Application of the Adjoint Method in gradient-based Optimization to the $\mathcal{M}1$-Model in EPMA

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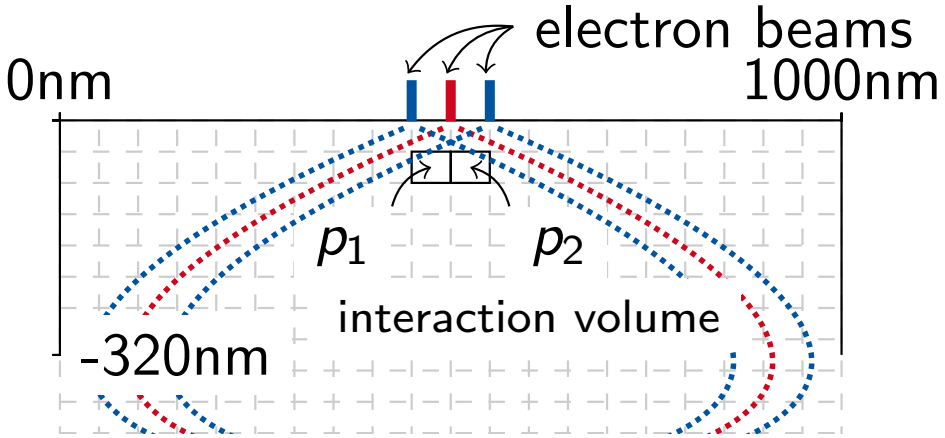
Motivation

Goal: **Increase the spatial resolution of EMPA to a pixel size smaller than the interaction volume**

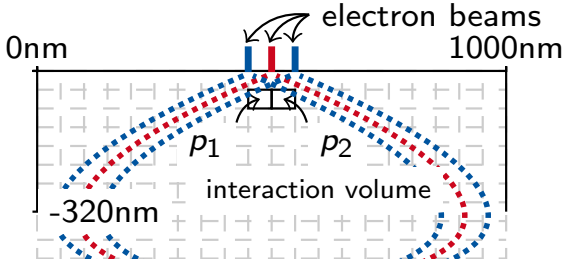
- More sophisticated reconstruction methods
- $\mathcal{M}1$-Model (deterministic electron transport/collision model)
- Gradient-based optimization



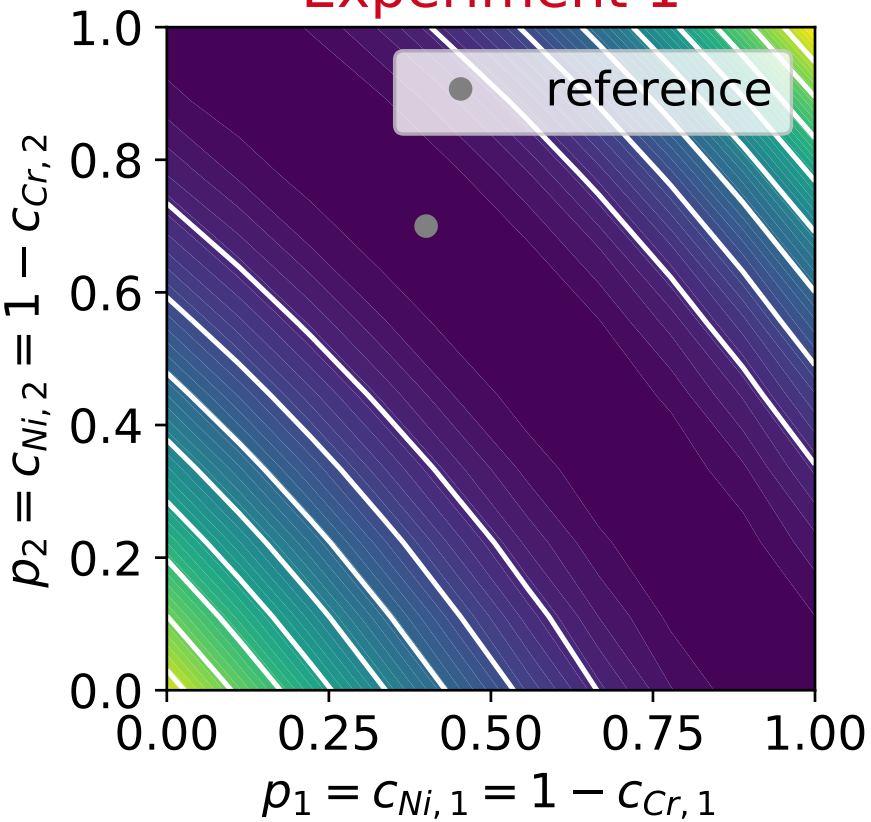
Sketch of experimental setup (material grid, beam positions, variable cells $p_{\{1,2\}}$, interaction volume)

$$c^* = \arg\min_c \frac{1}{2} \sum (k^{exp} - k^{model}(c))^2$$

Investigation of the objective function

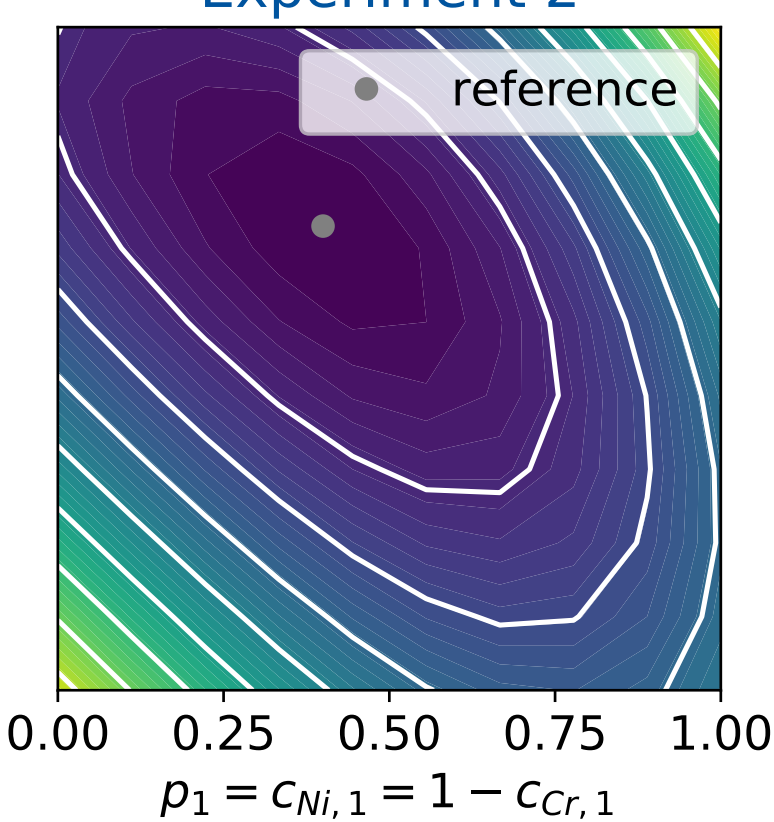


Experiment 1



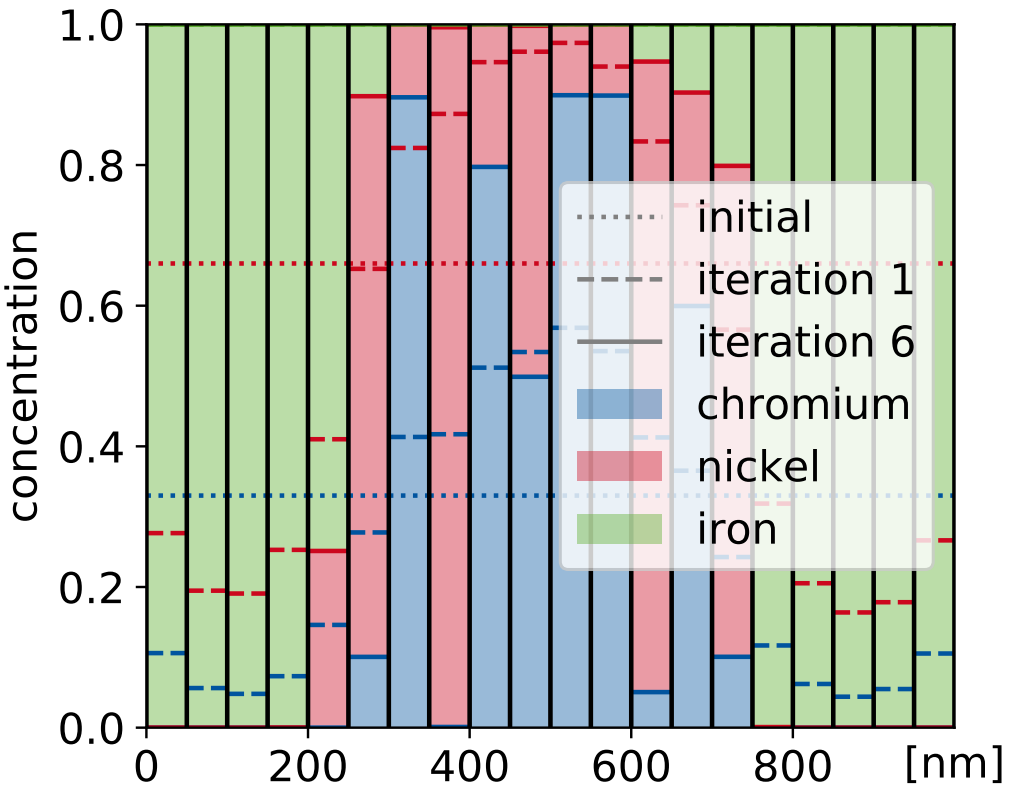
→ one beam position:
multiple minima

Experiment 2



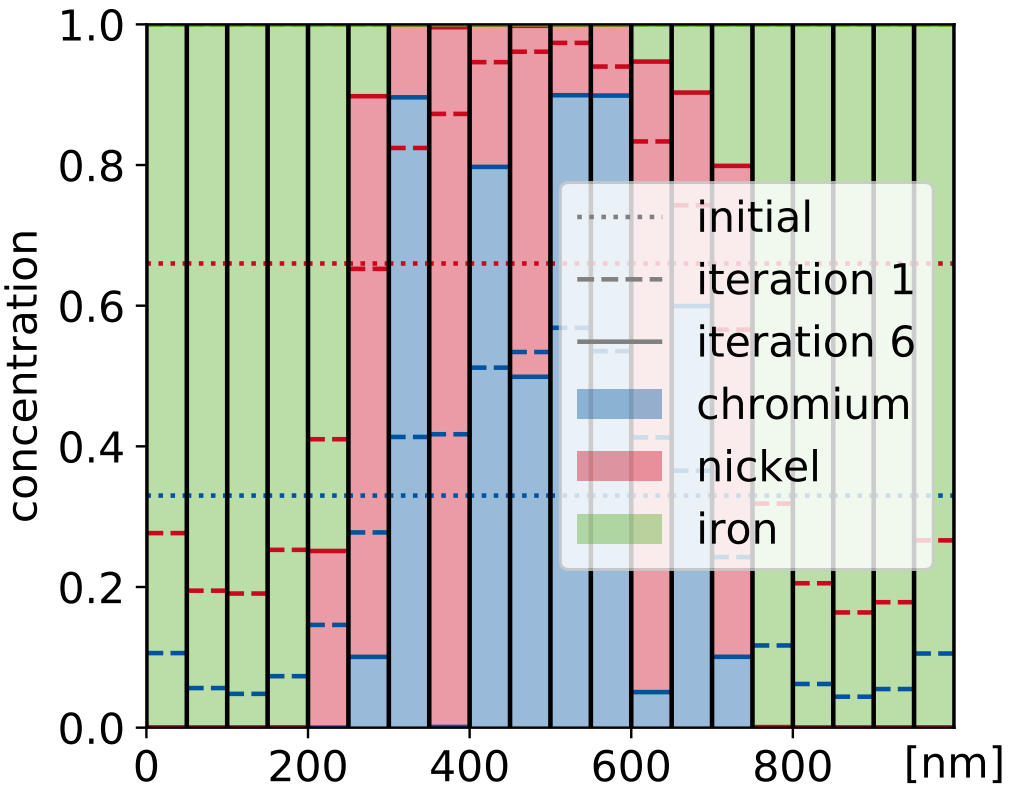
→ two beam positions:
unique minimum

Reconstruction example: vertical layers



- Reconstruction of concentration in vertical layers
- 20 electron beams (centered at each layer, 17keV)
- Minimum reached after 6 iterations

Reconstruction example: vertical layers



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First results indicate the potential to improve the spatial resolution of EPMA.