Modeling Trigger Delay of the SuperCDMS experiment

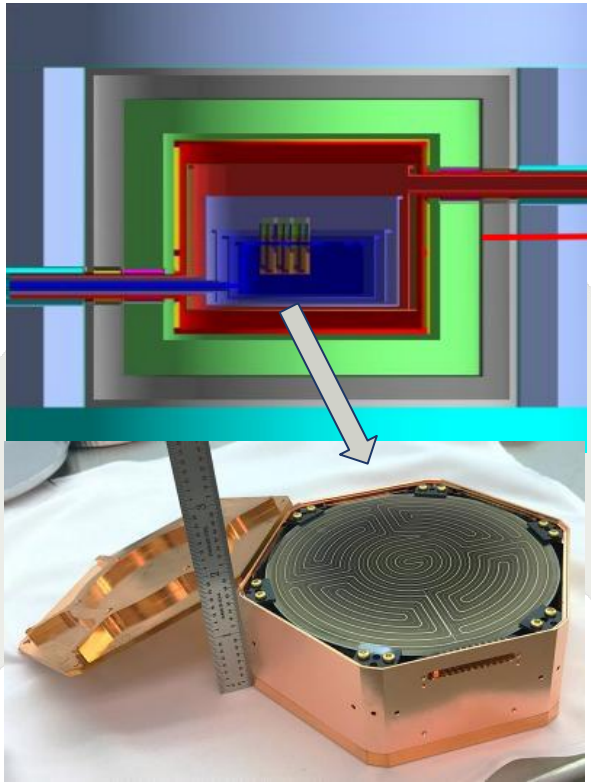
Tom Wu

UNIVERSITY OF TORONTO

The SuperCDMS Experiment: The Basics

- Location: Sudbury, Inside SNOLAB, Creighton Mine #9
- Depth and extra insulating shields from radiation.
- Semiconductor crystals: Si(0.6kg), Ge(1.4kg) as absorbers.
- 2 Types of Detectors: iZIP(Discrimination between Nuclear and Electronic Recoil) and HV (Lower threshold in certain mass ranges)
- Sensors cooled by a He-3 and He-4 mixture running at ~40mK

From Outside: Outer Neutron Shield, Gamma Shield, Inner Neutron Shield and Cryostat

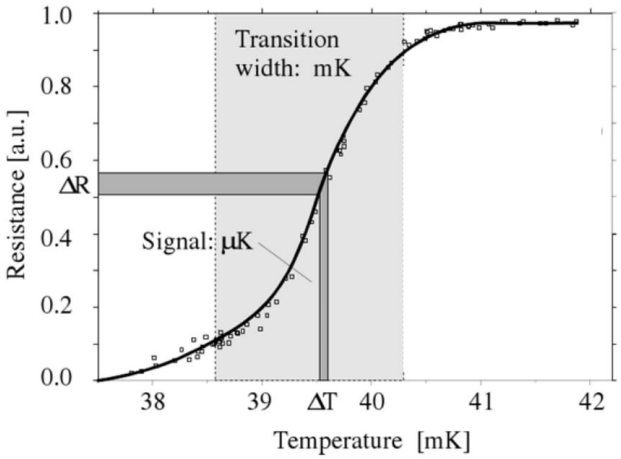


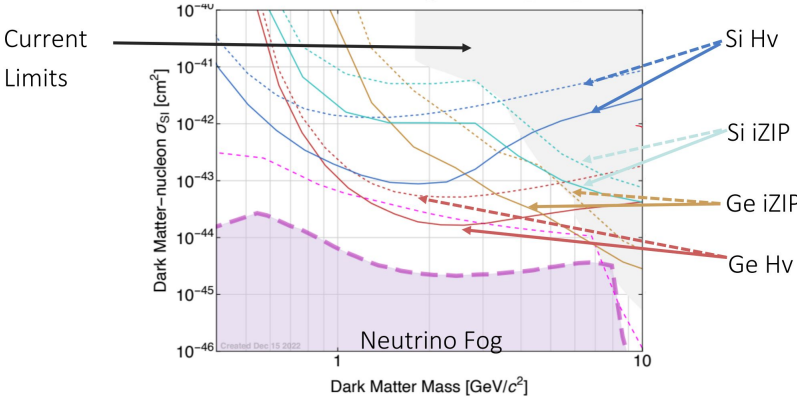
(SuperCDMS Collaboration)

UNIVERSITY OF TORONTO

The SuperCDMS Experiment: Sensors

- Phonon Channel: Transition Edge Sensors
- Charge Channel: Ionization Sensors
- Detects energy deposits as low as tens of eVs.
- More sensitive than current limits at 1-10Gev mass ranges
- Can also detect DM candidates in other mass ranges



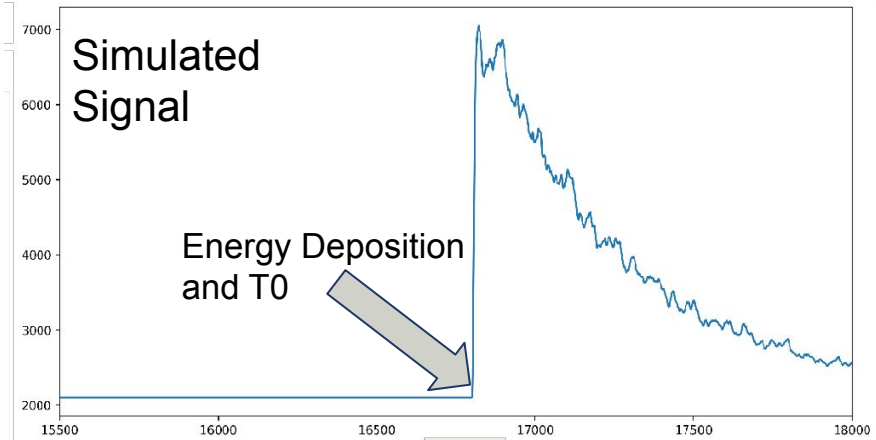


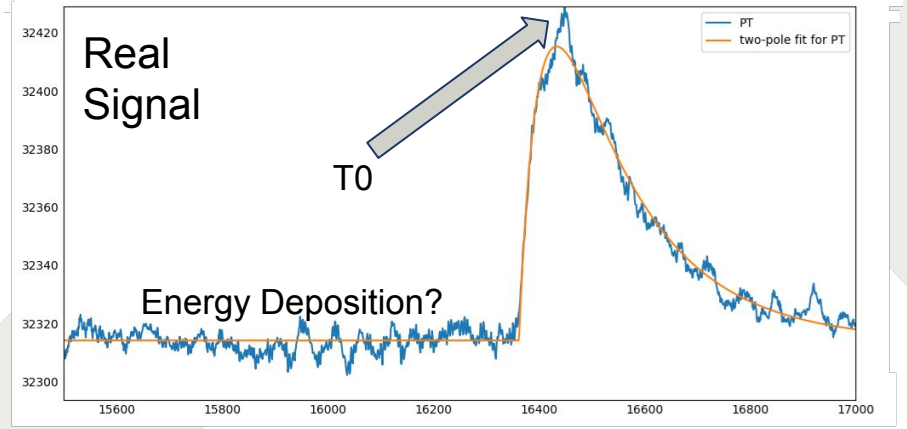
(SuperCDMS Collaboration)

UNIVERSITY OF TORONTO

Motivation

- Goal: Want simulate pulses to look and behave exactly the same as ones from real data.
- In real world we only get the pulses.
- A whole Detector Monte Carlo working group at UofT working on Simulations
- One important effect is the time delay

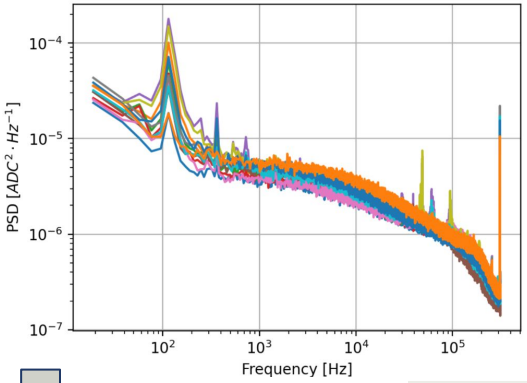


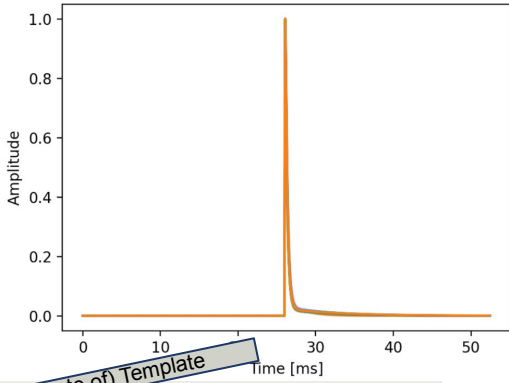


UNIVERSITY OF TORONTO

FIR Filtering

- Use FIR to implement Optimal Filter
- Search for the signal with templates
- Chi-square fit in the frequency domain
- Inverse discrete fourier transform to get FIR constants

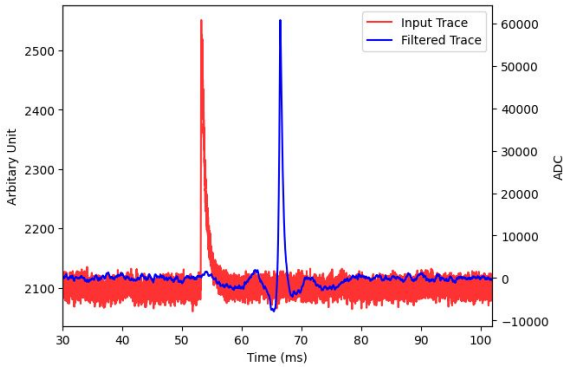




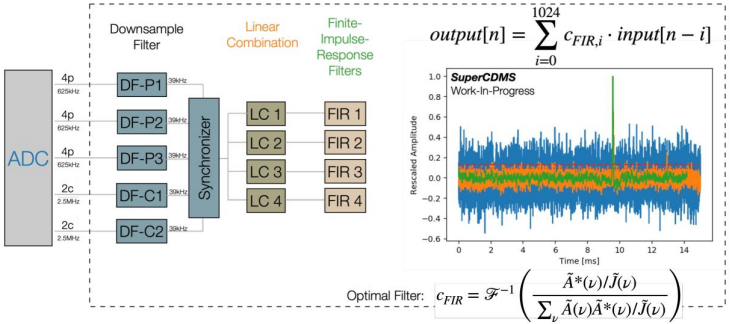
(Complex Conjugate of) Template

Noise spectrum

$$\phi(f) = \frac{s^*(f)}{J(f)}$$



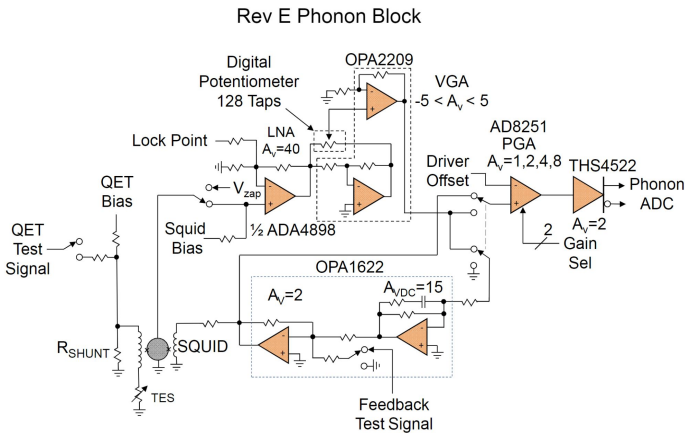
L1 Trigger Overview

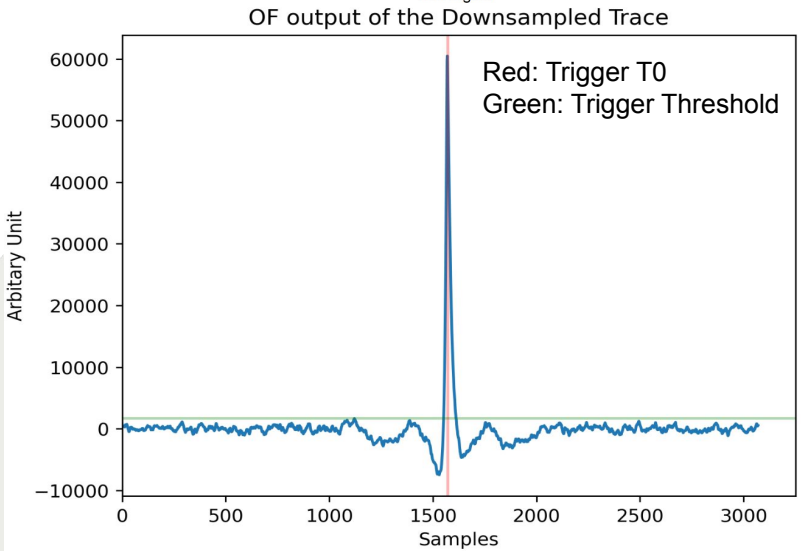


UNIVERSITY OF TORONTO

Triggering

- Goal: Find a point for the FPGA to slide and store signals around this point
- Trigger is “active” when the signal > threshold
- T0 of the event is the time of the peak
- Triggering is done real-time with the FPGA (Field Programmable Gate Array)

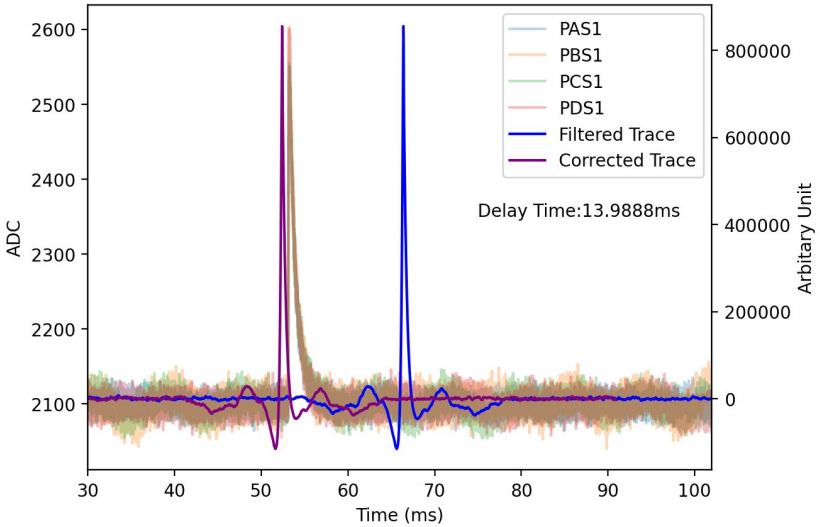




(Preliminary, Work in Progress)

Trigger Delay

- Offset factor depends on the trace and can be modeled.
- Each channel have different behavior.
- Peak of the purple trace lines up where the signals start to rise.
- Exploring Dependence on energy level and position of the energy deposition event



(Preliminary, Work in Progress)

Faint Colorful Traces: Raw Input from the channels
Blue Trace: Output of FIR Filter
Purple Trace: Trace Corrected for delay time

Conclusion

- Upon completion, SuperCDMS will be **the most sensitive** dark matter detection experiment in mass ranges 1 - 10 GeV
- The electronics uses a clever **filtering and triggering** system to recognize and store the important information in a cost-friendly manner.
- Building pipeline to model Trigger Delay Time helps event data reconstruction and analysis when real science data comes in **next year.**