Influence of space charge effect on dynamics of charged particles trapped in laser channels

E.N. Frolov[1,2,3], A.V. Dik[1,2], S.B. Dabagov[1,2,4]

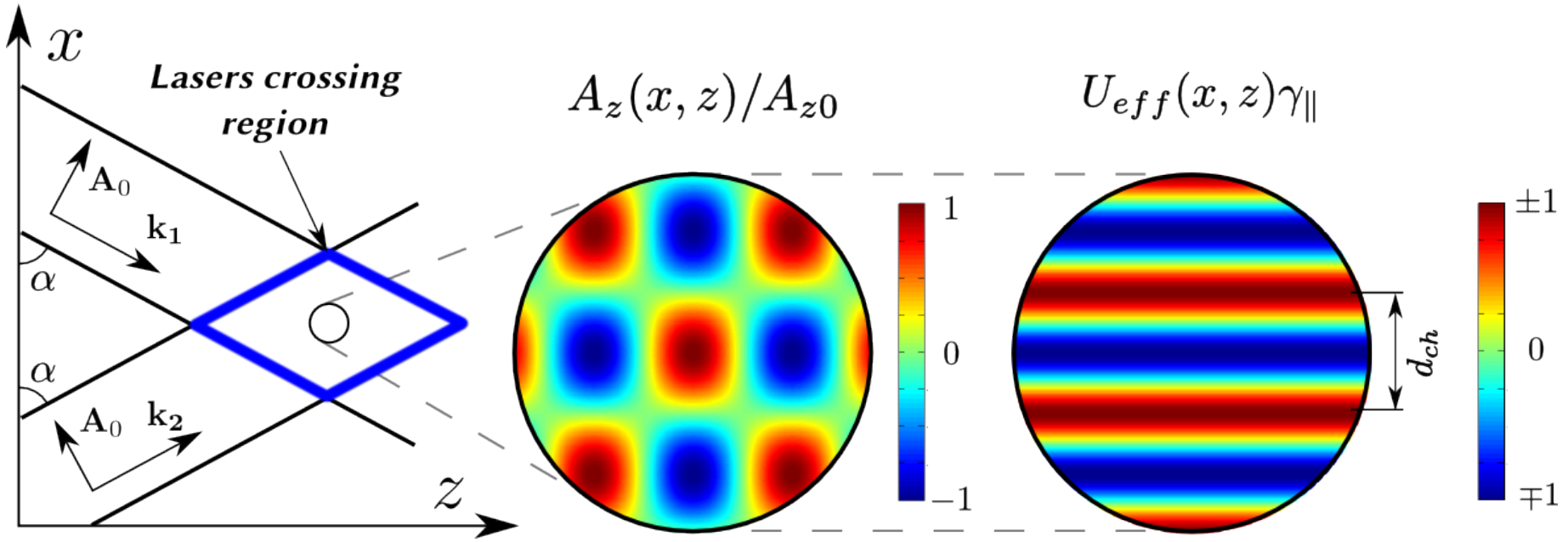
1 LPI RAS, Russia, Moscow
2 NRNU MEPhI, Russia, Moscow
3 TPU, Russia, Tomsk
4 LNF INFN, Italy, Frascati

Channeling-2016

Content

- System
- Calculation method
- Space charge

Channeling in laser fields



$$U_{am} = \frac{e^2 E_0^2(-\cos(2\alpha) - 2\bar{\beta}_z \sin\alpha + \bar{\beta}_z^2(1+\cos^2\alpha))}{2\bar{\gamma}_z k^2 mc^2(1-\bar{\beta}_z \sin\alpha)^2}$$

PIC. The most common

Maxwell

$$\frac{\partial \mathbf{B}}{\partial t} = -\nabla \times \mathbf{E}$$

$$\frac{\partial \mathbf{E}}{\partial t} = c^2 (\nabla \times \mathbf{B} - \mu_0 \mathbf{J})$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$$

Particle sources

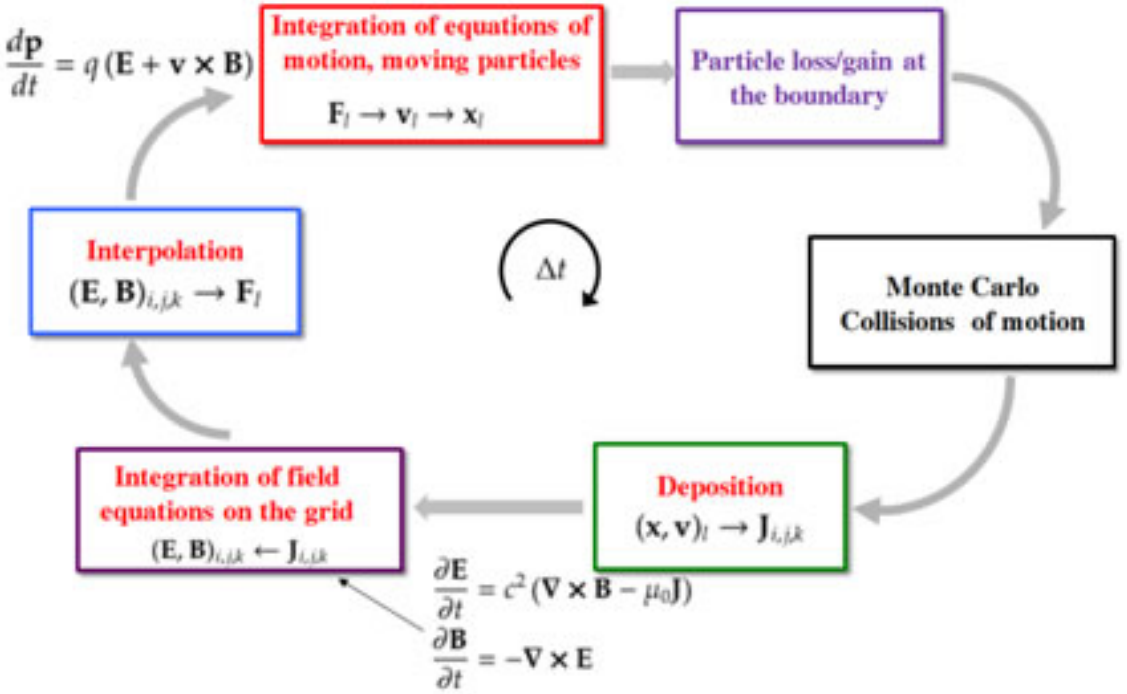
$$\mathbf{J} = \sum_i q_i \mathbf{v}_i \delta(\mathbf{x} - \mathbf{x}_i)$$

$$\rho = \sum_i q_i \delta(\mathbf{x} - \mathbf{x}_i)$$

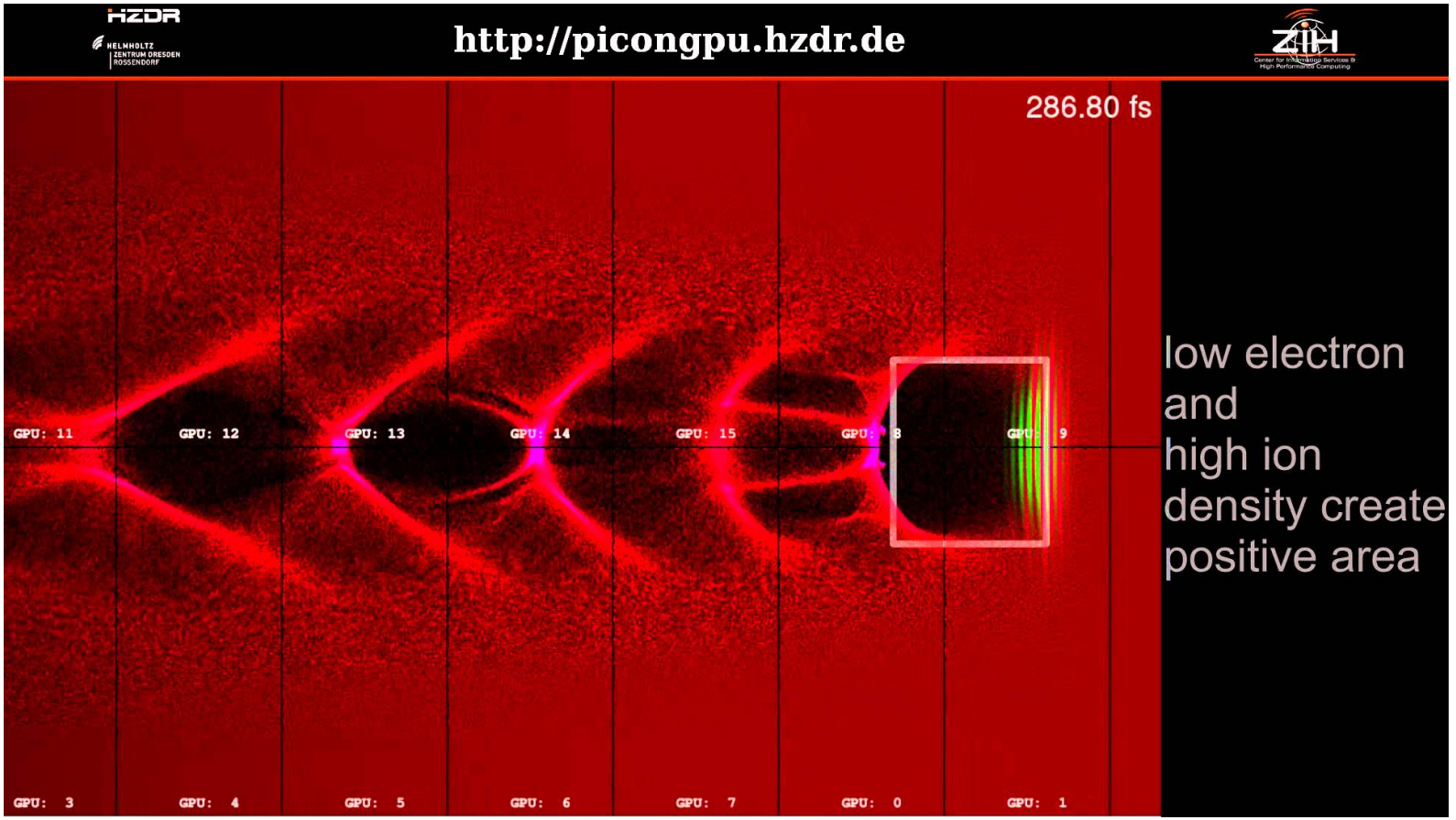
Particle dynamics

$$\frac{d}{dt}(\gamma_i \mathbf{v}_i) = \frac{q_i}{m_i} [\mathbf{E}(\mathbf{x}_i, t) + \mathbf{v}_i \times \mathbf{B}(\mathbf{x}_i, t)]$$

$$\frac{d\mathbf{x}_i}{dt} = \mathbf{v}_i$$



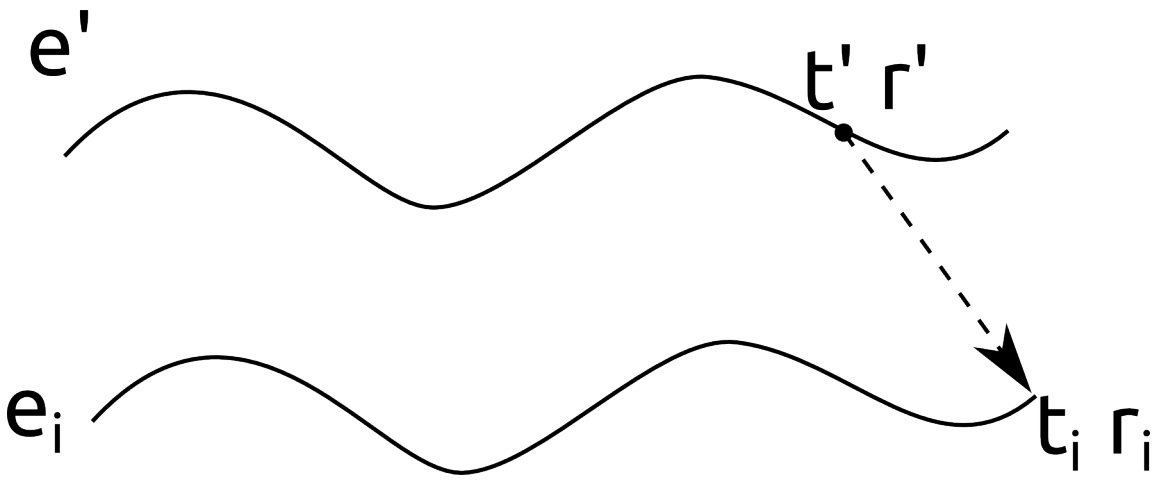
PIC. Amazing results



PIC. Why not?

- No screening in our case
- Heavy field calculations
- Interest in long calculation regions

Used method



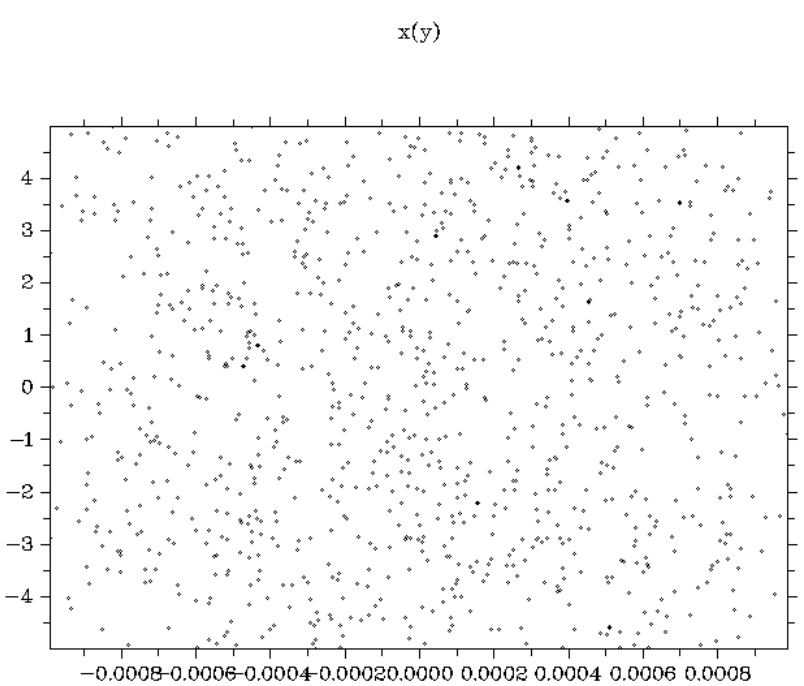
$$\mathbf{E} = e\frac{1-v^2/c^2}{\left(R-\frac{\mathbf{Rv}}{c}\right)^3}\left(\mathbf{R}-\frac{\mathbf{v}}{c}R\right)+\frac{e}{c^2\left(R-\frac{\mathbf{Rv}}{c}\right)^3}\left[\mathbf{R}\left[\left(\mathbf{R}-\frac{\mathbf{v}}{c}R\right)\dot{\mathbf{v}}\right]\right]$$

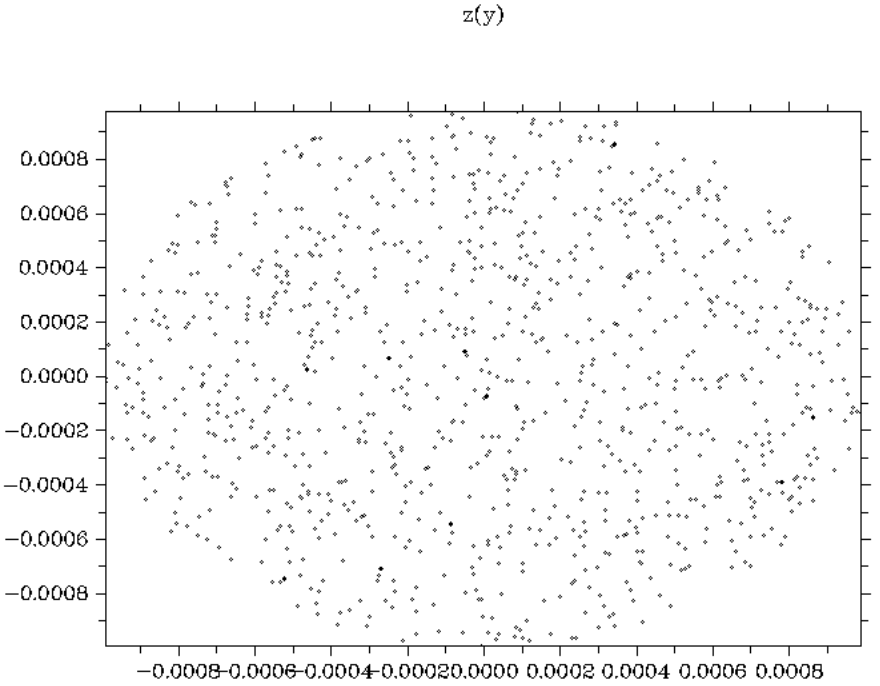
Realized on: C++

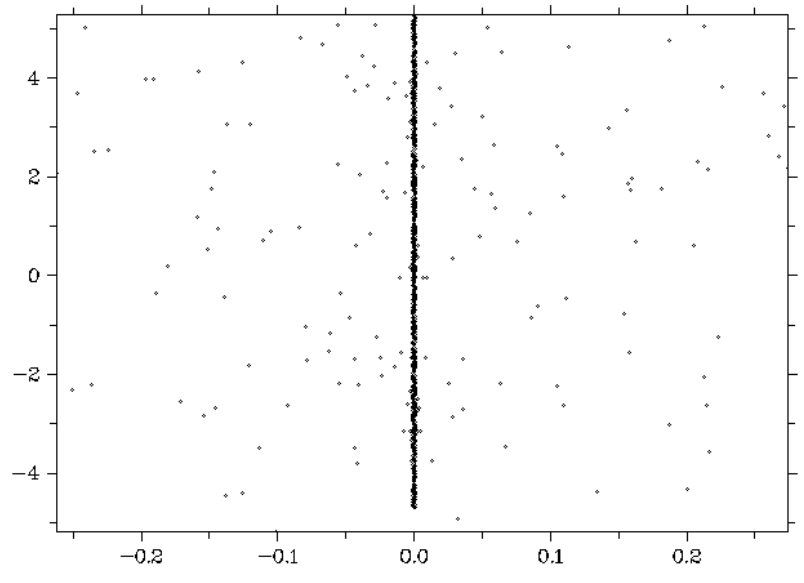
Current state

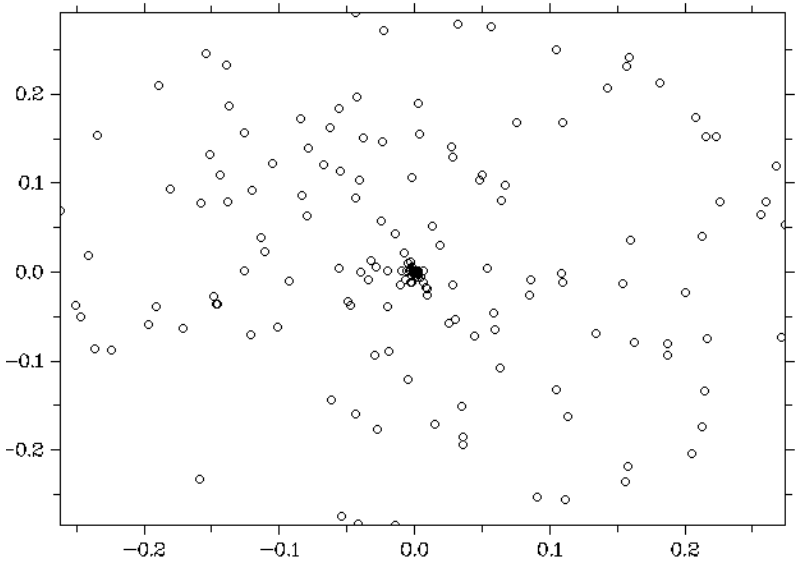
- Rewritten from scratch
- Increased “amount” of particles
- Acceptable computation speed

Non-Channeled beam

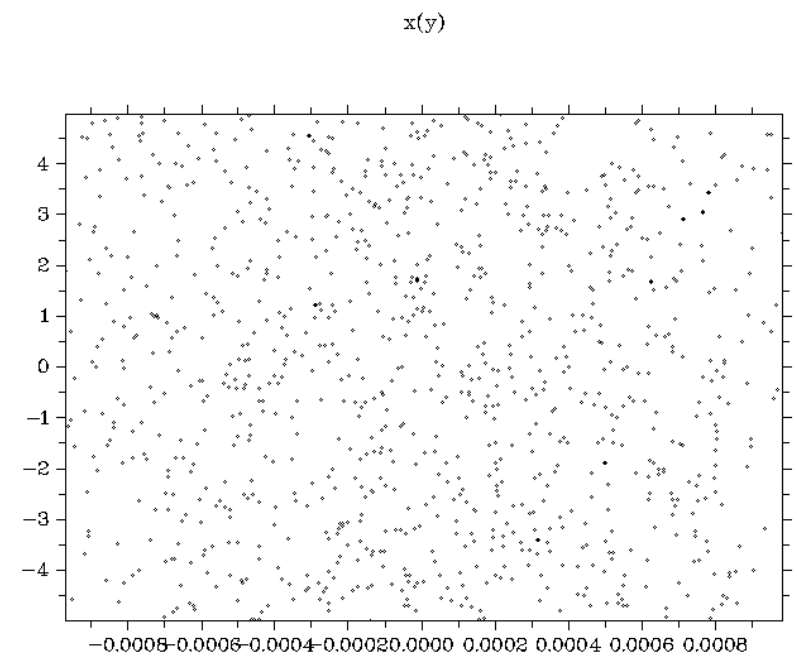


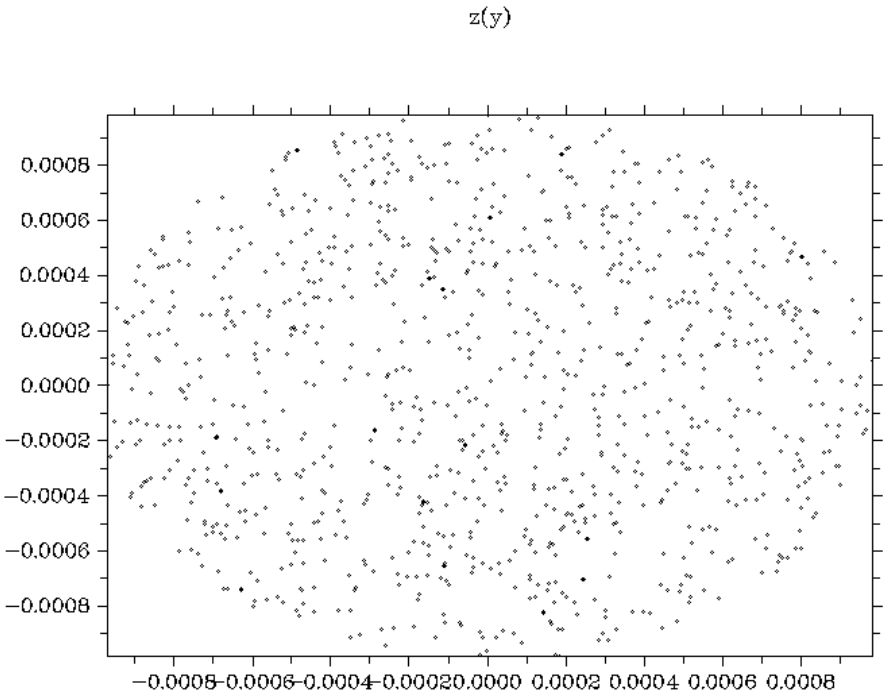


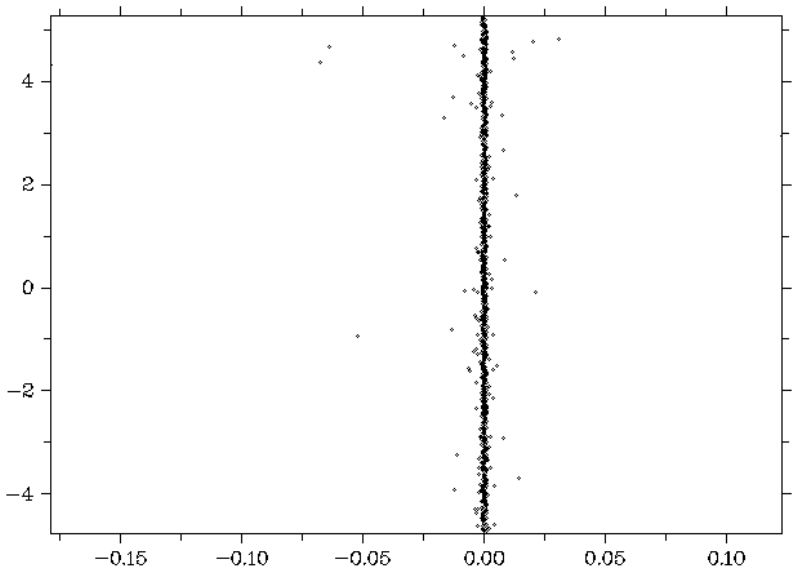


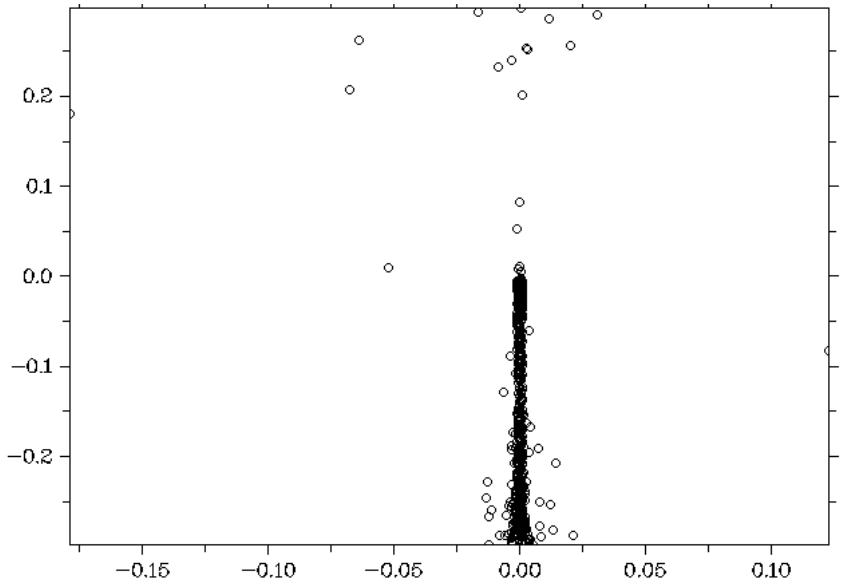


Channeled beam

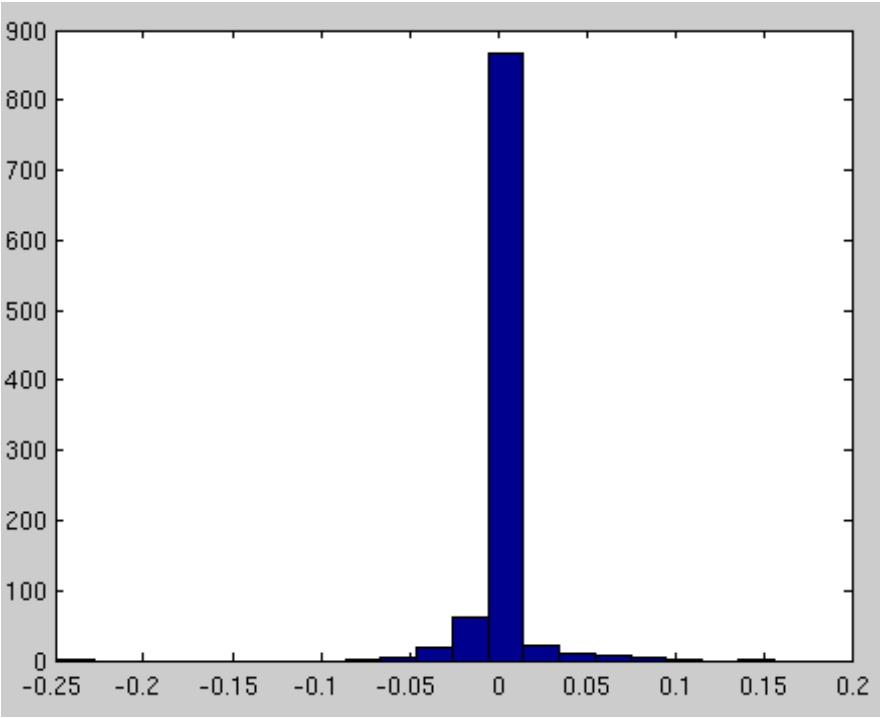


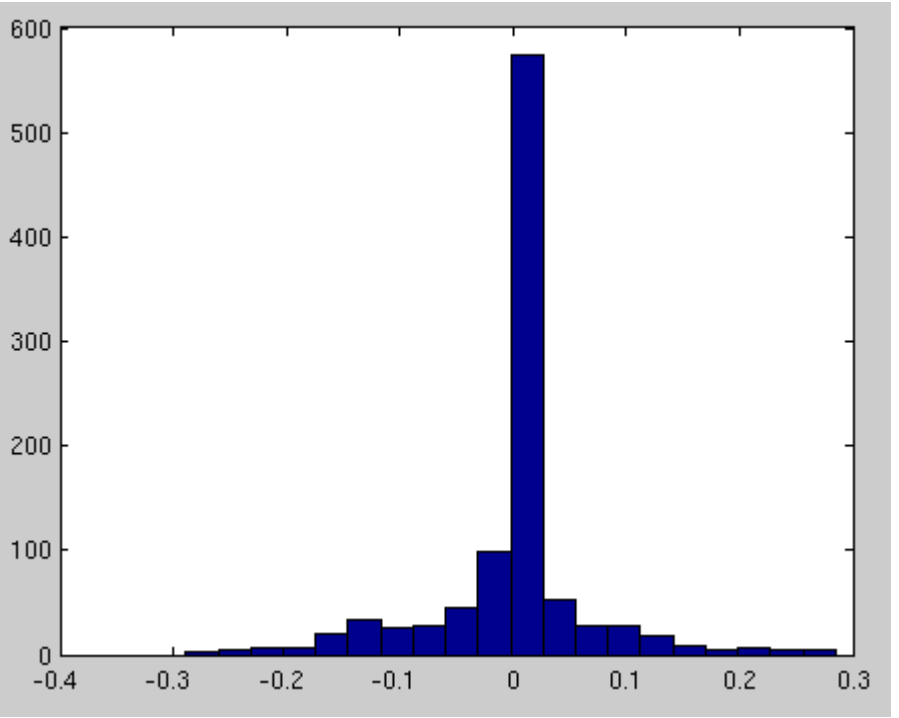






Histograms for both beams





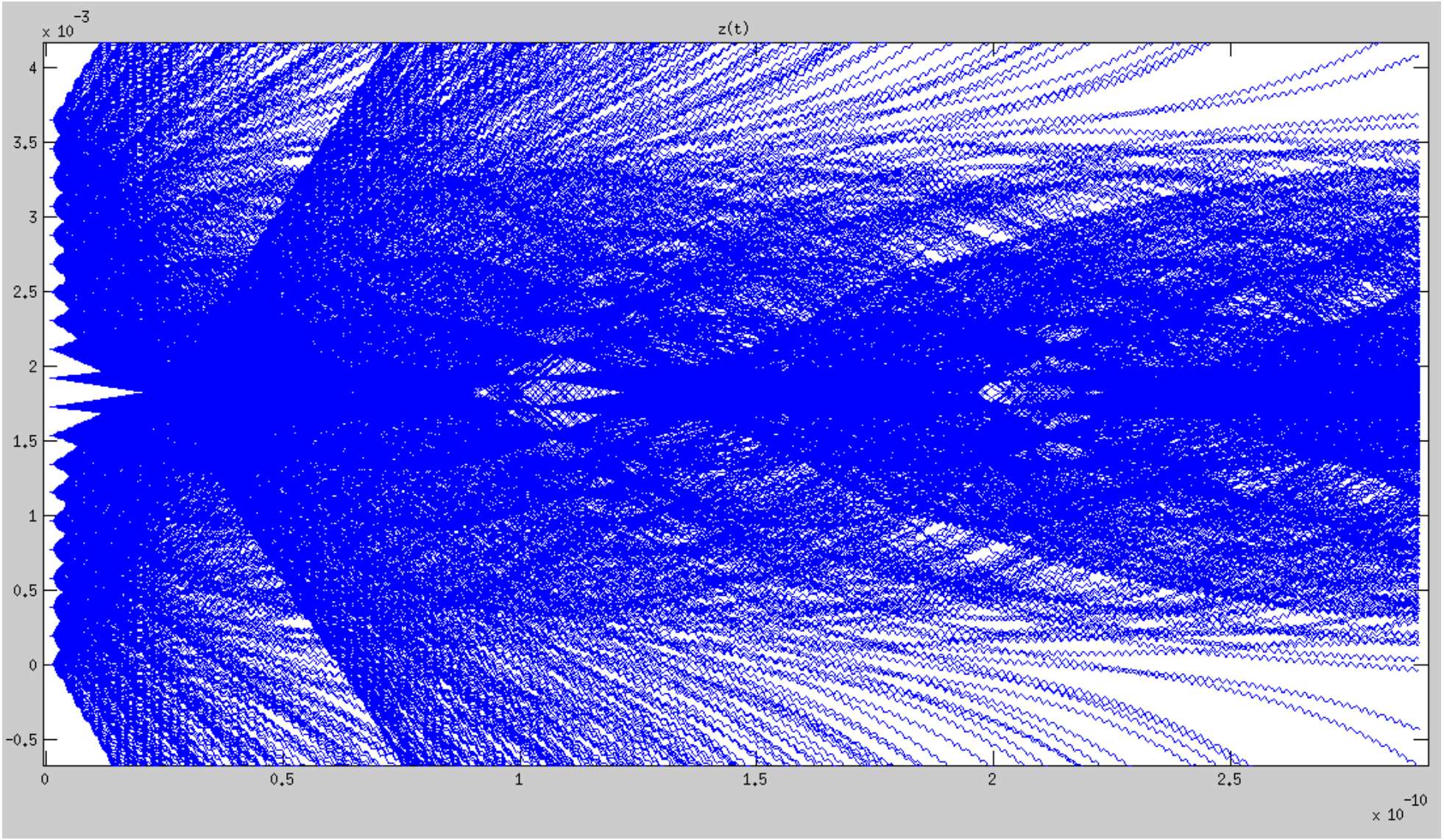
TODOs:

- Manage close collisions
- Generate beam
- Add radiation losses

- Play with real parameters
- Play with various geometries

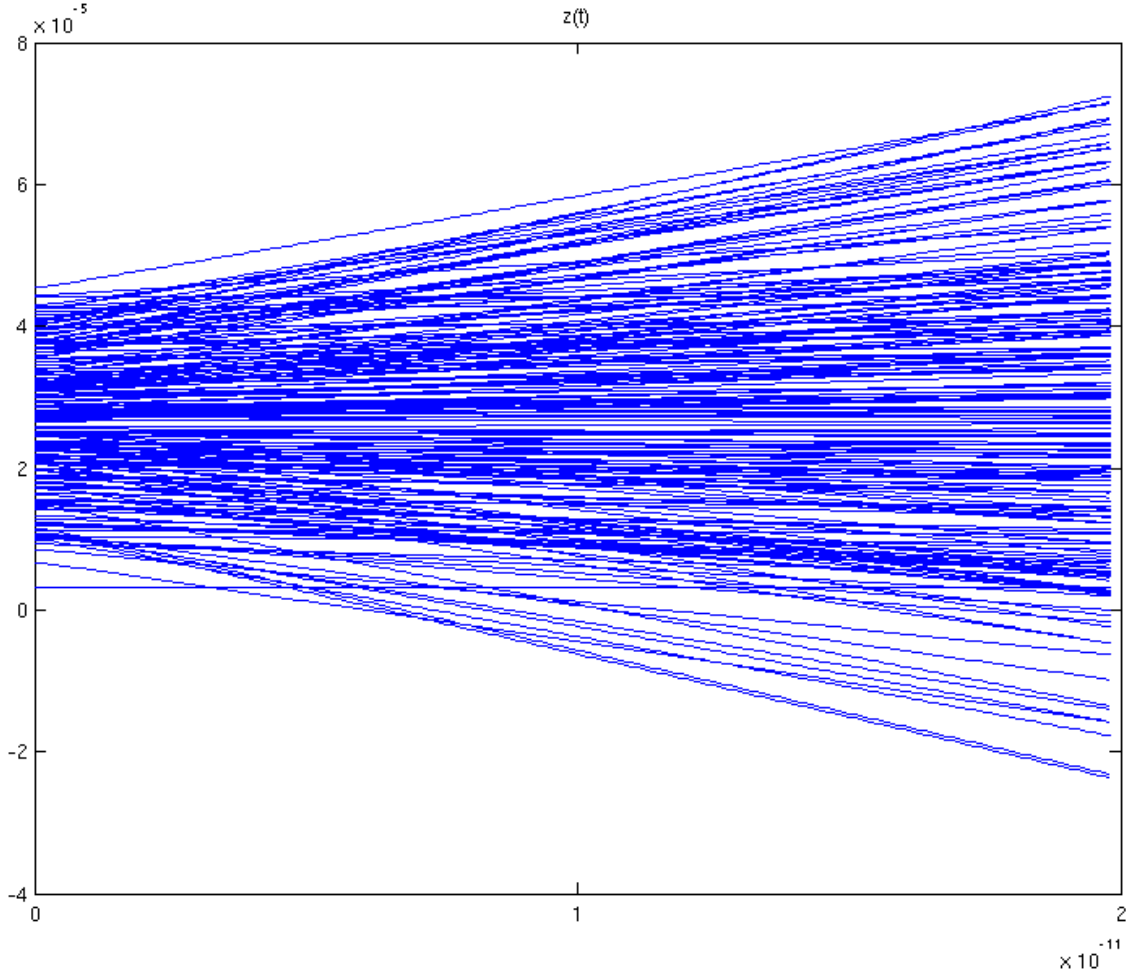
Thank you!

No space charge



Space charge. Binary collisions

- N=200
- 200 steps
- Minutes of work



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Potential inversion