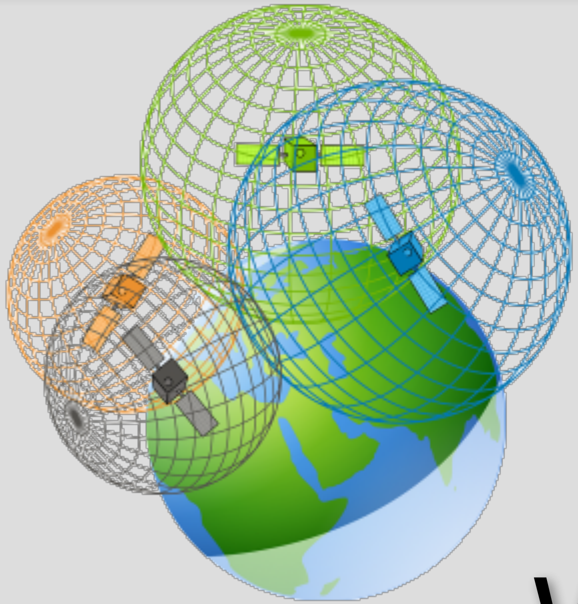
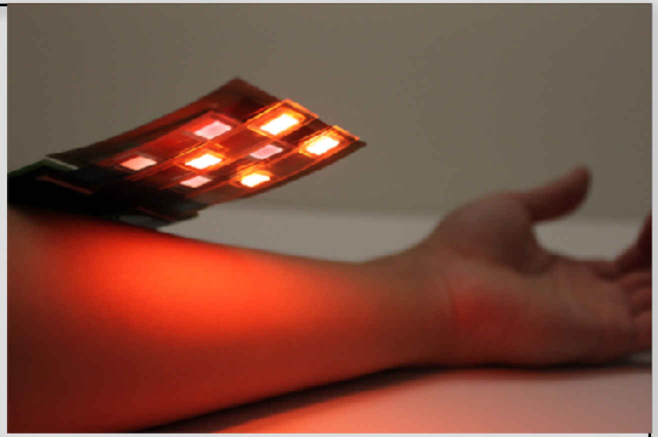




Welcome to EECS 16A!

Designing Information Devices and Systems I

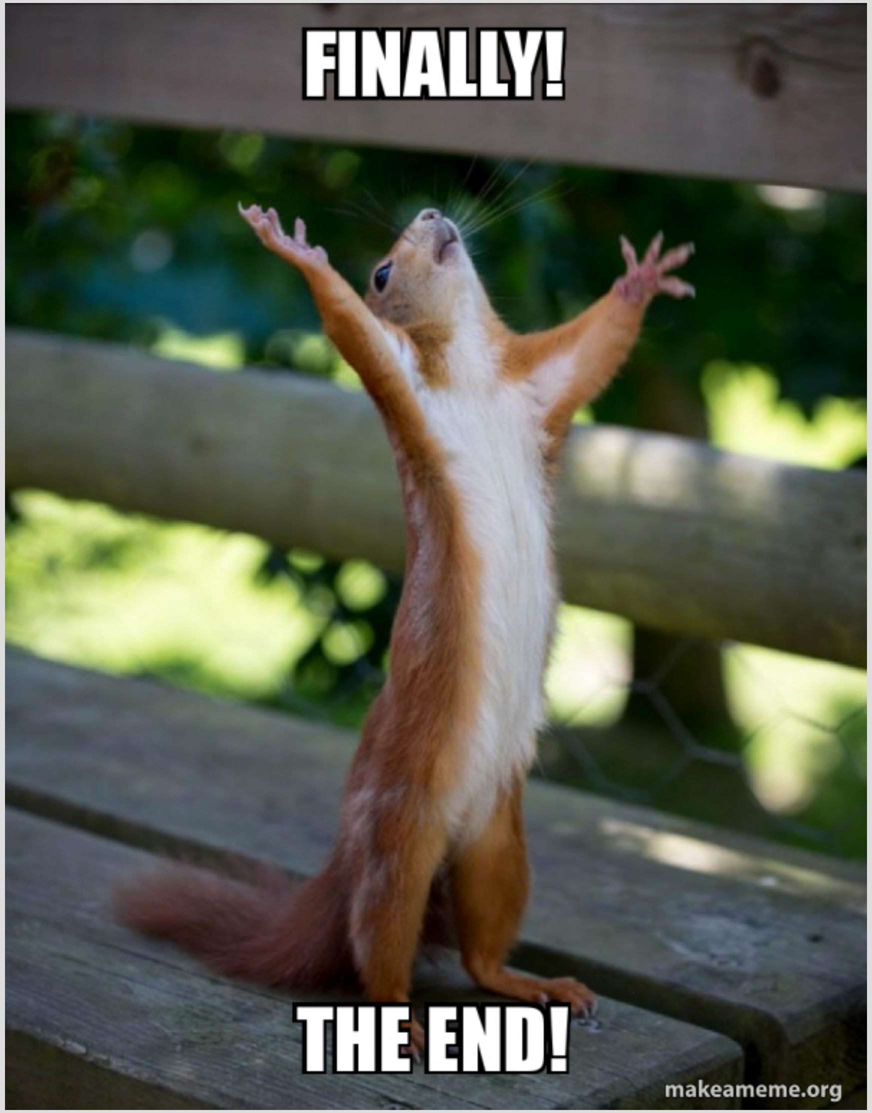
Ana Arias and Miki Lustig

Fall 2021

Lecture 14B

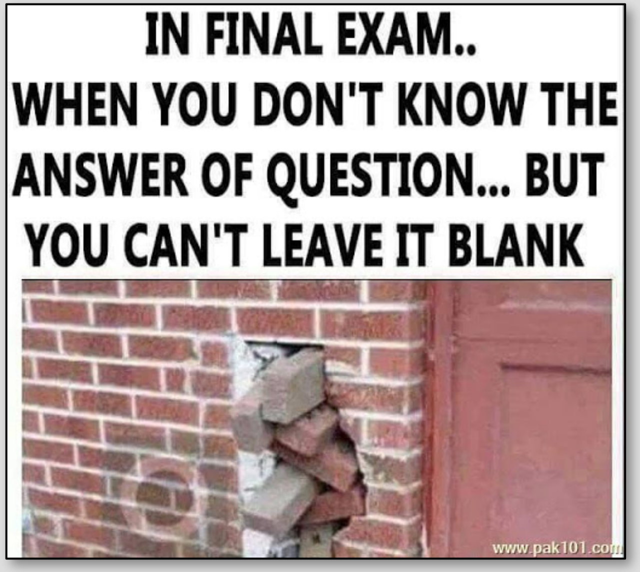
Last Lecture

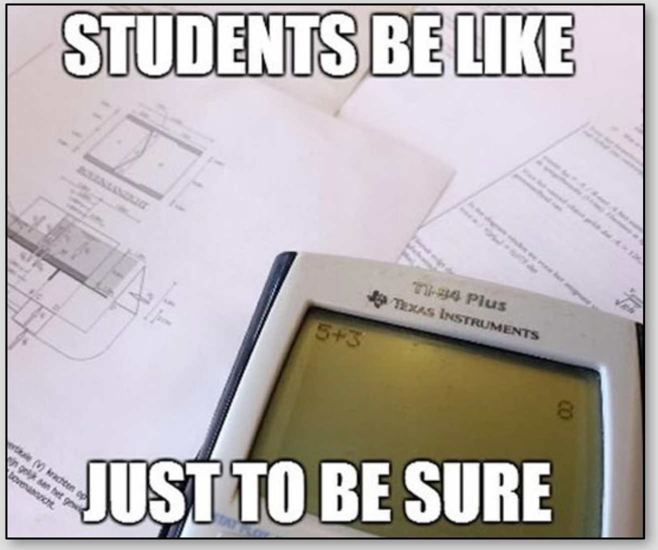

YOU DID IT!!!!

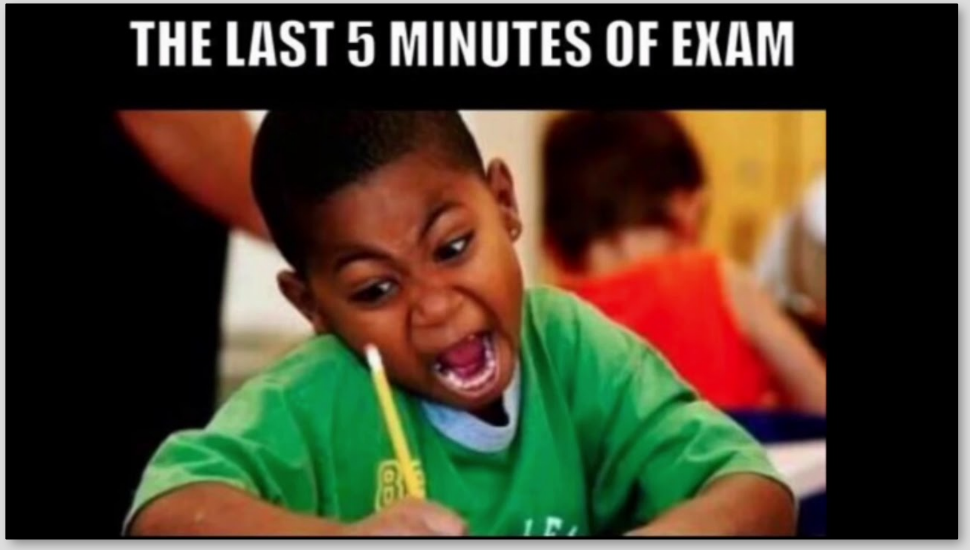


The End

Oh, except for the final exam…







Learning Goals

Stuff We did:

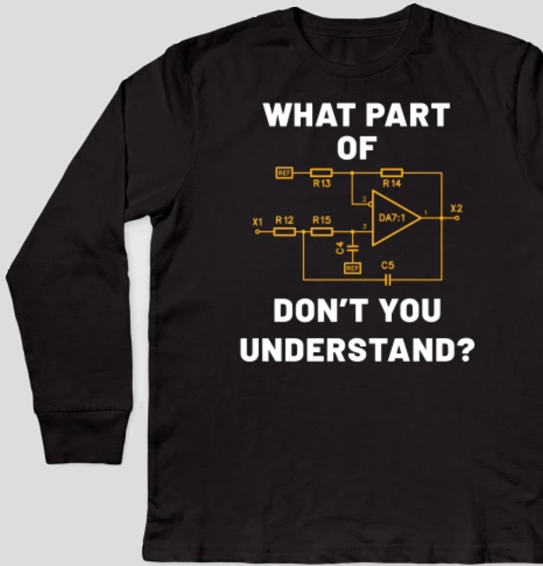
EECS 16A

- Module 1: Introduction to systems
  - How do we collect data? build a model?
- Module 2: Introduction to circuits and design
  - How do we use a model to solve a problem
- Module 3: Introduction Signal Processing and Machine Learning
  - How do we “learn” models from data, and make predictions?

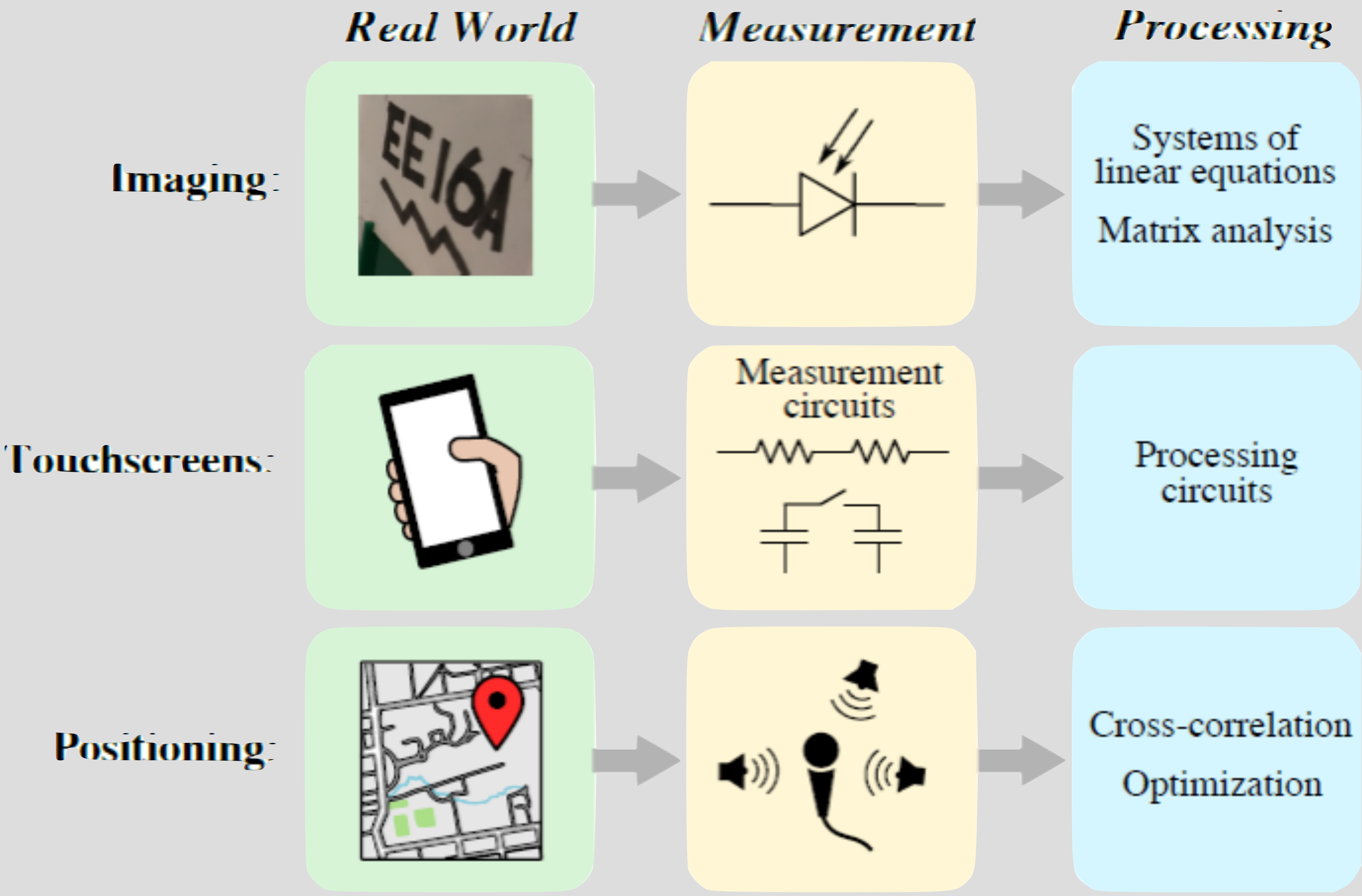
Stuff you will do next

EECS 16B

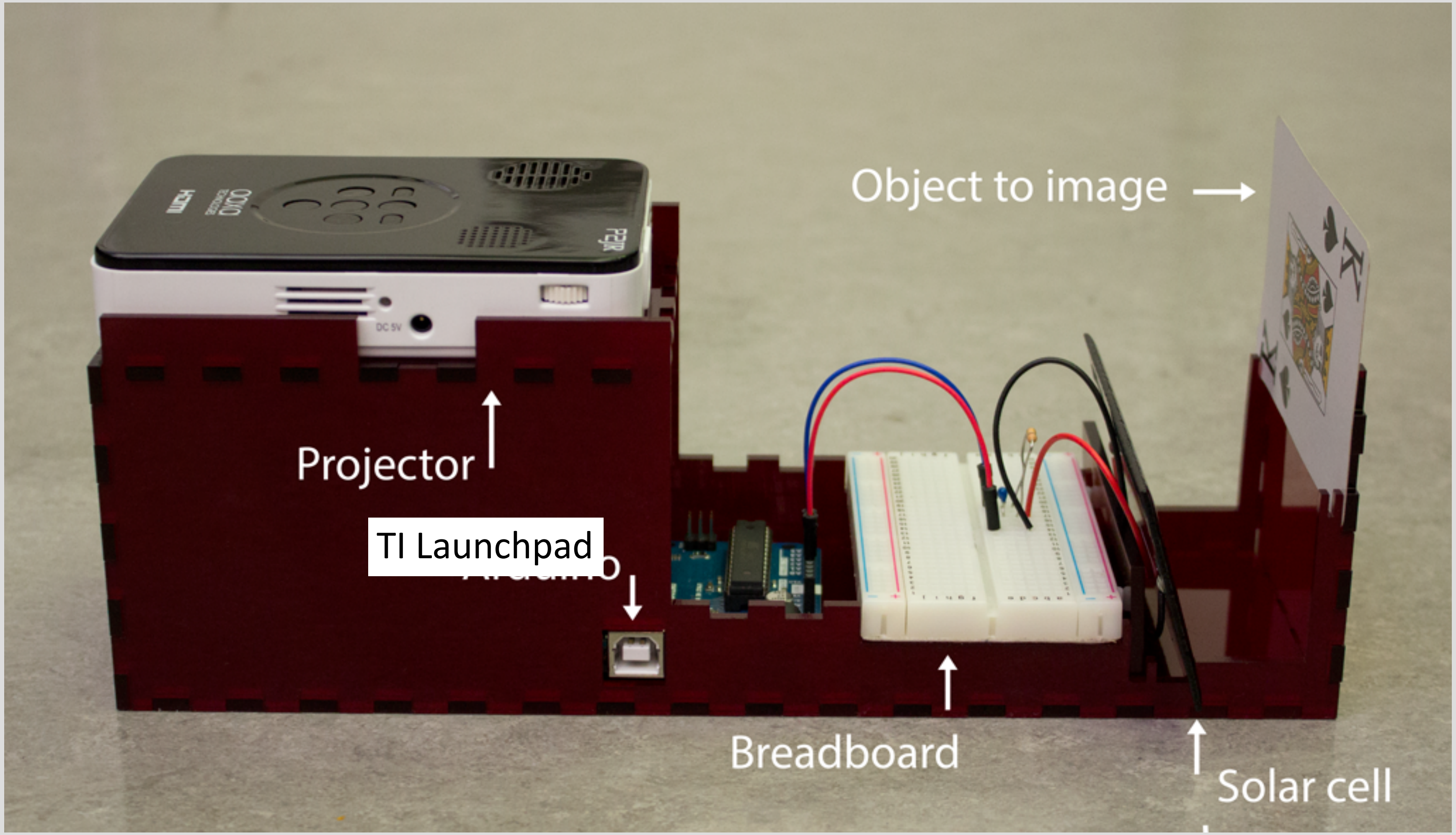
- Module 4: Advanced circuit design / analysis
- Module 5: Introduction to control and robotics
- Module 6: Introduction to data analysis and signal processing



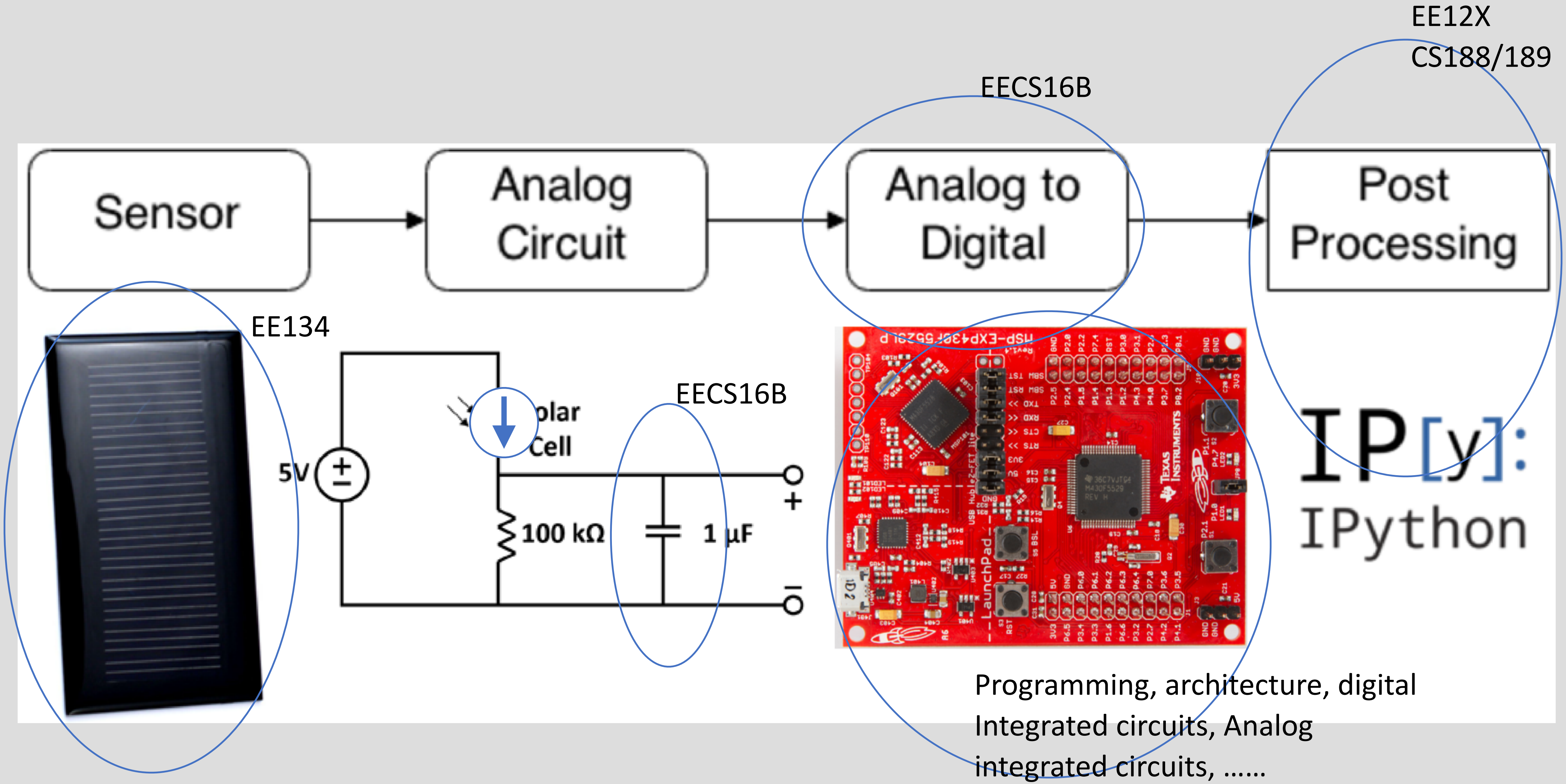
What you built:



Back to Imaging Lab #1

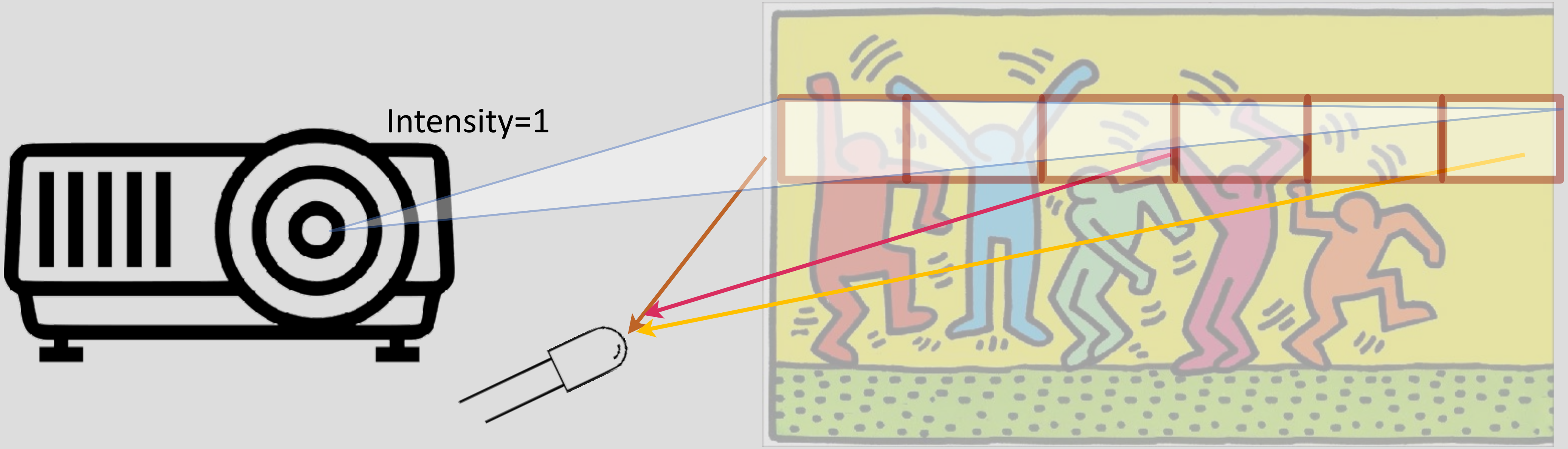


Imaging Lab #1



Non-moving Single Pixel Camera

- Use a projector to illuminate several pixels!
- Sense reflected light with a sensor
- Make many measurements and solve the equations!

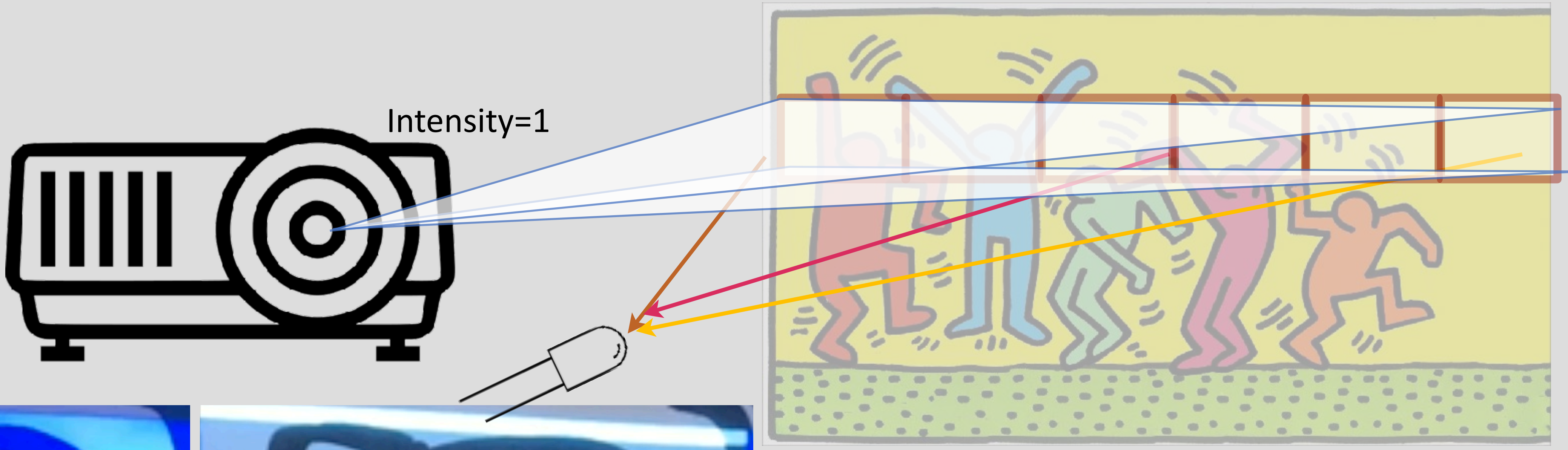


$$y_1 = x_1 + x_2 + x_3 + x_4 + x_5 + x_6$$

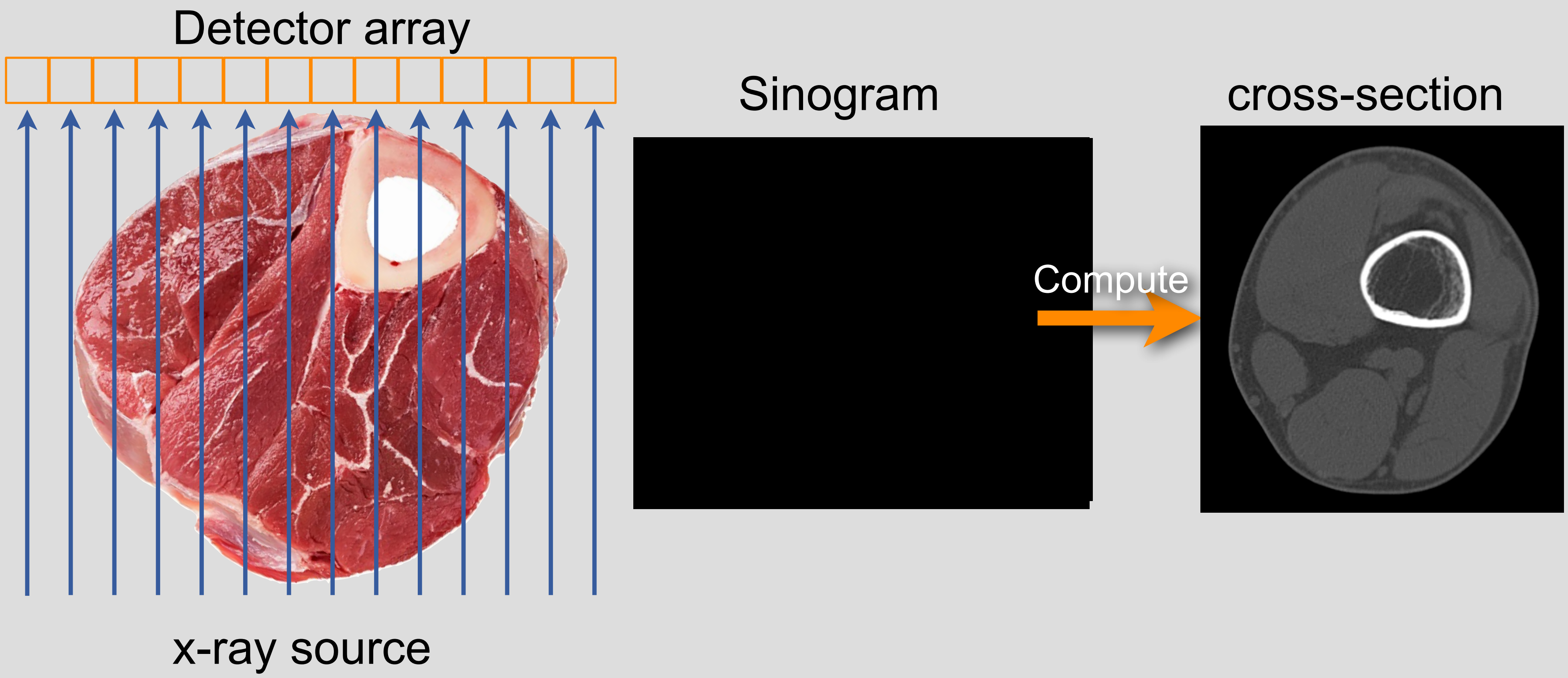
Similar math as Tomography!

Non-moving Single Pixel Camera

- How many measurements do you need?
- What are the best patterns?



Computed Tomography



Modeled sensing as $\vec{y} = A\vec{x}$, which are inner products!

Studied when there is a solution for $\vec{y} = A\vec{x}$, (range, null space, Eigen-values, linear dependence)

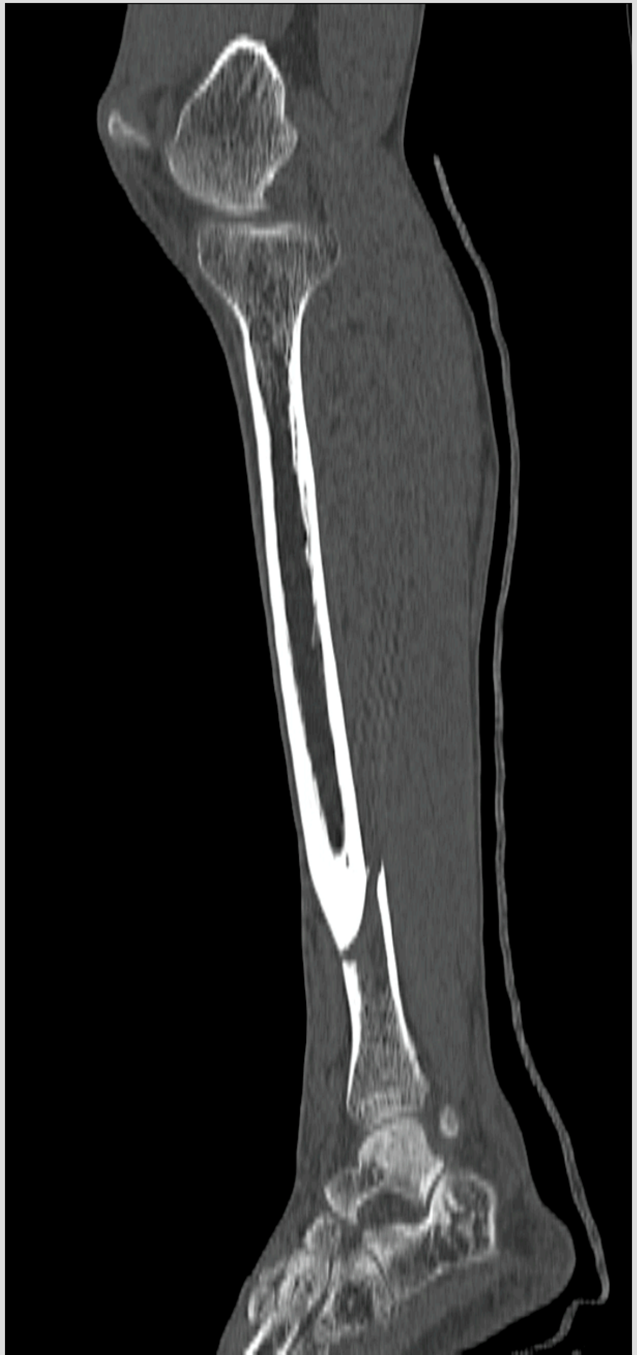
Now, know how to solve $\vec{y} = A\vec{x}$, when you have more measurements — that are inconsistent!

From Projections

Projections

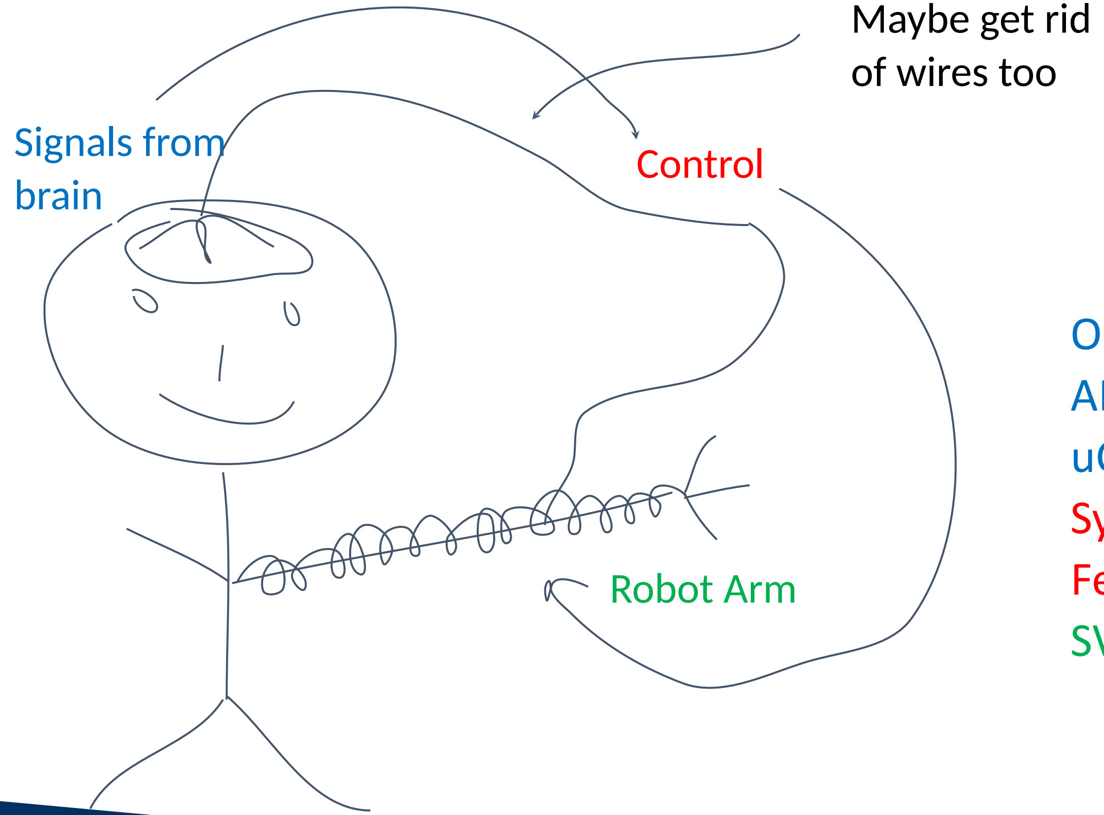
Axial Slices

Sagittal Slices



EECS16B: Designing Information Devices and Systems II

Big goal: Get signals from brain and interpret them



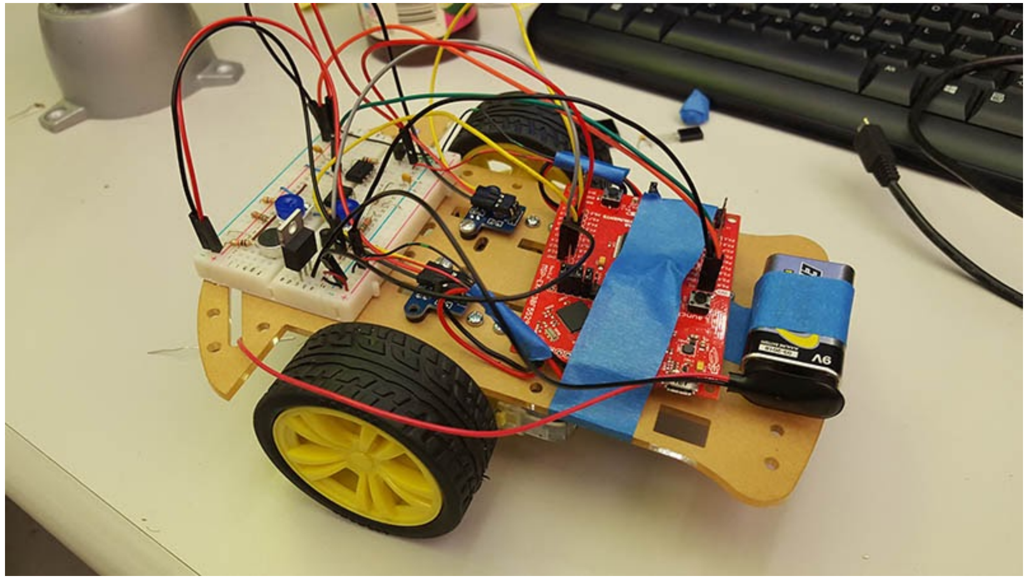
Module 1 – Circuits: Interfaces (brain, voice)

Module 2 – Control: Controls (feedback, stability)

Module 3 - Classification: Figuring out the intention

Voice controlled robo car lab project – from scratch!

OpAmp Filters,
ADCs/DACs,
uController,
SysID,
Feedback,
SVD, PCA



Demo video

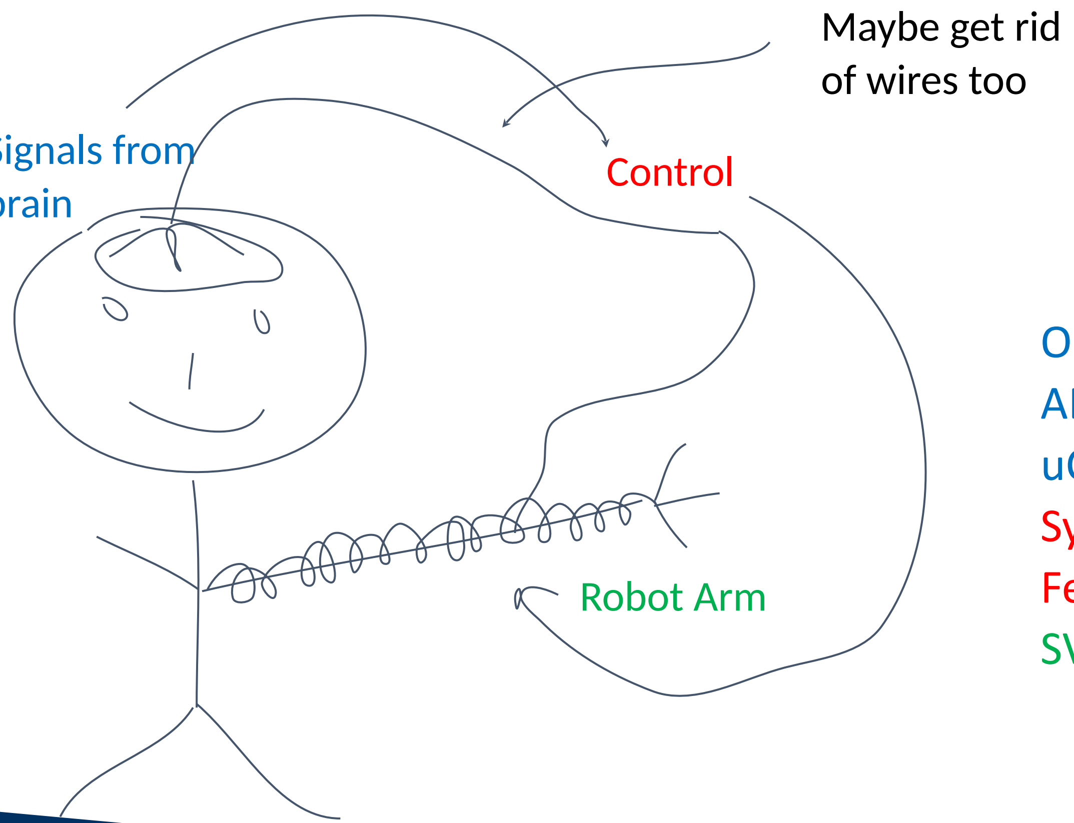
Design Contest (make our SIXT33N better!)

Berkeley UNIVERSITY OF CALIFORNIA

Profs. Murat Arcak and Vladimir Stojanović, Spring 2022
fav song "Under Pressure", Queen

EECS16B: Designing Information Devices and Systems II

Big goal: Get signals from brain and interpret them



Module 1 – Circuits: Interfaces (brain, voice)

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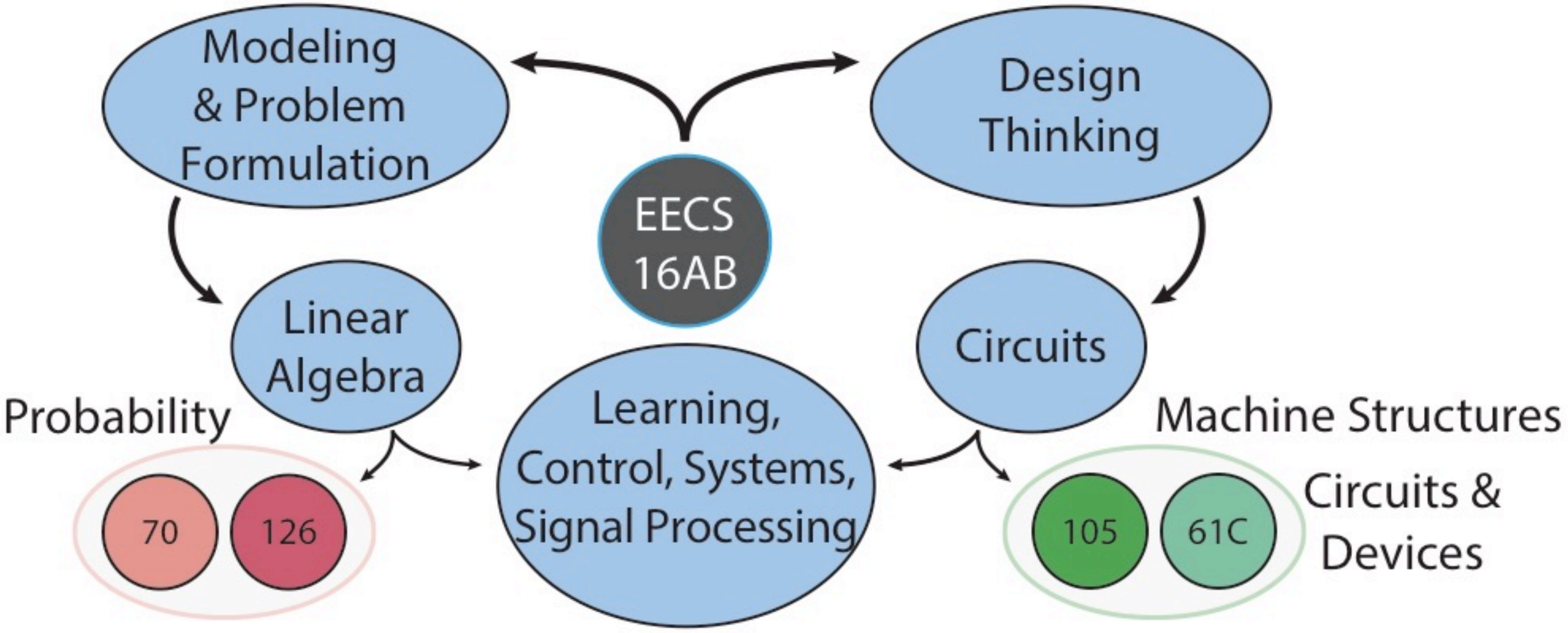
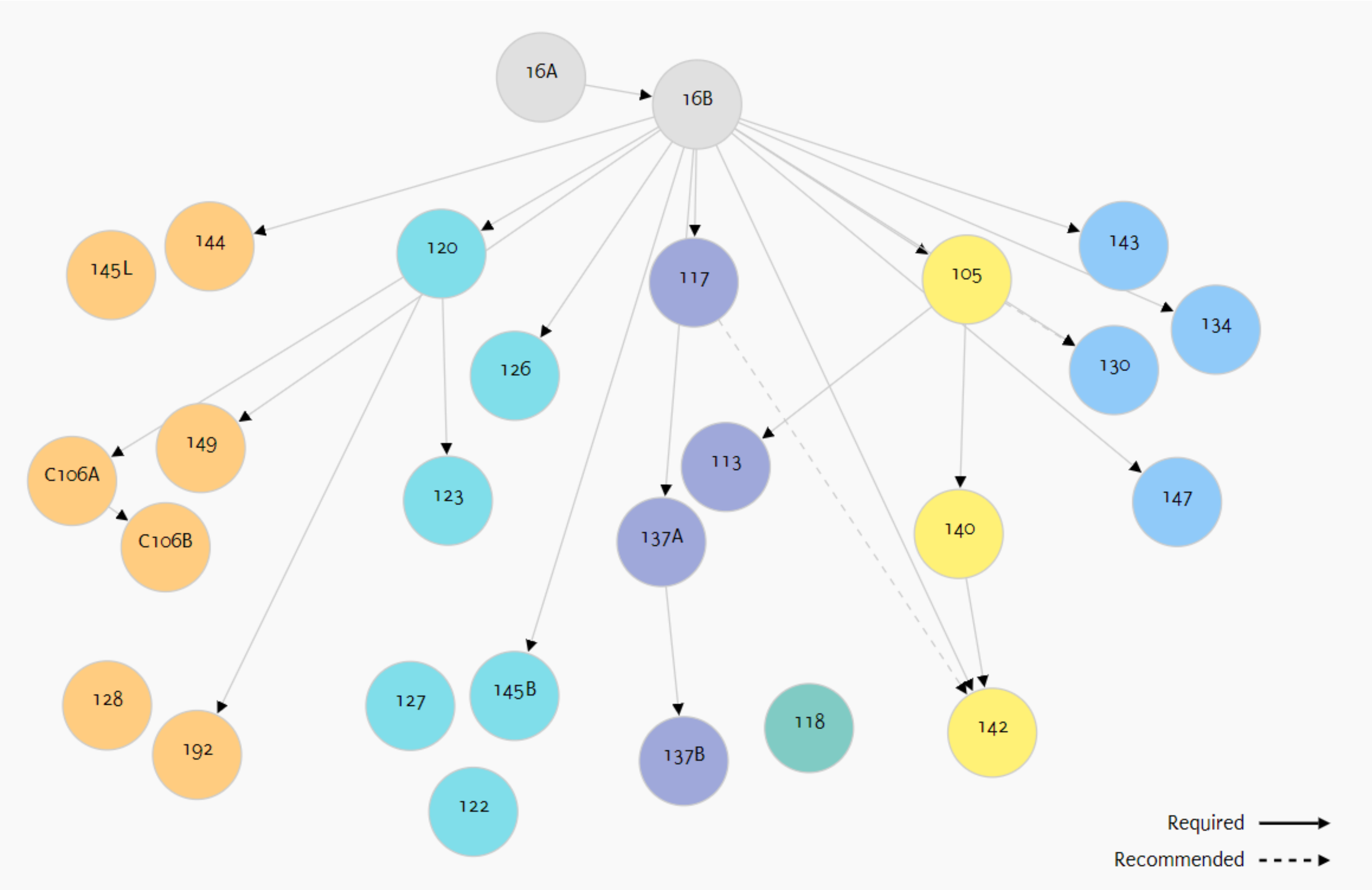


How to approach something unfamiliar
and systematically build understanding

Linear Algebra: conceptual tools to model
Circuits: How to go from model to design, grounded in physical world

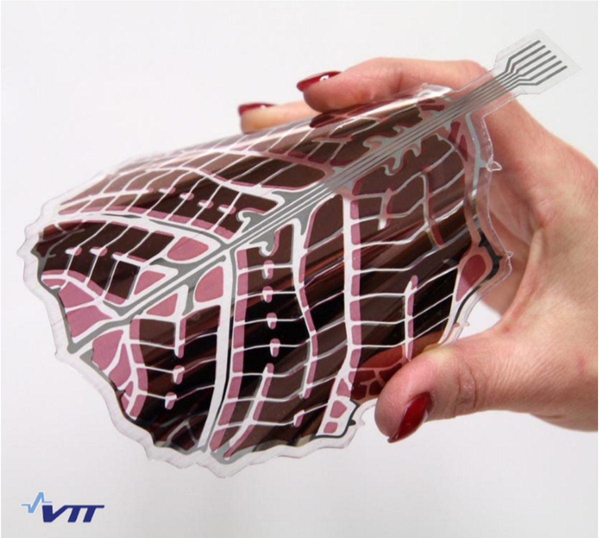
Intro to foundational concepts in Machine Learning

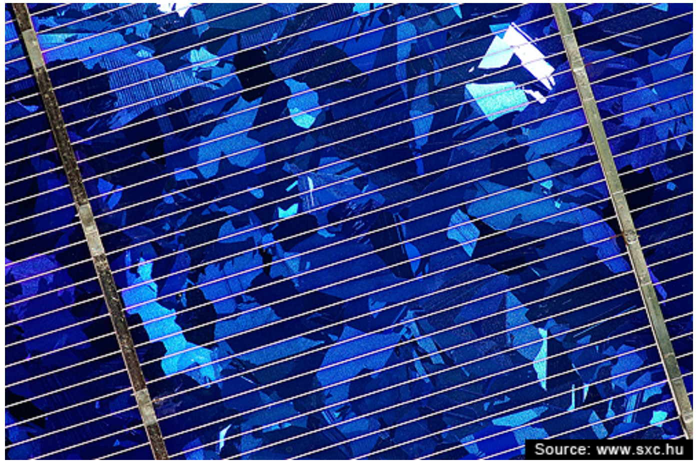
EECS course map



Fundamentals of Photovoltaic Devices
EE134

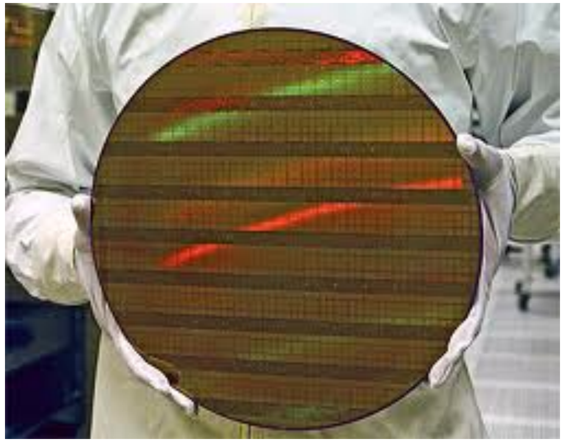
- Introduction to solar energy conversion, applications and technologies – **1 week**
- Fundamentals of Solar Radiation – **2 weeks**
- Electrons and holes in Semiconductors – **1 week**
- Charge generation and recombination – **1 week**
- Junctions – **1 week**
- Monocrystalline Solar Cells – **2 weeks**
- Thin Film Solar Cells – **2 weeks**
- Managing light – **1 week**
- Strategies for High Efficiency– **2 weeks**
- Economic Considerations – **1 week**





Microfabrication Technology
EE143

- IC and MEMs fabrication principles
- Hands on experience on fabrication and characterization of micro-structures
- Clean room experience

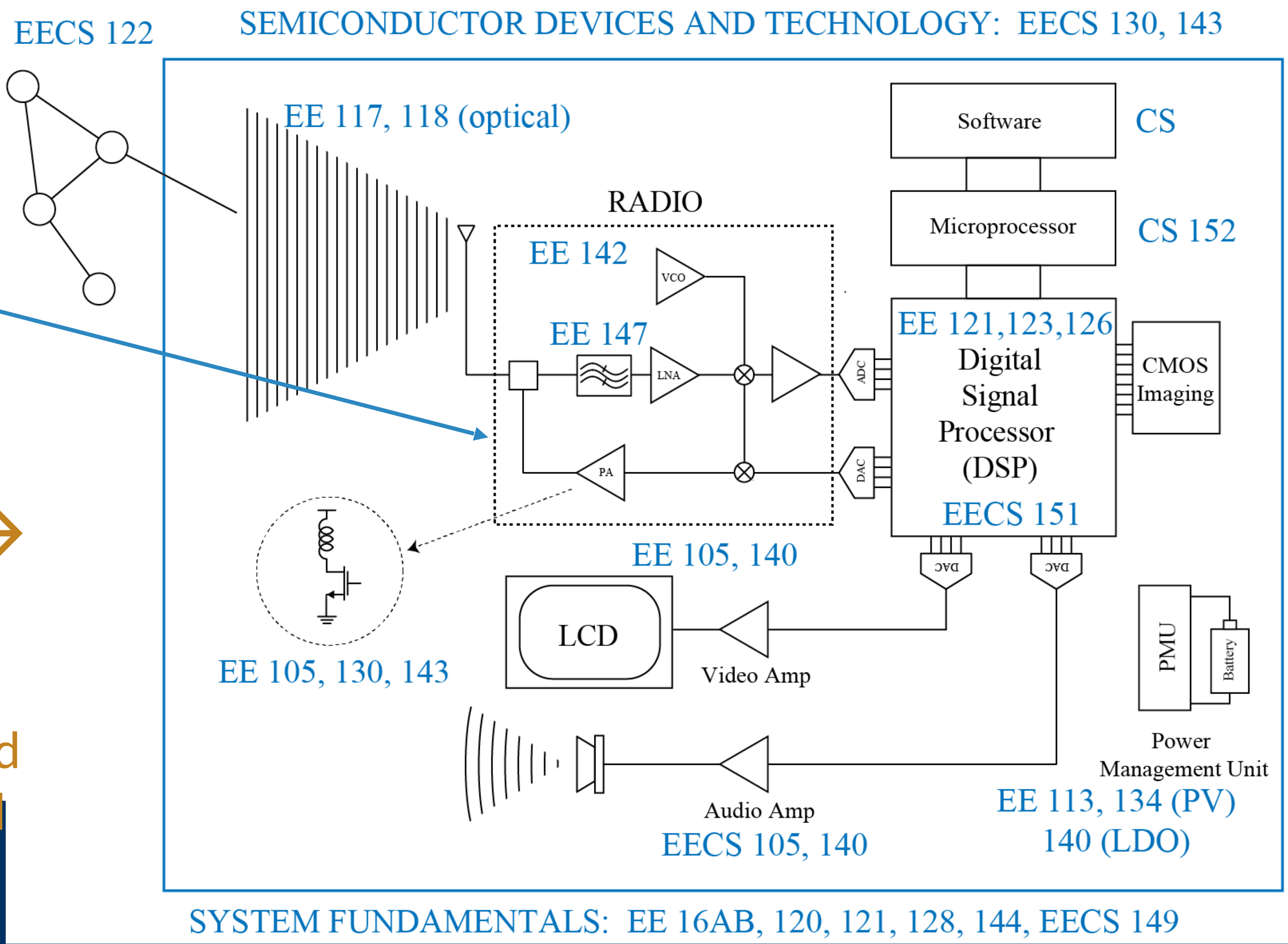


- Introduction to Materials and Processing (1-2 weeks)
- Photolithography (1 week)
- Etching (1 week)
- Oxidation (1 week)
- Deposition (1 week)
- Diffusion (1 week)
- Ion Implantation (1 week)
- Metallization/CMP (1 week)
- Simulation/Layout (1 week)
- Process Integration (1 week)
- Introduction to Devices and other patterning techniques (2 weeks)
- Nanolithography and Nanofabrication (1 week)

EE142 in the grand scheme of things:

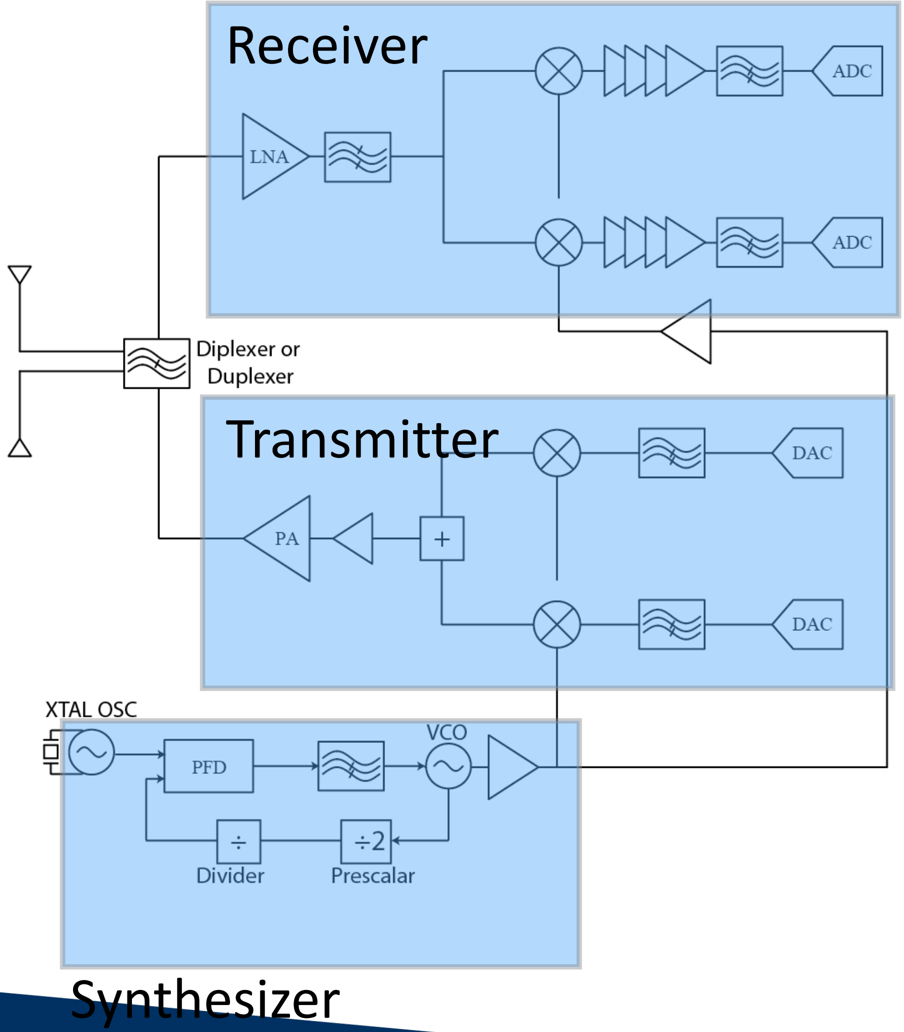
EE142: 16AB→ 105 → 140* → 142**

* 140 recommended
** 120 is also useful

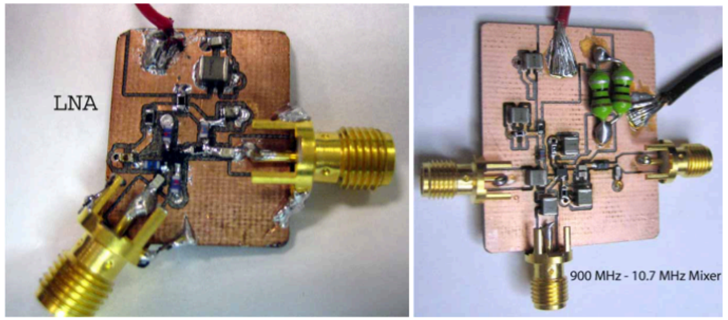


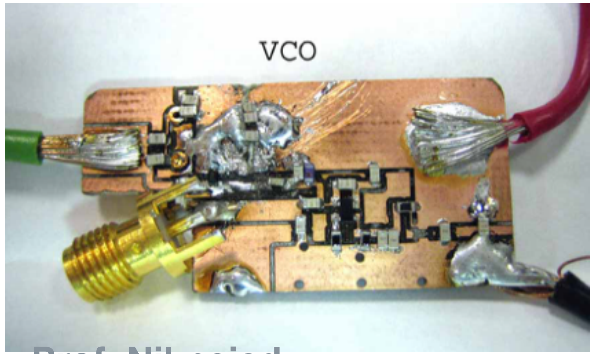
Systems:

Course Content:



Results:





Prof. Niknejad
Offered: Spring semester
In-person lab ! Hands on training with RF test and measurement equipment.

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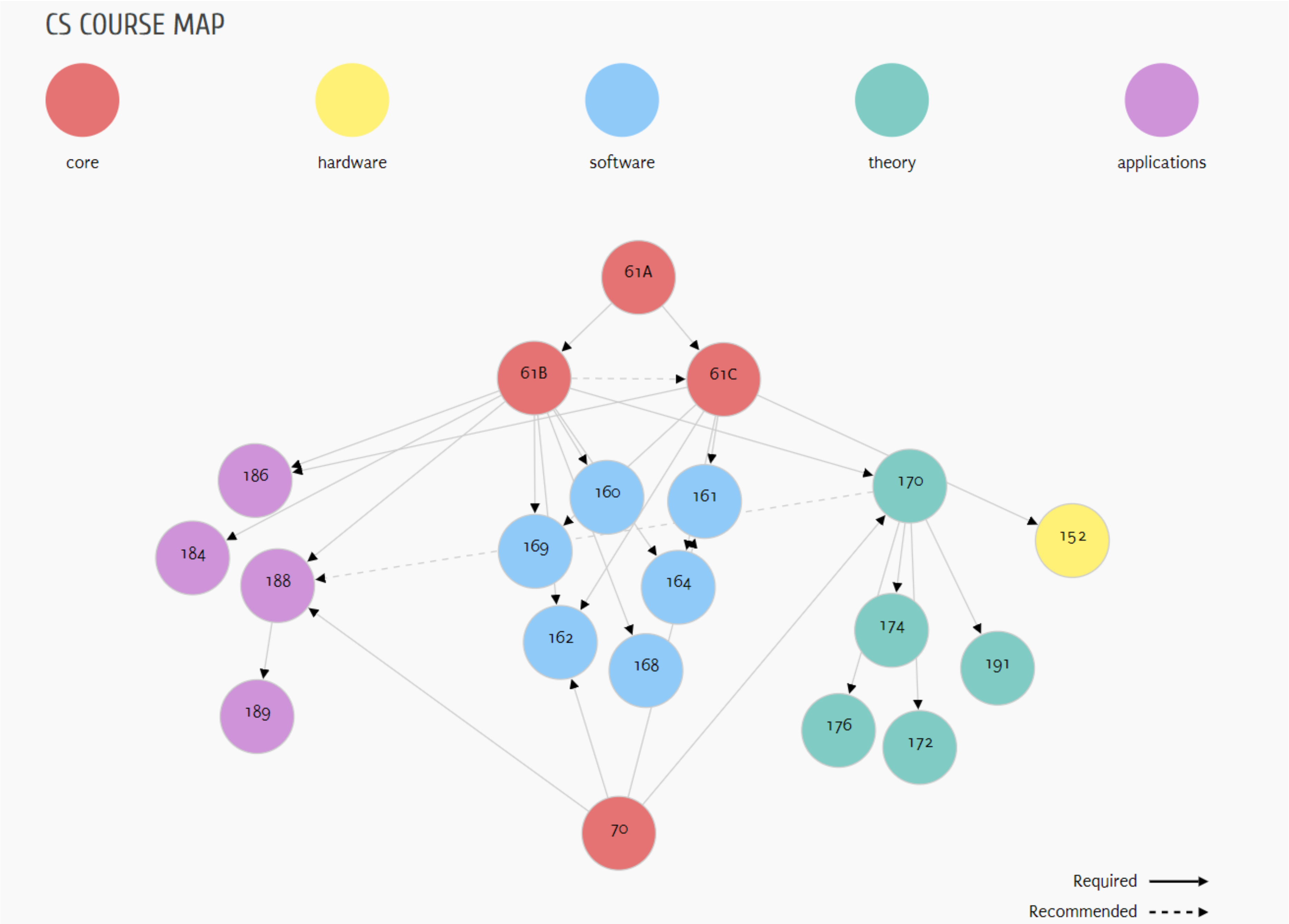
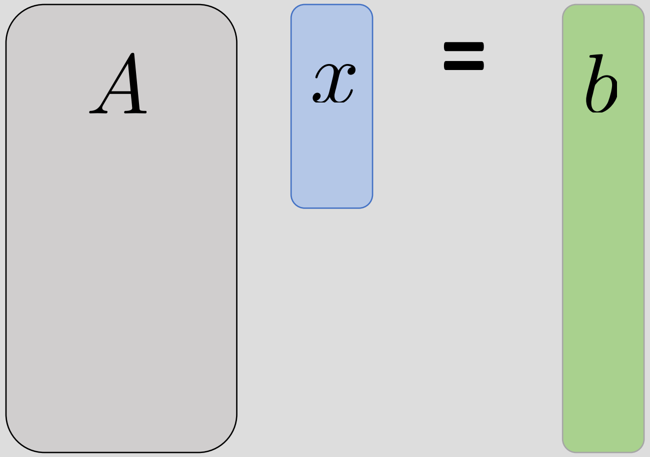
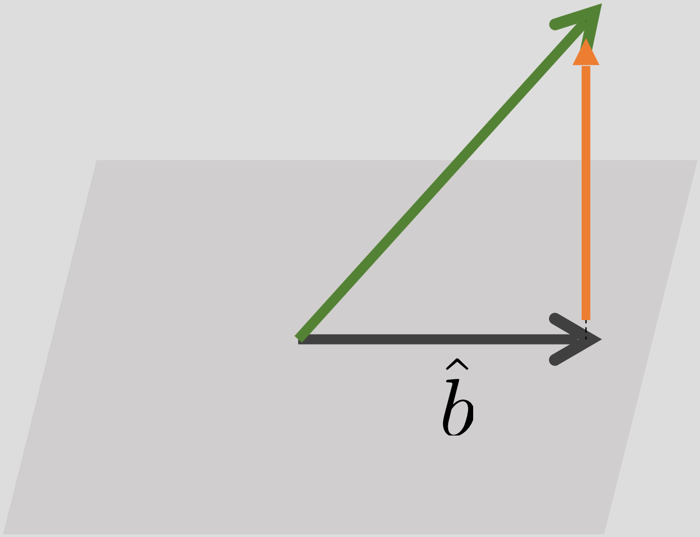

CS COURSE MAP
core
hardware
software
theory
applications
61A
61B
61C
186
184
188
189
160
161
169
164
162
168
170
152
174
191
176
172
70
Required
Recommended

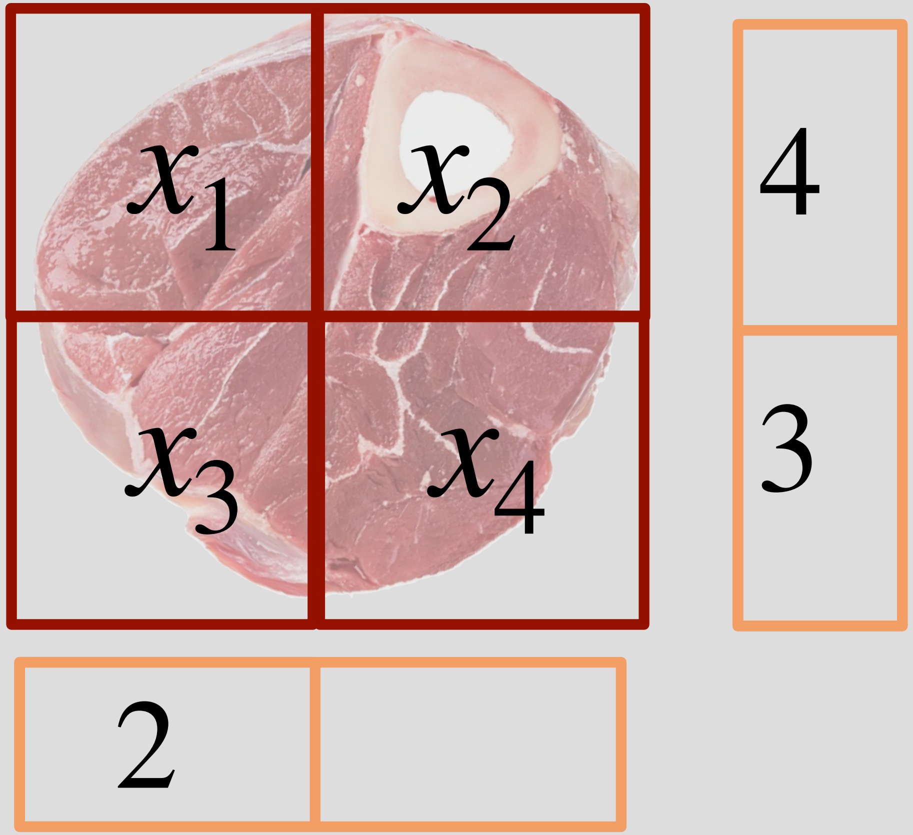
*<u>Over</u>*determined system: use least squares





- the least-squares solution “minimally perturbs” b

Back to Tomography

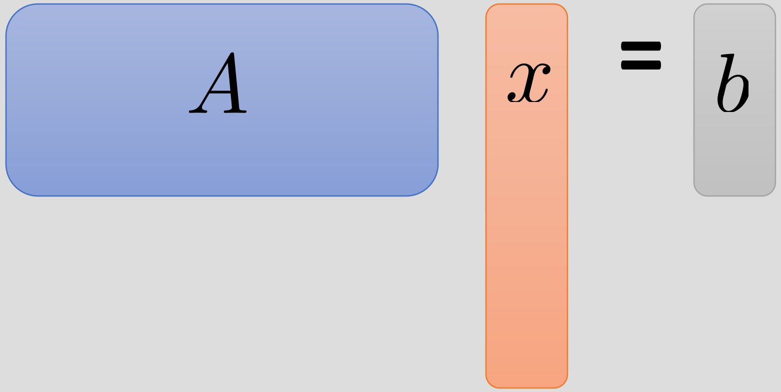


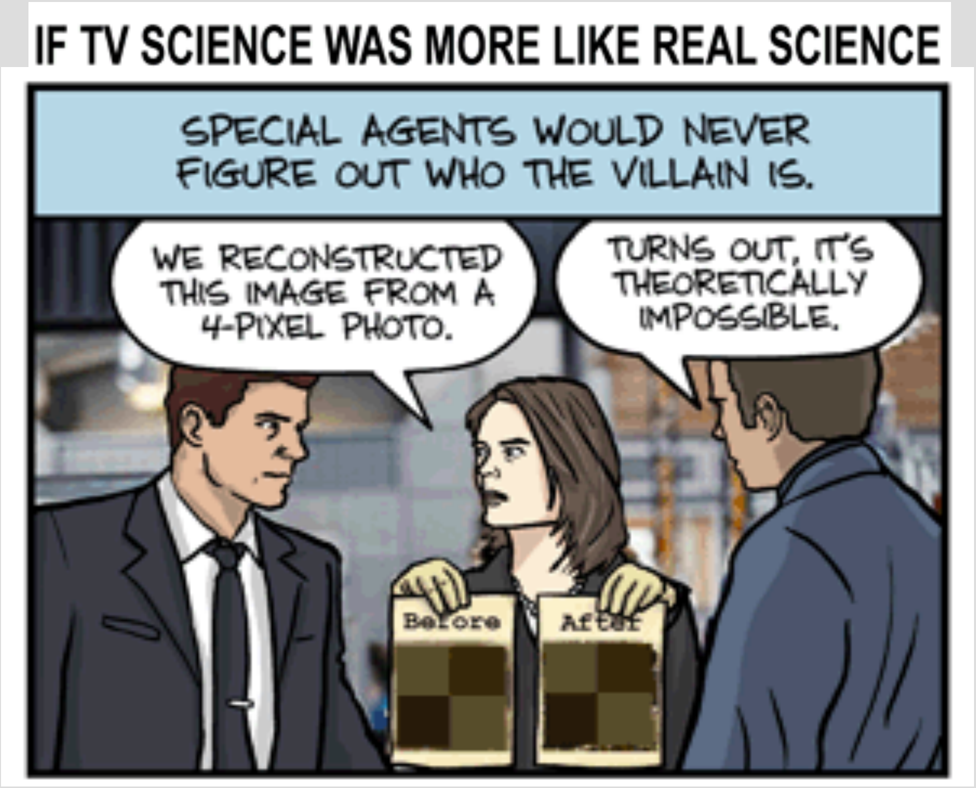
$$1 \cdot x_1 + 1 \cdot x_2 + 0 \cdot x_3 + 0 \cdot x_4 = 4$$
$$0 \cdot x_1 + 0 \cdot x_2 + 1 \cdot x_3 + 1 \cdot x_4 = 3$$
$$1 \cdot x_1 + 0 \cdot x_2 + 1 \cdot x_3 + 0 \cdot x_4 = 2$$

$$\left[\begin{array}{cccc|c} 1 & 1 & 0 & 0 & 4 \\ 0 & 0 & 1 & 1 & 3 \\ 1 & 0 & 1 & 0 & 2 \\ & & & & \\ & & & & \end{array}\right]$$

How do we solve it?

*<u>Under</u>*determined system: ????

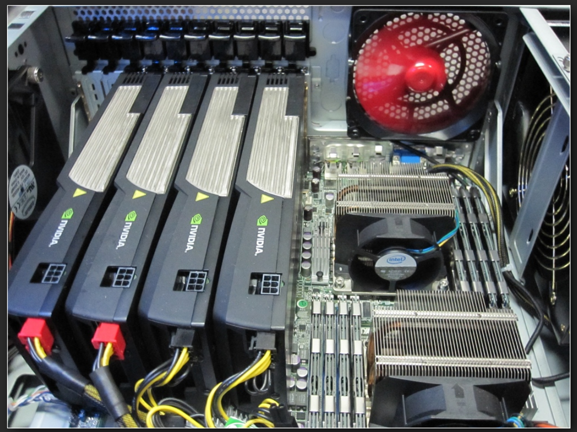




Computational MRI

Joint optimization:

- Data Acquisition
- Image reconstruction
  - System/data modeling
  - Algorithms
  - Computation



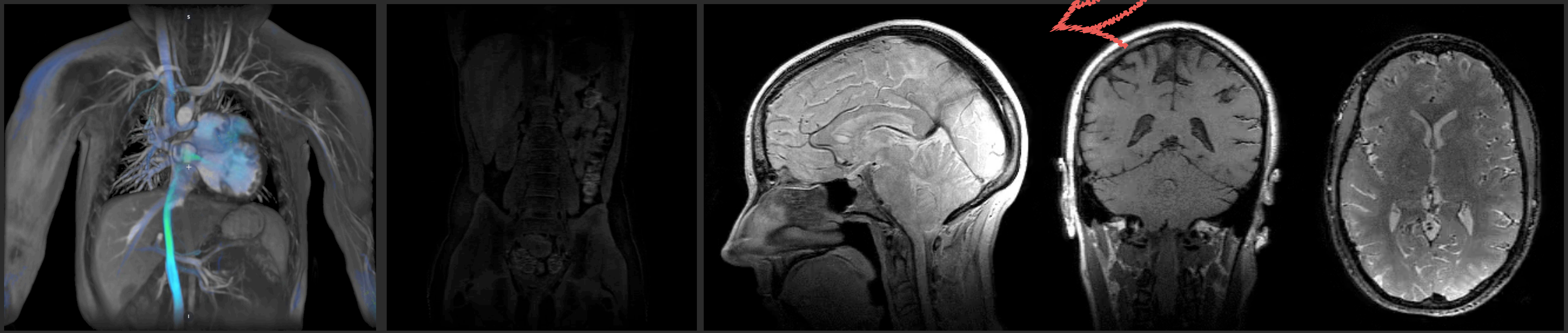


Image Compression

Natural signals/images are compressible

- Standard approach: First collect, then compress

10011010011010
00100111010101
00110100010001
01011010101010
10110010111011
10111010101011
01101101010011
1111

Compression

101000110100
1101011

Image compression

- Non compressed:
  - 3024 x 4032 x 3 colors = 36 Mb
- Compressed = 2 Mb

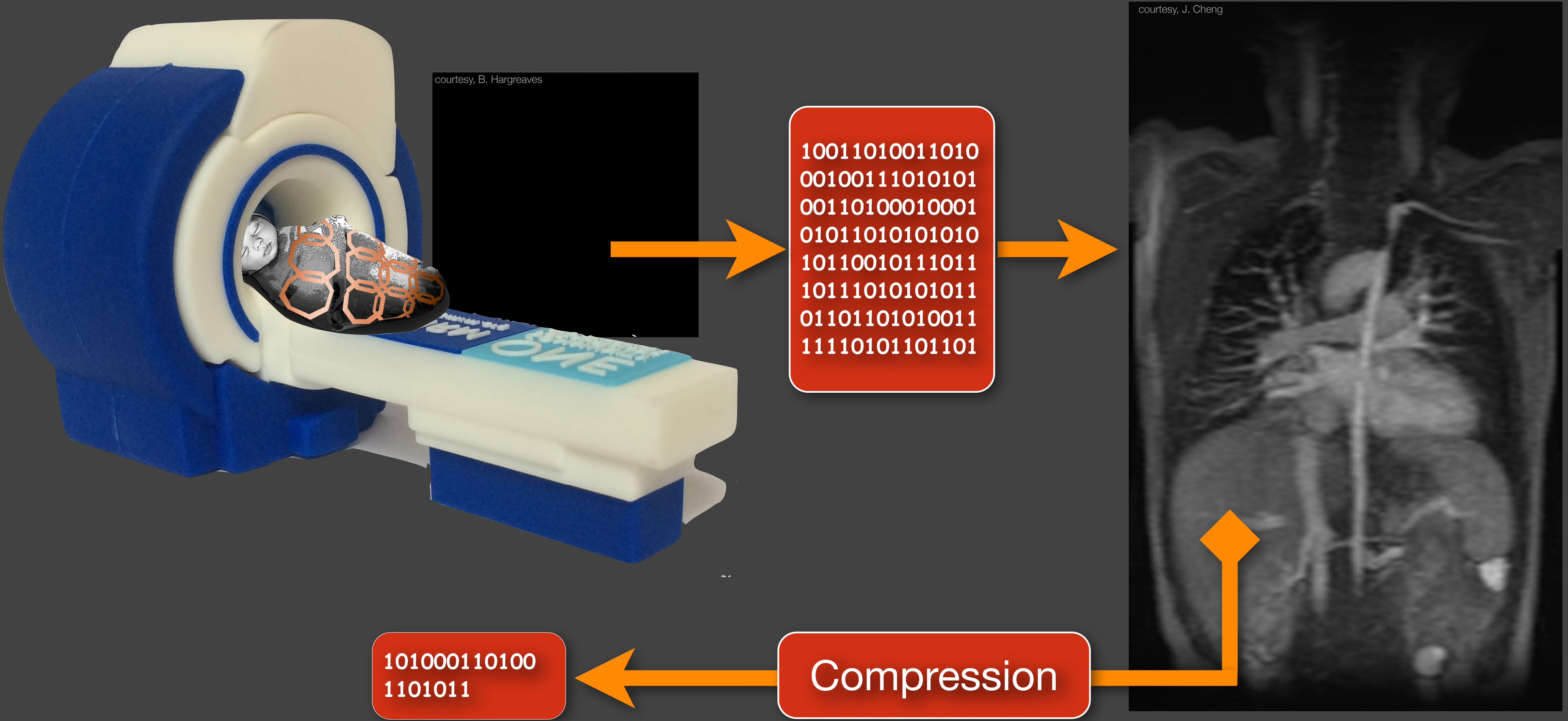
- 18x Compression ratio

Video Compression

- HD Video
  - 1920 x 1080 x 30FPS x 3 colors x 54 second = 10 Gb
- Compressed = 71.6 Mb

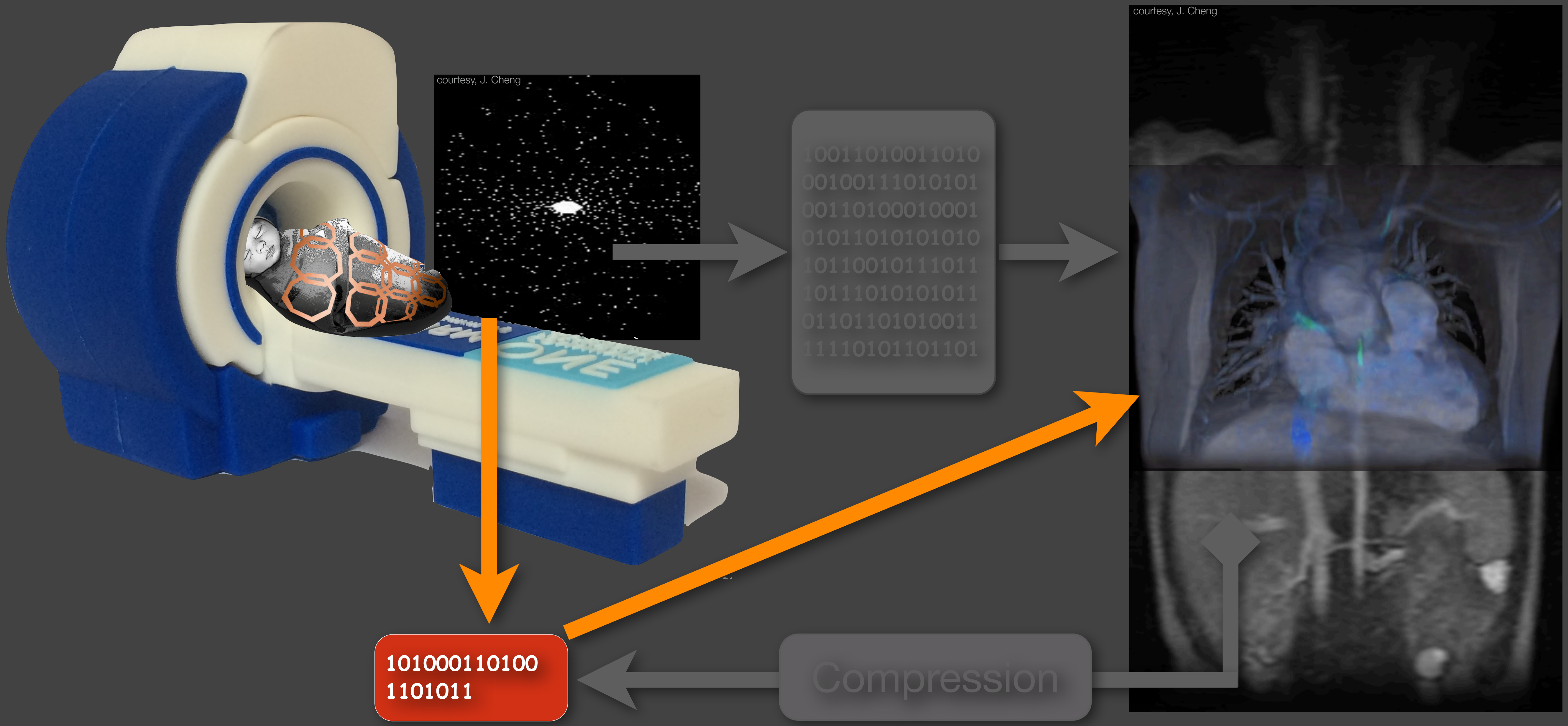
- x140 Compression!

Magnetic Resonance Imaging



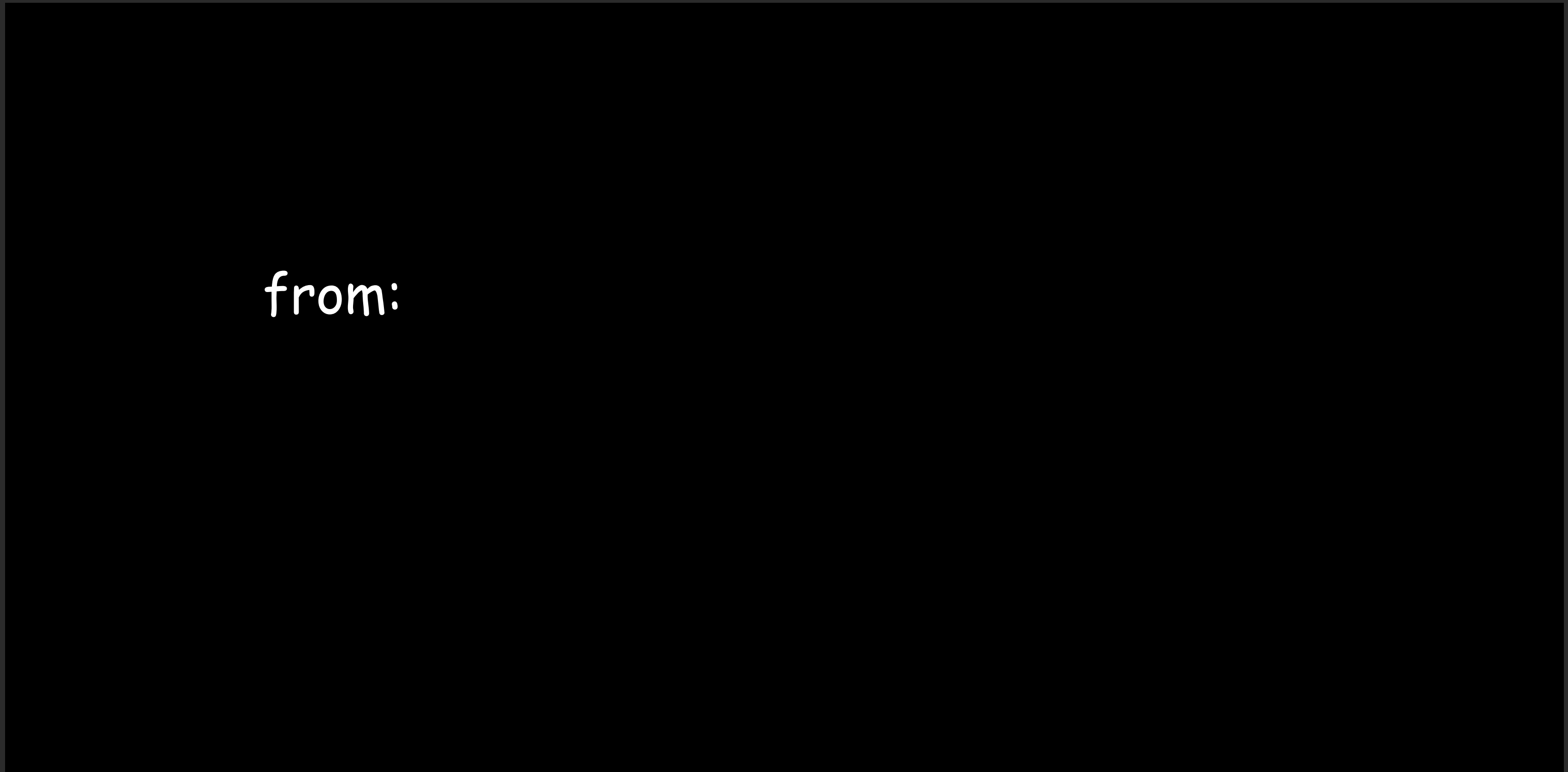
Candes, Romberg, Tao 2006
Lustig, Donoho Pauly 2007

Compressive Imaging



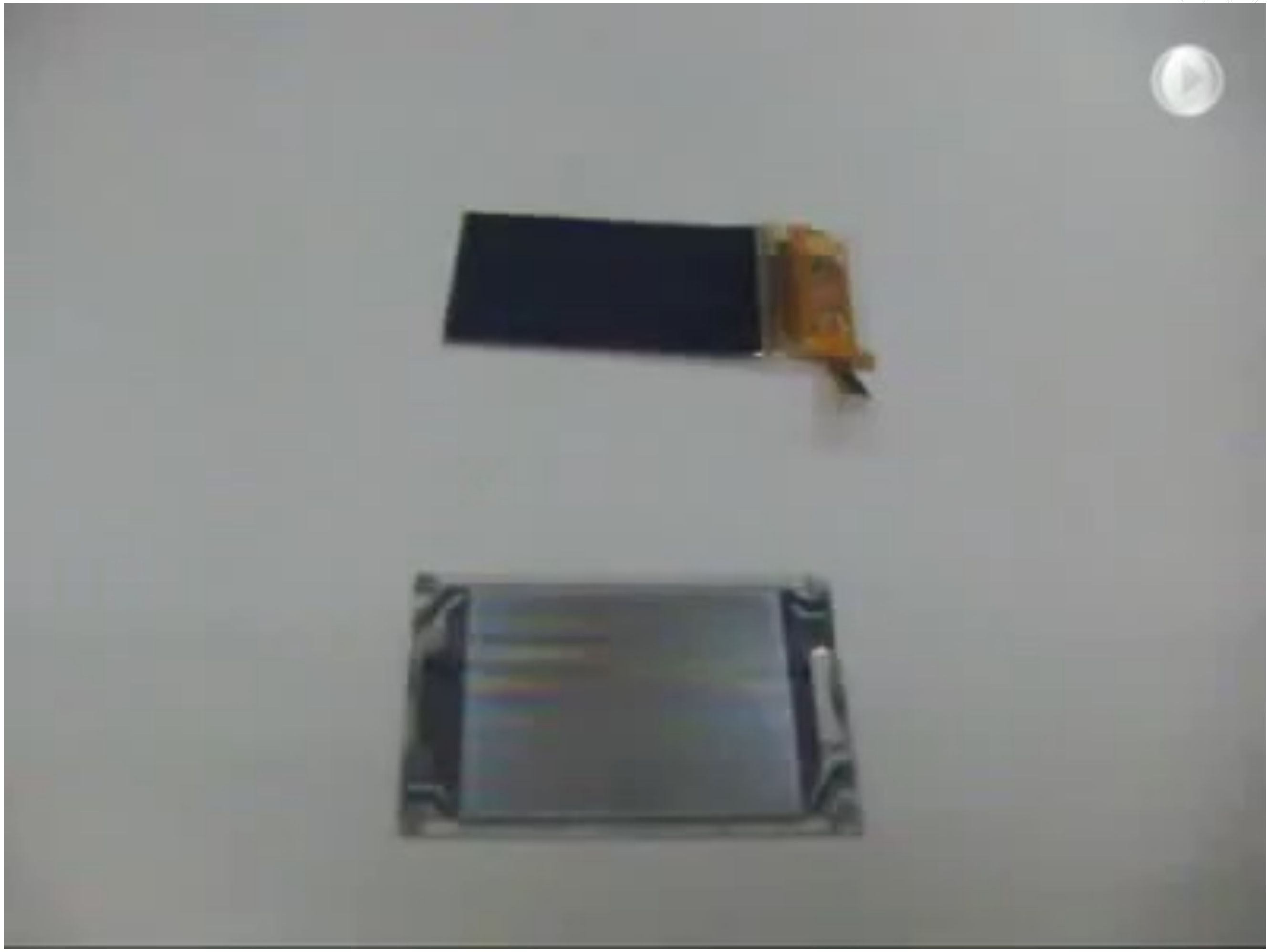
Candes, Romberg, Tao 2006
Lustig, Donoho Pauly 2007

Enhancing an Image Hollywood Style



- You got an image enhancer ?....
- This software is state-of-the-art
- With the right combination of algorithms...

Flexible Electronics



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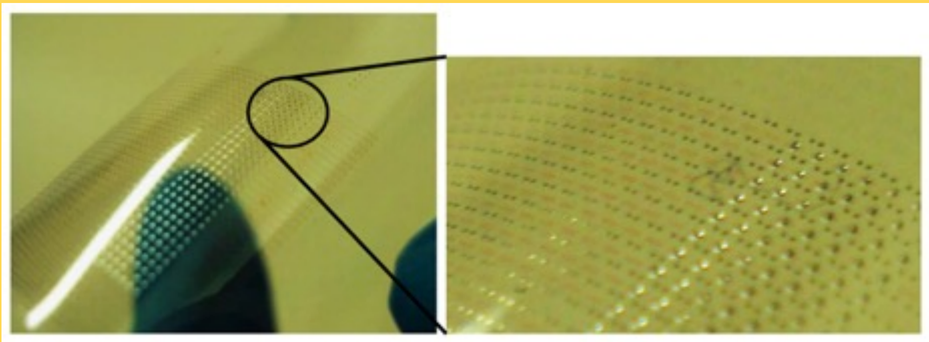
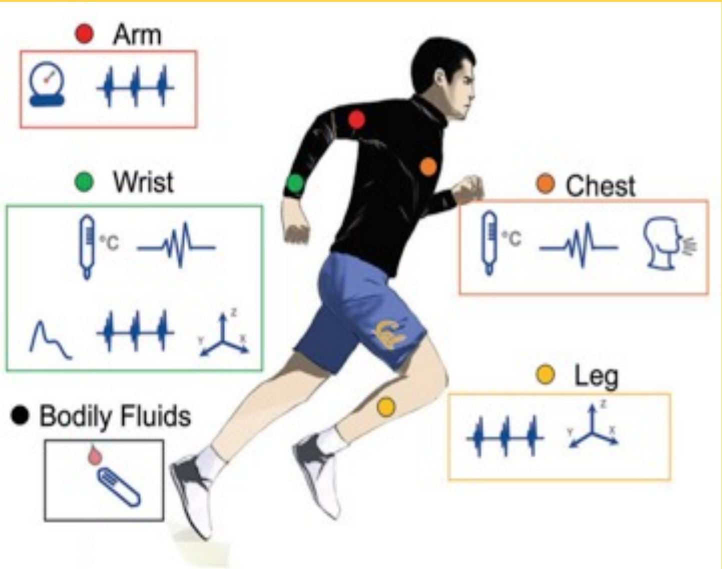
Flexible, Large-Area Electronics

Large-Area Sensing



Nature Photonics 11 (3), 193-199 (2017)

Medical Devices



Advanced Functional Materials 26 (47), 8764-8775 (2016)

Power Sources

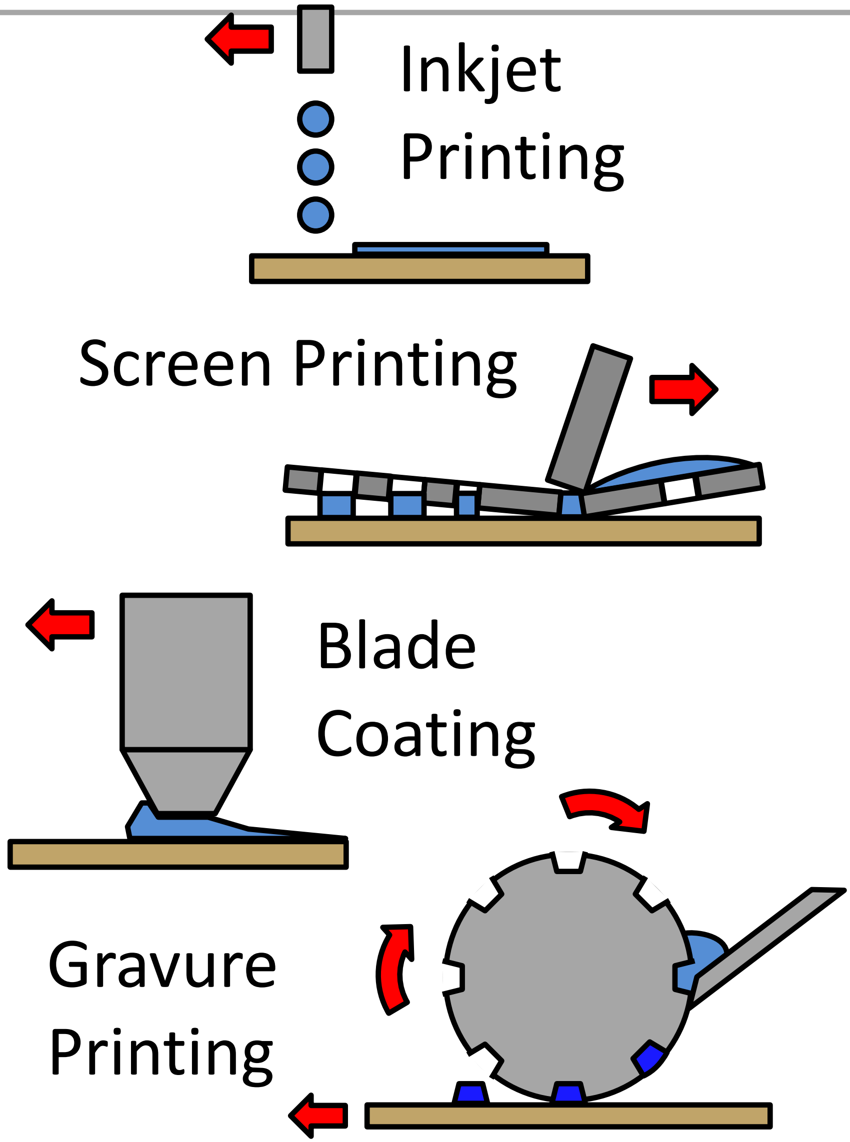
Science Advances 3 (6), e1602051 (2017)

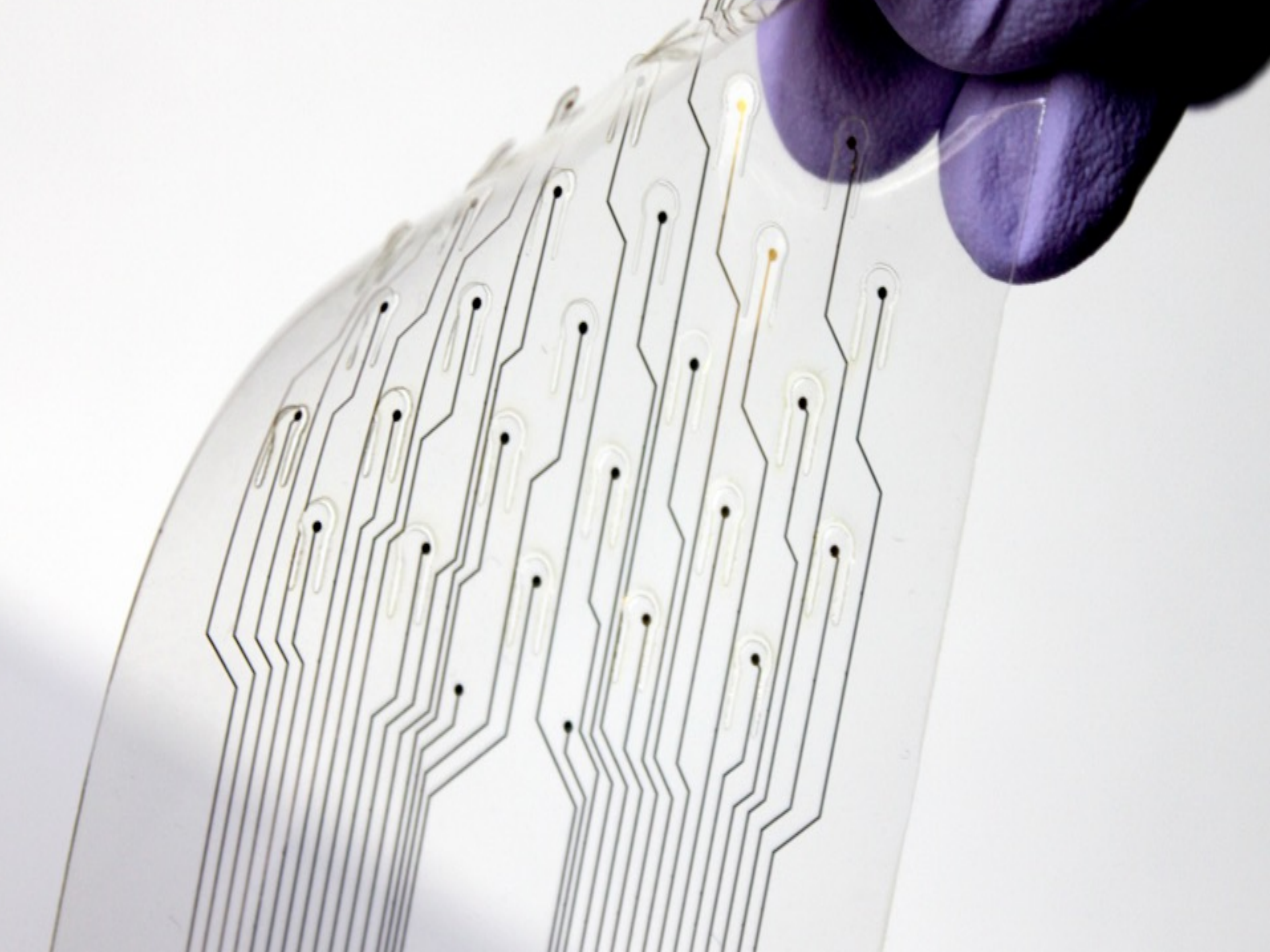
vs. conventional rigid electronics:

- ✓ Less bulky
- ✓ Improved comfort for wearables
- ✓ Improved signal quality

Printing for materials deposition

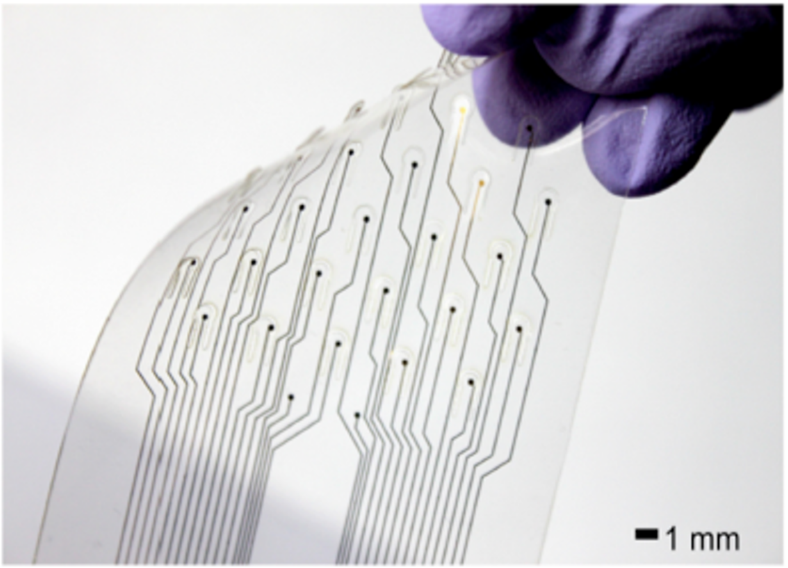
- Electronic materials are directly deposited on flexible substrates using additive printing processes
- Printing enables customization and coverage of large areas at high speed
- Hybrid electronic systems use a combination of printed and conventional (e.g. silicon) devices

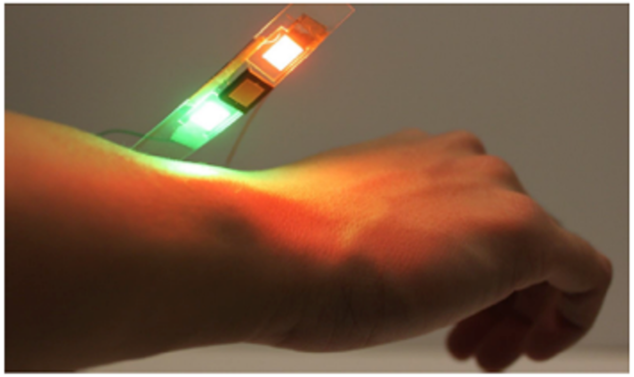


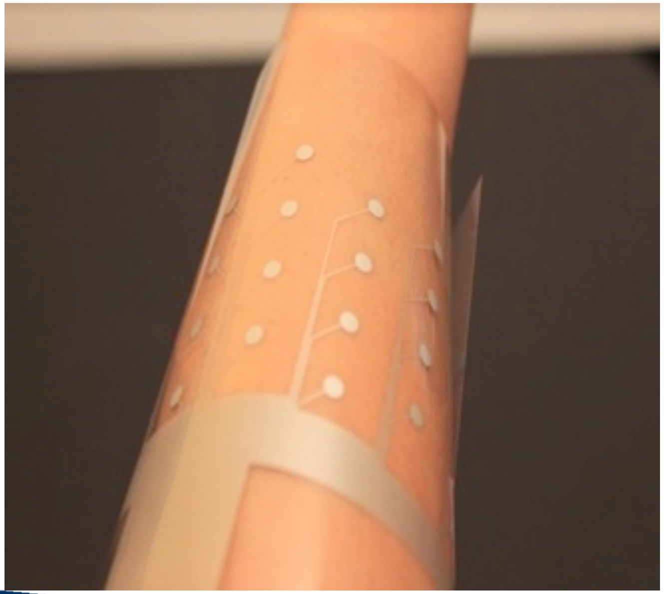


Move away from one size fits all

Form Factor







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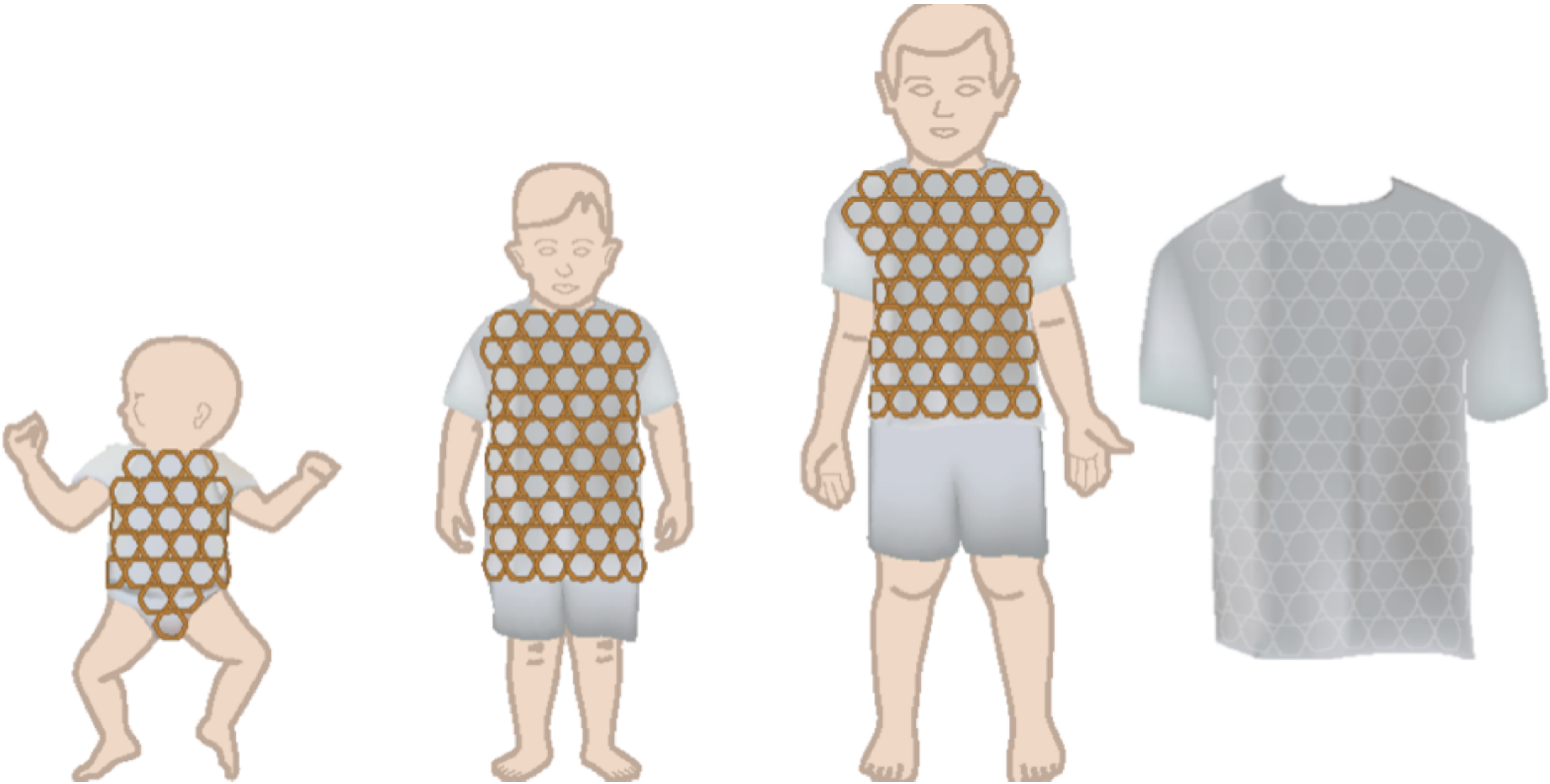
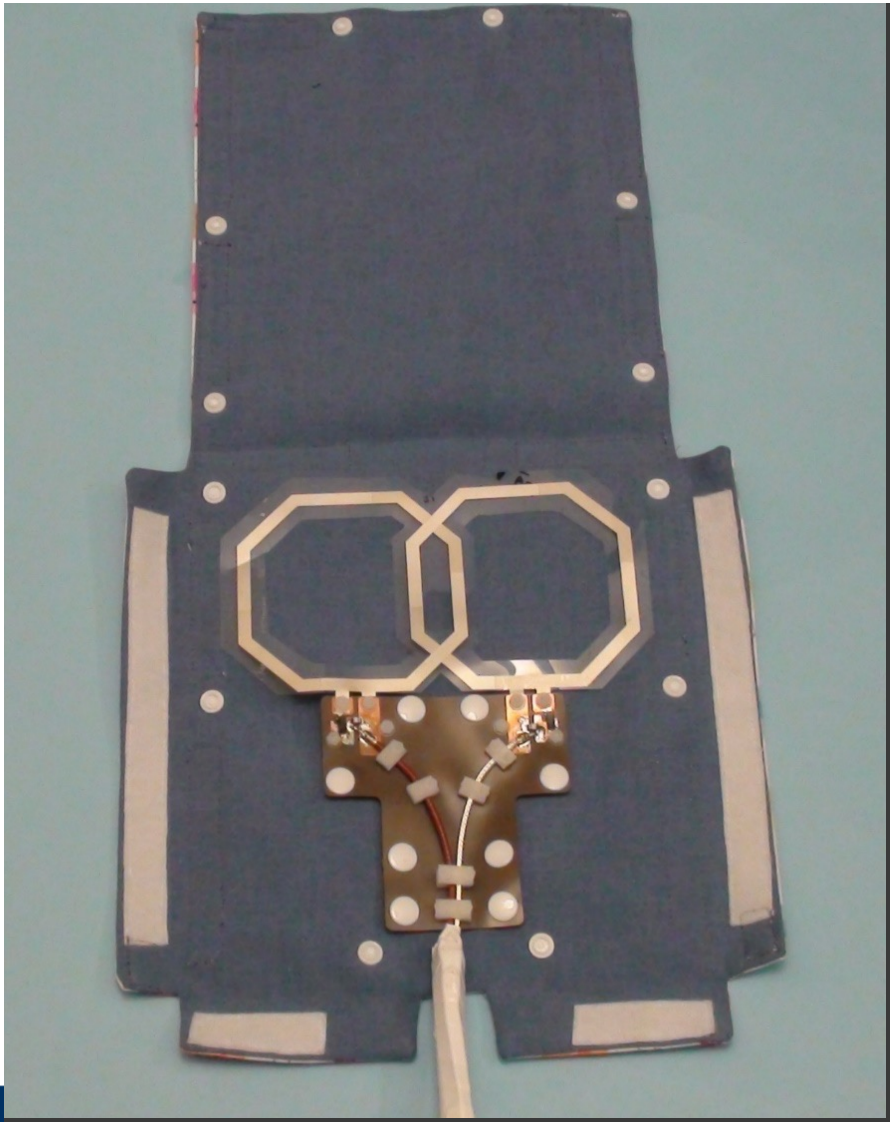
Magnetic Resonance Imaging (MRI)

Design Mind Set

The Vision





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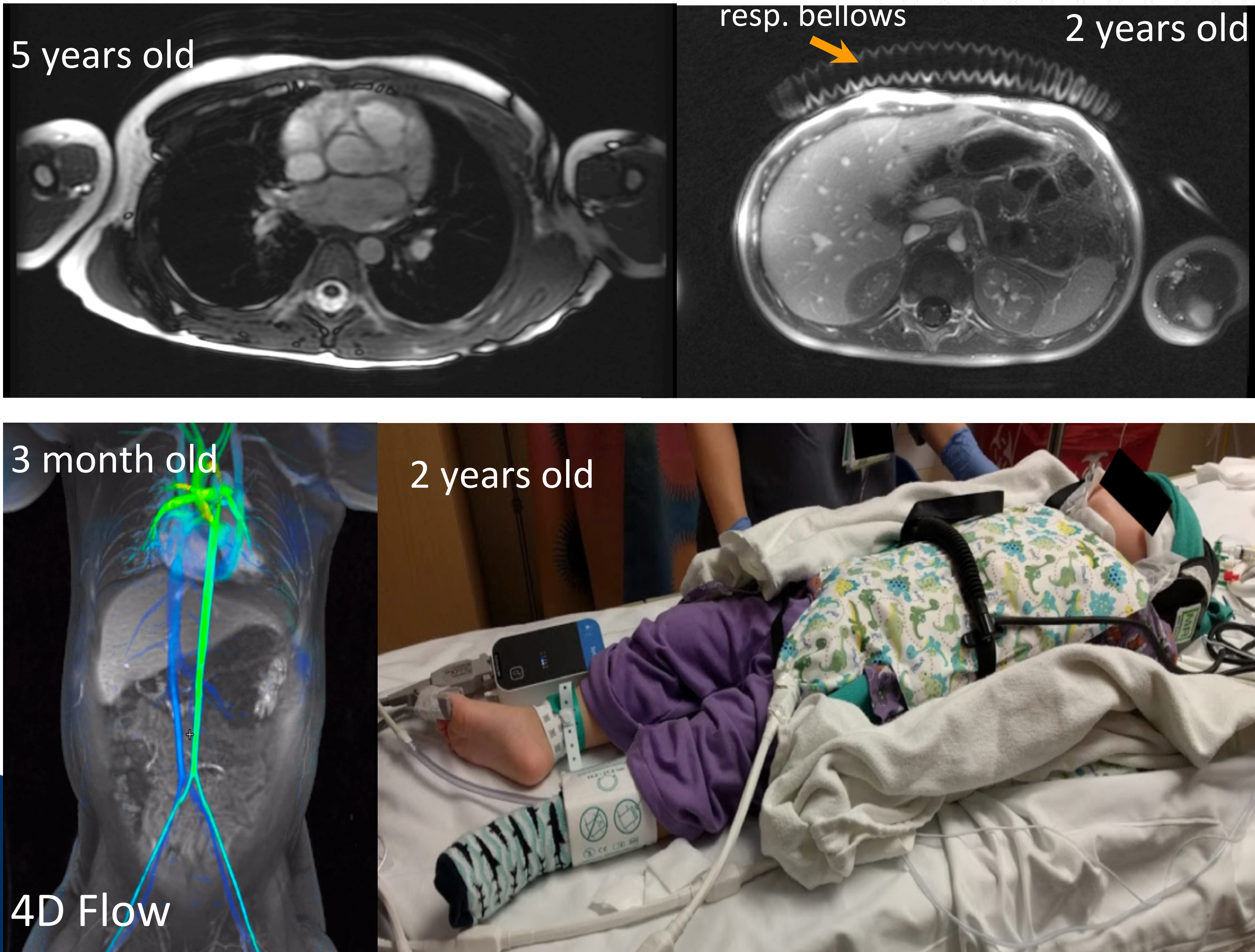
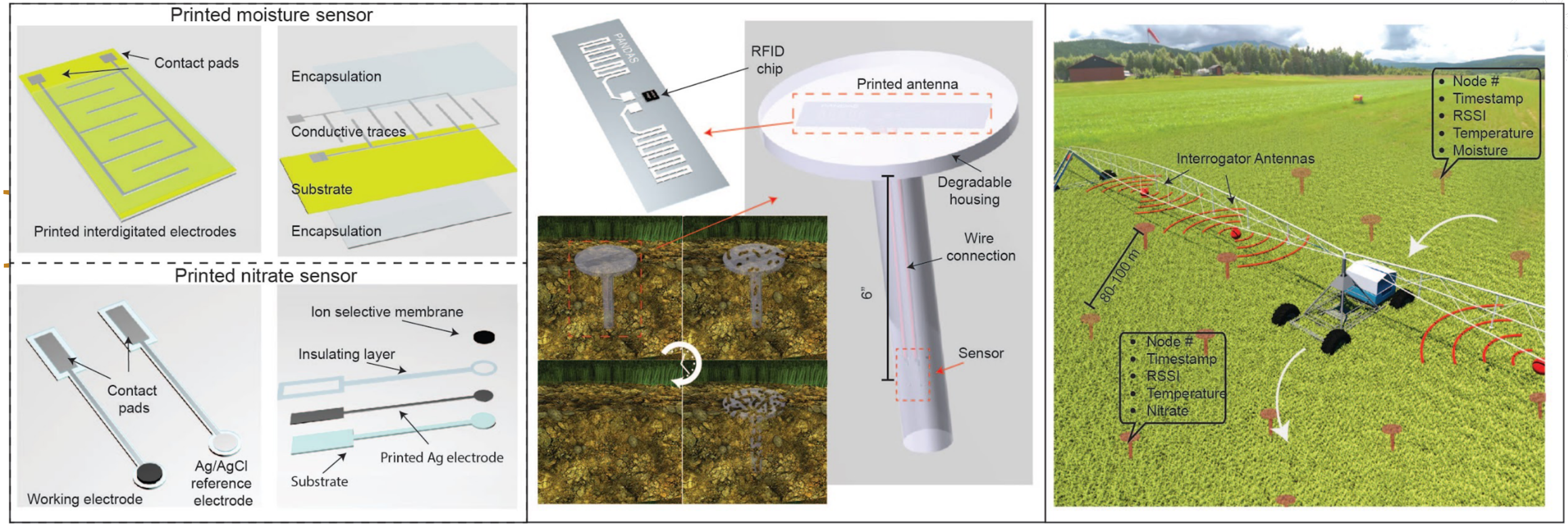
3 kg, 10 week old patient


5 years old
resp. bellows
2 years old
3 month old
4D Flow
2 years old

Precision Agriculture

Sensor Node Concept



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Getting Involved in Research

Tiffany Reardon
Associate Director of Engineering Excellence Programs
Engineering Student Services

Treardon@Berkeley.edu

Berkeley
UNIVERSITY OF CALIFORNIA

Tiffany Reardon

Center for Access to Engineering Excellence

Engineering ESS Student Services

Pre-Engineering Program PREP

Berkeley Engineering

T-PREP

Transfer Pre-Engineering Program

Will You Enjoy Research?

- Hands-on work
- Cross-cultural teamwork
- Questioning everything
- Creating new knowledge

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Finding research at UC Berkeley

Campus:

- research.berkeley.edu
- Undergraduate Research Apprenticeship Program (URAP),
  Haas Scholars and Summer Undergraduate Research Fellowship (SURF) Program , UCDC
  Paid or for units
- Firebaugh Scholars project
- Research Centers across campus

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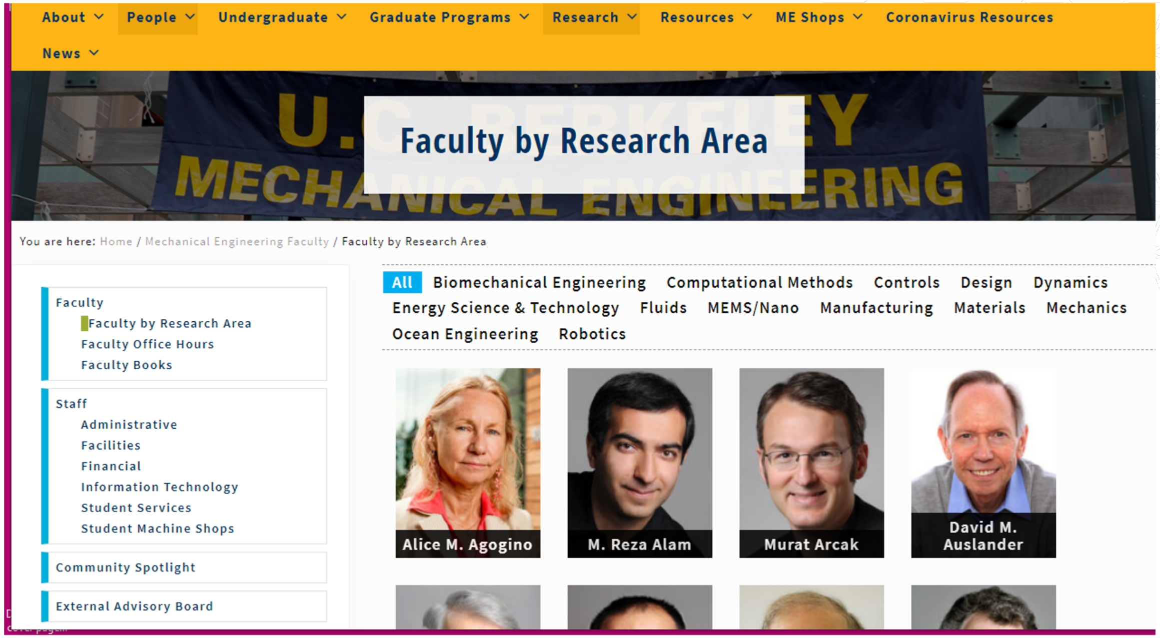
College:

- beehive.berkeley.edu
- ESS Newsletter



Departments:

- Department Research Pages
- https://mse.berkeley.edu/research/
- meet faculty at their office hours

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When meeting a professor and/or interviewing:

BE PREPARED

- Prepare a resume with:
  - relevant coursework (and grades for those courses)
  - skills that could help in research (e.g. project experience, management experience, teamwork experience)
- Familiarize yourself with professor's current projects
  - skim some of their journal publications
  - ask around to find people who know what the research group is like
- Be articulate when conveying your interests
  - Tell why you want to do the work, more than just "to get experience" or "resume building"

Summer Opportunities (off Campus)

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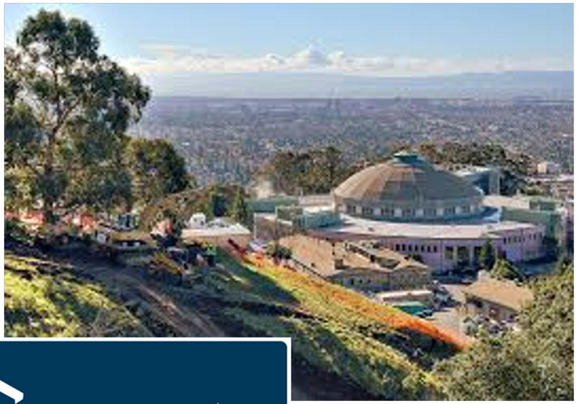
The closest off-campus option: Lawrence Berkeley National Lab (LBNL)

- Chemical Sciences Division
- Climate & Ecosystem Sciences Division
- Computational Research Division
- Energy Geosciences Division
- Engineering Division
- Environmental Energy Technologies Division
- Genomics Division
- Materials Sciences Division
- Nuclear Science Division
- Physics Division
- Scientific Networking Division

Science Undergraduate Laboratory Internship Summer 10 Weeks
Apply in October



Divisions

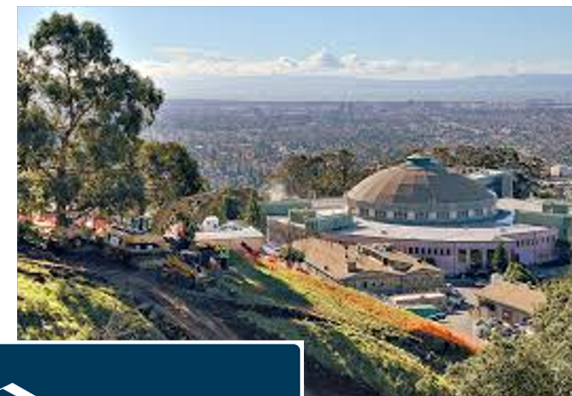
BioEngineeriong &BioMedical Sciences
ESnet Energy Sciences Network
NERSC National Energy Research Scientific Computing Center

Departments
Agile BioFoundry

Advanced Light Source
https://als.lbl.gov/

National Energy Research Scientific Computing Center
https://www.nersc.gov/

Agile BioFoundry
http://agilebiofoundry.org/



BERKELEY LAB

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Visit other campuses (REU)

- REU = Research Experience for Undergraduates
- Hosted by a university department or center
- Funded by the National Science Foundation
- Must be US citizen or permanent resident
- Cohort program with 10ish participants and professional training
- 8-10 weeks, $4000-$8000, depending on housing
- Can help you decide whether to pursue a research-focused graduate degree, and show you are qualified for that degree!

Benefits of an REU

- REU's can strengthen your graduate & fellowship applications

- REUs demonstrate:
  - Interest in the major
  - Preparation for your intended major/college
  - Personal qualities such as leadership or motivation

- Experience life as a researcher
- Meet other scientists and engineers
- Fee waivers for Grad School!

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How to find an REU

Pathways to Science Search
pathwaystoscience.org/Undergrads.asp

NSF REU Search
http://www.nsf.gov/crssprgm/reu/reu_search.jsp

REUFinder (by Tiffany Reardon!)
https://reufinder.com/

Tip: Only apply to programs you are eligible or qualified for!

Carnegie Mellon's Research Experiences for Undergraduates in **Software Engineering** (REUSE) program

first- and second-year undergraduate students. Neither research experience nor advanced coursework in computer science or software engineering is required.

Johns Hopkins NANOTECHNOLOGY FOR BIOLOGY AND BIOENGINEERING RESEARCH EXPERIENCE FOR UNDERGRADUATES (REU) PROGRAM

University of Arizona Cognitive and Autonomous Test Vehicle REU

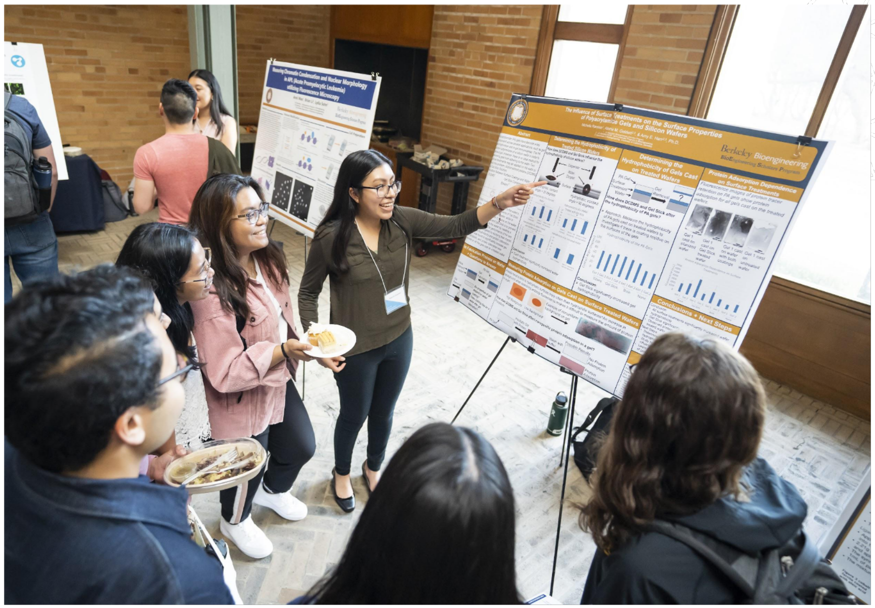
Auburn University Smart UAV's

Northwestern University Center for Synthetic Biology REU

UC San Diego Designing for Safety & Safety by Design

What is the application process like?

- Transcripts
- 2-3 Essays
- Resume or CV
- Letters of Recommendation



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Terms You Will encounter

- Rolling admissions

- Rising Sophomores
  Rising Juniors
  Non-graduating Seniors

- PI (Principal Investigator)

Typical REU Essay Questions

- Please explain why you wish to conduct summer research *of the type offered by the program* and how this relates to your overall interests and goals.

- Describe a major challenge (personal, professional, and/or engineering) you have encountered in your life, how you overcame it, and what you learned as a result of the experience.

Letters of Recommendation

- Approach your faculty “in person”
- Ask if they can give you a ***strong*** letter of recommendation
- Things to take with you when asking for a letter:
    - Drafts of your essays
    - Resume
    - Transcript
- Give your faculty as much time as possible to write their letters

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Tips for Successful Applications

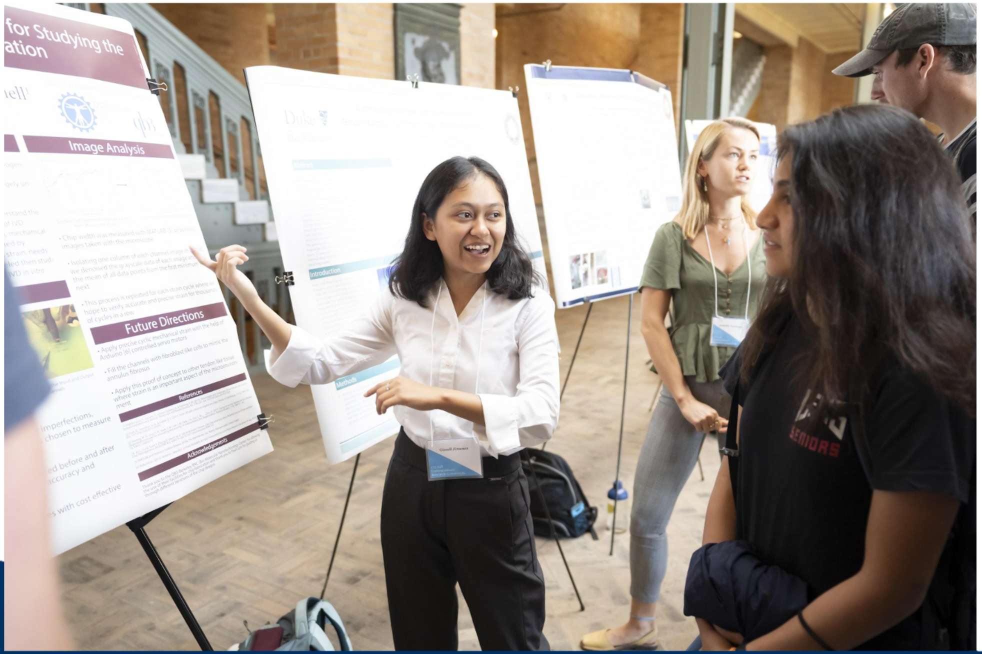
- If you have uncertainties, ask *before* you apply.
- Read FAQ's.
- Be sure that your schedule permits full participation in the program.
- Meet all deadlines, don't ask for extensions.
- Apply to more than one program.
- Verify that your application has been received.

How To Make The Most Of An REU

- Be responsive to all communication
- Calibrate your expectations in advance
  - Familiarize yourself with the research topic
  - Think about your living and social situation
  - Consider how to bring your support structure with you
- Keep an open mind – learning happens very differently during research than during class
- Take advantage of the opportunity
- Research is experimental by nature; your results will not define your future success

Summer Research *is* a Job

- Research project includes study, problem-solving, and discovery.
- Communication responsibilities include weekly meetings, written paper, poster and/or slide presentations.
- You are part of two teams – research group and REU cohort



What NOT to do

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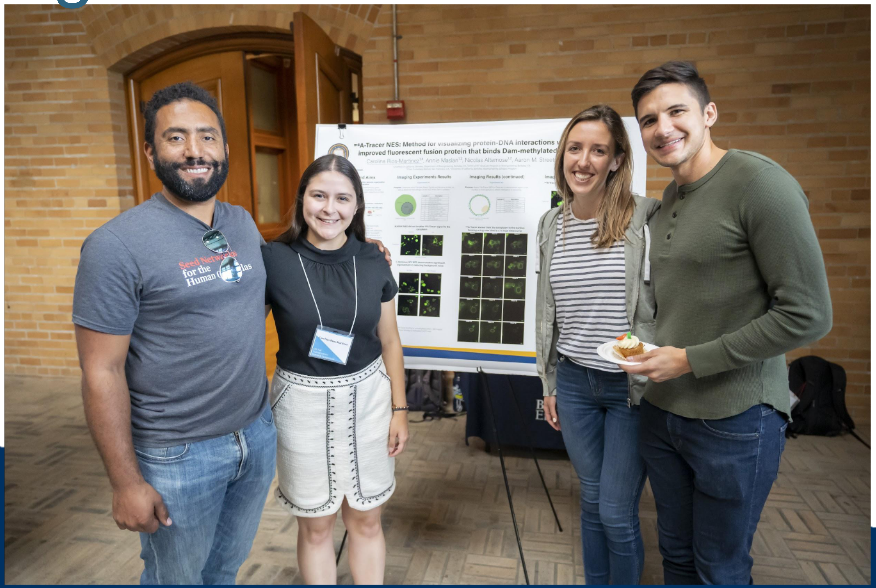
What NOT to do

- Disregard lab meetings, especially with faculty mentor
- Consider this opportunity a summer vacation
- Take an unannounced trip away
- Enroll in summer-session courses
- Misrepresent UC Berkeley

Faculty & Graduate Mentor

- Consider this experience a 9 -10 week interview
- Take initiative – offer alternatives to undesirable results
- Graduate student is your daily supervisor
- Adjust to lab protocol
- Prepare for research meetings
- Meet with faculty mentor



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Follow

REUFinder

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