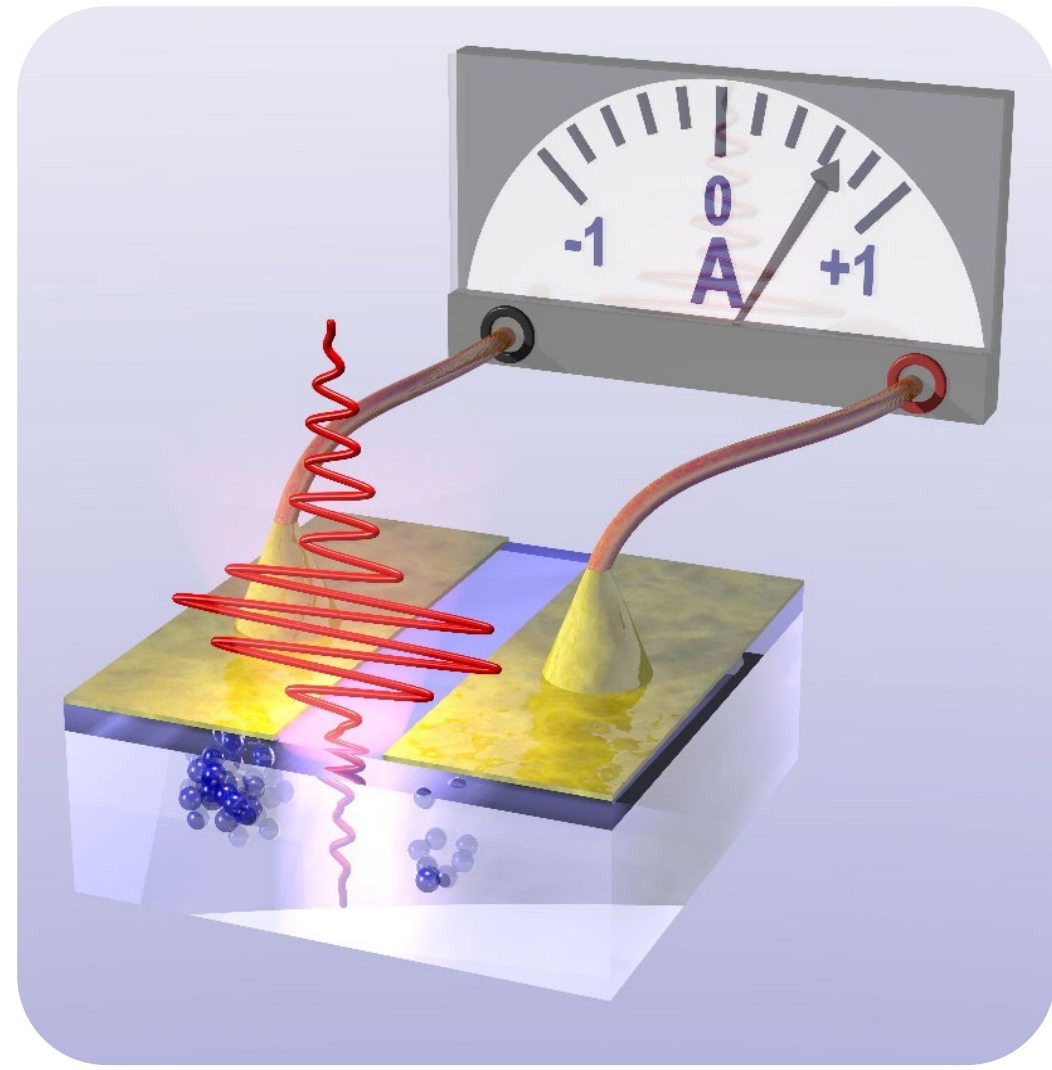


Wigner 121 Scientific Symposium

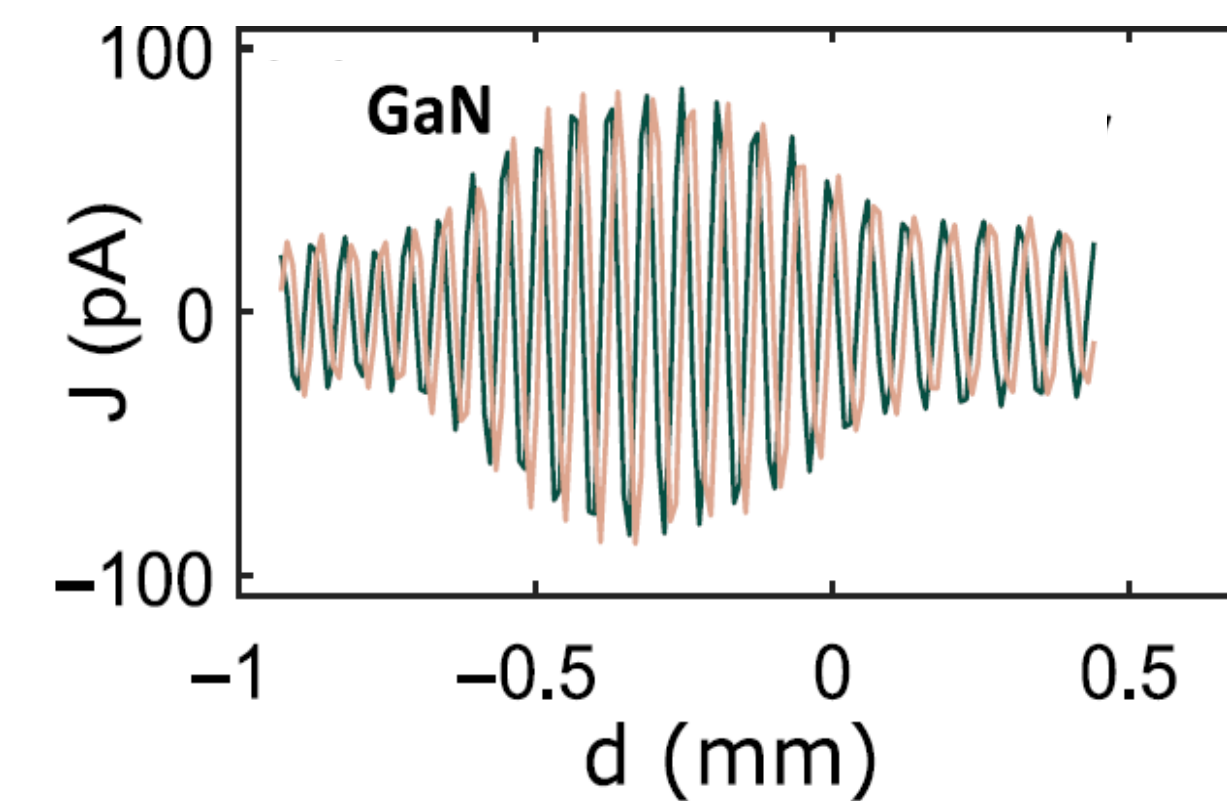
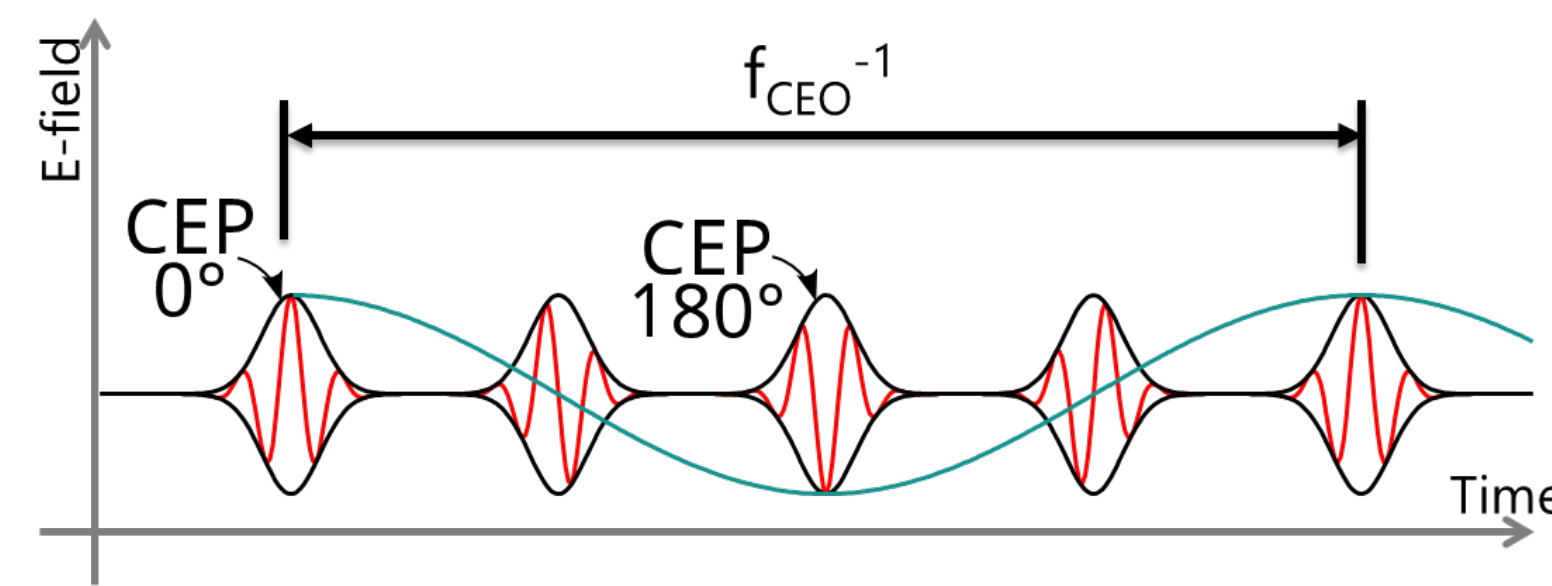
Wigner Research Centre for Physics
Institute for Solid State Physics and Optics
Dept. of Applied and Nonlinear Optics Research
Ultrafast Nanooptics Research Group

Péter Dombi, Péter Rácz, Václav Hanus, Péter Sándor, Zsuzsanna Pápa, Viktória Csajbók, Béla Lovász, Beatrix Fehér, Balázs Bánhegyi, Gellért-Zsolt Kiss, Gábor Ligeti

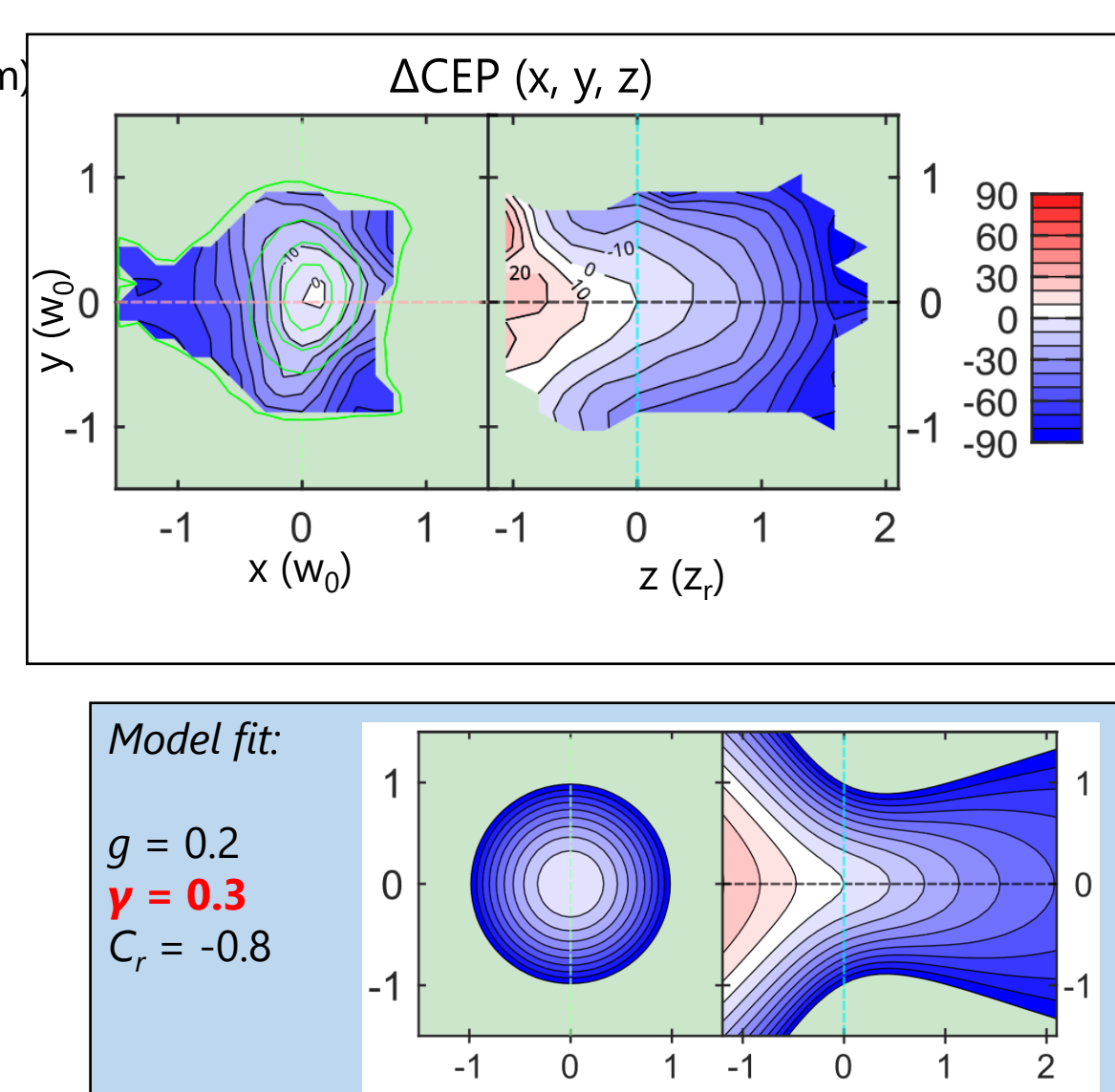
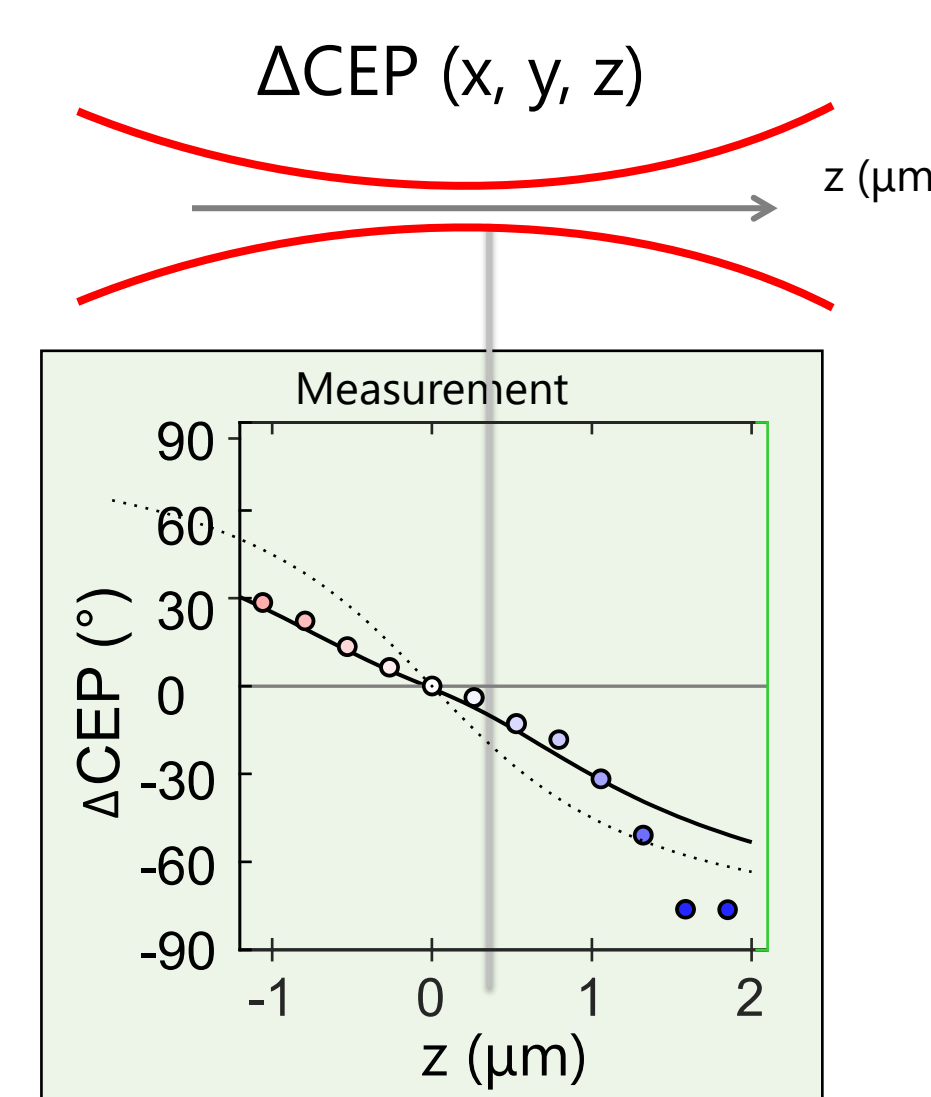
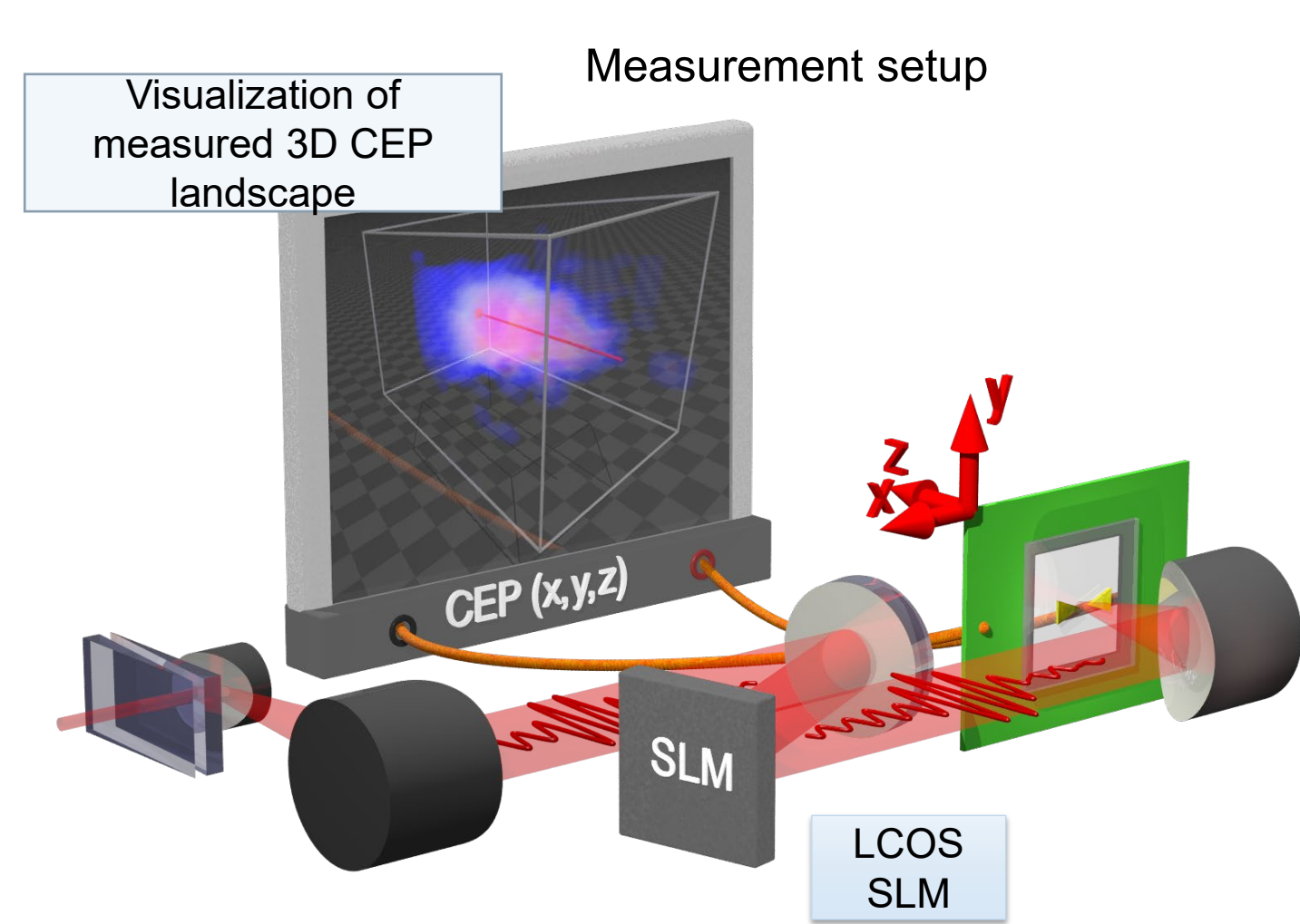
Transient metallization of dielectrics & on-chip phase scanner



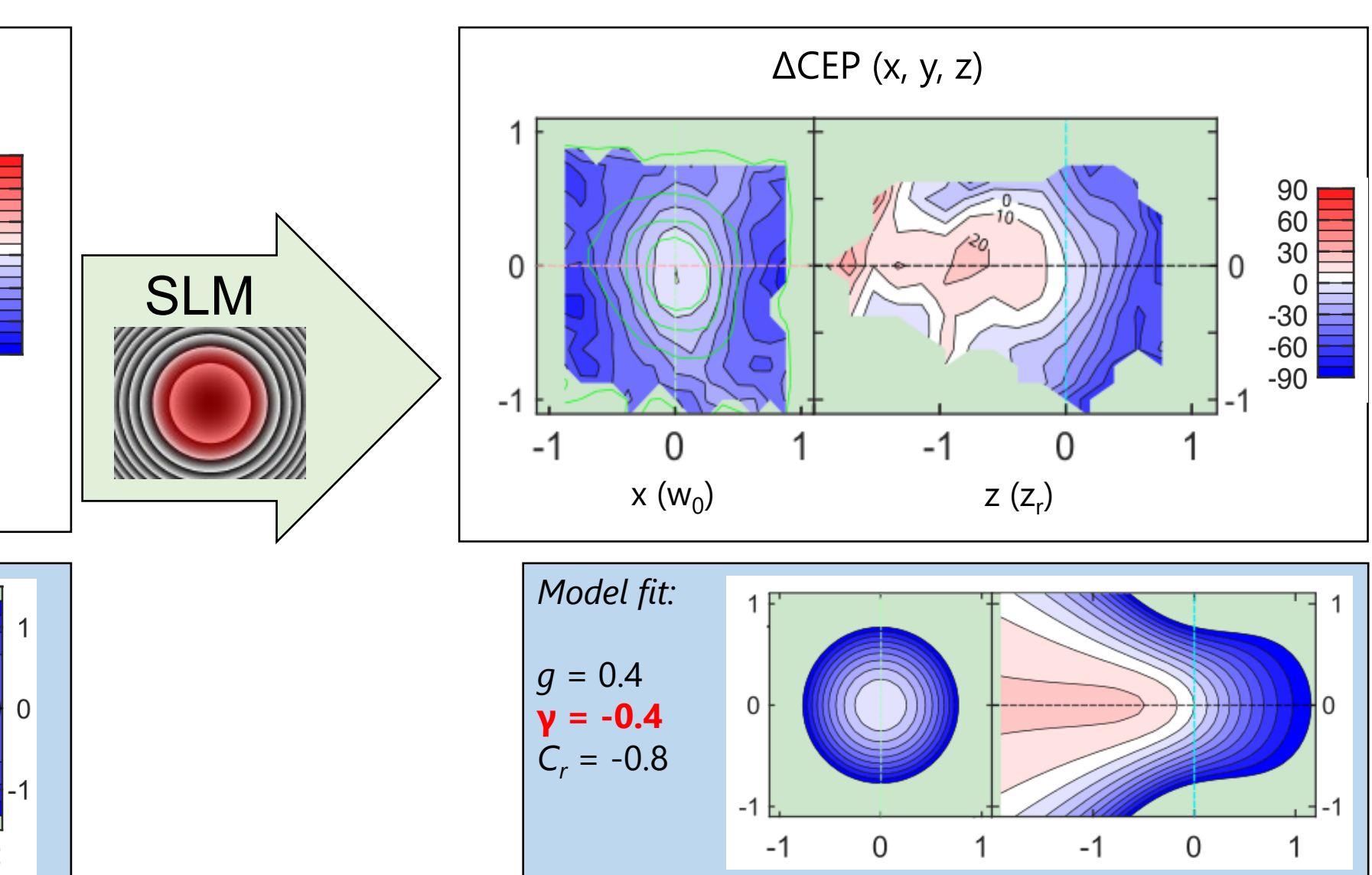
CEP measurement with optically induced currents on wide bandgap semiconductors (GaN, HfO₂, SiO₂) [1]:



Spatial CEP measurements [2]:



Application: CEP control with spatial light modulator (SLM)
Convex volume of flat CEP achieved [2]:



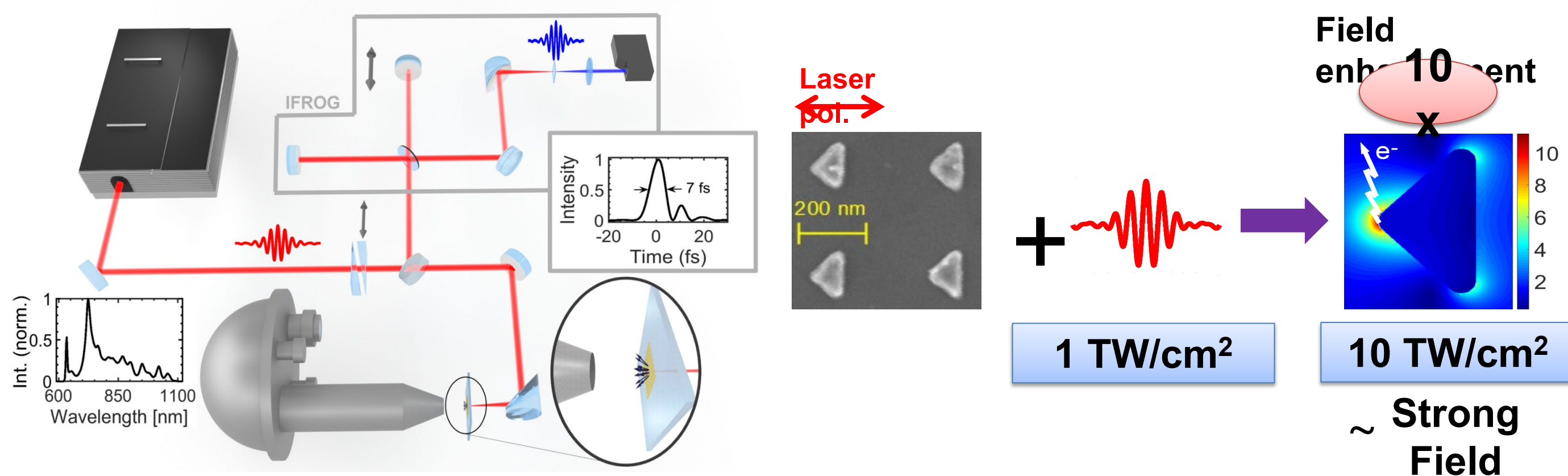
[1] V. Hanus, et al., „Light-field-driven current control in solids with pJ-level laser pulses at 80 MHz repetition rate” *Optica*, 8, 570 (2021)

[2] V. Hanus et al., „Carrier-envelope phase on-chip scanner and control of laser beams” *Nature Commun.*, 14, 5068 (2023)

Nonadiabatic tunneling of photoelectrons

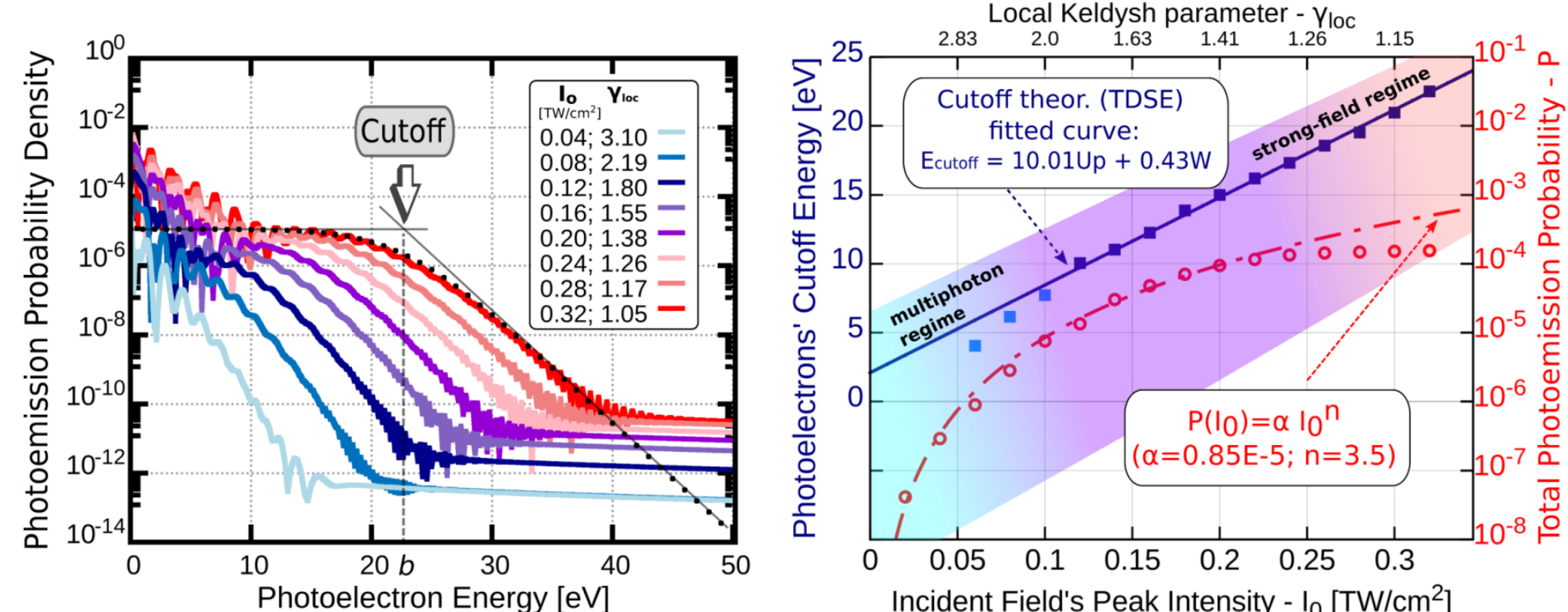
The Keldysh scale parameter γ indicates the type of the photoemission. The nonadiabatic tunneling: $\gamma \sim 1$, Multi-photon emission $\gamma \gg 1$ Adiabatic tunnel emission (strong-field) ($\gamma \ll 1$).

$$\gamma = \frac{\omega \sqrt{2mW_b}}{eE_0}$$



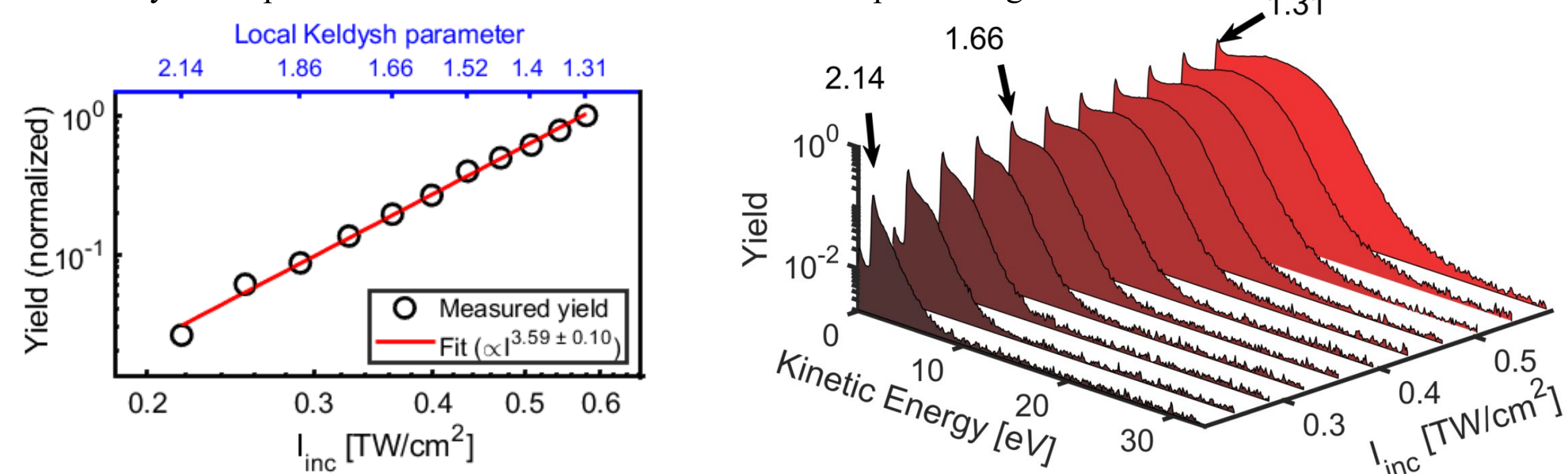
Theoretical Calculations

- 1D TDSE calculations: maximal kinetic energy for electrons accelerated in the near field: $E_{cutoff} = 10.01U_p + 0.43W$ (1) (U_p : ponderomotive potential, W : work function of the metal)
- 1D TDSE calculations show emergence of the plateau
- Electron emission by 3-4 photon absorption, consistent with broad laser spectrum and $W=5.3$ eV



Experiments:

- Plateau like structure signals that the rescattering process of the electrons takes place, typical for the tunnel regime
- Nonlinearity of the photoemission is characteristic for the multiphoton regime

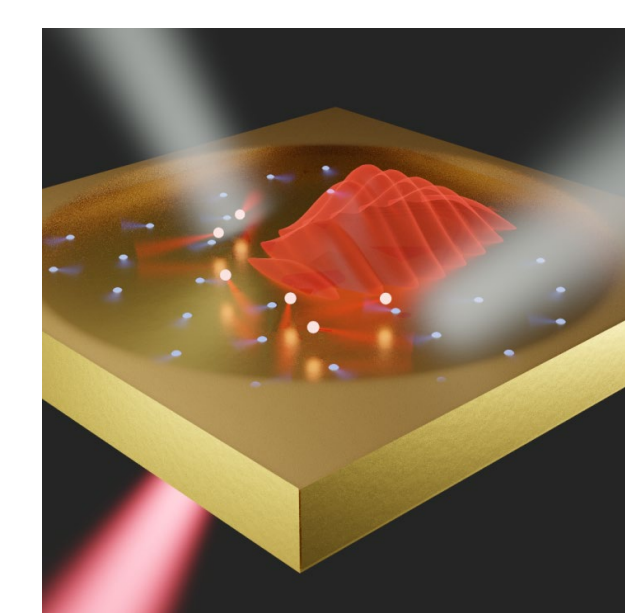
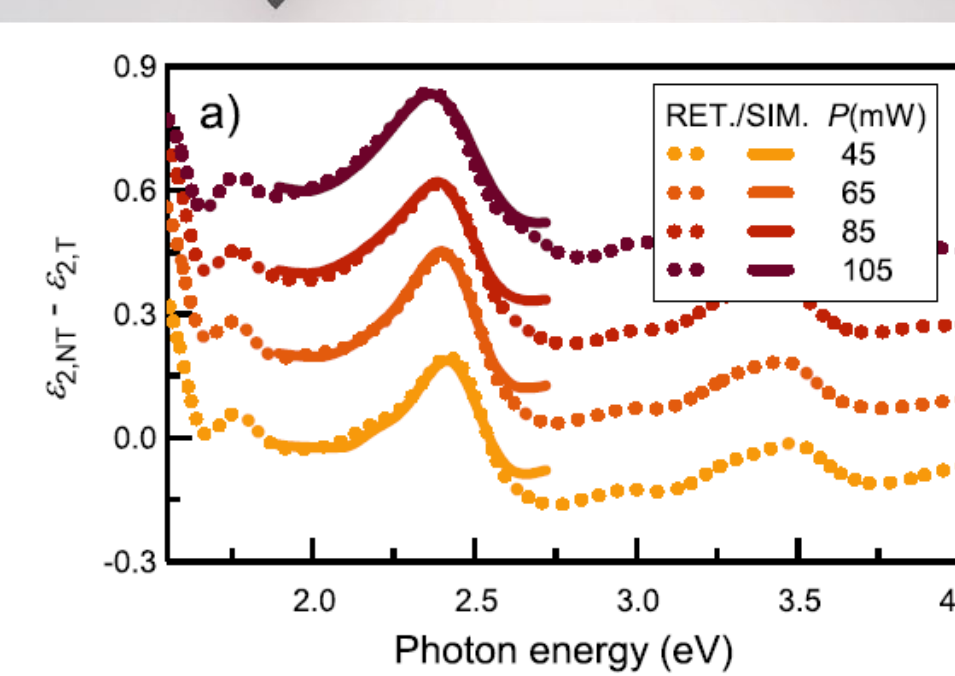
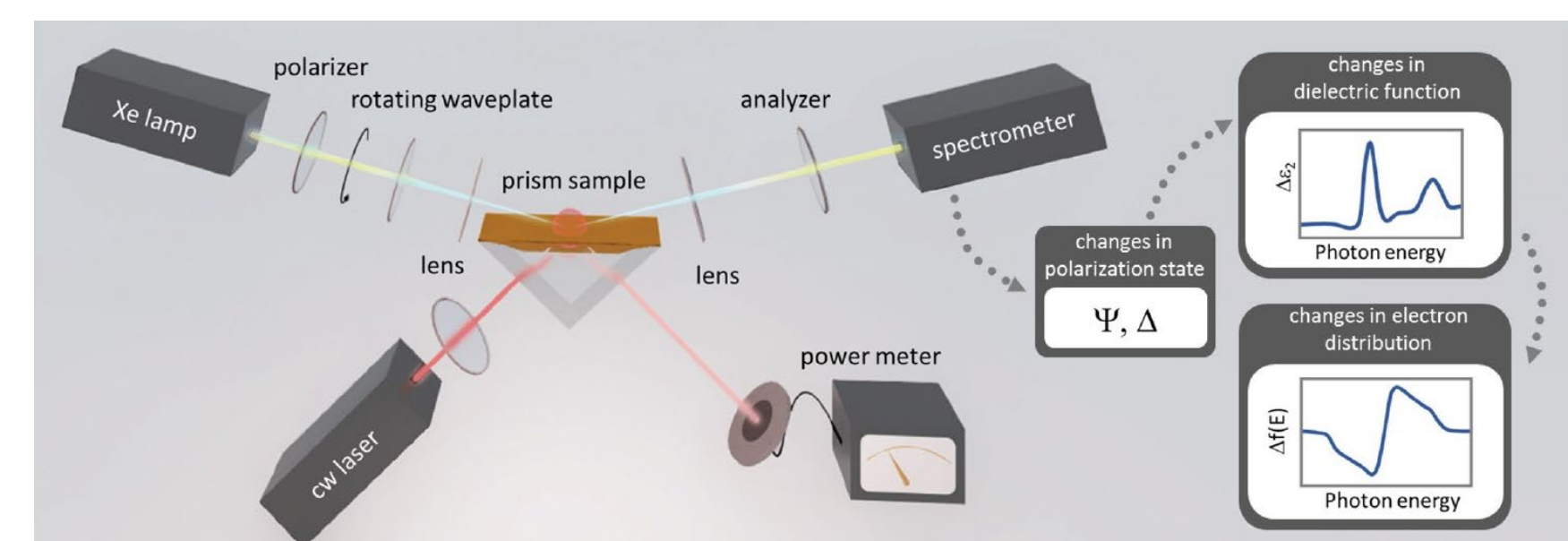


- in the transition regime multiphoton scaling and rescattered electrons are present [3]

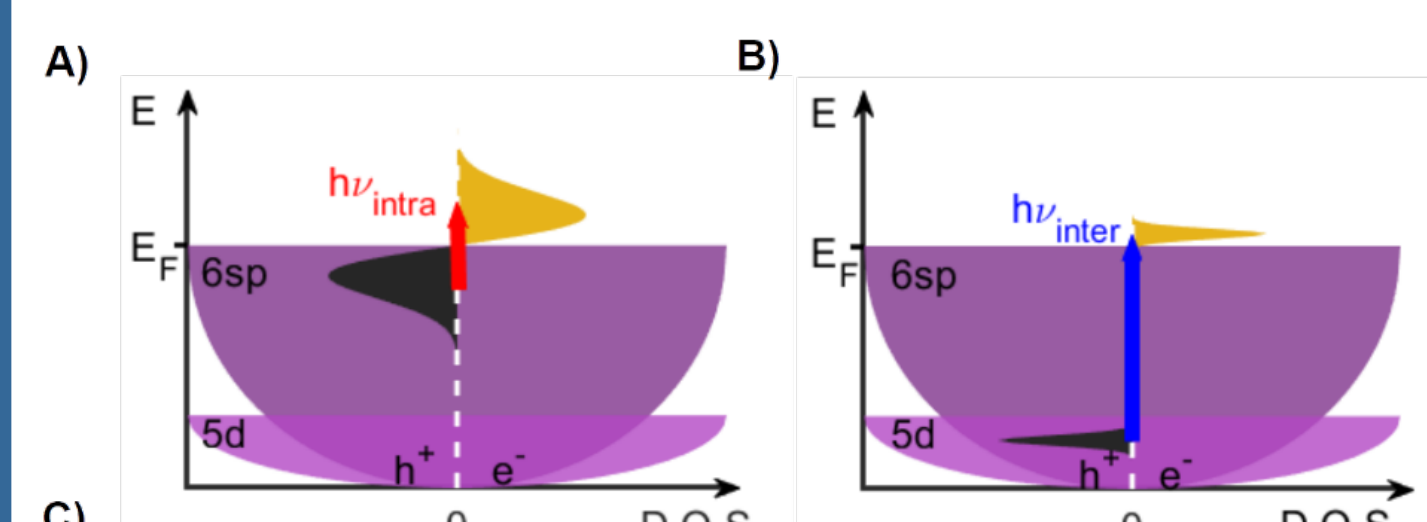
[3] B. Lovász, P. Sándor et al, *Nano Lett.* 22, 2303 (2022)

Femtosecond hot electron dynamics

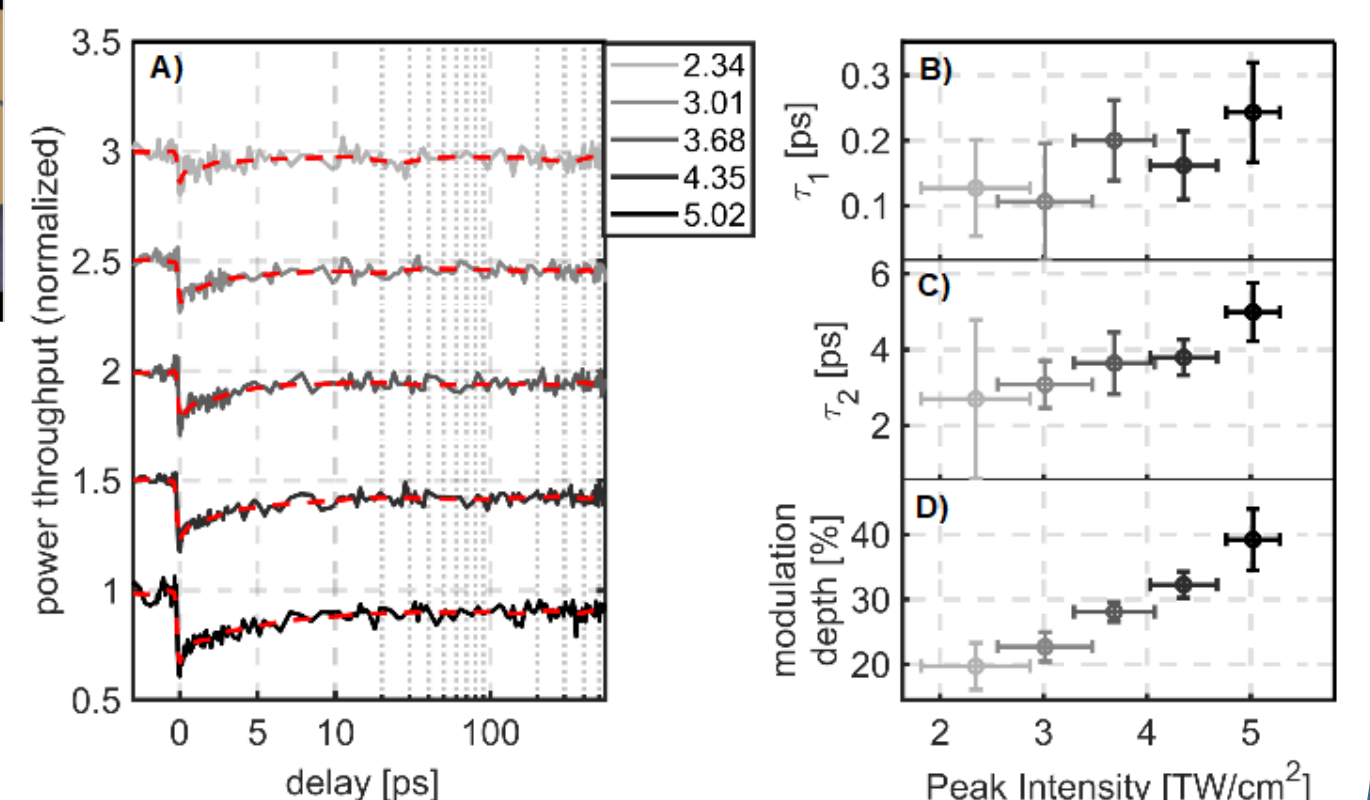
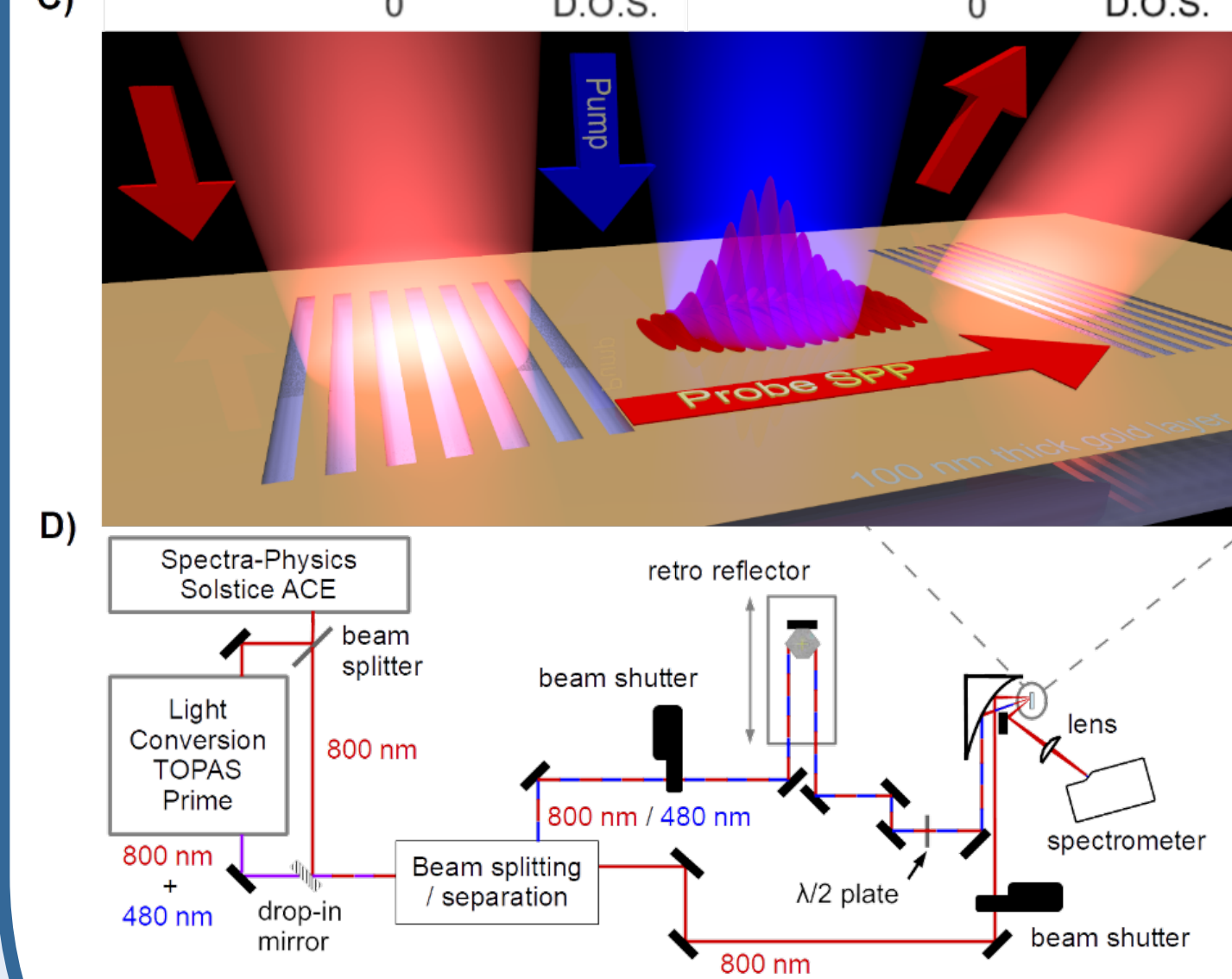
- Ellipsometry can be used to measure the optical properties (dielectric constant) of materials
- SPPs are excited by a cw laser at the resonant angle of incidence from the backside,
- Ellipsometric response is recorded on the gold-air interface with white-light probing



- The electrons in the upper few nm with higher energy [4]



- Ultrafast surface plasmon probing of interband and intraband excitations [5]
- Optical pump / plasmon probe scheme developed
- 2-component decay of hot electrons observed, ~100-250 fsec & 1-5 psec
- setup also works as an ultrafast switch for plasmonic wavepackets



[4] J. Budai, Z. Pápa, P. Petrik, P. Dombi., *Nature Commun.*, 13, 6695 (2022)

[5] B. Lovász, P. Sándor, J. Budai, Z. Pápa, P. Dombi, submitted (2023)

