First Measurements of Photoelectron Transverse Energy Distribution Curve using TESS

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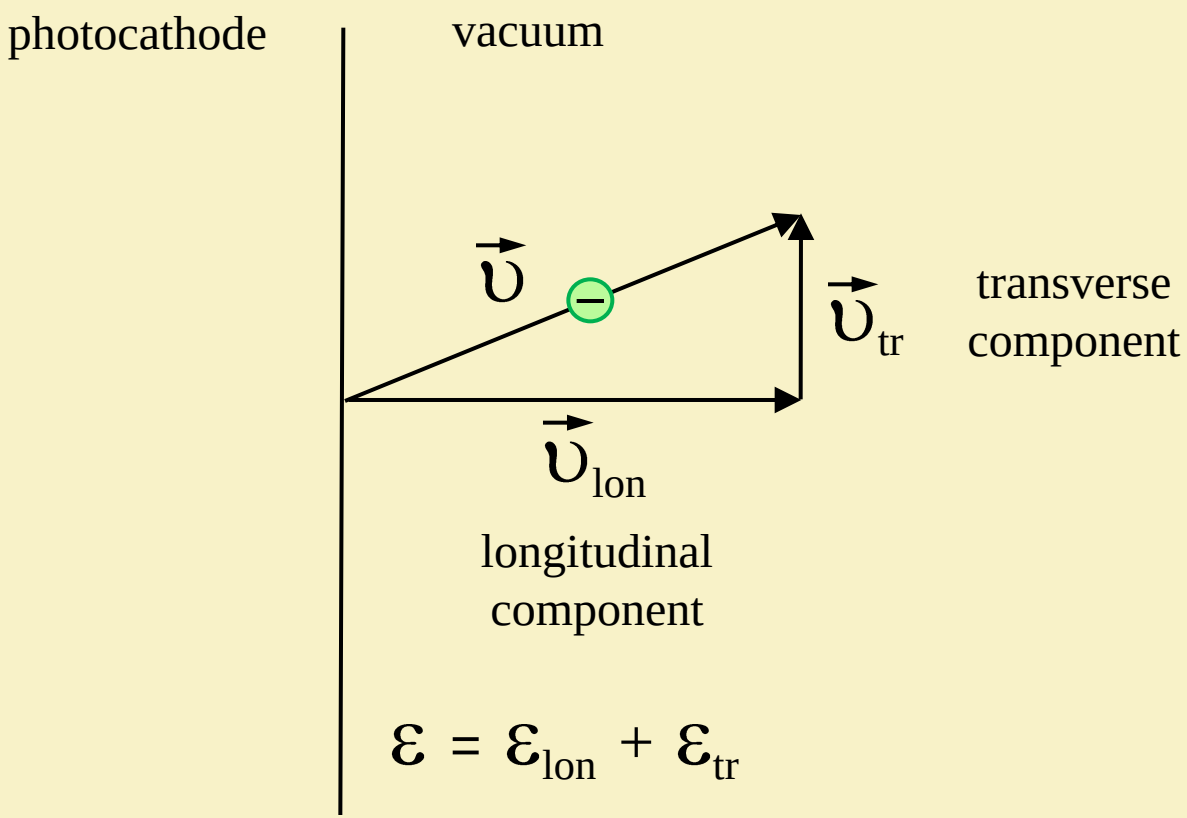
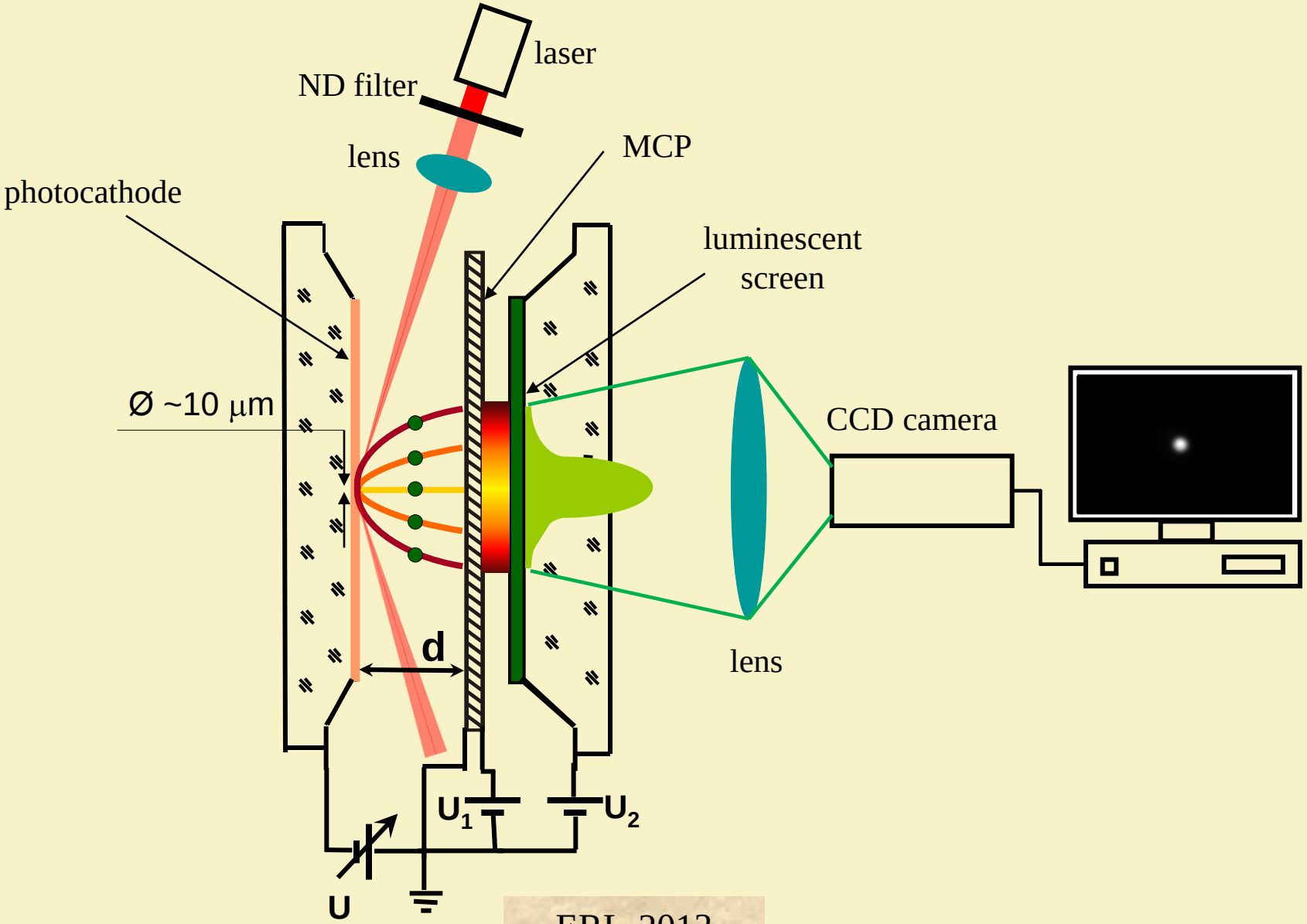
TESS - Transverse Energy Spread Spectrometer, located at Daresbury Laboratory, UK.

Principles of the technique



Principles of the technique



Principles of the technique

Electron transit time from photocathode to MCP front surface τ is equal to

$$\tau = d \times \sqrt{\frac{2\,m_e}{e\,U_{acc}}} \times \left(\sqrt{1 + \frac{\varepsilon_{lon}}{e\,U_{acc}}} - \sqrt{\frac{\varepsilon_{lon}}{e\,U_{acc}}} \right)$$

where d – distance between photocathode and MCP, U_{acc} – accelerating voltage, applied between photocathode and MCP, ε_{lon} – longitudinal energy of the electron, m_e- free electron mass, e – electron charge.

In photocathode plane electron moves a distance r

$$r = \sqrt{\frac{\varepsilon_{tr}}{2\,m_e}} \times \tau \qquad \text{and} \qquad \varepsilon_{tr} = \frac{m_e r^2}{2\,\tau^2}$$

Principles of the technique

Conversion of $I_{el}(r)$ to $N(\varepsilon_{tr})$

Amount of electrons which hit the ring with radius r and thickness ∂r is equal to

$$\partial N = A \times 2\pi r\, \partial r \times I_{el}(r)$$

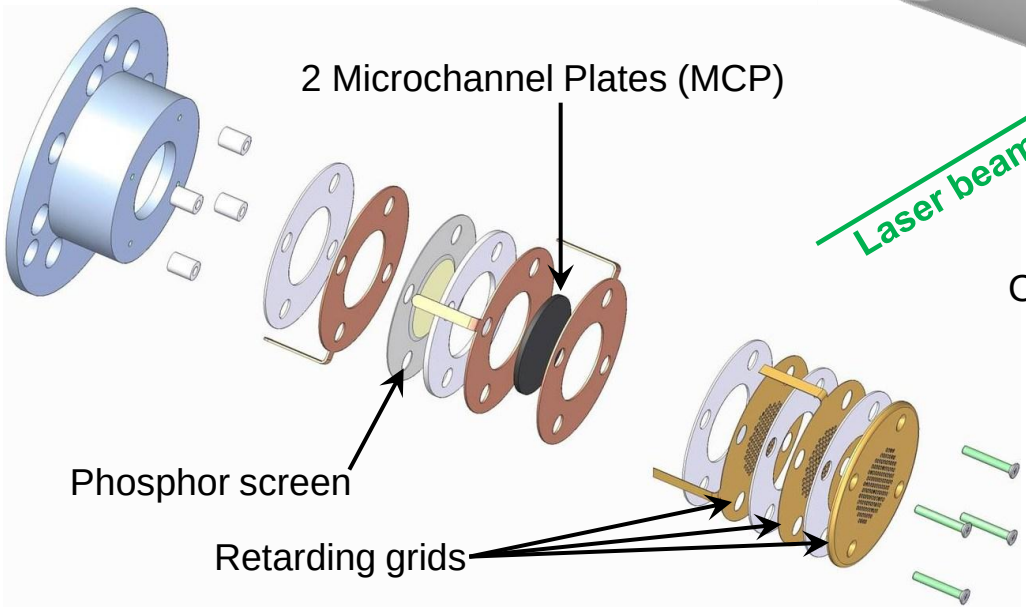
$$N(\varepsilon_{tr}) = \partial N / \partial \varepsilon_{tr} = \frac{A\, 2\pi r\, \partial r\, I_{el}(r)}{m_e r / \tau^2 \times \partial r} \sim I_{el}\left(r = \sqrt{\frac{\varepsilon_{tr}\, 2\tau^2}{m_e}} \right)$$

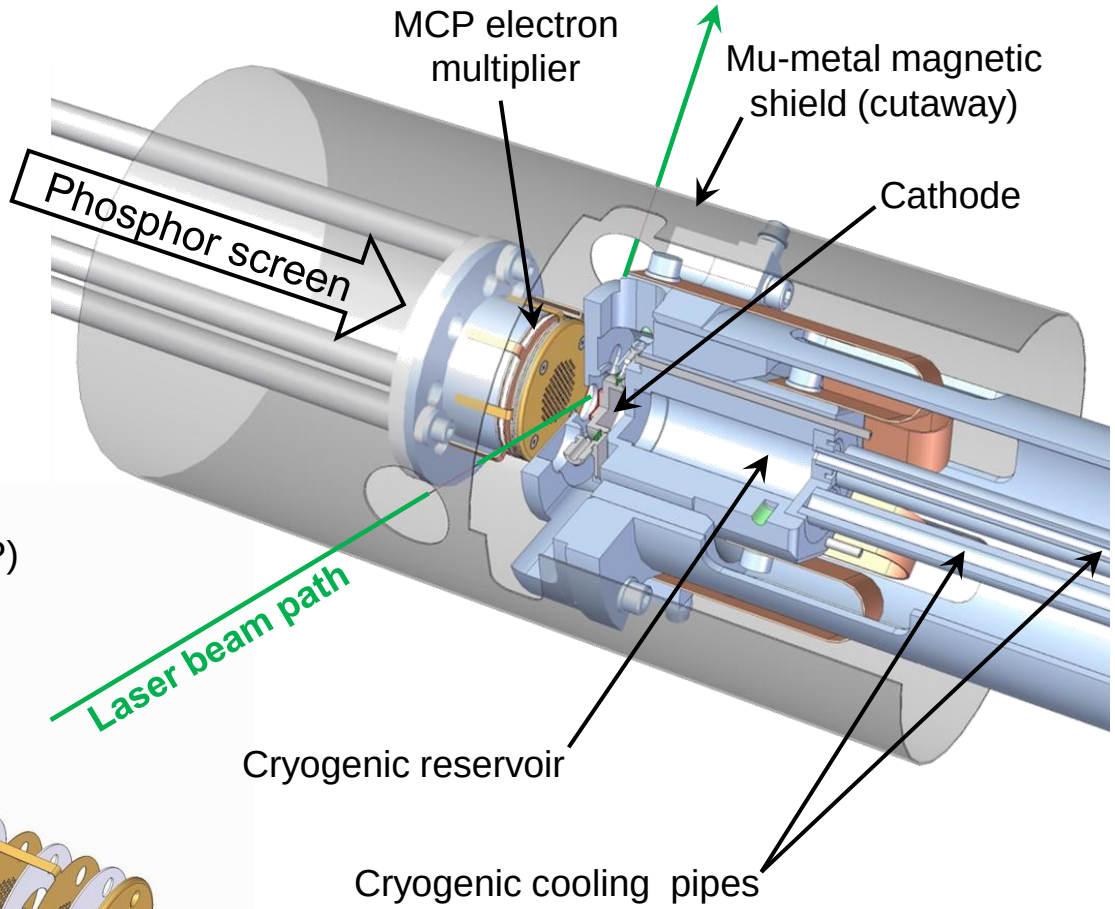
If we can neglect ε_{lon} ($\varepsilon_{lon} << e\, U_{acc}$)

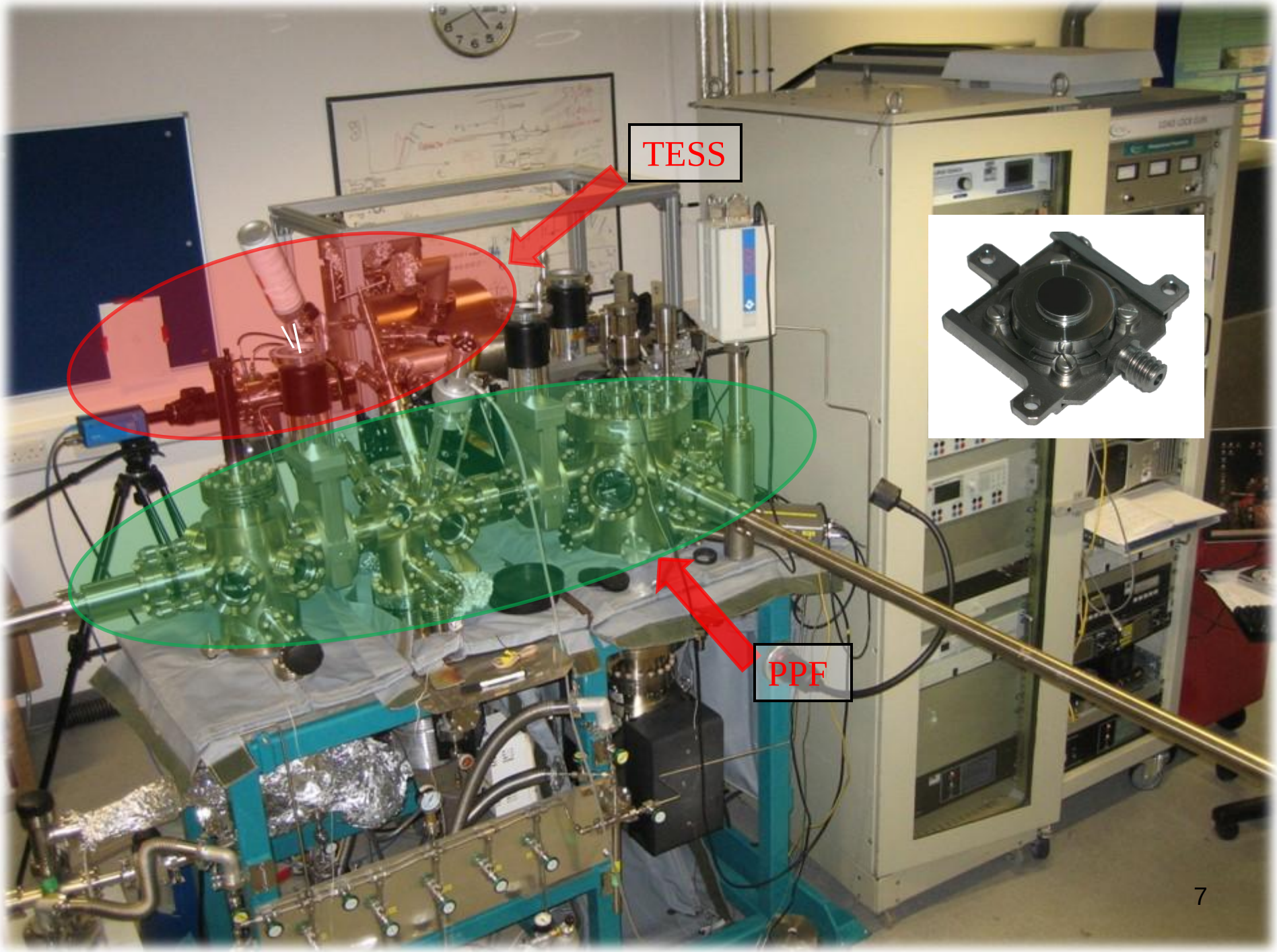
$$\tau = d \times \sqrt{\frac{2\, m_e}{e\, U_{acc}}} \quad \text{and} \quad N(\varepsilon_{tr}) \sim I_{el}\left(r = 2d \times \sqrt{\frac{\varepsilon_{tr}}{e\, U_{acc}}} \right)$$

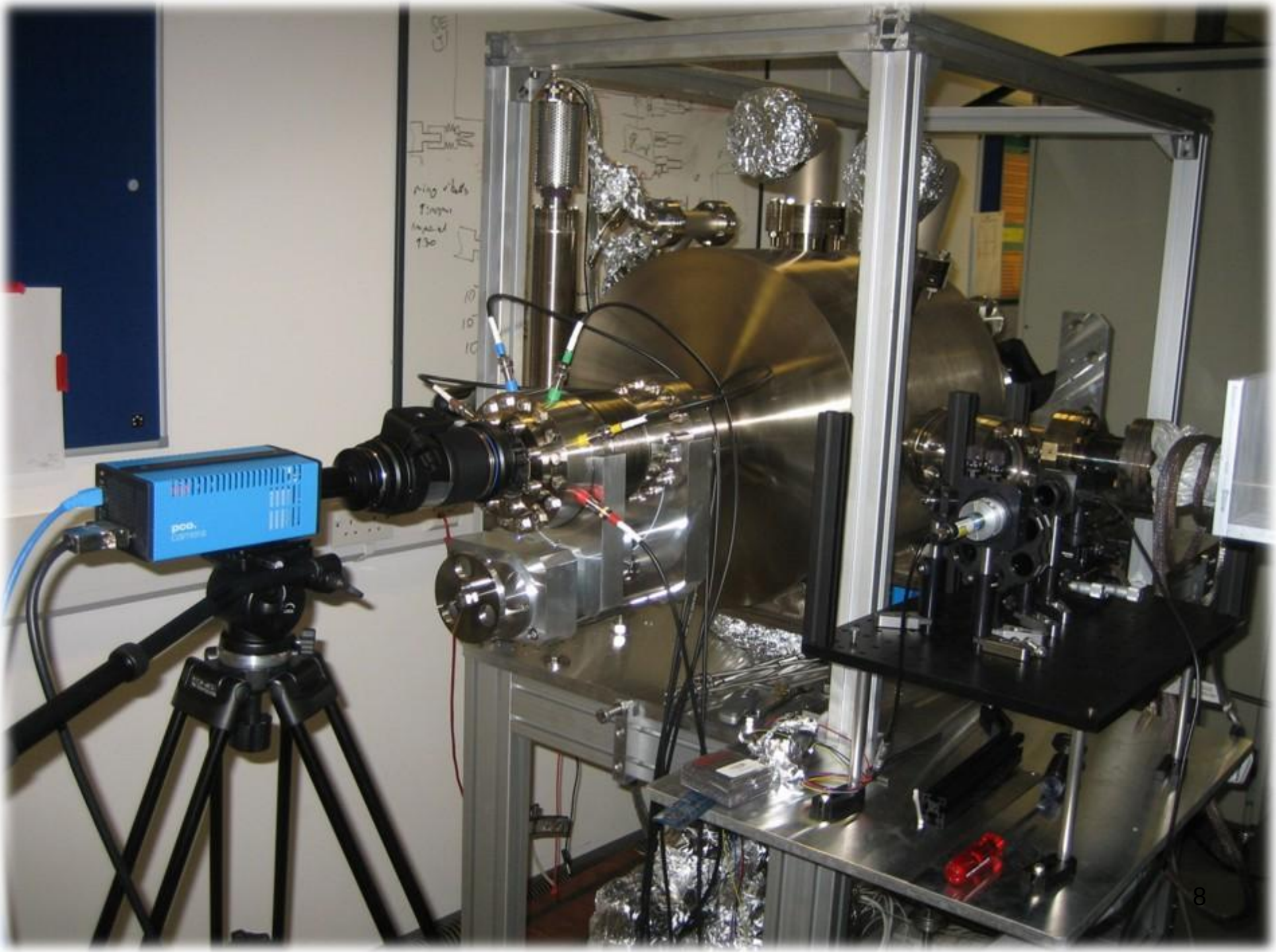
TESS – The Transverse Energy Spread Spectrometer

- Independent control of cathode & grid potentials
- Ability to cool the photocathode to LN_2 temperature
- Ability to change the wavelength of the laser beam
- Ability to 'poison' the cathode through a leak valve

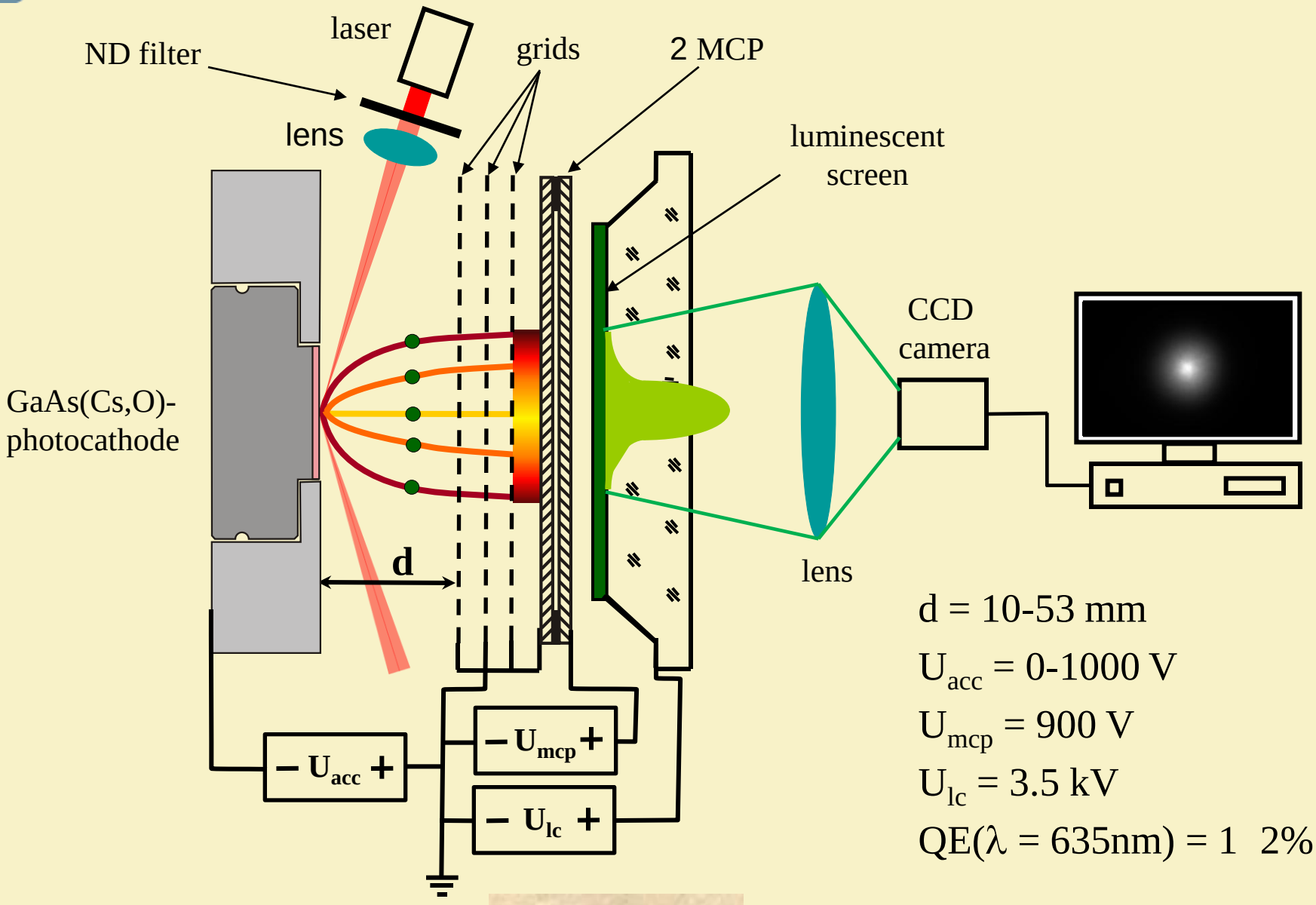





TESS
PPF



TESS measurements conditions



d = 10-53 mm

U_{acc} = 0-1000 V

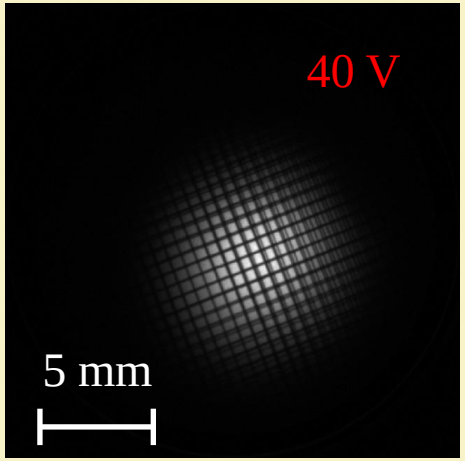
U_{mcp} = 900 V

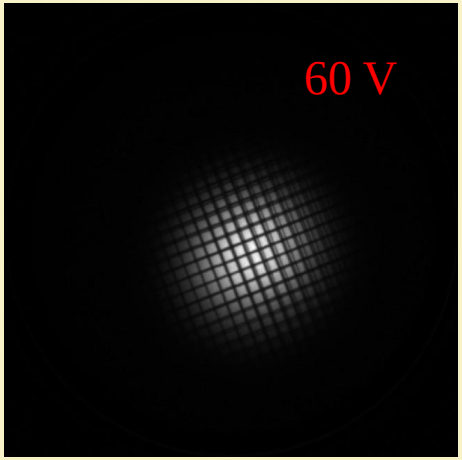
U_{lc} = 3.5 kV

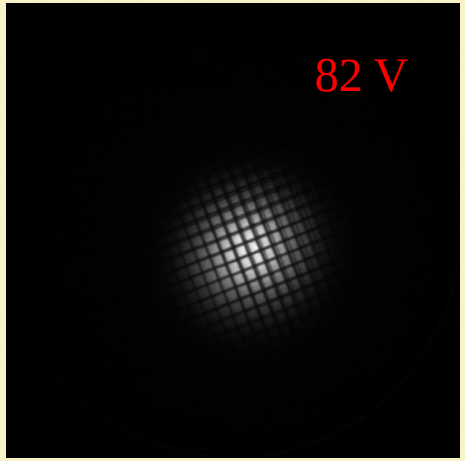
QE(λ = 635nm) = 1 2%

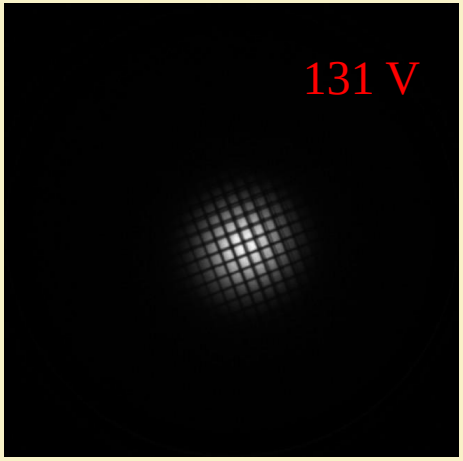
TEDC measurements at different accelerating voltages

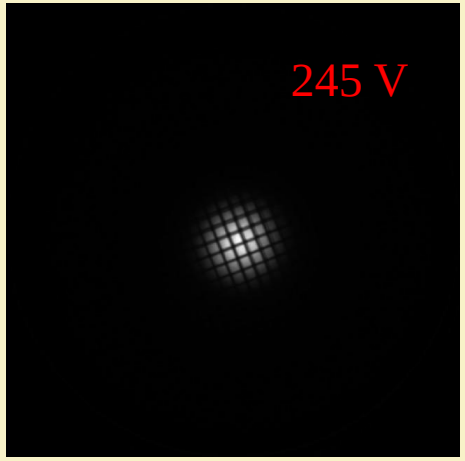
17.06.2013 p-GaAs(Cs,O) photocathode











d = 33 mm λ = 635 nm

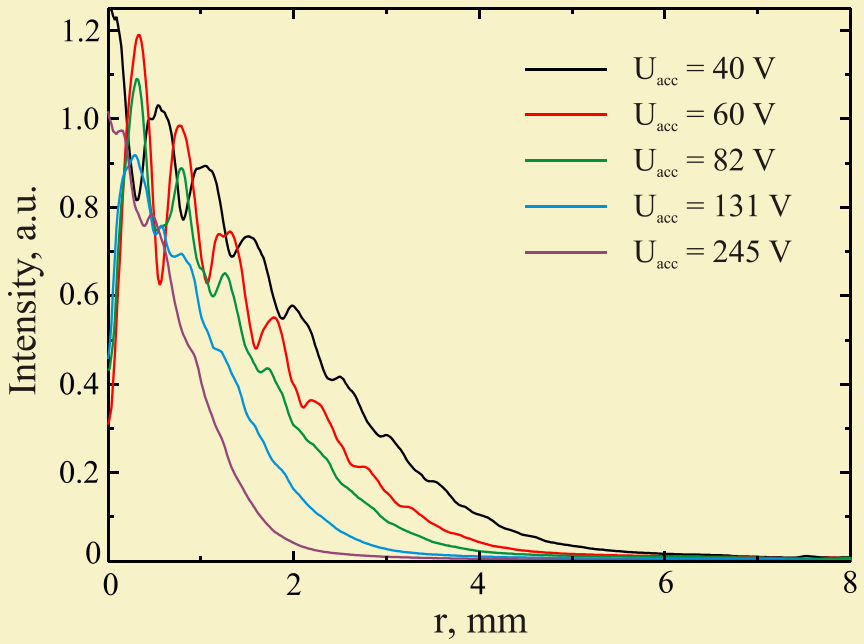
T = 300 K

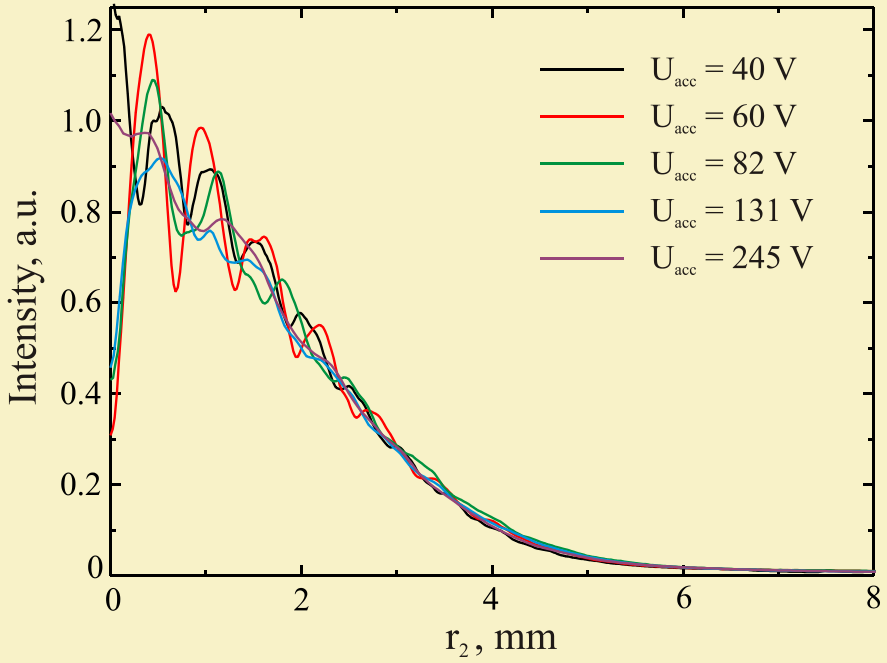
5 mm

TEDC measurements at different accelerating voltages

17.06.2013 p-GaAs(Cs,O) photocathode

Screen luminescence profiles





d = 33 mm λ = 635 nm

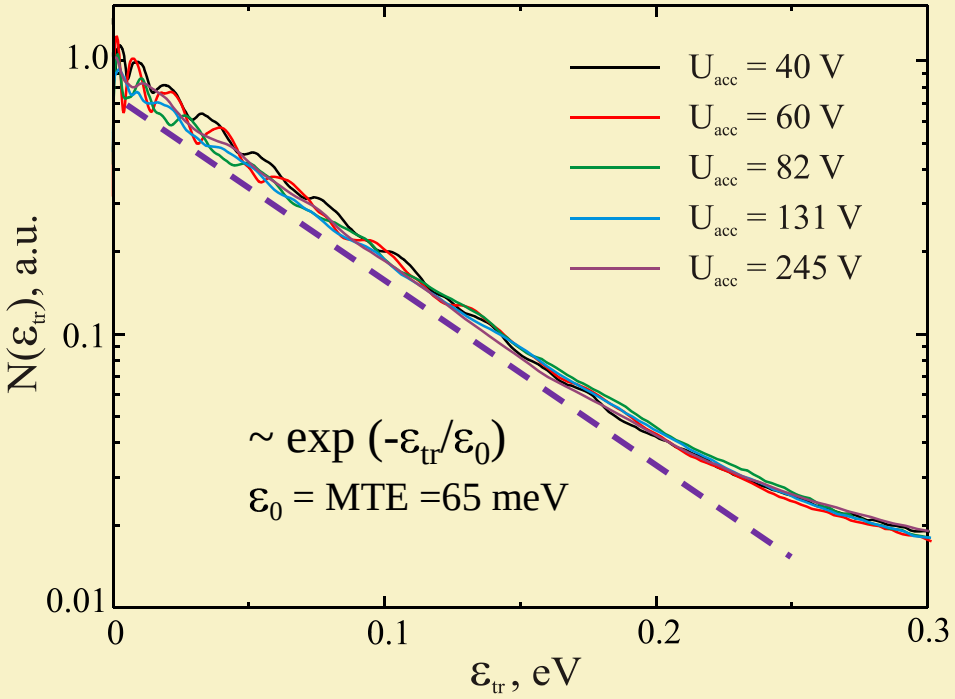
T = 300 K

$$\tau = d \times \sqrt{\frac{2\,m_e}{e\,U_{acc}}} \Rightarrow r_2 = r \quad (U_{acc}/40)^{1/2}$$

TEDC measurements at different accelerating voltages

17.06.2013 p-GaAs(Cs,O) photocathode

Transverse energy distribution curves

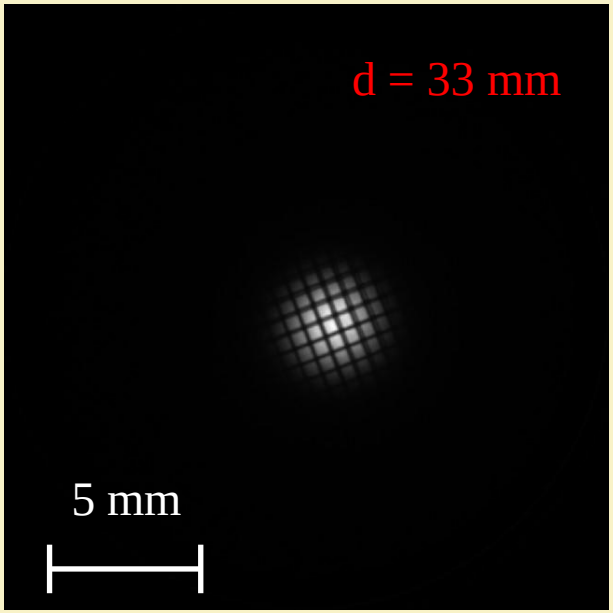


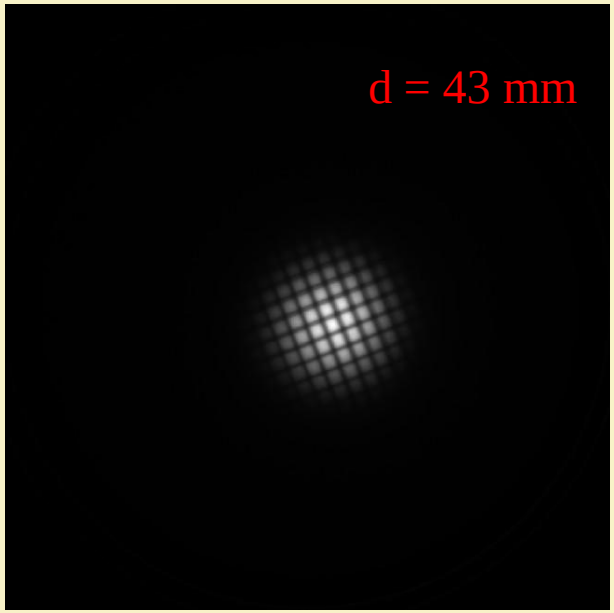
d = 33 mm λ = 635 nm T = 300 K

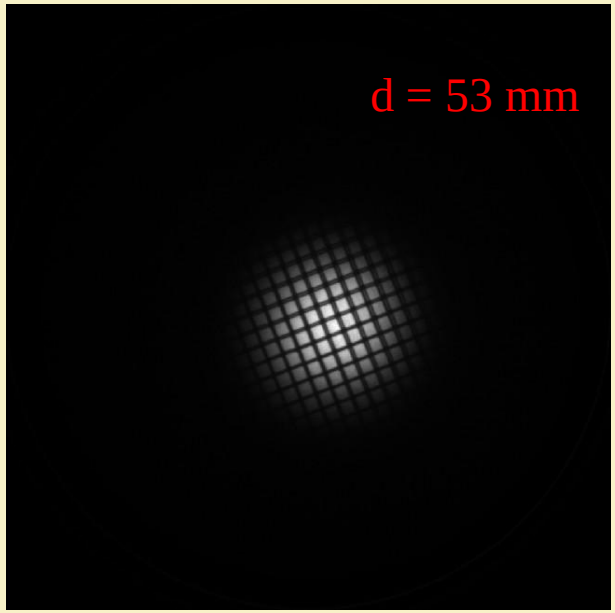
ERL-2013

TEDC measurements at different drift distances

20.06.2013 p-GaAs(Cs,O) photocathode





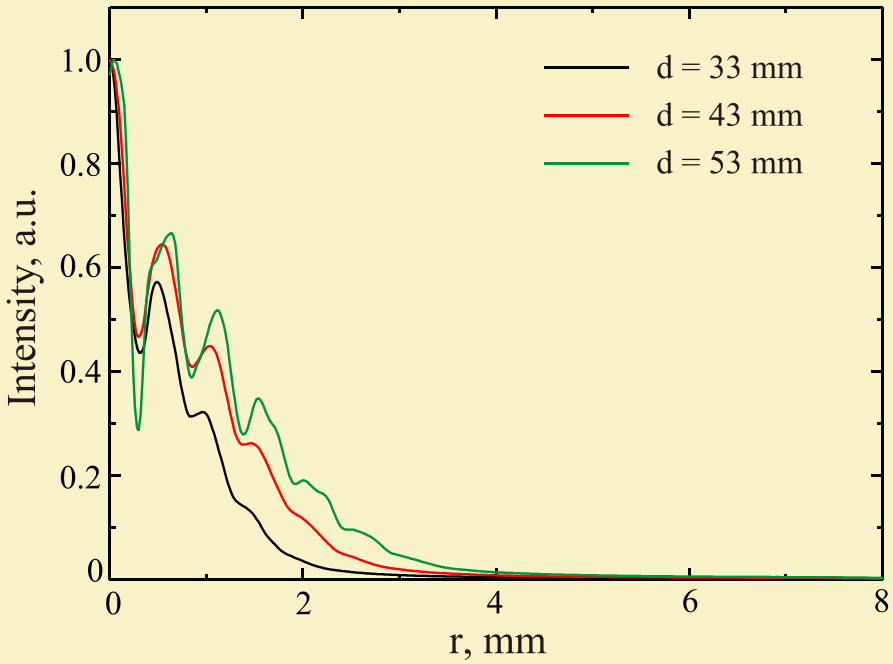


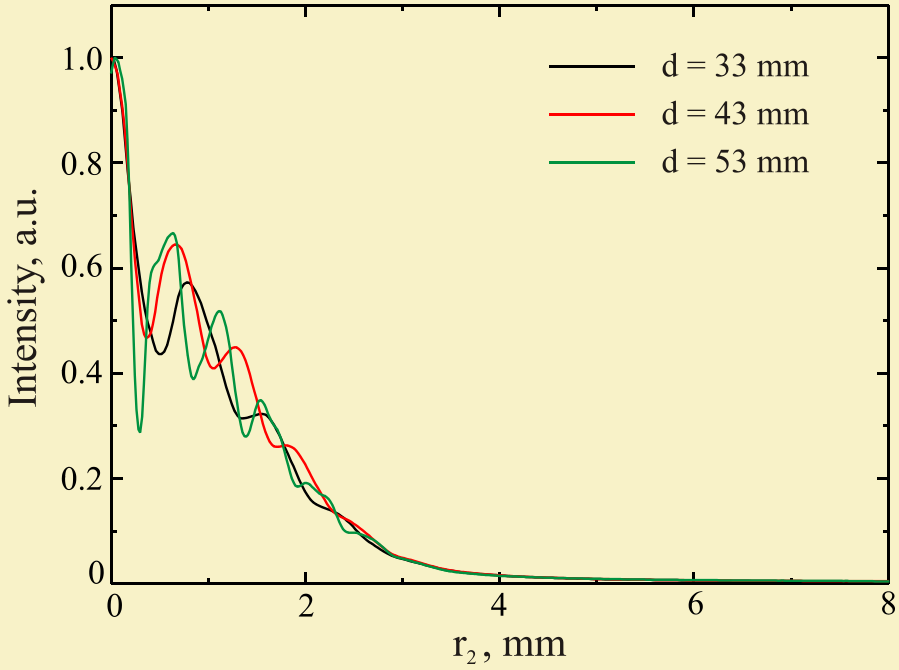
U_{acc} = 205 V λ = 635 nm T = 300 K

TEDC measurements at different drift distances

20.06.2013 p-GaAs(Cs,O) photocathode

Screen luminescence profiles





U_{acc} = 205 V λ = 635 nm

T = 300 K

$$\tau = d \times \sqrt{\frac{2\,m_e}{e\,U_{acc}}} \Rightarrow r_2 = r \quad 53/d$$

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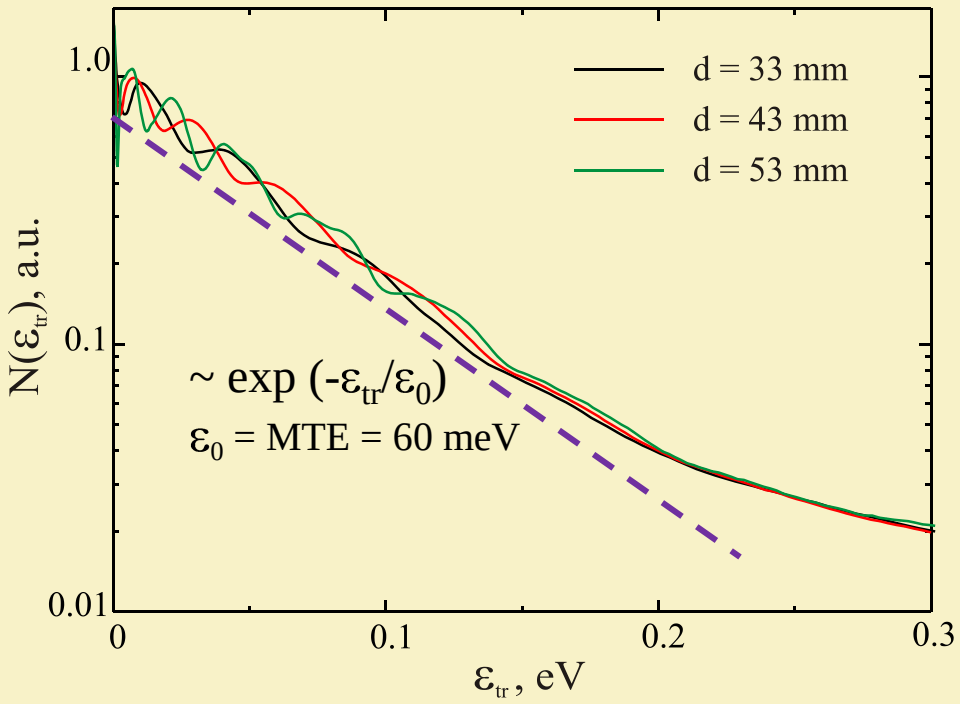
TEDC measurements at different drift distances

20.06.2013 p-GaAs(Cs,O) photocathode

Transverse energy distribution curves



U_{acc} = 205 V λ = 635 nm T = 300 K

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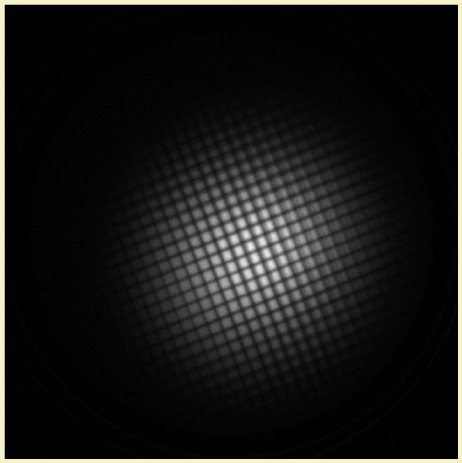
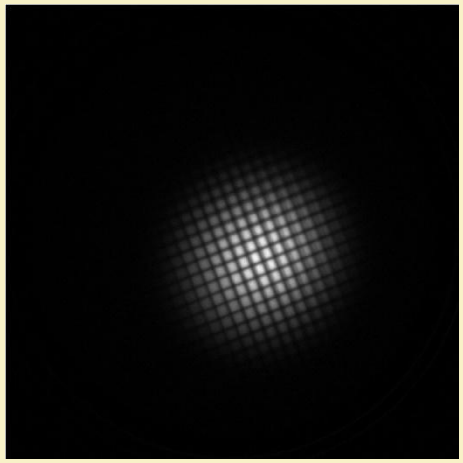
TEDC measurements with different light wavelength

21.06.2013 p-GaAs(Cs,O) photocathode d ≈ 43 mm T = 300 K

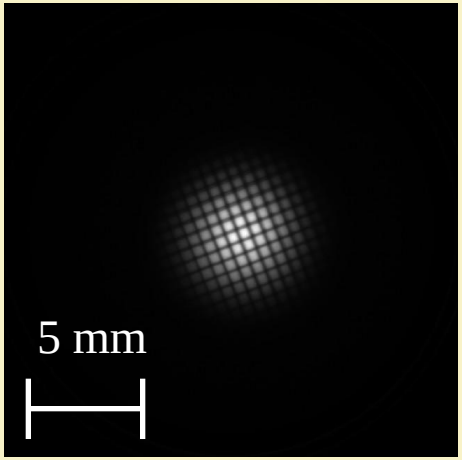
λ = 532 nm

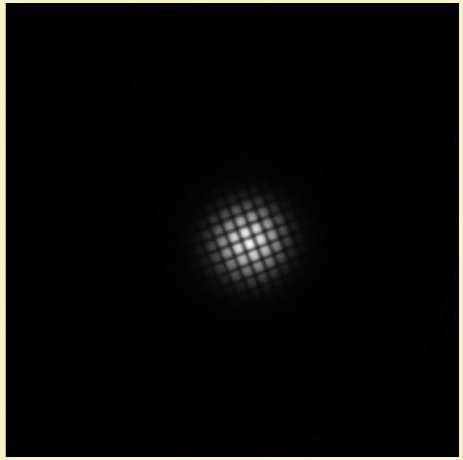
λ = 635 nm





U_{acc} = 60 V



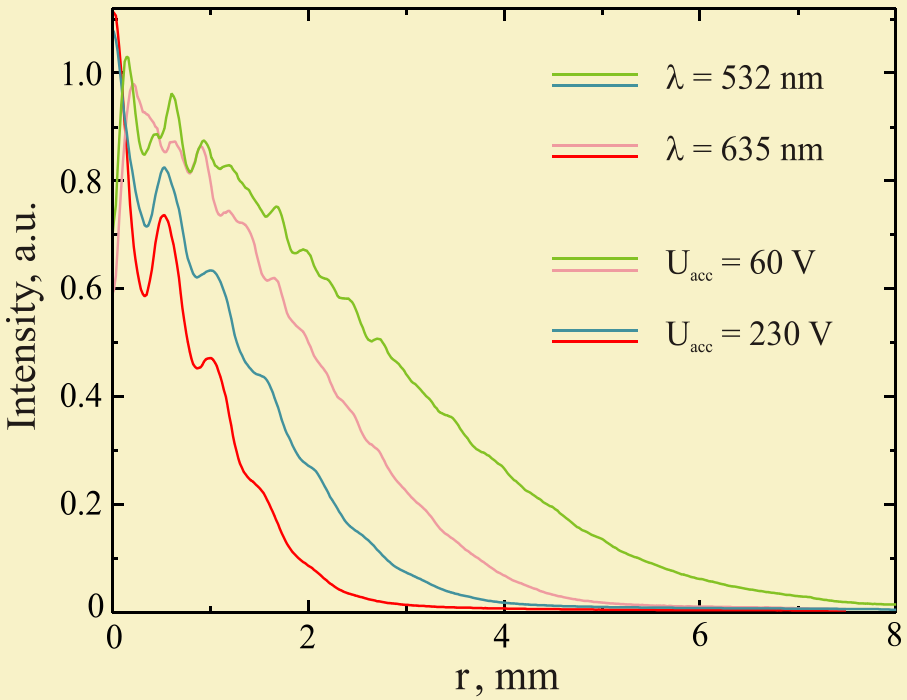


U_{acc} = 230 V

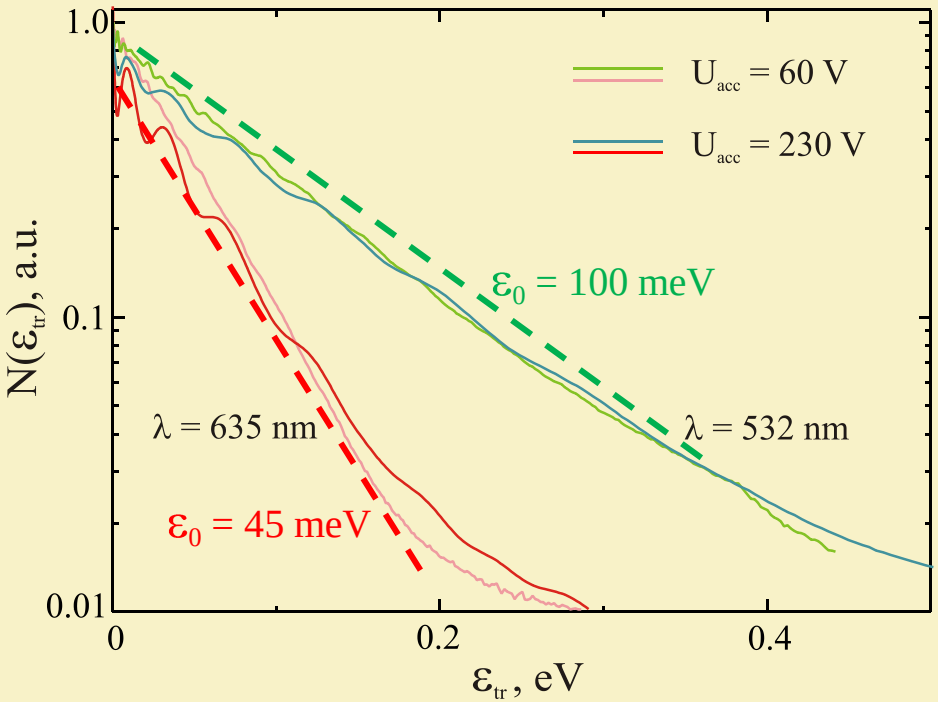
TEDC measurements with different light wavelength

21.06.2013 p-GaAs(Cs,O) photocathode d ≈ 43 mm T = 300 K

Screen luminescence profiles



Transverse energy distribution curves



MTE_{635}=45±7 meV MTE_{532}=100±15 meV

Summary

- Transverse Energy Spread Spectrometer (TESS) - A new set-up for measuring transverse energy distribution curves (TEDC) of electrons emitted by a reflectance-mode photocathode, has been developed, constructed and commissioned.
- TESS enables one to measure:
  - TEDC of the electrons emitted by all kinds of solid-state reflectance-mode photocathodes: semiconductor photocathodes, metal photocathodes, bi-alkali and multi-alkali photocathodes;
  - TEDC dependence on the wavelength of exciting radiation;
  - TEDC during photocathode degradation, including poisoning of the photocathode by the gases, precisely introduced into the vacuum chamber;
  - TEDC of the electrons, emitted from photocathodes at RT and LN_2 temperatures.