

One-dimensional PIC/MCC simulation of HiPIMS discharges

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Outline

- Particle-In-Cell/Monte Carlo Collision (PIC/MCC)
- Particle simulation of magnetron discharges: 1D vs 2D
- HiPIMS discharge characteristics
 - Discharge characteristics
 - Electron kinetics
 - Gas rarefaction

PIC/MCC simulation

Advantages

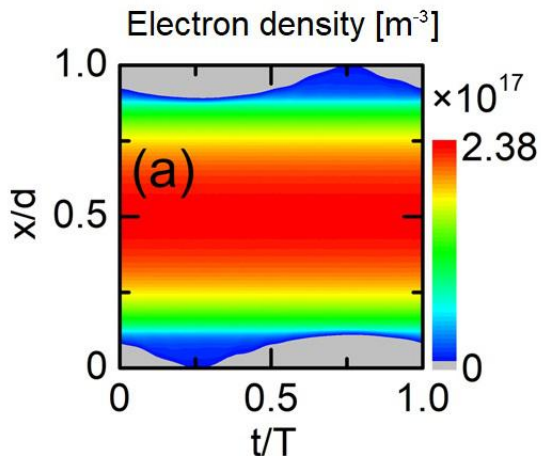
- Self-consistent
- Complete

Developed by

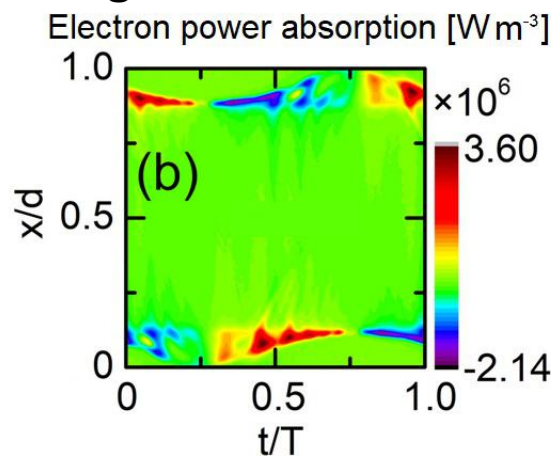
ASTRA *Bocong Zheng*

- Efficient PIC software
- Applications in
 - Ion sources
 - Microplasmas
 - RF plasmas
 - Magnetized plasmas
 - etc.

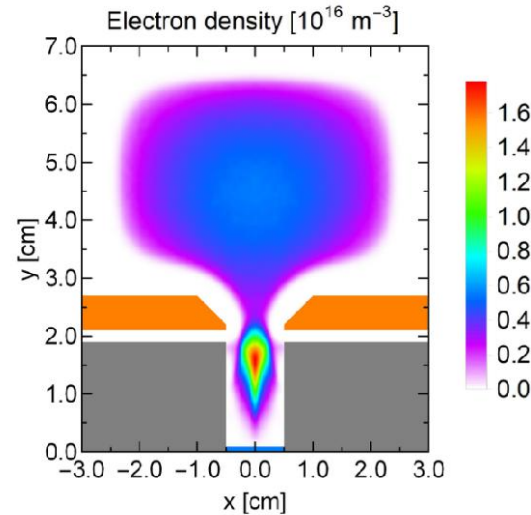
CCP discharges



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



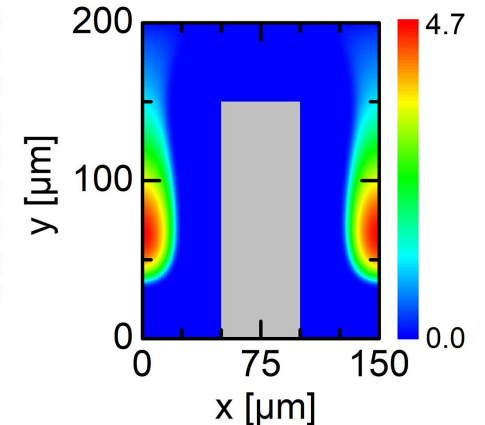
Ion sources



B. Zheng et al., In preparation

microhollow cathode discharges

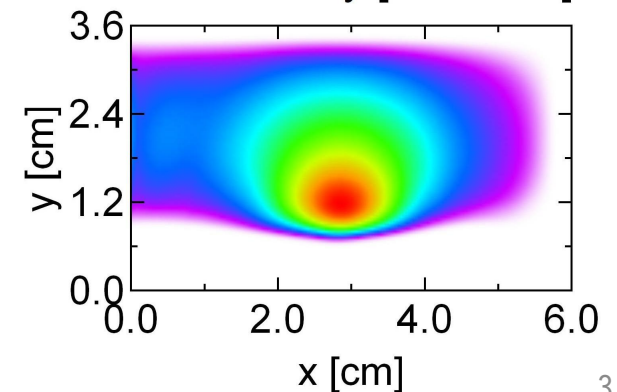
Electron density [$\times 10^{20} \text{ m}^{-3}$]



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

Magnetron discharges

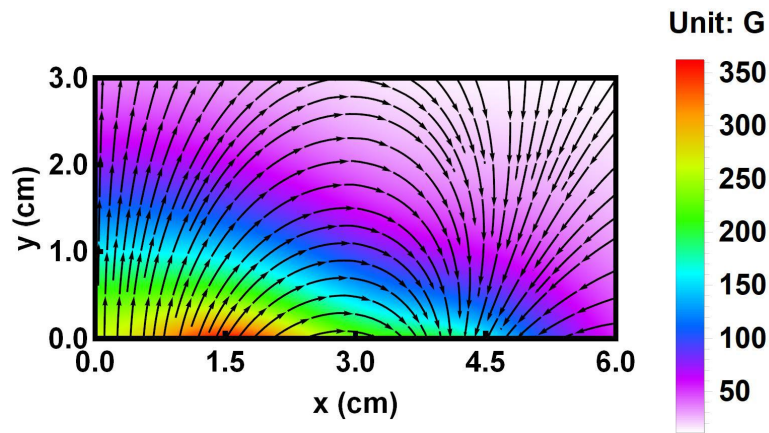
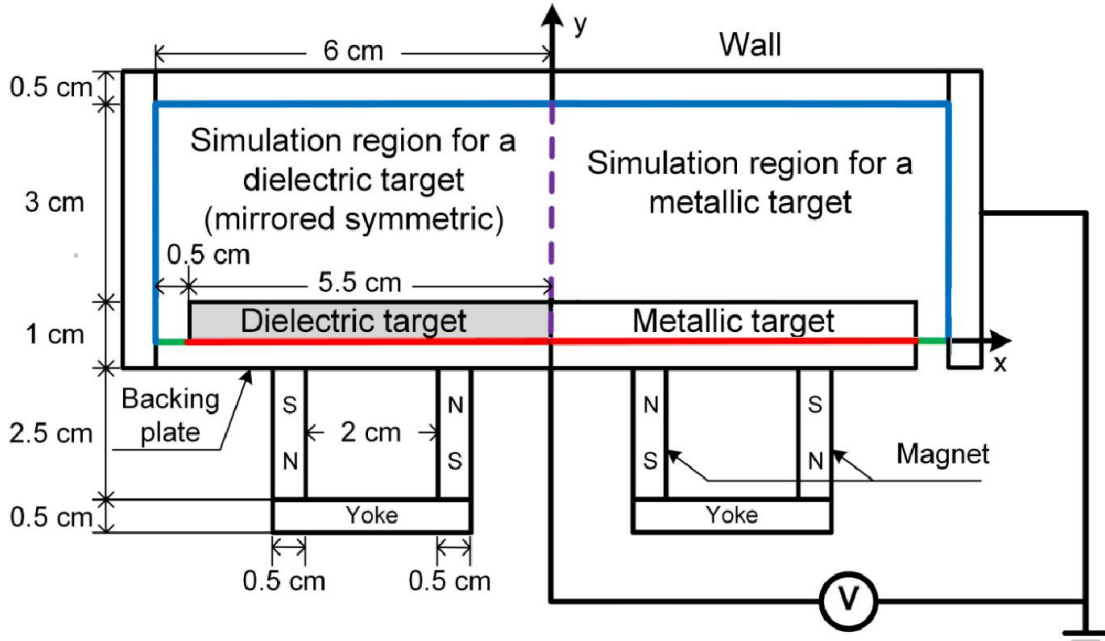
Electron density [10^{16} m^{-3}]



B. Zheng et al., PSST (2021)
[doi:10.1088/1361-6595/abe9f9](https://doi.org/10.1088/1361-6595/abe9f9)

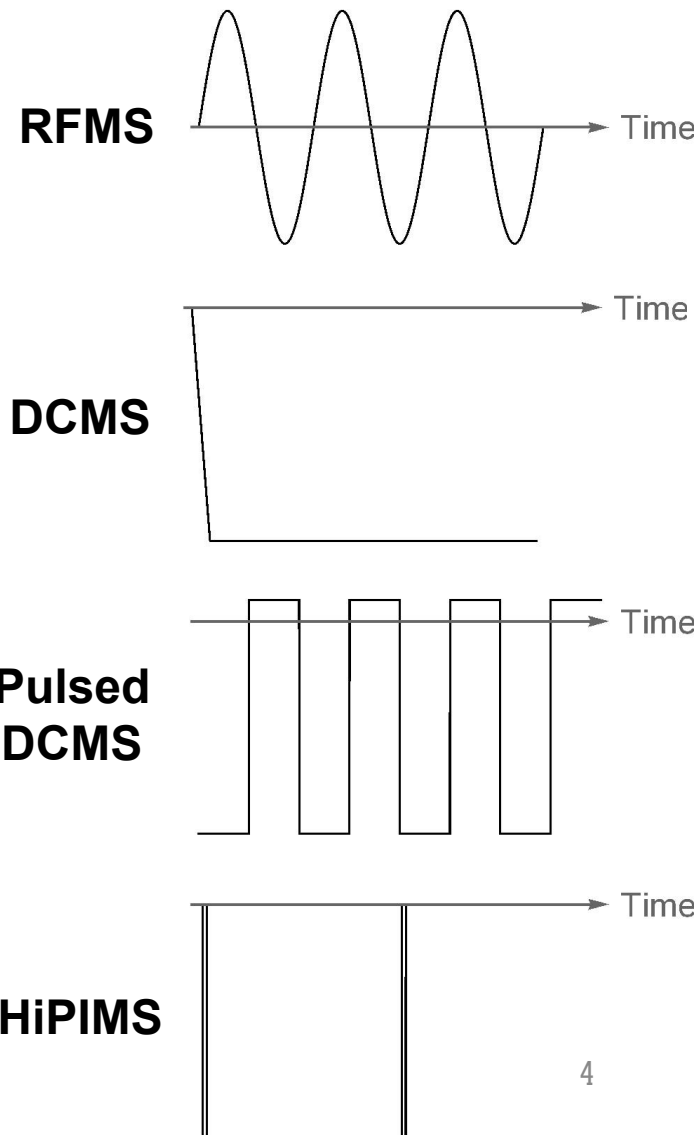
Magnetron sputtering discharges

Schematic of a magnetron sputtering set-up

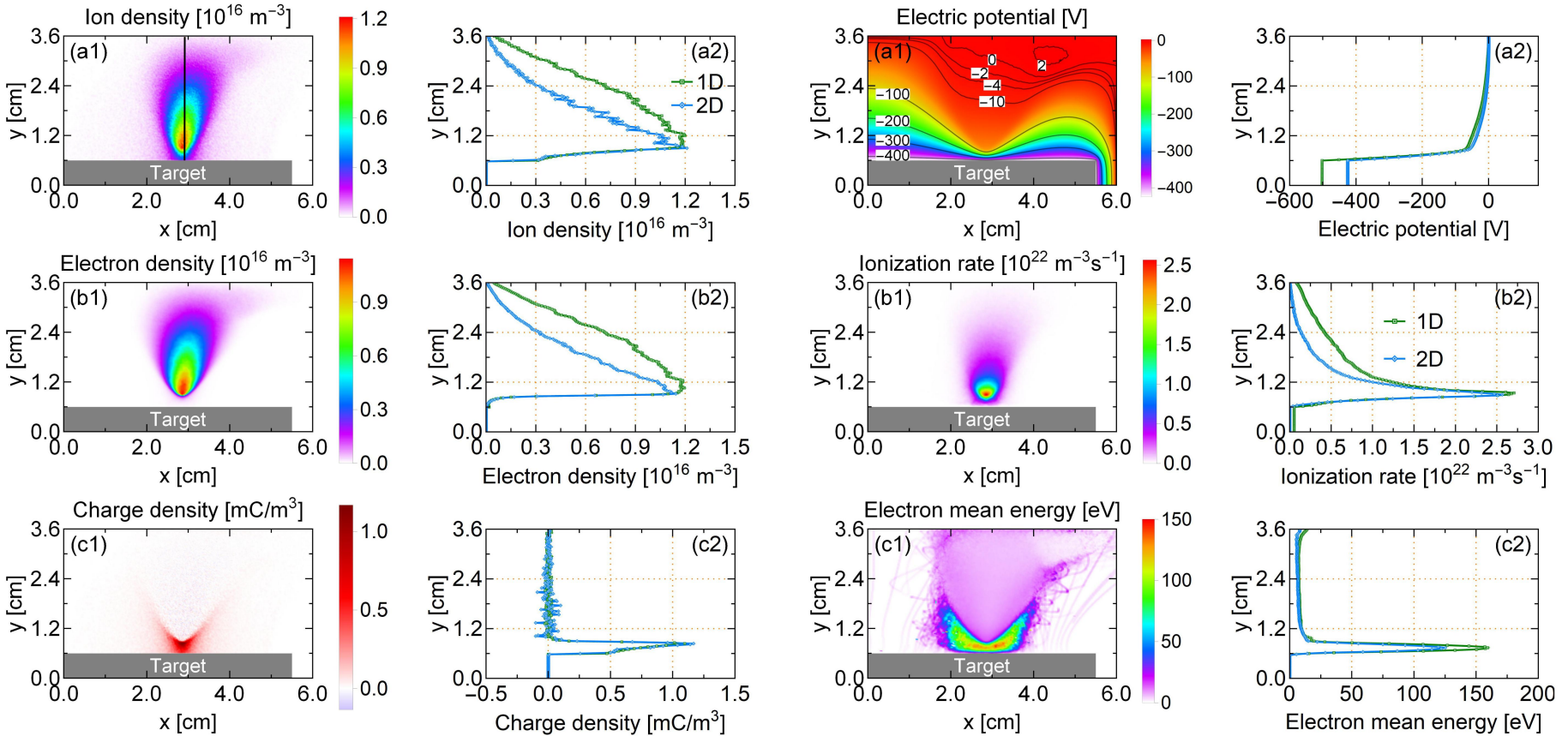


Magnetic field

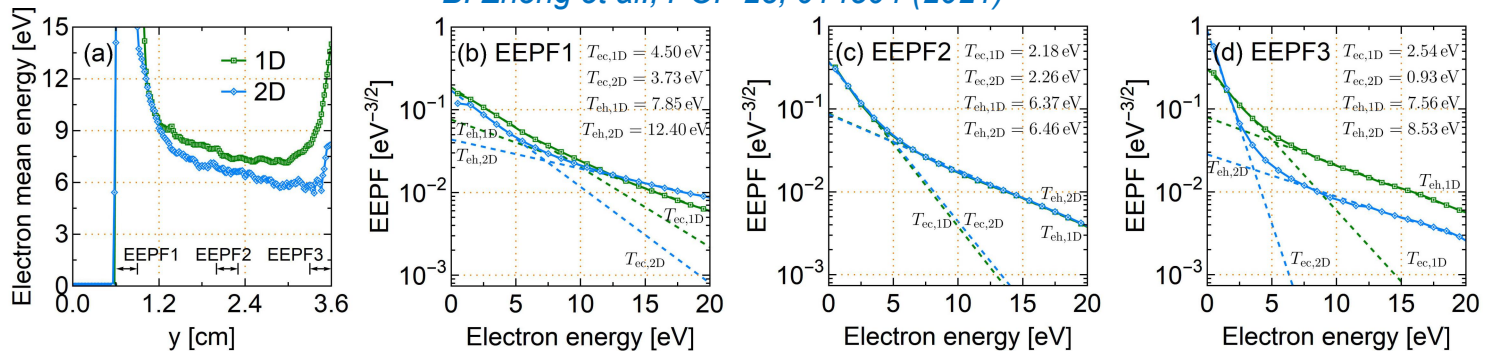
Voltage waveforms



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



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



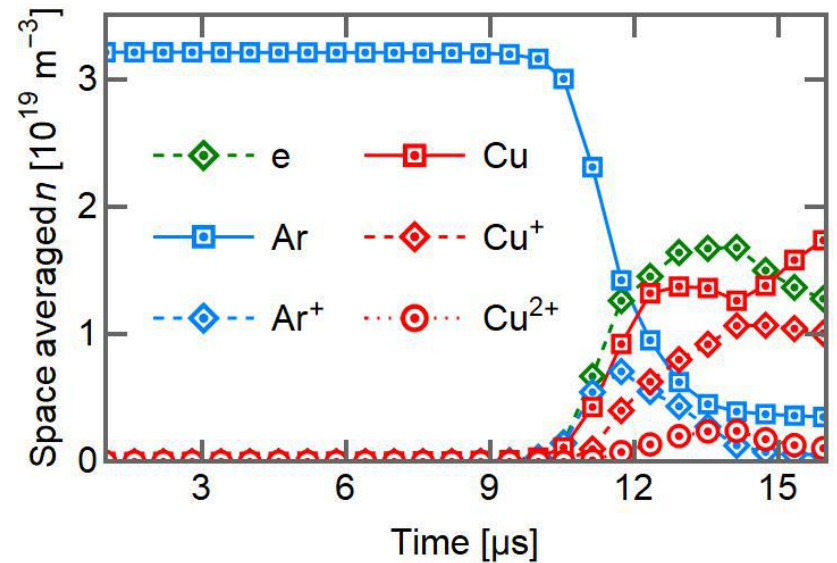
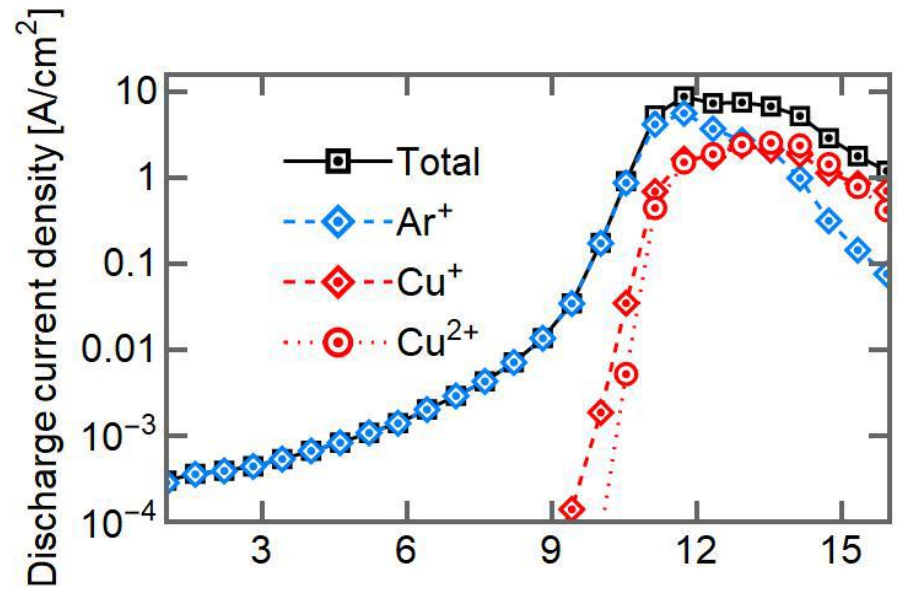
Discharge characteristics

■ Additional physical processes

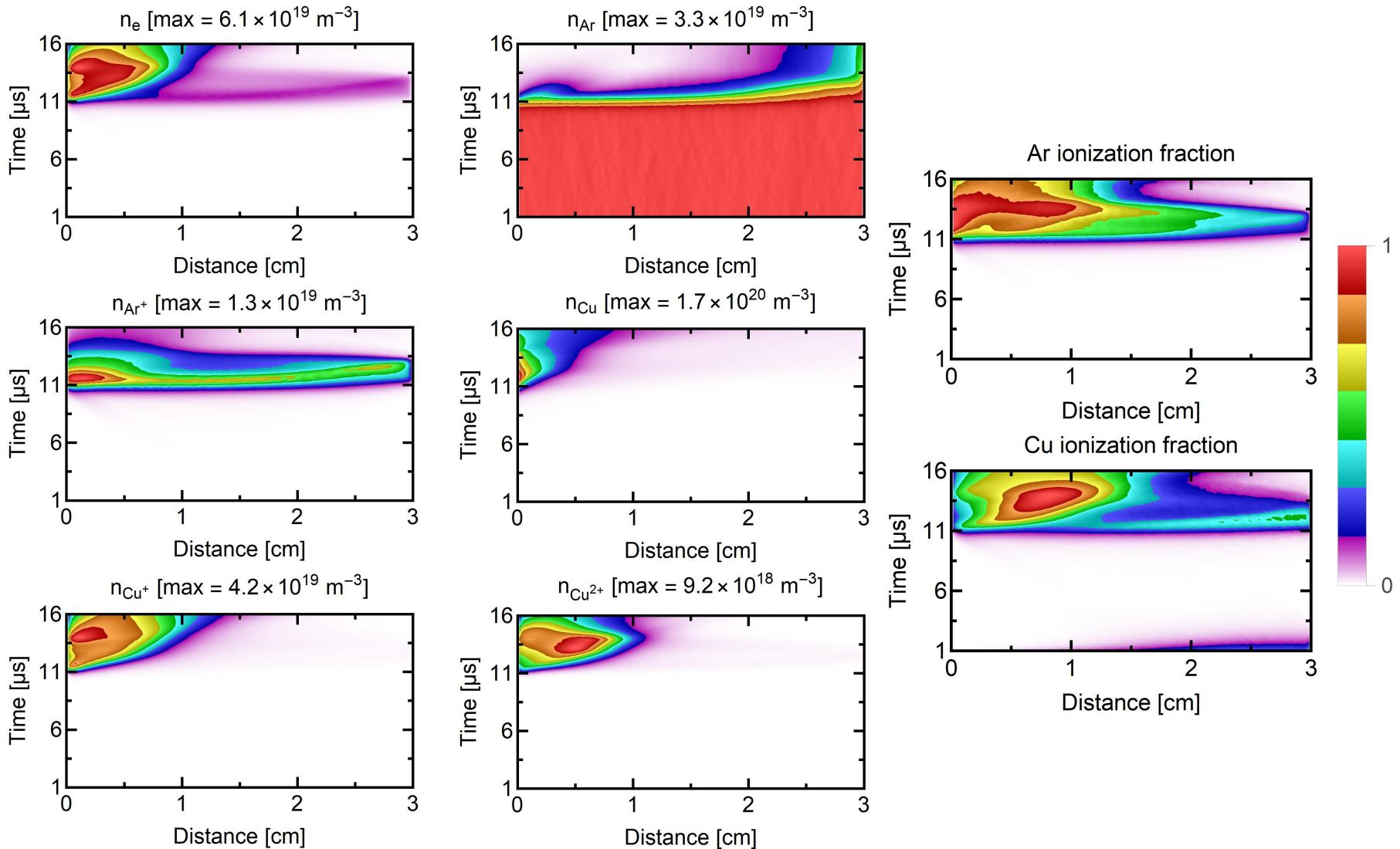
- Coulomb collisions
- Sputtering wind
- Metal ions
- SEE induced by metal ions

■ Discharge parameters

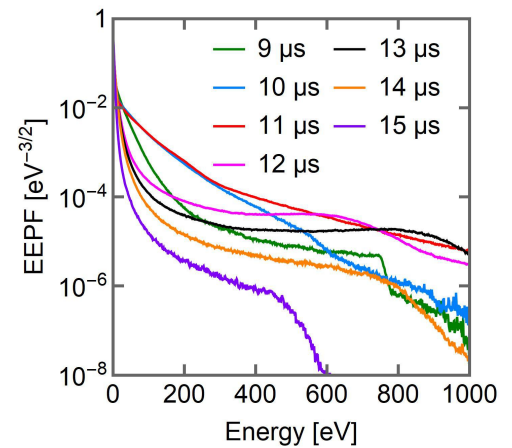
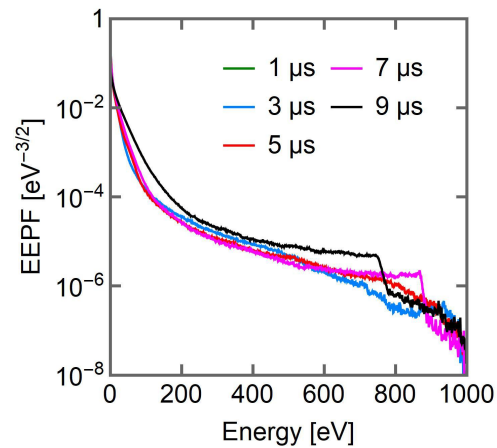
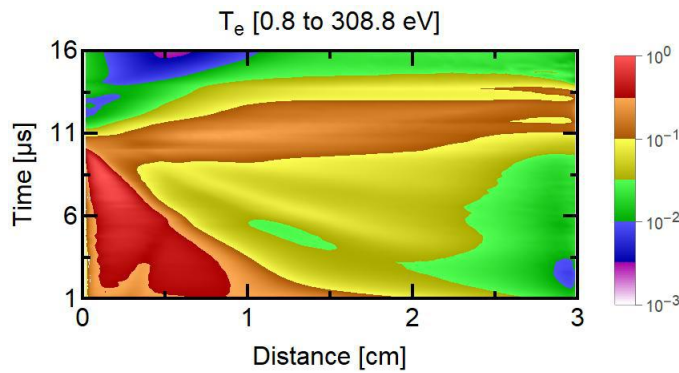
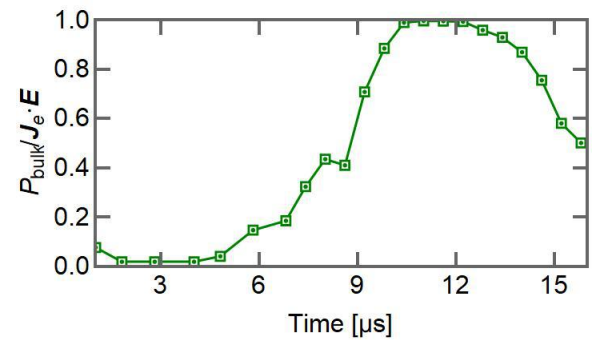
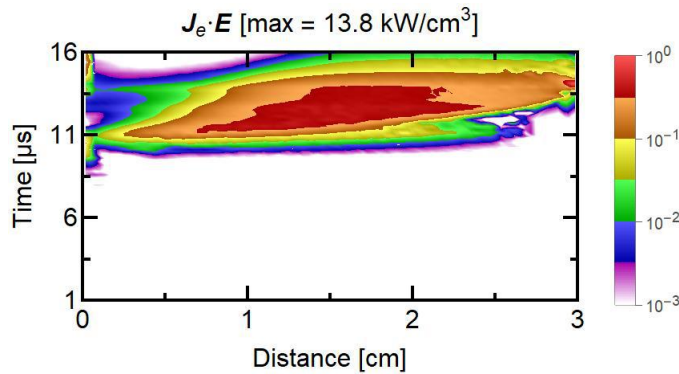
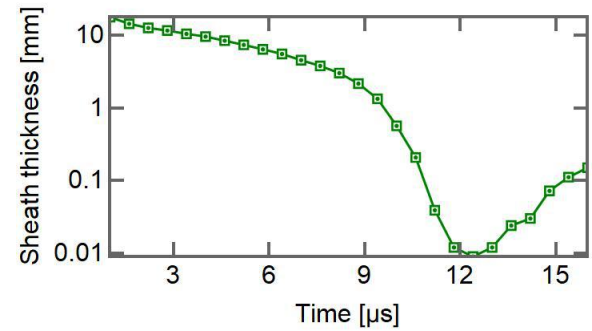
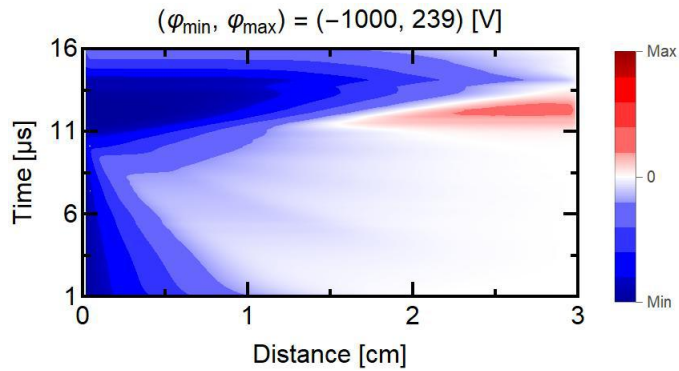
- Voltage: -1 kV
- Pressure: 1 mTorr
- Gas: Ar
- Target: Cu
- Gap length: 3 cm



Spatiotemporal dynamics of species

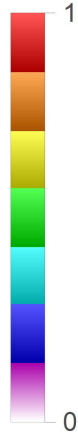
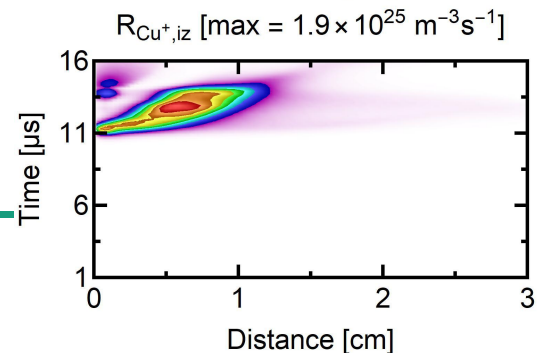
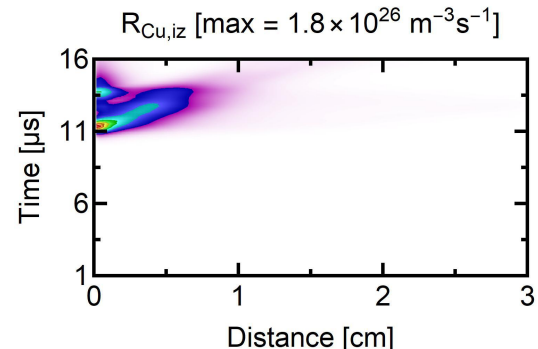
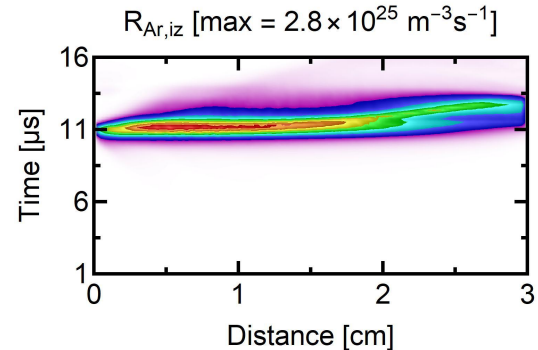
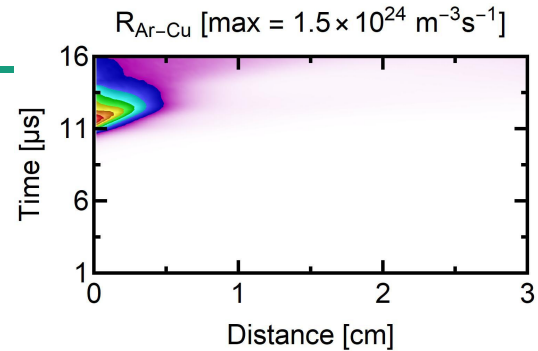
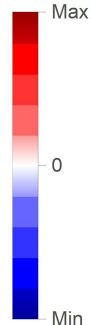
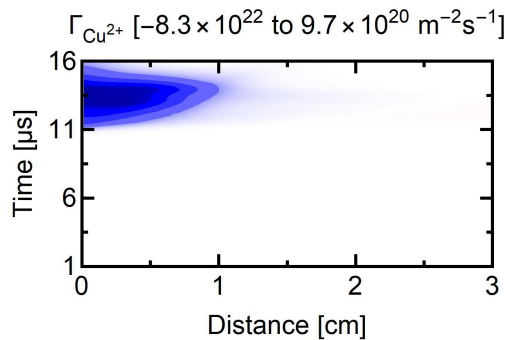
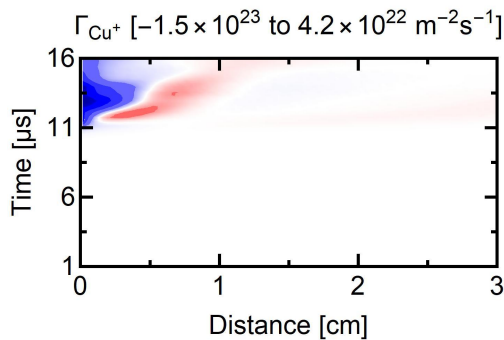
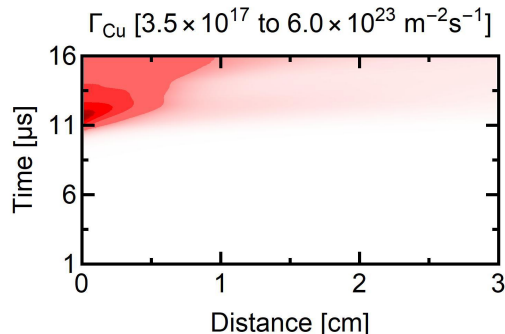
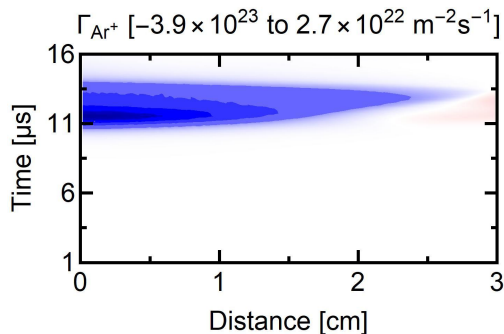
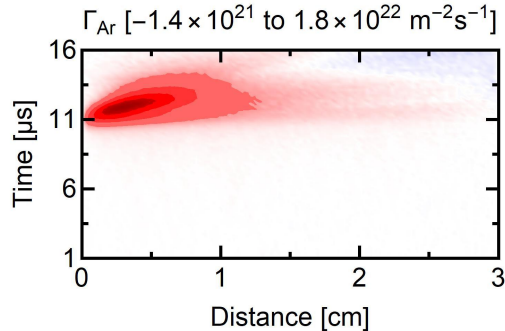
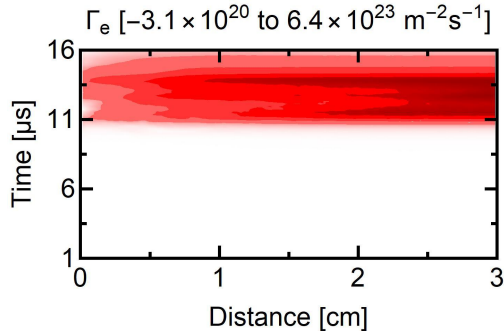


Electron kinetics



Gas rarefaction

Sputtering wind vs ionization



Thank you

- The slides can be downloaded at bczheng.com/talks/Zheng21_SVC.pdf
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