Studies of NEA-photocathodes

V.V. Bakin, D.V. Gorshkov, H.E. Scheibler,

S.N. Kosolobov and **A.S.Terekhov**

Rzhanov Institute of Semiconductor Physics SB RAS, Novosibirsk, Russia

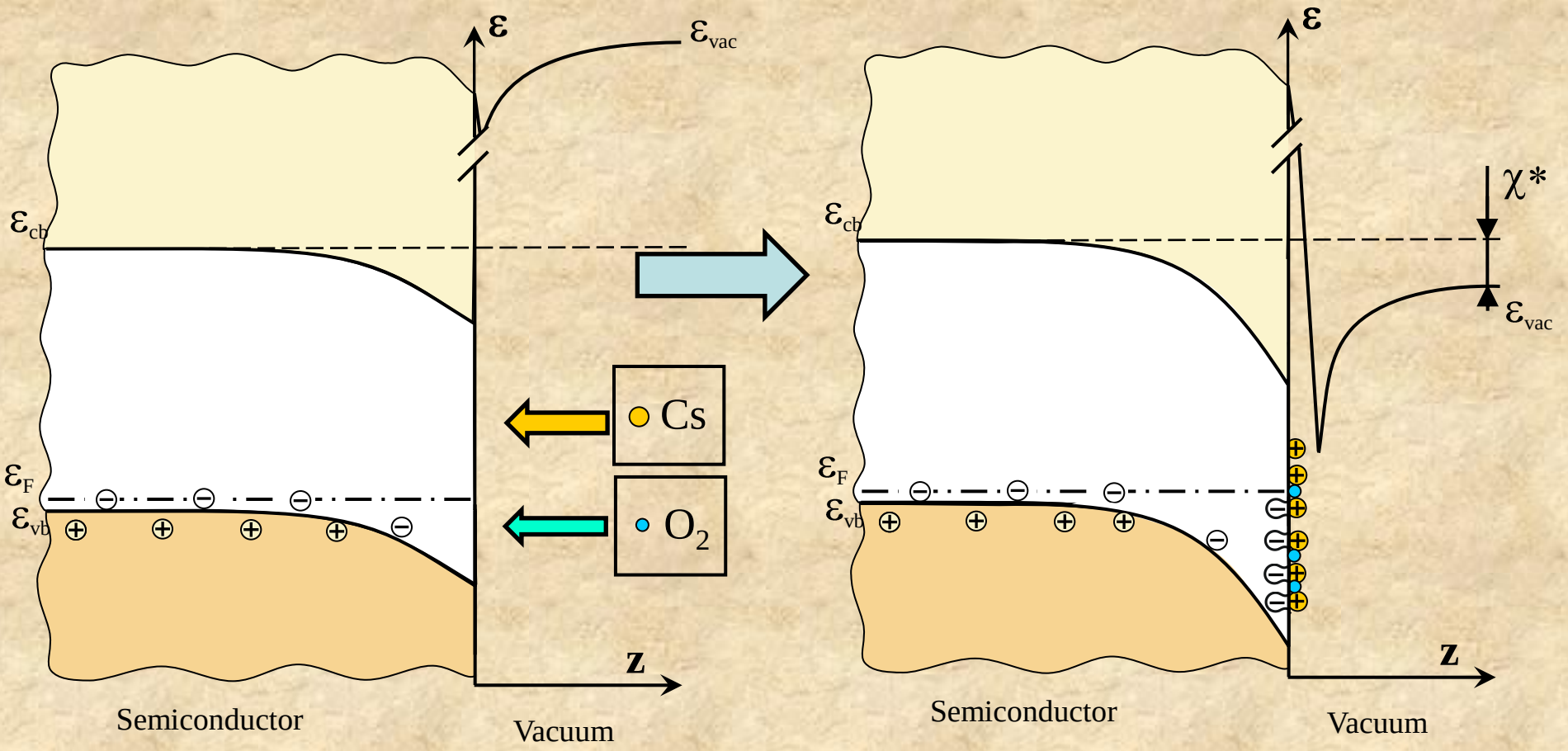
E-mail: terek@isp.nsc.ru

Outlook

1. Motivation.
2. Actual models of (Cs,O)-activation layer.
3. Photoelectron escape model.
4. Parallel plate electron spectrometers.
5. Summary.

2. Actual models of (Cs,O)-activation layer.

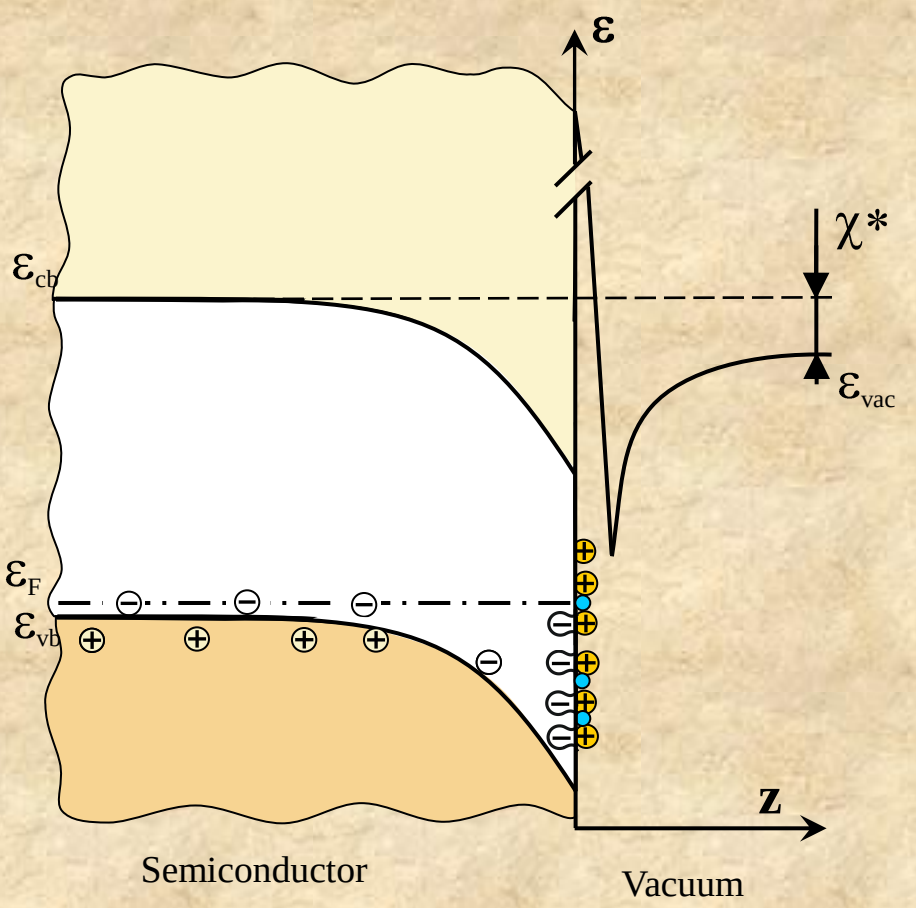
Photocathode activation



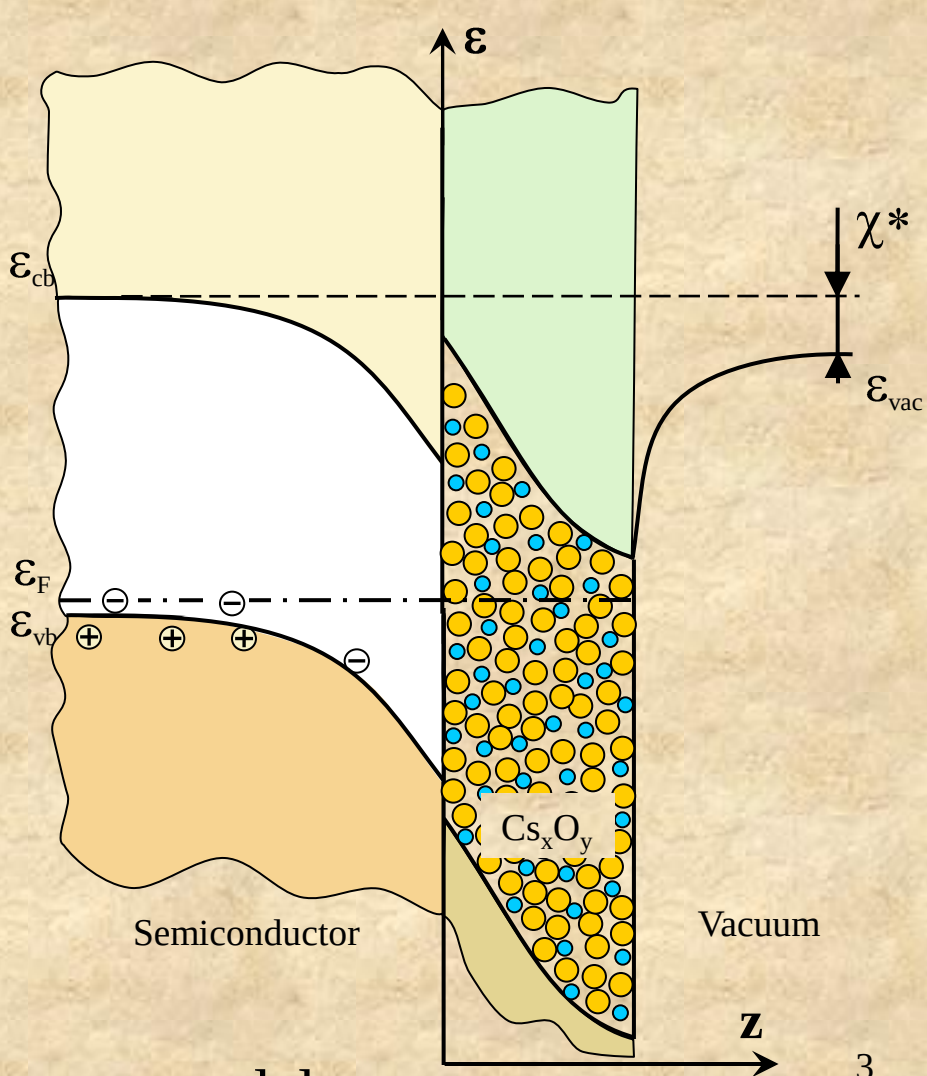
3. Photoelectron escape model.

2. Actual models of (Cs,O)-activation layer.

Dipole layer model



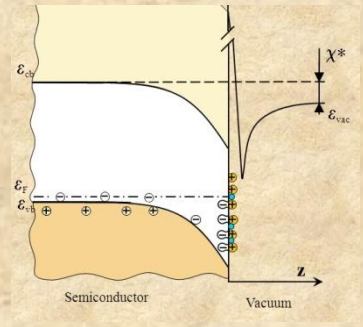
Heterojunction model



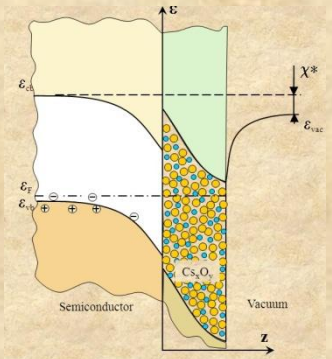
3. Photoelectron escape model.

2. Actual models of (Cs,O)-activation layer.

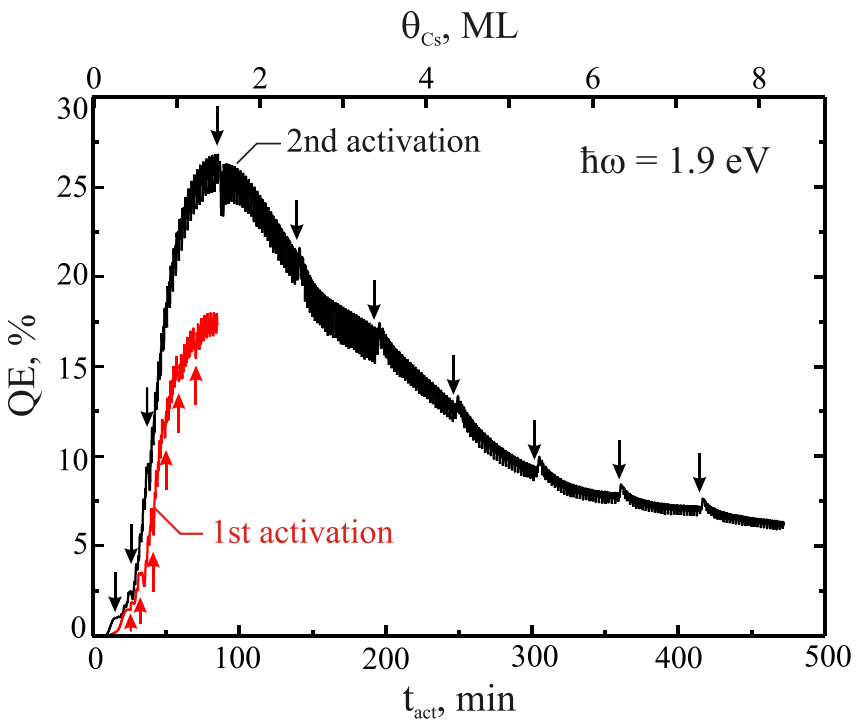
Dipole layer model



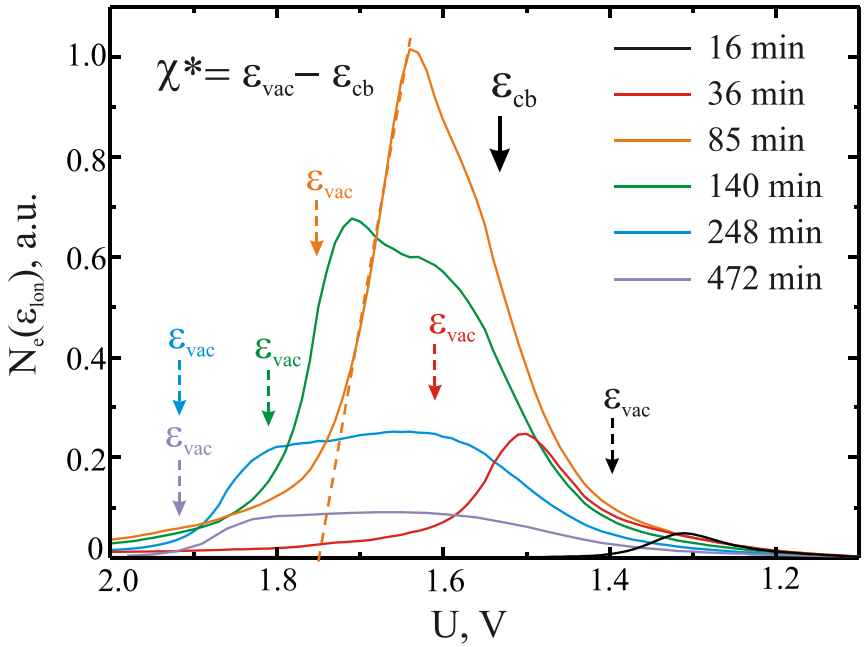
Heterojunction model



Prolonged activation



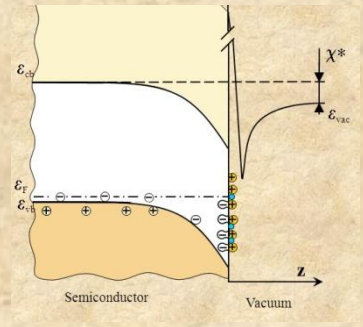
$N_e(\varepsilon_{lon})$-distributions



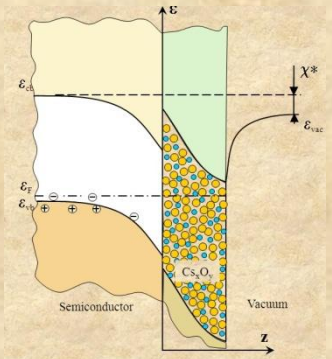
3. Photoelectron escape model.

2. Actual models of (Cs,O)-activation layer.

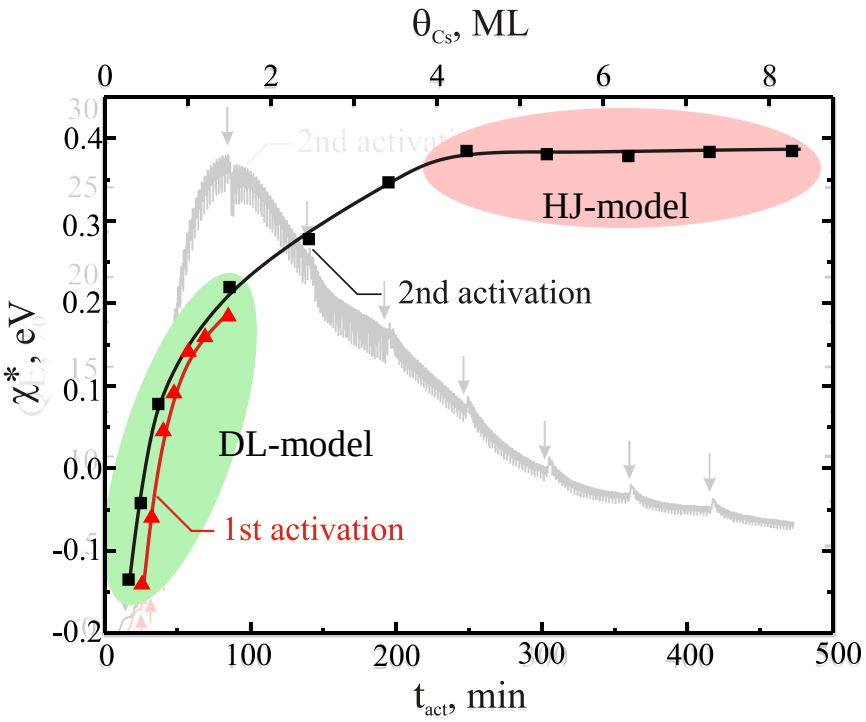
Dipole layer model



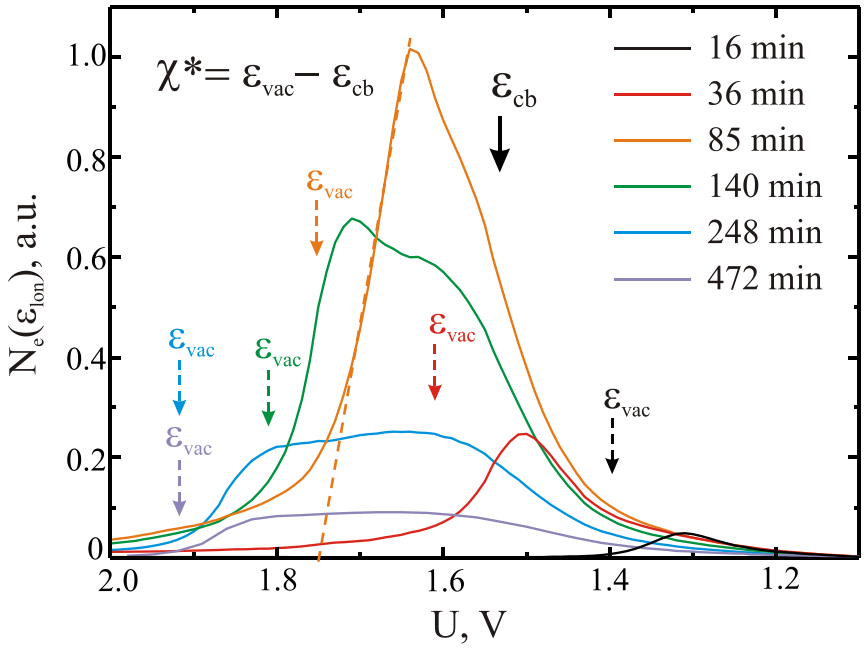
Heterojunction model



Prolonged activation

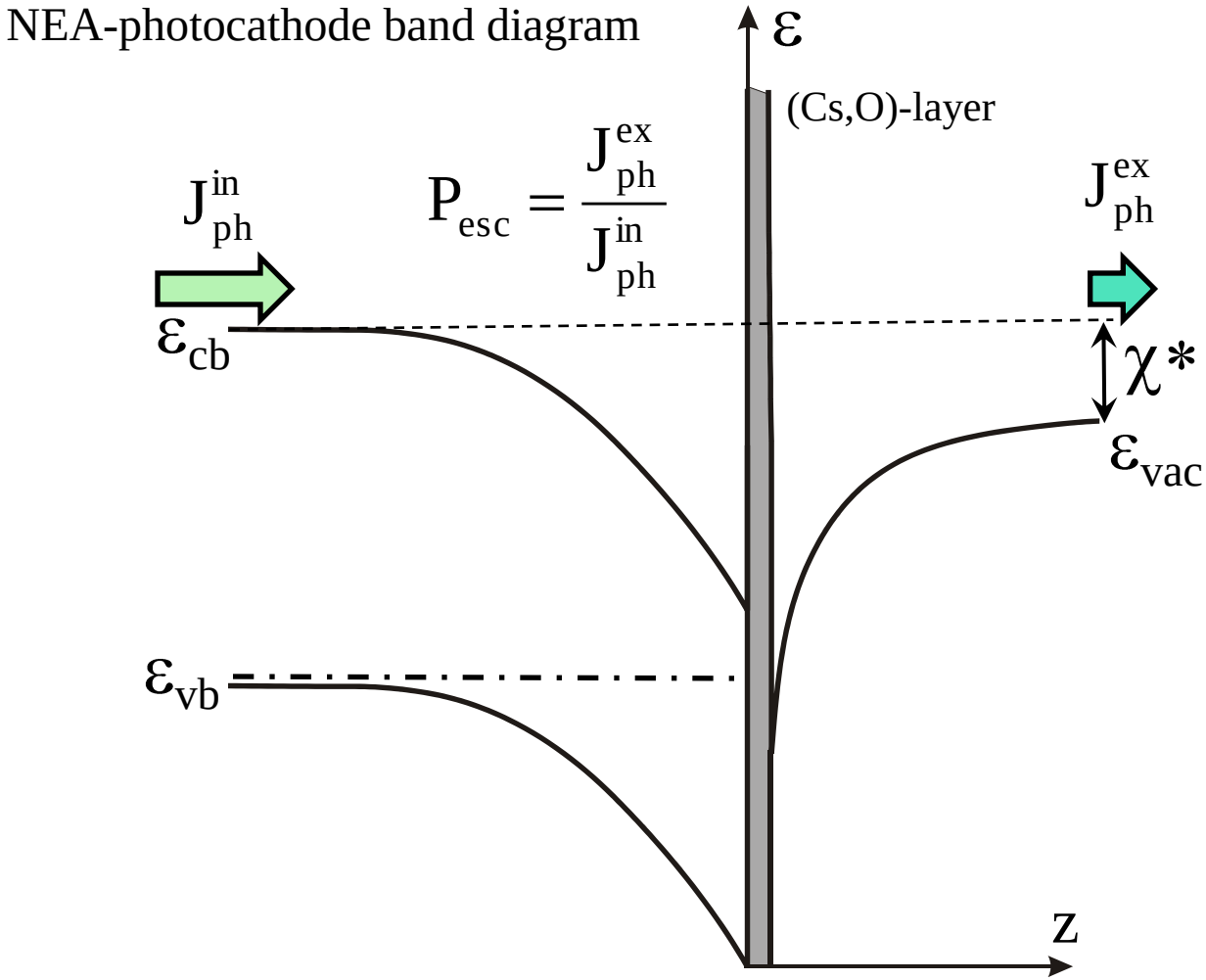


$N_e(\varepsilon_{lon})$-distributions



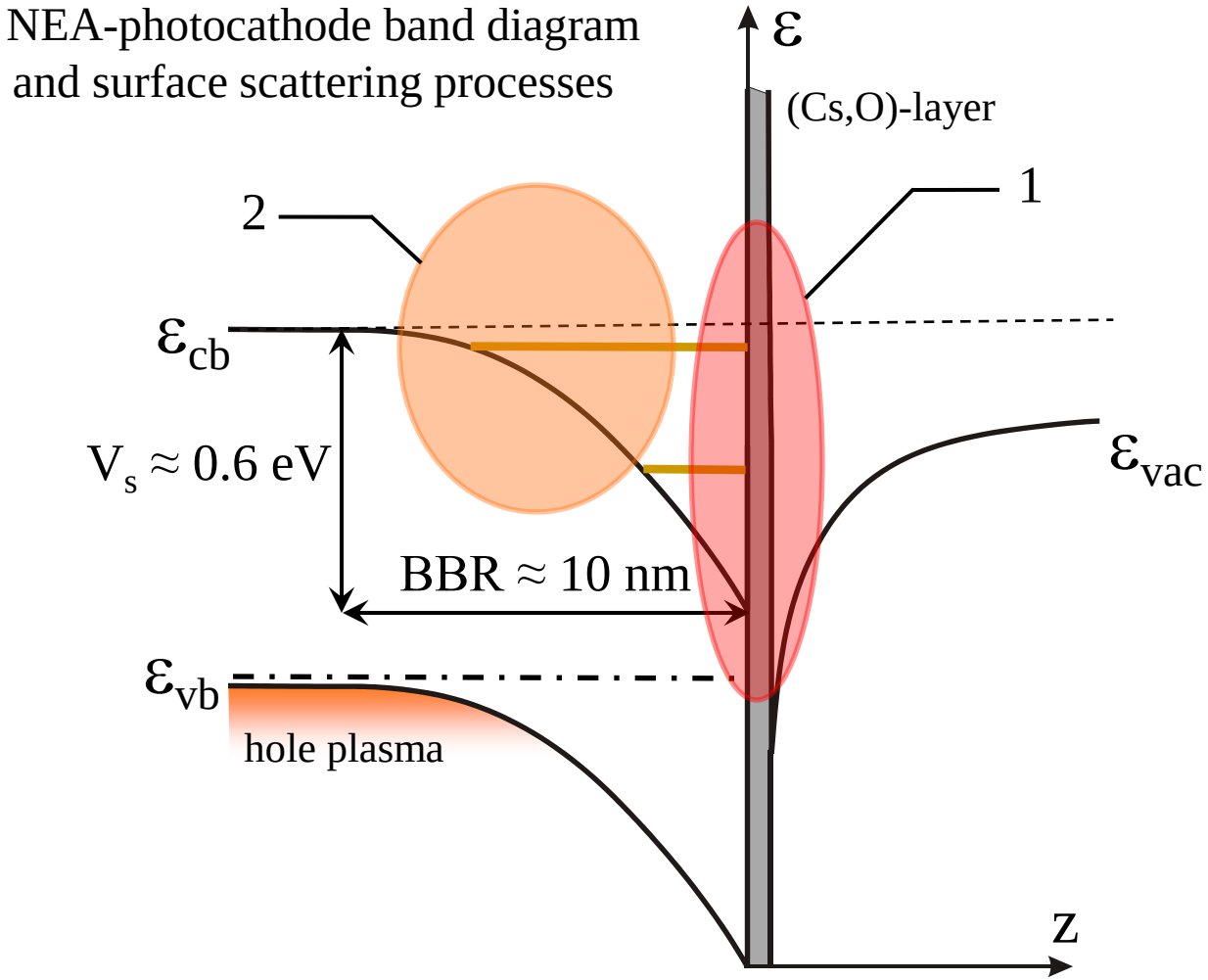
3. Photoelectron escape model.

3. Photoelectron escape model.



4. Parallel plate electron spectrometers.

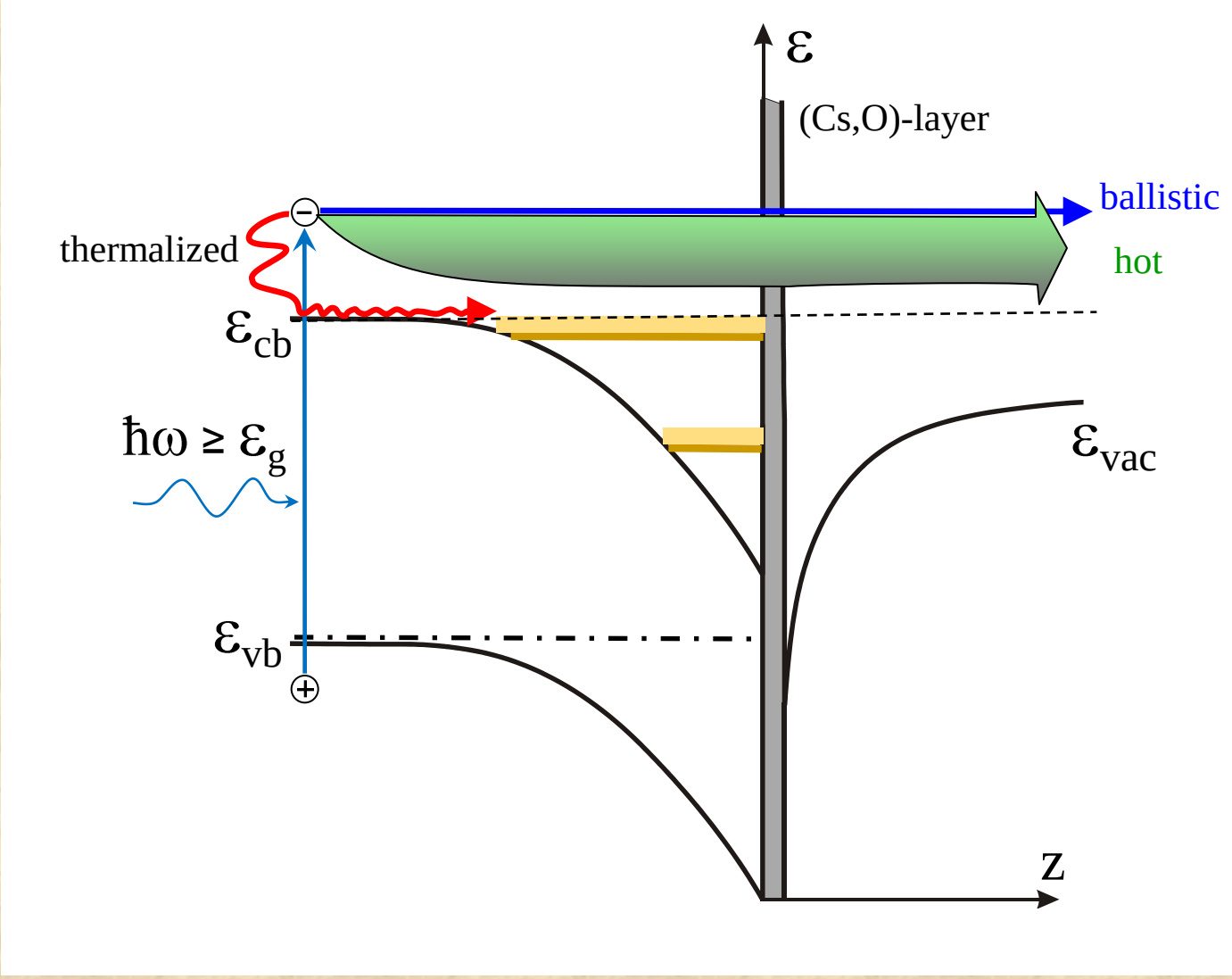
3. Photoelectron escape model.



1. Surface optical phonons.
2. Surface plasmons.
3. BBR- induced random electric field.
4. (Cs,O)-induced random electric field.

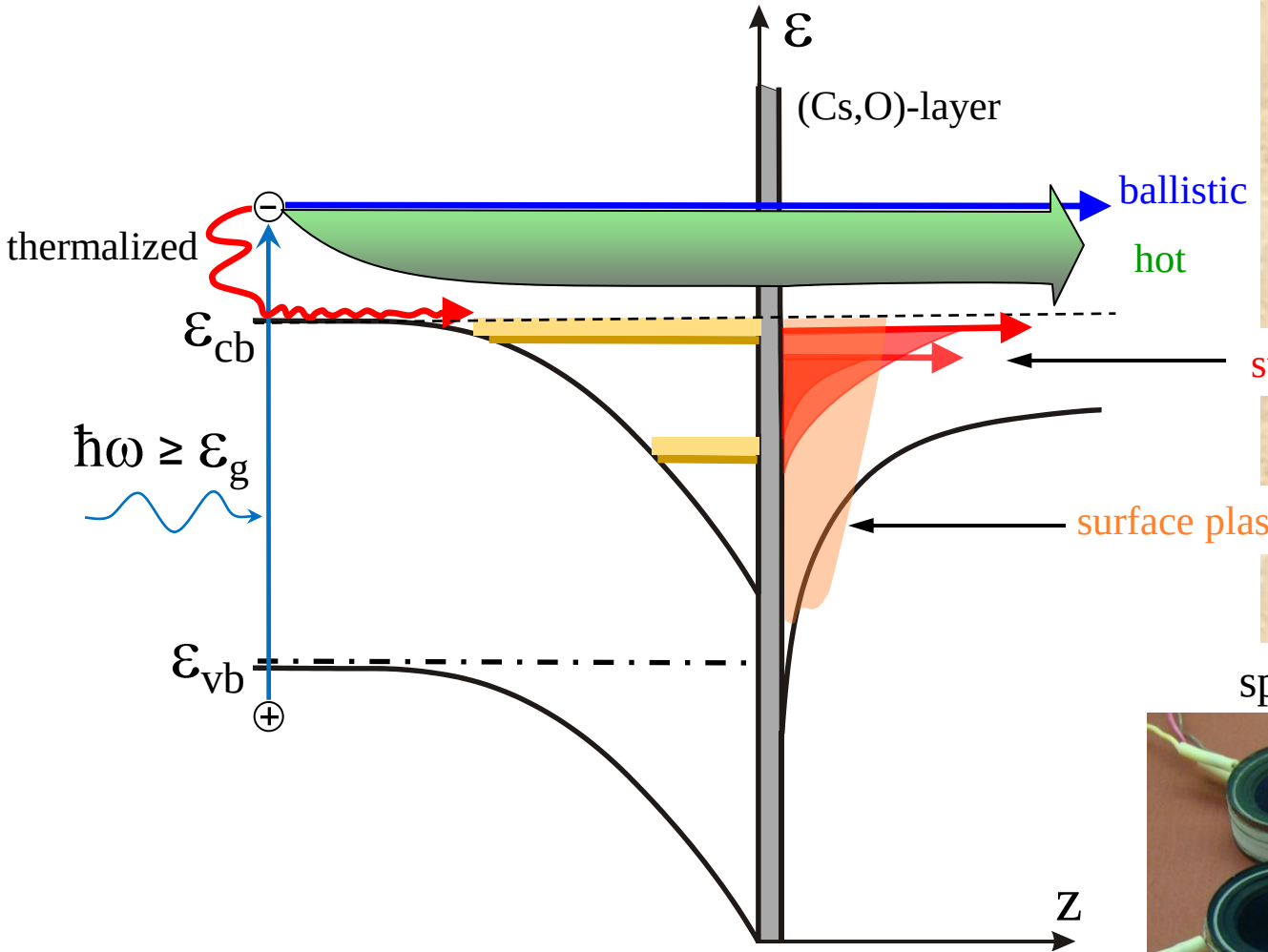
4. Parallel plate electron spectrometers.

3. Photoelectron escape model.



4. Parallel plate electron spectrometers.

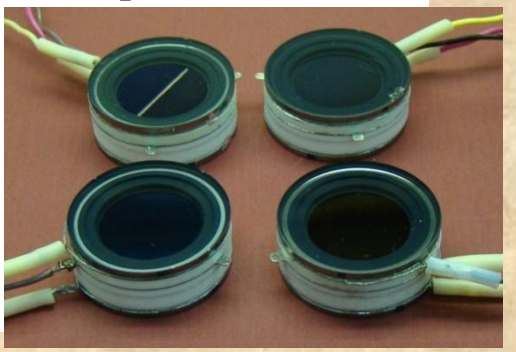
3. Photoelectron escape model.



surface phonon losses

surface plasmon losses

spectrometers



4. Parallel plate electron spectrometers.

3. Photoelectron escape model.

Experiment

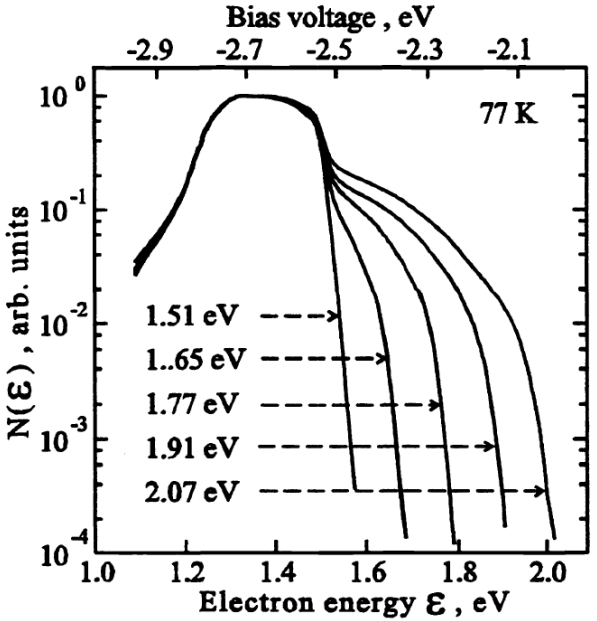


Fig.1 Electron distribution curves measured at various photon energies.

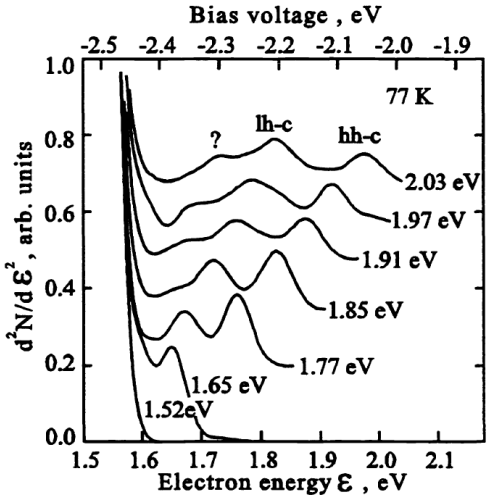


Fig.2 Secondary derivatives of the EDC at various photon energies.

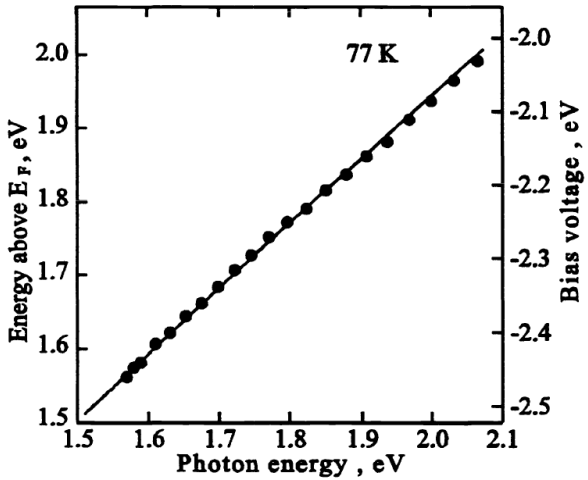


Fig.3 The measured (points, right scale) and calculated (solid line, left scale) energies of ballistic photoelectrons at different photon energies.

A.S. Terekhov, D.A. Orlov, SPIE Proc. v.2550, p.157 (1995)

4. Parallel plate electron spectrometers.

3. Photoelectron escape model.

Experiment

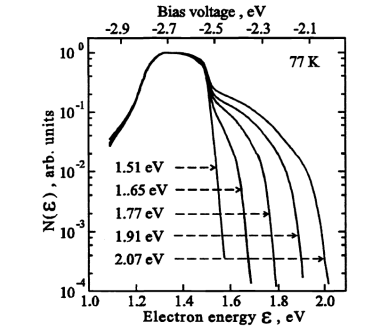


Fig.1 Electron distribution curves measured at various photon energies.

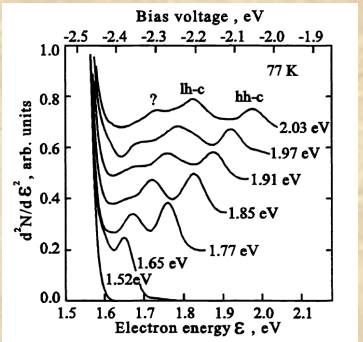


Fig.2 Secondary derivatives of the EDC at various photon energies.

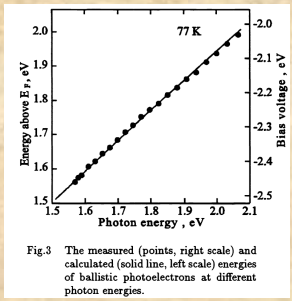
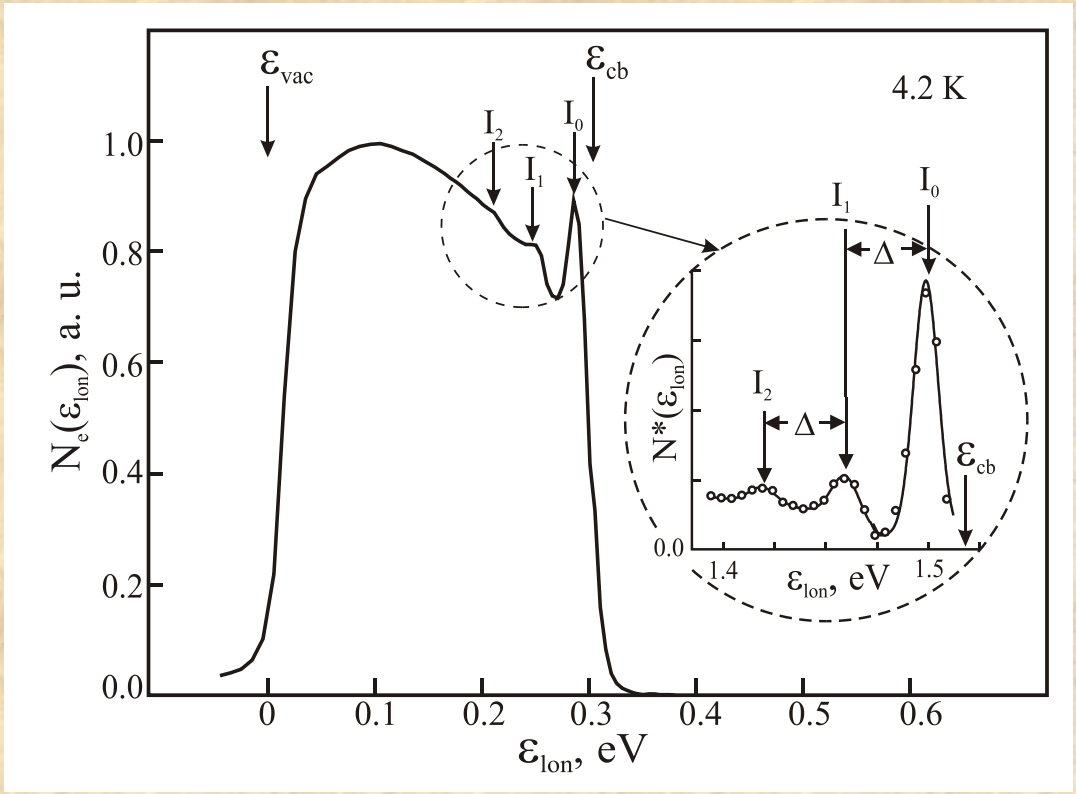


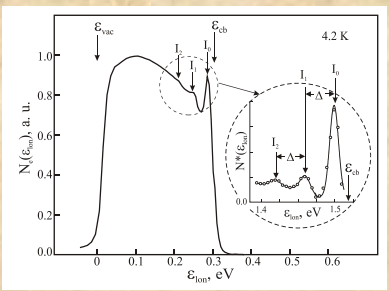
Fig.3 The measured (points, right scale) and calculated (solid line, left scale) energies of ballistic photoelectrons at different photon energies.



D.A. Orlov et.al., JETP Letters v.71, p.220 (2000)

4. Parallel plate electron spectrometers.

3. Photoelectron escape model.



Experiment

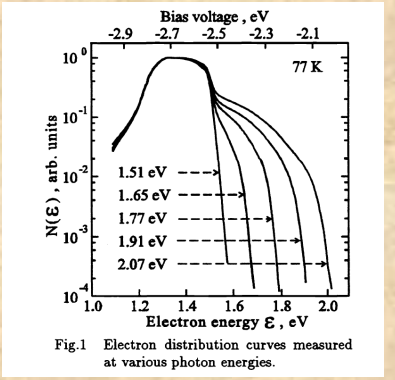


Fig.1 Electron distribution curves measured at various photon energies.

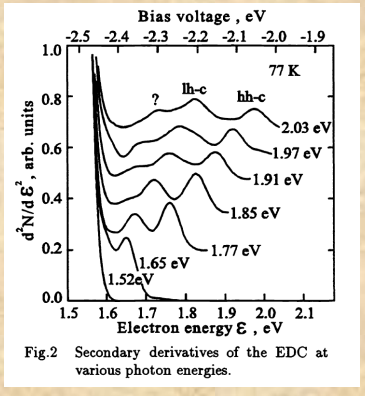


Fig.2 Secondary derivatives of the EDC at various photon energies.

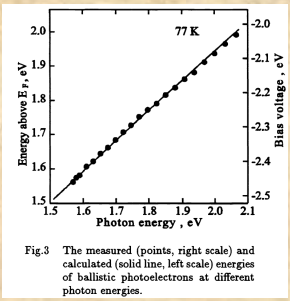
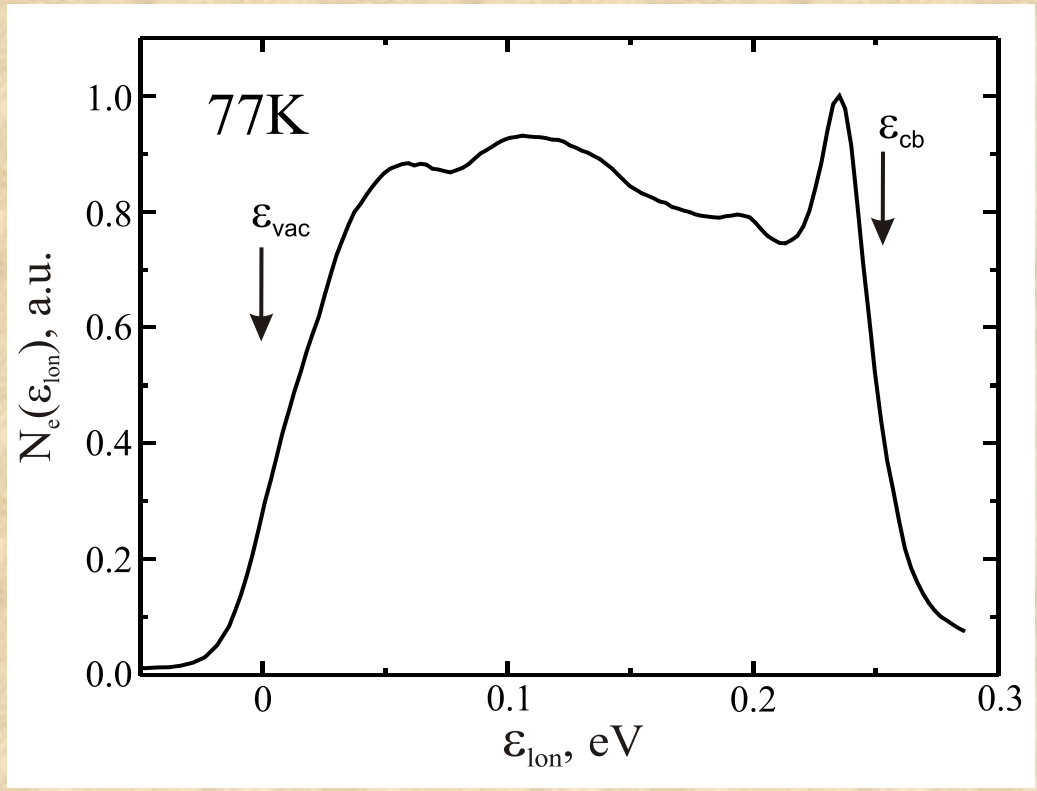


Fig.3 The measured (points, right scale) and calculated (solid line, left scale) energies of ballistic photoelectrons at different photon energies.

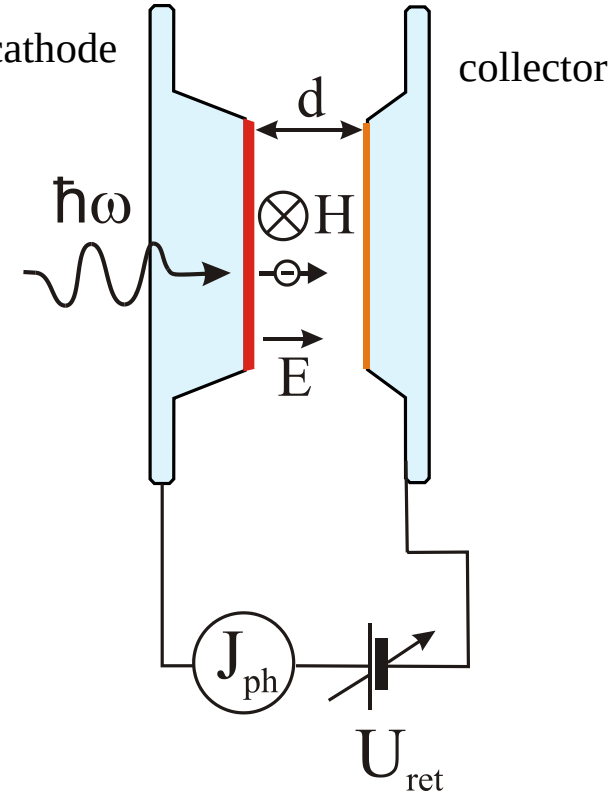


V.V. Bakin et. al., JETP Letters v.77, p.167 (2003)

4. Parallel plate electron spectrometers.

4. Parallel plate electron spectrometers.

$N_e(\varepsilon,\theta)$ -spectrometer



Theory

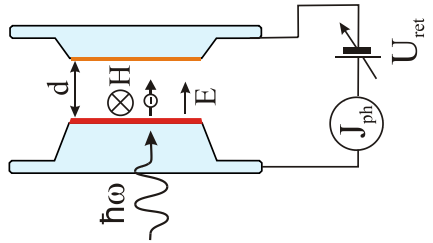
$$J_{ph}(U_{ret}, H) = \int\int G[E, H, d, N_e(\varepsilon,\theta)]\, d\varepsilon\, d\theta$$

V.E. Andreev et.al., Journal of Inversed and Ill-Posed problems, v.7, No.5, p.427 (1999)

5. Summary.

4. Parallel plate electron spectrometers.

$N_e(\varepsilon,\theta)$ -spectrometer

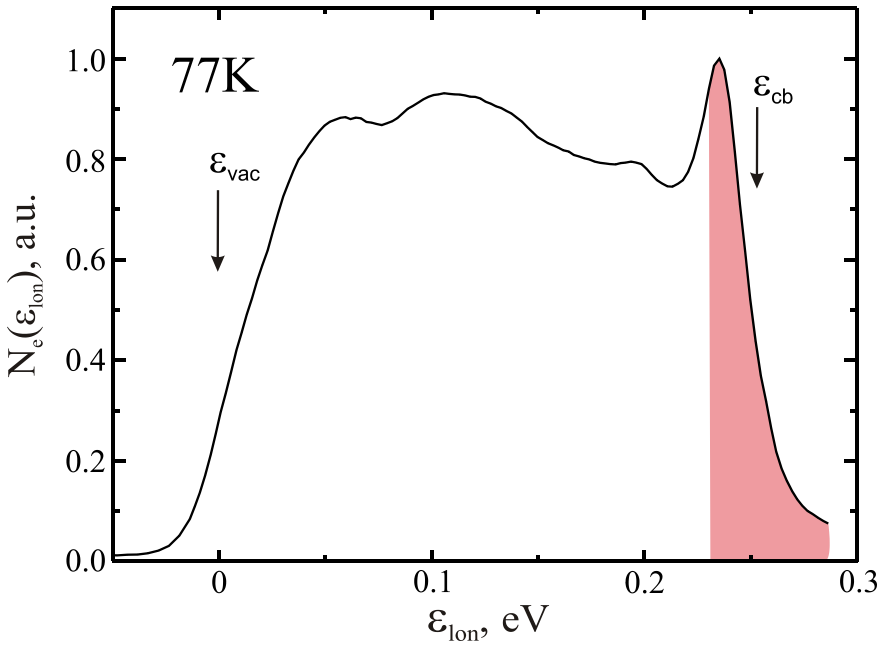


Theory

$$J_{ph}(U_{ret}, H) = \int\int G[E, H, d, N_e(\varepsilon,\theta)]\, d\varepsilon\, d\theta$$

V.E. Andreev et.al., Journal of Inversed and Ill-Posed problems, v.7, No.5, p.427 (1999)

Experiment

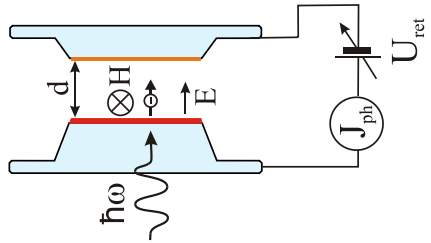


V.V. Bakin et. al., JETP Letters v.77, p.167 (2003)

5. Summary.

4. Parallel plate electron spectrometers.

$N_e(\varepsilon,\theta)$ -spectrometer

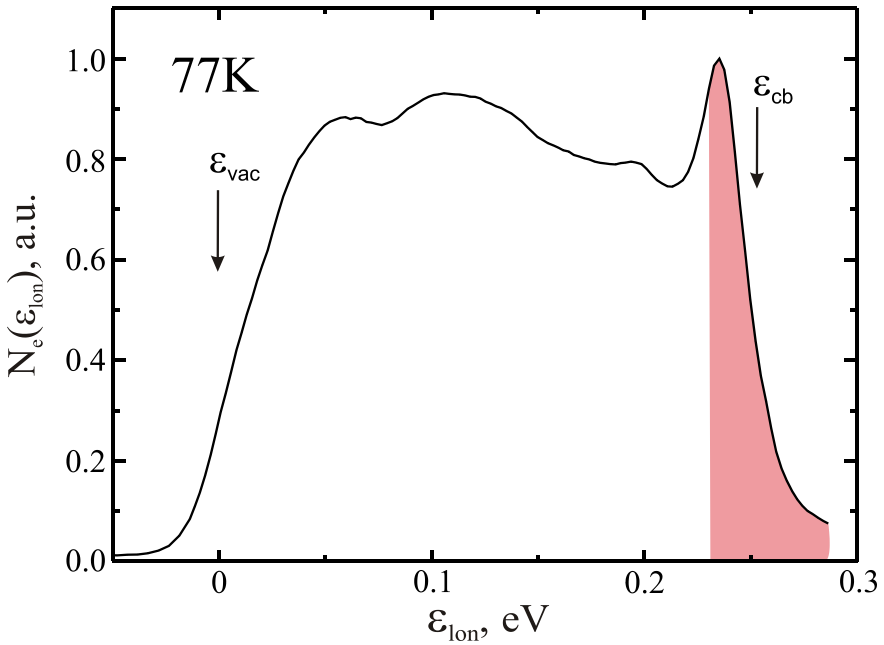


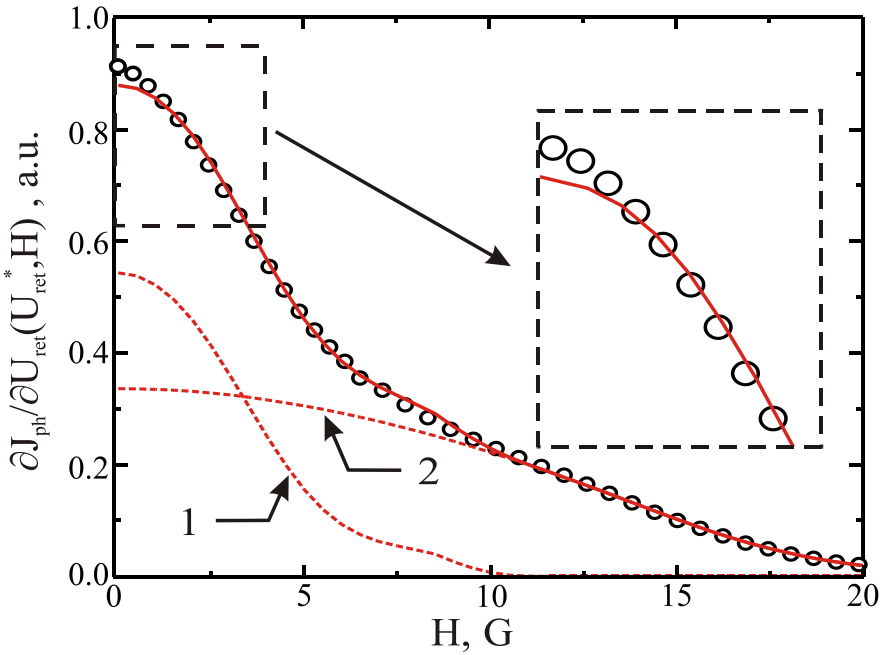
Theory

$$J_{ph}(U_{ret}, H) = \int\int G[E, H, d, N_e(\varepsilon,\theta)]\, d\varepsilon\, d\theta$$

V.E. Andreev et.al., Journal of Inversed and Ill-Posed problems, v.7, No.5, p.427 (1999)

Experiment

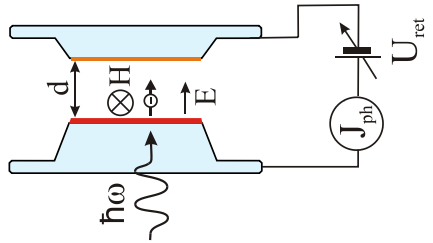




5. Summary.

4. Parallel plate electron spectrometers.

$N_e(\varepsilon,\theta)$ -spectrometer

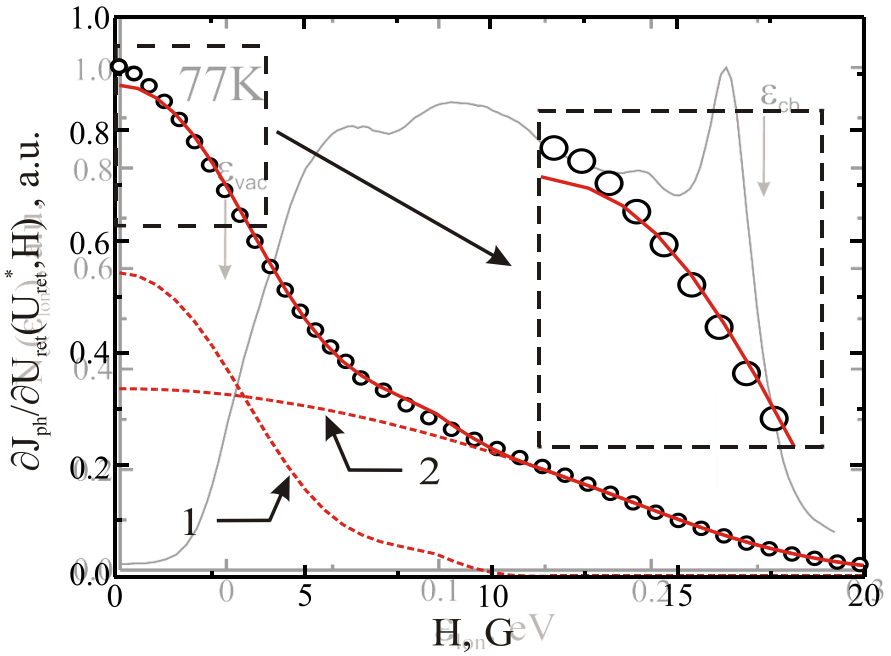


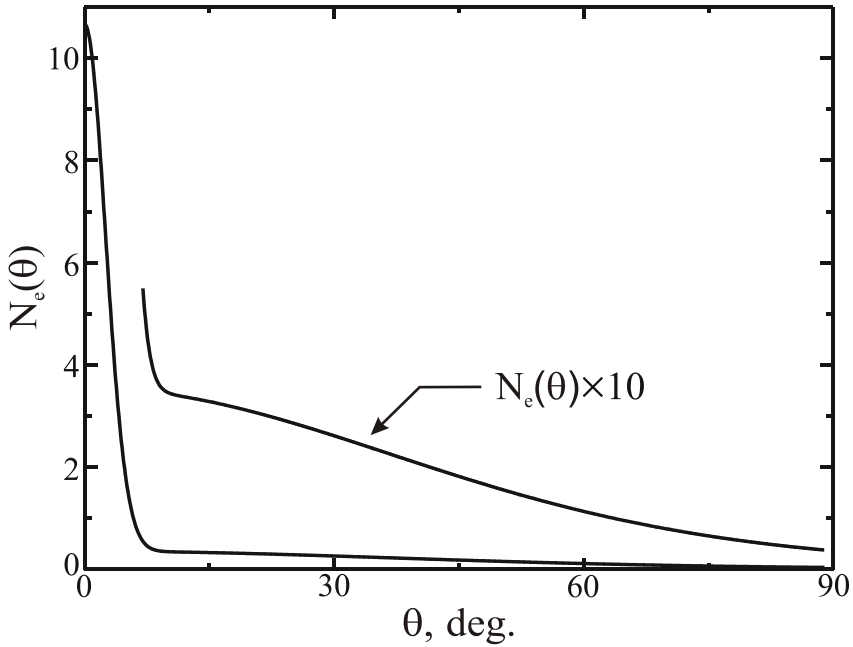
Theory

$$J_{ph}(U_{ret}, H) = \int\int G[E, H, d, N_e(\varepsilon,\theta)]\, d\varepsilon\, d\theta$$

V.E. Andreev et.al., Journal of Inversed and Ill-Posed problems, v.7, No.5, p.427 (1999)

Experiment

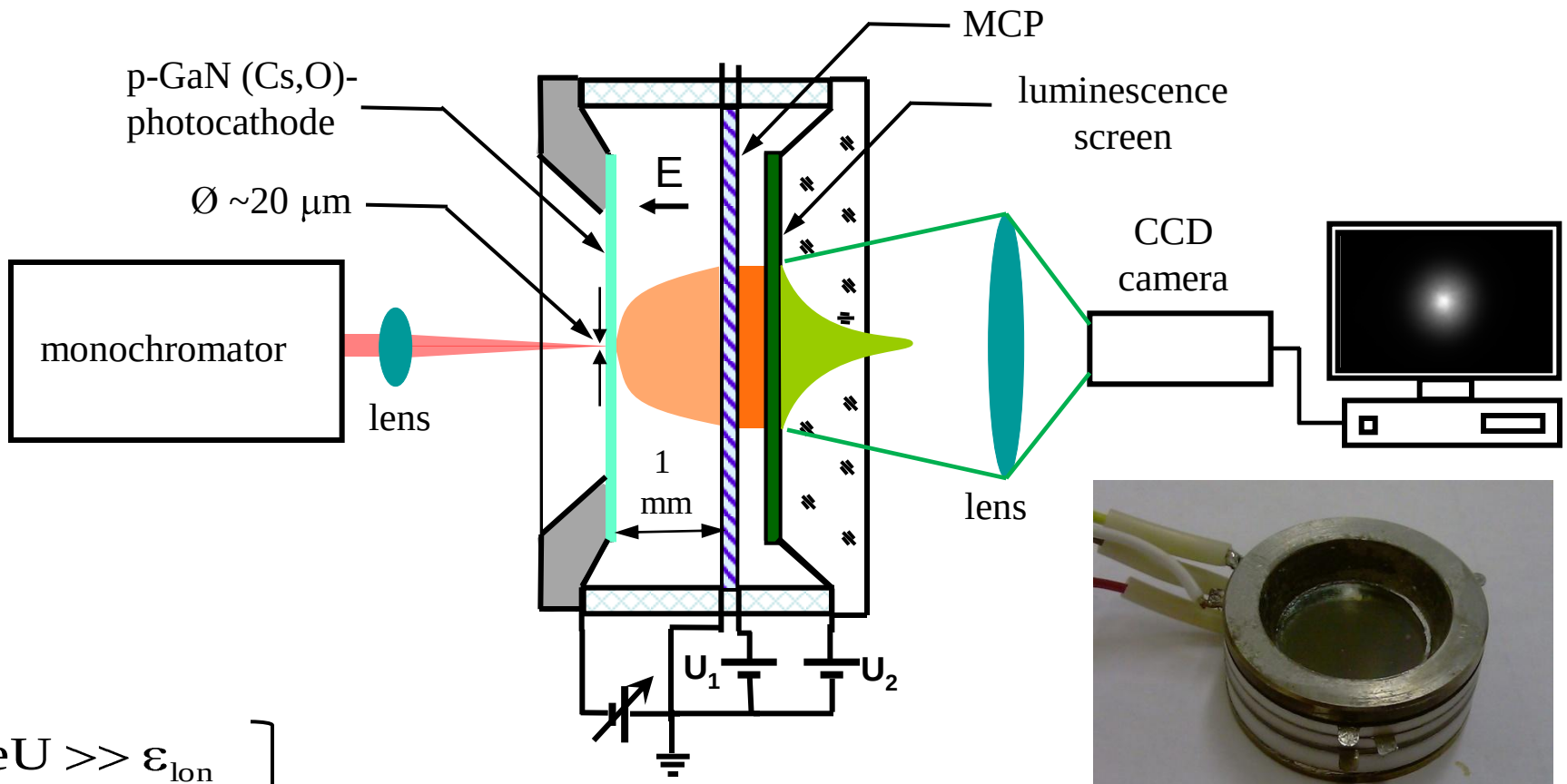




5. Summary.

4. Parallel plate electron spectrometers.

$N_e(\varepsilon_{tr})$ -spectrometer



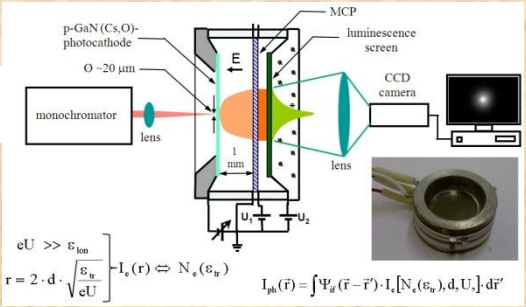
$$\left.\begin{array}{l} eU >> \varepsilon_{lon} \\ r = 2 \cdot d \cdot \sqrt{\dfrac{\varepsilon_{tr}}{eU}} \end{array}\right\} I_e(r) \Leftrightarrow N_e(\varepsilon_{tr})$$

$$I_{ph}(\vec{r}) = \int \Psi_{if}(\vec{r} - \vec{r}') \cdot I_e[N_e(\varepsilon_{tr}), d, U] \cdot d\vec{r}'$$

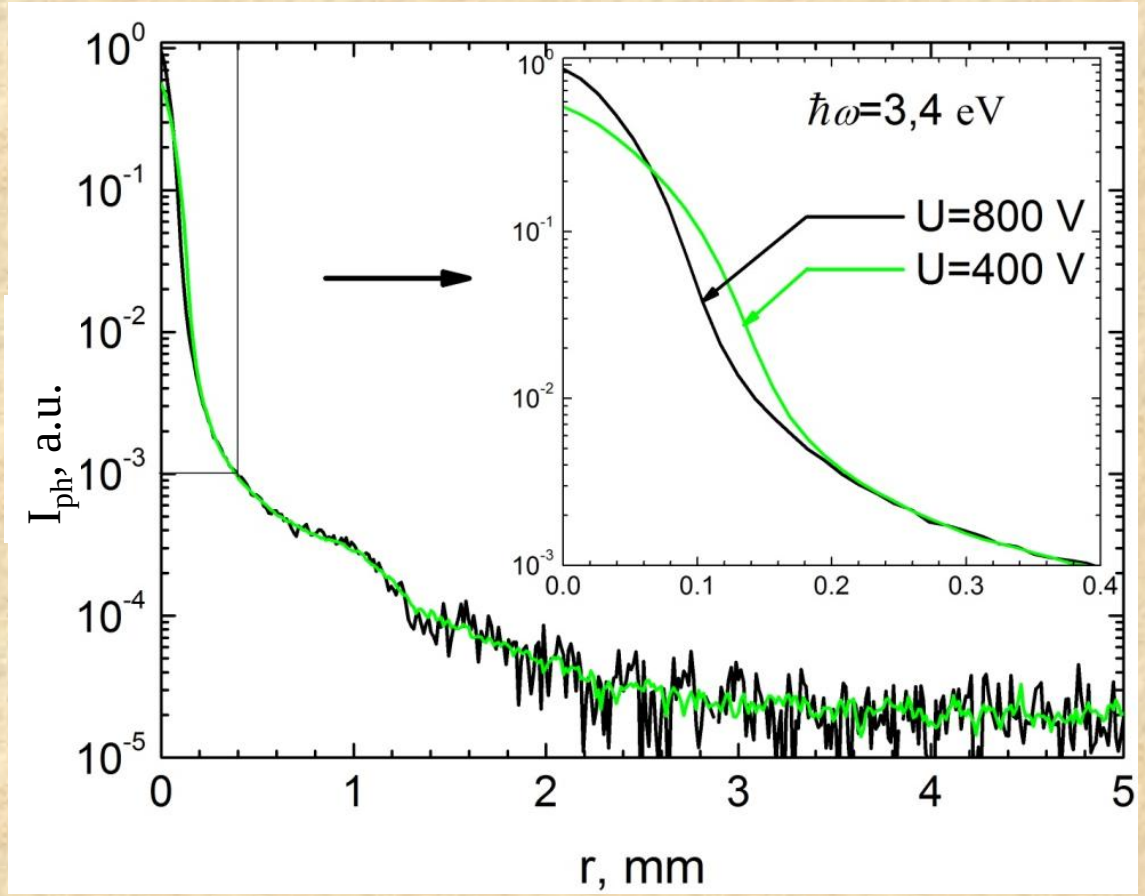
5. Summary.

4. Parallel plate electron spectrometers.

$N_e(\varepsilon_{tr})$ -spectrometer



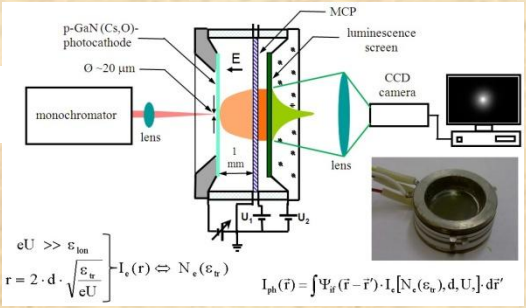
Experiment



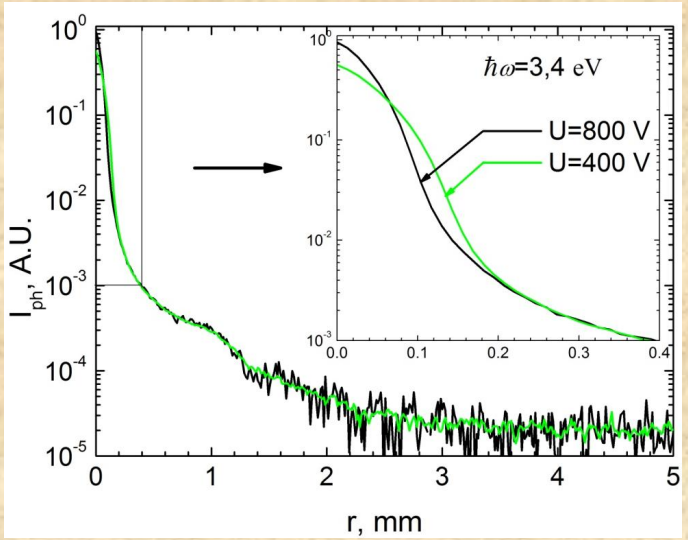
5. Summary.

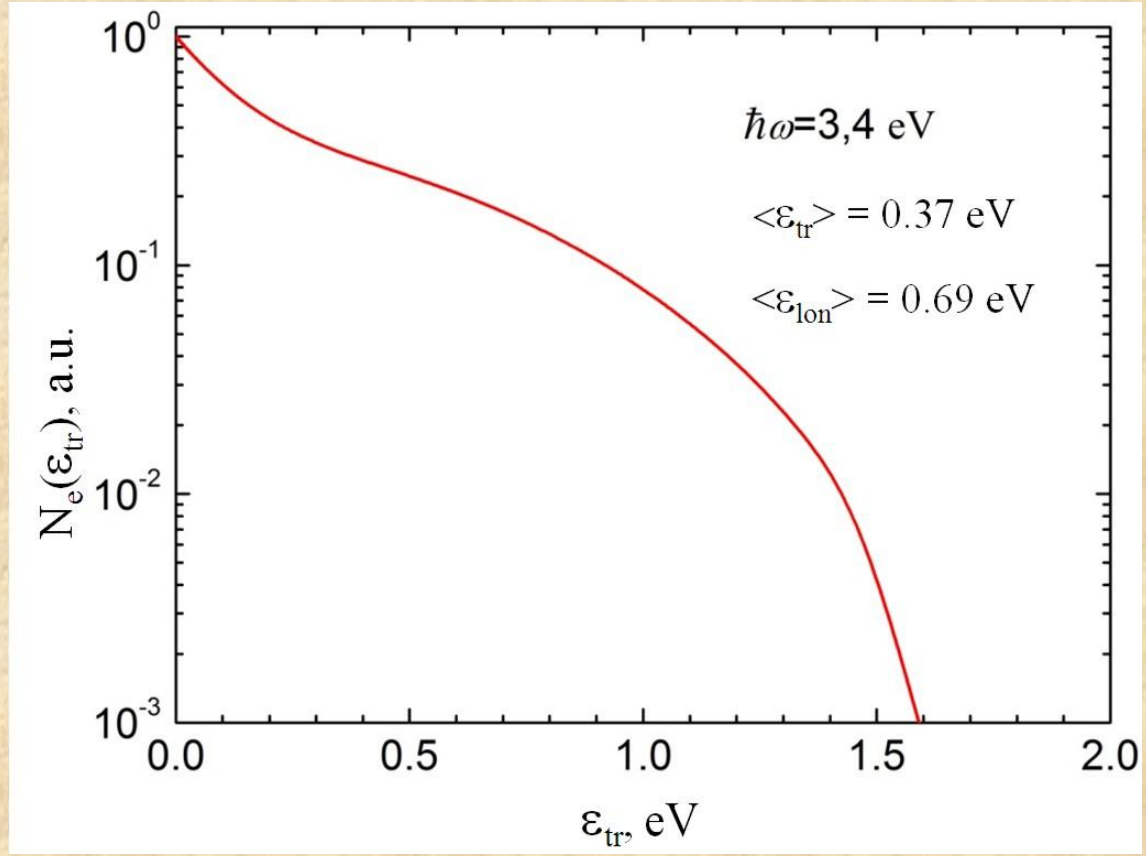
4. Parallel plate electron spectrometers.

$N_e(\varepsilon_{tr})$ -spectrometer



Experiment

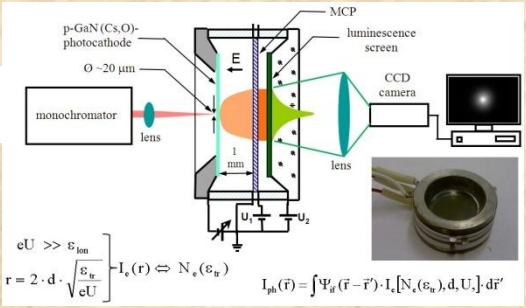




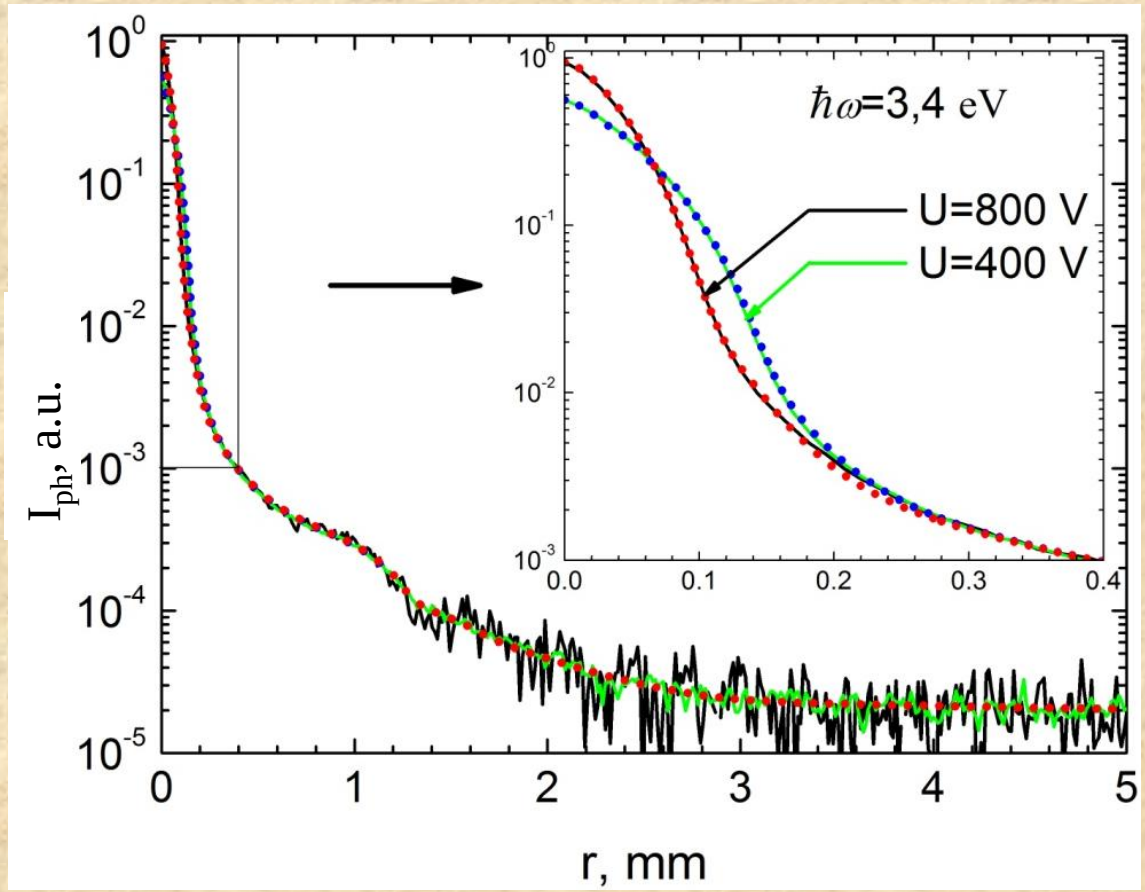
5. Summary.

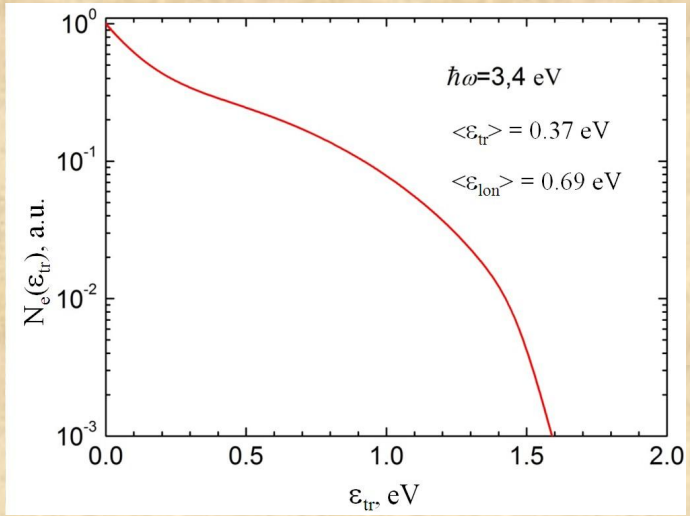
4. Parallel plate electron spectrometers.

$N_e(\varepsilon_{tr})$ -spectrometer



Experiment





5. Summary.

Summary

- p-GaAs (Cs,O) – photocathodes with practically useful values of QEs (> 10%) can be activated with considerably different properties of (Cs,O) – layers, which lead to different escape models and to different energy distributions of emitted electrons.
- Low temperature studies of photoemission of from p-GaAs (Cs,O) – photocathodes enable us to develop photoelectron escape model, which is based on size quantization of electron spectra within band bending region, includes inelastic scattering of photoelectrons by surface optical phonons and by surface plasmons. Ballistic photoemission and diffusive scattering of emitted electrons are revealed also.
- Transverse energy distribution of photoelectrons from p-GaN (Cs,O) – photocathode was measured within broad range, which enable one to calculate MTE and to evaluate the halo of electron beam.