

ThomX presentation: MadX simulation

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Goal

- Goal: simulate the injection on ThomX ring.
- Advancements presented here:
 - ▶ Verification of the consistency of the change of frame at the entrance of the ring
 - ▶ Presentation of new lattice definitions used in MadX simulations
 - ▶ Presentation of beam envelope plots using particle tracking

Injection representation in MadX

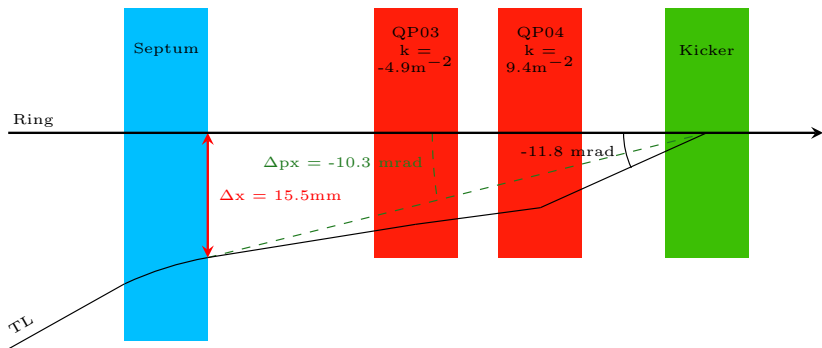


Figure: Diagram of beam injection on ThomX ring

At the end of the septum, the beam follows a reference path that is not the one of the ring. This leads to deviation of the beam in the quadrupoles QP03 and QP04 because it does not pass along their magnetic center. I chose to take it into account by doing a change of frame at the exit of the septum:

- $\mathbf{x} \rightarrow \mathbf{x} + \Delta\mathbf{x}$
- $\mathbf{px} \rightarrow \mathbf{px} + \Delta\mathbf{px}$

Frame change and Twiss calculation

This frame change has been implemented in ThomX and comparisons have been done by using a tracking module of MadX (see previous presentation). But similar comparisons can be done with the calculation of beam propagation (hence Twiss parameter) during injection (see following figure).

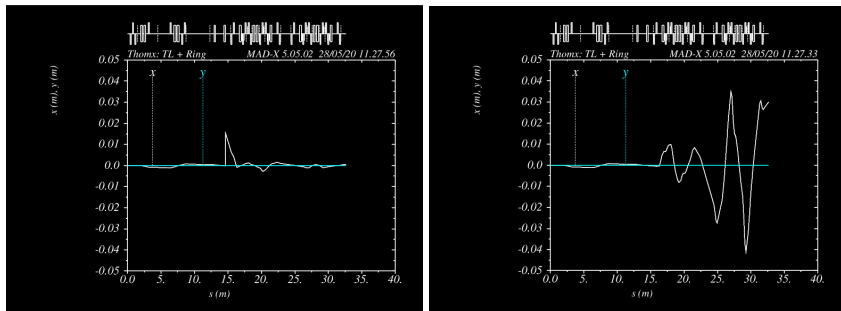


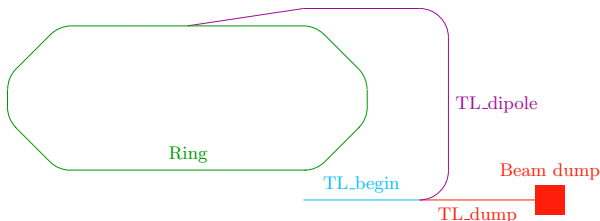
Figure: Comparison of the beam center of mass along the accelerator during injection with a change of frame (left figure) or without (right figure). Scaling is the same on both plots.

One can see on the first plot a peak around 15 m that shows the change of frame. Those plots show good agreement with theory.

First draft of new Thomx's lattice on MadX

Why changing the lattice?

- To use ThomX nomenclature
- MadX does not allow two elements with the same name
- To simplify line's modifications (Previous version: modifications must be done several times)



$$\text{TL_straight} = \text{TL_begin} + \text{TL_dump}$$

$$\text{TL} = \text{TL_begin} + \text{TL_dipole}$$

$$\text{TL_first_turn} = \text{TL} + \text{Ring}$$

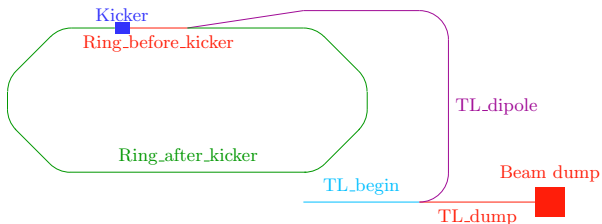
Figure: Representation of the lattice definition of ThomX in MadX

At this step calculations have been done with both lattice definitions and the results with both lattices are identical. This show that both definitions are similar and that the second one is correctly implemented.

Issue with multiple turns on the ring

- Upgrade: multiple turns after injection in the ThomX ring.
- Drawbacks with the kicker:
 - ▶ kicker always on: propagation incorrect after the second turn
 - ▶ kicker always off: injection incorrect
- Solution, splitting the ring in three parts:
 - ▶ Ring before the kicker
 - ▶ Kicker
 - ▶ Ring after the kickerand creating 2 rings:
 - ▶ Ring with the kicker
 - ▶ Ring with a drift at the place of the kicker (named simply "Ring")

Upgrade of the ring definition



```
TL_straight = TL_begin + TL_dump  
TL = TL_begin + TL_dipole  
Ring_with_kicker = Ring_before_kicker + kicker + Ring_after_kicker  
Ring = Ring_before_kicker + Ring_after_kicker  
TL_first_turn = TL + frame change + Ring_with_kicker  
TL_n_turn = TL_first_turn + (n-1)*Ring
```

Figure: Representation of lattice definition of ThomX in MadX with multiple turns possible

In this new lattice definition one can see that both ring definitions are present and that a new line with n number of turn is defined, n being an integer. 200 turns have already been simulated without problem.

Verification of the kicker presence only in the first ring

Below is shown MadX sketch of a line defined with :

- Transfer line
- One injection turn in the ring
- A second turn in the ring

The line seems correctly defined and no obvious mistakes can be seen.

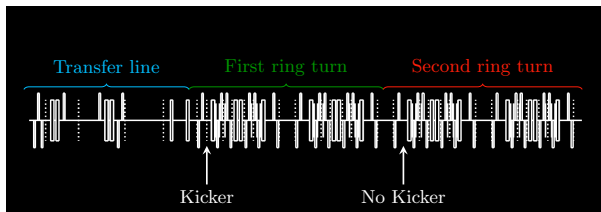


Figure: Check for the presence of the kicker in the first ring turn and not in the second one in the lattice representation of MadX

Periodic solutions calculate of the ring: identical results in both cases

Plot of β parameters using the tracking of particles

I have developed a code which allows the plotting of the "beam envelop" of the particles tracked by MadX tracking module by plotting for each particles the value $\beta_i = i^2/\epsilon$ where $i = x,y$ and ϵ is the emittance of the beam. This method can also be used to follow each particles separately and every parameter of the particles.

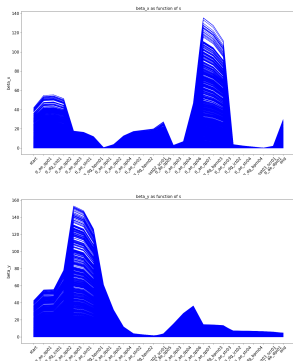
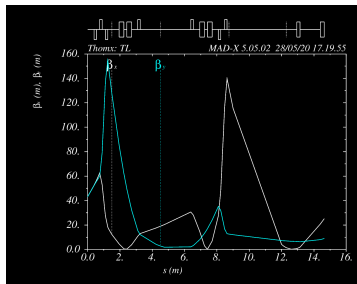


Figure: Comparison of β function calculated by Twiss module of MadX (left) and β envelope calculated by Tracking module (right). Up right is the envelope of β_x and down right is β_y

Remark: horizontal axis are different:

- left: meter along the accelerator
- right: regular space between each elements

Conclusion

- Twiss module of MadX takes into account the change of frame
- Frame change seems to simulate an injection nearly perfectly
- New lattice definitions have been created
- This lattice give reasonable results
- A method to follow particles and plot "beam" envelope has been implemented
- Comparison with Twiss calculations seem to validate this method

Next step:

- Create a code to correct automatically septum's and kicker's parameters given RI-BPM2 and RI-BPM3 offset measure
- Waiting for correct lattice to simulate the transfer line (Ezgi/Christelle)