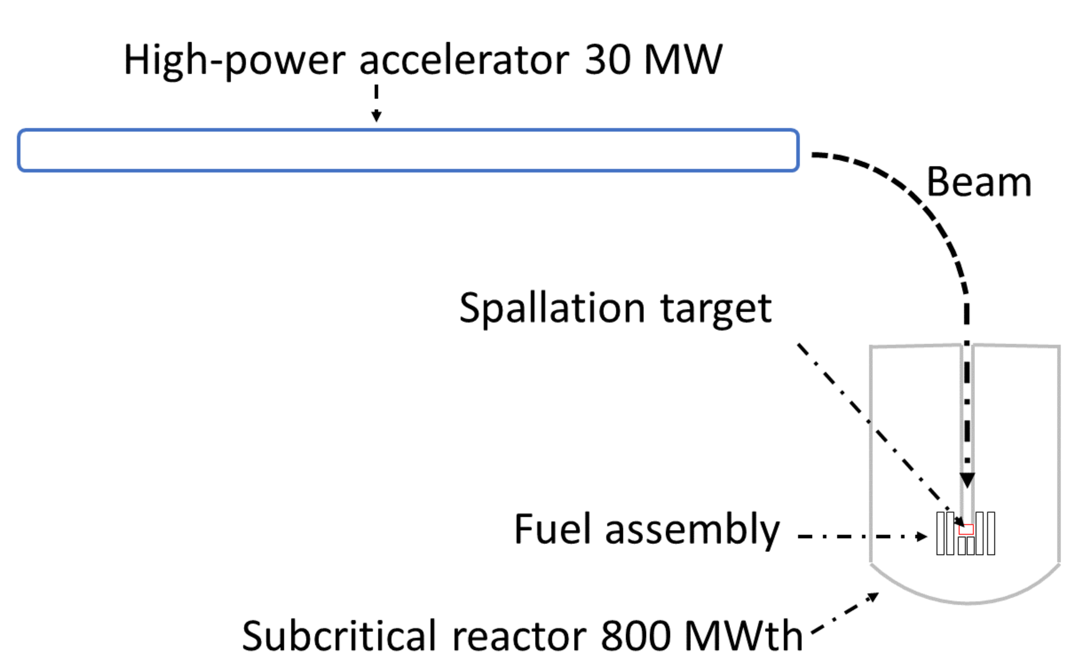

Figure 1: General scheme for the ADS.

Table 1: Main characteristics of the JAEA-ADS accelerator

Parameter		Beam trip duration
Particle	Proton	
Beam current (mA)	20	
Beam energy (GeV)	1.5	
Duty factor (%)	100 (cw)	
Beam loss (W/m)	< 1	
Beam trips per year [5]	2×10^4	≤ 10 s
	2×10^3	from 10 s to 5 min
	42	> 5 min

Beam optics

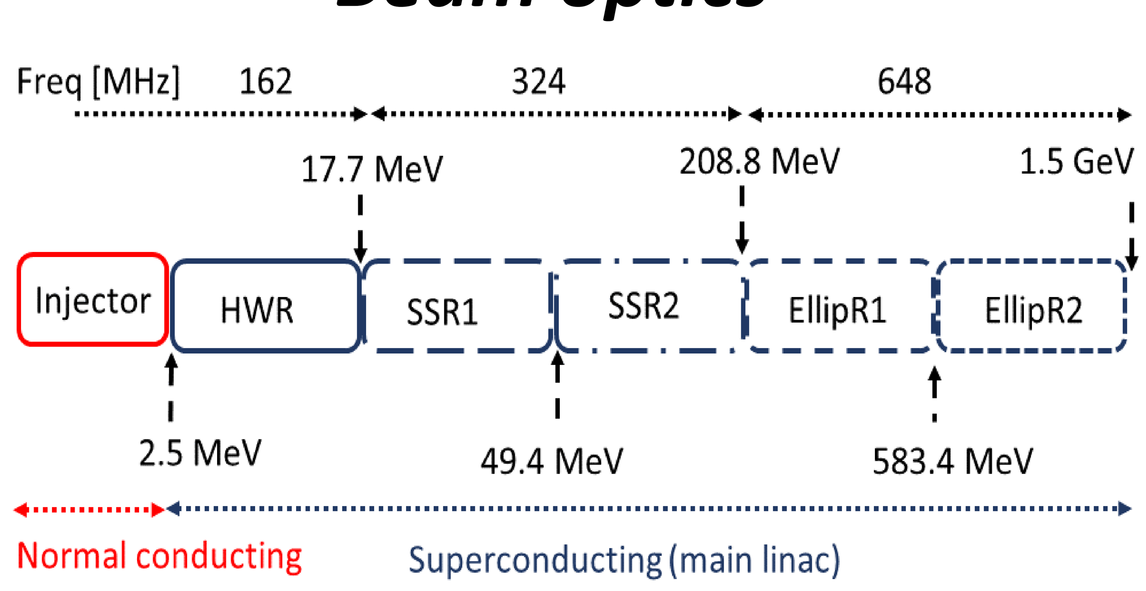

Figure 2: Linac lattice configuration.

Table 2: Lattice configuration in the main linac

Section	Layout	Period (m)	Total cavities
HWR	S-C	0.7	25
SRR1	S-C^2	1.7	66
SSR2	S-C^3	3.4	72
EllipR1	DQ-C^3	5.7	60
EllipR2	DQ-C^5	9.9	70

Table 3: Parameters of the main linac

Parameters	
Input $\varepsilon_{norm,rms,x}$ (π mm mrad)	0.24
Input $\varepsilon_{norm,rms,y}$ (π mm mrad)	0.23
Input $\varepsilon_{norm,rms,z}$ (π MeV deg / mm mrad)	0.08/0.39
Number of Cavities	293
Number of magnets	153
Length (m)	416

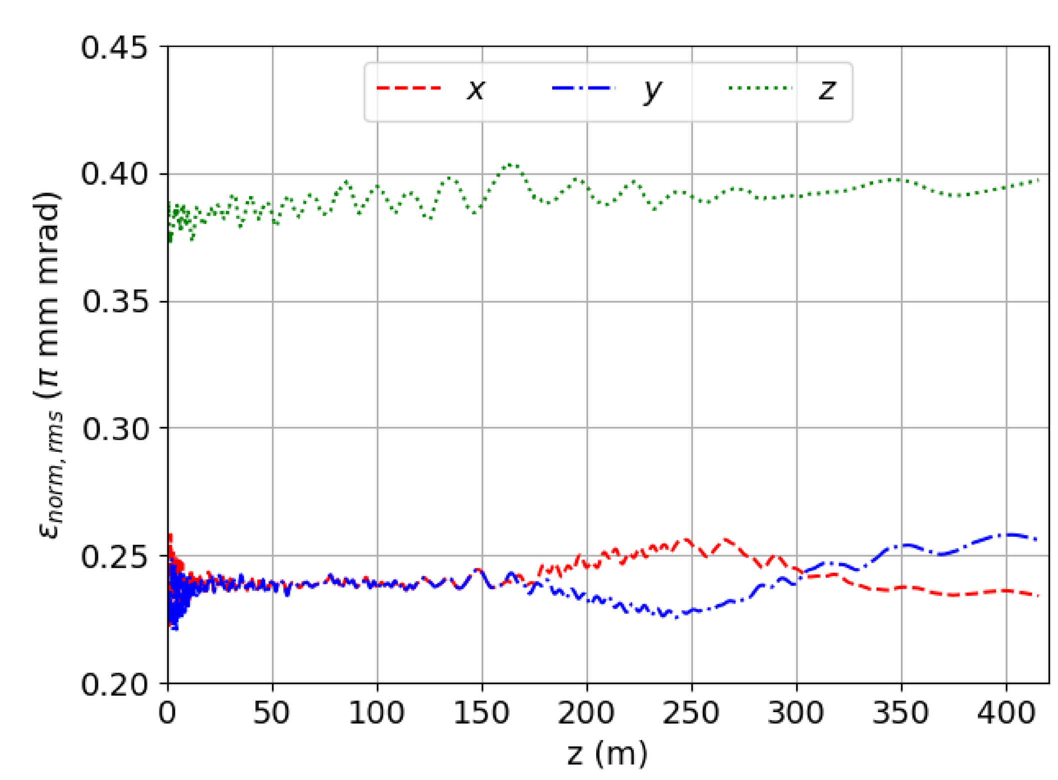

Figure 3: rms emittance evolution

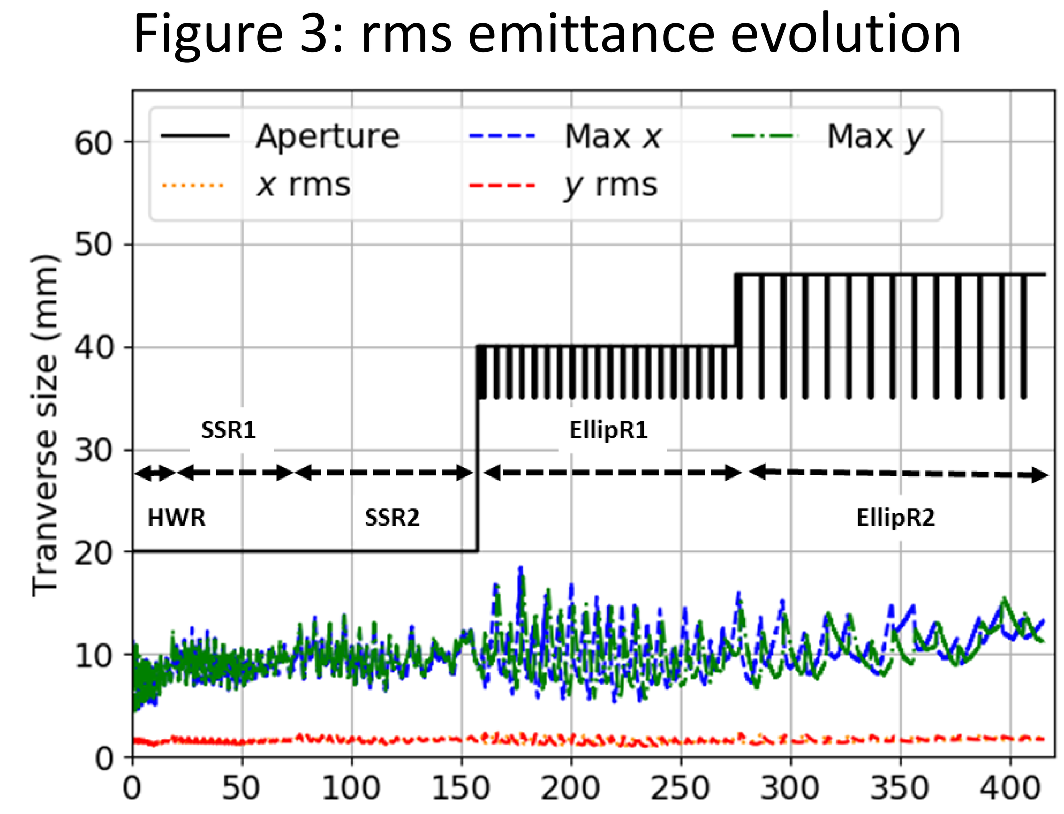

Figure 4: Transverse envelopes.

Table 4: Summary of beam optics performance of the main linac

Parameters	Value x/y/z
Beam power lost (W/m)	0
$\varepsilon_{norm,rms}$ growth (%)	3.7/10.8/1.2
Maximum transverse size (mm)	13.3/11.2
rms transverse size (mm)	1.9/ 1.6

Fault-tolerance

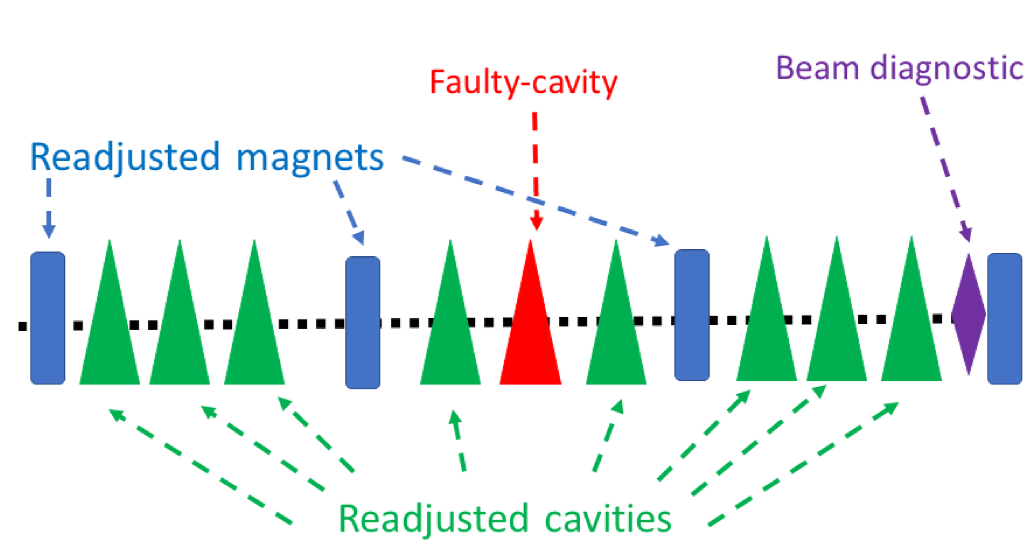

Figure 5: Fault-tolerance scheme.

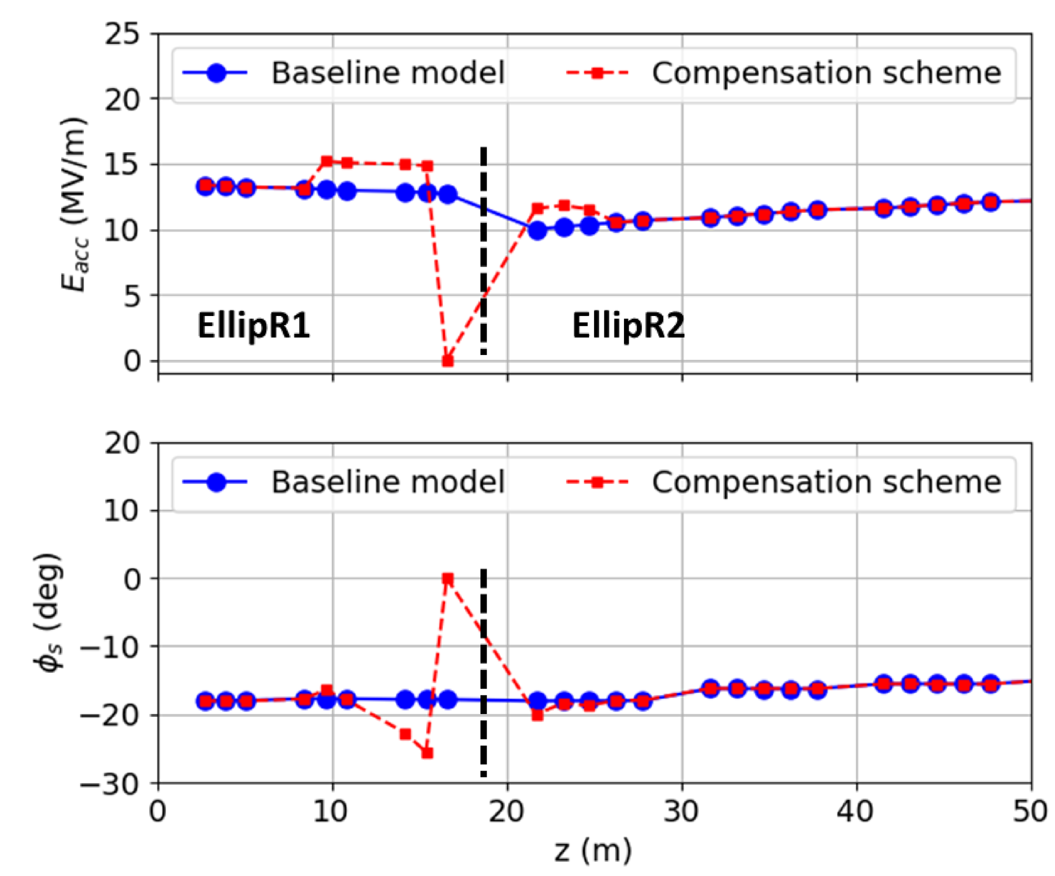

Figure 6: Eacc and φ_s for the Fault-cavity scheme.

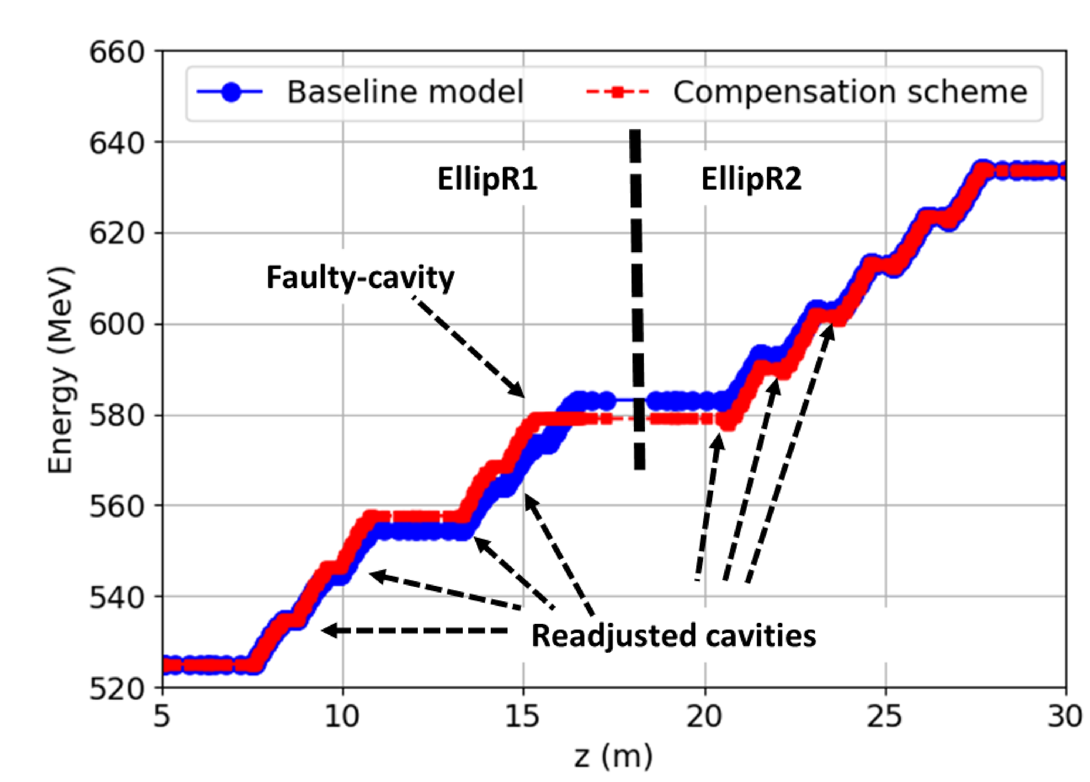

Figure 7: Beam energy for compensation scheme for the failure in the last EllipR1's cavity.

Table 5: Summary of SRF faulty-cavity schemes. The beam parameters are compared to the baseline one at the end of the linac

Faulty cavity	293	223	91
Description	Last cavity of EllipR2	Transition between EllipRs	Transition between SSRs
N_{up} - N_{down}	5-0	4-3	3-3
$\Delta\varepsilon_{norm,rms,t}$ (%)	0	0.6	-0.1
$\Delta\varepsilon_{norm,rms,z}$ (%)	0	1.8	2.9
Mismatch_t (%)	0.04	0.01	0.01
Mismatch_z (%)	0.12	0.05	0.02
ΔE (%)	0.02	0	0

Conclusions

The JAEA-ADS linac required a reliability-oriented design. To this end, the linac model is developed to achieve a robust optic design and fault-tolerance capabilities.

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