Comparison of Modulator Simulation with Theory

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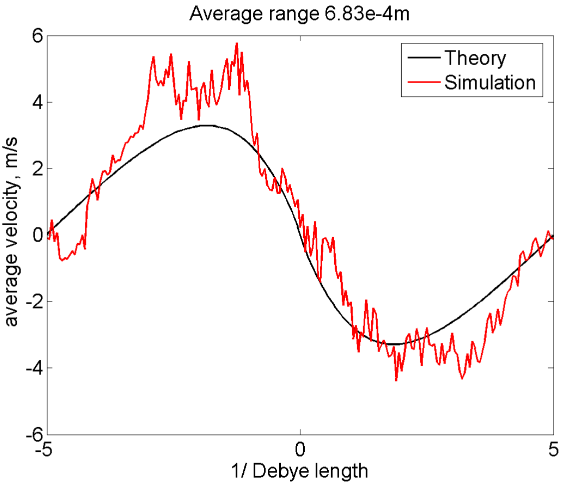
Averaging range

- Velocity modulation changes when we measure it using different averaging range in transversal direction
- Theory uses $\sigma = 6.83e-4m$ as the averaging range

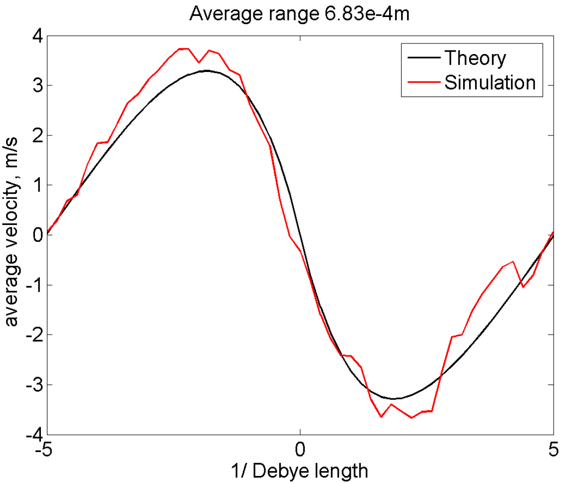
Previous comparison



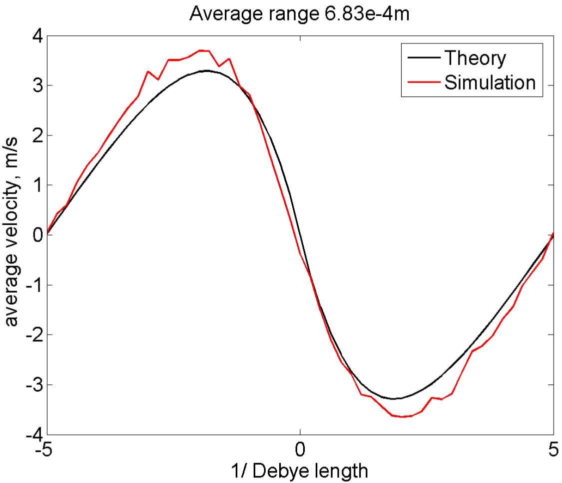
Previous comparison

- Previous comparison was incorrect due to insufficient precision because of post-processing of data.
- Rerun simulations using different domain size but keep the same averaging range, and gather original data with full precision.

Comparison with domain size -8e-4m to 8e-4m



Comparison with domain size -6.83e-4m to 6.83e-4m



Magnetic field of quadrupole

$$\begin{pmatrix} B_x \\ B_y \\ B_z \end{pmatrix} = -\frac{\mathsf{G}}{\mathbf{b1}} \cdot \begin{pmatrix} B_{\text{fringe,x}}\left(\mathbf{b1}\,x, \mathbf{b1}\,y, \mathbf{b1}\,(z - \tfrac{1}{2}L)\right) + B_{\text{fringe,x}}\left(\mathbf{b1}\,x, \mathbf{b1}\,y, \mathbf{b1}\,(-z - \tfrac{1}{2}L)\right) \\ B_{\text{fringe,y}}\left(\mathbf{b1}\,x, \mathbf{b1}\,y, \mathbf{b1}\,(z - \tfrac{1}{2}L)\right) + B_{\text{fringe,y}}\left(\mathbf{b1}\,x, \mathbf{b1}\,y, \mathbf{b1}\,(-z - \tfrac{1}{2}L)\right) \\ B_{\text{fringe,z}}\left(\mathbf{b1}\,x, \mathbf{b1}\,y, \mathbf{b1}\,(z - \tfrac{1}{2}L)\right) - B_{\text{fringe,z}}\left(\mathbf{b1}\,x, \mathbf{b1}\,y, \mathbf{b1}\,(-z - \tfrac{1}{2}L)\right) \end{pmatrix}$$

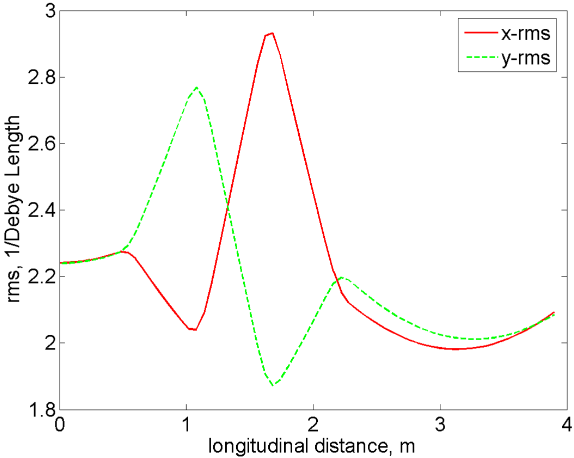
Magnetic field of quadrupole (continue)

$$\mathbf{B}_{\text{fringe}}(x,y,z)=\frac{1}{4}\begin{pmatrix} -y-2\arctan\left(-\dfrac{\sin(y)}{e^{-z}+\cos(y)}\right)+\dfrac{y\sinh(z)}{\cos(x)+\cosh(z)} \\ -x-2\arctan\left(-\dfrac{\sin(x)}{e^{-z}+\cos(x)}\right)+\dfrac{x\sinh(z)}{\cos(y)+\cosh(z)} \\ \dfrac{y\sin(x)}{\cos(x)+\cosh(z)}+\dfrac{x\sin(y)}{\cos(y)+\cosh(z)} \end{pmatrix}$$

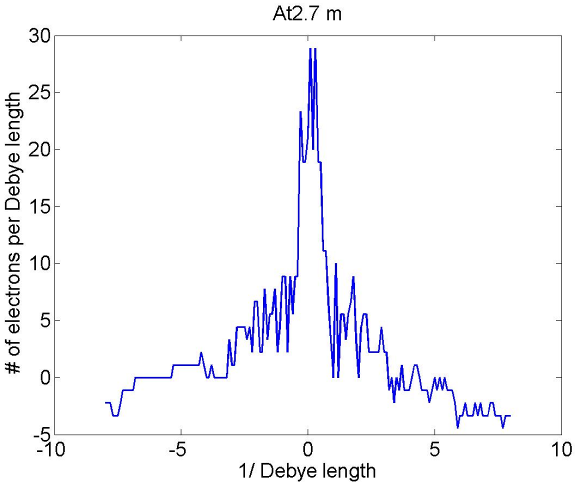
Magnetic field of quadrupole (continue)

- $G = K = K_1 \cdot B\rho$
- $b_1 = \pi / r_{bore}$
- $r_{bore} = 3cm$

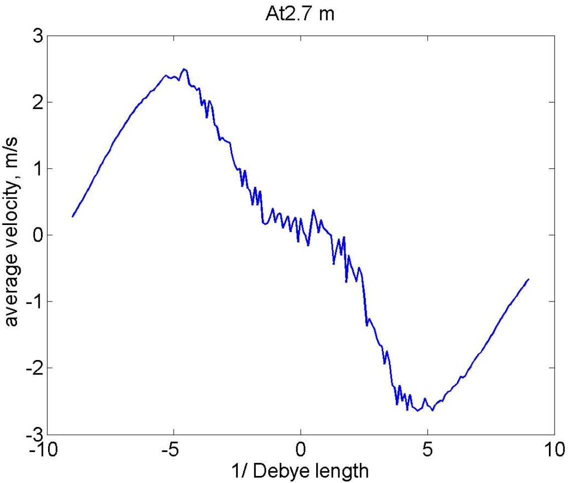
RMS change due to quadrupoles



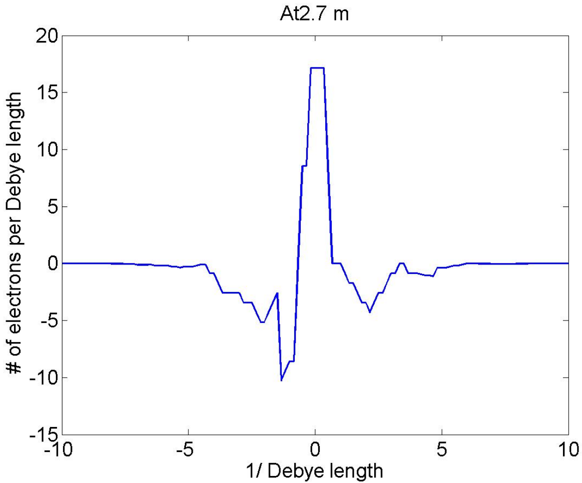
Modulator, longitudinal number distribution



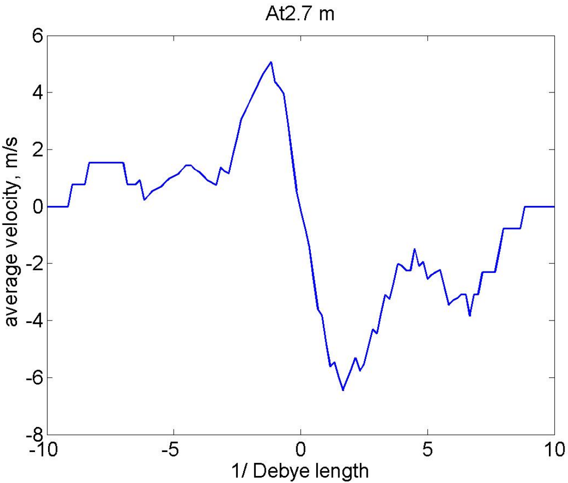
Modulator, longitudinal velocity distribution



Modulator, transversal number distribution

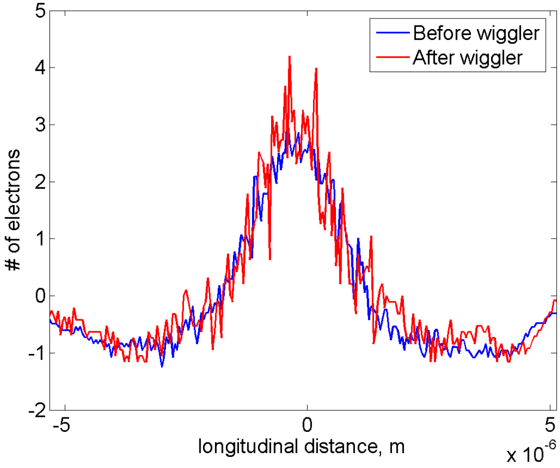


Modulator, transversal velocity distribution

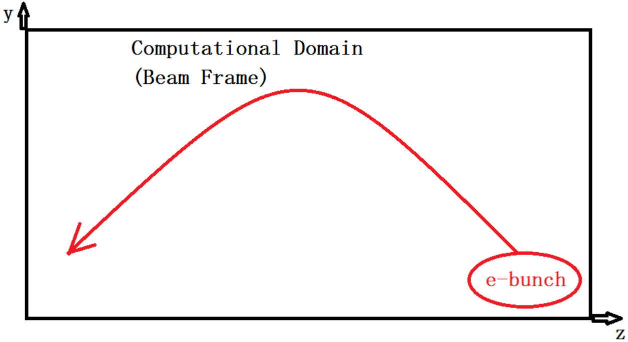


- Run modulator simulations using 1/10 of the previous electron number density
- Take the output of modulator as input of wiggler
- Increase wiggler magnetic field strength by 5 times (from 0.2T to 1.0T).

Wiggler simulation



Motion of electron bunch



Motion of electron bunch

- Stronger wiggler magnetic field makes electron bunch move further along negative z direction, which requires larger computational domain.