IFMIF LIPAc – Beam Commissioning Simulations

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The Broader Aproach

Broader Approach: a scientific collaboration between **F4E** and **JAEA**.

Objectives: upstream research for future fusion reactors.

Three sub-projects :
- **IFERC**, a supercalculator for fusion plasma simulations.
- **JT-60**, a satellite tokamak of ITER designed to address some physical issues.
- **IFMIF**, detailed hereby.

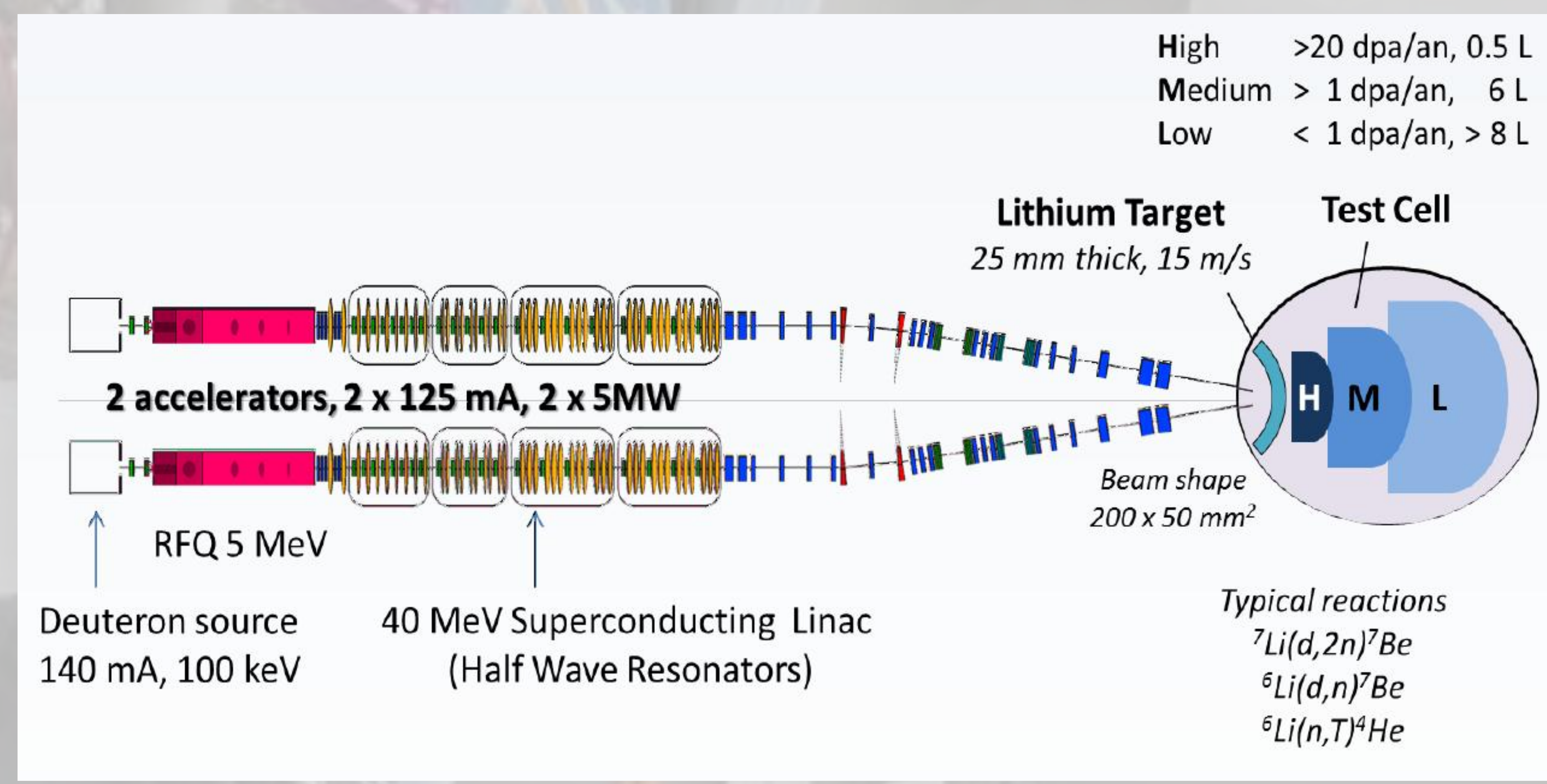
All three projects are meant to tackle DEMO's issues. DEMO is the fusion tokamak supposed to be built after ITER and before PROTO.

The IFMIF Project

IFMIF project: two accelerators, a Lithium target and a set of test cells.

Objectives: testing new materials capable of resisting DEMO's neutron flux.

DEMO's tokamak materials will be exposed **to 30 displacement per atom per year** against **0.3 dpa/year** for **ITER**.



A continuous beam of 2x125*mA* medium energy (40*MeV*) Deuteron ions is sent on the liquid Lithium target for a total of 10*MW*. The flux of generated neutrons will then irradiate the test cells.

The IFMIF accelerator will be:
- **-the most intense ever built**
- **-the most powerful**
- **-the one with the strongest space charge effect**
- **-the one with the longest RFQ**

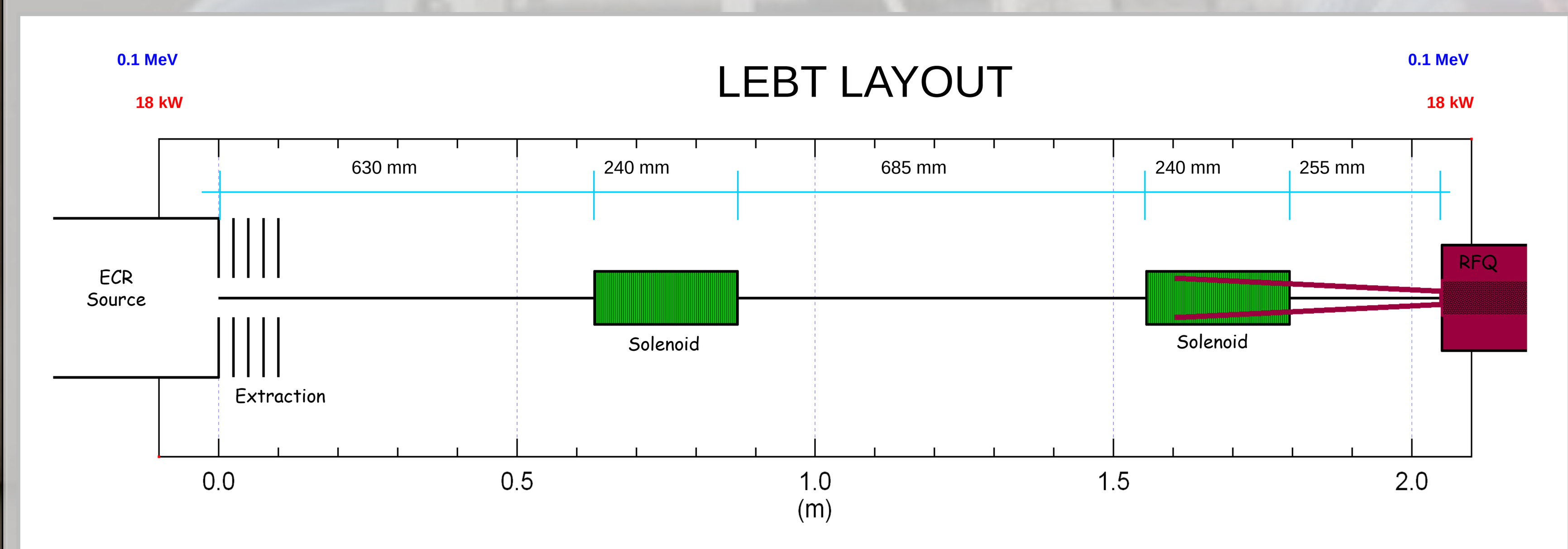
A prototype accelerator (LIPAc) is designed, built and tested at CEA Saclay.

Beam Commissioning Simulations

Objectives:

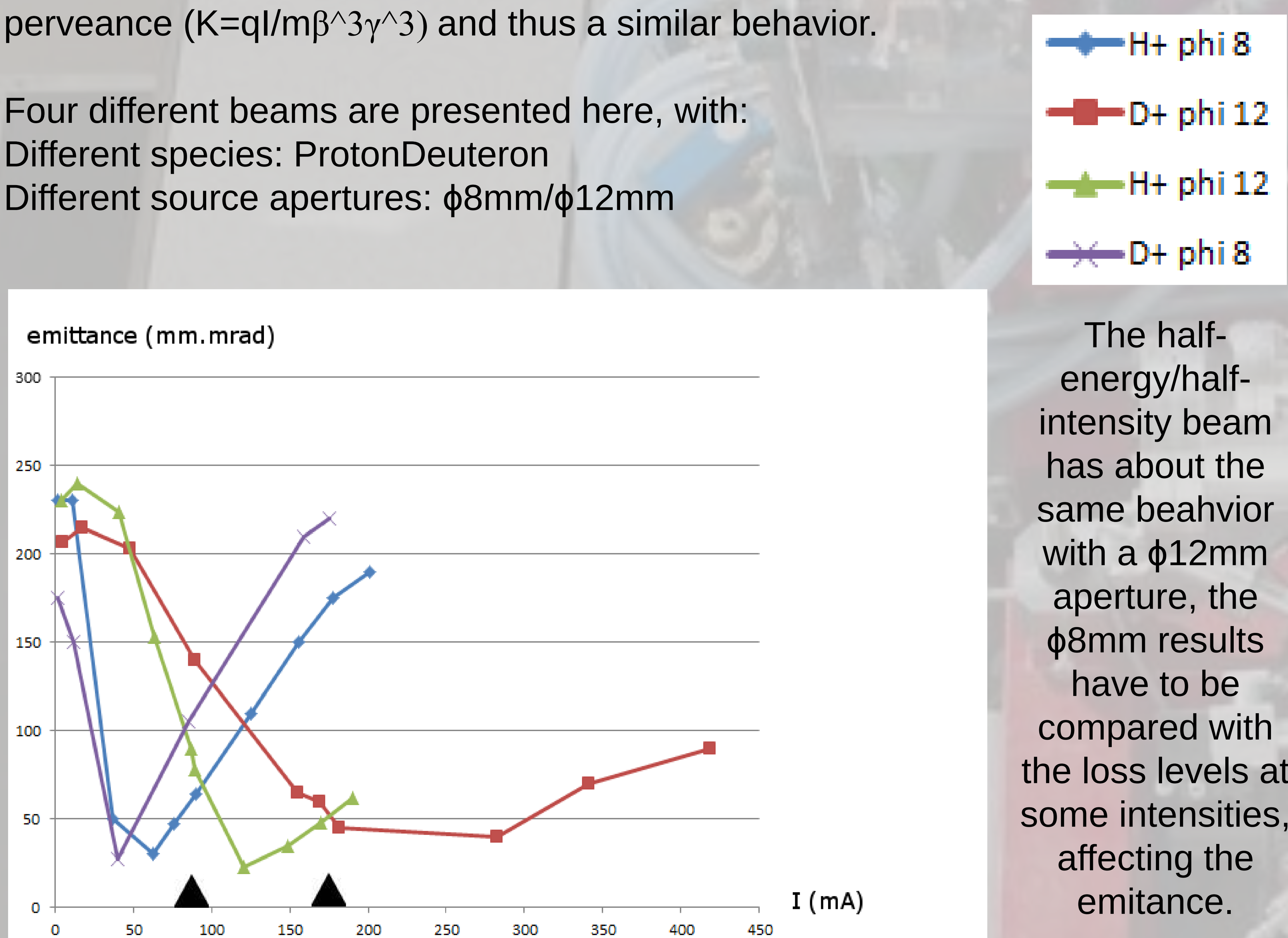
-**support the ongoing tests** on the physical **LIPAc prototype** (margins, feasibility studies, power losses, forbidden sets of tuning)

-improve our understanding of the behaviour of the beam with a set of varying tunings of the **LEBT** (low energy section of the line)



Influence of the extracted beam intensity: (simulated using AXCEL)
The black triangles emphasize the designed settings of the device, both in proton mode and in deuteron. The proton beam with half energy and intensity is used for tests as it doesn't cause material activation and has the same general perveance (K=qI/mβ^3γ^3) and thus a similar behavior.

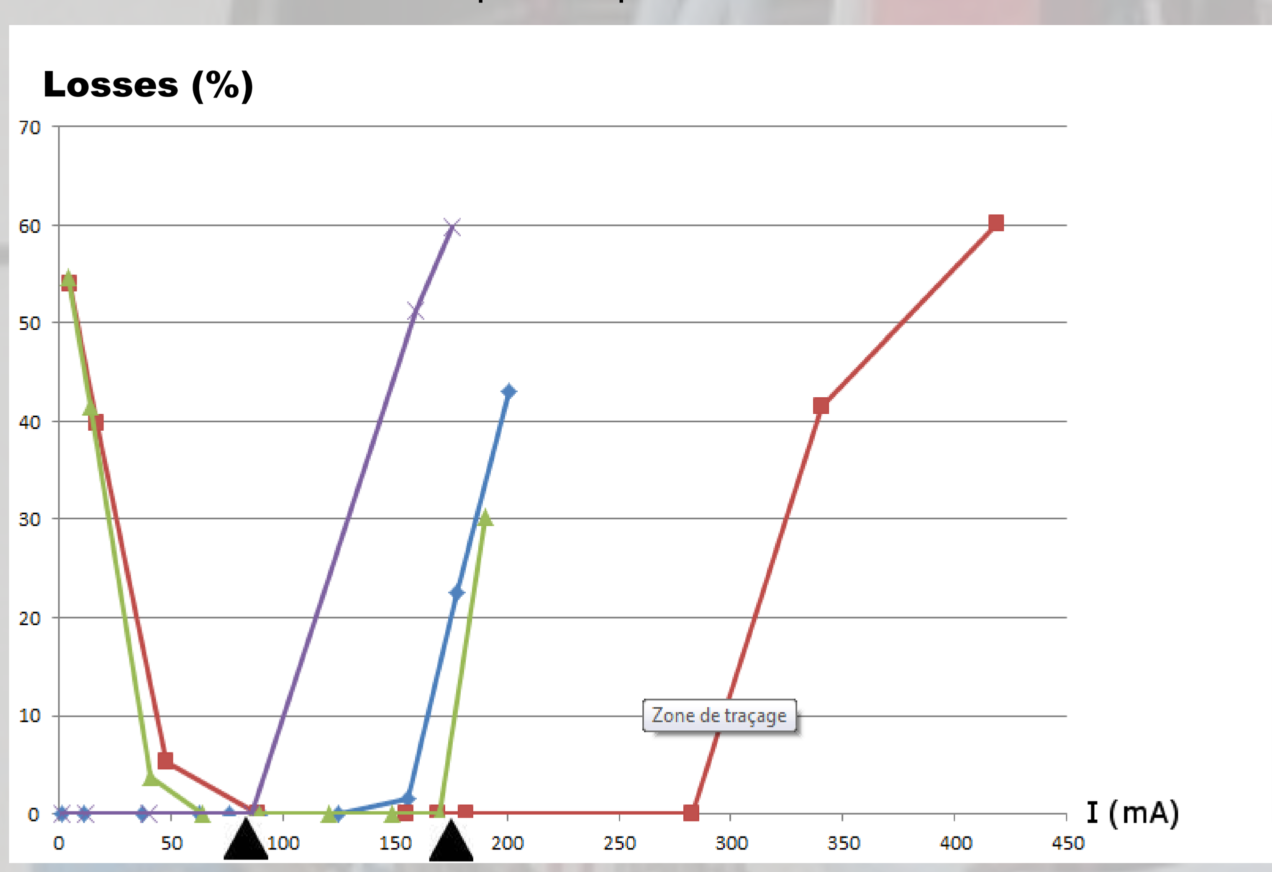
Four different beams are presented here, with:
Different species: ProtonDeuteron
Different source apertures: ϕ8mm/ϕ12mm



The half-energy/half-intensity beam has about the same beahvior with a ϕ12mm aperture, the ϕ8mm results have to be compared with the loss levels at some intensities, affecting the emitance.

emitance = volume of the beam distribution in the phase space

The Deuteron beam with ϕ8mm aperture causes losses at half the designed intensity, this geometric configuration was thus abandonned.



RFQ Transmission Studies

To reach higher energies, the beam has to go through the Radio Frequency Quadrupole (RFQ) where it is periodically focused and accelerated by a RF EM-wave, the beam is also bunched in the RFQ.

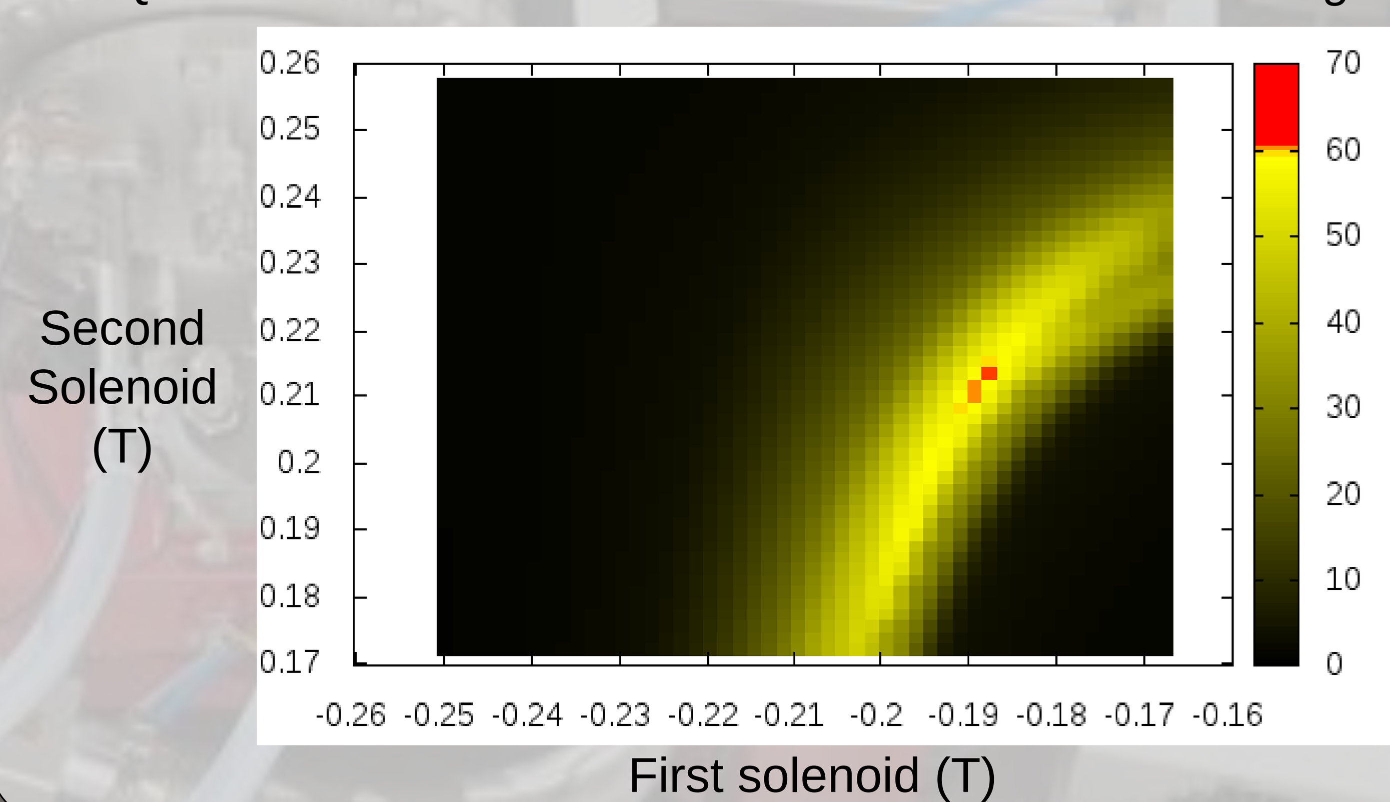
The beam has to meet the **RFQ's entry requirements**:
- -pass with minimum particles losses
- -avoid material activation
- -avoid material deterioration due to the high power
- -best output beam parameters for the rest of the line

The required **beam radius, divergence and emitance** (+Twiss parameters) are met using the LEBT's 2 solenoids.

A set of simulations were carried out on the Irfu's cluster DAPINT using the particle transport codes **ParTran & Toutatis** in order to determine which were the finest set of tuning for the considered 87.5mA/50keV H+ beam.

The transmission factor only reaches a maximum of 70% because the considered RFQ was actually designed for Deuteron ions acceleration.

RFQ transmission ratio as a function of both solenoids' magnetic fields



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