**Clinical Problem:** Curing early stage cancer depends eliminating all tumor cells, but there is no way to detect microscopic disease in the body.

**Technical Challenges**
- Illumination
  - Blood: Absorption
  - Blood: Non-Uniform Coating
  - Antibody Non-Specific Binding
- Background
  - Remove Reflected Light
  - Blood: Autofluorescence

**Proposed Solutions**
- Optical filters
- CMOS Imager
- GHz resolution for Time Gated Imaging

**Results**
- Antibodies “per cell” [100 μm²]
- Signal vs Number of Antibodies

**Next Steps**
- Integration of setup into microscope with fiber optic extension with improved optical filter.
- Fiber optic illumination of sample with time-gated imaging.
- Integration of imaging chip with optical fiber illumination.
- Imaging of in-vitro cell samples with mm resolution.

**In-Vivo Temperature Measurement:** Radiation therapy for cancer can benefit from well controlled local heating of the tissue, but no reliable method exists to monitor temperature in-vivo over a 2 month period. Our goal is to develop an implantable low-power wireless temperature sensor.

**Magnetic Label Flow Cytometer**
- **Goal:** Reduce the complexity and cost of flow cytometry to bring it to the point of care.
- **Concept:** Label cells with magnetic nanoparticles, flow them over a magnetic sensor, and count them.
- **Advantages of magnetic labels:**
  - Greatly simplified sample prep
  - No background
  - Label response not affected by storage, biochemical interactions
  - Can analyze whole blood
- **What about multiple colors?**
  - Magnetic actuation → can sort cells without complex fluids
  - Much lower cost → no lasers, photomultiplier tubes, or filters
- **Idea:** Use Neel relaxation in superparamagnetic nanoparticles
  - Relaxation time constant is a strong function of particle size and material
  - Can use this effect to distinguish different types of particles by measuring phase shift
  - Multi-color flow cytometry with magnetic labels!