Chemistry and Physics of the Heaviest Elements

- Heavy Element Chemistry with long-lived isotopes only accessible using actinide targets

- Determination of the chemical properties of the elements is the most fundamental goal in all of chemistry. $102 \leq Z \leq 114$ represents 12% of the periodic table

Isotopes of Elements 102-108 for Chemistry

- Isotopes of elements from Z=102 through Z=114, with half-lives long enough for chemical separations can be produced in reactions with long-lived actinide targets:

• 10-s	$^{269}108$	$^{248}Cm(^{26}Mg,5n)$	$^{244}Pu(^{30}Si,5n)$
• 15-s	$^{267}107$	$^{248}Cm(^{23}Na,5n)$	$^{244}Pu(^{27}Al,4n)$
• 15-s	$^{265}106$	$^{248}Cm(^{22}Ne,5n)$	$^{244}Pu(^{26}Mg,5n)$
• 34-s	$^{262}105$	$^{248}Cm(^{19}F,5n)$	$^{244}Pu(^{23}Na,5n)$
• 78-s	$^{261}104$	$^{248}Cm(^{18}O,5n)$	$^{244}Pu(^{22}Ne,5n)$
• 26-s	$^{256}103$	$^{238}U(^{23}Na,5n)$	$^{244}Pu(^{19}F,5n)$
• 3.1-m	$^{255}102$	$^{238}U(^{22}Ne,5n)$	$^{242}Pu(^{26}Mg,5n)$

The New Elements (DUBNA/LLNL) 113, 114, 115, 116, and 118

NEED OF CONFIRMATION

- 1 ms $^{294}118$ $^{249}Cf(^{48}Ca,3n)$
- 61ms $^{293}116$ $^{248}Cm(^{48}Ca,3n)$
- 87ms $^{288}115$ $^{243}Am(^{48}Ca,3n)$, $^{287}115$ $^{243}Am(^{48}Ca,4n)$
- 2.6 s $^{289}114$ $^{244}Pu(^{48}Ca,3n)$
- 0.48 s $^{284}113$ $^{243}Am(^{48}Ca,3\text{-}4n)^{288,287}115 \rightarrow \alpha \rightarrow ^{284,283}113$

"MISSING ELEMENTS"

$^{249}Bk(^{48}Ca,xn)^{297-x}117$; $^{254}Es(^{48}Ca,xn)^{302-x}119$;

$^{249}Cf(^{50}Ti,xn)^{299-x}120$

Heavy Element Chemistry and Physics

- **CHEMISTRY POSSIBLE**

- **29-s $^{285}112$ $^{244}Pu(^{48}Ca,3n)^{289}114 \rightarrow \alpha \rightarrow$**
- **3.6-s $^{280}111$ $^{243}Am(^{48}Ca,3n)^{284}113 \rightarrow \alpha \rightarrow$**
- **11.1-s $^{281}110$ $^{244}Pu(^{48}Ca,3n)^{289}114 \rightarrow \alpha \rightarrow \alpha \rightarrow$**

OUR ISOTOPE NEEDS

^{242}Pu, ^{244}Pu, ^{243}Am, ^{245}Cm, ^{249}Bk, ^{249}Cf, ^{254}Es

^{48}Ca

National Security Needs prepared by Dave Vieira (LANL)

- This encompasses selected isotopes that are of interest to the Stockpile Stewardship or Threat Reduction (nuclear forensic) Programs. Improved knowledge of their properties (such as neutron-induced cross sections, fission yields, etc.) are needed to improve our understanding, modeling, and certification of nuclear weapon systems in the US arsenal. In some cases these isotopes are needed as tracers.
- 1. Selected actinide species including: $^{232\text{-}238}U$, $^{235\text{-}239}Np$, $^{236\text{-}245}Pu$, $^{240\text{-}244}Am$ and their decay products. In most cases isotope enriched. Short-lived isotopes such as ^{237}U (6.75 d, can be produced in HFIR), ^{240}Am(2.12 d, can be produced at ICF) are of currently of high interest.

Dave Vieira (LANL)

- Selected fission products, activation products, and neutron-deficient isotopes. A partial, list of isotopes includes the following:
- ^{7,10}Be ^{73,74}As, ^{83}Rb, ^{88}Y, ^{88,95}Zr, ^{101,102}Rh, ^{105}Ag, ^{135,137}Cs, ^{144}Ce, ^{151}Sm, $^{149\text{-}155}$Eu, $^{148\text{-}153}$Gd, ^{157,158}Tb, ^{166}Ho, $^{168\text{-}171}$Tm, $^{173\text{-}174,177}$Lu, ^{178m}Hf, ^{179}Ta, ^{181,185,188}W, ^{194}Os, $^{189\text{-}194}$Ir, ^{195}Au, ^{204}Tl, ^{210}Bi

F. Meiring Nortier, Donna Smith (LANL / IPF)

- IPF Produces: Na-22, Ge-68, As-73, Sr-82, Y-88, Cd-109
- LANL Uses: H-3, C-14, Cl-36, Ge-76, Sr-90, I-129, Cs-137, Ba-133, Pm-149, Eu-152,154,155, Gd-153, Tm-170,171, Lu-173, Tl-204, Ra-226,228, Th-228,229, Ac-225, Cf-252, Np-237, all Th, U, Np, Pu and Am isotopes
- A continued growth in the use of all tracers is expected. Milligram quantities of actinide isotopes will be needed to study neutron induced fission. H-3, Pm-149, Ac- 225 and high purity actinides are listed as a high priority
- The main issue among the various LANL users is the availability of isotopes in sufficiently high purity levels. Purity of isotope dilution tracers is critical for making high-quality actinide measurements with minimal uncertainties.
- For stable isotopes cost is a major factor

DATA NEEDS FOR GNEP

ELSEVIER

Available online at www.sciencedirect.com

SCIENCE DIRECT®

Annals of Nuclear Energy 33 (2006) 700–733

annals of NUCLEAR ENERGY

www.elsevier.com/locate/anucene

Nuclear data sensitivity, uncertainty and target accuracy assessment for future nuclear systems

G. Aliberti [a,*], G. Palmiotti [a], M. Salvatores [a], T.K. Kim [a], T.A. Taiwo [a], M. Anitescu [a], I. Kodeli [b], E. Sartori [b], J.C. Bosq [c], J. Tommasi [c]

[a] *Argonne National Laboratory, 9700 S. Cass Ave, Argonne, IL 60439, USA*
[b] *NEA Databank, Paris, France*
[c] *CEA-Cadarache, DER/SPRC Bât. 230, 13108 St-Paul-Lez-Durance, France*

Received 5 December 2005; accepted 2 February 2006
Available online 5 May 2006