Overview

I. General scenario for *charge migration* in extended systems under intense (X-ray) pulses

II. Self-similar electron dynamics: (Semi-)quantitative model

III. Ion dynamics:
reduction of radiation damage (Coulomb explosion)

1. Supply screening electrons
2. remove positive charge (but not relevant ions!)

mpipks

Finite Systems

Photo activated Coulomb complexes & charge migration

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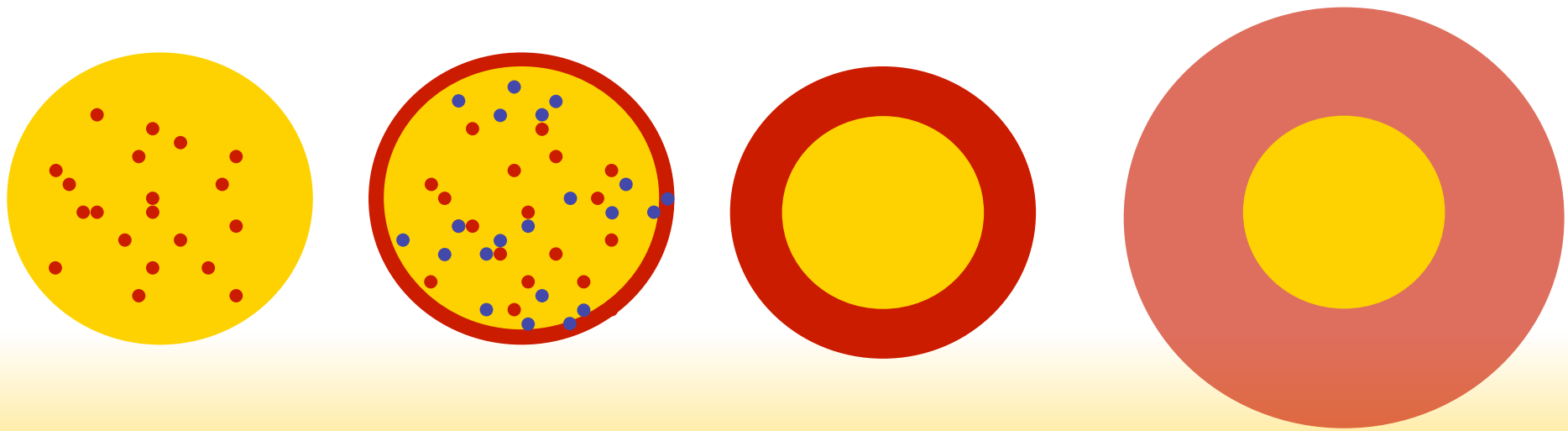
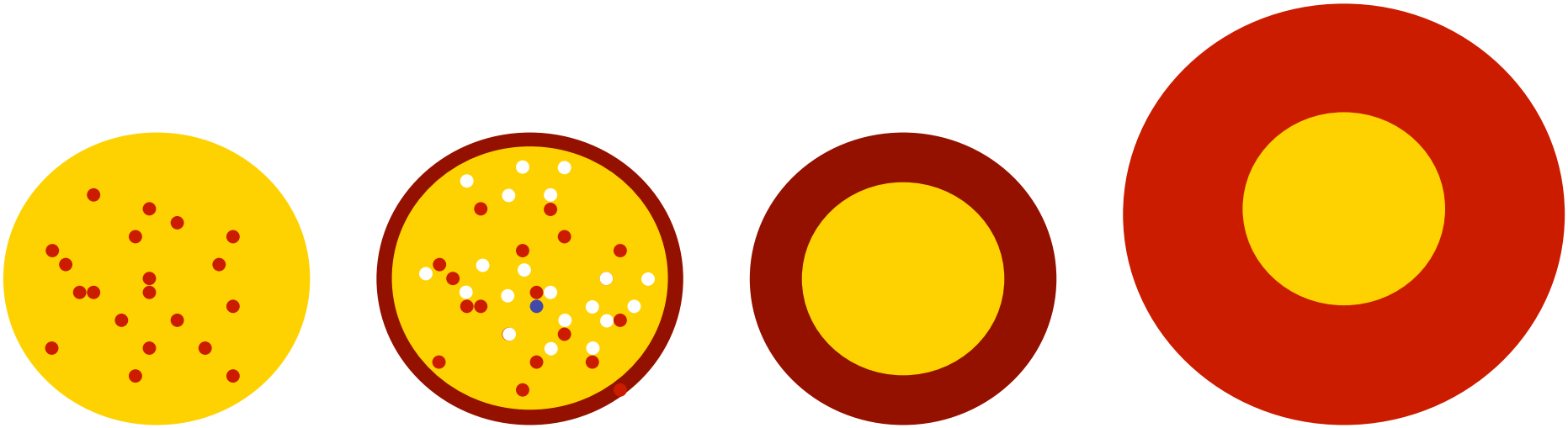
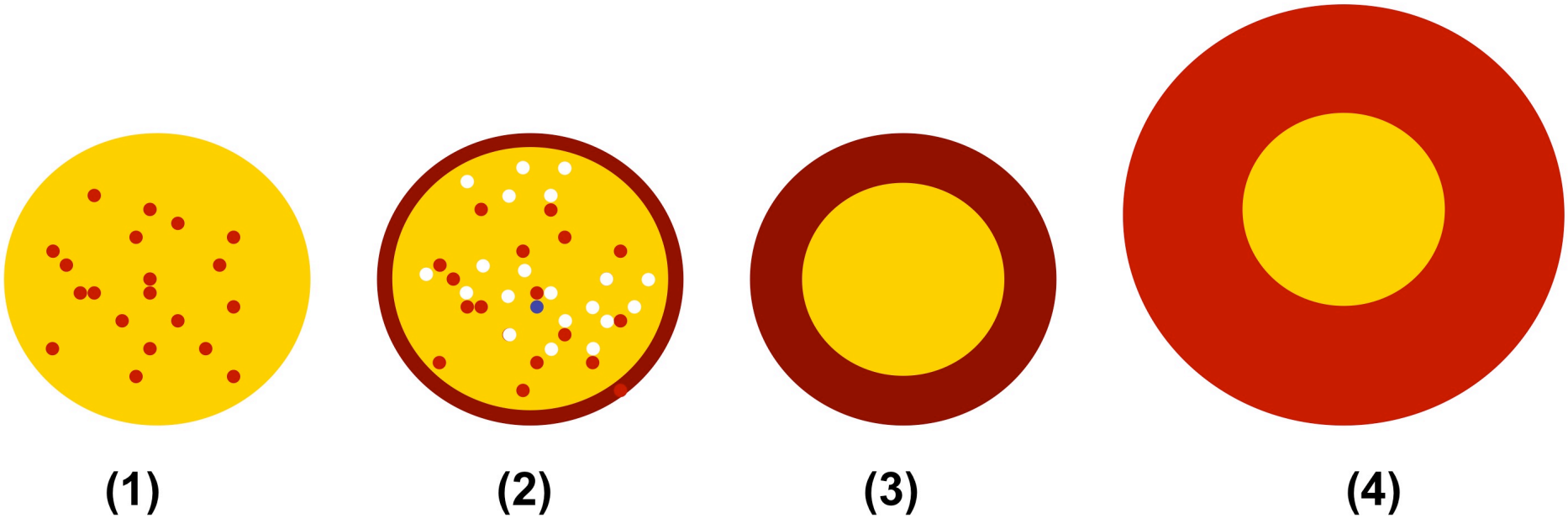
Electron migration in clusters under intense light

- Energy absorption from light leads to loss of electrons





(1) (2) (3) (4)


(1)
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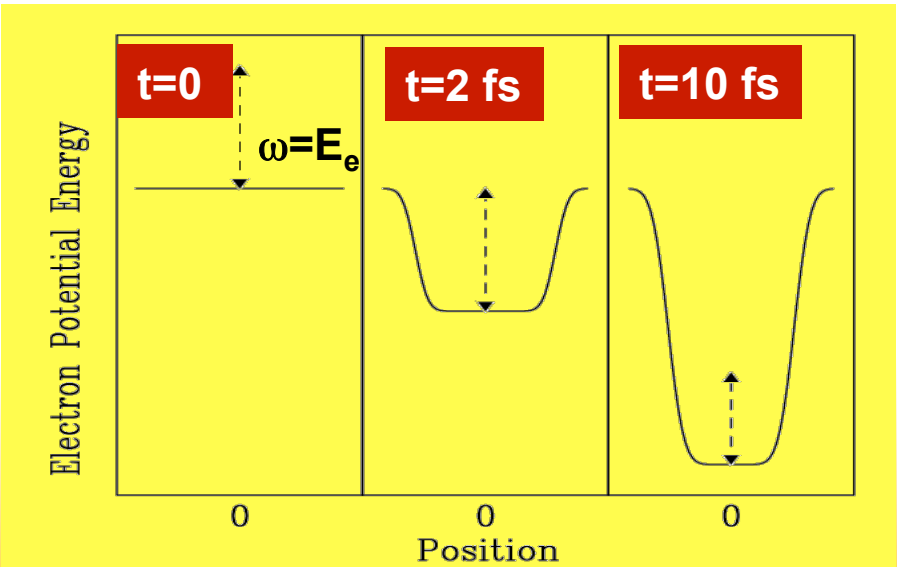
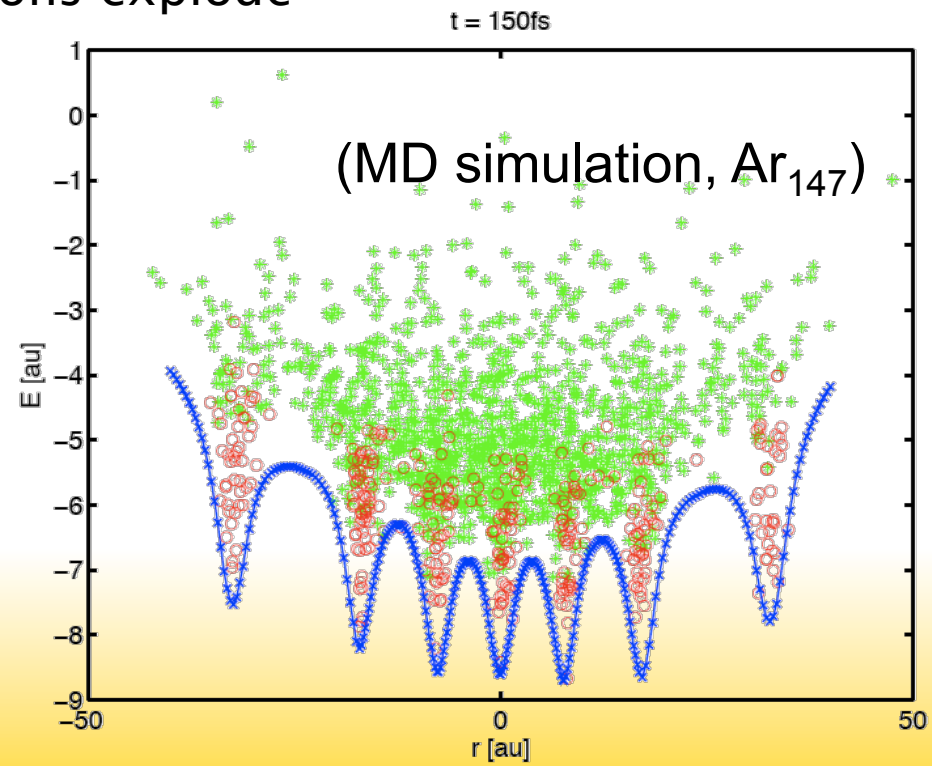
Electron migration in clusters under intense light

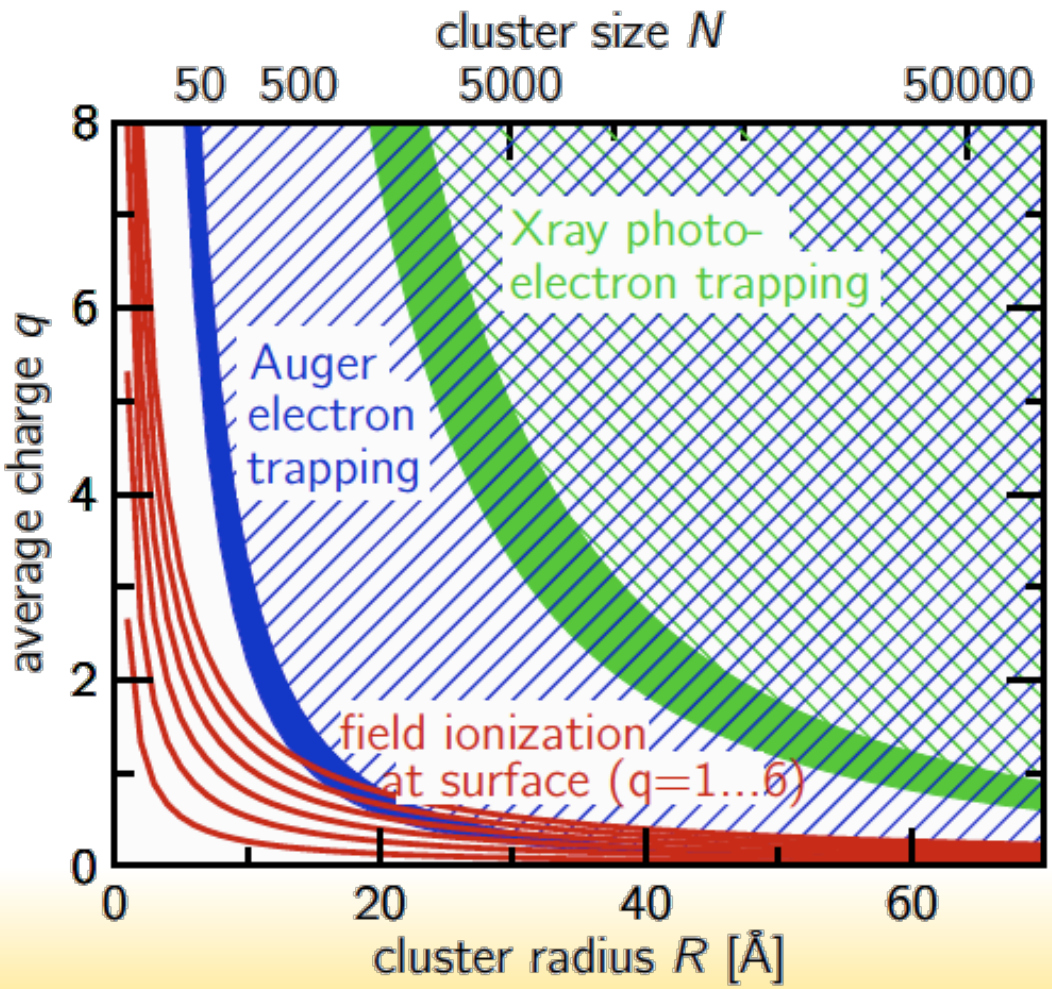
- Energy absorption from light leads to loss of electrons
  - ➜ ionic charge builds up
    - ➜ bound electrons from surface atoms are field ionized;

      electrons are trapped and form a (quasi-neutral) plasma
    - ➜ non-screened surface ions explode





12 keV pulse: Trapping of different types of dynamically generated electrons by a Neon-cluster core (charge q/ion)



large radial fields

Bethe rule for atomic (over-barrier) ionization:

$$F_Q \geq \frac{(E_{\mathrm{ip}})^2}{4Q}$$

neon: $F_Q \approx \frac{Q}{7}$

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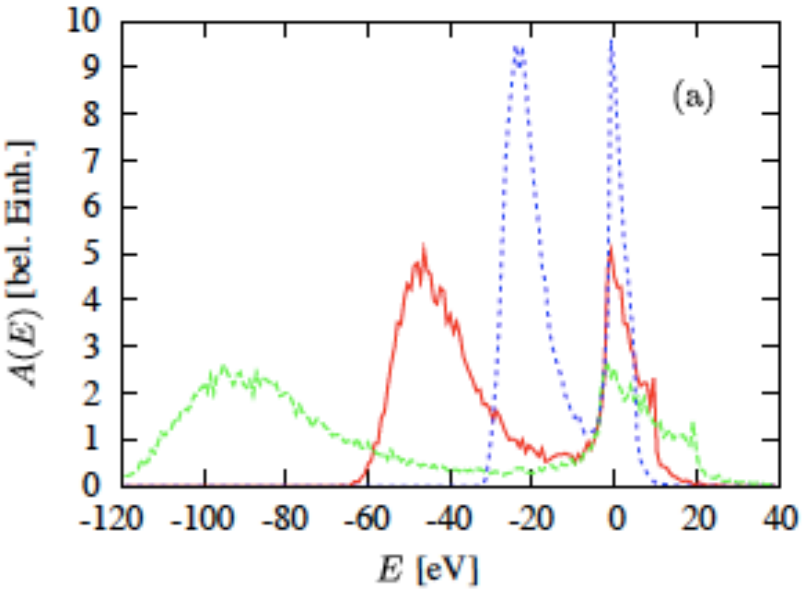
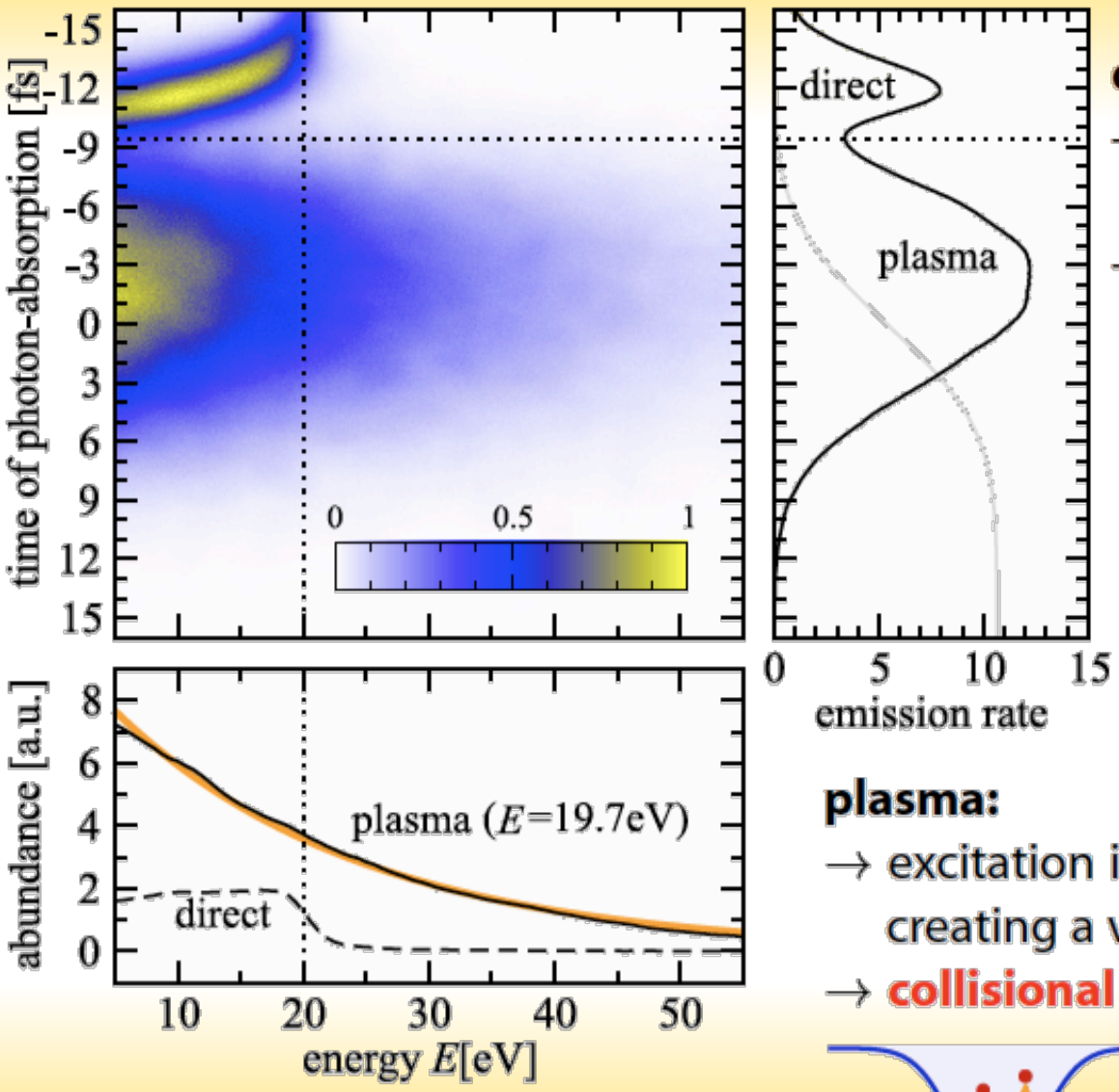
Electron spectrum dP(E)/dE after photo activation for a cluster with N=123 activated electrons



(R,E*,T) = (26 au, 10 eV, 10 fs)
(13 au, 20 eV, 7.7 fs)
(52 au, 5 eV, 14.4 fs)

R: cluster radius
E*: excess energy/electron
T: pulse duration

time-resolved dynamics



direct:

– sequential (multi-step) ionization

– measured and simulated [Bostedt et al. PRL 100 (2008) 133401]

plasma:

→ excitation into the cluster potential creating a very dense electron plasma

→ **collisional auto-ionization**

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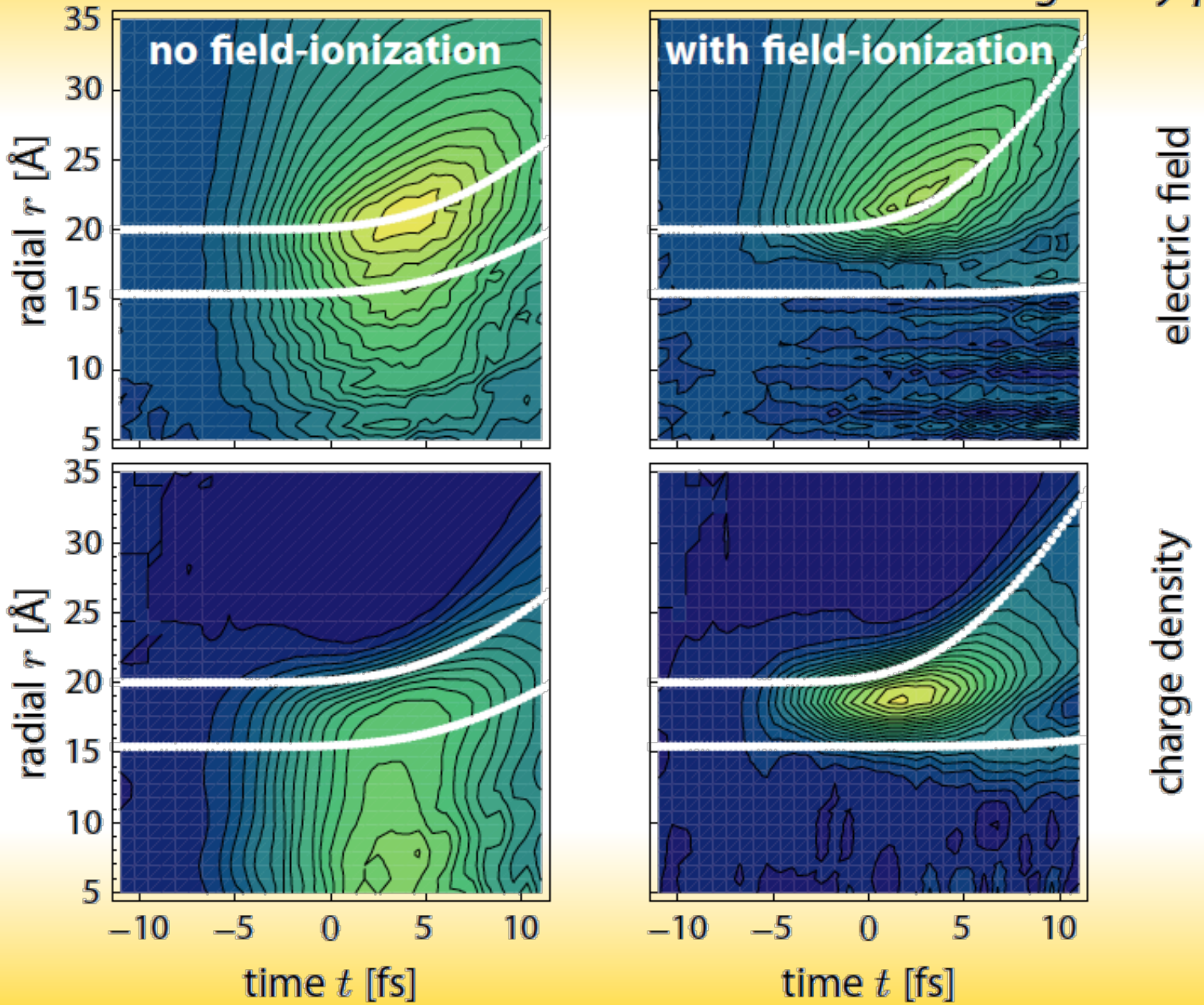
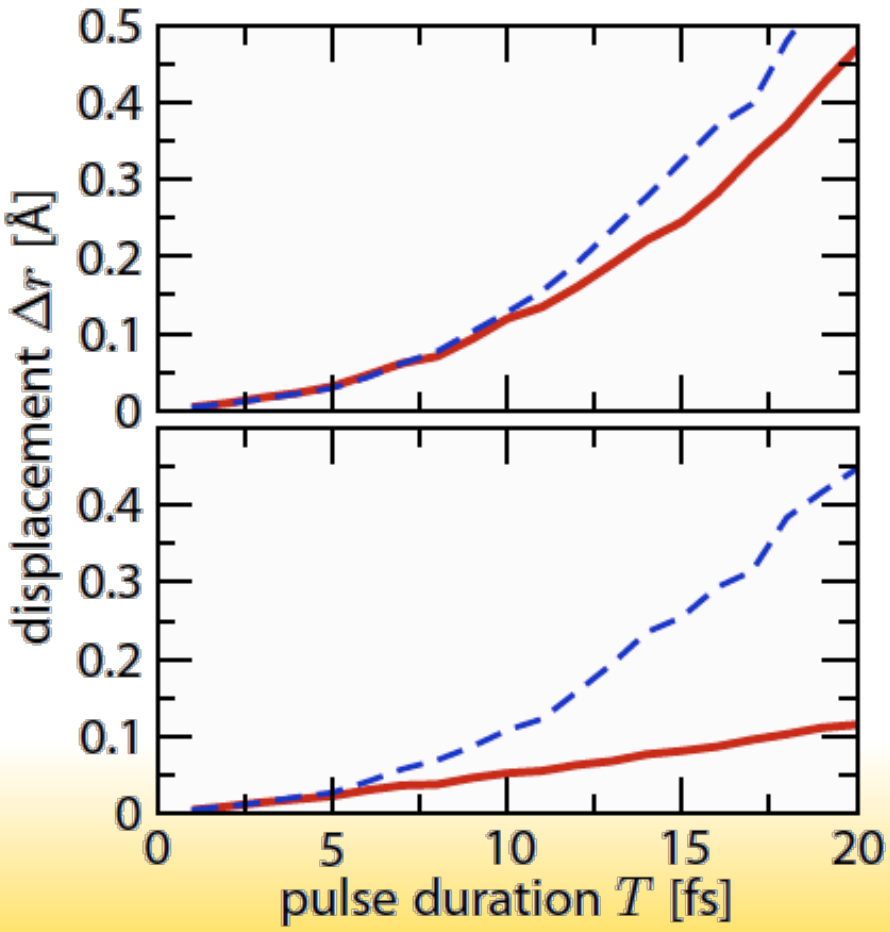
medium-size neon cluster in strong X-ray pulse



mean displacement: pulse-length dependence

mean displacement $\Delta r = \frac{1}{N}\sum_{i=1}^{N} |\vec{r}_i(-\infty) - \vec{r}_i(0)|$

fixed photon number per pulse: 10^{12}



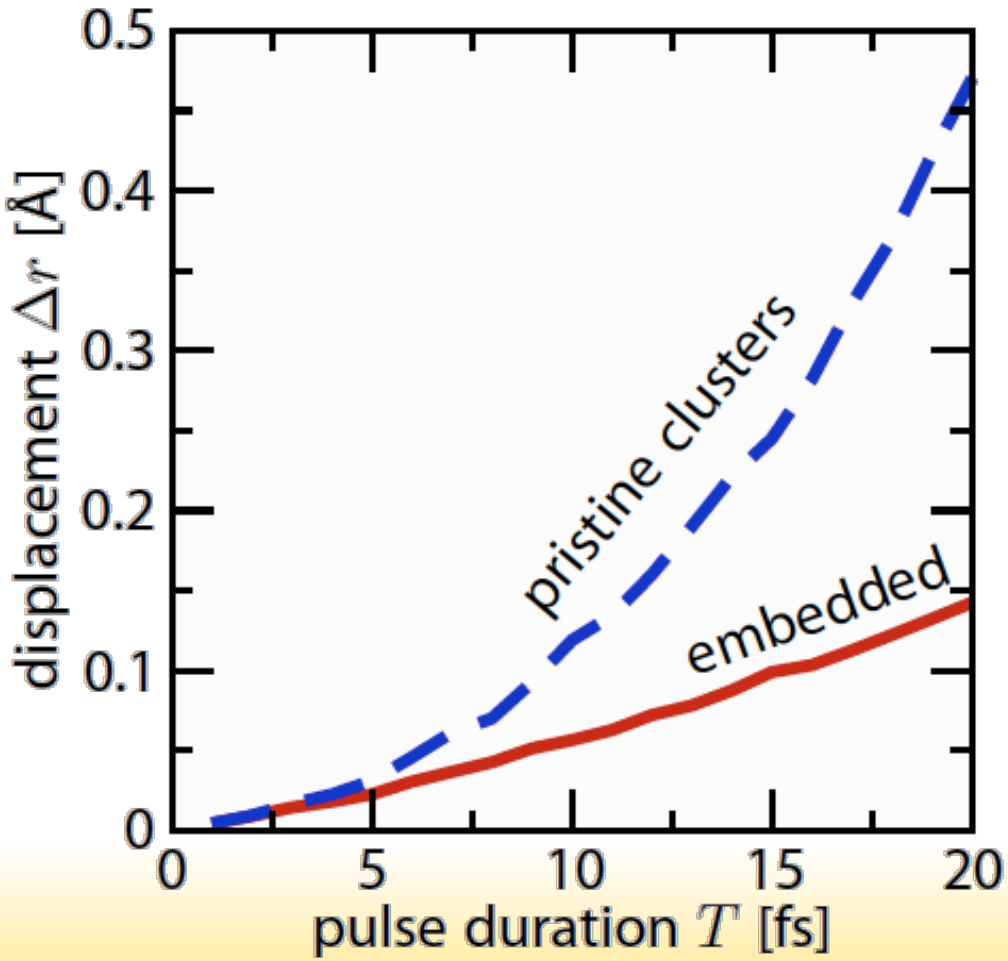
full cluster

"half" cluster

→ **helium droplet as sacrificial layer**

H_2O droplet [Hau-Riege et al. (2007)]

Ne_{1500} versus $Ne_{1500}@He_{15000}$
pulse-length dependence



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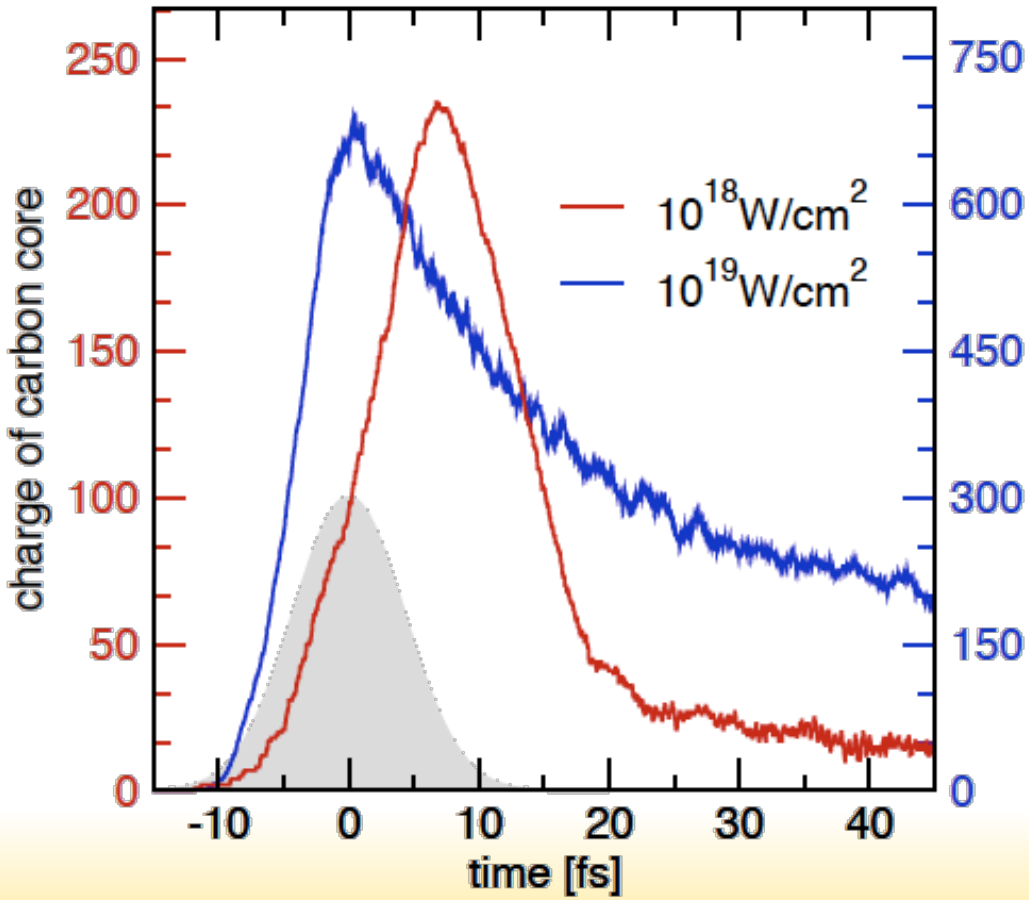
ultra-fast neutralization

$(CH_4)_{297}$ @ 1 keV, 10 fs (available at LCLS/Stanford, used by Ditmire et al.)

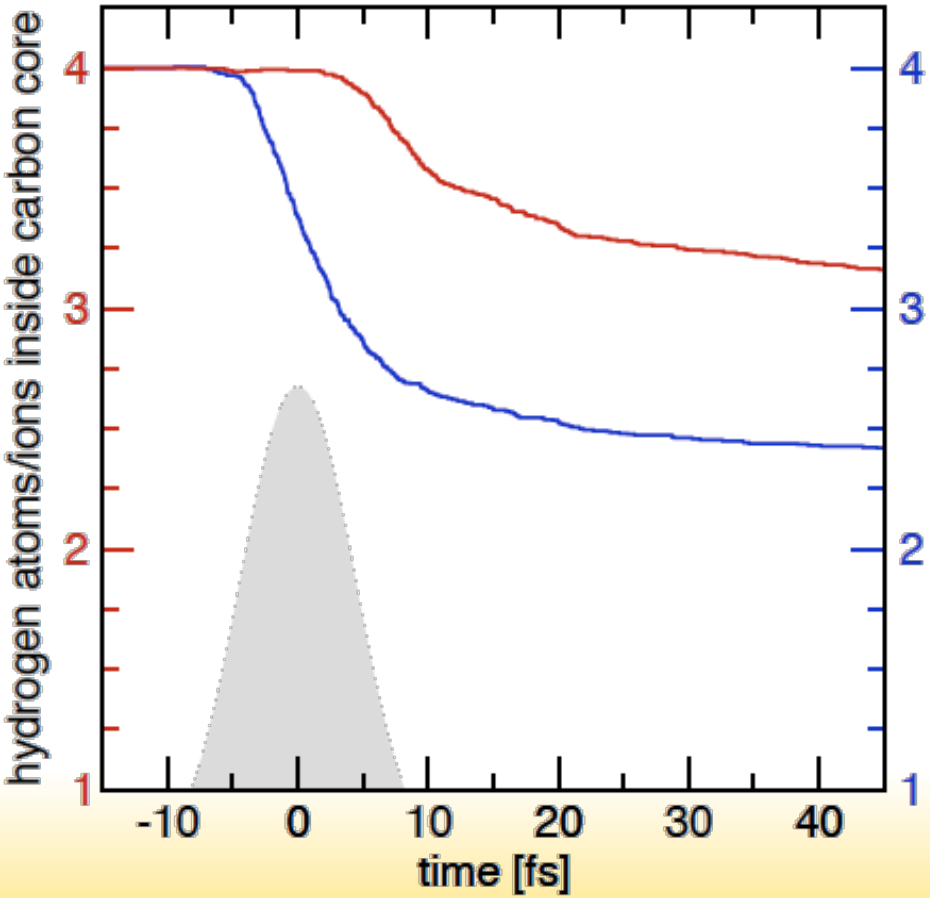


overall charge within the "carbon core"

core is almost neutralized on a femtosecond time scale ?

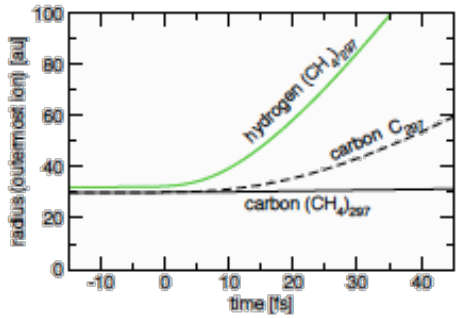
ultra-fast neutralization

$(CH_4)_{297}$ @ 1 keV, 10 fs (available at LCLS/Stanford, used by Ditmire et al.)



protons per CH_4 molecule within the "carbon core"

proton ejection on a femtosecond time scale!



inverse charge migration
→ inner tamper!

Reduction of Coulomb explosion through ejection of protons