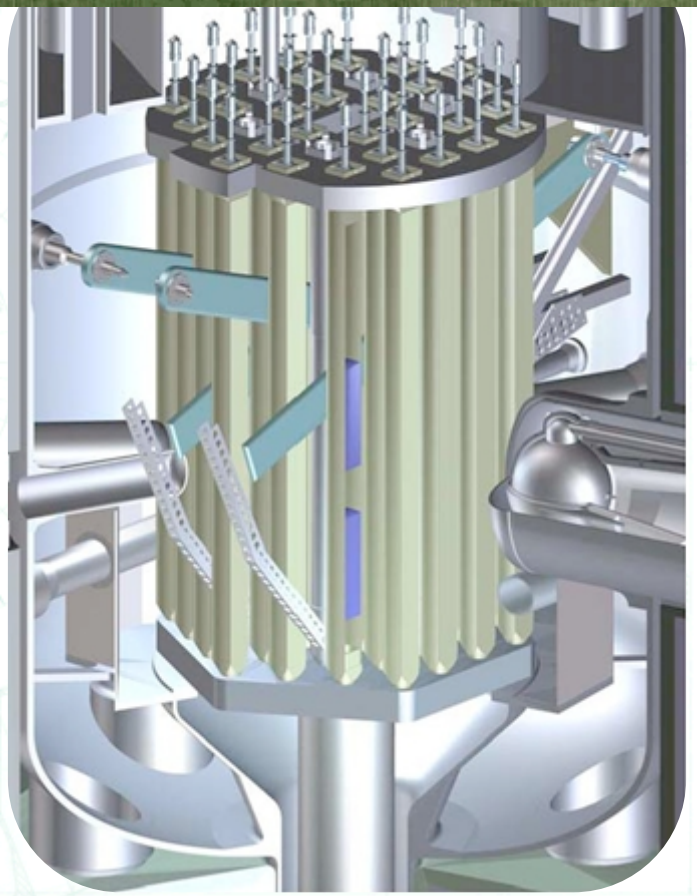
NIST Center for Neutron Research

Scram Rod Response Data Acquisition

Joe Reyenga
William Riedel

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

NBSR Overview



- 20 MW D_2O cooled and moderated
- Tank type reactor, MTR type fuel
- **4 semaphore-type shim arms, 1 regulating rod**
- Variation on Argonne CP-5 class reactor

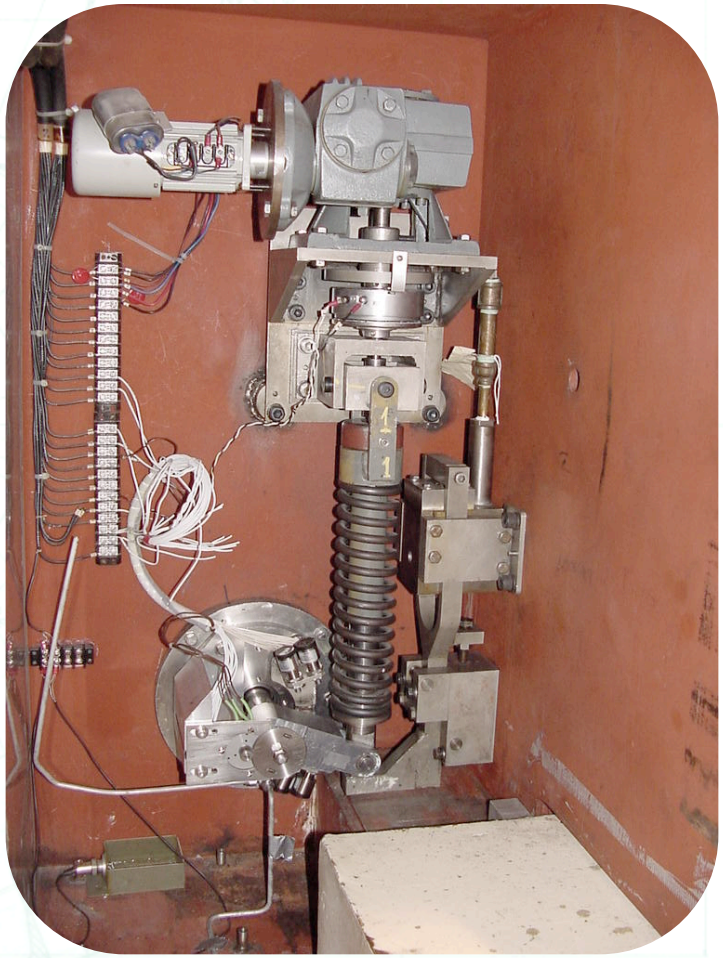
Problem Statement

- Outdated Equipment Used for Scram Response Test
- Labor Intensive Manual Method for Measuring Response Time
- Data Recorded to and stored on 3½” Floppy Disks

Shim Drive

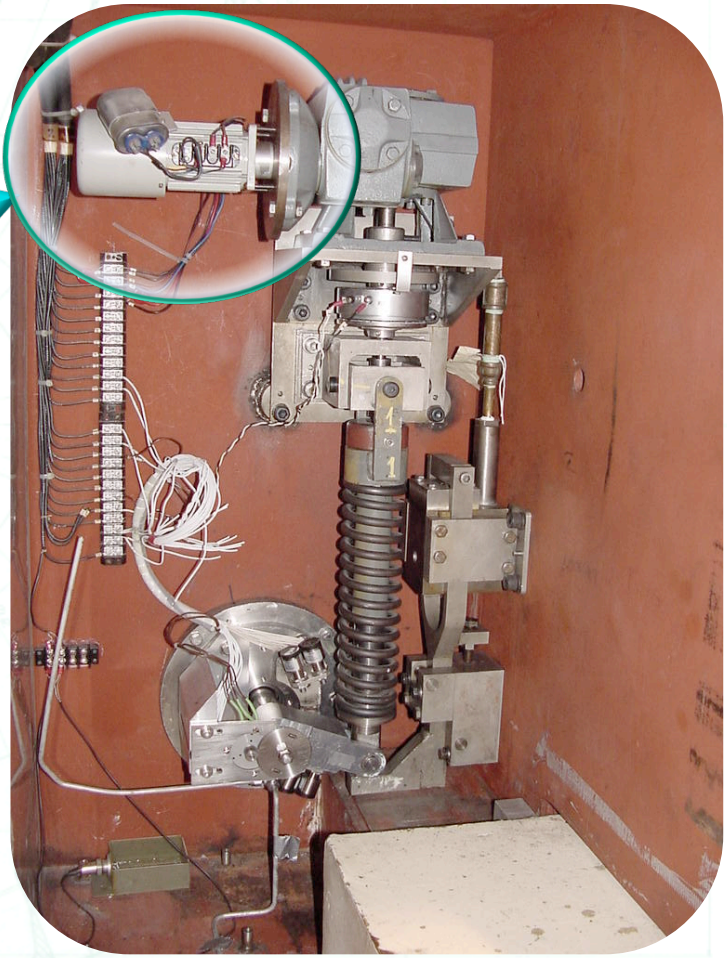
- Spring Compresses as Shim is Withdrawn

- Scram
  - Electromagnetic Clutch Releases
  - Gravity + Spring drive the shim into the core



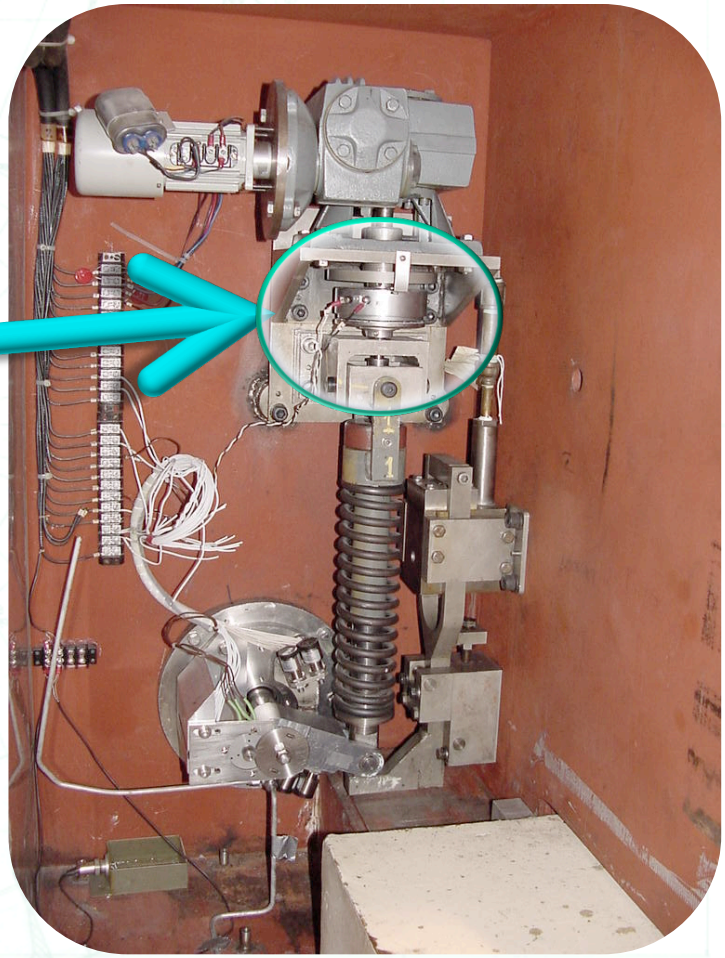
Shim Drive and Scram

Shim
Drive
Motor



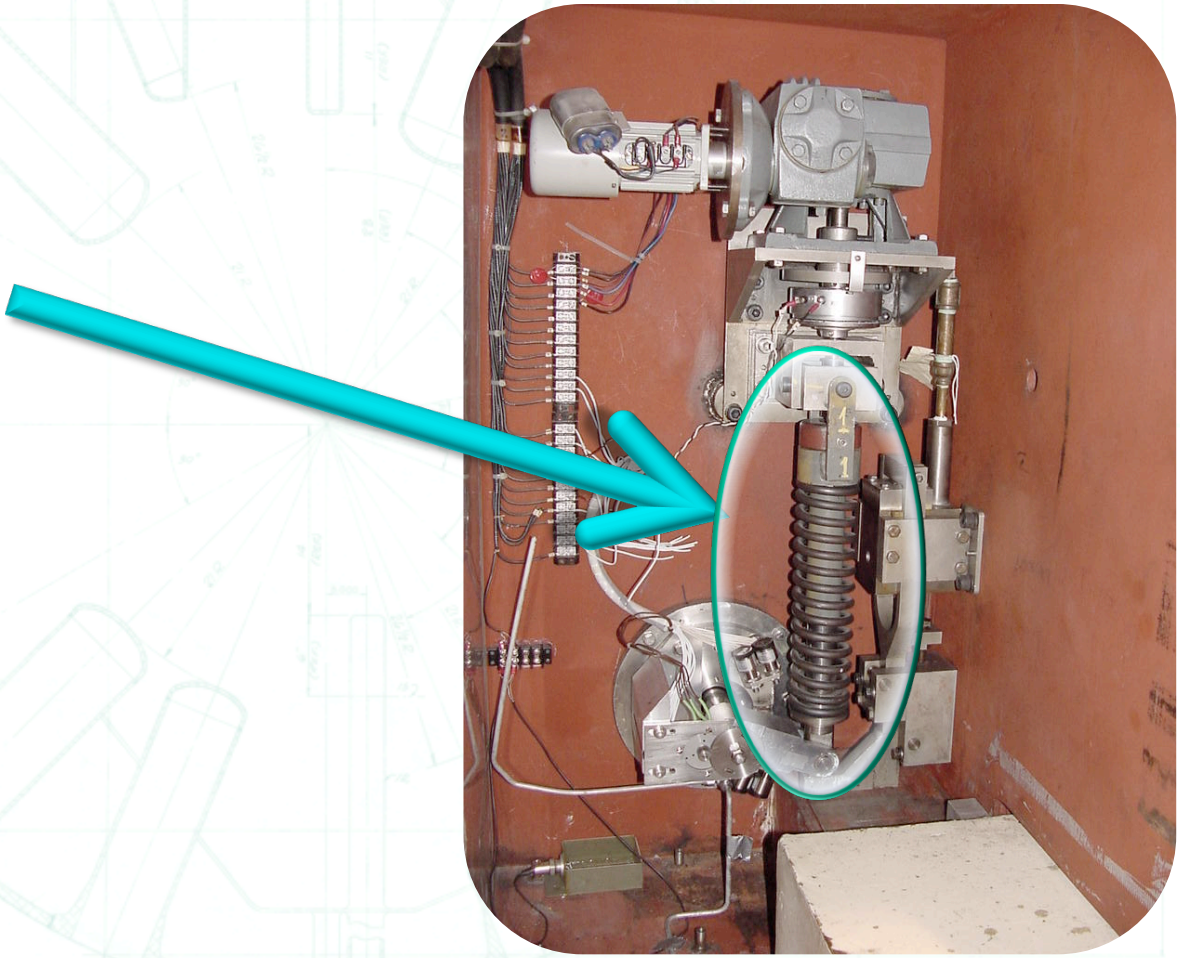
Shim Drive and Scram

Electro-
Magnetic
Clutch



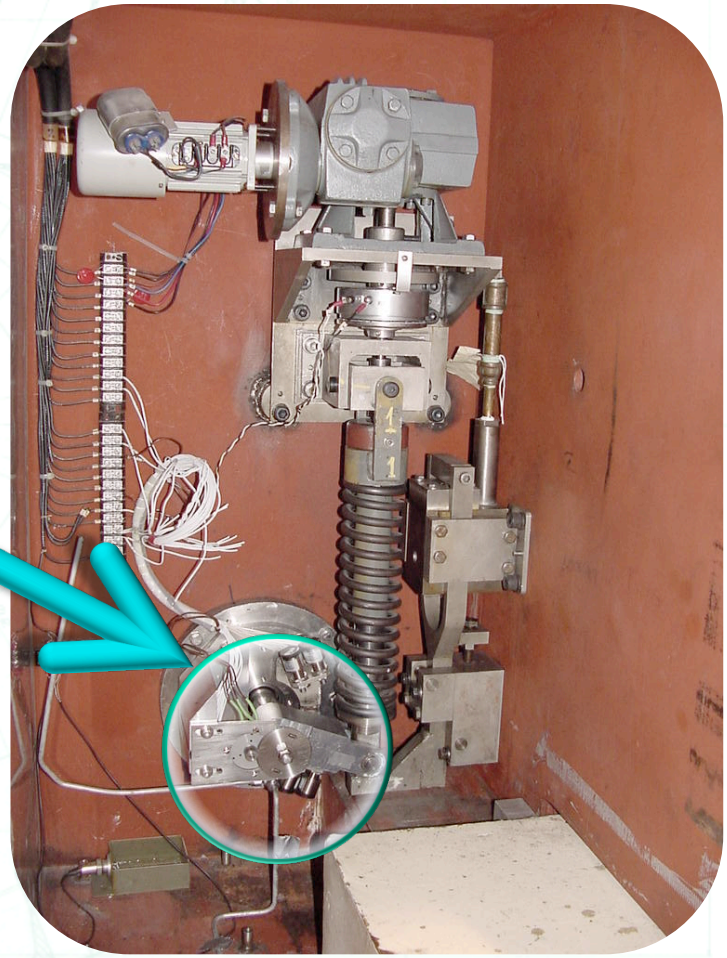
Shim Drive and Scram

Spring
Assist



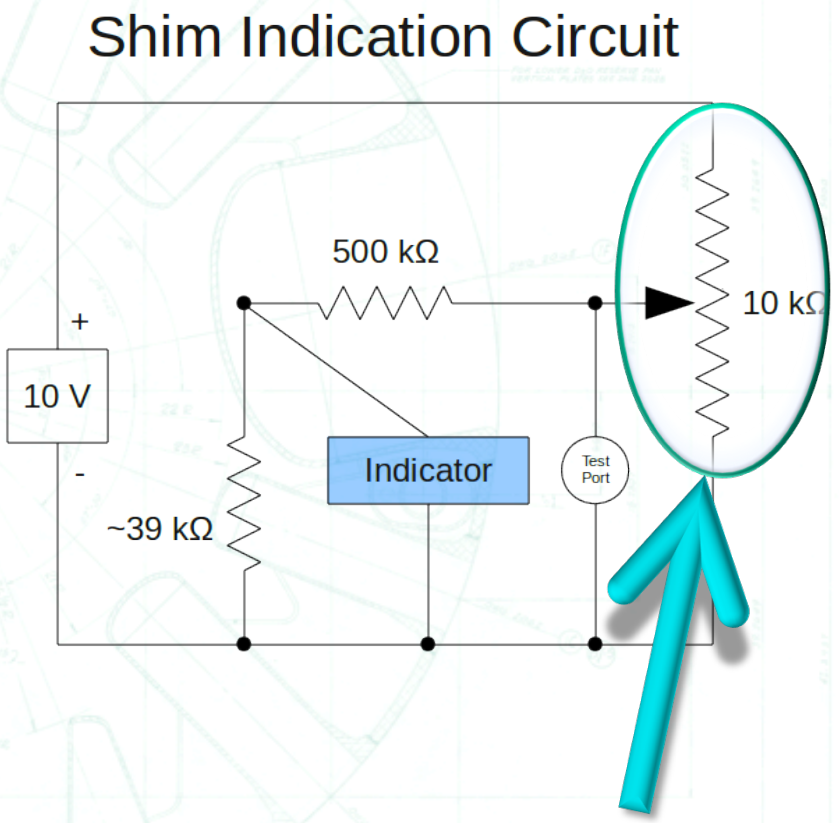
Shim Drive and Scram

Position Potentiometer

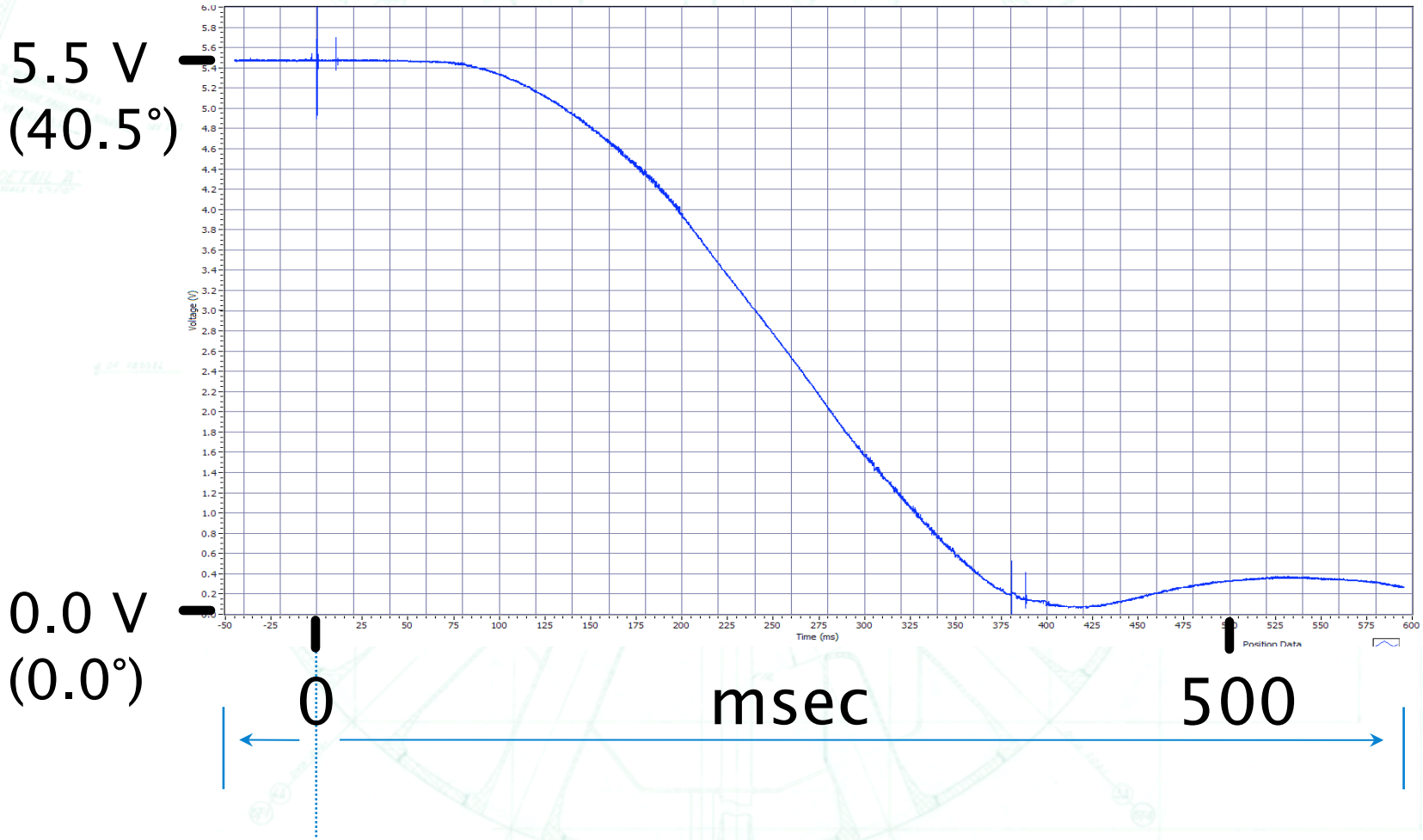


Shim Position Indication

- Potentiometer Coupled to Shim Angle
- Voltage Divider Circuit
- Separate Indicator and Test Ports



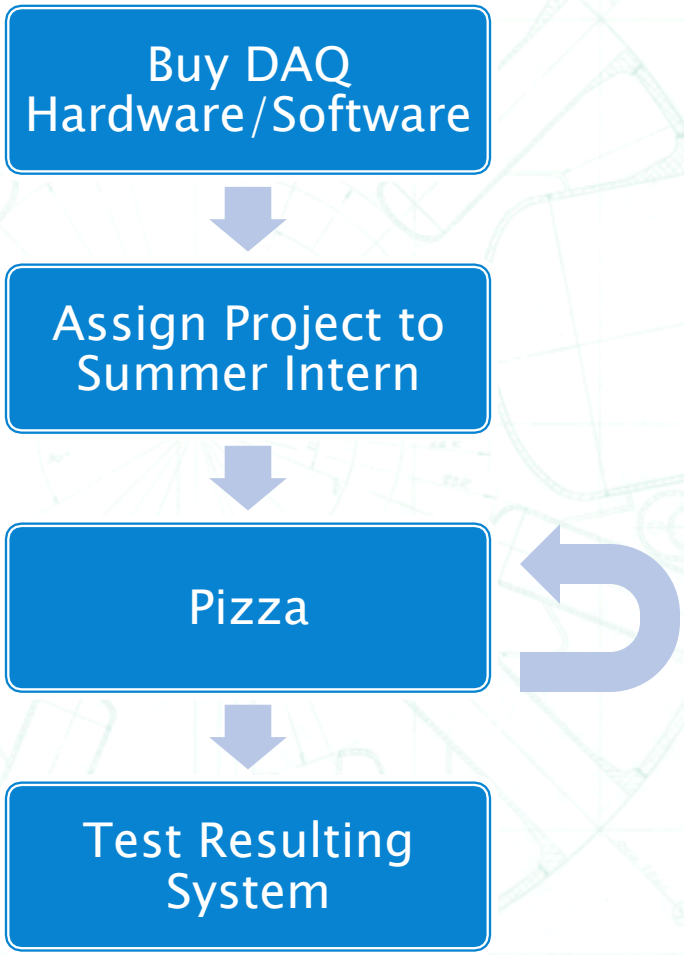
Typical Scram Response Curve



Existing Scram Test Data Recorder

- Yokogawa OR1400 Oscillographic Recorder
  - Printed to Hard Copy
  - Data Stored on 3 ½" Floppy

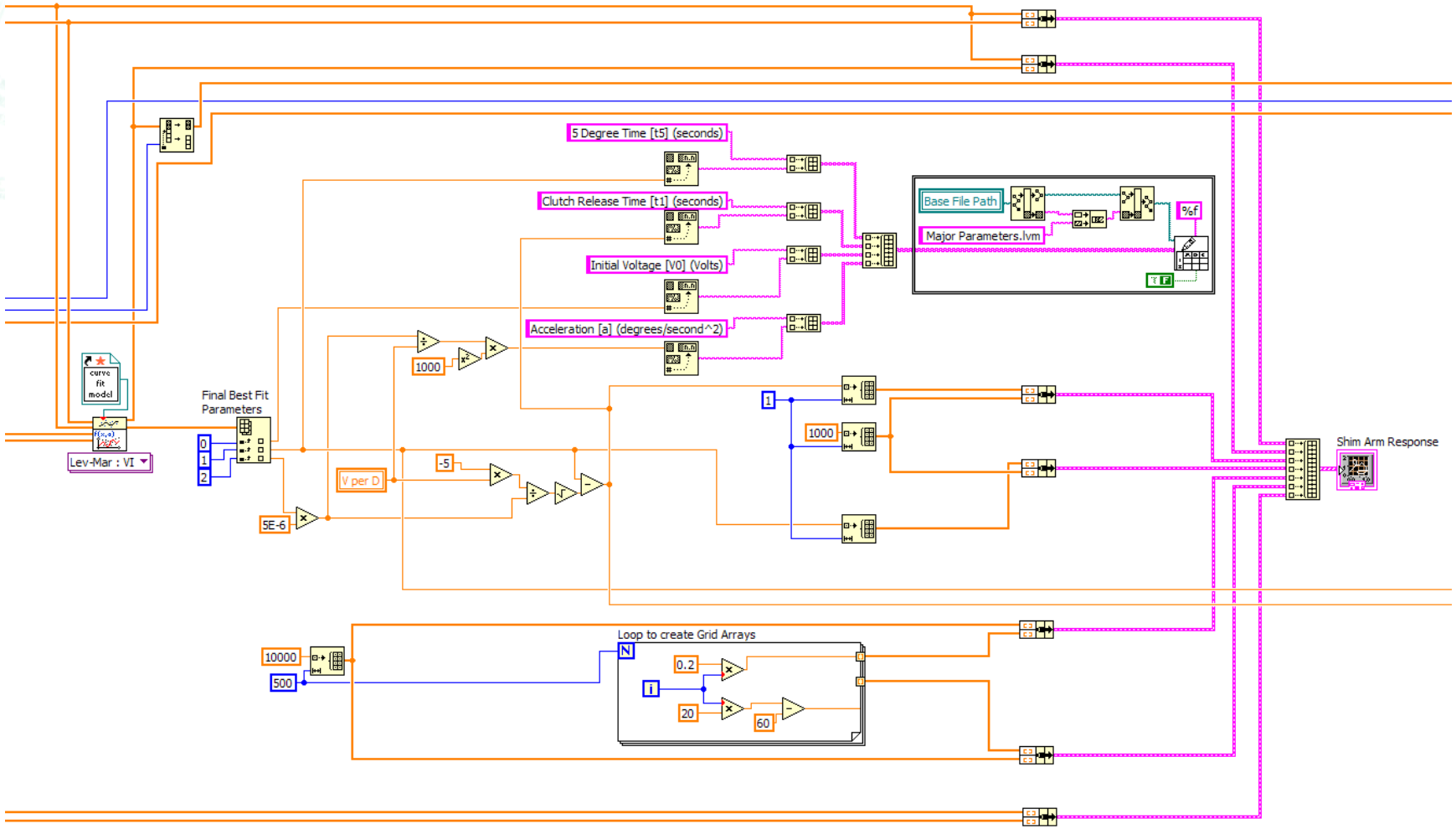
Project Process Model



NI Data Acquisition Module

- Ethernet Communication
- 16 Channel Bank-Isolated Analog Input Module
- >50kHz Sample Rate

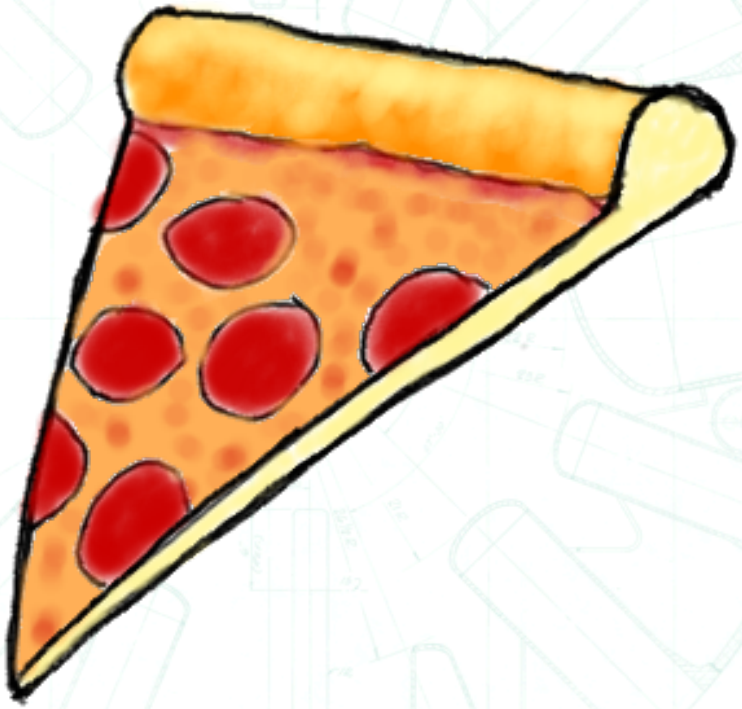
NI LabVIEW


5 Degree Time [t5] (seconds)
Clutch Release Time [t1] (seconds)
Initial Voltage [V0] (Volts)
Acceleration [a] (degrees/second^2)
Base File Path
Major Parameters.lvm
%f
curve fit model
Lev-Mar : VI
Final Best Fit Parameters
0
1
2
1000
V per D
-5
5E-6
1
1000
Shim Arm Response
10000
500
Loop to create Grid Arrays
N
i
0.2
20
60

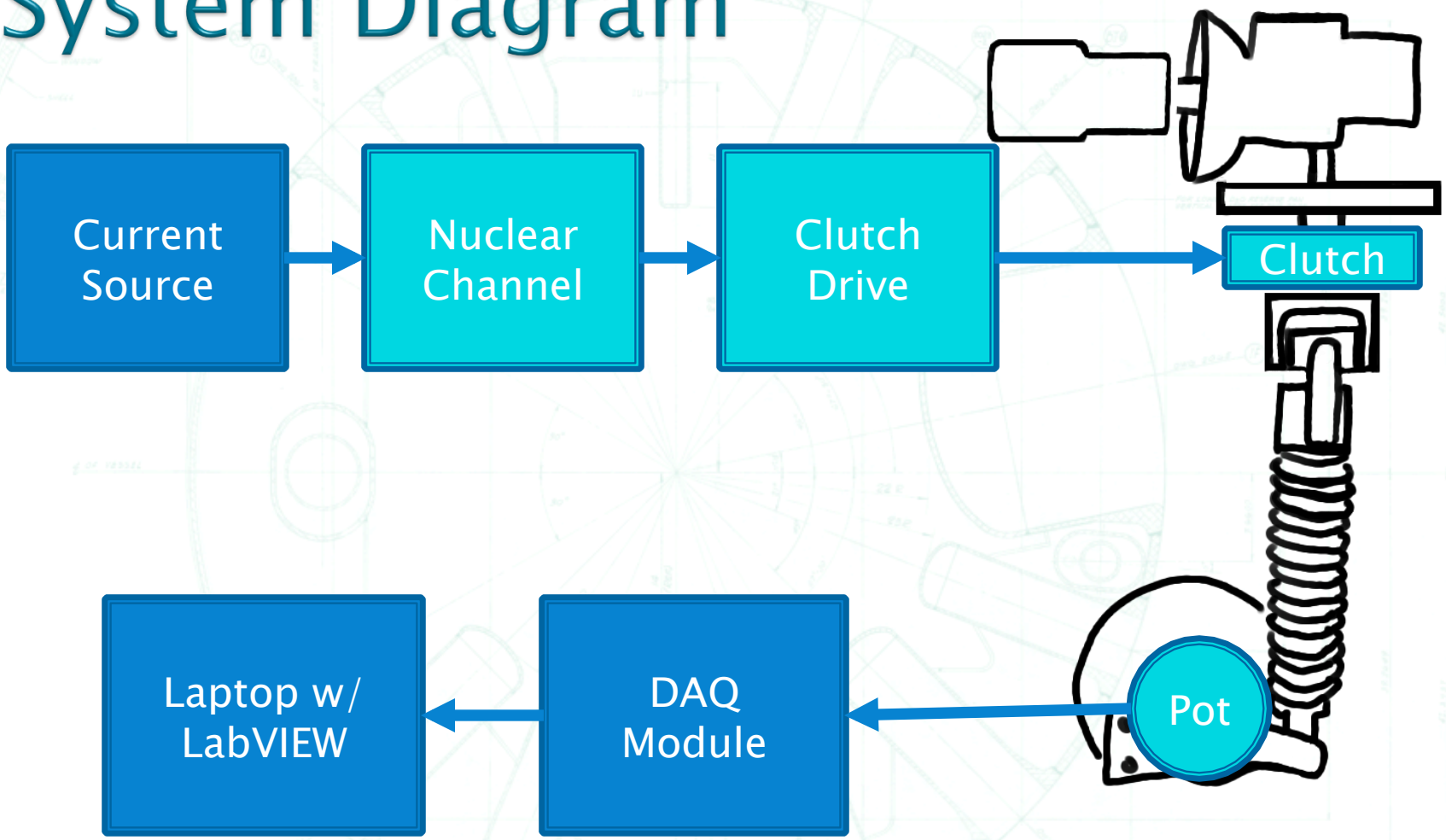
William's Summer Project Goals

- Acquire Scram Response Curve
- Fit Scram Curve to Theoretical Model
- Provide a User-Friendly Interface
- Plot and Save Data

Motivation

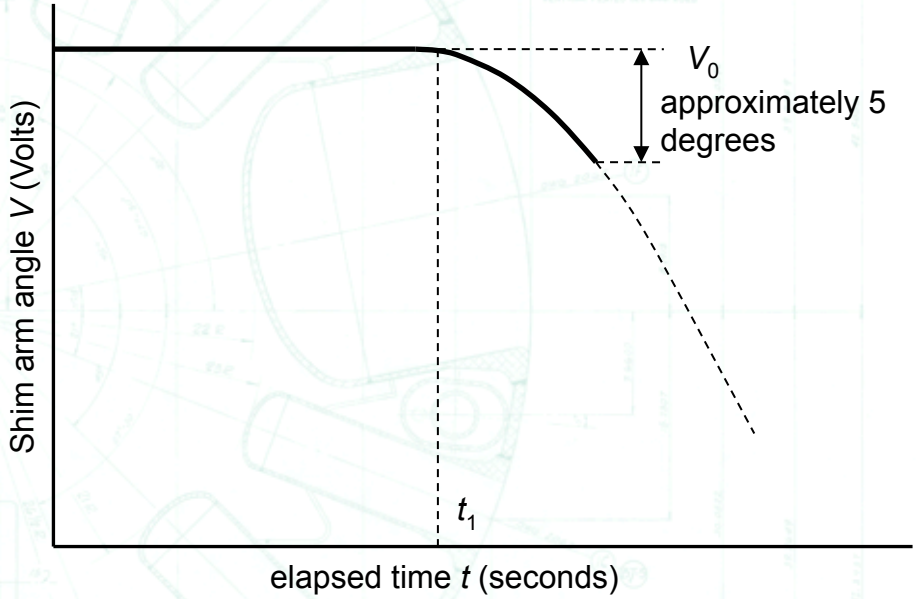


System Diagram



Theoretical Model

- Important Values to find:
  - 5° time
  - clutch release
  - Shim acceleration

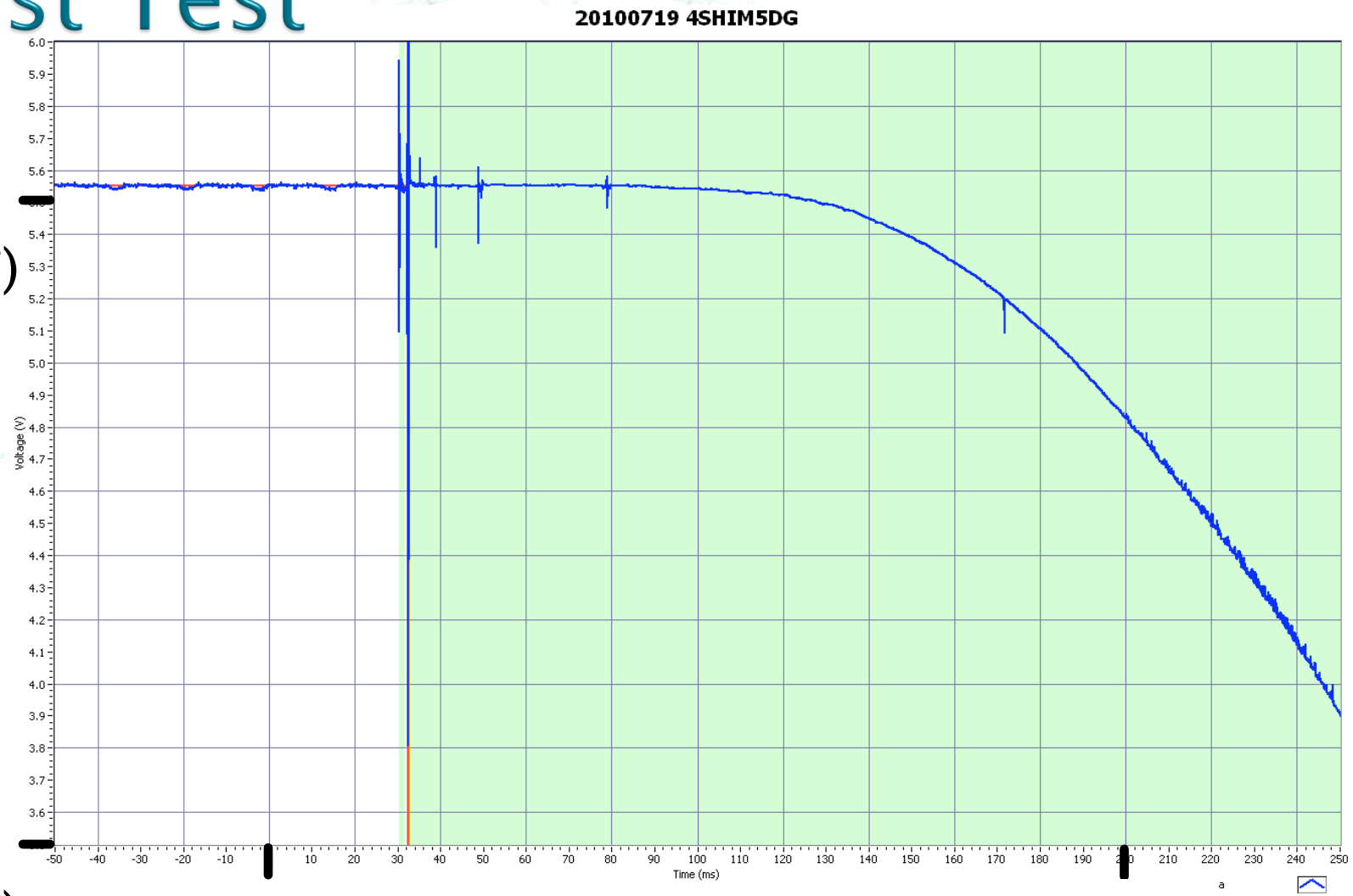


- Levenberg–Marquardt Algorithm
  - $Y(x) = f(x, a_1,\ldots,a_n)$

$$V(t) = \begin{cases} V_0 & t < t_1 \\ V_0 + a(t - t_1)^2 & t \geq t_1 \end{cases}$$

Testing

First Test

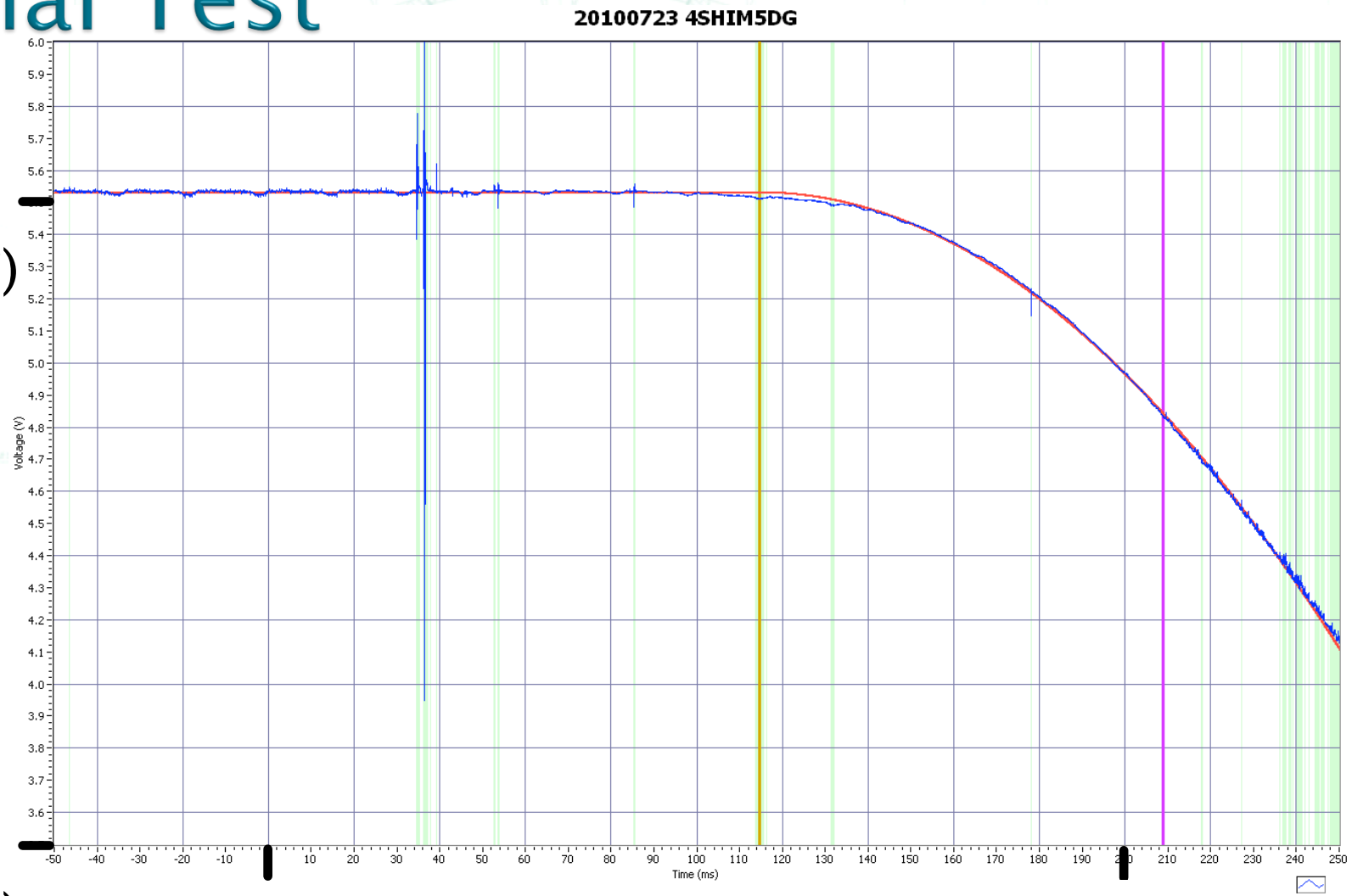


5.5 V
(40.5°)

3.5 V
(25.8°)

0 msec 200

Final Test



5.5 V
(40.5°)

3.5 V
(25.8°)

0 msec 200

NIST Center for Neutron Research

NIST

Conclusion

- Summer intern successfully produced Scram Response Test System
  - Only 10 week internship
  - No prior knowledge of LabVIEW
  - No prior knowledge of Data Acquisition equipment
  - No prior knowledge of Nuclear Reactor Systems
- All Design Objectives were met

Acknowledgements

- William Riedel
  willriedel@gmail.com
  Brown University

- NBSR Reactor Operations

- NBSR Instrument Shop