Chicane optimization

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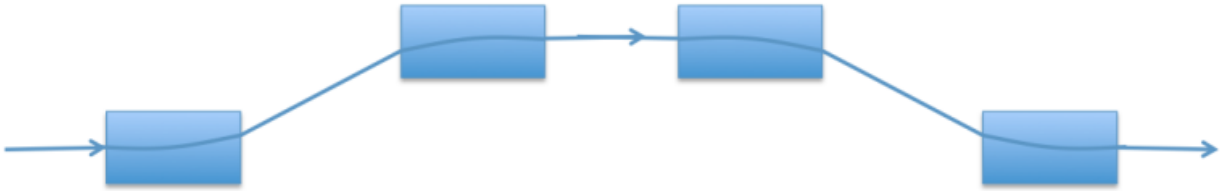
Chicane definitions



- The main reason to use a chicane:
  - Compress the beam.
  - Separate the electrons from the positron beam.
  - Momentum selection.

Chicane definition

- Transfer matrix:

$$\begin{bmatrix} x_{exit} \\ x'_{exit} \\ z_{exit} \\ \delta_{exit} \end{bmatrix} = \begin{bmatrix} R_{11} & R_{12} & R_{15} & R_{16} \\ R_{21} & R_{22} & R_{25} & R_{26} \\ R_{51} & R_{52} & 1 & R_{56} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_0 \\ x'_0 \\ z_0 \\ \delta_0 \end{bmatrix}$$

- y,y' elements are zeros.

Dipole matrix

- The dipole matrix is defined as :

$$M_{dipole}(\rho\theta) = \begin{bmatrix} \cos\theta & \rho\sin\theta & 0 & \rho(1-\cos\theta) \\ -\frac{1}{\rho} & \cos\theta & 0 & \sin\theta \\ -\sin\theta & -\rho(1-\cos\theta) & 1 & -\rho(\theta-\sin\theta) \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

- $L_{dipole} = \rho\theta$
- ρ is the bend radius.
- θ is the bend angle.

Drift Matrix

- The dipole matrix is defined as:

$$M_{drift} = \begin{bmatrix} 1 & L_{drift} & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & L_{drift}/\gamma^2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$M_{chicane} = M_{dipole}(-\rho, -\theta) \times M_{drift} \times M_{dipole}(\rho, \theta) \times M_{drift} \times M_{dipole}(\rho, \theta) \times M_{drift} \times M_{dipole}(-\rho, -\theta)$$

Case 1 : Uncoupled calculation

- **Using z & $\frac{\Delta P}{P}$ space, we get:**

$$\begin{bmatrix} z_{exit} \\ \delta_{exit} \end{bmatrix} = \begin{bmatrix} 1 & R_{56} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} z_0 \\ \delta_0 \end{bmatrix}$$

- We get:

$$\begin{aligned} z_{exit} &= z_0 + R_{56}\delta_0 \\ \delta_{exit} &= \delta_0 \end{aligned}$$

- Then we can get R_{56}:

$$\begin{aligned} \Delta z &= z_{exit} - z_0 \\ R_{56} &= \frac{\Delta z}{\delta_0} \end{aligned}$$

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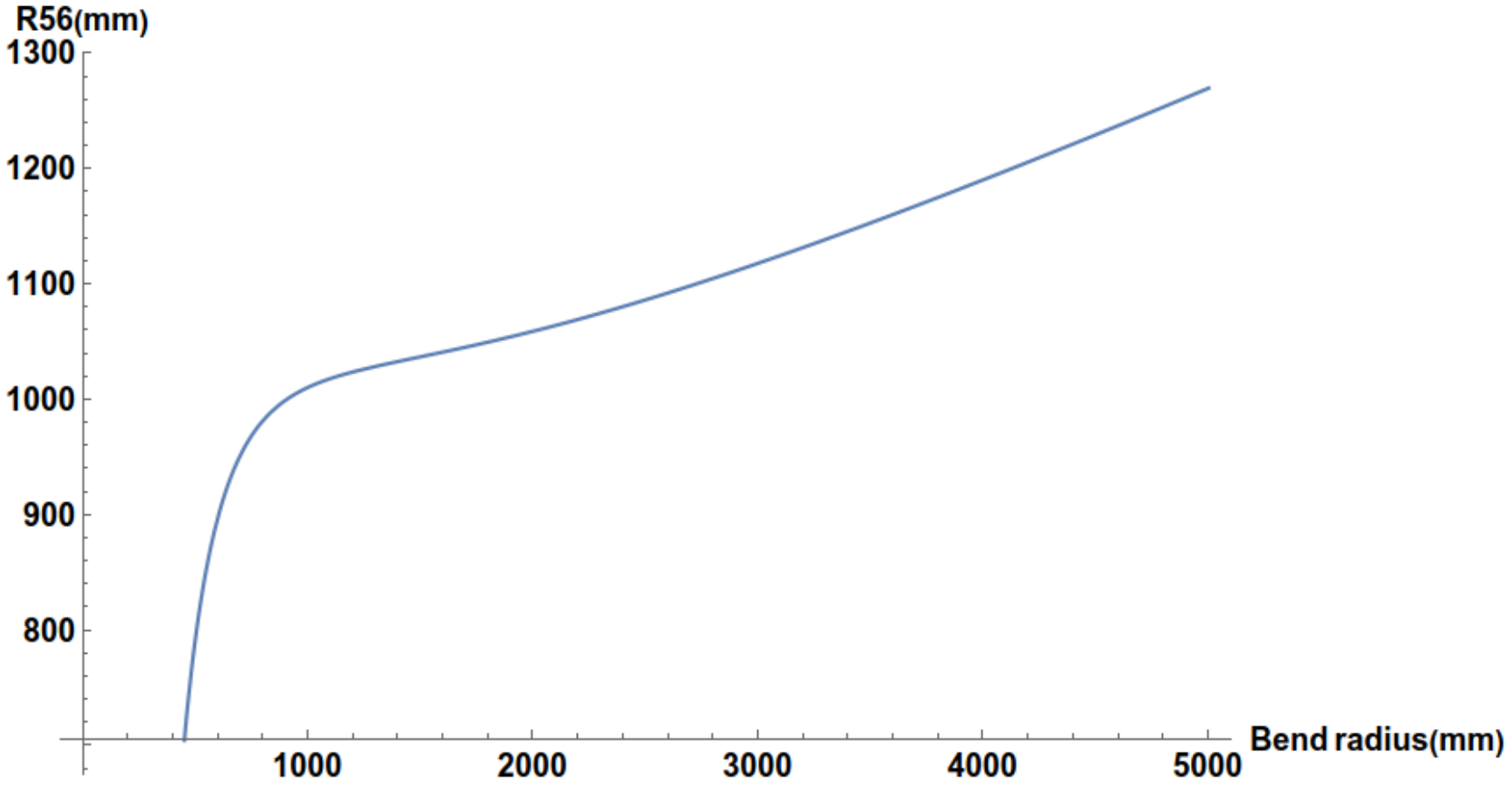
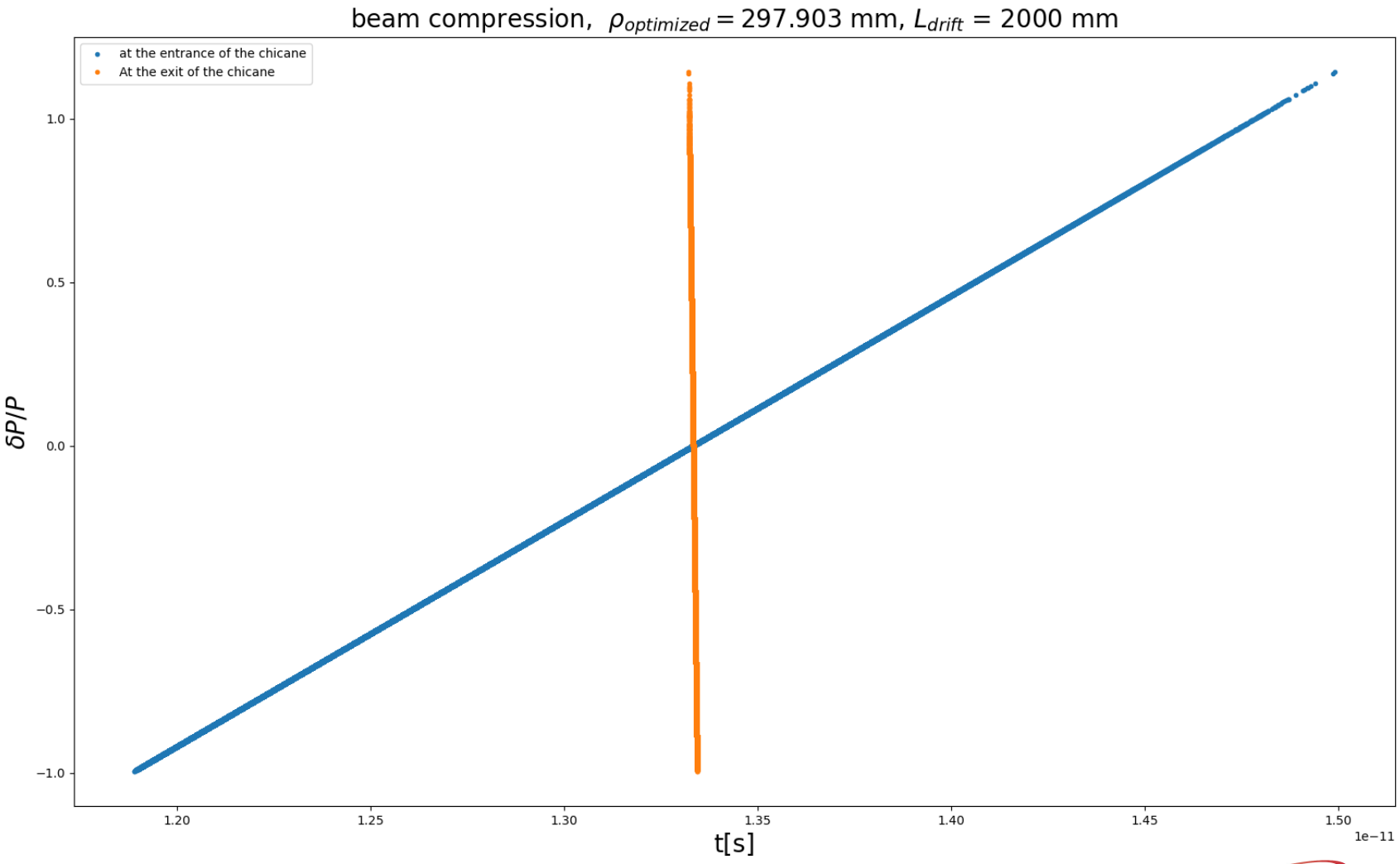
Case 1 : Uncoupled calculations

- From $M_{chicane}$, we plot the $R_{56}(\rho)$:



Case 1 : Beam compression



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Case 2 : Coupled calculations

$M_{chicane} = M_{dipole}(-\rho, -\theta) \times M_{drift} \times M_{dipole}(\rho, \theta) \times M_{drift} \times M_{dipole}(\rho, \theta) \times M_{drift} \times M_{dipole}(-\rho, -\theta)$

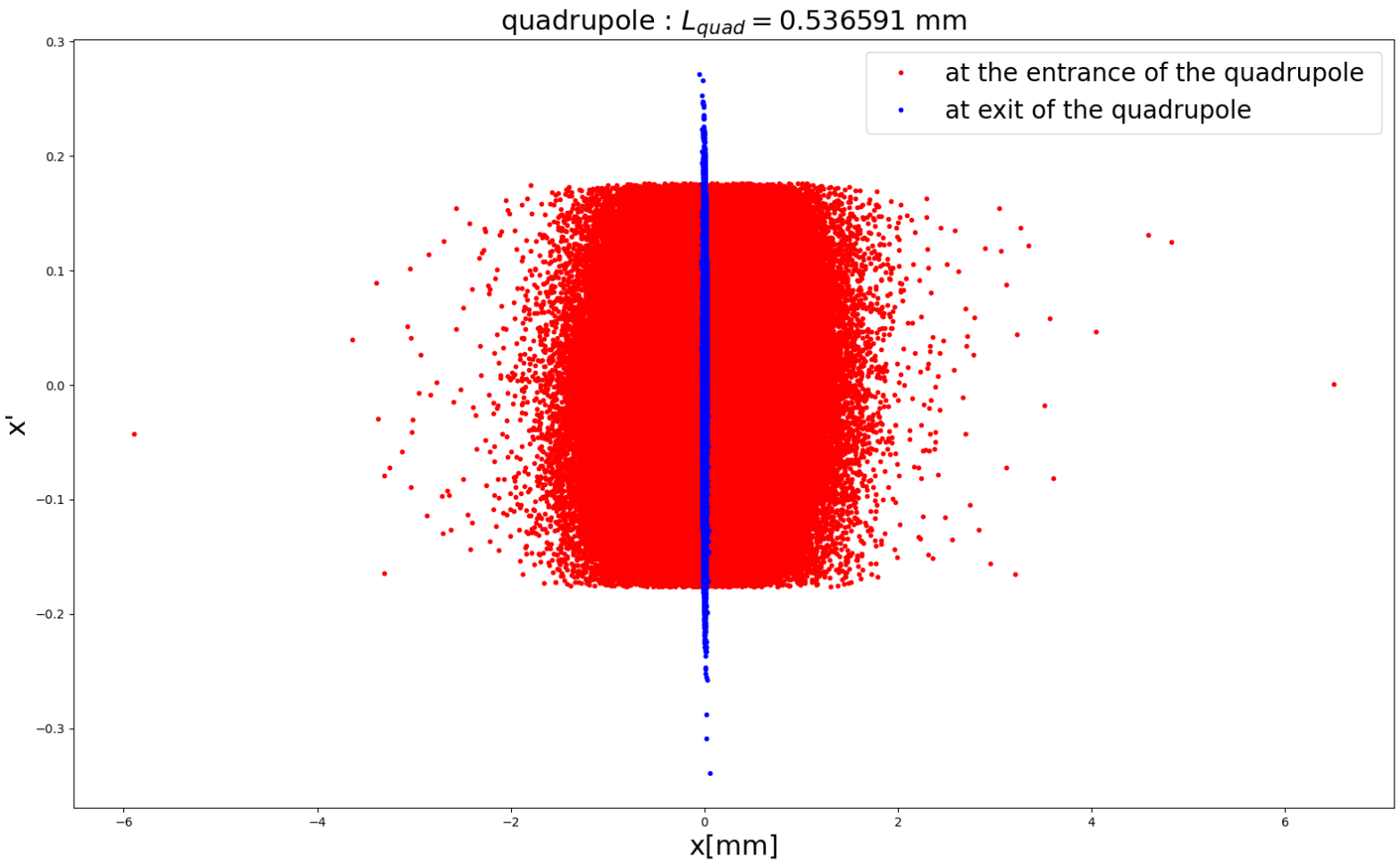
$$M_{chicane} = \begin{bmatrix} M_{11} & M_{12} & M_{15} & M_{16} \\ M_{21} & M_{22} & M_{25} & M_{26} \\ M_{51} & M_{52} & 1 & M_{56} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{aligned} \Delta z &= M_{51}x_0 + M_{52}x_0' + M_{56}\delta_0 \\ M_{56} &= \frac{\Delta z + [coupled - term]}{\delta_0} \end{aligned}$$

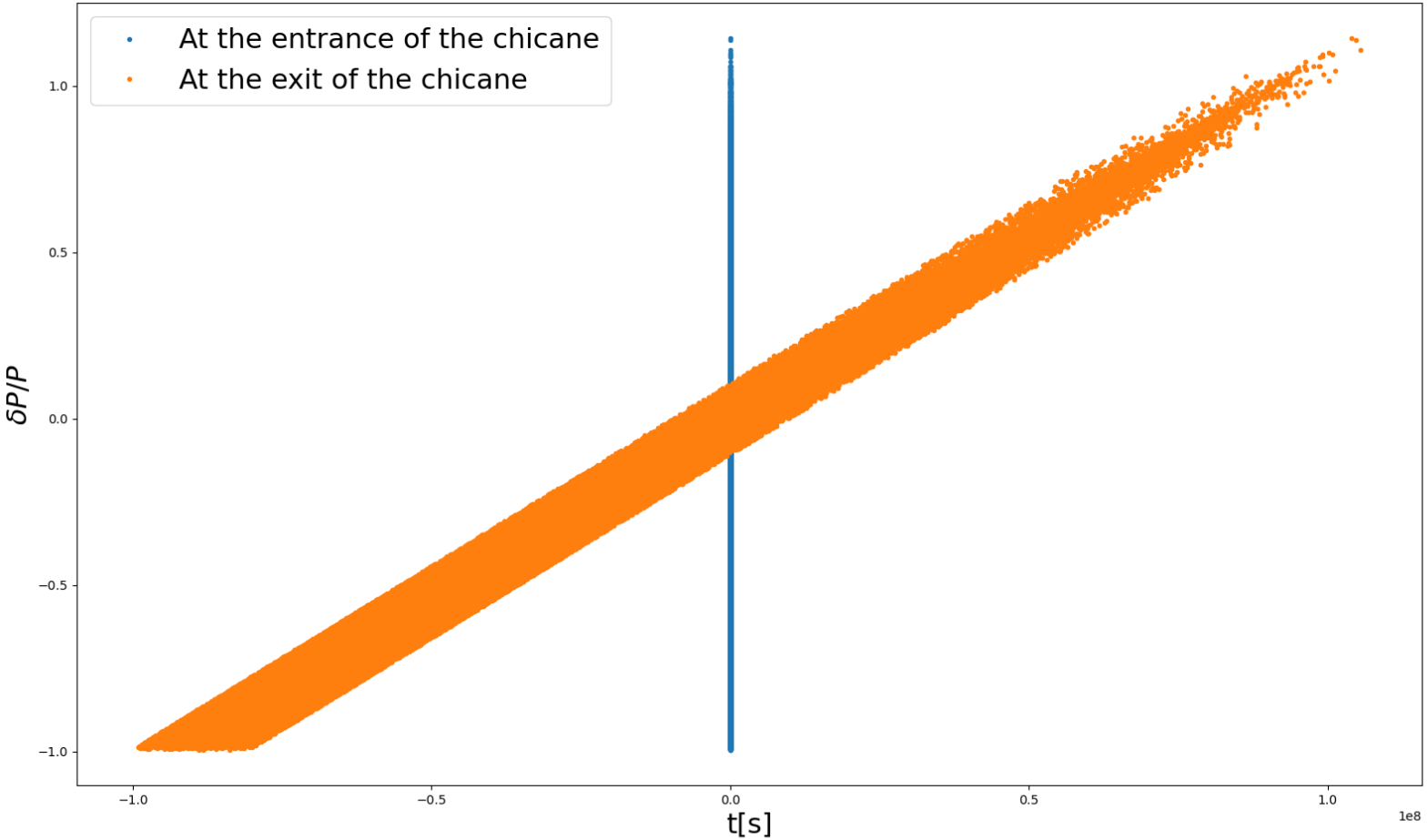
Where:

$$coupled - term = M_{51}x_0 + M_{52}x_0'$$

Case 2 : Coupled calculations



Case 2 : Coupled calculations



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Conclusion

- Dipoles and drift parameters $\rightarrow$ better chicane compression.
- Dipole dispersion affect the chicane compression.
- How can we cancel dipole dispersion in the chicane matrix?