

2021-02-26

SNOLAB Experience

Boulby G3 Workshop

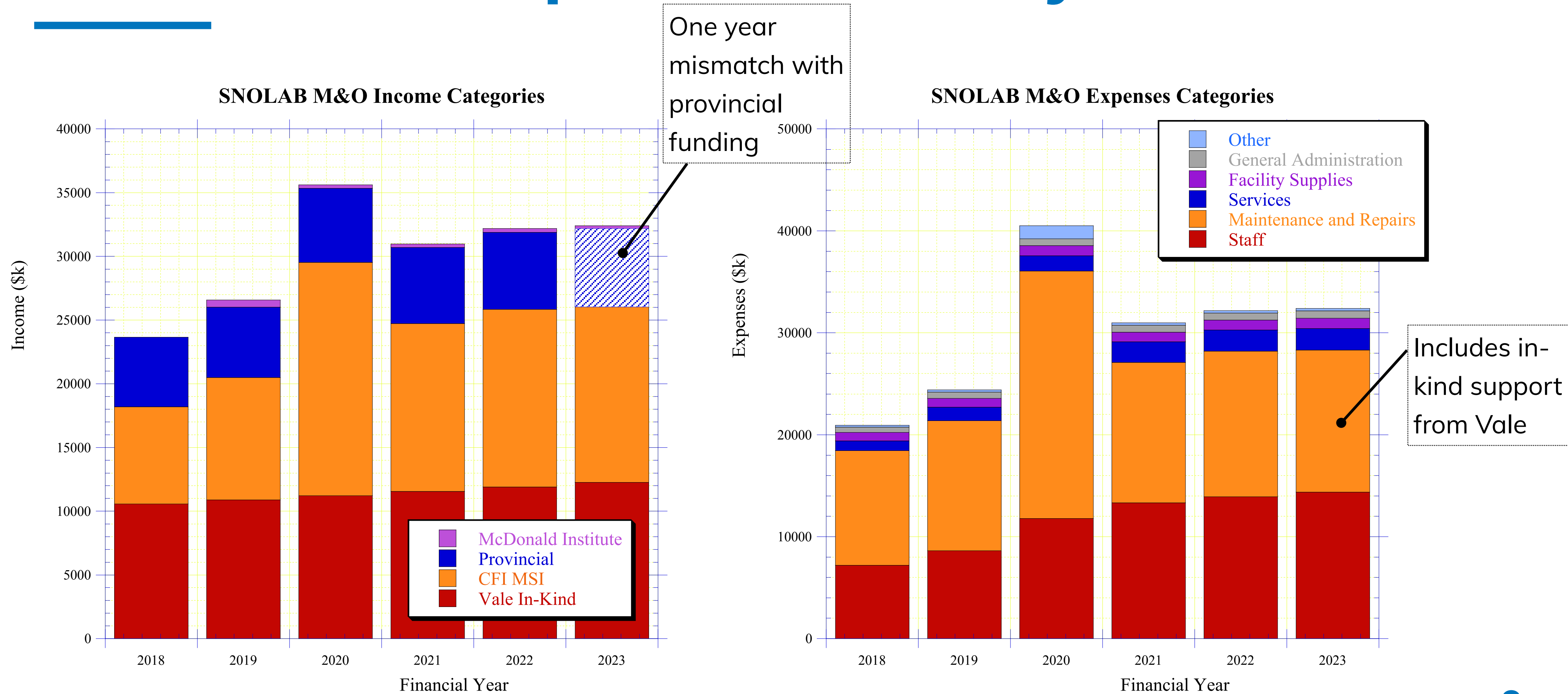
Nigel Smith

Executive Director



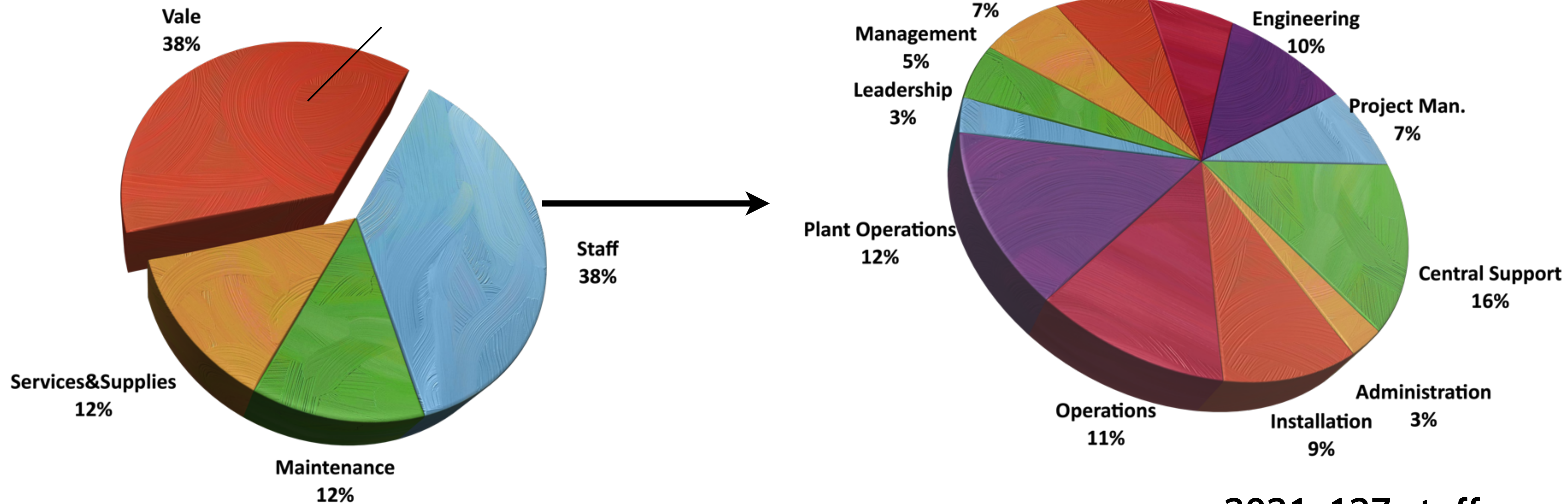
SNOLAB by the Numbers

MSI Income/Expense Summary



SNOLAB by the numbers

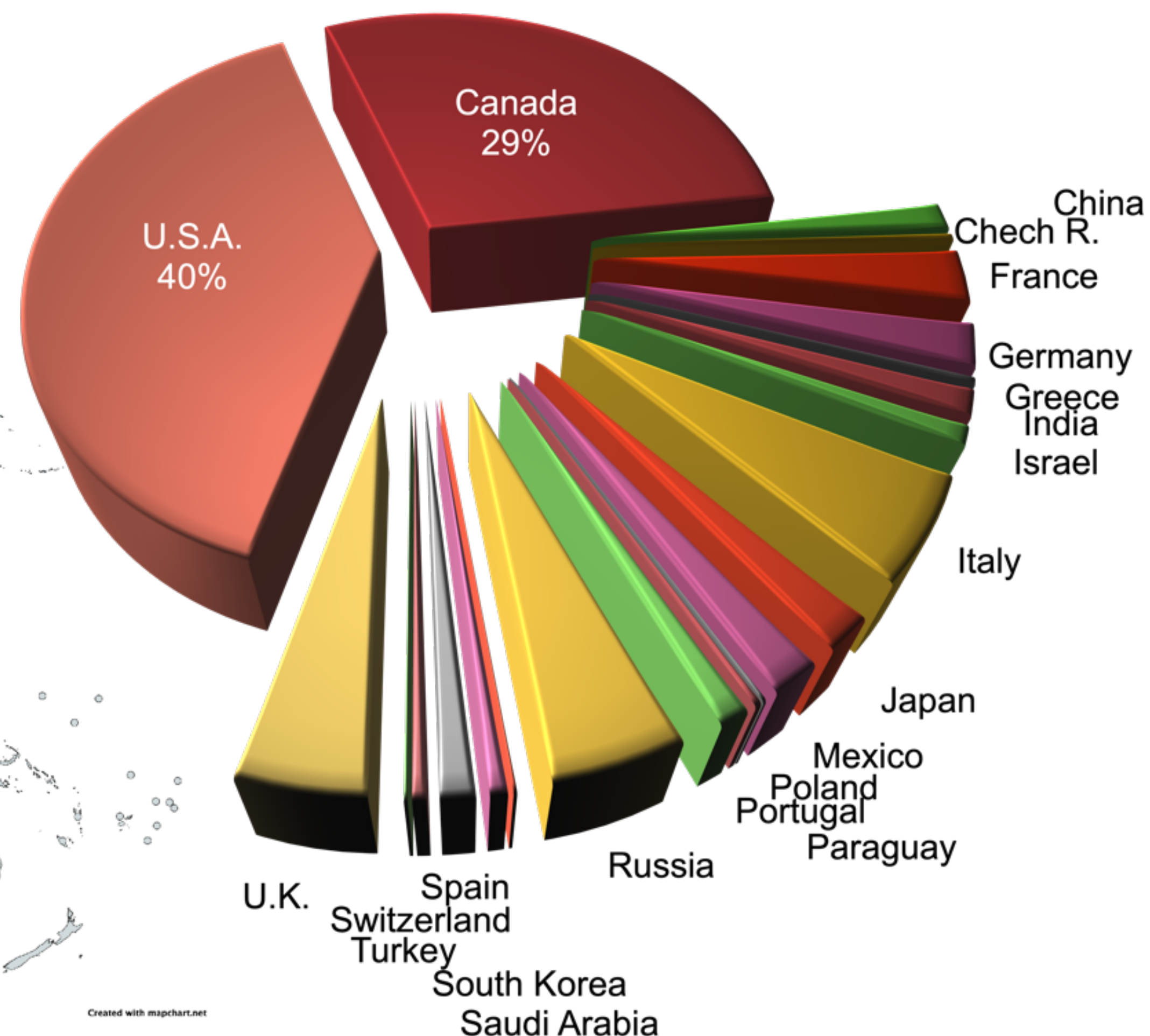
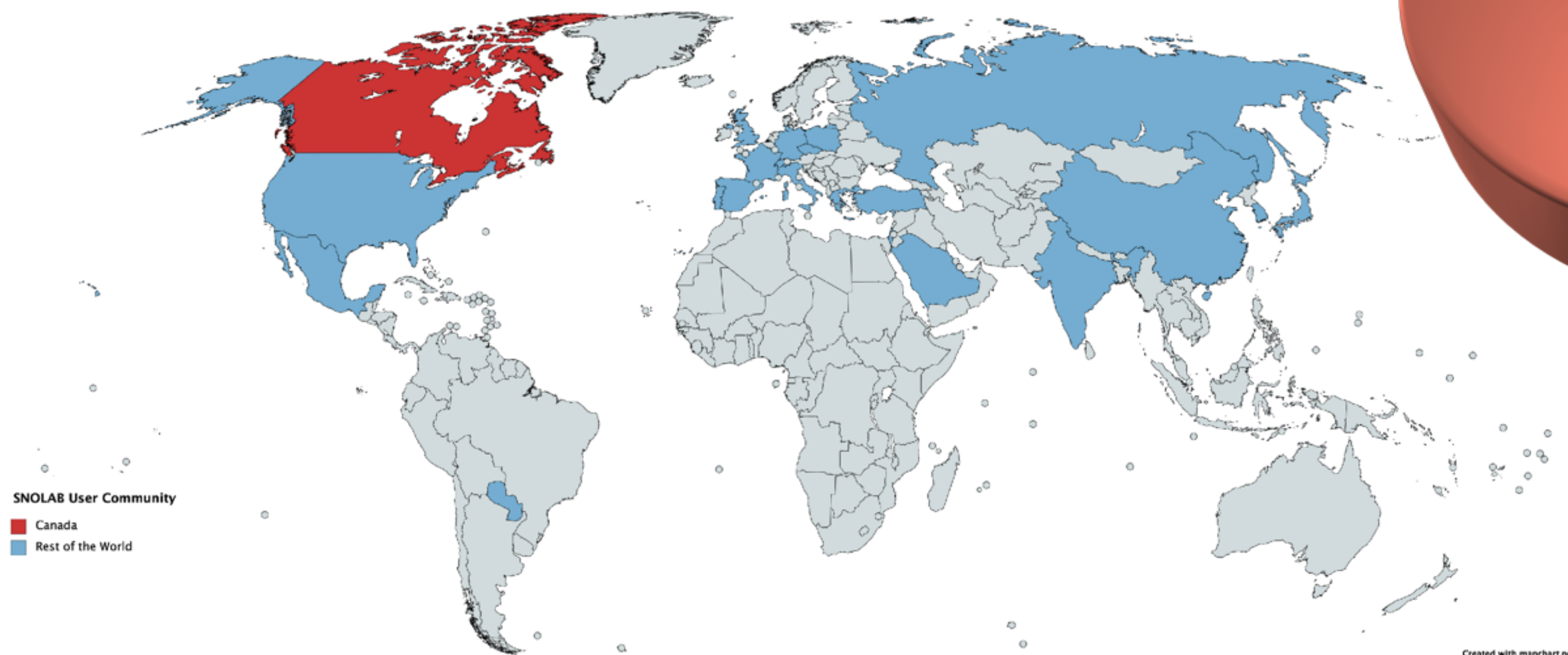
Vale is in-kind shaft operations



2021: 137 staff

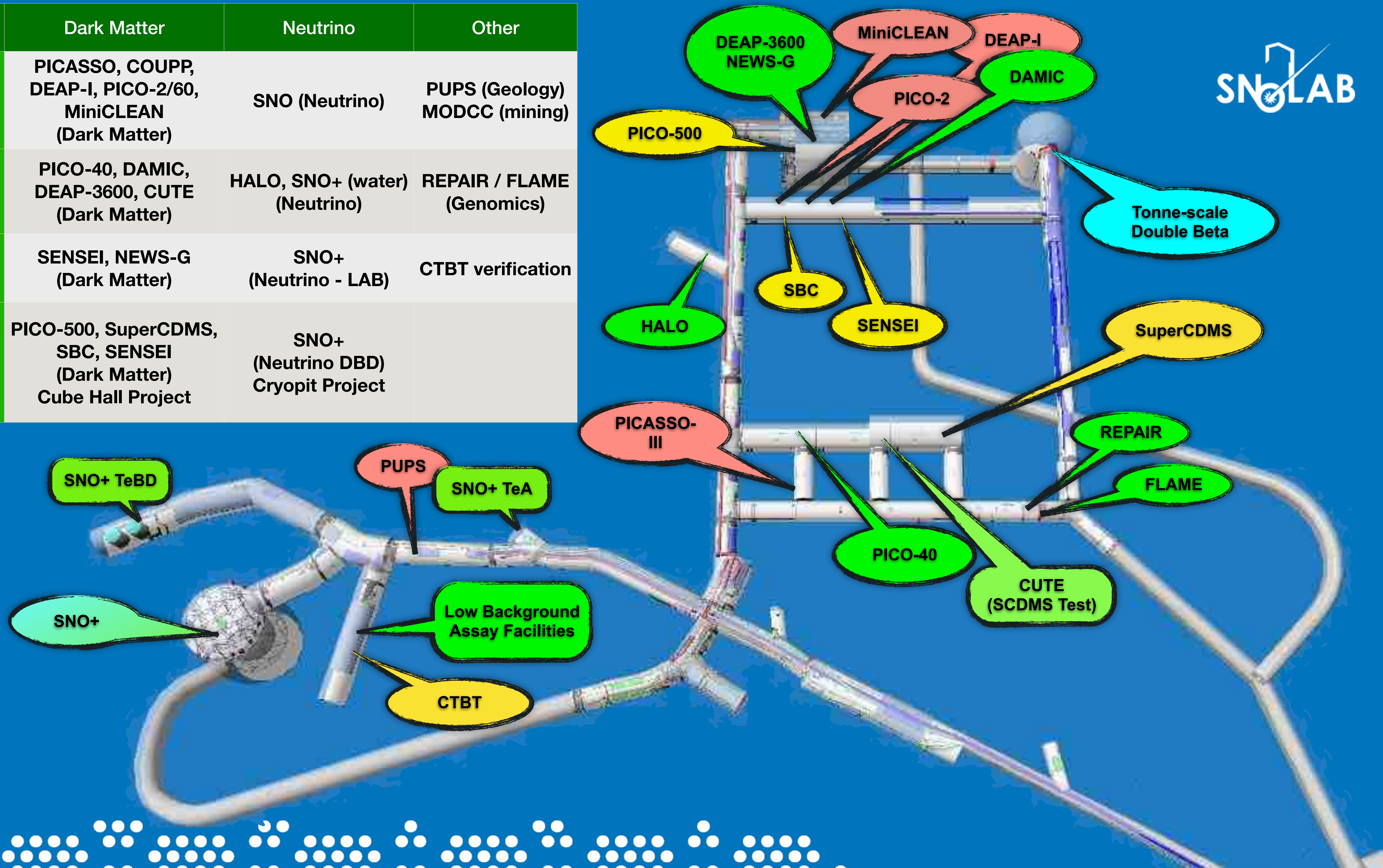
SNOLAB Science stakeholders

- Supported community has grown to >850 users from 129 institutes across 21 countries



SNOLAB Overview

	Dark Matter	Neutrino	Other
Completed	PICASSO, COUPP, DEAP-I, PICO-2/60, MiniCLEAN (Dark Matter)	SNO (Neutrino)	PUPS (Geology) MODCC (mining)
Current	PICO-40, DAMIC, DEAP-3600, CUTE (Dark Matter)	HALO, SNO+ (water) (Neutrino)	REPAIR / FLAME (Genomics)
2021 Start	SENSEI, NEWS-G (Dark Matter)	SNO+ (Neutrino - LAB)	CTBT verification
2021	PICO-500, SuperCDMS, SBC, SENSEI (Dark Matter) Cube Hall Project	SNO+ (Neutrino DBD) Cryopit Project	



Current projects

- SNO+
 - LAB completed by end of this month
 - PPO deployed end of summer
- DEAP-3600
 - Science runs completed
 - Neck refurbishment underway (COVID delayed)
- PICO
 - Progress on target fabrication
 - Underground ops and PICO-500 delayed
- News-G
 - Construction complete
 - Target deployed from Modane
- SuperCDMS / CUTE
 - Construction well advanced / ops underway

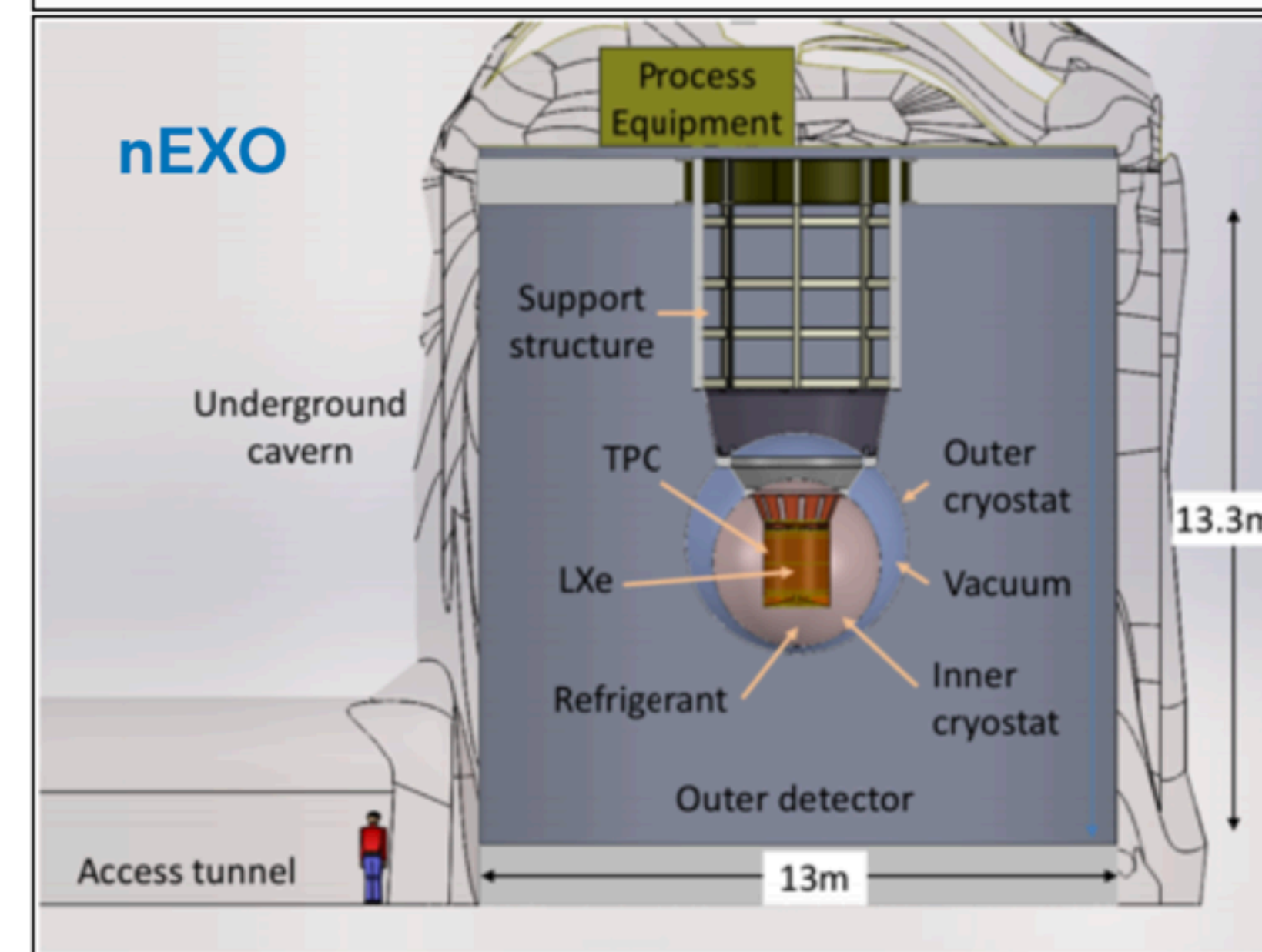
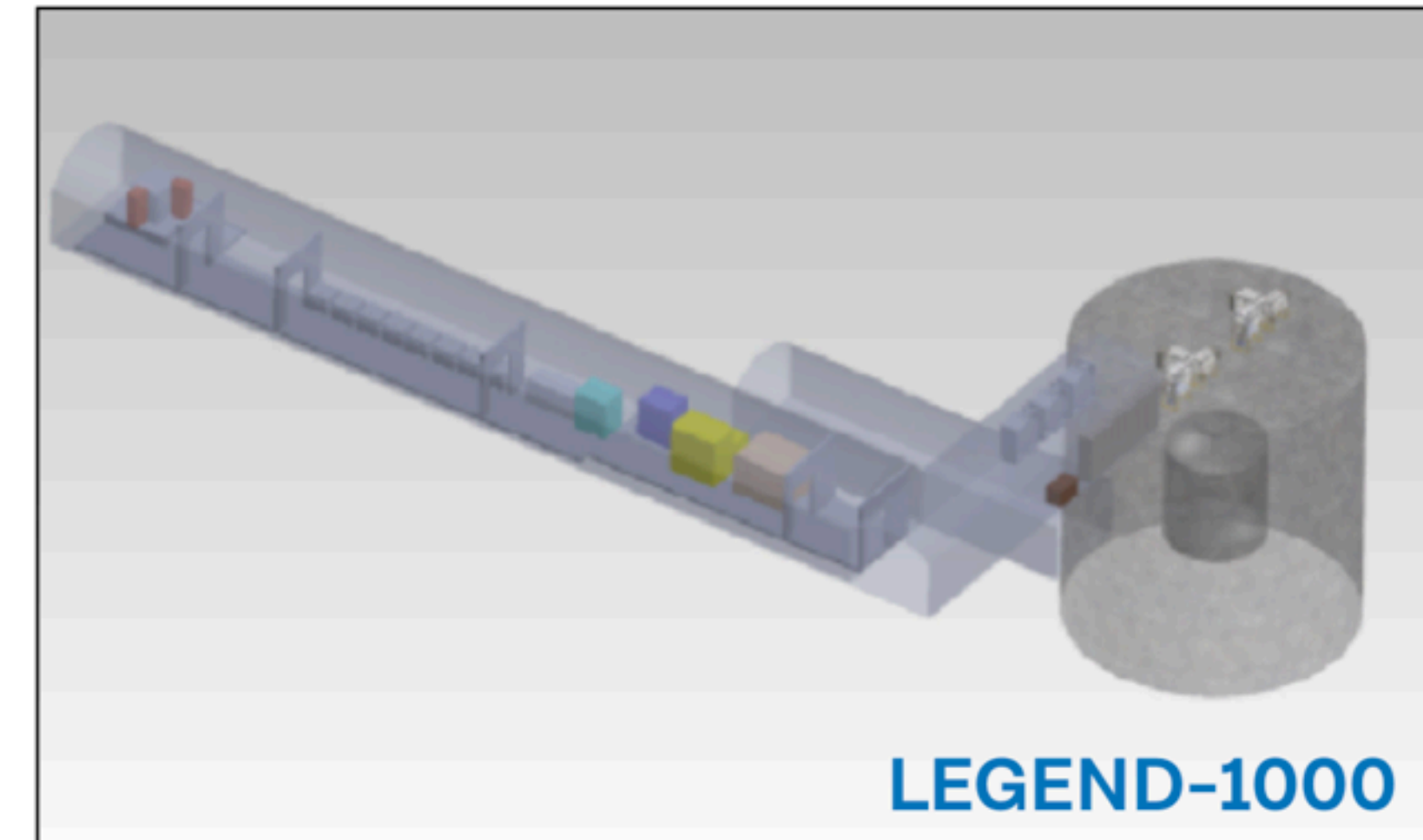


Future strategy overview

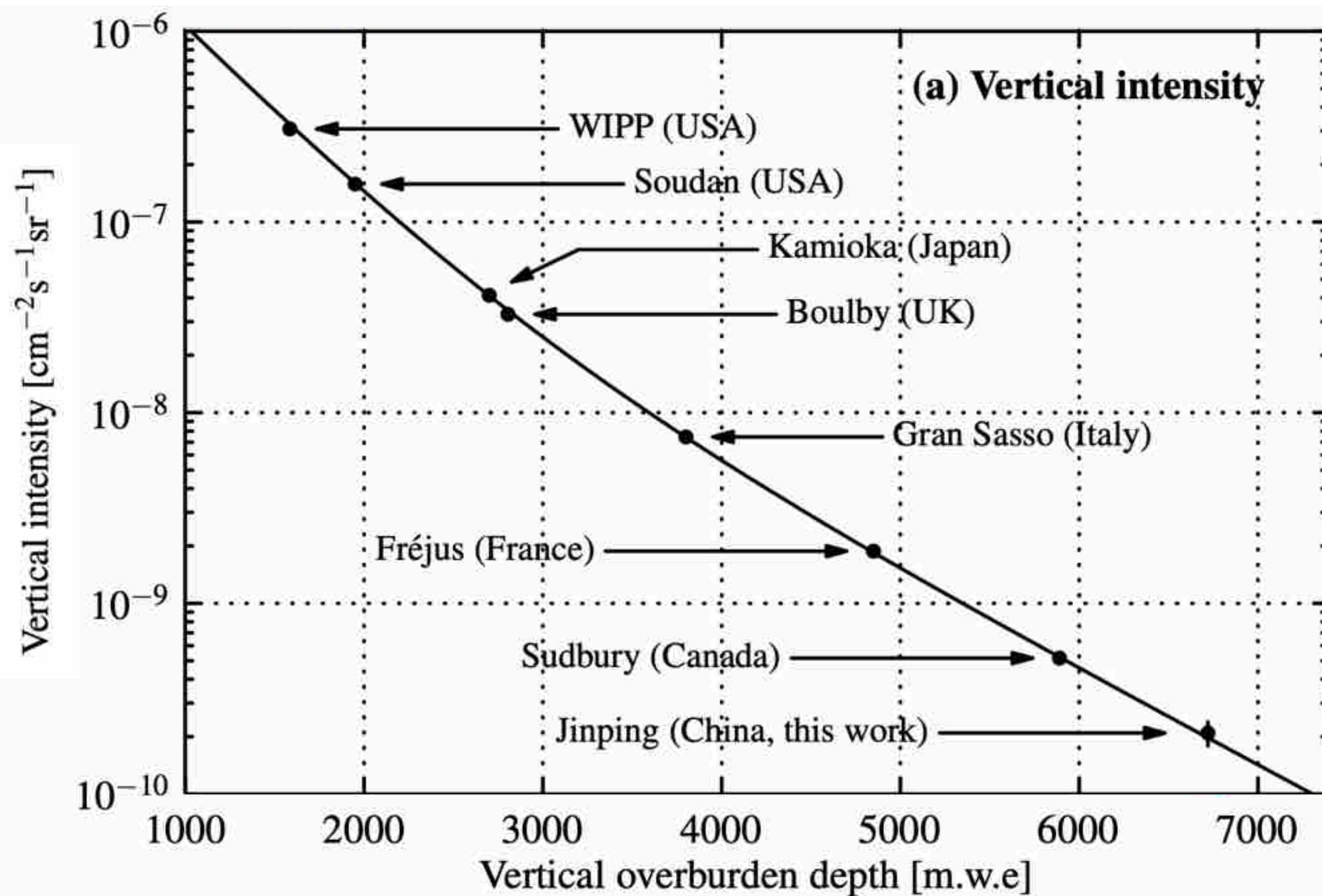
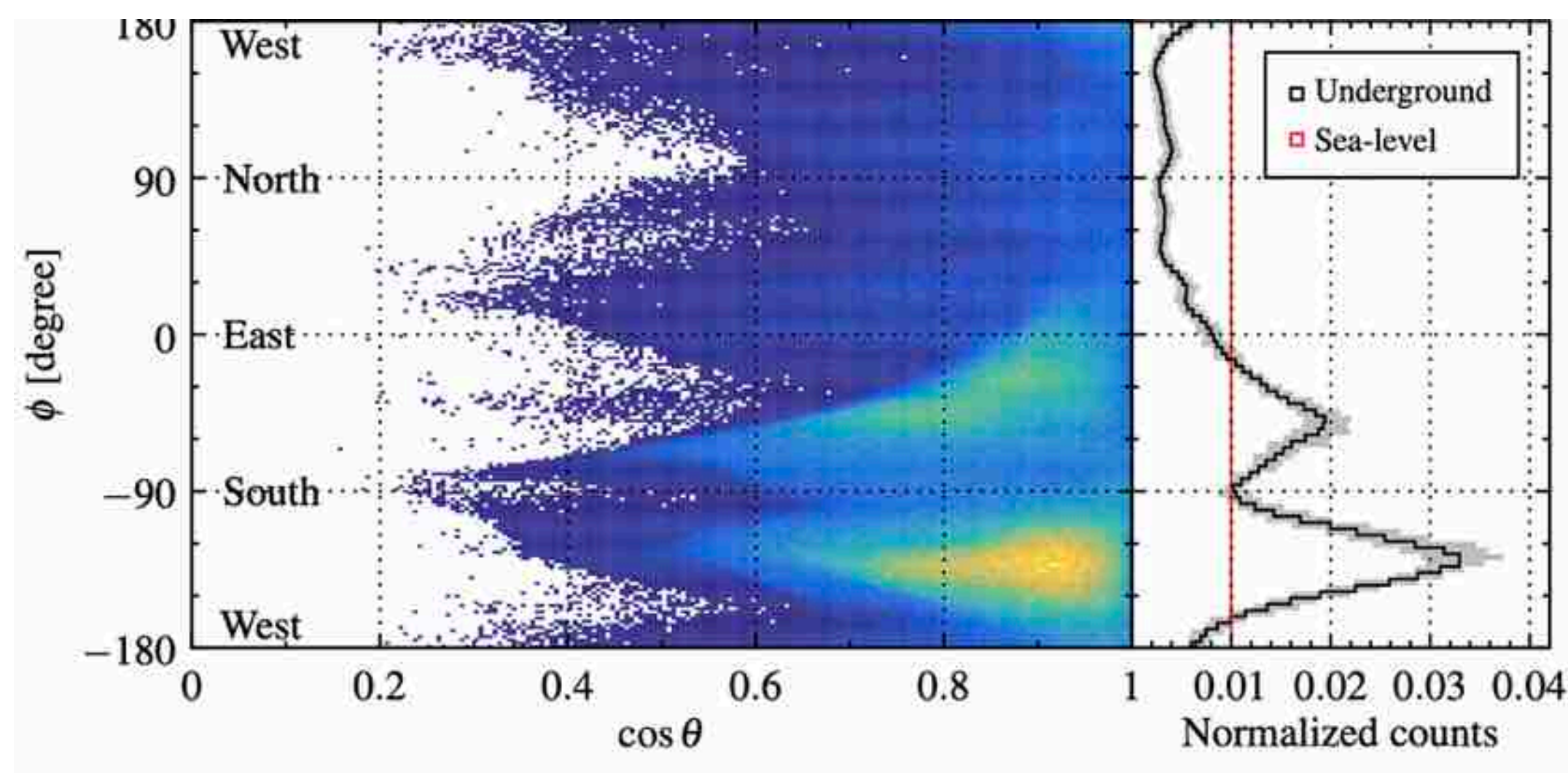
- Focus on maximising science return from investment made in SNOLAB and community, following community strategy discussions (ACP, LRP, P5/NSAC, SNOLAB)
 - Next SNOLAB strategic plan in development during 2021 (FY24-FY29 to align with MSI programme)
 - Future Projects workshop in May
- Support and deliver existing programme (following appropriate strategy)
- Combination of major projects (\$400M), smaller scale facilities (PICO-500/SuperCDMS), capabilities
- Medium term focus is double-beta decay with second gen project in Cryopit
 - Discussions with DOE/NSF as well as Canadian stakeholders
- Longer term focus is G3 dark matter project (eg ARGO liquid argon 300 tonne, DARWIN liquid xenon)
 - ARGO collaboration has specified SNOLAB as target location
- Maintain opportunity for smaller scale development and diversification of science
- Maintain capabilities, especially where overlap/connectivity
 - Cryogenics and liquid noble management
 - Low background production, construction, assay, cleaning, etc.

G2 $0\nu\beta\beta$ programme

- US Second generation $0\nu\beta\beta$ programme has CD-0 from December 2108
- DOE have been focussed on the EIC decision, including location: this is concluded; Now switching to $0\nu\beta\beta$ programme
- DOE aiming to engage broader international community to develop a global programme of at least two tonne-scale experiments
 - Looking to develop strategy at summit meeting this spring/summer with interested government stakeholders
- SNOLAB is working with two likely technologies on planning hosting in Cryopit, and capabilities to support the selected project.
- Depth requirement is critical in $0\nu\beta\beta$ projects due to neutron and cosmogenic activation in-situ
 - LEGEND-1000 analysis shows project 'likely possible' at LNGS
 - What happens if both projects need the SNOLAB depth?

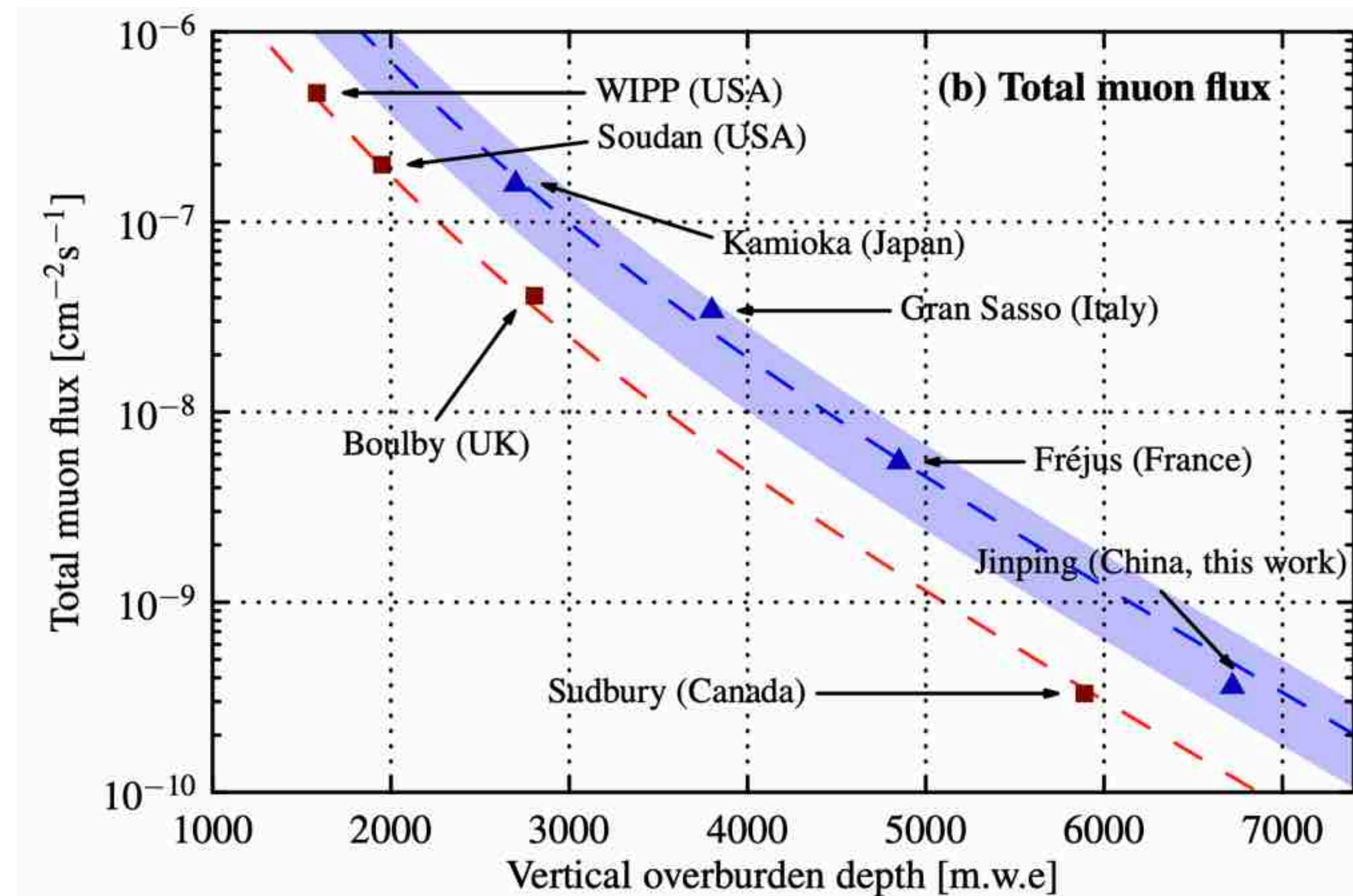
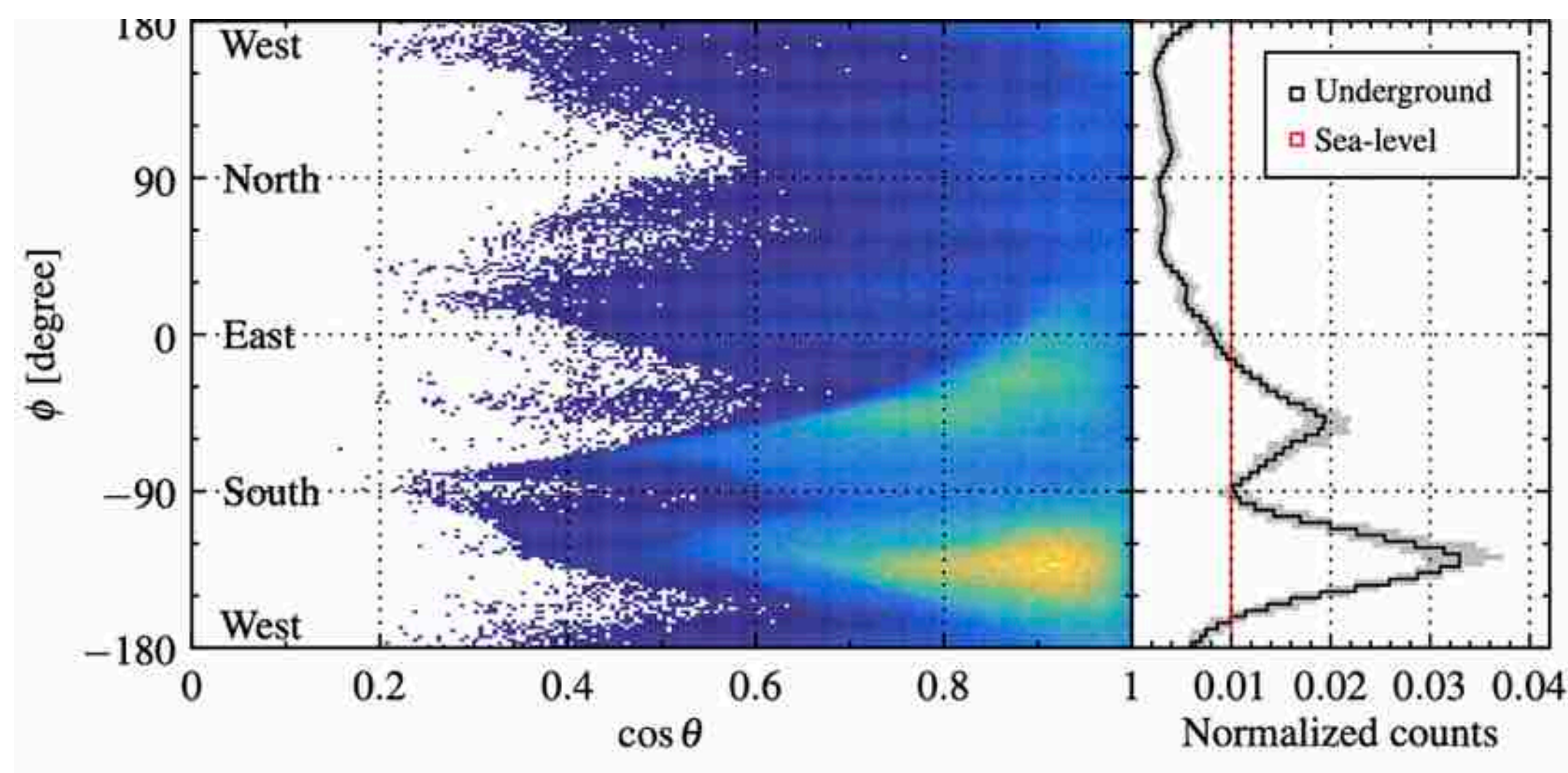


Note on depth and muon flux



- Integrated muon flux
 - CJPL: $3.53 \times 10^{-10} \text{ cm}^{-2} \text{ s}^{-1}$
 - SNOLAB: $3.31 \times 10^{-10} \text{ cm}^{-2} \text{ s}^{-1}$

Note on depth and muon flux

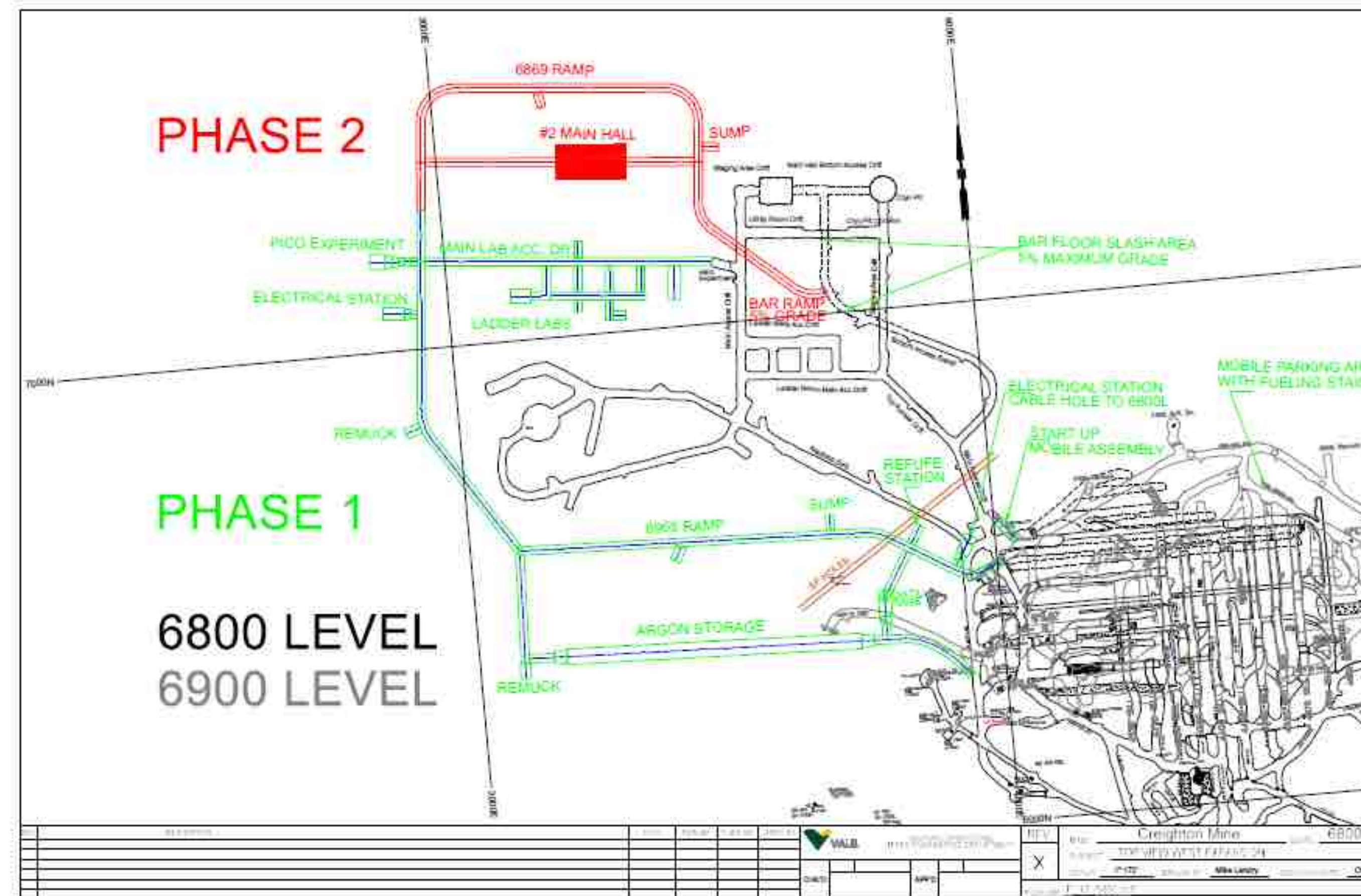


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SNOLAB Expansion

Potential future expansion

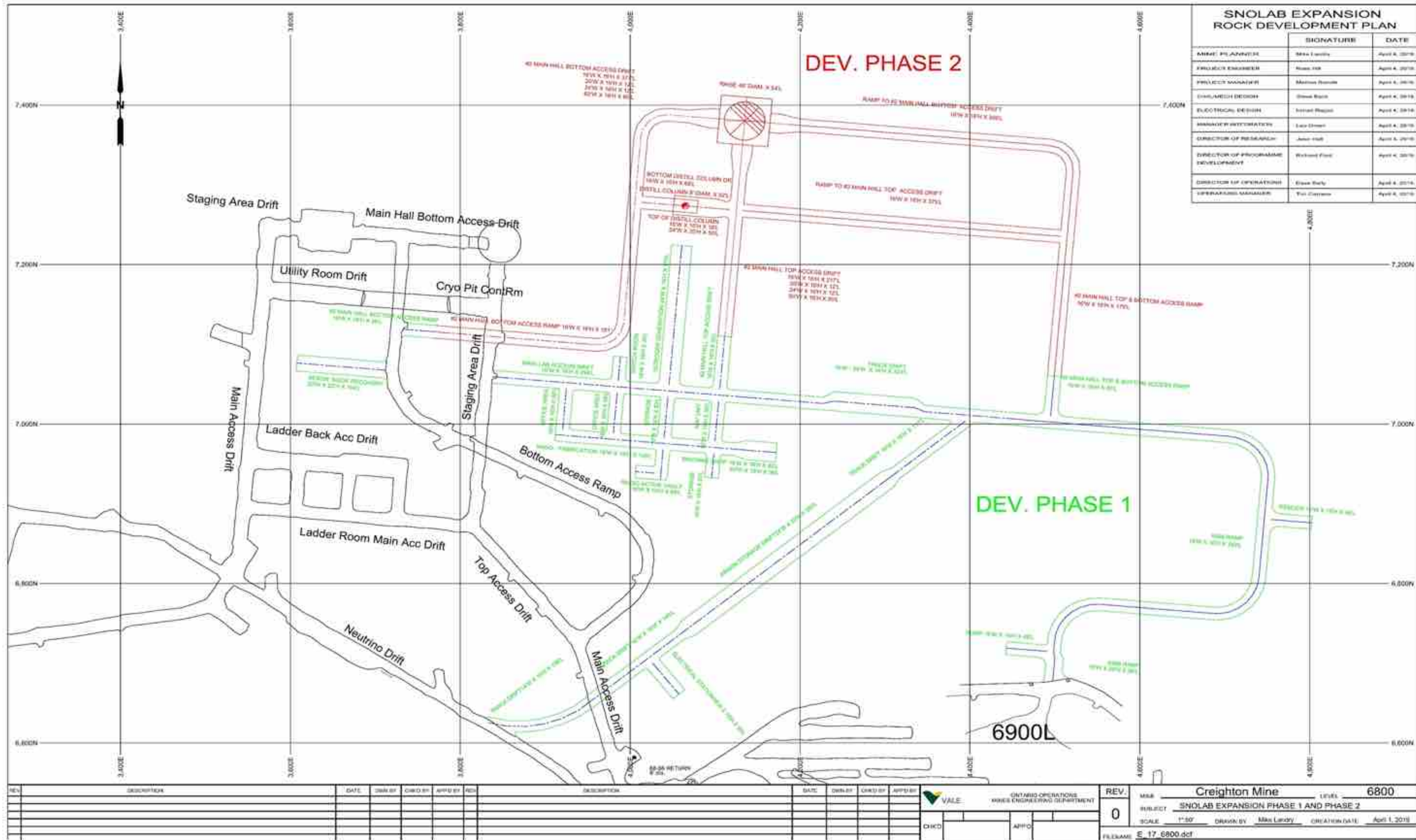
- Evaluation of expansion possibilities completed
- Included current (ambitious) plans as communicated by international community for additional major cavity
- Cost prohibitive O(\$200M) without appropriate funding programme - we will be ready for any stimulus programme that may occur after COVID
- Such development would require substantial RoI (eg additional project at cost \$400M) and substantial support from community
- Space will be fixed at SNOLAB for the foreseeable future, recycling cavities for new experiments



BACKGROUND – 2019 STUDY

- SNOLAB undertook a feasibility study to evaluate cost and schedule for a capital expansion project to expand laboratory facilities and provide an additional large cavern.
- This study concluded that an expansion project could be undertaken for CDN\$120MM.

2019 Mine Design



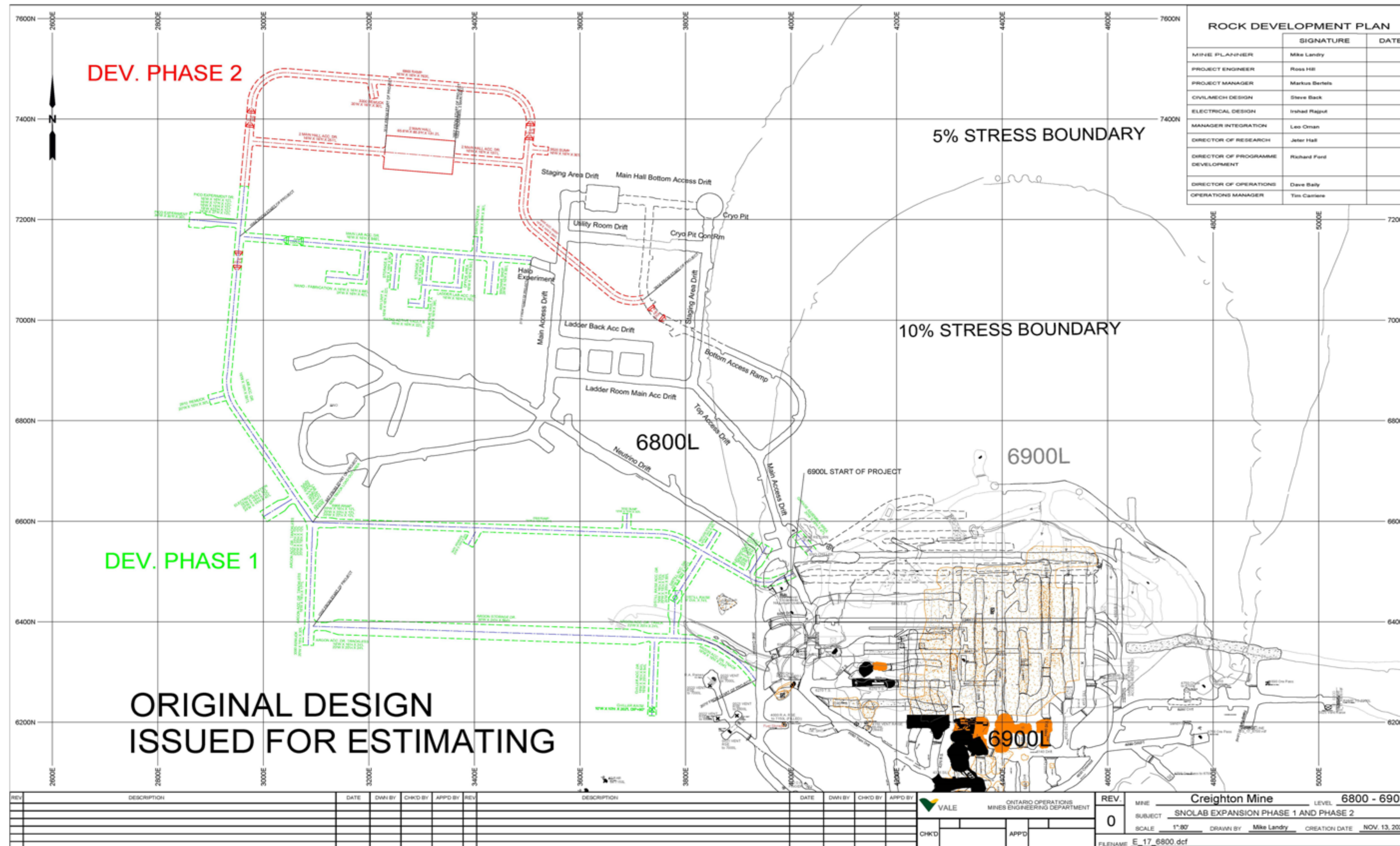
ROCK DEVELOPMENT –GEOTECHNICAL CONSTRAINTS

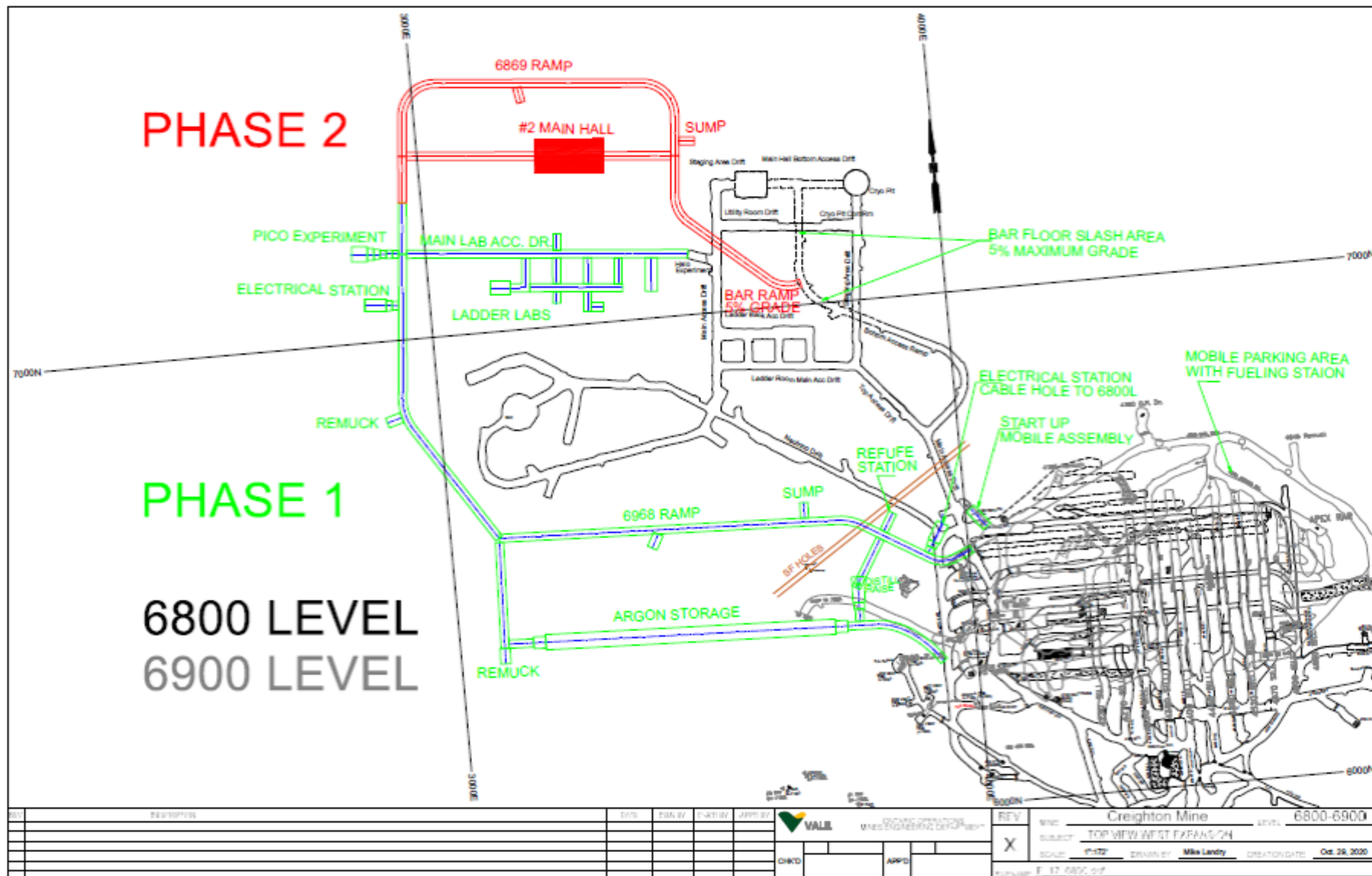
- Access drifts must be placed in ground where mining-induced stresses differ from virgin conditions by no more than 10%
- Permanent infrastructure must be placed in ground “remote from the effects of mining”, as defined by ground where mining-induced stresses differ from virgin conditions by less than 5%.
- Permanent infrastructure must be placed to withstand a magnitude 4.3N event at “target location”, as defined by staying sufficiently remote that peak particle velocity seen at location of facility will not exceed 400 mm/s.
- New cavern must be driven in nominal east-west orientation, and placed such that neither its east-west nor its north-south axis intercepts those of the Main Cube Hall.

ROCK DEVELOPMENT – OPERATIONAL OBJECTIVES

- Prioritise accessibility between new and existing lab facilities by placing new facilities close to Refuge Station, and at same elevation as current facilities.
- Prioritise accessibility between new and existing caverns by placing new cavern to share “BAD” working area, and “BAR” emergency egress, with existing Cube Hall and Cryopit. Grade of access drifts between large excavations must be kept to maximum plus or minus 5%.
- Top access drift into new cavern must be driven nominally flat, on level with new lab facilities, and aligned with top of existing Cube Hall.
- New cavern must be placed such that its length can be increased, from 40m length to 80m length, at any time up to start of its development.
- Argon gas must be stored on 6800 Level with ability to handle it by rail. Distillation column must be placed in close proximity to Argon Gas Storage.
- New chiller station must be placed such that total volume of return air available to SNOLAB will flow through it, new raise to 6600L will direct return air into same pathway to No 11 Shaft as used now, and exposure of operations to potential leakage of Argon Gas will be minimized. Text

2020 Mine Design





Project Execution - Safety

- Develop project safety plan and goals in alignment with SNOLAB policies.
- Establish workflows for review and assessment of vendor safety programs, auditing program of contractor's programs in the field.
- Incorporate SNOLAB assessments of safety program effectiveness as a technical criteria for award.
- Incorporate safety metrics into weekly progress reporting.
- Participate in 'safety in design' using SNOLAB hazard mitigation and constructability review processes.
- Provide third party review, if required, for higher risk mining or construction activities.
- Incorporate 'lessons learned' in final project report.

Project Execution - Design Engineering

- Design engineering is proposed to commence early 2022, and is estimated to take 18 months.
- Effort is low intensity as development advance will take time to get to construction areas.
- Estimate includes use of a third party consultant, however an opportunity exists to do the work internally.
- Design could be issued IFT with clean line drawings and adjusted once wireframe survey is available.
- Establish workflows for review and incorporation of SNOLAB operating experience.
- Incorporate progress metrics into engineering deliverables listing with 'rules of credit' and hours by deliverable.
- Incorporate 'safety in design' using SNOLAB hazard mitigation and constructability review processes.
- Support a detailed estimate (70% engineering progress) to finalize budgets.
- Support procurement process with technical evaluation of proposals.
- Generate a turnover package inclusive of 'as-built' design deliverables, operating and maintenance deliverable and commission reports.

Project Execution – Key Mining Risks

- Rock hoisting:
 - 175 TPD rock hoist not met or shaft extension (2024 start?) takes priority for rock hoist.
 - Rock storages not developed.
 - Rock handling surcharge greater than current agreement.
 - Additional logistical requirements not met (3 trucks per day).
- Main hall cavern location situated in bad ground.
- Ventilation conditions deteriorate and mining productivity decreases.
- Poor ground conditions are encountered during development.
- Poor performance from main development contractor.
- Impact from upswing in mining business cycle:
 - Increased demand for experienced miners and staff.
 - Increased lead times for mobile equipment

ROCK QUANTITY

PHASE	DESCRIPTION	TONS ROCK (incl 10% overbreak)
PHASE 1	HEADINGS SHARED BY ARGON DRIFT, LADDER LAB & CAVERN	30,890
	HEADINGS SHARED BY LADDER LAB AND CAVERN	21,819
	HEADINGS DIRECTLY ATTRIBUTABLE TO LADDER LAB	28,624
	HEADINGS DIRECTLY ATTRIBUTABLE TO ARGON STORAGE	54,381
	HEADINGS DIRECTLY ATTRIBUTABLE TO PICO EXPERIMENT	4,891
	HEADINGS DIRECTLY ATTRIBUTABLE TO CHILLER STATION	6,289
	HEADINGS DIRECTLY ATTRIBUTABLE TO DISTILLATION COLUMN	7,184
	SUBTOTAL PHASE 1	154,078
PHASE 2	HEADINGS DIRECTLY ATTRIBUTABLE TO NEW CAVERN	113,659
TOTAL FOR PHASE 1 & 2 PROJECT		267,737

PROJECT SCHEDULE - MINING

Project Milestone Schedule	2021			2022				2023				2024				2025				2026				2027				2028				2029				
	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3		
Application for funding submitted																																				
Finalize RFQ package for early works contract	■	■																																		
Provisional agreement with Procurement on "Rapid Award - Early Works Contract"		■	■																																	
Funding approved - authorized to spend starting in March 2023							■																													
Award Early Works Contract							■																													
Mobilize Contractor for "Early Works"							■	■																												
Execute Early Works Contract							■	■	■	■	■	■	■	■	■																					
Prepare RFQ and award "Phase 1 Contract"									■	■	■	■	■	■																						
Mobilize Contractor for "Phase 1 Contract"									■	■	■	■	■	■																						
Phase 1 Contract Lateral Development at 175 TPD														■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Phase 1 Alimak raise - Chiller Raise & Distillation Column																																				
Phase 1 Contract "Shotcrete/ Concrete/Miscellaneous in Permanent Facilities"																																				
Diamond Drilling to define Phase 2 Cavern																																				
Prepare and Award "Phase 2 Contract"																																				
Mobilize Phase 2 Contractor																																				
Phase 2 Contract Lateral Development at 175 TPD																																				
Phase 2 Shotcrete/Concrete/Miscellaneous at No 2 Main Hall Bottom Access																																				

A night landscape featuring a calm lake in the foreground, a dark treeline in the middle ground, and several tall, illuminated industrial chimneys or towers in the distance. The sky is a deep blue-purple, filled with numerous stars and a single bright meteor streaking across the upper left. The word "Questions?" is overlaid in white, italicized font on the right side of the image.

Questions?