Commercializing a Next-Generation Source of Safe Nuclear Energy

Low Energy Nuclear Reactions (LENRs)

Nucleosynthetic Networks Beginning with Nickel 'Seed' Nuclei, Why Cascades of Fast Beta-Decays are Important, and Why end-products of LENR networks are mostly stable isotopes

Technical Overview

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March 24, 2011

"Out of intense complexities , intense simplicities emerge."

Winston Churchill

W-L mechanism in condensed matter LENR systems

Weak interaction processes are very important in LENRs

1. E-M radiation on metallic hydride surface increases mass of surface plasmon electrons

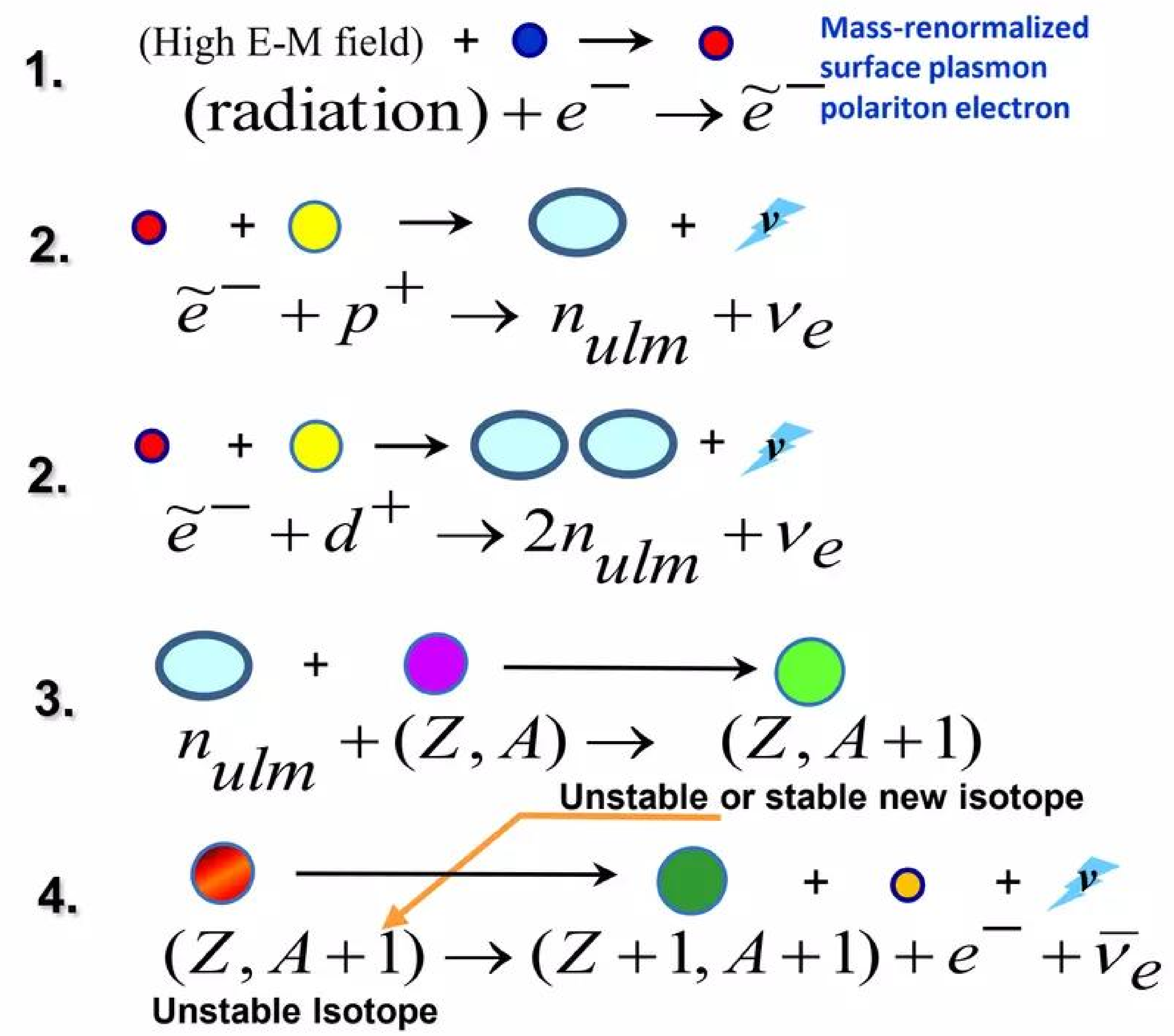
2. Heavy-mass surface plasmon polariton electrons react directly with surface protons (p^+) or deuterons (d^+) to produce ultra low momentum (ULM) neutrons (n_{ulm} or $2n_{ulm}$, respectively) and an electron neutrino (ν_e)

3. Ultra low momentum neutrons (n_{ulm}) are captured by nearby atomic nuclei (Z, A) representing some element with charge (Z) and atomic mass (A). ULM neutron absorption produces a heavier-mass isotope ($Z, A+1$) via transmutation. This new isotope ($Z, A+1$) may itself be a stable or unstable, which will perforce eventually decay

4. Many unstable isotopes β^- decay, producing: transmuted element with increased charge ($Z+1$), ~ same mass ($A+1$) as 'parent' nucleus; β^- particle (e^-); and an antineutrino

➡ <u>Note</u>: colored shapes associated with diagram on next Slide

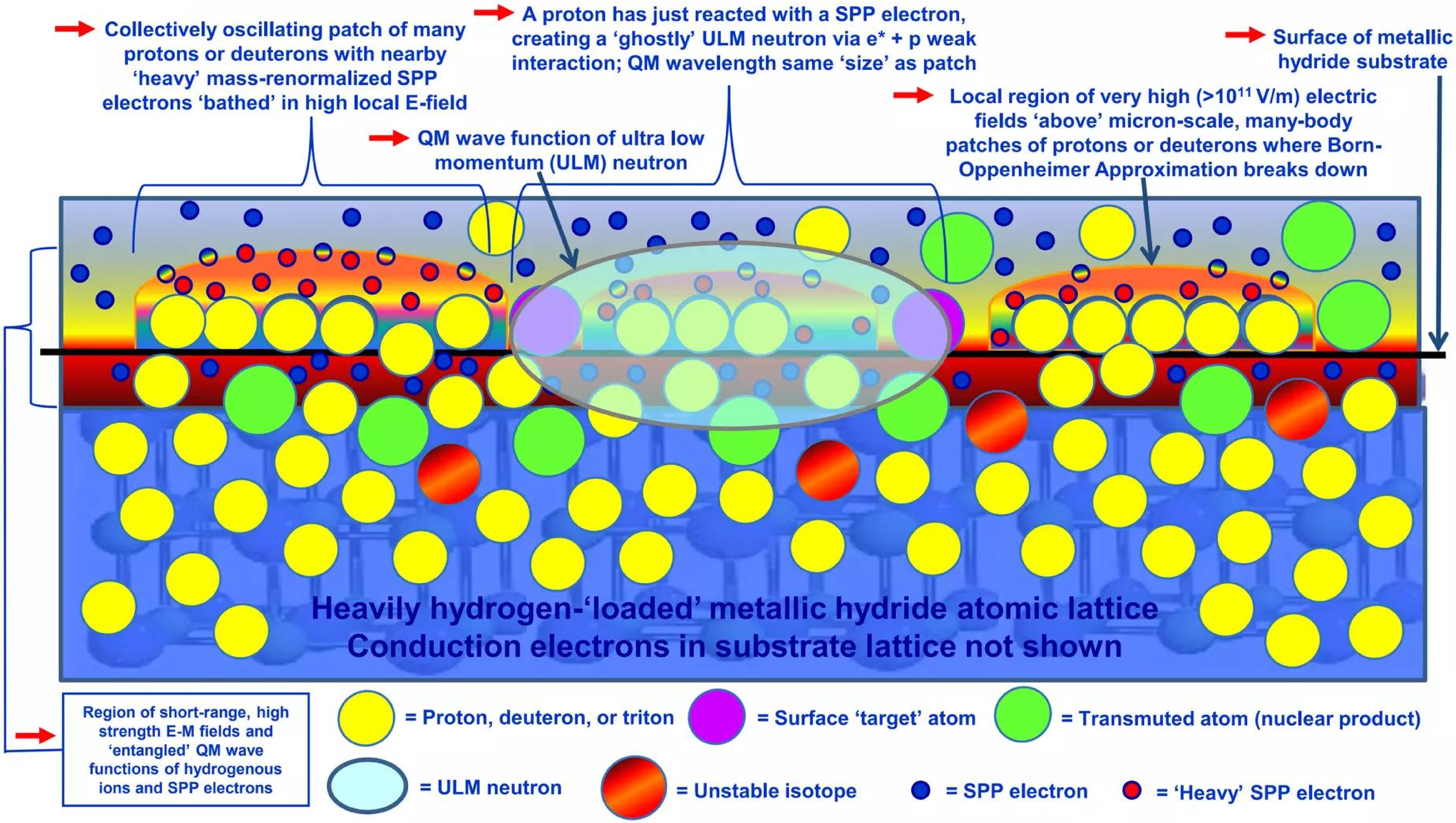
➡ **No strong interaction fusion or heavy element fission occurring below; weak interaction $e + p$ or $e + d$**



➡ **Weak interaction β^- decays (shown above), direct gamma conversion to infrared (not shown), and α decays (not shown) produce most of the excess heat calorimetrically observed in LENR systems**

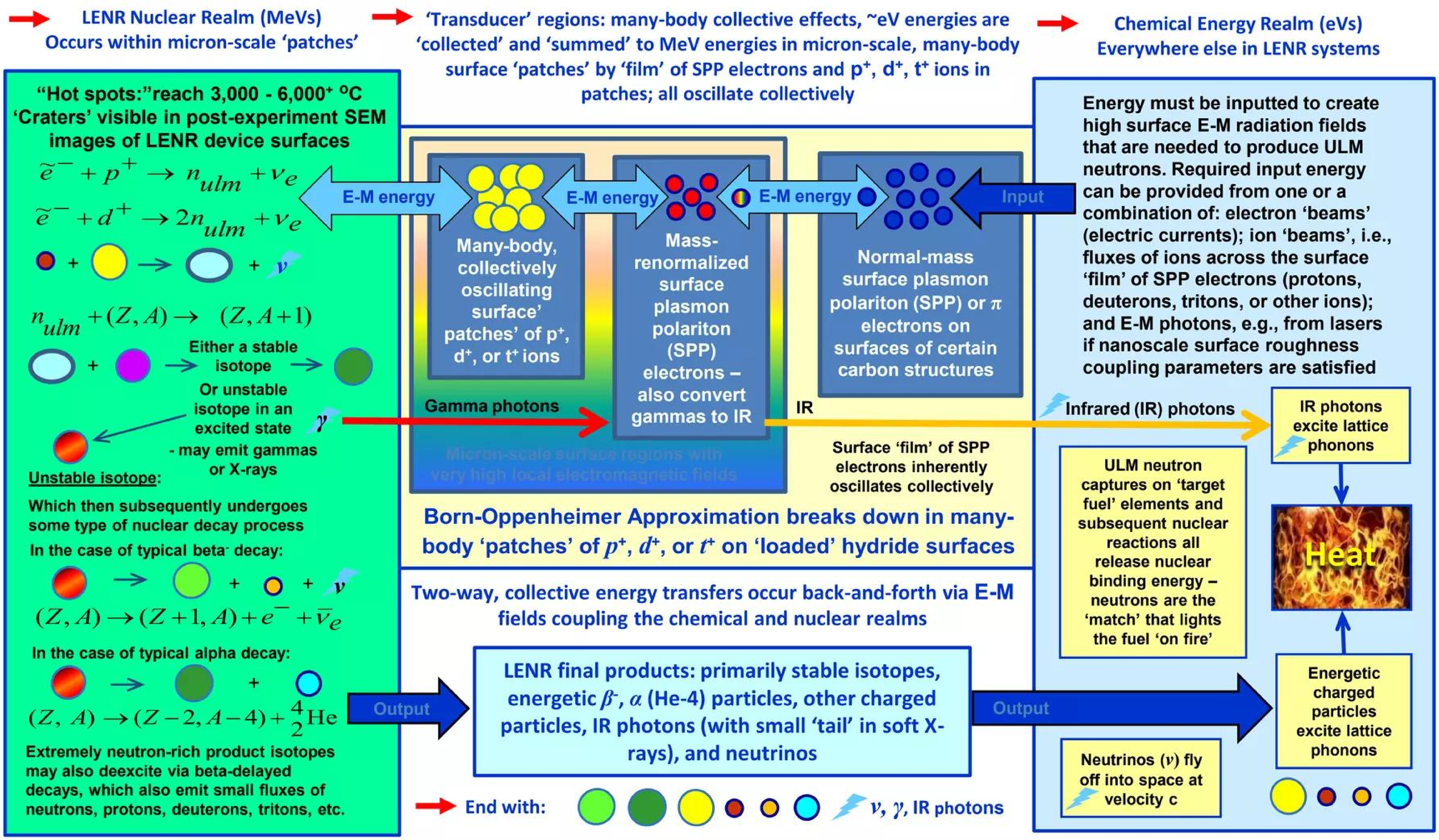
Conceptual details: W-L mechanism in metallic hydrides

Side view – not to scale – charge balances in diagram only approximate



High level overview: W-L mechanism in condensed matter

Chemical and nuclear energy realms can interconnect in small regions



Technical side note re ULM neutron capture cross-sections

- ✓ **Unlike energetic neutrons produced in most nuclear reactions, collectively produced LENR neutrons are effectively 'standing still' at the moment of their creation in condensed matter. Since they are vastly below thermal energies (ultra low momentum), ULM neutrons have huge DeBroglie wavelengths (from *nm* to ~100 *microns*) and accordingly large capture cross-sections on nearby nuclei; most or all will be locally absorbed; few will be detectable as 'free' neutrons**

- ✓ **For the vast majority of stable and unstable isotopes, their neutron capture cross-section (relative to measurements of cross-sections at thermal energies where *v* = 2,200 *m/sec* and neutron DeBroglie wavelength is ~2 *Angstroms*) is proportional to ~1/*v*, where *v* is velocity of a neutron in *m/sec*. Since *v* is extraordinarily small for ULM neutrons, their capture cross-sections on atomic nuclei will therefore be correspondingly larger. After being collectively created, an enormous percentage of the ULMNs produced will be locally absorbed before scattering on nearby atoms can elevate them to thermal kinetic energies; per Prof. S. Lamoreaux (Yale) thermalization would require ~0.1 to 0.2 *msec*, i.e. 10^{-4} *sec*., a very long time on typical 10^{-16} - 10^{-19} *sec*. time-scale of nuclear reactions**

***Please note*: ultra low momentum (ULM) neutrons have enormous absorption cross-sections on 1/v isotopes. For example, Lattice has estimated the ULMN fission capture cross-section on U-235 to be ~1 million barns (b) and on Pu-239 at 49,000 b, vs. ~586 b and ~752 b, respectively, for 'typical' neutrons at thermal energies**

A neutron capture expert recently estimated the ULMN capture cross-section on He-4 at ~20,000 b vs. a value of <1 b for thermal neutrons; this is a huge increase

By comparison, the highest known thermal n capture cross section for any stable isotope is Gadolinium-157 at ~49,000 b

The highest measured cross-section for any unstable isotope is Xenon-135 at ~2.7 million b

***Crucial technical point*: ULMNs have many-body scattering, NOT 2-3 body scattering as, for example, in plasmas or thermalized neutrons traveling through condensed matter**

Decays of Neutron-rich Halo Nuclei More Complicated - I

Can dynamically vary their decay 'choices' depending on their 'environment'

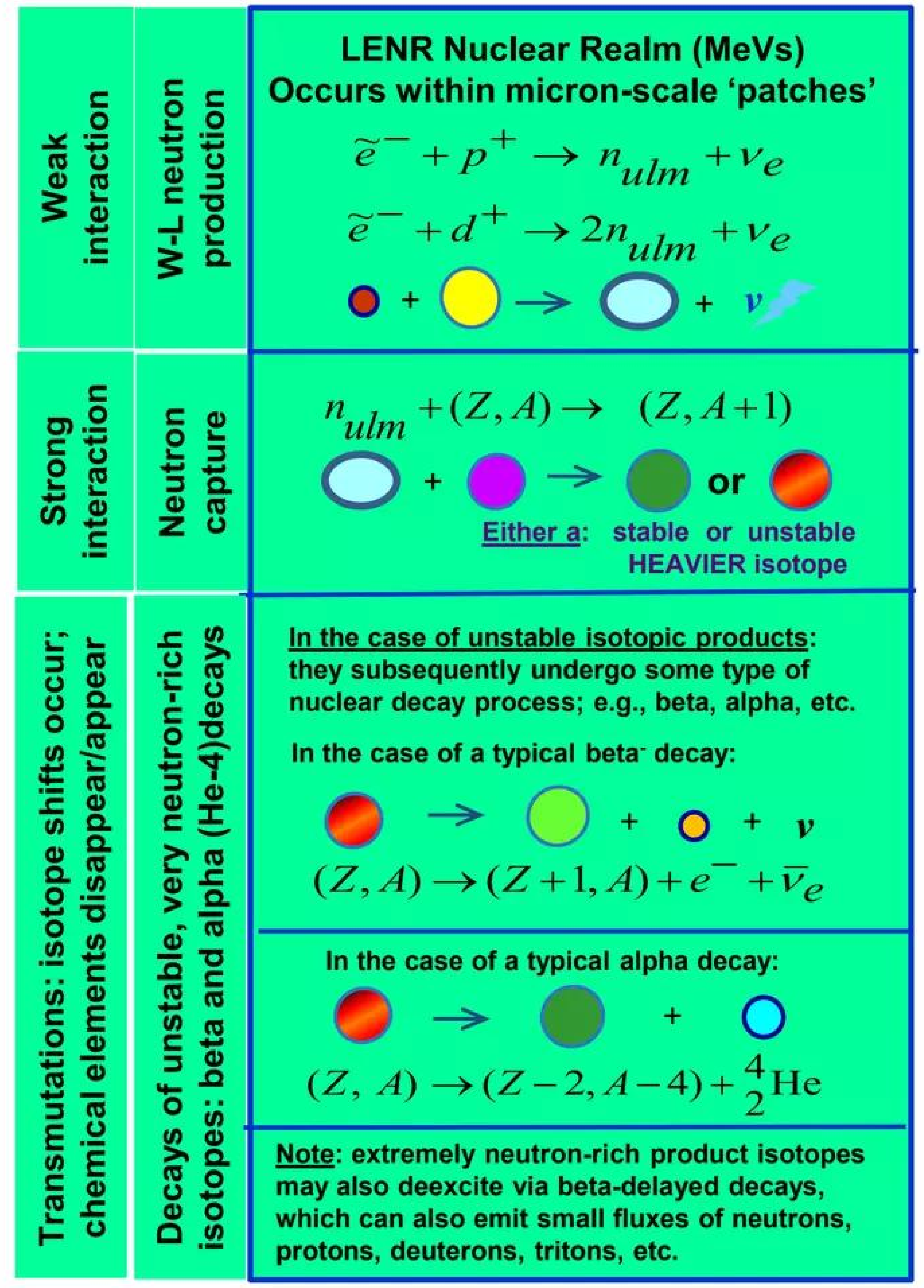
- "Excited states of nuclei formed in beta decay, for example, can show other types of radioactive behavior. In such beta-delayed radioactivity, the excited nuclear states can emit other particles ... If, however, the excitation [of the 'daughter' nucleus] is high enough, then it is possible that an alpha particle, a neutron or a proton are emitted from this state… This radioactivity is beta-delayed because the particles are only emitted after a time equal to the half-life of the beta particle [emission]." W. Scharf, "Particle Accelerators and Their Uses," pp. 726 Taylor & Francis 1991.
- Few observations of beta-delayed particles published prior to 1965
- 12 types of beta-delayed particle emissions have been observed
- Over 100 beta-delayed particle radioactivities are known today
- Theoretically, perhaps >1,000 isotopes could exhibit such decays

Decays of Neutron-rich Halo Nuclei More Complicated - II

Can dynamically vary their decay ‘choices’ depending on their ‘environment’

Per W-L theory, once ULM neutron production begins at high rates, populations of unstable, very neutron-rich ‘halo’ isotopes build-up locally on 2-D surfaces. Such nuclei likely have substantially lengthened half-lives because they may have a difficult time emitting beta electrons or neutrons (both of which are fermions) into locally unoccupied Q-M states. By contrast, alpha (He-4) particle and gamma photon emissions are bosons and are unaffected by the exclusion principle. If fermionic decay channels are ‘blocked’, neutron-rich halo nuclei may emit bosons or continue capturing ULM neutrons as long as it is energetically favorable or until they finally get so neutron-rich and excited, or a previously occupied local state opens-up, that ‘something breaks’ and β^- decay cascades ending in stable isotopes can begin. This is one important reason why LENR systems typically do not end-up with large amounts of long-lived, radiologically ‘hot’ isotopes

Importantly, the neutron-capture phase of LENRs can release substantial amounts of nuclear binding energy, much of it in the form of prompt and delayed gammas (which are bosons). Unique to LENR systems and according to W-L theory, those gammas are converted directly to infrared photons by heavy SP electrons also present in nuclear-active ‘patches’ on surfaces in LENR systems. As explained elsewhere, beta-decay cascades of unstable isotopes with short half-lives can proceed very rapidly, release large amounts of binding energy, and produce complex arrays of different transmutation products that, if neutron fluxes are high enough, can rapidly traverse rows of the periodic table; in one spectacular experiment, Mizuno went from K to Fe in <2 minutes



Decays of Neutron-rich Halo Nuclei More Complicated - III

Can dynamically vary their decay 'choices' depending on their 'environment'

- ✓ **At this point in our understanding of nuclear physics, note that extremely neutron-rich 'halo' nuclei that comprise intermediate products created in condensed matter LENR nucleosynthetic networks are, in many respects, still little understood and poorly characterized. For example: neutron capture cross-sections are unknown for many; short half-lives can be difficult to measure accurately; true location of neutron 'dripline' unclear at higher A**

- ✓ **In condensed matter LENRs, neutron-rich halo isotopes may continue to absorb ULM neutrons as long as capture Q-values remain favorable (prompt and delayed capture gammas are converted into infrared by heavy SP electrons) and as long as they are unable to decay via a variety of available channels that include emitting neutrinos and β^- electrons (fermions) and/or shedding low-energy neutrons (fermions) into unoccupied states in local continuum. Importantly, *LENR systems have much higher local densities of occupied fermionic states than various neutron-rich fragments made in radioactive-ion beam collider experiments***

Decays of Neutron-rich Halo Nuclei More Complicated - IV

Can dynamically vary their decay 'choices' depending on their 'environment'

- ✓ **Key consequences of this unique situation in LENR systems (very dense occupation of local fermionic states) are that: (1) effective half-lives of very neutron-rich intermediate isotopes can sometimes be substantially longer than measured 'textbook' half-lives of comparatively isolated excited nuclei; and (2) % branching ratios for alternative β^--delayed decay channels that are normally 'available' to such isotopes may change markedly compared to isolated nuclei – branching ratios can shift dynamically if decay channels are 'blocked,' i.e., unavailable. Thus certain types of decays can be 'frustrated' in LENR systems until unoccupied states 'open-up,' for whatever reason**

- ✓ **From low (better understood) to high values of A, unstable neutron-rich isotopes far from the valley of stability have >> greater variety of decay channel 'choices' compared to less neutron-rich nuclei. These include emissions of *beta*$^-$ electrons along with delayed gammas, neutrons (up to 3), protons, alpha particles (He-4), tritons (Tritium), and/or deuterons (Deuterium). Although production cross-sections often small, in some isotopes they are large, e.g., in N-18 ~12% of β^- decays also emit He-4**

Extensive evidence for transmutations via W-L mechanism

- ✓ **Utilizing the W-L theory of LENRs, readers are encouraged to examine reported experimental data and evaluate evidence for transmutations and nuclear energy releases in LENR systems**
- ✓ **In doing so, please be aware that :**
  - **Any element or isotope present in LENR experimental apparatus having an opportunity to move into close physical proximity to surfaces or nanoparticles on which ULM neutrons are being created can potentially 'compete' with other nuclei (that are located within the same micron-scale domains of spatially extended ULM neutron Q-M wave functions) to absorb produced ULMNs**
  - **Some reported transmutation products may appear rather mystifying until one determines *exactly what elements/isotopes were initially present in the apparatus when an experiment began*. In many cases, materials located inside experiments are poorly characterized; thus 'starting points' for ULMN captures on initial 'seed' nuclei may be very unclear**

There is an extensive body of experimental data on LENRs. Some of it can be found via the following resources:

- ***References cited in publications by Widom, Larsen, and Srivastava on the W-L theory of LENRs***
- ***Go to the free website www.lenr-canr.org Several hundred .pdf downloadable papers are available on site (most documents are not peer-reviewed)***
- ***Go to the free website www.newenergytimes.com Investigative articles and news, as well as number of downloadable papers on site***
- ***Query Internet search engines like Google using various key words such as: "low energy nuclear reactions", "cold fusion energy -Adobe" , "cold fusion", and so forth***

Extensive evidence for transmutations via W-L mechanism

Ca. 2002, Miley's informal survey of researchers' experiments reveals that Fe (#1), Zn (#2), and Cu (#3) most commonly reported LENR transmutation products

Frequency	Transmutation Elements
1	23 (F, Lu, Tb, I, Br, Xe, Os, Pr, Li, B, O, Sc, Ge, Se, Rb, Y, Zr, Eu, Sm, Gd, Dy, Ho, Nd)
2	14 (Ag, V, Yb, C, As, Sb, Te, Pd, Au, Cs, Mo, Ba, Nb, In)
3	9 (Cl, Hf, Re, Na, Ga, Sr, Sn, Cd, Ir)
5	4 (Co, S, Ti, Pt)
6	4 (Ni, K, Mn, Pb)
7	3 (Al, Mg, Si)
11	2 (Ca, Cr)
12	1 (Cu)
14	1(Zn)
15	1 (Fe)

Source of Table: Circa 2002 by Prof. George Miley, Dept. of Nuclear Engineering, University of Illinois at Urbana-Champaign

Extensive evidence for transmutations via W-L mechanism

Examples of results reported prior to 1st arXiv preprint of W-L theory (May 2005)

Isotopes	Miley, G.,	Ohmori,T. et al.	Ohmori,T. and Mizuno, M.	Mizuno,M and Enyo, M.,	Ohmori,T. et al.,	Chernov, I.P. et al.,	Iwamura, Y
	1997	2000	1998	1996	1998	1998	2002
Cu-63	3.6%±1.6			30.83%		44%	
Cu-65	-8.1%±3.6			-30.83%		-44%	
Fe-54		0%	-0.85%		-0.81%		
Fe-56		-0.75%	-29.75%	-21.75%	-16.79%		
Fe-57		0.78%	30.88%	18.88%	16.58%		
Fe-58					1.01%		
Re-185		11%		14.60%			
Re-187		-11%		-14.60%			
Ag-107	3.9%±1.2						
Ag-109	-4.3%±1.3						
Mo-96							26.26%
Ti-48						-33.30%	
Ti-49						8.60%	
Ti-50						17.80%	

Source: Circa 2003 by Prof. George Miley, Dept. of Nuclear Engineering, University of Illinois at Urbana-Champaign

Extensive evidence for transmutations via W-L mechanism

Ca. 2000, on the basis of experiments involving Nickel-cathode light water (Ni-H) P&F-type electrolytic cells, Miley reports claim of a rough correlation between calorimetrically measured excess heat and nuclear binding energy calculations

Figure 3.	Run Number (Ref. 2, 3)	Excess Power (W)	
		Calculated	Measured
	#7	1.9 ± 0.6	4.0 ± 0.8
	#8	0.5 ± 0.2	0.5 ± 0.4
	#18	0.7 ± 0.3	0.6 ± 0.4

Figure 3. Results from energy balance calculations for three earlier thin-film experiments. All experiments used Li_2SO_4 in H_2O for the electrolyte and thin-film Ni coated cathodes.

Quoting discussion of Fig. 3 directly from the paper: "As seen from this figure, reasonably good agreement is obtained between the excess power measurement and the calculated values using the binding energy calculations described here. Two of the results show quite close agreement, but one has a mean measured value that is a factor of two larger than the calculated value. While these results are not definitive, still, in view of the many uncertainties in both of the calculated values (due to uncertainties in the yield measurements) and in the calorimetry, the agreement obtained strongly suggests a relation between products and excess heat."

Source URL = http://www.lenr-canr.org/acrobat/MileyGHonthereact.pdf

Miley, G.H., "*On the Reaction Product and Heat Correlation for LENRs*"
Presented at the 8th International Conference on Cold Fusion – 2000 in Lerici (La Spezia), Italy

Extensive evidence for transmutations via W-L mechanism

Below is a facsimile of information copied from a slide presented by Prof. George Miley at a "Fusion Trends" conference ca. 2003

Summary - Key Experimental "Signatures" for LENRs

LENR

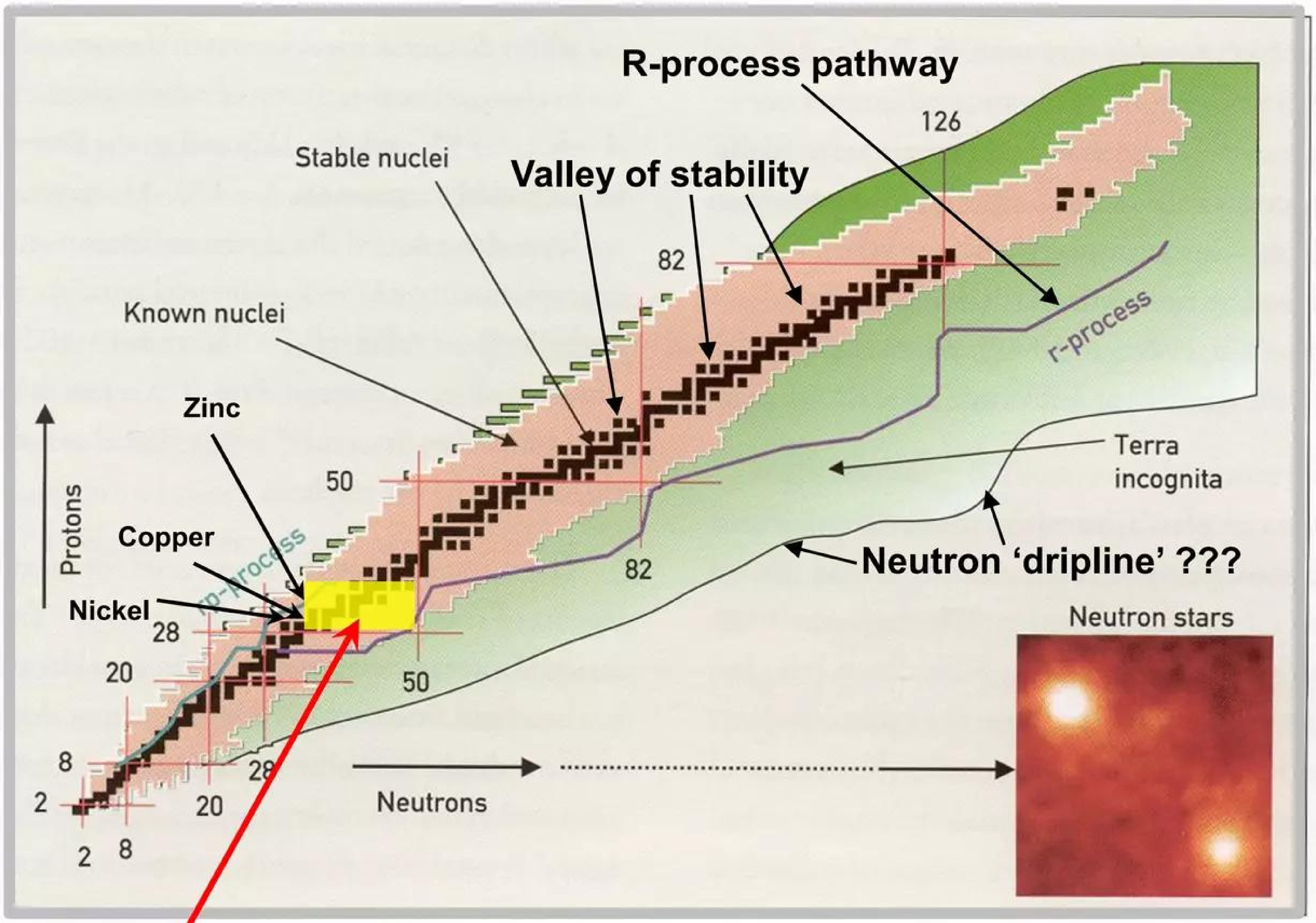
- **Large reaction rates for key elements, e.g. Zn, Cu, Fe, Mg, and Ag.**
- **Peak mass zones of high yields separated by low yield "gaps"**
- **Non-natural isotope ratios for key products**
- **Lack of energetic n, gamma radiation, but**
  - **Low-energy (~20 keV) X-ray/beta radiation along with MeV level protons and alphas**

<u>Source of Slide</u>: Prof. George Miley, Dept. of Nuclear Engineering, University of Illinois at Urbana-Champaign

Preview of Nucleosynthetic Pathways - I

'Map' of Vast Isotopic Nuclear Landscape

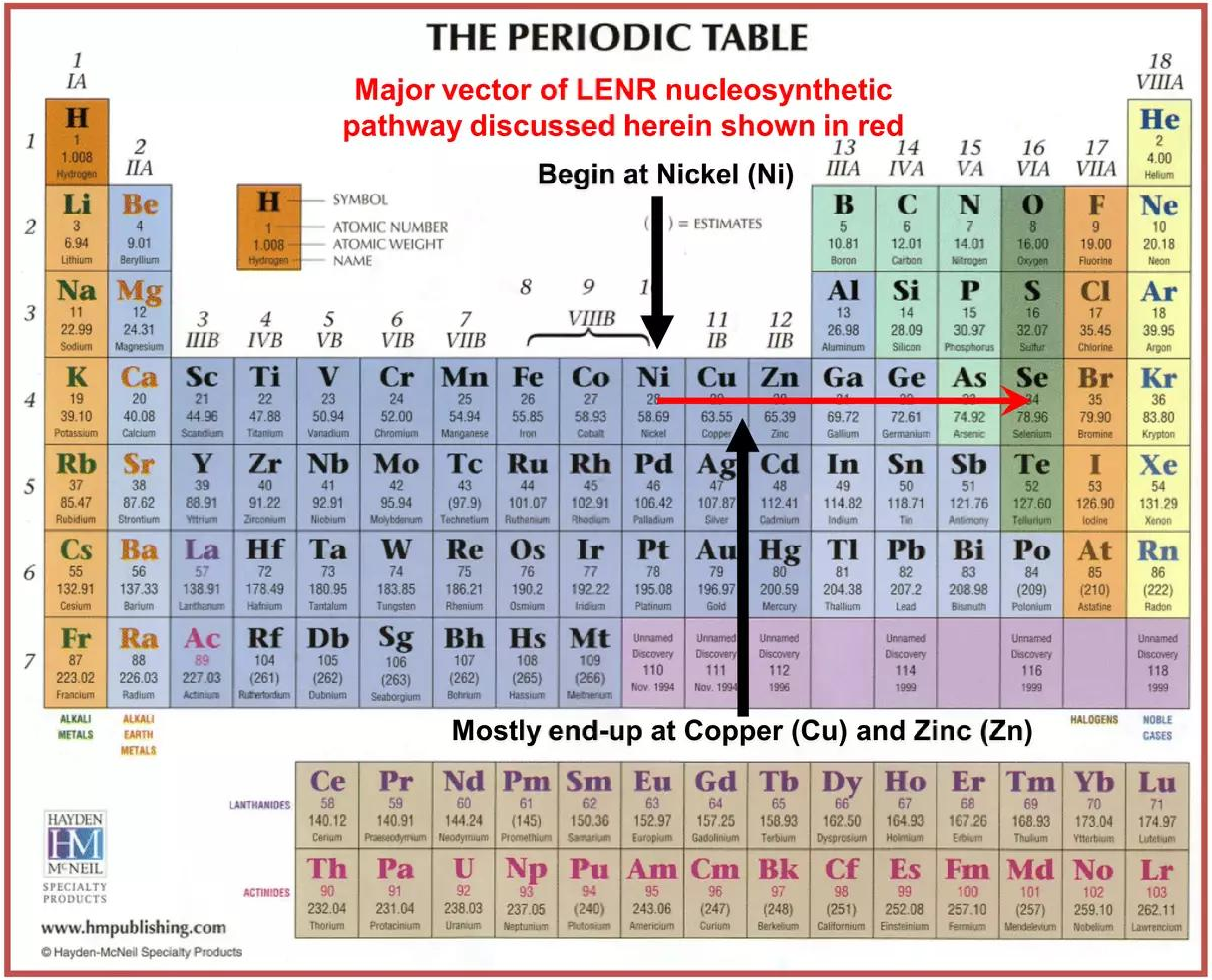
The neutron-capture so-called "r-process" (see path on chart) that astrophysicists believe occurs mainly in stellar supernova explosions is thought to produce most of the nuclei heavier than Iron (Fe). It operates in the neutron-rich region of the nuclear landscape to the right of the valley of stability to beta$^-$ decay. Extremely neutron-rich isotopes have a much wider variety of available decay channels in addition to 'simple' β^-.



In this presentation, we will apply W-L theory and examine a model LENR Ni-seed nucleosynthetic network operating in the *approximate* yellow rectangular region from the valley of stability (small black squares) out thru very neutron-rich, beta$^-$ decay isotopic regions that lie to the 'right' of valley of stability around Nickel (Ni), Copper (Cu), and Zinc (Zn)

While they differ from stellar environments in many important aspects, LENR systems can produce large fluxes of a wide variety of extremely neutron-rich nuclei from low to very high values of A. Thus, they may someday be able to provide nuclear physics with a new and exciting, much lower-cost experimental tool for exploring the far reaches of the nuclear landscape and boundaries of nuclear stability. This possibility deserves further careful study.

Preview of Nucleosynthetic Pathways - II

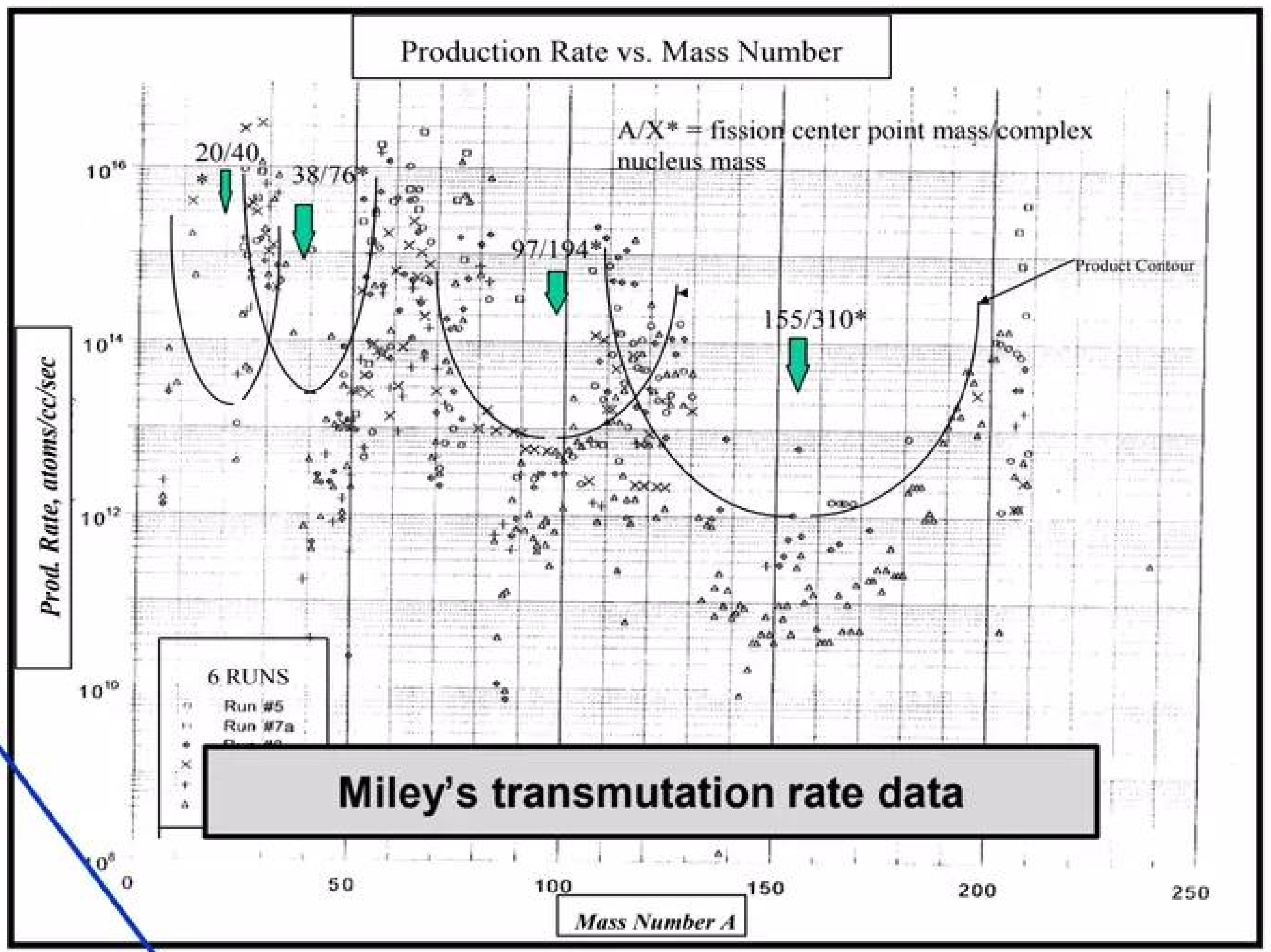


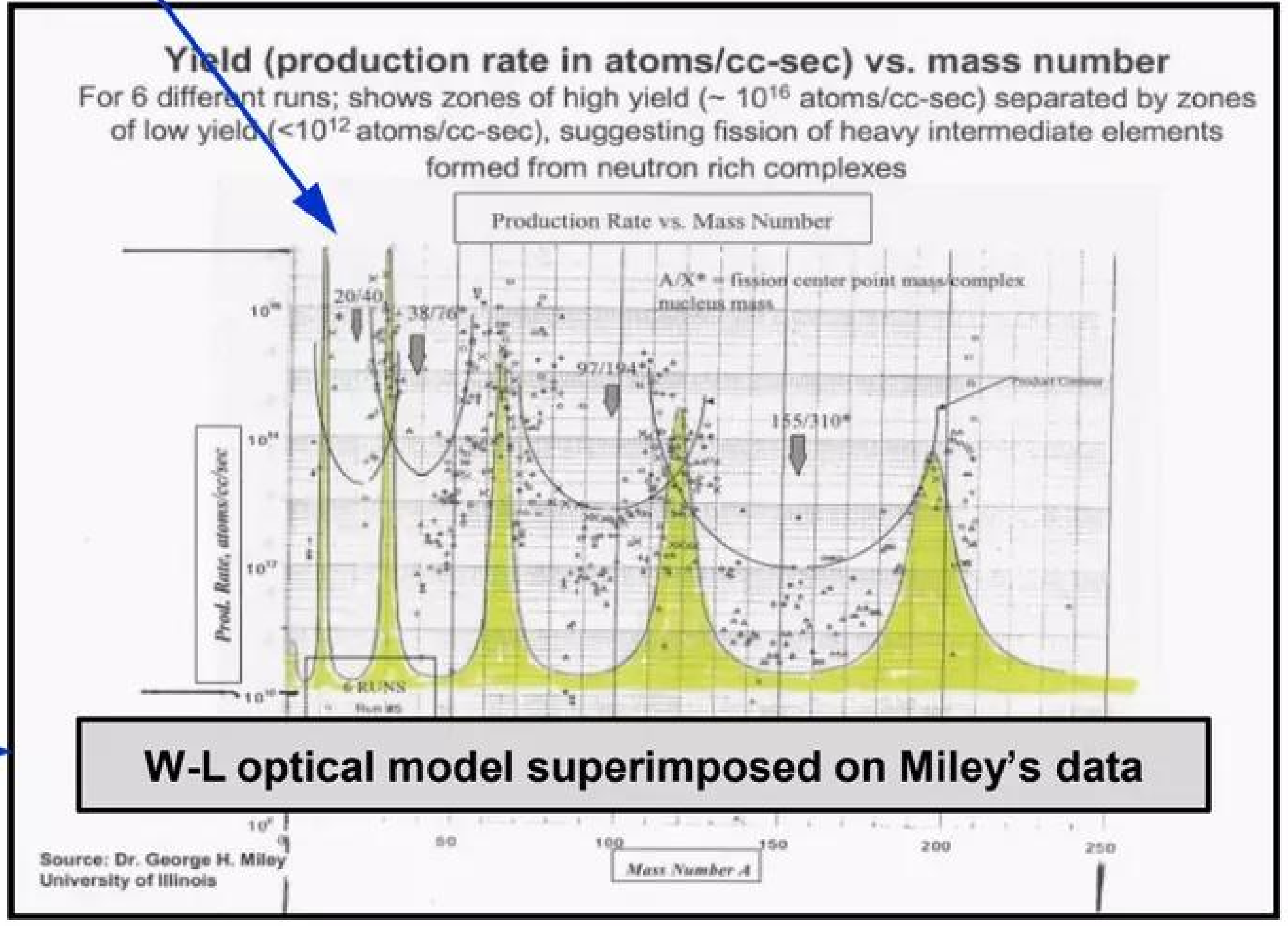
Five-peak mass-spectrum is a 'fingerprint' of ULM neutrons

Miley's dataset is 'smoking gun' for ULM neutron absorption by nuclei

- ✓ **Top chart to right is Miley's raw data; chart below is same data only with results of W-L neutron optical potential model of ULMN neutron absorption by nuclei (yellow peaks) superimposed on top of Miley's data; good correspondence of Miley obs. vs. W-L calc.**
- ✓ **Model <u>not</u> fitted to data: only 'raw' calc output**
- ✓ **W-L model only generates a five-peak resonant absorption spectrum at the zero momentum limit; neutrons at higher energies will not produce the same result**
- ✓ **This means that 5-peak product spectrum experimentally observed by Miley and Mizuno is a unique 'signature' of W-L ULM neutron production and absorption (capture) in LENRs**

<u>See</u>: "*Nuclear abundances in metallic hydride electrodes of electrolytic chemical cells*" arXiv:cond-mat/0602472 (Feb 2006) A. Widom and L. Larsen



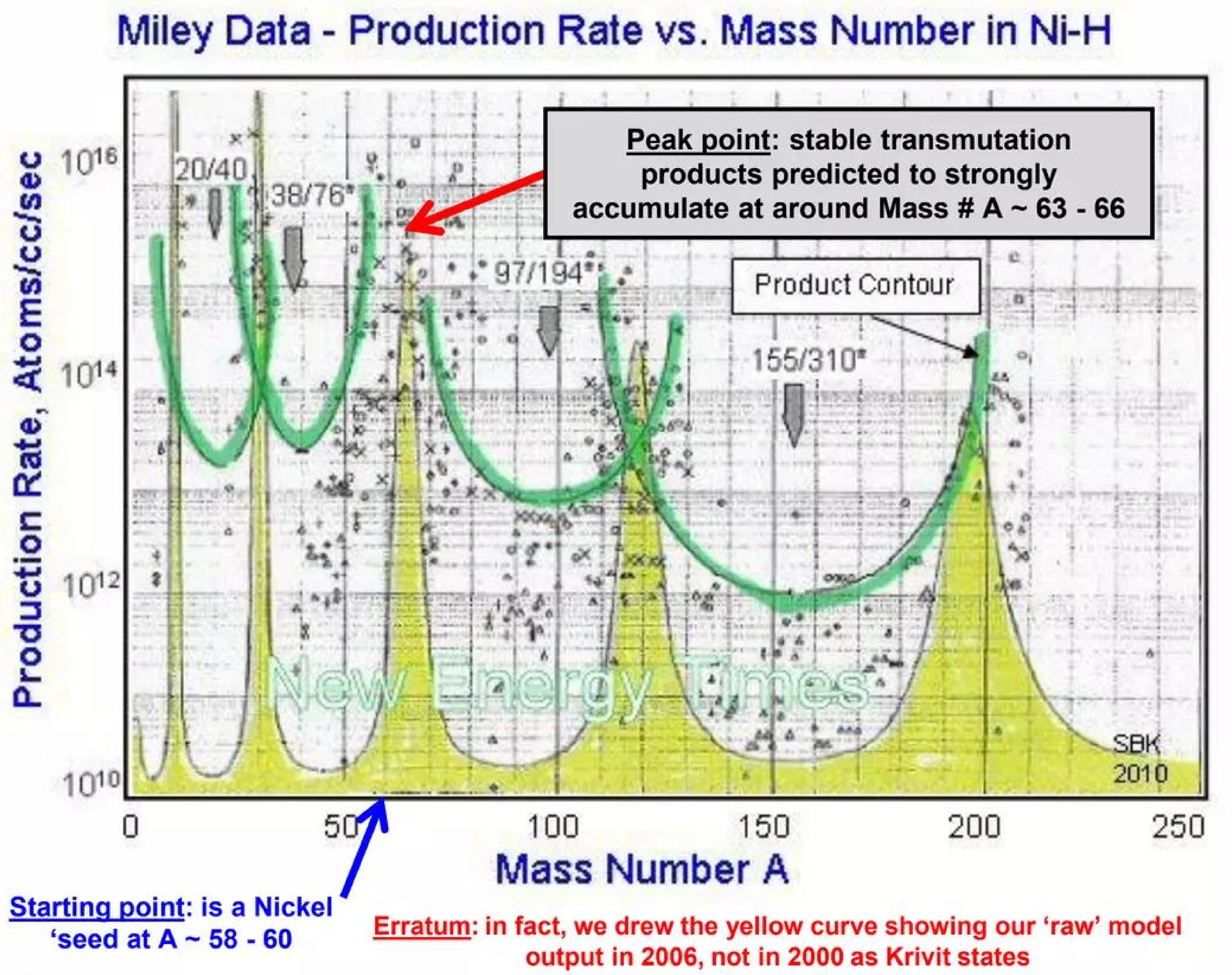


Five-peak mass-spectrum is a 'fingerprint' of ULM neutrons

W-L ULM neutron absorption model (2006) strongly predicts a stable product isotopic abundance peak at around mass # A ~63 - 66 (i.e., stable isotopes will tend to accumulate around that value of mass), that is, at around ~Cu thru ~Zn, which is clearly observed in Miley's 1996 experimental data shown to the right. The next major mass-peak number where somewhat larger quantities of stable LENR transmutation products are predicted by W-L to accumulate lies out at A ~120, which is also observed in Miley's (and Mizuno's) data.

Please recall that Miley's ending transmutation product rate data came from multiple P-F type electrolytic Ni-H experimental cell systems that were run for up to several weeks. Also, the beginning Nickel 'seed' in Miley's experiments was a prosaic Ni cathode comprised of (this is starting point):

Ni-58 ~ 68.0%
Ni-60 ~ 26.2%
Ni-61 ~ 1.14%
Ni-62 ~ 3.63%
Ni-64 ~ 0.92%



Erratum: in fact, we drew the yellow curve showing our 'raw' model output in 2006, not in 2000 as Krivit states

Upper 5-peak peak curve drawn by Miley in 1996 based on 6 experimental runs of transmutation yields from Ni-H LENR systems [1]. Lower curve, shaded in yellow, drawn by Larsen in 2000 with no fitting, based on Widom-Larsen ultra-low momentum neutron absorption model. [2]

1. Miley, G.H, and Patterson, James, "Nuclear Transmutations in Thin-Film Nickel Coatings Undergoing Electrolysis," Journal of New Energy, Vol. 1(3), pg. 5, (1996)
2. Larsen, Lewis, Feb. 7, 2009 slides

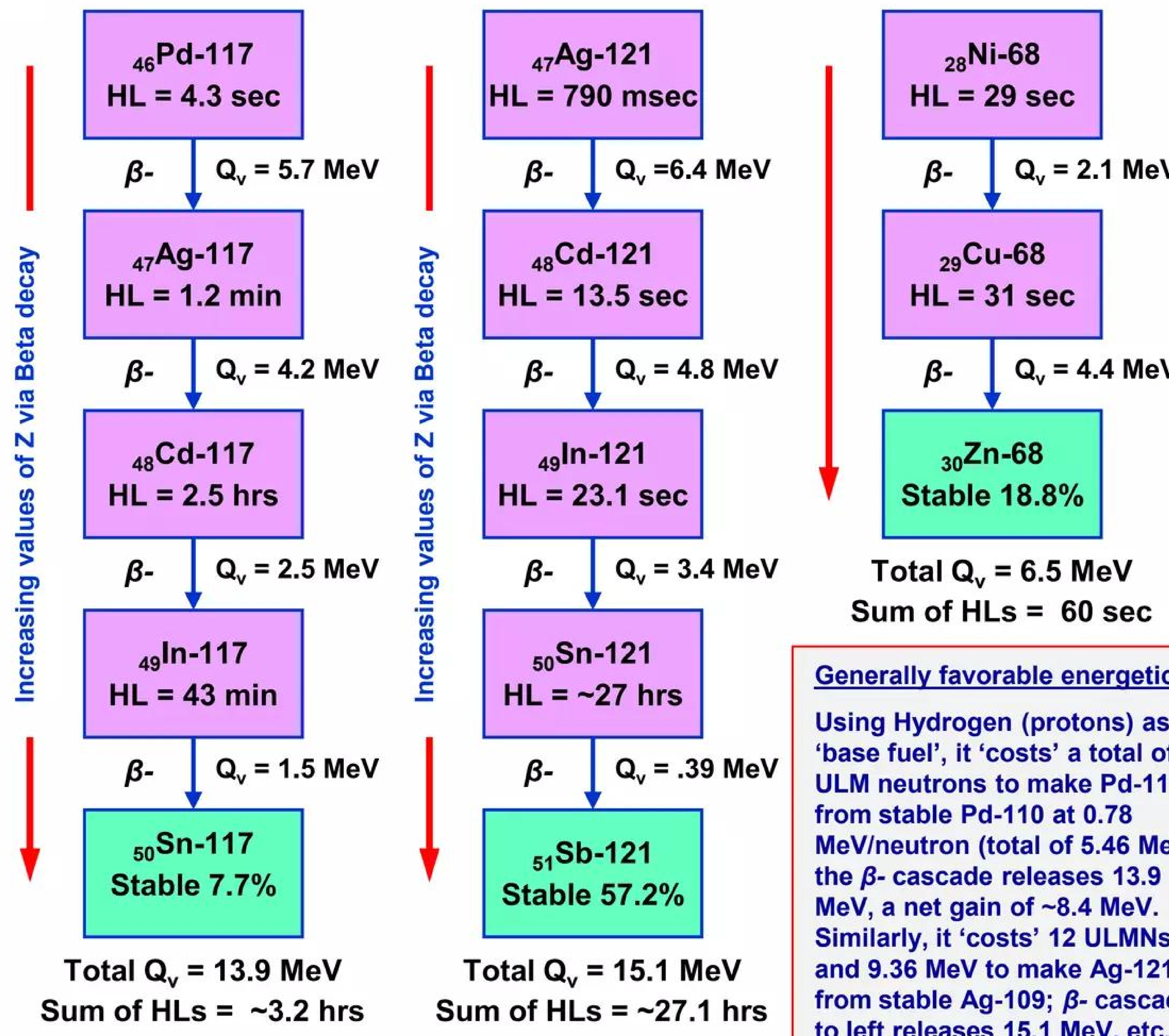
Source of modified graphic: New Energy Times

β^- decay chains: very neutron-rich nuclei decay into stable isotopes

Cascades of rapid, energetic β-decays are a unique and characteristic feature of LENR systems

- ✓ **Acc. to W-L theory, over time, large fluxes of ULM neutrons will result in a build-up of large populations of unstable, *very neutron-rich isotopes***
- ✓ **At some point, all such n-rich isotopes must decay, often by series of very fast β^- cascades**
- ✓ **β^- decays release energetic β particles (electrons) that transfer kinetic energy to local matter, heating it up**
- ✓ **Depending on half-lives, β^- chains can rapidly traverse rows of the periodic table, terminating in production of stable, higher-Z elements. Long-running experiments with <u>large</u> ULMN fluxes may produce a great variety of different elements/isotopes**

Representative examples of rapid β^- decay cascades:



<u>Generally favorable energetics</u>:

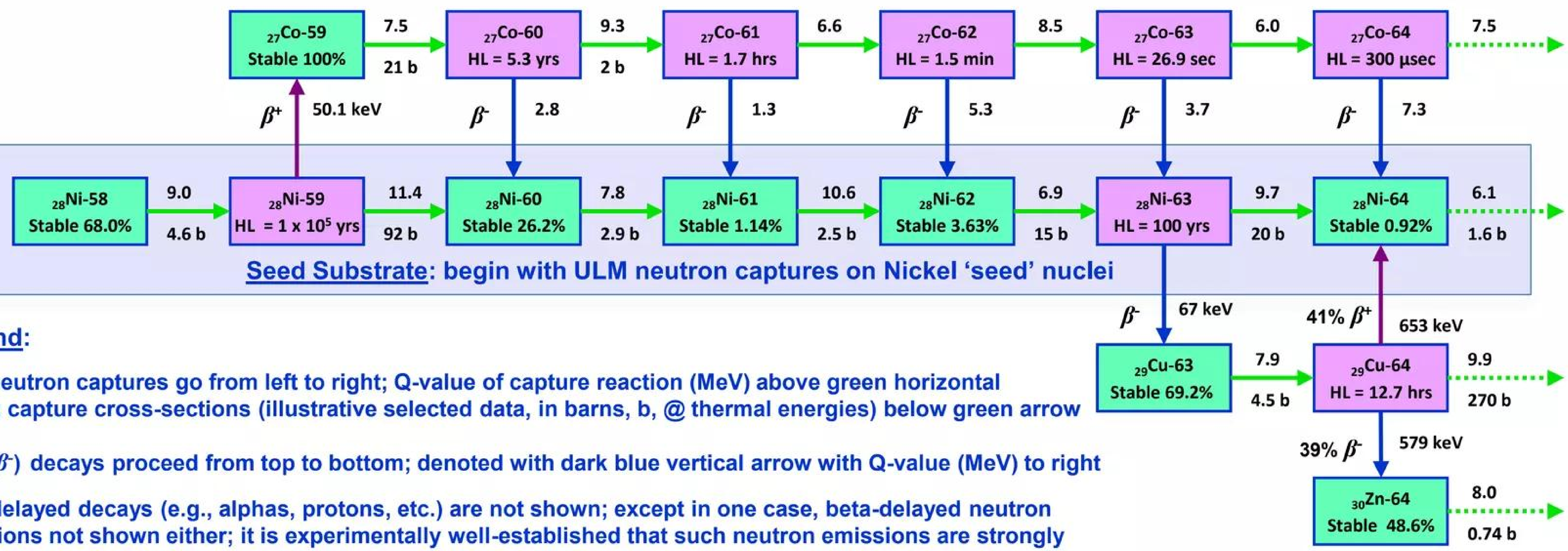
Using Hydrogen (protons) as 'base fuel', it 'costs' a total of 7 ULM neutrons to make Pd-117 from stable Pd-110 at 0.78 MeV/neutron (total of 5.46 MeV); the *β*- cascade releases 13.9 MeV, a net gain of ~8.4 MeV. Similarly, it 'costs' 12 ULMNs and 9.36 MeV to make Ag-121 from stable Ag-109; *β*- cascade to left releases 15.1 MeV, etc.

LENR W-L ULM neutron capture on Ni 'seeds,' neutron-rich isotope production, and decays

Stable 'target' seed nuclei on or very near LENR nuclear-active Nickel surfaces: Ni-58, Ni-60, Ni-61, Ni-62, and Ni-64

Increasing values of A via ULM neutron capture

Increasing values of Z via Beta decay



Legend:

ULM neutron captures go from left to right; Q-value of capture reaction (MeV) above green horizontal arrow; capture cross-sections (illustrative selected data, in barns, b, @ thermal energies) below green arrow

Beta (β^-) decays proceed from top to bottom; denoted with dark blue vertical arrow with Q-value (MeV) to right

Beta-delayed decays (e.g., alphas, protons, etc.) are not shown; except in one case, beta-delayed neutron emissions not shown either; it is experimentally well-established that such neutron emissions are strongly suppressed in condensed matter LENR systems (they are rarely observed by experimentalists and then typically only amount to relatively small, very 'bursty' fluxes of such neutrons); gamma emissions not shown ('automatically' converted to IR photons by 'heavy' e^* SP electrons)

Neutrino emissions not shown ('automatically' accompany beta decay)

Electron captures (e.c.) or β^+ indicated by purple vertical arrow; their Q-value (MeV) to right

Accepted natural abundances of stable isotopes (green boxes) are indicated in %

Half-lives of unstable isotopes (purplish boxes) when measured are shown as HL = xxxx

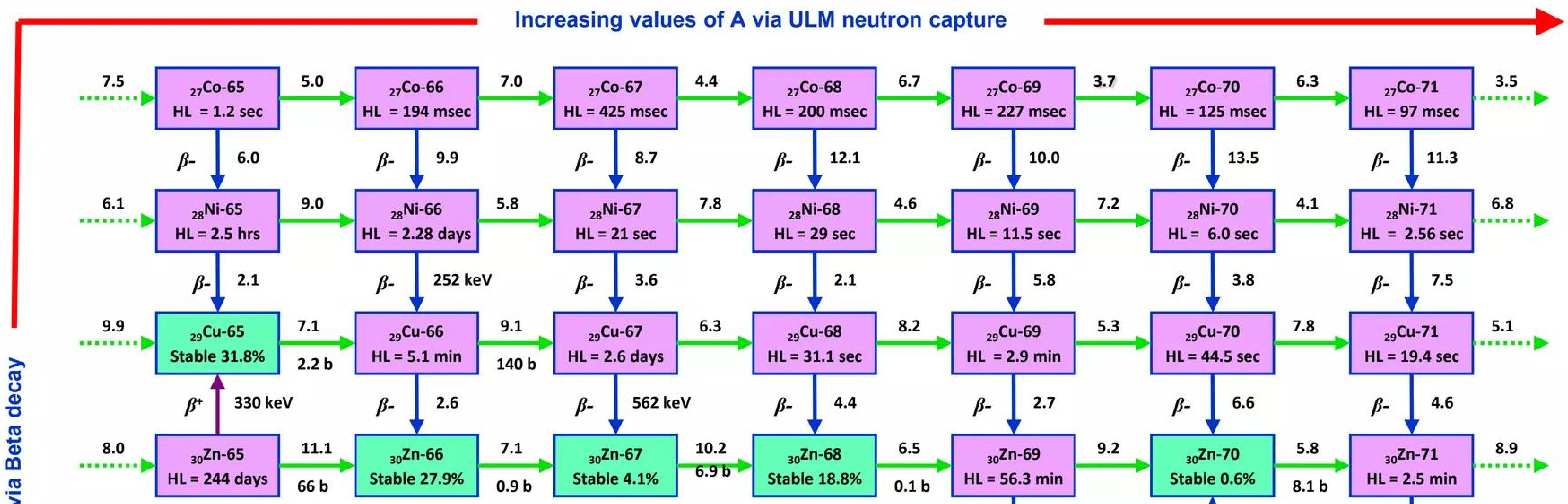
Nucleosynthetic network model assumes that Nickel isotopes are the ONLY 'seed' nuclei present in the system at the beginning of ULM neutron production and capture processes

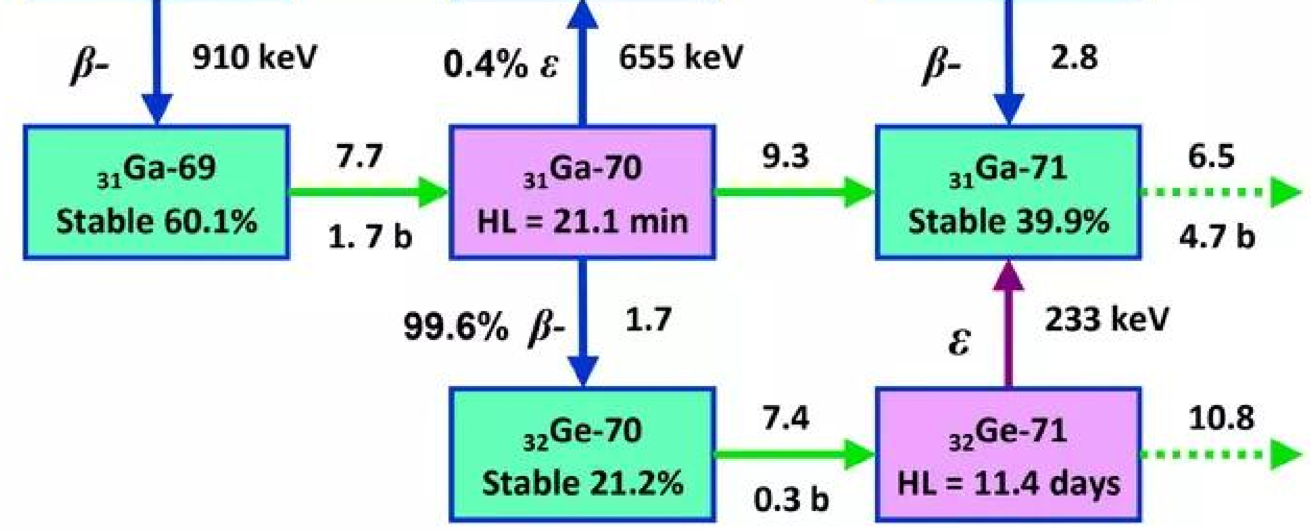
All other things being equal, in 'competition' to absorb (capture) ULM neutrons, nuclei with relatively larger capture cross-sections at thermal energies will have proportionately larger capture cross-sections at ULMN energies (which can be larger by a factor of as little as 5x or as much as 1,000,000x, depending upon the Q-M DeBroglie wavelength of an ULM neutron)

Network continues to next slide

N.B: in some cases, *Q-values for ULM neutron capture reactions are significantly larger than Q-values for 'competing' beta decay reactions.* Also, neutron capture processes are much, much faster (~picoseconds) than most beta decays; if ULM neutron fluxes (rates) are high enough, neutron-rich isotopes of a given element can build-up (move along same row to right on the above chart) >>> faster than beta decays can transmute them to different chemical elements (e.g., move downward to other rows on chart)

LENR W-L ULM neutron capture on Ni 'seeds,' neutron-rich isotope production, and decays





Nickel-59: at 92 barns, has largest neutron capture cross-section of 5 stable Nickel isotopes; when exposed to fluxes of ULM neutrons, rapidly depleted vs. other stable Ni isotopes

Nickel-63: at 20 barns, has second-largest neutron capture cross-section of 5 stable Nickel isotopes; when exposed to fluxes of ULM neutrons, rapidly depleted vs. other stable Ni isotopes by transmutation to Ni-64 via ULM neutron capture

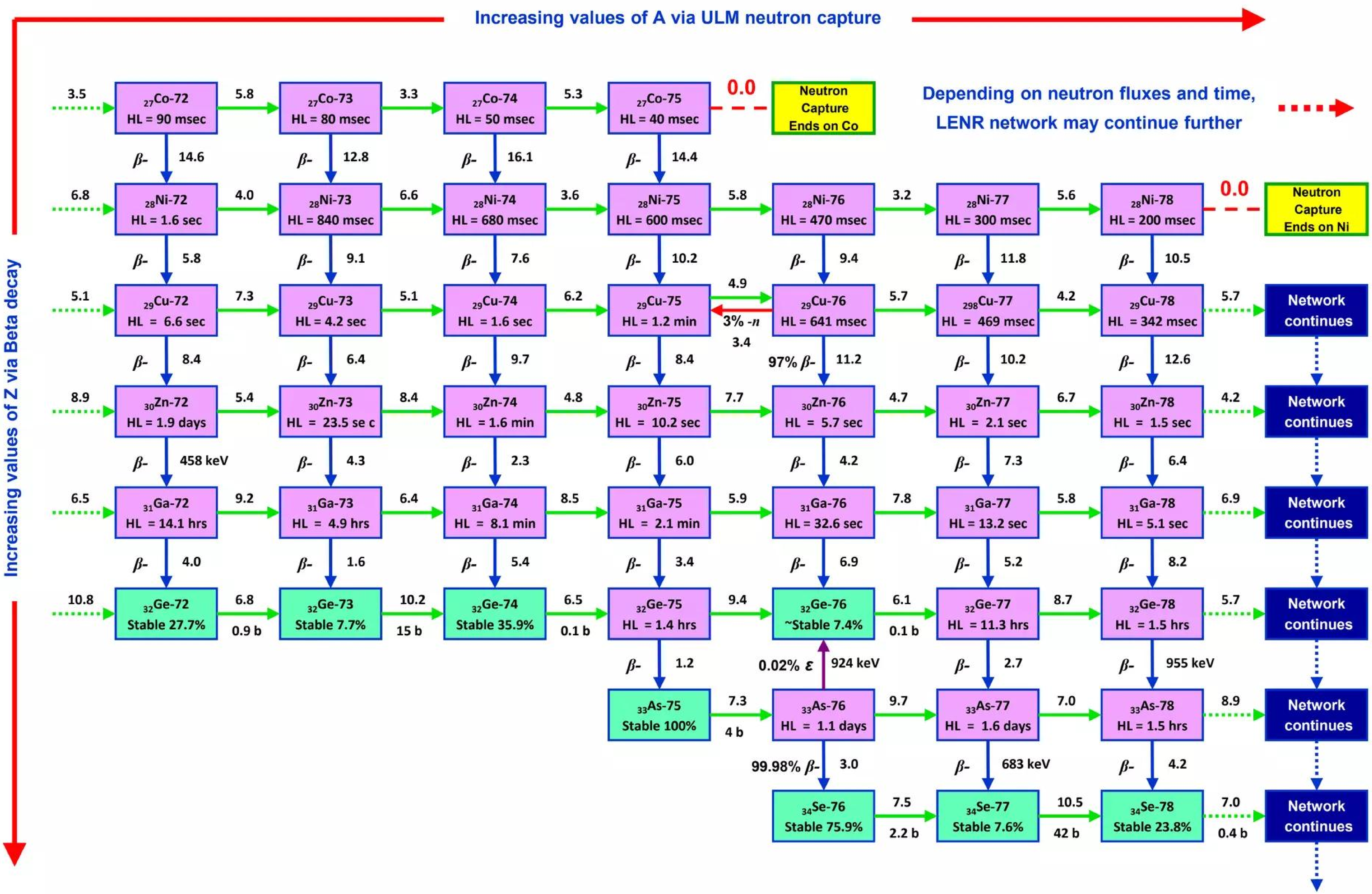
Cobalt isotopes: during ULM neutron production, any small amounts of Cobalt-59 produced by decay of Ni-59 would probably be rapidly converted back into heavier Ni isotopes via ULM neutron capture; prior to Cobalt-60 being converted to Co-61 by neutron capture, any emitted 1.33 and 1.17 MeV Co-60 gammas would be efficiently converted to IR by 'heavy' SP electrons. *To my knowledge, Co-60 gamma signatures have never been claimed to have been observed in any LENR experiment*

Network continues to next slide

Predicted accumulation of stable isotopes at masses A~ 63 - 66: a narrow-width stable isotope abundance peak at around these masses is predicted by the W-L optical model (see previous Slides); model also implies that production of stable isotopes should fall-off relatively rapidly just beyond Copper and Zinc, assuming all other things being equal

Values of A and Z reached by Ni-seed nucleosynthetic networks in experiments depend on overall rates of ULM neutron production (which in turn depend upon the nature of the input energy) and time: the summation across all local neutron fluxes in micron-scale surface regions and their total duration in time (neutron dose history per unit of area) will determine exactly how far a given experiment can proceed into the labyrinth of our above-described Ni-seed network. In gas-phase LENR experiments in which energy is inputted into SP electrons solely through a combination of pressure and temperature, local ULMN fluxes would likely be modest (in comparison to experiments with additional high-current electrical input) and it might likely be difficult for the network to go very far beyond Zinc during a relatively short period of time (say, a few weeks). At the other extreme, electrolytic LENR experiments can sometimes trigger large bursts of ULM neutron production: in one such result, Mizuno went from K to Fe in 2 minutes (Lattice June 25, 2009, SlideShare)

LENR W-L ULM neutron capture on Ni 'seeds,' neutron-rich isotope production, and decays



Conclusions & Intriguing Opportunities for Further Study

- ✓ In condensed matter, W-L production of ULM neutrons creates local, micron-scale regions containing populations of unstable, very neutron-rich nuclei/isotopes; local continuum has densely occupied fermionic states (e.g., SP electrons and neutrons); in parallel, W-L gamma suppression mechanism converts gammas to IR photons with a variable ‘tail’ in soft X-rays
- ✓ Unlike nuclei lying close to the ‘valley of stability,’ neutron-rich isotopes have a vastly larger repertoire of different decay and deexcitation channels/modes that can vary quite rapidly and dynamically in time, depending upon the ‘sensed’ quantum-mechanical ‘local continuum environment’; importantly, the closer such unstable nuclei get to the so-called neutron ‘dripline,’ the more complex and richly varied their behavior can potentially become
- ✓ Think of a neutron-rich nucleus as a collective, many-body quantum system that ‘senses’ its local continuum through decay channels that are quantum mechanically connected (via entanglement) to the ‘outside’ world; in effect, such excited nuclei perform dynamic quantum computation in order to ‘decide’ how to move toward the lowest possible energy state in the least amount of time within given extant constraints (e.g., fermionic decay ‘frustration’)
- ✓ While many different decay/deexcitation modes are available to neutron-rich nuclei, the most common last stage in their varying and often circuitous ‘descent’ from excited states to lower, more stable energy states (while maximizing entropy production along the way) are cascades of very fast, spontaneous beta decay chains that eventually terminate in stable isotopes/elements
- ✓ Altogether, this explains why LENR systems emit very little ‘hard’ neutron or gamma photon radiation and are strongly prone to producing ending arrays of stable isotopes/elements

Commercializing a Next-Generation Source of Safe Nuclear Energy

Selected Technical Publications

"***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

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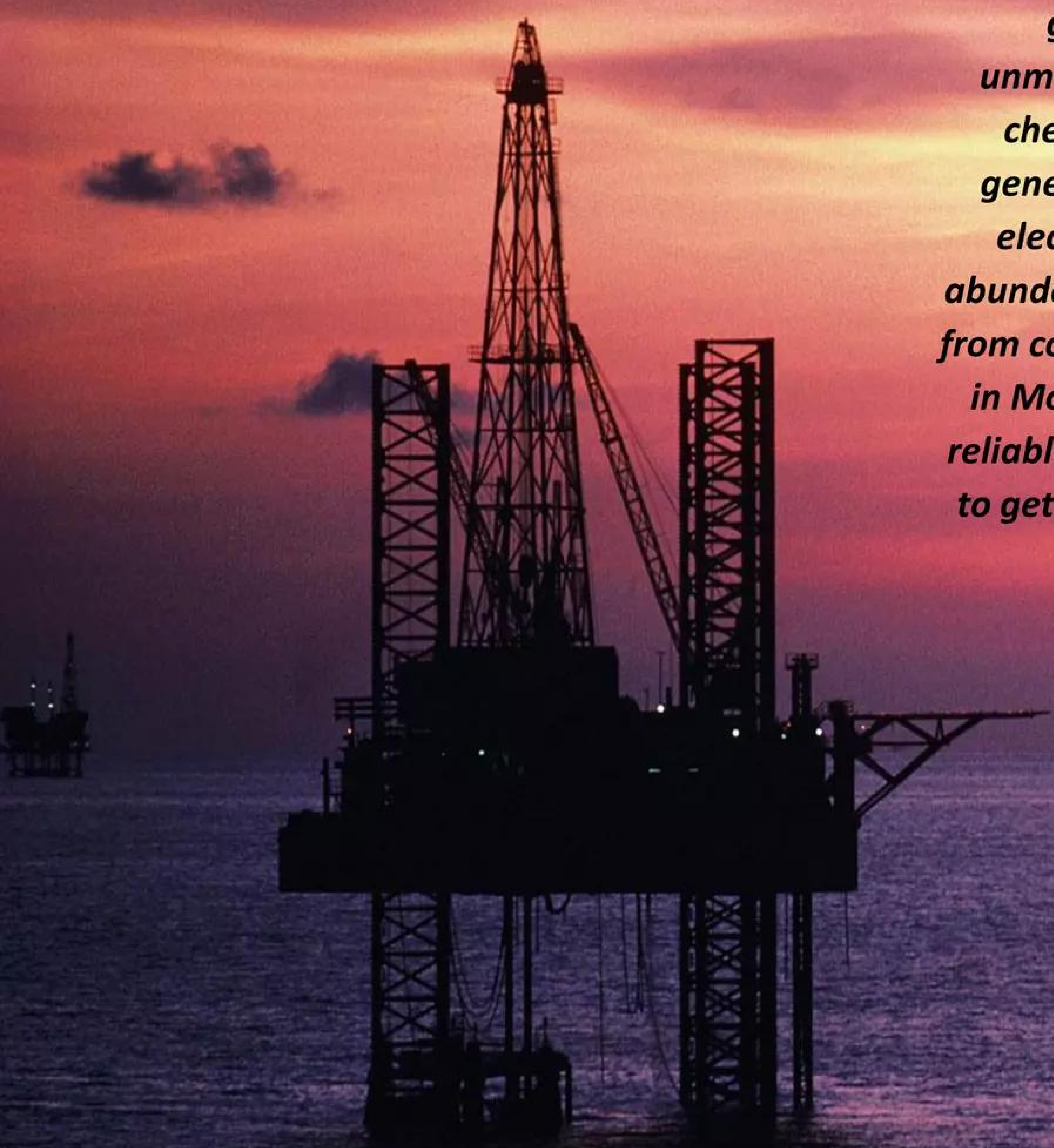

"No single solution will defuse more of the Energy-Climate Era's problems at once than the invention of a source of abundant, clean, reliable, and cheap electrons. Give me abundant clean, reliable, and cheap electrons, and I will give you a world that can continue to grow without triggering unmanageable climate change. Give me abundant clean, reliable, and cheap electrons, and I will give you water in the desert from a deep generator-powered well. Give me abundant clean, reliable, and cheap electrons, and I will put every petrodictator out of business. Give me abundant clean, reliable, and cheap electrons, and I will end deforestation from communities desperate for fuel and I will eliminate any reason to drill in Mother Nature's environmental cathedrals. Give me abundant clean, reliable, and cheap electrons, and I will enable millions of the earth's poor to get connected, to refrigerate their medicines, to educate their women, and to light up their nights."

Thomas Friedman, "Hot, Flat, and Crowded" 2008 pp.186