

# *Elevation Influence on Two different Radon Monitors*

Bill Brodhead  
WPB Enterprises, Inc  
[www.wpb-radon.com](http://www.wpb-radon.com)

[wmbrodhead@gmail.com](mailto:wmbrodhead@gmail.com)  
610 613-8004

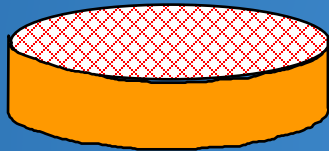
Big Thanks to the following individuals for making the following elevation measurements:

Henry Boyea (2150 ft)    Leo Moorman (5100 ft)    Brad Turk (7170 ft)

We know Radon Monitors are  
influenced by Environmental Effects.

Are we correcting for these detector influences?

Charcoal detectors are influenced by:



**Exposure Variation** (No high to low correction is made)

**Humidity** (Is corrected for)

**Exposure Temperature** (Some Companies Correct)

50F + 40% | 60F + 20% | 80F - 20% | 90F - 40%

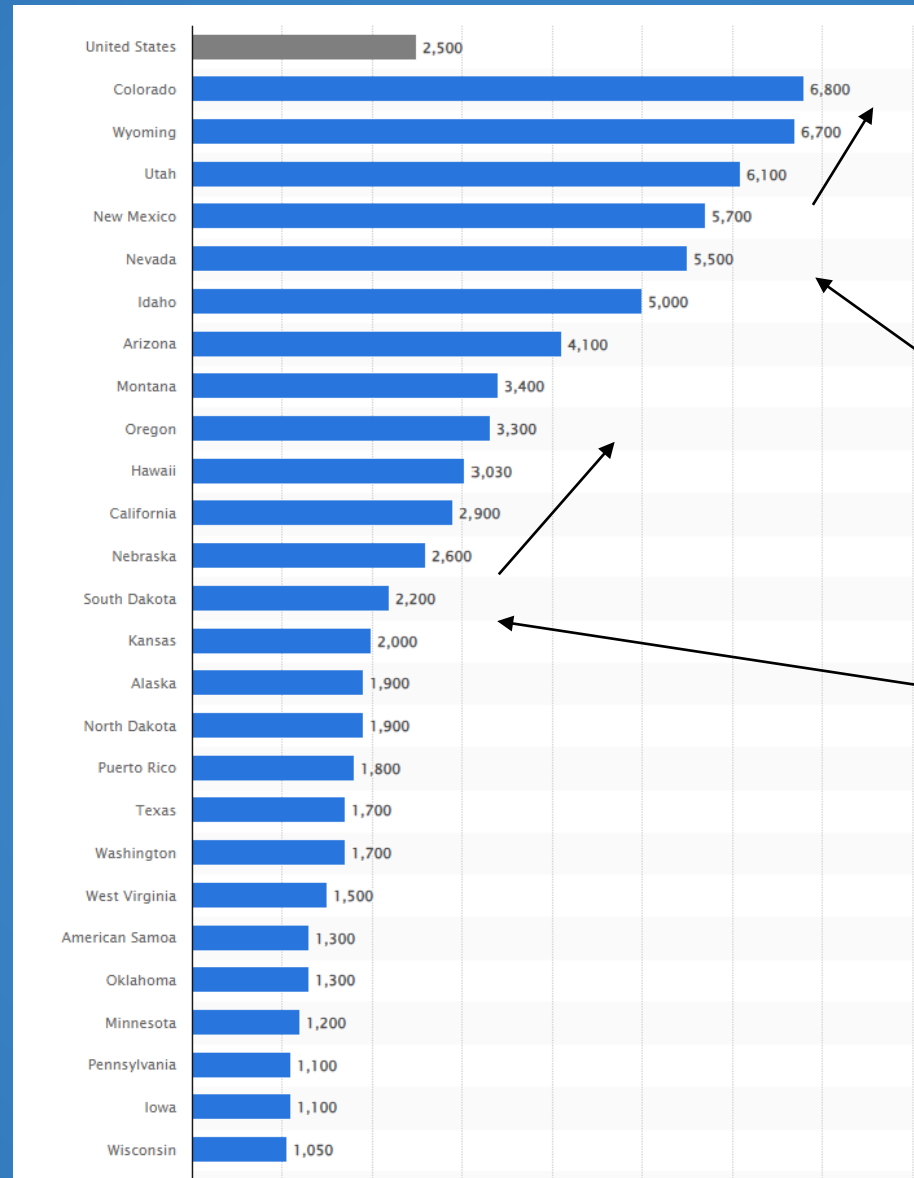


CRM's may be sensitive to **Thoron**

Keep away from soil or rocks

What about  
Elevation's  
effect?

Air is less dense  
at higher  
elevations



Average  
Elevation of  
US states

6 states average  
above 5000 feet

13 states average  
above 2000 feet



## 2005 paper: Elevation Effects on Radon Cell Counting Efficiency

8% to 10% Higher Counts at  
6000-ft versus 820-ft of elevation

Alpha emission	820-ft (266-m)	6000-ft (1969-m)
Radon-222	4.12 cm	4.99 cm
Polonium-218	4.70 cm	5.70 cm
Polonium-214	6.70 cm	8.13 cm

Alpha's  
Travel

5 cm = 2 in

7.6 cm = 3 in

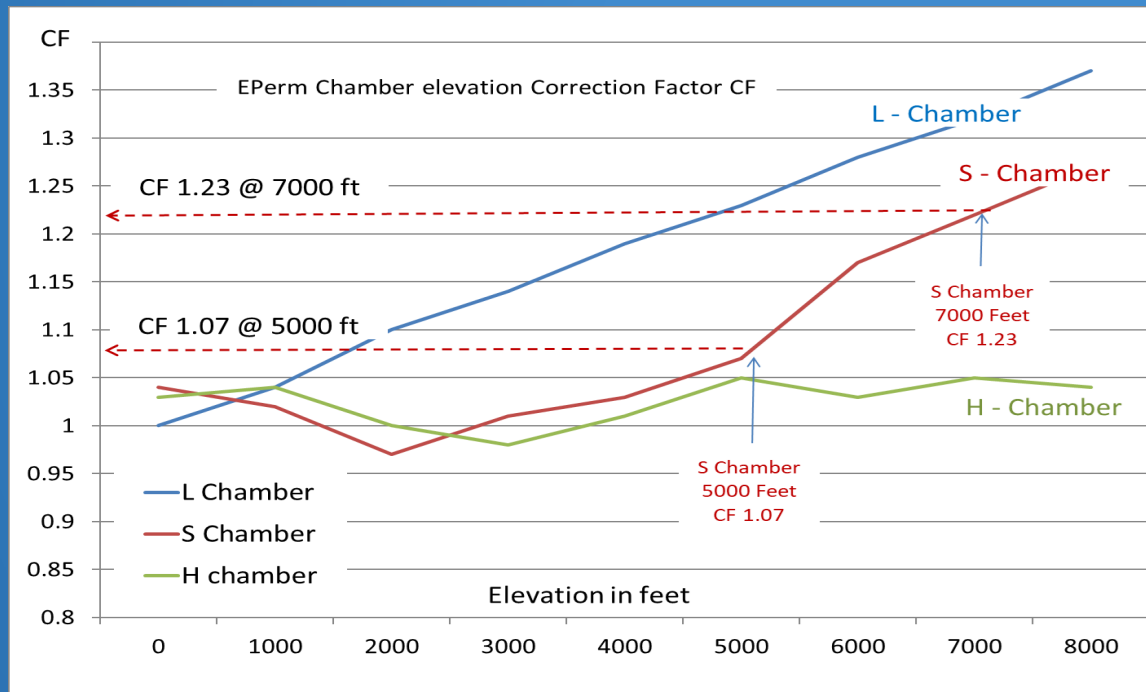
Alpha Particles travel 21% farther at  
6000 feet versus 820 feet



35 Years ago  
Kotrappa 1991 paper:  
Elevation Correction  
Factors for E-Perm  
Radon Monitors

EPerm is a **Pulse Ion Detector**

Multiply S-Chamber results by **1.23** @ 7000 ft



Correction  
Factor  $\swarrow$   
**CF**  $\searrow$

$\leftarrow$  L-Chamber CF  
5000 ft + 1.23  
7000 ft + 1.32

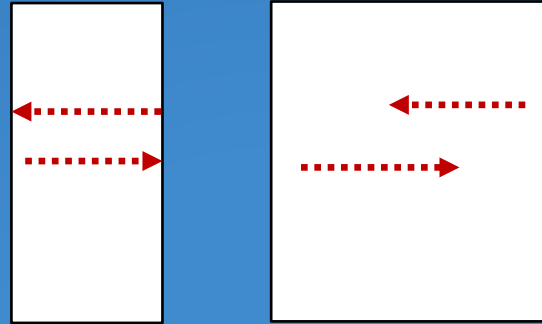
$\leftarrow$  S-Chamber CF  
5000 ft + 1.07  
7000 ft + 1.23

$\leftarrow$  H-Chamber  
N/C

## Pulse Ion Detectors -> Count Ionization from alpha travel path

Small Chamber  
Alpha's mostly  
hit the wall

300 foot  
elevation  
Test

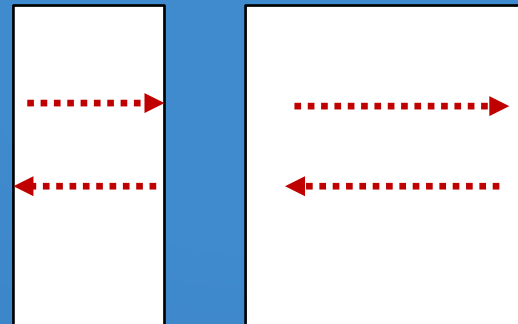


Bigger Ion Chamber  
Many alpha's  
don't hit the wall

Alpha's travel farther in less dense air

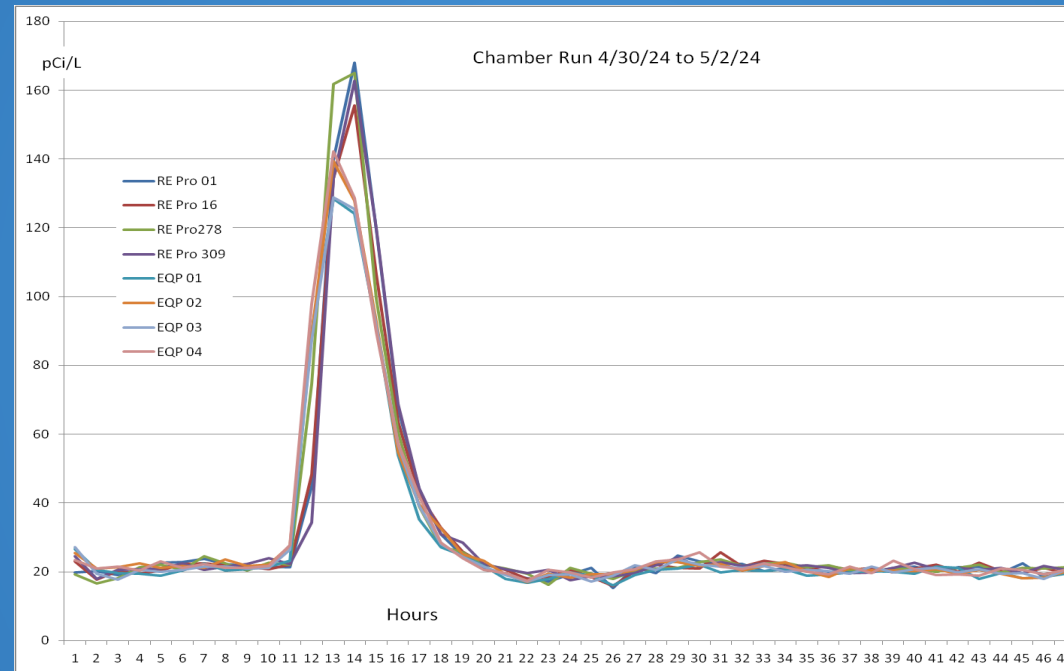
Small Chamber  
Alpha travel is  
the same but  
less ionization

5000 foot  
elevation  
Test



Bigger Chamber  
Alpha's still don't  
hit the wall  
Same Ionization  
takes place

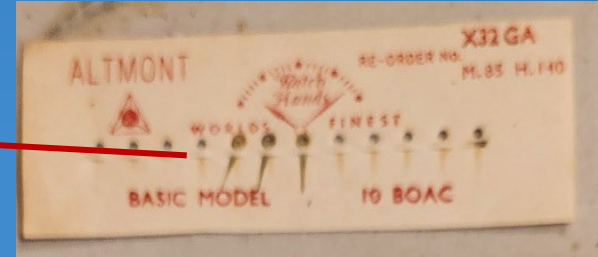
Two - Pulse Ion Radon Monitors  
were re-calibrated to be within  
a few percent of each other  
and spiked to 140 to 160 pCi/L



WPB Chamber monitors were  
recently spiked at KSU radon chamber



## Two Identical radon chambers used Radium Watch Hands for radon sources



Three or Four  
watch hands  
suspended  
in each chamber

Air circulating fan

4 RadonEye  
Pro's

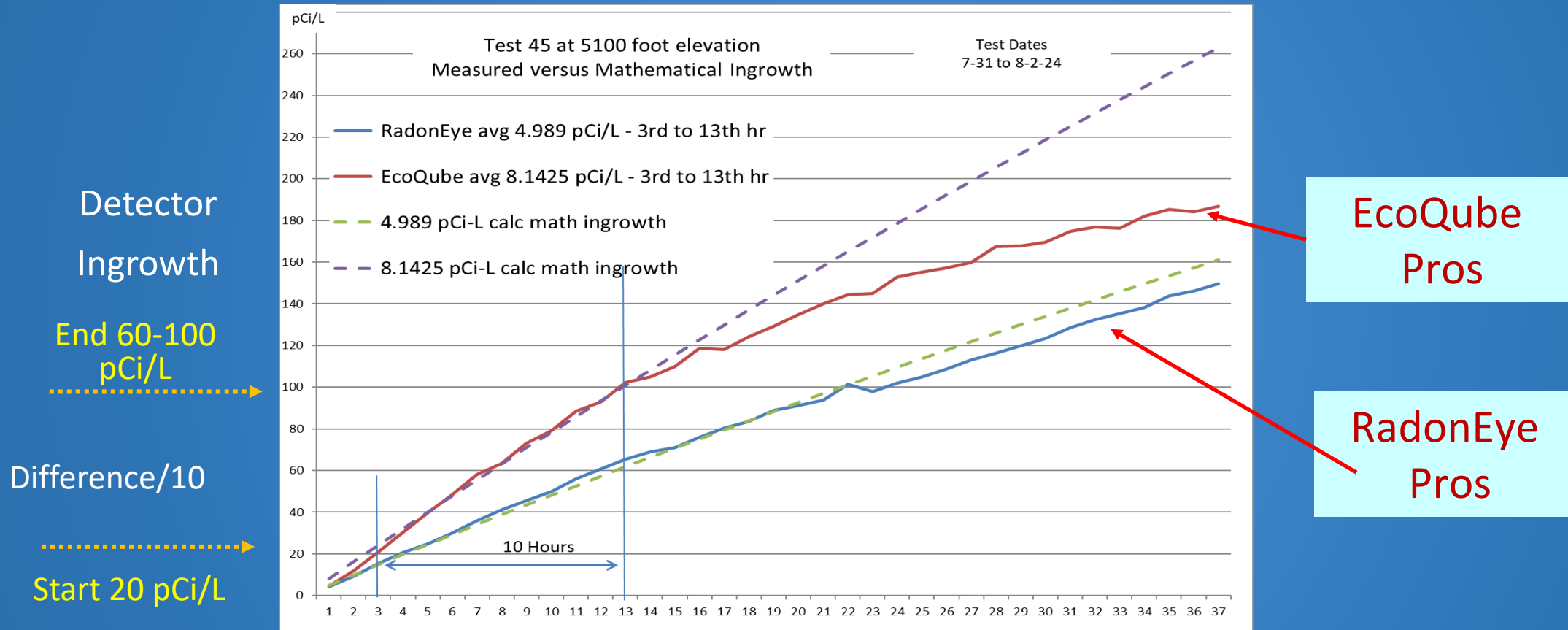
4 EcoQube  
Pro's



# Mathematical Ingrowth compared to Measured

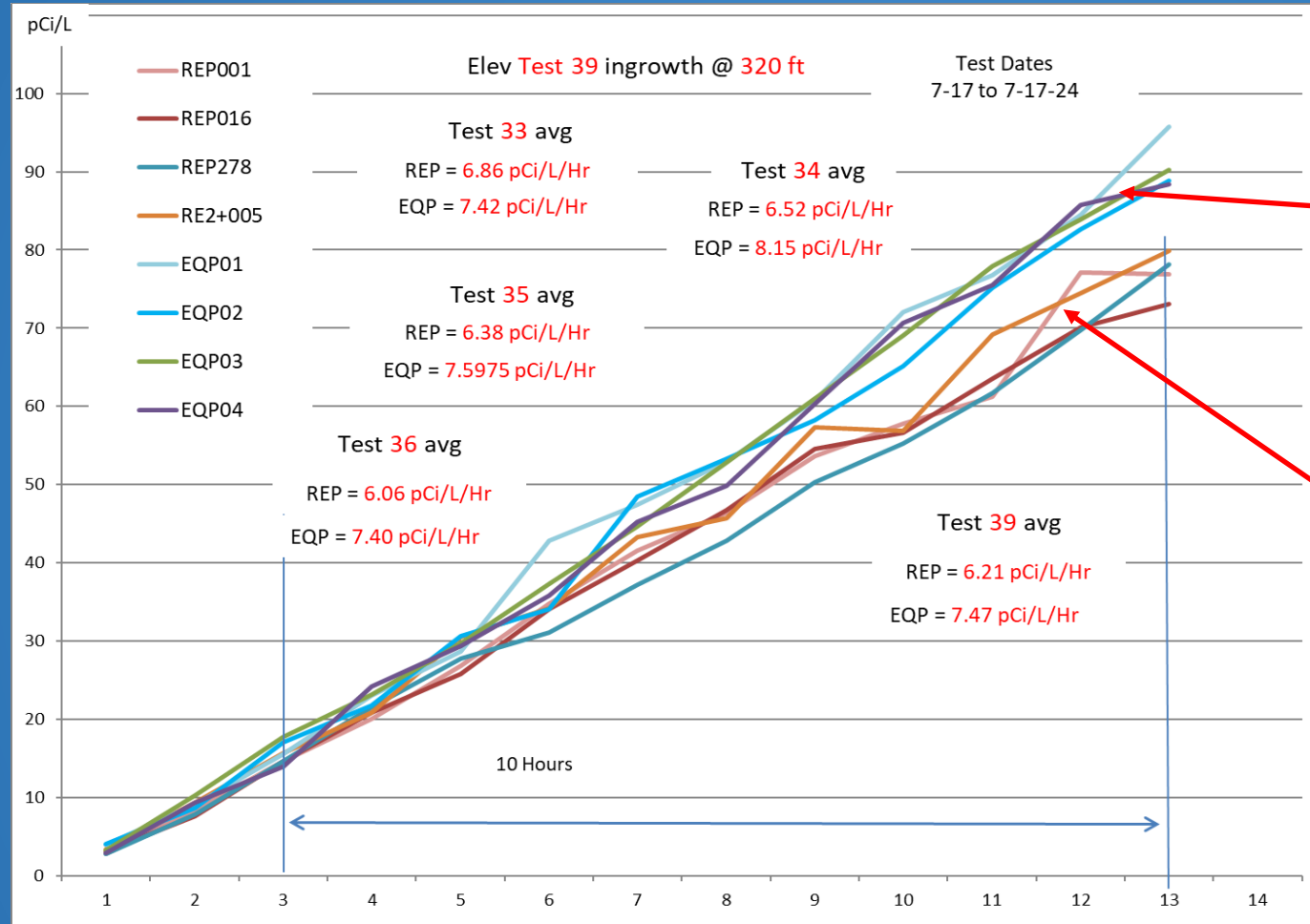
Fall Off around 100 pCi/L  
3<sup>rd</sup> to 10<sup>th</sup> Hr used for ingrowth

Reason for fall off  
after 100 pCi/L  
not determined



( 3<sup>rd</sup> hour subtracted from 10<sup>th</sup> hour ) / 10 = pCi/L ingrowth/hr

Each Test run 1<sup>st</sup> - 14 hours was plotted  
Radon climbed to 100 pCi/L

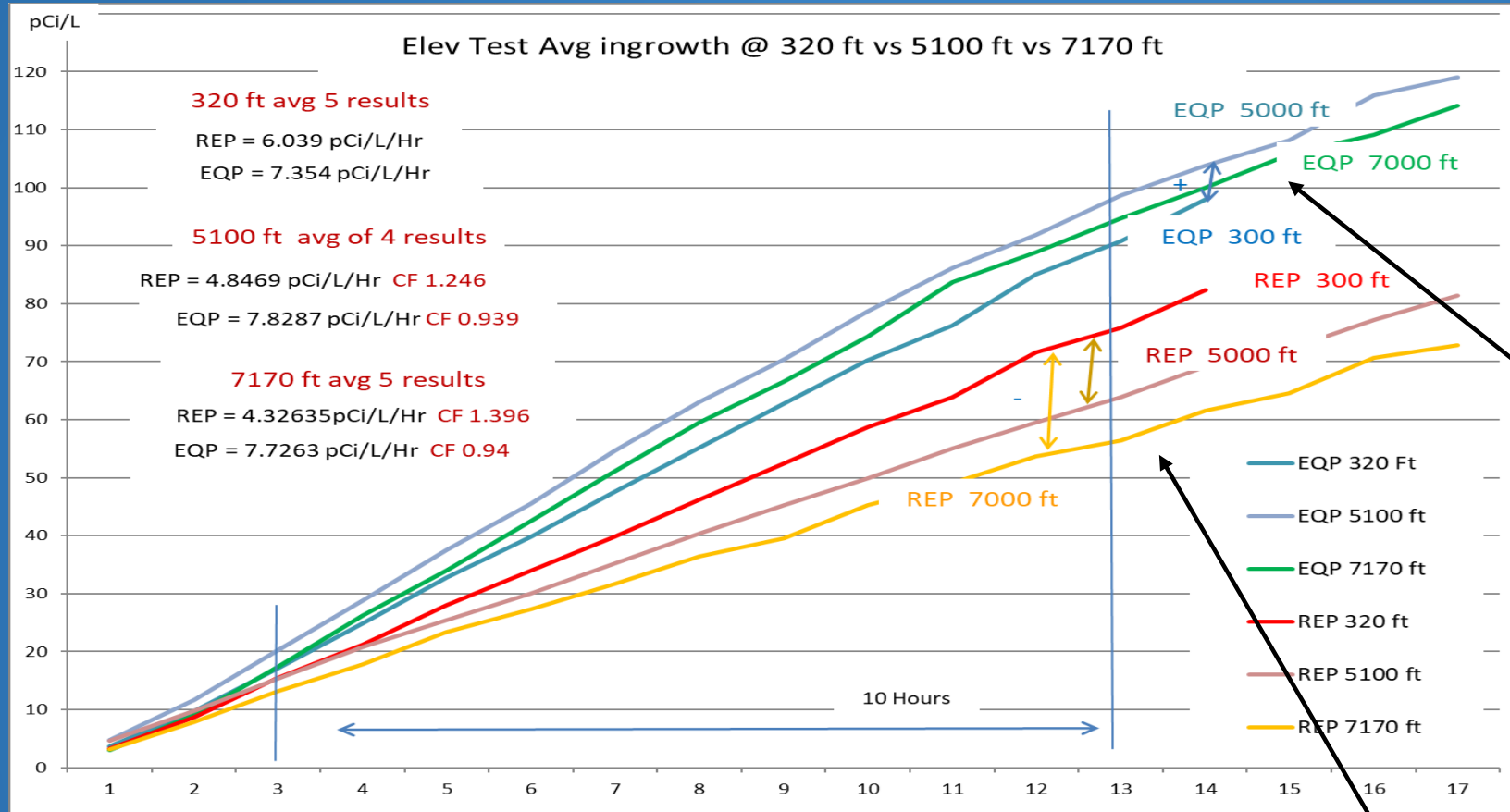


EcoQube  
Pros

RadonEye  
Pros

( 3<sup>rd</sup> hour result subtracted from 10<sup>th</sup> hour ) / 10 = ingrowth/hr

**Note:** Final Elevation comparison requires 1 more test at 320 feet



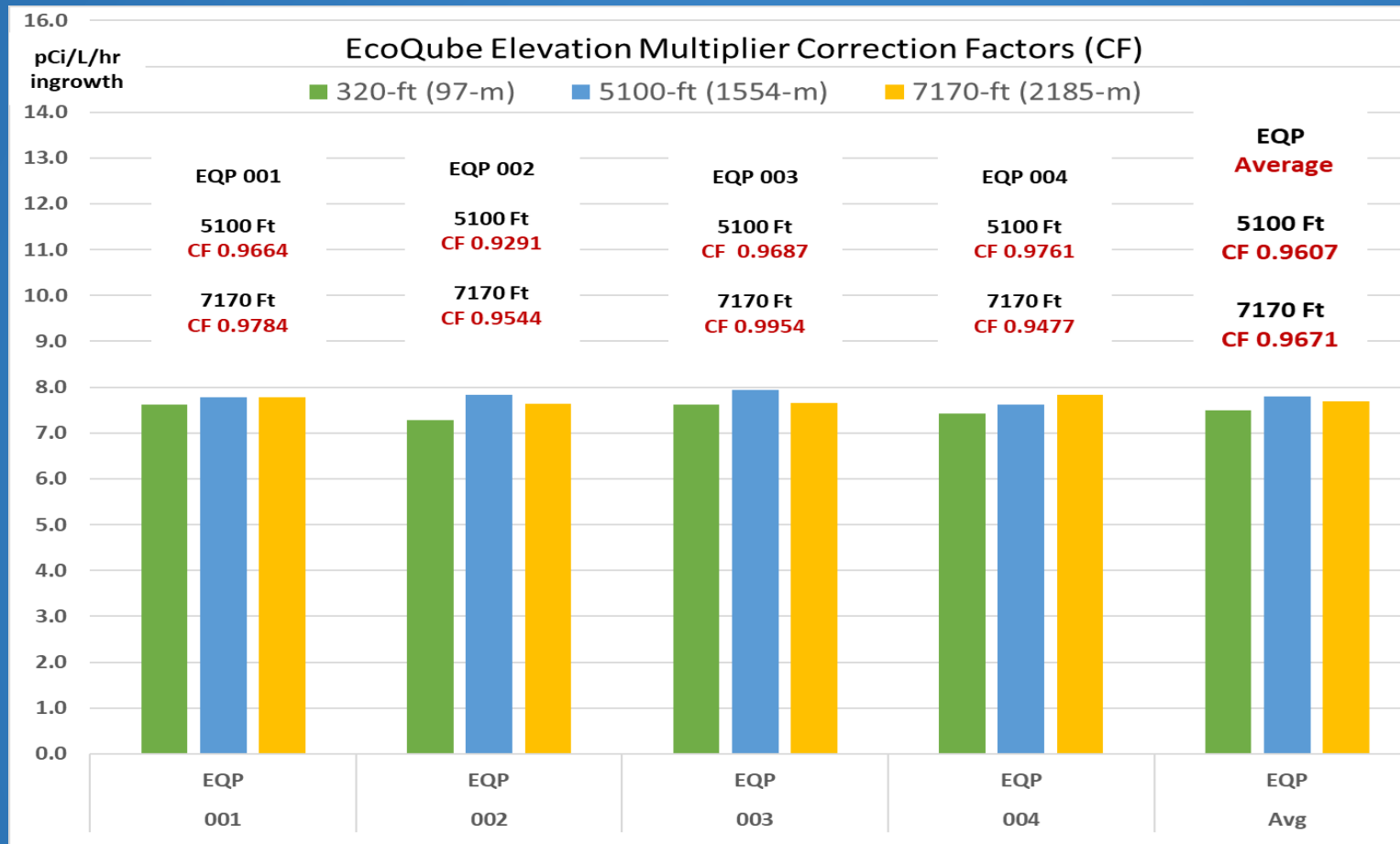
EcoQuBE Pro increased by +6% at higher elevations

Need to retest at 320 feet

To match 320 feet - RadonEye needs CF  
1.08 CF at 2150 feet  
1.25 CF at 5100 feet  
1.40 CF at 7170 feet

RadonEye Decreased by -7% & -20% & -28 %

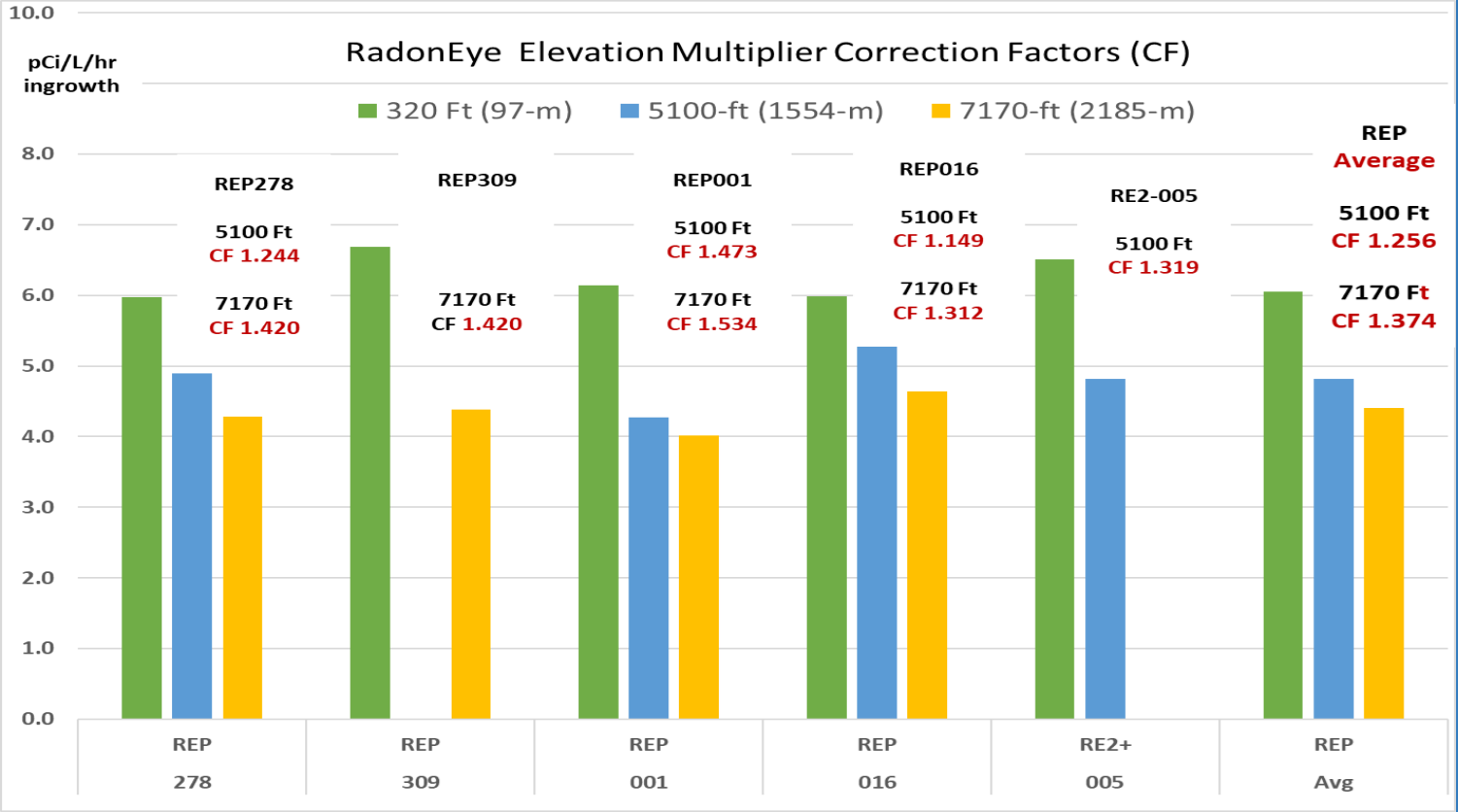
## Individual EcoQube Pro test average ingrowth



**Note:**  
Repeat testing  
at 320 feet  
needs  
to be done  
to confirm  
reference  
ingrowth

Good precision between EcoQube Pro monitors  
Very little elevation change

# Individual RadonEye test average ingrowth

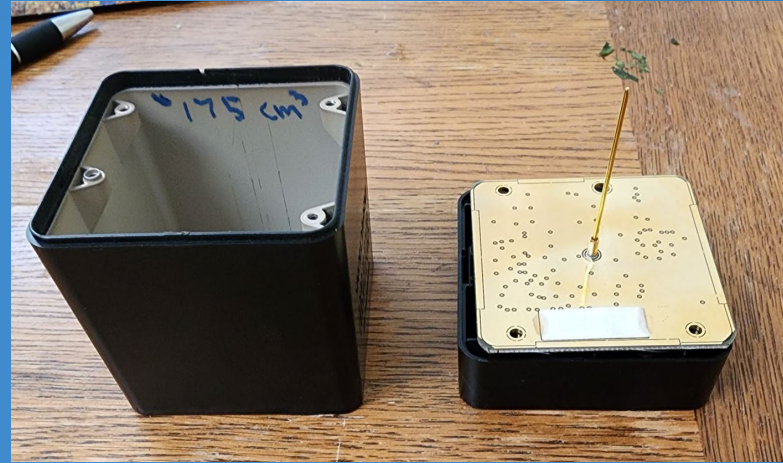


RadonEye's had greater variation in elevation CF  
5100 feet CF 1.15 to CF 1.47  
7170 feet CF 1.312 to CF 1.534

Two Pulse Ion Radon Detectors  
from the same company  
had very different performances



RadonEye Pro



EcoQube Pro

The best way to determine  
environmental influence  
on Radon Monitors is to test it!



Conference Papers on  
Commercial PFE Testing  
Calculating Piping Pressure Drop  
Onsite Radon in Water Measurements  
Elevation Influence

Available at:  
[www.wpb-radon.com](http://www.wpb-radon.com)

Bill Brodhead  
WPB Enterprises, Inc  
[wmbrodhead@gmail.com](mailto:wmbrodhead@gmail.com)  
610 613-8004

Big thanks to Ecosense for providing radon monitors and testing volunteers