Using Kerr Effect to measure the electric field. Magnetometry with paramagnetic atoms.

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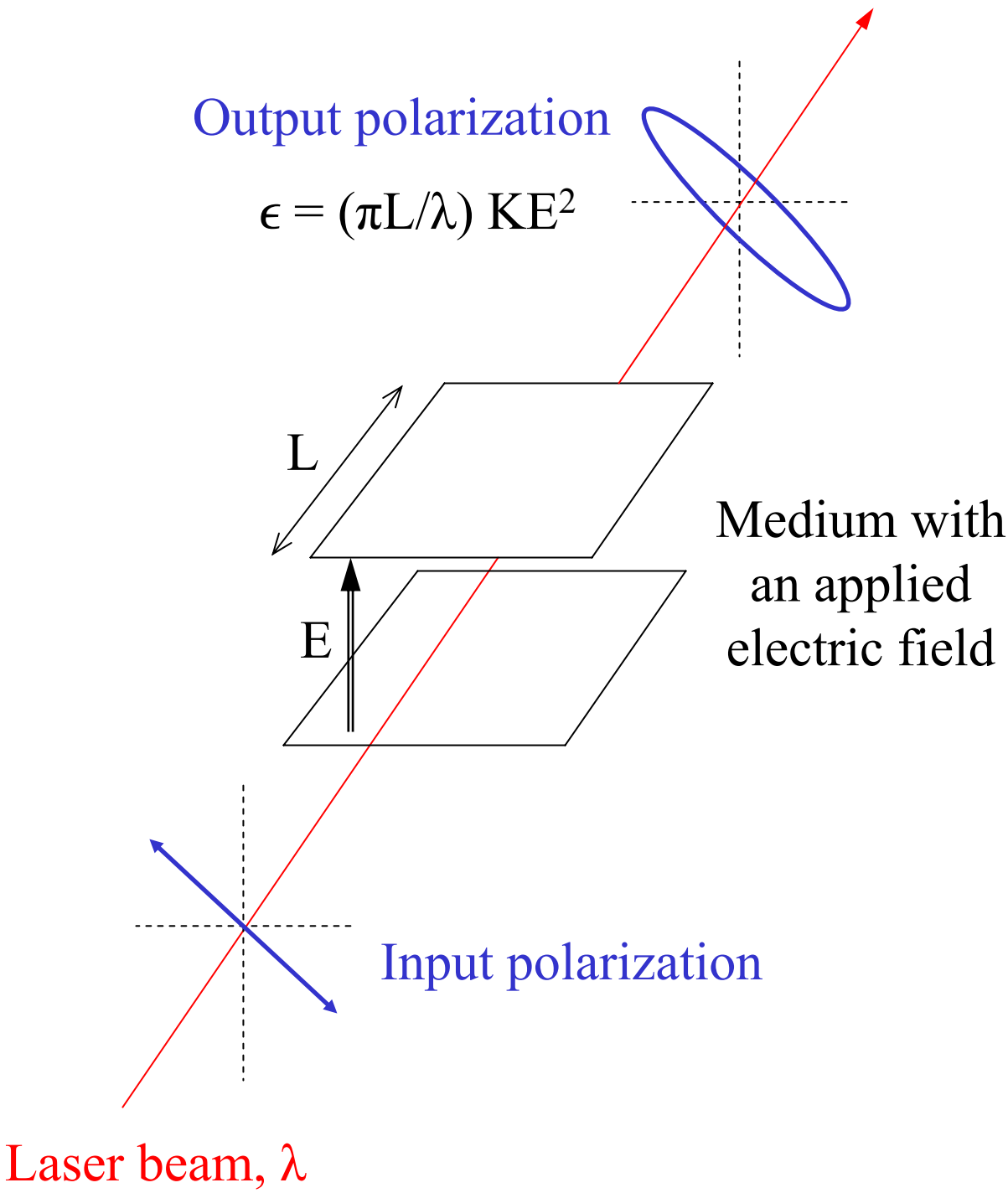
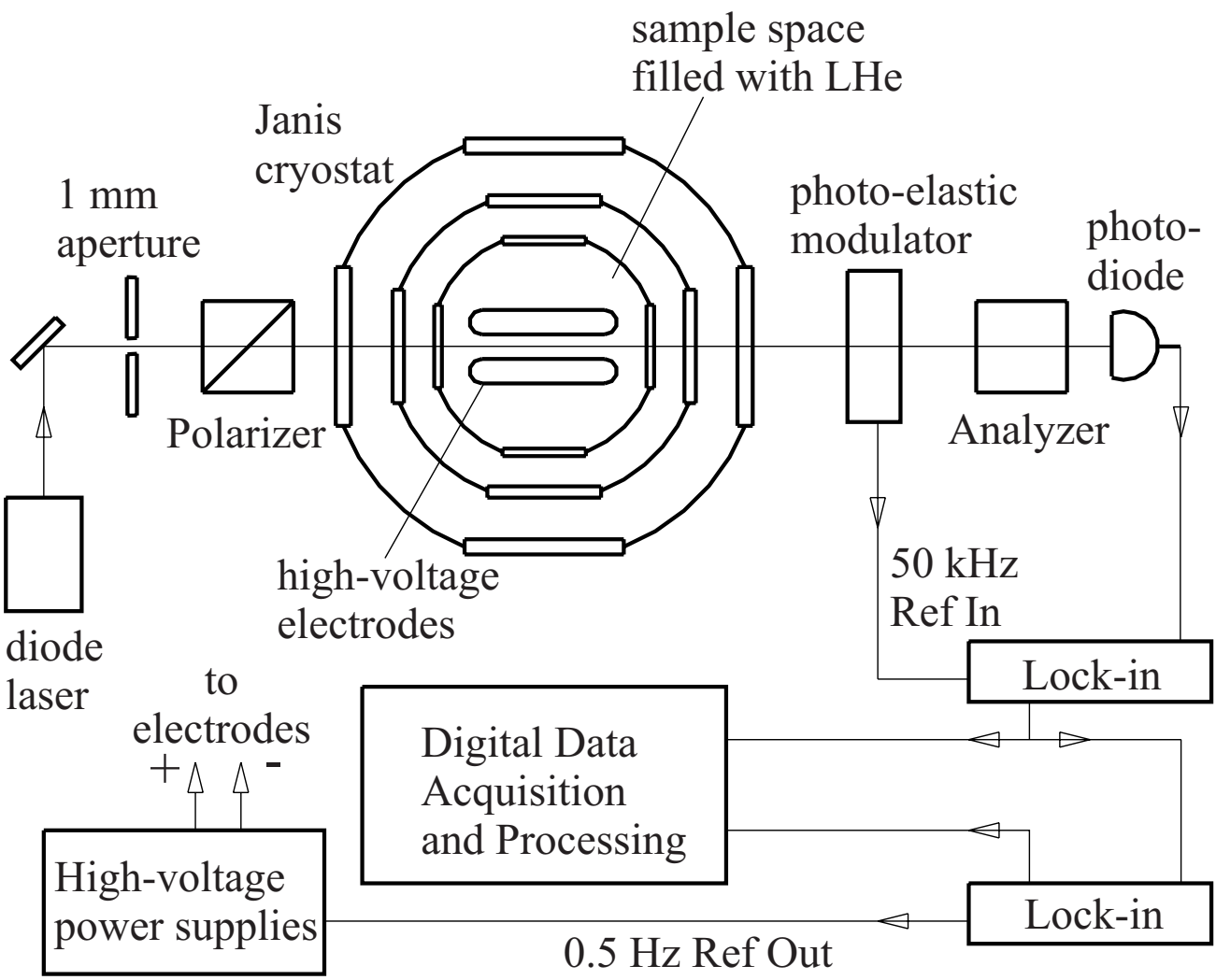
Kerr effect


Output polarization
$\epsilon = (\pi L/\lambda)\, KE^2$
L
E
Medium with an applied electric field
Input polarization
Laser beam, λ

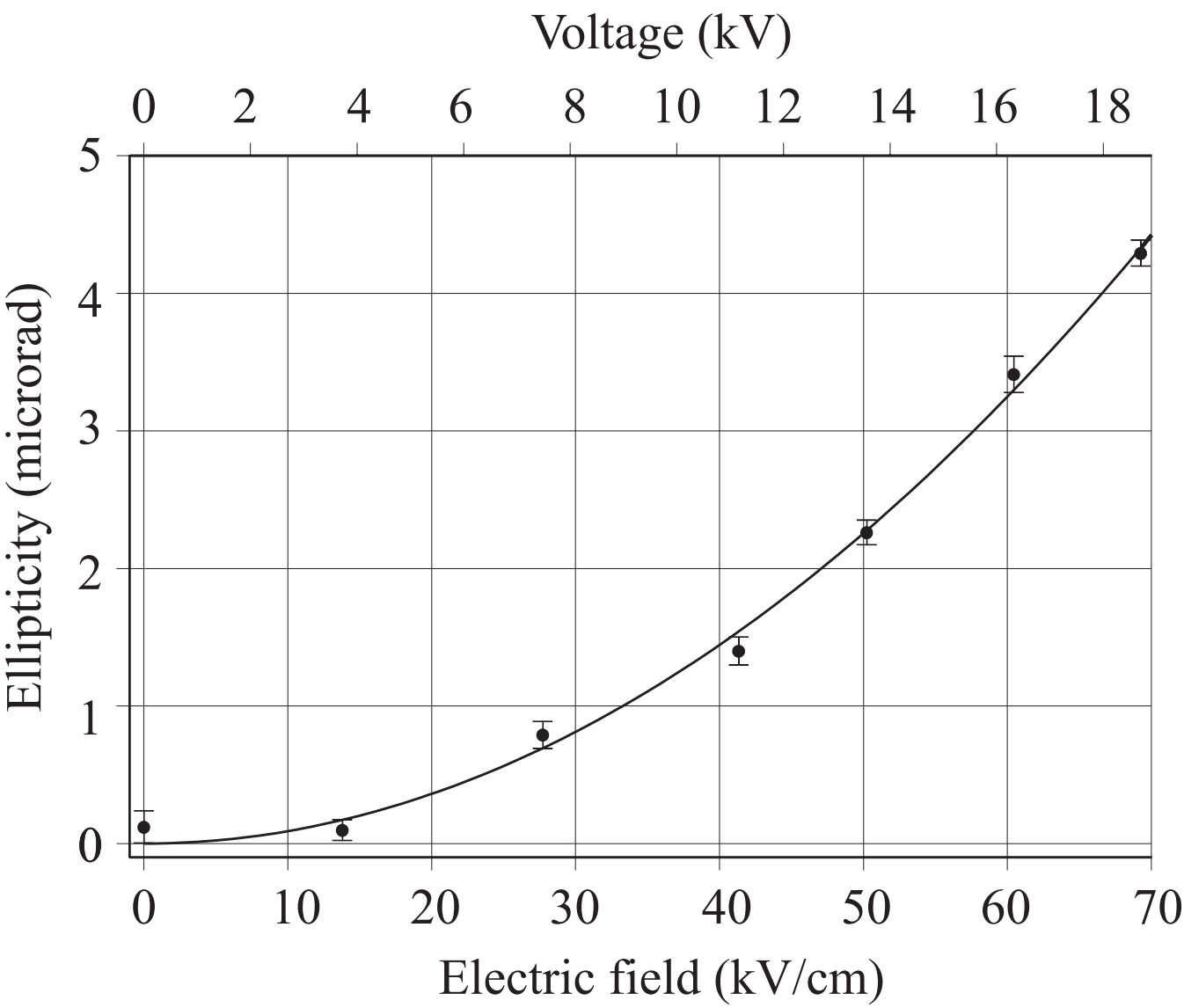
Kerr effect setup



Phys. Rev. Lett. **93**(15), 153003 (2004)

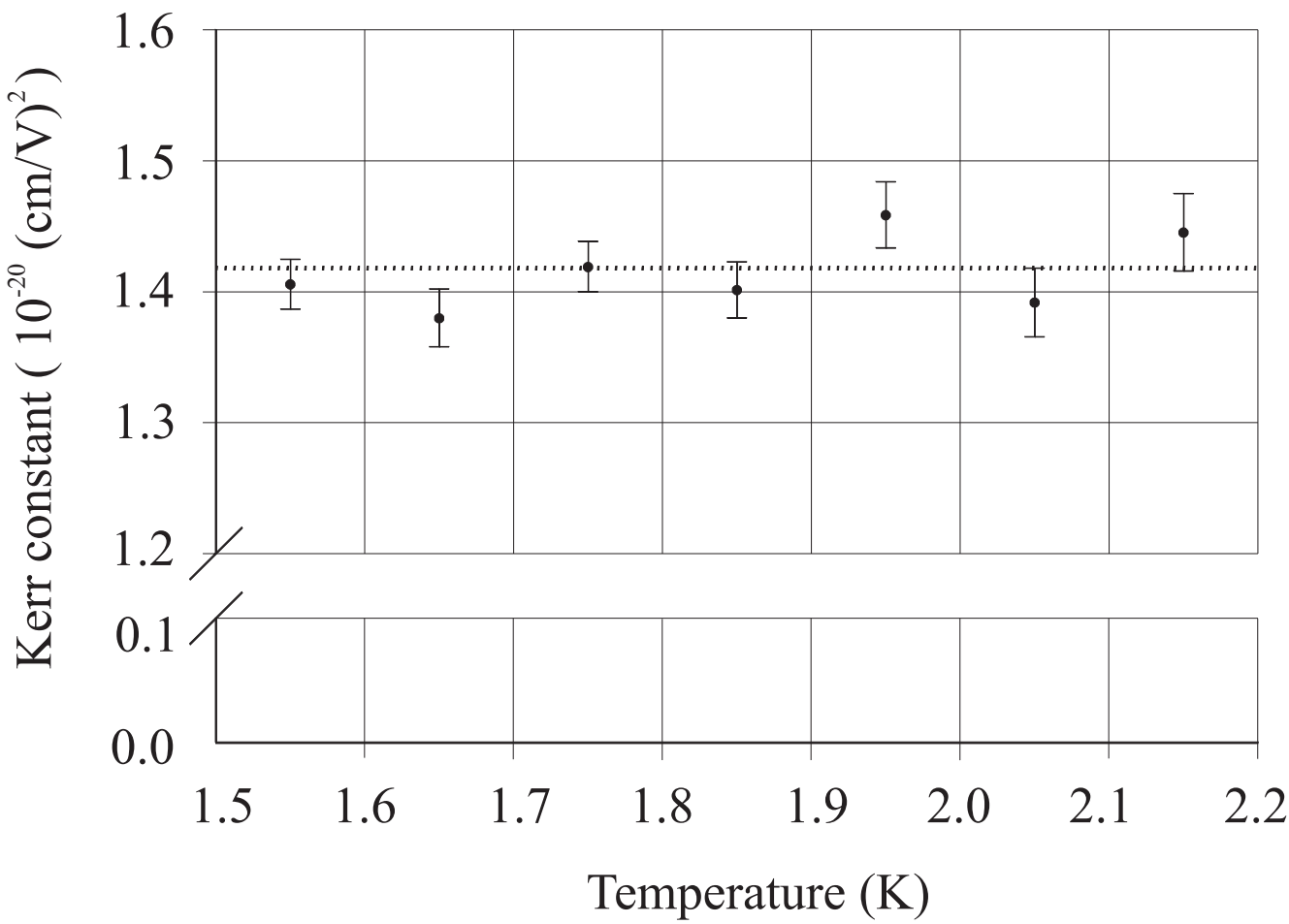
Results: LHe

Measured Kerr constant for LHe at 1.5 K:
$K = (1.43 \pm 0.02^{(stat)} \pm 0.04^{(sys)}) \times 10^{-20}\ (cm/V)^2$



T-dependence: LHe

Within the experimental error, the LHe Kerr constant does not depend on temperature in the range 1.5 K to 2.2 K.



Electric field monitoring in the nEDM experiment

E = 50 kV/cm, L = 100cm

$\rightarrow \epsilon = 2\times10^{-4}$ rad

Aim for diagnostic measurements of at least 1% precision.

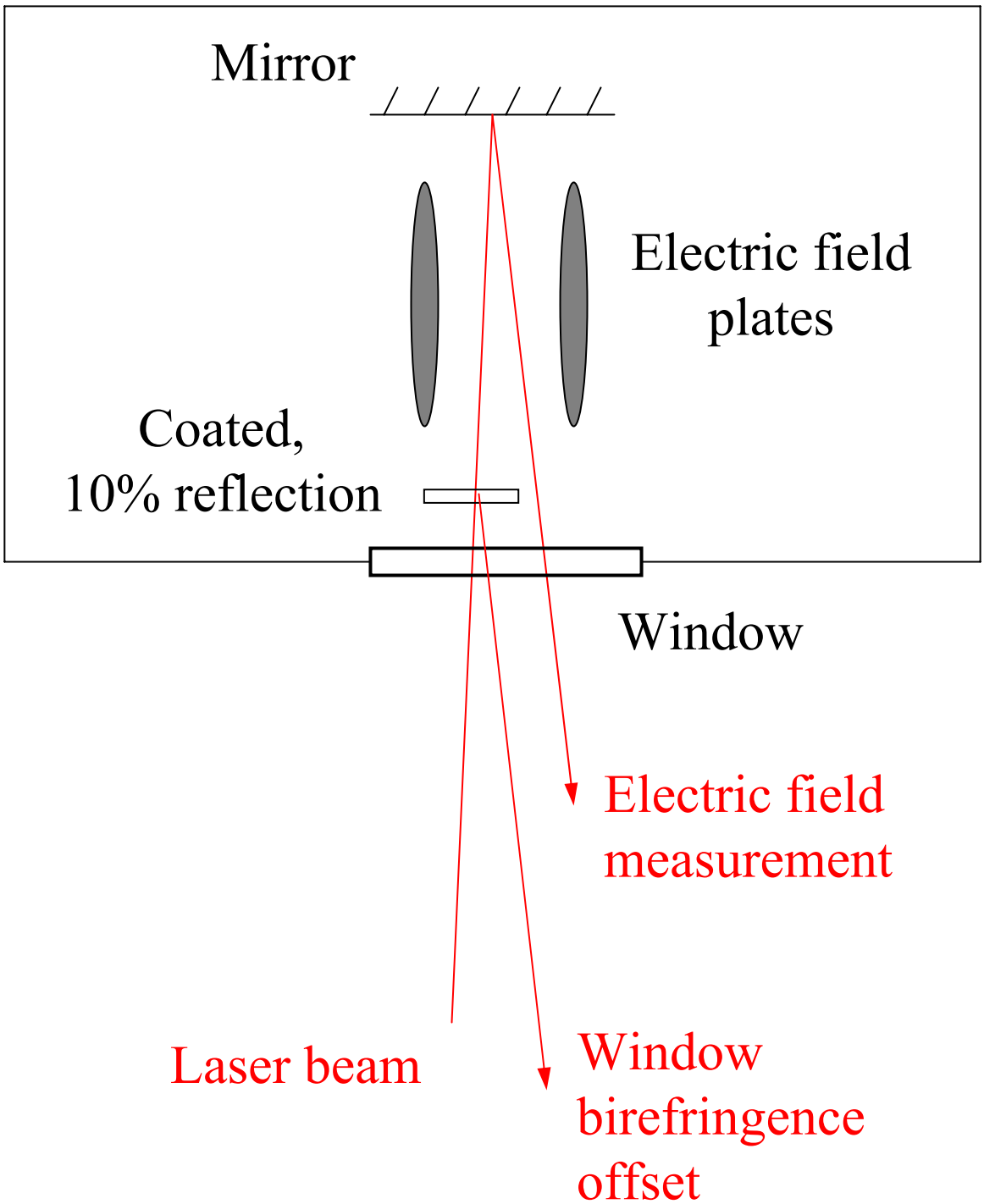
Polarimeter sensitivity:

10^{-7} rad/$\sqrt{\text{Hz}}$.

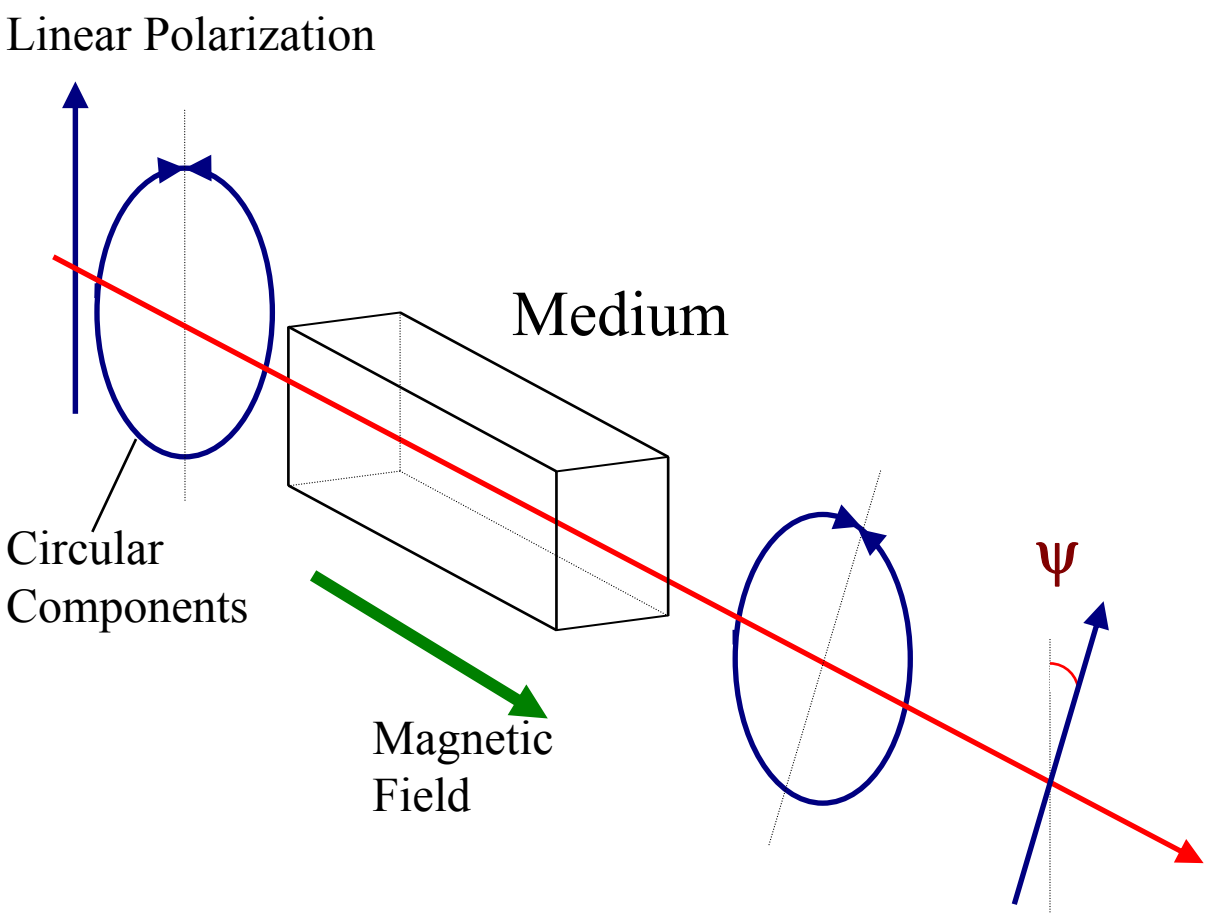
Obstacle: window birefringence drifts

$\sim 10^{-5}$ rad

Some new ideas



Atomic magnetometer



3mm to 10cm

K, Rb, Cs

Room-temperature magnetometry

- Optimal NMOR magnetometry sensitivity

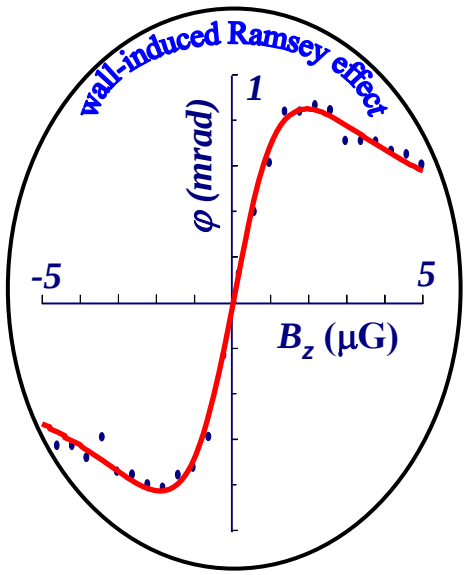
$\sim 3 \cdot 10^{-12}$ G/Hz$^{1/2}$

0.3 fT

(D.B., D.F. Kimball, V.V.Yashchuk, and M. Zolotorev, PRA 2000)

- Even better: M.V. Romalis et. al. (Princeton), *Nature* 596, (2003)

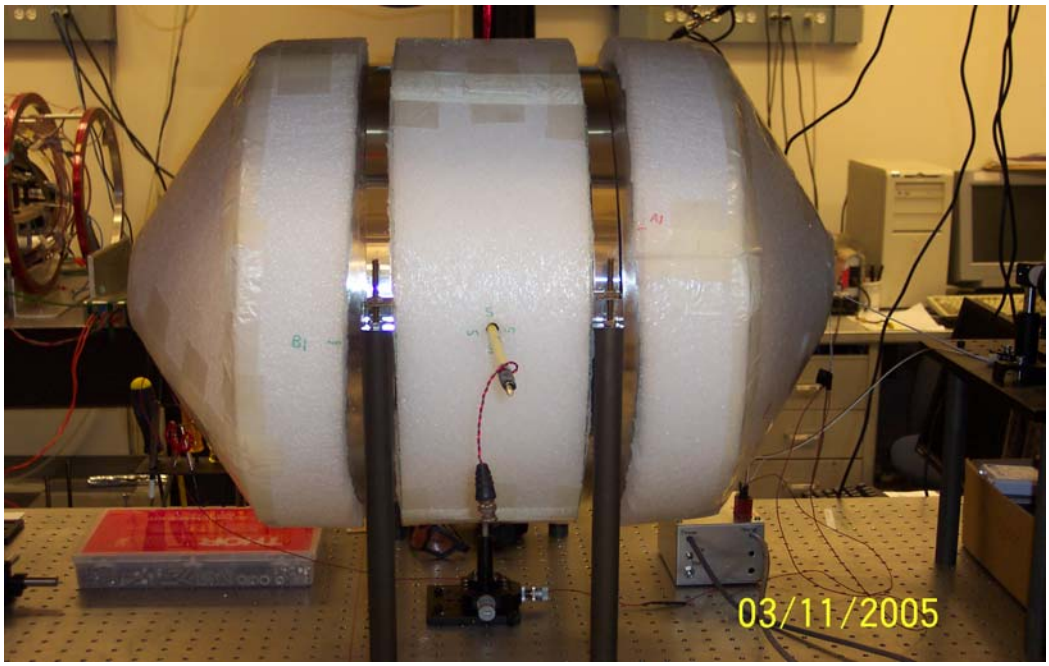
Magnetic-field-dependence of optical rotation



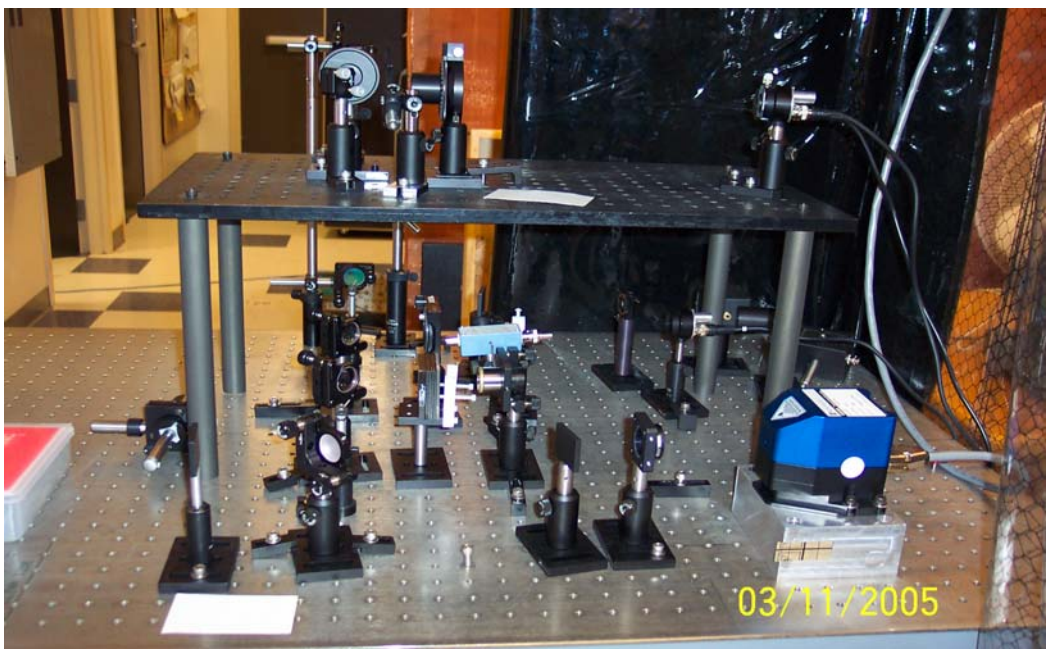
D. B., V. Yashchuk, and M. Zolotorev, Phys. Rev. Lett. ***81****, 5788 (1998)*

What does it look like?

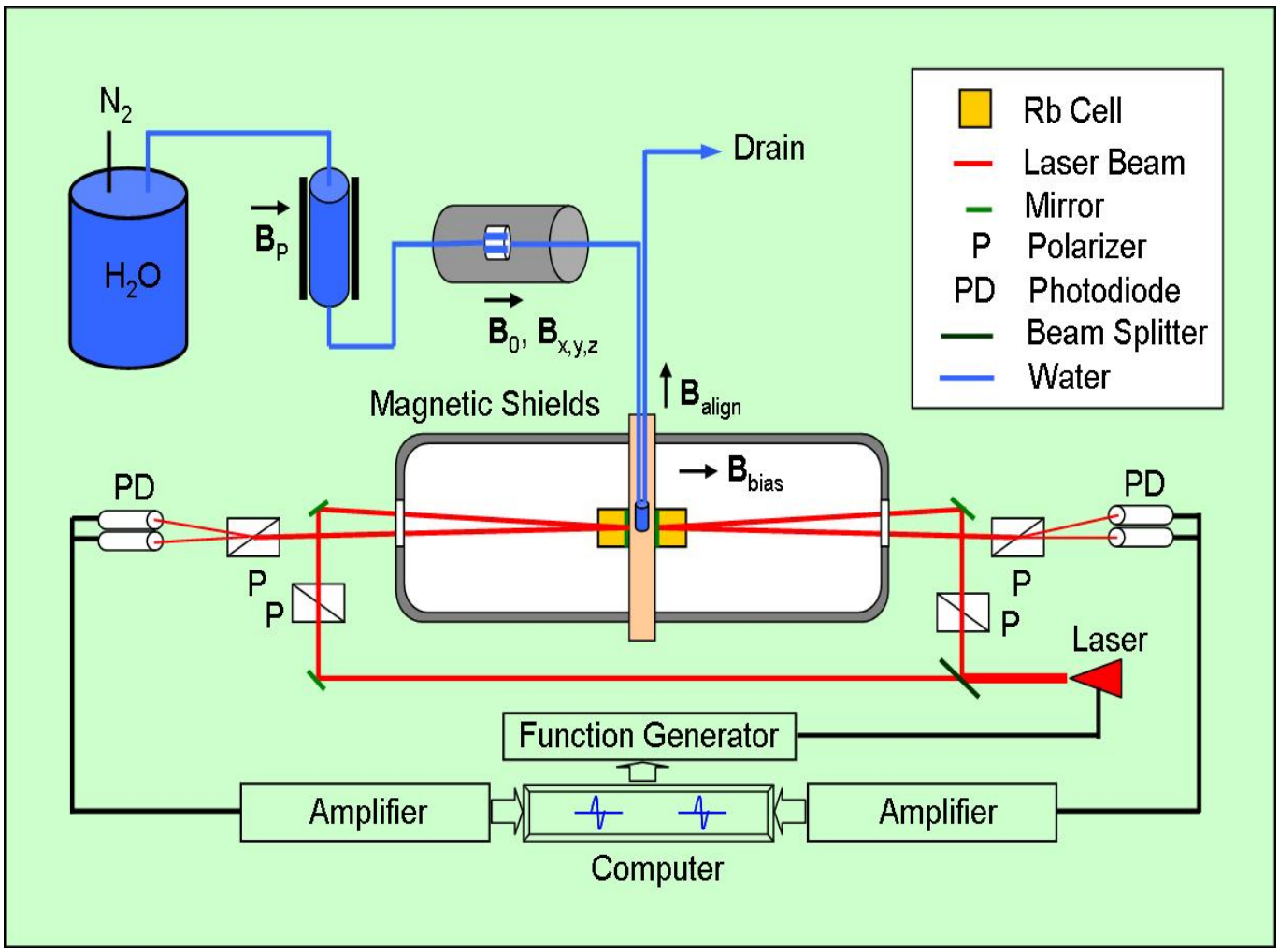
Magnetic Shield



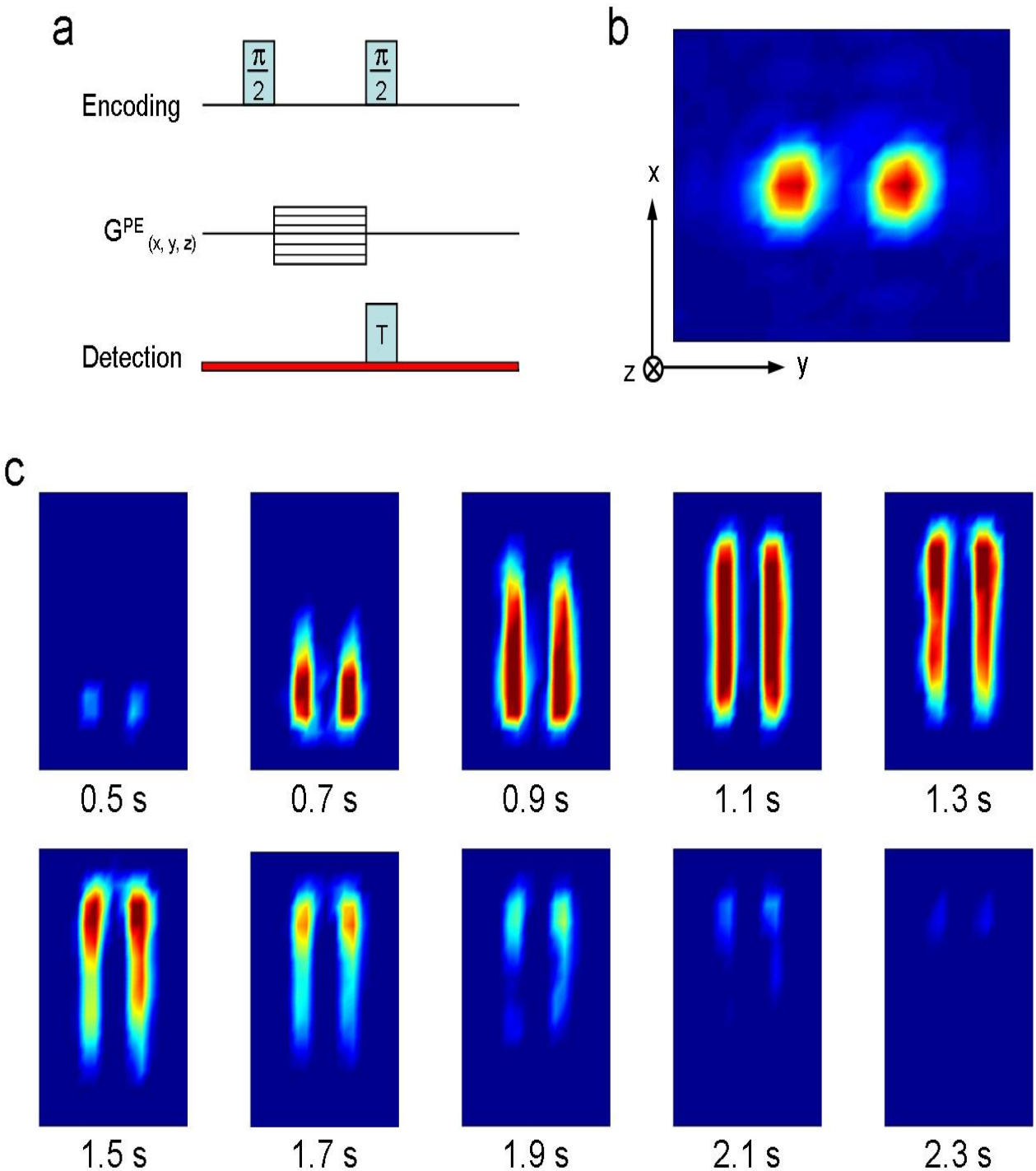
Optical Setup (one side)



Magnetic resonance with atomic magnetometers

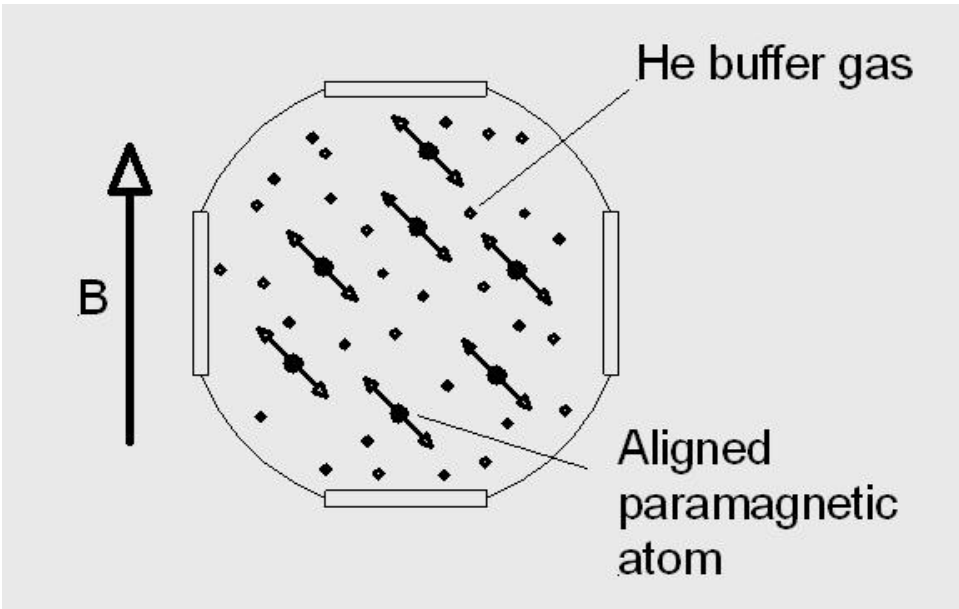


First MRI with atomic magnetometer: 02/06



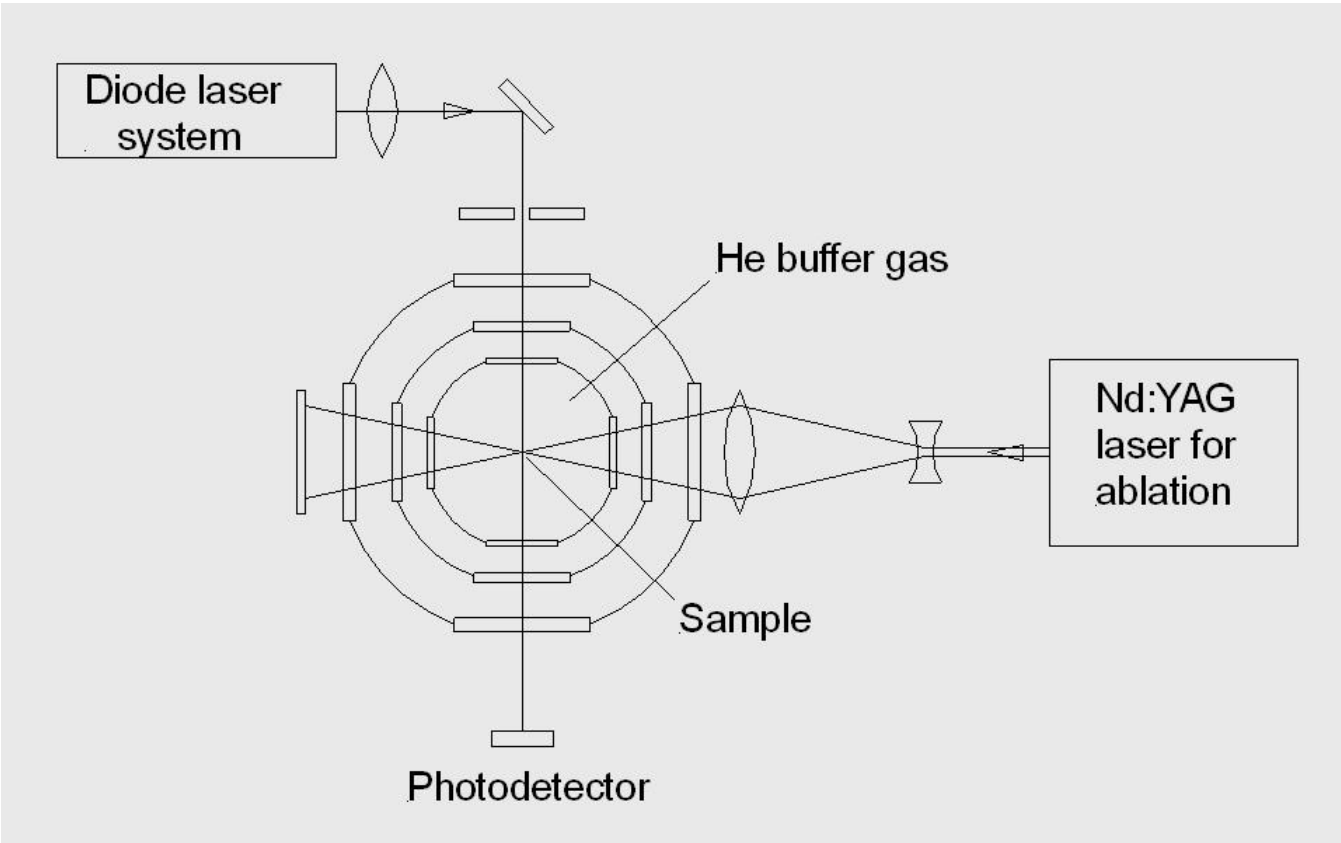
A cold magnetometer

- **Concept:**
  paramagnetic atoms "confined" in He buffer gas at T ~ 2K, where spin-orbit relaxation is suppressed.



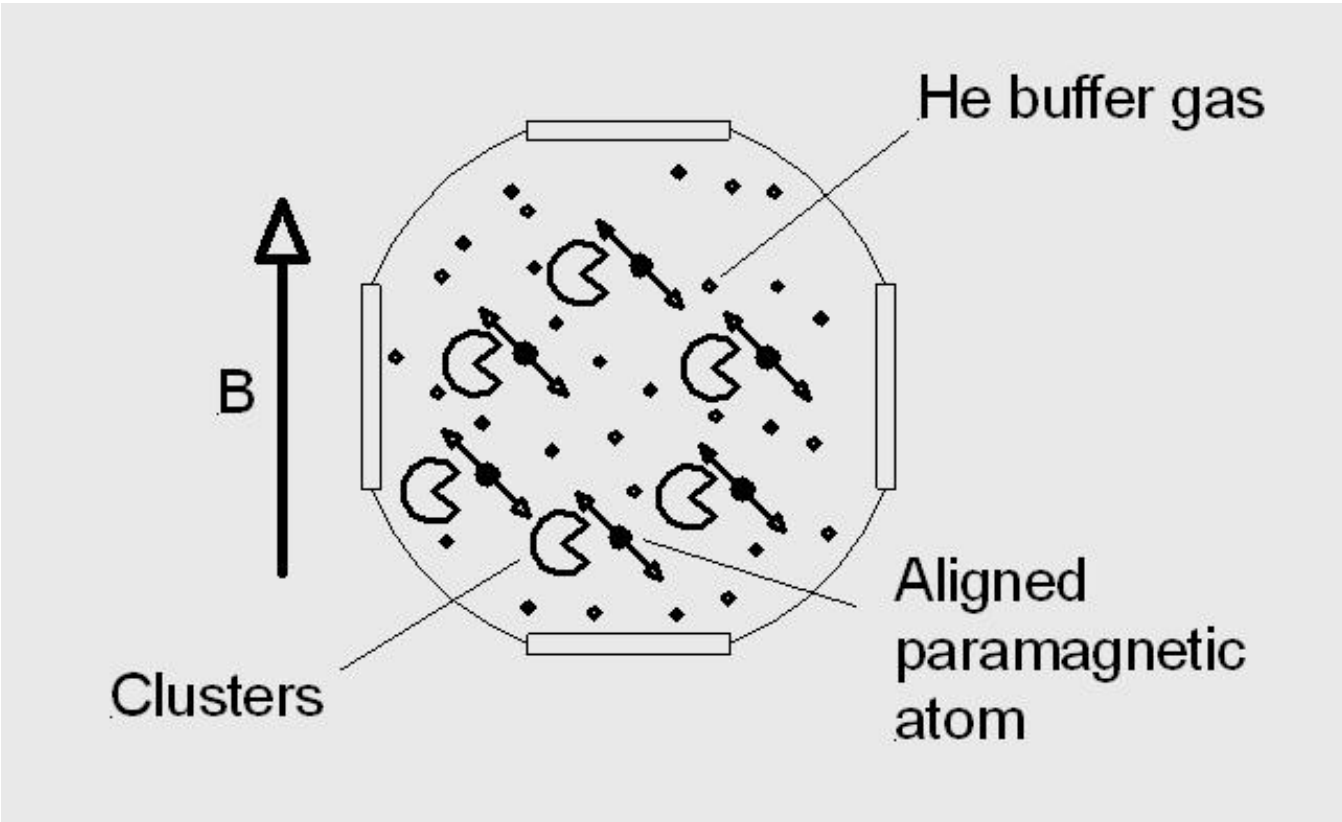
- **Goal:**
  shot-noise limited sensitivity of
  $\delta B \sim 3\times10^{-13}$ G/$\sqrt{\text{Hz}}$

The progress



- Achieved filling with: Li, Rb, Ag densities ~ 10^{11} cm^{-3}
- Optically pumped Li

The problem



Ideas

- **Photoionization:**
  photoionize the clusters and get rid of them with a small electric field.
- **Aerosols:**
  Ablation of microparticles to avoid producing clusters.
- **Desorption:**
  Implant atoms into the LHe film on the cell windows with laser ablation. Then desorb them back into the cell with Light-Induced Atomic Desorption (LIAD).