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The effect of electron beam reflection in axial channeling mode

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Origins of the approach

1965 Lindhard [1] – Classical mechanics is proved to be applicable for description of channeled particles dynamics in the transversal plane

1981 Beloshitsky, Kumakhov [2] – Introduction of kinetic equations for transversal energy and moment.

1991 Lukshin, Maslov, Smirnov [3] – Integration of Kumakhov-Beloshitskiy equations

1991 Lukshin, Maslov, Smirnov [4] - Stochastic model is introduced on XIV на XIV Intern. Conf. on Atomic Collisions in Solids.

2000 Lukshin, Maslov, Smirnov, Polimatidi – [5] Results are published

1995 Akhiezer, Shulga, Grinenko, Truten, Syshshenko [6] – model and calculations for straight and bent crystals

2002 Maslov, Polimatidi [7]- modification for bent crystal

[1] J. Lindhard. Dansk. Selsk. mat.-fys. Medd. 1965. Vol.~34, N~14.

[2] V.V.Beloshitskiy, M.A.Kumakhov Multiple scattering of electrons at axial channeling – Radiation effects, 1981, 56(1-2)

[3] N.I.Kozlov, A.K.Maslov, V.A.Muralev,A.N.Chizh Numerical modeling of axial channeling of ultrarelativistic electrons. Preprint 34, Keldysh, 1991

[4] N.I.Kozlov, A.V. Lukshin, S.N. Smirnov. Mathematical model of ultrarelativistic electron passage through thick crystal including axial channeling, multiple scattering and γ -quanta radiation. – Proc. of the XIV Intern. Conf. on Atomic Collisions in Solids. 28 July - 8 Aug. 1991, University of Salford, UK, B2, N16.

[5] A.V. Lukshin, A.K. Maslov, I.V. Polimatidi, S.N. Smirnov. Stochastic model of ultrarelativistic electrons passage through a thick monocrystals. Matem. Mod, 2000, 9:12, 25-44 (in Russian)

[6] A.I. Akhiezer, N.F. Shulga, V.I. Truten, A.A.Grinenko, V.V. Syshchenko. Dynamics of charged high-energy particles in straight and bent crystals // *Uspekhi fizicheskikh nauk*.1995.v. 165,No10, p. 1165-1192 (in Russian).

[7]A.K. Maslov, I.V. Polimatidi Modeling of axial channeling of ultra-relativistic charged particles in a bent single crystal. Computational Mathematics and Mathematical Physics, 2002, 42:12, 1780–1791

Problem

- Investigate evolution of high-energy (0.1-1 GeV) electron beam passing through thin crystal in axial channeling mode
- It was known that in planar channeling mode there is effect of beam reflection

Model 1/2

- Particle ensemble evolution in the transversal plane
- Coherent scattering is taken into account via interaction with continuous 2D potential of atomic axes
- Non-coherent scattering is introduced via diffusion coefficient
- Radiation is not taken into account

Model 2/2

$$\begin{cases} d\mathbf{r} = (m(E))^{-1} \mathbf{p} dt, \\ d\mathbf{p} = -\nabla U(\mathbf{r}) dt + \sigma_p(\mathbf{r}, E) d\mathbf{w}. \end{cases}$$

- 4D stochastic differential equation

\mathbf{r}, \mathbf{p} - transverse component of coordinate and impulse

$U(\mathbf{r})$ - averaged potential in the transversal plane

σ_p - diffusion coefficient - non-coherent scattering

Numerical results 1

Ge, <111>

$E = 1 \text{ GeV}$

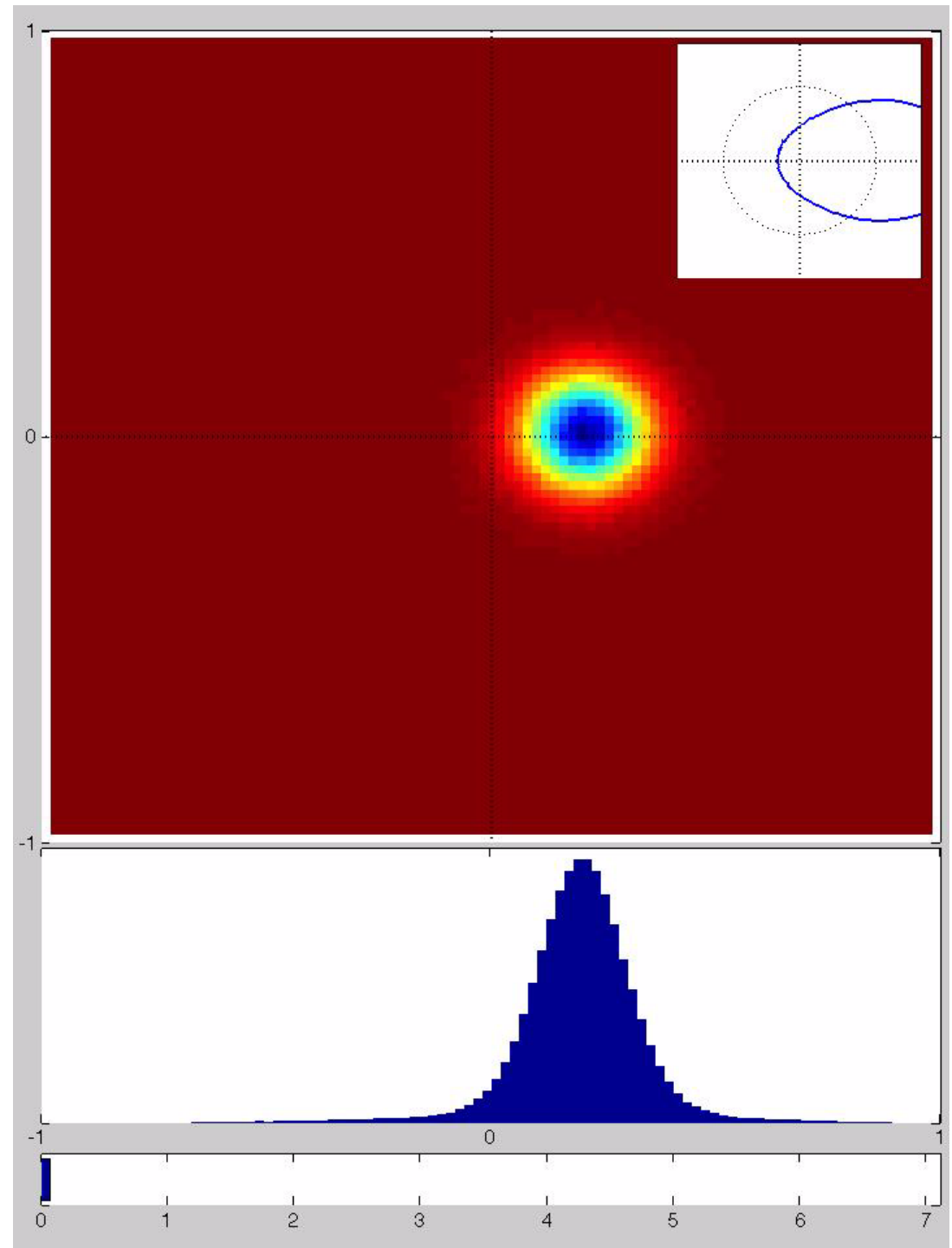
$\theta < 0.2 \theta_L$

$0 < z < 7.1 \mu\text{m}$



Animation is available
in 

<http://youtu.be/GXk6aNxCUk8>



Numerical results 2

Ge, $\langle 111 \rangle$

$E = 1 \text{ GeV}$

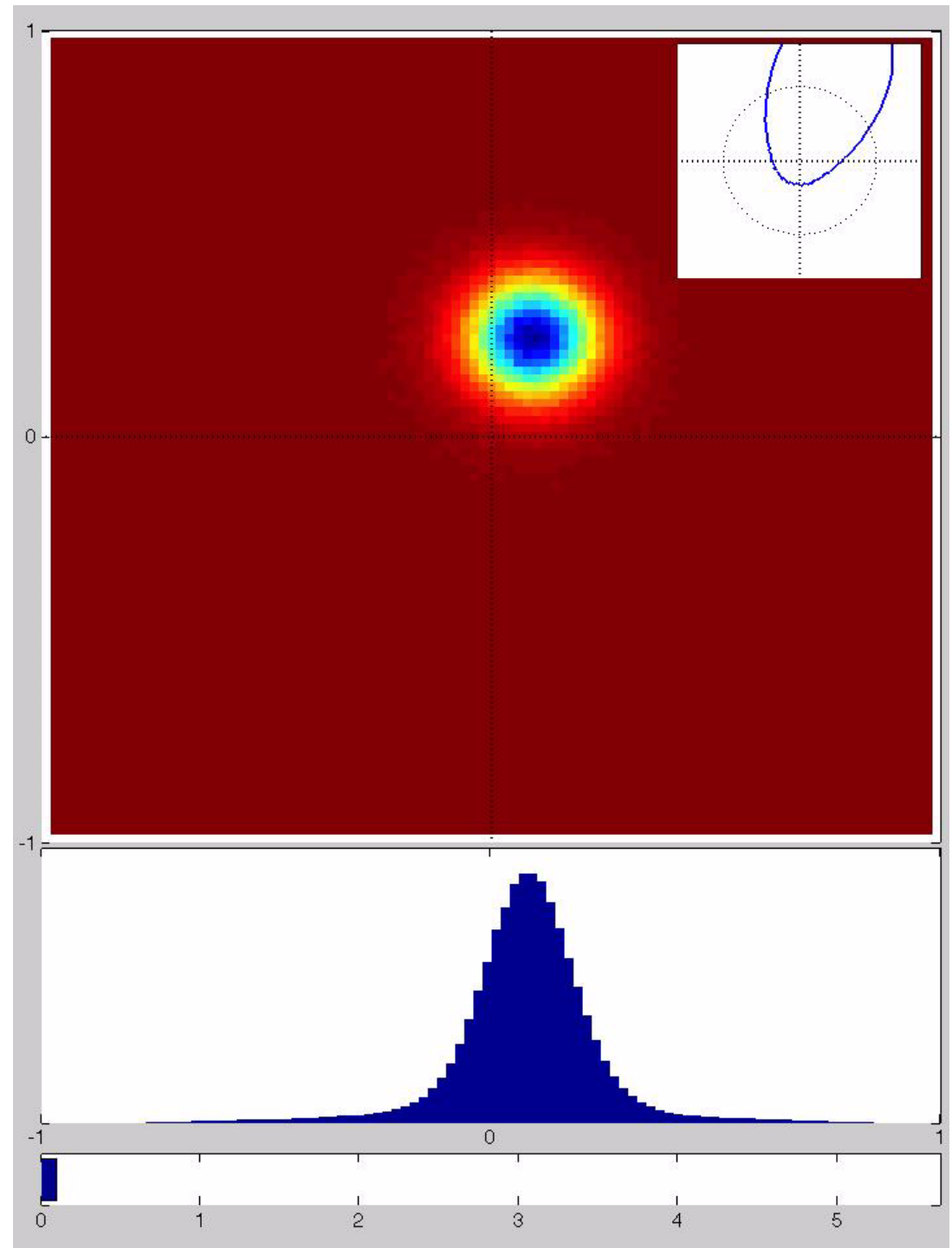
$\theta < 0.2 \theta_L$

$0 < z < 5.6 \mu\text{m}$



Animation is available
in  Tube

http://youtu.be/-7SLnc_gkJ8



Numerical results 3

Ge, $\langle 111 \rangle$

$E = 1 \text{ GeV}$

$\theta \ll \theta_L$

$0 < z < 5.6 \mu\text{m}$

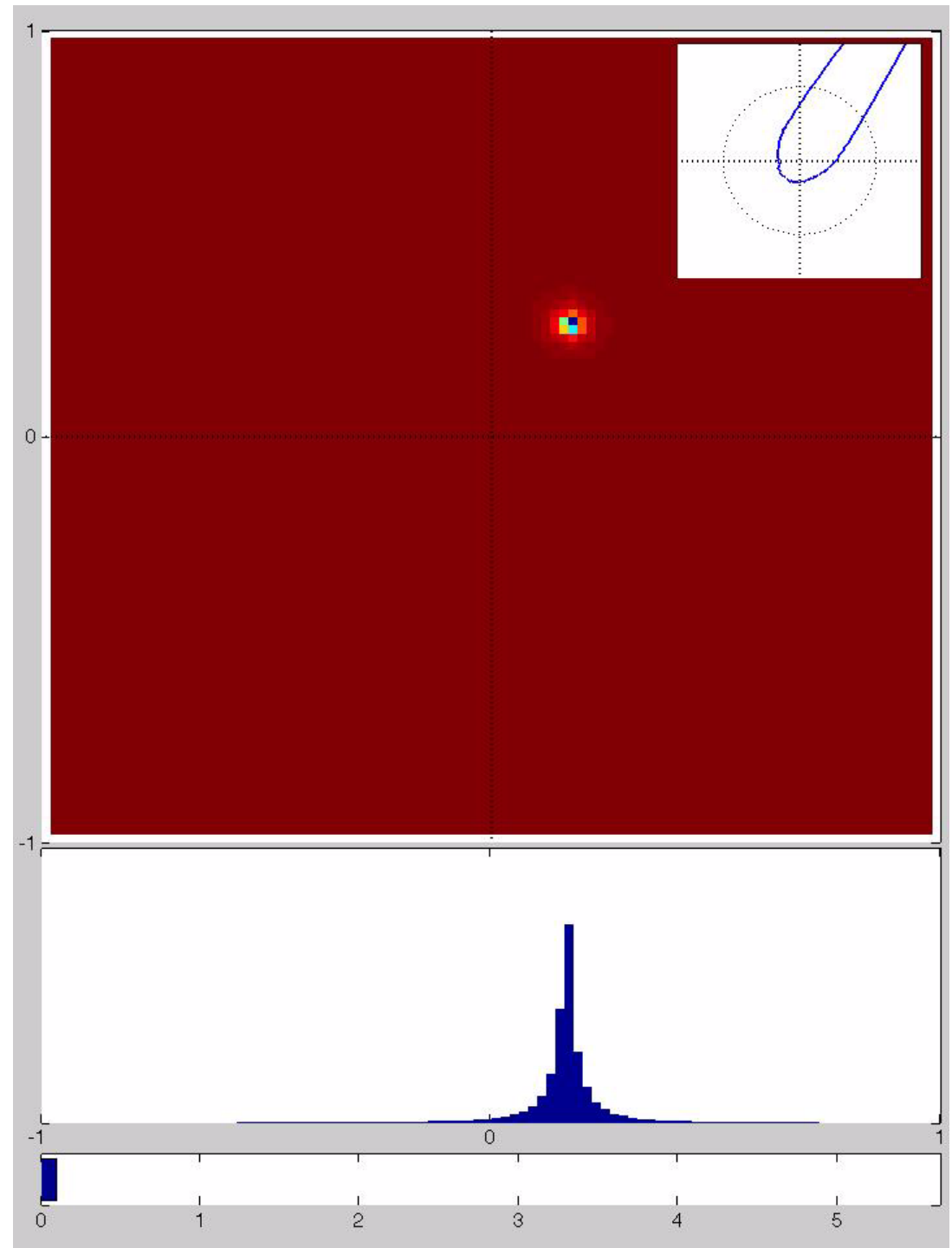


Animation is available
in  **Tube**

<http://youtu.be/IMLCoIWzH7k>

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Numerical results 4

Ge, $\langle 111 \rangle$

$E = 1 \text{ GeV}$

$\theta \ll \theta_L$

$0 < z < 5.6 \text{ } \mu\text{m}$

$\theta_1 \sim \theta_L$

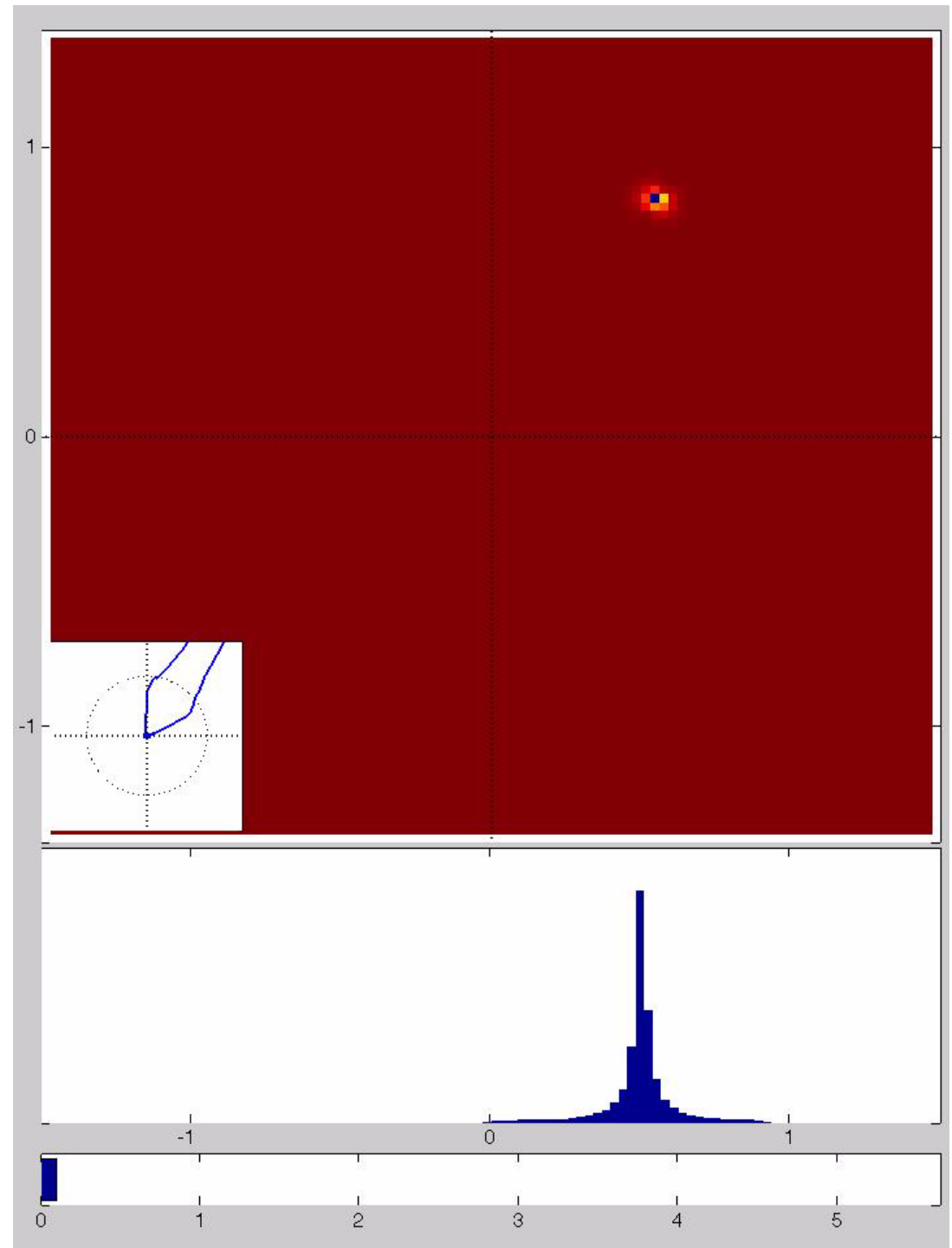


Animation is available
in 

<http://youtu.be/IX1DHsQfIKQ>

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Conclusions

- Numerical experiment confirms the effect of partial beam reflection / refraction in the axial channeling mode
 - For thin crystals
 - Small angle to the crystal axis is crucial
 $\sim 0.1 \div 0.4 \theta_L$

Thank you for your attention!

Any questions?