Stored Light Optimization Experiments at W&M

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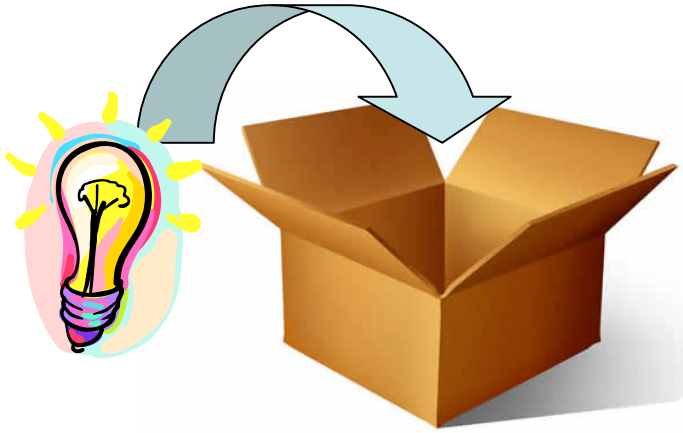
Outline

- What we want to do
- How we can do it (EIT & Stored Light)
- How we achieve it (our Experiment)
- What we did (some Results)
- What we're going to do

Storing Light

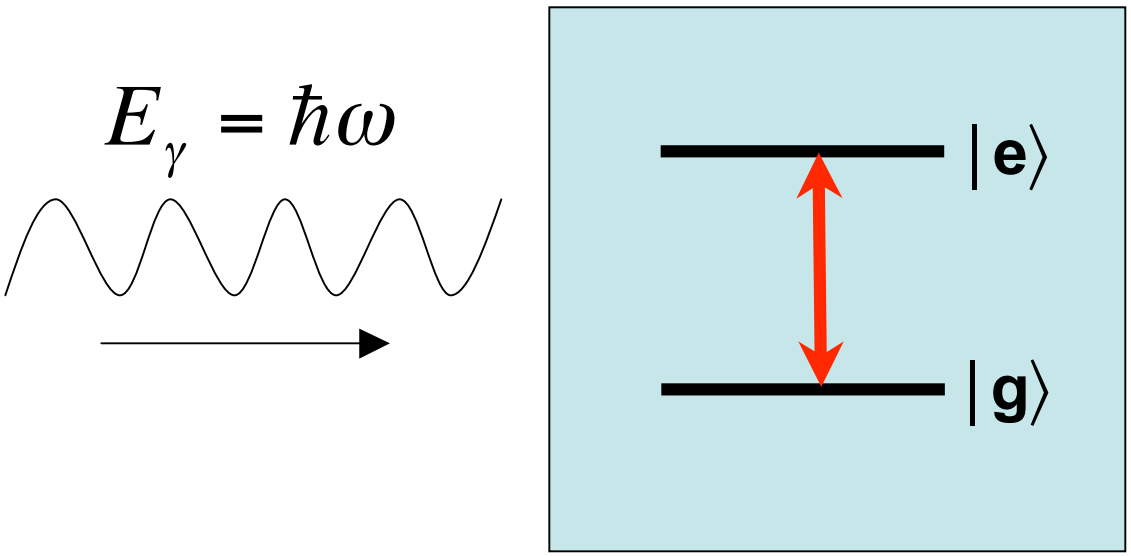


Step 1

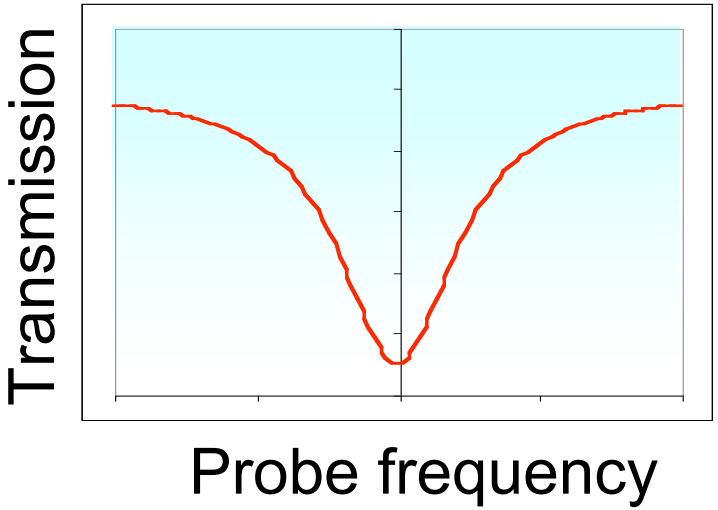
Step 2

Step 3

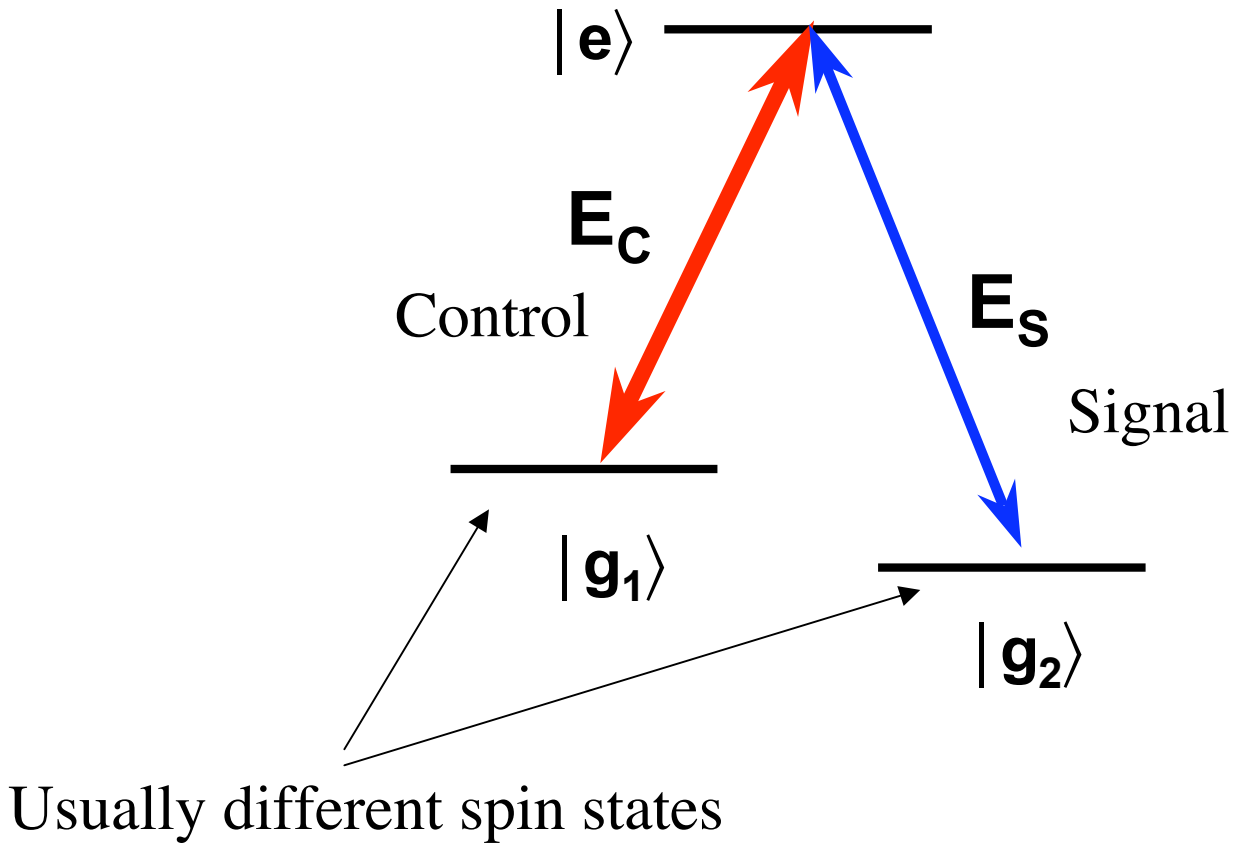
The Textbook 2-level System



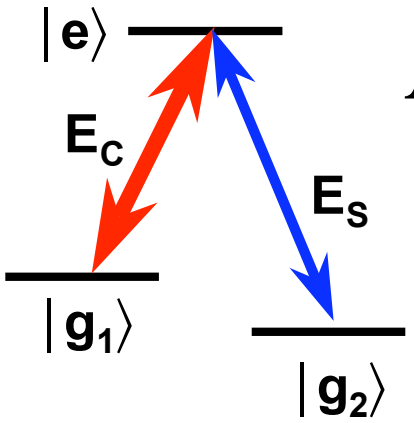
Photon is absorbed

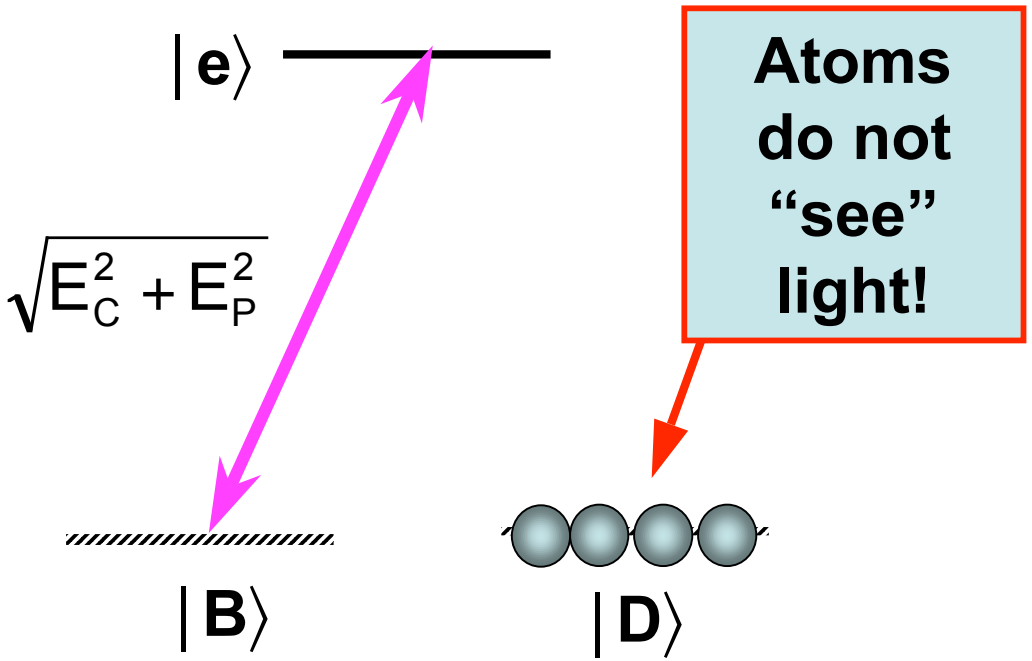


A 3-level System: EIT



A 3-level System: EIT



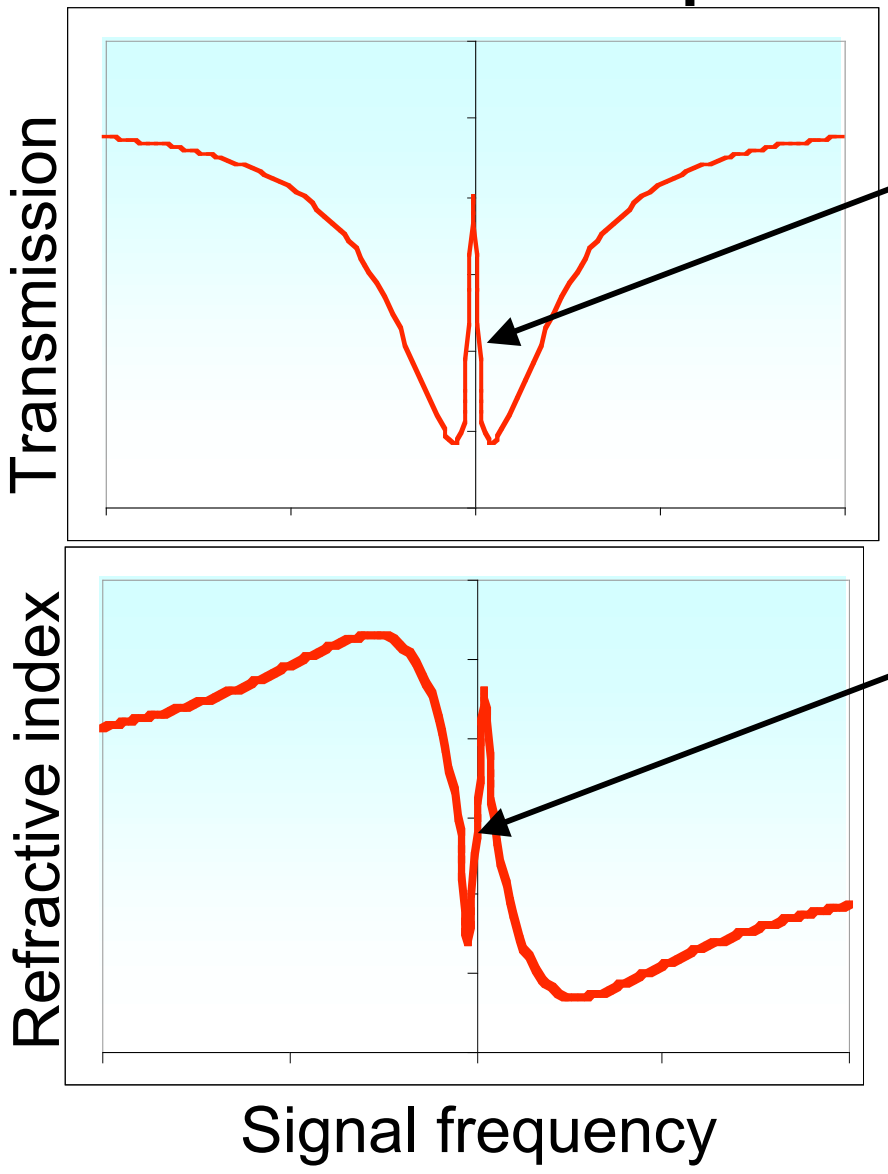


Bright and Dark States:

$$|B\rangle = \frac{E_S|g_1\rangle + E_C|g_2\rangle}{\sqrt{E_S^2 + E_C^2}}$$

$$|D\rangle = \frac{E_C|g_1\rangle - E_S|g_2\rangle}{\sqrt{E_S^2 + E_C^2}}$$

Electromagnetically Induced Transparency (EIT)

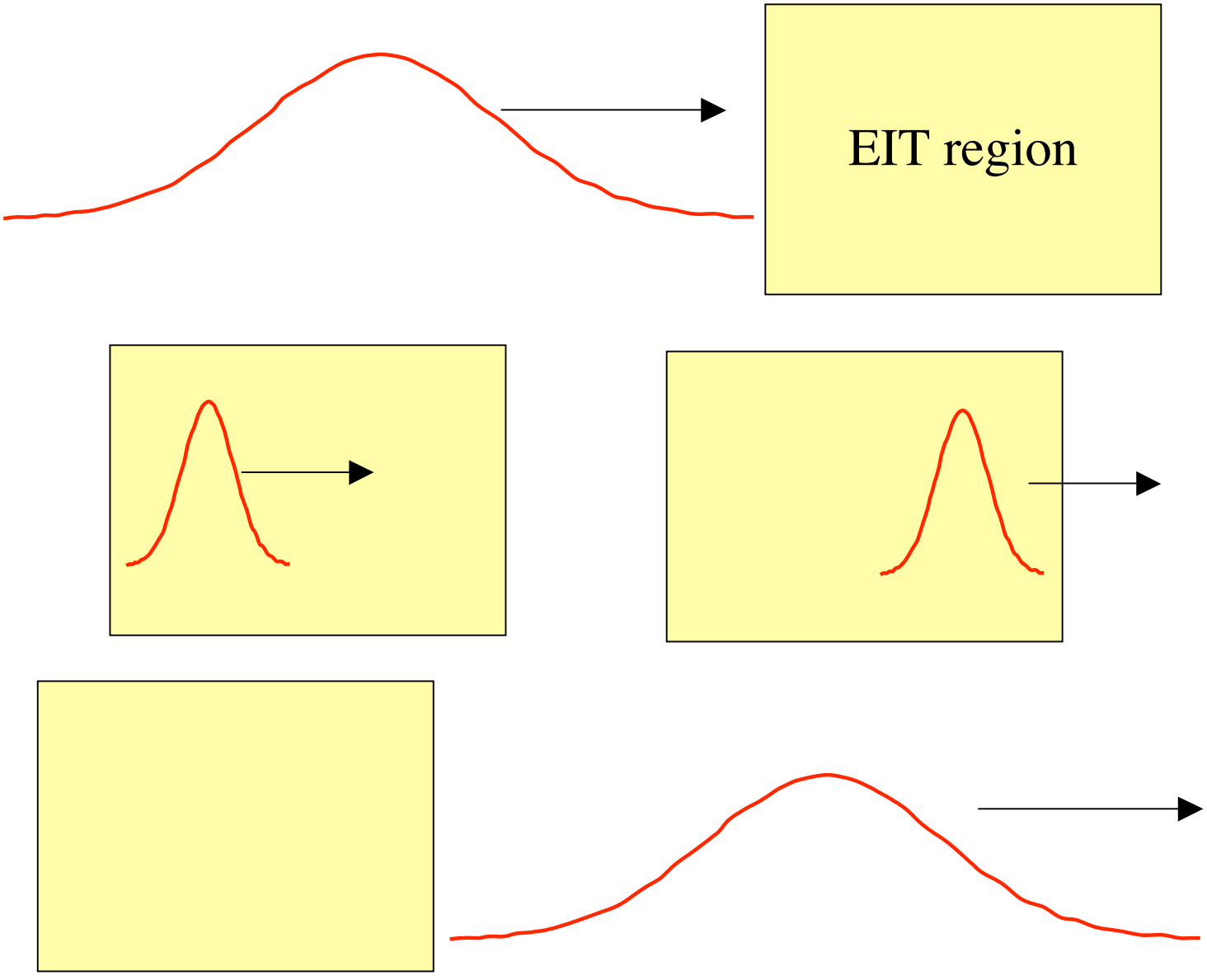


Narrow transmission resonance

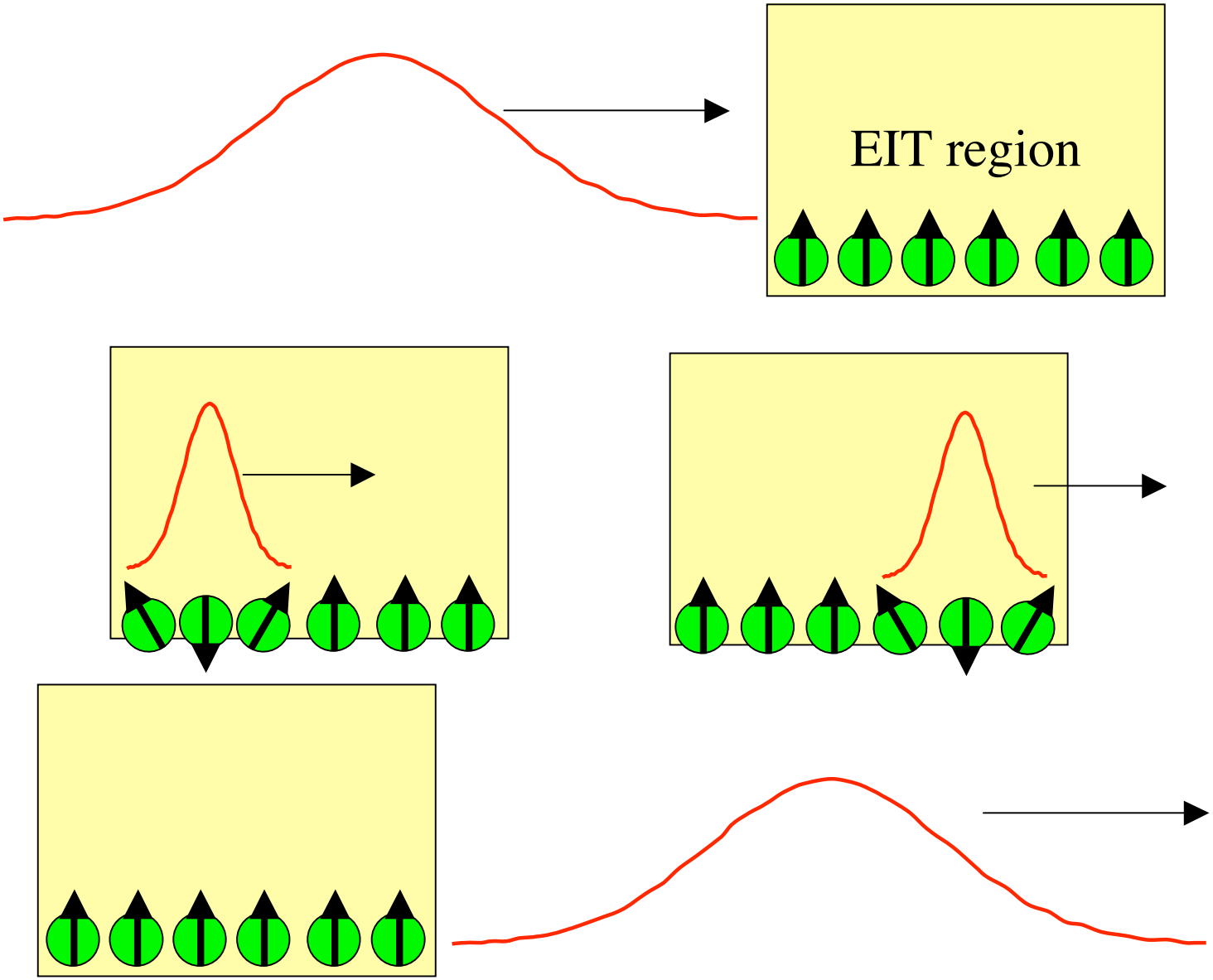
Steep dispersion $\omega \frac{dn}{d\omega} >> 1$

$$v_g = \frac{d\omega(k)}{dk} = \frac{c}{n + \omega \frac{dn}{d\omega}}$$

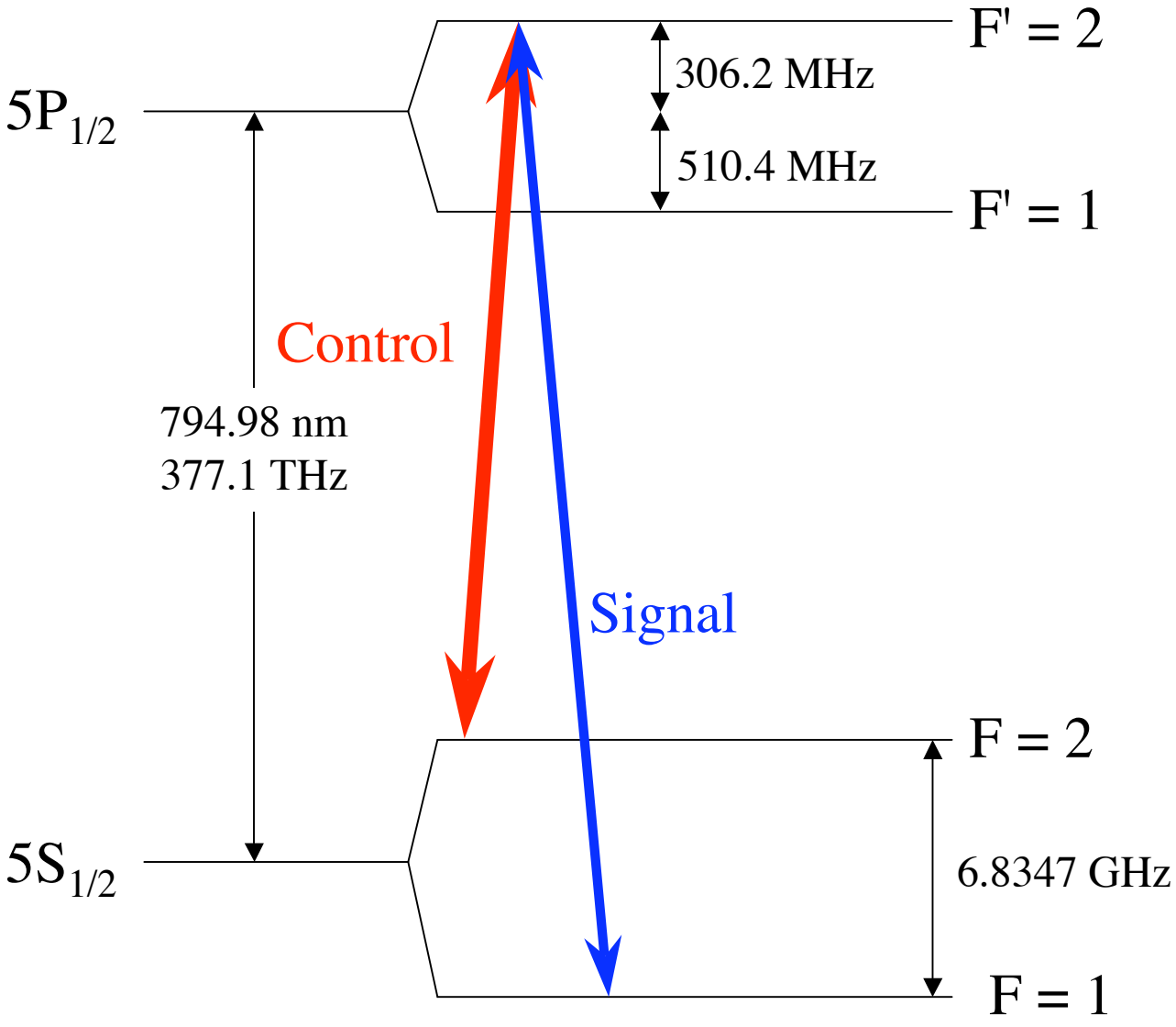
Stored Light Cartoon



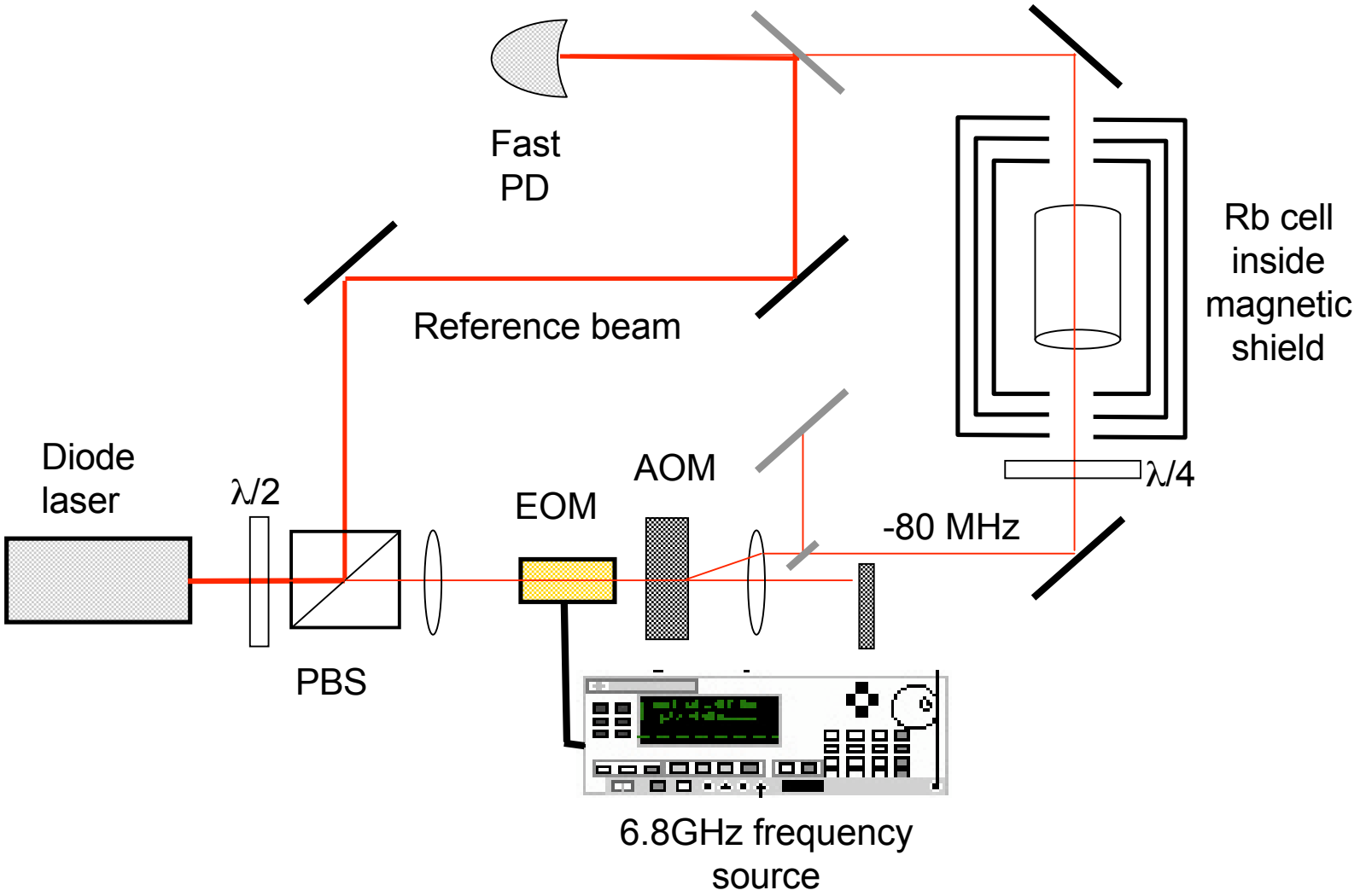
Spin Waves



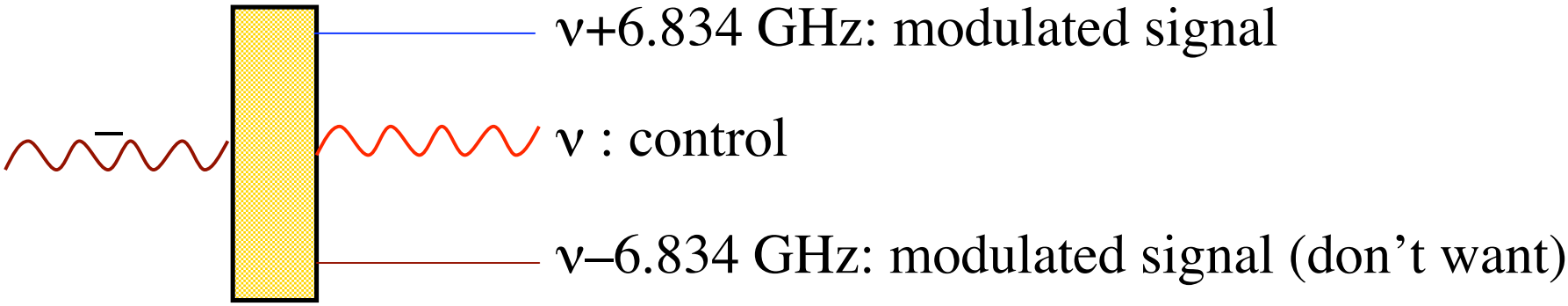
Our Setup I: a ^{87}Rb Transition



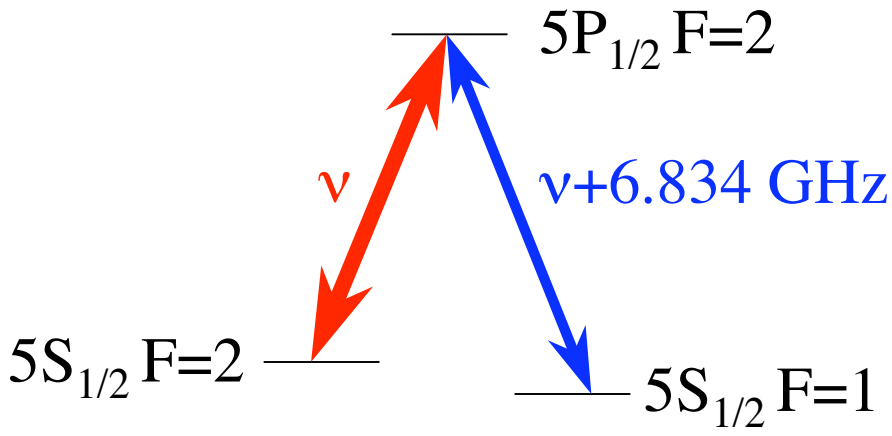
Our Setup II


Fast
PD
Reference beam
Rb cell
inside
magnetic
shield
Diode
laser
λ/2
AOM
EOM
-80 MHz
λ/4
PBS
6.8GHz frequency
source

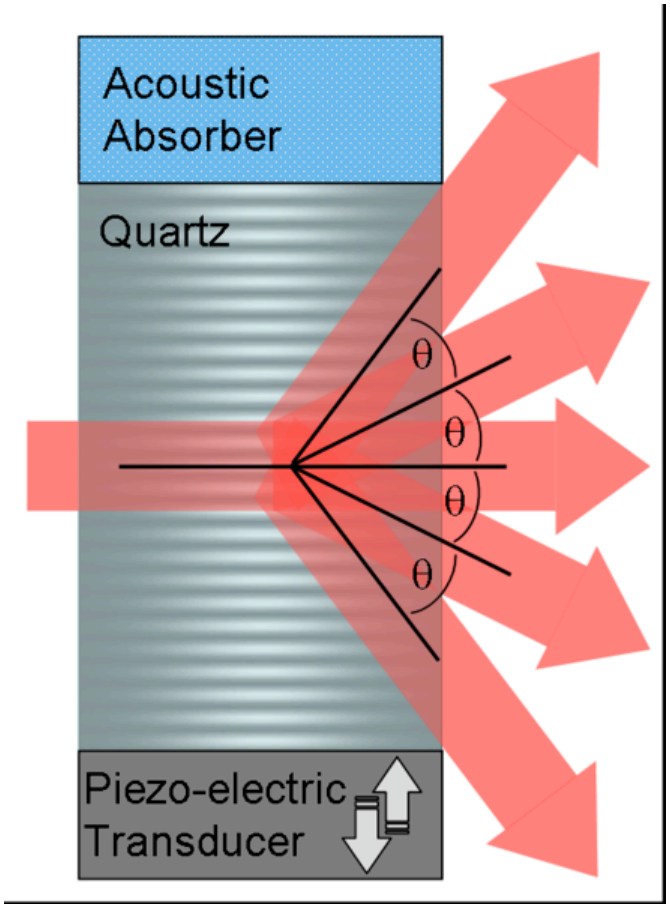
Producing Fields: EOM



EOM phase-modulates our cw beam at 6.834 GHz and creates 2 new "sidebands".

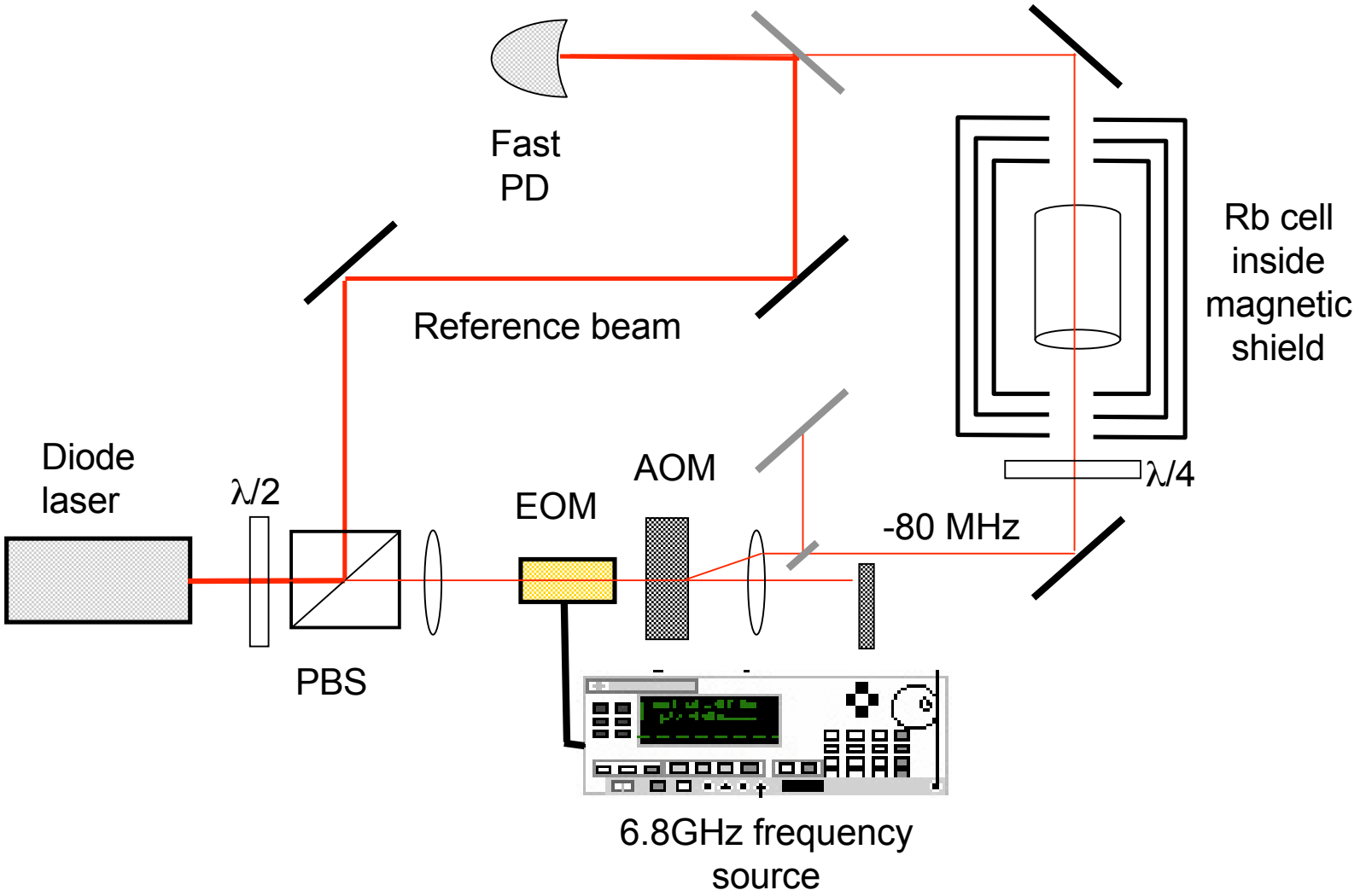


Producing Fields: AOM



- Modulates the Control field's power
- Shifts the frequencies of all 3 waves by –80MHz

Our Setup III

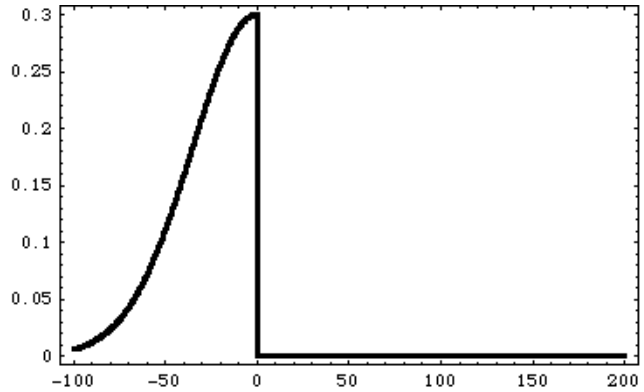


Experiment

1. Send signal to store on 6.834GHz–80MHz channel.
2. Write this signal to the atoms with a control field.
3. Turn the control field off for some time.
4. Turn the control field back on in a certain way to retrieve the signal.
5. Look at Beat Note between signal and reference (6.754 GHz) to see what we stored.
6. Look at Beat Note between –1 sideband (we assume that the medium is transparent to this frequency) to see what we sent.
7. Compute efficiency.

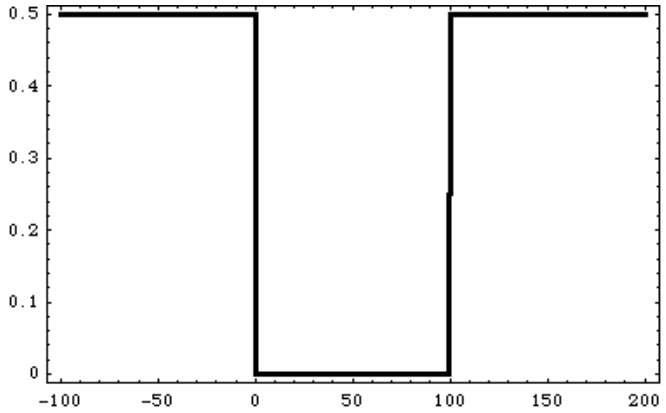
Optimizing Storage

Start with an
arbitrary Probe shape:

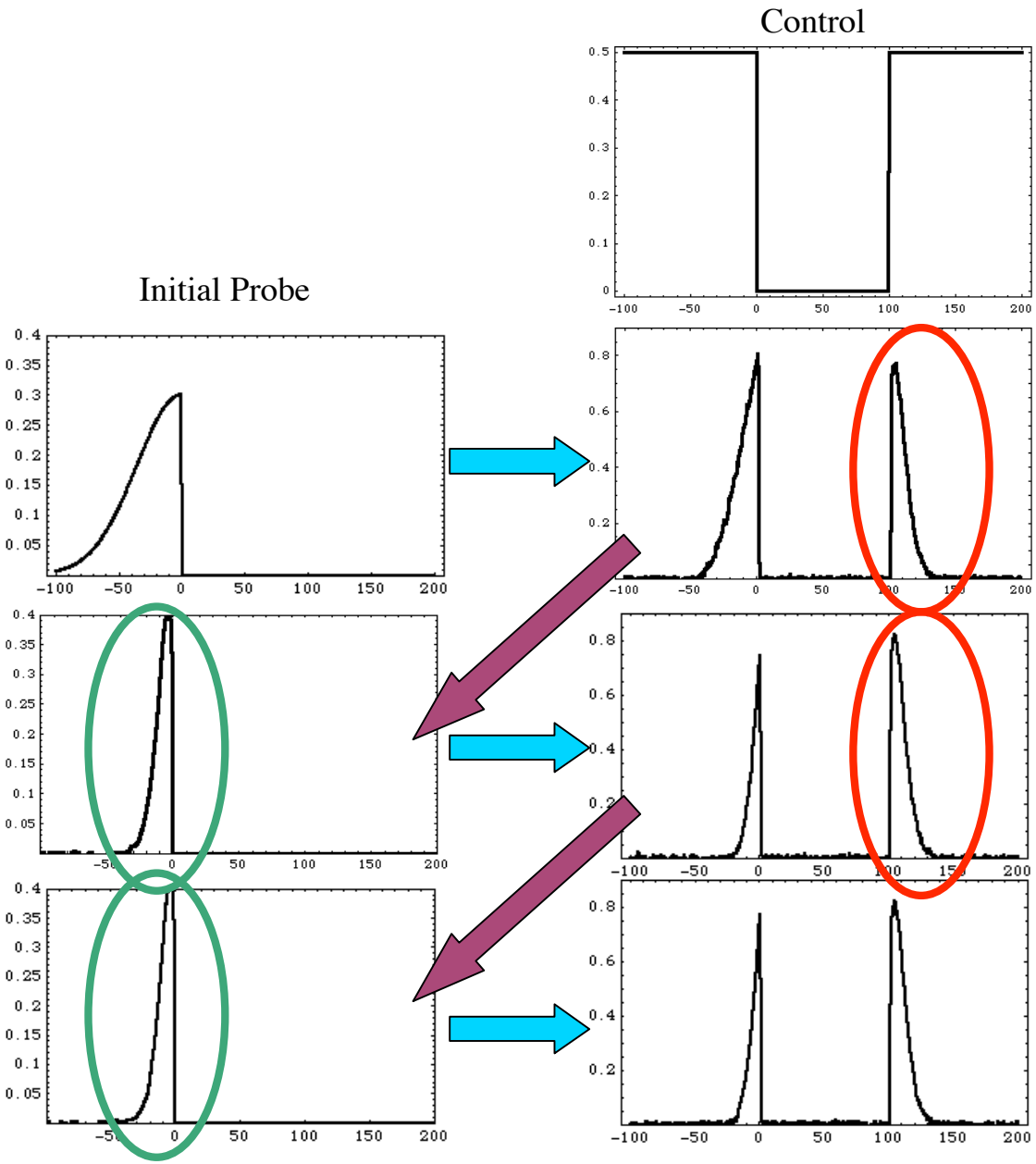


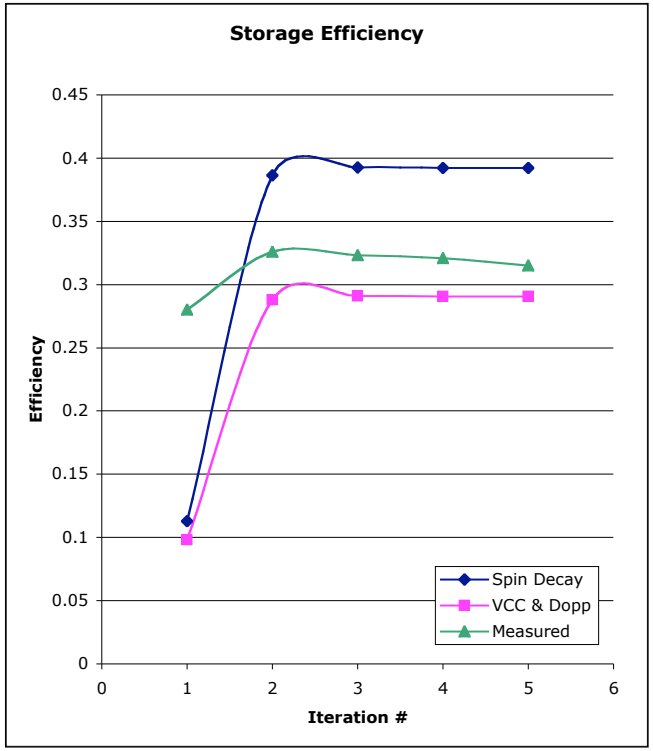
time (μsec)

And the control field
that you want:



Optimizing Storage

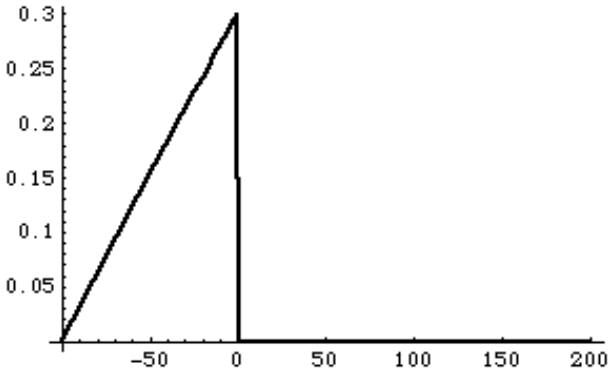




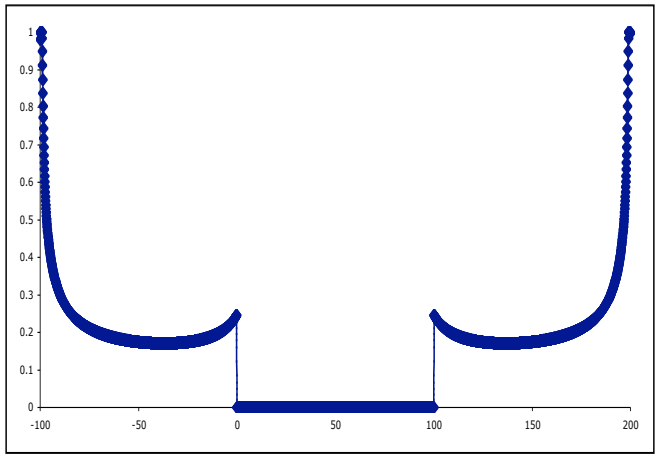
Optimizing Storage II

Alternatively, we can solve the coupled "Equations of Motion" for the Electric Field, Spin, and Polarization for a given Probe that we want to store. We'll determine the Control field that we should use to optimize efficiency:

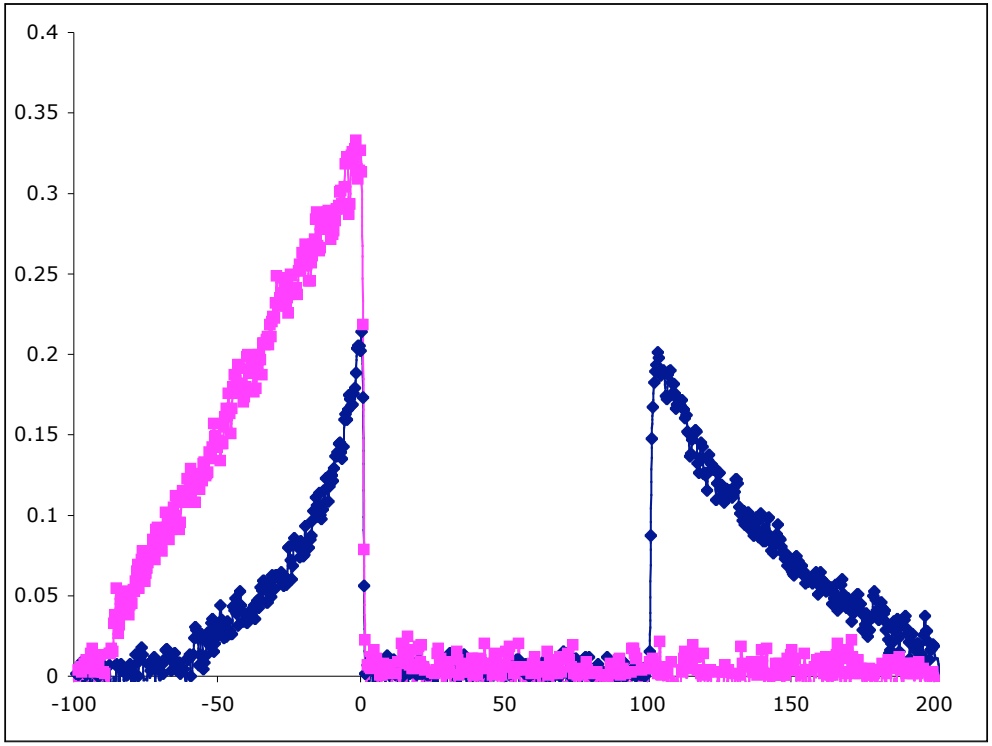
e.g., Storing a Ramp:



If we use this control, we should get ~42.5% efficiency and retrieve the mirror-image of our storage:



Optimizing Storage II



Eff = 28.5%

Predicted: ~36%

Problems and Plans

- Storage efficiency is generally lower than predicted—is this due to interference of –1 sideband?
  - Remove –1 sideband
  - Lower Temperature
- Work on Simulations