Ground-state properties in the vicinity of ^{68}Ni

Thomas Elias Cocolios

Instituut voor Kern- & Stralingsfysica
Katholieke Universiteit Leuven

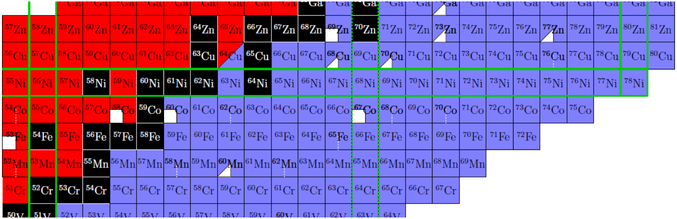
May 27^{th}, 2010

Outline I

1. Around ^{68}Ni
2. Specific interest in Fe, Co and Ni
    - Deformation in the Fe isotopes
    - Intruder isomers and collectivity in the Co isotopes
    - The magic reference: the Ni isotopes
3. Beams of Fe and Co at DESIR

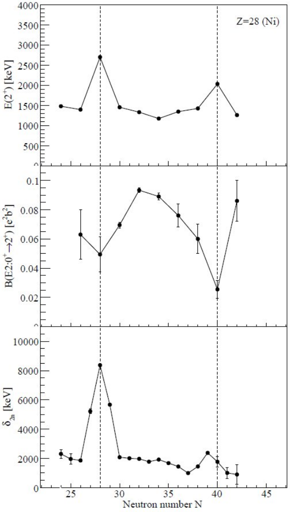
Outline

1. Around ^{68}Ni
2. Specific interest in Fe, Co and Ni
3. Beams of Fe and Co at DESIR



Neutron-rich nickel region

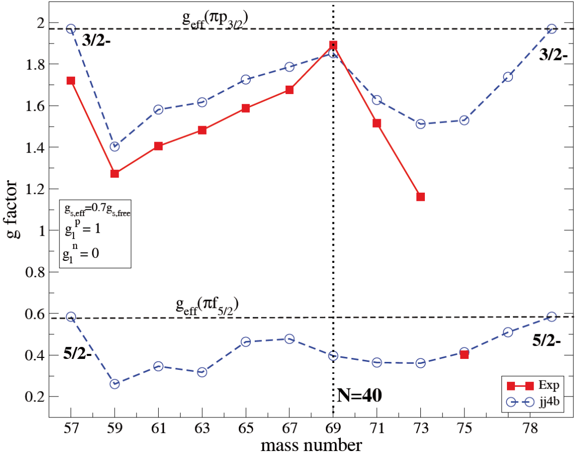
- $Z = 28$: magic shell closure
- $N = 40$: sub-shell closure with parity change to the $\nu g_{9/2}$



- Evidence for magic behaviour;
- Understood from the parity change accross the $N = 40$ shell gap;
- the $\nu g_{9/2}$ orbital still gives headaches to our community...

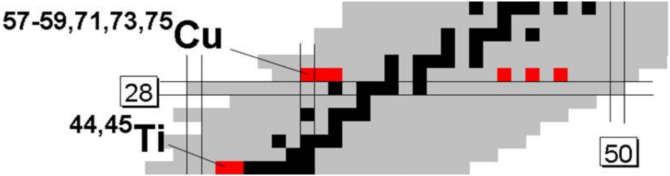
A moment on magicity

Nailing the structure of the neutron-rich Cu isotopes.



Pieter Vingerhoets, Ph.D. work

Limited knowledge



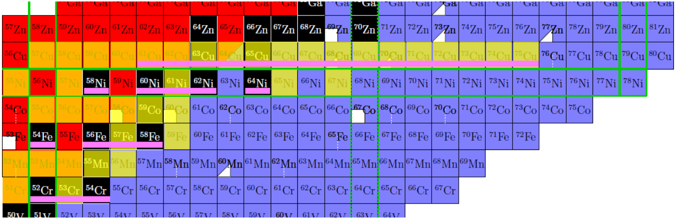
http://www.gsi.de/forschung/ap/projects/laser/survey_e.html

Laser spectroscopy

Nothing but the Cu isotopes have been done!

- Note that the Mn isotopes are currently under investigation at IGISOL and ISOLDE -

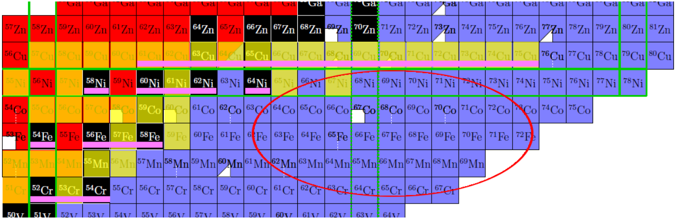
Limited knowledge



Moments and radii

All in all, only isotopes very close to stability have been studied.

Limited knowledge



Moments and radii

All in all, only isotopes very close to stability have been studied.

Outline

Deformation?

	N=36	N=37	N=38	N=39	N=40	N=41	N=42	N=43	N=44
Zn (Z=30)	^{66}Zn −0.20 / 0.22	^{67}Zn −0.16	^{68}Zn −0.17 / 0.21	^{69}Zn −0.17	^{70}Zn 0.24 / 0.23	^{71}Zn 0.26	^{72}Zn 0.23 / 0.23	^{73}Zn 0.23	^{74}Zn 0.20 / 0.25
Cu (Z=29)	^{65}Cu −0.17	^{66}Cu −0.16	^{67}Cu −0.16	^{68}Cu −0.16	^{69}Cu 0.08	^{70}Cu 0.11	^{71}Cu 0.12	^{72}Cu 0.12	^{73}Cu 0.14
Ni (Z=28)	^{64}Ni −0.17 / 0.18	^{65}Ni −0.12	^{66}Ni −0.12 / 0.16	^{67}Ni −0.08	^{68}Ni 0.01 / 0.10	^{69}Ni −0.05	^{70}Ni 0.01 / 0.18	^{71}Ni 0.05	^{72}Ni 0.05
Co (Z=27)	^{63}Co 0.15	^{64}Co 0.14	^{65}Co 0.14	^{66}Co 0.09 ?	^{67}Co 0.14 ?	^{68}Co 0.13 ?	^{69}Co 0.16	^{70}Co 0.17	^{71}Co 0.16
Fe (Z=26)	^{62}Fe 0.18	^{63}Fe 0.15	^{64}Fe 0.24	^{65}Fe 0.30	^{66}Fe 0.27	^{67}Fe 0.30	^{68}Fe 0.26	^{69}Fe 0.27	^{70}Fe 0.23
Mn (Z=25)	^{61}Mn 0.23	^{62}Mn 0.24	^{63}Mn 0.26	^{64}Mn 0.30	^{65}Mn 0.28	^{66}Mn 0.29	^{67}Mn 0.28	^{68}Mn 0.28	^{69}Mn 0.24
Cr (Z=24)	^{60}Cr 0.17	^{61}Cr 0.14	^{62}Cr 0.28	^{63}Cr 0.31	^{64}Cr 0.28	^{65}Cr 0.30	^{66}Cr 0.27	^{67}Cr 0.29	^{68}Cr 0.26

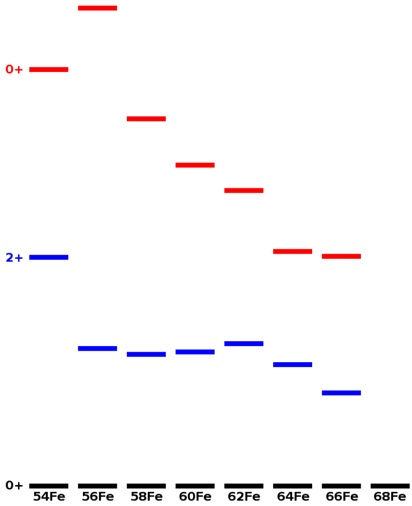
Absolute value of the quadrupole deformation parameter β_2

- 0.00 – 0.10
- 0.11 – 0.20
- 0.21 – 0.30
- 0.31 – 0.40
- stable

Y. Aboussir, J.M. Pearson, A.K. Dutta, and F. Tondeur. ADNDT 61(1995)127.

The changes in the mean square charge radii of the even-even Fe isotopes would directly reveal whether this picture holds.

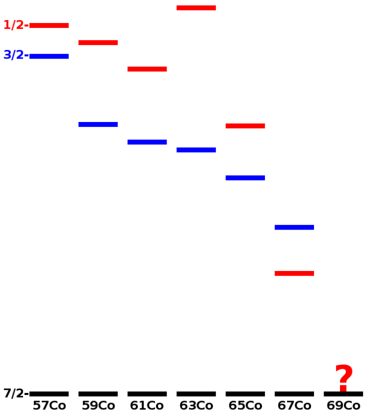
Shape coexistence



- The lowering 2^+ energy is a sign of collectivity in the Fe isotopes;
- The close vicinity of an excited 0^+ energy level may lead to mixing of different configurations and shapes.

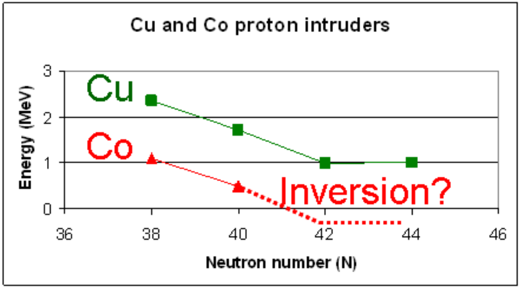
Intruder states in the Co isotopes

The 1/2- isomer in ^{67}Co



- When the $(1/2^-)$ level goes below the $(3/2^-)$ level, it becomes isomeric;
- Confirmation of the spin is required;
- What happens beyond $N = 40$?

Intruder states in the Co isotopes
. . . and beyond?



Dieter Pauwels, Ph.D. work

The comparison to the intruding $7/2^-$ energy level in the odd-A Cu isotopes suggests that the intruding $1/2^-$ level in the odd-A Co isotopes may become the ground state beyond $N = 40$.

Magic nuclei are our fundations

- The nickel nuclei should remain spherical;
- There are hints of shape coexistence;
- They shall become the reference, like Sn at $Z \sim 50$ or Pb at $Z \sim 82$.

Outline

In-trap decay of Mn

A target-free secondary reaction

- Intense beams of Mn are achievable with a laser ion source (GISELE);
- The half-lives are short-enough ($T_{1/2} < 1s$ for $A \leq 60$) that trapped ions can decay to Fe. . . and Co;
- The extracted beam can be sent to your favorite setup. . .

In-trap decay of Mn

A target-free secondary reaction

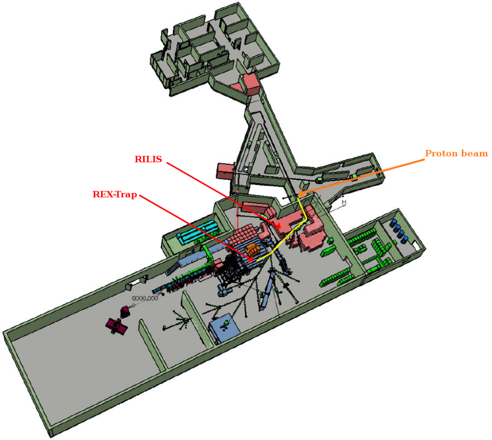
- Intense beams of Mn are achievable with a laser ion source (GISELE);
- The half-lives are short-enough ($T_{1/2} < 1s$ for $A \leq 60$) that trapped ions can decay to Fe. . . and Co;
- The extracted beam can be sent to your favorite setup. . .

In-trap decay of Mn

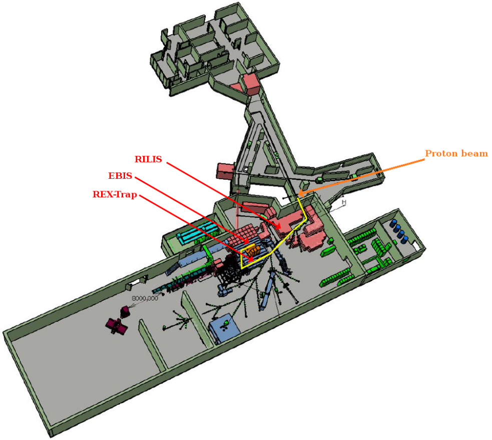
A target-free secondary reaction

- Intense beams of Mn are achievable with a laser ion source (GISELE);
- The half-lives are short-enough ($T_{1/2} < 1s$ for $A \leq 60$) that trapped ions can decay to Fe. . . and Co;
- The extracted beam can be sent to your favorite setup. . .

Proof of principle
Coulomb excitation of ^{61}Fe at ISOLDE

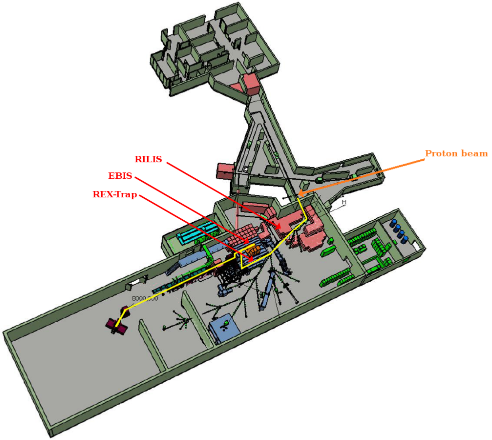


Proof of principle
Coulomb excitation of ^{61}Fe at ISOLDE

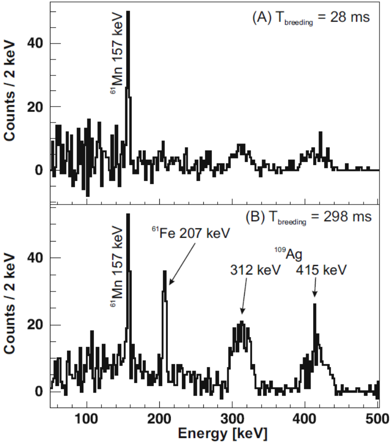


Proof of principle

Coulomb excitation of ^{61}Fe at ISOLDE



Proof of principle
Coulomb excitation of ^{61}Fe at ISOLDE

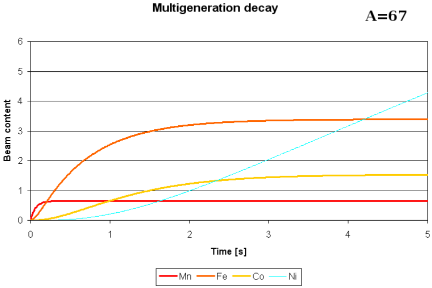


J. Van de Walle et al., EPJA 42(2009)401.

Typical case

$A = 67$

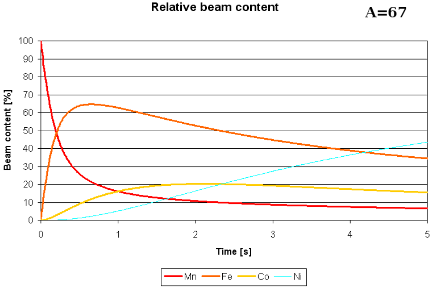
Mn	Fe	Co	Ni
45 ms	470 ms	425 ms	21 s



Typical case

$A = 67$

Mn	Fe	Co	Ni
45 ms	470 ms	425 ms	21 s



Conclusion

- Ground-state properties of neutron-rich Fe, Co, and Ni isotopes can bring valuable information to the understanding of the $N \sim 40$, $Z \leq 28$ region;
- The knowledge is very limited due to the difficulty of producing those beams;
- In-trap decay of Mn at DESIR is a possible solution up to $A = 69$.