Majors' tracks for innovation and entrepreneurship

APS Physics Department Chairs Meeting, College Park MD, June 2014

6/9/14

Duncan Carlsmith, University of Wisconsin - Madison

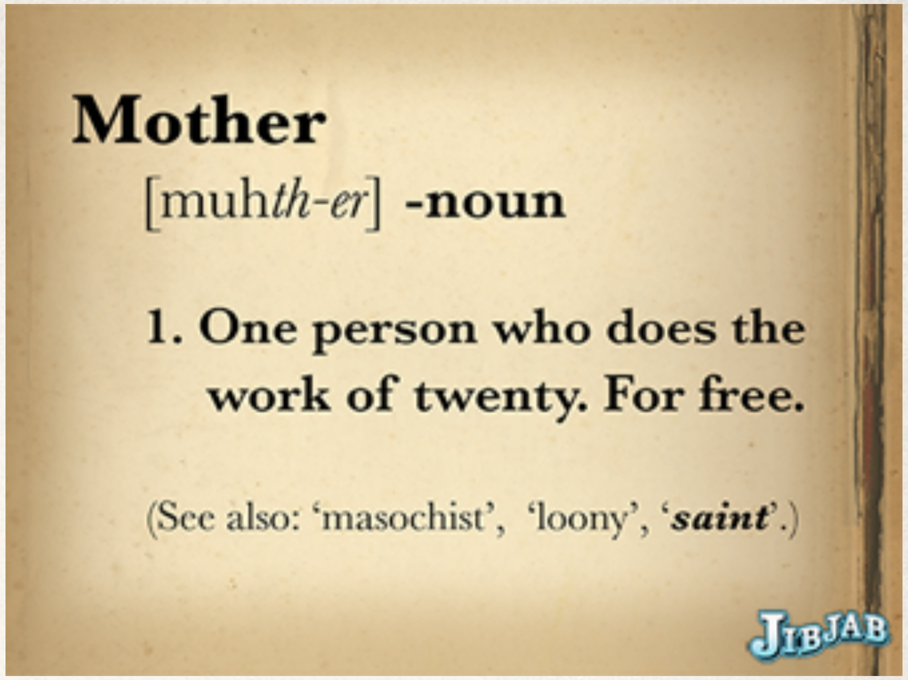
Outline of talk

- Innovation/entrepreneurship trends
- Student innovators and entrepreneurs
- UW-Madison Garage Physics: project-driven learning and support for entrepreneurs.
- Entrepreneurial ecosystem: UW-Madison example
- Program suggestions

Takeaways

- Entrepreneurship is increasingly visible nationally and globally.
- A successful entrepreneur and a successful scientist share many attitudes and skills.
- Physics departments can assist, even provide a home for, interdisciplinary student groups needing a space for research and development, and rapid prototyping.
- Physics departments can provide resources to students interested in exploring entrepreneurship.

Definitions: innovation, entrepreneurship, science, and technology



- *Entrepreneurship* is the process of identifying and starting a new business venture. (from Old French *entreprendre* to undertake)

- *Innovation* is introducing something new (from Latin *innovate* to renew)

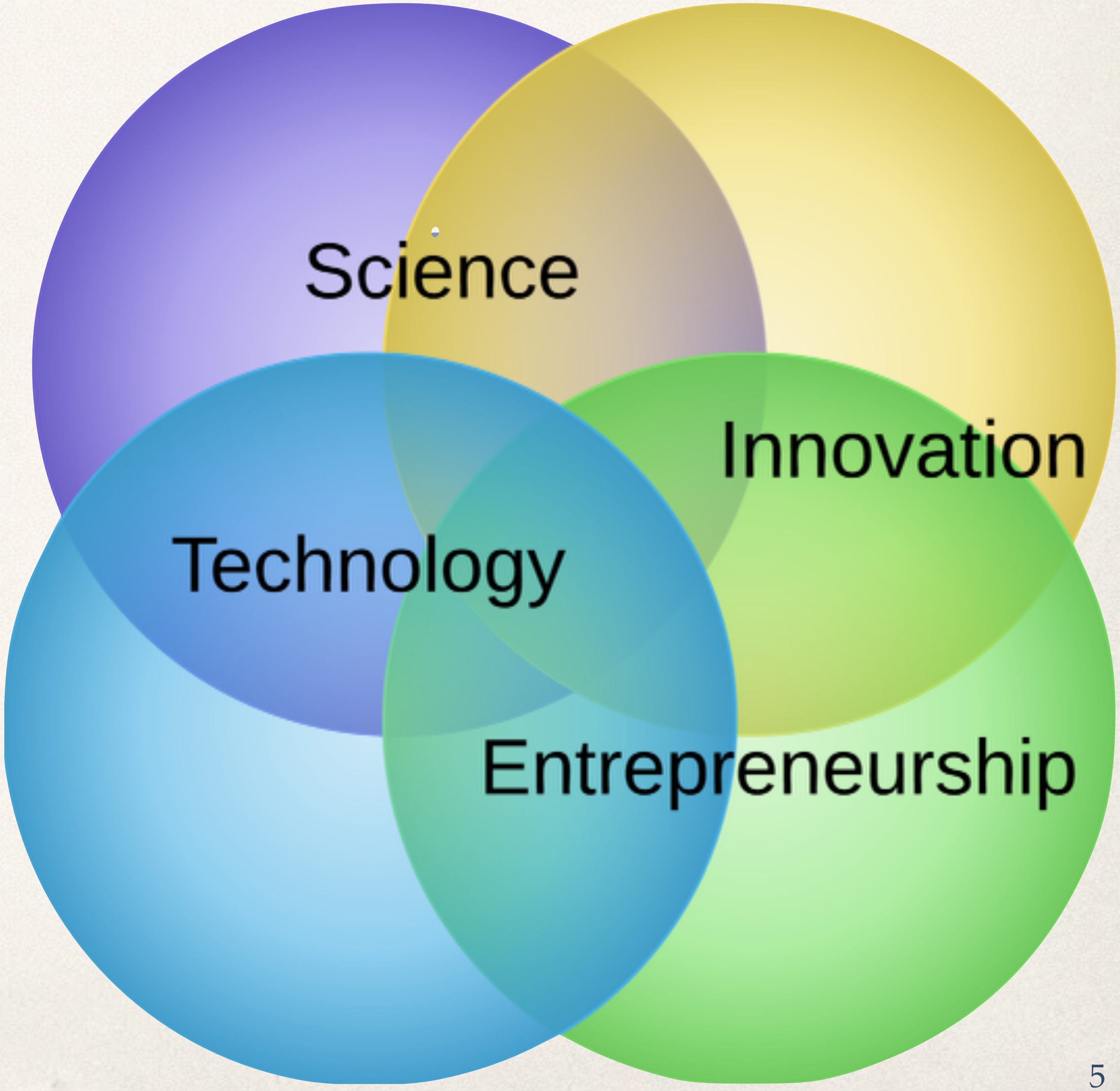
- *Science* is the intellectual and <u>practical</u> activity encompassing the systematic study of the structure and behavior of the physical and natural world through observation and experiment.

- *Technology* is the application of scientific knowledge for practical purposes. (from Greek *tekhnologia* 'systematic treatment', from *tekhnē* 'art, craft' + -logia.

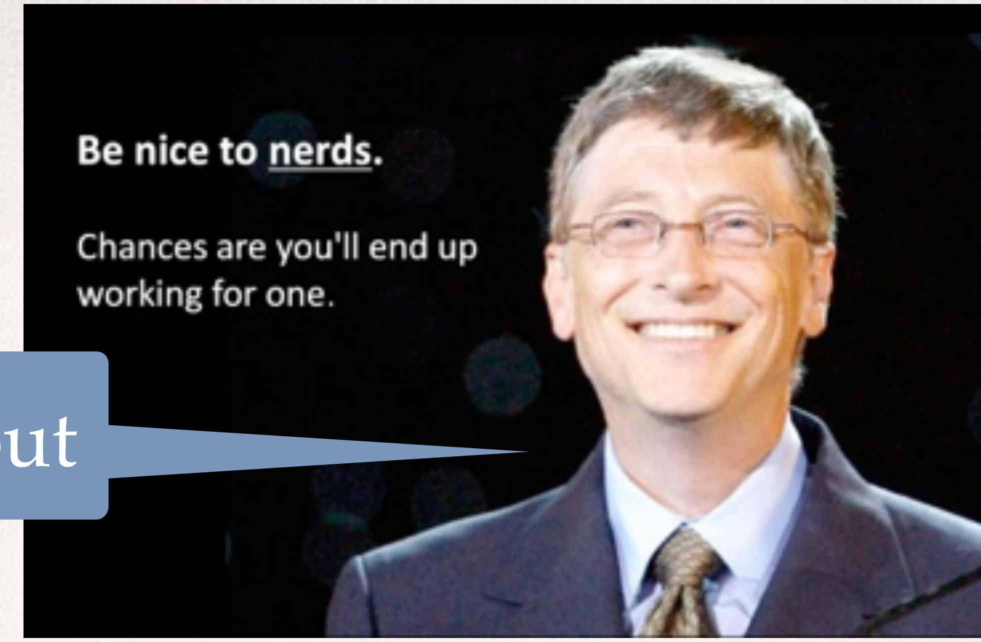
Synergy yields growth

- Science, innovation, entrepreneurship, and technology work together in driving socioeconomic, intellectual, and cultural growth.

- Think camera, motor, radio… transistor, computer, mobile phone, DNA chip…



Famous contemporary entrepreneurs, a variety of backgrounds



- Elon Musk, SpaceX, Tesla Motors, PayPal (BS **Physics** U.Penn)
- Jack Dorsey, Twitter (left NYU without degree)
- Larry Page, Google (BS Comp. Eng. U. Mich, MS CS Stanford)
- Sergey Brin, Google (BS Math U. Maryland, PhD ABD CS Stanford)
- Mark Zuckerberg, Facebook (left Harvard)
- Reid Hoffman, PayPal (BS Cognitive Science Stanford)
- Sarah Blakeley, Spanx (BA Communications Florida State)

Entrepreneurs in the U.S.

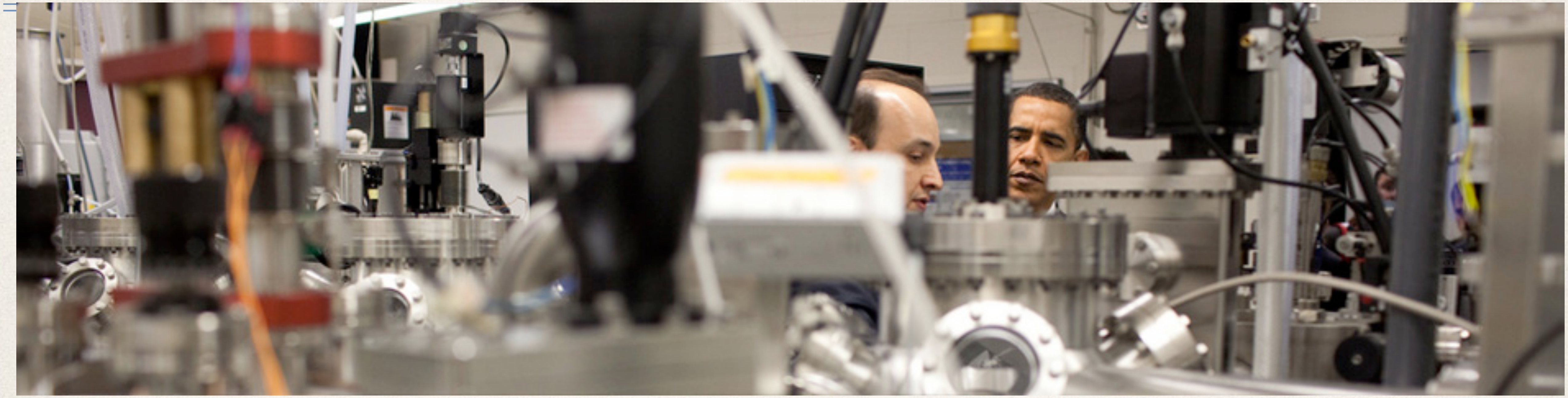
Global Entrepreneurship Monitor

http://www.gemconsortium.org/docs/2804/gem-usa-2012-report

- 13% of adults of all ages (not just millennials) active; 7 women/10 men.
- 3/4 start a business to pursue an **opportunity** rather than out of necessity.
- Industries: business service 33%, transforming 22%, consumer 41%
- 69% nascent at home, 82% self funded
- ~half adults will be unemployed/self-employed at some point.
- Funding challenges and fear of failure plague the youngest and oldest entrepreneurs most.

Federal support for entrepreneurship

"Entrepreneurs embody the promise of America: the idea that if you have a good idea and are willing to work hard and see it through, you can succeed in this country. And in fulfilling this promise, entrepreneurs also play a critical role in expanding our economy and creating jobs." — President Barack Obama, January 31, 2011



- Federal support for small businesses is long standing. **SBIR** bridges advanced research generated innovations. New White House programs **Startup America** and **Presidential Ambassadors for Global Entrepreneurship** support entrepreneurship nationally and globally.

- Recent recognition of the role of higher education in entrepreneurship is illustrated by NSF **I-CORPS** (research spin-offs) and **IGERT** (graduate student e-training and assistance) programs.

Presidential Ambassadors for Global Entrepreneurship

- Steve Case, Revolution; America Online, Williams Poli Sci
- Helen Greiner, CyPhy Works; iRobot Corporation, MIT Mech. Eng.
- Reid Hoffman, LinkedIn
- Rich Barton, Zillow, Stanford, Eng.
- Tory Burch, Tory Burch, U. Penn. Art History
- Quincy Jones, Quincy Jones Productions,

Technology

Social media

Culture

- Salman Khan, Khan Academy, MIT Math, EE, CS
- Daphne Koller, Coursera, Hebrew U
- Hamdi Ulukaya, Chobani, Ankara Poli Sci
- Nina Vaca, Pinnacle Technical Resources, Texas State Speech Comm.
- Alexa von Tobel, fLearnVest, Harvard psychology

Education

University entrepreneurship and innovation programs

- Business schools increasingly offer academic courses in entrepreneurship, focused on business startups, typically at MBA or professional certificate level. Blank's *Lean Launchpad* and similar courses are online.

- Innovation centers, often an outgrowth of an engineering school, are increasing in number. Programs focus on innovation with applied technology.

- Attention now focusing on undergraduates. See NCIIA for support for your program.

Hi Harvard innovation lab

MIT Fablab

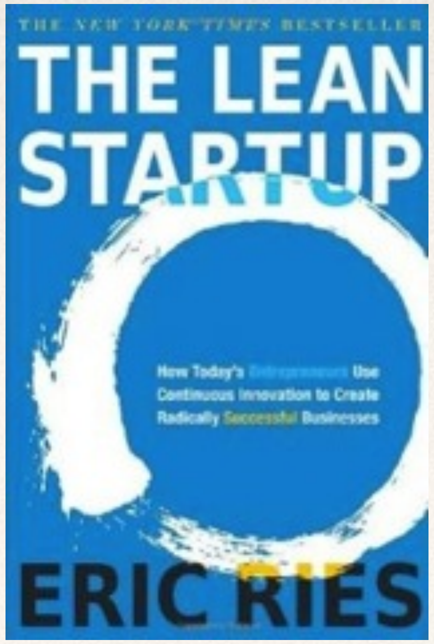
TLTL Transformative Learning Technologies Lab

https://tltl.stanford.edu/

Farley Center for Entrepreneurship + Innovation
NORTHWESTERN UNIVERSITY

Duke UNIVERSITY | INNOVATION CO-LAB

Low new millennium startup barriers



- Lean startup models: Incubators and accelerators invest small amounts in and mentor nascent entrepreneurs, making many low-cost high risk investments, undercutting more discriminating and aggressive investing angels. Crowd source funding is represented by Kickstarter. *The Lean Startup* is a popular guide turning traditional biz dev. on its head: research, biz plan minimum viable product, trial, repeat. Touted as scientific method. Barriers to entry lowered.

- Space: Co-working office spaces/communities are sprouting up; the Makerspace/DIY movement, shareware culture, Fritzing with low-cost electronics, Fablab/3d printing materials fabrication technologies all enable rapid prototyping of software and hardware. Barriers to entry lowered.

- Information: Patents, technical, science, social, and market information is a click away. Barriers lowered.

- Collaboration: A colleague is a available by video conference on your mobile phone with one click. Sharing documents is a click away. Barriers lowered.

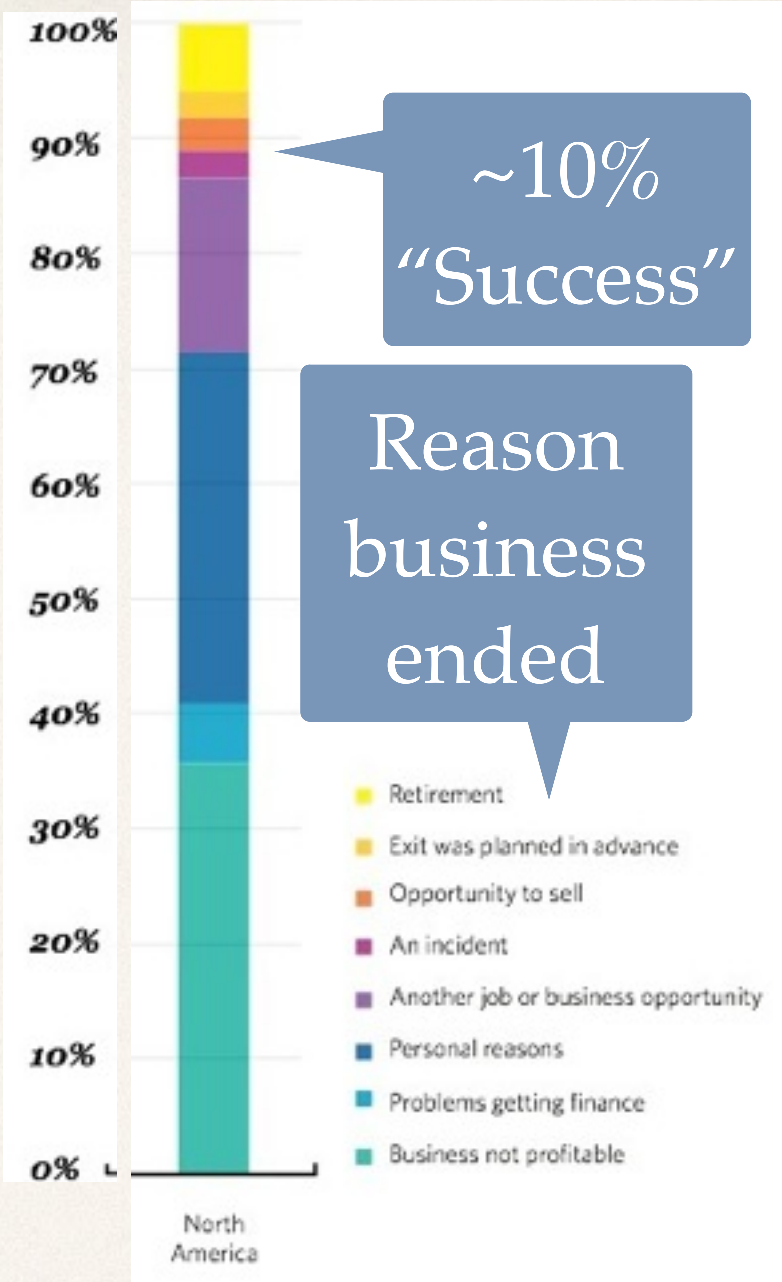
- Culture: Science, technology, innovation, entrepreneurship: the new sexy. APPLE and GOOGLE new models for success. Startup Weekend and TV show Shark Tank reflect popular interest in entrepreneurship.

Beyond the hype

- Thinking up a business is fun. Ideas are cheap. Exploring them is fun. Try a Startup Weekend!

- Launching a business poses many challenges: financing, legal responsibilities and liabilities, intellectual property, human resources, marketing, production, quality control, customer management. There are gotcha's and uncertainties. Nimbleness and open mindedness (ability to "pivot") valuable. The same can be said for running a physics research organization. Business is about experimentation.

- 10% "succeed." 30% end for personal reasons. 35% of startups end for lack of profitability.

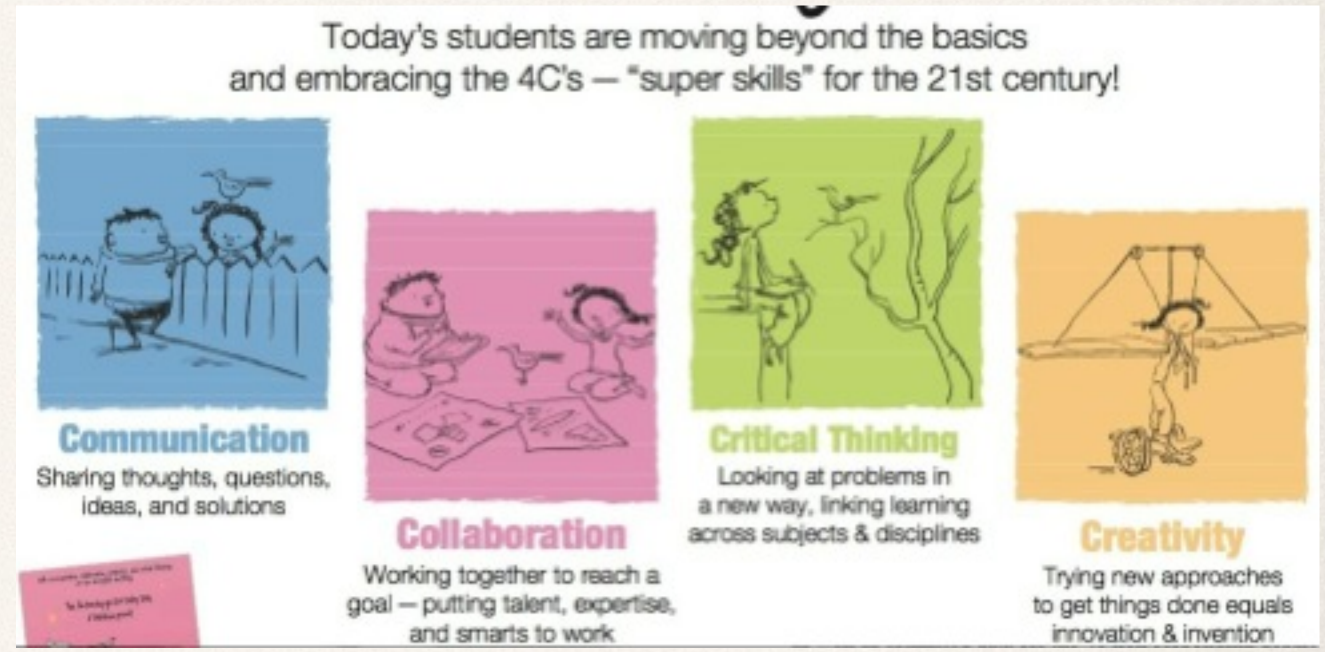


Global Entrepreneurship Monitor 2013 Report

Higher education goals

- Ventures (scientific, social, or commercial) demand critical thinking, creativity, communication, and collaboration. Cultural and interpersonal skills are demanded.
- Technical training e.g. STEM is valuable also.
- Physics curricula typically focus on critical thinking via analytic problem solving, and exposure to fundamental principles and applications in their historical progression.
- Soft skills not a physicist's forte. Idealization/ simplification not complexity valued.

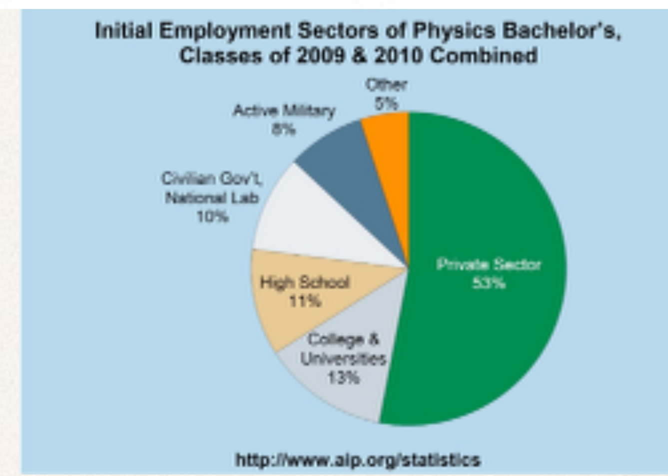
http://www.nea.org/assets/docs/A-Guide-to-Four-Cs.pdf

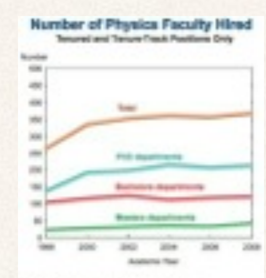


Physics students follow many tracks

- 6800 bachelor's degrees are awarded in the U.S. annually.
- 53% of physics majors are employed in the "private sector."(not .gov or .edu)
- 1800 PhD degrees (~half domestic) are awarded in the U.S. annually.
- 350 physics faculty are hired. (5% of bachelors)
- Physics majors follow many tracks in life. For most students, physics classroom and research experience does not lead to a physics academic or research career.

Total Physics Degrees Academic Year 2011-2012	
Bachelor's	6,778
Exiting Master's	801
Enroute Master's	992
PhDs	1,765





Sources: aps.org and aip.org.

The whole student; where entrepreneurship fits in physics ed

Social cultural knowledge: history of physics, physics as a community , natural philosophy, integrity

"Perspective"

Who am I?

Scientific reasoning: physical laws , problem analysis, quantitative reasoning

"Skills"

Experiential learning: REU, internships, business,policy, finance, law, international ENTREPRENEURSHIP

Communication skills: library, papers, lab reports, presentations and posters, collaboration

Model undergraduate entrepreneur

- UW undergraduate Eric Ronning, an engineering student in 2011 UW-Madison introductory physics.
- In 2011, Ronning 3d-printed a prototype prosthetic hand at local makerspace Sector67. In 2012, as a sophomore, Ronning launched **reprothetics.com**, and, in 2113, developed new pump mixer design. In 2014, assisted by Morgridge Institute for Research’s medical devices group, Ronning competed for the $1M Hult Prize, to develop a hardware and software system to address chronic, non-communicable disease in urban slums.
- *“Though health care is not within the scope of our studies as engineers, we think that our unique experiences of brainstorming, prototyping and problem solving will make for a successful and innovative result that tailors to the Wisconsin Idea of giving back,”* Ronning said.

http://discovery.wisc.edu/home/morgridge/media/rehand-grabs-spotlight-in-collegiate-inventors-competition/rehand-grabs-spotlight-in-collegiate-inventors-competition.cmsx

How to foster undergraduate entrepreneurship

HOUSTON #3

UCLA #8

#16

- Challenge students to identify, evaluate, and develop solutions to real world problems throughout the curriculum. Promote looking at/looking for problems as opportunities/ challenges. (engagement, brain storming, wide and deep education, life long learning)
- Provide opportunities for just-in-time learning with existing technology (play time) and provide a chance to MAKE something that matters to them.
- Educate specifically in innovation through examples and opportunities throughout the curriculum, and provide scaffolding in rudiments of startup development.
- Connect to a community of peers, mentors, and role-models, both on and off campus. Invite entrepreneurs to classes, to give seminars. Value them.
- Provide space and financial support for student R&D, finding partners, mutual support.
- Provide support network for taking a venture idea to a competition, into startup and beyond.

Student motivation

- “I am applying what I learn in physics class and can learn what I need when I need it.”
- “I am taking charge of my learning, my life. Maybe my ideas are good ones.”
- “I like the sound of CEO. If those students can do it, may I can!”
- “If this venture comes to nothing, I have nothing to lose.”
- “If this venture flies, I can pay for college and, gosh, dream big.”

Garage Physics: Innovation and entrepreneurship in an open maker-style laboratory

- Garage Physics is a new open lab for undergraduate research and project oriented learning at UW-Madison. The Garage supports research training, interdisciplinary innovation, and entrepreneurship in a maker-style environment.

- In 2013-14, independent projects included quadcopter construction, 3d-printing for recycling and food, and muography for archaeology.

- The Garage was also home to a class in sustainability, which has produced Arduino controlled hydroponic food production and grey water recycling prototypes.

- The operation of the lab, the graduate student mentoring model, and a potpourri of projects will be described.

Garage Physics operation

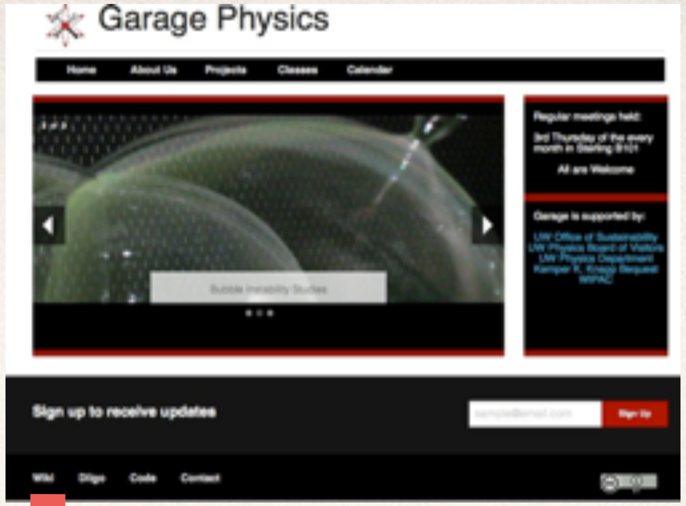
- Lab and surplus research equipment provided by Physics Department and faculty.Online basic safety training and buddy rule required for key access.

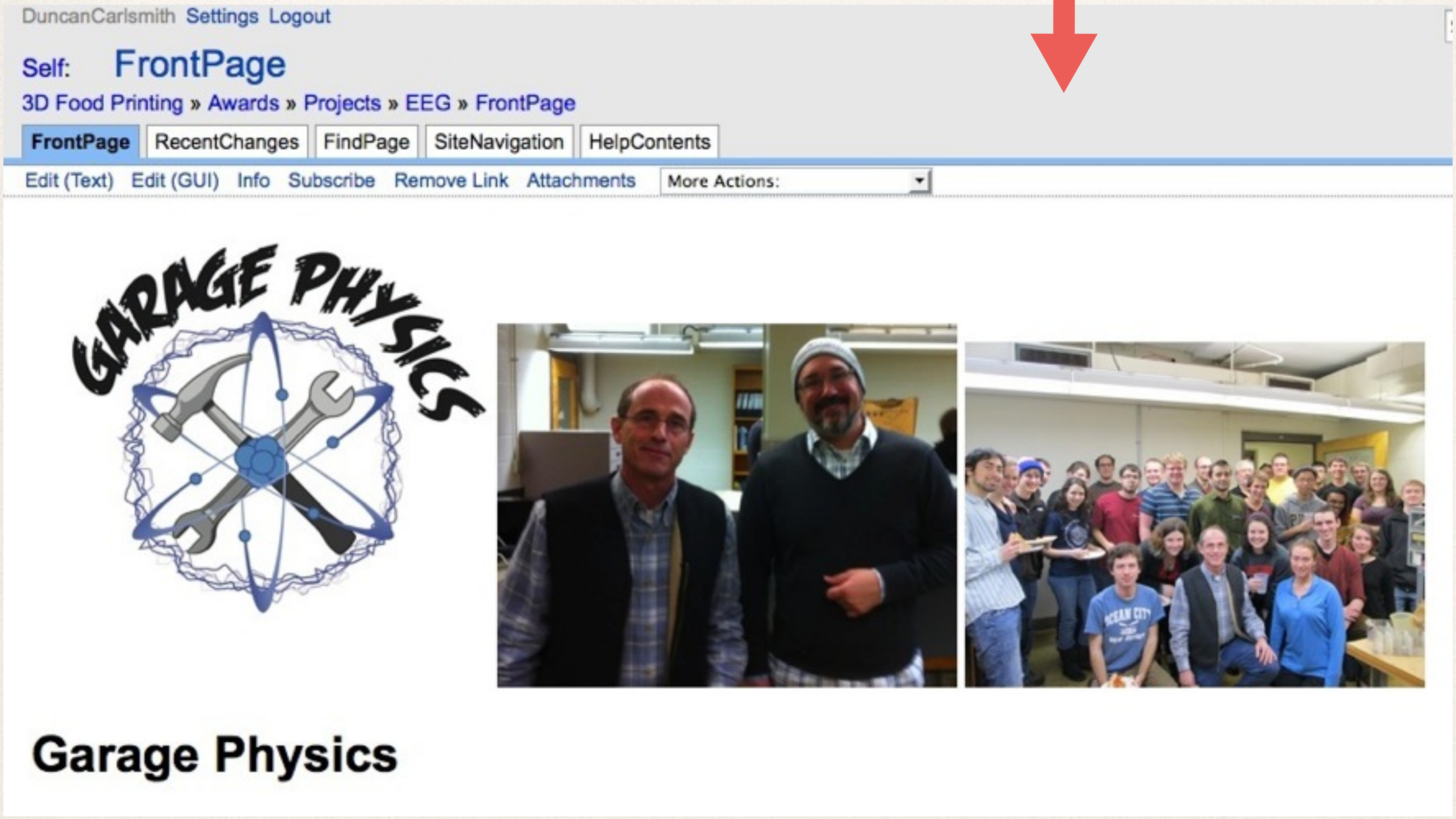
- 2013-14, Physics Board of Visitors Fund for Undergraduate Research supported projects. SIRE grant supported ECE379 graduate assistants (Ebert, Wisher, Graf, Lacy). In 2014-15, additional support from Kemper Knapp bequest.

- Instructional lab manager and two physics graduate students provide assistance and supervision. Undergrads in Physics Club provide office hours.

- Monthly formal projects meeting. Monthly informal pizza meeting.

Garage Physics wiki





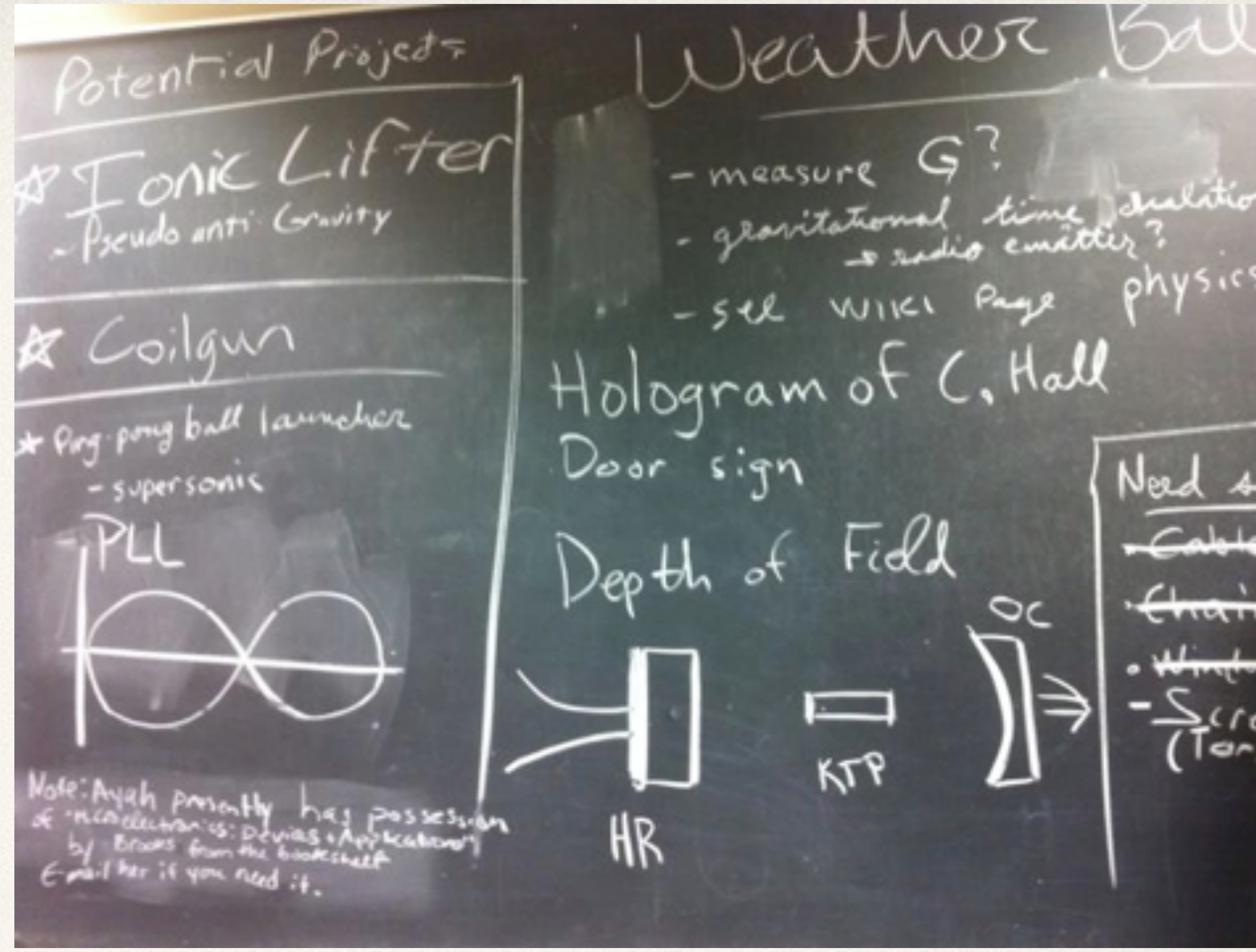
- To learn about Garage Physics, visit www.physics.wisc.edu/garage.

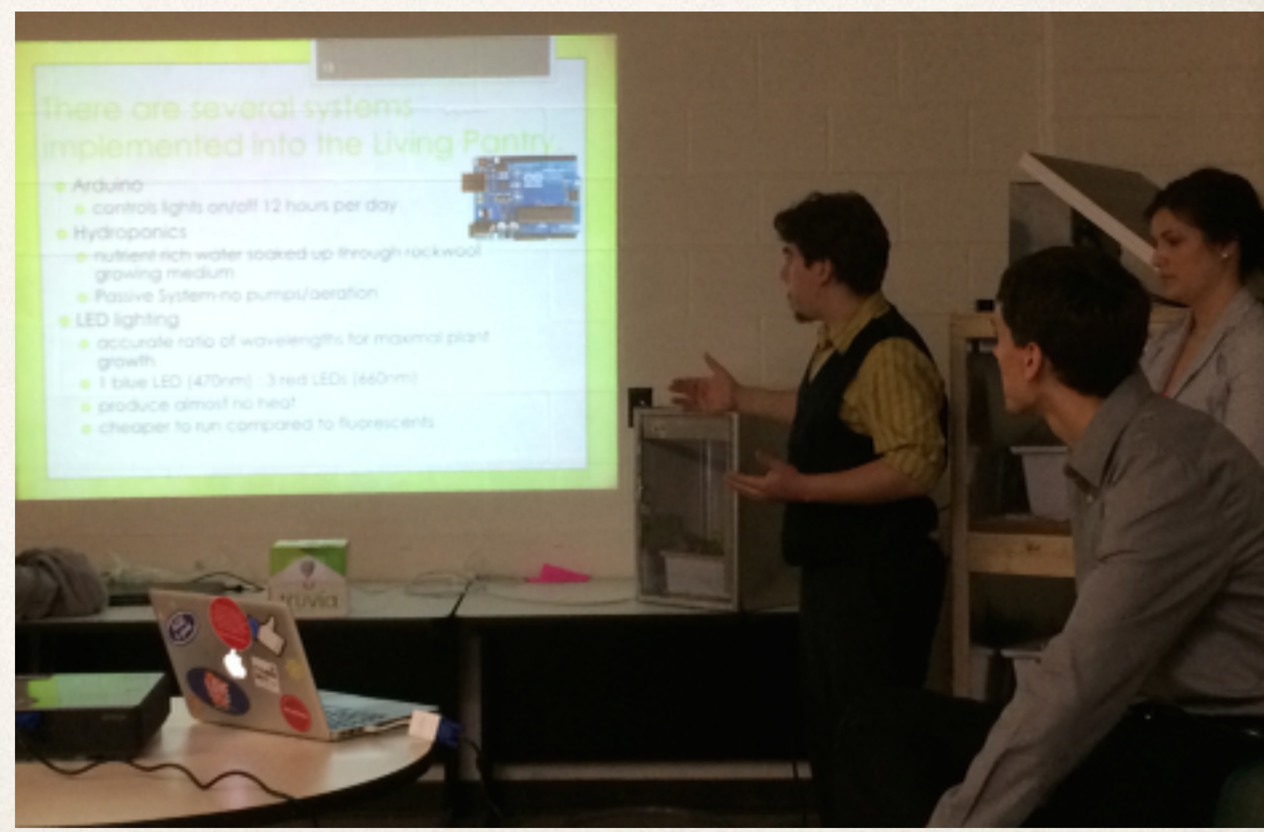
What students do in Garage

- Take a mini-class in soldering or shop, SolidWorks CAD, Arduino, or 3d-printing.
- Join or launch a research project. Earn independent study credit or work “off the grid.” Undergrads and graduate students welcome.
- Connect with other physics majors and graduate students, with students and scientists outside physics, and with the business community.
- Explore entrepreneurship and applications of physics.
- Travel. Participate in Science Fair, Startup Fair, and business competitions.
- Learn about and practice teamwork and presentation skills and tools.

Project sample (2013-14)

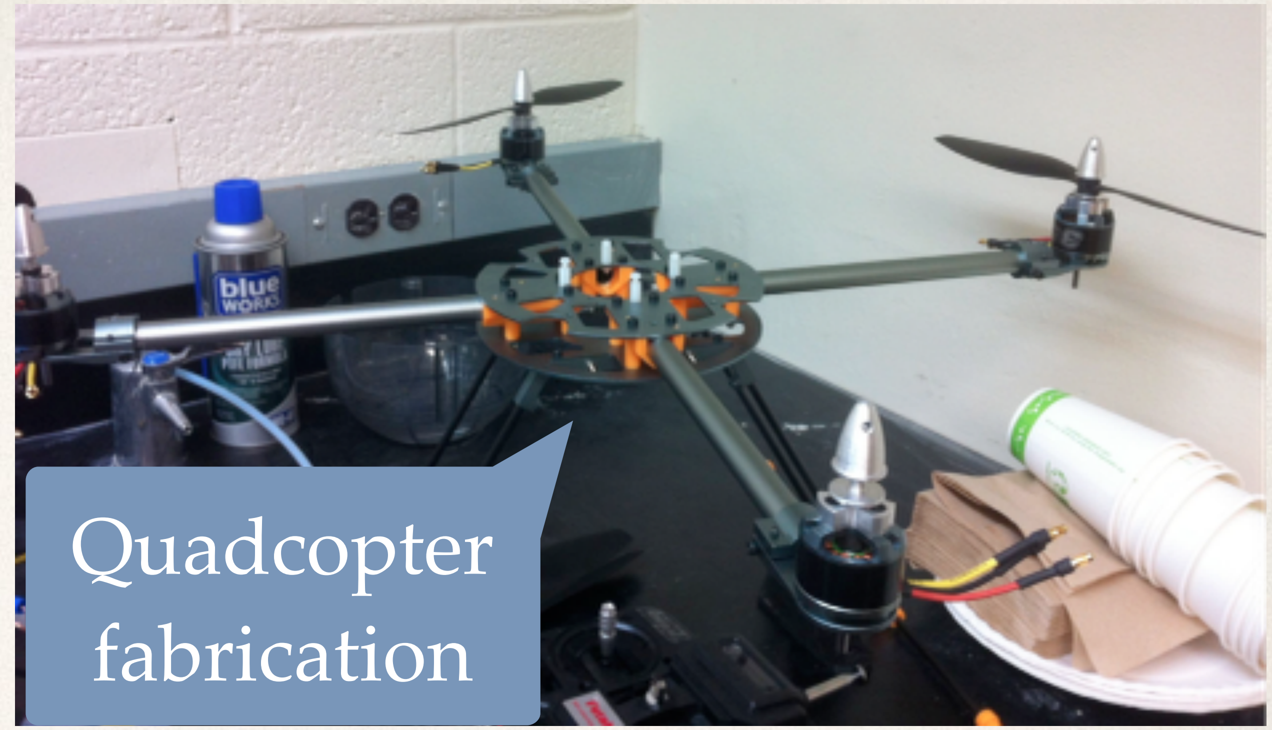
- Quadcopters
- EEG brain computer interfaces
- Bubble membrane dynamic stability
- 3d printing recycling
- Sustainability initiatives
- Muon tomography, LIDAR, and photogrammetry for archaeology
- High altitude balloon

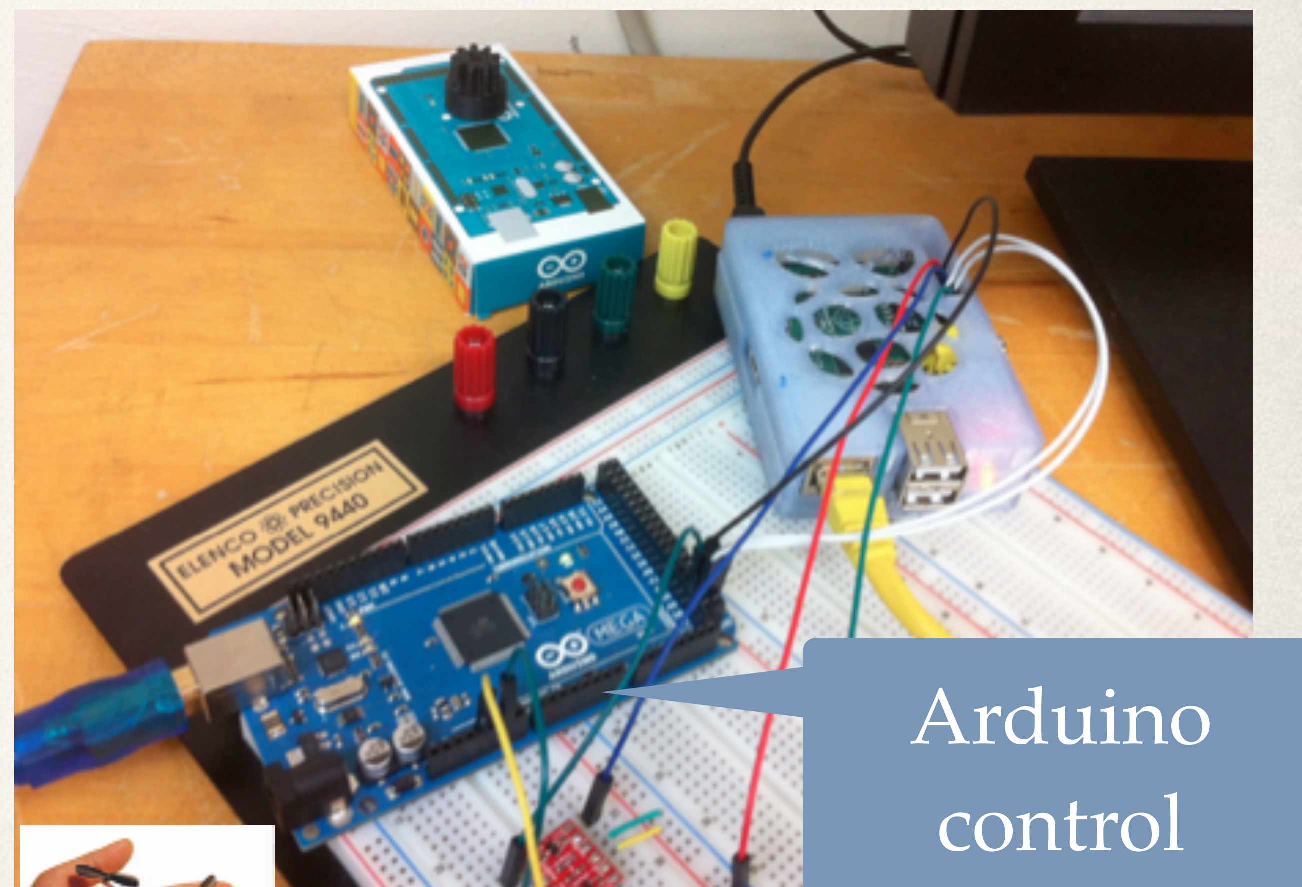


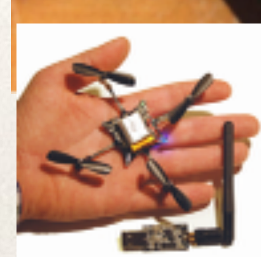


Quadcopter

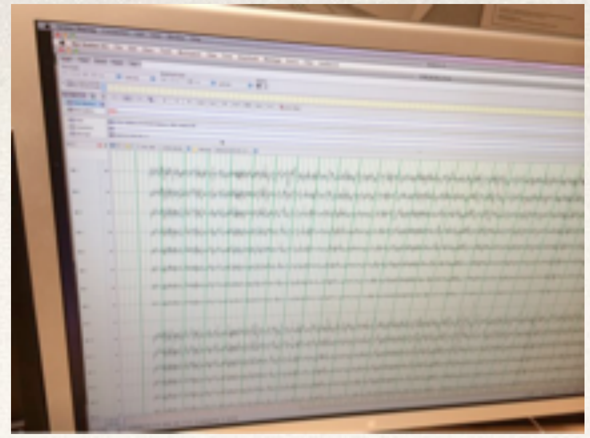
- Drone/Unmanned Aerial Vehicles (UAV) platforms are a “ballooning” industry. A multi-copter is an electric powered multiple-rotor helicopter. Flight is controlled by varying rotor speeds independently.
- A UW-Madison/University of Copenhagen student collaboration constructed two quadcopters from scratch and collaborated on control by Arduino and Raspberry PI consumer-grade computers.
- Landmine detection? LIDAR? Swarm search and rescue? amazon.com?







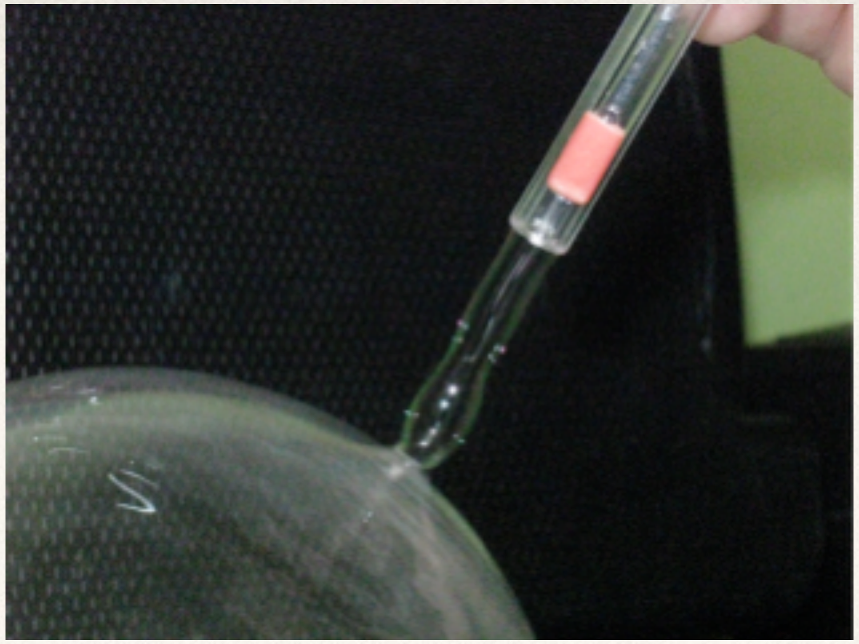
EEG/BCI



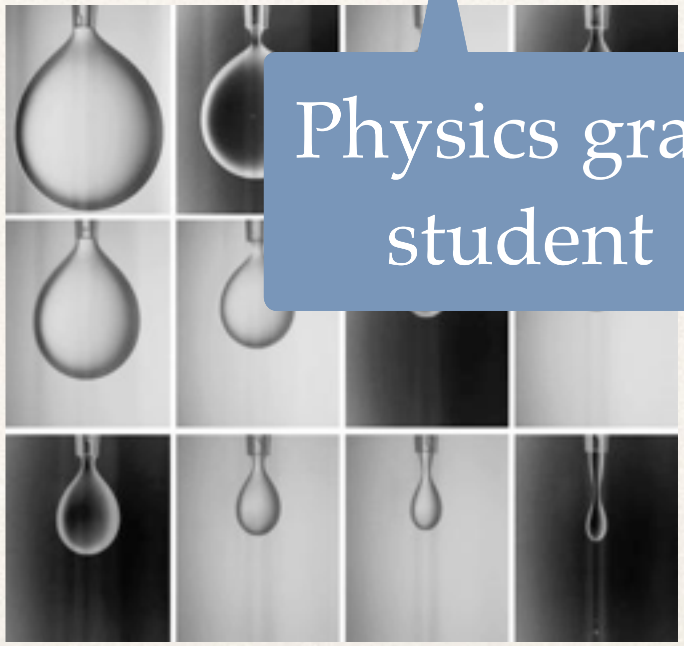
- Electroencephalography (EEG) records brain electrical activity.
- Brain computer interfaces (BCI) allow a person to control something like a robot with their thoughts.
- The goal of this EEG/BCI project is to use EEG to control a quadcopter and then the internet of things.
- HIVEMIND competed in Burrill Biz Competition.

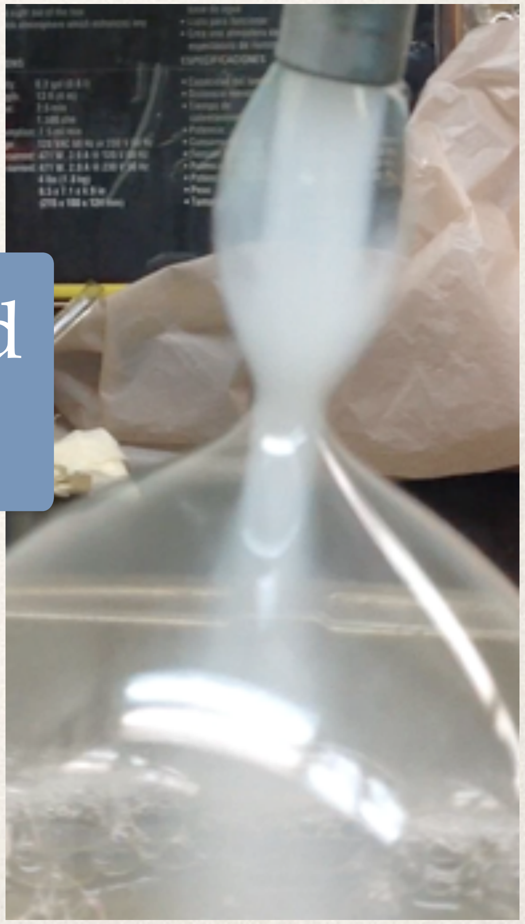
Bubble stability

- If you blow a bubble with a straw, an oddly stable tube structure appears.
- The goal of this research project is to understand the stability and shapes, and the relation to the Rayleigh-Plateau instability in drop formation.
- Applications to microbubbles for drug delivery?



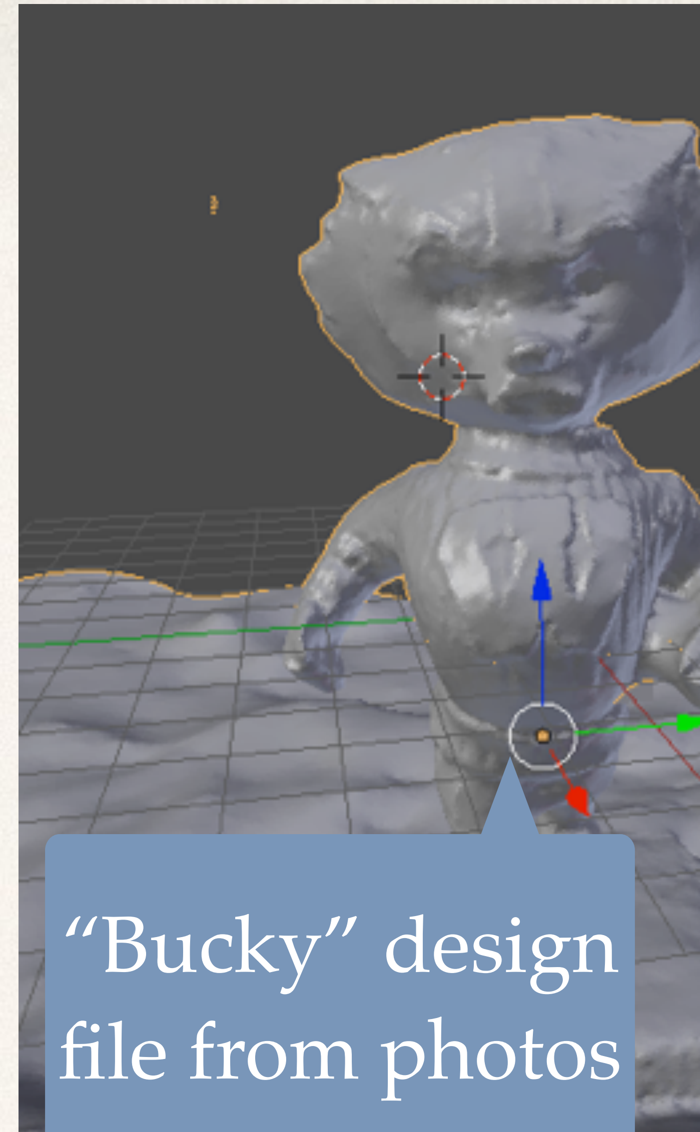
Physics grad student

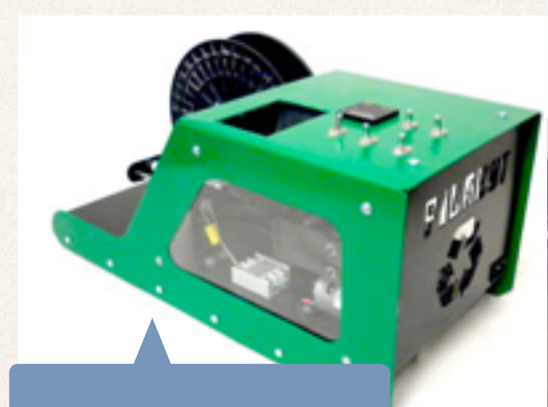


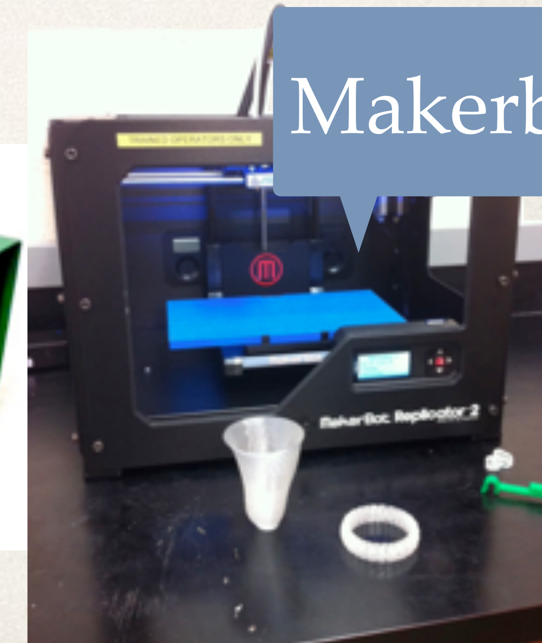


3d Printing recycler

- A 3d printer such as the Makerbot in Garage “prints” a three dimensional object as a succession of layers.
- Many startups (one by UW graduate students) are marketing such printers.
- The goal of this project is to investigate “personal recycling” of plastic using 3d printers.



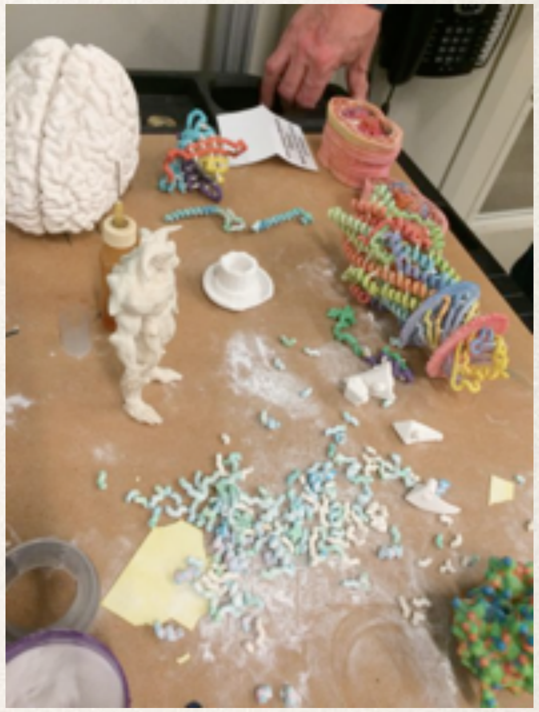


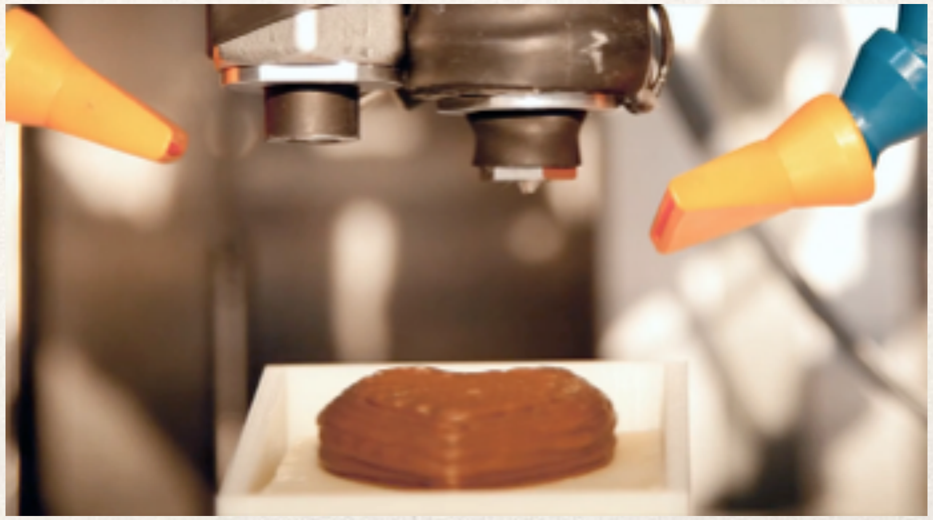


SpaceX finishes qualification testing for 3-D printed rocket engine

3d food printing

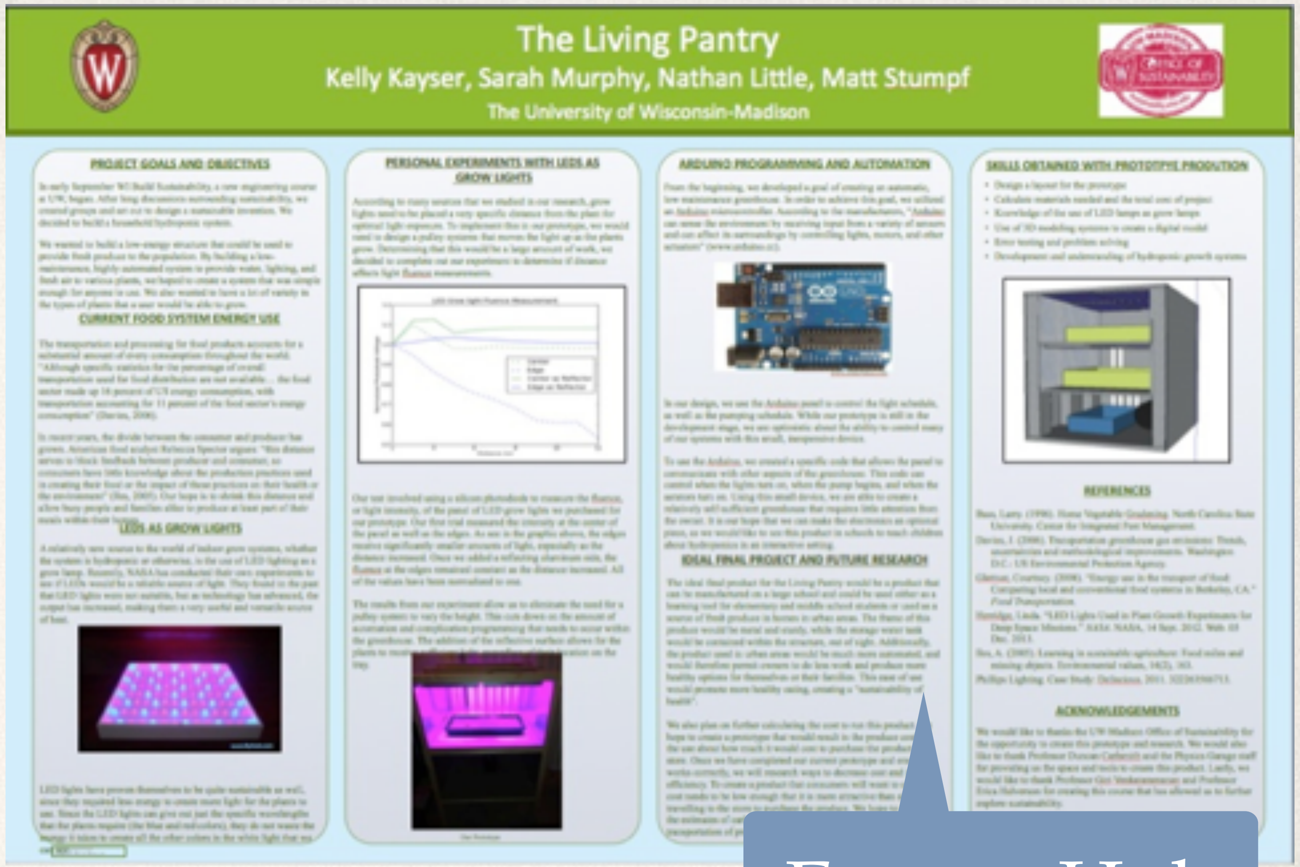
- The goal of this project is to 3d print foods that could not be made with conventional techniques.
- Fractal cake anyone?
- New tastes?





Living pantry

- One student group in a Garage-based interdisciplinary class WI Make Sustainability prototyped in Fall ’13 an Arduino-controlled LED-lit hydroponic food production appliance.
- Living Pantry V2 competed in 2014 Ag. Innovation Competition ($100,000 1st prize)
- Markets: consumer, restaurants, K12, food deserts, space.

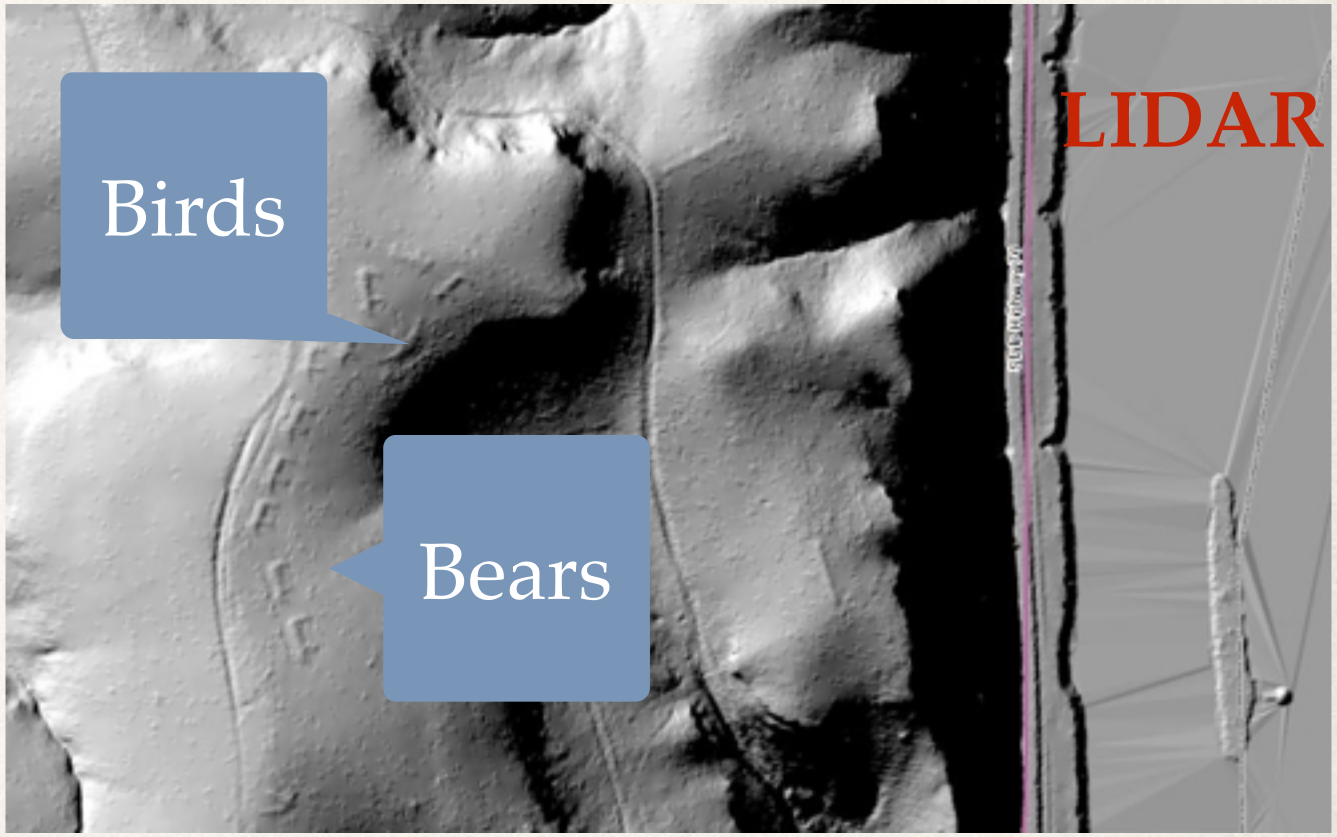


Energy Hub conference

3rd year CS major

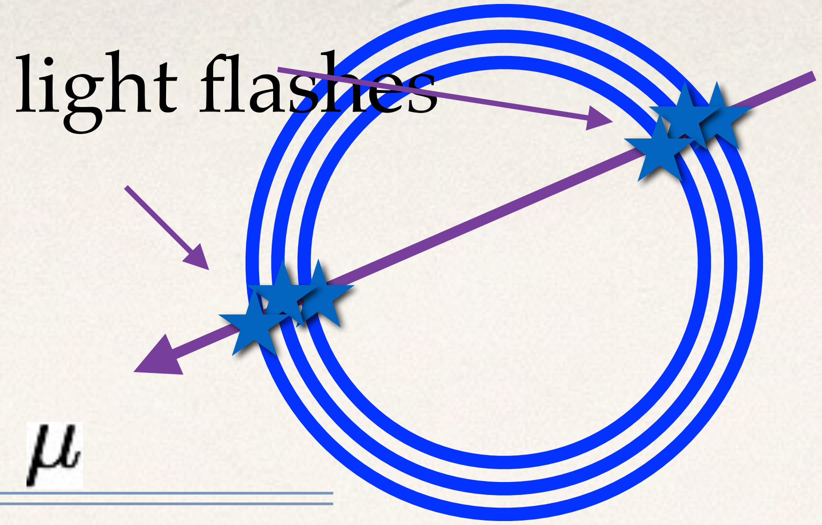
LIDAR

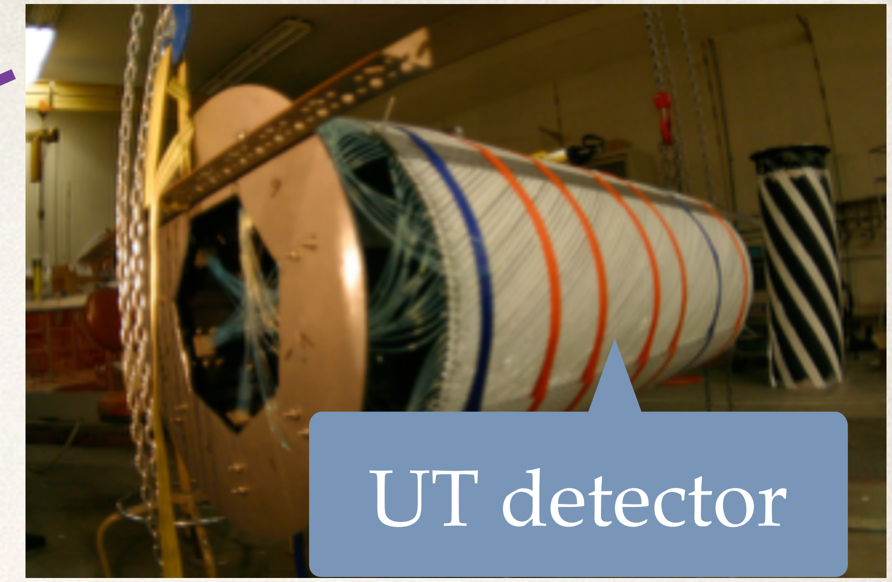
- This project uses public laser Light Detection and Ranging (LIDAR) data to "see through the foliage" for archaeological survey.
- Human occupation in Wisconsin dates back at least 12,000 years. Goal is to find all mounds through digital pattern recognition.
- Applications to agricultural and geological survey.

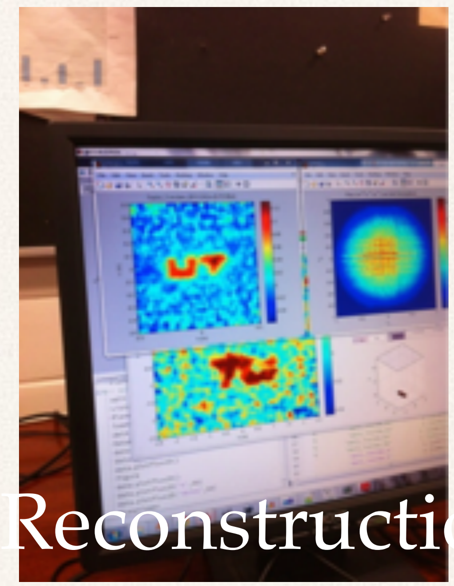


LIDAR-based digital elevation model of effigy mounds in Midwest.

Muon tomography







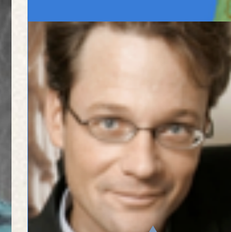

- Two UW-Madison undergraduates with support from Garage Physics and a Wisconsin Space Grant in collaboration with the UT-Austin Mayan Muography group study muon tomography feasibility through GEANT simulation and analysis of UT-Austin data and participate in applications in Belize and at Troy.


2nd yr, Physics

- Now undergraduate research fellows at Wisconsin Institute for Discovery.

WISCONSIN INSTITUTES FOR DISCOVERY
AT THE UNIVERSITY OF WISCONSIN-MADISON


2nd yr, Physics


Fac. Classics

High altitude balloon

- Student designed helium balloon with GPS tracker system and mobile phone camera payload and radar reflector. All street legal. Airport approved launch.
- Flew from Madison to ~100,000′ and landed near Poynette.
- We are hiring a professional tree-climber to recover the payload. Collect spores next time?

Entrepreneurship in Garage

- Entrepreneurship resources in WIKI. Diigo, email, personal, and instructional encouragement.

- Visits/presentation by directors of Ag. Innovation Prize, by Orbitec business development director, and by Dane County Regional Development Association. Student Business Incubator judges of projects.

- Garage students participated in Entrepreneurship Certificate program and summer crash course, Startup Weekend, Hackathon, Startup Fest (gathering of students and local entrepreneurs), local accelerator events, local co-working space.

- Three Garage groups entered business competitions without success but learned loads. Two nascent student companies applied to use Garage.

Partners in the ecosystem

- Garage Physics connects to a variety of campus and community partners supporting student research and entrepreneurship.

- An entrepreneurial "ecosystem" is recognized as paramount in nurturing entrepreneurship.

Wisconsin School of Business Certificate in Entrepreneurship	http://bus.wisc.edu/bba/academics-and-programs/majors/certificate-entrepreneurship
Weinert Center for Entrepreneurship	http://bus.wisc.edu/centers/weinert
Entrepreneurial Residential Learning Community	https://www.housing.wisc.edu/erlc
Undergraduate Symposium	https://www.learning.wisc.edu/ugsymposium/
UW-Madison Educational Innovation	http://edinnovation.wisc.edu/
Morgridge Institute	http://discovery.wisc.edu/morgridge/
Discovery to Product	http://d2p.wisc.edu/
Wisconsin Institute for Discovery	http://wid.wisc.edu/
MERLIN mentors	http://merlinmentors.org/
Advocacy Consortium for Entrepreneurs (ACE)	http://inwisconsin.com/entrepreneurs-and-innovators/launch_blog/uw-madisons-ace-program-for-entrepreneurs/
Wisconsin Alumni Research Foundation	http://www.warf.org/
Wisconsin Center for Education Research	http://www.wcer.wisc.edu/
Wisconsin Delta Program	http://www.delta.wisc.edu/
Capitol Entrepreneurs	http://www.capitalentrepreneurs.com/
Accelerate Madison	http://acceleratemadison.org/
UW Madison Student Business Incubator	http://uwmadsbi.com/
100State	http://100state.com/

Important UW ingredients

- Entrepreneurial Residential Learning Community (1st year)
- Student Business Incubator
- Innovation Center(s) and access to diverse campus physical and human resources
- Academic scaffolding and business competitions
- Connections to community networks and resources.

WISCONSIN SCHOOL OF BUSINESS
UNIVERSITY OF WISCONSIN-MADISON
TOGETHER FORWARD

Required Foundation Courseswork (3 credits)

- MHR 322 - Introduction to Entrepreneurial Management (Fall/Spring) *restricted to non-business majors*
- MHR 422 - Entrepreneurial Management (Fall/Spring)

Wisconsin School of Business - Advanced ESHIP (choose at least 3 credits from list)

- GEN BUS 310 - Fundamentals of Accounting & Finance for Non-Business Majors (Non-business students are highly encouraged to take this course OR Accounting 100 OR 300 before OR concurrently with MHR 422. Prior to fall 2010, GEN BUS 310 was GEN BUS 365.)
- MHR 434 - Venture Creation (Fall/Spring)
- MHR 427 - Entrepreneurial Growth Strategies (Spring)
- MHR 441 - Technology Enterpreneurship (Spring) (Prior to fall 2011 was MHR 365)
- FIN 457 - Entrepreneurial Finance (Fall)

STUDENT BUSINESS INCUBATOR

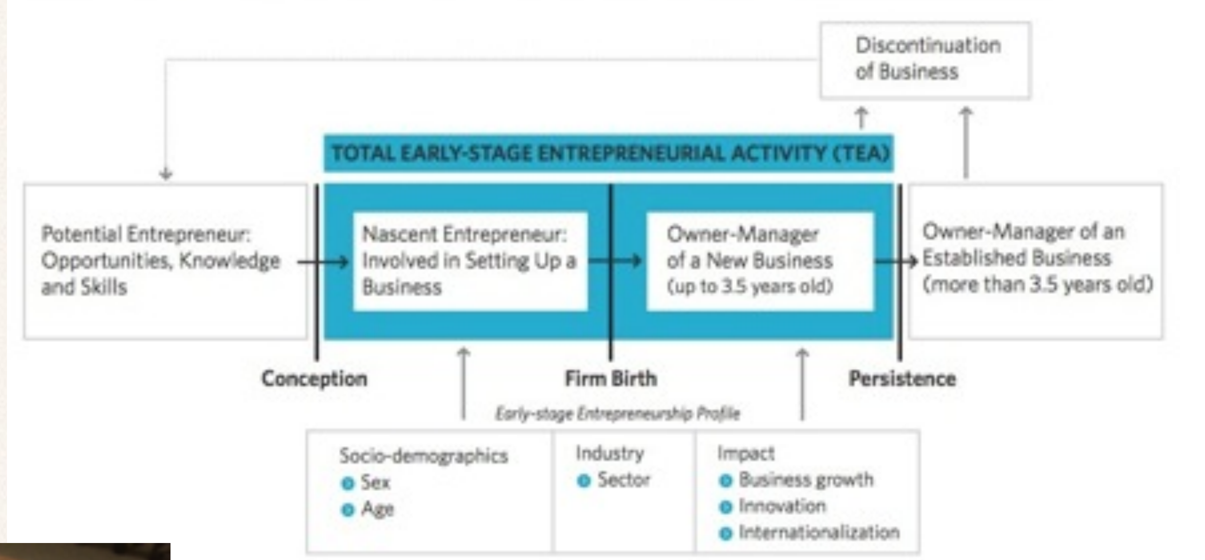
GARAGE PHYSICS

The entrepreneurship process

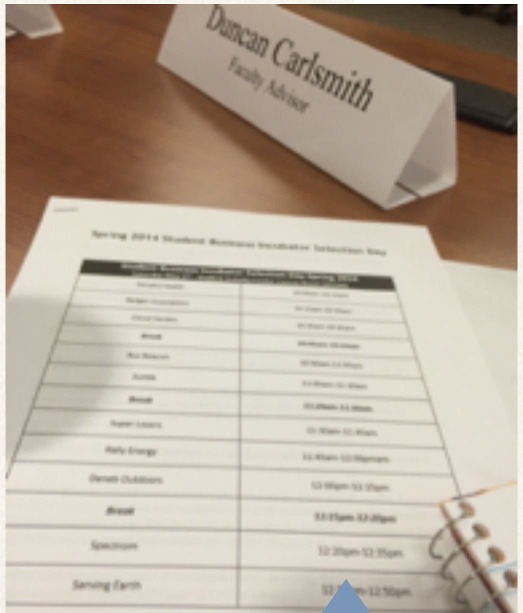
Global Entrepreneurship Monitor 2013 Report

- Many factors influence success.
- Faculty interest is extremely important!

FIGURE 1.1 THE ENTREPRENEURSHIP PROCESS AND GEM OPERATIONAL DEFINITIONS



Support student entrepreneurial orgs



Get involved as a judge and advisor

Justin Beck, Perblue CEO, UW intro physics with Carlsmith

PerBlue

Stay in touch with students

Steps you can take

- Learn about and support your campus and local entrepreneurial ecosystem, especially a Student Business Incubator and business competitions. Support participation in national level competitions and events. Investigate funding sources such as NCIIA.
- Encourage your university to offer entrepreneurship classes to all undergraduates, preferably 1st year, and encourage physics majors to take one, or to study entrepreneurship on-line and act on it independently.
- Create an open innovation lab. Staff it with physics graduate students. Connect to other faculty, scientists, staff. Encourage all disciplines.
- Connect yourself and students to alumni and build community.
- Keep track of your students. They might just be immensely successful and reward you.
- See Reinventing the Physicist: Innovation and Entrepreneurship Education for the 21st Century http://www.aps.org/programs/education/conferences/innovation.cfm

Takeaways

- Entrepreneurship is increasingly visible nationally and globally.
- A successful entrepreneur and a successful scientist share many attitudes and skills.
- Physics departments can assist, even provide a home for interdisciplinary student groups needing a space for research and development, and rapid prototyping.
- Physics departments can provides resources to students interested in exploring entrepreneurship.

Thank you for your attention