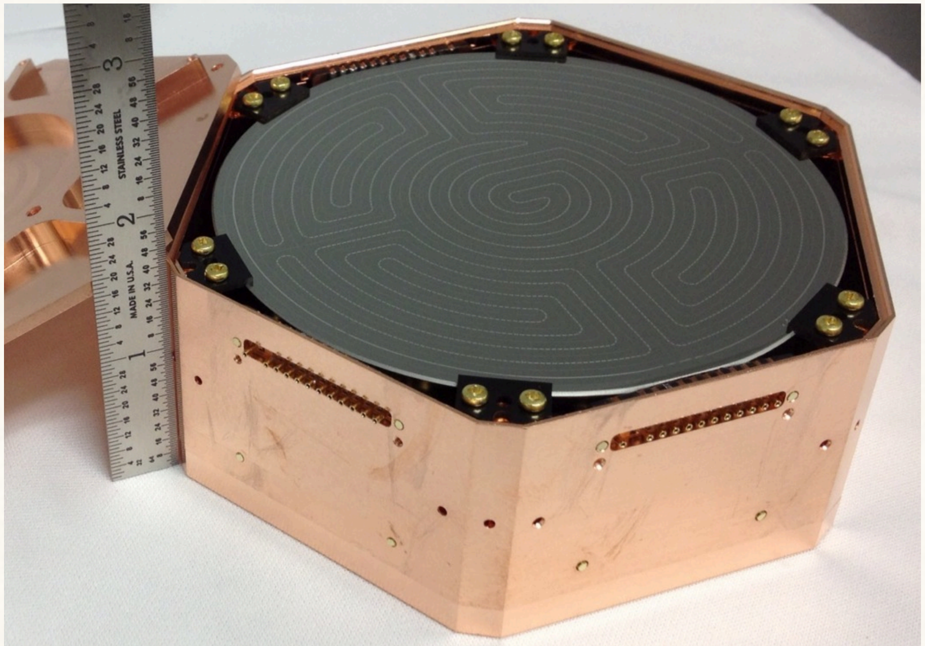
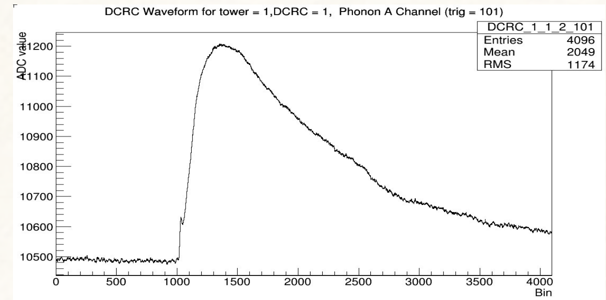
SuperCDMS SNOLAB Data Acquisition



Bill Page

Overview

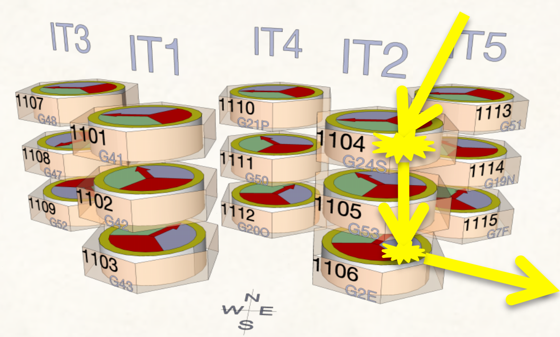
- The raw CDMS data



- Customized data acquisition hardware —DCRCs

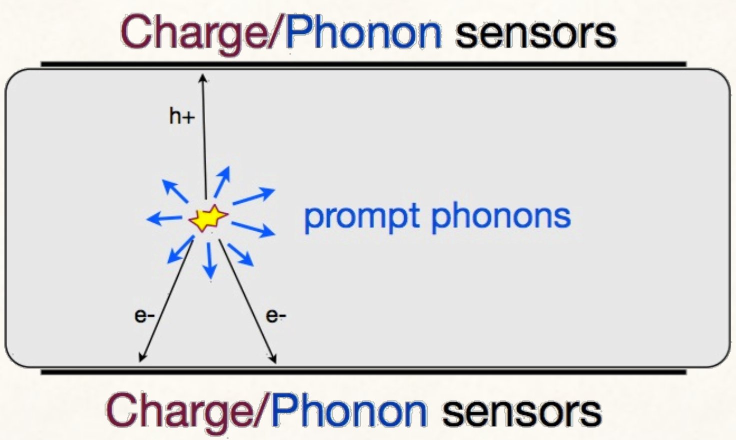
- DAQ decisions for the later data analysis

- The DAQ's role in neutron discrimination

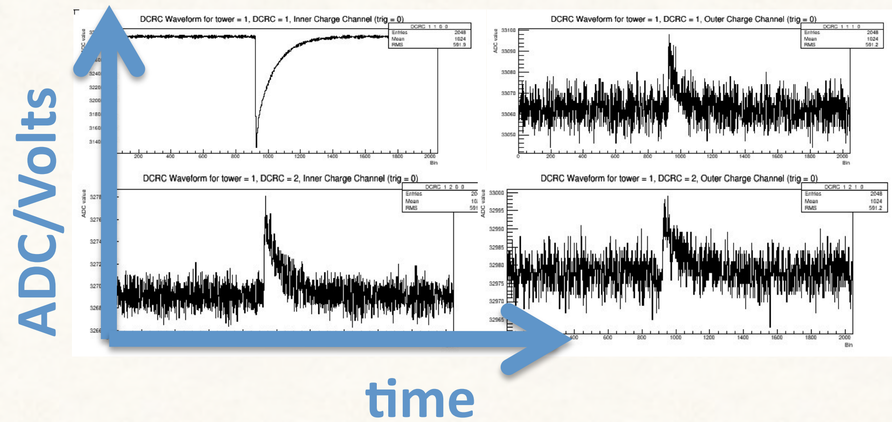


- High rate Barium calibrations and the need for an efficient DAQ architecture

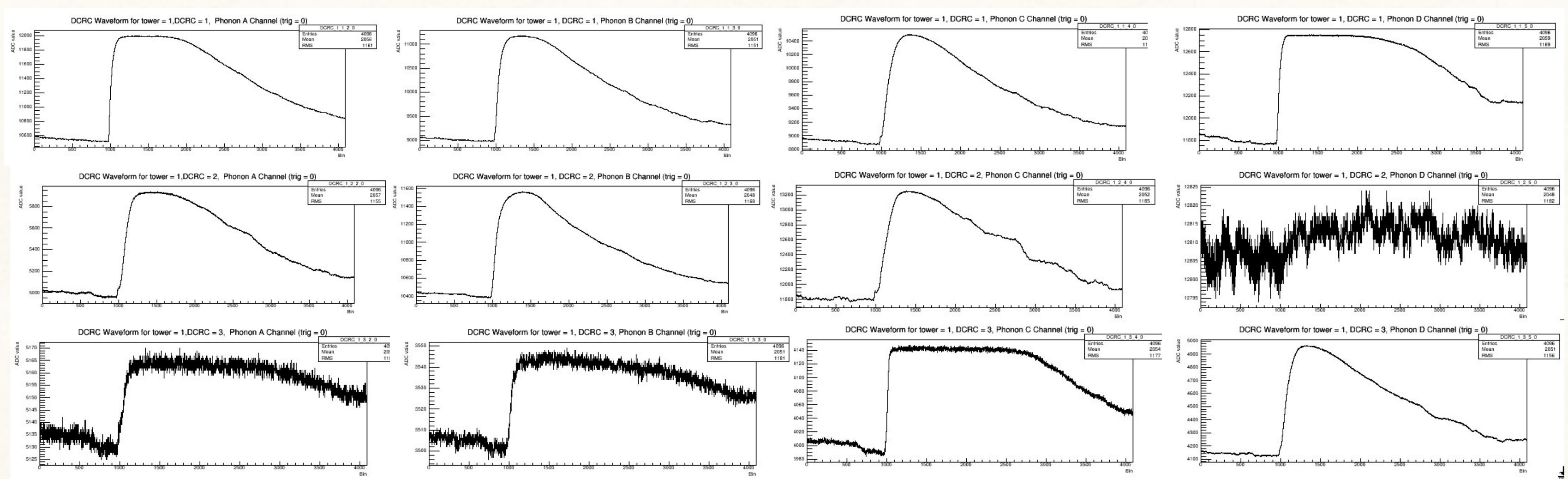
A Single Event



Charge Pulses:



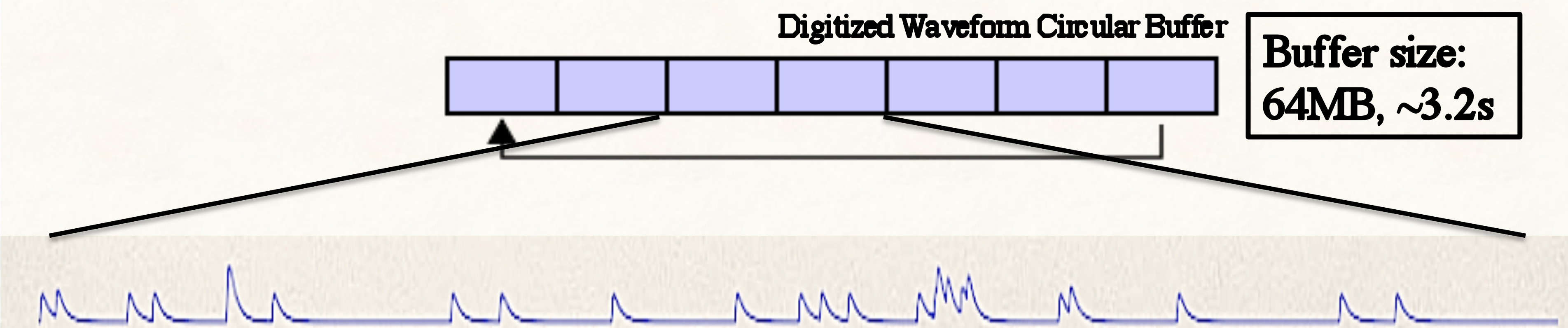
Phonon Pulses:



DCRCs

Detector Control and Readout Cards

- one card per detector
- continuously digitizing signal from phonon/charge channels
- zero-deadtime acquisition
- records trigger time stamps



DCRCs

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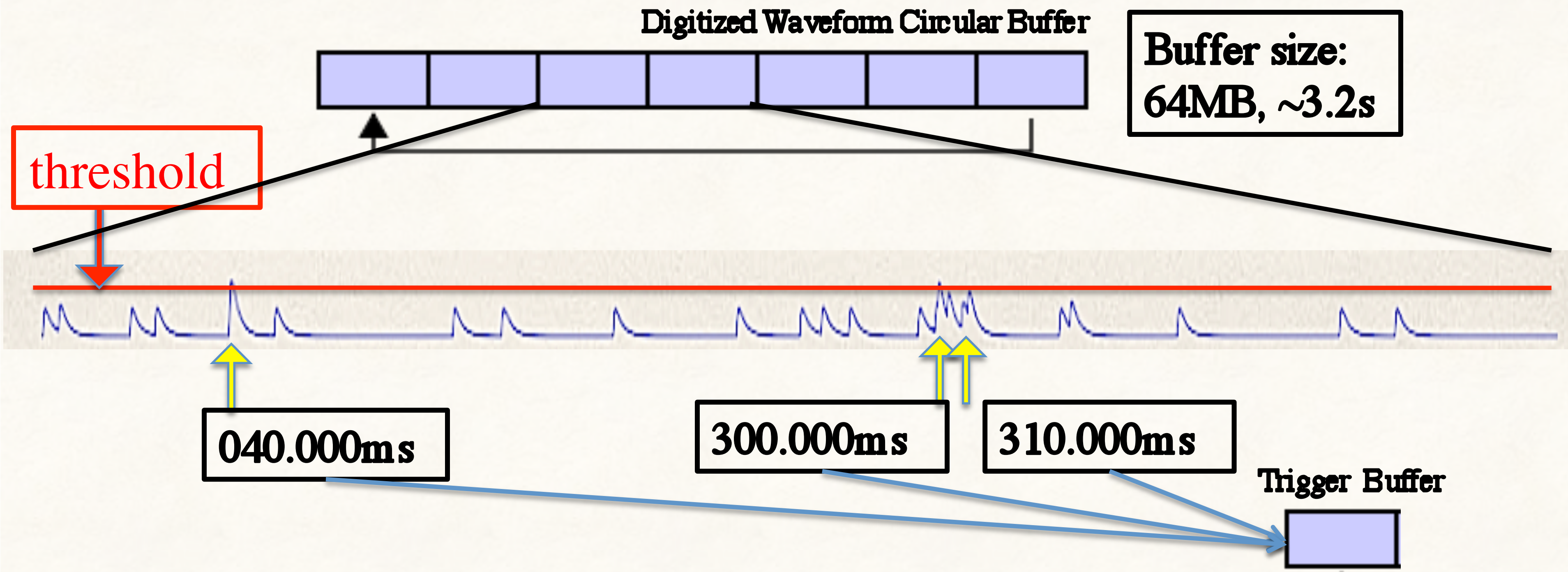


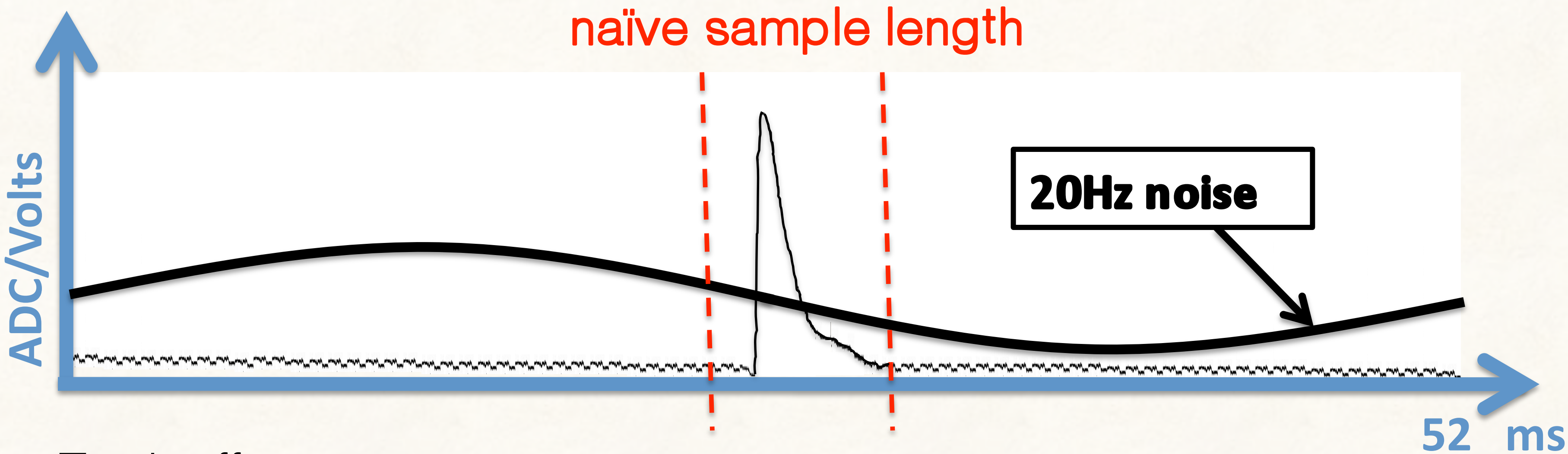
The Waveforms

What Length?

- phonon pulses are ~1 ms
- monitor low frequency noise (~50ms)

What Sample Rate (resolution)?

- phonon pulse rise times are ~10μs



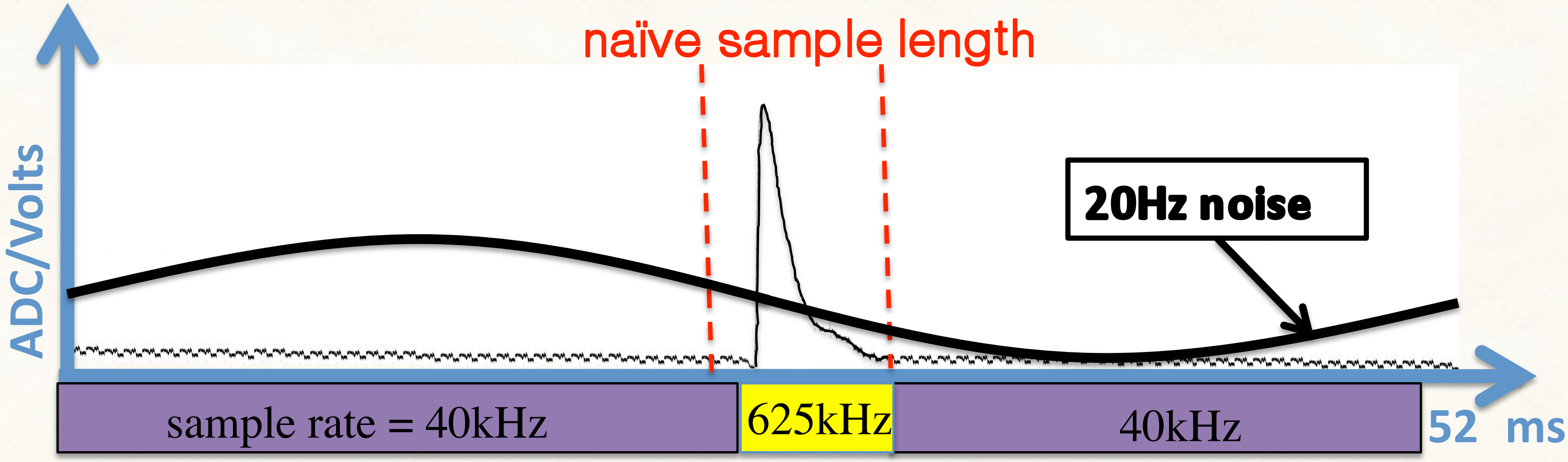
Tradeoffs:

1. high resolution phonon pulses
2. filtering low frequency noise
3. reasonable event data size

The Waveforms

What Length?
- phonon pulses are ~1 ms
- low frequency noise

What Sample Rate (resolution)?
- phonon pulse rise times are ~10μs



<u>Hybrid Sampling with 52ms waveforms</u>
- good resolution near pulse (can see ~10μs features)
- distinguish low frequency noise (down to 20Hz)
- reduced data throughput (141kB per event)

Running Modes

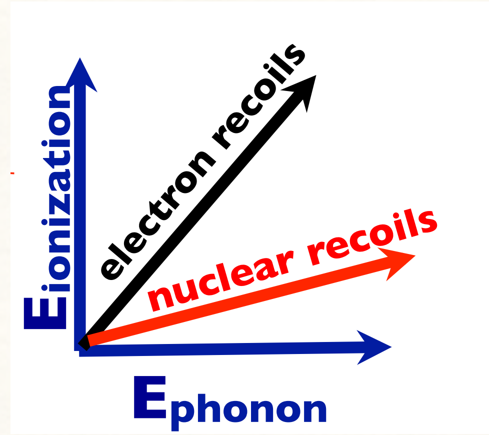
1. WIMP Search (Low Background)
- 90% of run time
- low interaction rate of alphas, betas, gammas, and neutrons

2. Calibration
- radioactive Ba source for electron recoils
- radioactive Cf source for nuclear recoils

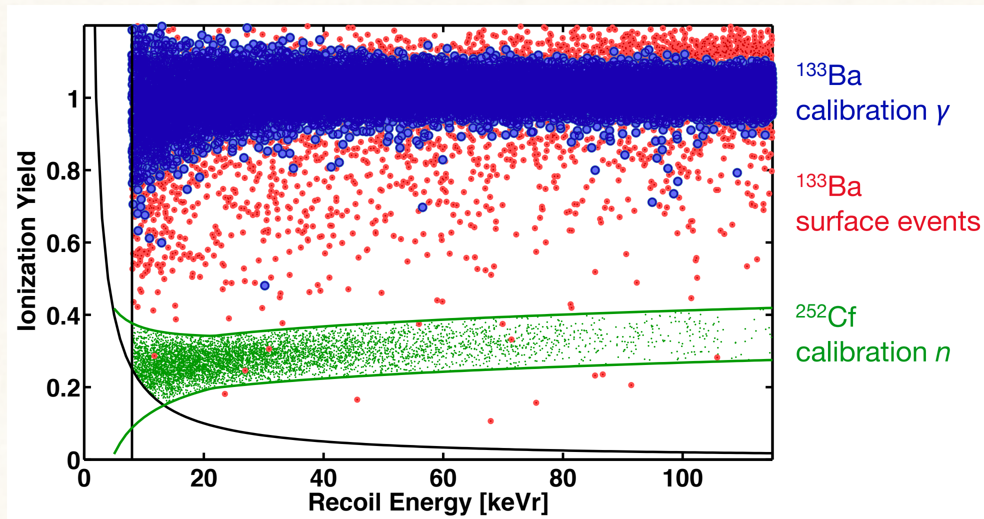
Low Background and Neutron Discrimination

Neutron Background

- cosmogenic: muons scattering in cavern
- radiogenic: Uranium and Thorium contamination
- <u>indistinguishable from WIMPs</u>



Projected Backgrounds	
Years	5
Exposure	400 kg-year
Neutron (cosm.)	0.008 events
Neutron (rad.)	0.04 events
Other Bkg.	0.20 events



<u>DAQ plays important role in achieving low neutron background</u>

Low Background and Neutron Discrimination

Shielding/Veto:

- active neutron veto
- polyethylene moderator

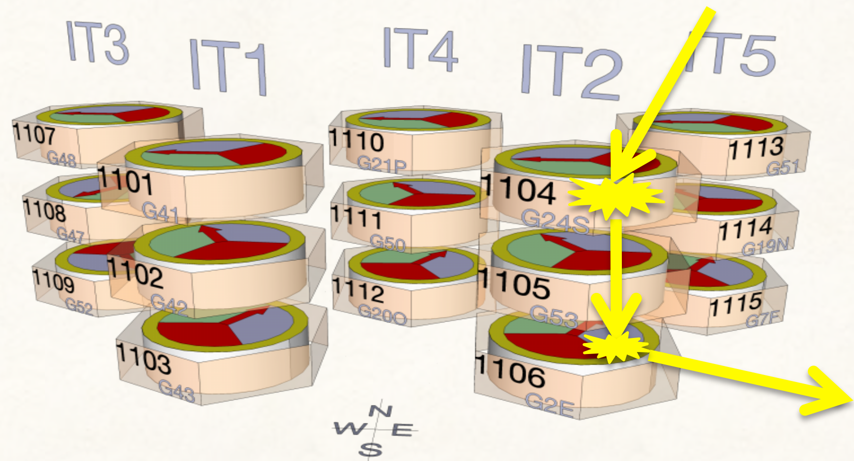
Analysis Rejection:

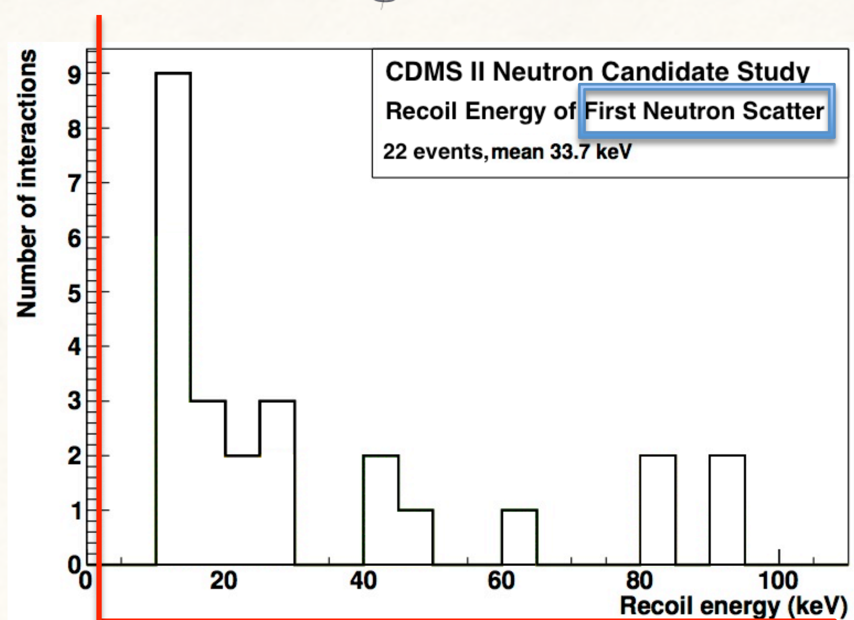
- cut on coincident scatters (80% of neutrons coincident scatter)

What if second scatter is below the DCRC threshold?

<u>Full Readout Mode</u>

- last line of defense
- readout every detector on every trigger
- 100 times data throughput
- only necessary if electronic noise requires a higher trigger threshold

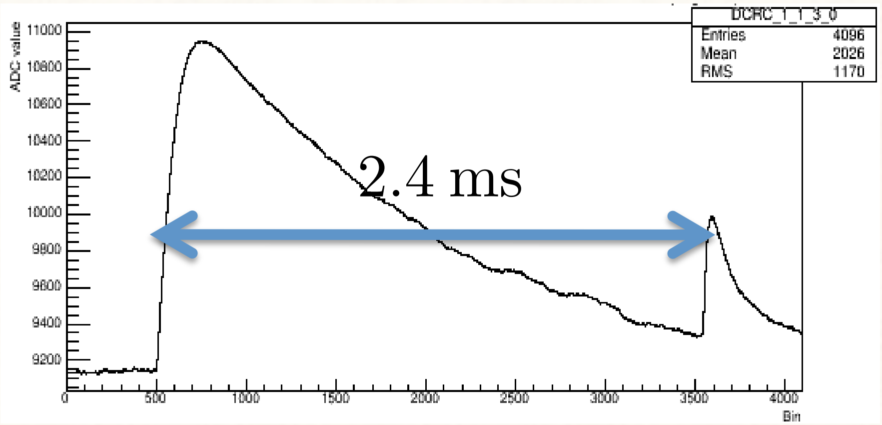


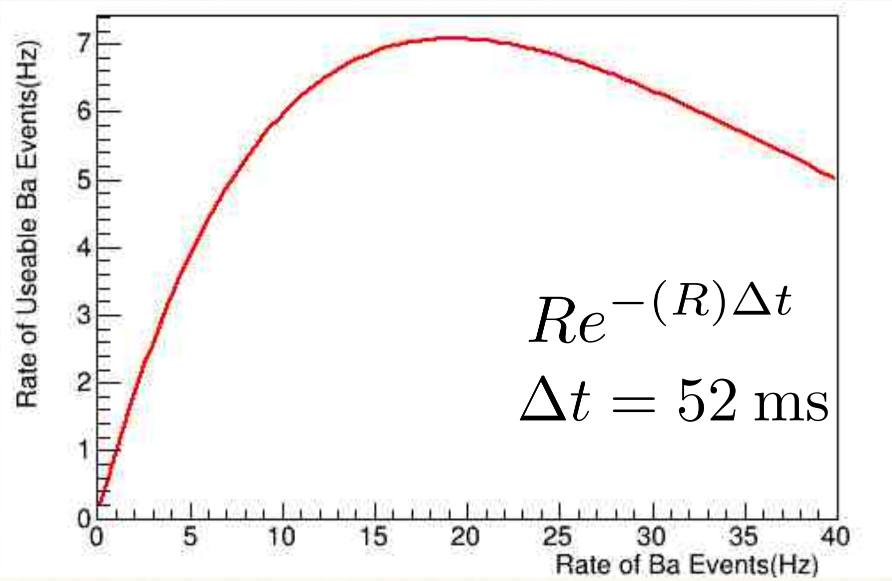


CDMS II 2keV trigger threshold

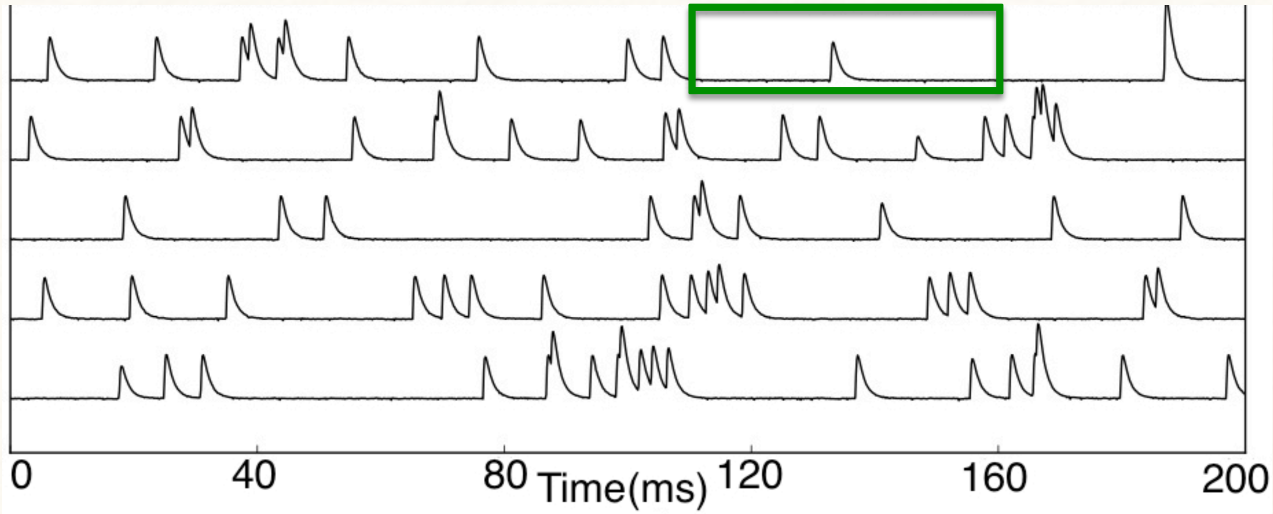
Barium Calibration Pileup

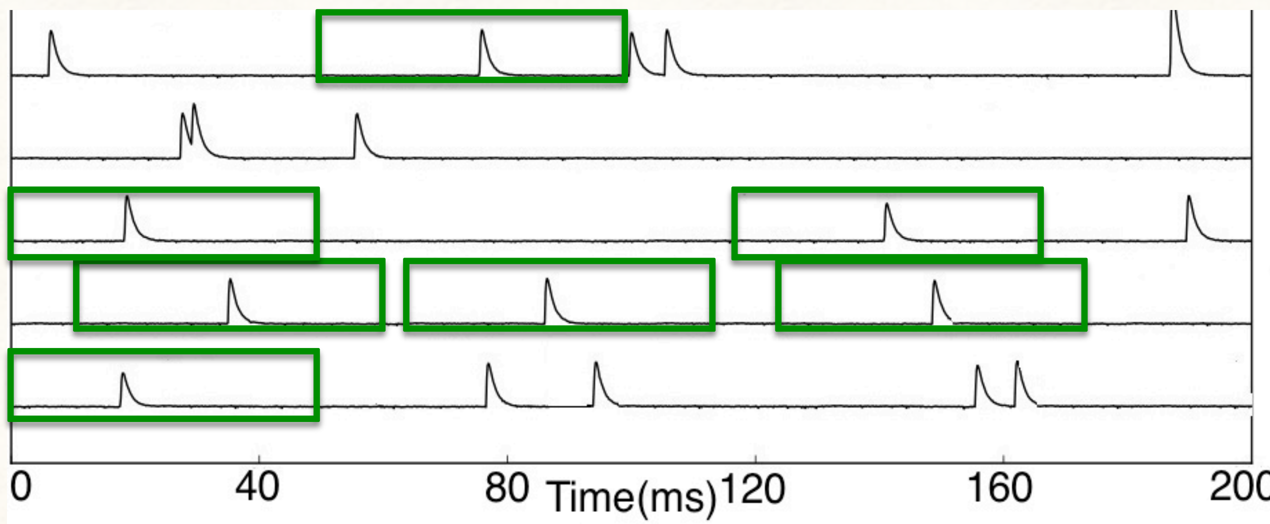
- maximize calibration data and minimize time
- piled-up events spoil each other
- tradeoff between events and usable events
- 52ms of pileup-free waveforms means 20Hz event rate





Barium Calibration Pileup



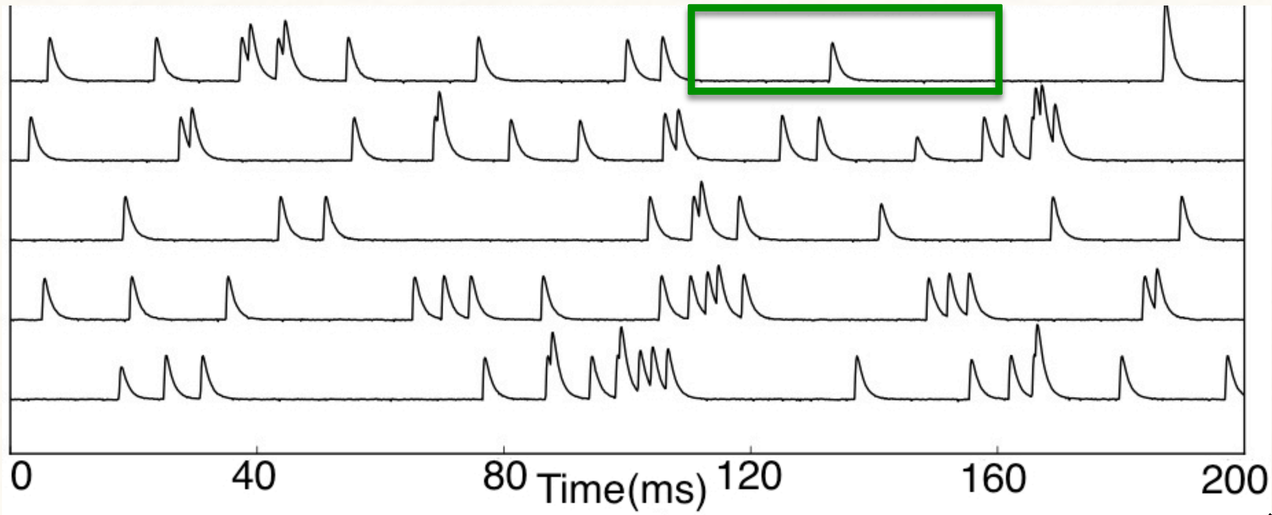


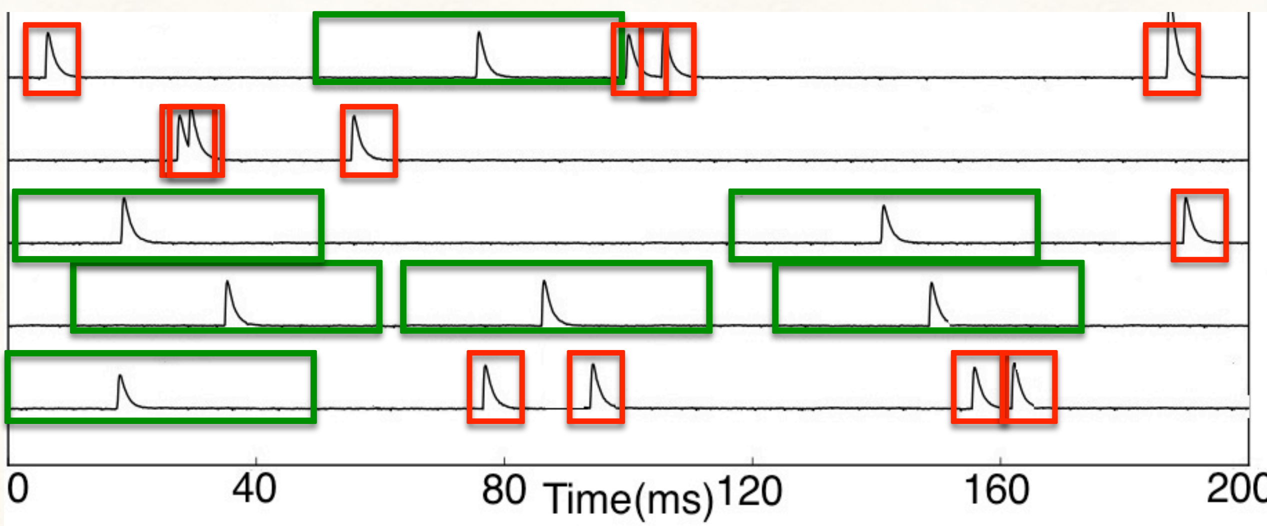
Usable Event Criteria:

- 52ms pileup-free waveforms
- 26ms prepulse

Event Rate (Hz)	Usable Events (Hz)
75	1
20	7

Barium Calibration Pileup





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The DAQ must reject piled-up triggers

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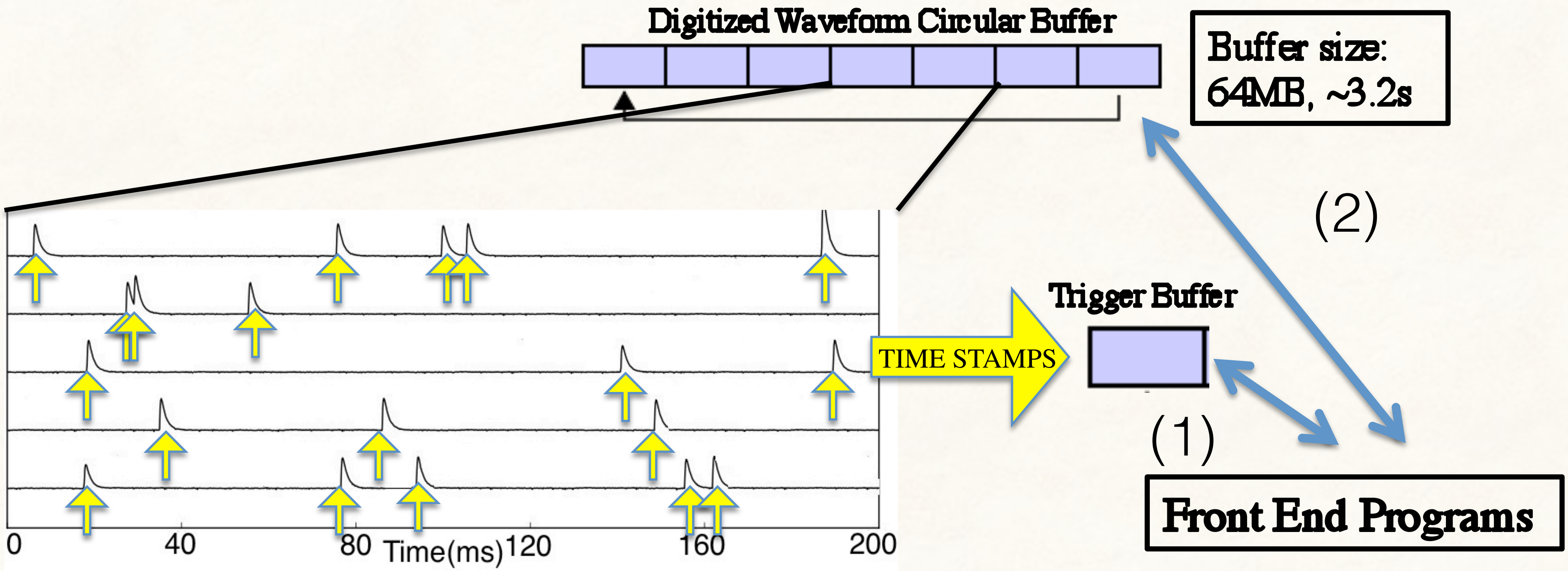

Front End Programs use 2 stage reading process

- read in trigger time stamps (1)
- make efficient trigger decisions
- read waveforms of usable events (2)

7 Hz, 141kB events, ~100 detectors $\Rightarrow$ 100 MB/s

Conclusion

- DCRCs digitize data in circular buffer
- zero-dead time acquisition
- DCRC trigger time stamp memory buffer for trigger decisions
- long waveforms (52ms) for filtering low frequency noise
- hybrid sampling rate for reducing data throughput
- full readout option for neutron discrimination
- optimal Barium calibration event rate with efficient real-time pileup rejection