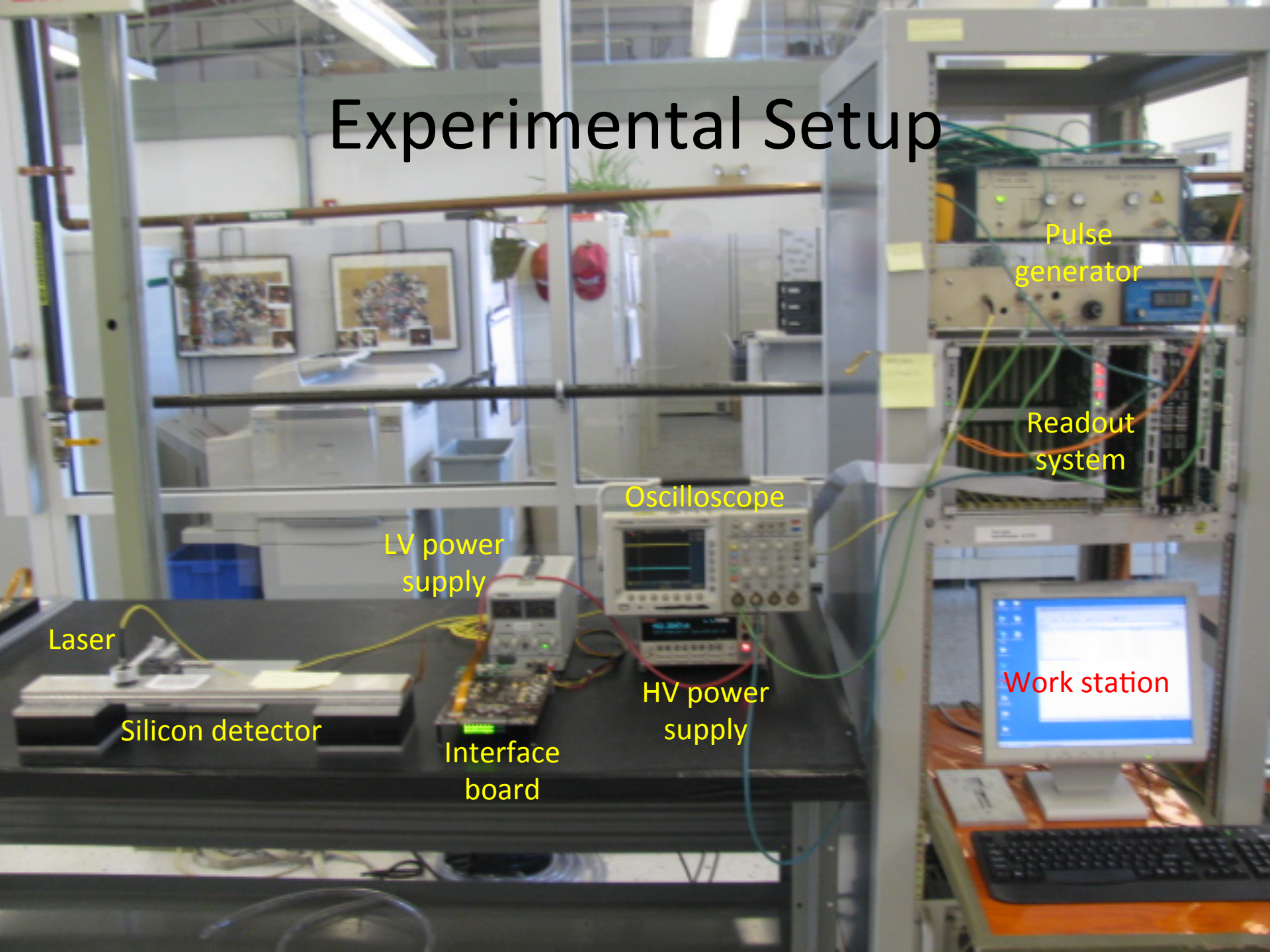
Silicon Tracking Laser Lab (EDIT 2012)

SiDet (Lab C) at Fermilab

Purpose

- Understand the basic structure and characteristics of the silicon detector
- Introduce to the elements of the readout system
- Optimize the operational parameters and determine the depletion voltage

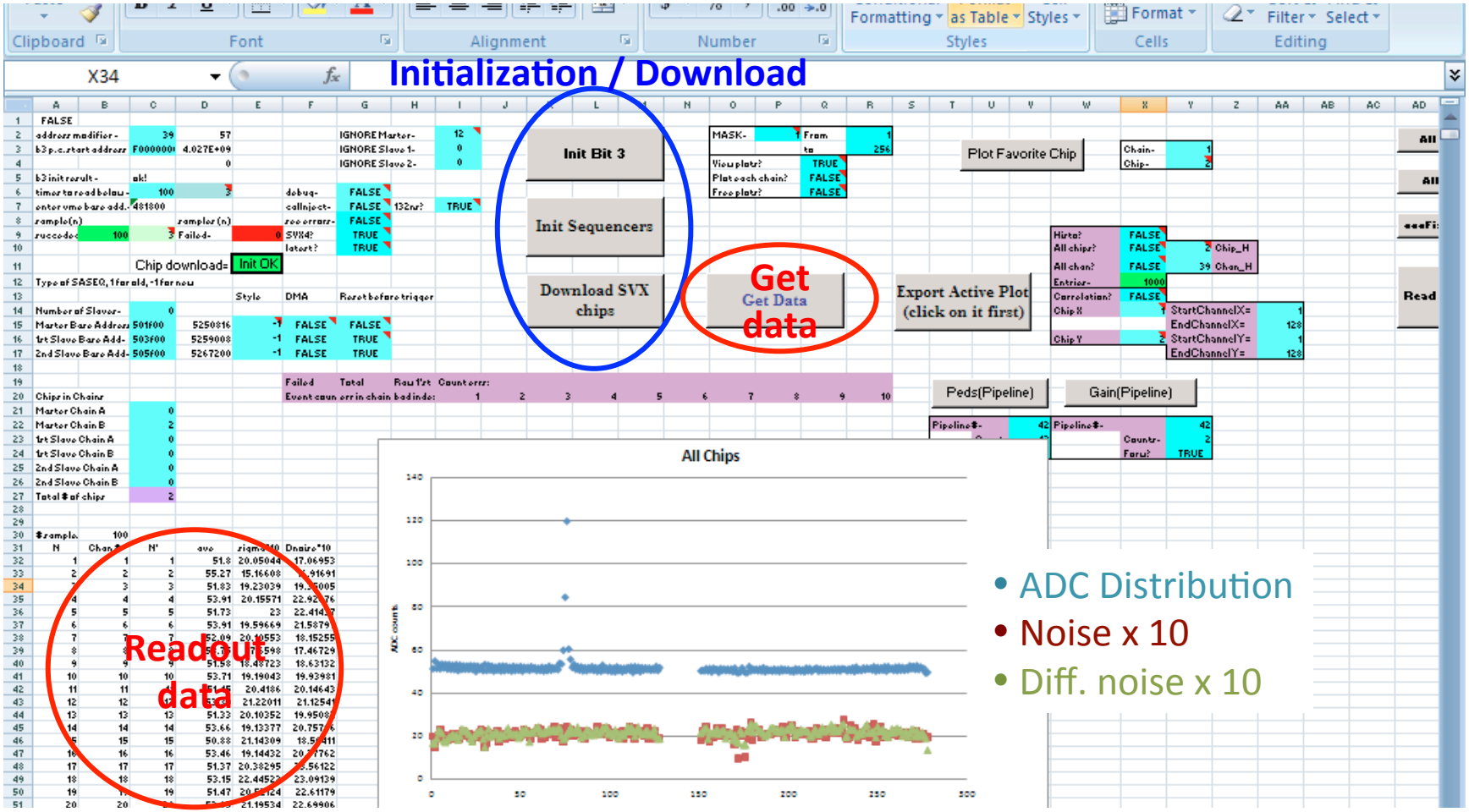
Experimental Setup



Experimental Setup

- Silicon detector
  - Housed inside the beryllium box with a hall
- Pulse generator
  - Generates laser pulse onto silicon sensor through the hall
  - Introduces time-delay w.r.t. trigger (up to 150 ns)
- Readout system
  - Interface board (interface of HV to sensor and LV to chip)
  - SEQ (controls chip, relays readout)
  - SBC (delivers data to workstation)
- Analysis tool
  - MS Excel
  - You need a personal USB to store all data

Data Taking / Analysis



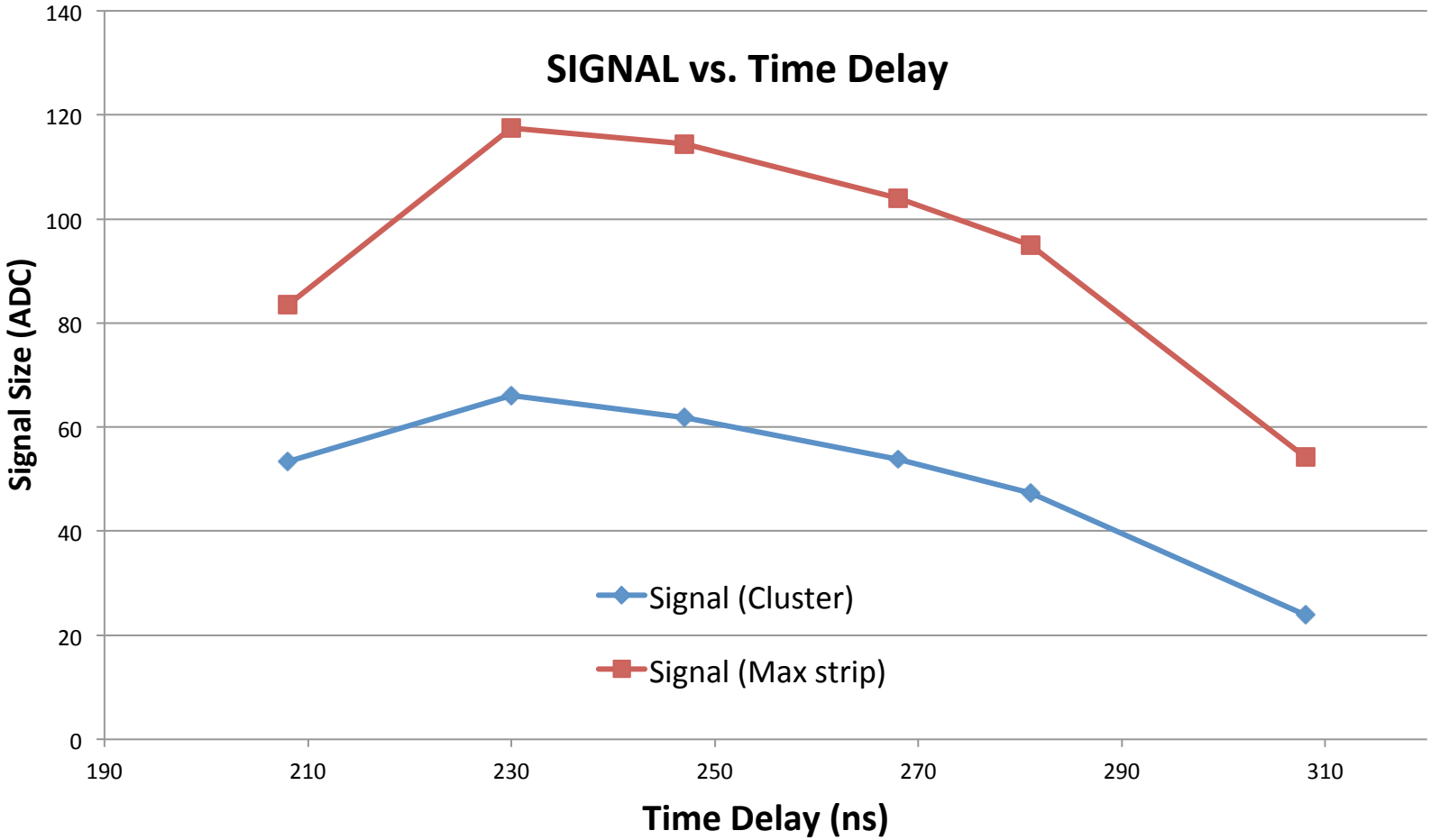
General Steps

- Ensure all electrical connections are secured and power supplies are on
  - LV: ~5 V; HV: up to 210 V
- Open the Excel spreadsheet
- Initialize the system
  - ‘Init Bit 3’ and ‘Init Sequencers’ buttons
- Download chip parameters
  - ‘Download SVX Chips’ button
- Get data
  - ‘Get Data’ button
- 100 events will be readout and data will be displayed both in text and graphically in the same sheet
- Consider pedestal-subtracted signal
  - Average ADC of non-signal strips
- Each time, copy those data into a separate sheet for the further analysis

Measurement I

- Time delay
  - Constant delay between trigger and readout
  - Optimal time delay maximize the signal size
- Procedure
  1) Use a fixed HV (100 ~ 200 V)
  2) Adjust the nozzle 'Delay' on the pulse generator to change the delay time
  3) Get data and record the delay value from the oscilloscope
  4) Repeat 2)~3) from the left end (0 ns) to right end (150 ns) of the nozzle with a 20~30 ns interval
  5) Plot the max signal value as a function of the delay time to determine the optimal time delay

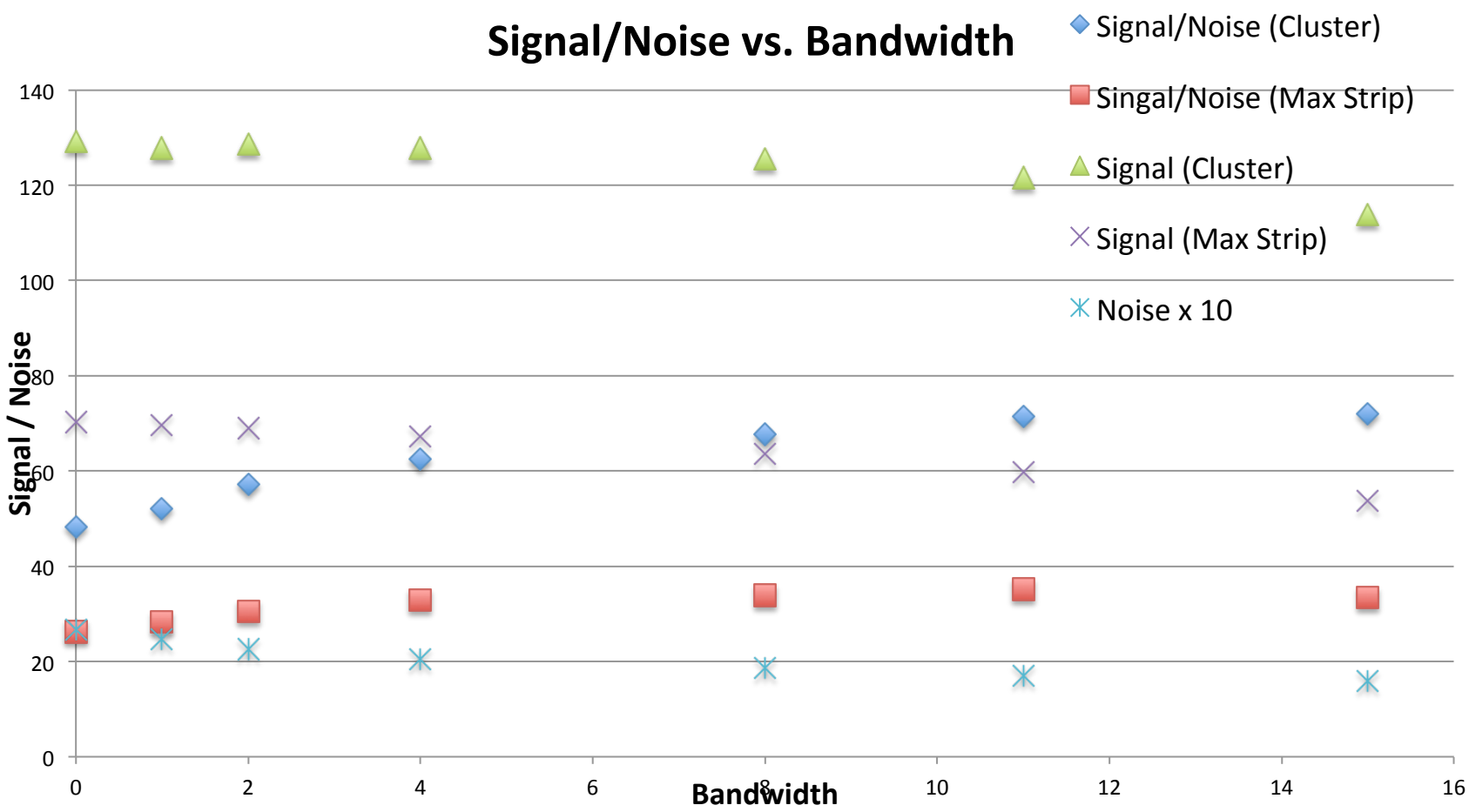
Example I


SIGNAL vs. Time Delay
Signal Size (ADC)
140
120
100
80
60
40
20
0
190
210
230
250
270
290
310
Time Delay (ns)
Signal (Cluster)
Signal (Max strip)

Measurement II

- Bandwidth (BW)
  - BW adjusts the rise time of preamp
    - Rise time will depend on input capacitance, bias current, and BW setting
- Procedure
  a) Use a fixed HV (100 ~ 200 V)
  b) Change the bandwidth parameter value from the 'Init_SVX 4_Master_new' sheet
  c) 'Init SEQ' followed by 'Download'
  d) Get data
  e) Repeat b)~d) from 0 to 15 by a 2~3 interval
  f) Plot the max signal/noise as a function of the BW to determine the optimal BW
    - Use the average noise over non-signal strips

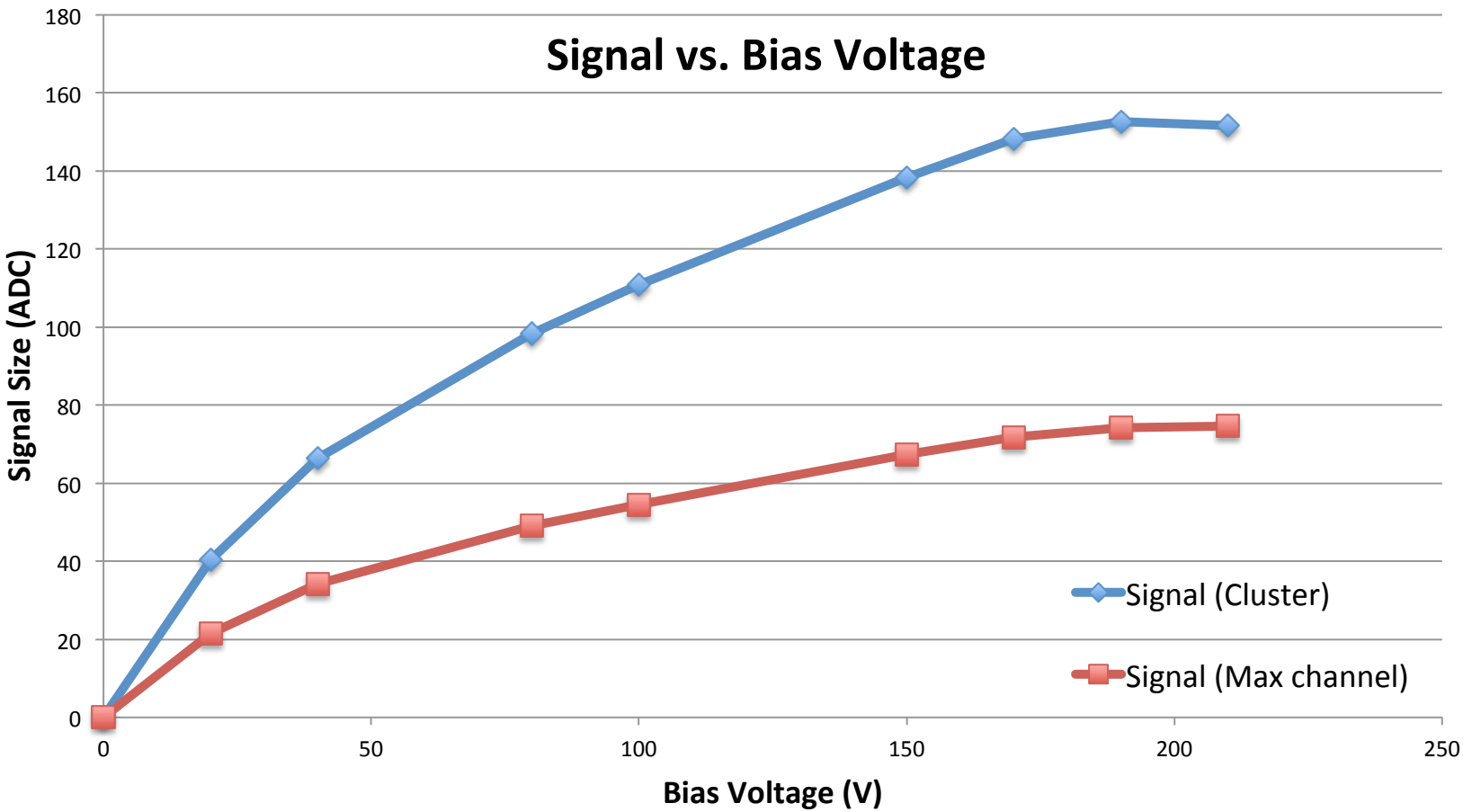
Example II


Signal/Noise vs. Bandwidth
Signal/Noise (Cluster)
Singal/Noise (Max Strip)
Signal (Cluster)
Signal (Max Strip)
Noise x 10
Signal / Noise
Bandwidth
0
20
40
60
80
100
120
140
0
2
4
6
8
10
12
14
16

Measurement III

- Depletion voltage
  - Bias voltage generates the large depletion region in the sensor to enhance the signal
- Procedure
  1) Use the optimal time delay and BW determined in Measurements I/II
  2) 'Init SEQ' followed by 'Download'
  3) Get data for a given HV
  4) Repeat 3) from 0 to 210 V with a ~20 V interval
  5) Plot the max signal as a function of bias voltage
  6) Determine the depletion voltage at the point where the signal is 95% of the maximum

Example III


Signal vs. Bias Voltage
Signal Size (ADC)
180
160
140
120
100
80
60
40
20
0
0
50
100
150
200
250
Bias Voltage (V)
Signal (Cluster)
Signal (Max channel)

Back-Up

Introduction

- Silicon sensor
  - p-n junction
  - Low ionization energy (large signal)
  - Long mean free path (good charge collection efficiency)
  - High mobility (fast charge collection)
  - Low Z (low multiple scattering)
  - Very well developed technology
- Readout chip
  - SVX series (SVX 4)
  - Low noise, deadtimeless,…
- Silicon detector
  - Good energy/space/time resolution