# Design and Evaluation of a Bioelectric Guidewire

Erin Sutton

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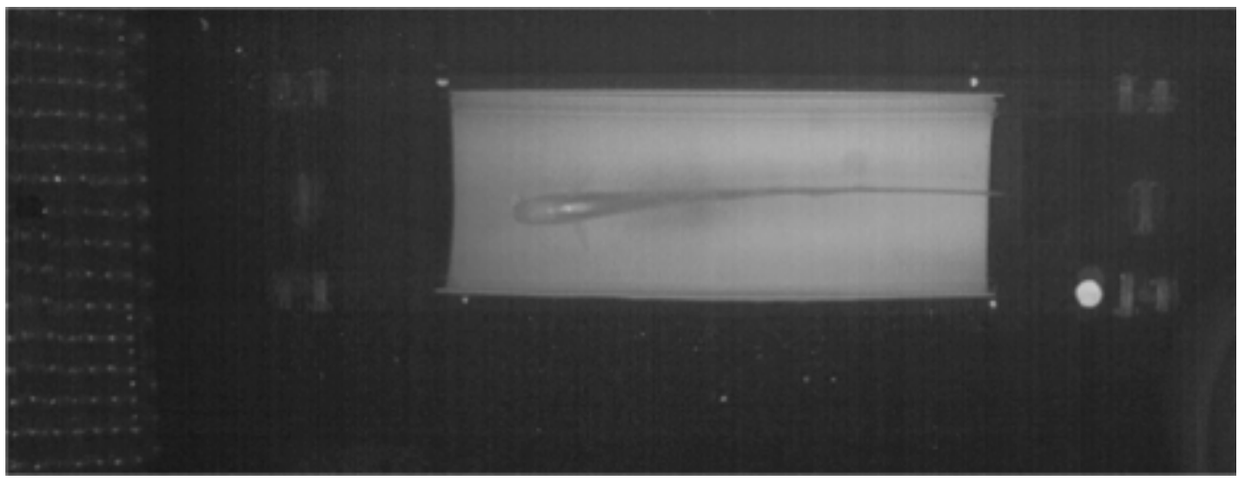
# Clinical Need

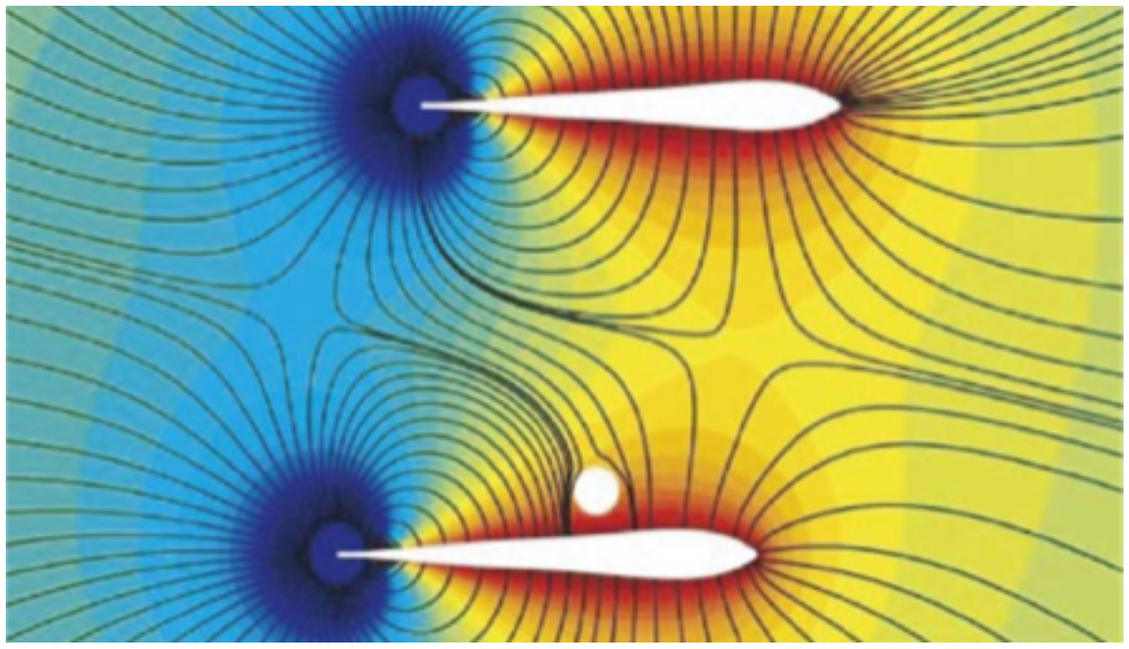
- 8 million intravascular procedures performed under fluoroscopy each year Schauer 2009
- Radiation dose equivalent to 250-3500 chest x-rays CDRH 2010
- Pediatric, pregnant patients especially vulnerable
- Technically challenging

*Can we meet these challenges without radiation?*

# Inspiration



- electric fish use vision and electrosense to characterize and localize objects

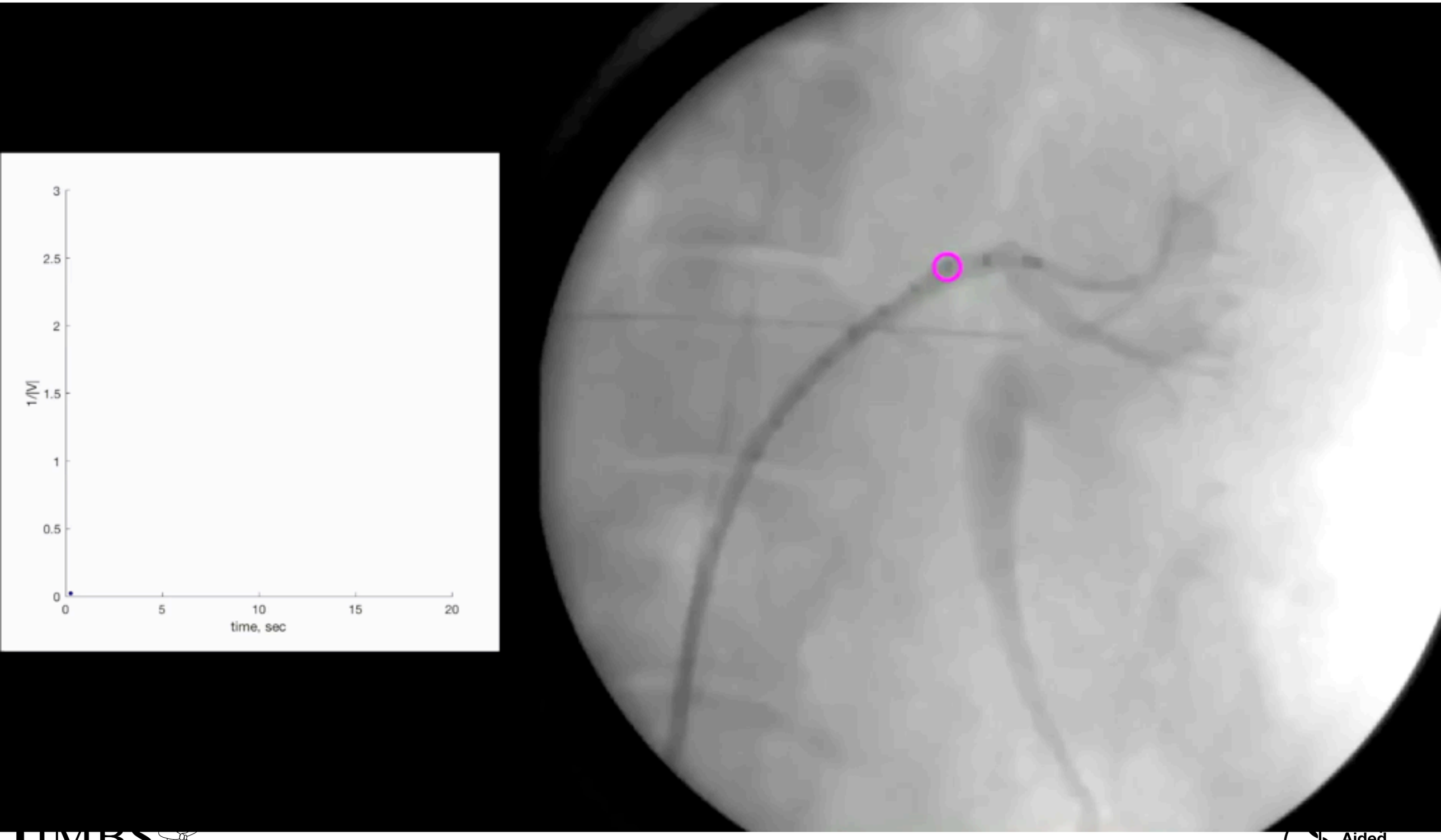


Stamper 2009

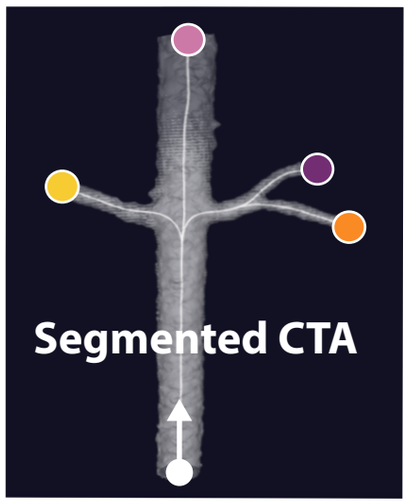
- EOD creates electric field

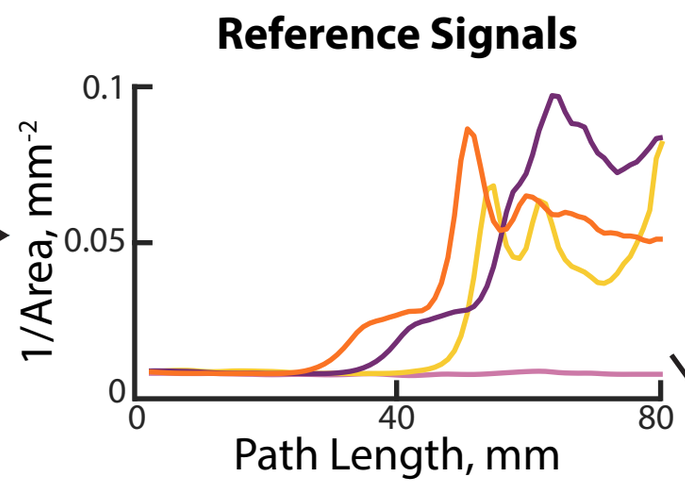
- measure changes to electric field caused by objects of different impedance

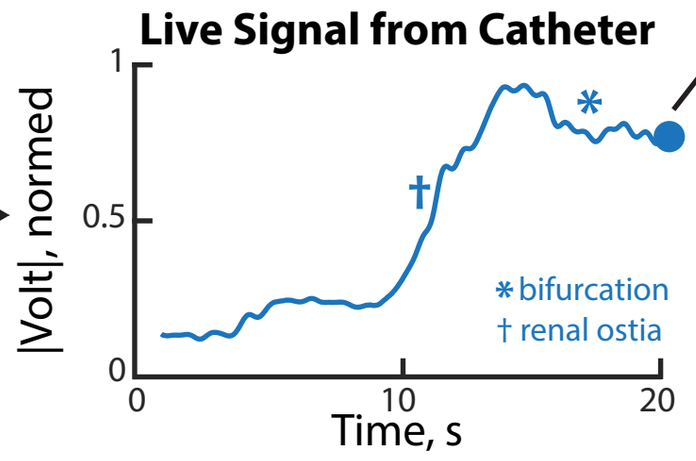
# In Vivo Catheter Test

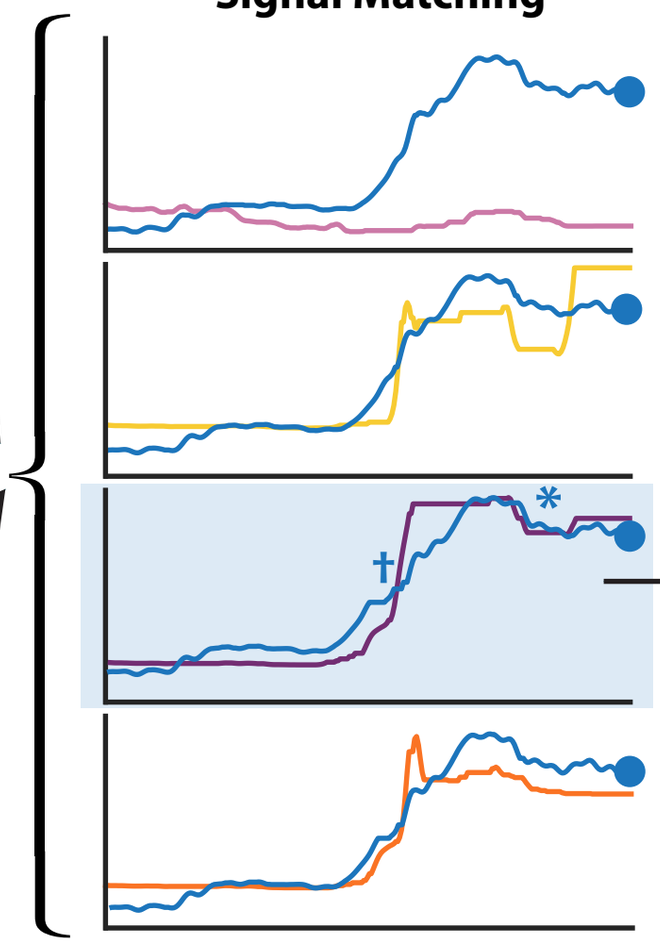


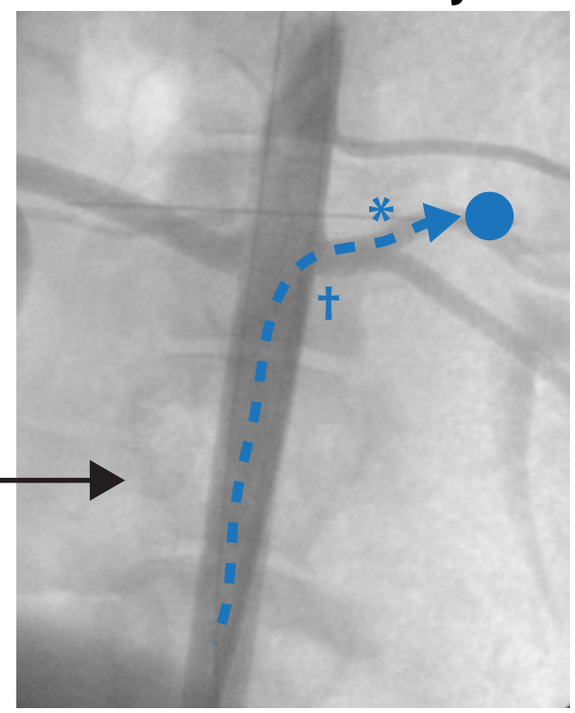
# Bioelectric Navigation



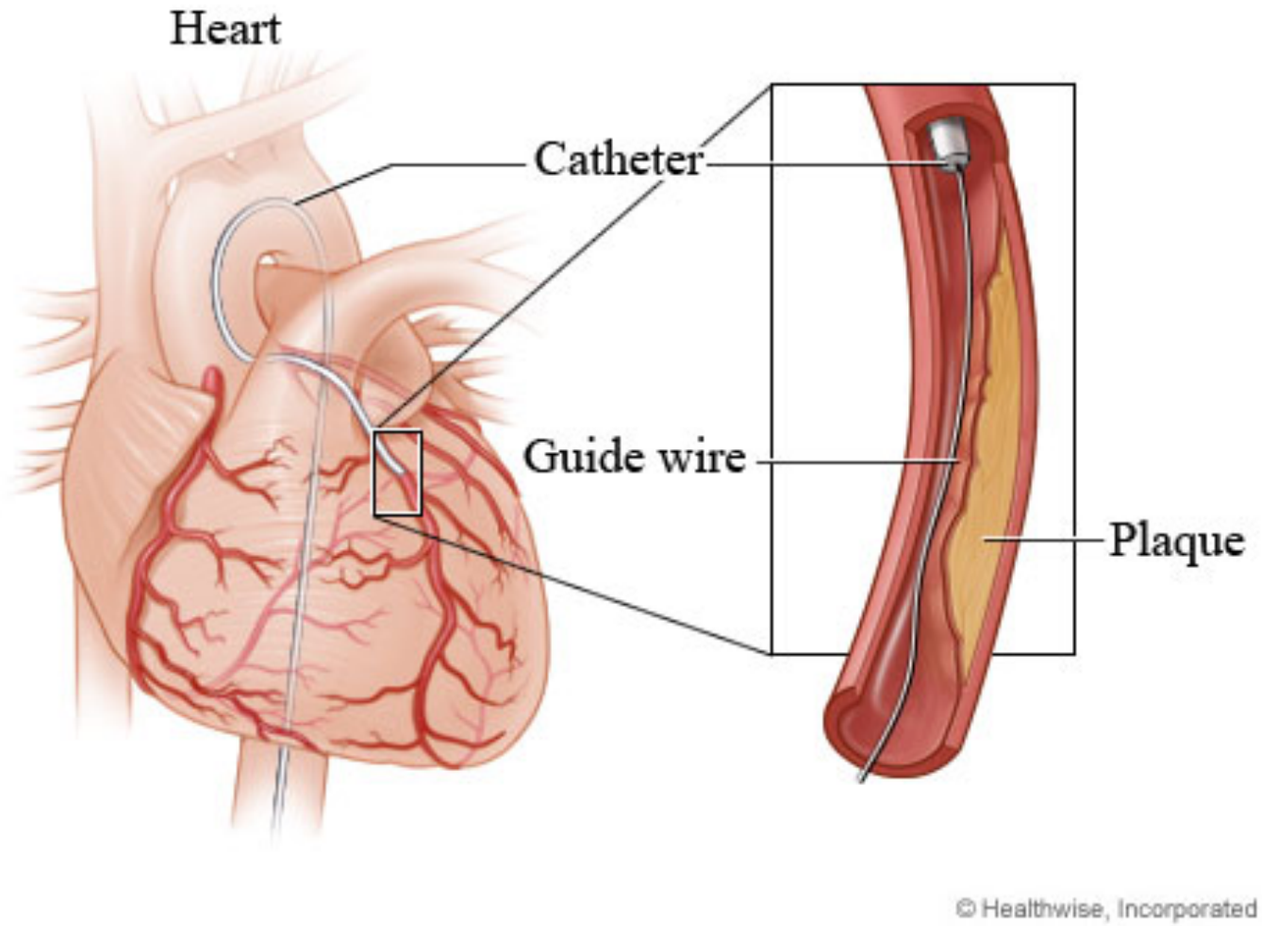



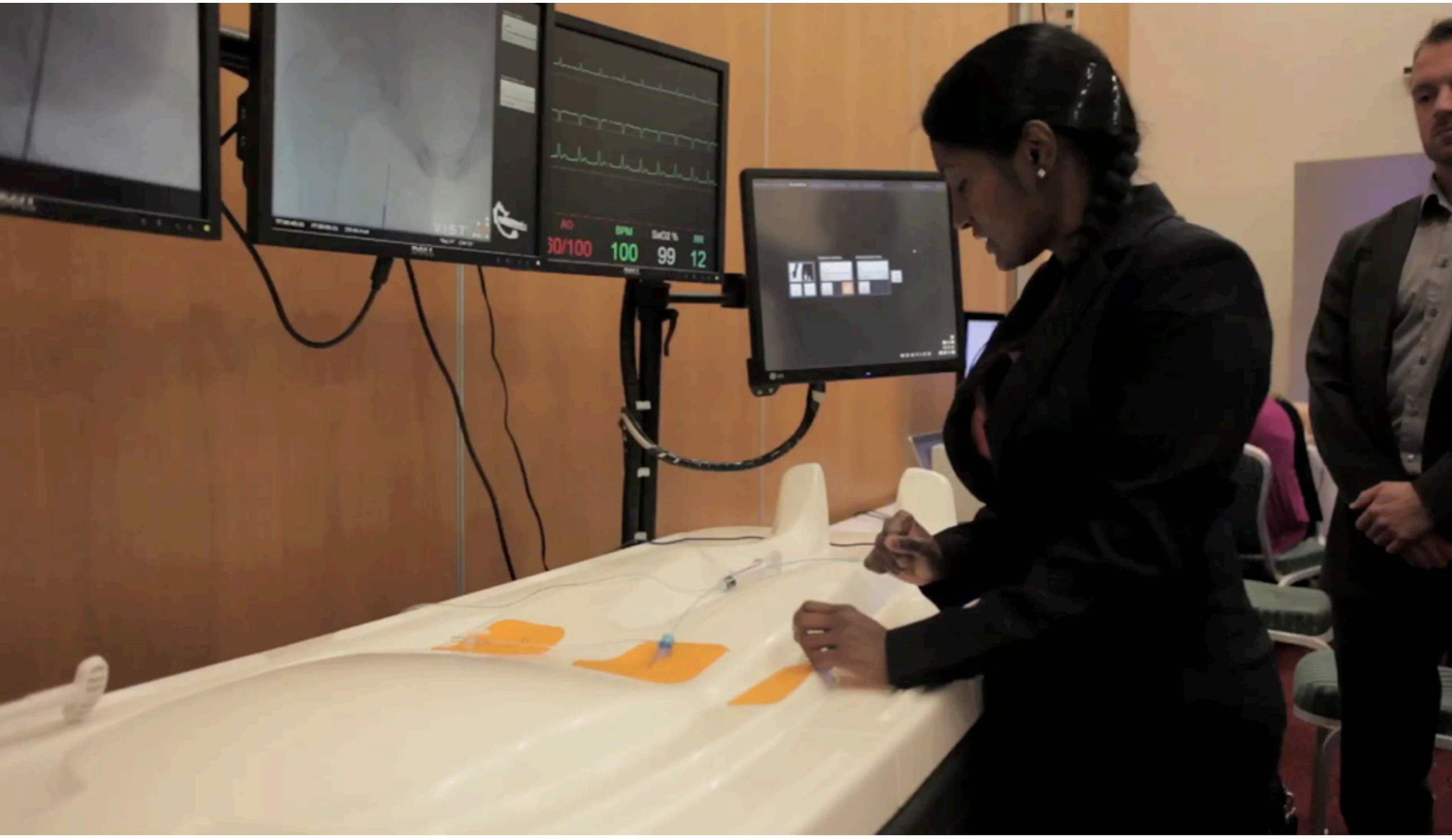



# Project Goal

The state of the art for intravascular navigation is to navigate a guidewire under fluoroscopy to the area of interest then advance a catheter over the guidewire. The current BN prototype uses a commercially available, non-irrigated 6F catheter, too large to be used as a guidewire. The goal of this project is to create a guidewire based on the BN technology.








Source: CAMP/TUM

# Team

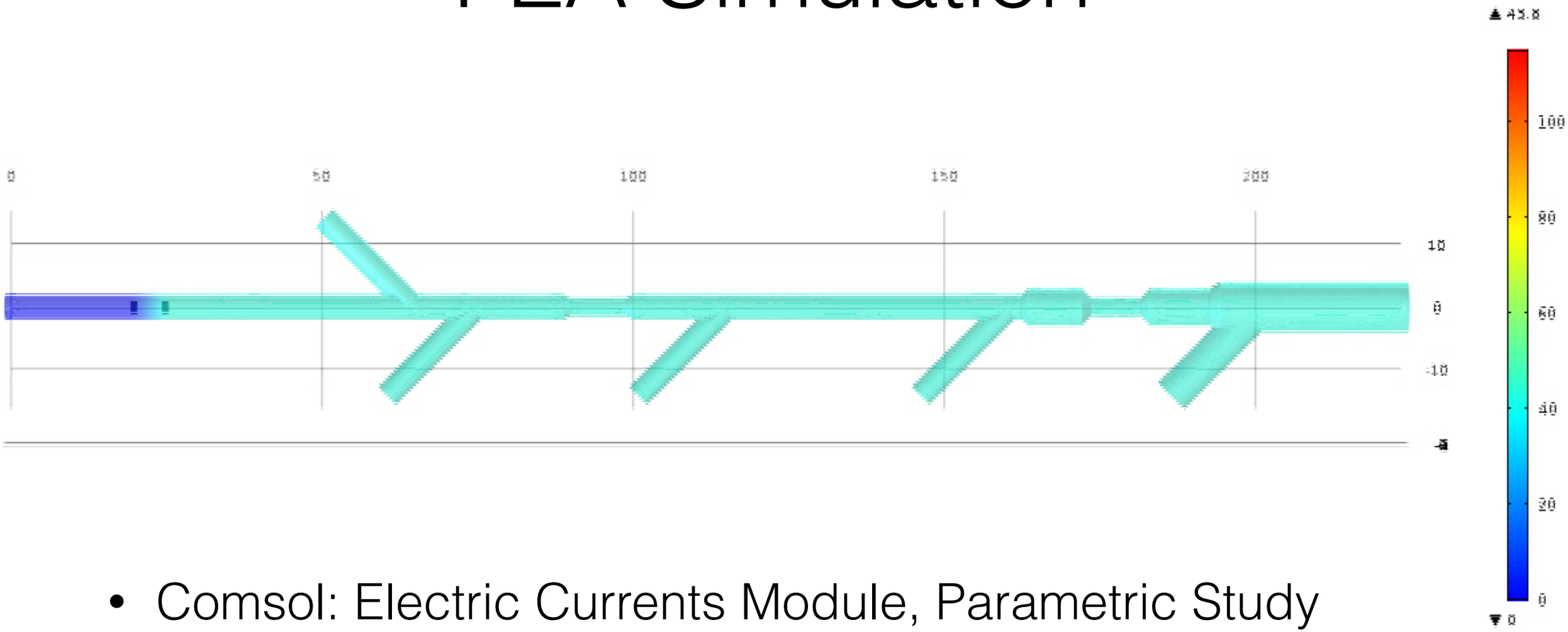
- Erin Sutton
- Bernhard Fuerst
- Nassir Navab
- Noah Cowan

Source: Miller-Stephenson Medical

# Work Plan

- *Research guidewire construction*
- Simulate 3-electrode guidewire in COMSOL
- Design guidewire
  - ✤ Define design constraints
  - ✤ Fully develop at least 3 designs
  - ✤ Perform decision analysis with mentors to pick design
  - ✤ Improve embodiment design
  - ✤ BOM
- Build guidewire
- Test guidewire in acrylic phantom
  - ✤ Measure voltage as guidewire passes through all paths
  - ✤ Use video as ground truth
  - ✤ Compare results with catheter's performance
  - ✤ Detect branches as small as 2 mm

# FEA Simulation



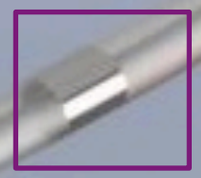

- Comsol: Electric Currents Module, Parametric Study
- Spacing based on Kassab et al. *Ann Biomed Eng*. 2004
- Configurable electrodes

"Spring"

- Copper wire soldered to copper wire

"Cylinder"

- Copper wire soldered to Pt cylinders



"Braid"

- Copper braid wound around core
- Selectively exposed wire

# Design Alternatives

# Decision Analysis

Patents, literature

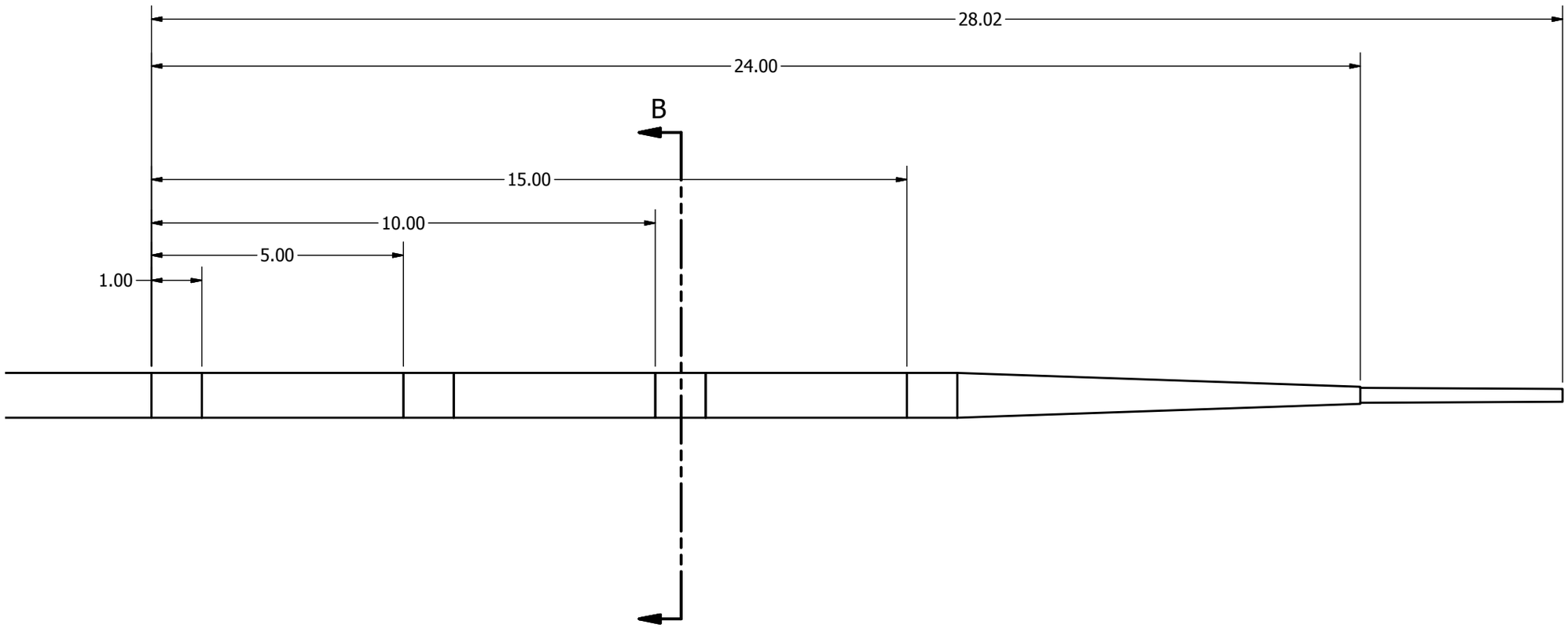
Custom vs off-the-shelf, my skills, available tools

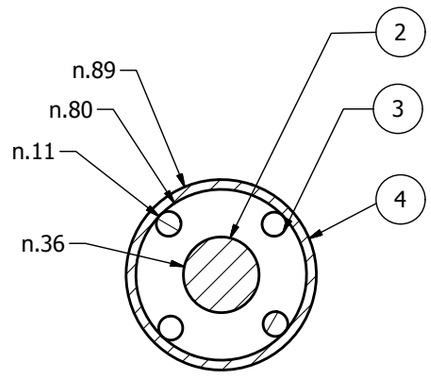
Electrode/wire connection, corrosion

Repeated bends in tortuous paths

| | Weight | Cylinder | | Spring | | Braid | |
|---|---|---|---|---|---|---|---|
| | | Raw | **Weighted** | Raw | **Weighted** | Raw | **Weighted** |
| Evidence | 5 | 10 | **50** | 7 | **35** | 3 | **15** |
| Ease of Manufacture | 4 | 5 | **20** | 8 | **32** | 6 | **24** |
| Durability | 4 | 8 | **32** | 4 | **16** | 3 | **12** |
| Flexibility | 3 | 5 | **15** | 7 | **21** | 7 | **21** |
| Electrode Surface Area | 5 | 10 | **50** | 6 | **30** | 3 | **15** |
| | | | | | | | |
| Total | | | **167** | | 134 | | 87 |

# Embodiment Design

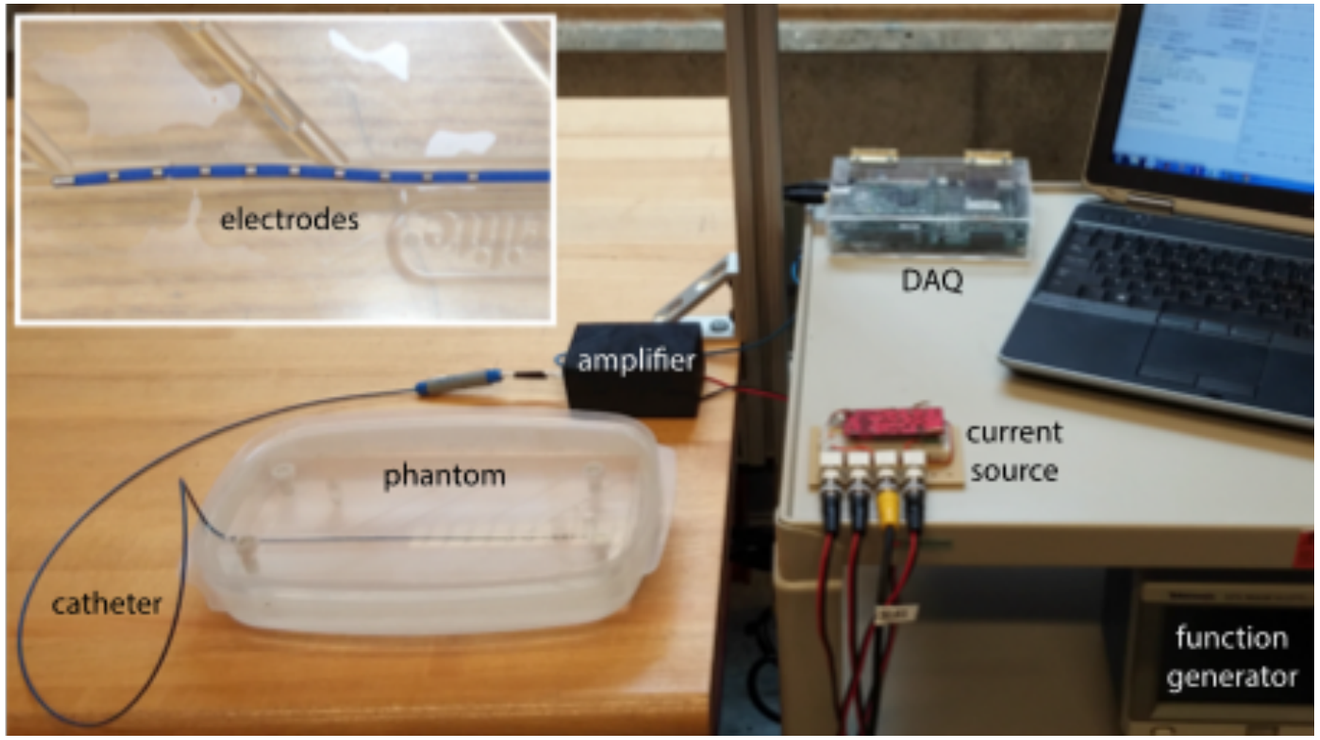


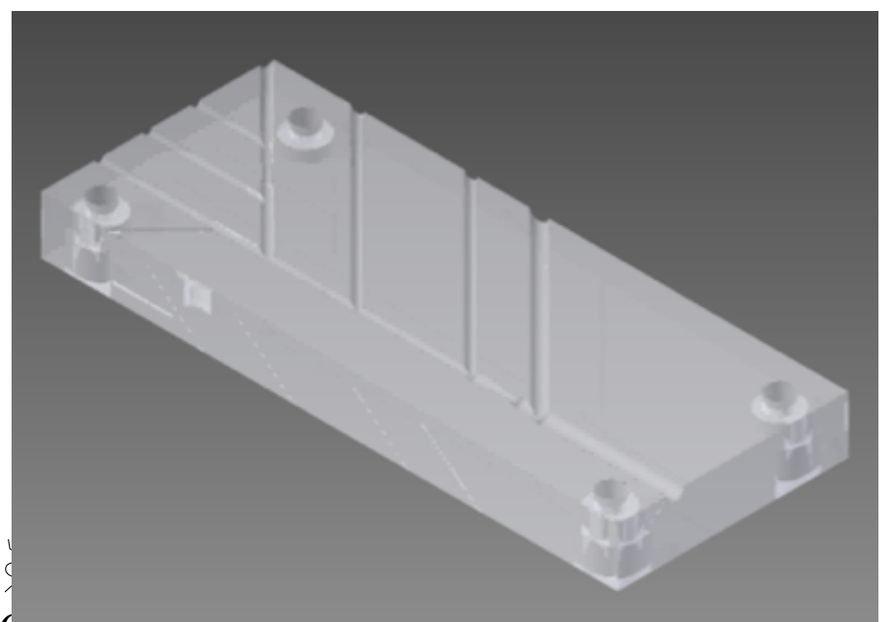




SECTION B-B
SCALE 40 : 1

- 0.014” commercial guidewire core
- 0.035” Pt cylinders
- 34 AWG coated stainless steel wire

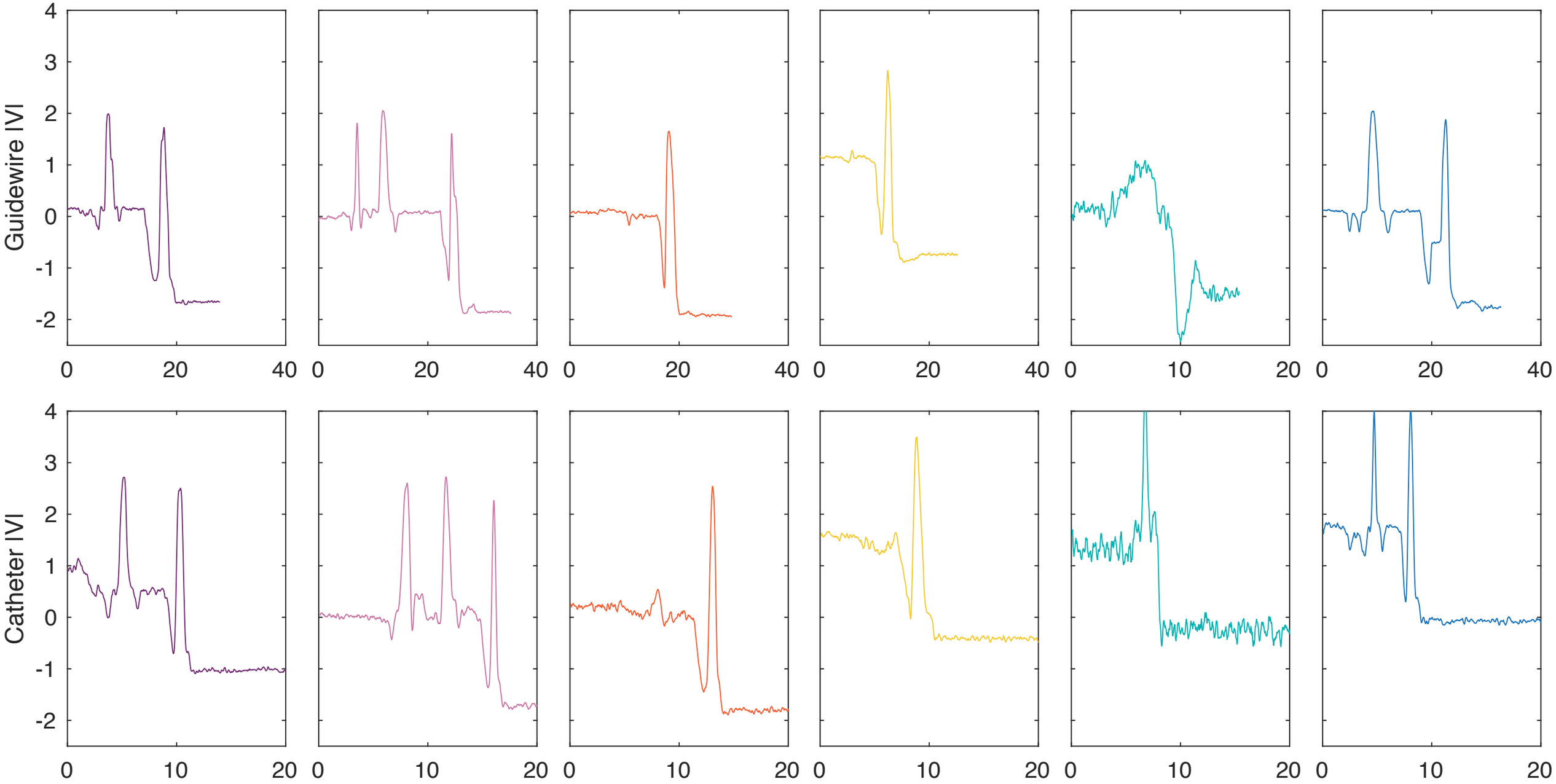
# Experimental Setup



- phantom in 0.9% NaCl bath
- camera records guidewire trajectory as it is drawn through 6 paths at 1-2 mm/s
- signal to input electrode is ±5 mV at 730 Hz at constant 18 μA
- voltage between electrodes amplified and filtered
- DFT and matching in Matlab

# Results

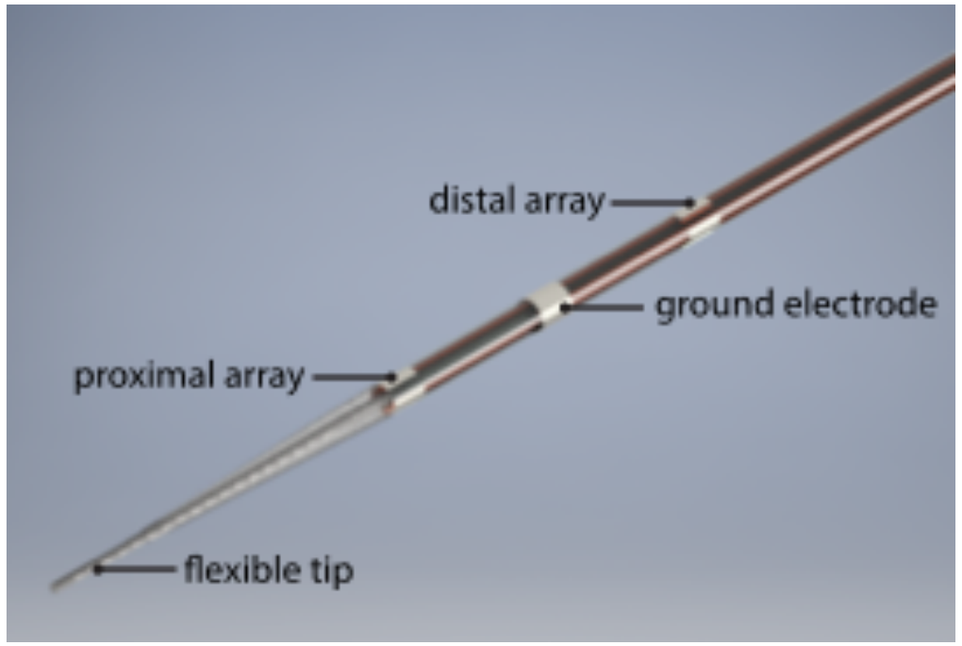


| Minimum | Expected | Maximum |
|---|---|---|
| Project Plan report and presentation | | |
| simulation with single stenosis | simulation in phantom's main path | simulation with configurable electrodes |
| repaired current sources | replacement current sources | design for new current sources |
| CAD design of a single guidewire | several CAD designs for guidewire | |
| Checkpoint presentation | | |
| working guidewire prototype | | |
| experiment design report | | ACUC submission for *in vivo* experiment |
| experimental results from acrylic phantom study | | ~~results from experiment in gelatin phantom~~ |
| Final poster and report | | |

# Deliverables

# Next Steps

- Guidwire
  - ✤ professional prototype
  - ✤ cadaver and *in vivo* studies
- Catheter
  - ✤ *in vivo* study
  - ✤ software: GUI and matching algorithm
  - ✤ add direction detection




# Let's Graduate!

- CIS II final poster — May 18, 2:30-5
- catheter paper — May
- thesis — June
- defense — early July
- vacation — lolz
- have baby — August 10-ish
- thesis edits — October
- start job — November

Please come to grade!

# References


- D.A. Schauer and O.W. Linton. NCRP Report No. 160, Ionizing radiation exposure of the population of the United States, medical exposure–are we doing less with more, and is there a role for health physicists? ***Health Phys***, 97(1):1–5, 2009.
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- Stamper, S., Roth, E., Cowan, N., and Fortune, E. (2012). Active sensing via movement shapes spatiotemporal patterns of sensory feedback. ***J Exp Biol***, 215(9):1567-1574.
- UK Endovascular Trainees. [UKETS]. (2013, June 26). ***Cardiac Catheterisation Part 1 – Left Coronary***. [video]. Retrieved from https://youtu.be/zF8jk_F9Beo.