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# Beam Dynamics Simulations for the DTL Section of the High Brilliance Neutron Source

Sarah Lamprecht[#,1], M. Droba[1], K. Kümpel[1], O. Meusel[1], N. Petry[1], H. Podlech[1,2], M. Schwarz[1], C. Zhang[3]

[1]IAP, Goethe University Frankfurt, Frankfurt am Main, Germany [2]also at Helmholtz Research Academy Hesse for FAIR (HFHF), Frankfurt am Main, Germany
[3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

## Abstract

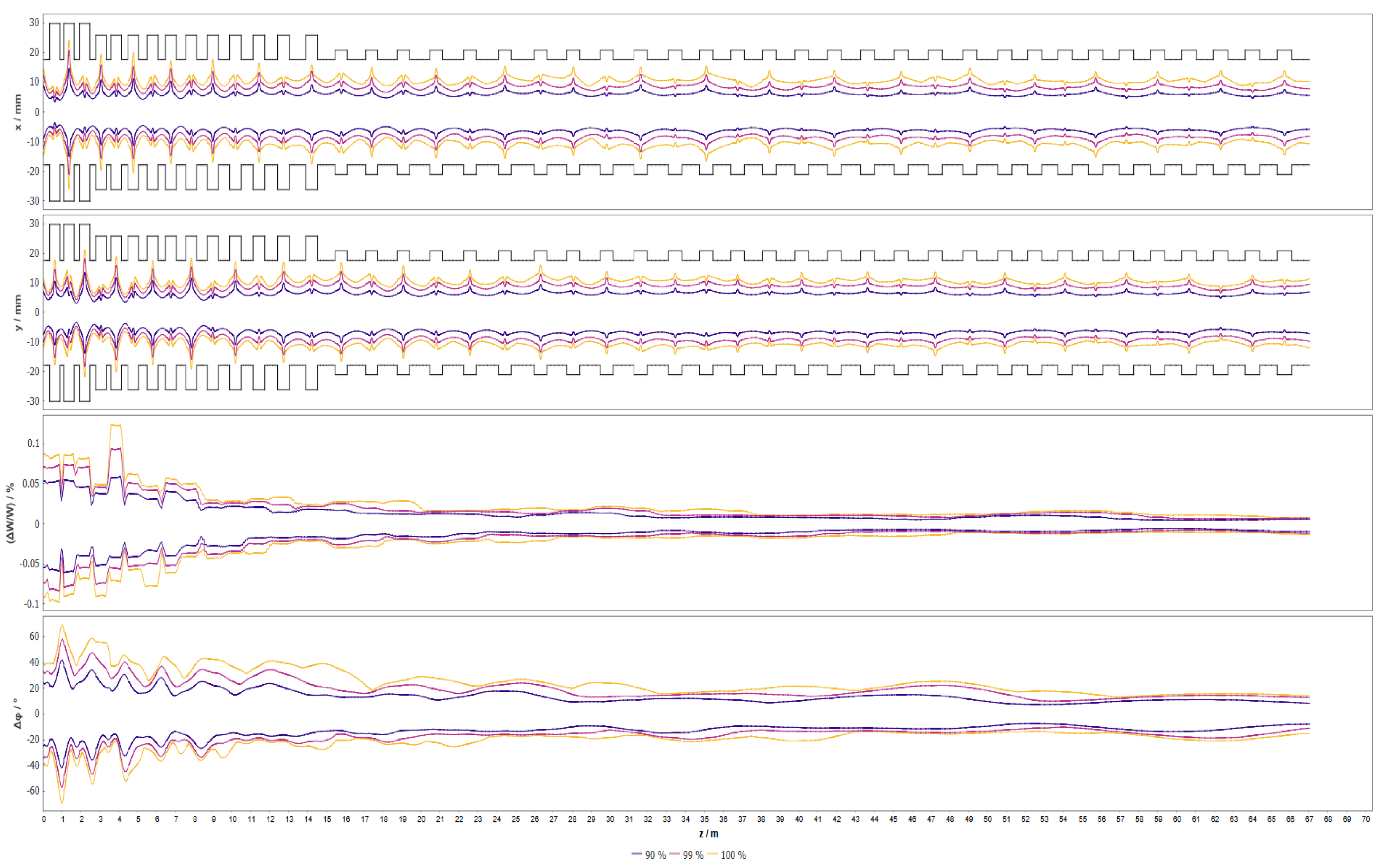
As various experimental reactors in Europe are already or will be decommissioned over the next years, new neutron sources will be necessary to meet the demand for neutrons in research and development. The High Brilliance Neutron Source is an accelerator driven neutron source currently under development at the Forschungszentrum Jülich. The drift tube accelerator will accelerate a proton beam of 100 mA coming from the MEBT2 section with an input energy of 2.5 MeV up to an end energy of 70 MeV. It will consist of normal conducting CH-type cavities. The first cavities will use the constant phase acceleration scheme. For higher energies a concept using constant beta acceleration scheme is under development. The operating frequency will be 176.1 MHz. The transversal focussing lattice will consist of quadrupole triplet lenses after each cavity. Due to the high beam current, the beam dynamics concept requires special care. Here, the current status of the beam dynamics for the drift tube linac is presented. The beam dynamics calculations have been performed with LORASR, a beam dynamics code developed and used at the IAP, Frankfurt, Germany. They have been partly automated using Python code.

| Parameter | Specifications |
|---|---|
| Particle type | Protons |
| Accelerator type | RF Linac |
| Peak beam current | 100 mA |
| Final energy | 70 MeV |
| Beam duty factor | 4.8 % |
| RF duty factor | 10 % |
| Pulse length | 167/667 µs |
| Repetition rate | 96/96/24 Hz |
| Peak beam power | 7 MW |
| Average beam power | 336 kW |

| Parameter | Specifications |
|---|---|
| DTL structures | CH-DTL cavities |
| Type | Normal conducting |
| Frequency | 176.1 MHz |
| Input energy | 2.5 MeV |
| # of cavities | 45 |
| Rebunchers | 3 |
| Focussing lattice | Triplets |
| Length | 67 m |
| RF amplifier | Solid state |

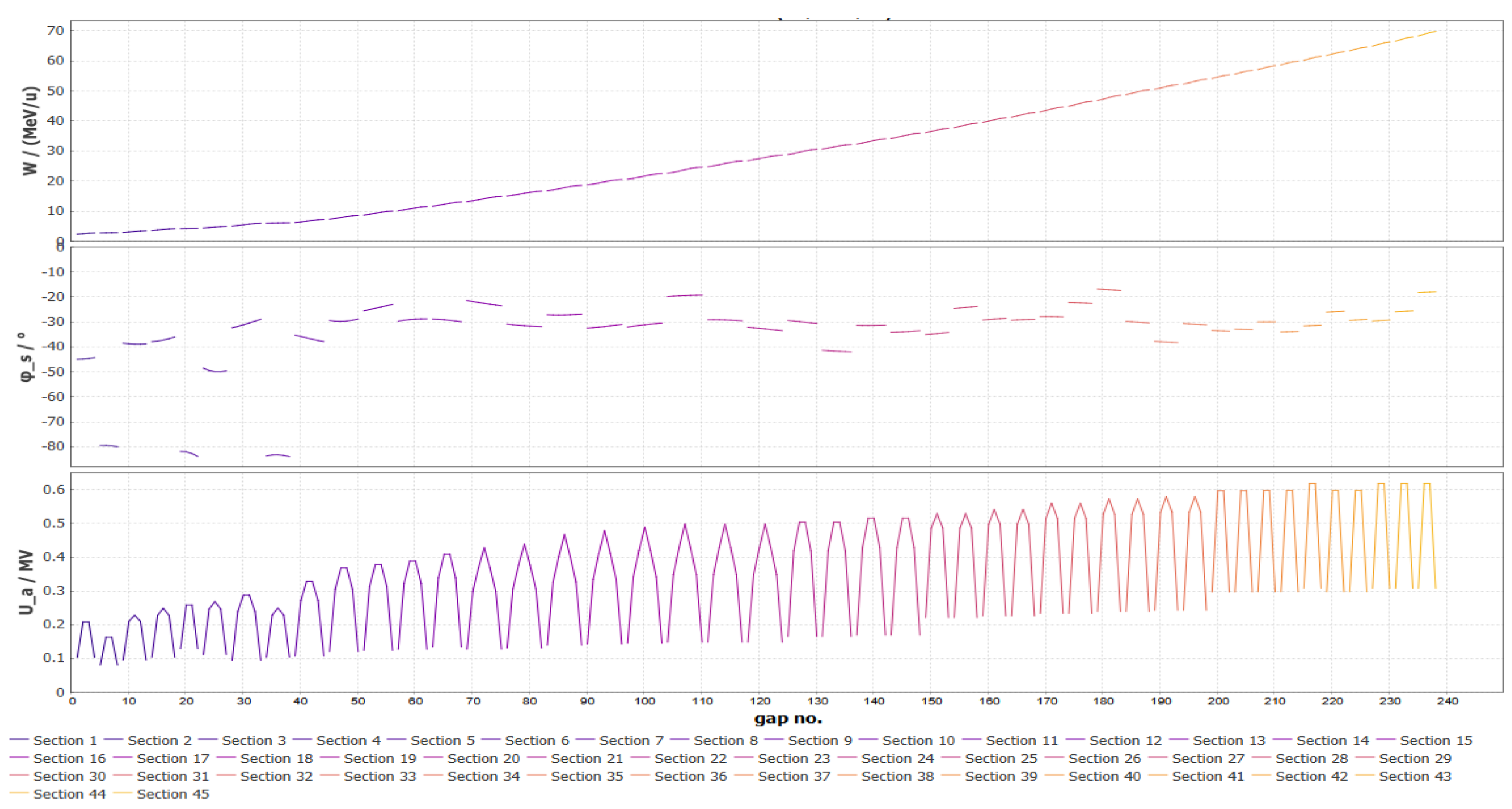
Top level requirements for HBS (left) and general linac properties (right).

## Longitudinal and transversal beam envelopes



Simulated beam envelopes for the HBS drift tube linac from the end of MEBT2 section to the last cavity.

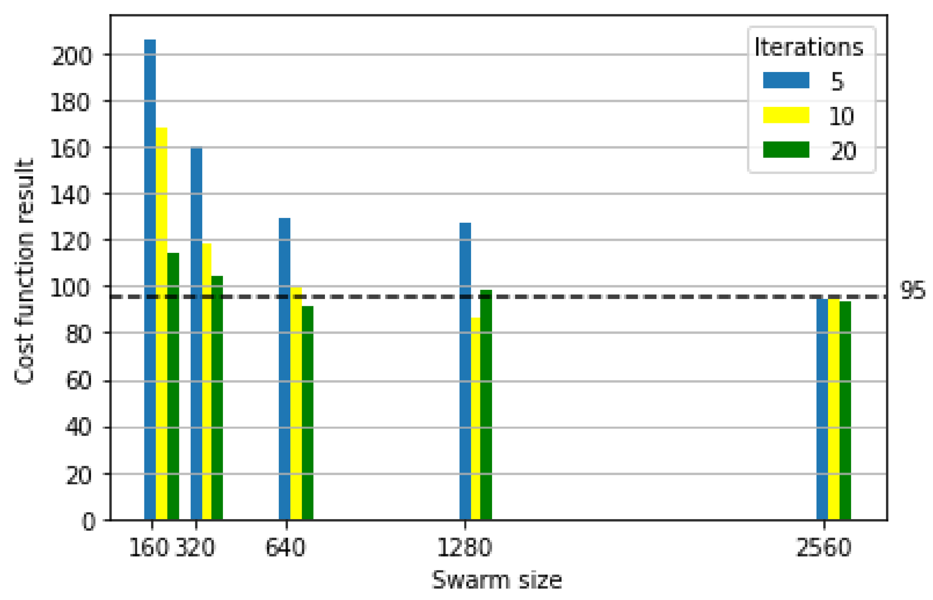
## Design properties




Beam energy, phases and cavity voltages for all 45 cavities.

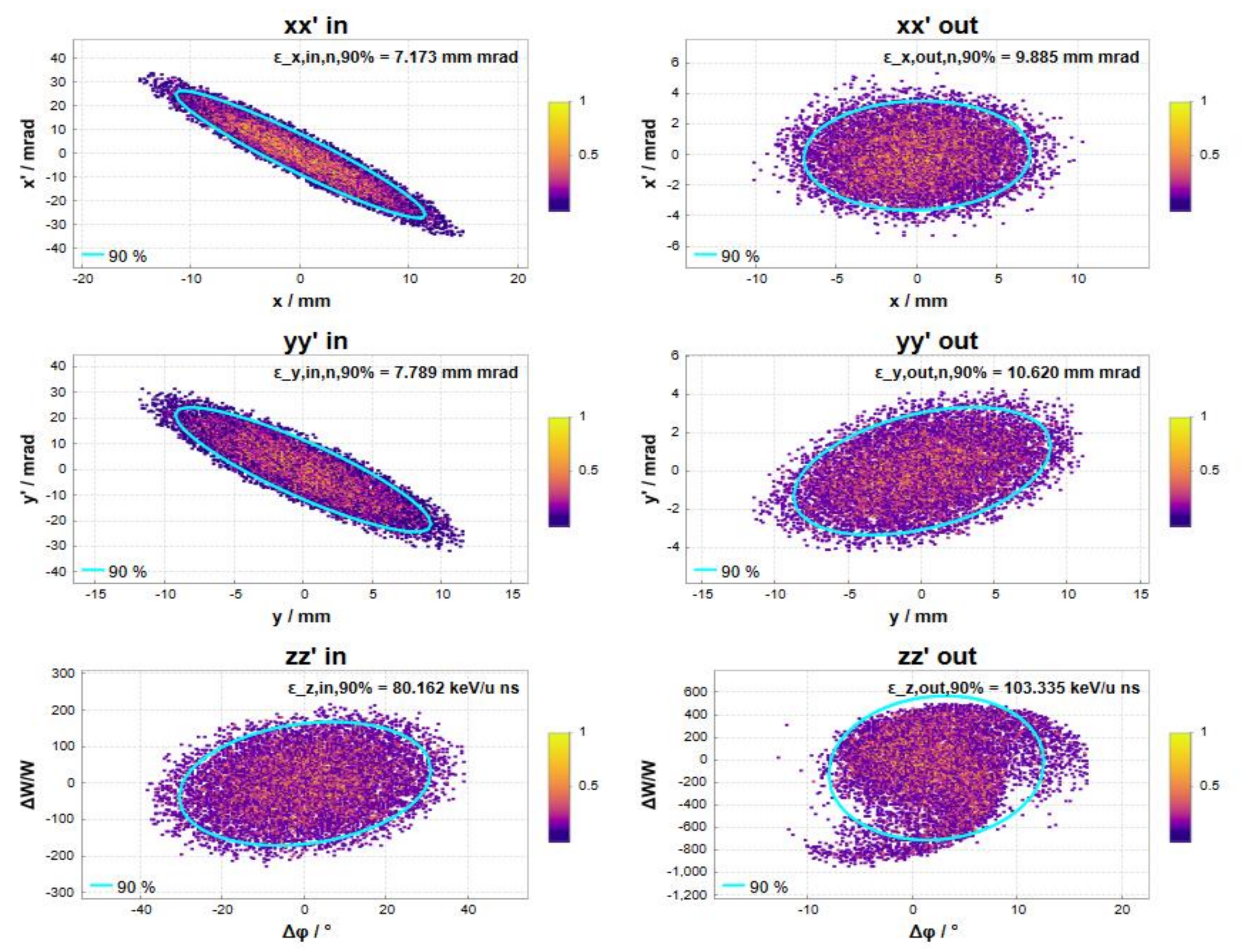
## Calculations

Because of the high number of parameters which must be chosen for a beam dynamics design for so many cavities, an optimization algorithm has been coded using Python. The code runs the actual beam dynamics code LORASR in batch mode and uses the returned results for optimization. It is based on particle swarm optimization and is capable of multiprocessing, and therefore timesaving. It optimizes a certain number of cavities, and then automatically moves to the next ones. The whole calculation of all 45 cavities presented here took about 99 h.




Performance test for the PSO. The first three cavities have been optimized with different swarm sizes and iterations of the PSO. It can be observed that a minimum (possibly global) solution of the cost function is found at a certain level of calculations.

## Input and output emittance areas




Simulated transverse and longitudinal input and output phase space portraits.

| Value | Input emittance | Output emittance | Growth |
|---|---|---|---|
| $\varepsilon_x$ | 1.67 mm mrad | 2.28 mm mrad | + 36.5 % |
| $\varepsilon_y$ | 1.82 mm mrad | 2.47 mm mrad | + 35.7 % |
| $\varepsilon_E$ | 18.64 keV ns | 23.70 keV ns | + 27.2 % |

Input and output rms emittance values.

## Outlook

An updated design optimized with the PSO is currently under development, using higher CH voltages at the beginning, reducing the number of cavities and improving the beam quality. Furthermore, it is planned to switch to cavities using constant beta acceleration scheme for higher energies, which are more cost efficient.

[#] Sarah Lamprecht- Institute of Applied Physics (IAP) - Max-von-Laue Str. 1 - 60438 Frankfurt am Main - lamprecht@iap.uni-frankfurt.de - www.linac-world.de