Automated Radium Analyses Using MnO_2 Resin and a Radon Analyzer

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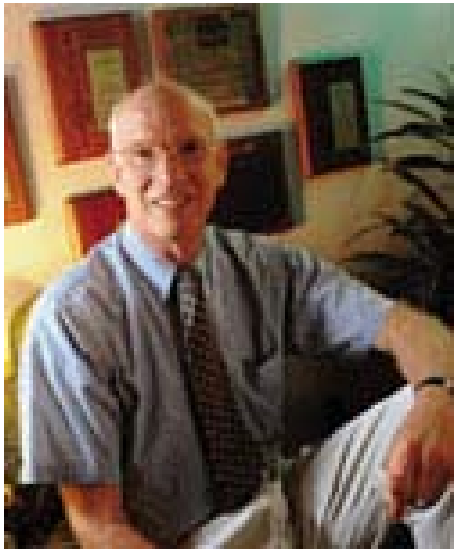
Acknowledgments

PGRF:

- E. Philip Horwitz
- Dan McAlster

PGRF℠
REALIZING THE FUTURE℠



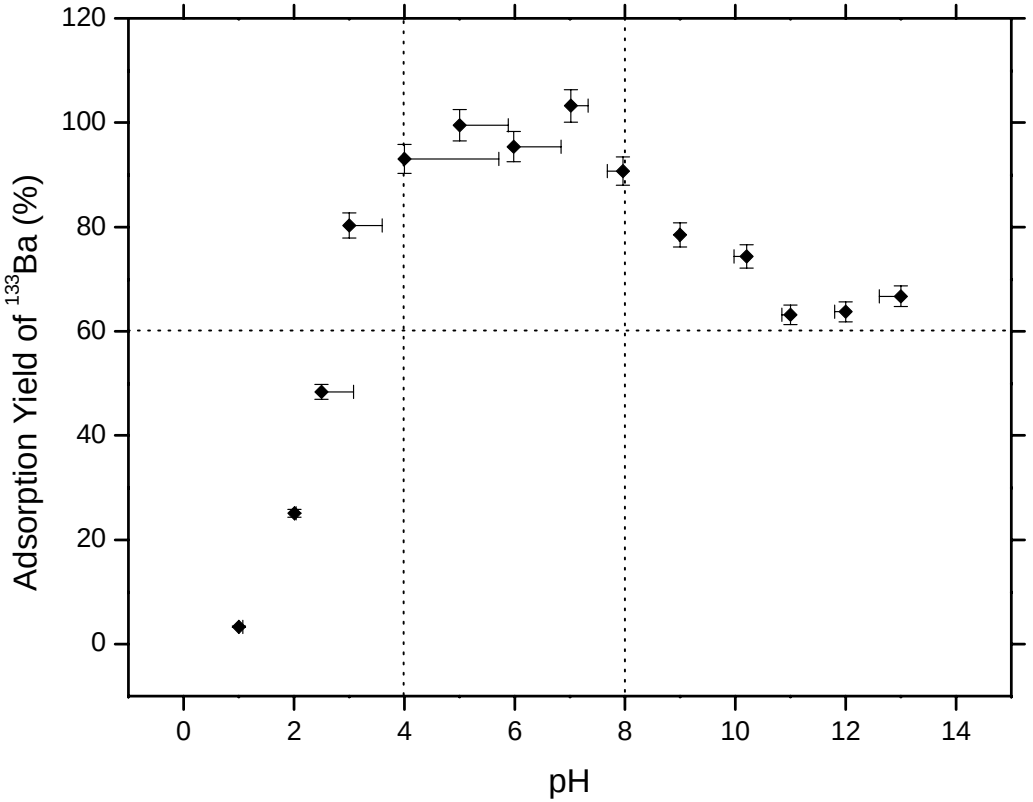
Natural Radium Isotopes

Isotope	Direct Parent	Half-life	Decay Mode	Energy MeV
^{223}Ra	^{227}Th	11.4 d	α	5.61 5.72
^{224}Ra	^{228}Th	3.66 d	α	5.69
^{226}Ra	^{230}Th	1600 y	α	4.78
^{228}Ra	^{232}Th	5.75 y	β	0.046

MnO_2 Resin

- Developed by PGRF, based on “Mn Resin” used by oceanographers
- High adsorption of Ra, trivalent and tetravalent actinides (Ac, Am, Pu, Th)

Adsorption vs. pH



- **pH = variable**
- **Resin = 25 mg**
- **Solution = 10 mL**
- **Reaction time = 90 min**

The optimum pH for adsorption of Ra^{2+} is from 4 to 8 – nearly all natural waters fall into this range.

Moon et al. / Applied Radiation & Isotopes 59 (2003) 255-262

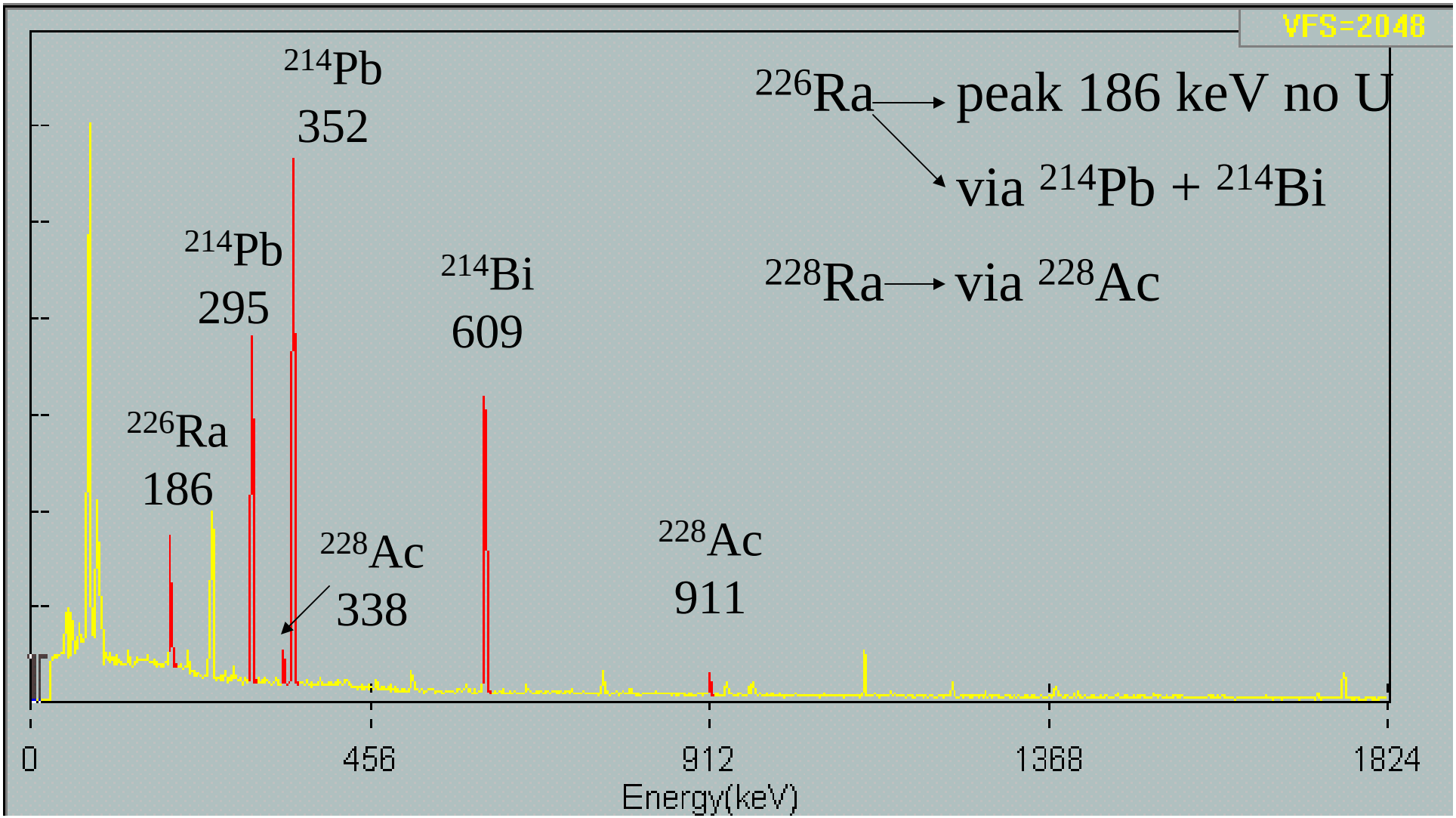
Suggested Applications

1. Drinking water analysis of Ra-226 and Ra-228 via preconcentration and γ-spectrometry
2. Preconcentration of Ra isotopes and separation via Ln and DGA Resins (see S. Maxwell, Eichrom Sp. ’05 Oak Ridge Wkshop)
3. Automated analysis of α-emitting Ra isotopes via a radon-in-air analyzer

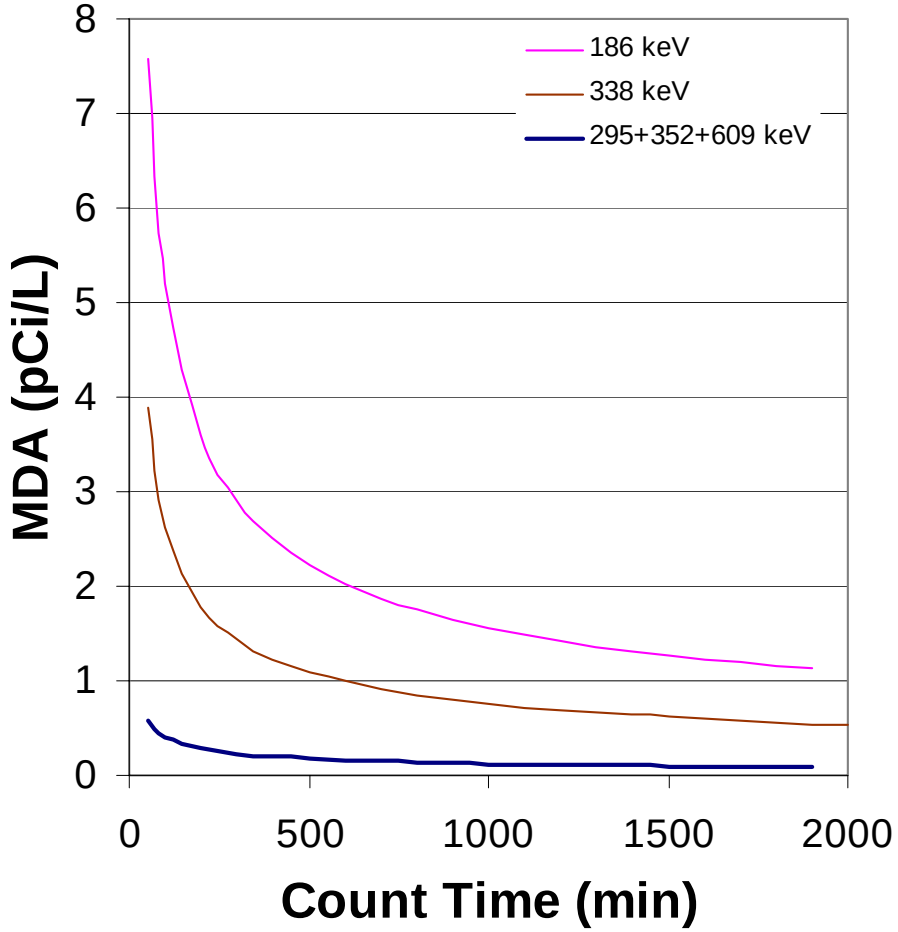
Gamma-Spect Analysis

React MnO_2 Resin in a batch mode, let settle, decant/ centrifuge, transfer to counting vial for γ-spect analysis

Gamma Spectrum



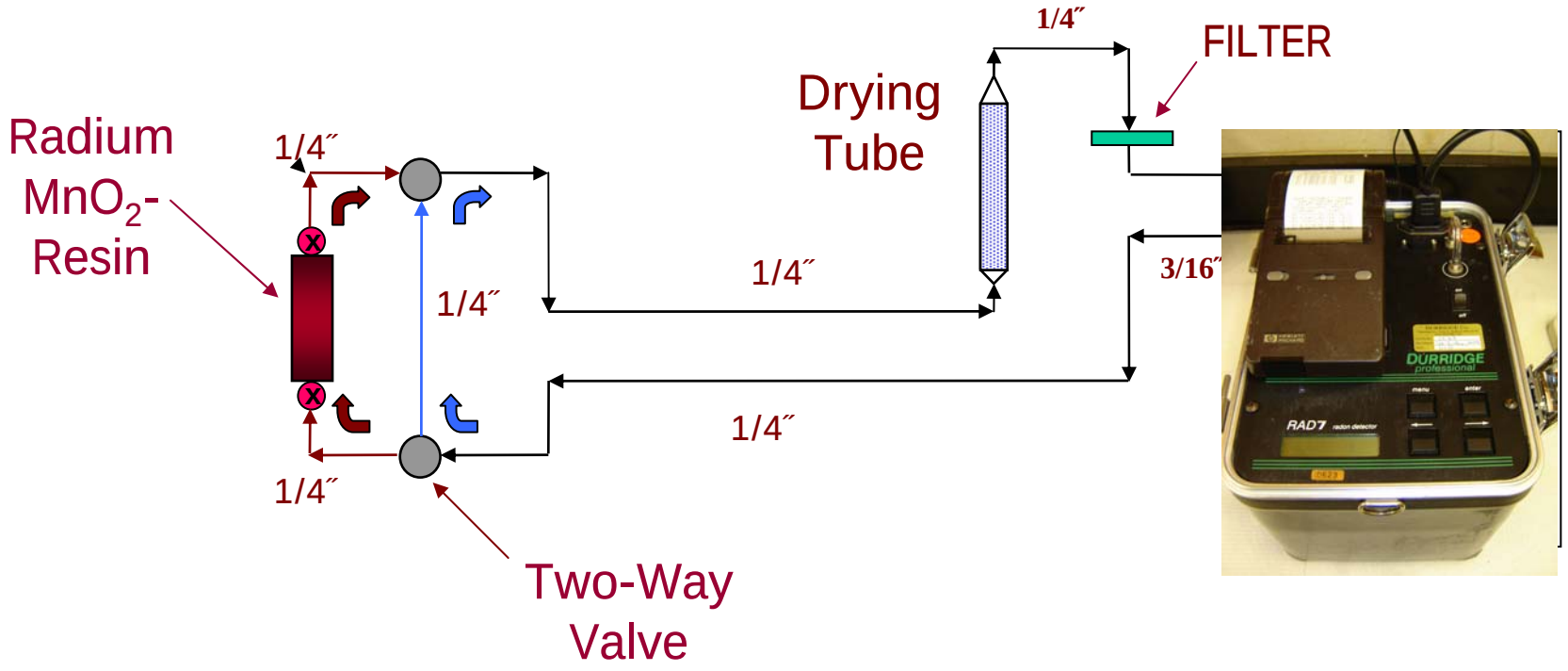
MDA Gamma Spect



- ~100-cc Ge well detector
- 2-liter volume
- 295+352+609 keV assumes 50% equilibrium (4-day ingrowth)

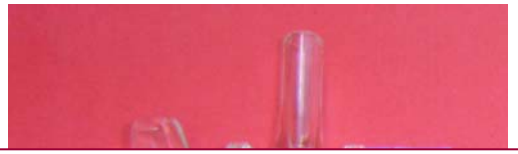
$$\mathrm{MDA\ (pCi/L)} = \frac{2.71 + 4.66\sqrt{B \bullet T}}{2.22 \bullet T \bullet \mathrm{eff} \bullet \mathrm{intensity} \bullet \mathrm{vol}}$$

Automated Assay α-Emitters



Air flows initially (10 min) from the RAD-7 through the cartridge to purge radon from the resin. The valves are then switched so the air circulates through a drying tube and the RAD-7 while counting in progress (~3 hours).

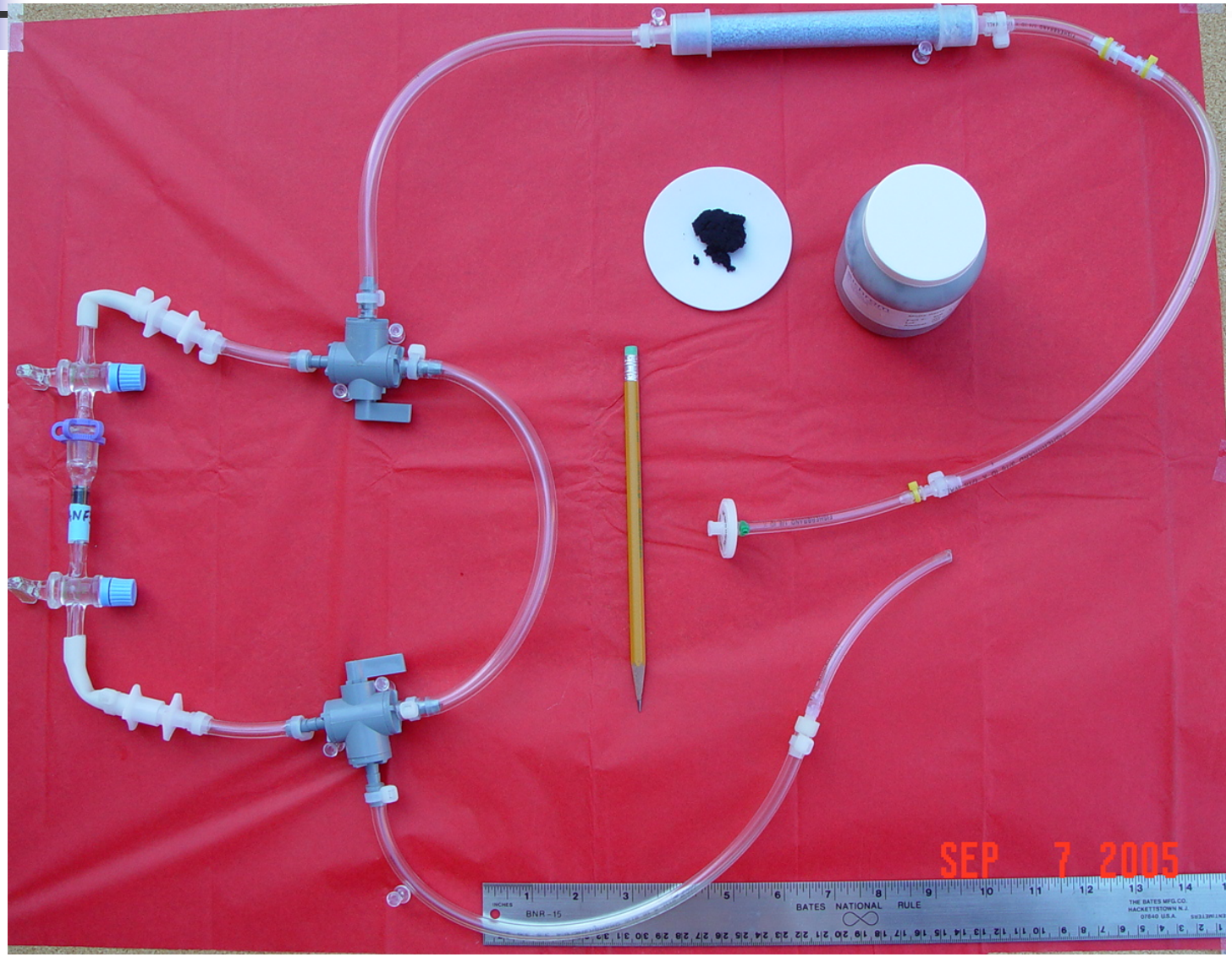
The Cartridge



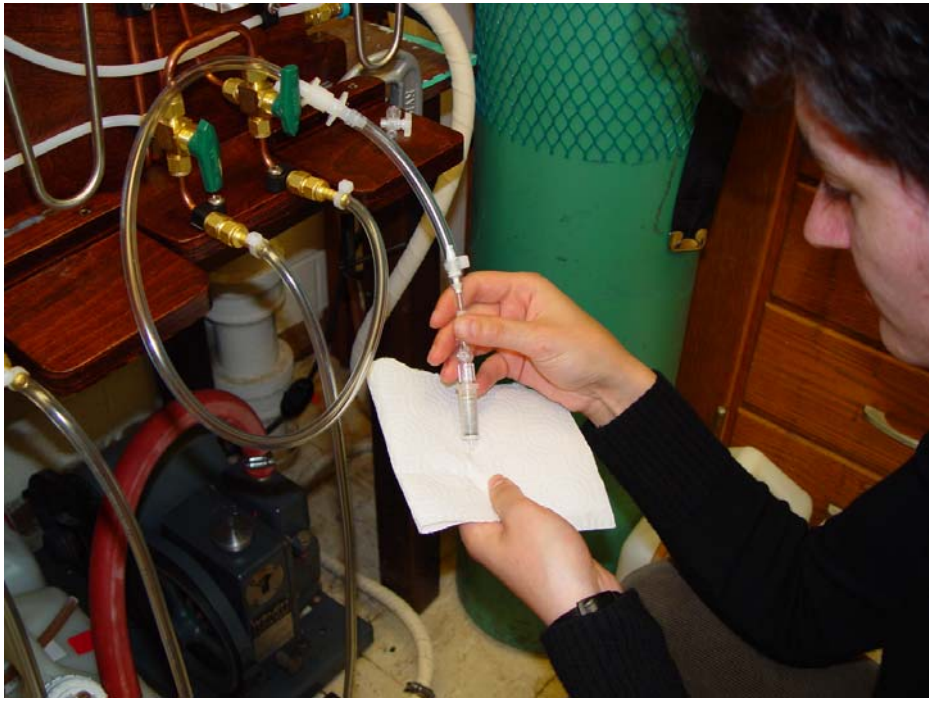
Lillie Glassblowers
Don Lillie
3431 Lake Drive
Smyrna, GA 30082-2814

Tel: 770-436-8959
Fax: 770-435-0695

Connectors to RAD-7



Setting Sample Ingrowth



The samples and standards are re-set for ingrowth by passing helium through the cartridge to ensure no Rn-222 is present at t=0. A small amount of water is then added to enhance Rn emanation.

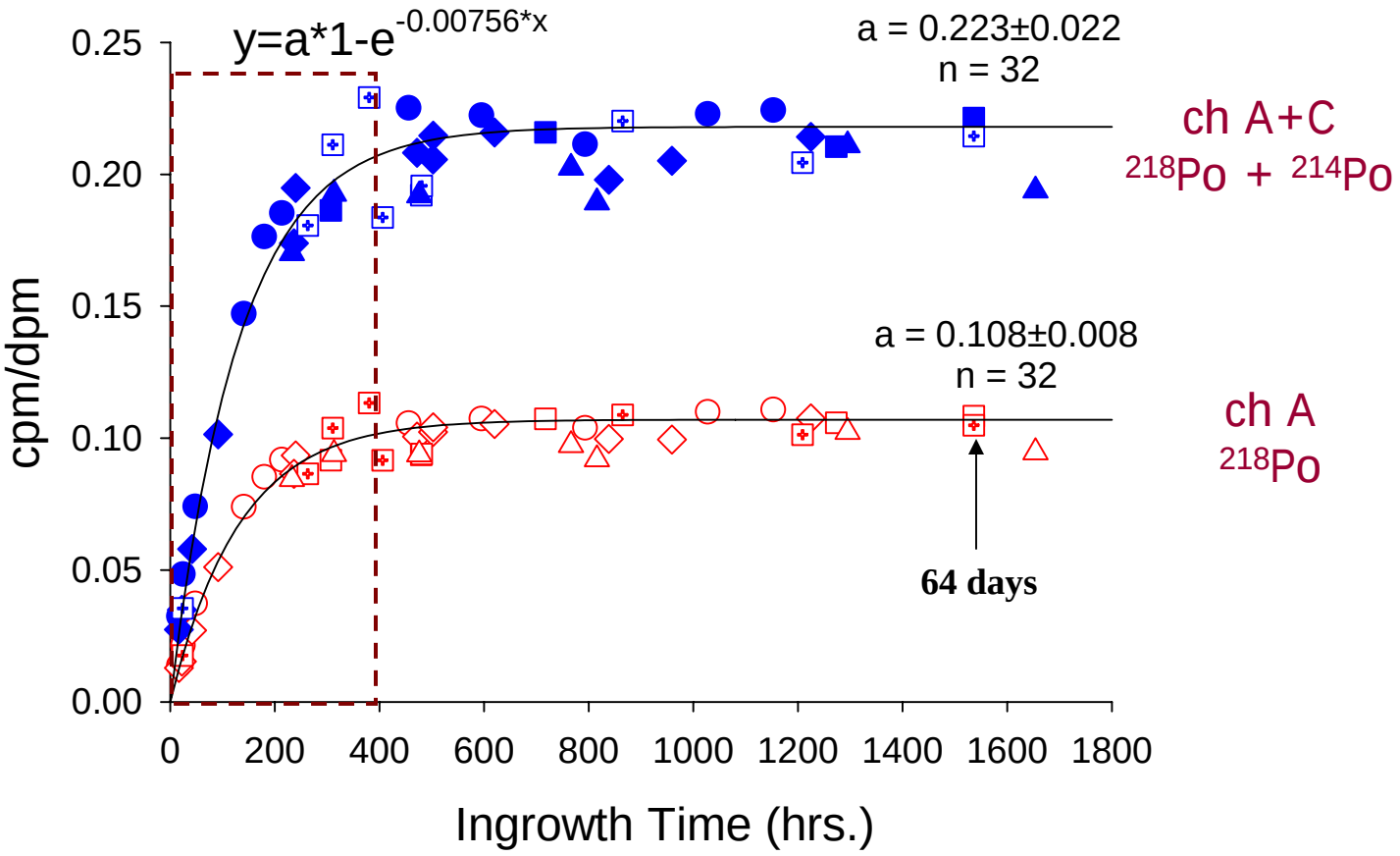
Suggested ^{226}Ra Protocol

1. Load sample on resin, close stopcocks, allow ~5 days ingrowth for Ra-226
2. Attach to RAD-7 manifold, purge RAD-7, pump air through cartridge/RAD-7 for 10 minutes, close valves
3. Count for a few 15-min cycles for quick analysis (Po-218) or several hours for more sensitive analysis (Po-218 + Po-214)
4. Calculate results:

$$^{226}Ra\,(pCi/L) = \frac{net\ cpm}{2.22 \bullet eff \bullet vol} \bullet \frac{1}{1-e^{-\lambda t_1}} \bullet \frac{\lambda t_2}{1-e^{-\lambda t_2}}$$

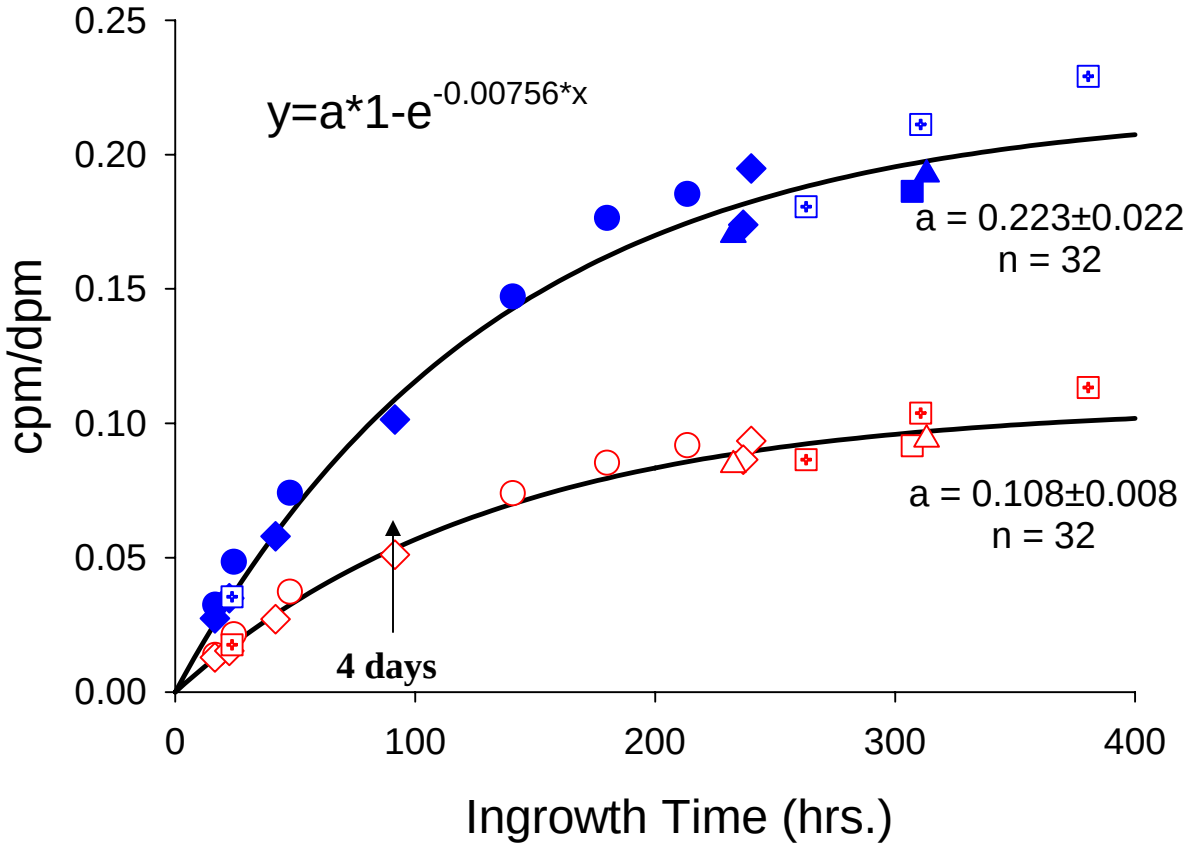
where: t_1 = ingrowth time; t_2 = count time

^{226}Ra Calibration 1



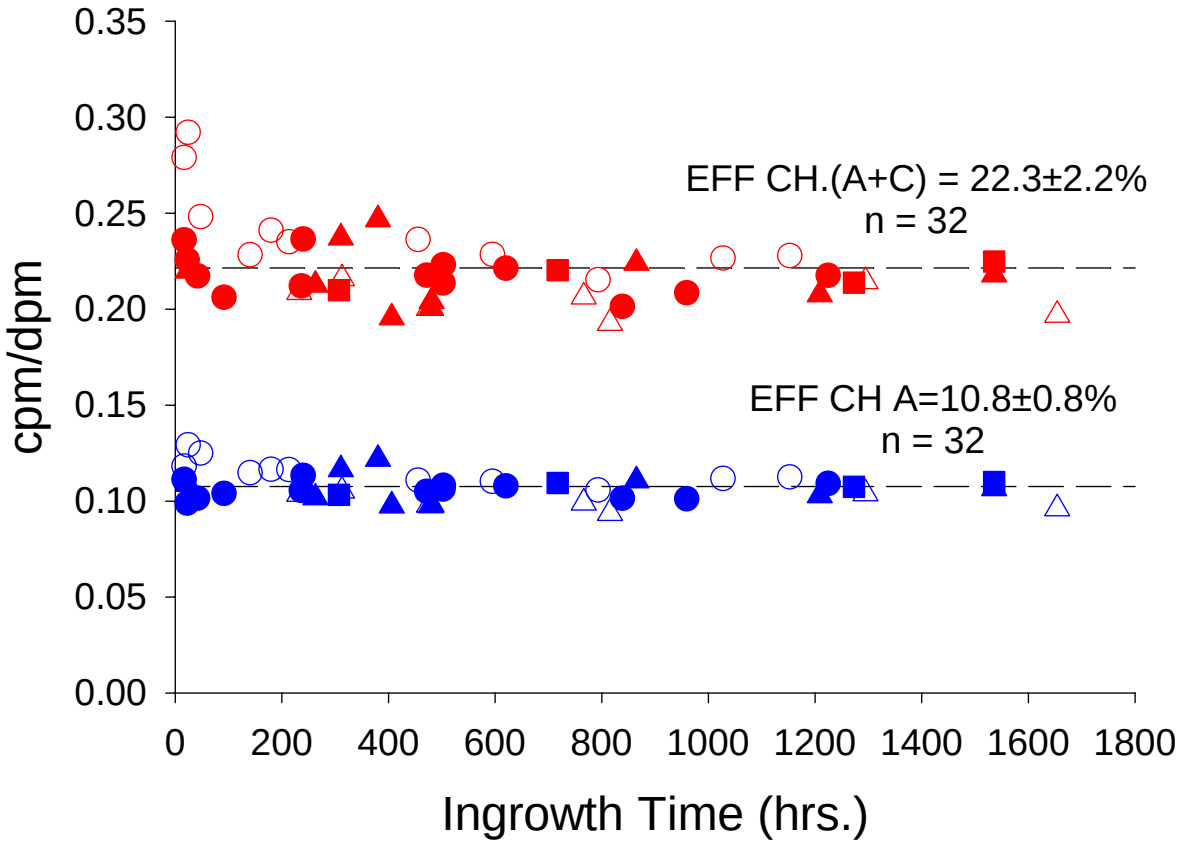
5 standards were prepared with NIST-traceable ^{226}Ra solution in different cartridges and with different ^{226}Ra activities. Rn ingrowth proceeded as predicted.

^{226}Ra Calibration 2



An ingrowth period of ~4-5 days is sufficient for determination of ^{226}Ra.

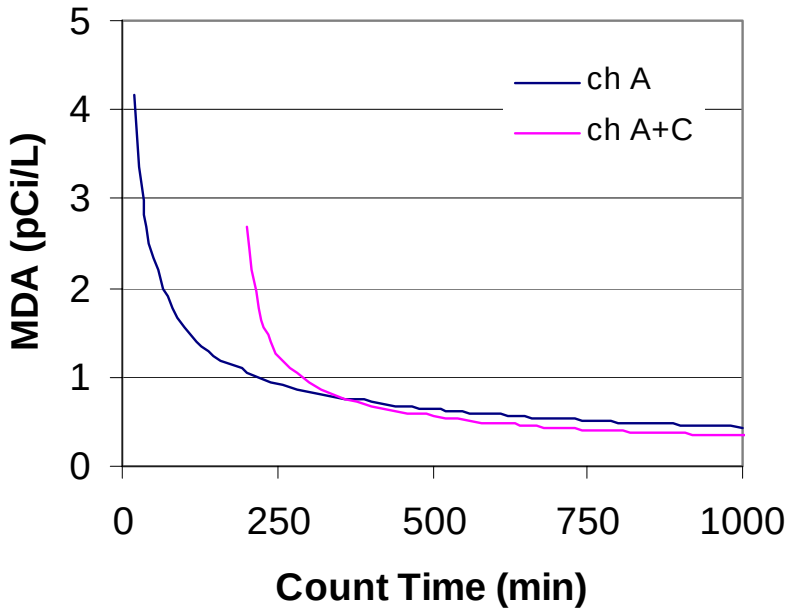
^{226}Ra Efficiencies



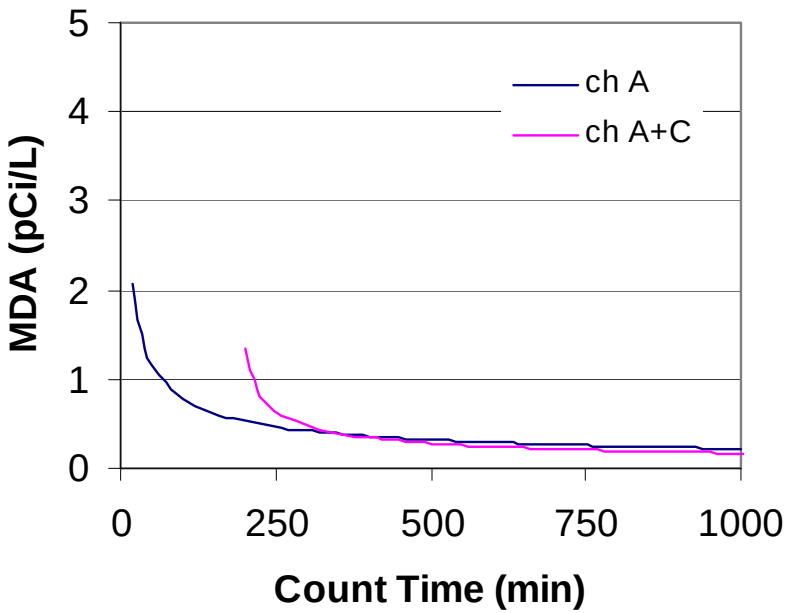
Consistent efficiency estimates over variable hold times imply that the glass cartridges are gas tight.

^{226}Ra MDAs: Auto Counting

1 liter

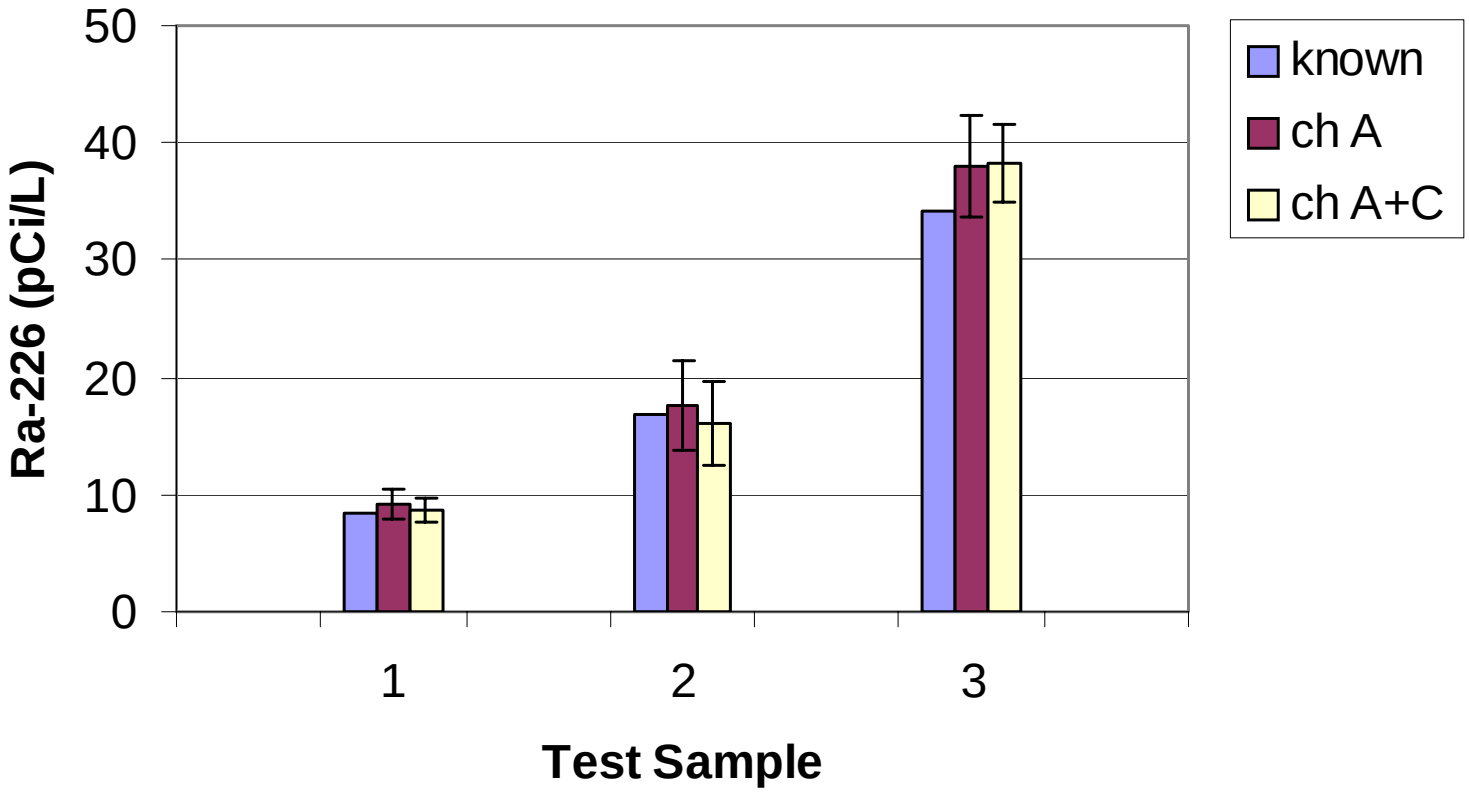


2 liters



MDAs calculated assuming 96% yield, typical blanks for A and C channels, and an equilibrium fraction of 0.5 (~4 days ingrowth)

Test Samples...



Using ch A+C, #1 and #2 are within 5% of the known activities; sample #3 ~12%.

Summary

- MnO_2 Resin is an excellent adsorber of Ra from natural waters
- May be used for preconcentration to combine with traditional techniques (e.g., α-spect, γ-spect)
- Interfacing with a RAD-7 Radon analyzer allows determination of ^{226}Ra (and ^{223}Ra, ^{224}Ra) without chemical separations
- FSU $\neq$ UF!