INTEGRATION OF THE MOMENT-BASED BEAM-DYNAMICS SIMULATION TOOL V-CODE INTO THE S-DALINAC CONTROL SYSTEM *

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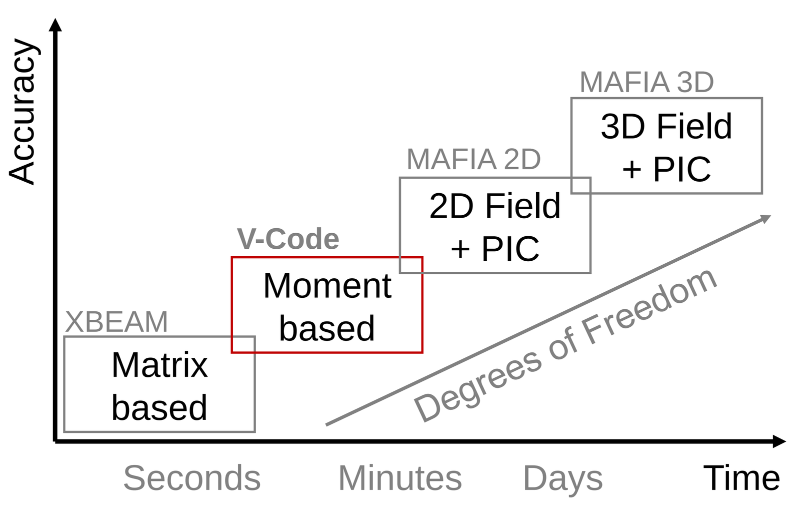
Introduction

Fast and accurate beam-dynamics simulation programs within accelerator control systems can advantageously assist the operators and provide a more detailed insight into the actual machine status.

The Superconducting Linear Accelerator S-DALINAC installed at the Institute for Nuclear Physics (IKP) at the Technische Universität Darmstadt consists of a 10 MeV injector and a 40 MeV linac. Utilizing two recirculations, the linac can be used up to three times, leading to a maximum energy of 130 MeV.

The V-Code simulation tool implemented at the Computational Electromagnetics Laboratory at the Technische Universität Darmstadt (TEMF) is a fast tracking code based on the moment approach.

In this contribution an overview of the numerical model of the V-Code is presented together with implemented features for its dedicated integration into the control system of the S-DALINAC.



Numerical Model

Moment Approach:

- Representing the density distribution function by a discrete set of moments
- Stating a time evolution equation for each moment using the Vlasov equation
- Evaluating these various ODEs with a standard time integration method

Moment Definition:

- Weighted mean value in 6D phase space : $M_\mu = <\mu> = \int \mu \cdot f(\vec{r},\vec{p})\, \mathrm{d}^3r\, \mathrm{d}^3p$
- Numerically advantageous choice:

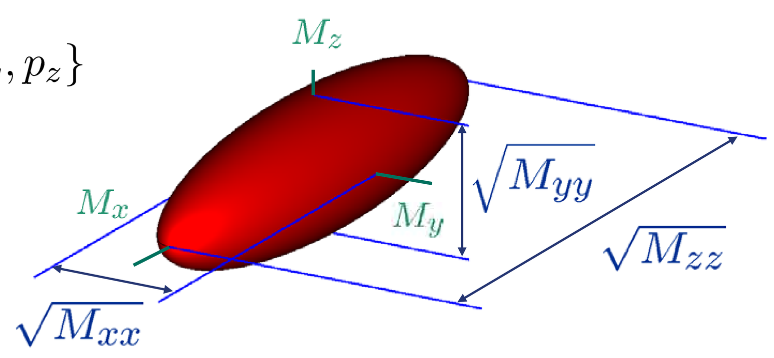
– First order raw moments: $\mu \in \{x, y, z, p_x, p_y, p_z\}$

→ description of the center of mass

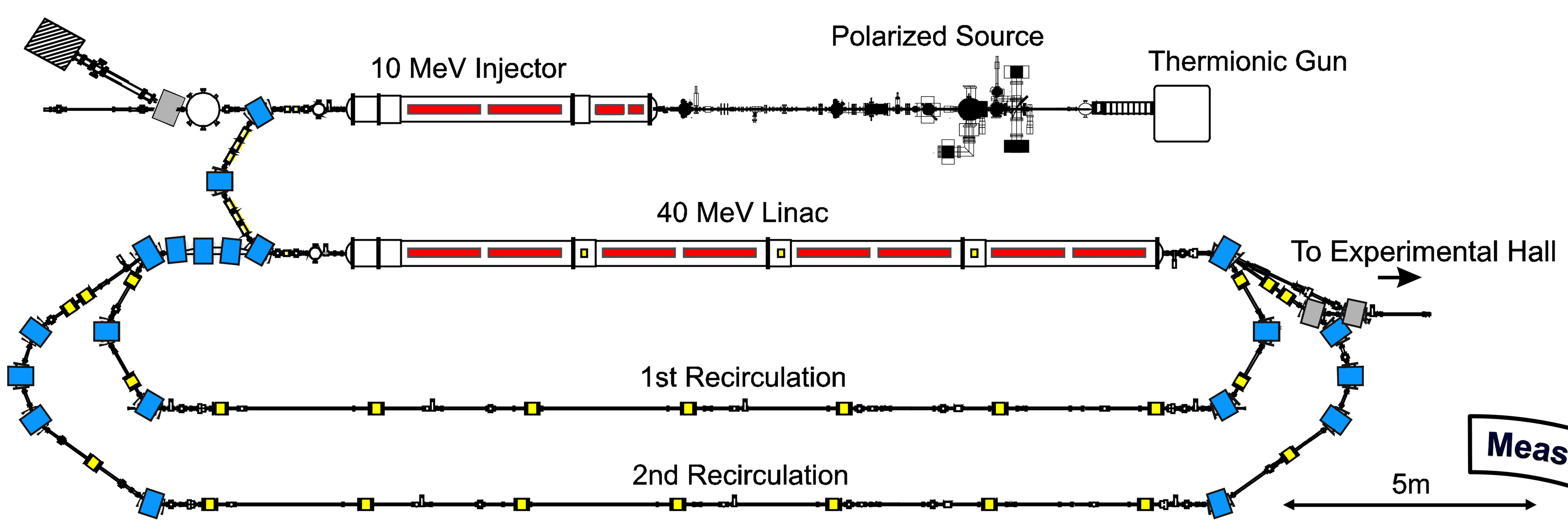
– Higher order central moments:

$\mu \in \{(x - <x>)^{l_1} \cdot \ \dots \ \cdot (p_z - <p_z>)^{l_6}, \ \dots\}$

→ translatory invariant measures of the shape and orientation

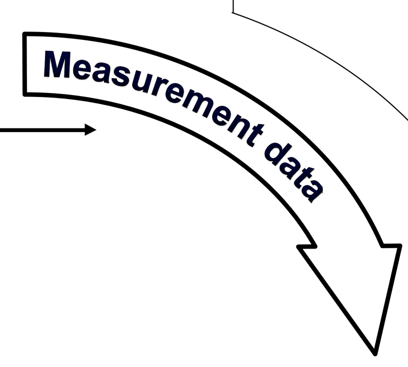


Application



V-Code User Interface

- The GUI provides a clearly arranged overview of the full 6D phase space at any position along the beamline.
- It provides a fast and handy access to each beamline element parameter.
- Reference markers can be displayed on top of the simulation data.

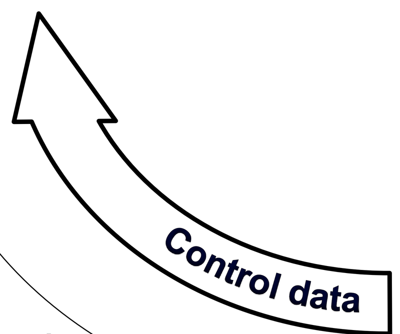


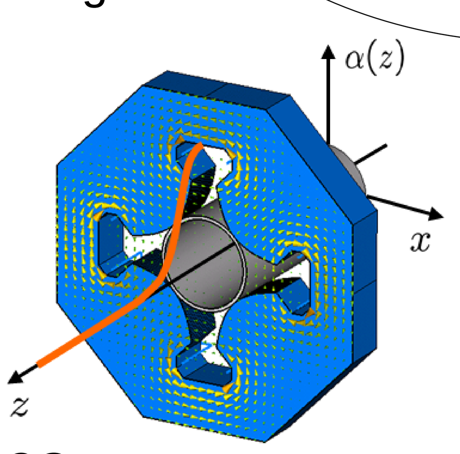
Online Simulations

- Within this operating mode the parameter settings are read from an external source.
- This external source may be either an other software tool or for example the control desk of the accelerator machine.

Beamline Elements

- Within V-Code a beamline is represented as a consecutive alignment of several independent beamline elements along a straight axis.
- Drift spaces between beam forming elements are re-presented by beamline elements within which no external electromagnetic fields are present.

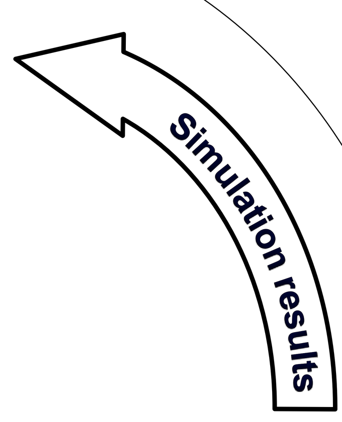




S-DALINAC control system

Automatic Beam Adjustment

- With a fast online simulation code, finding an optimal parameter setup for beamline can be automated by implementing objectives and evaluation rules.

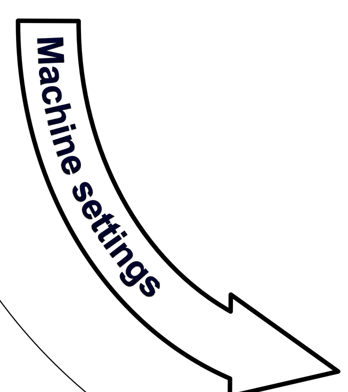


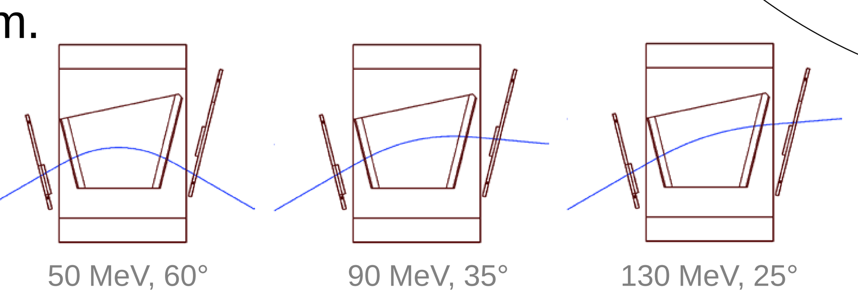
Simulation Results

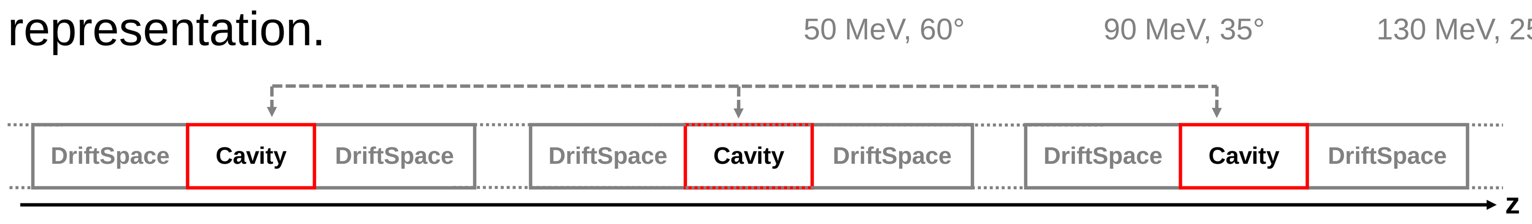
- The simulation was initiated right after the injector with a 10 MeV bunch.
- The results for this 121 m section were calculated in ~2.6 s on one core of a 2.4 GHz Intel Xeon CPU.

Recirculating Beamlines

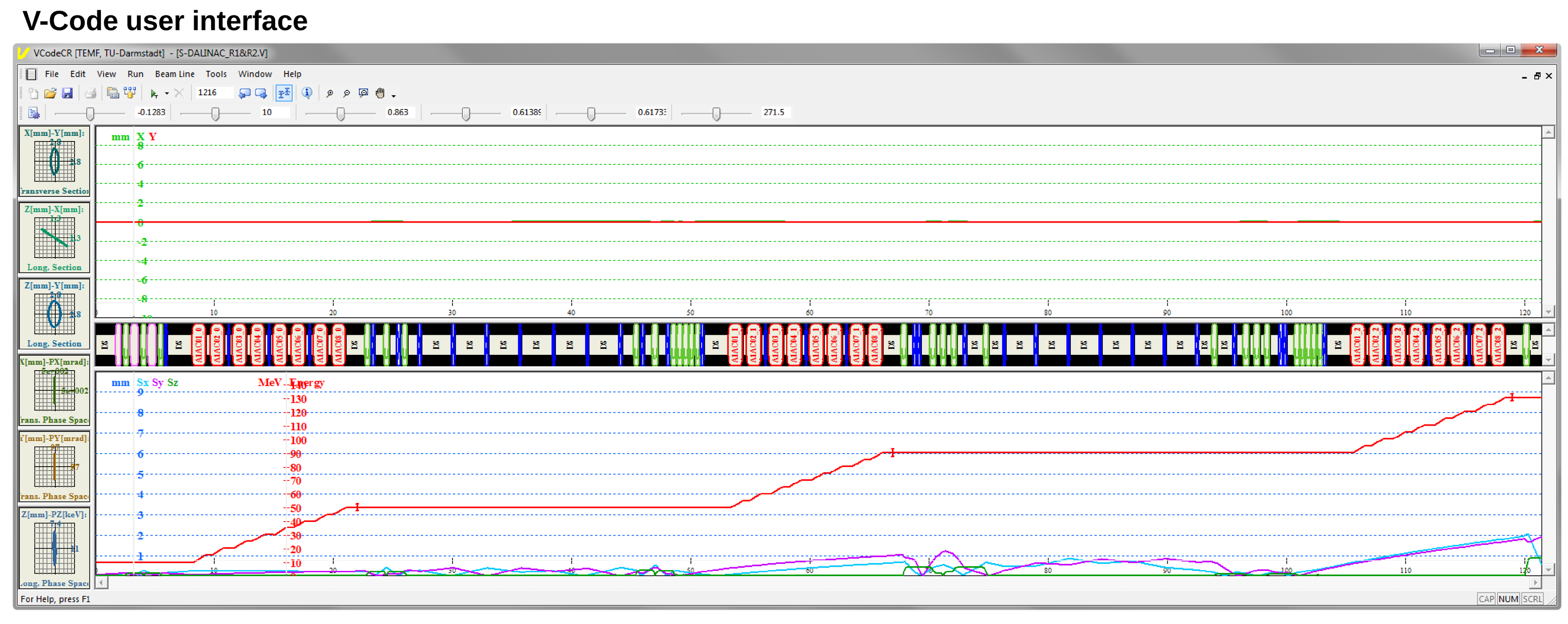
- In order to handle the recirculations a reference path defining the length of the element has to be settled for the bending magnets.
- During the two recirculations several beam line elements are repassed multiple times by the beam.
- Within V-Code, beamline elements that are passed n-times are placed n-times along the beamline representation.







V-Code user interface



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