Kinetic investigation of electron energization in magnetron discharges: RFMS, DCMS, and HiPIMS

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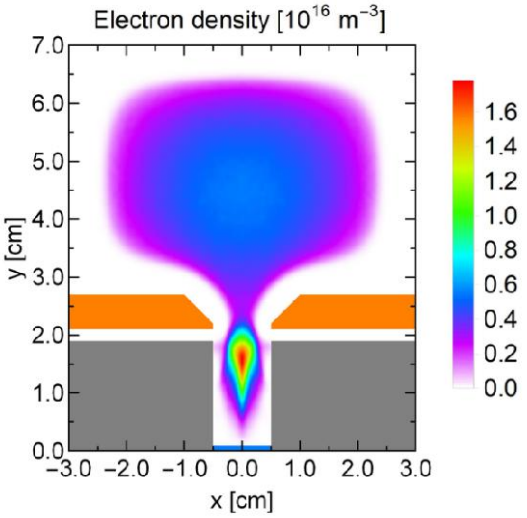
Outline

- Particle-In-Cell/Monte Carlo Collision (PIC/MCC)
- Magnetron sputtering setup
- Electron energization in magnetron sputtering discharges
  - Radio Frequency Magnetron Sputtering (RFMS)
  - Direct Current Magnetron Sputtering (DCMS)
  - High Power Impulse Magnetron Sputtering (HiPIMS)

PIC/MCC simulation

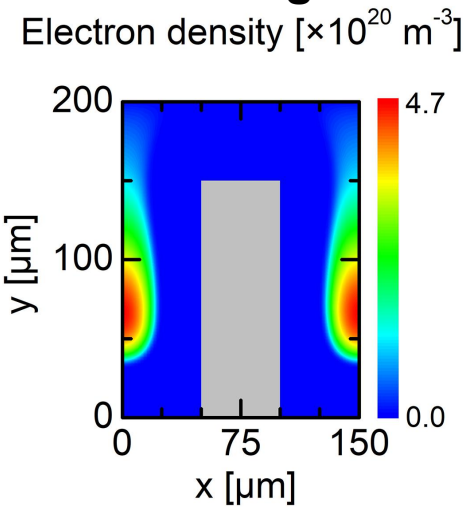
- Advantages
  - Self-consistent
  - Complete
- **ASTRA** Developed by ***Bocong Zheng***
  - Efficient PIC software
  - Applications in
    - Ion sources
    - Microplasmas
    - RF plasmas
    - Magnetized plasmas
    - etc.

Ion sources



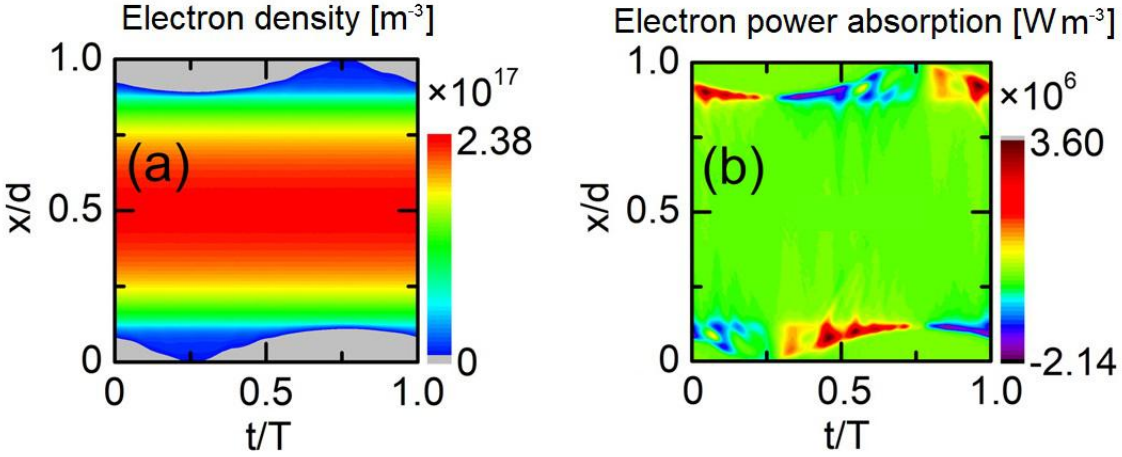
B. Zheng et al., In preparation

microhollow cathode discharges



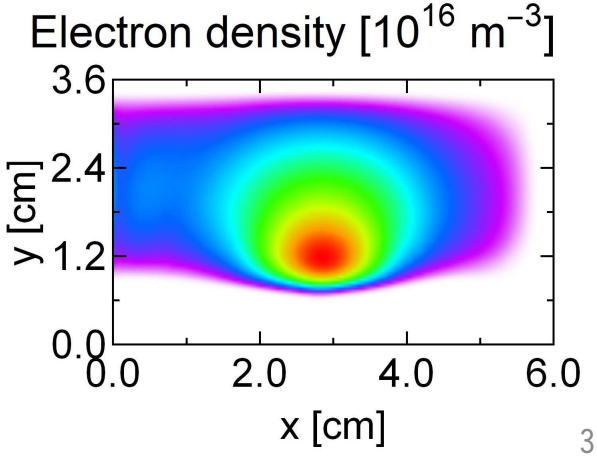
Y. Fu, B. Zheng et al., JAP 129, 023302 (2021)

CCP discharges



Y. Fu, B. Zheng et al., APL 117, 204101 (2020)

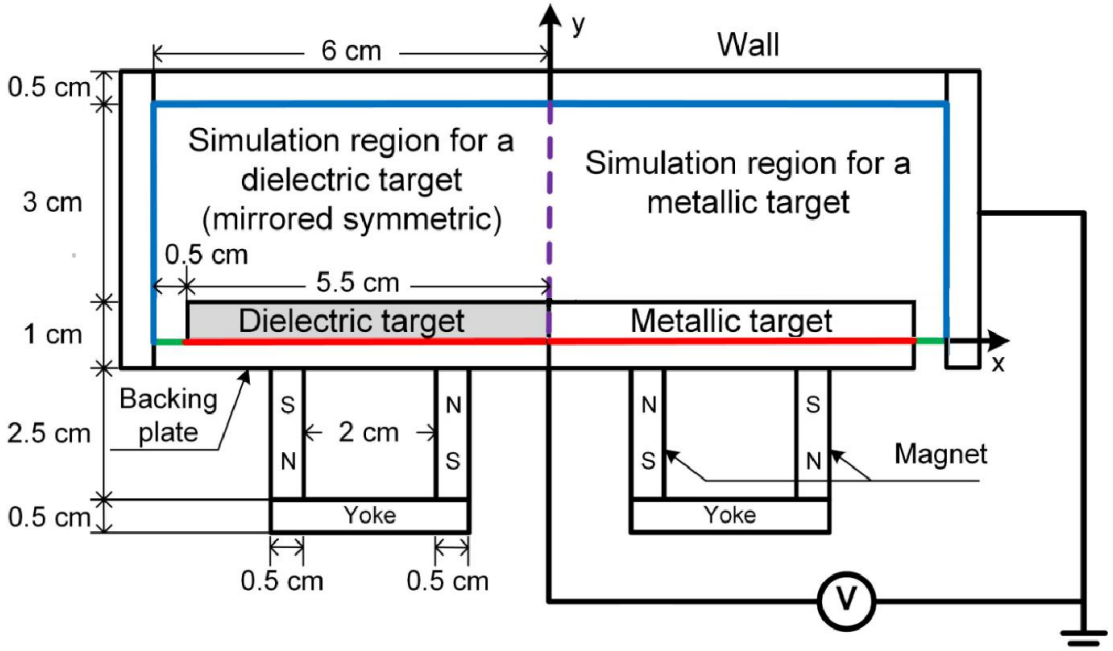
Magnetron discharges

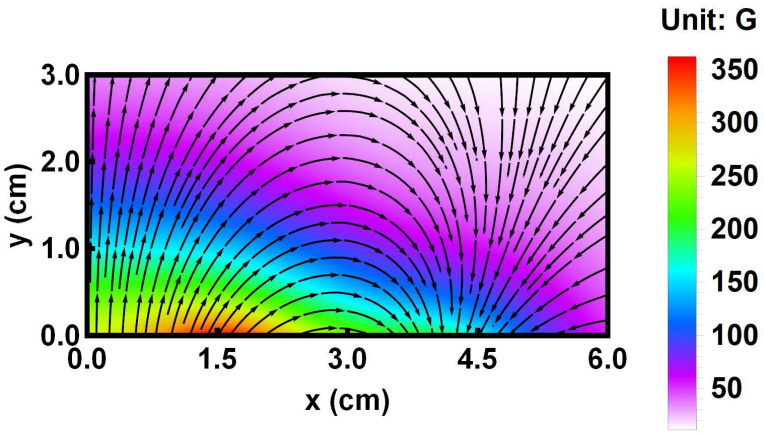


B. Zheng et al., PSST 30, 035019 (2021)

Magnetron sputtering discharges

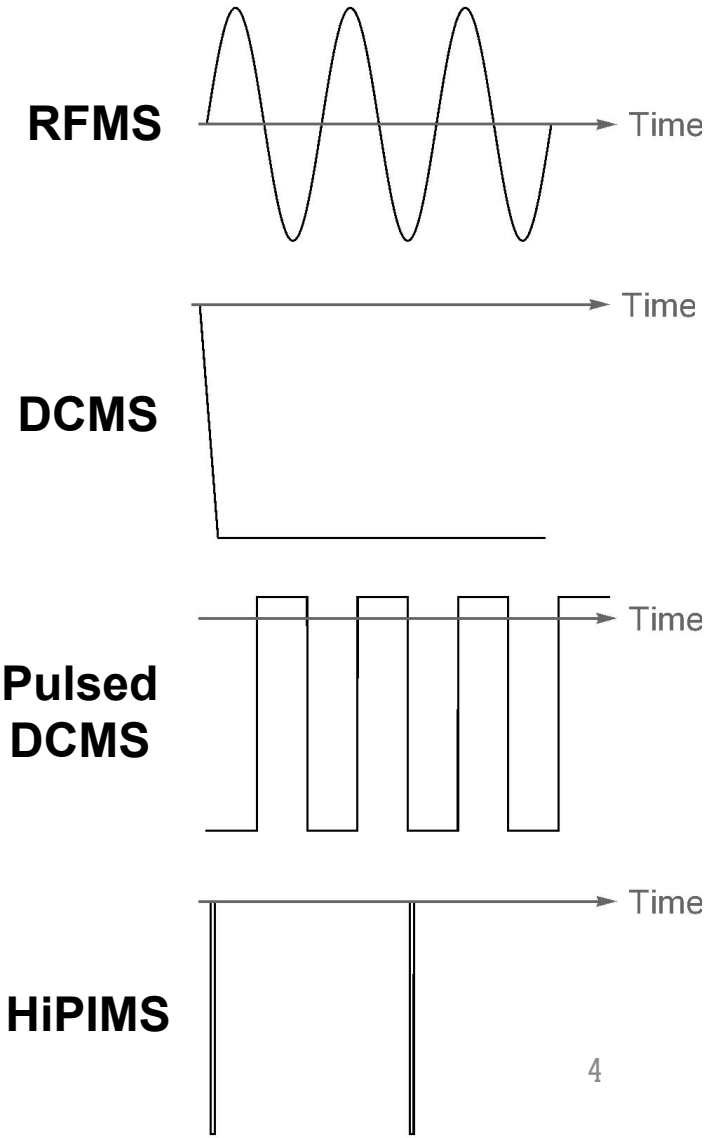
Schematic of a magnetron sputtering set-up



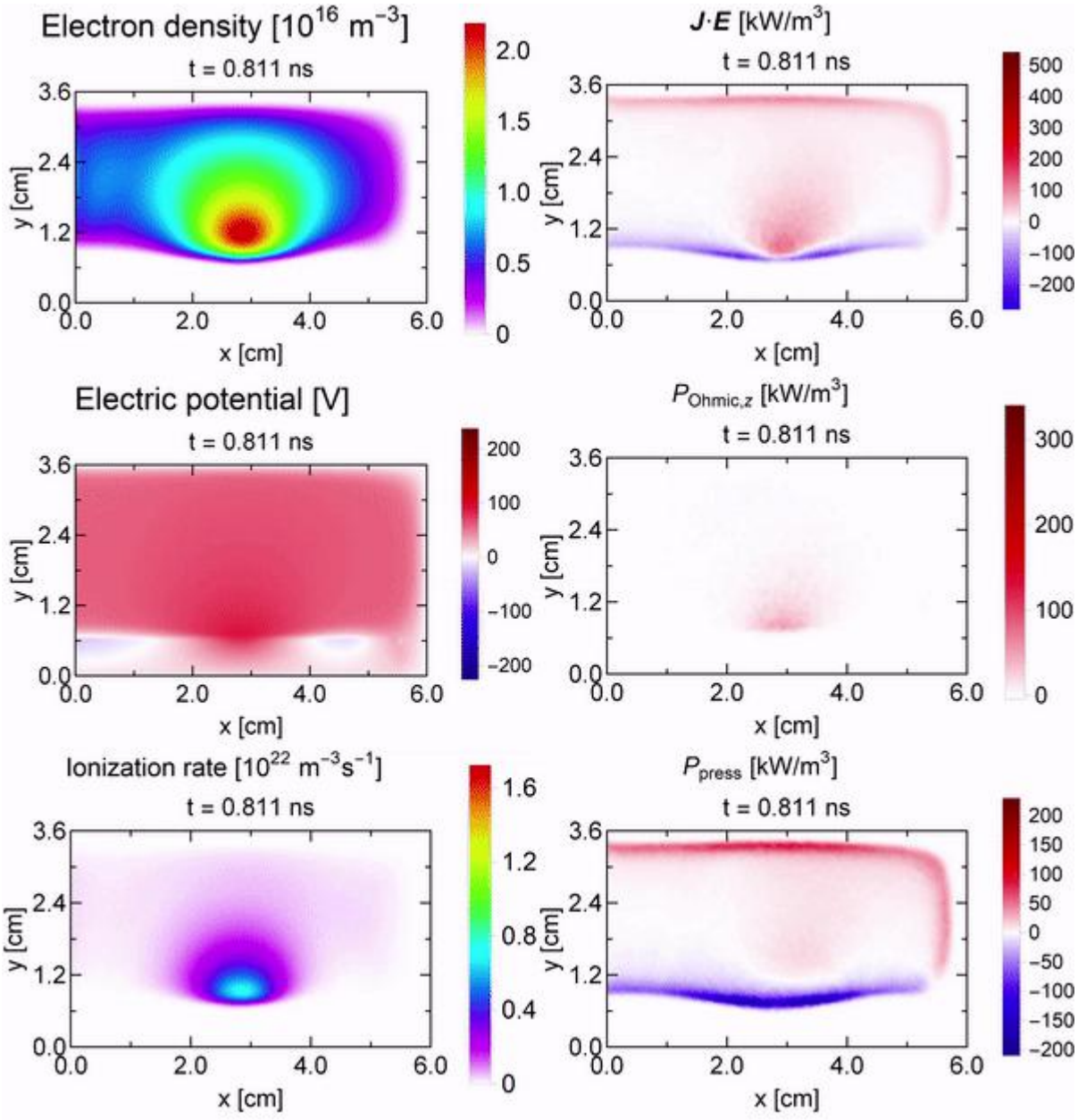


Magnetic field

Voltage waveforms

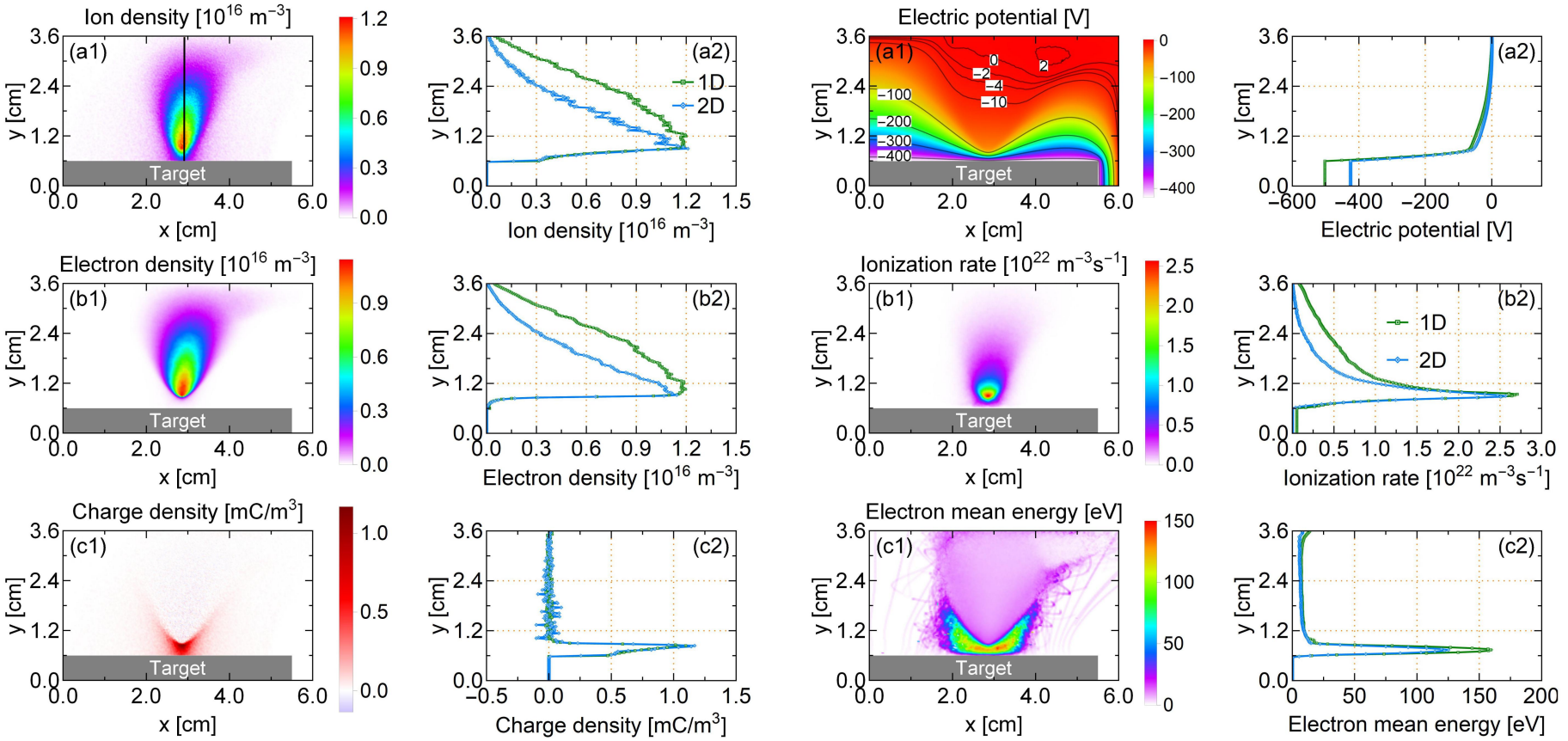


Electron dynamics in RFMS discharges

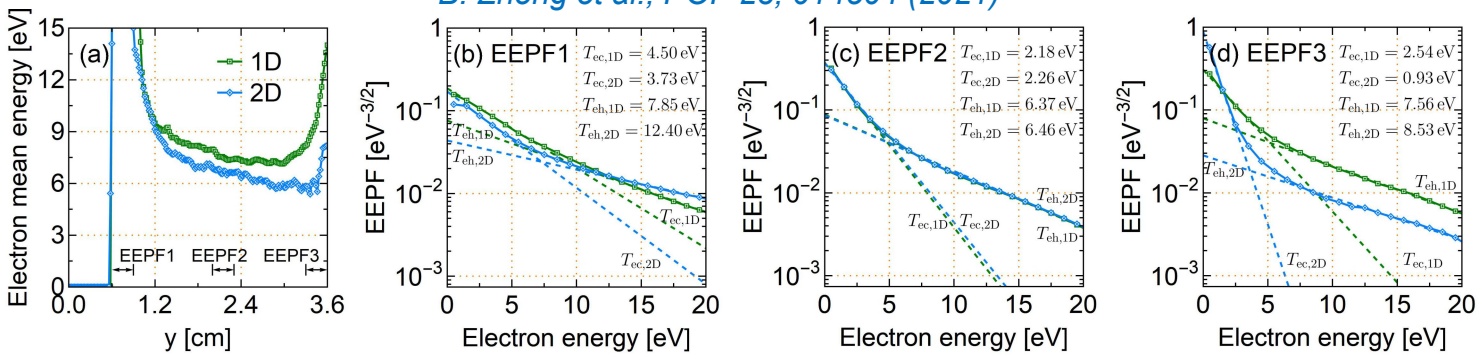


B. Zheng et al., PSST 30, 035019 (2021)

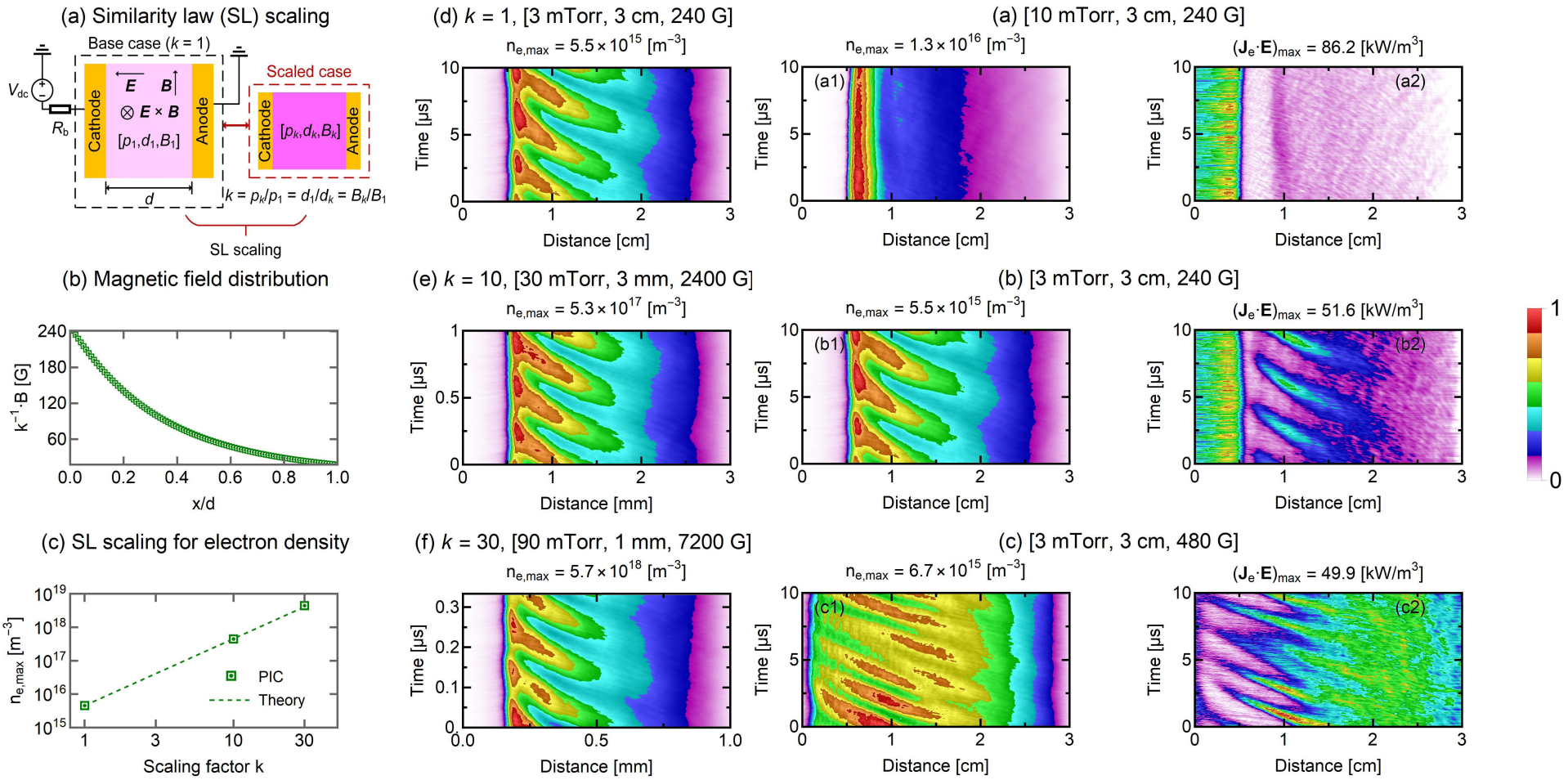
PIC simulation of DC magnetron discharges: 1D vs 2D



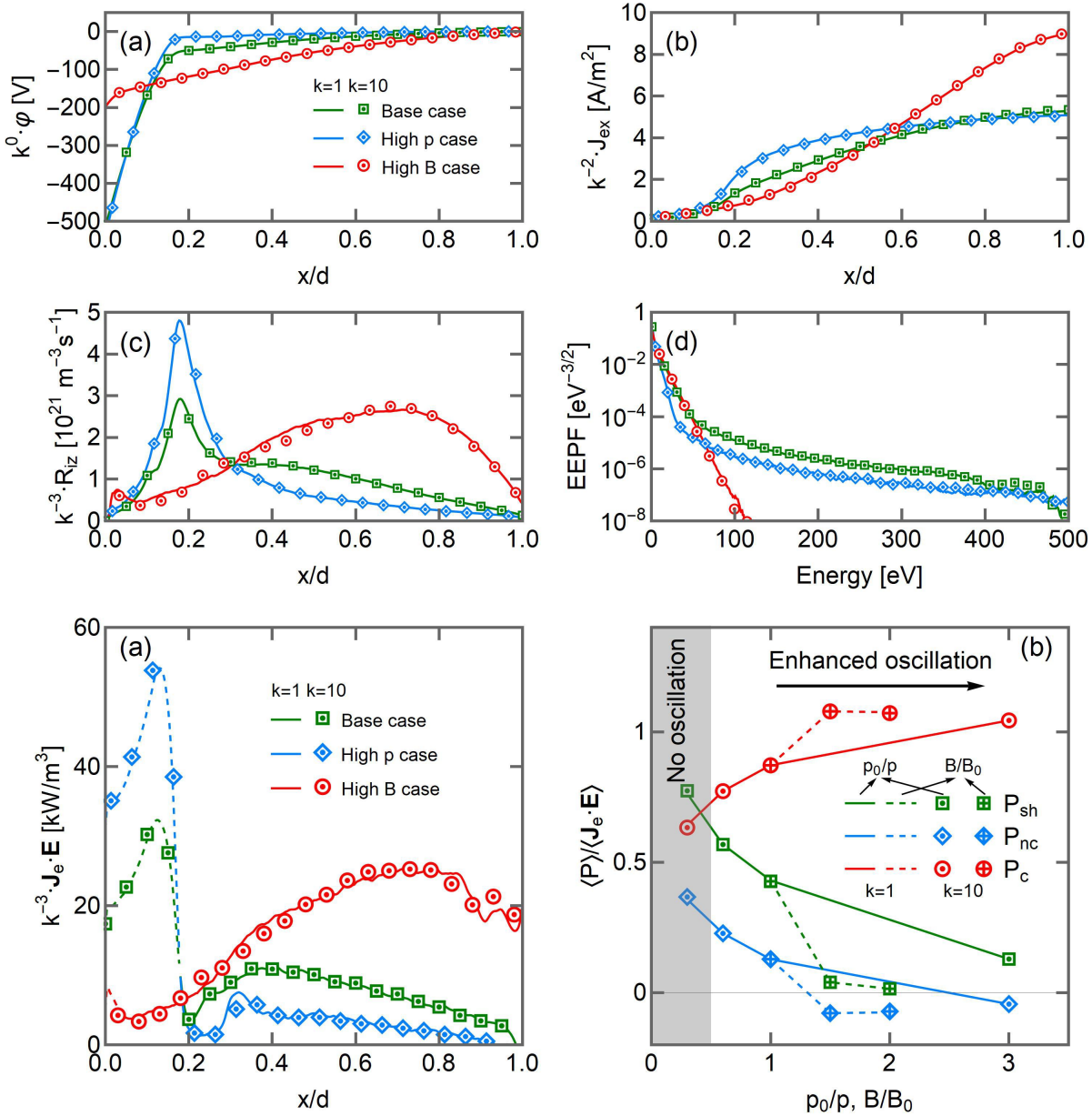
B. Zheng et al., POP 28, 014504 (2021)



DCMS: breathing oscillations and electron energization

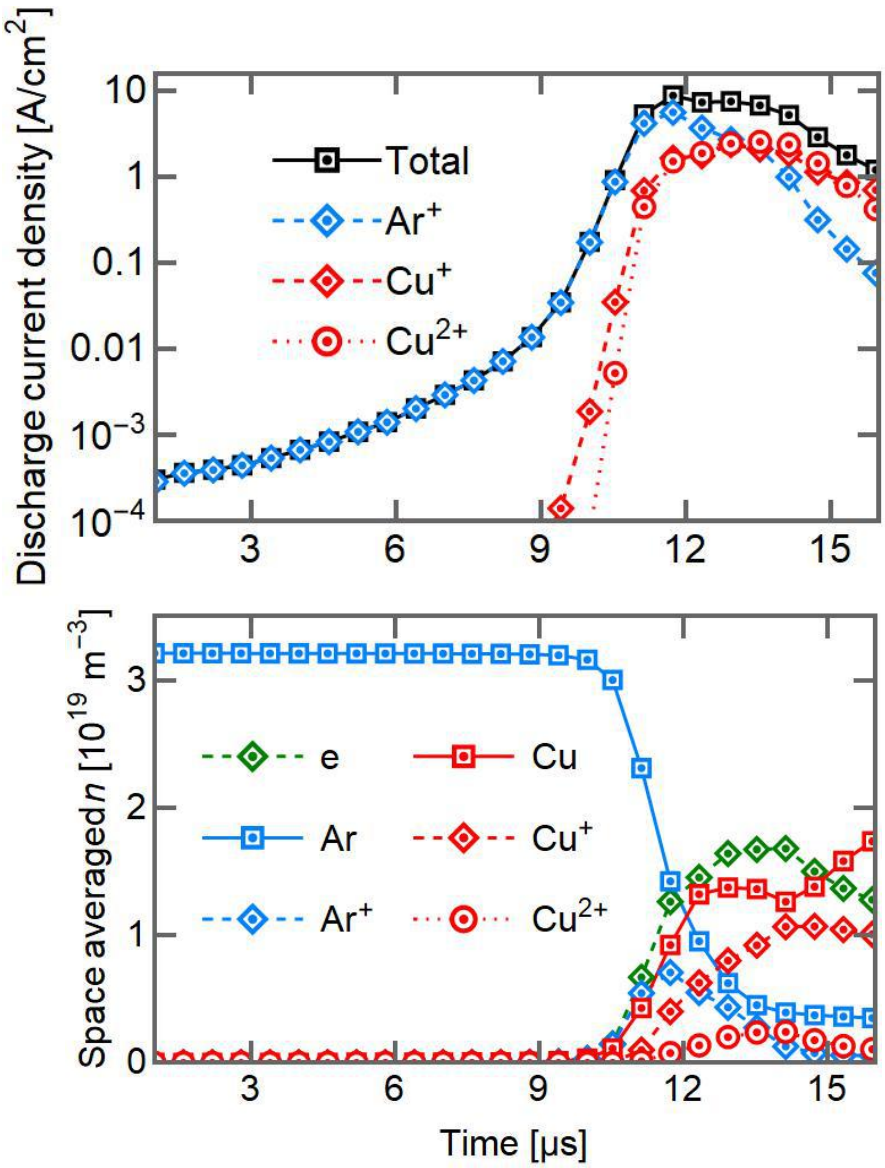


DCMS: breathing oscillations and electron energization

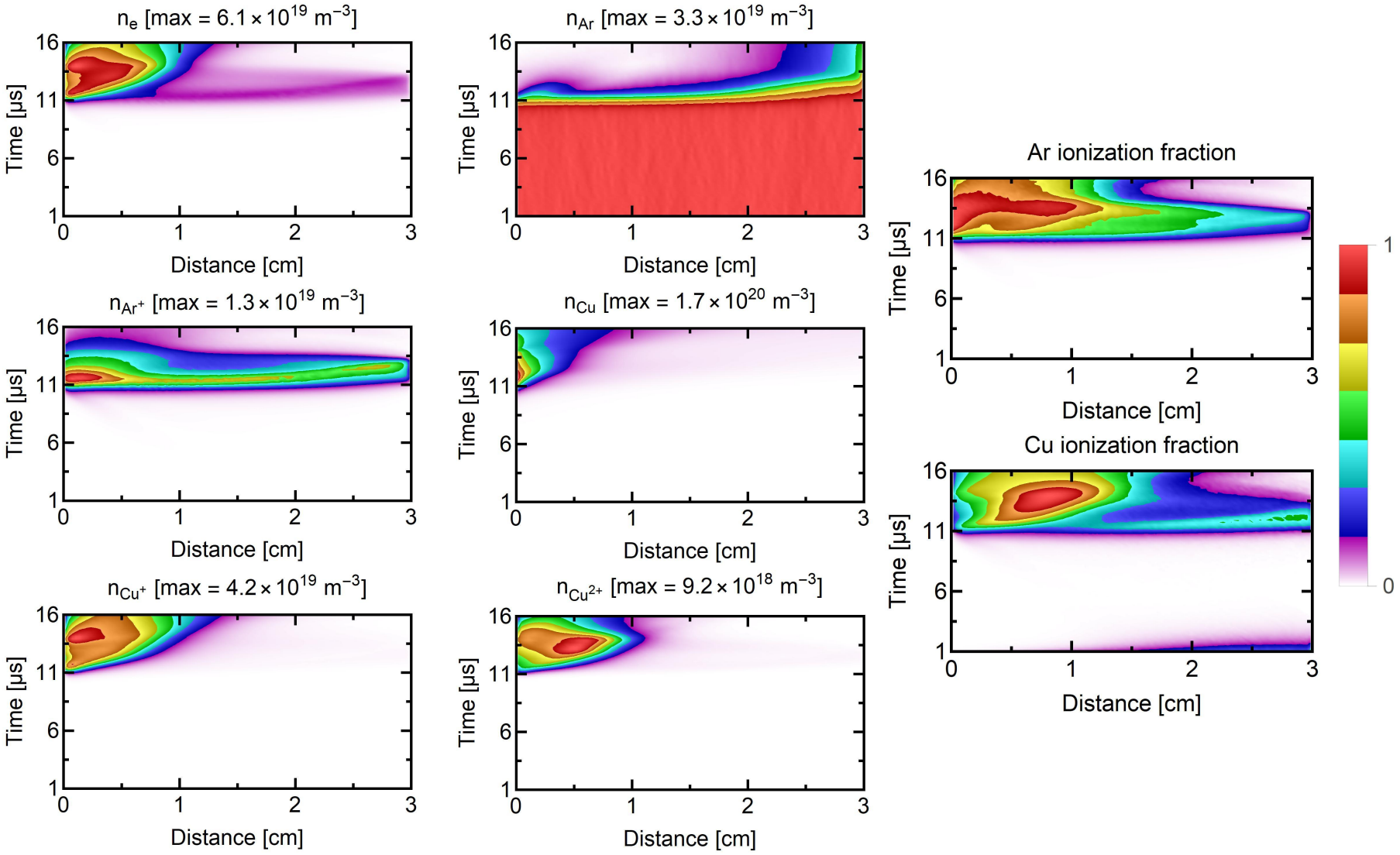


HiPIMS discharge

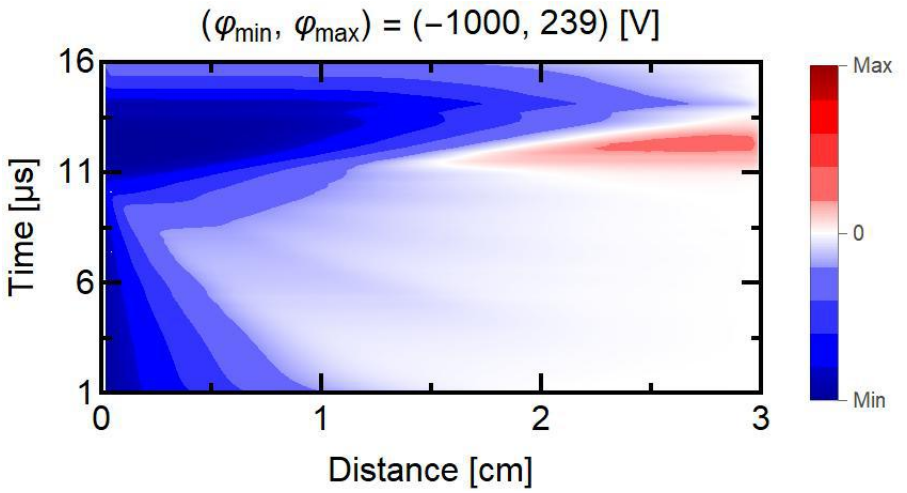
- Additional physical processes
  - Coulomb collisions
  - Gas rarefaction
  - Metal ions
  - SEE induced by metal ions
- Discharge parameters
  - Voltage: -1 kV
  - Pressure: 1 mTorr
  - Gas: Ar
  - Target: Cu
  - Gap length: 3 cm

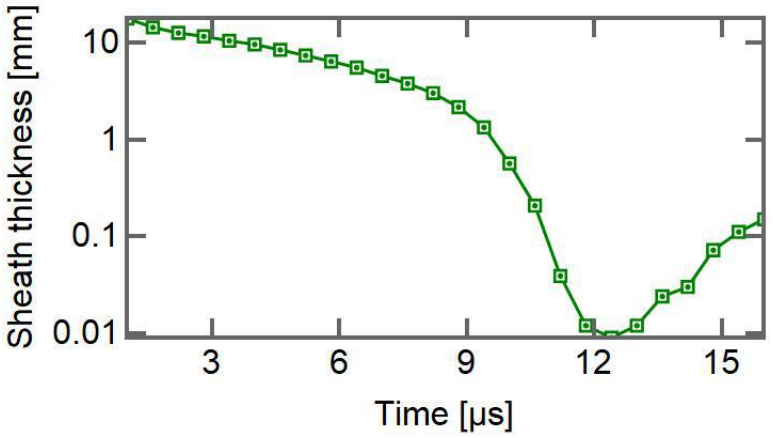


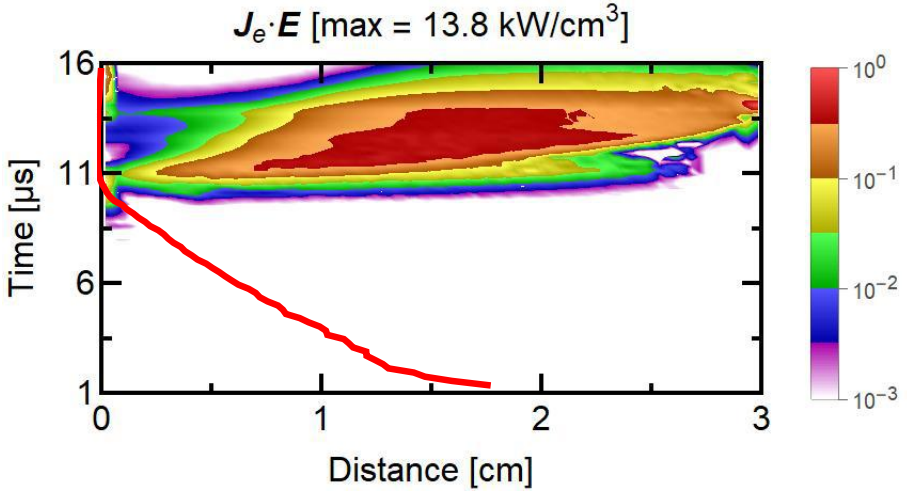
Spatiotemporal dynamics of species

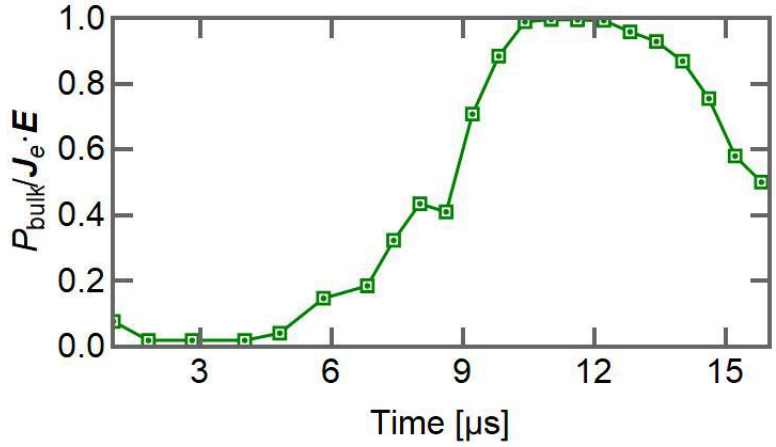


Electron energization









Thank you

- The slides can be downloaded at bczheng.com/talks/zheng21_PlasmaTech.pdf
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- Website: bczheng.com