Updates on SURF Assays & Discussion on Backgrounds for the Vertical Drift (VD) Designs

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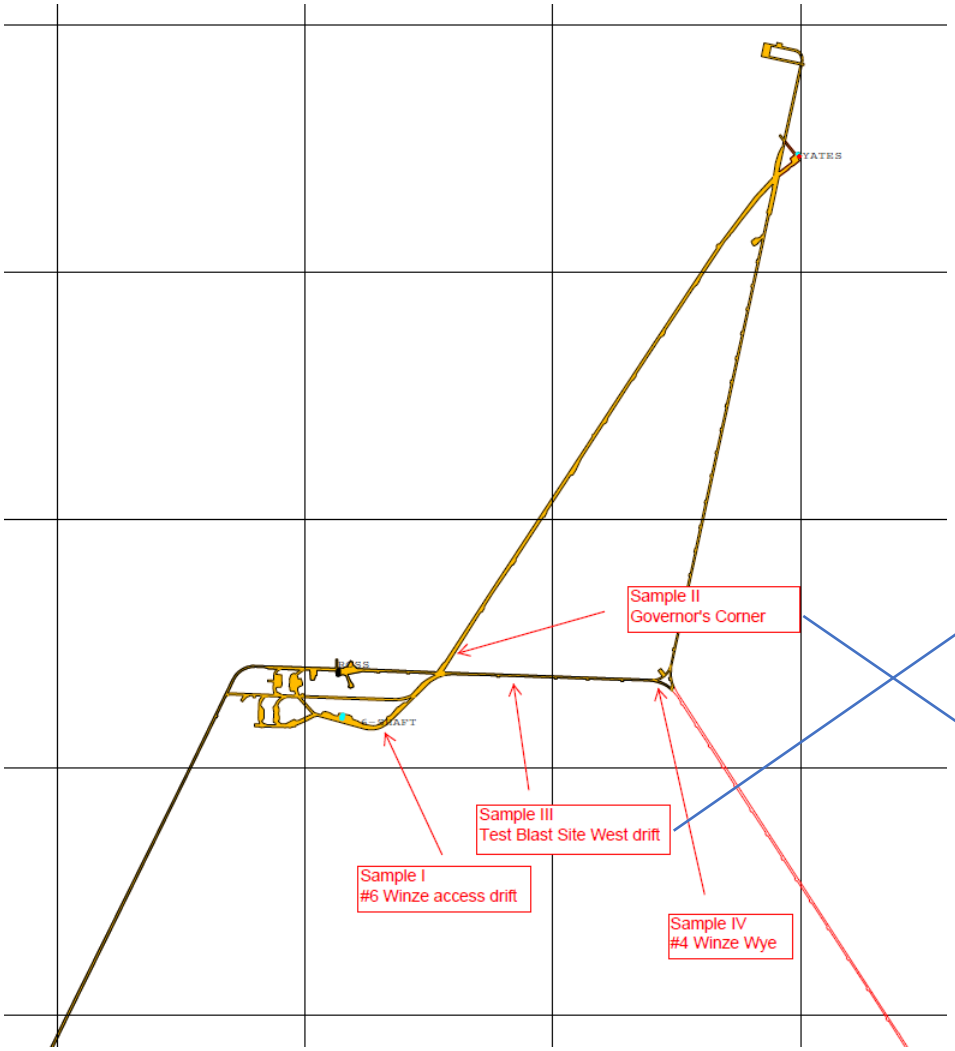
SOUTH DAKOTA MINES

DEEP UNDERGROUND NEUTRINO EXPERIMENT

DUNE Backgrounds Task Force Meeting

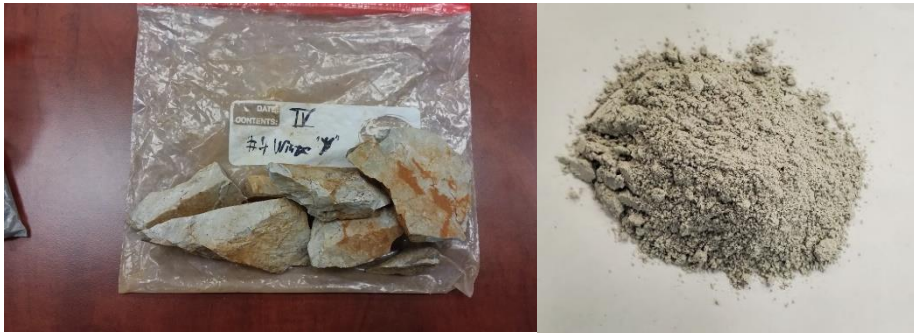
Jul 21, 2021

Collected 4 Representative Rock Samples at Ross Campus Just Before Lockdown



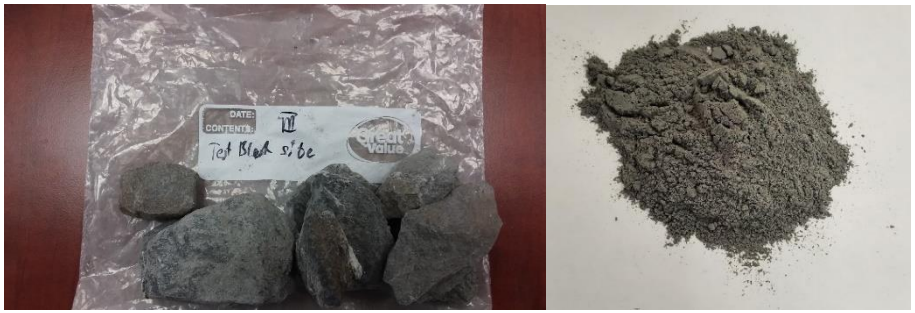
4 Representative FD Rock Samples from Ross Campus

from #6 Winze before & after crushing



from #4 Winze before & after crushing

Governors' Corner before & after crushing



Test Blast Site before & after crushing

Manual Course Crushing Needed

Sample #2 from Governors Corner at SURF 4850 Level.

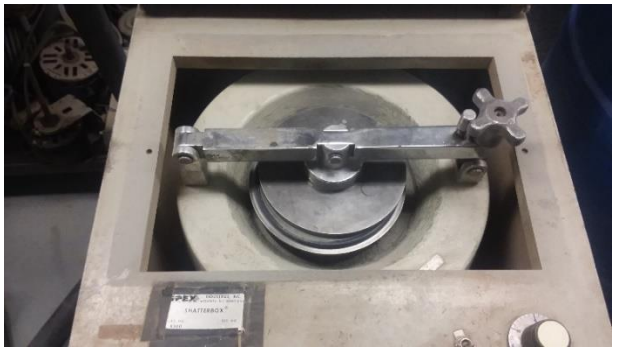
Bucket and mallet used to crush samples into small pieces.

Sample #2 during crushing operation.

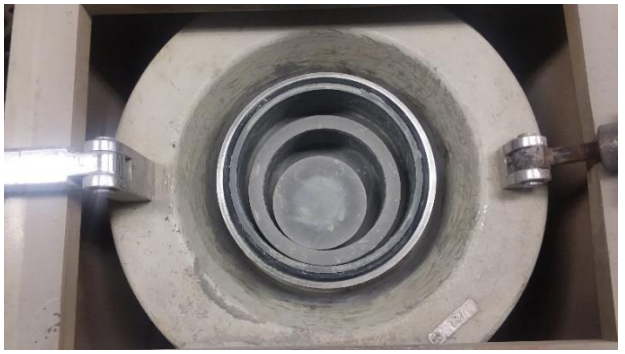
Sample #2 crushed to size for milling.

Rock Crusher Machine for Last Step

Milling machine external view.



Milling machine hood open.



Milling machine internals before fill.

Milling machine with aggregate sample.

Milling machine with milled sample.

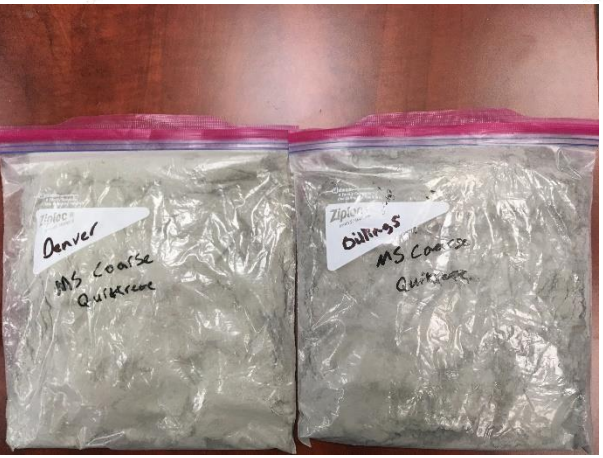
New vs Old Sample Locations:

Thanks to James Rickard (SURF FSCF Resident Engineer)
for new samples from excavation!

Thanks to Serenity Engel (SURF Summer Intern)
for receiving and prompt transport to SD Mines!

- New Excavation Samples
- Old Analyzed Samples

2 new shotcrete suppliers
in addition to Pete Lien:



Thanks to Faith Beall (REU student at SD Mines)
for preparing γ-ray assay analysis scripts
for fast turn-around time and
for improving Ge-detector maintenance!

EFIG: Immediate Action Item (LBNF/DUNE)

Shotcrete/Concrete Contractor Bid

sample	description	U-238 [Bq/kg]	error [Bq/kg]	ppm U	err. [ppm]	Ra-226 [Bq/kg]	error [Bq/kg]	Th-232 [Bq/kg]	error [Bq/kg]	ppm Th	err. [ppm
#1	DUNE Ross - #6 Winze	35.6	5.0	2.88	0.40	66.0	0.8	48.9	0.4	12.03	0.09
#2	DUNE Ross - Governor's Corner	24.4	6.9	1.98	0.56	79.1	1.1	20.5	0.4	5.05	0.10
#3	DUNE Ross - Test Blast Site	63.0	7.8	5.11	0.63	146.0	1.5	19.6	0.4	4.83	0.11
#4	DUNE Ross - #4 Winze	107.0	9.5	8.66	0.77	172.5	1.3	38.1	0.5	9.38	0.13
mean	**mean DUNE rock**	**57.5**	3.7	**4.66**	0.30	**115.9**	0.6	**31.8**	0.2	**7.82**	0.05

shotcrete	*& concrete ingredients:*	U-238 [Bq/kg]	error [Bq/kg]	ppm U	err. [ppm]	Ra-226 [Bq/kg]	error [Bq/kg]	Th-232 [Bq/kg]	error [Bq/kg]	ppm Th	err. [ppm
Pete Lien	sand (Cheyenne River, Oral/SD)	33.9	12.2	2.75	0.99	38.3	1.2	15.8	0.5	3.89	0.12
TCC	sand (commercial bag)	54.0	18.3	4.38	1.48	42.4	1.9	19.1	0.8	4.70	0.19
Croell	sand (Fisher in Nisland/SD)	75.4	24.5	6.11	1.98	119.3	3.1	40.3	1.2	9.91	0.30
Pete Lien	gravel (Rapid City limestone quarry)	28.1	6.5	2.28	0.53	38.2	0.9	0.8	0.3	0.20	0.06
TCC	gravel (bag from South America)	42.6	11.2	3.45	0.91	98.2	1.5	7.8	0.4	1.92	0.11
Croell	gravel (Rogers Pit, Sundance/WY)	15.1	7.6	1.22	0.61	27.1	1.0	1.0	0.3	0.25	0.07
GCC	Portland cement (Rapid City)	47.1	16.4	3.81	1.33	65.1	2.1	12.7	0.7	3.13	0.18
Whelan Energy	fly ash (power plant, Hastings/NE)	100.7	21.5	8.16	1.74	174.6	3.3	80.6	1.4	19.83	0.33
SURF	water (4850 Davis industrial & sump)	3.8	6.4	0.31	0.52	0.6	0.7	0.1	0.2	0.03	0.06
mean	**mean Pete Lien**	**31.430**		**2.546**		**42.832**		**5.996**		**1.475**	
mean	mean TCC	46.114		3.735		71.267		13.795		3.393	
mean	mean Croell	40.981		3.319		65.272		17.915		4.407	
mean	mean combined contractors	39.5		3.2		59.8		12.6		3.1	

⇒ **Pete Lien (Rapid City) shotcrete/concrete 2x better than others (and rock)!**

⇒ **Followed-up on subcontractor status in Feb->Apr 2021 with Elaine McCluskey (LBNF)**

⇒ **Need to figure out logistics of collection (w/ documentation for mapping) of rock samples during excavation to get samples asap in order to maximize throughput of assays (expect ~100/year) -> contact James Rickard (SURF FSCF Resident Engineer)**

⇒ **Get more shotcrete material samples from Pete Lien in Rapid City to study variations**

Immediate Action Item for Assays from Excavation & *Shotcrete/Concrete Contractor*

SHOTCRETE AND CONCRETE MATERIAL SUBMITTALS FROM EXCAVATION CONTRACTOR, TMI
April 2021

This is a list of materials submitted by TMI to the FSCF team for approval as part of the shotcrete and concrete submittals to meet the FSCF excavation specifications in the construction contract. This docdb file contains the following, all stored in dune-doc-22555:

Shotcrete in caverns:
Shotcrete mix design ("SF-2"): see document titled *TMI-SUB-EXC-033713-03-00003-00-Shotcrete Report 113403 TM W-SF2 Rapid City*
Shotcrete supplier: TCC Materials
Materials supplier for TCC:

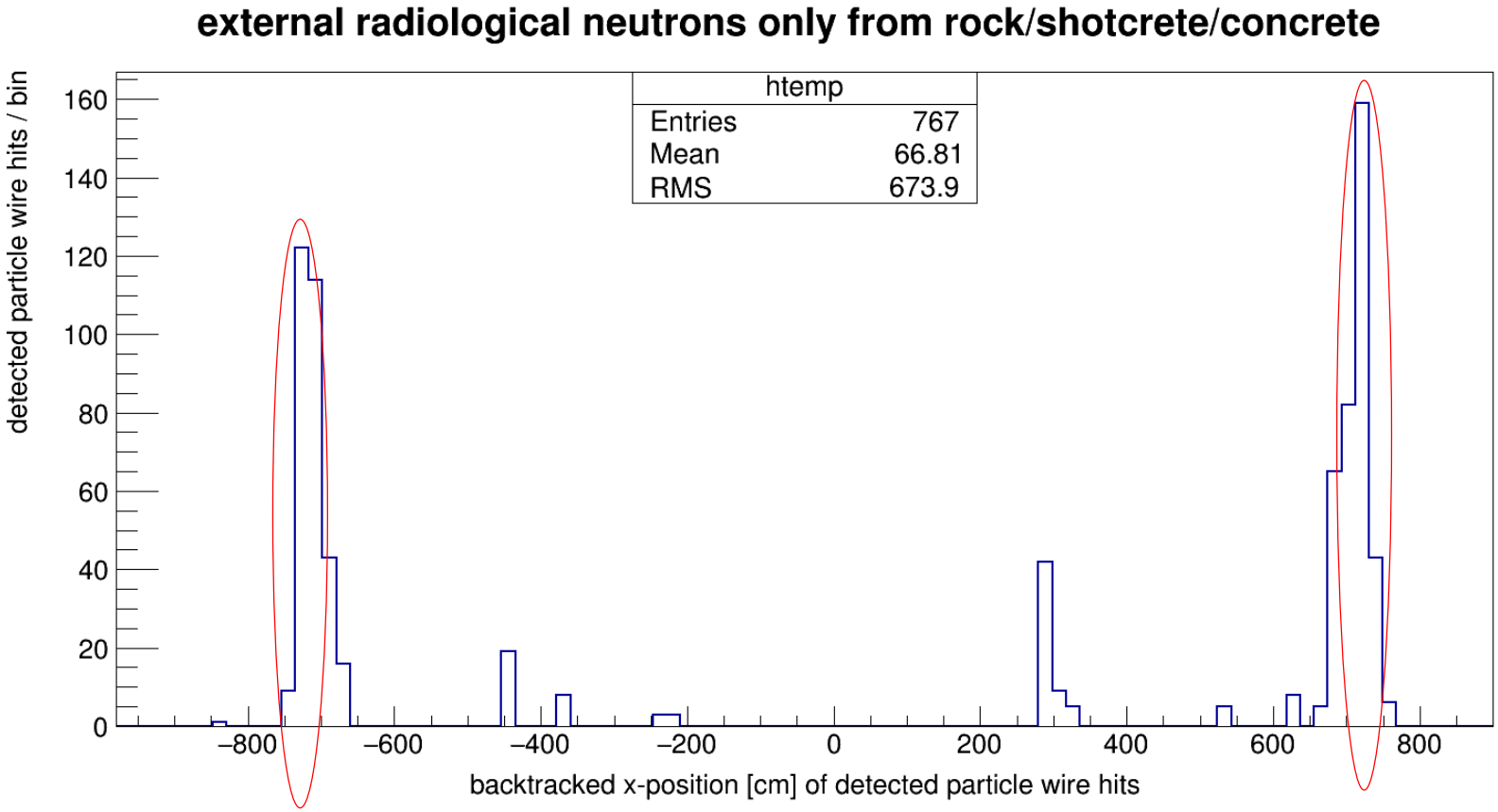
- Fine aggregate ("Concrete sand"): through Pete Lien & Sons from Oral Sand Source in Oral, South Dakota. See document titled: *TMI-SUB-EXC-033713-03-00003-00-Concrete Fine Aggregate - Oral Sand ASTM C33 Spec*
- Coarse aggregate: through Pete Lien & Sons (Rapid City) from Pete Lien and Sons Rapid City Quarry in Rapid City, SD. See document titled: *TMI-SUB-EXC-033713-03-00003-00-Size #8 Concrete Aggregate*
- Cement: GCC of America Cement from Rapid City, SD. See document titled *TMI-SUB-EXC-033713-03-00003-00-Type-I-II-Rapid-City*
- Silica fume: Elkam, see document titled *TMI-SUB-EXC-033713-03-00003-00-Elkem_CERT_001*
- Air entraining admixture: see document TMI-SUB-EXC-033713-03-00003-00-Vinsol ASTM C260 & AASHTO M154 statement

Concrete in caverns:
Not yet submitted – no concrete to be placed until 2022

⇒ **Serenity Engel intern over summer at Sanford Lab helped**

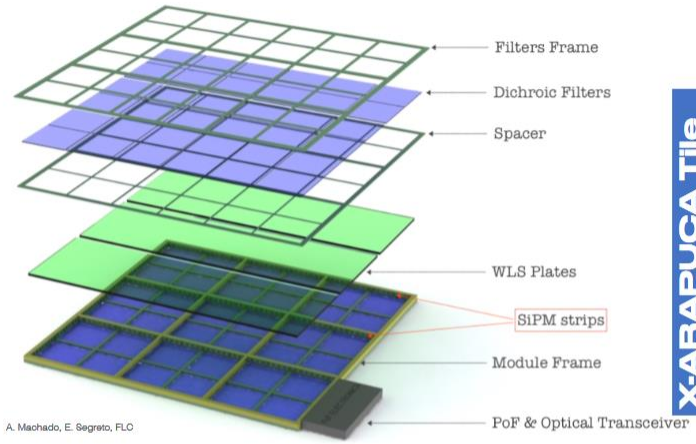
⇒ **Faith Beall REU (BHSU -> SDSMT) helped**

VD BGs Issue:
Less Passive LAr Shielding for External Neutrons



-> neutron background simulation for SP design
showed that many external neutrons capture within ~0.5 m of LAr shell thickness

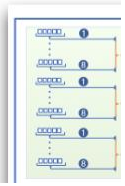
Latest Basic VD PDs Design Concept (X-ARAPUCA Tiles and MegaCells)



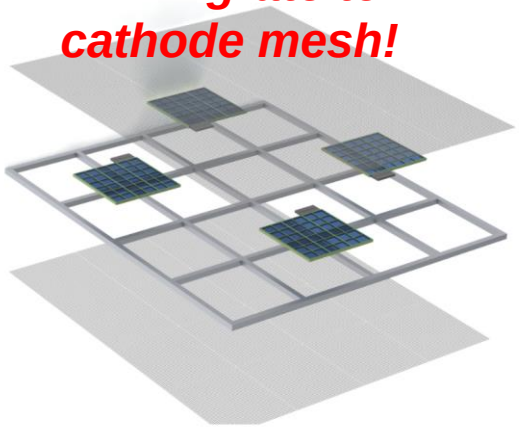
X-ARAPUCA Tile

TABLE V. PD basic unit: X-ARAPUCA Tile

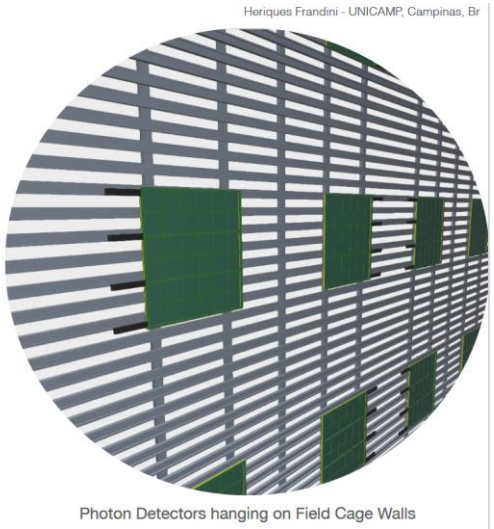
	Quantity	Dimensions
Area	1	630×630 mm^2 $= 0.4$ m^2
Thickness	1	22 mm
Weight	1	~ 4.5 kg
Optical Area	2 (two-sided)	600×600 mm^2 $= 0.36$ m^2
Sectors ("MegaCell")	3	600×200 mm^2 $= 0.12$ m^2
Dichroic Filters	36×2	100×100 mm^2
WLS plates	3	600×200 mm^2 $= 0.12$ m^2
PhotoSensors (SiPM)	360	6×6 mm^2
Read-out Channels	3	
SiPMs per channel	120	



-> radon daughters will migrate to cathode mesh!



Photon Detector into the Cathode frame under conductor mesh (exploded view)



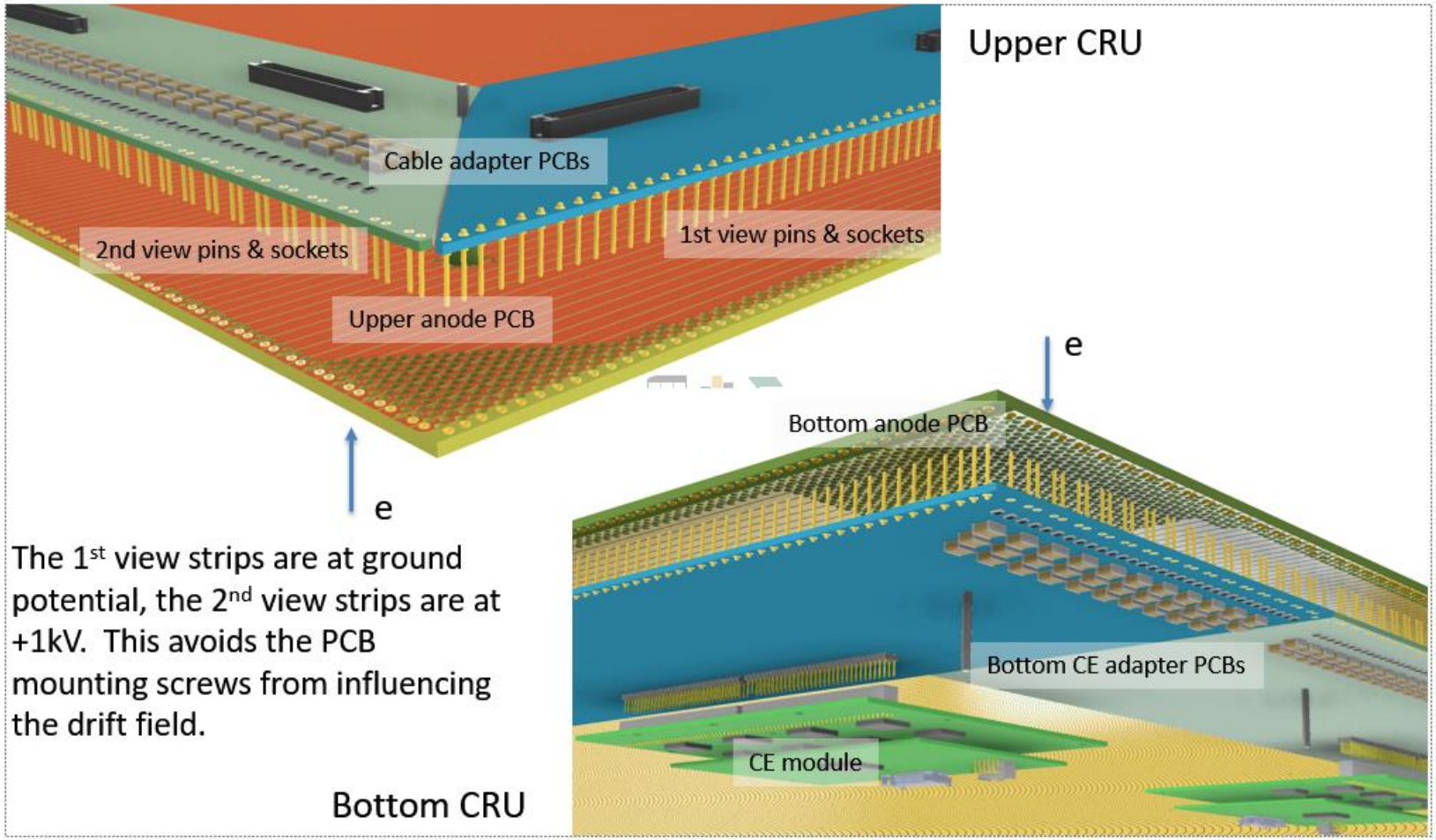
Photon Detectors hanging on Field Cage Walls

-> should make a radon daughter plate-out test underground (1000 Bq/m^3) (tribo-electric effect attracting even more charged radon daughters?)

Latest Basic VD 2-View Anode Design Concept

-> should make a radio-assay (gamma-ray spectroscopy) of PCBs can be high in K-40 and U-238 chain (radon emanation into LAr?)

2-View Design: CRU Assembly Details



The 1st view strips are at ground potential, the 2nd view strips are at +1kV. This avoids the PCB mounting screws from influencing the drift field.

VD Backgrounds Simulation: Discussion

- *Should have full 10 kton geometry with detailed VD detector design to study realistic impact of internal and external backgrounds*

- *Don't want to implement detailed VD detector design multiple times for each VD design proposal*

- *Easy solution (?): Use existing full 10 kton geometry for SP design, cut out SP detector parts (APA, CPA etc.) and then just paste in reduced volume e.g. 1x6 VD detector parts*

- *Could do the same with pasting in reduced volume e.g. 1x2x6 SP detector parts for faster DAQ trigger, SNB and solar neutrino studies*

- *Should commit full 10 kton geometries in various fully and partially equipped configurations to dune-tpc in LArSoft (so that users outside BG TF can use it in their fhicl's if they want to)*

- *VD design requires us to implement more background details near the inner edges of the cryostat, as PDs will be possibly placed on corrugation. CRU's need to be assayed as they probably contain more internal backgrounds than APAs*