Visualization of Nuclear Decay Activity for Forensics and Jurisprudence

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Abstract

- This poster presents multiple information visualization techniques for scientific visualization of the nuclear isotope decay process, including: *Pie Chart*, *Circle Packing* & *Directed Graphs*.
- Visualization is complementary to underlying digital library (DL) information structures which support implementation of nuclear forensics discovery. DL methods are used to support the identification, localization and detection of illicit nuclear materials.

A Digital Library Approach

- Nuclear material data is a digitized record of assays for component isotopes and elements. Decay and morphing activity of radioactive atoms is built into the search algorithm to facilitate record matching.
- The data demonstration items for *circle packing* are unclassified weapons grade nuclear material samples from the Plutonium Metal Standards Exchange Program at the Laboratory Chemistry and Materials Science Division, Los Alamos National Laboratory (LANL).
- The *decay chains* are built from the Nuclear Wallet Cards (NWC), which catalogues properties for ground and isomeric states of all known nuclides. NWC is published by National Nuclear Data Center, Brookhaven National Laboratory.
- Table 1 shows the physical properties for some sample isotopes (U-234, U-235, and U-238) from the Nuclear Wallet Cards.

Table 1: Nuclear Wallet Cards

A	Z	Element	Decay mode	Branch %	Daughter isotope	Natural abundance %	Half-life year	Half-life sec
234	92	U	Alpha	100	Th-230	0.0054	2.455E+5	7.55E+12
235	92	U	Alpha	100	Th-231	0.7204	7.04E+8	2.22E+16
238	92	U	Alpha	100	Th-234	99.2742	4.468E+9	1.41E+17

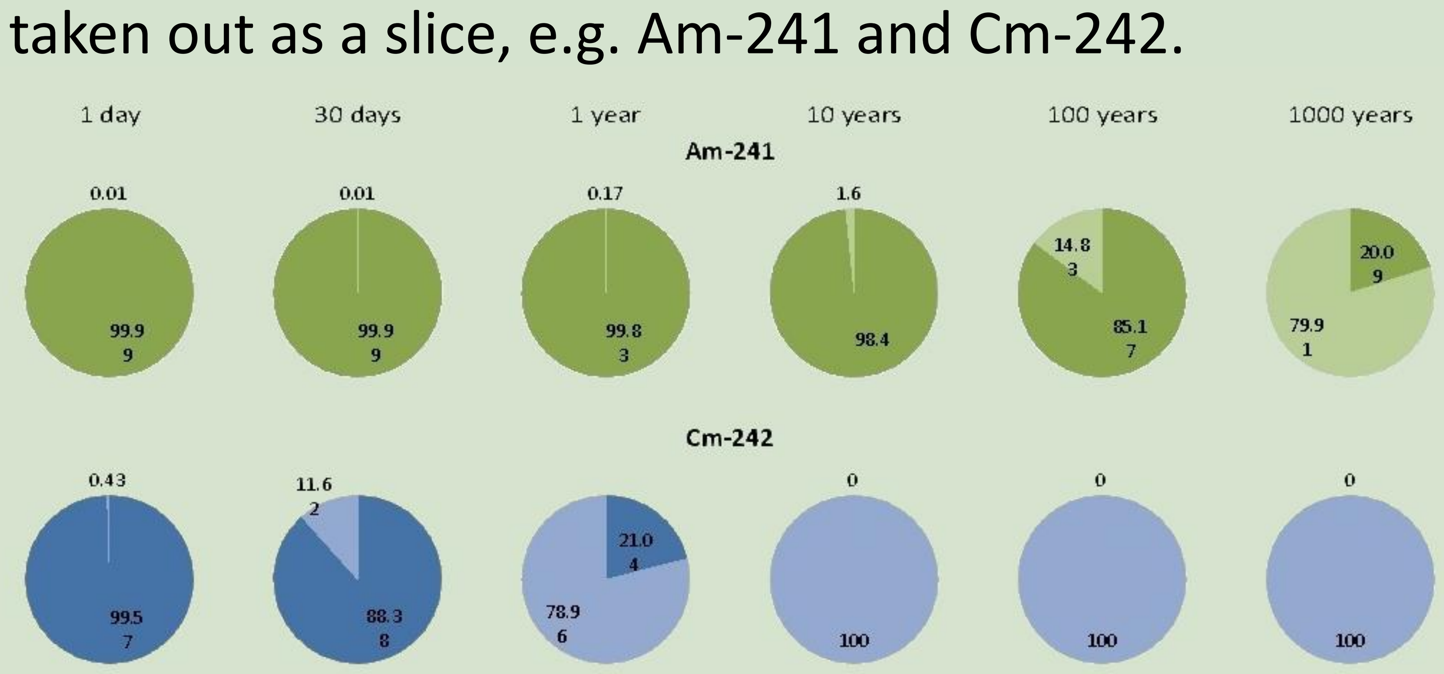
Pie Chart

Theory

- Temporal sequenced pie chart is used as visual signature to display quantitative decay amounts over time periods from months to millennia.

Implementation

- Calculate the amount of isotope left after given time (1 day, 30 days, 1 yr, 10 yrs, 100 yrs, 1000 yrs) using a set initial amount of material (100 g). Then use ratio percent to create pie chart with the amount decayed taken out as a slice, e.g. Am-241 and Cm-242.



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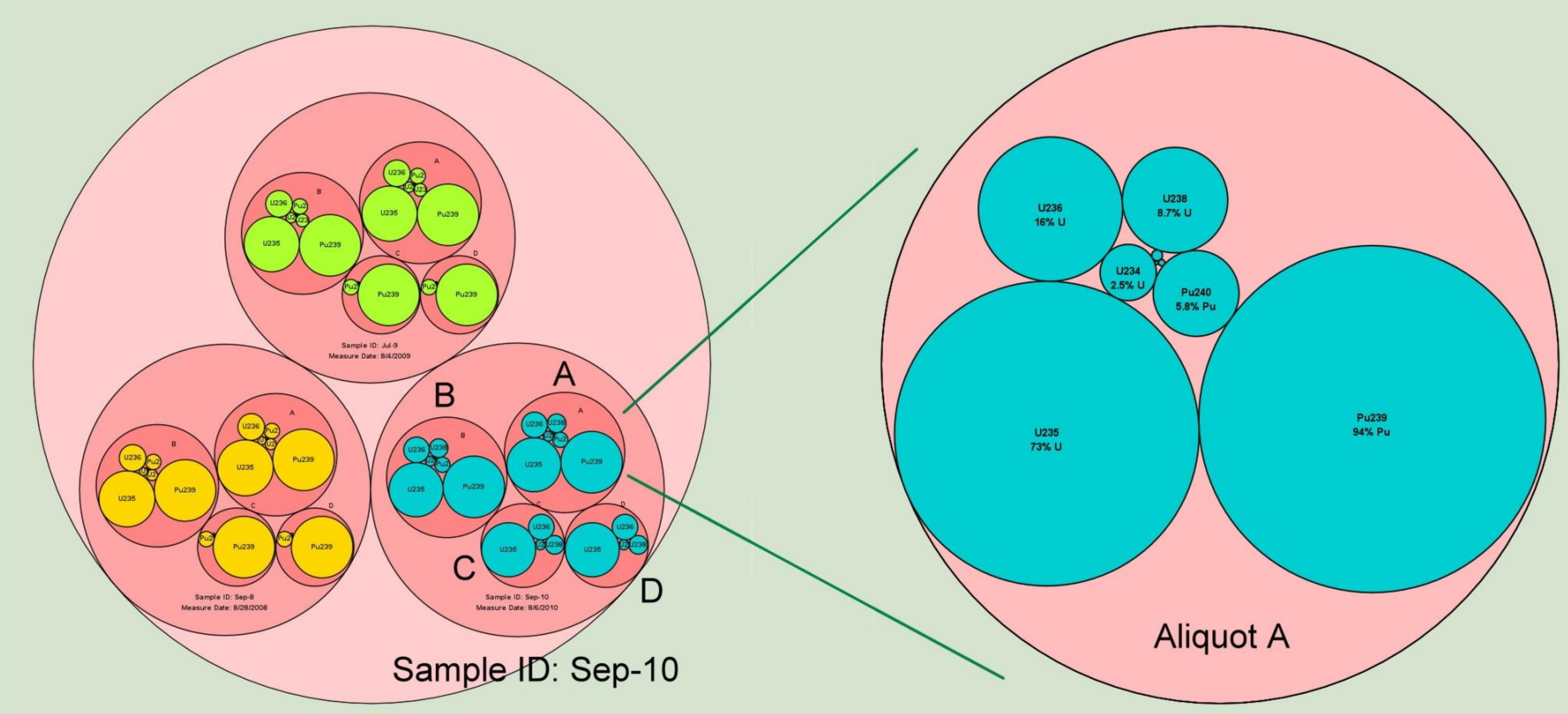
Circle Packing

Theory

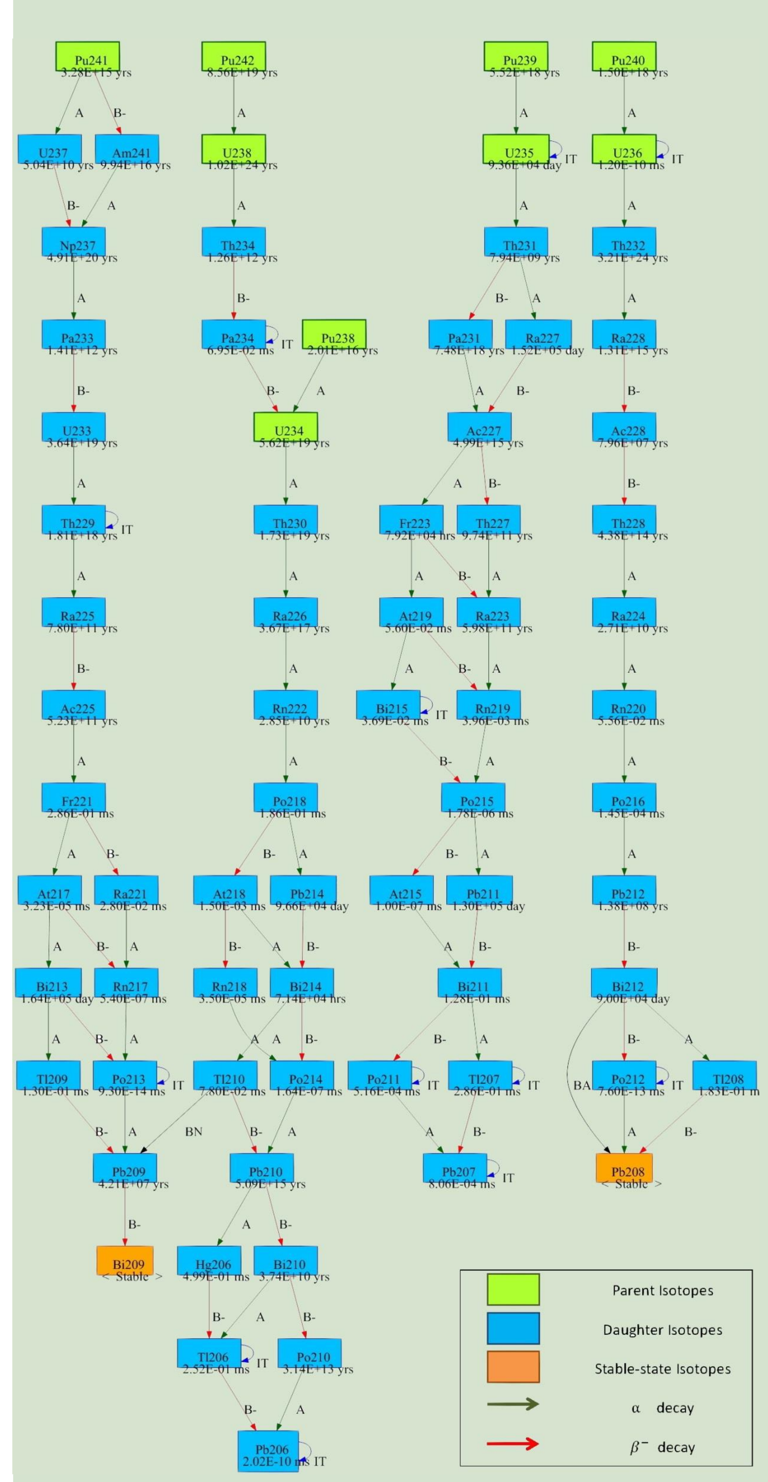
- Circle packing, a geometry where enclosure diagrams use containment to represent the hierarchy, is used to visualized nuclear material isotope composition.

Implementation

- The nuclear material sample assay taken from LANL is analyzed by dividing it into aliquots which are subject to isotopic specific tests.
- In the example, three samples measured on different dates are presented with unit circles. Within each circle are the sample's aliquots and various isotopes observed are displayed inside the aliquot circles. The area of the isotope circle is determined by the numerical value of weight percentage of that isotope within its element. (e.g. aliquot A from sample ID Sep-10 consists of U-234 (2.5% U), U-235 (73% U), U-236 (16% U), U-238 (8.7% U), Pu-239 (94% Pu) and Pu-240 (5.8% Pu).)



Directed Graph



Theory

- Nuclear material decays are modeled as a directed graph where isotopes are represented by nodes and decay events from parent to daughter are represented by directed arcs.

Implementation

- The graph displays a composite of nuclear decay chains with root parents being the various isotopic assays recorded in the sample nuclear material, including Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, U-234, U-235, U-236, and U-238.
- Types of radioactive decay and isotope half-lives are highlighted on the graph. The directed-graph of networked decaying isotopes is built to illustrate the decay network until the isotopes reach a stable state.