Experimental optimization of the momentum resolution in momentum measurements

1. **Some introduction to the problem**
2. **Some related equations and plots**
3. **Some conclusion**

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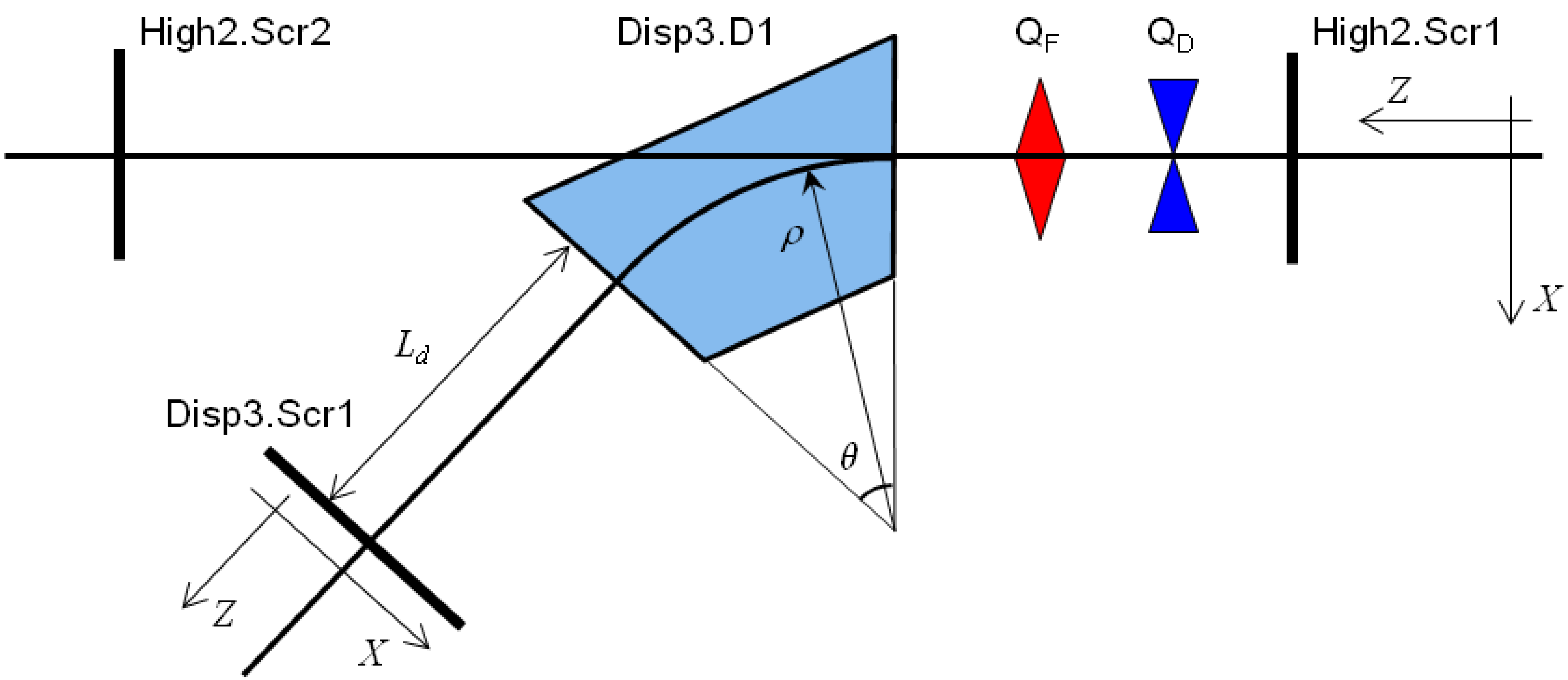
PPS June 2013

HELMHOLTZ
GEMEINSCHAFT

DESY

HEDA2 momentum measurements



$$D_x = \rho(1 - cos(\theta)) + L_d sin(\theta), \qquad \theta = 60°$$

$$\sigma_x = D_x \frac{\Delta p}{p}$$

$$D_x = 0.9\ m$$

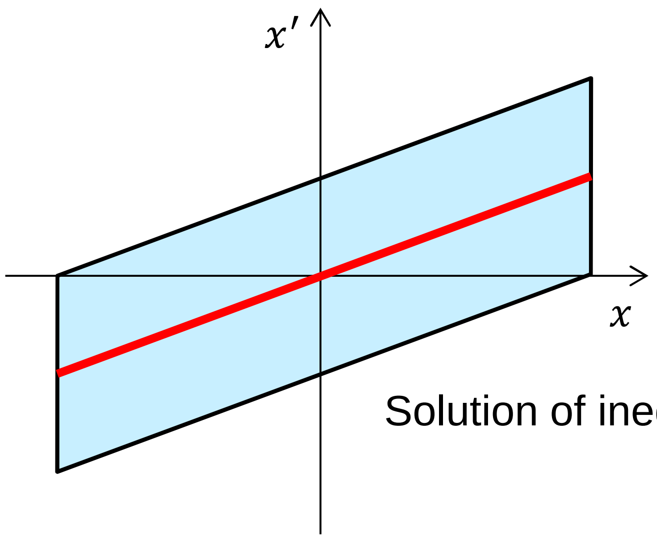
DESY

Momentum resolution optimization

$$x_2 = R_{11}x_0 + R_{12}x'_0 + R_{16}\delta p_0$$

$$R_{11} = -0.516$$
$$R_{12} = 0.867 \text{ [m]}$$
$$R_{16} = 0.905 \text{ [m]}$$

$$|R_{11}x_0 + R_{12}x'_0| < R_{16}\delta p_0$$



Solution of inequation

Transport matrix

$$\begin{pmatrix} x \\ x' \\ y \\ y' \\ z \\ \delta p \end{pmatrix}_2 = \begin{bmatrix} R_{11} & R_{12} & 0 & 0 & 0 & R_{16} \\ R_{21} & R_{22} & 0 & 0 & 0 & R_{26} \\ 0 & 0 & 1 & L_d + R\theta & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ R_{51} & R_{52} & 0 & 0 & 1 & R_{56} \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{pmatrix} x \\ x' \\ y \\ y' \\ z \\ \delta p \end{pmatrix}_0$$

Some equations

$$x_2 = R_{11}x_0 + R_{12}x'_0 + R_{16}\delta p_0$$

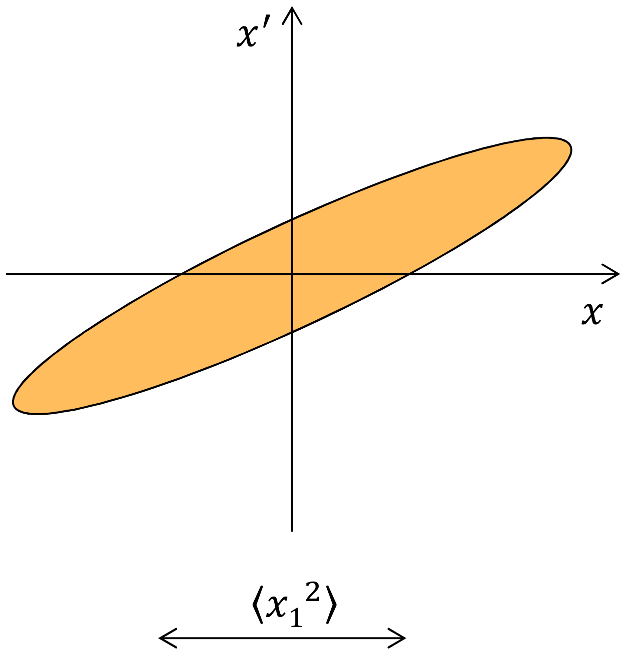
$$\langle {x_2}^2 \rangle = \langle {R_{11}}^2 {x_0}^2 \rangle + \langle {R_{12}}^2 {x'_0}^2 \rangle + \left\langle {R_{16}}^2 \delta {p_0}^2 \right\rangle + \langle R_{11}R_{12}x_0x'_0 \rangle + \langle R_{11}R_{16}x_0\delta p_0 \rangle + \langle R_{12}R_{16}x'_0\delta p_0 \rangle$$

$\langle R_{11}R_{16}x_0\delta p_0 \rangle \rightarrow 0$, $\langle R_{12}R_{16}x'_0\delta p_0 \rangle \rightarrow 0$

$$\langle {x_2}^2 \rangle = \langle {R_{11}}^2 {x_0}^2 \rangle + \langle {R_{12}}^2 {x'_0}^2 \rangle + \langle R_{11}R_{12}x_0x'_0 \rangle + \left\langle {R_{16}}^2 \delta {p_0}^2 \right\rangle$$

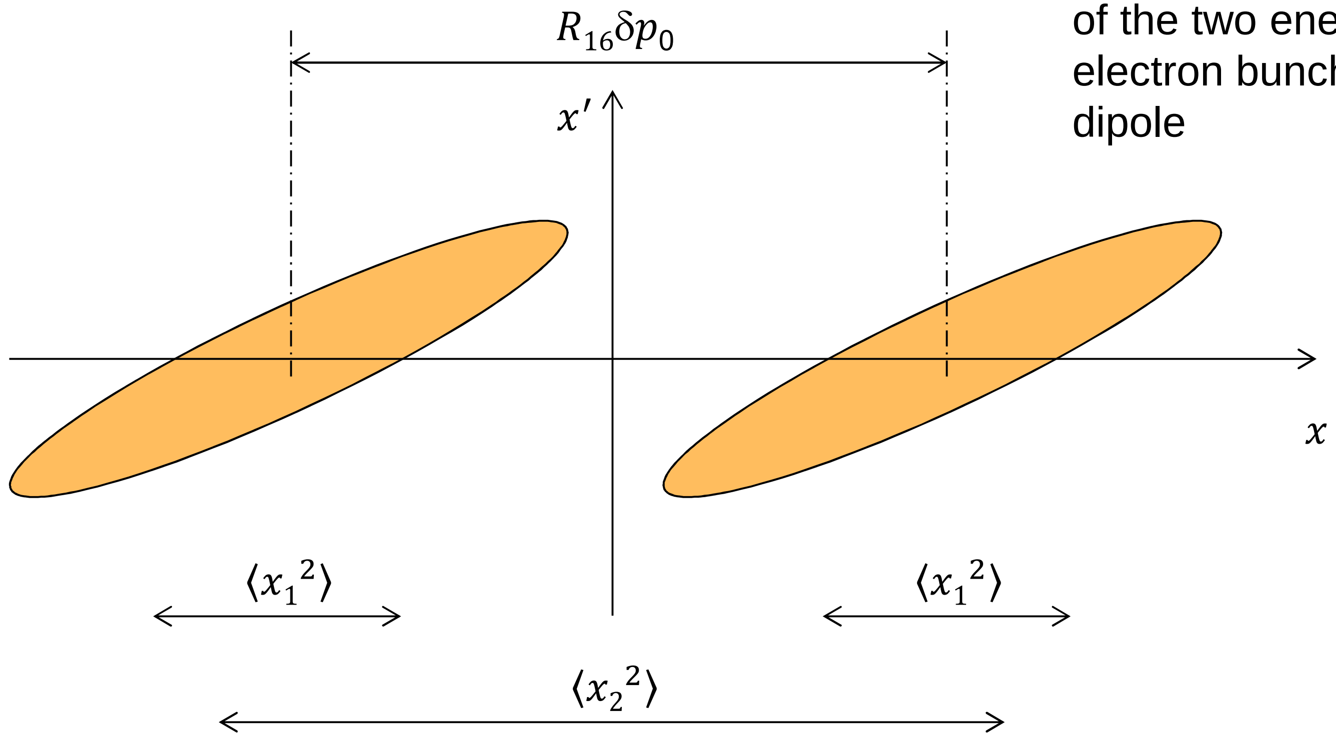
$$\langle {x_2}^2 \rangle = \langle {x_1}^2 \rangle + \left\langle {R_{16}}^2 \delta {p_0}^2 \right\rangle$$

Initial phase space after the dipole magnet



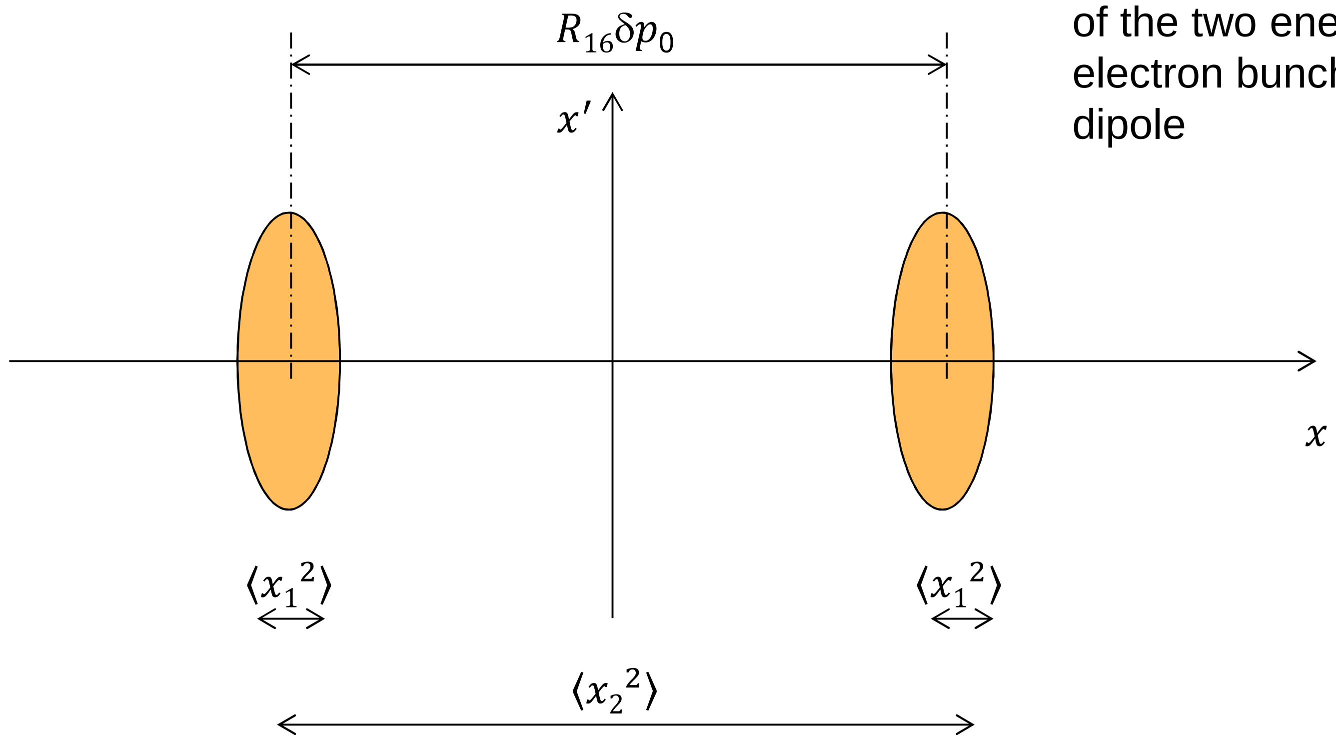
Transverse phase space of the mono energetic electron bunch after the dipole

After the dipole magnet



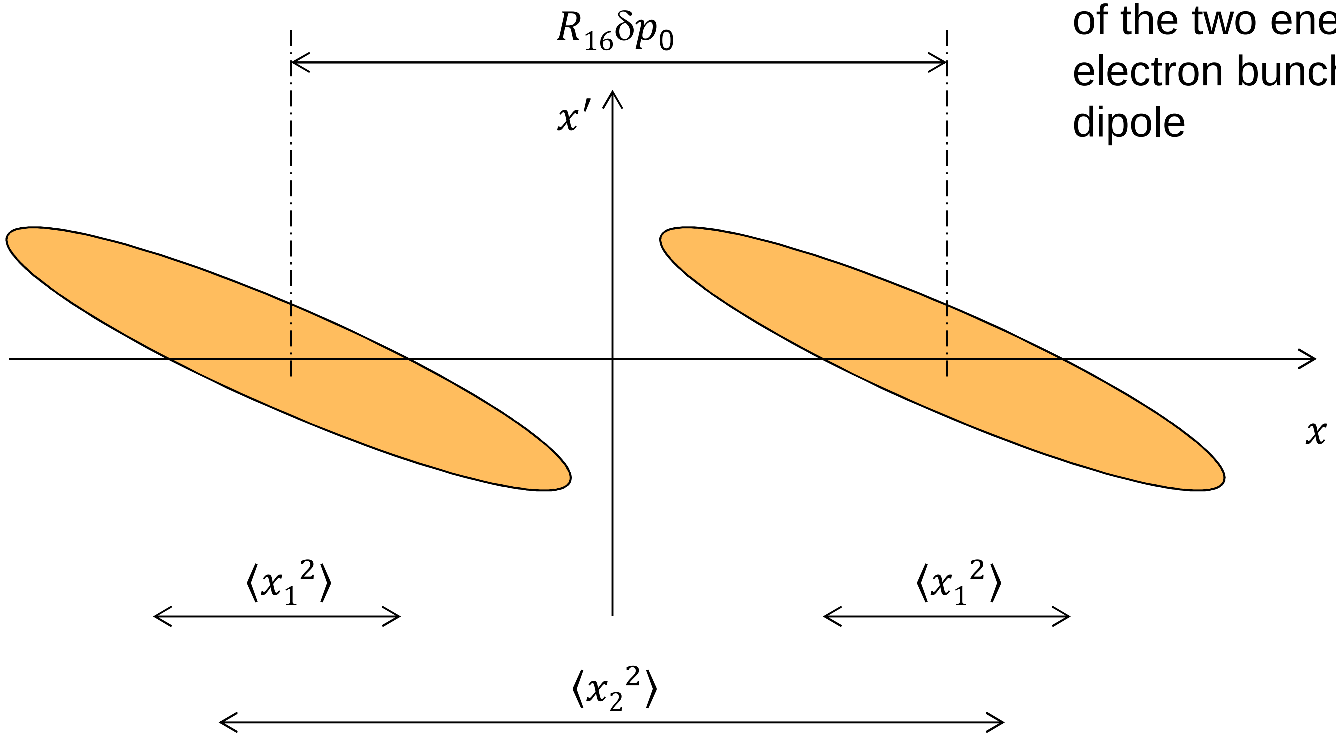
Transverse phase space of the two energies electron bunch after the dipole

After the dipole magnet



Transverse phase space of the two energies electron bunch after the dipole

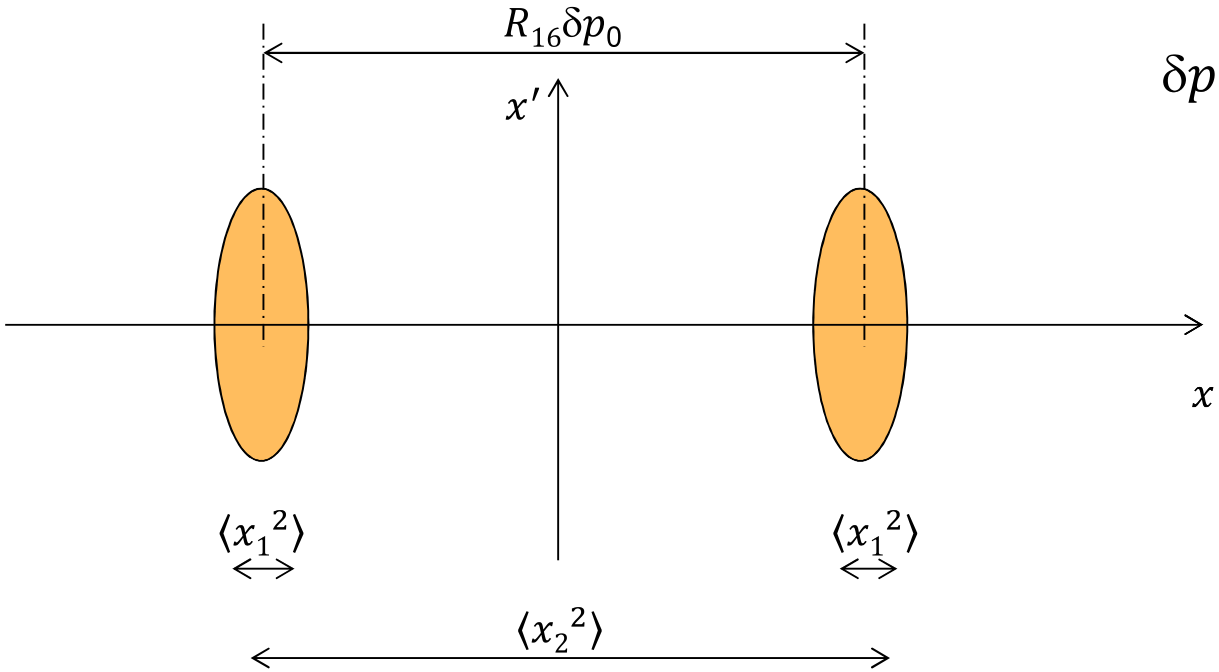
After the dipole magnet



Transverse phase space of the two energies electron bunch after the dipole

Conclusion

- To get the highest momentum resolution one need to play with the beamline optics upstream the dipole in such way, that the measured RMS size of the beam downstream the dipole will be minimal in the dispersive direction.



$$\delta p = \frac{\sqrt{\langle x_1{}^2 \rangle}}{R_{16}}$$