Determination of Radon Adsorption to Atmospheric Aerosols by Disequilibria of its Progeny

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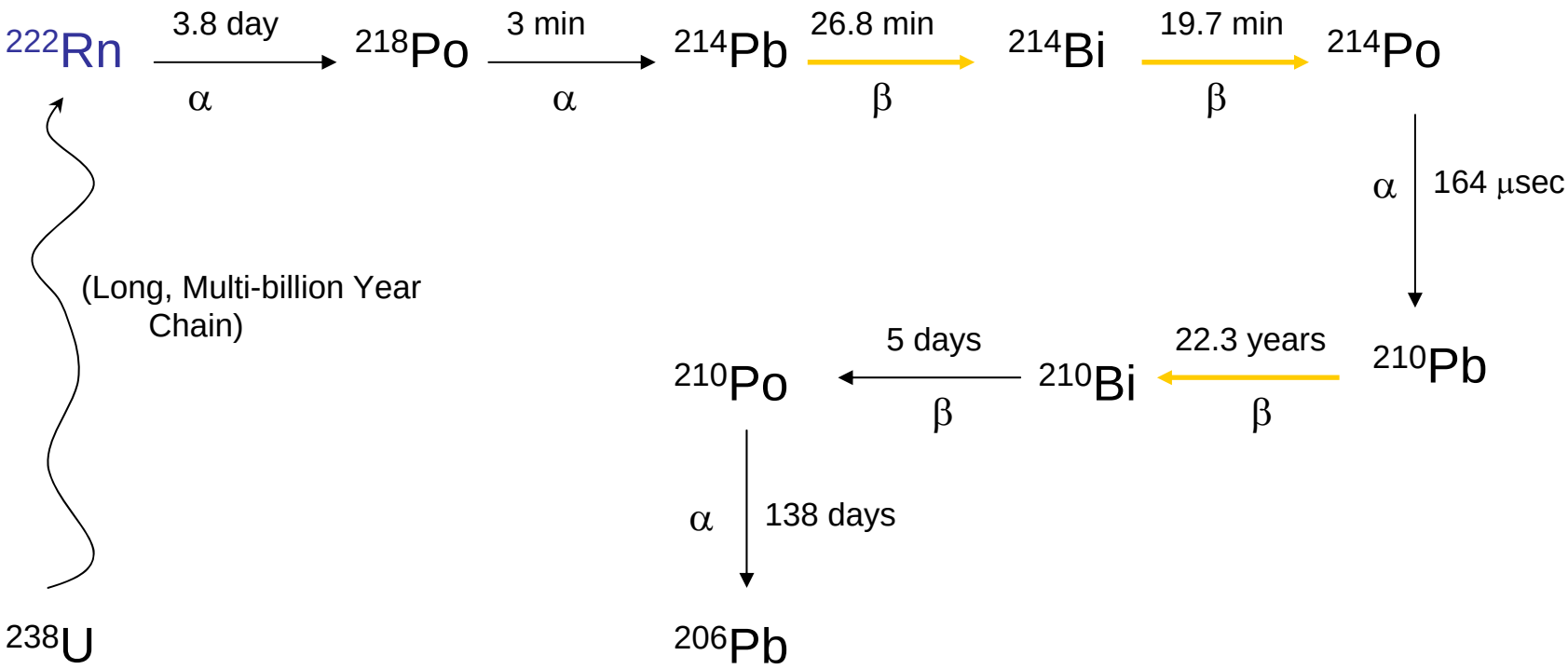
Background: Aerosols

- Defined as any suspended particle or colloid in the size range of ~.002 to 10 μm in effective diameter
- Because of this broad definition, aerosols have diverse compositions, thus broad climate effects
  - We've heard stories from Torreon, Mackenzie, Adele, Mikey, and soon…Shallena
- One important question: How long do they stay suspended in the atmosphere?

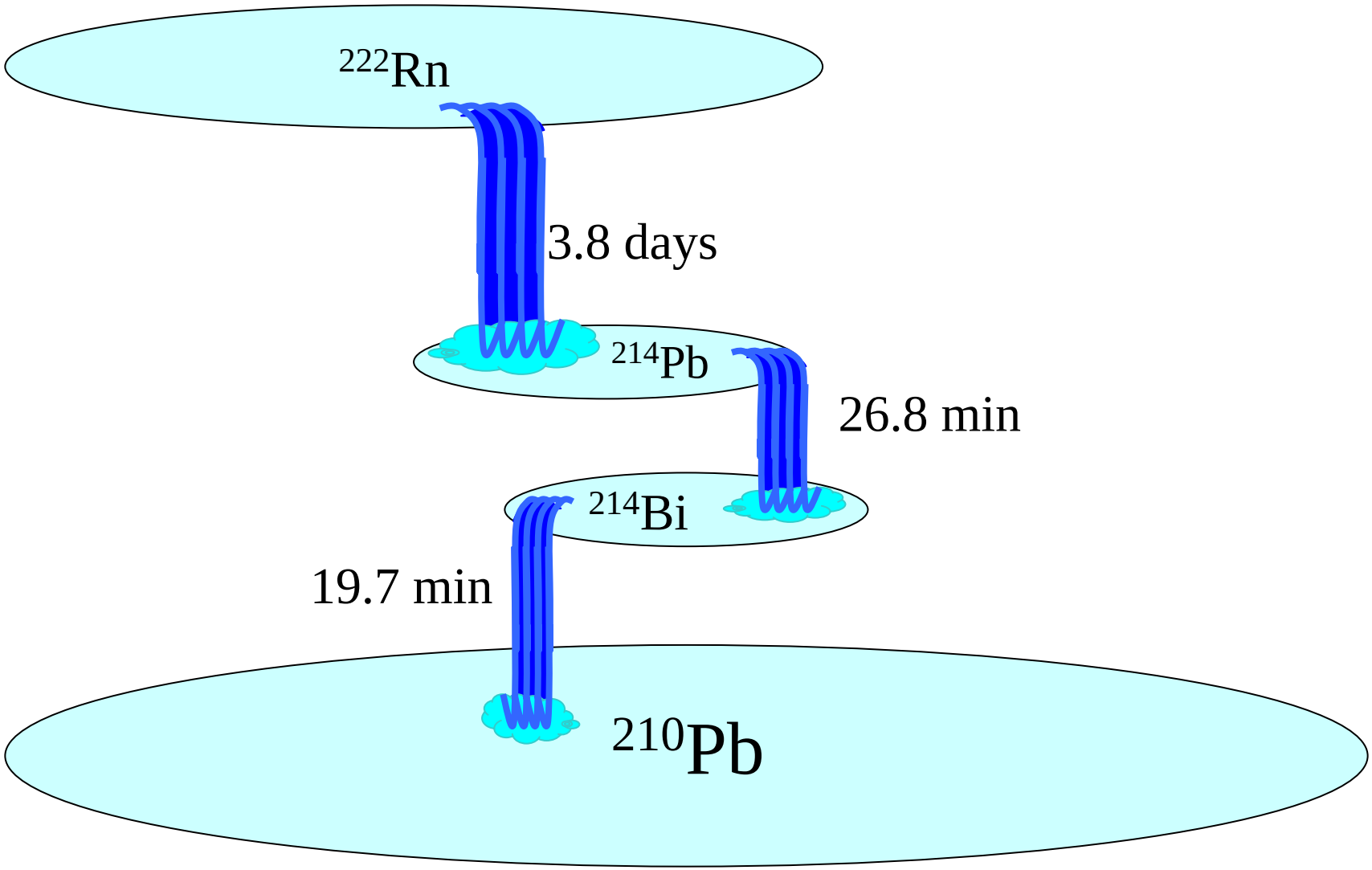
Background: Radionuclear Tracers

The ^{238}U decay series



Tropospheric Tagging

The Pool Analogy



Aerosol Age-dating

- By measuring the radionuclear activities and taking the ratio between them, atmospheric lifetimes can be derived

$^{210}Po/^{210}Pb = T_R^2/(T_R+1/\lambda_{Bi})(T_R+1/\lambda_{Po})$

$^{210}Bi/^{210}Pb = T_R/(T_R+1/\lambda_{Bi})$

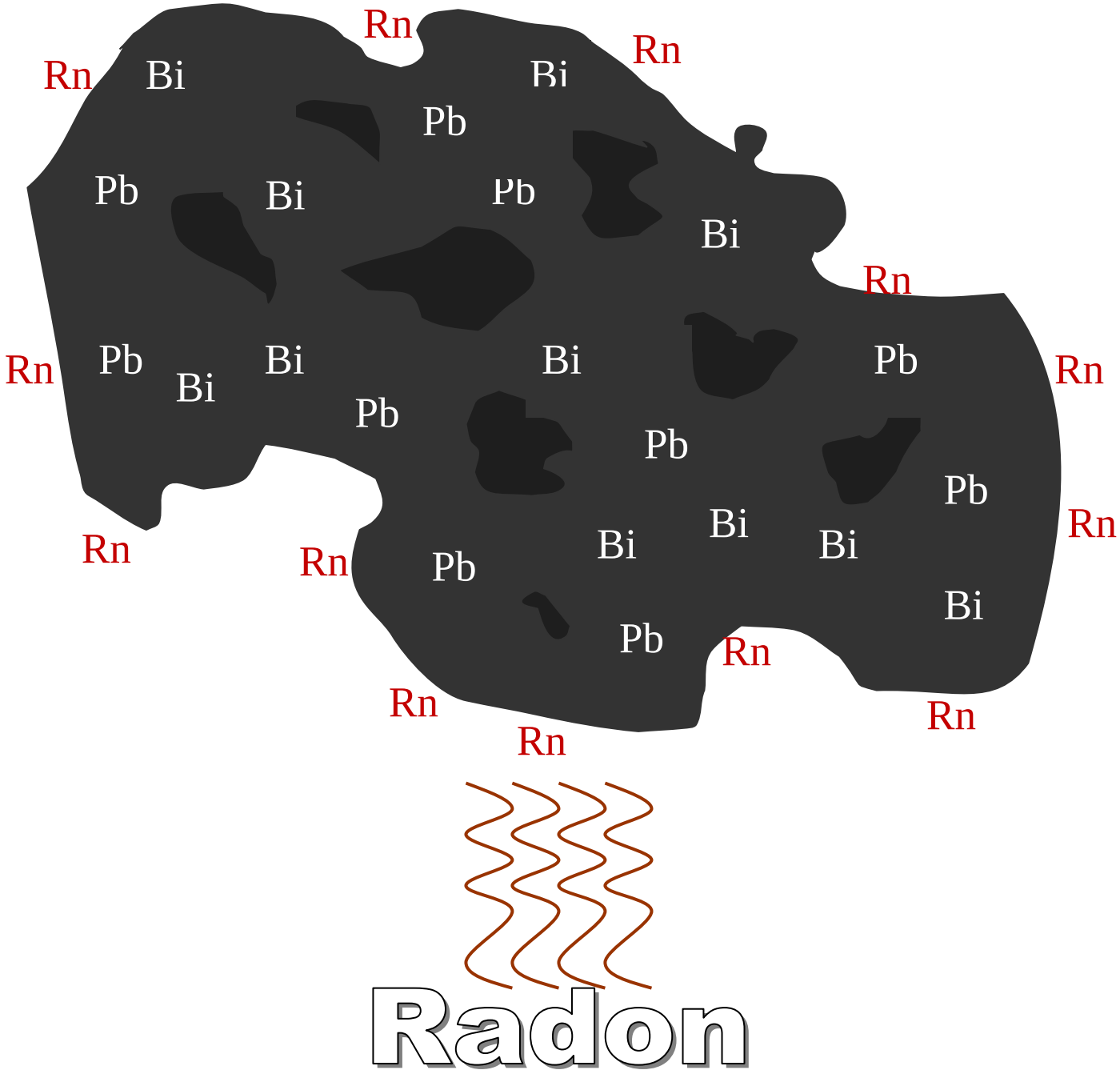
- Where λ is an element's decay constant

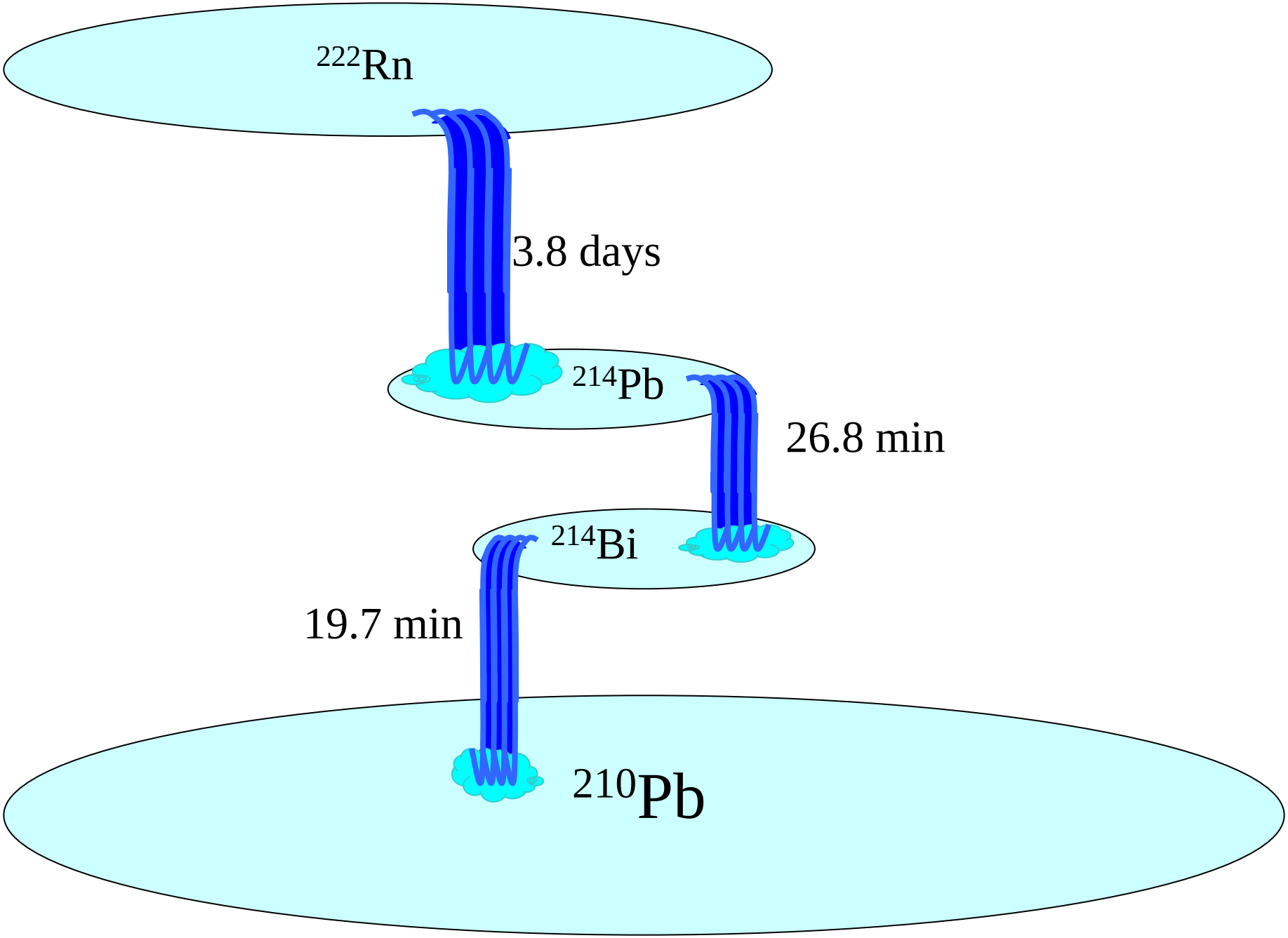
Solving for T_R gives an approximated residence time for the given radionuclide

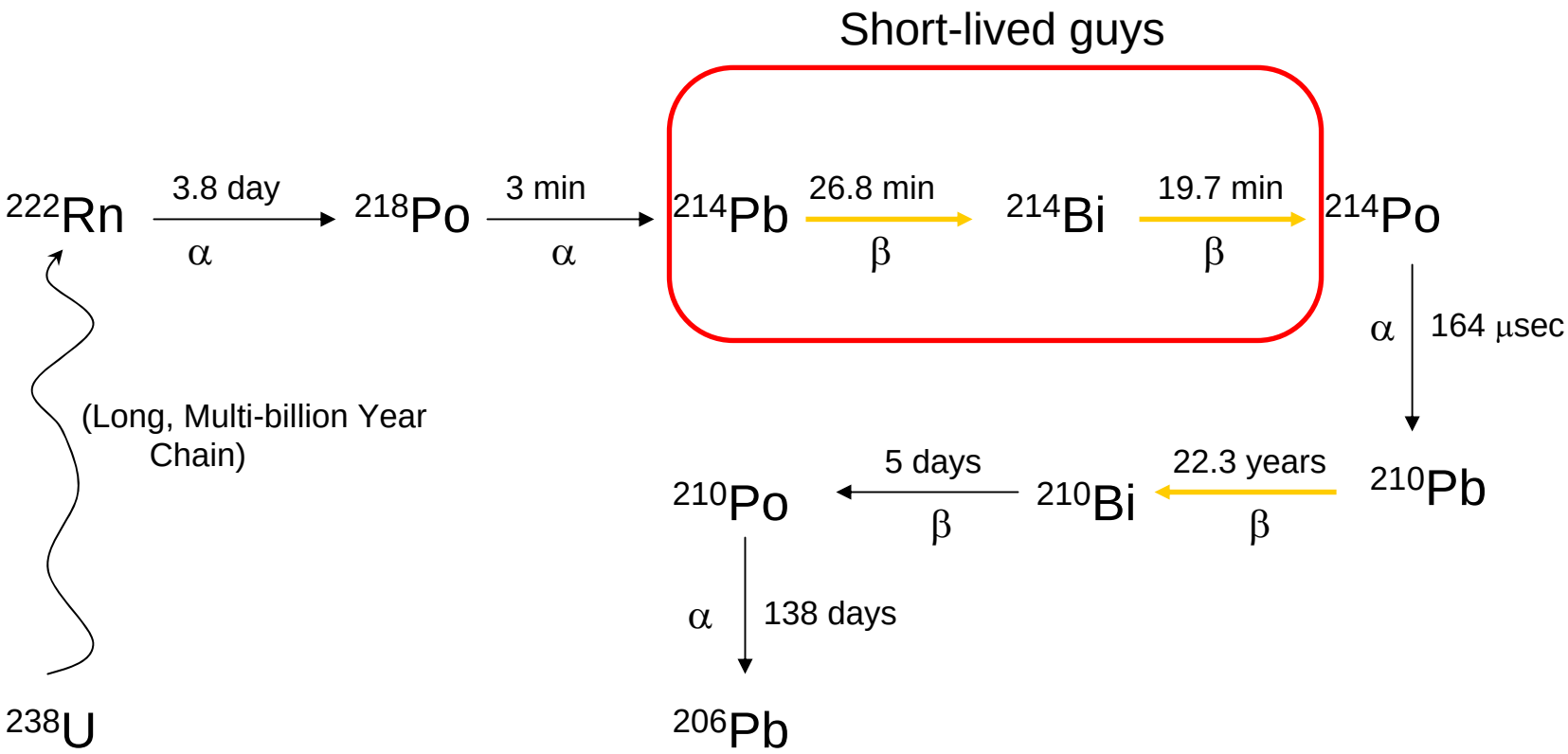
Radon Our Parade

- However, these ratios can be distorted by concurrent decay and growth of a specific nuclide
- Remember the pools
- If Radon is filling the pools of Bismuth and Polonium, their decay will be affected

- Radon Gas, with its known affinity for oils, can adsorb on to the surface of aerosols with more “oily” surfaces


Rn
Rn
Rn
Bi
Bi
Pb
Pb
Bi
Pb
Bi
Rn
Rn
Pb
Bi
Bi
Pb
Rn
Bi
Pb
Pb
Pb
Bi
Bi
Rn
Rn
Rn
Pb
Bi
Rn
Pb
Rn
Rn
Rn
Rn
Radon


^{222}Rn
3.8 days
^{214}Pb
26.8 min
^{214}Bi
19.7 min
^{210}Pb

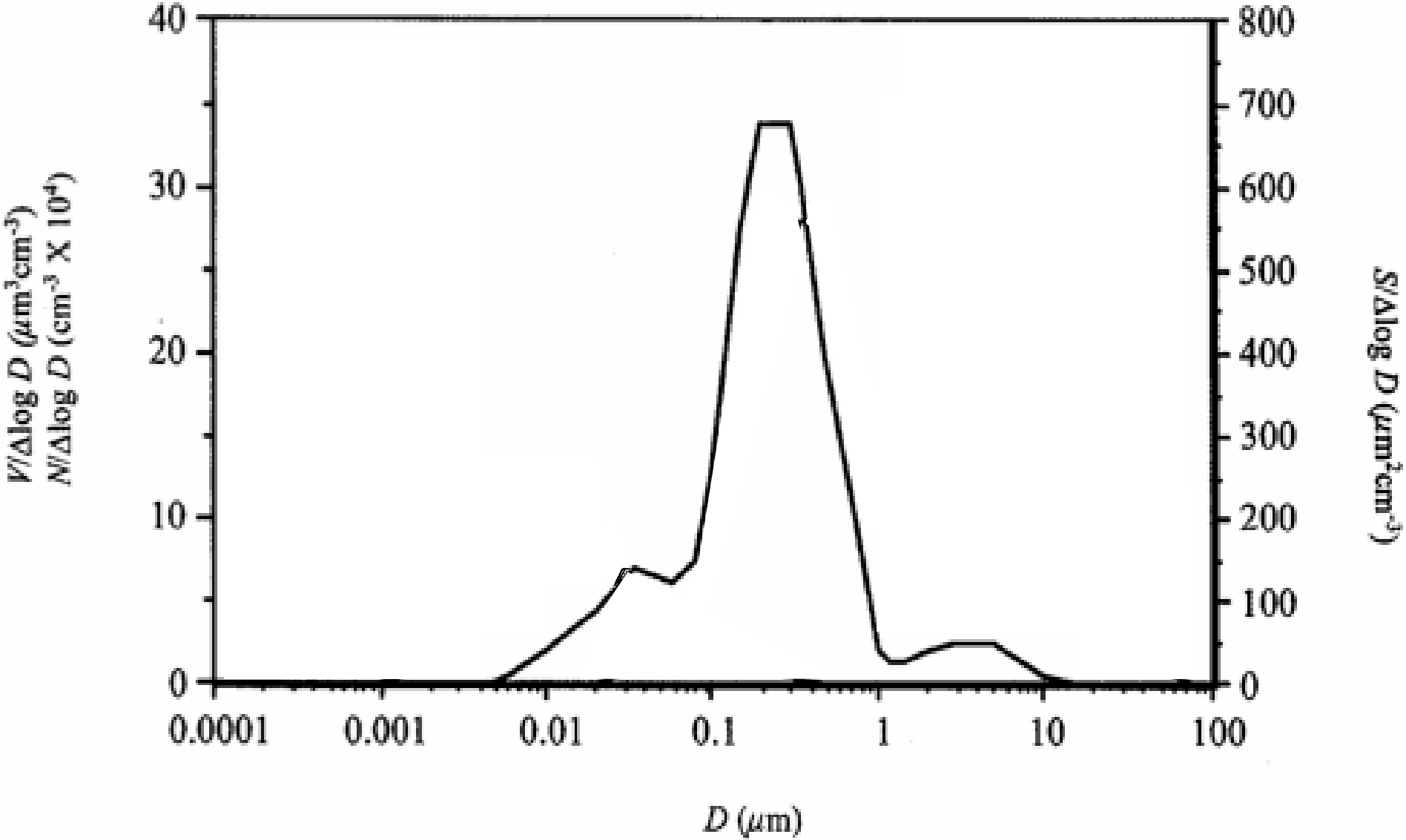

Short-lived guys
^{222}Rn
3.8 day
α
^{218}Po
3 min
α
^{214}Pb
26.8 min
β
^{214}Bi
19.7 min
β
^{214}Po
α
164 μsec
^{210}Pb
22.3 years
β
^{210}Bi
5 days
β
^{210}Po
α
138 days
^{206}Pb
(Long, Multi-billion Year Chain)
^{238}U

Experimental

- To address the radon adsorption question
- 11 samples taken by impaction
  - Sample times ranged from 3-150 hours

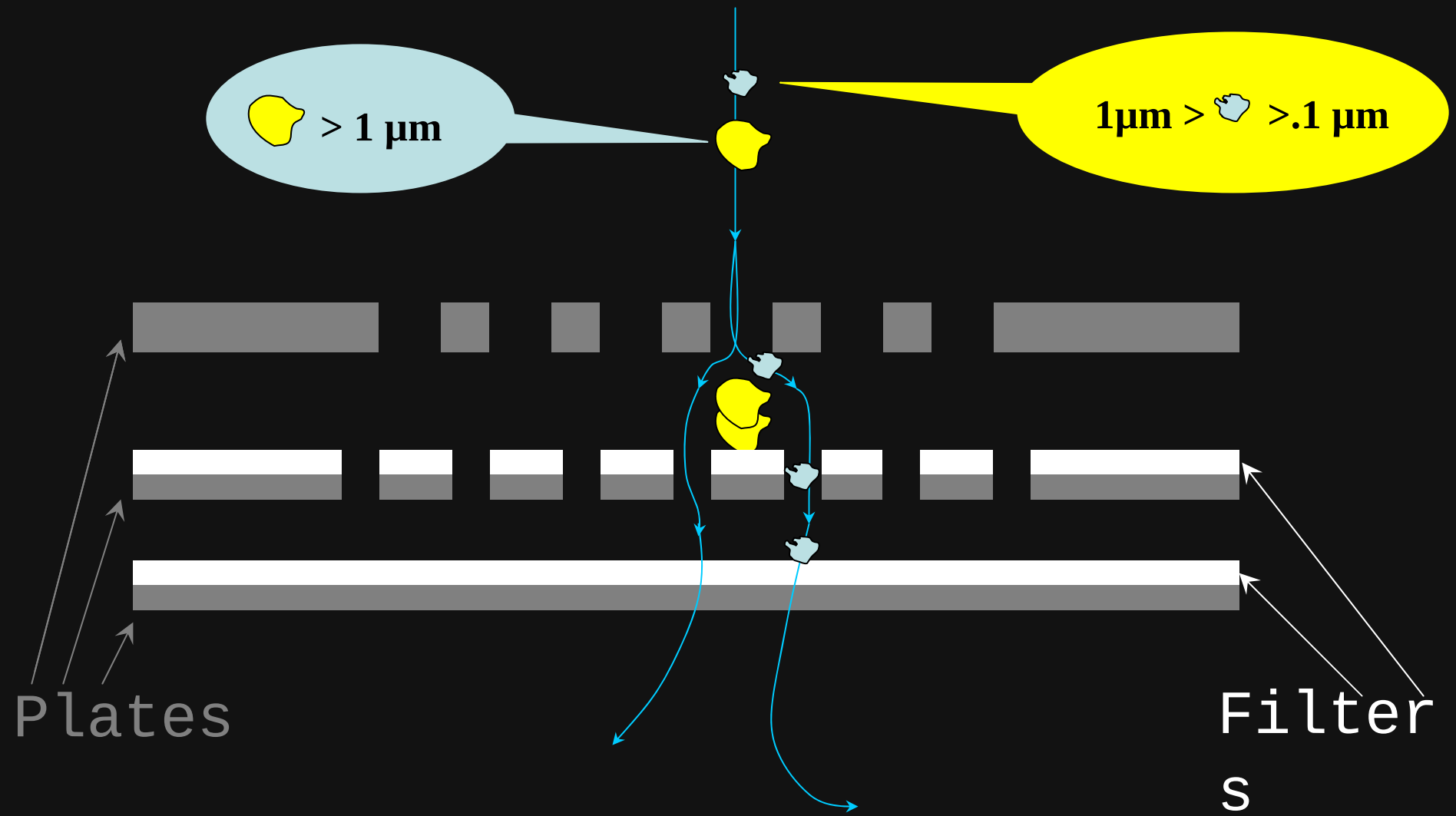
- Filters gamma-counted *immediately* to track decay of short-lived ^{214}Pb and ^{214}Bi

Surface Area Distribution of Aerosols



Impactors

Impactor Theory



Gamma Counting

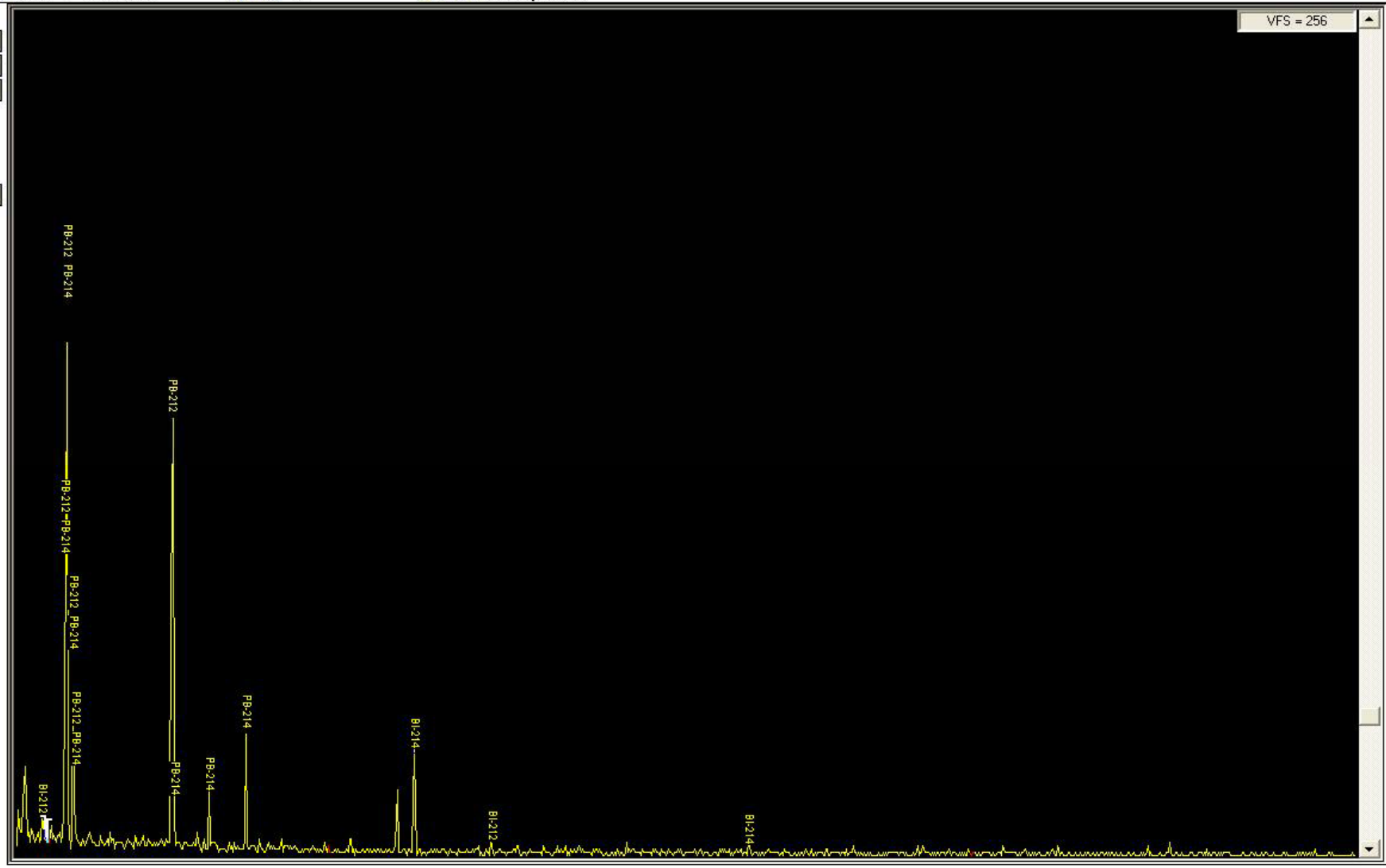
Using a Canberra DSA 1000 Broad Energy Gamma Ray Spectrometer

Gamma - Q4 69.9 HR count 26.CNF*

File MCA Calibrate Display Analyze Edit Options Datasource Help

Idle | Channel: 2434 : 609.4 keV | Counts: 31 | Preset: 86400/210.88

Acquire
Start Stop
Expand On
Clear
ROI Index:
- +
Datasource
Prev Next



NUCLIDE INFO

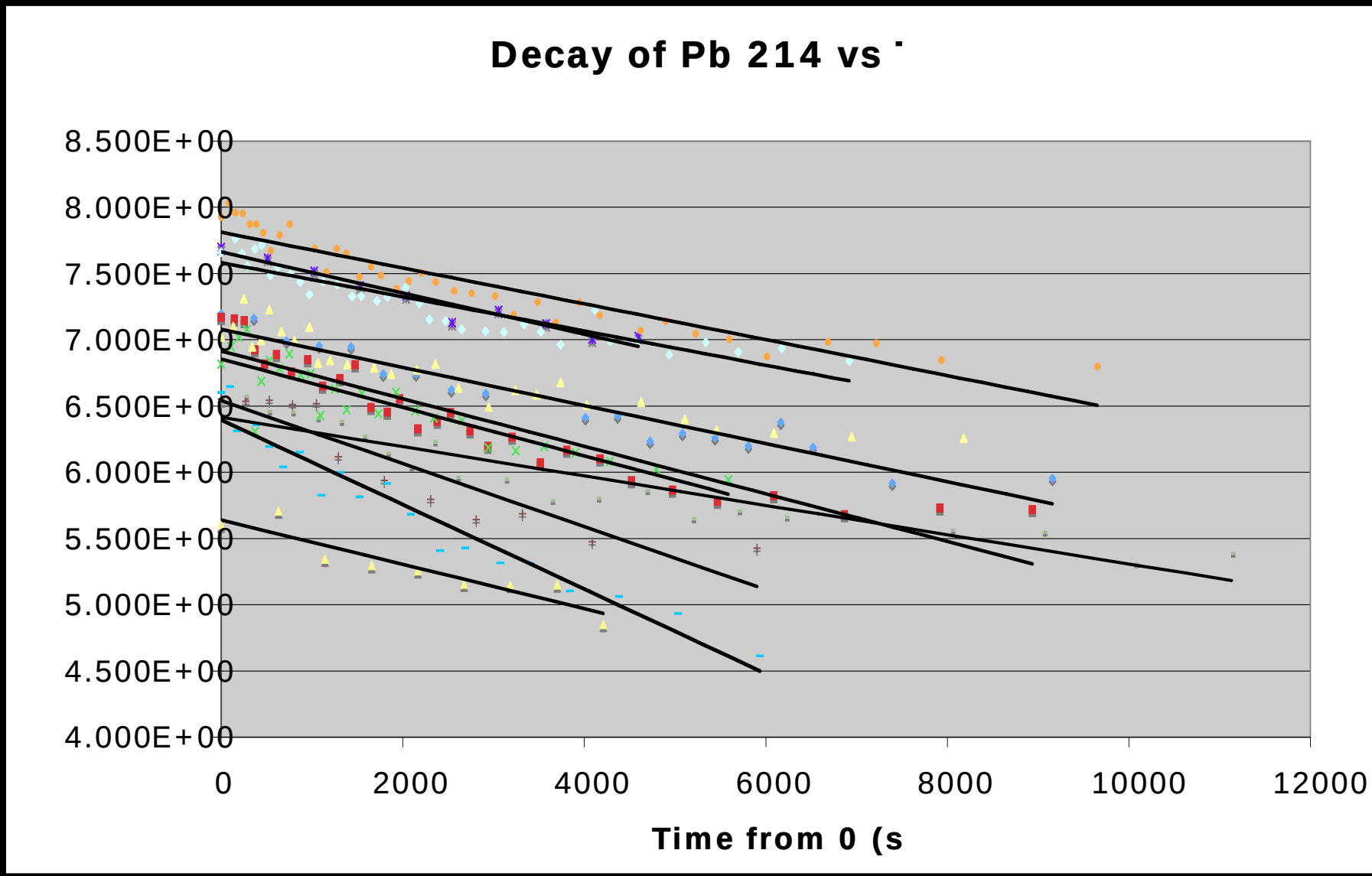
Next
Prev

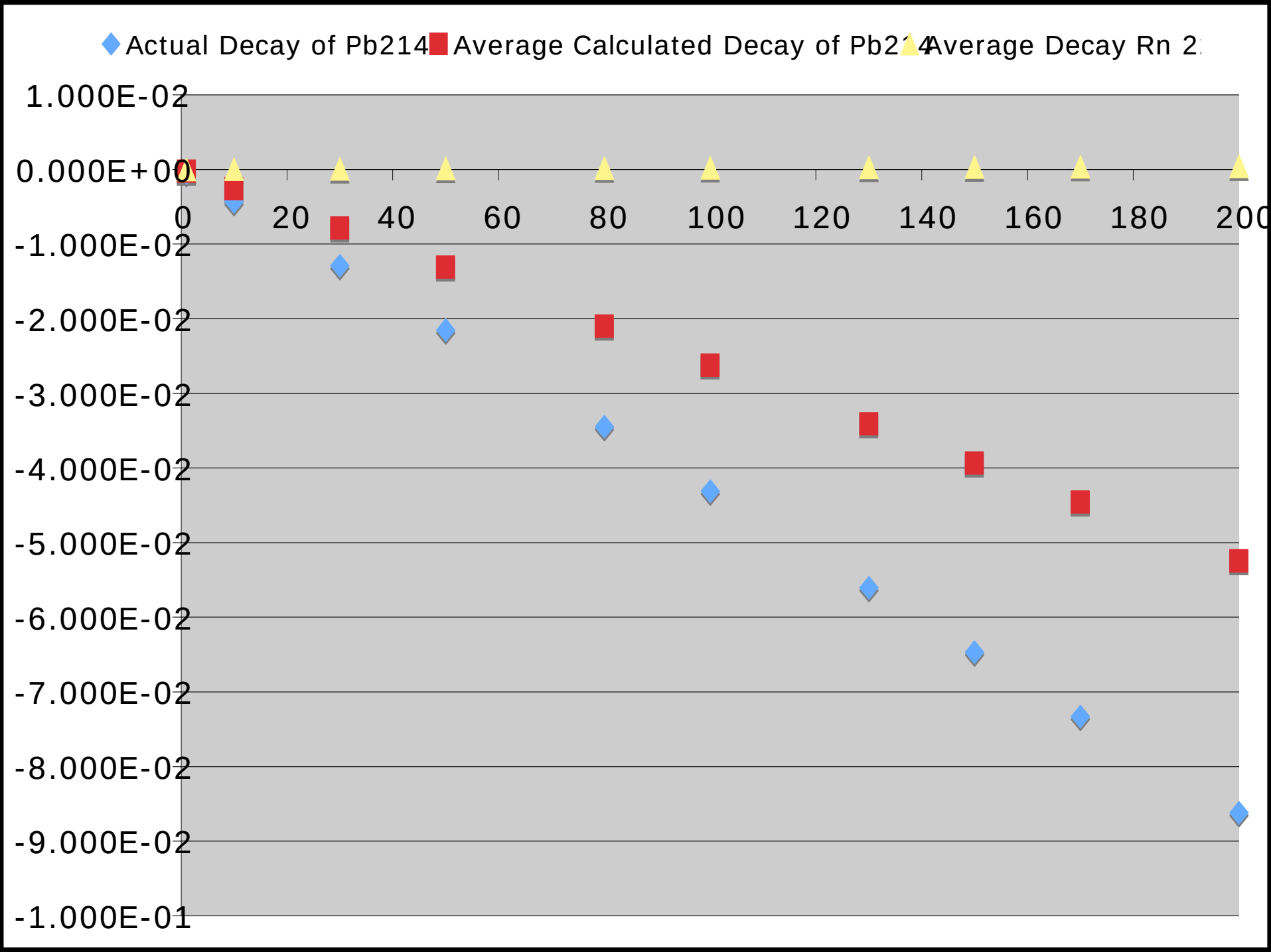
FWHM: Area:
Nuclide: BI-214 Half-life: 1600.01y
Energy: 609.3 keV Yield: 46.3%
Activity:

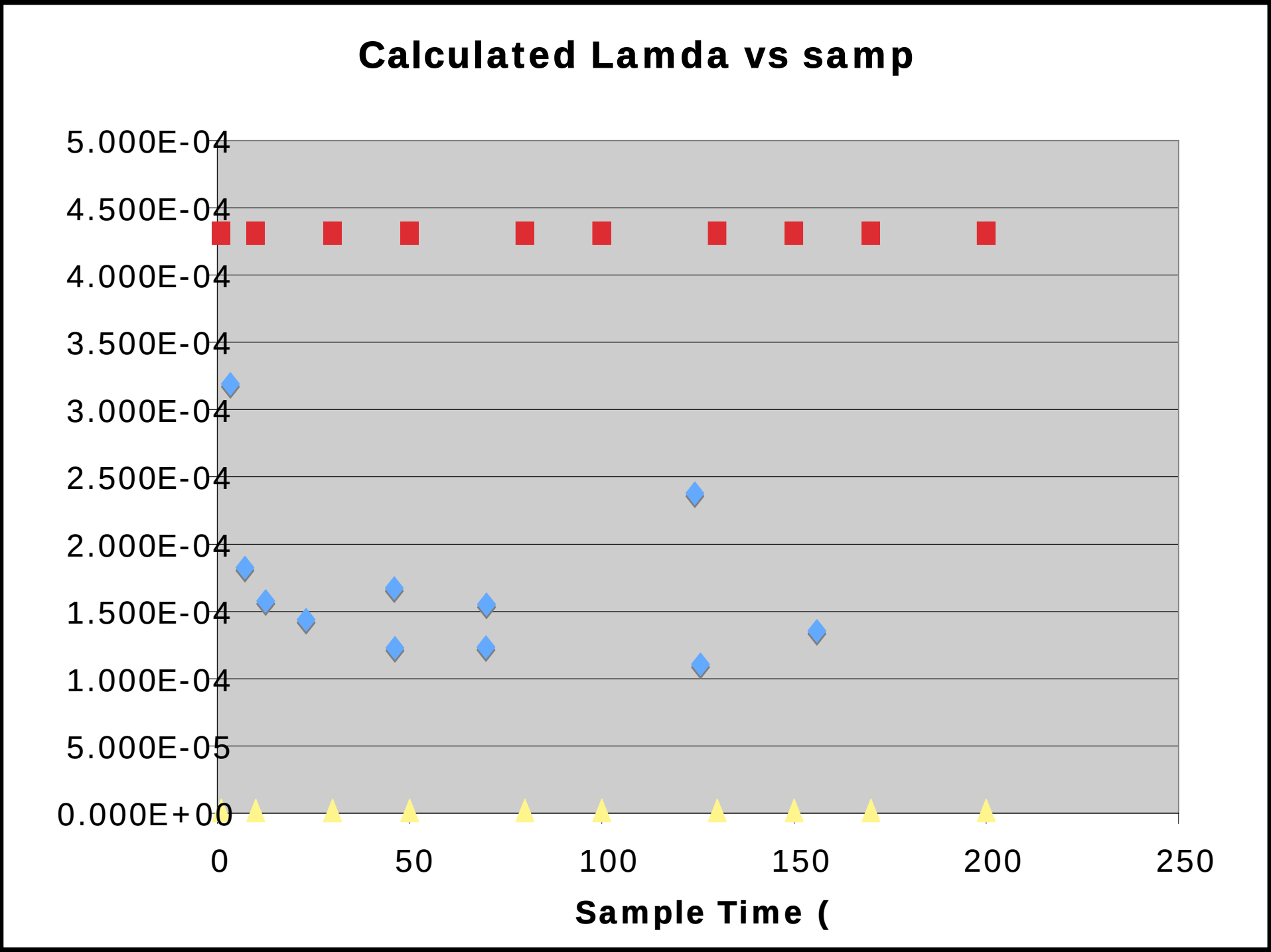
For Help, press F1 Execution Status: ready

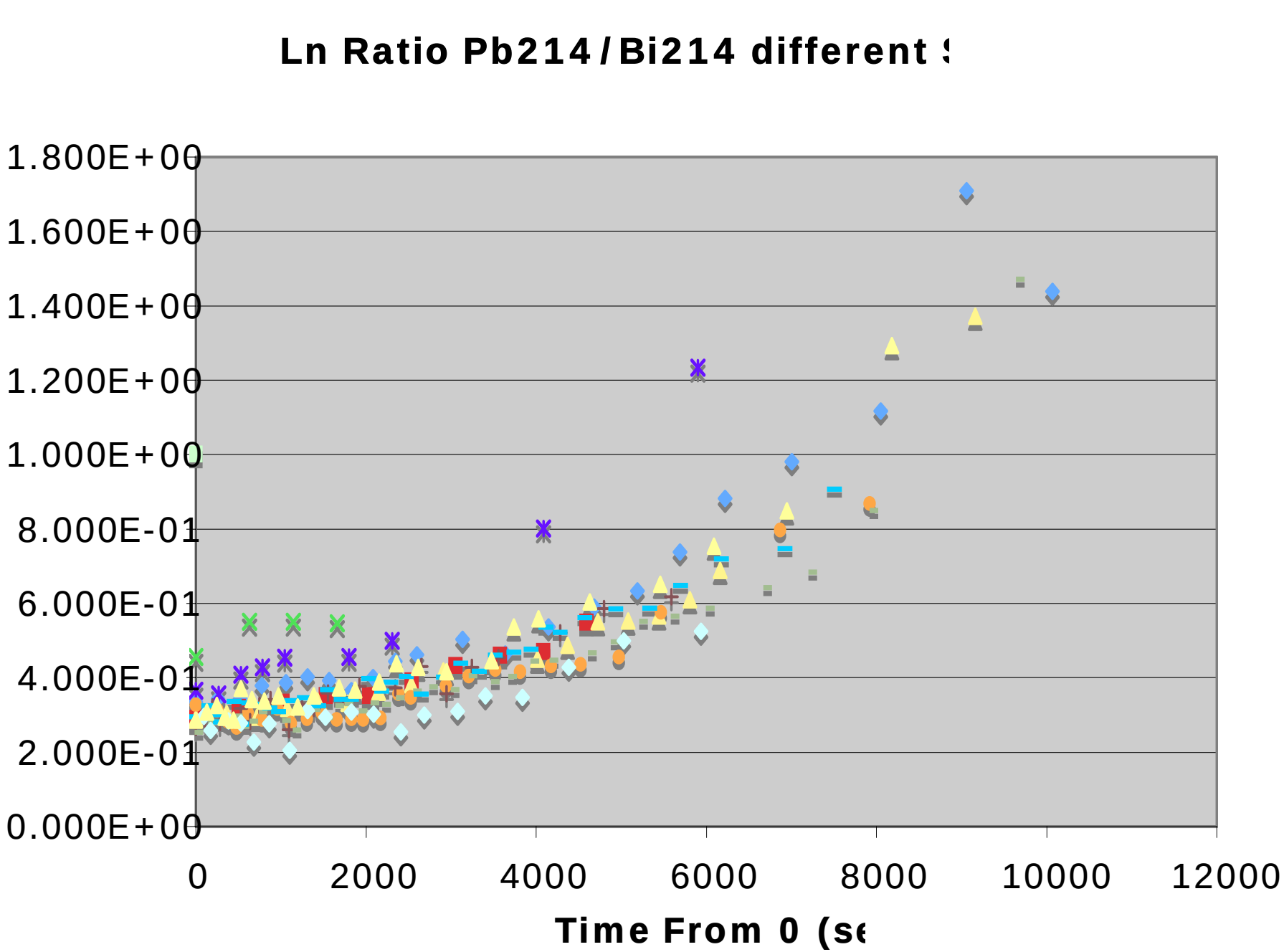
start Genie 2000 VDM Gamma - Q4 69.9 HR ... 11:23 AM

Results


Decay of Pb 214 vs
8.500E+00
8.000E+00
7.500E+00
7.000E+00
6.500E+00
6.000E+00
5.500E+00
5.000E+00
4.500E+00
4.000E+00
0
2000
4000
6000
8000
10000
12000
Time from 0 (s


Actual Decay of Pb214
Average Calculated Decay of Pb214
Average Decay Rn 2
1.000E-02
0.000E+00
-1.000E-02
-2.000E-02
-3.000E-02
-4.000E-02
-5.000E-02
-6.000E-02
-7.000E-02
-8.000E-02
-9.000E-02
-1.000E-01
0
20
40
60
80
100
120
140
160
180
200


Calculated Lamda vs samp
5.000E-04
4.500E-04
4.000E-04
3.500E-04
3.000E-04
2.500E-04
2.000E-04
1.500E-04
1.000E-04
5.000E-05
0.000E+00
0
50
100
150
200
250
Sample Time (


Ln Ratio Pb214/Bi214 different S
1.800E+00
1.600E+00
1.400E+00
1.200E+00
1.000E+00
8.000E-01
6.000E-01
4.000E-01
2.000E-01
0.000E+00
0
2000
4000
6000
8000
10000
12000
Time From 0 (se

Preliminary Conclusions

- Work in progress, bear in mind
- Data strongly suggests radon adsorption
  - Lead appears to approach transient equilibrium with Radon
- Potential Connection between sample time and radon adsorption

Current/Future Work

- Chemical extraction of ^{210}Pb from ^{210}Po and ^{210}Bi
  - Hopefully to gain further evidence on “excess” polonium problem
    - Or is it the “excess” *alpha* problem?
- Simultaneous Radon Counting
- In-line combustion system for Total Carbon determination

Beta Counting

Extraction

Acknowledgements

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