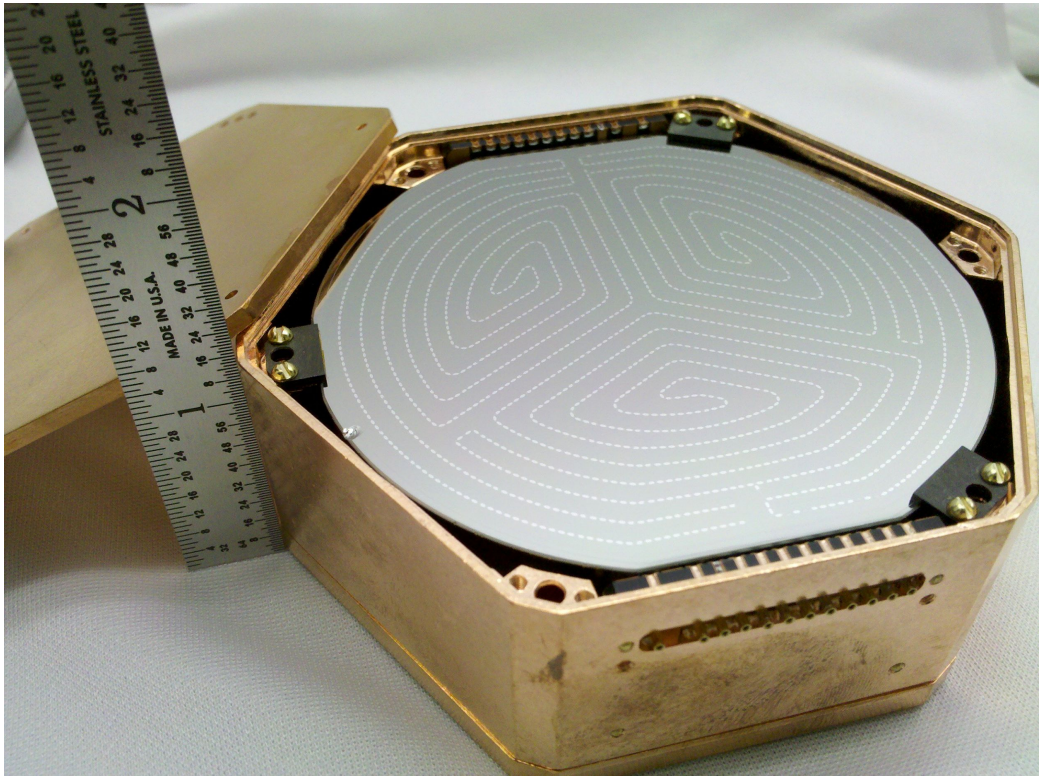
Data Acquisition for SuperCDMS

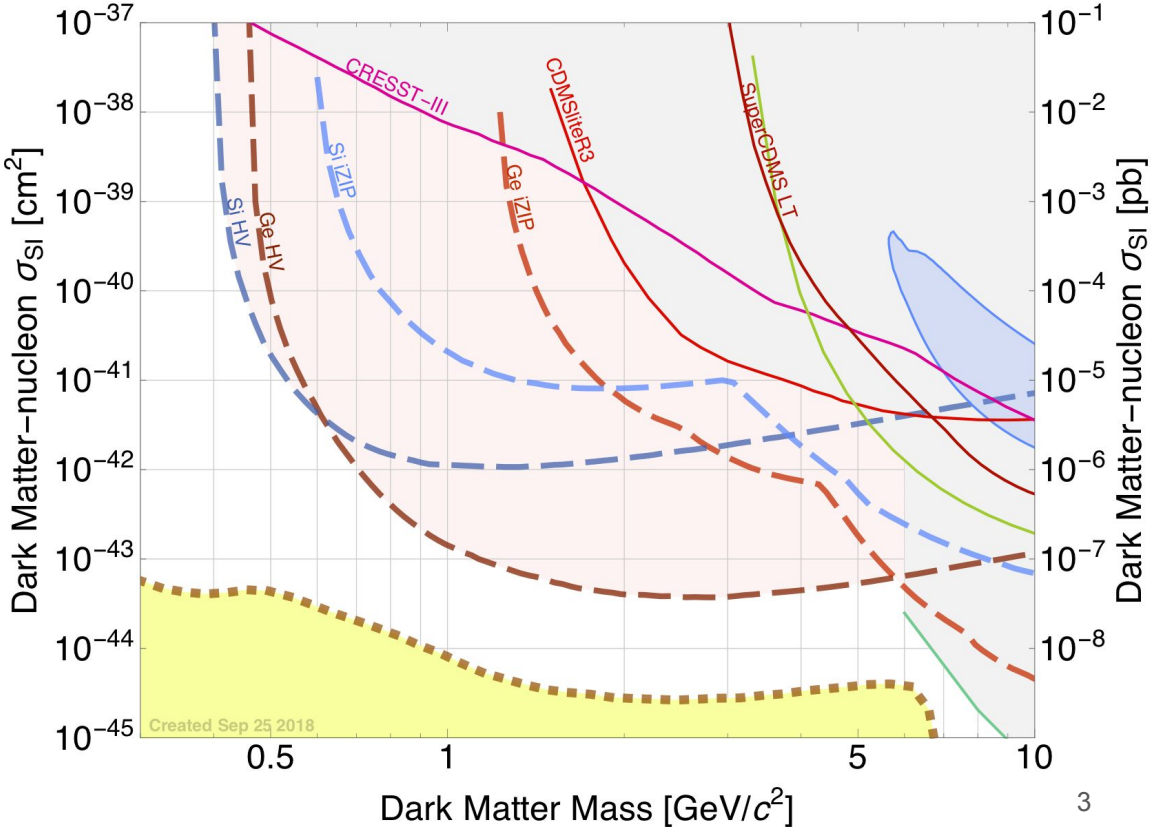
The Super Cryogenic Dark Matter Search

- Earth-based direct-detection of dark matter
- 24 detectors (Si and Ge crystals) will be installed at SNOLAB
- Manageable data rate, O(100) TB/year

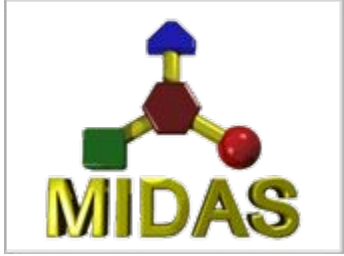


Building the SuperCDMS DAQ

- Focuses on low-mass region ⇨ low threshold
  - Very sensitive to low-frequency noise
  - Plan to sample 52 ms, reduce data volume with “hybrid sampling”
- Limited space ⇨ custom digitizer hardware
- Low event rate
  - < 7 Hz during calibration at SNOLAB!
  - Above-ground test facilities typically < 100 Hz



MIDAS DAQ



SuperCDMS uses the MIDAS DAQ, which is maintained primarily by TRIUMF staff. They hold user workshops every other year and are fairly responsive.

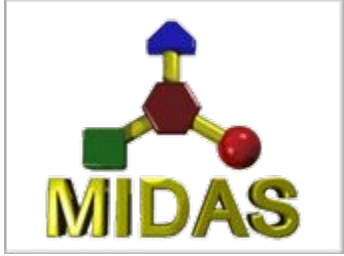
MIDAS DAQ provides

- A DAQ framework controllable through HTTP requests
- Complete state information for the DAQ and experiment in the Online Database
- Logging of user-selected parameters in the Online Database to mySQL tables
- Sequencer scripting language that allows programmed control of the DAQ

SuperCDMS provides

- “Frontend” code that reads triggers and data from SuperCDMS electronics
- Customized detector controls that use MIDAS HTTP API to provide users with convenient controls

MIDAS DAQ: What's worked well



- **The HTTP interface has been extremely valuable**, allows us to build web-based custom controls
  - Can control the MIDAS DAQ state with http requests - this has provided excellent remote utility
- **R&D Facilities use the sequencer utility heavily**
- SuperCDMS uses a fork of MIDAS
  - We do encounter serious bugs and need to update
  - We primarily use the fork as a way to get more control over MIDAS updates
- Having a dedicated MIDAS DAQ liaison (Ben Smith) has been critical to merging changes back to MIDAS

Needs and Challenges: SuperCDMS SNOLAB

- Installation and Maintenance
  - Typically need expert help to install/upgrade the DAQ
  - The major issue here is inconsistent build environments (mySQL 5.8 is the most problematic)
  - Have trouble with this despite requiring the same distribution (centos7) on all DAQ machines!
- Connecting additional detectors to the DAQ, e.g. accelerometer to monitor dry fridge vibration
  - GPS timing would be great
  - Other timing protocols (e.g. White Rabbit) may work but need to be implemented
- Triggering near the noise wall
  - Can build filters into L2 triggers, BUT
  - Still need to address analysis issues like determining the trigger efficiency
- Best practices for blinding
  - Immediate plan is data division
  - Some have suggested salting at the DAQ level

Opinion

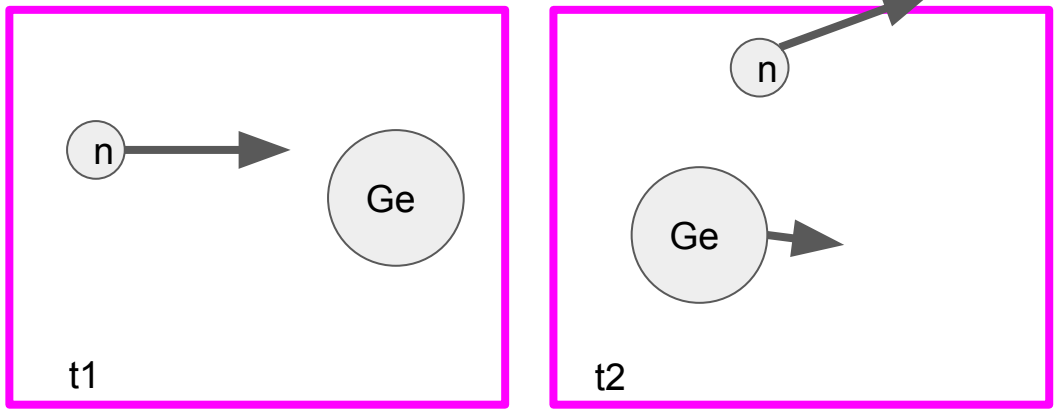
The MIDAS DAQ for SuperCDMS at SNOLAB will be able to meet our needs

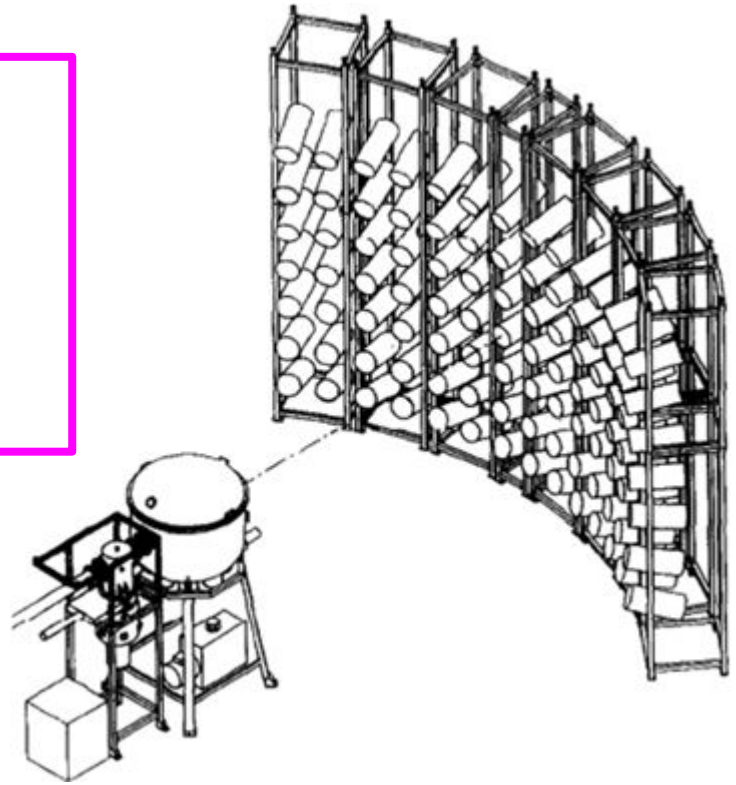
- We'll have to think a little about some analysis issues but nothing insurmountable.

But DAQ for SuperCDMS R&D efforts is tougher

- Out of scope, but good to support: provides early testing of DAQ and analysis toolchain
- Too much hardware variety for us to support
- Wider variety of DAQ problems to solve

SuperCDMS Calibration and R&D DAQ needs 1

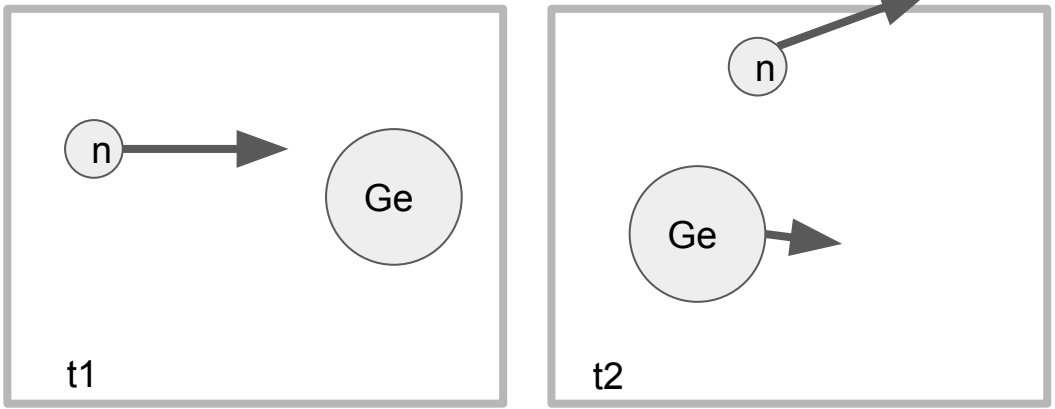


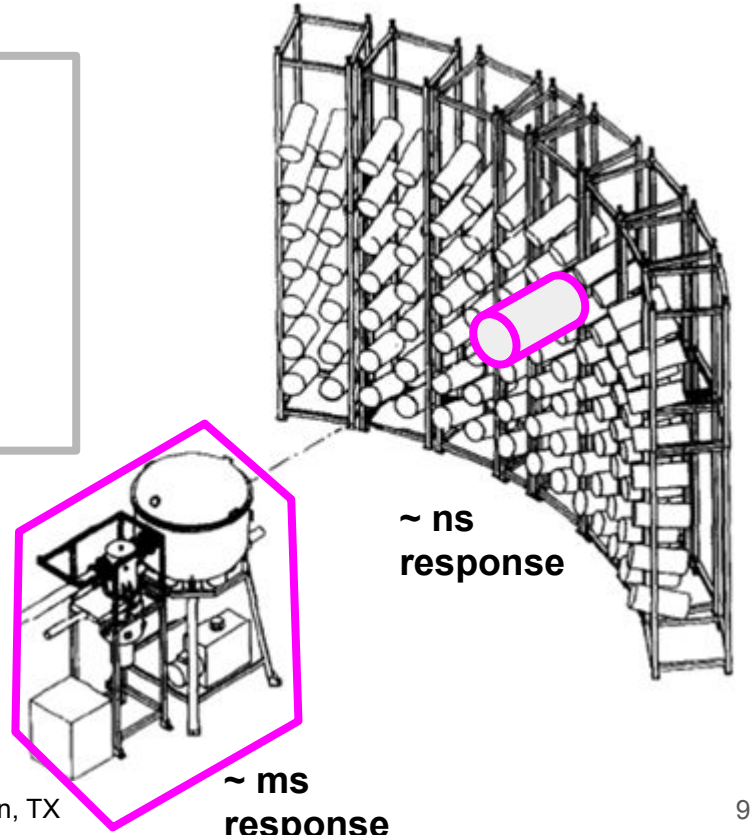


In principle, this is a perfect setup for calibrating dark matter detectors:

The recoil energy of the Ge is uniquely determined if
- You know the incoming neutron energy
- And a backing array allows you to determine the neutron's outgoing angle.

SuperCDMS Calibration and R&D DAQ needs 1





In principle, this is a perfect setup for calibrating dark matter detectors:

But this poses challenges

- Dark matter detectors have much slower response times than most backing arrays
- Backing arrays can have ~kHz rates

Needs and Challenges: R&D

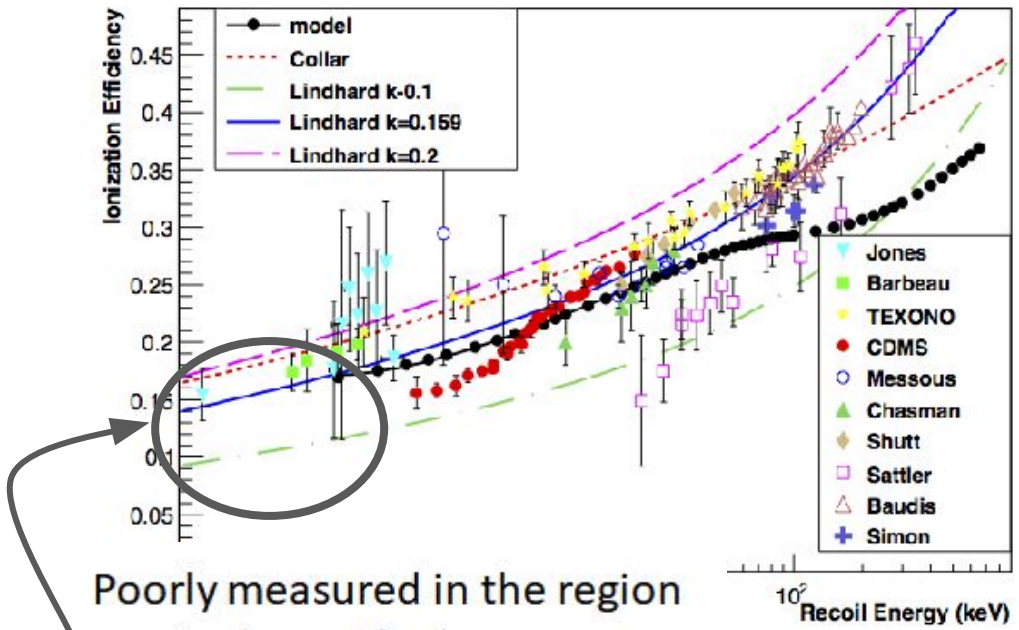
- R&D efforts would really benefit from DAQ and analysis tools support
  - But it takes time to support all the hardware the R&D folks cobble together
  - When they make their own DAQ the data format is totally different than the “main experiment” data format
  - **Effort on small read/write library that all experimenters can use is starting to pay off**
- Need to merge data from different DAQ systems with dramatically different time scales
  - Microsecond timing is probably enough (depending on the beam rate)
  - GPS is a candidate but is expensive/rarely implemented
  - Need to coordinate trigger/latch with user facilities

Thank you!

The SuperCDMS@SNOLAB and R&D efforts share many issues:

- How do we provision machines consistently?
  - Package managers like Spack? Or Guix/NIX?
- How do we combine information with different time scales?
  - This issue is more severe for above-ground R&D since they have higher rates,
  - But is still a concern for the SNOLAB experiment
  - Known solutions here but facilities often lack implementation of any
- How do we ensure some consistency in tooling?
  - We’re starting to have some success with a small library for data I/O
  - This is used to read and write data in the SNOLAB DAQ
  - And can be used by anyone to ensure their data looks the same as SNOLAB data

SuperCDMS Calibration and R&D DAQ needs 1



Many dark-matter searches assume dark matter will interact with the **nuclei** in our detectors.

Gamma sources give us peaks, but **this calibrates electron recoils**, not nuclear recoils.

Use yield to convert the electron-recoil energy scale to a nuclear recoil energy scale.