BEAM LOSS MINIMIZATION FOR SIS18 SLOW EXTRACTION

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CONTENTS

MOTIVATION

- reduce the undesirable activation of accelerator components
- prevent electrostatic septum (ES) damage
- automated minimization of uncontrolled particle loss during slow extraction

Figure: Damaged wires at SIS18 ES (47% of the length) during beam operation, May 2022, high intensity U, about $4 \cdot 10^{10}$ ions/cycle. Successfully repaired, 2023 at beam shut-down [1].

INTRODUCTION

Operation mode

- Resonance tune $Q_x = \frac{13}{3}$
- Chromaticity $Q'_x = -6$
- Excitation by six sextupoles
- 2 orbit bumps at ES and magnetic septum (MS)
- Standard technique: quadrupole driven extraction

Quadrupole driven extraction [2]

- tune ramp by 2 quadrupoles
- chromaticity is uncorrected
- all separatrix sizes go to spill
- different momentum are extracted

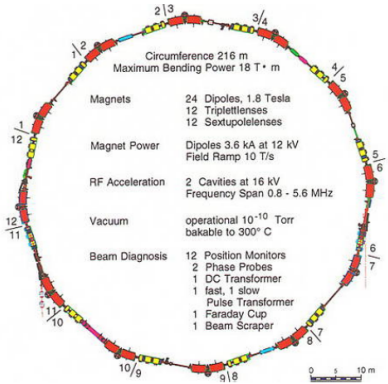

Figure: SIS18 lattice with sections.

SIMULATION

MADX [3] + XSUITE [4]

- sextupole phase
- sextupole amplitude
- ES deflection angle
- ES bump
- MS bump

$(k_2L)_n = (k_2L)_a * sin(2\pi * (n-1)/6 + \phi)$ - strength of the resonances sextupoles

n - number of a sextupole
$(k_2L)_a$ - sextupole amplitude
ϕ - sextupole phase

30-40% increase in particle transmission

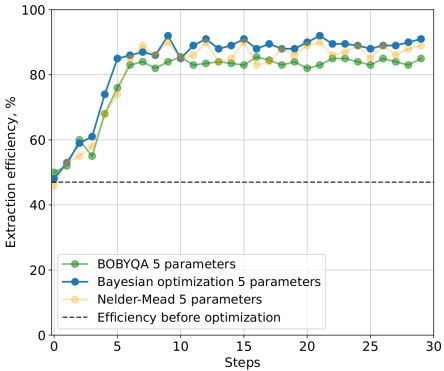

Figure: Beam loss optimization results.

EXPERIMENT

DESCRIPTION

- initial settings are not optimal
- minimization of particle loss by maximizing extraction efficiency N_{ext}/N_{tot}

N_{ext} - number of extracted particles from the ionization chamber in the transfer channel
N_{tot} - number of particles from the current transformer in the SIS18 ring

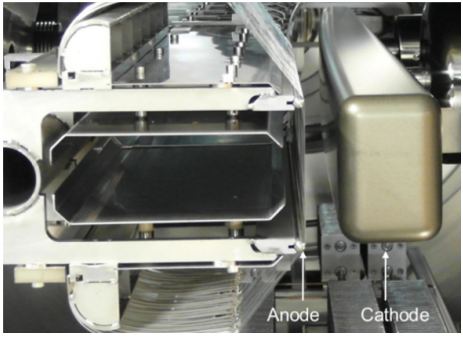

Figure: ES extraction septum with anode wires and cathode.

EXPERIMENT

RESULTS

- each step takes less than 1 min
- 10-15 min for optimization
- 40% increase in particle transmission

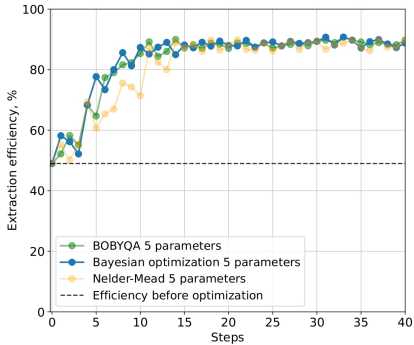

Figure: Beam loss optimization using different algorithms.

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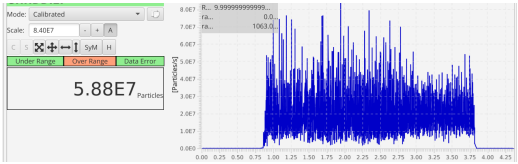

Figure: ParamModi screenshot of the extracted beam after optimization.

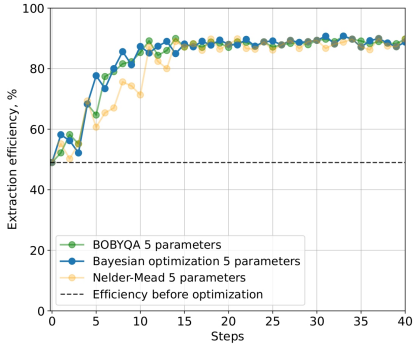

Figure: Beam loss optimization using different algorithms.

CONCLUSIONS AND OUTLOOK

1. Numerical model to predict the losses
2. Automated optimization for slow extraction at SIS18 for the first time
3. Changing 5 parameters gives 90% efficiency
4. Validation of simulation by comparing with experiment

5. Sensitivity analysis for each parameter
6. Losses after ES

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Thank you for your attention!

REFERENCES

1. B. Gålnander, D. Ondreka, Electrostatic septa with heavy ions: challenges for machine protection, 5th Slow Extraction Workshop, Wiener Neustadt, Austria, 2024.
2. S.Sorge , P.Forck, and R.Singh, Spill ripple mitigation by bunched beam extraction with high frequency synchrotron motion, Phys. Rev. Accel. Beams 26, 014402 (2023).
3. https://madx.web.cern.ch/
4. https://xsuite.readthedocs.io/en/latest/