Phil Horwitz: A Career in Separation Science

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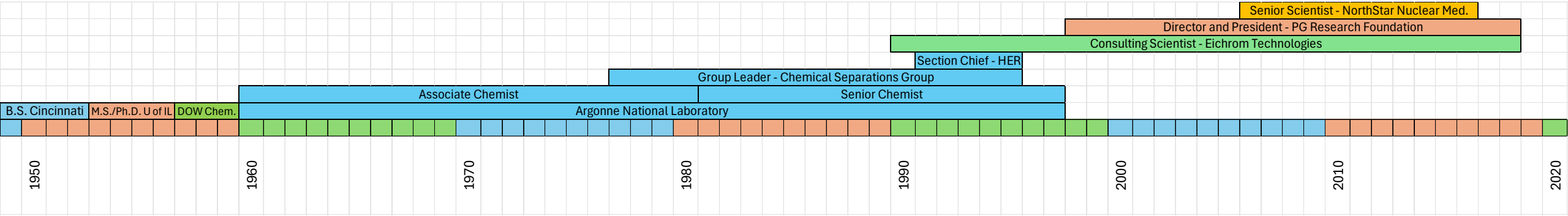
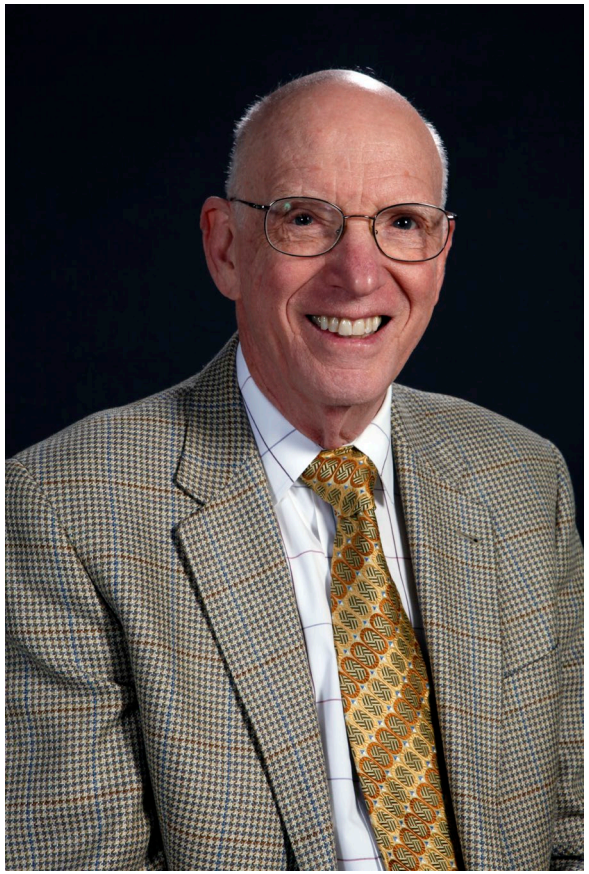
68th RRMC November 4, 2025 Idaho Falls, ID

eichrom® TECHNOLOGIES
A GCI COMPANY

RRMC
Radiobioassay & Radiochemical Measurements Conference





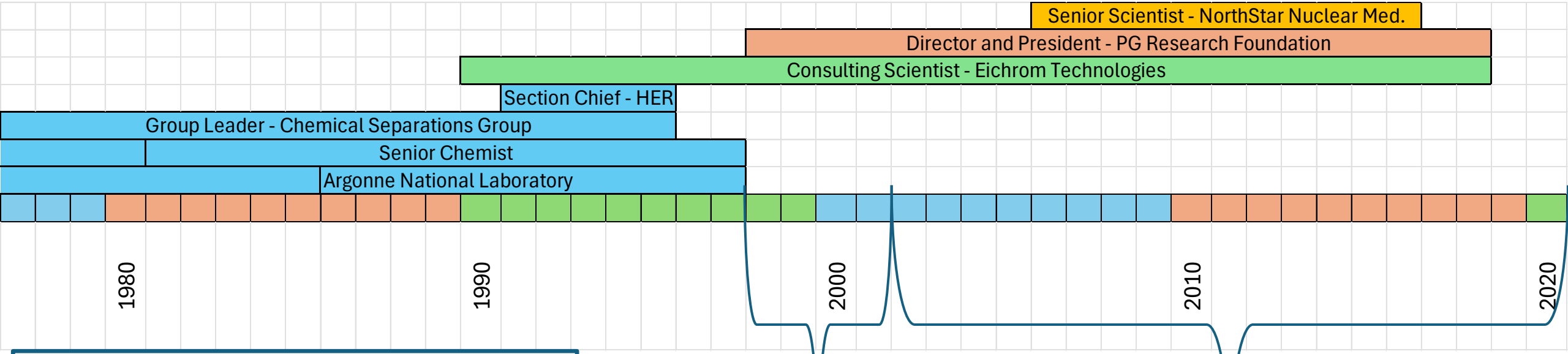
Born: June 3, 1930 Died: December 28, 2024

<u>Reviews of Phil Horwitz Research:</u>

D.R. McAlister, H. Kurosaki, S. Happel, E.P. Horwitz, "Development of EXC Resins for Metal Ion Separations," Bunseki, 2, 44-50, (2020).

(Contact speaker for English language version.)

E.R. Bertelsen, J.A. Jackson, J.C. Schafer, "A Survey of Extraction Chromatographic f-Element Separations Developed by E. P. Horwitz," Solv. Extr. Ion Exch., 38(3), 251-289, (2020).



Eichrom honors the passing of our **founder, mentor and friend**, Dr. E. Philip Horwitz.

Phil was an avid gardener, runner and nutrition enthusiast.

A self-proclaimed "simple separation scientist," he made out-sized contributions to the fields of solvent extraction, radioanalytical chemistry, isotope geochemistry, nuclear medicine, and radioisotope production.

Loyola – Chicago
Argonne Guest
Graduate

PG Research Foundation
Eichrom Technologies

Al Herlinger

Peter Zalupski

Dominique Stepinski

Mark Dietz
Ken Nash
Renato Chiarizia
Art Gelis

Mark Jensen
John Ferraro
Mark Antonio
Andy Bond

Herb Diamond
Paul Rickert
Marian Borkowski
Rich Barrans

PGRF Lab

Phil's CV

45 patents, >180 peer reviewed journal articles, hundreds of conference presentations

TRUEX Process (CMPO) - Minor Actinides from PUREX Raffinate)

SREX Process (DtBCH18C6) – Sr from acidic spent nuclear fuel waste

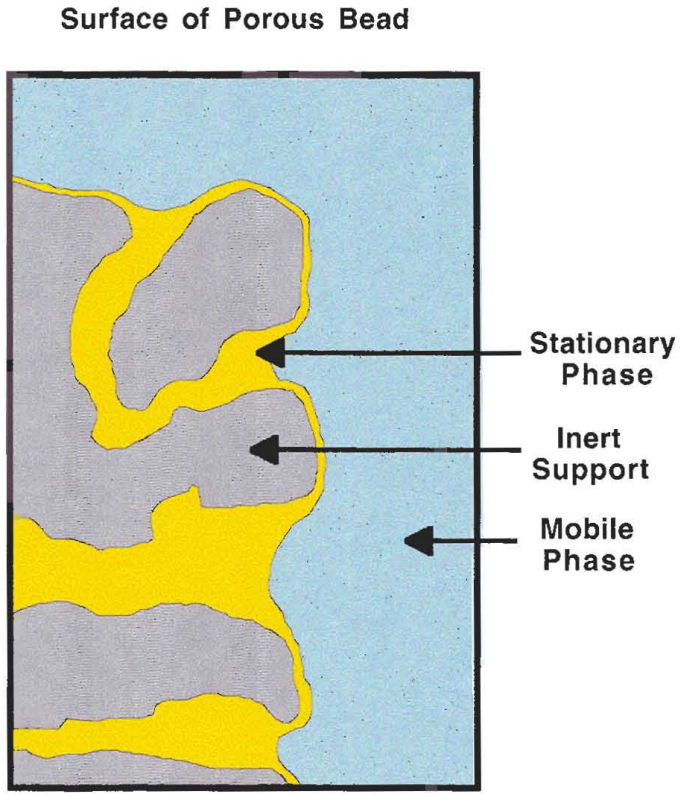
ABEC Resin (PEG-2000) – Tc from caustic spent nuclear fuel waste and Tc-99m from low specific activity Mo-99

4 R&D 100 awards (TRUEX, EXC Resins, Diphonix, ARSIIe)

Glenn T. Seaborg Actinide Separations Award – 1992
Becquerel Medal (RSC Radiochemistry Group) – 2004
Founders Award (Radiobioassay and Radiochemical Measurements Conference) – 2007
Glenn T. Seaborg Award for Nuclear Chemistry (ACS) - 2016

2016 ACS Symposium (Seaborg Award)

Depiction of Extraction Chromatography (EXC)



Relationship Between SX and EXC

$$k' = D \bullet \frac{v_s}{v_m}$$

k' = retention volume (FCV to peak maximum)
D = distribution ratio
v_s = volume of stationary phase
v_m = volume of mobile phase

Lipophilic (Hydrophobic) Extractants Physically Sorbed in the pores of an inert support.

Combines selectivity of solvent extraction with the ease of operation of chromatography

Not covalently bound

Limited to aqueous mobile phases

Phil's Mantras

1) Chance favors the prepared mind
    - Better to be lucky than good
    - Borrowed from Louis Pasteur
    - Develop and maintain a toolbox of skills/methods

2) Always extractant the minor component
(unless you can't, then use solvent extraction).

3) What goes in must come out
(the solvent extraction graveyard is full of compounds with very high D, k', Dw, Dv……)

4) Always plot elution curves on a semi-log scale

Phil's Mantras (cont'd)

Work safely

- No evaporations
- Smaller columns/less waste
- Faster chemistry without compromising quality

Learn Together (Collaborate)

- National labs
- Universities
- Industry

Train and learn from the next generation of scientists

Phil’s Lunchtime Discussions

Any topic, often not politically correct

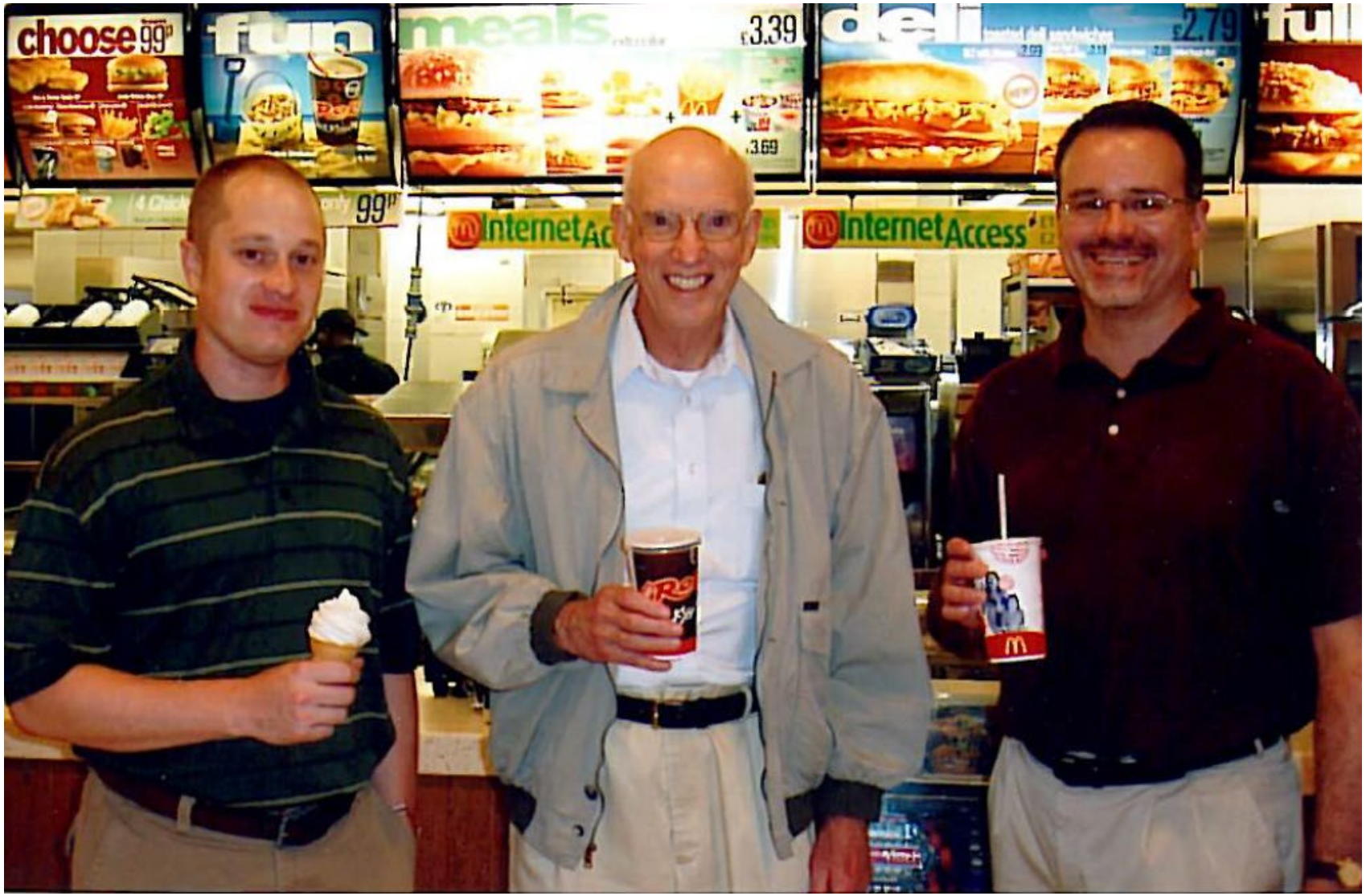
“I don’t know” is not an acceptable answer

If you sit at Phil’s table (or any adjacent table touching Phil’s table), you must participate

Phil’s lunch did not look delicious

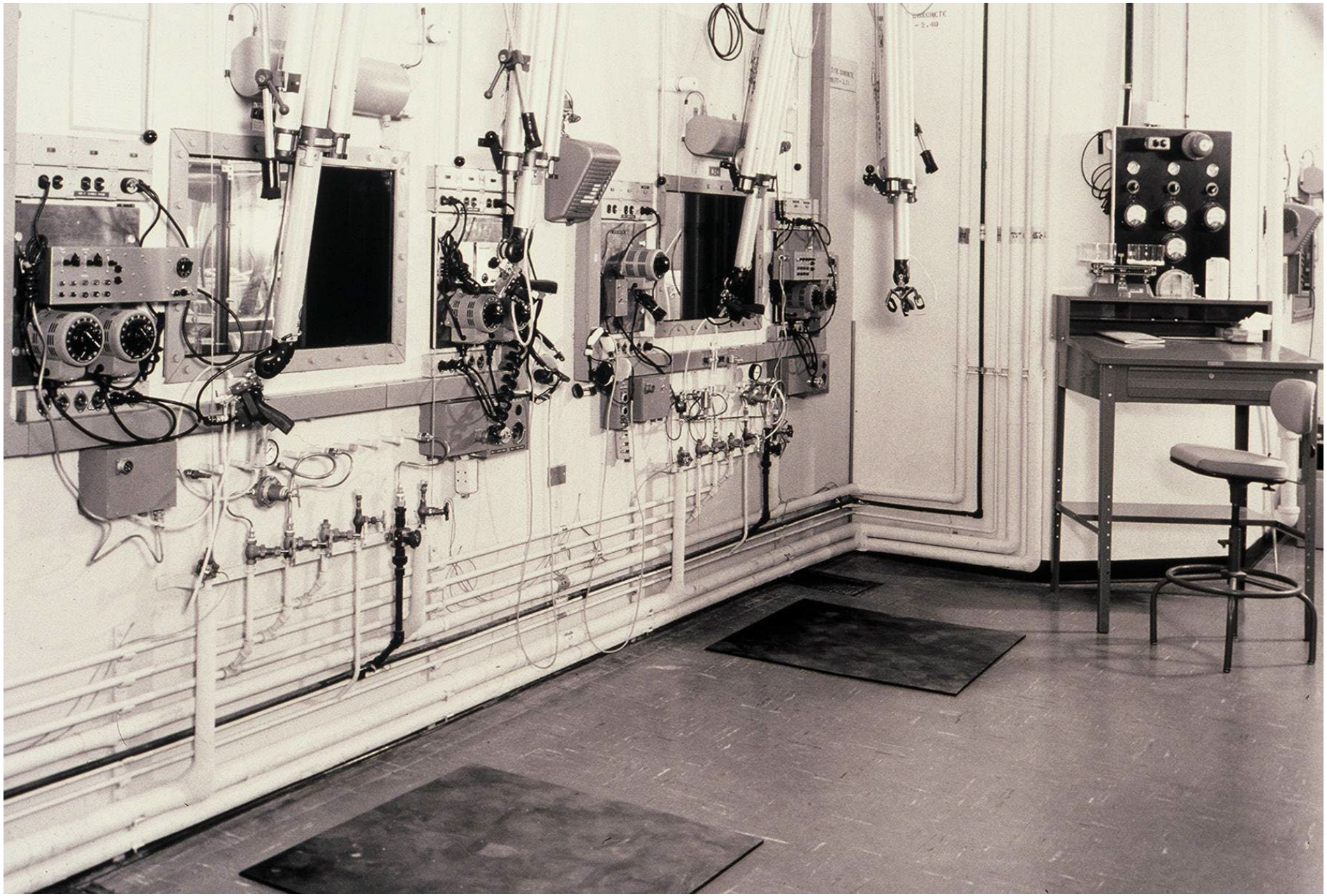
-proprietary nona-veggie mix
-low sodium very veggie juice
-juice plus vitamins

Phil didn’t like to travel, but…



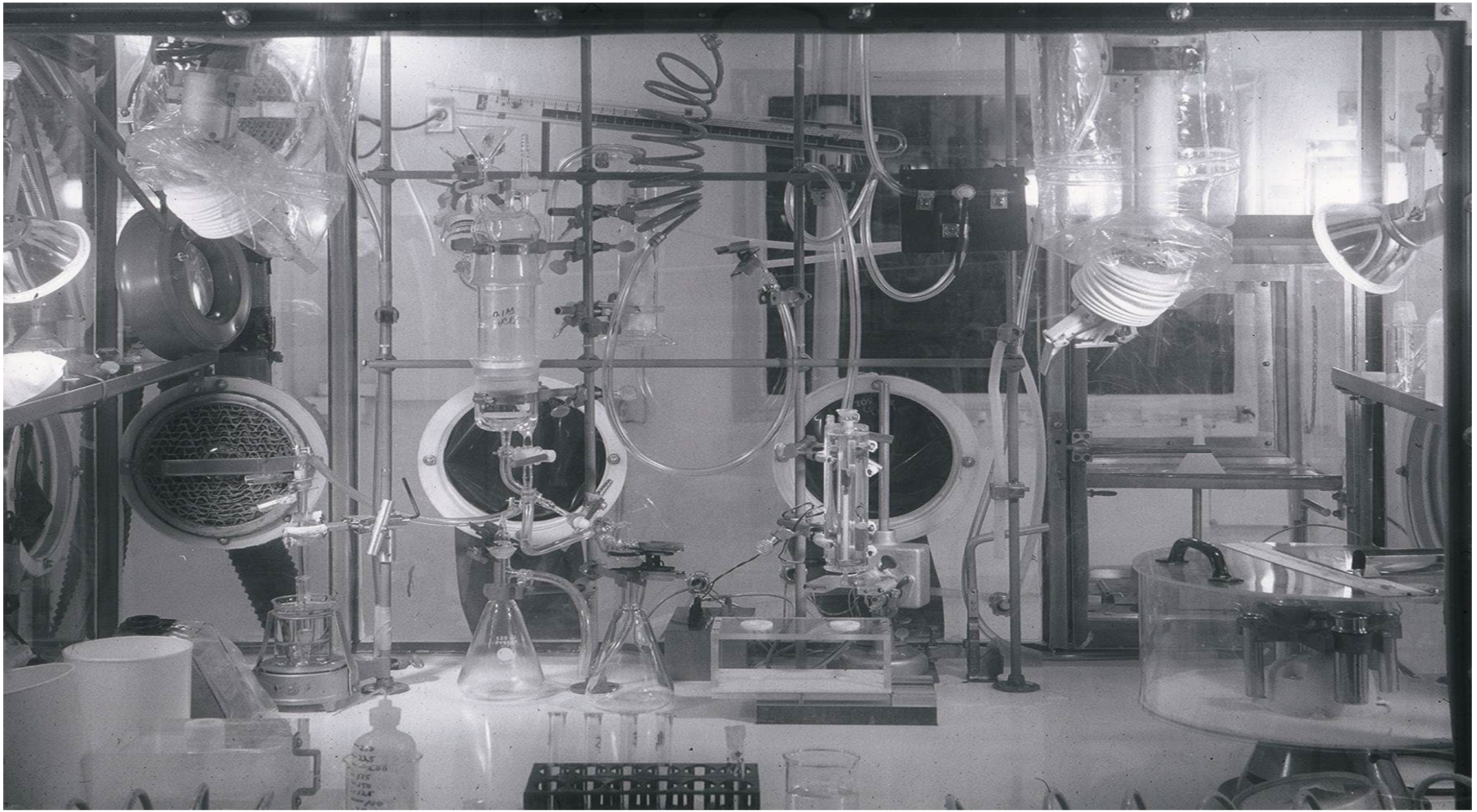
Dan, Phil, and Mike (Oxford McDonalds, 2006)

Argonne Hot Cells (M-Wing)

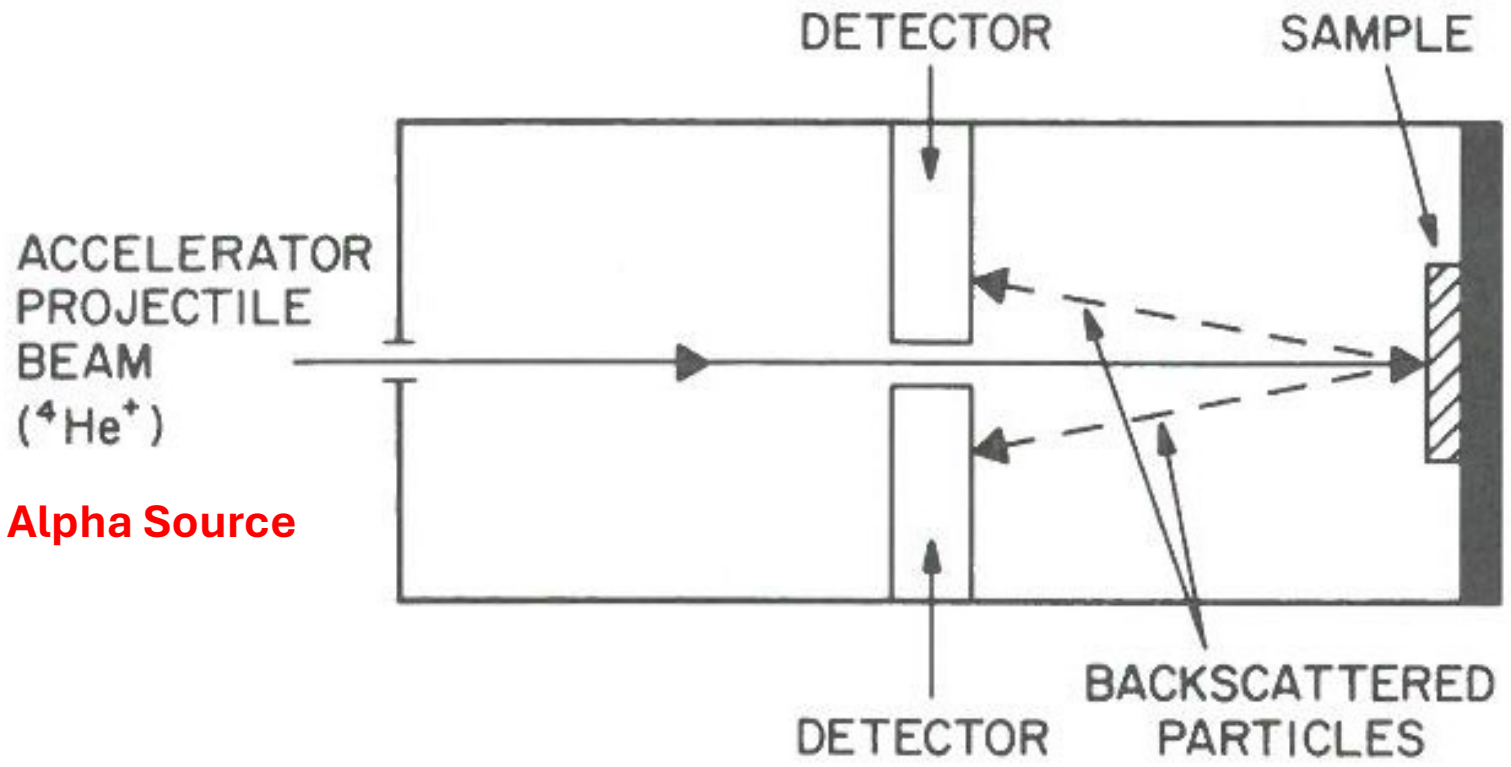


Argonne Hot Cells (M-Wing)

Argonne Hot Cells (M-Wing)



^{242}Cm alpha sources for Lunar Exploration



Rutherford Alpha Backscatter

Energy of scattered particle = element

Intensity of each peak = relative amount

^{242}Cm alpha sources for Lunar Exploration

Alpha Scattering Experiment of the NASA Surveyor Lunar Program

Required: point source of α particles of high intensity and quality

Criteria for selection of alpha-active isotope

- Half-life < 1 year to have weightless source
- Half-life > 2 months to minimize decay before measurements were completed
- Alpha particles have to be monoenergetic and > 5.8 MeV
- Isotope has to be available in curie quantities free of isotopic interferences
- Chemical properties has to allow separation from all impurities

Preparation of $^{242}_{96}$Cm ($t_{1/2}$ = 162.5 days)

Neutron capture of ^{241}Am

150-250-mg samples ^{241}Am encapsulated in high-purity aluminum

$$^{241}_{95}\text{Am}\ (n,\gamma)\ ^{242}_{95}\text{Am} \xrightarrow{84\%} {}^{242}_{96}\text{Cm} + \beta$$

$$^{242}_{95}\text{Am} \xrightarrow{16\%\ \text{E.C.}} {}^{242}_{94}\text{Pu}$$

Dates of ^{242}Cm Production Runs

November 7-15, 1963
November 11-30, 1964
September 8-27, 1966
November 13-27, 1967

E.P. Horwitz, C.A.A Bloomquist, H.W. Harvey, D. Cohen, L.J. Basile, “Purification of 10 Curies of 242Cm,” Argonne National Laboratory Report ANL-6998, February (1965).

Dissolved in nitric acid

Evaporated

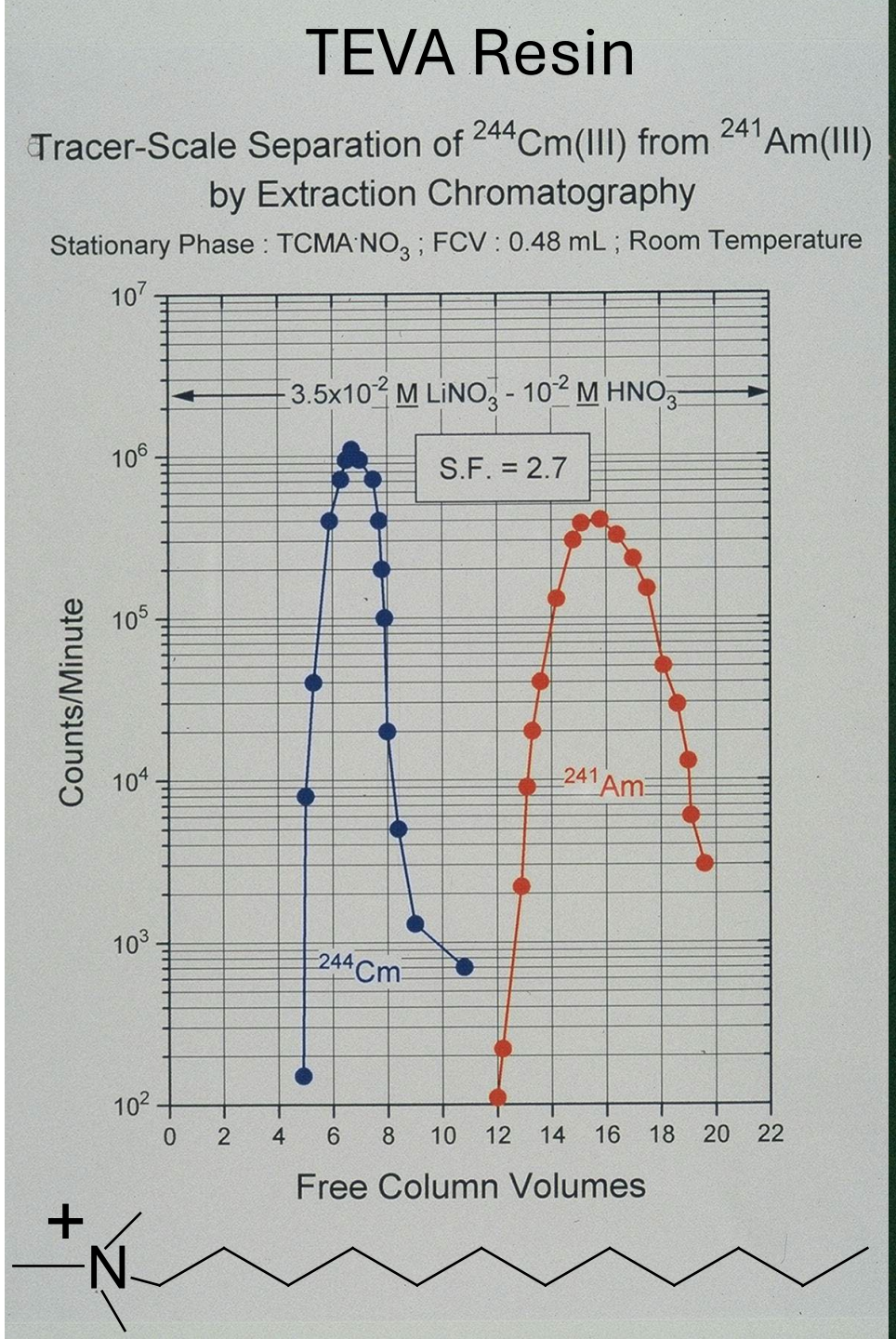
Dissolved in $LiNO_3$ for Am/Cm extraction by liquid anion exchanger **(remove Al-cladding)**

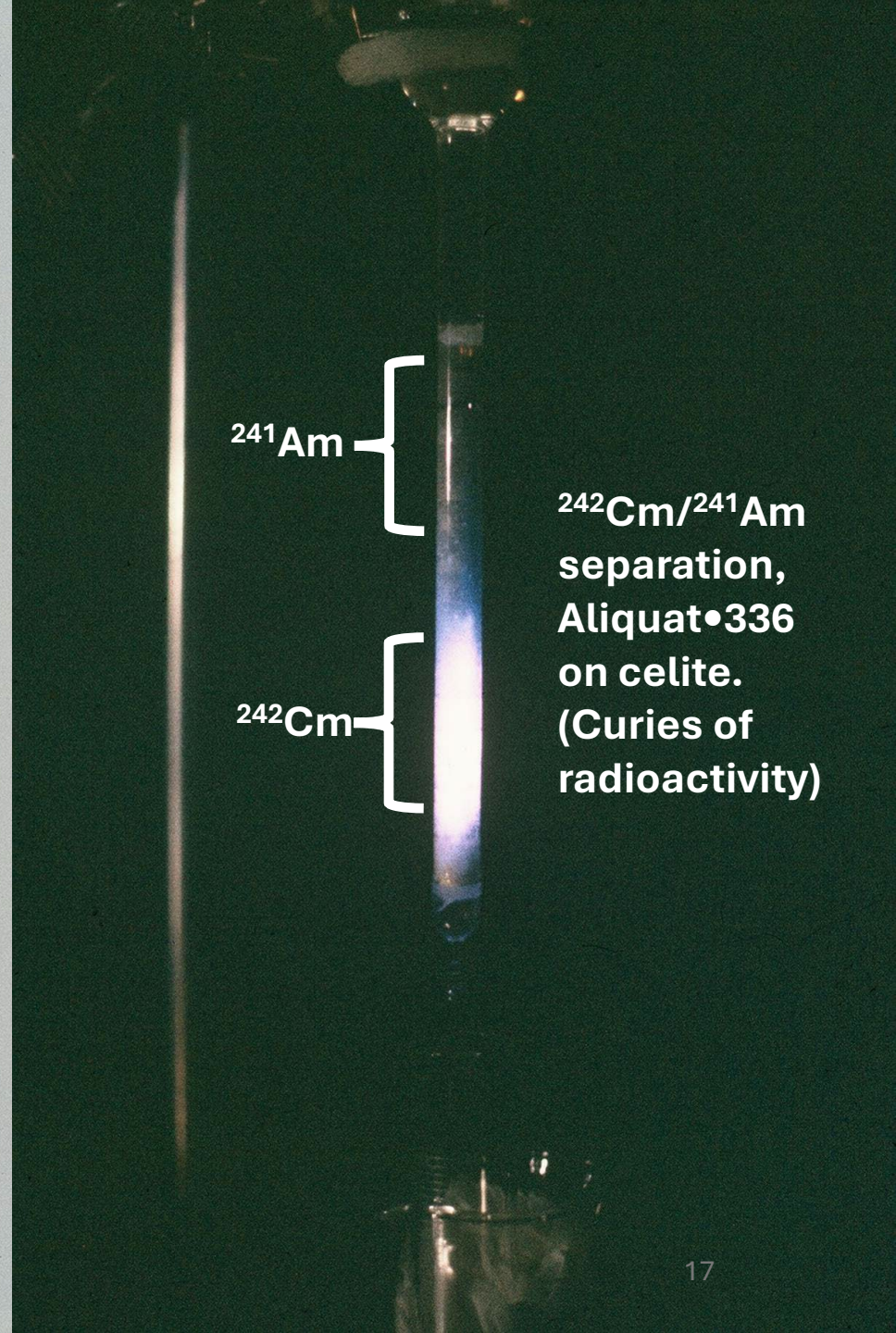
Am/Cm recovered in 3M HCl.

Am(V) precipitated as $KAmO_2CO_3$. Cm(III) remains soluble. **(Main Am removal step).**

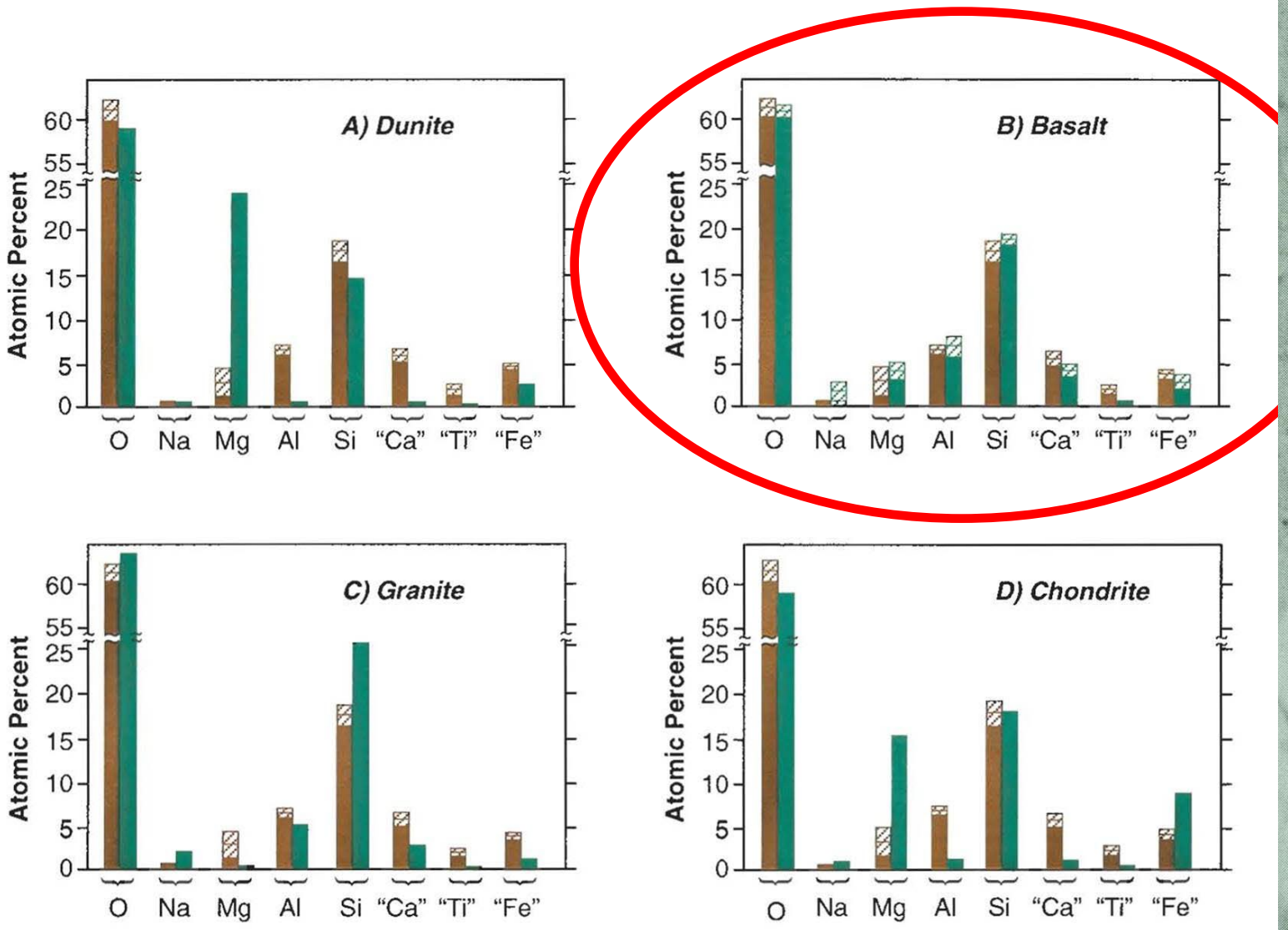
Final Cm purification by EXC with liquid anion exchanger. **(TEVA). Removes final traces of Am-241.**

TEVA Resin

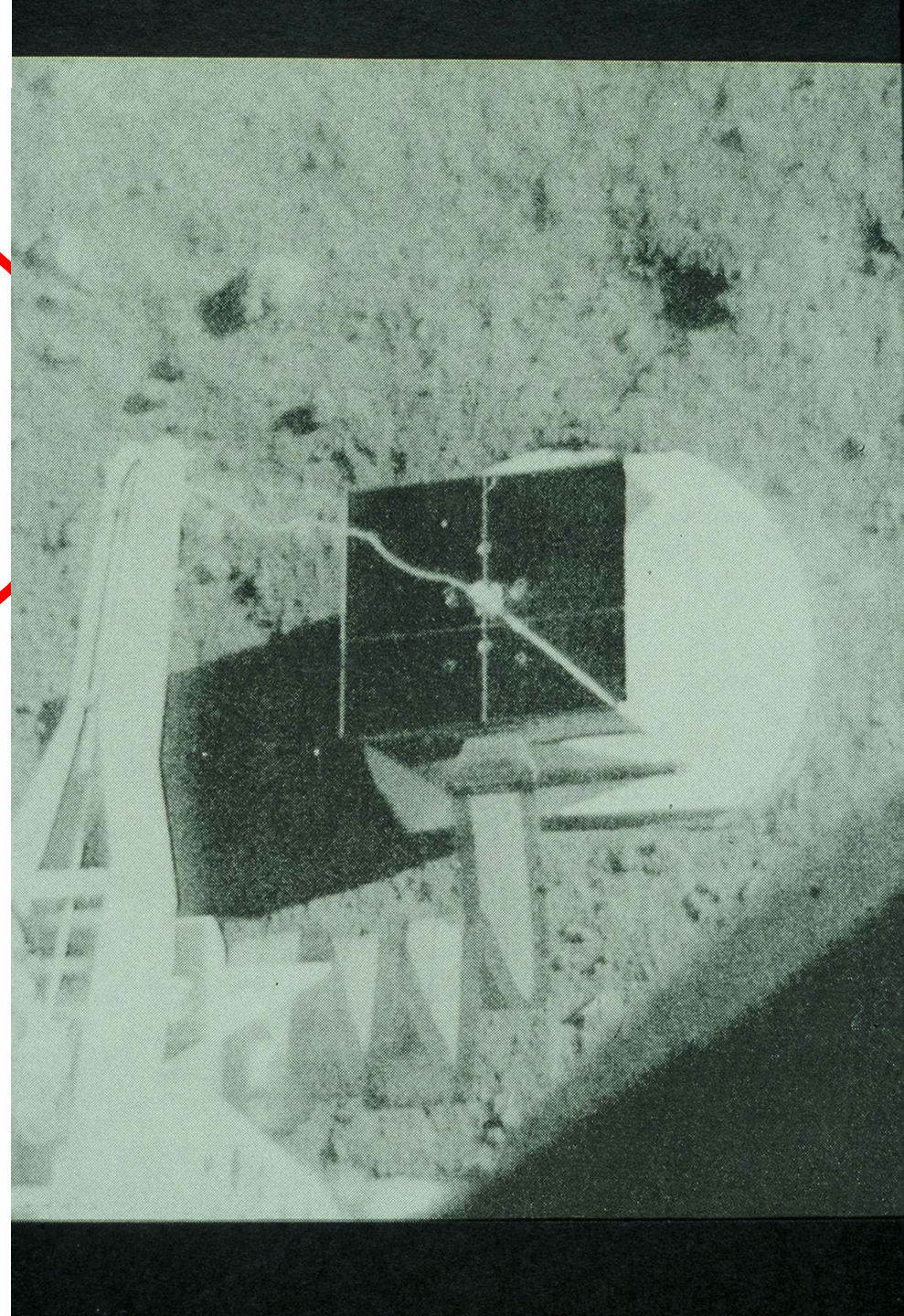




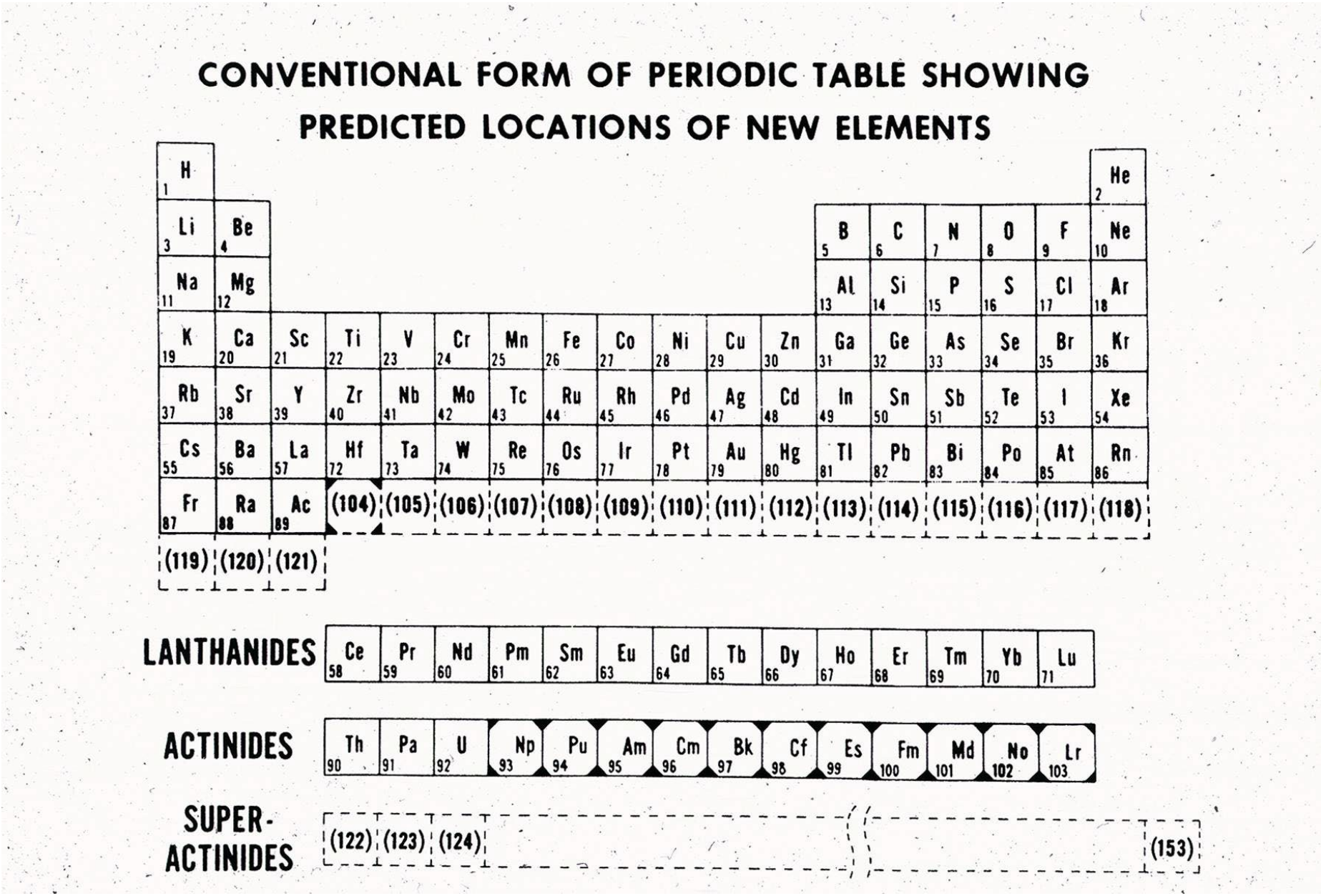
Comparison of Lunar Surface to Known Minerals



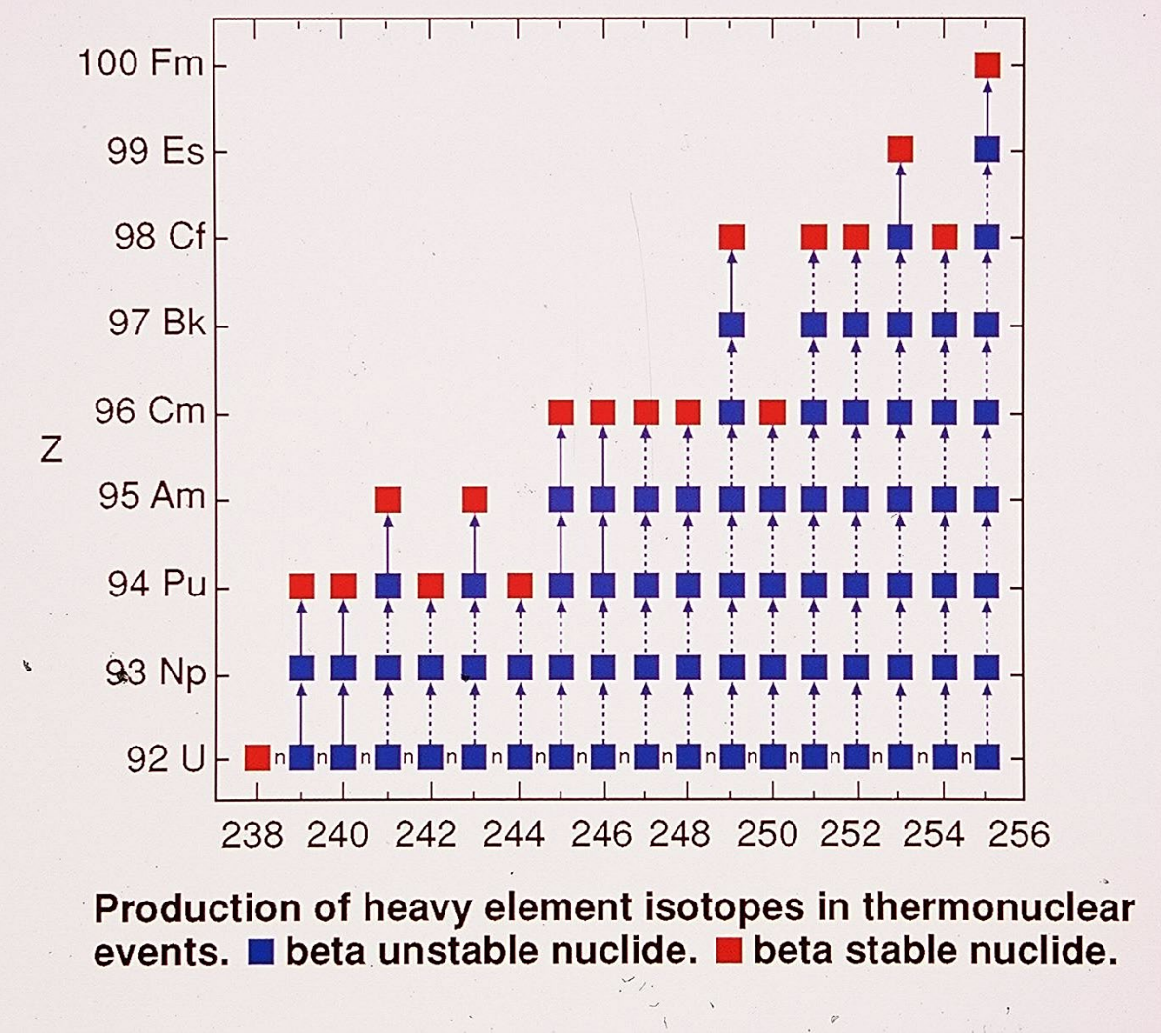
Comparison of the Observed Chemical Composition of the Lunar Sample (Brown Bars) with the Average Composition of Selected Materials (Green Bars)



Search for new elements (1969-1971)



Search for new elements



Production of heavy element isotopes in thermonuclear events. ■ beta unstable nuclide. ■ beta stable nuclide.

Secondary reactions induced by GeV protons

$$^{238}_{92}\mathrm{U}\ (\text{beam stop}) + {}^{1}_{1}\mathrm{H} \xrightarrow{12\ \mathrm{GeV}} \text{Spallation Products}$$

$$\text{Spallation Products} + {}^{238}_{92}\mathrm{U} \longrightarrow {}^{290}_{110} \qquad {}^{298}_{114}$$

Search for new elements

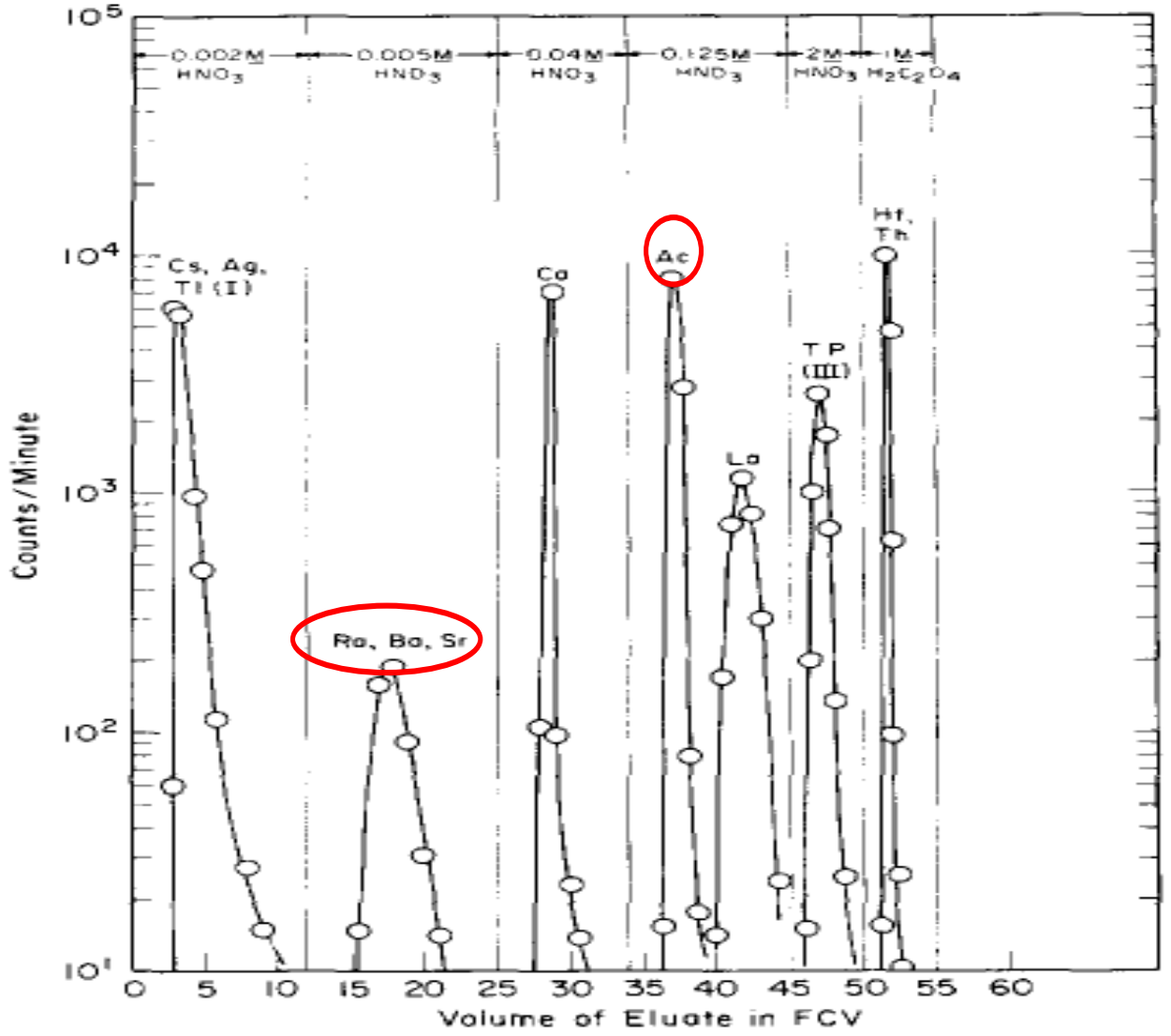
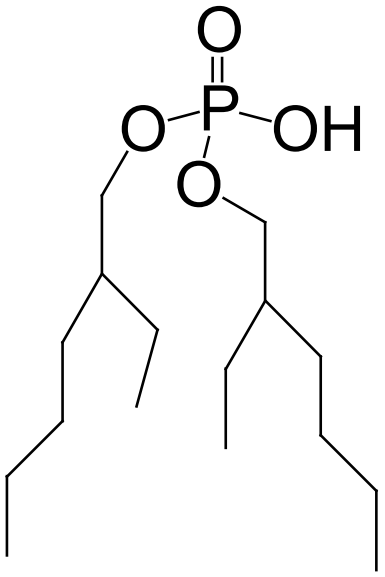
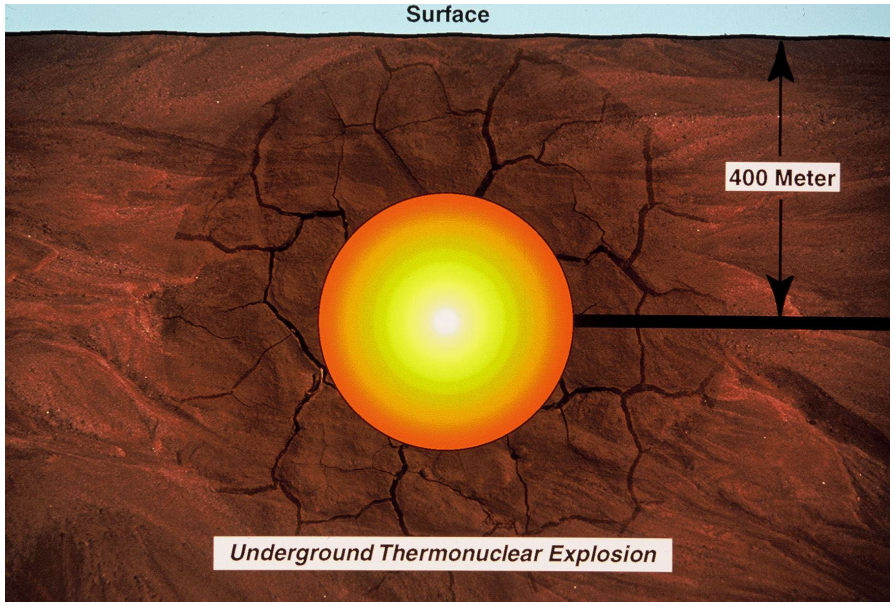


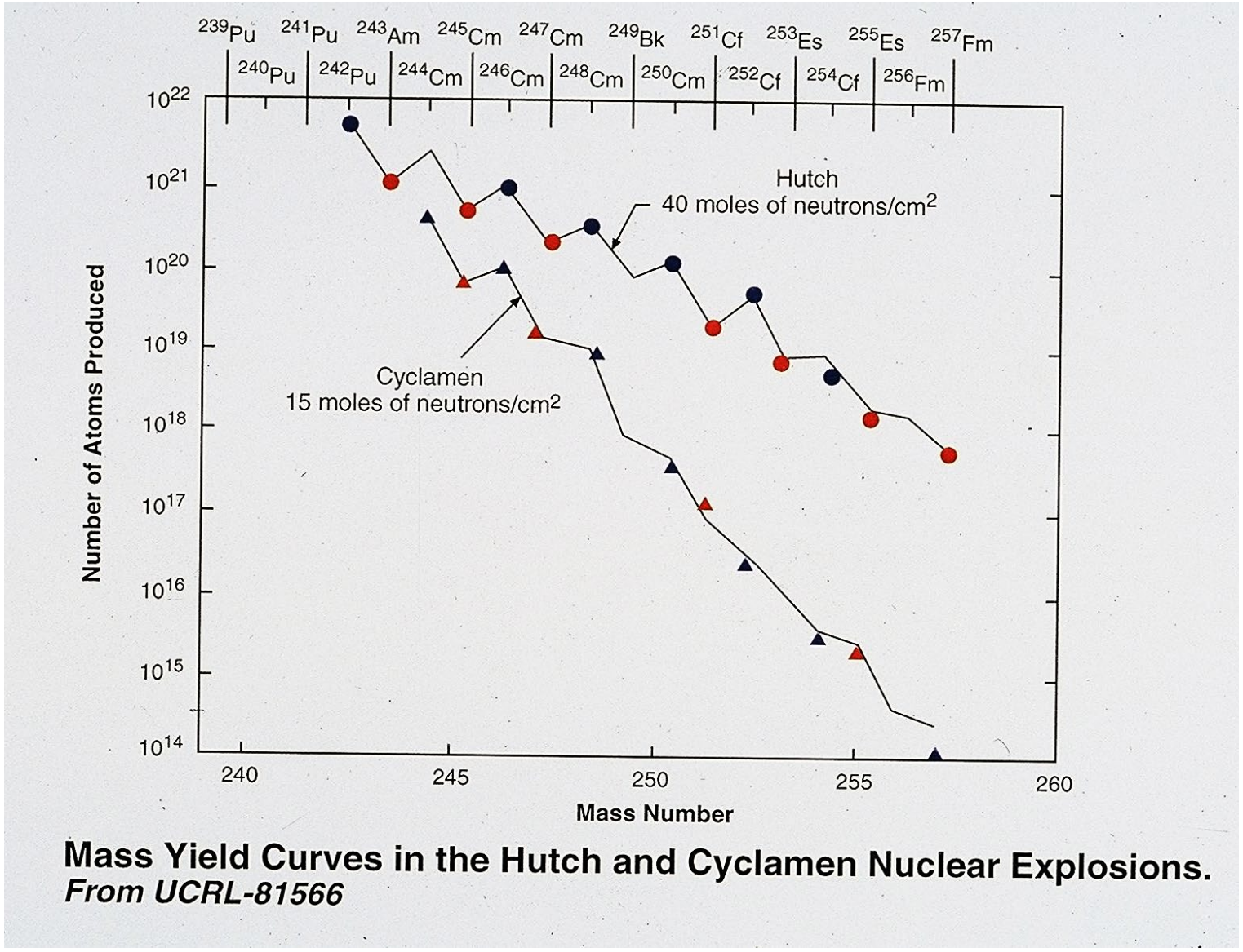
Fig. 9. Sequential separation of group *C* elements using 8·82 *w/o* HDEHP on Celite (35 μ). Column bed size 0·062 $cm^2 \times 5$ cm; 50°C; $v = \sim 5$ cm/min; FCV = 0·22 ml.



LN Resin

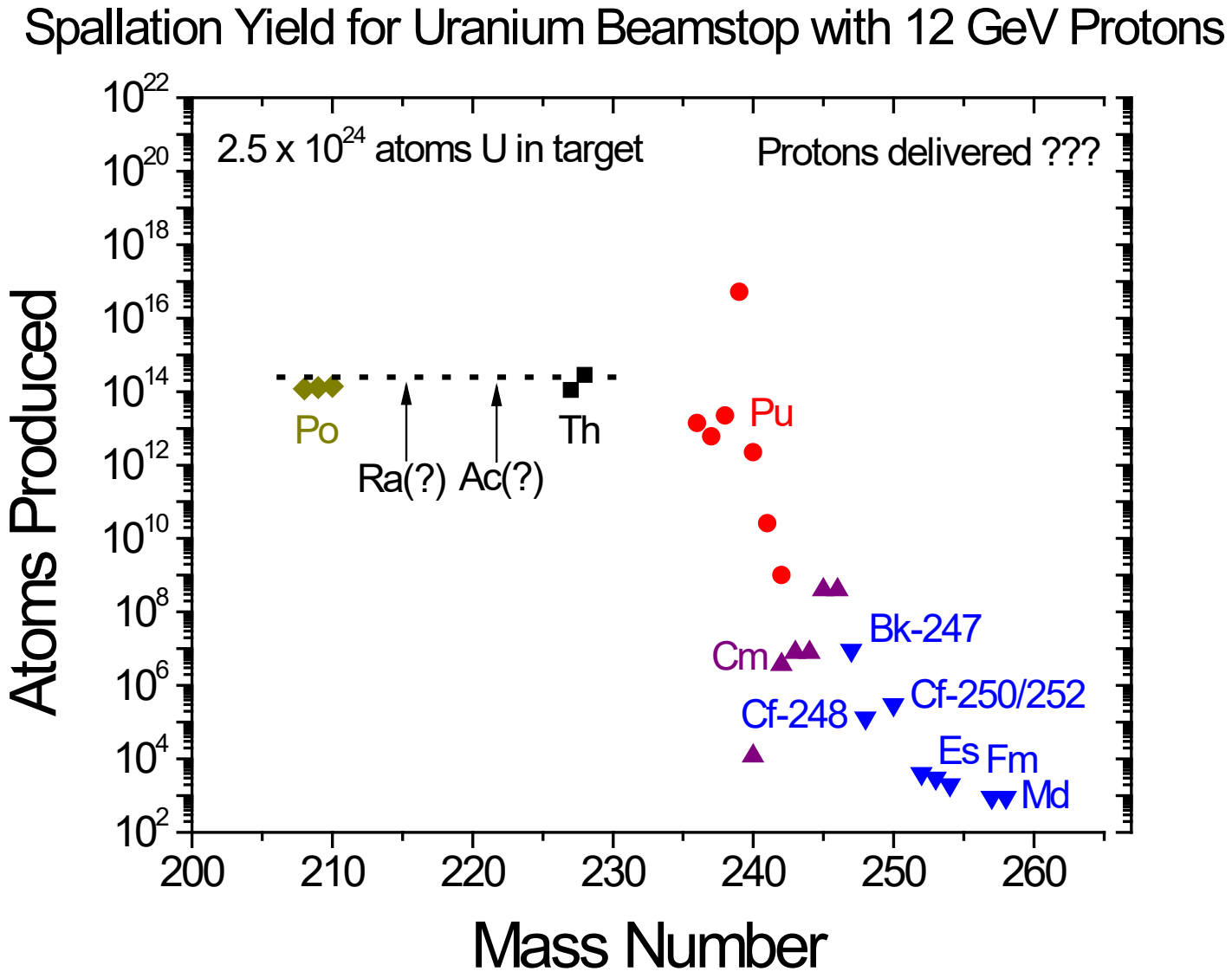
Search for new elements





Mass Yield Curves in the Hutch and Cyclamen Nuclear Explosions.
From UCRL-81566

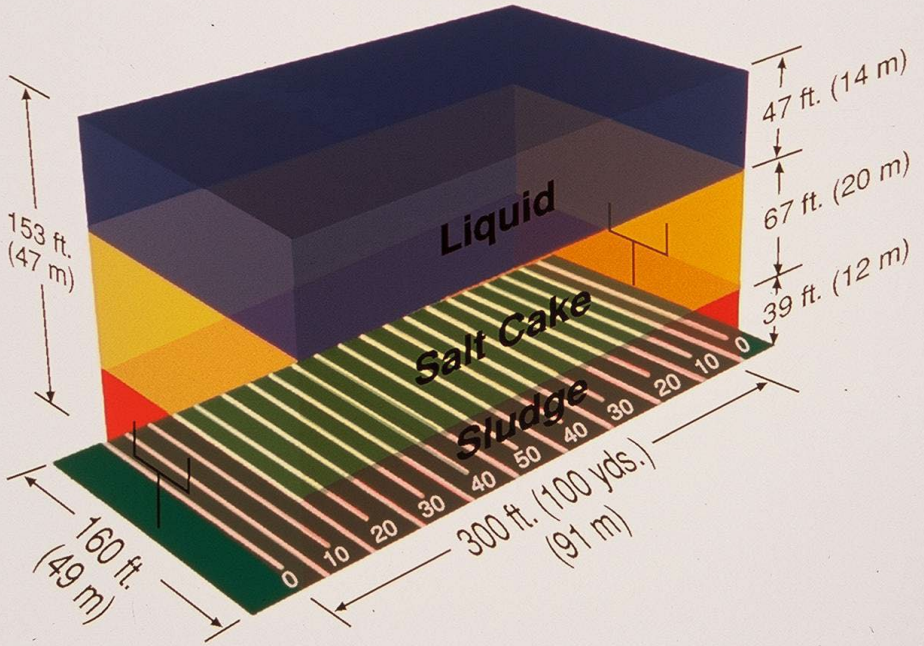
Search for new elements



J.P. Unik, E.P. Horwtiz, K.L. Wolf, I. Ahmad, S. Fried, D. Cohen, P.R. Fields, C.A.A. Bloomquist, D.J. Henderson, "Production of Actinides and the Search for Super-Heavy Elements Using Secondary Reactions Induced by GeV Protons," *Nuclear Physics*, A191, 233-244 (1972).

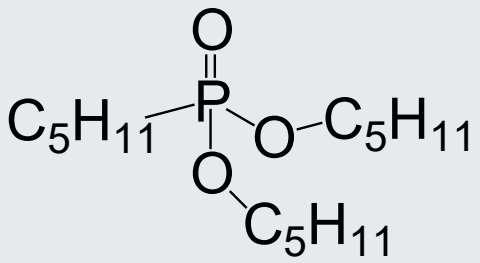
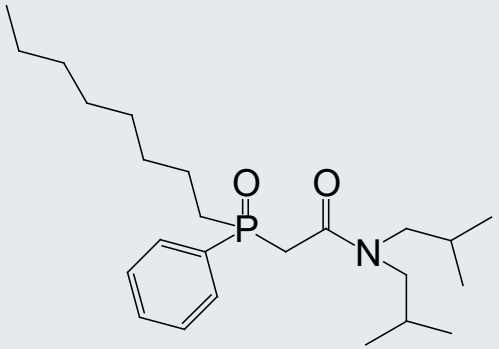
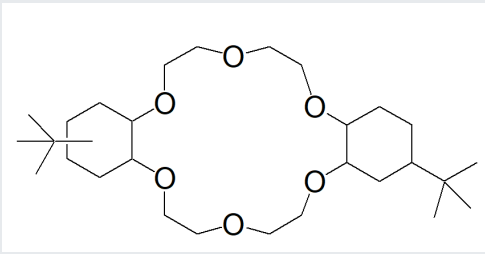
Waste tank cleanup

The 55 million gallons (208 x 10^3 cubic meters) of radioactive waste in Hanford's underground storage tanks would fill a football field to a height of about 150 feet.

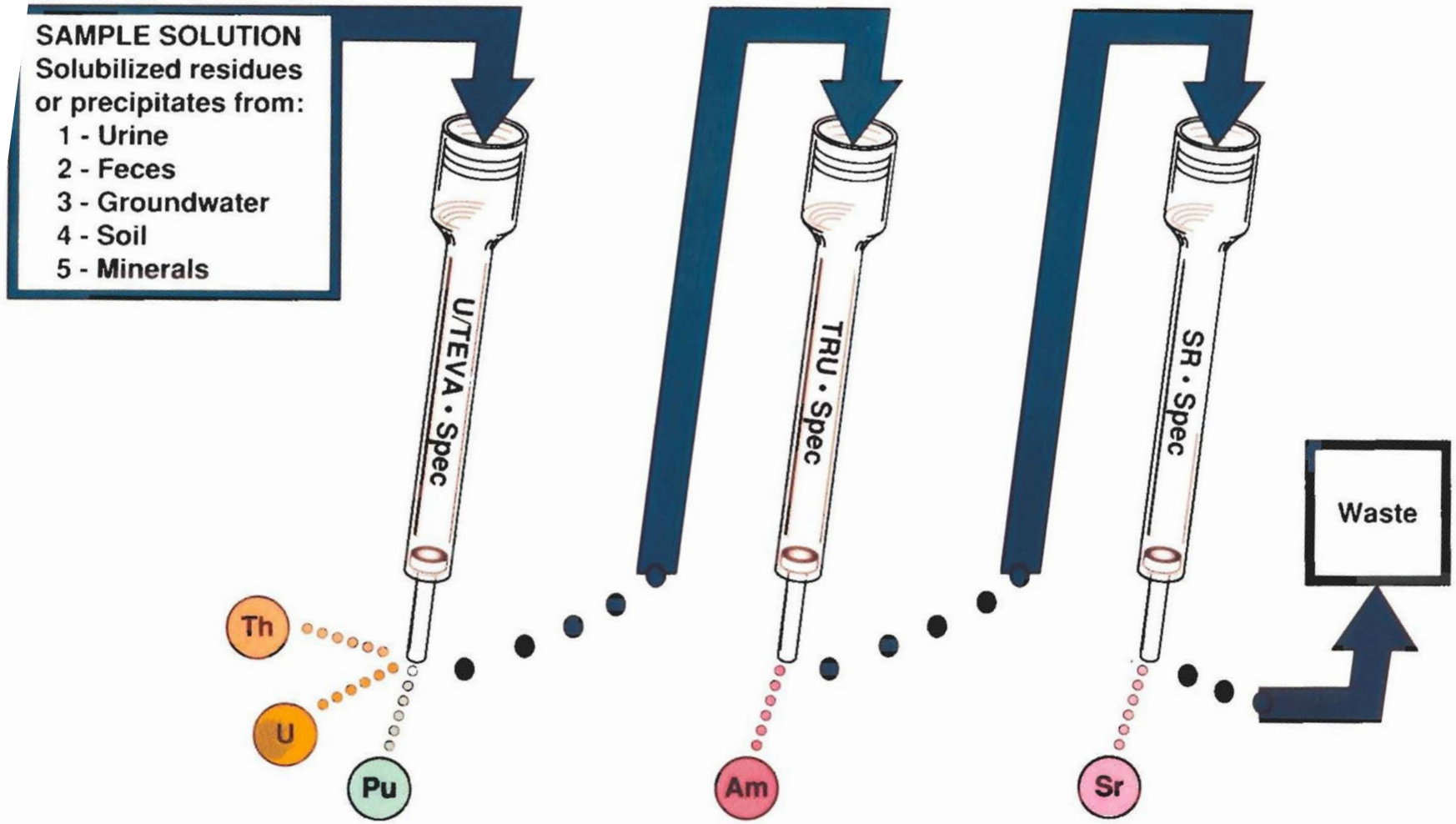


From PNL-10773

Waste tank cleanup

Process	PUREX	TRUEX	SrEx
Target	U/Pu	Am/Cm/minor actinides	Sr(Pb)
Extractant	 TBP (DA[AP])	 CMPO/TBP	 D*t*BCH18C6
Resin	UTEVA	TRU(RE)	Sr Resin (Pb Resin)

Multi-Radionuclide Separation using Tandem Spec Column Arrangement



Phil's Legacy (Eichrom Current R&D Team)

Daniel McAlister, Ph.D. - Group Leader
23 years at Eichrom/PGRF
Loyola University Chicago
Guest Graduate Argonne National Laboratory
Separation Science, Radiation Protection, Analytical Chemistry

Eddie Rush, B.S. - Scientist
17 years at Eichrom
University of Illinois at Chicago
Organic Synthesis, Radiochemistry

Madeleine Eddy, Ph.D. - Scientist
3 years at Eichrom
Colorado School of Mines
Radiochemistry, Solvent Extraction, Actinide-Lanthanide Separations

Phil's Legacy (Eichrom Resources)

Radioactive Materials Laboratory

Broad Scope License, any radionuclide of elements 1(H) – 103(Lr), **no Rf, Db, Sg…** ☹

Permitted mCi amounts of Ac-225, Ac-227, Pb-203, Th-228, 1Ci F-18.

Alpha spectrometry, HPGe gamma, LSC, Na(Tl)I gamma, MP-AES, ~~**ICP-MS**~~

~~**Cyclotron**~~

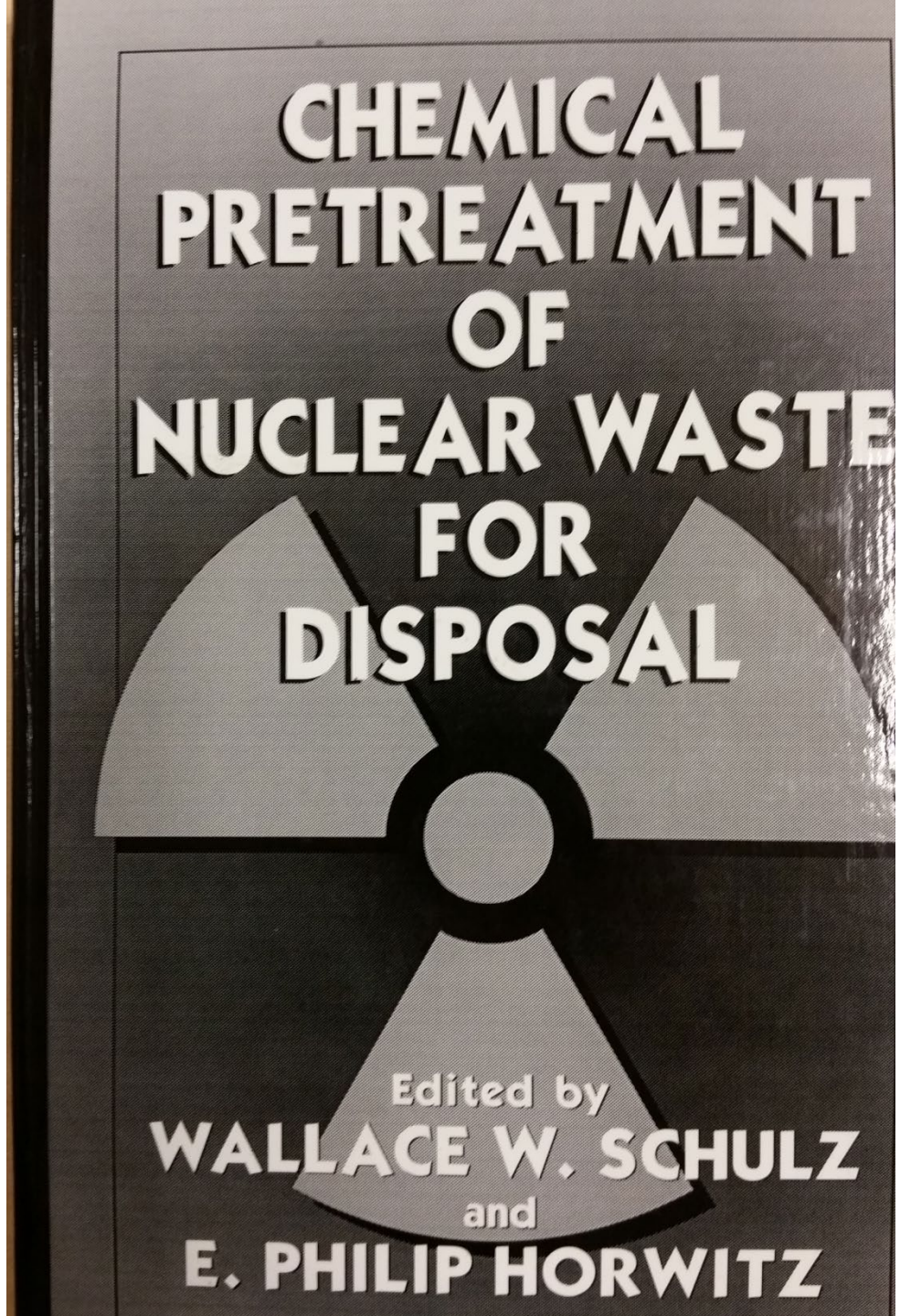
~~**Nuclear Reactor**~~

Phil’s Legacy (Eichrom Library)

To Dan

Best of good fortune to a fine Chemist and person

Phil Horwitz

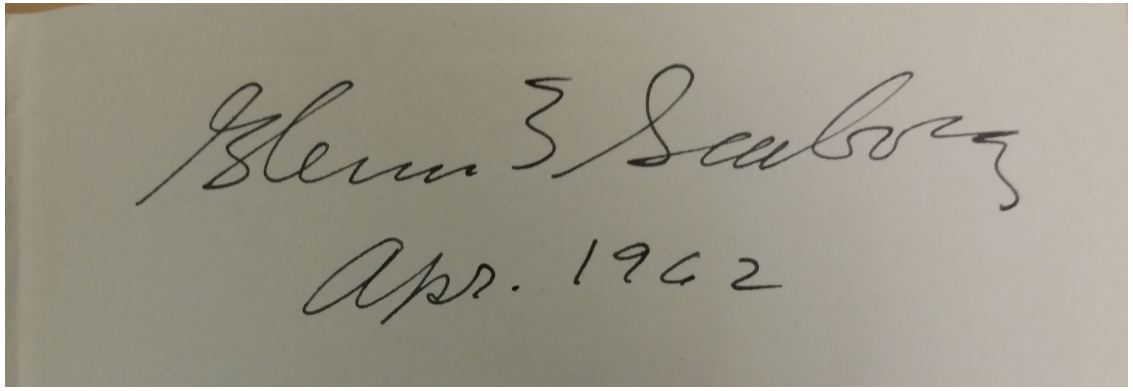


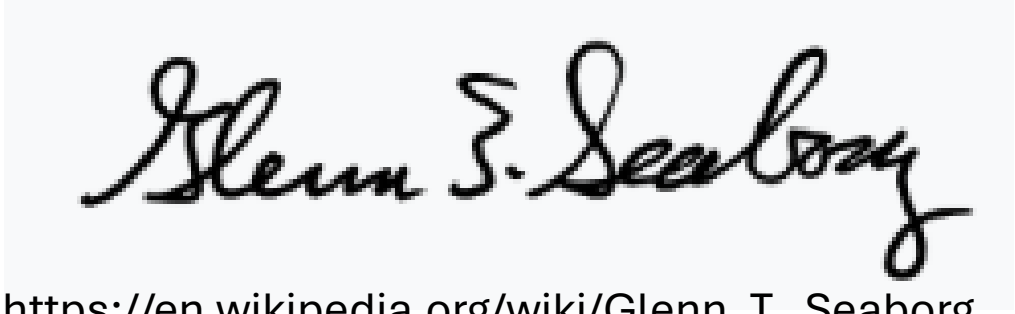
ADVENTURES IN RADIOISOTOPE RESEARCH

The Collected Papers of
GEORGE HEVESY
in Two Volumes

VOLUME TWO

PERGAMON PRESS
OXFORD · NEW YORK · LONDON · PARIS
1962





https://en.wikipedia.org/wiki/Glenn_T._Seaborg

Phil’s Legacy (Memorial Messages)

Phil was amazing both professionally and personally - had an opportunity to travel with him and found he always took the stairs when possible, grew his own vegetables and would often pass on the high end restaurants for simpler meals. He once talked me into McDonalds 😉 as we were on the way to meet a larger group for dinner, that meal was quite an honor.

Phil’s Legacy (Memorial Messages)

Though I never had the privilege of knowing Dr. Horwitz personally, his work has profoundly influenced my journey in the field of radiochemical separations. I began my studies by delving into his groundbreaking papers on extraction chromatographic separations, which laid the foundation for so many of us in the field. His legacy will continue to inspire generations of researchers.

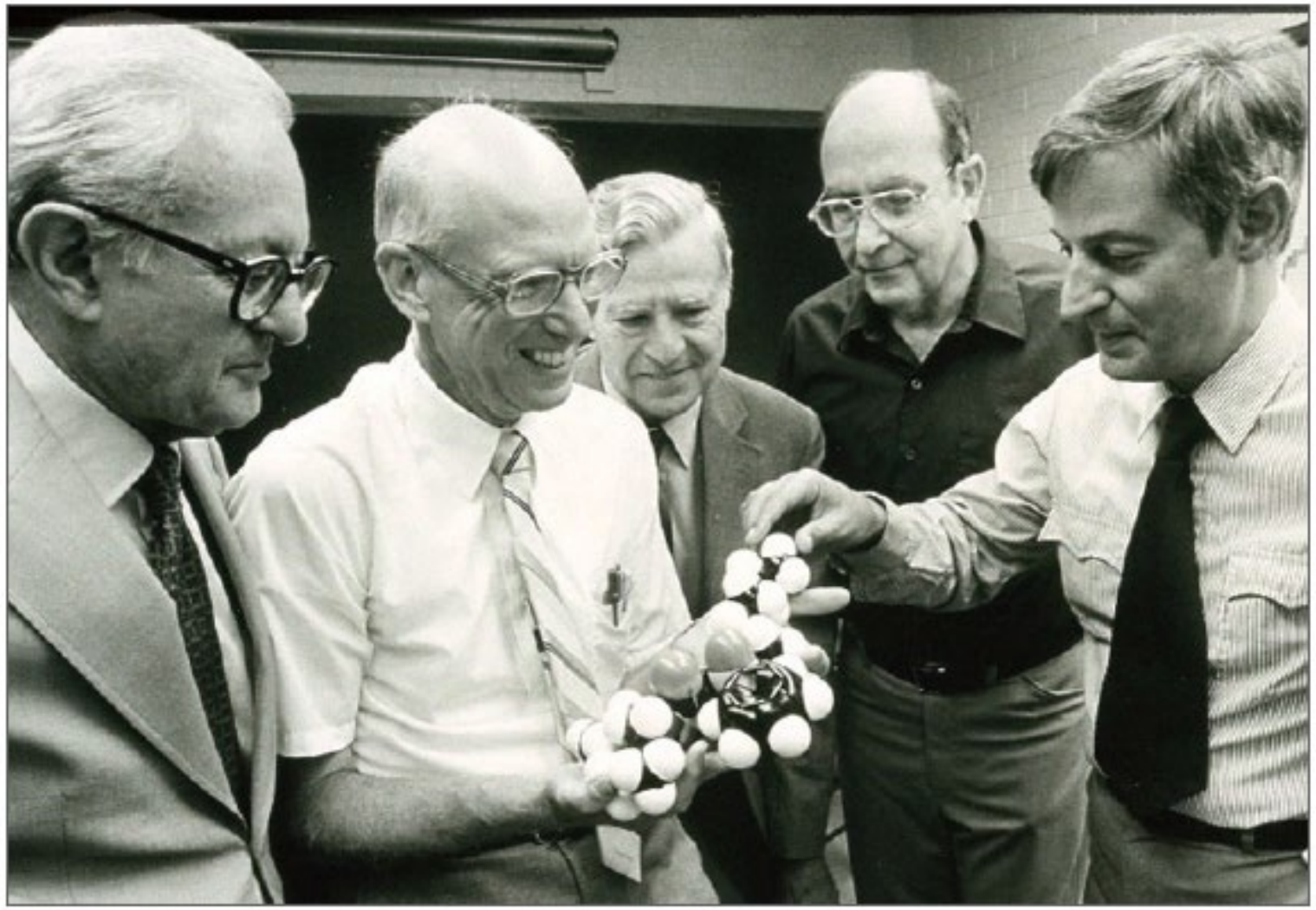
Phil’s Legacy (Memorial Messages)

Phil was inspiration to us, and he was a mentor to me. His scientific contributions are well known and as a person, he demonstrated the healthy lifestyle that was ahead of its time; as a runner in any weather and diet that was packed full of raw vegetables. 'Always firing on all cylinders' I am so fortunate to have known you. ILLINI!

Phil's Legacy (Memorial Messages)

Phil was a great scientist, mentor to many, a terrific human being, and an avid college football fan. He always gave me a hard time about FSU being so highly ranked in the polls as he didn't think the ACC was much of a conference compared to the Big-10 (Big-18 now?). After this year, I am starting to agree with him…

Phil's Legacy (Memorial Messages)



Phil understood the importance of solvent extraction, often with a smile referring to it as the "premier technique." He followed up his conviction by co-founding the journal Solvent Extraction and Ion Exchange in 1983, serving as Editor in Chief for the next two decades.

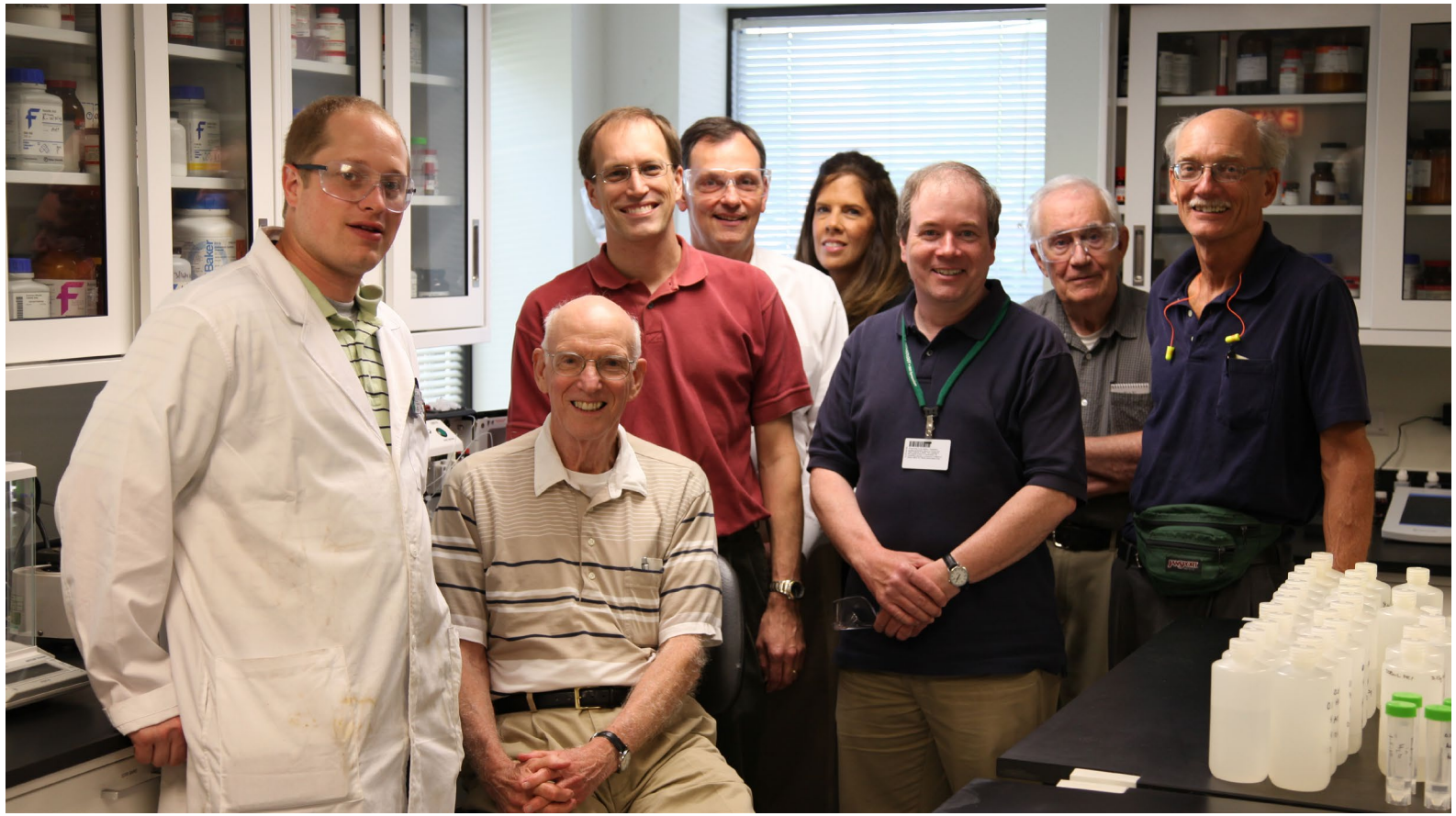
Phil’s Legacy (Memorial Messages)

I doubt that the world will ever understand or even know of the beneficial changes introduced by Phil to the field of analytical chemistry. Those of us who benefited from those enhancements will be forever grateful.

Phil's Legacy (Memorial Messages)

If it weren't for Phil, radiochemists couldn't do much of what we do the way we do it. It was ~33 years ago when I first used SrSpec columns that allowed me to do Sr seperations in the back of a semi trailer out on a field site.

Phil’s Legacy (Memorial Messages)



It’s hard to imagine my career without the time at Eichrom. It was there that I really started to become an independent scientist. Phil’s creativity and simplicity in presenting ideas left a mark that has followed throughout my career.

Mike Fern 35 years at Eichrom