LENR transmutations can occur all around us

Neutrons can be created when Hydrogen atoms (protons) are present within many different types of electric discharges

that can include among diverse other things:

atmospheric lightning on earth and other planets,

arcs between electrodes in air, water, hydrocarbons,

nano-arcs (internal shorts) in electrochemical batteries

Lewis Larsen
President and CEO
Lattice Energy LLC
May 3, 2016

Contact: 1-312-861-0115 Chicago, Illinois USA
lewisglarsen@gmail.com

Image: Getty

LENR transmutations can occur all around us

Electromagnetic energy available in intense electric discharges can create neutrons via direct electroweak reactions between protons and electrons; those neutrons are captured by atoms that are transmuted into other isotopes and chemical elements. This is revolutionary because scientists have long-assumed that collapsing stars or particle accelerators were the only places where such a process would be possible.

The pervasiveness of neutron-catalyzed nucleosynthesis has important implications for better understanding of the chemical evolution of presolar dust grains exposed to nebular lightning; chemical evolution of solid planetary materials and gases; isotope geochemistry; and even the genesis of certain types of thermal runaways that can occur in electrochemical batteries.

Neutrons are created in many types of electric discharges

Captured by local atoms - transmute them into other isotopes/elements

Process is nucleosynthesis - formerly thought restricted almost entirely to stars

- ✓ Nucleosynthesis of chemical elements in Nature heretofore believed to require temperatures and pressures found in hot cores of stars; otherwise need fission reactors, accelerators, or weapons to do it
- ✓ Beginning in 2005, physics published in the Widom-Larsen theory of LENRs explained how and predicted that many-body collective quantum and electromagnetic effects would create neutrons via electroweak reactions in broad range of environments including electrochemical cells, exploding wires, electric discharges, natural lightning, and magnetic flux tubes located far outside stellar cores
- ✓ Widom-Larsen theory implies nucleosynthesis is more common and occurs in vastly more places than was ever before thought possible
- ✓ Herein will provide examples of published third-party data that are consistent with predictions of our theory and fully explained by it

Widom-Larsen theory of ultralow energy neutron reactions

Three key publications that begin in March of 2006 referenced below

Many-body collective effects enable radiation-free green nuclear power

"Ultra low momentum neutron catalyzed nuclear reactions on metallic hydride surfaces"
A. Widom and L. Larsen
European Physical Journal C - Particles and Fields 46 pp. 107 - 112 (2006)

http://www.slideshare.net/lewisglarsen/widom-and-larsen-ulm-neutron-catalyzed-lenrs-on-metallic-hydride-surfacesepjc-march-2006

"Energetic electrons and nuclear transmutations in exploding wires"
A. Widom, L. Larsen, and Y. Srivastava
Cornell physics preprint arXiv:0709.1222v1 [nucl-th] (2007)

http://arxiv.org/PS_cache/arxiv/pdf/0709/0709.1222v1.pdf

"A primer for electro-weak induced low energy nuclear reactions"
Y. Srivastava, A. Widom, and L. Larsen
Pramana - Journal of Physics 75 pp. 617 - 637 (2010)

http://www.slideshare.net/lewisglarsen/srivastava-widom-and-larsenprimer-for-electroweak-induced-low-energy-nuclear-reactionspramana-oct-2010

LENRs operate like stellar processes in condensed matter

Electroweak $e^- + p^+$ reactions can occur in domains besides supernovae

- ✓ In our *European Physical Journal C - Particles and Fields* paper (2006) we explained how many-body collective quantum effects in condensed matter can produce ultralow energy neutrons via the electroweak $e^- + p^+$ reaction in tabletop apparatus under very modest macrophysical conditions. Results of subsequent neutron-catalyzed transmutation reactions resemble astrophysical *s*- and *r*-processes only at temperatures vastly lower than with stars
- ✓ We next analyzed and explained case of LENR transmutation products observed in high pulsed-current exploding wires with cylindrical geometries; note that collective many-body magnetic effects (B-fields) dominate therein. This case differs from condensed matter electrochemical cells wherein micron-scale, nuclear-strength local E-fields and local breakdown of Born-Oppenheimer are much more important
- ✓ Once one understands LENRs in magnetically dominated collective systems, lightning discharges are conceptually like a big exploding wire up in the sky. Moreover, predicted electroweak $e^- + p^+$ reactions inside solar coronal loops and flares is direct extension of the same physics principles

Condensed matter ultralow energy neutron reactions LENRs

Image credit: co-author Domenico Pacifici
From: "Nanoscale plasmonic interferometers for multispectral, high-throughput biochemical sensing"
J. Feng *et al.*, *Nano Letters* pp. 602 - 609 (2012)

Laura 13

No deadly gamma radiation

No dangerous energetic neutron radiation

Insignificant production of radioactive waste

Vastly higher energies vs. chemical processes

Revolutionary, no CO_2 , and environmentally green

Fully explained by physics of Widom-Larsen theory

Stars and fission reactors not required to make neutrons

Can be produced from protons and electrons in electroweak reactions

Many-body collective electromagnetic and quantum effects obviate high temps

Electroweak LENRs in condensed matter do not emit energetic neutron or gamma radiation

Require source(s) of input energy — Input energy creates electric fields > 2.5 x10^{11} V/m

Collective many-body quantum effects: many electrons each transfer little bits of energy to a much smaller number of electrons also bathed in the very same extremely high local electric field

Many-body collective electroweak neutron production — Heavy-mass e^{-*} electrons react directly with protons

Quantum electrodynamics (QED): smaller number of electrons that absorb energy directly from local electric field will increase their effective masses ($m = E/c^2$) above key thresholds β_0 where they can react directly with a proton (or deuteron) → neutron and neutrino

$$\text{Energy}_{\text{E-field}} + e^{-}_{sp} \rightarrow e^{-*}_{sp} + p^{+} \rightarrow n^{0} + \nu_e$$

ν_e neutrinos: ghostly unreactive photons that fly-off into space; n^0 neutrons capture on nearby atoms

Radiation-free LENR transmutation

Neutrons + capture targets → heavier elements + decay products

Neutrons induce nuclear transmutations that release enormous amounts of clean, CO_2-free heat

Electroweak neutron production has two distinct modes

Magnetic mode dominates in electric discharges: sparks, arcs, lightning

Production of neutrons from protons and electrons via electroweak catalysis:

Many-body collective effects in condensed matter and plasmas + input energy

$\text{Energy}_{E\text{-field}} + e^{-}_{sp} \rightarrow e^{-*}_{sp} + p^{+} \rightarrow n + \nu_e$ [high electric fields on substrate surfaces]

$\text{Energy}_{B\text{-field}} \rightarrow e^{-} + p^{+} \rightarrow lepton + X$ [plasmas inside cylindrical magnetic fields]

Collective electroweak production of neutrons on μ-scales on condensed matter substrates and via direct particle acceleration in magnetic fields of discharges

Transmutation of atoms that capture neutrons into other heavier isotopes/elements:

Both types of processes release nuclear binding energy (heat)

n + atom $(Z, A) \rightarrow (Z, A+1)$ [neutron capture on nearby atoms]

$(Z, A+1) \rightarrow (Z+1, A+1) + e_{\beta}^{-} + \bar{\nu}_e$ [unstable products beta$^-$ decay]

Commonly rapid β^- decays of unstable neutron-rich isotopic products

Many-body collective effects span vast range of length-scales

W-L-S theory and its collective effects extend from LENRs in condensed matter systems to environments found in high-current exploding wires, e.g., large wire inductors, as well as up to large-length-scale, magnetically dominated modes that occur in astrophysical systems

Length Scale	Type of System	Electromagnetic Environment	Many-body Collective Phenomena	Comment
Submicron	Certain earthly bacteria and some fungi	Very high, short-range electric fields	Transmutations, high level of gamma shielding	Obtain unavailable trace elements; survive deadly gamma or X-ray radiation
Microns	Hydrogen isotopes on metallic surfaces	Very high, short-range electric fields on solid substrates	Transmutations, high level of gamma shielding, heat, some energetic particles	This regime is useful for small-scale commercial power generation
Microns to many meters	Exploding wires, planetary lightning	Dusty plasmas: mixed high-current and high local magnetic fields	Transmutations, 'leakier' gamma shielding, heat; X-rays up to 10 keV, larger energetic particle fluxes	This regime is useful for large-scale commercial power generation
Many meters to kilometers	Outer layers and atmospheres of stars (flux tubes)	Ideal and dusty plasmas: high mega-currents of electrons, protons, and ions inside large-scale, ordered magnetic structures with substantial internal electromagnetic fields	Energetic charged particles and neutrons (MeVs to EeVs), X-rays, gamma-ray bursts, and ultra-high-energy cosmic rays (TeVs to EeVs)	Provides explanation for heating of solar corona and radioactive isotopes in stellar atmospheres
Up to several AU (distance from earth to Sun)	Neutron stars and active galactic nuclei in vicinity of compact, massive objects (black holes)			Provides mechanism for creating extremely high energy particles in plasma-filled magnetic flux tubes with sufficient field strengths

Note: mass renormalization of electrons by high local E-fields not a key factor in magnetically dominated regimes on large length scales

W-L-S theory spans vast range of length-scales and energies

E-fields in condensed matter vs. B-field particle acceleration in plasmas

Short-range collective electric field effects dominate

Longer-range collective magnetic field effects begin to dominate

Long-range collective magnetic field effects dominate

local electric fields

Organized magnetic fields with plasmas

Low - medium electric and/or ion currents

Regime: ultralow energy neutron reactions (LENRs) in condensed matter

$e^* + p^+ \rightarrow$ 1 neutron + neutrino or $e^* + d^+ \rightarrow$ 2 neutrons + neutrino

Neutron production, capture, release energy, and transmutation products

- Microorganisms – biological transmutations by certain types of earthly bacteria & fungi
- Pressure gradients across membranes – e.g., Iwamura, Li, & Arata-Zhang - gas phase
- Current-driven P&F-type chemical cells - liquid phase; glow discharge cells - gas phase
- Laser-triggered chemical cells – e.g., Letts, Cravens, Violante, etc. - liquid or gas phase

High currents: electrons and/or ions

- RF-triggered dusty plasmas - gas phase
- Current-driven dusty plasmas - gas phase
- Vacuum diodes – e.g. Proton-21, Kiev, Ukraine, Sandia NL (US) in 1970s - gas phase
- Exploding wires – e.g., Wendt & Irion, Chicago 1922; Z-pinch, Sandia NL - gas phase
- Piezoelectric and pyroelectric processes in solid-state materials – Carpinteri, Naranjo
- Magnetic flux compression generators, e.g. US (LANL), Russia
- Lightning (terrestrial, planetary, nebular), especially in dusty environments – e.g., Dwyer
- ULMN-catalyzed subcritical fission reactors (<<< nuclear waste) - reprocess old wastes

Higher fluxes of neutrons

Scales-up to very large length scales | Huge range of magnetic field strengths

Mega-scale currents

Mixed regime: high energy particle reactions and/or LENRs on dust

Magnetic effects dominate large length-scale plasmas: $e^- + p^+ \rightarrow$ *lepton* $+ X$

- Stars - additional nuclear reactions occur in photospheres, flares, and further out in coronas
- Dusty, hydrogen-rich nebular plasma clouds exposed to stellar photon and particle radiation
- Magnetars/active galactic nuclei: W-L mechanism can in theory create UHE TeV cosmic rays

>>>> fluxes

~0 eV Ultra low energy neutrons .... MeV neutrons ...GeV...TeVs ...EeVs

Increasing neutron and charged particle energies

High-current discharges produce complex product mixtures

Many-body collective effects enable electron-proton electroweak reactions

Collective many-body electroweak reactions require input energy

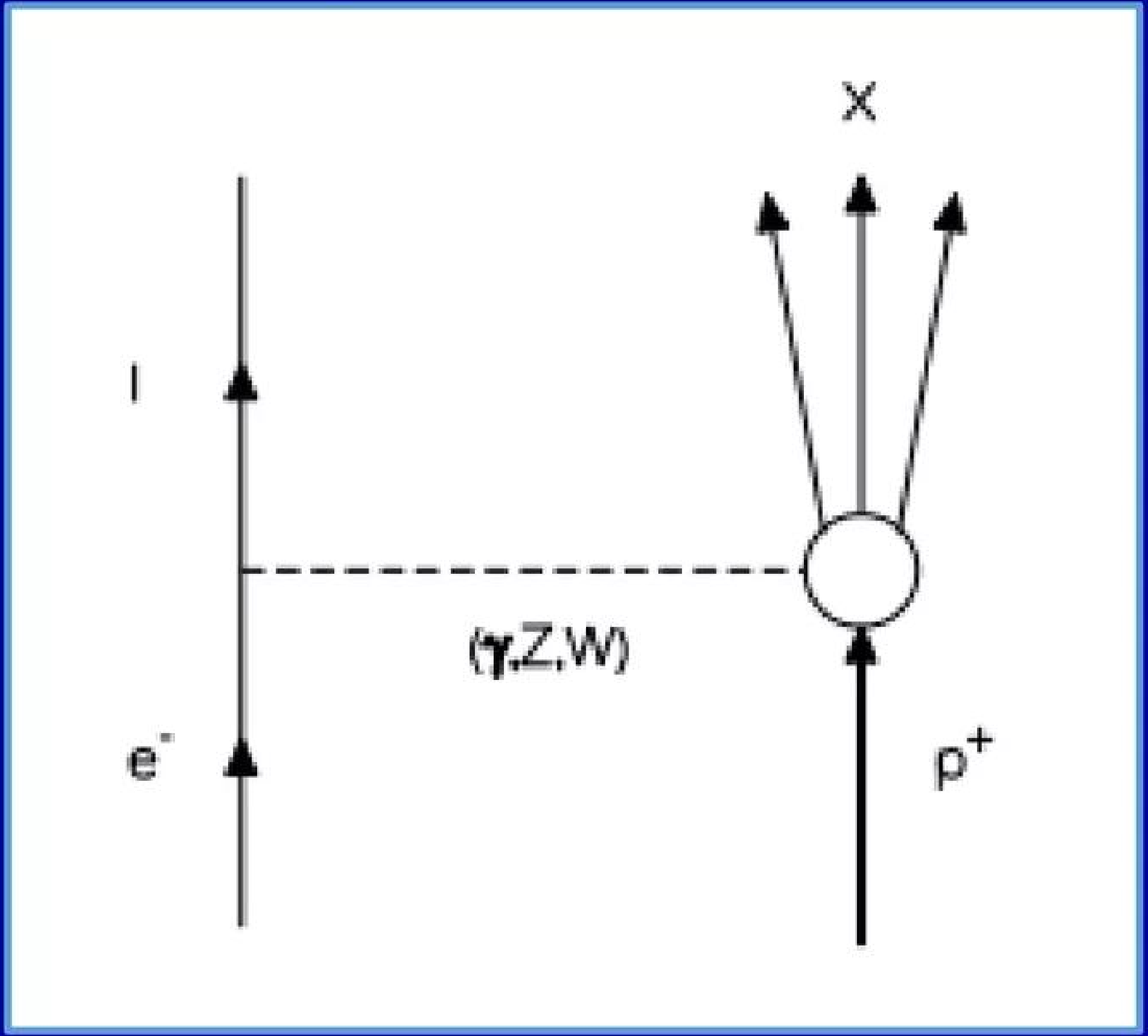
$$e^{-*} + p^{+} \rightarrow n + \nu_e$$
$$e^{-} + p^{+} \rightarrow lepton + X$$

When electric fields dominate

Magnetic fields dominate at very high energies in plasmas

- ✓ FIG.2 shows the electro-weak boson exchange Feynman diagram for electron-proton scattering in colliding electron and proton 'beams' inside plasma-filled magnetic flux tubes at high energies
- ✓ Expression { $e^{-} + p^{+} \rightarrow l + X$ } includes photon γ and Z exchange wherein the final state lepton is an electron for the case of photon γ or Z exchange and the final state lepton is a neutrino for the case of W^{-} exchange. On a very high energy scale of ~300 GeV, all of these exchange processes have amplitudes of similar orders of magnitude
- ✓ High-current electric discharges, e.g. big lightning bolts, will be accompanied by increased neutrino emission over a broad energy scale plus MeV-energy protons, neutrons & relativistic electrons. Plethora of final X states including electron, muon and pion particle anti-particle pairs may also be produced in extremely high-current discharges

FIG. 2: Boson exchange diagrams for electron-proton scattering into a lepton plus "anything" (X)



"High energy particles in the solar corona" A. Widom, Y. Srivastava, and L. Larsen arXiv:nucl-th/0804.2647v1 (2008)

Lighting bolts: one type of high-current electrical discharge

Quoted from "Primer" paper published in *Pramana* (2010)

- ✓ pp. 621: "We can write it in a more useful (system of unit independent) form using the Alfven current $I_0 \approx$ 17 kA, which was defined in eq. (4) ... Thus, we see that even with a moderate $(v/c) \approx 0.10$, if currents are much larger than the Alfven value [that is, electron currents >17 kA [i.e., >17,000 Amperes] flowing through a conductor with a cylindrical geometry, i.e., like a wire], the chemical potential can be of the order of MeVs or higher. This is an example of how the collective magnetic kinetic energy can be distributed to accelerate a smaller number of particles with sufficient energy to produce neutrons."

- ✓ pp. 629: "A typical electron in the current with a mean kinetic energy of 15 keV would have an average speed $(v/c) \approx 0.25$. On the other hand, even for such low mean speed, the chemical potential given in eq. (11), for $(I/I_0) \approx 200$ becomes large $\mu \approx (mc^2)(200)(0.25)$ = 25 MeV; (55) [which is] comfortably sufficient for an electron to induce a weak interaction LENR. Overall energy conservation will of course require that only a certain fraction of about (15 keV/25 MeV) = 6×10^{-4} of the total number of electrons in the current will be kinematically allowed to undergo weak interactions."

- ✓ Comment: on Earth, bolts of lightning have a duration of 30 - 50 microseconds and are well-known to involve electrical current pulses on the order of 30,000 to 100,000 Amperes (3×10^4 A to 1×10^5 A --- N.B. 'superbolts' on Jupiter are 10x larger). Importantly, such values for peak current easily exceed a key threshold identified in our published theoretical work, $I_o \approx$ 17,000 Amperes

Electric discharges provide energy to create neutrons

Neutrons created on solid surfaces will have ultralow kinetic energies

Neutrons produced by direct particle acceleration in hot plasmas can be energetic

During electric discharges, electroweak neutron production via e + p reaction can simultaneously occur in complex, highly variable mixtures of three modes:

1. Nuclear-strength μ-scale local electric fields in condensed matter surfaces of electrodes. Neutrons mostly ultralow energy and local gamma emissions are directly converted into infrared photons (IR) by unreacted heavy electrons per W-L theory; virtually no emissions of MeV-energy gammas or neutrons. MeV energy betas (electrons) commonly emitted; sometimes MeV alpha particles
2. Nuclear-strength μ-scale local electric fields on surfaces of condensed matter particles embedded in discharge plasmas. These plasma-bathed particles --- typically with dimensions of nm to microns --- can either arise from ablation of electrode surfaces or were present in local gaseous environment and simply get trapped when discharge plasmas form. Neutrons made in this ~1. mode are mostly ultralow momentum; gammas are converted into IR by heavy electrons
3. Many-body collective *magnetic* effects dominate this mode. W-L-S mechanism operates via direct acceleration of charged particles (mainly electrons and protons) by electromagnetic fields within plasma channels. Neutron, proton, and electron energies can range from thermal up to tens of MeVs; produces energetic X-rays & gammas up to tens of MeVs; also energetic X particles

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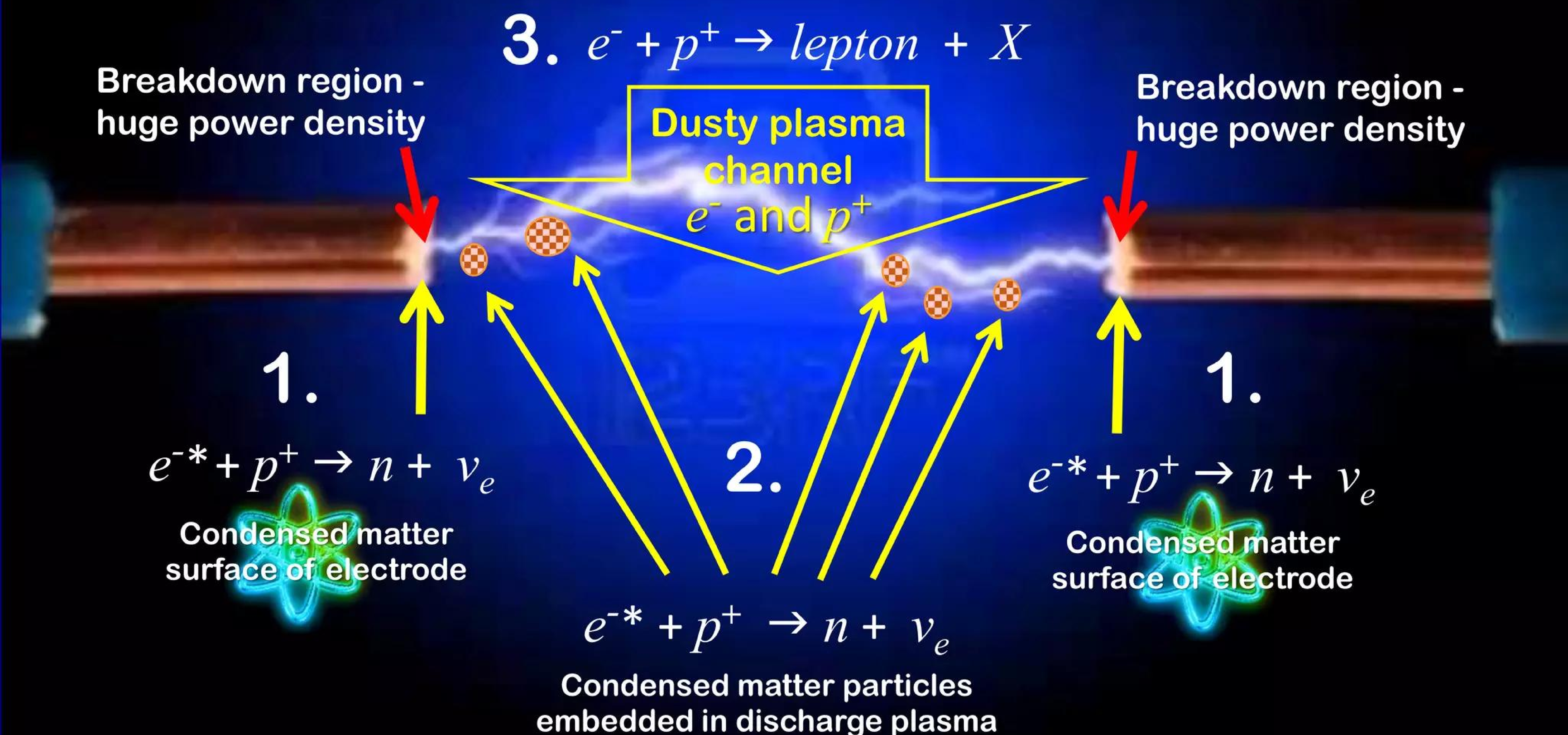


Huge power densities at electrode surface during discharge

Estimated power density in microscopic surface regions is 10^{21} W/sec·m^3

"Experimental study of high field limits of RF cavities"
D. Seidman, Northwestern Univ. and J. Norem, Argonne N. L. (2005)
http://www.hep.uiuc.edu/LCRD/LCRD_UCLC_proposal_FY05/2_49_Seidman_Norem.pdf

"[Electric arc] breakdown at surfaces was discovered by Earhart and Michelson, at [the University of] Chicago, in 1900 … While checking the new 'electron' theory of gas breakdown at small distances, they discovered that there were two mechanisms present, at large distances gas breakdown dominated, and at small distances [i.e., on small length-scales] breakdown of the surface was correctly identified as the mechanism. The break point where the two mechanisms met, at atmospheric pressure, occurs at about 300 V … This was confirmed 5 years later by Hobbs and Millikan, and is consistent with modern data on vacuum breakdown."

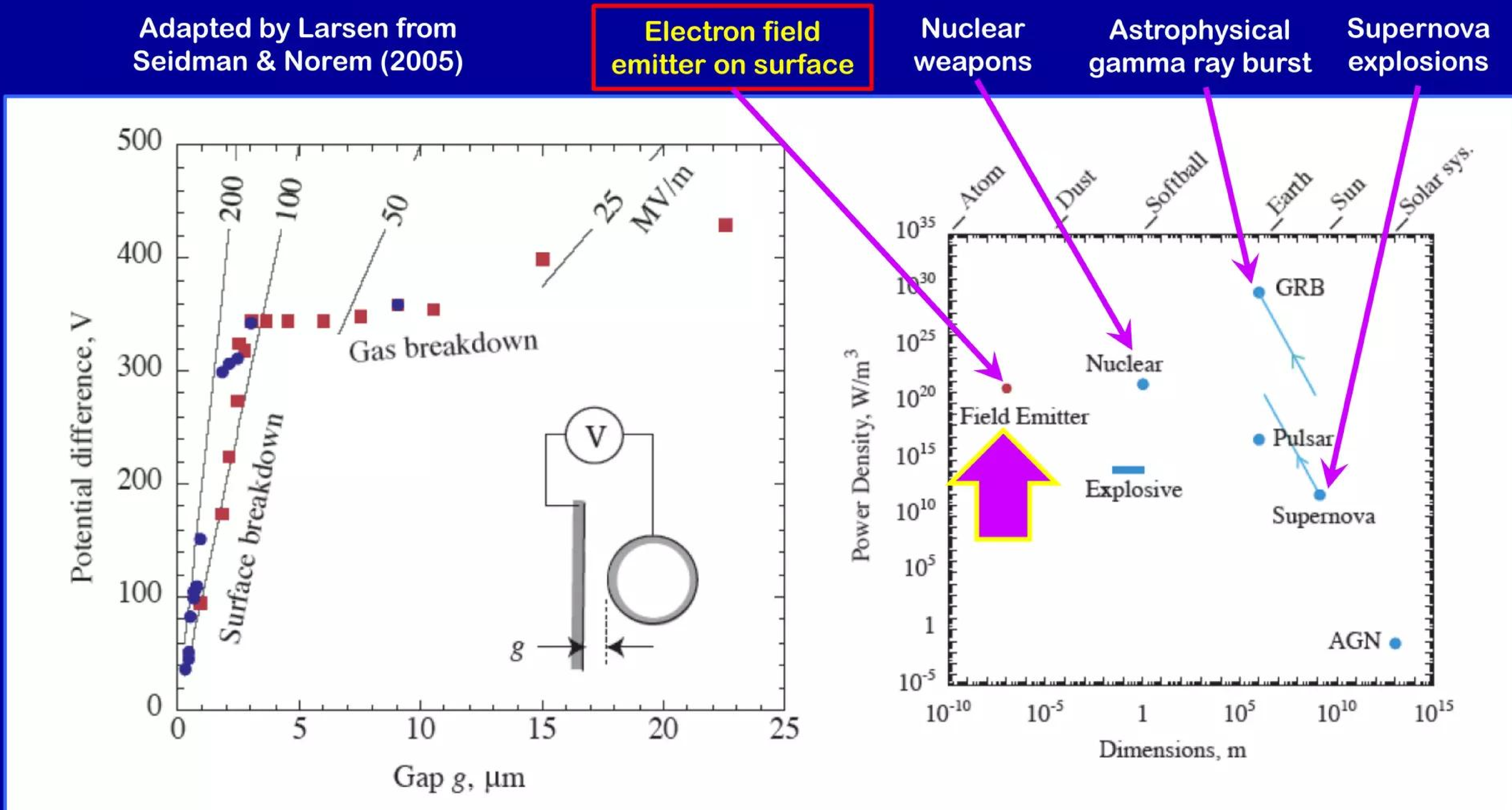
"Although high electric fields have been used in DC and RF applications for many years, up to now there has been no fundamental agreement on the cause of breakdown in these systems … Until our work, no theoretical understanding of this process developed over the last 100 years, although many papers have been written."

"Another interesting feature of this [electrical breakdown] mechanism is that the power densities involved are enormous. The numbers can be obtained from the values we measured for field emitted currents, electric field, the emitter dimensions, and volume for transferring electromagnetic field energy into electron kinetic energy. Combining these gives, (10 GV/m)(10^{-7} m)(1 mA)/(10^{-7}m)^3 = 10^{21} W/sec·m^3, a value that seems to be greater than all other natural effects, except perhaps Gamma Ray Bursters (GRB's). The power density is comparable to nuclear weapons. Michelson and Millikan noticed the 'hot sparks' in 1905, bought a vacuum pump, (which they didn't have), and invented vacuum ultraviolet spectroscopy. Both moved on, and did not look in detail at the mechanisms involved."

Power densities on electrode spots akin to gamma ray bursts

Stromgrew (1965): power density in Sun's core $E_{(J)}$ = 276.5 Joules/sec·m^3

Peak power density in an LENR-active site could be $E_{(J)}$ = 1.0 x 10^{21} Joules/sec·m^3



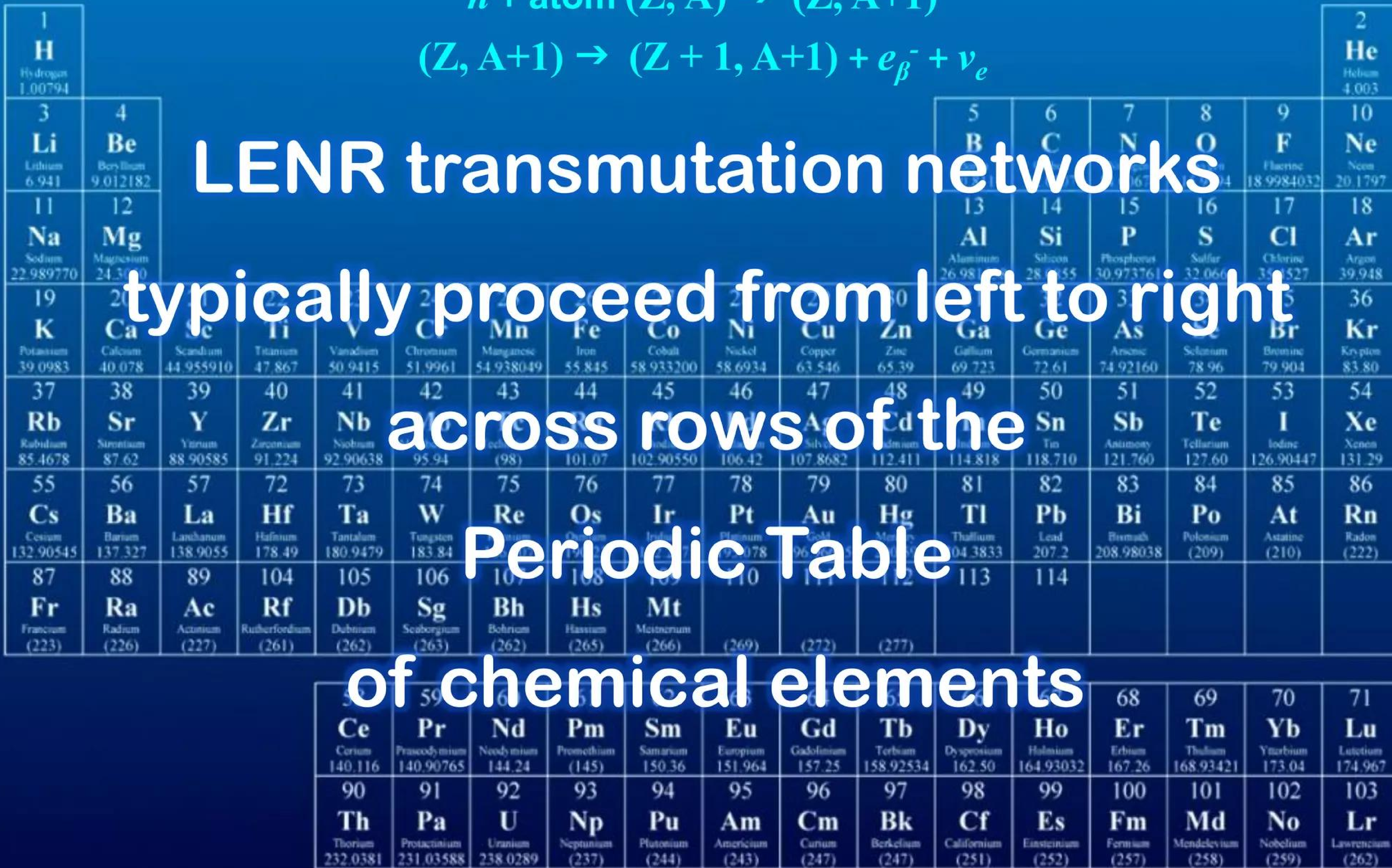
Source: Fig. 2, pp. 3, Seidman & Norem 2005 DOE proposal, "Experimental study of high field limits of RF cavities"

Neutrons are charge-neutral; atoms readily absorb them

Capture of neutrons by atoms will transmute them into other isotopes

$$n + \text{atom}\,(Z, A) \rightarrow (Z, A+1)$$

$$(Z, A+1) \rightarrow (Z+1, A+1) + e_{\beta}^{-} + \nu_e$$



LENR transmutation networks typically proceed from left to right across rows of the Periodic Table of chemical elements

Neutrons are produced in atmospheric lightning discharges

Gurevich *et al.* (2012) detected low energy neutrons from lightning bolts

See Lattice PowerPoint below where their 2012 *PRL* paper is cited and discussed

"New Russian data supports Widom-Larsen theory neutron production in lightning"
L. Larsen on SlideShare - April 4, 2012
http://www.slideshare.net/lewisglarsen/lattice-energy-llcnew-russian-data-supports-wlt-neutron-production-in-lightningapril-4-2012

Lattice comments: since 1985 (G. Shah *et al.*, *Nature* 313 pp. 773) experimental reports of an association between thunderstorm lightning discharges and detection of neutron production have been published episodically in major peer-reviewed journals. However, this new, highly reliable data collected by Russian scientists and published in *Phys Rev Lett* is the first instance in which: (a) observed neutron fluxes associated with lightning discharges could be accurately counted, well-estimated quantitatively, and temporally correlated with lightning discharges; and (b) better insights were achieved into energy spectra of such lightning-produced neutrons. Importantly, size of the neutron fluxes observed by Gurevich *et al.* are too large to be explained by a photonuclear mechanism (in recent years was thought by many to successfully explain neutron production in lightning channels). Given that fusion processes had been decisively excluded in years prior to a recent rise in popularity of the conjectured photonuclear mechanism (e.g., see L. Babich & R. R-Dupre, 2007), the Widom-Larsen-Srivastava (WLS) many-body, collective magnetic e^- + p^+ weak-interaction mechanism is the only remaining theoretical approach that can plausibly explain key features of this reported data

Low-energy neutrons are produced in lightning at Tien-Shan

Data reported by Mitko et al. (2013) consistent with Widom-Larsen theory

Lightning discharges also correlated with emission of gammas and MeV electrons

"Bursts of gamma-rays, electrons and low-energy neutrons during thunderstorms at the Tien-Shan"
G. Mitko *et al*. *Journal of Physics*, Conference Series 409 pp. 012235 (2013)

http://iopscience.iop.org/article/10.1088/1742-6596/409/1/012235/meta

Abstract: "New data of the last measurement season held at the Tien-Shan complex for investigation gamma-radiation, accelerated electrons and low-energy neutrons during thunderstorms are presented. The flux of gamma-radiation in the energy range of 40 - 1200 keV shows a strict correlation with instantaneous intensity of atmospheric discharge. Its energy spectra measured for the first time with riches statistics and improved resolution typically have an absolute intensity about 50 - 100 quanta$\cdot$cm$^{-2}\cdot$s^{-1}, and demonstrate considerable evolution in the course of discharge. The signals from an avalanche of accelerated electrons have been directly observed inside thunderclouds. A lower energy estimation for these electrons is about 10 MeV. For the first time, during electric discharge moments in thunderstorms, there were found considerable intensity enhancements of the neutron intensity in the range of thermal energies: up to 100 - 200 standard deviations, or 3 - 8 times above the background, so the observed neutron flux reaches the values of (20 - 40) $\cdot$ 10^3 m^{-2} $\cdot$ min^{-1}."

Lightning associated with plumes of charged volcanic ash

Electroweak neutron production is certainly occurring in these plumes

Volcano-driven nucleosynthetic products will accumulate over geological time

Image of volcanic lightning from April 2015 eruption in Villarica, Chile

Intense lightning is known to occur on Jupiter and Saturn

Neutron production occurring since Hydrogen abundant in atmosphere

Is lightning-driven nucleosynthesis occurring on exoplanets and brown dwarfs?

"Lightning as a possible source of the radio emission on HAT-P-11b"
G. Hodosan *et al.*, *MNRAS* accepted for publication (2016)

http://arxiv.org/pdf/1604.07406.pdf

Abstract: " … Lightning induced radio emission has been observed on Solar System planets. There have been many attempts to observe exoplanets in the radio wavelength, however, no unequivocal detection has been reported. Lecavelier des Etangs *et al.* … carried out radio transit observations of the exoplanet HAT-P-11b, and suggested that a small part of the radio flux can be attributed to the planet. In the current letter, we assume that this signal is real, and study if this radio emission could be caused by lightning in the atmosphere of the planet. We find that a lightning storm with 530 times larger flash densities than the Earth-storms with the largest lightning activity is needed to produce the observed signal from HAT-P-11b …"

"Atmospheric electrification in dusty, reactive gases in the solar system and beyond"
C. Helling *et al.*, arXiv:1601.04594v2 [astro-ph.EP] January 29, 2016

http://arxiv.org/pdf/1601.04594v2.pdf

" … Earth, Jupiter, and Saturn are cloudy solar system planets for which atmospheric discharges in form of lightning is confirmed observationally in radio and in optical wavelengths. Space exploration and ground based observations have shown that lightning is a process universal in the solar system …"

Gas giant planets: abundant Hydrogen in atmospheres

Intense lightning on such planets will generate neutrons just like Earth

Neutron-driven transmutation could have significant impact over geological time

Table 2. *Composition of the Atmospheres of Jupiter, Saturn, Uranus, and Neptune*

Gas	Jupiter[a]	Saturn	Uranus	Neptune
H_2	86.4 ± 0.3%	88 ± 2%	~82.5 ± 3.3%	~80 ± 3.2 %
^4He	13.6 ± 0.3%	12 ± 2%	15.2 ± 3.3 %	19.0 ± 3.2 %
CH_4	$(1.81 \pm 0.34) \times 10^{-3}$	$(4.7 \pm 0.2) \times 10^{-3}$	~2.3 %	~1-2 %
NH_3	$(6.1 \pm 2.8) \times 10^{-4}$	$(1.6 \pm 1.1) \times 10^{-4}$	<100 ppb	<600 ppb
H_2O	520^{+340}_{-240} ppm	2–20 ppb		
H_2S	67 ± 4 ppm	<0.4 ppm	<0.8 ppm	<3 ppm
HD	45 ± 12 ppm	110 ± 58 ppm	~148 ppm	~192 ppm
$^{13}CH_4$	19 ± 1 ppm	51±2 ppm		
C_2H_6	5.8 ± 1.5 ppm	7.0 ± 1.5 ppm		
PH_3	1.1 ± 0.4 ppm	4.5 ± 1.4 ppm		
CH_3D	0.20 ± 0.04 ppm	0.30 ± 0.02 ppm	~8.3 ppm	~12 ppm
C_2H_2	0.11 ± 0.03 ppm	0.30 ± 0.10 ppm	~10 ppb	60^{+140}_{-40} ppb
HCN	60 ± 10 ppb	<4 ppb	<15 ppb	0.3 ± 0.15 ppb
HC_3N			<0.8 ppb	<0.4 ppb
C_2H_4	7 ± 3 ppb	~0.2 ppb[b]		
CO_2	5-35 ppb	0.3 ppb	40 ± 5 ppt	
C_2H_6			10 ± 1 ppb	$1.5^{+2.5}_{-0.5}$ ppm
CH_3C_2H	2.5^{+2}_{-1} ppb	0.6 ppb	0.25 ± 0.03 ppb	
CO	1.6 ± 0.3 ppb	1.4 ± 0.7 ppb	<40 ppb	0.65 ± 0.35 ppm
CH_3CN				<5 ppb
GeH_4	$0.7^{+0.4}_{-0.2}$ ppb	0.4 ± 0.4 ppb		
C_4H_2	0.3 ± 0.2 ppb	0.09 ppb	0.16 ± 0.02 ppb	
AsH_3	0.22 ± 0.11 ppb	2.1 ± 1.3 ppb		

[a] ^3He 22.6±0.7 ppm, Ne 21±3 ppm, Ar 16±3 ppm, Kr 8±1 ppb, Xe 0.8±0.1 ppb.
[b] assuming a total stratospheric column density of 1.54%10^{25} cm^{-2}.
From Lodders & Fegley 1998 and updates: Mahaffy et al. 2000, Atreya et al. 2003, Lodders 2004, Wong et al. 2004

To get better fix on true chemical and isotopic composition of the Sun, NASA's 2001 Genesis probe was designed to collect and return (2004) samples of pristine solar wind for in-depth analysis

See paper: "Solar composition from the Genesis Discovery Mission," D. Burnett and Genesis Science Team, *PNAS* (2011)

Quoting: "…Several well studied natural processes exist which fractionate isotopes relative to the assumed Standard model values, but none of these explain the variations shown on Figure 3 … origin of the discrepancy [in O] is unknown."

Burnett *et al.* (ibid.) finally concluded,

"…variations in $^{15}N/^{14}N$ [ratio] are much larger than O [ratio] and cannot be explained by well studied mechanisms of isotope fractionation."

Neutrons created in laboratory discharges first reported 1949

Researchers attempting to trigger D+D fusion reaction in Deuterium gas

Stopped experiments because mistakenly thought neutrons were background

pp. 19 in “Fusion Research in the UK: 1945 - 1960” by J. Hendry and J.D. Lawson, AEA Technology (1993)

Quoting: “… at the Harwell meeting in … 1947, some brief calculations … to obtain fusion in a discharge in Deuterium at atmospheric pressure. Typical figures suggested were a discharge of length 10 cm and radius 1 cm, carrying 3 million Amps, to give sufficient magnetic field … It was recognized that the discharge would have to be built up very rapidly to avoid excessive radiation loss during heating (of order 10^{11} Watts) and a total energy of about 2 x 10^{7} Joules would be required to reach ignition temperature. It appears … that Meek, together with J. D. Craggs … had independently considered the possibility though their calculations indicated that it was unlikely that neutrons would be observed … They did not expect to be able to detect thermonuclear neutrons, but nevertheless felt if was worthwhile making a search … In 1949 Reynolds and Craggs; using a high current generator … passed 100 sparks each of 300 kA [300,000 Amperes] through Deuterium at atmospheric pressure. A few neutrons were found, but these were later found to be background, since the same number were observed in 100 sparks in Hydrogen. After this experiment there was no further work specifically directed toward fusion.”

They were unware of possibility for *electroweak* neutron production with Deuterium or Hydrogen in their experimental system. Thus incorrectly concluded that observed neutrons were just background radiation. Results are consistent with Widom-Larsen

Thanks to Steven Krivit and Brian Austin for providing more clarification on a mystery revealed on page 492 of Brian’s book: “Schonland: Scientist and soldier: from lightning on the veld to nuclear power at Harwell: the life of Field Marshal Montgomery's scientific adviser” CRC Press (2016)

Neutrons produced in laboratory high-voltage discharge

Data reported by Agafonov et al. (2016) consistent with Widom-Larsen

Energy range of detected neutrons from thermal to several MeV; >15 MeV gammas

"Observation of hard radiations in a laboratory atmospheric high-voltage discharge"
A. Agafonov *et al.*, arXiv:16044.07784v1 [physics.plasm-ph] 26 April 2016

http://arxiv.org/abs/1604.07784

Abstract: "The new results concerning neutron emission detection from a laboratory high-voltage discharge in the air are presented. Data were obtained with a combination of plastic scintillation detectors and 3He filled counters of thermal neutrons. Strong dependence of the hard x-ray and neutron radiation appearance on the field strength near electrodes, which is determined by their form, was found. We have revealed a more sophisticated temporal structure of the neutron bursts observed during of electric discharge. This may indicate different mechanisms for generating penetrating radiation at the time formation and development of the atmospheric discharge."

Lattice comments: experiments were designed to approximate natural lightning discharges in Earth's atmosphere. Reported data is consistent with what would be predicted by the Widom-Larsen theory; indicates that varying mixture of all three LENR modes were probably occurring in their system. Local electric field strength is crucial for electroweak neutron production on condensed matter surfaces; this is exactly why they produced much higher neutron fluxes with "needle" cathode vs. hemispherical shape --- needle geometry vastly intensified local E-fields at its tip

Carbon-13 abundance shifts in DC arc synthesis of fullerenes

Chemical fractionation or electric discharge LENRs could create results

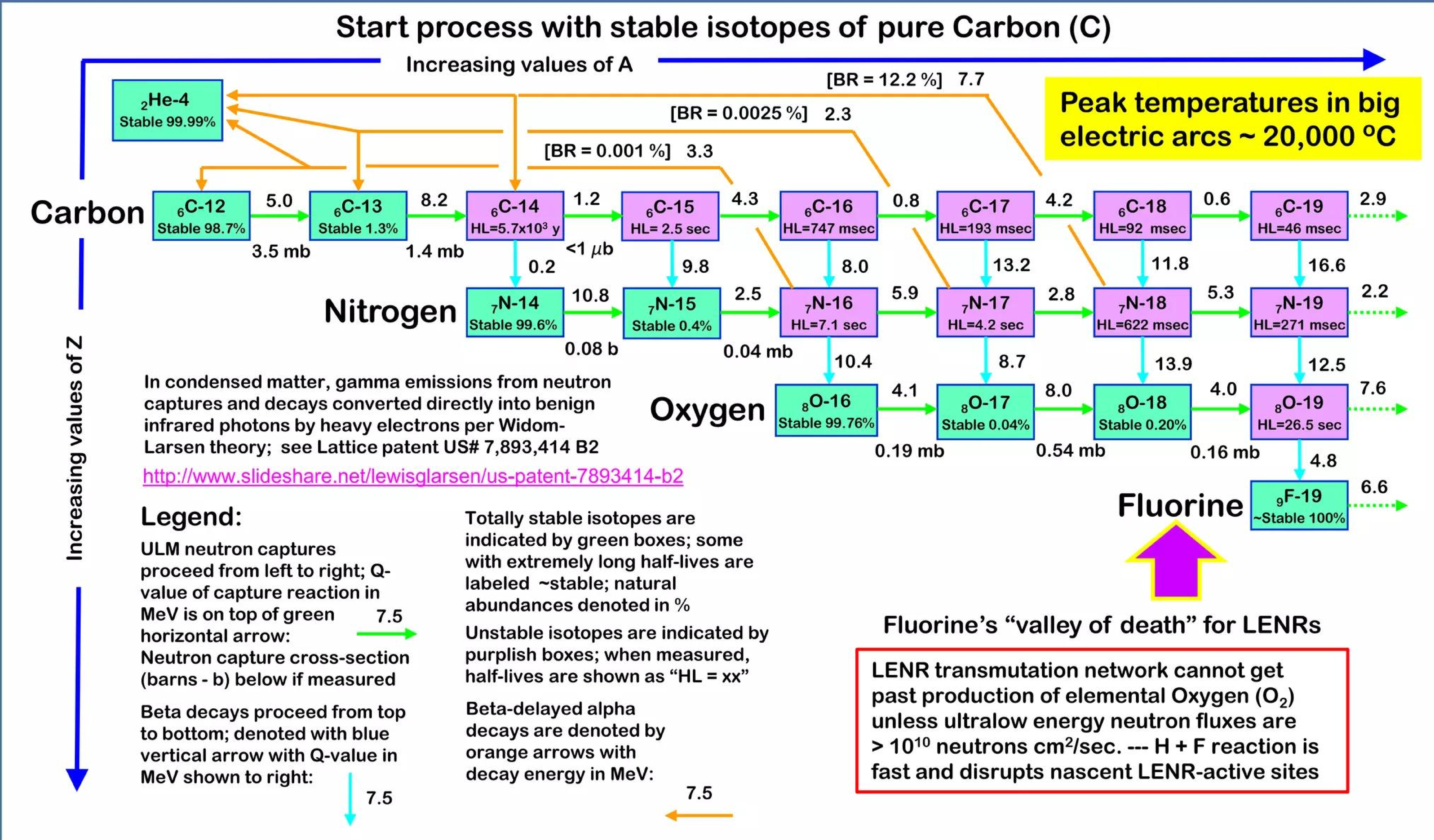
See next slide: LENR transmutation network can alter Carbon-13 abundance

"Isotope fractionation in the synthesis of fullerenes"
K. Thomas *et al.*, *Carbon* 32 pp. 991 - 1000 (1994)
https://www.researchgate.net/publication/264411377_Isotope_fractionation_in_the_synthesis_of_fullerenes

Abstract: "The synthesis of fullerenes by the direct current (DC) carbon arc evaporation method produces a number of different carbon materials. This investigation has involved the structural characterisation of the materials and the study of their isotopic composition. The cathode deposit was a highly ordered graphite with the basal planes oriented in the axial direction of the graphite rod. Raman microprobe spectroscopy, X-ray powder diffraction, and temperature programmed combustion measurements also showed that the material was heterogeneous. The structural characterisation results were consistent with the deposit being formed at progressively lower heat-treatment temperatures with increasing deposition. The fullerene soot was a very heterogeneous material with a large surface area. Isotope composition studies showed that the raw fullerene soot, fullerene depleted soot (toluene extract), C_{60}, and C_{70} were enriched in ^{13}C relative to the graphite anode, whereas the cathode deposit was depleted in ^{13}C. The measurements show that C_{60} is richer in ^{13}C compared with both C_{70} and the toluene-extracted soot. The implications regarding the mechanisms for the formation of fullerenes are discussed."

LENR C → N → O neutron-catalyzed transmutation network

Carbon 1st transmuted to Nitrogen; sometimes self-terminates at Oxygen

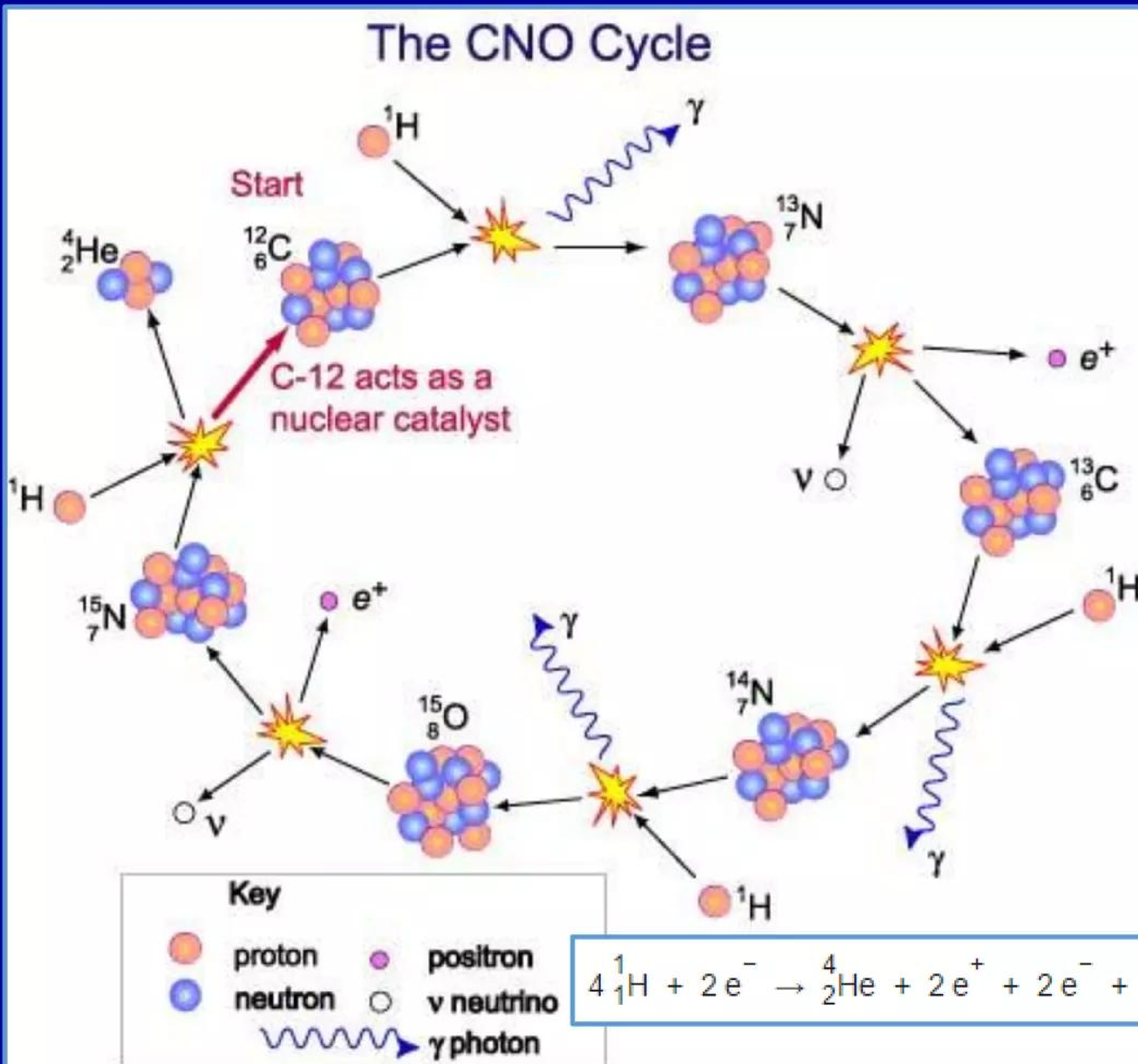


C → N → O cycle in stars involves nuclear fusion reactions

Neutrons are not involved in these reactions at very high temperatures

CNO fusion cycle is dominant source of energy in stars 1.3x larger than our Sun

Stellar CNO cycle energy release = 26.7 MeV vs. 10.8 MeV for LENR neutron capture on ^{14}N



Excellent temperature for CNO cycle in stars is ~ 17 million °C

$$^{12}C + p \rightarrow {}^{13}N + \gamma$$

$$^{13}N \rightarrow {}^{13}C + e^{+} + \nu_e$$

$$^{13}C + p \rightarrow {}^{14}N + \gamma$$

$$^{14}N + p \rightarrow {}^{15}O + \gamma$$

$$^{15}O \rightarrow {}^{15}N + e^{+} + \nu_e$$

$$^{15}N + p \rightarrow {}^{12}C + {}^{4}He$$

$$4\,{}^{1}_{1}H + 2e^{-} \rightarrow {}^{4}_{2}He + 2e^{+} + 2e^{-} + 2\nu_e + 3\gamma + 24.7\ MeV \rightarrow {}^{4}_{2}He + 2\nu_e + 3\gamma + 26.7\ MeV$$

Iron produced in arcing between Carbon electrodes in H_2O

Neutron fluxes high enough for LENR transmutation network to reach Fe

Large electrical energy input enabled neutron production rate to be $>10^{10}$ cm^2/sec.

"Technical overview - Carbon seed LENR networks"
L. Larsen on SlideShare - September 3, 2009
http://www.slideshare.net/lewisglarsen/lattice-energy-llctechnical-overviewcarbon-seed-lenr-networkssept-3-2009

Lattice comments: data presented in Table II on pp. 269 of Singh *et al*. show results of mass spectroscopic analysis of Fe isotopes present in the anomalous Iron found in carbonaceous particulate debris situated at the bottom of their Pyrex reaction vessel. Observed Fe isotope ratios shown in Table II were unremarkable in that they did not differ significantly from natural terrestrial abundances. In context of Widom-Larsen theory of neutron-catalyzed LENRs, this result is not surprising. Fe's natural abundance values are the end-result of several episodes of neutron-catalyzed r-/s-process nucleosynthesis occurring over billions of years; they reflect Nature's optimization of element nucleosynthesis. A priori, why should LENRs be different?

Prosaic chemical processes cannot produce nuclear transmutations in closed experimental systems; elements previously absent cannot suddenly appear. Based on Lattice's reanalysis of their data in context of the W-L theory of LENRs, the most reasonable explanation is that both Sundaresan & Bockris and Singh *et al*. probably observed LENR nuclear transmutation products in their Carbon-arc experiments at Texas A&M and BARC that published in *Fusion Technology* (1994)

Iron produced in arcing between Carbon electrodes in H_2O

Repeated the Texas A&M and BARC work reported in *Fusion Technology*

NPR 原子核物理评论（1984 年创刊）
Nuclear Physics Review(started in 1984)

"Nuclear transmutation induced by Carbon arcing under water"
W. Zhi-gang & J. Xing-liu, *Nuclear Physics Review* 21 pp. 428 - 429 (2004)

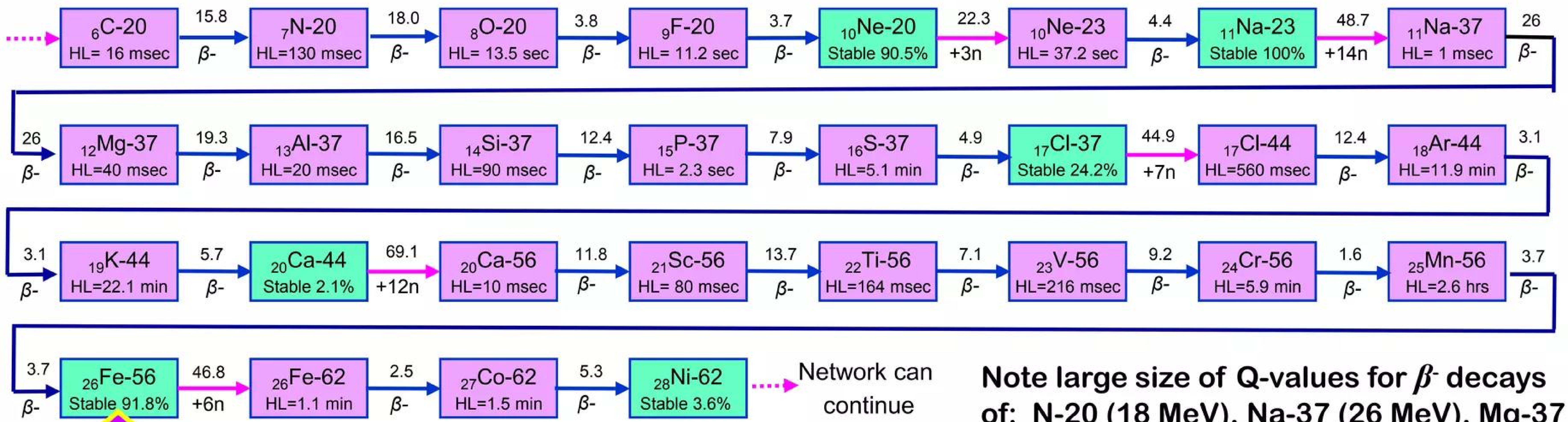
Abstract: "There exist various phenomena for electric discharge, such as radiation with wide bands, collective acceleration, electron degeneracy and 'linear atom', etc. which occur in dense state of matter. The arcing was created in the gap between two purified carbon rods in deionized water. The original carbon contained a few millionth iron, and the detritus contained up to thousands millionth iron based on the analysis by an atomic emission spectroscope (AES). It is deduced that the plasma filaments with superdense matter due to micropinch effect make nuclear transmutation possible. The excess of iron isotope ^{58}Fe comparing with natural iron was determined by neutron activation analysis."

Lattice comments: Successfully (perhaps inadvertently) repeated Carbon-arc experiments conducted at Texas A&M University and the Bhabha Atomic Research Center (BARC - India) that were reported and published in *Fusion Technology* (1994); a peer-reviewed journal of the American Nuclear Society

LENR transmutation pathway makes Fe within several hours

Only way this happens so fast is by following very neutron-rich pathways

Start process with stable isotopes of pure Carbon (C) ---- see previous Slide #26



Note large size of Q-values for β^- decays of: N-20 (18 MeV), Na-37 (26 MeV), Mg-37 (19.3 MeV), and Al-37 (16.5 MeV)

$_{26}Fe^{56}$ created via neutron captures and beta decays

LENR neutron fluxes in high-current Carbon-arc experiments were high enough to pass through the Fluorine 'valley of death.' Above example is but one of many possible LENR nucleosynthetic pathways from Carbon to Iron; final product results observed in a given experiment will reflect sum total across many parallel alternate reaction paths. Neutron production occurs near the Carbon rod tips and on nanoparticles floating in the water in regions of high currents and electric fields between electrodes. If data of Sundaresan & Bockris and Singh *et al.* are correct, only way that Iron can be produced from Carbon within an hour or two is via LENR nucleosynthetic pathways that involve extremely neutron-rich isotopes

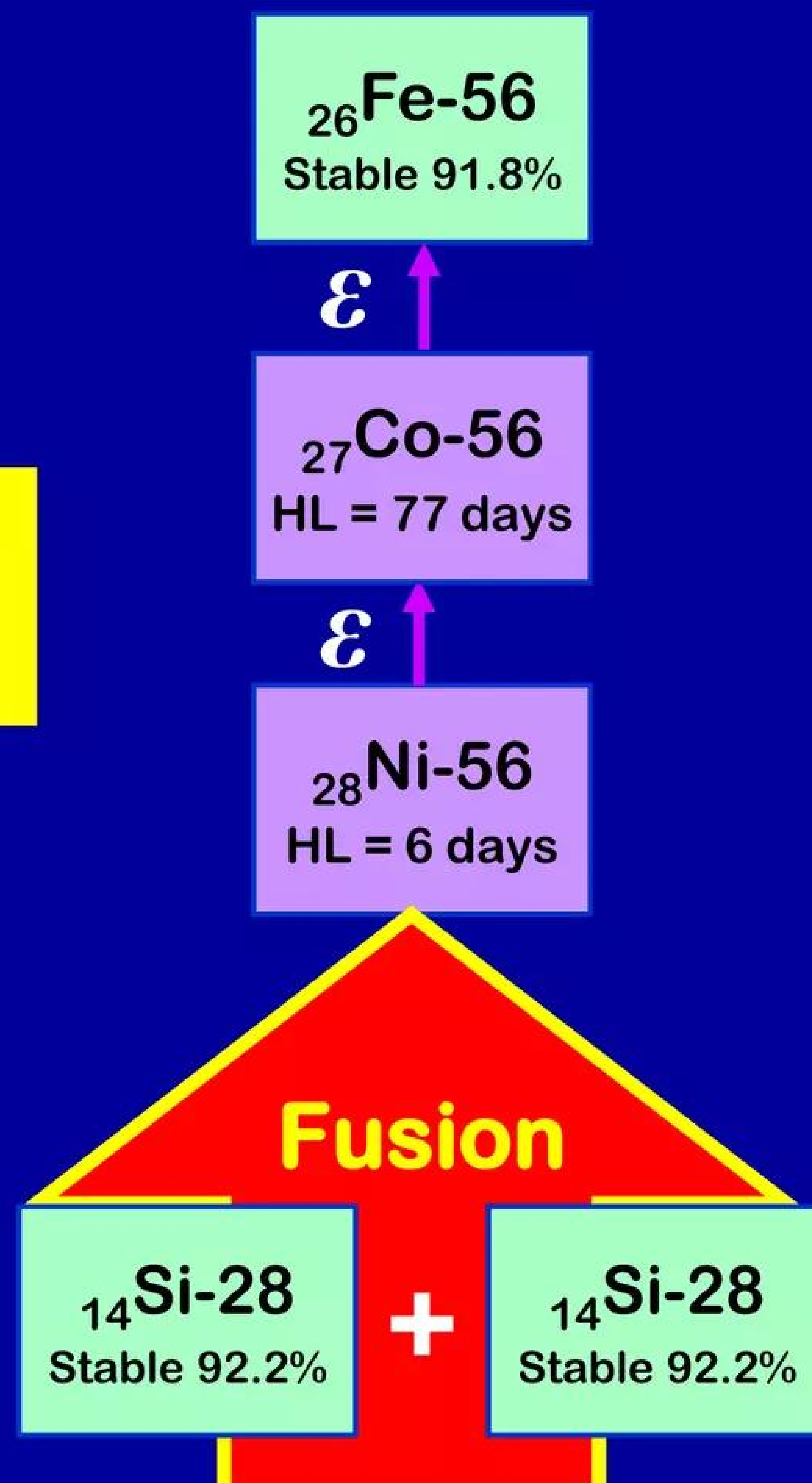
Transmutation pathway to Iron ^{56}Fe in stellar supernovas

Fusion of Silicon creates ^{56}Ni followed by two electron capture decays

After 60 years of study many details about stellar nucleosynthesis are still unclear

$_{26}Fe^{56}$ is created via fusion of Si-28 followed by two electron capture decays

Initial temperature of material in Type-1a stellar supernova explosion is > 4 billion ^{o}C

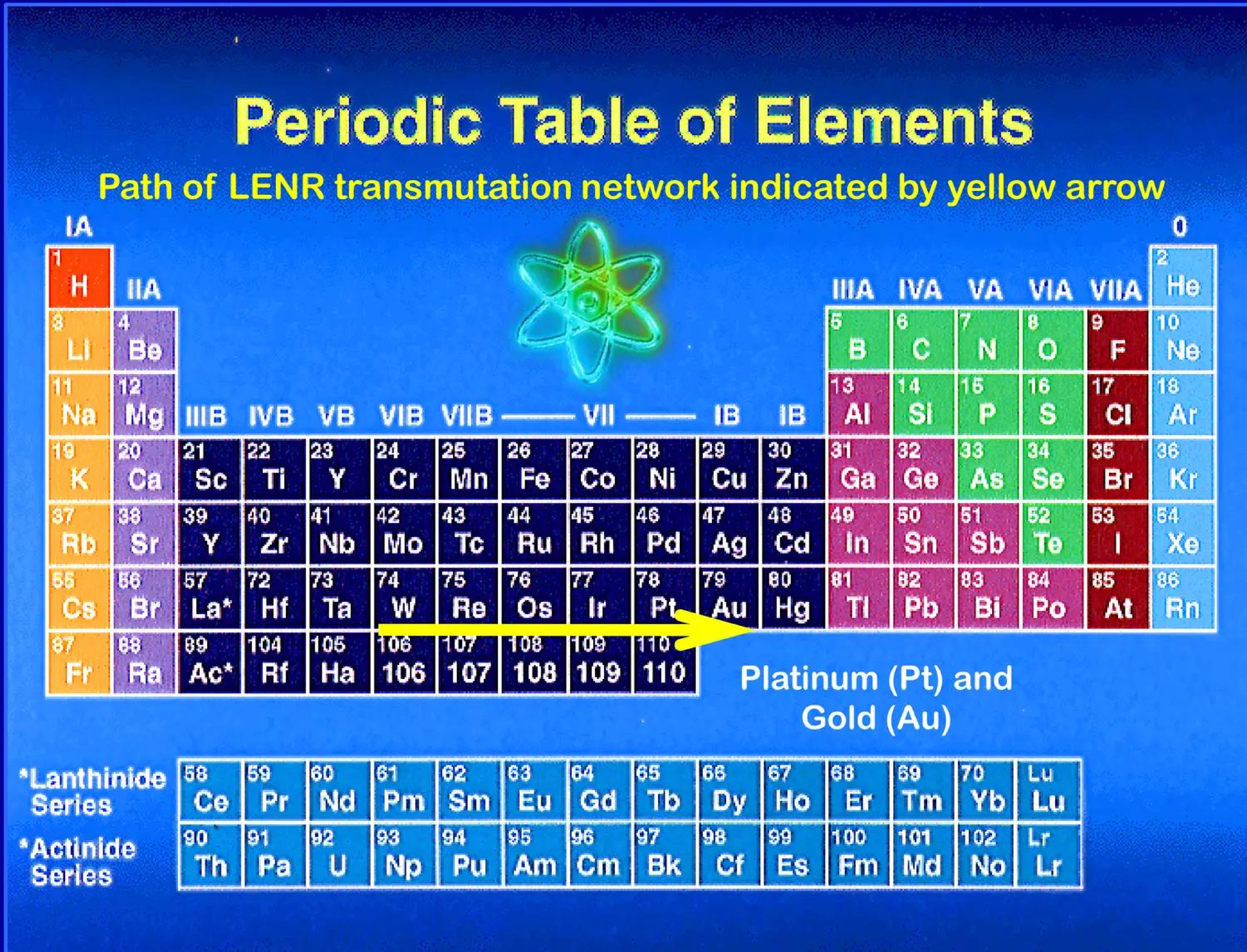


Supernova remnant: Crab Nebula

Credit: NASA - Hubble

LENR transmutation pathway follows row of Periodic Table

Tungsten (W) → Rhenium → Osmium → Iridium → Platinum → Gold (Au)



Electric discharge in transformer oil by Nagaoka et al. (1924)

High currents between Thorium-free Tungsten electrodes produced Gold

Clipped images of original news story

Courtesy of Google

Montreal Gazette

pp. 10 June 20, 1925

SHOWS TRANSMUTED GOLD IN NEW YORK

Dr. Nagaoka of Tokio Taking Specimens to Brussels Congress

(Special to The Gazette.)

New York, June 19.—Bits of porcelain containing microscopic specks of gold which once was mercury were presented to Dr. George F Kunz today by Dr. H. Nagaoka, of Tokio, the "Japanese Einstein, who succeeded in producing artificial gold by disintegrating atoms of quicksilver in a powerful electrical field.

The Japanese scientist, who sails early tomorrow morning on the Olympic for Europe to attend the International Research Congress at Brussels, brought with him a number of gold-specked fragments from the porcelain flasks in which the mercury was treated. In more than 200 experiments the change from mercury to gold has been confirmed, Dr. Nagaoka said.

Dr. Nagaoka said that he was engaged in trying to accelerate the radio-activity of uranium and to speed up its decay. This experiment failed because the radio-active substances set up electrical effects of their own which protected them against the intense electrical action which Dr. Nagaoka sought to bring to bear against them. In this investigation, however, he found a way to concentrate an intense electrical activity in a very small field. It occurred to him that his artificial electrical storm might be severe enough to wreck atoms and change their nature With this in view he experimented on the mercury and obtained gold.

"We have also obtained from the quicksilver a white metal which we have not been able to identify," he said. "We can prove that it is not platinum, but can't tell what it is. It occurs in such small quantities that it defies ordinary methods of analysis. The mercury may be changed into still other substances, but we have not any further evidence on it. It appears, however, that the changes which are forced on the atom are somewhat complex."

Dr. Nagaoka said that he was sceptical about the reports that Dr. A. N. Miethe of Berlin had obtained gold from quicksilver. He said that the amount of electricity used by Dr. Miethe was not sufficient to break down the mercury atom into gold, and that he suspected the gold to be a contamination.

"It might have come from the quicksilver, it might have come from the silica glass used in the experiment, or it might have come from the carbon electrode. I do not believe it was the result of any changes in atoms."

Dr. Nagaoka also expressed doubt that Rutherford had succeeded in effecting "transmutation" or the disintegration of atoms by bombarding them with alpha particles. He said there was no way of confirming by chemical analysis or otherwise the supposed changes in atoms resulting from the bombardment by the alpha particles given off by radium.

http://news.google.com/newspapers?nid=1946&dat=19250620&id=2W0tAAAAIBAJ&sjid=0IsFAAAAIBAJ&pg=5346,2683180

Electric discharge in transformer oil by Nagaoka et al. (1924)

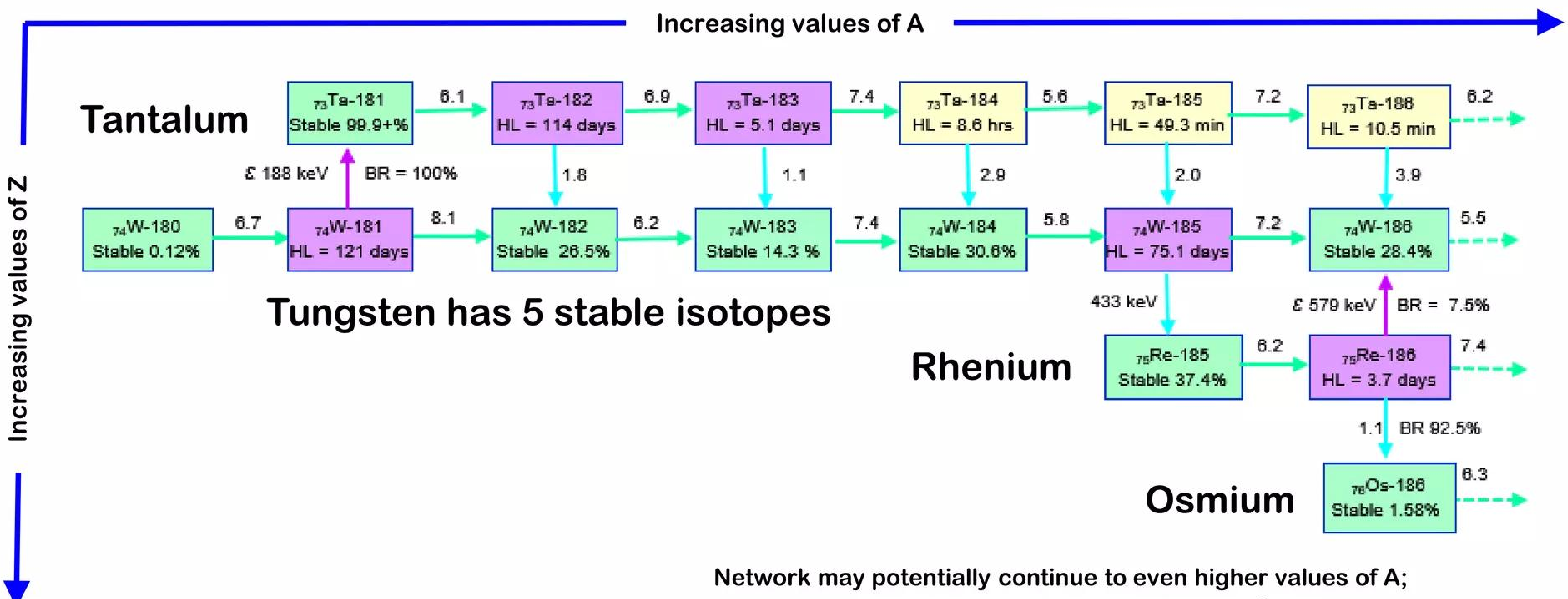
High currents between Thorium-free Tungsten electrodes produced Gold

Results were published in *Nature*; > 200 successful experiments; still not believed

"Mystery of Prof. Hantaro Nagaoka's 1920s Gold experiments in Japan"
L. Larsen on SlideShare - December 27, 2013

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-mystery-of-nagaokas-1920s-gold-experiments-why-did-work-stop-by-1930-dec-27-2013

Start process with stable isotopes of pure Tungsten (W) metal

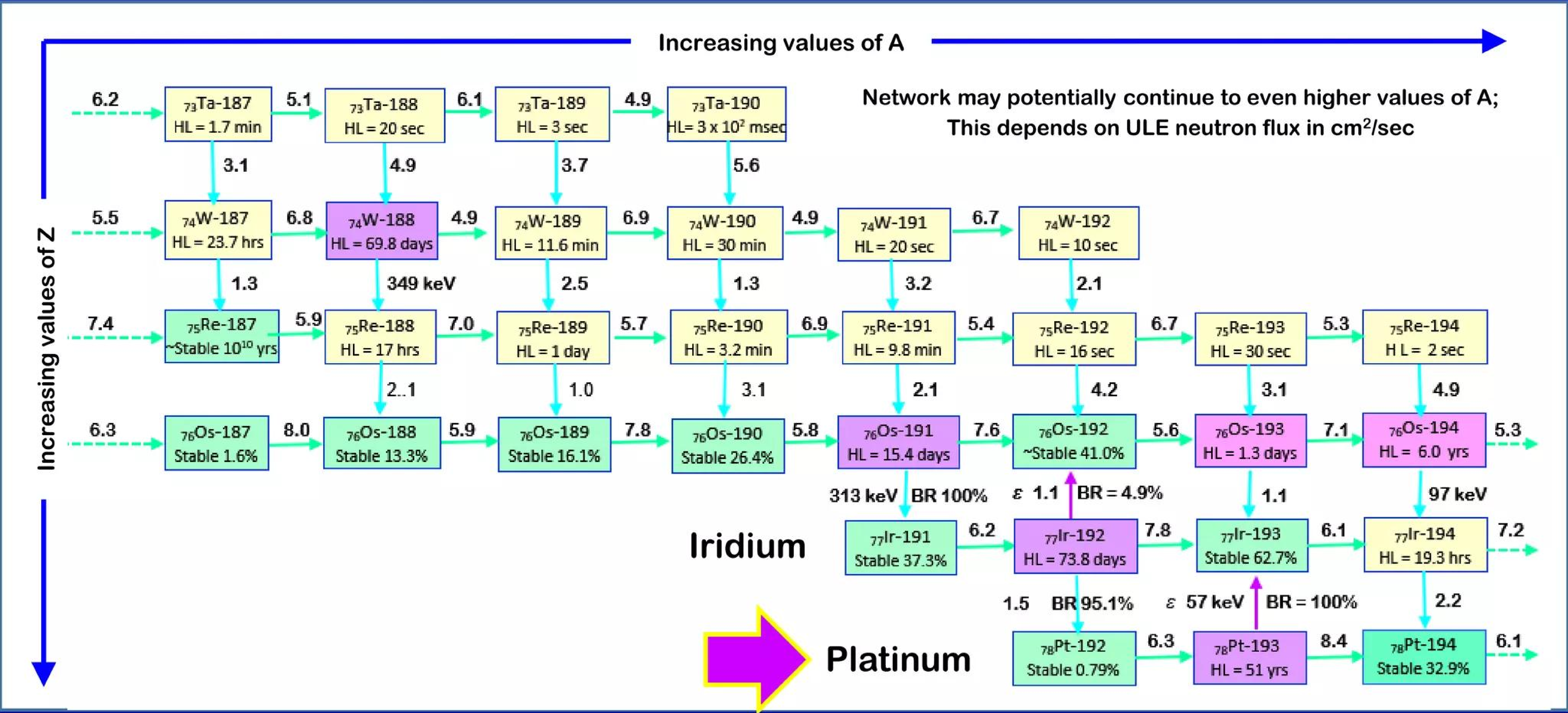


Network may potentially continue to even higher values of A;
This depends on ULE neutron flux in cm^2/sec

Nagaoka's results are explained by Widom-Larsen theory

LENR transmutation network begins with neutron captures on Tungsten

From Sept. 1924 to June 1925, Nagaoka *et al.* at RIKEN in Japan conducted ~200 experiments with high-current electric arc discharges between Tungsten electrodes immersed in liquid hydrocarbon transformer oil in which they detected successful transmutation of Tungsten into macroscopic, visible flecks of Gold and Platinum. In July 1925, *Nature* published a Letter to the Editors where he reported these results



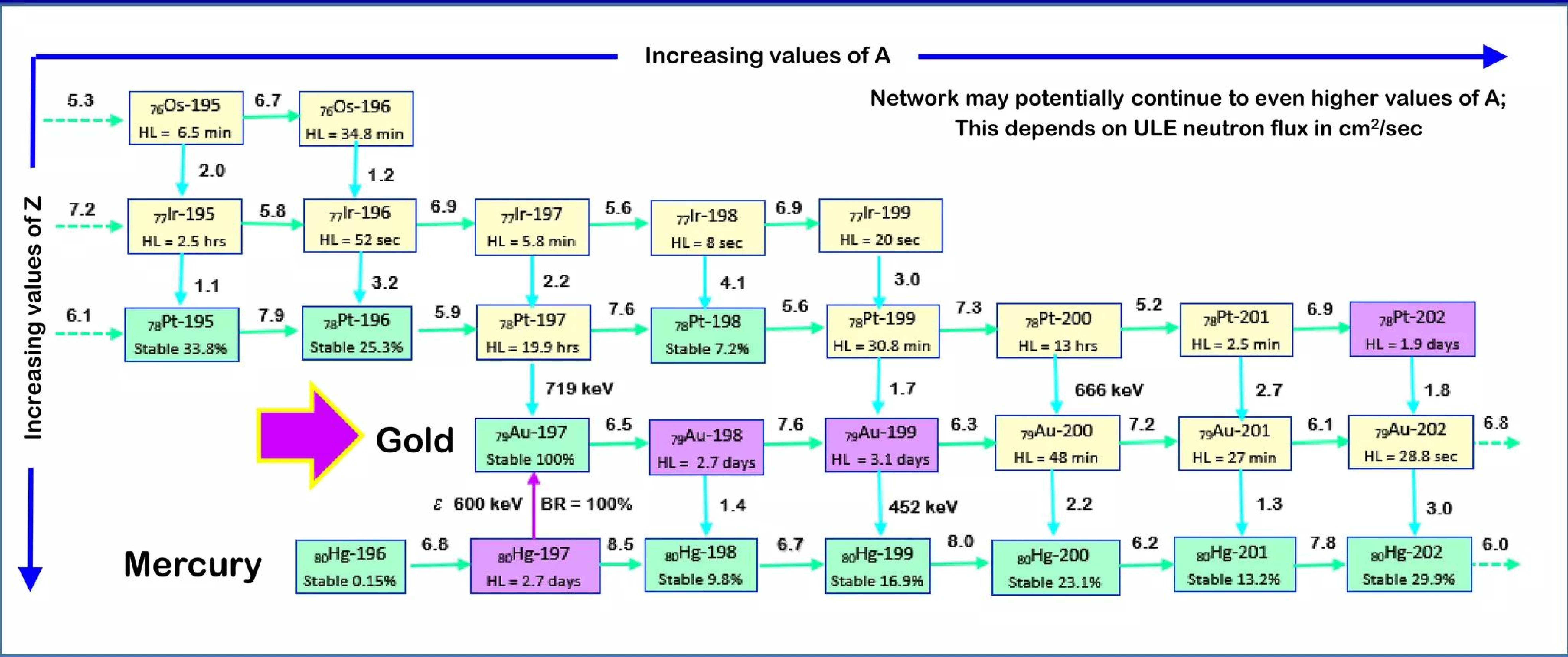
W → Au LENR pathway confirmed by Mitsubishi (2012)

MHI confirmation used different experimental technique than Nagaoka

Deuterium permeation creates much smaller neutron fluxes vs. electric discharge

"LENR transmutation networks can produce Gold"
L. Larsen on SlideShare - December 7, 2012

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-lenr-transmutation-networks-can-produce-golddec-7-2012

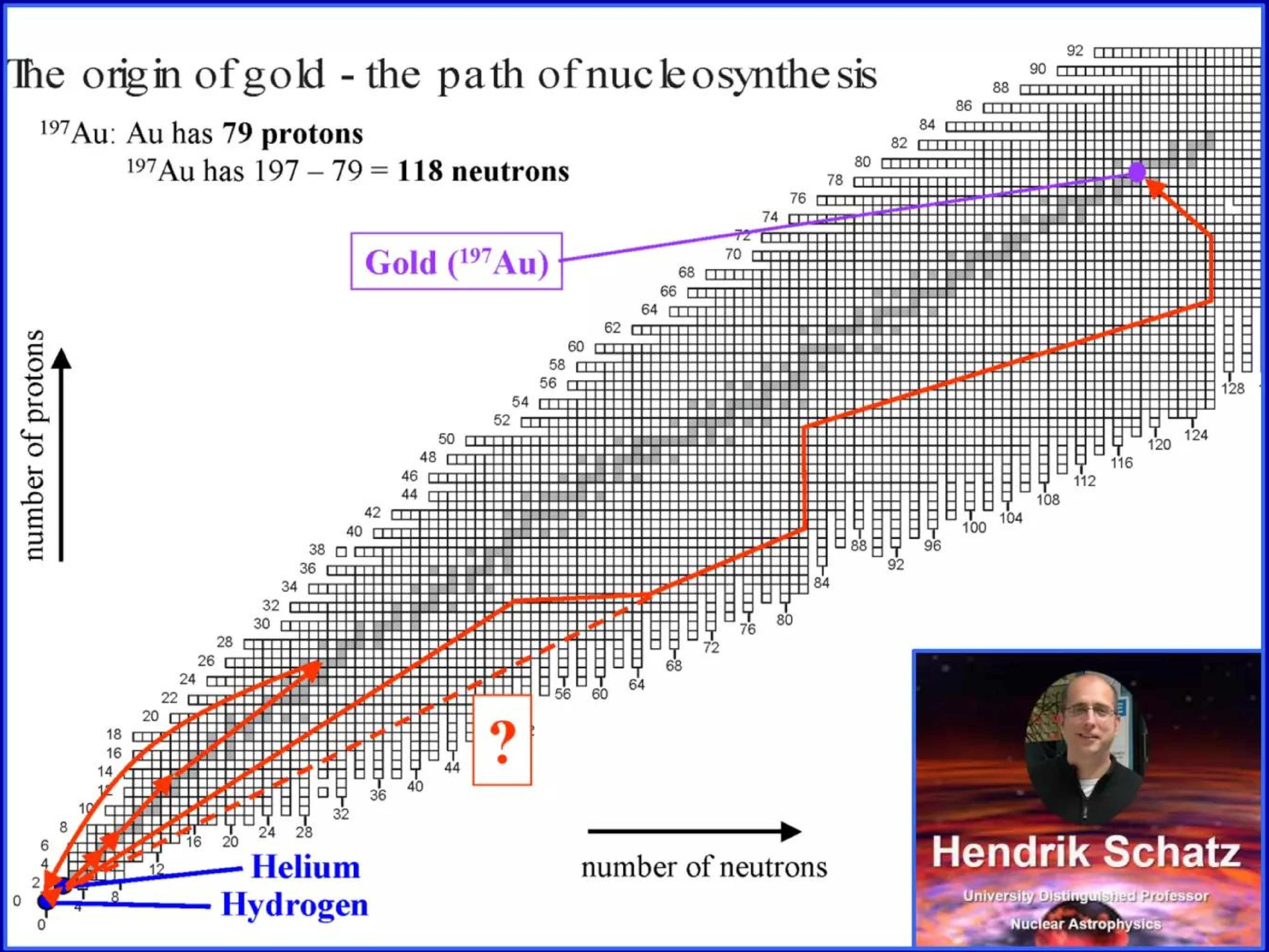


Hendrik Schatz's concept of Gold production in supernovas

Nucleosynthetic pathway to Au traverses extremely neutron-rich isotopes

Others believe Gold and Lead created during violent mergers of two neutron stars

Figure from Slide #20 in "How to make Gold" by Prof. Hendrik Schatz, Michigan State University



https://people.nscl.msu.edu/~schatz/

Supernova explosions are not required to produce Gold

"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

Neutron production observed in aqueous glow-discharge cell

First indirect experimental detection of ultralow energy LENR neutrons

"Two conference papers published by Cirillo *et al*. involving Widom-Larsen theory"
L. Larsen on SlideShare - November 30, 2011

http://www.slideshare.net/lewisglarsen/two-conference-papers-by-cirillo-et-al-involving-widomlarsen-theory-published-online-nov-15-2011

"Experimental evidence of a neutron flux generation in a plasma discharge electrolytic cell"
D. Cirillo *et al.*, *Key Engineering Materials* 495 pp. 104 - 107 (2012)

https://www.researchgate.net/publication/220043356_Experimental_Evidence_of_a_Neutron_Flux_Generation_in_a_Plasma_Discharge_Electrolytic_Cell

Conclusions: "A neutron detection method based on a CR-39 nuclear track detector coupled to a boron converter was successfully employed to show neutron generation by plasma discharge in an electrolytic cell with alkaline solution. An average of 720 $n \cdot s^{-1} \cdot mm^{-2}$ thermal neutron flux was estimated in the proximity of the plasma discharge, at the tungsten cathode of the electrolytic cell, while the blank detector sample shows no tracks. This method can give only a rough estimation of the plasma generated neutron flux, owing to the reduced cross section of the sequential events required to produce a track on the CR-39 detector. Nevertheless, the proposed method clearly evidences a thermal neutron flux generation in this low energy system."

Internal shorts and electric arcs sometimes occur in batteries

Neutrons could easily be produced since Hydrogen (protons) is available

"Battery energy density and product safety - thermal runaways and ULE neutron reactions"
L. Larsen on SlideShare - April 14, 2016

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-battery-energy-density-product-safety-thermal-runaways-and-ultralow-energy-neutron-reactions-april-14-2016

- ✓ Internal shorts and electric arcs are well-known to be associated with extreme types of battery thermal runaway events that are called field-failures
- ✓ Since various types of Hydrogenous moieties (protons) are abundant in inside batteries, it is probable that some presently indeterminate numbers of neutrons could be created by internal shorts in high-electric-field regions near electrode surfaces. It is a near-certainty that some neutron production would occur in high-current internal electric arcs such as what happened during 2013 immolation of a GS-Yuasa battery in a Boeing Dreamliner parked on the ground at Logan Airport. Local neutron captures heat microscopic volumes of battery materials to 4,000 to 6,000° K and, along with out-of-control rates of chemical reactions, contribute to much higher peak runaway temperatures
- ✓ As discussed in Lattice PowerPoint noted above, there is intriguing published experimental data showing peculiar isotopic shifts in some battery materials. More investigation is needed to determine whether such shifts are being caused by LENR neutron captures or simply chemical fractionation at work

Working with Lattice

Partnering on commercialization and consulting on certain subjects

1-312-861-0115 lewisglarsen@gmail.com

L. Larsen c.v.: http://www.slideshare.net/lewisglarsen/lewis-g-larsen-cv-june-2013

- ✓ Lattice welcomes inquiries from large, established organizations that have an interest in discussing the possibility of becoming Lattice's strategic capital and/or technology development partner
- ✓ Lewis Larsen also independently engages in fee-based consulting. This separate work covers subjects such as: micron-scale, many-body collective quantum effects in condensed matter; Lithium-ion battery safety engineering issues including minimizing risks for occurrence of thermal runaways; and development of ultra-high-temperature superconductors. Additional areas of expertise include: long-term strategic implications of LENRs for high cap-ex long term investments in power generation technology; energy storage technologies; and LENR impact on petroleum-related assets. Will consult on these subjects as long as it does not involve disclosing Lattice proprietary engineering details relating to developing LENR power generation systems

