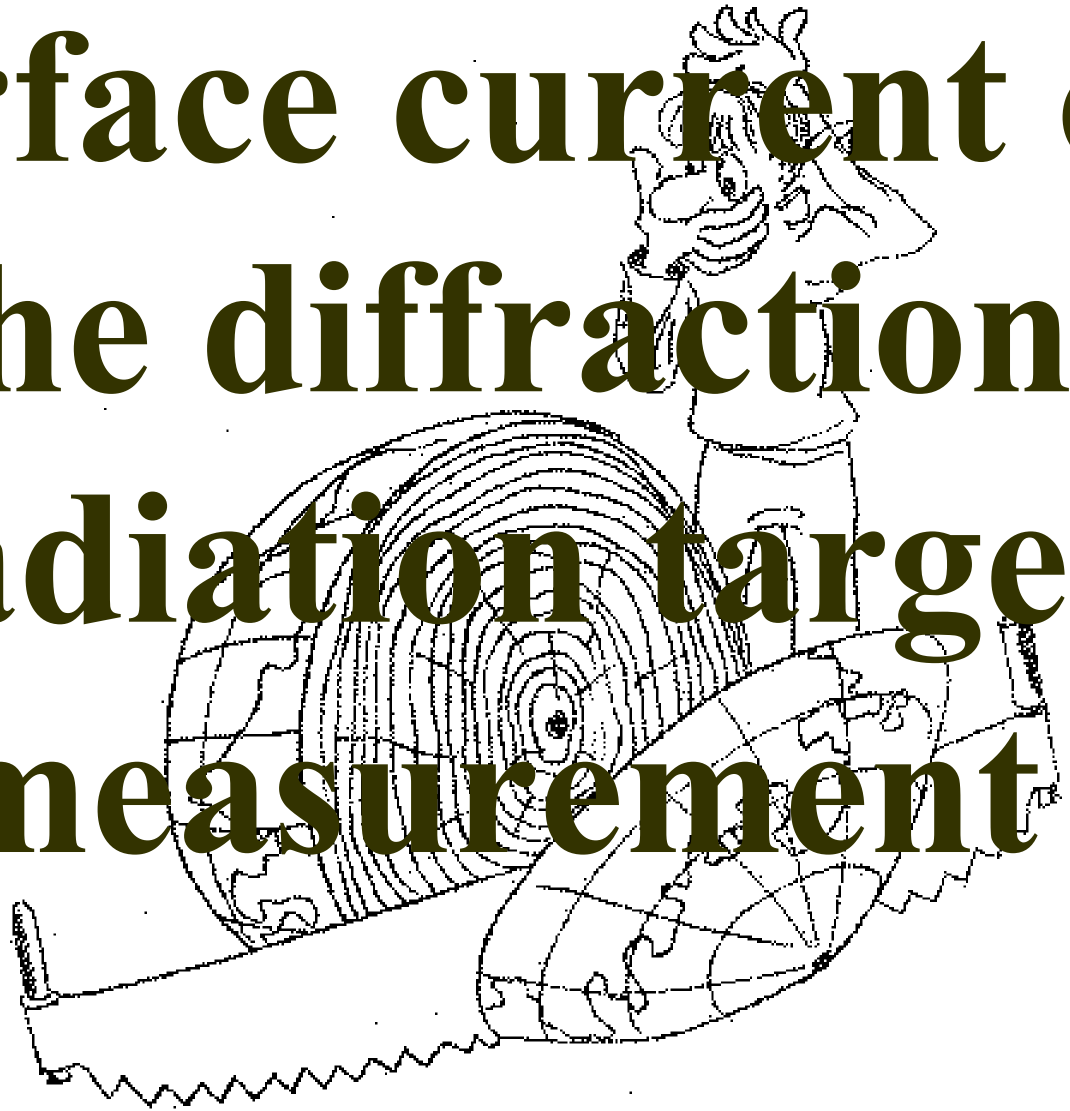
Surface current on the diffraction radiation target measurement



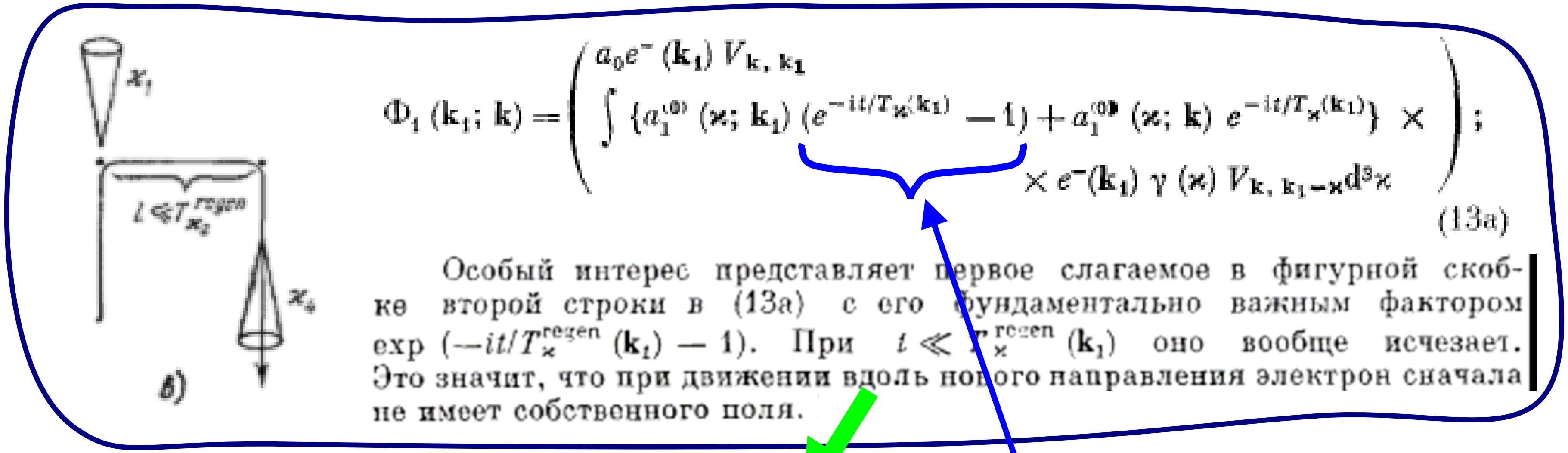
Tomsk NPI microtron 2008

Two interpretations of the shadow effect

• 1. *Naked or half-naked electron*

E. L. Feĭnberg, Sov. Phys. Uspekhi, 1979, 22 (6)

Solution in frame of QED

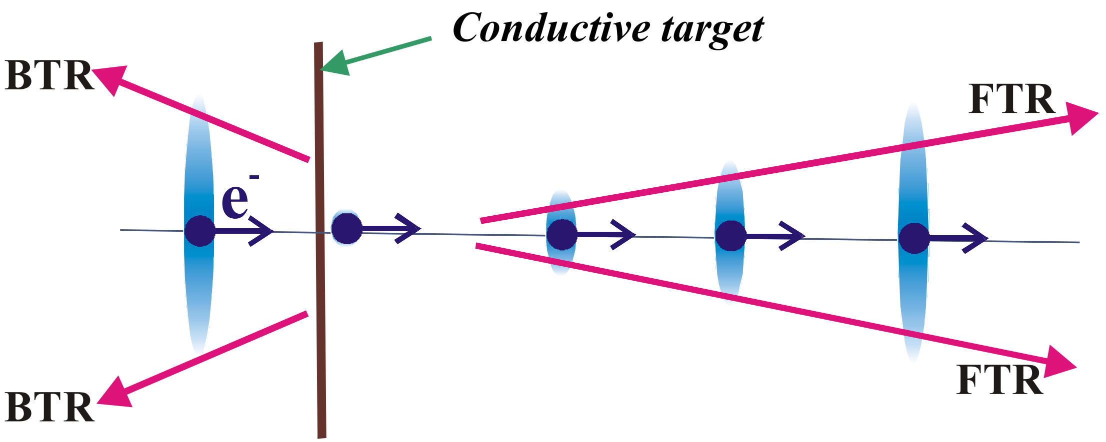


$$\Phi_1(\mathbf{k}_1;\mathbf{k}) = \begin{pmatrix} a_0 e^-(\mathbf{k}_1)\, V_{\mathbf{k},\mathbf{k}_1} \\ \int \{a_1^{(0)}(\varkappa;\mathbf{k}_1)\underbrace{(e^{-it/T_\varkappa(\mathbf{k}_1)}-1)} + a_1^{(0)}(\varkappa;\mathbf{k})\, e^{-it/T_\varkappa(\mathbf{k}_1)}\} \times \\ \times e^-(\mathbf{k}_1)\,\gamma(\varkappa)\, V_{\mathbf{k},\mathbf{k}_1-\varkappa}\, d^3\varkappa \end{pmatrix}; \qquad (13a)$$

Особый интерес представляет первое слагаемое в фигурной скобке второй строки в (13а) с его фундаментально важным фактором $\exp(-it/T_\varkappa^{regen}(\mathbf{k}_1) - 1)$. При $t \ll T_\varkappa^{regen}(\mathbf{k}_1)$ оно вообще исчезает. Это значит, что при движении вдоль нового направления электрон сначала не имеет собственного поля.

The greatest interest held the first addenda in braces of the second line in (13a) with its fundamentally important factor $\left(-it/T_x^{regen}(k_1)-1\right)$. For $t \ll T_x^{regen}(k_1)$ this addenda disappears. This means that during the motion along the new direction the electron has not its own field.

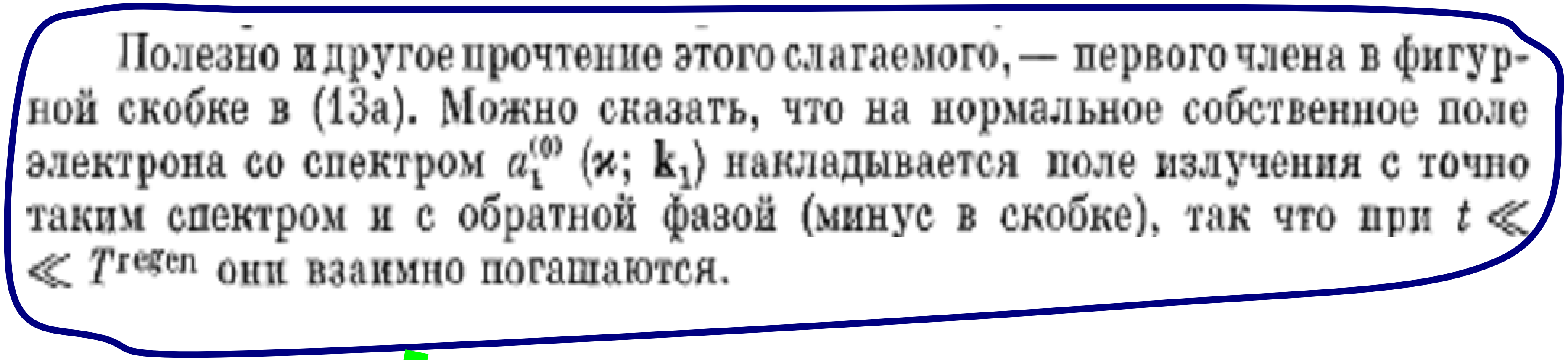
The same for transition radiation geometry:



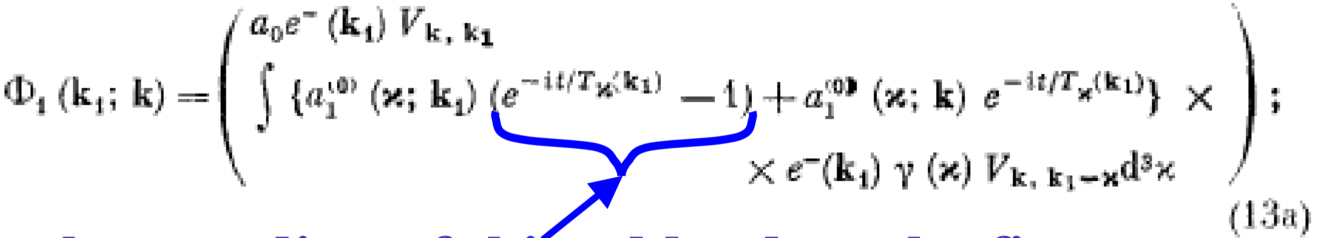
The field of electron reflects from the screen (BTR).

The electron transit from instable naked state to the stable state with electromagnetic field. This process follows by FTR.

E. L. Feĭnberg *some lines lower:*



Полезно и другое прочтение этого слагаемого, — первого члена в фигурной скобке в (13a). Можно сказать, что на нормальное собственное поле электрона со спектром $a_1^{(0)}(\varkappa;\ \mathbf{k}_1)$ накладывается поле излучения с точно таким спектром и с обратной фазой (минус в скобке), так что при $t \ll T^{\text{regen}}$ они взаимно погашаются.

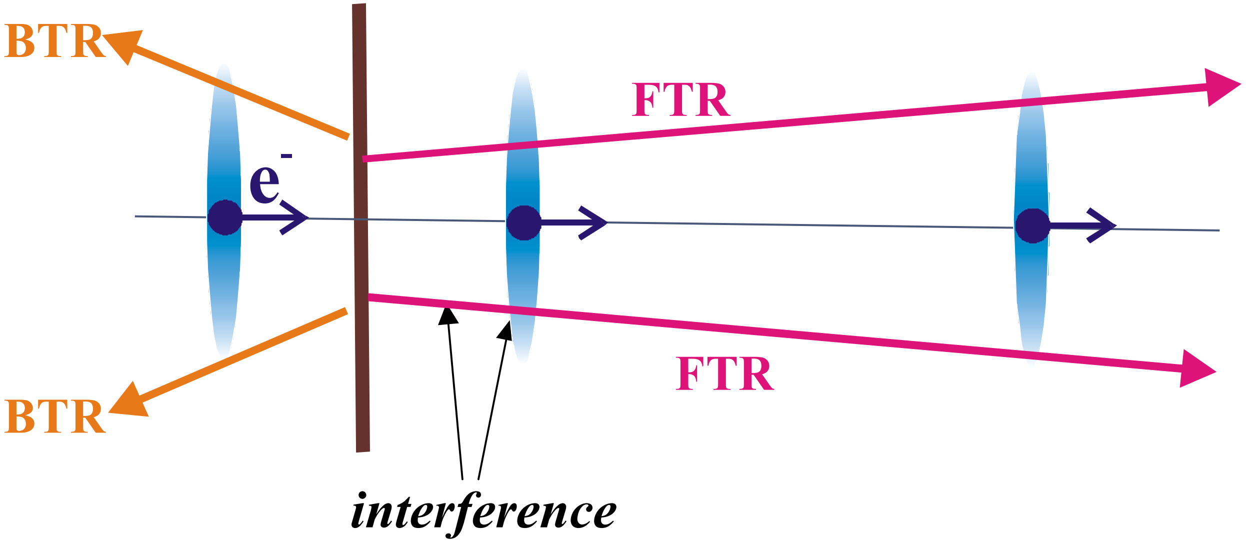


$$\Phi_1(\mathbf{k}_1;\ \mathbf{k}) = \begin{pmatrix} a_0 e^-(\mathbf{k}_1)\, V_{\mathbf{k},\,\mathbf{k}_1} \\ \int \{a_1^{(0)}(\varkappa;\ \mathbf{k}_1) \underbrace{\left(e^{-it/T_\varkappa(\mathbf{k}_1)} - 1\right)} + a_1^{(0)}(\varkappa;\ \mathbf{k})\, e^{-it/T_\varkappa(\mathbf{k}_1)}\} \times \\ \times e^-(\mathbf{k}_1)\, \gamma(\varkappa)\, V_{\mathbf{k},\,\mathbf{k}_1-\varkappa} d^3\varkappa \end{pmatrix}; \qquad (13a)$$

It is useful the another reading of this addenda, - the first addenda in braces in (13a). We may say that on the electron field with the spectrum $a_1^{(0)}(\chi;k_1)$ superposes the radiation field with exactly the same spectrum and with the opposite phase (minus in parentheses), so that for $t \ll T_x^{regen}$ they annihilate each other.

Second interpretation in our geometry:

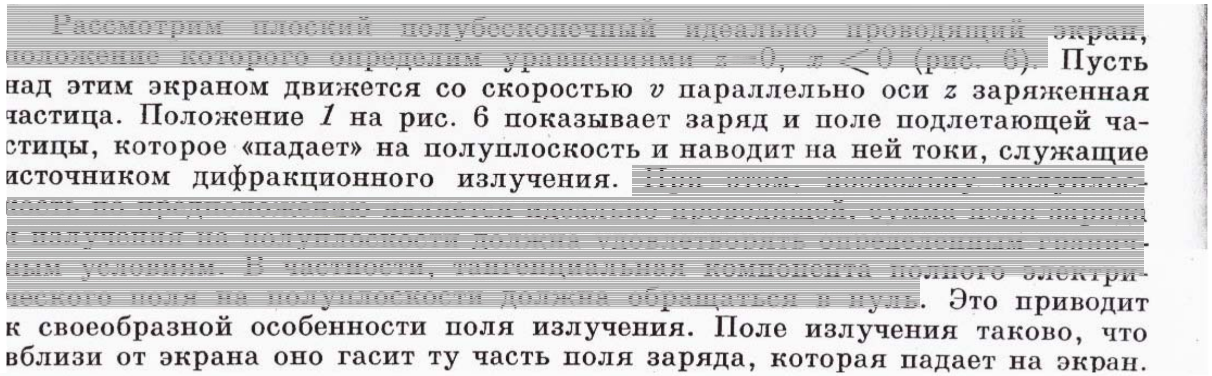
2. *Interference between the FTR from the target and the field of electron*



The electron field induces a current on the screen, which emits a BTR and FTR.

FTR is emitted with the faze opposite to the faze of the electron field.

B. M. BolotovskiI. Preprints of Lebedev Institute of Physics, Russian Academy of Sciences,Vol 140 (1982), p. 95



Рассмотрим плоский полубесконечный идеально проводящий экран, положение которого определим уравнениями $z = 0$, $x < 0$ (рис. 6). Пусть над этим экраном движется со скоростью v параллельно оси z заряженная частица. Положение *1* на рис. 6 показывает заряд и поле подлетающей частицы, которое «падает» на полуплоскость и наводит на ней токи, служащие источником дифракционного излучения. При этом, поскольку полуплоскость по предположению является идеально проводящей, сумма поля заряда и излучения на полуплоскости должна удовлетворять определенным граничным условиям. В частности, тангенциальная компонента полного электрического поля на полуплоскости должна обращаться в нуль. Это приводит к своеобразной особенности поля излучения. Поле излучения таково, что вблизи от экрана оно гасит ту часть поля заряда, которая падает на экран.

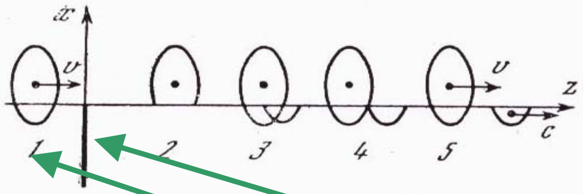


Рис. 6

Let us a charged particle moves over the screen parallel to the axis *z* with a velocity *v*. Position 1 in Fig. 6 shows the field of charged particle. It attacks the semi-surface and induces a current on it, which becomes a source of the diffraction radiation.

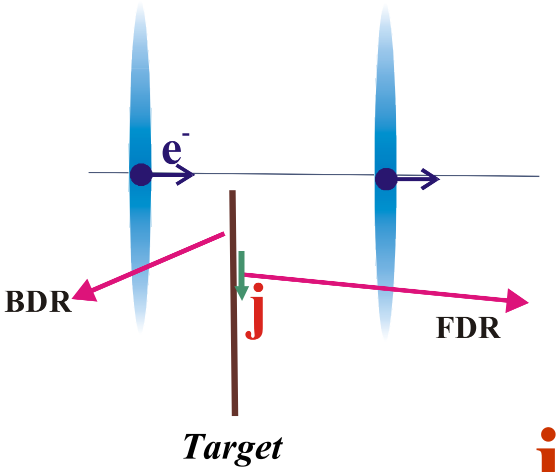
This results the peculiar feature of the radiation field. Radiation field is such one, that close to the screen it kills the part of particle field, which attacks the screen.

Is there any difference between these two interpretations?

Diffraction radiation field from ideally conductive semi-surface:

(A.P. Kazantsev, G.I. Surdutovich, Sov. Phys. Dokl. 7 (1963) 990.)

$$A(R) = \frac{e^{i\omega R}}{R}\int dr' e^{-i\omega R r'/R} j(r') = \frac{2\pi e^{i\omega R}}{R} j(k_0, q_0),$$



No surface current → no FDR ⇒

⇒ interpretation 1

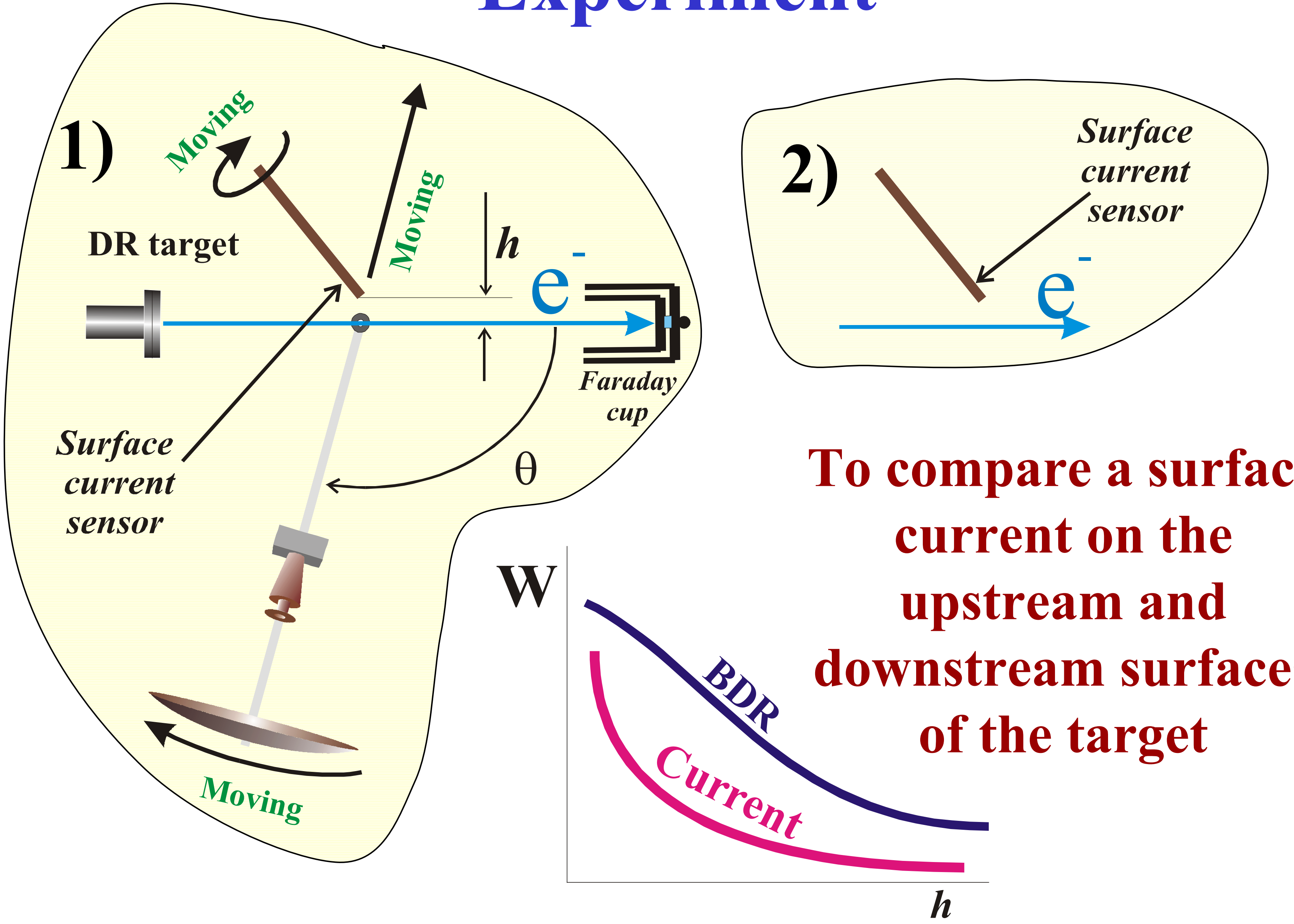
Surface current exists →

→ FDR ⇒ interpretation 2

i.e. these two interpretations are physically not identity

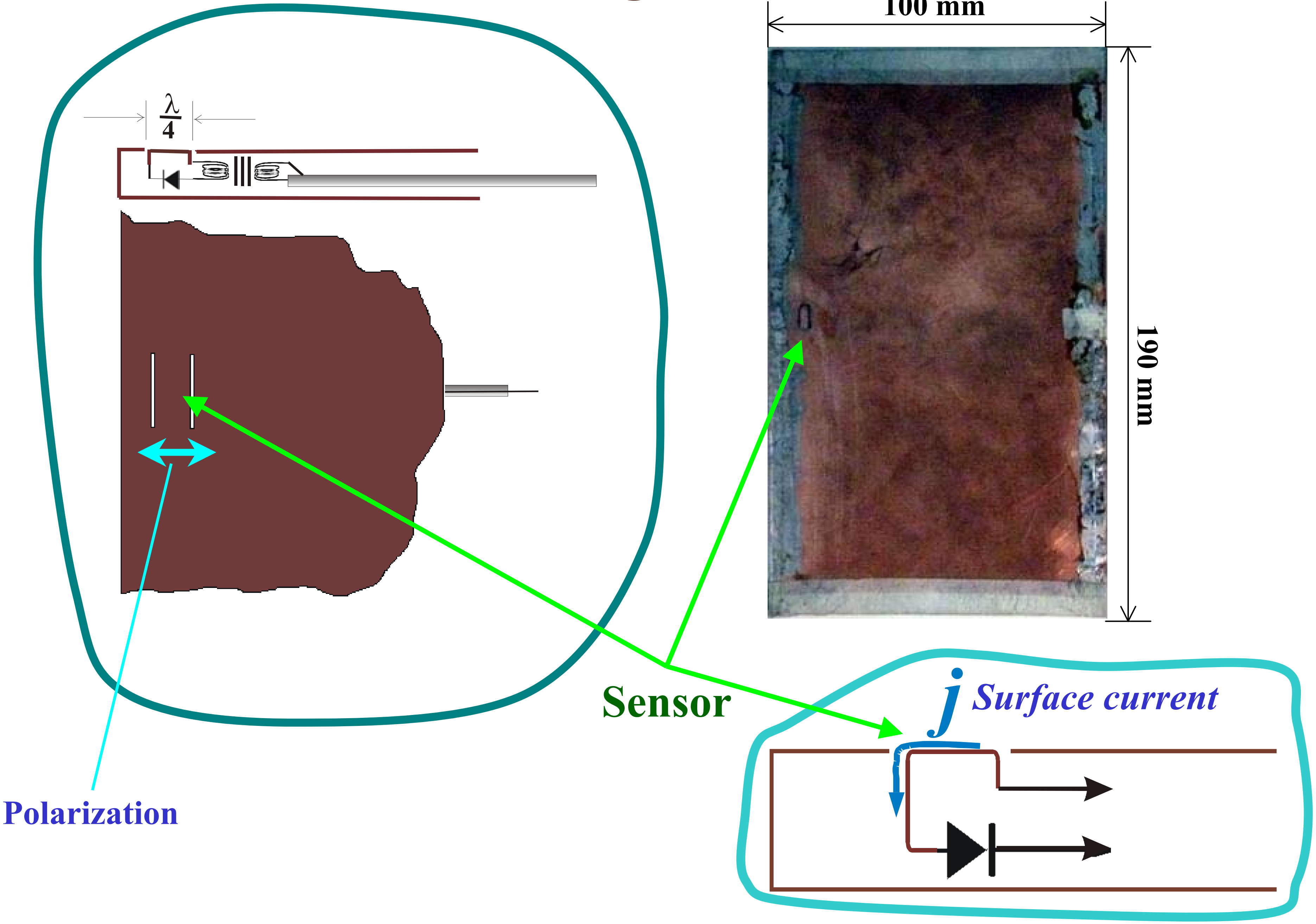
The proper interpretation may be choused by checking of a surface current on the downstream target surface.

Experiment



To compare a surface current on the upstream and downstream surfaces of the target

Target

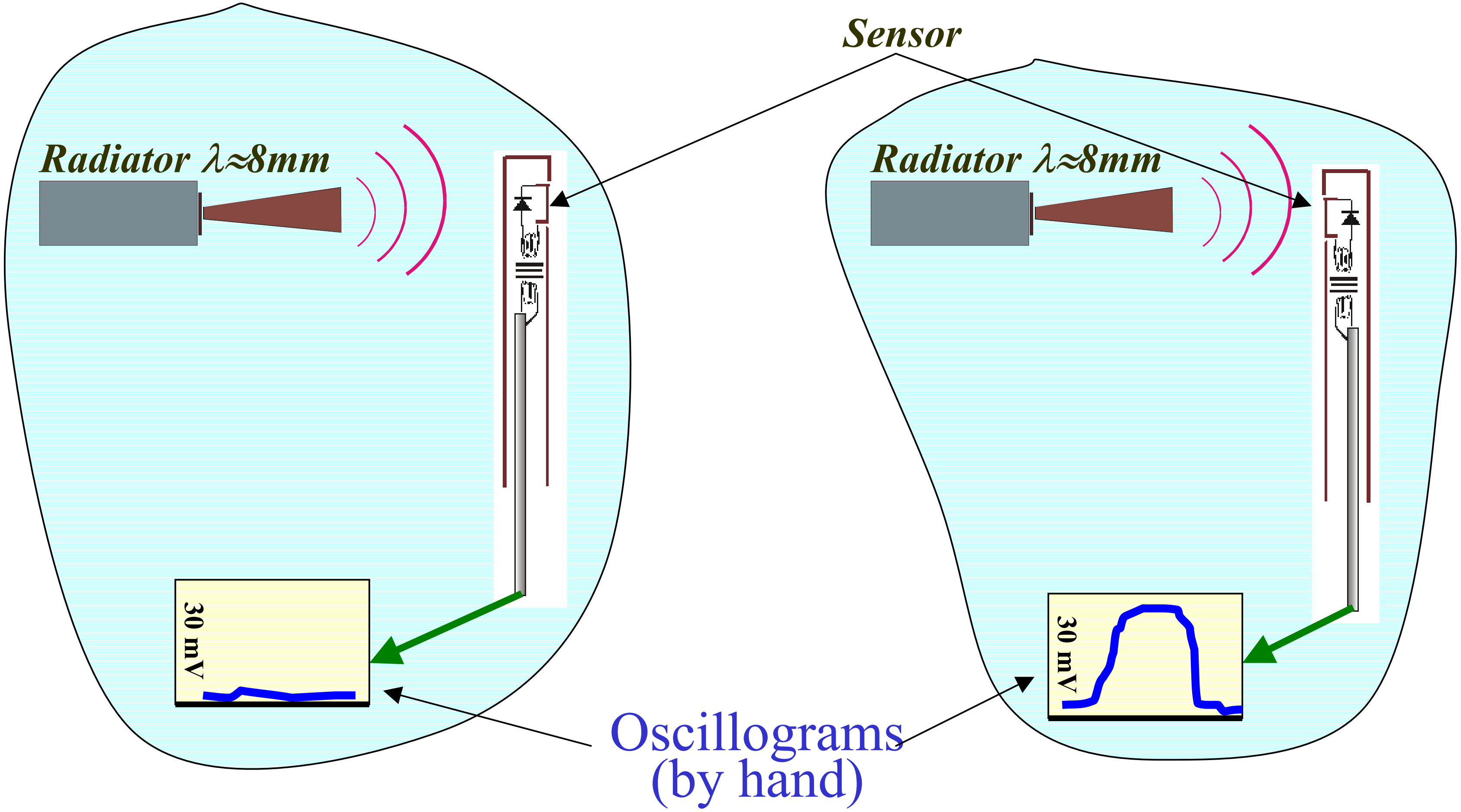


Sensor

Surface current

Polarization

Stand test of the target



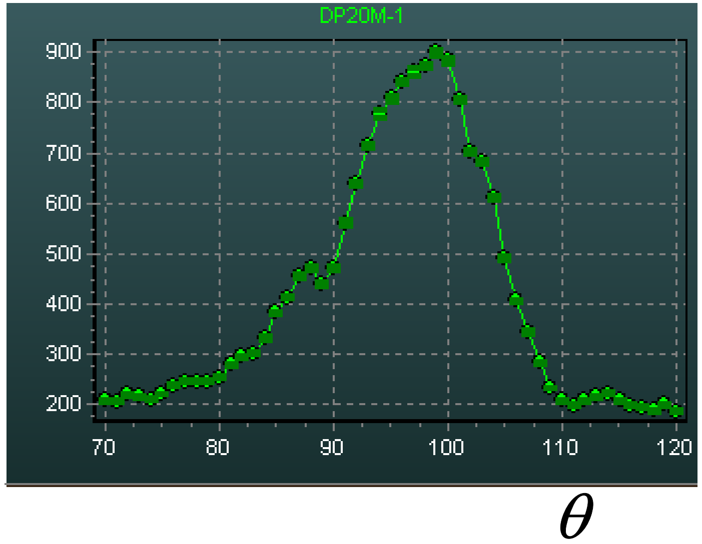
Oscillograms
(by hand)

Estimated sensitivity (lower limit) ≈50 mV/(mA/cm)

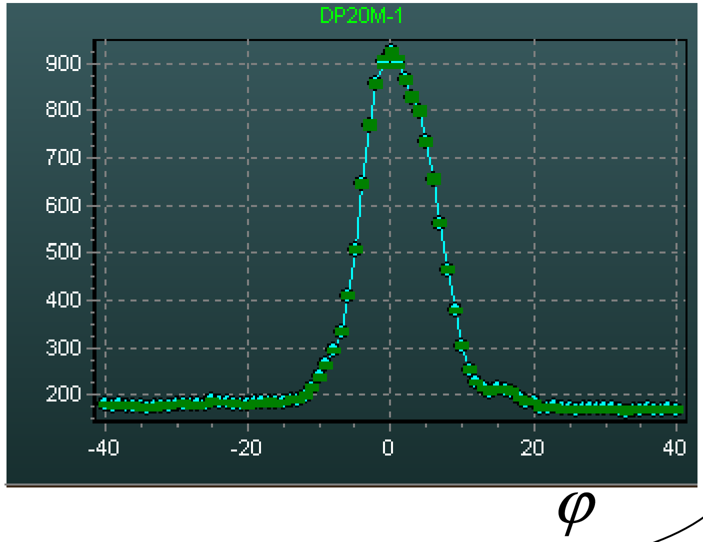
Measurements

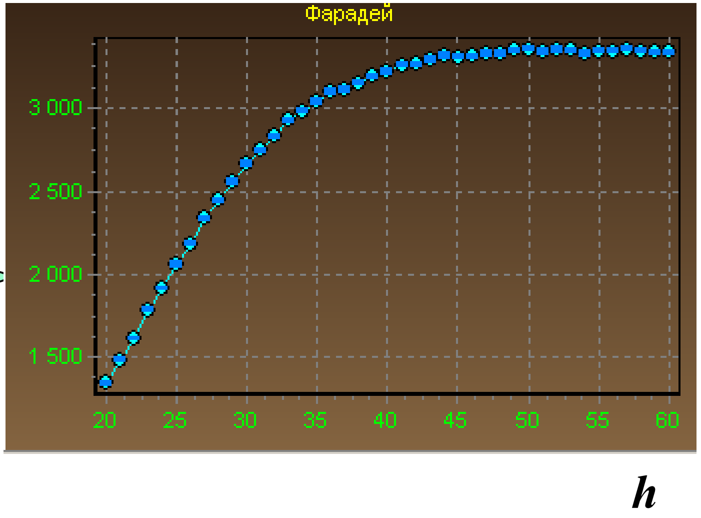
Diffraction radiation as a function on impact-parameter

Polar dependence

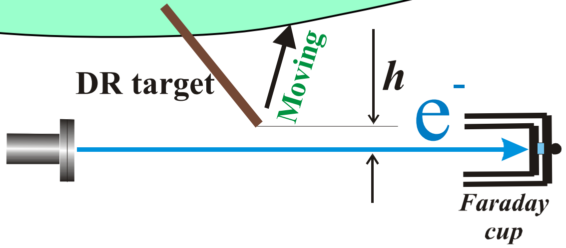


Azimuthal dependence

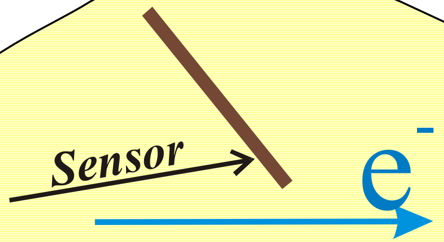


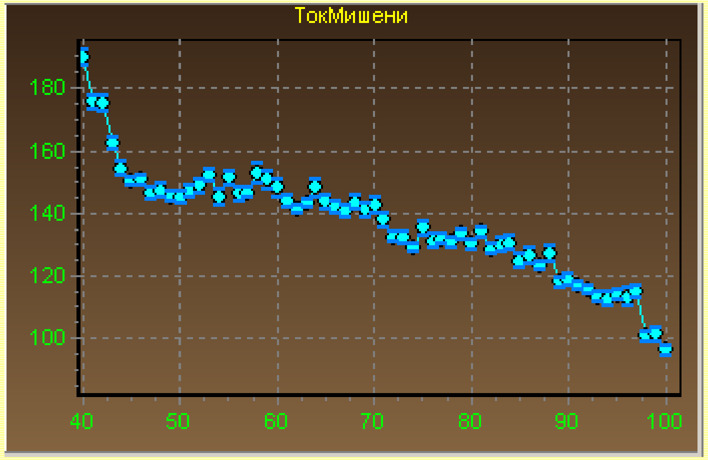


Faraday cup reading as a function on impact-parameter

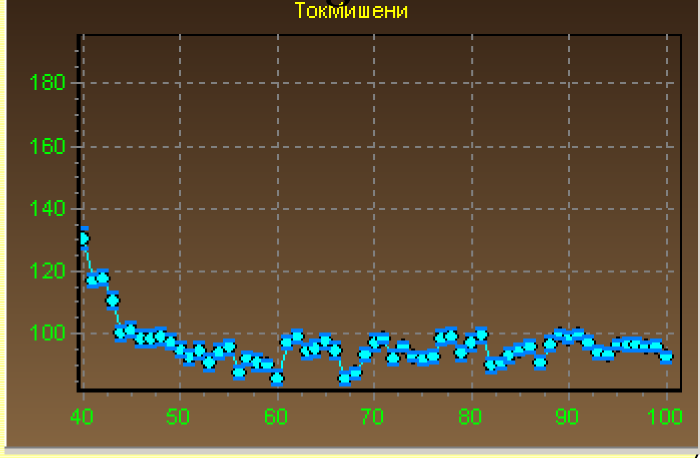


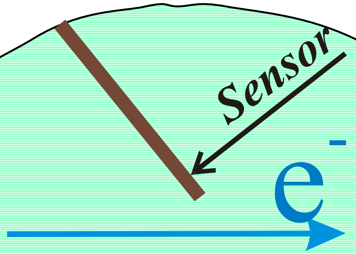
Experimental run surface current dependences on the impact parameter

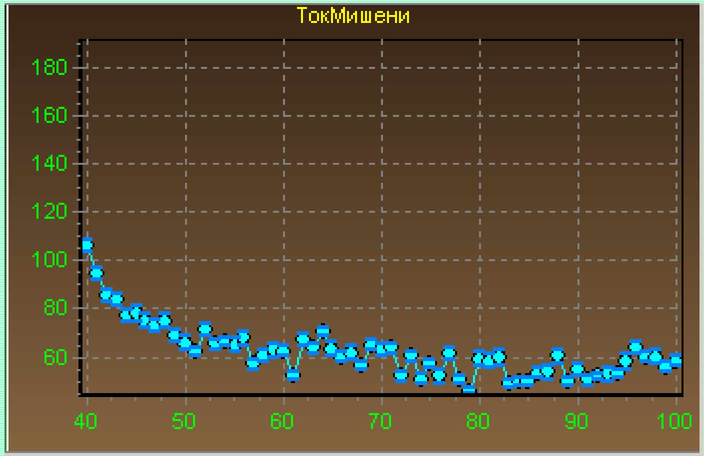




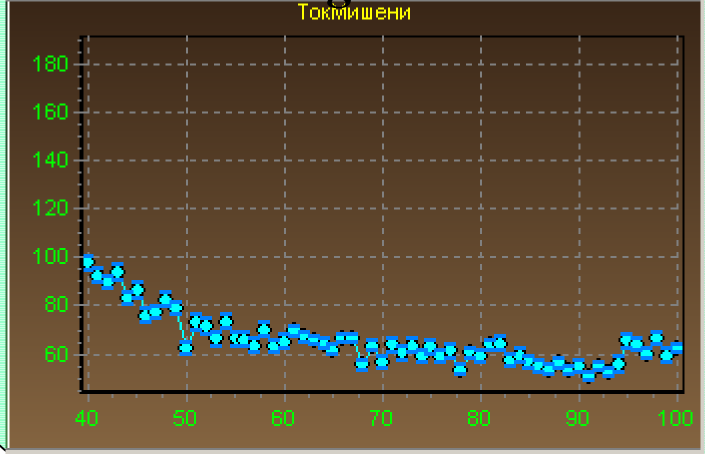
Background



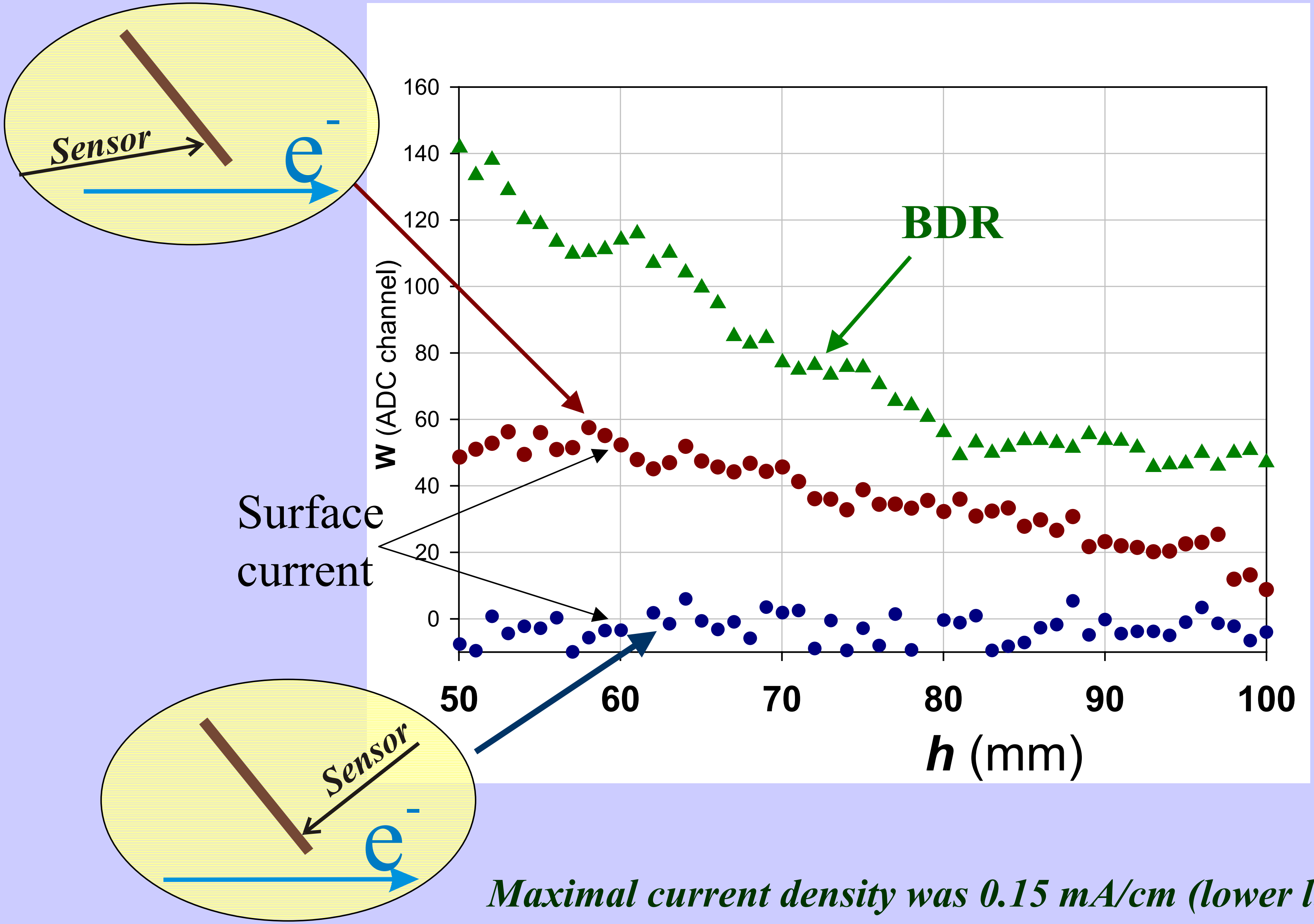




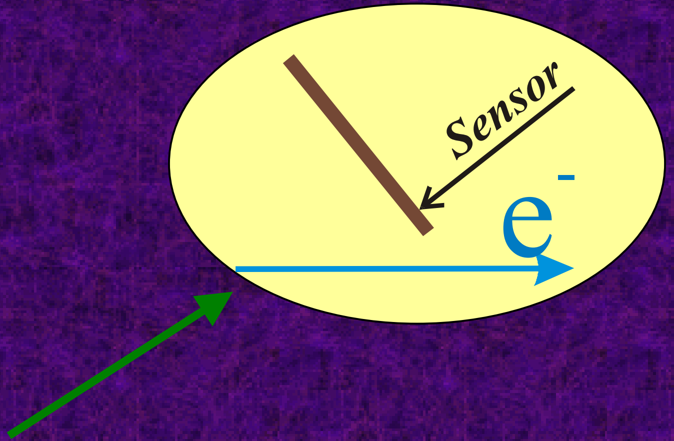
Background



After the background subtraction



Maximal current density was 0.15 mA/cm (lower limit)



No surface current on the downstream surface is induced by an electron field. Therefore no diffraction or transition radiation may be emitted from this surface.

Thank you for attention