STFC Opportunities Call 2019

Feasibility Study for Developing the Boulby Underground Laboratory into a Facility for Future Major International Projects

Imperial College London: H Araújo, T J Sumner
University of Sheffield: V Kudryavtsev, V Pec
University College London: J Dobson, C Ghag, R Saakyan
Rutherford Appleton Laboratory: P Majewski, S. Greenwood
Boulby Underground Laboratory: S Paling, P Scovell
[SNOLAB: N Smith]

3.2.6 BUILDING INTERNATIONAL INFLUENCE

Promoting the UK through international research collaboration and leadership of international projects

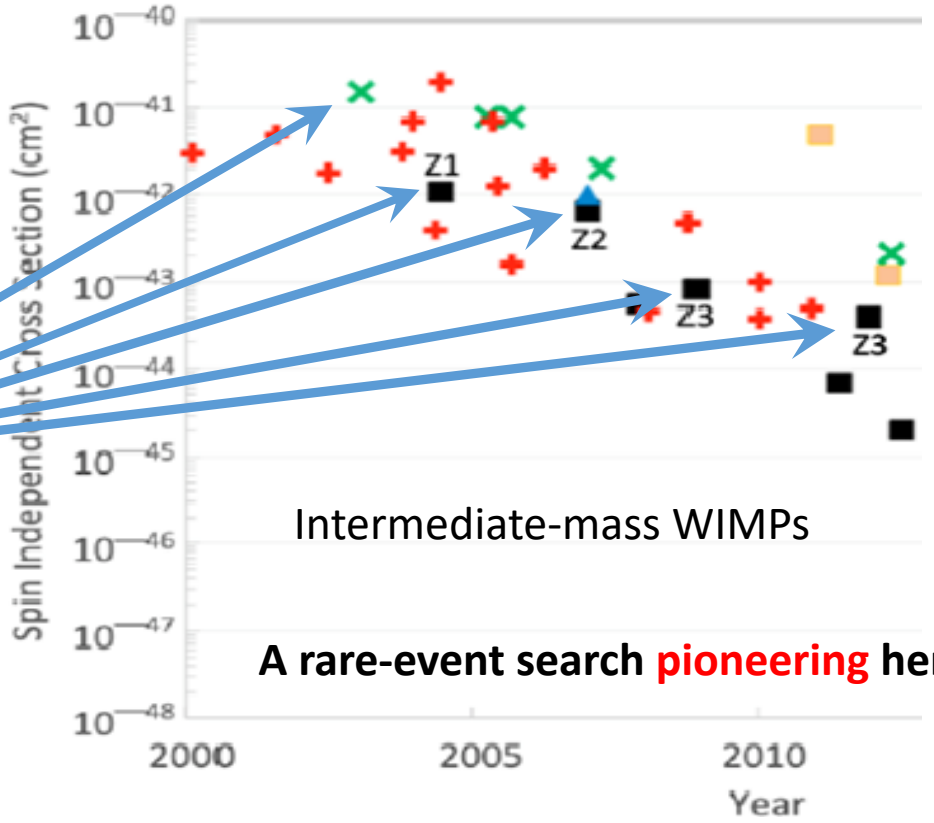
- Site Review
- User Requirements
  - DM searches
  - 0νββ decay
- Facility Definition
- Costing

Long-term strategic goal

Enhance the UK's reputation and influence through the delivery of world-leading research and innovation, attracting international investment and providing opportunities for UK companies.

- Develop Boulby Underground Laboratory into a world-class facility that could potentially host a major international project in fundamental science.

A keen (and proud) industrial host



Intermediate-mass WIMPs

A rare-event search pioneering heritage

A thriving Laboratory

- BUGS – ultra-low radio-assay facility
- DRIFT/CYGNUS
- NEWS-G
- BISAL/MINAR – life in extreme conditions, planetary exploration R&D
- Misc. particle, geo and environmental studies
- AIT/NEO

An opportunity

- Beyond the Standard Model Physics
  - Direct Dark Matter Searches using LXe and/or LAr, or gas TPCs, or ….
  - Neutrinoless double beta decay
  - QS FP → DM/GW/…
  - …

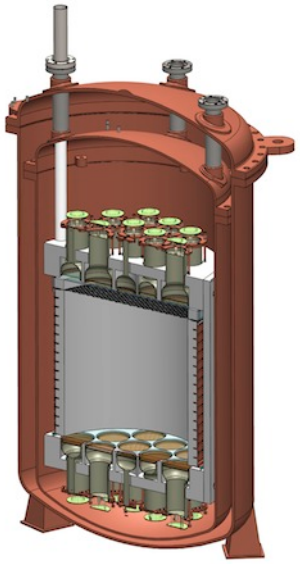
- Develop Boulby Underground Laboratory into a world-class facility that could potentially host a major international project in fundamental science.

- Typical experiment requirements and expectations of facility support
- Use cases for 50-500 tonnes liquid targets for Dark Matter and 1000kg solid targets for 0vBB derived from existing experiments/proposals
- Consultation with wider community (two meetings)
- Recommendation for future developments with timescales and costs

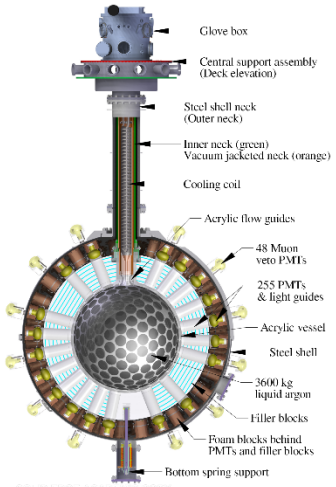
Report due mid-2021

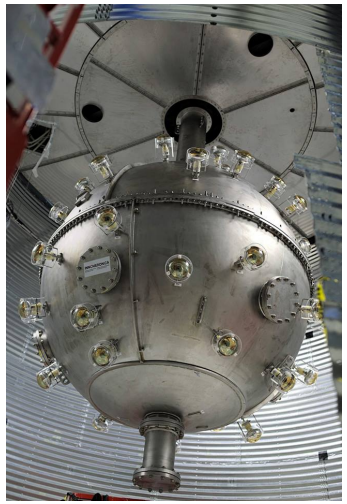
Next Generation Experiments Requiring Large Facilities

DS-50 – 50 kgms Xe

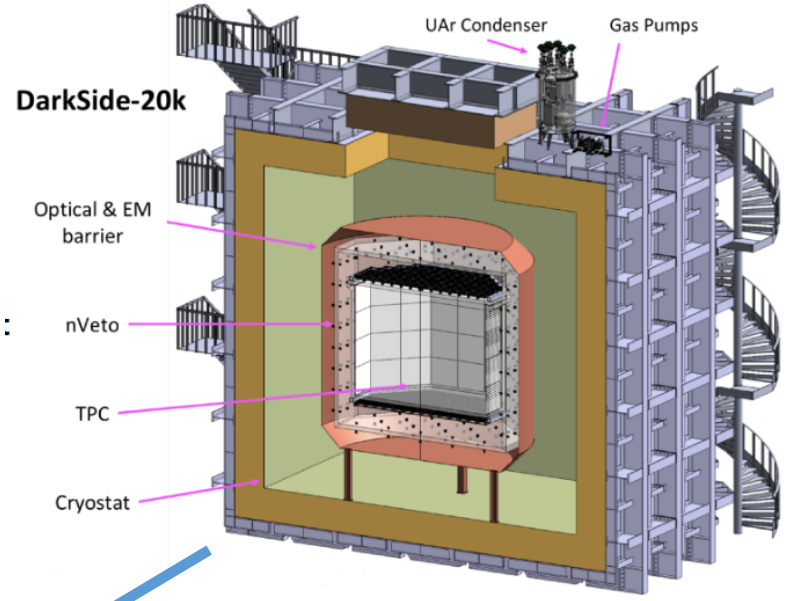


Argon

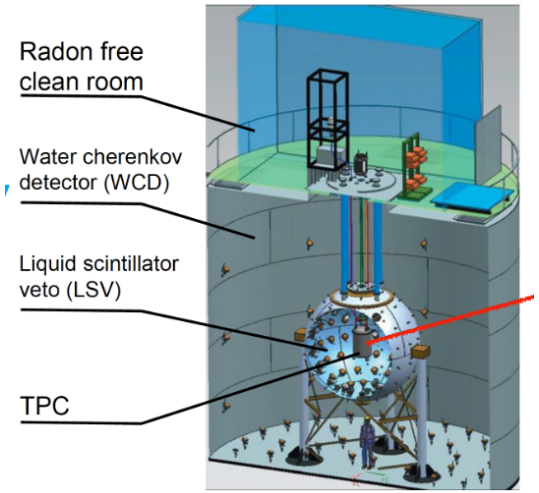




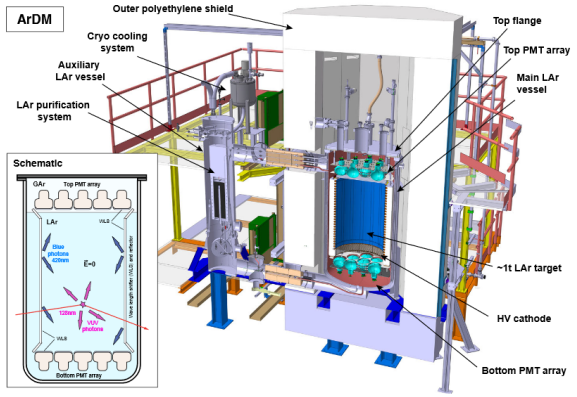
DS-20k – 50 tonnes Ar



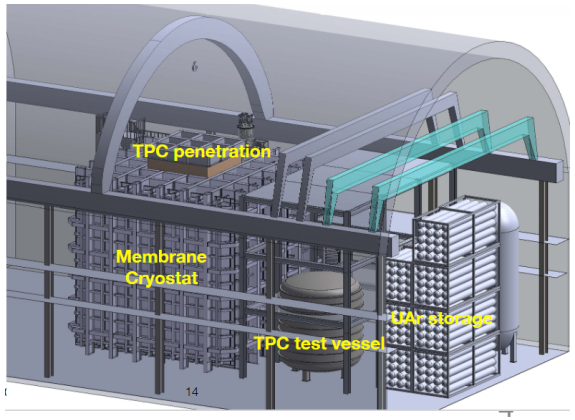
DEAP 3600 – 4 tonnes Ar



ArDM – 1 tonne Ar

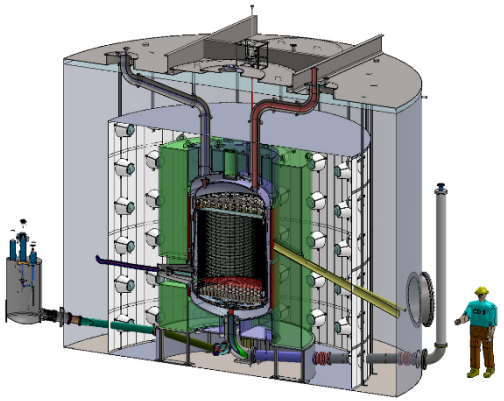


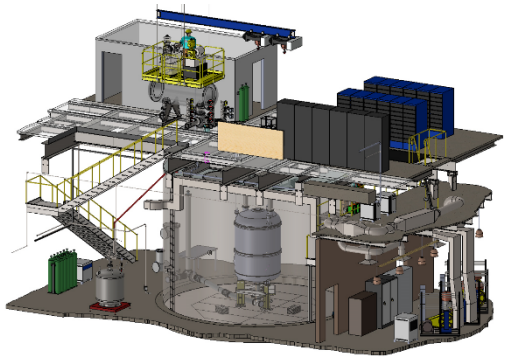
ARGO
370 tonnes



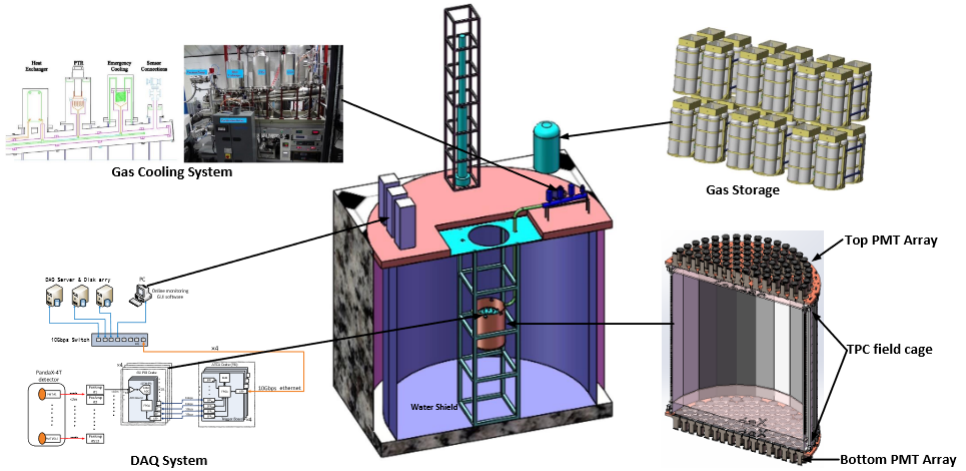
Next Generation Experiments Requiring Large Facilities

LZ – 11 tonnes Xe

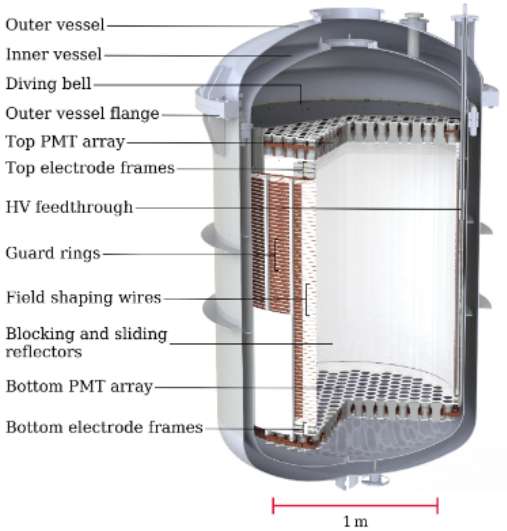


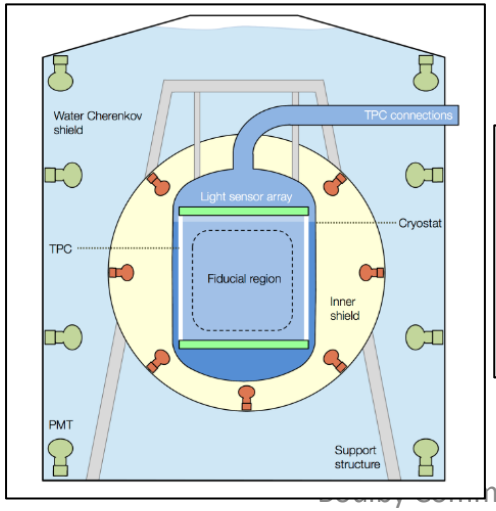


PandaX – 6 tonnes Xe



XenonnT – 8.5 tonnes Xe





DARWIN – 50 tonnes Xe

PandaX – 30 tonnes

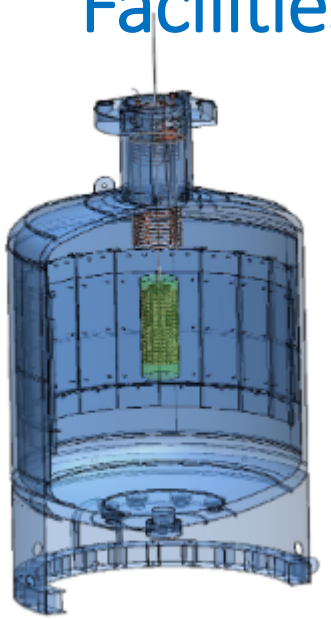
LXe G3 – 90 tonnes

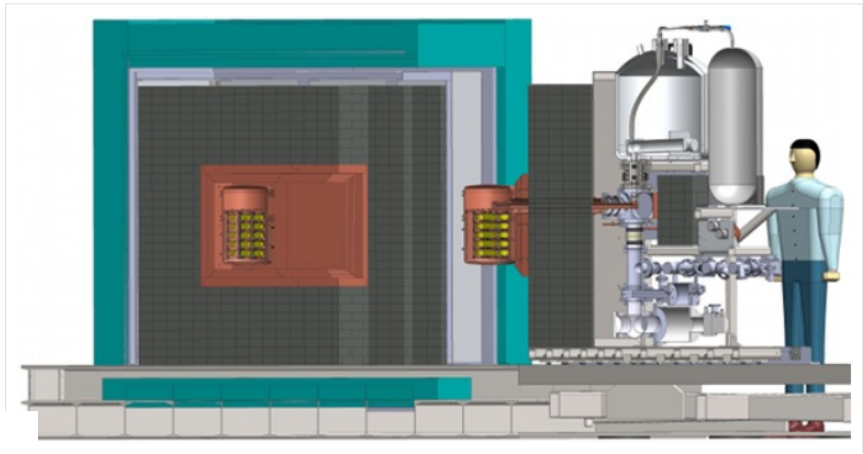
Xenon TPCs

Next Generation Experiments Requiring Large Facilities

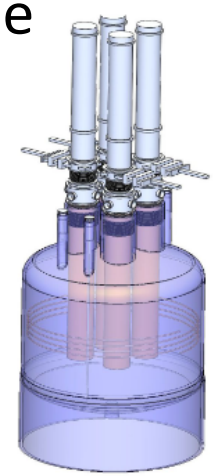
GERDA – 45 kg Ge

MAJORANA– 44 kg Ge





LEGEND – 200 kg Ge



LEGEND – 1 tonne Ge

ββ-decay

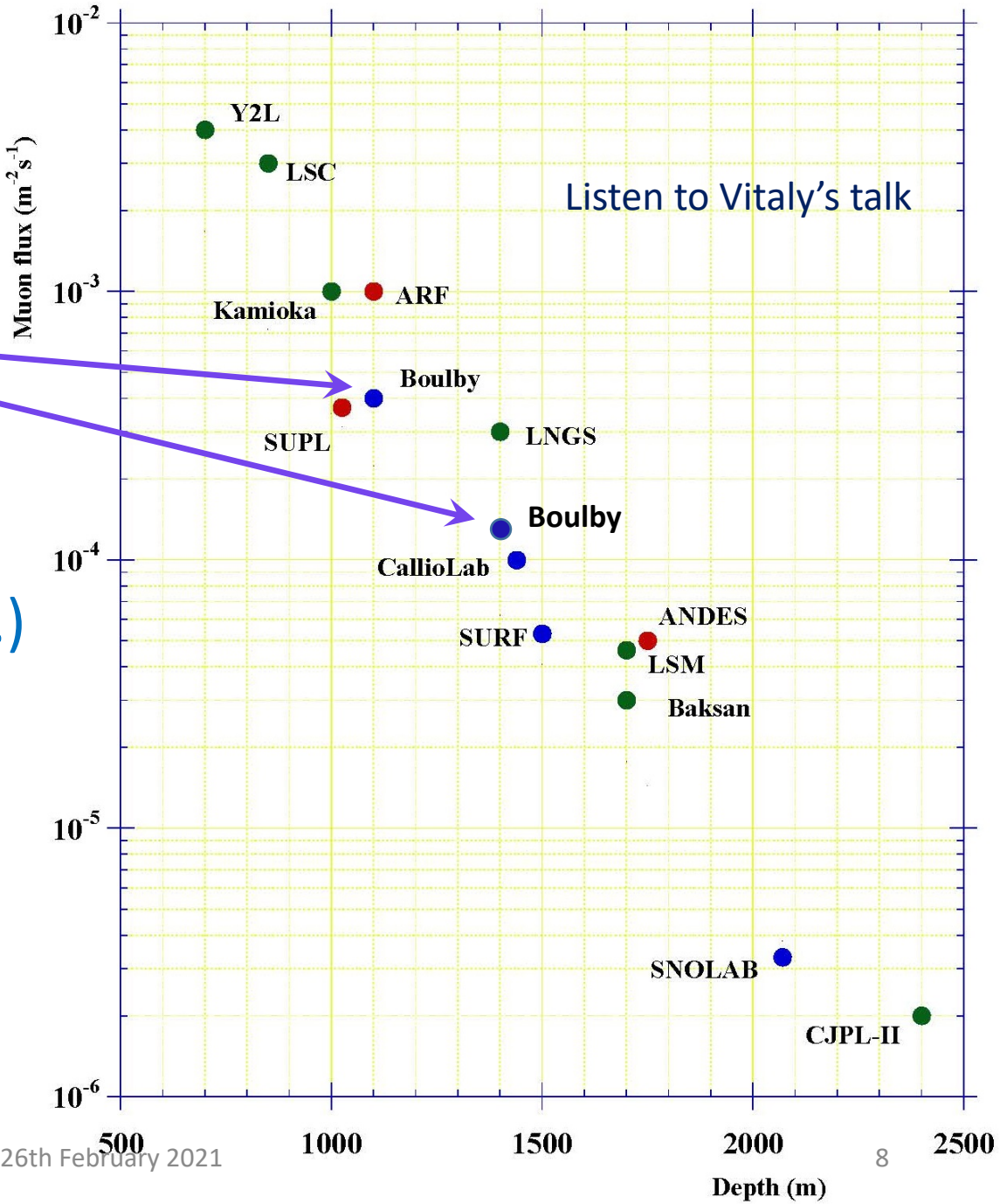
Item	LAr	LXe	$\beta\beta$ Decay	Comments
Target Material	liquid argon	liquid xenon	Germanium	
Target Mass	400 t	90 t	1 t	
Instrument				
Height (m)	7.0	3.9	~ 1.5	
Diameter/Width (m)	7.0	5.0	$(4\times)0.5$	
Cryostat Type	Membrane	Vacuum	Vacuum	
Veto/Shield				
Veto thickness (m)	3.0	0.65	3.0	
Veto type	LAr/Gd loaded plastic	Gd loaded liquid	LAr	
Shielding thickness (m)	1.5	2.2 – 4	2.5	
Shielding type	Cryostat wall	Water	Water	
Overall Footprint	15–18 m square	11 m diameter	12 m diameter	
Overall Height	15–18 m	12 m	12 m	
Ancillary Equipment				
Cooling	✓	✓	✓	
Gas circulation	✓	✓	✓	
Purification		✓	✓	
UG Depth				
1100 m	✓	✓	×	Muon-induced background
1400 m	✓	✓	✓	
Main Cavern Size Requirements				
Floor Area (m^2)	490	320	320	Assumed circular
Height (m)	25	25	25	

Underground Segment

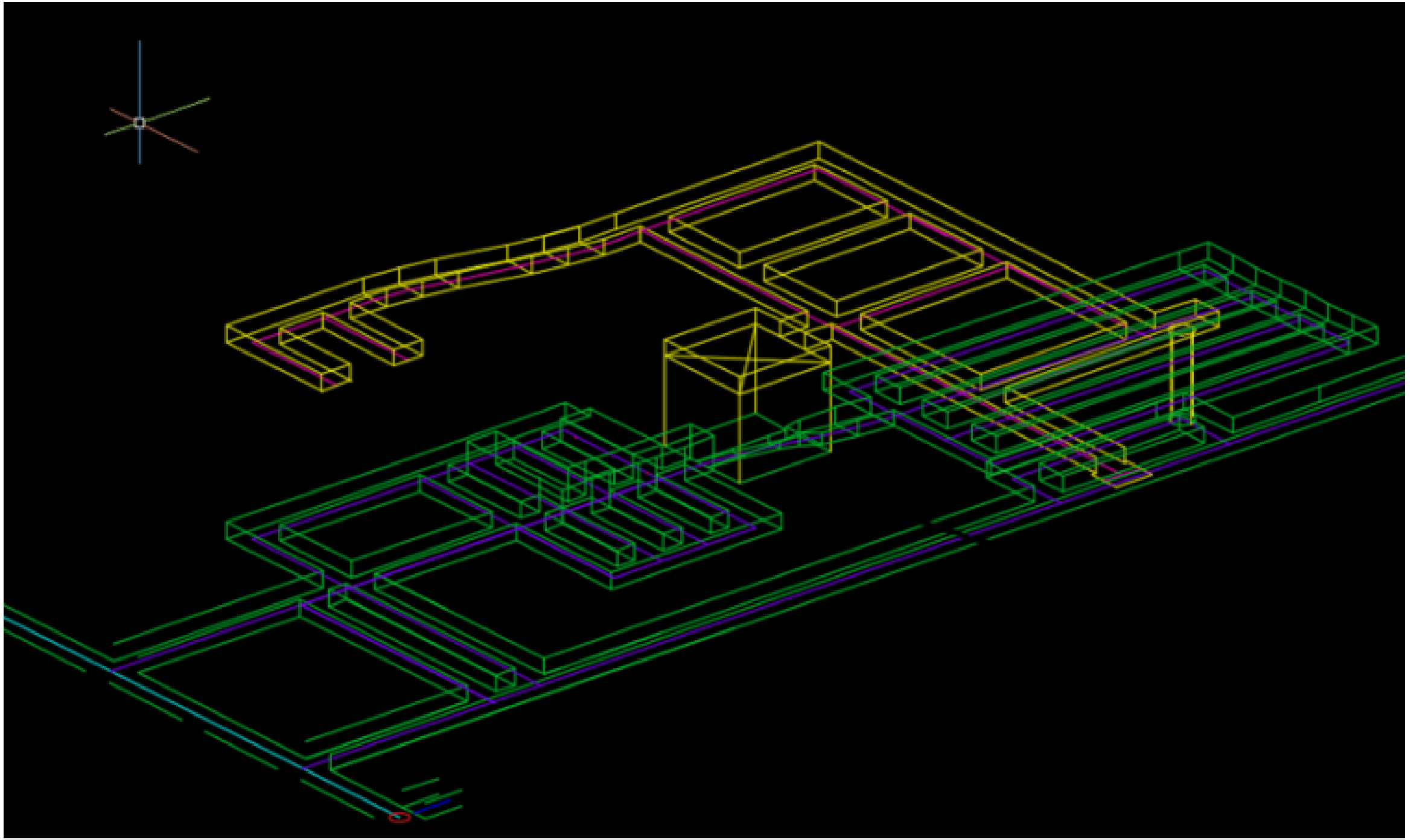
- Two sites under industrial study by ICL/AMCO
  - 1100 m and 1400 m
  - ~ 4000 m^2 space defined
  - Workshops
  - Cleanrooms
  - Experiment Hall (25m x 25m dia.)
  - Purification plants
  - Staging areas, etc

Surface Segment

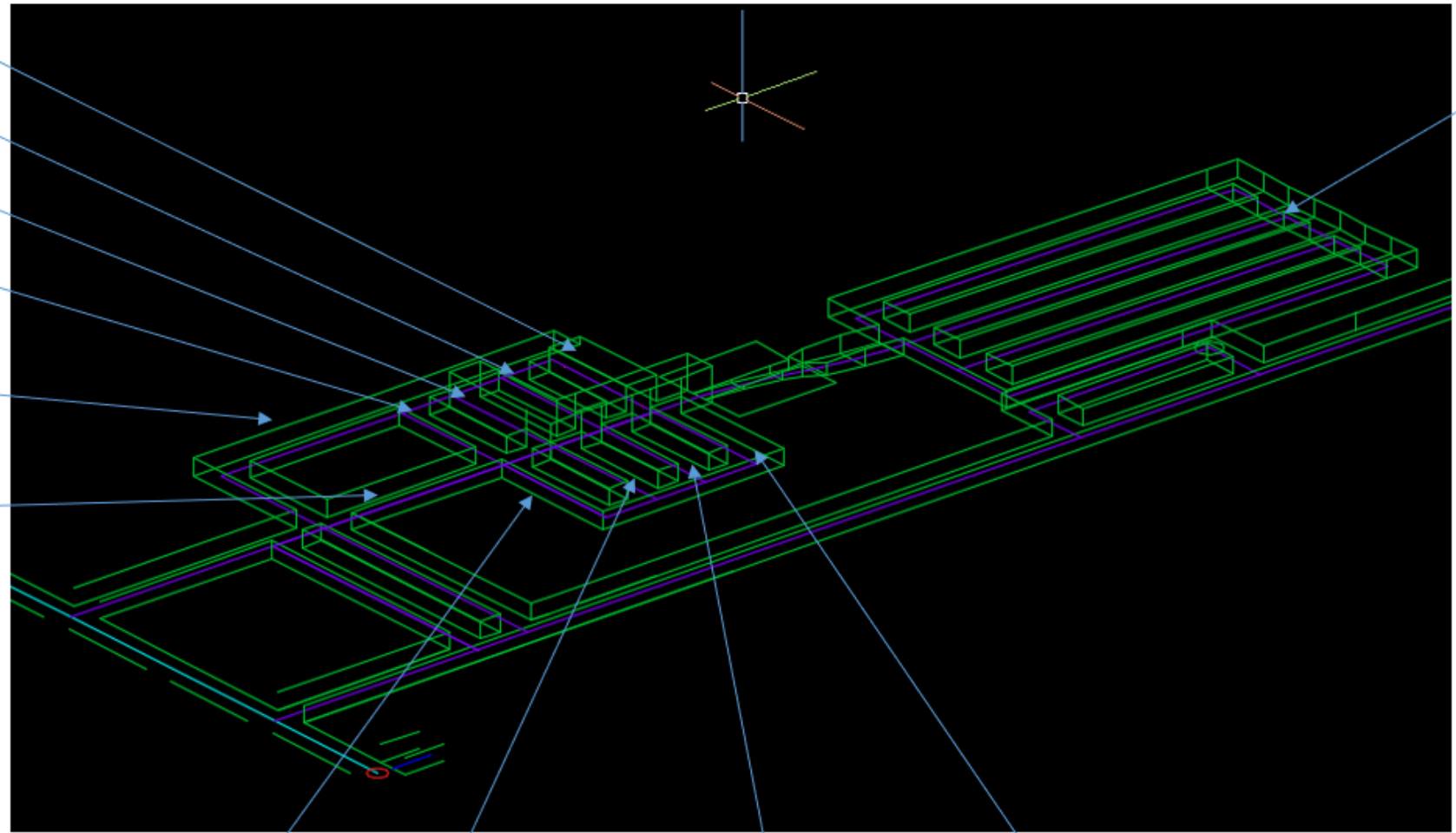
- ~ 30 fte support eventually
- Surface building



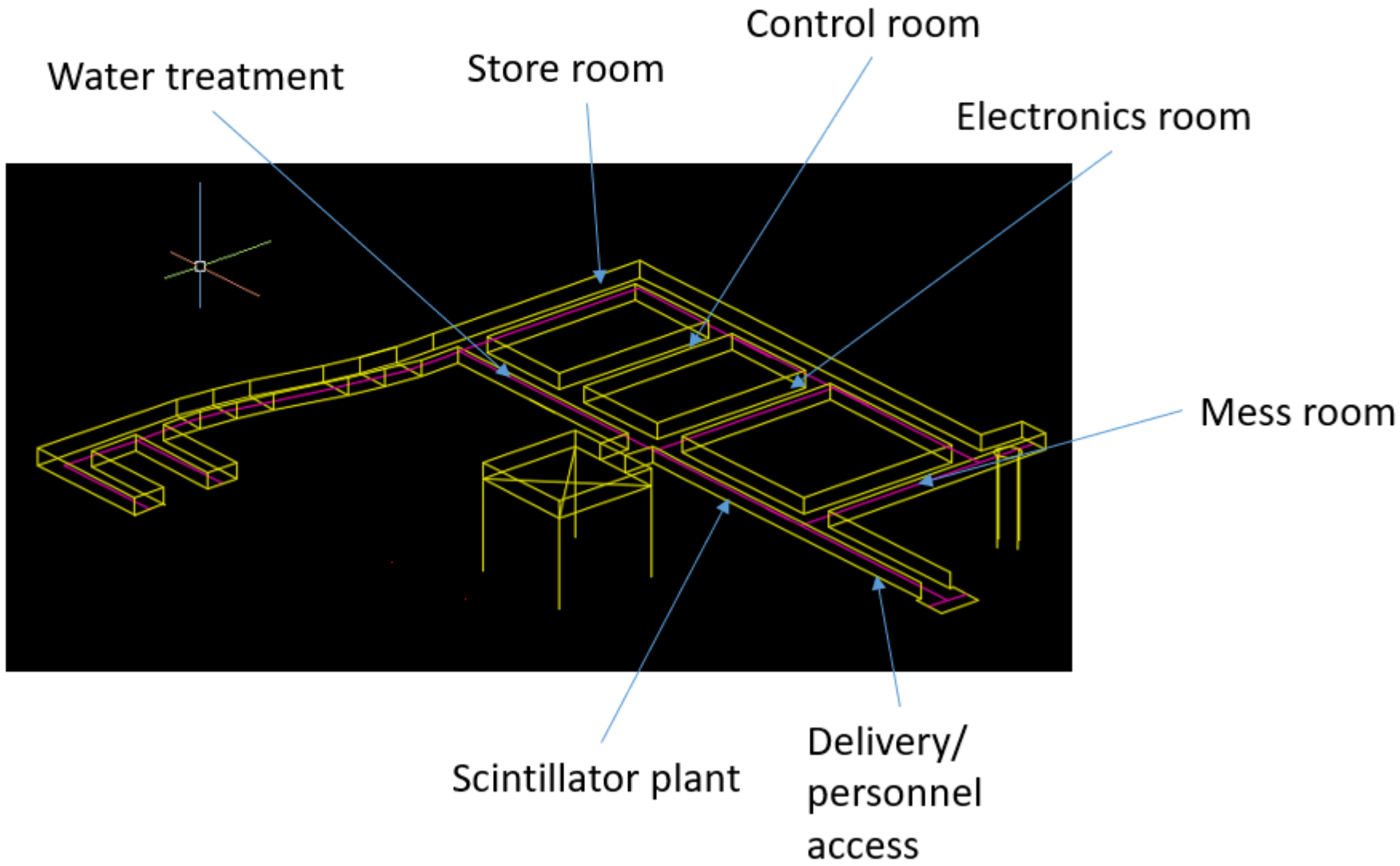
Item	Current	Option1	Option2	Units	Comments
Underground					
Depth	1,100	1,100	1,400	m	
Volume	7,200	25,650	27,560	m^3	'Current' does not include AIT/NEO
Laboratory Area	~ 800	3,800	4,300	m^2	
Muons	35.3	35.3	12	$/m^2/$ day	
Radon	<3	<3	[<3]	Bq/m^3	Option 2 TBC
Surface					
Staff	6	31	31	FTE	Not necessarily all local. ICL contribution not shown
Visitors	2-3	20-25	20-25	persons	Most intense during construction/commissioning
Building floor area		2,600	2,600	m^2	Includes offices, laboratories, workshops, rest rooms, changing facilities
Power					
Costs					
UG Construction	-	XXX	YYY	£M	
Surface Building	-	11.5	11.5	£M	Construction, fees, internal costs, 35% contingency
Power	-	XXX	YYY	£M	625 kVA backup generator plus cabling to UG
Operating				£M/pa	
Schedule					
Construction	-	XXX	YYY	months	
Lifetime		20	20	years	Design lifetime

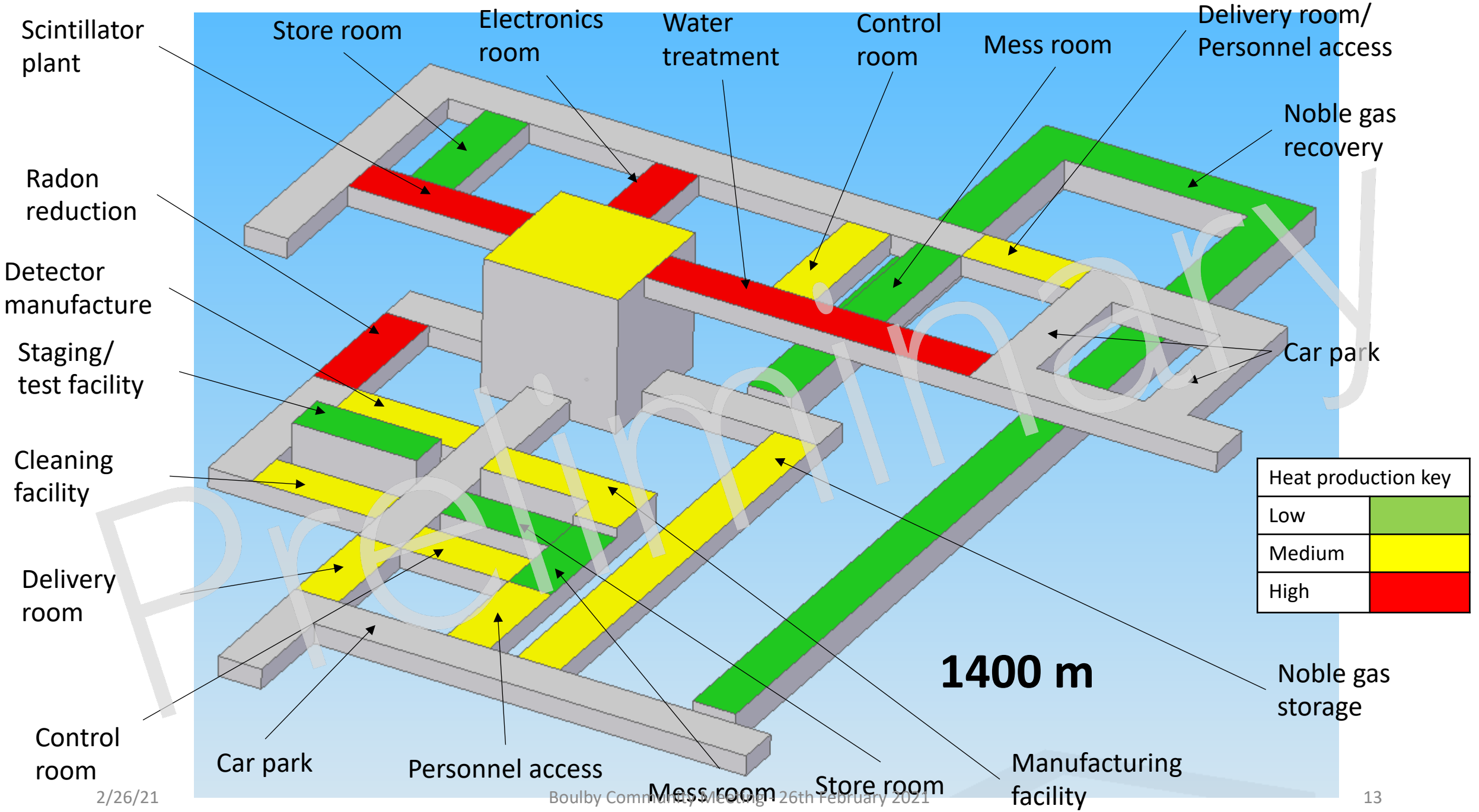


PH Layout Updates – Lower level



PH Layout Updates – Upper level





Function	FTE	Space (m^2)	Comments
Directorate			
Director	1.0	10	Office
Deputy Director	1.0	10	Office
Project Manager			Includes experiment liaison
PA to Director	1.0	10	Office
Operations/Admin.			
Facility Manager	1.0	10	Office
Mine Liaison	0.5		
Support(HR/Ins./etc)	1.0	10	Office
Safety	4.0	40	Offices - facility safety, experiment safety
Finance	2.0	20	Offices - includes procurement
IT	2.0	20	Offices
Maintenance	4.0	40	Includes cleaning (surface and UG)
Medical Support	1.0	10	Includes site specific training
PR/Outreach	3.0	30	
Science Support	2.0	30	
Technical Support	3.0		Includes specialist cleanroom
Goods Manager	1.0	10	
Receptionist	1.0		
Workshops			
Technician	2.0	10	Office
Mechanical W/S		50	Workshop
Electronics W/S		50	Workshop
Laboratories			
Development		100	General R&D, prototyping
Assembly/Integration		100	Clean room facility
Control Room		20	Experiment control/monitoring
Meeting Rooms			
Conference Room		200	To allow 'off-site' access?
Meeting Room		50	
Meeting Room		50	
User/Staff Facilities			
User Offices		100	20 desks
General Area		100	informal
Kitchen/Seating Area			
W/Cs			
Changing Rooms			
Showers			
Medical Room			
Laundry			
Storage General storage			Stationary, IT, cleaning, tools, etc
PPE room			Lamps, self rescuers, gowns, boots, etc
Delivery			
Short-term store			
Long-term store			
Totals	30.5 FTE	1,080 m^2	

Surface Building Requirements

- Staff levels
  - Functional roles within facility if a major experiment is attracted to Boulby - ~30 FTE
- Visitor levels
  - 25-30 per day (construction/commissioning)
  - User facilities expected of a well founded site

Review/Cost by STFC Estates using industry standards.

Laboratory		Overburden m	Overburden mwe	Muons /m^2/d	Volume m^3	Radon Bq/m^3	Access	Mining	Operator	Refs.
LSC (Canfranc)	SP	850	1,155	371	10,000	100	H	N	U. Zaragoza	[7]
Kamioka	JP	1,000	2,700	86.4	150,000	80	H	N	ICRR/U. Tokyo	[4]
BUL (Boulby)	UK	1,400	3,560	12	27,600	<3	V	Y	STFC	[1]
LNGS (Gran Sasso)	IT	1,400	3,400	29.5	180,000	80	H	N	INFN	[6]
LSM (Modane)	FR	1,700	4,800	5.4	3,500	15	H	N	CNRS/CEA	[5]
SURF (Sanford Lab)	USA	1,490	4,300	4.6	7,160	300	V	N	SDSTA	[8]
SNOLAB	CA	2,070	6,010	0.27	30,000	130	V	Y	SNOLAB Institute	[10]
CJPL (Jinping)	CN	2,400	6,720	0.17	300,000	40	H	N	U. Tsinghua	[2]

Laboratory		Projects	Directorate	Managers	Officers	Others	Total FTE	Budget M£ pa	ISC	Refs.
LSC (Canfranc)	SP	8	6				12		9	[7]
Kamioka	JP	7	1	20	10		94			[4, 28]
BUL (Boulby)	UK	8					30			[1]
LNGS (Gran Sasso)	IT	17	7	21	18		100	11.5	10	[6, 20]
LSM (Modane)	FR	7–9	4	2	2	5	13	0.8		[5, 25]
SURF (Sanford Lab)	US	5	9				150	17.7		[8, 11]
SNOLAB	CA	12	4	6	5		135	11.0		[10]
CJPL (Jinping)	CN	5	6	4			[20]		10	[2, 24, 28]

Challenges – listen to talk by Paul

- Vertical access restrictions
- Underground safety
- Target recovery (
- Limited scheduled rides
- ….

Opportunities

- World class facility
- Leverage of UK lead roles
- ‘Local’ workplace
- …

Interested?

- Brief science description
- Concept design for experiment
- Location (existing lab, new lab, 1100, 1400)
- ….

Top level estimated requirements

- Size, power, data, …
- Specialist materials
- Specialist processing
- …

TO BE DISCUSSED IN MORE DETAIL AT NEXT WORKSHOP MEETING IN TWO WEEKS