

SNOLAB Facility & Science Programme

> Nigel J.T. Smith Director, SNOLAB

# The SNOLAB Facility



- Operated in the Creighton nickel mine, near Sudbury, Ontario, hosted by Vale Ltd.
- Underground campus at 6800' level, 0.27µ/m<sup>2</sup>/day
- Developed from the original SNO detector as part of a competition to develop international facilities within Canada
- Construction funding from Canada Foundation for Innovation
- Additional construction funding from NSERC, FedNOR, NOHFC for surface facility
- Operational funding through CFI, MRI/MEDI (Province of Ontario)
  - Operated under 'free-at-point-of-access' model ubiquitous in nuclear and particle physics
- Managed as a joint venture between five Canadian Universities (Alberta, Carleton, Queen's, Laurentian, Montréal)
  - Will incorporate as a not-for-profit during 2017

## **SNOLAB** Location





# Surface Facilities

- Surface Facility (3100 m<sup>2</sup>)
- Operational from 2005 -Provides offices, conference room, dry, warehousing, IT servers, clean-room labs, detector construction labs, chemical + assay lab
  - 440m<sup>2</sup> class-1000 clean room for experiment setup and tests





# Facility design considerations



- Design criteria seismic activity
  - Mining induced seismic activity quasi-random
  - SNO and SNOLAB in the stable hanging wall of norite
  - Lab placed outside the lifetime 5% stress boundary from mining activity
  - Orientation to give cavities along line of maximum stress
  - Secondary support: 2m rockbolts, 7/10m cables, mesh and shotcret
  - Design criteria now 4.3 Nuttli, following 4.1 event in SNO
  - Forcing function applied to experiment designs maximum velocity 800 mm/s at 5 Hz
- Background minimisation
  - Norite rock: 1.00 ± 0.13 % K, 1.11±0.13 ppm U and 5.56±0.52 ppm Th
  - Dust suppression required all experimental areas shotcreted and painted to capture dust and contamination
- Entire facility to be maintained as a C2000 clean-room
  - Minimise potential for cross-contamination of experiments from dust introduced into lab
  - Minimise burden on experiments, trained crew for materials
  - Controlled single point access for materials and personnel, including personnel showers and change area

# Seismic design criteria





ANDES 5<sup>th</sup> Design Workshop, Buenos Aires

29<sup>th</sup> June, 2016

# **Facility Services**



- Ventilation
  - 100,000 cfm mine air flow to laboratory, mainly used for cooling of chillers
  - 10% make-up air fed in lab 13 air handling units in lab
  - Maintains pressure differentials for cleanliness
  - 10 air changes/hour nominal; 5 air changes/hour in cavities
- Cooling
  - 1 MW cooling capability from 5 cooled water units delivering 10°C water to the laboratory.
    100kW from rock in steady state (42°C base)
  - 20% utilised at present with minimal expt. load
- Power distribution
  - 3-phase 13.8 kV fed to facility
  - Stepped to 3-phase 600V (total 3000 kVA)
  - 3MW Surface Generator planned
- Water
  - Utility water derived from mine water
  - UPW as a general capability for experiments (150l/min 183 k $\Omega$ m)
  - Waste disposal through mine systems (except sewage STP)











# **SNOLAB M&O Support**



- Support recently renewed (from April 1<sup>st</sup>):
  - CFI MSI Proposal funded for three years at \$28.6M (Request was five years)
  - \$28.8M co-funding secured from Province of Ontario, over five years to 2022
  - 'in-kind' support from Vale at ~\$12M/year from running the mine
- Mandate evolution
  - Need to develop from a site to a national laboratory operating within the international field
  - Additional capabilities required to support future programme
  - Staff increase from ~75 to ~100
- MSI Requirements for 2020
  - SNO+ should have achieved publishable results from its water and LAB phases
  - DEAP-3600 should have published results on dark-matter limits from its 2016-2018 running.
  - SuperCDMS should have be in its installation phase.
  - A major experiment should be identified for installation in the Cryopit.
  - Several smaller multi-disciplinary projects should have achieved publishable results.
  - SNOLAB should produce, in consultation with the research community, a vision, a strategic long term plan and a proposal for the facility beyond 2022.

# **SNOLAB** Organisation





**Nigel J.T. Smith** 

ANDES 5<sup>th</sup> Design Workshop, Buenos Aires

29<sup>th</sup> June, 2016

# **Current Science Programme**



Experiment	Neutrino	Dark Matter	Other	Space allocated	Status
COUPP-4		V		"J"-Drift	Completed
CUTE		V	Test Facility	Ladder Labs	In Preparation
DAMIC		V		"J"-Drift	Operational
DEAP-1		V		"J"-Drift	Completed
DEAP-3600		V		Cube Hall	Operational
DEAP-50T/CLEAN		V		Cube Hall	Letter of Intent
DMTPC		V		Ladder Labs	Concept Phase
DUST			Test Facility	Ladder Labs	Letter of Intent
FLAME			Genomics	External Drifts	Operational
LEGEND (Ge1T)	V			Cryopit	Letter of Intent
nEXO	V			Cryopit	Concept Phase
HALO	V			Halo Stub	Operational
MiniCLEAN		V		Cube Hall	Commissioning
MODCC			Mining Data Centre	Surface Facility	Operational
NEWS		V		Cube Hall	In Preparation
PICASSO-III		V		Ladders Labs	Completed
PICO-2L		V		"J"-Drift	Completed
PICO-60		V		Ladder Labs	Operational
PICO-500		V		Ladder Labs	Letter of Intent
PUPS			Seismicity	Various	Completed
REPAIR			Genomics	Chem Labs	Operational
SuperCDMS		V		Ladder Labs	In Preparation
SNO+	$\checkmark$			SNO Cavern	Commissioning

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### **Progress on experiments**



- SNO+: Uses existing SNO detector. Heavy water replaced by scintillator loaded with <sup>130</sup>Te. (<sup>130</sup>Te  $\rightarrow$  <sup>130</sup>Xe + e<sup>-</sup> + e<sup>-</sup>)
  - Detector submerged, DAQ exercised, water physics data taking started.
  - LAB process plant construction completed, commissioning underway, LAB is on site. Te plant in construction, diol process development continues.
- DEAP-3600: Single phase Liquid Argon using PSD
  - Detector is collecting dark matter data from Nov 2016.
  - Analysis expected to be completed by TAUP meeting
- MiniCLEAN: Single Phase Liquid Argon using PSD
  - Cool-down complete; reviews completed, argon fill underway.
- SuperCDMS-SNOLAB: Dark matter Si / Ge crystals with ionisation / phonon readout
  - Planning well advanced for deployment, especially CUTE test facility.
- PICO: Rapid expansion bubble chambers. Insensitive to MIPS at operating temperature, threshold devices; alpha discrimination proven;
  - PICO-60: New run completed, analysis finalised, paper arXiv:1702.07666.
  - PICO-40 under construction (right-side up chamber)

# **SNO+** experiment

- 780 tonnes of liquid scintillator as active volume
  - Can be loaded with double beta decay isotope
- ~9500 PMTs
- 1500 + 5300 tons ultra-pure water shielding
- 6800' underground in SNOLAB







Organic scintillator Linear Alcyl Benzene (LAB) and PPO Add 130Te and as loading for double beta phase -3-

# Calibrations



Drive tests laser ball – April 2017 – PSUP mounted camera system

### **Currently Taking Data (24/7 shifts)**





First neutrino *candidate*: 2017-02-05, upward-going, no outward-looking PMTs triggered

# **PICO-60 Recent Results**



- Superheated fluid bubble chambers
- Particle interactions nucleate bubbles
  - Good discrimination against backgrounds
  - Alphas 'louder'
  - Gammas do not nucleate
- Visual and acoustic sensors

Propylene Glycol (hydraulic fluid) Water (buffer) CF<sub>3</sub>I (target)



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arXiv: 1702.07666

# WIMP - Proton Exclusion



The 90% C.L. limit on the SD WIMP-proton cross section from PICO-60 C3F8 blue, along with limits from PICO-60 CF3I (red), PICO-2L (purple), PICASSO (green), SIMPLE (orange), PandaX-II (cyan), IceCube (dashed and dotted pink), and SuperK (dashed and dotted black)

### DAMIC-100 in Snolab

- DAMIC-100(grams) uses high-resistivity, 675 μm, 16 M Pix, 5.6 g per piece CCDs. Developed by LBNL Microsystems Lab.
  18 CCDs planed to be installed there. 18 × 5.6g = 100.8g.
- DAMIC-100 has started commission in April, 2016.
- Snolab, the world's second-deepest underground lab facility, 2070 m overburden of rock provides 6010 meter water equivalent shielding from cosmic rays.





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# **DEAP-3600** Design





## **DEAP-3600** Construction





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#### Electron Recoil Band Background Model

Background Model in ER Band (0.2 < fprompt < 0.4) MC components scaled to radioassay data



- Empiric energy calibration based on 1460 keV (<sup>40</sup>K) and 2614 keV (<sup>208</sup>TI) peak
- Scaling of MC simulations to known screening / literature values (this is not a fit)
- Low energy region (< 0.5 MeV) dominated by <sup>39</sup>Ar
- Mid energy region (0.5 2.6 MeV) dominated by gamma from outside components (mainly PMT glass)
- High energy region (> 2.6 MeV) dominated by <sup>42</sup>K and beta components from very close <sup>208</sup>TI sources

#### - Gamma line measurements can be used to constrain ( $\alpha$ ,n) neutron production

#### **Neutron Background**

- Neutrons produced by
  - ( $\alpha$ ,n) reactions in close and far material
  - fission neutrons
  - cosmogenic neutrons (muon induced)
- Extensive neutron MC campaign using radio-purity assays and ( $\alpha$ ,n) yields from SOURCES-4C
  - Dominant source is ( $\alpha$ ,n) in PMT glass ( $\approx$ 70%)
  - Well constrained from γ-background and consistent with target values





#### Data driven limit on neutron interactions:

- Idea: Eventually all neutrons capture and leave gamma signature
  - 2.2 MeV  $\gamma$  form <sup>1</sup>H in acrylic
  - 6.1 MeV  $\gamma\text{-}cascade$  from  $^{40}\text{Ar}$  in LAr
  - Search for n  $\gamma$  coincidences
- Preliminary result:
  - No coincidence found above expected random background
  - Limit on neutron interactions consistent with target value

### **Cryogenic Detector Programme**



- US G2 Down-select funded SuperCDMS-SNOLAB with emphasis on low energy WIMPS. Cryostat and system to accommodate full 400 kg capacity with ~25kg will be initially deployed.
  - Potential future international developments
- SNOLAB and SuperCDMS working to coordinate between funding agencies, laboratory and experiment, through the project lifecycle.



### Spin independent results summary





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# **New Directions**



- MODCC mining data observatory using pp culture
  - Rock wall stresses are a major problem for mining groups as ore bodies go deeper
- Genomics projects underway
  - Metabolism in fruit flies in a mining environment
    - Intent to study stresses on miners and potential mitigation
  - Low radiation effect on cell mutation (NLT study)
    - Study effect of sub-background radiation levels and radiation type on cell mutation
    - introduce radiation species individually







# **Community supported**



- 164 faculty researchers from 78 institutions over 15 countries
  - ~25% of faculty are Canadian
- >500 faculty, highly qualified personnel and technical support
- ~11,000 underground person-shifts per year (~50/dayshift)



# **User-base by Country**





### **KPMG Economic Impact Assessment**



- KPMG Independent economic assessment completed to understand impact on local and national economy
  - Headline figure: \$3 of direct economic activity per \$ of government investment (\$7.8/\$ of Provincial funding)
  - Similar to other public funded endeavours
  - Does not trap societal and long-term impact of SNOLAB



# **Progress on facility systems**



- SNOLAB Infrastructure:
  - Low background capabilities increased in priority due to community needs and review feedback
  - New HPGe detectors from Vue des Alpes and Soudan installed
  - Development of refuge to provide additional size and underground office space underway
  - MODCC project completed refurbishment of surface facility third floor
  - Capital infrastructure secured for surface generator plant emergency power
- SNOLAB Processes:
  - Overhaul of SNOLAB operational policies/procedures continues
  - Experiment lifecycle management now implemented including gateways, with required reviews at each stage to ensure clear understanding of resource requirements

# Life Cycle Phases



- Process implemented Fall 2015; aligns with DOE and TRIUMF
- Each phase leads to a GateWay, prior to passing to next phase
- SNOLAB Projects Office supports projects through the process; all projects have a project coordinator assigned
- Expressions of Interest accepted at any time, natural EAC biannual cycle



# Lab developments underground





## Lab Developments - surface



- 3MW surface generators funded.
  - Provides full power back-up for facility to ensure lab can be operated
  - Removes environmental and planned maintenance drop-outs
  - Project approved fully by Vale following regulatory assessments
- Anticipate generator purchase this FY, installation through 2018 to ensure on-line for SuperCDMS (main requirement)



### Planning for the next generation project

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#### 2017 Future Projects Workshop

#### August 16th and 17th, 2017 at SNOLAB, Sudbury, Canada

As part of its medium term planning process, SNOLAB is undertaking a scoping review of potential future small- and medium-scale experiments seeking to locate in the underground campus at 2070m in the Creighton mine. This Future Projects Planning workshop is part of this horizon scanning exercise, and experimental collaborations that have an interest in using any space underground, including any of the large-scale experimental areas within SNOLAB, over the next five to ten years are invited to present their capabilities, status, plans, and infrastructure requirements.

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#### Registration

If you are interested in attending or presenting at FPW 2015, please register HERE.

#### Schedule

Schedule and talks will be available on Global Indico - SNOLAB

#### **More Information**

For more information, please contact: Ken Clark SNOLAB Research Scientist Ken.Clark[at]snolab.ca (705) 692 7000 x 2244

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## **TAUP & TRISEP 2017 in Sudbury**



XV International Conference on Topics in Astroparticle and Underground Physics

**TAUP** 2017

24 - 28 July 2017 Sudbury, ON, Canada

# PI · SNOLAB · TRIUMF TRISTITUTE SUMMER SCHOOL ON ELEMENTARY PARTICLES

SUDBURY, ONTARIO

JULY 10-21, 2017

# Summary



- SNOLAB is a world-leading facility for deep underground science located near Sudbury, Ontario
- SNOLAB provides an ultra-quiet radiation environment to study weak or rare interactions in particle detectors
  - The science programme addresses some of the fundamental questions in contemporary physics
  - The Science programme is expanding to include other fields (genomics, mining innovation)
- SNOLAB supports world-class science, with results from existing projects being delivered
- SNOLAB attracts both national and international recognition and presents a continuing major research and innovation opportunity for Canada and Ontario