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First observation of scattering of sub-GeV electrons in ultrathin Si crystal at planar alignment and relevance to crystal-assisted rainbow scattering

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This work presents continuation of experimental and theoretical studies of the scattering of 255 MeV electrons by aligned crystals at SAGA-LS accelerator facility. In the previous series of experiments we studied the doughnut scattering (DS) [1], scattering at planar alignment (SPA) [2] and mirroring [3-5]. The advantage of these studies is the fixed electron beam energy and different crystal thicknesses which allows distinguish these types of scattering. The goal of the present paper is experimental and theoretical search for another type of scattering named rainbow scattering (RS).

The RS is very specific type of scattering which in general appears in the scattering of the waves and particles (both classical and quantum), see e.g [6-7]. The earlier works on appearance of RS at ions channeling are reviewed (axially channeled 7-MeV and 2-MeV protons) in [8]. The very precise studies of crystal-assisted RS in the case of non-relativistic ions were performed by N. Neškoví´c et al, since Ref. [9].

In the classical theory of crystal rainbows the key aspect is an unusual dependence of the deflection angle on the impact parameter with a crystal axis. The RS for high-energy electrons (100 and 500 MeV) at axial alignment was theoretically considered in Ref. [10] using both classical and quantum approaches and Lindhard's string potential. The theory predicted some contradictions between classical and quantum approaches. Recently, similar contradictions between classical and quantum theories of RS in the case of planar alignment and 4 –50 MeV electrons were discussed in [11] but again using non-realistic planar channeling potential.

At the moment, there is a lack of the experimental data on high-energy electrons RS in a crystal. Our experimental data on 255 MeV electrons scattering in an ultrathin 0.58 micrometer (111) Si crystal and extended computer simulations put some light on this problem.

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