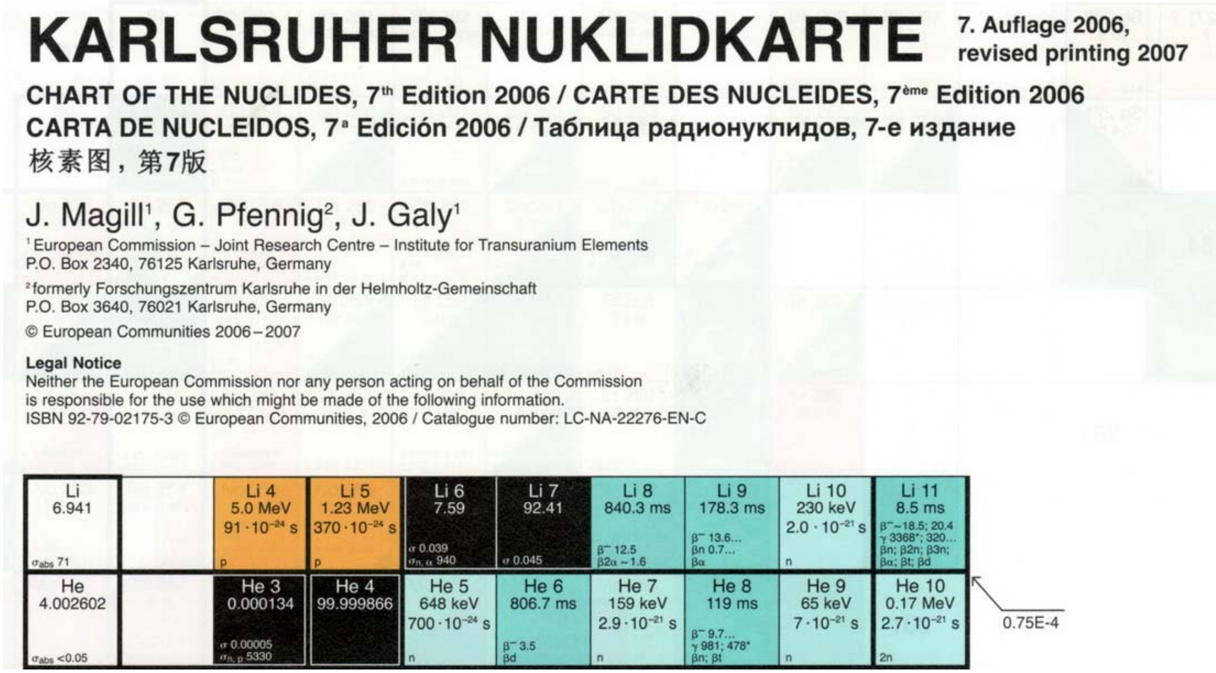
The Nickel Isotopes – Status of Theory - Then and Now

Alex Brown – Michigan State University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核素图，第7版
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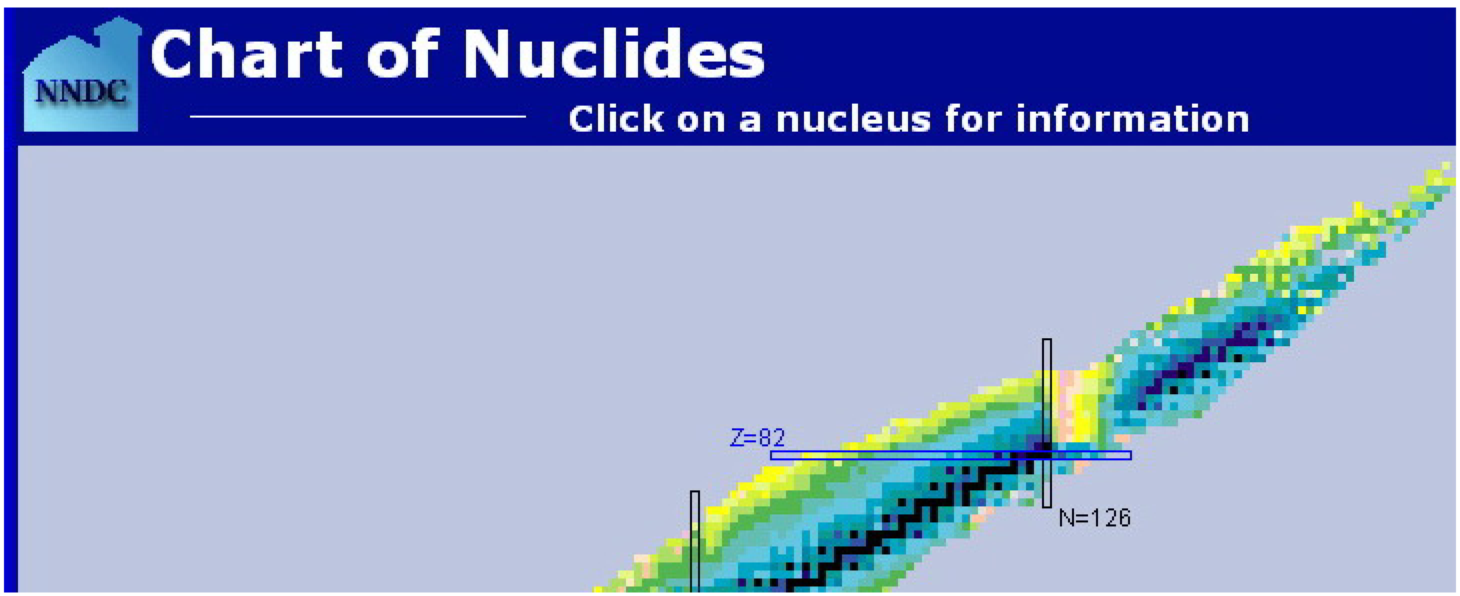
Li 6.941 σ_{abs} 71
Li 4 5.0 MeV $91 \cdot 10^{-24}$ s p
Li 5 1.23 MeV $370 \cdot 10^{-24}$ s p
Li 6 7.59 σ 0.039 $\sigma_{n,\alpha}$ 940
Li 7 92.41 σ 0.045
Li 8 840.3 ms β^- 12.5 $\beta 2\alpha$ ~1.6
Li 9 178.3 ms β^- 13.6... βn 0.7... βα
Li 10 230 keV $2.0 \cdot 10^{-21}$ s n
Li 11 8.5 ms β^-~18.5; 20.4 γ 3368*; 320... βn; β2n; β3n; βα; βt; βd
He 4.002602 σ_{abs} <0.05
He 3 0.000134 σ 0.00005 $\sigma_{n,p}$ 5330
He 4 99.999866
He 5 648 keV $700 \cdot 10^{-24}$ s n
He 6 806.7 ms β^- 3.5 βd
He 7 159 keV $2.9 \cdot 10^{-21}$ s n
He 8 119 ms β^- 9.7... γ 981; 478* βn; βt
He 9 65 keV $7 \cdot 10^{-21}$ s n
He 10 0.17 MeV $2.7 \cdot 10^{-21}$ s 2n
0.75E-4


NNDC
Chart of Nuclides
Click on a nucleus for information
Z=82
N=126

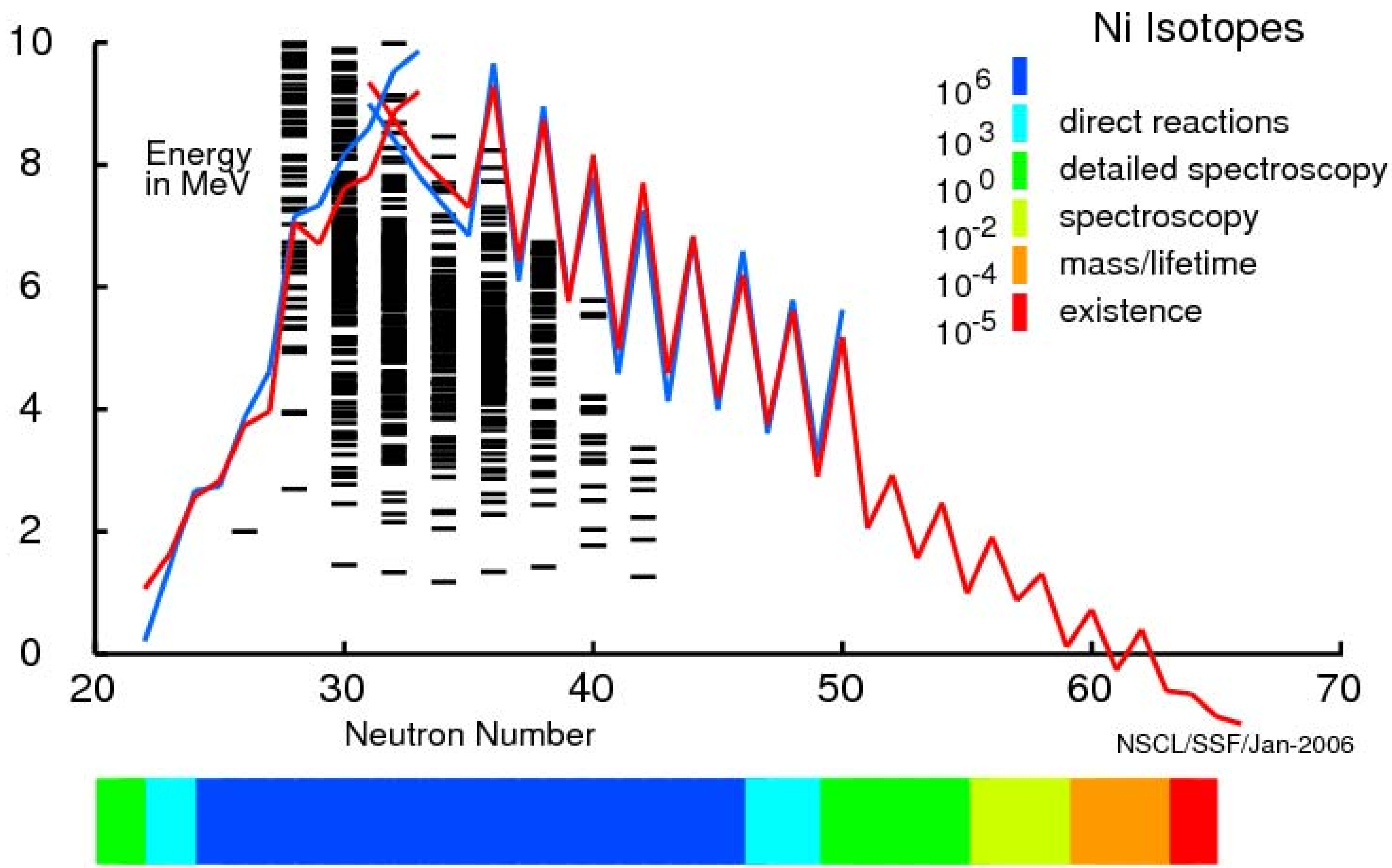
NSCL

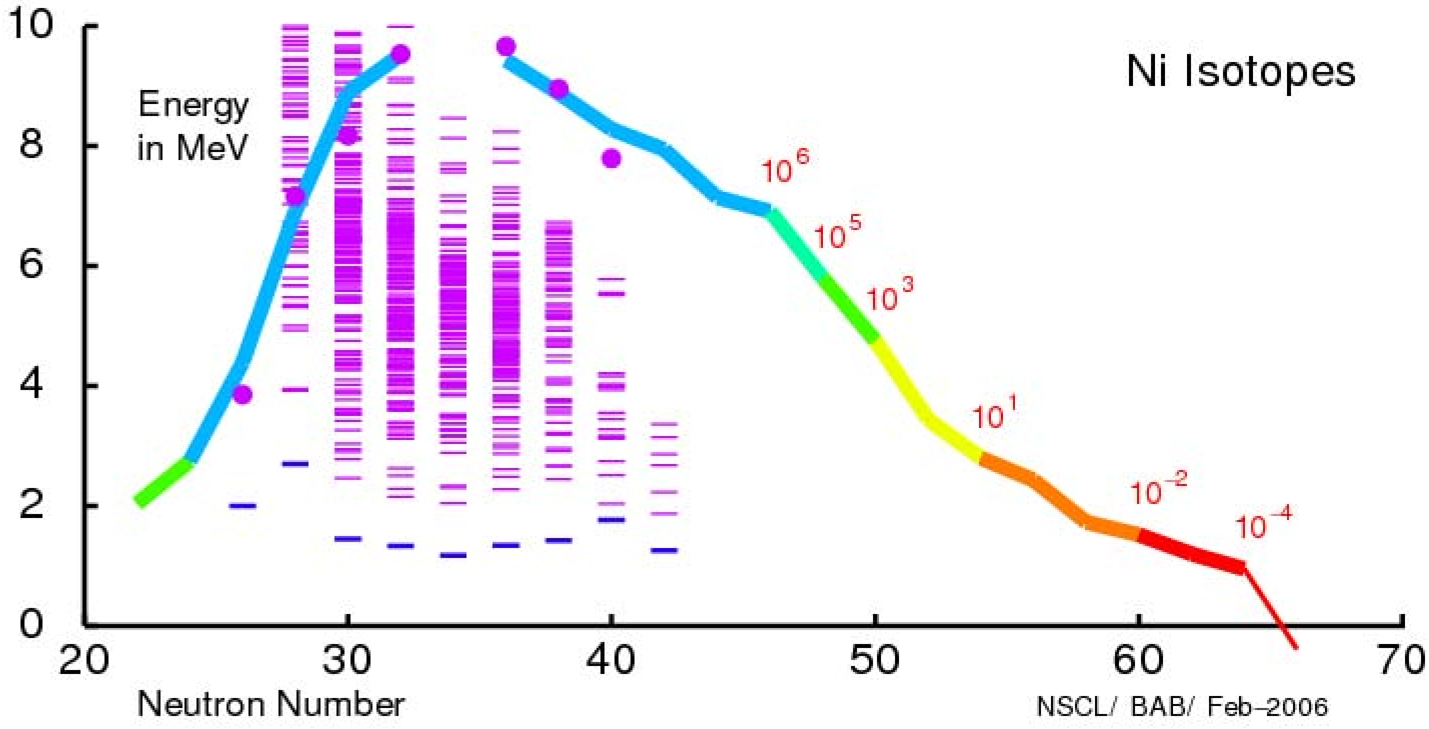
Ni 48	Ni 49	Ni 50	Ni 51	Ni 52	Ni 53	Ni 54	Ni 55	Ni 56
~2 ms ?	13 ms	12 ms	>200 ns	38 ms	45 ms	104 ms	209 ms	6.075 d
2p 1.35 ?	β^+ βp 3.7	β^+ βp	β^+ ?	β^+ βp 1.34; 1.06	β^+ βp 1.90	β^+ γ 937 g	β^+ 7.7… γ (2919; 2976; 3303)	ϵ; no β^+ γ 158; 812; 750; 480; 270…

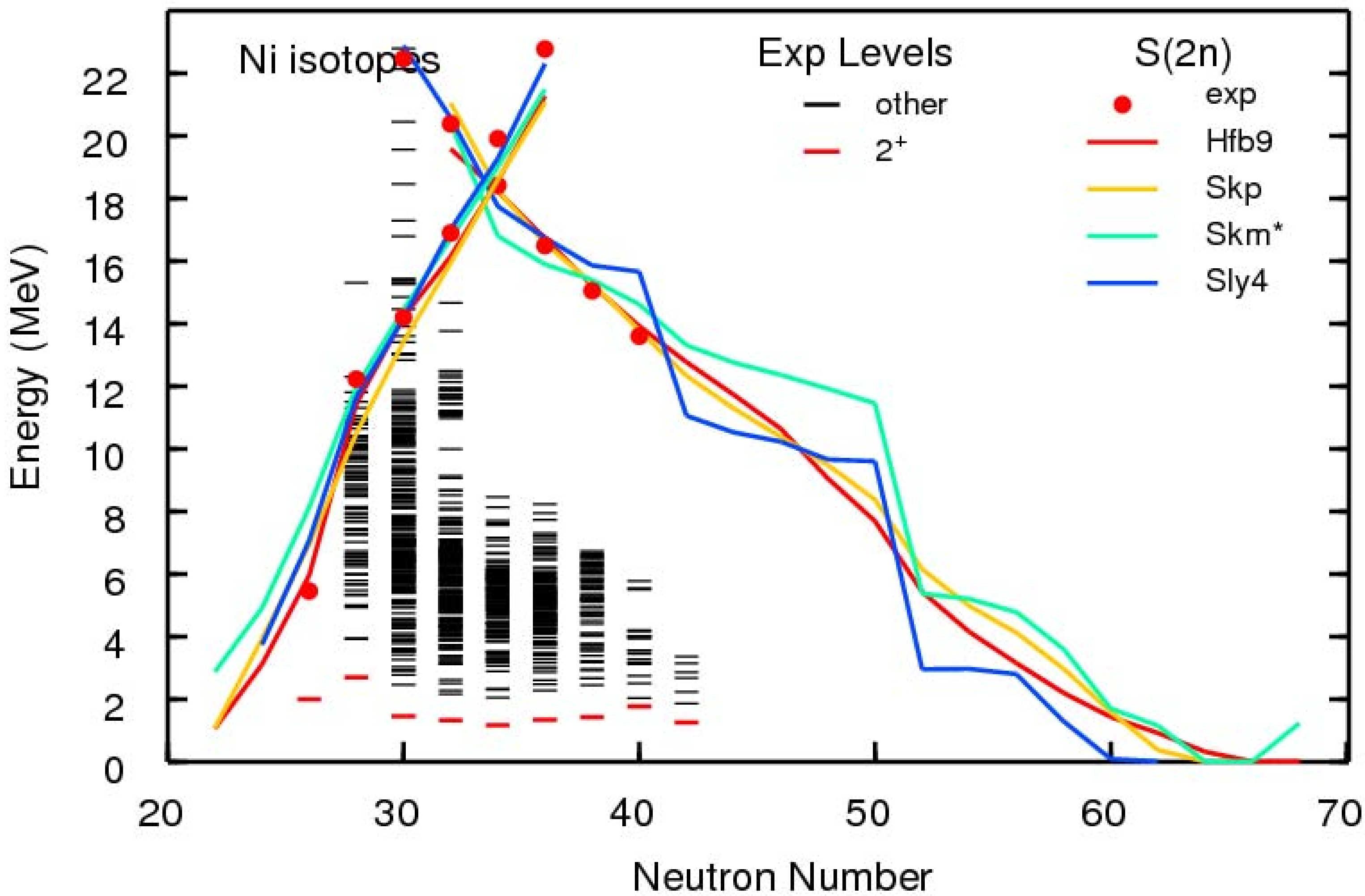
Ni 56	Ni 57	Ni 58	Ni 59	Ni 60	Ni 61	Ni 62	Ni 63	Ni 64	Ni 65	Ni 66	Ni 67	Ni 68
6.075 d	36.0 h	68.0769	$7.5 \cdot 10^4$ a	26.2231	1.1399	3.6345	100 a	0.9256	2.52 h	54.6 h	21 s	29 s
ϵ; no β^+ γ 158; 812; 750; 480; 270…	ϵ β^+ 0.8… γ 1378; 1920; 127…	σ 4.6 $\sigma_{n,\alpha}$ <0.00003	ϵ; β^+ … no γ; σ 77.7 $\sigma_{n,\alpha}$ 14; $\sigma_{n,p}$ 2 σ_{abs} 92	σ 2.9	σ 2.5 $\sigma_{n,\alpha}$ 0.00003	σ 15	β^- 0.07 no γ σ 20	σ 1.6	β^- 2.1… γ 1482; 1115; 366… σ 22	β^- 0.2 no γ	β^- 3.8… γ (1937; 1115; 822…)	β^- γ 758; 84 g

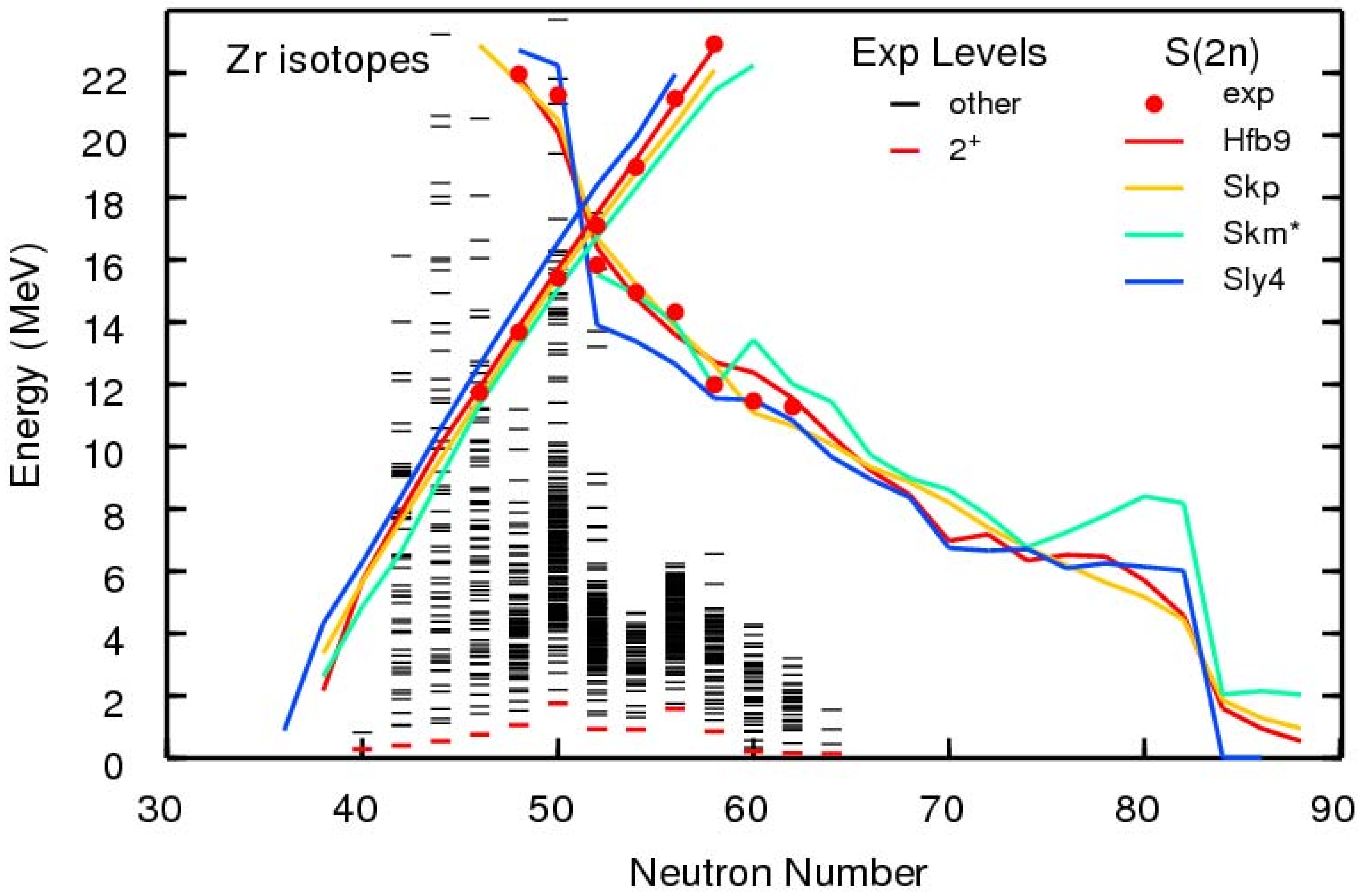
Ni 68	Ni 69	Ni 70	Ni 71	Ni 72	Ni 73	Ni 74	Ni 75	Ni 76	Ni 77	Ni 78
29 s	11.4 s	6.0 s	2.56 s	1.57 s	0.84 s	0.9 s	344 ms	238 ms	128 ms	110 ms
β^- γ 758; 84 g	β^- γ 1871; 680; 1213; 1483…	β^- 3.3… γ 1036; 78… m_2	β^- γ 534; 2016	β^- γ 376; 94	β^- γ 166; 1010	β^- γ 166*; 694 βn	β^-	β^-	β^-	β^-

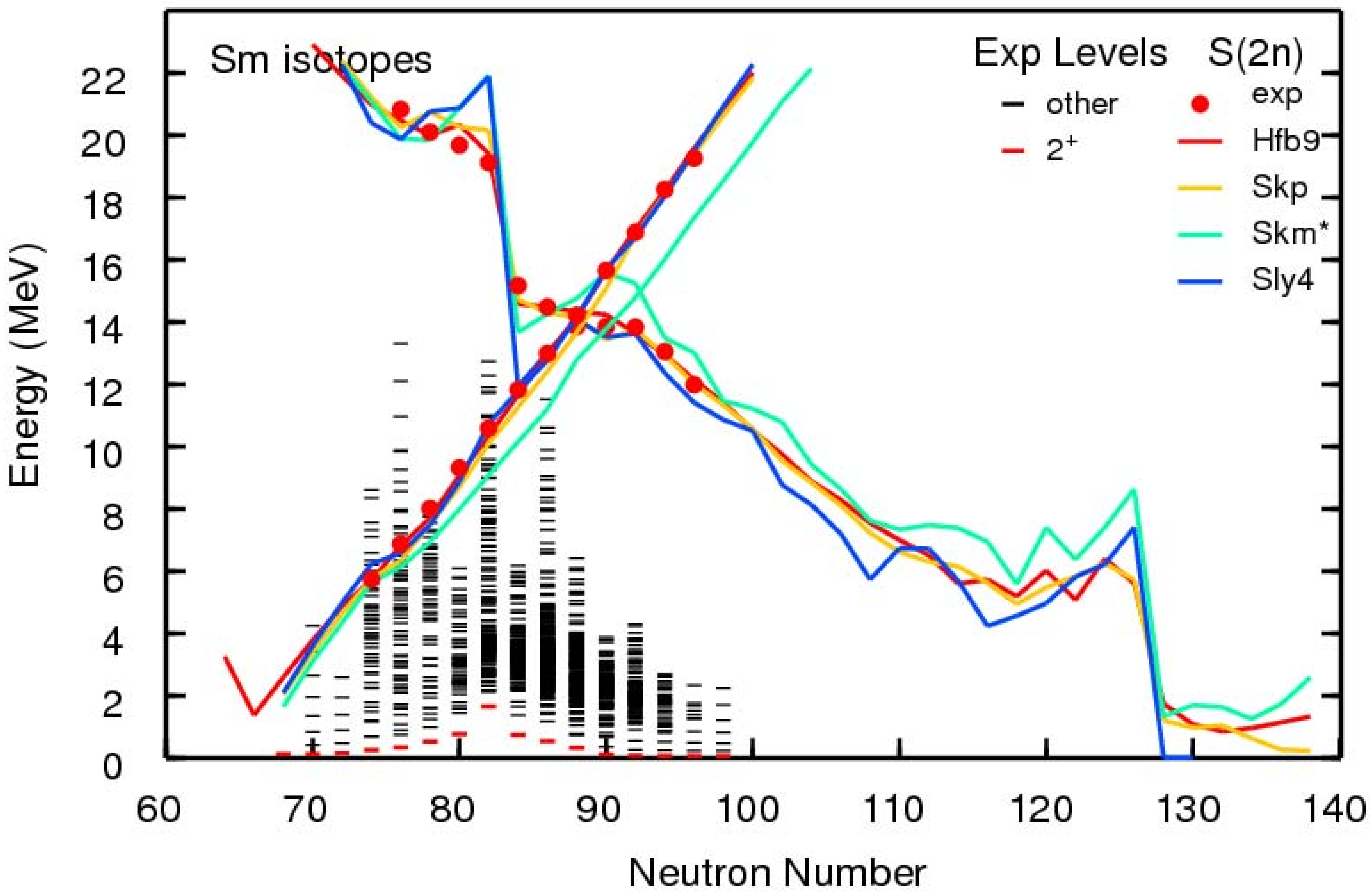

Isotope Science Facility
at Michigan State University
Upgrade of the NSCL rare isotope
research capabilities

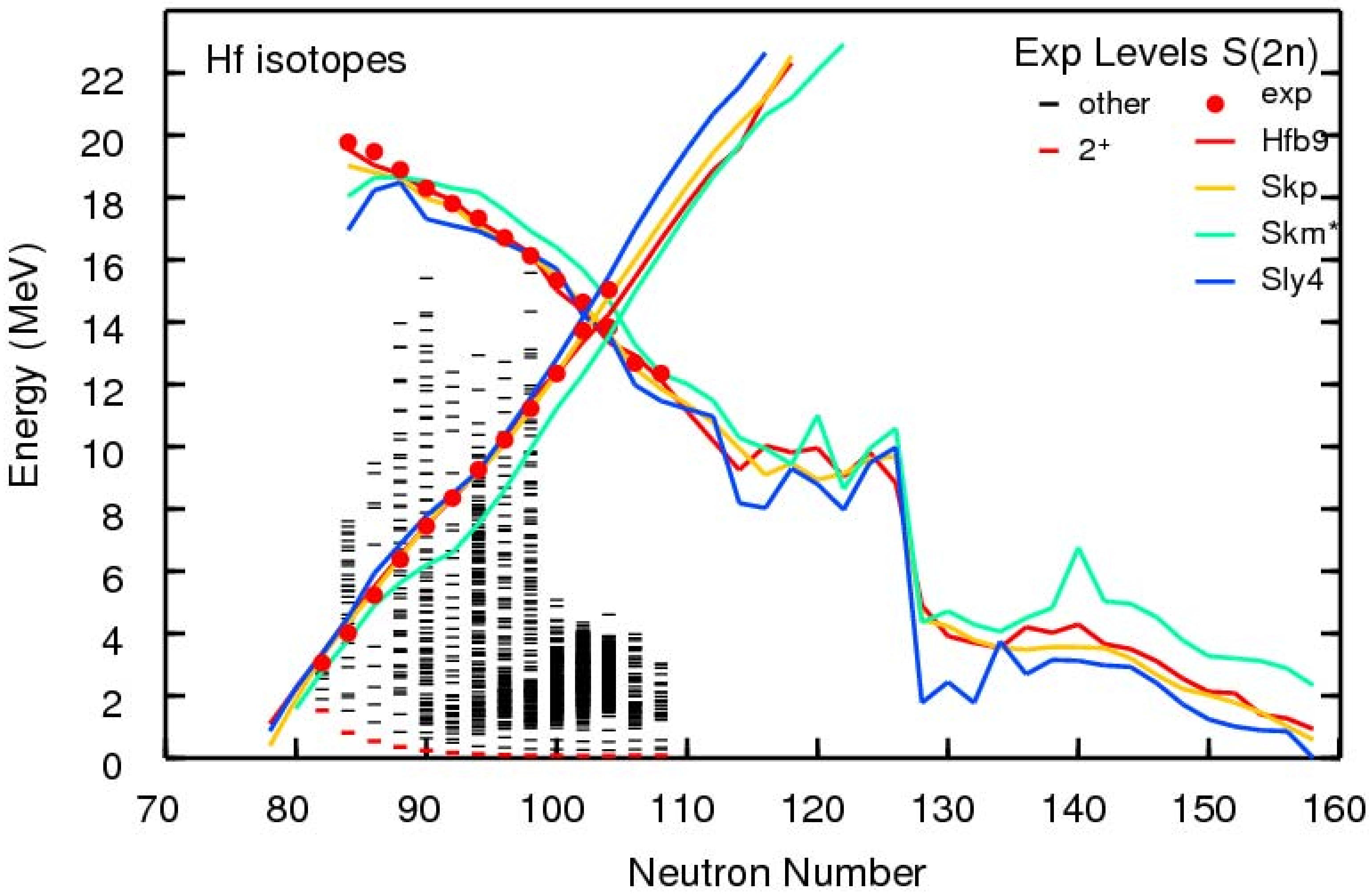

Ni Isotopes
Energy in MeV
Neutron Number
10
8
6
4
2
0
20
30
40
50
60
70
10^6
10^3 direct reactions
10^0 detailed spectroscopy
10^{-2} spectroscopy
10^{-4} mass/lifetime
10^{-5} existence
NSCL/SSF/Jan-2006

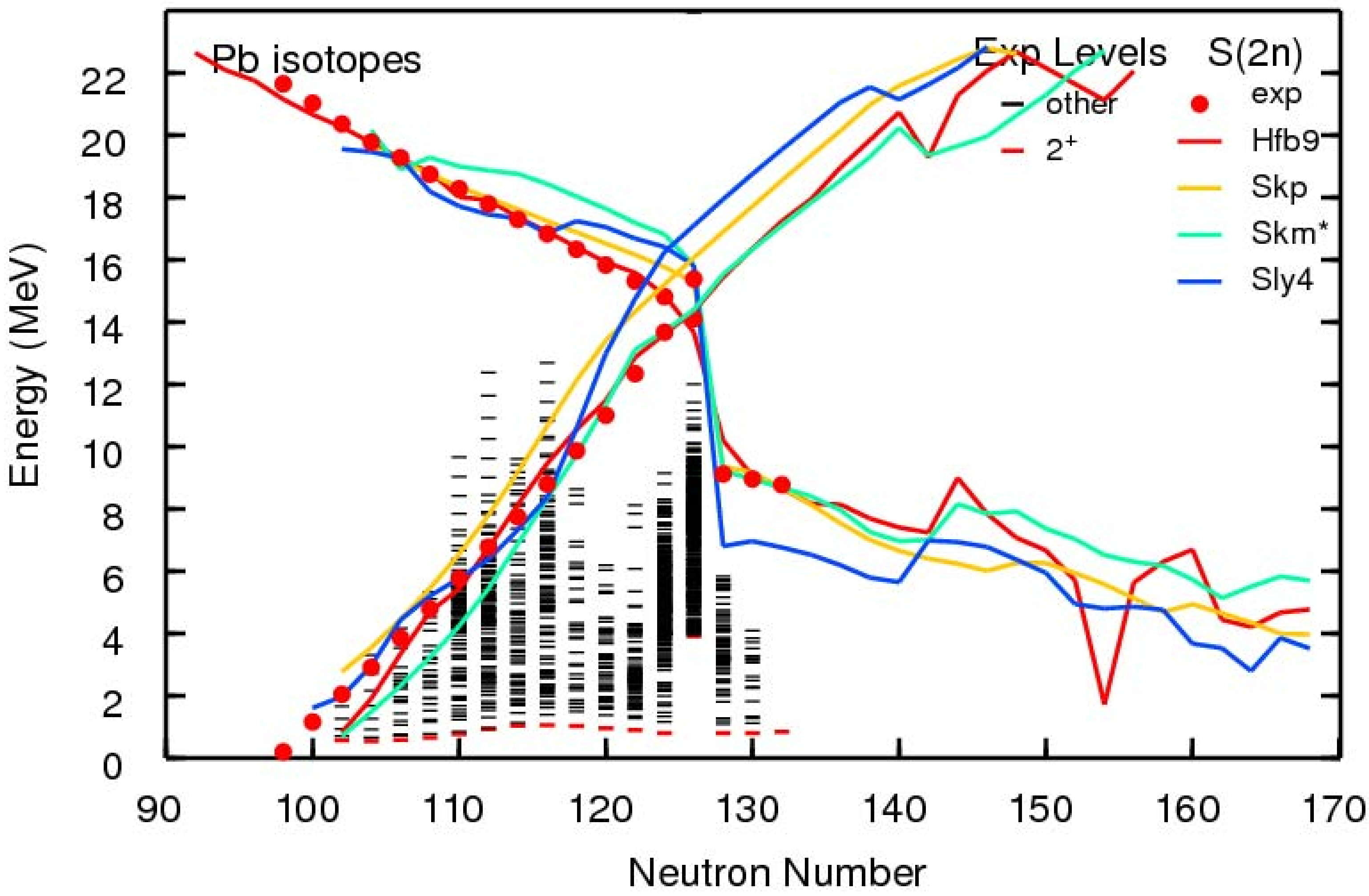

Ni Isotopes
Energy
in MeV
10
8
6
4
2
0
20
30
40
50
60
70
Neutron Number
10^6
10^5
10^3
10^1
10^{-2}
10^{-4}
NSCL/ BAB/ Feb–2006

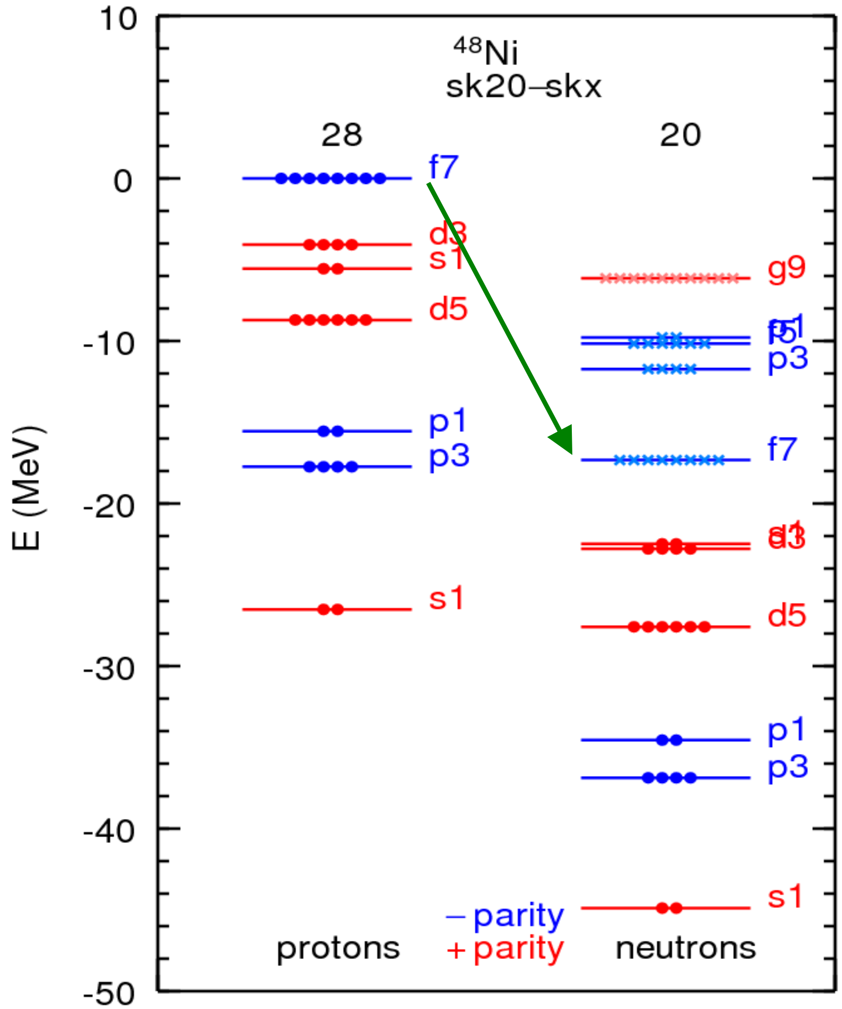

Ni isotopes
Exp Levels
other
2^+
S(2n)
exp
Hfb9
Skp
Skm*
Sly4
Energy (MeV)
Neutron Number
0
2
4
6
8
10
12
14
16
18
20
22
20
30
40
50
60
70


Zr isotopes
Exp Levels
other
2+
S(2n)
exp
Hfb9
Skp
Skm*
Sly4
Energy (MeV)
Neutron Number
0
2
4
6
8
10
12
14
16
18
20
22
30
40
50
60
70
80
90

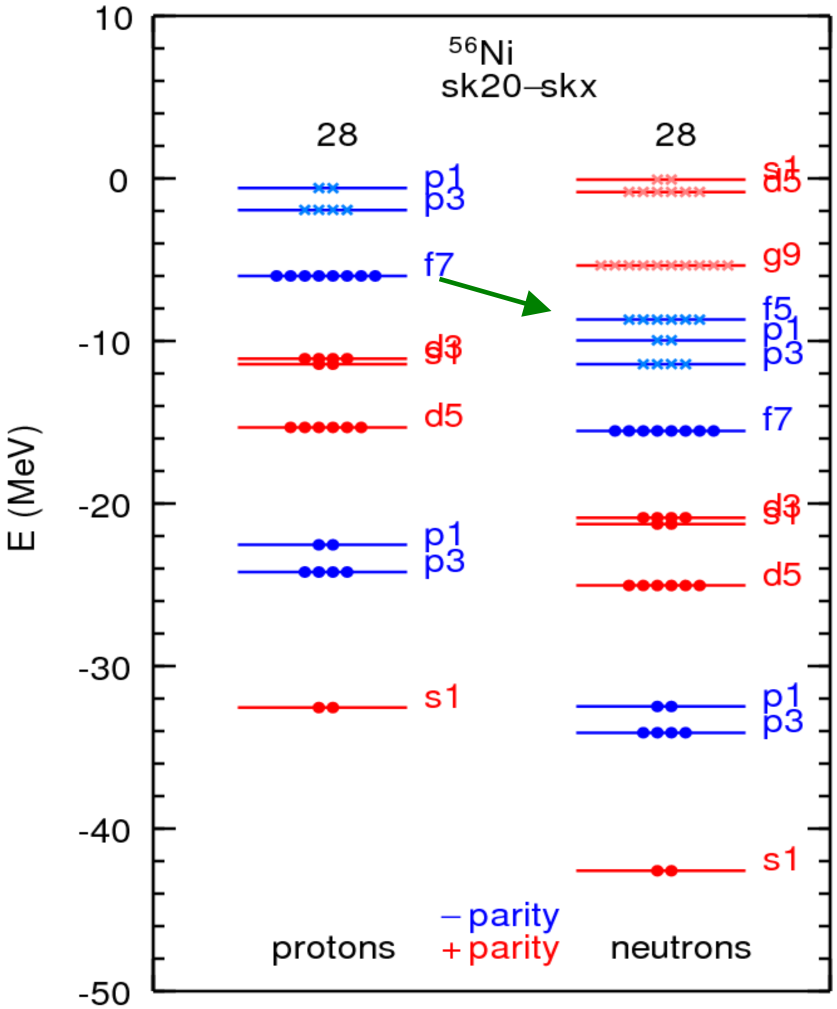

Sm isotopes
Exp Levels
other
2+
S(2n)
exp
Hfb9
Skp
Skm*
Sly4
Energy (MeV)
Neutron Number
0
2
4
6
8
10
12
14
16
18
20
22
60
70
80
90
100
110
120
130
140


Hf isotopes
Exp Levels S(2n)
other
2+
exp
Hfb9
Skp
Skm*
Sly4
Energy (MeV)
Neutron Number
0
2
4
6
8
10
12
14
16
18
20
22
70
80
90
100
110
120
130
140
150
160

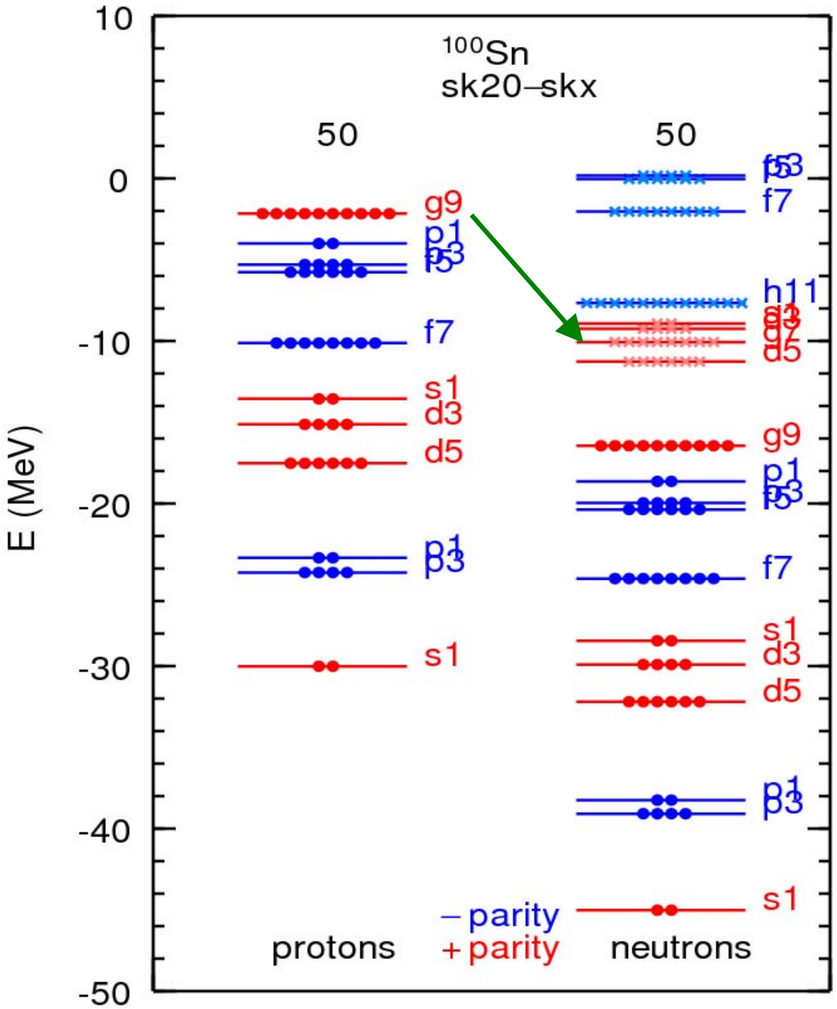

Pb isotopes
Exp Levels
other
2+
S(2n)
exp
Hfb9
Skp
Skm*
Sly4
Energy (MeV)
Neutron Number
0
2
4
6
8
10
12
14
16
18
20
22
90
100
110
120
130
140
150
160
170



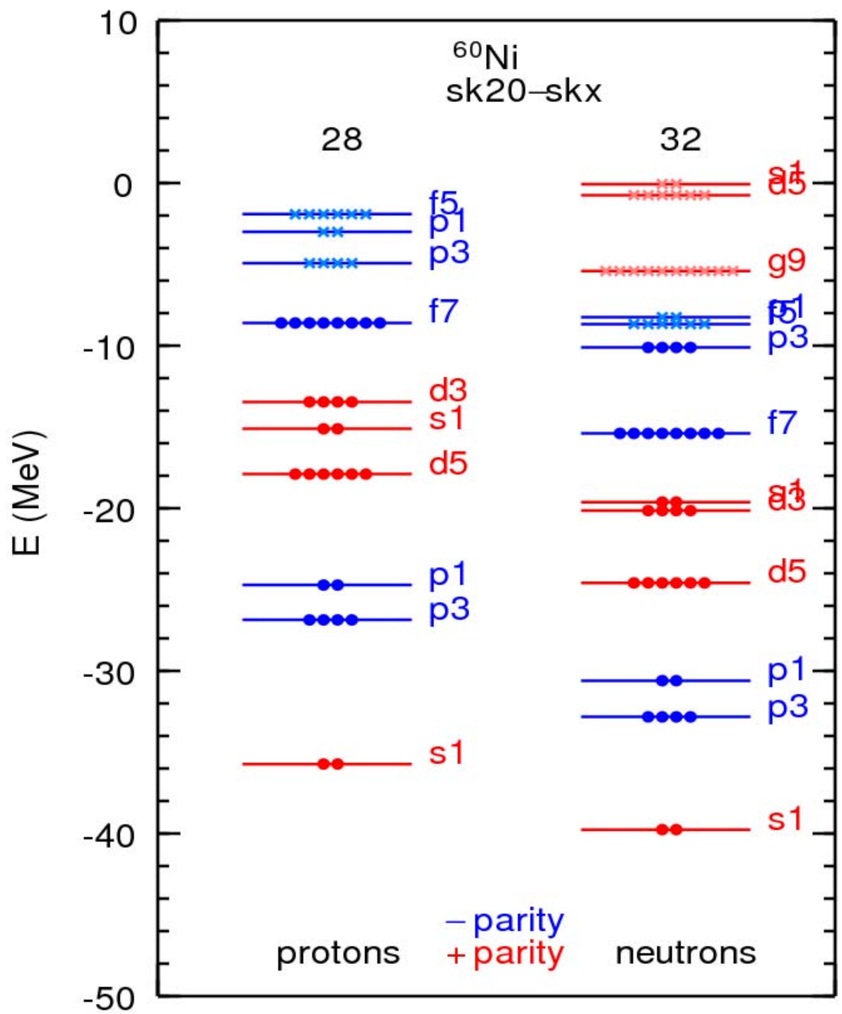
^{48}Ni
sk20–skx
28
20
f7
d3
s1
d5
p1
p3
s1
g9
p1
f5
p3
f7
s1
d3
d5
p1
p3
s1
E (MeV)
10
0
-10
-20
-30
-40
-50
– parity
+ parity
protons
neutrons



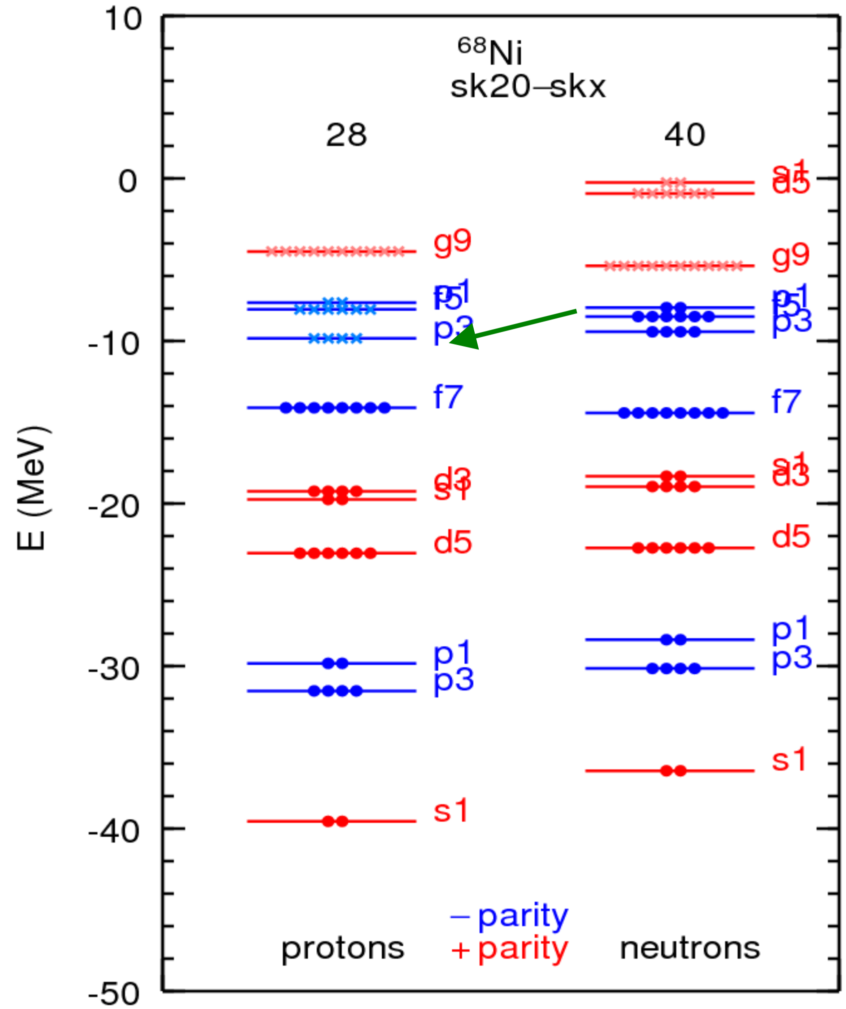
10
0
-10
-20
-30
-40
-50
E (MeV)
56Ni
sk20–skx
28
28
p1
p3
f7
d3
s1
d5
p1
p3
s1
s1
d5
g9
f5
p1
p3
f7
d3
s1
d5
p1
p3
s1
– parity
+ parity
protons
neutrons



^{100}Sn
sk20–skx
50
50
E (MeV)
protons
– parity
+ parity
neutrons



^{60}Ni
sk20–skx
28
32
E (MeV)
10
0
-10
-20
-30
-40
-50
f5
p1
p3
f7
d3
s1
d5
p1
p3
s1
s1
d5
g9
p1
f5
p3
f7
s1
d3
d5
p1
p3
s1
− parity
+ parity
protons
neutrons



68Ni
sk20−skx
28
40
E (MeV)
10
0
-10
-20
-30
-40
-50
g9
p1
f5
p3
f7
d3
s1
d5
p1
p3
s1
s1
d5
g9
p1
f5
p3
f7
s1
d3
d5
p1
p3
s1
− parity
+ parity
protons
neutrons

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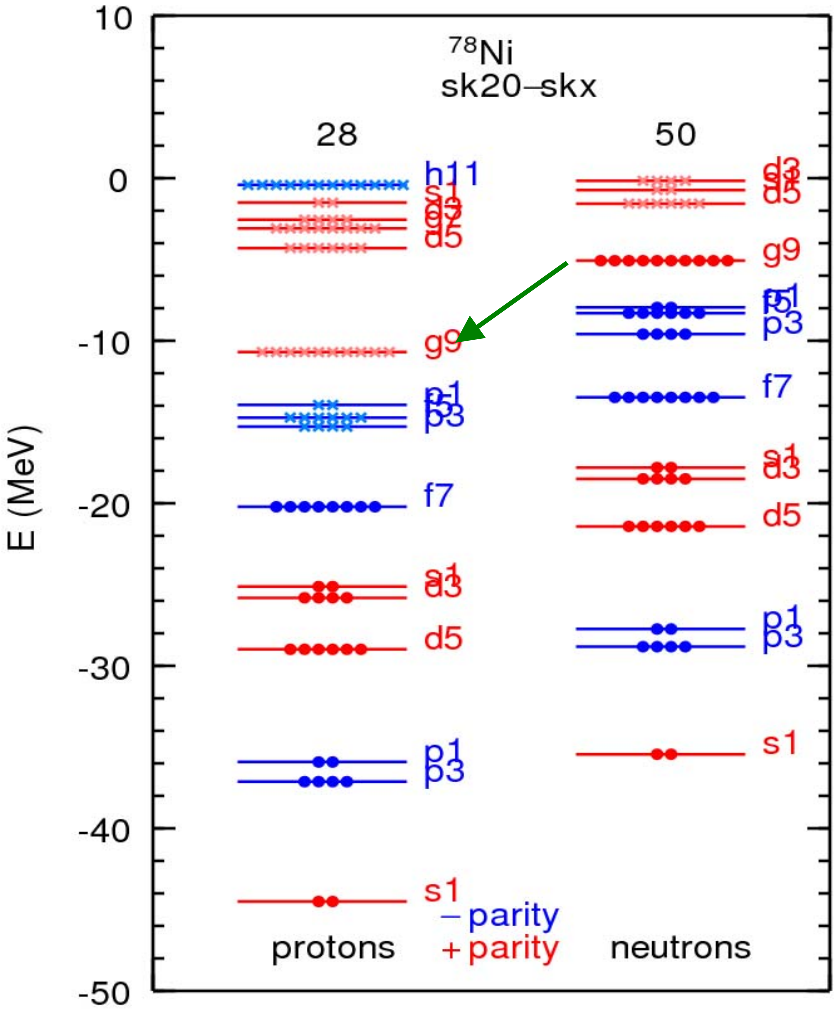

B. Alex Brown, USNDP, BNL, Nov 6, 2008

Nuclear Physics **A322** (1979) 61–91; © *North-Holland Publishing Co., Amsterdam*

CHARGE-DEPENDENT TWO-BODY INTERACTIONS DEDUCED FROM DISPLACEMENT ENERGIES IN THE $1f_{\frac{7}{2}}$ SHELL †

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Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48824

and

R. SHERR

Joseph Henry Laboratories, Princeton University, Princeton, New Jersey 08540

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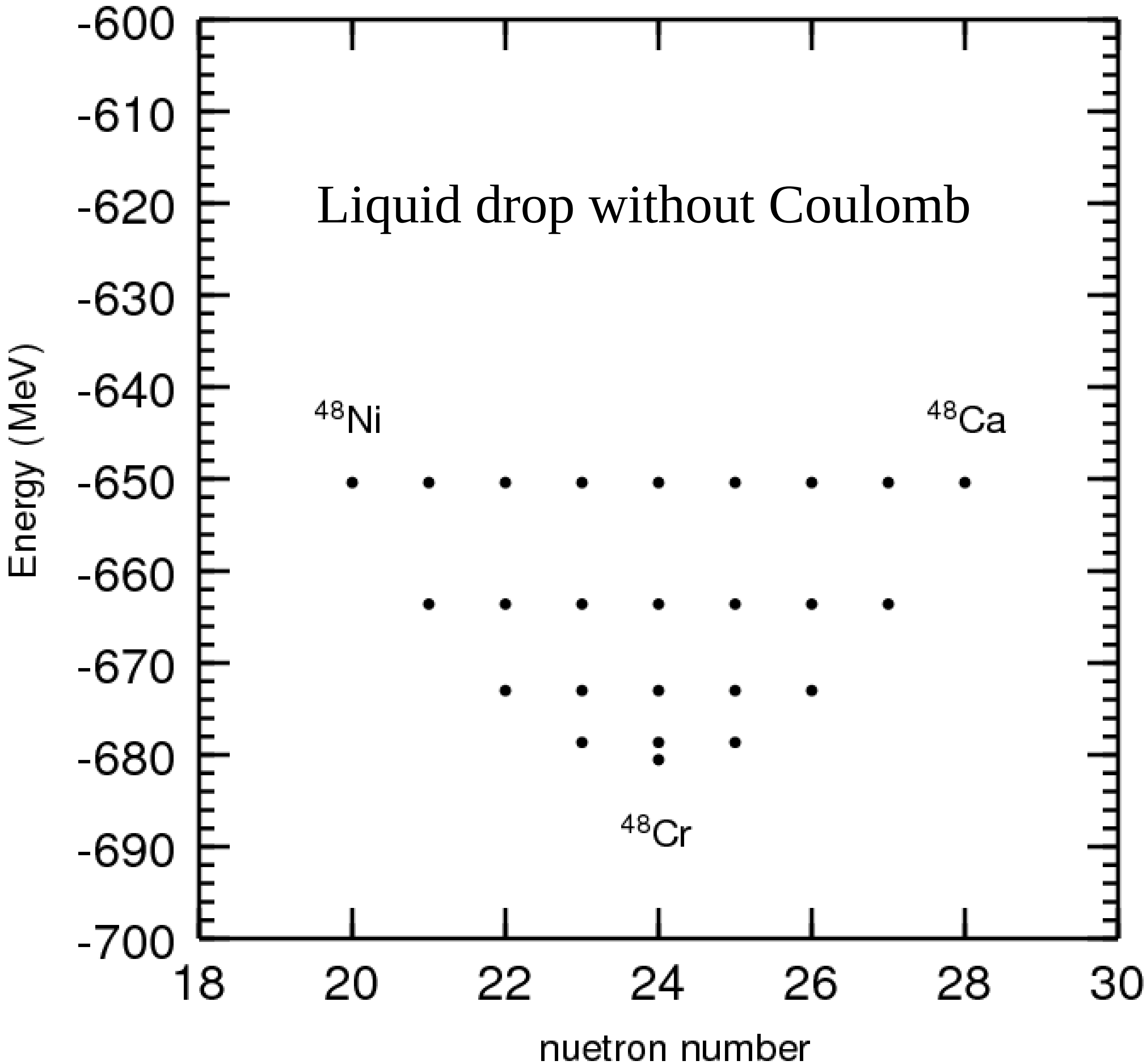
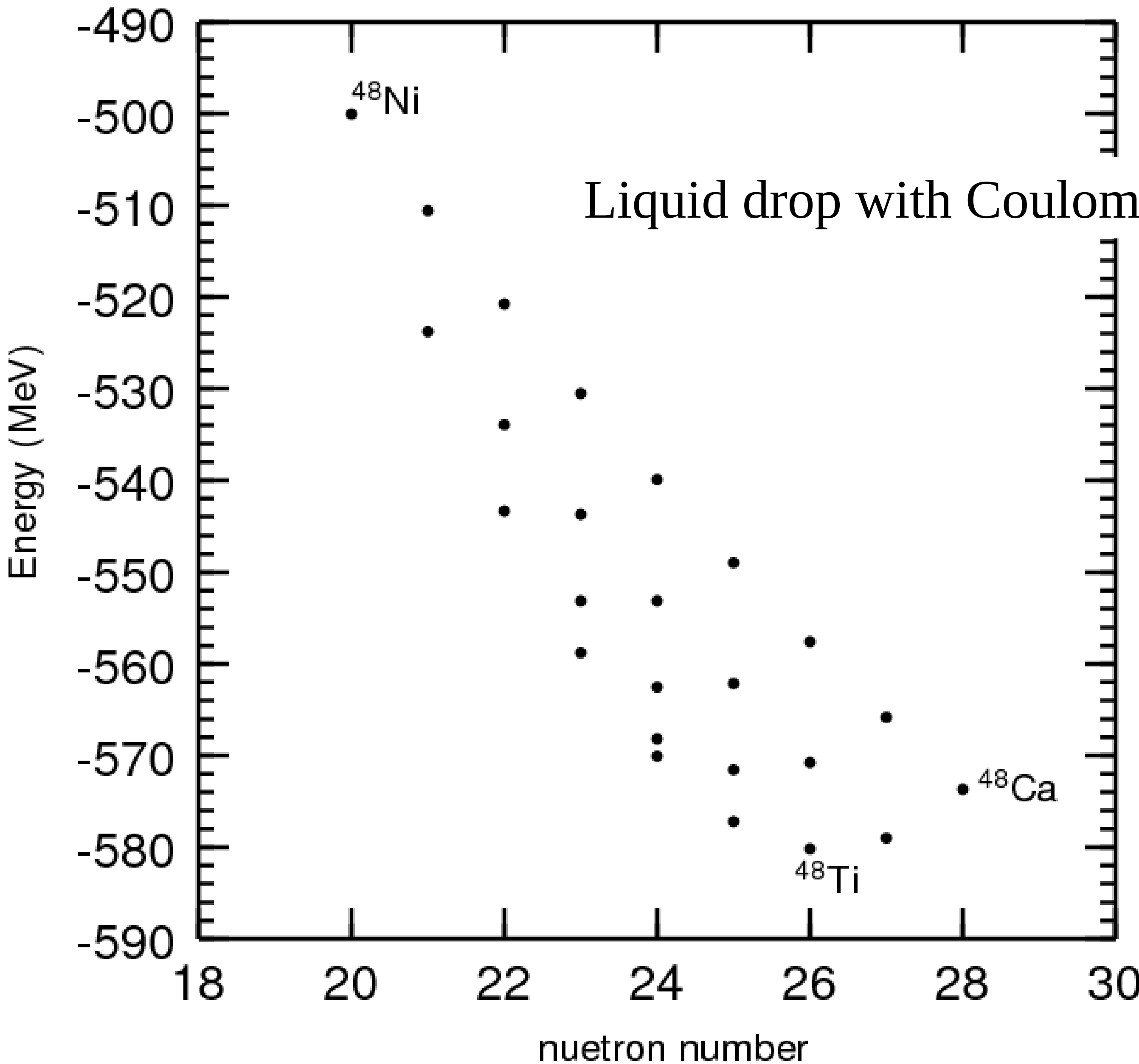
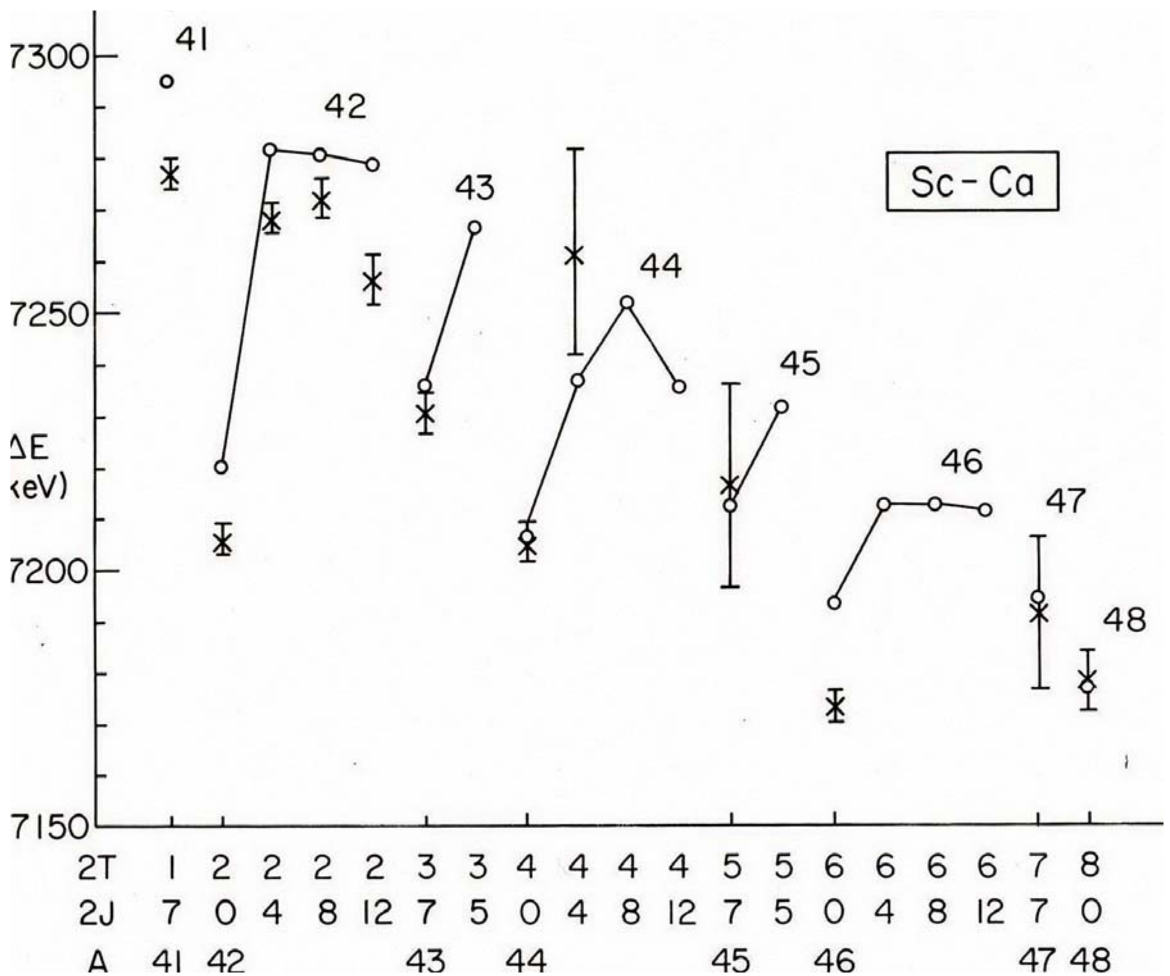

Liquid drop without Coulomb
Energy (MeV)
-600
-610
-620
-630
-640
-650
-660
-670
-680
-690
-700
18
20
22
24
26
28
30
nuetron number
48Ni
48Ca
48Cr

Liquid drop with Coulomb

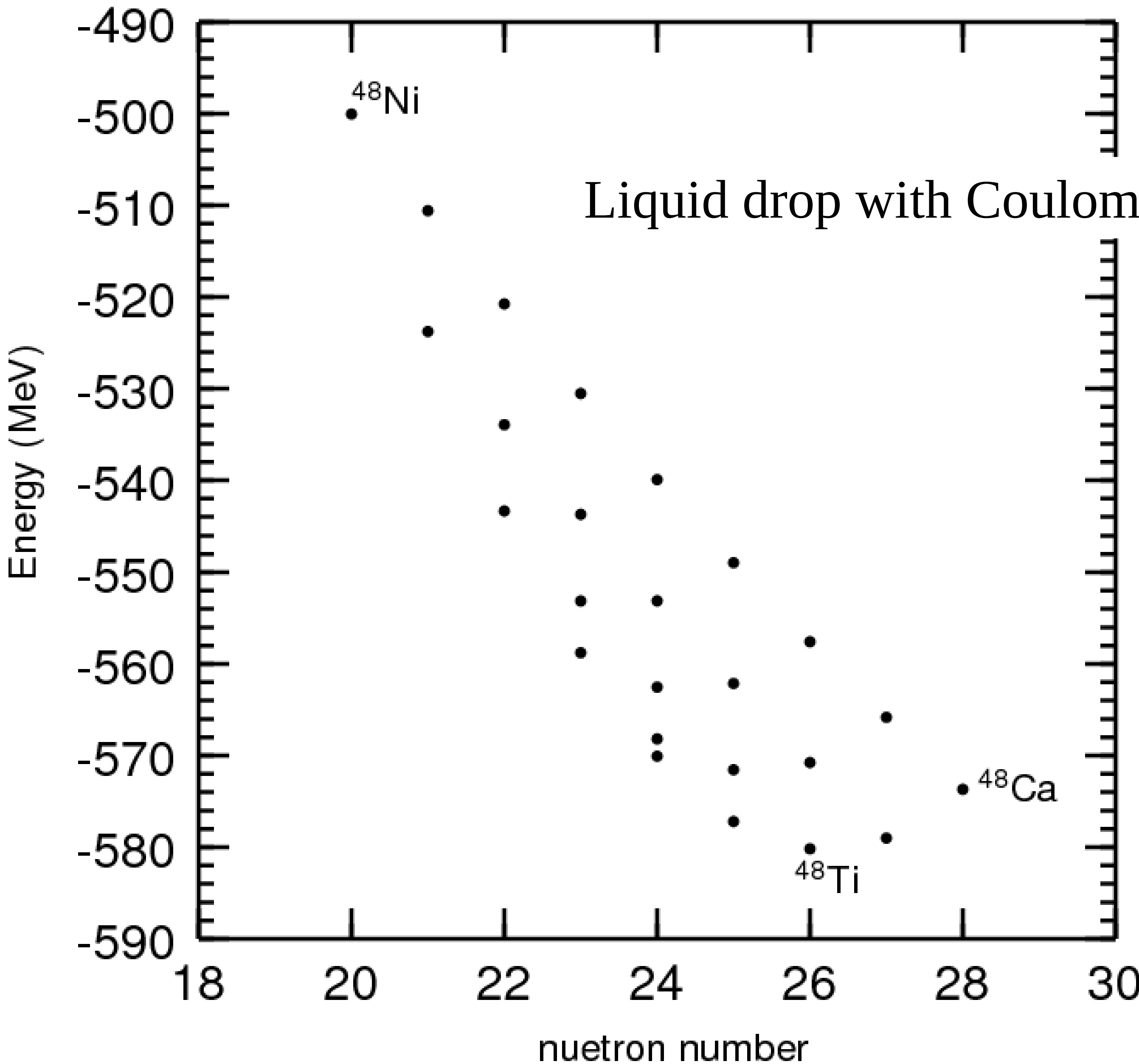


About 60 energies of isobaric analogue states for A=41-55 measured to few keV accuracy

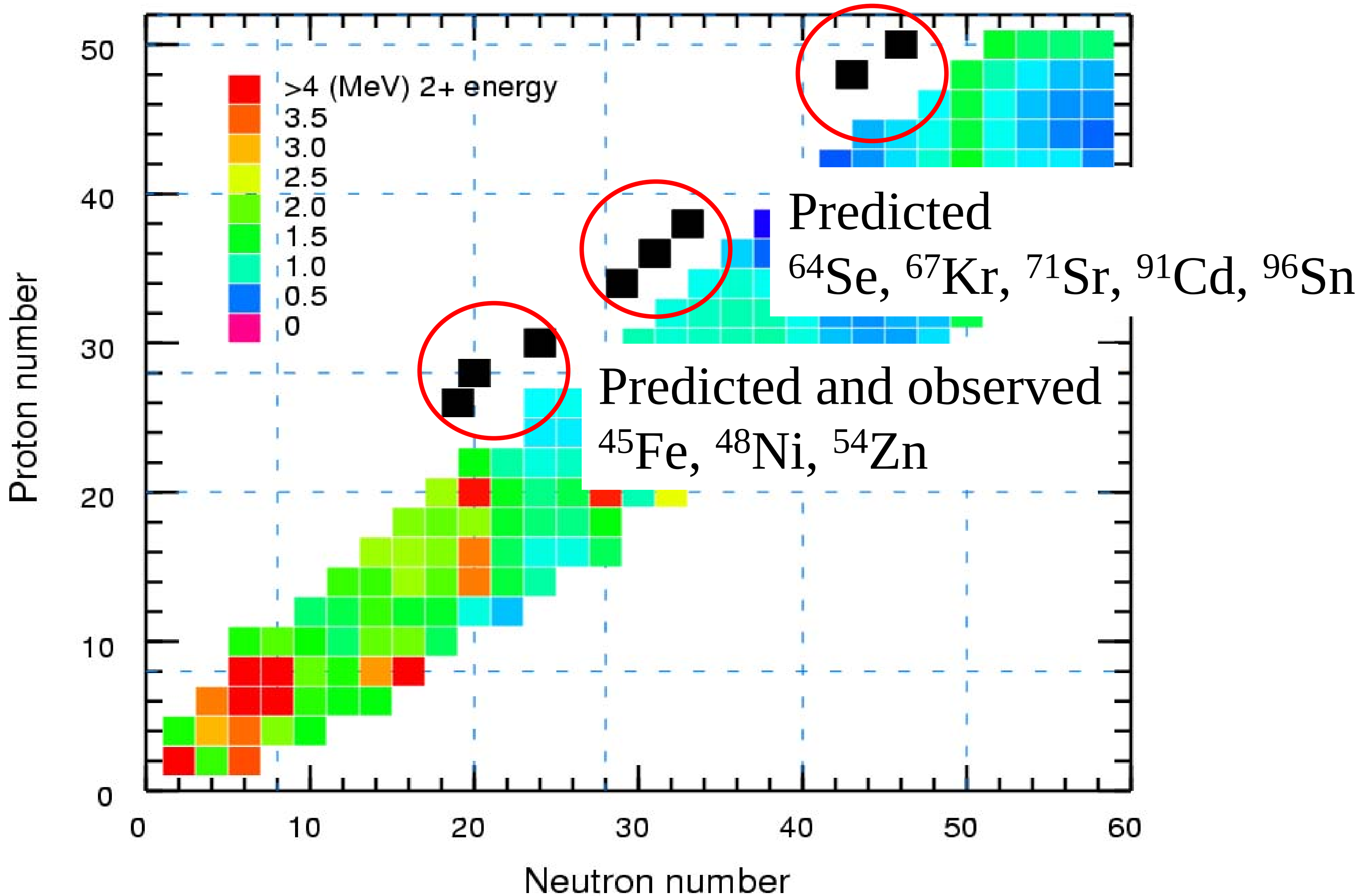
$(f_{7/2})^n$ models with 8 parameters fit all of them to 12 keV rms



Liquid drop with Coulomb



Di-proton decay



Q-value results for ^{48}Ni

Q(exp) = 1.35 (2) MeV Dossat et al. 2006 (one event)

Q(th) = 1.36 (13) Brown 1991 (IMME)

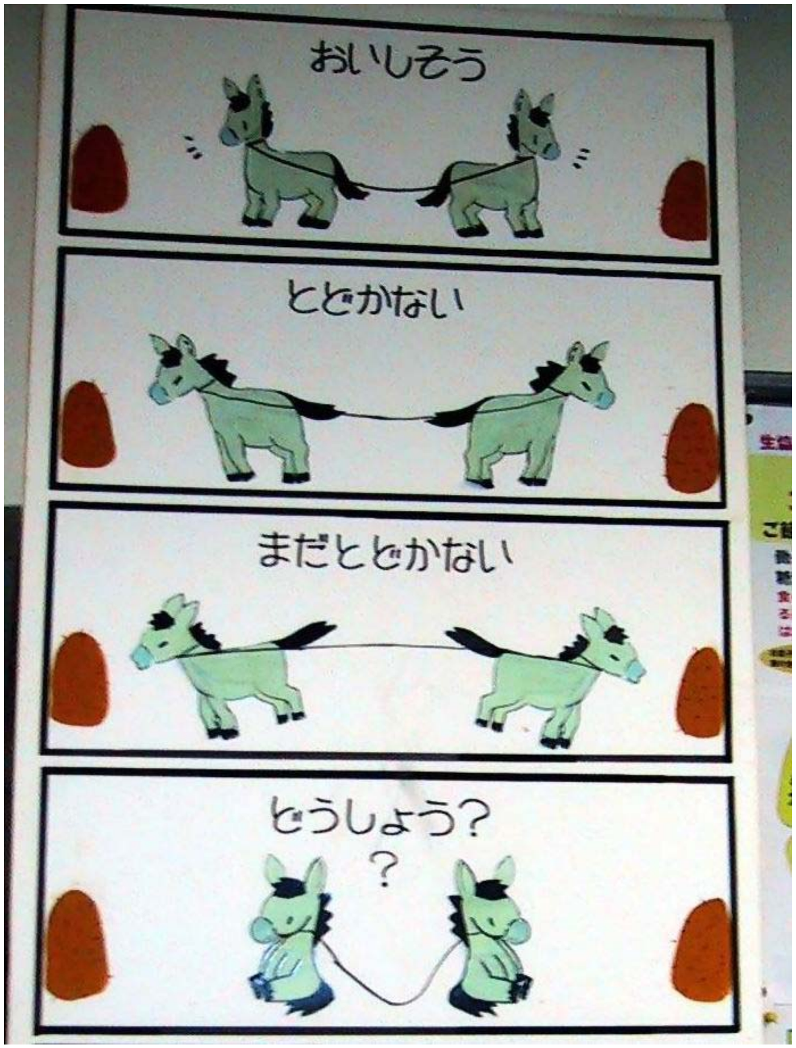
3.1 (6)   Audi-Wapstra extrapolation 2003

0.0-2.0 Nazarewicz et al 1996 (mean-field)

Di-proton decay = horses to hay

What is the cluster dynamics of di-proton decay ?

^{48}Ni di-proton vs ^{48}Ca(p,t)^{46}Ca ?



Results for di-proton decay

Nucleus	exp Q_{2p} (MeV)	exp (a) $T_{1/2}$ (ms)	theory (b) $T_{1/2}$ (ms)	S (c)
^{45}Fe	1.151(15)	2.4 - 3.9	14 - 22 (d)	0.272
^{48}Ni	1.35(2)	<21	4 - 11	0.188
^{54}Zn	1.48(2)	2.7 - 5.9	3 - 8	0.313

(a) B. Blank, J. Giovinazzao, M. Pfutzner…..

(b) B. A. Brown and F. C. Barker, Phys. Rev. C67, 041304(R) (2003).
includes correlations (pairing) – three-body Coulomb asymptotics in R matrix with pp resonance as an intermediate state

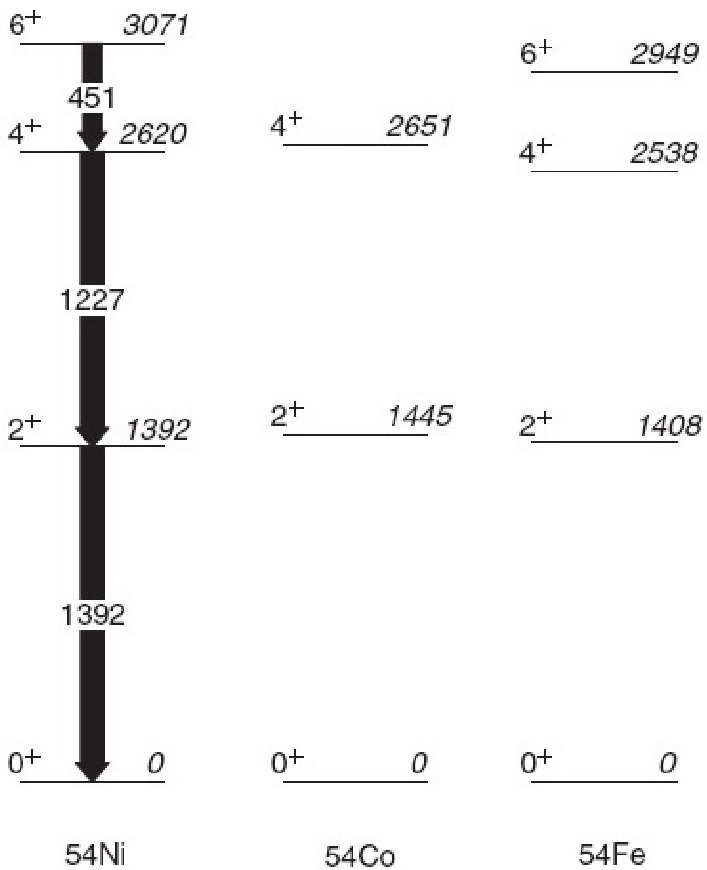
(c) Two-particle spectroscopic factor

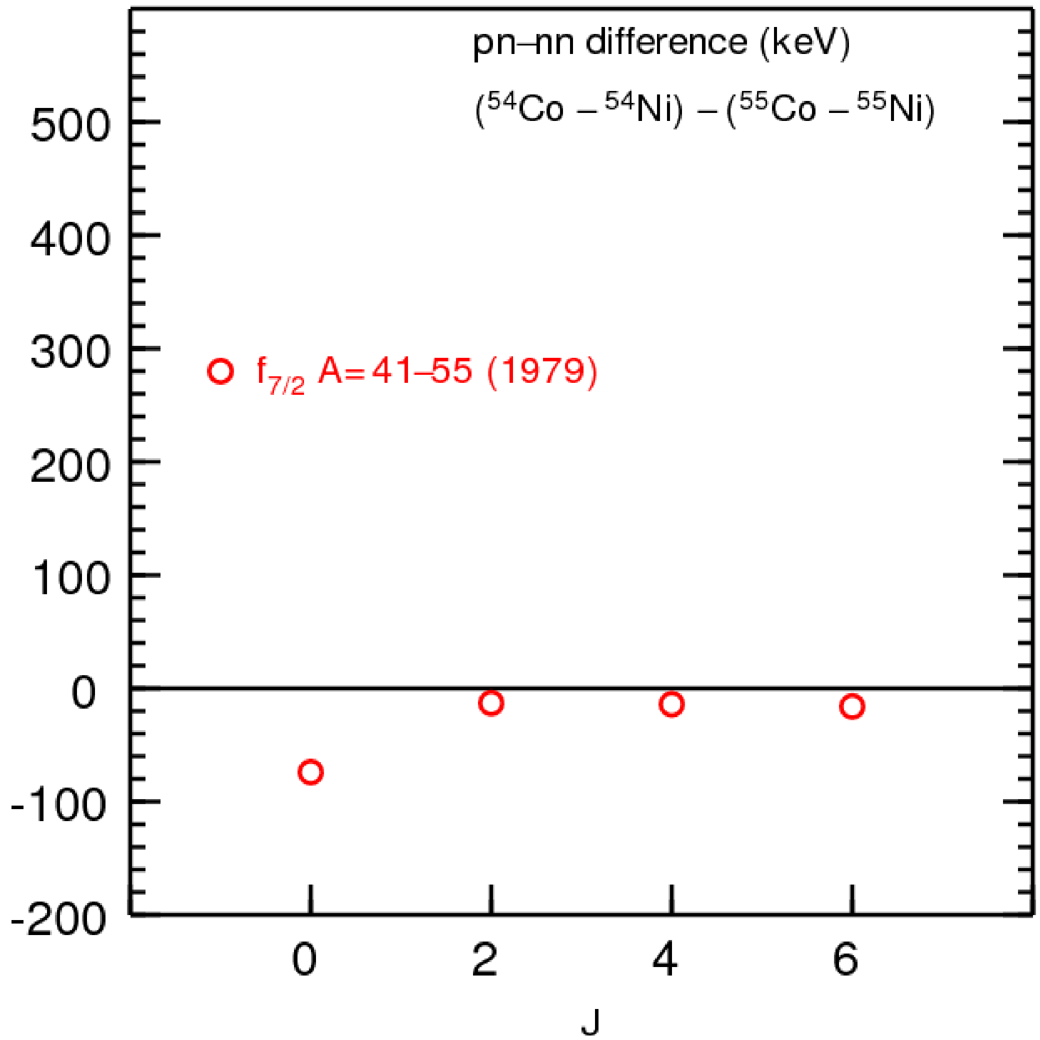
Grigorenko and Zukov, Phys. Rev. C, 68, 054005 (2003).
single-particle model (no correlations)
but includes full three-body decay with Coulomb

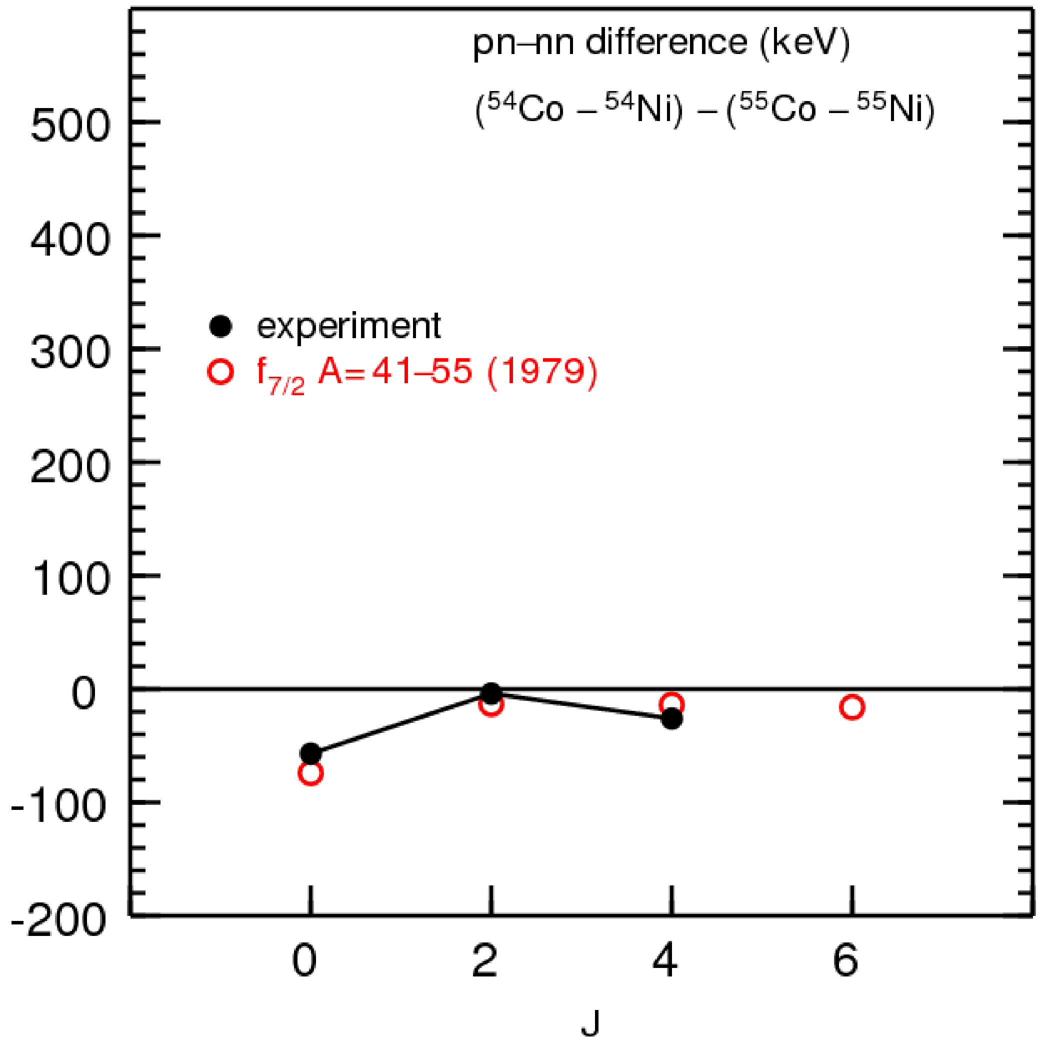
PRL **97,** 152501 (2006) PHYSICAL REVIEW LETTERS week ending 13 OCTOBER 2006

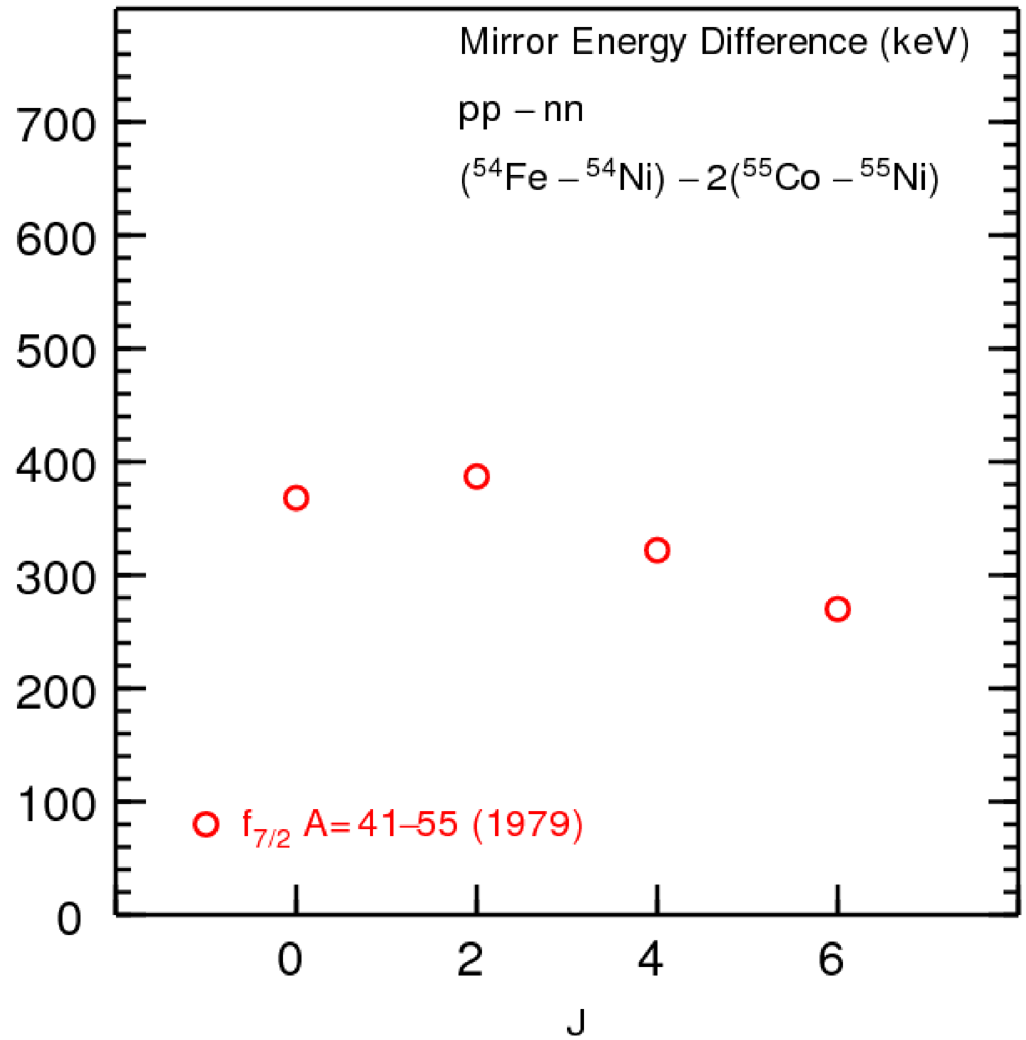
Observation of ^{54}Ni: Cross-Conjugate Symmetry in $f_{7/2}$ Mirror Energy Differences

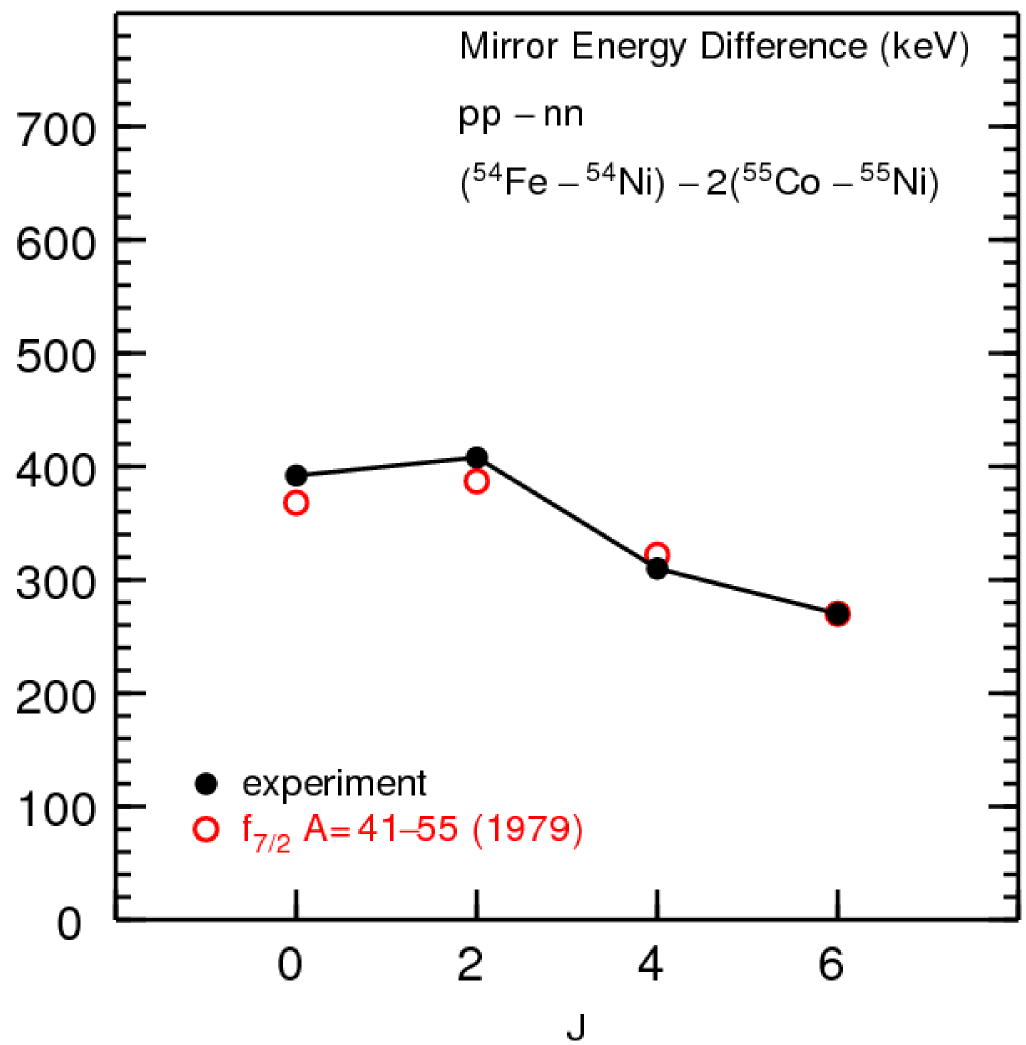
A. Gadea,[1] S. M. Lenzi,[2] S. Lunardi,[2] N. Mărginean,[1,3] A. P. Zuker,[4] G. de Angelis,[1] M. Axiotis,[1] T. Martínez,[1] D. R. Napoli,[1] E. Farnea,[2] R. Menegazzo,[2] P. Pavan,[2] C. A. Ur,[2,3] D. Bazzacco,[2] R. Venturelli,[2] P. Kleinheinz,[5] P. Bednarczyk,[4,6] D. Curien,[4] O. Dorvaux,[4] J. Nyberg,[7] H. Grawe,[8] M. Górska,[8] M. Palacz,[9] K. Lagergren,[10] L. Milechina,[10] J. Ekman,[11] D. Rudolph,[12] C. Andreoiu,[12] M. A. Bentley,[13] W. Gelletly,[14] B. Rubio,[15] A. Algora,[15] E. Nacher,[15] L. Caballero,[15] M. Trotta,[16] and M. Moszvński[17]



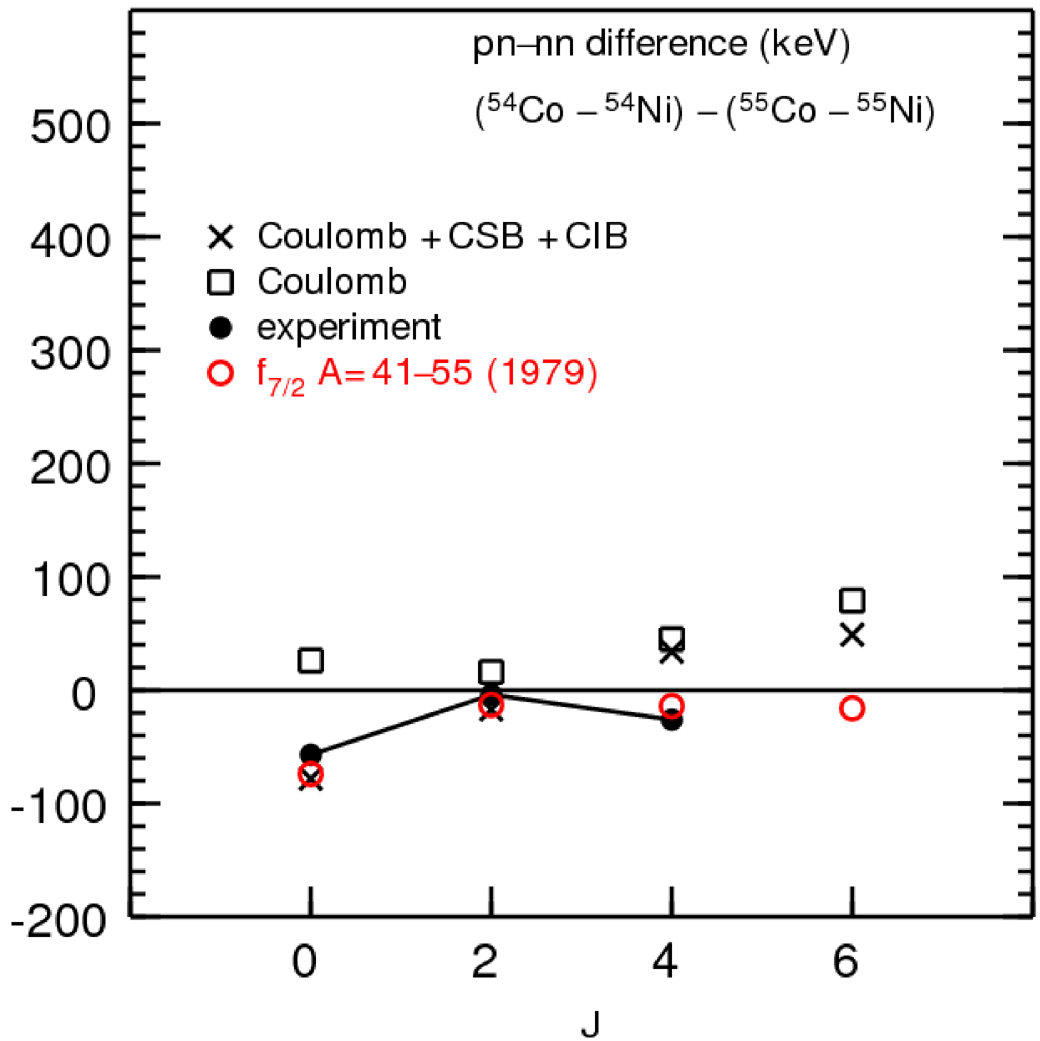

pn–nn difference (keV)
(^{54}Co – ^{54}Ni) – (^{55}Co – ^{55}Ni)
$f_{7/2}$ A=41–55 (1979)
500
400
300
200
100
0
-100
-200
0
2
4
6
J


pn–nn difference (keV)
(^{54}Co – ^{54}Ni) – (^{55}Co – ^{55}Ni)
experiment
$f_{7/2}$ A=41–55 (1979)
500
400
300
200
100
0
-100
-200
0
2
4
6
J

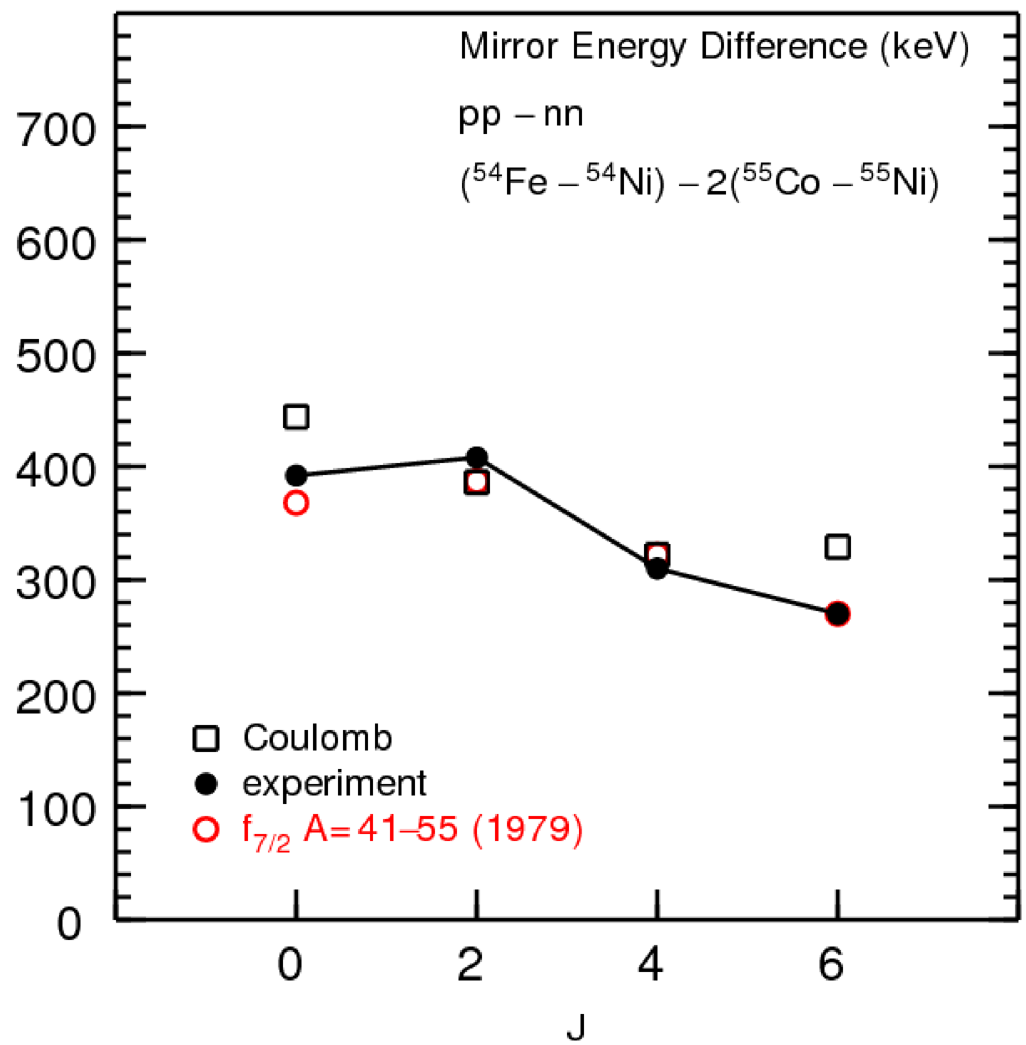

Mirror Energy Difference (keV)
pp – nn
(54Fe – 54Ni) – 2(55Co – 55Ni)
f7/2 A=41–55 (1979)
700
600
500
400
300
200
100
0
0
2
4
6
J


Mirror Energy Difference (keV)
pp – nn
(^{54}Fe – ^{54}Ni) – 2(^{55}Co – ^{55}Ni)
700
600
500
400
300
200
100
0
experiment
$f_{7/2}$ A=41–55 (1979)
0
2
4
6
J

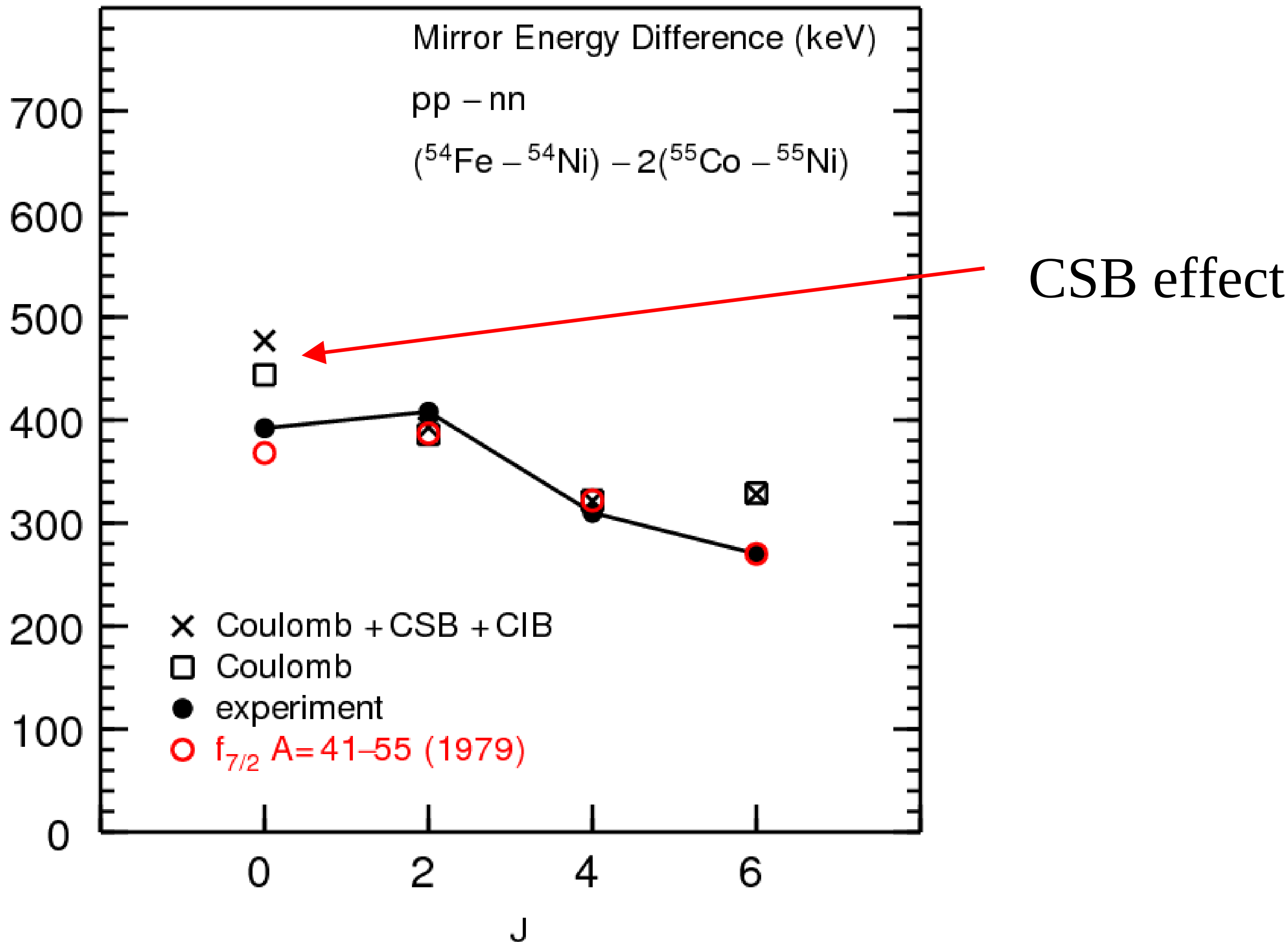
N3LO V-lowk 6hw 2nd order – "full" pf shell (Angelo Signoracci)



N3LO V-lowk 6hw 2^{nd} order – "full" pf shell (Angelo Signoracci)



N3LO V-lowk 6hw 2nd order – “full” pf shell (Angelo Signoracci)



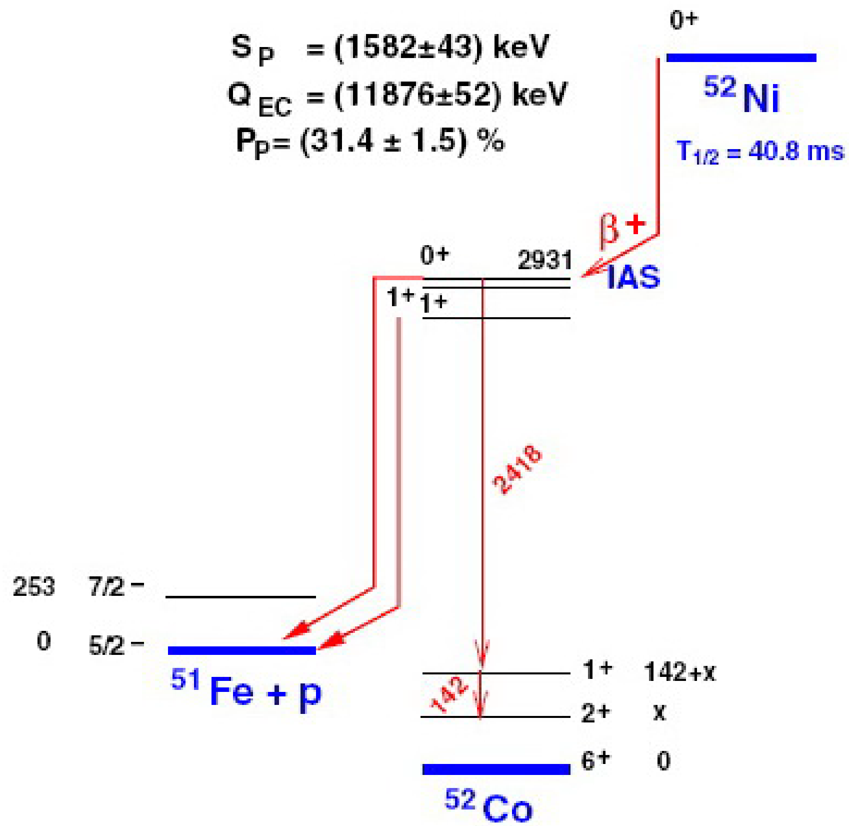
	N^{3}LO[a]	Experiment[b]
	$^1S_0$	
a^C_{pp}	−7.8188	−7.8196±0.0026
r^C_{pp}	2.795	2.790±0.014
a^N_{pp}	−17.083	
r^N_{pp}	2.876	
a^N_{nn}	−18.900	−18.9±0.4
r^N_{nn}	2.838	2.75±0.11
a_{np}	−23.732	−23.740±0.020
r_{np}	2.725	2.77±0.05
	$^3S_1$	
a_t	5.417	5.419±0.007
r_t	1.752	1.753±0.008

From n+d -18.7(6) PRL 83, 3788 (1999)
-16.3(40 PRL 85, 1190 (2000)

NSCL

Bertram Blank – isospin forbidden proton decay

^{52}Co 0^+ T=4 to ^{51}Fe $5/2^-$ T=1/2

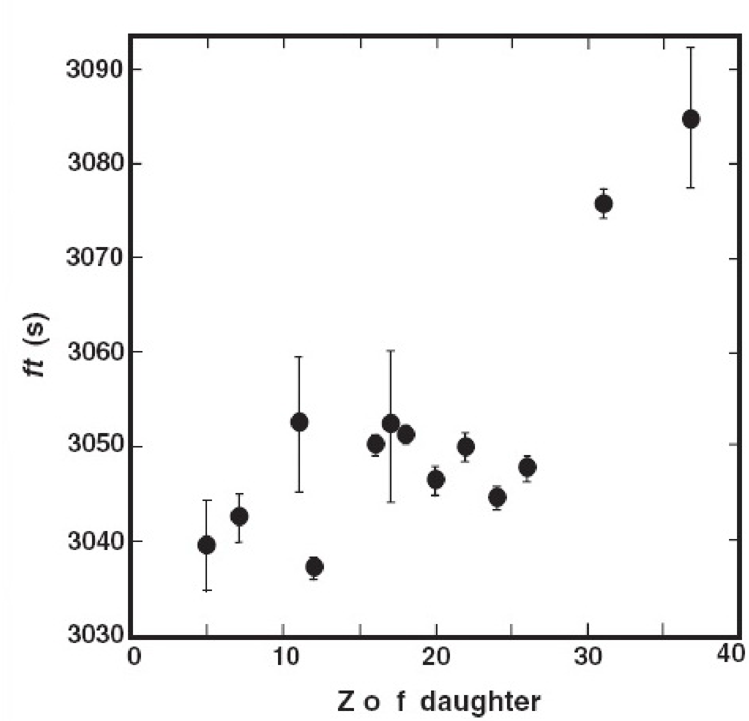


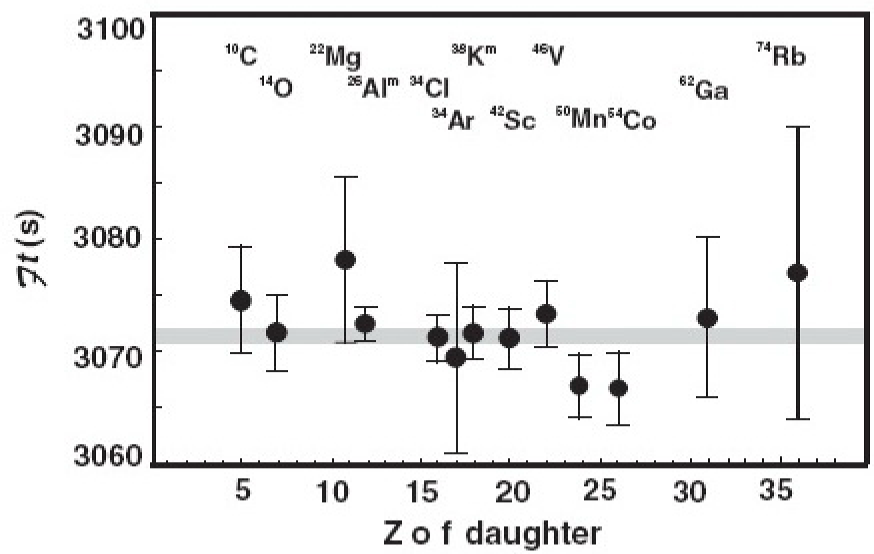
NSCL

PHYSICAL REVIEW C **77**, 025501 (2008)

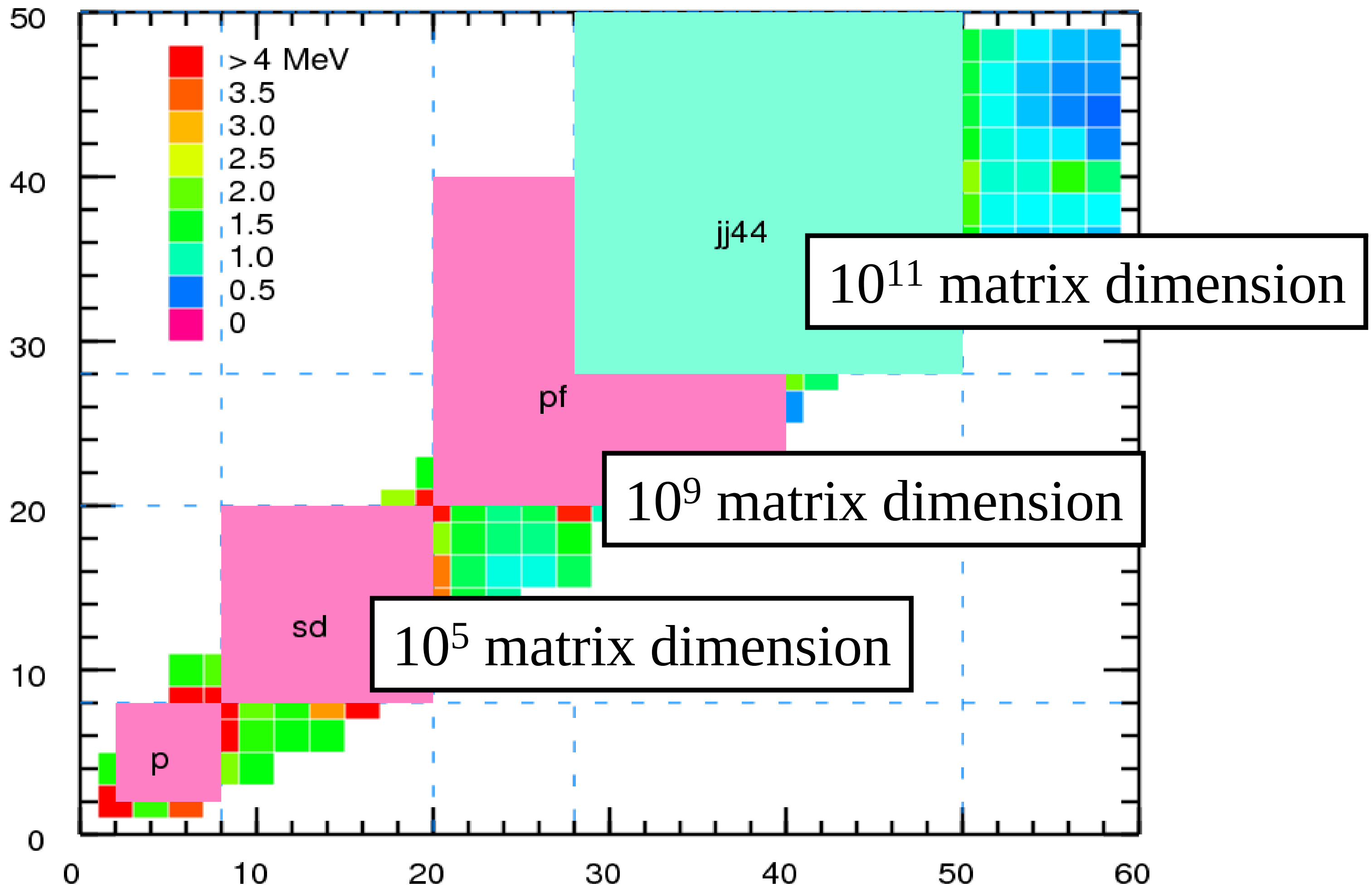
Improved calculation of the isospin-symmetry-breaking corrections to superallowed Fermi β decay

I. S. Towner* and J. C. Hardy
Cyclotron Institute, Texas A&M University, College Station, Texas 77843, USA





$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 1.0000 \pm 0.0011.$$



jj44 means $f_{5/2}$, $p_{3/2}$, $p_{1/2}$, $g_{9/2}$ orbits for protons and neutrons

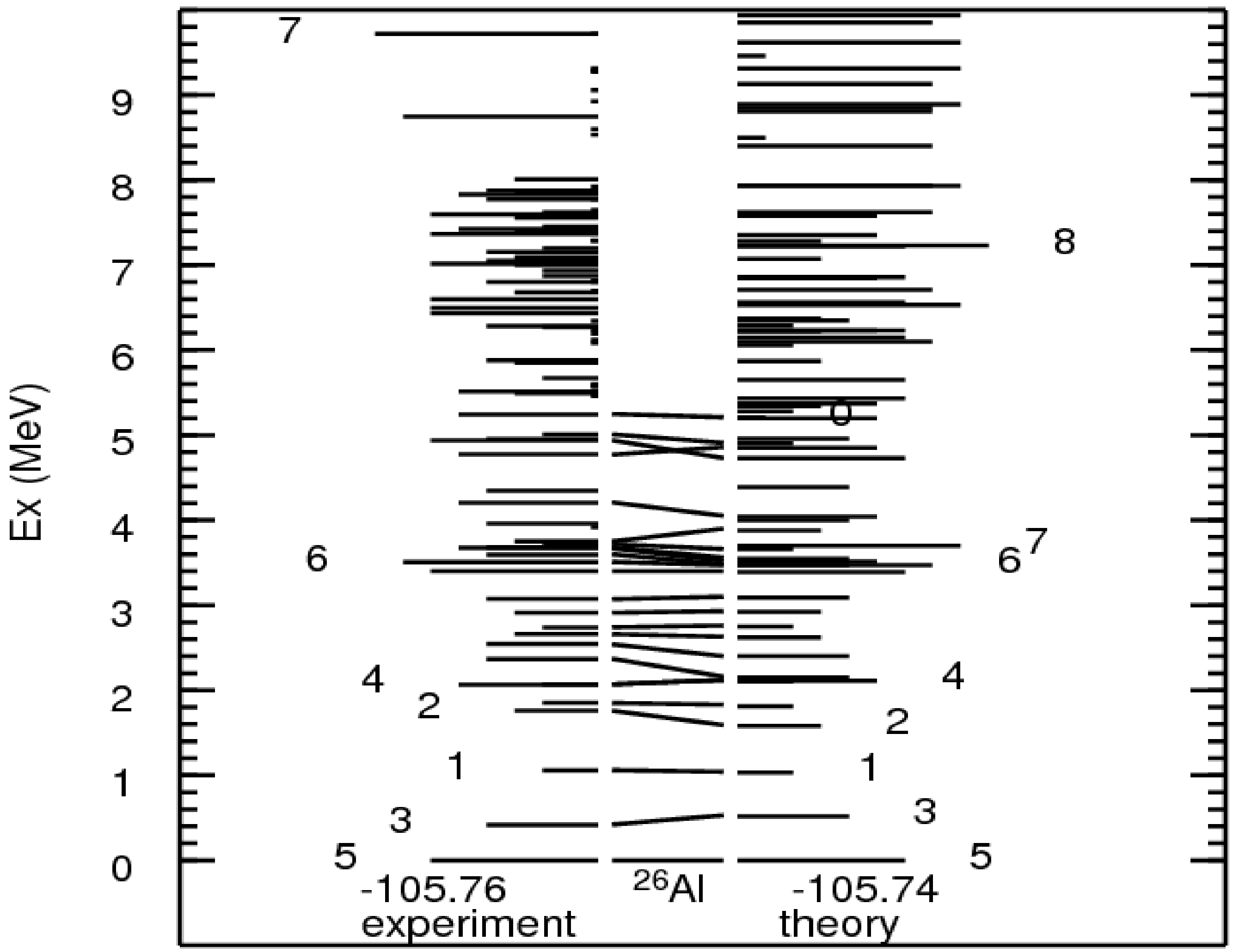
NSCL

A tour of the sd shell on the web

Home | Bookmarks

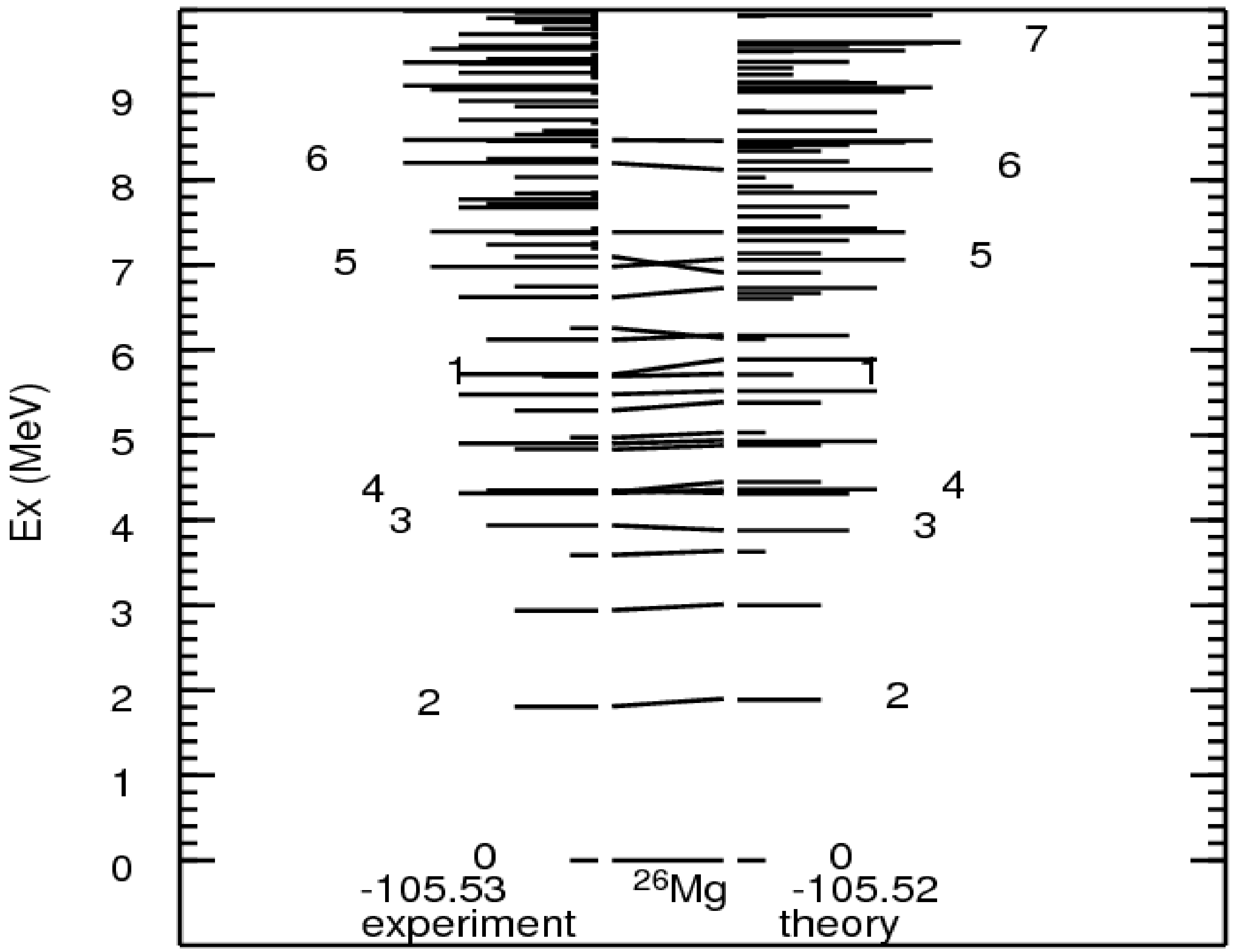
K											38, 0	39, 1/2
Ar										36, 0	37, 1/2	38, 1
Cl									34, 0	35, 1/2	36, 1	37, 3/2
S								32, 0	33, 1/2	34, 1	35, 3/2	36, 2
P							30, 0	31, 1/2	32, 1	33, 3/2	34, 2	35, 5/2
Si						28, 0	29, 1/2	30, 1	31, 3/2	32, 2	33, 5/2	34, 3
Al					26, 0	27, 1/2	28, 1	29, 3/2	30, 2	31, 5/2	32, 3	33, 7/2
Mg				24, 0	25, 1/2	26, 1	27, 3/2	28, 2	29, 5/2	30, 3	31, 7/2	32, 4
Na			22, 0	23, 1/2	24, 1	25, 3/2	26, 2	27, 5/2	28, 3	29, 7/2	30, 4	31, 9/2
Ne		20, 0	21, 1/2	22, 1	23, 3/2	24, 2	25, 5/2	26, 3	27, 7/2	28, 4	29, 9/2	30, 5
F	18, 0	19, 1/2	20, 1	21, 3/2	22, 2	23, 5/2	24, 3	25, 7/2	26, 4	27, 9/2	28, 5	29, 11/2
O	17, 1/2	18, 1	19, 3/2	20, 2	21, 5/2	22, 3	23, 7/2	24, 4	25, 9/2	26, 5	27, 11/2	28, 6
	9	10	11	12	13	14	15	16	17	18	19	20

Positive parity states for ^{26}Al

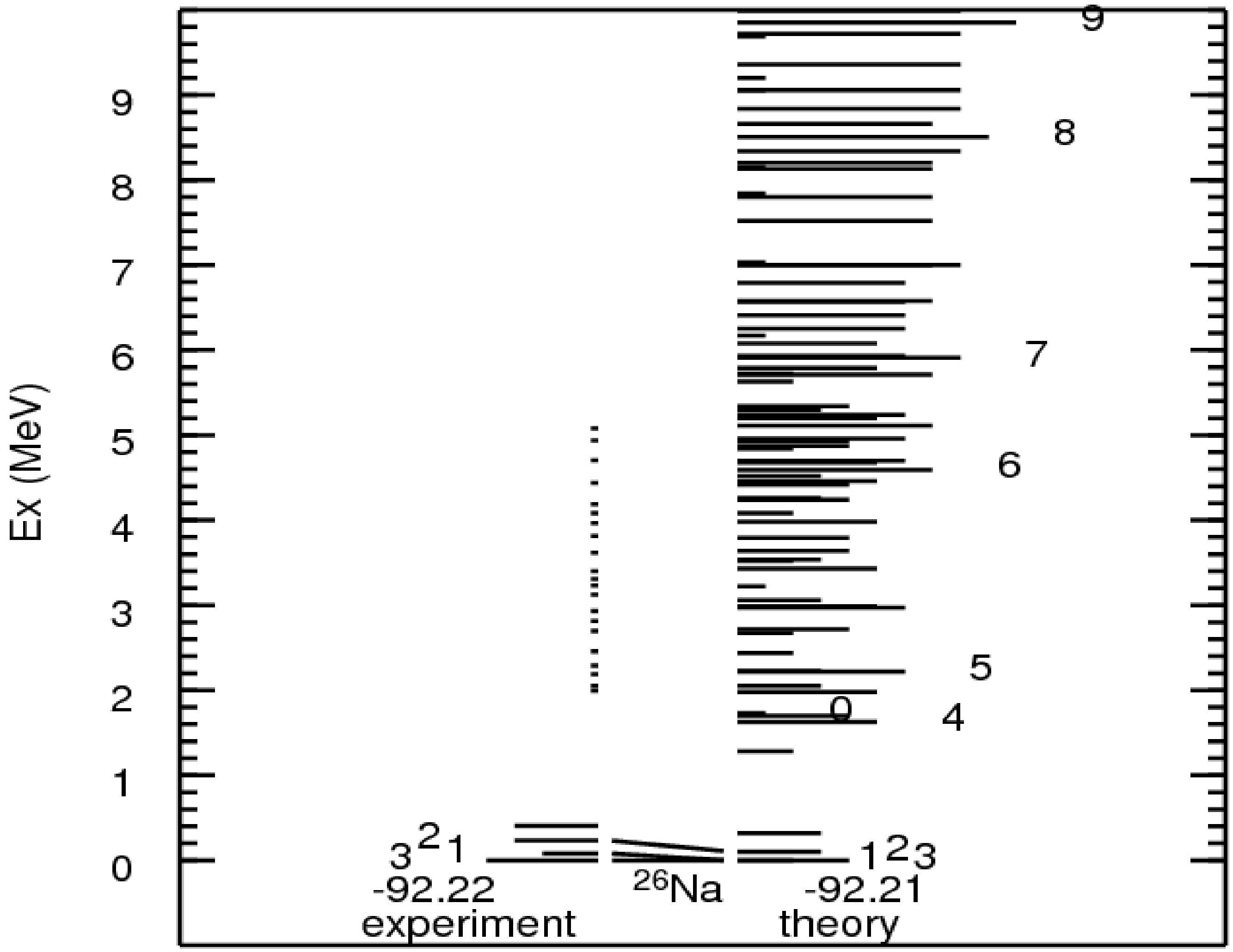


NSCL

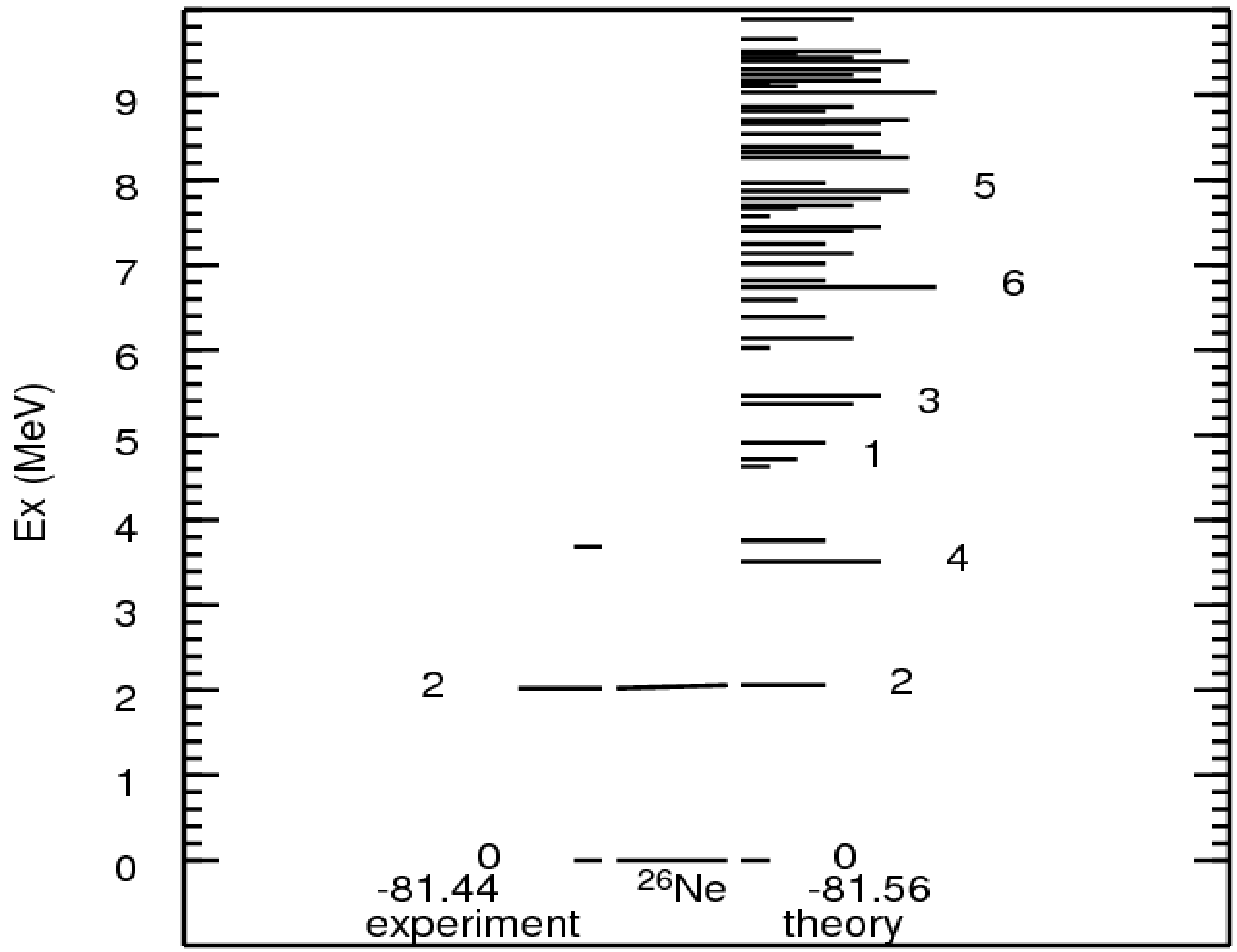
Positive parity states for ^{26}Mg



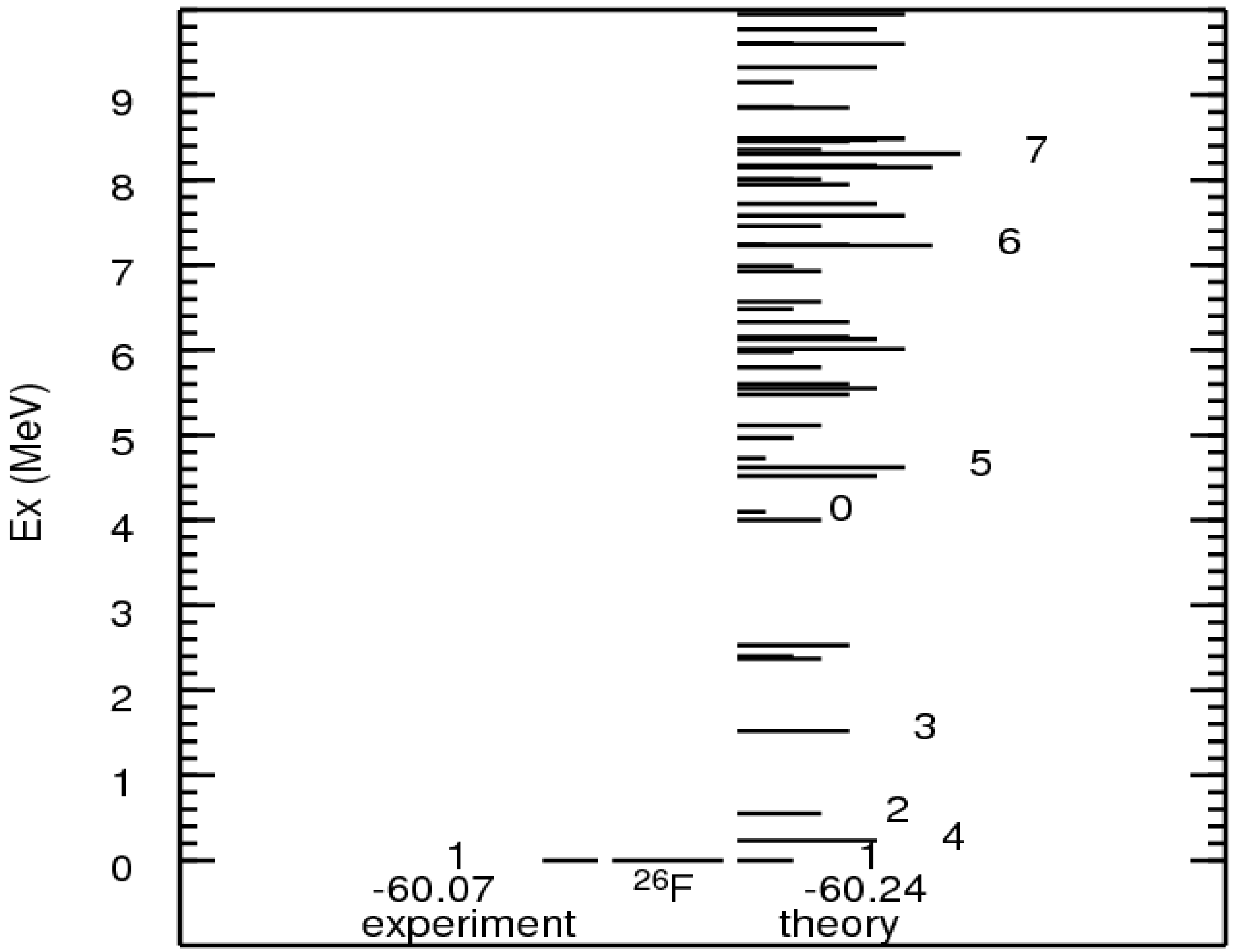
Positive parity states for ^{26}Na



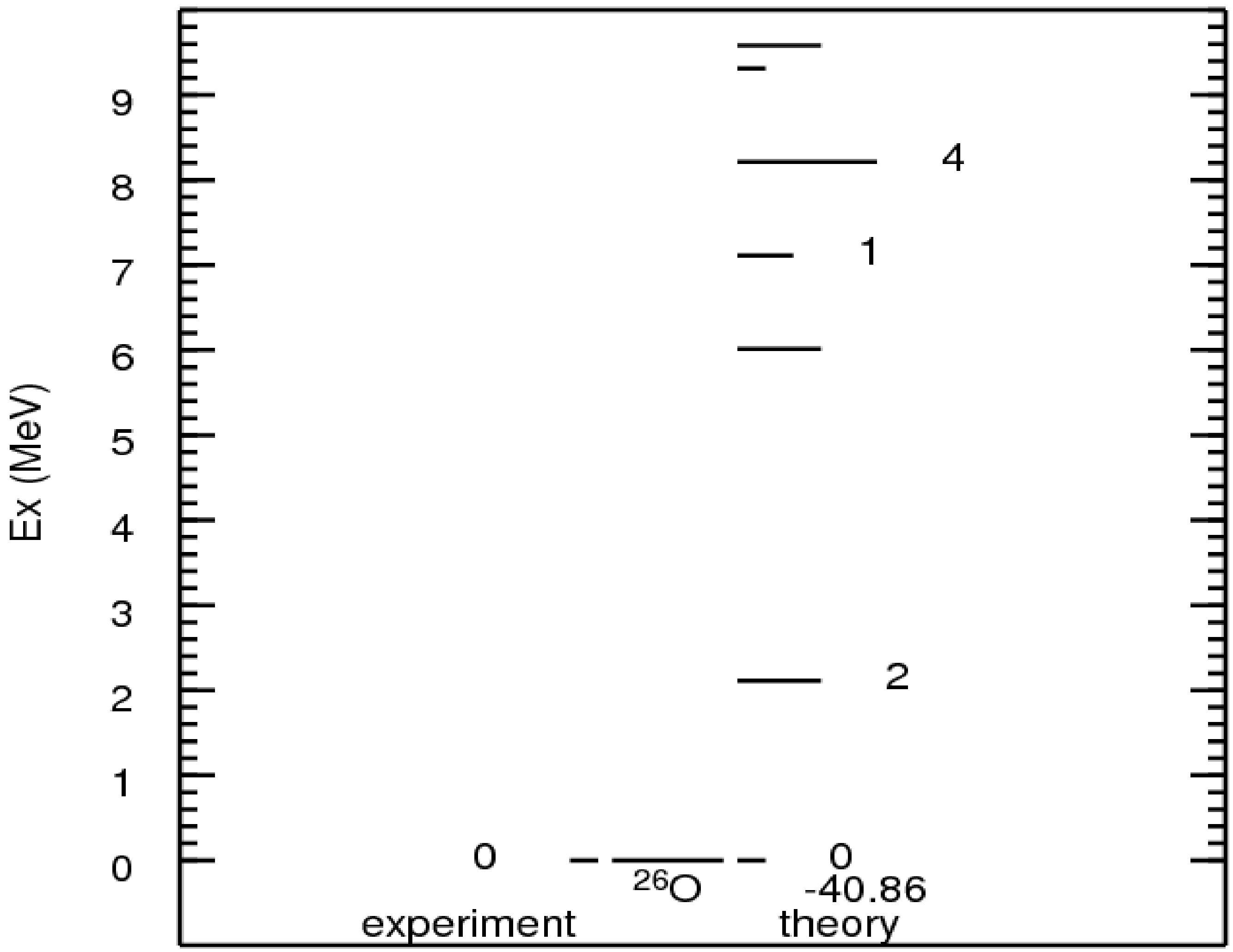
Positive parity states for ^{26}Ne



Positive parity states for ^{26}F



Positive parity states for ^{26}O

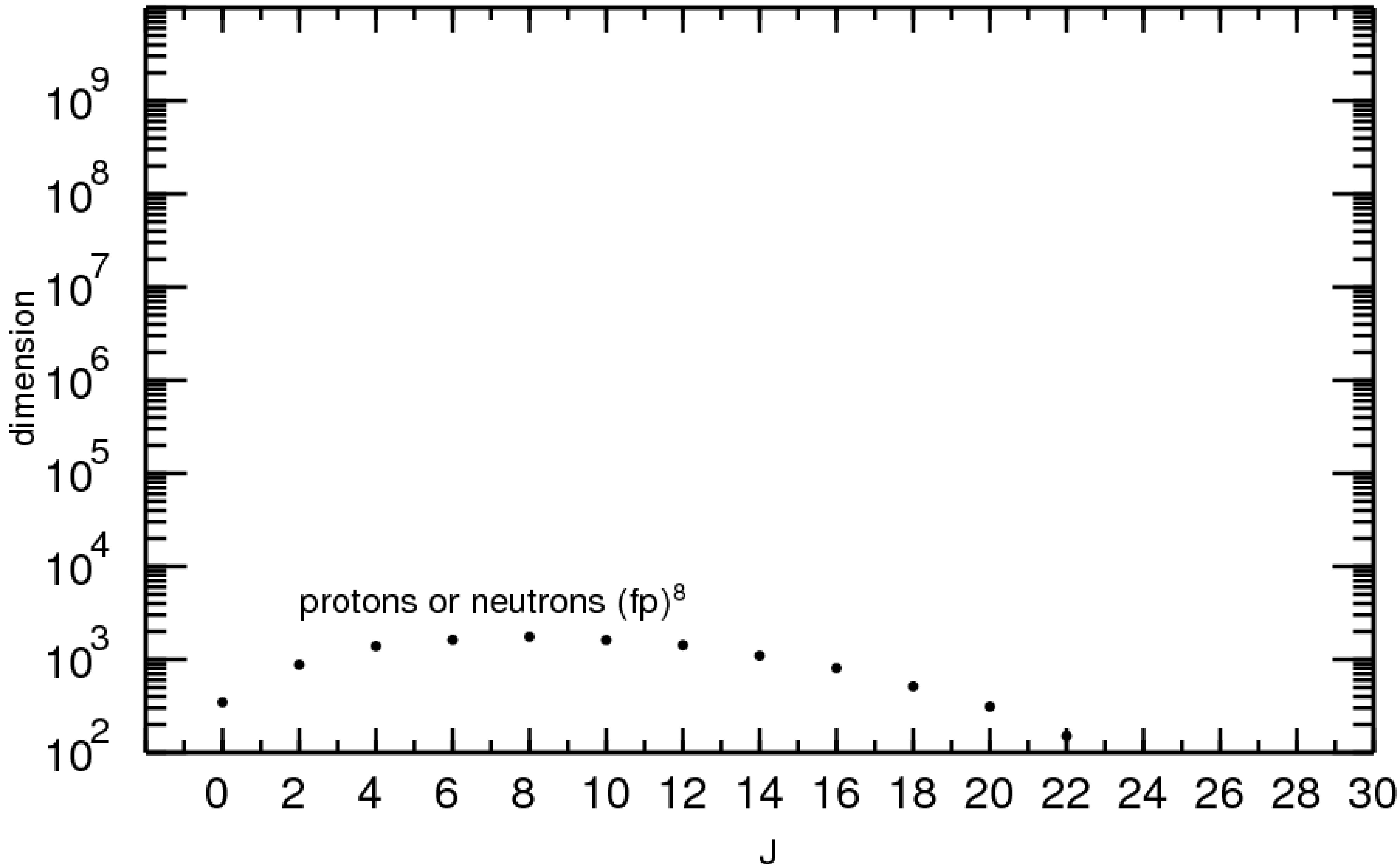


How to count basis dimensions

- Protons and neutrons – all of those allowed by the triangle conditions $[(J_p)]$ x $[(J_n)]$ J_{pn} $D_{pn} = D_p D_n$
- Number of states for a given M-value – the sum of the J dimensions from J_{max} down to $J = M$

- J-scheme – basis has good J (or JT)
- M-scheme – basis does not have good J – only M is fixed but the eigenstates will have good J since H is rotationally invariant.

Example for ^{48}Ca in the pf shell



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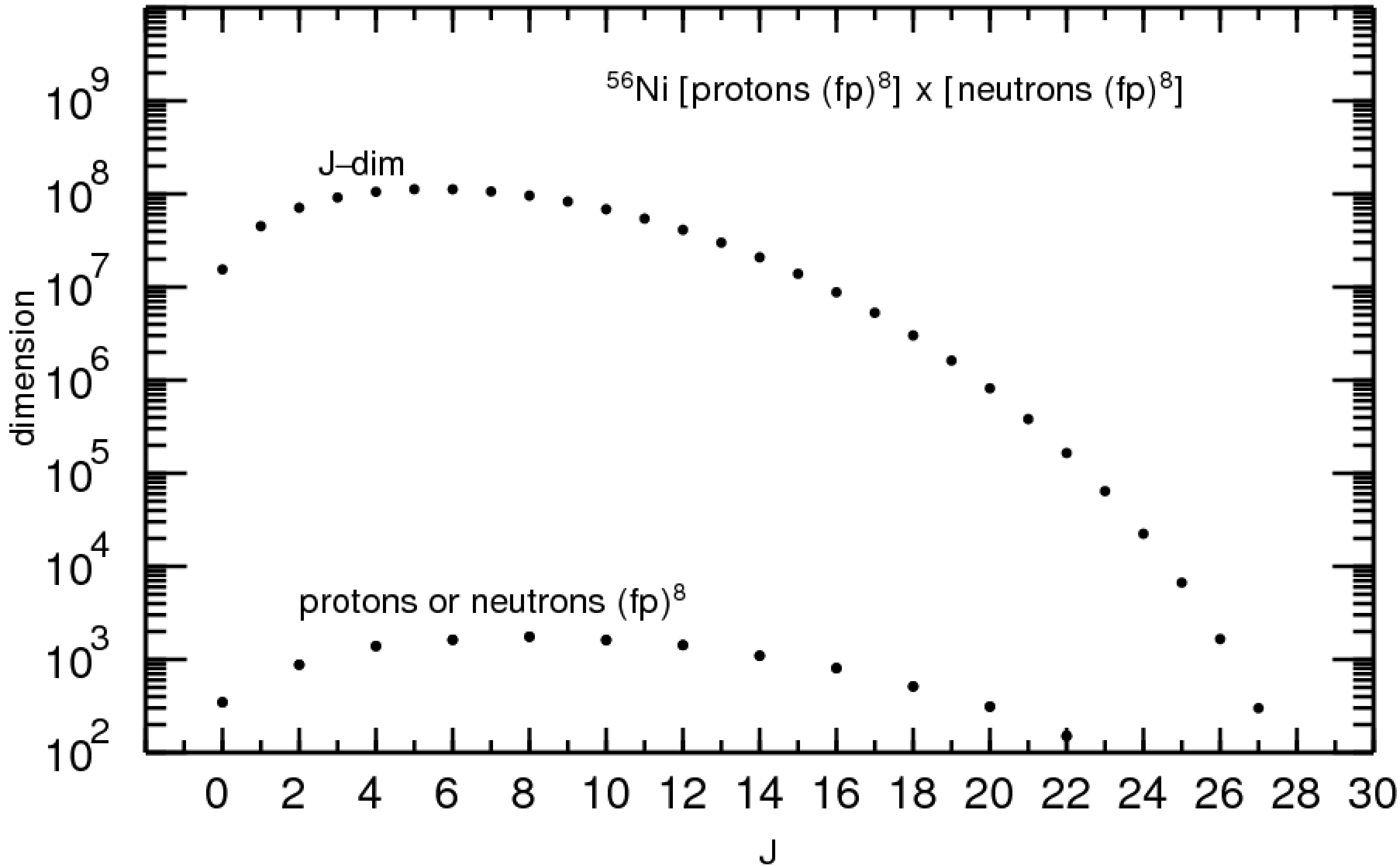
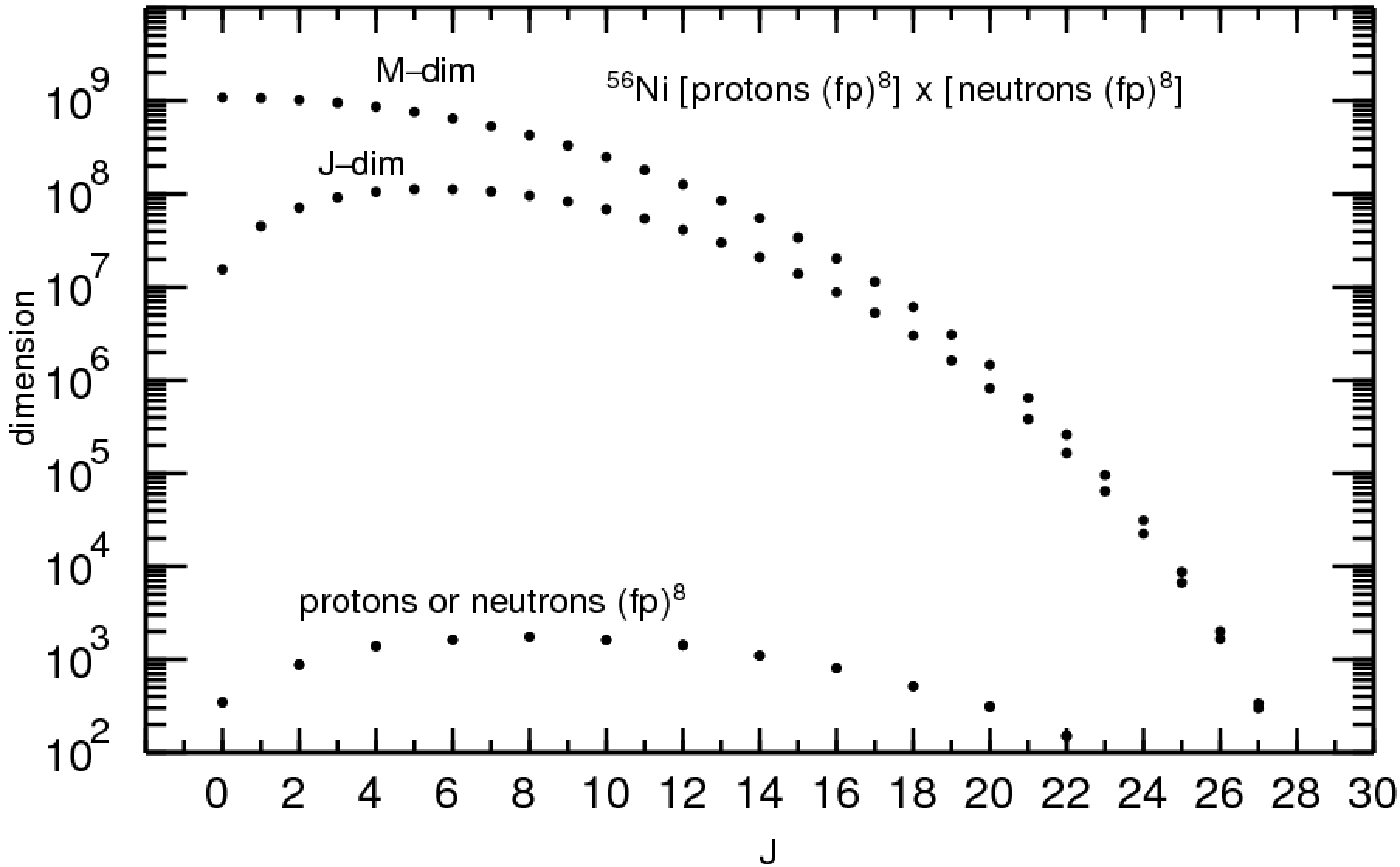
B. Alex Brown, USNDP, BNL, Nov 6, 2008

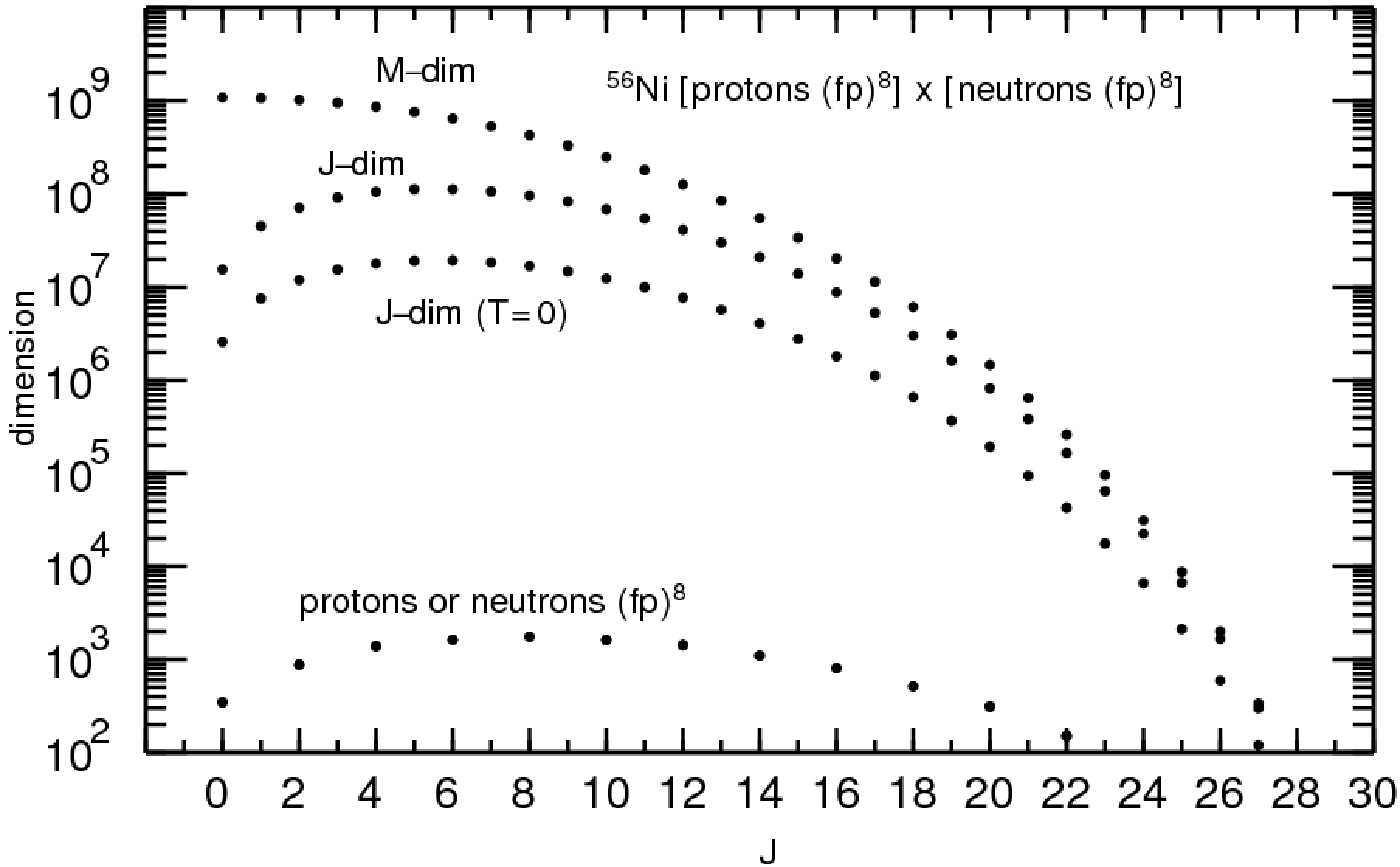
Example for ^{56}Ni in the pf shell



Example for ^{56}Ni in the pf shell



Example for ^{56}Ni in the pf shell



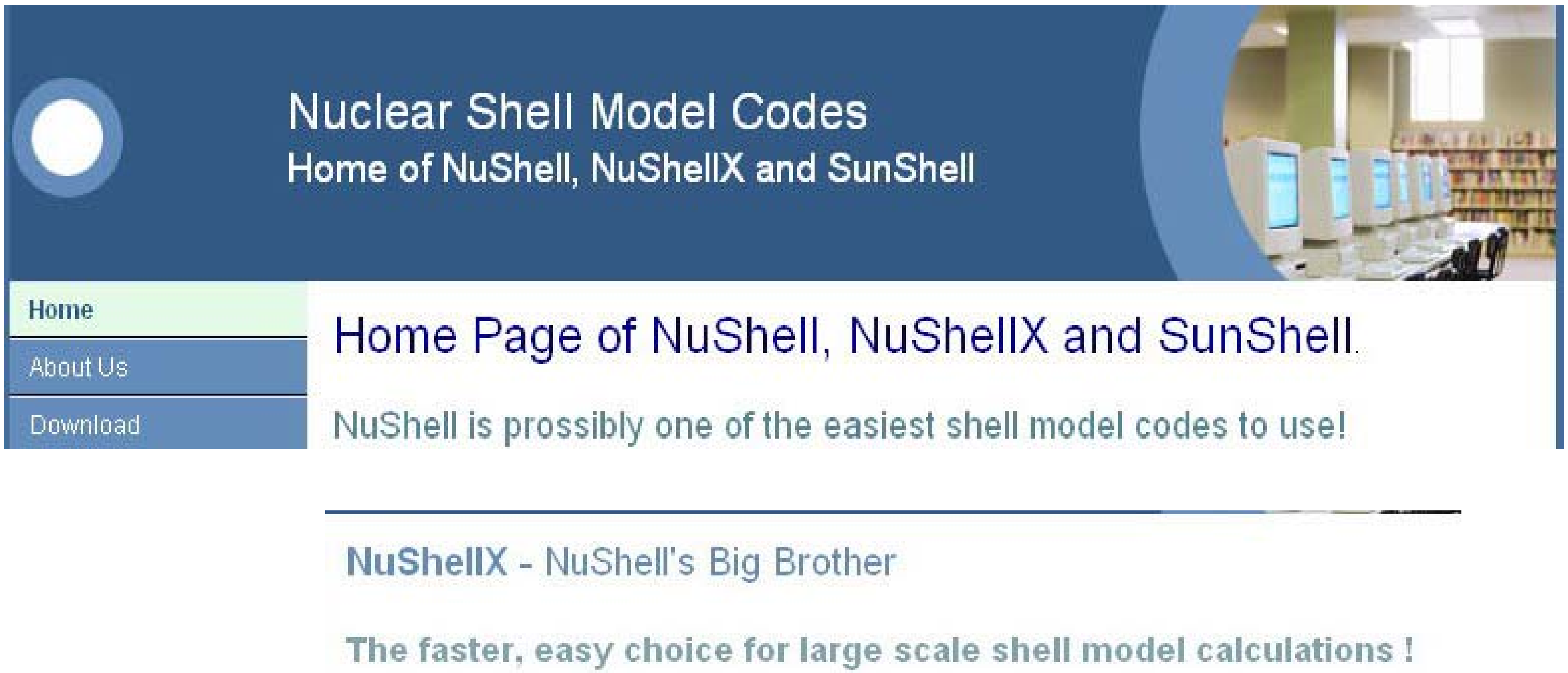
B. Alex Brown, USNDP, BNL, Nov 6, 2008

Codes

- M-scheme (matrix not stored) (~10^{10} M-states)
  - Antoine (Caurier)
  - Redstick (Ormand and Johnson)
  - CMUShell (Horoi)
  - Mshell (Mizuzaki)
  - MFDn (Vary et al)
- JT-projected M-scheme (matrix stored) (~10^{5} JT-states)
  - Oxbash (Brown and Rae) (now replaced by NuShell@MSU)
  - NuShell (Rae)
  - NuShell@MSU (Brown and Rae) (NuShell with Oxbash style input and output)
- J-scheme (matrix not stored) (~10^{8} J-states)
  - Nathan (Caurier)
  - EICODE (Toivanen)
  - NuShellx (Rae)
  - NuShellx@MSU (Brown and Rae) (NuShellx with Oxbash style input and output)

available on the web

Bill Rae (Garsington) has made big advances
Oxbash -> Nushell -> Nushellx
Nushellx uses the [Jp Jn] J coupling to eliminate storage of the matrix.
Similar to Nathan (Caurier et al) and Eicode (Toivanen) but faster.
NuShellx@MSU uses these codes as a core for nuclear structure applications.



Effective interactions – what are the two-body matrix elements?

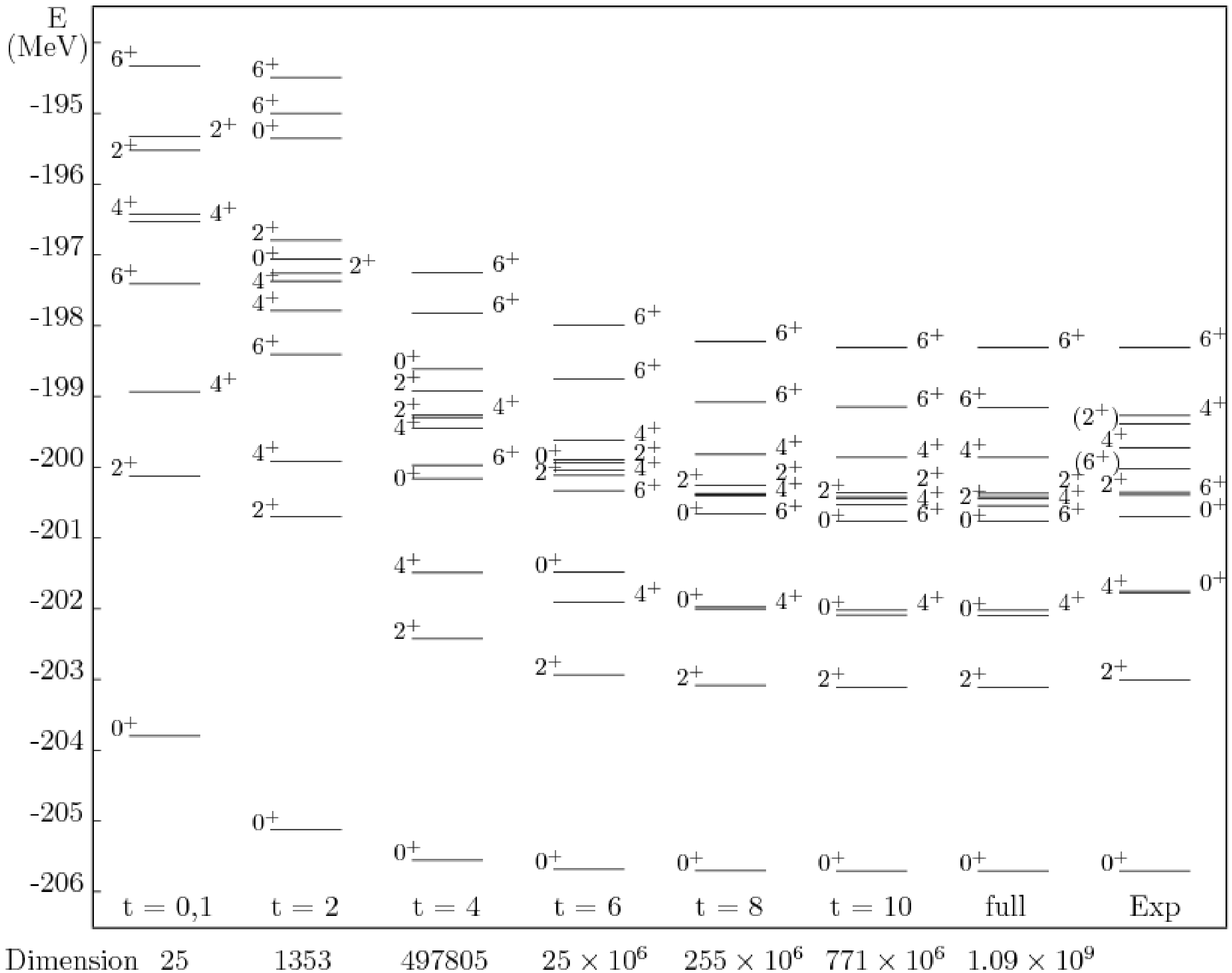
For sd shell USD, USDA, USDB interactions obtained from a fit to data
use singular-value-decomposition method to obtain values
for 20-30 of the most important linear combinations of TBME
from about 600 energies

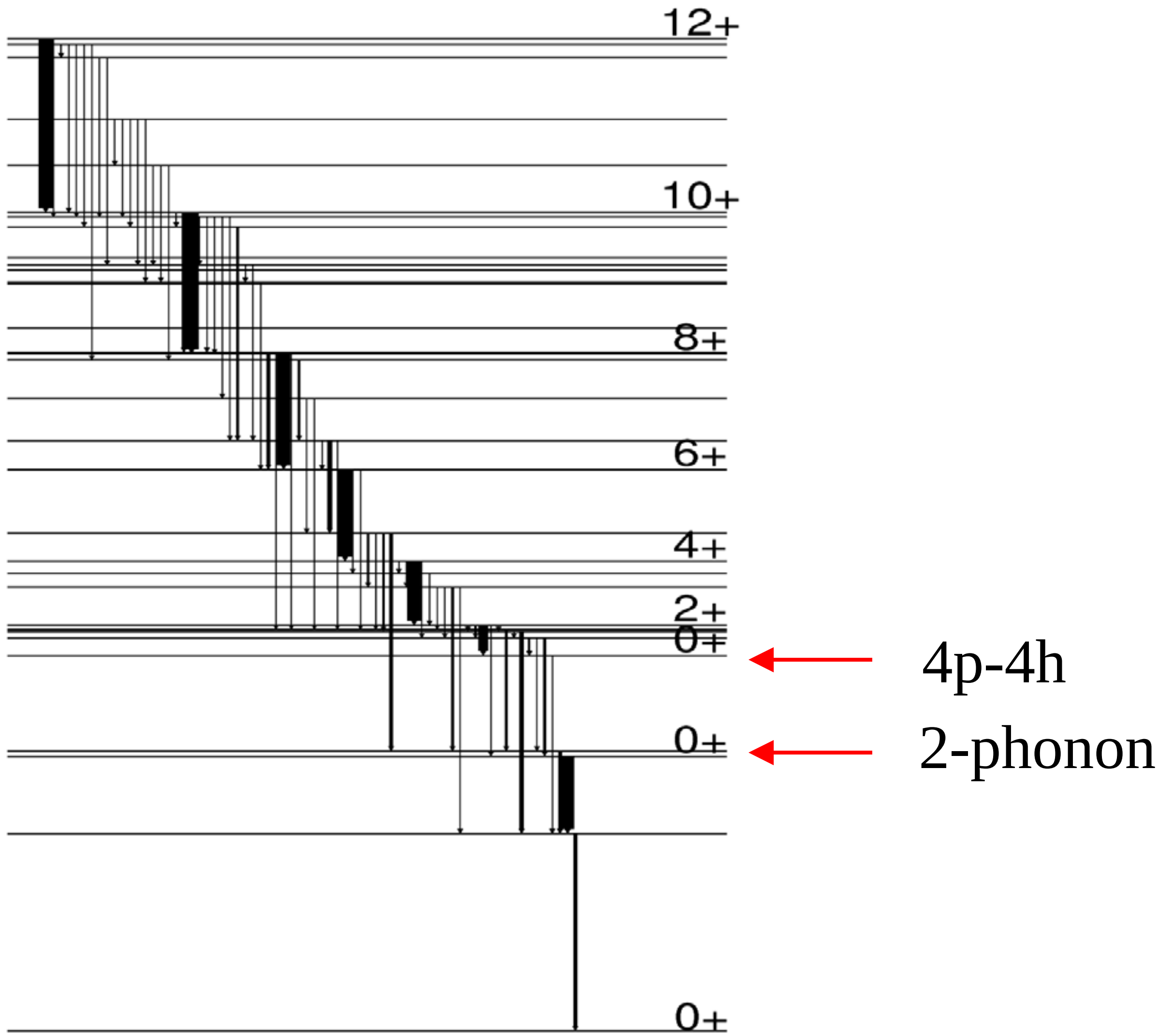
For pf same procedure for about 600 energies
M. Honma, T. Otsuka, B. A. Brown and T. Mizusaki,
Phys. Rev. C65, 061301 (2002) - GPFX1, GPFX1A

For heavier nuclei this method becomes unfeasible – we need better
methods for understanding the nuclear medium and model space
dependence of the NN and NNN interactions
(tomorrow) talk at Stony Brook on ^{132}Sn and ^{208}Pb regions

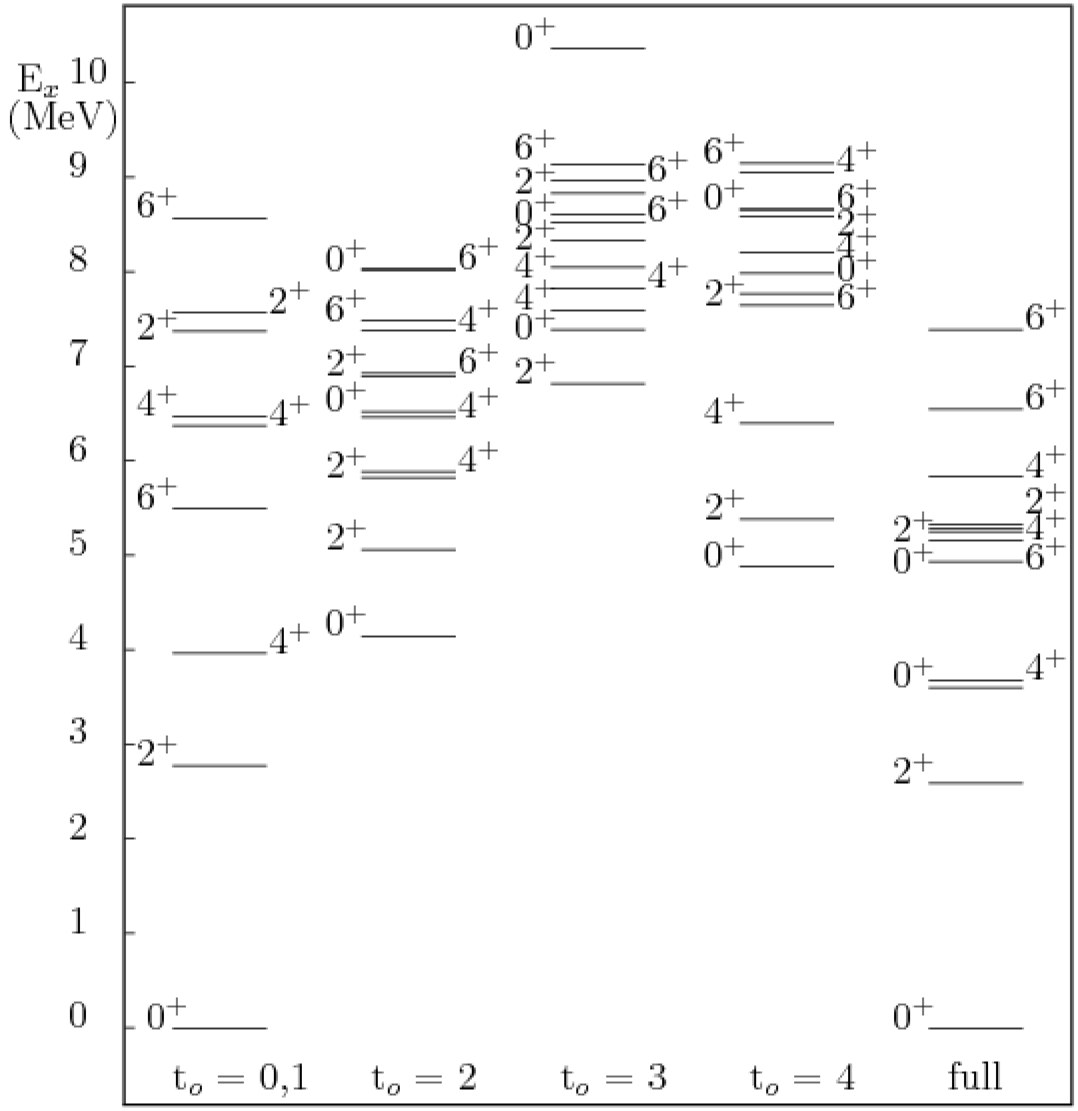
Full pf space for ^{56}Ni with GXPF1A Hamiltonian (order of one day computing time)

M. Horoi, B. A. Brown, T. Otsuka, M. Honma and T. Mizusaki, Phys. Rev. C 73, 061305(R) (2006).




12+
10+
8+
6+
4+
2+
0+
4p-4h
0+
2-phonon
0+

Pure configurations



Requires an effective shell gap 0.9 MeV smaller than full fp

^{58}Ni(p,t)^{56}Ni

PHYSICAL REVIEW C VOLUME 10, NUMBER 5 NOVEMBER 1974

Levels of ^{56}Ni†

H. Nann* and W. Benenson

Cyclotron Laboratory and Department of Physics, Michigan State University, East Lansing, Michigan 48824

(Received 5 August 1974)

The ^{58}Ni(p, t)^{56}Ni reaction was studied at 40 and 45 MeV beam energy. An energy resolution of 10–25 keV permitted observation of 60 levels with excitation energy up to 10.5 MeV. Spin and parity are assigned to levels which were excited with characteristic angular distributions. These include 0^+ states at 3.95, 5.00, 6.44, 7.91, 9.92, 9.99, and 10.02 MeV.

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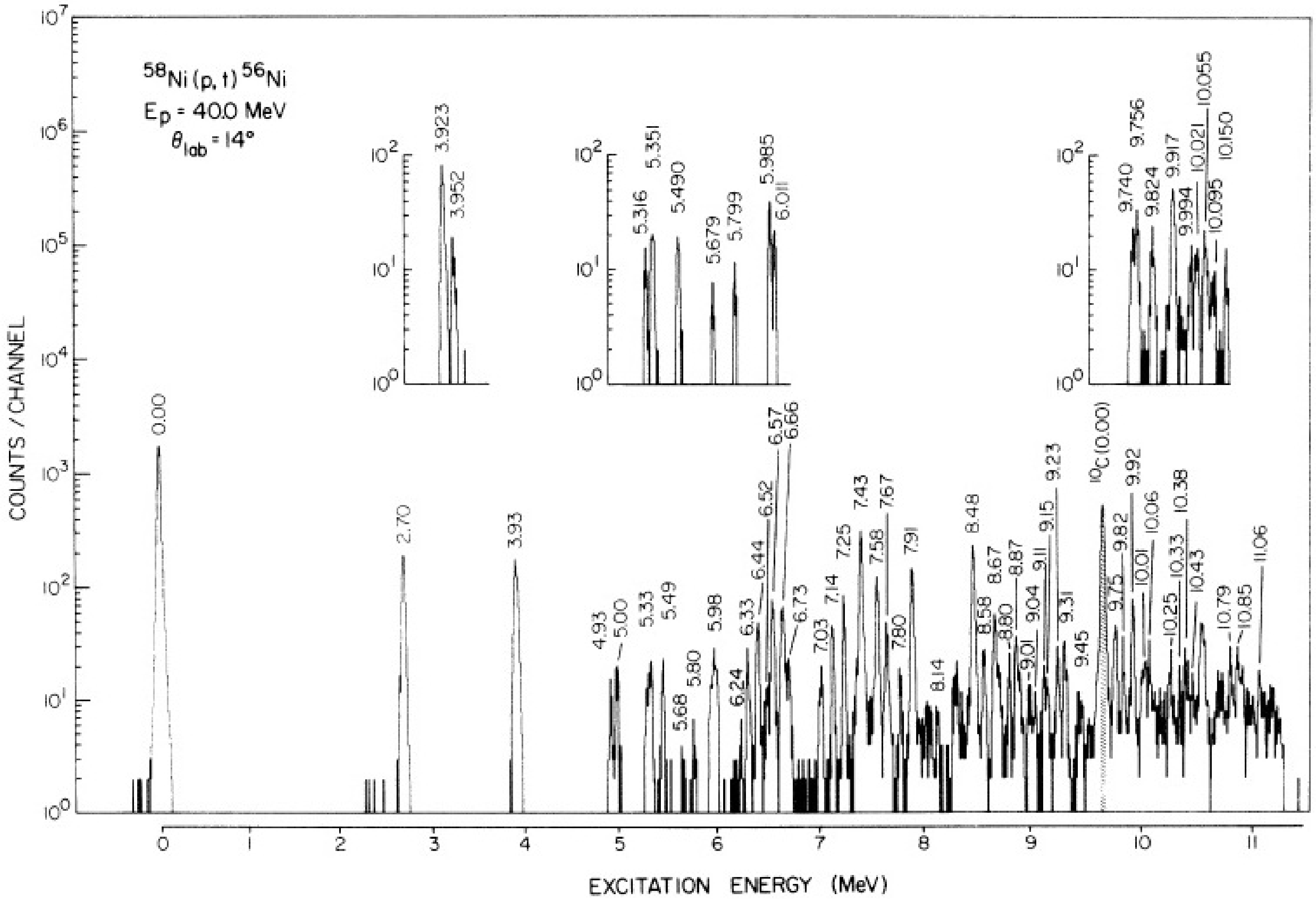
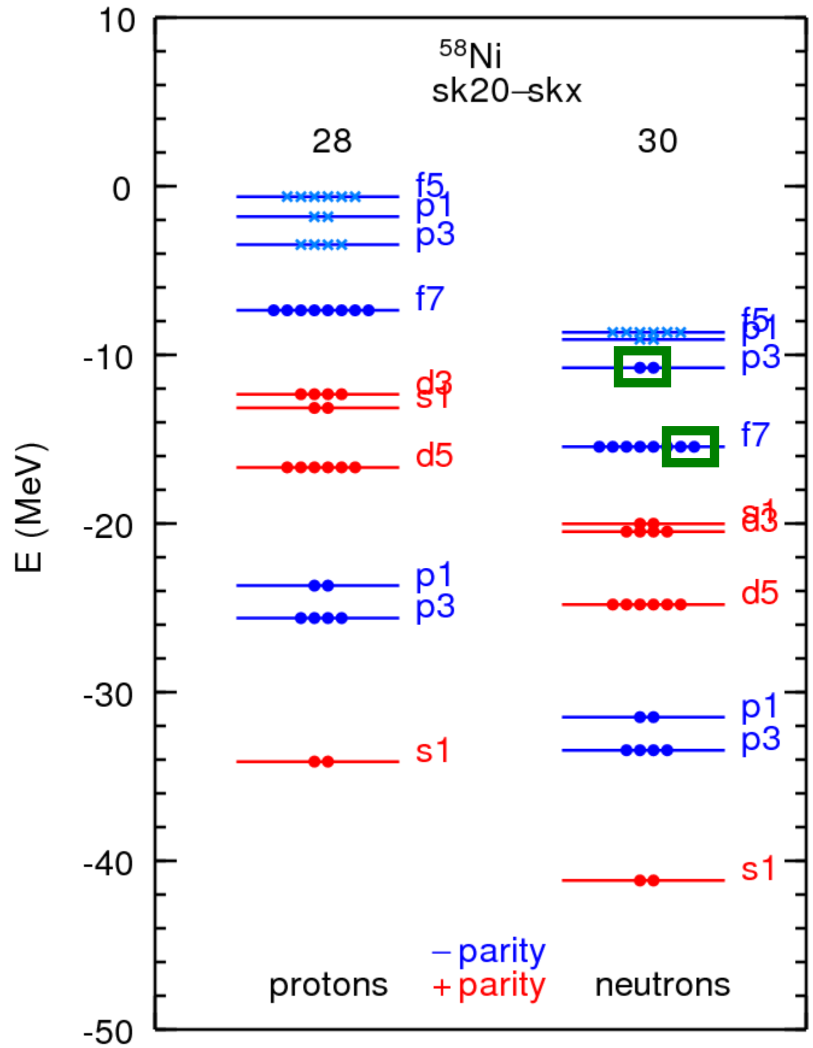
NATIONAL SCIENCE FOUNDATION

60 levels 10 keV resolution



B. Alex Brown, USNDP, BNL, Nov 6, 2008



^{58}Ni
sk20–skx
28
30
f5
p1
p3
f7
d3
s1
d5
p1
p3
s1
f5
p1
p3
f7
s1
d3
d5
p1
p3
s1
E (MeV)
10
0
-10
-20
-30
-40
-50
– parity
+ parity
protons
neutrons

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^{58}Ni(p,t)^{56}Ni

Pairing vibrations expect three 0^+ levels with T=0,1,2 strength 2:3:1 and spacing that goes as T(T+1)

[13] A. Bohr, in *International Symposium on Nuclear Structure, Dubna, 1968* (IAEA, Vienna, 1968), p. 179.
[14] O. Nathan, in *International Symposium on Nuclear Structure, Dubna, 1968* (see Ref. 13), p. 191.

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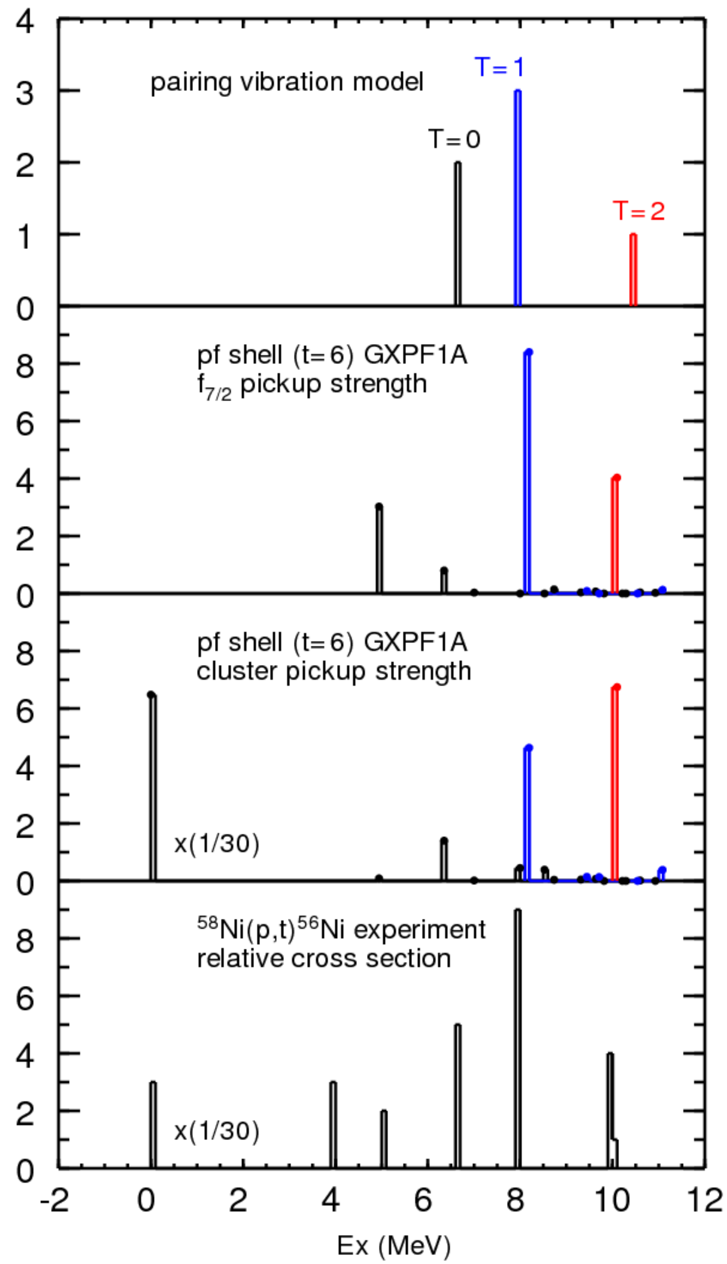
$^{58}Ni(p,t)^{56}Ni$

Relative strength
For 0^+ states in ^{56}Ni



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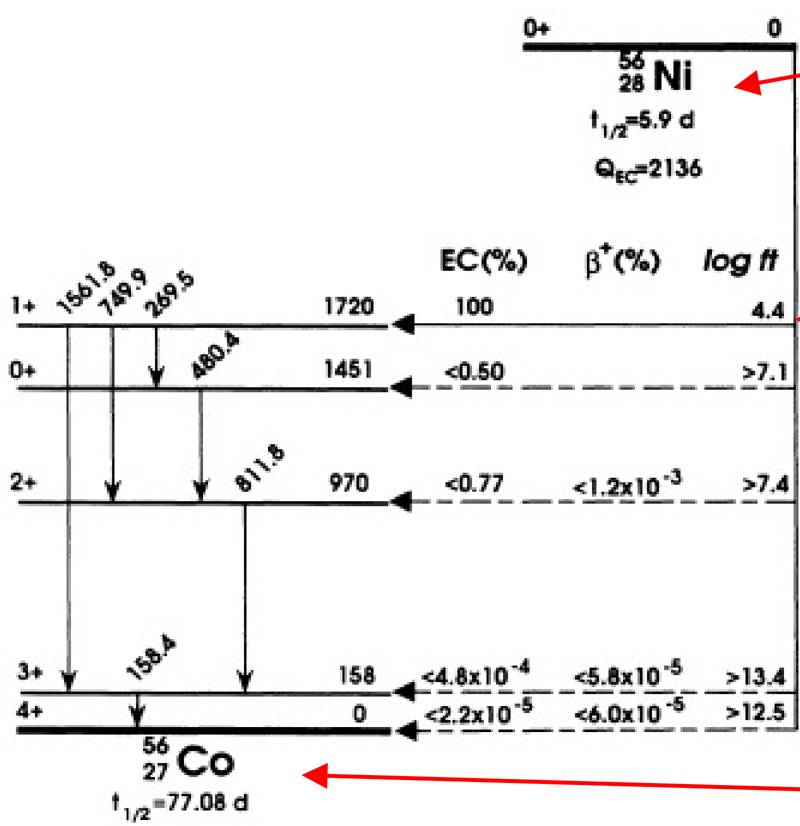
B. Alex Brown, USNDP, BNL, Nov 6, 2008

PHYSICAL REVIEW C VOLUME 42, NUMBER 2 AUGUST 1990

Reinvestigation of ^{56}Ni decay

Bhaskar Sur, Eric B. Norman, K. T. Lesko, Edgardo Browne, and Ruth-Mary Larimer
Nuclear Science Division, Lawrence Berkeley Laboratory, 1 Cyclotron Road, Berkeley, California 94720



End product of Si burning in stars.

Without electrons half-life of ^{56}Ni increases from 5.9 days to 10^5 years.

B(GT) = 0.155 compared to $(f_{7/2})^{-1} (f_{5/2})$ value of 48x2/7 = 13.71

B(F) < 0.0005

After explosion light output from ^{56}Co decay with half-life of 77 days.

STELLAR WEAK INTERACTION RATES[1] FOR INTERMEDIATE-MASS NUCLEI. II. $A=21$ TO $A=60$

GEORGE M. FULLER[2] AND WILLIAM A. FOWLER
W. K. Kellogg Radiation Laboratory, California Institute of Technology
AND
MICHAEL J. NEWMAN
Applied Theoretical Physics Division, Los Alamos National Laboratory, University of California, Los Alamos
Received 1981 June 12; accepted 1981 August 3

THE ASTROPHYSICAL JOURNAL, **252**:715–740, 1982 January 15

ELECTRON CAPTURE AND β-DECAY IN PRESUPERNOVA STARS

M. B. AUFDERHEIDE
Physics Department, State University of New York at Stony Brook; and Department of Physics, Brookhaven National Laboratory
G. E. BROWN, T. T. S. KUO, and D. B. STOUT
Physics Department, State University of New York at Stony Brook
AND
P. VOGEL
Physics Department, California Institute of Technology
Received 1989 September 25; accepted 1990 April 2

THE ASTROPHYSICAL JOURNAL, **362**:241–250, 1990

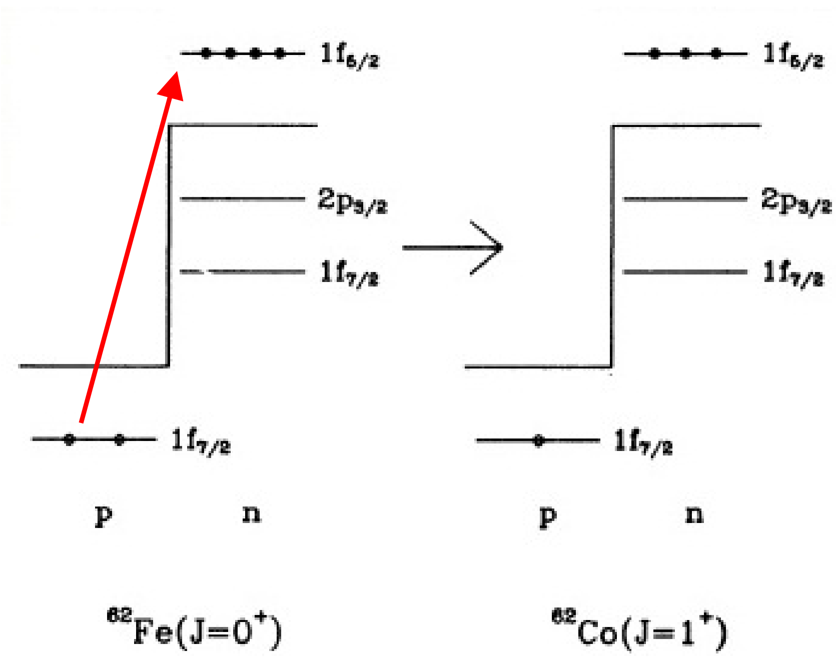
RATE TABLES FOR THE WEAK PROCESSES OF *pf*-SHELL NUCLEI IN STELLAR ENVIRONMENTS

K. LANGANKE[1] and G. MARTÍNEZ-PINEDO[2]

Institut for Fysik og Astronomi, Århus Universitet, DK-8000 Århus C, Denmark

Atomic Data and Nuclear Data Tables **79**, 1–46 (2001)

^{62}Fe to ^{62}Co model from Aufderheide et al. 1990



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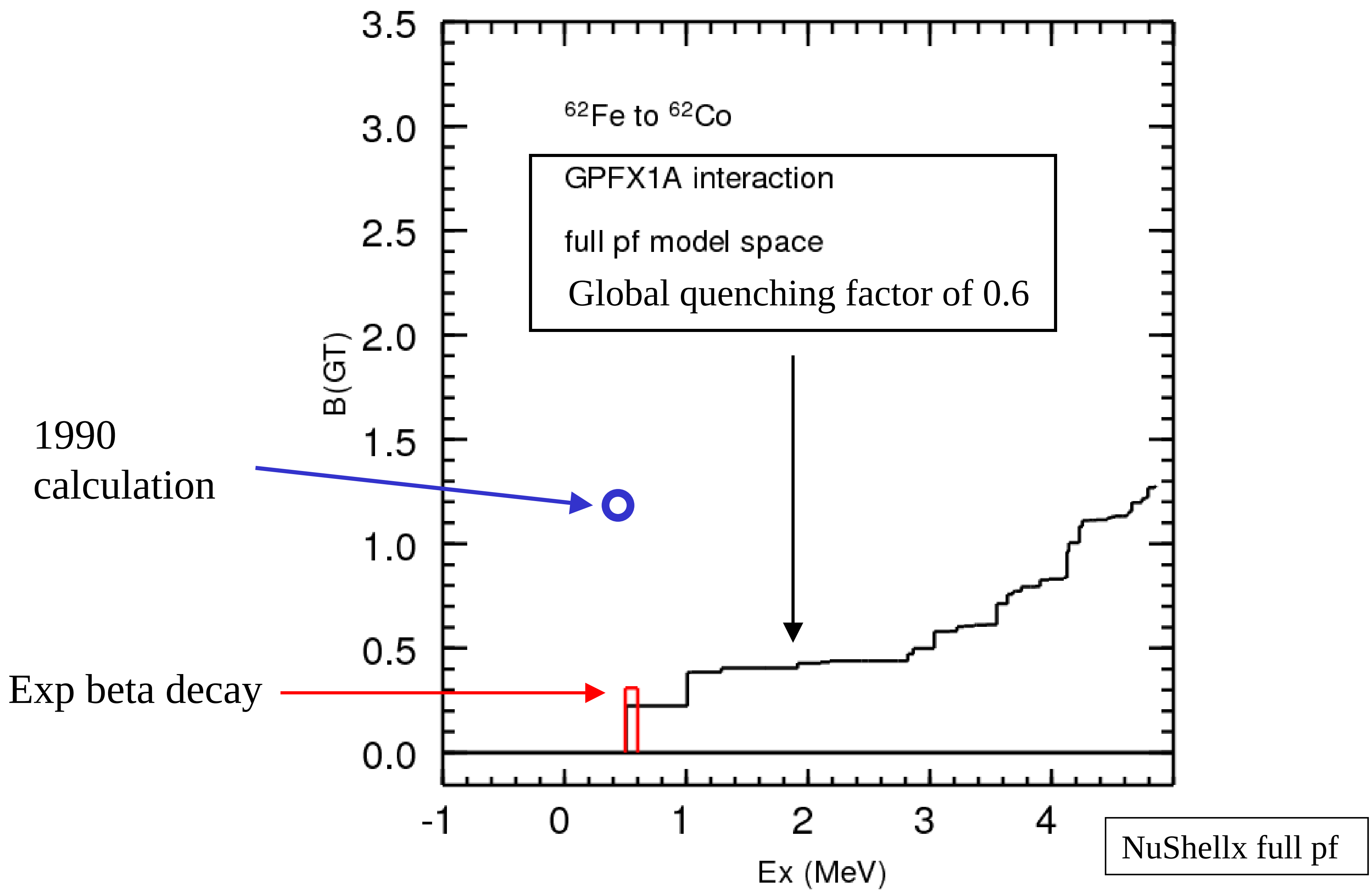
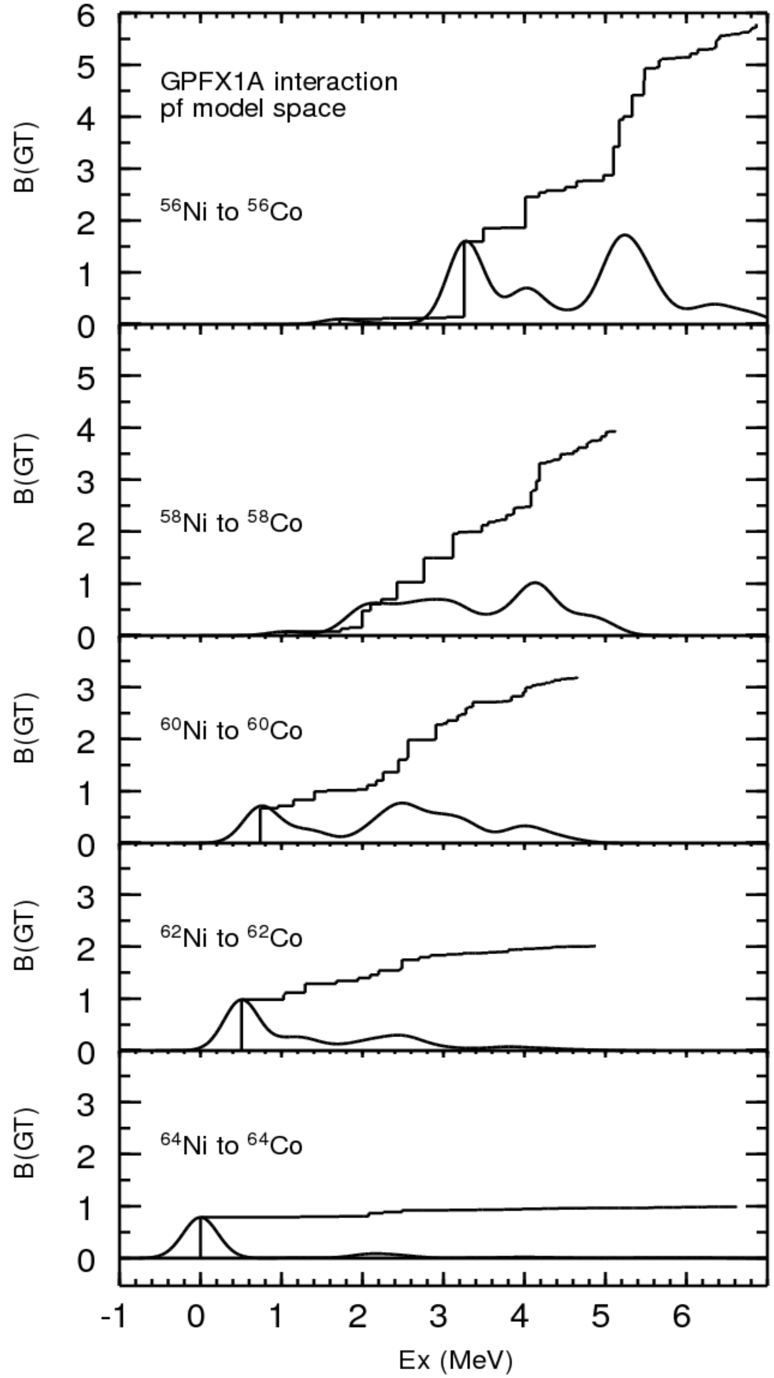
B. Alex Brown, USNDP, BNL, Nov 6, 2008



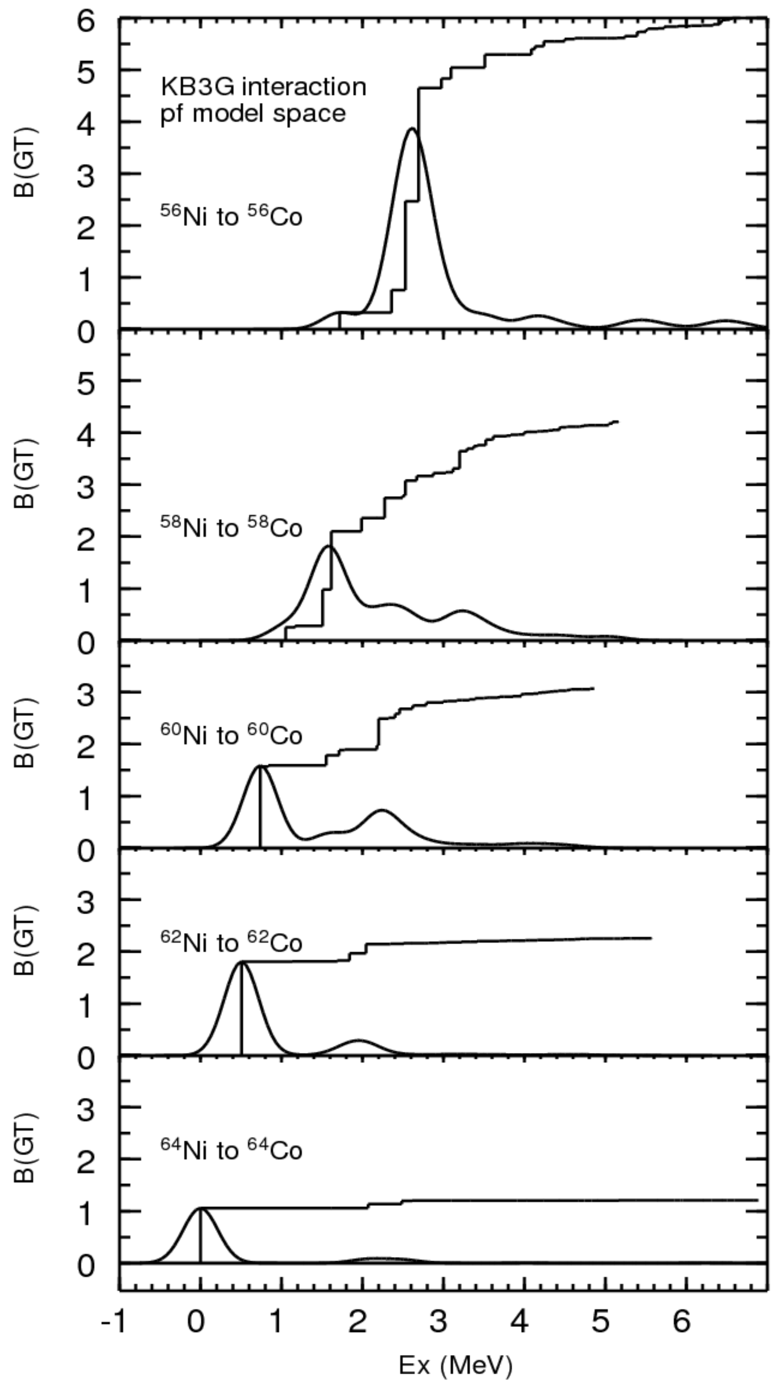
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
B(GT)
-1
0
1
2
3
4
Ex (MeV)
^{62}Fe to ^{62}Co
GPFX1A interaction
full pf model space
Global quenching factor of 0.6
1990
calculation
Exp beta decay
NuShellx full pf



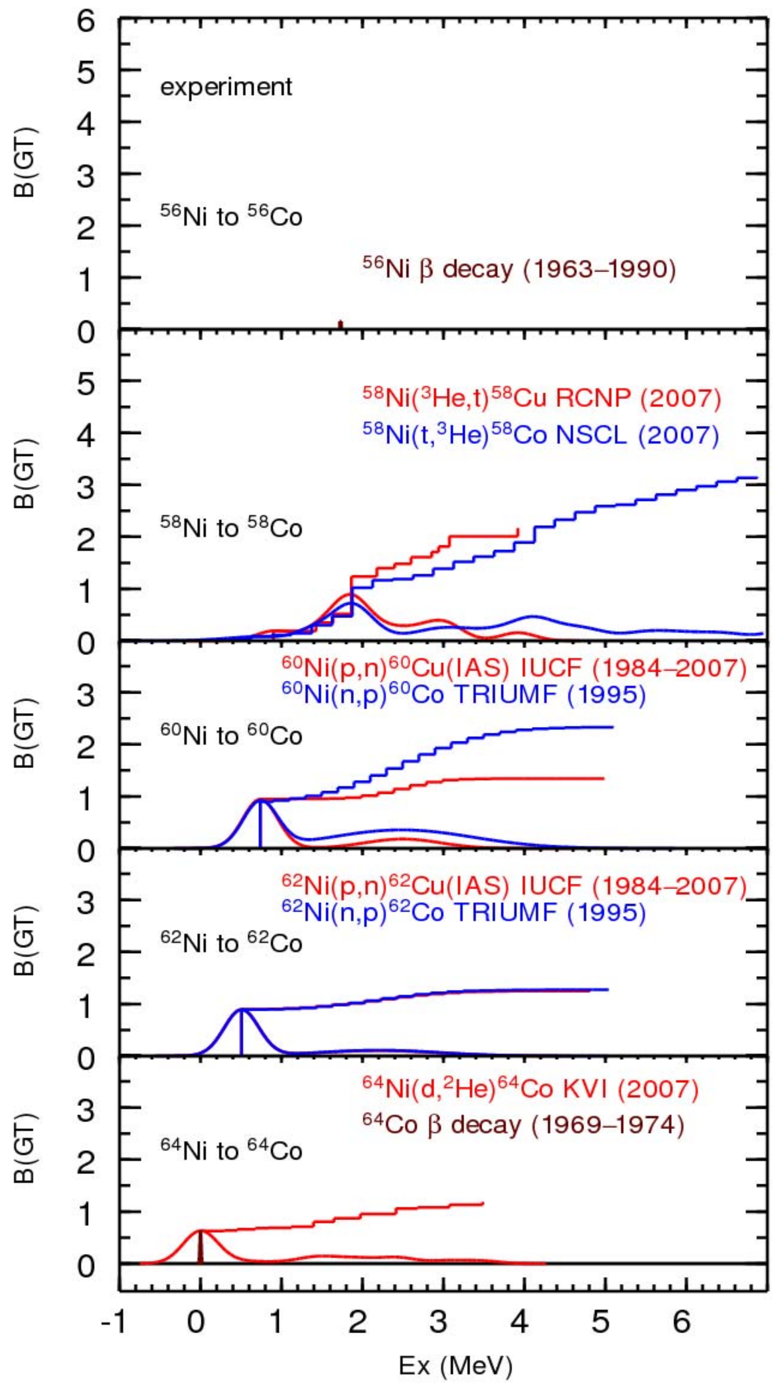
B(GT) for electron capture for Ni to Co

NuShellx t=6

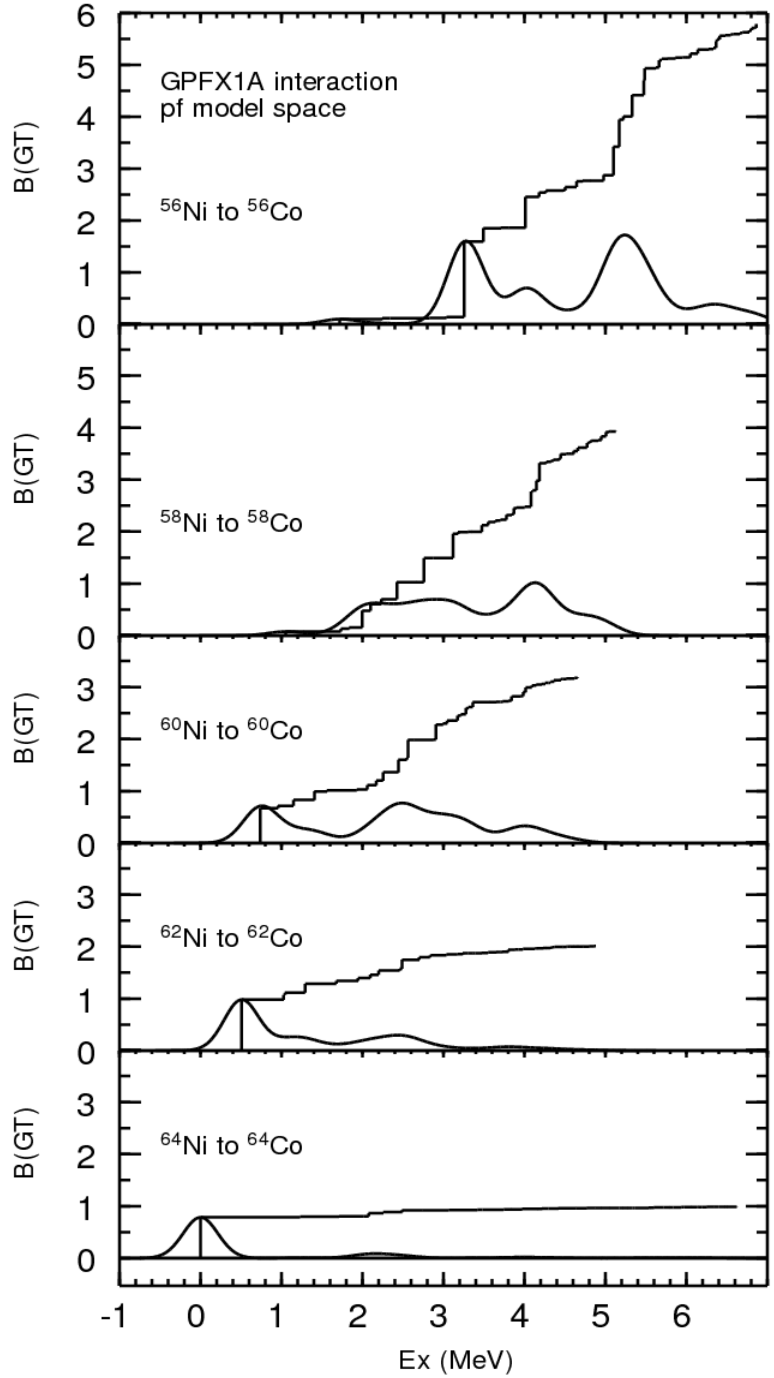
B(GT) for electron capture for Ni to Co



NuShellx t=6

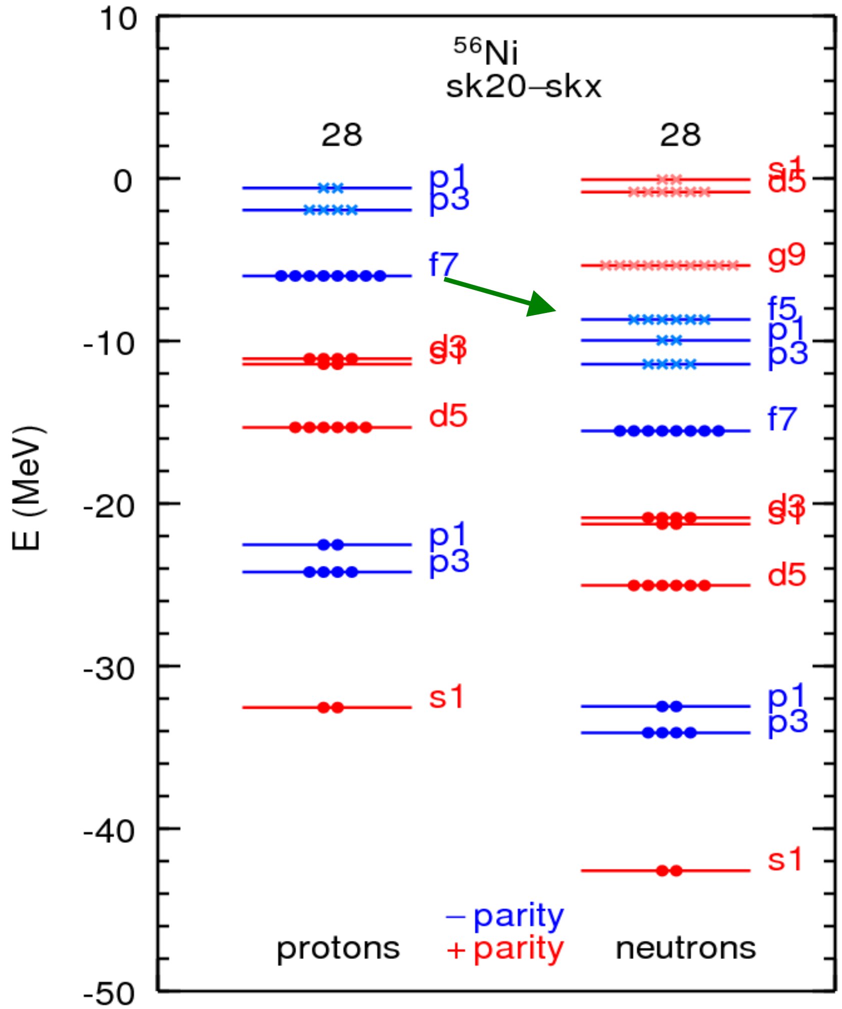


experiment
^{56}Ni to ^{56}Co
^{56}Ni β decay (1963–1990)
^{58}Ni(^{3}He,t)^{58}Cu RCNP (2007)
^{58}Ni(t,^{3}He)^{58}Co NSCL (2007)
^{58}Ni to ^{58}Co
^{60}Ni(p,n)^{60}Cu(IAS) IUCF (1984–2007)
^{60}Ni(n,p)^{60}Co TRIUMF (1995)
^{60}Ni to ^{60}Co
^{62}Ni(p,n)^{62}Cu(IAS) IUCF (1984–2007)
^{62}Ni(n,p)^{62}Co TRIUMF (1995)
^{62}Ni to ^{62}Co
^{64}Ni(d,^{2}He)^{64}Co KVI (2007)
^{64}Co β decay (1969–1974)
^{64}Ni to ^{64}Co
B(GT)
Ex (MeV)

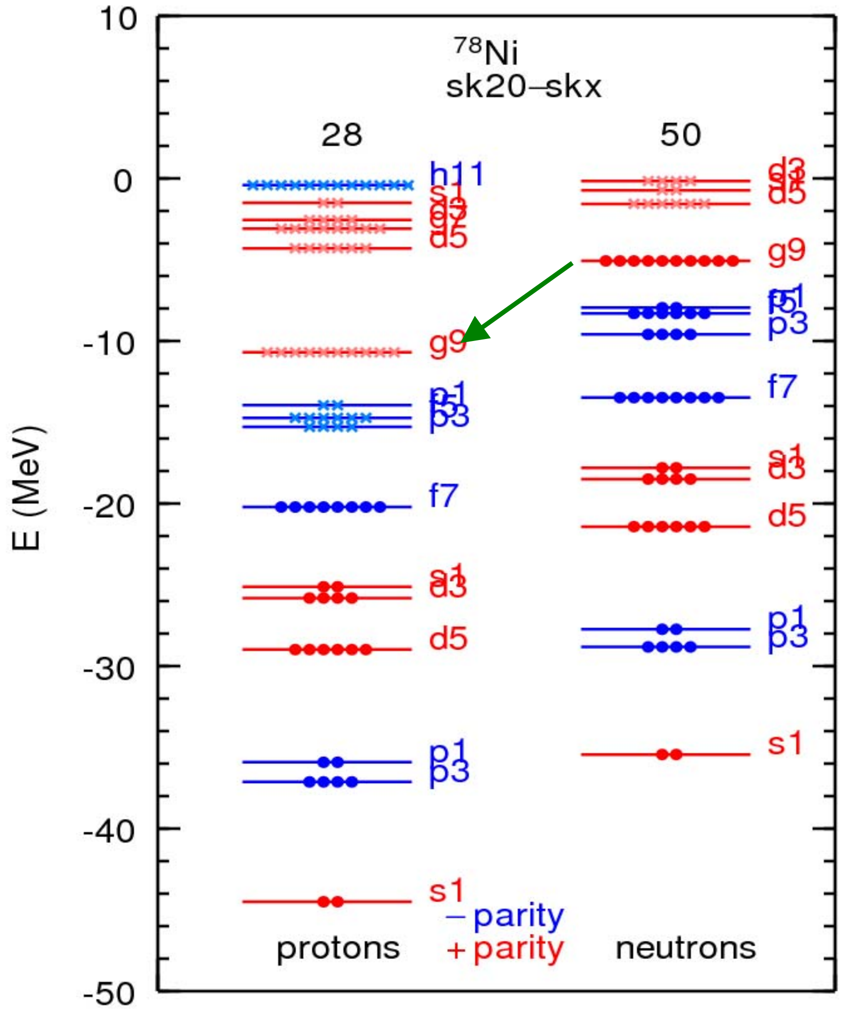


GPFX1A interaction
pf model space
^{56}Ni to ^{56}Co
^{58}Ni to ^{58}Co
^{60}Ni to ^{60}Co
^{62}Ni to ^{62}Co
^{64}Ni to ^{64}Co
B(GT)
Ex (MeV)

NuShellx t=6

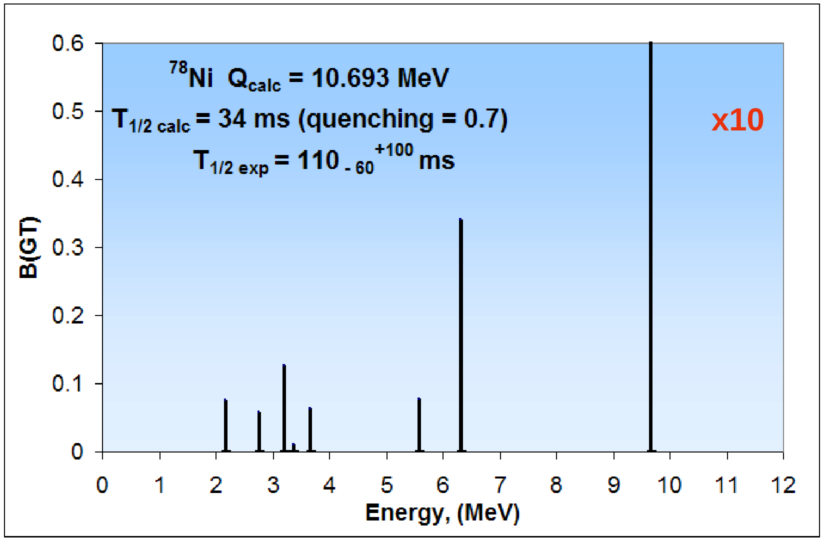


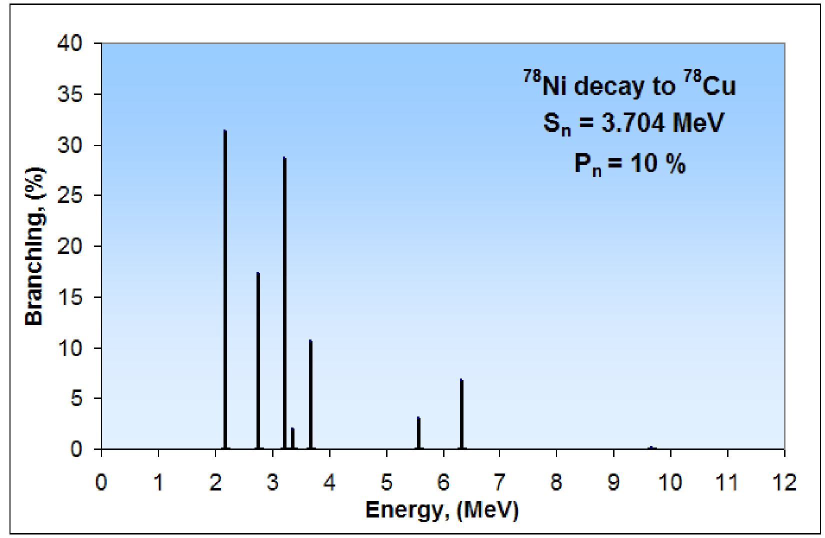
^{56}Ni
sk20–skx
28
28
E (MeV)
10
0
-10
-20
-30
-40
-50
p1
p3
f7
d3
s1
d5
p1
p3
s1
s1
d5
g9
f5
p1
p3
f7
d3
s1
d5
p1
p3
s1
– parity
+ parity
protons
neutrons

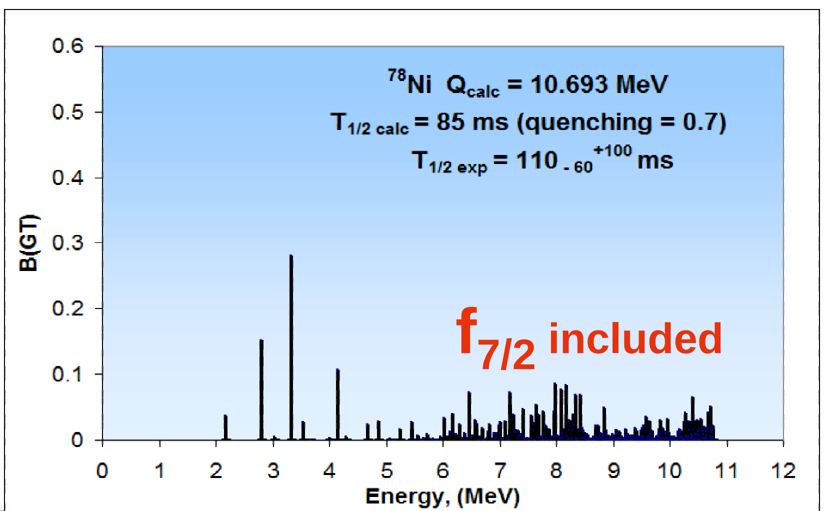


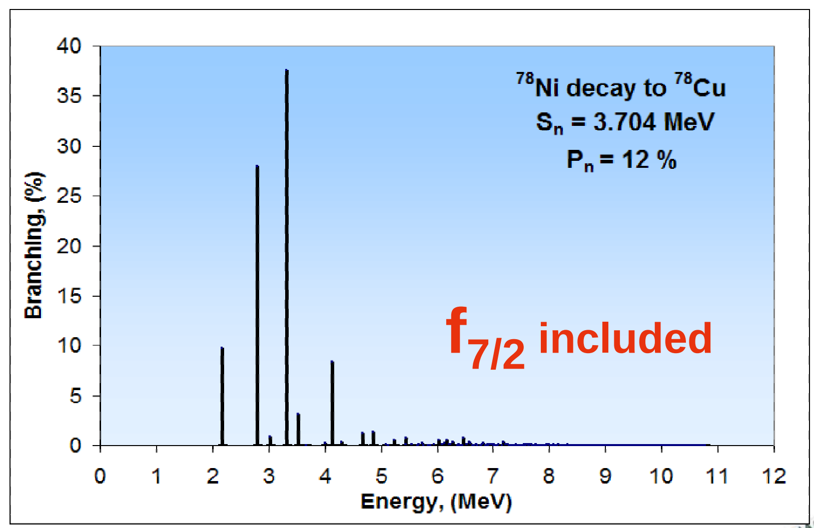
^{78}Ni
sk20–skx
28
50
h11
s1
d3
g7
d5
g9
p1
f5
p3
f7
s1
d3
d5
p1
p3
s1
d3
s1
g7
d5
g9
p1
f5
p3
f7
s1
d3
d5
p1
p3
s1
– parity
+ parity
protons
neutrons
E (MeV)
10
0
-10
-20
-30
-40
-50

^{78}Ni: beta-decay (Lisetsky)









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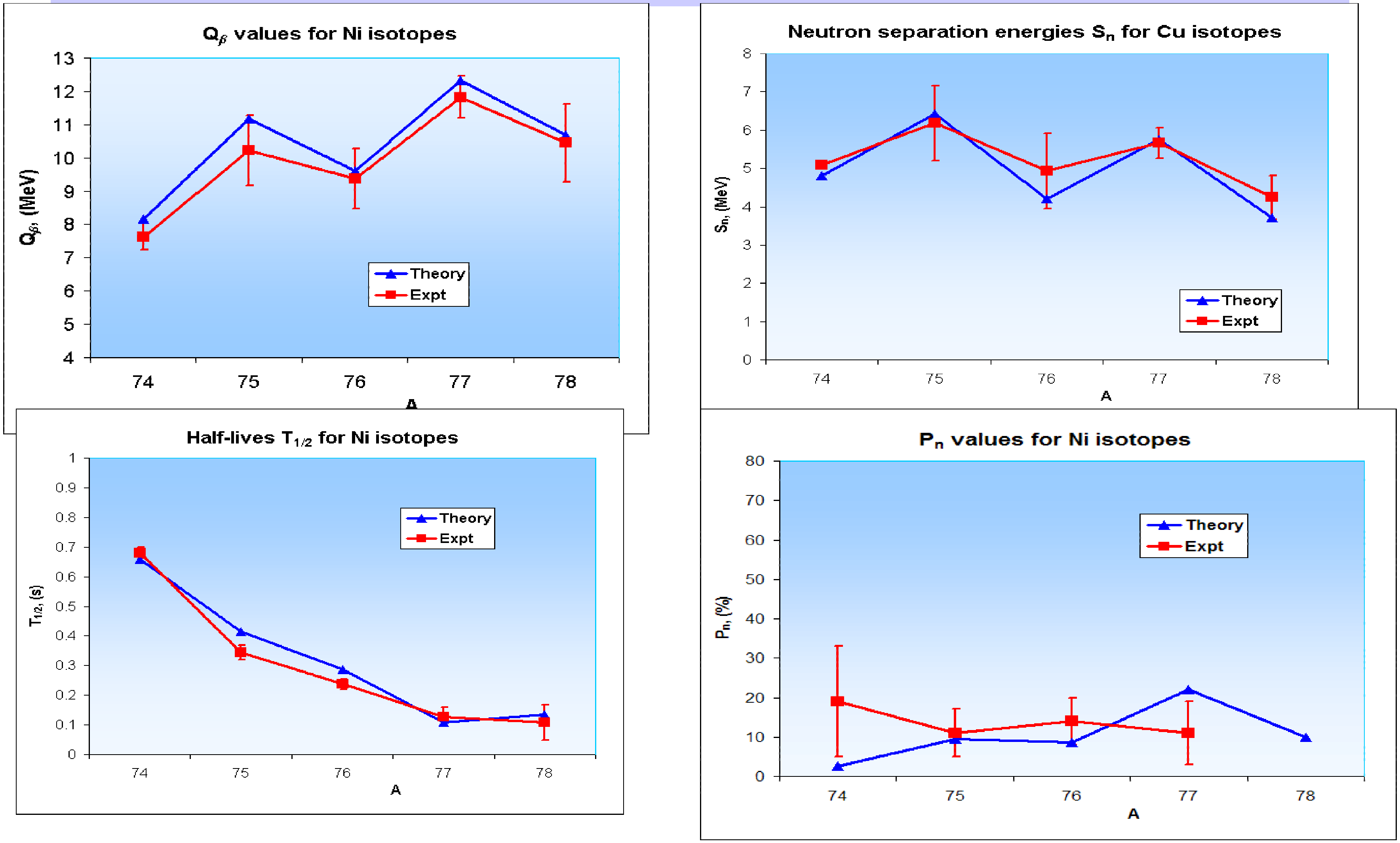
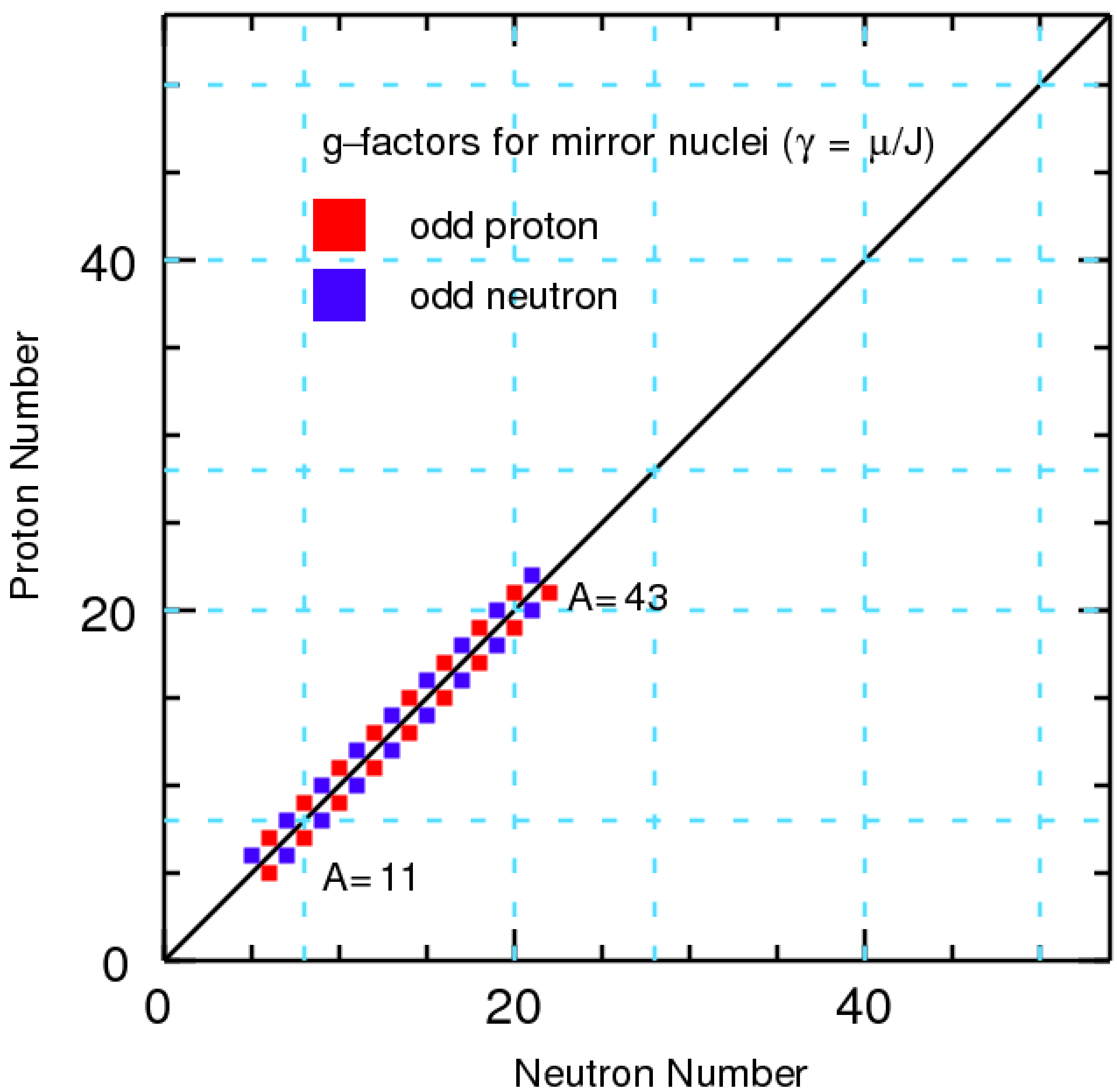
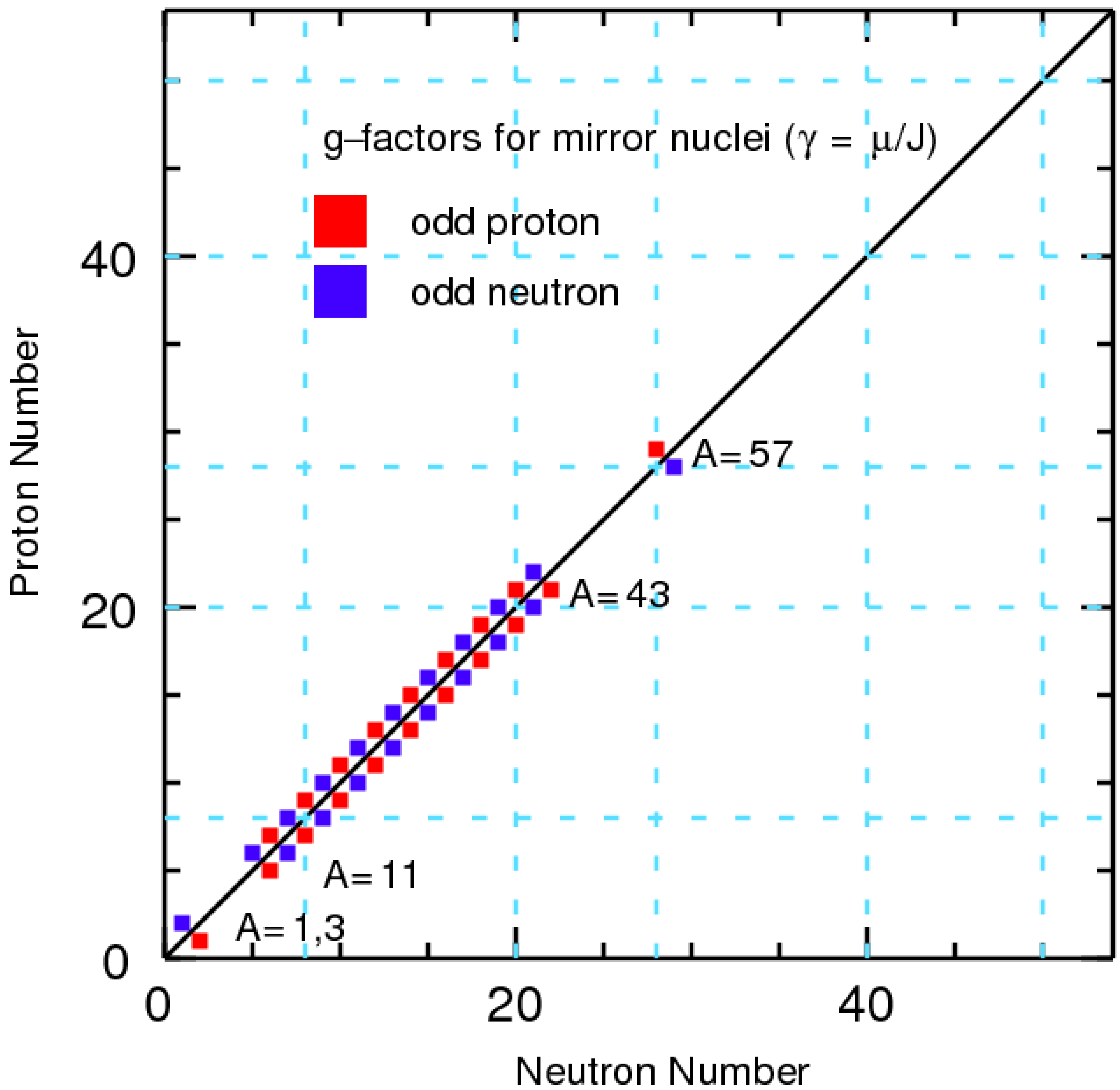
Ni: Beta-decay results (Lisetsky)

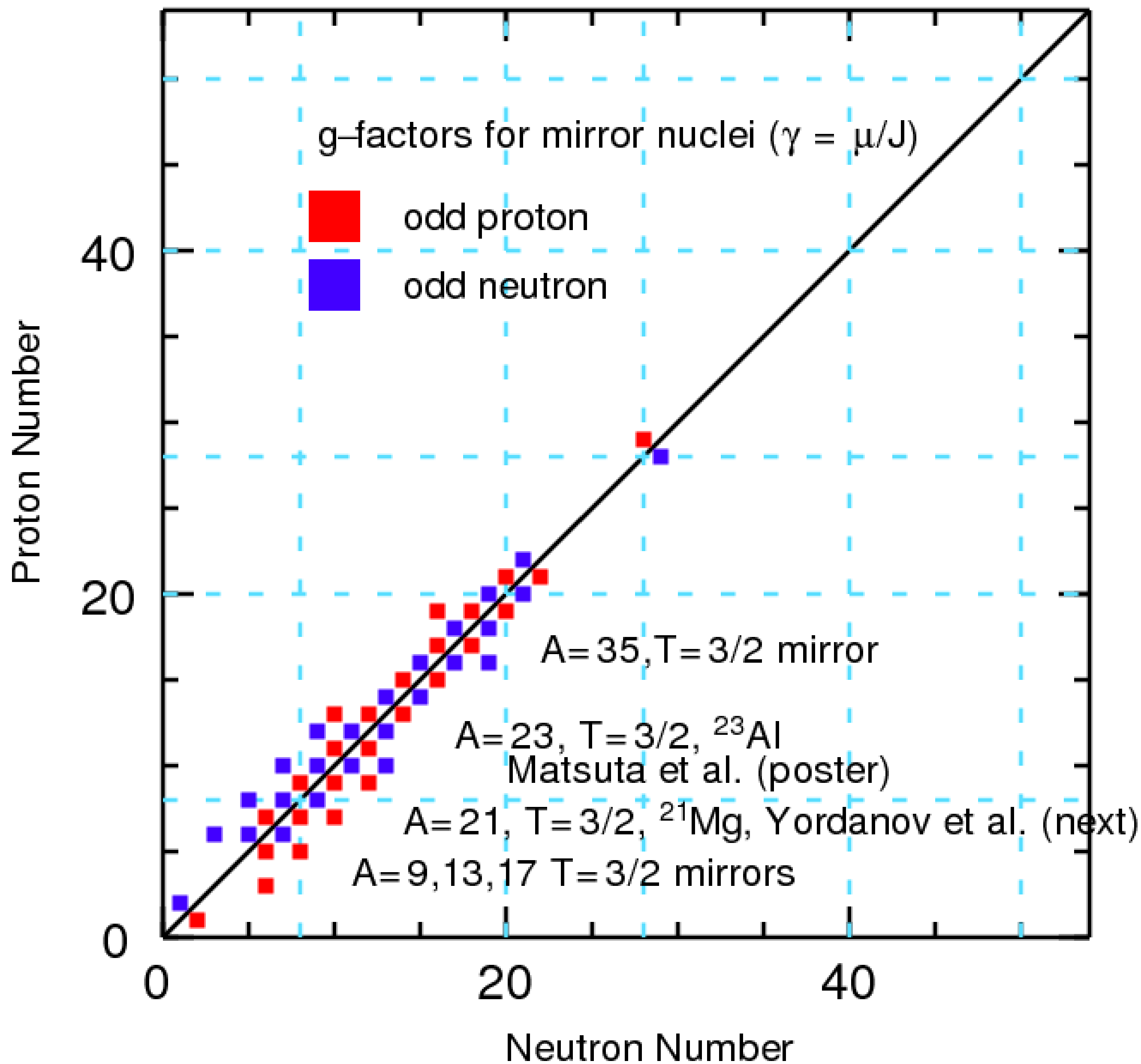


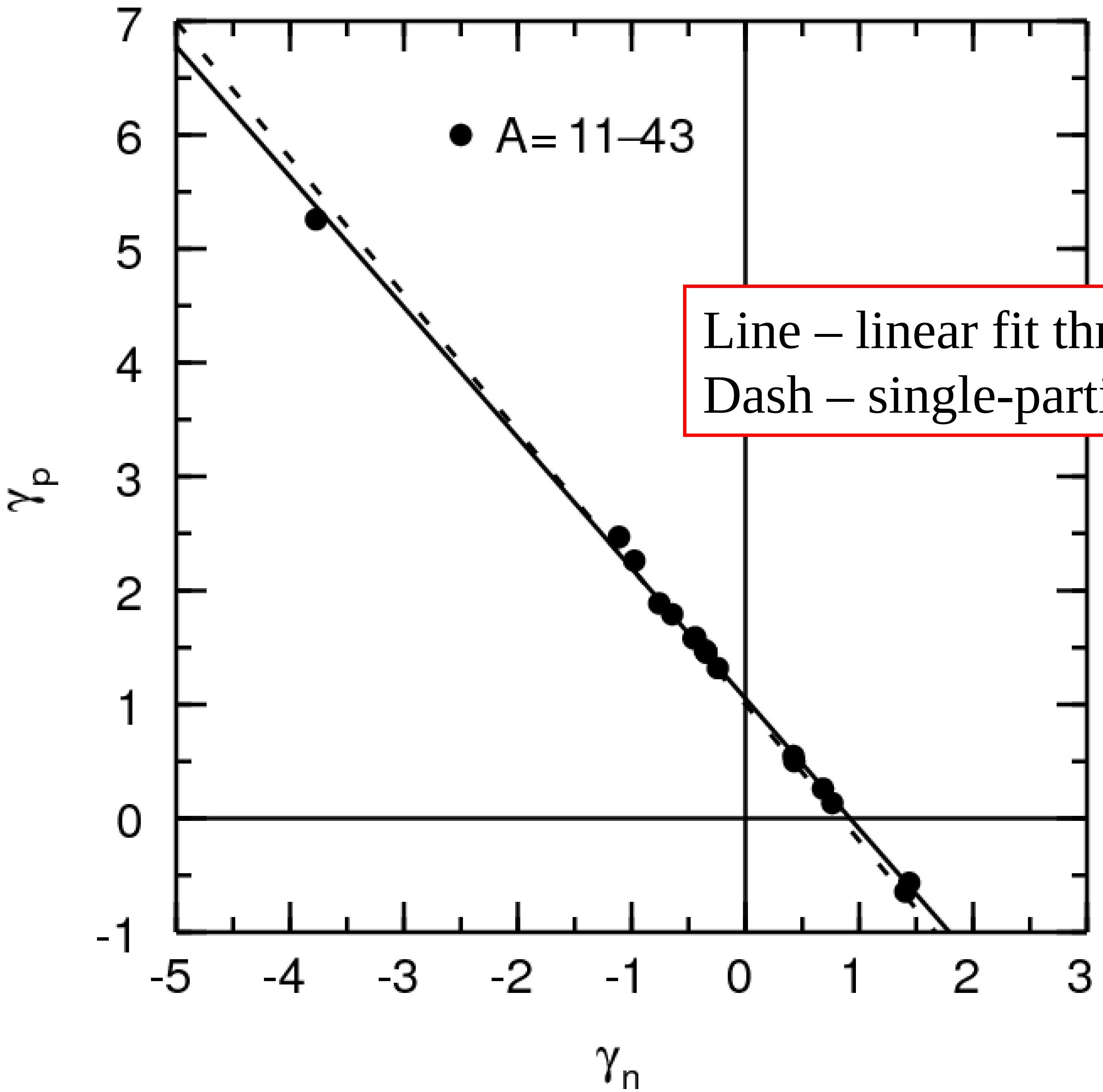
P. T. Hosmer et al., PRL 94, 112501 (2005)


g–factors for mirror nuclei (γ = μ/J)
odd proton
odd neutron
A= 43
A= 11
Proton Number
Neutron Number
0
20
40
0
20
40

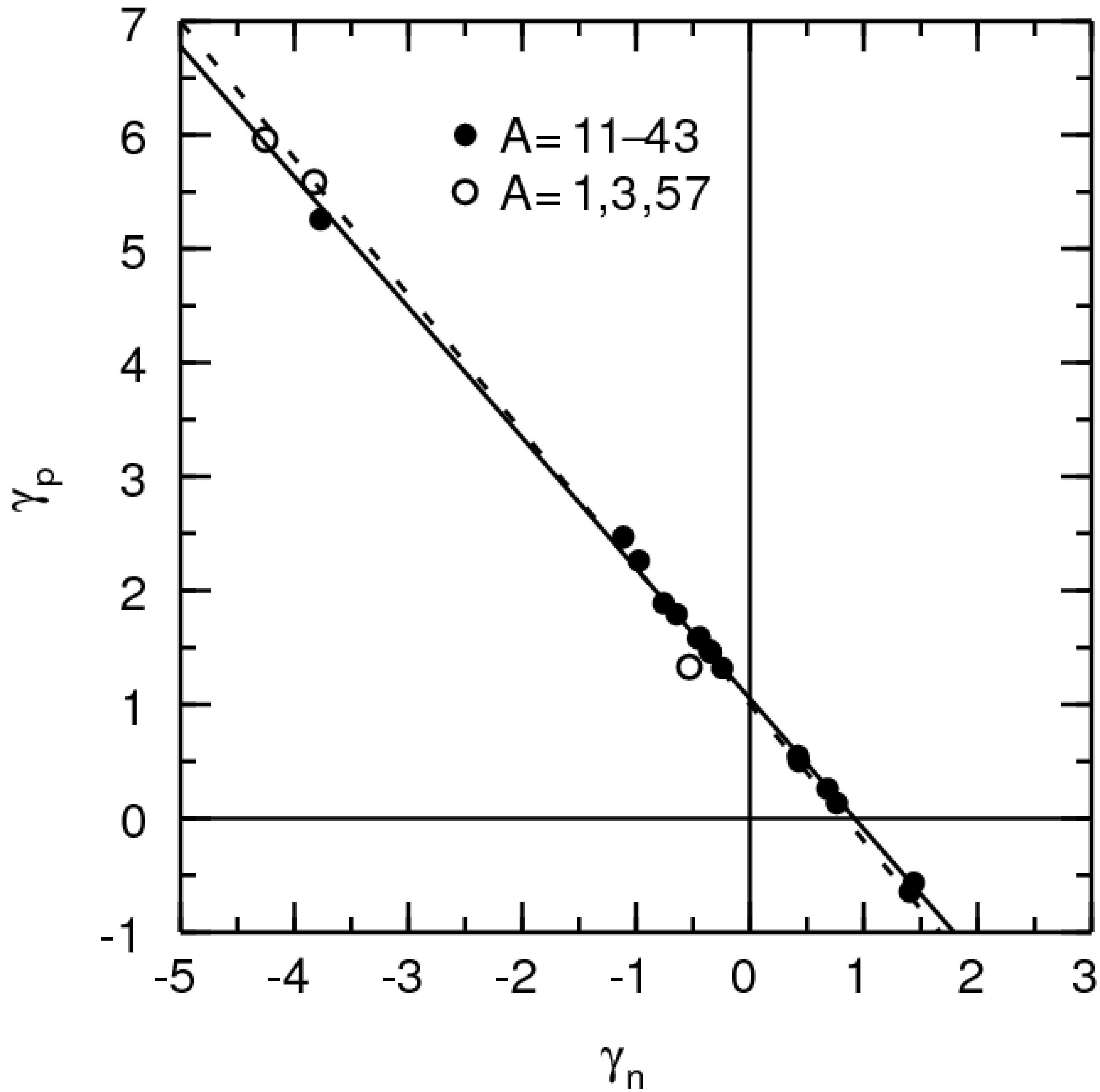


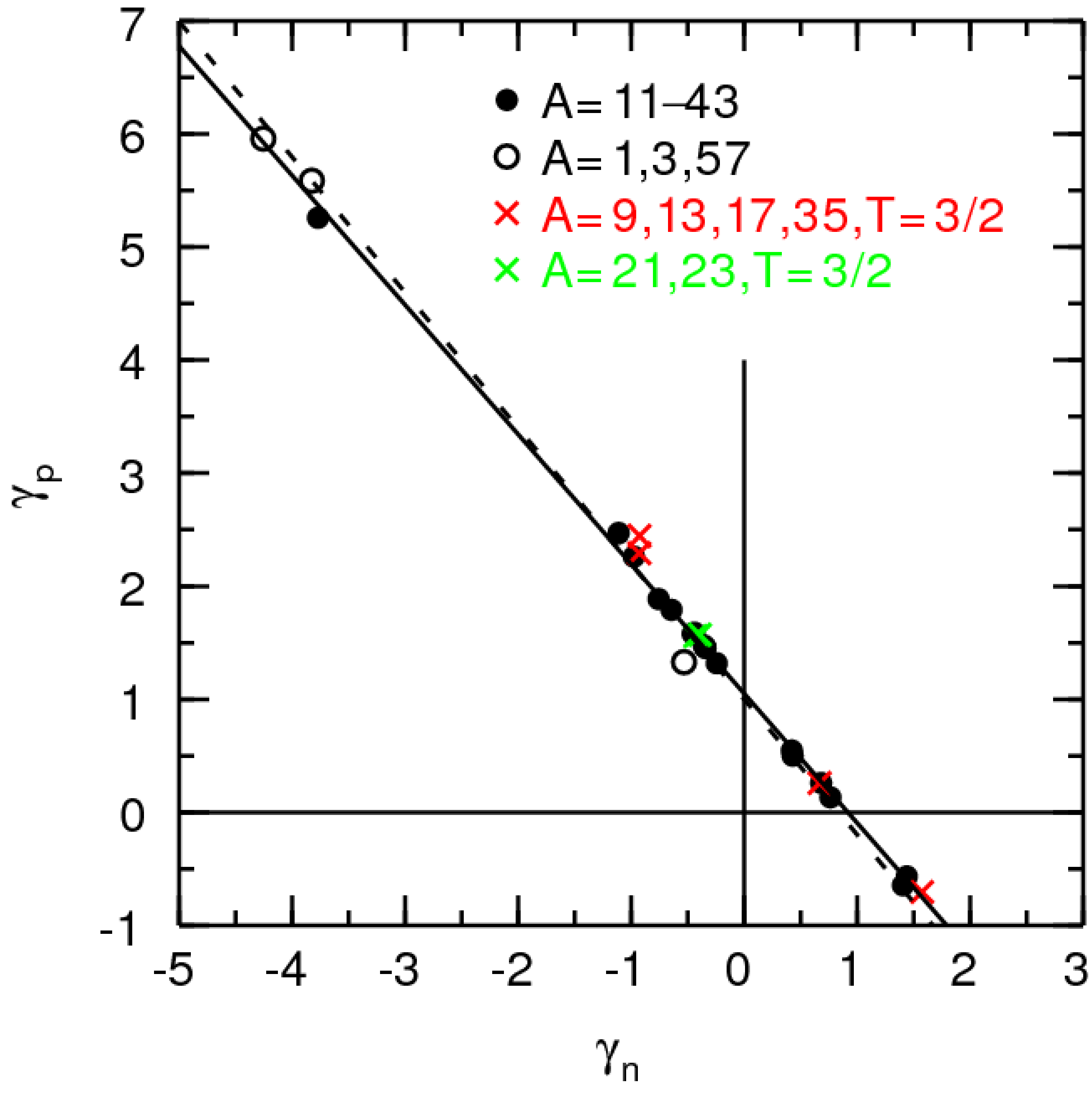
g–factors for mirror nuclei (γ = μ/J)
odd proton
odd neutron
A=57
A=43
A=11
A=1,3
Proton Number
Neutron Number
0
20
40


g–factors for mirror nuclei (γ = μ/J)
odd proton
odd neutron
A=35,T=3/2 mirror
A=23, T=3/2, 23Al
Matsuta et al. (poster)
A=21, T=3/2, 21Mg, Yordanov et al. (next)
A=9,13,17 T=3/2 mirrors
Proton Number
Neutron Number
0
20
40
0
20
40



Line – linear fit through data
Dash – single-particle value


A= 11–43
A= 1,3,57
γp
γn
7
6
5
4
3
2
1
0
-1
-5
-4
-3
-2
-1
0
1
2
3



A= 11–43
A= 1,3,57
A= 9,13,17,35,T= 3/2
A= 21,23,T= 3/2
γ_p
γ_n

Phys. Rev. C 77, 064311 (2008)

Correlations between magnetic moments and beta decay

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New Look at Magnetic Moments and Beta Decays of Mirror Nuclei

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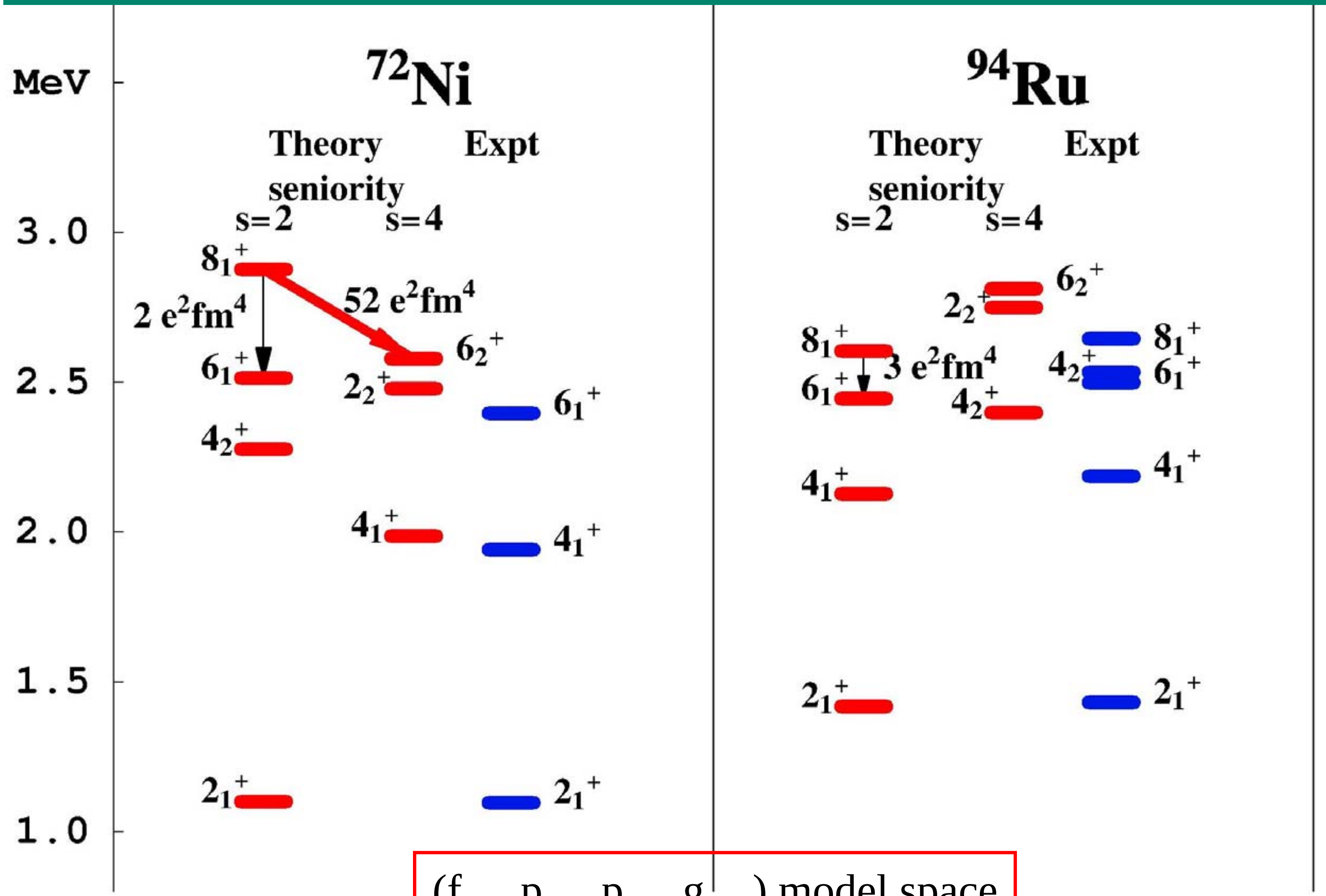
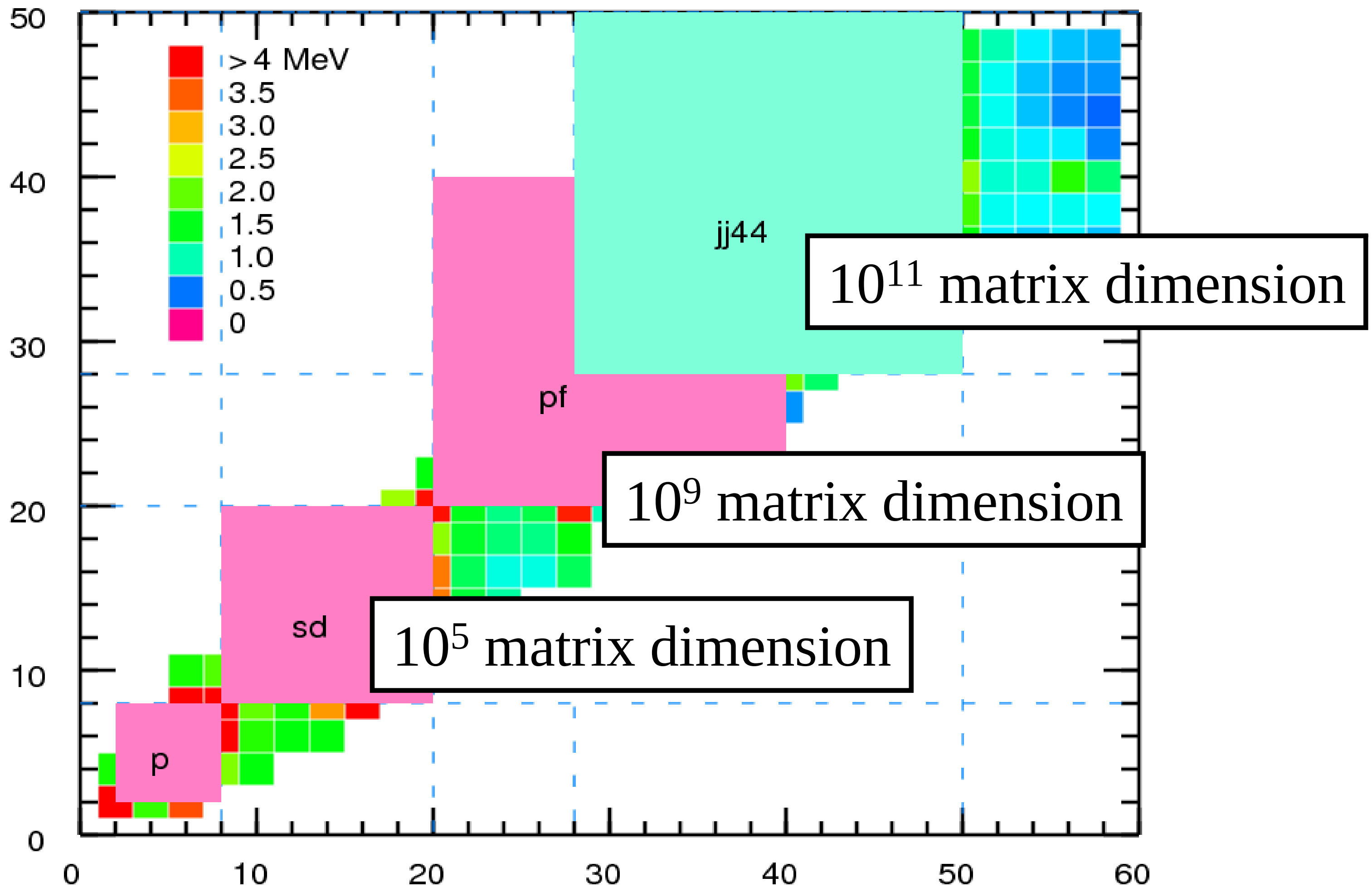
Faded seniority isomerism near ^{78}Ni

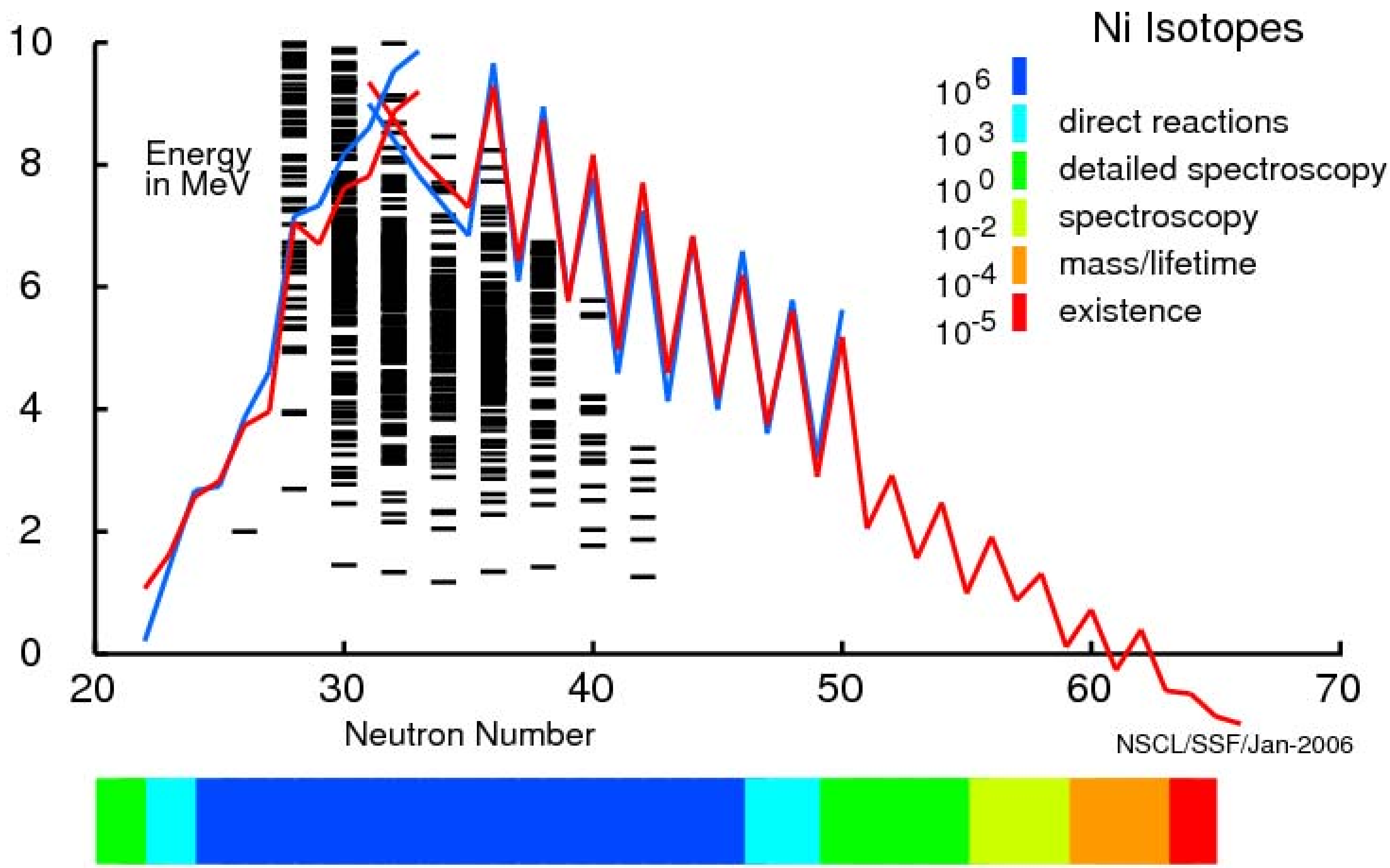


(f $_{5/2}$ p $_{3/2}$ p $_{1/2}$ g $_{9/2}$) model space

A. Lisetskiy et al., PRC 70, 044312 (2004)



jj44 means $f_{5/2}$, $p_{3/2}$, $p_{1/2}$, $g_{9/2}$ orbits for protons and neutrons



Ni Isotopes
10
8
6
4
2
0
20
30
40
50
60
70
Energy in MeV
Neutron Number
10^6
10^3
10^0
10^{-2}
10^{-4}
10^{-5}
direct reactions
detailed spectroscopy
spectroscopy
mass/lifetime
existence
NSCL/SSF/Jan-2006