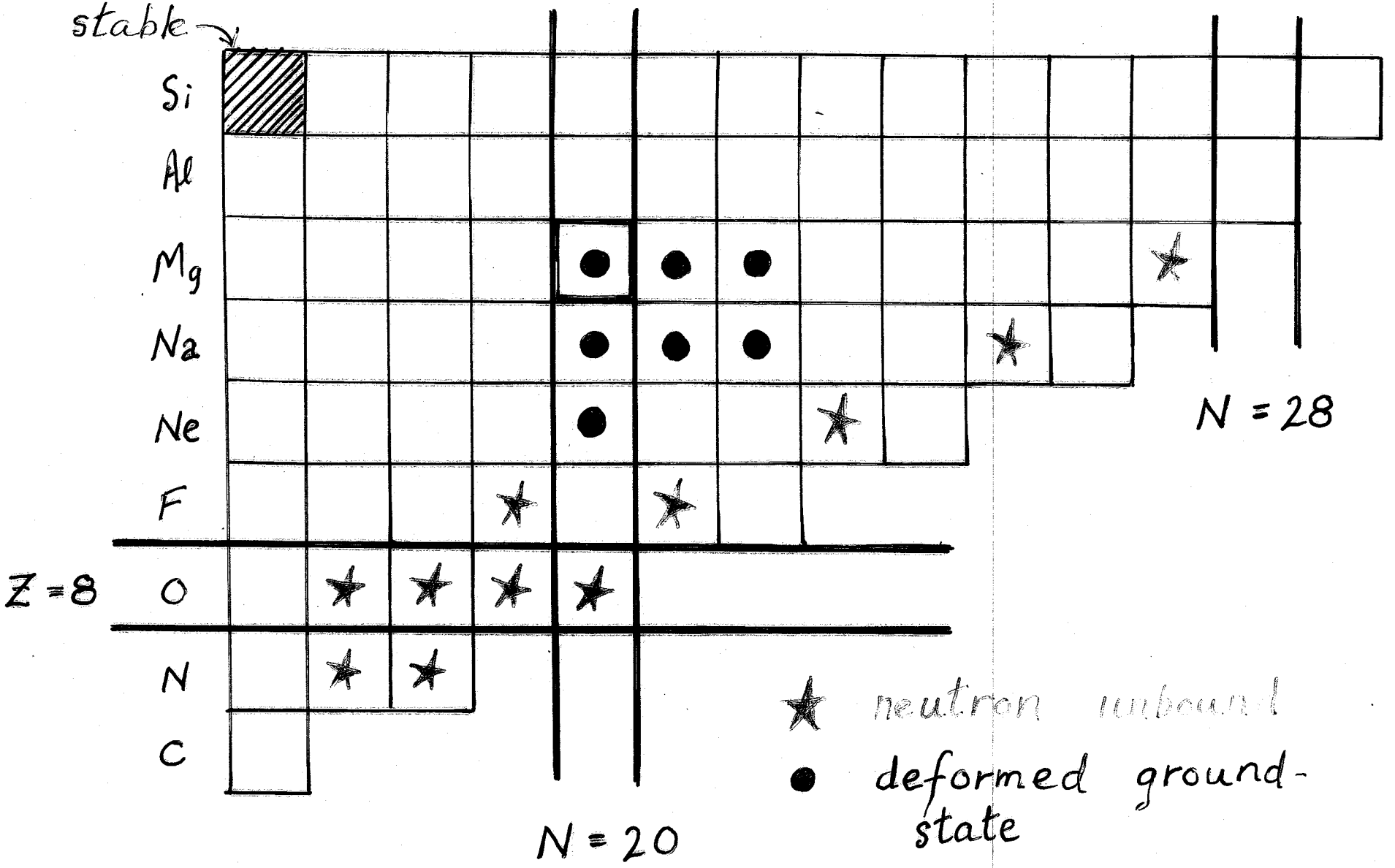
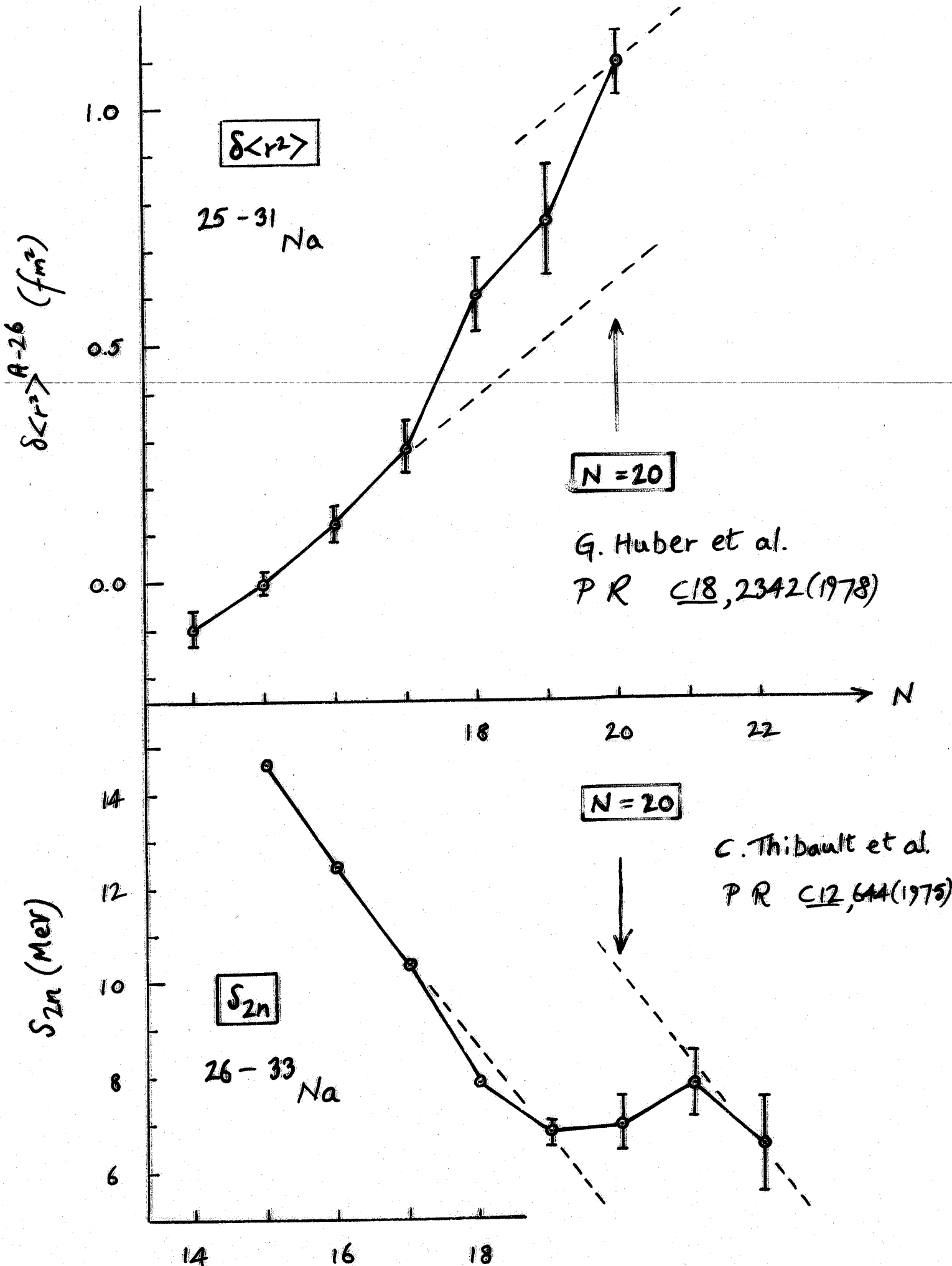
Shape Coexistence in Neutron-Rich Nuclei

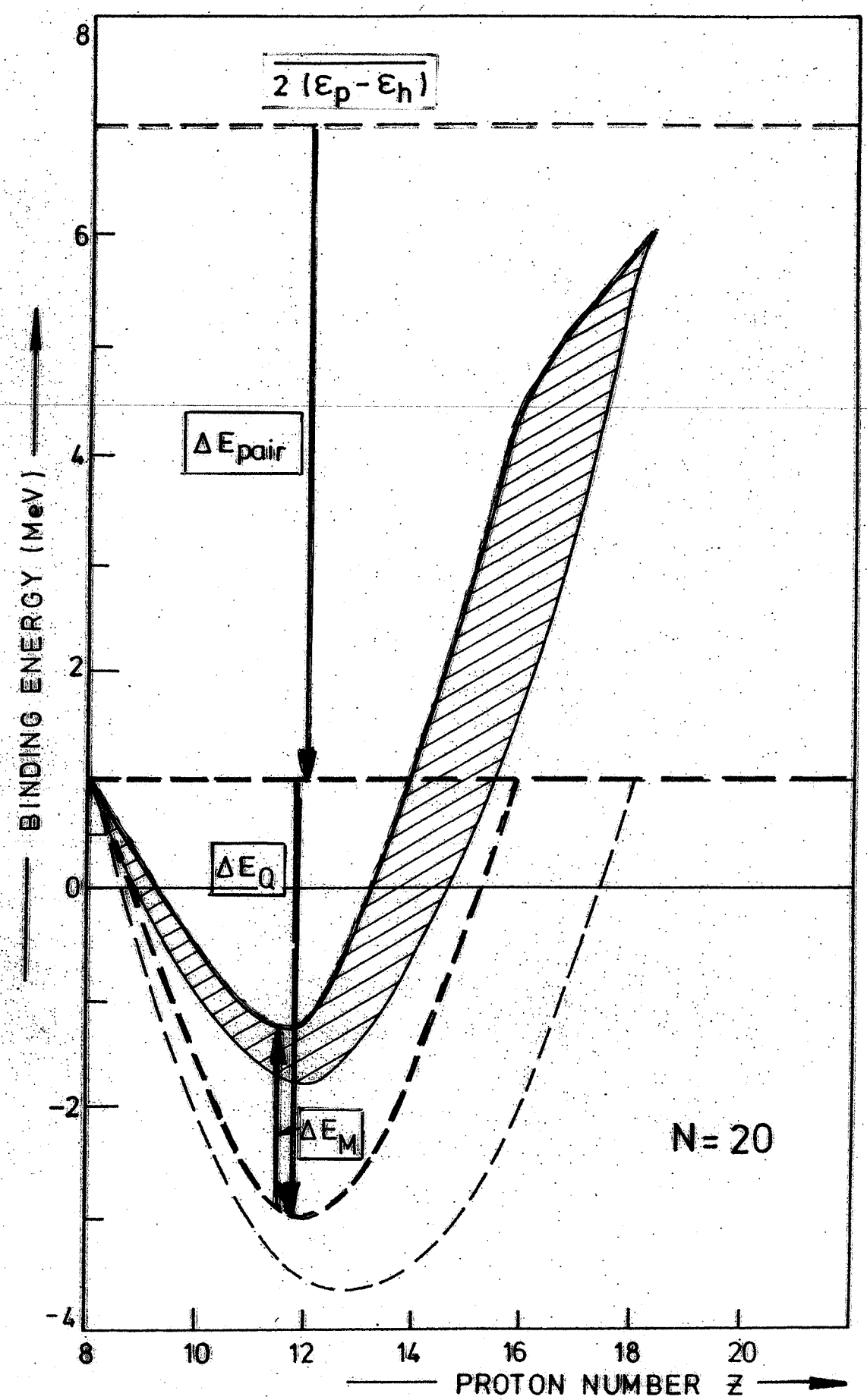
- $N \sim 20$ and ^{32}Mg
- $Z \sim 28$ and ^{68}Ni
- $N \sim 50$ and ^{78}Ni
- $Z \sim 40$ and ^{100}Zr
- $Z \sim 50$ and Cd, Pd isotopes

  - Shells and Subshells
  - Pairing
  - Monopole shifts
  - Intruder states

The region of deformation near $^{32}_{12}Mg_{20}$

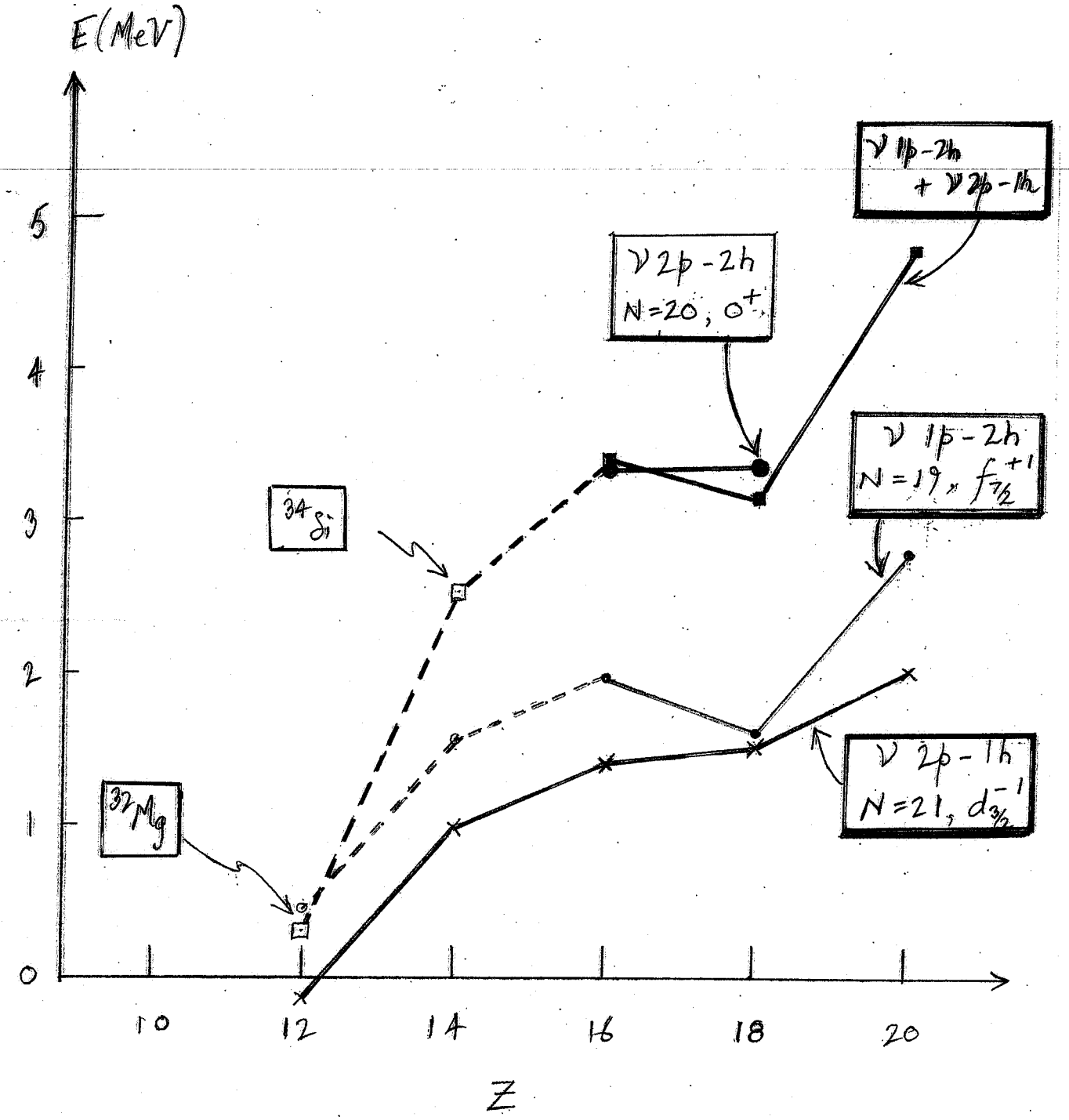


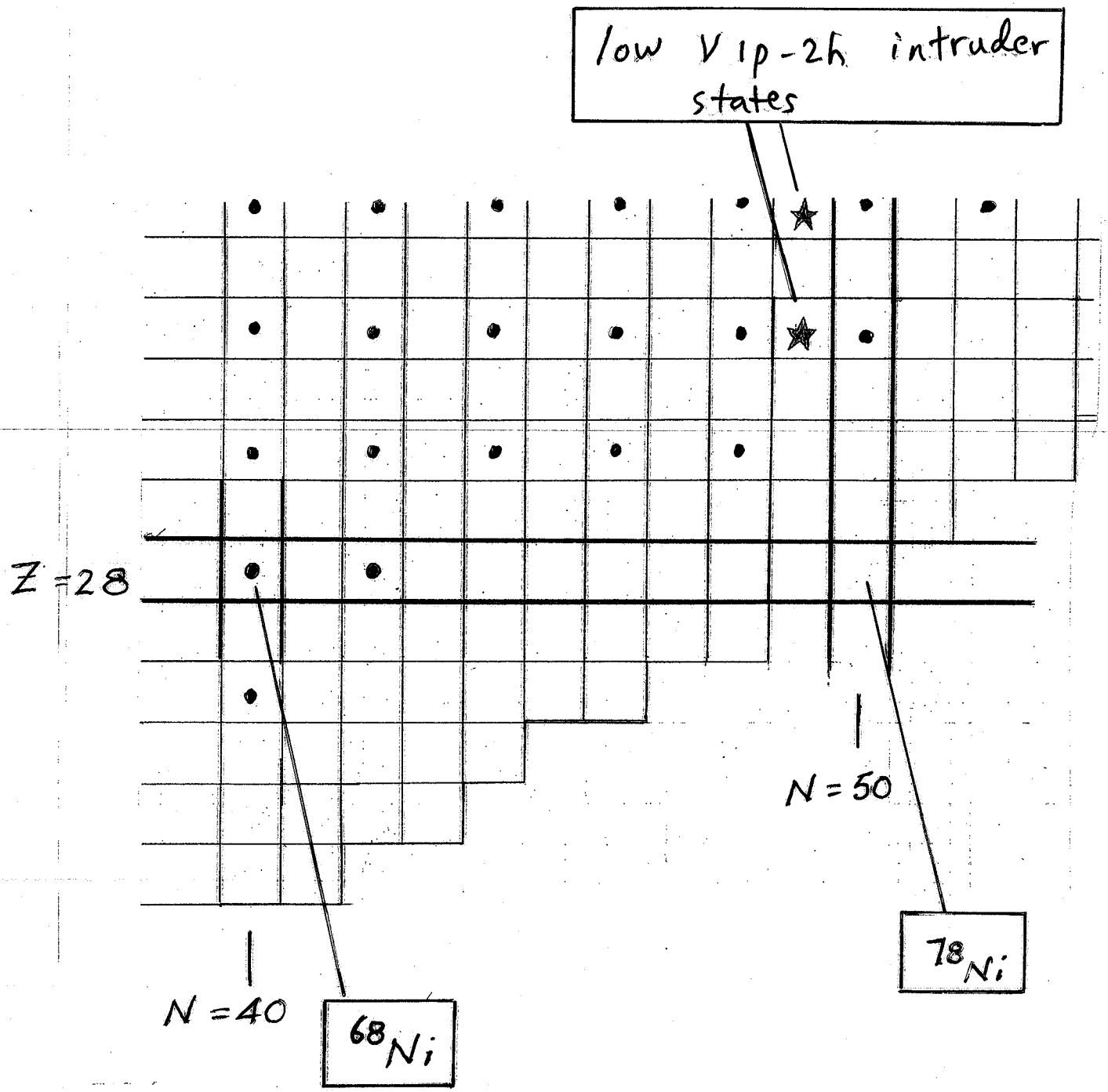

δ<r²>
25 - 31 Na
δ<r²>A-26 (fm²)
1.0
0.5
0.0
N = 20
G. Huber et al.
P R C18, 2342 (1978)
N
18
20
22
14
12
10
8
6
S2n (MeV)
S2n
26 - 33 Na
N = 20
C. Thibault et al.
P R C12, 644 (1975)
14
16
18



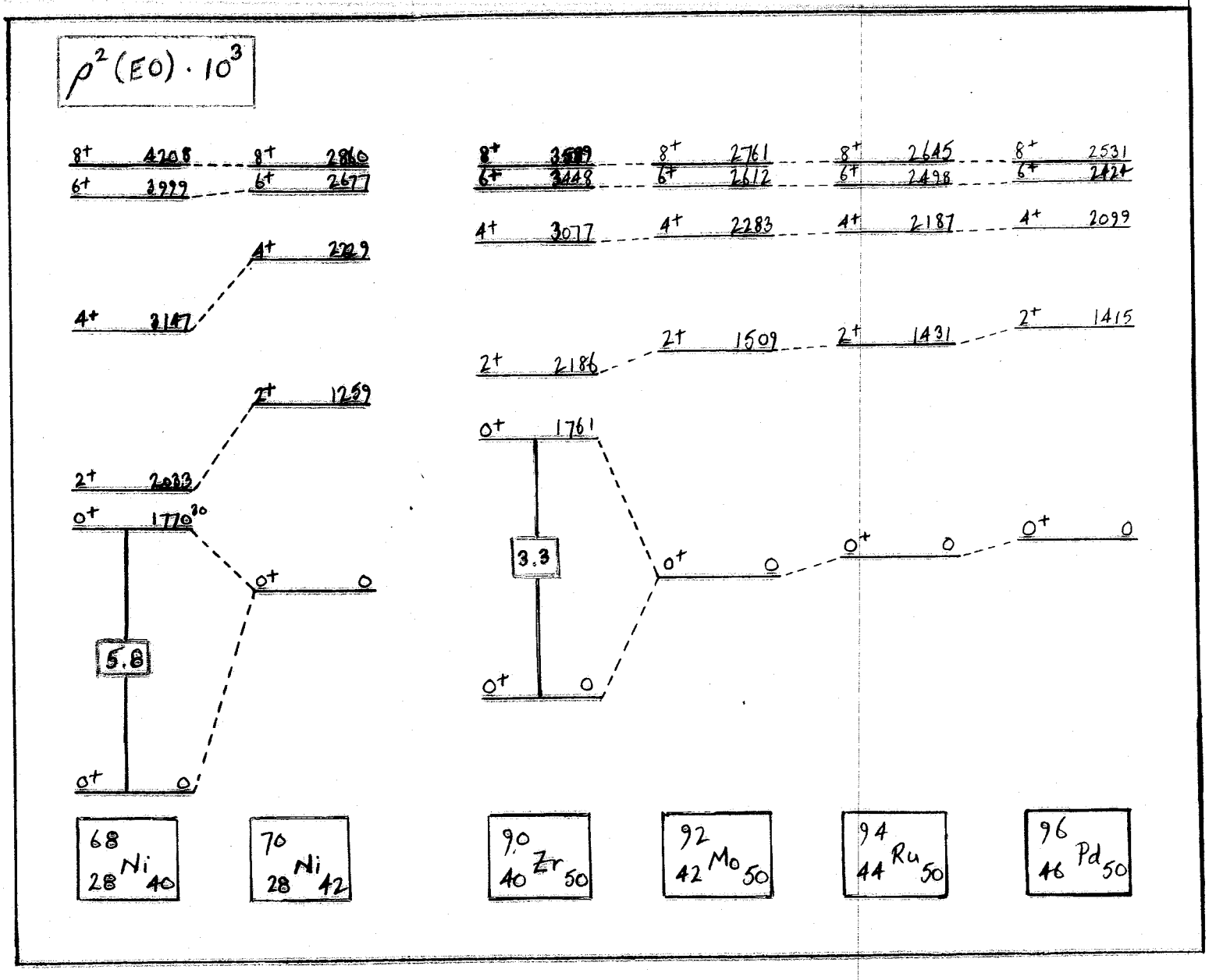
K. Heyde and JW, J. Phys. G 17, 135 (1991).

Estimate of Deformed ν 2p-2h State Energy in N = 20 Isotones from N = 19, 21 $f_{7/2}^{+1}$, $d_{3/2}^{-1}$ Intruder States

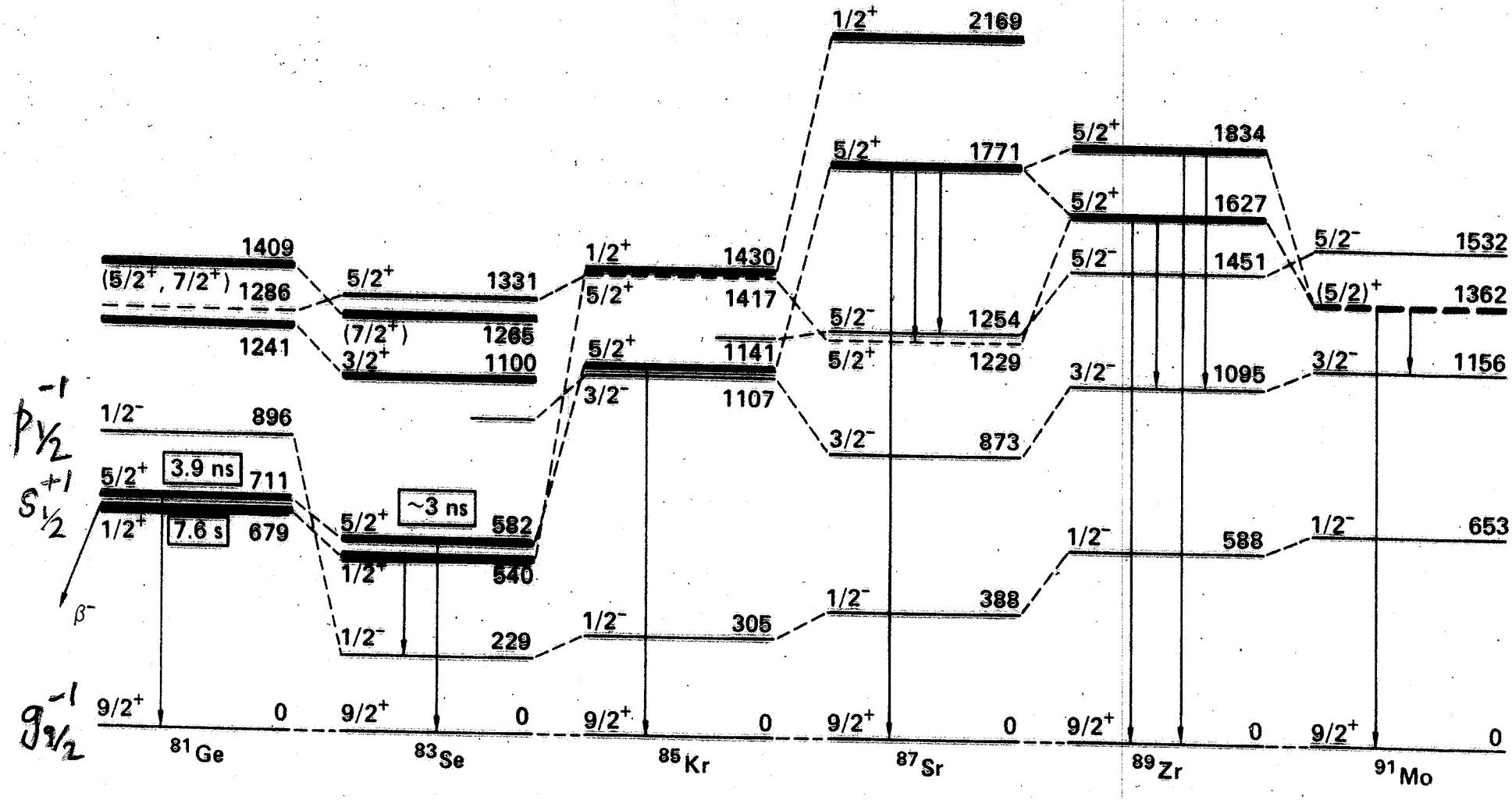




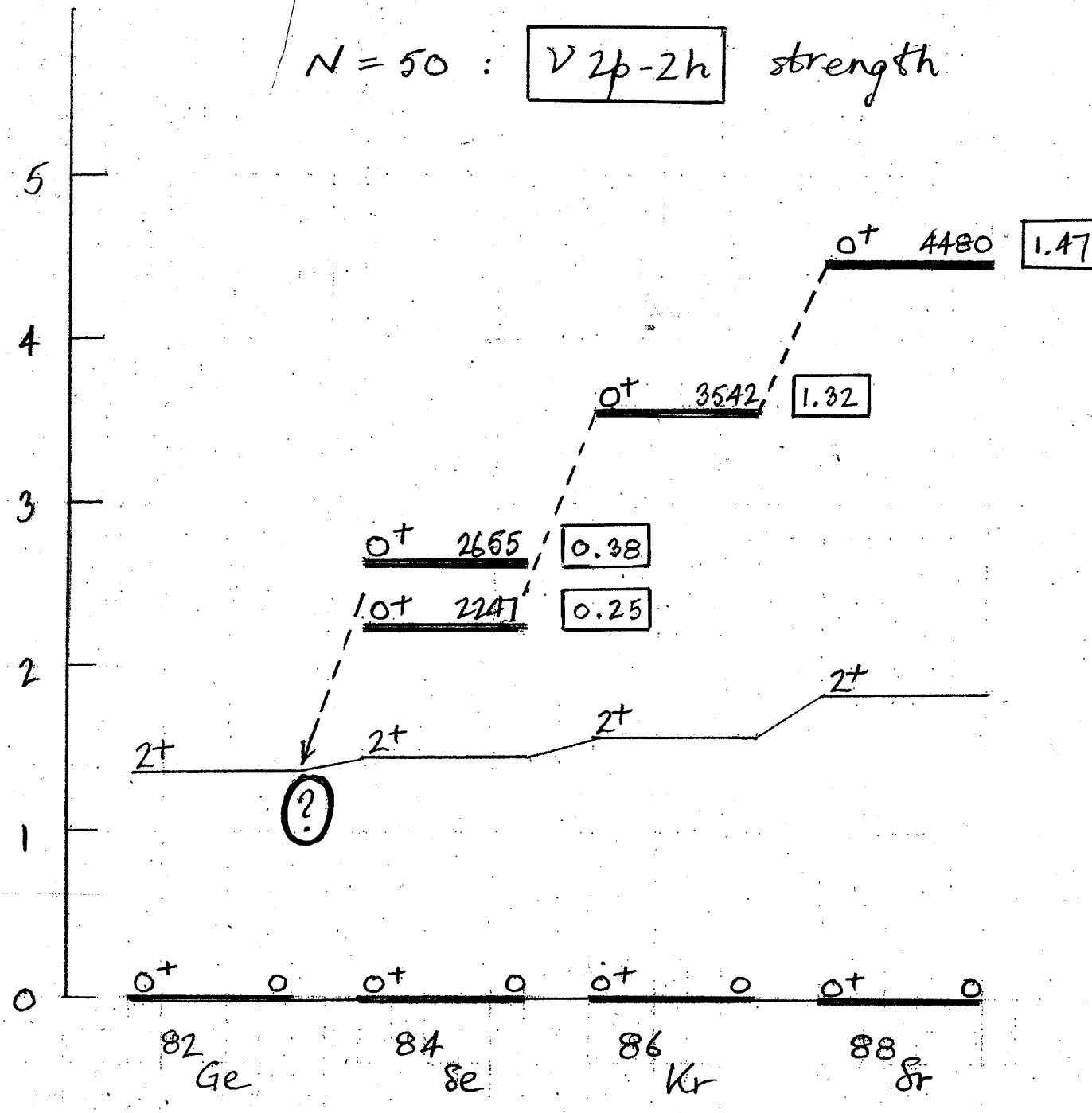
• $E(2_1^+)$ measured



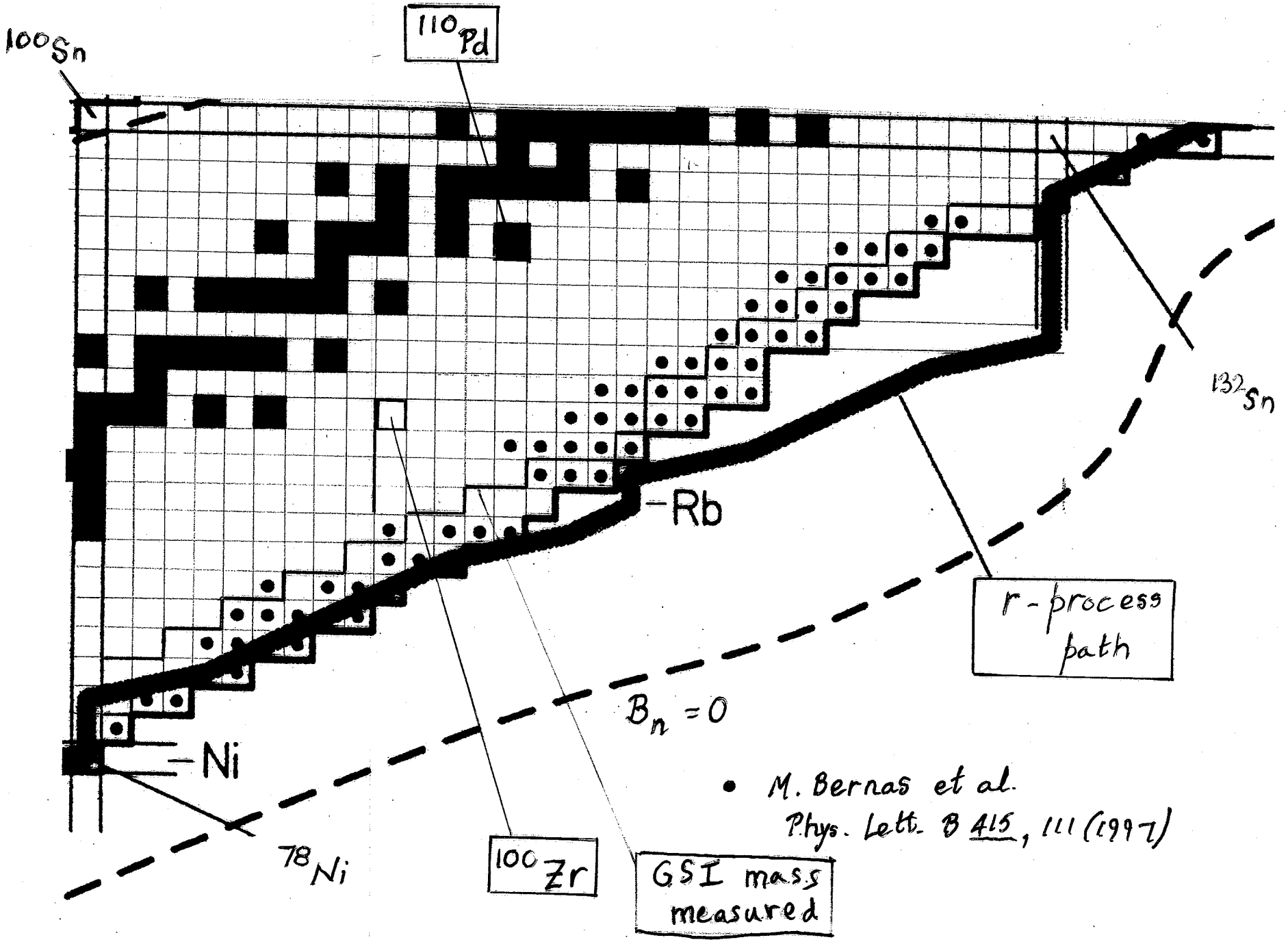
$\Rightarrow \quad e_\nu^{eff} \approx e_\pi$

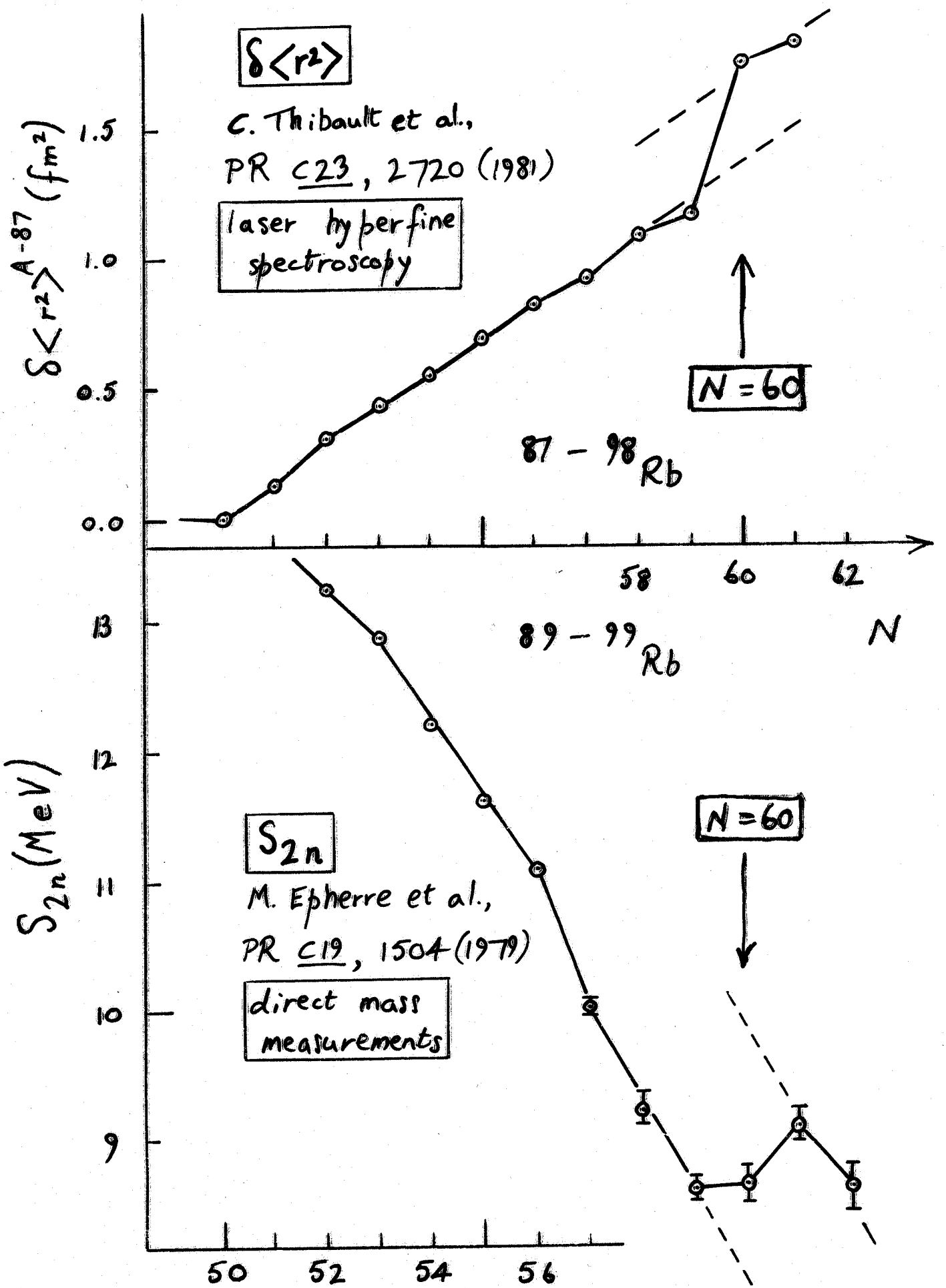

1409
(5/2+, 7/2+) 1286
1241
1/2− 896
5/2+ 3.9 ns 711
1/2+ 7.6 s 679
β−
5/2+ 1331
(7/2+) 1265
3/2+ 1100
5/2+ ~3 ns 582
1/2+ 540
1/2− 229
1/2+ 1430
5/2+ 1417
5/2+ 1141
3/2− 1107
1/2− 305
1/2+ 2169
5/2+ 1771
5/2− 1254
5/2+ 1229
3/2− 873
1/2− 388
5/2+ 1834
5/2+ 1627
5/2− 1451
3/2− 1095
1/2− 588
5/2− 1532
(5/2)+ 1362
3/2− 1156
1/2− 653
9/2+ 0
81Ge
83Se
85Kr
87Sr
89Zr
91Mo
p−1 1/2
s+1 1/2
g−1 9/2

ν 1p-2h

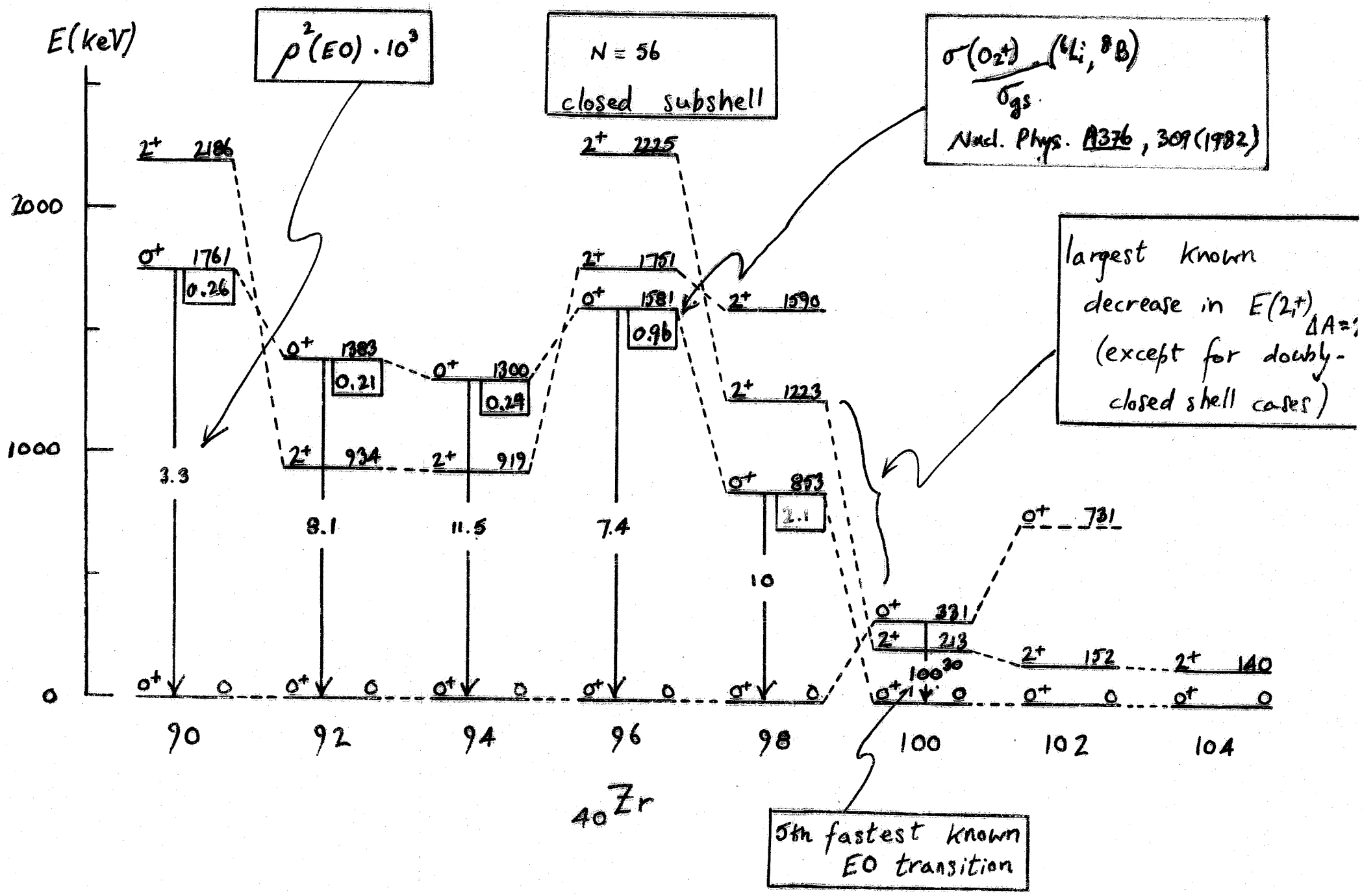


$$\frac{\sigma_{(t,p)}(0^+_{ex})}{\sigma_{(t,p)}(0^+_{gs})}$$


100Sn
110Pd
132Sn
Rb
Ni
78Ni
100Zr
r-process path
Bn = 0
GSI mass measured
• M. Bernas et al.
Phys. Lett. B 415, 111 (1997)


δ⟨r²⟩
C. Thibault et al.,
PR C23, 2720 (1981)
laser hyperfine spectroscopy
N = 60
87 – 98 Rb
δ⟨r²⟩^{A-87} (fm²)
1.5
1.0
0.5
0.0
58
60
62
N
89 – 99 Rb
S2n
M. Epherre et al.,
PR C19, 1504 (1979)
direct mass measurements
N = 60
S2n (MeV)
13
12
11
10
9
50
52
54
56

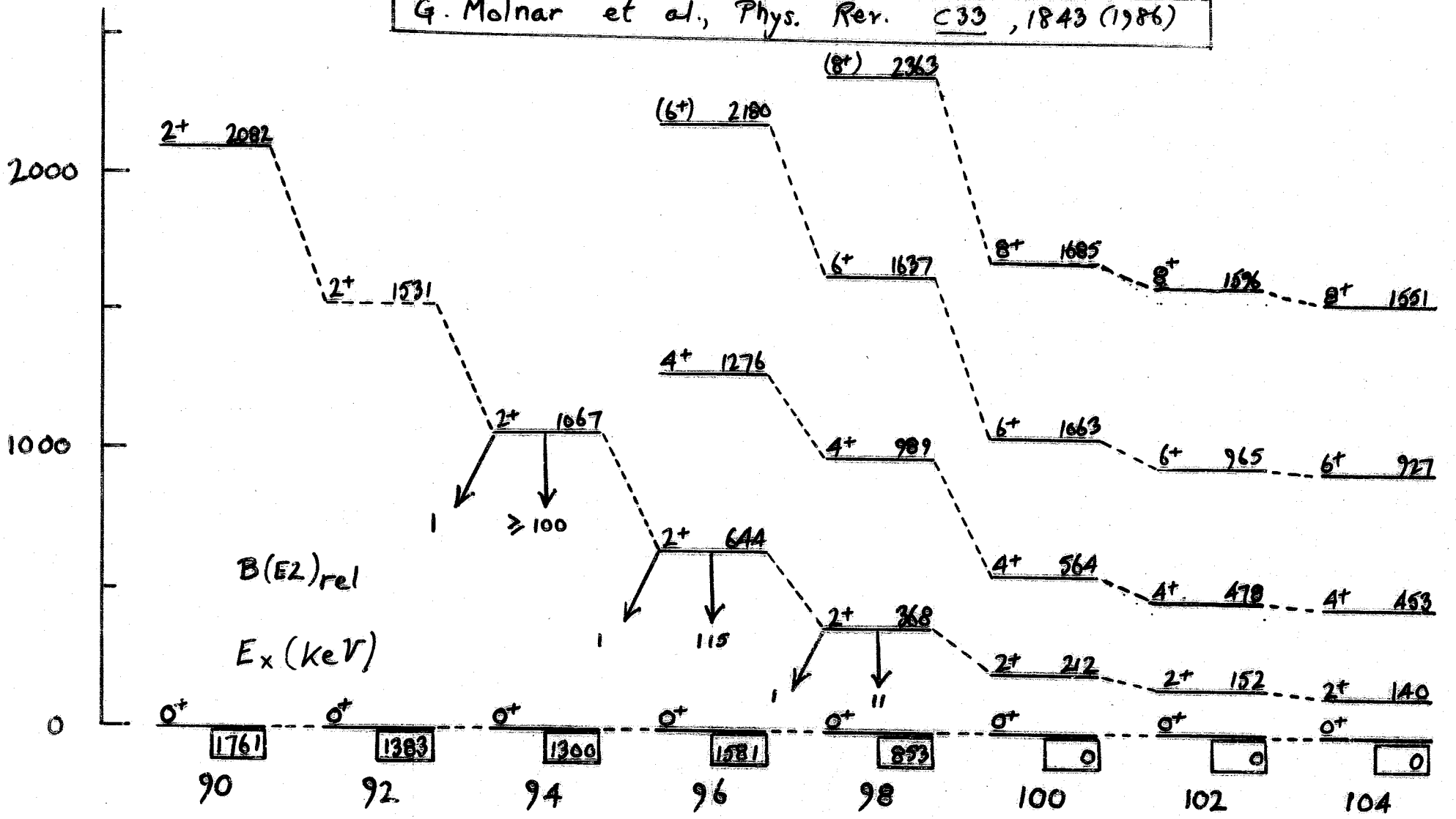
Systematics of 2_1^+ and 0_2^+ at $Z = 40$

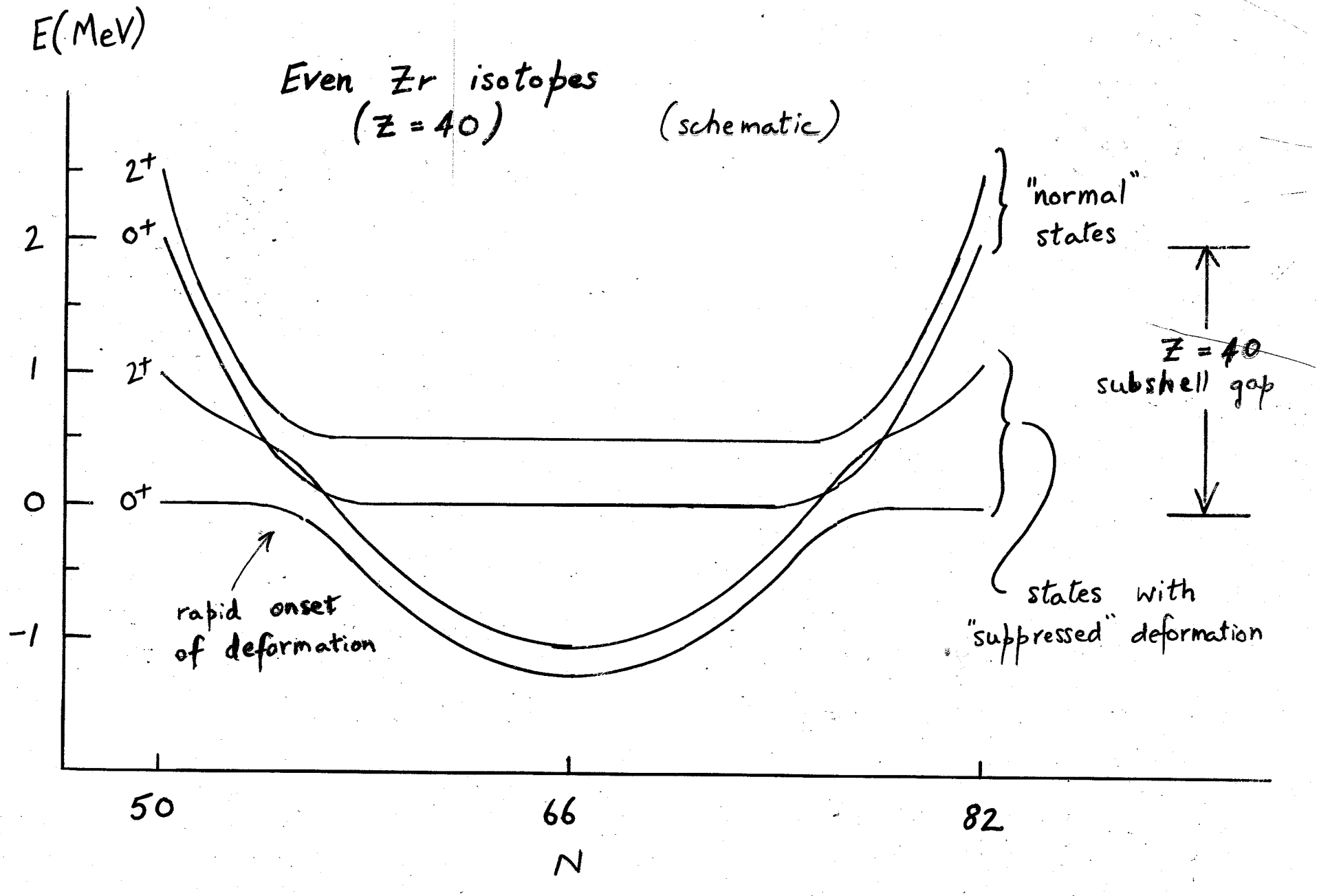


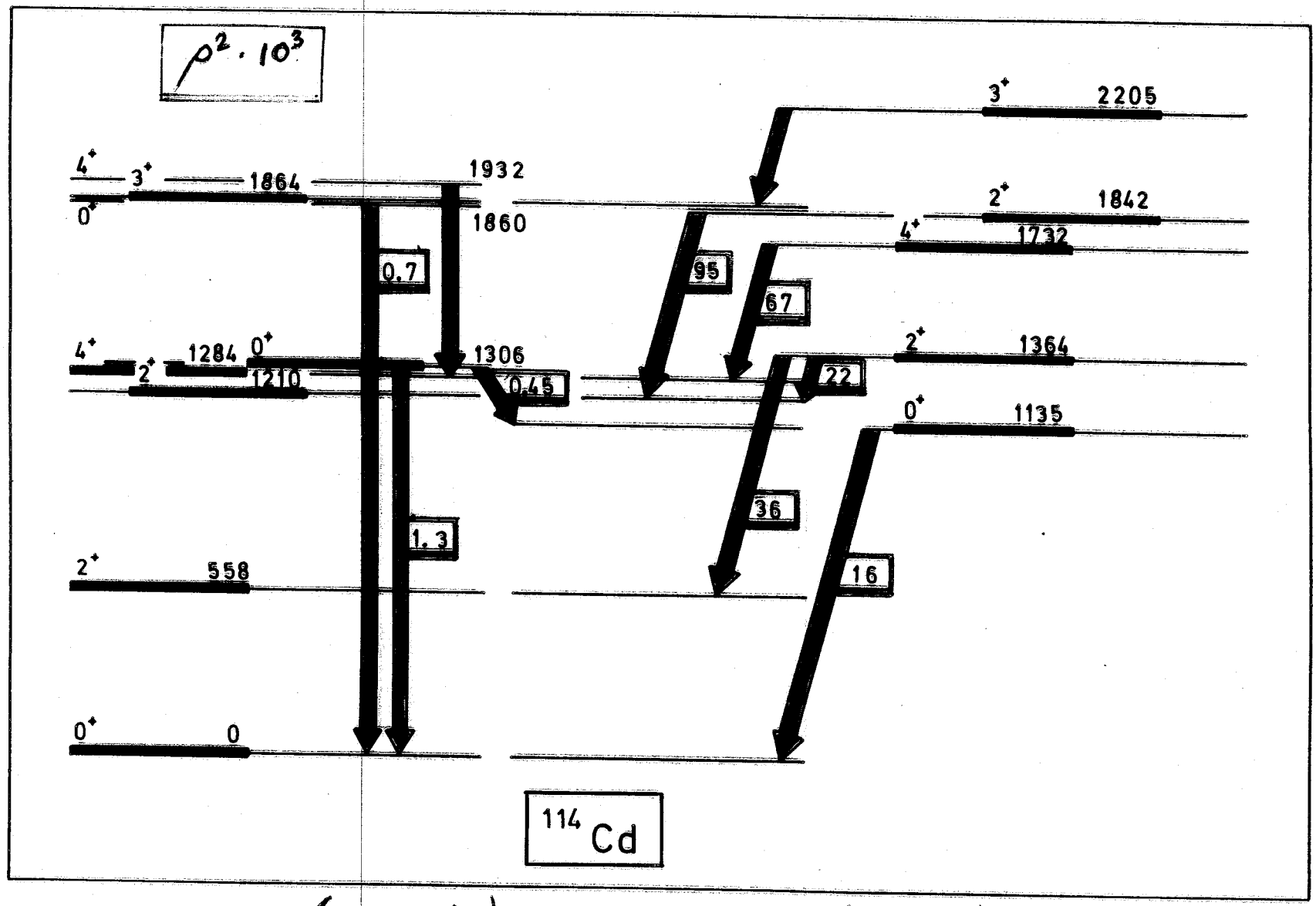
Intruder bands at Z = 40 ($\pi\, 2p\text{-}2h)_{Z=40}$)

R.A. Meyer et al., Phys. Lett. 177B, 271 (1986)

G. Molnar et al., Phys. Rev. C33, 1843 (1986)



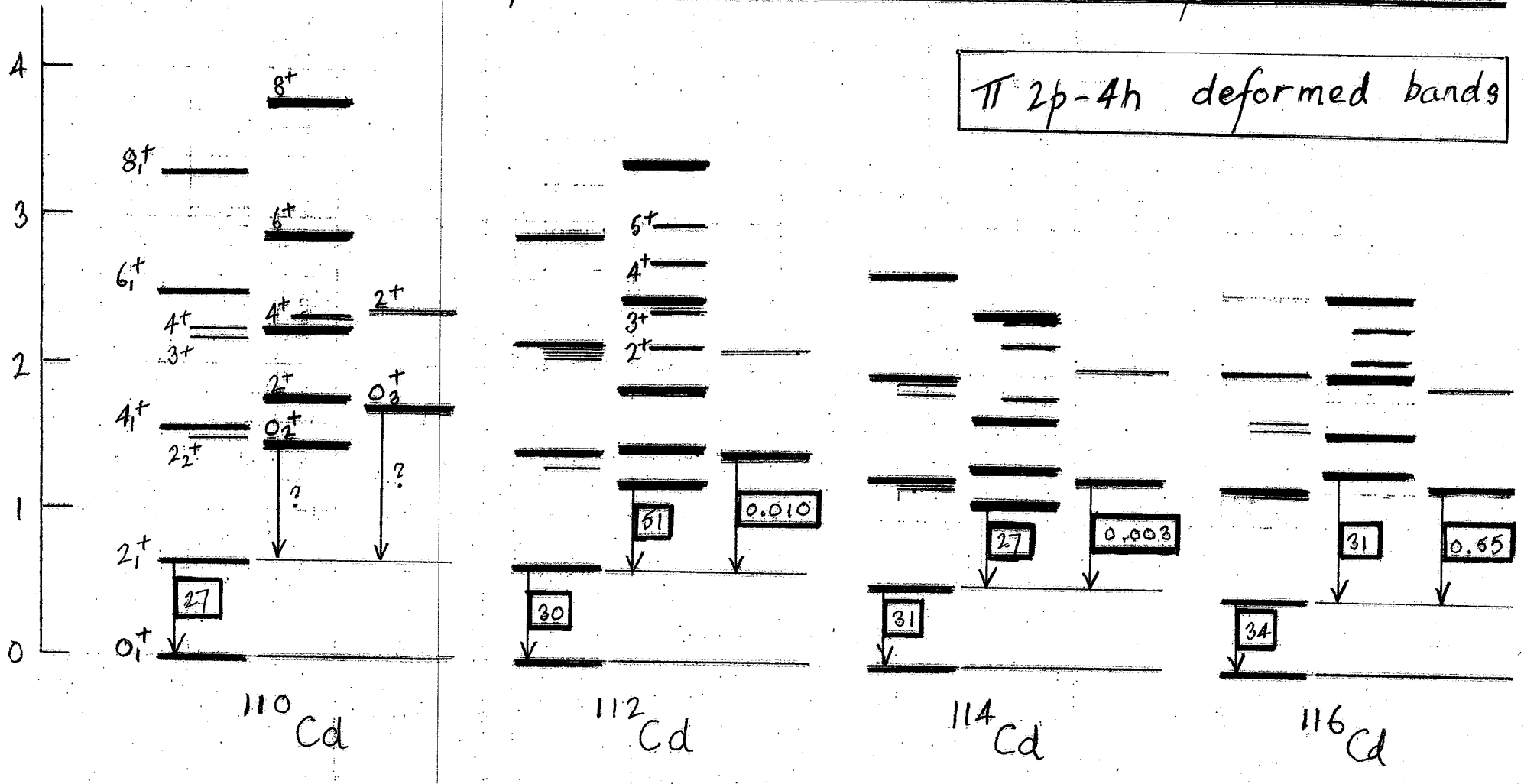

E(MeV)
Even Zr isotopes
(Z = 40)
(schematic)
2+
0+
2+
0+
2
1
0
-1
"normal" states
Z = 40 subshell gap
states with "suppressed" deformation
rapid onset of deformation
50
66
82
N



C. Fahlander (Uppsala) + A. Mheemeed (Munich)

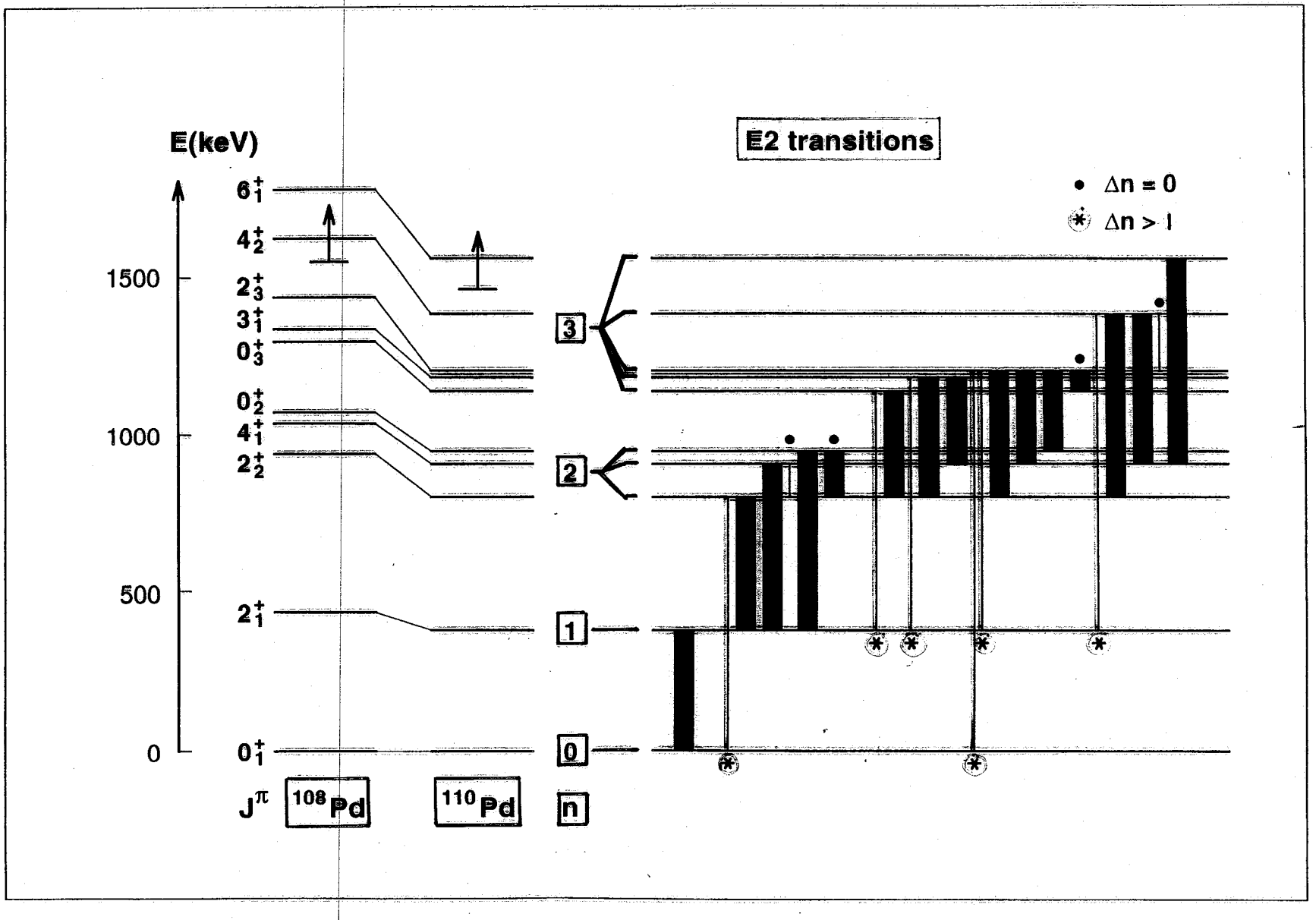
multi - Coulex (n, γ), (n, e⁻) (Grenoble)

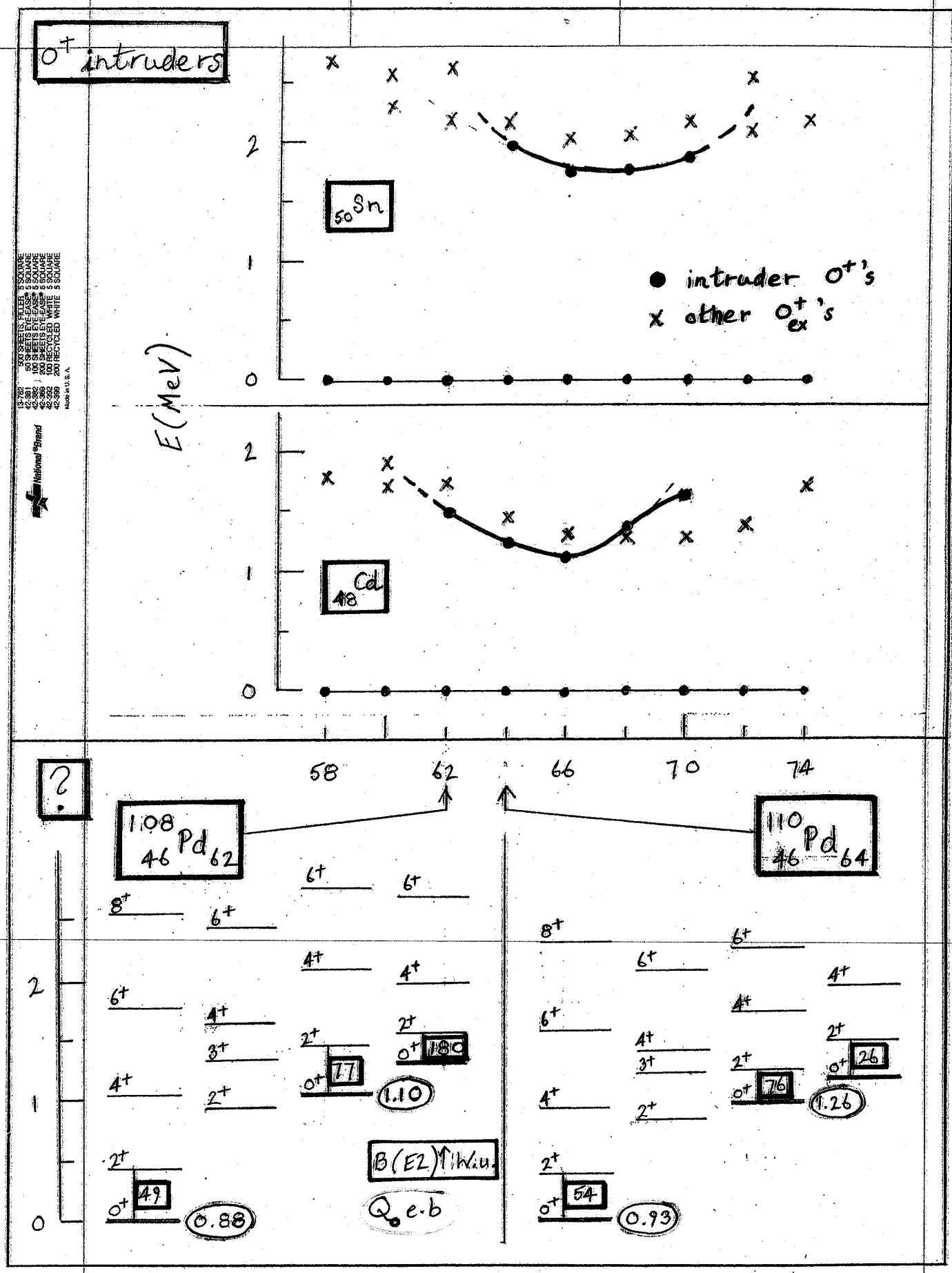
Cadmium isotopes: where are the 0^+ two-phonon states?



B(E2)↓ W.u.

Multiphonon structure in $^{108,110}Pd$: L.E. Svensson, Ph.D. thesis, Uppsala, 1989
L.E. Svensson et al., Nucl. Phys. A584, 547 (1995).





Pd's : Uppsala/Rochester