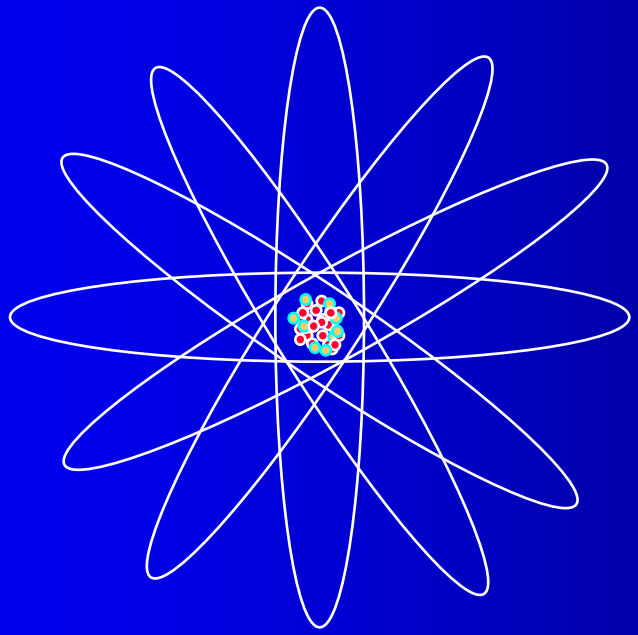
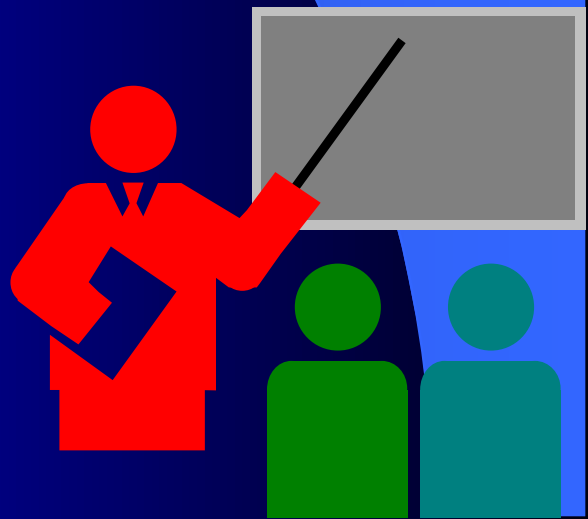
Introduction to Radon & Radioactivity

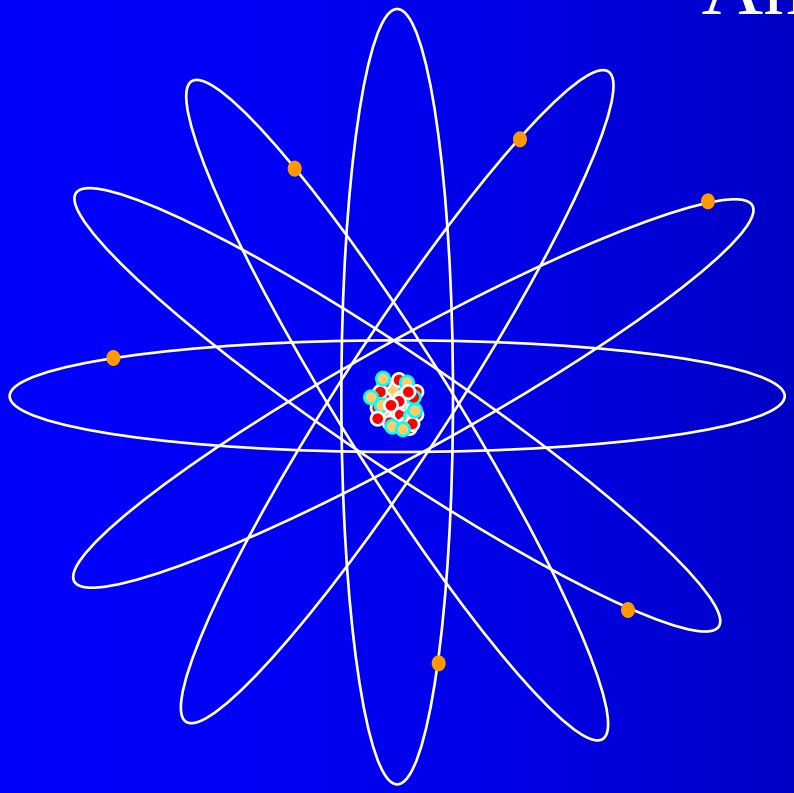


Why view these Radon slides?

- Protect your family's health
- Understand the science
- Learn how to do a radon test
- Learn about mitigation methods
- Be informed



A Simple Model of an Atom



An atom is composed of:

Nucleus (Atomic Mass)

composed of:

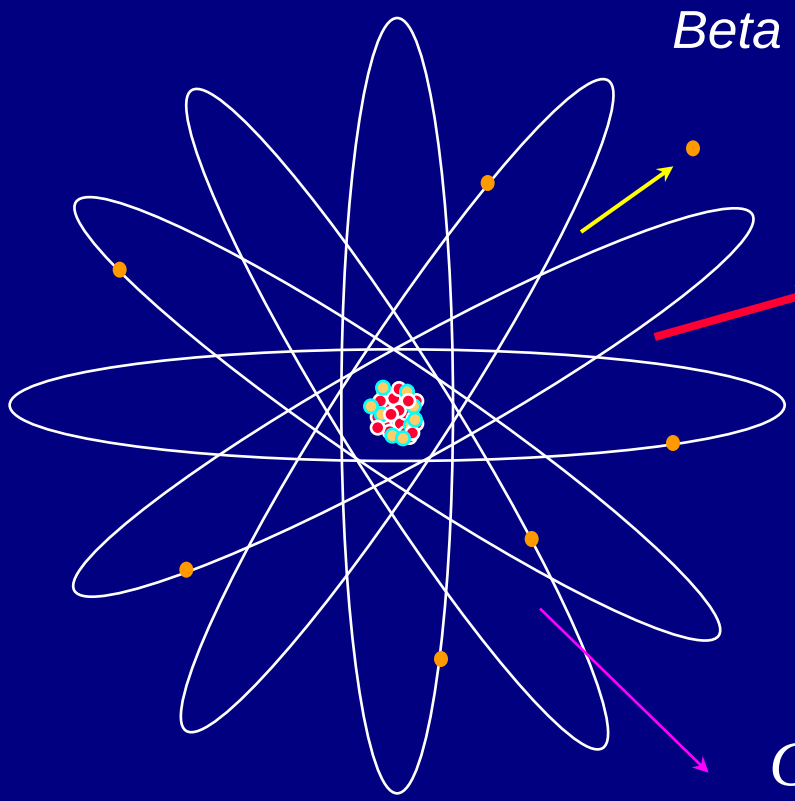
- \+ Protons (Atomic number)
- Neutrons

Orbiting around the Nucleus are:

- \- Electrons

If protons were the size of a baseball the electrons, the size of beebees, would be from several hundred yards to miles away

Radioactivity means an atom occasionally gives off energy or a particle



Beta emission

Alpha emission

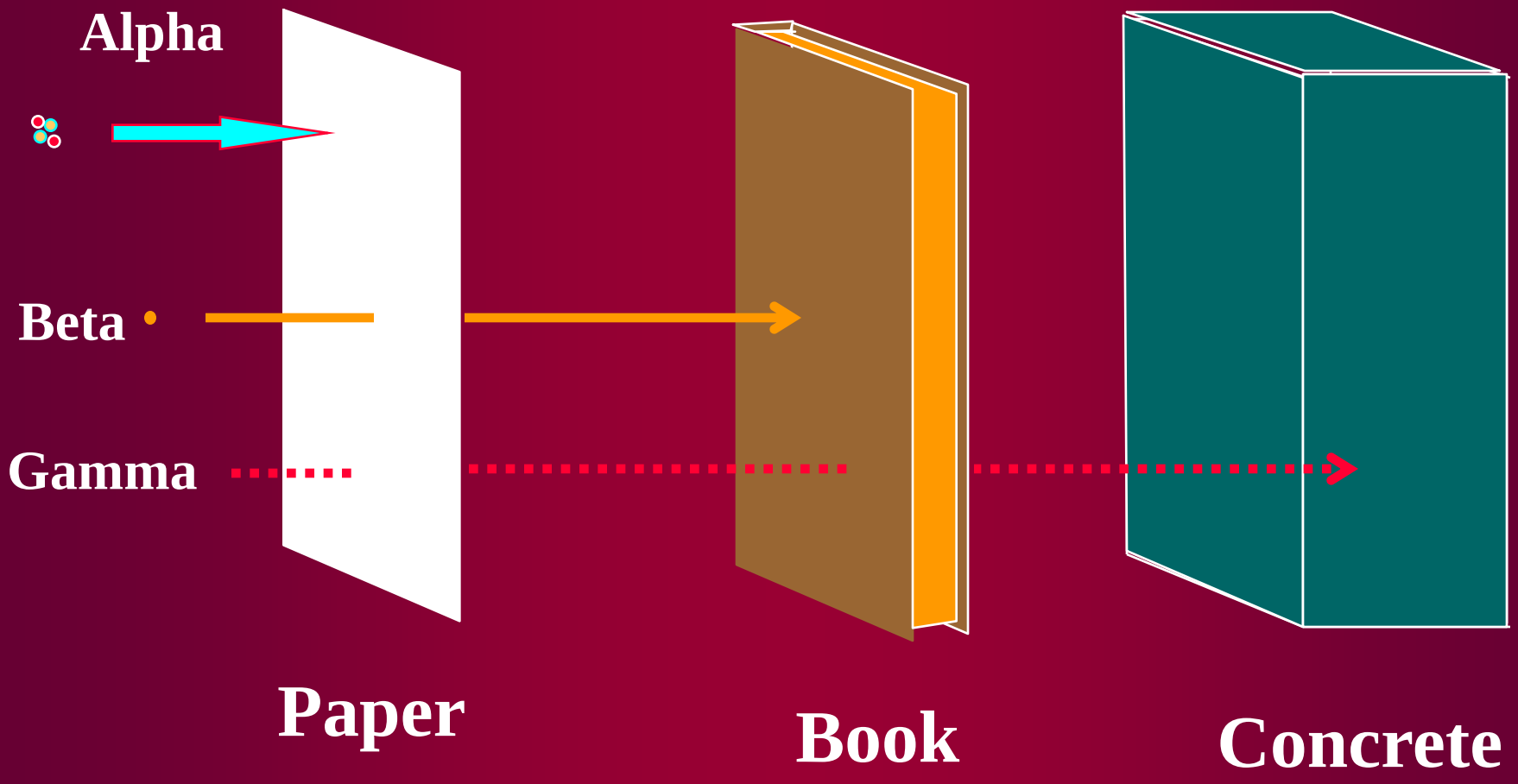
2 proton's & 2 neutrons

Gamma emission

The energy emission is called a radioactive decay

Decay causes an Atom to change identity

Penetrating Power of Alpha - Beta - Gamma

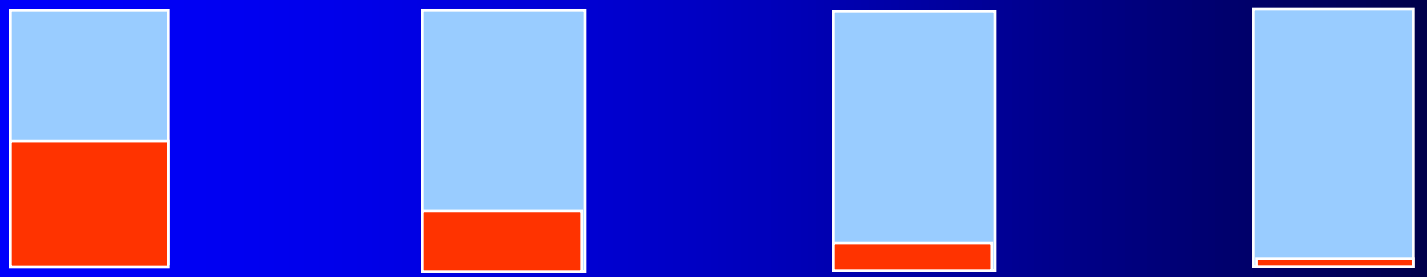


Radioactive Elements are identified by

the Energy given off

or

the Decay Rate (Half Life)



Percentage Remaining after each half life

Half life is the amount of time required for half the element to decay.

Radon Decay Chain

Uranium 238 (4 Billion yrs)

Radium 226 (1620 yrs)

Radon 222 (3.8 days)

Radon Decay Products

Polonium 218 (3 min)

Polonium 214 (u sec)

Bismuth 214 (20 min)

Lead 214 (27 min)

Lead 210 (20 yrs)

The half life of each element is listed in the brackets

Bill:

The elements in the decay chain of Uranium 238 are solid particles except Radon (gas)

Radon is a NOBLE GAS

Which means it does not stick or cling to anything and it is:

Naturally Occurring
Colorless, Odorless, Tasteless
and free to float through the soil and up into our homes before it decays

Radon is measured in pCi/L units

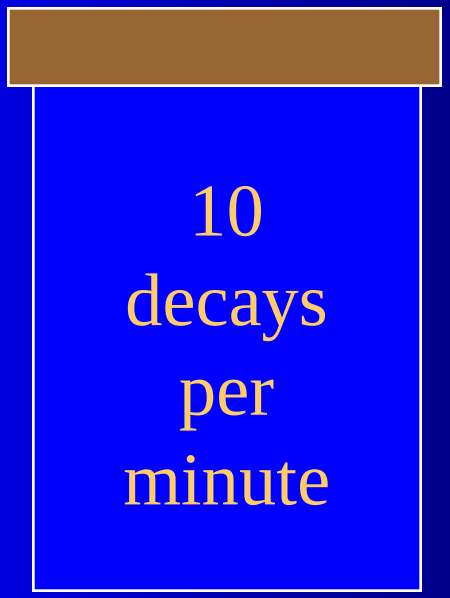
Pico is a Trillionth

Curie comes from Madame Curie

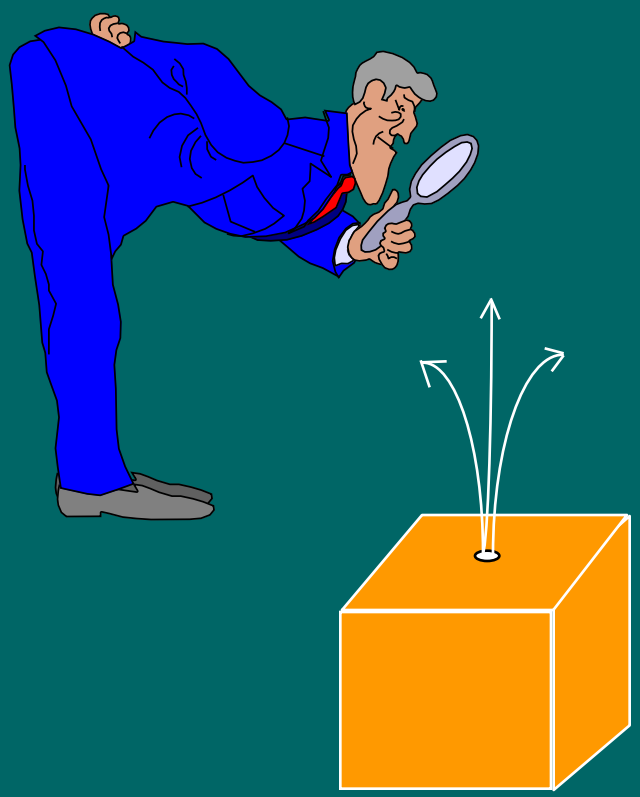
Madame Curie discovered
a gram of radium produce
37 billion decays per second

One PicoCurie or a trillionth
of a curie equals
2.22 decays per minute

A one liter jar
with 4 pCi/L has:



How little is 4 pCi/L ?

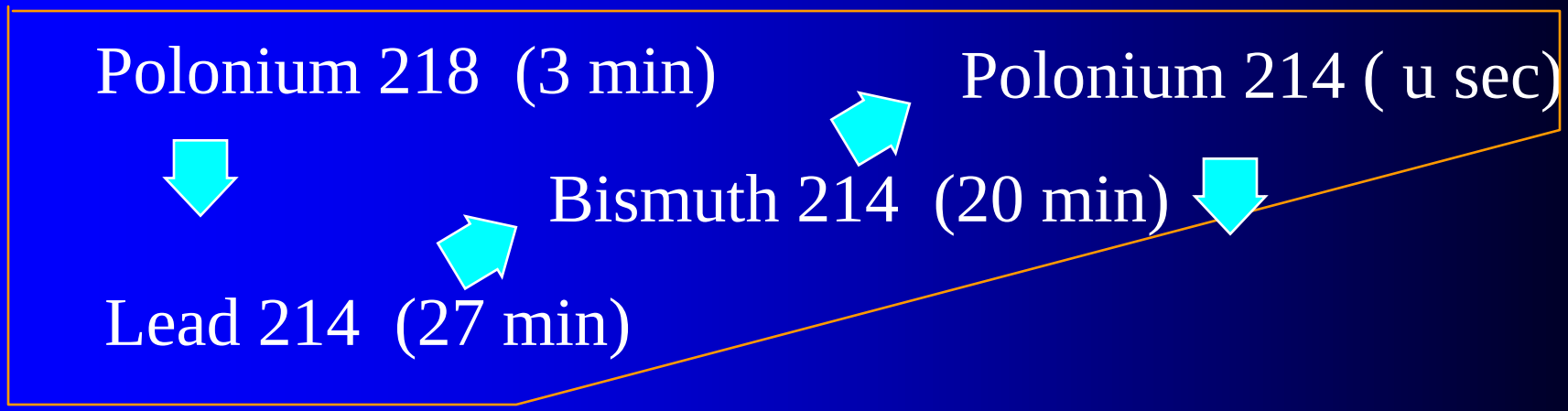


One Cubic Inch Box

If 10 million molecules per second was escaping, it would take 1 million years to empty this box

Only 2500 radon atoms are needed to reach 4 pCi/L in this box

Characteristics of Short Lived Radon Decay Products (RDPs)



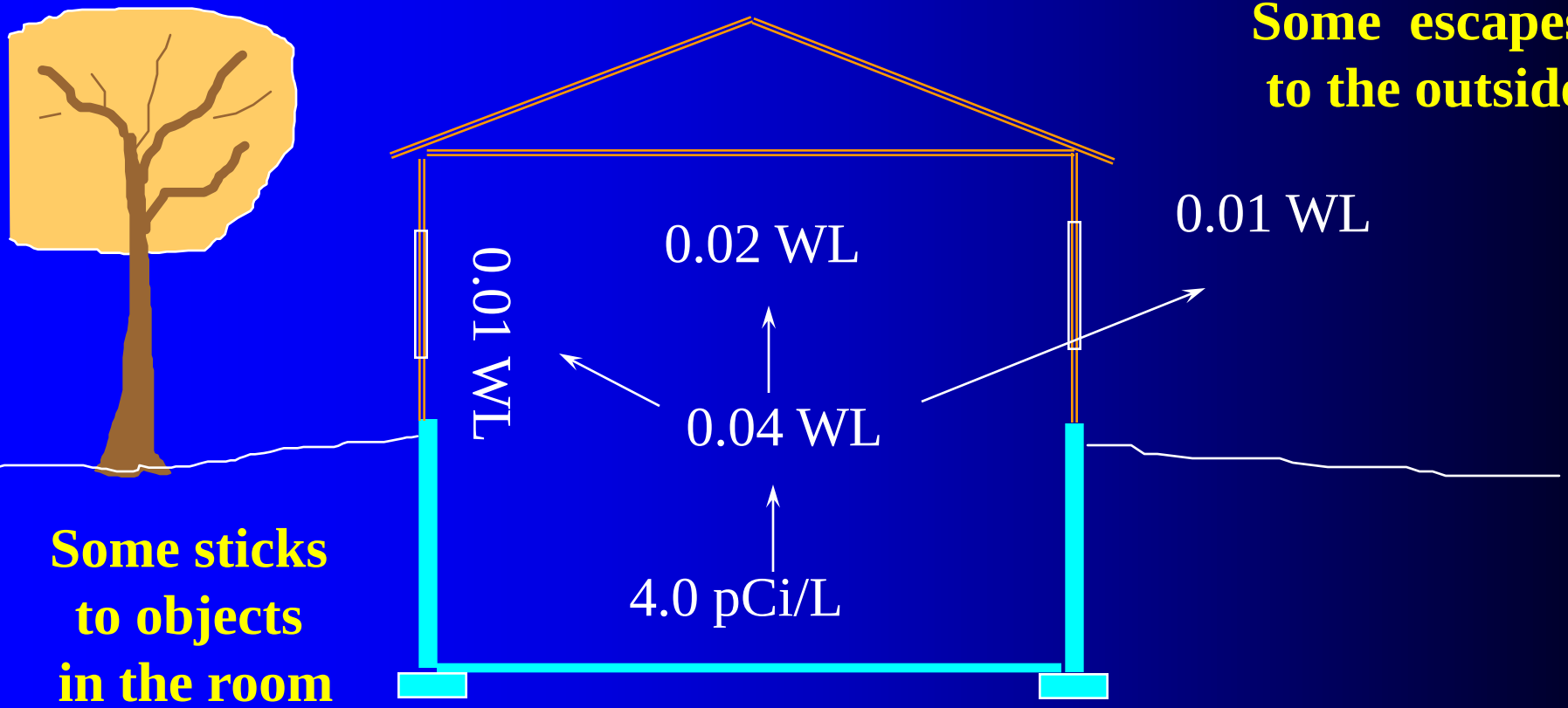
They are sticky particles

Two Polonium's emit Alpha Particles

20 times more dangerous than Radon

Measured in units of WL (working level)

Radon Decay Products released from the decay of radon are measured in units of WL



4.0 pCi/l produces about 0.02 WL in the air

Health Affects from Radon & Radon Decay Products

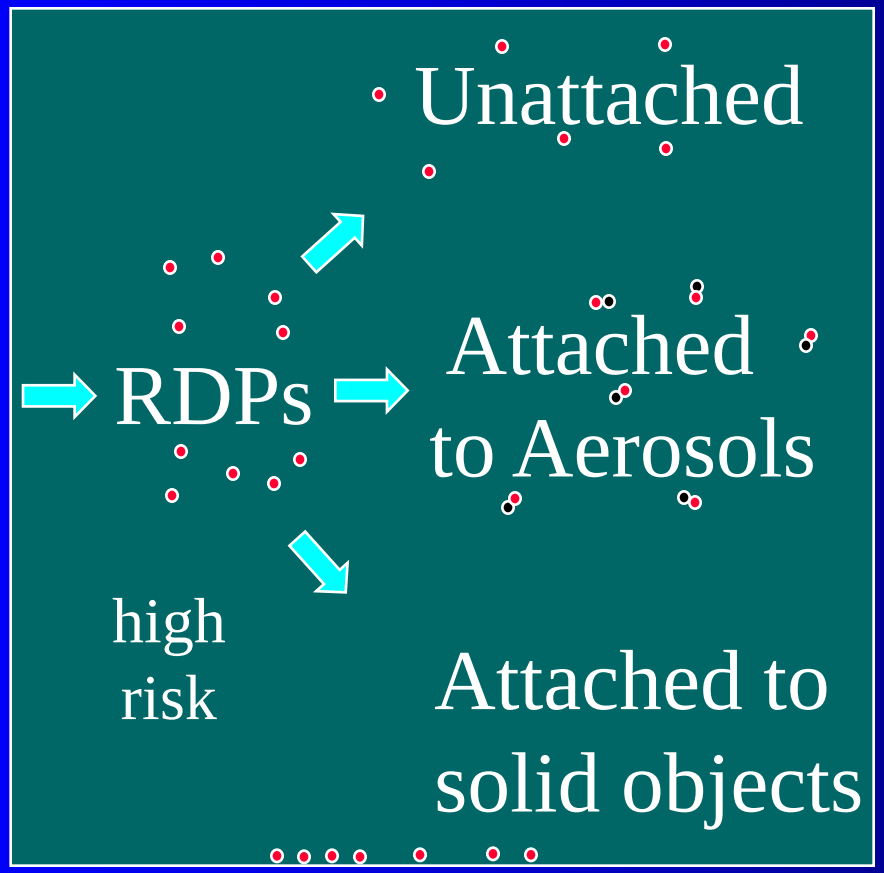
History of Radon

1400's	Underground miners were dying from an unknown lung disease
1879	Lung Cancer first identified in European miners
1950's	Connection made between Lung Cancer and RDPs
1984	Extremely high radon found in Pennsylvania home (2700 pCi/L)
1999	BEIR VI says about 18,500 Americans die each year from exposure to radon

The radon decay products (RDP's) produced by radon are the primary health risk?

Radon

low risk



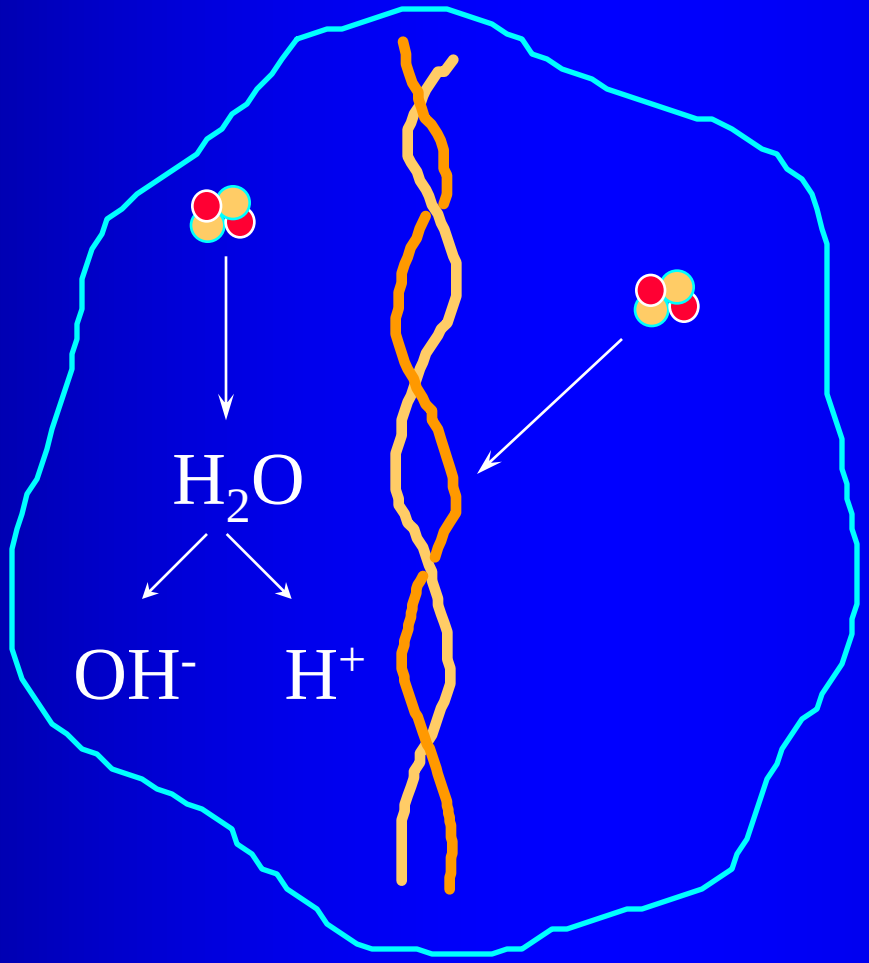
Most dangerous

Most exposure

No risk

Alpha emissions from radon decay products damage Lung Cells

Free radicals are formed in the cell fluid



Double strand DNA is split by alpha particles

A Lung Cell struck by an alpha particle will:

Die or

Heal itself or

become Cancerous

This is a micro-scope view of plastic that has been struck multiple times by alpha particles from radon and radon decay products

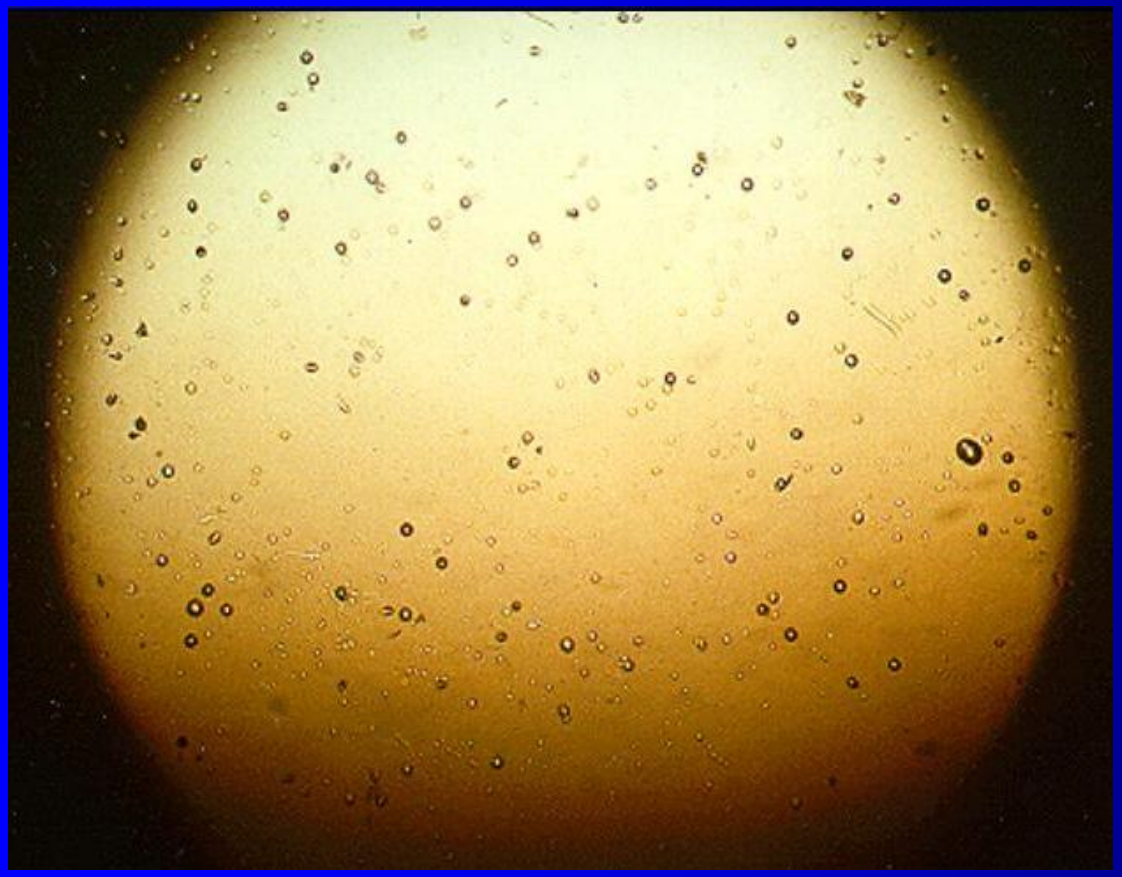


Photo by Dr. Jim Burkhart

This kind of
damage is
what your
lungs receive
from exposure to
radon
and
radon decay products

Radon risk is best determined by actual people studies

Miner Studies

Scientists believe the miner studies provide the best determination of radon risk because of the number of miners exposed to radon even though they are mostly male smokers, exposed to other pollutants

Case Control Studies

Best type of study but expensive because it requires a large carefully sampled group of lung cancer patients and similar group who do not have lung cancer

Geographic Studies

Increased lung cancer by area is not considered a good study

1988 BEIR IV study of 22,190 miners with 360 Lung Cancers

Lifetime average pCi/L	Expected lung cancer	Observed lung cancer	Relative increase
0	17	21	No change
1-2	39	46	No change
2-5	19	41	Double
5-10	13	40	Triple
10-20	11	39	3.5 times
36-96	15	66	Four times
96-200	5	45	Nine times

Notice that lung cancer rates doubled when miners were exposed to equivalent of 2 to 5 pCi/l over a lifetime

‘94 Swedish Case Control Study

1360 Swedes with lung cancer.
2847 Swedes without lung cancer

Averaged 27 years of Lived-in Radon measurements

Less than 4 pCi/L average = no excess lung cancer

4 to 10 pCi/L average = 30% increased lung cancer

Greater than 10 pCi/L average = 80% increased lung cancer

Sleeping with windows open = no excess lung cancer

Lung Cancer is leading cause of Cancer deaths

164,000 new cases of Lung Cancer in 2000.

Radon causes Lung Cancer for 16,000 smokers and 2500 non-smokers per year.

Radon is responsible for 22% of non-smoker lung cancer

3000 deaths per year from Passive Smoking - 2000 from Asbestos

There is a dramatic increase of Lung Cancer in Woman

26% of the population smokes - 90% would like to quit but Can't

Lung Cancer symptoms are so general that 75% of the time it has spread to other organs by the time it is detected

Five year survival rate in 1964 was 5% - in 2000 it is only 14%

Carcinogen Ratings

Class A

(demonstrated cancer causing) asbestos tobacco smoke, benzene, RADON

Class B

(probable cancer causing) DDT, alar, PCB, chewing tobacco, cholesterol

Class C

(limited animal evidence)

Class D

(inadequate evidence) saccharin

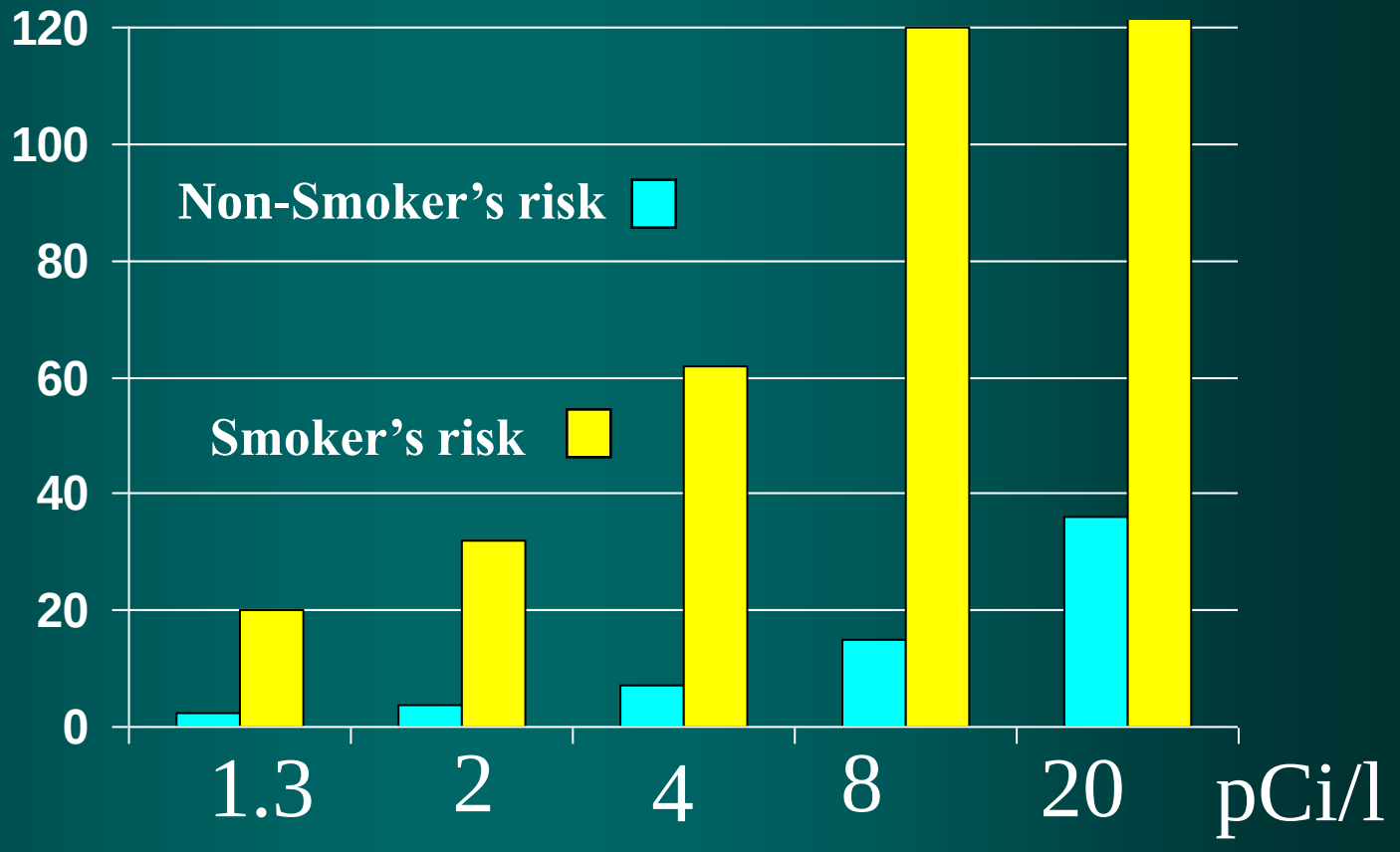
There are Four Factors necessary for a "Class A" carcinogen rating and Radon has all of them

- Physical Model of how it happens
  (alpha damage to lung cells)
- Animal studies showing an effect
  (animals exposed to radon had a higher rate of lung cancer)
- Occupational or Residential studies
  (miner studies and case control studies show a connection)
- Opportunities for exposure
  (more time spent indoors with house sealed up)

EPA has calculated how many many people would die of lung cancer if:

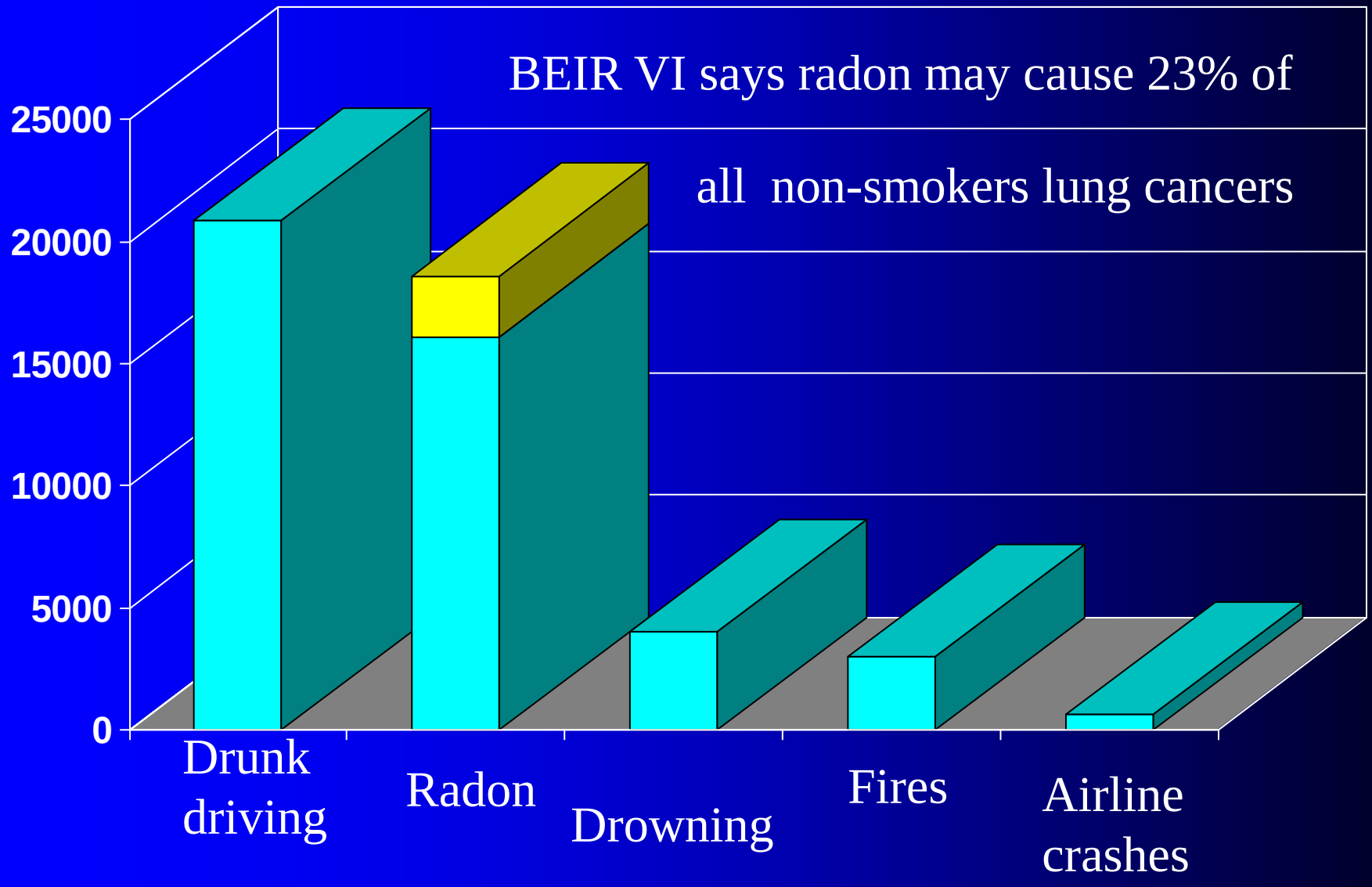
260 die out of 1000

Number of people who would die of lung cancer if a 1000 of them were exposed to these amounts of radon

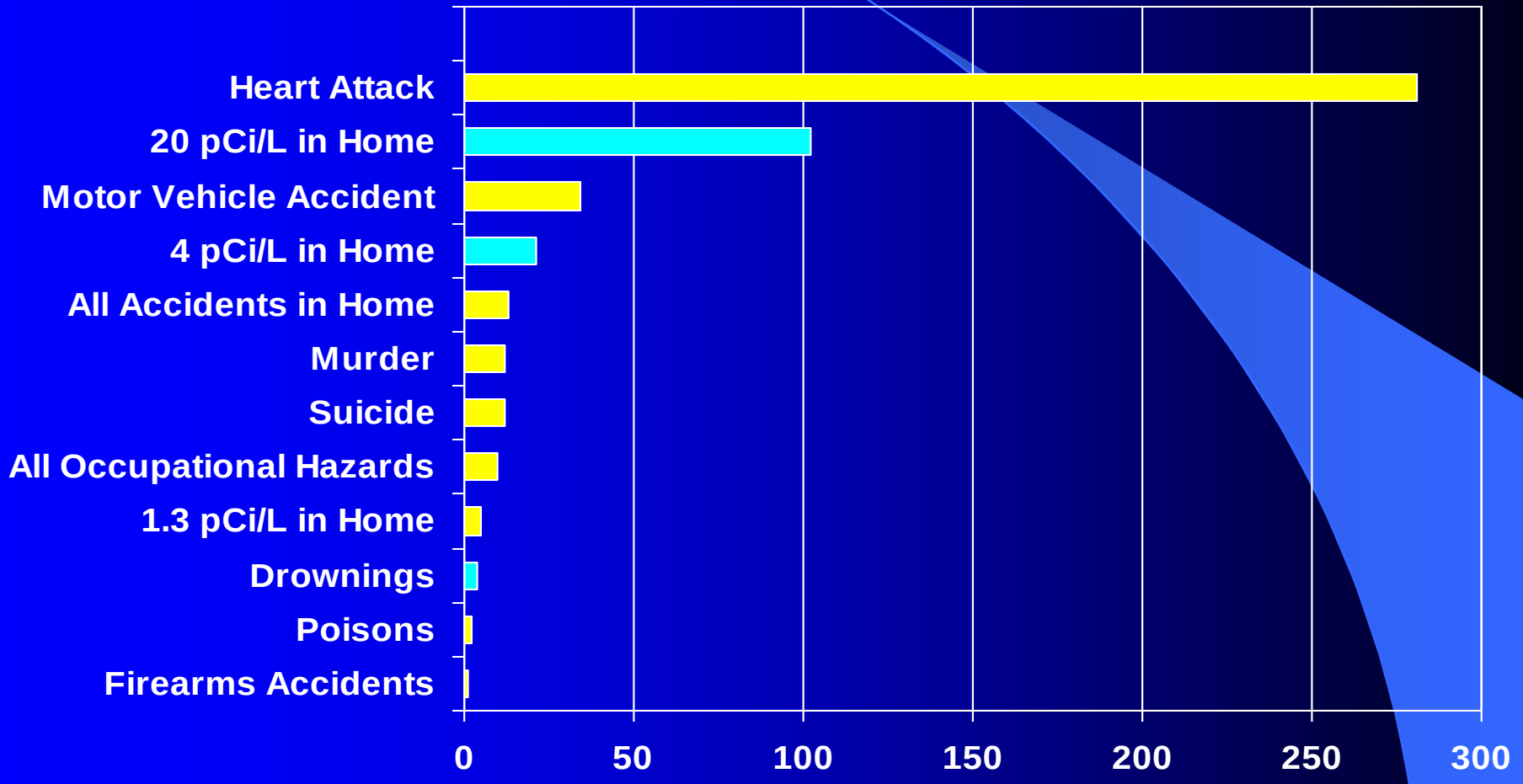


Average radon concentration over a lifetime

Comparison to other causes of Death

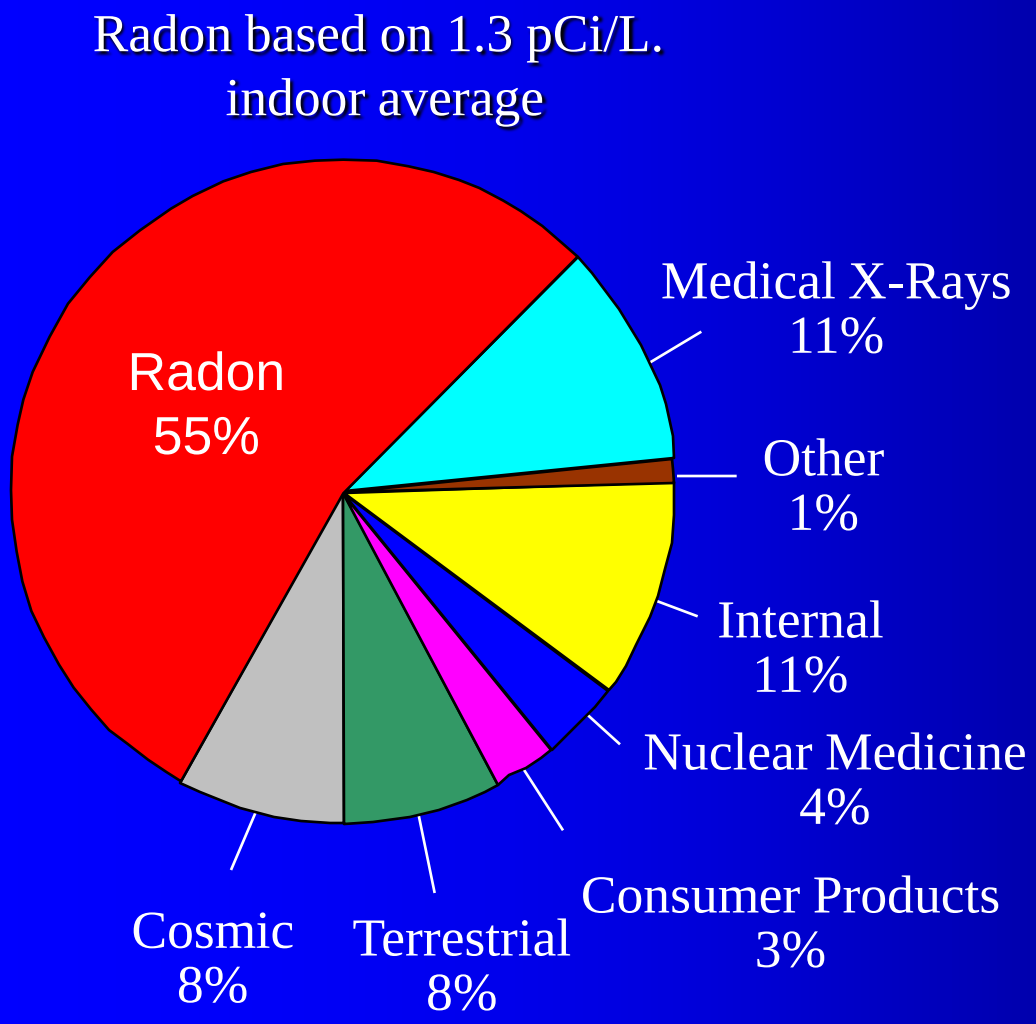


Comparison of estimated deaths annually per 100,000 persons for different causes



Jacobsen, c1990, University of Michigan

Sources of Radiation Exposure to the U.S. Population



Radon is by far the greatest single source of radiation to the general public.

These Organizations consider Radon to be Dangerous

American Lung Association

American Medical Association

Environmental Protection Agency

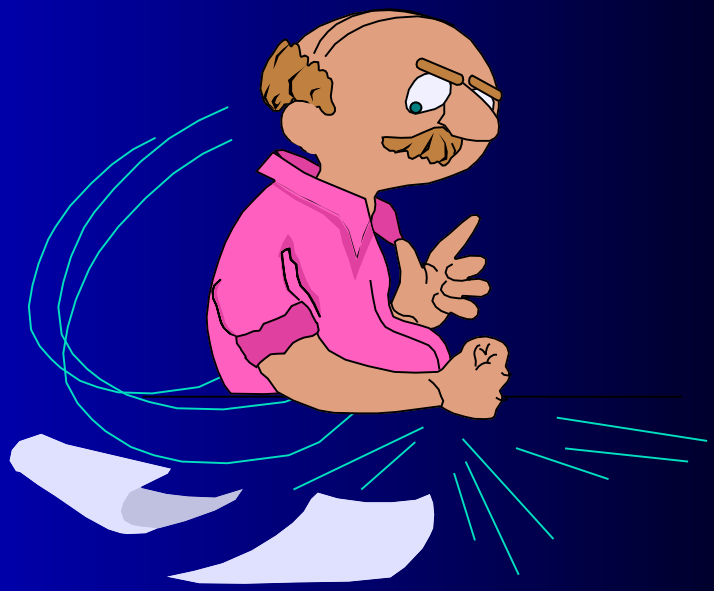
National Academy of Sciences

US. Surgeon General

American Cancer Society

EPA and Surgeon General recommend that everyone test their home for radon

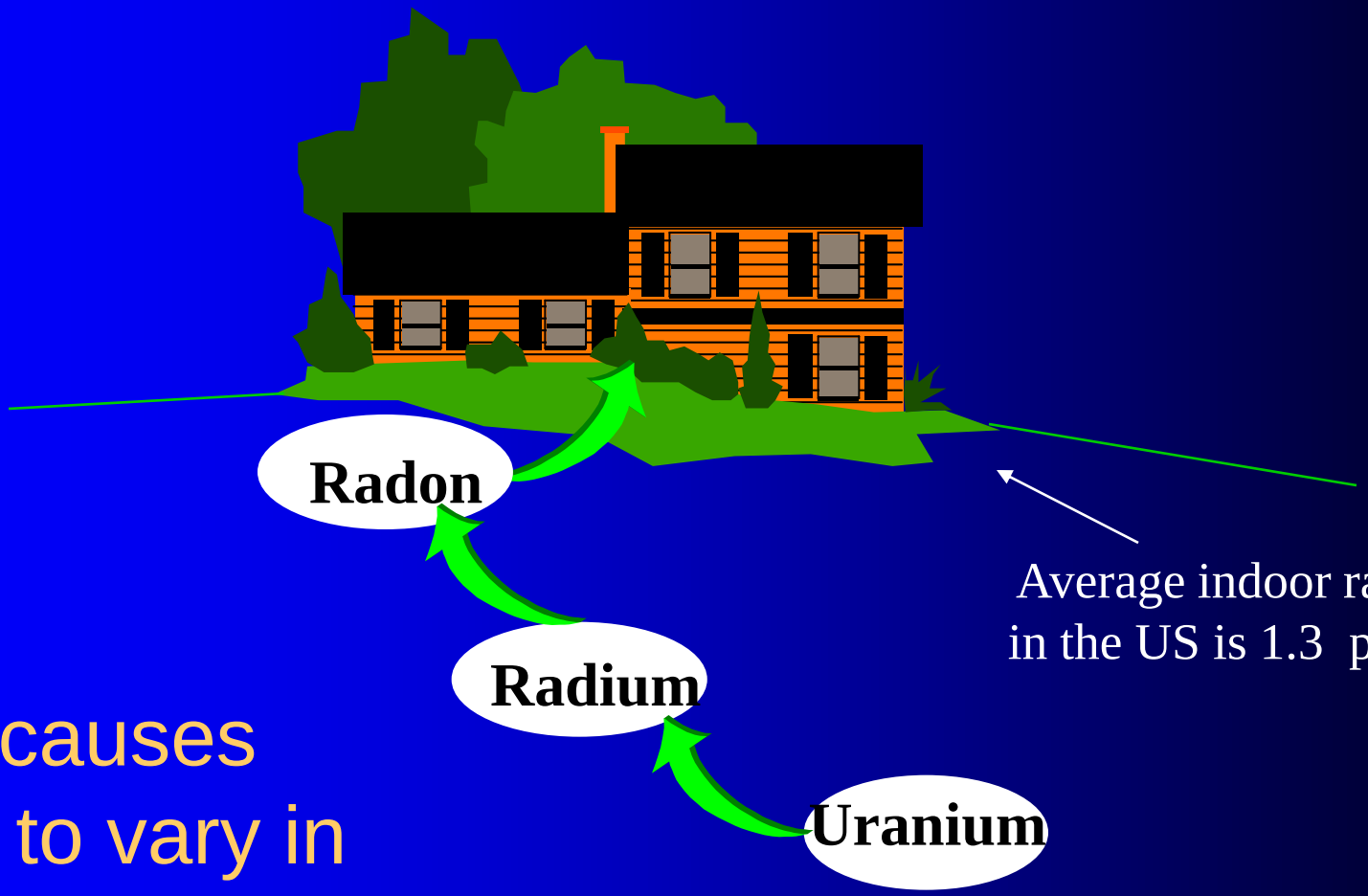
and



If your home is above 4 pCi/L, Fix It

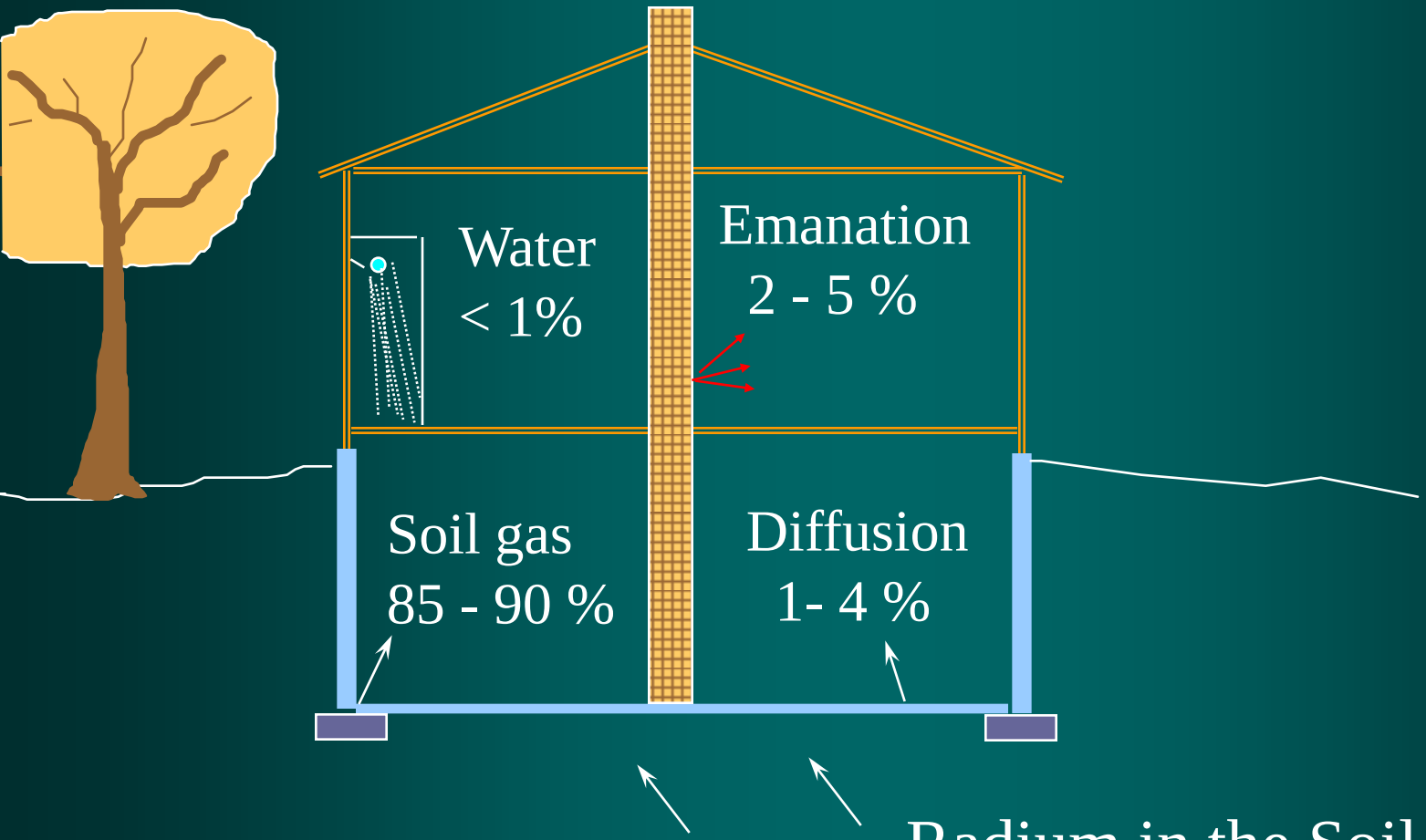
Radon Entry & Behavior

Average outdoor radon in the US is 0.4 pCi/L

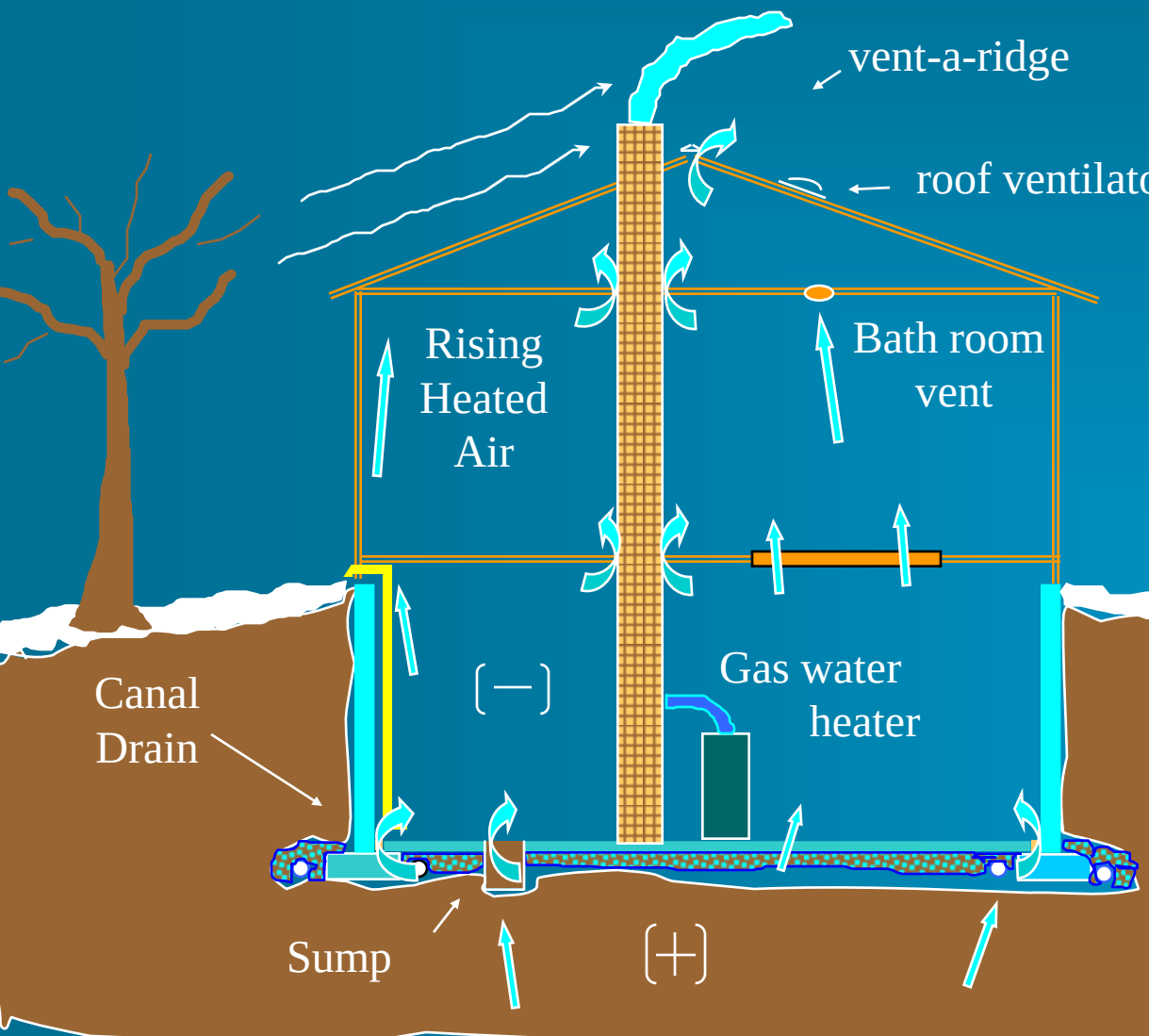


What causes radon to vary in vacant & occupied houses

Radon gets into our homes in several ways



Stack Effect is warm air escaping out the top of our homes in the heating season

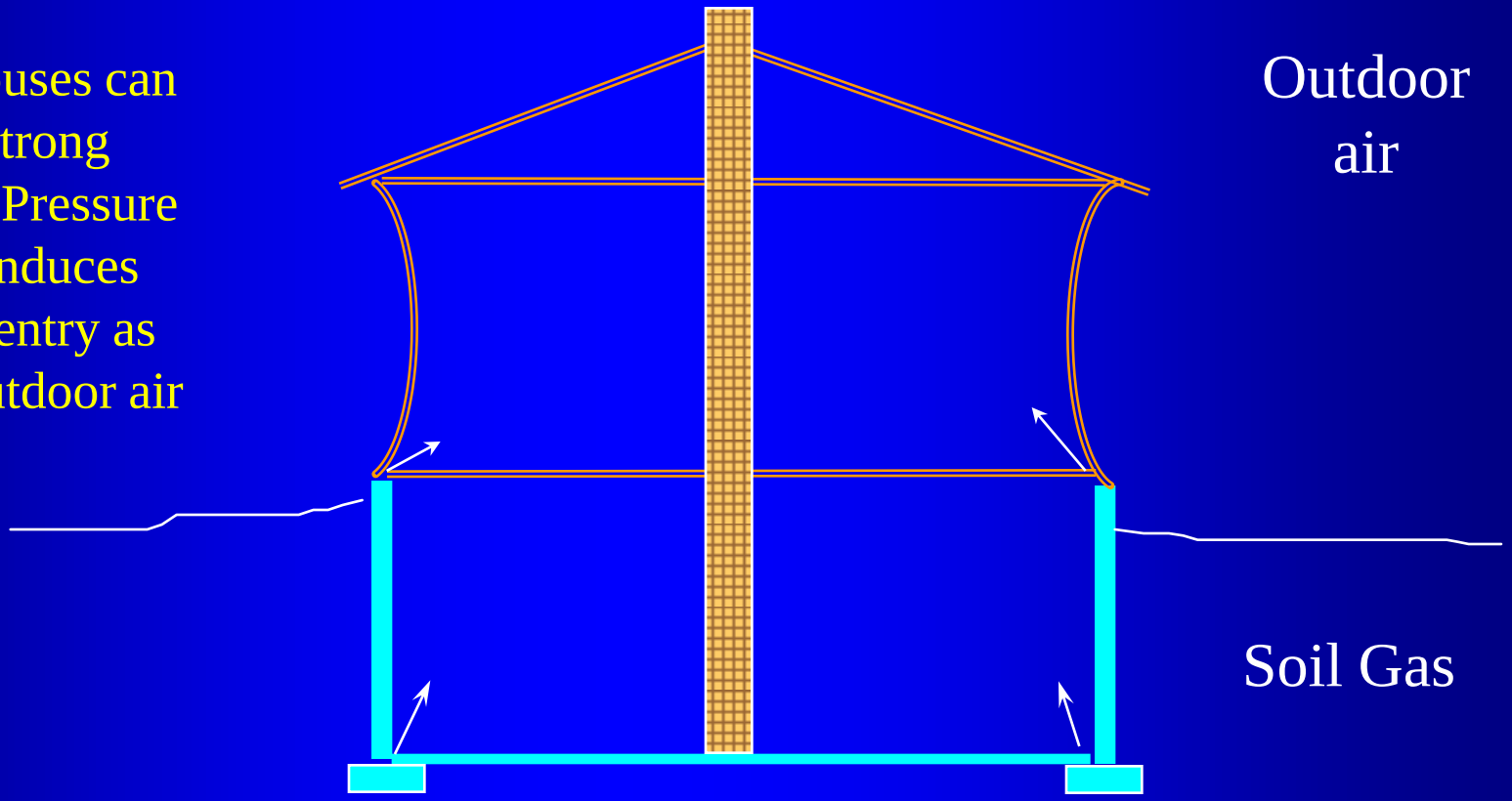


Escaping warm air creates a negative house pressure

Negative house pressure draws in radon laden soil gas

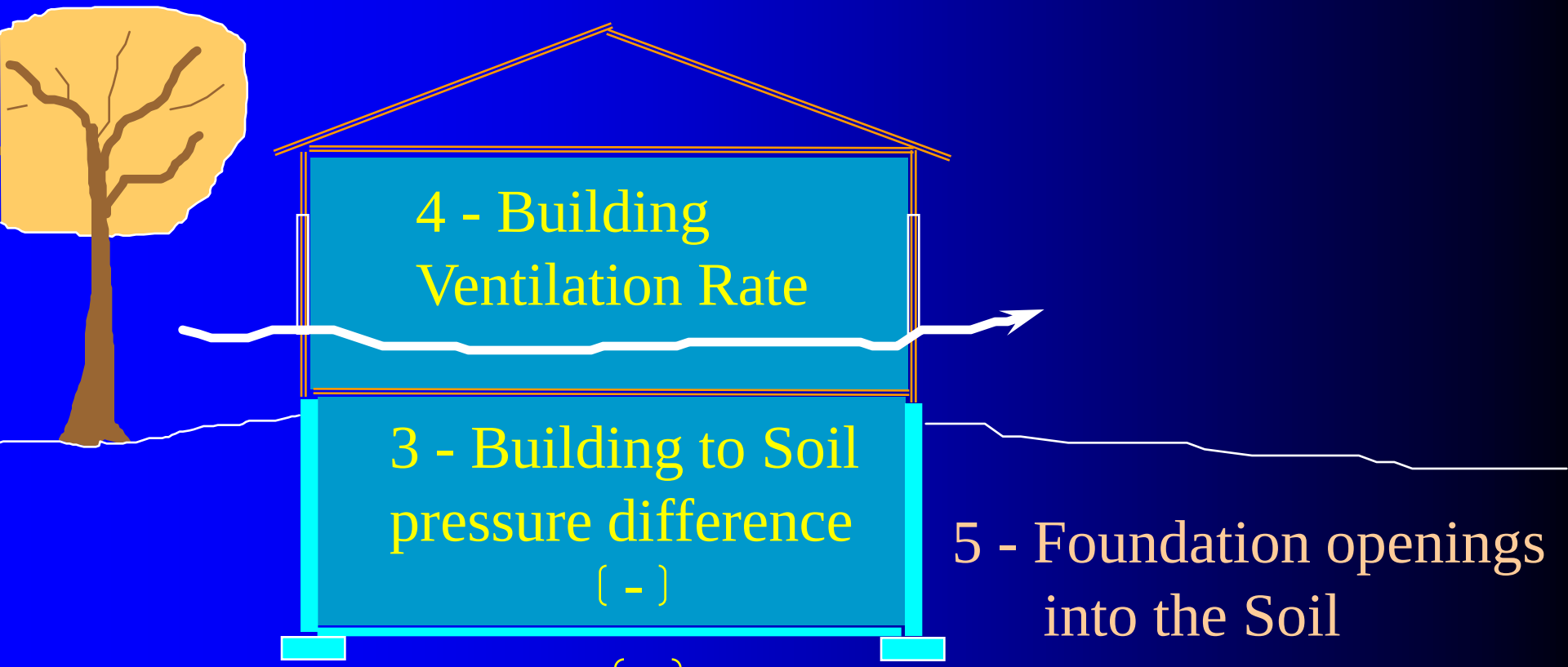
A drafty house can still have radon

Drafty houses can have strong Negative Pressure which induces soil gas entry as well as outdoor air



There is no correlation between radon levels and house age or house ventilation levels

Indoor Radon Levels depend on these factors:

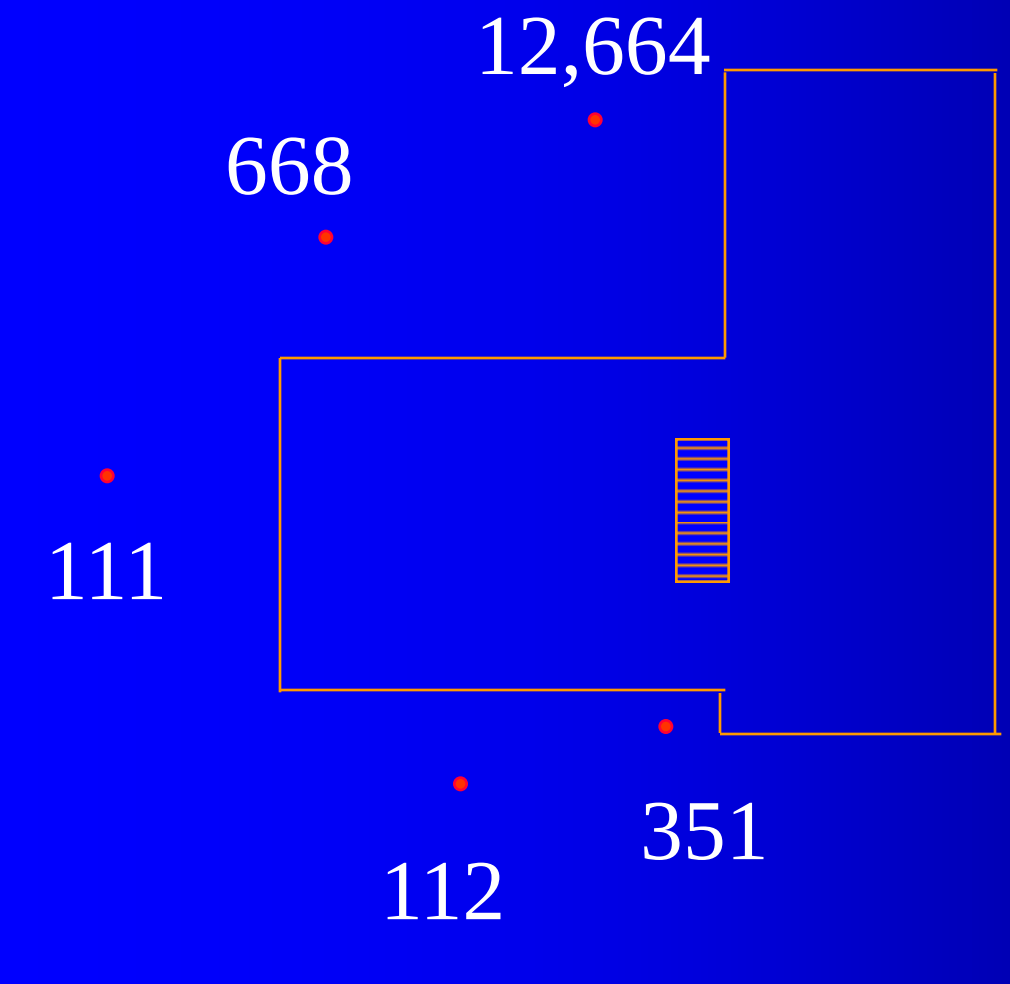


5 - Foundation openings into the Soil

1 - Radon Strength in the Soil

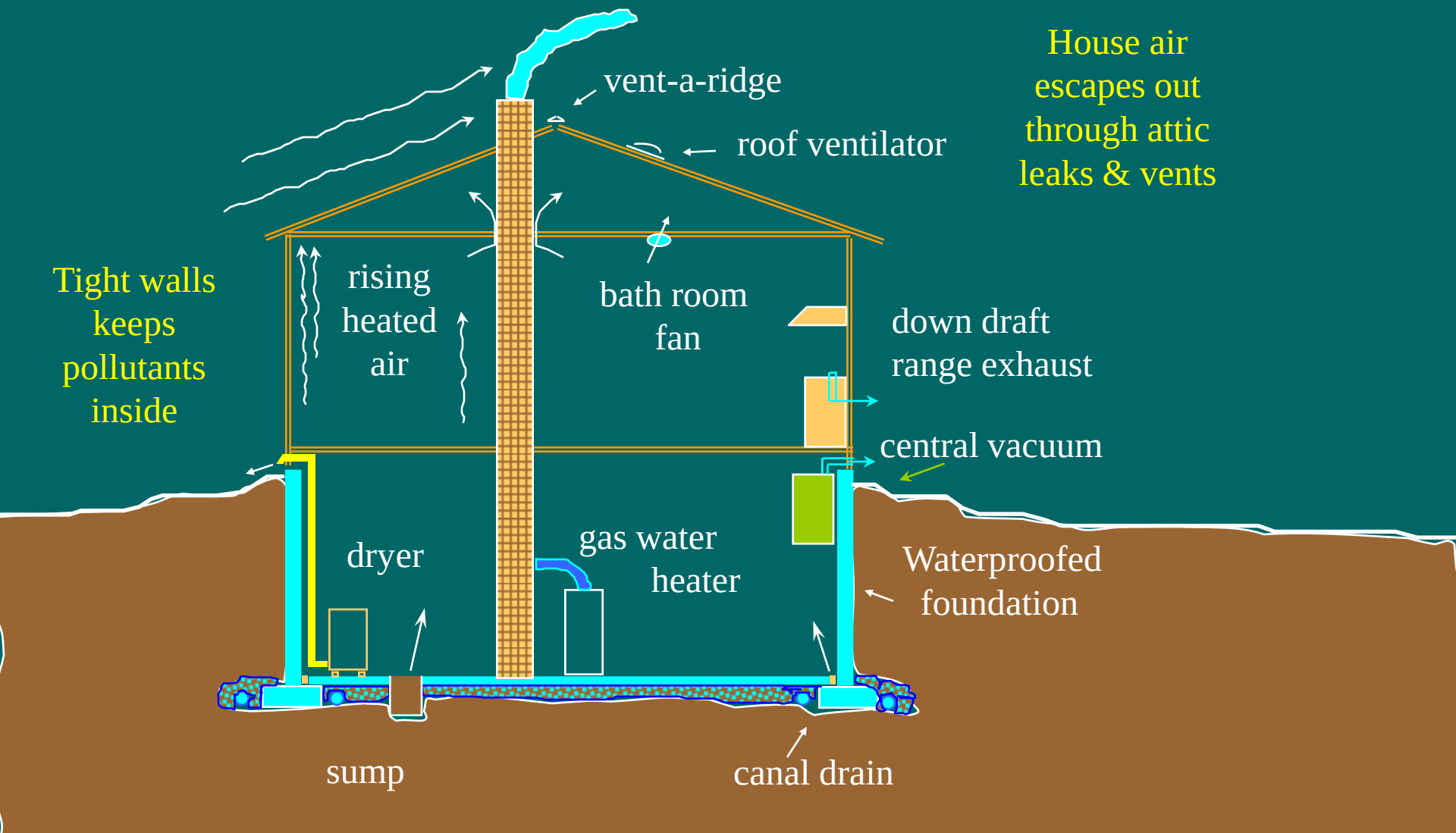
2 - Soil Porosity

There can be large variations in radon levels in the soil



These were actual radon levels measured in the soil around a home in NJ

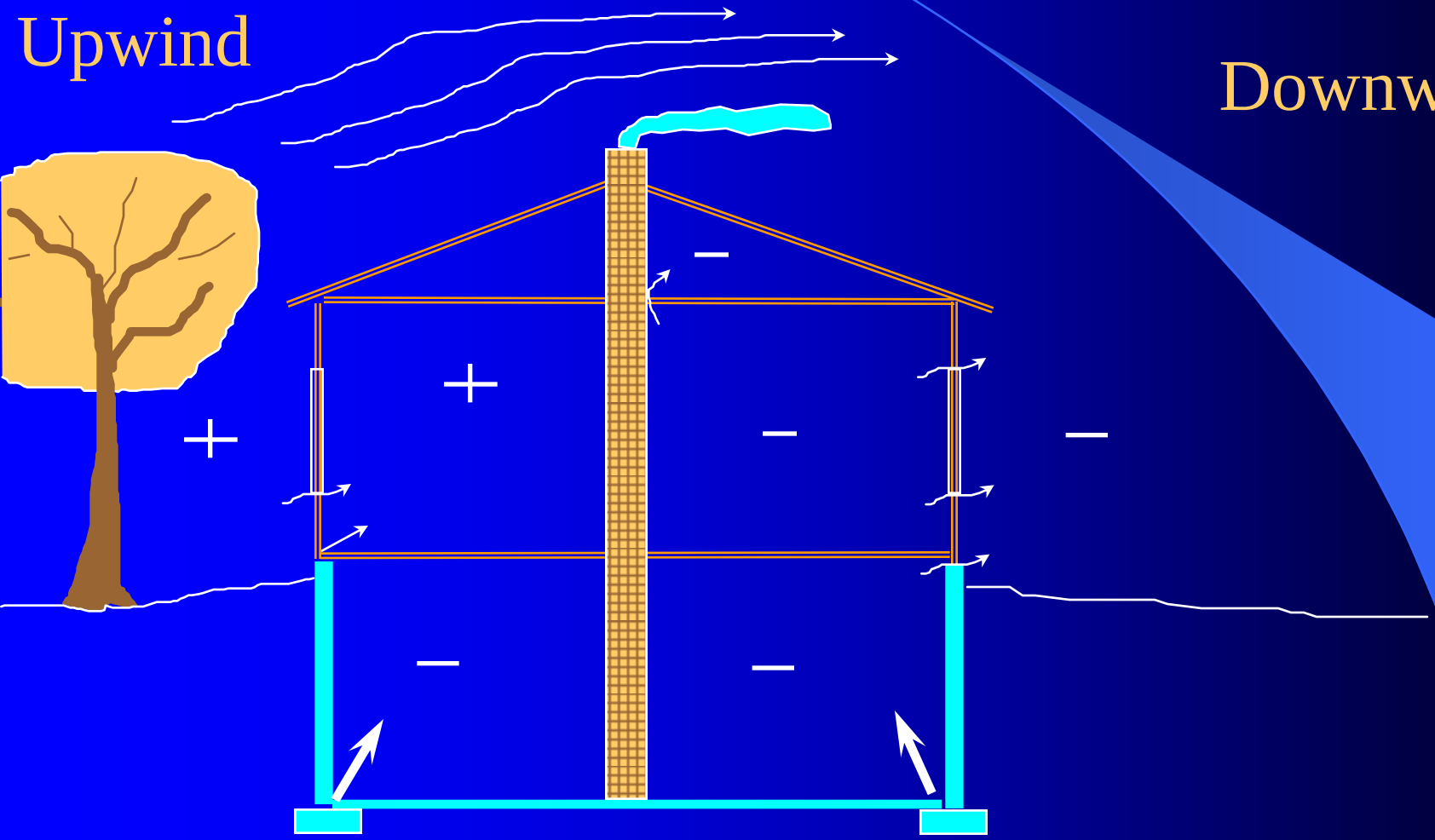
Houses act like Soil Vacuum Cleaners



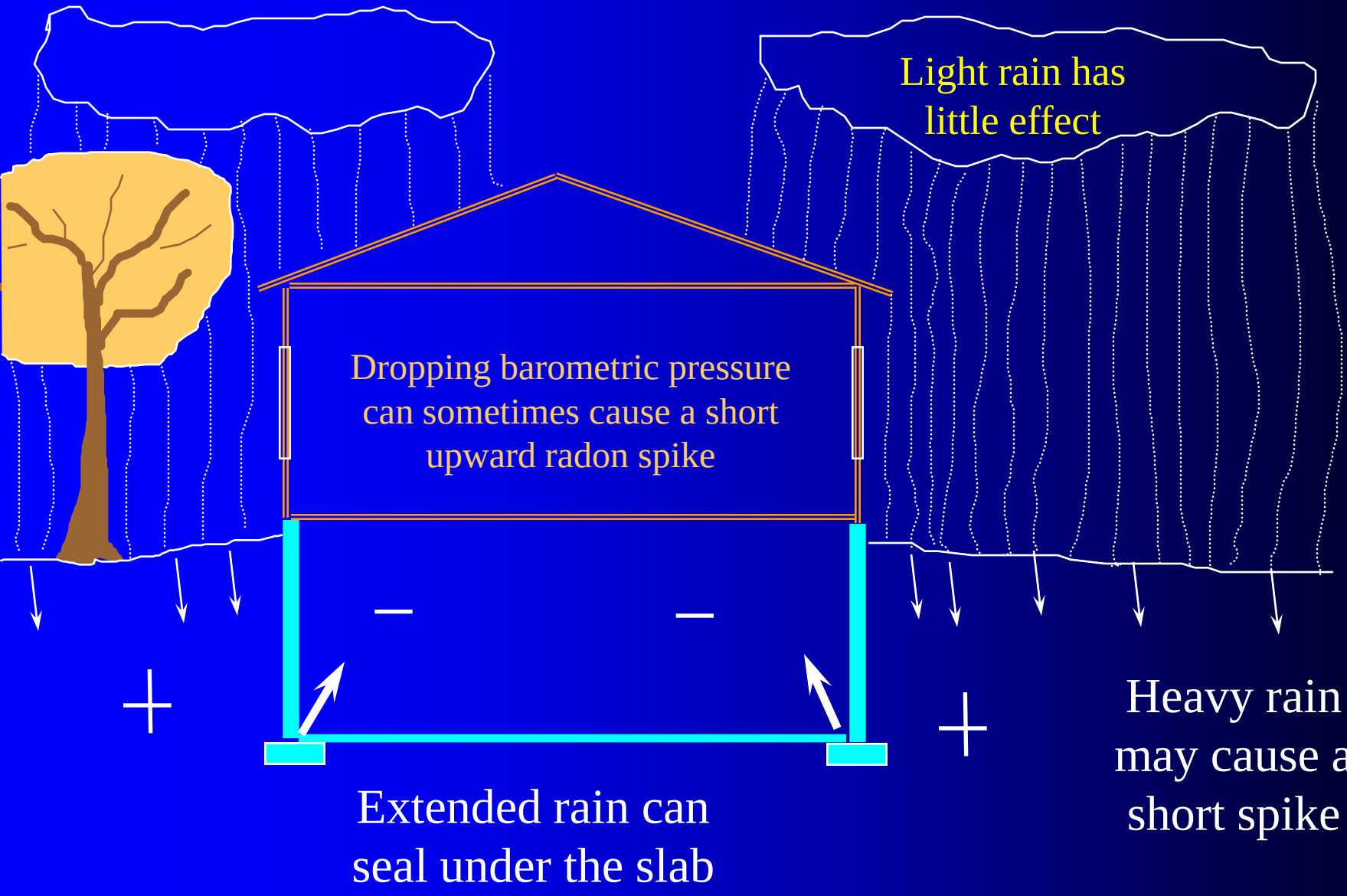
Common household appliances can cause negative pressures inside a home

	Typical cfm
Air tight wood stove	30
Combustion Appliance	20 - 70
Bathroom Fan	25 - 90
Clothes Dryer	100
Wood Fireplace	170
Downdraft range exhaust	300 - 400

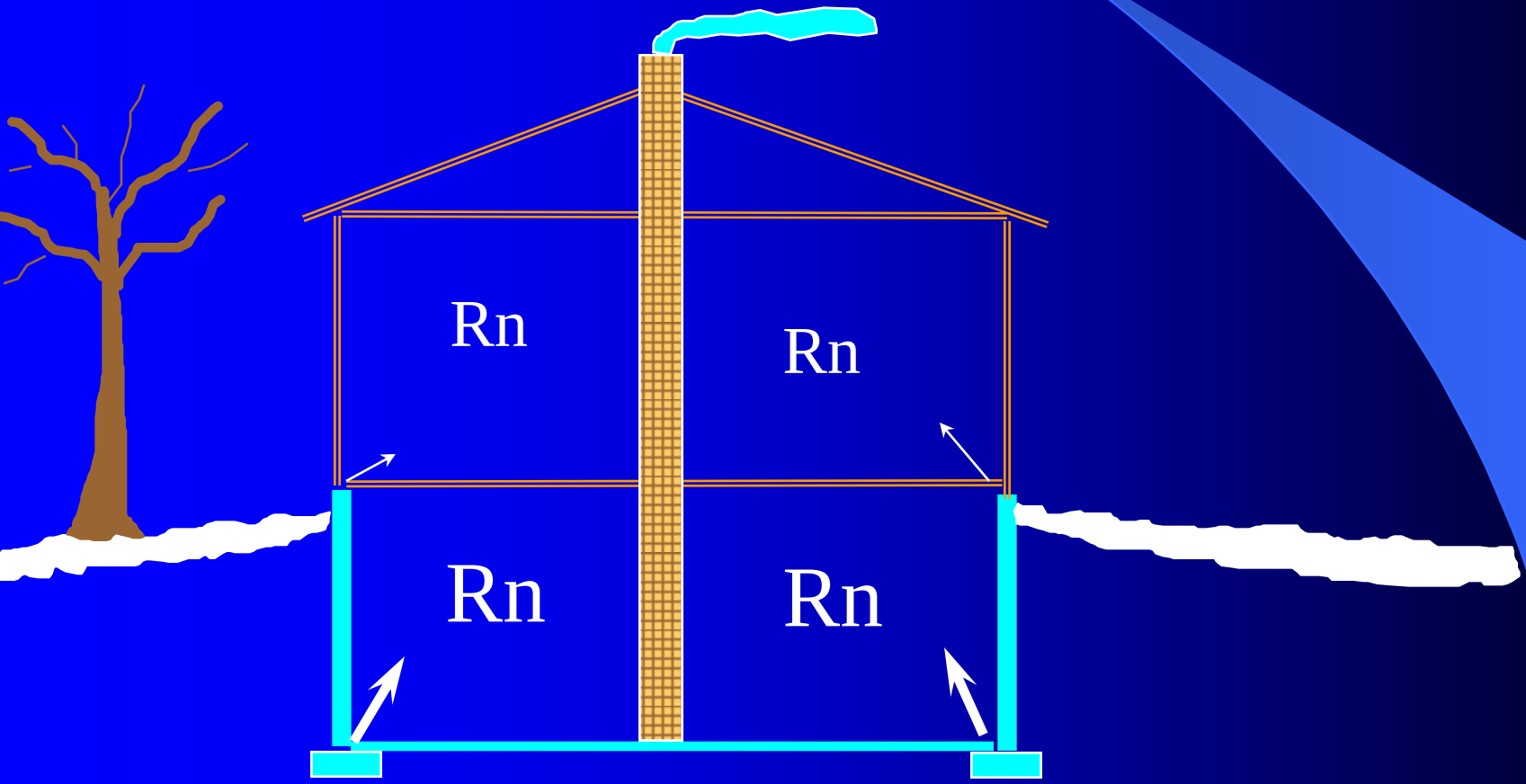
Strong wind can affect the radon levels



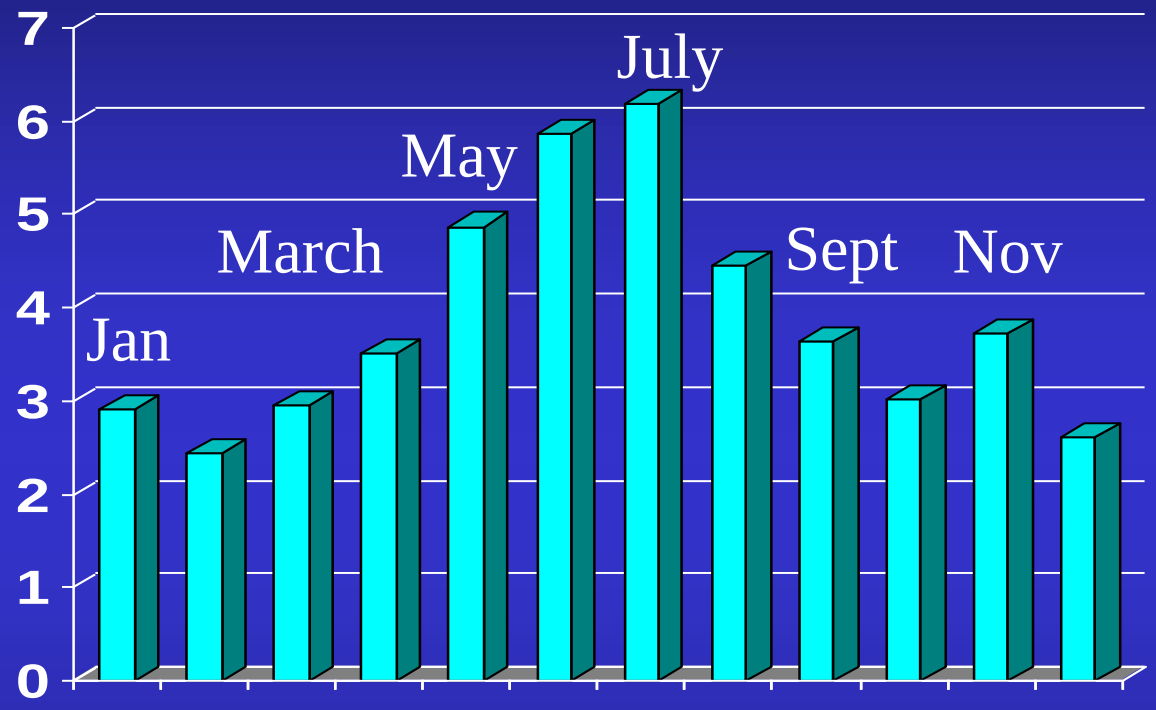
Heavy rain may also affect radon levels



Radon Levels tend to be Higher in the Winter



First floor tends to have 2 times to 6 times lower radon levels than the basement



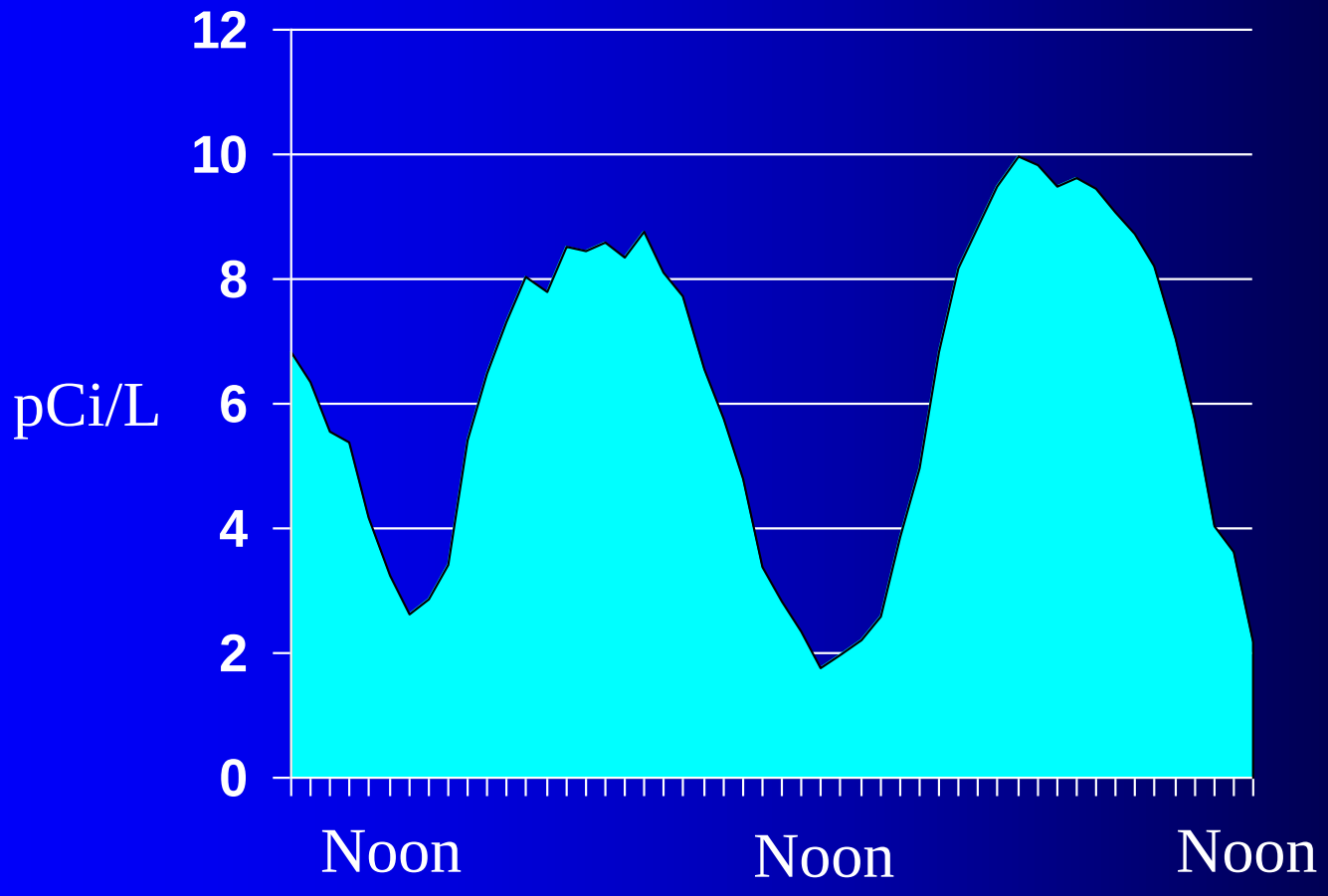
This data is based on multi-level radon tests done in 871 Pennsylvania homes

In the Summer the 1st floor is 4 to 6 times lower than the basement

In the Winter the 1st floor is 2 to 3 times lower than the basement

Radon levels fluctuate hour by hour

Usually radon levels are higher at night and lower during the day



Daily radon variation is usually greater in the summer

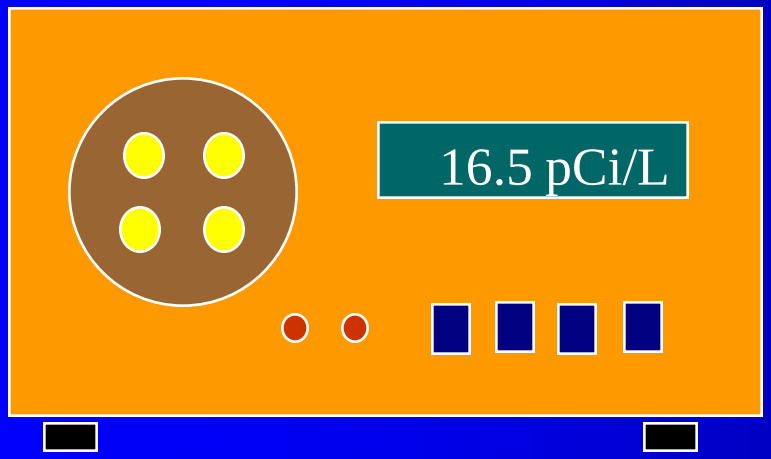
Radon Measuring Devices

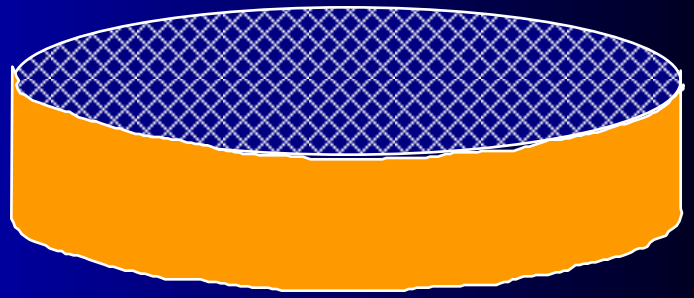
Two generic types of test devices

Continuous Radon Monitor or CRM

or

Passive Detector





CRM provides:

hour by hour radon changes

tamper resistant features

Passive detectors:

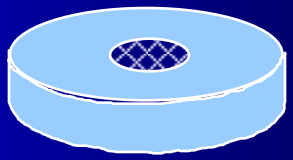
provide only a single average result

are less expensive

Both methods can be accurate

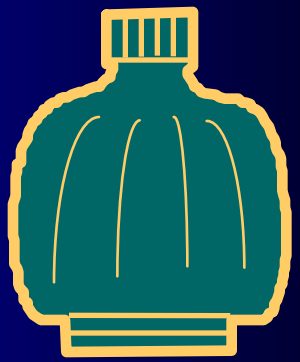
Four Types of Passive Detectors

- **Open Face Charcoal**
  (2 - 4 day exposure)
- **Diffusion Barrier Charcoal**
  (3 - 7 day exposure)

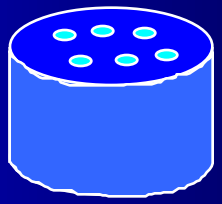


- **Electret Ion Chamber**

(2 - 7 days or 90 - 365 days exposure)

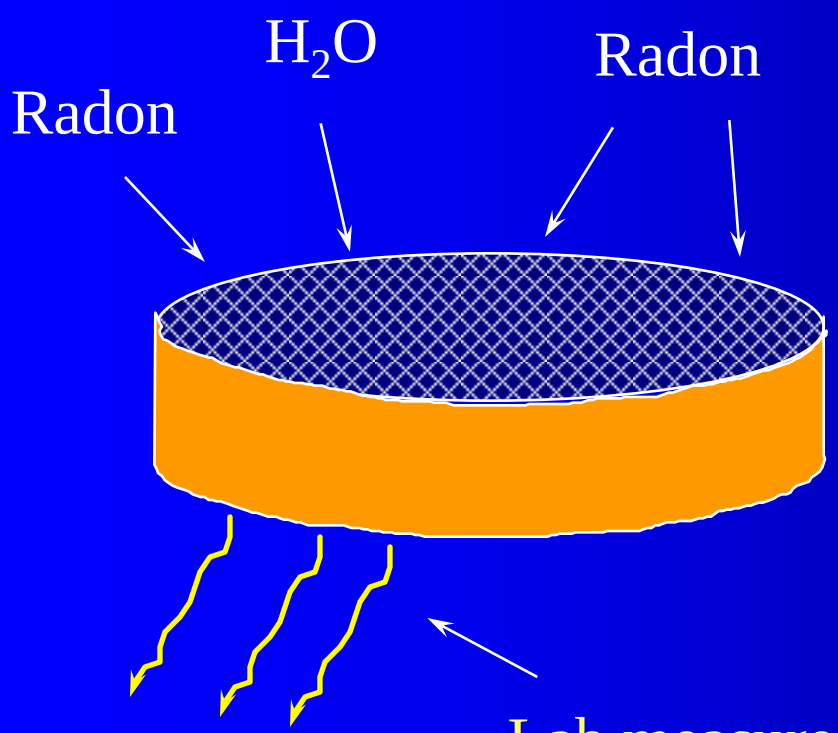


- **Alpha Track Detector**
  (90 - 365 day exposure)

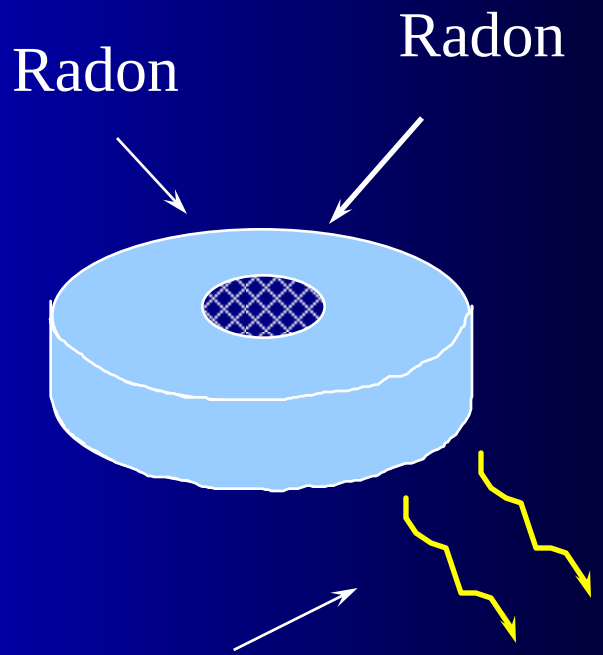


Activated Carbon Charcoal Detectors

Open Face



Diffusion



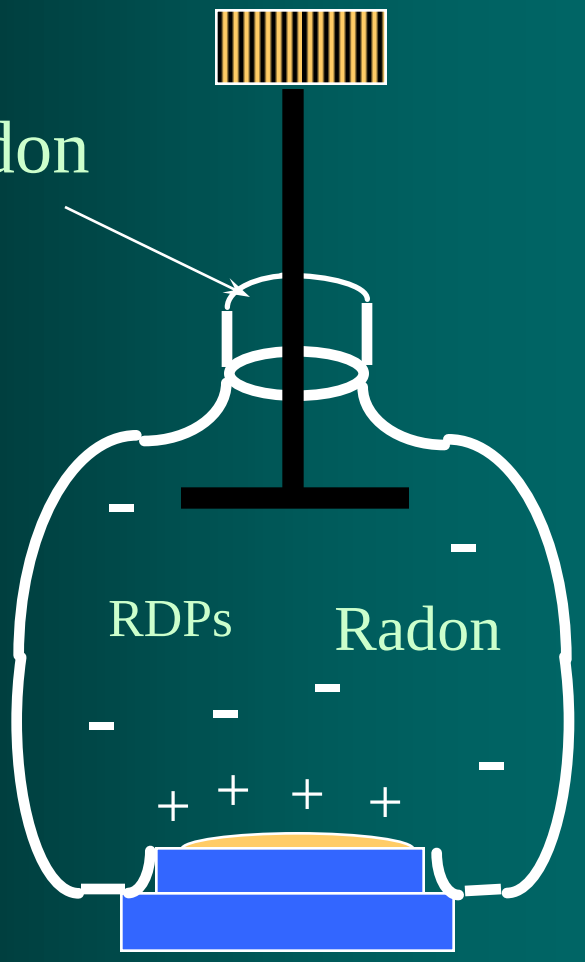
Lab measures gamma from decay of RDP's

Detector must be returned to lab promptly

Charcoal detector characteristics

- Easy to use
- Least expensive
- Long shelf life
- Lab analyzes the results
- Has reasonable accuracy
- Must expose a specific amount of time
- Open Face are sensitive to high humidity

Electret Ion Chamber (EIC) characteristics



The decay of Radon & Radon decay products (RDPs) inside the chamber causes ionization. This causes the electret to lose volts

Electret voltage is read before & after exposure to determine Radon levels

Electret Ion Chamber (EIC) characteristics

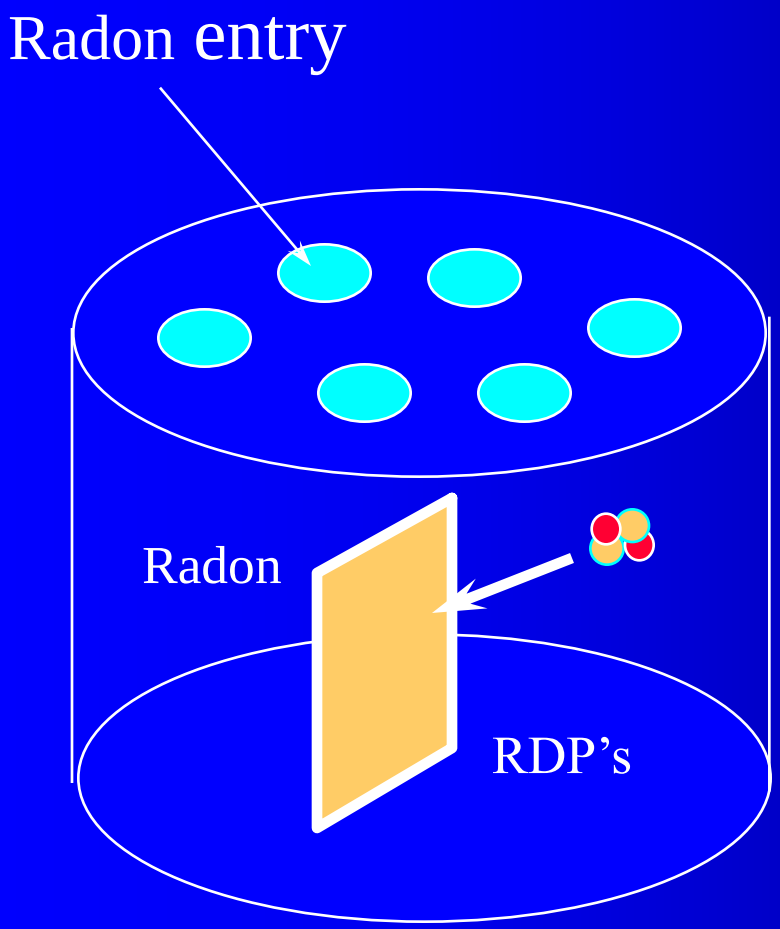
EIC's have demonstrate good accuracy
but it's always best to expose Duplicates

EIC's are more tamper resistant than charcoal detectors

Can vary exposure from 2 to 365 days
depending on chamber size & electret

The tester company analyzes the result.

Alpha Track Detectors



Alpha particles from decay of radon and RDP's damage the plastic chip

Marks are enhanced at the laboratory and counted

The detector is not affected by the testing environment

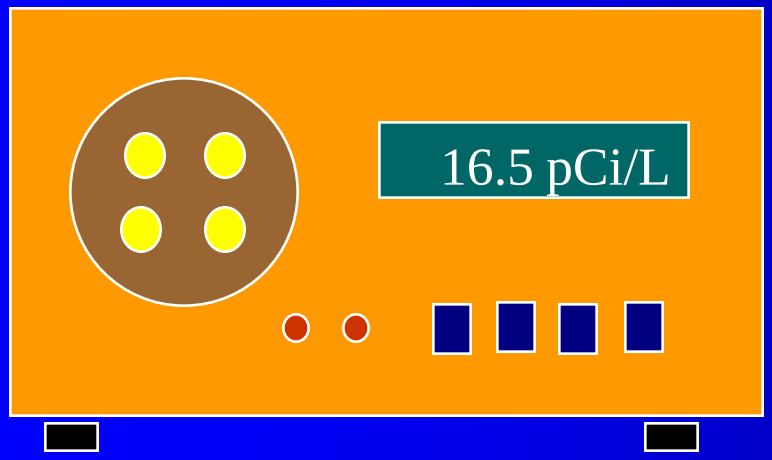
Alpha Track characteristics

Alpha Tracks can measure the average radon levels over 90 to 365 days

They are not affected by the testing environment

Cannot be used for short term tests

Continuous Radon Monitors (CRMs)



CRMs record hour by hour radon variation by counting alpha emissions from Radon or Radon & RDPs

Some CRMs can also monitor hourly temp., barometric pressure, motion, humidity etc.

Are CRMs the best choice for Real Estate testing ?

CRM's can have Tamper Resistant features

CRM's have demonstrated excellent accuracy

CRM's can indicate the impact of weather on test results

What are Remote calculated CRM's ?

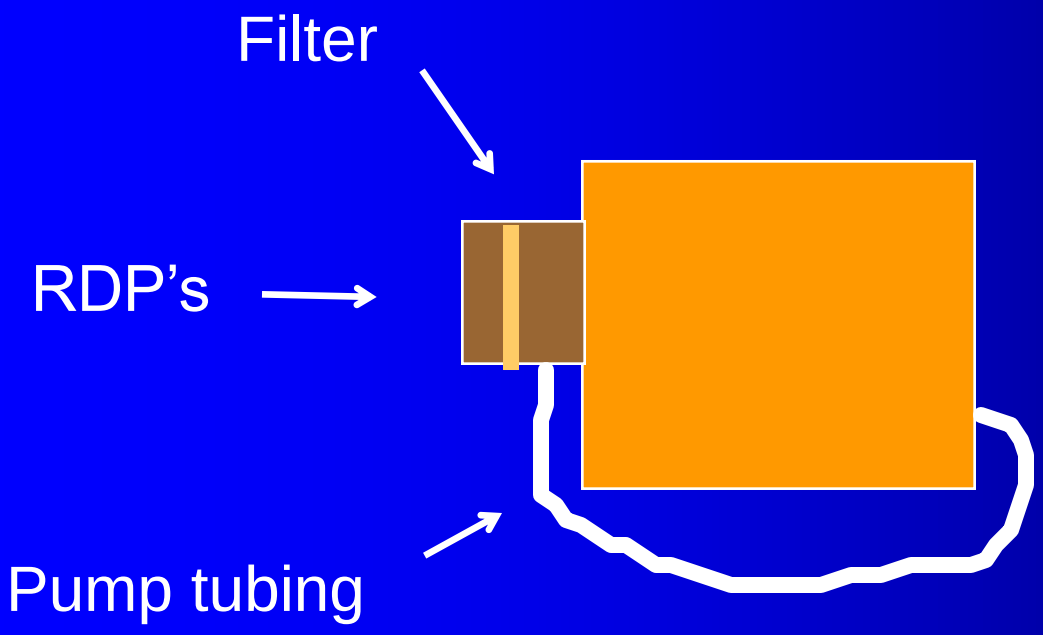
A tester leases
a CRM from
an Equipment Supplier

The tester modems the CRM data to the equipment supplier who faxes results back to Tester's office

Grab Samples & Sniffer tests

- Grab samples or sniffer test are used by mitigators to diagnose radon entry
- These measurements cannot be used to determine the need for mitigation

Continuous Working Level Monitors (CWM)



CWM's measure alpha decays from RDPs collected on a filter

CWM only measure radon decay products (WL) not Radon (pCi/L)

CWM's can measure very low concentrations

How can you determine a Tester's qualifications ?

Is Tester state certified ?

In non-certifying states they should be NEHA or NRSB listed

Does Tester use tamper resistant features?

Does Tester obtain a signed "Non-interference Agreement"?

You can always test your own home

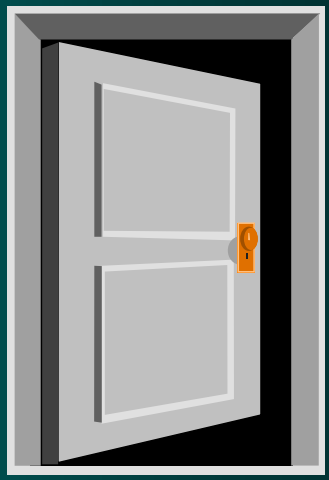
You can purchase charcoal detectors or long term alpha tracks via the internet, calling a supplier or from a local hardware or building supply store

Just follow the instructions and promptly mail the detectors back to the laboratory

Measuring Radon

The EPA recommends the following specific Testing Protocols

You must maintain closed house conditions during a short term radon test



- Fireplace damper closed
- Window air conditioners recycle only
- All windows & doors closed except for normal entry and exit
- Attic fans are OK but don’t use window or whole house fans
- Closed conditions 12 hrs prior to start of test and all during the short term test

Short Term test is 2 - 7 days

while a

Long Term test is 3 to 12 months

Short Term requires closed house conditions

Long Term averages seasonal variations &
does not require Closed House conditions

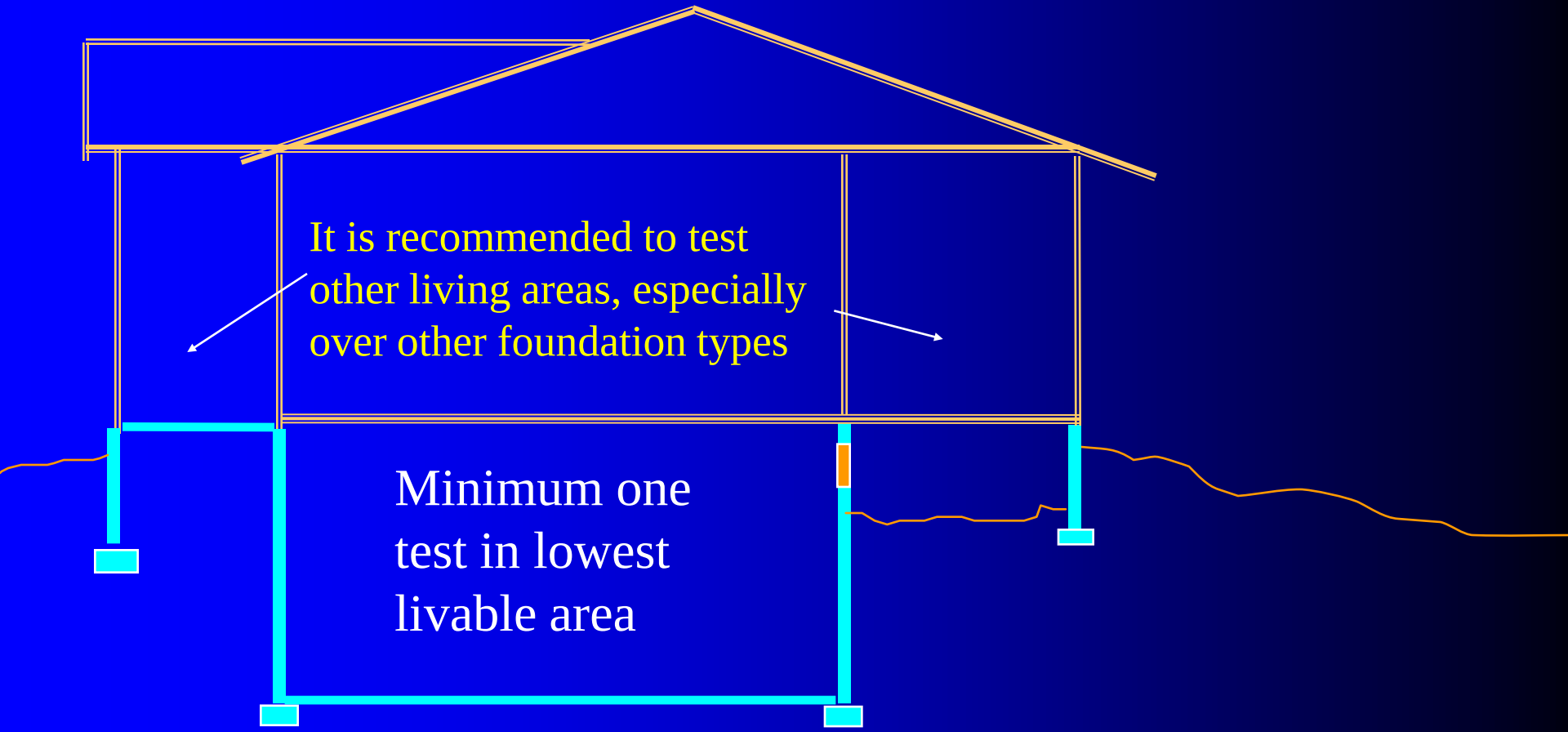
94% of the time Short Term tests provide the
same mitigation decision as a Long Term test

Consider Retesting if :

- Test conditions were not maintained
- Extended heavy Rain or Winds speeds greater than 25 mph for longer than an hour (a Severe Storm)
- One test result is less than 4 pCi/L and the other is greater and the greater is twice the level of the lesser result

(Duplicate results 2.5 pCi/L & 6.0 pCi/L)

What rooms should be Tested ?



What does "Lowest Livable" mean ?

- Lowest area of the home that could be used as a playroom, family room or office without needing major structural change such as a concrete floor or more headroom.

- If a basement only needs a carpet for children to play in, it is considered Livable

- A small furnace room is not Livable

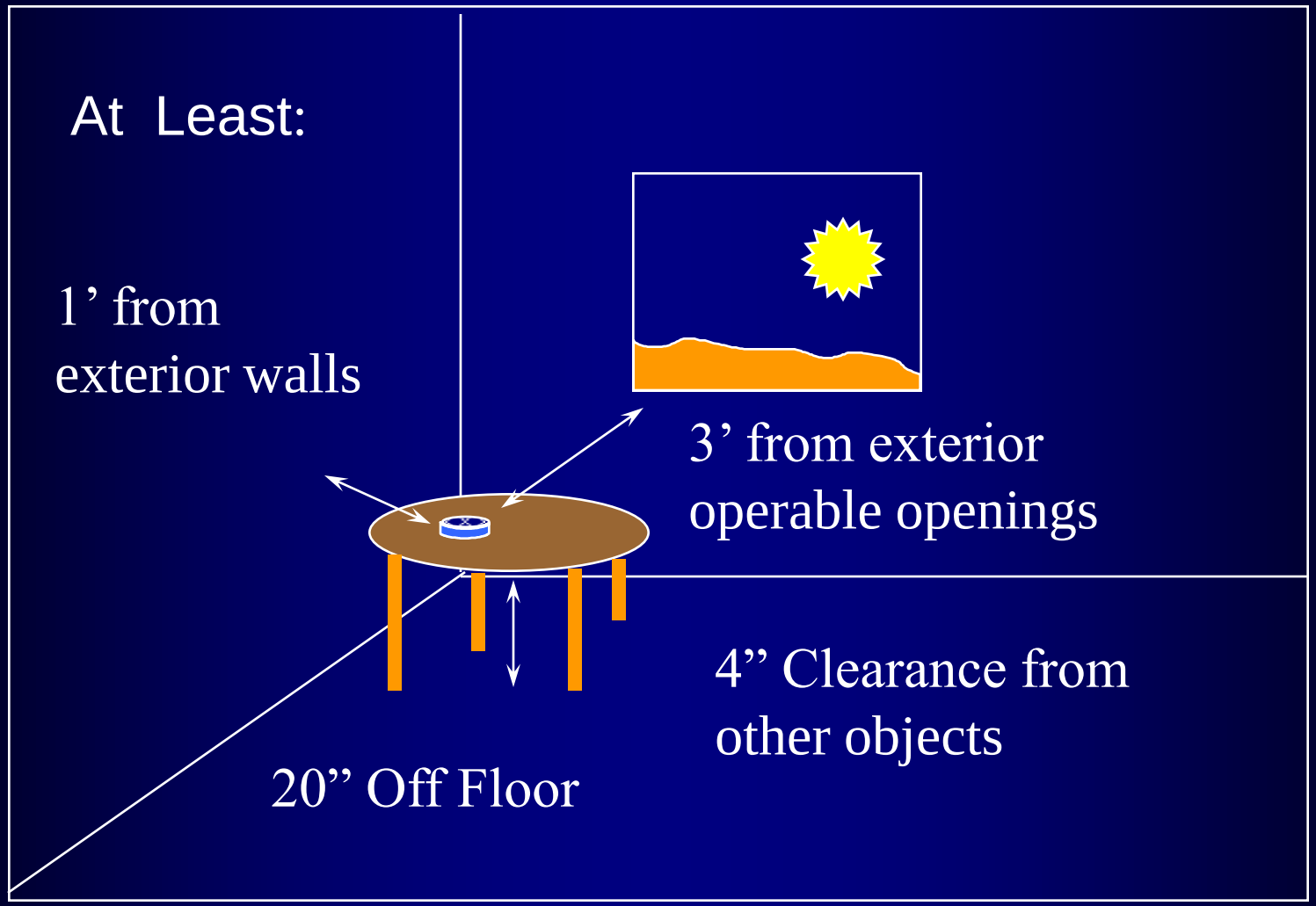
Do NOT test:

Closets, Bathrooms,
Kitchens, storerooms, garages,
crawl spaces, or attics

You can test:

Bedrooms, Family rooms,
Living Rooms, Dining Rooms,
Office or Study

How far must a Detector be from windows & doors ?



What is a typical variation in Duplicate results ?

- Duplicate radon results greater than 4 pCi/L should be within 10% to 30% of each other
- If duplicates have a greater variation than this, contact the Tester or the laboratory
- The lower the radon levels, the greater the variation between duplicate results

Commercial Buildings

EPA **has not defined workplace radon levels.**
4 pCi/L action level is typically used

Use School Testing protocols for guide

Radon fix typically involves HVAC equipment

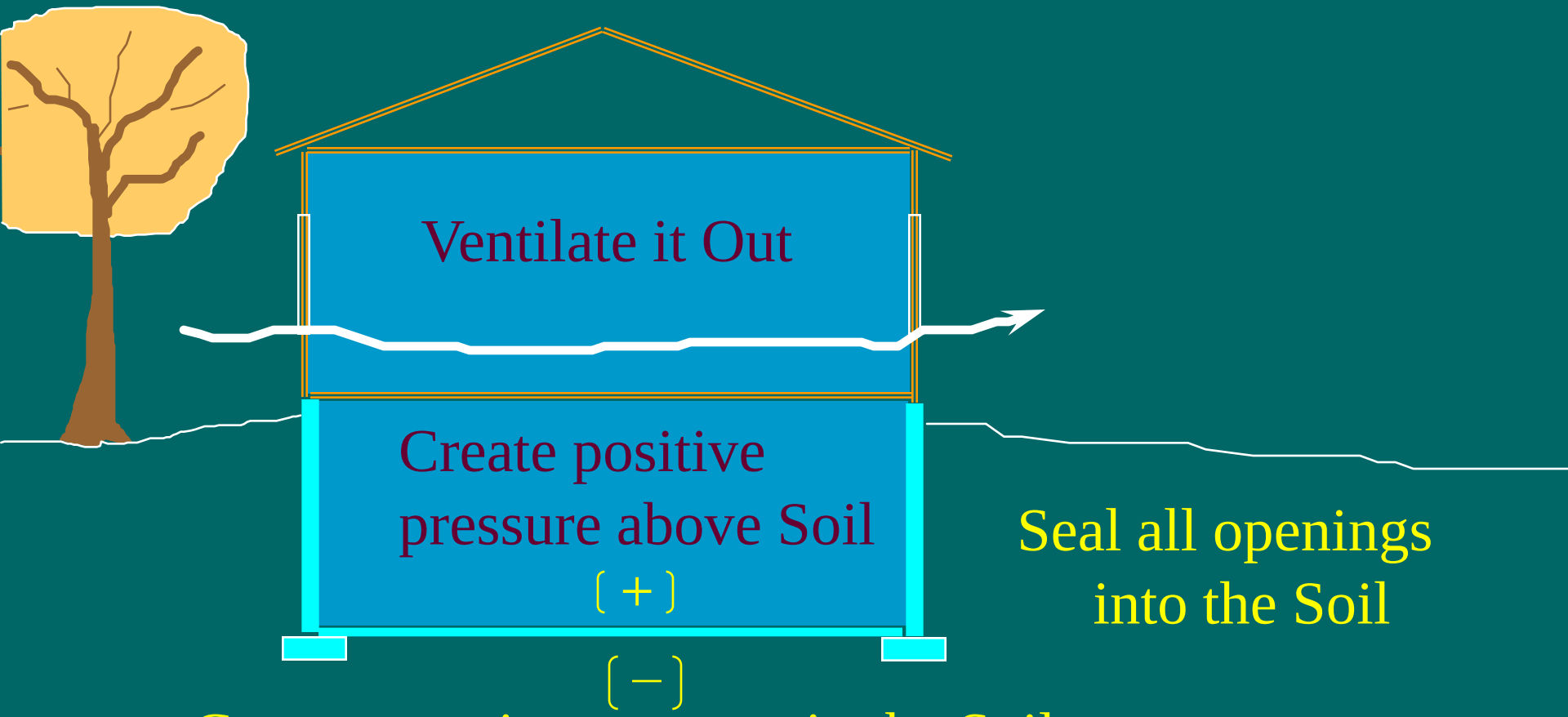
Mitigators need commercial experience

School Testing Protocols

- Test all rooms in contact with the soil
- Test the whole building at the same time
- Test during occupied days (work week)
- Maintain closed building conditions
- HVAC should be operating normally

Radon Mitigation

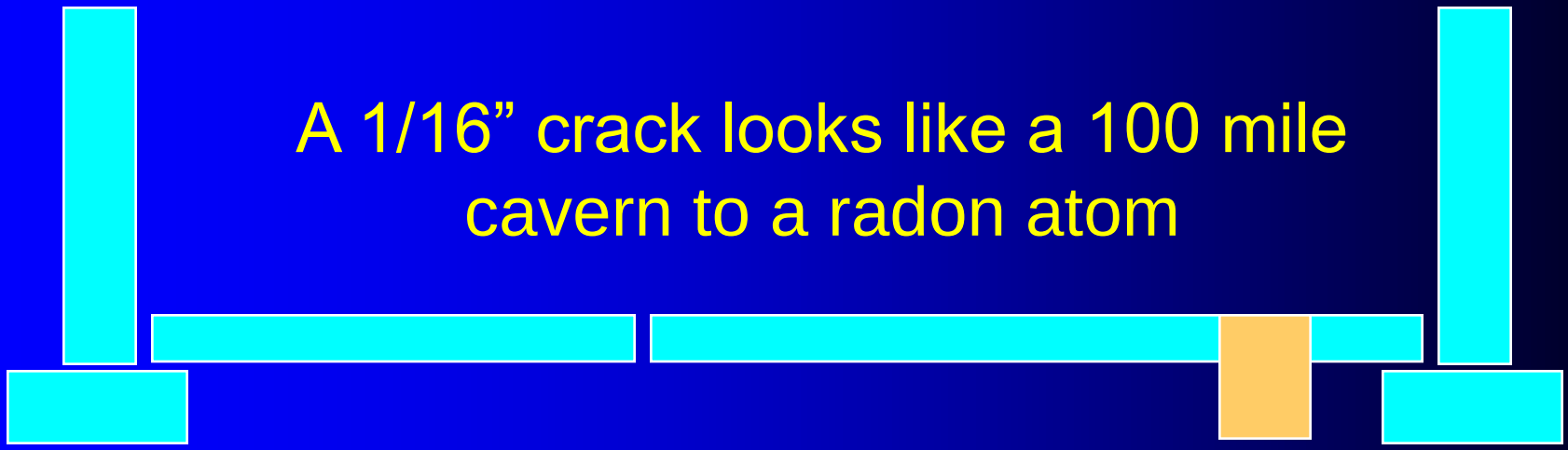
Four Mitigation Methods



Sealing an open sump pit will usually not reduce Radon Levels ?

One research project found it only took the equivalent of ten feet of a 1/16” crack in the basement floor to maintain radon levels above the Guideline

A 1/16” crack looks like a 100 mile cavern to a radon atom

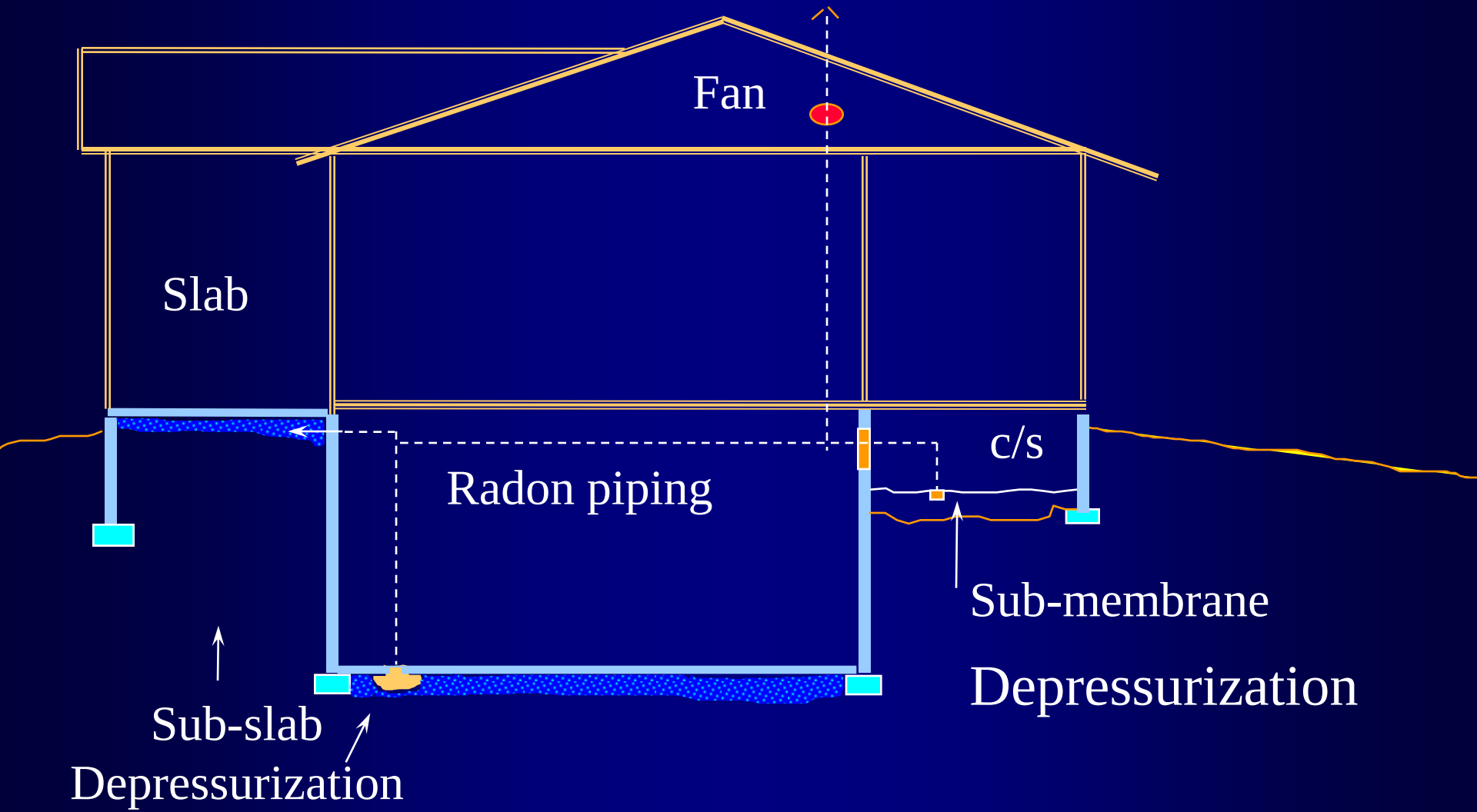


Can Radon Sealing cause a water problem?

A properly installed radon system should not cause a water problem nor will it typically fix a wet basement.

Caution: Flooding during heavy rains

Active Soil Depressurization (ASD)



Radon Fan Locations

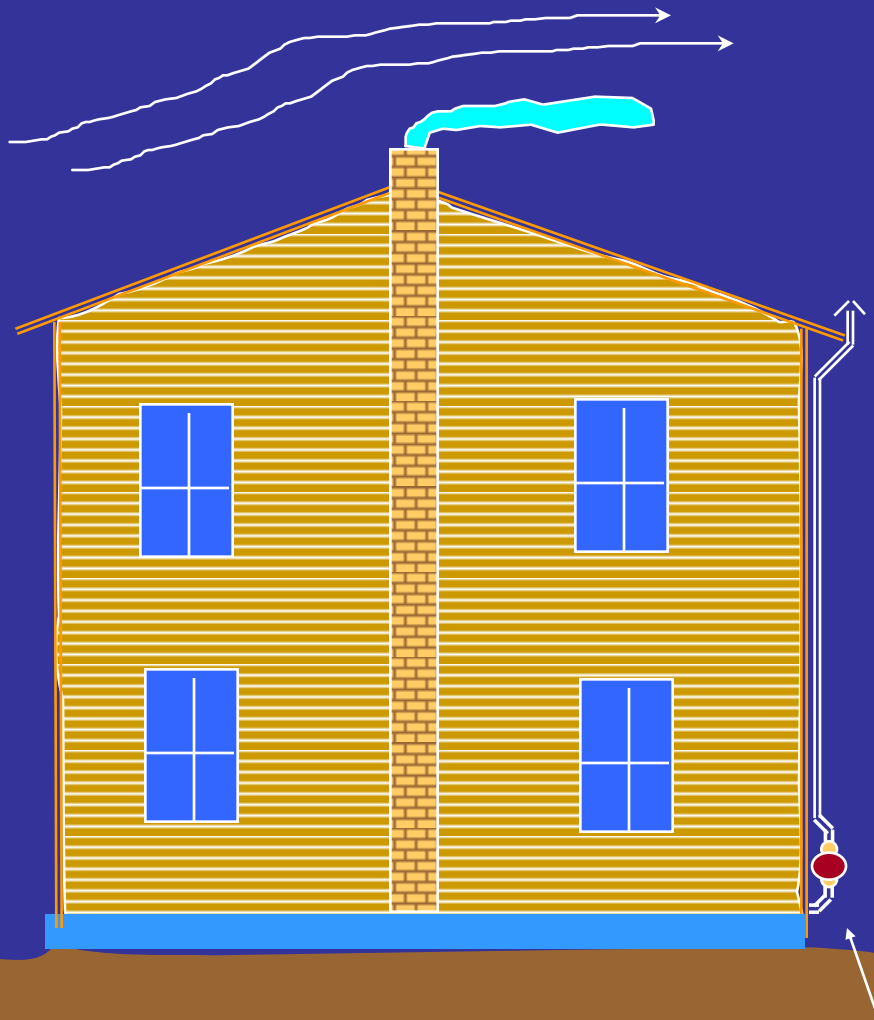
Good

- **Outside**
- **House Attic**
- **Garage Attic**

Not OK

- **Basement**
- **Crawl Spaces**
- **Below grade**

Radon Exhaust Requirements



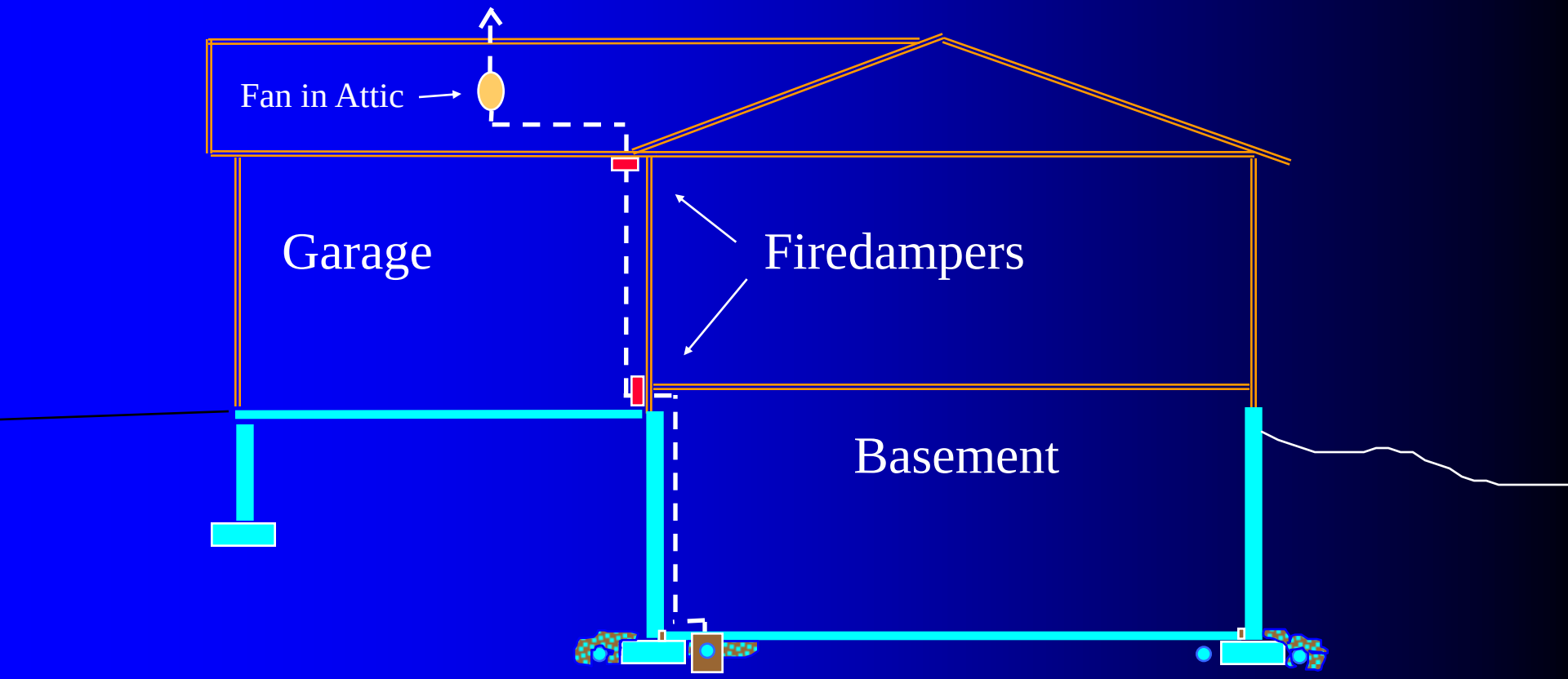
Radon Exhaust
above edge of roof

2’ higher than
windows within 10’

Minimum 10’ off
the ground

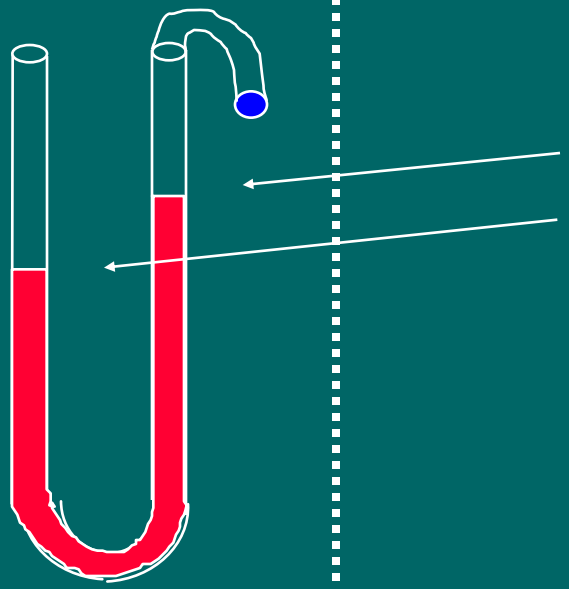
Radon fan

The Wall between garage and house is typically a Firewall and needs fire protection



System Vacuum Gauge

If oil is level, system is off or stopped



The difference in oil levels indicates the strength of the vacuum in the system

Note: Vacuum gauges do not indicate Rn Levels

Radon System must have a Label

Radon Reduction System

Installer's:

Name
Phone Number
Certification id #

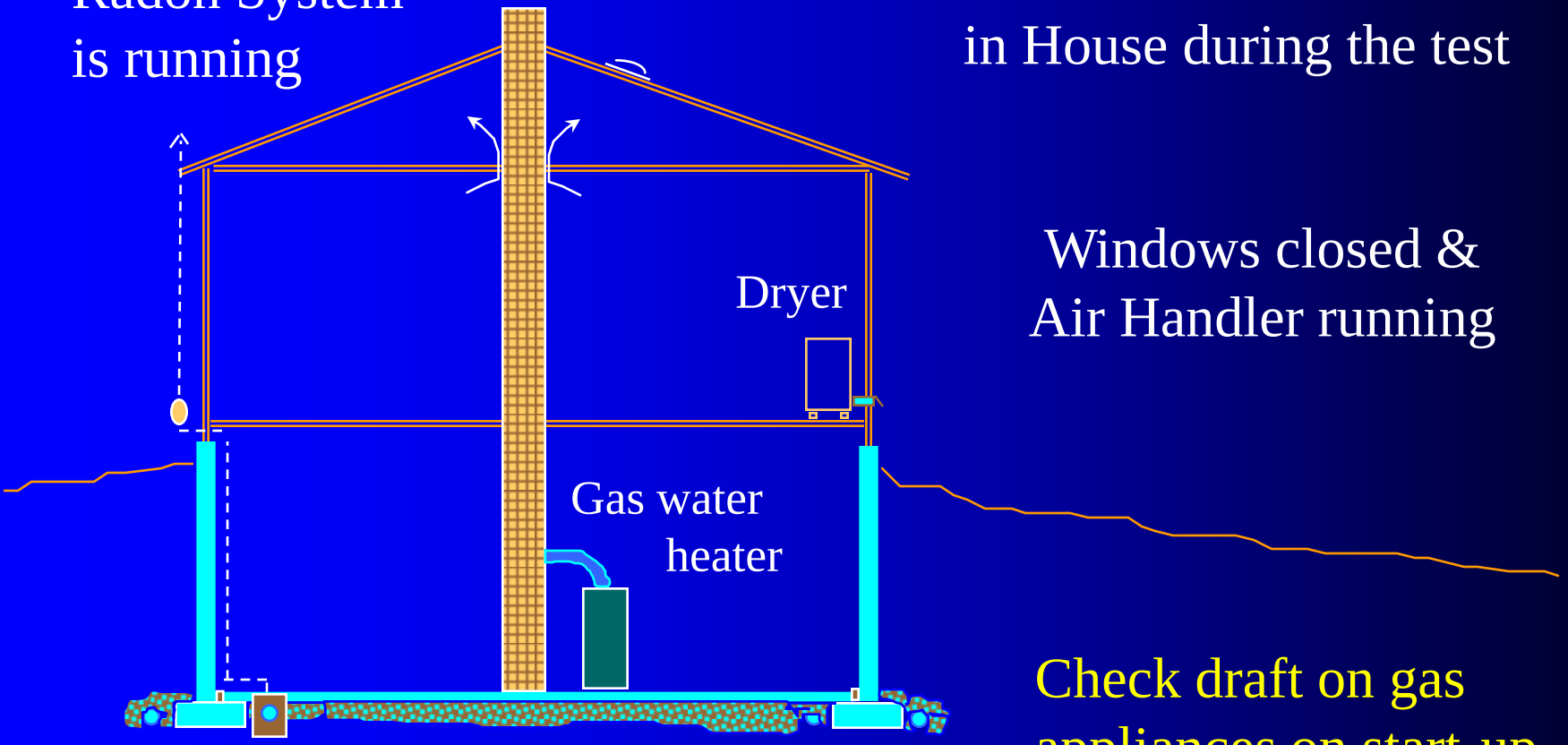
EPA recommends
Re-testing every 2 Years

There should be an information package attached to the radon pipe

Gas appliances require a Backdraft Test

Check after Radon System is running

Run other exhaust fans in House during the test



Windows closed & Air Handler running

Check draft on gas appliances on start-up

Post Mitigation Testing

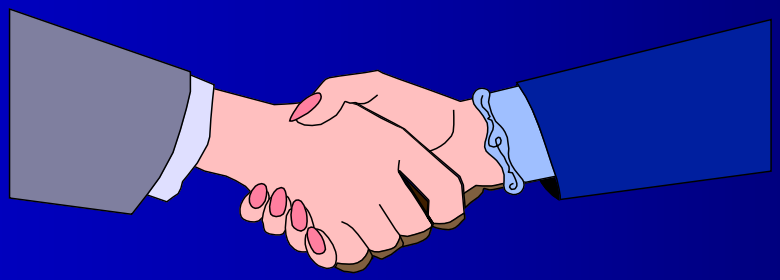
- Within **30 days** do a Short term test
- Wait **24 hours** before starting the test
- Place short term test in the lowest livable area
- An independent re-test is Best

How do you know if a Mitigator is qualified ?

- Mitigator must be Certified by the State

or in non certifying states he should be listed with NEHA or NRSB

- Does the Mitigator have referrals ?
- Will the Mitigator be in business and provide good service over the length of their warranty ?



Radon in Water

Issues to be

familiar with

EPA states in the "Home Buyers & Sellers Guide to Radon":

"If you have tested the air in your home and found a radon problem, and your water comes from a well, have the water tested."

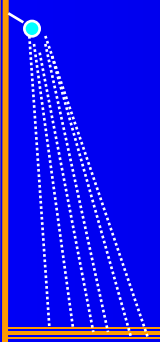
Radon comes out of the water when you:

- Expose the water to air
  - Taking a shower
- Agitate the water
  - Doing the laundry
- Heat the Water
  - Using the Dishwasher

It takes a lot of radon in the water to raise the radon levels in the air?

If radon in water is 10,000 pCi/L then:

A 10 minute shower will raise bathroom to about 30 pCi/L



Average water use in an average size house will raise the overall radon average 1 pCi/L

Radon in Water Health Risk

Primary Risk is the increased
radon in the air from water usage

10,000 pCi/L in the water raises
the average radon in air about 1 pCi/L

There is a small risk of stomach & other
cancers from ingestion of water with radon

There are no Federal Guidelines

States

EPA

EPA has suggested two options:
An MCL of 300 pCi/L or
an AMCL of 4000 pCi/L if the state has
a Multi-media radon in Air Program

Percentage of PA wells that would not pass a 3000 pCi/L Standard ?

Communities w/ground water systems	25 to 499 people	500 to 3299 people	3300 to 10,000 people	more than 10,000 people
# in PA	1,336	362	65	41
percentage above 3000 pCi/L	7 %	4 %	4 %	5 %

Testing the Radon in Water

- Water samples are collected from fresh cold tap water & shipped to analysis laboratory

- A certified tester can provide this test for a cost similar to testing radon in the air

Radon in Water can be reduced with:

- Granular Activated Carbon (GAC)
  5’ tall tank(s) filter the water
  Cost about $900 - $1,500

- Aeration System
  Radon is bubbled out of the water
  Cost about $3,500 - $4,500

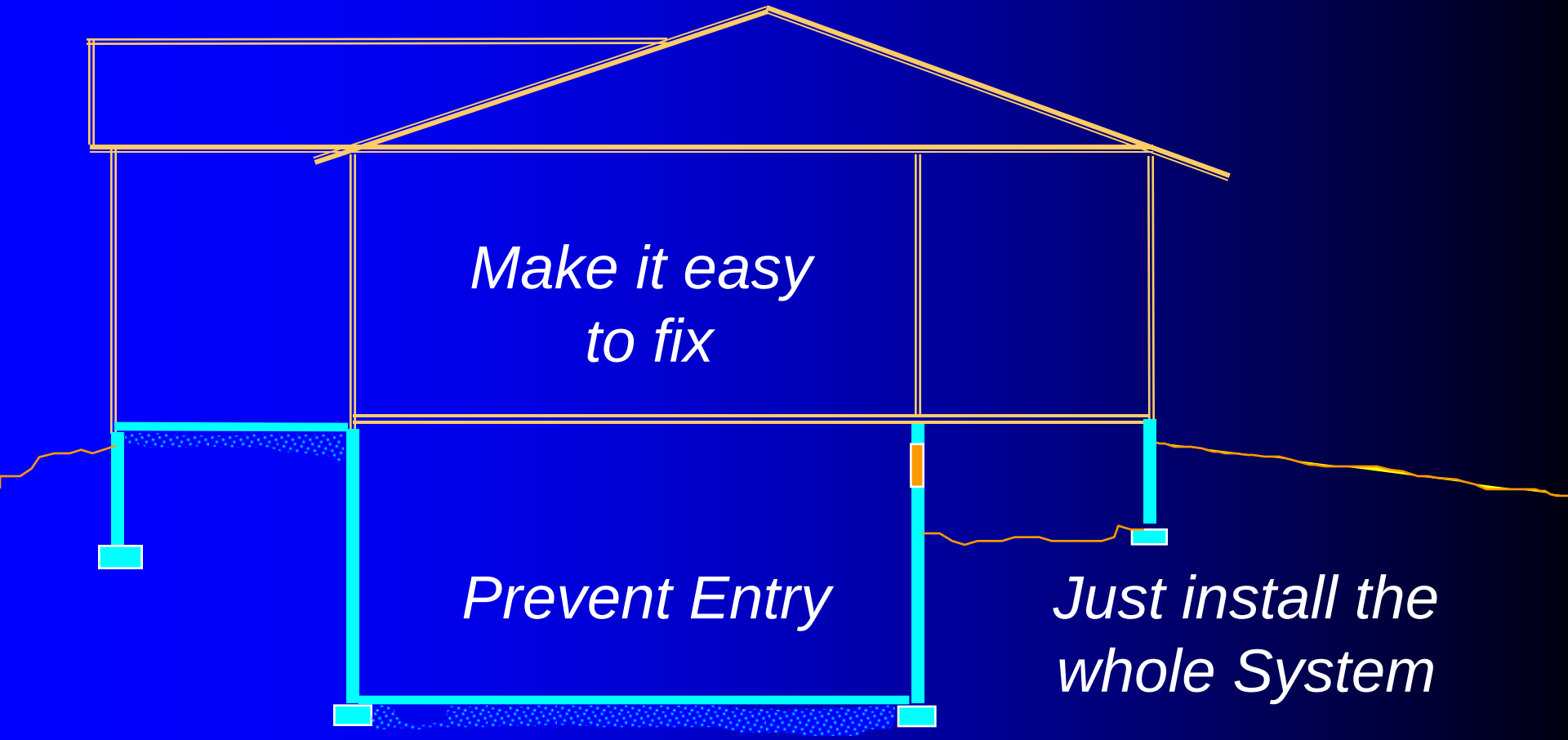
Concerns about using Granular Activated Carbon

- Other contaminants can reduce system performance
- GAC can emanate gamma if radon in water is very high
- GAC should only be used for levels below 20,000 pCi/L
- Carbon needs to be replaced every 1 - 5 years

Some Aeration concerns

- System must discharge above roof
- System needs cleaning at least once per year
- Can have Bacteria growth during non-use periods
- Radon removal, however, is excellent

New Construction and Radon

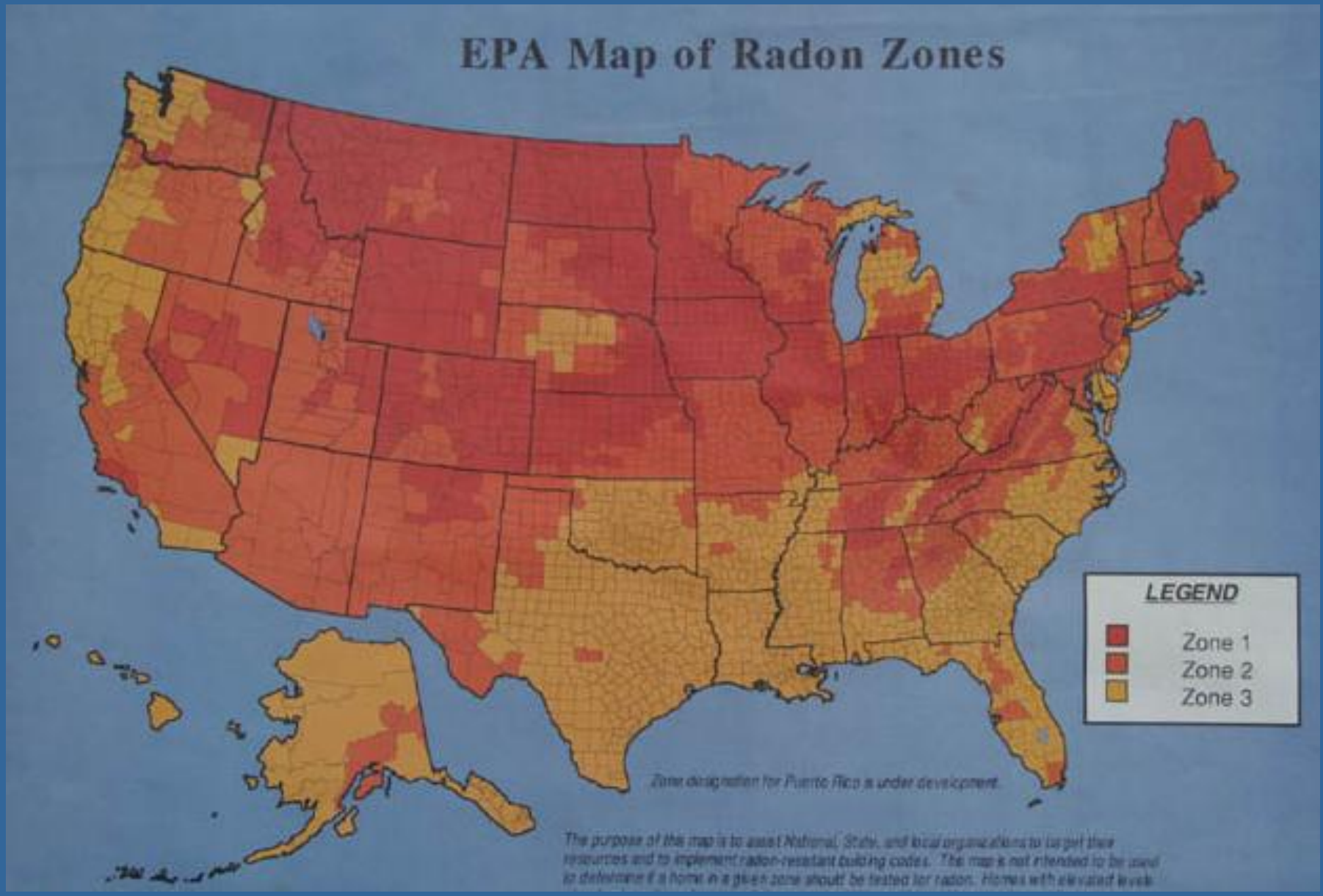


Should land be tested before construction ?

- The soil can be tested
- A strong radon source from the soil could be easily missed
- It is better to use the cost of pre-construction soil testing for radon resistant features

EPA has defined Radon Zones

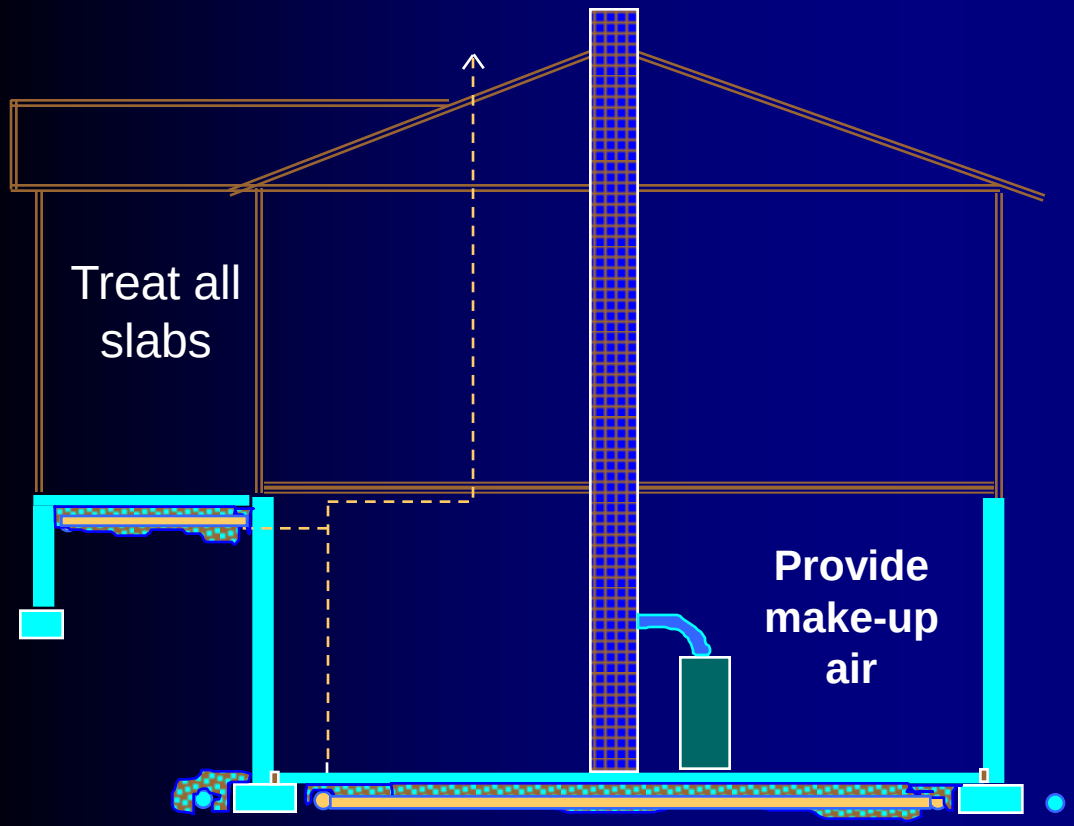
- Zone 1 - expect 4.0 pCi/L or greater
- Zone 2 - expect 2.0 to 4.0 pCi/L
- Zone 3 - expect 2.0 pCi/L or less



For more detailed state maps go to: EPA radon maps

Recommendations for Zone 1

3” or 4” Passive vent to roof



Soil gas collection system under all slabs

Leave adequate room for fan installation

Have wiring for fan

Seal the Sump pit

No channel drains

Minimize concrete cracks & openings

Certified Mitigation Companies

If the work is being done in a state
with a radon certification program,
the mitigator must be certified with the state

If the state has no certification program
then the mitigator should be certified with a
nationally recognized certifying agency
such as NEHA or NRSB

Certified Testing Companies

If the testing is being done in a state with a radon certification program, the tester must be certified with the state

If the state has no certification program then the tester should be certified with a nationally recognized certifying agency such as NEHA or NRSB

To Determine Certification

- Call your state radon office or visit their website
- Ask the tester or mitigator who he is certified with
- Check the website of the certification agency to verify the certification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