Catalogue of Losses for the Linear IFMIF Prototype Accelerator

LINAC14, Geneva

N. Chauvin[1]*, P.A.P. Nghiem[1], M. Comunian[2], C. Oliver Amoros[3], D. Uriot[1]

*Nicolas.Chauvin@cea.fr

[1] Commissariat à l'Énergie Atomique et aux Énergies Alternatives, DSM/Irfu; F-91191 Gif-sur-Yvette, France.
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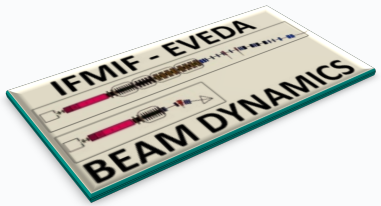
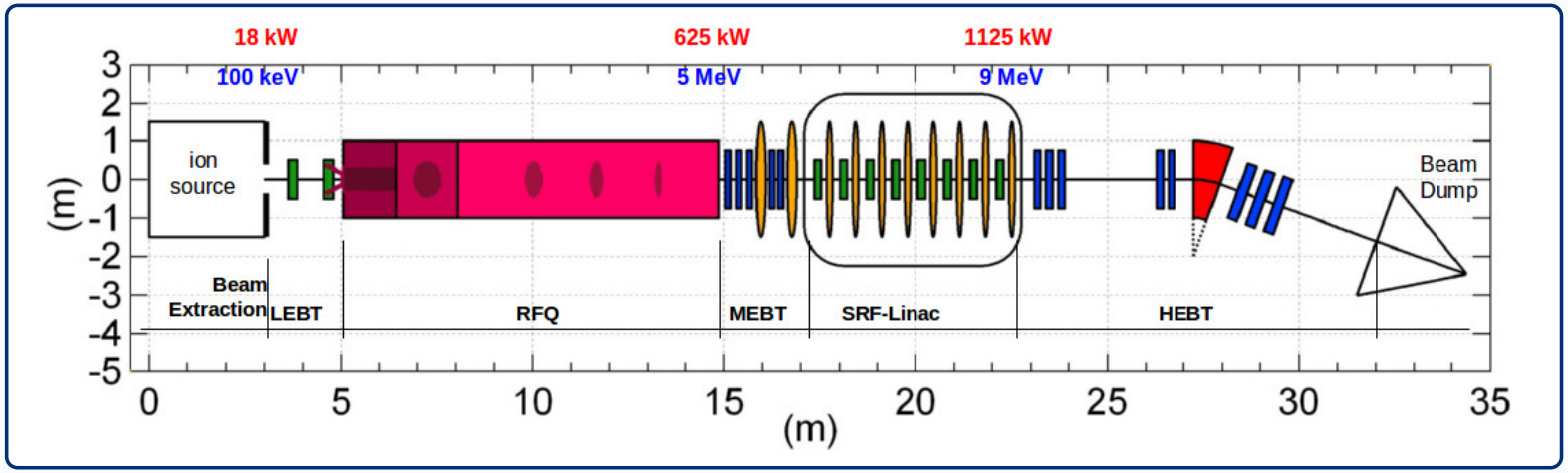


September 4, 2014

Introduction
LIPAc layout and main parameters



LIPAc Main Parameters

- Deuteron beam
- Continuous beam
- Intensity: 125 mA
- Frequency: 175 MHz
- IFMIF final energy: 40 MeV
- LIPAc final energy: 9 Mev
- Hands-on maintenance
- Goal of LIPAc: validate design and technology

LIPAc Beam Losses Issues

High Beam Power

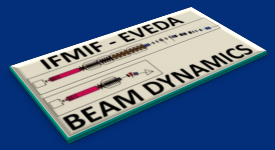
- The **whole** accelerator is concerned by **high power beam**: from 15 kW in the LEBt to 1.125 MW in the HEBT.
- Even a **tiny part** of the beam, when lost, represents a **significant power deposition**.

Beam Losses

- **Accidental loss** leads to sudden **heat deposition** and can damage equipment.
- **Permanent loss** can **activate** material: hands-on? Also cooling cryogenic systems potential problems.

High beam power almost all along the accelerator: meticulous and exhaustive prediction of losses is needed

LIPAc Beam Losses Issues



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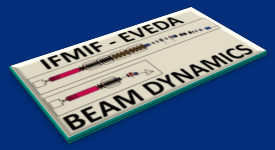

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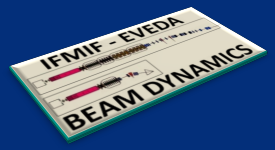
Procedure for Catalogue of Losses



Double Issue

1. **Define thoroughly the loss situations in the accelerator lifetime**
2. **Define the protocols to simulate and estimate them**

A. **Ideal machine:** nominal conditions, without any error.

B. **Machine "day one":** machine tolerances, no correction, tunable parameters ±10 % of nominal values.

C. **Beam commissioning, tuning, exploration:** same as **B** but with orbit correction.

D. **Routine operation:** machine tolerances, orbit correction, tuned parameters.

E. **Sudden failure:** individual or combination of sudden trips of tunable parameters from 0% to 110% of nominal values.

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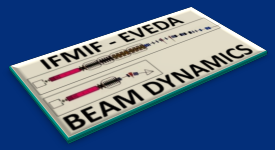

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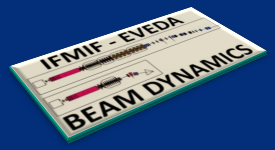

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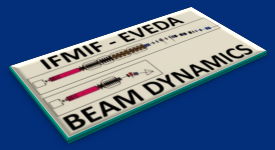

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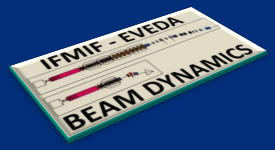

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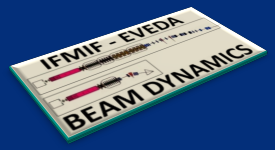

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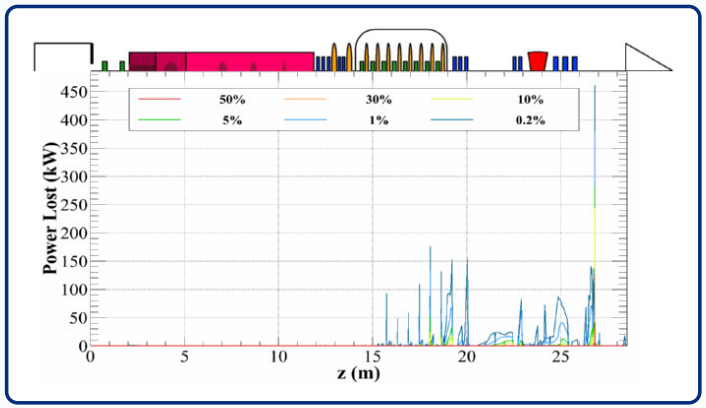
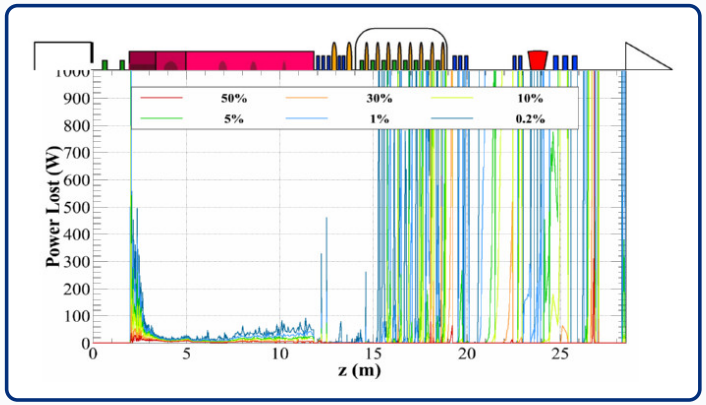
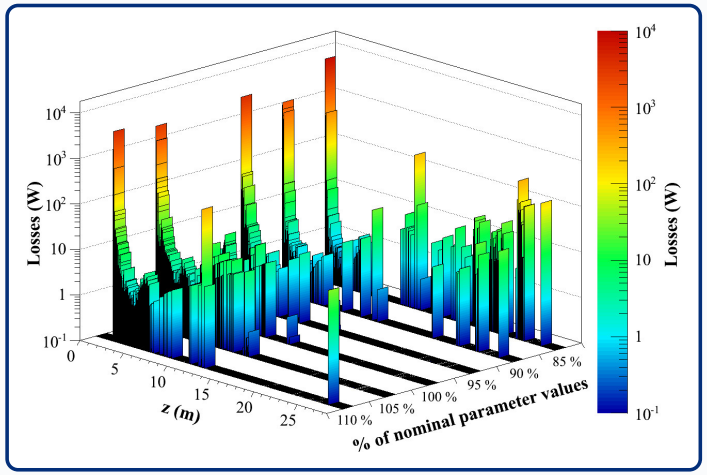
Simulation Results

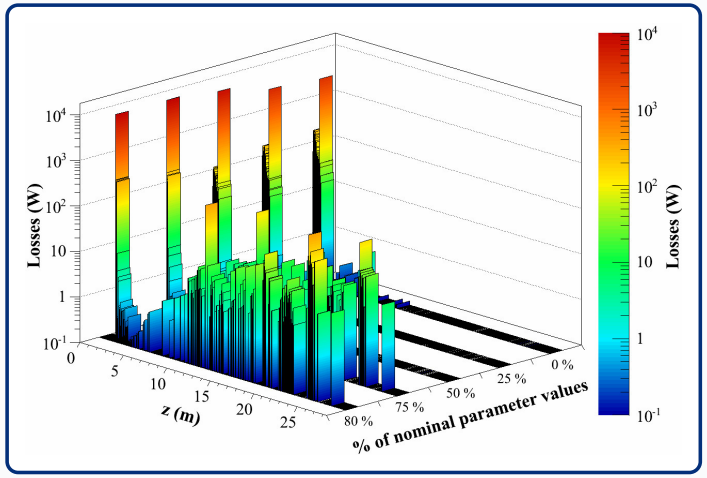
Some examples...





Results for beam commissioning and tuning





Results in case of sudden failure of LEBT and RFQ

Thank you for your attention

If you want to know more about this work...

... please come to poster THPP014 !

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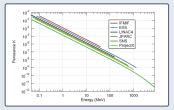
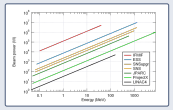
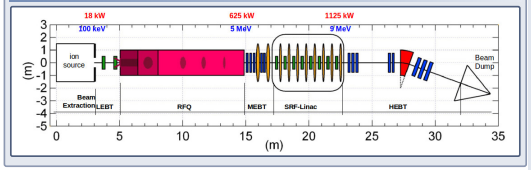
Abstract: One of the activities of the EVEDA (Engineering Validation and Engineering Design Activities) phase of the IFMIF (International Fusion Materials Irradiation Facility) project consists in building, testing and operating, in Japan, a 125 mA/9 MeV deuteron accelerator, called LIPAc, which has been developed in Europe.
For the accelerator safety aspects, a precise knowledge of beam loss location and power deposition is crucial, especially for a high intensity, high power accelerator like LIPAc. This paper presents the beam dynamics simulations allowing to estimate beam losses in different situations of the accelerator lifetime: starting from scratch, beam commissioning, tuning or exploration, routine operation, sudden failure. Some results of these studies are given and commented. Recommendations for hot point protection, beam stop velocity, beam power limitation are given accordingly.

IFMIF LIPAc characteristics & orders of magnitude

- Deuteron beam.
- Intensity: 125 mA (5 MW @ 40 MeV).
- Continuous beam.
- IFMIF Energy: 40 MeV ($\beta = 0.166$).
- LIPAc Energy: 9 Mev ($\beta = 0.094$).
- Hands-on maintenance.

IFMIF LIPAc Layout



Beam losses issues

- The *whole* accelerator is concerned by **high power beam**: from 15 kW to 1.125 MW.
- Even a *tiny part* of the beam, when lost, represents a **significant power deposition**.
- *Accidental loss* leads to sudden **heat deposition** and can damage equipment.
- *Permanent loss* can **activate** material: hands-on? cooling cryogenic systems?

High beam power in almost all along the accelerator: careful and exhaustive prediction of losses is needed

Procedure for catalog of losses

Define exhaustively all the loss situations in the accelerator lifetime
Define the protocols to simulate and estimate them

- **A. Ideal machine:** nominal conditions, without any error.
- **B. Machine "day one":** machine tolerances, no correction, tunable parameters ±10 %.
- **C. Beam commissioning, tuning, exploration:** same as **B** but with orbit correction.
- **D. Routine operation:** machine tolerances, orbit correction, tuned parameters.
- **E. Sudden failure:** individual or combination of sudden trips of tunable parameters from 100% up to 110%, or down to 0%.

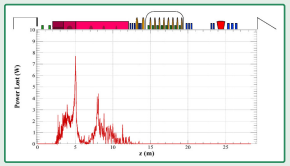
A - Ideal machine

All calculations performed with **TraceWin**.

End-to-end simulations.

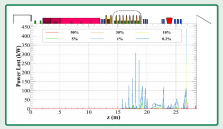
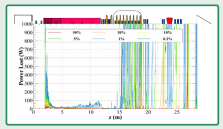
Tracking of 10^6 macro-particles.

Simulation with full beam power.



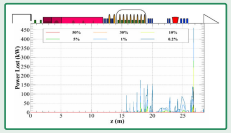
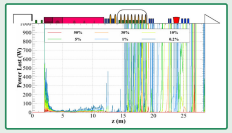
B - Machine "day one"

500 end-to-end simulations with errors randomly distributed (tolerances) and tunable parameters (fields and gradients) ±10%. No orbit correction.

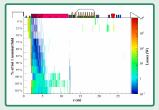
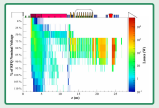
C - Beam commissioning, tuning or exploration

Same as B case but with orbit correction.

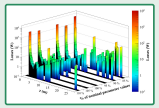
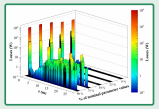



E1 - Sudden failure in low energy section (E<5MeV)

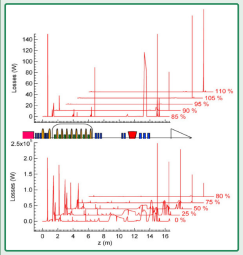
Elements (LEBT solenoids and RFQ) are set to 0 to 110% of their nominal values.

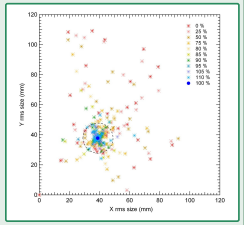
All the elements are set yo 0 to 110% of their nominal values.

E2 - Sudden failure in high energy section (E>5MeV)



Maximum beam losses in case of sudden failure of individual elements.



RMS beam size at the beam dump in case of sudden failure of individual elements in the high energy section (E>5MeV)

Conclusions

- CoL is useful to estimate the losses during the accelerator lifetime.
- CoL can be used to assess the machine safety aspects.

For LIPAc

- The high energy section should be started with 10^{-5} beam power (LEBT chopper).
- In case of failure, the beam should be stopped when the elements vary outside of a 95-105% range of their nominal values.

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