Beam Dynamics Simulation for the PITZ Gun

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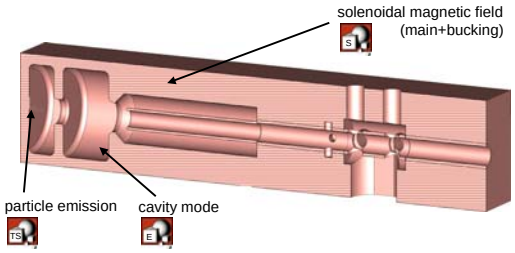
Introduction

Beam dynamics simulation including the geometry

Space charge dominated processes inside the RF gun contribute significantly to the emittance of a charged particle beam. To clarify the effects resulting additionally from the surrounding beam line components detailed numerical studies have to be performed.

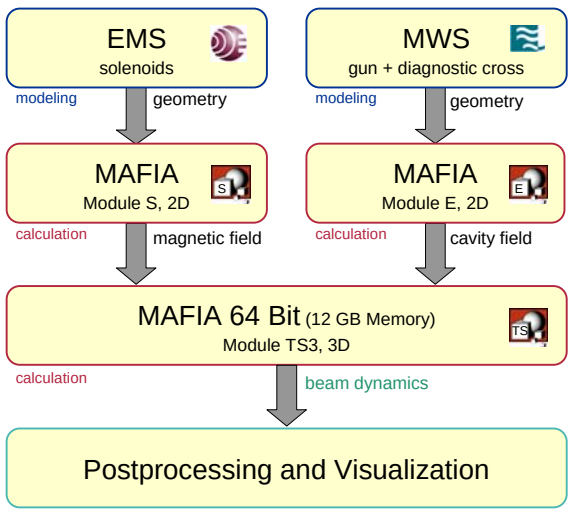


3D PIC Simulation

Field and Eigenmode Calculation

For expressive beam dynamics simulation precise geometry modeling and suitable field calculation are indispensable.
To perform all calculations well-established simulation codes are fit together to take full advantage of each individual software package.

Program interplay:



Simulation Parameter

Bunch Parameter and Field Data Settings

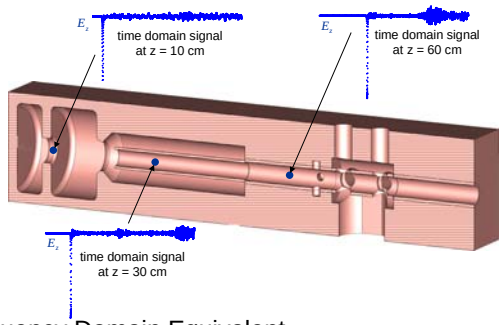
Survey of the gun and bunch parameters used for the PIC simulations.

T_{FWHM}	=	20 ps	B_{max}	=	0.17369 T
T_{rise}	=	4 ps	z_0	=	0.2784 m
E_{kin}	=	5 eV	E_{max}	=	42 MV/m
Q_{Bunch}	=	−1 nC	φ_0	=	38°

Grid Demands

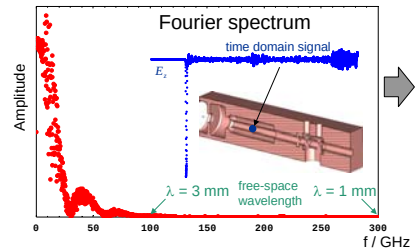
Time Domain Signals

The computational grid must be able to resolve all field components. Due to the short bunches the crucial frequency inside the gun is determined by the wake field excited by the beam.



Frequency Domain Equivalent

A Fourier transformation of the time domain signals is used to determine the minimum requirement for the necessary grid settings. In addition to the propagating frequencies also the phase lag has to be taken into account.



To resolve the fields in the beam tube:

$\Delta z \leq 0.3$ mm

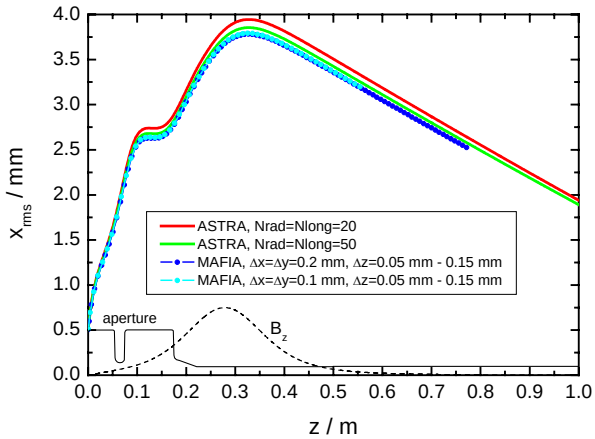
To resolve the field during emission the grid must be even finer. Experiments so far leads to:

$\Delta z \leq 0.05$ mm

Simulation Results

Simulation Model

For the simulation of the beam dynamics inside the RF gun a three dimensional MAFIA TS3 model of the complete structure including the external solenoids, the cavity, the subsequent beam tubes and the diagnostic doublecross down to one meter total length from the cathode has been set up.



Cross-checking the results with ASTRA showed that due to memory limitations and long processing times a really suited grid setting has to be found. The standard scheme used so far give way to further improvements.