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/Pophon sensors

h+

prompt phonons
e-

e-

Charge Pulses:

Phonon Pulses:

ADC/Volts
time

Bill Page — UBC

SuperCDMS SNOLAB Data Acquisition
Detector Control and Readout Cards

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

Buffer size: 64MB, ~3.2s
Detector Control and Readout Cards

- continuously digitizing signal from phonon/charge channels
- records trigger time stamps

![Detector Control and Readout Cards](image_url)

**Digitized Waveform Circular Buffer**

- Buffer size: 64MB, ~3.2s

- Trigger Buffer

- Threshold

- 040.000ms
- 300.000ms
- 310.000ms
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

Hybrid Sampling with 52ms waveforms
- 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
- indistinguishable from WIMPs

### Projected Backgrounds

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Years</td>
<td>5</td>
</tr>
<tr>
<td>Exposure</td>
<td>400 kg-year</td>
</tr>
<tr>
<td>Neutron (cosm.)</td>
<td>0.008 events</td>
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<tr>
<td>Neutron (rad.)</td>
<td>0.04 events</td>
</tr>
<tr>
<td>Other Bkg.</td>
<td>0.20 events</td>
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DAQ plays important role in achieving low neutron background
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?

**Full Readout Mode**
- 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

\[ R e^{-R \Delta t} \]
\[ \Delta t = 52 \text{ ms} \]
Barium Calibration Pileup

Usable Event Criteria:
- 52ms pileup-free waveforms
- 26ms prepulse

<table>
<thead>
<tr>
<th>Event Rate (Hz)</th>
<th>Usable Events (Hz)</th>
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<tbody>
<tr>
<td>75</td>
<td>1</td>
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<tr>
<td>20</td>
<td>7</td>
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Barium Calibration Pileup

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The DAQ must reject piled-up triggers
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