Connecting field ionization to photoionization via 17 GHz microwave fields

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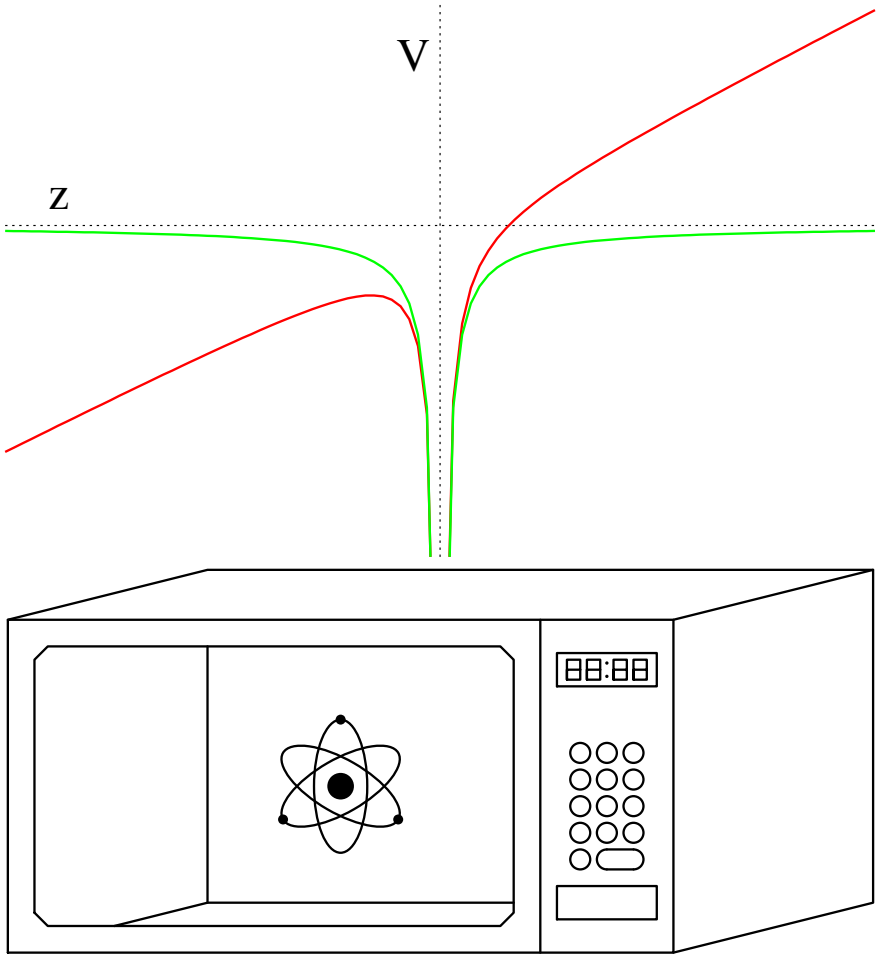
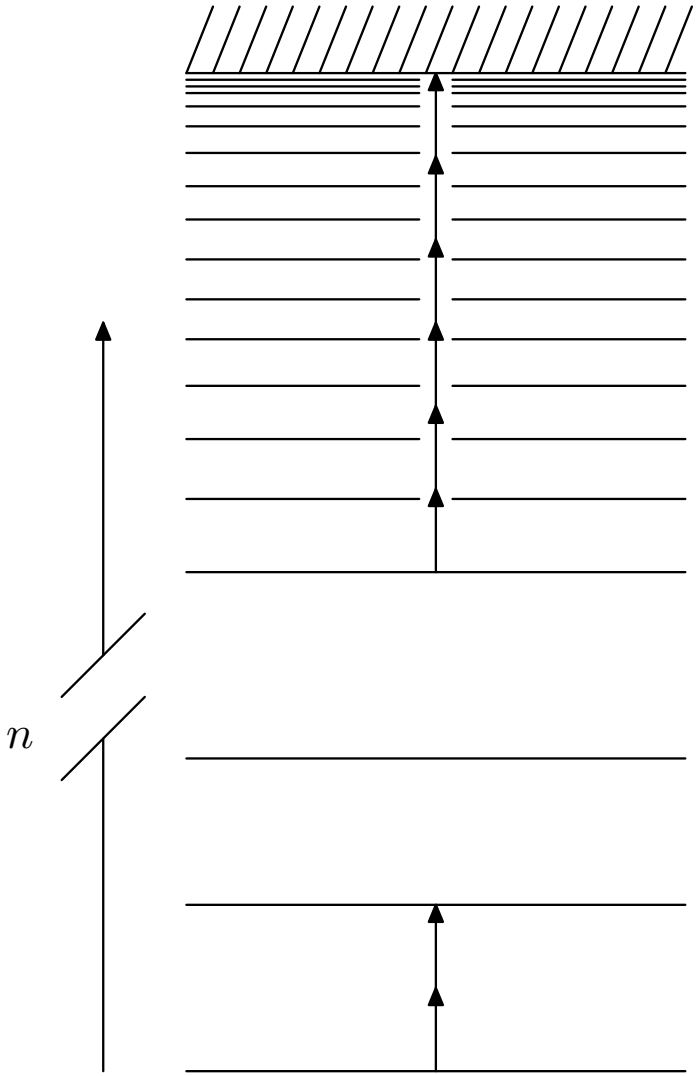
Introduction

Rydberg atoms

- $W = \frac{-1}{2n^2}$
- $r \propto n^2$
- $Lifetime \propto n^3$
- $\omega_{kepler} \propto 1/n^3$
- $V_{coulomb} = \frac{-1}{|z|}$



Microwave Ionization



$\omega \rightarrow 1/n^2$

What happens as we approach the photoionization limit?

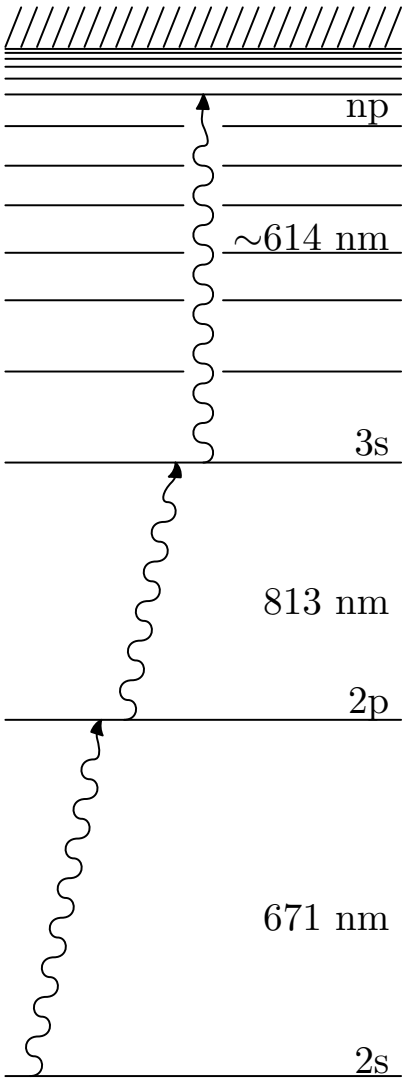
$\omega \approx 1/n^3 = \omega_k$

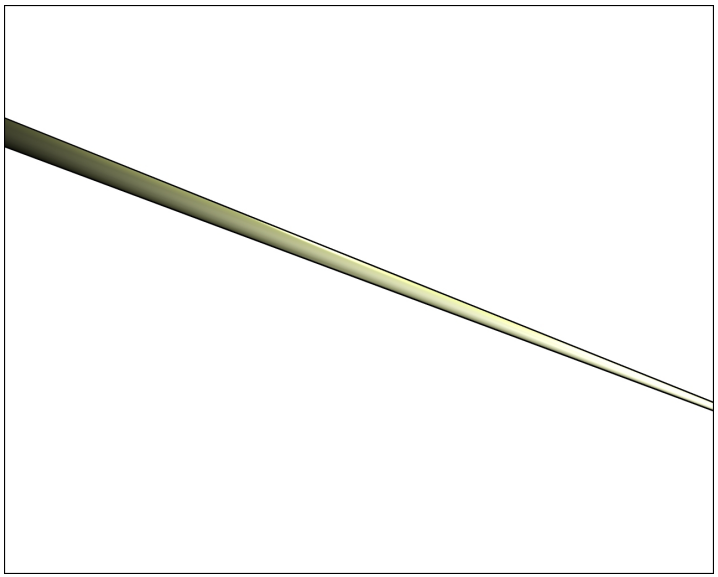
Field Ionization Process

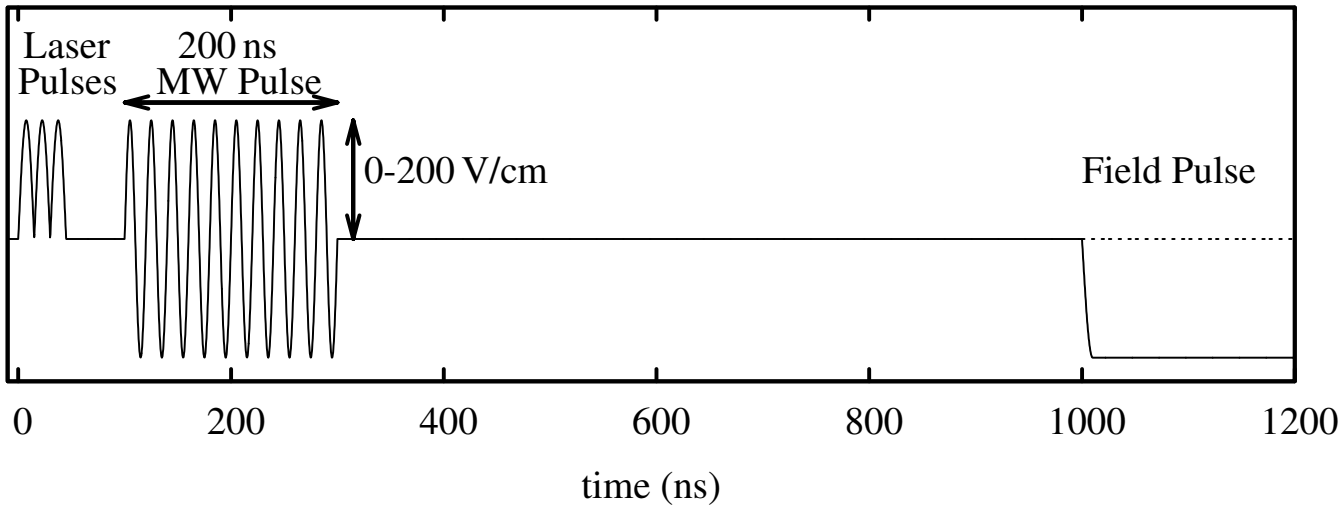
$F = 1/9n^4$

$\omega < 1/n^3 = \omega_k$

Experimental Setup







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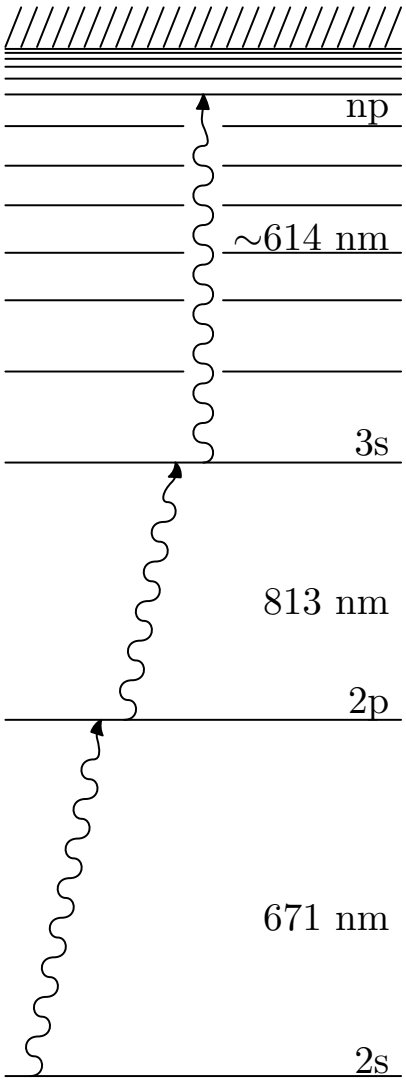

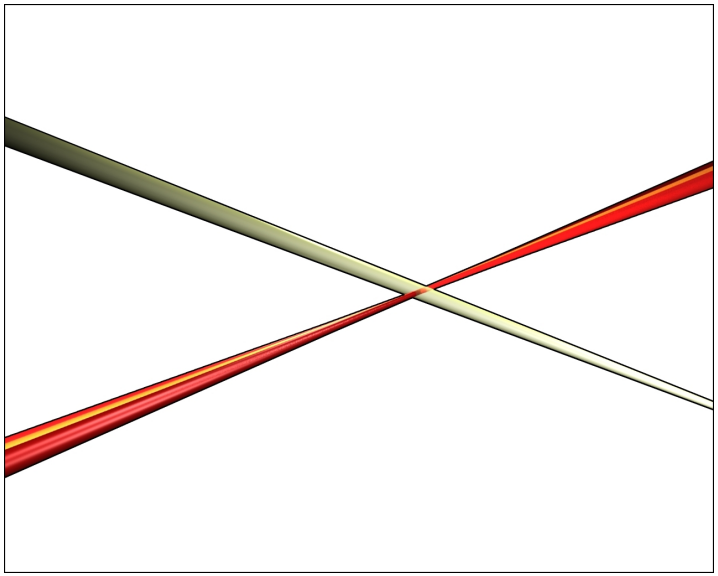

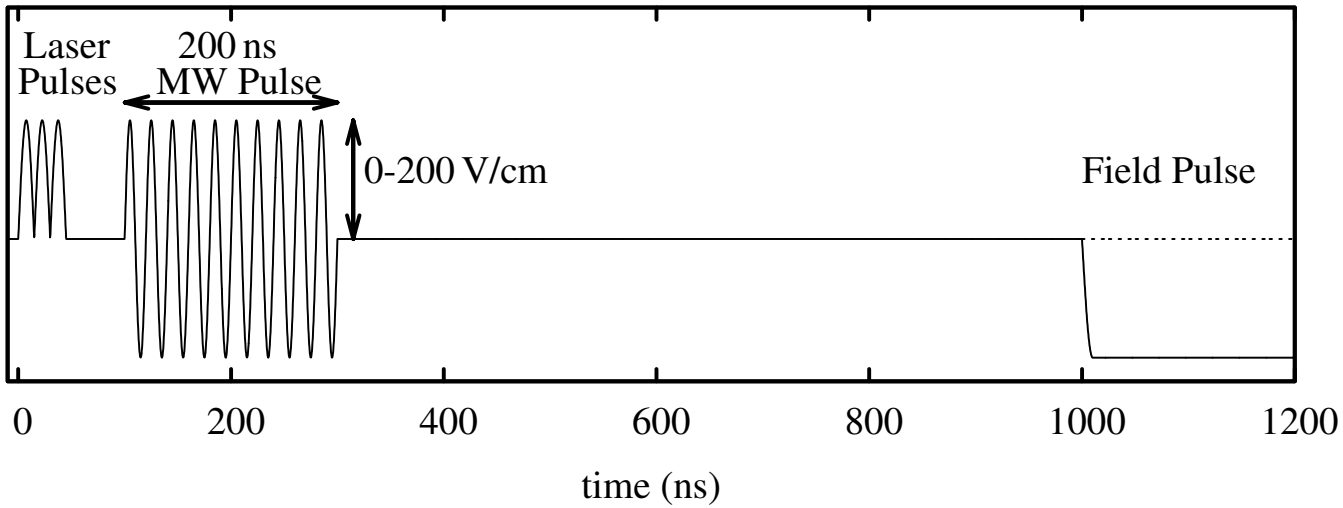

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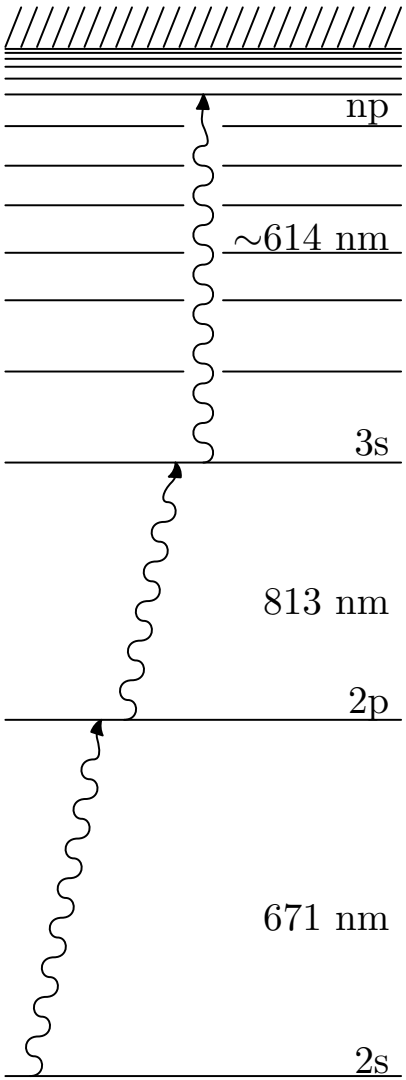

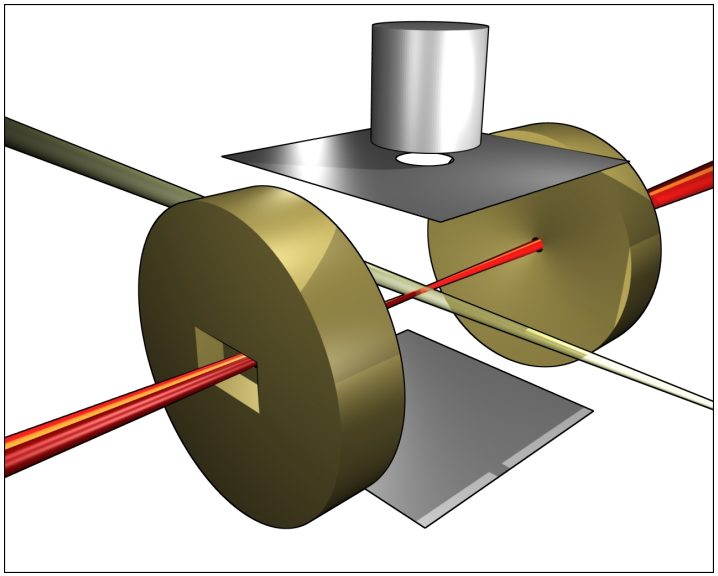

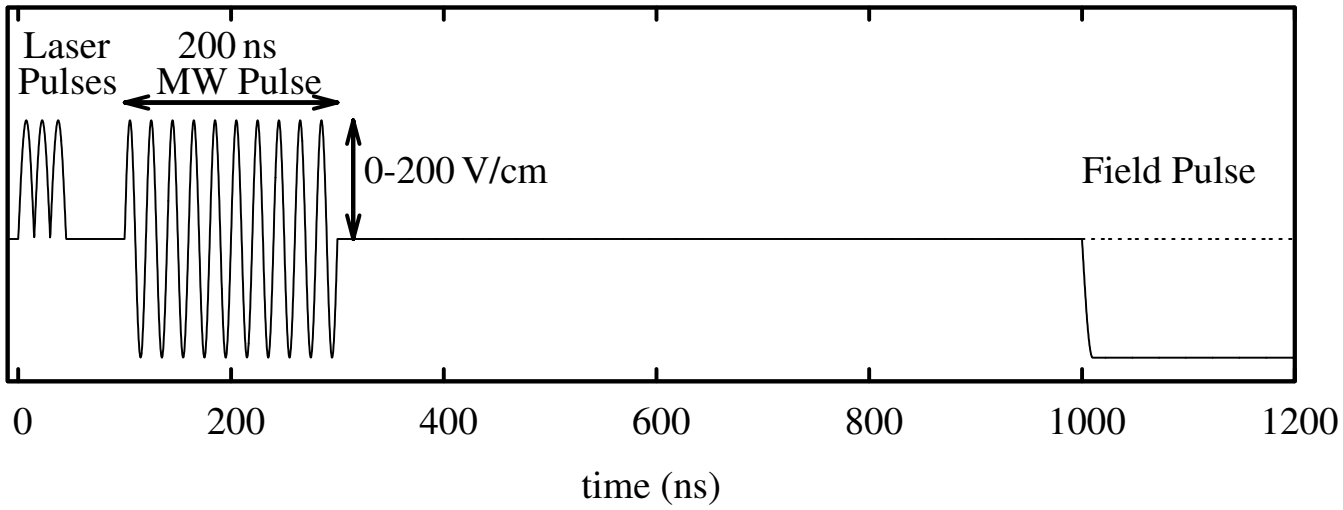

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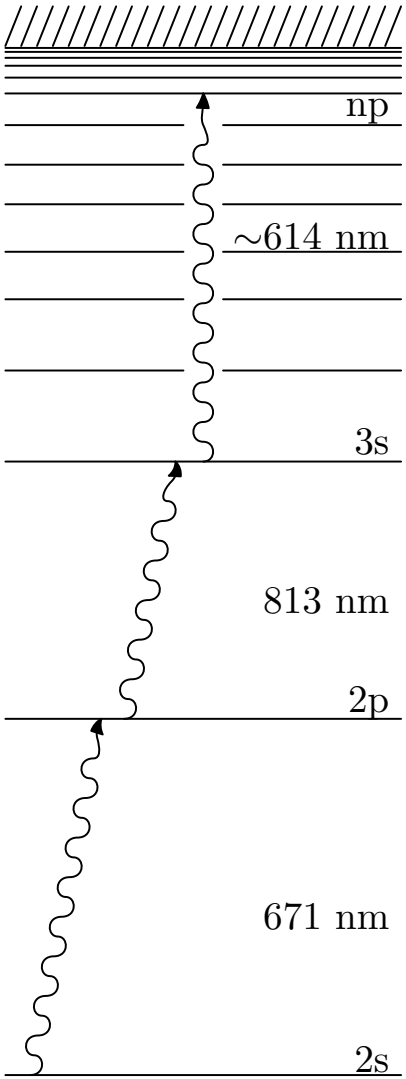
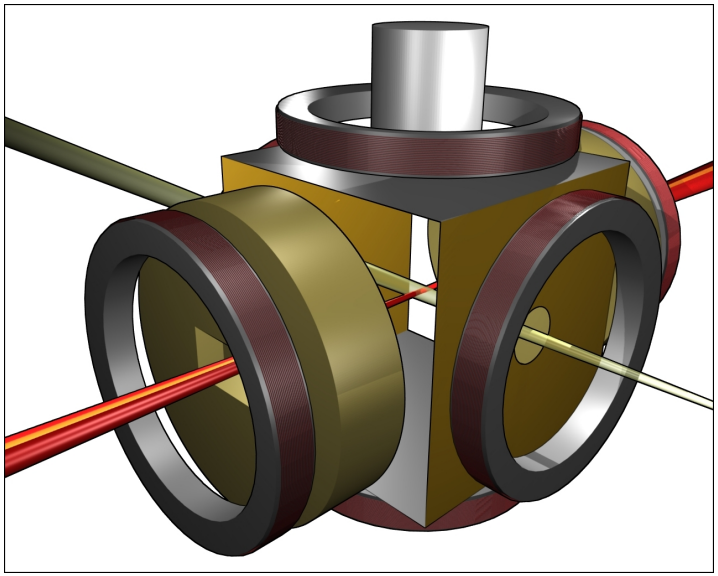
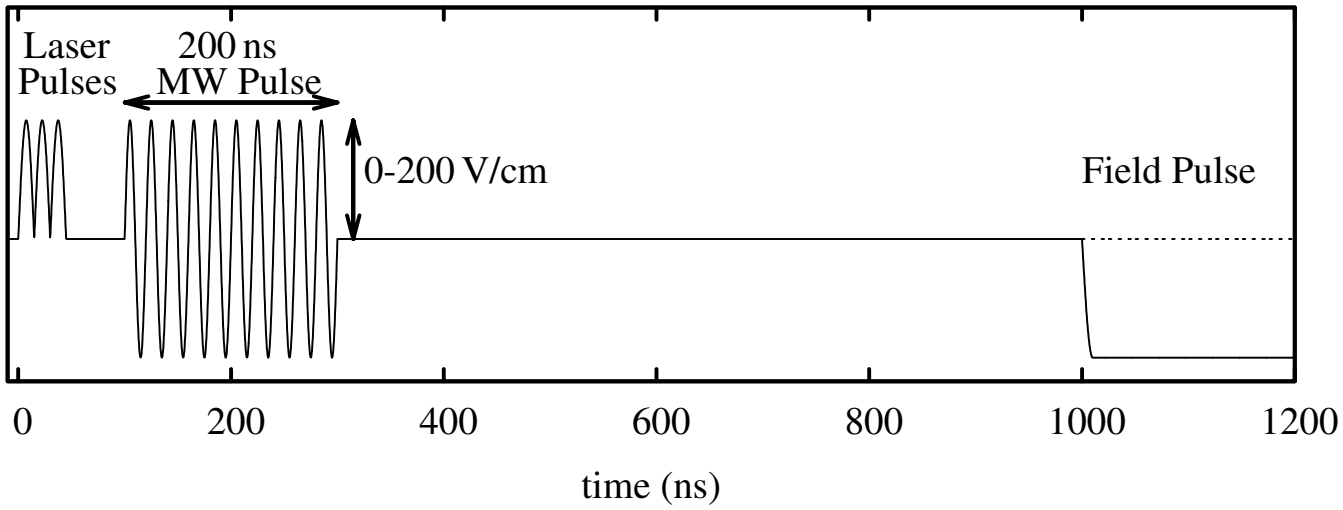
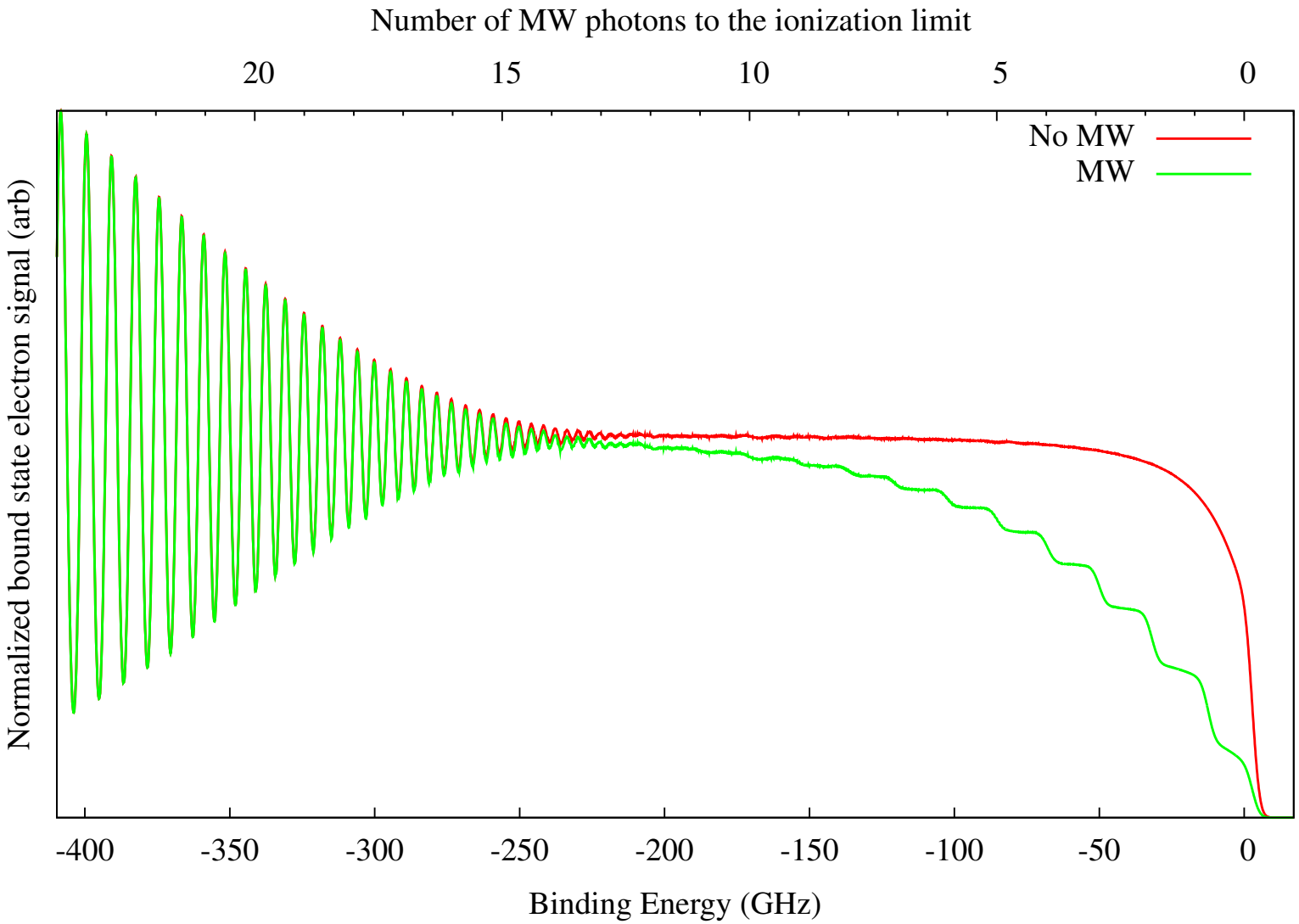


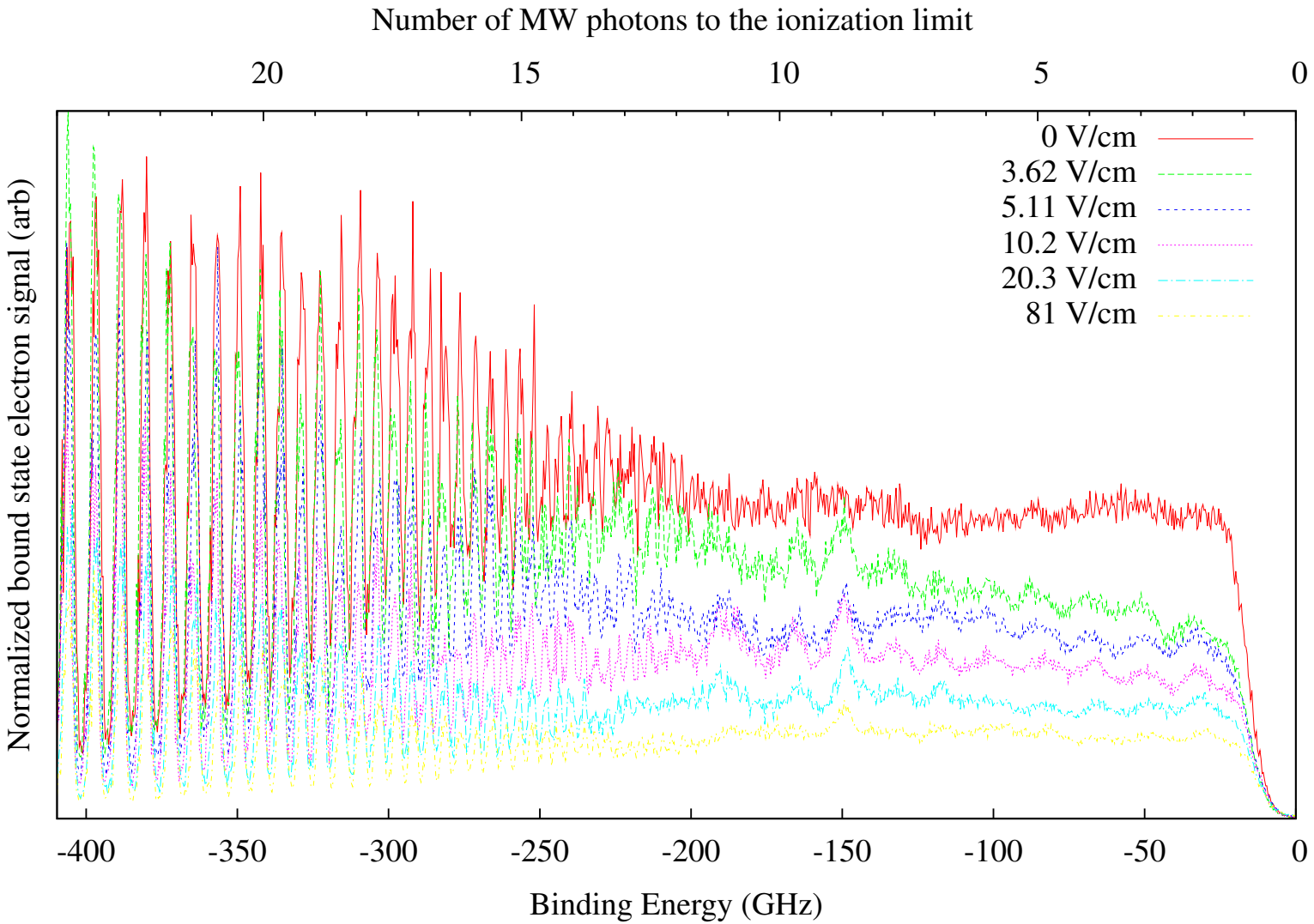




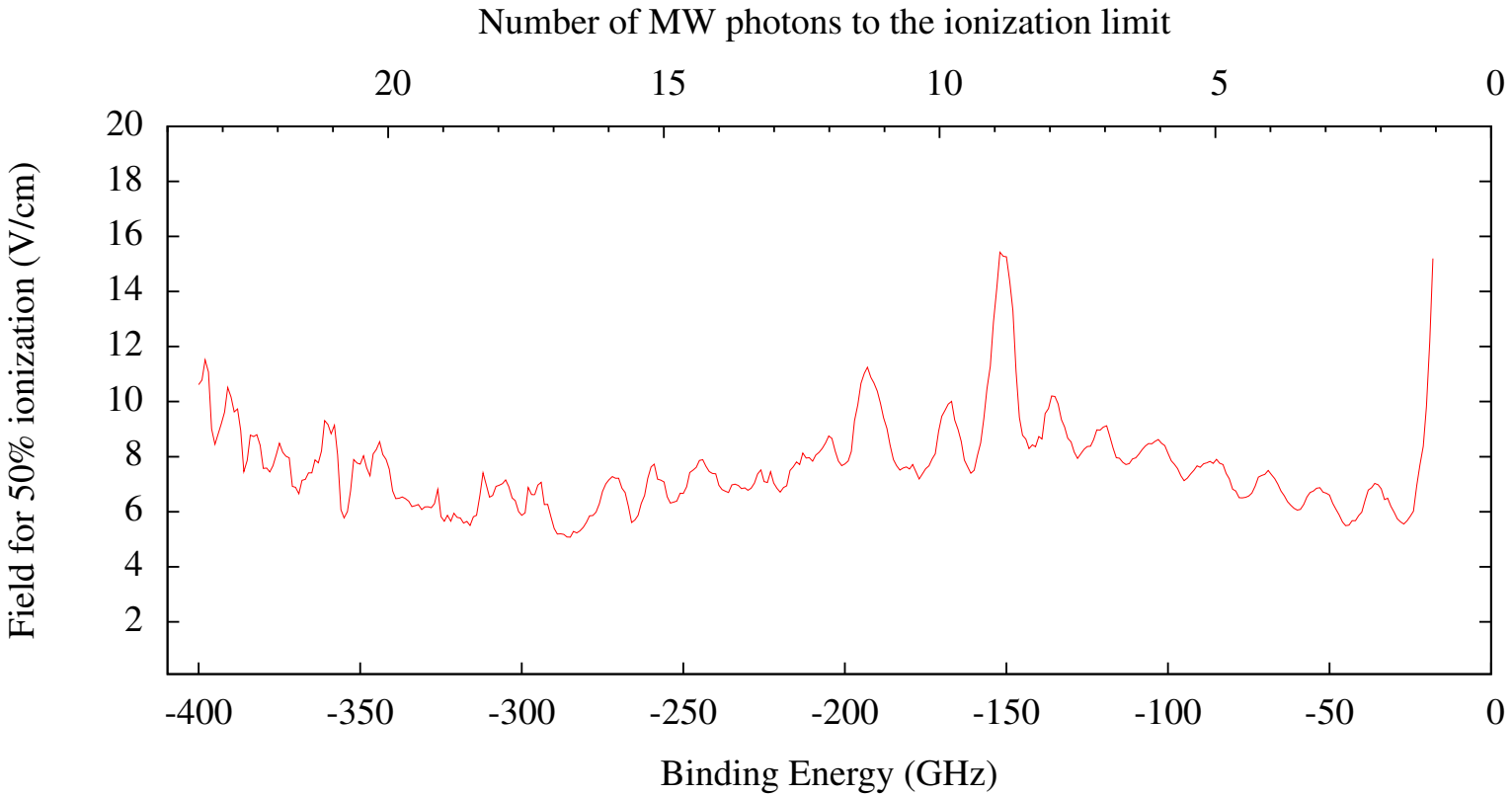
Expected Results



Microwave Ionization Steps



50% Ionization



$$\text{Rabi width} = \frac{0.4108}{\omega^{5/3} n^3} \cdot F \geq \frac{1}{n^3} \rightarrow \boxed{F = 2.4\omega^{5/3}}$$

Schelle et al., *Phys. Rev. Lett.* 102, 2009.
Jensen et al., *Phys. Rev. Lett.* 62, 1989.

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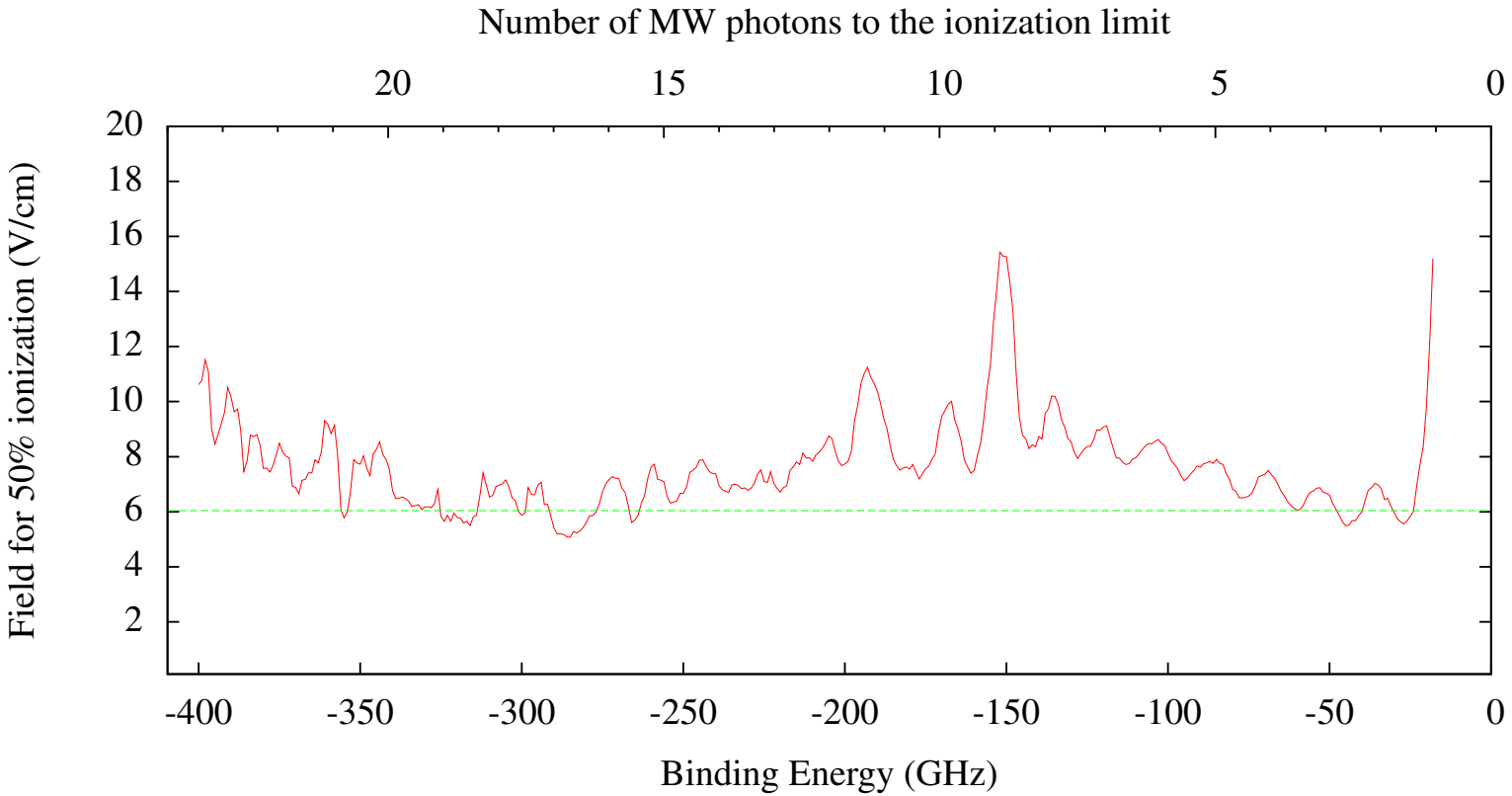

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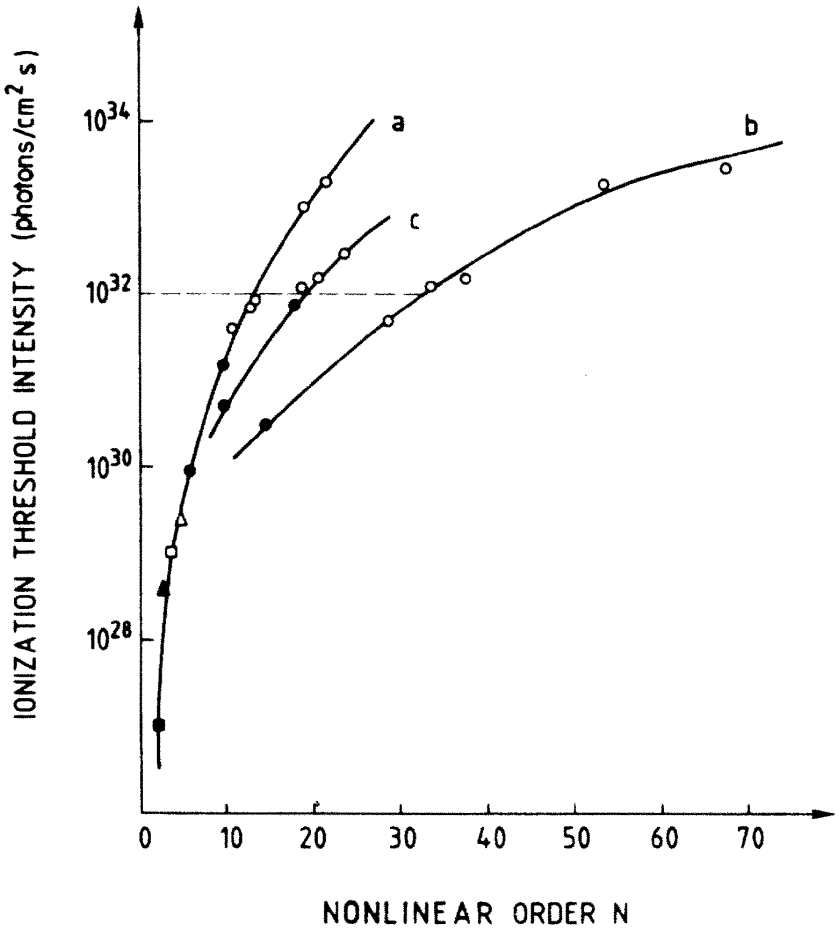
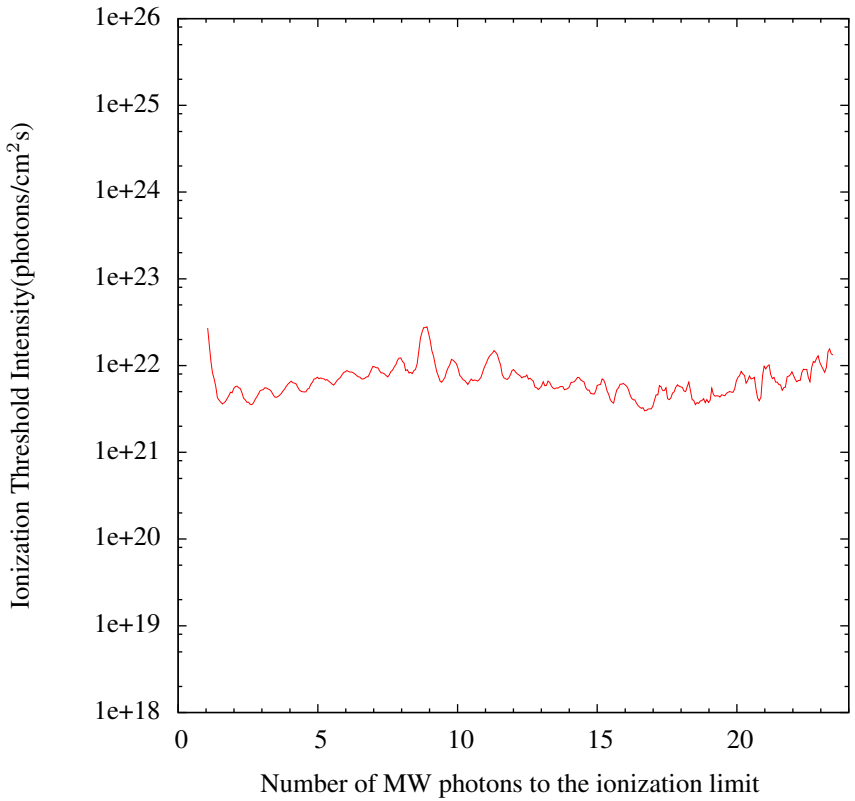
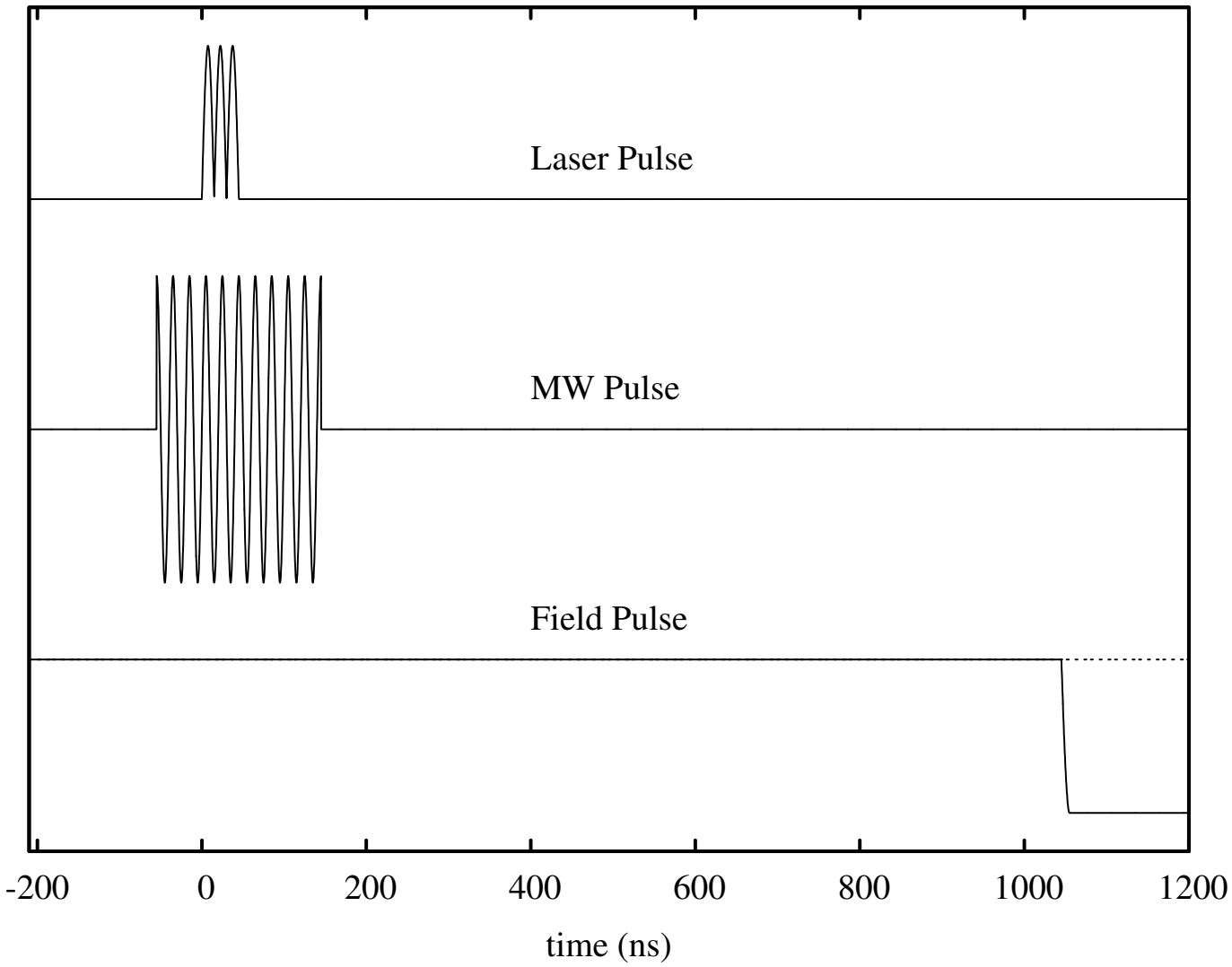
Ground State Ionization Comparison





l'Huillier et al., *Phys. Rev. A* 27, 1983.

Above-Threshold Bound States - Timing



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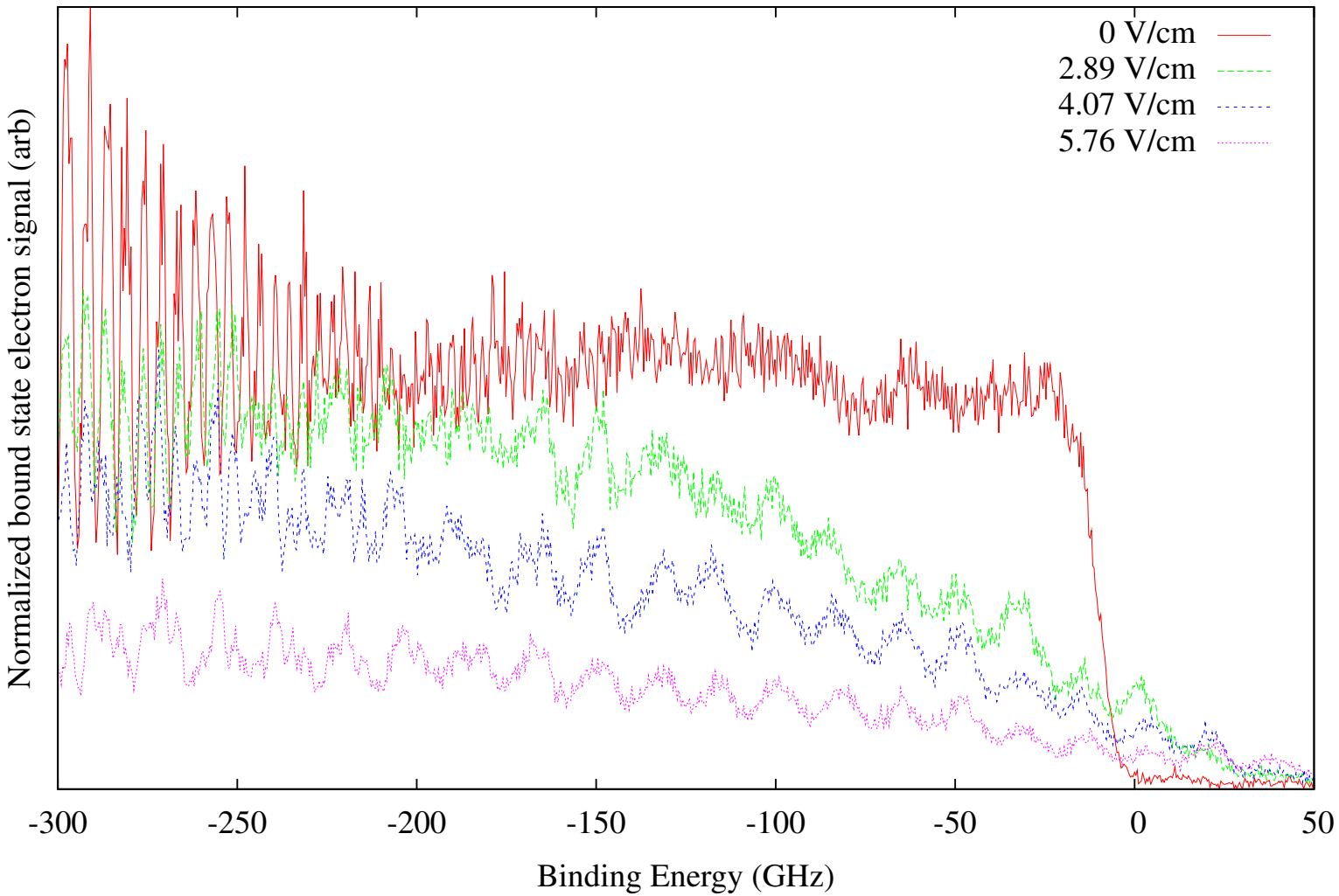
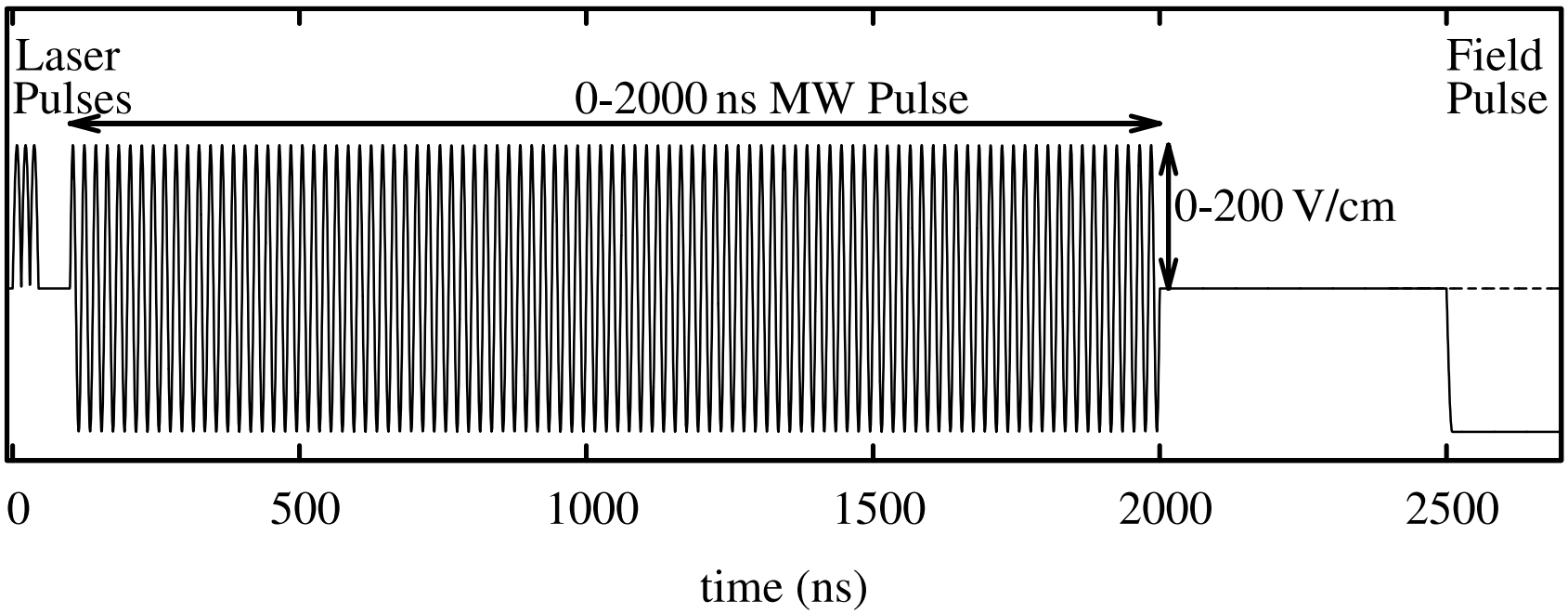
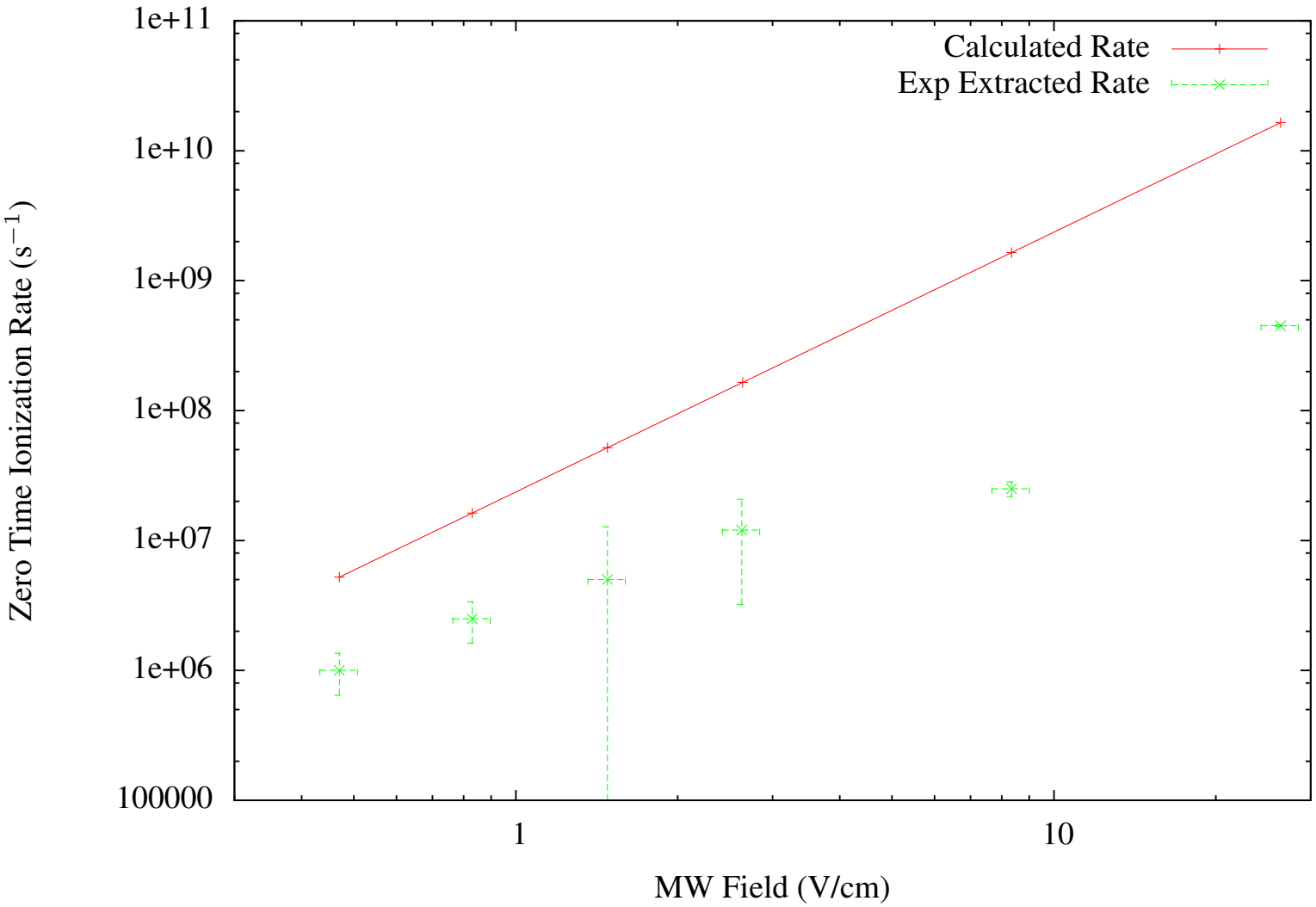


MW pulse can drive states both up *and* down in energy

Ionization Rates - Timing



Ionization Rates - Experiment



Summary

- First measurement of 50% microwave ionization from the field ionization limit to the photoionization limit
- Results in agreement with recent theoretical predictions of Schelle et al. and Jensen et al.
- Multiphoton ionization microwave field intensity similar to single-photon ionization field intensity
- Microwave ionization is n independent when $\omega_{MW} > \omega_{kepler}$
- Single-photon ionization rates lower than perturbation theory prediction