


# Evolution of Rydberg atom clouds in a linear magnetic trap

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# Rydberg Atom Overview

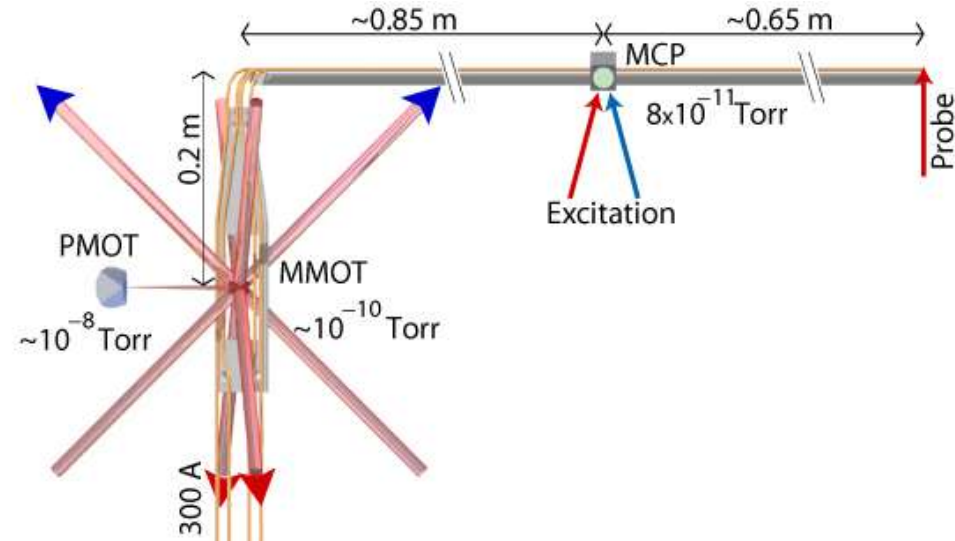
- ▶ Large since  $r \sim n^2$
  - ▶ Long lifetimes,  $\tau \sim n^3$  for low angular momentum,  $n^5$  for high angular momentum
  - ▶ Very susceptible to electric fields,  $\alpha \sim n^7$
  - ▶ Strong interaction with other Rydberg atoms and also with blackbody radiation
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# Experiment Development

- ▶ Long term goals:
  - Continuous BEC to outcouple for a continuous atom laser
  - Atom interferometry
- ▶ Current project has roots in detection of atoms in a linear guide without fluorescence
  - Fluorescence destroys all atoms in the guide
  - Field ionization is only destructive to atoms in the region of interest

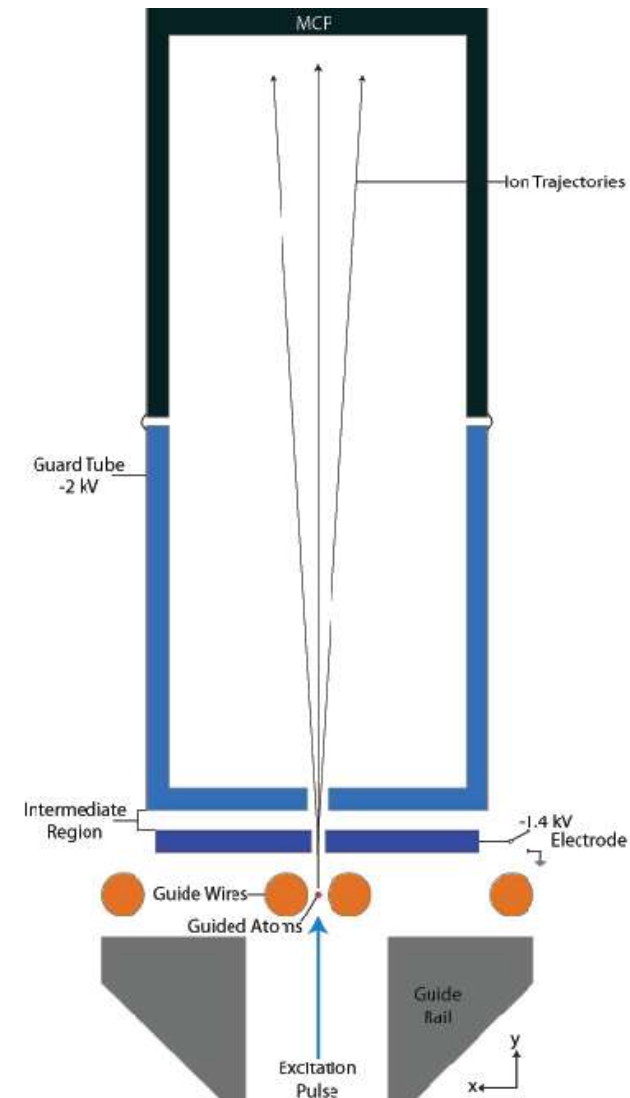
# Experimental Setup

- ▶ 1.5 m high-gradient linear magnetic guide
- ▶  $^{87}\text{Rb}$
- ▶  $T_{\perp} \approx 420 \mu\text{K}$
- ▶  $T_{\parallel} \approx 1 \text{ mK}$
- ▶ Atoms in  $|F=1, m_F=-1\rangle$
- ▶ Central volume density  $10^9 \text{ cm}^{-3}$
- ▶  $\Phi \approx 2 \times 10^7 \text{ s}^{-1}$



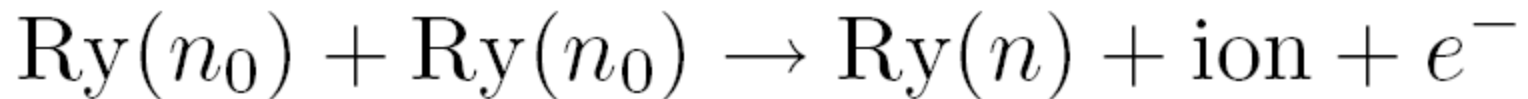
# Excitation/Extraction Region

- ▶ Atoms excited  $5S \rightarrow 5P$  then  $5P \rightarrow nS$  or  $nD$
- ▶ Control various electrodes to apply electric fields
- ▶ Variable delay time between excitation and extraction
- ▶ Image onto a micro-channel plate (MCP) and collect counts as a function of time



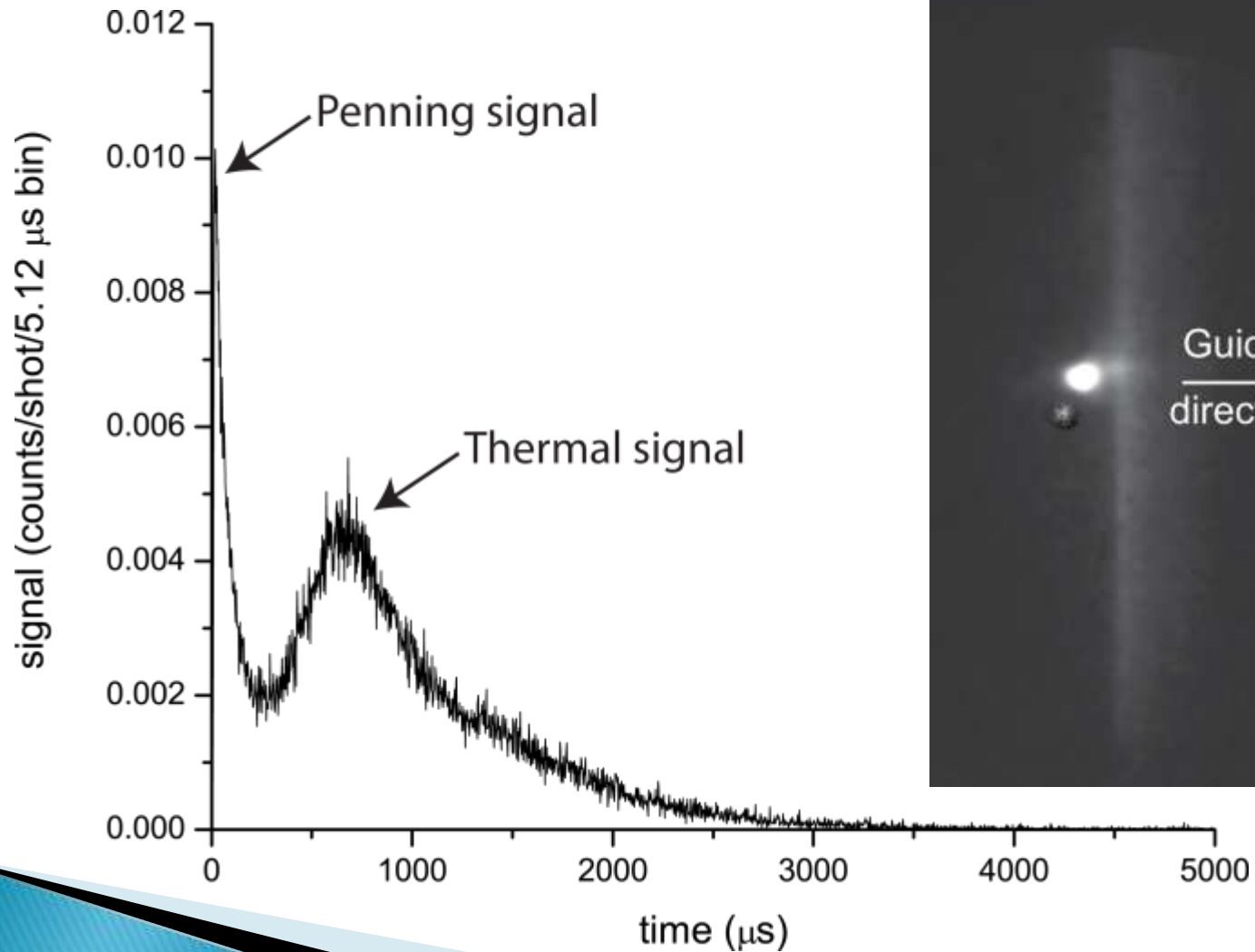
# Penning Ionization

- ▶ Collision of two Rydberg atoms can result in Penning ionization, given by

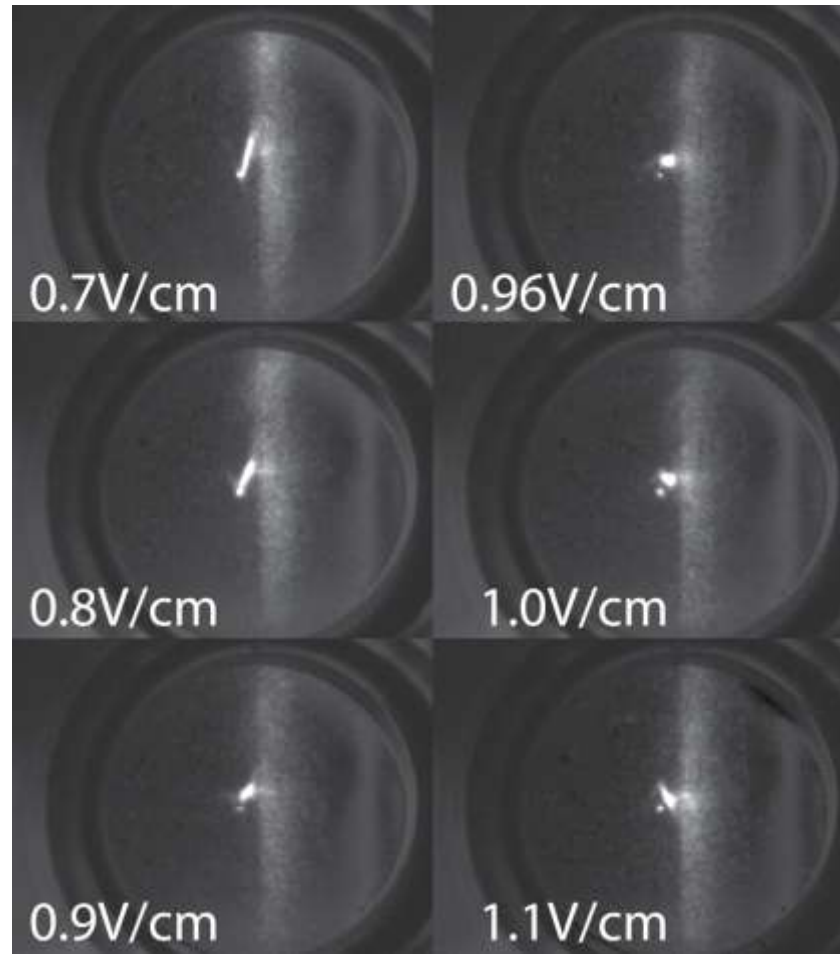


- ▶ Inelastic process
- ▶ Ionization energy is taken from one atom, leaving it in a lower- $n$  state with higher angular momentum
  - Longer lifetime

# Without Extraction

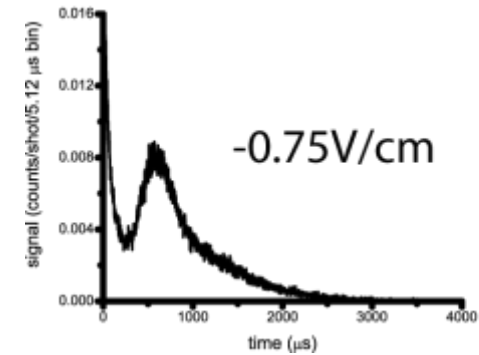
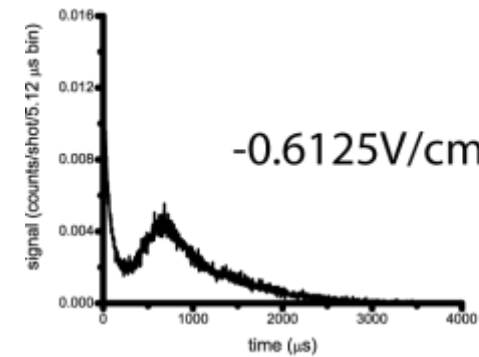
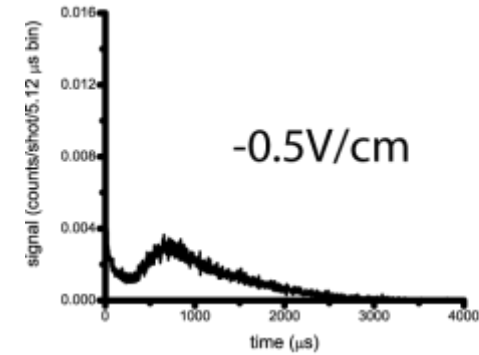
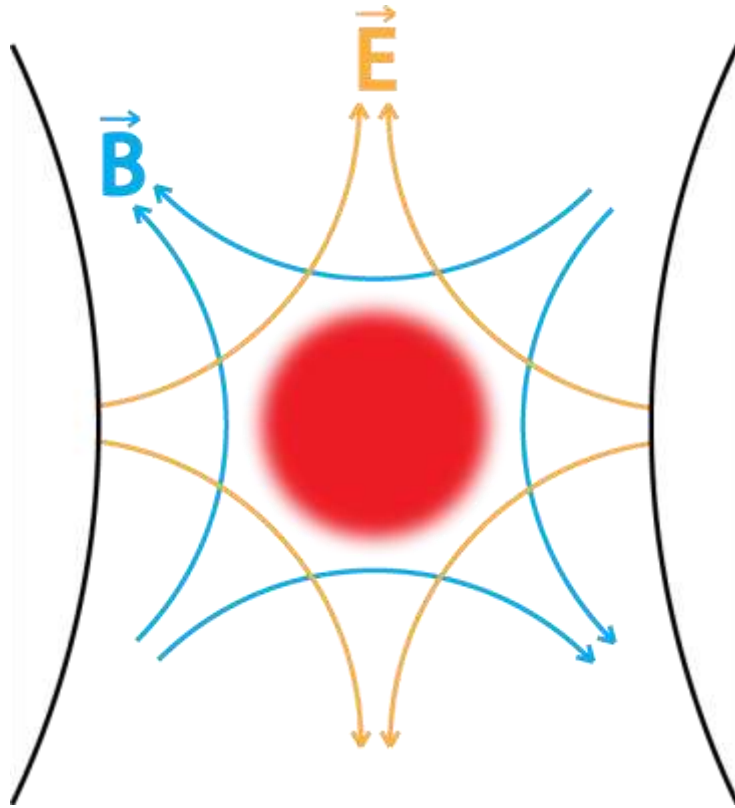


# Horizontal Electric Field Zeroing

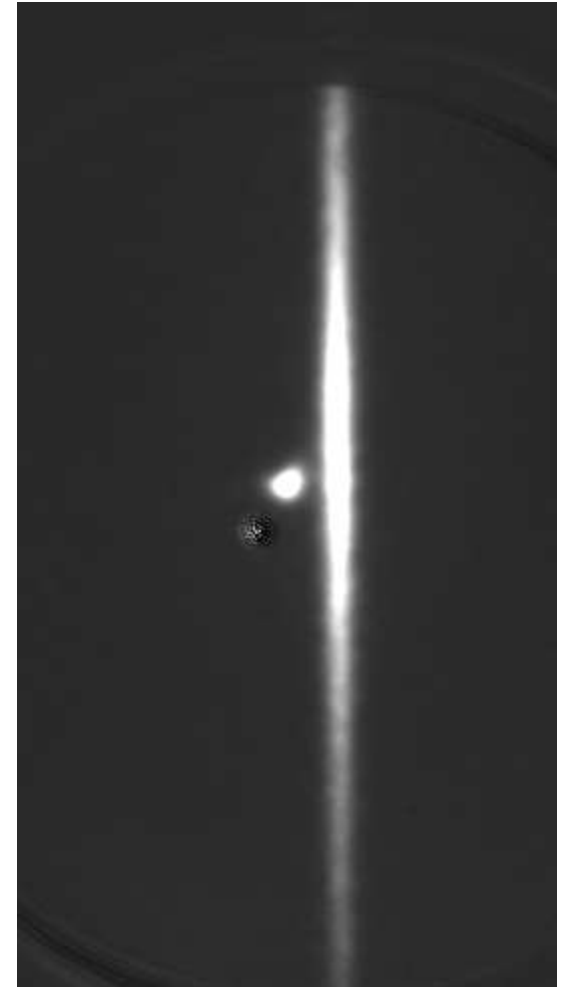
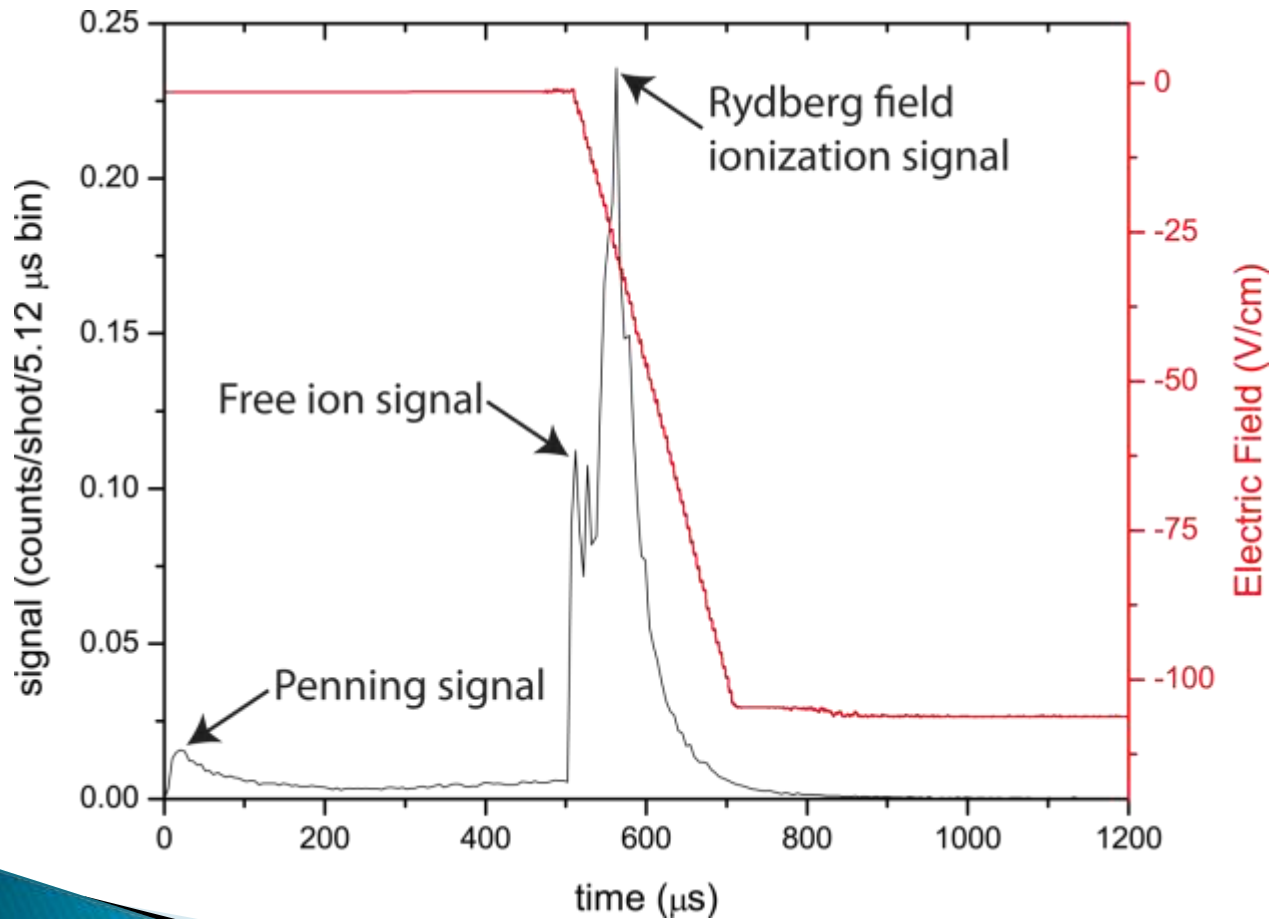




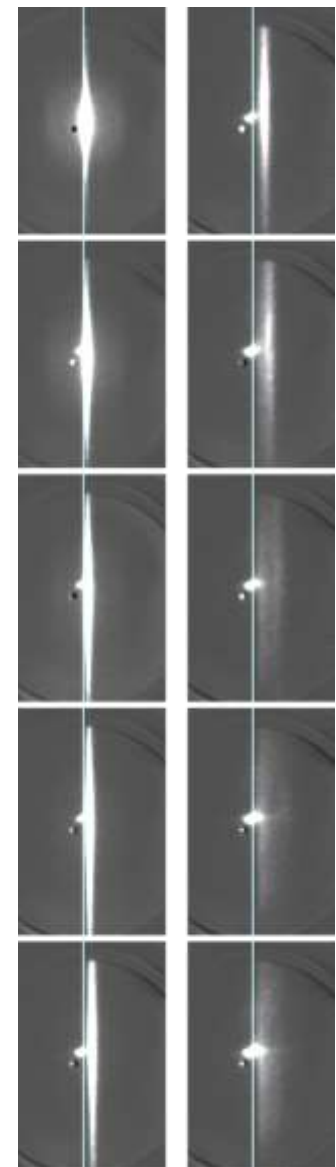
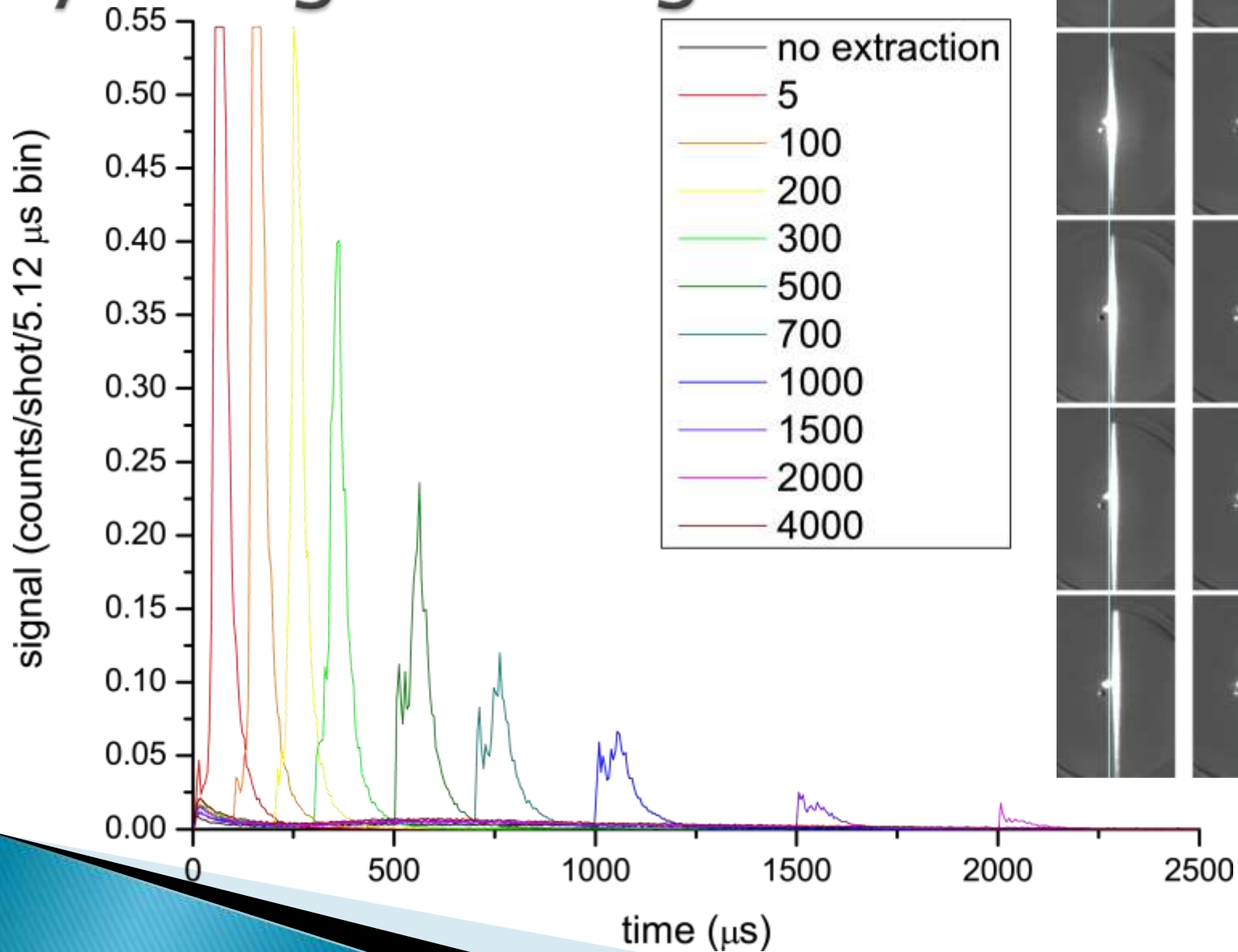
# Vertical Tomography



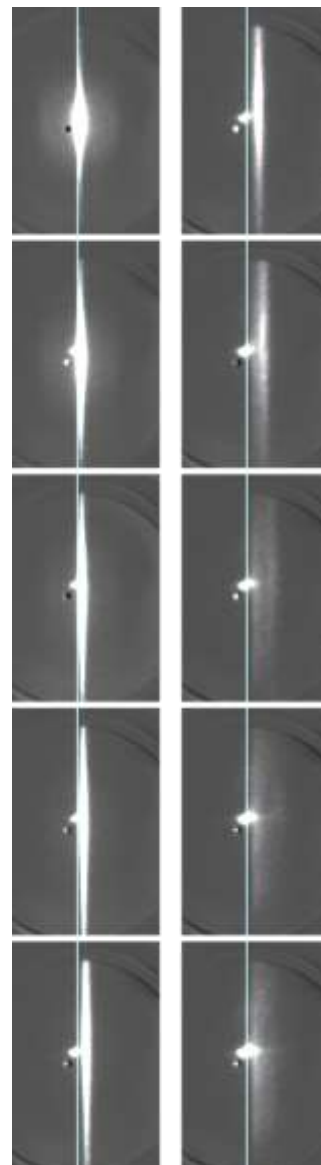
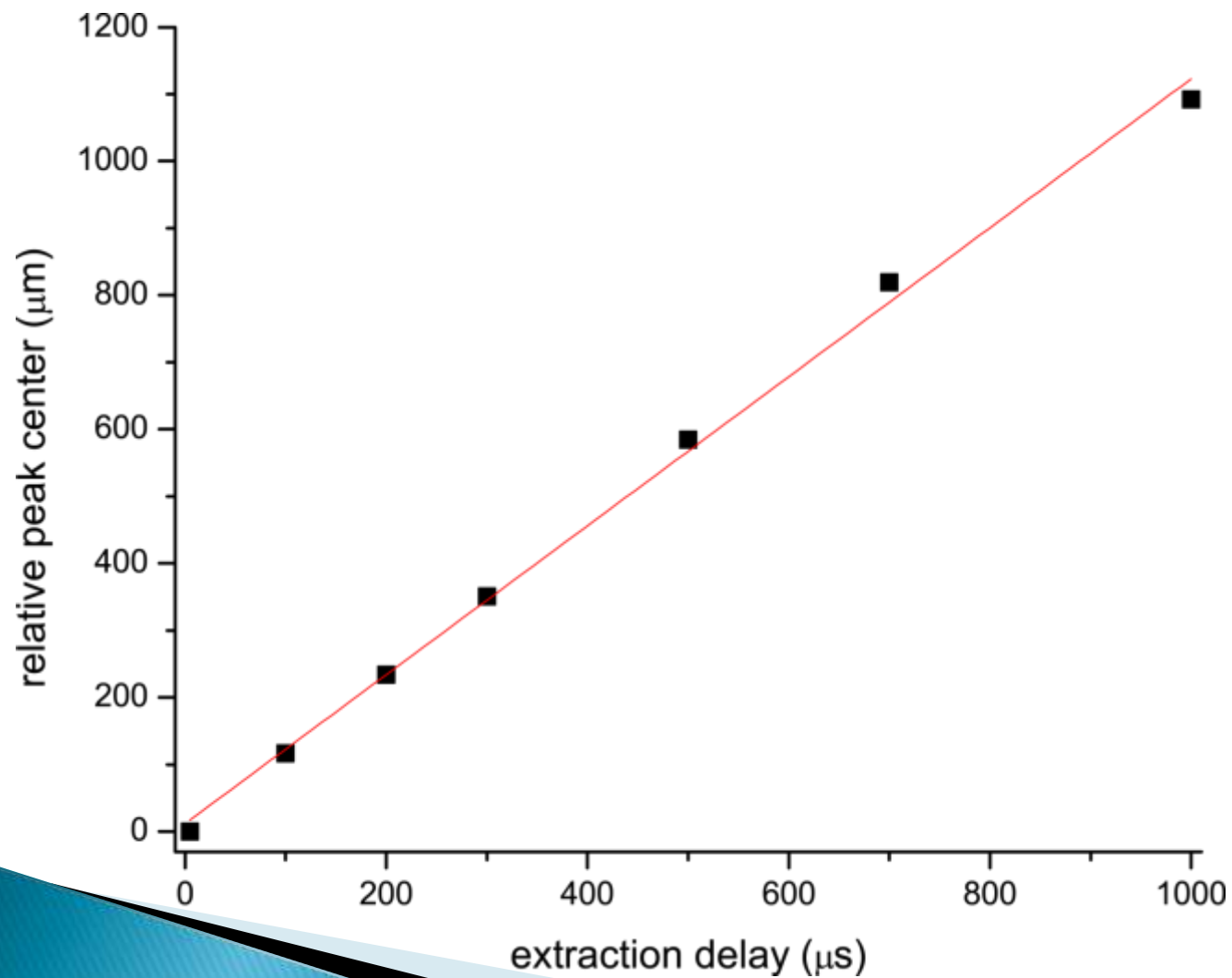
# Sample Signal at 500 $\mu\text{s}$




# Rydberg Guiding



# Velocity = 1.11 m/s



# Overview

- ▶ Rydberg interactions in a linear magnetic guide
    - Penning ionization
    - Thermal ionization
    - Guiding of Rydberg atoms
  
  - ▶ Next steps
    - Continue studies on 59D
    - Compare 59D to 61S
    - Complete setup for new experimental apparatus
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# Raithel Group

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