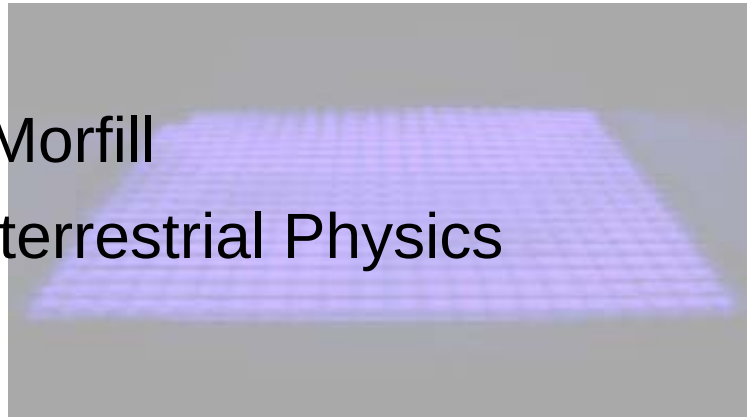
Modeling of Plasma Chemistry of Hand Plasma Sterilization Device

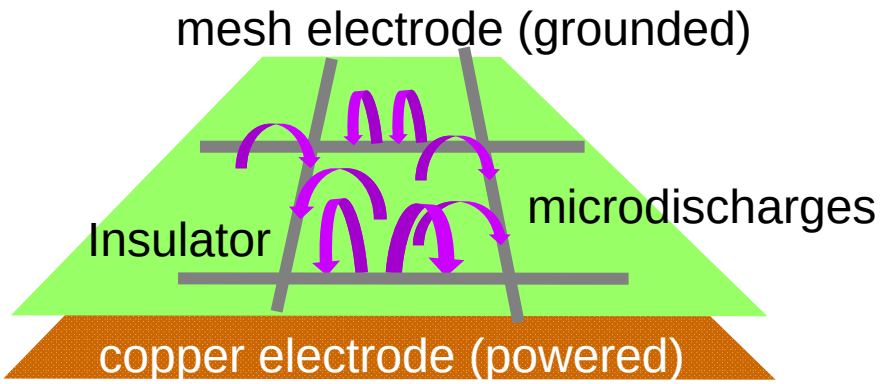
Yuki Sakiyama and David B. Graves,
Department of Chemical and Biomolecular Engineering,
University of California, Berkeley

Tetsuji Shimizu and Gregor E. Morfill
Max Planck Institute for Extraterrestrial Physics

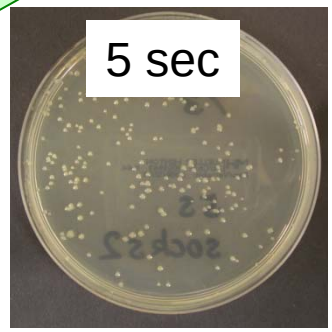


Motivation: hand sterilization dispenser

G. Morfill et al., New J. Phys. **11**, 115019 (2009)



Sterilization through socks

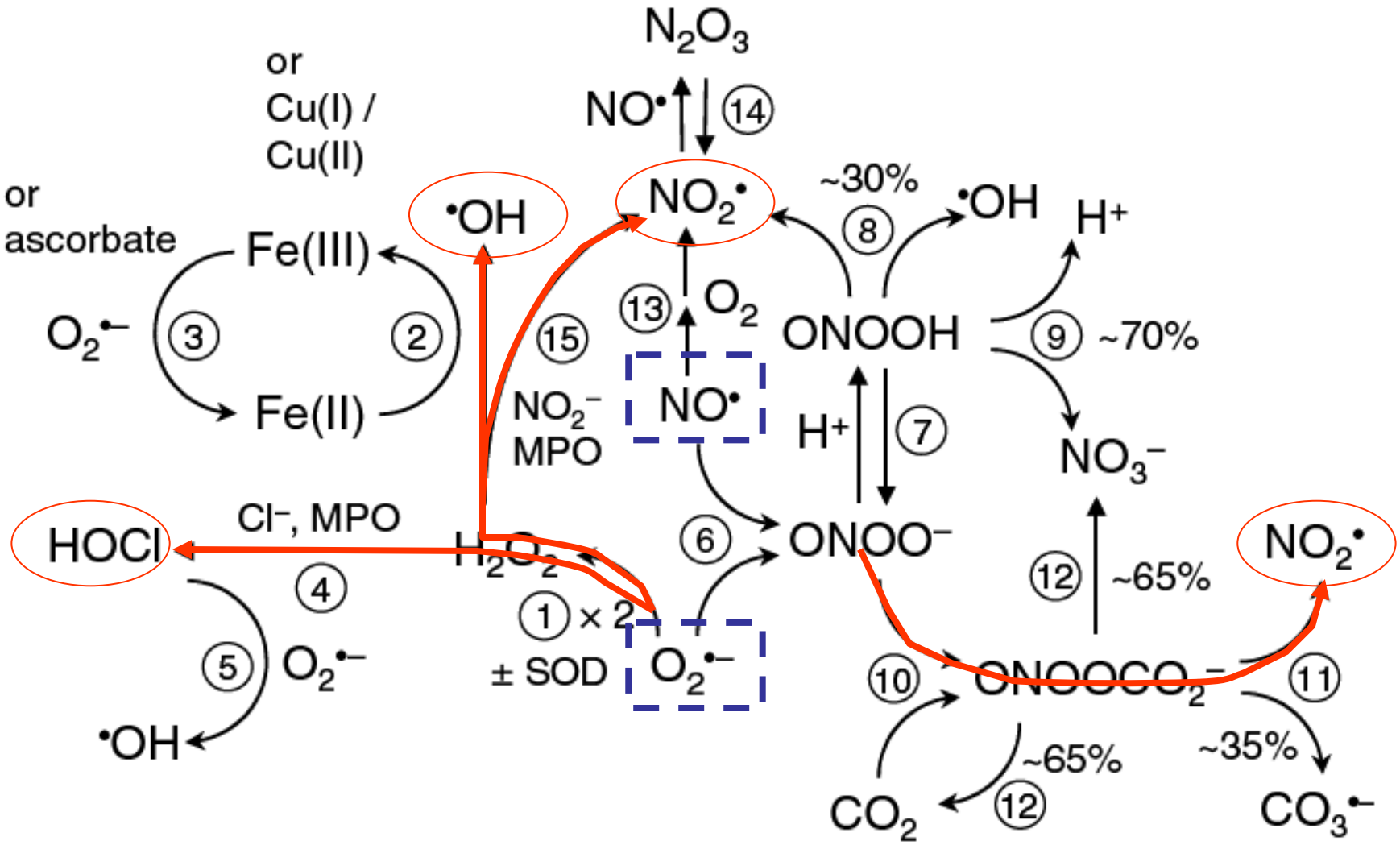


- Power: 50 Watts/100 cm^2
- Voltage: 5-10 kV_{pkpk}
- Frequency: 1-10 kHz

T. Shimizu, et al. Wed 10:15am!

Motivation: importance of ROS/RNS

R. B Mikkelsen, Oncogene **22** (2003) 5734

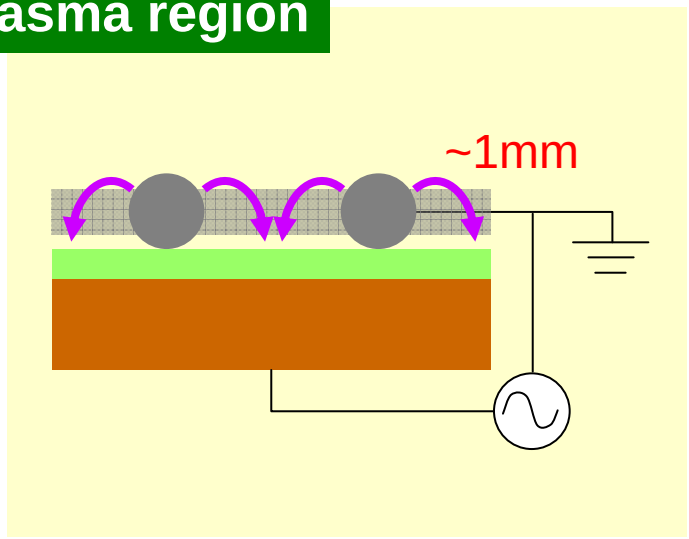


Model: strategy

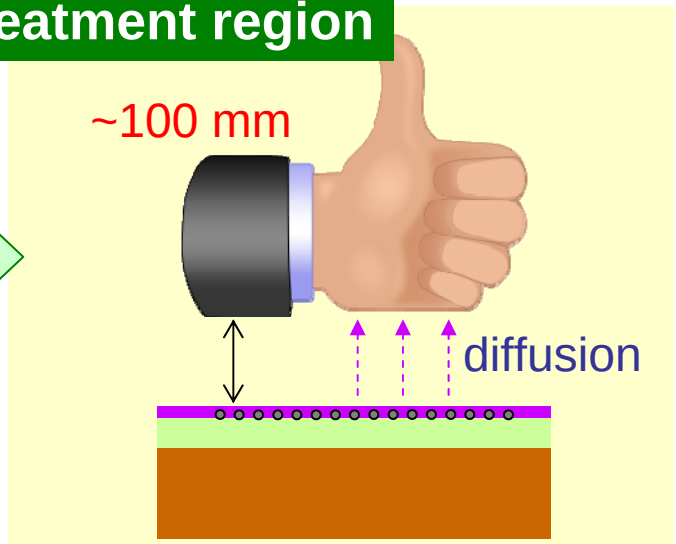
The goal of the project

- Developing numerical models to predict the device performance
- Controlling ROS/RNS to optimize the therapeutic effects

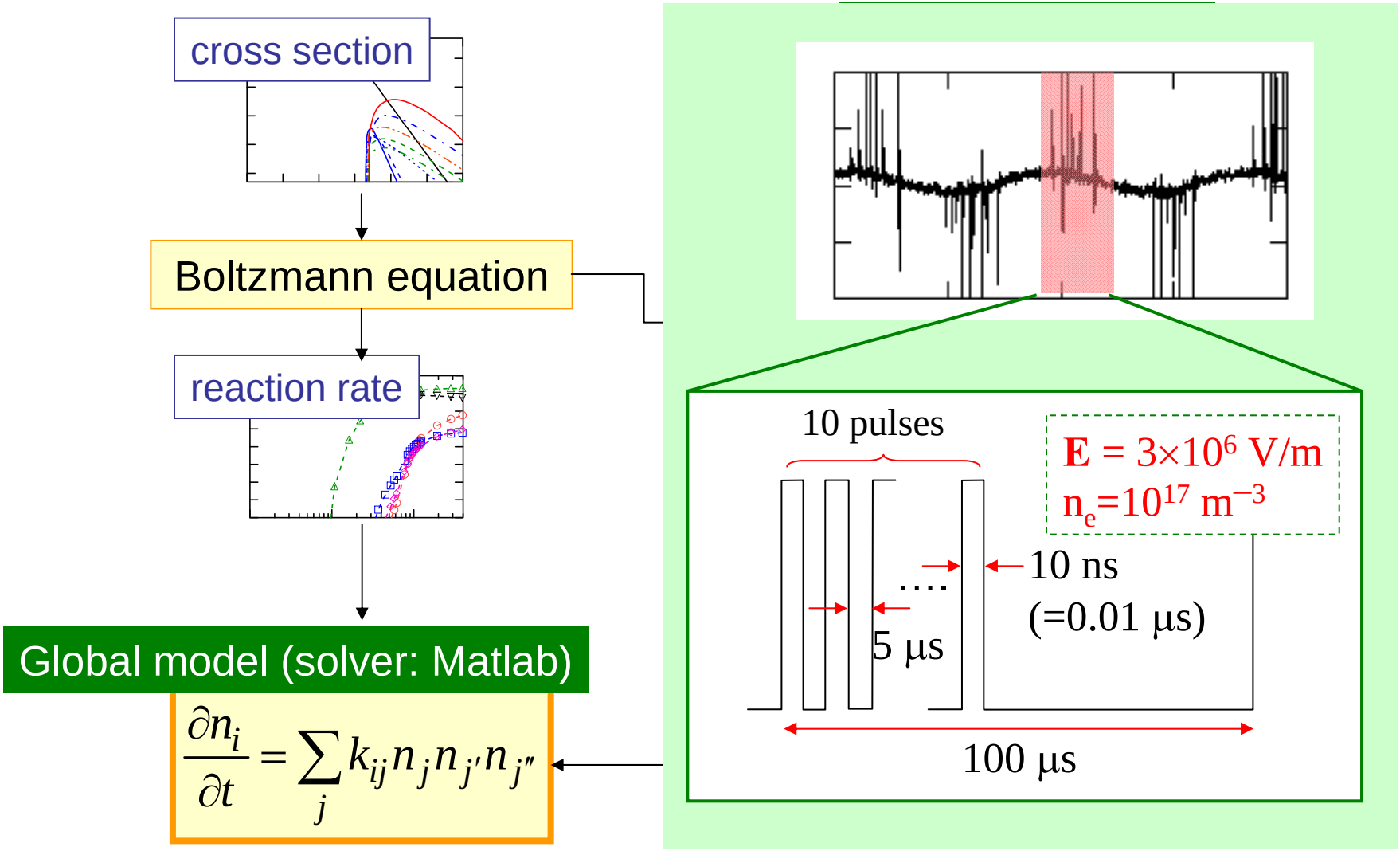
Plasma region



Treatment region



Model: governing equation



Model: plasma chemistry

48 species

11 negative particles: e, O^-, O_2^-, O_3^-, O_4^-, H^-, OH^-, NO^-, N_2O^-, NO_2^-, NO_3^-

16 positive particles: N^+, N_2^+, N_3^+, N_4^+, O^+, O_2^+, O_4^+, NO^+, N_2O^+, NO_2^+, H^+, H_2^+, H_3^+, OH^+, H_2O^+, H_3O^+

21 neutrals: N, N*, N_2, N_2*, N_2**, O, O*, O_2, O_2*, O_3, NO, N_2O, NO_2, NO_3, N_2O_5, H, H_2, OH, H_2O, HO_2, H_2O_2

630 reactions

21 electron impact excitation/ionization/dissociation

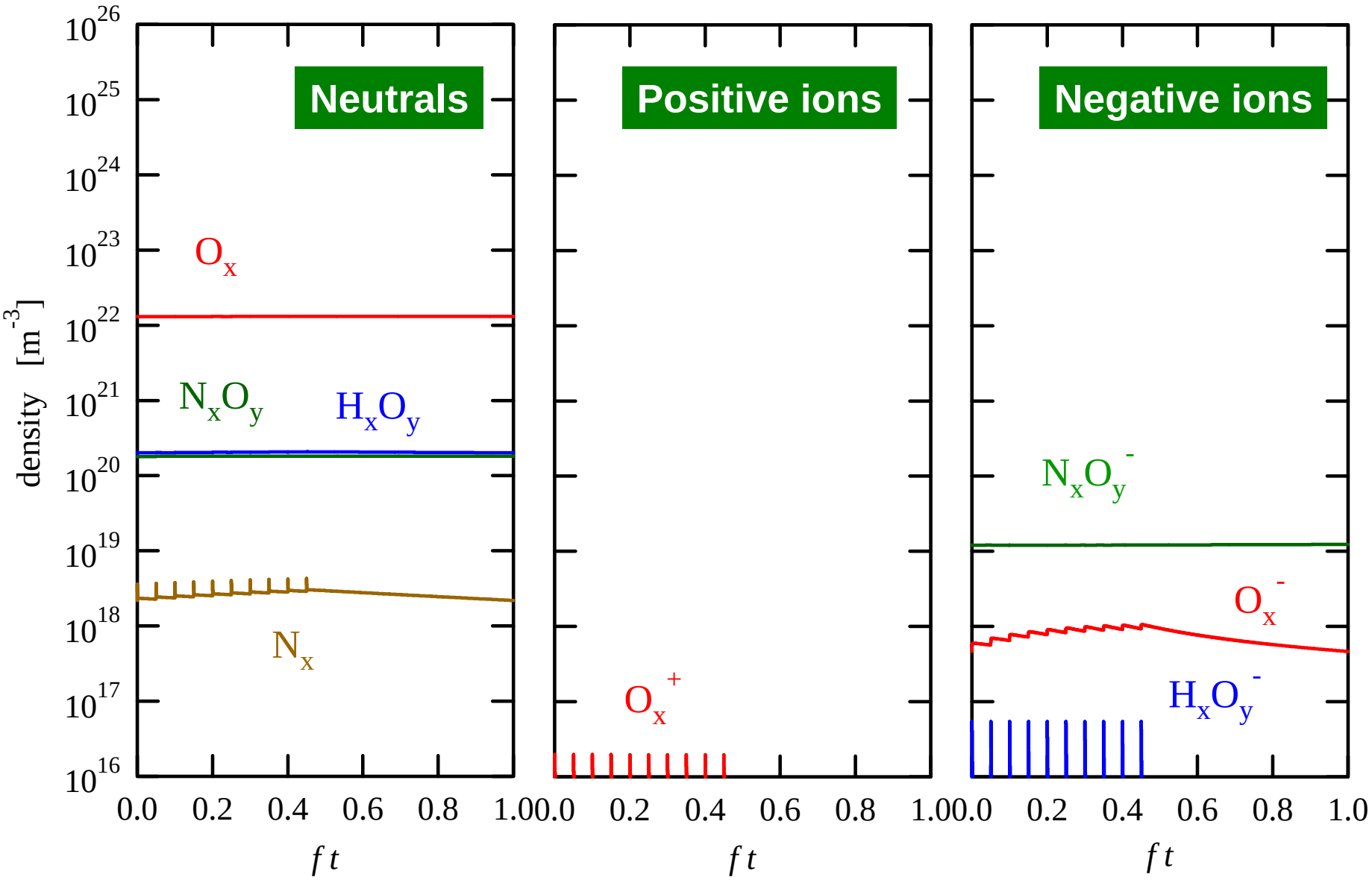
76 electron recombination/attachment

159 charge transfer

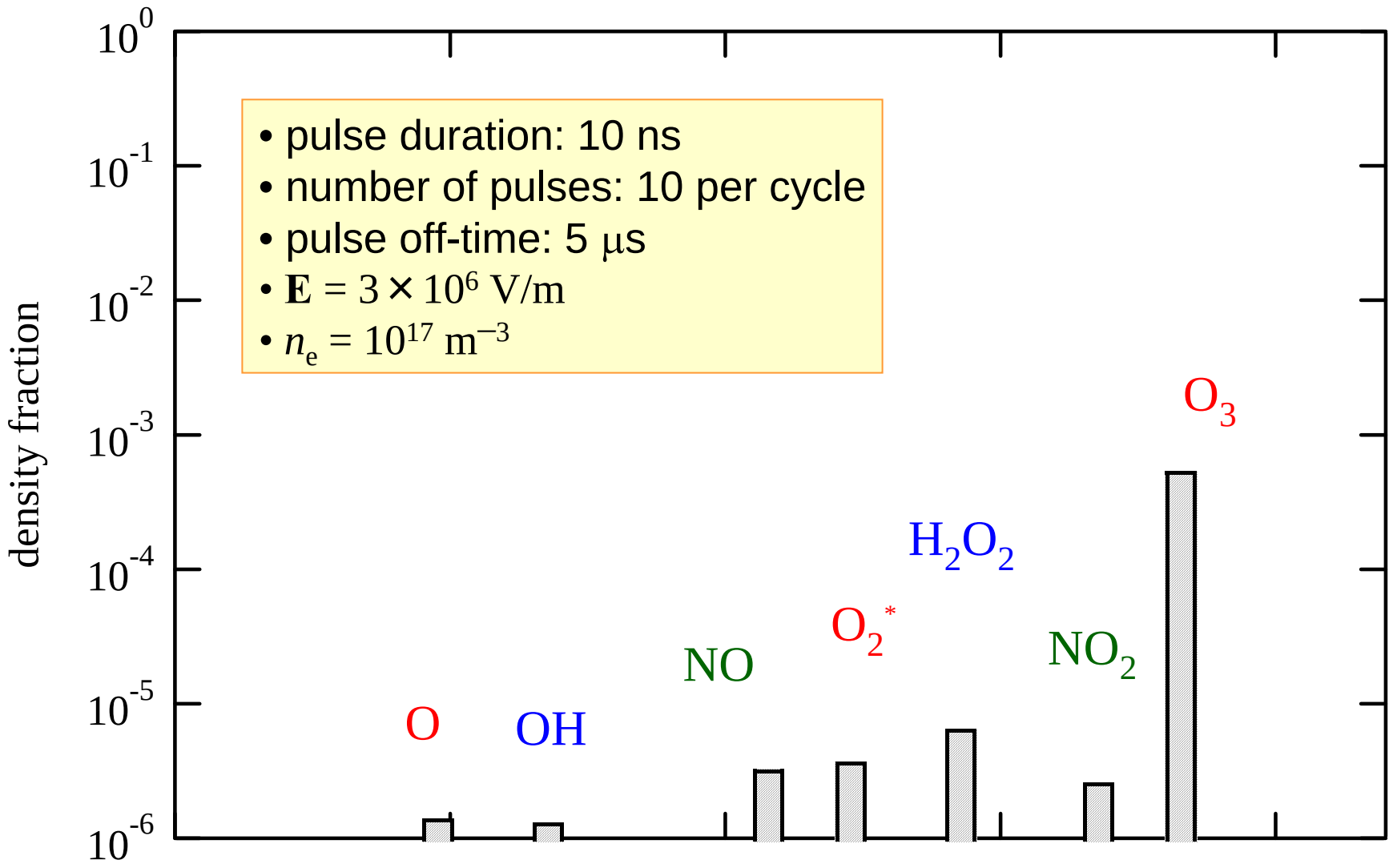
245 ion recombination

129 neutral-neutral reactions

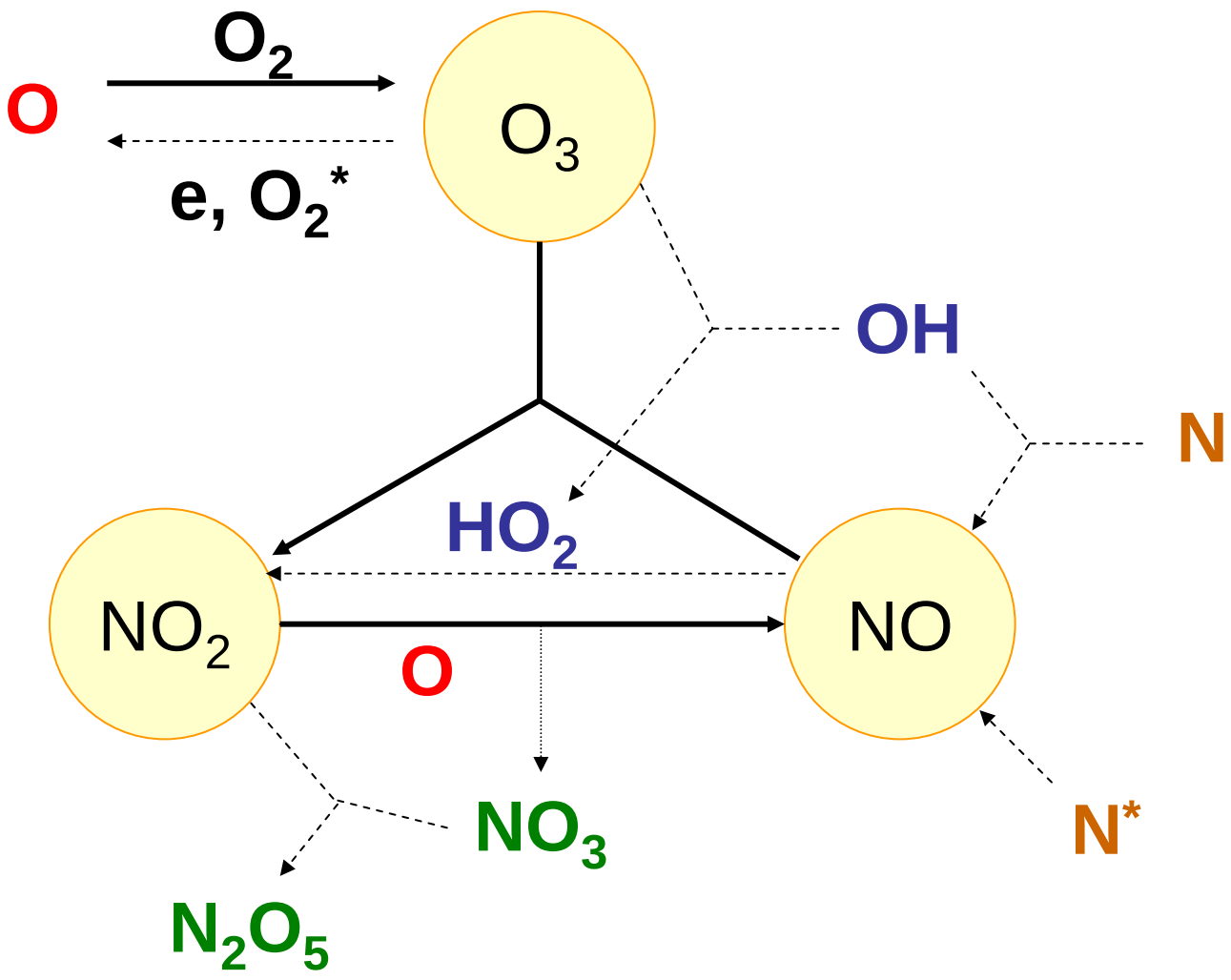
Dynamics of reactive species



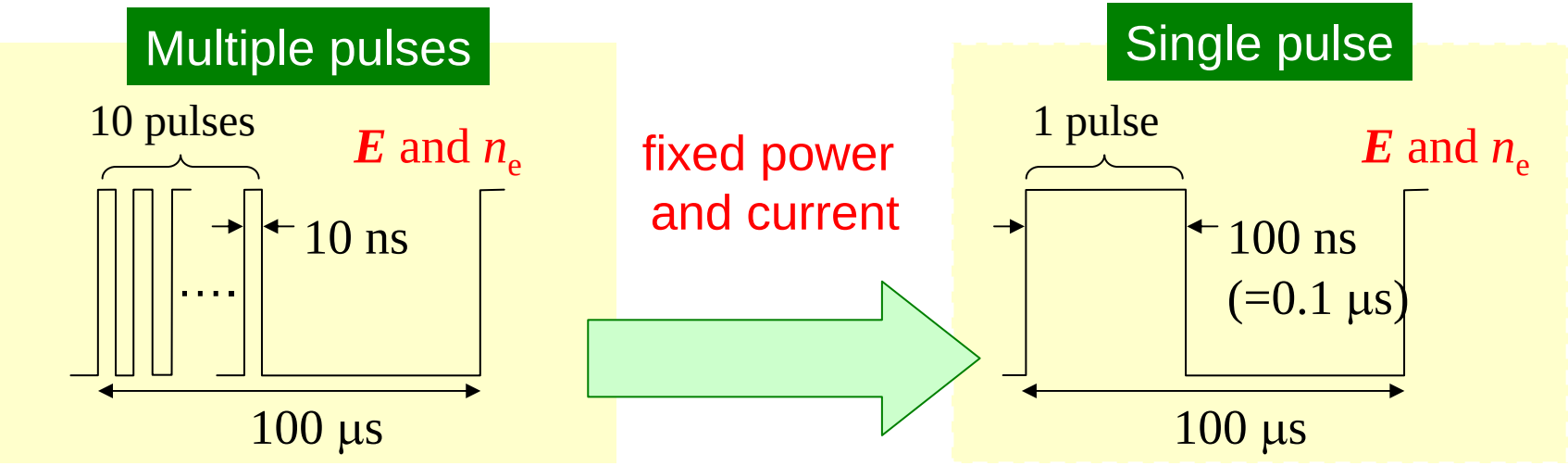
Phase-averaged density

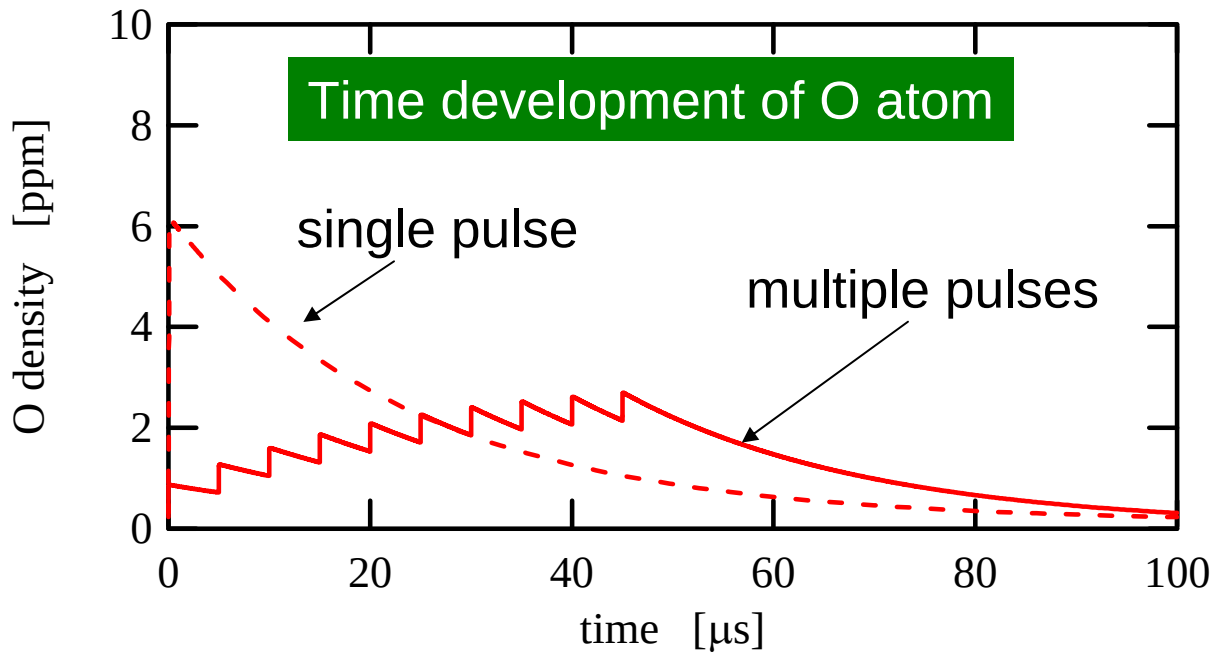


Reaction networks between O_3, NO, and NO_2



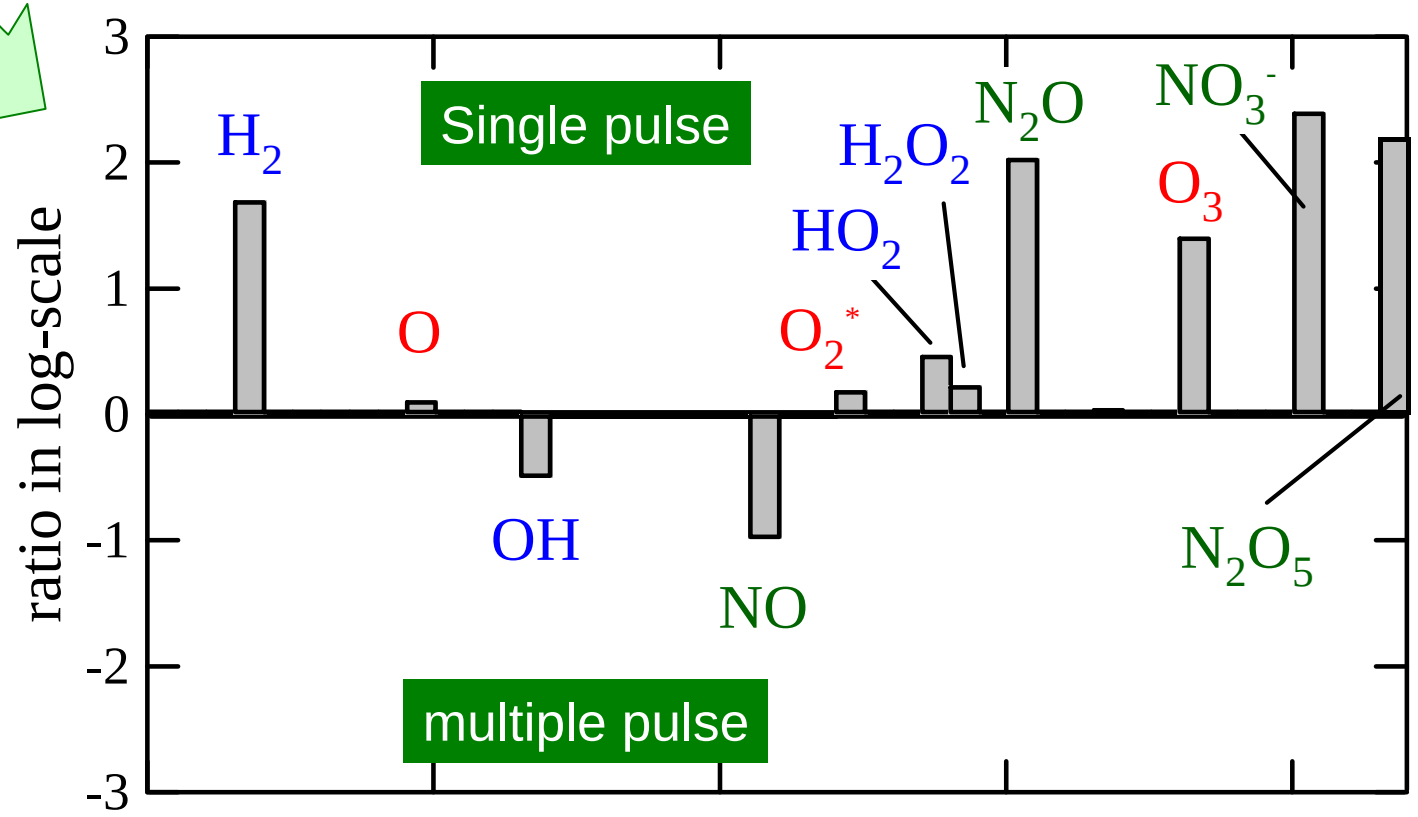
Control of plasma chemistry (1)





Control of plasma chemistry (2)

$$= \log\left(\frac{\text{density with single pulse}}{\text{density with multiple pulses}}\right)$$



Concluding Remarks

1. We have developed a global model of air barrier corona discharge.

2. A global model for air BCD suggests the most abundant species is O_3, followed by H_2O_2, O_2^*,NO, NO_2, O, and OH.

3. Concentration of ROS/RNS can be controlled by modifying the discharge current waveform.