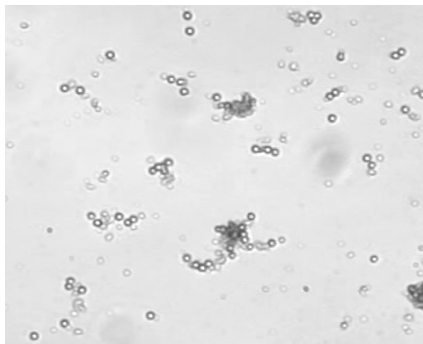
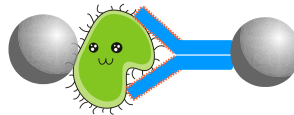
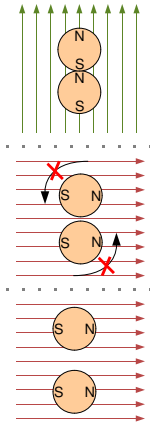


Controlling Superparamagnetic Microspheres with Helmholtz coils



Rui Caldeira
September 2010

The idea



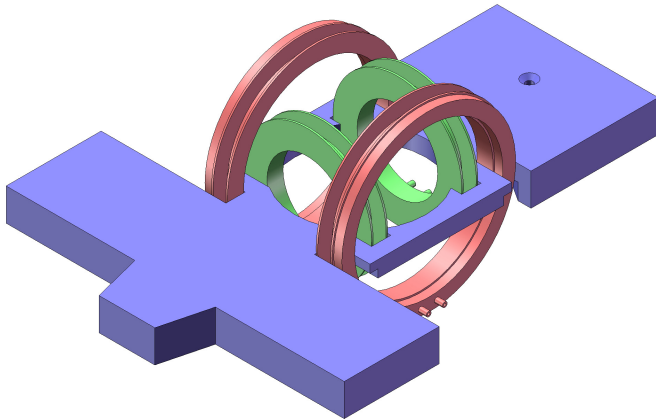
Antibody-Bacteria bond



DNA unzipping

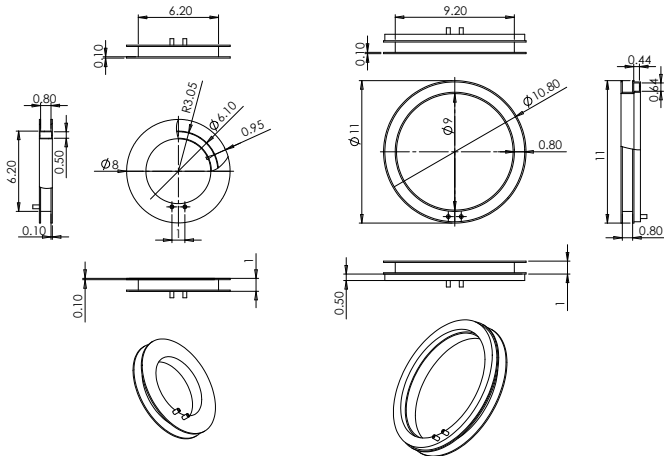
- ▶ Platform free control of macromolecules
- ▶ Using self-created magnetic field non-uniformity

Design



- Perpendicular Helmholtz coils with radius 4 and 5.5 cm

Design



Specifications

Small Coils

- ▶ **Turns:** 300
- ▶ **Resistance:** 10Ω
- ▶ **Radius:** 4cm
- ▶ **Magnetic field:** 18mT
- ▶ **Power dissipated:** 90W

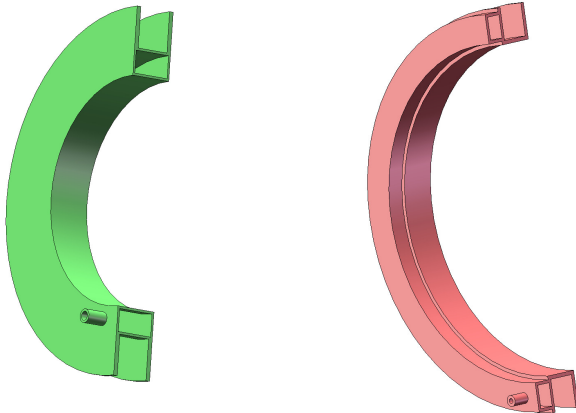


Big Coils

- ▶ **Turns:** 320
- ▶ **Resistance:** 11Ω
- ▶ **Radius:** 5.5cm
- ▶ **Magnetic field:** 12mT
- ▶ **Power dissipated:** 80W

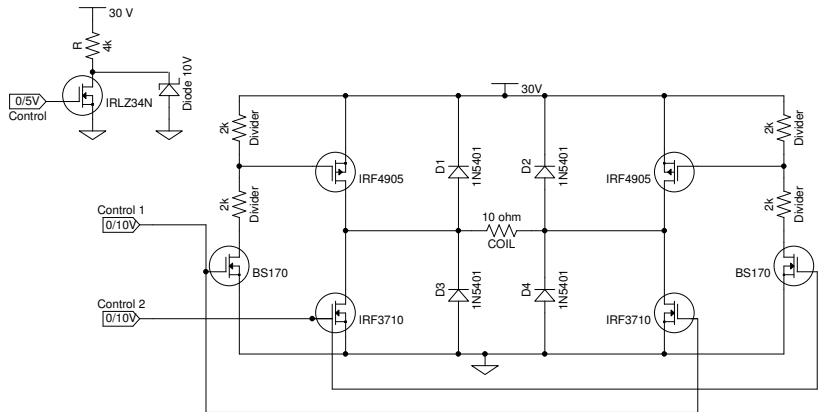


Cooling chambers



- Tight chambers for cooling by pumped water

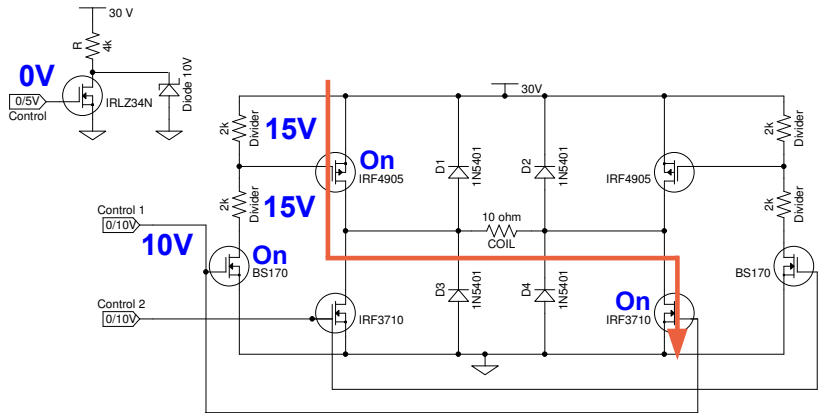
Electronics



- ▶ **Operating voltage:** 30V
- ▶ **Maximum current:** 10A
- ▶ **Control voltage:** 5V

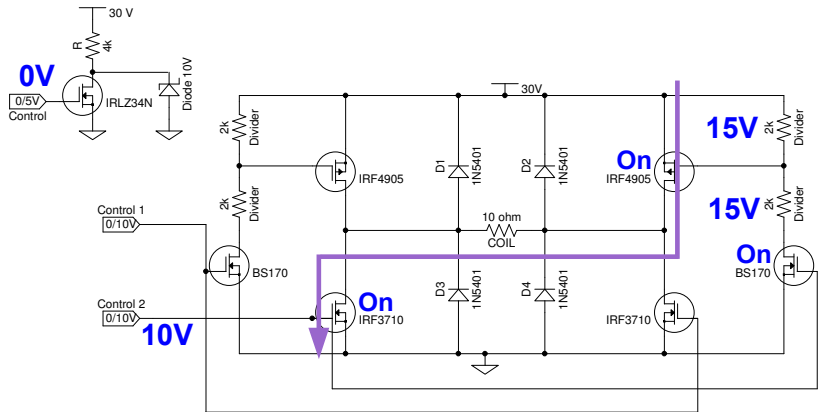
- What to build?
- Electronics

Electronics



- Half-Bridge circuit
- Direction of current controlled
- This circuit controls one Helmholtz coil

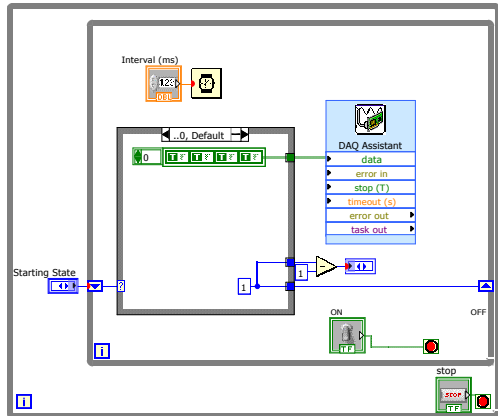
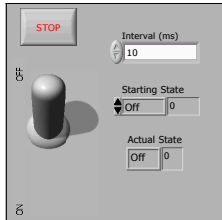
Electronics



- ▶ Coils are parallel, so resistance is actually 5Ω
- ▶ Control signals cannot be 10V at the same time
- ▶ Power dissipation on transistors is low

- What to build?
- Under control

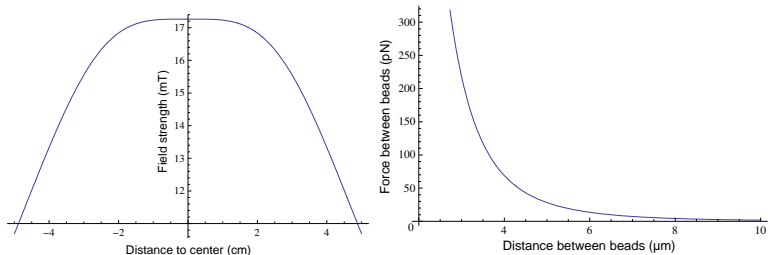
Under control



- Labview control with USB-6008
- Coils can be controlled independently
- Direction of magnetic field (but not intensity)

- └ What to build?
- └ Limitations

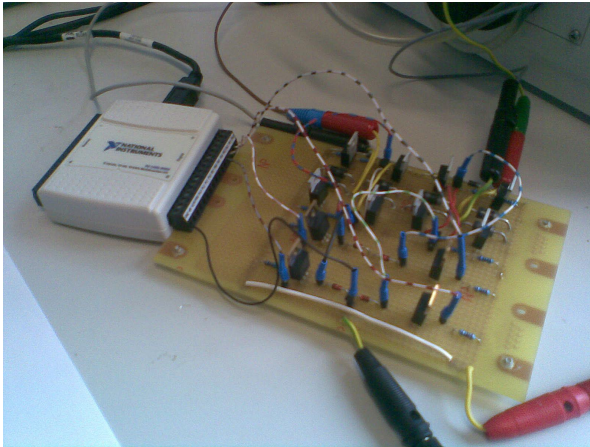
Limitations



- ▶ Field's uniformity limited to a central area
- ▶ Area is approx. 2x2 cm
- ▶ Force decreases rapidly with distance between beads
- ▶ Distance is up to $4\mu m$

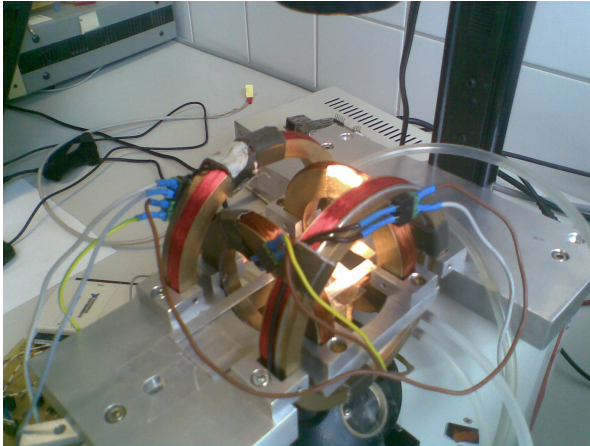
- └ What to build?
- └ The real thing

Electronics



- └ What to build?
- └ The real thing

Coils and Microscope



- └ What to build?
- └ The real thing

Cooling system



- └ What to build?
- └ The real thing

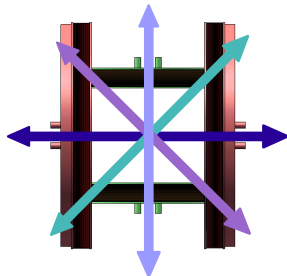
All together



- └ What to build?
- └ Modes of operation

Modes of operation

- ▶ Alternated
- ▶ Diagonal Alternated
- ▶ Electromotor
- ▶ Diagonal Electromotor
- ▶ All around
- ▶ Noise
- ▶ Manual

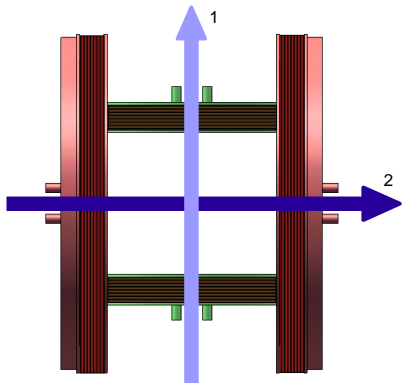


- ▶ The two alternated modes permit burst and continuous mode
- ▶ All modes permit pause between change of direction

- └ What to build?
- └ Modes of operation

Alternated

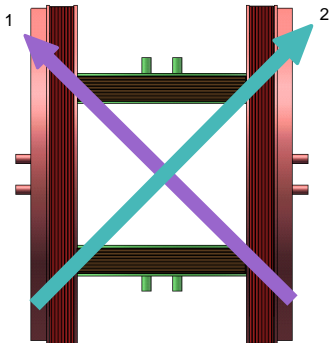
- ▶ Each pair of coils alternately turned on
- ▶ Two directions:
N, E or S, W, or N, W, or S, E
- ▶ Difficulty in separating spheres
- ▶ Spheres turn to follow magnetic field



- └ What to build?
- └ Modes of operation

Diagonal Alternated

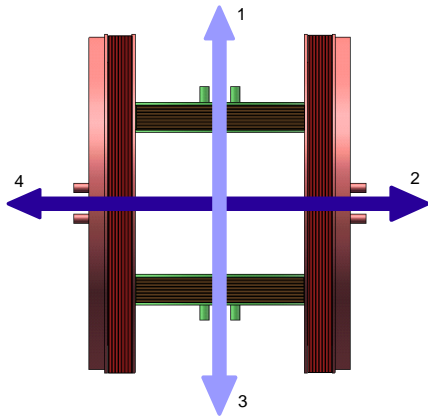
- ▶ Both Helmholtz coils are turned on
- ▶ Two directions: NE, NW or SE, SW
- ▶ Stronger and uniform field of 20 mT
- ▶ Still some difficulty in separating



- └ What to build?
- └ Modes of operation

Electromotor

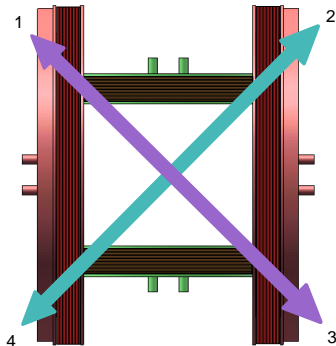
- ▶ Alternating directions:
N, E, S, W
- ▶ Makes spheres pairs rotate
- ▶ Better separation of spheres pairs
- ▶ Spheres tend to agglomerate



- └ What to build?
- └ Modes of operation

Diagonal Electromotor

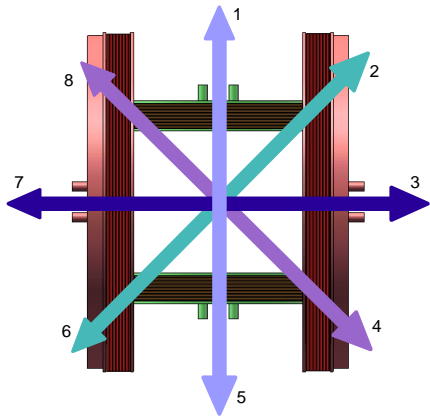
- ▶ Alternating directions:
NW, NE, SE, SW
- ▶ Makes spheres pairs rotate
- ▶ Better separation
because of stronger field
- ▶ Best of operation modes



- └ What to build?
- └ Modes of operation

All around

- ▶ Alternating directions:
NW, N, NE, E, SE, S, SW,
W
- ▶ Makes spheres pairs
rotate
- ▶ Non-uniformity of field
strength
- ▶ Finer rotation



- └ What to build?
- └ In action

In action

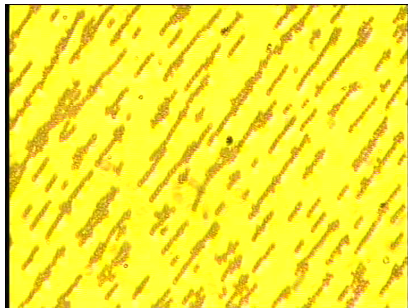


└ And now...

└ ...what to do next?

...what to do next?

- ▶ Experiment with different densities and different beads
- ▶ Various frequencies and different operation modes
- ▶ Begin experiments with macromolecules, bacteria, eggs...

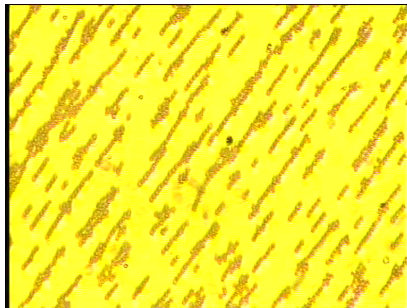


└ And now...

└ ...what to do next?

...what to do next?

- ▶ Experiment with different densities and different beads
- ▶ Various frequencies and different operation modes
- ▶ Begin experiments with macromolecules, bacteria, eggs...



- ▶ **Any questions? Any ideias?**