Isomeric ratios for nuclei with Z=62-67 and A=142-152

produced in the relativistic fragmentation of ^{208}Pb

RISING

Szymon Myalski

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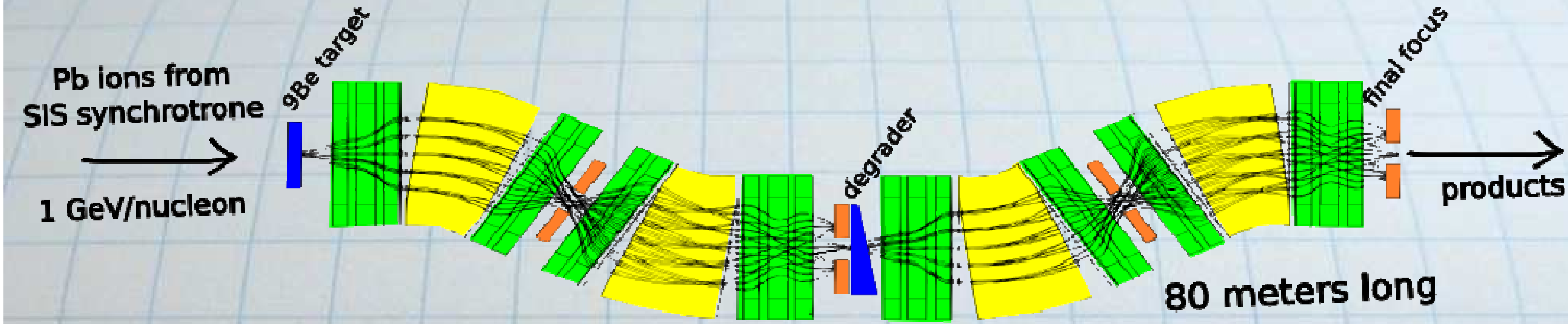
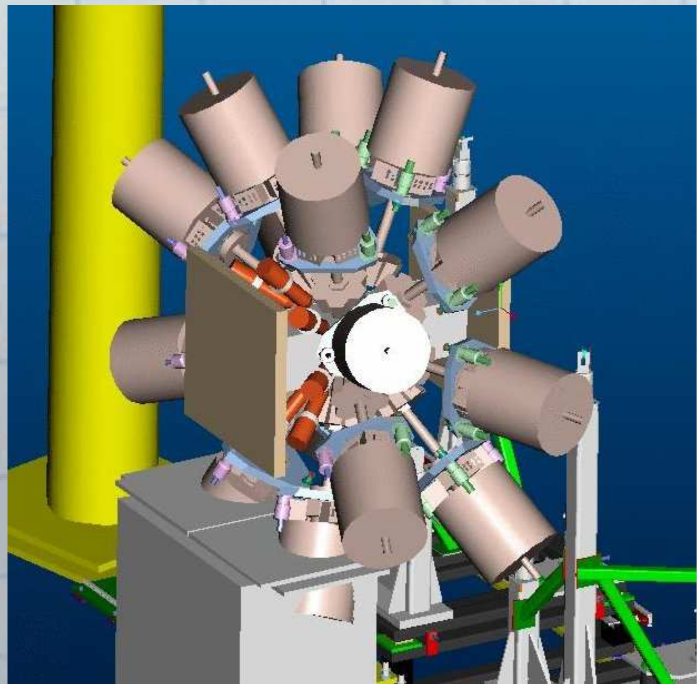
Polish Academy of Sciences

EXPERIMENTAL SETUP
in short...



FRS fragment separator, GSI, Darmstadt

- -SIS synchrotrone
- -1 GeV 298Pb beam
- -FRS fragment separator
- -RISING array (15 cluster germanium detectors)



ISOMERIC RATIO

$$R = \frac{Y}{N_{imp} F G}$$

amount of 27+ isomer

all 148Tb isomer

corrections

Isomeric Ratio - Formula

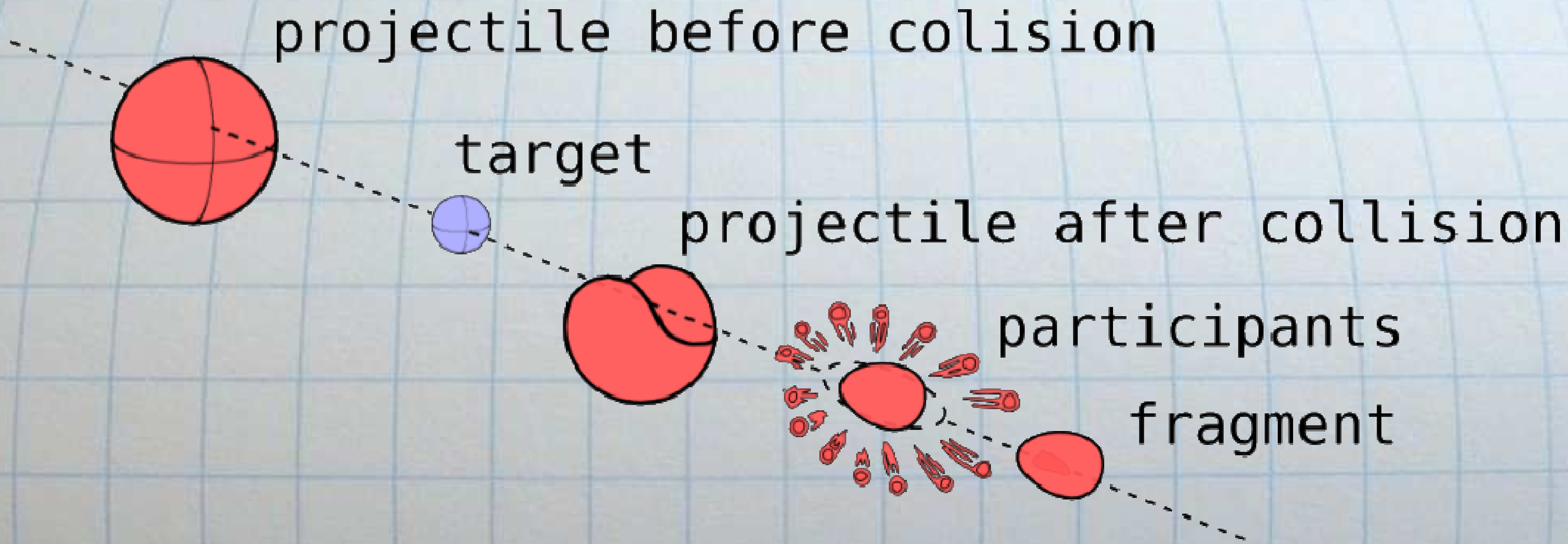
FOR EACH TRANSITION

$$R = \frac{Y}{N_{imp} F G}$$

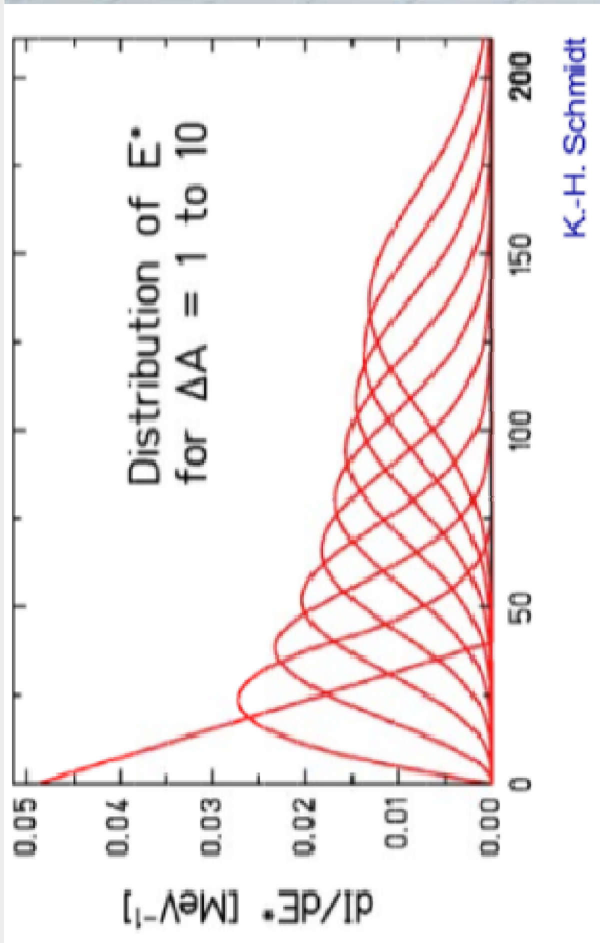
$$Y = \frac{N_\gamma (1+\alpha)}{\varepsilon_{eff} b_\gamma}$$

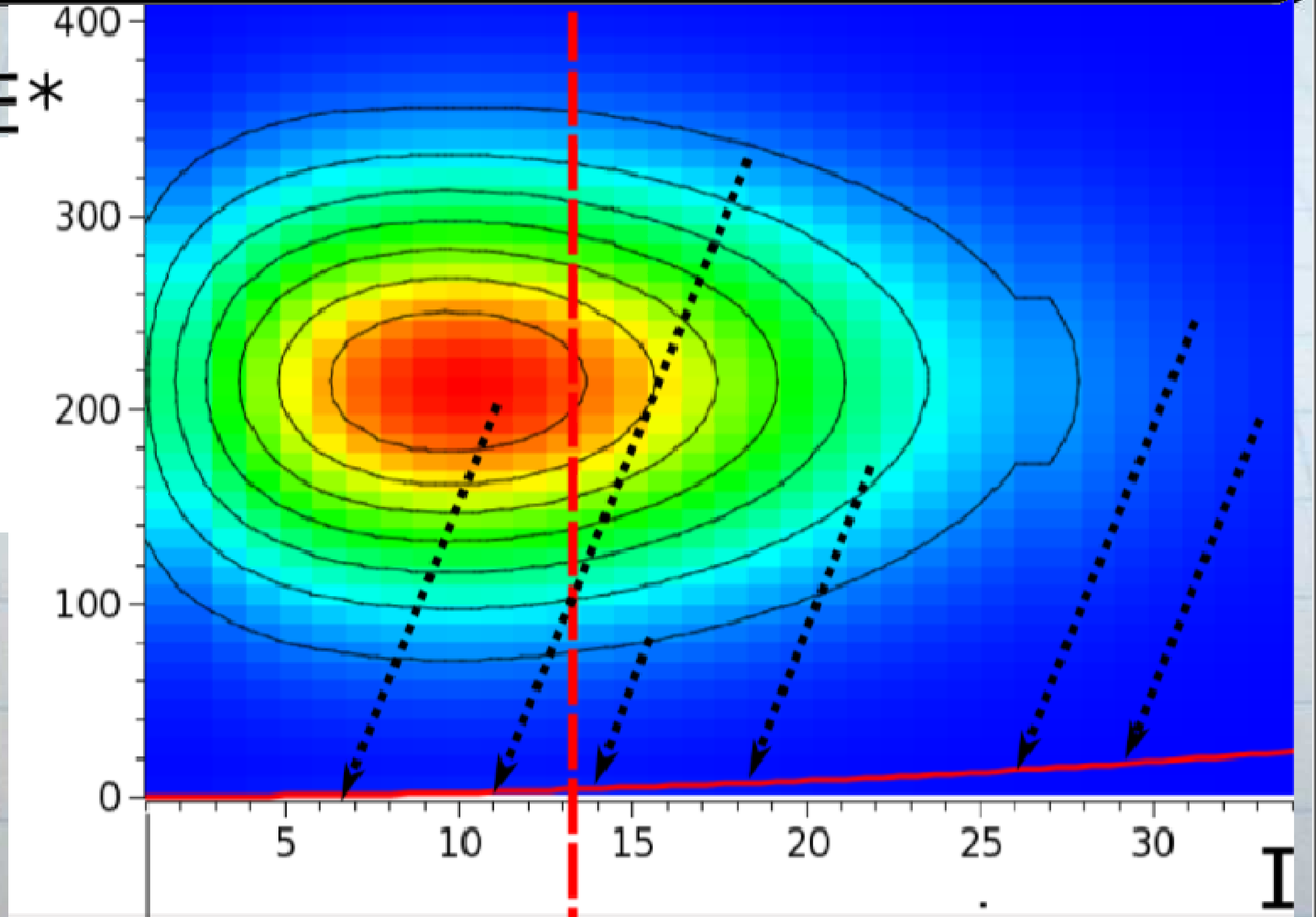
$$G = exp(-\lambda t_{start})$$

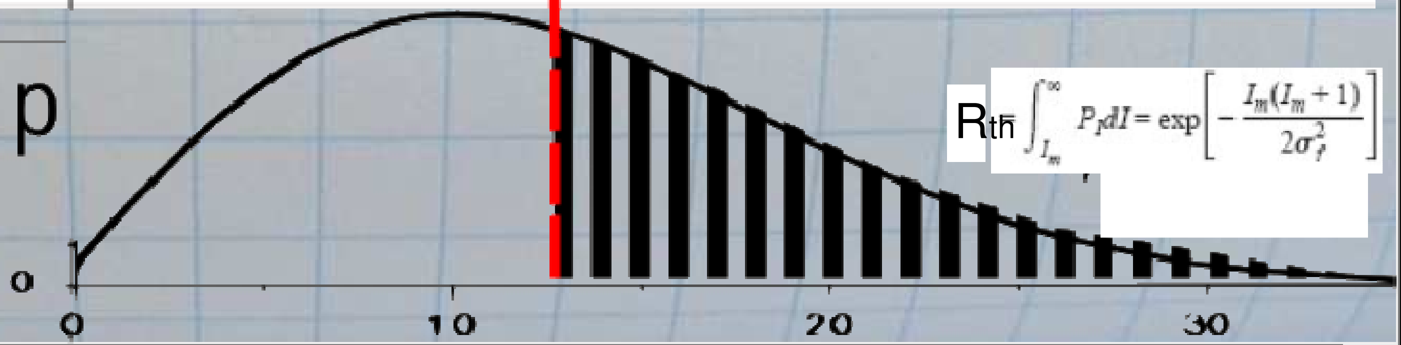
$$F = exp[-(\ldots$$



Nuclear fragmentation



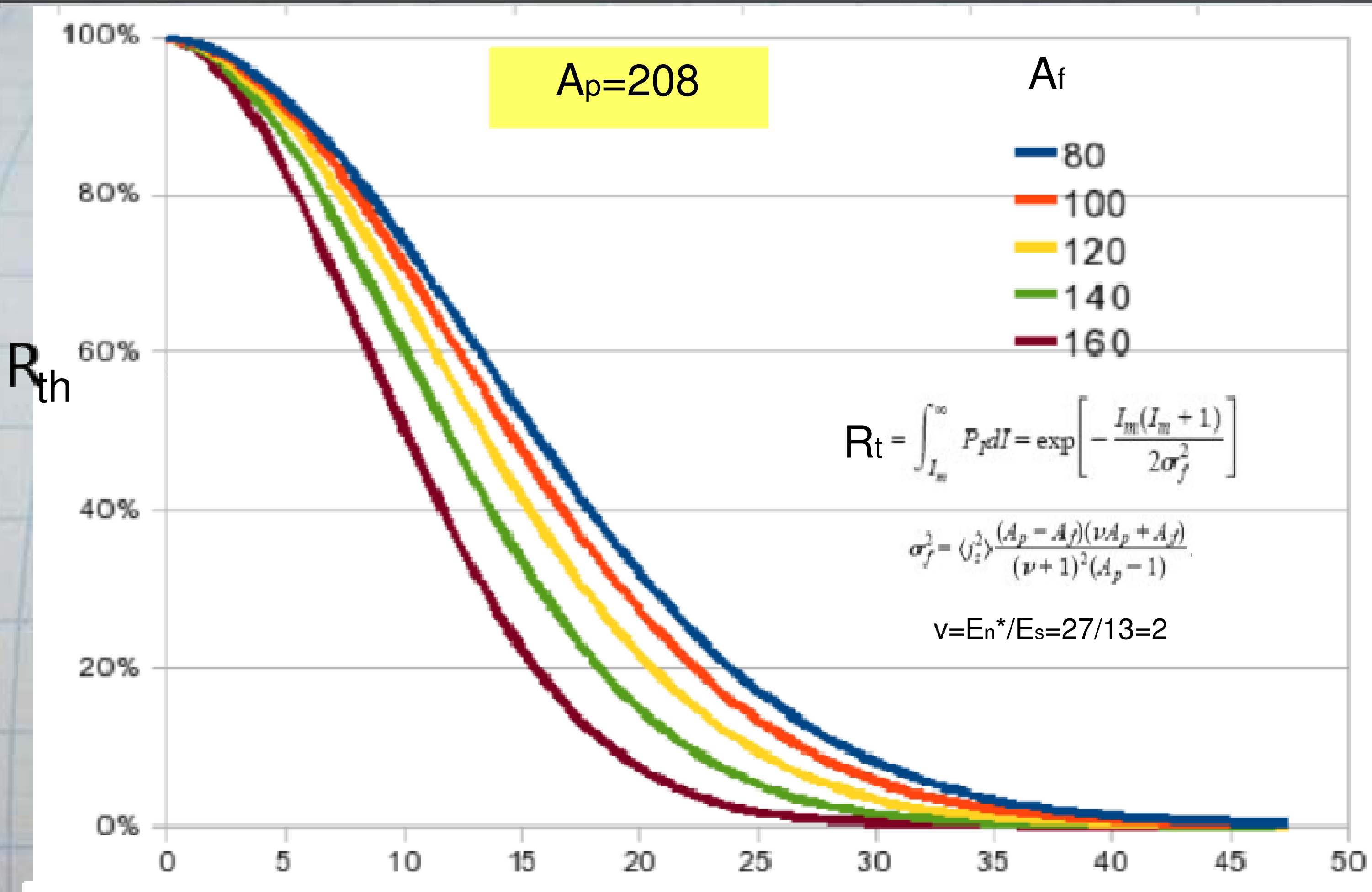




$$R_{th} \int_{I_m}^{\infty} P_I dI = \exp\left[-\frac{I_m(I_m+1)}{2\sigma_f^2}\right]$$

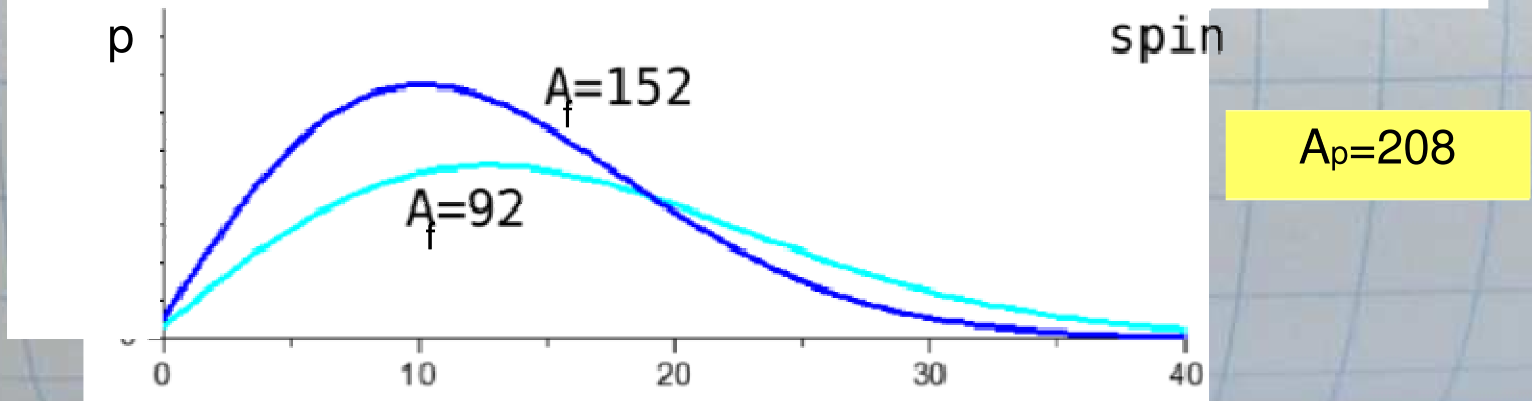
$$P_I = \frac{2I+1}{2\sigma_f^2}\exp\left[-\frac{I(I+1)}{2\sigma_f^2}\right],$$

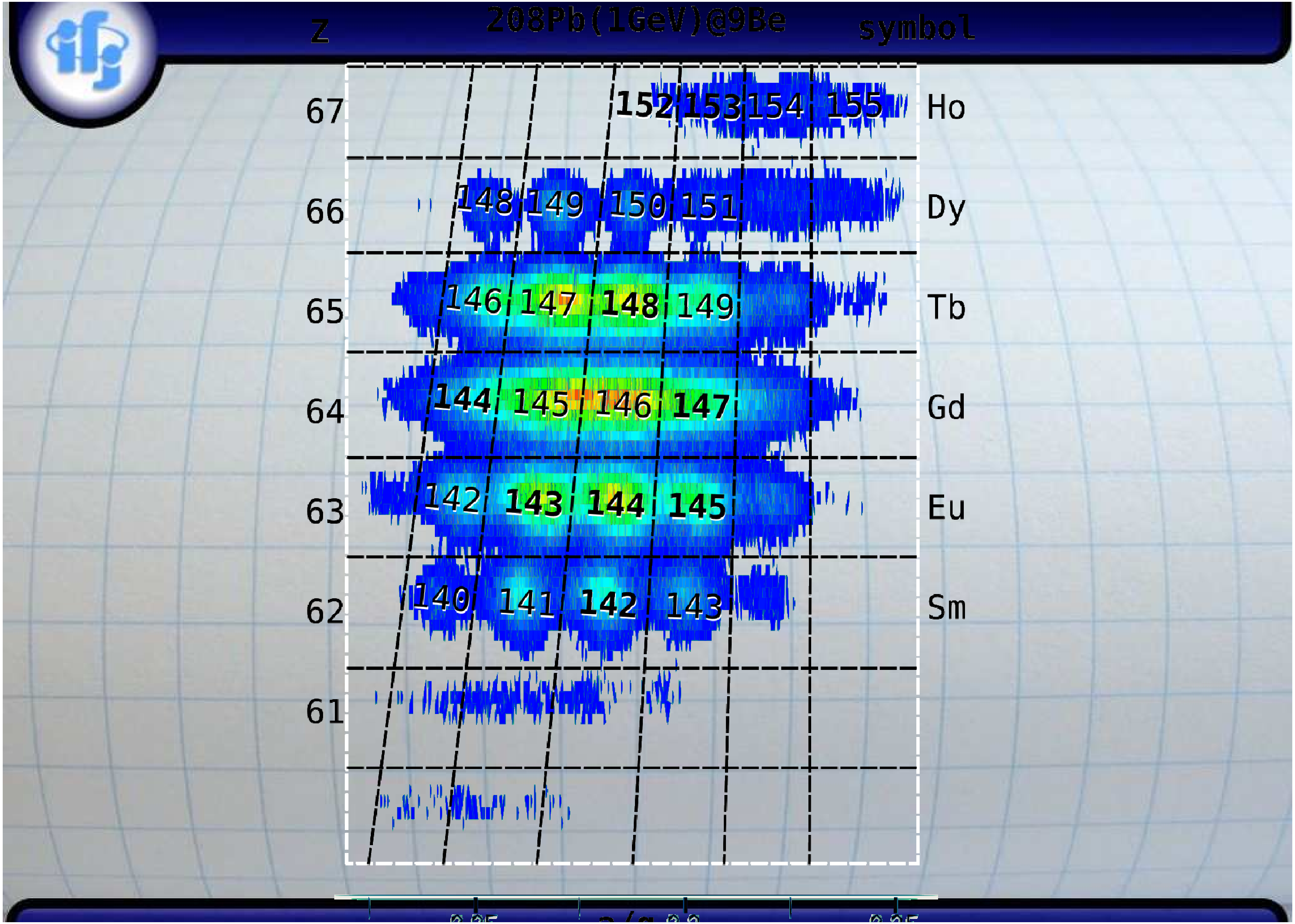
M. de Jong, A. V. Ignatyuk, and K-H. Schmidt,
Nucl. Phys. A613, 435 (1997).



$$R_{th} = \int_{I_m}^{\infty} P_f dI = \exp\left[-\frac{I_m(I_m+1)}{2\sigma_f^2}\right]$$

$$\sigma_f^2 = \langle j_z^2 \rangle \frac{(A_p - A_f)(\nu A_p + A_f)}{(\nu+1)^2 (A_p - 1)}$$

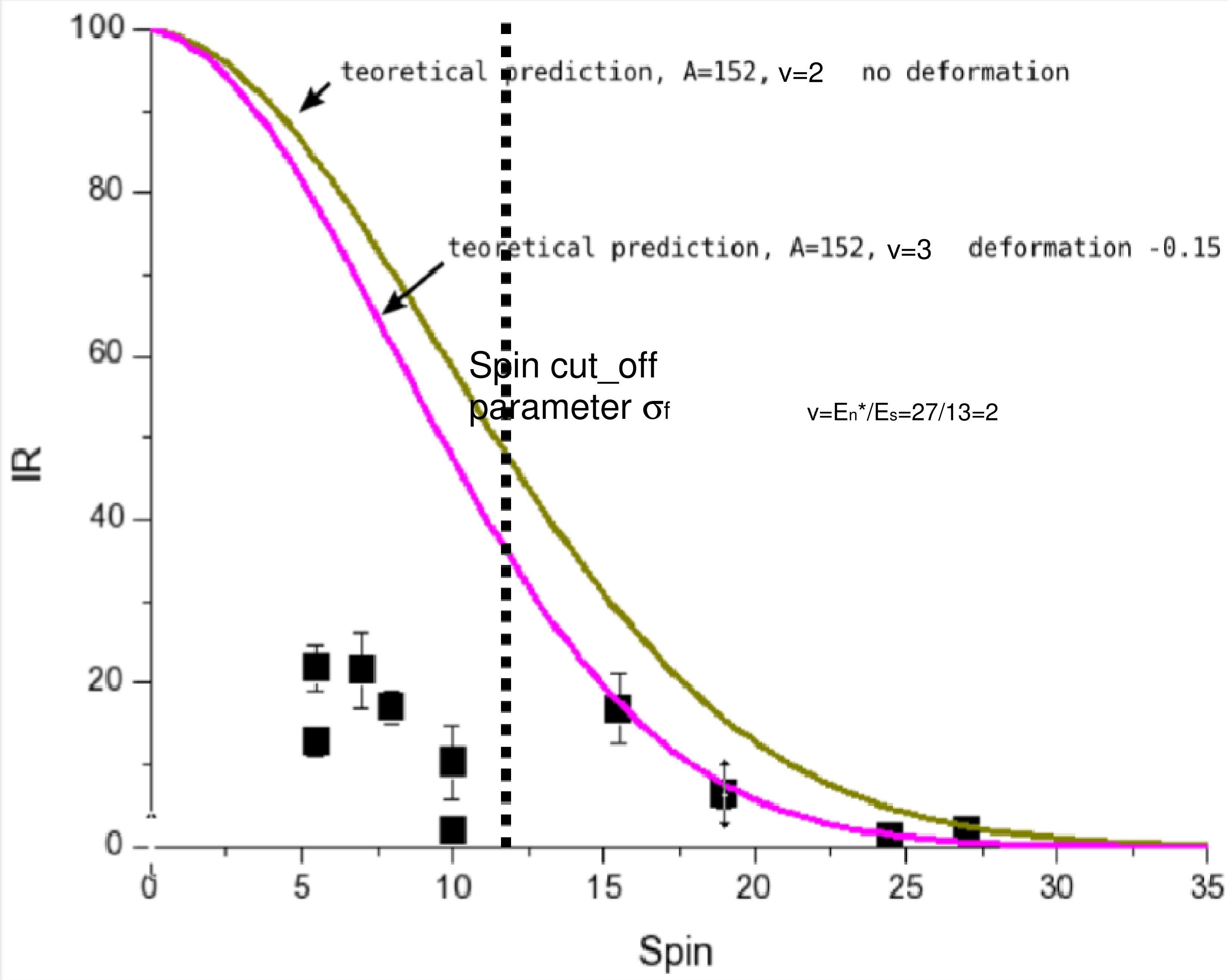




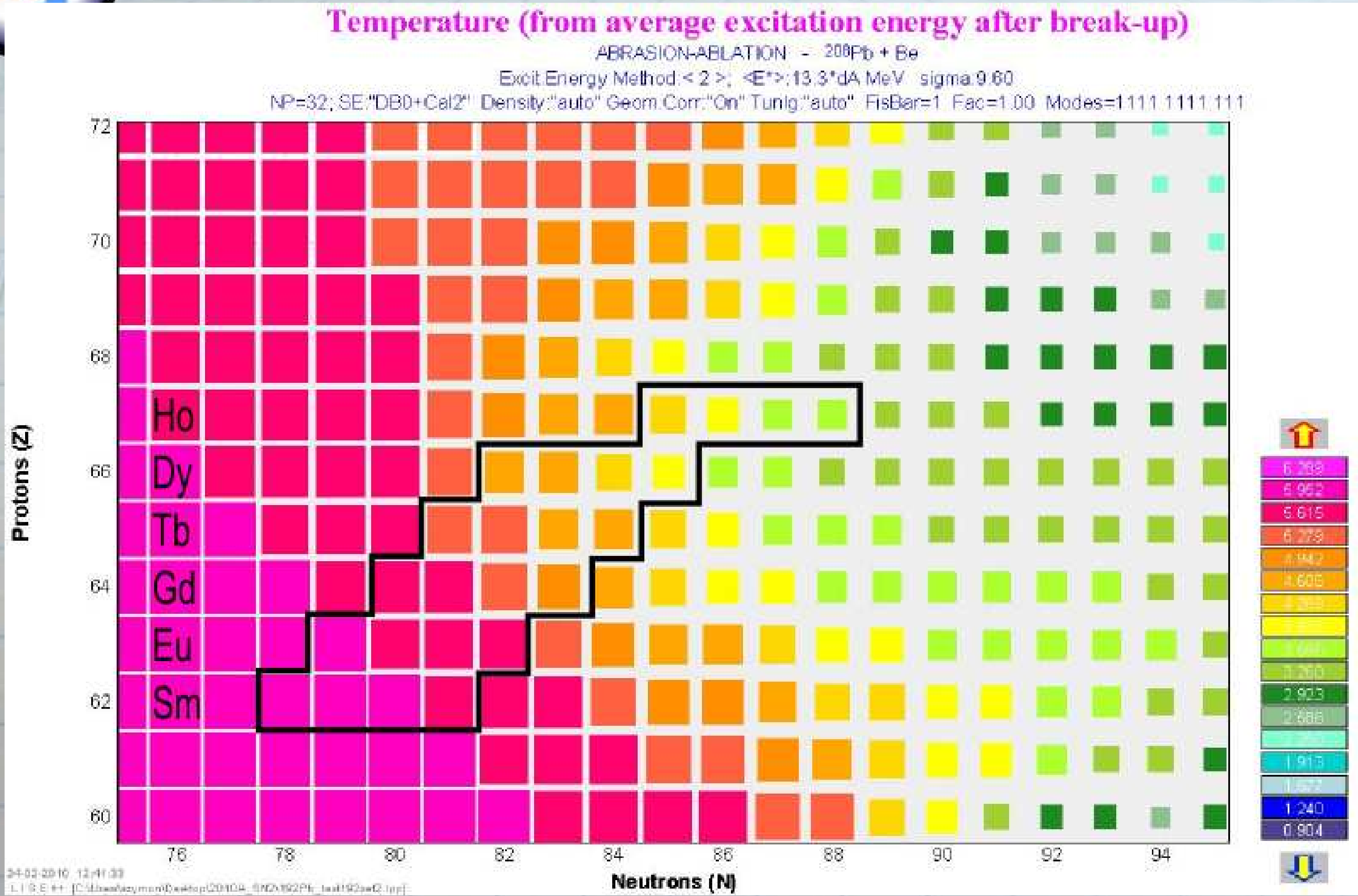
Z
208Pb(1GeV)@9Be
symbol
67
66
65
64
63
62
61
152 153 154 155
148 149 150 151
146 147 148 149
144 145 146 147
142 143 144 145
140 141 142 143
Ho
Dy
Tb
Gd
Eu
Sm

RESULTS

NUCLEUS	SPIN	HALF-LIFE nanoseconds	ANALYTICAL IR %	EXPERIMENTAL IR %
^{152}Ho	19^-	8400[300]	13	6.4[18]
^{153}Ho	$31/2^+$	245[20]	28	16.9[42]
^{148}Tb	27^+	1310[7]	3	1.9[3]
^{144}Gd	10^+	145[30]	59	10.3[46]
^{147}Gd	$49/2^+$	760[43]	5	1.1[3]
^{143}Eu	$11/2^-$	50000[500]	84	12.8[17]
^{144}Eu	8^-	1000[100]	72	17.1[20]
^{145}Eu	$11/2^-$	490[30]	84	21.7[28]
^{142}Sm	10^+	480[60]	61	2.0[7]
^{142}Sm	7^-	170[2]	78	21.5[46]



teoretical prediction, A=152, v=2 no deformation
teoretical prediction, A=152, v=3 deformation -0.15
Spin cut_off
parameter σf
v=En*/Es=27/13=2
IR
Spin
100
80
60
40
20
0
5
10
15
20
25
30
35


Temperature (from average excitation energy after break-up)
ABRASION-ABLATION - 208Pb + Be
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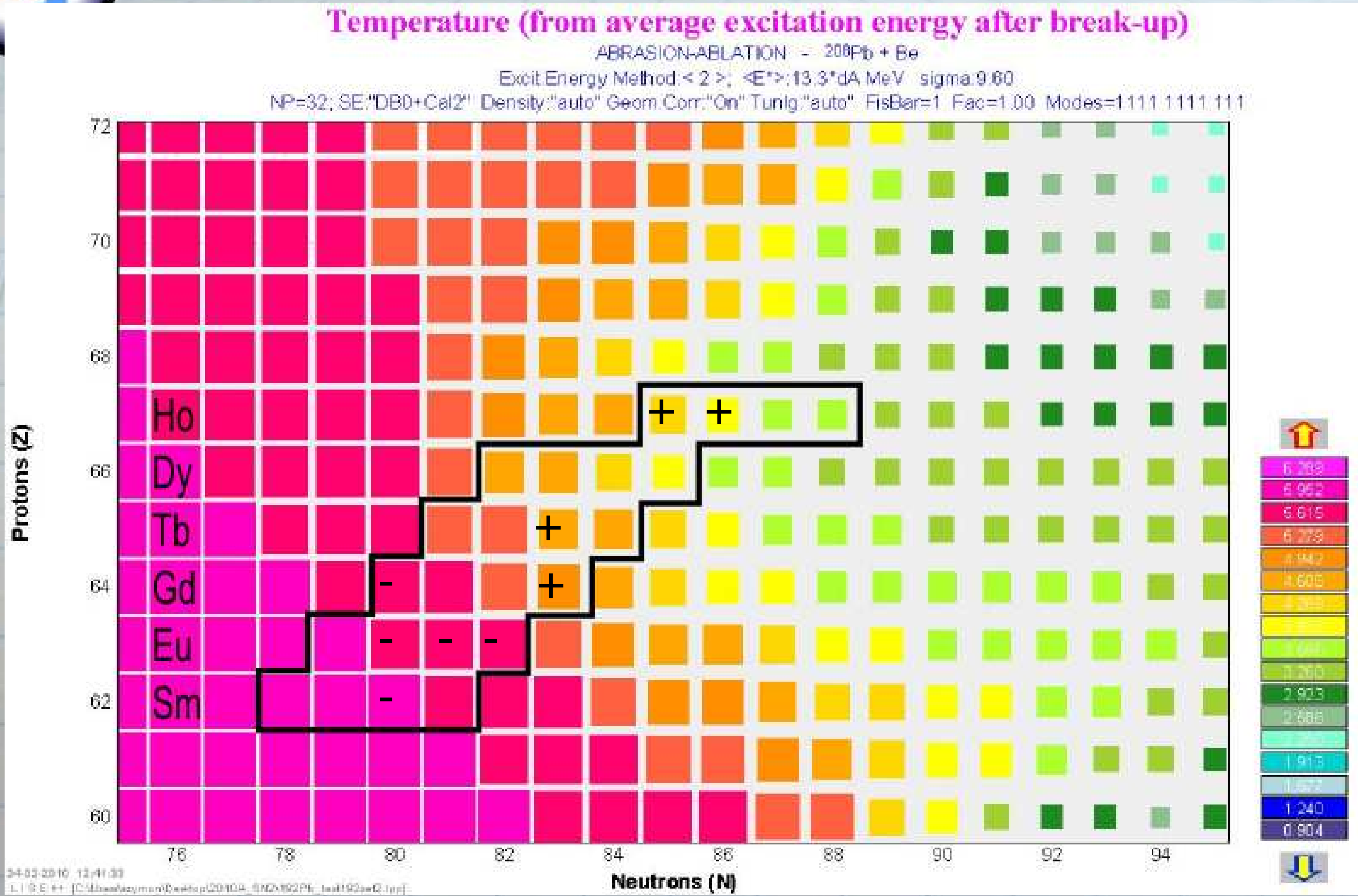
Protons (Z)
72
70
68
66
64
62
60
Ho
Dy
Tb
Gd
Eu
Sm
76
78
80
82
84
86
88
90
92
94
Neutrons (N)
2.923
2.586
1.913
1.240
0.904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NP=32; SE:"DB0+Cal2" Density:"auto" Geom.Corr:"On" TunIg:"auto" FisBar=1 Fac=1.00 Modes=1111.1111.111
Protons (Z)
Neutrons (N)
Ho
Dy
Tb
Gd
Eu
Sm
72
70
68
66
64
62
60
76
78
80
82
84
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88
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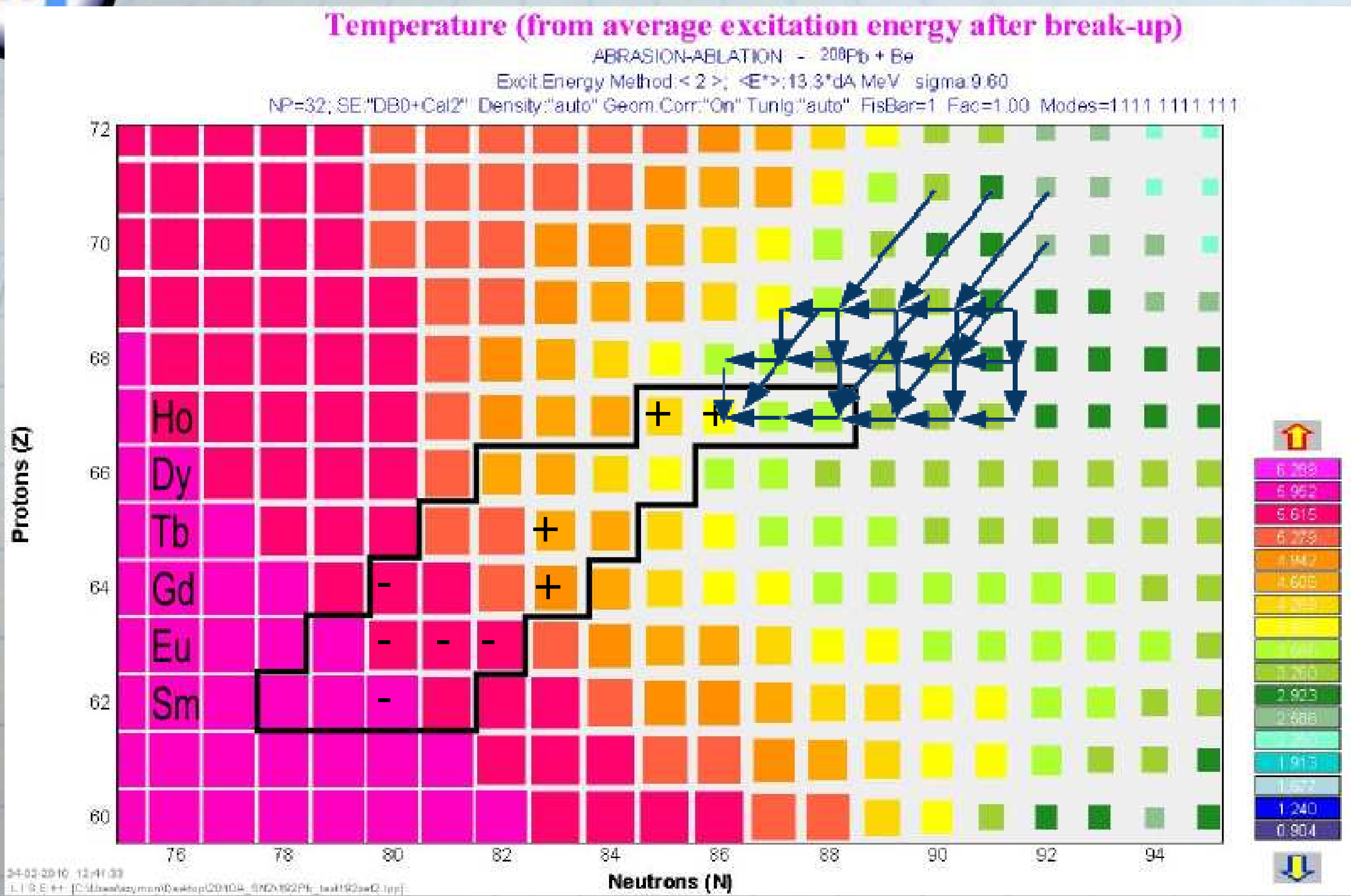
1.240
0.904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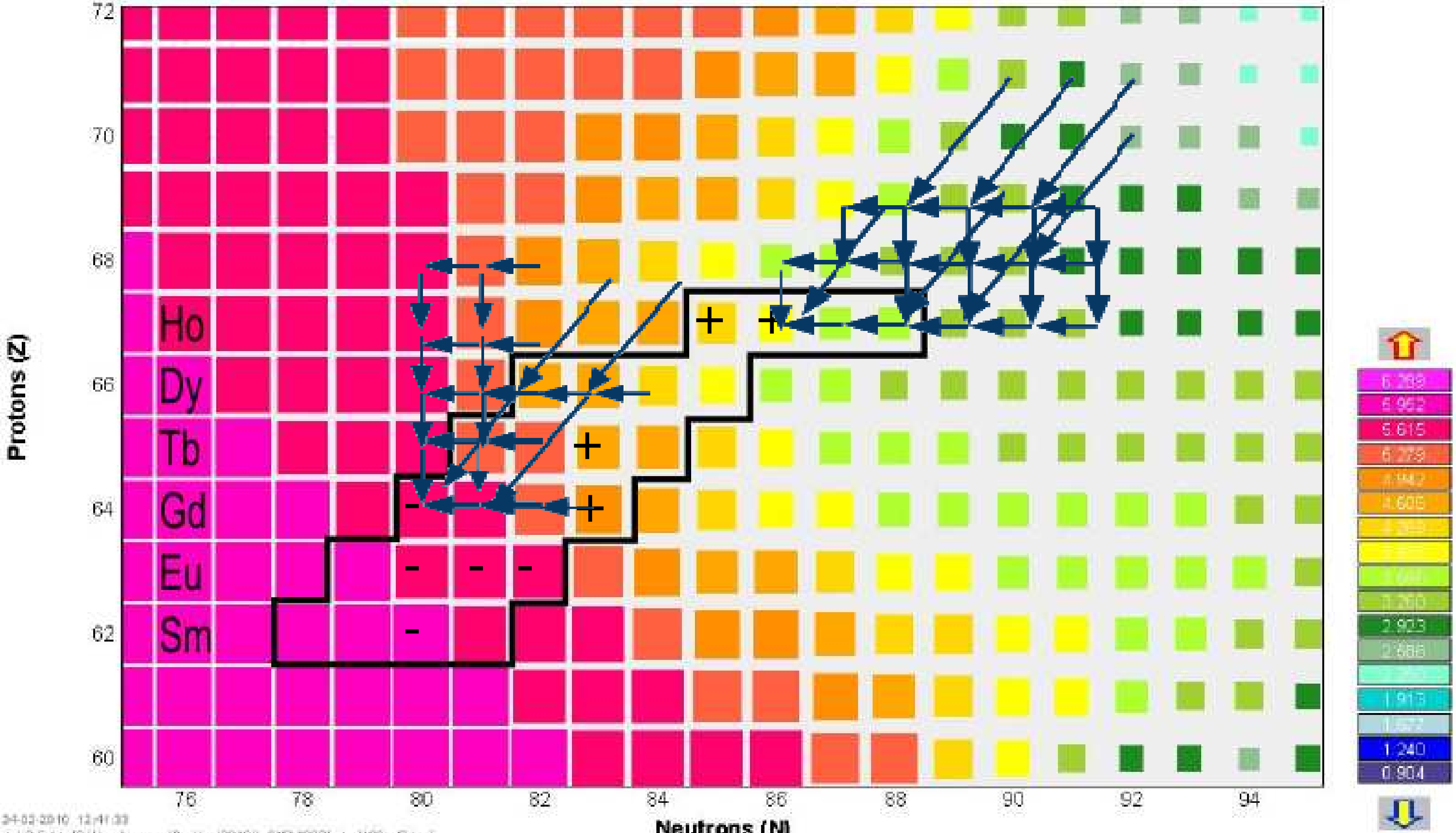
NP=32; SE:"DB0+Cal2" Density:"auto" Geom.Corr:"On" TunIg:"auto" FisBar=1 Fac=1.00 Modes=1111.1111.111
Protons (Z)
Neutrons (N)
Ho
Dy
Tb
Gd
Eu
Sm
72
70
68
66
64
62
60
76
78
80
82
84
86
88
90
92
94
6.962
5.615
1.913
1.240
0.904

Temperature (from average excitation energy after break-up)

ABRASION-ABLATION - ^{208}Pb + Be

Excit.Energy Method:< 2 >; <E*>:13.3*dA MeV sigma:9.60

NP=32; SE:"DB0+Cal2" Density:"auto" Geom.Corr.:"On" TunIg:"auto" FisBar=1 Fac=1.00 Modes=1111.1111.111



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CONCLUSIONS

- For high spins (above spin cut-off parameter $\sigma f=12$) there is relatively good agreement with the analytical formula for IR, while for lower spins (below σf) there is no agreement at all

- For nuclei, which are created from relatively cold fragments there seems to be good agreement, while for nuclei created from hot fragments there is no agreement. This may be related to fact that emission of (charged) particles can substantially remove angular momentum and therefore bypass the isomeric state
- Attempts are being made, to understand this process better (using cascade code, and other tools)

I would like to thank all my collaborators

S.Myalski [1], F.Becker[2], P.Bednarczyk[1,2], G.Benzoni[3], B.Blank[4], C.Brandau[5], A.M.Bruce[6], L.Caceres[2,7], F.Camera[3], W.N.Catford[5], I.J.Cullen[5], Zs.Dombradi[8], P.Doornenbal[2], E.Estevez[9], A.B.Garnsworthy[5,10], H.Geissel[2], W.Gelletly[5], J.Gerl[2], M.Górska[2], H.Grawe[2], J.Grębosz[1,2], A.Heinz[11], R.Hoischen[12], G.Ilie[11,13], G.A.Jones[5], A.Jungclaus[7], A.Kelic[2], M.Kmiecik[1], I.Kojouharov[2], F.G.Kondev[14], T.Kurtukian-Nieto[9], N.Kurz[2], S.Lalkovski[6,15], Z.Liu[5], A.Maj[1], F.Montes[2], Zs.Podolyak[5], M. Pfützner[16], S.Pietri[5], W.Prokopowicz[2,17], P.H.Regan[5], D.Rudolph[12], T.Saito[2], H.Schaffner[2], S.Schwertel[18], T.Shizuma[5,19], A.J.Simons[5], S.J Steer[5], S.Tachenov[2], P.M.Walker[5], E.Werner-Malento[20], O.Wieland[3], H.J.Wollersheim[2]

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and Thank You for your attention

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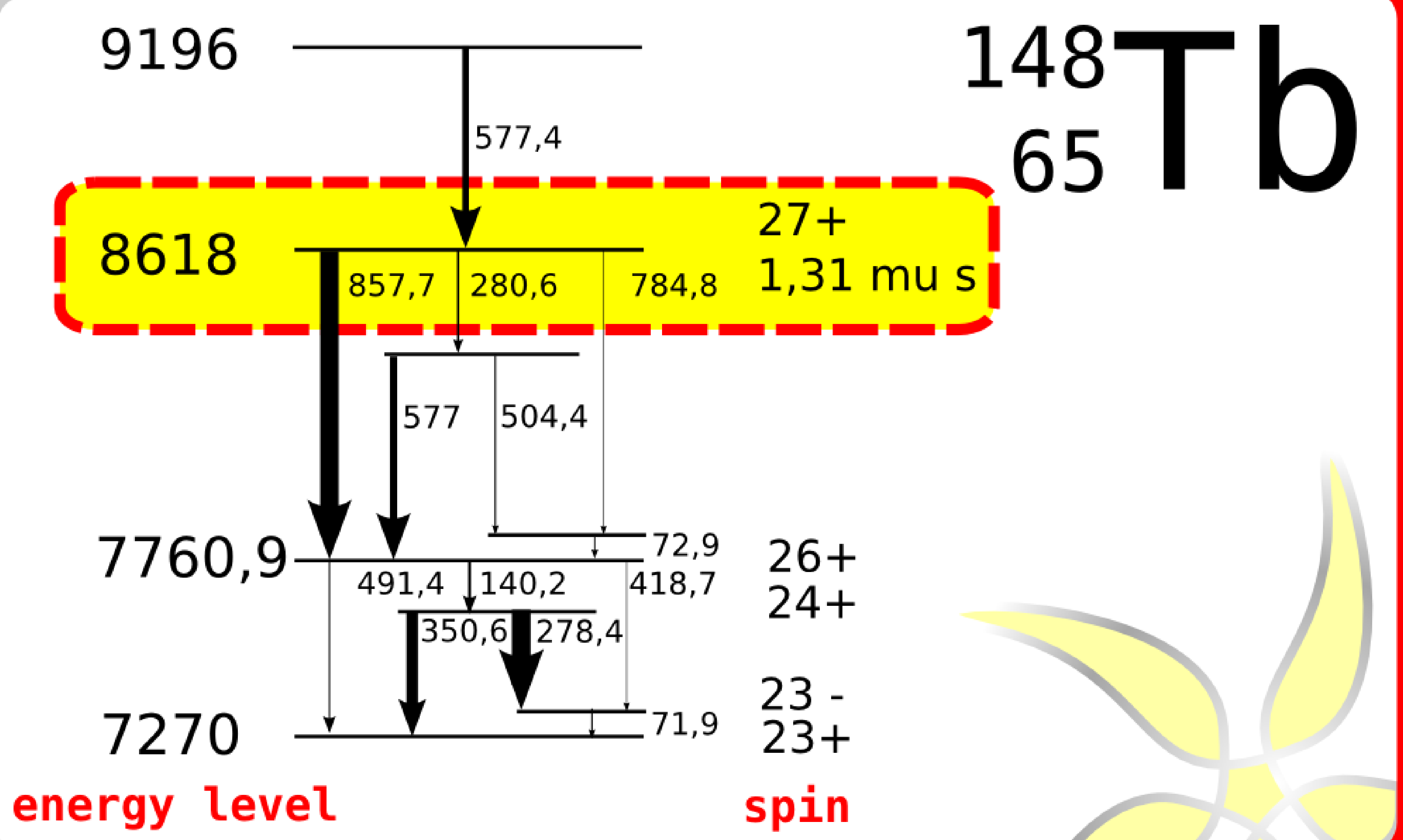
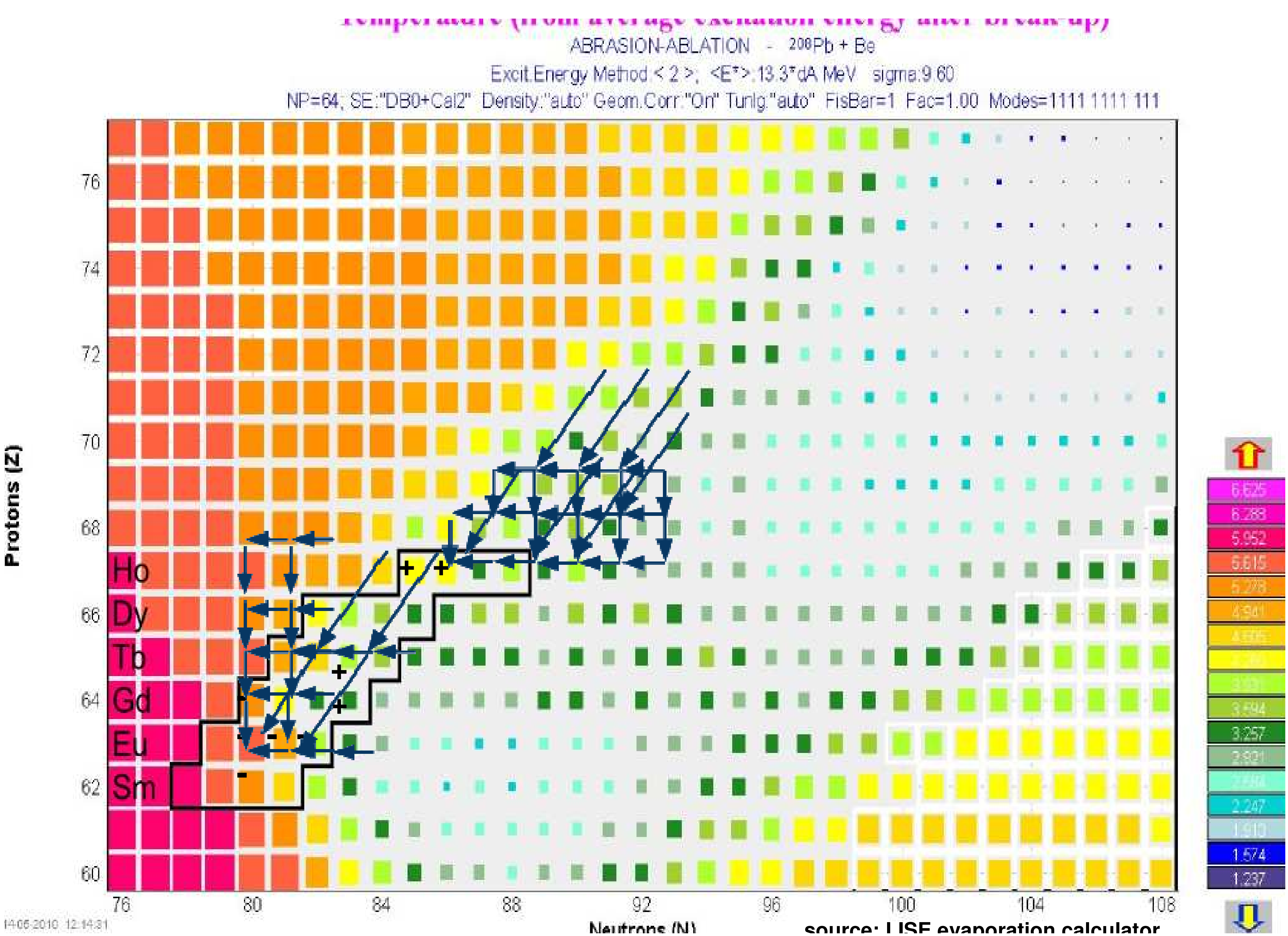


Other decay branches ?


[Temperature (from average excitation energy after break-up)]
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NP=64; SE:"DB0+Cal2" Density:"auto" Geom.Corr:"On" Tunlg:"auto" FisBar=1 Fac=1.00 Modes=1111 1111 111
Protons (Z)
Neutrons (N)
Ho
Dy
Tb
Gd
Eu
Sm
76
74
72
70
68
66
64
62
60
76
80
84
88
92
96
100
104
108
6.625
6.288
5.952
5.615
3.257
1.574
1.237
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source: LISE evaporation calculator