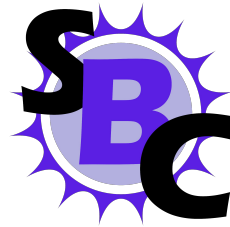


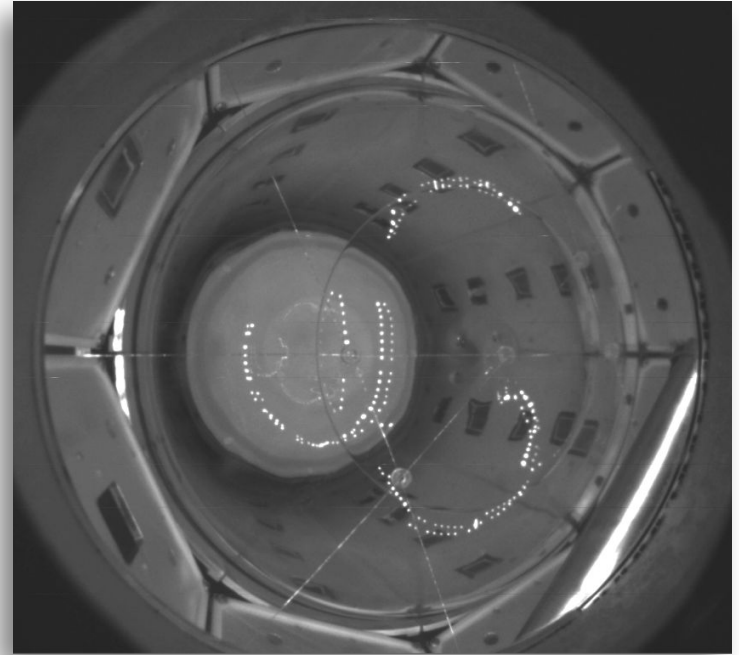
Towards a Low-Mass WIMP Search with the Scintillating Bubble Chamber

Gary Sweeney
for the SBC Collaboration

CAP Congress 2026
Ottawa, Ontario



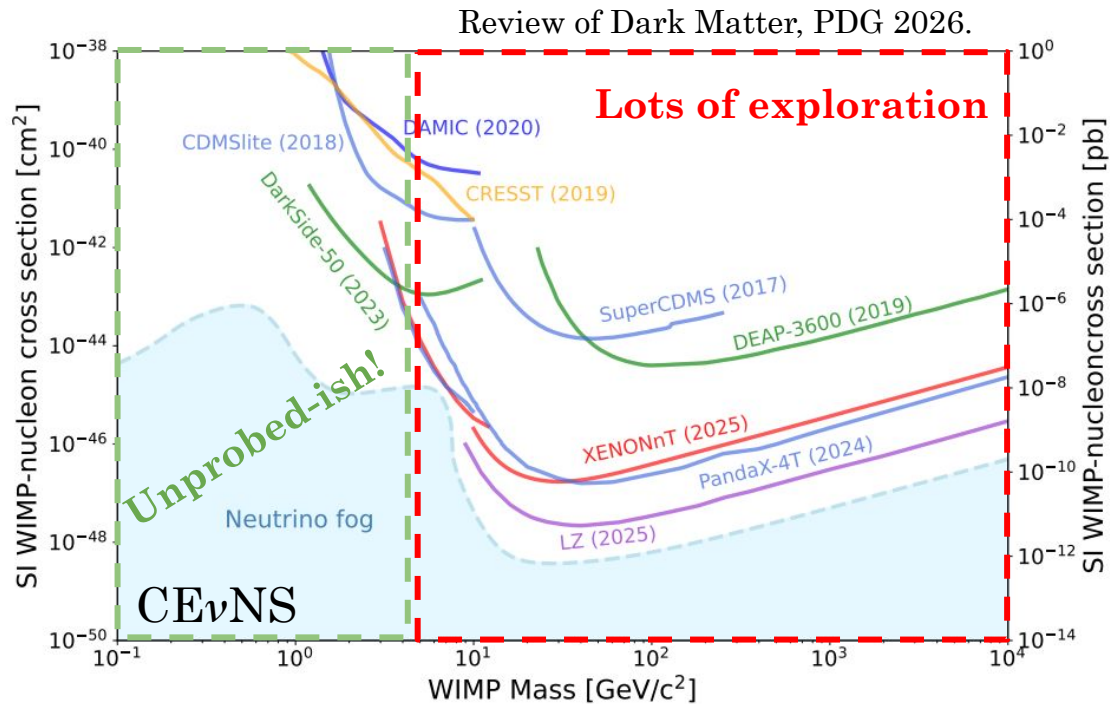
Arthur B. McDonald
Canadian Astroparticle Physics Research Institute



Towards Lower Masses



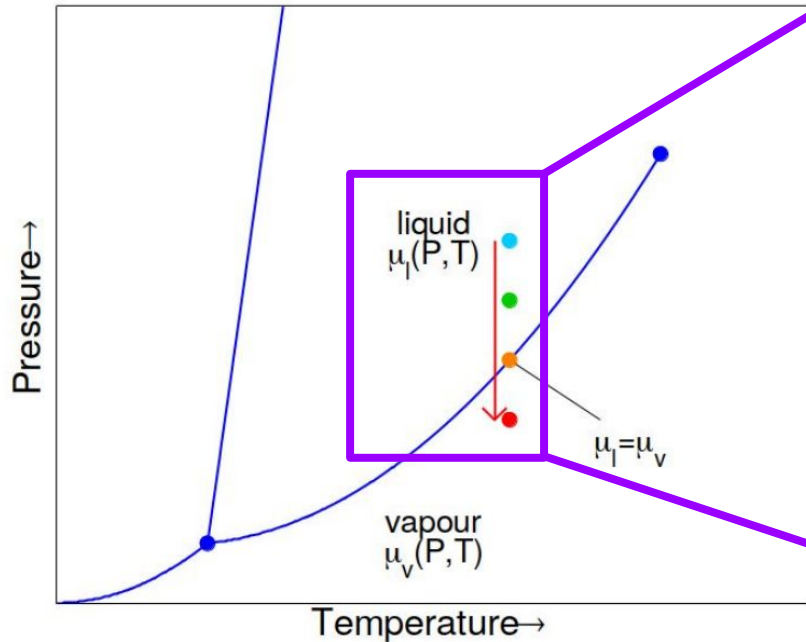
- Canonical WIMP parameter space heavily explored \rightarrow low mass theories becoming more popular.
- GeV-scale WIMP-nucleon scattering requires sub-keV nuclear recoil thresholds.
- Increased challenges from detector size and background control.
- Useful for $CE\nu NS$ studies!



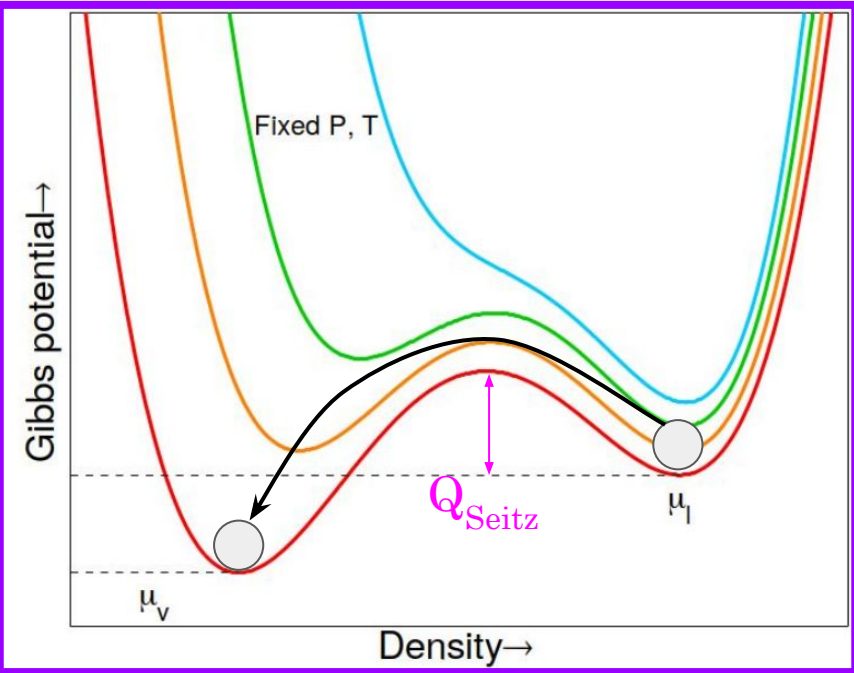
Liquid Noble Bubble Chambers



- Bubble chamber technology with a liquid noble as the target fluid.



More on this tomorrow!

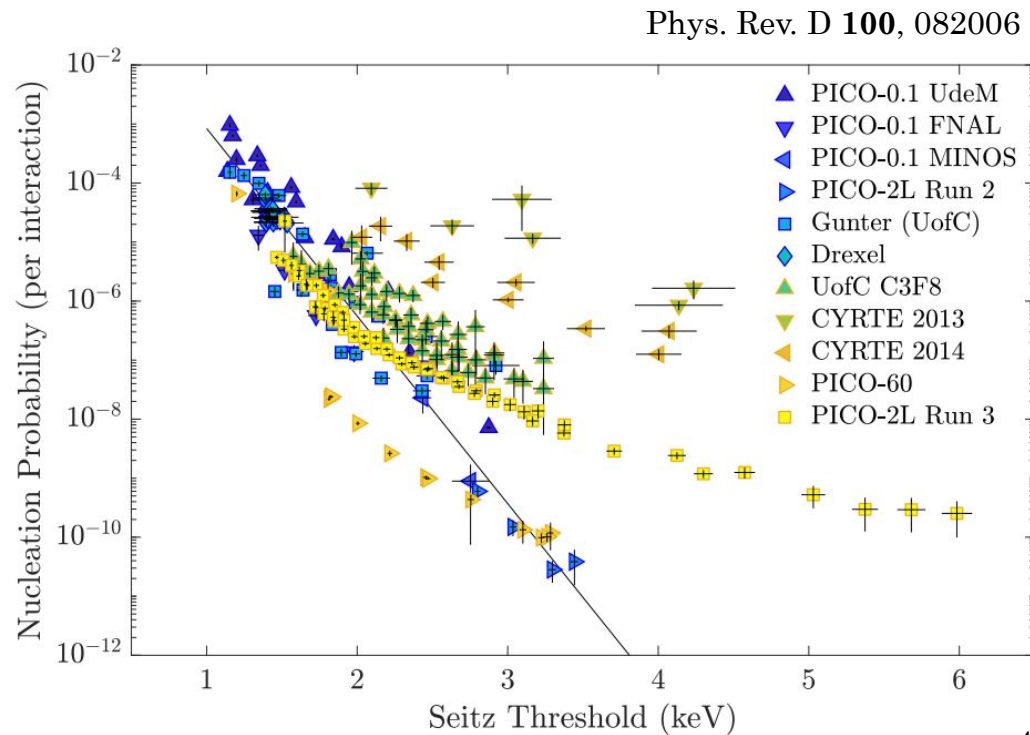
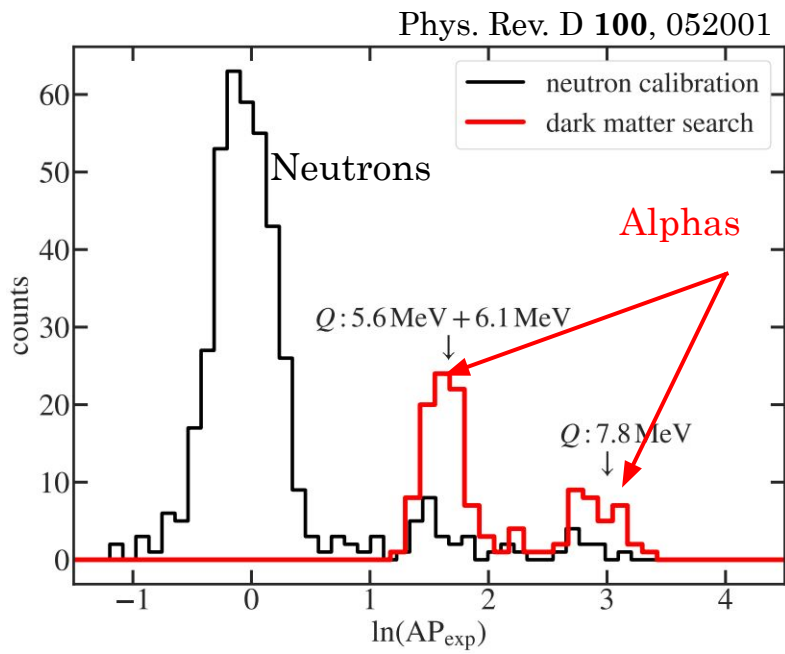


If deposited Energy $> Q_{Seitz}$ → bubble!

Liquid Noble Bubble Chambers



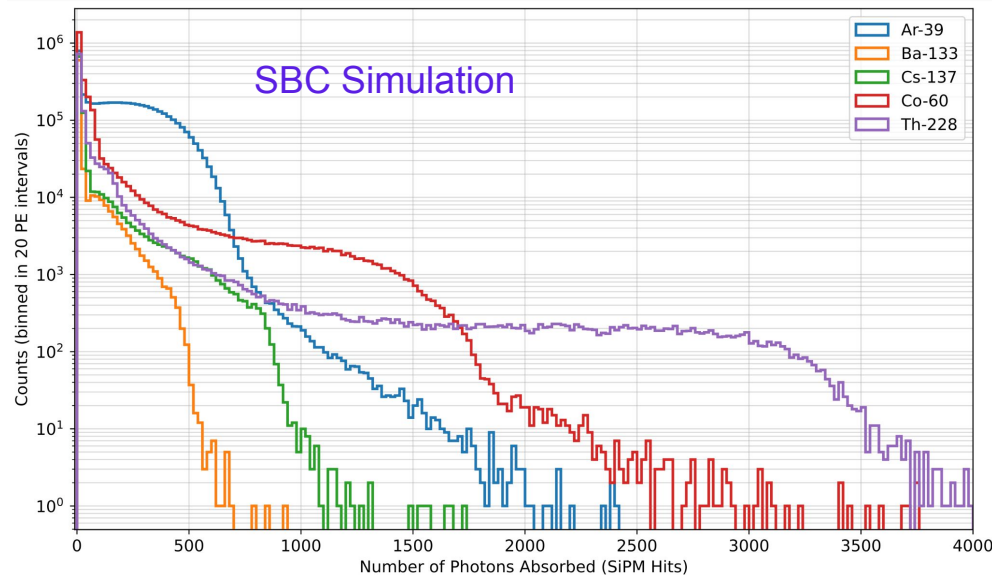
- Bubble chambers provide:
 - Controlled threshold.
 - Electron recoil rejection.
 - Acoustic identification.



Liquid Noble Bubble Chambers



- Bubble chamber technology with a liquid noble as the target fluid.
- Bubble chambers provide:
 - Controlled threshold.
 - Electron recoil rejection.
 - Acoustic identification.
- Liquid noble scintillators provide:
 - Excellent light yields, $O(10 \text{ ph/keV})$.
 - Energy reconstruction.

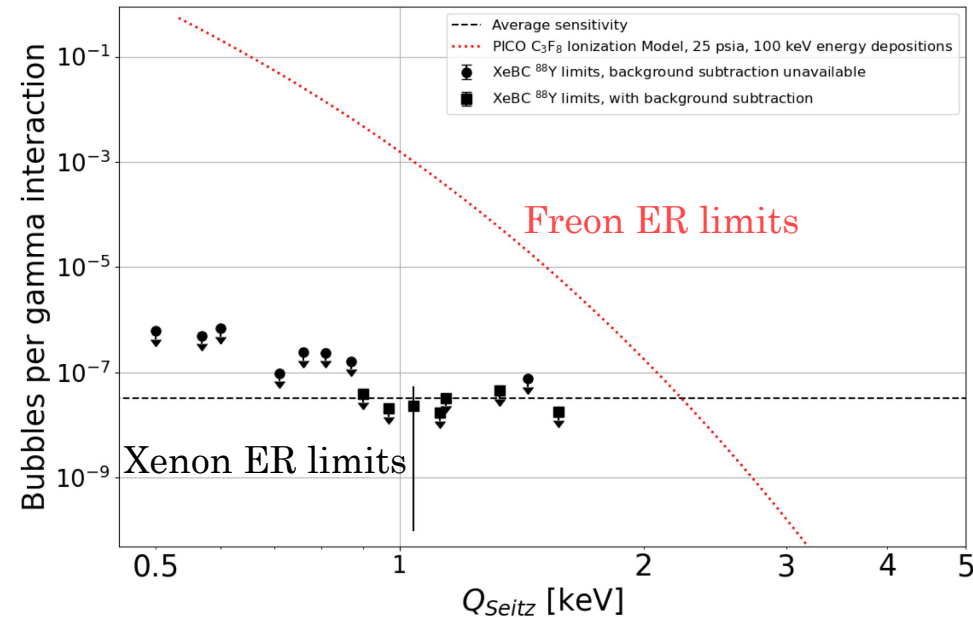


Liquid Noble Bubble Chambers



- Bubble chamber technology with a liquid noble as the target fluid.
- Bubble chambers provide:
 - Controlled threshold.
 - Electron recoil rejection.
 - Acoustic identification.
- Liquid noble scintillators provide:
 - Excellent light yields, $O(10 \text{ ph/keV})$.
 - Energy reconstruction.
- Added benefits from atomic targets.

Phys. Rev. D **111**, 032002 and *Universe* **2023**, 9(8), 346

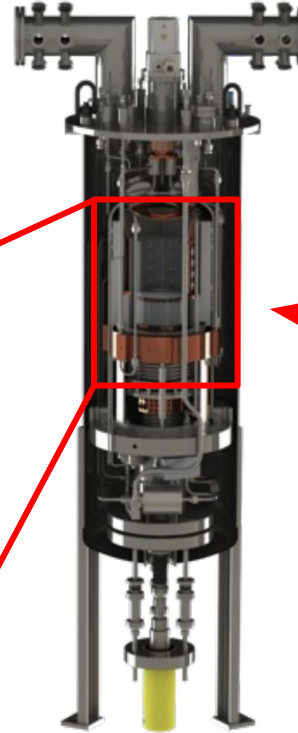
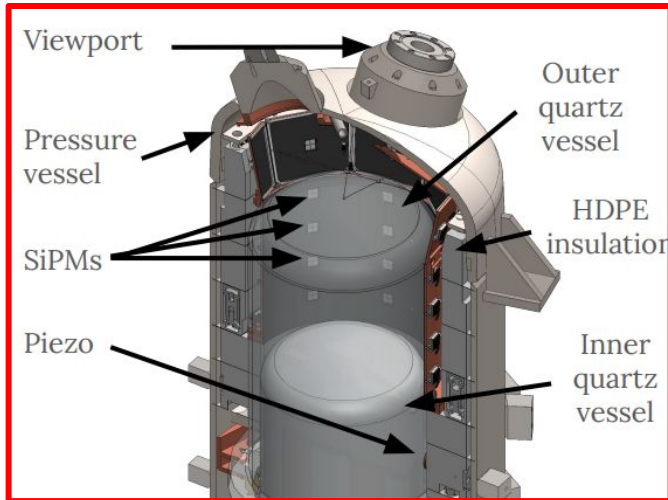


XeBC showed no evidence of ER induced bubble nucleation down to 500 eV.

SBC-LAr10



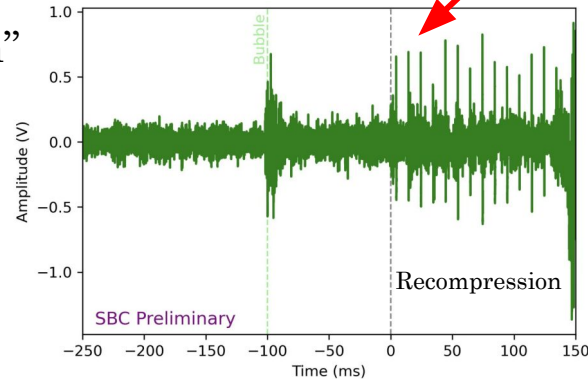
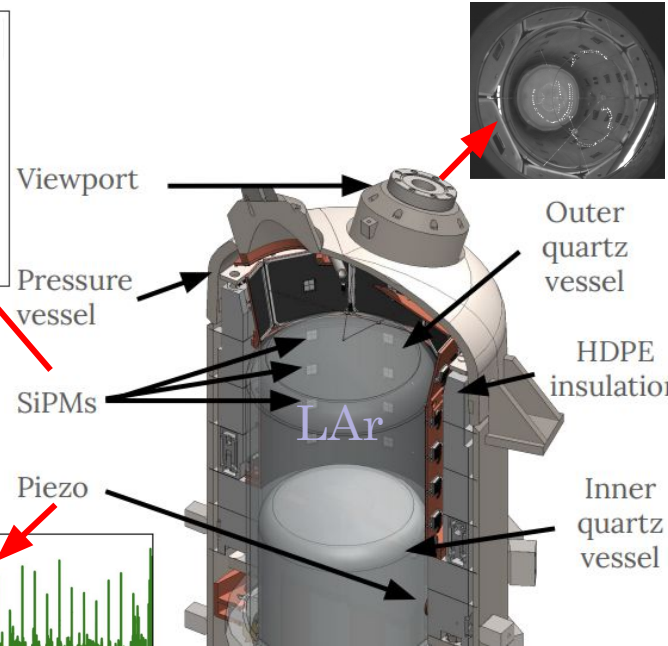
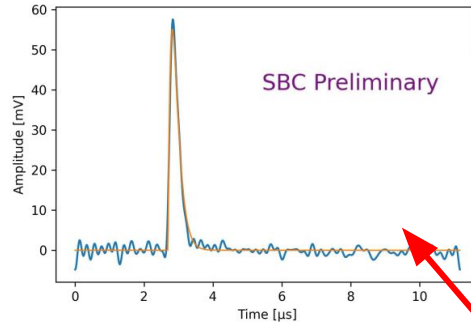
- First chamber developed for engineering and calibration runs.
- Target: xenon doped liquid argon (doping level ~ 100 ppm).



SBC-LAr10



- First chamber developed for engineering and calibration runs.
- Target: xenon doped liquid argon (doping level ~ 100 ppm).
- 24 LAr-facing silicon photomultipliers (SiPMs) to collection scintillation.
- 8 piezoelectric transducers to “listen” to the bubble formation.
- 3 cameras 22° off-norm to provide positional information.



SBC-LAr10 – Calibration Plan



- Achieve and maintain stable operation at O(100 eV) thresholds.

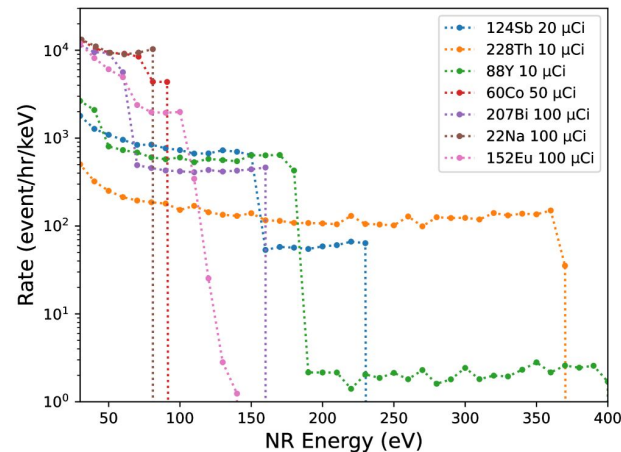
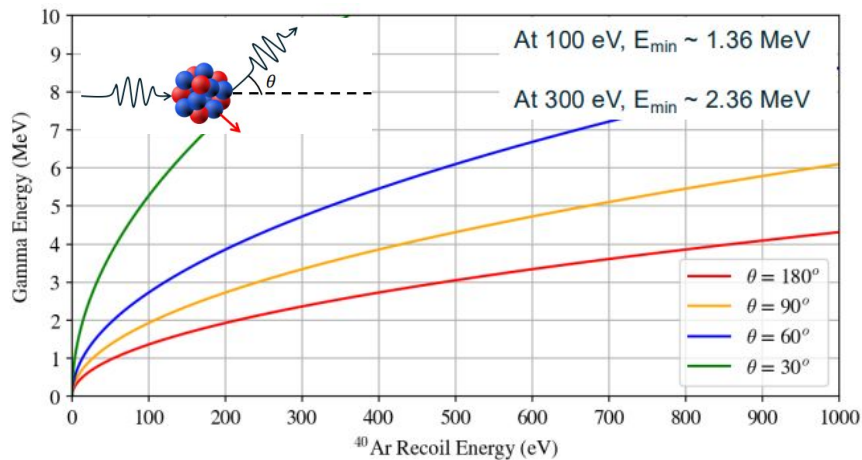
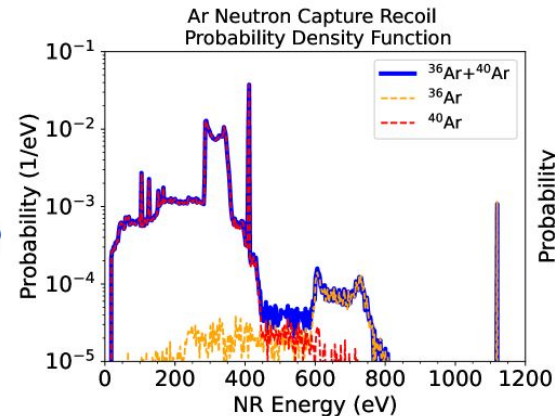
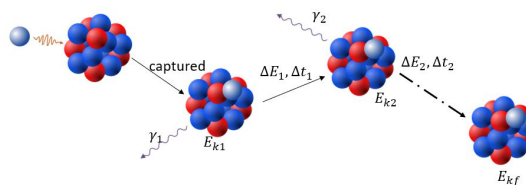
Design Goals	
Target Volume	10 L (10 kg LAr @ 130 K)
Nucleation Threshold	100 eV (30 psi , 130 K)
Thermodynamic Regulation	± 0.5 K, ± 0.1 bar, (± 5 eV Seitz threshold)
Scintillation Detection	~2% collection, 1 photon/ 5 keV n.r.
Bubble Imaging	100 fps, mm resolution
Acoustic Reconstruction	Time-of-nucleation to ± 25 μ s

SBC-LAr10 – Calibration Plan

See our calibration plan:
JINST 21 (2026) 03, P03020



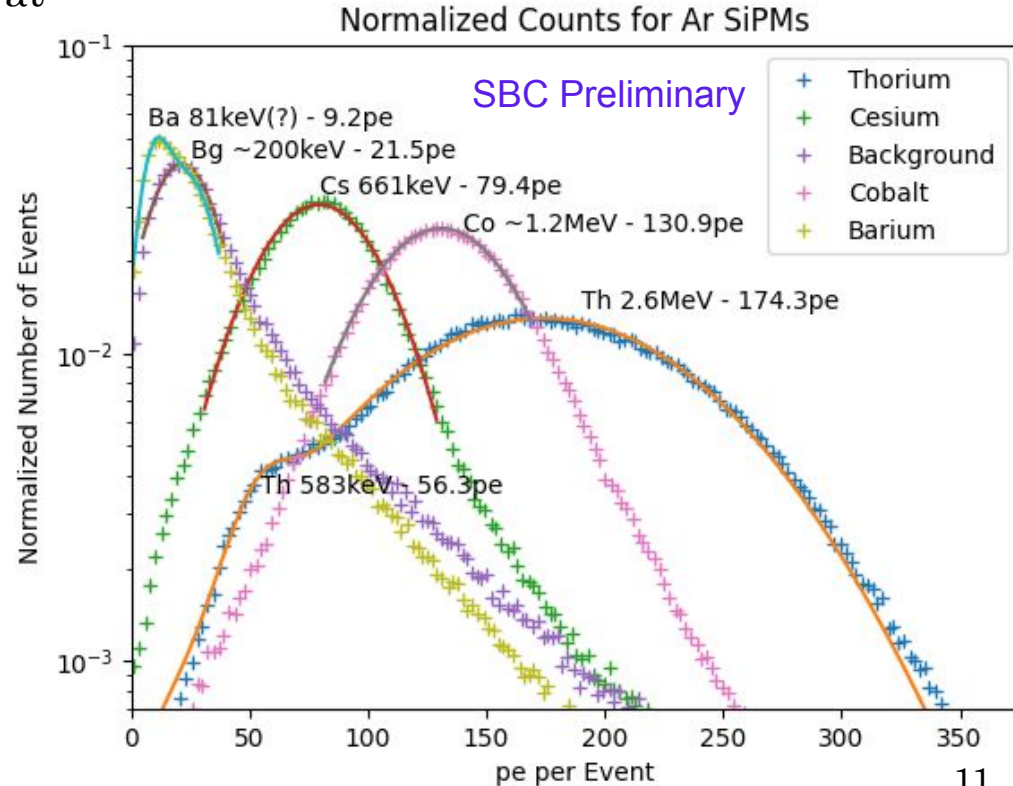
- Achieve and maintain stable operation at O(100 eV) thresholds.
- Calibrate nucleation threshold and understand potential backgrounds:
 - n-capture induced nucleation.
 - Gamma-induced nucleation.



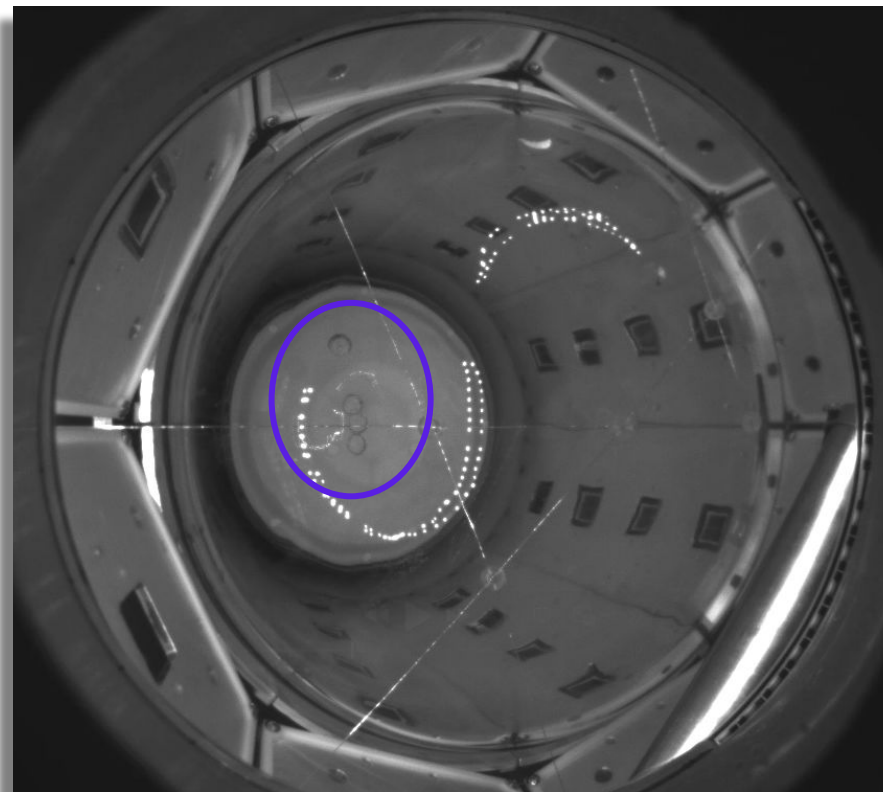
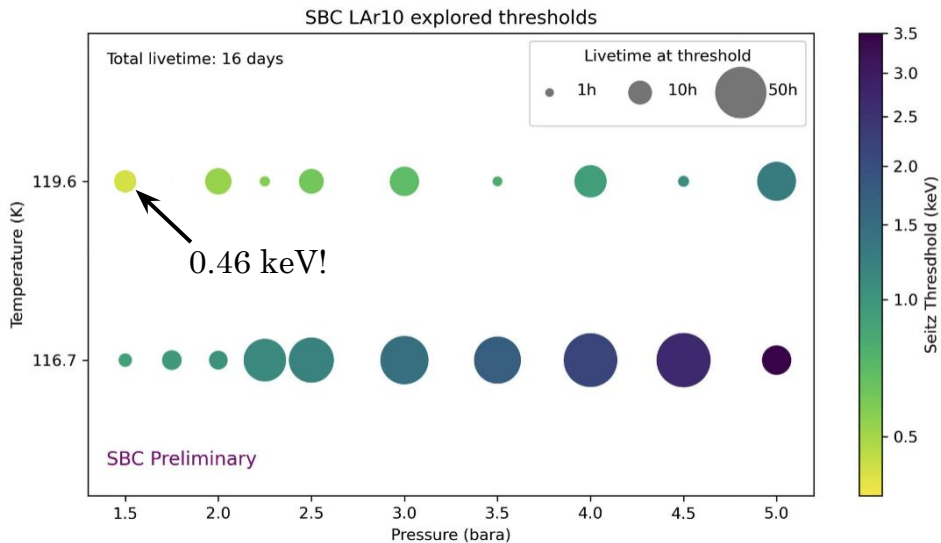
SBC-LAr10 – Calibration Plan



- Achieve and maintain stable operation at $O(100 \text{ eV})$ thresholds.
- Calibrate nucleation threshold and understand potential backgrounds:
 - n-capture induced nucleation.
 - Gamma-induced nucleation.
- Determine photon collection efficiency and estimate limits for energy reconstruction.



SBC-LAr10 – Calibration Plan

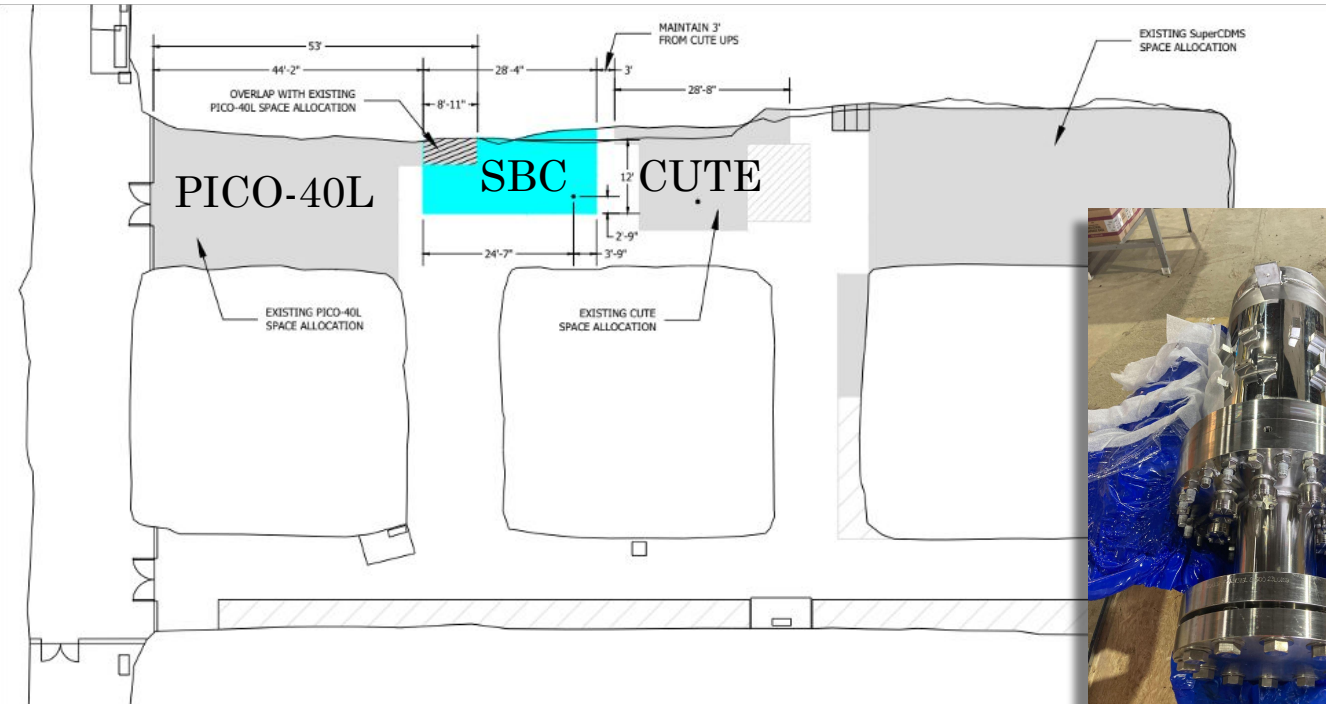


- First run complete, analysis ongoing!

SBC-SNOLAB



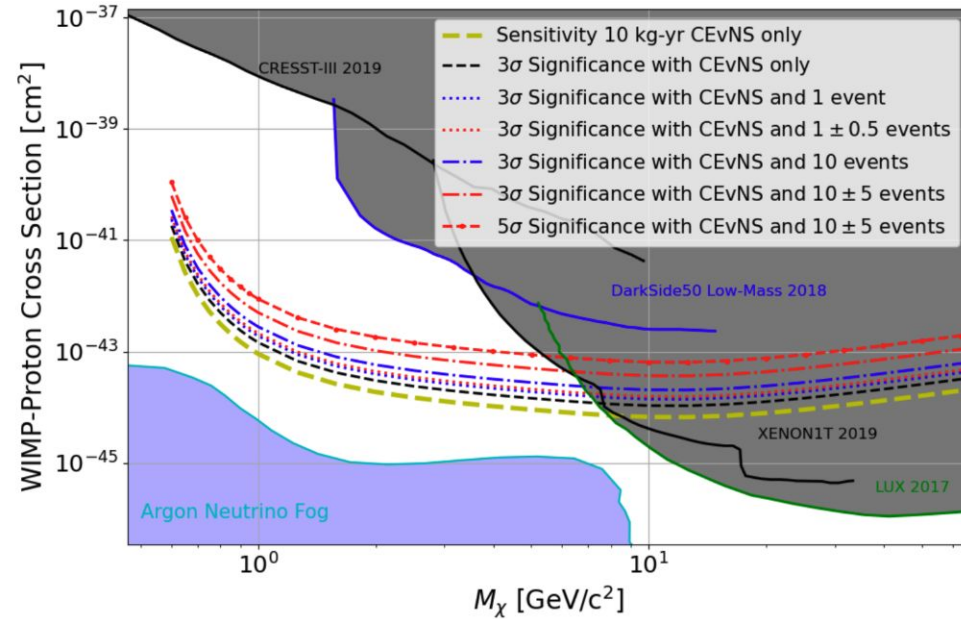
- Radiopure clone of SBC-LAr10 to be operated deep underground at SNOLAB.



Pressure vessel and vacuum jacket at SNOLAB!

- Radiopure clone of SBC-LAr10 to be operated deep underground at SNOLAB.
- Perform a WIMP search at 100 eV targeting the 1-10 GeV parameter space.
- Challenges posed by sub-keV scale NRs induced by neutrons and gammas.

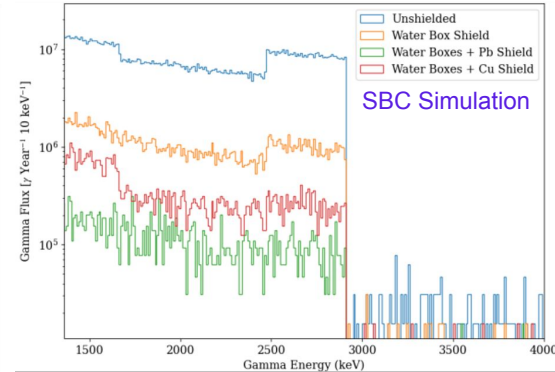
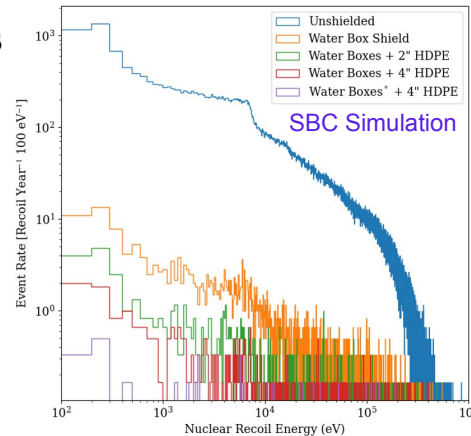
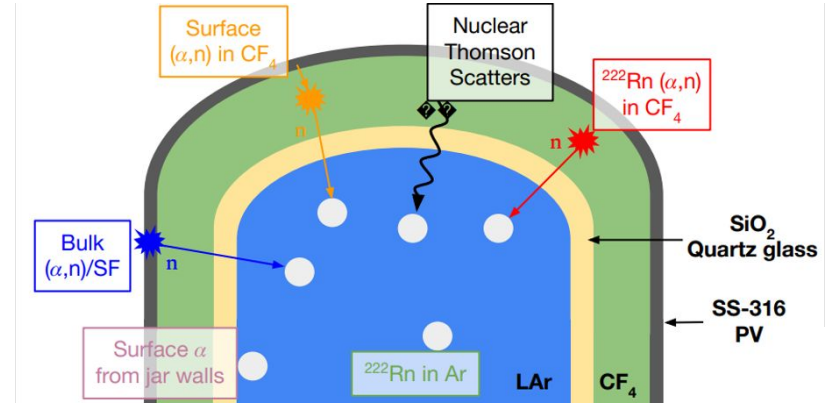
M. J. Bressler, PhD thesis, Drexel University, 2022.



SBC-SNOLAB



- Radiopure clone of SBC-LAr10 to be operated deep underground at SNOLAB.
- Perform a WIMP search at 100 eV targeting the 1-10 GeV parameter space.
- Challenges posed by sub-keV scale NRs induced by neutrons and gammas.
- Extensive work ongoing with material radiopurity and external shielding design.



SBC-SNOLAB – Current Progress



- Majority of detector materials have been assayed and analyzed for background contributions.

Gamma Counting - HPGe Counters								
Part	Th-232		U-238 Upper Chain (U-238 to Th-230)		U-238 Lower Chain (Ra-226 to Pb-206)		U-235	
	mBq/kg	ppb	mBq/kg	ppb	mBq/kg	ppb	mBq/kg	ppb
Silver Plated Bolts	3.42 ± 1.10	0.84 ± 0.27	< 63.11	< 5.11	< 1.40	< 0.11	< 0.79	< 1.4
SS 304 (welded HSS tubes)	4.50 ± 2.51	1.11 ± 0.62	< 73.78	< 5.98	< 1.61	< 0.13	< 0.93	< 1.64
SS 316 (IA Bellow Support Flange)	15.84 ± 1.97	3.9 ± 0.48	< 42.9	< 3.47	4.94 ± 0.86	0.4 ± 0.07	< 0.57	< 1
Copper (SiPM Panel Petals)	< 1.03	< 0.25338	30.31 ± 15.16	< 0.03	< 0.15	< 0.01215	< 0.22	< 0.39
HDPE	2.85 ± 0.66	0.7 ± 0.16	< 25.16	< 2.04	15.63 ± 0.94	1.27 ± 0.08	< 0.26	< 0.46
PTFE	< 9.43	< 2.32	< 292.9	< 23.73	< 4.7	< 0.38	< 4.56	< 8.03
Formlabs Photopolymer Resin	< 0.32	< 0.07872	< 9.12	< 0.74	0.89 ± 0.31	0.072 ± 0.025	< 0.25	< 0.44
Formlabs 3D Printed Mounts	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
FBK SiPMs	< 6.48	< 1.59	< 15.80	< 1.28	< 2.03	< 0.16	< 1.24	< 2.18
Cirtex PCB Boards	< 42.74	< 10.51	< 339.20	< 27.48	< 7.47	< 0.61	< 11.52	< 20.27
Brass Pins	9605 ± 372	2360 ± 90	9792 ± 758.6	793.15 ± 61.45	4972 ± 196.5	402.73 ± 15.92	282.6 ± 19.92	497.38 ± 35.06
Kapton Coated SiPM Coaxial Cables	< 46.6	< 11.46	< 630.2	< 51.05	< 2.87	< 0.23	< 6.25	< 11
Silver Epoxy	< 13.30	< 3.27	< 892.6	< 72.3	< 7.54	< 0.61	< 10.43	< 18.35
Kapton Coated RTD Wires	< 23.91	< 5.89	< 65.03	< 5.27	< 5.92	< 0.48	< 2.43	< 4.27
HSQ-900 Quartz (unpolished)	16.72 ± 8.16	4.11 ± 2.01	< 115.94	< 9.39	< 1.96	< 0.16	1.75 ± 1.29	3.07 ± 2.27

Alpha Counting			
Part	Alpha Emissivity	Analysis Method	Notes
	nBq/cm2		
HDPE	332.6 ± 240.8	XIA Ultra10-1800	
Copper - Polished	1938 ± 544	XIA Ultra10-1800	Side 1 - was pretty clean, just needed wipe down
Copper - Unpolished	2822 ± 540	XIA Ultra10-1800	Side 2 - required extensive cleaning
FBK SiPMs	1470 ± 92	XIA Ultra10-1800	
Fused Silica Sample	10,361 ± 531	XIA Ultra10-1800	
PTFE	< 49	XIA Ultra10-1800	Upper limits reported due to limited statistics
SS-316 flange coupon	1742 ± 96	XIA Ultra10-1800	
Copper Petal	783 ± 41	XIA Ultra10-1800	
Kapton Wire	-	XIA Ultra10-1804	Awaiting results

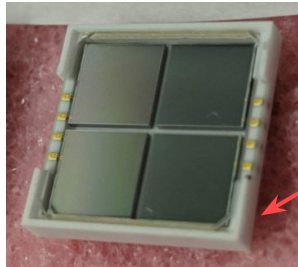
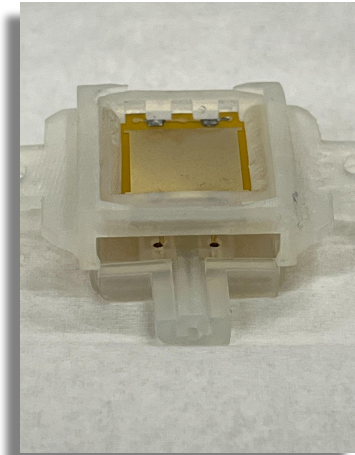
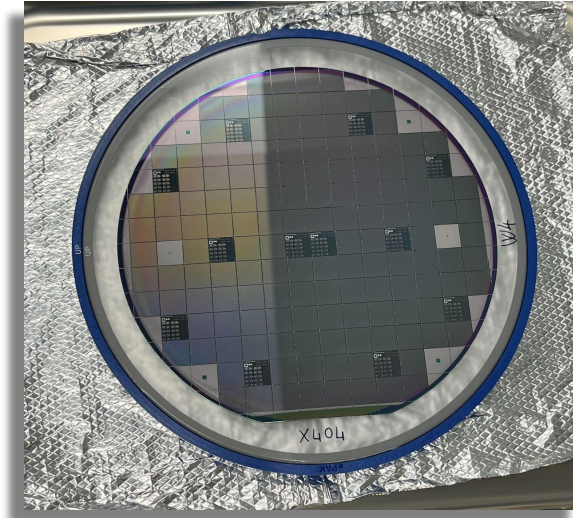
Assembly/Component	Total Event Rate [single bubble/year/10 kg]	Event Rate in ROI [single bubble/year/10 kg]
HV Electrode Tower	< 0.526	< 0.345
<i>OFHC Cu Electrode</i>	<i>< 0.077</i>	<i>< 0.051</i>
<i>HDPE Insulator</i>	<i>< 0.401</i>	<i>< 0.259</i>
<i>OFHC Cu Support</i>	<i>< 0.048</i>	<i>< 0.035</i>
IA Upper Assembly	< 2.982	< 1.823
<i>OFHC Cu Cam. Refl.</i>	<i>< 0.019</i>	<i>0.014</i>
<i>HDPE Castle</i>	<i>< 2.277</i>	<i>1.378</i>
<i>OFHC Cu Panels/Petals</i>	<i>< 0.686</i>	<i>0.431</i>

Radiopurity counting performed by SNOLAB Low Background Group

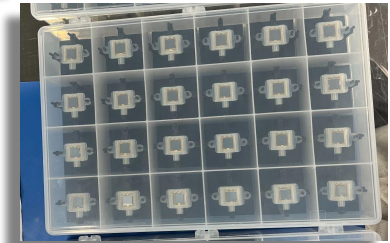
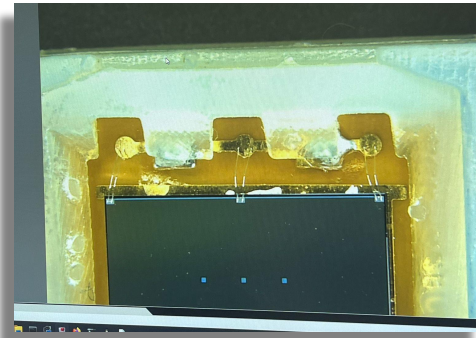
SBC-SNOLAB – Current Progress



- Majority of detector materials have been assayed and analyzed for background contributions.
- Developed custom SiPM modules to combat high activity of Hamamatsu VUV4s.
 - SiPM Wafers from FBK.
 - Fabrication at TRIUMF.
 - Characterisation at Queen's.



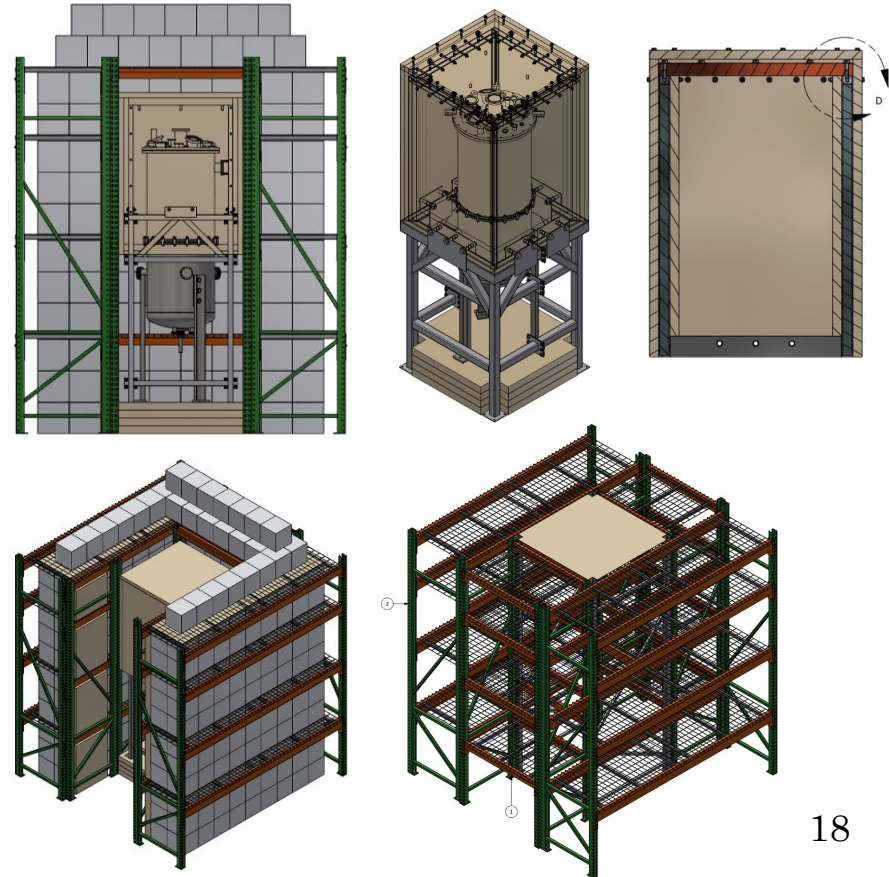
Ceramic tray of VUV4 main cause of activity.



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 - SiPM Wafers from FBK.
 - Fabrication at TRIUMF.
 - Characterisation at Queen's.
- Completed the second TDR at SNOLAB and moving to construction phase of SBC and external shielding soon!



Outlook for SBC

- Plenty of analysis ongoing with the calibration runs for SBC-LAr10.
- SBC-SNOLAB construction to begin soon.
- Exciting time for the SBC collaboration!

Thank you!
Merci!



UC Santa Barbara

