HZB Facility Talk

T. Kamps (HZB/HU Berlin)

presented at ARD ST3 Annual Meeting in Zeuthen

25.06.2025, 15:50 to 16:15

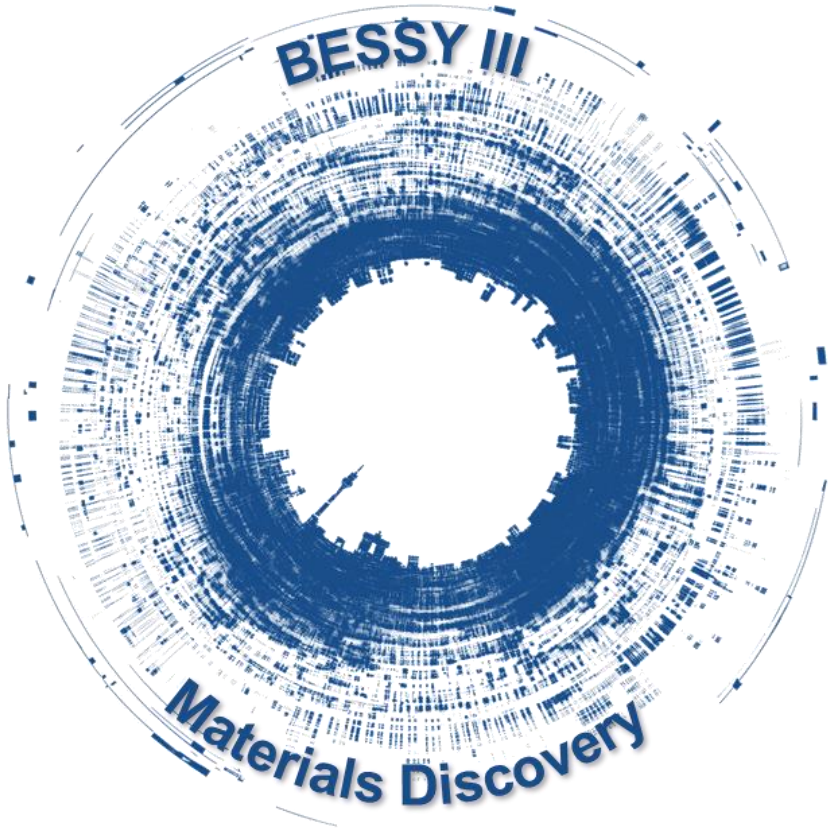
brighter
faster
smarter

Thanks and acknowledgements

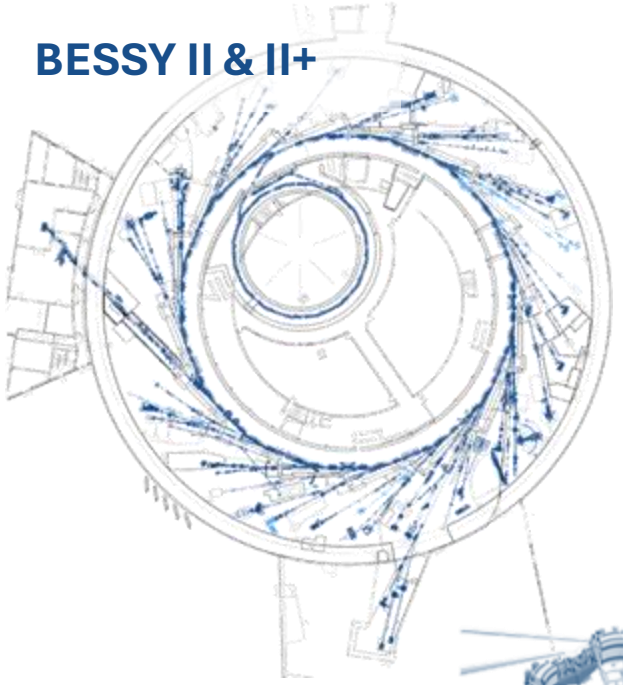
Thanks to everyone at HZB and to our partners, especially the ones helping me with material for this presentation: Andreas Jankowiak, Anny Gora, Ilya Asparuhov, Bettina Kuske, Benat Alberdi Eusain, Sebastien Joly, Axel Neumann, Emily Brookes, Ezgi Ergenlik, Guido Klemz, Jonas Dube, Julius Kühn, Chen Wang, Rena Dähllmann, Cäcilie Zec, and many more…

Helmholtz-Zentrum Berlin, Adlershof campus

Improving performance – providing new opportunities – enabling science



BESSY II & II+



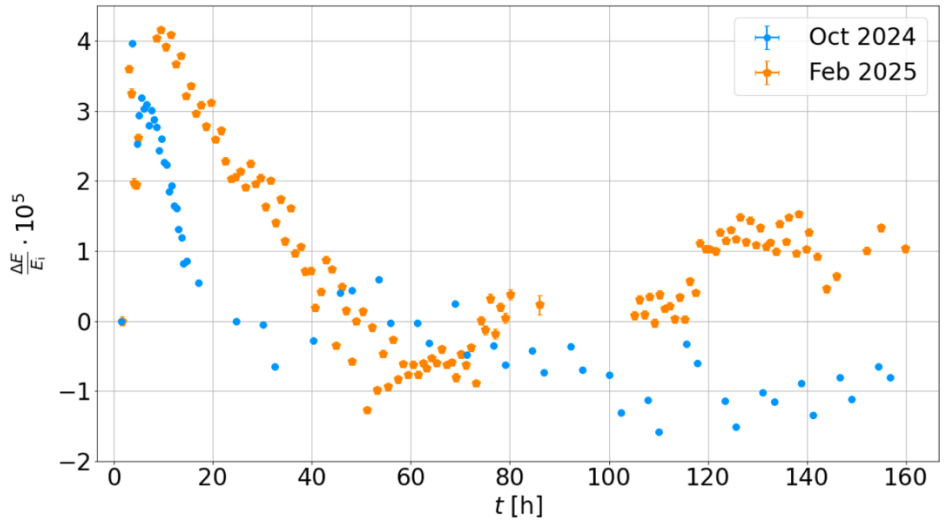
Proton Therapy

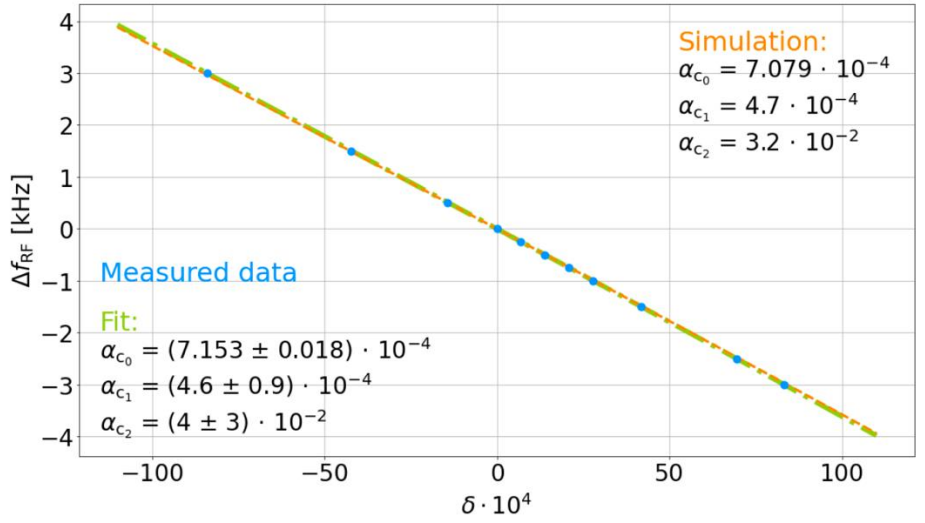
Supralab SEALAB
From Materials to Beam

We participate in ST3 with 5 FTEs. Our focus in ST3 is on tailoring transverse and longitudinal beam properties at the extreme: enabling TRIBS and SSMB operation in storage rings, exploring ultrafast operation modes for SRF photoinjectors.

Towards continuous, high-precision beam energy measurement at Bessy II

- Precise knowledge key for PTB users and many measurement techniques, like chromaticity or momentum compaction factor.
- At Bessy II, the system and procedures for a spin-depolarization-based method have been upgraded, reducing acquisition time from 4 h to 10 min, yielding new opportunities.
- Long-term measurements reveal the impact of machine restart and steering modalities on the beam energy.
- Improved precision of higher-order momentum compaction reveals more insights into machine operation.

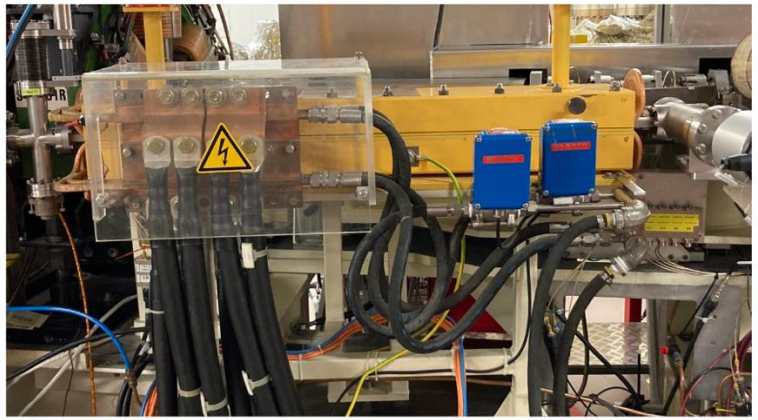




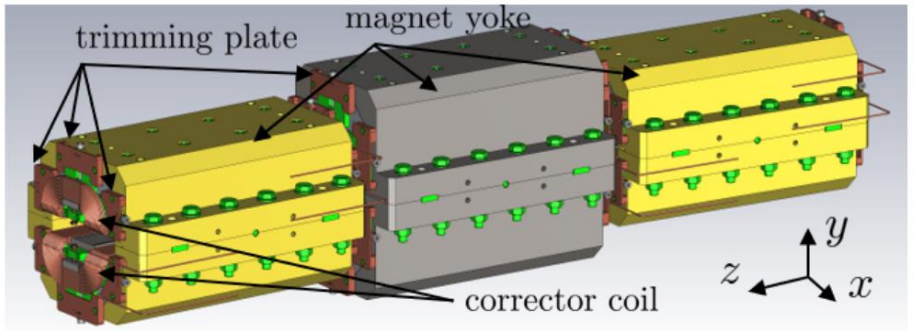
A. Gora et al., DOI:10.18429/JACoW-IPAC25-MOPS053

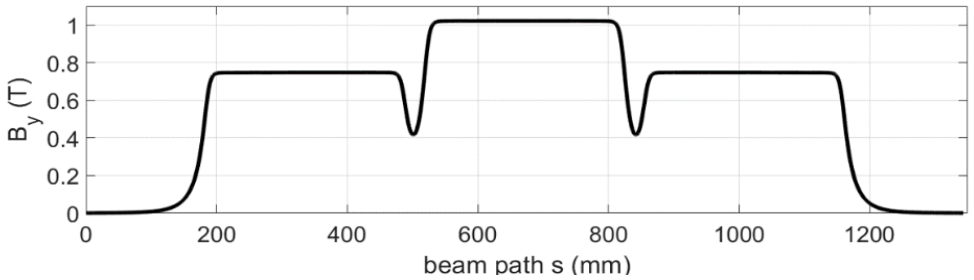
Implementation of permanent magnets (PM) for the Bessy II transfer line

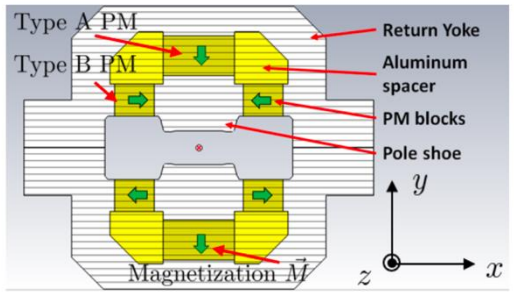
30 kW -> 200 MWh/year transfer line dipole



CST model of permanent magnet triplet





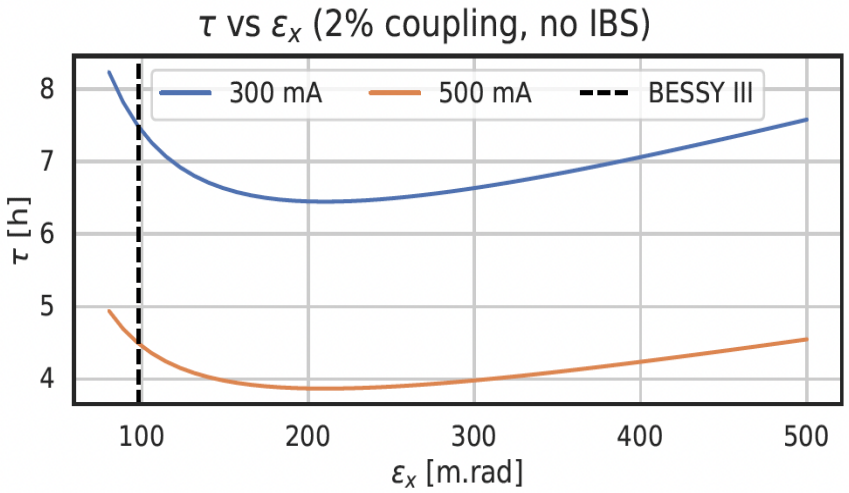


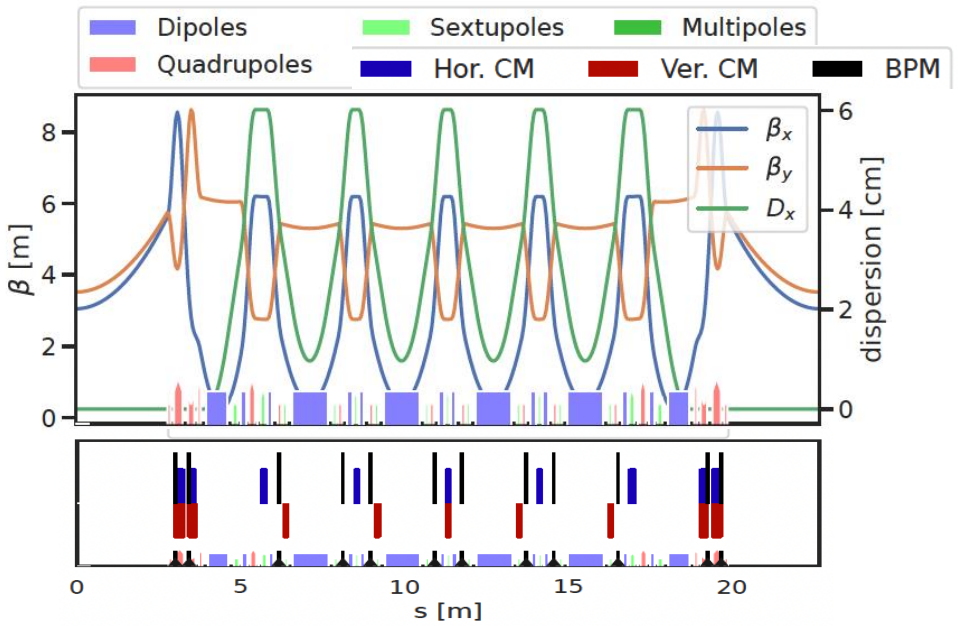
- PM dipole triplet developed to replace energy-inefficient electromagnets, benefiting also beam stability.
- Hybrid design with movable trimming plates and corrector coils.
- Complete model with CST and ASTRA to study the impact of cross-talk and fringe fields on beam trajectory.
- Implementation at Bessy II+ shortly.

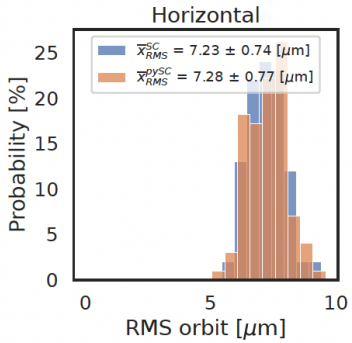
I. Asparuhov et al., DOI:10.18429/JACoW-IPAC25-THPB043

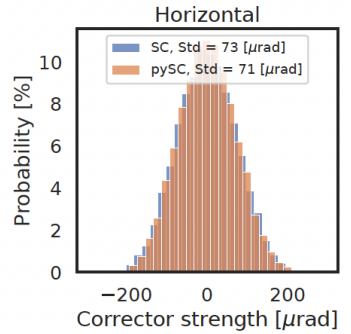
Next stepping stones towards a technical design of the Bessy III lattice

- Effects of intrabeam scattering on emittances and Touchek lifetime need to be studied for low-emittance lattices.
- Mitigation strategies using betatron coupling and resonant excitation of synchrotron sidebands have been developed.









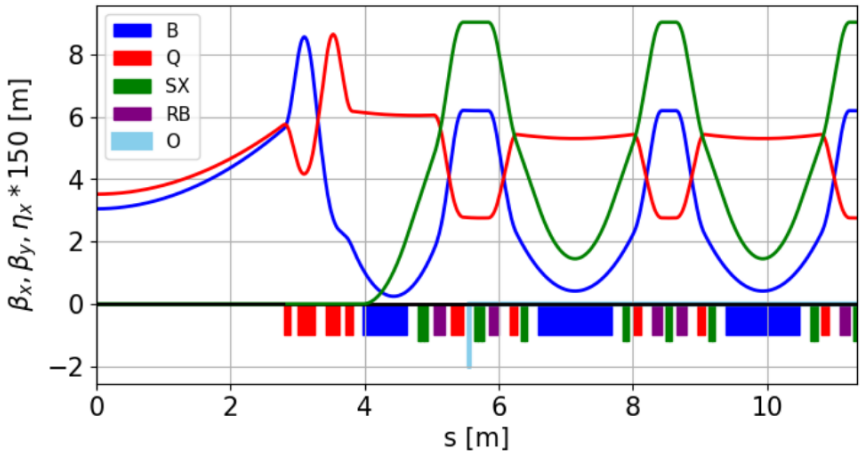
- Strong focusing lattices are sensitive to alignment and magnetic errors.
- Orbit correction schemes (Bessy II, SLS2, Bessy III) were tested with the pySC toolkit.
- Bessy III solution balances performance and constraints.

S. Joly et al., DOI:10.18429/JACoW-IPAC25-WEPM023 and WEPM024

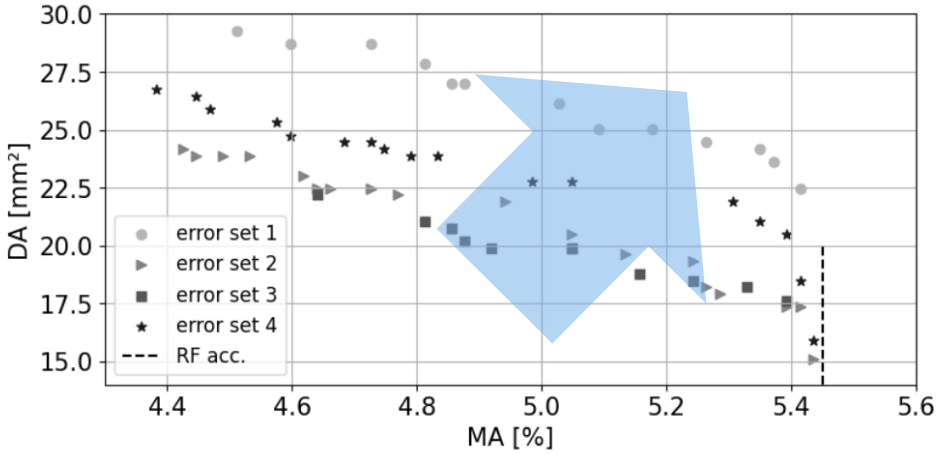
Optimization of sextupoles in the Bessy III candidate lattice

- Use sextupole families in Bessy II to balance requirements from chromaticity and to maximize DA and MA.
- MOGA optimization of DA over MA with different error estimates.
- Implemented analytical method to minimize resonance driving terms for tunes.

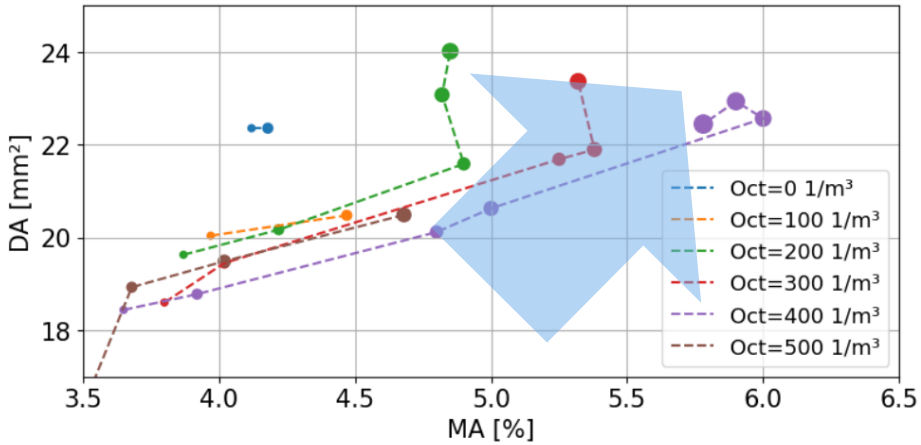
BESSY III lattice including sextupoles and octupoles



Trade-off for dynamic over momentum aperture

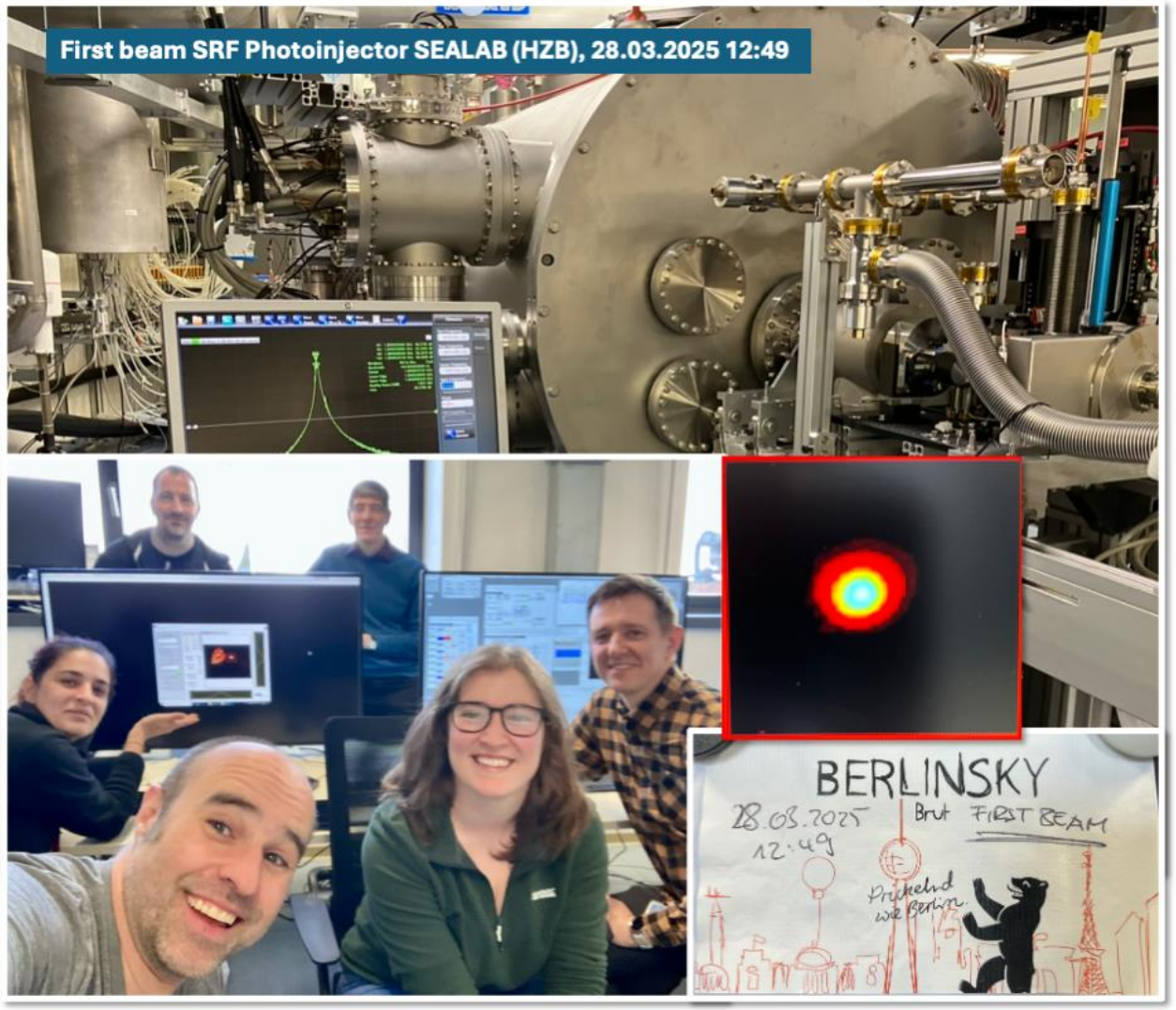


DA over MA with driving term minimization



B. Kuske, B. Alberdi-Esuain, DOI:10.18429/JACoW-IPAC25-WEPM053

First beam from the present SRF gun March 2025

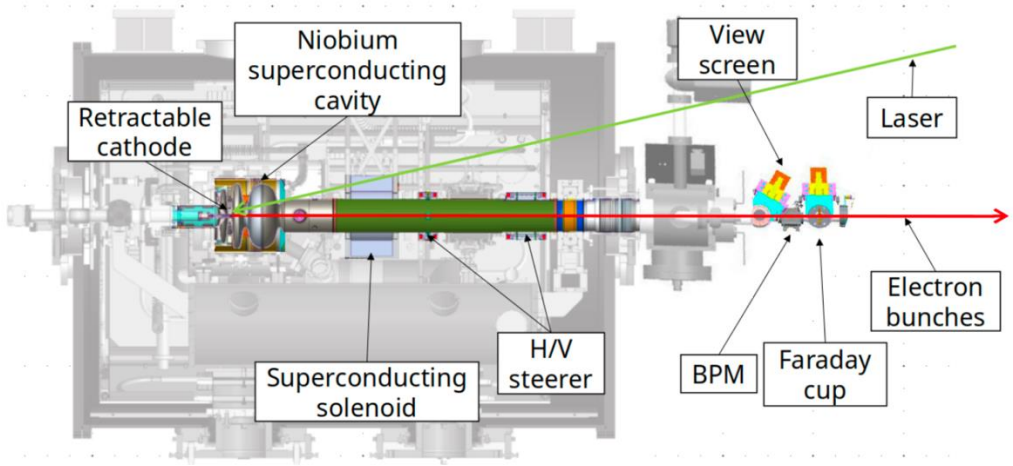


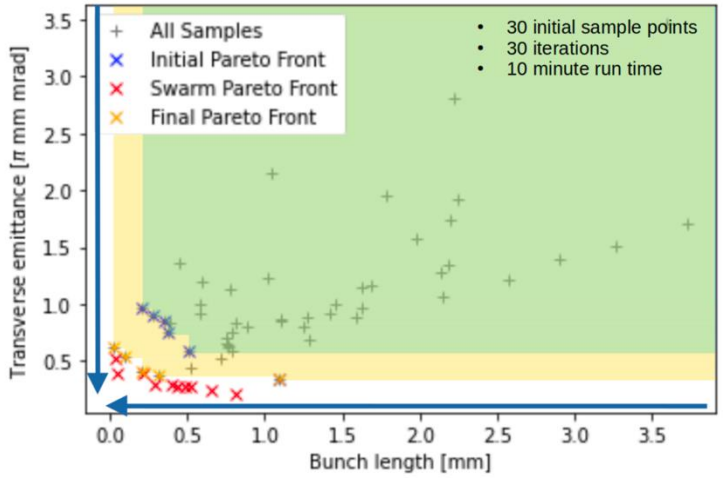
T. Kamps et al., DOI:10.18429/JACoW-IPAC25-WECN02

MOBO Optimization of the versatile SRF gun for many applications

- The versatile SRF gun may serve many applications, such as being a tool to explore parameter space.
- Developed a multi-modal framework with analytical expressions and a neural-network surrogate model trained with high-fidelity ASTRA beam dynamics simulation data.
- Multi-Objective Bayesian Optimisation (MOBO) delivers fast tuning for competing objectives in several minutes of CPU time on a laptop computer.

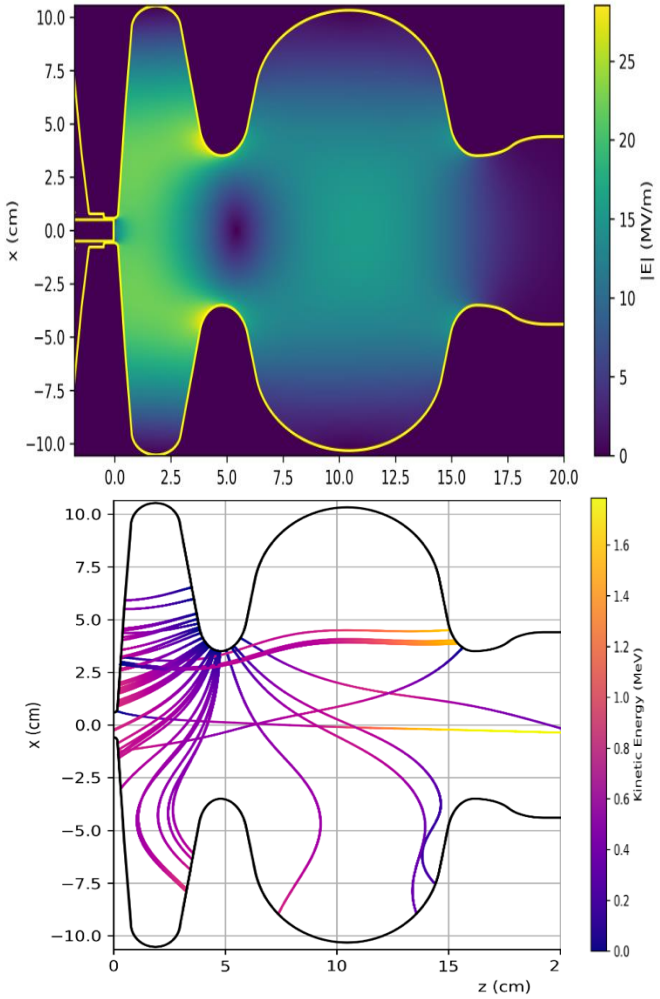
Parameter	ERL	UED	EBWT
Bunch charge	77pC	0.1pC	77-500pC
Emittance	<1µm	10^-3µm	1-6µm
Pulse length	2-3ps	1fs	2-10ps
Kinetic energy	>10MeV	2-7MeV	<10MeV
Rep rate	1.3GHz	0.1-1MHz	1.3GHz
Av current	10mA	10-100nA	10-100mA



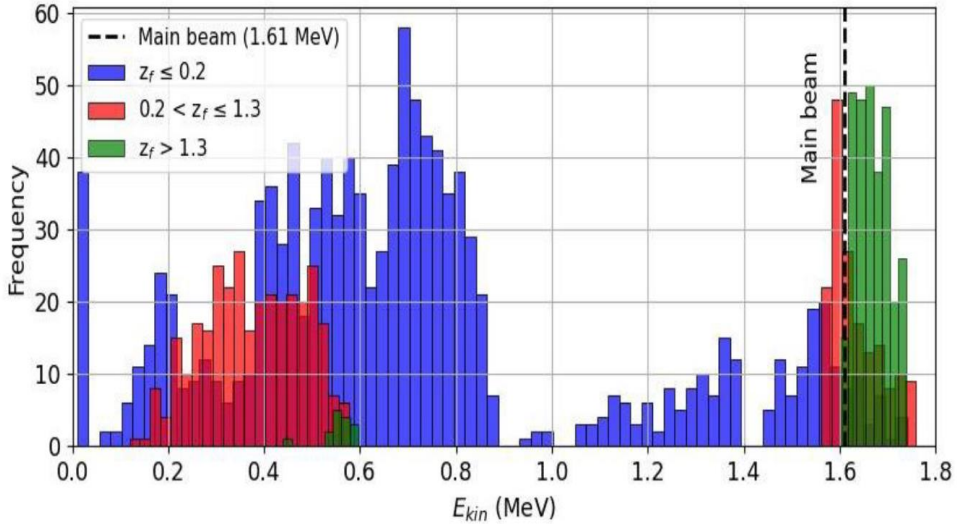


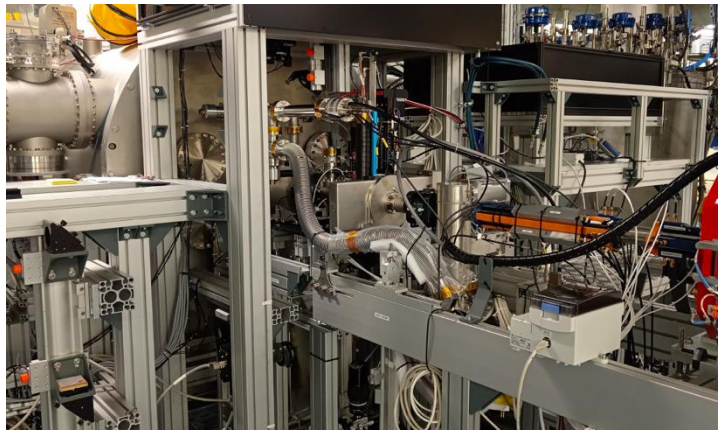
E. J. Brookes et al., DOI:10.18429/JACoW-IPAC25-WEPS043

Modelling dark current and beam loss in the SRF gun



- Dark current from field emission limits the performance of SRF guns.
- Studied the generation and transport of unwanted electrons.
- Most electrons generated (95%) will re-impact the cavity walls, while a few (5%) exit the gun and deposit 25% of emitted power in the beamline.
- The next step is the computation of energy deposit and locating good spots for beam loss monitors.





B. Alberdi, R. Dählmann, et al., DOI:10.18429/JACoW-IPAC25-TUPM007

Summary

- The Bessy II+ program delivers an upgrade path for our existing lightsource.
- Implement and test technological solutions valid for Bessy III.
- Commissioning and parameter space exploration with SEALAB ongoing.
- ST3 relevant for our studies to reach 6D smart control of beam parameters.