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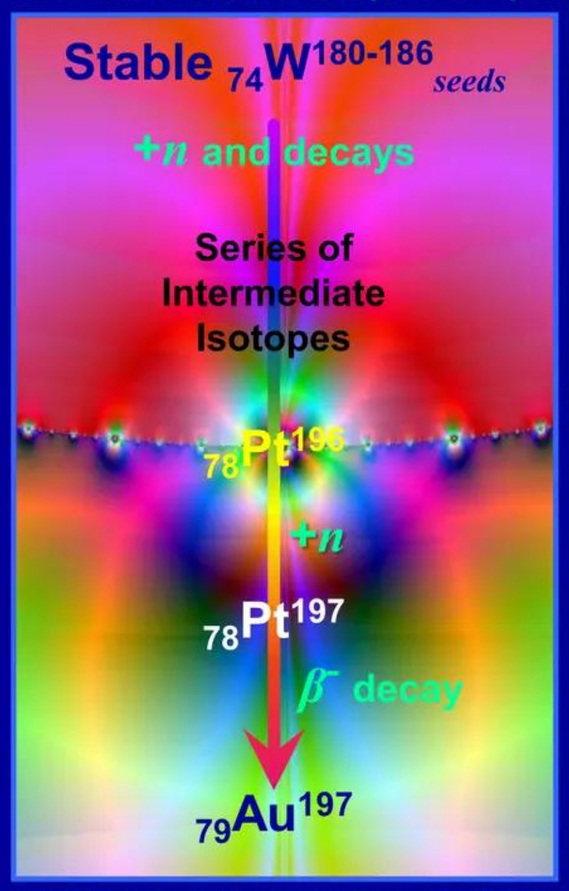
Low Energy Nuclear Reactions (LENRs)

Neutron-catalyzed LENR transmutations produce Gold from Tungsten

Mitsubishi Heavy Industries presented new data at Winter ANS meeting

Comparable results: three sets of experiments separated by as much as 88 years

Example 1
Production of Gold: one possible path



Neutron-catalyzed transmutations

Technical Comments

Lewis Larsen

President and CEO
Lattice Energy LLC
December 7, 2012

"For the truth of the conclusions of physical science, observation is the supreme Court of Appeal."

Sir Arthur Eddington
"The Philosophy of Physical Science" pp. 9 (1939)

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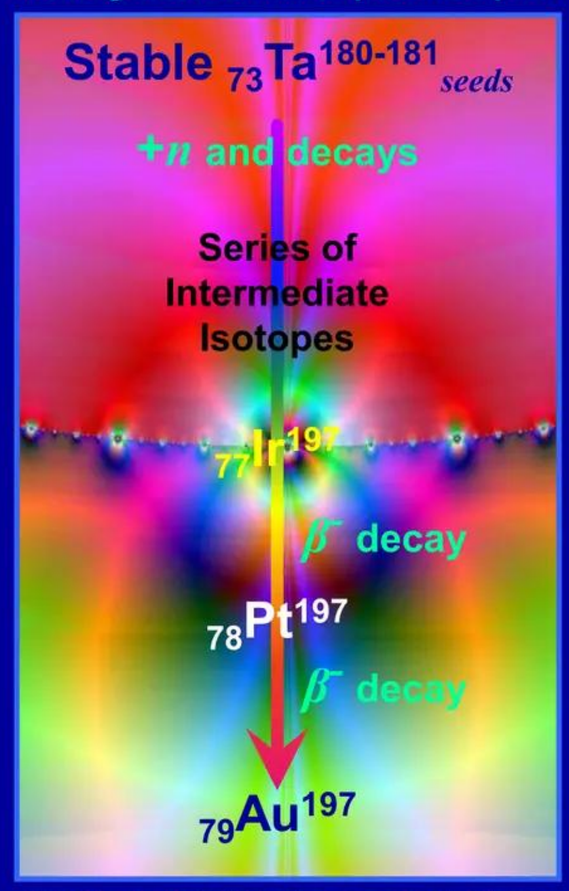
http://www.slideshare.net/lewisglarsen

Example 2
Making Gold: another possible path



Neutron-catalyzed transmutations

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Summary of technical comments

- ✓ **Widom-Larsen theory of LENRs predicts that Gold can be created via nucleosynthetic transmutation process that involves $e + p$ electroweak neutron production followed by captures of ultra low momentum (ULM) neutrons on stable isotopes of Tungsten**
- ✓ **This theoretical prediction has been effectively confirmed in data from at least three sets of published laboratory experiments that differ significantly in experimental techniques but nonetheless involve exactly the same underlying Widom-Larsen nucleosynthetic process and LENR network pathway: W → Re → Os → Ir → Pt → Au**
- ✓ **These measured data provide effectively comparable experimental confirmations of our theoretical prediction that are separated in time by as much as ~88 years; namely, Nagaoka *et al.* (Japan, 1925); Cirillo *et al.* (Italy, *circa* 2004), and just recently at the American Nuclear Society 2012 Winter Meeting session on LENRs in San Diego, CA, Yasuhiro Iwamura *et al.* (Mitsubishi Heavy Industries, Japan, 2012)**
- ✓ **Given these experimental confirmations, it opens up a future possibility that this LENR-based transmutation process could potentially convert less expensive scrap Tungsten into Platinum and Gold end-products if it can be commercialized and scaled-up from laboratory apparatus; whether this might ever be cost-competitive with conventional hard rock mining still remains an open technological question**

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Potential market applications for LENRs

Applications	Description	Target Markets
LENRs enable safe, green carbon-free nuclear energy production and power generation at reasonable cost - Vastly greater energy densities and longevity at a lower price per kWh compared to chemical power sources	Scale-up and integrate LENR heat sources w. different energy conversion technologies: e.g., develop portable battery-like devices using thermoelectrics that can convert raw heat directly to DC electricity; or, use heat to rotate a shaft for propulsion (e.g., Stirling or modern steam engines in motor vehicles)	SAFE - no radiation shielding or nuclear waste issues; could also eventually enter portable power markets and compete directly against chemical batteries, small fuel cells, and microgenerators
Bitumen extraction, heavy oil recovery, and/or oil shale processing According to Prof. K. Deffeyes of Princeton University, about 2/3 of oil remaining in the ground worldwide is classified as "heavy"	Use well-hole LENR thermal sources to heat-up bitumen or heavy oil underground: reduce production costs, enhance recovery; could use LENR heaters for *in-situ* underground upgrading and downstream process heat	Major benefit to large oil producers – can help increase long-term supplies of oil and reduce total production costs as well as its process CO_2 footprint
Develop much cleaner fission power generation technologies Use LENRs and ultra low momentum neutrons (ULMs) for triggering fission	Design new types of LENR-based subcritical fission reactors that can burn existing fissionable fuels down to stable isotopes – little or no long-lived radioactive wastes	Retrofit new ULM-neutron reactors into existing nuclear fission power systems; much better safety and lower costs
Nuclear waste treatment Transmute dangerous radioactive nuclear waste using LENRs; generate additional power from waste burn-up	Develop turnkey systems for on-site clean-up of existing worldwide inventories of fission wastes from nuclear power plants	Nuclear waste remediation and clean-up – opportunities in many countries, e.g., US, France, Japan, China, etc.
Transmutation of stable elements Produce almost any very valuable element or isotope in the periodic table at competitive costs compared to present mining and refining operations	Use LENRs to transmute less expensive elements into much more valuable ones – first do it abiologically; later migrate to methods using various species of genetically engineered bacteria	Mostly target precious and rare metals production, e.g., platinum, gold, rhodium, rare earth elements, etc

Time

First Targets

Potential Long-term Opportunities

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Contents

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LENR physics and transmutations now understood and published

Technical papers on the Widom-Larsen theory

"**Ultra low momentum neutron catalyzed nuclear reactions on metallic hydride surfaces**" Eur. Phys. J. C **46**, pp. 107 (March 2006) Widom and Larsen – initially placed on arXiv in May 2005 at http://arxiv.org/PS_cache/cond-mat/pdf/0505/0505026v1.pdf; a copy of the final *EPJC* article can be found at: http://www.newenergytimes.com/v2/library/2006/2006Widom-UltraLowMomentumNeutronCatalyzed.pdf
"**Absorption of nuclear gamma radiation by heavy electrons on metallic hydride surfaces**" http://arxiv.org/PS_cache/cond-mat/pdf/0509/0509269v1.pdf (Sept 2005) Widom and Larsen
"**Nuclear abundances in metallic hydride electrodes of electrolytic chemical cells**" http://arxiv.org/PS_cache/cond-mat/pdf/0602/0602472v1.pdf (Feb 2006) Widom and Larsen
"**Theoretical Standard Model rates of proton to neutron conversions near metallic hydride surfaces**" http://arxiv.org/PS_cache/nucl-th/pdf/0608/0608059v2.pdf (v2. Sep 2007) Widom and Larsen
"**Energetic electrons and nuclear transmutations in exploding wires**" http://arxiv.org/PS_cache/arxiv/pdf/0709/0709.1222v1.pdf (Sept 2007) Widom, Srivastava, and Larsen
"**Errors in the quantum electrodynamic mass analysis of Hagelstein and Chaudhary**" http://arxiv.org/PS_cache/arxiv/pdf/0802/0802.0466v2.pdf (Feb 2008) Widom, Srivastava, and Larsen
"**High energy particles in the solar corona**" http://arxiv.org/PS_cache/arxiv/pdf/0804/0804.2647v1.pdf (April 2008) Widom, Srivastava, and Larsen
"**A primer for electro-weak induced low energy nuclear reactions**" Srivastava, Widom, and Larsen Pramana – Journal of Physics **75** pp. 617 (October 2010) http://www.ias.ac.in/pramana/v75/p617/fulltext.pdf

Other recent documents relevant to this technical comment

Nagaoka (1925), Cirillo (*ca.* 2004), and Iwamura (2012): their results all agree

"Low Energy Neutron Reactions (LENRs): in theory, neutron-catalyzed LENR transmutations can produce Gold; already observed experimentally; may also occur naturally in the earth"

Lewis Larsen, Lattice Energy LLC [66 PowerPoint slides – not peer reviewed]
May 19, 2012 --- published by the company on SlideShare.net

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-lenr-transmutationnetworks-can-produce-goldmay-19-2012

Selected documents concerning ANS Winter meeting LENR session held on November 14, 2012:

- ✓ **Dec. 7, 2012: *New Energy Times* article by Steven Krivit article about this session (substantial part of its entire content is subscriber-only), titled, "Mitsubishi Reports Toyota Replication"**
  http://news.newenergytimes.net/2012/12/06/mitsubishi-reports-toyota-replication/
- ✓ **Dr. Yasuhiro Iwamura's 44-slide PowerPoint for presentation (free content - see Slides #26 - 29):**
  http://newenergytimes.com/v2/conferences/2012/ANS2012W/2012Iwamura-ANS-LENR.pdf
- ✓ **Iwamura's related 4-page paper published in *Transactions of the ANS* (free content - see page #3 just under Fig. 6 "*SIMS Analysis for W Transmutation Expts*"; note: cites 2006 W&L *EPJC* paper):**
  http://newenergytimes.com/v2/conferences/2012/ANS2012W/2012Iwamura-ANS-LENR-Paper.pdf
- ✓ **Online YouTube video for viewing Iwamura's live presentation at the ANS meeting (free content):**
  http://youtu.be/VefCEaLAkRw (running time is ~43 minutes; Dr. Iwamura's English is excellent)

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Historical Perspective

2012 - WLT's modern alchemy based on well-accepted nuclear science

"Alchemy, derived from the Arabic word 'al-kimia' is both a philosophy and an ancient practice focused on the attempt to change base metals into gold, investigating the preparation of the 'elixir of longevity', and achieving ultimate wisdom, involving the improvement of the alchemist as well as the making of several substances described as possessing unusual properties. The practical aspect of alchemy generated the basics of modern inorganic chemistry, namely concerning procedures, equipment and the identification and use of many current substances. Alchemy has been practiced in ancient Egypt, Mesopotamia (modern Iraq), India (modern Indian subcontinent), Persia (modern Iran), China, Japan, Korea, the classical Greco-Roman world, the medieval Islamic world, and then medieval Europe up to the 20th century, in a complex network of schools and philosophical systems spanning at least 2,500 years."

Source for above quote: Wikipedia article as of July 7, 2010

According to the WLT, LENRs and chemistry intersect on nm - μ length-scales in condensed matter systems under comparatively 'mild' conditions compared to interiors of stars, nuclear weapons, and fuel rods of operating fission reactors. Production of gold from lower-Z elements such as Tungsten (W) is not just some alchemist's fevered delusion. It is an understandable result of ULM neutron-captures on W and subsequent beta decays, both of which are presently well-accepted in mainstream nuclear science

US Atomic Energy Commission (AEC) produced Gold

Dreams of the ancient alchemists come true in the chain-reacting pile at Oak Ridge, Tenn.

U. S. Alchemists Make Gold

Applying atomic magic to aid medicine and research, radiochemists duplicate nature's elements and create new ones.

By Alden P. Armagnac

Drawings by Ray Pioch

AT Oak Ridge, Tenn., the United States Atomic Energy Commission has gone into the business of manufacturing synthetic gold. The atomic pile is the Philosopher's Stone, long sought by the ancient alchemists, which has the 24-carat touch.

Most curious part of the new enterprise is the odd behavior of the man-made gold. Though locked in the strongest vault, most of it would disappear within a week's time. Strange to say, this extraordinary way of acting actually enhances the gold's value. What makes it so desirable is the fact that it is radioactive. Hence the ray-emitting "radiogold" offers medical men a priceless tool for treating such maladies as leukemia, lymphoma and Hodgkin's disease. At one institution alone, Vanderbilt University Medical School in Nashville, Tenn., it has benefited 61 patients in the first year of use.

For therapy and for "tagging" chemicals used in research, Oak Ridge's alchemists—or "radiochemists," as they call themselves—produce scores of artificially radioactive elements like radiogold. But they are by no means limited to "freak" products that have no counterpart in nature.

MARCH 1948 159

Popular Science magazine, March 1948

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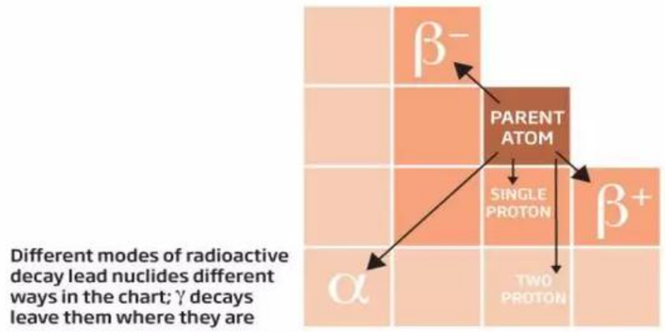
LENRs access vast areas of neutron-rich isotopic landscape

Region of neutron-catalyzed transmutation pathways discussed herein

Green nuclear process typically traverses rows of the Periodic Table



Different modes of radioactive decay lead nuclides different ways in the chart; γ decays leave them where they are

In this presentation, we will be discussing a theoretical LENR neutron-catalyzed nucleosynthetic network (yellow arrow) that begins in the region of Tantalum (Ta) and Tungsten (W) seeds, produces stable Gold ($_{79}Au^{197}$) and can extend to higher-Z elements as far as Lead (Pb) and Bismuth ($_{83}Bi^{209}$)

Stability (measured in half-lives) decreases the further away you go from the central black "line of stability"

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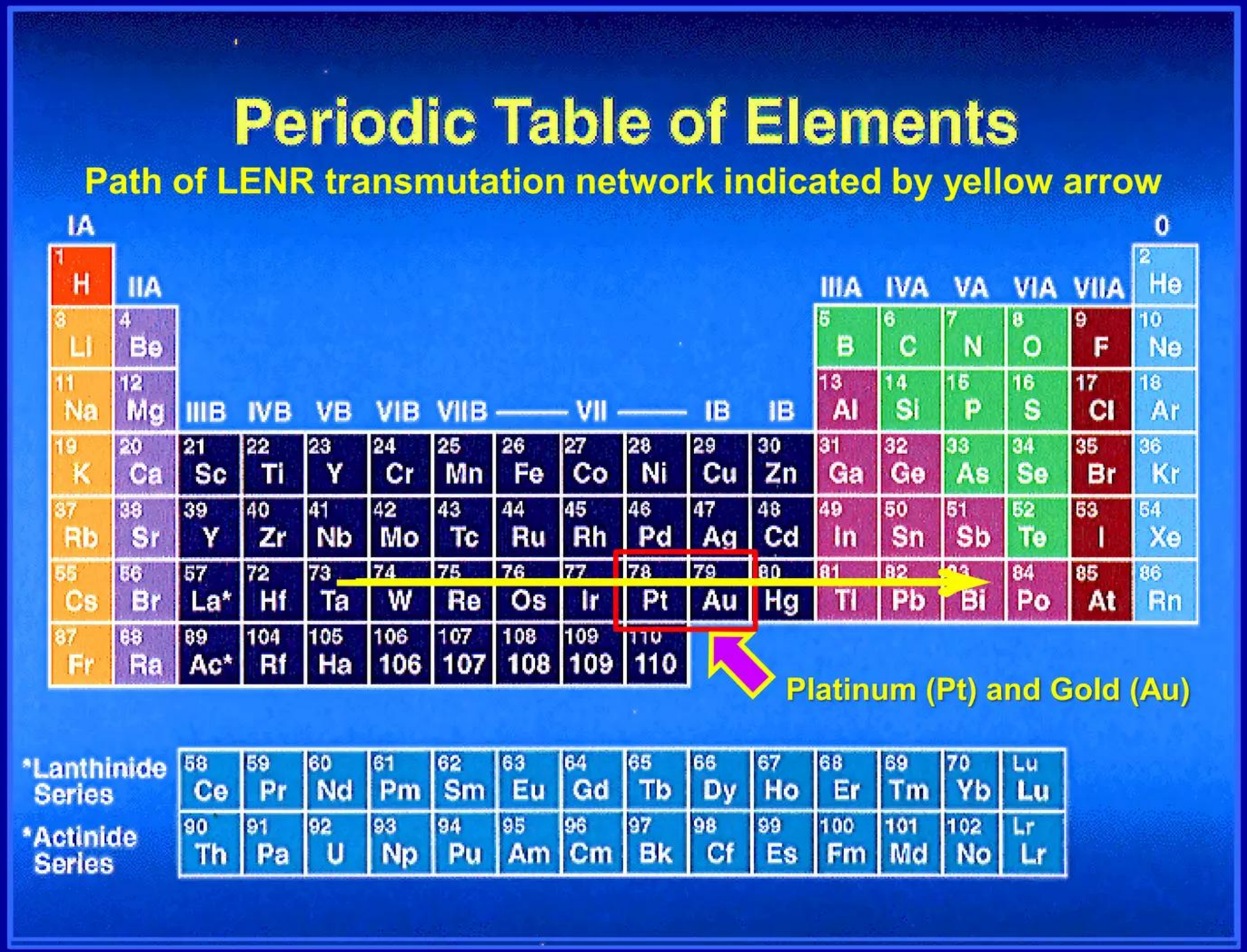
LENR Gold production traverses 6th row of Periodic Table

Begins w. stable W or Ta seeds and extends to Pb and Bismuth ($_{83}Bi^{209}$)



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$_{74}W^{180}$-seed LENR neutron-catalyzed transmutation network

Theoretical description of nucleosynthetic network for Gold

- ✓ We will now examine a hypothetical LENR transmutation network that begins with neutron captures on Tantalum (Ta) and Tungsten (W) seeds
- ✓ Explanatory legend for network diagrams appears on the next slide
- ✓ $_{74}W^{180}$-seed network produces Gold (Au) and Platinum (Pt); if sufficiently high neutron fluxes are maintained for enough time, it can reach Bismuth (Bi)
- ✓ While unstable intermediate network products undergo nuclear decays, their half-lives are generally short (especially those that are more neutron-rich); this network does *not* produce significant amounts of dangerous long-lived radioactive isotopes
- ✓ According to the WLT, in condensed matter systems LENRs occur in many tiny nm- to micron-scale surface sites or patches that only survive for several hundred nanoseconds before they die; such sites can form and re-form spontaneously
- ✓ Need input energy to make ultra cold neutrons that catalyze LENR transmutations
- ✓ Herein, we will cite and discuss compelling experimental evidence that this nucleosynthetic network in fact occurs both in the laboratory and out in Nature

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$_{74}W^{180}$-seed LENR neutron-catalyzed transmutation network

Legend:

Neutron capture and nuclear decay processes:

ULM neutron captures proceed from left to right except for upper-left corner; Q-value of capture reaction (MeV) in green either above or below horizontal arrow. →

Beta$^-$ (β^-) decays proceed from top to bottom; denoted with bright blue vertical arrow ↓ pointing down with Q-value (MeV) in blue either to left or right; beta$^+$ (β^+) decays are denoted with yellow arrow ↑ pointing upward to row above

Alpha decays, indicated with orange arrows, proceed mostly from right to left at an angle with Q-value (MeV) shown in orange located on either side of the process arrow. ↖

Electron captures (e.c.) indicated by purple vertical arrow; Q-value (MeV) to left or right. ↑

Note: to reduce visual clutter in the network diagram, gamma emissions (converted to infrared photons by heavy e^{-*} electrons) are not shown; similarly, except where specifically listed because a given branch cross-section is significant, beta-delayed decays also generally not shown; BR means "branching ratio" if >1 decay alternative

Color coded half-lives:

When known, half-lives shown as "HL = xx". Stable and quasi-stable isotopes (i.e., those with half-lives > or equal to 10^7 years) indicated by green boxes; isotopes with half-lives < 10^7 but > than or equal to 10^3 years indicated by light blue; those with half-lives < than 10^3 years but > or equal to 1 day are denoted by purplish boxes; half-lives of < 1 day in yellow; with regard to half-life, notation "? nm" means isotope has been verified by HL has not been measured

Measured natural terrestrial abundances for stable isotopes:

Indicated with % symbol; note that $_{83}Bi^{209}$ = 100% (essentially ~stable with half-life = 1.9×10^{19} yrs); $_{82}$Pb-205 ~stable with HL= 1.5×10^7 yrs;

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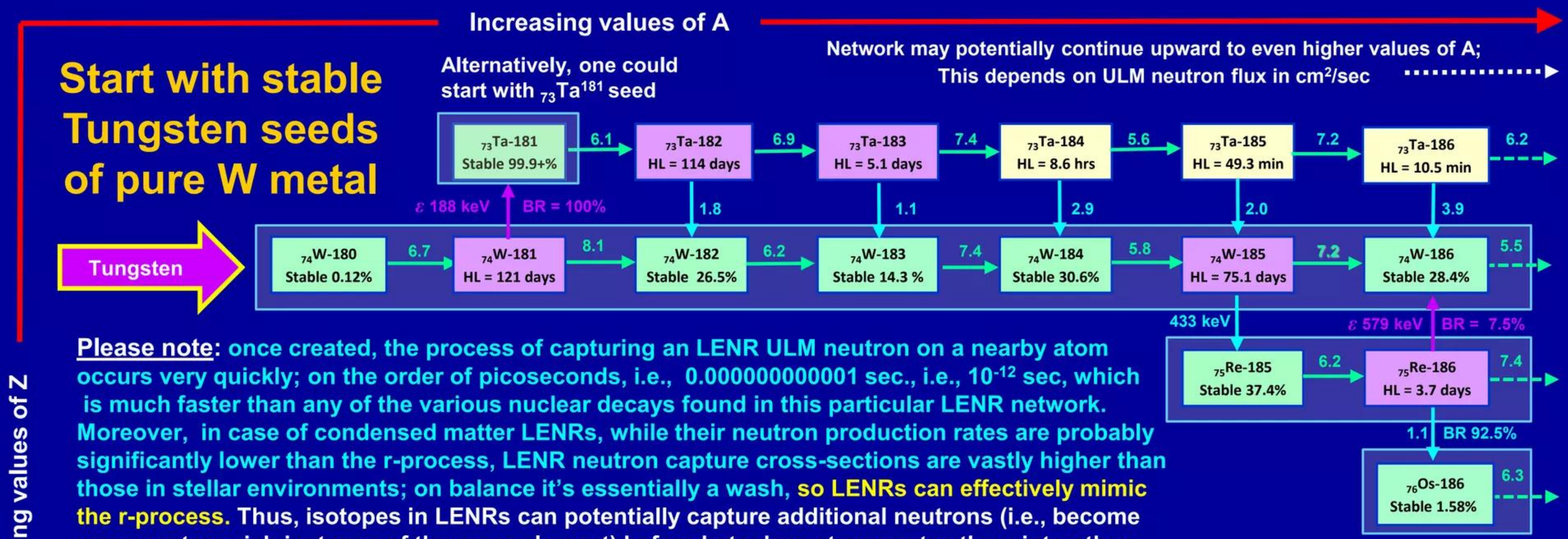
$_{74}W^{180}$-seed LENR neutron-catalyzed transmutation network



Please note: once created, the process of capturing an LENR ULM neutron on a nearby atom occurs very quickly; on the order of picoseconds, i.e., 0.000000000001 sec., i.e., 10^{-12} sec, which is much faster than any of the various nuclear decays found in this particular LENR network. Moreover, in case of condensed matter LENRs, while their neutron production rates are probably significantly lower than the r-process, LENR neutron capture cross-sections are vastly higher than those in stellar environments; on balance it's essentially a wash, so LENRs can effectively mimic the r-process. Thus, isotopes in LENRs can potentially capture additional neutrons (i.e., become more neutron-rich isotopes of the same element) before beta decay transmutes them into other higher-Z elements found in the Periodic Table. This is why the hot astrophysical r-process can make heavier elements than the s-process (i.e., go beyond Bismuth): with much higher produced neutron fluxes, the r-process can successfully traverse and bridge key regions of very short-lived isotopes that are found in ultra-neutron-rich, high-Z reaches of vast nuclear isotopic landscape

It should also be noted that all of the many atoms located within a 3-D region of space that encompasses a given ULM neutron's spatially extended DeBroglie wave function (whose dimensions can range from 2 nm to 100 microns) will compete with each other to capture such neutrons. ULM neutron capture is thus a decidedly many-body scattering process, not few-body scattering such as that which characterizes capture of neutrons at thermal energies in condensed matter in which the DeBroglie wave function of a thermal neutron is on the order of ~ 2 Angstroms. This explains why vast majority of produced neutrons are captured locally and are only rarely detected at any energies during course of LENR experiments; it also clearly explains why human-lethal MeV-energy neutron fluxes are characteristically not produced in condensed matter LENR systems.

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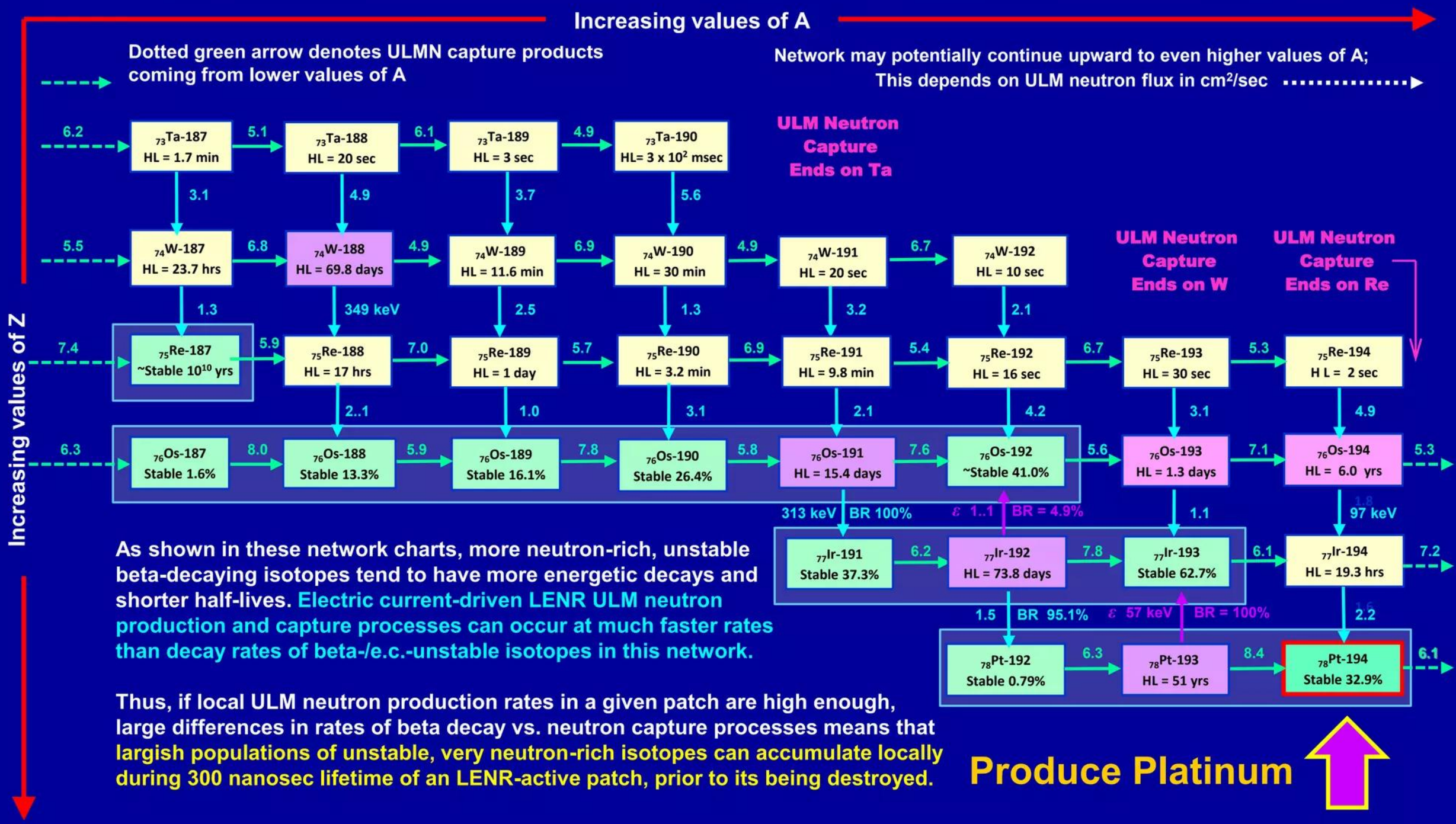
$_{74}W^{180}$-seed LENR neutron-catalyzed transmutation network



As shown in these network charts, more neutron-rich, unstable beta-decaying isotopes tend to have more energetic decays and shorter half-lives. **Electric current-driven LENR ULM neutron production and capture processes can occur at much faster rates than decay rates of beta-/e.c.-unstable isotopes in this network.**

Thus, if local ULM neutron production rates in a given patch are high enough, large differences in rates of beta decay vs. neutron capture processes means that **largish populations of unstable, very neutron-rich isotopes can accumulate locally during 300 nanosec lifetime of an LENR-active patch, prior to its being destroyed.**

Produce Platinum

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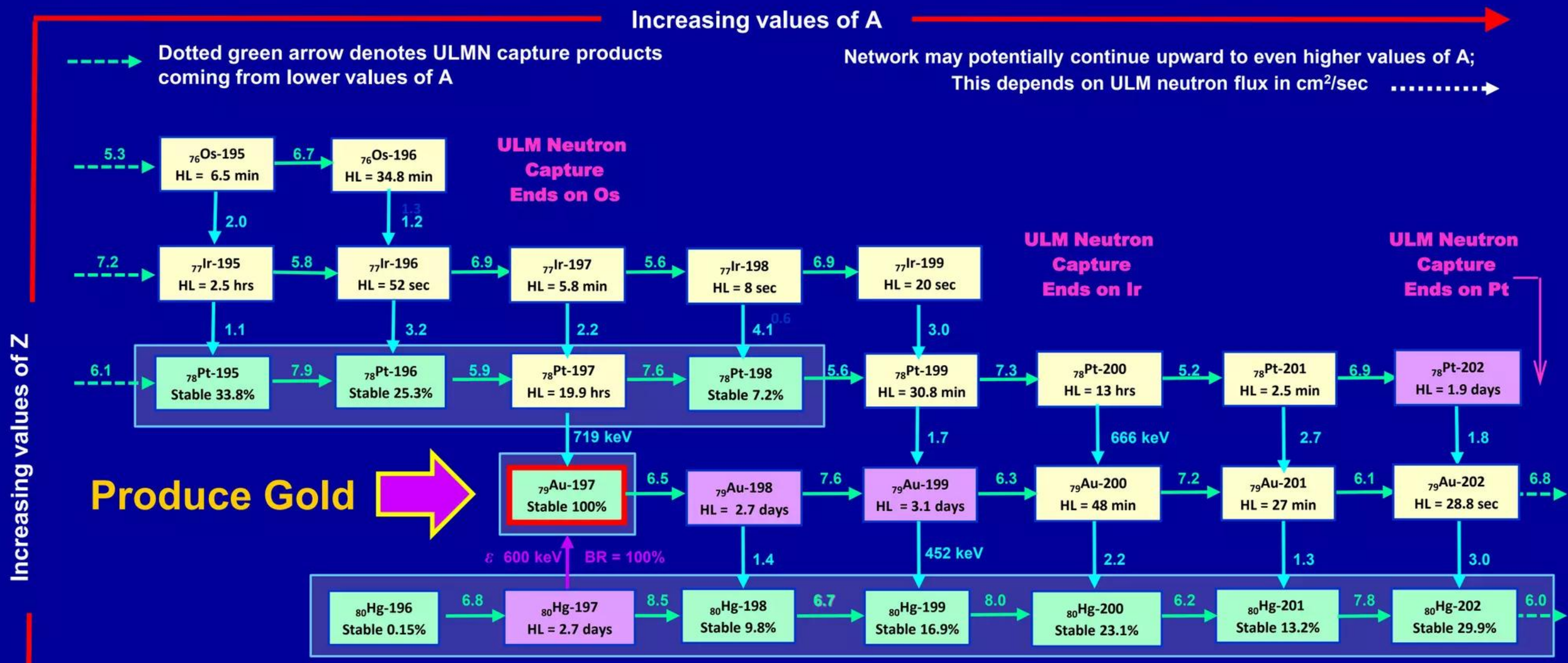
$_{74}W^{180}$-seed LENR neutron-catalyzed transmutation network



<u>Please note that</u>: Q-value for neutron capture on a given beta-unstable isotope is often larger than the Q-value for the alternative β^- decay pathway, so in addition to being a faster process than beta decay it can also be energetically more favorable. This can also contribute to creating fleeting yet substantial local populations of short-lived, neutron-rich isotopes. There is indirect experimental evidence that such neutron-rich isotopes can be produced in complex ULM neutron-catalyzed LENR nucleosynthetic (transmutation) networks that set-up and operate during brief lifetime of an LENR-active 'patch'; see Carbon-seed network on Slides # 11 - 12 and esp. on Slide #55 in http://www.slideshare.net/lewisglarsen/lattice-energy-llctechnical-overviewcarbon-seed-lenr-networkssept-3-2009

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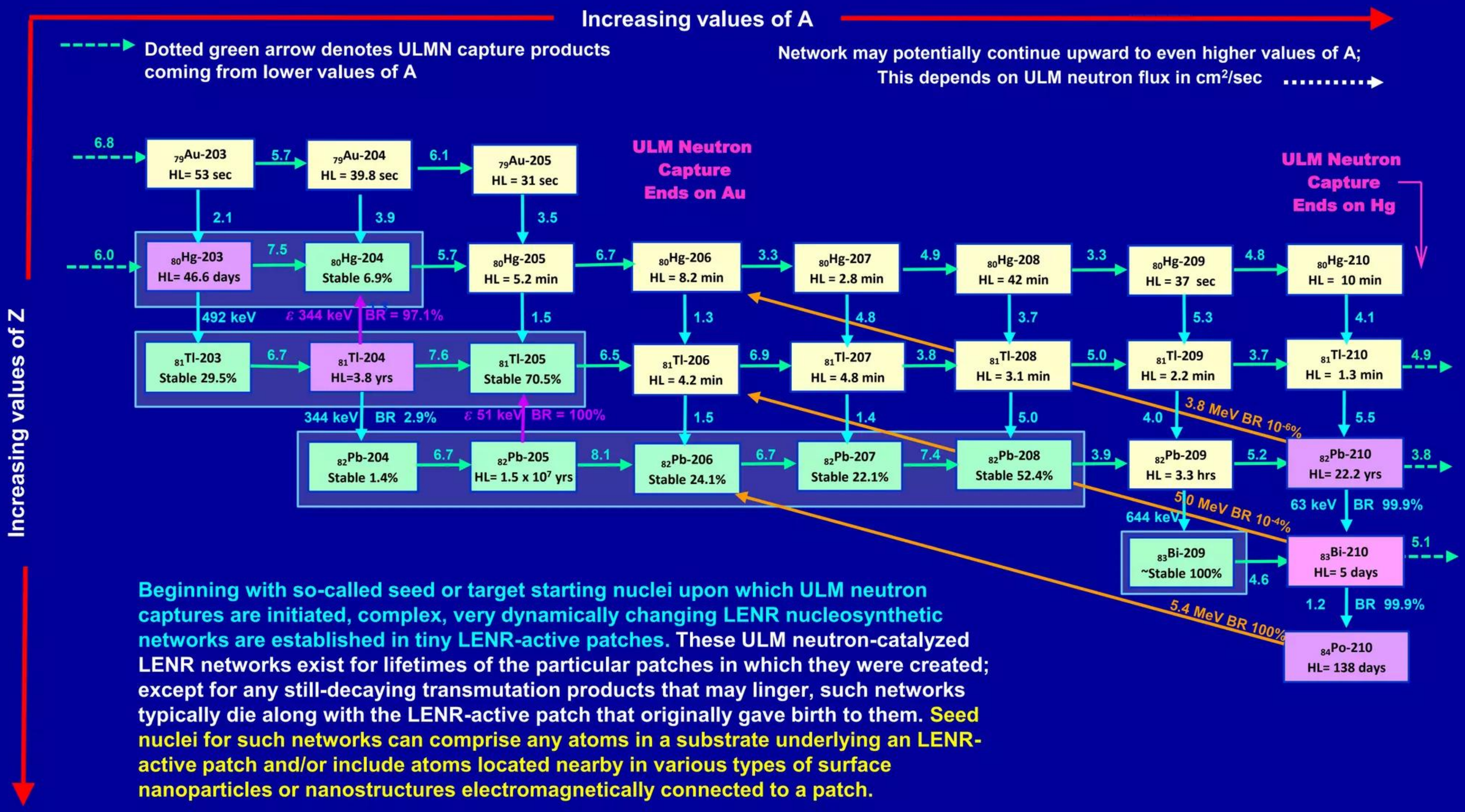
$_{74}W^{180}$-seed LENR neutron-catalyzed transmutation network



Beginning with so-called seed or target starting nuclei upon which ULM neutron captures are initiated, complex, very dynamically changing LENR nucleosynthetic networks are established in tiny LENR-active patches. These ULM neutron-catalyzed LENR networks exist for lifetimes of the particular patches in which they were created; except for any still-decaying transmutation products that may linger, such networks typically die along with the LENR-active patch that originally gave birth to them. **Seed nuclei for such networks can comprise any atoms in a substrate underlying an LENR-active patch and/or include atoms located nearby in various types of surface nanoparticles or nanostructures electromagnetically connected to a patch.**

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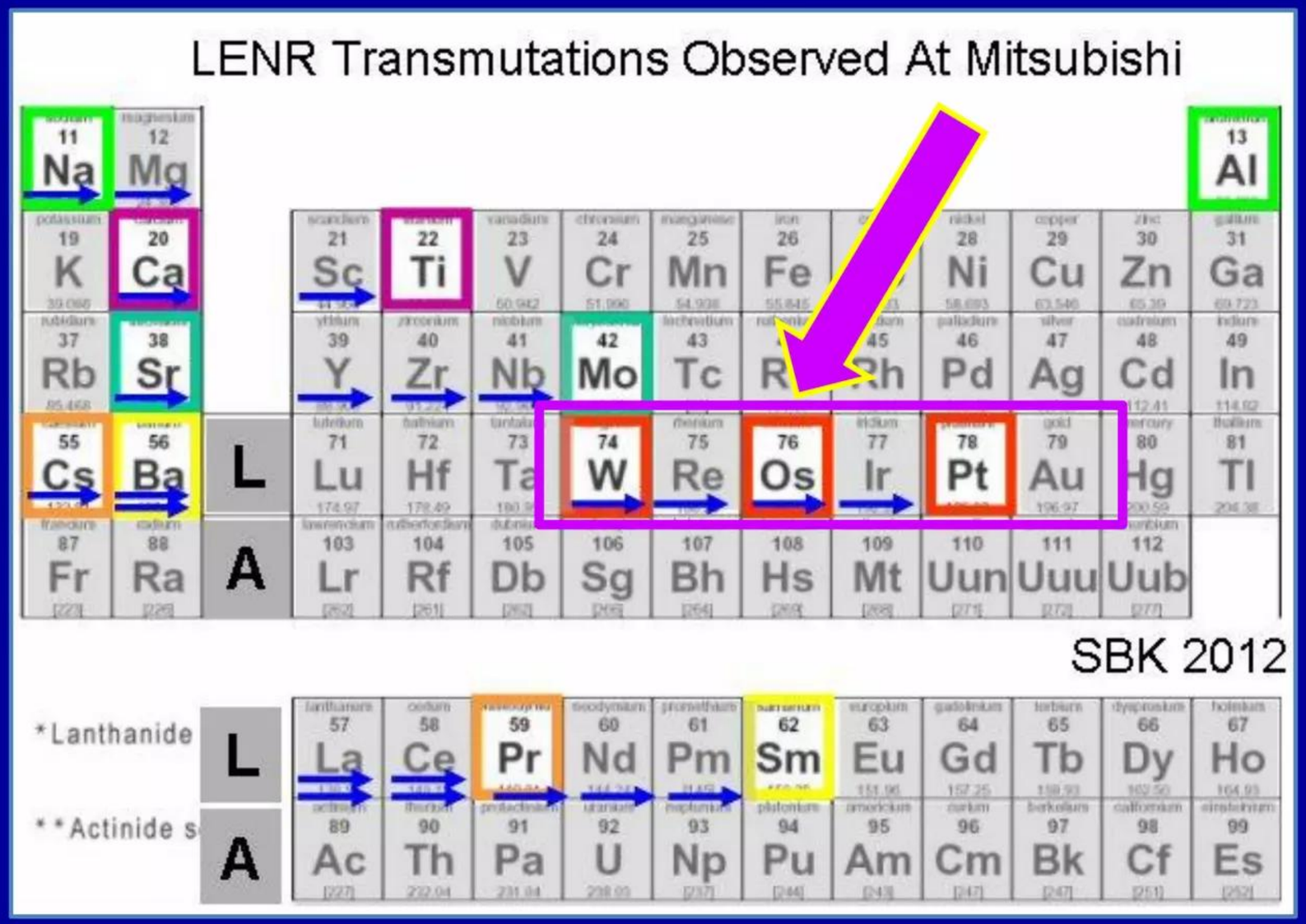
Summary: Mitsubishi's new W → Os → Pt experimental results

Sometimes just a picture is truly worth a thousand words



Source of adapted graphic is *New Energy Times*:
http://news.newenergytimes.net/2012/12/06/mitsubishi-reports-toyota-replication/

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Brief discussion: Mitsubishi's new experimental results

Lattice comments and excerpts from their ANS presentation and paper

- ✓ Technical notes: permeation technique used by Iwamura *et al.* in experiments with Tungsten (W) targets produces only relatively small fluxes of ultra low momentum neutrons; their electroweak neutron production rate was therefore insufficient to drive the W-L LENR transmutation network all the way out to the stable Gold isotope during elapsed time of the experiments (only got as far as Platinum – Pt, which was observed)
- ✓ Please carefully examine data found in PowerPoint slides, related paper published in ANS *Transactions*, and video of Dr. Iwamura's Nov. 14, 2012, ANS meeting presentation
- ✓ While Mitsubishi's carefully conducted LENR experiments did not reach Gold, they did observe key intermediate nucleosynthetic products, namely Osmium and Platinum
- ✓ Since Cirillo and Nagaoka's experiments had much higher levels of input energy in the form of electric currents, per W-L theory they would be expected to produce higher neutron fluxes and progress further into the LENR network: in fact, they did reach Gold
- ✓ Quoting directly from *New Energy Times* subscriber-only content concerning 2012 Winter ANS meeting, *"A member of the audience asked Iwamura whether other Japanese companies besides Toyota and Mitsubishi are working on LENR. Iwamura said yes but they were not disclosing it."* These companies are serious LENR players

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Production of Gold in electric arcs reported from 1924-26

Prof. Hantaro Nagaoka, famous Japanese physicist (1865 - 1950)
A brilliant, visionary man far ahead of his own time

"The [high-current electric arc] experimental procedure here sketched cannot be looked upon as the only one for effecting transmutation [of other elements into Gold]; probably different processes will be developed and finally lead to industrial enterprises … Experiments with various elements may lead to different transmutations, which will be of significance to science and industry. Meagre as is the result, I wish to invite the attention of those interested in the subject so that they may repeat the experiment with more powerful means than are available in the Far East."

Prof. Hantaro Nagaoka in *"*Letters to the Editor*," Nature*, July 18, 1925

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Production of Gold in electric arcs reported from 1924-26

Electric discharge with Hg in transformer oil: Nagaoka (Japan)

- ✓ Unlike, the comparatively unknown Wendt & Irion team at the U. of Chicago, Nagaoka was a world-renowned physicist and one of the most preeminent scientists in Japan when he began his high-current discharge transmutation experiments in September 1924
- ✓ For an appreciation of Hantaro's high scientific stature, please see Wikipedia article: http://en.wikipedia.org/wiki/Hantaro_Nagaoka
- ✓ Nagaoka was contemporary *competitor* of Ernest Rutherford; Hantaro's "Saturn model" of the atom was *only* competing model cited by Rutherford in his seminal 1911 paper on atomic nuclei
- ✓ Given the very international character of science even at that time, it is very likely that Nagaoka was aware of worldwide controversy swirling around Wendt & Irion's exploding wire experiments and of Rutherford's short but devastating critical attack on them in *Nature*
- ✓ It is also quite likely that Hantaro was aware of Robert Millikan's well-publicized views on subject of triggering transmutations with electric arcs (note: Millikan had just won a Nobel prize in physics)
- ✓ Lastly, he must have known about Miethe & Stammreich's work in Germany; they claimed to have changed Mercury into Gold in a high-voltage Mercury vapor lamp, "The reported transmutation of Mercury into Gold," *Nature* 114 pp. 197 - 198 (1924)

Please see:

"Preliminary note on the transmutation of Mercury into Gold," H. Nagaoka, *Nature* 116 pp. 95 -96 (18 July 1925)

Available for purchase on *Nature* archives at:

http://www.nature.com/nature/journal/v116/n2907/abs/116095a0.html

Abstract:

"The experiment on the transmutation of mercury was begun in September 1924, with the assistance of Messrs. Y. Sugiura, T. Asada and T. Machida. The main object was to ascertain if the view which we expressed in NATURE of March 29, 1924, can be realised by applying an intense electric field to mercury atoms. Another object was to find if the radio-active changes can be accelerated by artificial means. **From the outset it was clear that a field of many million volts/cm. is necessary for the purpose**. From our observation on the Stark effect in arcs of different metals (*Jap. Journ. Phys*., vol. 3, pp. 45â€“73) we found that with silver globules the field in a narrow space very near the metal was nearly 2 Ã -10^5 volts/cm. with terminal voltage of about 140. **The presence of such an intense field indicated the possibility of obtaining the desired strength of the field for transmutation, if sufficient terminal voltage be applied.** Though the above ratio of magnification would be diminished with high voltage, the experiment was thought worth trying, even if we could not effect the transmutation with the apparatus at hand."

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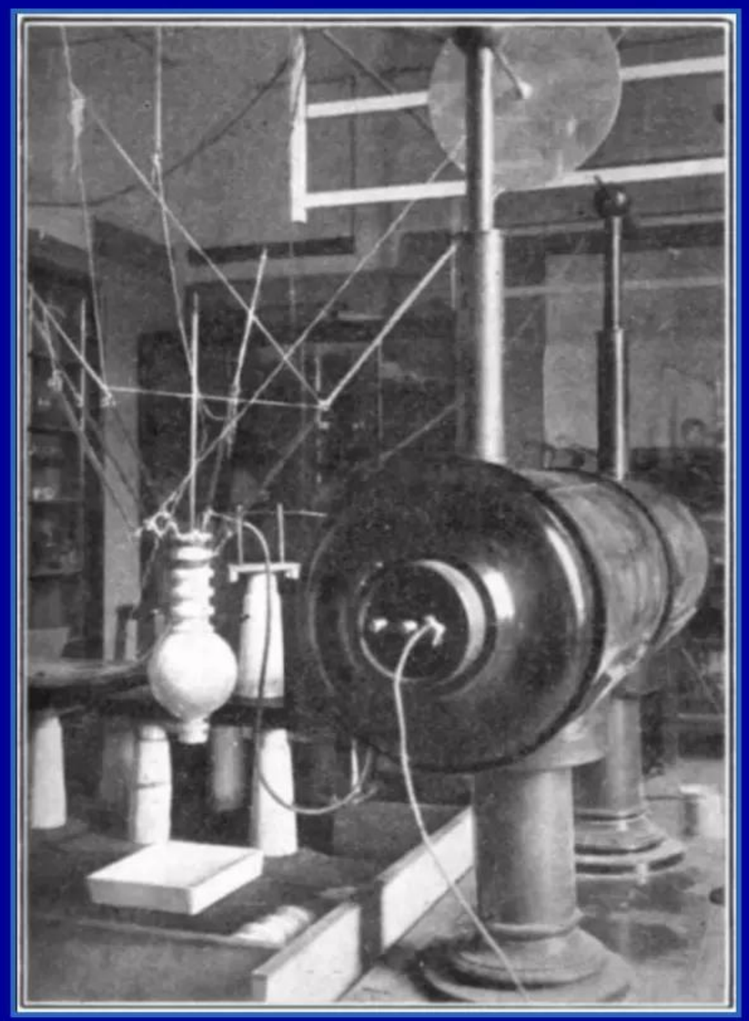
Production of Gold in electric arcs reported from 1924-26

Electric discharge with Hg in transformer oil: Nagaoka (Japan)

<u>Essence of Prof. Nagaoka's experiments</u>:

- ✓ In the simplest terms: Prof. Nagaoka created a powerful electric arc discharge between a spark gap comprising two metallic, Thorium-oxide-free Tungsten (W) electrodes (supplied by Tokyo Electric Company) bathed in a dielectric liquid "paraffin" (today referred to as "transformer oil;" general formula C_nH_{2n+2}) that was laced with liquid Mercury (Hg)
- ✓ Depending on experiment, arcing between Tungsten electrodes in oil was continued for 4 - 15 hours until, quoting, " … the oil and mercury were mixed into a black pasty mass." Please note that *Mercury readily forms amalgams with many different metals*, including Gold (Au) and Tungsten (W)
- ✓ Small flecks of Gold were sometimes quite visible to the naked eye in "black masses" produced at the end of a given experiment. They also noted that, "The Gold obtained from Mercury seems to be mostly adsorbed to Carbon."
- ✓ Microscopic assays were conducted by, "heating small pieces of glass with the Carbon," to form a so-called "Ruby glass" that can be used to infer the presence of gold colloids from visual cues very apparent under a microscope
- ✓ Critics complained about the possibility that the Gold observed was some sort of "contamination." Responding to critics, Nagaoka *et al*. further purified literally everything they could think of and also made certain that the lab environs were squeaky clean; they still kept seeing anomalous Gold. Also, in some experiments they also observed, "a minute quantity of white metal." Two years later in 1926, Nagaoka reported to *Scientific American* that they had finally been able to identify the "white metal" --- it was Platinum (Pt)

Fig. 1 – Apparatus for the electric discharge
H. Nagaoka, *Nature* July 18, 1925



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Production of Gold in electric arcs reported from 1924-26

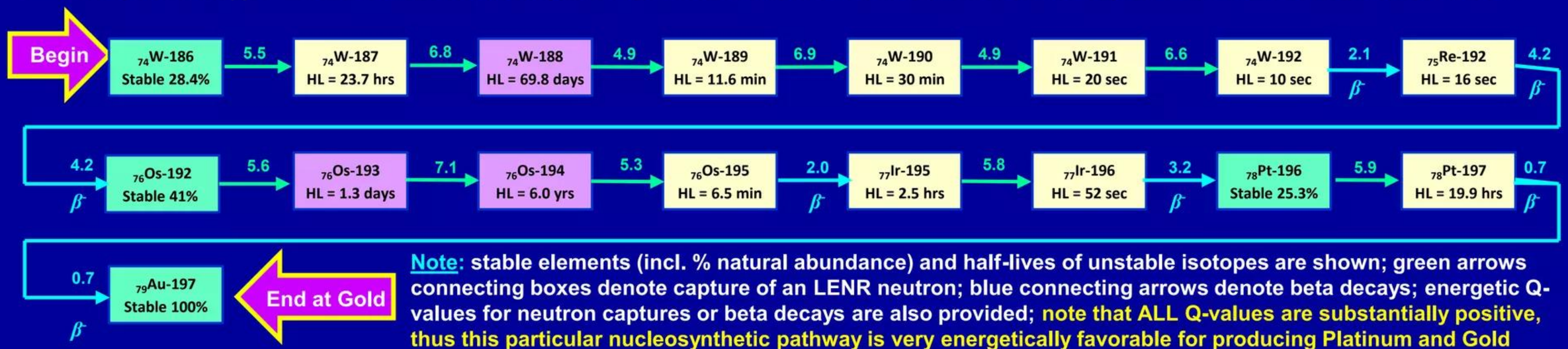
Electric discharge with Hg in transformer oil: Nagaoka (Japan)

Based on $WLT_{74}W^{180}$ LENR network , what *sequence* of reactions could have produced observed Gold and Platinum?

- ✓ **All of the ingredients for LENRs to occur were in fact present**: hydride-forming metal found therein was Tungsten (sadly, Nagaoka was unaware that Mercury was more-or-less a "red herring"); which was in contact with abundant Hydrogen (protons) in transformer oil (C_nH_{2n+2}); the Born-Oppenheimer approximation broke-down on surfaces of electrodes; and finally, there were large non-equilibrium fluxes of charged particles --- electrons in the high-current arc discharges. Unbeknownst to Nagaoka, his high-current arcs probably also produced small amounts of fullerenes, carbon nanotubes, and perhaps even a little graphene. **ULM neutron production rates via W-L weak interaction could have been quite substantial in his high-electric-current-driven experimental system because of large energy inputs**

- ✓ **What could have happened in Nagaoka's experiments was that Tungsten-seed, ULM neutron-catalyzed nucleosynthetic networks spontaneously formed.** What follows is but one example of an energetically favorable network pathway that could produce detectable amounts of the only stable Gold isotope, $_{197}Au$, within ~4 hours (shortest arc discharge period after which Au was observed). **Other alternative viable LENR pathways can produce unstable Gold isotopes, e.g., $_{198}Au$ with half-life = 2.7 days and $_{199}Au$ with HL = 3.1 days (both would be around for a time at end of a successful experiment)**

- ✓ One possible $_{74}W^{180}$-seed LENR network pathway that could produce Pt/Au in as little elapsed time as 4-5 hrs is as follows:



Note: stable elements (incl. % natural abundance) and half-lives of unstable isotopes are shown; green arrows connecting boxes denote capture of an LENR neutron; blue connecting arrows denote beta decays; energetic Q-values for neutron captures or beta decays are also provided; **note that ALL Q-values are substantially positive, thus this particular nucleosynthetic pathway is very energetically favorable for producing Platinum and Gold**

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Production of Gold in electric arcs reported from 1924-26

Final remarks re Nagaoka; today, Au is emitted from catalytic converters

Nagaoka's reported results may have been right , i.e., Au and Pt *were* produced:

- ✓ **Plausible LENR nucleosynthetic pathway shown in the previous Slide suggests that Nagaoka *et al.*'s claimed observations of macroscopically visible particles of Gold in their *ca.* 1920s electric arc experiments in transformer oil could very well have been correct**
- ✓ **Note that stable Gold can also be produced via neutron capture on stable $_{80}Hg^{196}$ which creates unstable $_{80}Hg^{197}$ that has a half-life of 2.7 days and decays via electron capture into stable $_{79}Au^{197}$. However, natural abundance (0.15%) of $_{80}Hg^{19}$ initially present in Nagaoka's 1920s experiments was so low that this alternative pathway cannot plausibly account for observed production of *macroscopically visible quantities of Au and Pt flecks***
- ✓ **It is puzzling why this seemingly fruitful line of inquiry appears to have died-out worldwide by the time Chadwick experimentally verified the neutron's existence in 1932? *Oddly, it does not appear that anyone else ever tried to exactly duplicate Nagaoka's experiments*. However, there were well-publicized failures to replicate Miethe & Stammreich's Gold experiments that were extensively chronicled in *Scientific American*. Interestingly, Miethe's experimental apparatus consisted of Mercury arc lamps with Tungsten electrodes inside *evacuated* quartz tubes; *no transformer oil was present in those arcs*. Perhaps Nagaoka's decision to use oil was exceedingly fortuitous: by doing so, he inadvertently guaranteed that his apparatus contained enormous quantities of hydrogen for making ULM neutrons**
- ✓ **Please take note of the quotation from Prof. Nagaoka reproduced on earlier Slide #18. In saying what he said, Hantaro clearly believed that some sort of commercial transmutation technology would eventually be developed at some point in the future. Thus, in our opinion not only was he a humble, brilliant scientist; he was also a rather bold visionary thinker --- truly a man far ahead of his own time**
- ✓ **Interestingly, in the present era it is certainly possible that minute quantities of Gold are actually being produced in automobile catalytic converters via the transmutation of some Platinum present in the converters: at right, please see citation to a 2003 paper in *Applied Geochemistry* and URL to yet another Lattice SlideShare presentation dated June 25, 2010**

Re other possibly anomalous sources of Gold:

G. Dongarra, D. Varrica, and G. Sabatino, "Occurrence of Platinum, Palladium, and Gold in pine needles of Pinus pinea from the city of Palermo (Italy)," *Applied Geochemistry* 18 pp. 109-116 (2003)

Quoting: "Preliminary data on the presence of Pt, Pd and Au in airborne particulate matter from the urban area of Palermo (Sicily, Italy) are presented. They were obtained by analysing 40 samples of pine needles (Pinus pinea L.) collected in and around the city. **Observed concentrations range from 1 to 102 μg/kg for Pt, 1 to 45 μg/kg for Pd and 22 to 776 μg/kg for Au. Platinum and Pd concentrations in pine needles are up to two orders of magnitude higher than their crustal abundances. They exhibit a high statistical correlation (R^2=0.74) which suggests a common origin."**

"Precious metal concentrations measured within the city centre are much higher than those occurring outside the town. The distribution patterns of Pt and Pd in the study area are compared to the distributions of Au and Pb. **Gold is enriched at the same sites where Pt and Pd are enriched, while Pb shows some discrepancies. The most probable local source of all of these elements is traffic.** Average Pt and Pd emissions in the city area are estimated to be about 136 and 273 g/a, respectively."

Discussed in Lattice presentation found at URL:

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-len-rs-in-catalytic-convertersjune-25-2010

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Cirillo & Iorio also produced Gold from Tungsten *ca.* 2004

Modern Italian work is ~theoretically equivalent to Nagaoka's

Electric discharge with $_{74}W^{180\text{-}186}$ cathode in alkaline H_2O instead of C_nH_{2n+2} + Hg

- ✓ Unaware of Nagaoka's much earlier work, *ca.* 2003 - 2004 D. Cirillo and E. Iorio in Italy inadvertently designed and constructed an LENR experimental system involving electric discharges and Tungsten electrodes that, from a WLT perspective, was ~theoretically equivalent to Nagaoka's 1920s experimental set-up; they subsequently observed and reported transmutation products that were consistent with Nagaoka's results reported in *Nature* and operation of the $_{74}W^{180}$-seed transmutation network that is described herein
- ✓ Cirillo & Iorio's modern set-up utilized an "aqueous electrolyte plasma glow-discharge cell"
- ✓ From an abstract broad-brush theoretical viewpoint, main differences between their new experimental system and Nagaoka's set-up of 80 years earlier was that: (1) in Cirillo & Iorio's experiments the protons needed to produce LENR neutrons came from hydrogen atoms in water (H_2O) instead of in transformer oil (C_nH_{2n+2}); and (2) no Mercury (Hg) was initially present in their system, so $_{80}Hg^{196} + n \rightarrow {}_{80}Hg^{197} \rightarrow {}_{79}Au^{197}$ electron-capture reaction can clearly be excluded as potential source of surface Gold they observed with SEM-EDX

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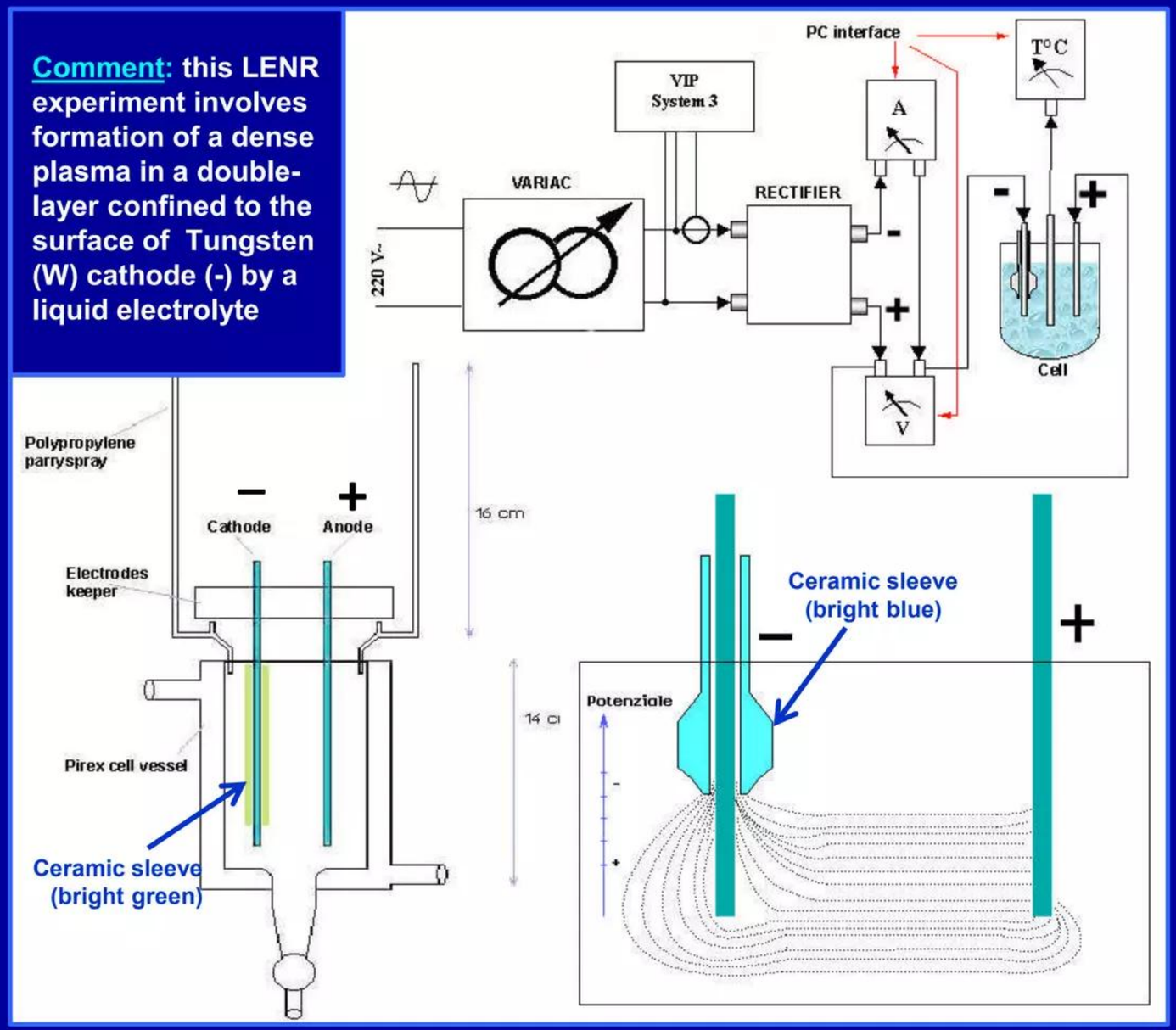
Cirillo & Iorio also produced Gold from Tungsten *ca.* 2004

Schematic overview of Cirillo & Iorio's LENR experimental apparatus

Comment: this LENR experiment involves formation of a dense plasma in a double-layer confined to the surface of Tungsten (W) cathode (-) by a liquid electrolyte



Comment on their experimental data:

Unbeknownst to the experimenters, they may have had either Barium (Ba) titanate and/or Dysprosium (Dy) as component(s) in the composition of the dielectric ceramic sleeve that was partially covering the cathode immersed in the electrolyte; Ba and/or Dy are commonly present in such ceramics. Under the stated experimental conditions, Ba and Dy could easily leach-out from the surface of the ceramic into the electrolyte, creating yet another target element that could migrate onto the surface of their Tungsten (W) cathode. Since none of the potential intermediate transmutation products such as Nd (Neodymium), Sm (Samarium), and Gd (Gadolinium) were observed, it is possible that there may have been LENR ULM neutron captures starting with Dy → Er (Erbium) → Tm (Thulium) → Yb (Ytterbium), LENR transmutation products that were also observed in these experiments

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Cirillo & Iorio also produced Gold from Tungsten *ca.* 2004

Used SEM-EDX to detect intermediate products of $_{74}W^{180}$-seed network

- ✓ Quoting: "… electrodes are cylindrical rods with a diameter of 2.45 mm, and a length of 17.5 cm … both are made of pure Tungsten [W] …cathode is partially covered with a ceramic sleeve, which allows … control [of] the dimensions of … exposed cathode surface submerged in … solution."

- ✓ In their experiments, Rhenium (Re), Osmium (Os), and Gold (Au) were observed post-experimentally as nuclear transmutation products on the Tungsten (W) cathode surface; other LENR transmutation products were also observed (please see our Comment on previous Slide)

- ✓ According to WLT, operation of the $_{74}W^{180}$-seed LENR transmutation network could in theory produce a nucleosynthetic pathway of W → Re → Os → Ir → Pt → Au ; in fact, Re, Os, and Au were claimed to have been observed by Cirillo & Iorio in these modern experiments

- ✓ Theoretically similar to Nagaoka's experiments in 1920s: LENR transmutation products were observed, Gold (Au) in particular, that can be explained with neutron captures and beta$^-$ decays beginning with Tungsten (W) as a seed

Paper (conference presentation - not peer-reviewed):

D. Cirillo and V. Iorio, "Transmutation of metal at low energy in a confined plasma in water" on pp. 492-504 in *Condensed Matter Nuclear Science – Proceedings of the 11th International Conference on Cold Fusion*, J-P. Biberian, ed., World Scientific (2006)

Free copy of paper available at:

http://www.lenr-canr.org/acrobat/CirilloDtransmutat.pdf

Abstract:

"Energetic emissions have been observed from an electrolytic cell when tungsten [W] electrodes are used to generate a confined plasma close to the cathode immersed an alkaline solution. In addition, energy generation has been observed, always close to the cathode, along with the appearance of new chemical elements in the experimental apparatus. These elements were not present in the cell before the experiment. This observation is proof of nuclear transmutations occurring within the cell. The results of this research and a theoretical model of the phenomenon were shown for the first time on April 18, 2004 during the second Grottammare (Ap) ONNE meeting in Italy."

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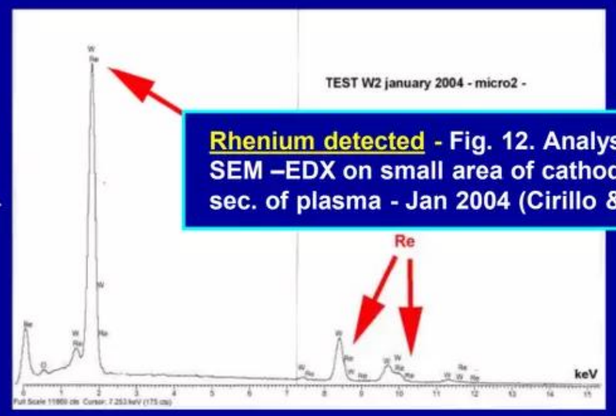
Cirillo & Iorio also produced Gold from Tungsten *ca.* 2004

Used SEM-EDX to detect intermediate products of $_{74}W^{180}$-seed network

Rhenium (Re) →



Rhenium detected - Fig. 12. Analysis conducted with an SEM –EDX on small area of cathode surface after 4000 sec. of plasma - Jan 2004 (Cirillo & Iorio, 2006)

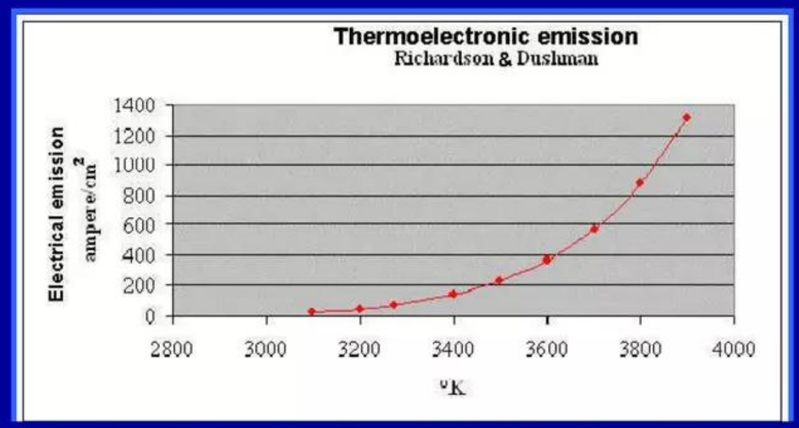
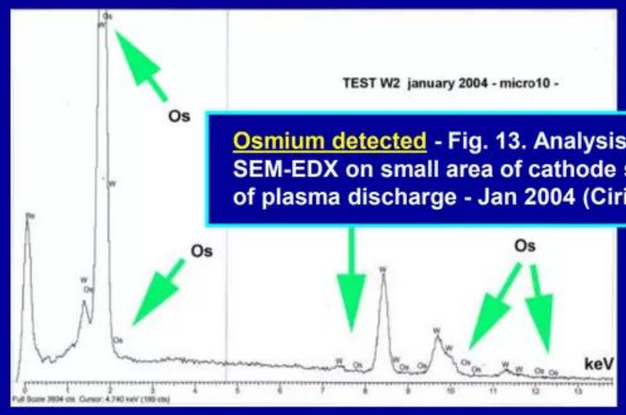


Fig. 10 – Tungsten thermionic emission (Cirillo & Iorio, 2006)

Osmium (Os) →



Osmium detected - Fig. 13. Analysis conducted with an SEM-EDX on small area of cathode surface after 4000 sec. of plasma discharge - Jan 2004 (Cirillo & Iorio, 2006)

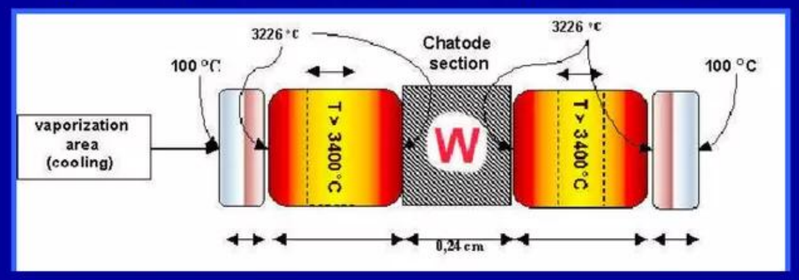
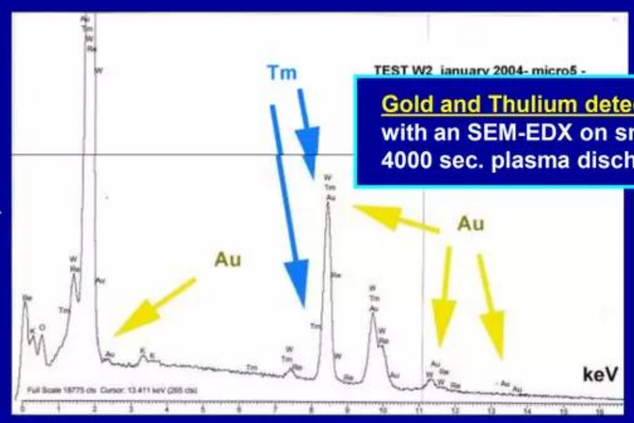


Fig. 11 – View of the plasma heat transfer mechanism (Cirillo & Iorio, 2006)

Gold (Au) and Thulium (Tm)
See comment on earlier Slide re Thulium →



Gold and Thulium detected - Fig. 14. Analysis conducted with an SEM-EDX on small area of cathode surface after 4000 sec. plasma discharge - Jan 2004 (Cirillo & Iorio, 2006)

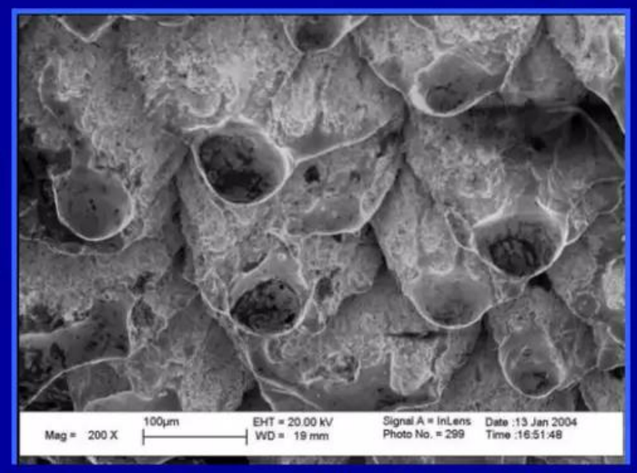


Fig. 9 – Tungsten fusion area [after 4,000 sec.] (Cirillo &Iorio, 2006)

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Final thoughts and conclusions

"An era can be said to end
when its basic illusions are exhausted."

Arthur Miller, American playwright and essayist
"When it came apart," *New York Magazine*
Dec. 30, 1974 - Jan. 6, 1975

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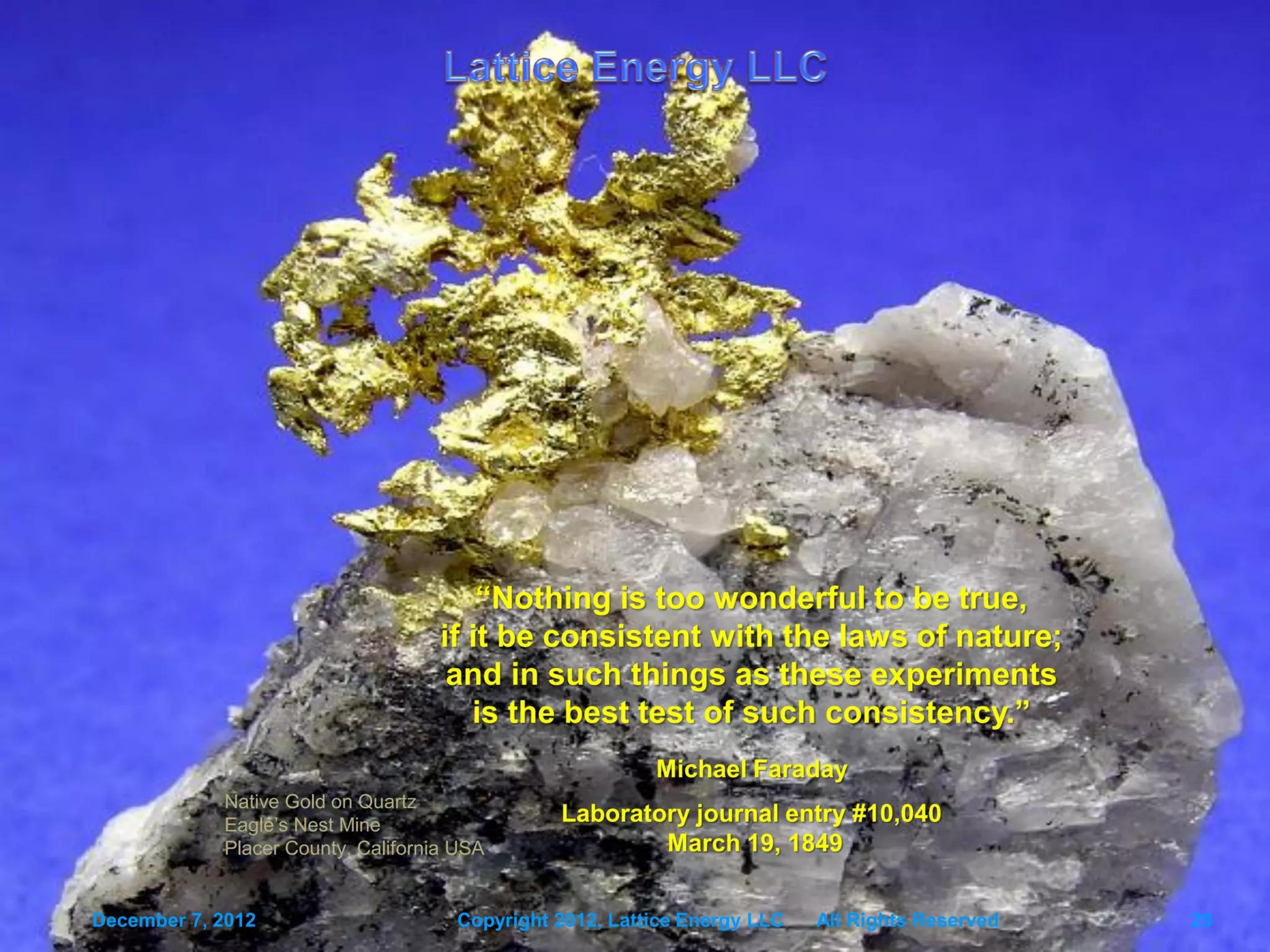
Final thoughts and conclusions

- ✓ **Herein, we have outlined a hypothetical WLT LENR neutron-catalyzed transmutation network that produces stable Platinum and Gold end-products from Tungsten seed scrap metal feedstock**
- ✓ **Published third-party data has been referenced which strongly suggests that W → Au precious metals production by WLT LENR transmutations was effectively observed in multiple laboratory experiments with measurements dating as far back as mid-1920s**
- ✓ **Speculative analysis of the potential economics of future W → Pt → Au transmutation factories for production of precious metals such as Gold and Platinum suggests that, if present relative price relationship of Tungsten vs. Gold and Platinum were to continue into the future, conversion of Tungsten into precious metals has definite potential to become a highly profitable business activity. If such processes can be scaled-up volume-wise and production costs reduced further by riding the "experience curve," LENRs might even compete with conventional mining, perhaps within <10 - 15 years**
- ✓ **Lattice would be interested in strategic partnering with a large established company in the gold mining or metals business. We are also willing to engage in fee-based private consulting with such companies as well as with hedge fund operators and central banks wishing to assess the potential long-term impact of LENR transmutation technology on their present Gold-related investments, assuming LENR technology can be successfully commercialized over time**



**“Nothing is too wonderful to be true,
if it be consistent with the laws of nature;
and in such things as these experiments
is the best test of such consistency.”**

Michael Faraday

**Laboratory journal entry #10,040
March 19, 1849**

Native Gold on Quartz
Eagle’s Nest Mine
Placer County, California USA