# Muon-shielded counting facility at Soudan

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#### Soudan LBCF

- The Soudan Low
   Background Counting
   Facility (LBCF) is located
   at the Soudan
   Underground Laboratory
   under the operation of
   the University of
   Minnesota
- This lab is located at a depth of 709 m or approximately 2100 mwe.



#### **LBCF** overview



#### LBCF Facility

- Former location of proton decay experiment.
- 10 × 13 × 40 meter experimental hall lined with proportional tubes.
- Includes room for experiments as well as a clean room and various general use detectors.

- Housed Experiments
  - Muon veto (Cosmic Shower Study)
  - Neutron Multiplicity Meter (study of high energy neutrons)
  - CoGeNT (Dark matter)
  - Medtronics (Cosmic related memory errors)
  - Low background screening(XIA alpha, BetaCage, Gopher HPGe)

#### **Muon Veto Shield**





- Tube construction
  - 700 × 20 × 5 cm (on average)
  - Extruded aluminum structure
  - 8 hexagonal wire chambers
  - 2 channel preamp readout
  - Filled with 90/10 Ar/CO2
- Tubes refurbished
- Gas system rebuild with new readout/control system
- New DAQ system
  - Reconfigurable system based on complex programmable logic devices (CPLDs)
  - LabView readout and GUI interface

#### **Gas Control System**



- Old recirculation system has been refurbished
- 90/10 Ar/CO<sub>2</sub> mixed from bulk gas
- Pump circulates gas through catalytic converters to remove any oxygen
- Old hardware control system replaced with a computer control system

## **Data Acquisition System**

- Preamps process raw signal and produce a 1.2 µs pulse for signals above ~10 keV (We should get ~20keV for a minimum ionizing particle).
- Signal stretched to 4 µs to account for drift time and fed into trigger CPLD
- Upon trigger the backplane then multiplexes signal and sends data + timestamp to LabView interface
- GPS timing card provides clocks and time stamp information(±2µs)
- Trigger logic & Data processing based in CPLDs for flexibility





G3 Backplane / MUX

## **Data Monitoring and Storage**

- 4 DAQ machines write data locally. During low load times data is transferred to MySQL server.
- Client users may access DAQ database for offline muon tagging.
- System can be remotely controlled through RDP client.
- Data can be visualized in a simply counter program or in a full GUI.



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## **GUI Shield Display**







A bet - 55 meet NW - 1 G:\LECF\vertextright Crate 1 4955\_rs.txt Time: 2009-05-28 22:55:59 469909 NW - 2 G:\LECF\vertextright Vertext 2 4380\_rs.txt Time: 2009-05-28 22:55:59.469909



#### **Angular Measurement**

- Ceiling contains two layers of crossed tubes
- Setup triggered off central stack of tubes
- Requires a minimum of 4 layers for consideration as an angle muon
- East wall gives wide angle muon measurements



# **Angular Distributions**

Azimuthal distribution of muons as measured for  $\theta < 0.5$ 





Zenith distribution of muons in the east-west direction with a fit of the form  $\cos^{n} \theta$  shifted to account for detector geometry (n = 4.28)



Lab lies below an E-W running ridge as well as is shadowed by the remaining Taconite deposits also running E-W

# **Neutron Multiplicity Meter**

- The Neutron Multiplicity Meter (NMM) is a Gadolinium loaded liquid scintillator detector designed to detect high energy neutrons designed and built by Case Western & UCSB
- Detects secondary thermal neutrons resulting from high energy neutron strikes on a lead mass below the active volume.
- Measurement is interesting to understand WIMP backgrounds.



- The NMM detector consists of 2 separate 570 gallon active volumes.
- Each active volume read out by two super-K photo tubes.
- Waveform digitizers read PMT signal and record window around trigger

#### NMM + muon veto

- Because of the veto shield we can study the EM accompaniment of the neutrons as well.
- We have placed supplementary tubes under the NMM.
- The data between the two experiments is linked via GPS time stamps.
- NMM can also assist in shower analysis by giving sampling energy while shield captures shower shape
- In addition to a detailed MC of the NMM run by UCSB/CW, we run a full shower MC of the LBCF with veto as active element

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#### **Example Events**

The veto shield event display for 2 muon events which intersect NMM Hit tube modules: One layer = blue or green, Double layer = red





#### Shower originates in lead

PMT Waveform digitizer trace on the neutron detector for the event on the right (above) as matched by time-stamps and showing both prompt and delayed pulses.

#### CoGeNT



- Coherent Germanium Neutrino Technology (CoGeNT) collaboration runs a Dark Matter search which is based on commercial low background detectors at Soudan.
- Their detector utilizes a 440 g p-type point contact germanium detector to probe regions of low WIMP mass (< 10 GeV)
- The collaboration's most recent results from their run at Soudan show possible dark matter evidence, but are far from conclusive.

## **Other users**

#### MEDTRONIC

- This is a test of memory's susceptibility to cosmic radiation
- By operating an array of memory chips in various conditions they (in Soudan, at sea level and at high altitude) they can measure the effect of cosmic radiation on the longevity of their chips.

#### SCREENING FACILITY

- Gopher HPGe detector for CDMS material screening.
- XIA alpha screener
  - Commercially designed proportional alpha counter
  - Prototype tested at Soudan with a model to be delivered
- Beta Cage
  - High purity proportional chamber counter
  - Useful to characterize CDMS detector surface background

#### **Summary**

- The Soudan LBCF is a user ready low background facility at a depth of 700 m.
- Active Muon Veto
  - Refurbished with new DAQ.
  - Keeps database for offline muon tagging.
  - Used to study particle showers.
- Already host to 2 collaborative efforts (NMM, CoGeNT) and several smaller ventures with plenty of space for more.
- http://www.hep.umn.edu/lbcf

#### **Extra 1 - Singles Rates**

**Plateau Curve for Veto Shield** 



#### Extra 2 – Singles Log with noise

**Plateau Curve for Veto Shield** 



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