

*RADIATION from RELATIVISTIC ELECTRONS  
in PERIODIC STRUCTURES*



# Direct Observation of a Semi-Bare Electron Coulomb Field Recover

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**Tomsk Polytechnic University  
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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.*

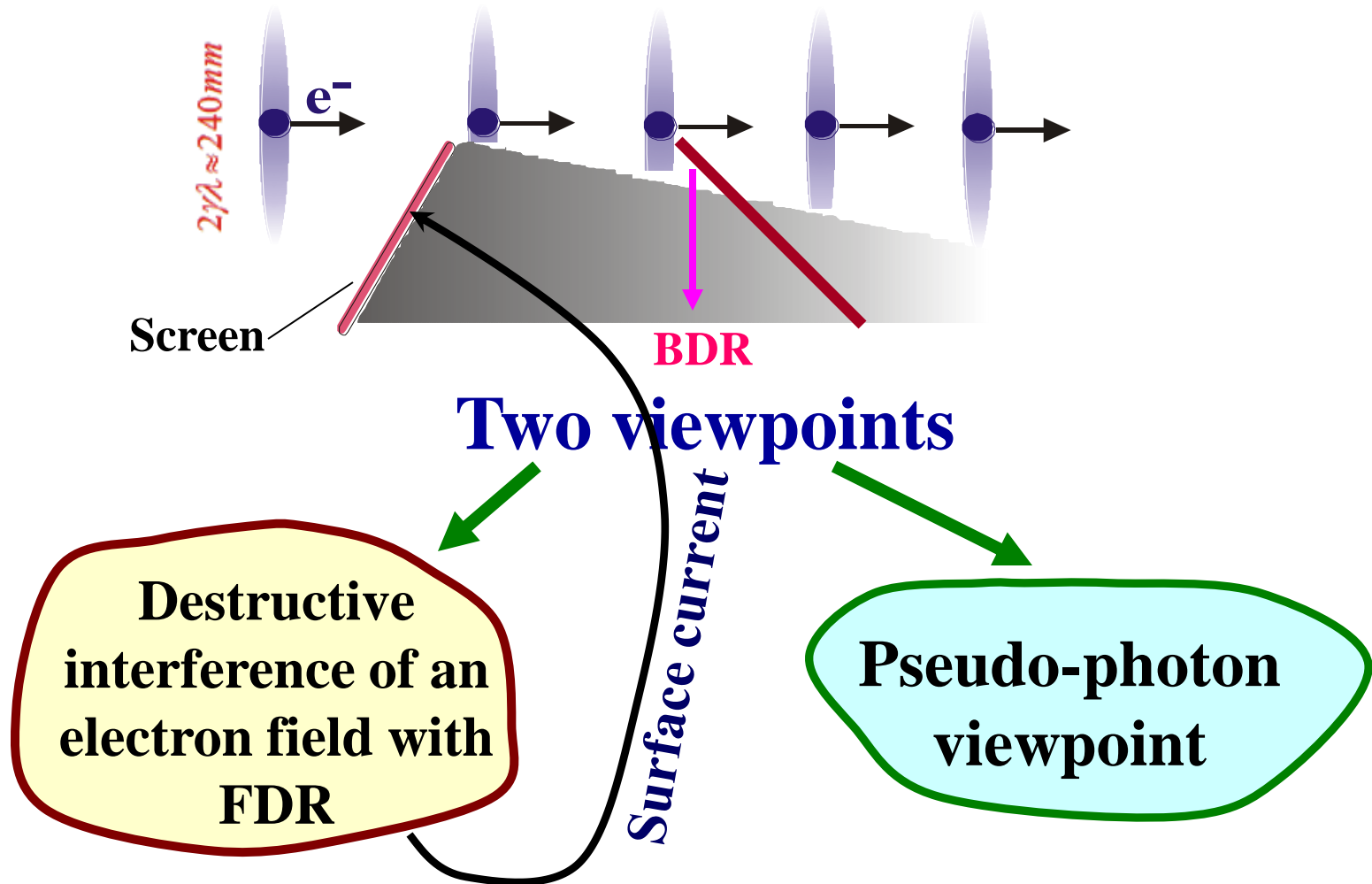
***That is, the experimental study of the properties of the electron field in the millimeter wavelength range provide information about the properties of the electron field up to the scale factor.***

# 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

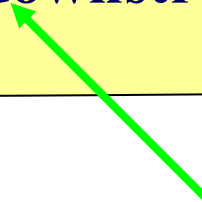
Electron field:  $\gamma \gg 1 \Rightarrow \begin{cases} v \approx c \\ E_{\parallel} \ll E_{\perp} \end{cases} \rightarrow \text{transversal}$

**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

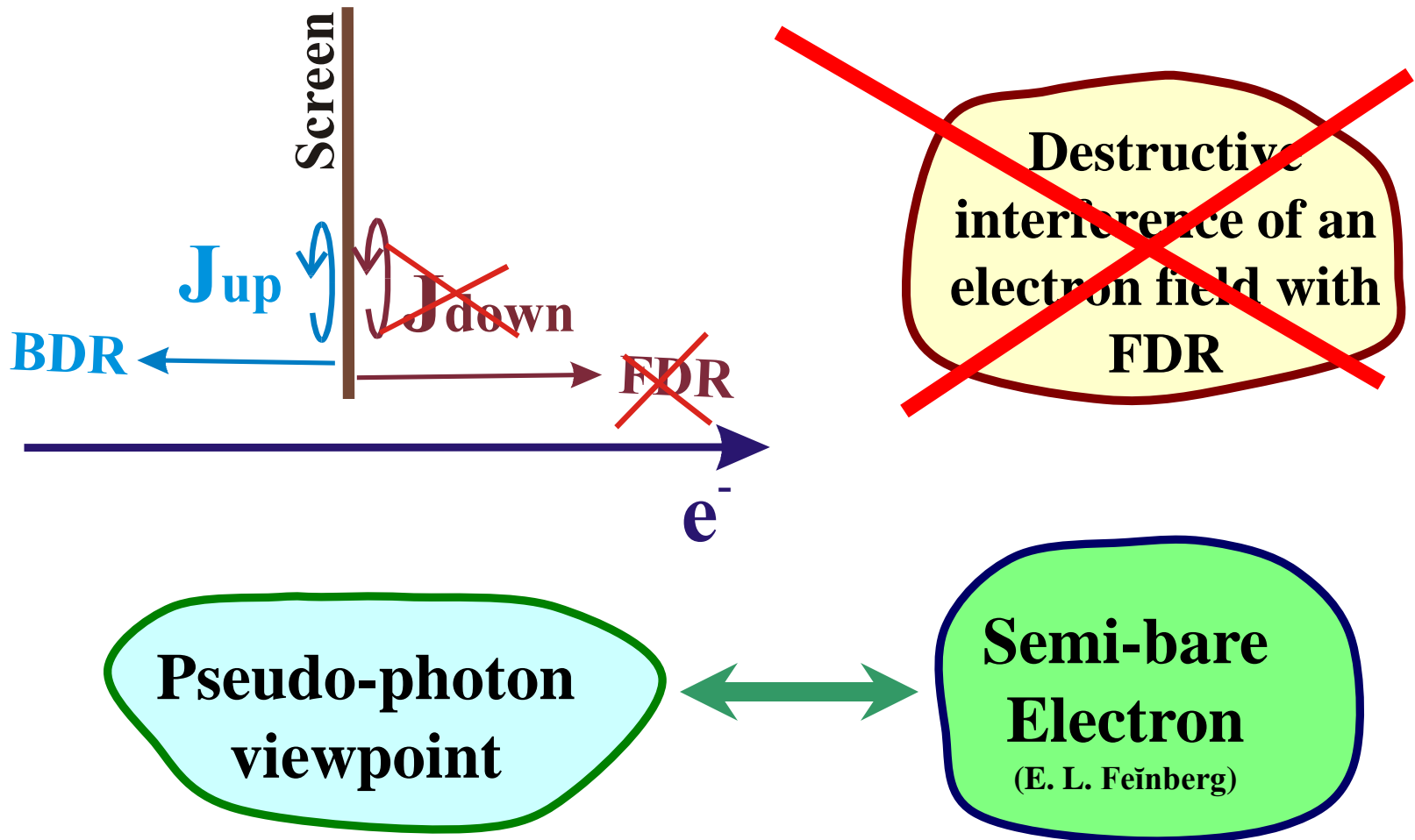


**This is in contradiction with "Surface current" viewpoint**

# RREPS-2009 Surface current excitation

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

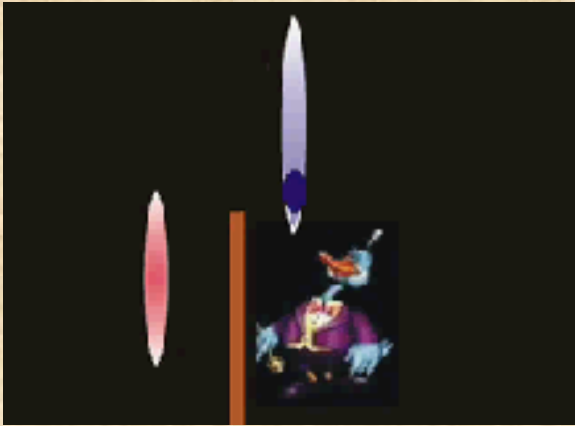
Journal of Physics: Conference Series 236 (2010) 012024



# 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**

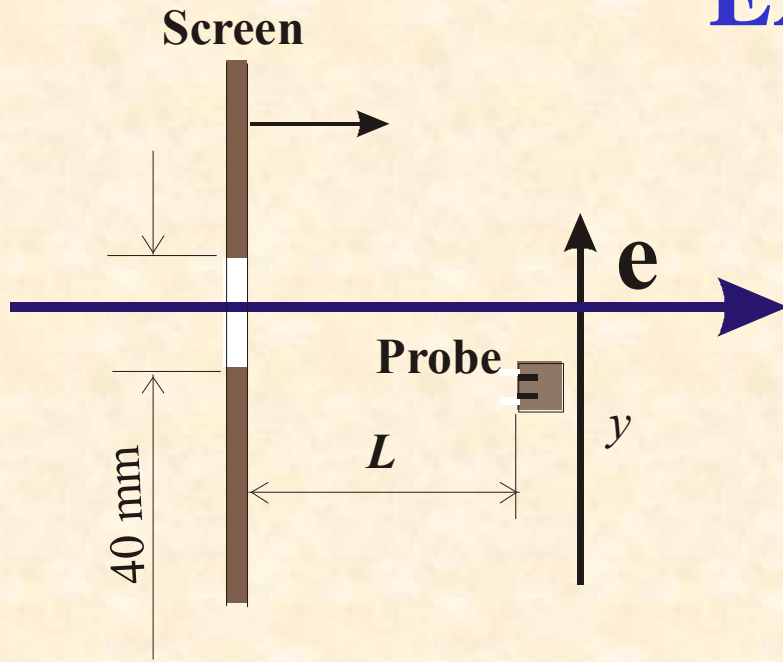
# Experimental equipment and technique

## Beam parameters

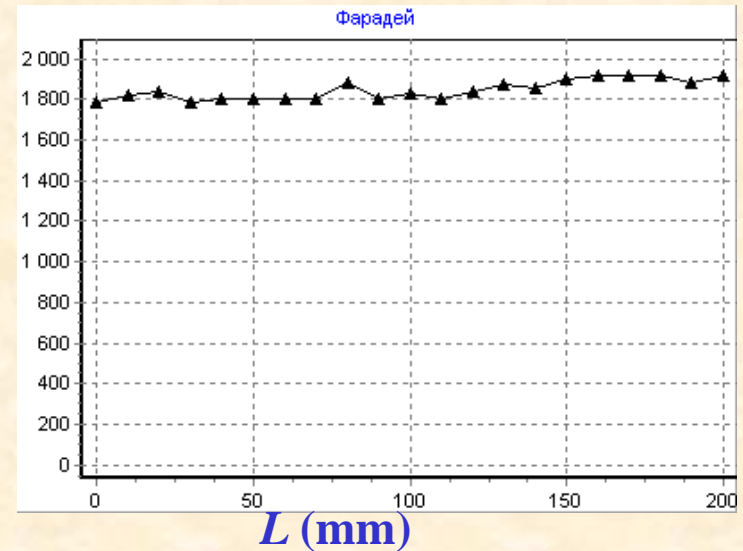
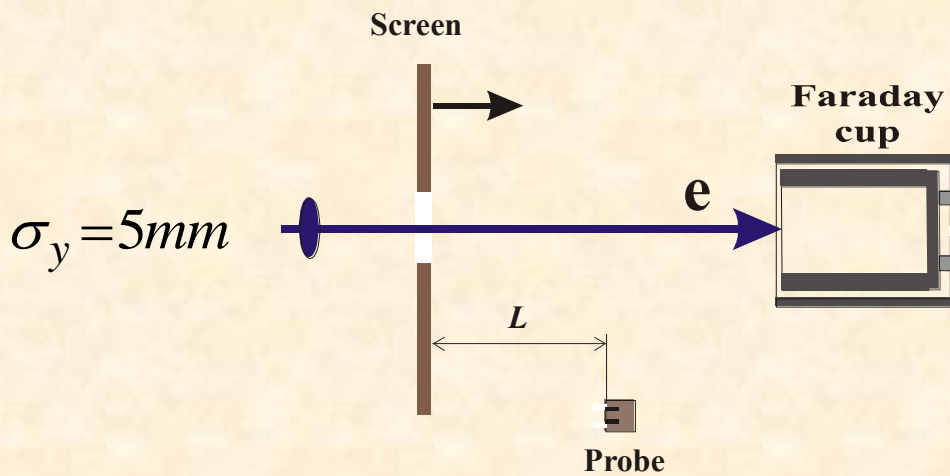
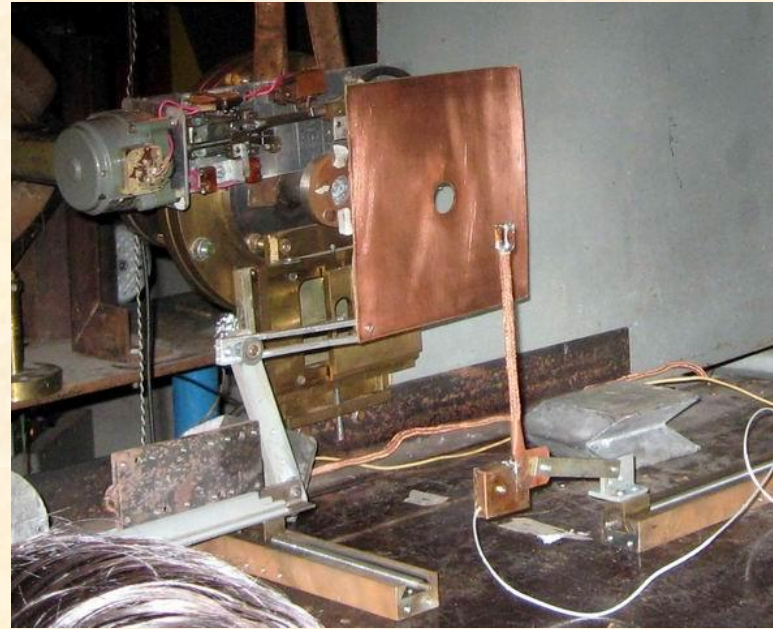
<b>Electron energy</b>	<b>6.1 MeV</b>
<b>Macro-pulse duration</b>	<b>2~6 ms</b>
<b>Pulse repetition rate</b>	<b>1~8 Hz</b>
<b>Micro-pulse length</b>	<b><math>\approx 6</math> ns</b>
<b>Electrons number per micro-pulse</b>	<b><math>\approx 10^8</math></b>
<b>Micro-pulses number per macro-pulse</b>	<b>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



# Experimental setup



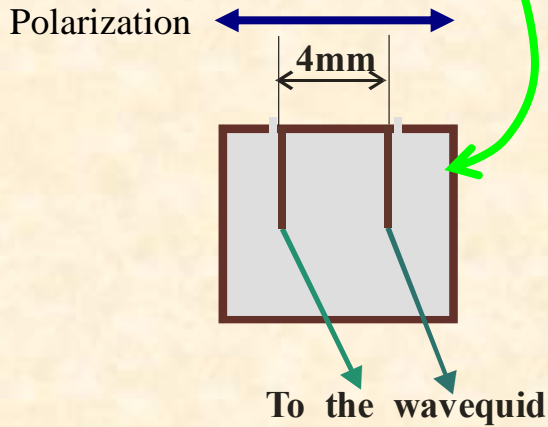
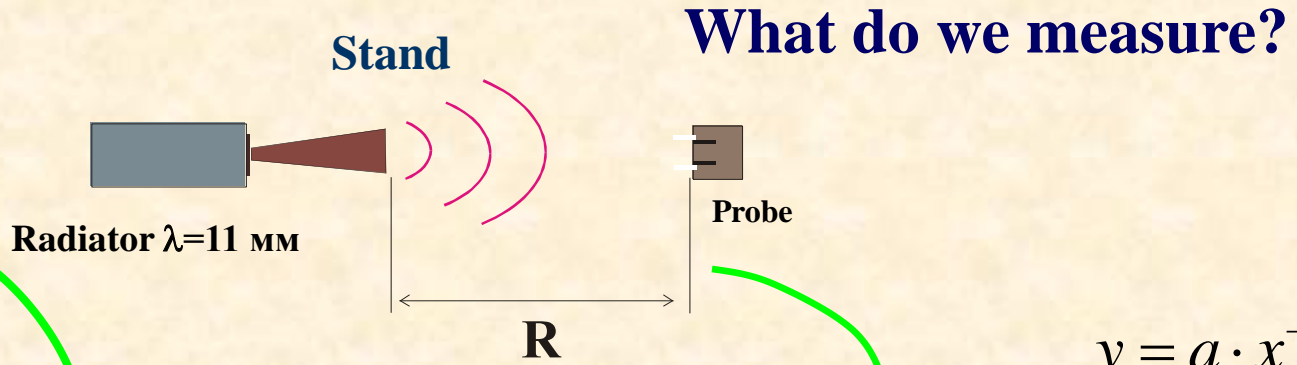
*Check of electron losses on the screen*



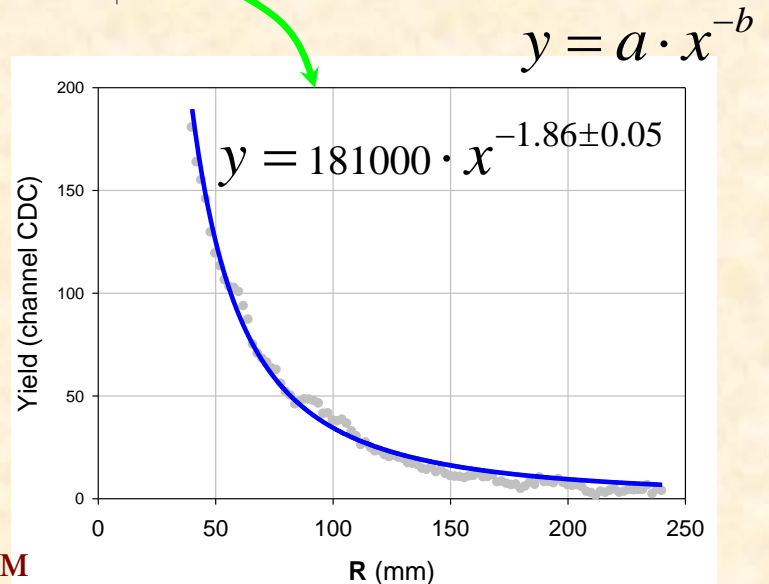
# Probe

*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 )

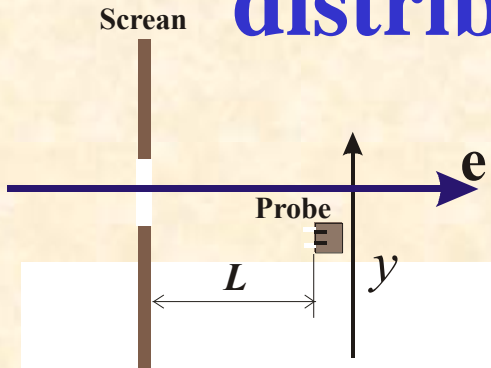
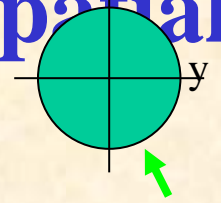


**Dependence on the distance R**

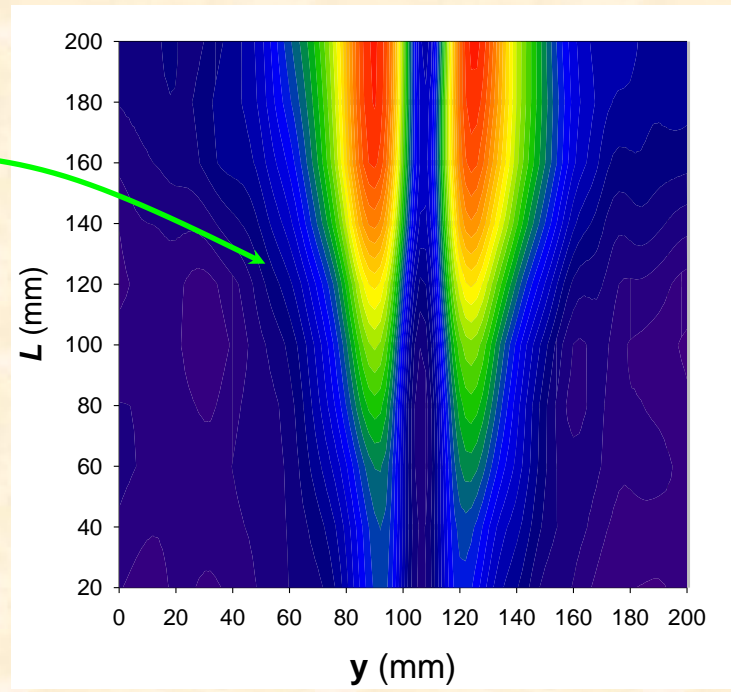
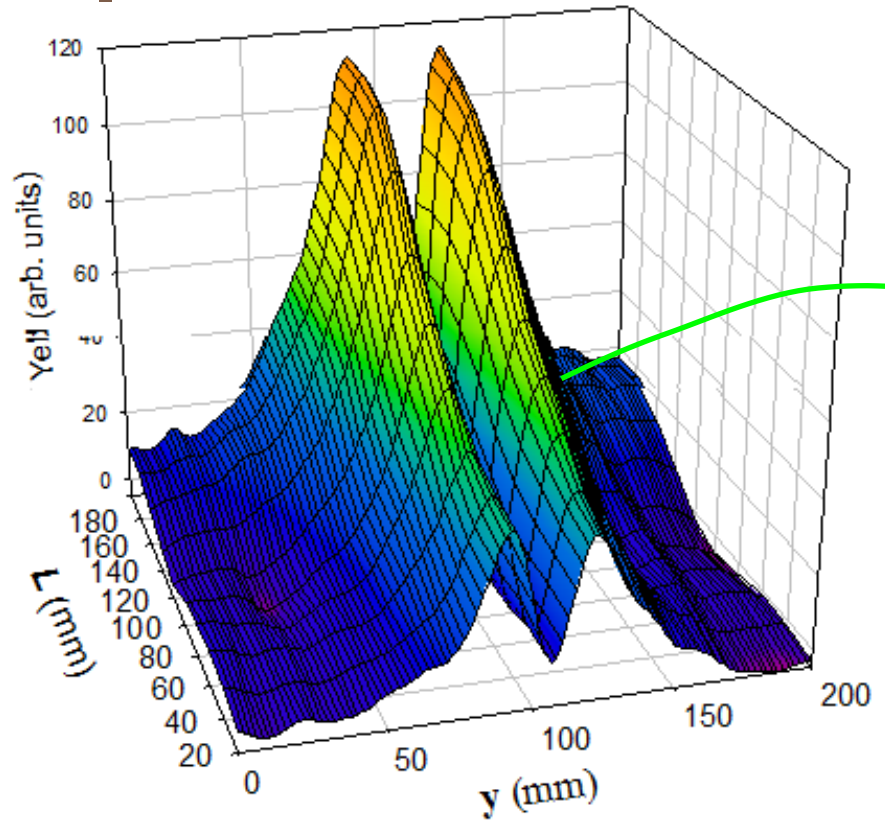
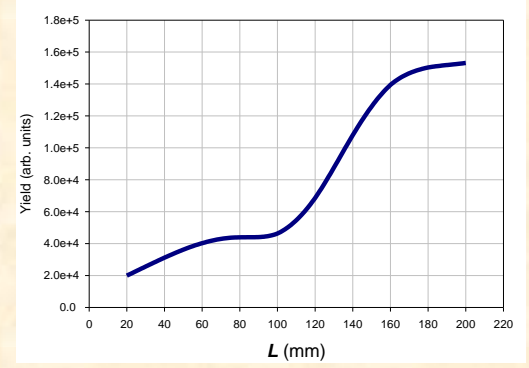


The maximum of sensitivity is provided for  $\lambda = 14 \text{ mm}$

# Measured electron bunch field spatial distribution

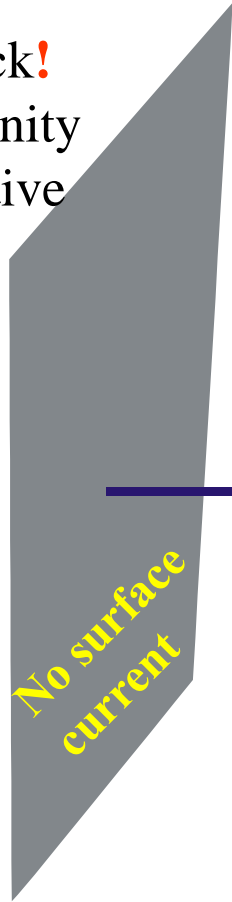


Integral over the transversal area



# Electron field recovery in the classical approximation

The thick!  
and Infinity  
conductive  
screen



No surface  
current

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

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

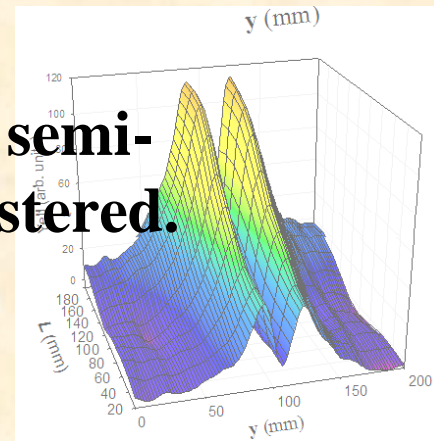
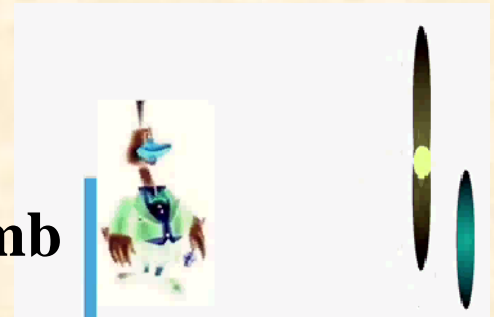
- The surface current model is not applicable for the forward radiation.

~~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