Worm Nose Touch Measurements @ ETH

April 3rd, 2008

Two Types of Worm Experiments

Behavioral (Active)
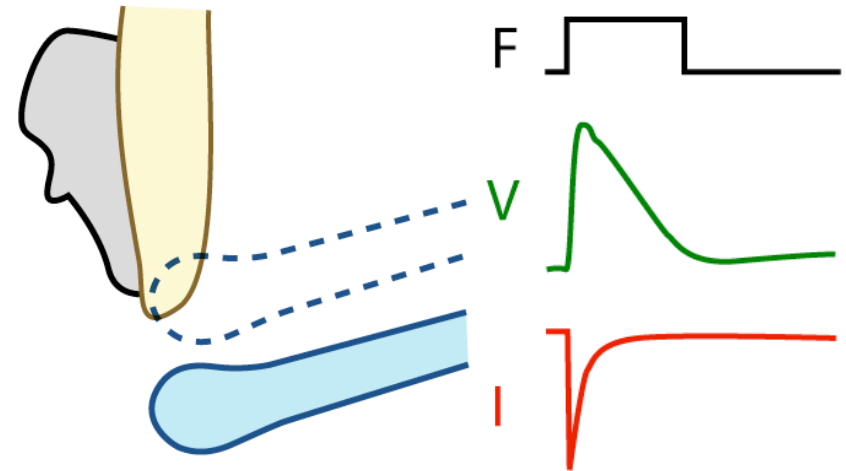
Physiological (Passive)

Touch sensitive

http://microsystems.stanford.edu/~jcdoll/
nosetouch/NoseTouch.mp4

Touch insensitive

http://microsystems.stanford.edu/~jcdoll/
nosetouch/osm-9mutCrawl_2.mp4

Worm is glued down (grey stuff), force is
applied to the nose with a glass probe,
voltage and current in neuron is recorded

Questions to Answer

1. What size force elicits a behavioral response?

2. Does this value agree with physiological experiments?

Force Measurement Probe

- In-plane electrostatic force sensor

- From silicon wafer (MEMS)

- Force resolution ~10nN

- Resonant freq ~350Hz

- www.femtotools.com

- Left arm is whacked off for worm measurements (normally an actuator for gripping)
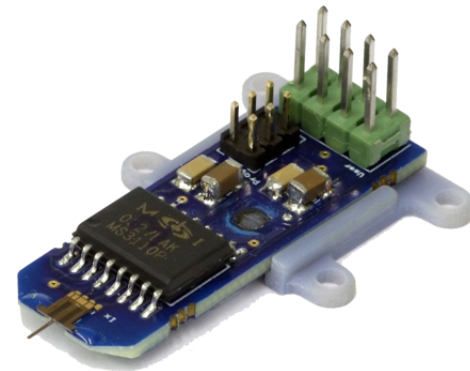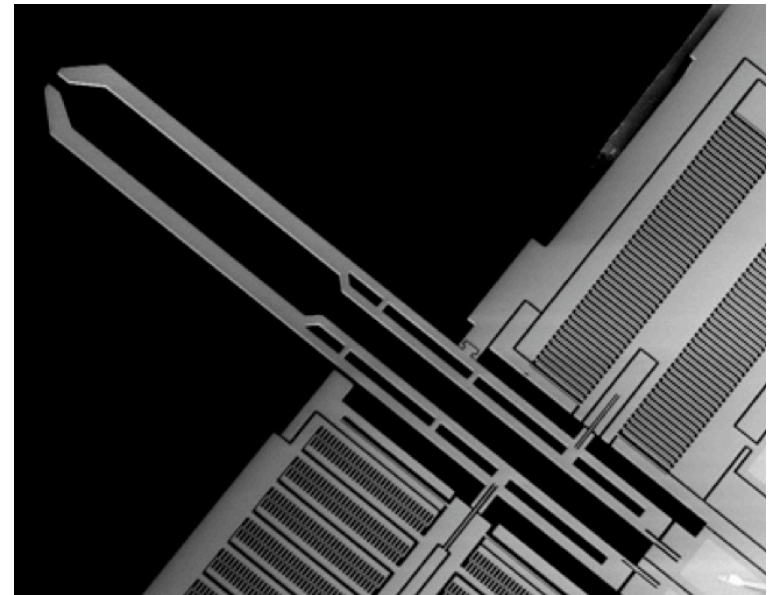
Experimental Setup
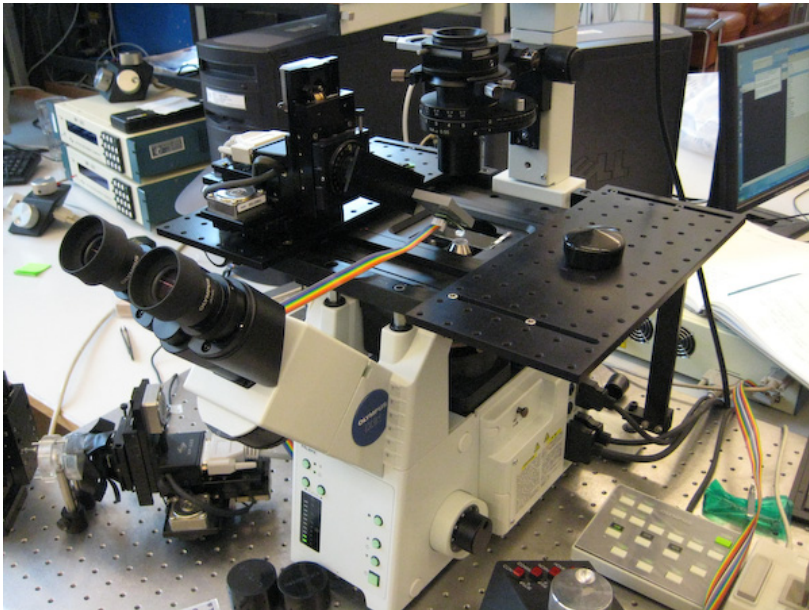
Worms on top of piece of agar, inverted microscope (100x mag), motorized stage. Sensor mounted on 3-axis motor (manual or computer control). Acquisition with Labview.

Experiment Procedure

- Bleach worms to synchronize
- At L4 (48 hours @ 25C) wash onto agar w/o food
- Cut out piece of agar, put on inverted microscope
- Move sample stage (x/y) and probe (z) manually to position for nose touches
- Take data + record movie
  - Move probe into the way of moving worm, let worm run into it
  - Sample at 100kHz and downsample to 10kHz
- Go back and watch movie, recording times of 'good' impacts (see next slide)
- Record approximate impact times, run through matlab script to grab data and make plots

What Counts as a Touch?

- Probe hits red area on worm

- Worm backs away
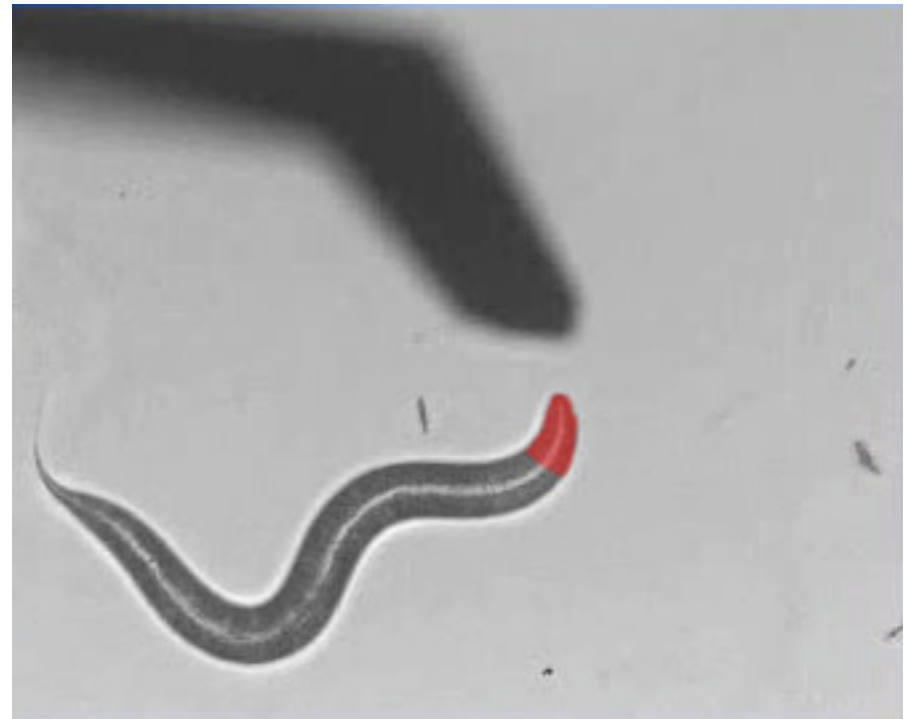
Data Analysis

- N2 data was poorly sampled (100kHz rate for 10 samples, ~15msec pause, repeat)
  - Effective sampling rate is ~65Hz
  - **Fixed for mutant worms**
- The 'push' on the probe is usually softer than the 'pull' away from it
  - Worms can generate more force than they respond to in nose touch
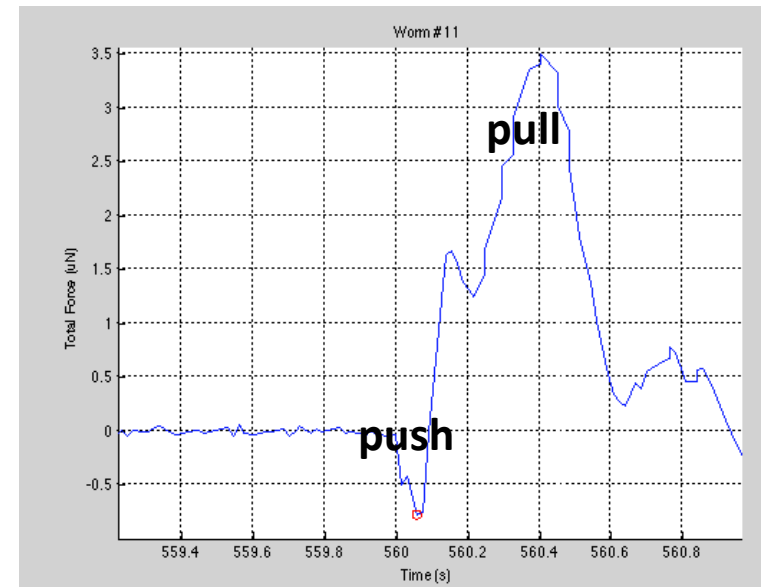
(from N2_Thursday_11)

Data

- Movies and histograms are online at:

  http://microsystems.stanford.edu/~jcdoll/
  nosetouch/

N2 Data Summary

8 worms
106 nose touches

Touches
Mean = 1.10 uN
STD = 0.91 uN
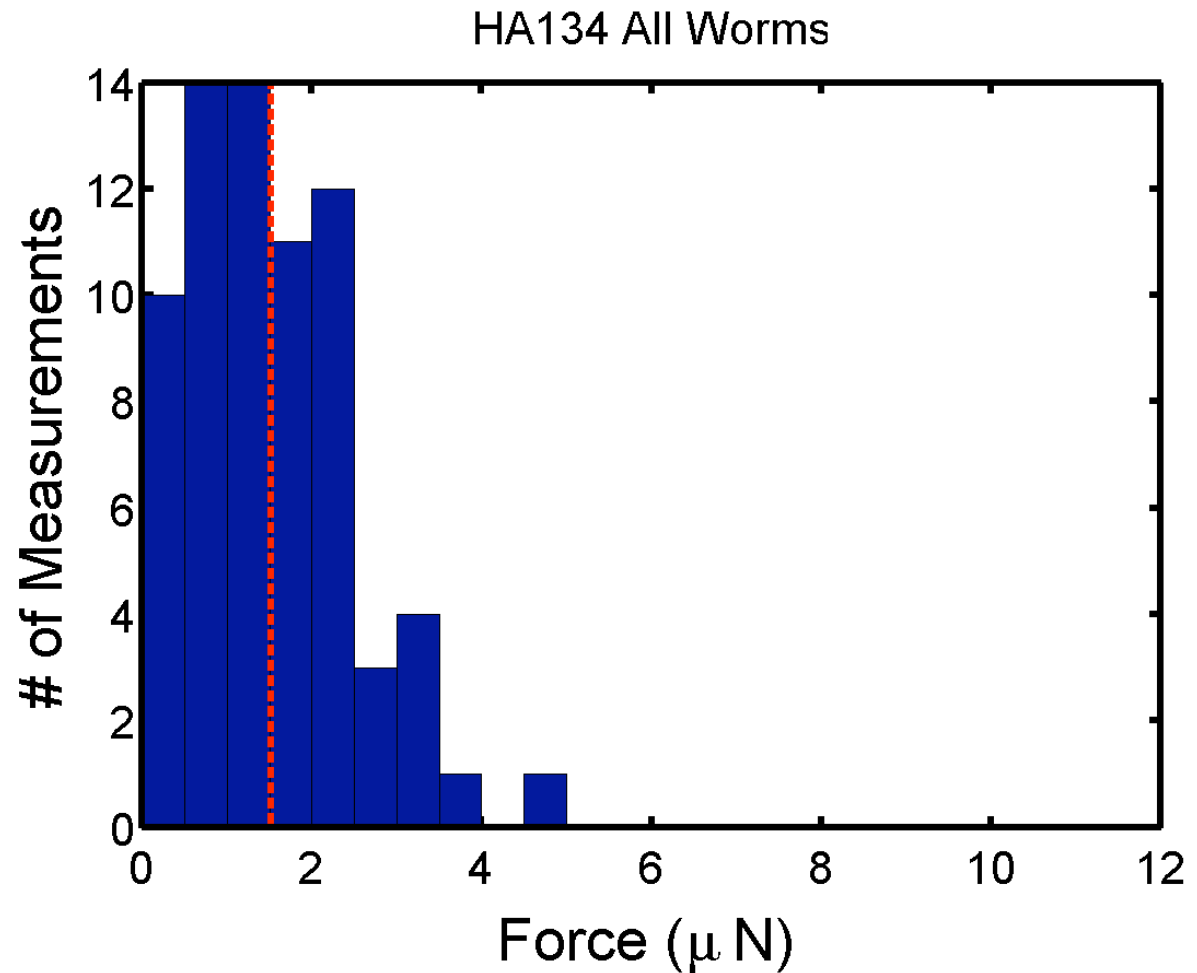
Mean of ind. worms
Mean = 1.11 uN
STD = 0.38 uN

All Forces
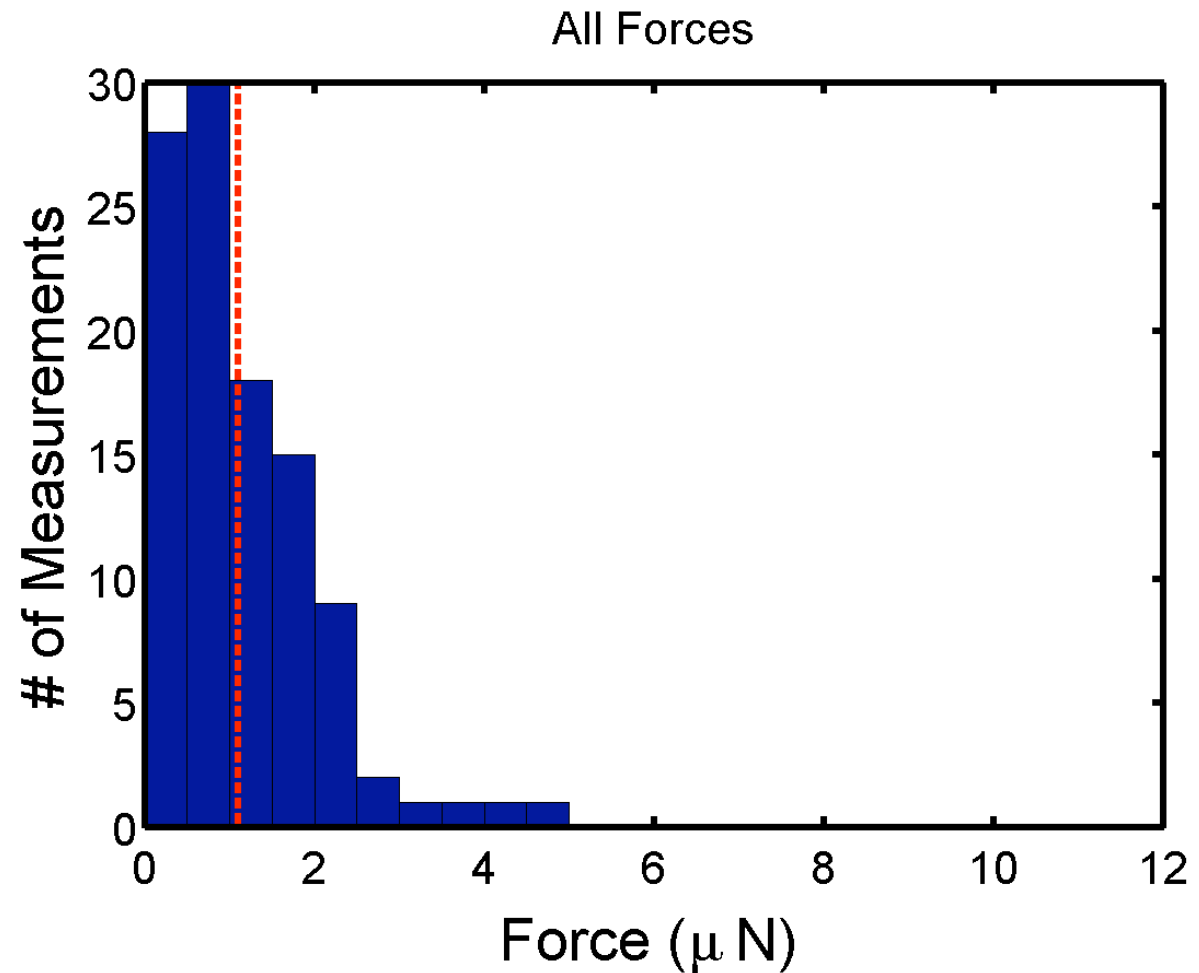
HA134 Data Summary

6 worms
70 nose touches

All Touches
Mean = 1.51 uN
STD = 1.01 uN

Mean of ind. worms
Mean = 1.56 uN
STD = 0.54 uN

HA134 All Worms

OSM9 Data Summary

5 worms
47 nose touches

All Touches
Mean = 1.85 uN
STD = 1.01 uN

Mean of ind. worms
Mean = 1.85 uN
STD = 0.32 uN

osm9 All Worms
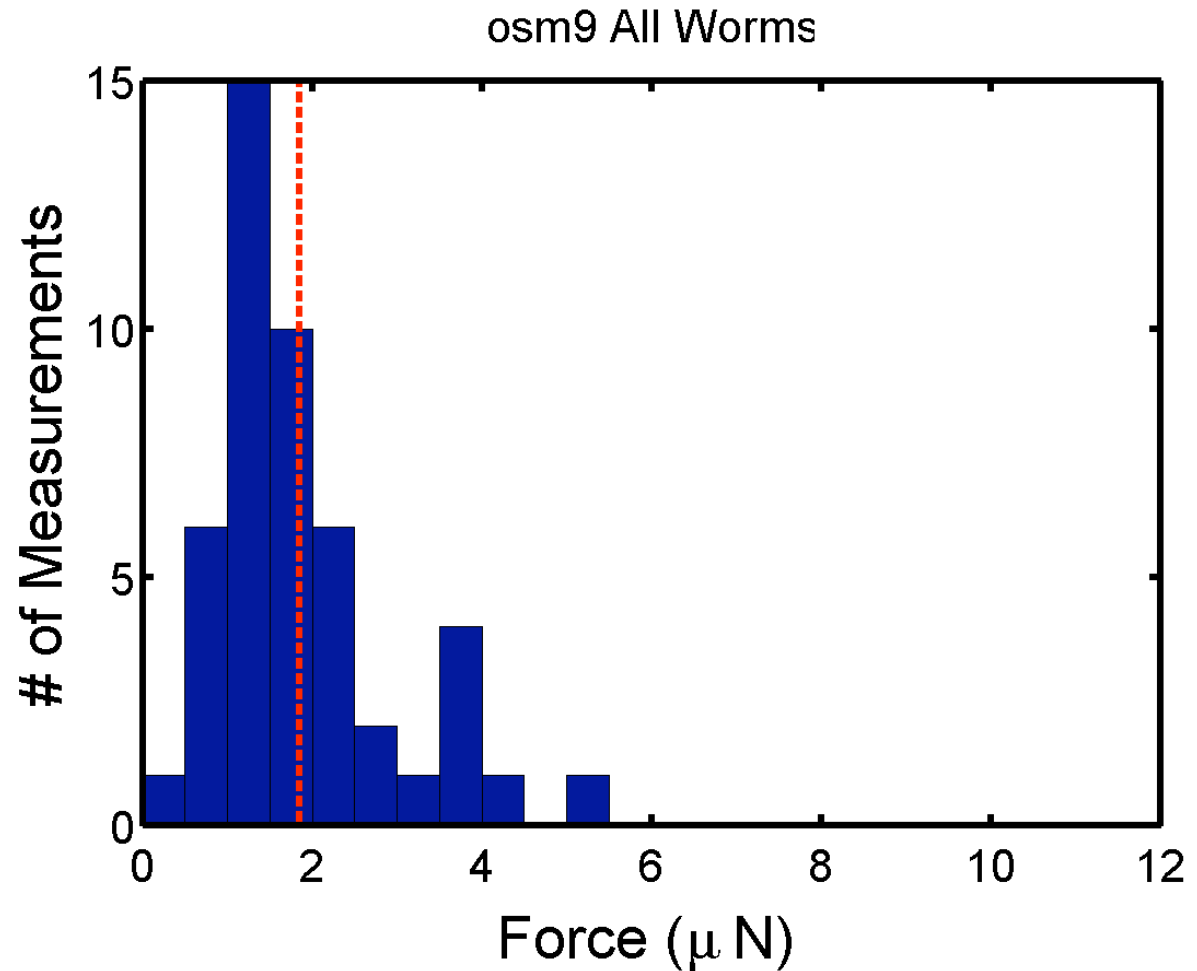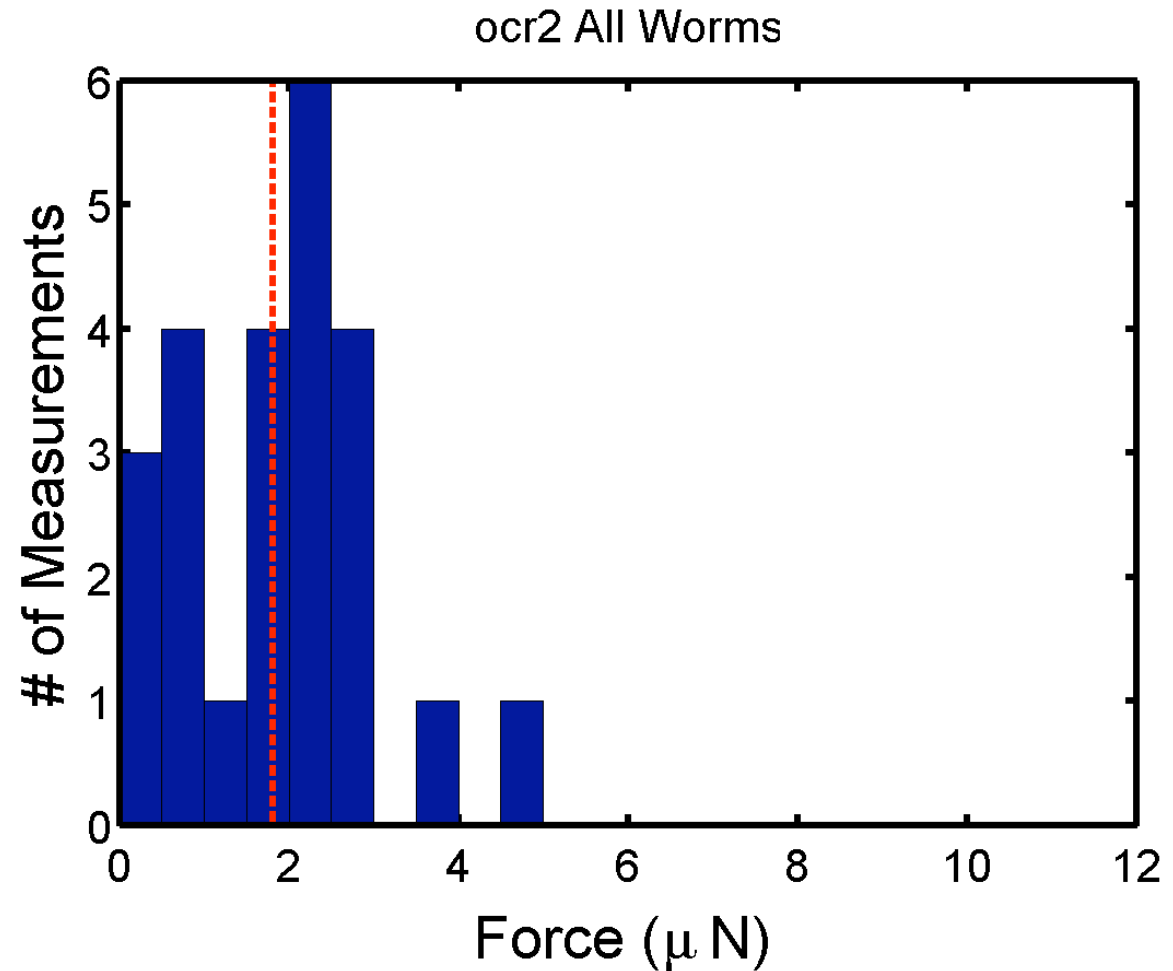
OCR2 Data Summary

5 worms
24 nose touches

All Touches
Mean = 1.81 uN
STD = 1.15 uN

Mean of ind. worms
Mean = 1.76 uN
STD = 0.63 uN

ocr2 All Worms

Thoughts on Data

- Not a huge difference between strains
  - Accuracy of force measurements e.g. surface tension from agar reducing measured force? Except moving probe lightly on surface only registers ~0.2-0.5uN force
  - All nose touch data is in the same ballpark
- The OSM9 and OCR2 looked pretty sensitive, they didn't just keep running into the probe (see movie at beginning)
  - Cross-contamination? (will check using eyebrow hair)
- N2 and HA134 are more lively than the other strains
- Right now just looking at force, didn't try to correlate it to worm size or factor in the angle between the nose and probe (to break up measured force into normal + shear)

Notes

- Force measurements are pretty straightforward, got N2 data in one afternoon and the three mutants in another afternoon
- Things we could measure
  - Nose touch sensitivity
  - Side touch sensitivity
  - Latency between touch and movement away
  - Does worm respond to force threshold or integration process?
- Other Stuff
  - Force generated during swimming
  - Cuticle mechanical properties of work (glue on gripper?)

PDMS Device

- There's variation in poking the worms on the nose in agar
  - Sometimes the probe sticks more to the agar than other times, they aren't always hit in the same place
- Fill PDMS channel, place upright, put probe at the end of the channel
  - How to keep a worm in the channel while still giving force probe access

Summary

- Initial data on N2 and mutants done

- Data looks good, although smaller difference between strains than at least I expected

- Where to go from here?