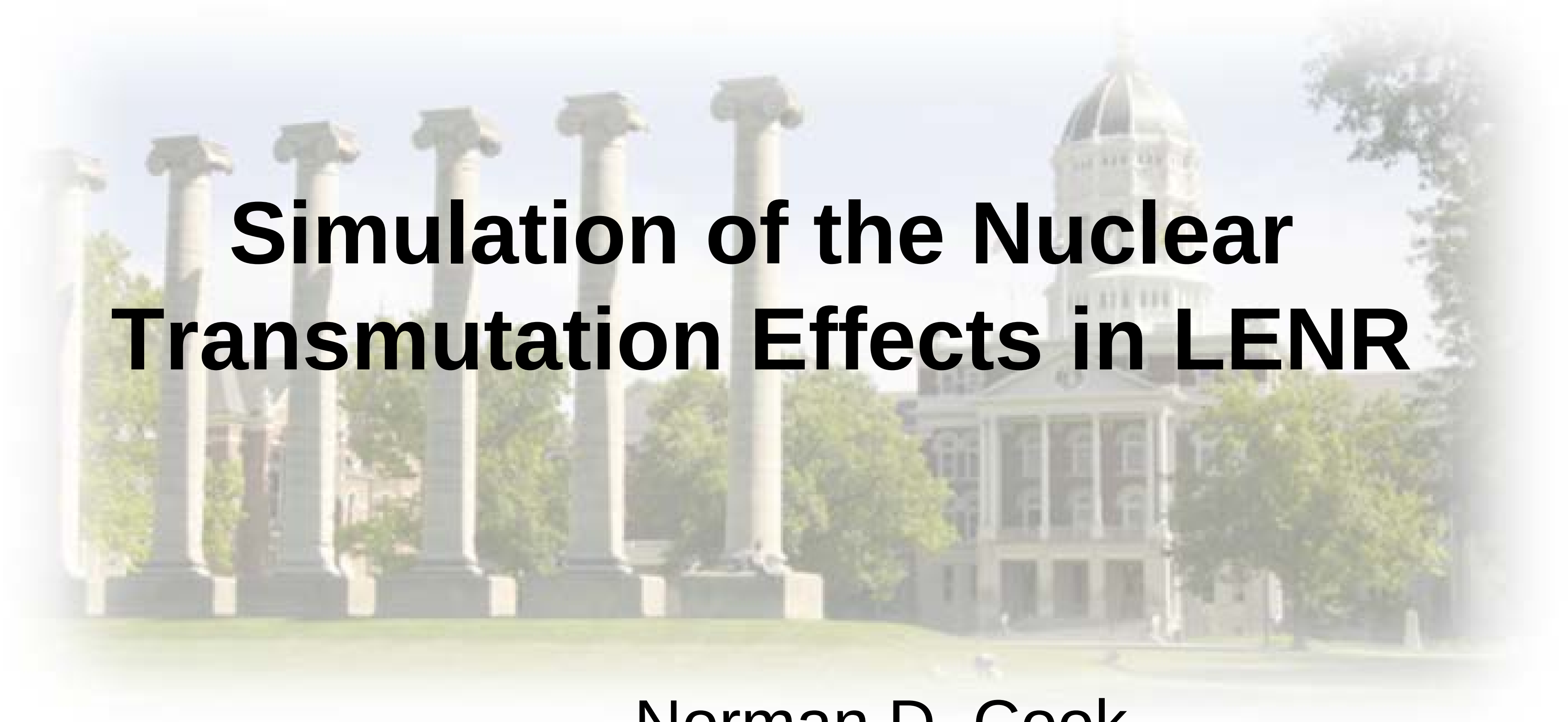

Simulation of the Nuclear Transmutation Effects in LENR

Norman D. Cook
Kansai University, Osaka, Japan
University of Southern California, LA, USA

Valerio Dallacasa
University of Verona, Verona, Italy

ICCF
18
JULY 21-27, 2013
UNIVERSITY OF MISSOURI
COLUMBIA, MISSOURI USA

Outline

- A lattice model for nuclear structure

  Wigner (1937), Everling (1958~2006), Canuto & Chitre (1974), Lezuo (1974, 1975), Cook & Dallacasa (1976~2013), Rossi (2010~2013)

- Lattice simulations of low-energy fission

  Fragment mass asymmetries for ^{233}U, ^{235}U, ^{239}Pu (1999)
  Cold fusion "ash" for $^{102\sim110}Pd$ (2006)
  Fragment mass asymmetry for ^{180}Hg (2010)
  Piezonuclear fission for $^{54\sim58}Fe$ (2013)

- Simulation of LENR transmutations

  Model-independent analysis

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  Wigner (1937), Everling (1958~2006), Canuto & Chitre (1974), Lezuo (1974, 1975), Cook & Dallacasa (1976~2013), Rossi (2010~2013)

- Lattice

  Frag

  Colo

  Frag

  Piez

- Simula

  Model-independent analysis

“The symmetries of the nuclear Hamiltonian are those of a face-centered cubic lattice,”

Eugene Wigner,

Physical Review 51, 106-131, 1937.

Outline

- A lattice model for nuclear structure

Wigner (1937), Everling (1958~2006), Canuto & Chitre (1974),
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Rossi (2010~2013)

> “The lowest energy solid-phase configuration of nuclear matter (Z=N) is an antiferromagnetic fcc lattice with proton/neutron layering,”
>
> V. Canuto & S.M. Chitre,
> *International Astronomy & Astrophysics Union Symposium* 53, 133, 1974;
> *Annual Review of Astronomy & Astrophysics* 12, 167, 1974; 13, 335, 1975.

Model-independent analysis

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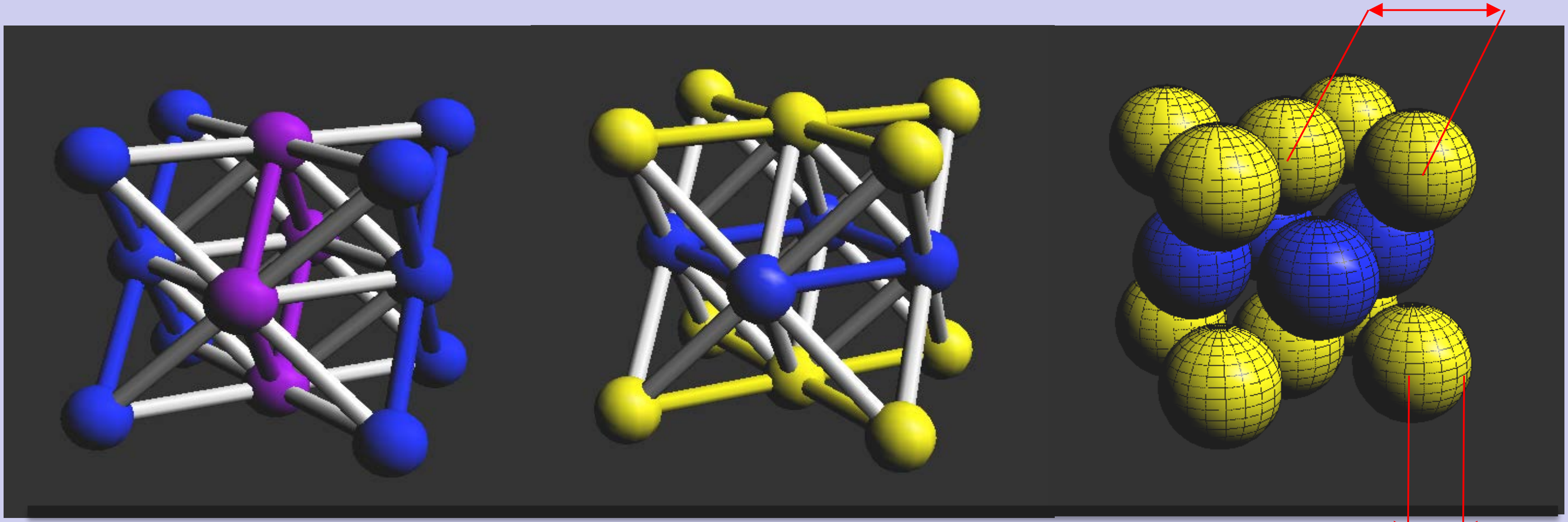
$\rho = 0.17$ nucleons/fm^3 → 2.03 fm



Atomkernen. 28, 195, 1976; *Physical Review* C36, 1883, 1987; etc.

0.86 fm

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PDF of “Models of the Atomic Nucleus”, 2nd ed., Springer, 2010; Mac and Windows graphical software, spreadsheets, etc., on the lattice model are available online.

“Your lattice model has been a tremendous instrument for me to work with the LENR.”
“I demand to all my employees to study your book.”
(Andrea Rossi, 2010~2013)

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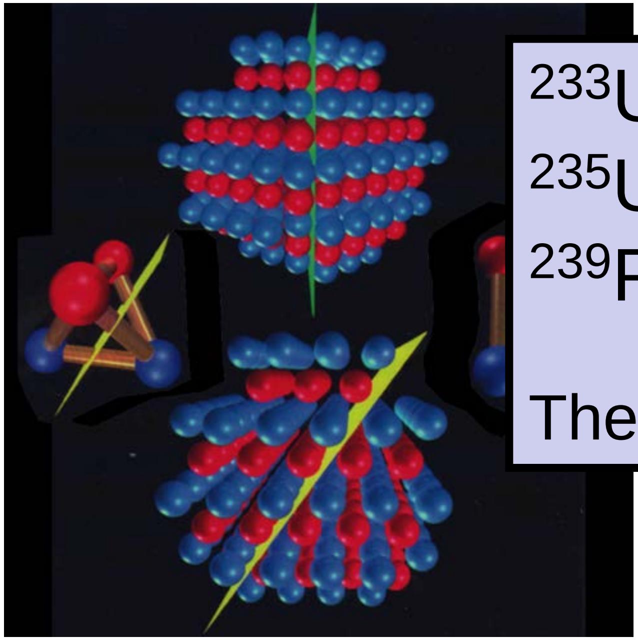
Lattice Simulations of LENR

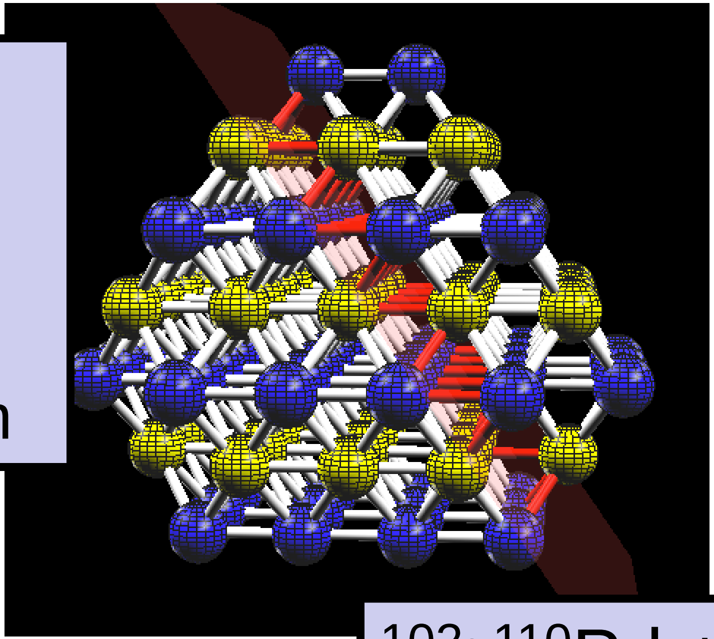


$^{233}U + n_{th}$

$^{235}U + n_{th}$

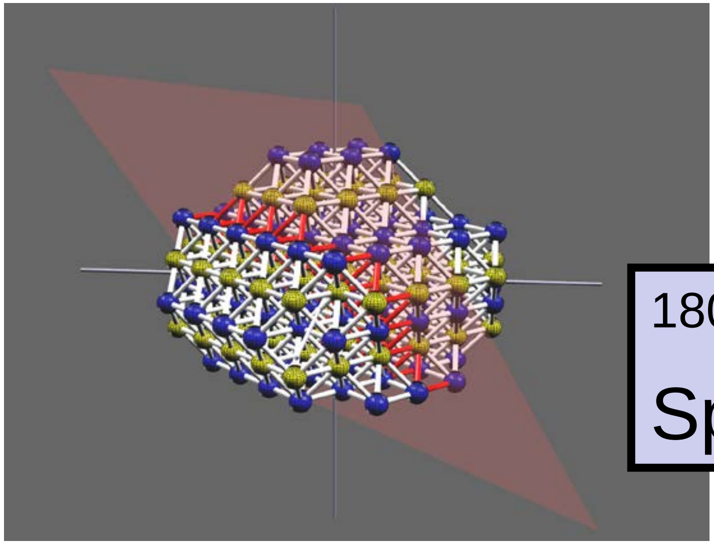
$^{239}Pu + n_{th}$

Thermal fission



$^{102\sim110}Pd + d$

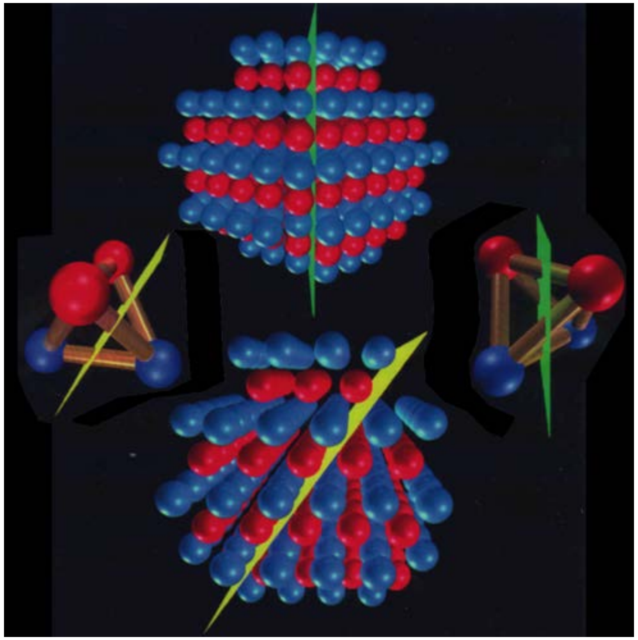
Cold fusion

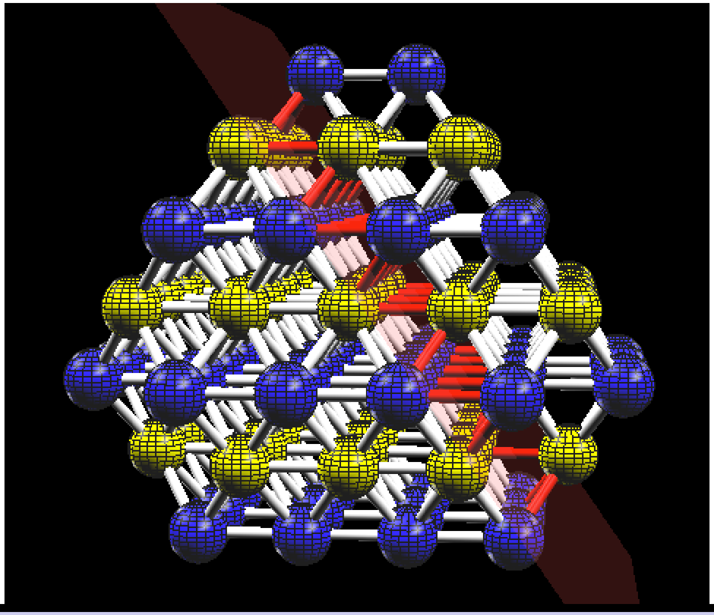


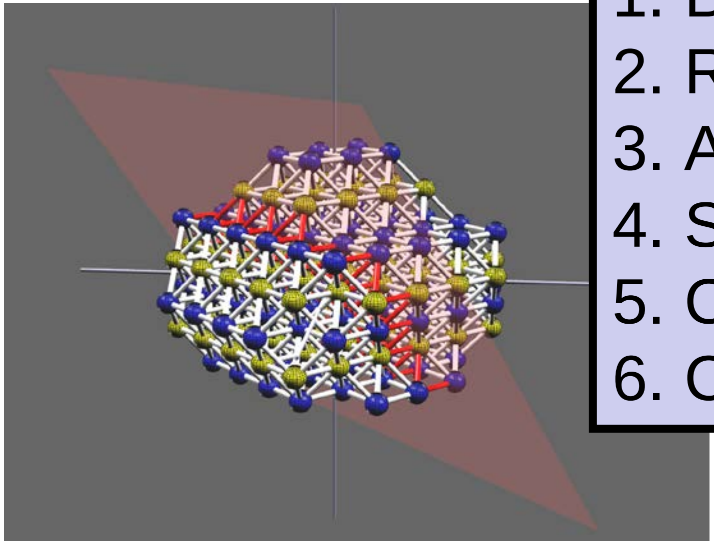
$^{180}_{80}Hg^{100}$

Spontaneous fission

Lattice Simulations of LENR

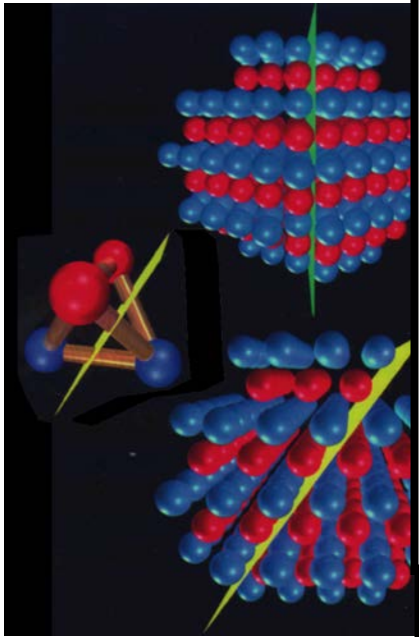


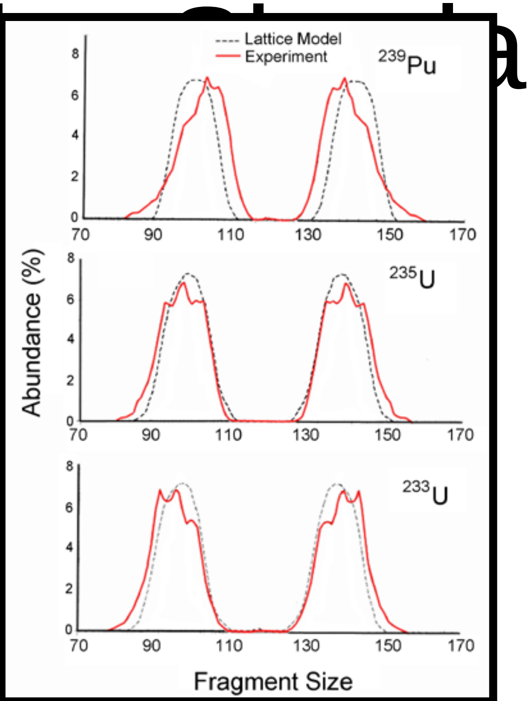




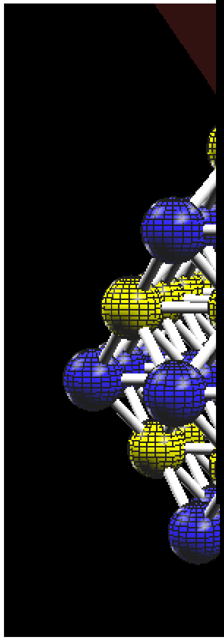
1. Build default lattice structure
2. Randomize surface
3. Add neutron/proton/deuteron
4. Scission the lattice many times
5. Calculate interfragment Q & bonds
6. Collect statistics

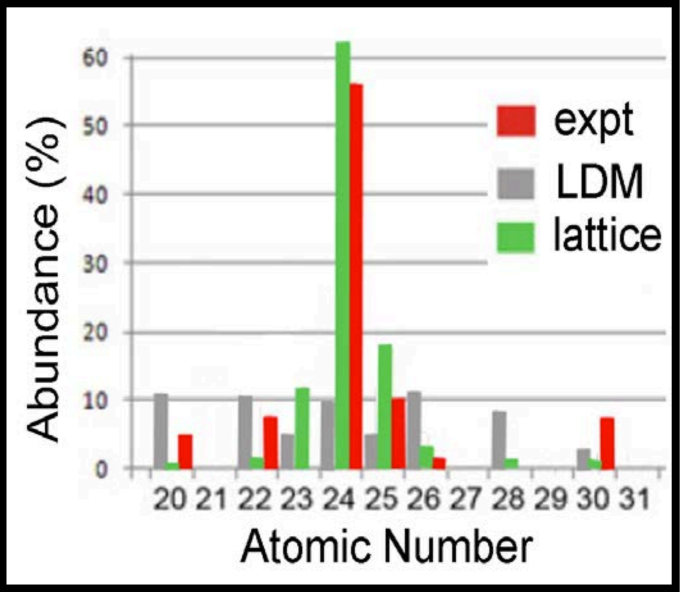
Latti ations of LENR



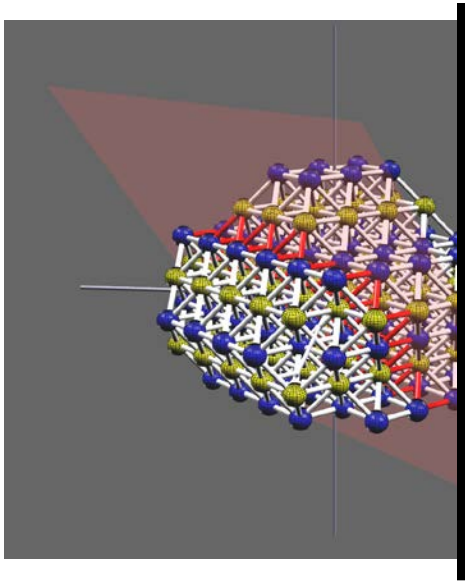


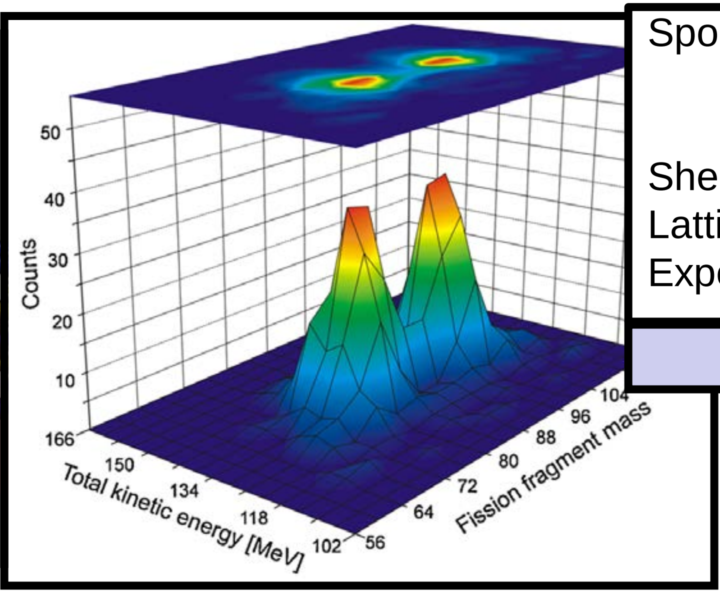
Hahn & Strassman, 1938





Mizuno et al., 1996





Spontaneous Fission of $^{180}_{80}\mathrm{Hg}^{100}$

Light-to-Heavy Fragment Ratio

Shell model & LDM: 1.00:1.00

Lattice model: 1.00:1.21

Experiment: 1.00:1.25

Antonov et al., 2010

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“Transmutation”

Many LENR studies on nuclear transmutations, but not many reporting details on isotopic ratios…

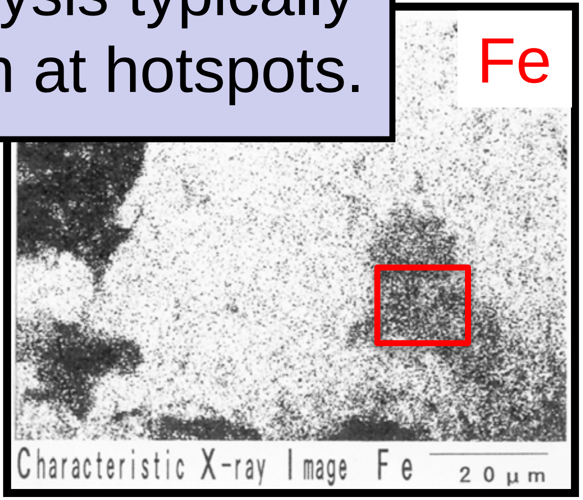
1. Palladium isotopes (Mizuno, 1996)

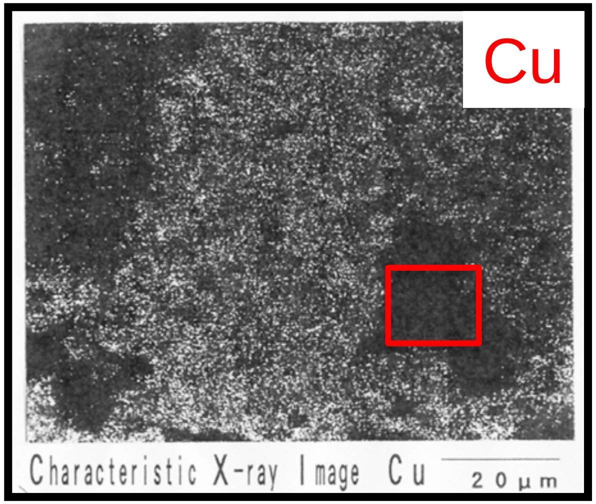
2. Nickel, Iron and Chromium isotopes
   (Focardi & Rossi, 2011; Defkalion, 2012;
   Mizuno, 2013)

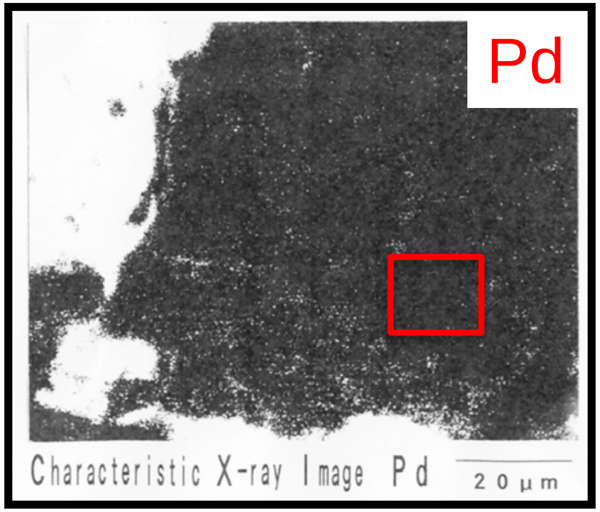
Assumptions behind the numerical simulation

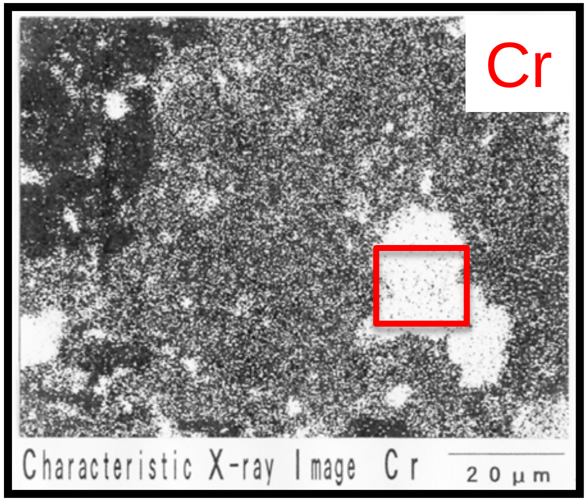
1. The surface region on the cathode “hotspot” (where SIMS analysis is done) contains a finite number of nuclei.

SIMS analysis typically undertaken at hotspots.

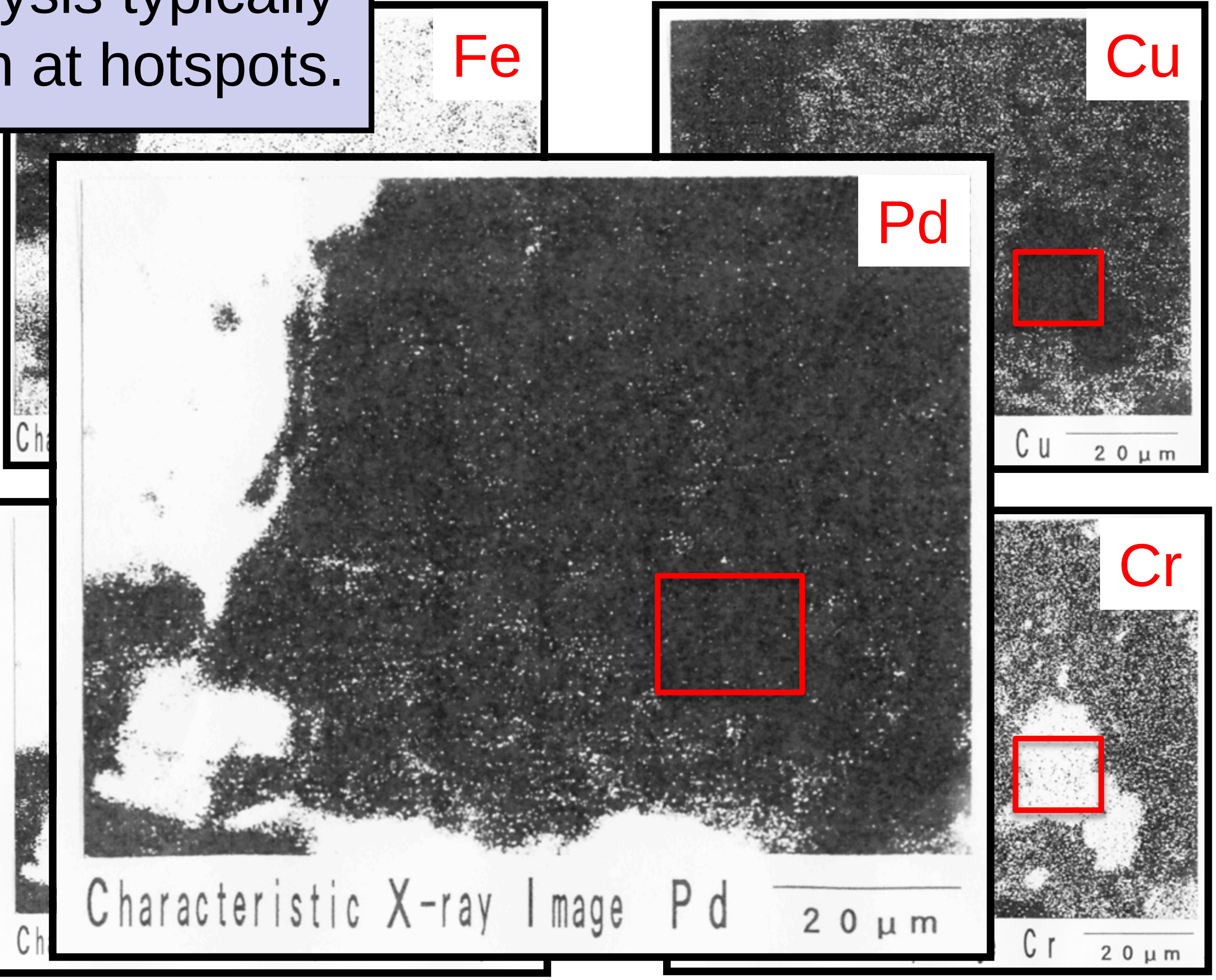








SIMS analysis typically undertaken at hotspots.



Assumptions behind the numerical simulation

1. The surface region on the cathode "hotspot" (where SIMS analysis is done) contains a finite number of nuclei.

2. Only isotopic depletion is allowed in reproducing the experimental data.

“Depletion only” simulations

(Isotopes at surface sites on the cathode are removed at random)

1. The 6 isotopes of Palladium.

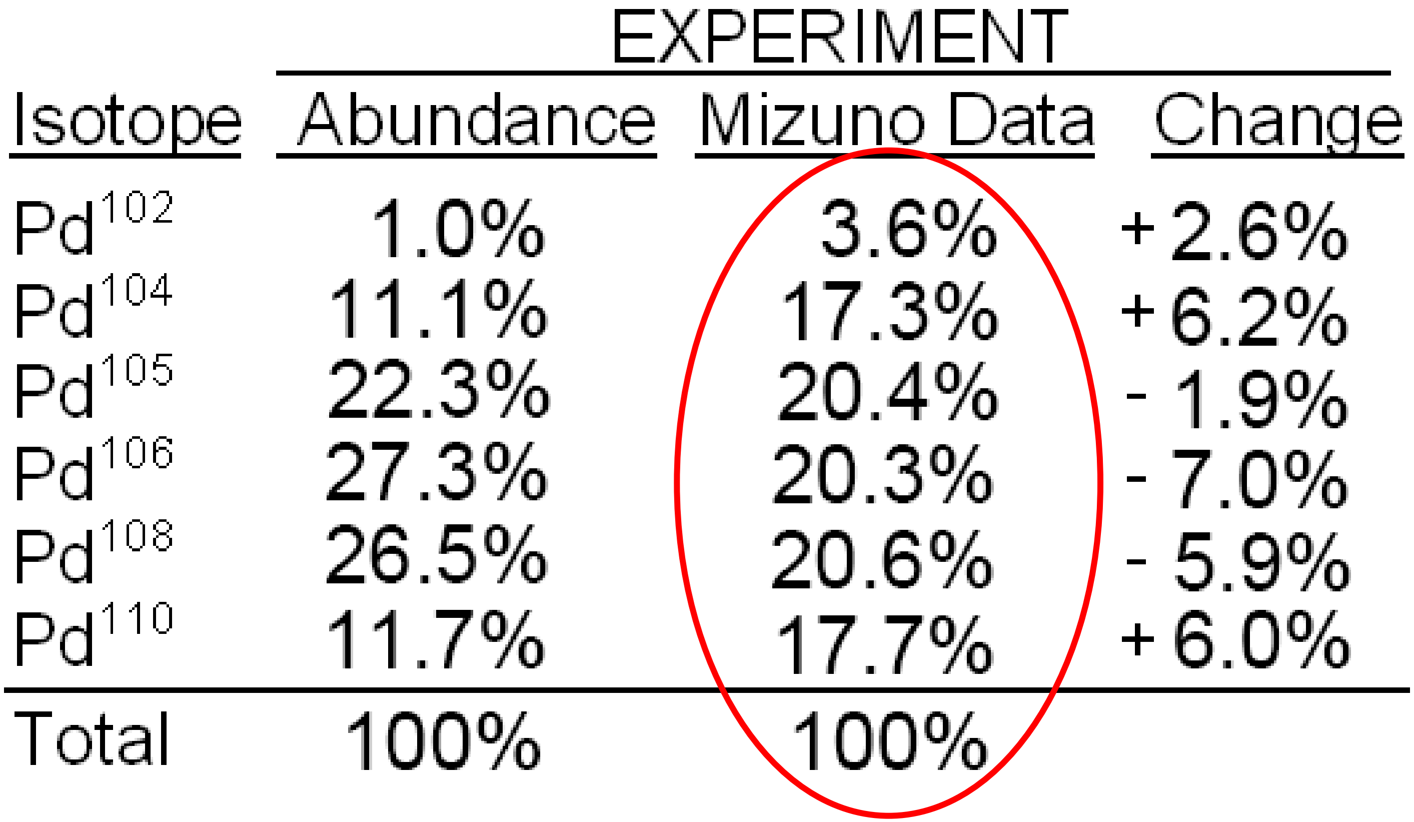
2. The 13 isotopes of alloy SUS304 (Nickel, Chromium and Iron).

Changes in Palladium isotopes in a Pd+D high- pressure, high-voltage electrolytic experiment

	EXPERIMENT		
Isotope	Abundance	Mizuno Data	Change
Pd^{102}	1.0%	3.6%	+ 2.6%
Pd^{104}	11.1%	17.3%	+ 6.2%
Pd^{105}	22.3%	20.4%	- 1.9%
Pd^{106}	27.3%	20.3%	- 7.0%
Pd^{108}	26.5%	20.6%	- 5.9%
Pd^{110}	11.7%	17.7%	+ 6.0%
Total	100%	100%	

Natural abundance
(Firestone, 1999)

Changes in Palladium isotopes in a Pd+D high- pressure, high-voltage electrolytic experiment



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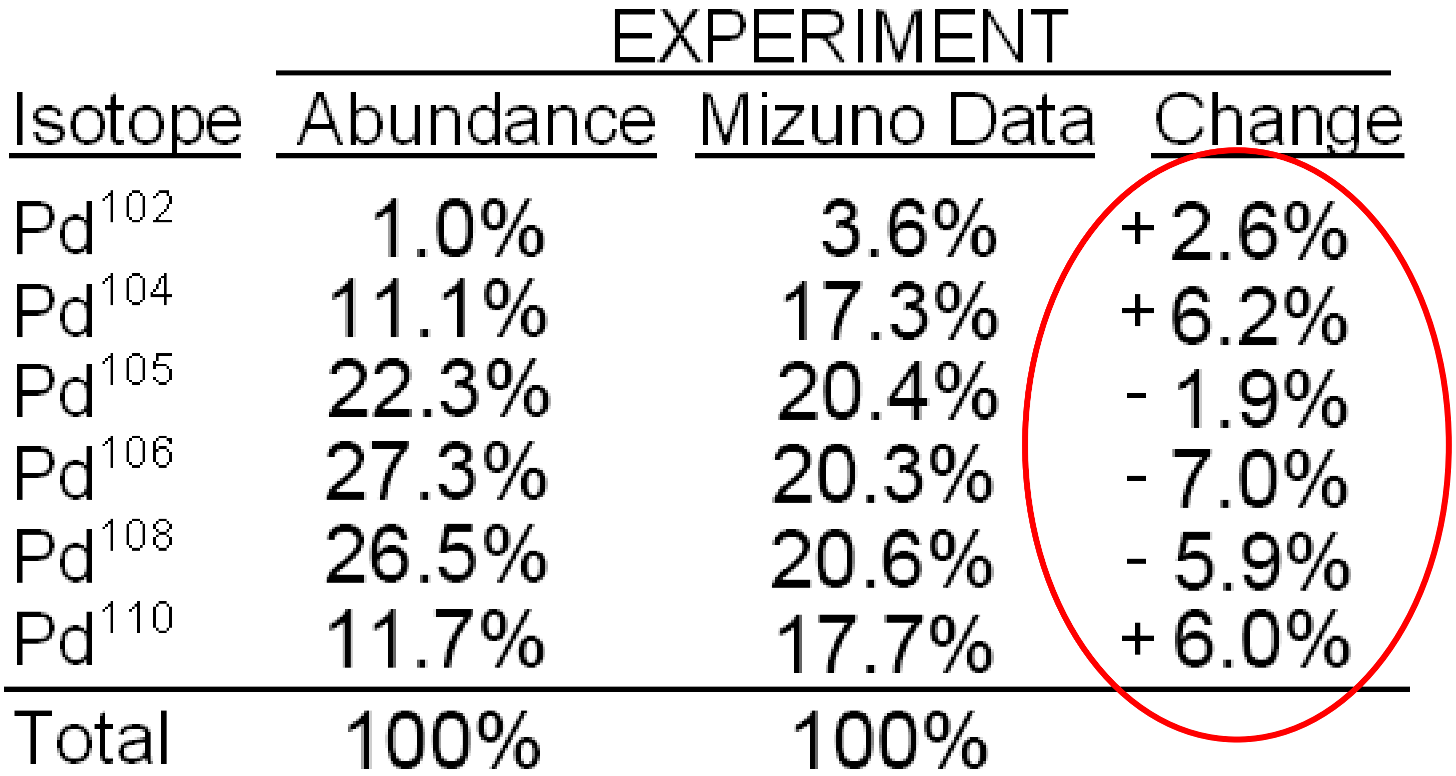
Total	100%	100%	

Abundance on the cathode surface after electrolysis
(Mizuno, 1996)

Changes in Palladium isotopes in a Pd+D high- pressure, high-voltage electrolytic experiment



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Pd^{108}	26.5%	20.6%	- 5.9%
Pd^{110}	11.7%	17.7%	+6.0%
Total	100%	100%	

Increases and decreases!!

“sloppy experimental work”, “nonsense”, “bad data”

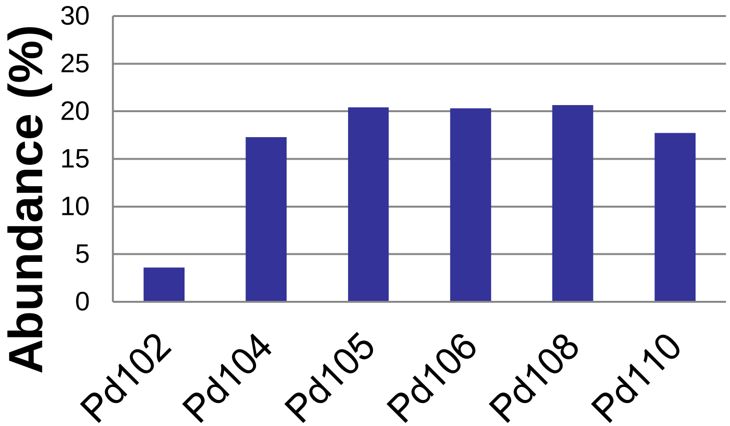
0% Depletion of Palladium

(Natural Abundance)

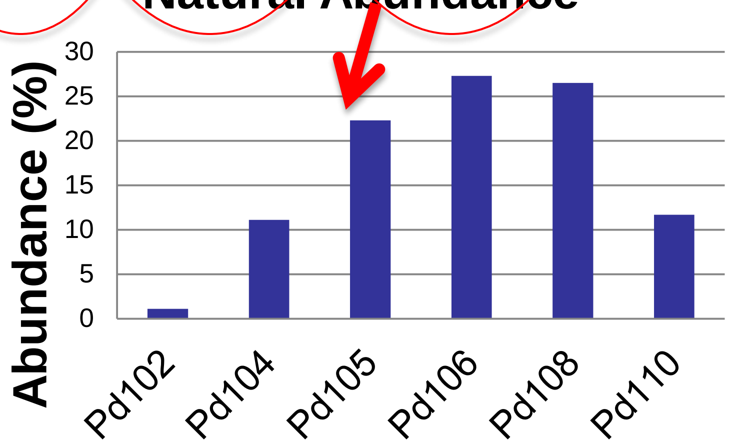
	MIZUNO EXPERIMENT		
Isotope	Before	After	Change
Pd^{102}	1.0%	3.6%	+2.6%
Pd^{104}	11.1%	17.3%	+6.2%
Pd^{105}	22.3%	20.4%	- 1.9%
Pd^{106}	27.3%	20.3%	- 7.0%
Pd^{108}	26.5%	20.6%	- 5.9%
Pd^{110}	11.7%	17.7%	+6.0%
Total	100%	100%	

SIMULATION				
Initial No.	Loss	Final No.	Abundance	Percentage Loss
1,020	0	1,020	1.0%	0%
11,140	0	11,140	11.1%	0%
22,330	0	22,330	22.3%	0%
27,330	0	27,330	27.3%	0%
26,460	0	26,460	26.5%	0%
11,720	0	11,720	11.7%	0%
100,000	0	100,000	100%	0%

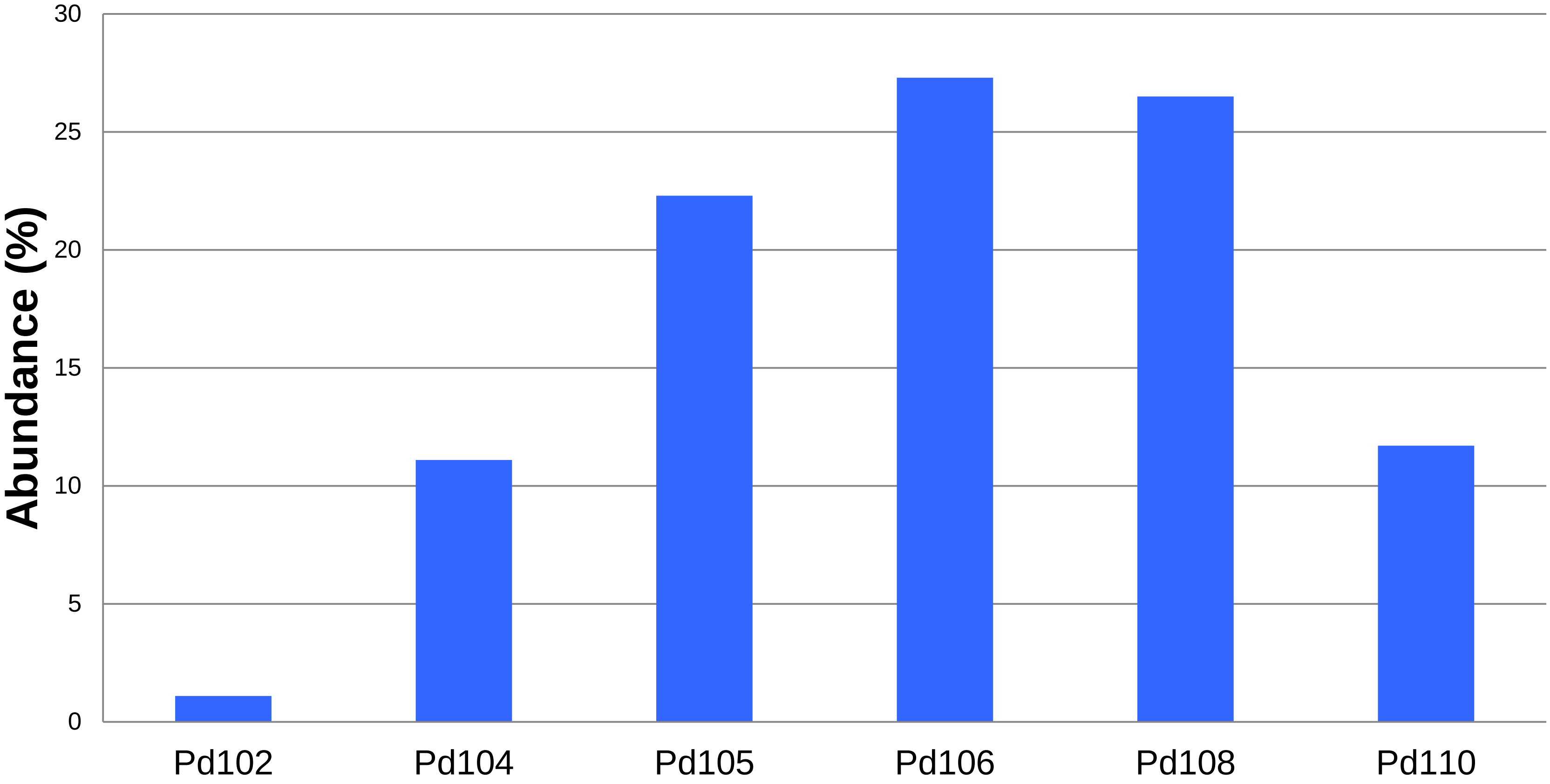
Final Abundance (expt.)



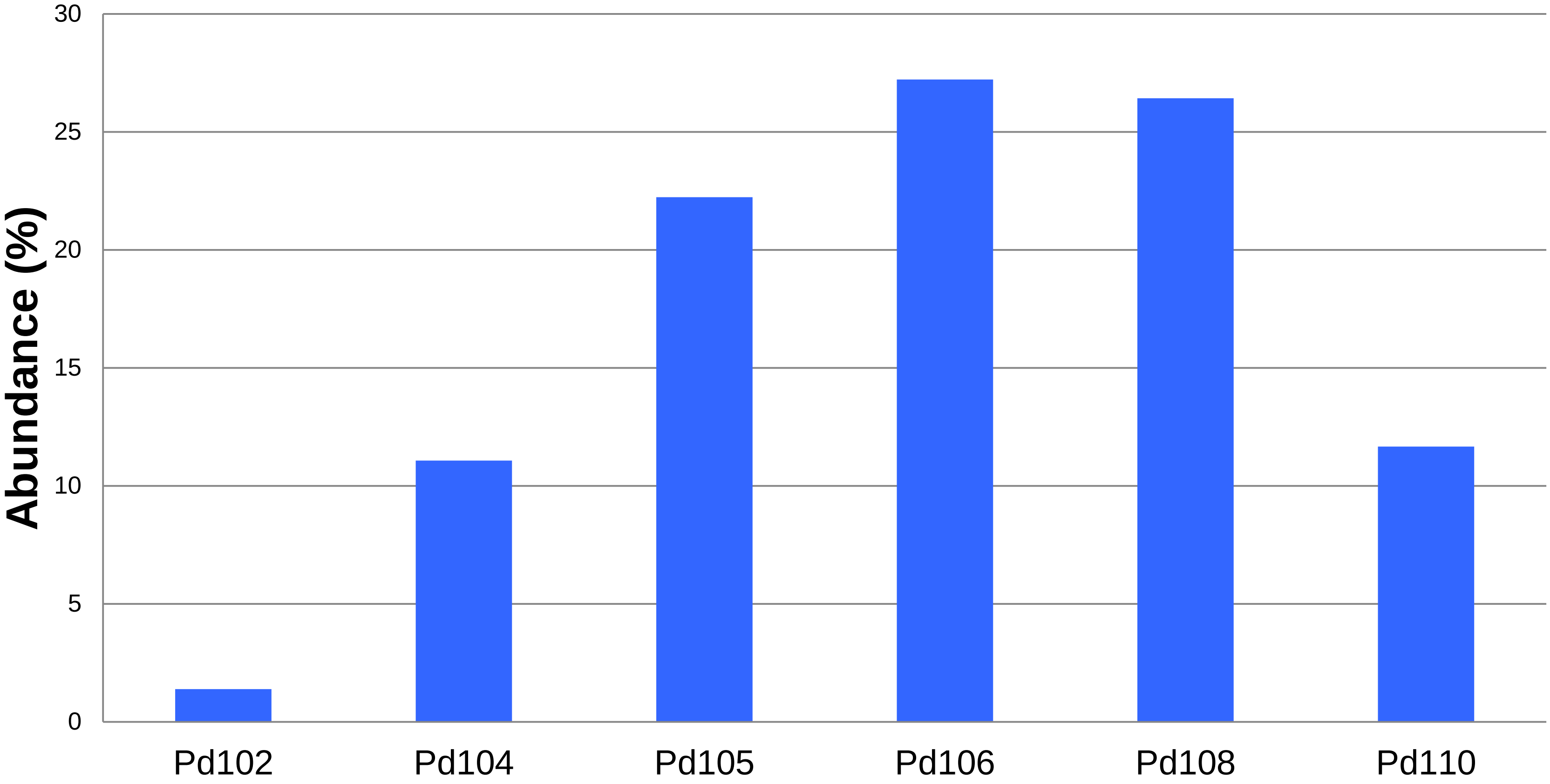
Natural Abundance



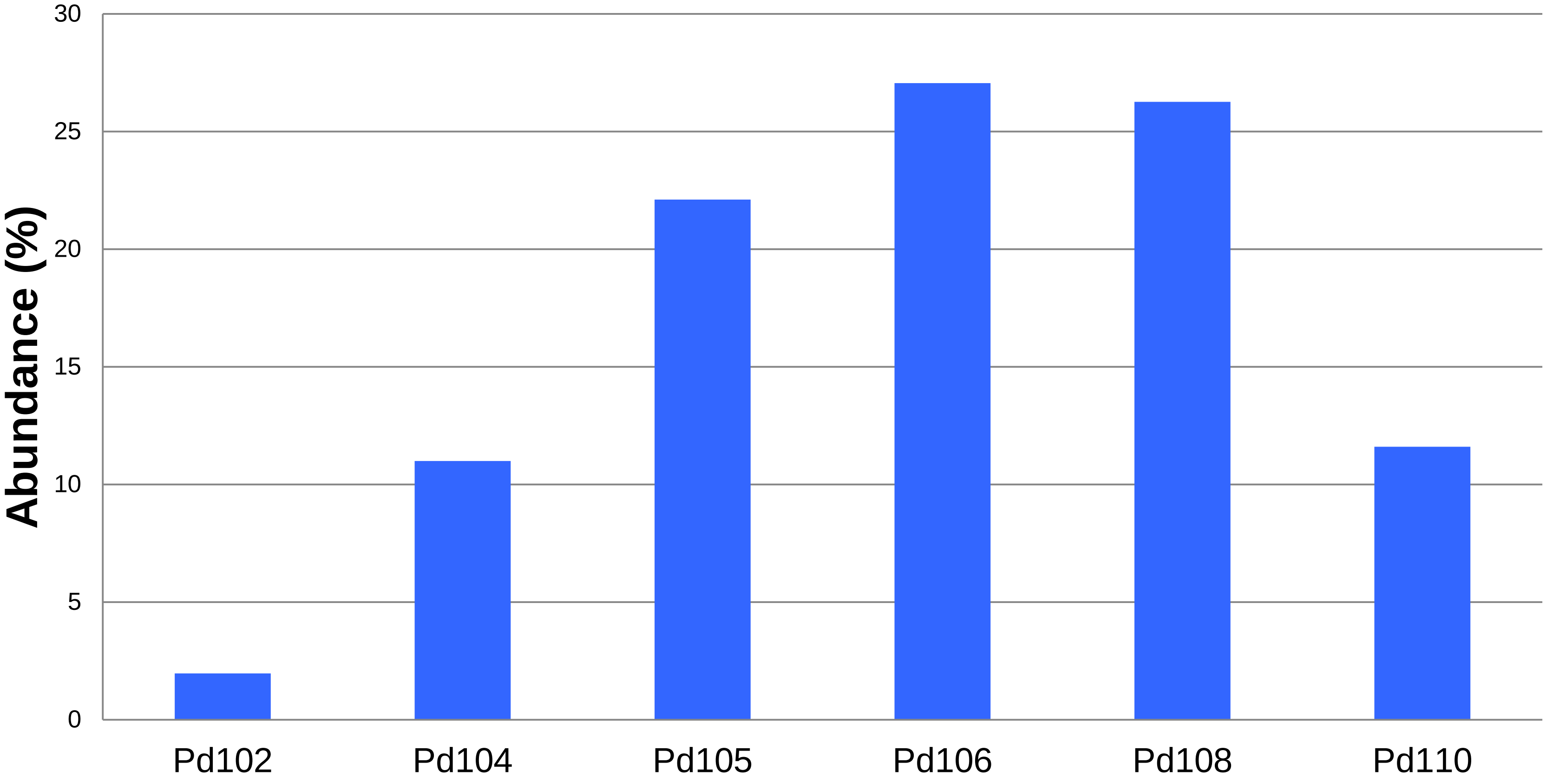
Natural Abundance: Depletion = 0%



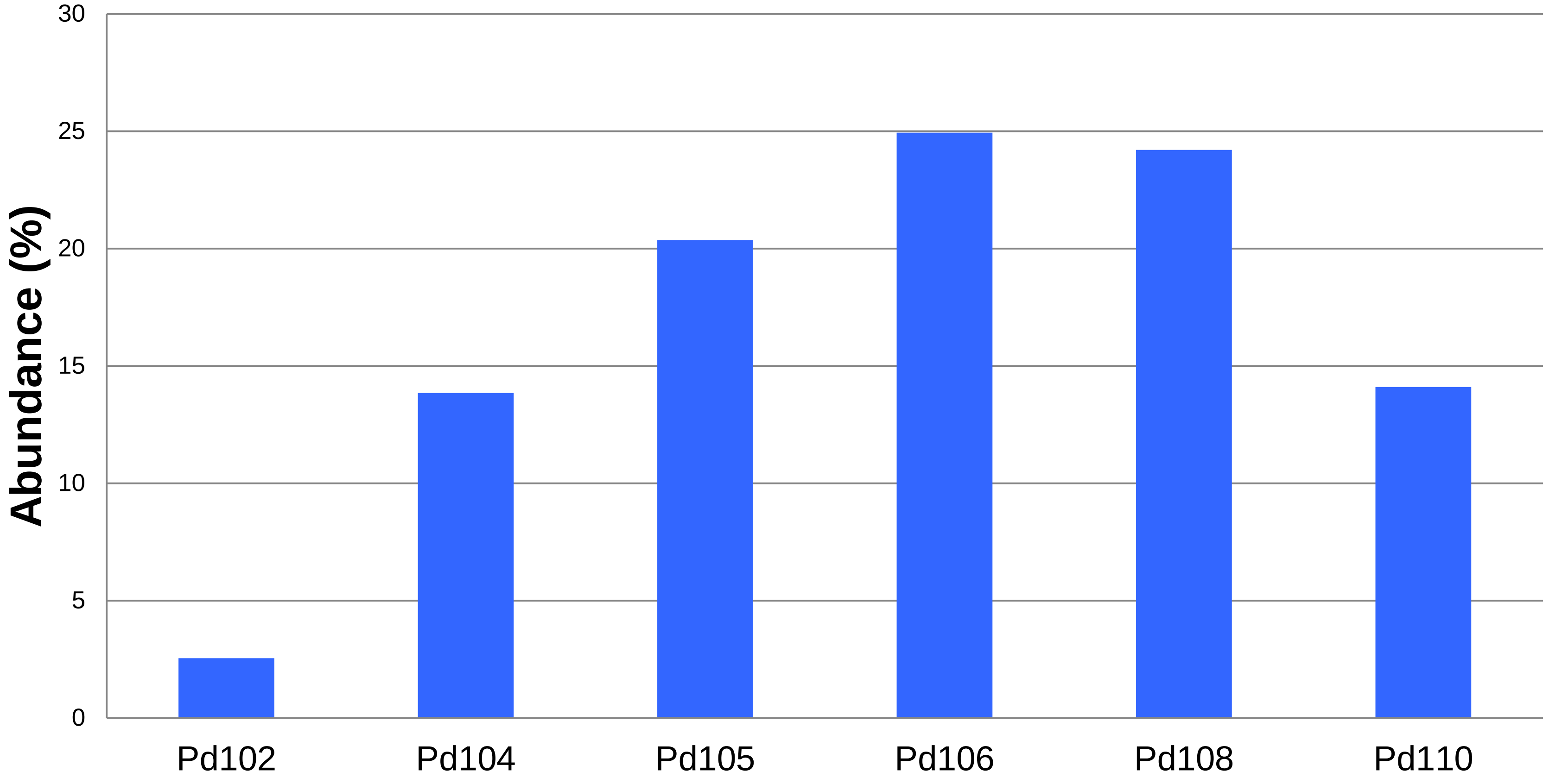
Mean Depletion = 68.7%



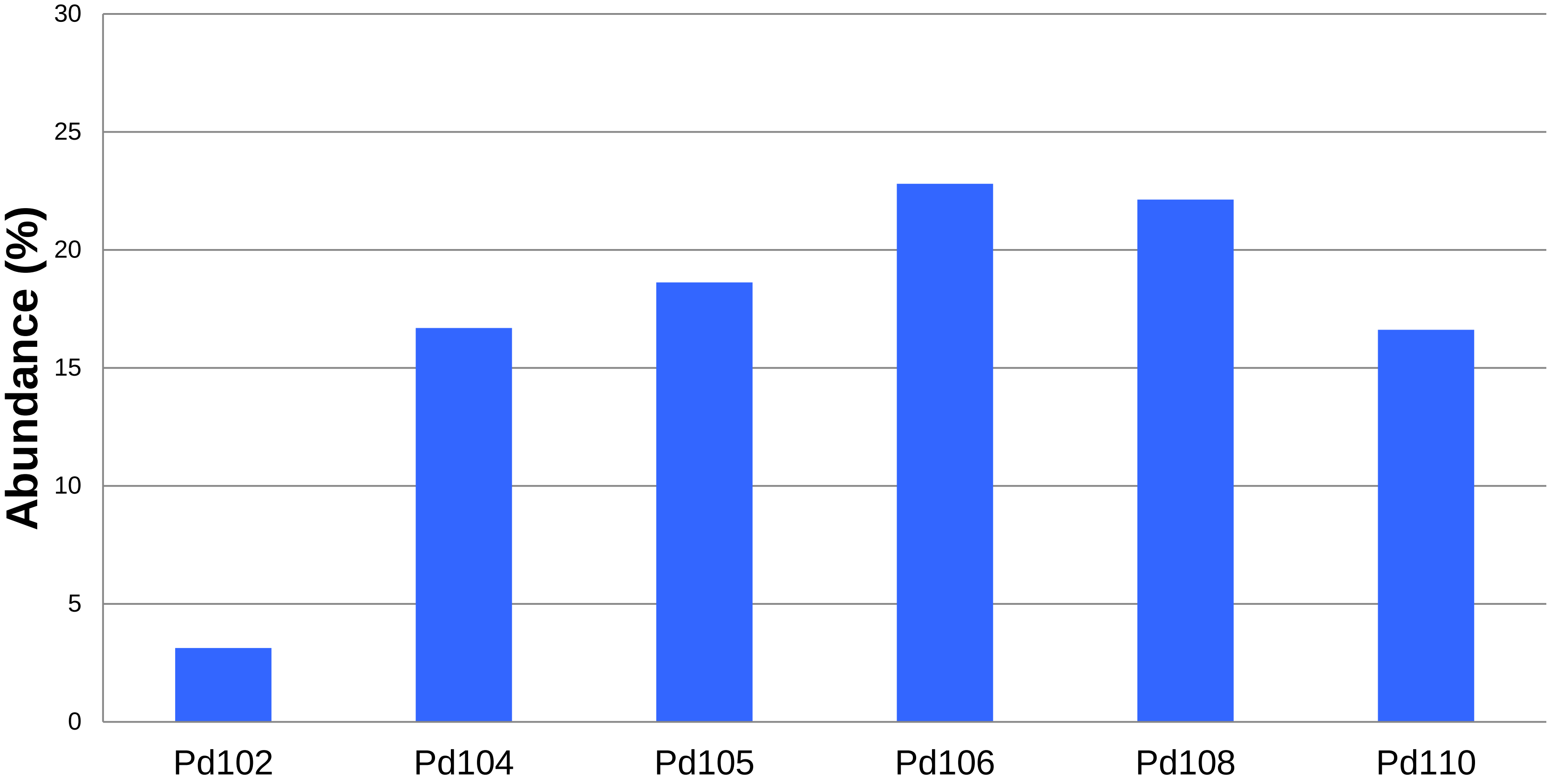
Mean Depletion = 77.3%



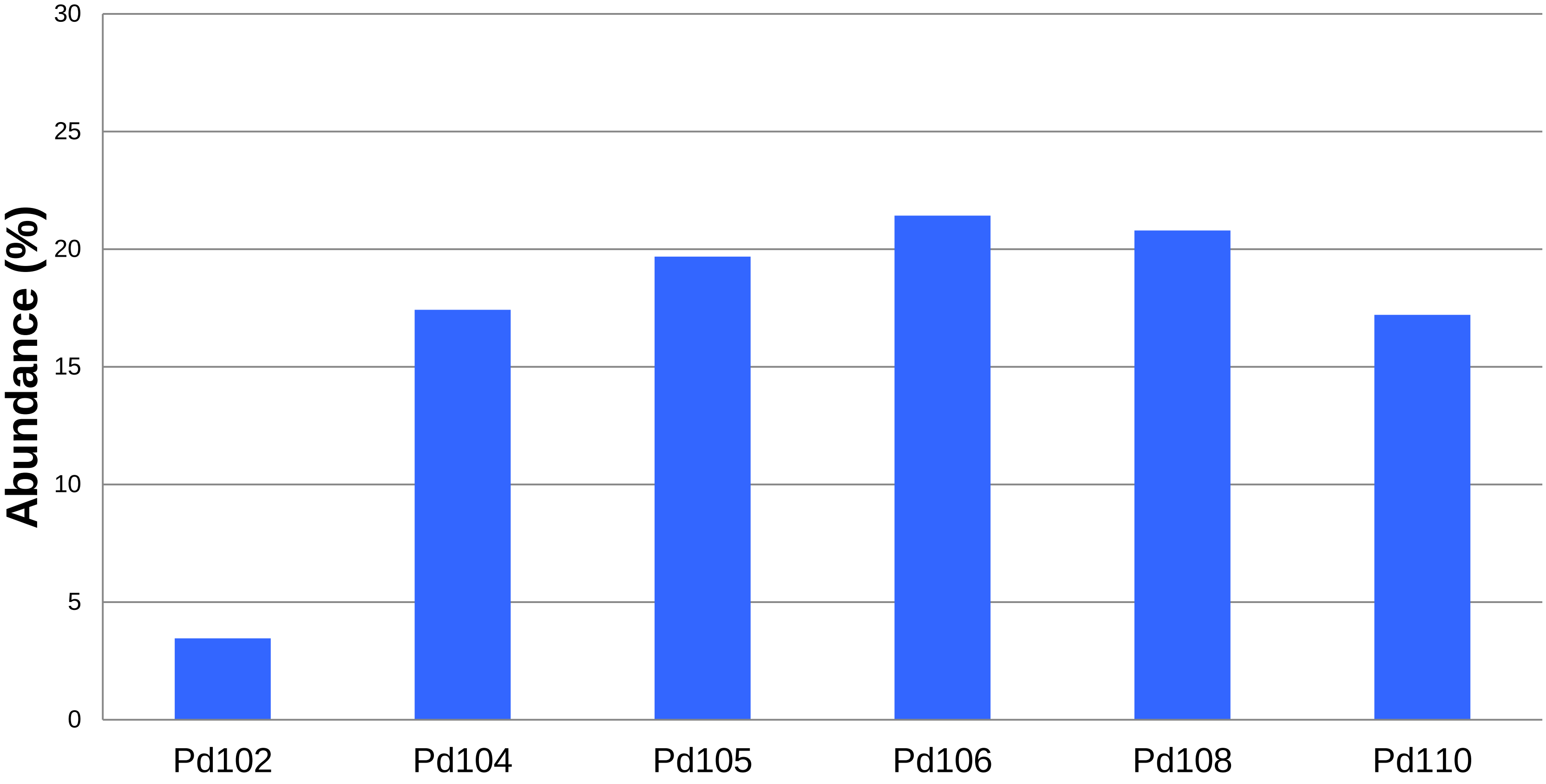
Mean Depletion = 80.1%



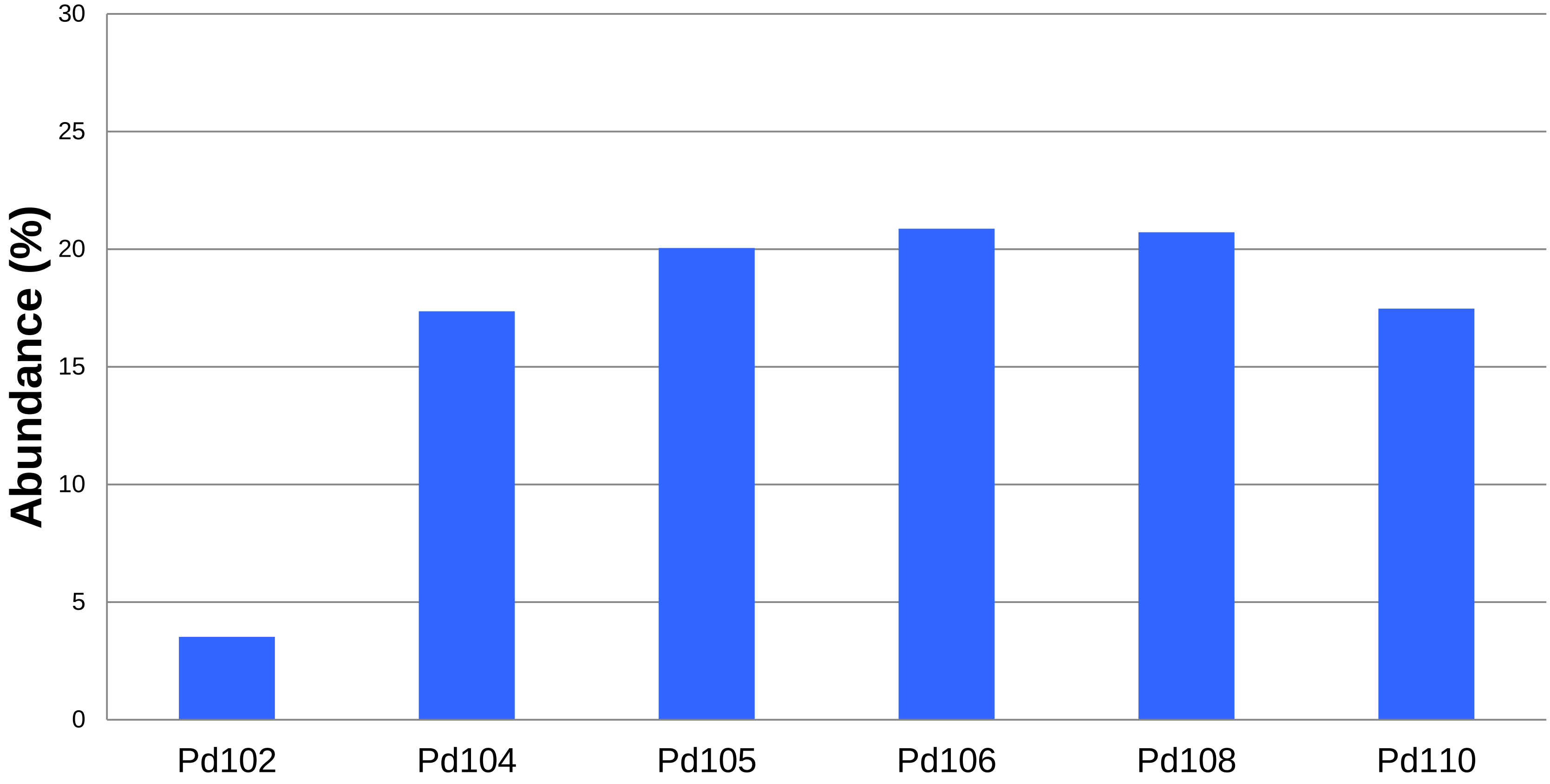
Mean Depletion = 83.5%



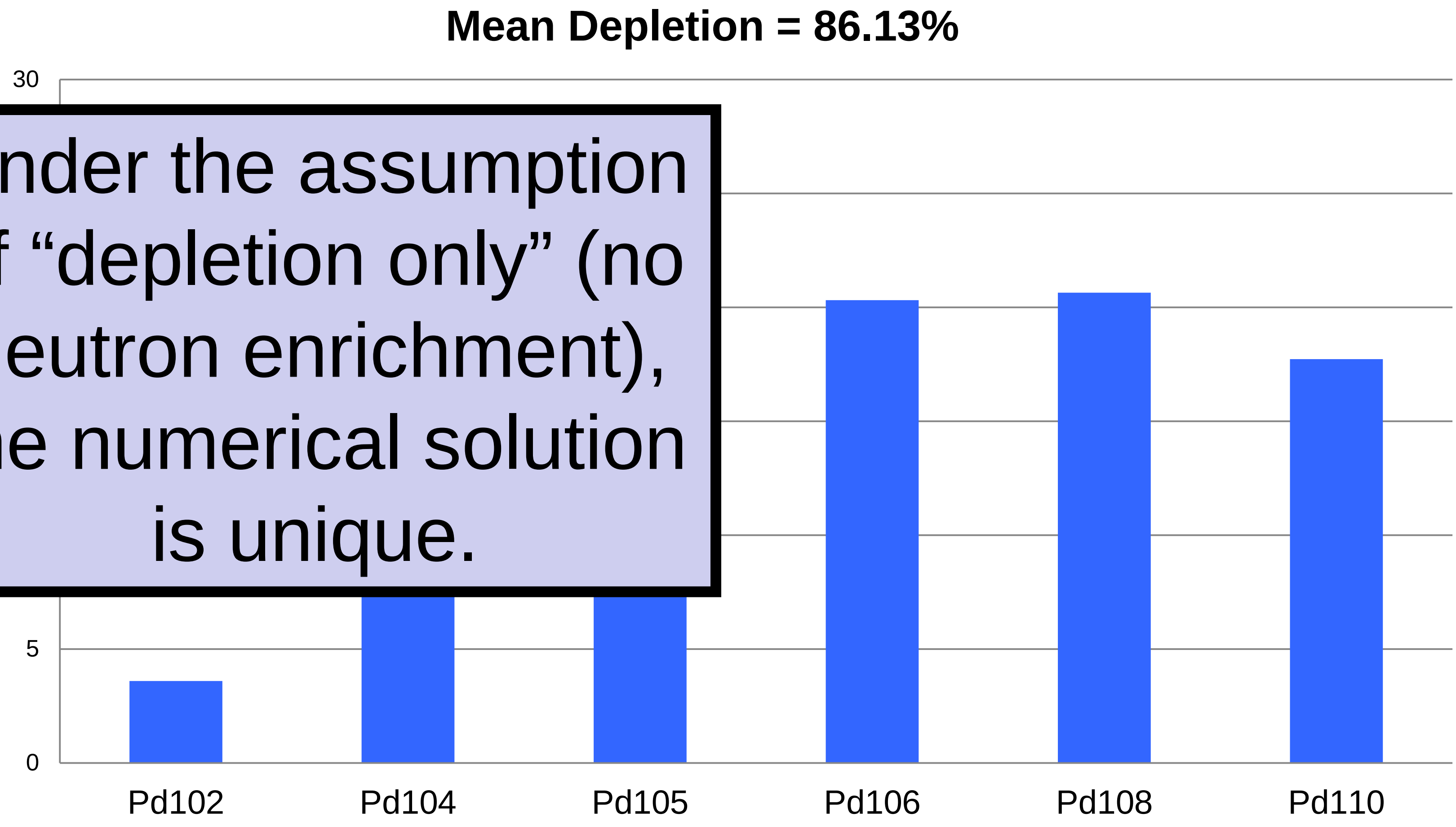
Mean Depletion = 85.3%



Mean Depletion = 85.7%

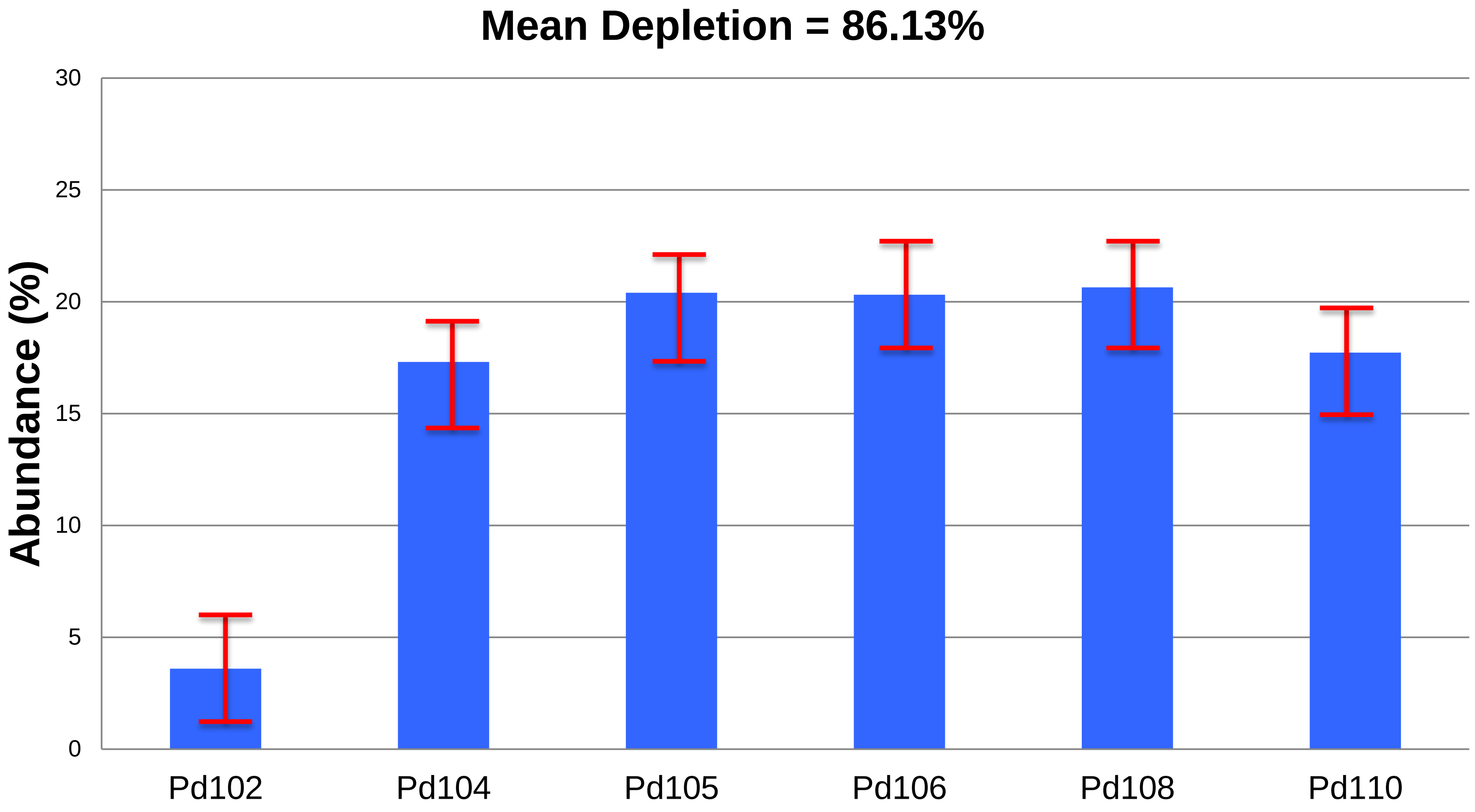


The abundances in the simulation match those found in the Mizuno experiment when the depletion is at 86.13%.



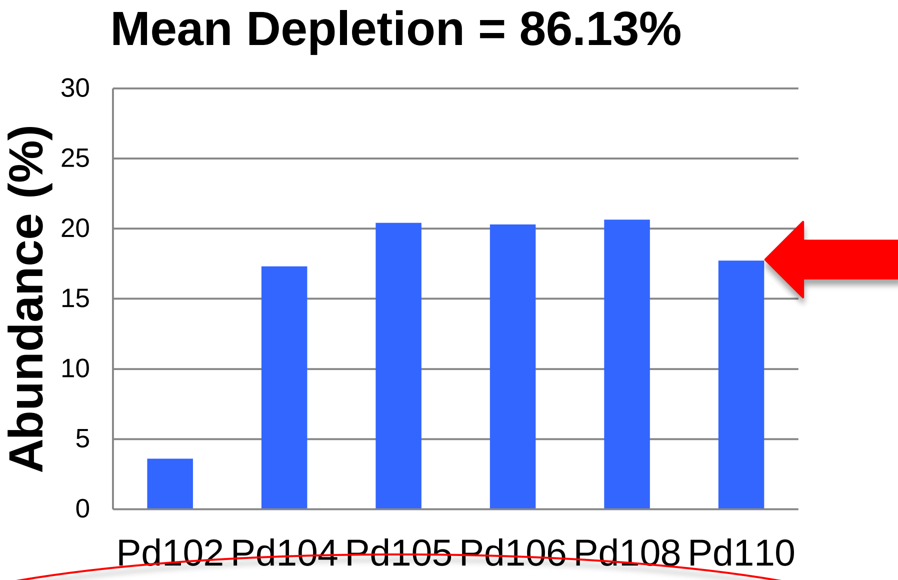
Under the assumption of “depletion only” (no neutron enrichment), the numerical solution is unique.

The abundances in the simulation match those found in the Mizuno experiment when the depletion is at 86.13%.

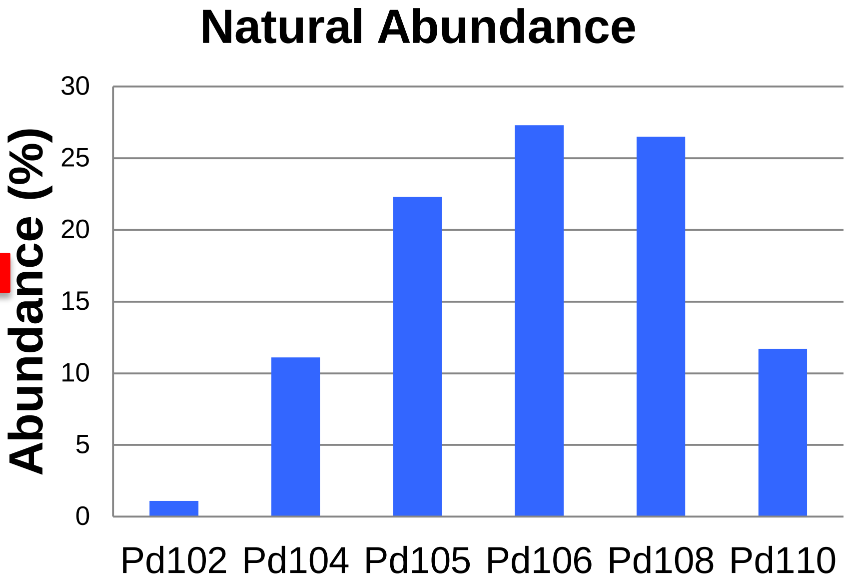


The “depletion only” simulation has successfully reproduced the experimental data.

But the manipulations that made the simulation work are what is of interest…



Mean Depletion = 86.13%

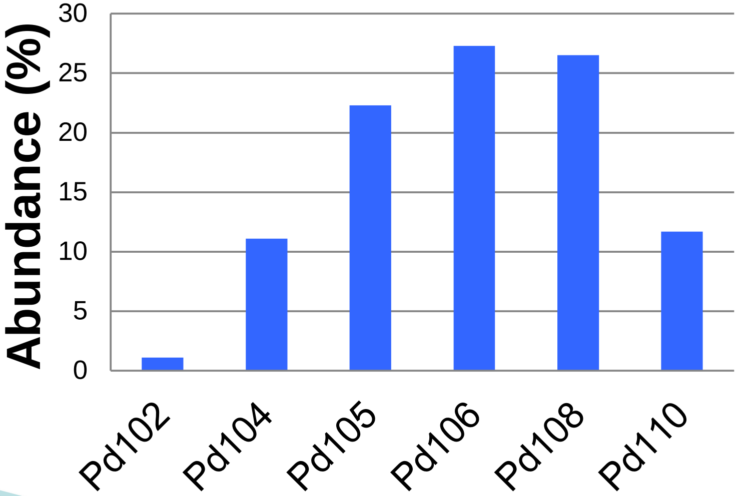


Natural Abundance

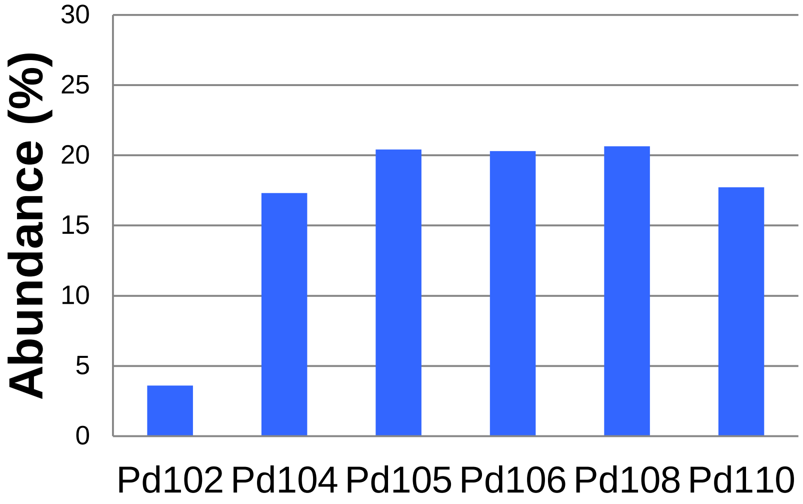
Changes: +2.6% +6.2% -1.9% -7.0% -5.9% +6.0%

The correct abundances were obtained with the depletion of all isotopes to approximately the same degree.

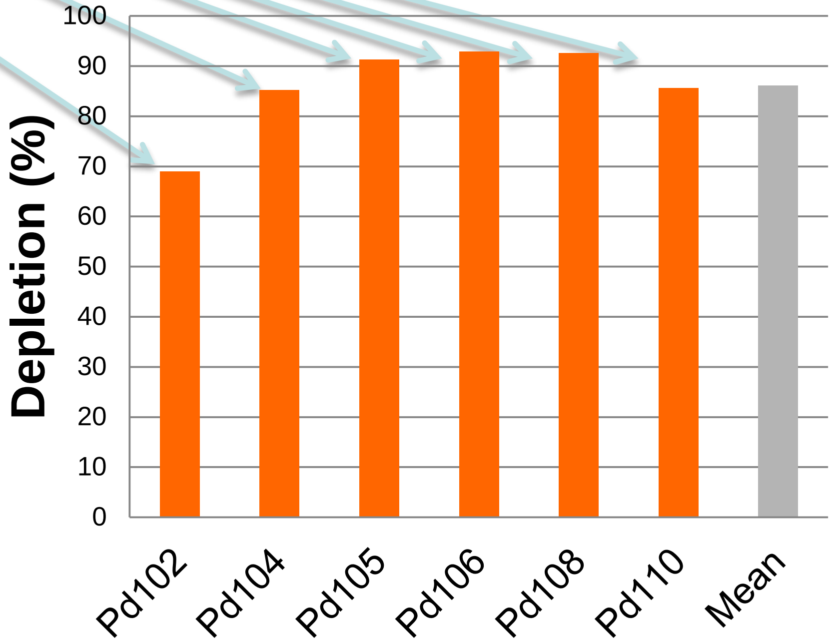
Natural Abundance



Mean Depletion = 86.13%



Depletion Rates Per Isotope



- The Mizuno (1996) results are …
  not “nonsense,” and at least
  suggestive of the involvement of ***all*** palladium
  isotopes in the LENR experiment.

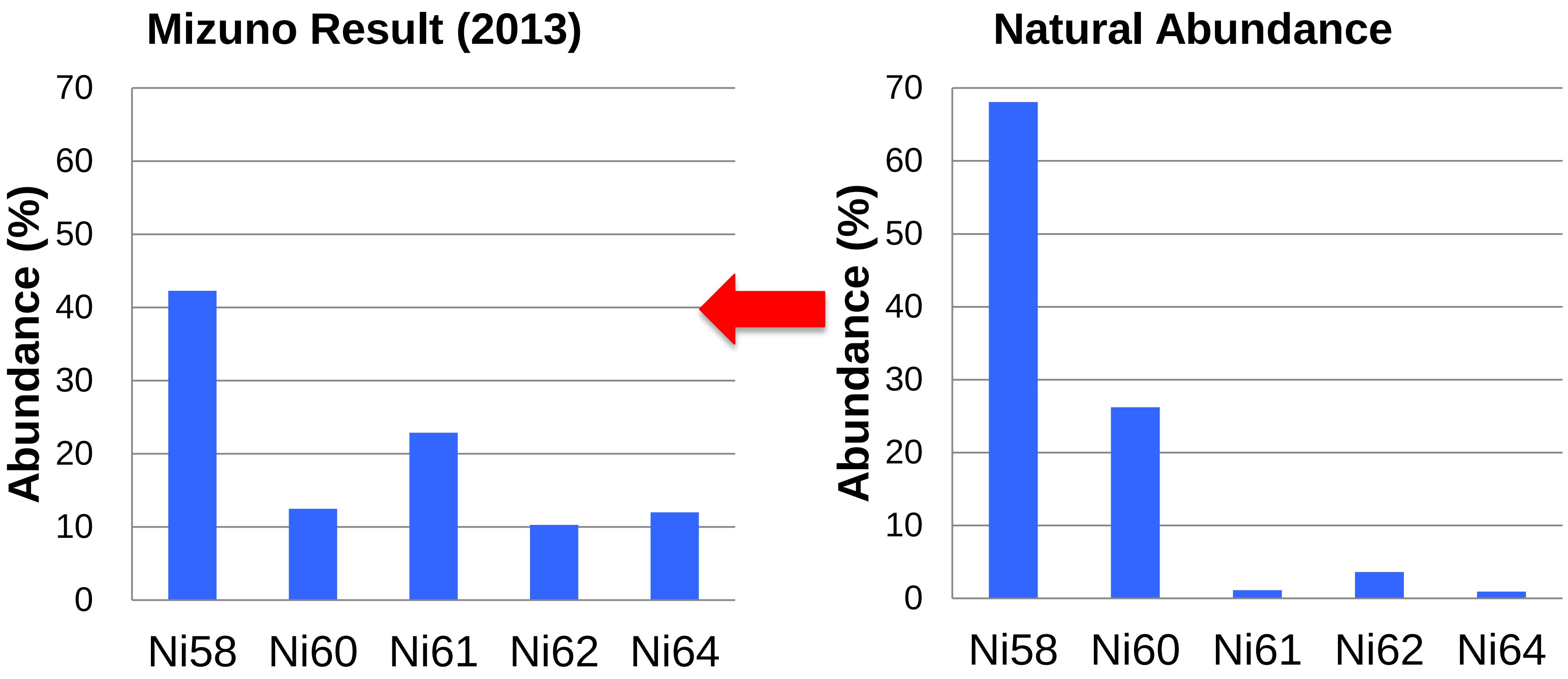
Simulation of Transmutation in Ni+H Systems

Focardi & Rossi, 2010; Defkalion, 2012; and Mizuno, 2013 (Patent Application May 29, 2013)

Nickel Transmutation

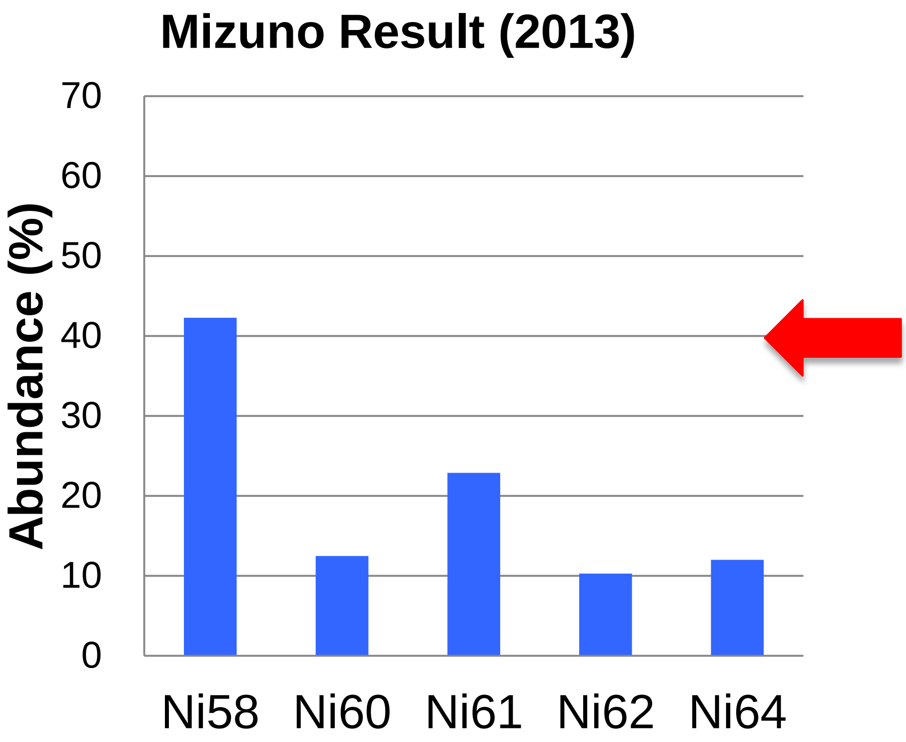
SUS304 alloy: 8% Nickel, 18% Chromium, 74% Iron

…used in a high-temperature alloy+$H_2$0 Hydrogen-generating system

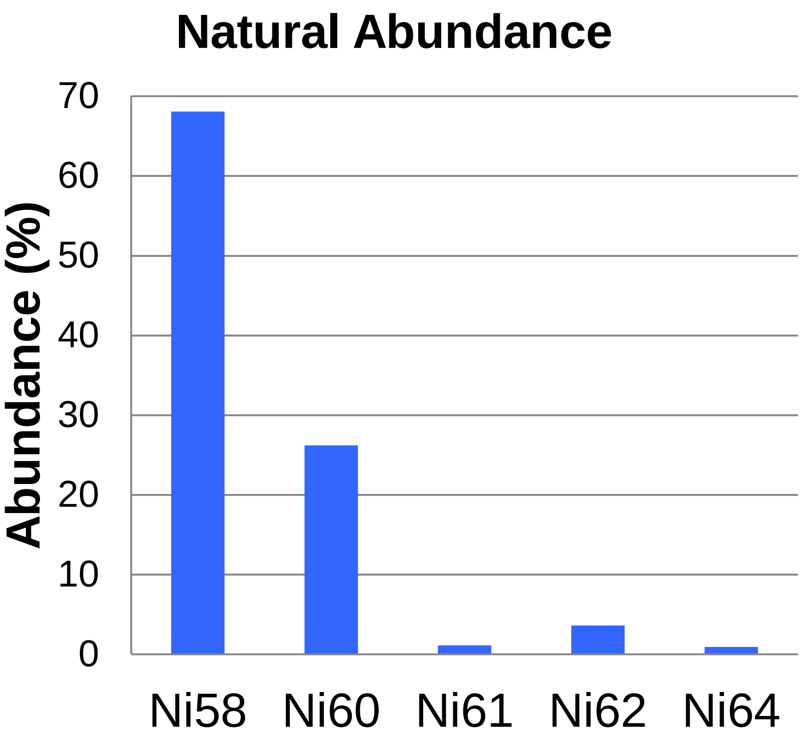


Nickel Transmutation

The raw data suggest that Ni-58 and Ni-60 were consumed, while neutrons were added to Ni-61, Ni-62 and Ni-64, but “depletion analysis” indicates otherwise…

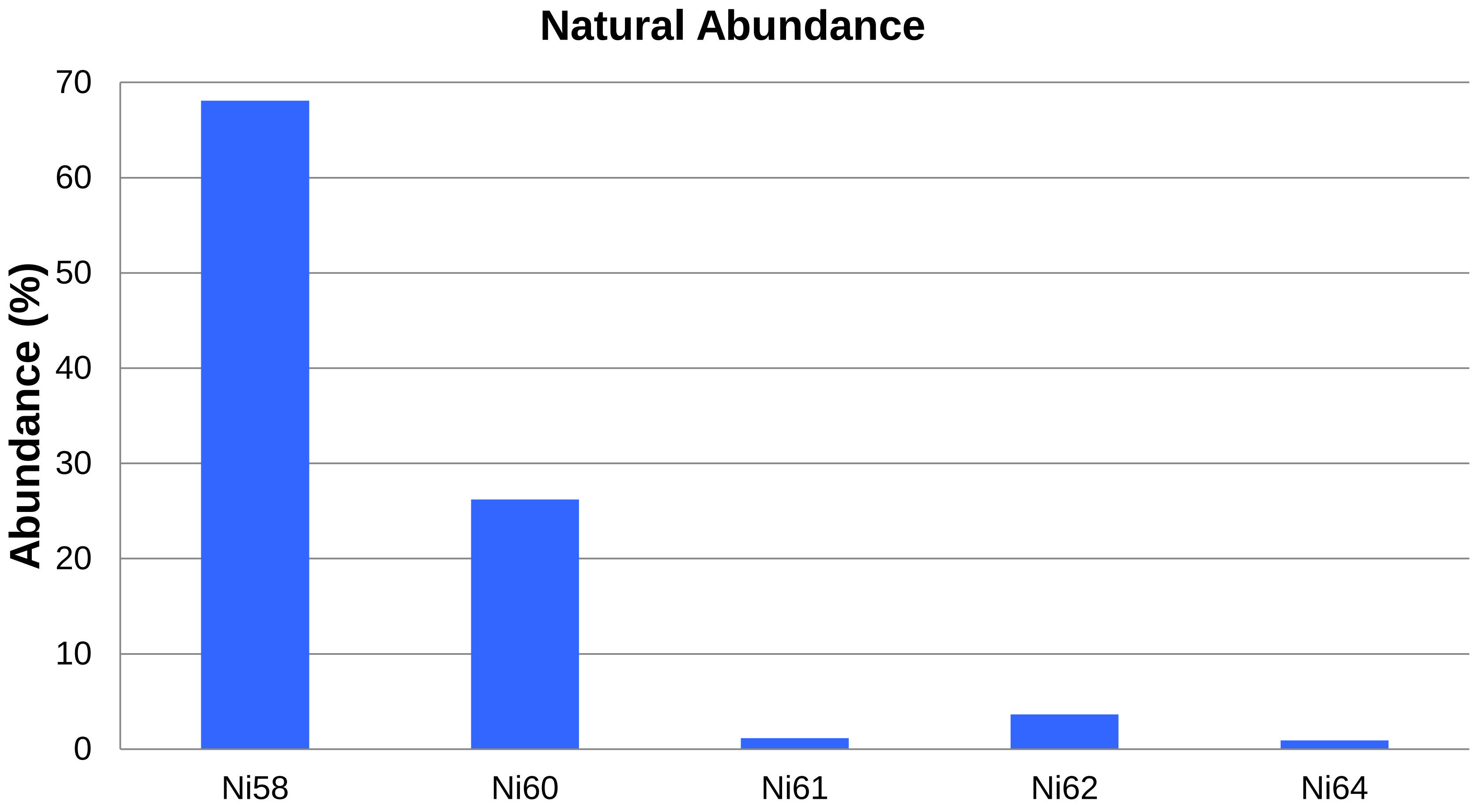


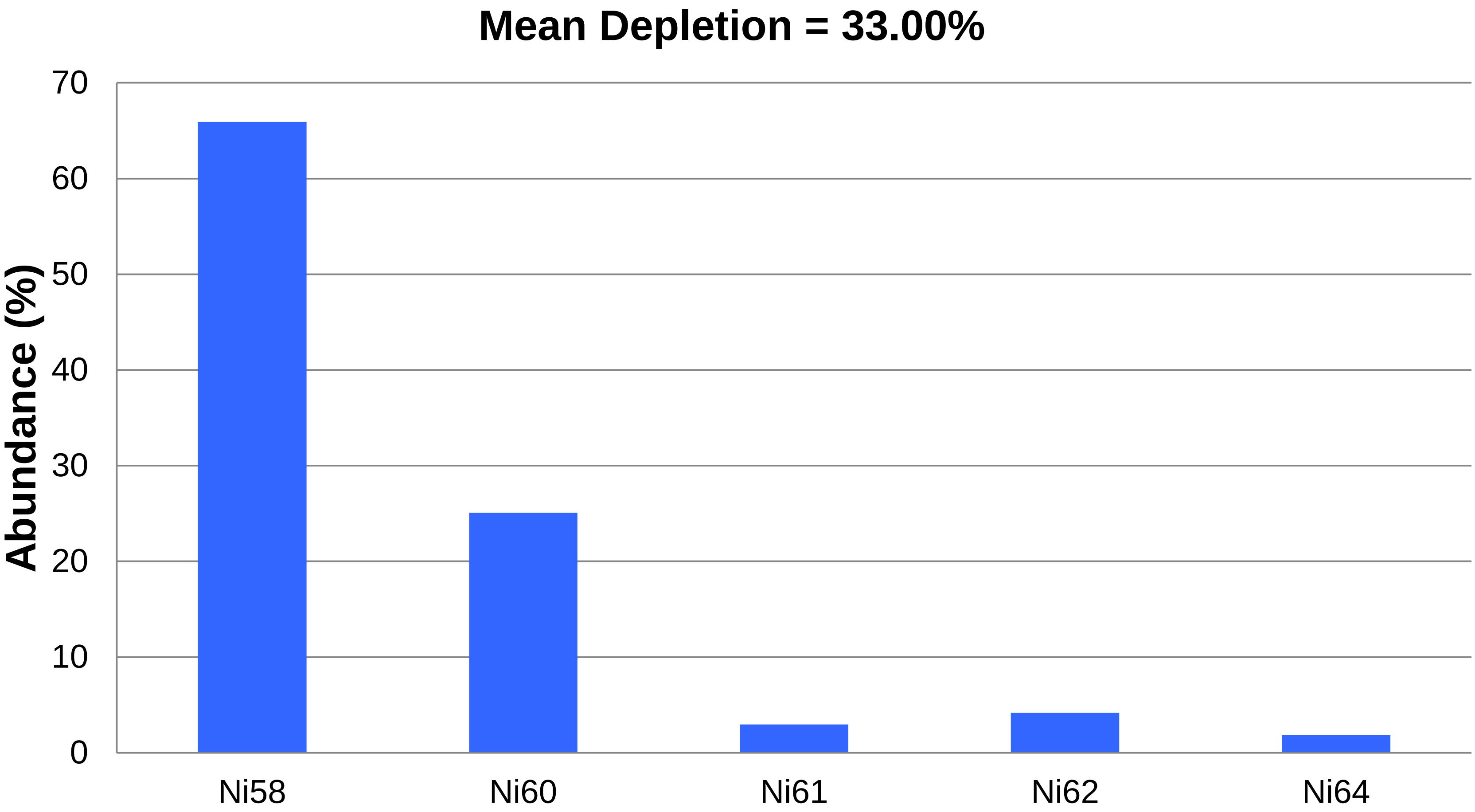
Mizuno Result (2013)



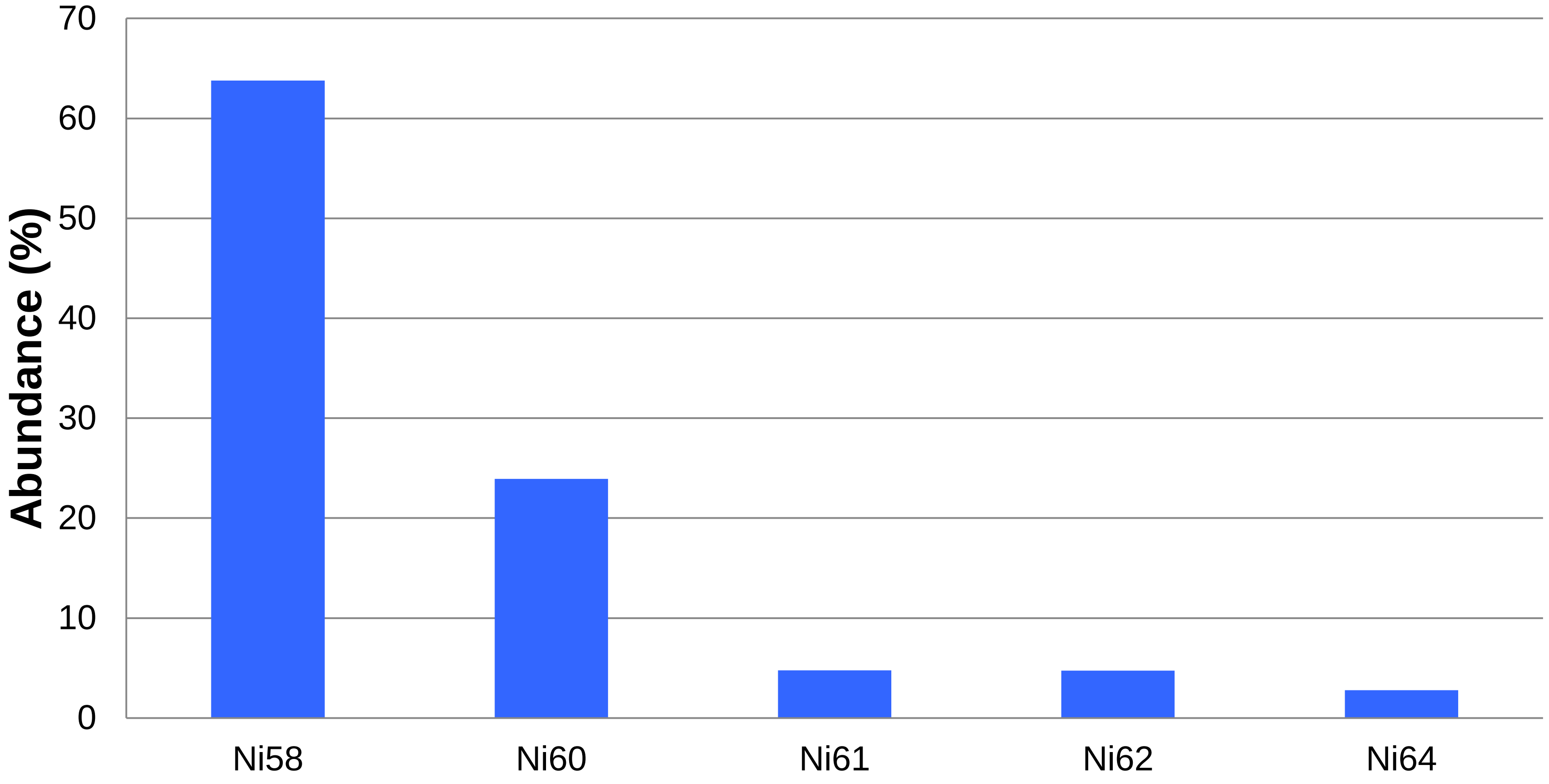
Natural Abundance

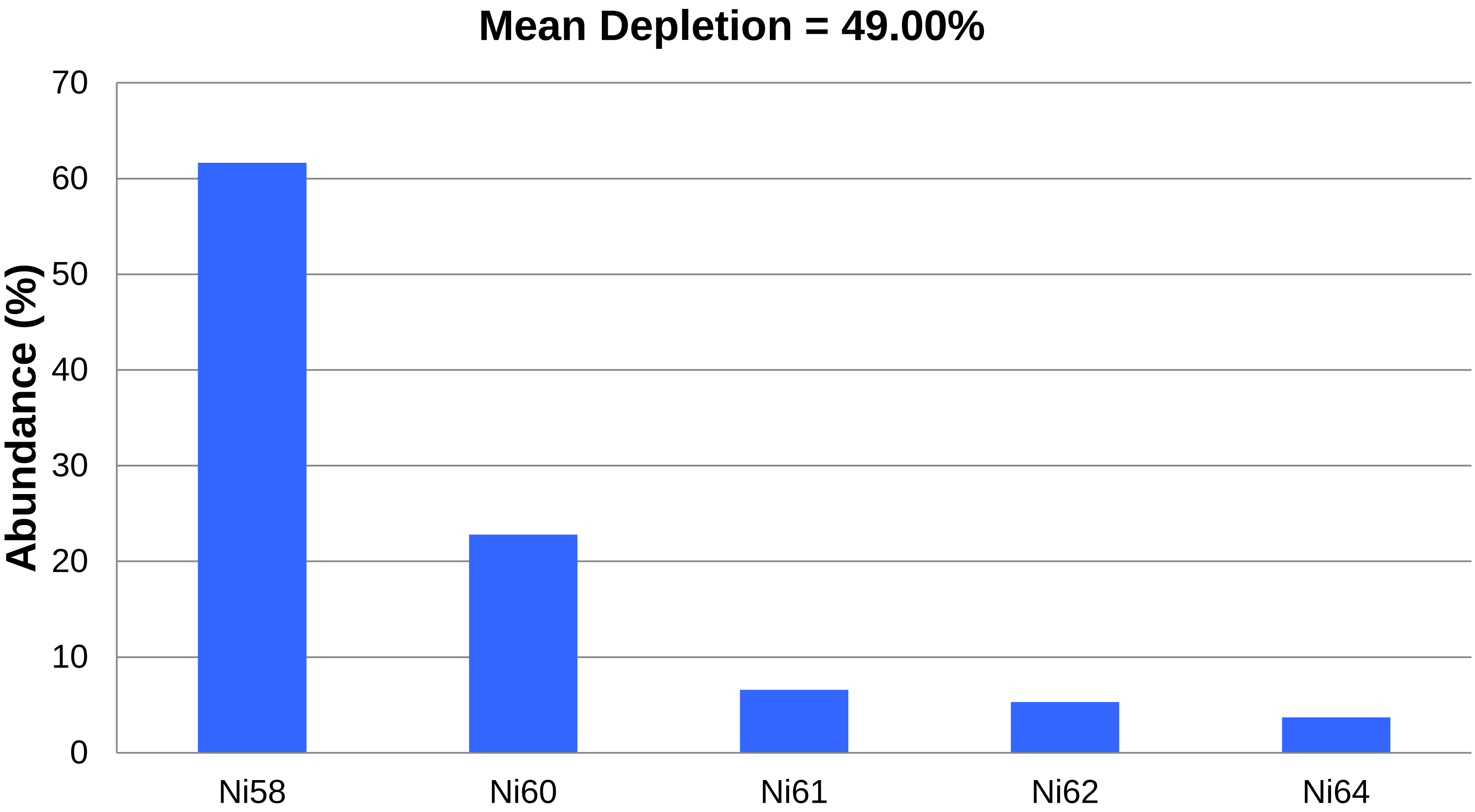
Before the start of electrolysis…



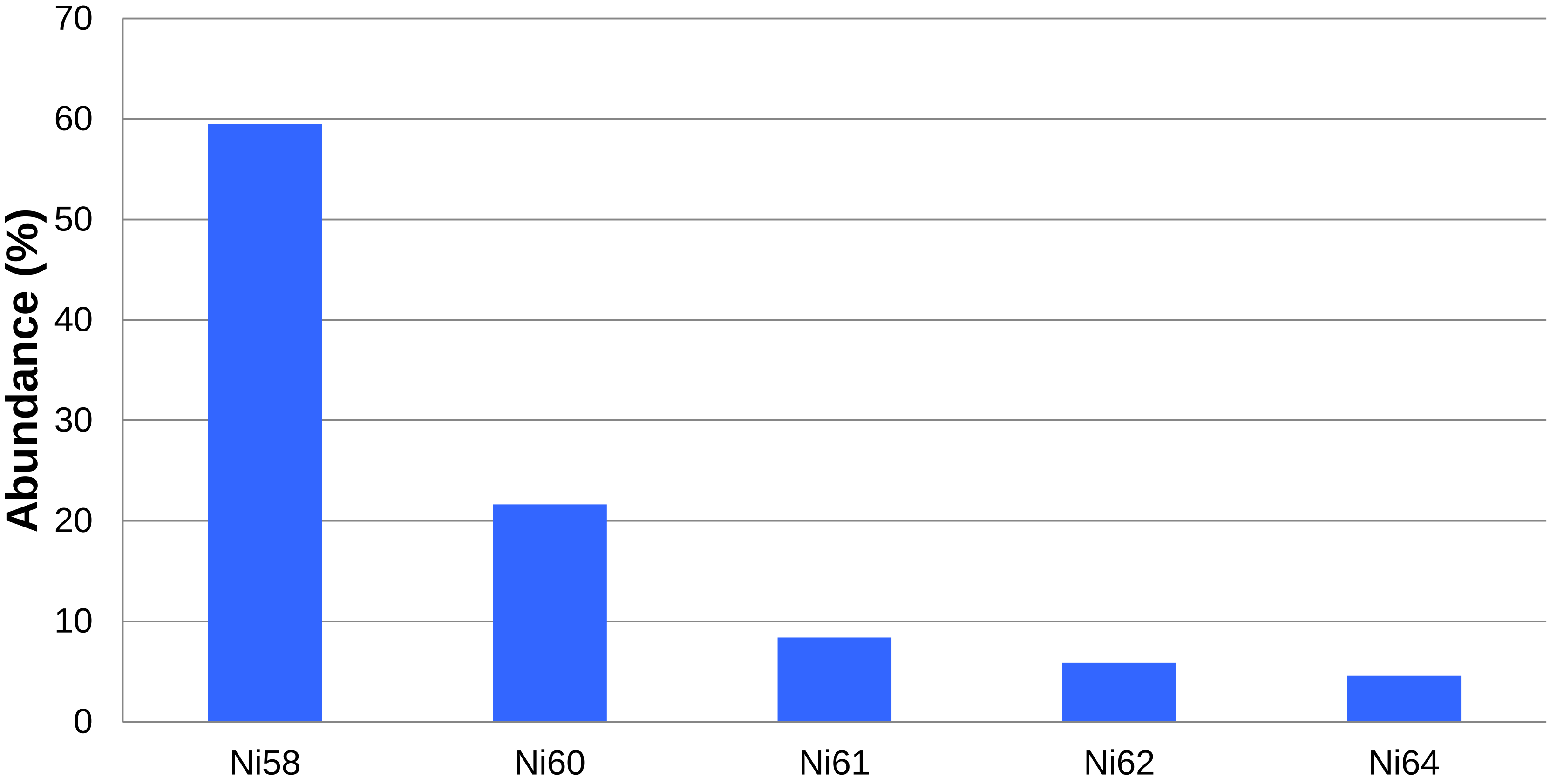

Mean Depletion = 33.00%
Abundance (%)
70
60
50
40
30
20
10
0
Ni58
Ni60
Ni61
Ni62
Ni64

Mean Depletion = 42.00%

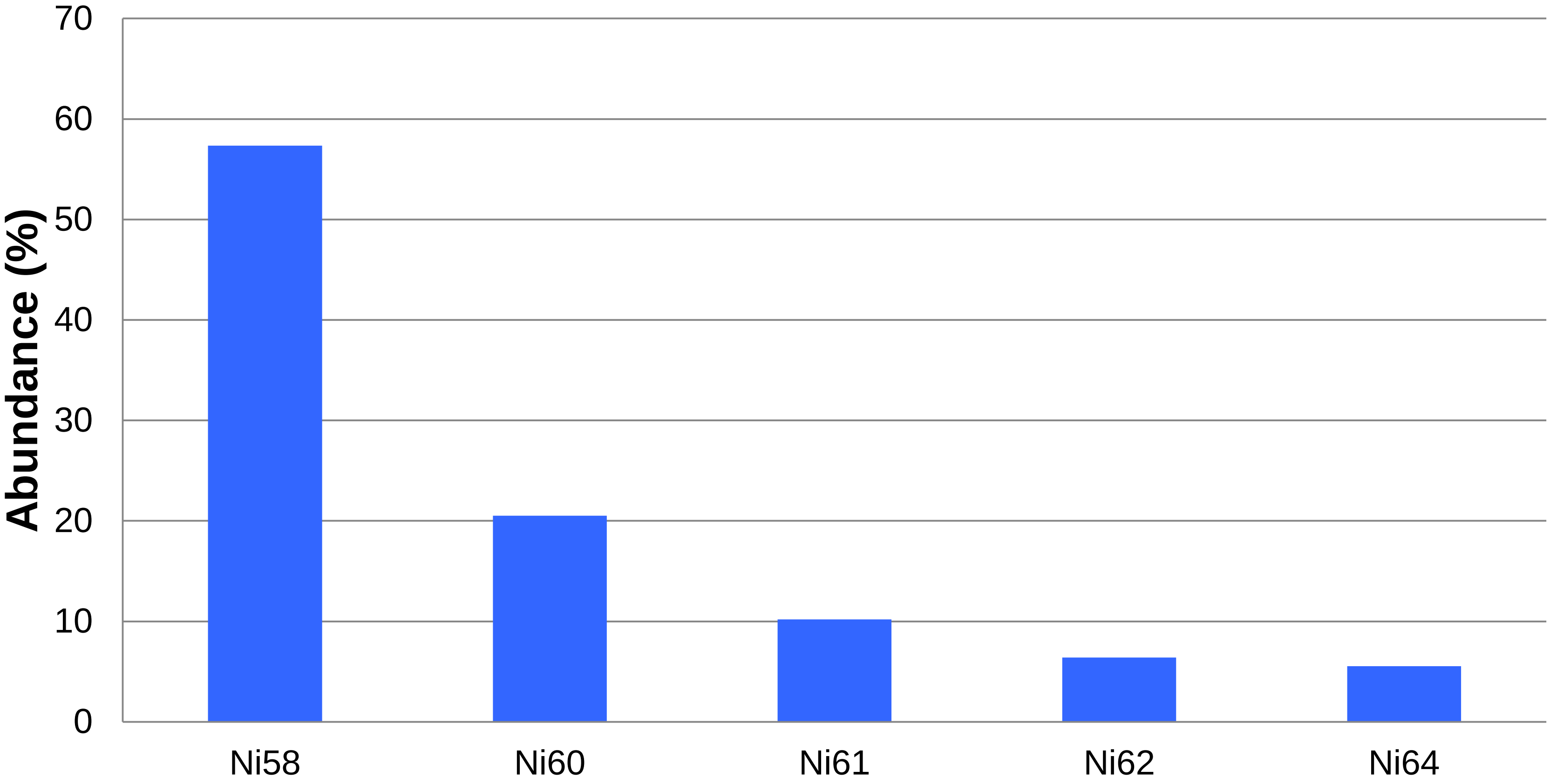



Mean Depletion = 49.00%
Abundance (%)
70
60
50
40
30
20
10
0
Ni58
Ni60
Ni61
Ni62
Ni64

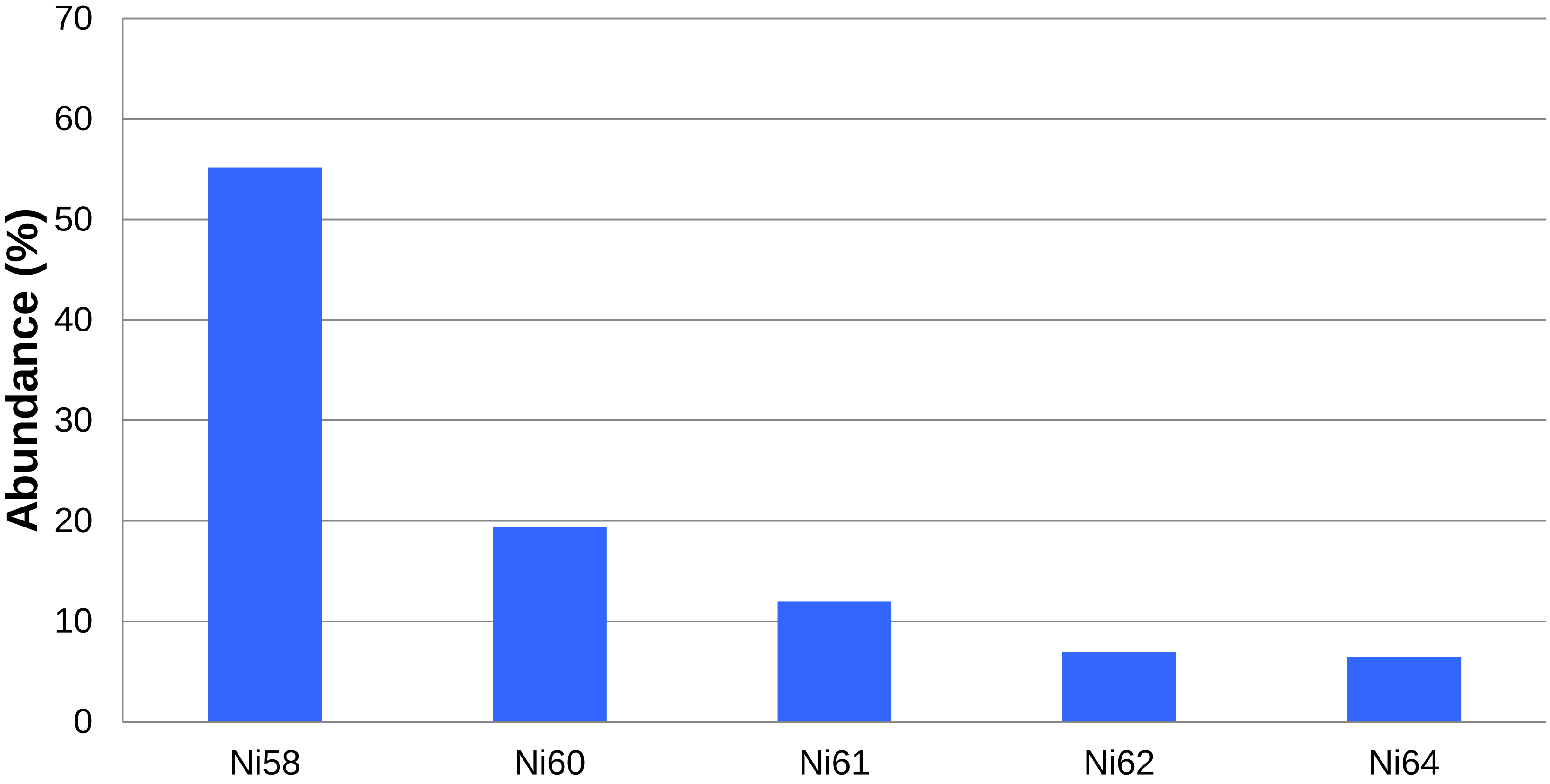
Mean Depletion = 57.00%



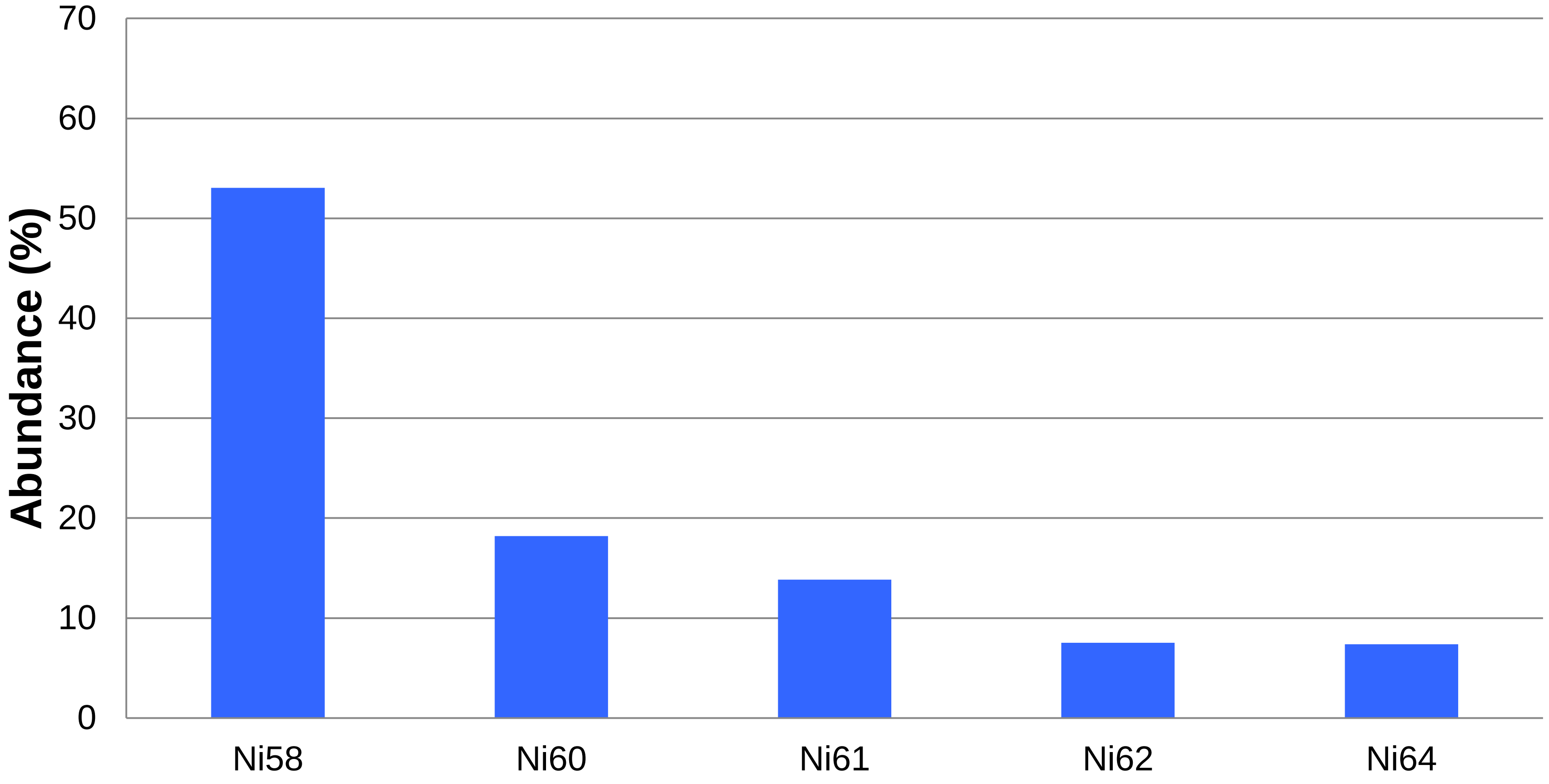
Mean Depletion = 63.00%

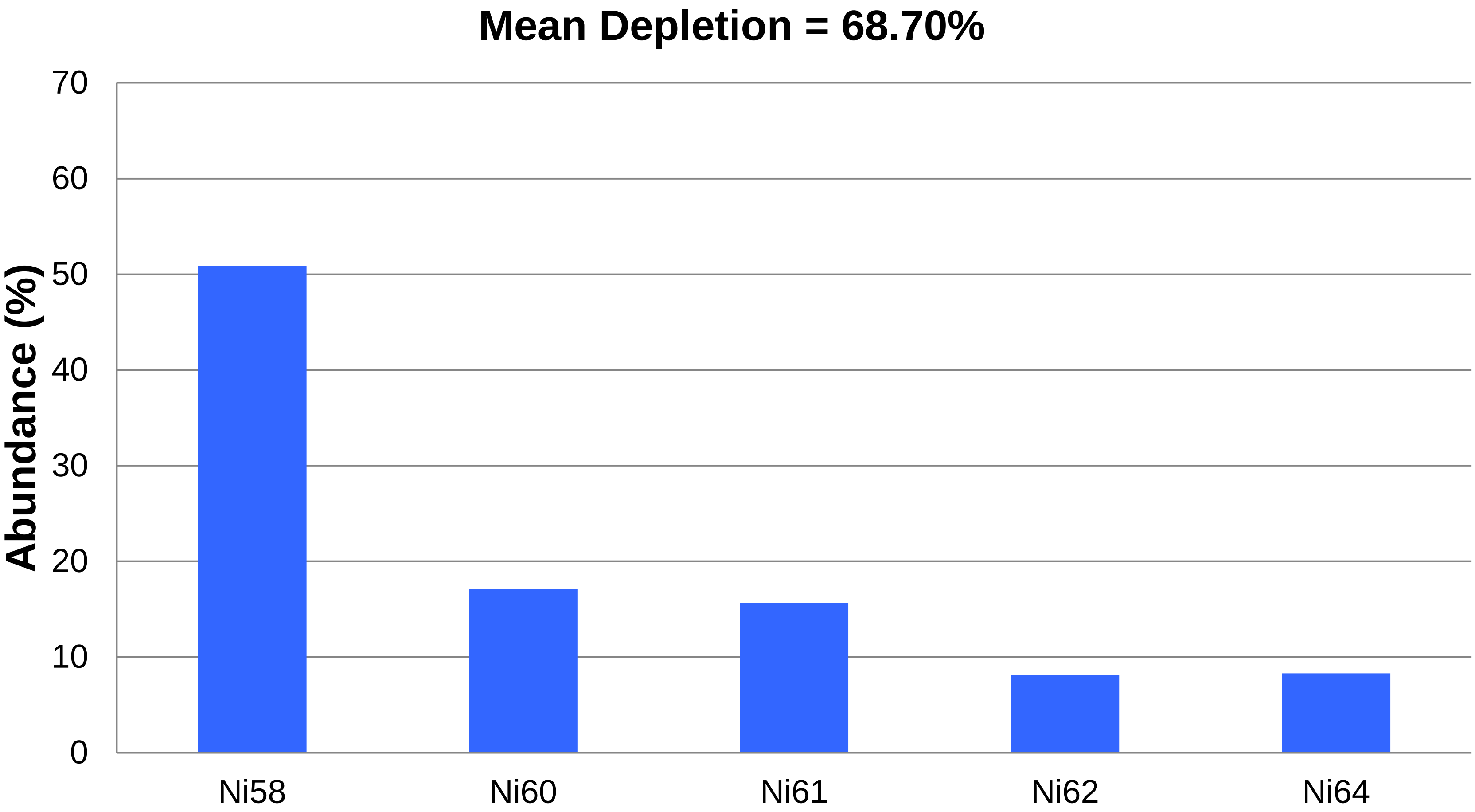


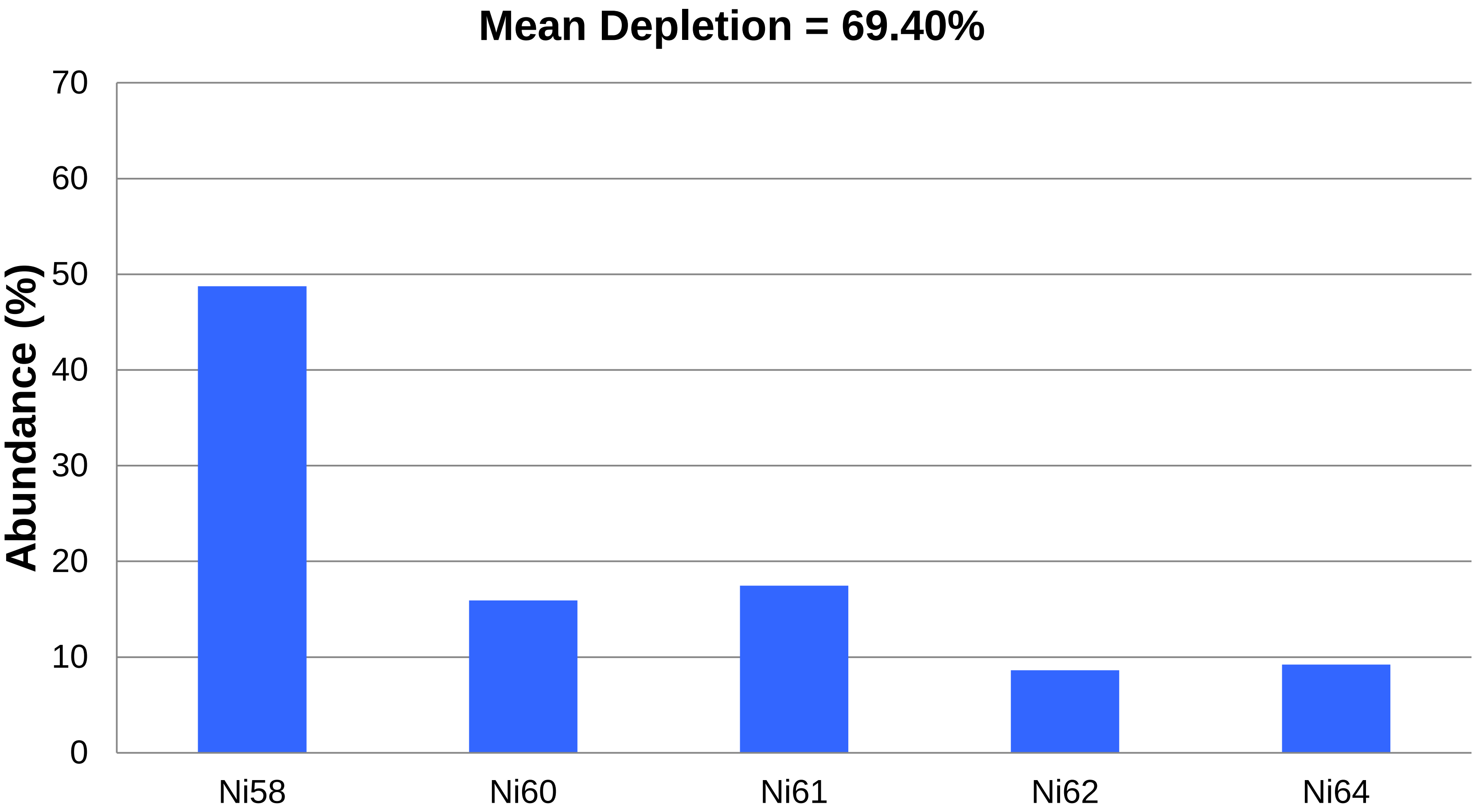
Mean Depletion = 66.80%



Mean Depletion = 67.80%

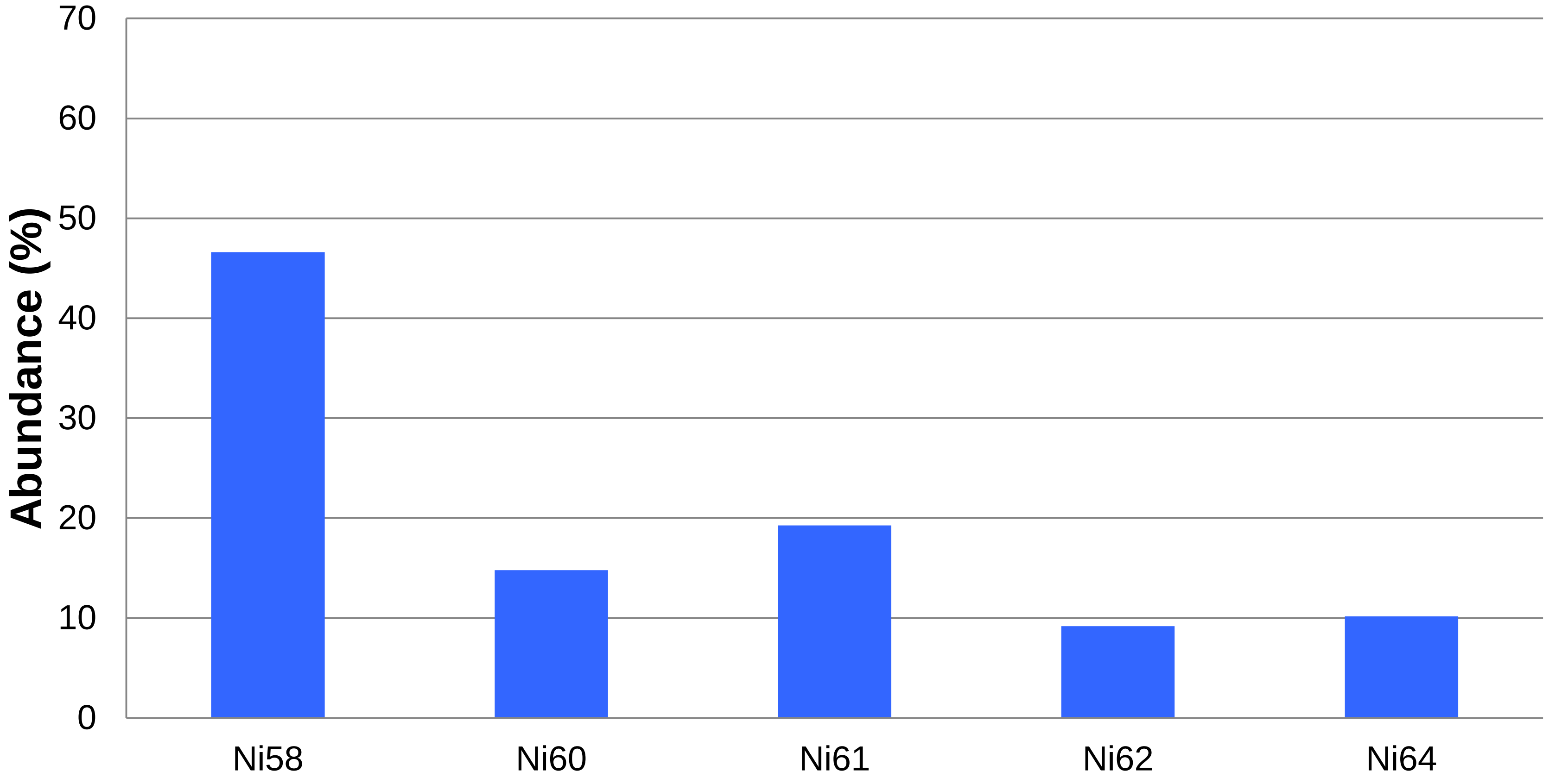



Mean Depletion = 68.70%
Abundance (%)
70
60
50
40
30
20
10
0
Ni58
Ni60
Ni61
Ni62
Ni64

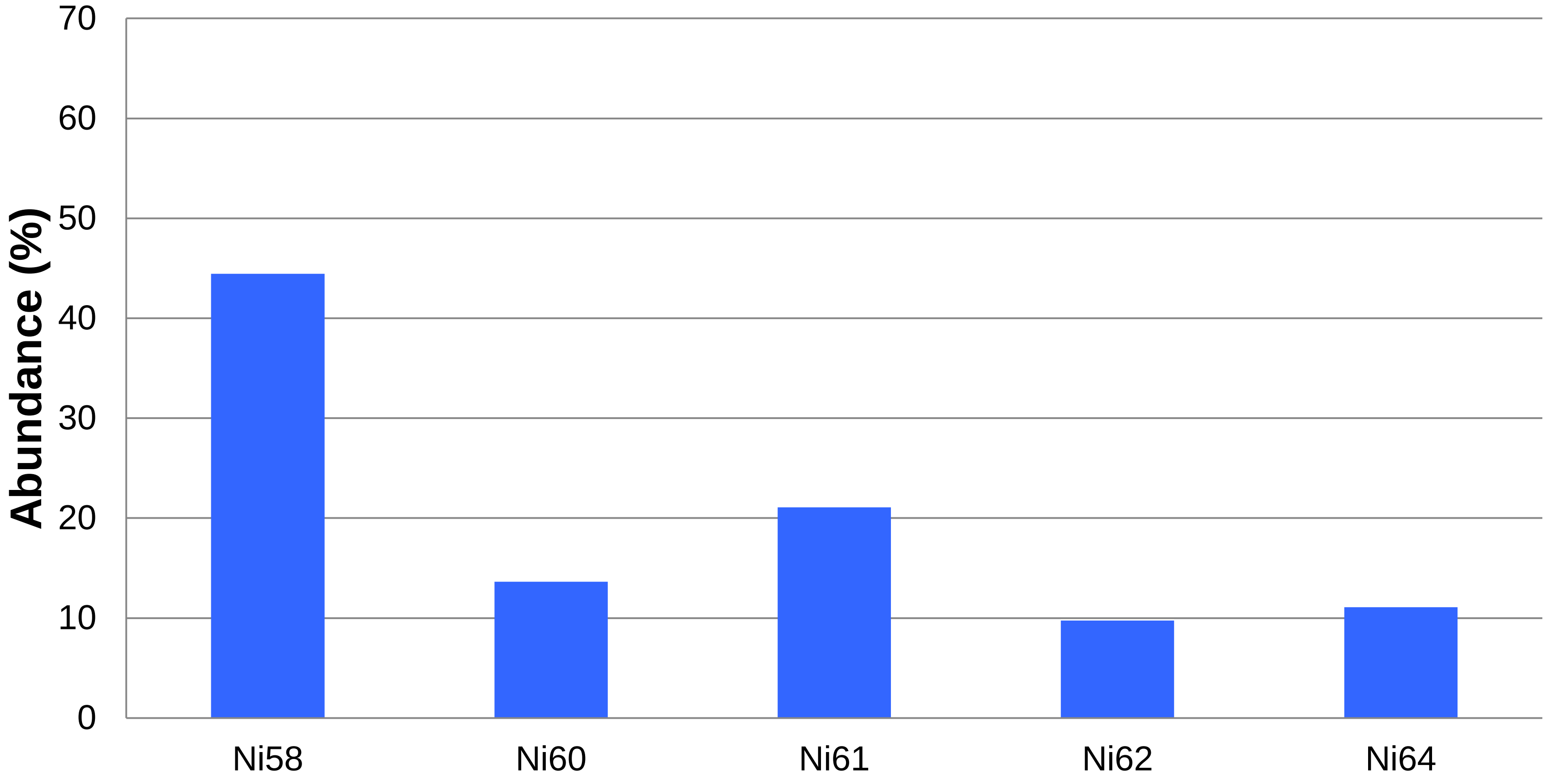


Mean Depletion = 69.40%

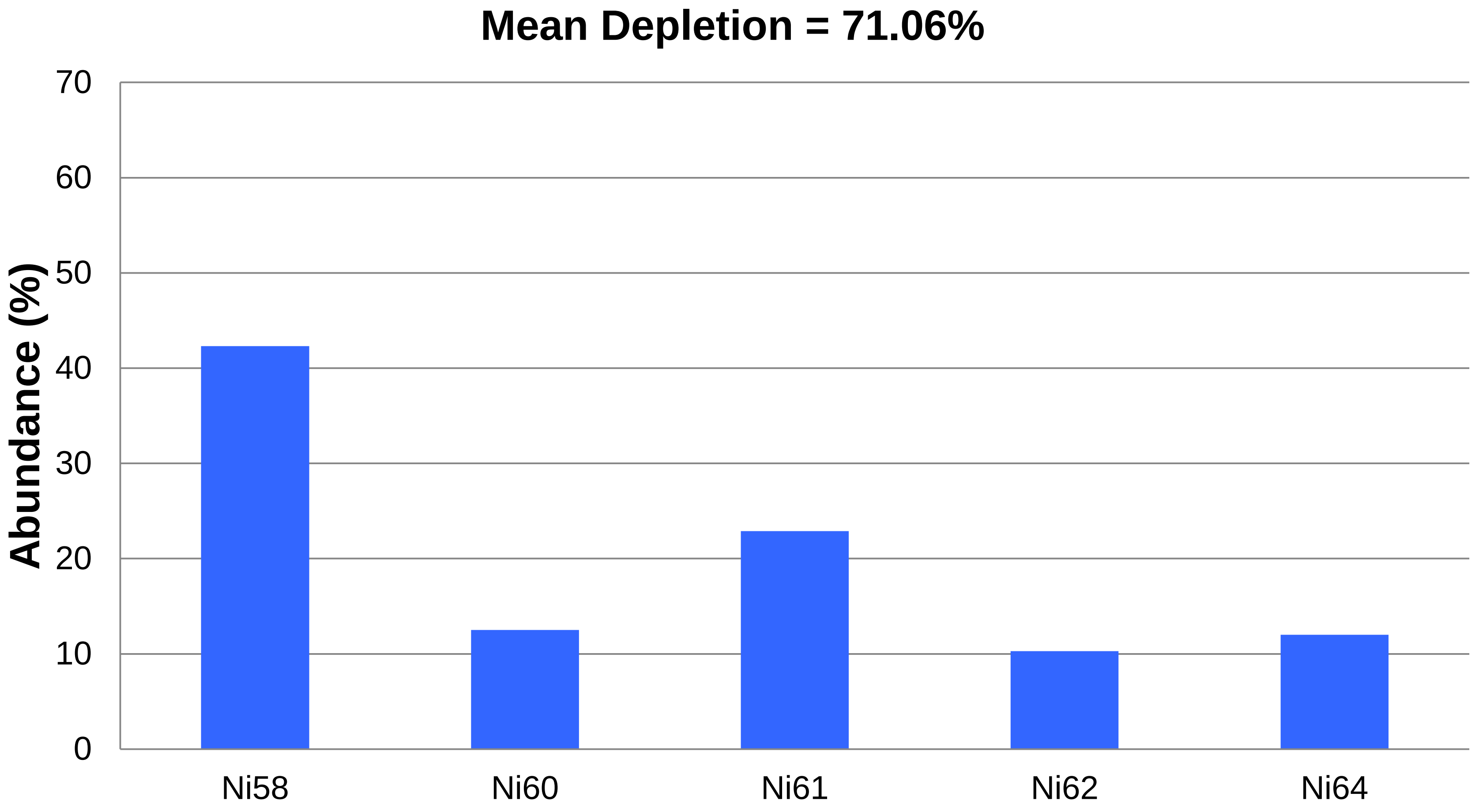
Mean Depletion = 70.10%



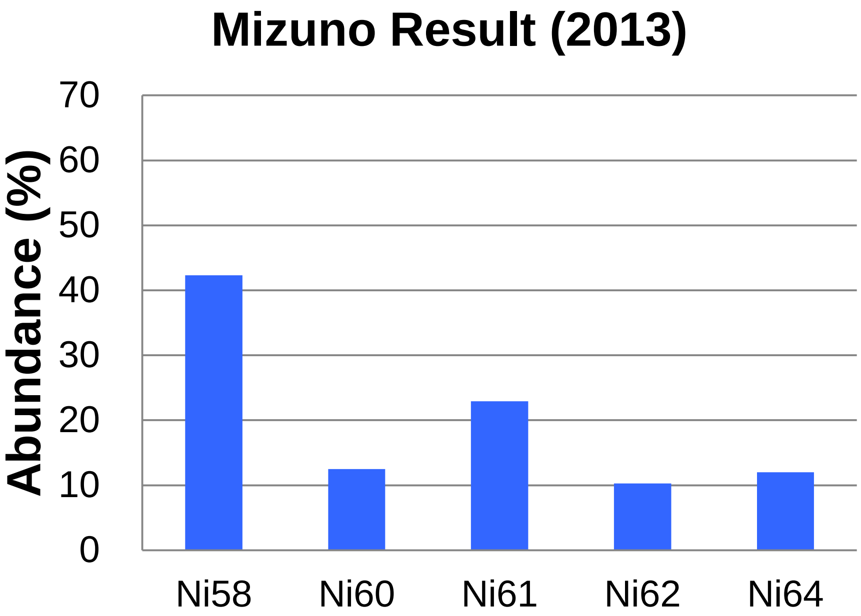
Mean Depletion = 70.60%



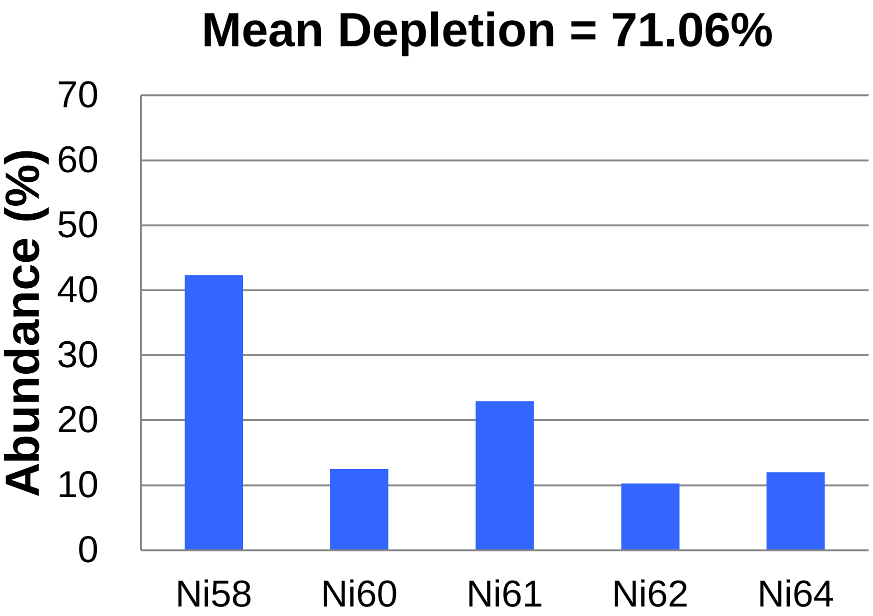
Final isotope abundances obtained with ~71% depletion of the surface isotopes…



Experiment

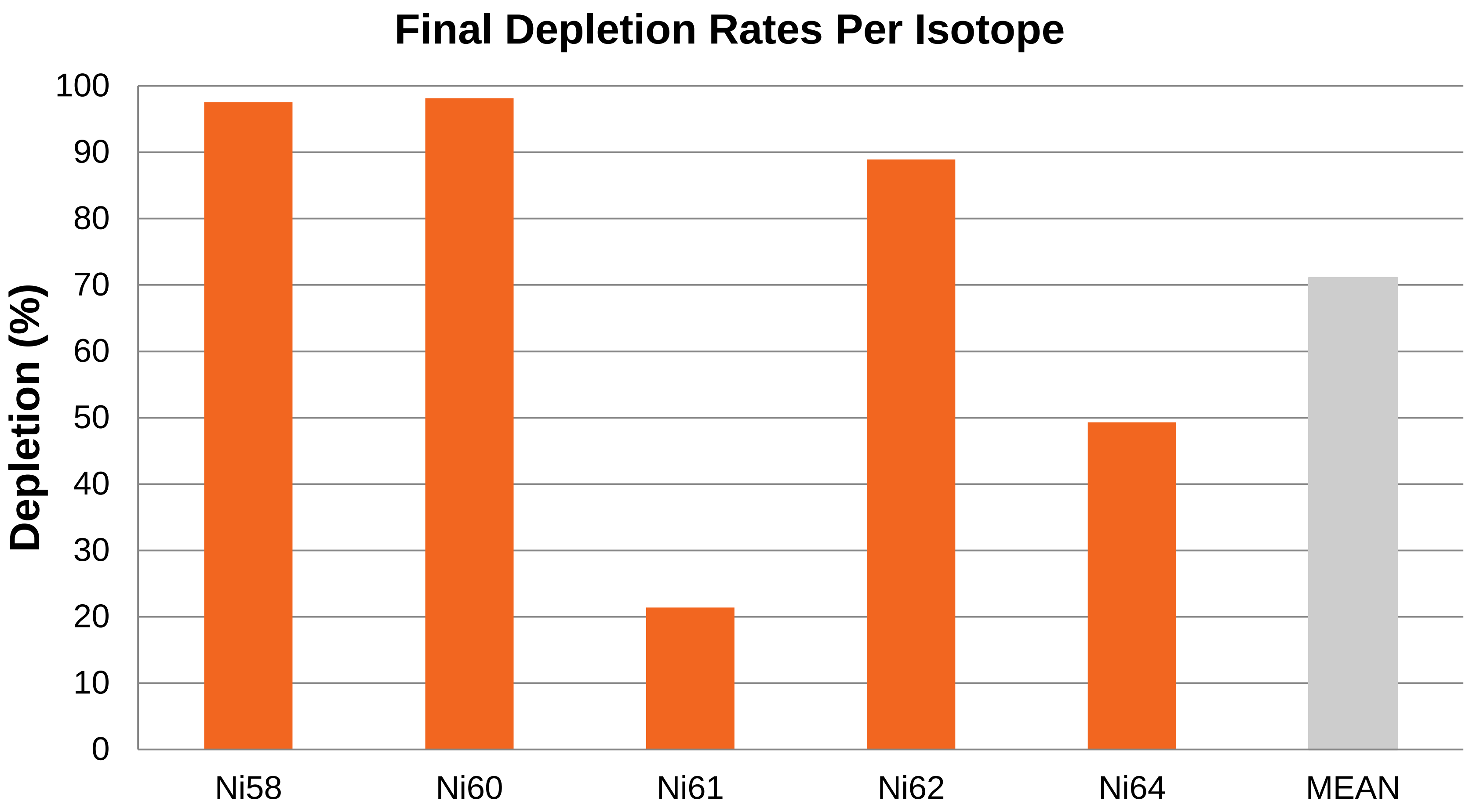


Simulation

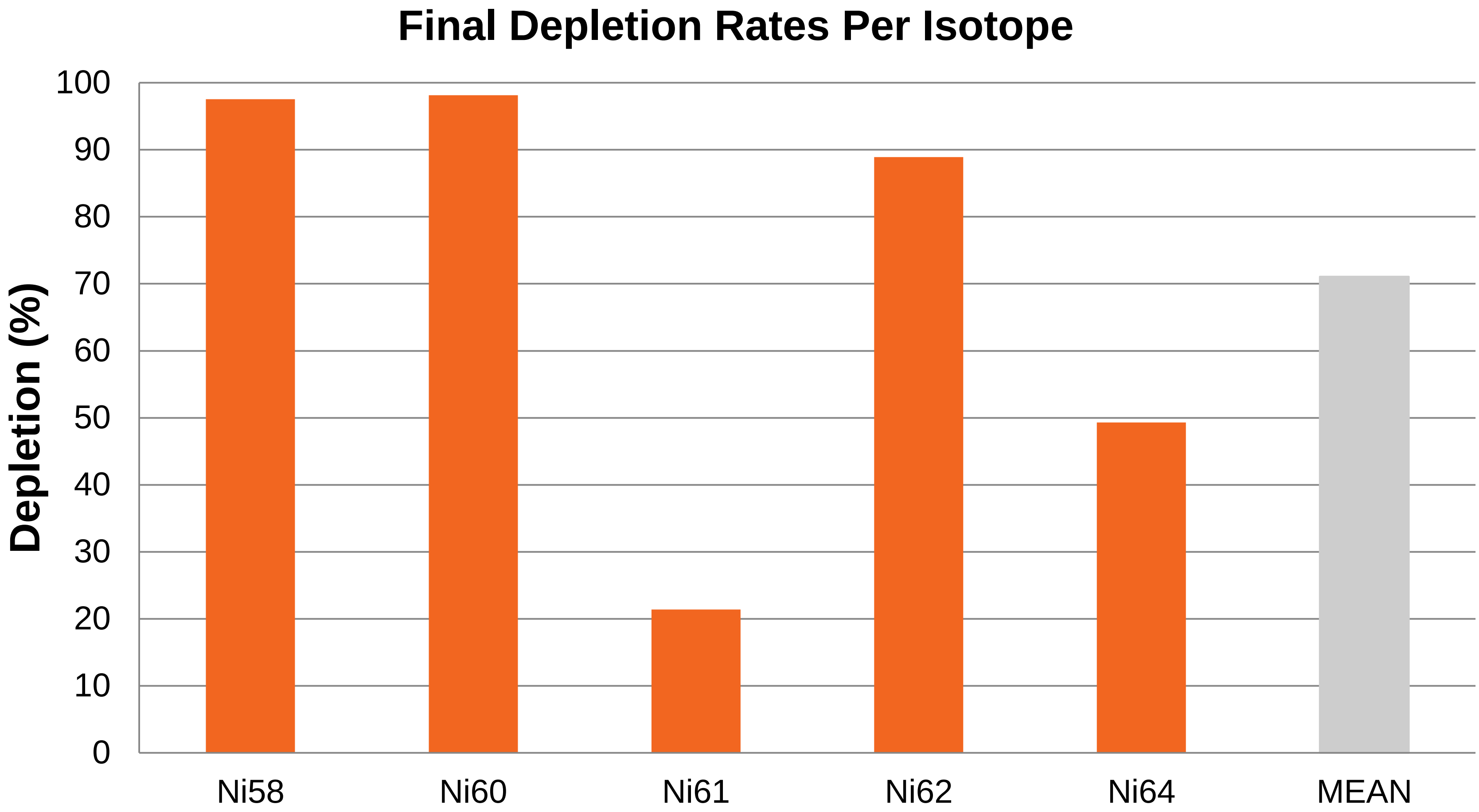


Again, the simulation successfully reproduced the experimental data…

Interestingly, Ni^{61} was not strongly depleted – apparently not participating in the LENR

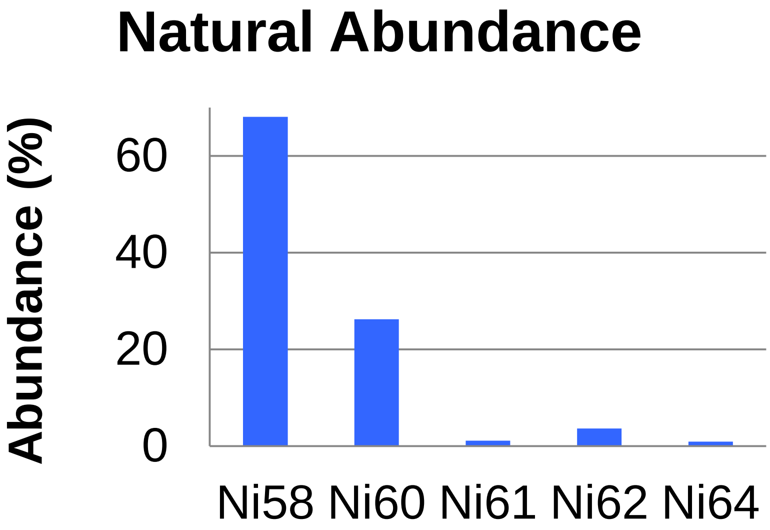


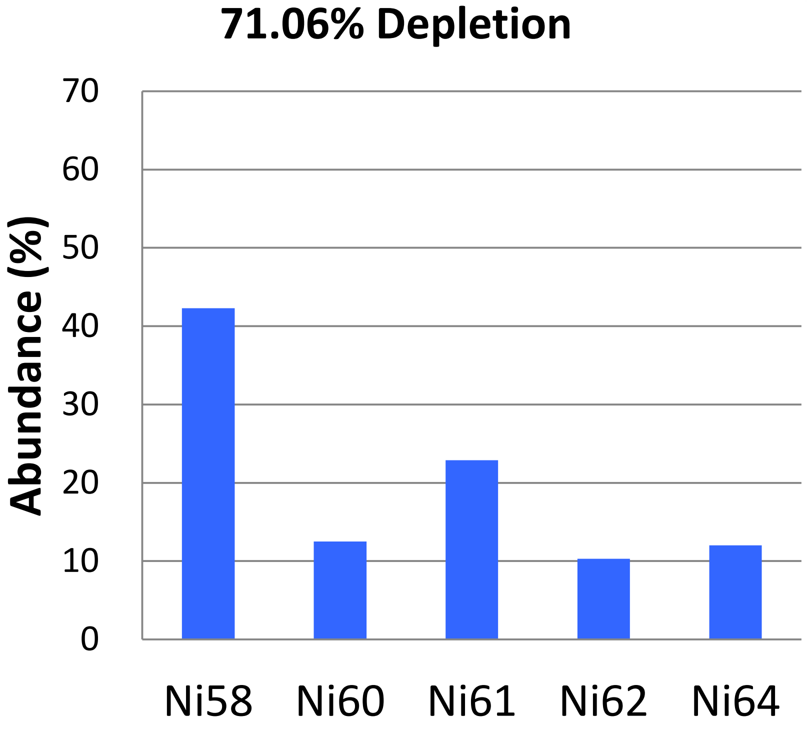
Is this independent replication of the Defkalion result? Little LENR effect with Ni^{61}

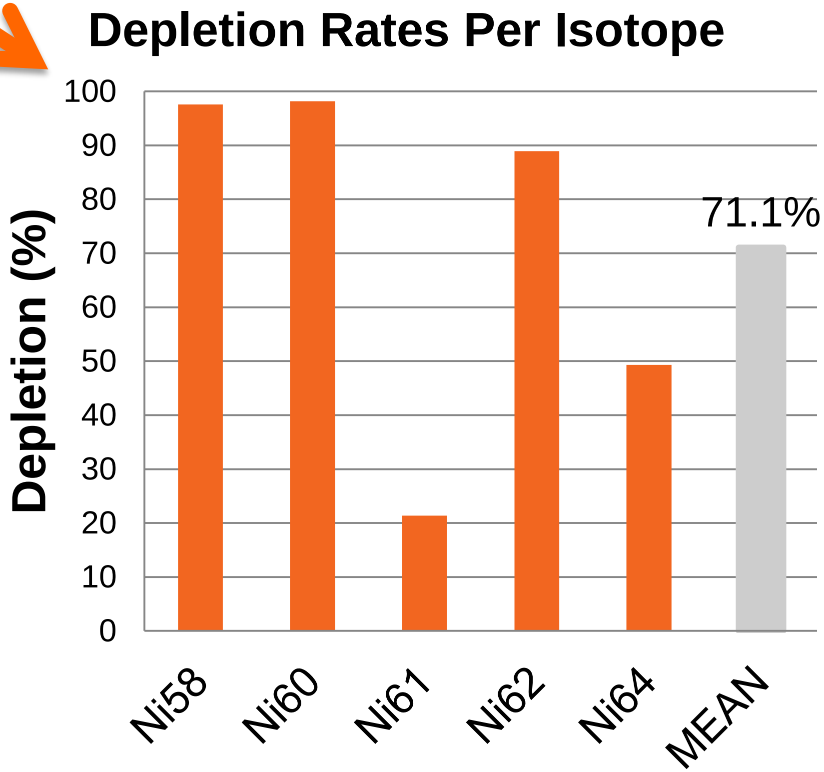


Nickel Isotopes

Strong depletion of all isotopes except Ni-61 reproduces the Mizuno results.





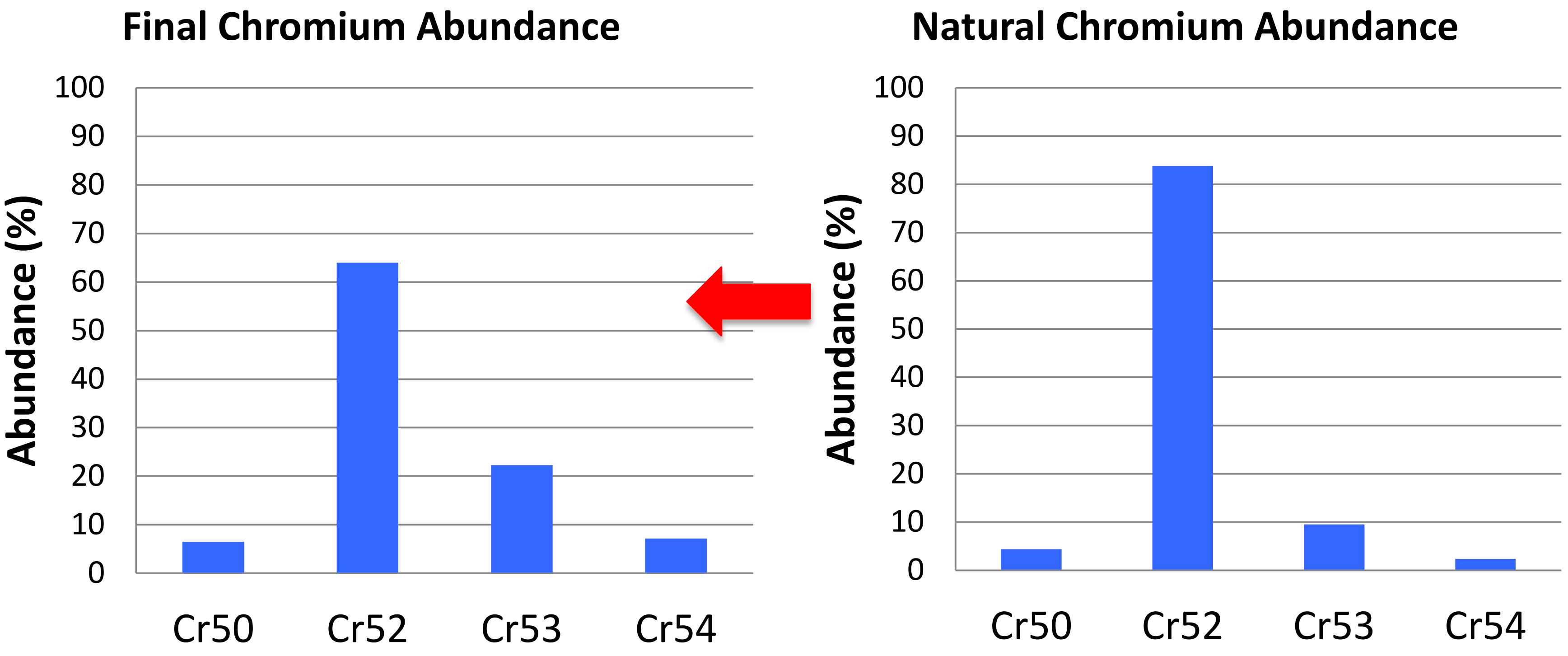


What about Chromium and Iron depletion in the Ni-Cr-Fe alloy?

SUS304 alloy: 8% Nickel, 18% Chromium, 74% Iron

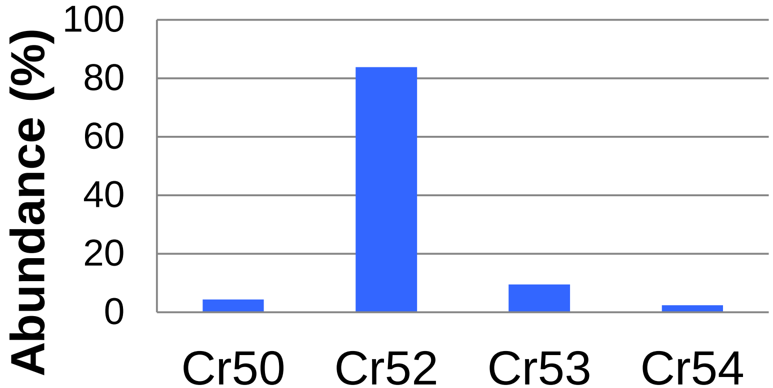
Cr Isotopes

Again, a comparison of the natural abundances and the post-electrolysis abundances “suggests” that Cr-52 was consumed, while neutrons were added to Cr-50, Cr-53 and Cr-54!!

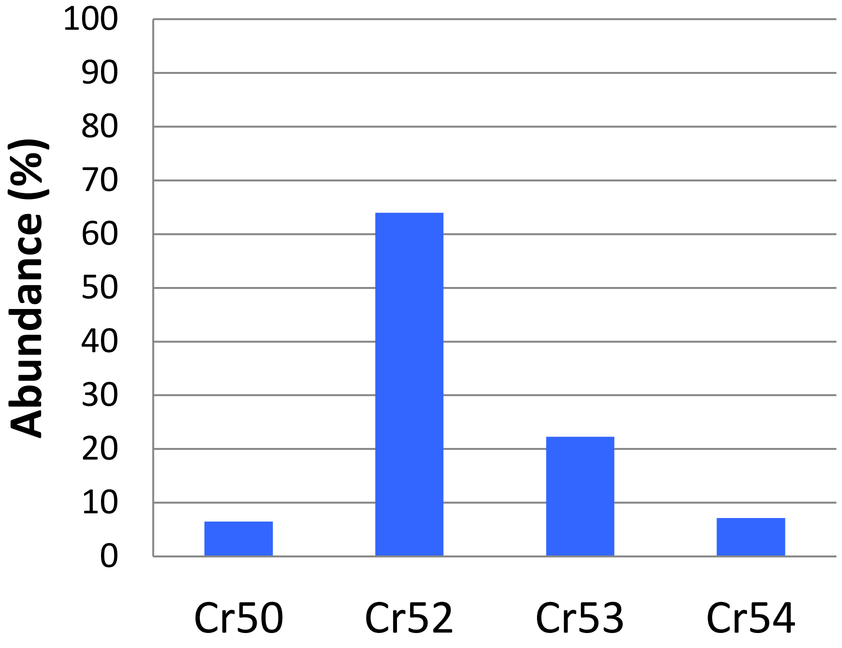


Chromium Isotopes

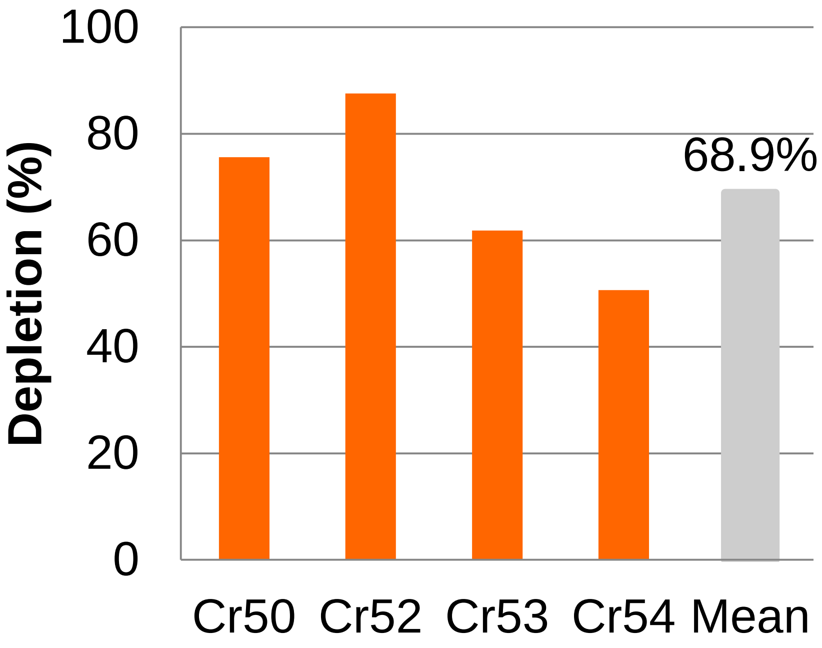
Strong depletion of <u>all</u> the Cr isotopes produces the experimental results.



Natural Chromium Abundance



Final Chromium Abundance

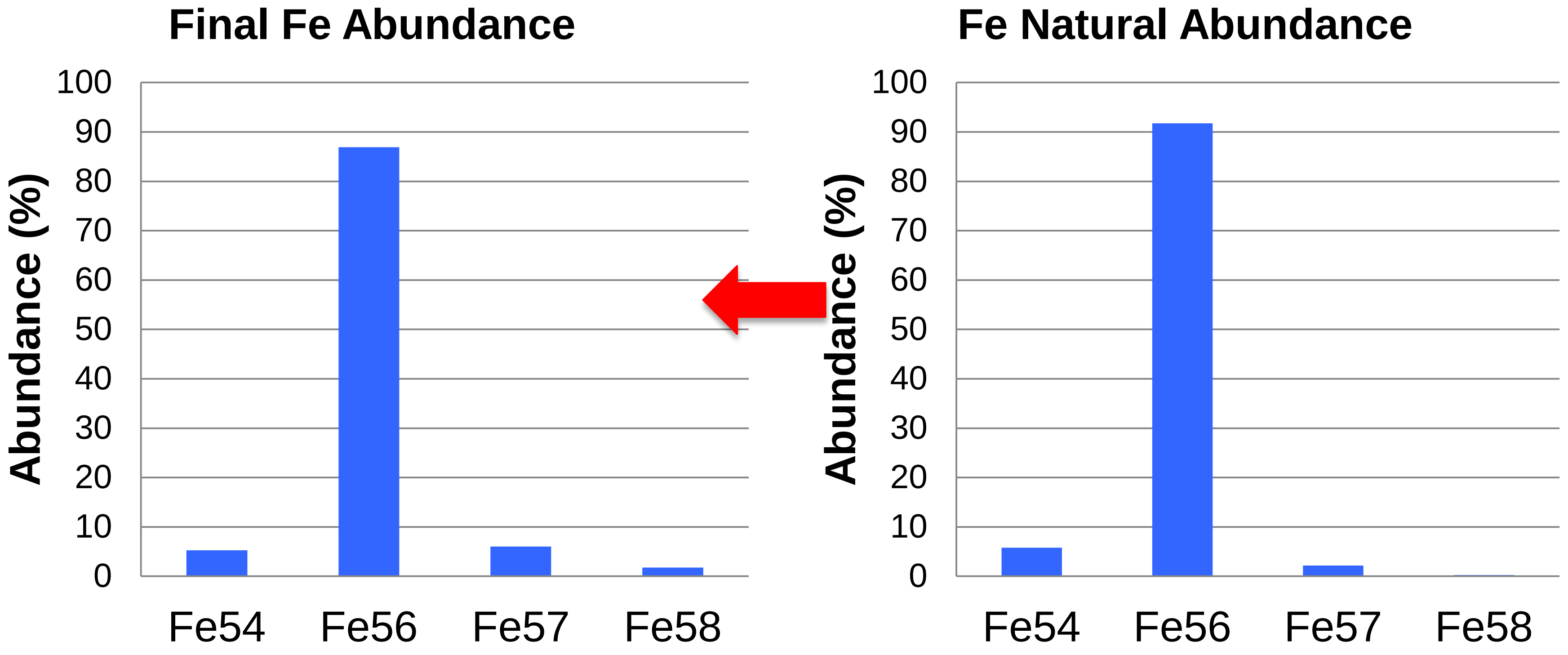


Cr Depletion Per Isotope

Fe Isotopes

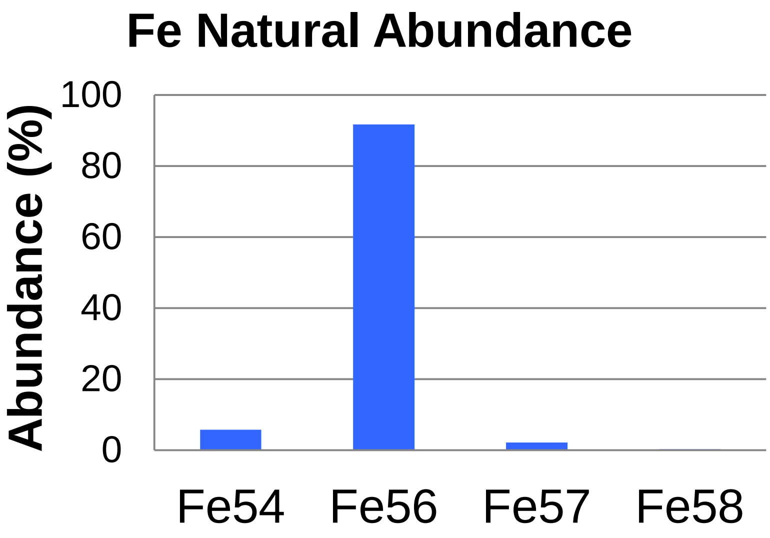
Again, the raw data suggest a decrease in Fe-56, while neutrons were added to Fe-57 and Fe-58!

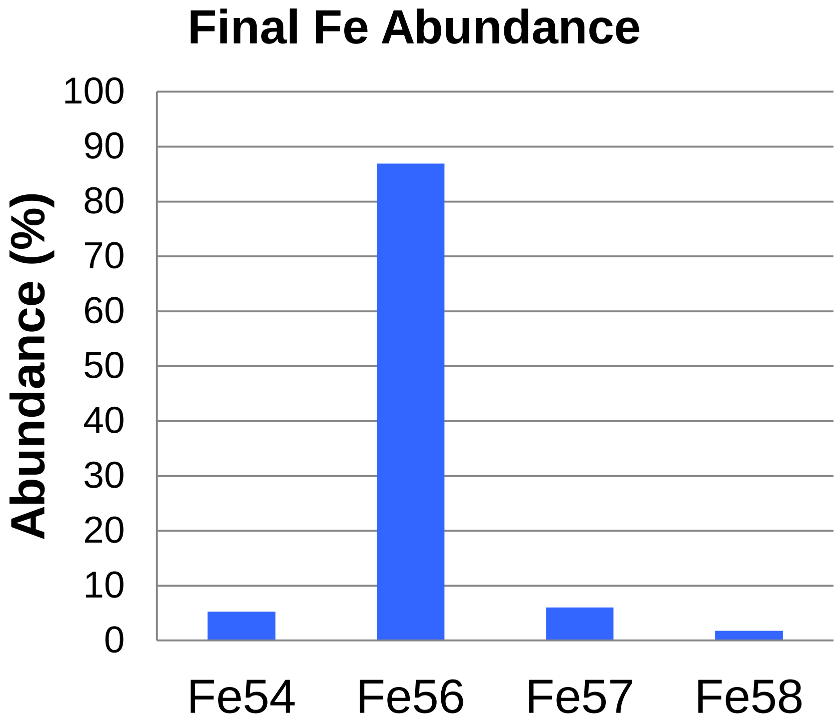
Changes in the abundance of Iron isotopes were reported as “small effects”…

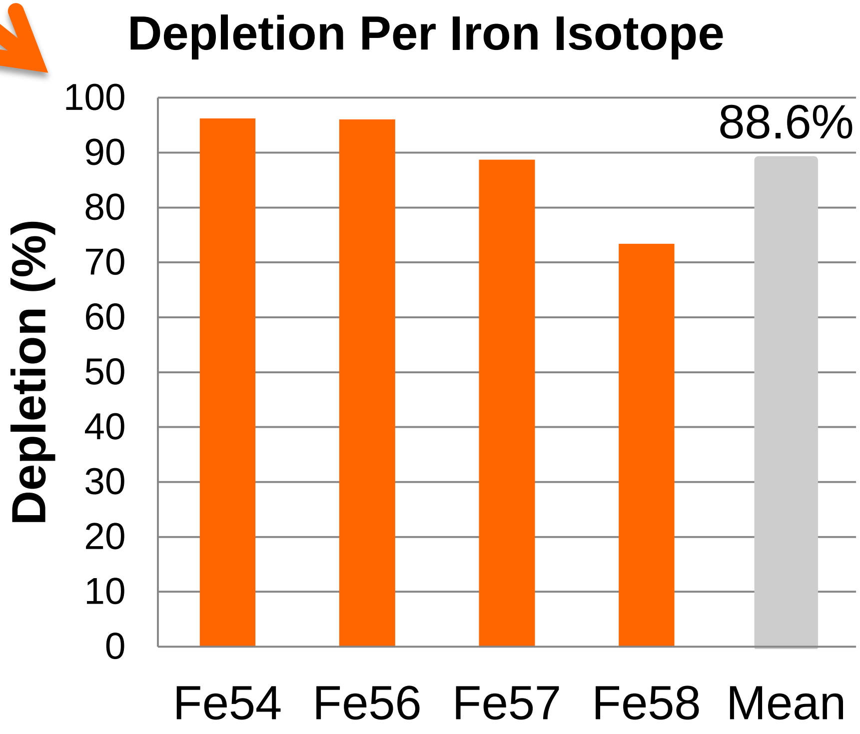


Iron Isotopes

Strong depletion of all the Fe isotopes produces the experimental results.

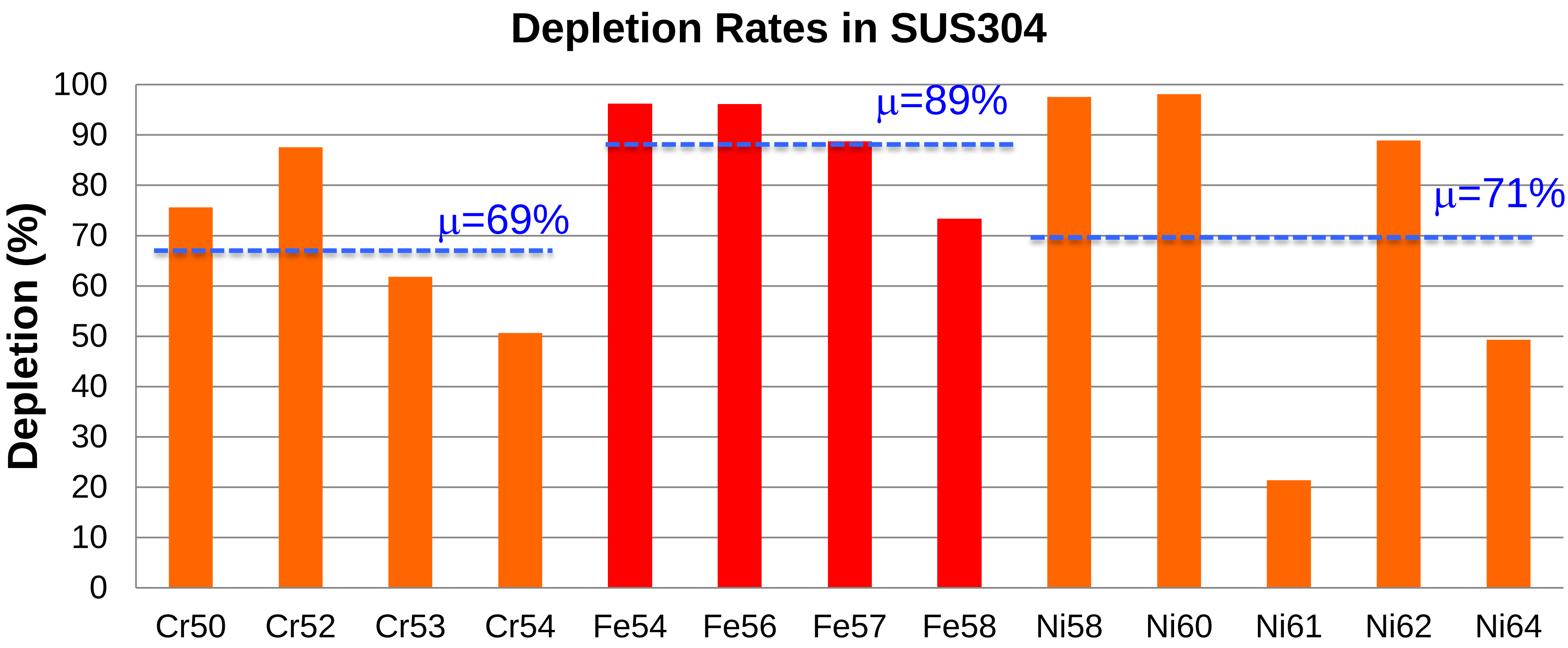

Fe Natural Abundance


Final Fe Abundance


Depletion Per Iron Isotope

SUS304 Alloy: 8% Nickel, 18% Chromium, 74% Iron

- Mean depletion of Iron isotopes: 88.6%
- Mean depletion of Chromium isotopes: 68.9%
- Mean depletion of Nickel isotopes: 71.1%



Jπ = 0+ 0+ 3/2- 0+ 0+ 0+ 1/2- 0+ 0+ 0+ 3/2- 0+ 0+

Conclusions (1/2)

The LENR transmutation data indicate extensive depletion of isotopes subsequent to “cold fusion” treatment.

Further analysis should include possible “accretion” effects (e.g., $Ni^{60}+H \rightarrow Cu^{61} \rightarrow Ni^{61}$, $Pd^{104}+D \rightarrow Ag^{106} \rightarrow Pd^{106}$, etc.).

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Conclusions (2/2)

If the depleted isotopes are replaced by fission products, then analysis of the nuclear fragments will require the use of a nuclear "model" to make predictions about fragment masses.

Thank you.

Comments and Questions, please!

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Thank you.

Comments and Questions, please!

Possible Nickel Accretion Mechanisms (Ni+H→…)

- (68%) Ni^{58} + H → Cu^{59} (81 sec) → Ni^{59} (0.075 Myr)(not observed)
- (26%) Ni^{60} + H → Cu^{61} (3 hr) → Ni^{61} (stable)
- (1.0%) Ni^{61} + H → Cu^{62} (10 min) → Ni^{62} (stable)
- (3.6%) Ni^{62} + H → Cu^{63} (stable)
- (0.9%) Ni^{64} + H → Cu^{65} (stable)

Possible Chromium Accretion Mechanisms (Cr+H→…)

- (4.3%) $Cr^{50} + H \rightarrow V^{51}$ (stable)
- (83.8%) $Cr^{52} + H \rightarrow Mn^{53}$ (3.7 Myr) (not observed)
- (9.5%) $Cr^{53} + H \rightarrow Cr^{54}$ (stable)
- (2.4%) $Cr^{54} + H \rightarrow Mn^{55}$ (stable)

Possible Iron Accretion Mechanisms (Fe+H→…)

- (5.8%) Fe^{54} + H → Fe^{55} (2.7 yr) → Mn^{55} (stable) (not observed)
- (91.7%) Fe^{56} + H → Co^{57} (271 d) → Fe^{57} (stable)
- (2.2%) Fe^{57} + H → Co^{58} (70 d) → Fe^{58} (stable)
- (0.3%) Fe^{58} + H → Co^{59} (stable)