Injection Feedback for a Storage Ring

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Introduction

ThomX [1] is a 50-MeV-electron accelerator using Compton backscattering to generate a high X-ray flux. For general information about ThomX, see paper [2], here we will focus on the beam injection in the ring.

Ring Injection

Injection components:
- Injection dipole: lead the beam to the ring or a beam dump
- Septum: redirect the beam in the ring pipe
- Kicker: correct the injection angle to put the ring on the nominal ring orbit

Computations of the Corrections

Goal
- Measure Beam position in BPM2 and BPM3 during injection
- Compute corrections on STR03, STR04 and kicker’s kick value to reach wanted parameters:

Computations
- Equation of propagation = classical linear transfer matrix + parametrization of kicker’s kick (χ) value and steerers deviation (Dev).
- From Eq. BPM2→BPM3, (x,y)BPM2, (x,y)BPM3 and χ, compute (x,px,y,py)BPM2
- From Eq. BPM2→BPM3, (x,y)BPM2, (x,y)BPM3 and χ, compute (x,px,y,py)BPM2 and χw
- Compute Dev3w and Dev4w such that:
  Eq.BPM2→STR3(current parameters) = Eq.BPM2→STR3(wanted parameters)
  \( w = \text{wanted} \)

Several Injections Feedback Testing

- 1000 beam centroids simulated
- Convergence reached in less than 48 iterations (ie ≈ 1 minute on ThomX).
- No losses in simulations during feedback operations

Robustness
If element displacement and misalignment are added then:
- Convergence always achieved
- Time for convergence may increase (up to 100 iterations)

Injection Feedback Testing

Simulation code: MadX [3]
Beam parameters at the beginning of the TL:
\( \beta_x = 43.25 \text{ m} \)
\( \beta_y = 10.95 \text{ m} \)
\( \alpha_x = 10.95 \text{ m} \)
\( \alpha_y = -10.93 \text{ m} \)

Emittance: \( 5.0 \times 10^{-8} \text{ m rad} \)
- Nominal beam size: \( \sigma = \sqrt{\beta_x} = 1.5 \text{ mm} \).
- Beam centroid simulated with a random particle selected within 5σ of the beam.

Injection estimator: \( E_y = \sqrt{\sum x^2 \text{BPM} \cdot \text{BPM}^{\prime} \text{ B}^{\prime}} \)

\( u = x, px, y \text{ or } py \)

BPM estimator as function of number of iteration

- Iteration 33: Convergence
  ie: \( E_x, E_y < 10 \mu \text{m} \) and \( E_{px}, E_{py} < 10 \mu \text{rad} \)

Conclusion

A system of feedback has been developed for the injection in the ThomX ring. Some preliminary tests have shown good and robust results.

Further investigations have to be done with beam fluctuations and BPM’s uncertainty to validate this behaviour.

Once ThomX commissioning starts this feedback will be applied to the real machine.

References