PERIODICAL DEPENDENCE OF RADIATION BY FAST POSITRONS ON THICKNESS AT PASSING THROUGH ULTRATHIN CRYSTAL

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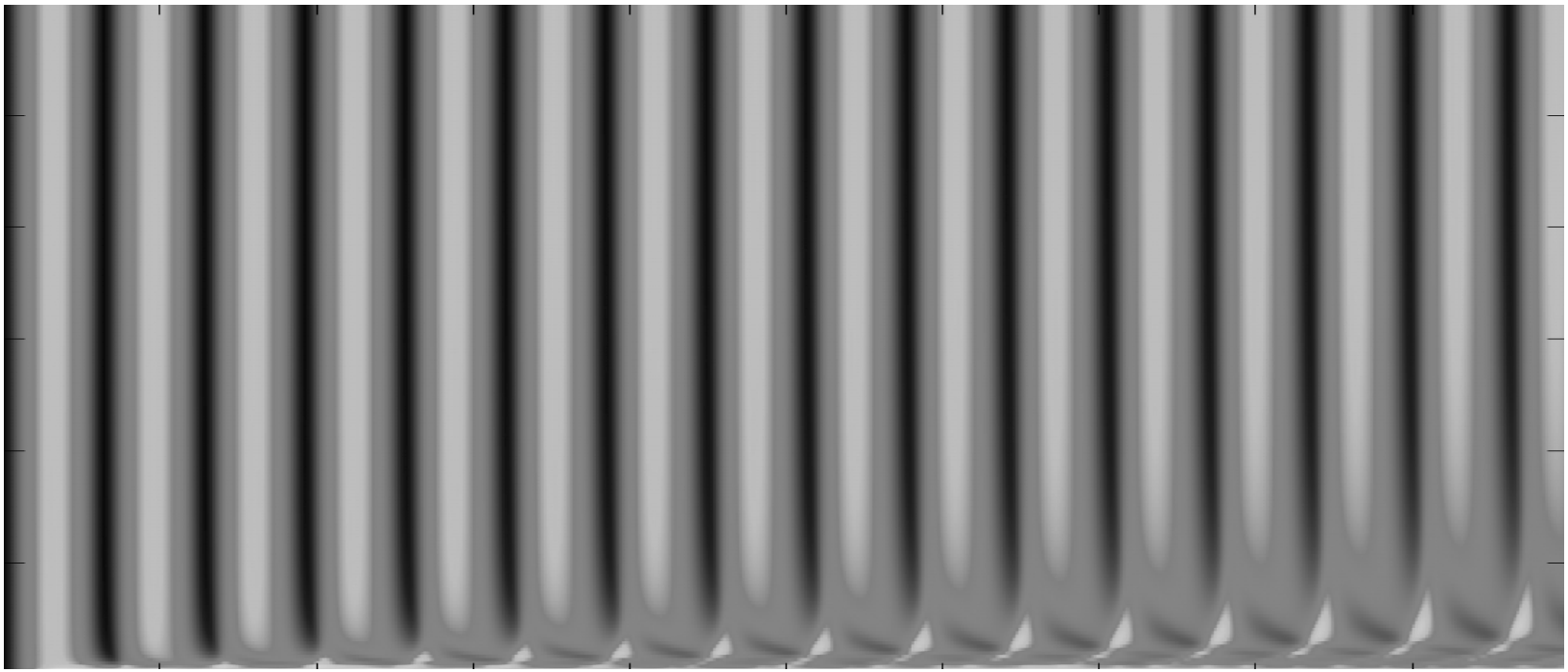


Channeling-2018, Ischia, Italy

Spectral Radiation Density (SRD) and its suppression effect

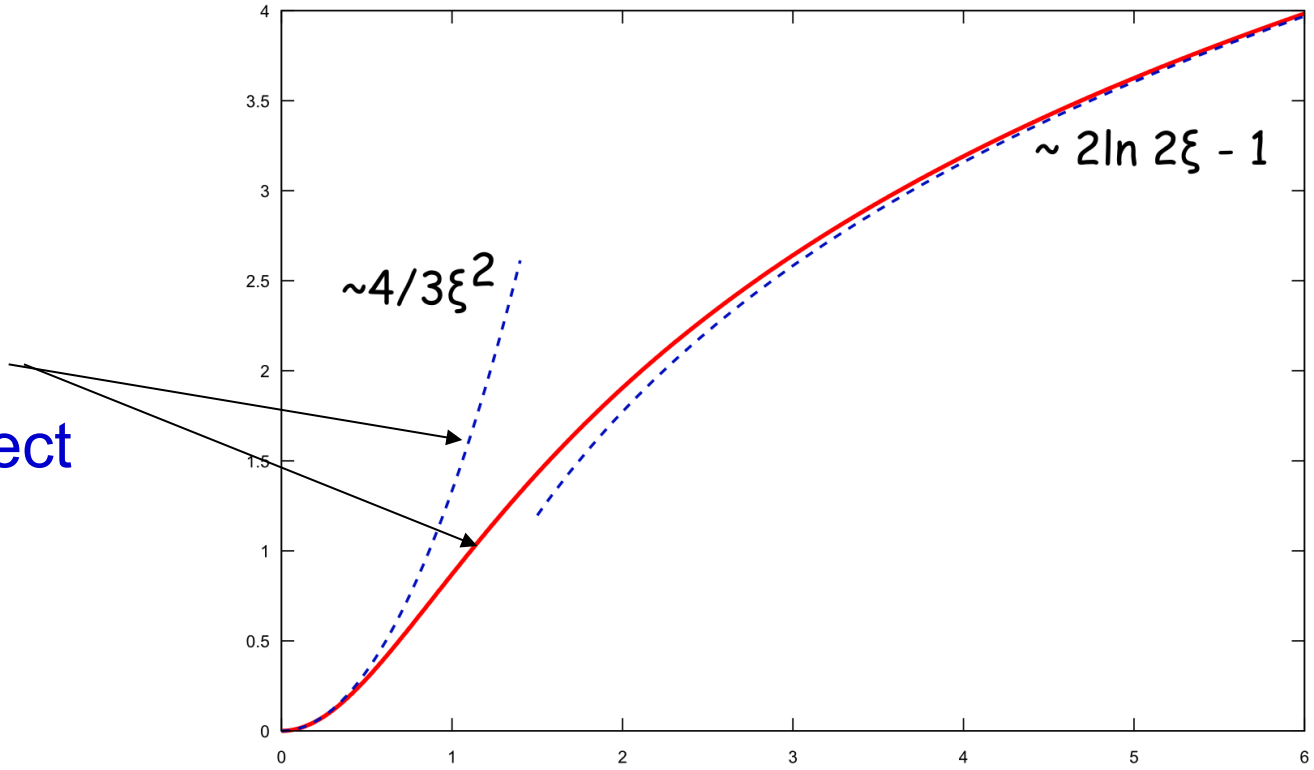
$$l_c \sim 2c\gamma^2/\omega$$ Radiation formation length

Spectral radiation density

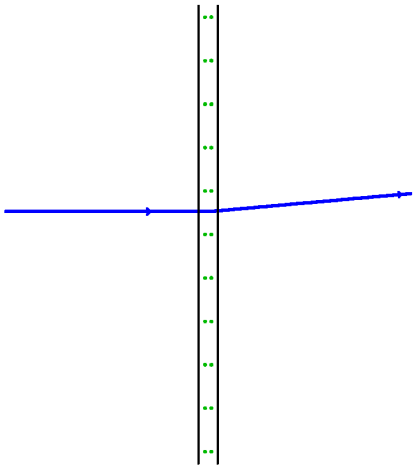
$$\frac{d\mathcal{E}}{d\omega} = \frac{2e^2}{\pi c}\left\{\frac{2\xi^2+1}{\xi\sqrt{\xi^2+1}}\ln\left(\xi+\sqrt{\xi^2+1}\right)-1\right\}, \qquad \xi = \gamma\vartheta/2$$

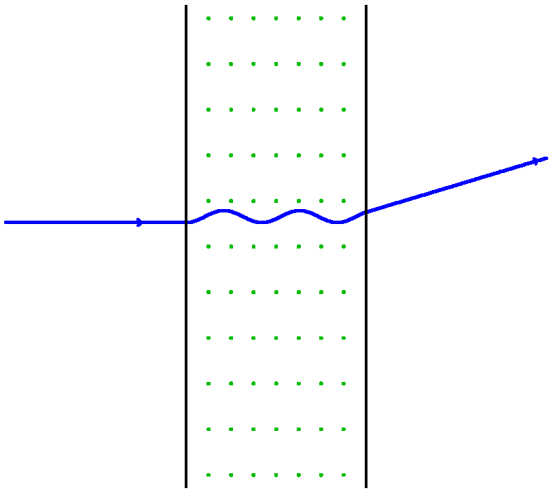
$$L \ll l_c$$

Radiation suppression effect



Ultrathin and Thin Crystals





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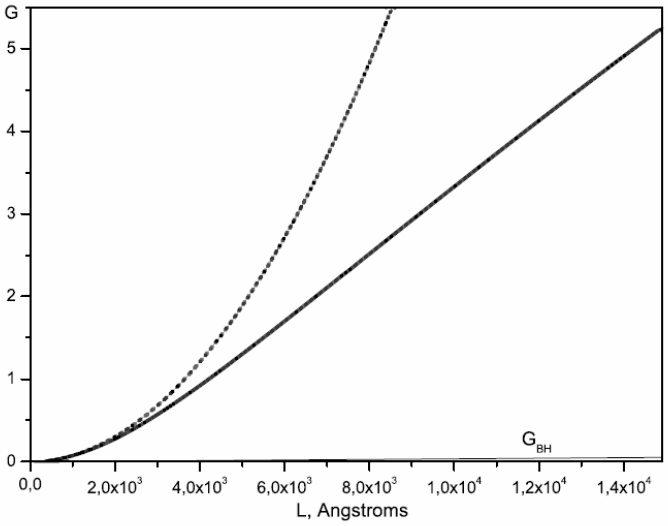


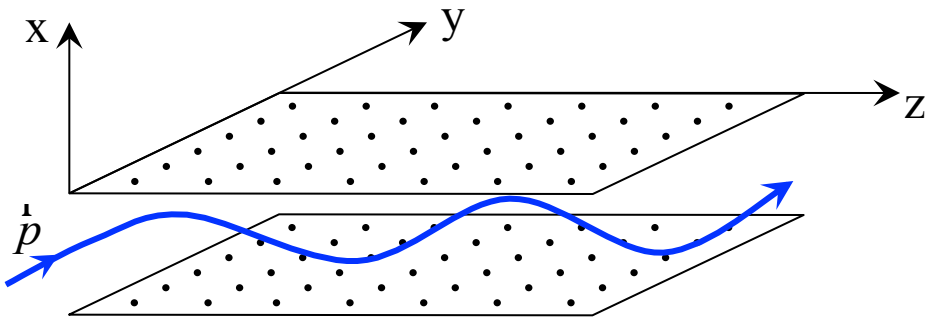
Fig. 2. Cross-section of radiation by high-energy electron in ultrathin targets.

Channeling

N.F. Shul'ga, S.N. Shul'ga, Physics Letters A., V. 378, 3074 (2014)

Planar channeling

J.Lindhard (1965)



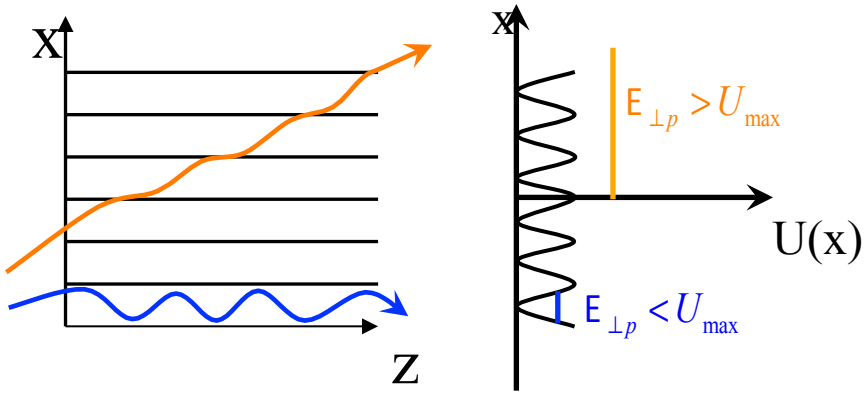
$$p_z = const \approx p$$

$$p_y = const \approx 0$$

$$E_\perp = \frac{E\psi_c^2}{2} = U_{\max} \quad \Leftrightarrow \quad \boxed{\psi_c \sim \sqrt{2U_{\max}/E}}$$

$$\ddot{x} = -\frac{1}{E}\frac{\partial}{\partial x}U(x)$$

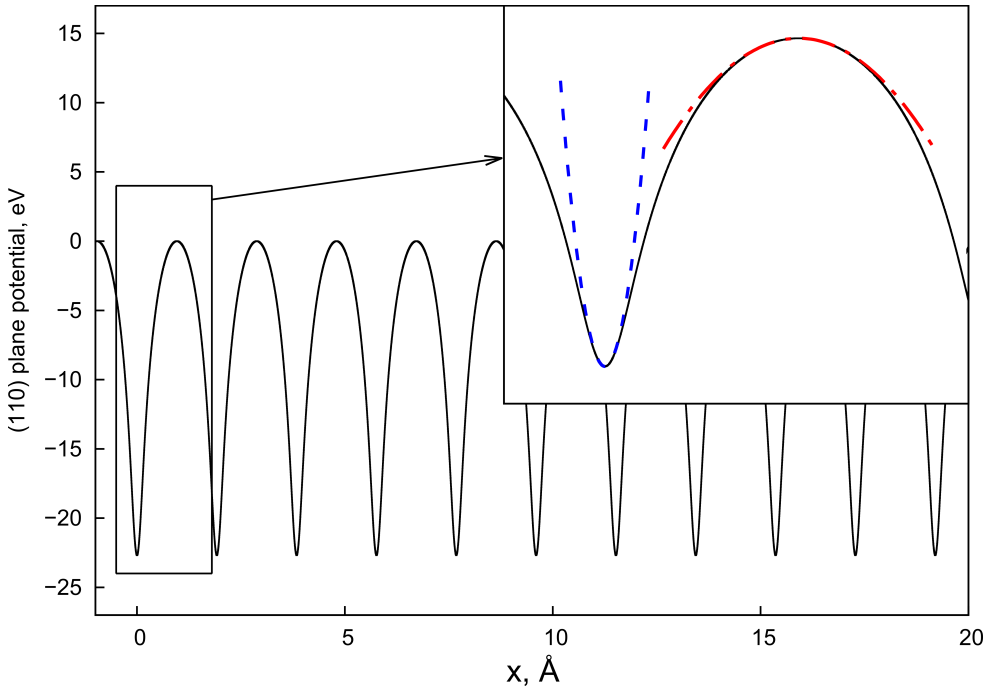
$$E_\perp = \frac{E\dot{x}^2}{2} + U(x)$$



Phenomenon of Above Barrier Motion: A. Akhiezer, N. Shul'ga (1978)

Continuous planes potential

$$U_{pl}(x) = \frac{1}{a_{pl}} \int_0^{a_{pl}} dy\, U_{ax}(x,y)$$

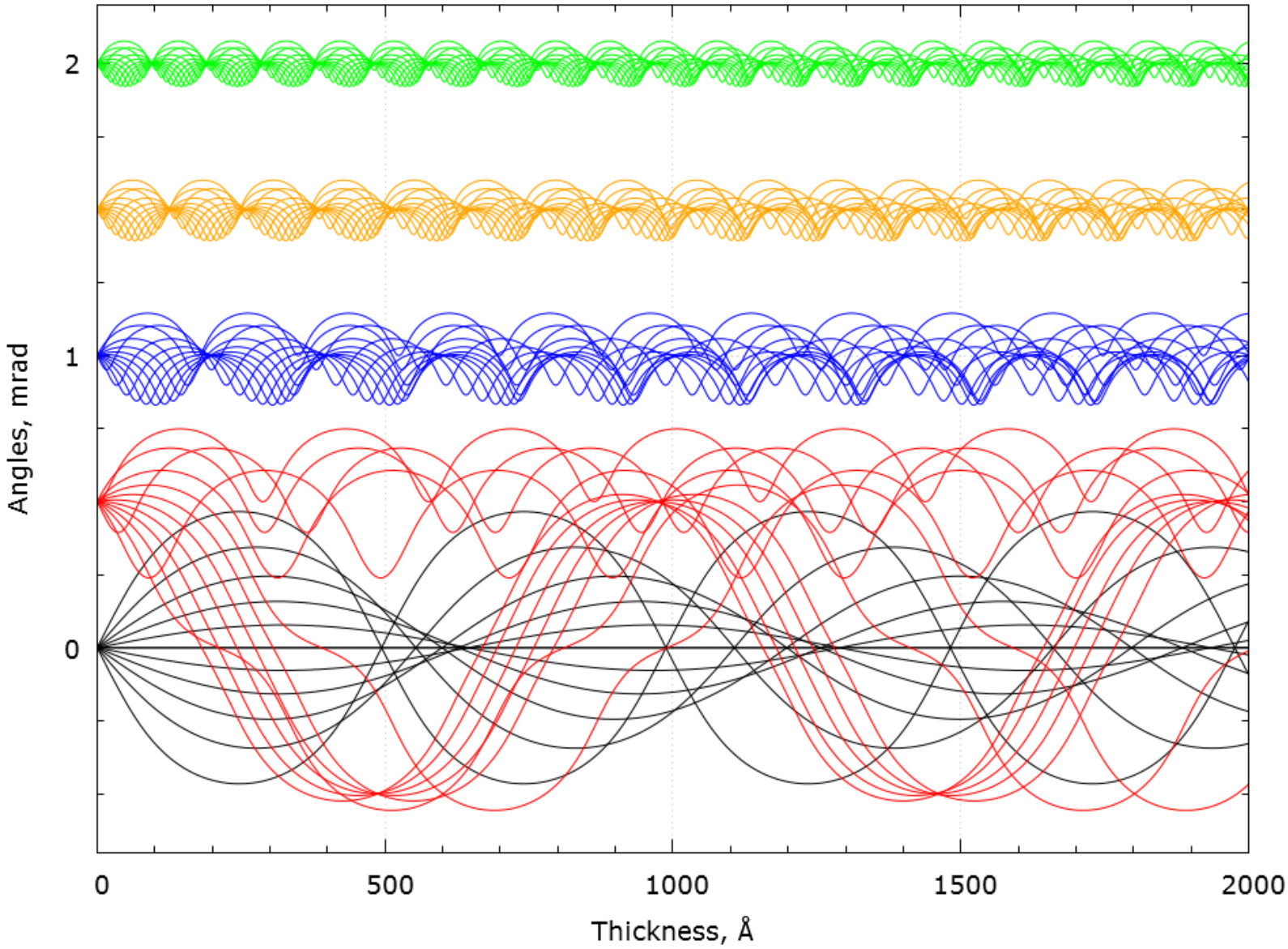


$$U_{ax}(\vec{\rho}) = \frac{1}{a_1 \bar{v}^2} \int d^2 v e^{-v^2/2\bar{v}^2} \int_{-\infty}^{\infty} dz\, u(\vec{\rho} + \vec{v}, z) \quad - \quad \text{string potential}$$

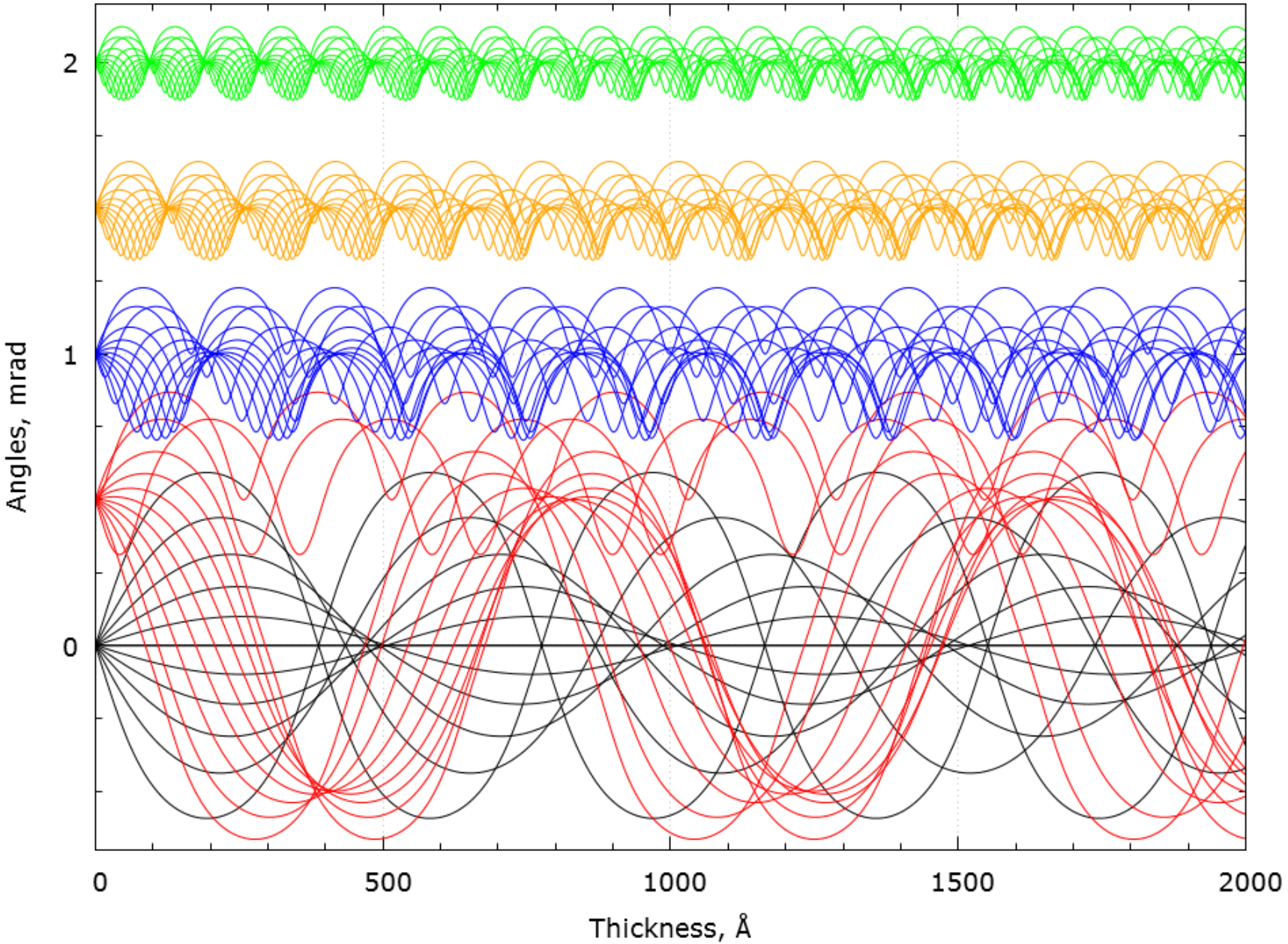
v - heat oscillations of atom coordinates

$$u_m(r) = \sum_i \alpha_i \exp(-\beta_i r/R) \quad - \quad \text{Moliere approximation for single atoms}$$

Angular trajectories of positrons in the Si (110) planes potential at different incidence angles



Angular trajectories of positrons in the Si (110) planes potential at different incidence angles



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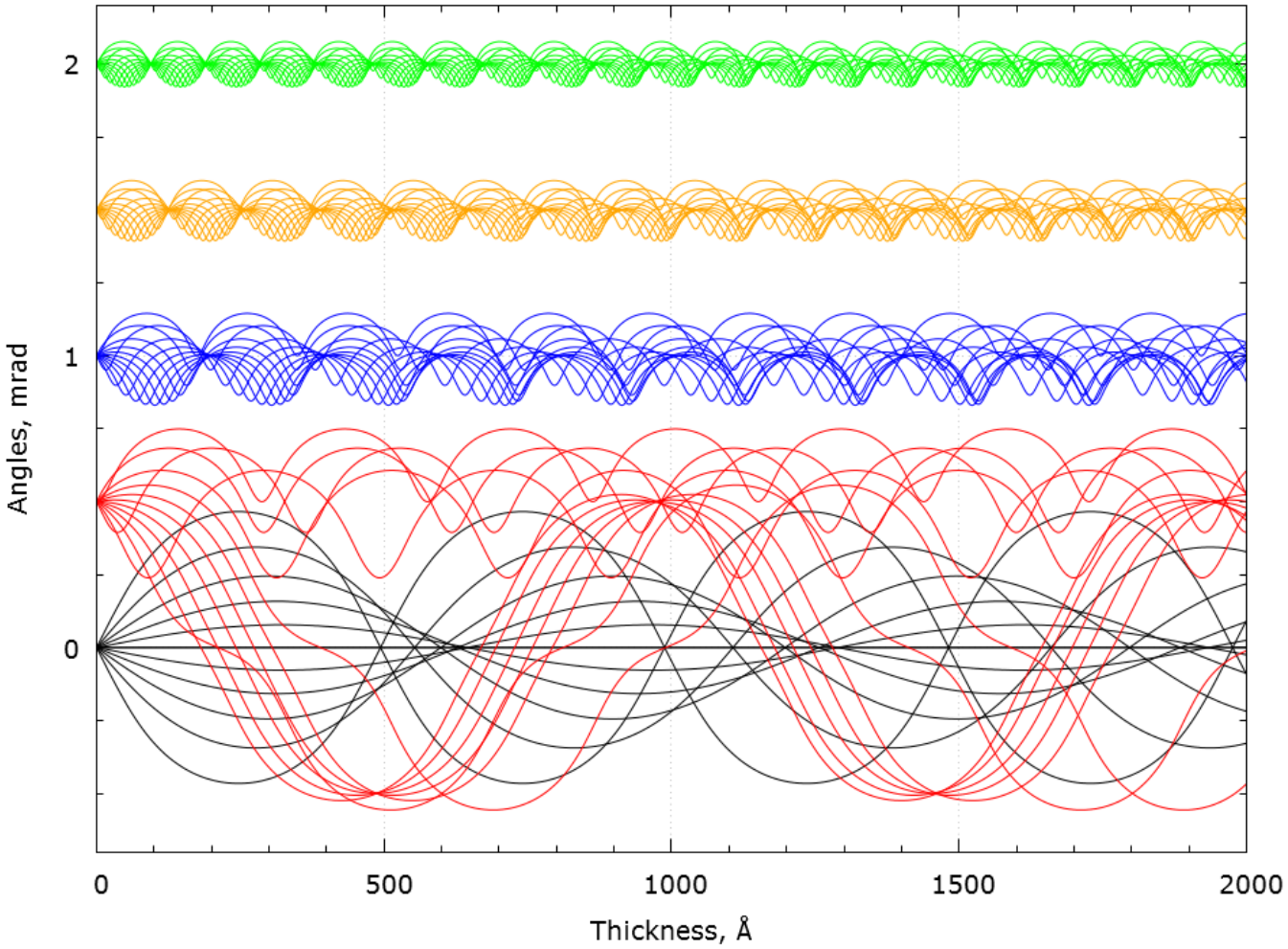


$$T_{ob} = d/\psi$$

$$\Delta\vartheta = \frac{d \cdot \overline{\nabla U}}{2} \cdot \frac{1}{\psi\, \varepsilon_{\parallel}\, \beta^2}$$

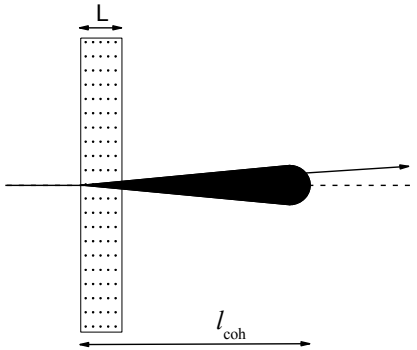
$$T_{1/2}[\text{Å}] = b \cdot \beta \sqrt{\varepsilon[eV]}$$

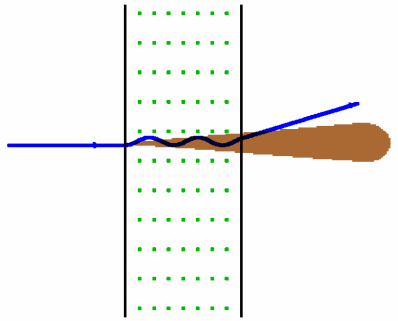
$$\theta_c = \sqrt{\frac{2U_0}{pv}} \approx \sqrt{\frac{2U_0}{\varepsilon}}$$

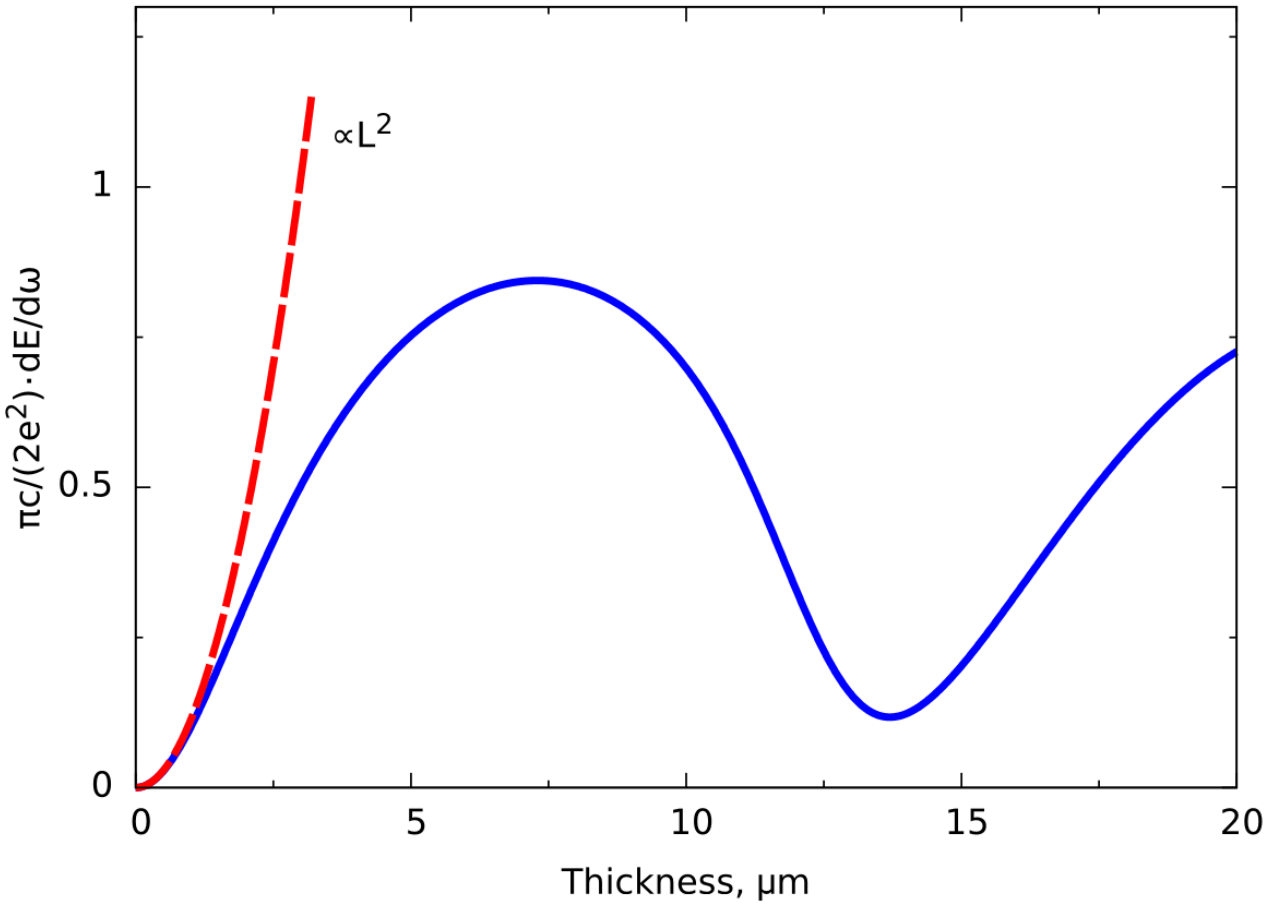
$$\left\langle \frac{d\mathcal{E}}{d\omega} \right\rangle = \frac{1}{N} \sum_n \left(\frac{d\mathcal{E}}{d\omega} \right)_n$$

Averaging over impact parameters

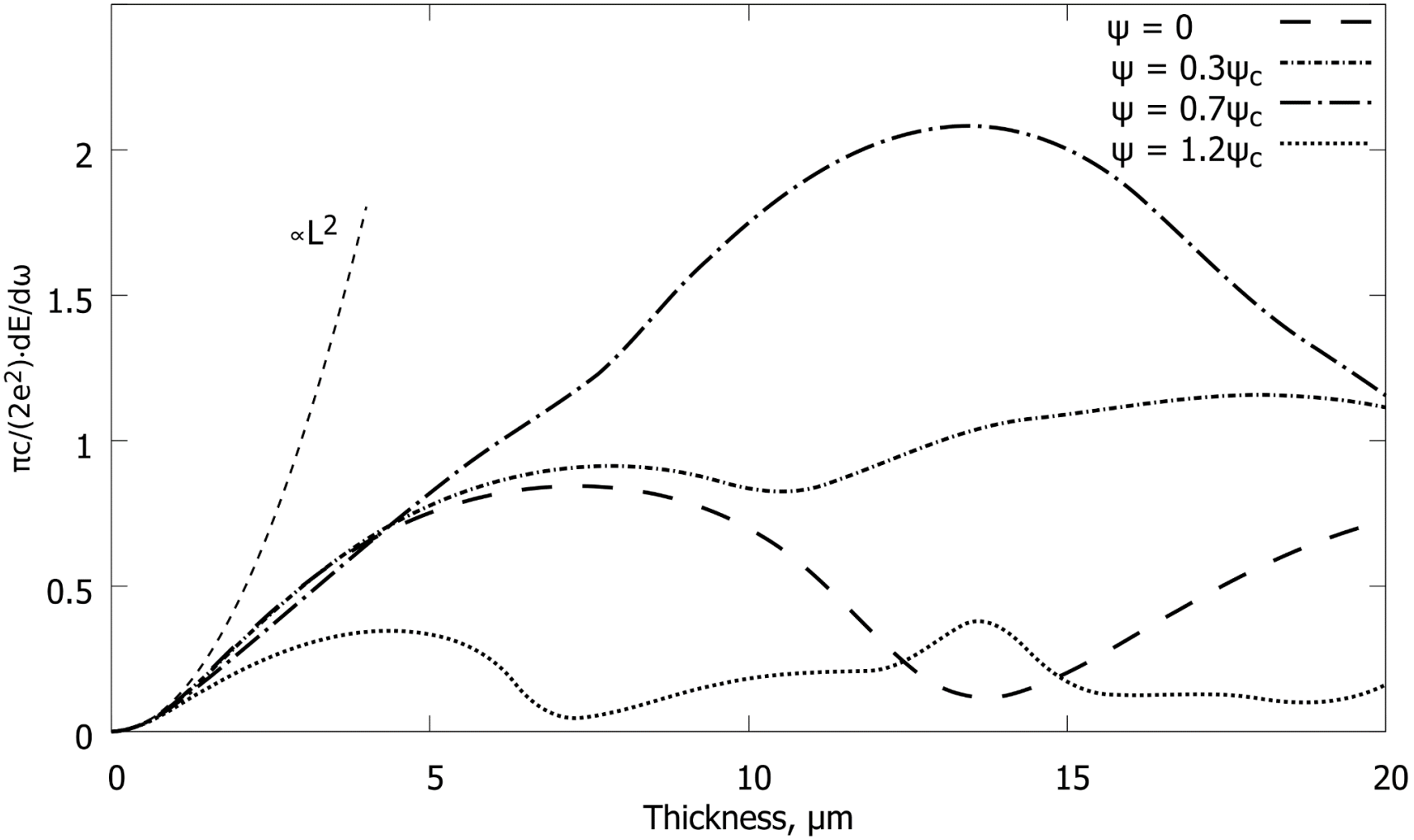
SRD of 100 Gev positrons incident perpendicular to Si (110) plane







SRD of positrons at different incidence angles relatively Si (110) plane



SRD of electrons at different incidence angles relatively Si (110) plane

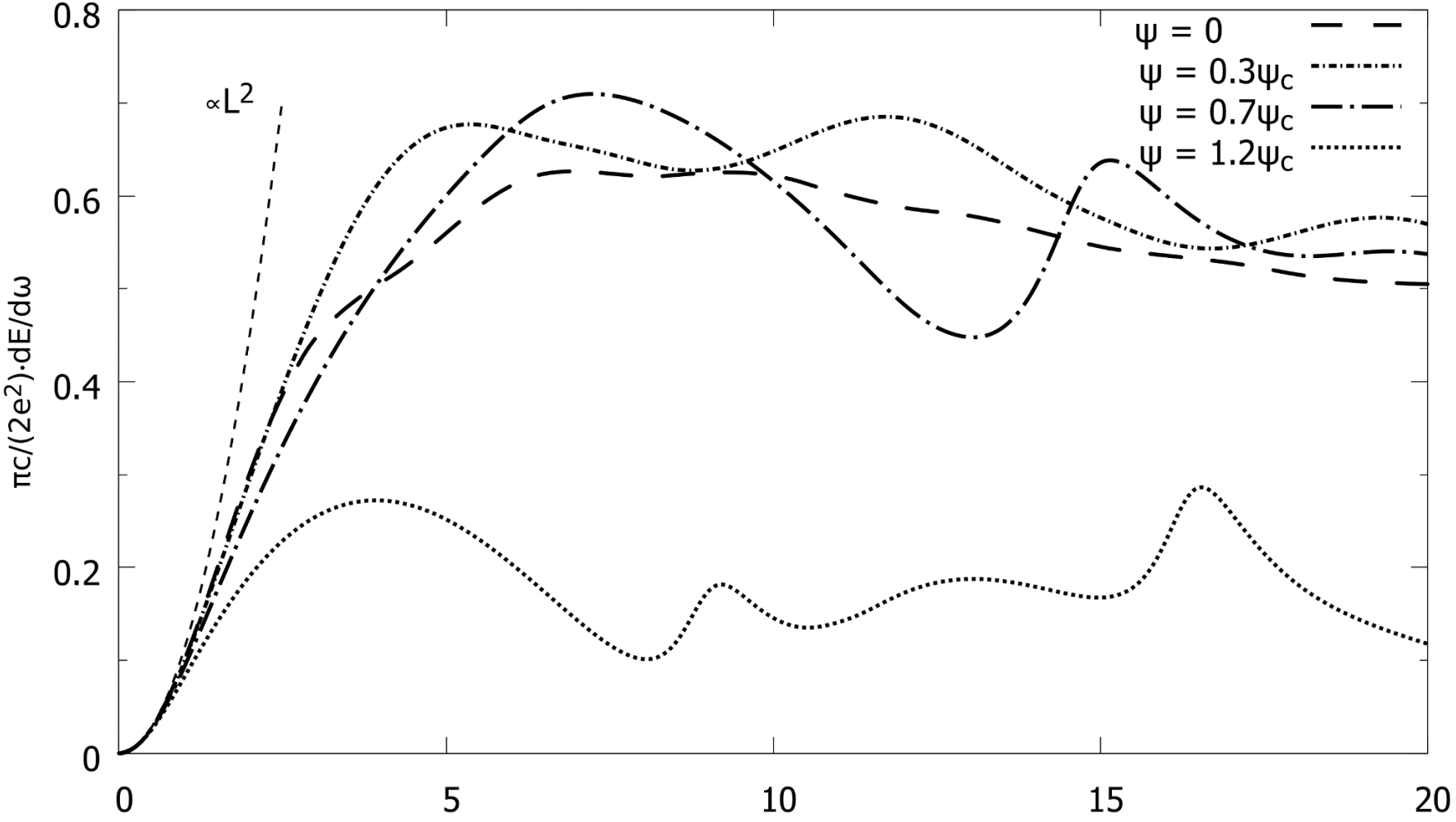


Diagram of dependence of SRD on thickness and particle energy at incidence parallel to the (110) Si planes

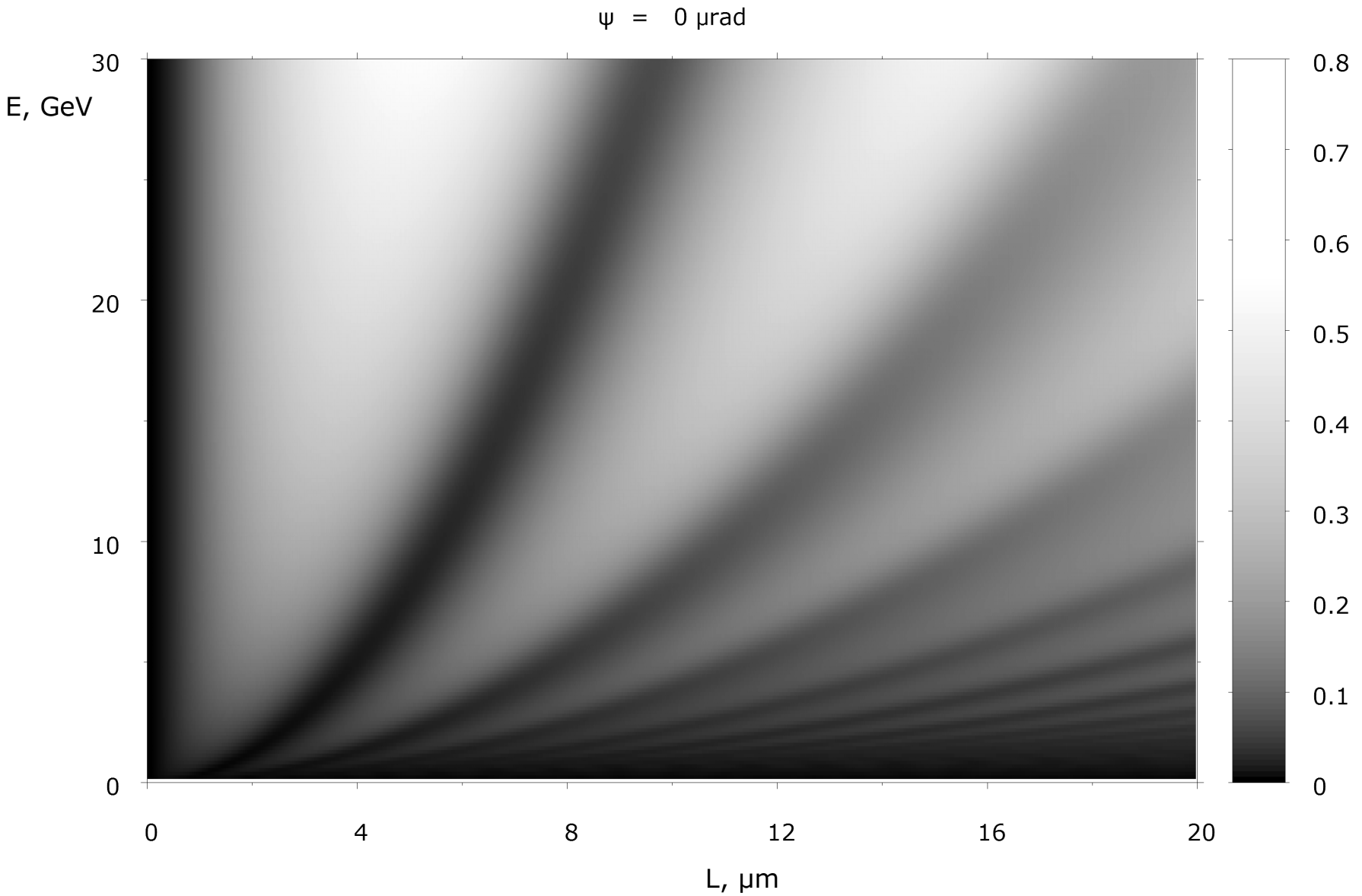


Diagram of dependence of SRD on thickness and particle energy at the incidence angle ψ=75μrad

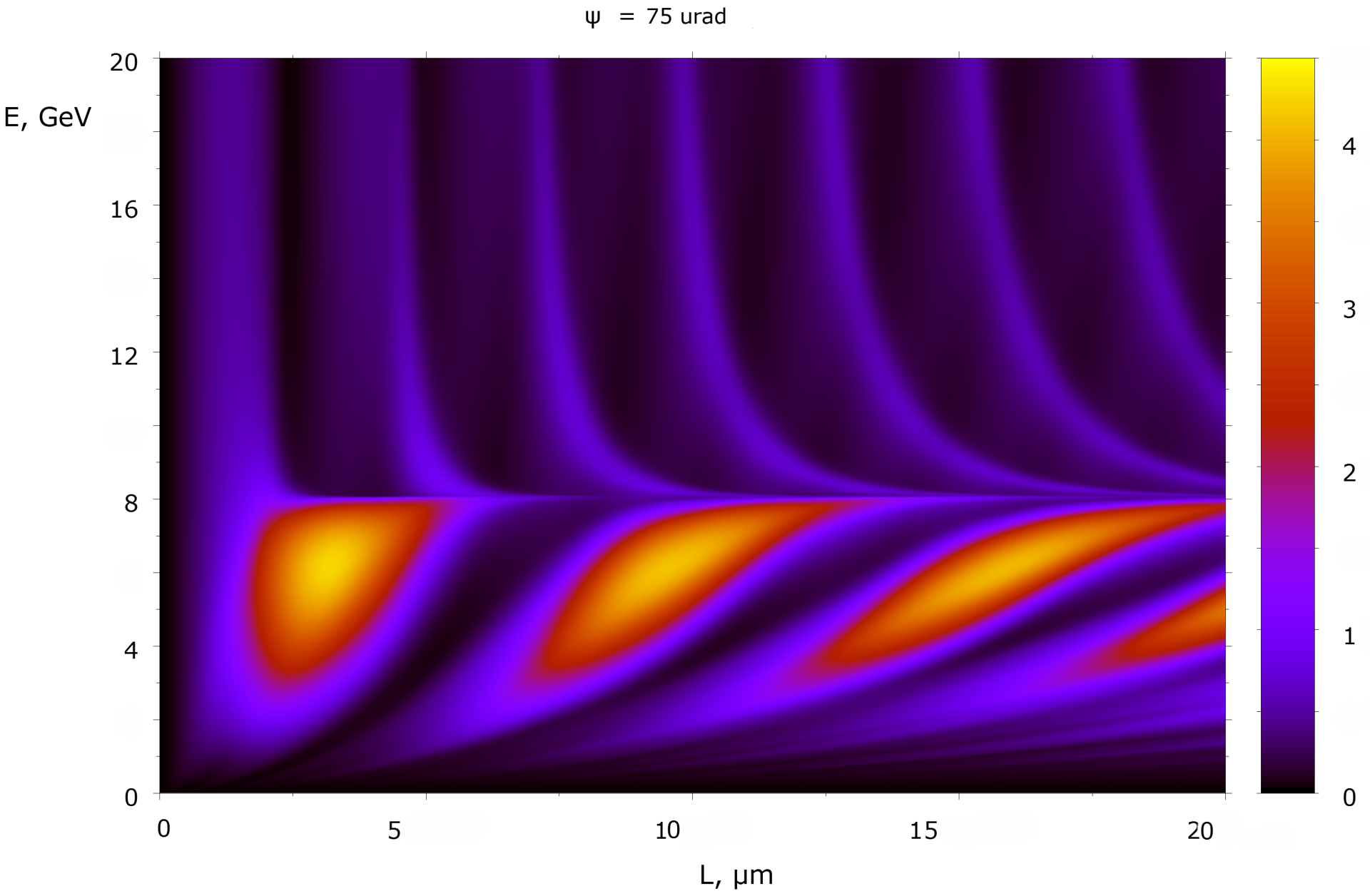
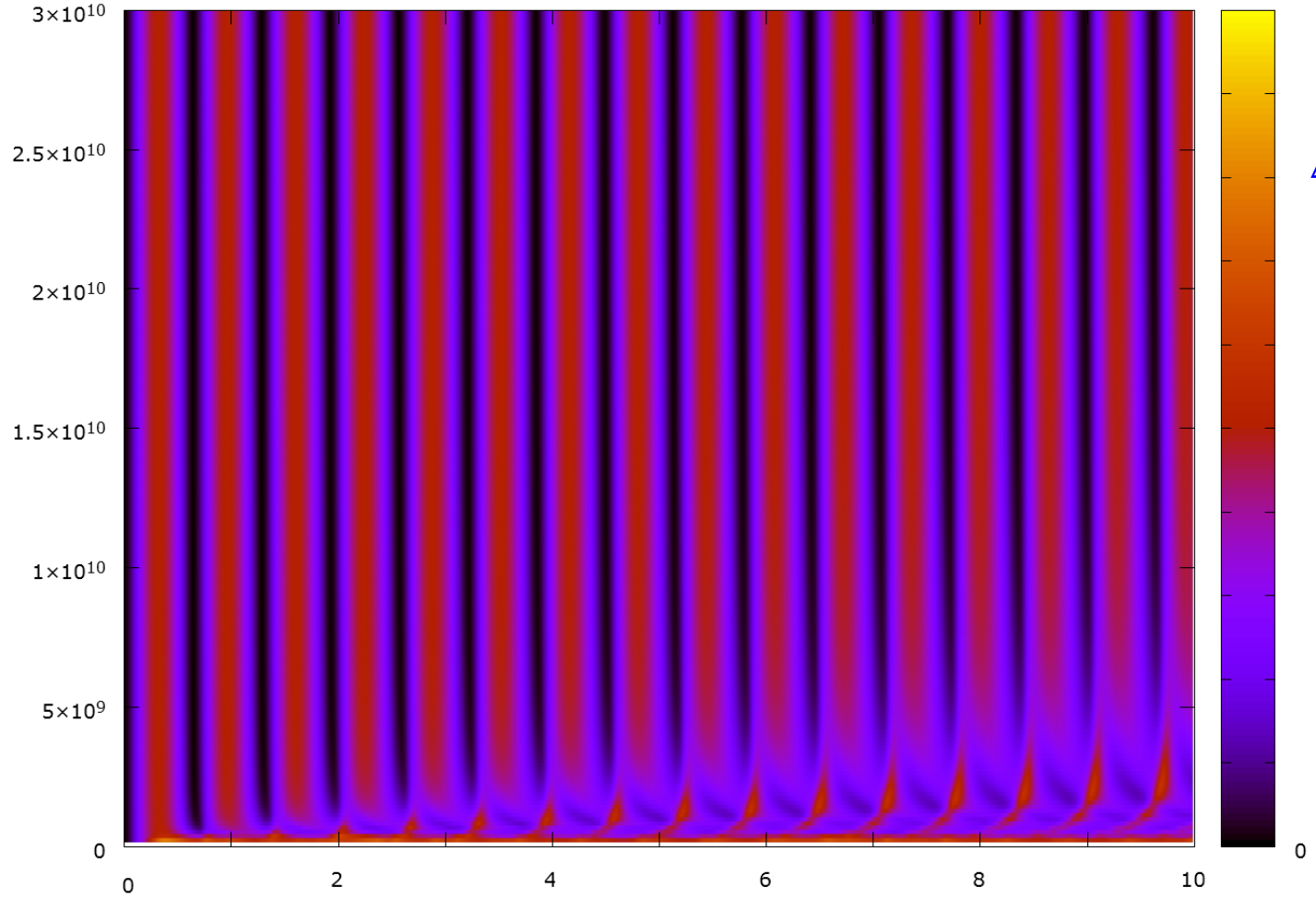


Diagram of dependence of SRD on thickness and particle energy (e^-) (mostly above-barrier motion)



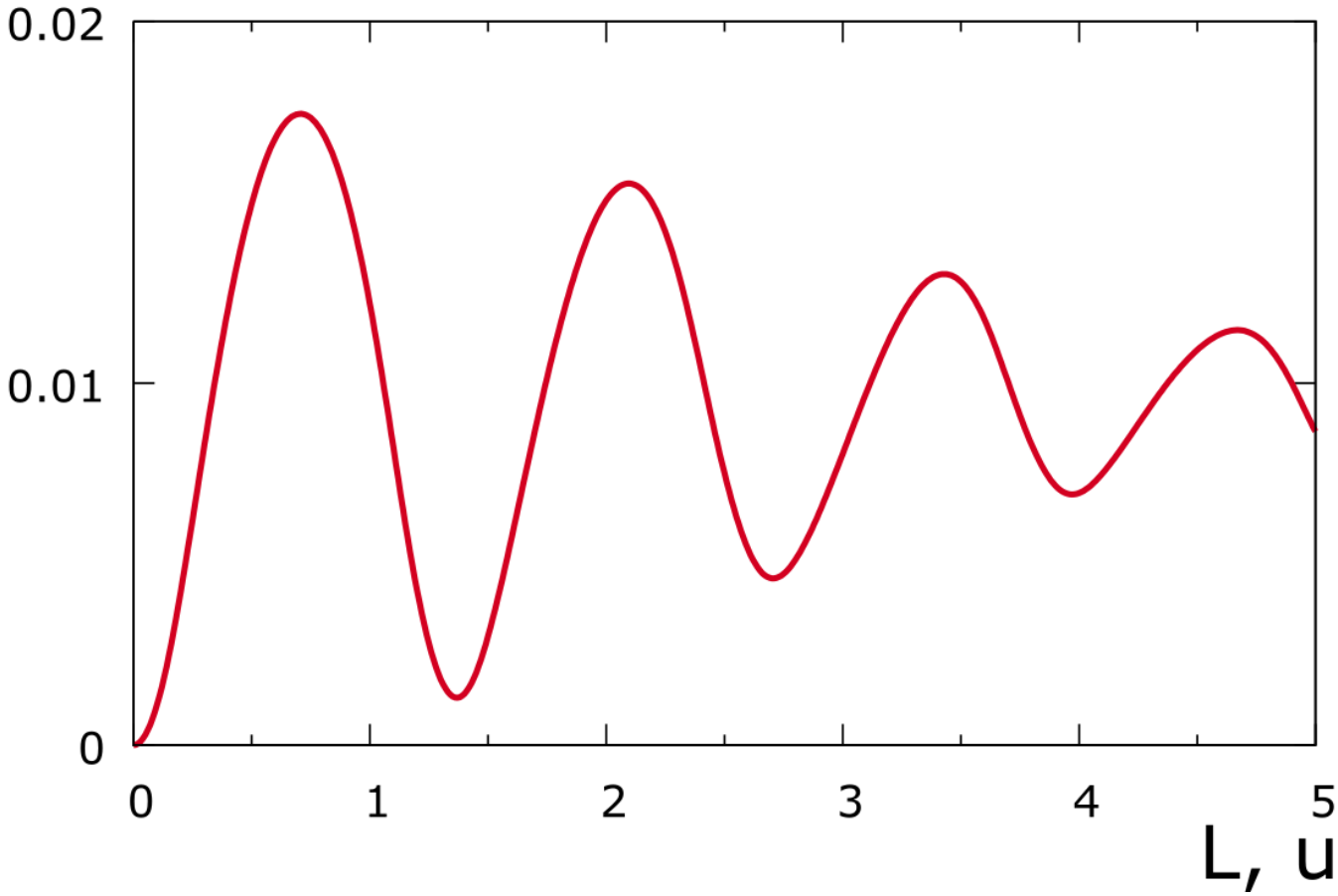
$$\Delta\vartheta = \frac{d\cdot\overline{\nabla U}}{2}\cdot\frac{1}{\psi\,\varepsilon_{\|}\,\beta^2}$$

$$\gamma = \frac{\varepsilon_{\|}}{mc^2} \propto \varepsilon_{\|}$$

$$\frac{d\mathcal{E}}{d\omega}(\xi)$$

$$\xi = \frac{\gamma\Delta\vartheta}{2} \propto \frac{\varepsilon_{\mathrm{P}}}{\varepsilon_{\mathrm{P}}} \xrightarrow[\varepsilon_{\mathrm{P}}\to\infty]{} const$$

SRD of 1GeV positrons at incidence parallel to Si (110) planes



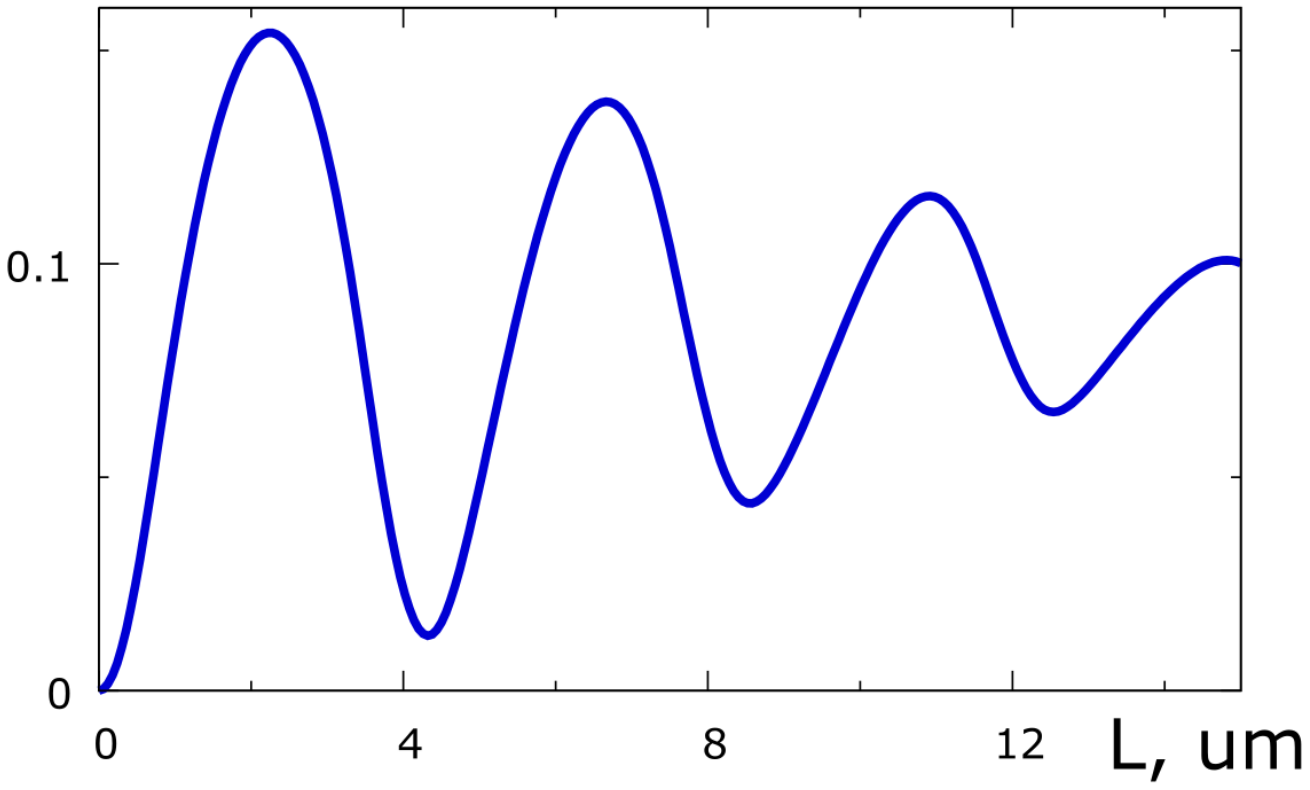
$T_{1/2} \sim 1.3\mu m$

$\xi = \gamma\vartheta / 2$

$\xi(\vartheta_c) \approx 0.21$

$T_{1/2} = l_c = 2c\gamma^2 / \omega \quad \Rightarrow \quad h\omega <\sim 0.87 MeV$

SRD of 10GeV positrons at incidence parallel to Si (110) planes



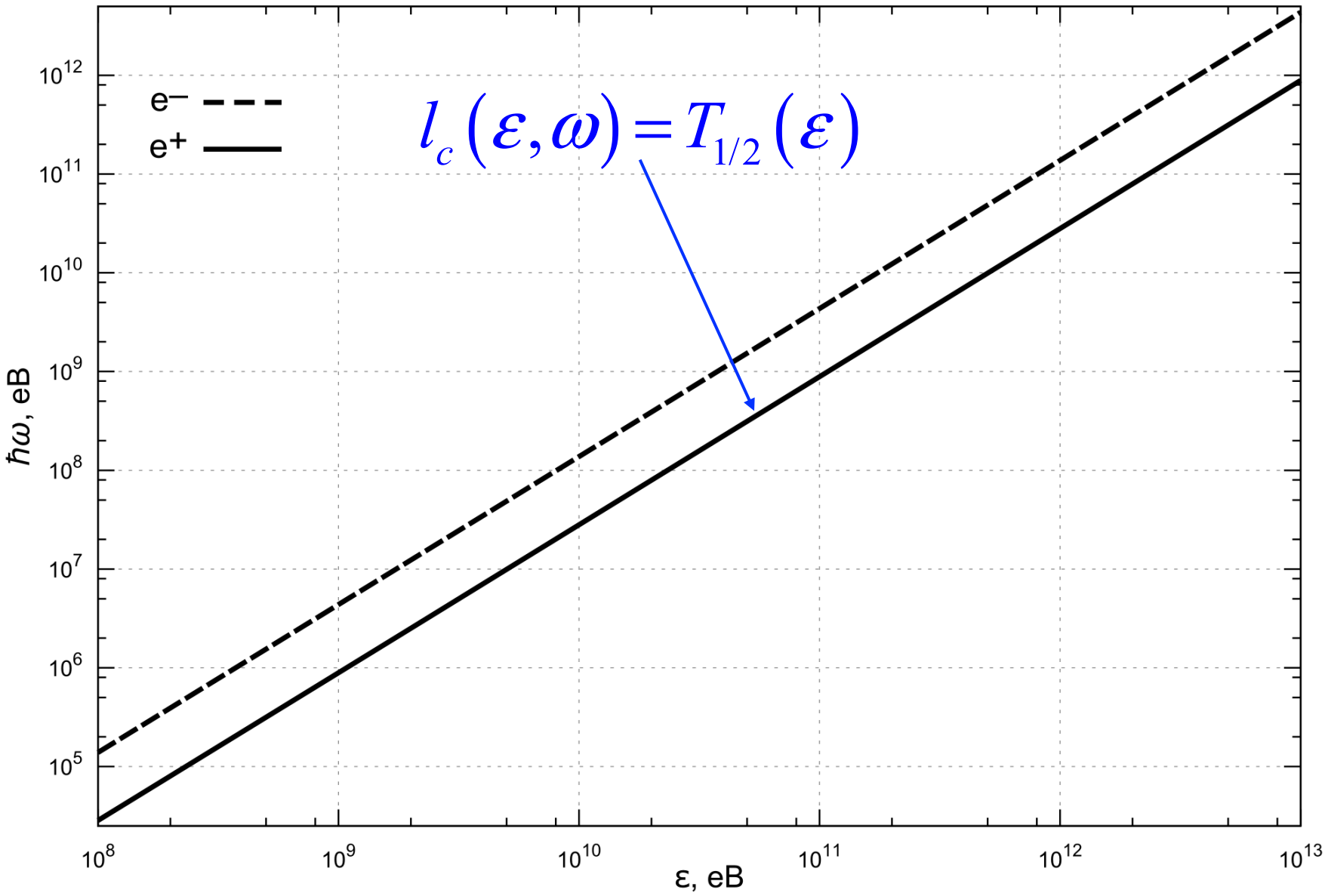
$$T_{1/2} \sim 4.2\mu m$$

$$\xi = \gamma\vartheta / 2$$

$$\xi(\vartheta_c) \approx 0.68$$

$$T_{1/2} = l_c = 2c\gamma^2 / \omega \quad \Rightarrow \quad \hbar\omega <\sim 37\,\mathrm{MeV}$$

Applicability range Si (110)



Conclusions

- For the motion of e- and e+ in the field of crystal planes, the effect of periodical spatial dependence of the coherent radiation density is possible besides with the effect of the radiation suppression effect
- At the angles ~0.7 of channeling angle the radiation maximum is reached
- At above-barrier motion energies neither spatial period of SRD oscillations, nor its amplitude does not depend on the particle energy if this energy is high enough
- The conditions for observing the considered effect can be reached at high energy experiments on existing expeimental setups

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Thank you! Grazie! Дякую!