



Lanthanide Isotope Purification

CF Technologies, Inc.

Hyde Park, MA

Presented by:

Laura Sinclair, Ph.D.

CF Tech Introduction

Our mission is to develop innovative, sustainable processes and products that meet and exceed our customers' technical and economic needs.

- In the Critical Fluid business for 30+ years
- 11 Patents
- Commercial Extraction Experience – Design, build, start-up, process improvements & maintenance
- Prior Metals Separation work – Separation of concentrated mixed rare earth elements from coal waste streams and phosphate waste
- Laura Sinclair, PhD prior work – Rare earth element extraction from bastnäsite concentrate

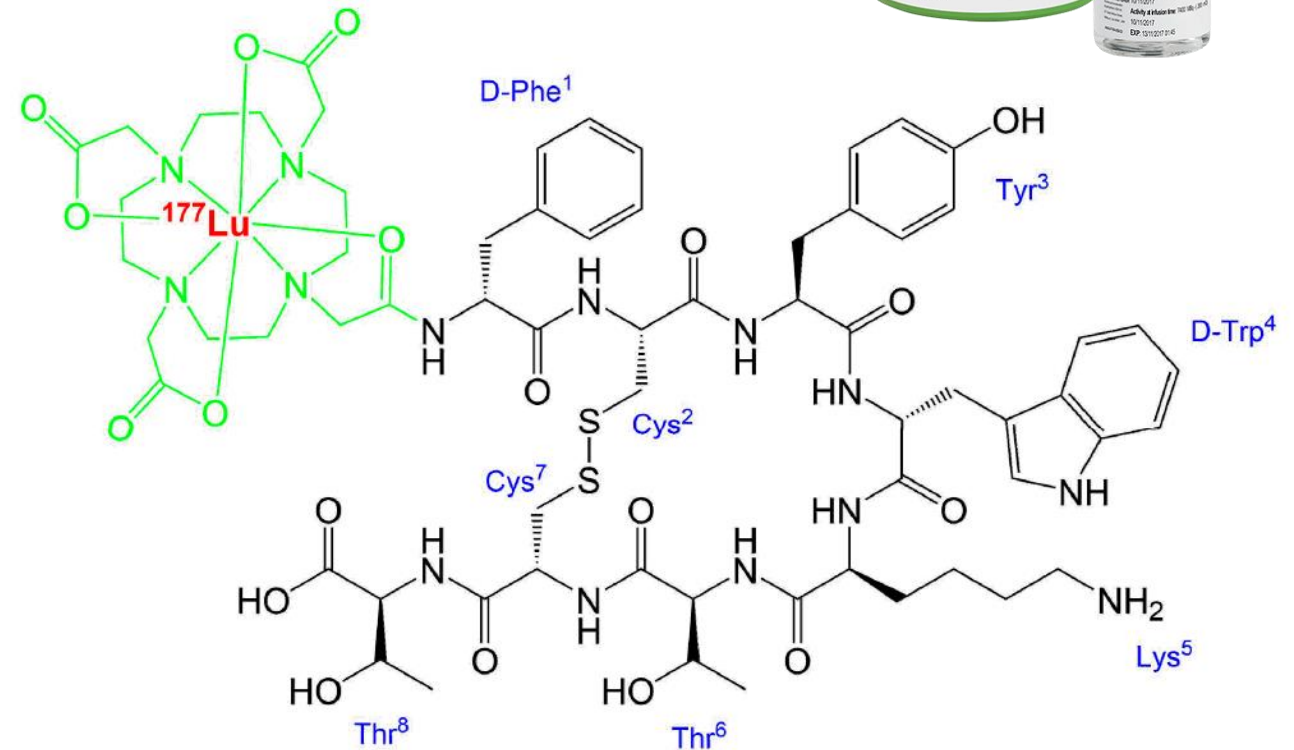
MIT Nuclear Reactor Laboratory

- Interdepartmental center that operates a high performance 6 MW nuclear research reactor.
- Thermal neutron flux of 5.6×10^{13} n/cm²s



Lanthanide Isotopes

- Medical isotopes used in cancer treatment
- ^{90}Y , ^{153}Sm , and ^{177}Lu based drugs approved
- ^{166}Ho and ^{161}Tb based drugs in clinical trials
- Rapid market growth
- >600,000 patients/year by 2025



Images: ITM Garching, Hennrich 2019

radionuclide (^{177}Lu) + chelator (DOTA) + targeting peptide (octreotate)

Supply Chain



- Goal: separate micro amounts of ^{177}Lu from macro amounts of ^{176}Yb

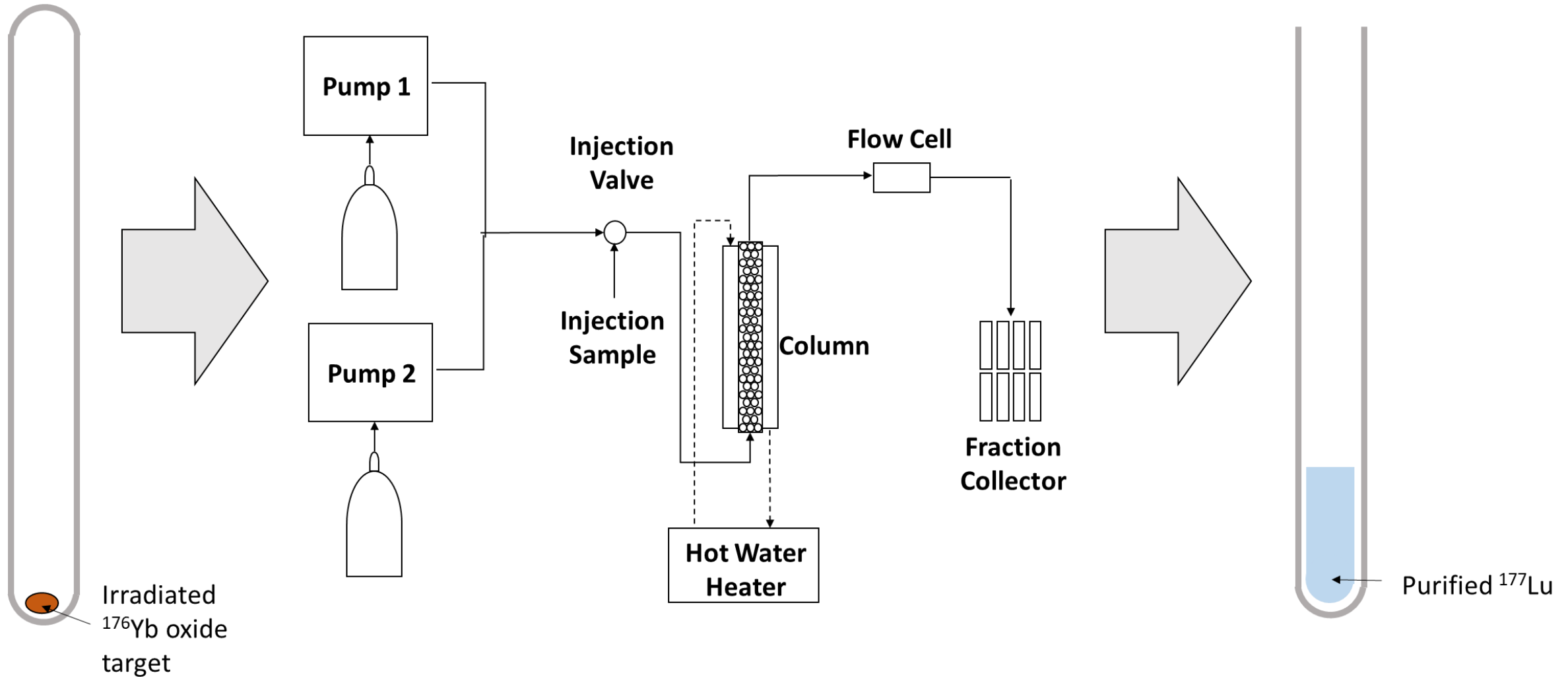
Current Options

Alternative	Advantages and Disadvantages
Aqueous ion exchange chromatography	<p>Advantages: Chemicals are cheap and readily available</p> <p>Disadvantages: Requires multiple stages to achieve desired purity and concentration, resulting in long processing times (6-8 hours) Methods are often limited to small target sizes (~150 mg) due to low separation factors.</p>
Extraction chromatography	<p>Advantages: Suitable for large targets (>300 mg)</p> <p>Disadvantages: Complex, many stages and resin types required The process is up to 16 hours and may need to be repeated multiple times to achieve desired purity</p>
Cementation	<p>Advantages: Applicable to medium-sized targets (at least 200 mg) Processing times are relatively short (3-4 hours), but may require extraction chromatography to clean up product</p> <p>Disadvantages: Residual mercury can be present which is a health risk for patients. One study found 3-19 ppm Hg</p>

Our solution

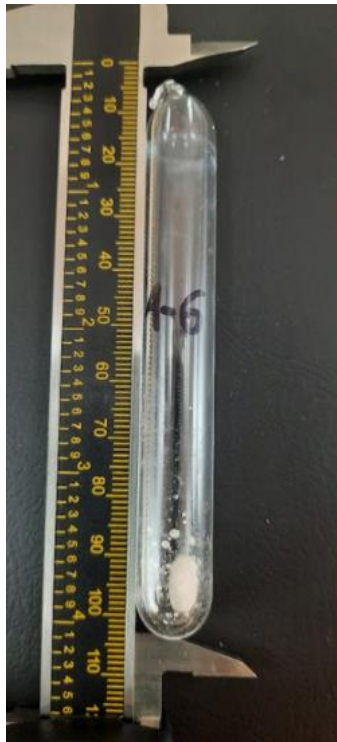
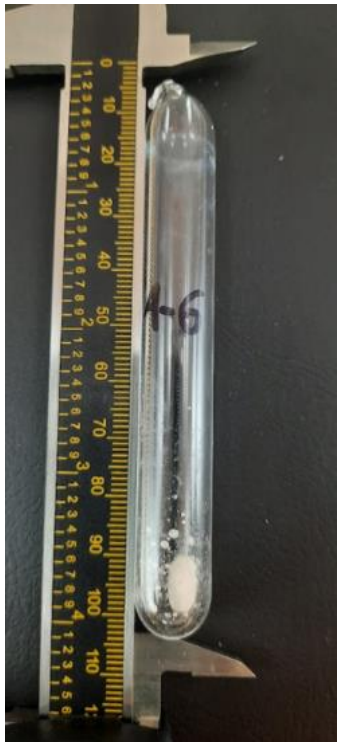
- Non polar solvents allow for innovative chemistries
- 4-5 hours (current processes=8-16 hours)
- Single column pass
- Cheap, off-the-shelf chemicals

Our solution

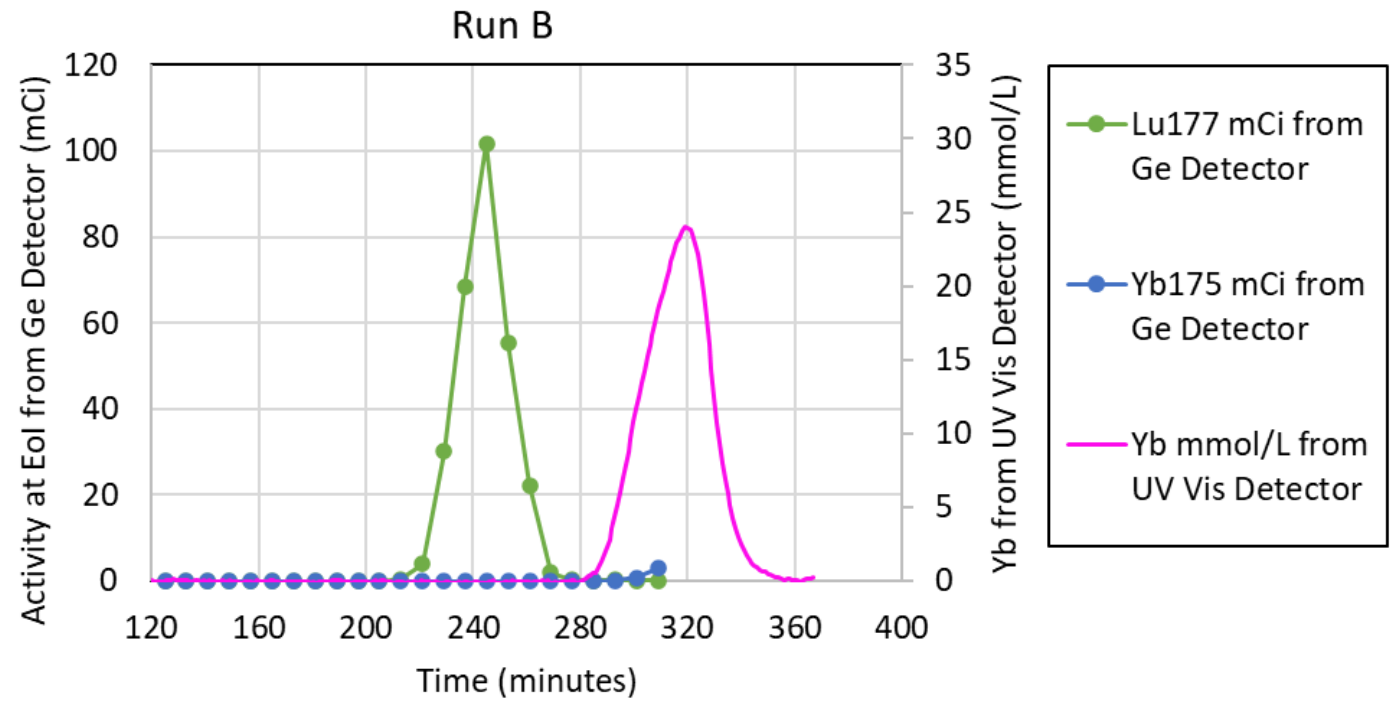
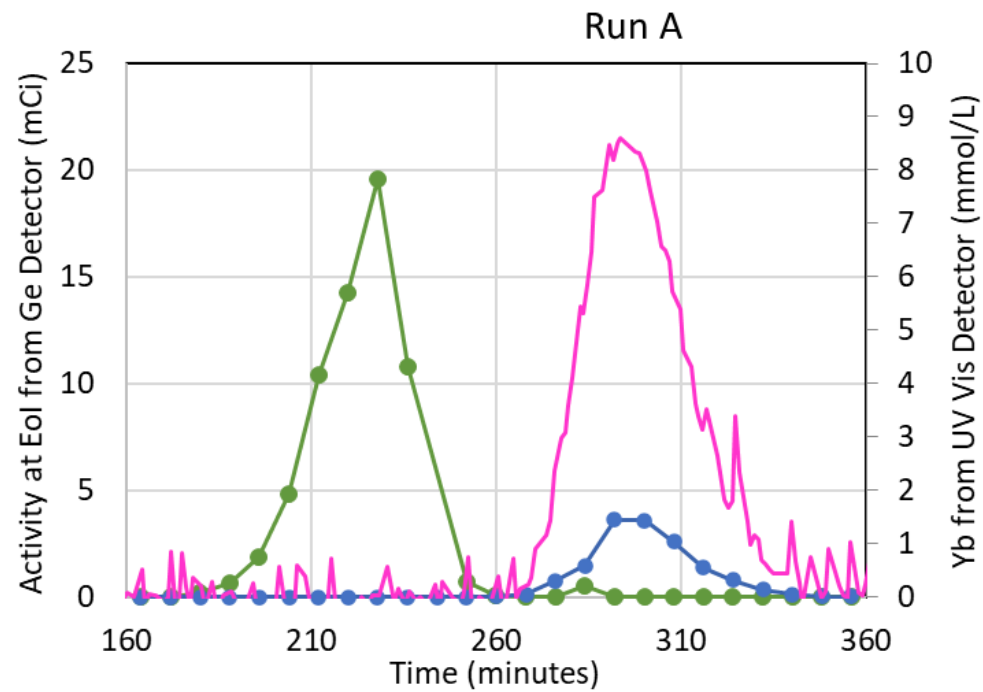


Irradiation Targets

34-72 mg ^{176}Yb as an oxide



Results



(Eol=End of Irradiation)

Results cont'd

	Target	Run A	Run B
Injected Activity		64.6 mCi	313 mCi
¹⁷⁷ Lu Recovery (¹⁷⁷ Lu recovered/ ¹⁷⁷ Lu injected)	>85%	107%*	91%
¹⁷⁶ Yb Recovery	>85%	87%	N/A
Decontamination Factor	>10 ⁵	>1.8 x 10 ⁶	>9.0 x 10 ⁵
Time to Recover Lu	<8 hours	4 hours	4.5 hours
Recovered ¹⁷⁷ Lu meets European Pharmacopeia purity standards?	¹⁷⁵ Yb<0.07% Cu<1 µg/GBq Zn<1 µg/GBq Pb<0.5 µg/GBq ¹⁷⁶ Yb<0.1 µg/GBq after 9 days	Yes	Yes
Recovered ¹⁷⁶ Yb suitable for re-irradiation?	¹⁷⁴ Yb<0.44% Cu< 43 µg/g Zn<23 µg/g Pb<43 µg/g	Yes	N/A

*Recoveries >100% attributed to background radiation on sodium iodide detector

Technical & Management Team



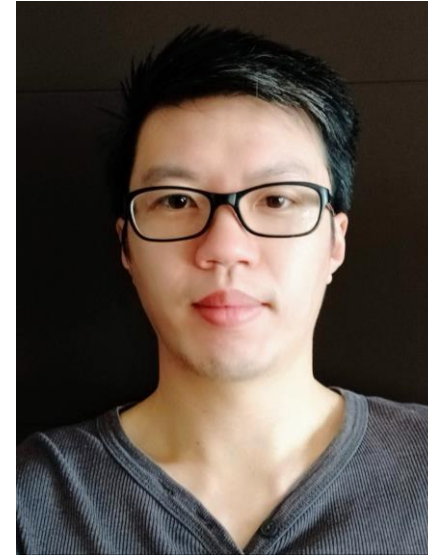
John Moses
President and Founder
WPI, BU
Innovative Design,
Scale-Up
MIT Research Affiliate
CF Tech since 1989



John Markiewicz
Chem/Chem E, Sr.
Technologist
U-Pittsburgh, UNH
Clean Energy, Oil Refinery
Scale-up & Commission
CF Tech partner/employee
since 1996



Laura Sinclair, Ph.D
R&D Chem Engineer
U-Toronto, Cornell
Idaho National Lab
Experimental Design
DOE R&D Project Lead
CF Tech since 2018



Frank Chan, Ph.D
R&D Chem Engineer
Monash U, Michigan
TU
NREL, Clean Energy
Research & Analysis
Lead
CF Tech since 2021



Jessica Sweeney
Vice President
BBA Hofstra U
Emerging Leaders MBA
Sales, Operations, Strategy
CleanTech Open
CF Tech since 2006

Acknowledgements

- Idaho National Laboratory
 - Bob Fox
 - Mary Case
- MIT Nuclear Reactor Laboratory
 - Gordon Kohse
 - Mike Ames
 - Thomas Bork
- DOE
 - Ethan Balkin
 - Michelle Shinn



Thank You!