PARTICLE LOSS MINIMISATION DURING SLOW EXTRACTION WITH OPTIMISATION ALGORITHMS

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Introduction

Aim: Automatic minimisation of uncontrolled particle loss during slow extraction with help of optimisation algorithms:

- Reading and sending data via Python bridge using the FESA classes of the chosen measurement devices and SIS18 parameters.
- Automatic generation of SIS18 parameters in each iteration from extraction efficiency using a Python program which calls a numerical algorithm.
- Measurement devices:
  - DC current transformer for measuring particle number of circulating beam N_{circ}.
  - Ionisation chamber in HHD for measuring number of extracted particles N_{ex}.

Optimised variable: extraction efficiency: $P_{\mathrm{eff}} = \dfrac{N_{\mathrm{ex}}}{N_{\mathrm{circ}}} \rightarrow$ max.

- Continuation of previous measurements.
- This time: application to RF KO extraction.

Measurement details

- Two shifts:
  - Additional shift: June 1, 2025. Only O. Kazinova.
  - According to schedule: July 12, 2025. Ion: U^{73+}.
    Shared with S. Appel and P. Madysa.
- Parameters used for optimisation:
  - Previous shifts on quadrupole driven extraction:
    Sextupole amplitude and phase, $(k_2 L)_{\mathrm{a}}$ and ϕ_{sx}, heights of CO bumps at electrostatic and magnetic extraction septa, and electrostatic septum's deflection angle.
  - Actual shifts on RF-KO extraction:
    Sextupole amplitude and phase, $(k_2 L)_{\mathrm{a}}$ and ϕ_{sx}, heights of CO bumps at electrostatic and magnetic extraction septa, electrostatic septum's deflection angle, and, in addition, horizontal tune and KO excitation frequency.
- Optimisation algorithms: BOBYQA, Bayesian optimisation, Nelder-Mead.

Results

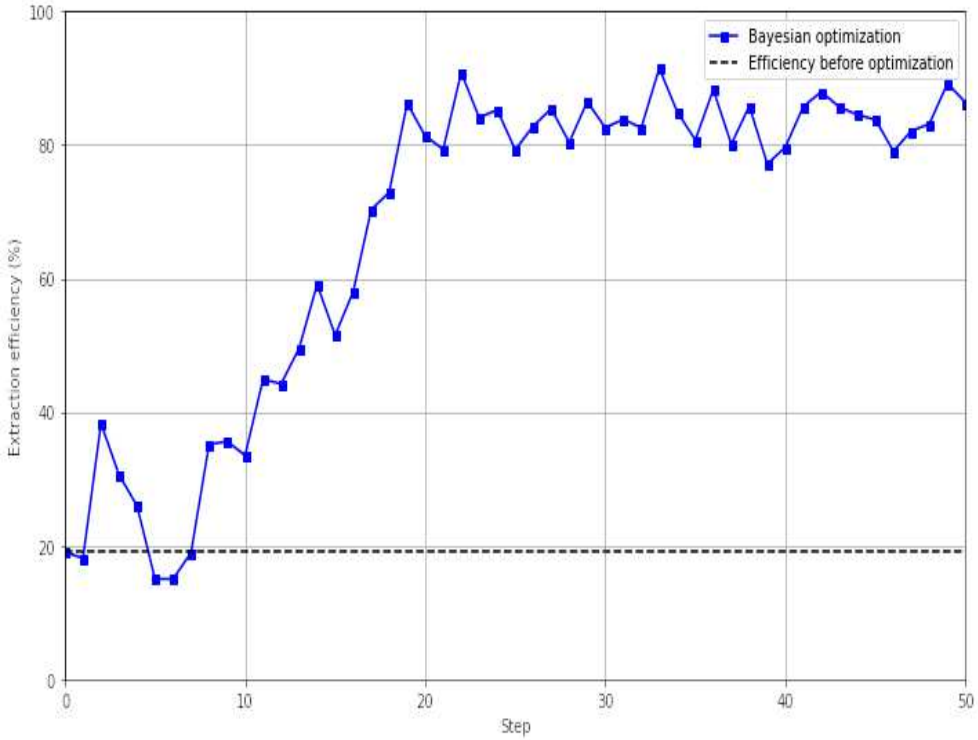

Figure: History of extraction efficiency optimised with Bayesian optimisation

Extraction efficiency similar to that found with quadrupole driven extraction measurement:

$$P_{\text{eff}} \approx 80 \ldots 90\ \%.$$