Acceleration of electrons in High Beta Section of SPL

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LINAC4 and SPL

LINAC4 | Low β Section | High β Section

LINAC4, currently under construction at CERN will accelerate H^- ions up to 160 MeV.

Low β section of SPL uses 10 cryo-modules, housing two periods each composed of a quadrupole doublet and three 5-cell cavities.

SPL, High β Section

High β section is composed of 23 cryo-modules bringing the H^- beam energy from ~700 MeV to ~5 GeV, each module houses a pair of quadrupoles and eight 5-cell cavities of $\beta_g = 1$.

Low beta section of SPL, $\beta_g = 0.65$, increases the H energy from 160 to ~700 MeV.

Transverse focusing is provided by superconducting quadrupoles ($L_{quad} = 450$ mm).

Electrons in SPL

High β_g section of SPL has been used to accelerate electrons.

The minimum energy of electrons to be re-circulated in SPL high β, was found to be at least 35MeV.

Energy gain in each turn is 4.8 GeV

Initial beam

The initial values for the emittance of the beam was chosen to be equal to the normalized emittances achieved in CTF3.

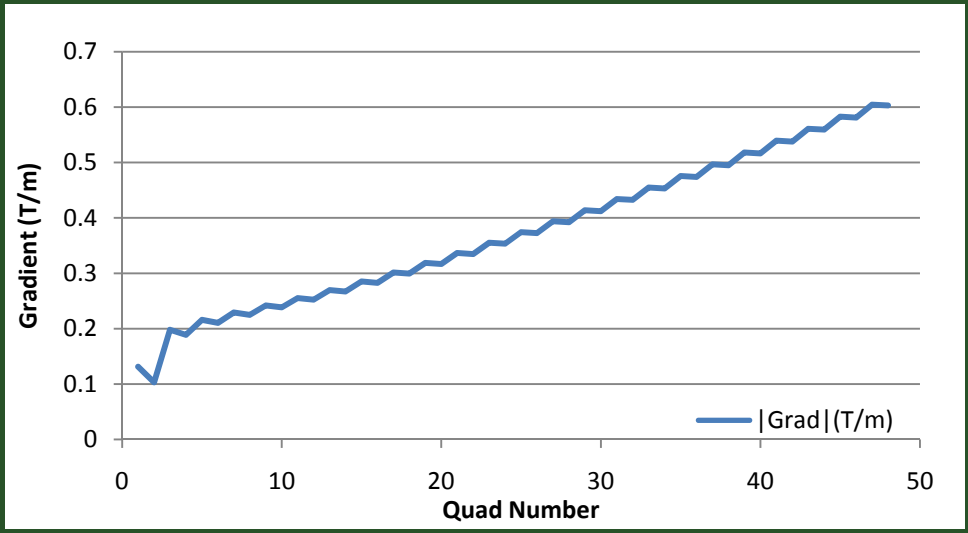
Twiss parameters are found before each run through the machine

	X plane	Y plane	Z plane
Init. Norm. Emittance (π.mm.mrad)	50	50	60

Acceleration + Quads

Energy gain in each turn is 4.8 GeV.

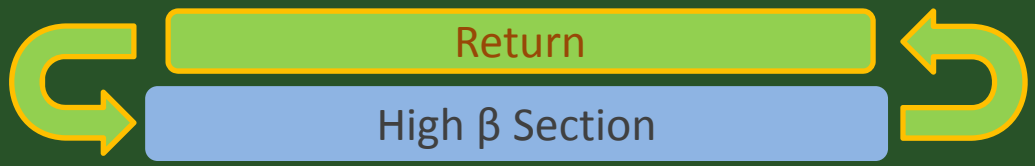
Quadrupole gradient stays constant during multi turn acceleration of electrons, but are different from H^-



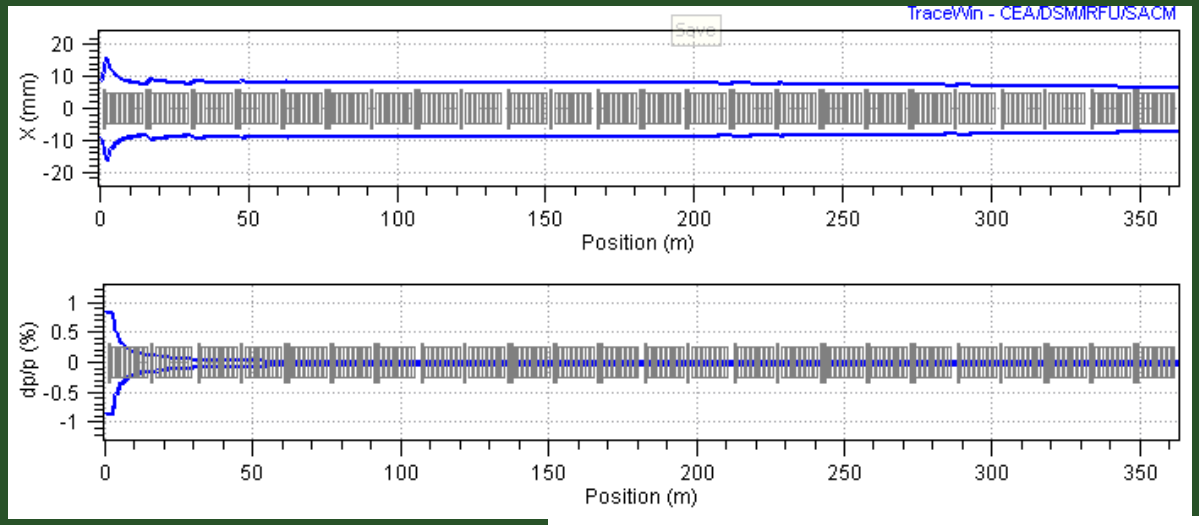
Re-circulating and Arcs

A beam of electrons can be re-circulated for more than 6 times keeping all the quads at a pre-defined value (plot at previous page) during the turns.

Arcs have not been designed yet.

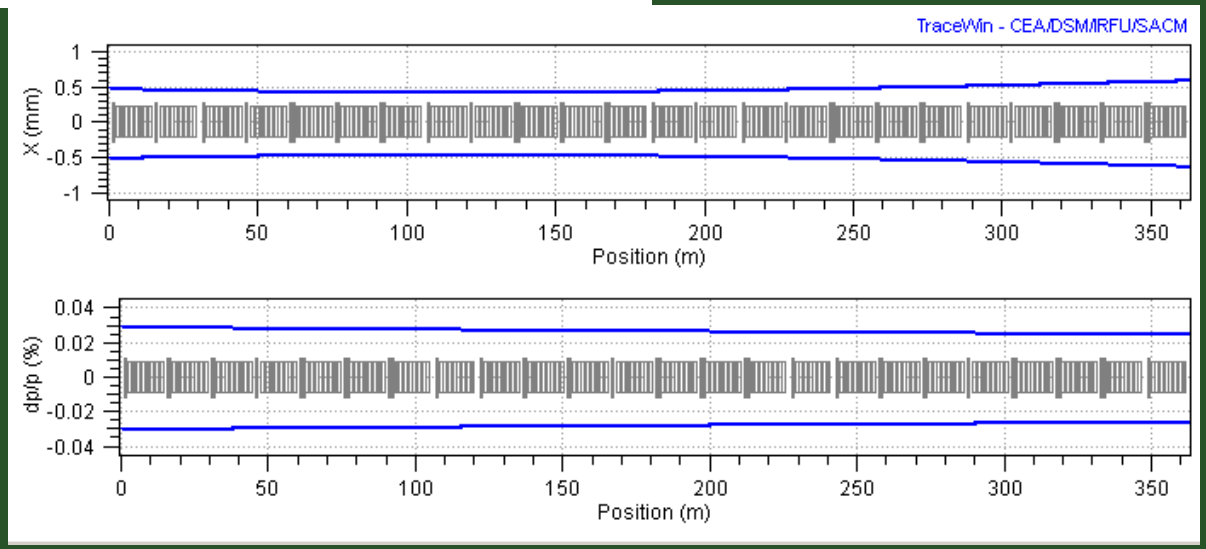


Envelopes

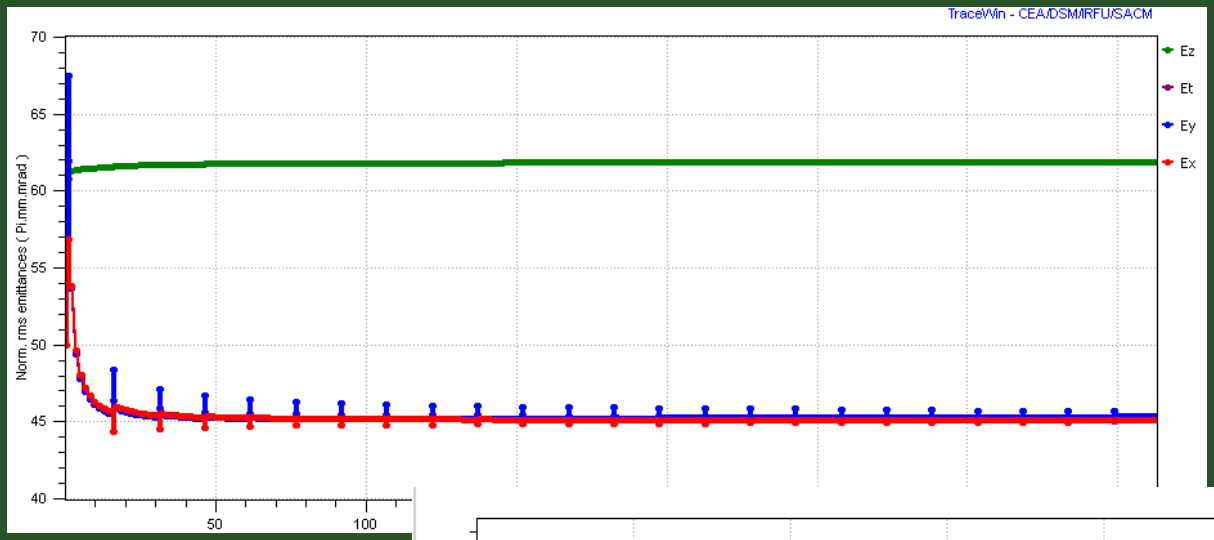


Envelopes in transverse and longitudinal for the first turn

and the last turn

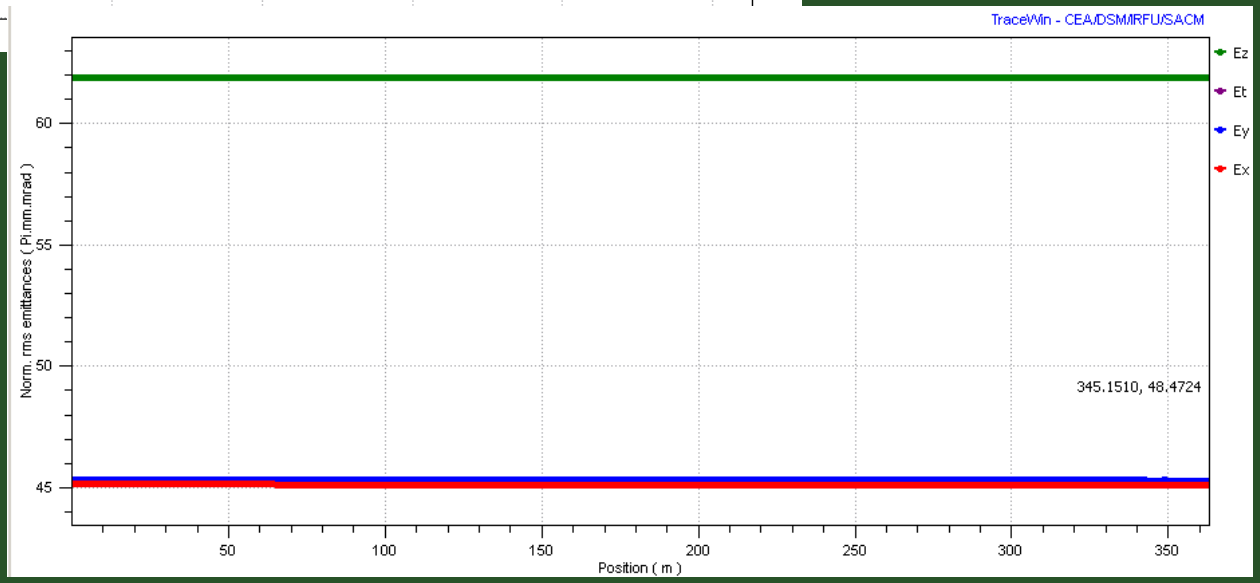


Emittances

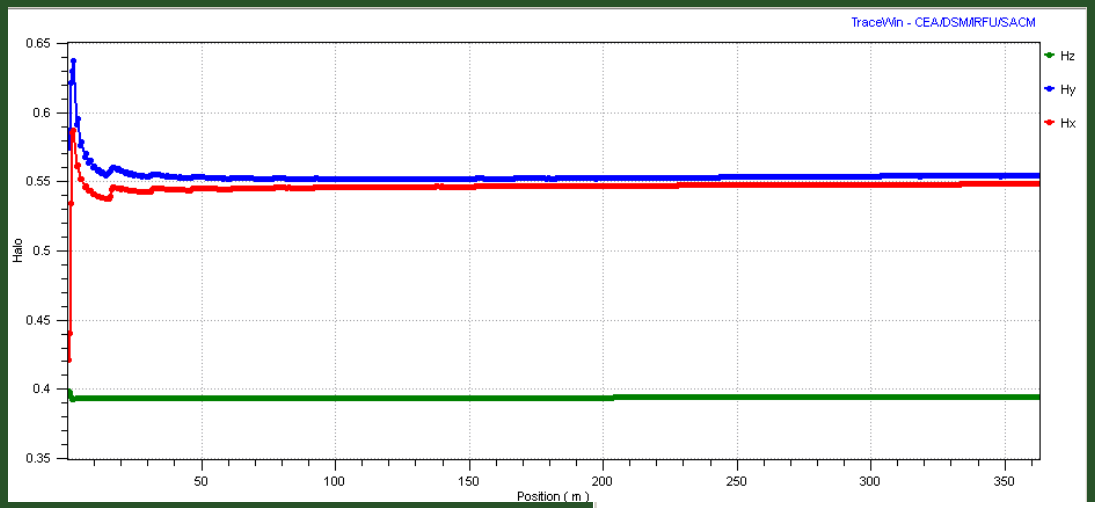


Emittance in the first run

Emittance in the next runs

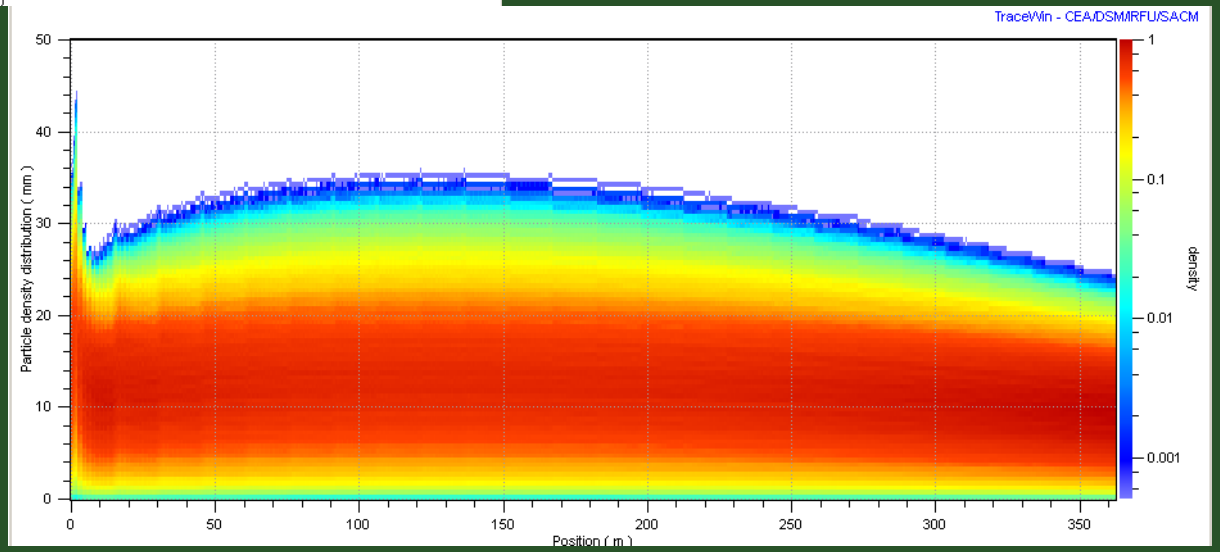


Halo and Density



Halo evolution along the line, after the first turn, it stays constant

Radial density of particles along SPL, beam aperture is 50 mm



Final Beam

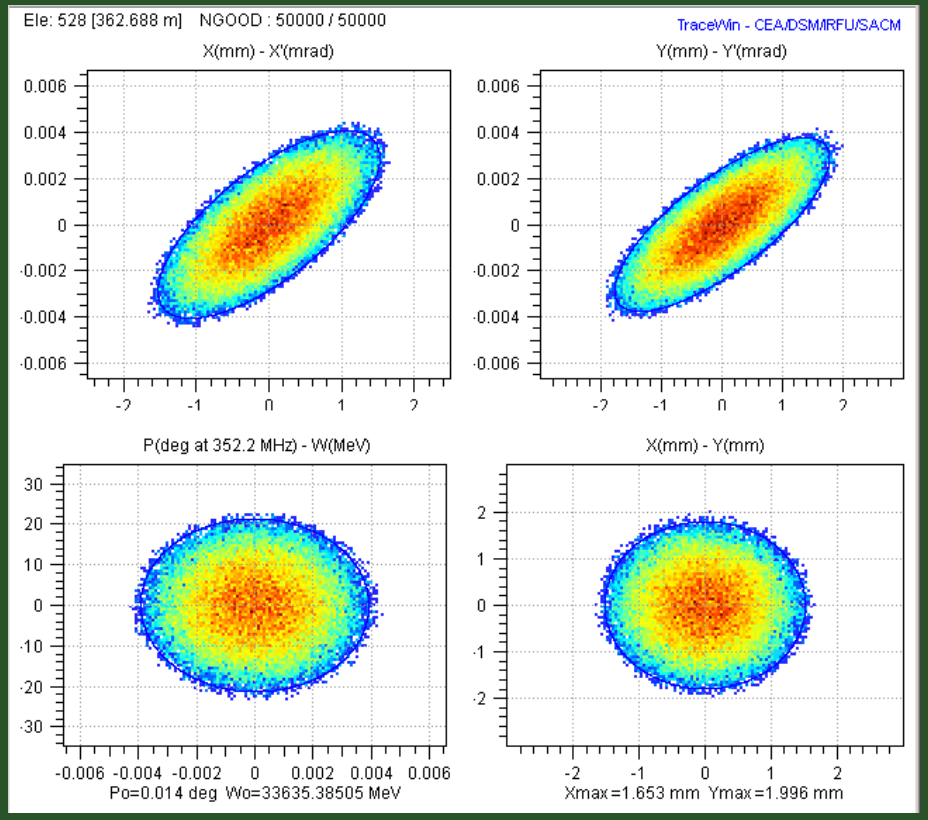
A beam of electrons accelerated 7 times through high beta SPL.

Energy: 33.6 GeV

Normalized RMS emit.

ε_x = 45 π.mm.mrad

$\varepsilon_{\phi E}$ = 0.0134 π.deg.MeV

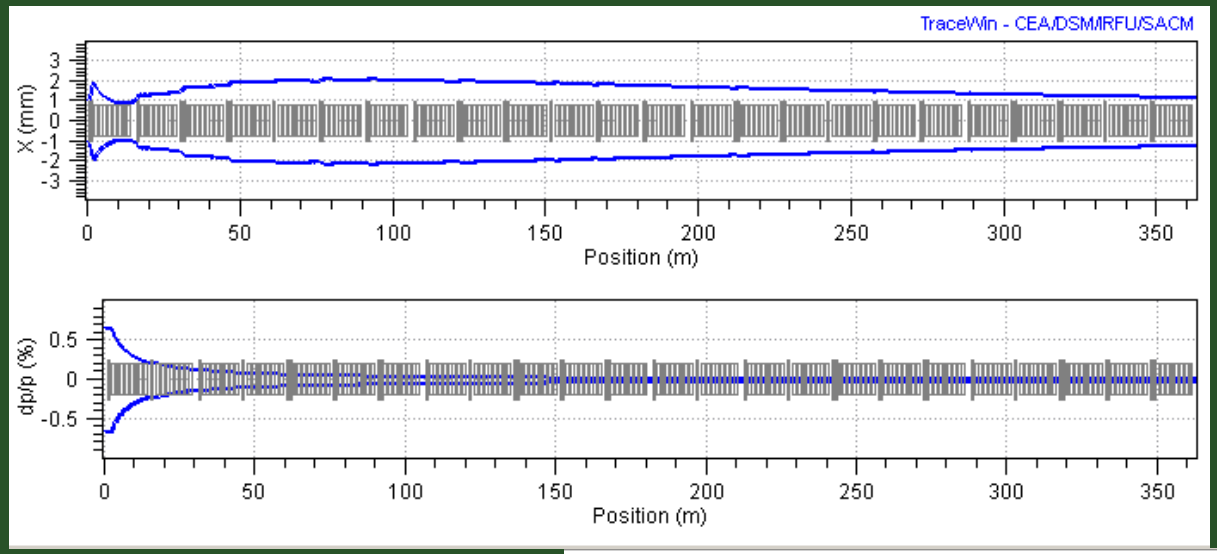


Constant Gradient Quadrupoles

High $\Delta\gamma/\gamma$ in the first period, $\Delta\gamma/\gamma \approx 7$, prohibits use of quadrupoles all along the SPL with a constant gradient.

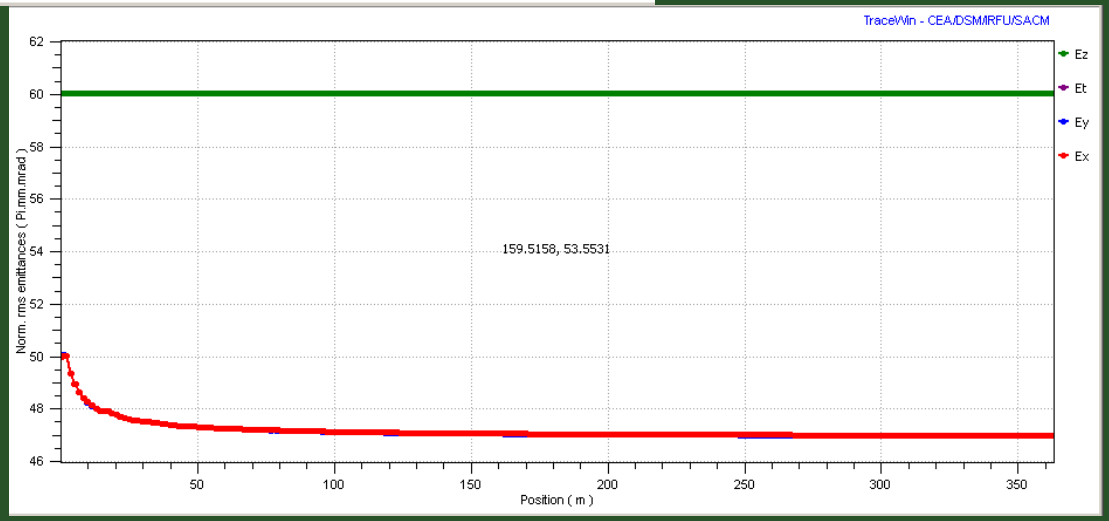
By increasing the input energy from 35 MeV to 100 MeV, the quadrupoles at SPL can be all set at a fixed gradient of 0.4 T/m.

Constant Gradient Quadrupoles

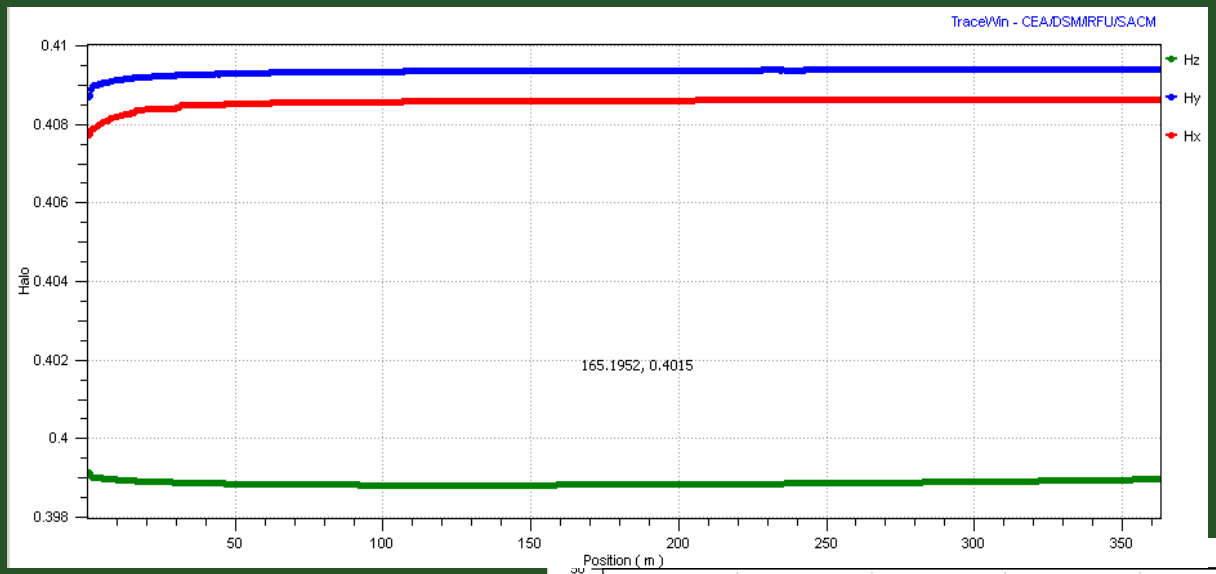


Envelops in the first run

Emittances in the first run

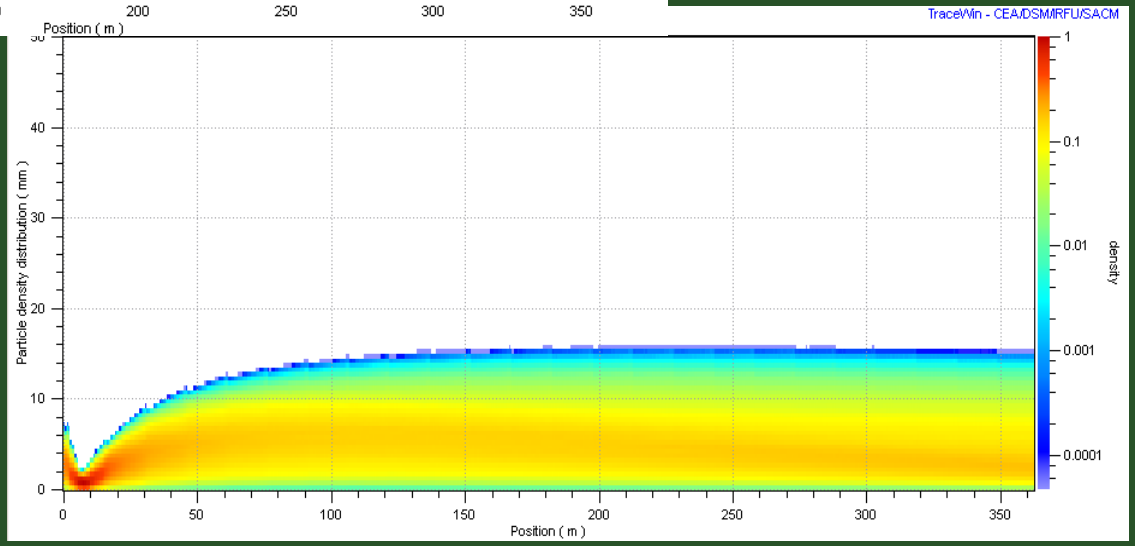


Constant Gradient Quadrupoles



Halos in the first run

Density in the first run



Further studies

Optimization of the initial energy

Designing the Arcs

Re-doing the study with the beam transported to the injection point using arcs

Integration of arcs in the SPL layout