EVALUATING THE ELECTRET RADON PROGENY INTEGRATED SAMPLING UNIT FOR USE MEASURING RADON AND RADON PROGENY IN A CAVE ENVIRONMENT

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The E-PERM

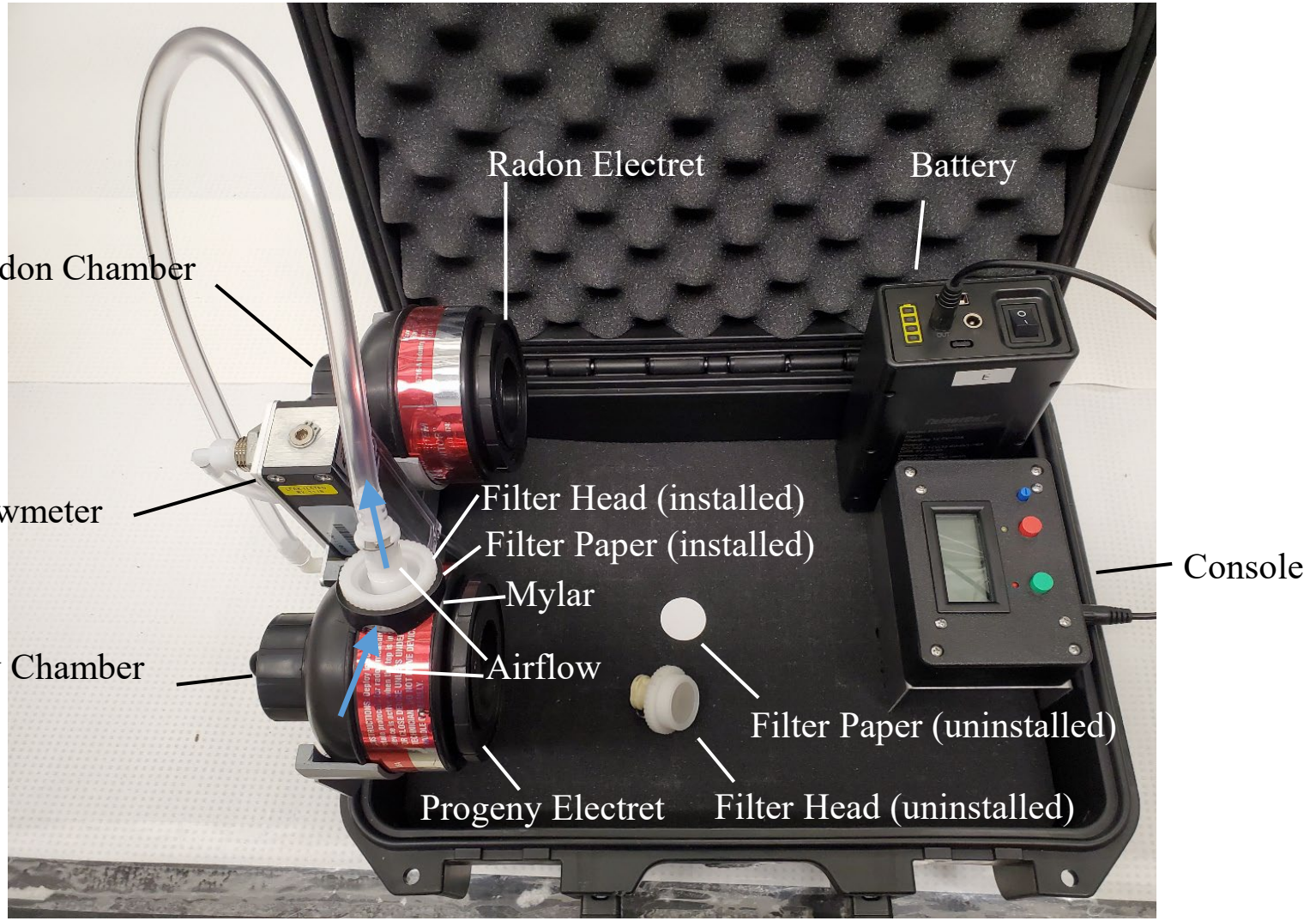
- An EIC sensor (electret ionization chamber)
- Can be used to measure ^{222}Rn concentration (RnC)
- With use of an RT chamber, can measure ^{222}Rn + ^{220}Rn concentration
- Has worked well in the harsh cave environment

The E-RPISU (Electret Radon Progeny Integrated Sampling Unit)

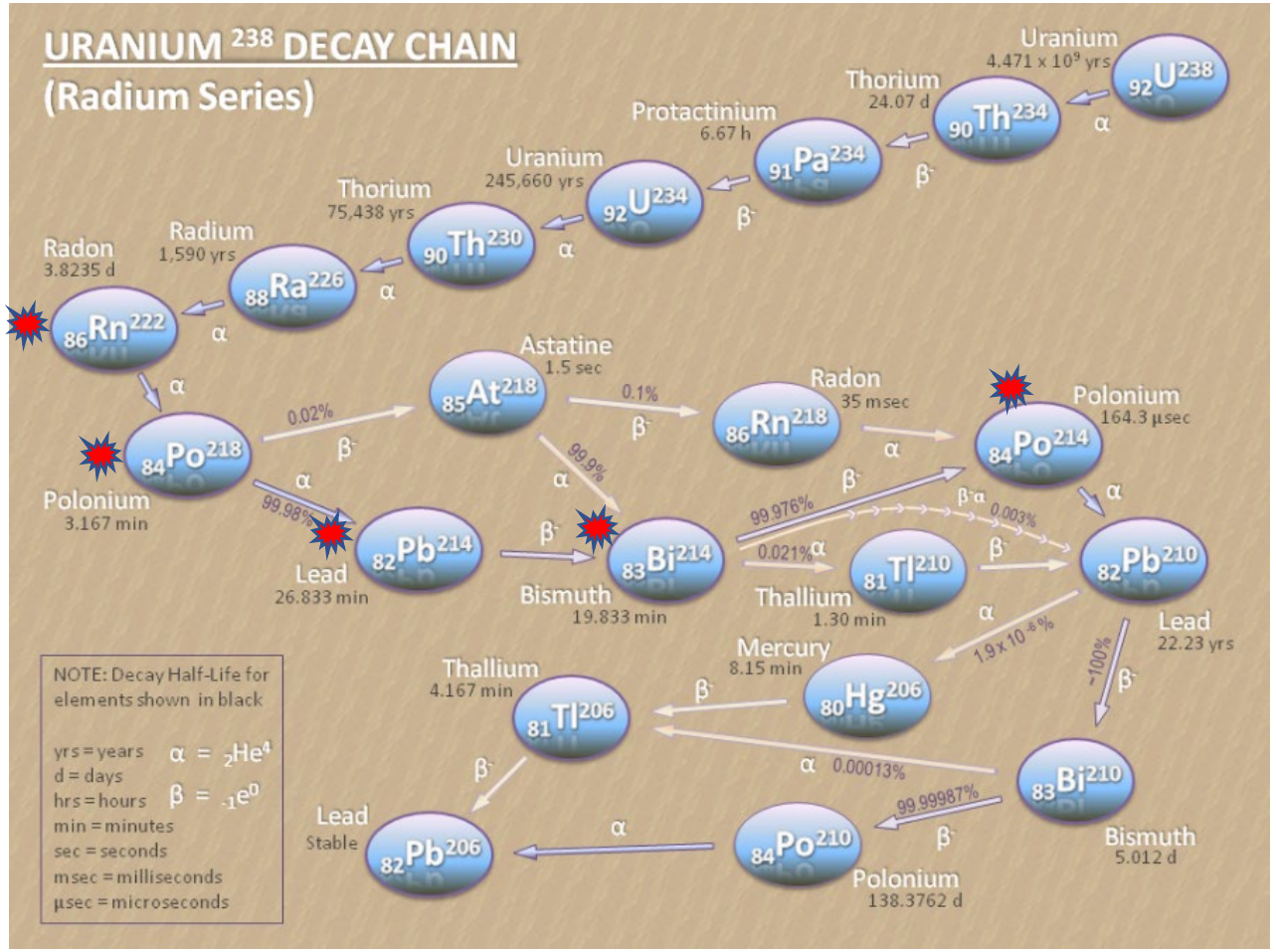
- Will measure ^{222}Rn concentration

- Can measure Working Level (WL)
  - A better health and safety measurement than RnC that takes into account the radiation from airborne radon progeny elements

A look at the E-RPISU



Radon Progeny – the decay scheme



- *http://ekengrenmeowser.blogspot.com/2013/09/uranium-apex-mineral.html*

The E-RPISU II

- Can measure Equilibrium Ratio (ER)
- Gives the percentage of progeny available in airborne form, thus available for inhalation
- A portion of the progeny will “plate out”, or stick environmental surfaces, making them unavailable for inhalation
- The ER is an important measure for risk assessment of a site

Will the E-RPISU work in a cave environment?

- 3 major concerns
- Addressing each will be a goal for this work
- **Goal A: Determine if the E-RPISU electrets can be stored in their chambers at the end of an experiment while the E-RPISU is being removed from the cave.**
- Why do we want to do this?

Airborne Particulates in Coldwater Cave

Focused on Formation

Defocused to foreground

Water droplets in Coldwater Cave

- Photo courtesy of Scott Dankof.

Goal A: Storing the electret in the chamber post-trial

- Have used this approach with E-PERM sensors successfully
- Unclear whether it will work for the E-RPISU given the progeny channel construction
- Description of experiment to evaluate

In-Cave Trial, Kemling Cave, K-34R		
Duration = 0.25 days		
Radon = 240.2 pCi/L		
Follow-Up Period		
Duration = 0.57 days		
	ST Electret Raw ΔV	Normalized ΔV
Stored in Chamber Radon	0	0
Stored in Chamber Progeny	2	2.2
Stored Capped Radon	0	0
Stored Capped Progeny	0	0

Units of ΔV and Normalized ΔV

- Normal units of pCi/L and WL not appropriate here
  - Why?

- ΔV is just final electret voltage minus initial electret voltage

- Normalization needed because electret sensitivity varies with absolute voltage, and E-RPISU sensitivity varies with average flow rate of the pump

Normalization Procedure

- $Normalized\ \Delta V\ (\text{radon}) = \frac{\text{raw}\ \Delta V}{(\frac{experimental\ CF}{midrange\ CF})}$
  - Where $CF = A + (B * \ln(\frac{I+F}{2}))$
- $Normalized\ \Delta V\ (\text{progeny}) = \frac{\text{raw}\ \Delta V}{\left(\frac{experimental\ ERP-CF}{midrange\ ERP-CF}\right)*(\frac{experimental\ avg.flow\ rate}{midrange\ avg.flow\ rate})}$
  - Where $ERP - CF = A + (B * (\frac{I+F}{2}))$

Goal A: Storing the electret in the chamber post-trial

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Goal A Conclusions

- OK to store electrets in the chambers while removing E-RPISU from the cave sites if:

- Direct removal of the E-RPISU from the cave without in-cave storage.

- Short time frame needed to remove the E-RPISU from the cave.

Goal B: Can the E-RPISU filter paper be reused without impacting the experimental voltage measurements?

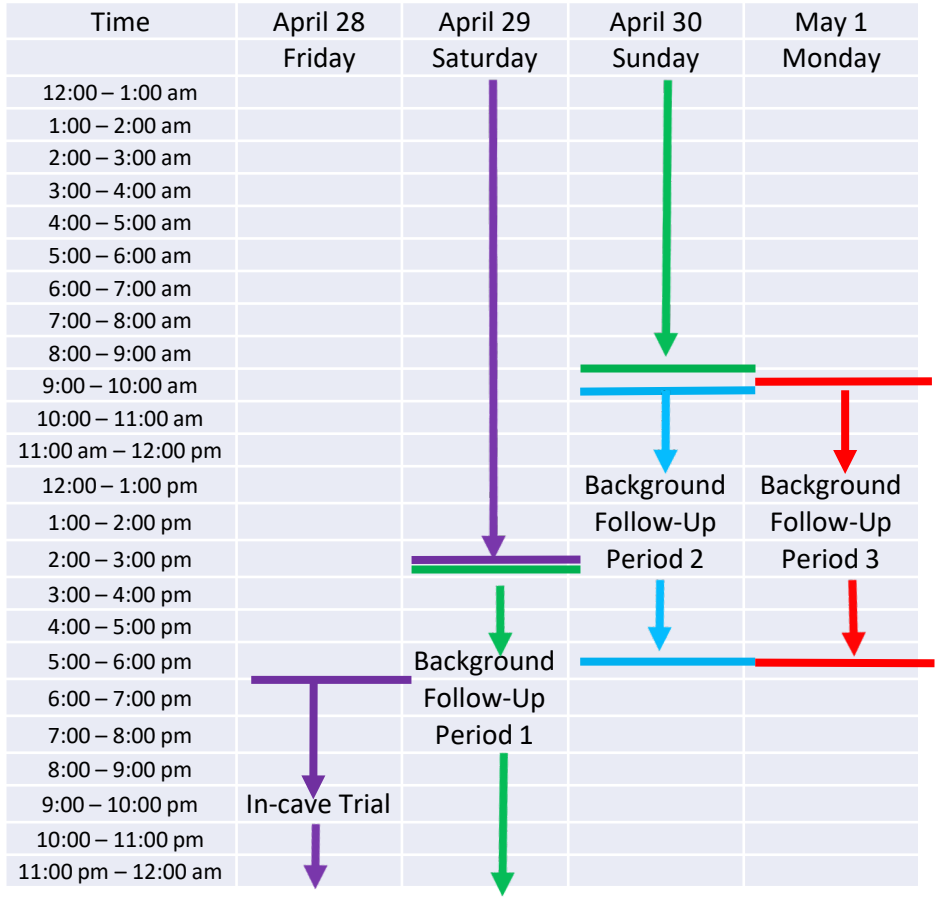
- Vendor guidance: Yes, if there are no visible particulates on the filter and a 4-hour waiting period is enforced
  - *Rad Elec, 2020. E-RPISU Operator's Manual, Version 1.0. Feb 14, 2020.*

- Concern: Our cave sites have much higher radon and progeny levels than "normal" indoor sites, not to mention higher particulate levels

- Description of experiment to evaluate

Goal B Data

Schedule of Trials



Data

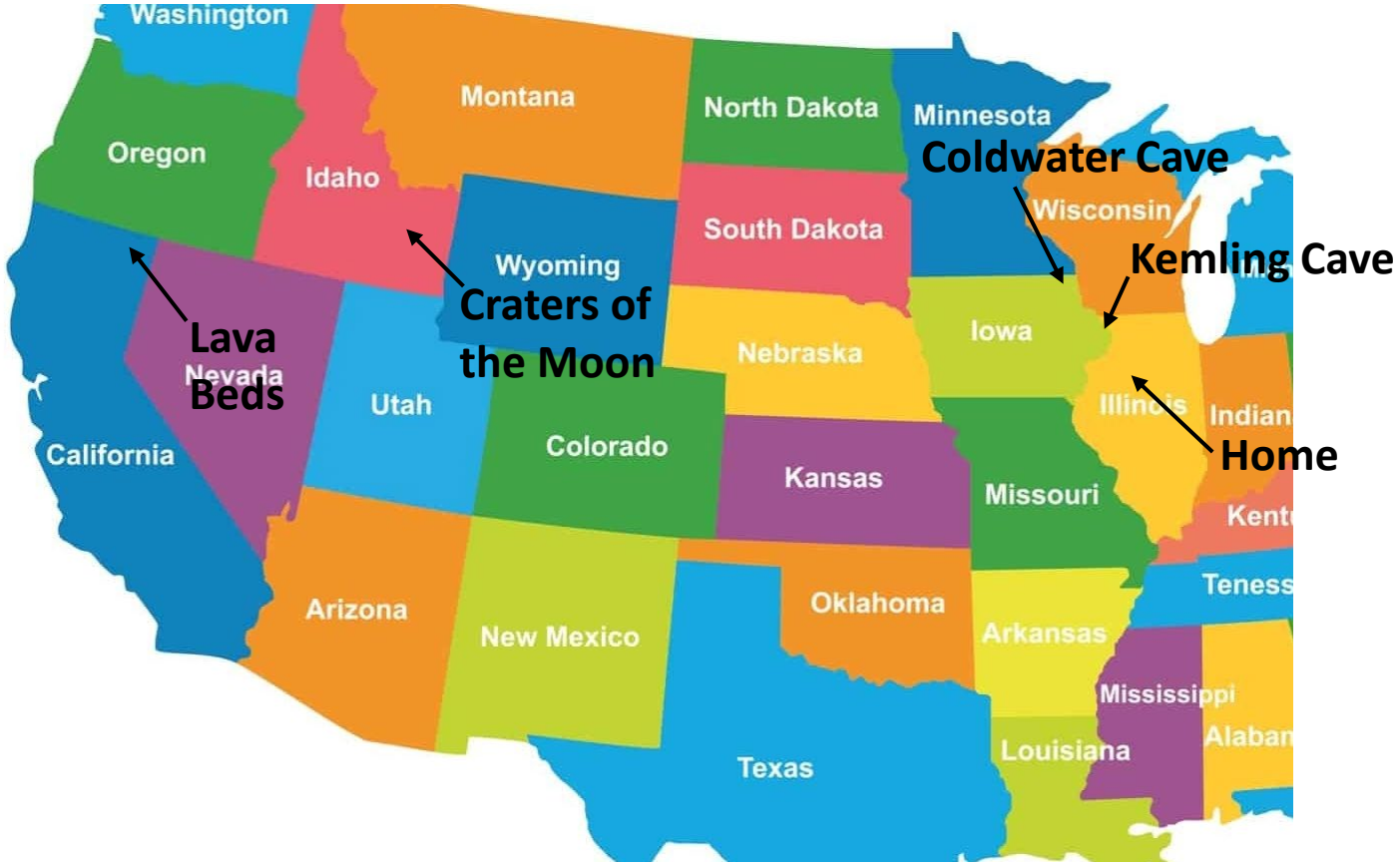
In-Cave Trial, Kemling Cave, K-34R		
Duration = 0.85 days		
Radon = 789.6 pCi/L		
Background Follow-Up Period 1		
Duration = 0.76 days		
	ST Electret Raw ΔV	Normalized ΔV
Carryover Radon	21	24.4
Carryover Progeny	241	263.4
Control Radon	1	1.2
Control Progeny	2	1.9
Background Follow-Up Period 2		
Duration = 0.32 days		
	ST Electret Raw ΔV	Normalized ΔV
Carryover Radon	0	0
Carryover Progeny	6	5.7
Control Radon	0	0
Control Progeny	1	0.9
Background Follow-Up Period 3		
Duration = 0.34 days		
	ST Electret Raw ΔV	Normalized ΔV
Carryover Radon	1	1.2
Carryover Progeny	2	2.3
Control Radon	0	0
Control Progeny	0	0

Goal B Conclusions

- The carryover signal is considerable right after the original trial in the cave, but it eventually fades to the point of being negligible
- Retiring filter papers that were visibly soiled was deemed a good idea and adopted.
- Even if unsoiled, we won't reuse filter paper until 48 hours have passed from it being immersed in a high-radon environment

Goal C: Are E-RPISU components carrying over radioactive signal from prior trials, and if so how large is the carryover and which E-RPISU components are carrying the signal?

- Why is this a concern?



Goal C

- The Goal B experiment clearly answered the first subtopic – yes, signal is being carried over
- Attempt to address the second and third subtopic
- If some of the components were carrying over signal, could they be replaced prior to a follow-up trial instead of replacing the entire unit?
- Description of experiment to evaluate
  - All done in Coldwater Cave, Station 4, 1st Upstream Breakdown

Goal C Data I

- Carryover from the filter paper?

- Compare E-RPISU restarted with no reconfiguration (exp C1) vs an E-RPISU where the filter paper was changed prior to restart (exp C2)

Experiment Number	C1	C2
In-Cave Time (days)	0.39	0.39
E-RPISU Initial Configuration		
Filter Installed?	X	X
E-RPISU Changes Prior To Blank Trial		
Electrets?	X	X
Filter paper?		X
Filter head?		
Chambers vented?		
New radon chamber?		
New progeny chamber?		
Results		
Cave Radon Concentration (pCi/L)	614.1	614.1
Radon carryover (relative % of original signal)	1.84	1.86
Progeny carryover (relative % of original signal)	4.65	1.39

Goal C Data II

- Carryover from the filter head?

- Exp C3 – both the filter paper and the filter head replaced prior to restarting

Experiment Number	C1	C2	C3
In-Cave Time (days)	0.39	0.39	0.35
E-RPISU Initial Configuration			
Filter Installed?	X	X	X
E-RPISU Changes Prior To Blank Trial			
Electrets?	X	X	X
Filter paper?		X	X
Filter head?			X
Chambers vented?			
New radon chamber?			
New progeny chamber?			
Results			
Cave Radon Concentration (pCi/L)	614.1	614.1	575.7
Radon carryover (relative % of original signal)	1.84	1.86	5.28
Progeny carryover (relative % of original signal)	4.65	1.39	0.82

Goal C Data III

- Carryover from the air in the chambers?

- Exp C4 – both the filter paper and the filter head replaced prior to restarting, plus the chambers vented

Experiment Number	C1	C2	C3	C4
In-Cave Time (days)	0.39	0.39	0.35	0.35
E-RPISU Initial Configuration				
Filter Installed?	X	X	X	X
E-RPISU Changes Prior To Blank Trial				
Electrets?	X	X	X	X
Filter paper?		X	X	X
Filter head?			X	X
Chambers vented?				X
New radon chamber?				
New progeny chamber?				
Results				
Cave Radon Concentration (pCi/L)	614.1	614.1	575.7	575.7
Radon carryover (relative % of original signal)	1.84	1.86	5.28	4.52
Progeny carryover (relative % of original signal)	4.65	1.39	0.82	0.84

Goal C Data IV

- <u>Carryover from the radon chamber?</u>

- Exp C5 – the filter paper, the filter head, and the radon chamber replaced prior to restarting

Experiment Number	C1	C2	C3	C4	C5
In-Cave Time (days)	0.39	0.39	0.35	0.35	0.33
E-RPISU Initial Configuration					
Filter Installed?	X	X	X	X	X
E-RPISU Changes Prior To Blank Trial					
Electrets?	X	X	X	X	X
Filter paper?		X	X	X	X
Filter head?			X	X	X
Chambers vented?				X	
New radon chamber?					X
New progeny chamber?					
Results					
Cave Radon Concentration (pCi/L)	614.1	614.1	575.7	575.7	577.4
Radon carryover (relative % of original signal)	1.84	1.86	5.28	4.52	0.33
Progeny carryover (relative % of original signal)	4.65	1.39	0.82	0.84	0.84

Goal C Data V

- <u>Carryover from both chambers?</u>

- Exp C6 – the filter paper, the filter head, and both chambers replaced prior to restarting

Experiment Number	C1	C2	C3	C4	C5	C6
In-Cave Time (days)	0.39	0.39	0.35	0.35	0.33	0.33
E-RPISU Initial Configuration						
Filter Installed?	X	X	X	X	X	X
E-RPISU Changes Prior To Blank Trial						
Electrets?	X	X	X	X	X	X
Filter paper?		X	X	X	X	X
Filter head?			X	X	X	X
Chambers vented?				X		
New radon chamber?					X	X
New progeny chamber?						X
Results						
Cave Radon Concentration (pCi/L)	614.1	614.1	575.7	575.7	577.4	577.4
Radon carryover (relative % of original signal)	1.84	1.86	5.28	4.52	0.33	0.78
Progeny carryover (relative % of original signal)	4.65	1.39	0.82	0.84	0.84	0.08

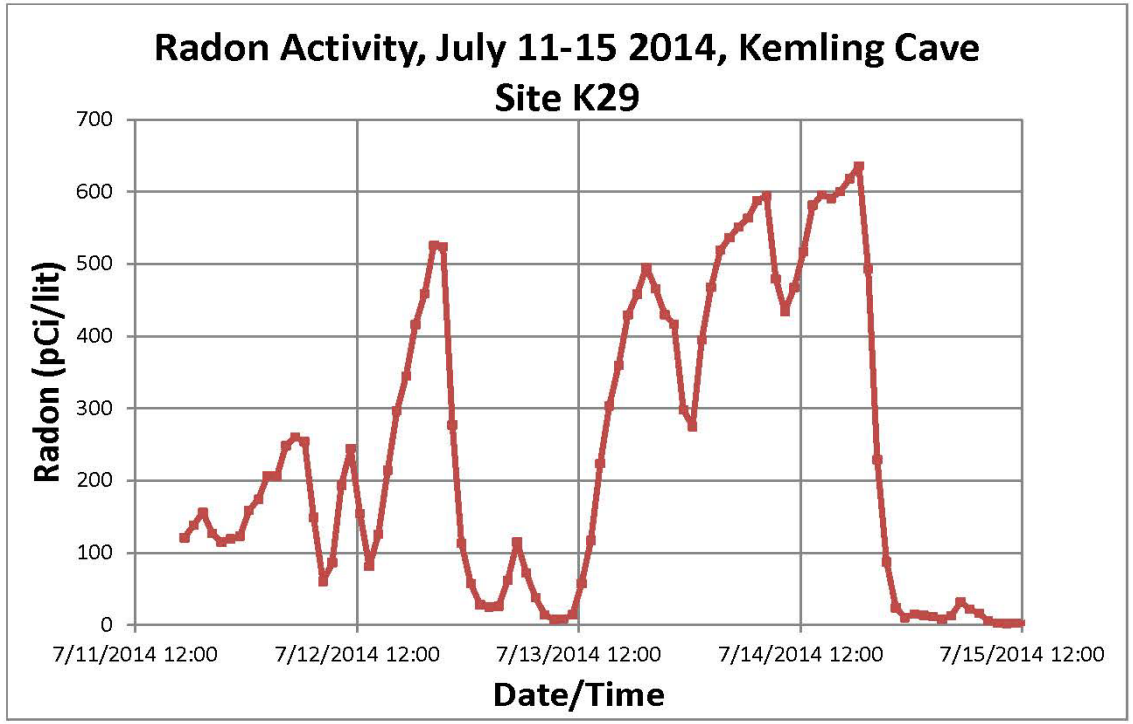
Goal C Conclusions

- There is definitely carryover of radioactive signal when reusing the E-RPISU with a short turnaround time after it has been in a high-radon environment
- The filter paper in the progeny channel is the major source of carryover, but the filter head and the chambers also contribute
- To avoid carryover when running a follow-up trial with a short turnaround time, the recommended best practice is to replace the filter paper, the filter head, and both chambers prior to starting the second trial

Comments on the size of the Carryover signal

- It should be noted that the minimum relative uncertainty of measurements with each channel of the E-RPISU is 5%
- The carryover signals are of a similar magnitude or smaller
- When do you really need to be careful regarding carryover?

Kemling Cave Data



Welch, L.E., Paul, B.E., and Jones, M.D., 2016. Use of Electret Ionization Chambers to Measure Radon in Caves. Proceedings of the 2016 International Radon Symposium, pp. 1-18. http://aarst-nrpp.com/proceedings/2016/Welch_USE_OF_ELECTRET_IONIZATION_CHAMBERS_TO_MEASURE_RADON_IN_CAVES.pdf.

Acknowledgements

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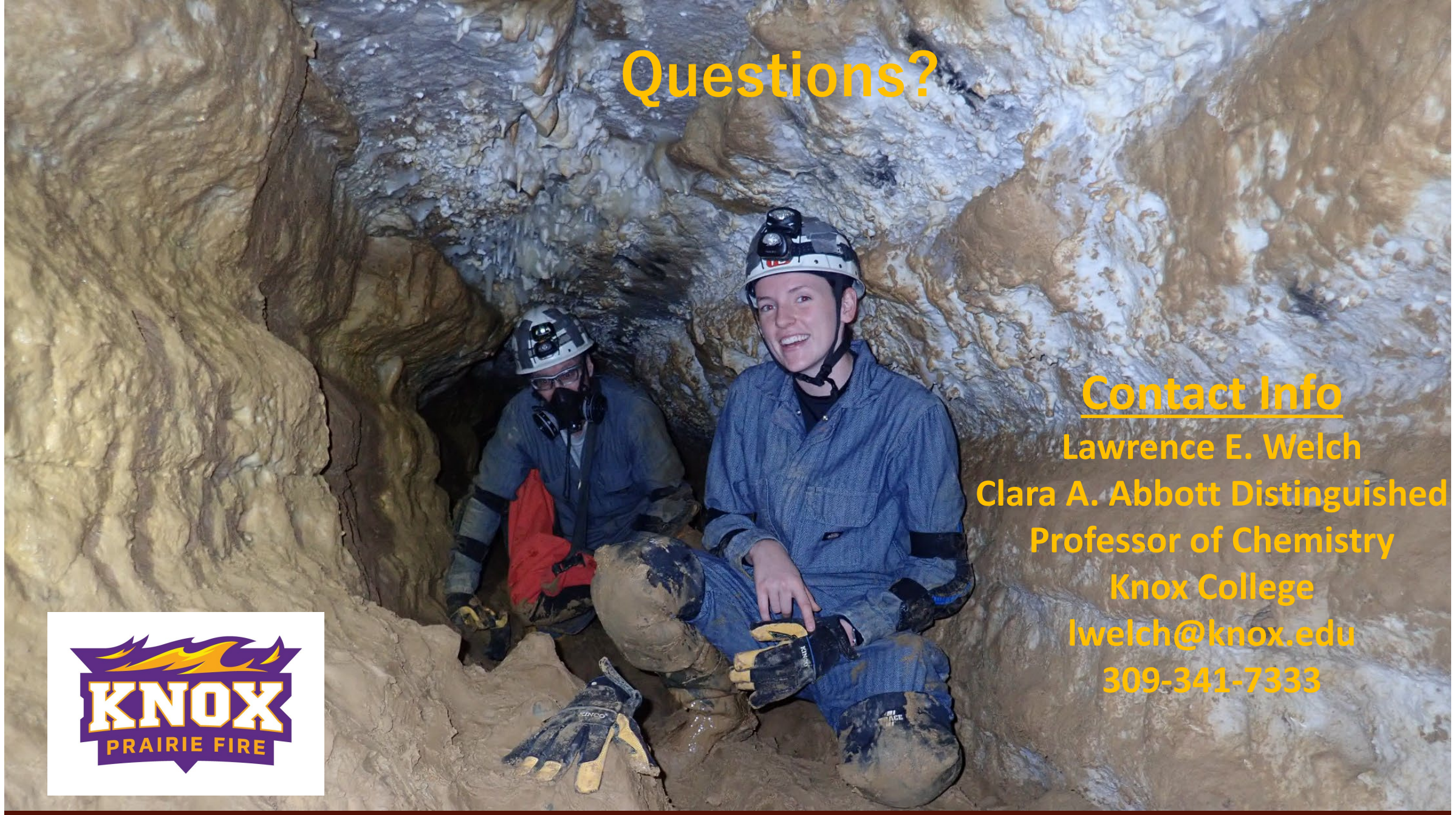
- Rad-Elec
- Funding from Knox College

Questions?



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