Spatial process model for the closed orbit feedback at the FAIR synchrotrons

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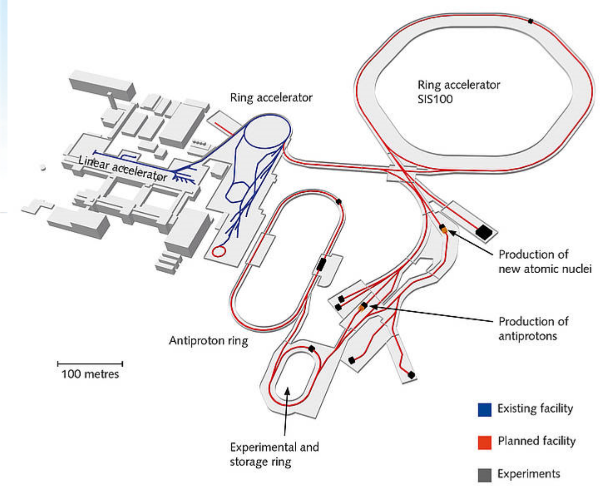
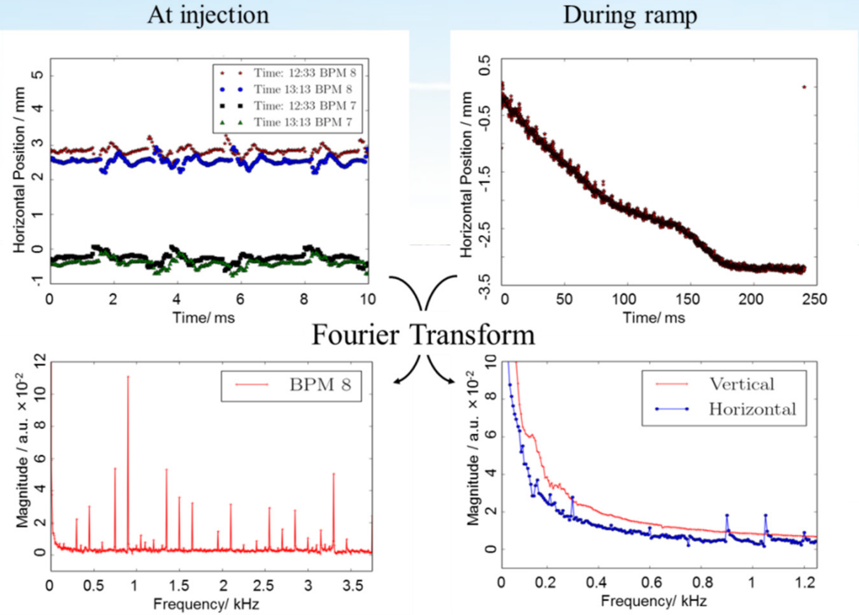
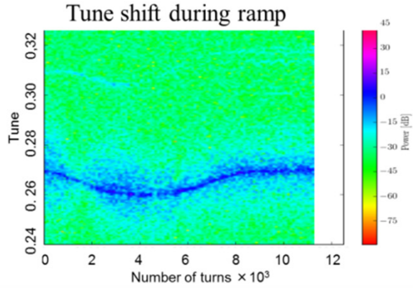
THMPA02

Project Goal







COFB requirements:

- Fast: bandwidth up to 1-2 kHz
- Robust against tune shifts and model changes during ramp
- Robust against sensor failure
- Test: at SIS18 Synchrotron GSI for FAIR Darmstadt

Spatial process model for SIS18

$$Y_i = \sum_{j=1}^{n} \frac{\sqrt{\beta_i \beta_j}}{2\sin(Q)} \cos(\pi Q - |\mu_i - \mu_j|)\, \theta_j$$

$$Y_m = \mathbf{R}_{mn} \vartheta_n$$

SVD is used for Eigen mode decomposition and inversion of ORM

$$\mathbf{R = USV^T} \qquad \mathbf{R^+ = VS^+ U^T}$$

Limitations of SVD in the context of robustness

- How to take ORM changes during ramp into account?
- How do singular values vary with tune shift?
- How to take model uncertainties into SVD singular values?
- What happens to COFB if one or two BPMs are missing?

Circulant Symmetry in SIS18

Due to symmetric placement of BPMs and correctors

$$\mathbf{R}_{circ} = \begin{bmatrix} r_0 & r_1 & r_2 & \cdots & r_n \\ r_n & r_0 & r_1 & \cdots & r_{n-1} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ r_1 & r_2 & r_3 & \cdots & r_0 \end{bmatrix}$$

$$\mathbf{R = FHF^*}$$

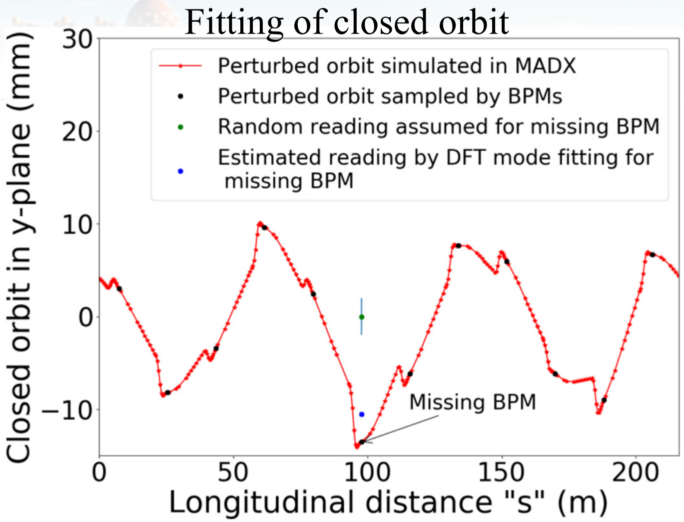
$$\sigma_k = \sigma_{kr} + j\,\sigma_{ki} = \sum_{1}^{N} R_{1n}\, e^{\frac{j2\pi kn}{N}}$$

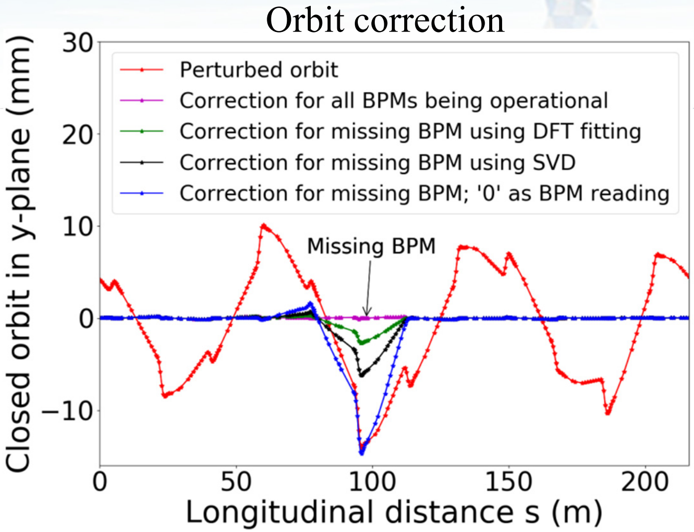
$$\mathbf{H} = diag(\sigma_k)$$

- Fourier modes give more physical interpretation of closed orbit distortion
- An equivalence also exists between SVD and DFT (exists on poster)

Robustness against missing BPMs

Fourier modes are used to estimate the orbit position at missing BPM location





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