

*RADIATION from RELATIVISTIC ELECTRONS
in PERIODIC STRUCTURES*



Direct Observation of a Semi-Bare Electron Coulomb Field Recover

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Geometric similarity of electron field properties

The electron size scale factor $r_e = \frac{e^2}{4\pi\epsilon_0 m_e c^2} \approx 2.8 \cdot 10^{-15} \text{ m}$

*Up to this value, the properties of the electron field are **similar** with respect to the geometric dimensions.*

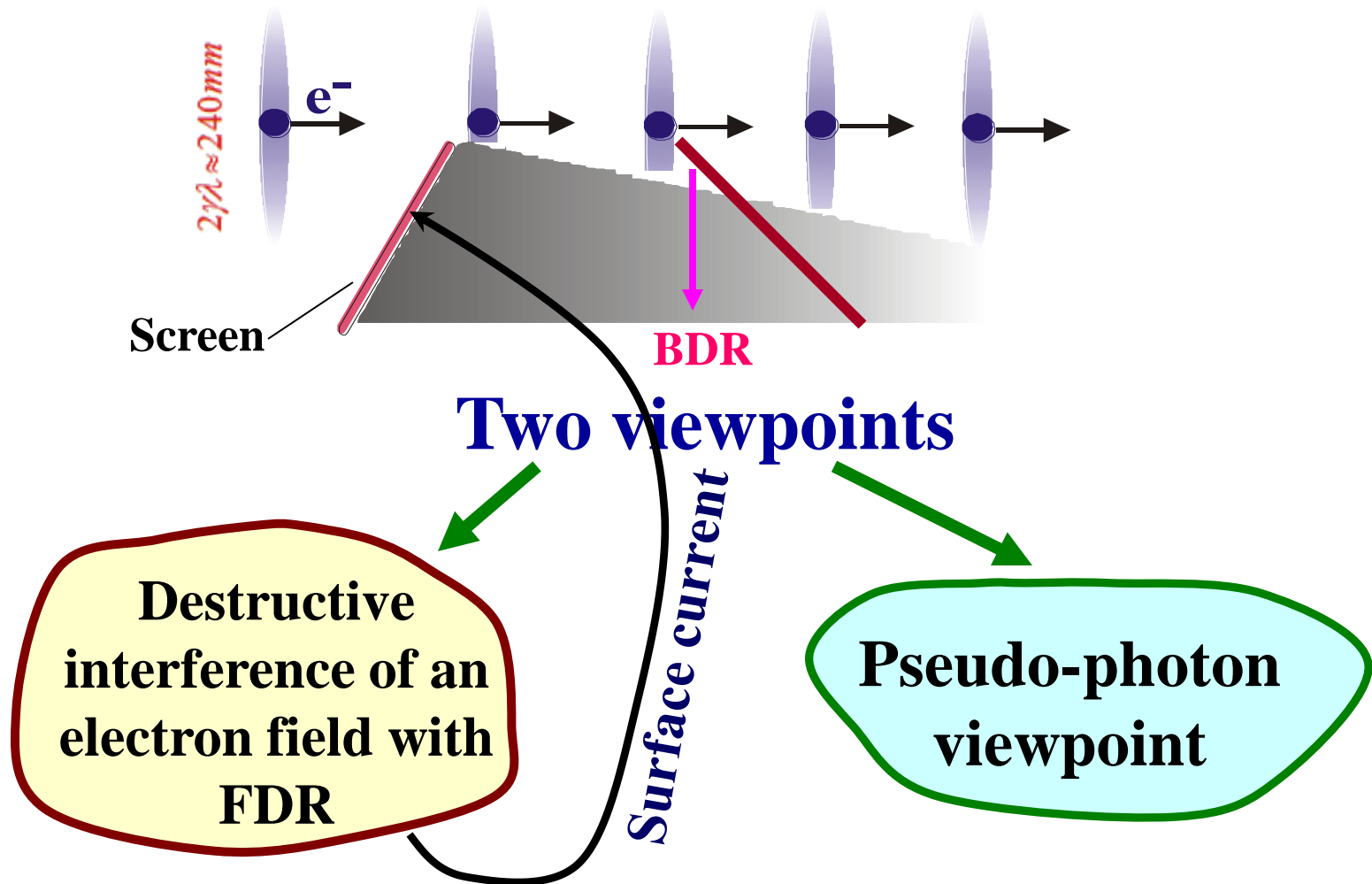
That is, the experimental study of the properties of the electron field in the millimeter wavelength range provide information about the properties of the electron field up to the scale factor.

Short history

Channeling 2008

Shadowing effect in a mm wave range

X.Artru, G. Naumenko, Yu. Popov, A. Potylitsyn, and L. Sukhikh



Pseudo-photon viewpoint

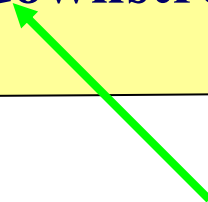
Electron field: $\gamma \gg 1 \Rightarrow \begin{cases} v \approx c \\ E_{\parallel} \ll E_{\perp} \end{cases} \rightarrow \text{transversal}$

Properties are close to one of real photons



Electron field:

- is reflected from conductive screen
- don't penetrate it
- don't induce current on downstream surface of screen

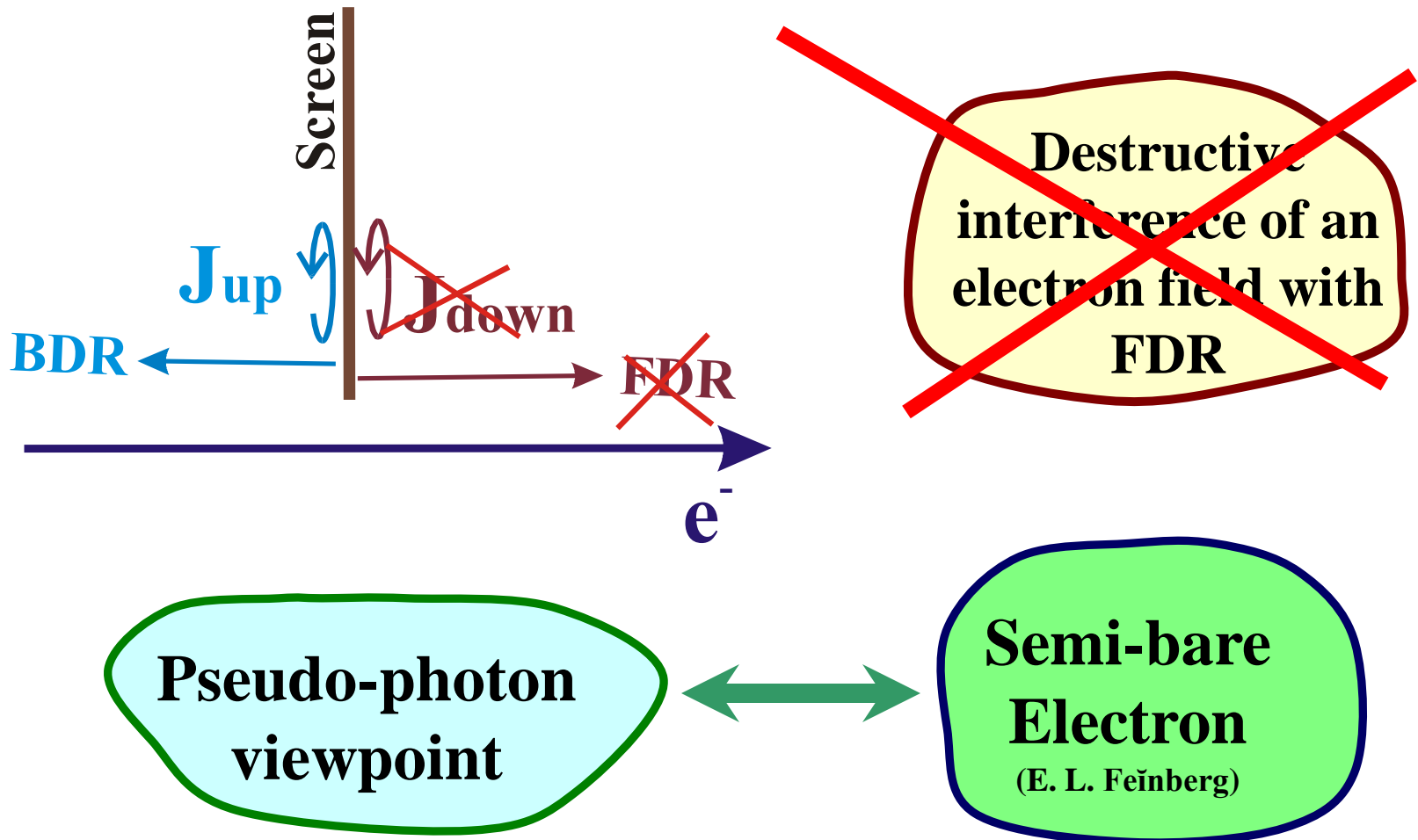


This is in contradiction with “Surface current” viewpoint

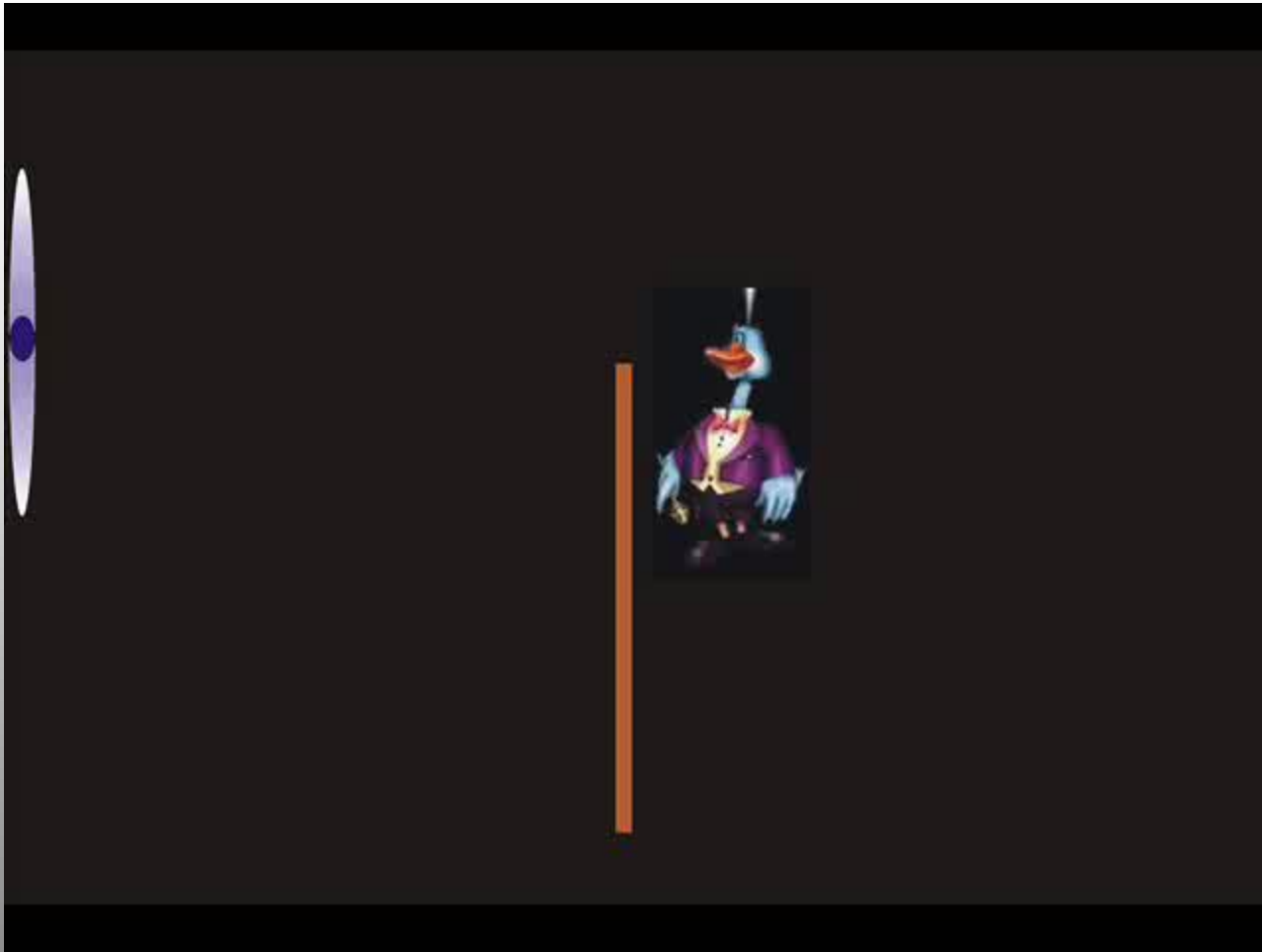
RREPS-2009 Surface current excitation

G.A. Naumenko, A.P. Potylitsyn, L.G. Sukhikh, Yu. Popov, M.V. Shevelev

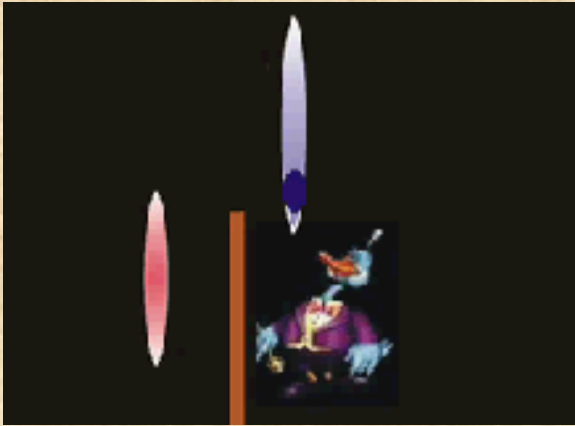
Journal of Physics: Conference Series 236 (2010) 012024



Shadow (semi-bare electron) effect



**Forward DR (TR) is the part of process
of semi-bare electron field recovery!**



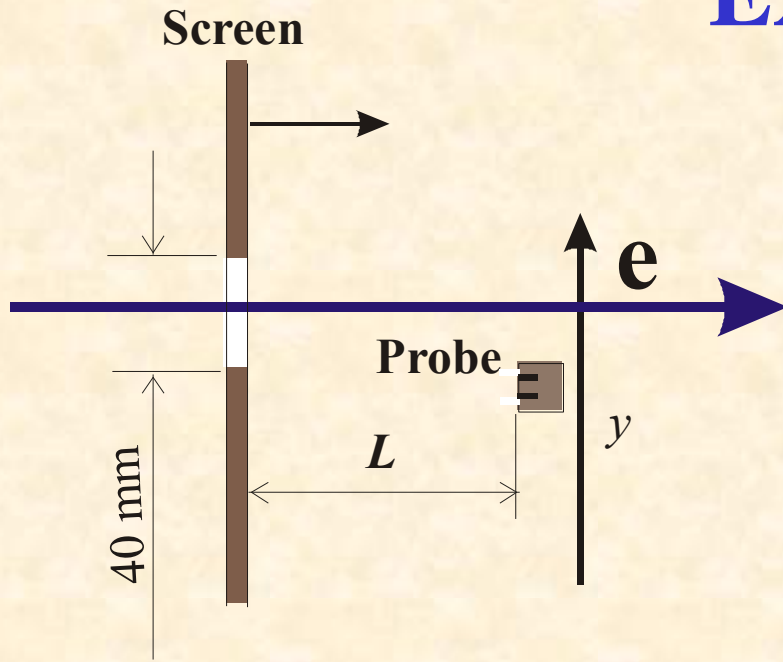
**Electron Coulomb field
recovery process
experimental observation**

Experimental equipment and technique

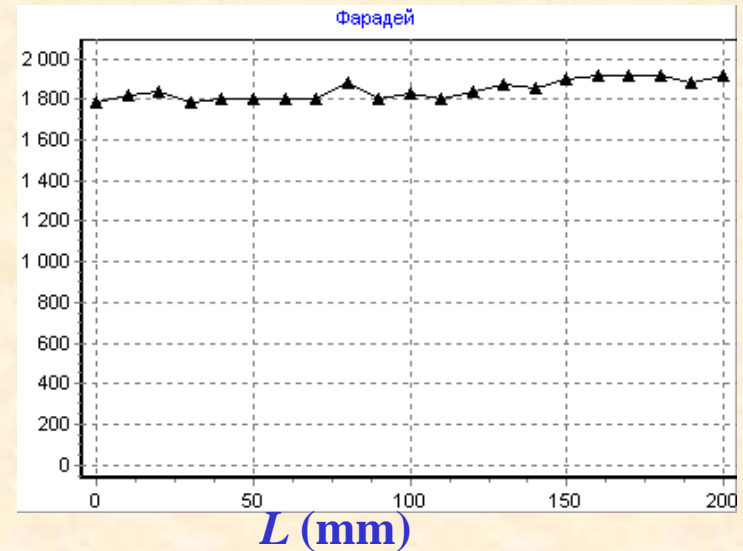
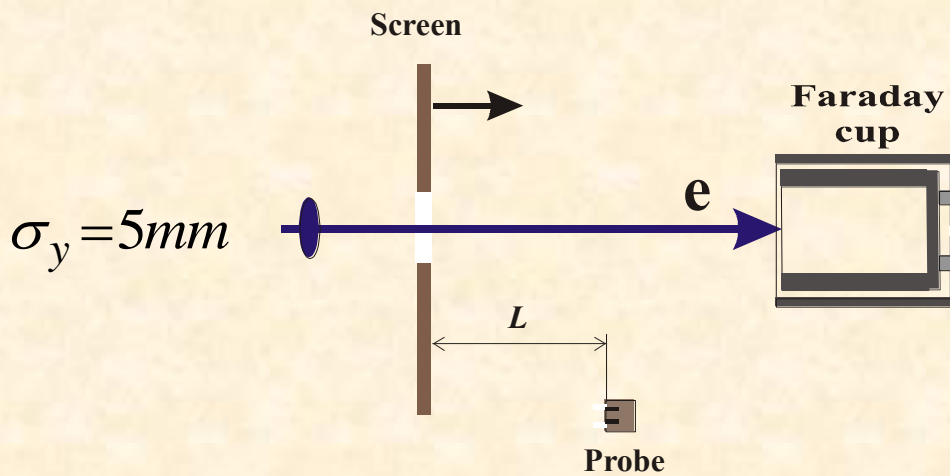
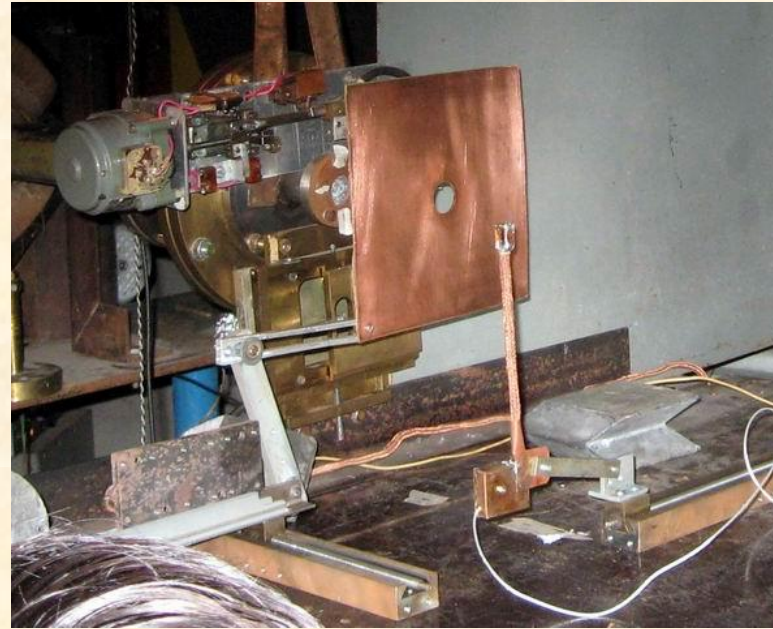
Beam parameters

Electron energy	6.1 MeV
Macro-pulse duration	2~6 ms
Pulse repetition rate	1~8 Hz
Micro-pulse length	≈ 6 ns
Electrons number per micro-pulse	$\approx 10^8$
Micro-pulses number per macro-pulse	$\approx 10^4$
Beam size at the output	4×2 mm²
<u>Emittance</u>: horizontal	$3 \cdot 10^{-2}$ mm \times rad
vertical	$1.5 \cdot 10^{-2}$ mm \times rad

Experimental setup



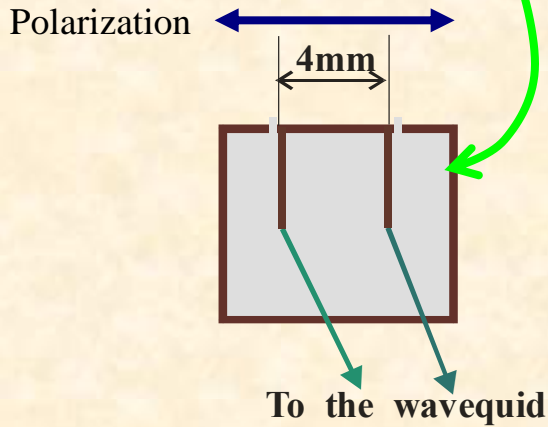
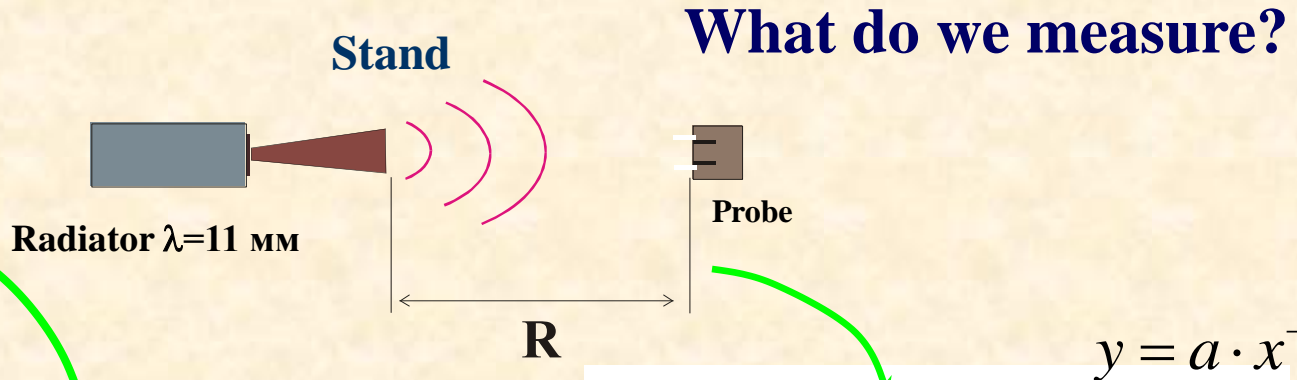
Check of electron losses on the screen



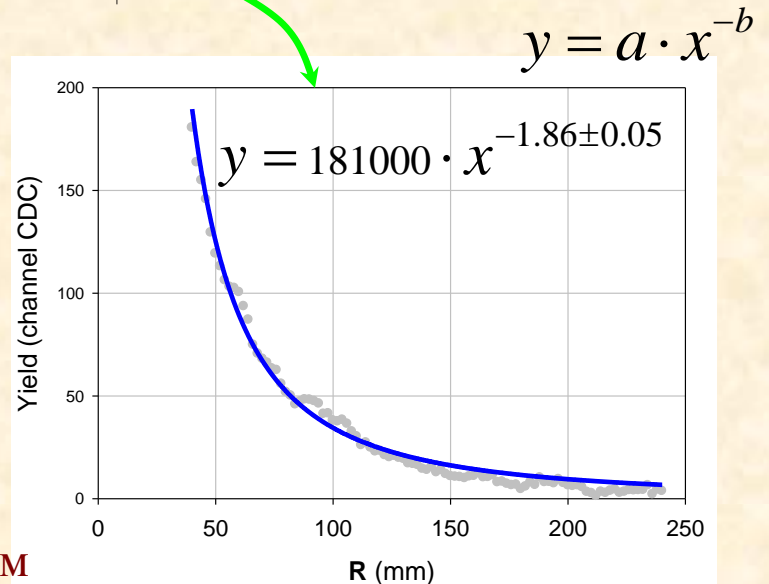
Probe

Based on the sensor of surface current induced by electromagnetic field.

(Sargsyan V 2004 Comparison of Stripline and Cavity Beam Position Monitors, TESLA Report 03)

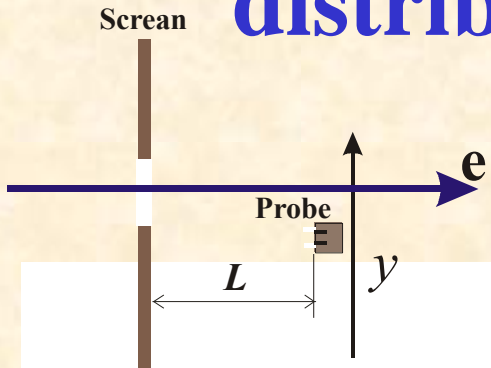
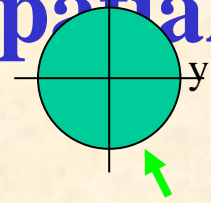


Dependence on the distance R

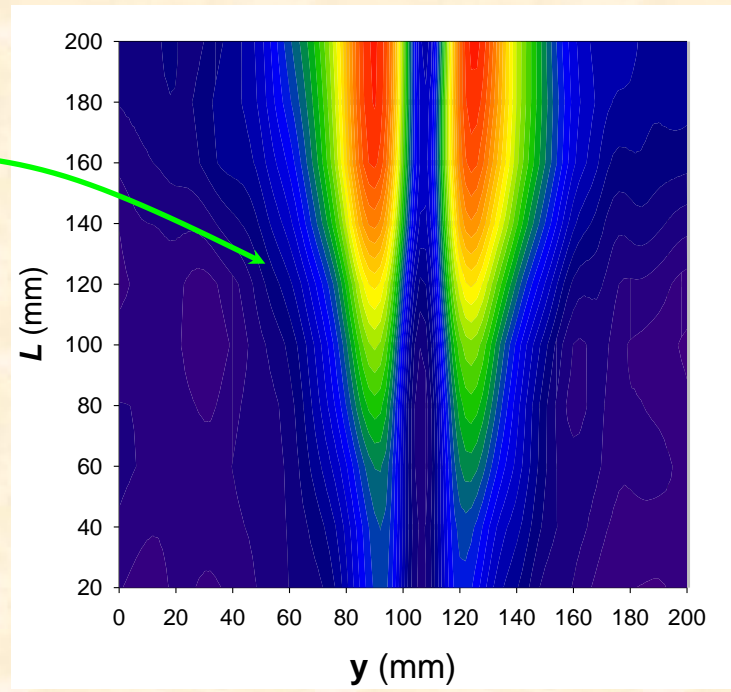
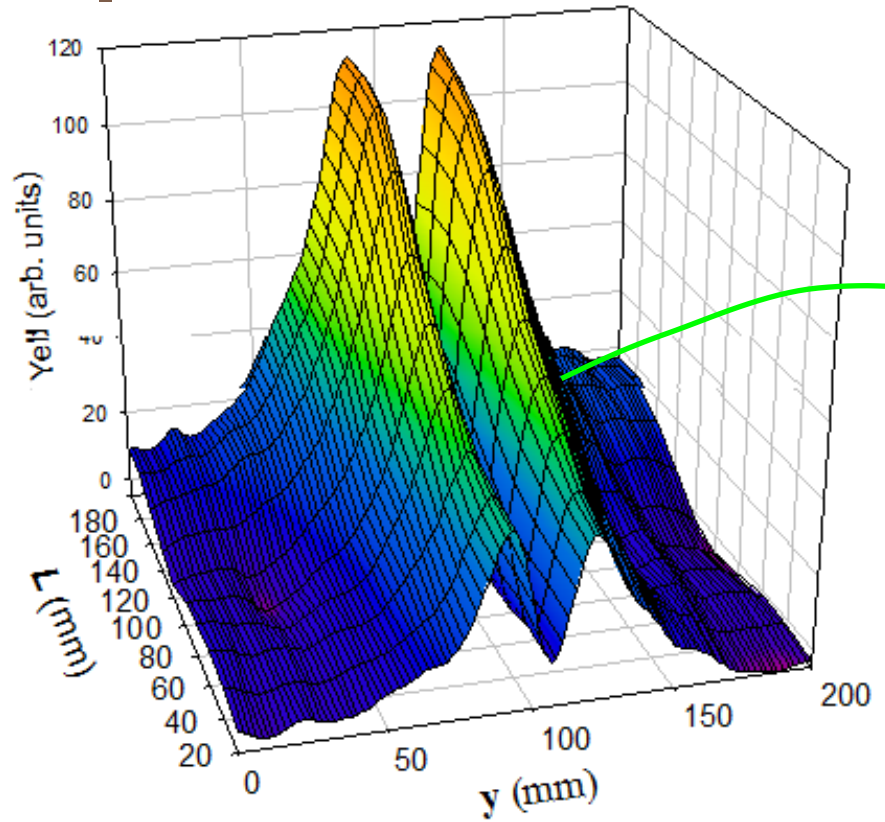
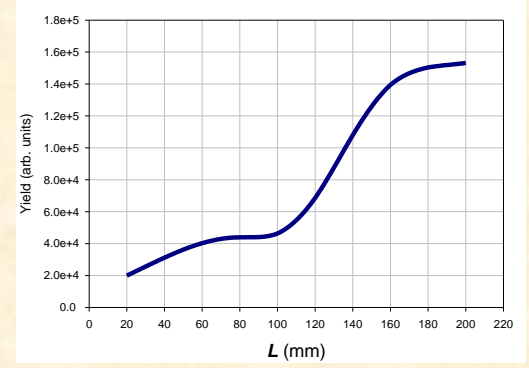


The maximum of sensitivity is provided for $\lambda=14$ mm

Measured electron bunch field spatial distribution

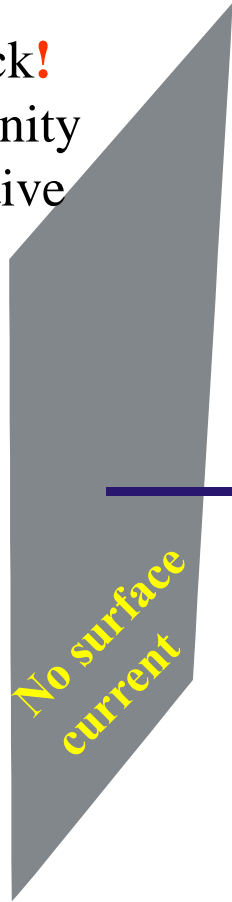


Integral over the transversal area



Electron field recovery in the classical approximation

The thick!
and Infinity
conductive
screen



$$\left\{ \begin{array}{l} \Delta \mathbf{E}_\omega + \omega^2 \mathbf{E}_\omega = 4\pi (\nabla \rho_\omega + i\omega \cdot \mathbf{j}_\omega) \\ \operatorname{div} \mathbf{E}_\omega = 4\pi \rho_\omega \\ \operatorname{div} \mathbf{j}_\omega + i\omega \cdot \rho_\omega = 0 \end{array} \right\} \begin{array}{l} \text{Maxwell equations} \\ \text{continuity equation} \end{array}$$

If for some $\Delta\omega$ $\mathbf{j}_\omega = 0$, equation is homogeneous (without radiation sources) \Rightarrow Not any radiation may be emitted in this frequency (wavelength) region.

Only relativistic electron current may be considered as a source of radiation

Resume

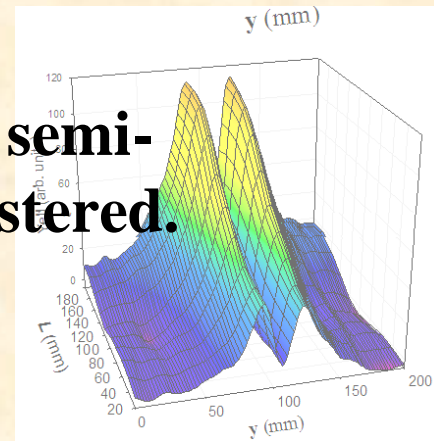
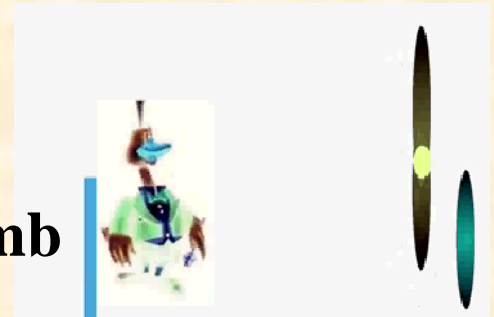
- The surface current model is not applicable for the forward radiation.

~~Destructive interference of an electron field with FDR~~

- Electromagnetic field evolution in forward direction may be explained only as the process of recovery of the Coulomb field of semi-bare electron.

- Forward TR and DR is the part of Coulomb field recovery process.

- The recovery of the Coulomb field of semi-bare electron was experimentally registered.



Thank you
for attention