

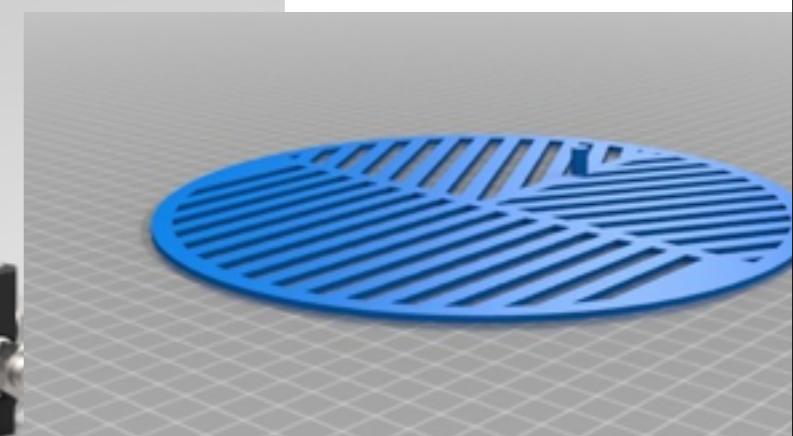
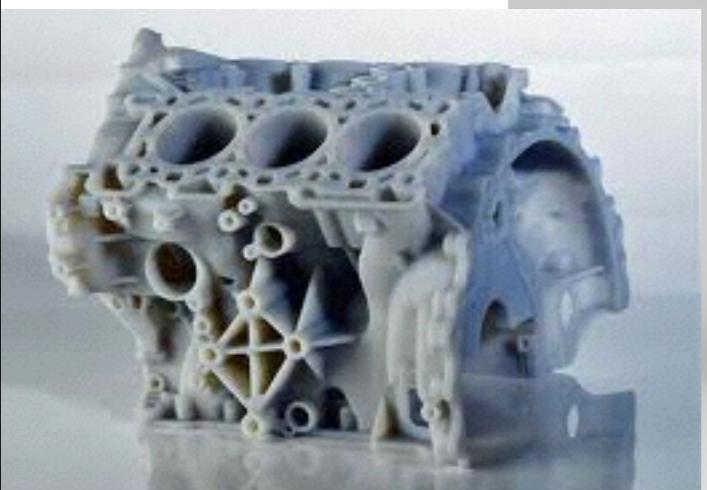
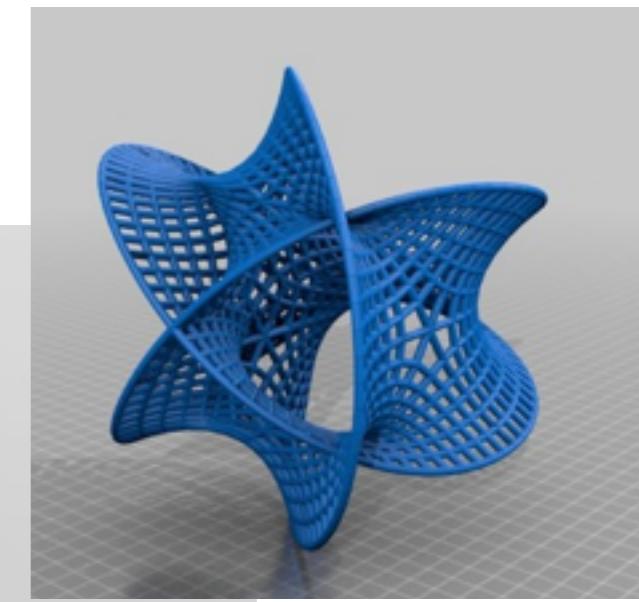
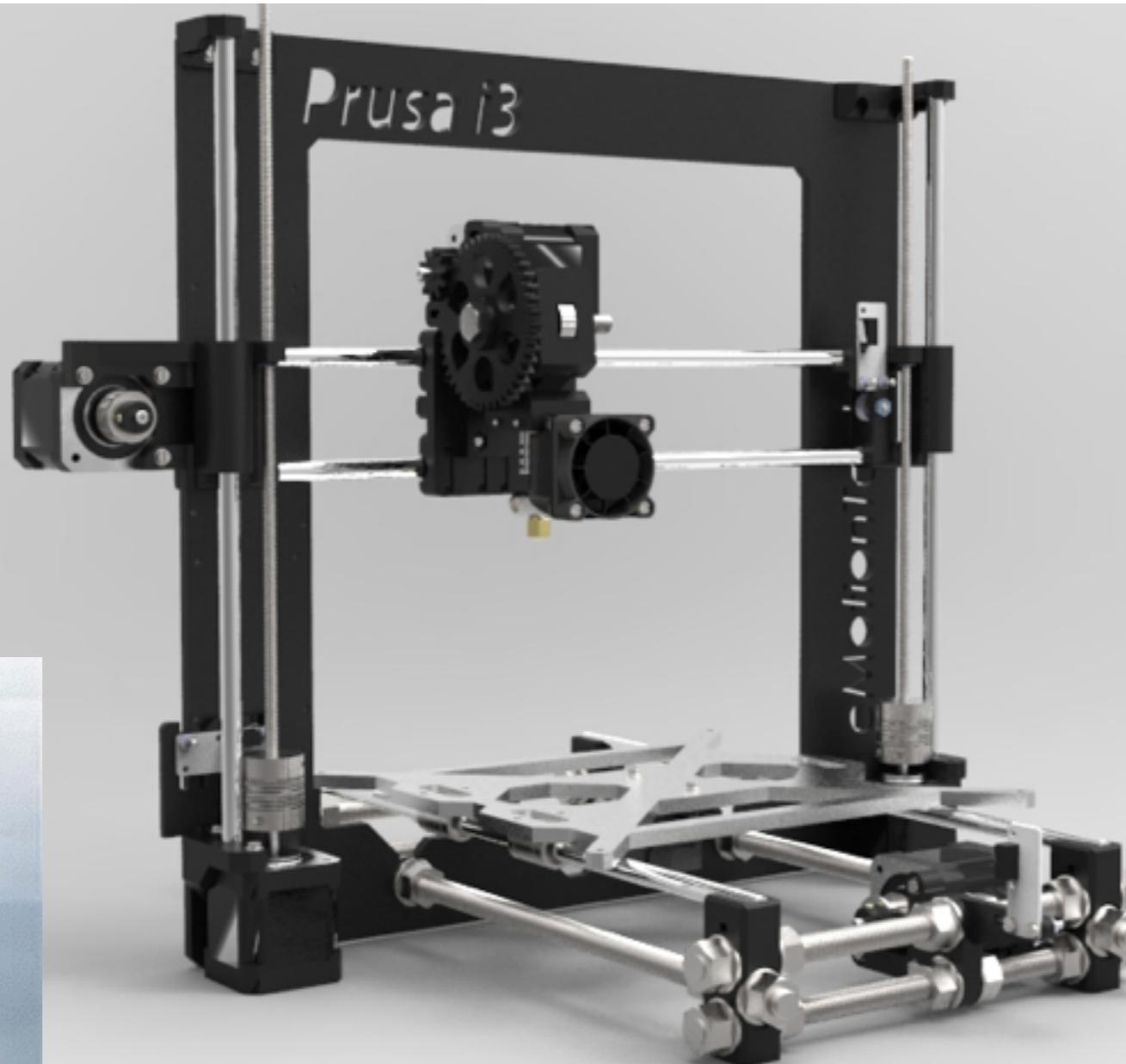
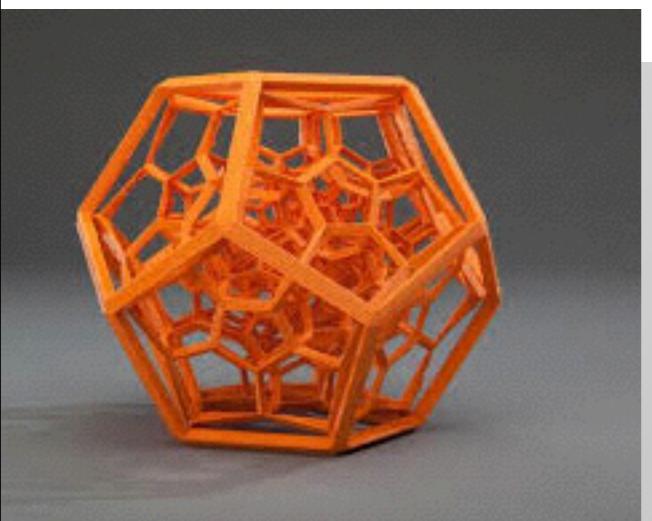
# 3D PRINTING:

## Student Projects and Undergraduate Research

Andrew M.C. Dawes  
Pacific University



# 3D PRINTING:



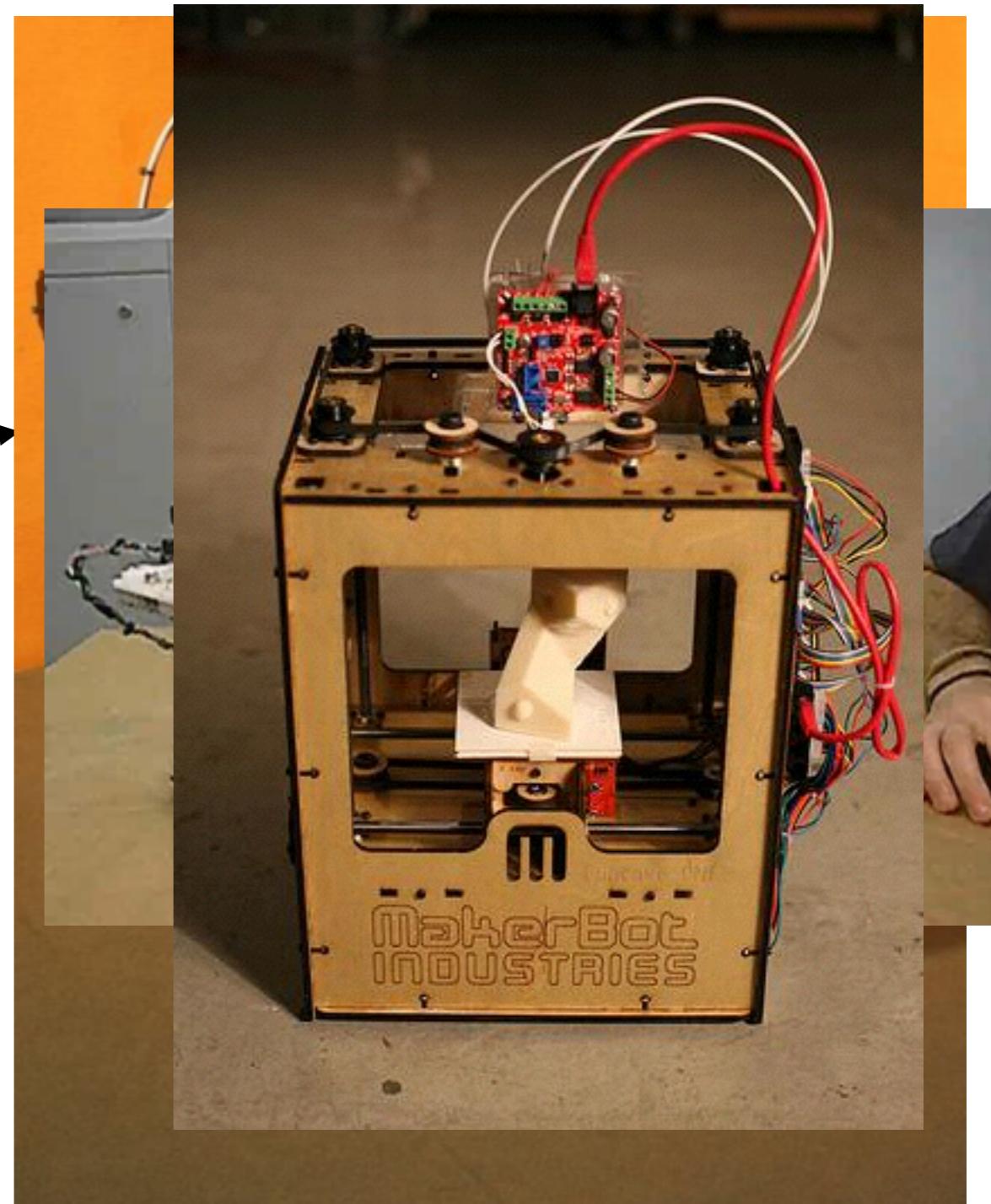
# 3D PRINTING:

“We see it as more of a lifestyle”

–Alyssa Reichental [3D Systems](#)

# History

- Additive manufacturing — 1984
- Commercial systems
- Maker movement ~ late 2000s
- Reprap — 2007
- Makerbot and many others



# Our story

Pacific  
University  
Oregon



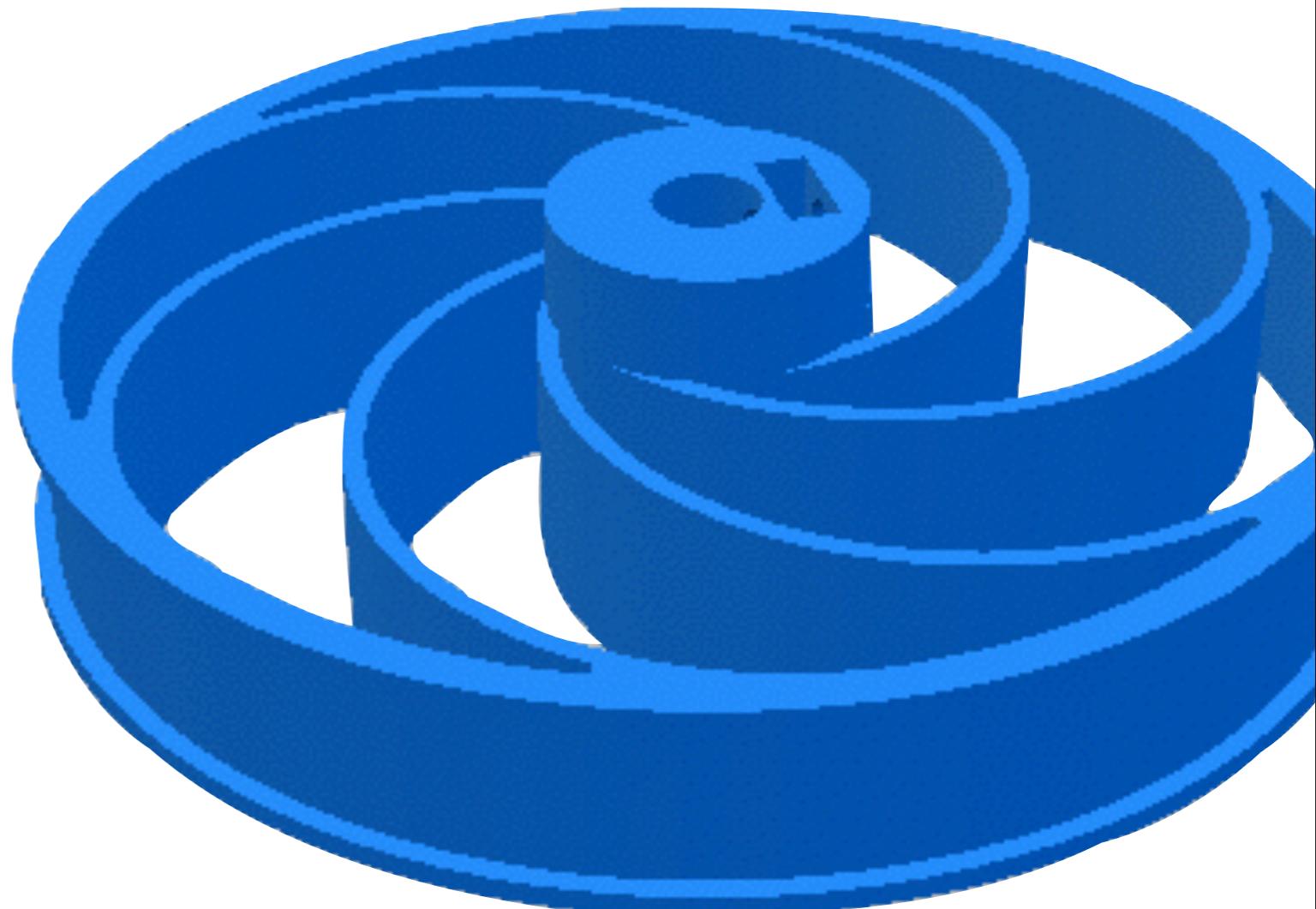
- Thing-o-matic #006696 —  
January 2012
- club project
- four-day build
- installed in dept. computer lab
- 24/7 student access



# Classroom use

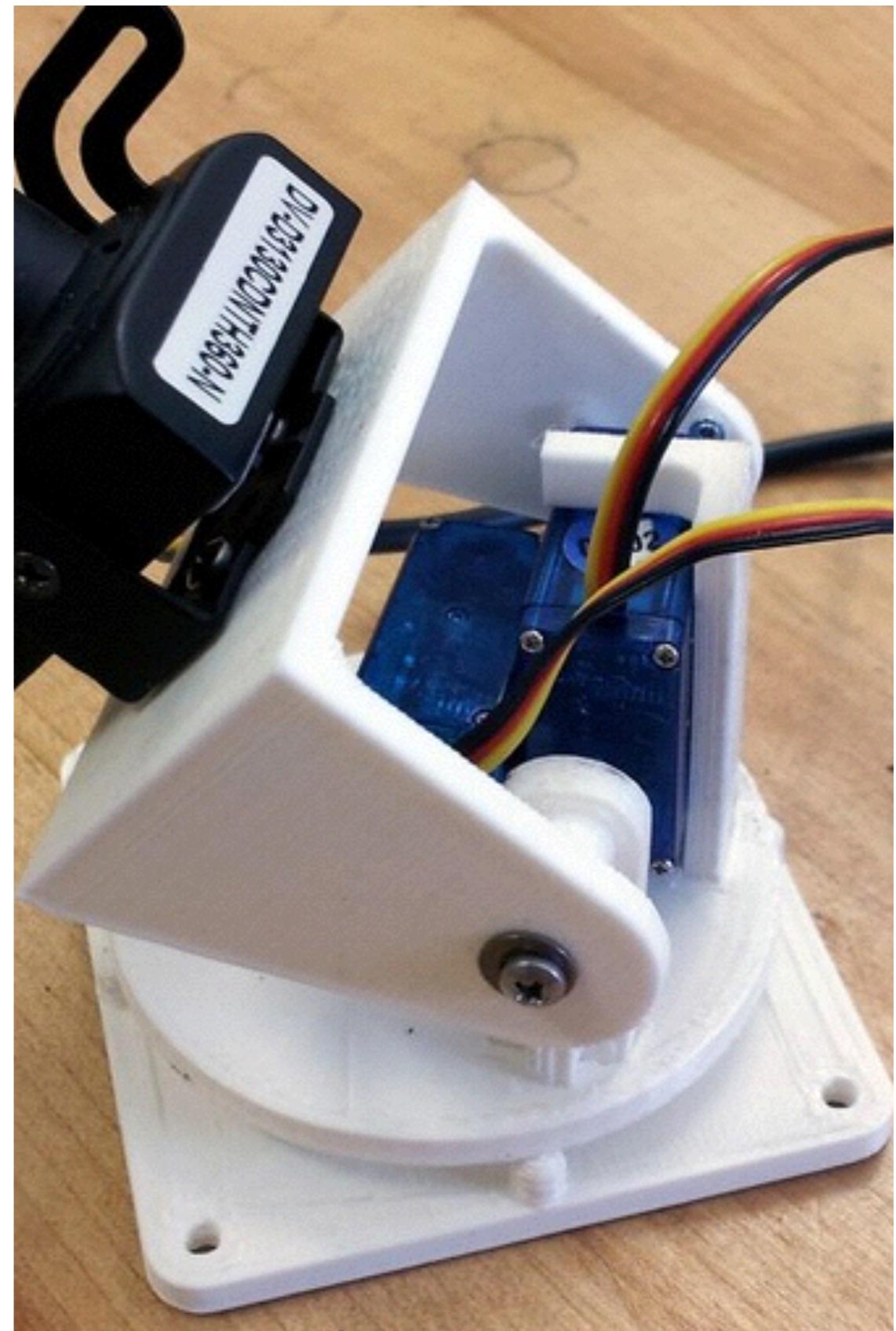
# Wheel for mousetrap car

suspension built-in  
scalable design  
hub fits round stock



# Pan/tilt mount

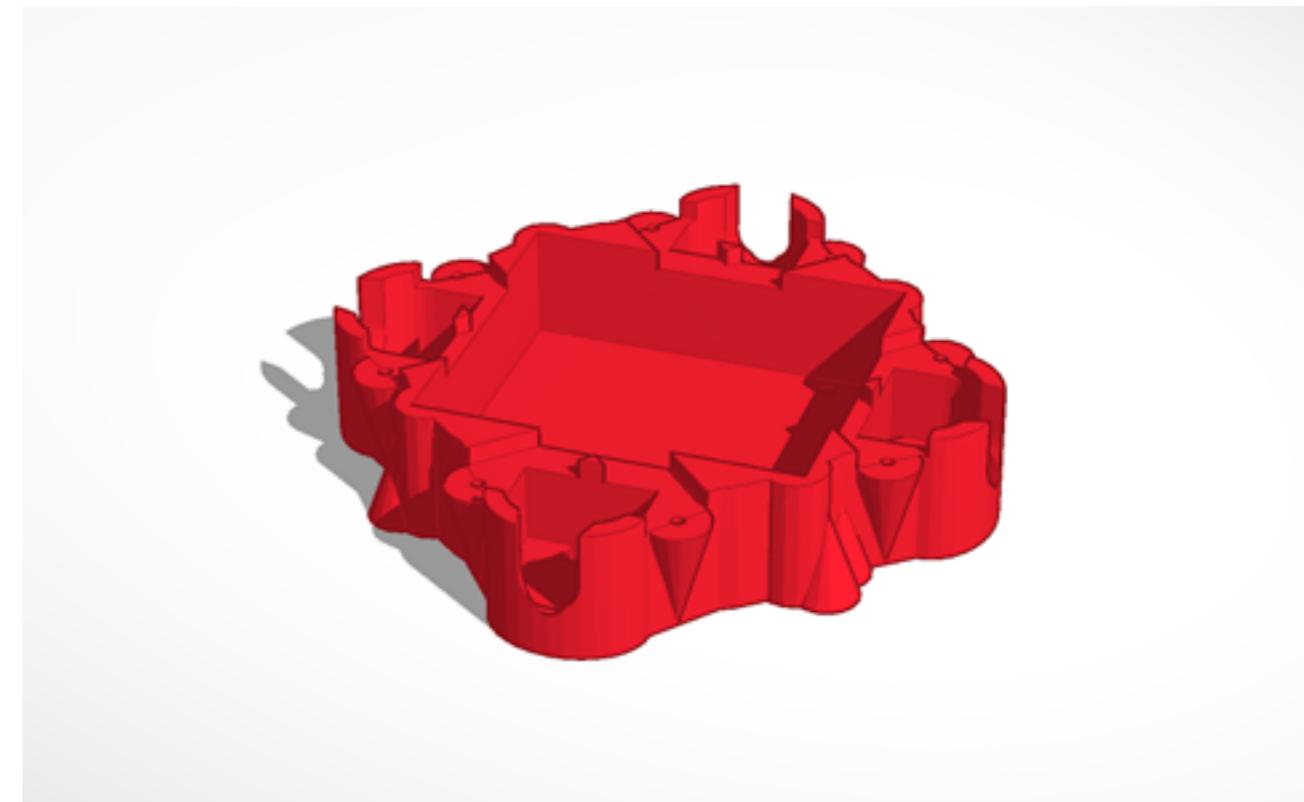
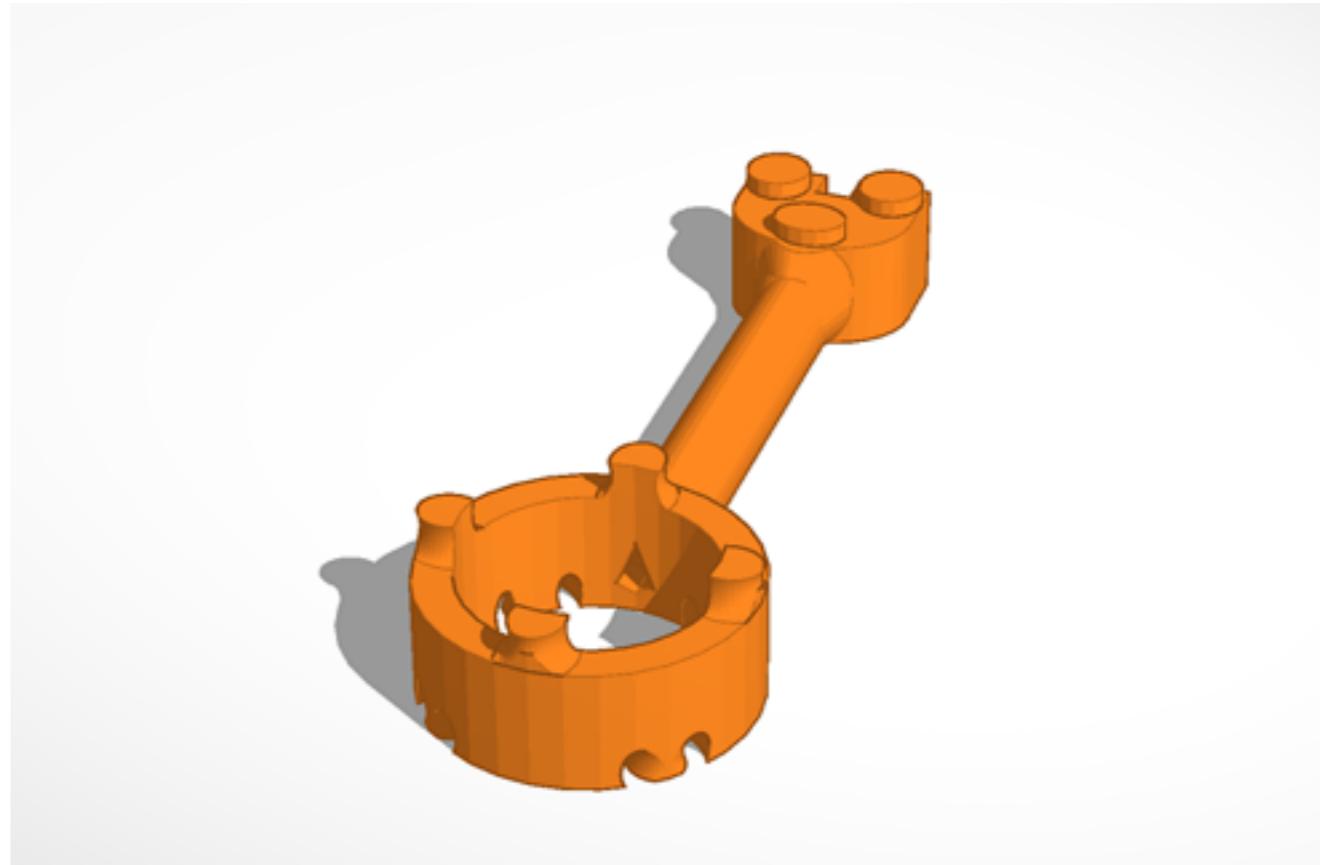
hobby servos  
arduino control  
2-axis movement



# Quadcopter frame

4 arms

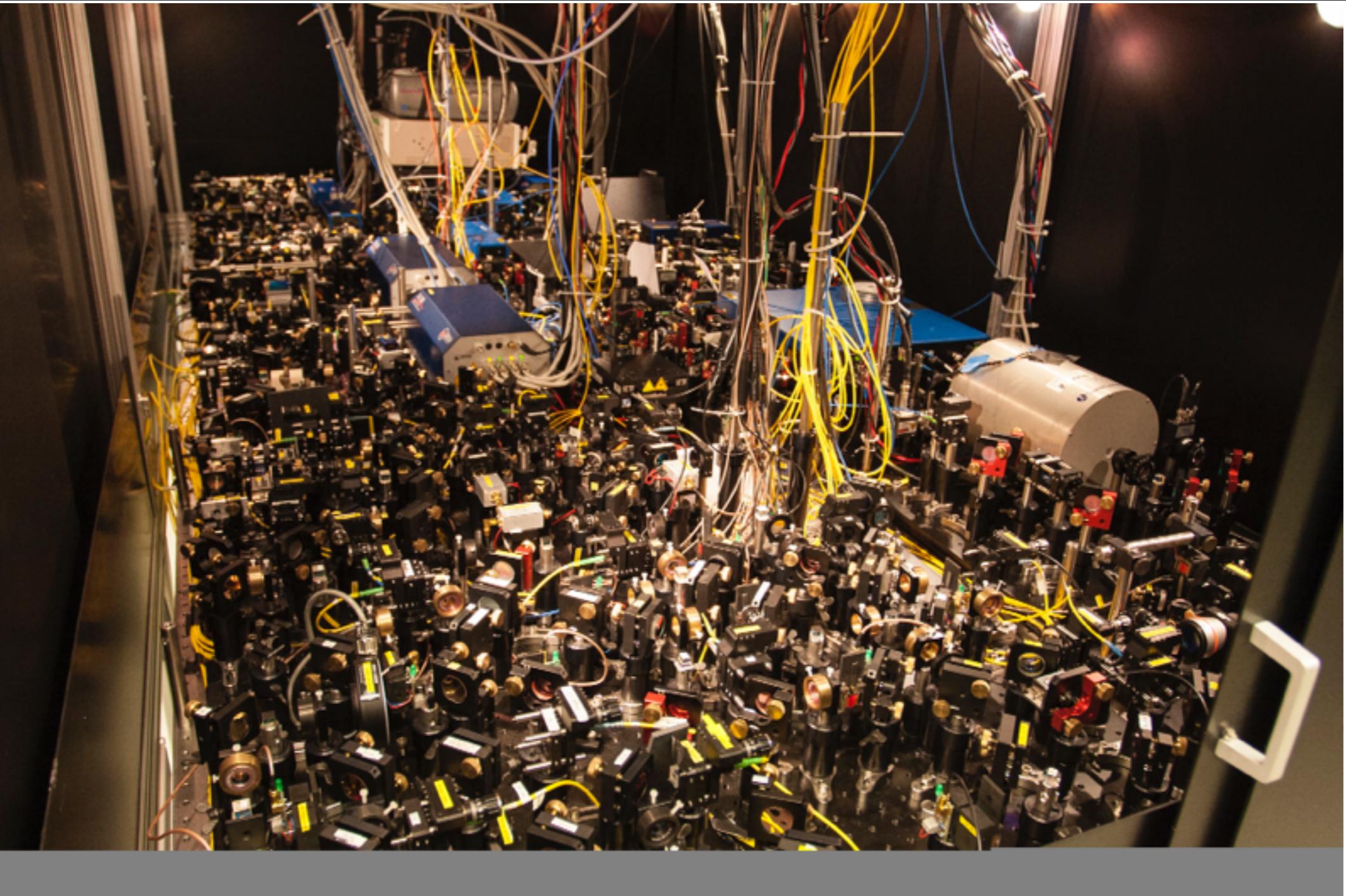
1 hub



# Other examples

- Knots (geometry)
- Script for GNUpot → 3d surface
- Summer camp G2CS

# Research use



# Stray light into CCD

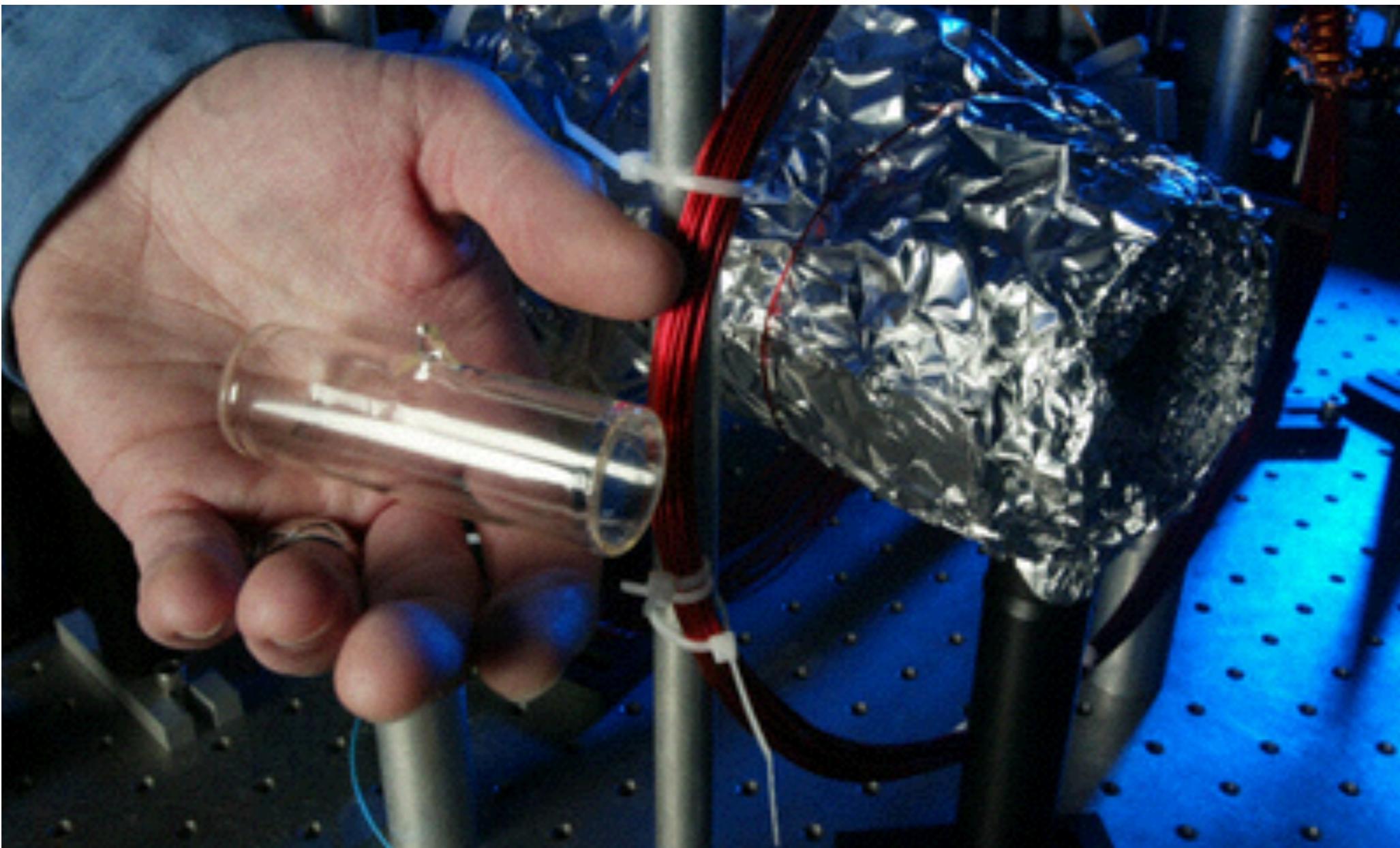
low light imaging disrupted by scatter from prior optics

# CCD camera baffle

standard PVC pipe

aligned mounting holes





# Rubidium vapor cell

variable B-field  
stable mount

# Vapor cell holder

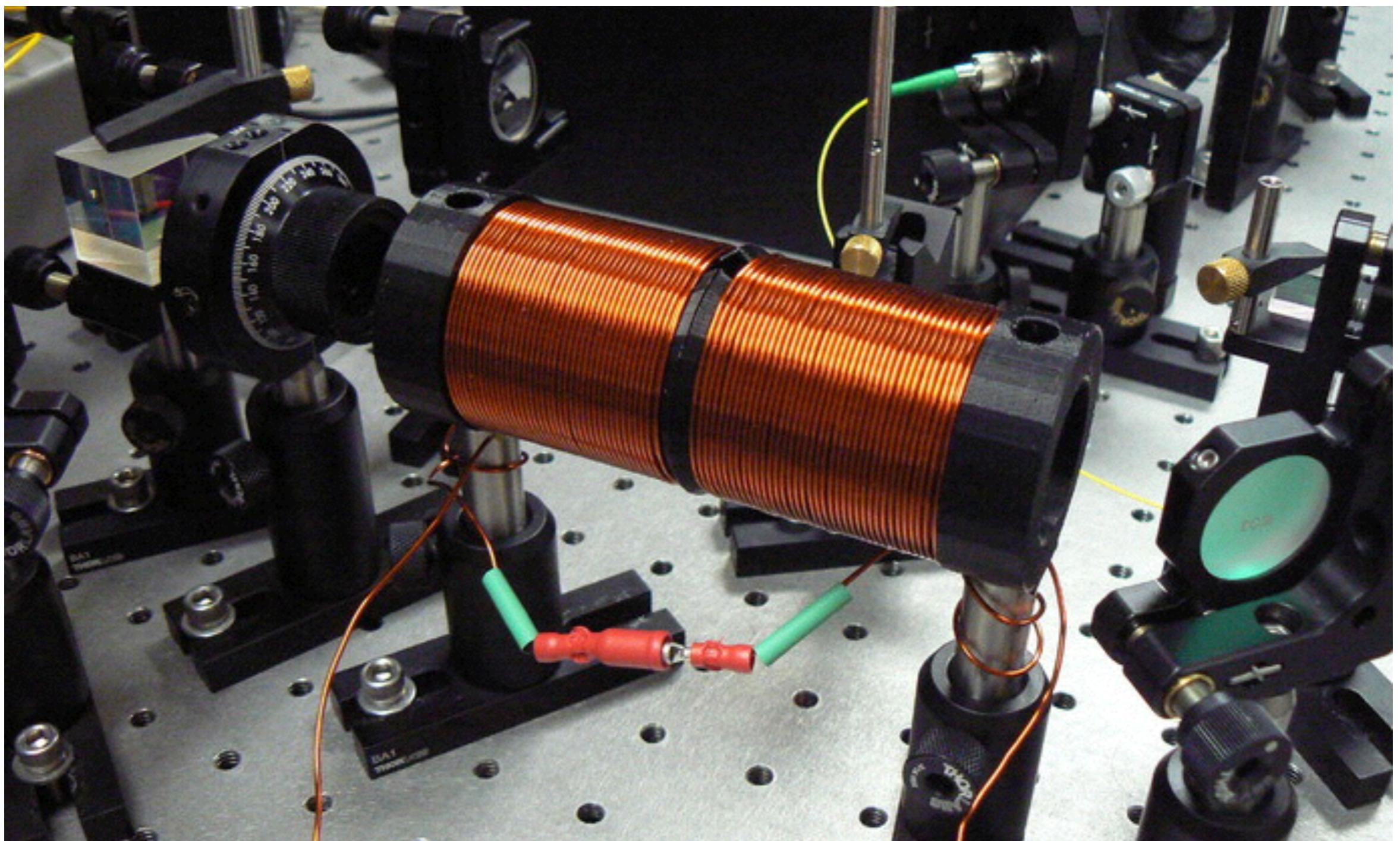
two-piece design

easy assembly

solenoid guides

1/4-20 mounting holes

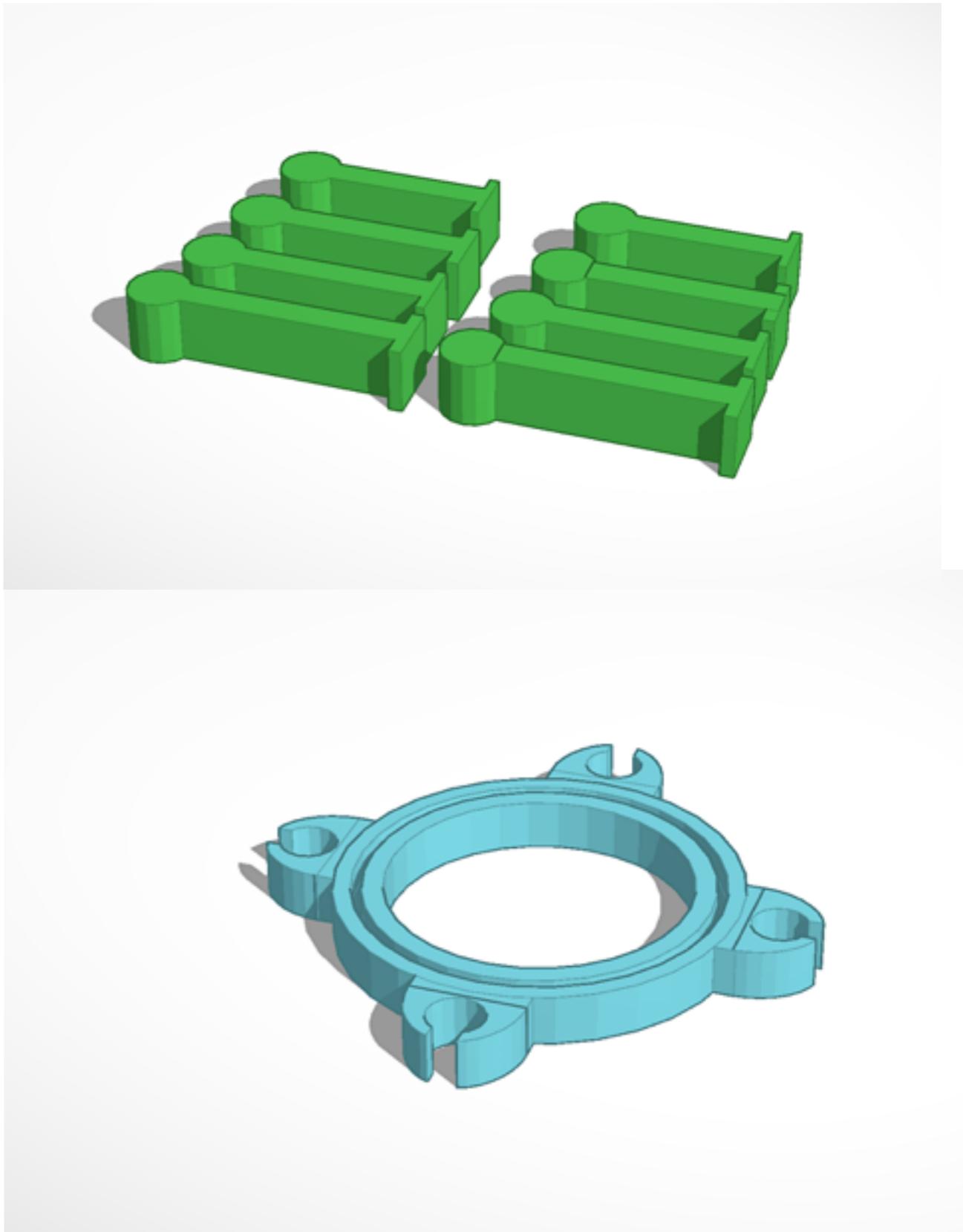




cell holder installed

# Cell holder

center vapor cell in a  
magnetic shield





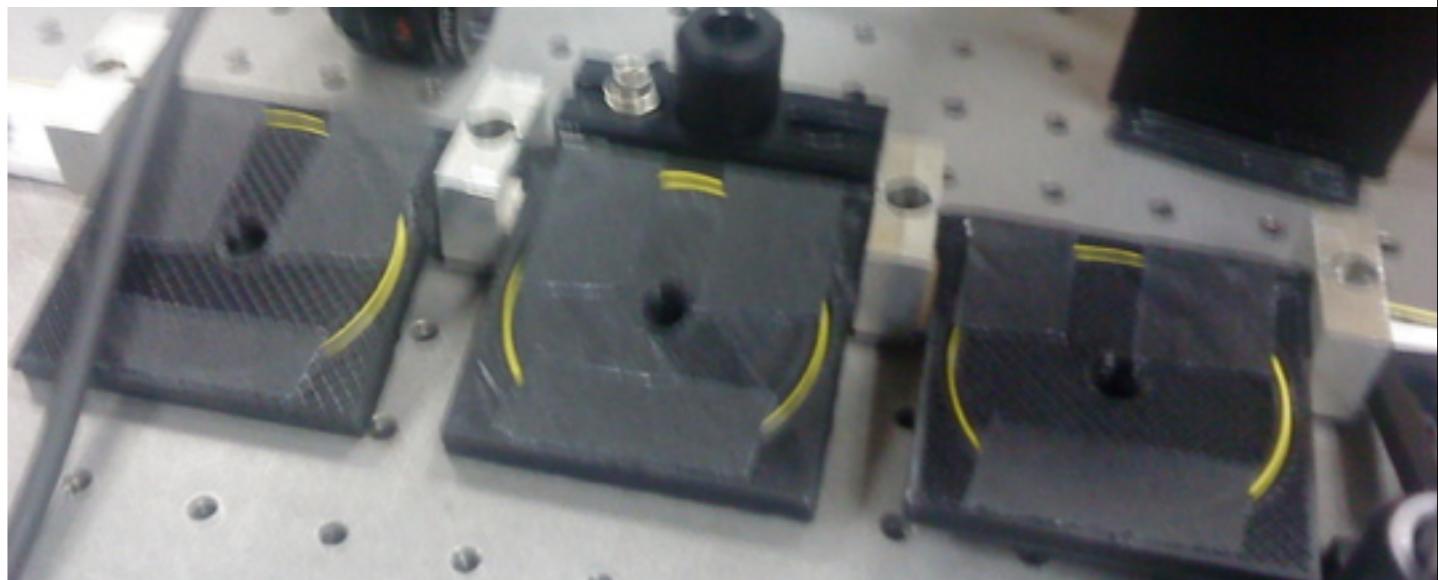
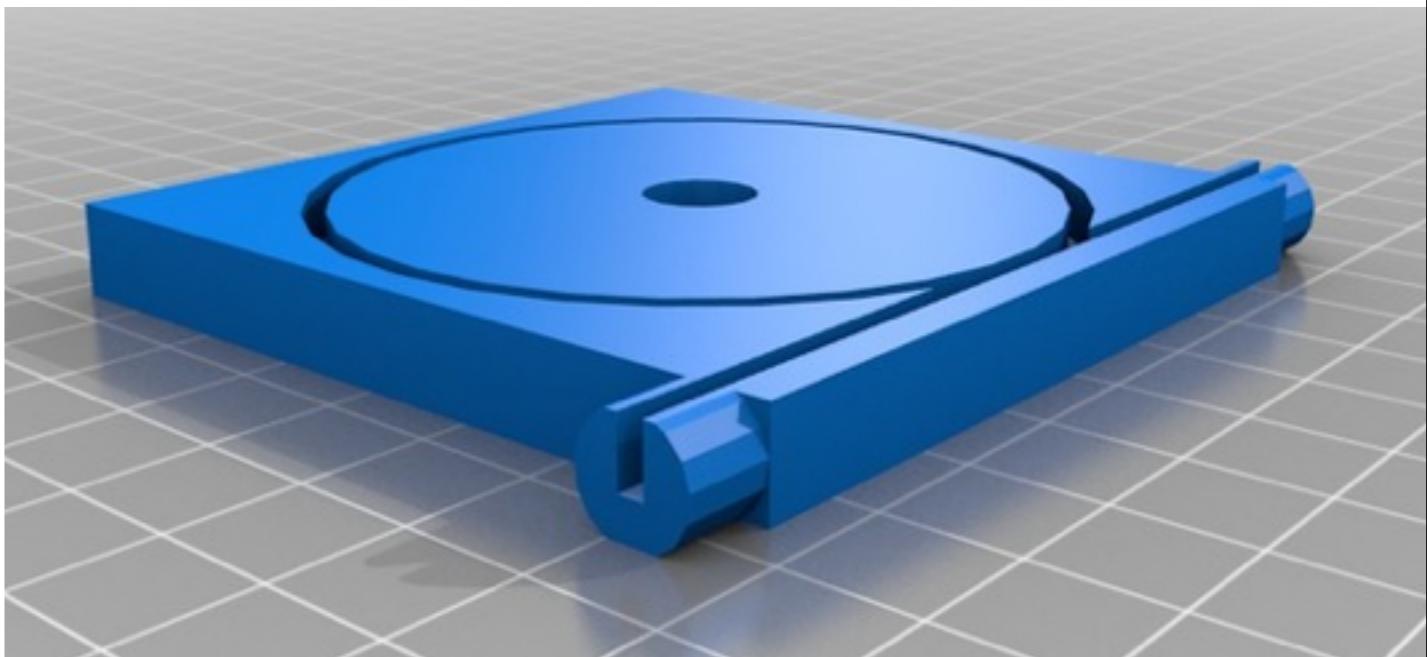
# Need: fiber polarizer

each paddle is a wave plate ( $\lambda/4$ ,  $\lambda/2$ ,  $\lambda/4$ )  
thorlabs: FPC560 \$211.20

# Fiber polarizer

3-paddle design

2 person-hours +  
4 printer-hours +  
\$4.50 of ABS plastic



**custom wavelengths**

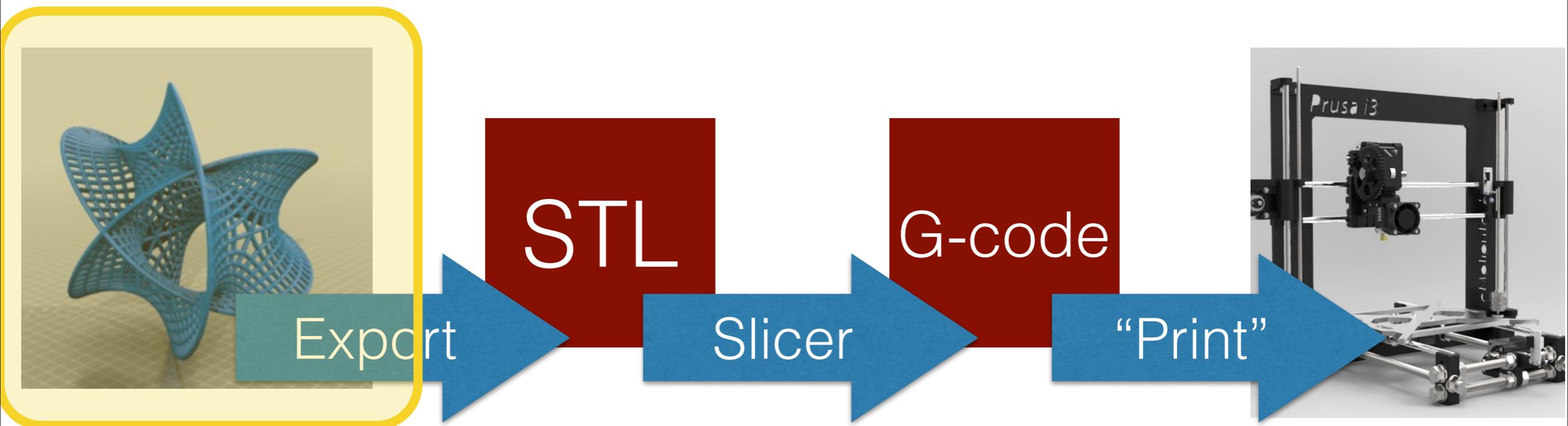
# Other examples

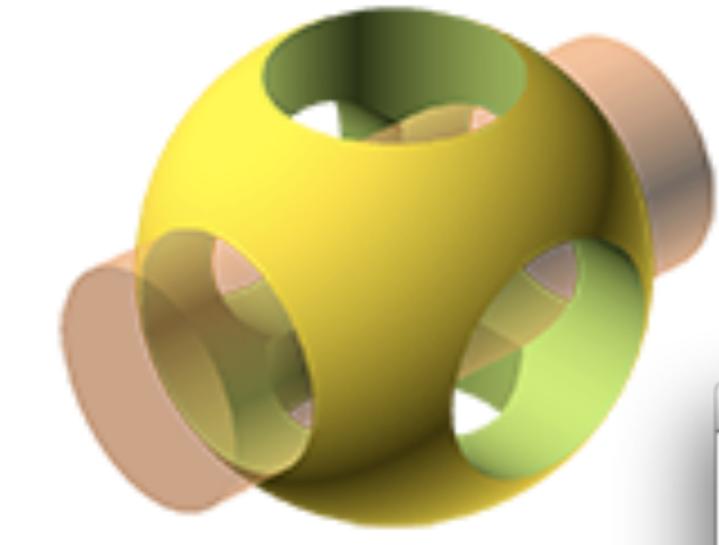
- Push-on fiber holder
- Optical table adapters (1/4-20 @ 1" centers)
- AOM mounting bracket
- Quickpost:

# Workflow

Design...

and print





# OpenSCAD

- Programmatic design
  - code → compile
- Ideal for:
  - specified geometry
  - algorithmic design
  - patterns

The screenshot shows the OpenSCAD application interface. The code editor window contains the following SCAD code:

```
module example001()
{
    function r_from_dia(d) = d / 2;

    module rotcy(rot, r, h) {
        rotate(90, rot)
        cylinder(r = r, h = h, center = true);
    }

    difference() {
        sphere(r = r_from_dia(size));
        rotcy([0, 0, 0], cy_r, cy_h);
        rotcy([1, 0, 0], cy_r, cy_h);
        rotcy([0, 1, 0], cy_r, cy_h);
    }

    size = 50;
    hole = 25;

    cy_r = r_from_dia(hole);
    cy_h = r_from_dia(size * 2.5);
}

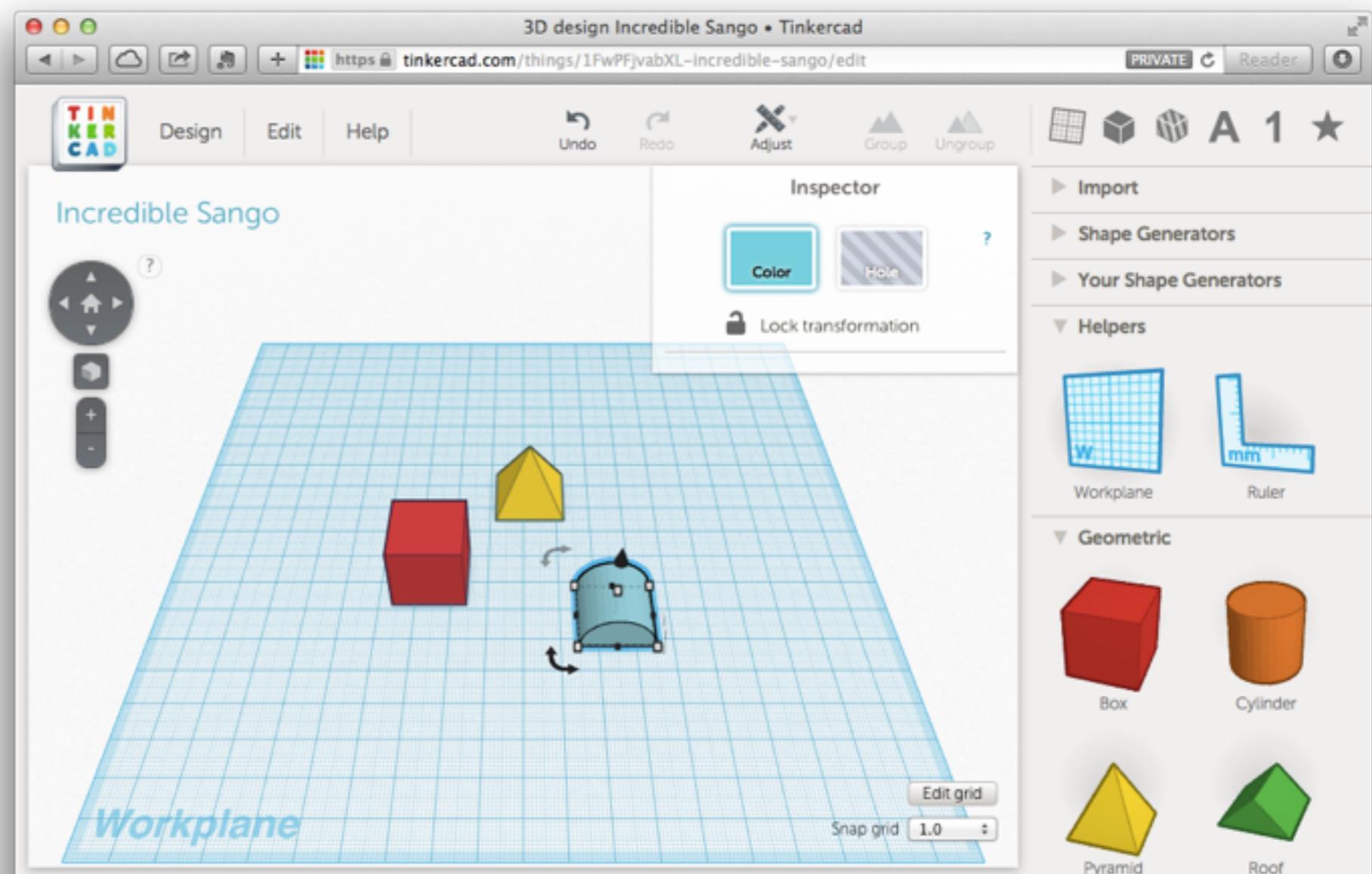
example001();
```

The preview window displays a 3D rendering of the yellow sphere with three nested rings. The status bar at the bottom shows: Viewport: translate = [ 0.00 0.00 0.00 ], rotate = [ 55.00 0.00 25.00 ], distance = 500.00.

Module cache size: 0 modules  
Compiling design (CSG Tree generation)...  
Compiling design (CSG Products generation)...  
PolySets in cache: 14  
PolySet cache size in bytes: 924880  
CGAL Polyhedrons in cache: 11  
CGAL cache size in bytes: 4901816  
Compiling design (CSG Products normalization)...  
Normalized CSG tree has 4 elements  
CSG generation finished.  
Total rendering time: 0 hours, 0 minutes, 0 seconds

# Tinkercad

- Fluid 3D design
  - click & drag
- Ideal for:
  - rapid prototyping
  - fast revisions
  - sharing

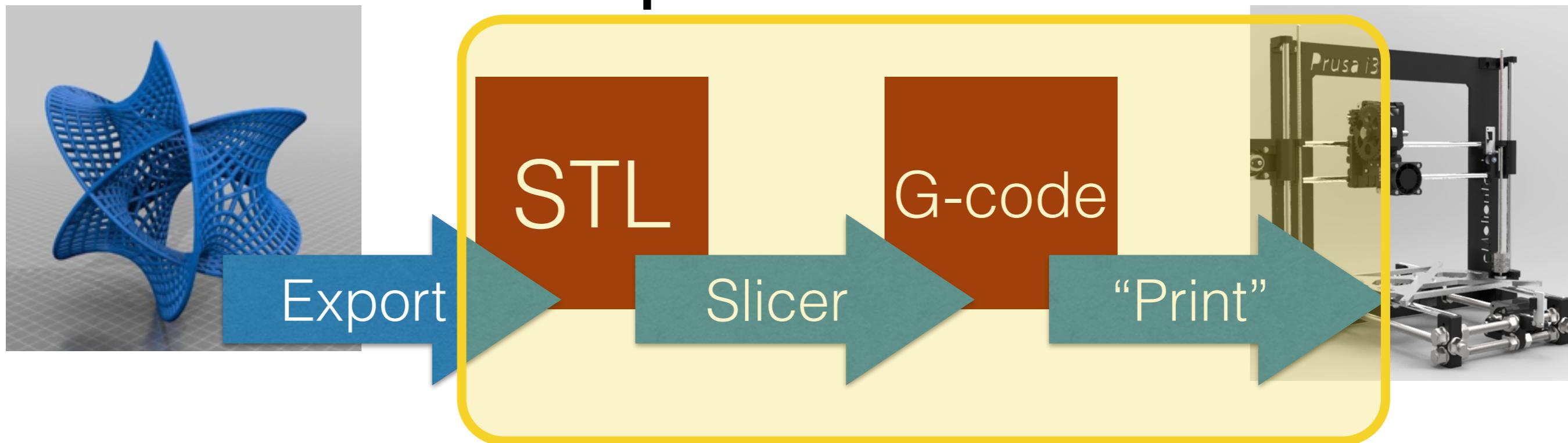


Demo

Design...

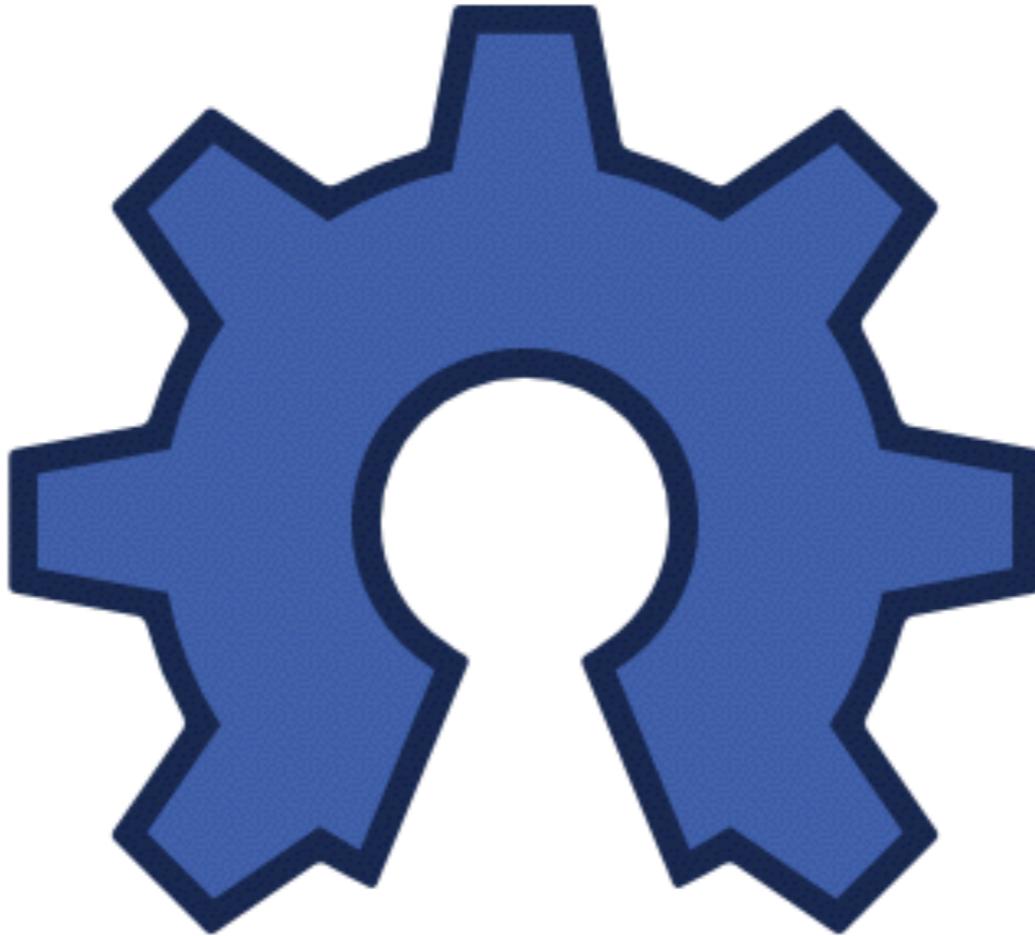
and print

## Repetier-Host



Demo

# Lessons learned



# open hardware

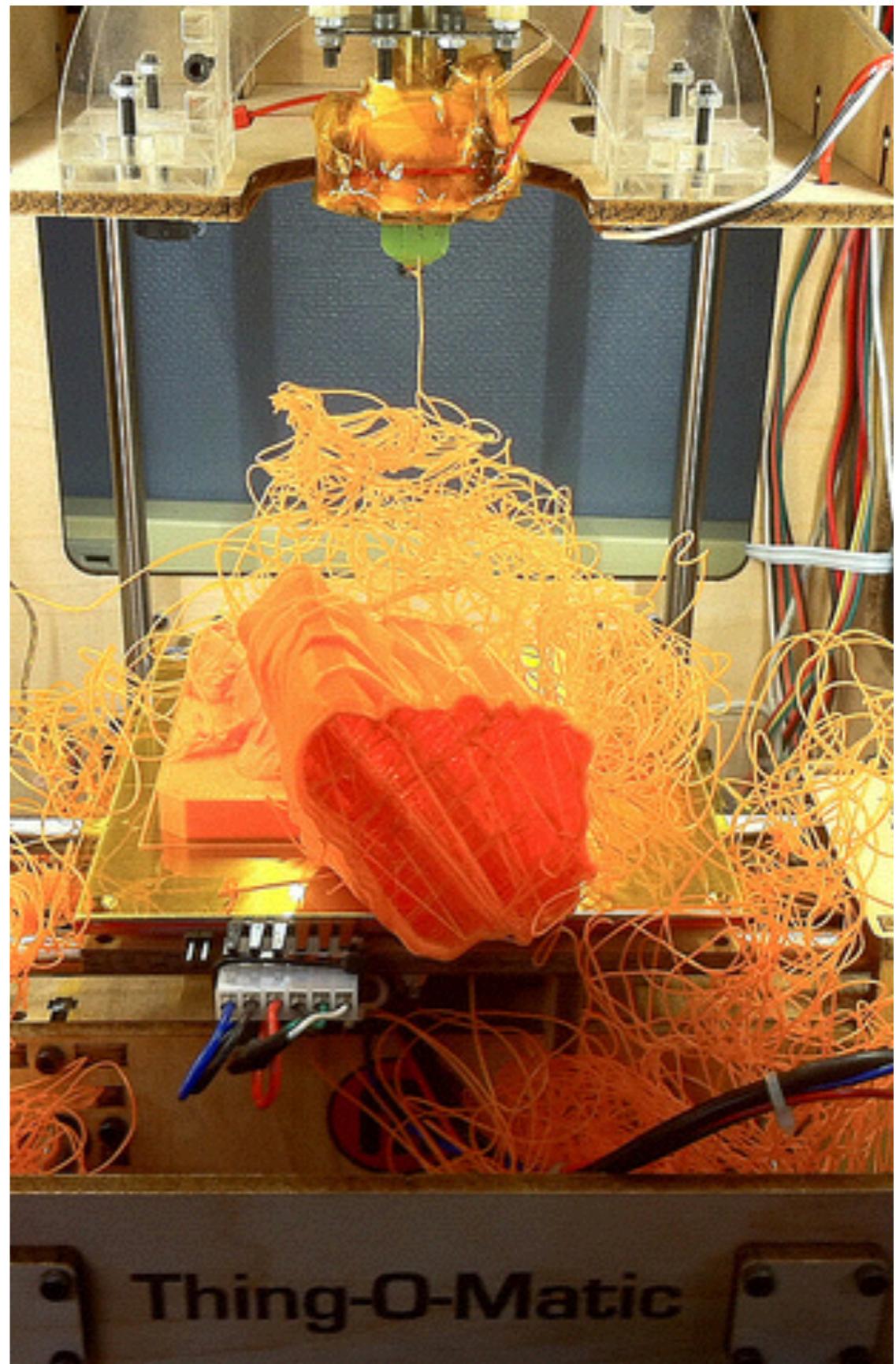
We bought our kit in January 2012, by September 2012  
Makerbot shifted to closed source development and  
effectively orphaned their prior products.

# Printer support

establish a list of expert users

culture of helping each other

communicate about what  
breaks (yes, it will break)



Next steps...

# Outreach

- 2014–2015 faculty development grant
- Prusa i3 (build from kit)
- Share with 7-8th graders during Fall semester
- iPad apps for design



“I could make that!”

# Thank you:

- Jeff Mintz
  - *Physics minor* — assembly and testing
- Noah Holte,
  - *Physics major* — cell holder, fiber paddles,
- Hunter Dassonville
  - *Physics major* — cell heater structure
- *NSF, Research Corp, Murdock Charitable Trust, Pacific U.*



# Outtakes



A LETTERS JOURNAL EXPLORING  
THE FRONTIERS OF PHYSICS

November 2013

---

EPL, 104 (2013) 48001

doi: 10.1209/0295-5075/104/48001

[www.epljournal.org](http://www.epljournal.org)

# Sculplexity: Sculptures of Complexity using 3D printing

D. S. REISS, J. J. PRICE and T. S. EVANS

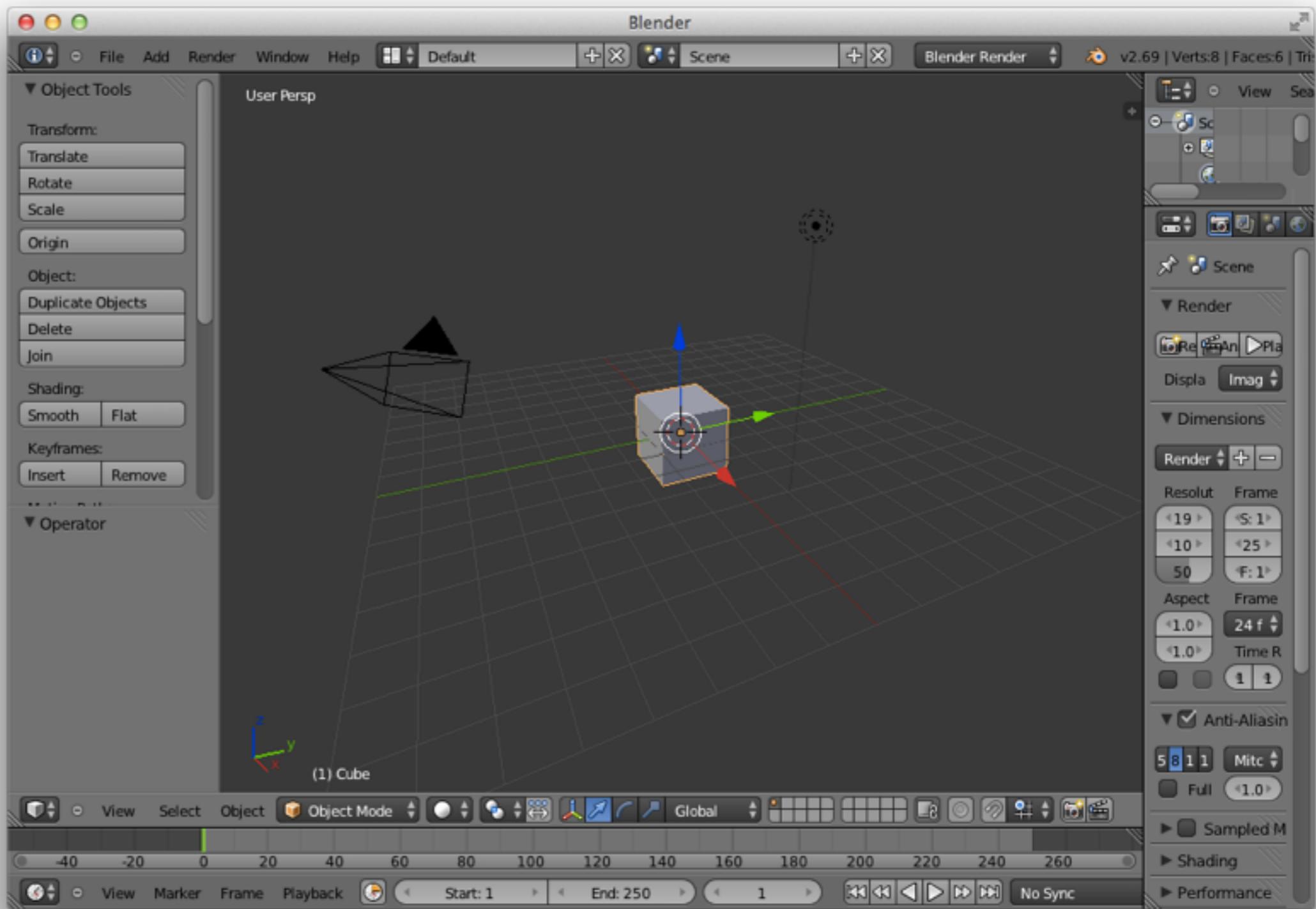
*Department of Physics, Imperial College London - London, SW7 2AZ, UK*

received 6 September 2013; accepted in final form 12 November 2013

published online 9 December 2013

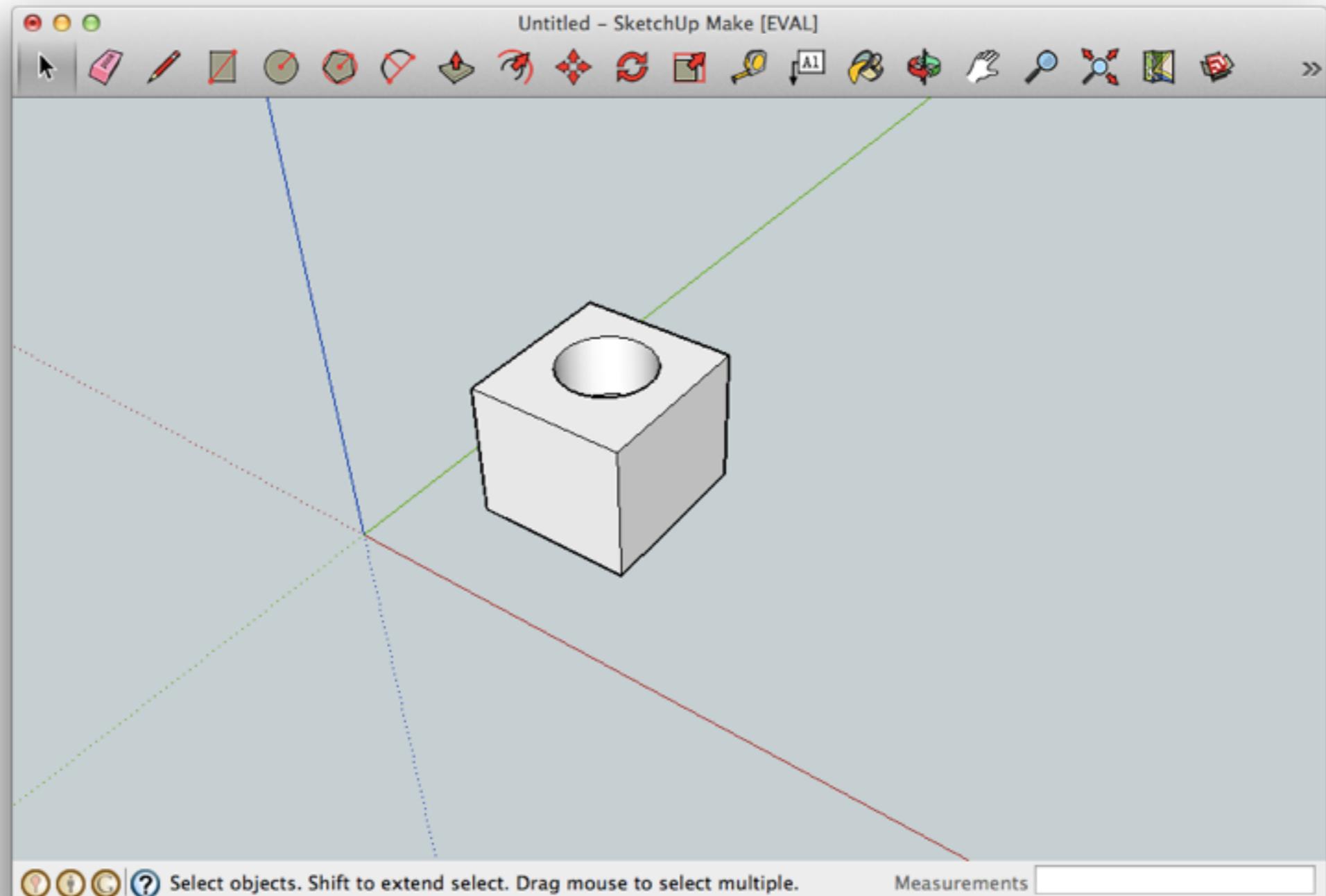
# Blender

- Advanced 3D design
- 3D raytracing
- Ideal for:
  - existing users



# Sketchup Make

- click & drag
- large 3D library
- free\*



\* Pro version is also available at an EDU discount