

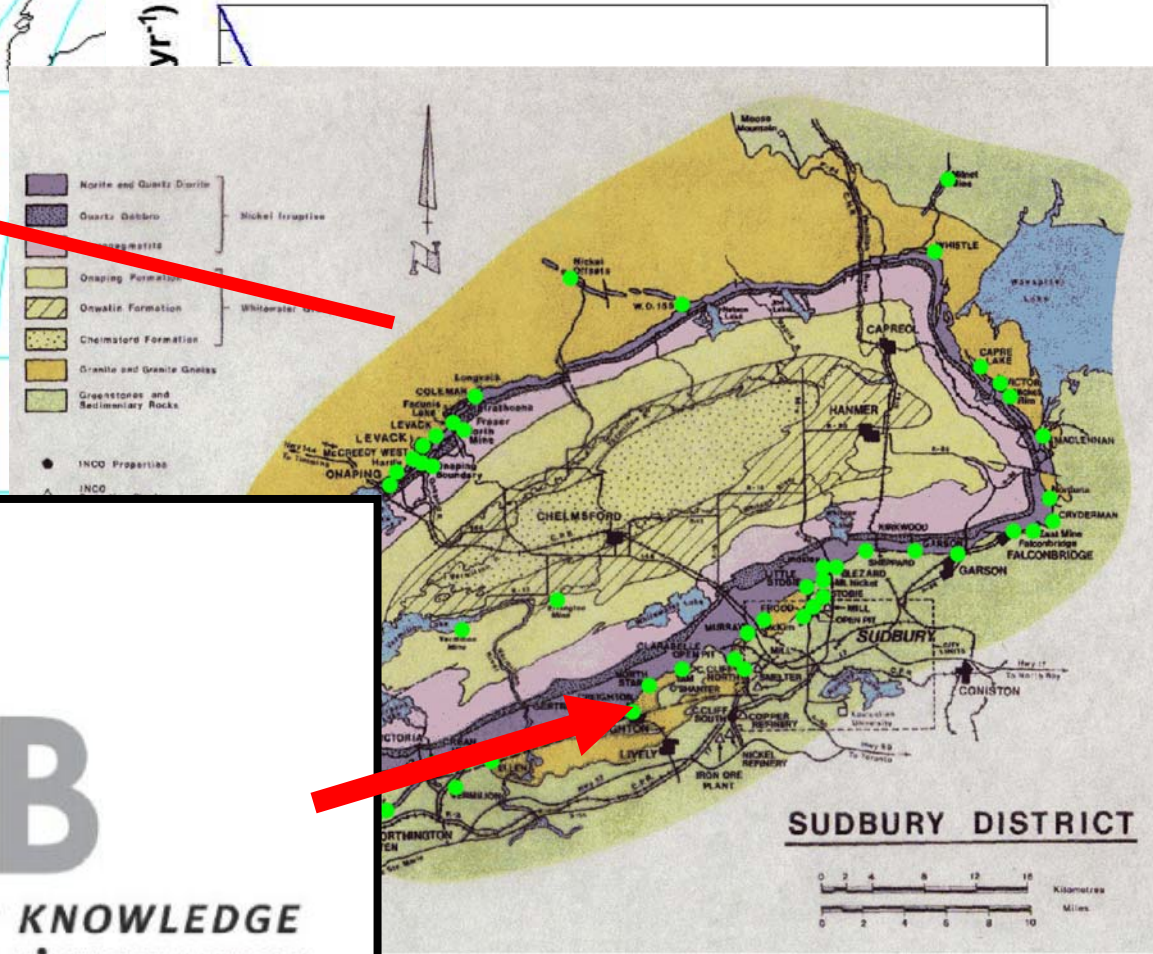
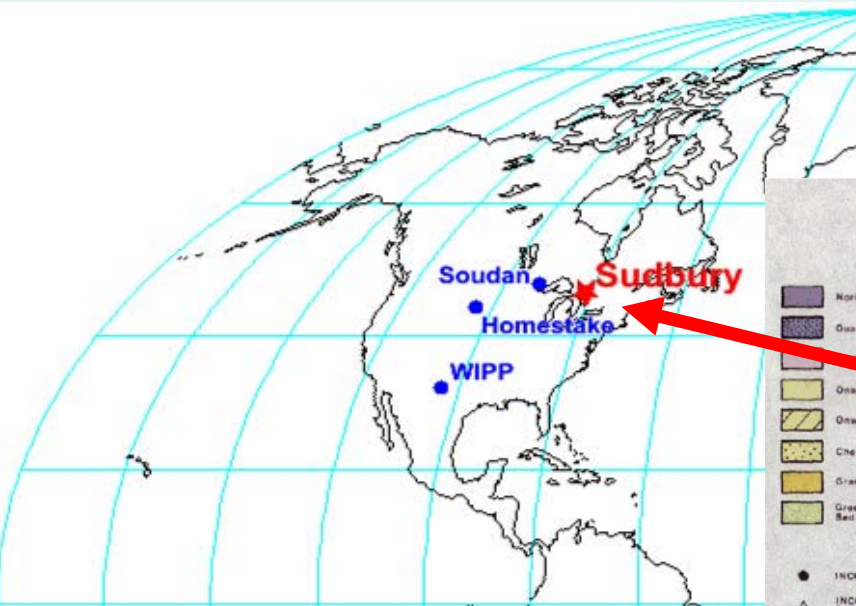


SNOLAB

Science, Design and Status

**Richard Ford (SNOLAB, Sudbury)
LRT2006 Workshop at Frejus Laboratory,
October 1st 2006, Aussios, France
<http://www.snolab.ca>**

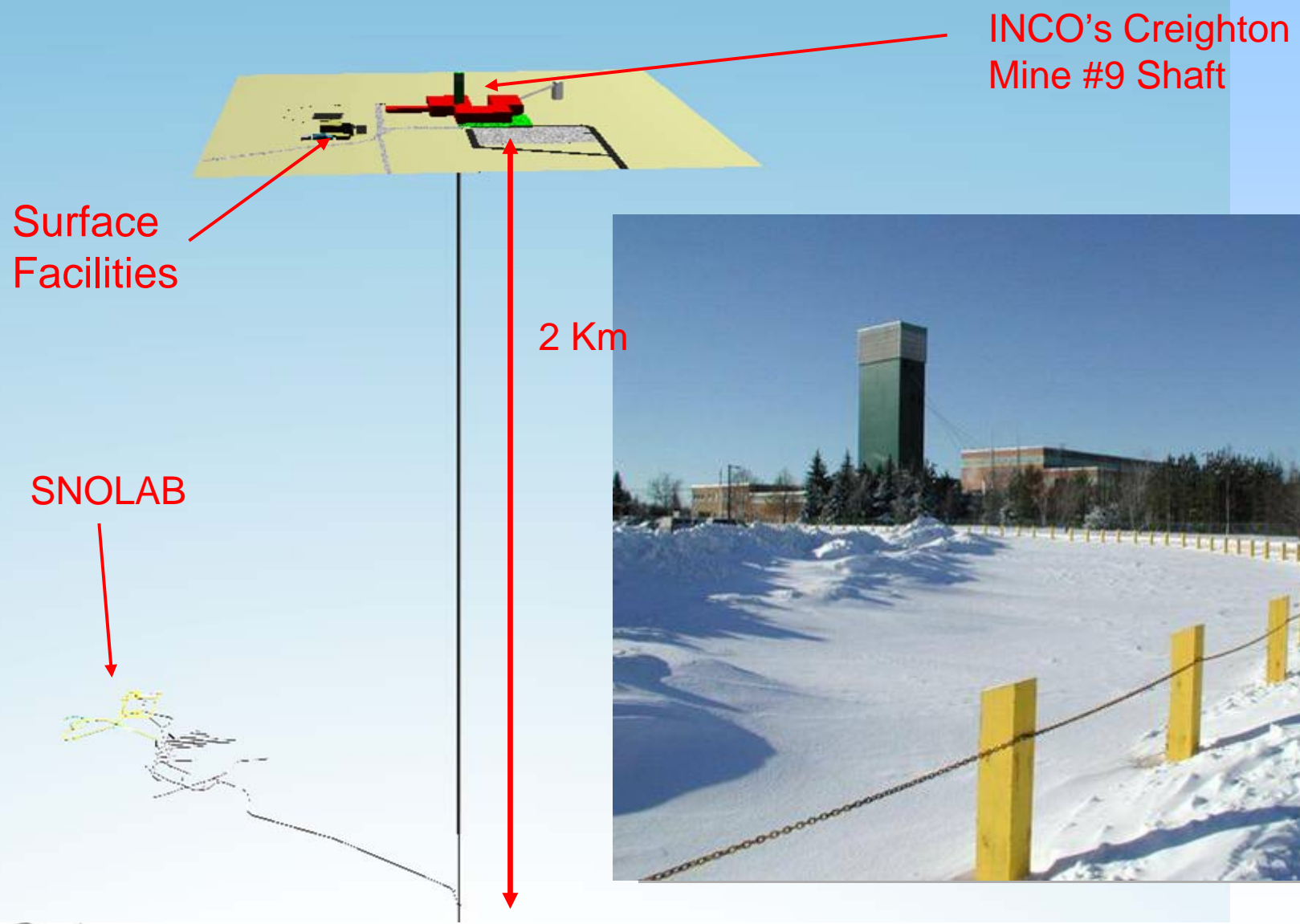
Deep Underground Laboratories



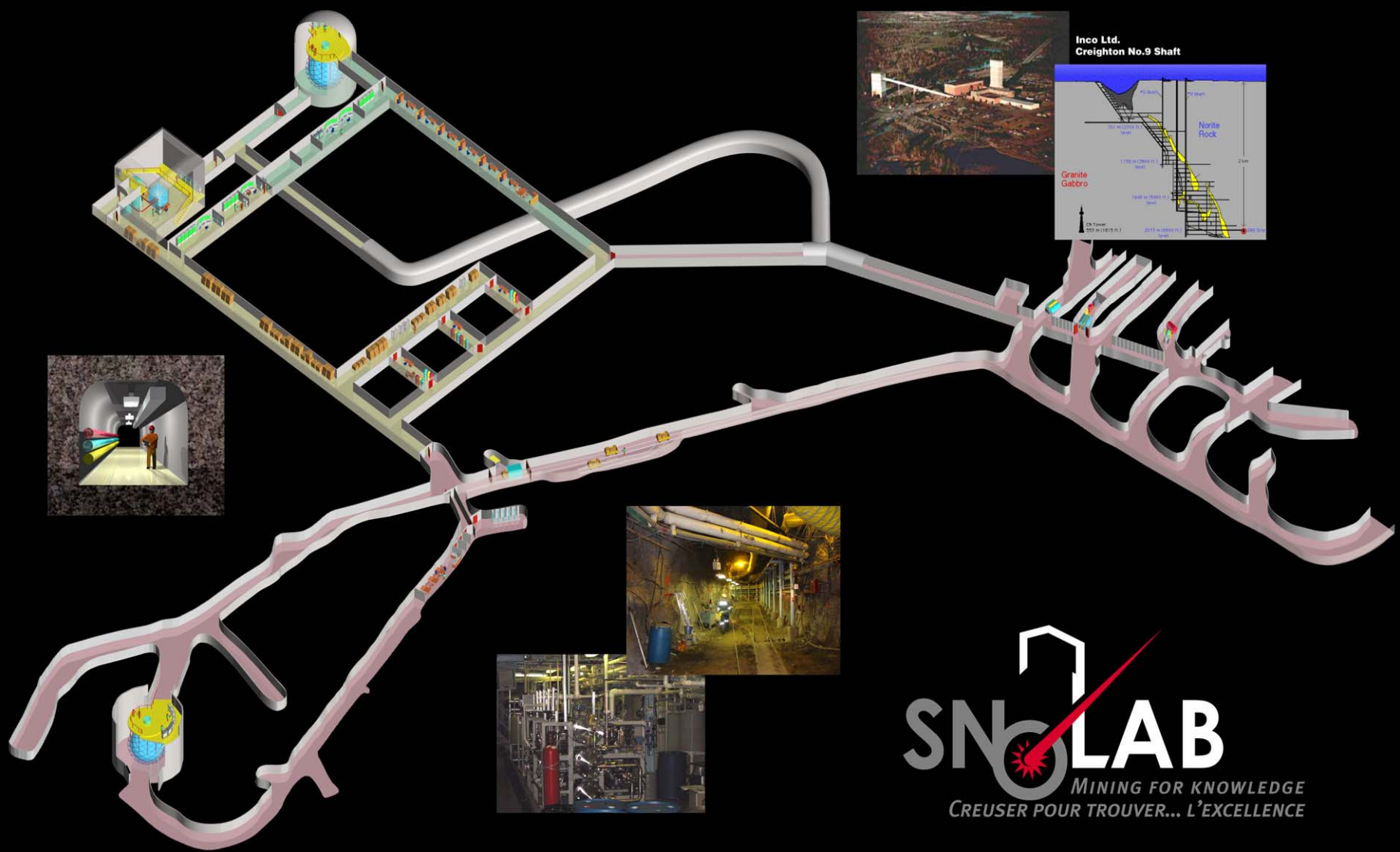
3000 4000 5000 6000 7000 8000
Depth, meters water equivalent

Creighton Nickel Mine and SNOLAB

SNOLAB - Mining for Knowledge



SNOLAB - Mining for Knowledge



SNOLAB
MINING FOR KNOWLEDGE
CREUSER POUR TROUVER... L'EXCELLENCE

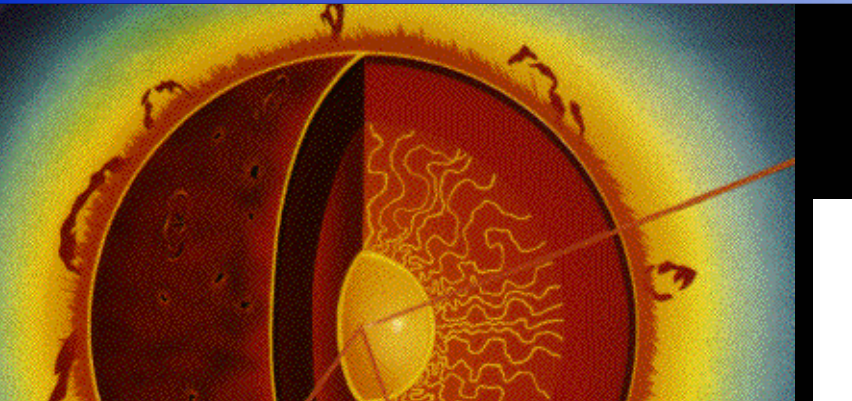
SNOLAB is funded through Canada Foundation for Innovation (CFI)

Why go underground?

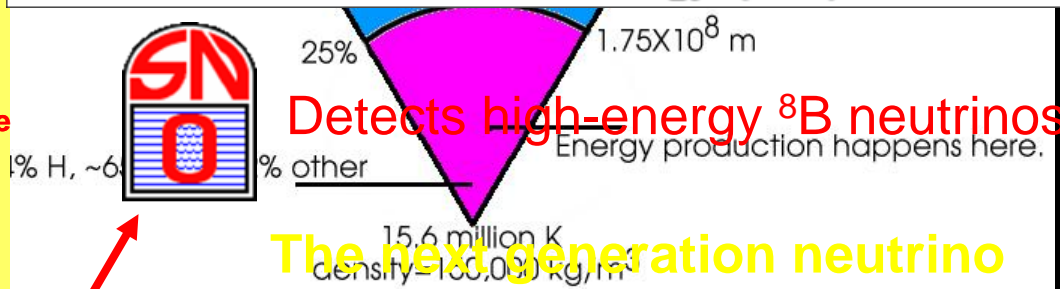
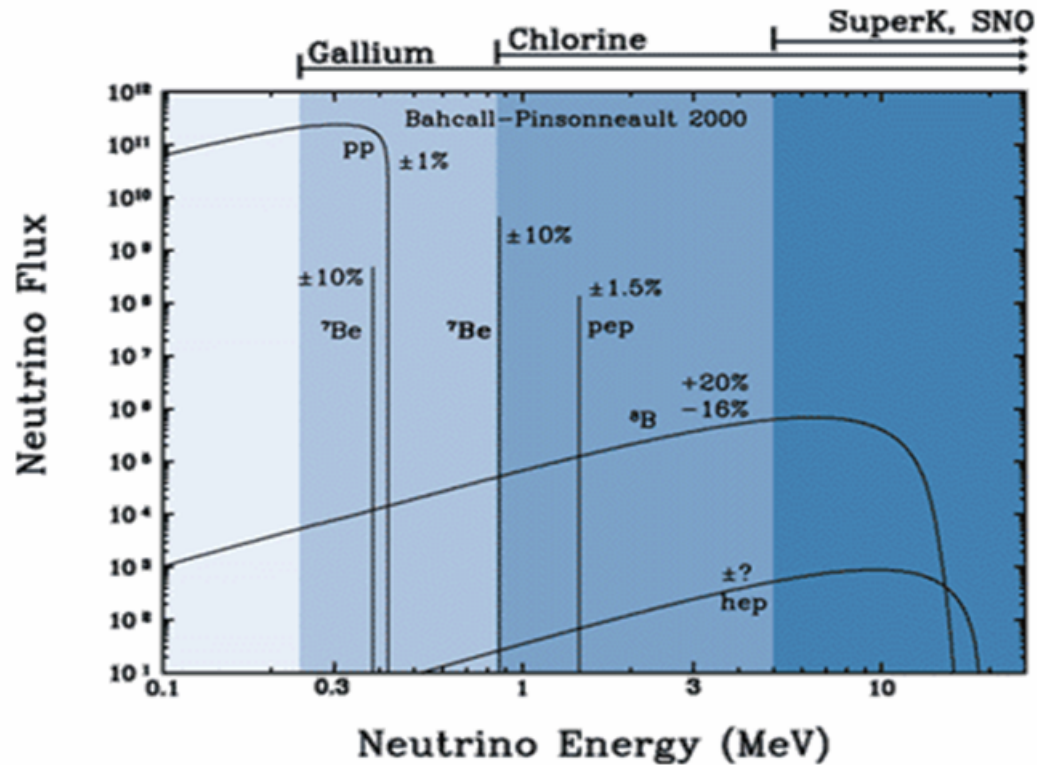
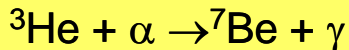
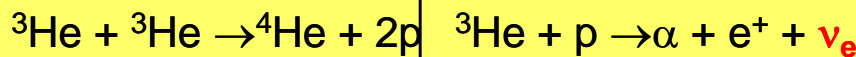
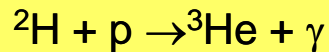
– Low cosmic ray background environment to see rare or low signal effects.

- Neutrino research
 - Solar Neutrinos
 - Cosmic ray neutrinos
 - Geo-neutrinos
 - Reactor neutrinos
 - Supernova neutrinos
 - Double beta decay
- Cosmology
 - Dark matter searches
 - Cosmic ray muons
- Low background counting
- High purity materials production
- Earth science research (seismology, geology, ...)
- Other interdisciplinary research or utility...(biology?)

Solar Neutrinos



SSM Energy Generation

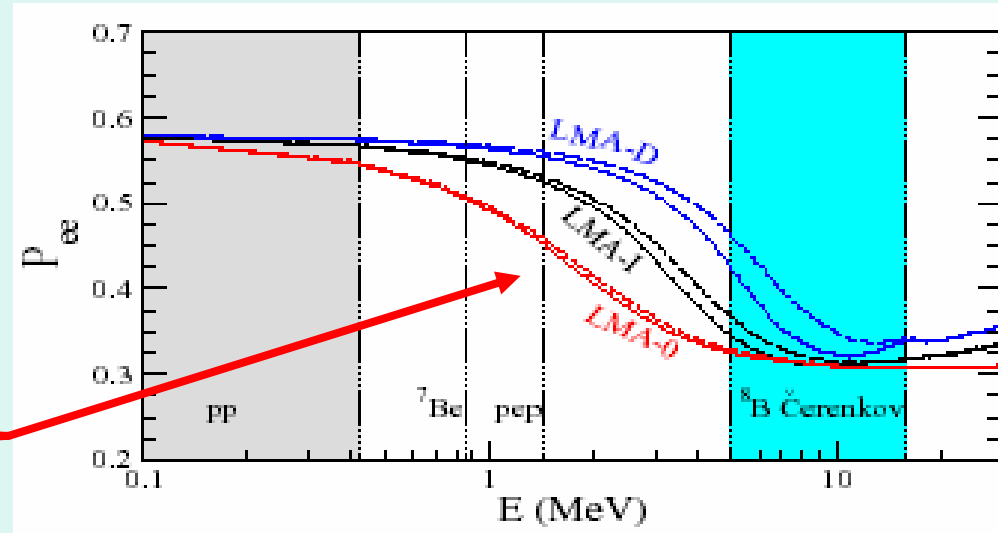


Detects high-energy ${}^8\text{B}$ neutrinos

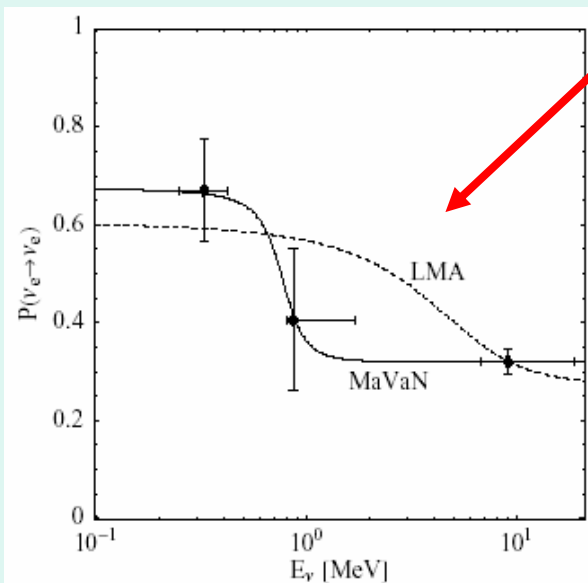
The next generation neutrino experiments must detect the low energy solar neutrinos. (eg. SNO+, CLEAN at SNOLAB)

SNO+ (SNO reloaded ... with scintillator!)

- Best fit to solar neutrino fluxes suggest MSW oscillations occur (LMA solution), but no direct evidence is observed (day/night effect or spectral distortion).
- Vacuum/matter transition
- Non-standard interactions
- Mass-varying neutrinos



Miranda, Tórtola, Valle, hep-ph/0406280



- pep solar neutrinos are at the right energy to test for new physics
- Can only be done at SNOLAB due to low ${}^{11}\text{C}$ cosmogenic background

Barger, Huber, Marfatia, hep-ph/0502196

Why go underground?

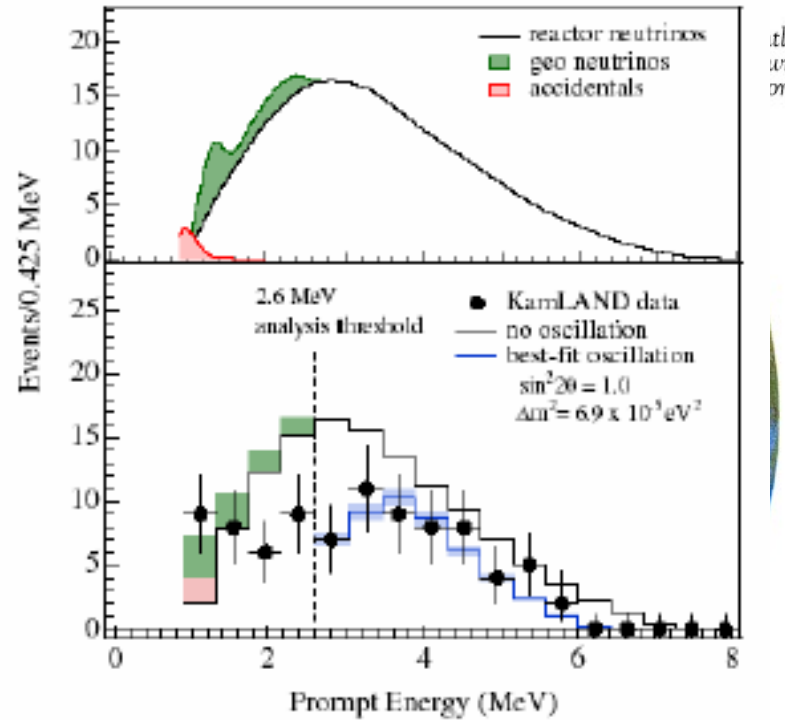
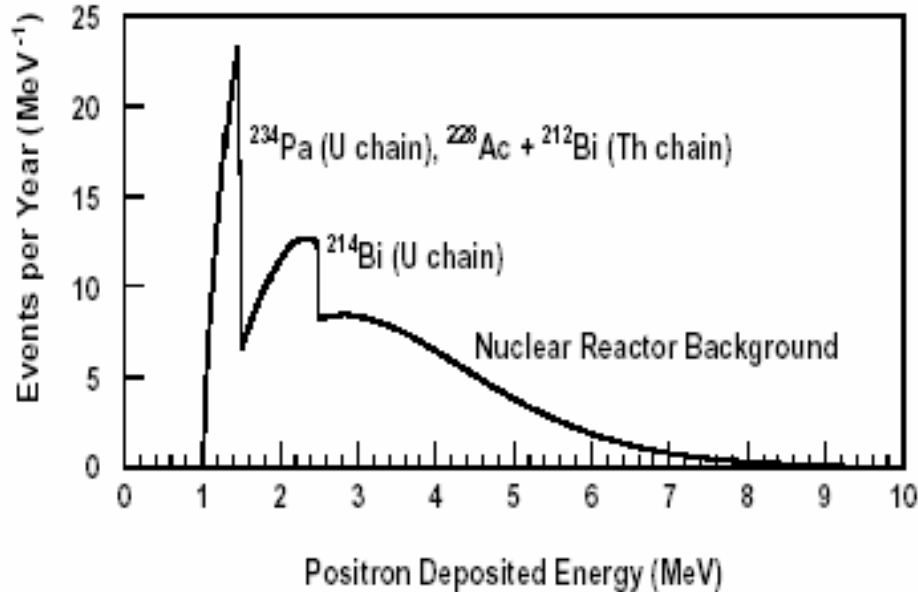
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- Other interdisciplinary research or utility...

Geo-Neutrinos in SNO+

Can we detect the antineutrinos produced by natural radioactivity in the Earth?

Radioactive decay of heavy elements (uranium, thorium) Antineutrino events:



Dorling Kindersley

Why go underground?

– Low cosmic ray background environment to see rare or low signal effects.

- Neutrino research
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 - Cosmic ray neutrinos
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Double beta decay

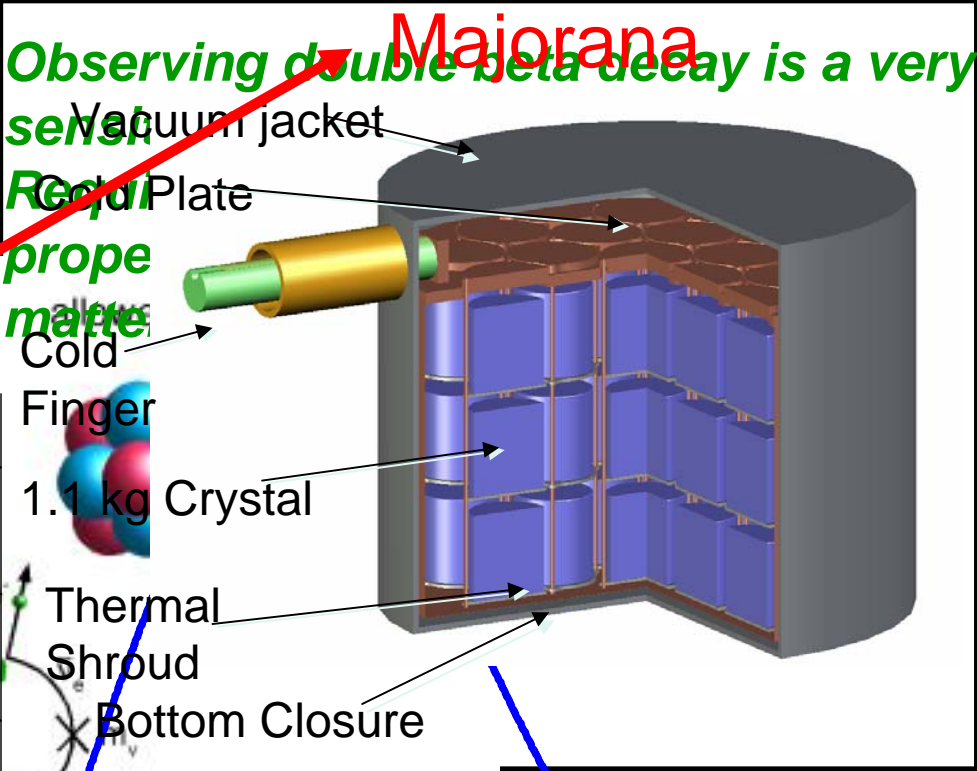
From F. Avignone

$$\bar{\eta} \equiv \langle G^{0\nu} | \mathcal{M}^{0\nu} |^2 \rangle \times 10^{13}$$

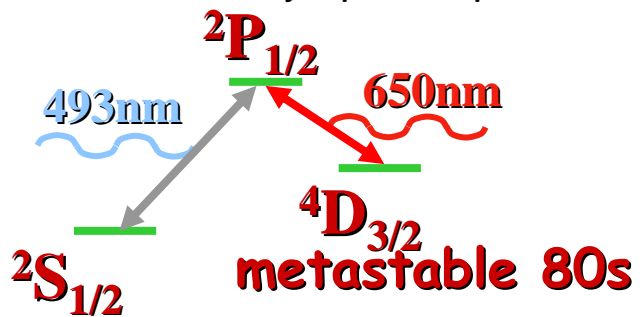
Isotope	$\bar{\eta}$
⁴⁸ Ca	0.54
⁷⁶ Ge	0.73
⁸² Se	1.70
¹⁰⁰ Mo	10.0
¹¹⁶ Cd	1.30
¹³⁰ Te	4.20
¹³⁶ Xe	0.28
¹⁵⁰ Nd	57.0

COBRA
(CdZnTe)

SNO++ (SNO overloaded)



EXO Ion drift detector with daughter Ba Identified by optical spectroscopy

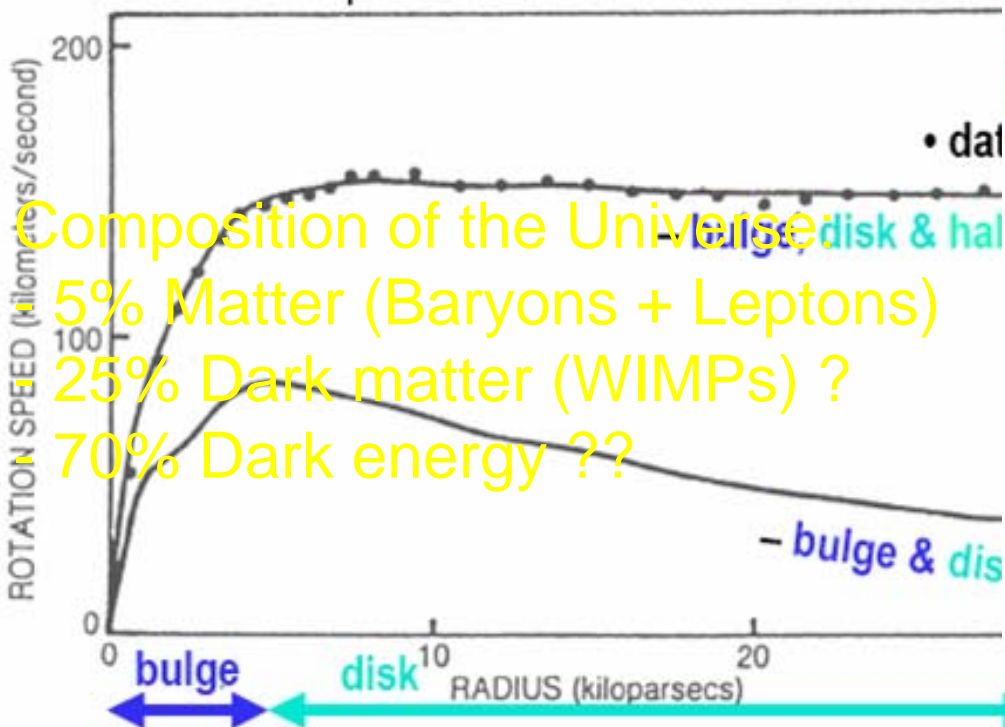


Why go underground?

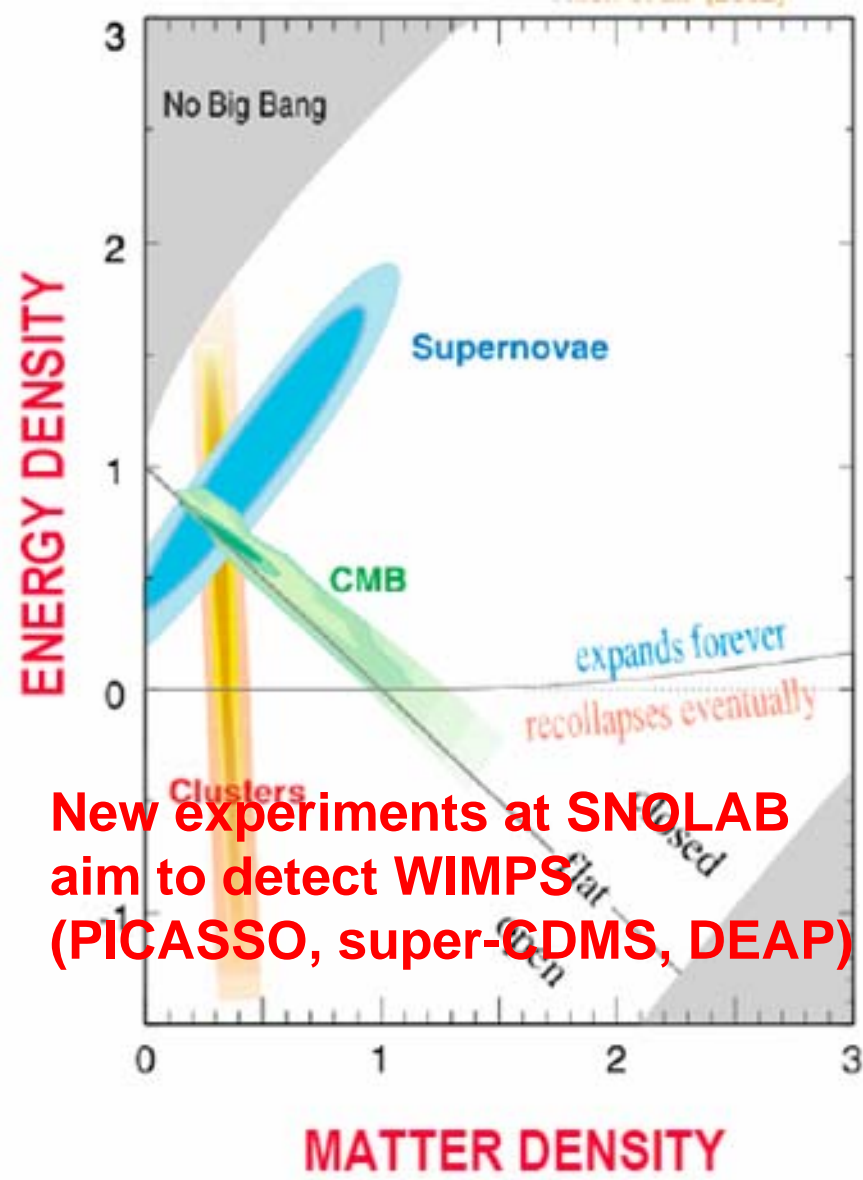
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- Other interdisciplinary research or utility...

We live in a dark universe...



Composition of the Universe:
 5% Matter (Baryons + Leptons)
 25% Dark matter (WIMPs) ?
 70% Dark energy ??



New experiments at SNOLAB aim to detect WIMPs (PICASSO, super-GDMS, DEAP)

We live in a dark universe...

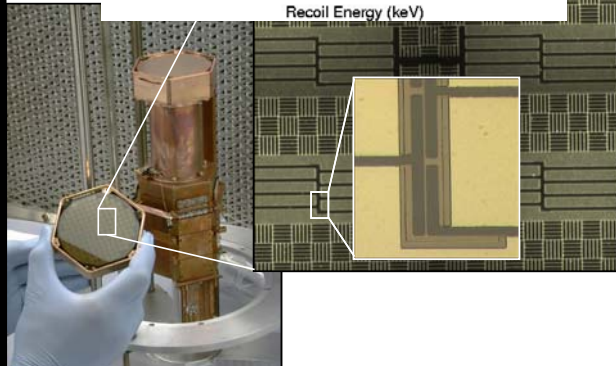
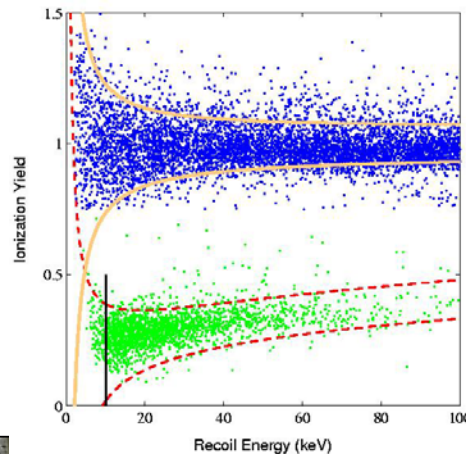
PICASSO

- High spin-dependent neutralino cross-section on ^{19}F
- Super-heated halocarbon droplets “frozen” in gel
- Nuclear recoil deposits heat, causing droplet to evaporate and “pop”, which is recorded by piezo-electric sensors



SuperCDMS

- Spin independent recoil on Ge crystal detectors
- Detect ionization yield (FET) and recoil energy from phonons (SQUID array)



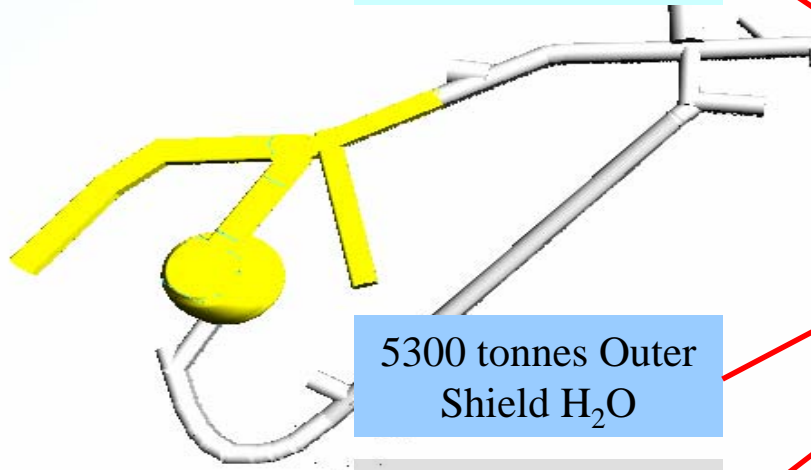
DEAP

- Spin independent scattering on ^{40}Ar .
- High scintillation yield
- Discrimination of γ/β background using scintillation time signature
- Ar is dense, cheap and cryostat is scalable



Existing SNO Facility

Existing
SNO Facility



1000 tonnes D_2O

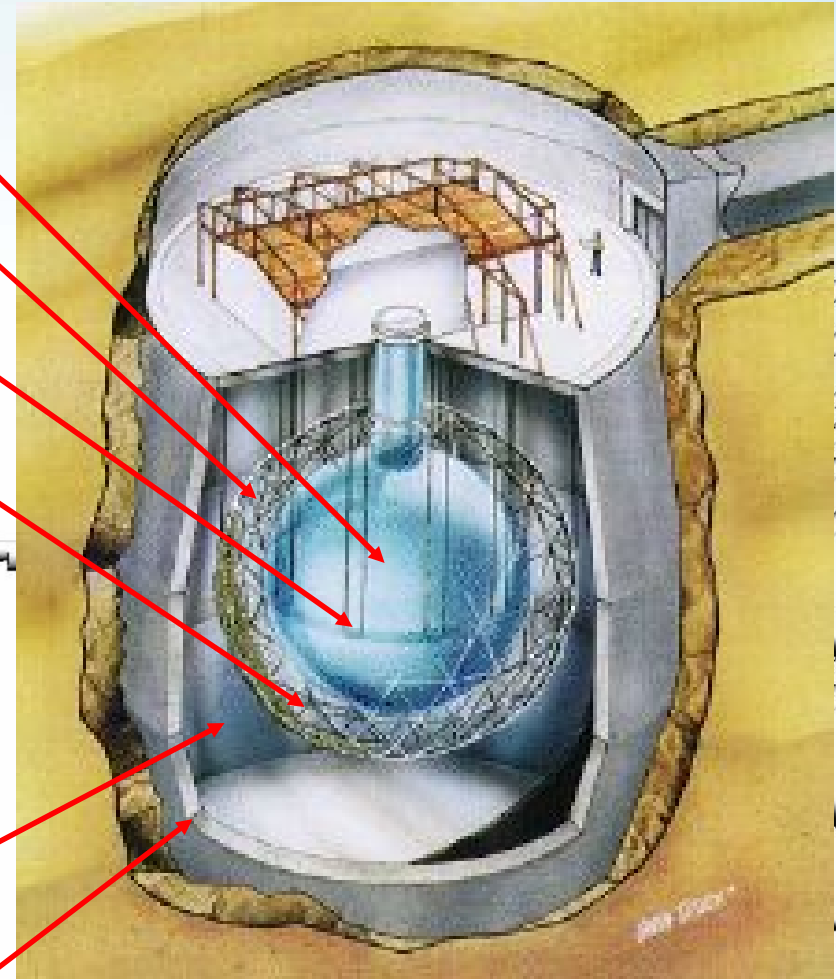
Support Structure
for 9500 PMTs

12 m Diameter
Acrylic Vessel

1700 tonnes Inner
Shielding H_2O

5300 tonnes Outer
Shield H_2O

Urylon Liner and
Radon Seal



Existing SNO Facility

Existing
SNO Facility

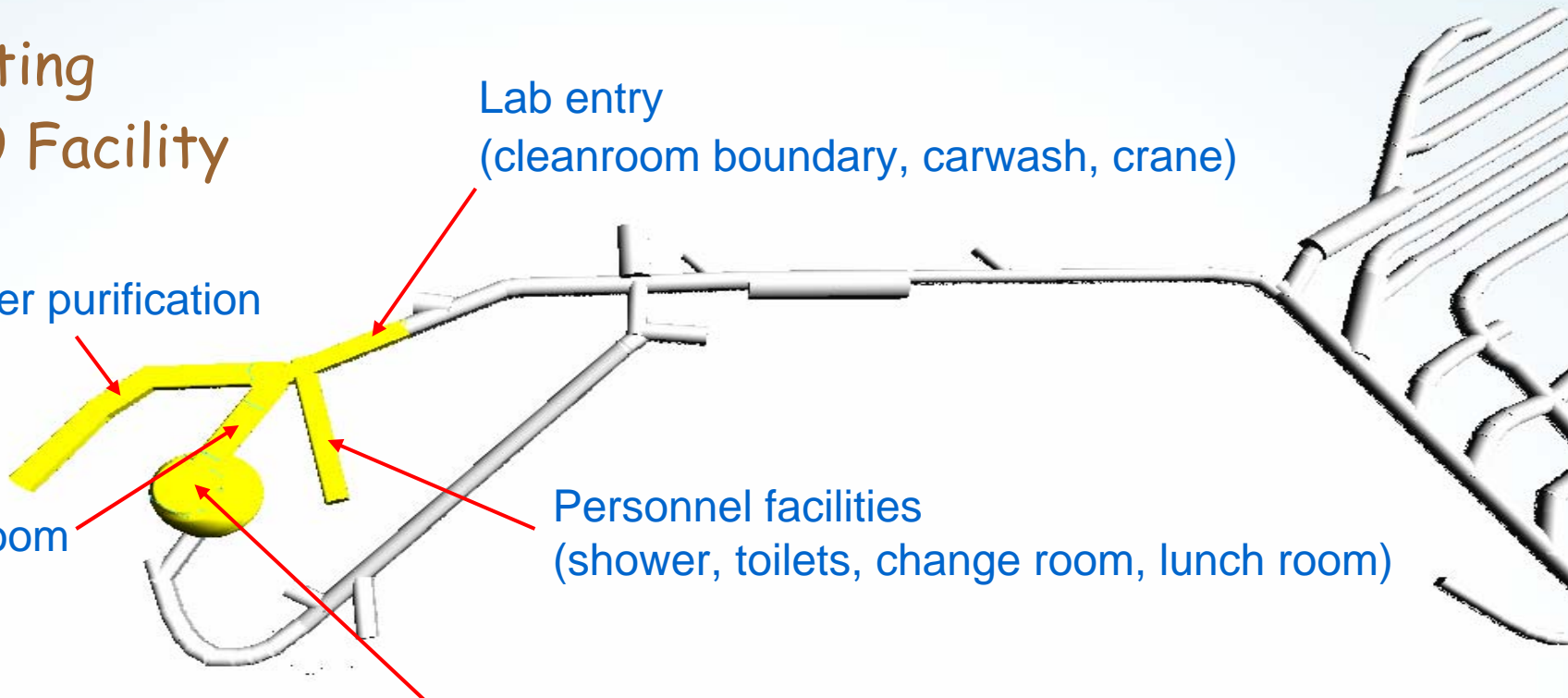
Lab entry
(cleanroom boundary, carwash, crane)

Water purification

Control room

Personnel facilities
(shower, toilets, change room, lunch room)

Detector



Existing SNO Facility

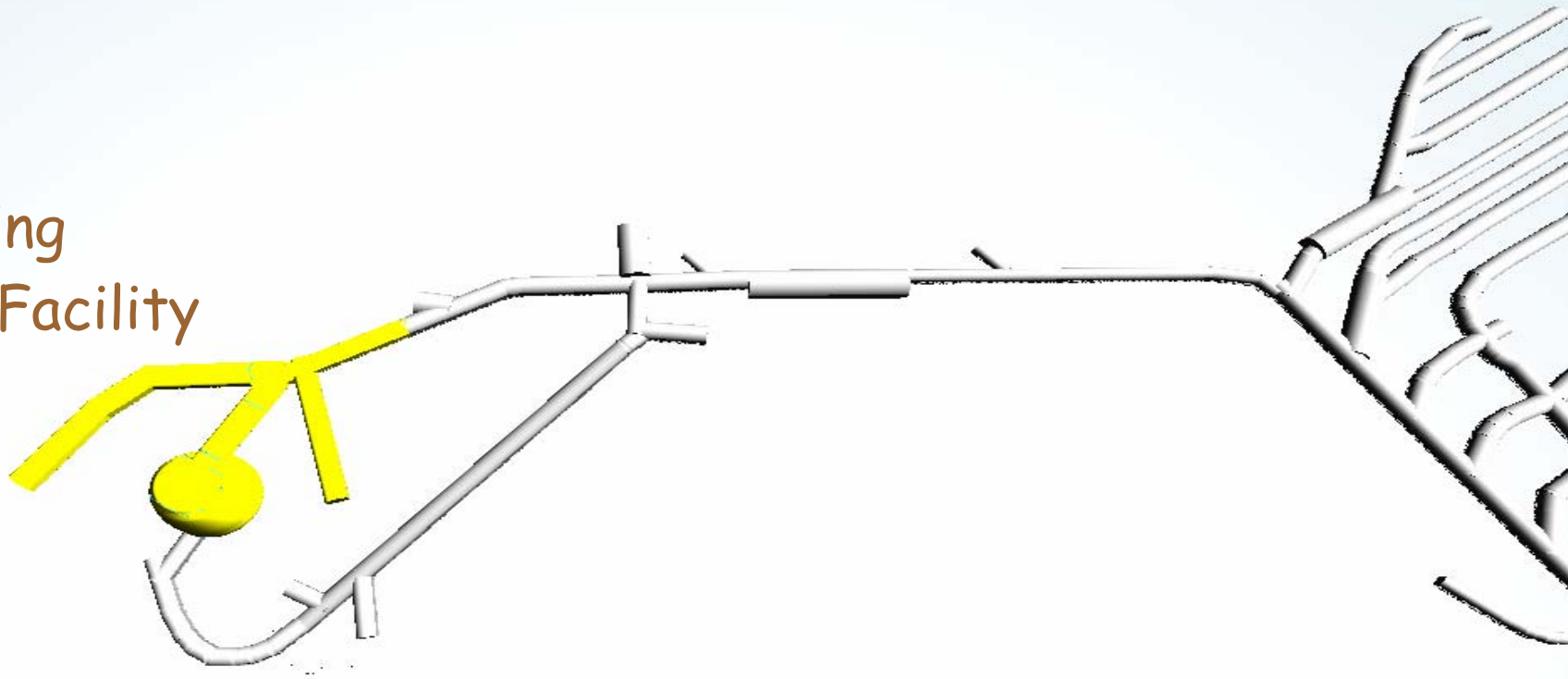
SNO:
Experiment with
an underground Lab

Construction
and transition



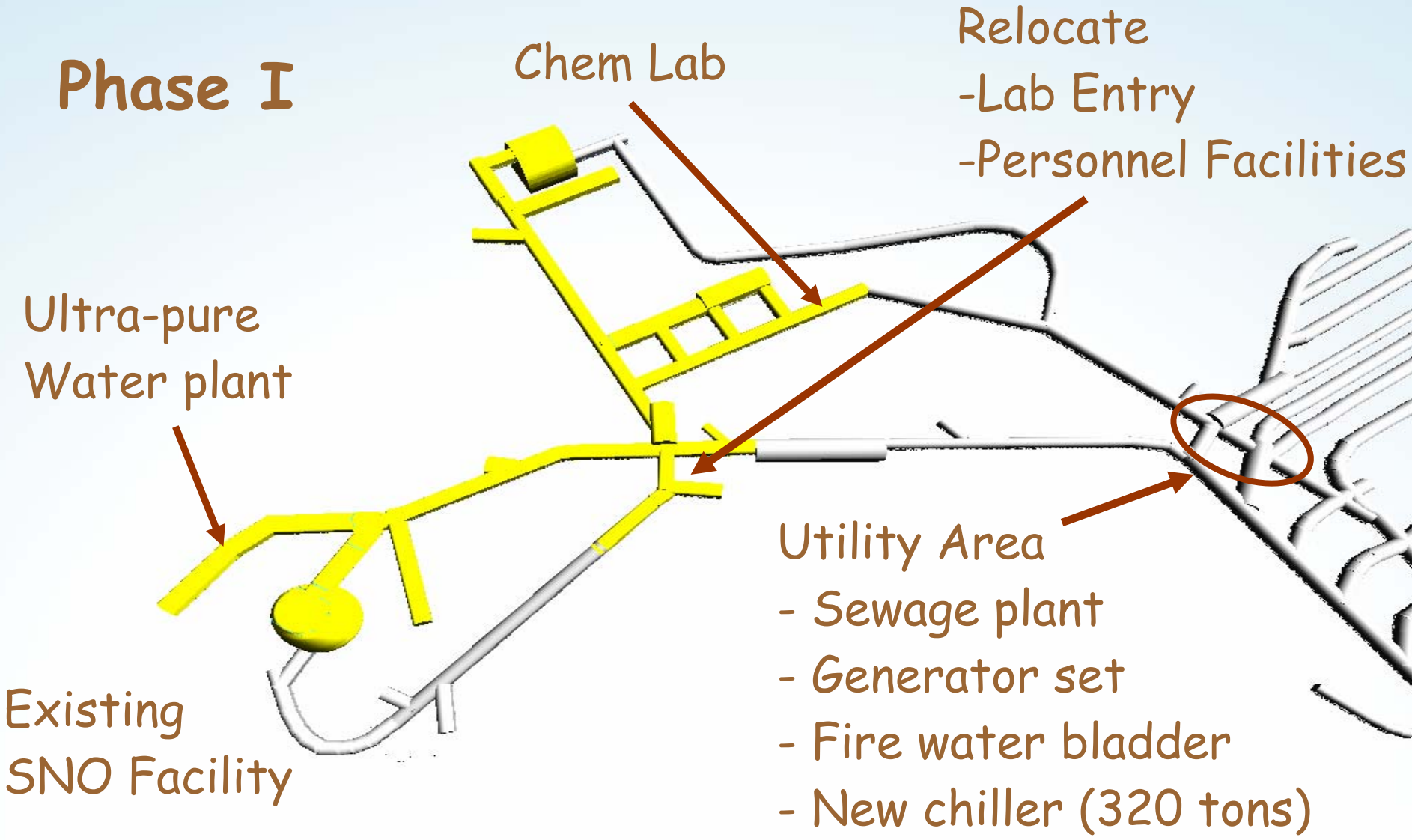
SNOLAB:
An underground lab
with experiments

Existing
SNO Facility



SNOLAB: Phase 1

Phase I

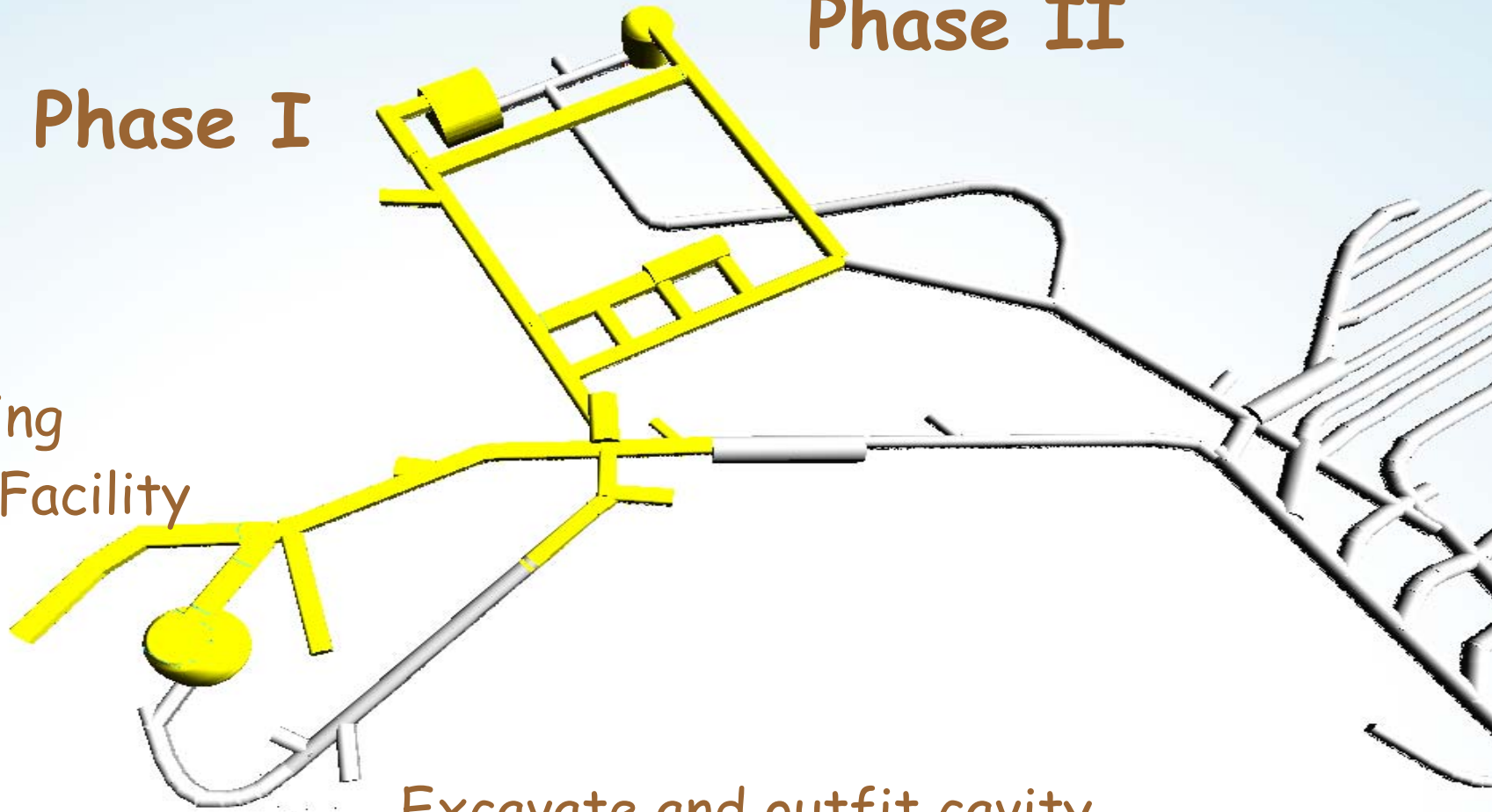


SNOLAB: Phase 2

Phase I

Phase II

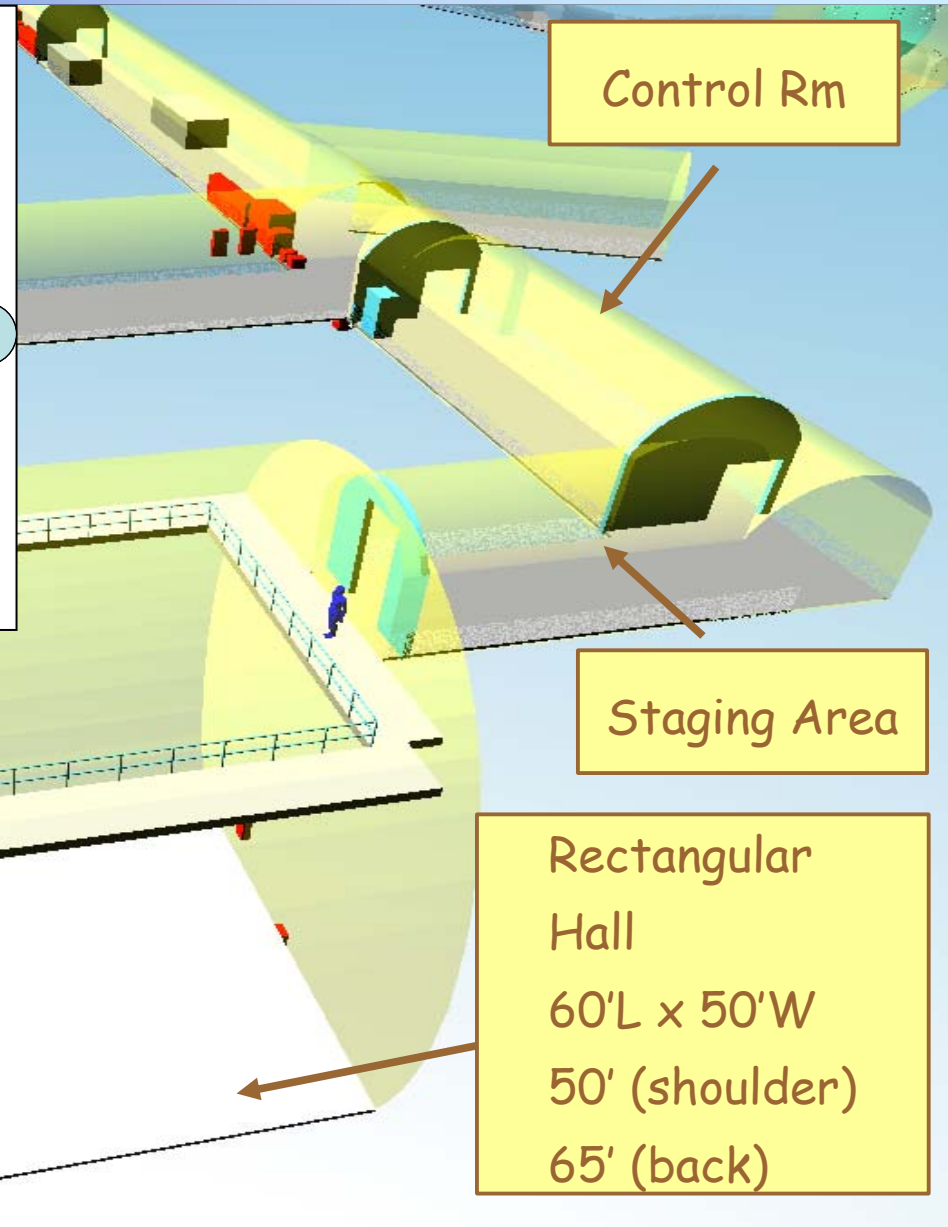
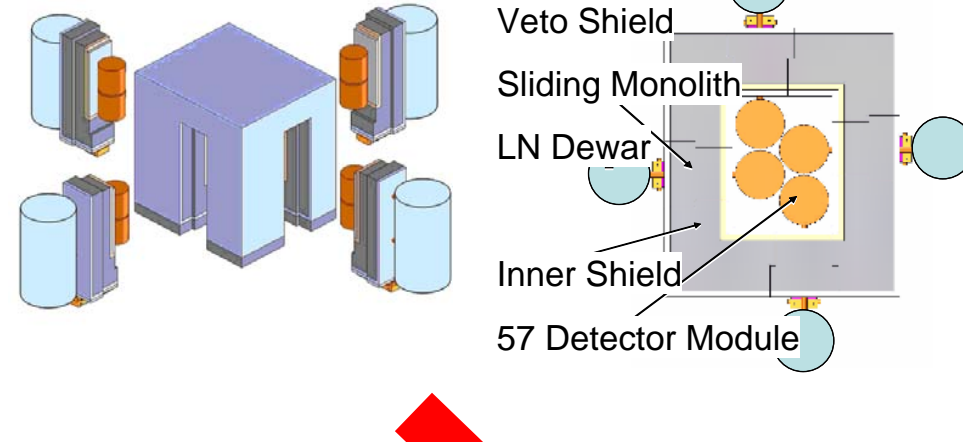
Existing
SNO Facility



Excavate and outfit cavity
for cryogenic experiment

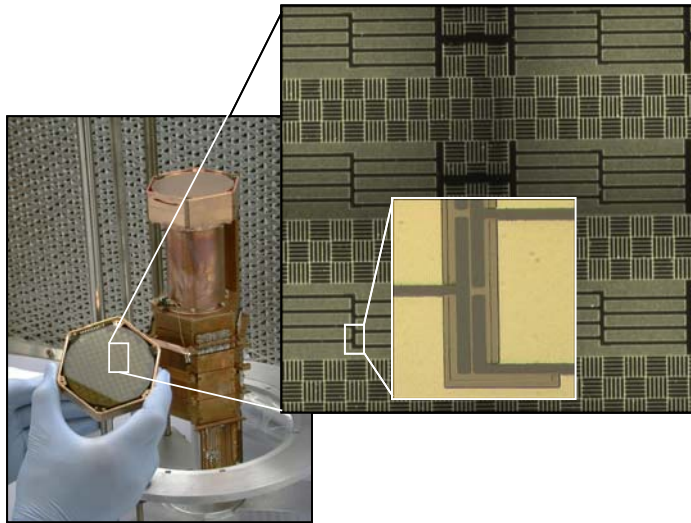
Rectangular Hall

Example: Majorana Detector Module



Ladder Labs

Example: CDMS Dark Matter Detector



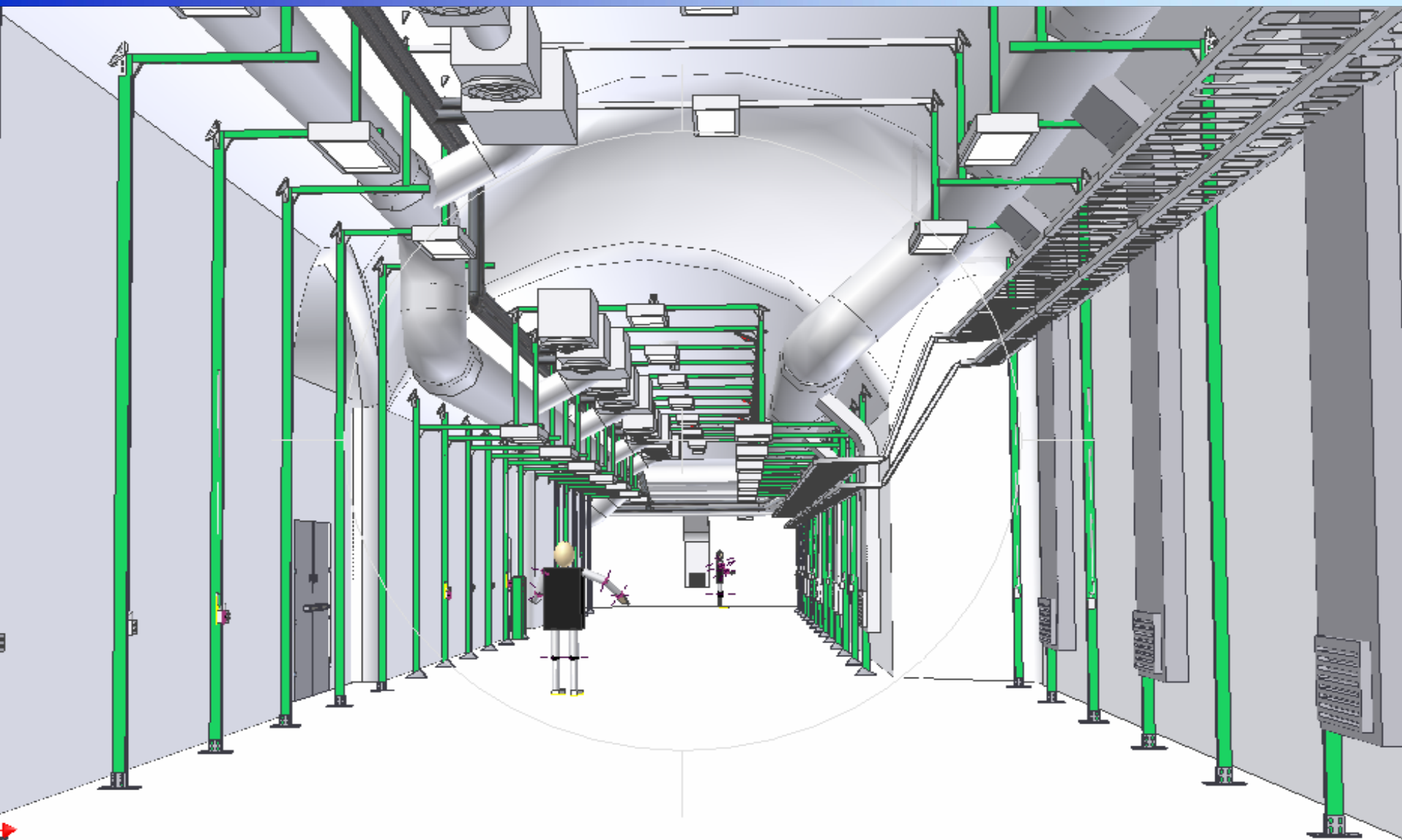
Wide Drift
20'x12'
(19' to back)

Wide Drift
25'x17'
(25' to back)

Example: DEAP prototype



Ladder lab outfitted



Cryopit

Staging Area

Utility Drift

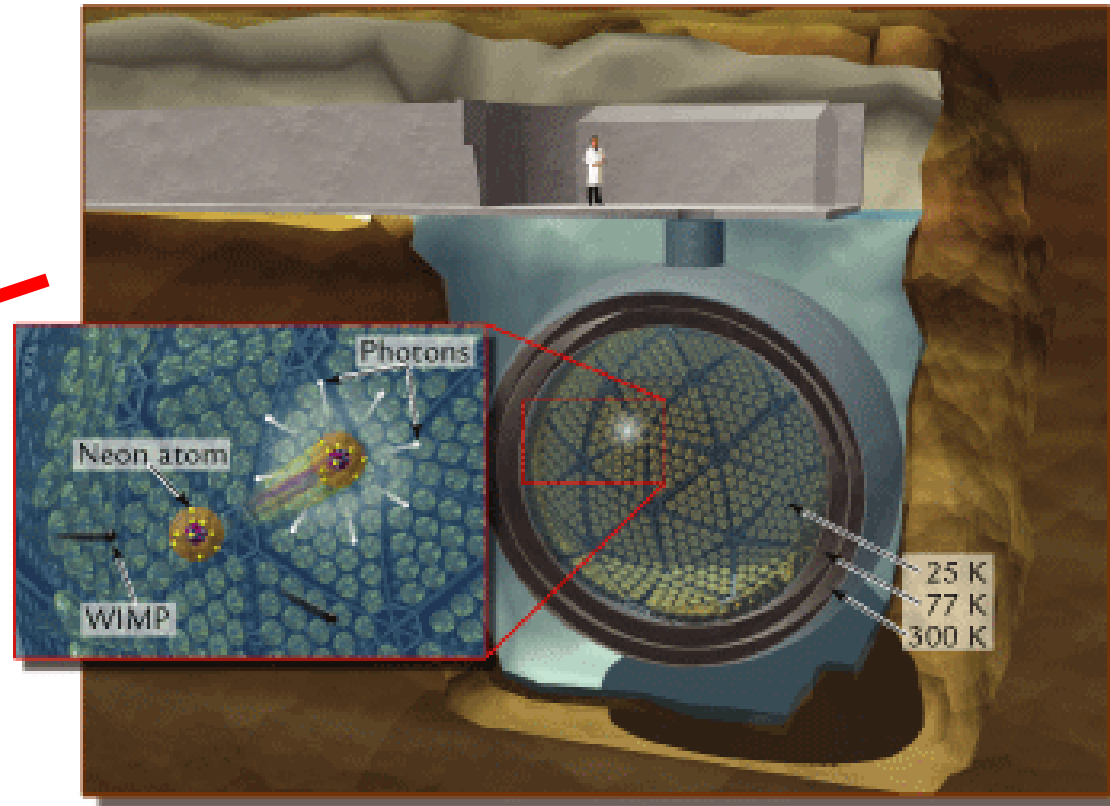
Example cryo-detector: CLEAN

Cryopit

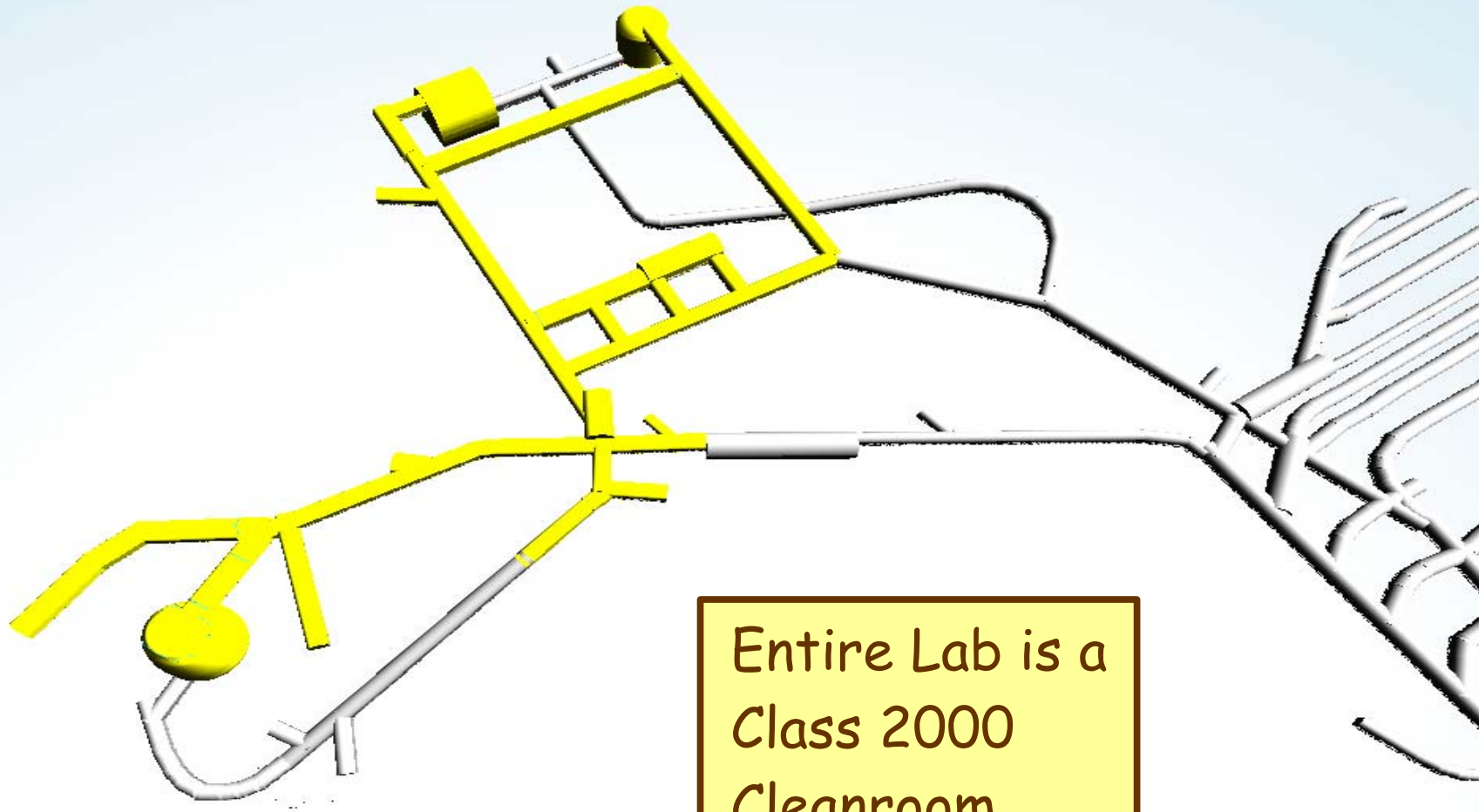
50' dia

50' (Shoulder)

65' (Back)



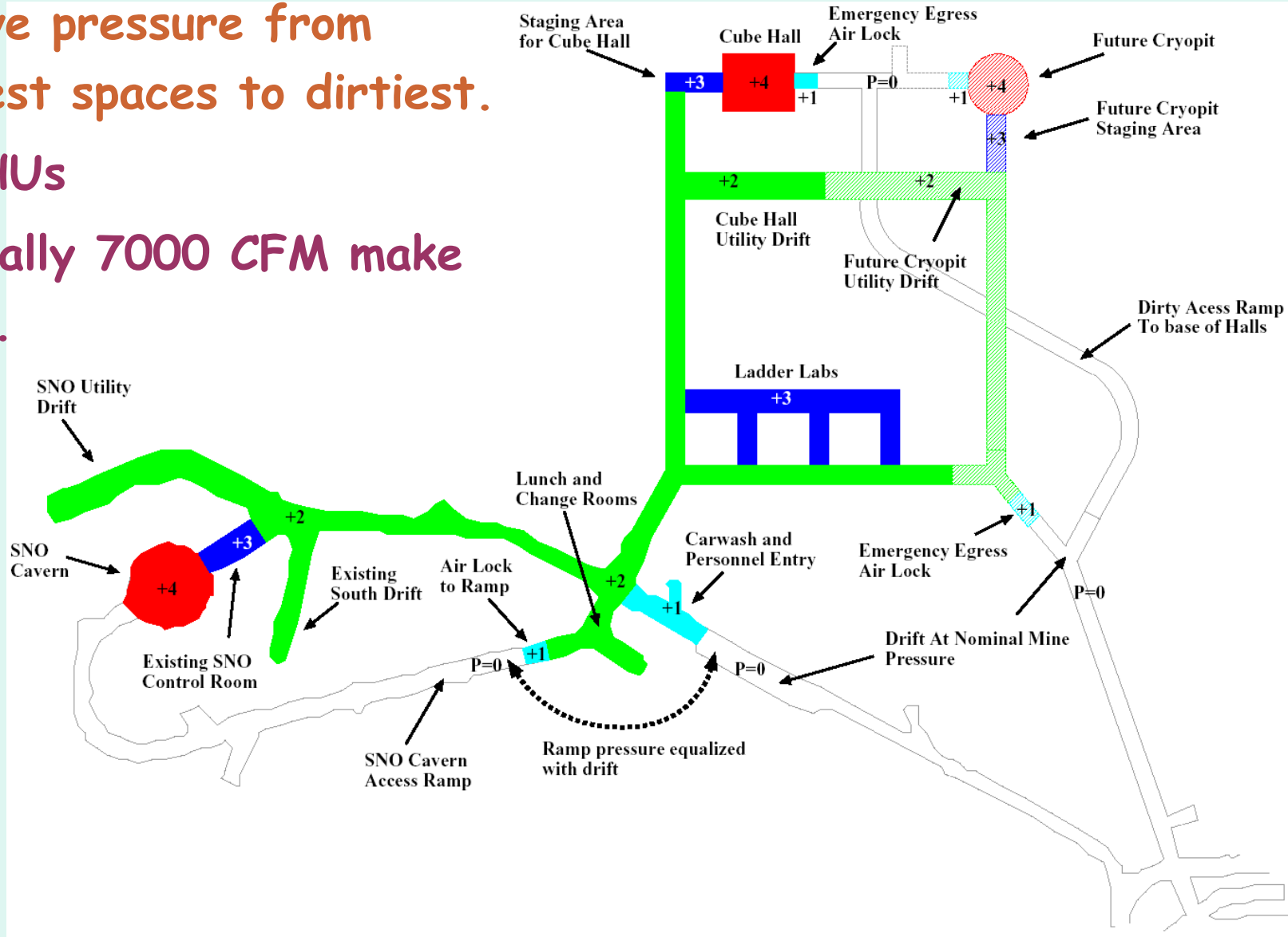
Cleanliness



Entire Lab is a
Class 2000
Cleanroom

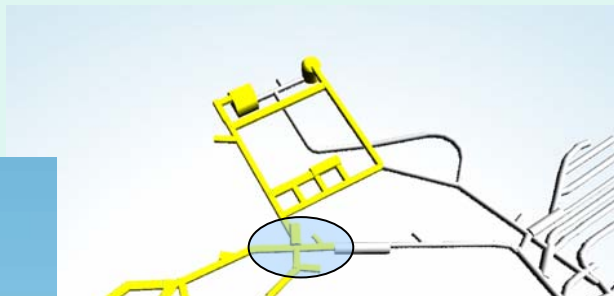
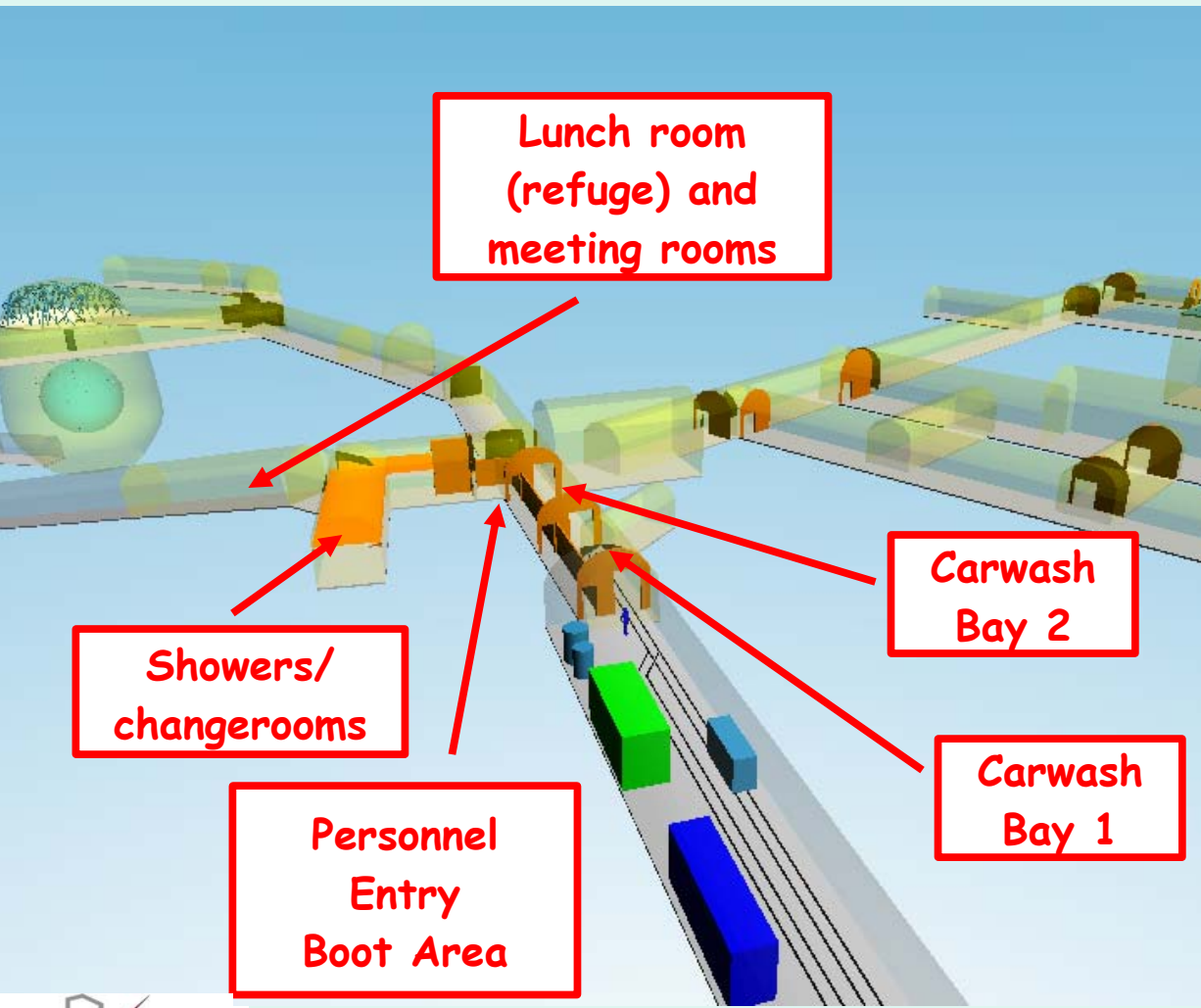
Ventilation: Pressure Zones

- Positive pressure from Cleanest spaces to dirtiest.
- 14 AHUs
- Nominally 7000 CFM make up air.



Personnel and Material Handling

Lab Entry



Backgrounds at SNOLAB

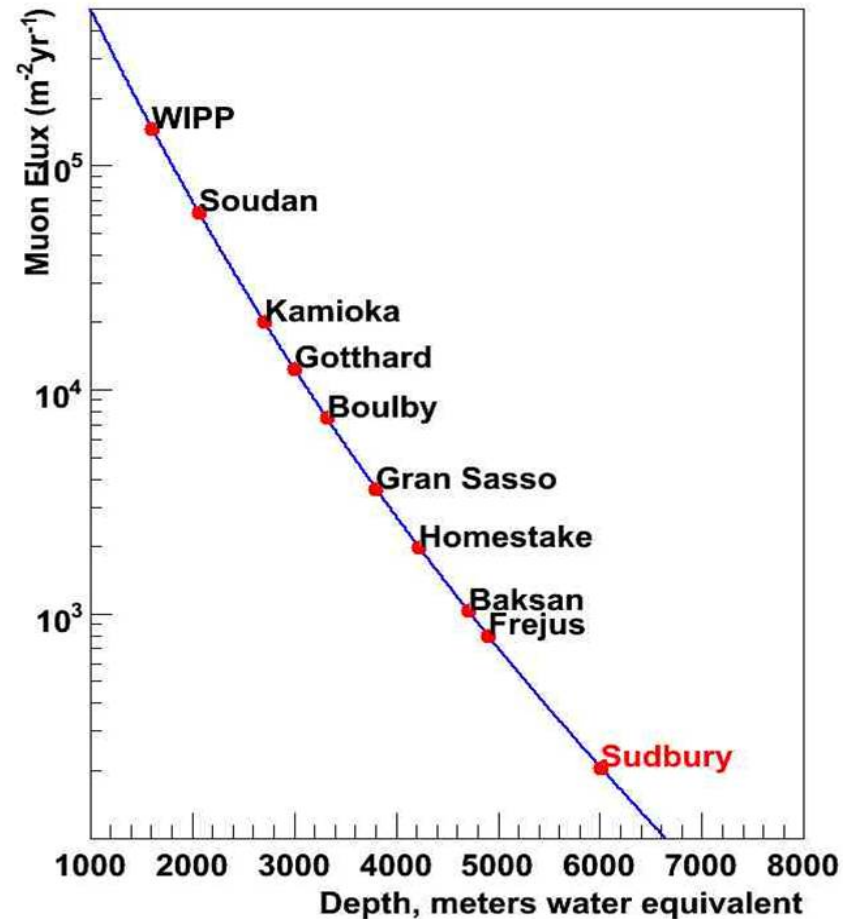
	Flux
Muons	$<0.27/\text{m}^2/\text{day}$
Neutrons (Thermal)	$4144.9 \pm 49.8 \pm 105.3 \text{ n}/\text{m}^2/\text{day}$
Neutrons (Fast)	$\sim 4000 \text{ n}/\text{m}^2/\text{day}$
Radon (Surface)	$0.15 \pm 0.12 \text{ pCi}/\text{L}$
Radon (UGLab)	$3.3 \pm 0.4 \text{ pCi}/\text{L}$

Rock (Norite)

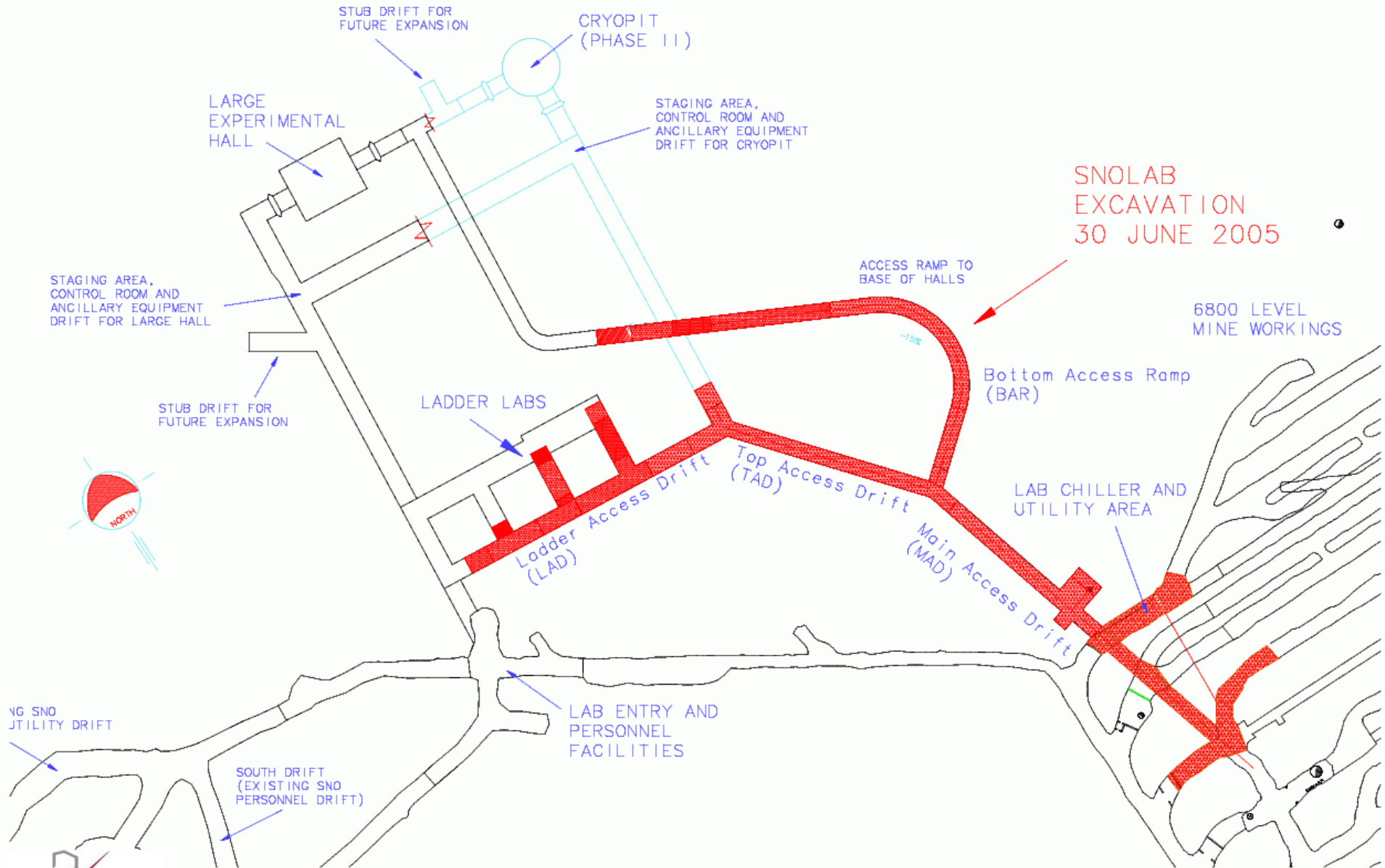
K	1.20%
^{238}U	1.2 ppm
^{232}Th	3.2 ppm

Other

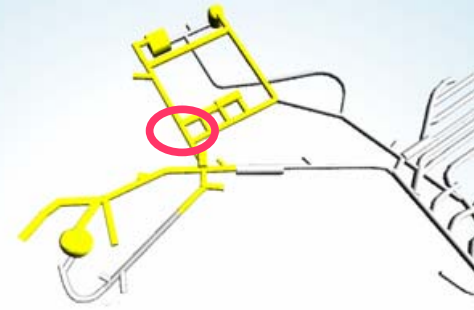
Bats	$2 \times 10^{-7} / \text{m}^2 / \text{day}$
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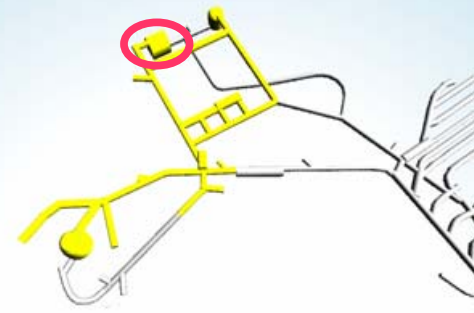
Status: Excavation - Last Year



Ladder Labs



Rectangular Hall



Utility Areas and Ventila

Ventilation "Cross Over"

9' Diameter Ventilation
Raises



Chiller Drift

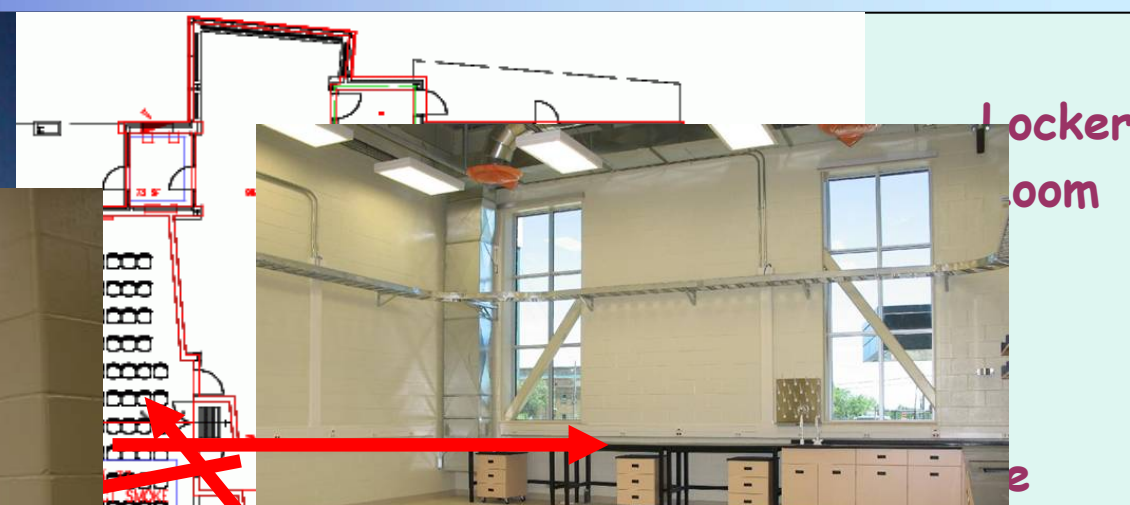


Surface Facilities



- 34000 sqft of space
- 4600 sqft class 1000 clean room (or better) with low background room
- Backup generator power and UPS
- Nitrogen boil-off gas piped to each lab (Rn free)
- Materials handling for underground
- Building engineered for seismic stability
- Climate controlled IT room
- + Offsite facilities at Laurentian U for hot source work

Surface Facilities - Main Floor



Locker room



Receiving



150 kW backup generator



Developing the Science Program

- The SNOLAB director David Sinclair will set the science program in consultation with an international experimental advisory committee.

EAC

Chair: Barry Barish
Secretary: Andrew Hime

Baha Balantekin (US)
Cliff Burgess (CAN)
Ken Ragan (CAN)
John Martin (CAN)
Kate Scholberg (US)
Takaaki Kajita (Japan)
David Wark (UK)

Scientific Merit

Infrastructure Needs

Progress on R&D

Technical Feasibility

Safety

Funding & Schedule

Participation & Management

- The science program is being developed through a series of participant workshops at the SNOLAB site
- The Vth workshop was August 21-22 2006 (see <http://www.snolab.ca>)

Developing the science program (cont.)

- Users submit letters of interest (LOI) to locate at SNOLAB
- The EAC will provide a letter of response (LOR) - questions or endorsement
- Small experiments or small spaces for prototyping can likely be arranged with very little fuss

- 18 LOI's have been received (20 expressed interest)
- The EAC has currently endorsed 9 projects, of which 6 have Canadian leadership roles or significant Canadian participation:

SNO+	Solar neutrinos, geo/reactor neutrinos, SN
CLEAN	Solar neutrinos, dark matter
SuperCDMS	Dark matter
PICASSO	Dark matter
DEAP	Dark matter
ZEPLIN	Dark matter
EXO	Double beta decay
Majorana	Double beta decay
HALO	Supernova

All these group need collaborators! – come to the workshops!

Schedule

Surface facility

- Ground breaking summer 2004
- Completed and occupied August 2005

Underground laboratory

- Excavation started November 2004
- Phase I excavation now 76% complete (Sept 2006)
- Phase I excavation to be completed spring 2007
- Outfitting to start Jan 2007, through early 2008
- Decision from CFI on phase II Jan 2007
- Outfitting phased so early space available in 2007

SNOLAB - Mining for Knowledge ...

A large yellow mining truck with a large bucket is parked in front of a tall green tower. The truck is positioned in the foreground, and the tower is the central focus in the background. The sky is blue with scattered white clouds. The text "The End" is overlaid in the center of the image.

The End

For more information: <http://www.snolab.ca>

Experimental Spaces

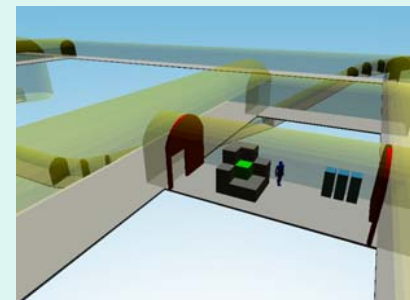
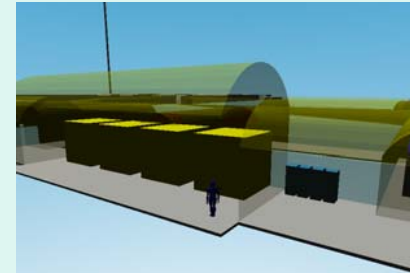
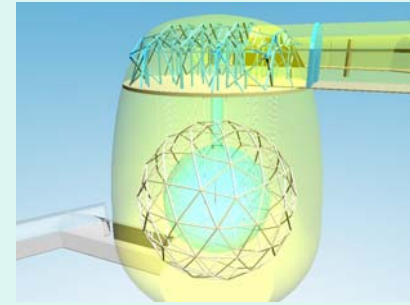
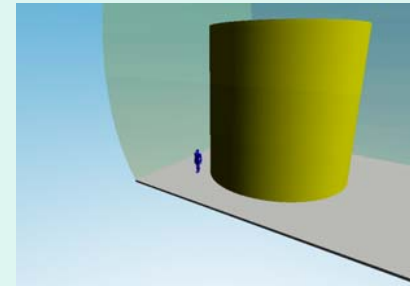
	Experimental Space		Length	Width	Height	Area
			(ft)	(ft)	Shoulder/Back	(sq ft)
Existing	SNO Cavern	Cavern	70(dia)		85'/100'	3848
		Utility Drift	187	23		4300
		Control Room	57	20		1140
	South Drift	Drift	106	17	10'/16'	1802
Phase I	Ladder Labs	Drift C1	105	20	12'/19'	2100
		Drift C2	75	25	17'/25'	1875
		Drift B&D	360	15	10'/15'	5400
	Rectangular Hall	Hall	60	50	50'/65'	3000
		Utility Drift	115	20	10'/17'	2300
		Staging Area	45	16	10'/15'	720
		Control Room	62	18	10'/16'	992
Phase II	Cryopit	Cavern	50(dia)		50'/65'	1963
		Utility Drift	141	20	10'/17'	2820
		Staging Area	66	16	10'/15'	1056
		Control Room	64	16	10'/15'	1024
					Existing SNO	11090
					Phase I	27477
					Phase II	34340

Experiments with interest to site at SNOLAB:

SNO	Solar Neutrinos
SNO + & SNO ++	Solar Neutrinos & Double Beta Decay
Lithium Detector	Solar Neutrinos
CLEAN	Solar Neutrinos & Dark Matter
Majorana	Double Beta Decay
GerDA	Double Beta Decay
EXO	Double Beta Decay
COBRA	Double Beta Decay
SuperCDMS	Dark Matter
ZEPLIN	Dark Matter
XENON	Dark Matter
DEAP	Dark Matter
PICASSO	Dark Matter
COUPP	Dark Matter
DRIFT	Dark Matter
Noble Liquid Tracking Detectors	Solar Neutrinos
HALO	Supernovae Neutrinos
LENA	Proton Decay, Solar Neutrinos, Supernovae Neutrinos
NOSTOS	Neutrino Oscillations (θ_{13})
TRIGA	Neutron-Antineutron Oscillations

Experimental Program

- 1 large experiment in the Rectangular Hall
 - (15 m scale)
- 1 large experiment in the SNO Cavern
 - (22 m scale)
- ~2 medium scale experiments in the ladder labs.
 - (4-6 m scale)
- Several smaller prototyping activities
 - (1-2 m scale)



The Lab and The User

- **The Experiment**

- Address safety and regulatory issues.
 - E.G. Fire suppression, Electrical, ...
- Experiment specific technical support and infrastructure.
 - E.G. Cryofridges, UPSs, Lifting devices, ...
- Compatibility with other experiments.
- "Birth to Grave" responsibility for apparatus and materials on site.
 - E.G. removal of equipment and disposal of hazardous materials.

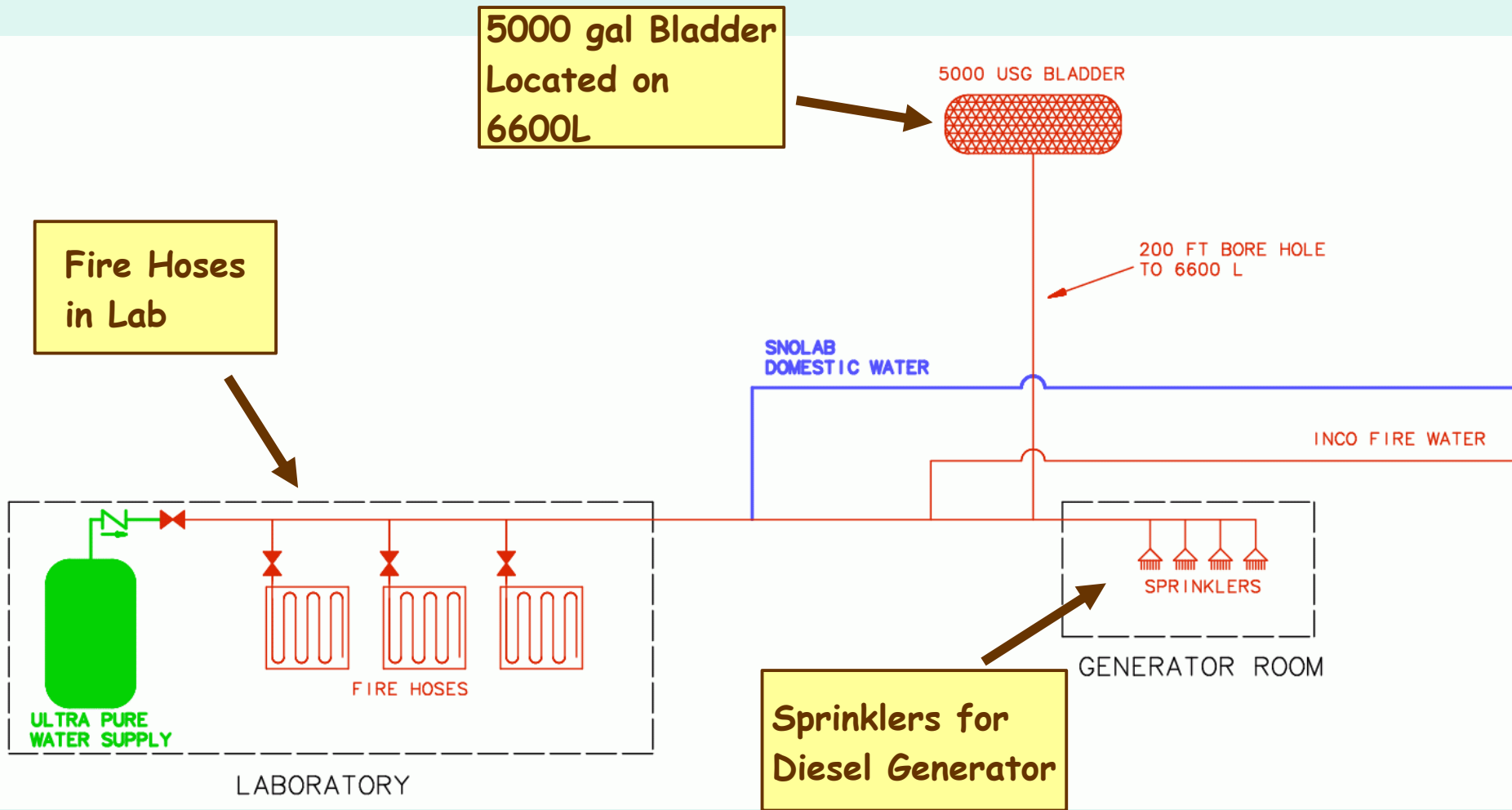
- **SNOLAB**

- Basic Lab infrastructure including Supervision, Maintenance, Cleaning
- Material Transportation
- Power/Cooling/Water
- Surface Lab, Office, Meeting Space, Change rooms
- Some Design
- Some Machining (Surface and UG)
- Assistance with Regulatory Issues
- Aspects of technical support including IT, Electrical, Mechanical, Chemistry.

Laboratory Infrastructure

- Computing & Network
- Space Allocation
- Power (Normal, Generator, UPS)
- Cooling (Air, Chilled Water)
- Fire Alarming and Suppression
- Slow Controls
- Radon Free Air? (UG and Surface)
- Low Background Counting
- LN2
- Water/Dewatering
- Technical Support (IT, Electrical, Mechanical/Maint, Cryogenics?, Electronics?)
- Clean Rooms
- Civil Work
- Surface Space
- Offsite Hot Lab

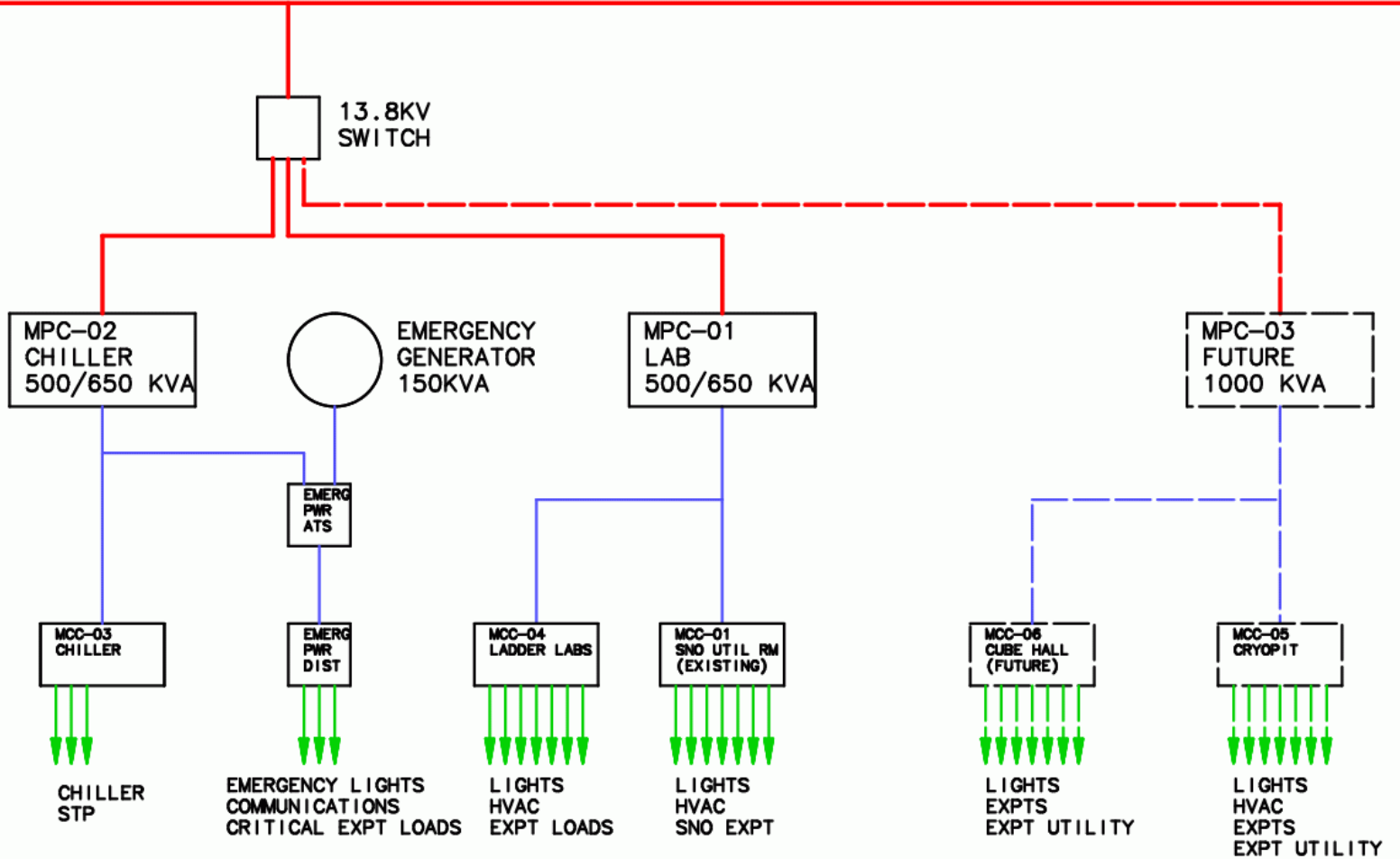
Fire Suppression



Power

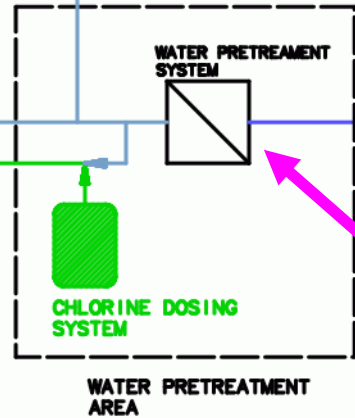
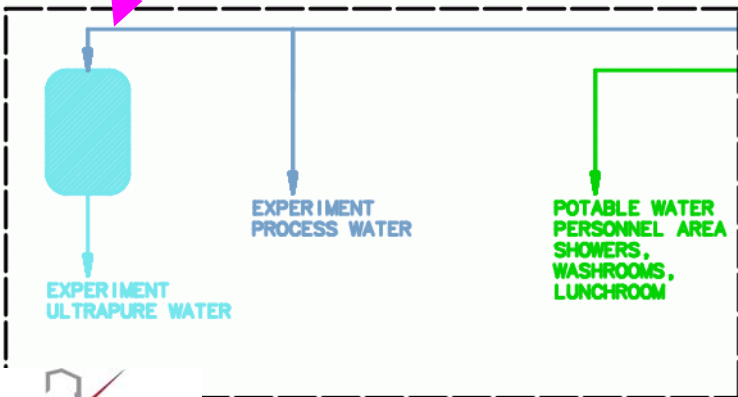
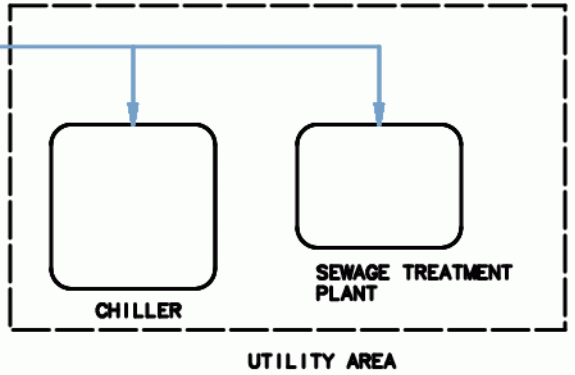
9 SHAFT 13.8KV FEEDER

6800 LEVEL 13.8KV FEEDER



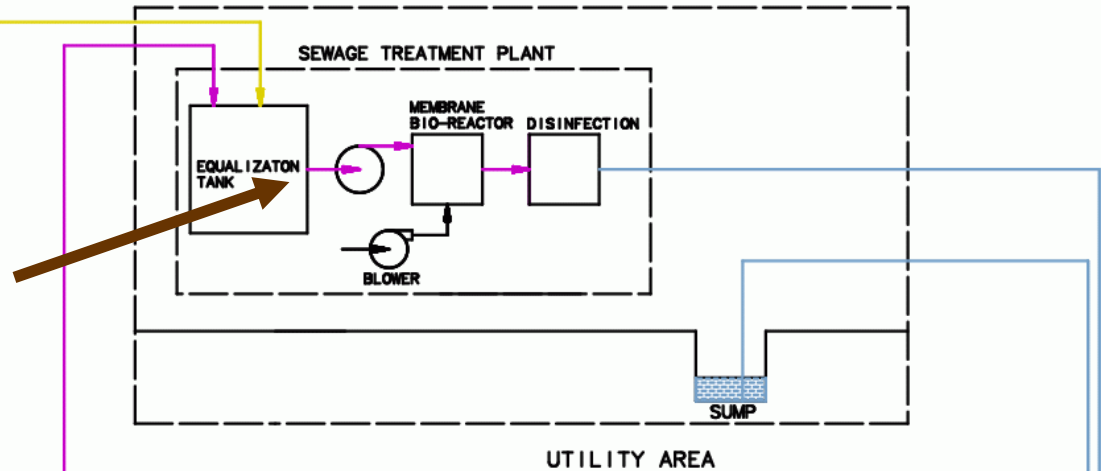
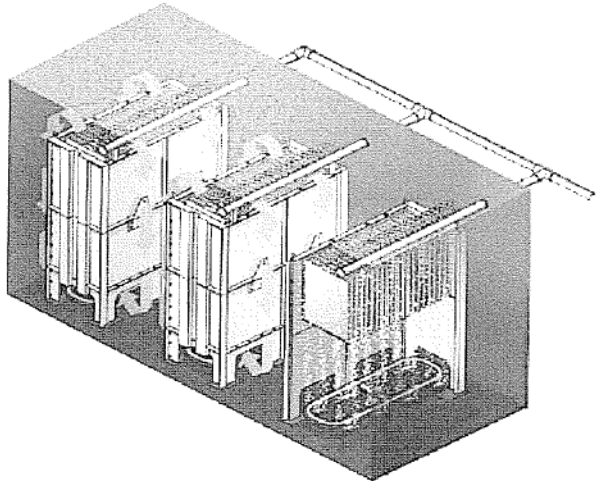
Water Supply

Ultra Pure Water System



Water Discharge

Membrane Bio-reactor Sewage Treatment Plant



PROCESS FORCED DRAINS

PROCESS FORCED DRAINS

FLOOR DRAINS

GREY WATER FROM SINKS AND SHOWERS

BLACK WATER FROM TOILETS

SUMP

SUMP

SUMP

MAIN SUMP

LABORATORY

Dewatering of the lab is done with a combination of sumps and forced drains

BORE HOLE TO MINE DEWATERING SYSTEM ON 7000 L

50 GPM
MAXIMUM
DISCHARGE

Laboratory Cooling

- 100,000 ACFM available for cooling.
- 320 tons (1100 kW) nominal
 - Including the SNO experiment, **~600 kW available for experiments**
- Chilled water to circulation loop to lab.
- Cooling provided to:
 - Air Handler Units
 - Secondary cooling coils in HVAC
 - Existing SNO water systems.
 - Future Experimental Processes.
- **Initial Power infrastructure will not allow full chiller capacity.**
 - **Will be upgraded as the experimental loads increase.**

Chiller

