UF4: Supporting Capabilities Feedback Session

UF4 conveners: Alvine Kamaha (UCLA), Brianna Mount (BHSU), Richard Schnee (SD Mines)

SNOWMASS Summer Meeting in Seattle

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Today

1. Quick reminder of report
   a. More details found in report and also Alvine's slides from yesterday

2. Request feedback and discussion (what did we miss?!?)
   a. We've been receiving feedback and have been trying to implement it real-time(ish)

Still Time For the Surveys

Survey for current and future underground experiments (survey link)

Survey for current and planned underground facilities (survey link)

Survey Respondents (so far...)

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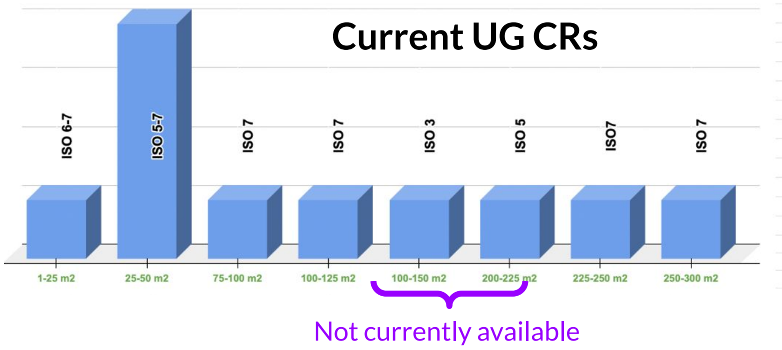
Experiments	
COSINE-100	Argo
COSINE-200	CANDLES
DarkSide-20k	CDEX
DarkSide-LowMass	CUPID
Hyper-Kamiokande	DARWIN
KamLAND-Zen	DM-Ice
Kton Xe TPC for 0vbb	LEGEND
Majorana Demonstrator	nEXO [1]
NEXT-CRAB	NEXT-100
NEXT w/ Ba-Tagging	NEXT-HD
PIRE-GEMADARC	NuDot
Snowball	PandaX
Super-Kamiokande	SBC
A possible neutrinoless-double beta-decay extension to DUNE	

Facilities
Berkeley Low Background Counting Facility, U.S.
Boulby, UK
Gran Sasso, Italy
JinPing, China
Kamioka Observatory SPRF, Japan
KURF, VA, U.S. (not available due to COVID)
LARAFA, French Pyrénées
LLNL Nuclear Counting Facility, U.S.
Modane, France
Pacific Northwest National Laboratory, U.S.
SNOLAB, Canada
SURF, SD, U.S. [2]
Y2L / Yemilab, Korea
U. Alberta, Canada
SD Mines, SD, U.S.
Canfranc, Spain

Cleanroom needs and availability



Cleanliness

- Most demands are for ISO 6-7 Cleanrooms.
- However stringent constraints on CR class, ISO 5 (and better) from:
  - Crystal preparation, growth & detector fabrication
  - G3 dark matter and $0\nu\beta\beta$ experiments (construction phase). These experiments also need multiple cleanrooms with varying ISO class for storage, assembly and cleaning
- Improvement in CR class monitoring could enable looser requirements for better CR ISO class

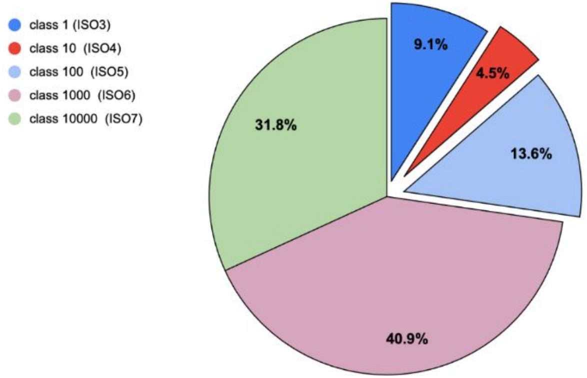
Size

- G3 dark matter detector (e.g. kiloton TPC detector) needs 100-300 m^2 size during detector construction phase **(available at LNGS, SURF & SNOLAB)**
- But stringent constraint of **ISO 3-5** for these larger cleanrooms **not currently met**.

Overall

- Future experiments will benefit from a few additional larger (100-300 m^2) cleanrooms with better ISO class than what currently exist (ISO-5 and better)

Future CR requirements

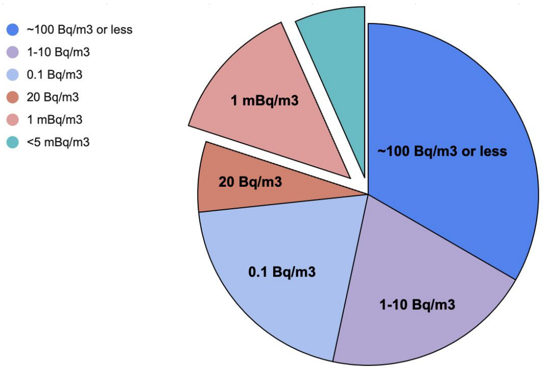


Radon reduced room needs and availability

- Existing underground radon-reduced cleanrooms are relatively small, **all < 100 m^2 with Rn level of [1-1000 mBq/m^3]**
- However, **future** larger-size **experiments need larger CR [100-300 m^2] with lower Rn level ~ 1 mBq/m^3**
- There is also a need to increase measuring and monitoring Rn level and plate-out rates in these rooms

Laboratory	Depth (mwe)	CR Area (m^2)	CR ISO Class	Rn Concentration (mBq/m^3)
Canfranc, Spain [11]	2400	70	ISO 5-6	<5
Gran Sasso, Italy	3100	13	ISO 7	10
Gran Sasso, Italy	3100	86	ISO 6	50
Gran Sasso, Italy	3100	32	ISO 6	50
Modane, France	4800	16		(planned)
SNOLAB, Canada	6000		ISO 6	(in progress)
SURF, SD, U.S.	4300	45	ISO 7	100
Y2L	1750	46	ISO 7	1000
Yemilab (planned)	2500	23	ISO 5	planned
Yemilab (planned)	2500	80	ISO 7	planned

Planned Need for RRCR



Bulk Material Assay: Complementary Techniques

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Sensitivity Required

- Most next-generation experiments are aiming for 100 nBq/kg assay capability for inner detector materials.

HPGe

- Currently more than 68 HPGe detectors in total serving underground experiments worldwide. With an estimate of ~1600 samples/yr and experiments need of ~100 samples/yr, we have an adequate number of HPGe within the community, ***if worldwide collaboration is implemented***.
- Current detector limits ~10 uBq/kg. Need to improve on sensitivity (e.g. multiple crystal HPGe detector, NAA, etc) for next-gen experiments
- Continued use of HPGe will be necessary for future experiments

ICP-MS

- Most of the underground facilities surveyed either have 1-2 ICP-MS systems and dedicated facilties on site at their surface facilities, or have relationships with nearby labs.
- Current best limit for ICP-MS for underground science is **~100 nBq/kg.**
- **Continued R&D needed to develop sample prep methods for new materials down to low sensitivities**

Alpha Screening and Radon Emanation

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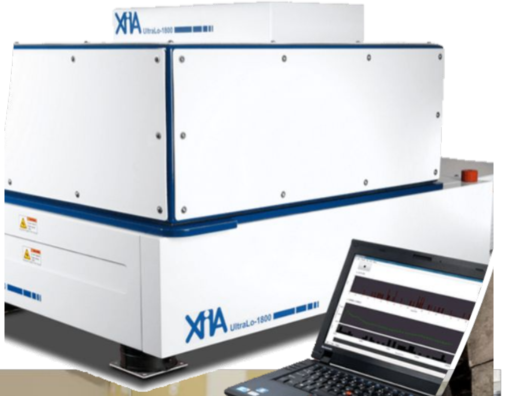
- **Alpha screening**
  - Improved sensitivity (beyond XIA Ultra-Lo 1800) would be beneficial. Current best underground sensitivity for XIA Ultra-low 1800 is ~1 mBq/m^2. Future experiments require down to .001 mBq/m^2.



- **Radon emanation**
  - Existing facilities appear sufficient in number for future experiments, provided there is sufficient sharing of resources
  - Improvements in sensitivity (beyond the standard 0.1 mBq) and/or ability to emanate large volumes of materials would be beneficial to future experiments.

3) Other UG support needs and availability

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Facility for UG material storage

1) Mainly used are non-CR space. If needed, materials may be bagged in Rn impermeable bags (or gloveboxes purged with low-Rn gas)
2) Minimally used are CR space

➢ **Such facility is present in all UG labs; for most, the non-CR space is sufficiently large**

UG material purification facilities

1) Water purification and Rn removal from water
2) Scintillator purification and degassing
3) Isotopic purification

➢ **Such facility is present in some UG labs**

UG detector fabrication & Machining facility

1) UG electroplating & electroforming: exist @SURF & PNNL, planned @Boulby & SNOLAB
2) UG Ge detector fabrication: **non-existing!**
3) UG Machining shops: exist @ SURF, SNOLAB, Gran Sasso

➢ **Such facility is present in some UG labs but more UG machining will be needed by future experiments**

Conclusion (UF4: Supporting Capabilities)

- The larger, lower-background experiments planned for the future will require larger support facilities that also enable lower backgrounds than are currently available.

- Gaps between existing facilities and future needs include the following:
  - Some experiments require larger and/or lower reduced-radon cleanrooms than currently exist.
  - Dust assay sensitivity needs to be improved modestly beyond current techniques, which are currently limited primarily by systematic, procedural contamination issues.
  - Existing surface-screening methods for radon-daughter plate-out are not sufficient to inform experiments during assembly as to whether their needs are met.
  - Most assay needs may be met by existing worldwide capabilities with organized cooperation between facilities and experiments.
  - Improved assay sensitivity is needed for assays of bulk and surface radioactivity for some materials for some experiments, and would be highly beneficial for radon emanation.
  - Improved infrastructures for UG detector fabrication and machining as needed by future exp.