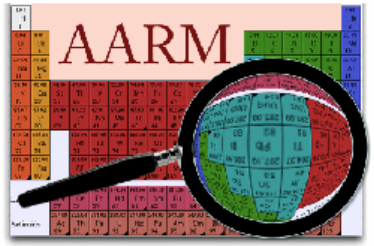
UNIVERSITY OF MINNESOTA



Muon Topology and Coincident Neutrons with the Soudan Veto-Shield

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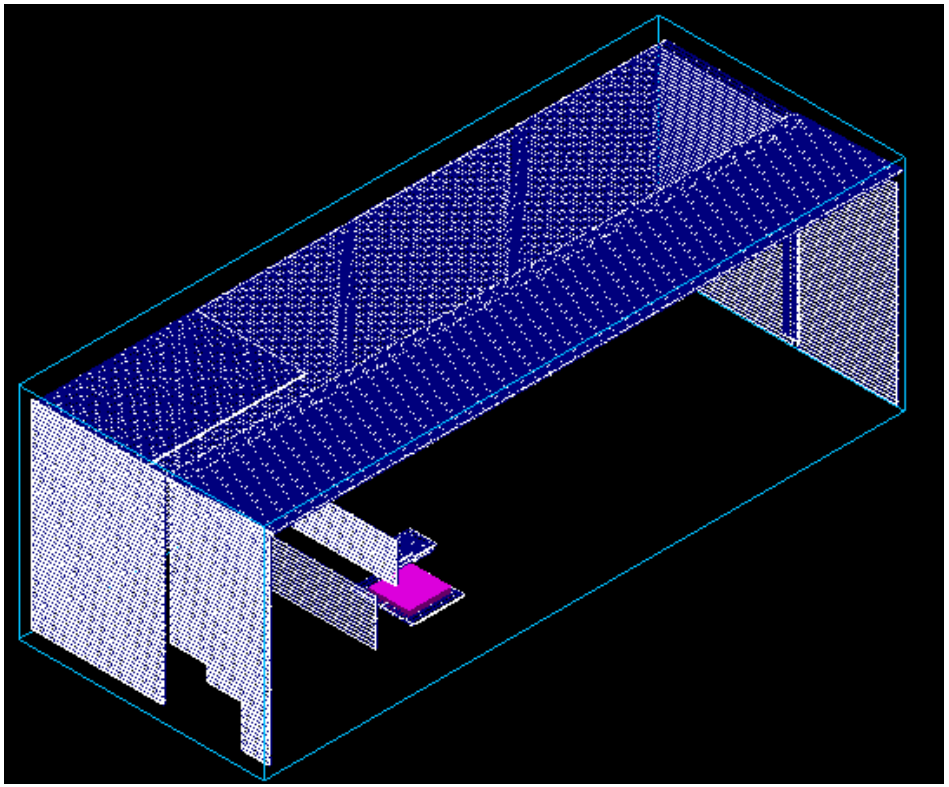
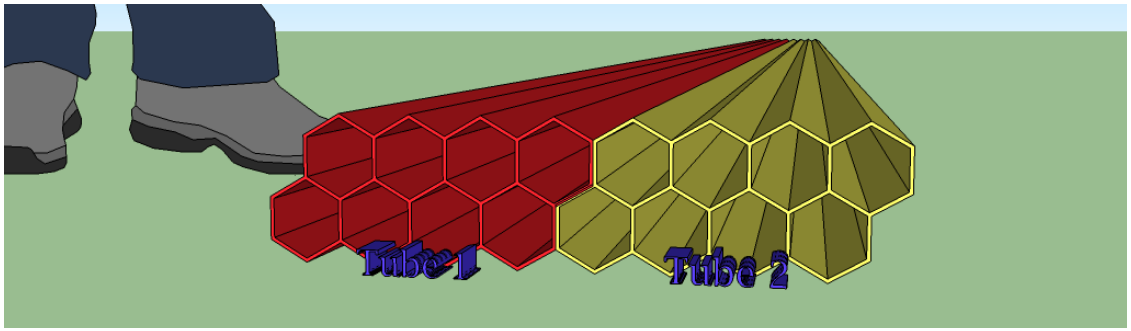
University of Minnesota

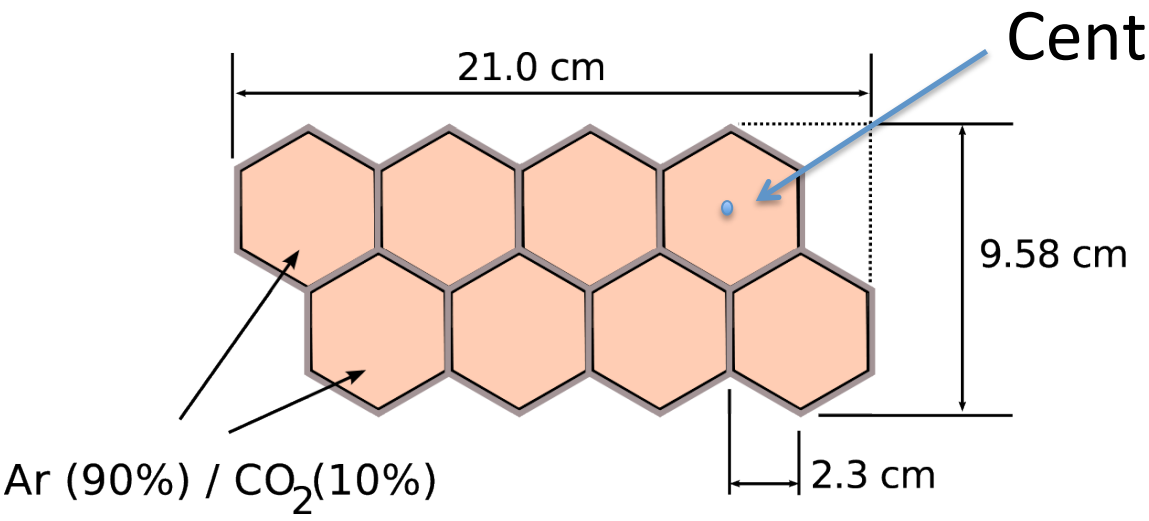
Systems In Place (Veto-shield)



- 32 m x 14.5 m x 11 m cavern
- Covered top and sides with proportional tubes
- Neutron Multiplicity Meter (NMM) placed toward the north-west (lead stack visible at left)

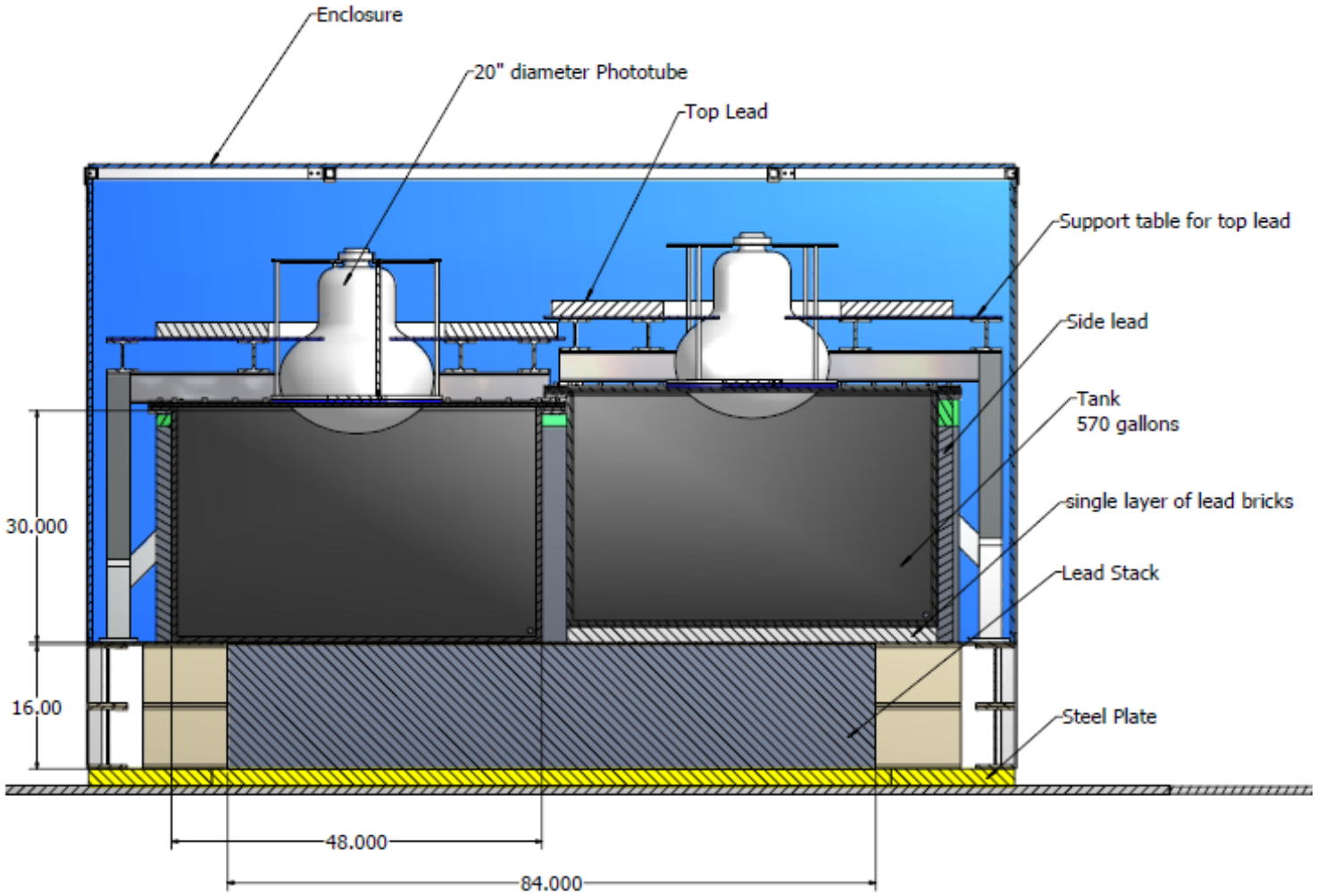
Veto-Shield Proportional Tubes



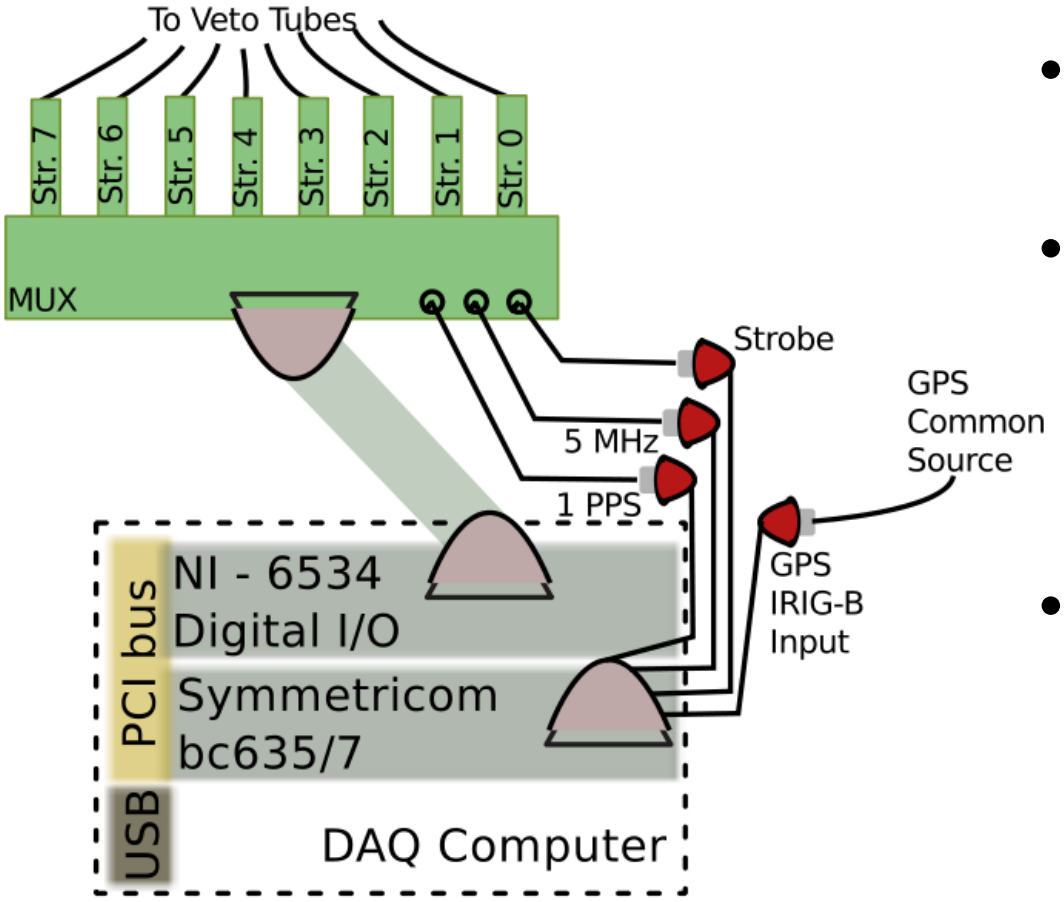


Center fed wires at 2350 V

Systems In Place (NMM)



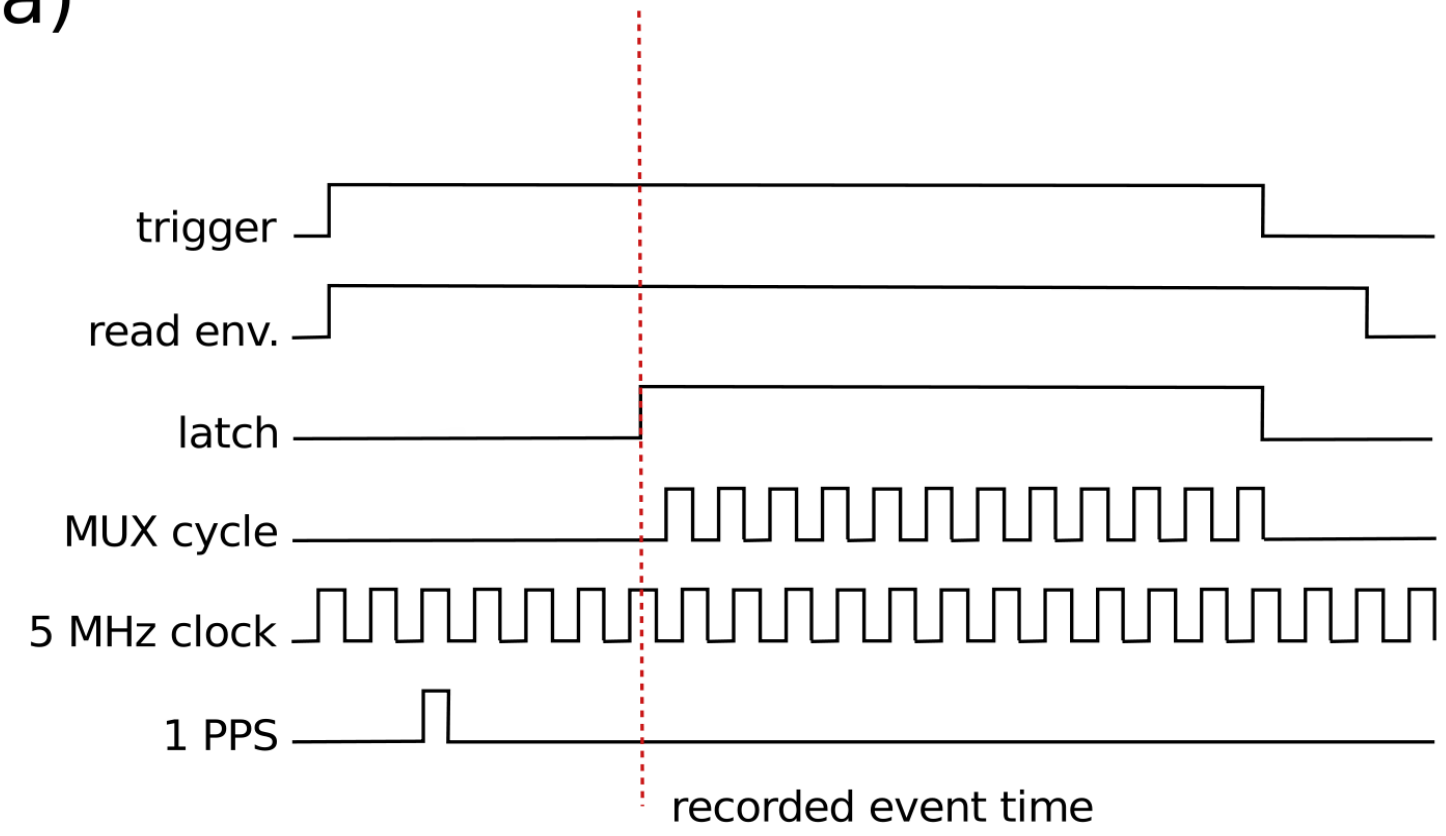
1 μs Correlated Timing



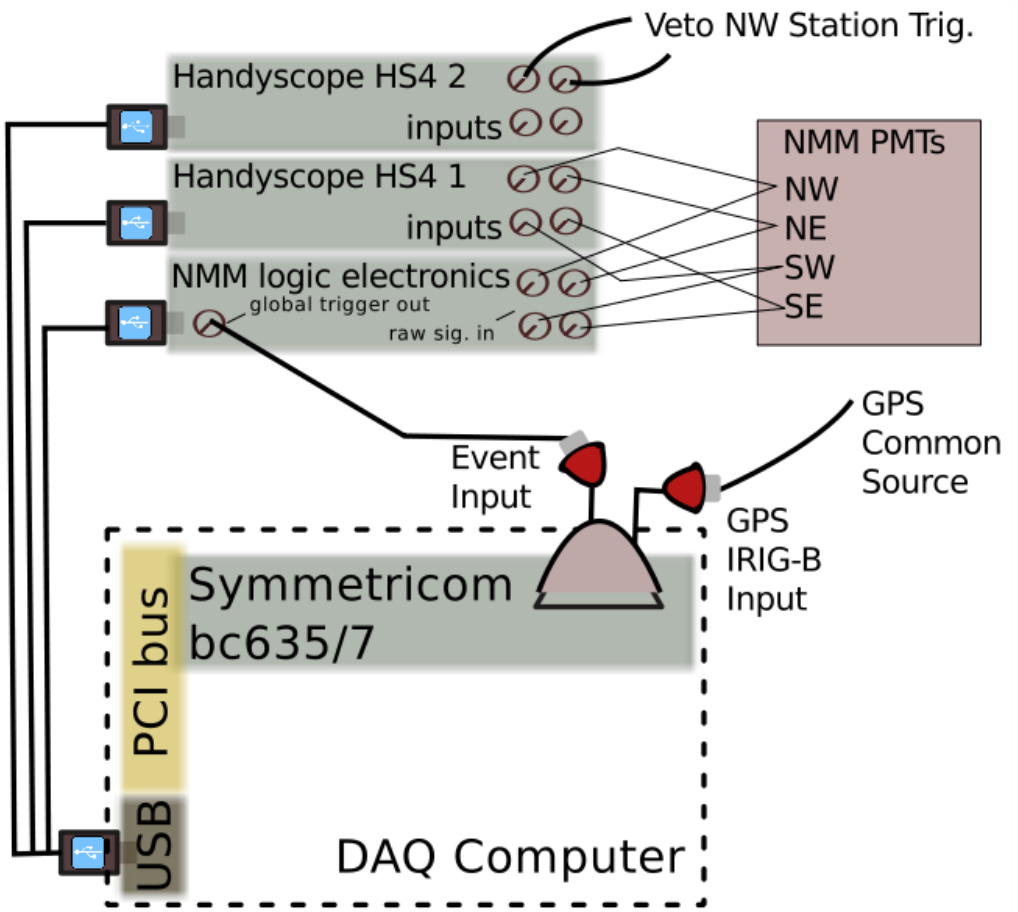
- Symmetricom card synced to GPS
- Front end electronics count a disciplined 5 MHz signal
- DAQ computer records the absolute time of every event – best accuracy about ~ 1 μs

1 μs Correlated Timing

a)



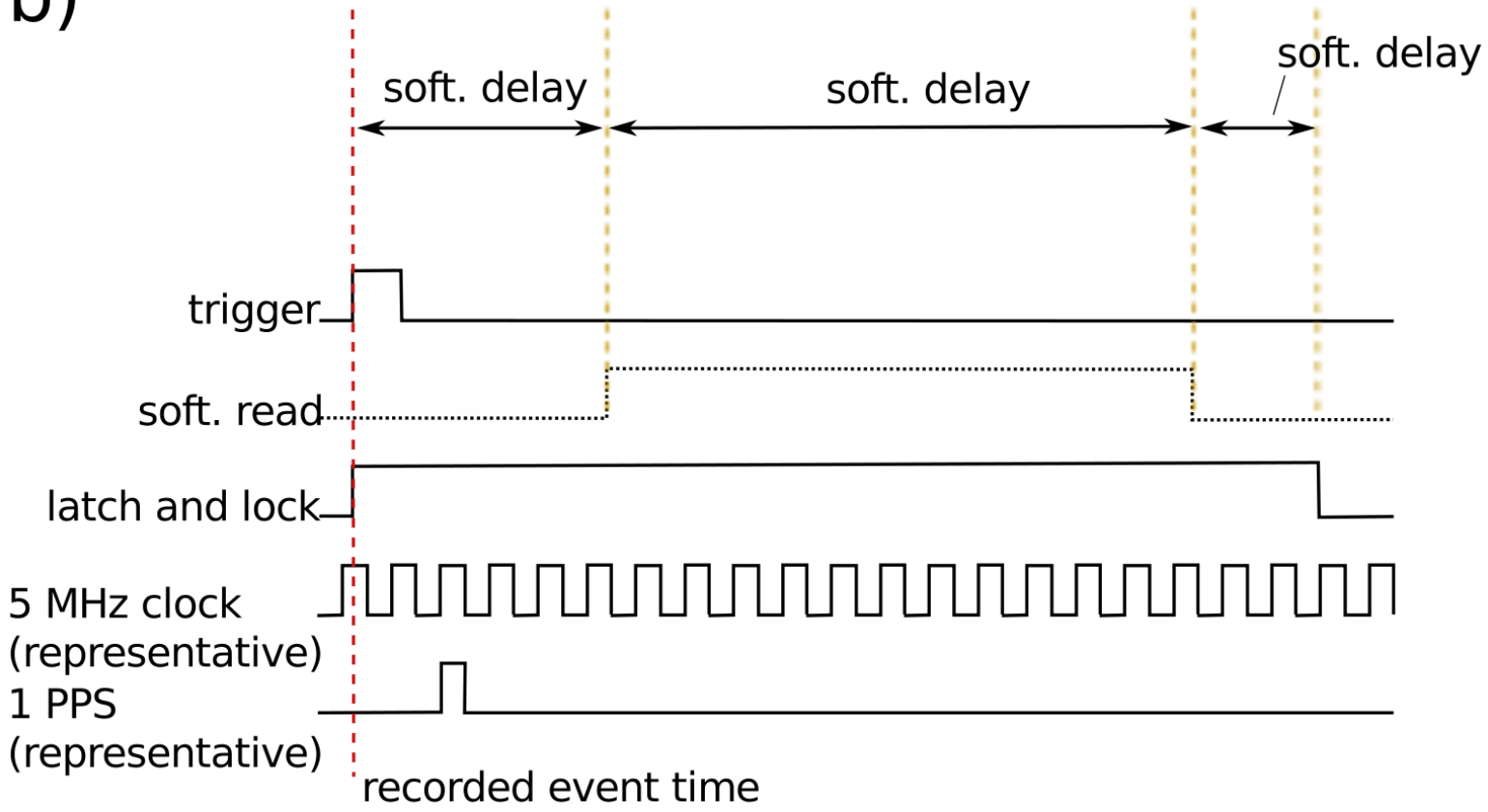
1 μs Correlated Timing



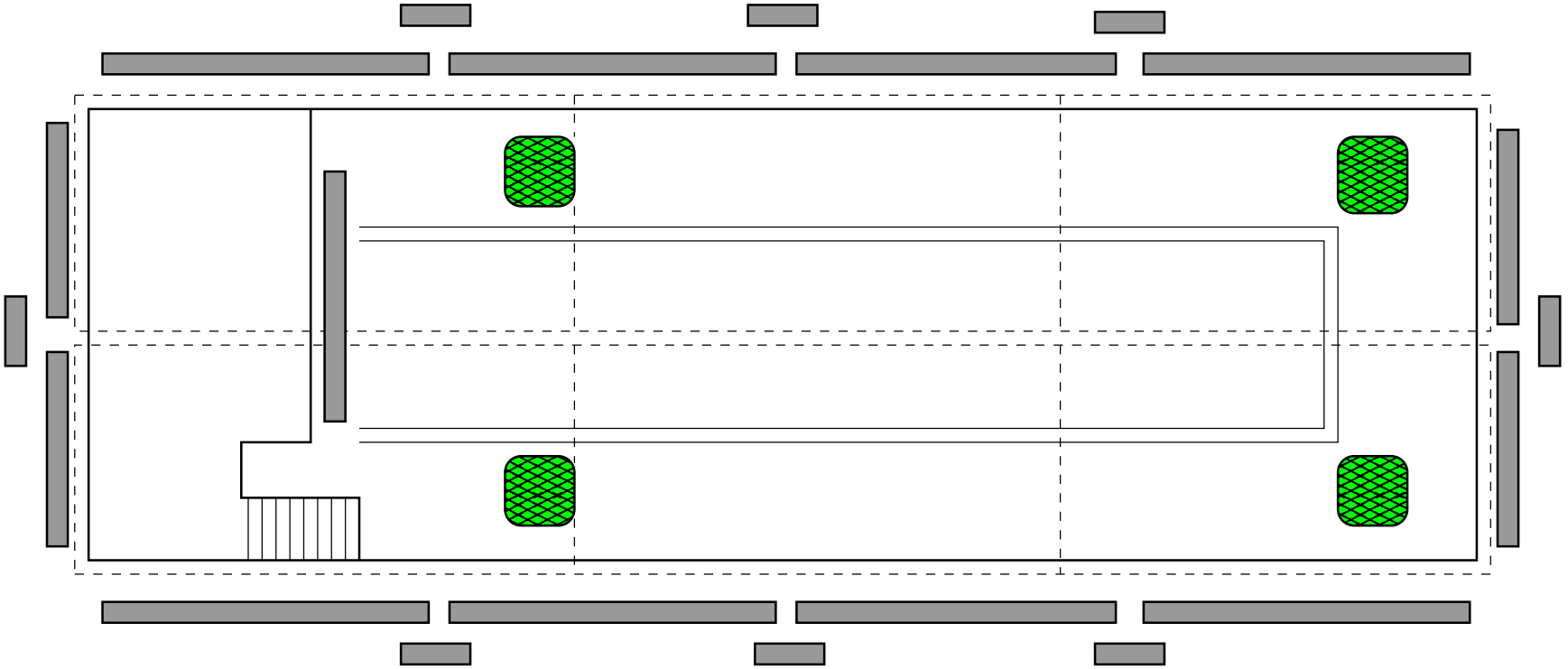
- Symmetricom card synced to GPS
- Time latched in response to hardware trigger from NMM
- DAQ computer records the absolute time of every event – best accuracy about ~ 1 μs

1 μs Correlated Timing

b)



Making a Facility



- Each quadrant (approx.) of the shield read out by an independent DAQ
- Other detectors inside the shield can be synced (like the NMM) to record coincident events

The Physics Case

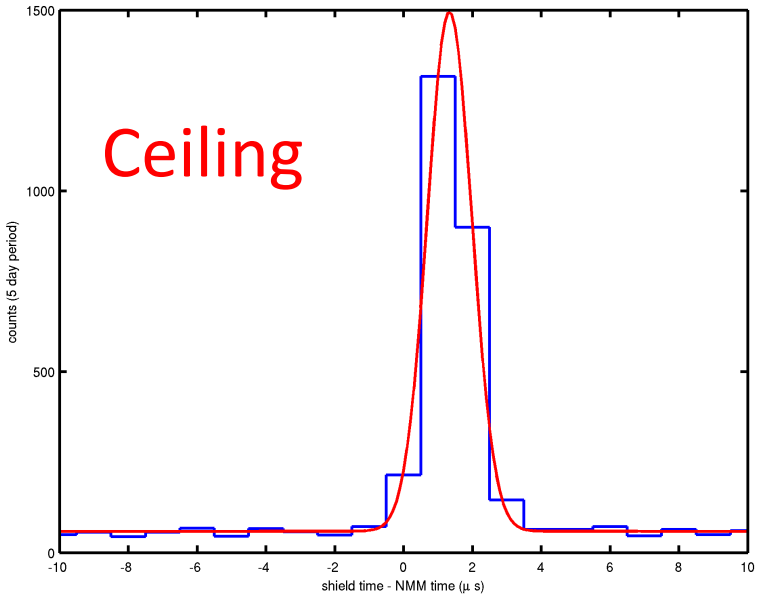
- Generally the facility has the ability to examine the *topology* of events of cosmogenic origin deep underground

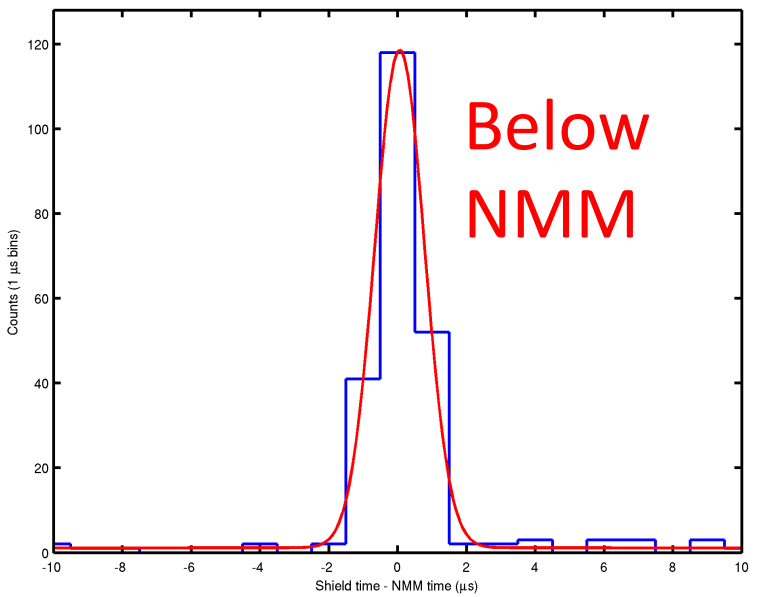
- Specific analyses can constrain simulations (2 ex.)
  - In conjunction with NMM can discover how HE neutrons correlate to *remote* cavern muons
  - Tagging vertical-going single muons will be used to study multiple-muon (muon bundle) events

- Use with existing experiments as active 'veto' or as tagger for background-type events

Coincident Events

Muons with NMM (special NMM run)



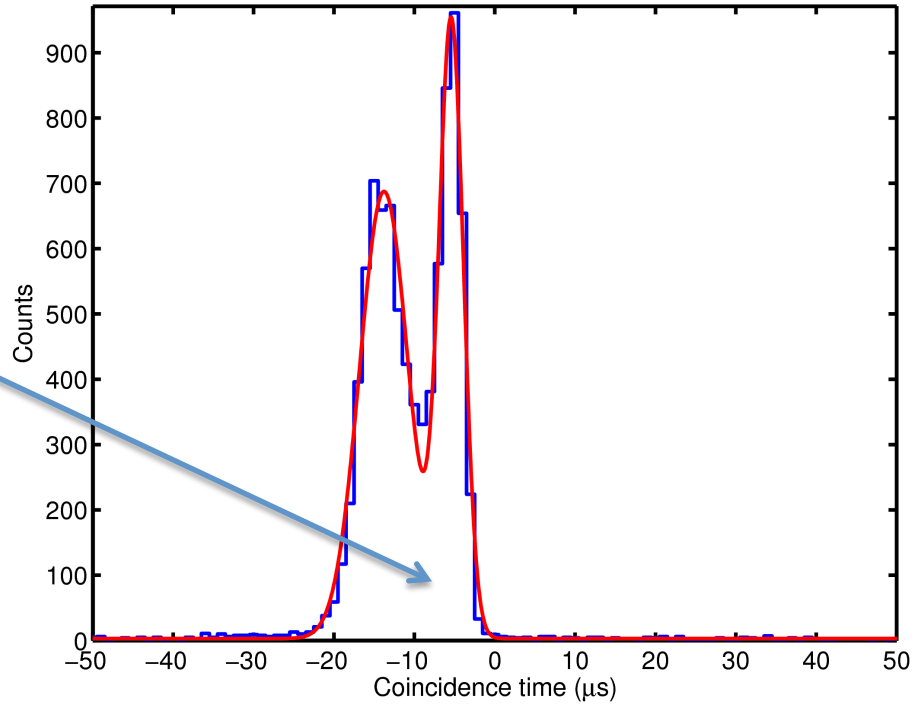


- Track these muons across the shield
- Use the muon NMM data to help with muon-bundle analysis
- Have about ~ 1 month of good correlated muon data

Coincident Events

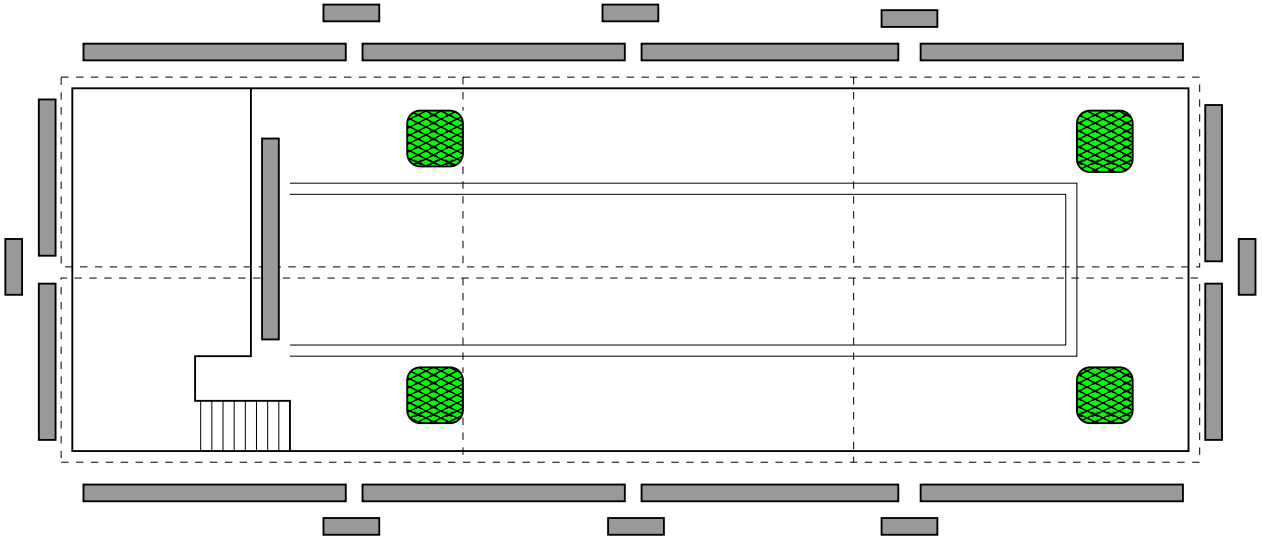
Neutrons with NMM

Delayed structure from mult. trigger



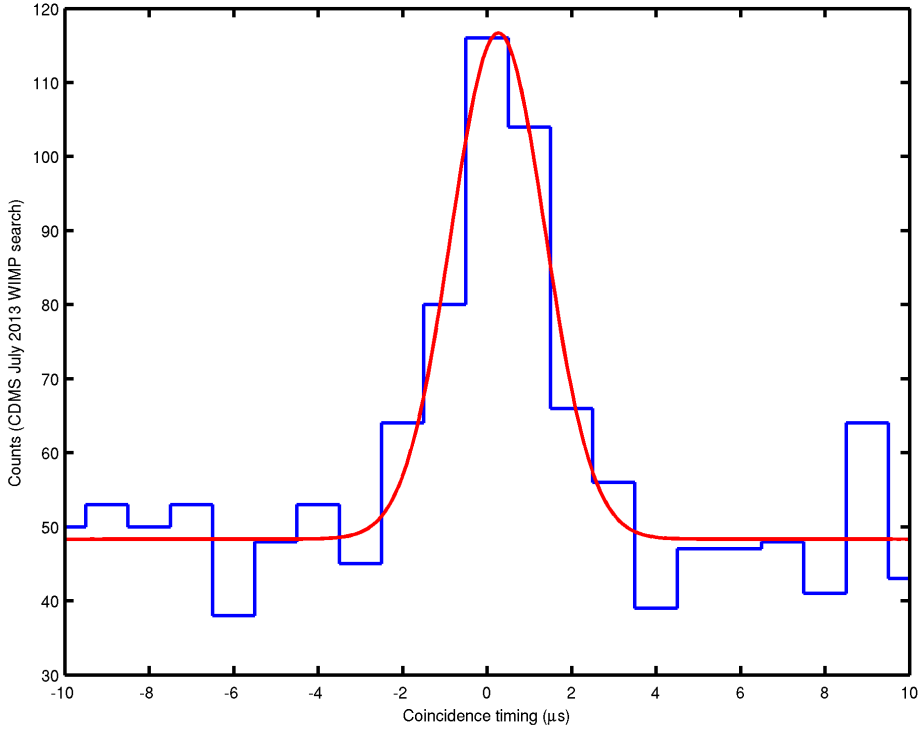
- Structure in the timing spectrum provides info about corr. activity
- This effort will extend and improve the NMM's primary goal, by answering questions about the parent muons related to the HE neutrons
- Have about ~ 6 months of good correlated muon data

The CDMS Experiment



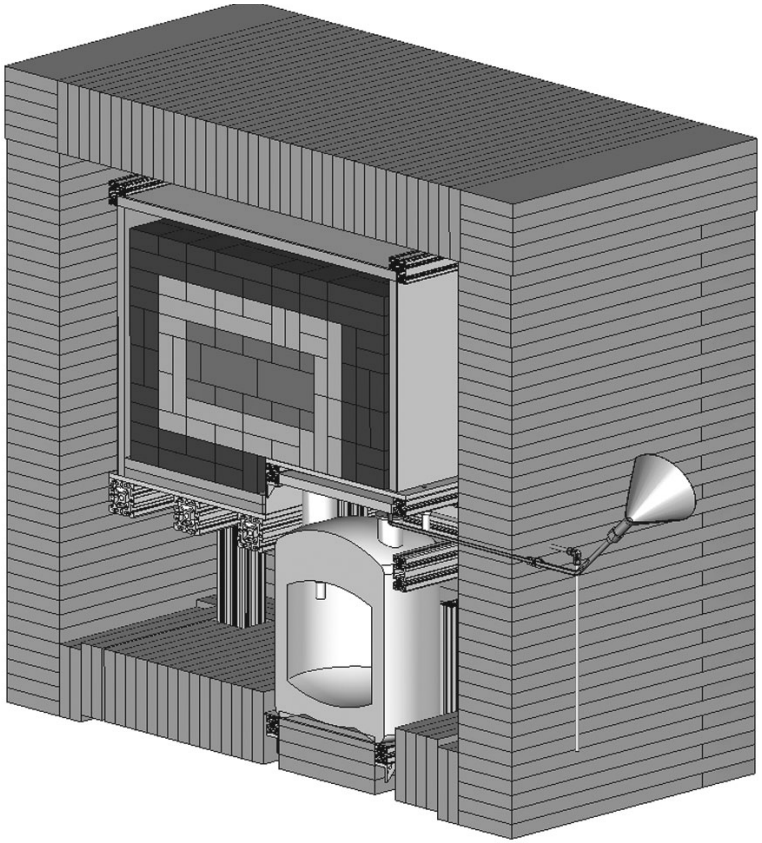
- CDMS detector located outside the shield, searching for rare WIMP scatter events
- Does have instrumentation with a GPS signal and Symmetricom readout
- Also equipped with an outer scintillator veto

CDMS Coincidences and Data Period



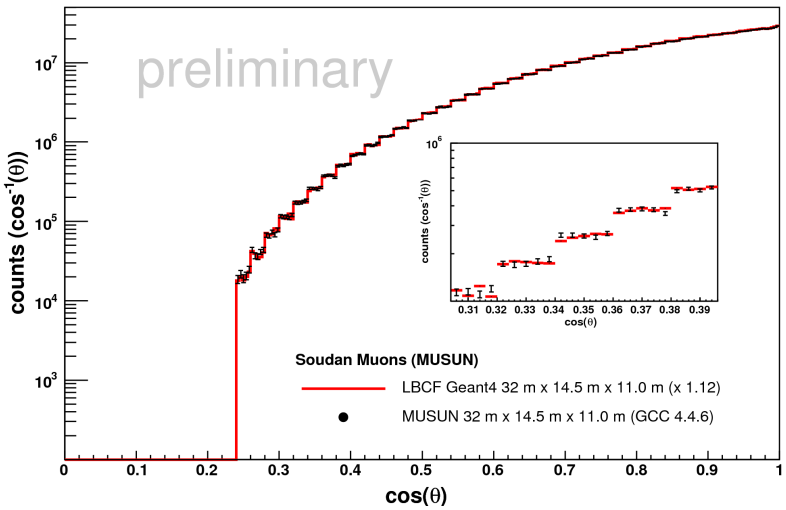
- Left is a sample correlating with only CDMS events with CDMS-veto activity
- The Veto-shield activity period spans from about June 2012 to present, overlapping with the SuperCDMS-Soudan runs

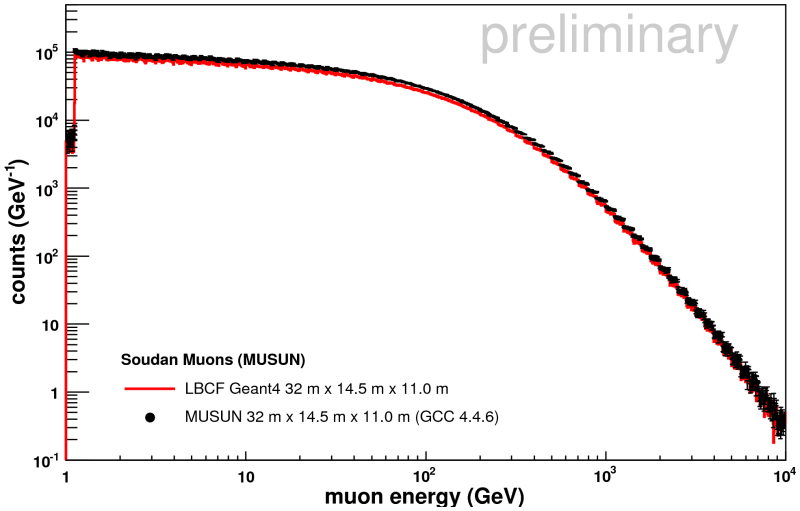
CoGeNT and C4



- CoGeNT and C4 are prime examples of detectors probing very interesting physics from *inside* the shield
- Can provide active vetoing info event-by-event
- Or ancillary info on background modulation
- DAQ hardware needs Symmetricom time implemented

The Soudan Simulation





- Aside from experimental vetoing or monitoring, independent physics requires efficiencies
- We have a Geant4 simulation of the whole cavern and are updating this with *all* detector structures in the mine to get full information
- Since the muon distributions at Soudan are known, can throw many properly distributed primaries

Summary

- The Veto-shield allows correlated timing at the ~ 1 μs level
- Many detectors can be used in conjunction with muon tracking
- Can be used as direct veto for Soudan low background experiments
- Rich possibilities for other physics results supporting neutron benchmarking efforts
- To-do list includes Veto-shield coincident analysis and simulation on timescale of Spring/Summer
- Always Interested in correlating new and interesting detectors underground – especially neutron detectors