Strategies for high availability of JAEA-ADS and ESS linacs

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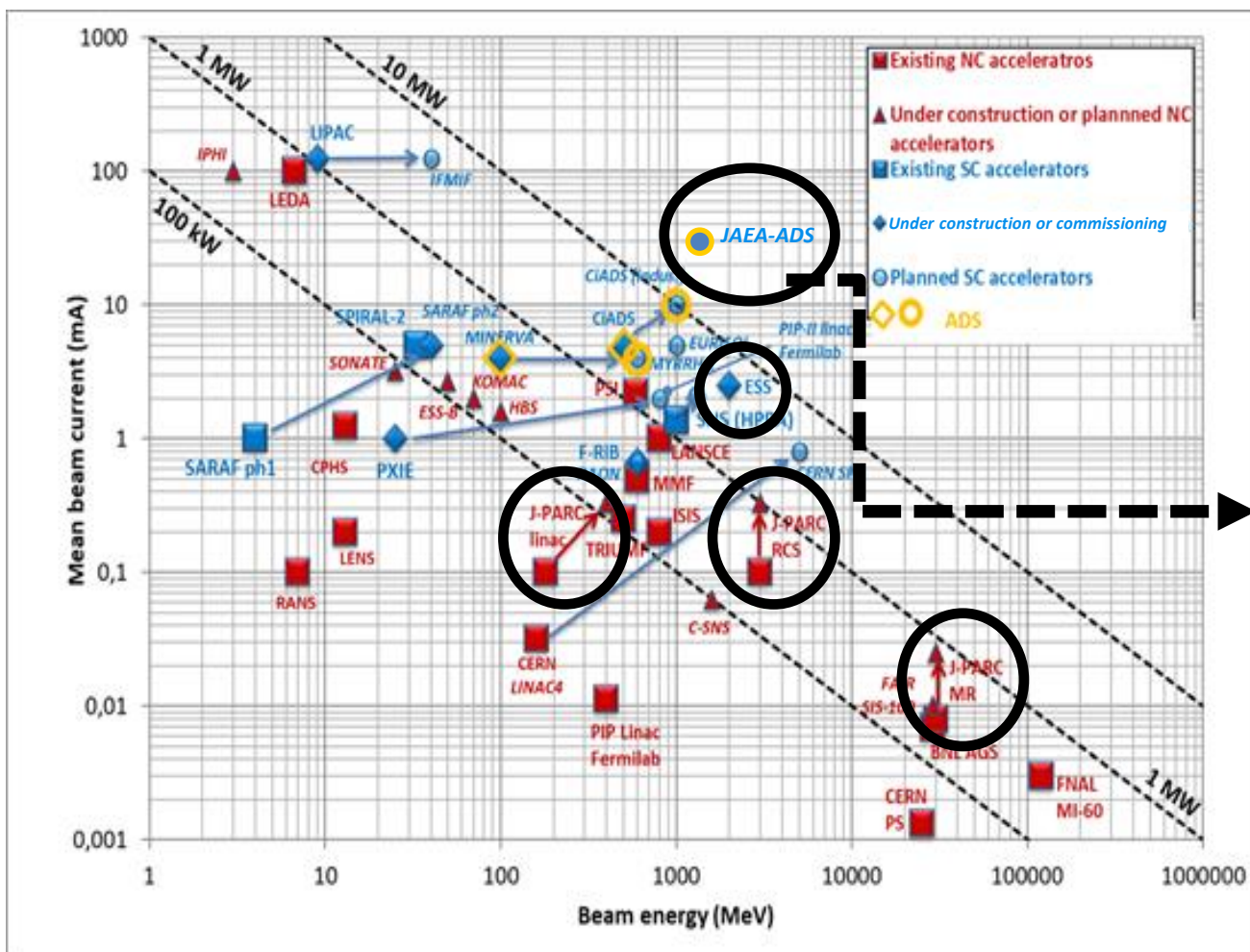
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Contents

- Introduction

- 2023 SAKURA Mobility Programme

- Summary

High-power map. Courtesy of J.L. Biarrotte and F. Bouly.
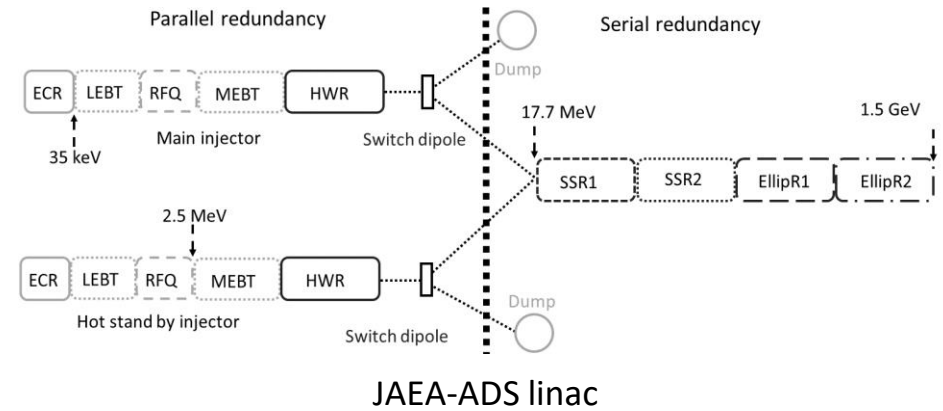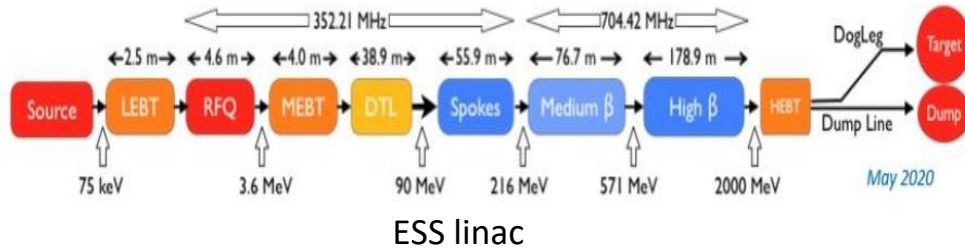
ESS and J-PARC accelerators work on the **MW power regime**
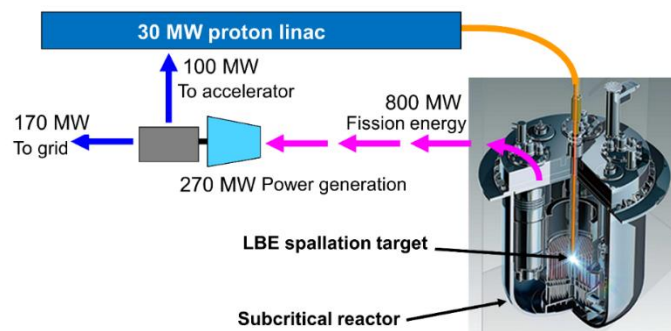
JAEA-ADS proposal

Expanding the high-power frontier

ESS & JAEA-ADS linac

ESS linac

JAEA-ADS linac

Common linac features		ESS	JAEA-ADS
Particle		Proton	
MW beam power source		5	30
Superconducting RF linac		• 90 MeV to 2 GeV • Double SR and Elliptical	• 2.5 Mev to 1.5 GeV • HWR, Single SR, & Elliptical
High duty		4%	CW
Space charge dependent		62.5 mA / 352.21 MHz	20 mA/162 MHz
High Availability: Restricted beam trips [1,2] <u>New strategies are required</u>	< 10s	2 x10^5	2x10^4
	10s < t < 5min	4 x10^4	2x10^3
	> 5min	350	42

[1] E. Bargallo et al, IPAC2015, MOPTY045, 1033 , 2015.

[2] H. Takei et al. J. Nucl. Sci. Technol., **49**, 21, 2012.

Motivation:

High availability in high-power linacs is **becoming essential** for their operation.

Goal:

Develop **advanced strategies to design and run** superconducting linacs efficiently.

Strategy:

- Passive: **Robust** beam optics **design** to **reduce** the probability of **beam trips** in linacs.
- Active: **Minimize beam downtime** by adjusting nearby elements settings for faster beam recovery. The so-called "**local compensation.**"

Procedure:

- Share knowledge and develop robust beam optics adjustment strategies to increase the availability of both the ESS and JAEA-ADS linacs.
- Share the experiences from the ESS linac design, construction, and commissioning to the design of JAEA-ADS linac.
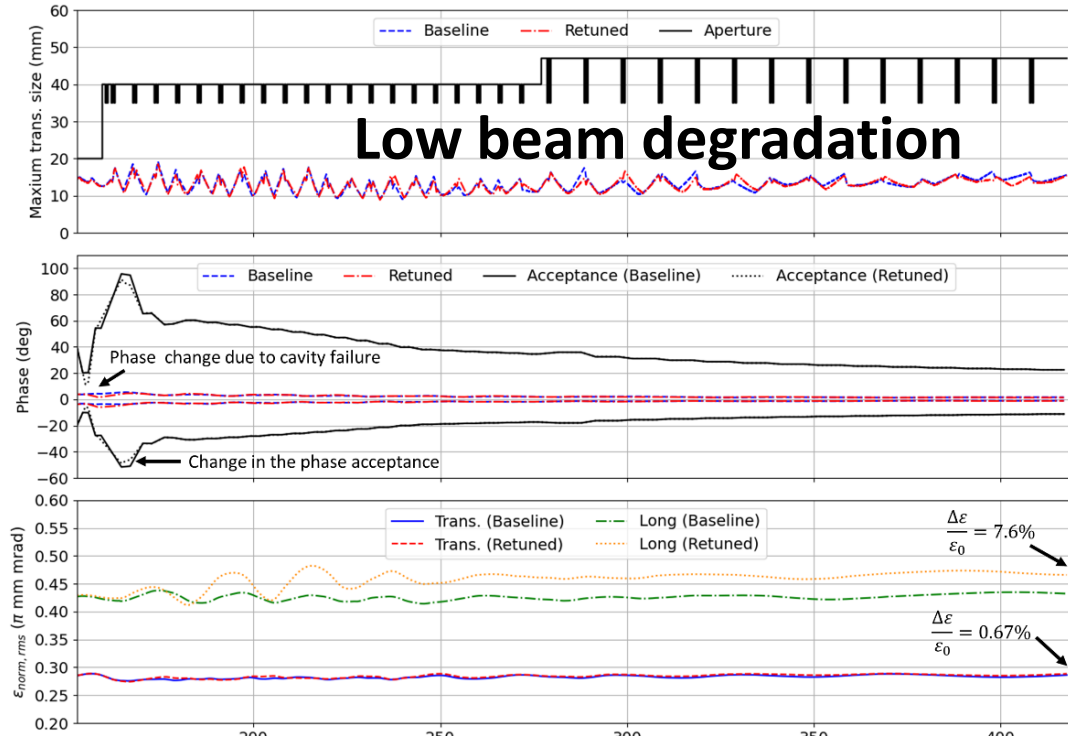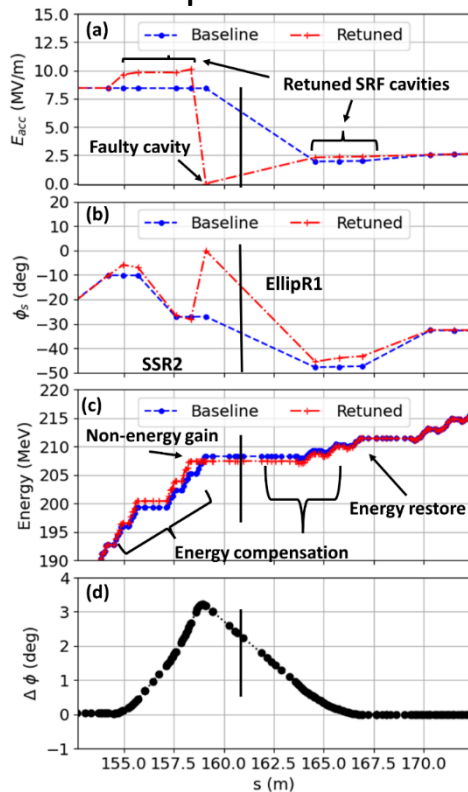
Local compensations

Goal:

Increase availability by **fast beam recovery** due to element failures (magnets of RF cavities).
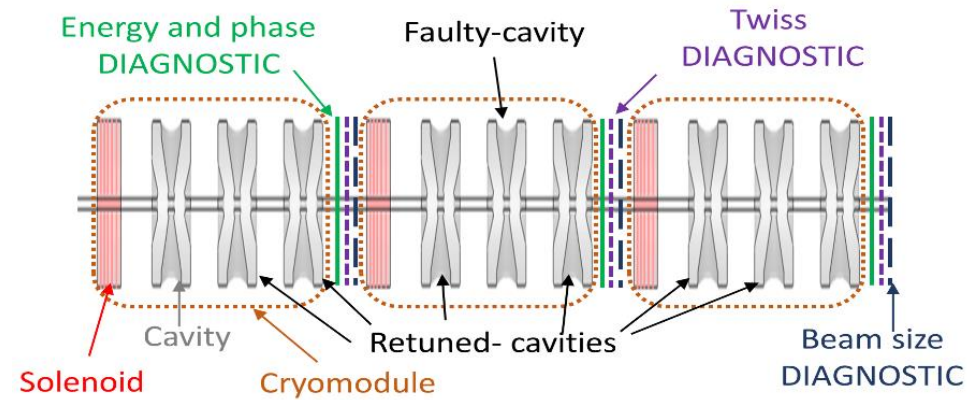
Local compensation (B. Yee-Rendon et al. PRAB, **25**, 080101, 2022)

Example:

Effective for single SRF compensations

Low beam degradation

$$\frac{\Delta\varepsilon}{\varepsilon_0} = 7.6\%$$

$$\frac{\Delta\varepsilon}{\varepsilon_0} = 0.67\%$$

Local compensations

- Local compensation **exploits the linac modularity**; thus, it can be suitable for any linacs.

- Some **margin in the elements' setting** (e.g., gradient in RF cavity and magnets) is required.

- **Upgrade control systems** (e.g., LLRF) **coupling with optics models** are necessary for its implementation.

- **Compensation policy** must be adjusted according to the linac reliability requirements.

Beam optics design: Low energy part

Goal:

> **Self-consistent** model **compatible** with the **RFQ.**
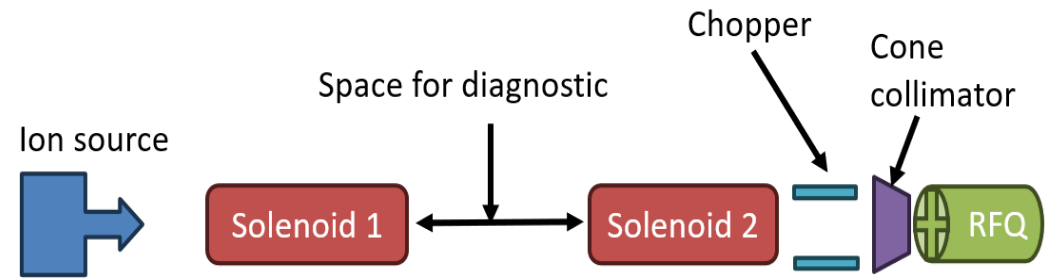
LEBT design (B. Yee-Rendon et al, PASJ2023, **WEP23**.,545, 2023)

Discussion outcomes:

> Explore **relocation** of the chopper and solenoids.
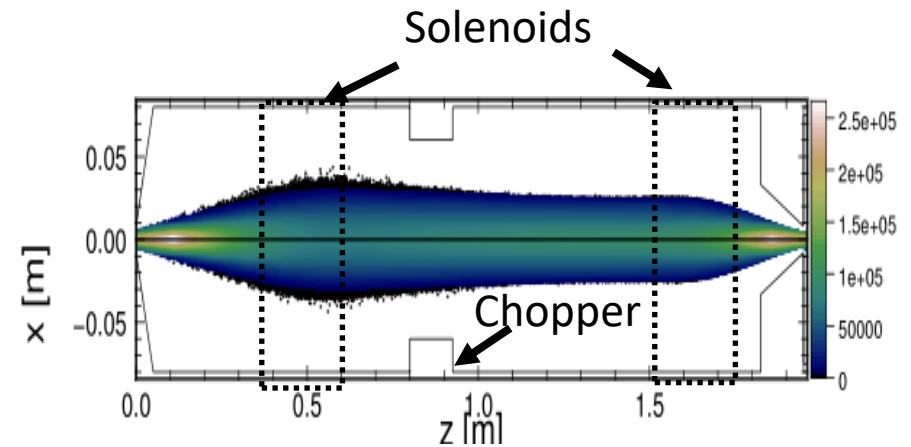
Follow-up:

- Analysis of different configurations.
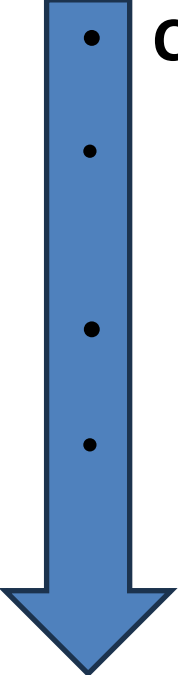
- Developed a model that satisfies the RFQ parameter.

JAEA-ADS LEBT baseline design

Summary

Results

- Design **review** of the JAEA-ADS superconducting linac.
- **Improved** the strategy for local compensations in superconducting linacs.

Current & future work

- **Continue the discussion** with our ESS colleague.

- Beam dynamic analysis of **local compensation in the ESS** lattice (applied proposal for **2024 SAKURA** Mobility Programme).

- **Local compensation implementation** first at ESS and later on JAEA-ADS.

- Consequently, **push forward the efficiency and availability** of present and future linacs.