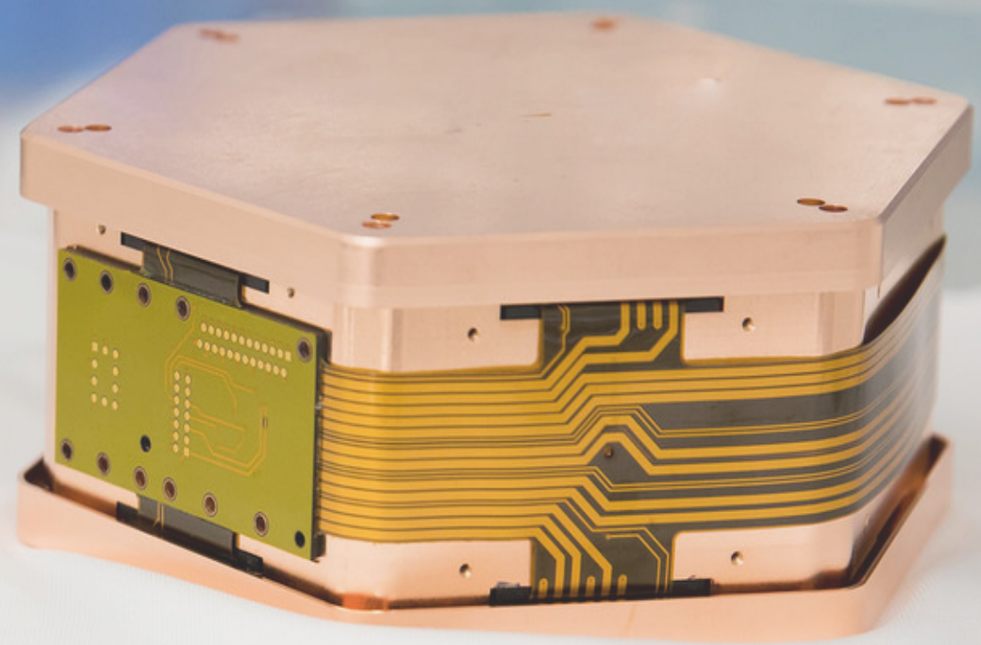
Validating the performance of the Trigger for the Super Cryogenic Dark Matter Experiment



Data Acquisition and Triggering meeting

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Photo from supercdms.slac.stanford.edu

Outline

- **SuperCDMS Trigger Validation Method**
- **Comparing Data to Trigger Simulation**
- **Conclusions and Future Plans**

Trigger Validation

Goal: Validating the performance of the Trigger

- Does the Trigger do what it is supposed to do?
- How often, when there is no input pulse, do we fire? How does that change as a function of the threshold?
- How often does the trigger make the right decision? How is this affected by the noise?

We created a test stand to simulate phonon signals and see how the Trigger responds

Trigger Simulation

- **Since the trigger is fully digital we can use a simulation as a way to verify that it works exactly as expected.**

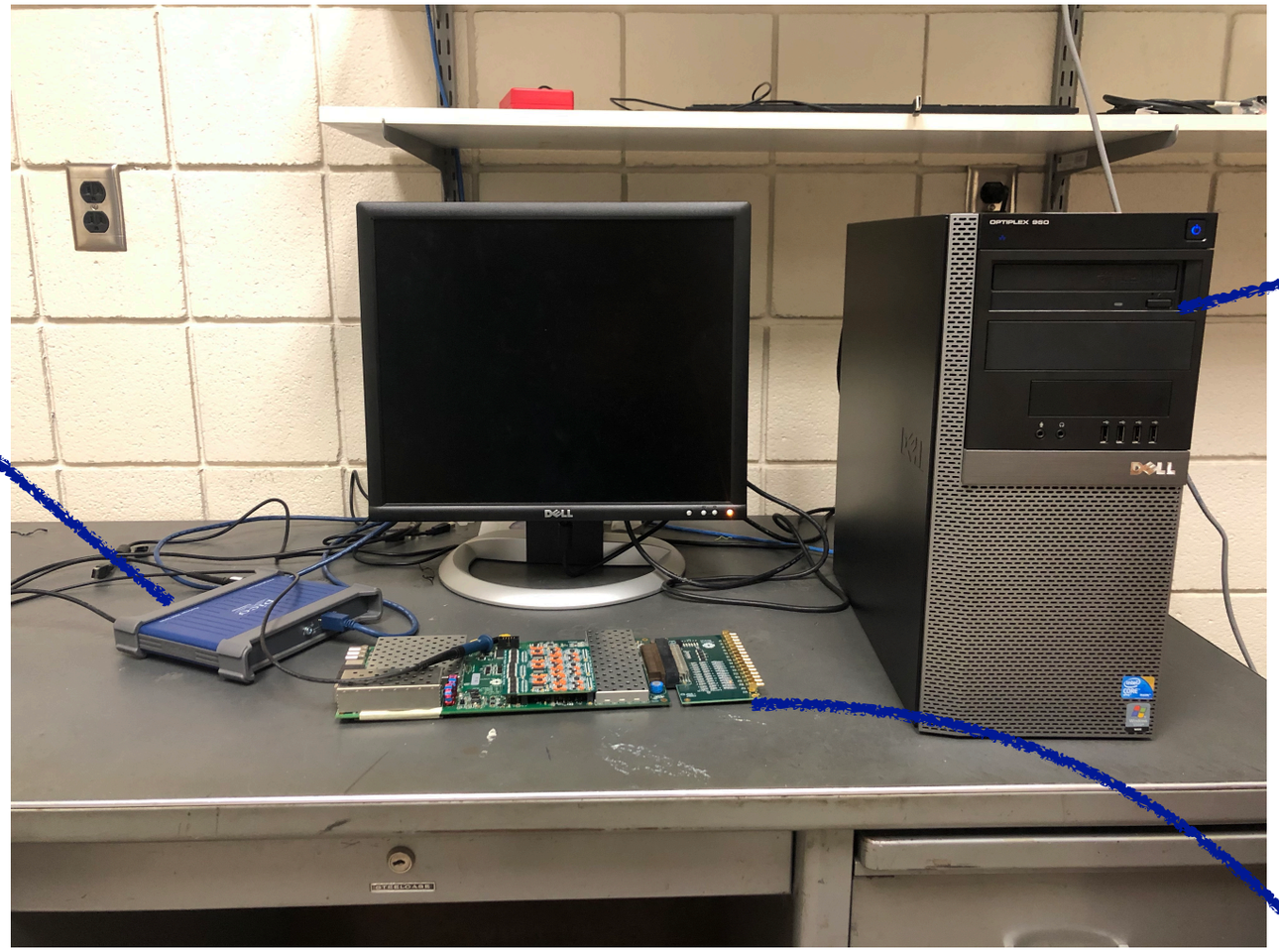
- **In this analysis we used Trigger Simulation Version 0.1 developed by Jon Wilson. (Repository: /DCRC/Trigger_Simulation.git)**

- **It simulates all of the Trigger modules and replicates the trigger decision bit by bit.**

TAMU Test Stand

Data Acquisition Computer
Midas v2.1.0-beta1

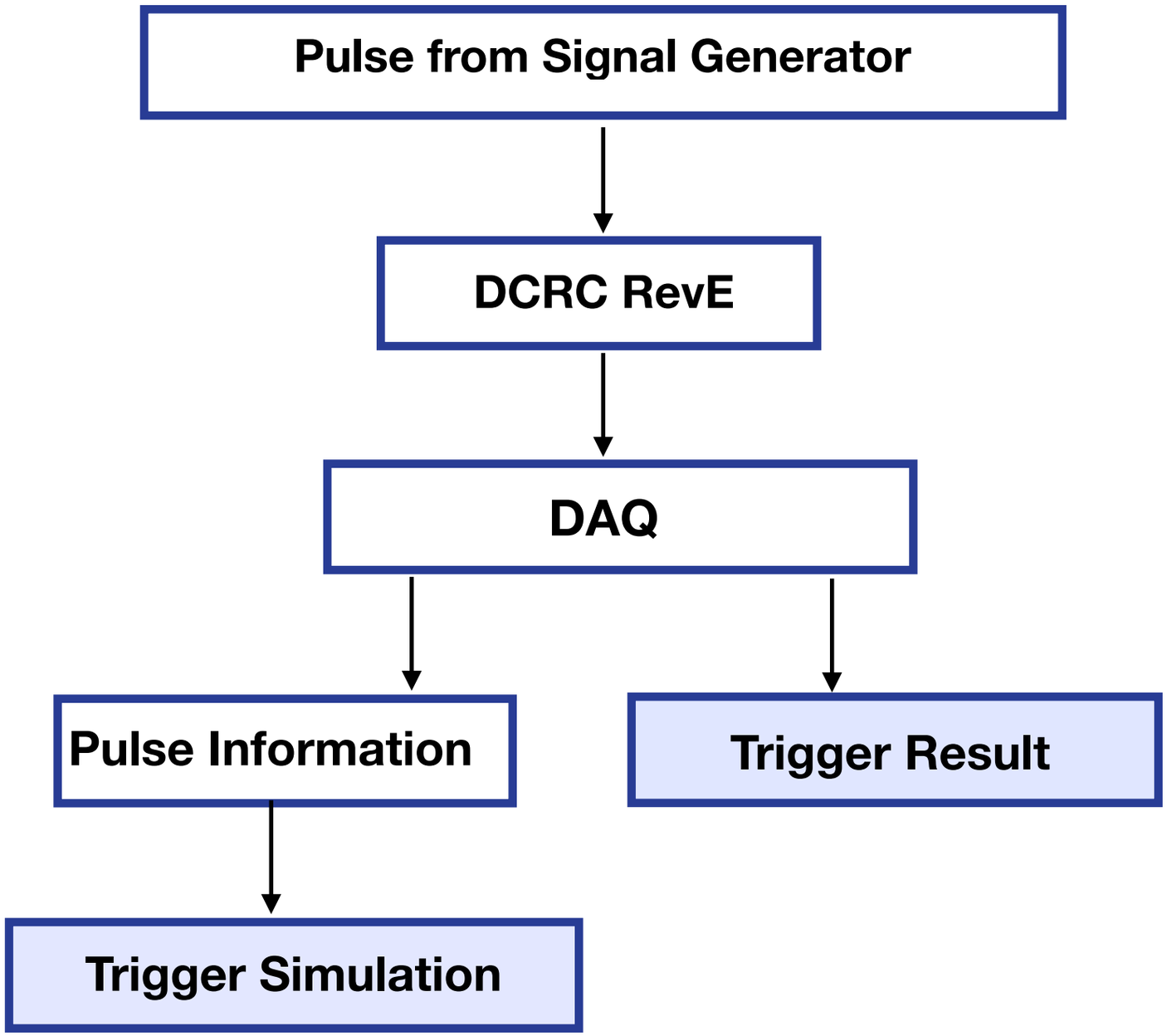
Pulse Generator



TAMU Test Stand

Data Acquisition/ Trigger Board
DCRC RevE

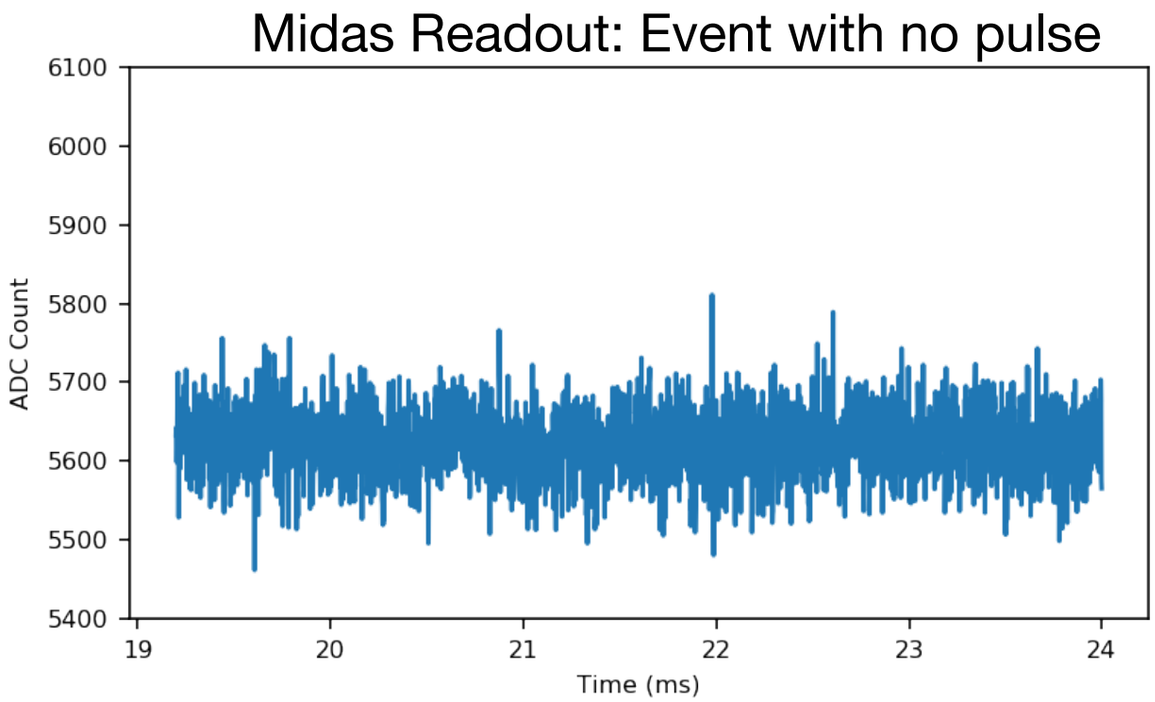
Validate the Trigger Using a Custom Trigger Simulation

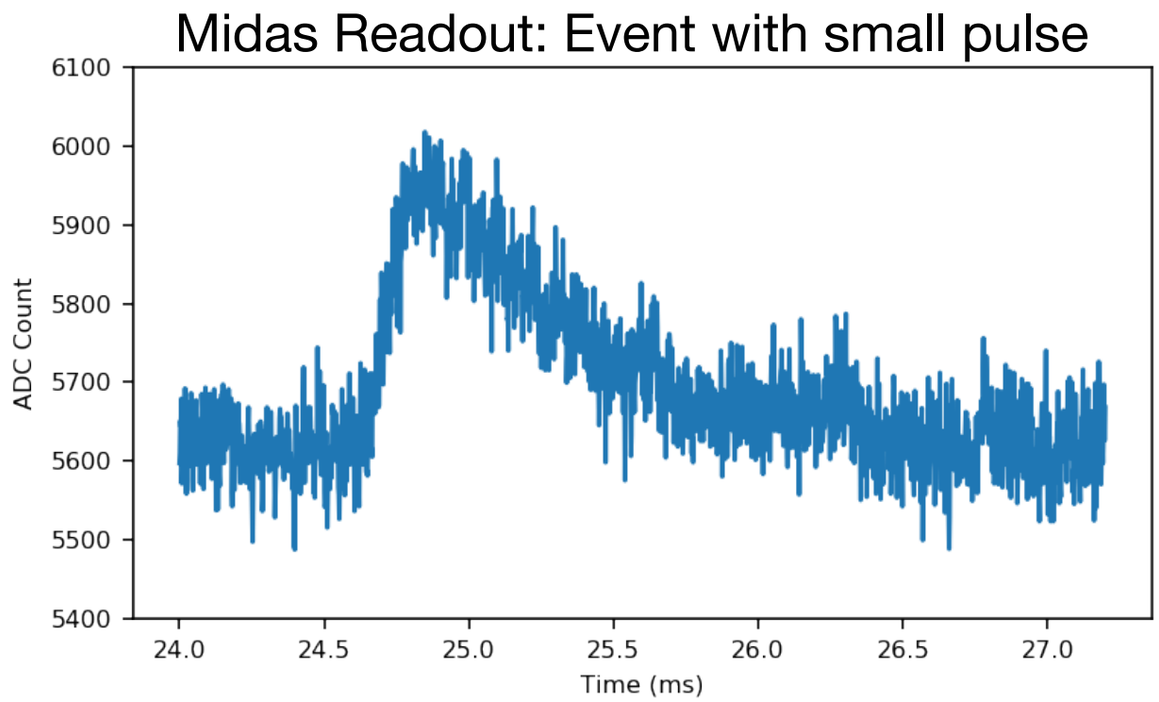


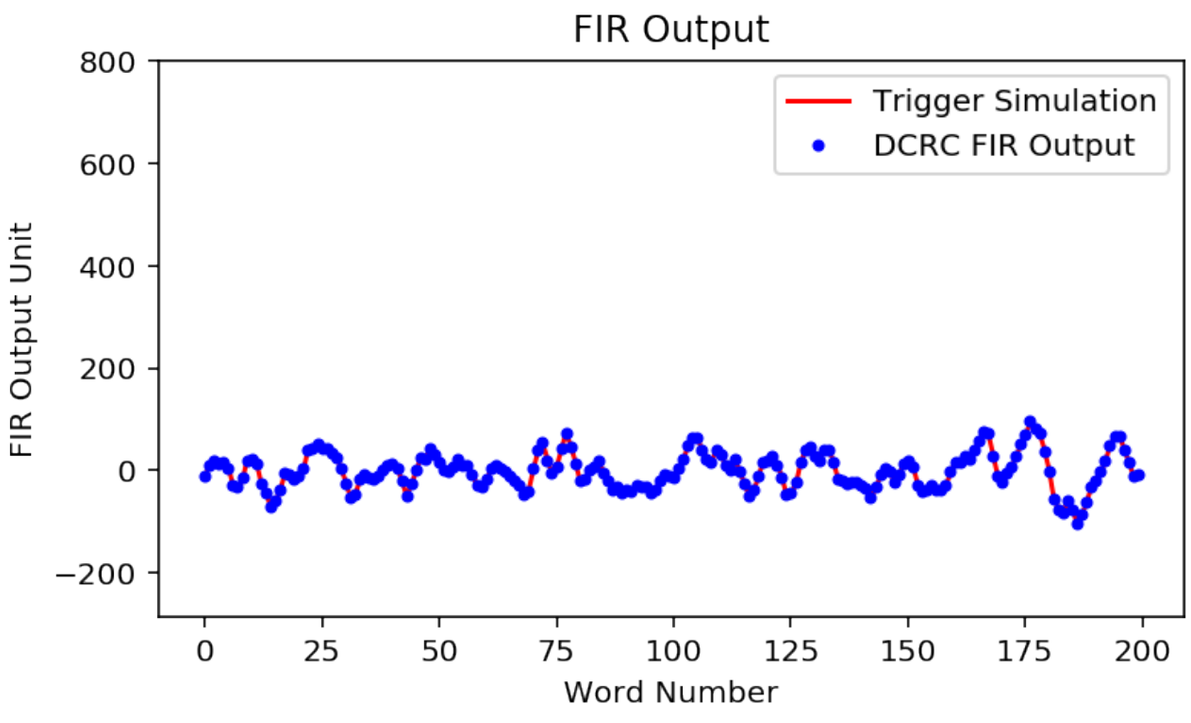
- **We compare real Trigger result with Trigger Simulation result to confirm that Trigger does what it is supposed to do**

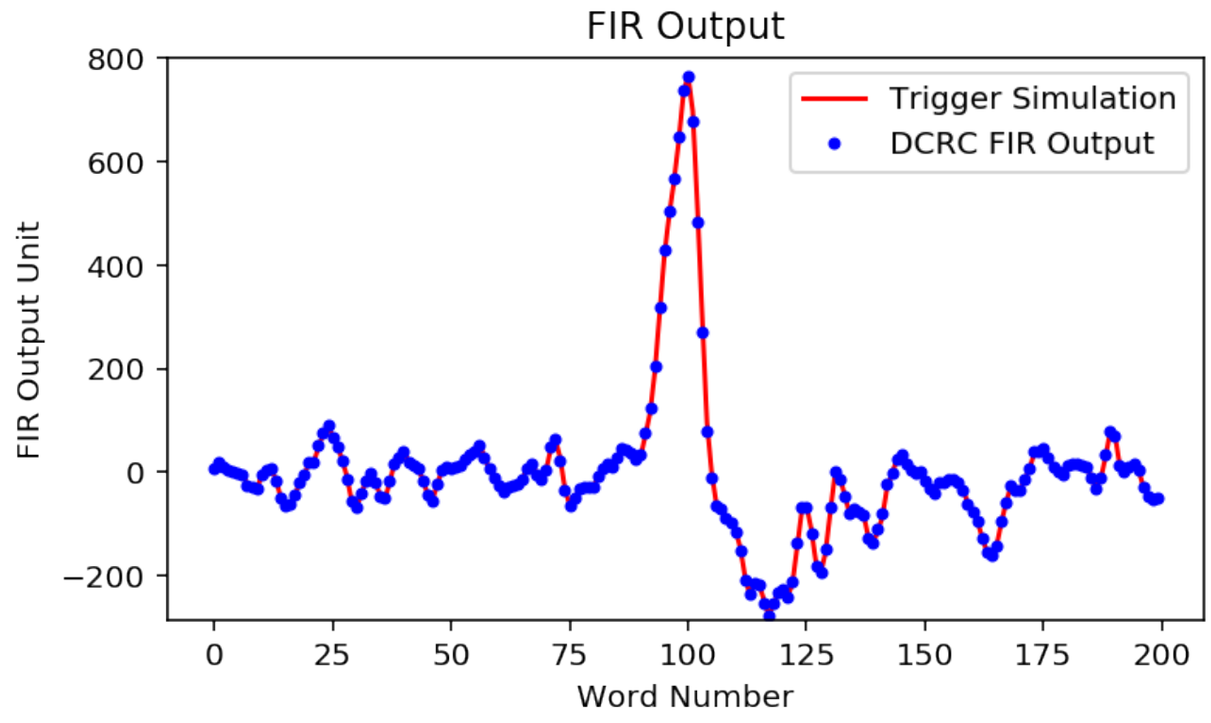
Results: Simulating WIMP events and Comparing with Simulation

Used a boxcar filter here.

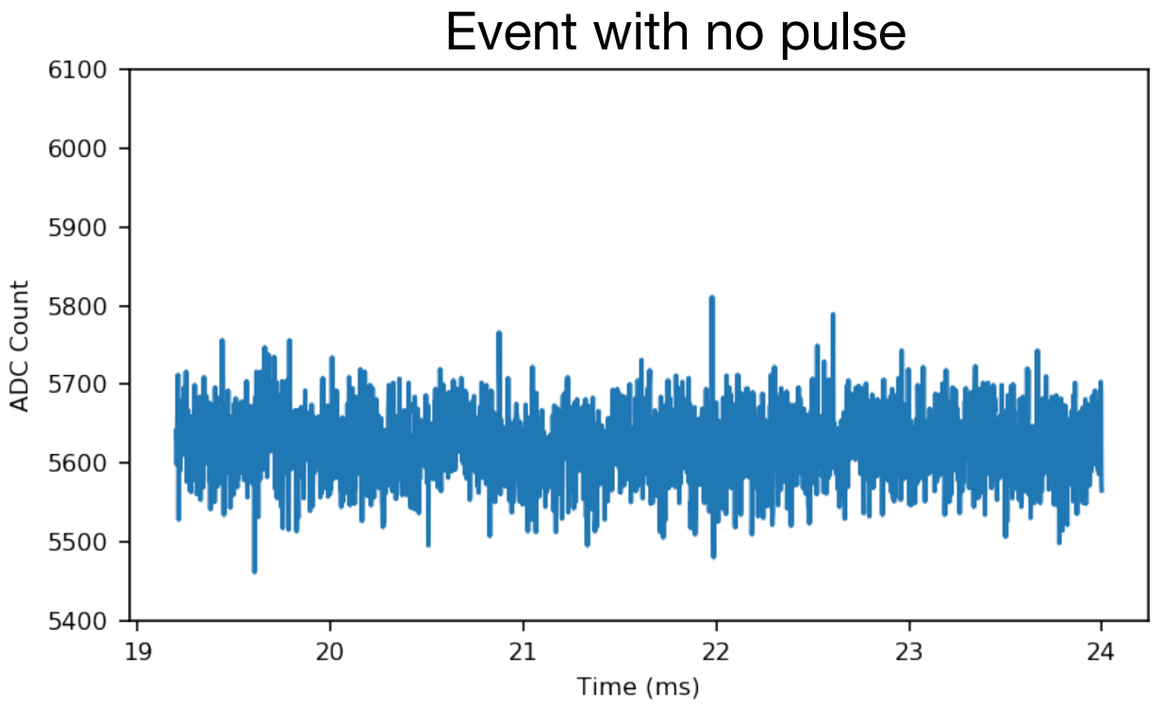


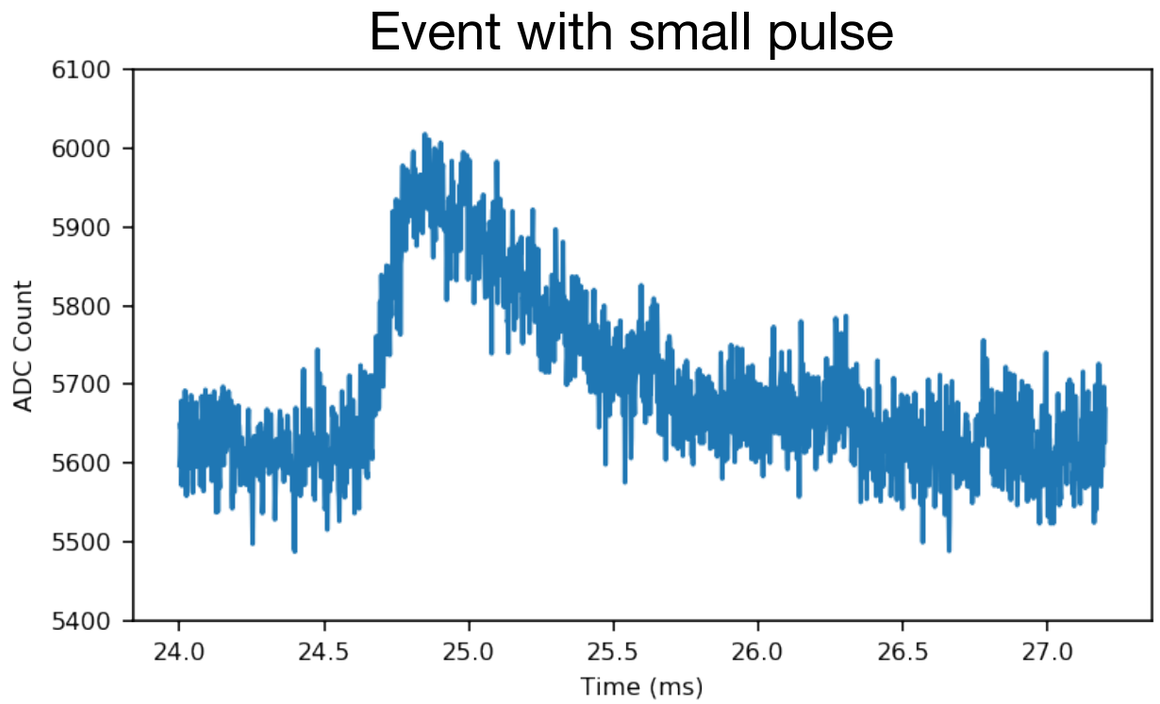


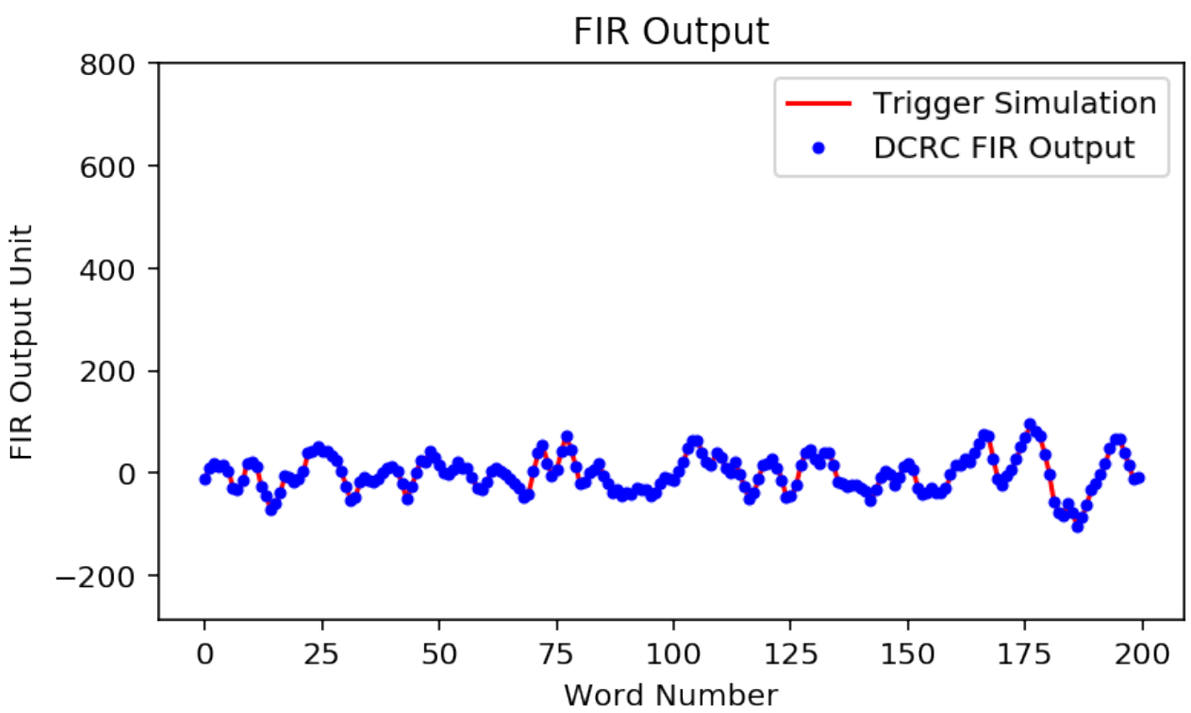


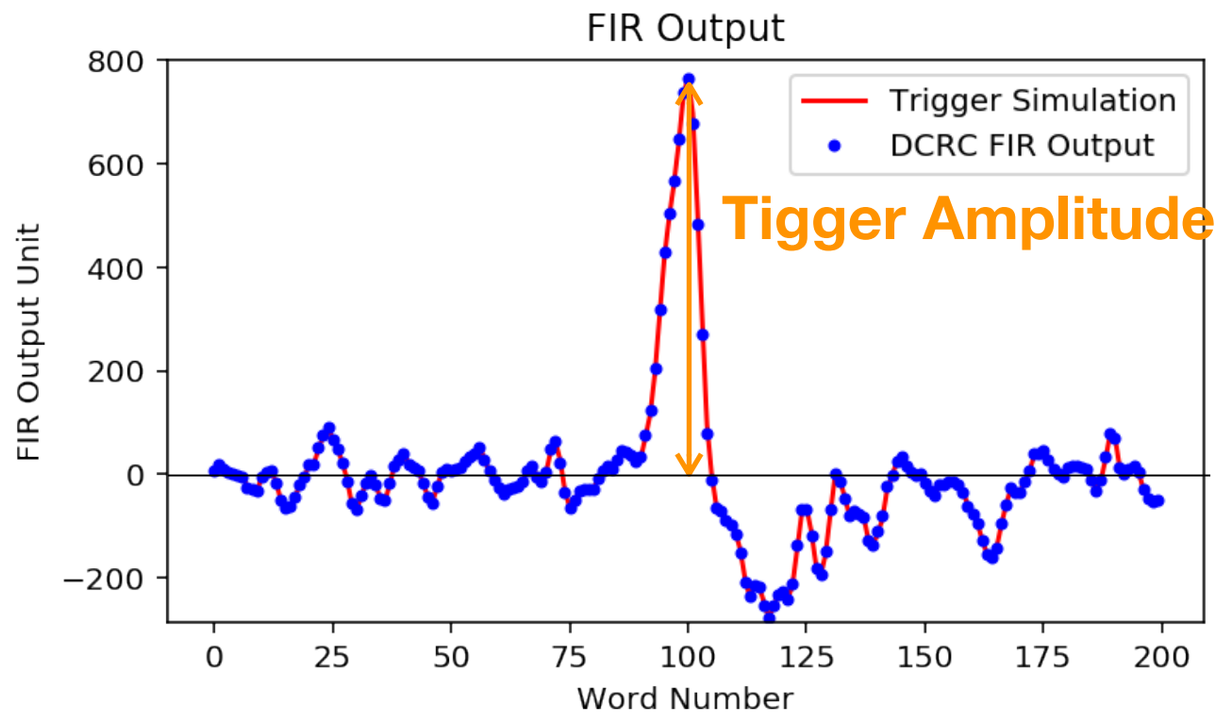


Results: Simulating WIMP events and Comparing with Simulation



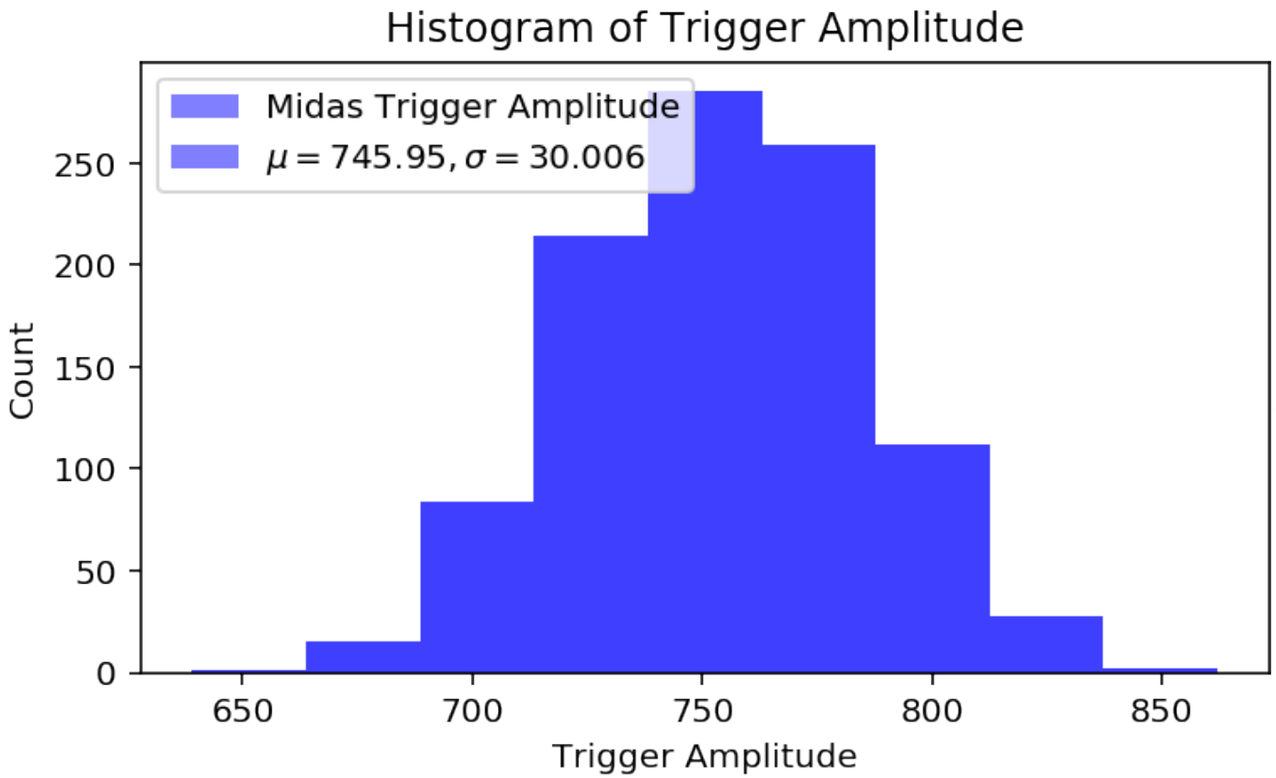


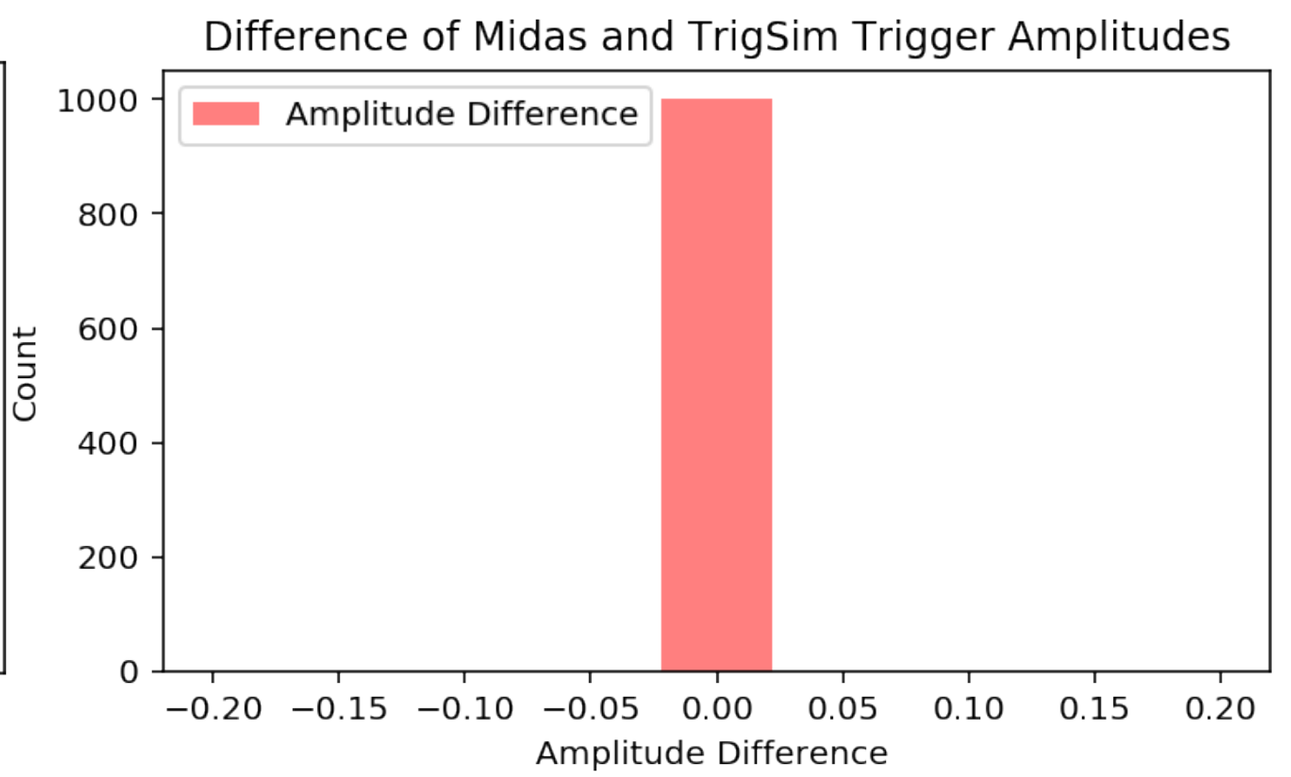




Trigger Amplitude Distribution

- **Example of Tigger Amplitude distribution at a low threshold where all of the events pass**
- **1000 identical pulses Injected to the DCRC by the Signal Generator**





How Well is the Trigger Working?

- **Trigger is doing what it is supposed to**

Why Do We See this Variations?

- **Pulse Generator is NOT Perfect**
- **Even if Pulse Generator was perfect we would still see variations in Trigger Amplitude because of Noise**

How well is the Trigger Simulation Working?

- **For all 1000 pulses send to the DCRC, the peak amplitude reported by the real trigger and our trigger simulation are identical**

Trigger Simulation is Reliable!

How to Make This Analysis Quantitative?

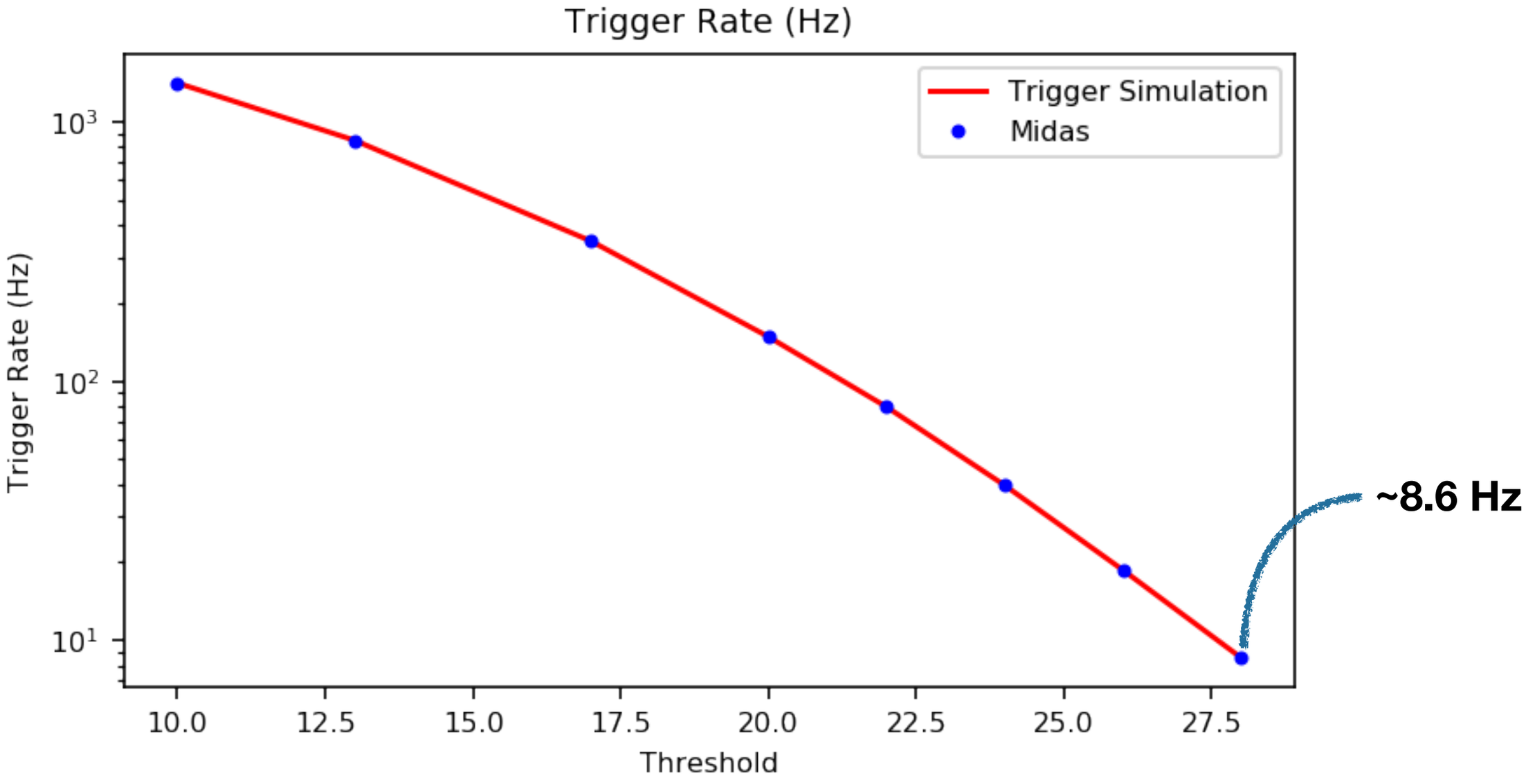
We make the following plots for both Trigger Simulation and Midas Trigger result and compare them.

- **Noise Trigger Rate - Threshold:** Number of times per second when there is no input signal (noise only) but the trigger fires anyway. Do this as a function of Threshold

- **Efficiency - Threshold:** Number of times it triggers/Total number of pulses sent to the DCRC. Do this as a function of Threshold

Trigger Rate - Threshold

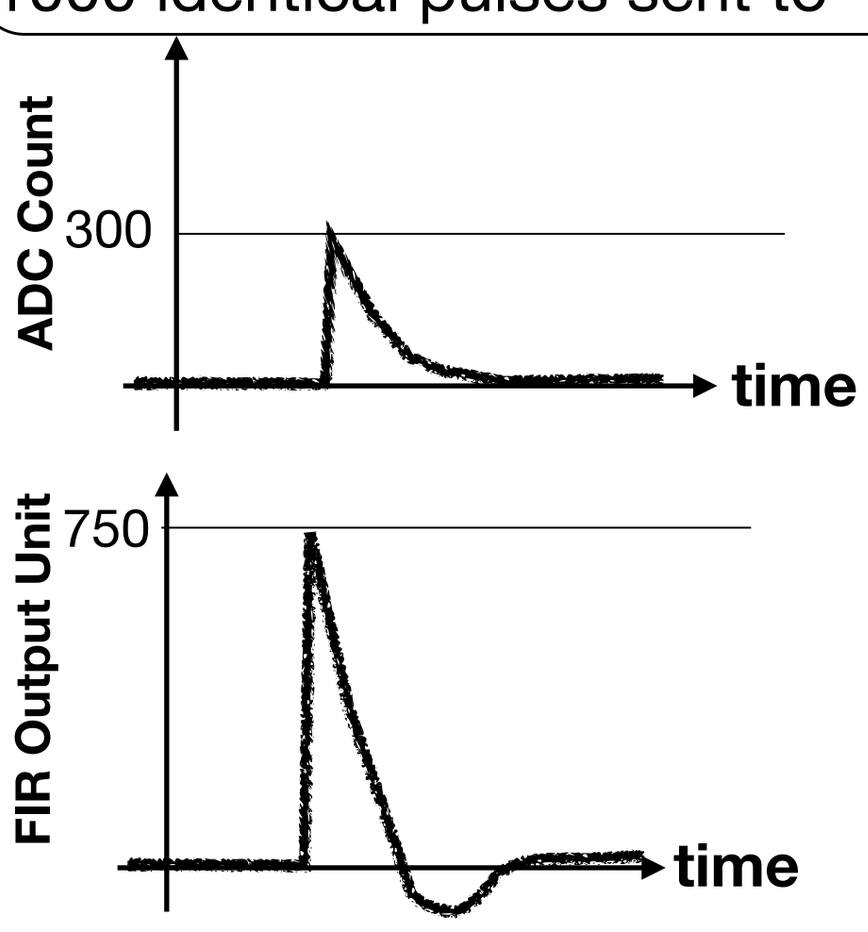
- **No input pulse injected to the DCRC**
- **Boxcar filter**
- **How many triggers per seconds do we get at each threshold?**
- **Trigger Rate is sharply falling as expected**

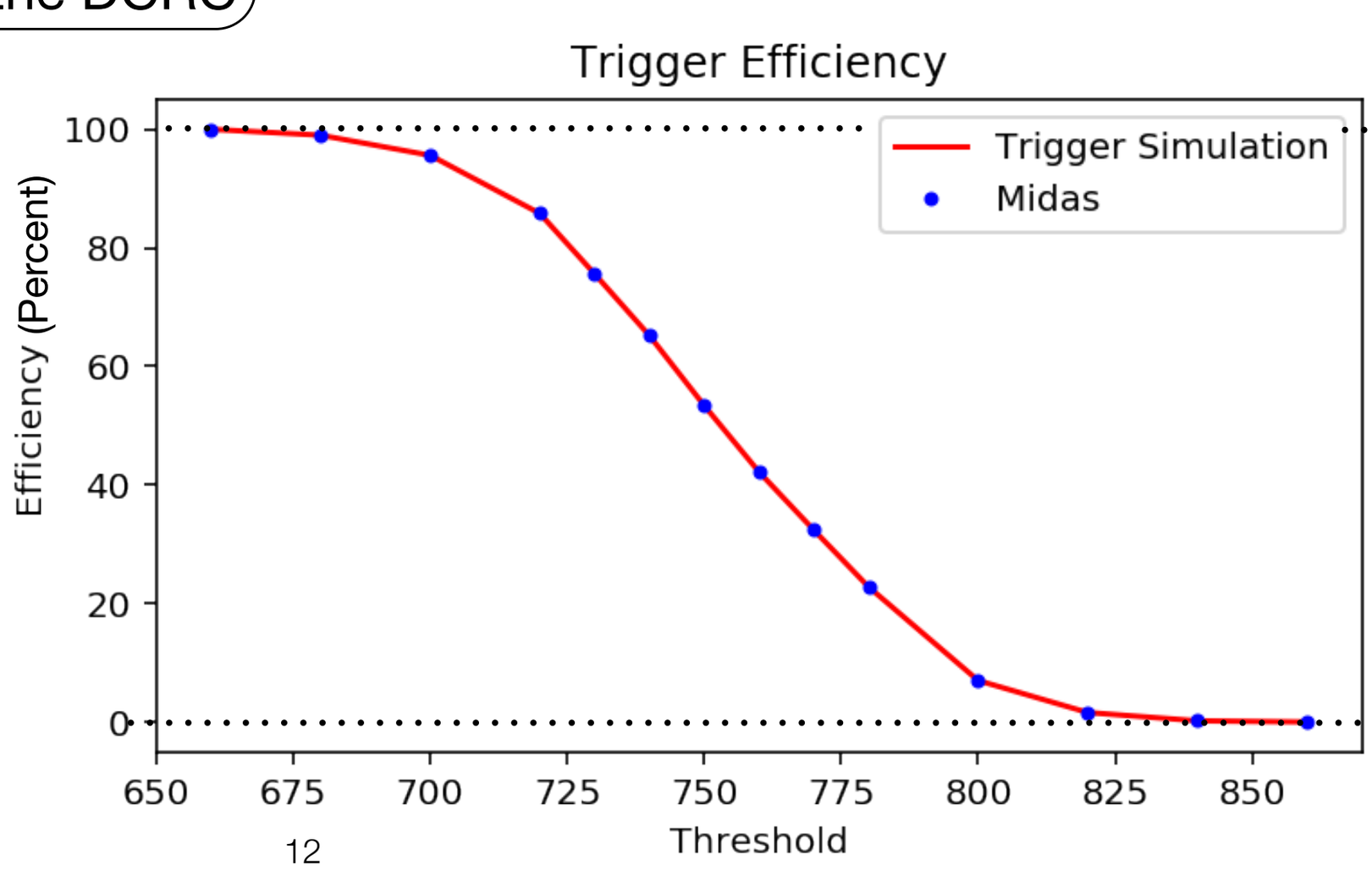


Efficiency - Threshold

- **We change the FIR amplitude required to accept (threshold) and at each step count the number of time the trigger accepts the event**
- **Since there is variation, due to noise, this means that we expect there to be some width to the distribution. This width will be smaller if we have less noise and use an optimal filter.**
- **Trigger Simulation and Midas Trigger Result are identical!**

1000 identical pulses sent to the DCRC





Summary of Trigger and Trigger Simulation Studies

- **Does the Trigger do what it is supposed to do?**
  - **We showed that Trigger Simulation and data agree perfectly. So Trigger is doing what it is programmed to do**
- **How often, when there is no input pulse, do we fire? How does that change as a function of the threshold?**
  - **Noise rate falls rapidly as a function of threshold**
- **How often does the trigger make the right decision? How is this affected by the noise?**
  - **Trigger is doing what it is planned to do. Variations in the Trigger Amplitude are from Noise**

Other Accomplishments and Future Plans

- **Trigger has been working perfectly with real detectors at least for 9 months**
- **The resolution of our trigger appears to be significantly affected by noise. Using an optimal filter and current electronics at the real experiment should lower the noise, and our simulations indicate that should really help**
- **Next steps:**
  - **Using Trigger in different modes**
  - **Testing Trigger on the Production DCRC Board**
  - **Using Trigger Simulation for online monitoring**
  - **Put detectors in the SNOLAB cavern**

Conclusions

- **We have brought a DCRC to TAMU and have simulated inputs from the detector using a pulse generator to test how well the trigger works**
- **By comparing real Trigger data to Trigger Simulation we made sure that they agree perfectly and Trigger Simulation is reliable**
- **We confirmed that Trigger is working as expected**