Sponge Quake Shear Box

- Stick-slip behavior of unstable patch in stable zone -

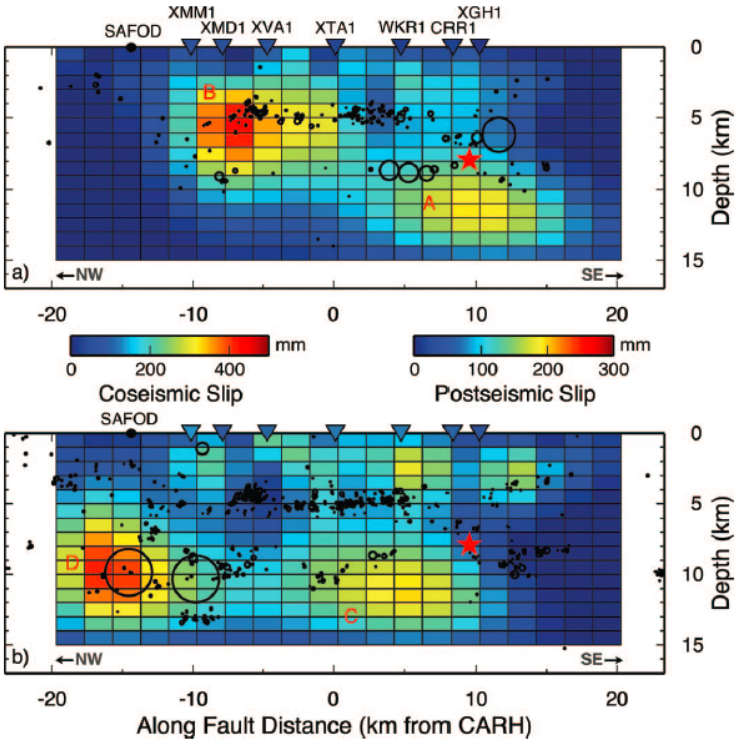
Kyungjae Im

Geosc 597-3 Class project - 2016F

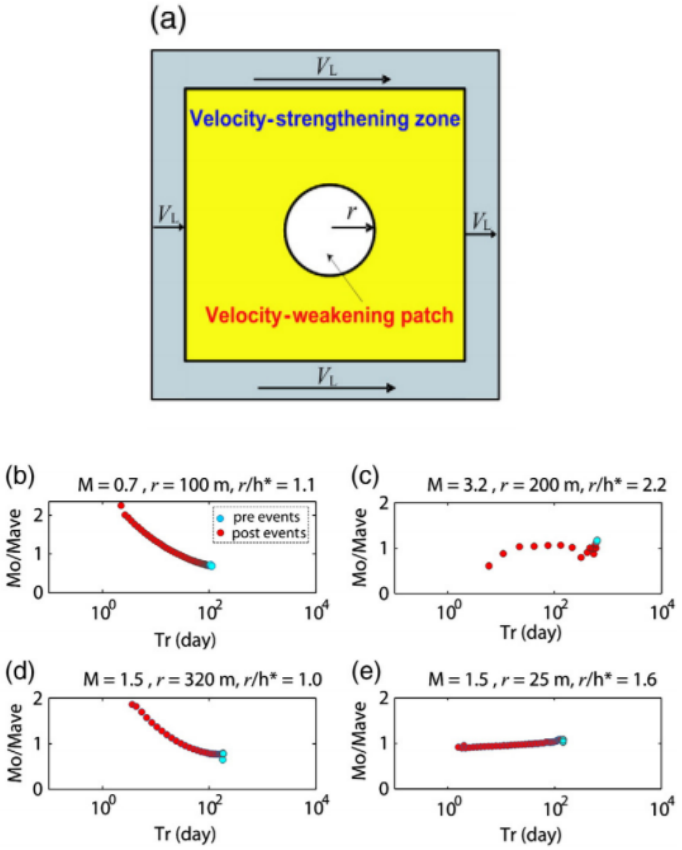
Problem Description

Natural earthquakes are in 3-D

- Critical nucleation length $L_c \sim G \cdot D_c/[(b-a)\sigma]$
- Frictional properties are complexly distributed



Coseismic and postseismic slip of 2004 parkfield earthquake [Johanson et. al. 2006]

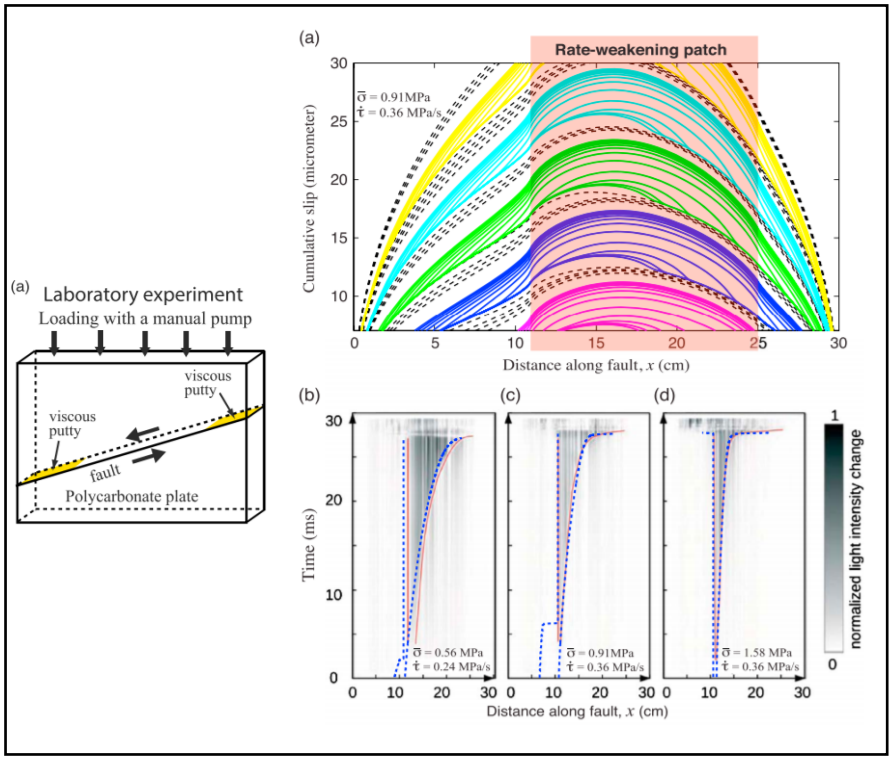


Simulation of repeating earthquakes with different nucleation patch size [Chen et. al. 2010]

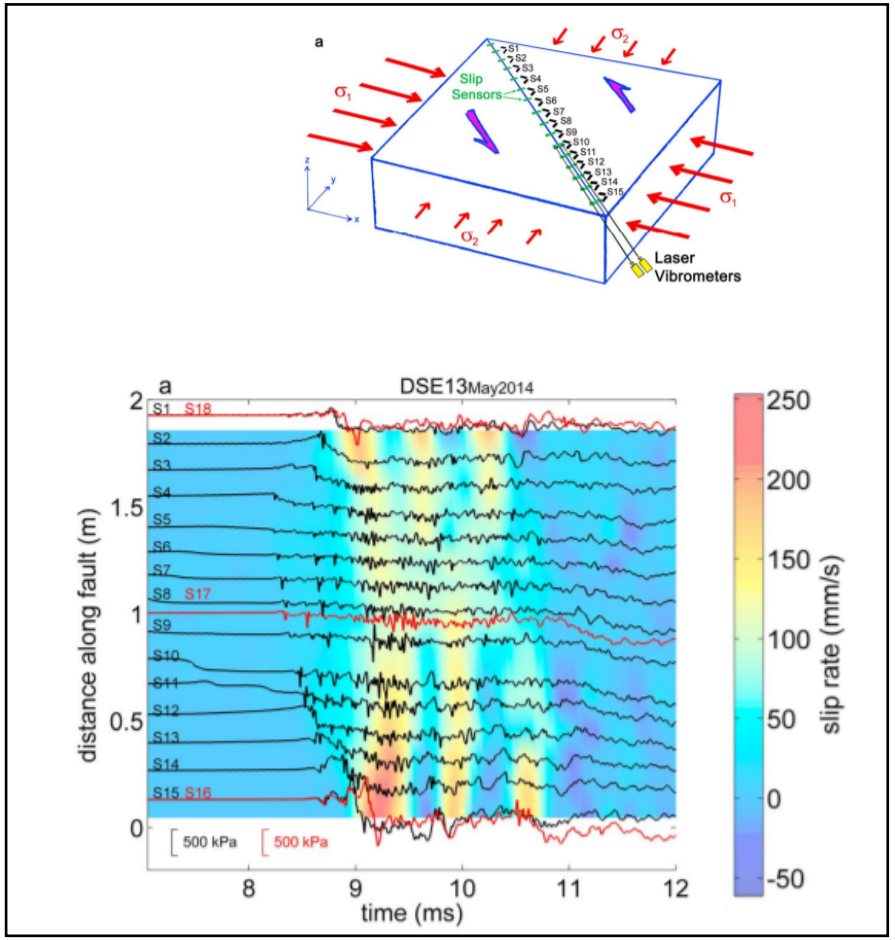
Problem Description

Why laboratory 1+ dimensional slip are difficult? → Rock is too stiff

- Large apparatus dimension required $L_c \sim G \cdot D_c/[(b-a)\sigma]$ (G ~10GPa)
- Deformation is tiny



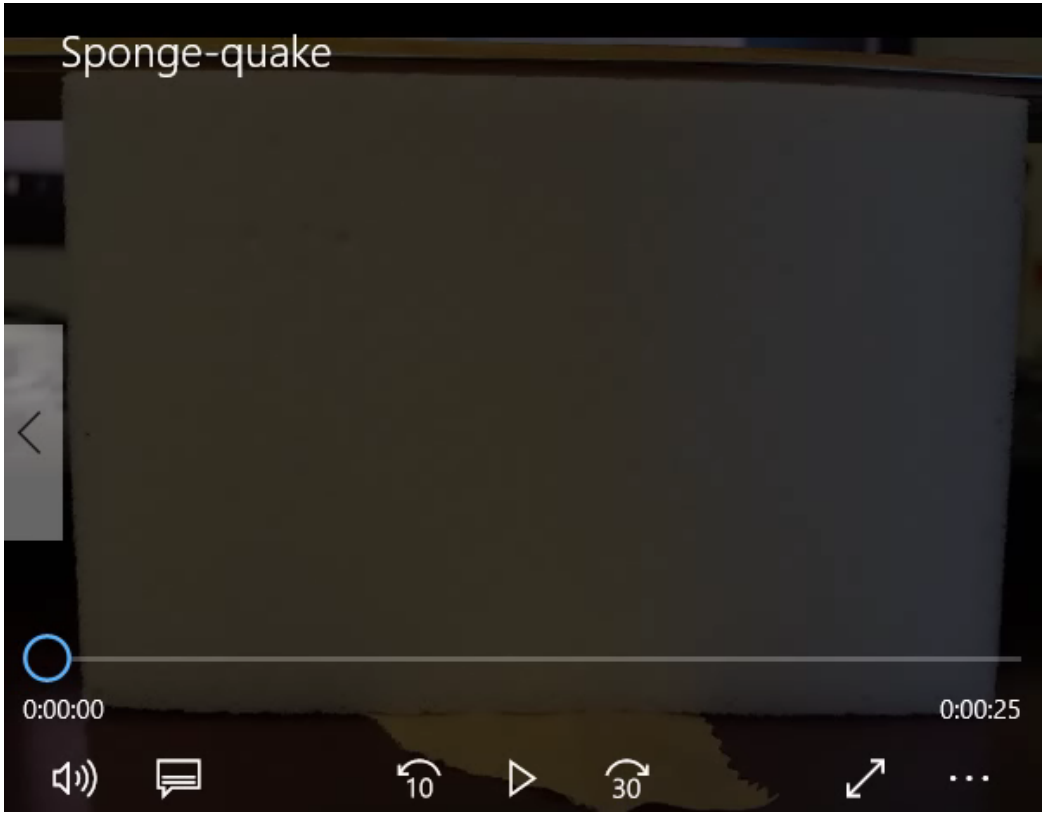
Fault nucleation experiment and simulation with 30cm PMMA
[Latour et. al. 2013, Kaneko et. al 2016]



Rupture propagation experiment with 2m granite
[McLaskey et. al. 2015]

Solution

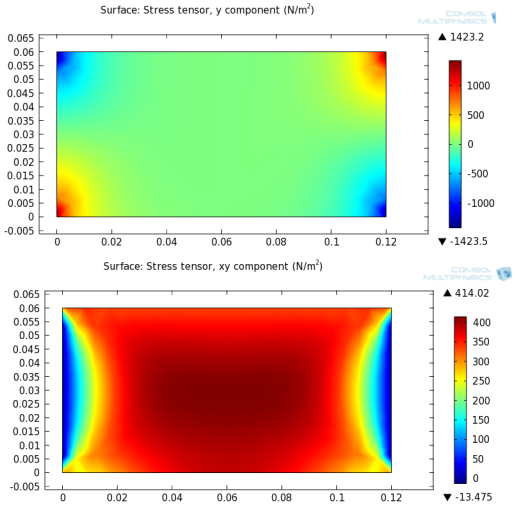
Soft & Elastic Material



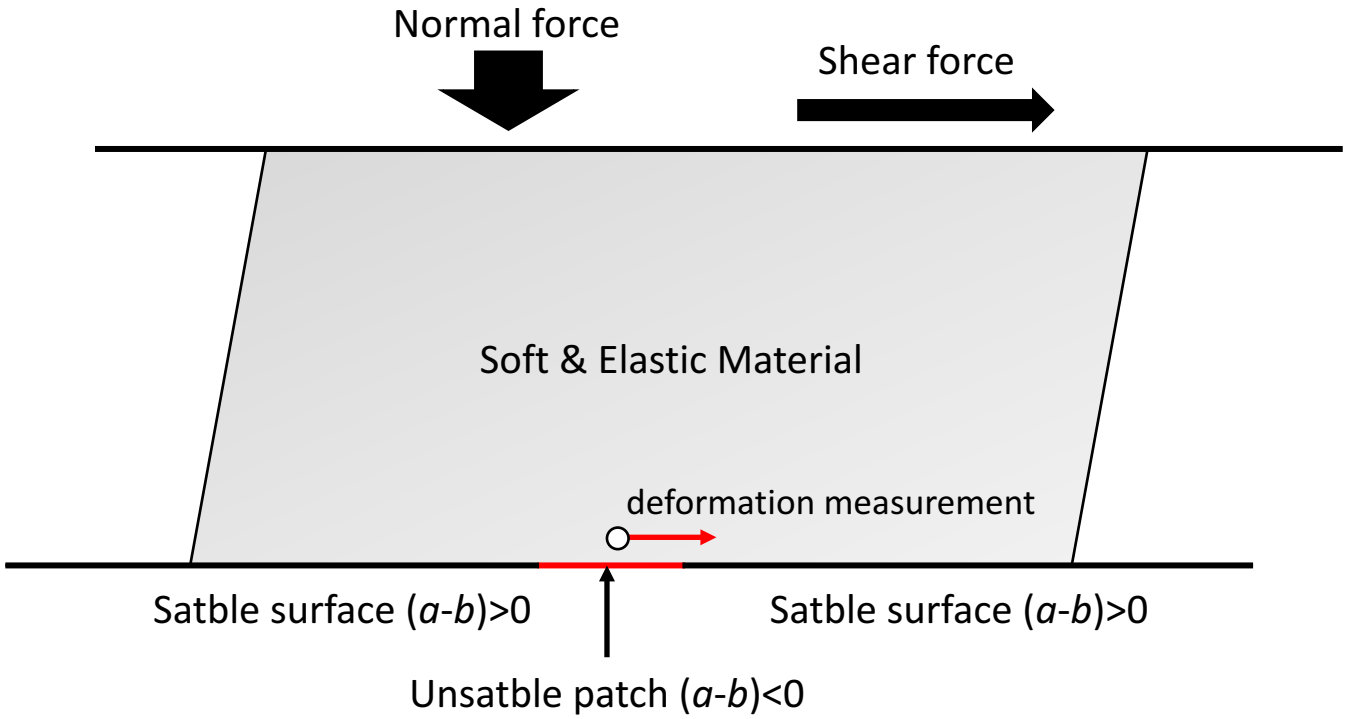
Solution

Solution Requirements

- Soft & elastic material
- Uniform normal & shear stress distribution
- Unstable patch within stable surface
- Deformation measurement



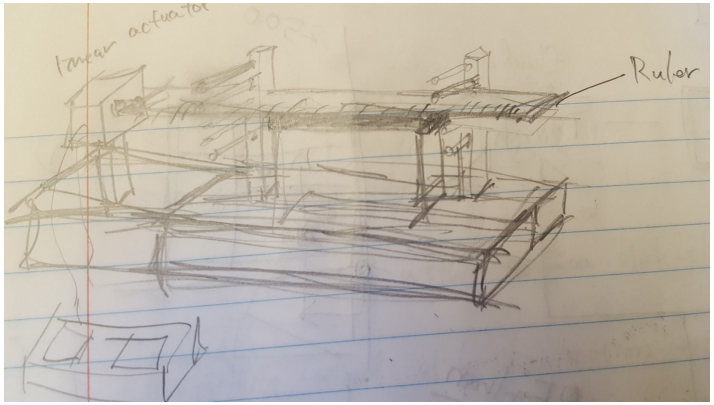
Normal and shear stress distribution with given configuration

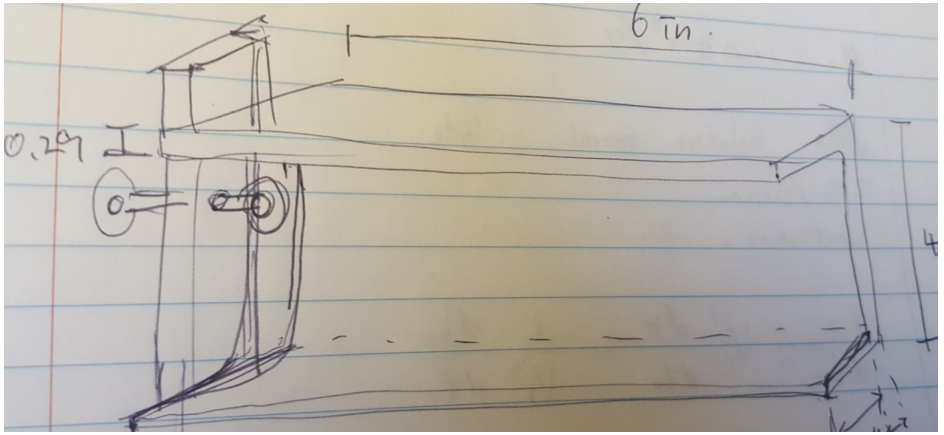


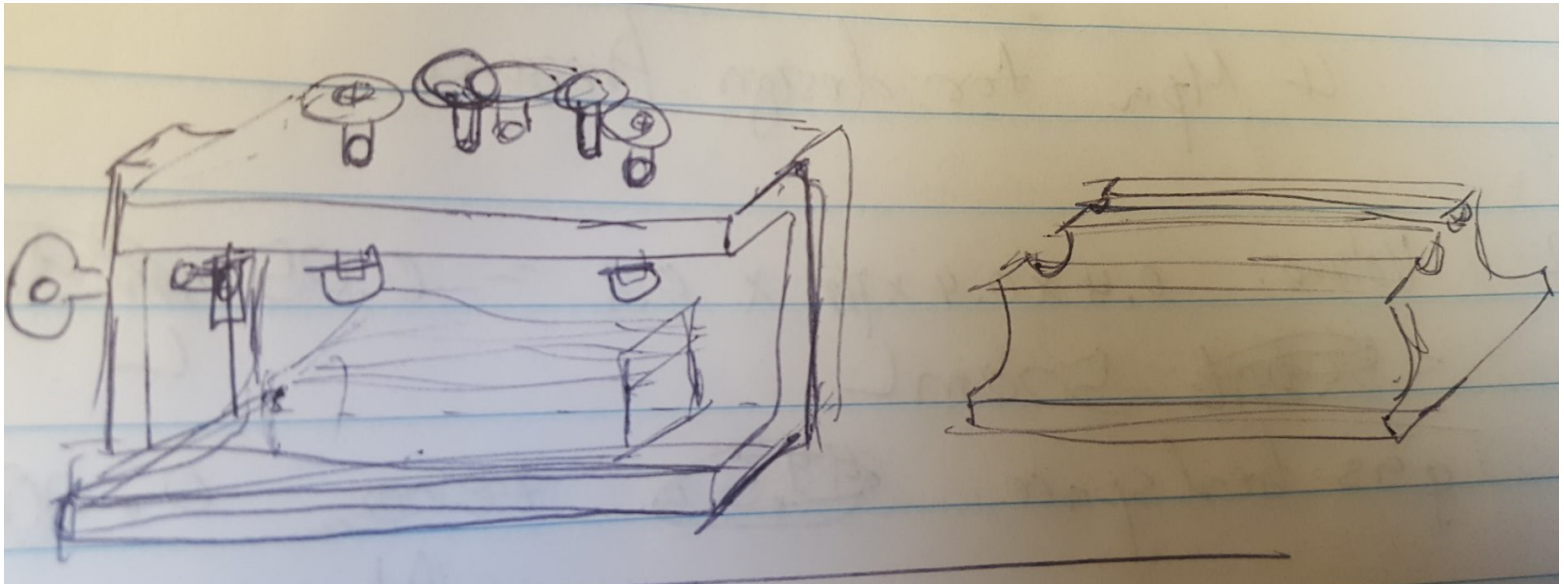
Solution

Mechanical Framework

Some sketches

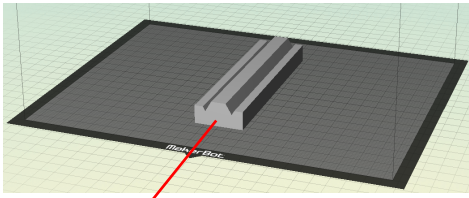




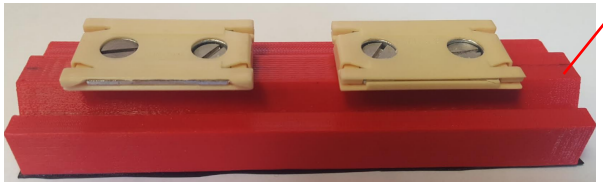


Solution

Final Mechanical Design

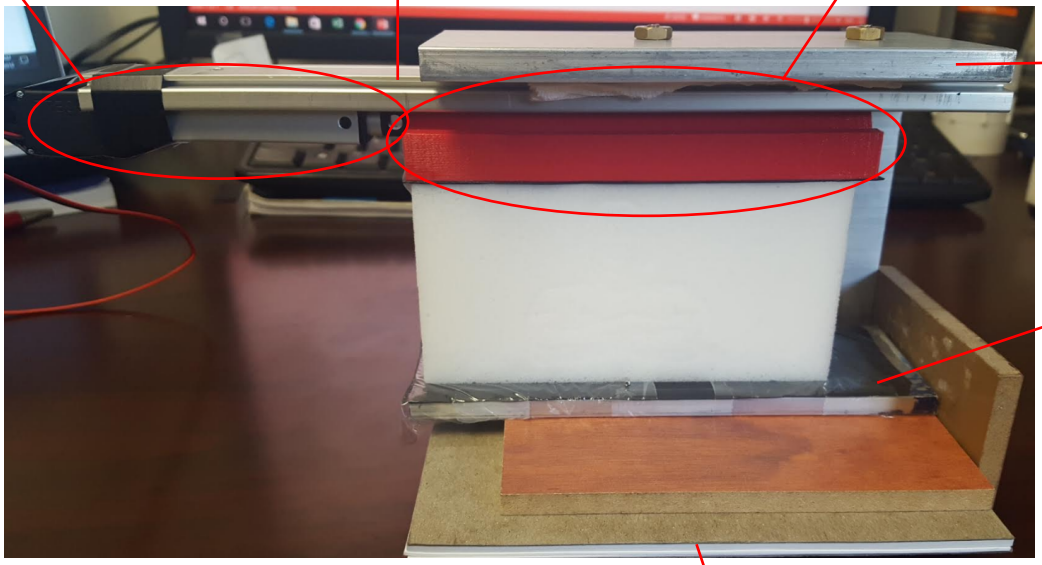


Carrige and
slider (3D printed)



Guide Rail

Linear Actuator



Alluminum U-channel
frame

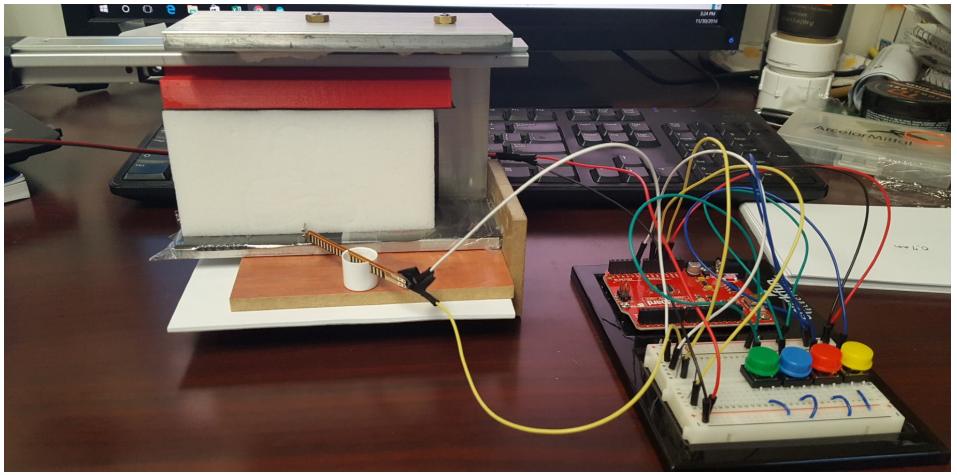
Slip surface

Normal stress adjusted with
Inserting thickness pre-measured papers

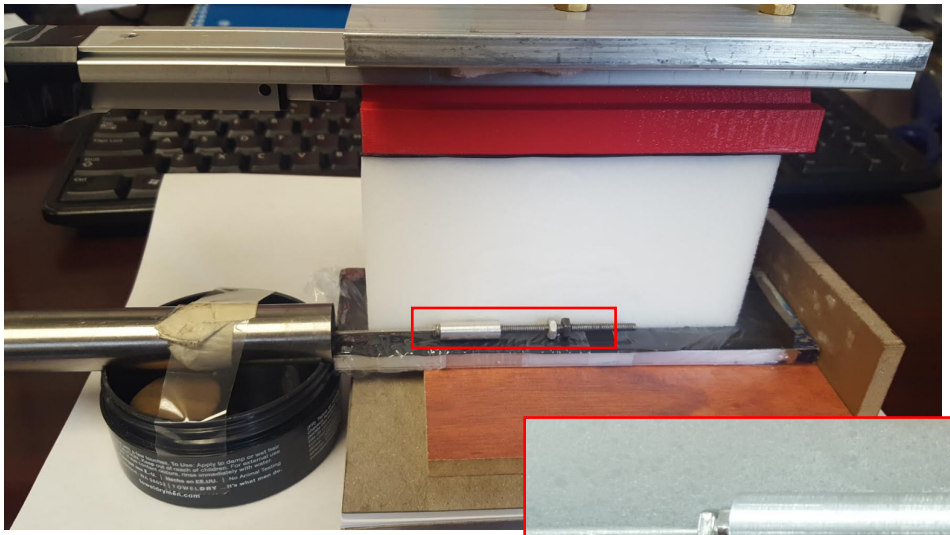
Solution

Measurement

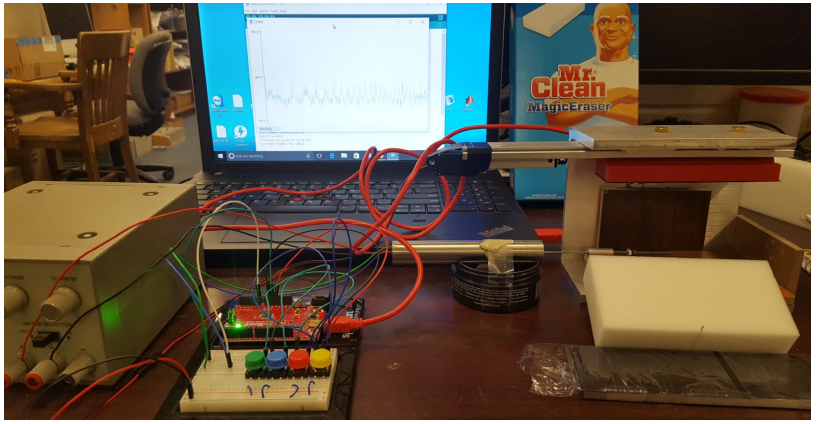
Initial Idea: Flex sensor
But resolution were poor….



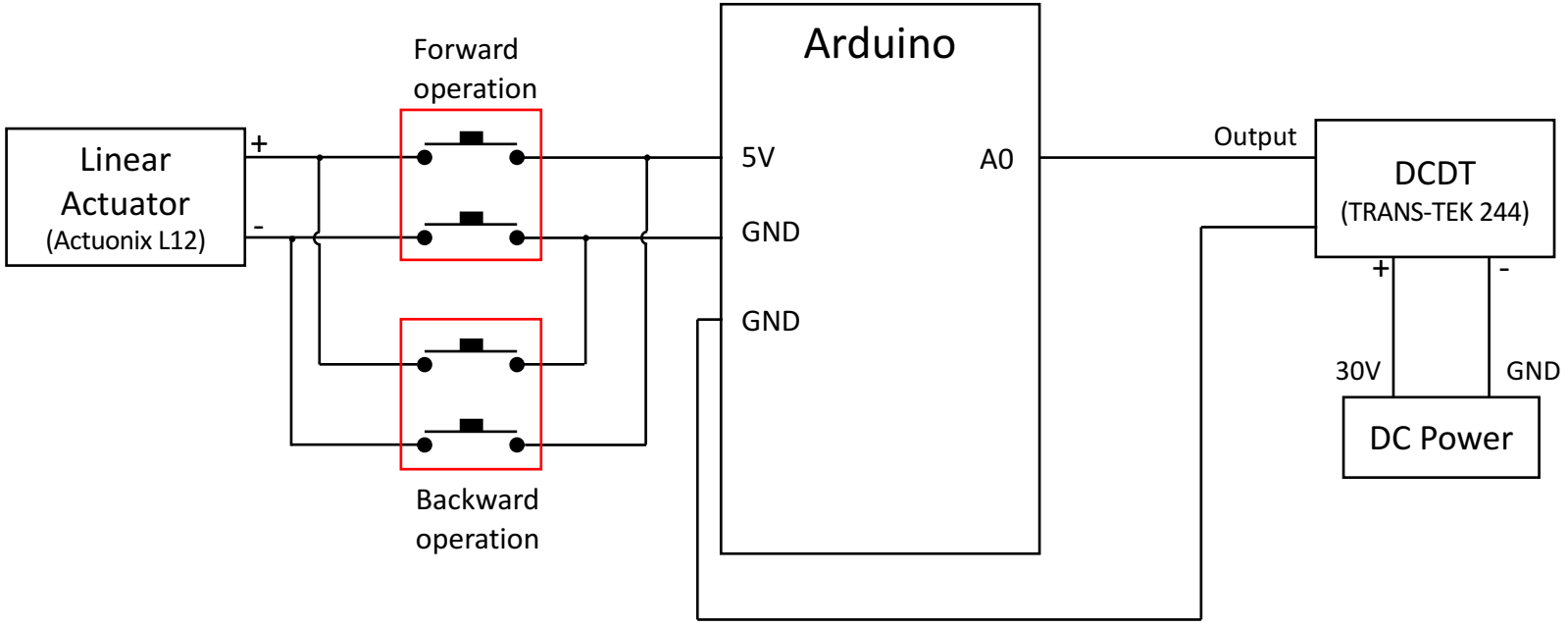
Revised Idea: DCDT



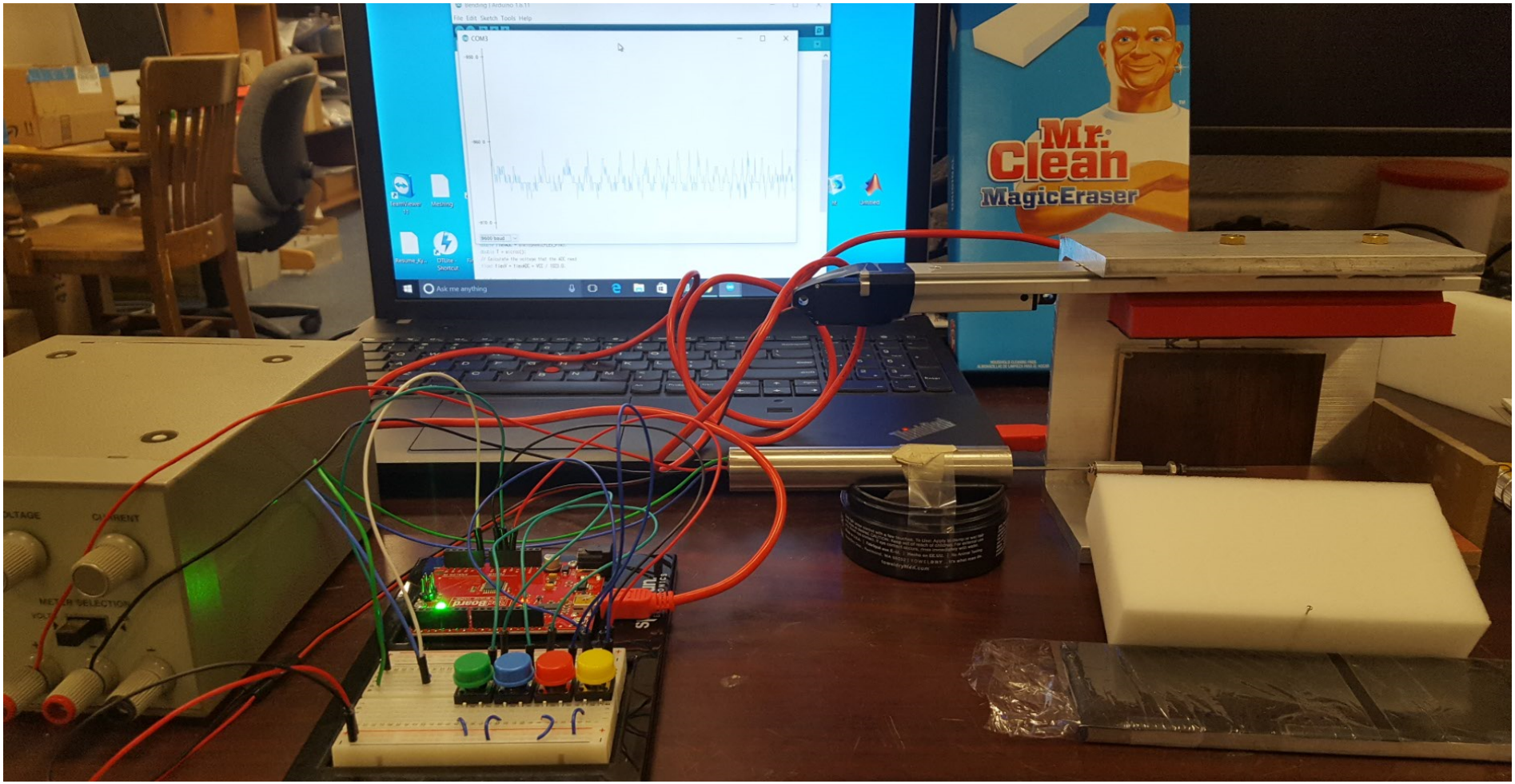
Solution



Electric circuit diagram



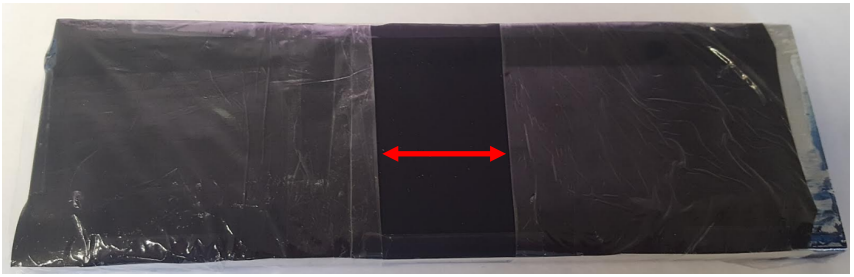
Demonstration



Experimental Setup

12 patch size with 8 Normal stress were tested

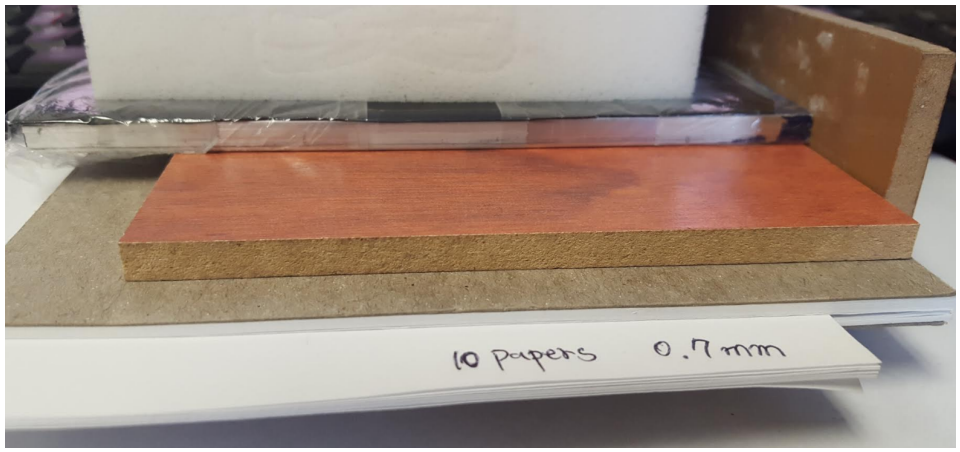
Rubber patch size (cm): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0



Normal Force

Paper count	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**
Normal Force (N)	1.6	4.3	7.1	9.8	12.5	15.3	18.0	20.8
Noarmal Stress (kPa)	0.5	1.3	2.2	3.0	3.9	4.7	5.6	6.4

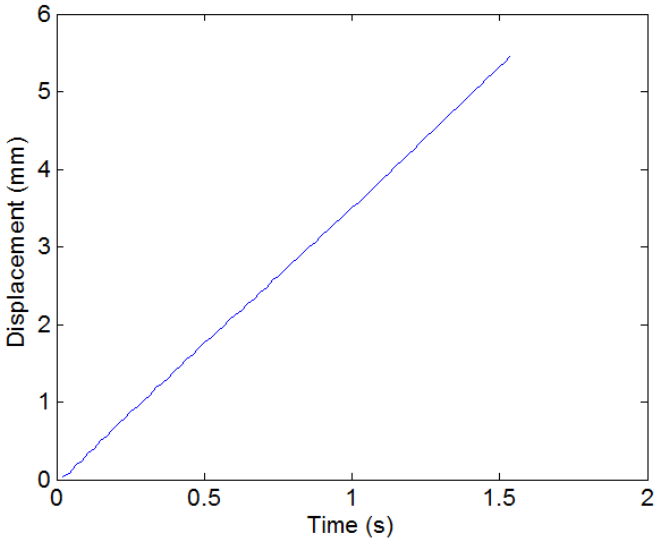
[1 paper (0.7mm): 2.74 N, Surface Area: 0.12 × 0.27 m^2]



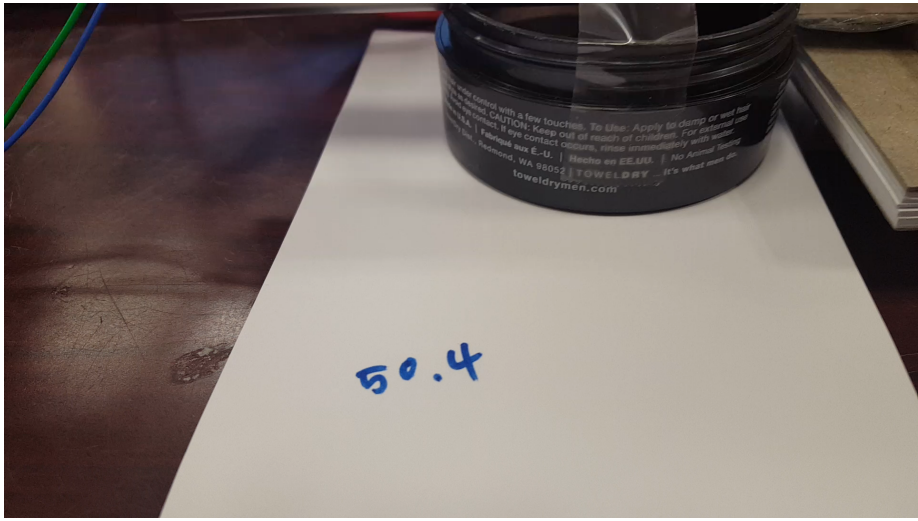
Result

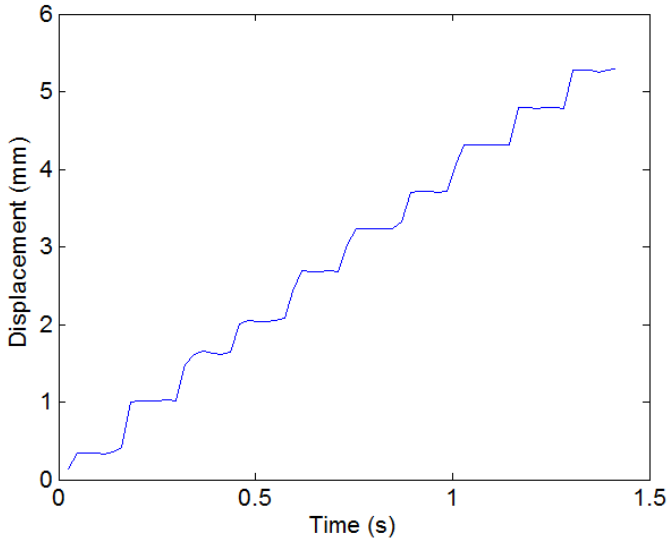
Stable sliding vs. stick slip

2.5cm / 4.3 N



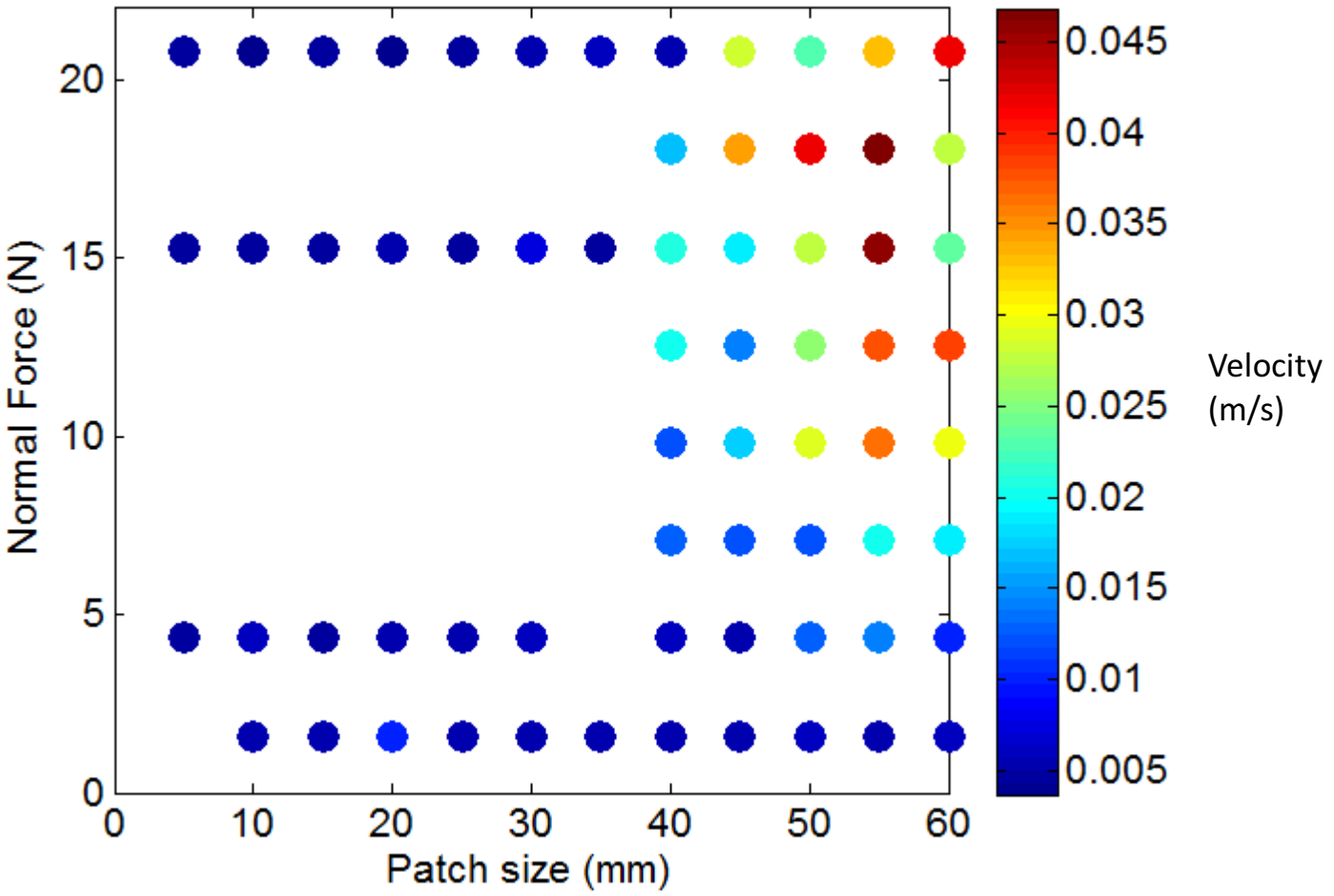
5.0cm / 12.5 N





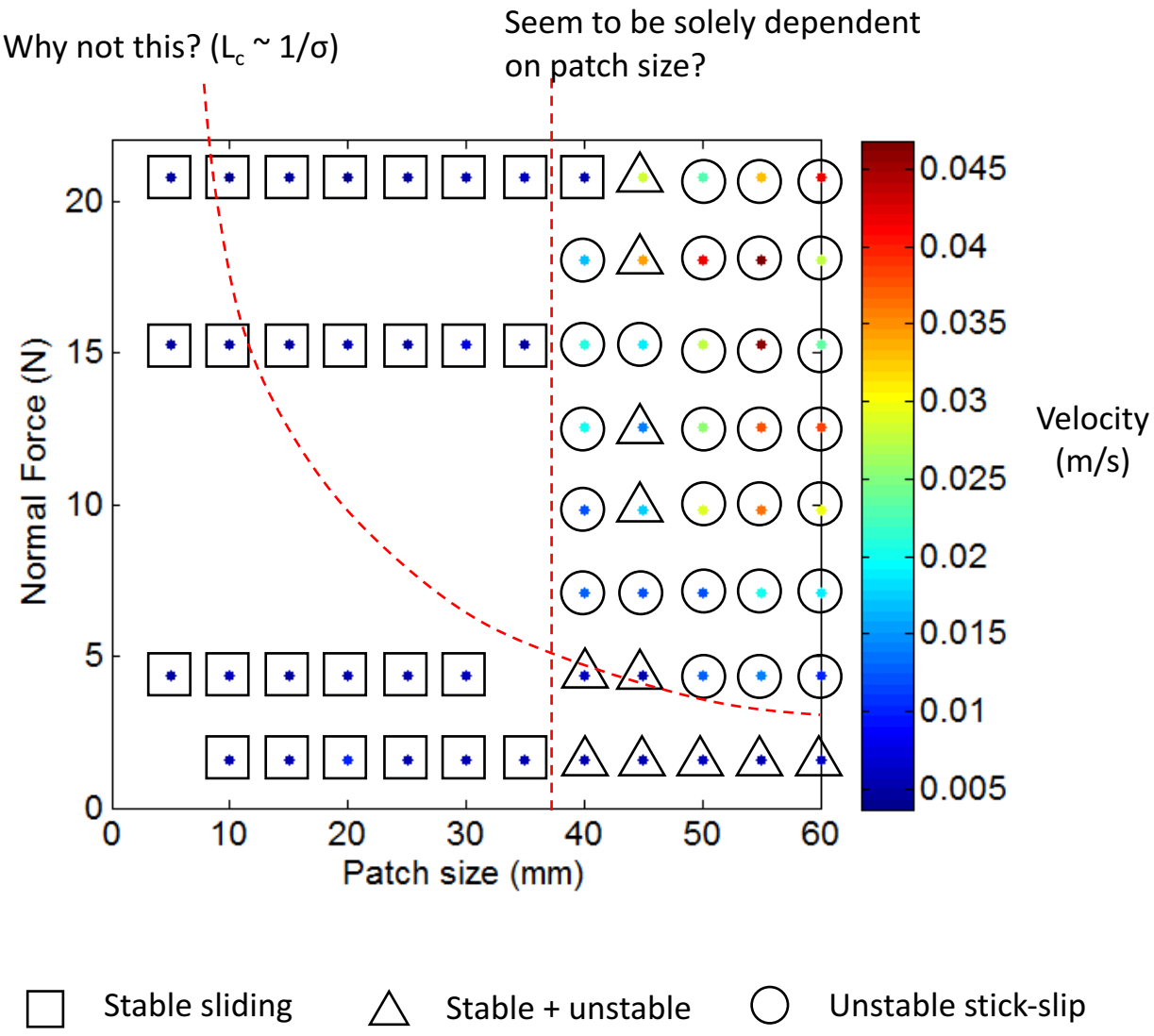
Result

Maximum velocities



Result

(Apparent) Stability and Discussion



Problems and Further Upgrade Items

Resolution and sampling interval

- Resolution: ~5μm (Arduino 10 bit 1023 interval with 5.5mm)
- Sampling interval: ~20ms

Longer sponge is required to provide better normal and shear stress condition

Results vari with sponge and surface condition (Sponge stiffness decreases with deformation experience)

Multiple loading velocity is required

Gouge?

Thank You