# Injection Feedback for a Storage Ring

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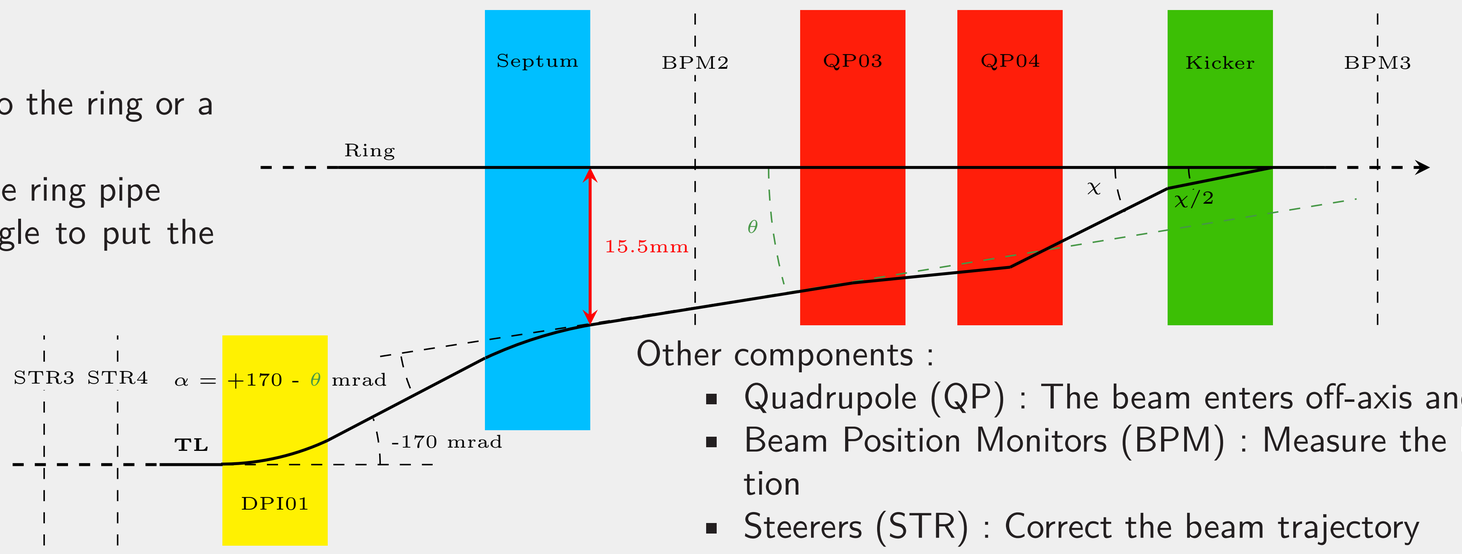
## Introduction

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:

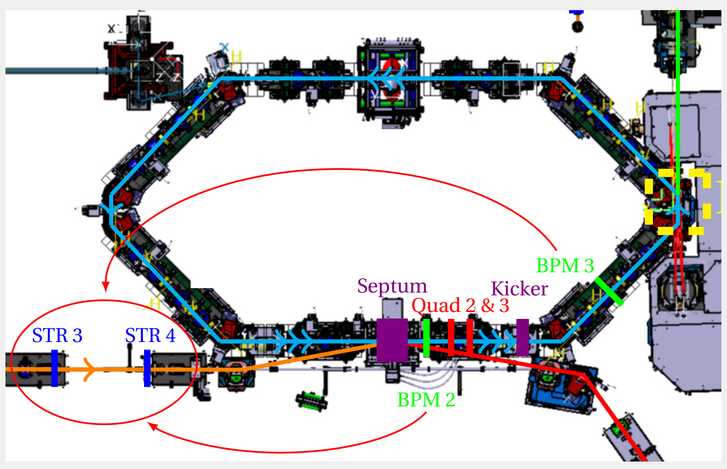
- Injection dipole: lead the beam to the ring or a beam dump
- Septum : redirect the beam in the ring pipe
- Kicker : correct the injection angle to put the ring on the nominal ring orbit




Other components :

- Quadrupole (QP) : The beam enters off-axis and thus is deflected
- Beam Position Monitors (BPM) : Measure the beam centroid position
- Steerers (STR) : Correct the beam trajectory

## Computations of the Corrections




### Goal

- Measure Beam position in BPM02 and BPM03 during injection
- Compute corrections on STR03, STR04 and kicker's kick value to reach wanted parameters:

| In : | BPM2 | BPM3 |
|---|---|---|
| x | −8.9 mm | 0 m |
| y | 0 m | 0 m |
| px | | 0 rad |

px = 0 in BPM3 → ▪ smooth the injection ▪ allow kicker computation

### Computations

▪ Equation of propagation = classical linear transfer matrix + parametrization of kicker's kick ($\chi$) value and steerers deviation (Dev).

▪ From Eq.$_{BPM2\rightarrow BPM3}$, (x,y)$_{BPM2}$, (x,y)$_{BPM3}$ and $\chi$, compute (x,px,y,py)$_{BPM2}$

▪ From Eq.$_{BPM2\rightarrow BPM3}$, (x,y)$_{BPM2,w}$, (x,y)$_{BPM3,w}$, compute (x,px,y,py)$_{BPM2,w}$ and $\chi_w$

▪ Compute Dev3$_w$ and Dev4$_w$ such that :

Eq.$_{BPM2\rightarrow STR3}$(current parameters) = Eq.$_{BPM2\rightarrow STR3}$(wanted parameters)

(w = wanted)

## Injection Feedback Testing

Simulation code : MadX [3]

Beam parameters at the beginning of the TL:

$$\beta_x = 43.25\,\text{m} \qquad \beta_y = 43.13\,\text{m}$$
$$\alpha_x = -10.95 \qquad \alpha_y = -10.93$$

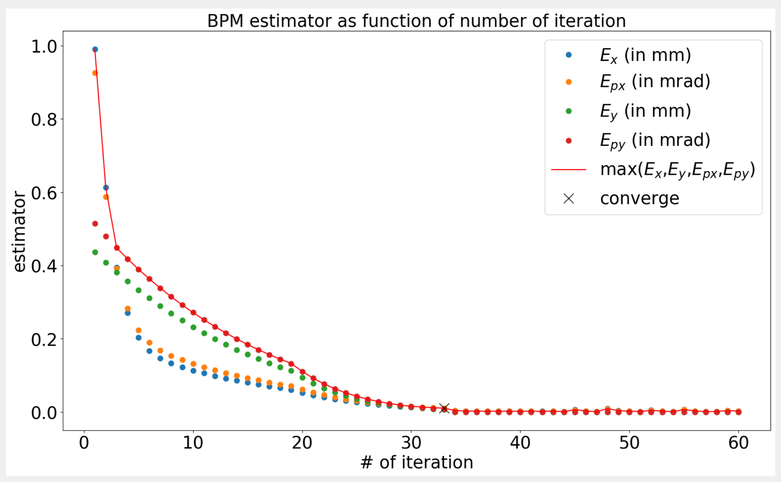
Emittance : $5.0 \times 10^{-8}$ m rad.

⇒ Nominal beam size : $\sigma = \sqrt{\epsilon\beta} = 1.5$ mm.

Beam centroid simulated with a random particle selected within $5\sigma$ of the beam.

Injection estimator : $E_v = \sqrt{\frac{\sum_{Ring's\ BPM} v^2}{\#\ of\ BPM}}$

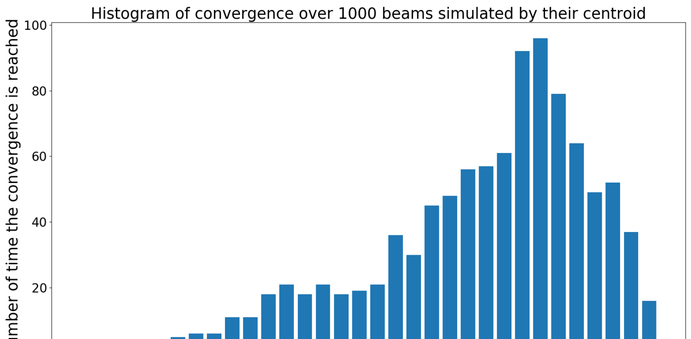
$v$ = x, px, y or py




▪ Iteration 33: Convergence

ie : $E_x, E_y$ <10 µm and $E_{px}, E_{py}$ <10 µrad

## 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)

## 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

[1] A. Variola, J. Haissinski, A. Loulergue, F. Zomer, (eds ). *ThomX Technical Design Report*. 2014, 164p. in2p3-00971281

[2] A. Moutardier, , C. Bruni, I. Chaikovska, S. Chancé, N. Delerue, E. Ergenlik, V. Kubytskyi, H. Monard *Loss maps along the ThomX transfer line and the ring first turn*, IPAC 2021

[3] F. Christoph Iselin. *The MAD Program (Methodical Accelerator Design): Physical Methods Manual*. Version 8.13 , 1994, `http://mad8.web.cern.ch/mad8/doc/phys_guide.pdf`