Multiphysics simulations and validations of a Target Ion Source system for the production of Radioactive Ion Beams

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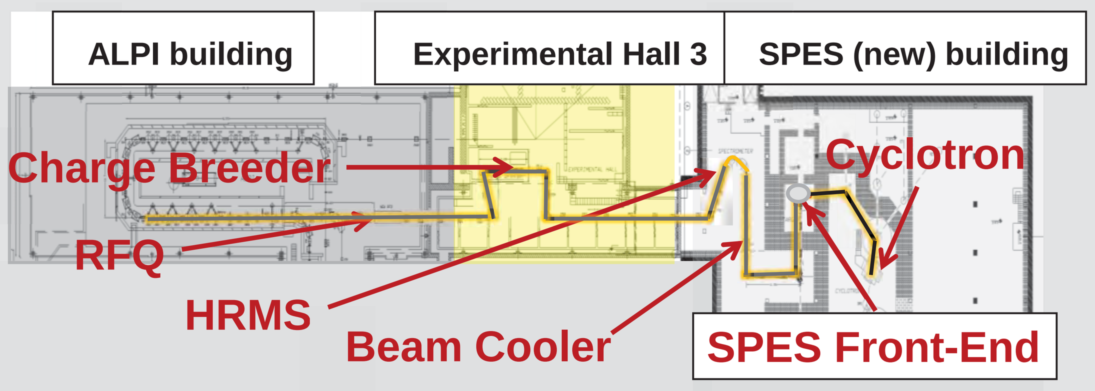
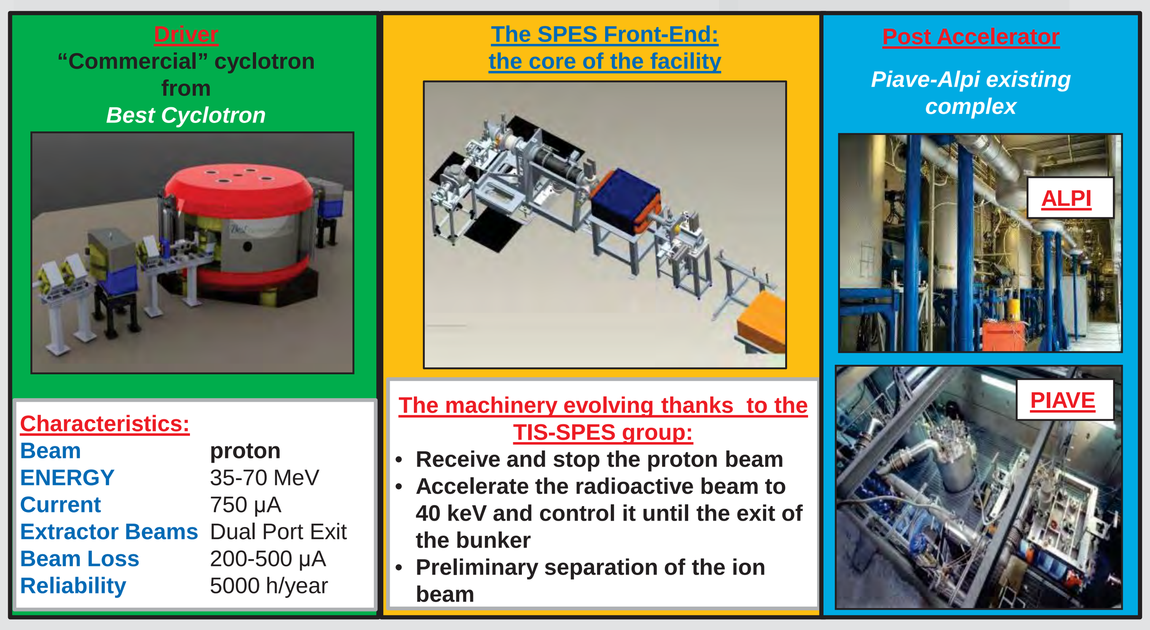
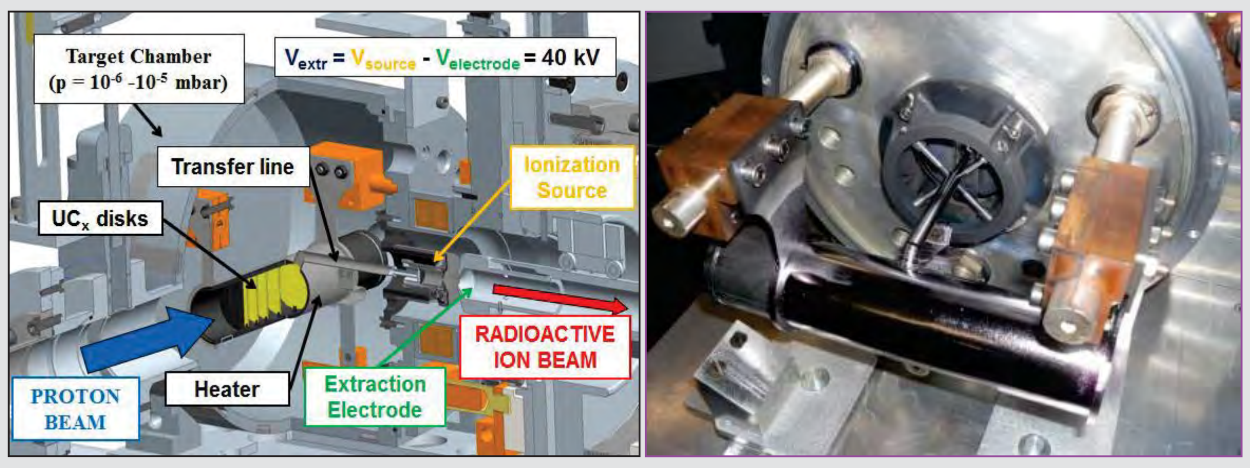
The SPES project (Selective Production of Exotic Species) aims to develop a facility at Legnaro National Laboratories (LNL) to produce Radioactive Ion Beams (RIB). The facility operates according to the isotope separation on-line technique (ISOL): the driver, a cyclotron, supplies a 200 μA 40 MeV proton beam to the SPES Front-End producing RIBs, thanks to the Target-Ion source system. To obtain higher ion beam energies, a series of subsystems (Beam Cooler, HRMS, Charge Breeder, RFQ) are being designed to allow the use of the post-acceleration PIAVE-ALPI.

The SPES facility





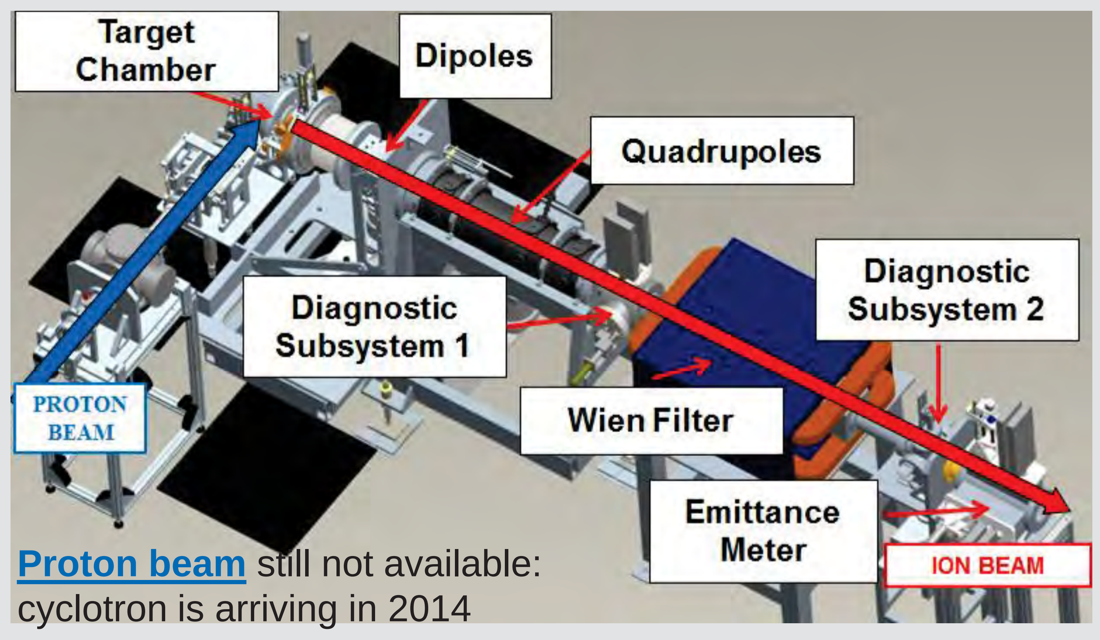
The core of the facility: the *Target Ion Source* (TIS) complex



PROTON BEAM ⇨ Target ⇨ Ionization source ⇨ Extraction electrode ⇨ RADIOACTIVE BEAM

Target Ion Source (TIS) complex

The off-line *Front-End* installed at *Legnaro National Laboratories*



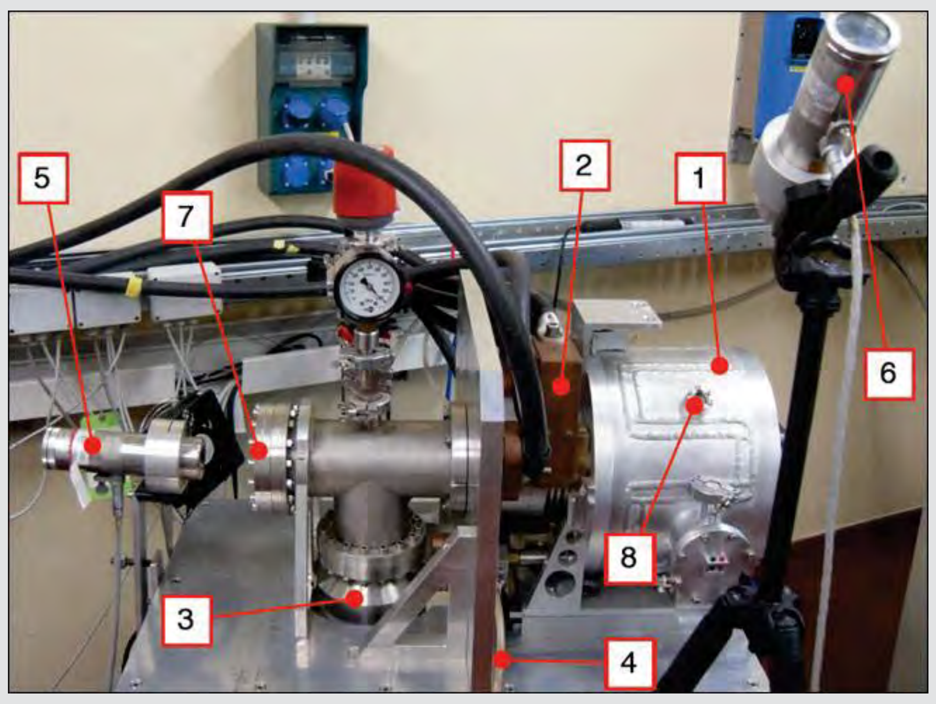
Proton beam still not available: cyclotron is arriving in 2014

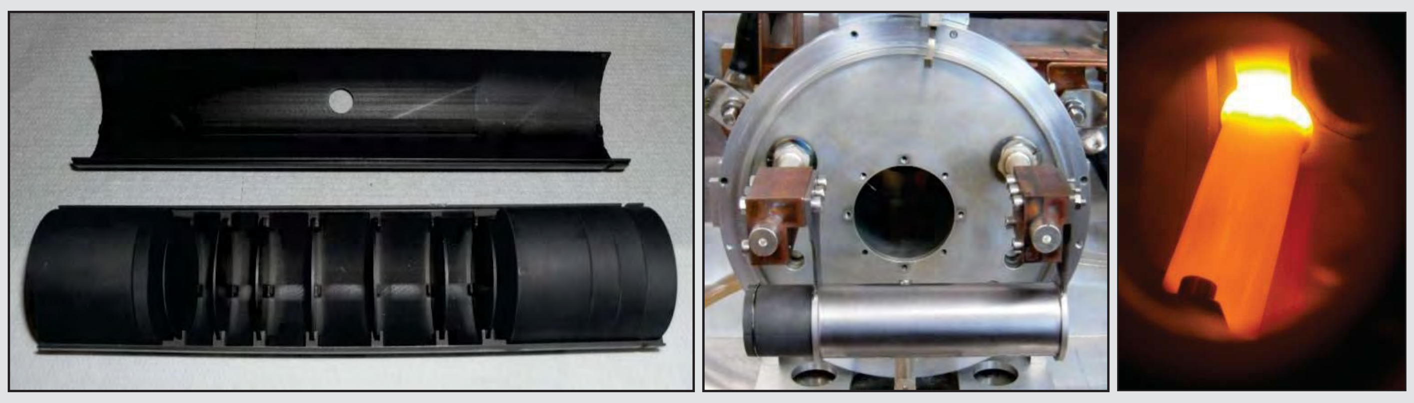
Main components of the Front-End

Dipoles: maintain the beam centered
Quadruples: focus the beam
Wien filter: speed separator
Diagnostic subsystem 1 & 2: reveal beam position and current intensity before and after the Wien filter
Emittance meter: measure of beam emittance

Experimental apparatus used to test the SPES target heater

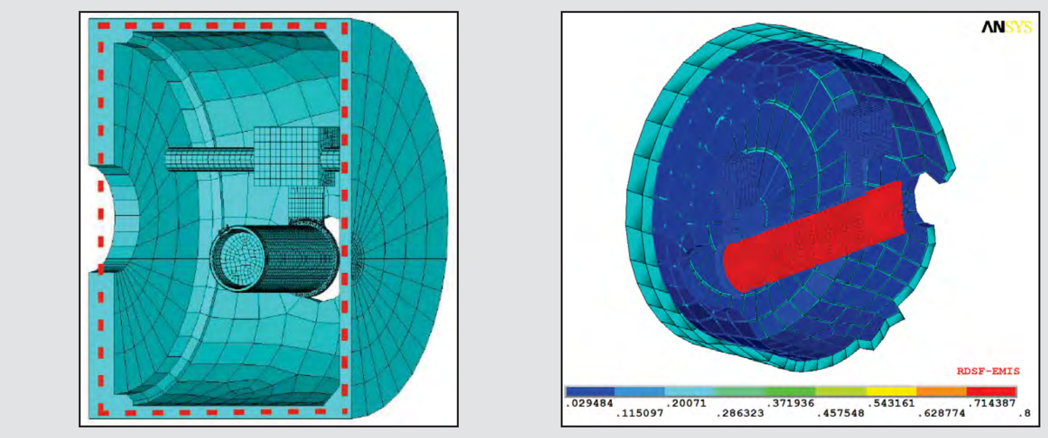
1. SPES vacuum chamber
2. Electrical feedthrough
3. Turbomolecular pump
4. Cooling system
5. Pyrometer n°1
6. Pyrometer n°2
7. Kodial window n°1
8. Kodial window n°2





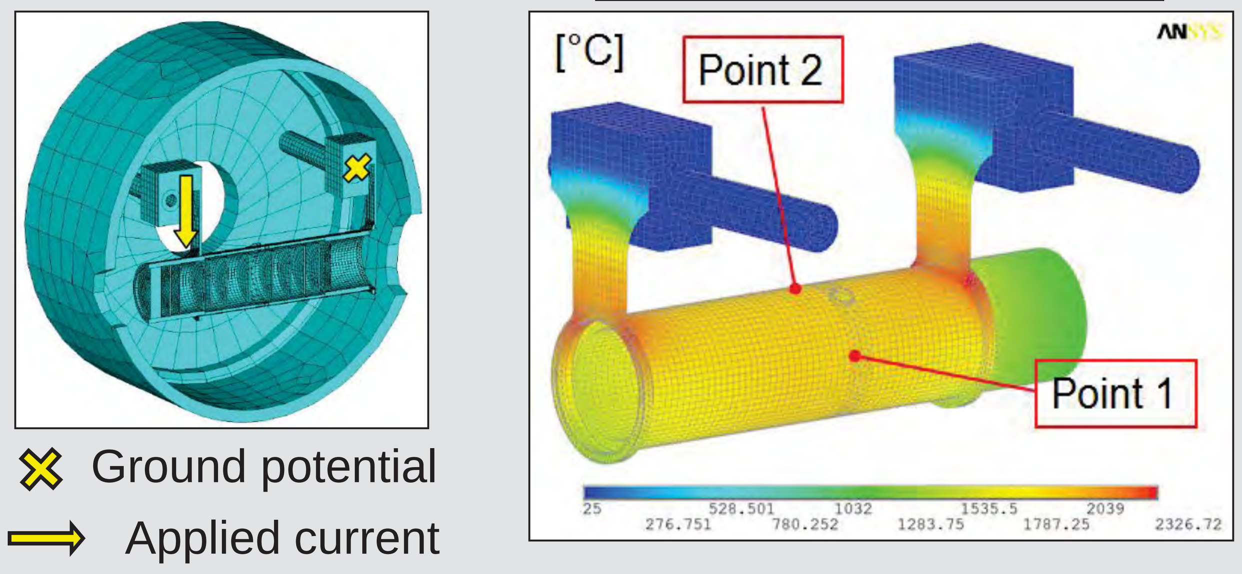
FEM model of the SPES target heater

Thermal boundary conditions



Ambient temperature Emissivity

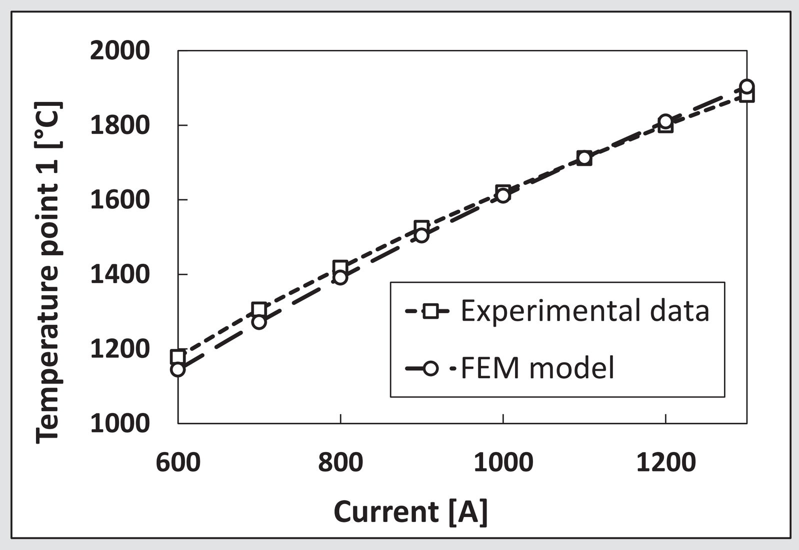
Electrical boundary conditions ***Solution of FEM model***

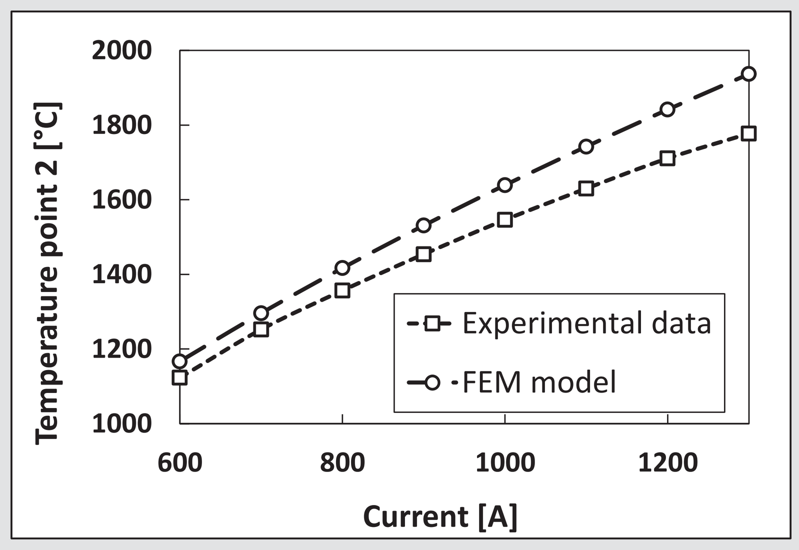


Ground potential

Applied current

Comparison: *Experimental data vs FEM model*





A typical problem of beam transport: the Wien Filter

The Wien velocity filter: operating principle

Average speed of the particles after extraction electrode: $$v_{ion} = \sqrt{\frac{2q_{ion}V_{extr}}{m_{ion}}}$$

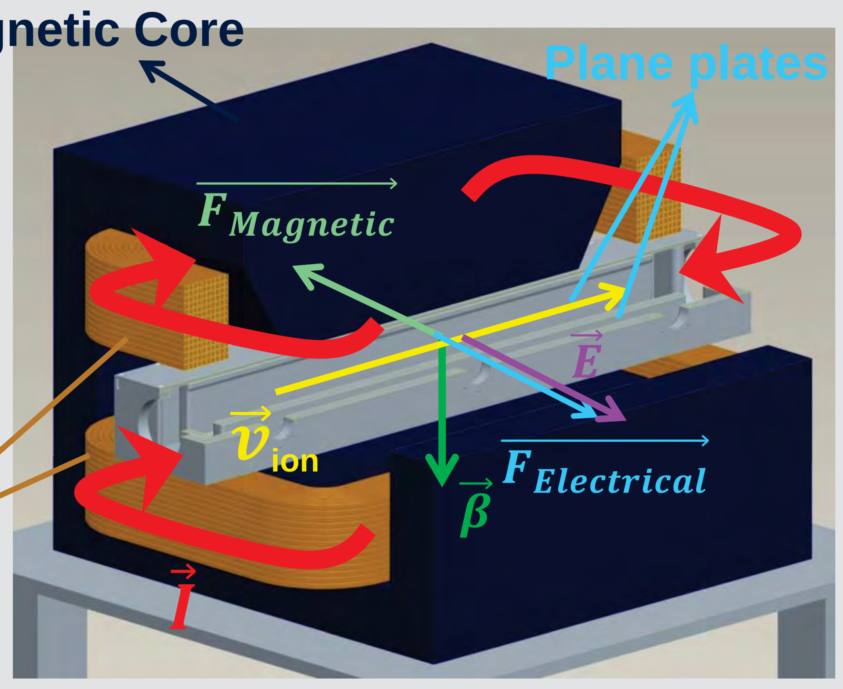
Lorentz force: $$\vec{F}_L = q(\vec{E} + \vec{v} \times \vec{\beta})$$

In the Wien Filter:

$$\vec{v}_{ion} \perp \vec{E}$$

$$\vec{v}_{ion} \perp \vec{\beta}$$

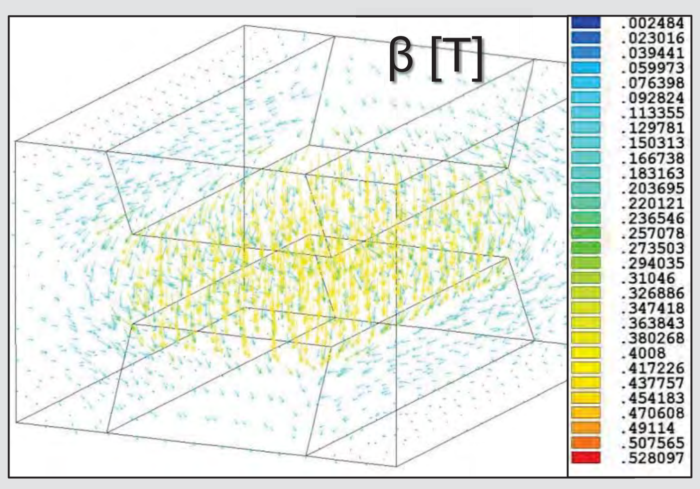
$$\vec{E} \perp \vec{\beta}$$

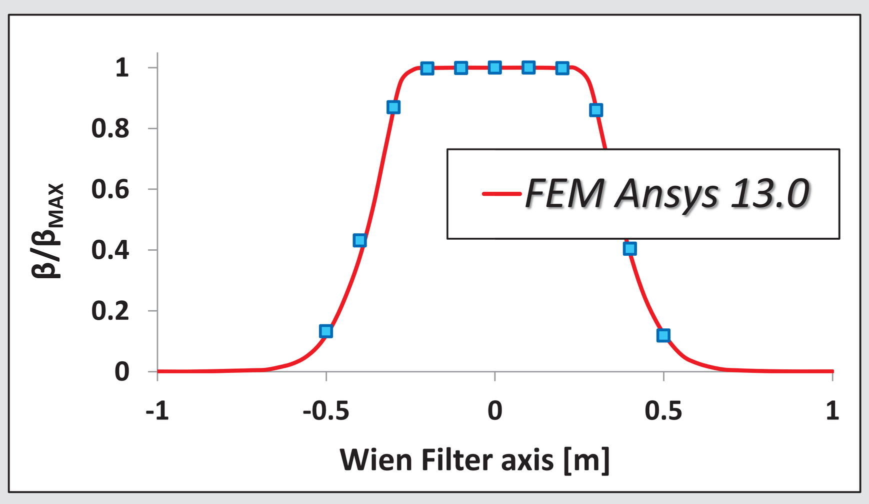


Speed of the particles with unchanged trajectory by the Wien filter: $$\vec{v}_{ion} = \frac{\vec{E}}{\vec{\beta}}$$

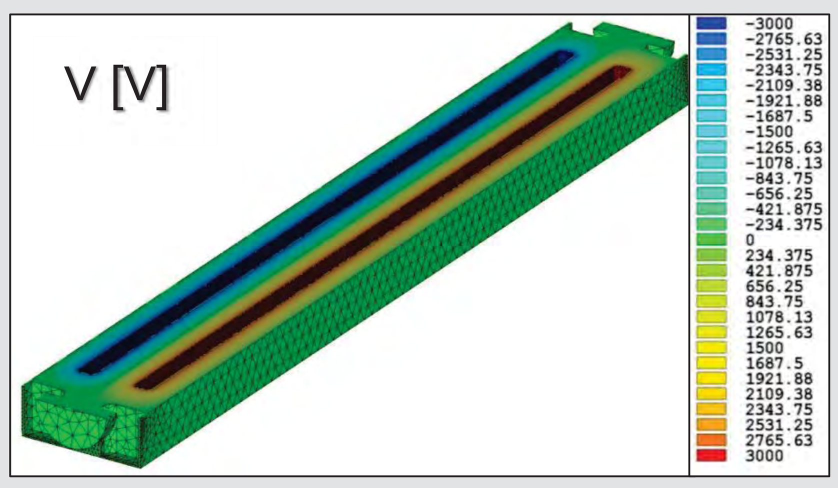
Mass of the particles selected by the Wien filter $$m_{ion\ selected} = 2q_{ion}V_{extr}\left(\frac{\vec{\beta}}{\vec{E}}\right)^2$$

Magnetostatic Simulation: magnetic field induced by the two coils



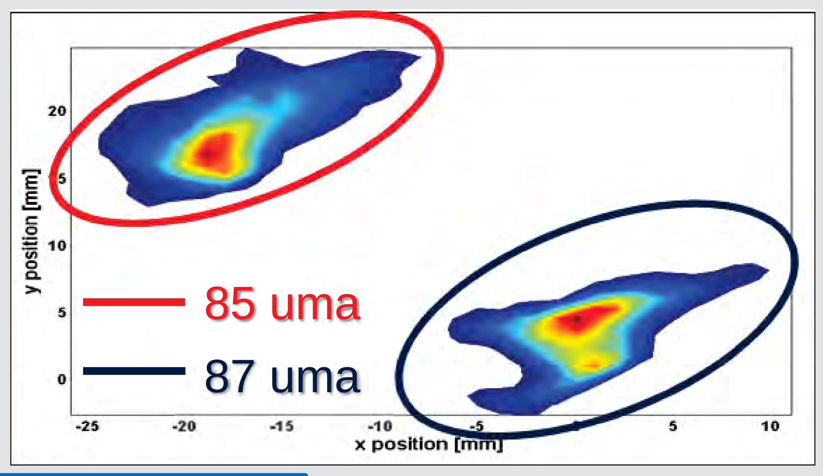


Electrostatic Simulation: electrical field induced by the two plane plates

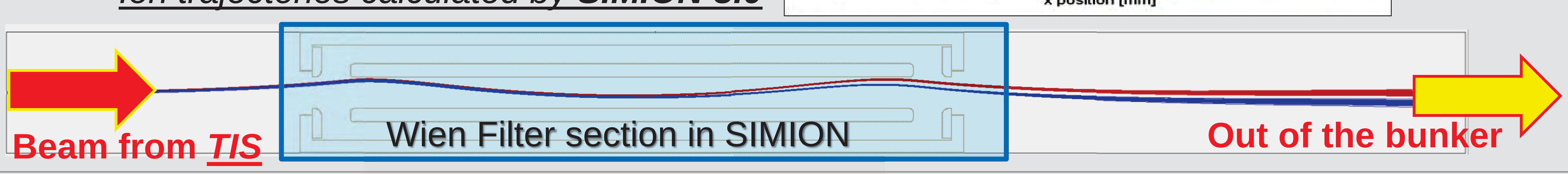


Results with ***SIMION 8.0***

(ion optics simulation program to calculate ion trajectories)



*Ion trajectories calculated by **SIMION 8.0***



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