The Nuclear Renaissance at UCI

A. J. Shaka
Chemistry Department
University of California, Irvine

© A. J. Shaka

A Brief History

- 1965: UCI TRIGA reactor specified, *as a single line item*, in Physical Sciences (now Rowland Hall). Dr. George Miller hired to oversee it.
- 1970s: Hot-atom chemistry, radiotracer work for atmospheric chemistry, smog formation.
- 1979. TMI LOCA. No adverse affects– except loss of public confidence.
- 1980s. NAA, radiochemistry, graduate student training, atmospheric chemistry.
- 1989. Chernobyl accident.
- 1995. Dr. Miller “retires”, becomes emeritus.

© A. J. Shaka

A Brief History

- 2001. 9/11.
- 2005. Decommissioning seriously considered. *"The thing is of no use! It's dangerous!"*
- 2007-8. I am made Vice-Chair for Facilities.
- 2007-10. A local politician runs on one issue: *shutting down the UCI TRIGA.*
- 2009. Prof. Nilsson is hired; I take interest in nuclear power, gradually become involved.
- 2010. Two students graduate with M.Sc. degrees– immediately hired. Three undergrads have the same experience.
- >$1.5M in grants for radiochemistry research.

© A. J. Shaka

ChemE Overview

- Fundamental extraction/solution behavior) with INL and ANL).
- Online process control/modeling of nuclear waste treatment processes (with PNNL).
- Radiolytic degradation of extraction systems and organic solvents (with INL and CSLB).
- Detection systems for proliferation and security applications (with EECS at UCI).

© A. J. Shaka

Chemistry/ChemE Overview

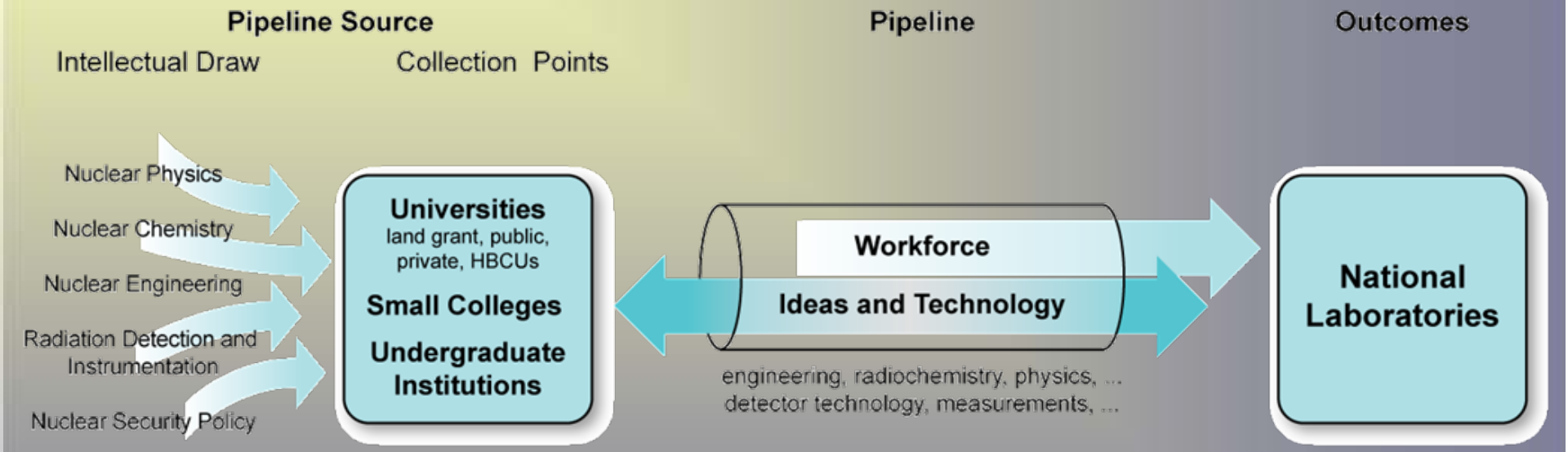
- Characterization of speciation in extraction systems by diffusion-ordered NMR spectroscopy (complex, micelle or inverse micelle formation).
- Small scale production of radioisotopes for pharmaceutical applications (with UCI Radiology).
- Refurbished Delayed Neutron System for detection of fissile material (U, Pu, Am).
- Education in nuclear and radiochemistry.

© A. J. Shaka

SUCCESS PIPELINE

Seven Universities Coordinating Coursework and Experience from Student to Scientist in a Partnership for Identifying and Preparing Educated Laboratory-Integrated Nuclear Experts

Nuclear Science and Security Consortium

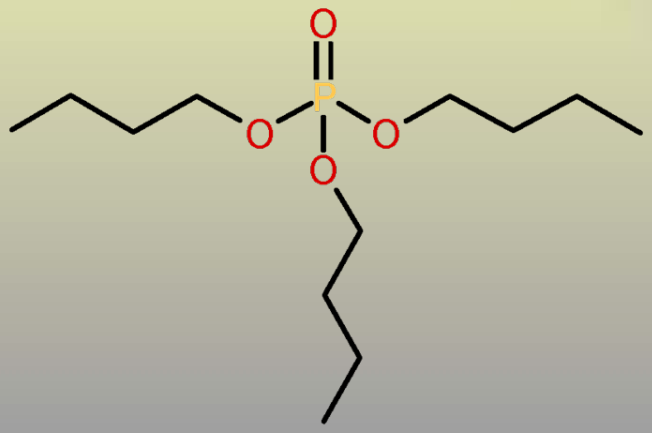


© A. J. Shaka

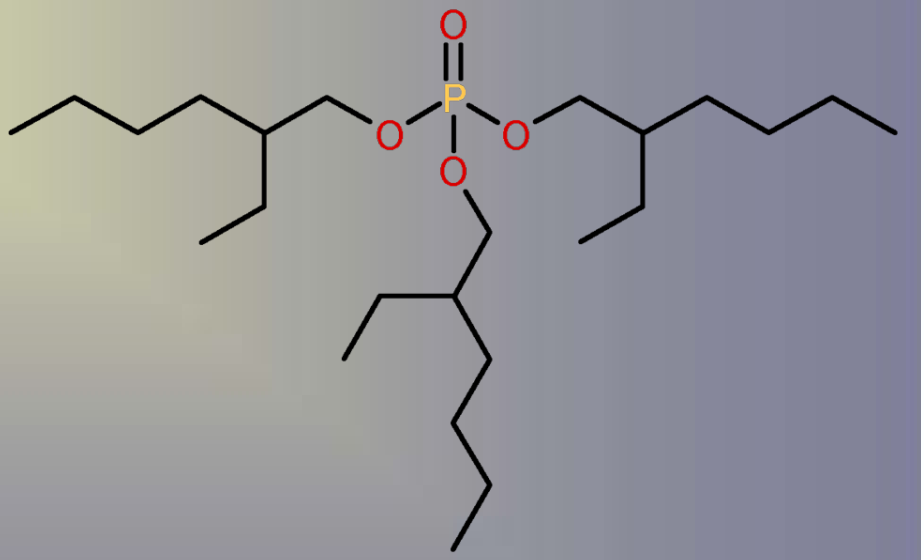
Solvent Extraction

- The Nilsson Lab is interested in liquid-liquid model extraction systems.

TBP



HDEHP



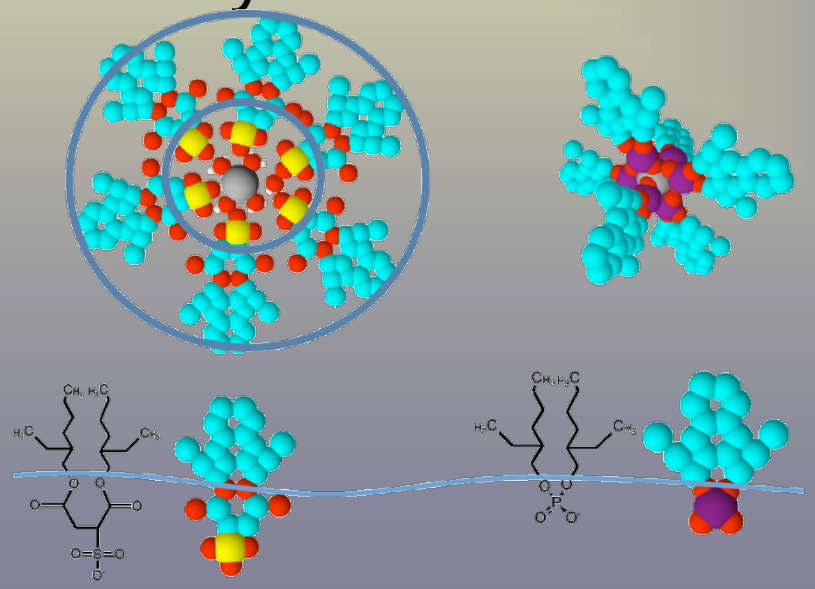
n-Dodecane

© A. J. Shaka

Solvent Extraction

- Radiolysis compromises extraction efficiency.
- Solutions are non-ideal.
- Third phase formation may occur.
- We would like to understand speciation in solution more thoroughly.

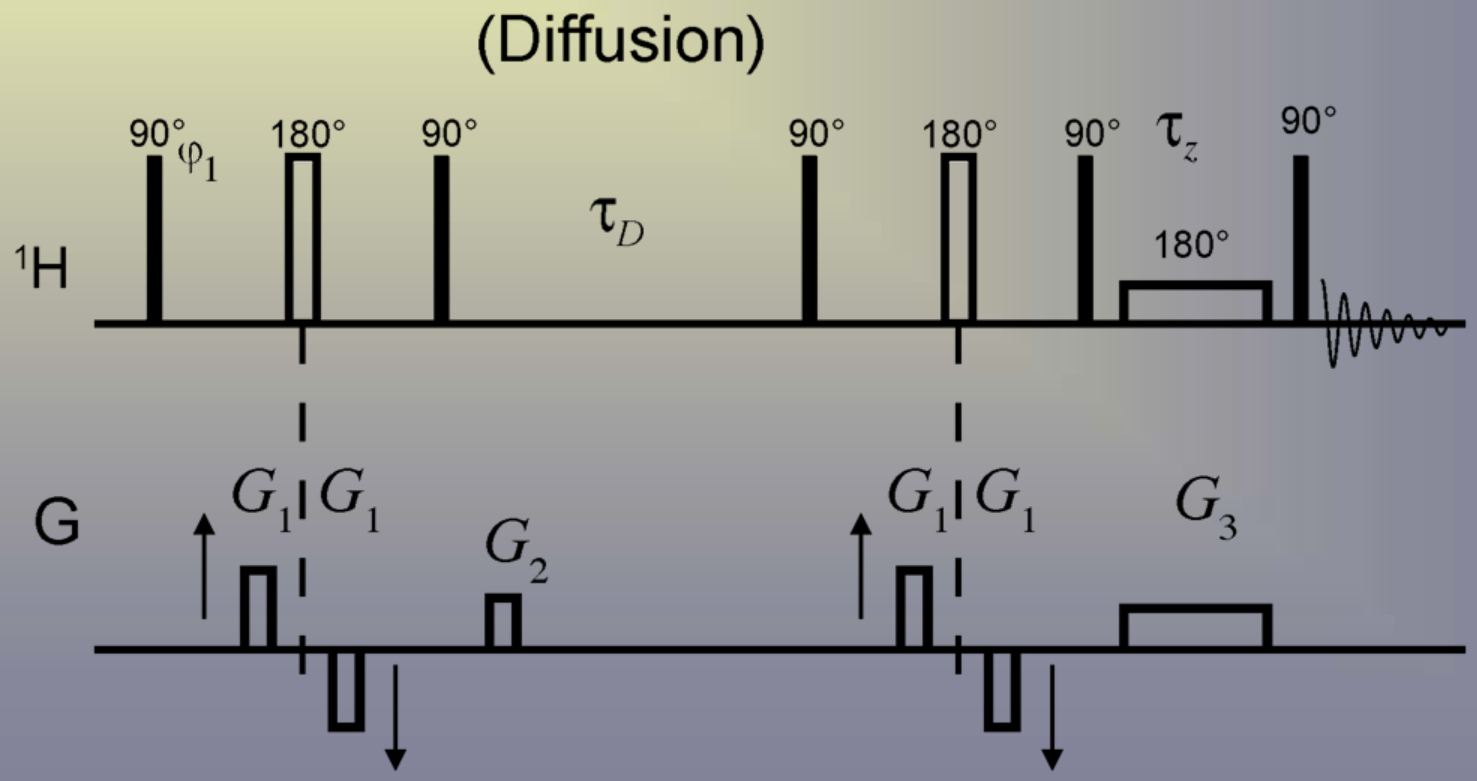
- α-radiolysis may cause different behavior.



© A. J. Shaka

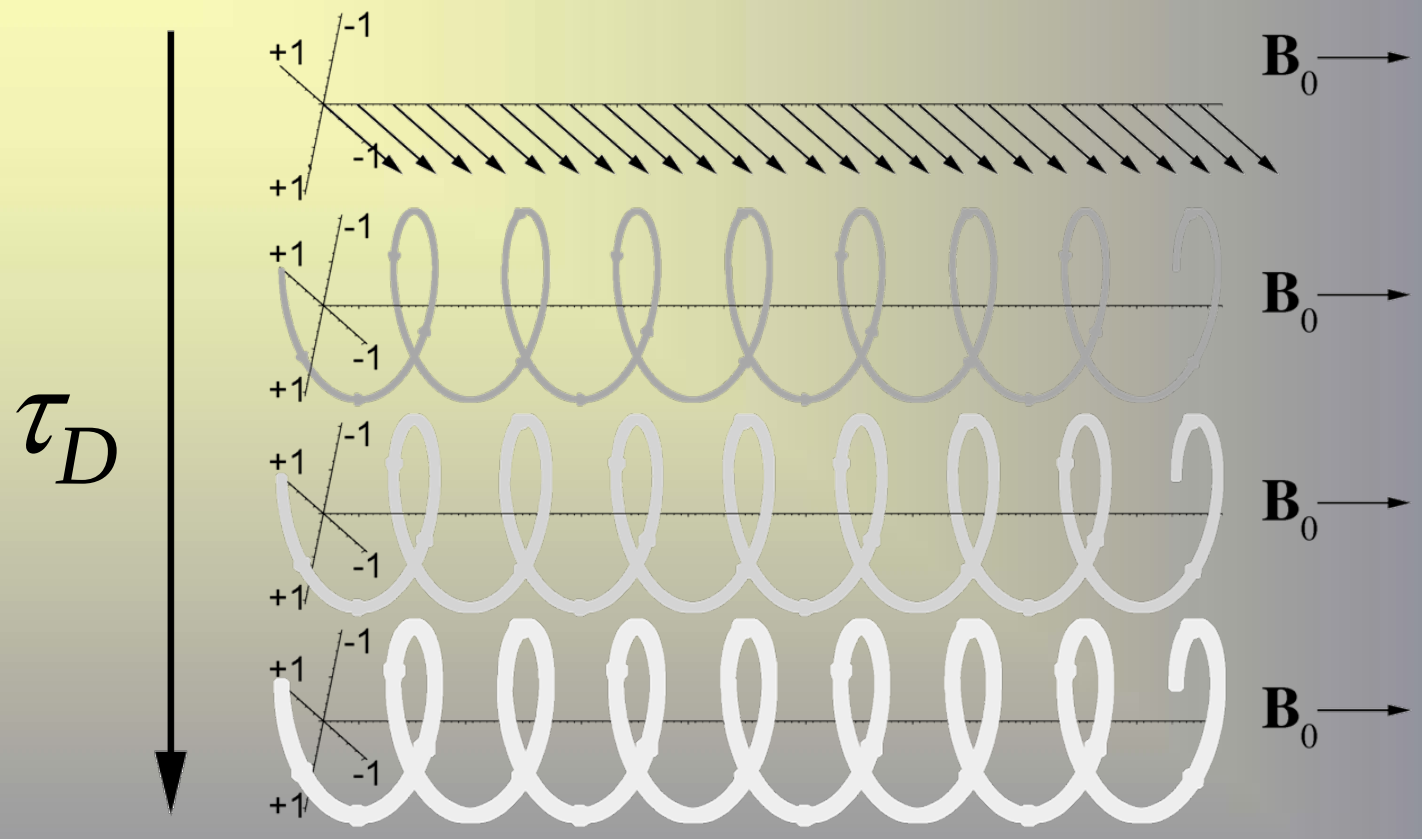
Solvent Extraction

- High-resolution NMR can make a contribution to our understanding.
- We can measure the rate of translational diffusion using DOSY-NMR.



© A. J. Shaka

DOSY Mechanism

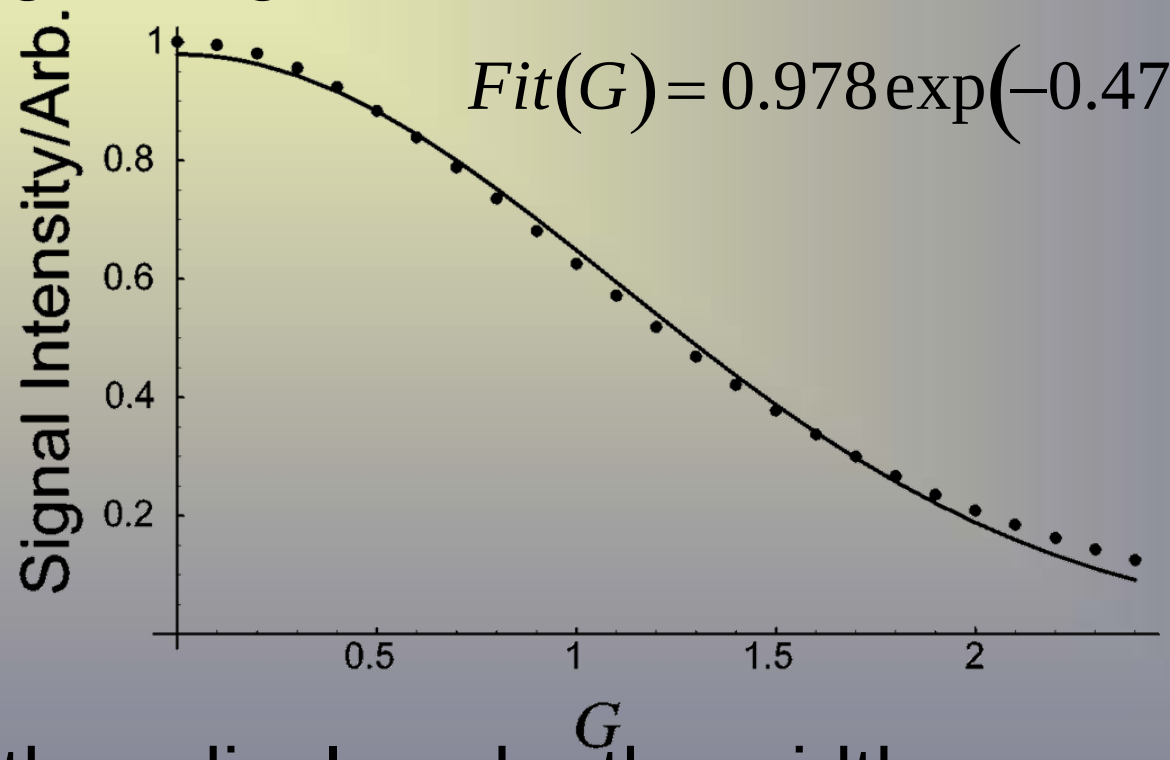


- Rephasing with the second gradient is imperfect because the spins diffuse off the helix.
- Diffusion is a random walk Gaussian function.

© A. J. Shaka

Following Diffusion

- We fit each series of NMR spectral points as a function of the gradient G using a single Gaussian.



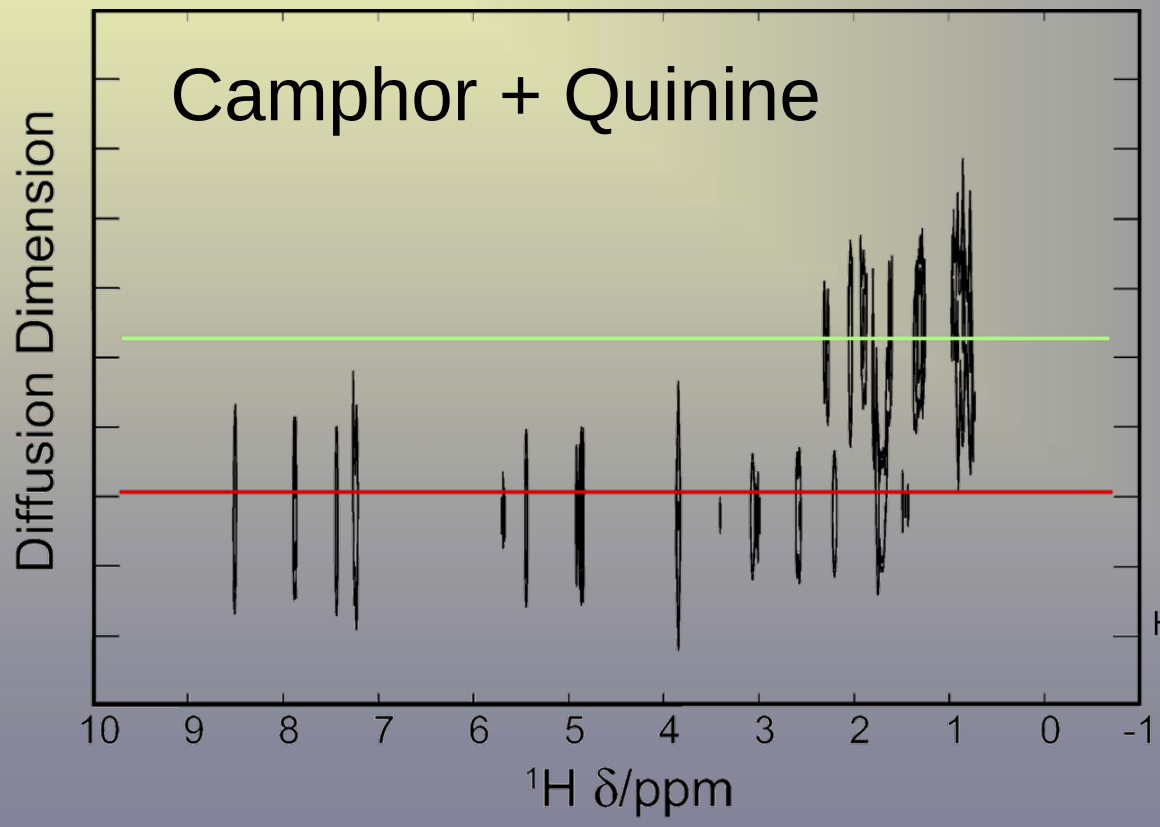
$$Fit(G) = 0.978\exp\left(-0.478G^2\right)$$

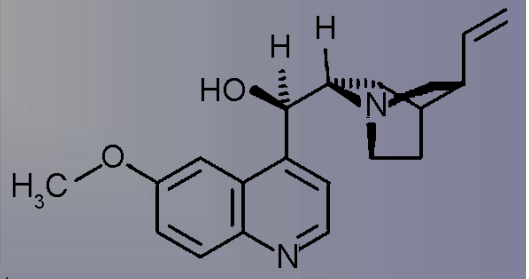
- We then displace by the width...

© A. J. Shaka

Separation Results

- Wherever the NMR spectra do not overlap, the separation is good.





© A. J. Shaka

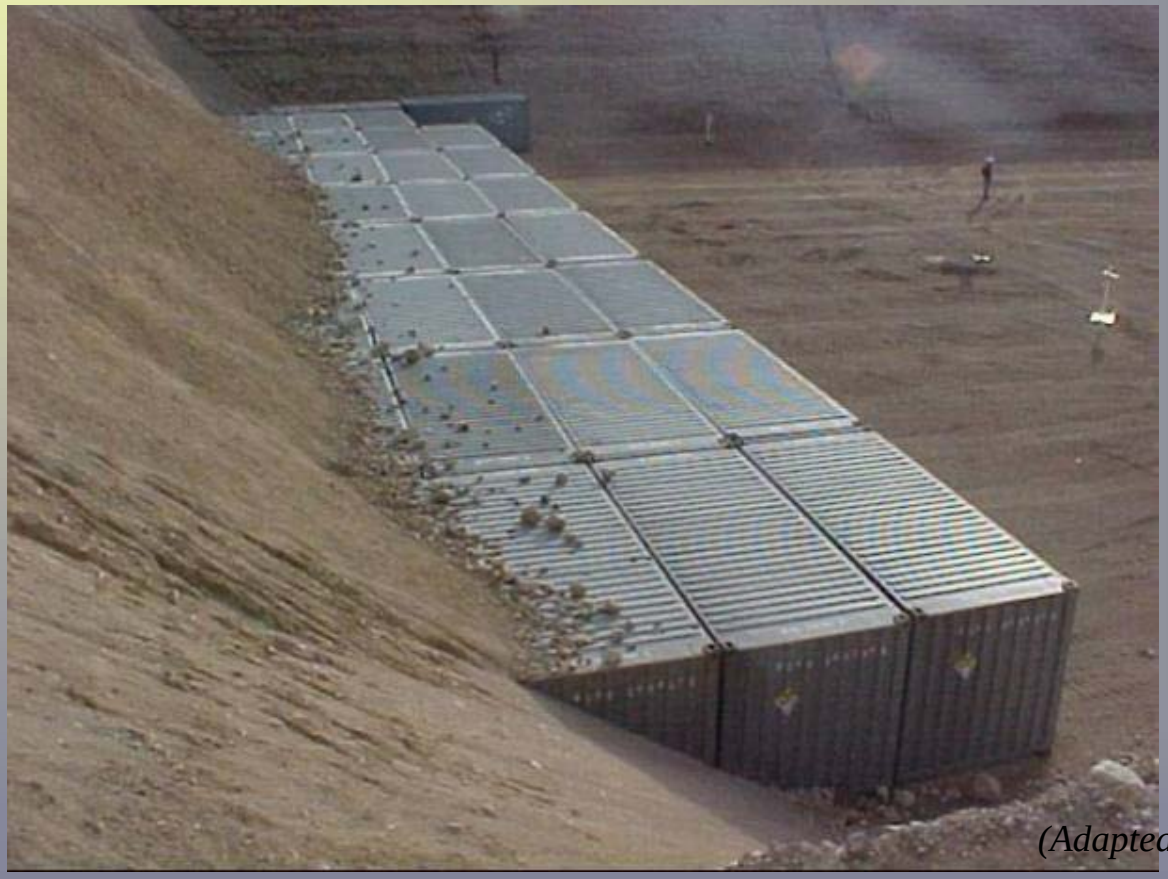
Why Not Thorium?

- ^{232}Th is a fertile isotope, in huge abundance.
- *Because it did not seem likely to make weapons from the thorium fuel cycle*, the only thorium molten salt reactor, at ORNL, was decommissioned in 1969.
- This was the first Liquid Fluoride Thorium Reactor LFTR ("lifter").

© A. J. Shaka

Practicality

- Thorium is as abundant as tin.
- Lots of it has *already* been mined!

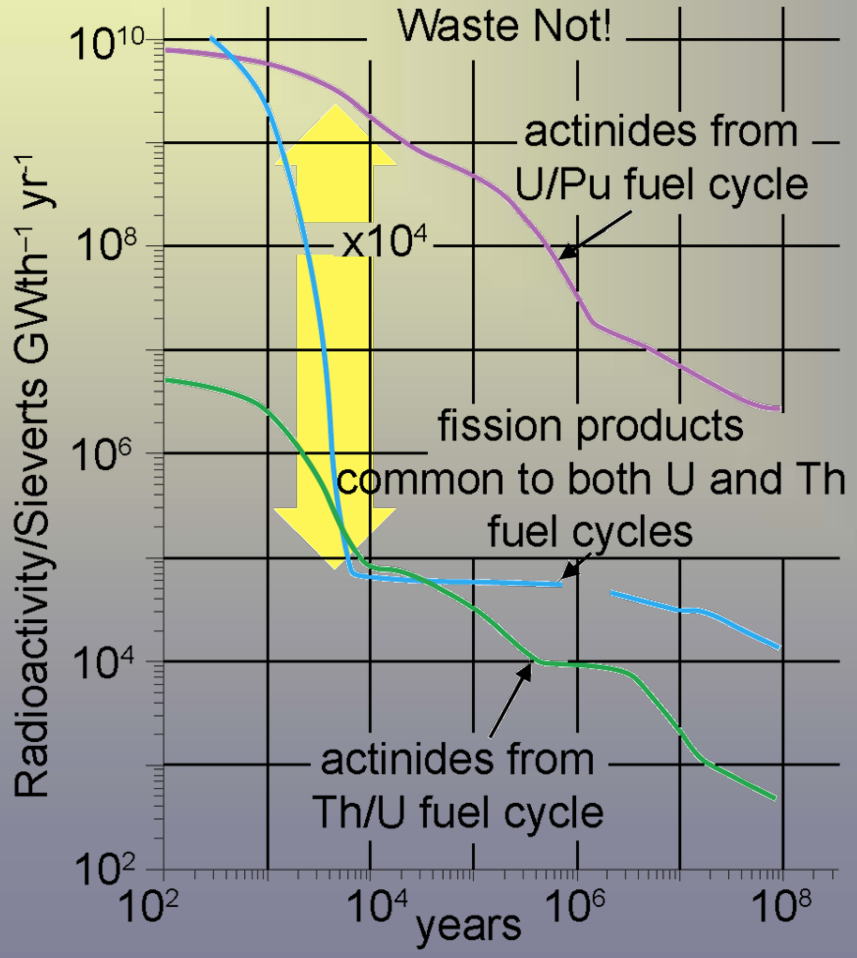


(Adapted from Wikipedia)

© A. J. Shaka

LFTR Is Clean

- Almost all radioactive products decay in centuries, rather than thousands of years.



Moir and Hargraves, American Scientist July 2010

© A. J. Shaka

Is Uranium Sexier?

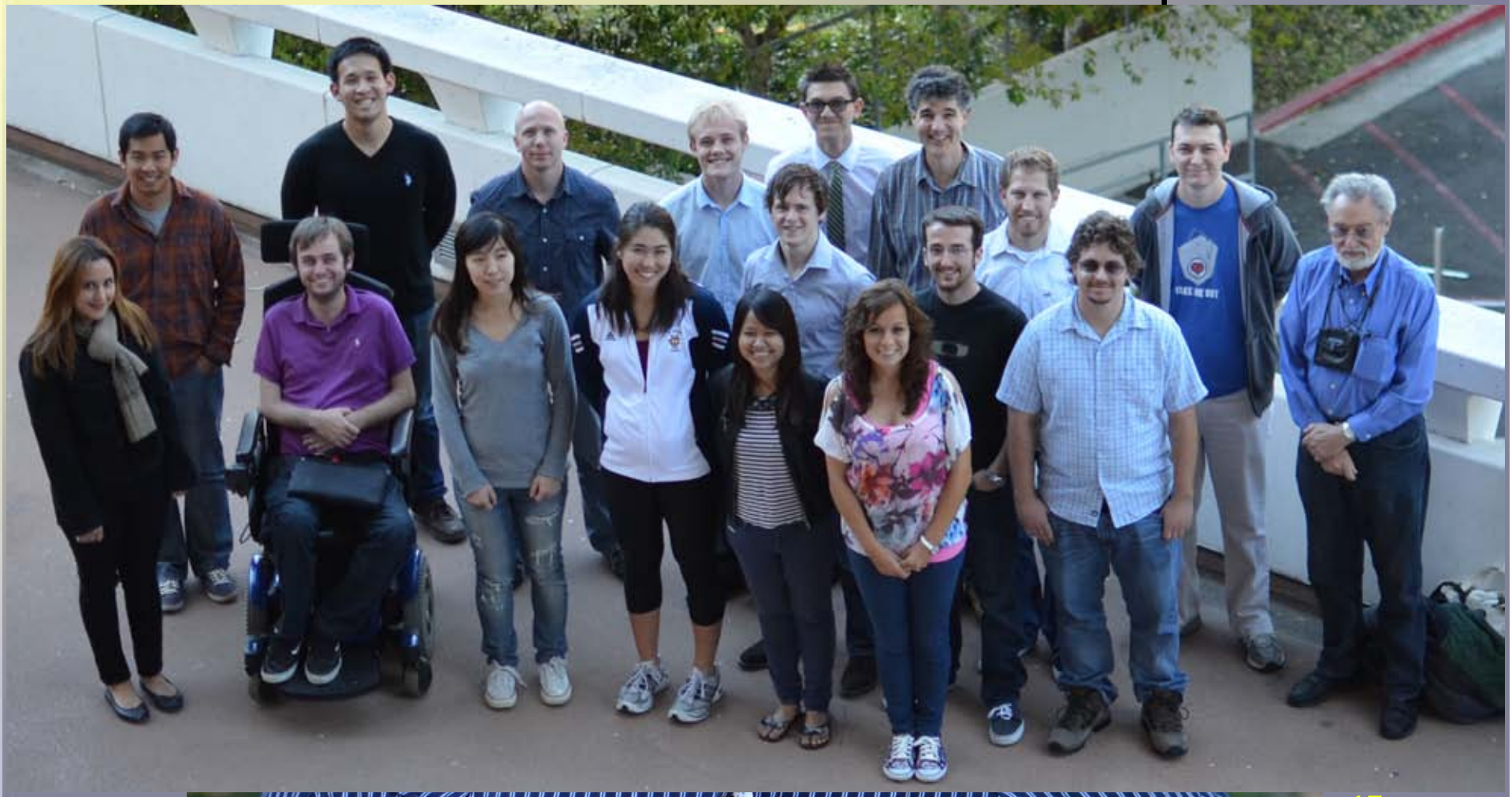
"I'm sure you're a nice man, but I'm not interested in hearing about Thorium."

THE NEW YORKER, NOVEMBER 14, 2011

© A. J. Shaka

Summary

- We had a source... added fuel... multiplied!



© A. J. Shaka