Earthquake Prediction with Unattached Radon Decay Products

Naomi H. Harley[1], Passaporn Chittaporn[1], Isabel M. Fisenne[2]

[1]New York University School of Medicine

[1]Retired Consultant

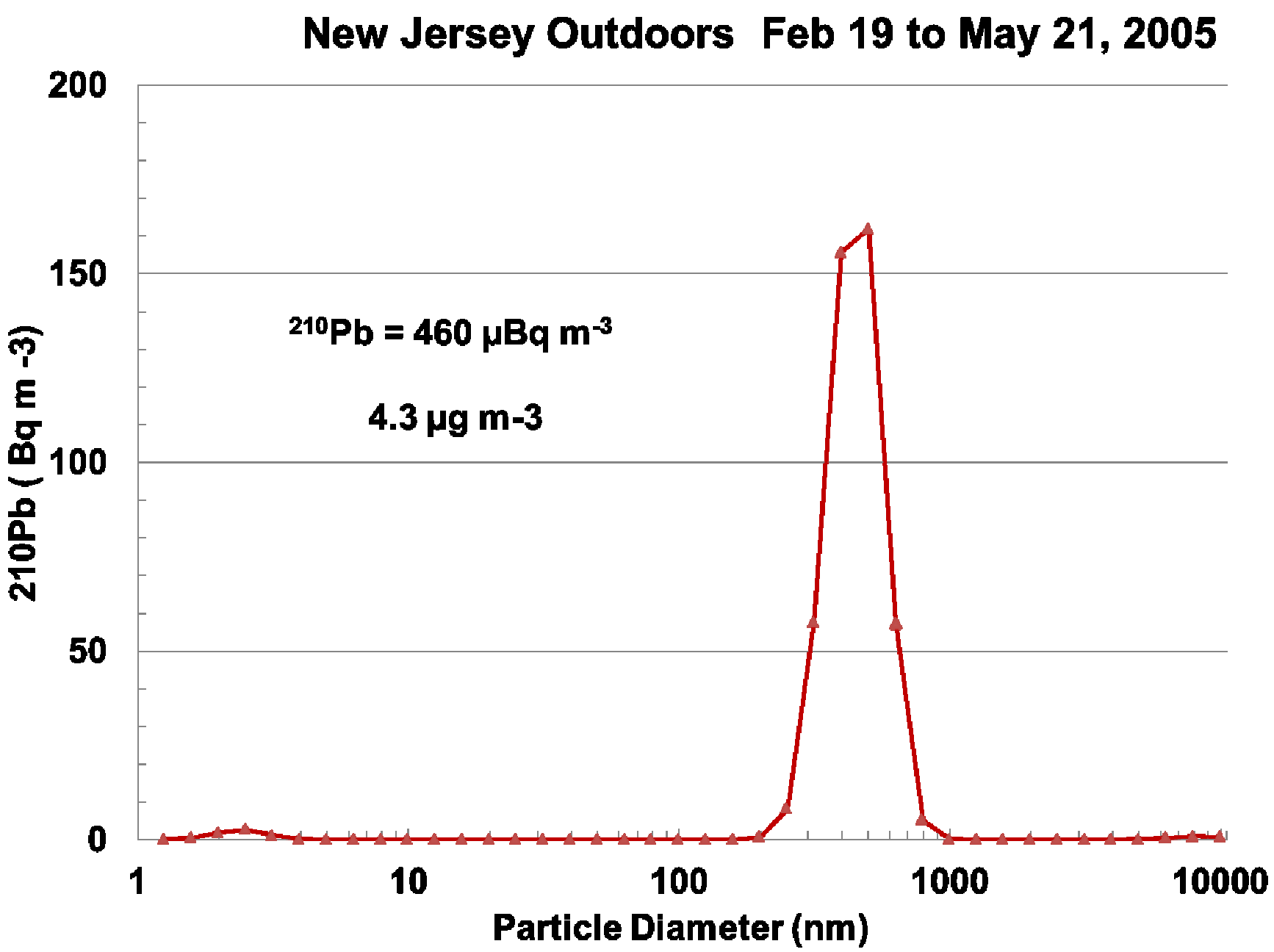
11th INTERNATIONAL WORKSHOP on the GEOLOGICAL ASPECTS OF RADON RISK MAPPING

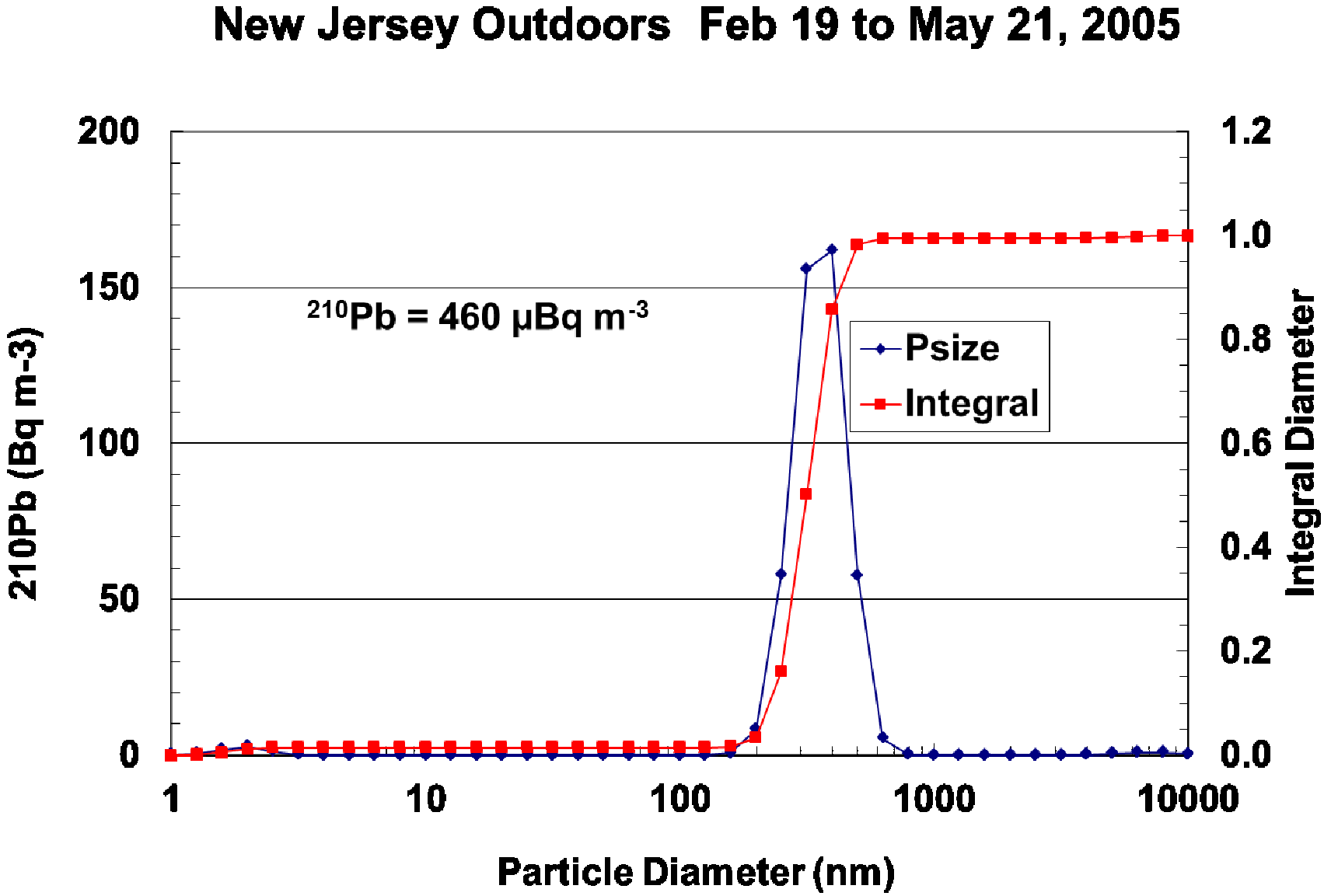
September 18th – 20th(22nd), 2012 Prague, Czech Republic


Westcott
China
NYU 4LEAF


MAGNEHELIC
20
40
60
80

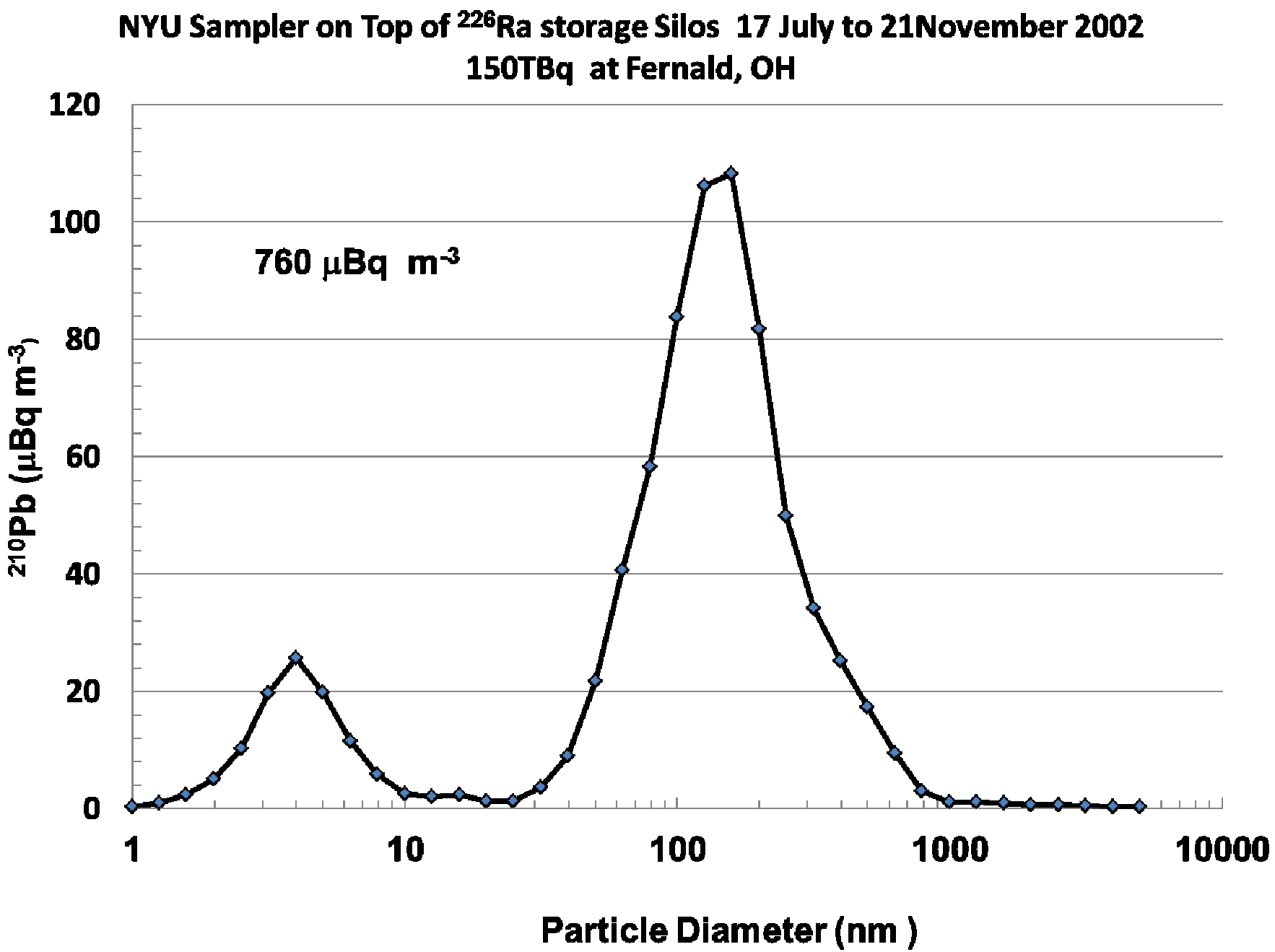

NYU IMP
Westcott

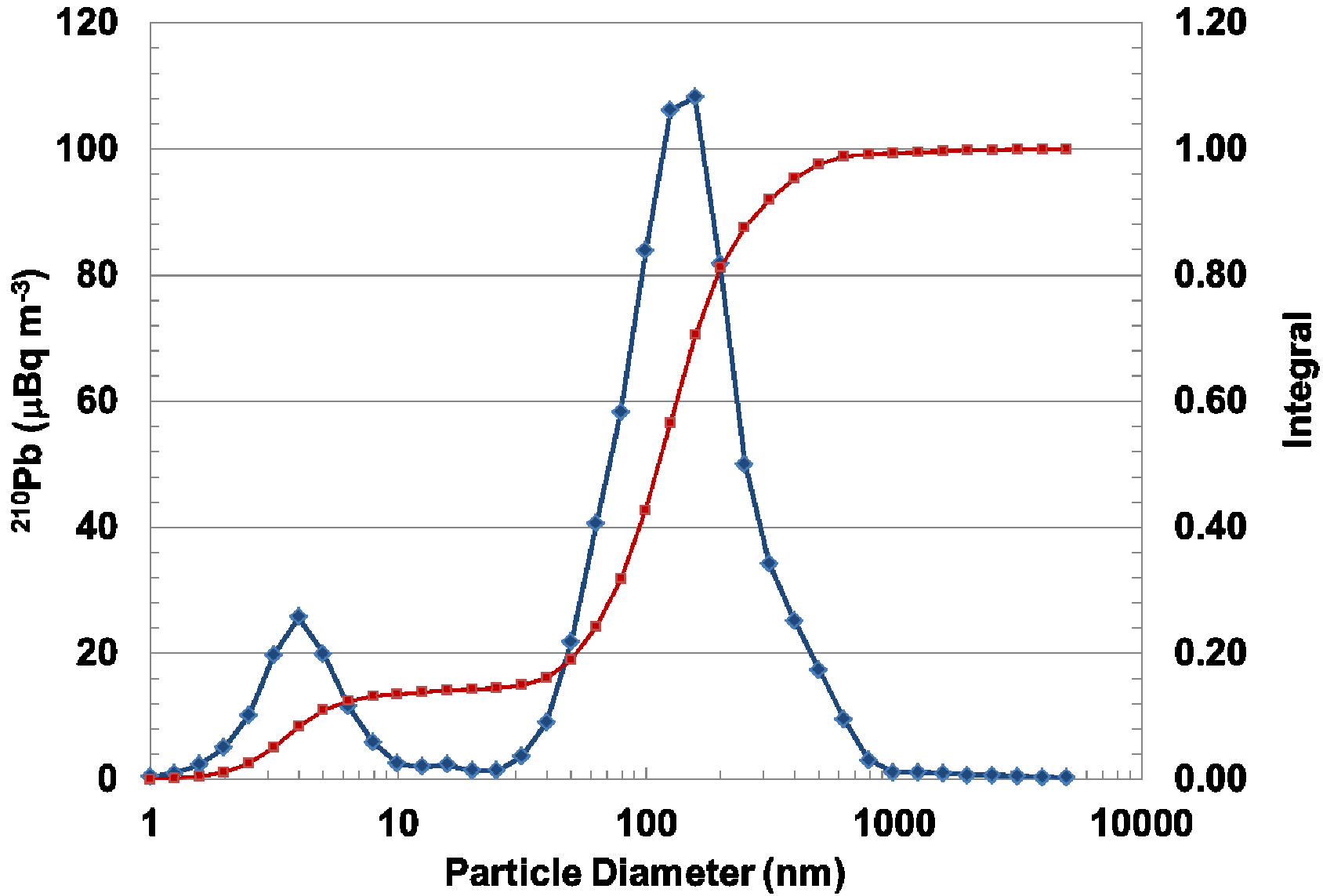

New Jersey Outdoors Feb 19 to May 21, 2005
200
150
100
50
0
210Pb (Bq m -3)
210Pb = 460 µBq m-3
4.3 µg m-3
1
10
100
1000
10000
Particle Diameter (nm)


New Jersey Outdoors Feb 19 to May 21, 2005
210Pb (Bq m-3)
200
150
100
50
0
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Integral Diameter
^{210}Pb = 460 µBq m^{-3}
Psize
Integral
1
10
100
1000
10000
Particle Diameter (nm)


K-65
RADON TREATMENT SYSTEM


^{226}Ra (K65) 150 TBq


NYU Sampler on Top of 226Ra storage Silos 17 July to 21November 2002
150TBq at Fernald, OH
760 μBq m-3
210Pb (μBq m-3)
120
100
80
60
40
20
0
1
10
100
1000
10000
Particle Diameter (nm)


NYU Sampler on Top of 226Ra Silos 17 July to 21November 2002
120
100
80
60
40
20
0
210Pb (µBq m-3)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Integral
1
10
100
1000
10000
Particle Diameter (nm)

Attachment Process

X= Attachment Rate (sec $^{-1}$)

$X_{avg} = \beta N = (10^{-5}) (2.5\ 10^{3}) = 0.025$

β = attachment coeff. (10^{-5} cm^3 sec^{-1})

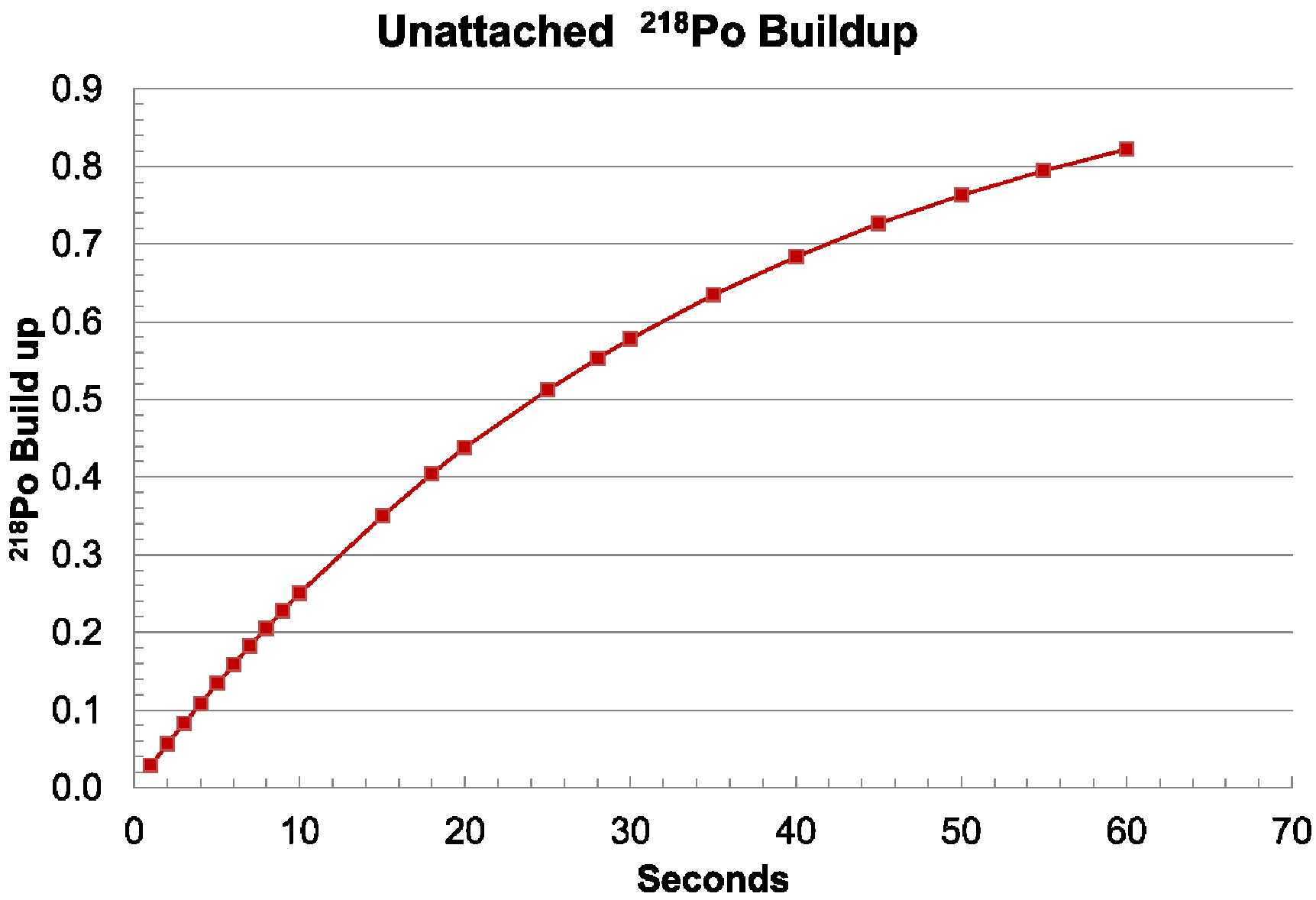
N = aero. conc. (2,500 particles cm^{-3})

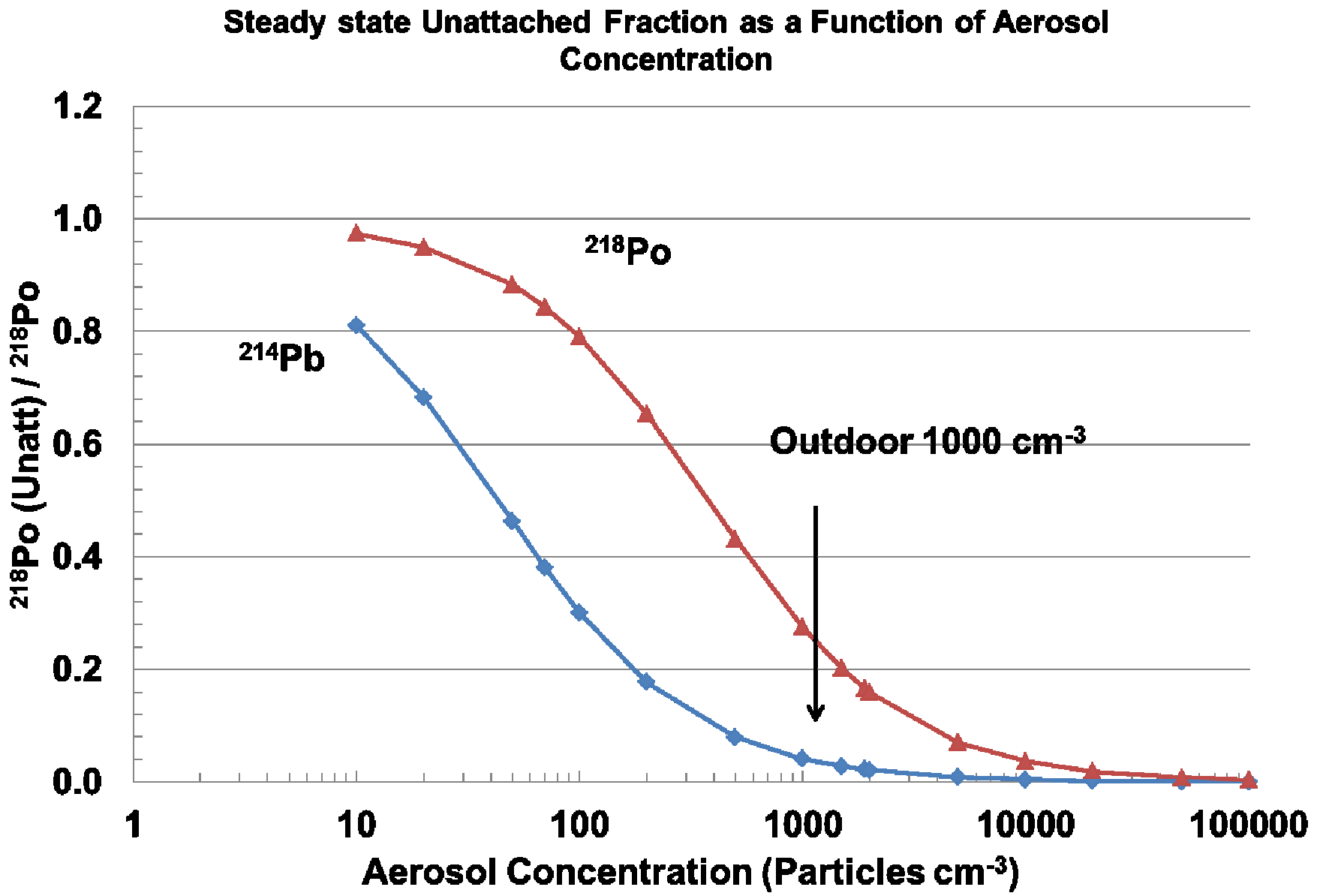
Half life of ^{218}Po atom before attachment

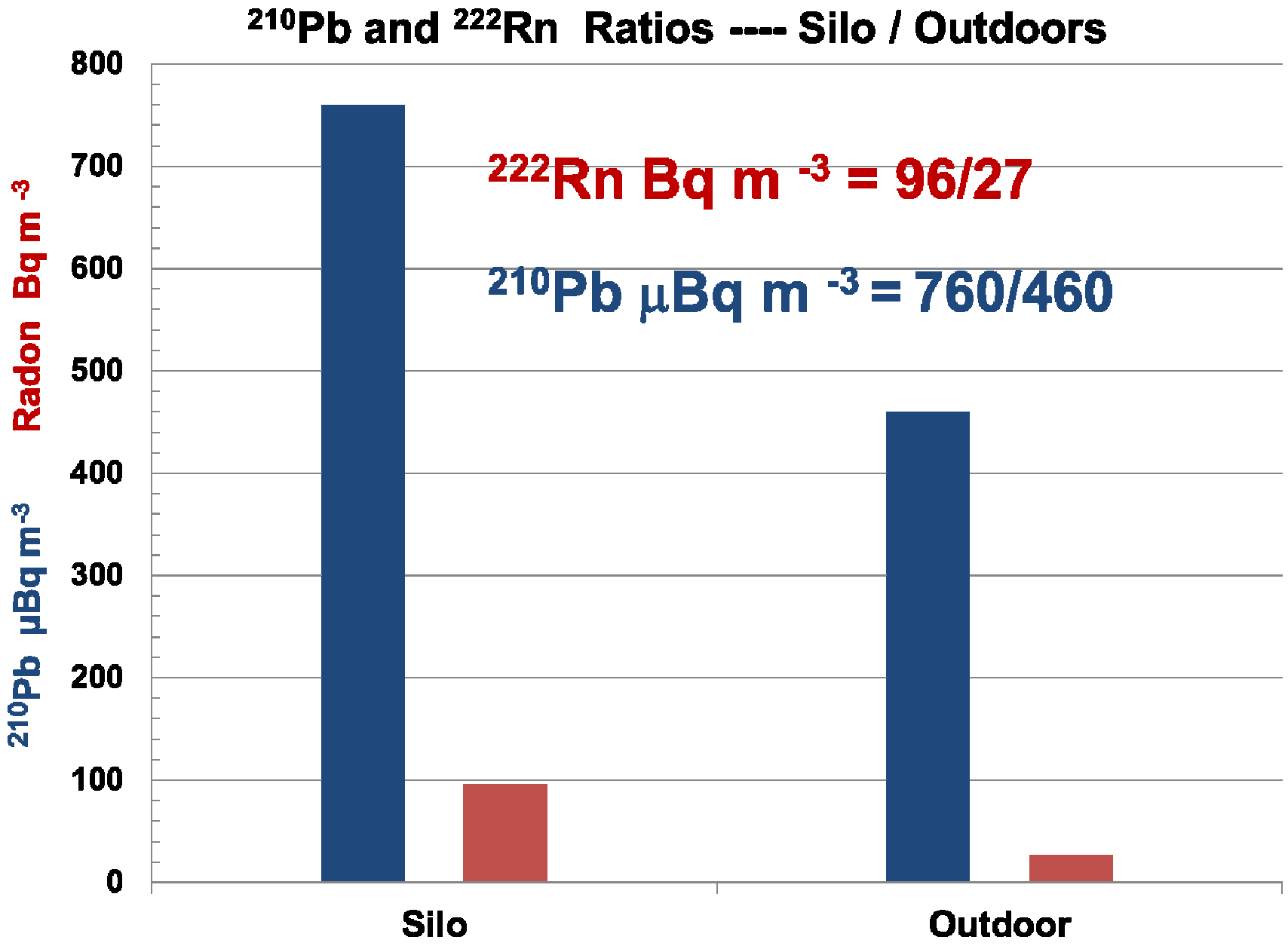
Attachment Rate X = 0.025 sec^{-1}

$X = (\lambda_{att}) = Ln (2) / T_{1/2}$; $T_{1/2} = 27$ sec

X from El-Hussein 1996


Unattached 218Po Buildup
218Po Build up
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
10
20
30
40
50
60
70
Seconds

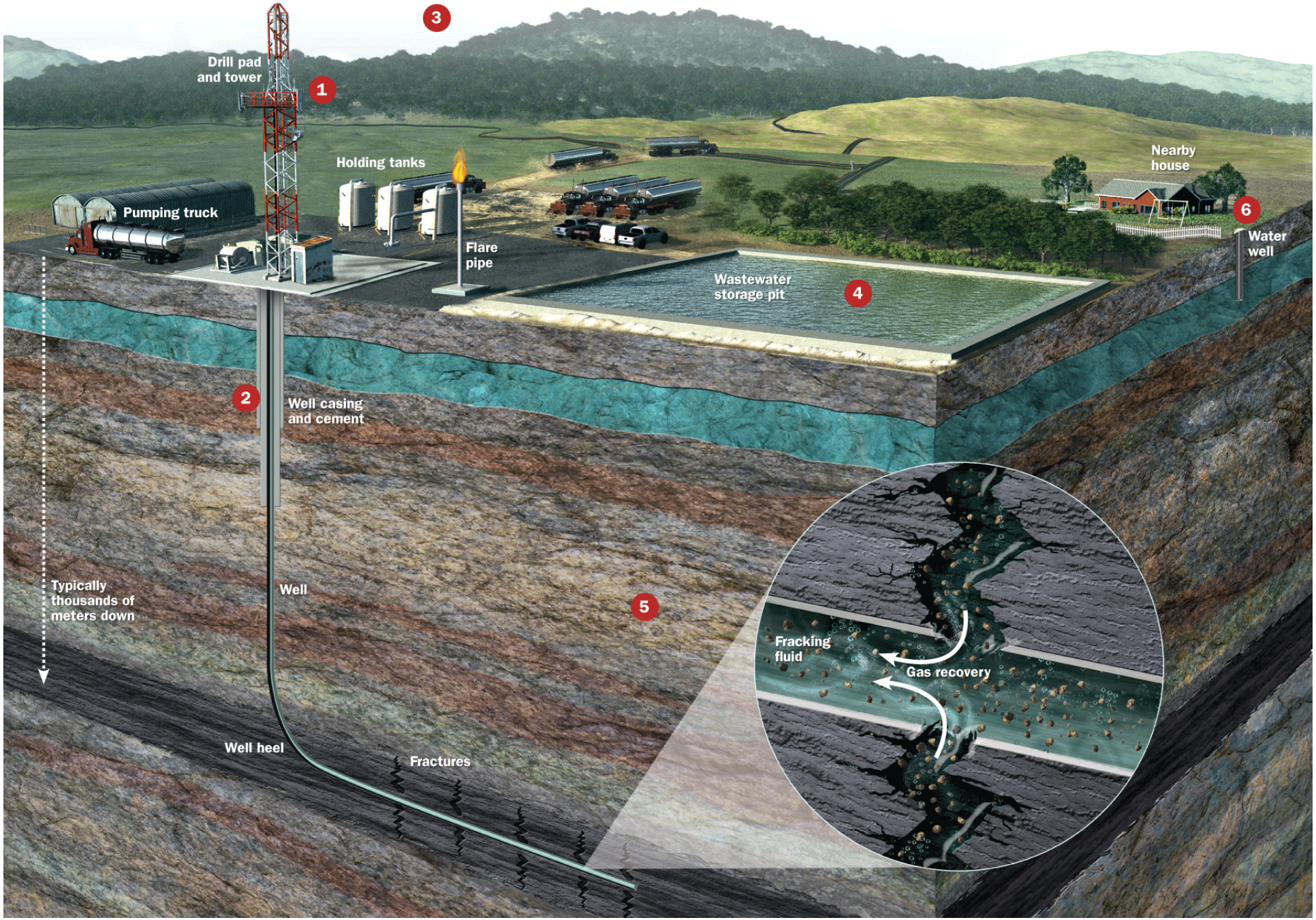

Steady state Unattached Fraction as a Function of Aerosol Concentration
1.2
1.0
0.8
0.6
0.4
0.2
0.0
218Po (Unatt) / 218Po
218Po
214Pb
Outdoor 1000 cm-3
1
10
100
1000
10000
100000
Aerosol Concentration (Particles cm-3)


^{210}Pb and ^{222}Rn Ratios ---- Silo / Outdoors
^{222}Rn Bq m $^{-3}$ = 96/27
^{210}Pb μBq m $^{-3}$ = 760/460
Radon Bq m $^{-3}$
^{210}Pb μBq m^{-3}
800
700
600
500
400
300
200
100
0
Silo
Outdoor

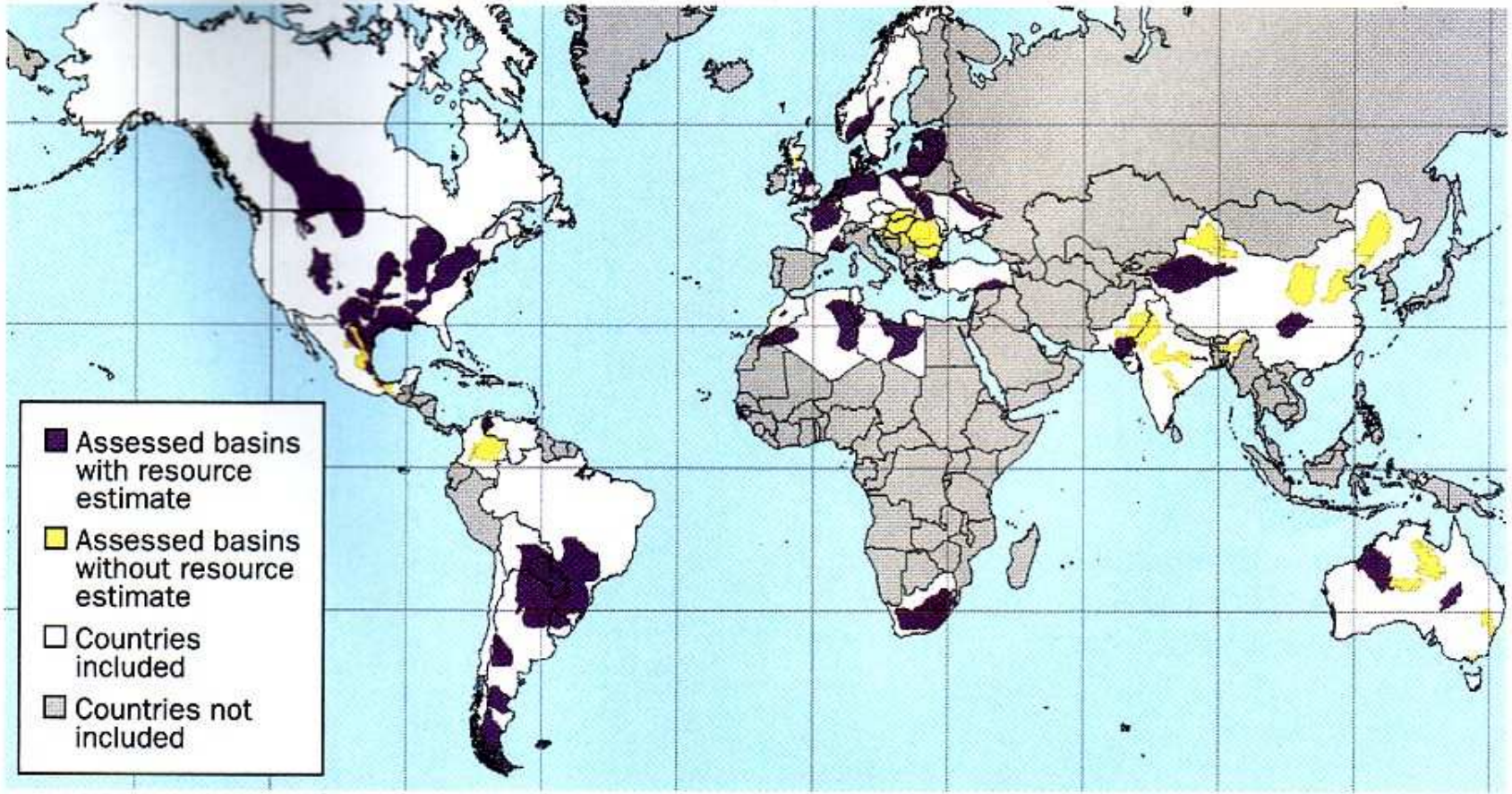
Possible Earthquake Research

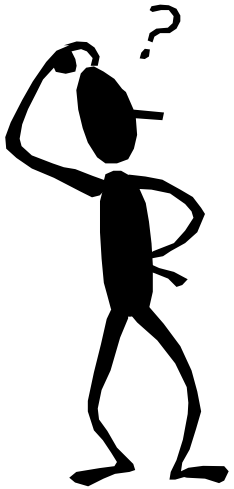
Hydraulic fracturing (Fracking) at 11,700 locations in US.

Increase in earthquakes mainly at wastewater injection sites


1
Drill pad and tower
2
Well casing and cement
3
Holding tanks
Pumping truck
Flare pipe
4
Wastewater storage pit
5
Fracking fluid
Gas recovery
6
Nearby house
Water well
Typically thousands of meters down
Well
Well heel
Fractures

Untapped resource With the help of hydraulic fracturing, drillers can access natural gas that was previously locked in shale beds. A recent report from the U.S. Energy Information Administration analyzed major shale basins (shown) in 32 countries around the world.





Questions

1.Geographic area measured for outdoor radon concentration?

2. Geographic area measured for point source of radon? Wind speed? Steady State?

3. Geographic area measured for Unattached ^{218}Po

4. Need aerosol particle concentration ?

5. Is real time unattached ^{218}Po data a good earthquake predictor?

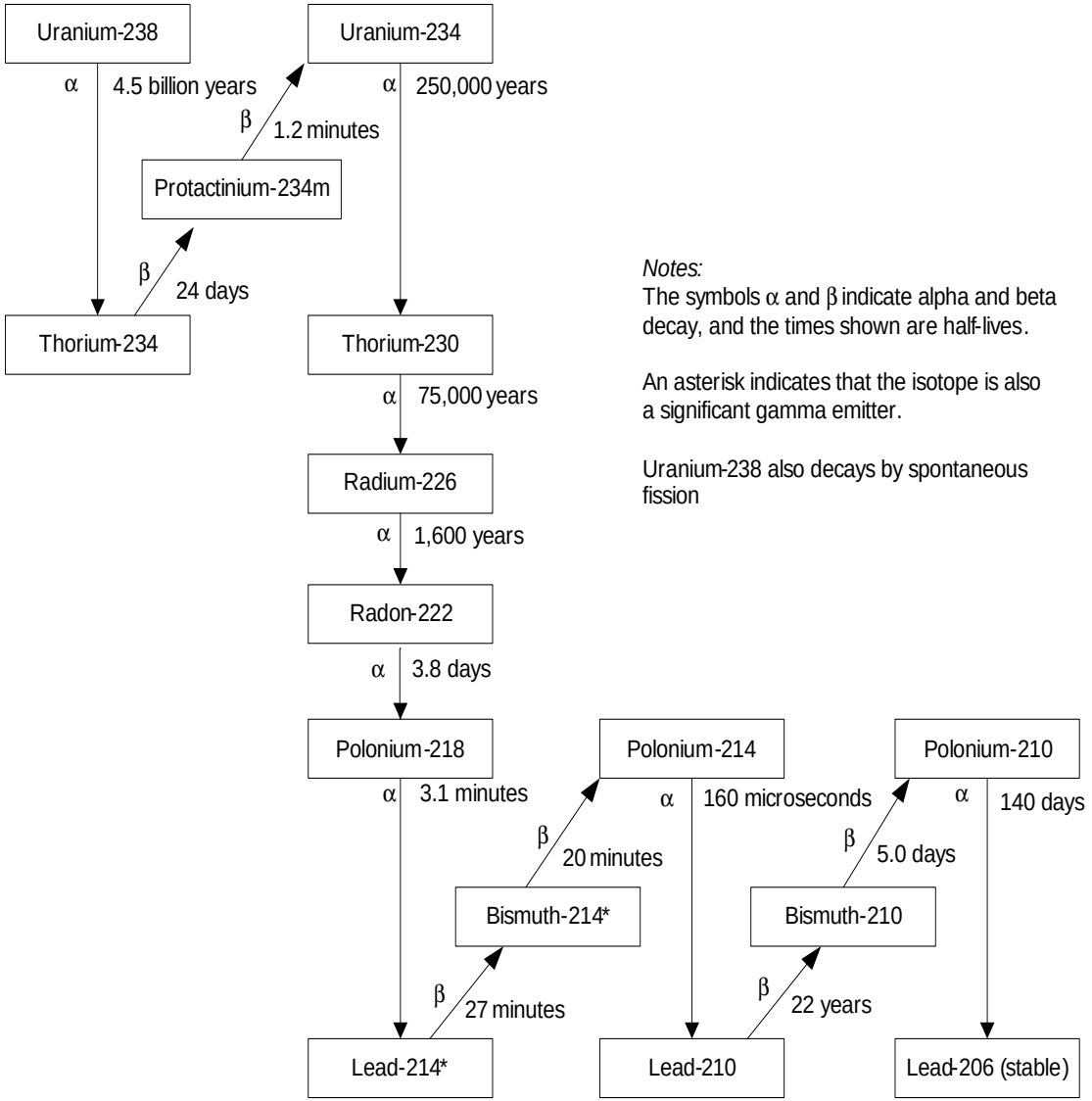
Future Applications

1. Hydraulic fracturing at 11,700 locations in US.

2. Earthquakes associated mainly with wastewater disposal

   Earthquakes ---- Magnitude
   2.3 Blackpool, England,
   4.0 Youngstown, Ohio, USA

3. Sensors at both fracking and wastewater disposal sites?



Notes:
The symbols α and β indicate alpha and beta decay, and the times shown are half-lives.

An asterisk indicates that the isotope is also a significant gamma emitter.

Uranium-238 also decays by spontaneous fission