Facility and science developments at SNOLAB

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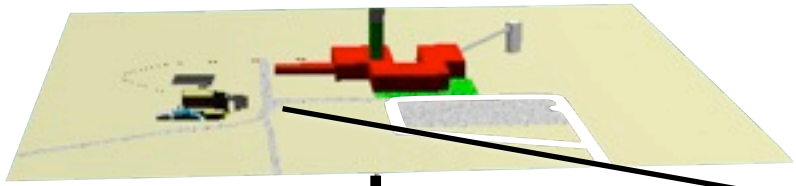
Happy Canada Day!

SNOLAB Objectives

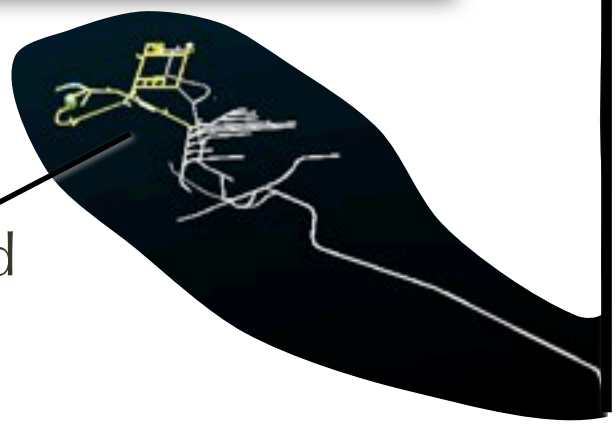
- To promote an International programme of Astroparticle Physics
- To provide a deep experimental laboratory to shield sensitive experiments from penetrating Cosmic Rays (2070m depth)
- To provide a clean laboratory
  - Entire lab at class 2000, or better, to mitigate against background contamination of experiments.
- To provide infrastructure for, and support to, the experiments
- Focus on dark matter, double beta decay, solar & SN experiments requiring depth and cleanliness.
  - Also provide space for prototyping of future experiments.
- Large scale experiments (ktonne, not Mtonne) at present.
- Goal has been to progressively create a significant amount of space for an active programme as early as possible.

SNOLAB Location



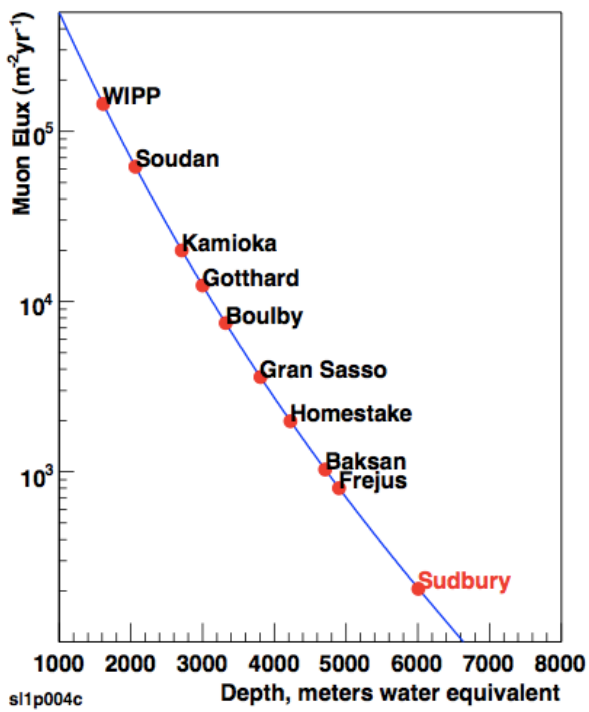
2km rock overburden (6000mwe)

Surface Facility



Underground Laboratory

Muon Flux = 0.27/m²/day



The SNOLAB facility

- Operated in the Creighton nickel mine, near Sudbury, Ontario, hosted by Vale Ltd.
- Developed from the existing SNO detector
- Underground campus at 6800′ level, 0.27μ/m^2/day
- Development funds primarily through CFI as part of a competition to develop international facilities within Canada
- Additional construction funding from NSERC, FedNOR, NOHF for surface facility
- Operational funding through NSERC, CFI, MRI (Ontario)
- Managed as a partnership between four Universities (Carleton, Queen's, Laurentian, Montréal)
  - Alberta soon to join

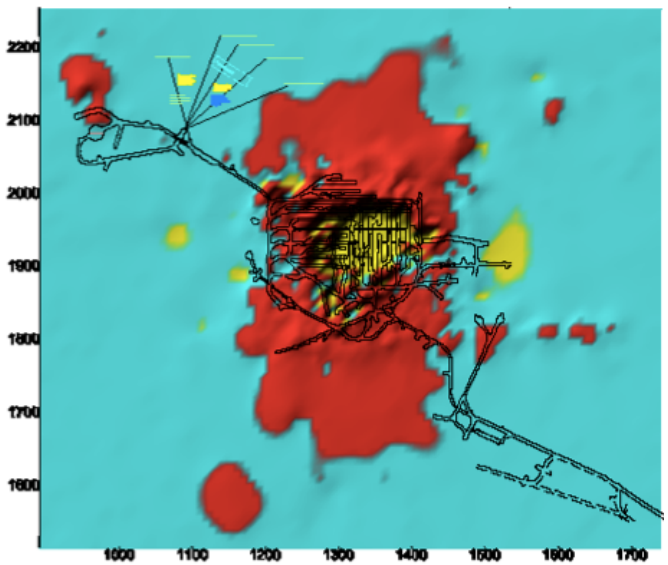
Facility design philosophy

- Initial underground design concept was single monolithic cavity
- Workshops held with community to determine experiment requirements
- Switched to multiple target cavities
  - Isolate experiments for background and noise control
  - Safety of large cryogenic liquid volumes: connection to raise
- Utility drifts separated from target volumes (à la SNO)
- 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

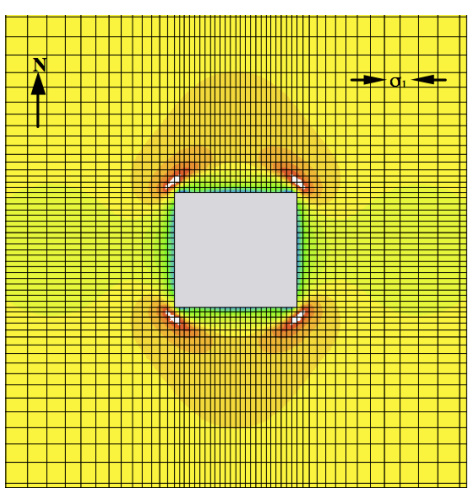
Facility design considerations

- Seismic activity
  - Mining induced seismic activity - quasi-random
  - SNO and SNOLAB designed to 4.1 Nuttli, such event seen (after completion of SNO)
  - Maximum event now taken as 4.3 Nuttli
- Design criteria - seismic
  - SNO and SNOLAB in the stable hanging wall of norite
  - Exploratory core drilling performed over lab area
  - Detailed analysis of cavity and lab design stress from ITASCA
  - 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 shot-crete
- 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 shot-creted and painted to capture dust and contamination

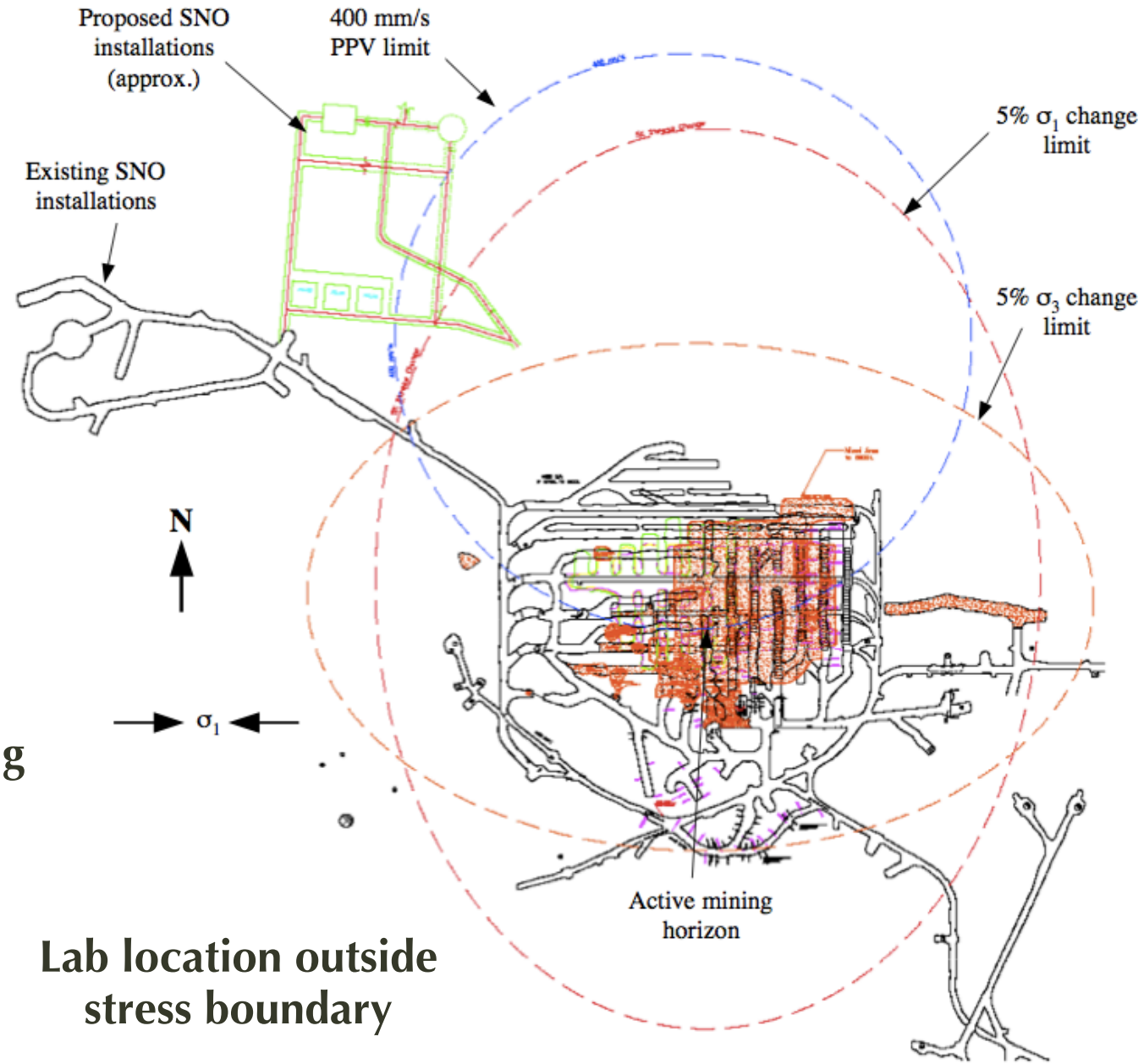
Seismic design criteria



5% stress contour



Stress modelling for all cavities



Lab location outside stress boundary

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 2000 kVA)
  - 150kW (++?) Generator planned
- Water
  - Utility water derived from mine water
  - UPW as a general capability for experiments (150l/min 183 kΩm)
  - Waste disposal through mine systems (except sewage - STP)

Experiment design considerations

- Transport
  - Cage size: 3.7 m x 1.5 m x 2.6 m, slinging for larger objects
- Seismic mitigation
  - 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
- Pressure
  - Air pressure is 25% higher than atmospheric
  - Excursions during ventilation changes and crown blasts (up to 3% seen)
    - managed through baffling and blast doors
    - design pressure for experiments up to 20 psi
- Radon (~130 Bq/m^3)
  - No direct radon suppression in air intakes
  - Cover gas used (LN_2 boil-off) on detector systems
  - Ventilation (make-up vs recirculation) minimises radon emission from walls
- H_2S
  - Long term exposure to mine air showed deposition of CuS on SNO electronics
  - Suppression is now installed in the air handling units

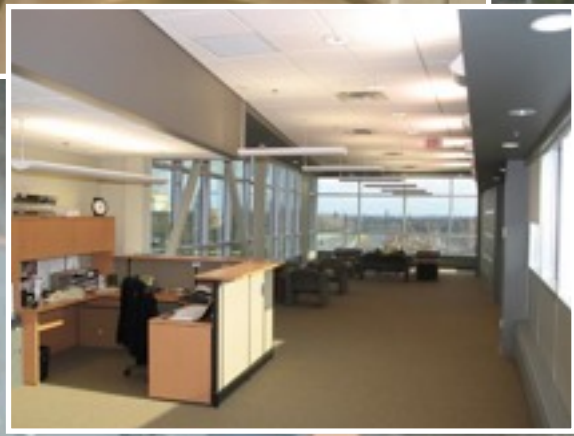
Support for Experiments

- Through a staff of ~55, SNOLAB Provides technical and administrative support to SNOLAB experiments (~250 users):
  - design, construction, operations
  - background assay, science support
  - materials transport, cleaning, EH&S, training, procurement
- The Research team members can act as collaborators on experiments, providing operational and scientific support
- Infrastructure support is provided through development of shielding systems, mechanical supports, access, EH&S, etc.
- Services provided as standard to experiments includes life safety, power, ventilation, compressed air, ultra-pure water, liquid nitrogen, IT and networking
- Vale provide materials transport through the shaft, maintain the safety of the infrastructure, regulatory checks, etc.
  - SNOLAB currently has ~50 people underground regularly, 3 dedicated cages
  - Cages integrated into Vale operations effectively (eg SNO D_2O movement)

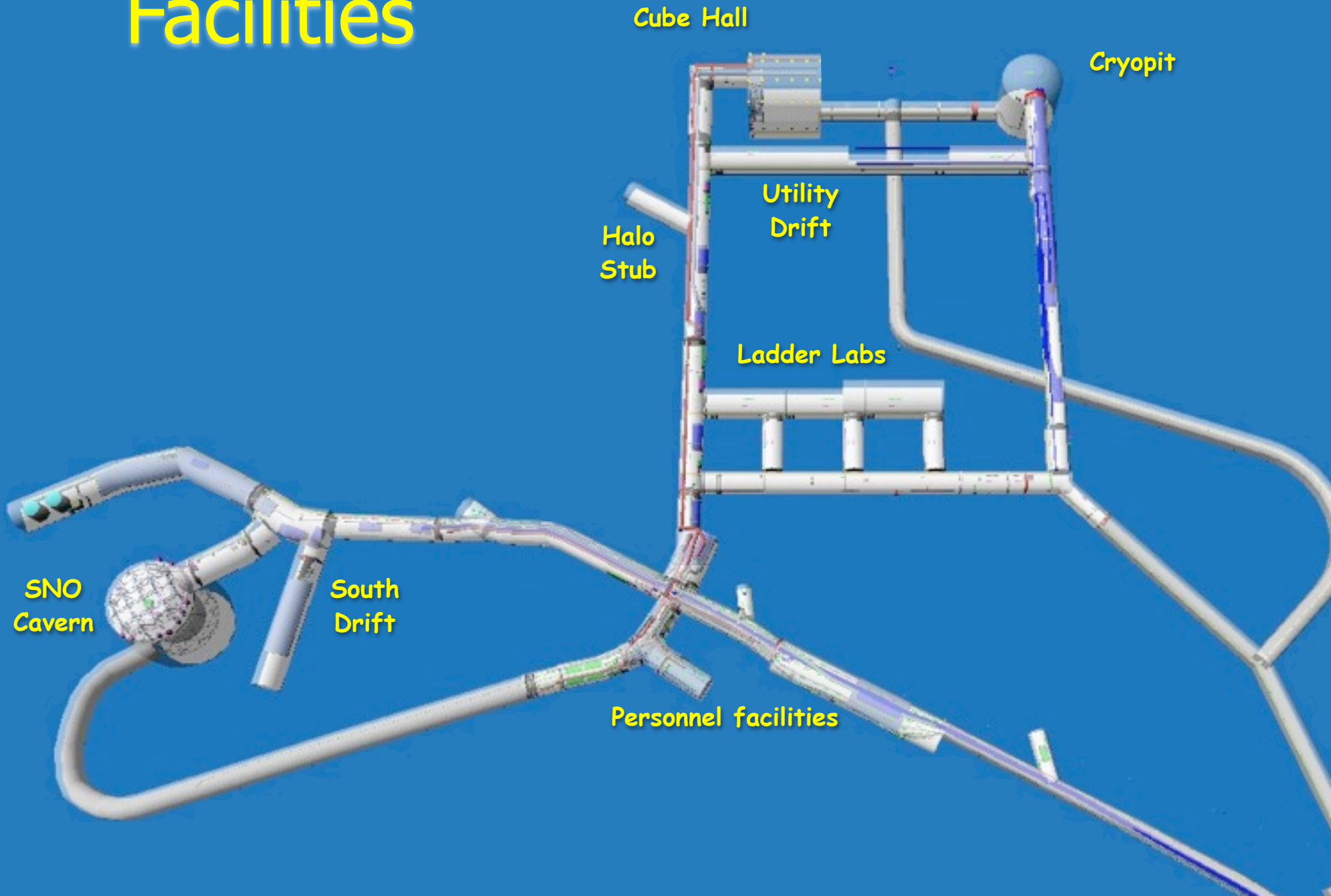
SNOLAB Overall Status

- Surface Facility (3100 m^2)
  - Operational from 2005 - Provides offices, conference room, dry, warehousing, IT servers, clean-room labs, detector construction labs, chemical + assay lab
  - 440m^2 class 1000 clean room for expt setup
- Underground Construction (Cube Hall, Cryopit, Ladder Labs)
  - Phase I excavation complete and outfitting began June 2007.
  - General outfitting in Phase I areas complete 2009, final clean 2010.
  - Phase-II excavation complete June 2008
  - Phase-II integration complete March 2011, final clean completed.
  - SNO cavity, Cube Hall and Ladder Labs hosting and developing experiments.
- Experimental Programme
  - Relocation / continued operation of DEAP-1 & PICASSO-III (and EXO-gas R&D).
  - New experiment deployed: COUPP-4
  - Construction support for HALO, SNO+, DEAP-3600, MiniCLEAN
  - Current allocations to: PICASSO-III, DEAP-I, SNO+, DEAP-3600, MiniCLEAN, SuperCDMS TF, SuperCDMS, COUPP, HALO.
- Operational funding currently secured to 2013

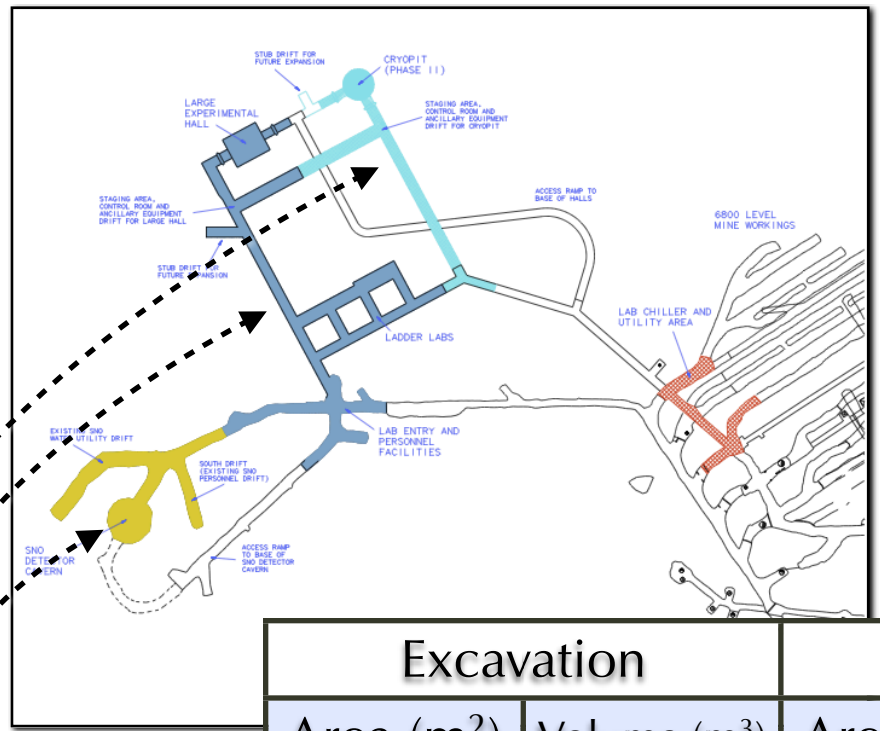
Surface Facilities



Underground Facilities



Laboratory Space



All clean spaces will be operated as Class2000 clean rooms (or better).

	Excavation		Clean Room		Laboratory	
	Area (m^2)	Volume (m^3)	Area (m^2)	Volume (m^3)	Area (m^2)	Volume (m^3)
Original SNO Areas	1860	16500	1130	13300	750	11700
Phase I	6070	38750	3900	29750	2430	23700
Phase II	7220	46650	4940	37250	3060	29550


Chiller


Chiller


Lab Entry
6800


Lab Entry


Lab
Entrance


Personnel
Facility


Lab
Entry


Galley/
Refuge


Meeting
Room


Cryopit


Cryopit


Cube
Hall

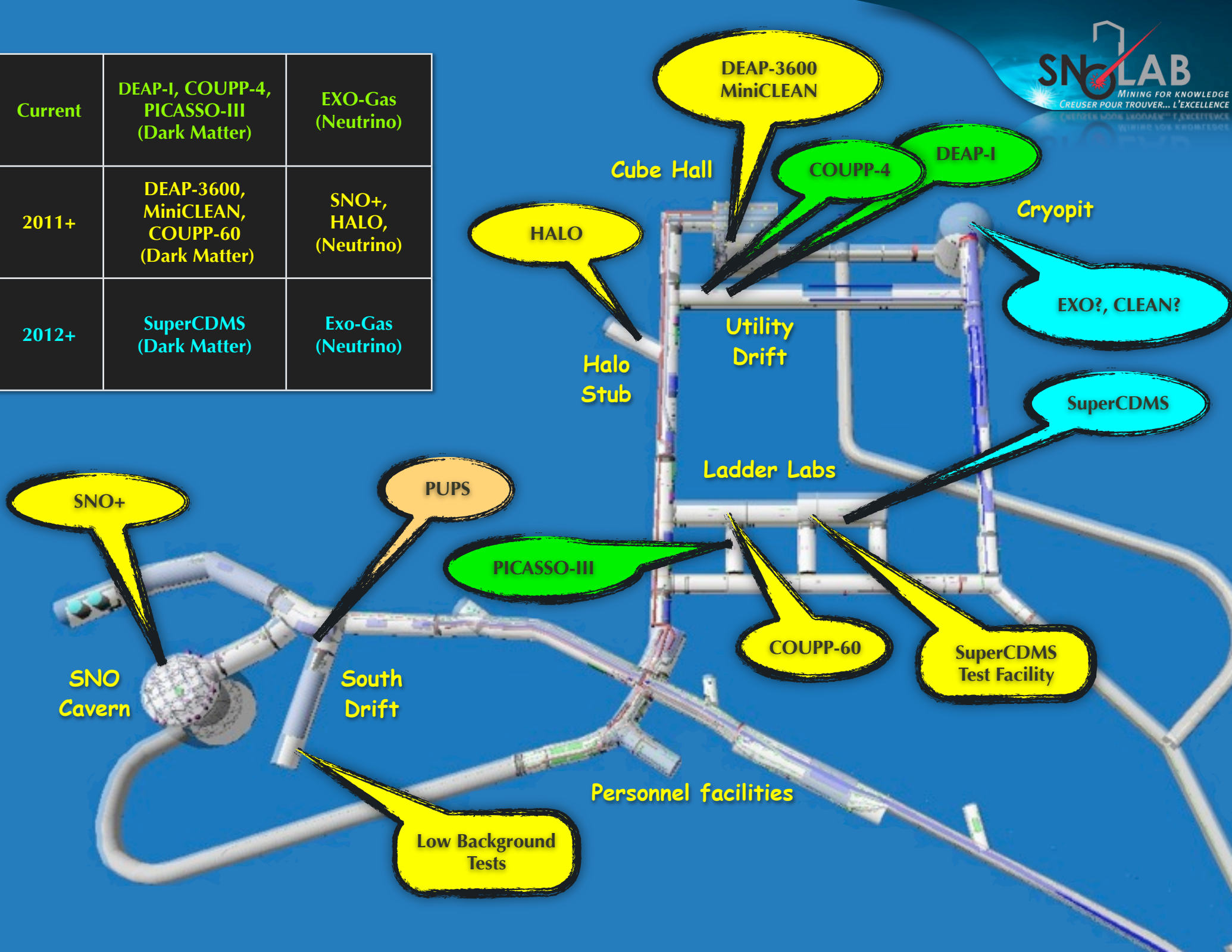

Ladder
Labs


Utility
Drift


Ladder
Labs


R&D 'J'
Drift

Current	DEAP-I, COUPP-4, PICASSO-III (Dark Matter)	EXO-Gas (Neutrino)
2011+	DEAP-3600, MiniCLEAN, COUPP-60 (Dark Matter)	SNO+, HALO, (Neutrino)
2012+	SuperCDMS (Dark Matter)	Exo-Gas (Neutrino)



Current programme: Dark Matter at SNOLAB

- Noble Liquids: DEAP-I, MiniCLEAN, & DEAP-3600
  - Single Phase Liquid Argon uses pulse shape discrimination.
  - Prototype DEAP-I operational in SNOLAB now, relocated to 'J' Drift. Successful demonstration of PSD and test bench for DEAP/CLEAN design/operations and background assessment.
  - Construction for DEAP-3600 and MiniCLEAN underway. Full DEAP-3600 capital funding granted (with SNO+)
  - Will measure Spin Independent cross-section.
- Superheated Liquid / Bubble chamber: PICASSO, COUPP
  - Superheated droplet detectors and bubble chambers. Insensitive to MIPS radioactive background at operating temperature, threshold devices
  - PICASSO currently operational in SNOLAB, relocated to Ladder Labs, demonstration of alpha rejection and test bench for scale-up of detector volumes.
  - COUPP-4kg deployment completed, 60kg summer this year.
  - Will measure Spin Dependent cross-section primarily, COUPP has SI sensitivity
- Solid State: SuperCDMS
  - State of the art Ge crystals with ionisation and phonon readout.
  - Currently operational in Soudan. Next phase will benefit from SNOLAB depth to reach desired sensitivity. Test facility in Ladder Labs under development.
  - Mostly sensitive to Spin Independent cross-section.

Current programme: 0νββ at SNOLAB

- SNO+ : $^{150}Nd \rightarrow {}^{150}Sm + e^- + e^-$
  - Uses existing SNO detector. Heavy water replaced by scintillator loaded with ^{150}Nd. Modest resolution compensated by high statistical accuracy.
  - Requires engineering for acrylic vessel hold down and purification plant. Technologies already developed.
    - SNO Cavity: repairs to cavity liner and modification of detector support to hold down the Acrylic Vessel for liquid scintillator.
    - SNO Utility Room: Excavation of pit for liquid scintillator purification system.
  - Capital funding received June 2009, turn on fall 2010.
- EXO-gas : $^{136}Xe \rightarrow {}^{136}Ba^{++} + e^- + e^-$
  - Ultimate detector aim = large volume Xe Gas TPC
  - Developing technique to tag Ba daughter. Electron tracking capability.
  - Development work at SNOLAB surface facility

Current programme: Natural neutrino sources

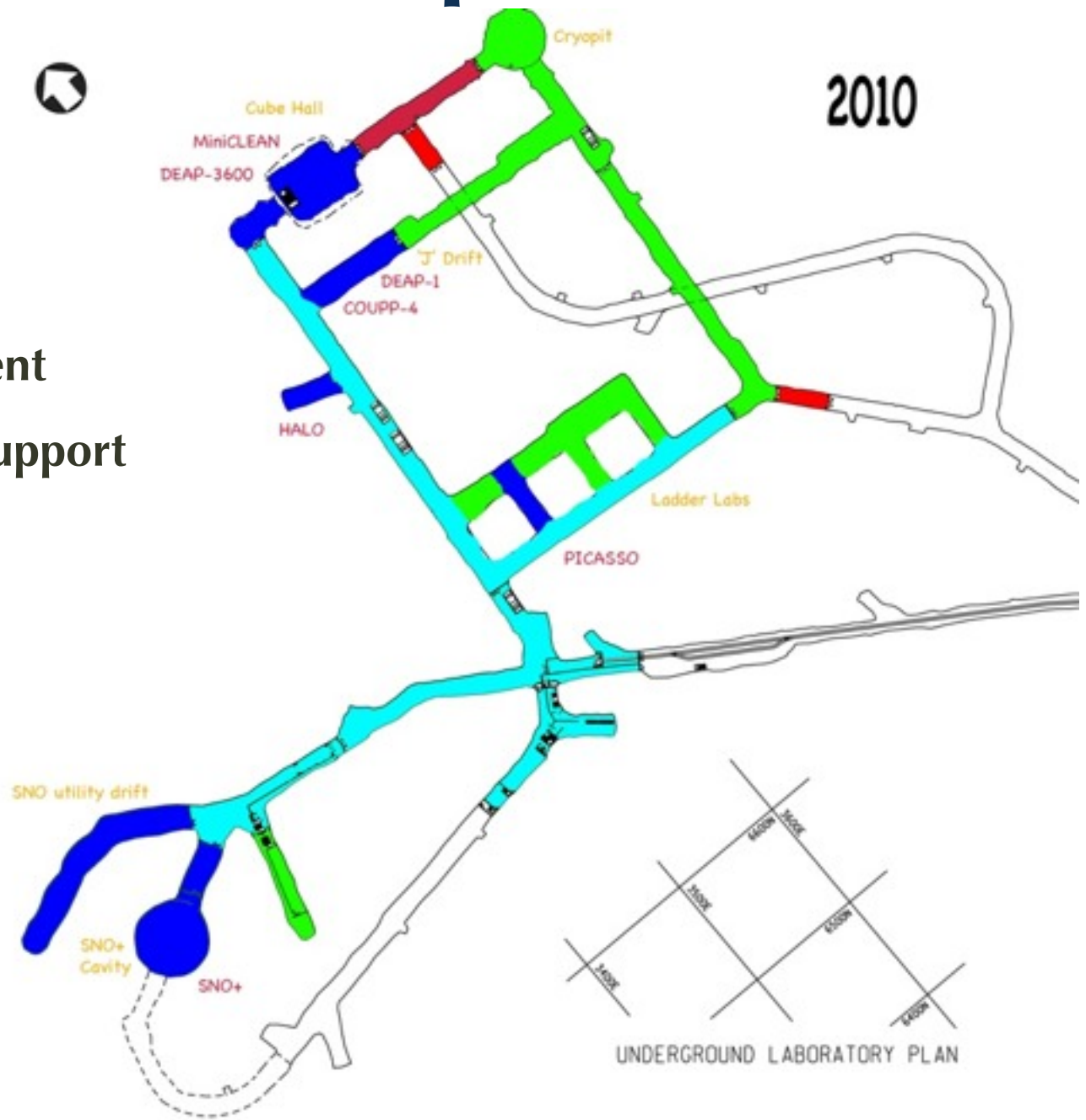
- SNO+ :
  - Will also measure
    - solar neutrino pep line (low E-threshold)
    - geo-neutrinos (study of fission processes in crust)
    - supernovae bursts (as part of SNEWS)
    - reactor neutrinos (integrated flux from Canadian reactors)
- HALO: Dedicated Supernova watch experiment
  - Charged/neutral current interactions in lead
  - Re-use of detectors (NCDs) and material (Pb) from other systems
  - Shielding partial re-use of PICASSO-II water cubes
  - Installation underway, completion by summer 2011
  - Will form part of SNEWS array

Experimental Programme

Experiment	Solar nu	0nuBB	Dark Matter	SuperNovae	Geo nu	Other	Space allocated	Status
SNO+	√	√		√	√		SNO Cavern	Underway
PICASSO-III			√				Ladders Labs	Underway
DEAP-1			√				J'-Drift	Underway
DEAP-3600			√				Cube Hall	Underway
MiniCLEAN			√				Cube Hall	Underway
HALO				√			Halo Stub	Underway
PUPS						Seismicity	Various	Completed
SuperCDMS			√				Ladder Labs	Request
EXO-gas		√					Ladder Labs	Request
COUPP			√				Ladder Labs	Underway
DarkSide			√				Ladder Labs	Request
COBRA		√					Ladder Labs	Request

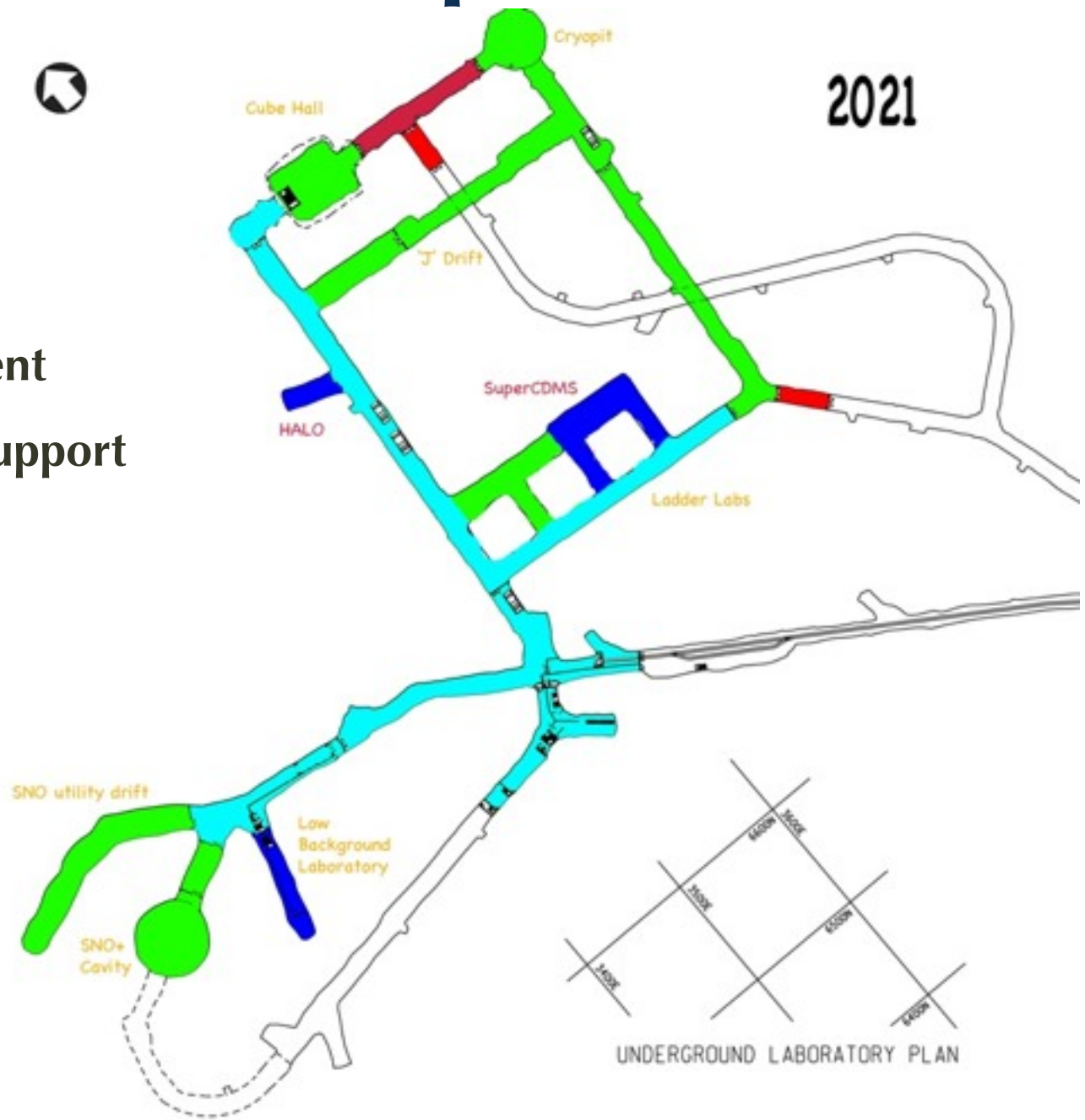
SNOLAB Space Evolution

- Available
- Experiment
- Utility/Support
- Access



SNOLAB Space Evolution

- Available
- Experiment
- Utility/Support
- Access



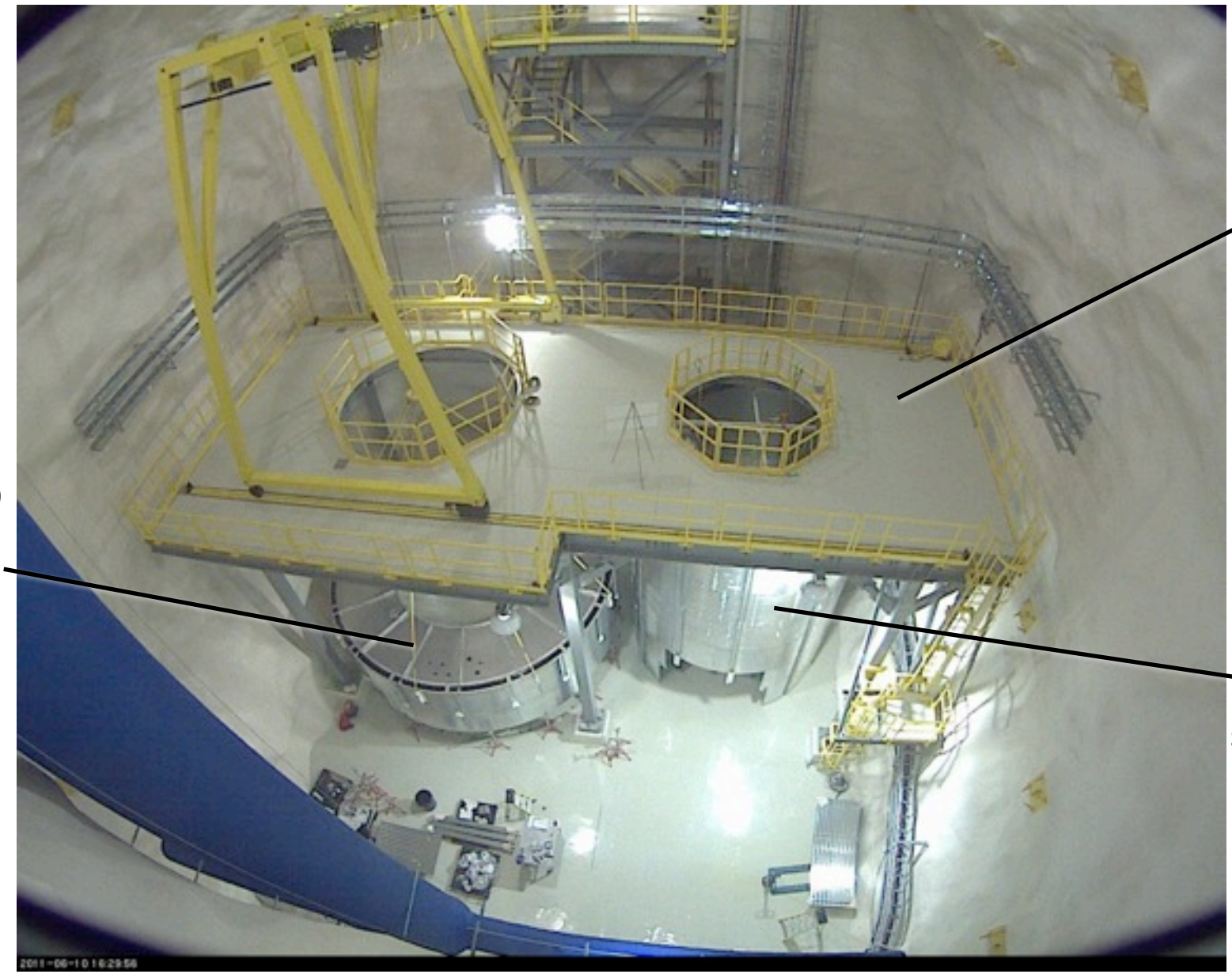
SNO+ Developments

Process system design advanced, inc. EH&S
Cavity work approved, underway -
construction of 'umbrella', hold-down ropes, anchor points, AV cleaning, ...

Protection umbrella constructed underneath SNO+ AV and PSUP for floor repair and anchor point installation

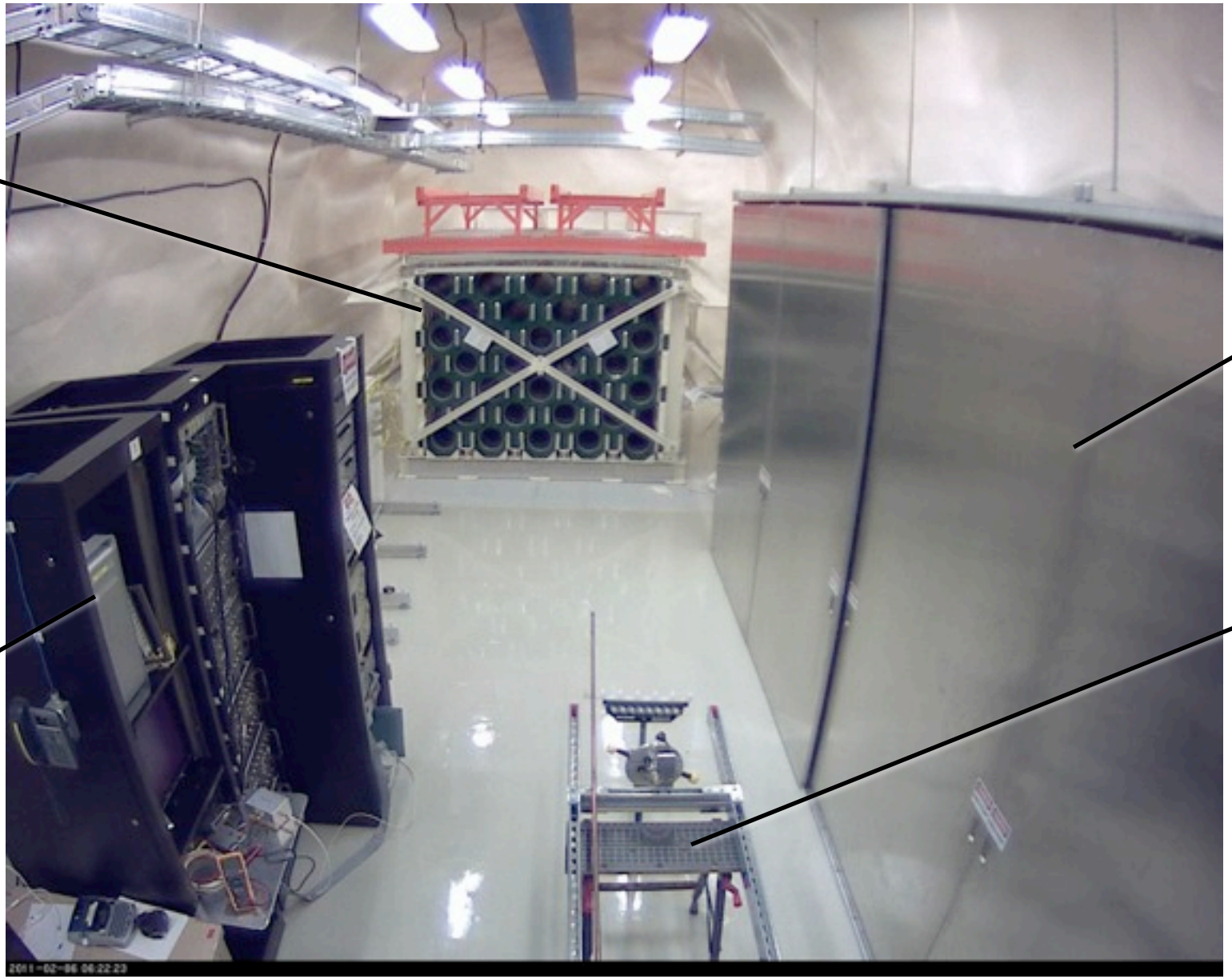
Excavating a larger space in the SNO+ Utility room to accommodate the liquid scintillator process systems.

Cube Hall - DEAP/miniCLEAN

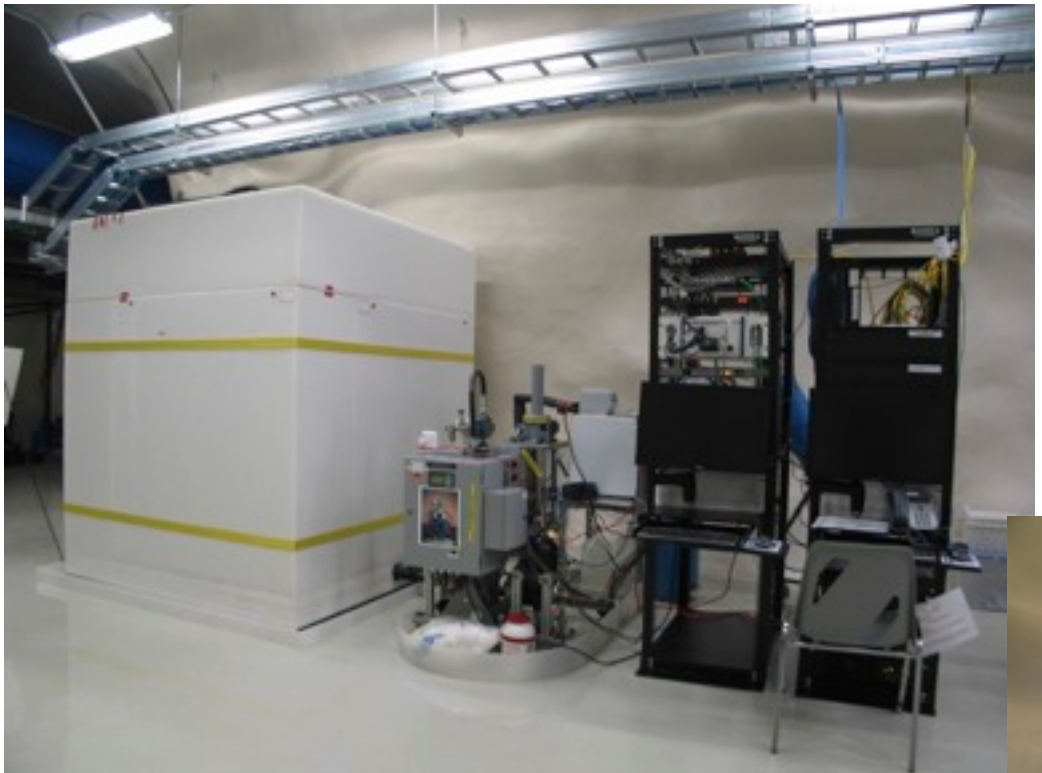


Ladder Labs - PICASSO

HALO


Target lead stack
NCD Racks (filled)
NCD DAQ (under refurb)
NCD Cutter
Water/Poly shielding boxes

'J'-Drift: R&D + rapid deployment

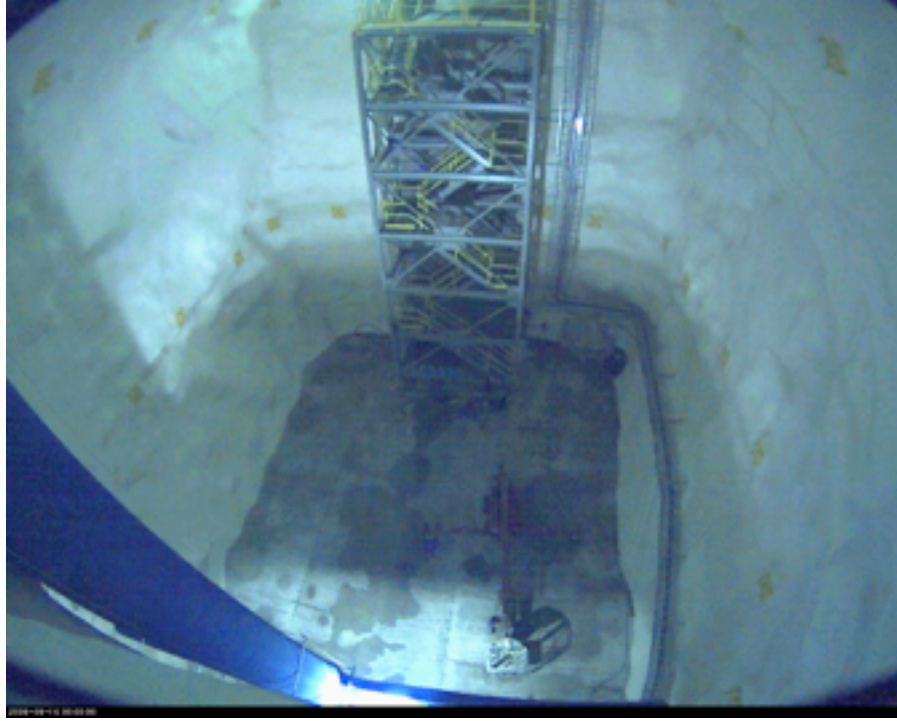


COUPP-4 bubble chamber, showing water tank shielding stack, pressure carts, DAQ racks

Relocation of DEAP-I completed. DEAP-I now operational again, backgrounds tests COUPP-4 deployed during summer 2010 from Fermilab - background limited

DEAP-I in the 'J'-Drift, showing water cube shielding and purifier stack

SNOLAB Facility Status Summary



- SNOLAB facility complete
- All major infrastructure in place
- Facility is now in transition to experimental programme
  - Deployment of support systems for first experiments underway (SNO+, DEAP-3600, MiniCLEAN, HALO)
  - Smaller scale experiments and R&D programmes underway (COUPP-4, DEAP-I, PICASSO-III)
  - Infrastructure requirements for additional systems being developed (COUPP, CDMS)
- SNOLAB is looking forwards to contributing to the world programme of underground science