Experiments beyond element 118

Christoph E. Düllmann

GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

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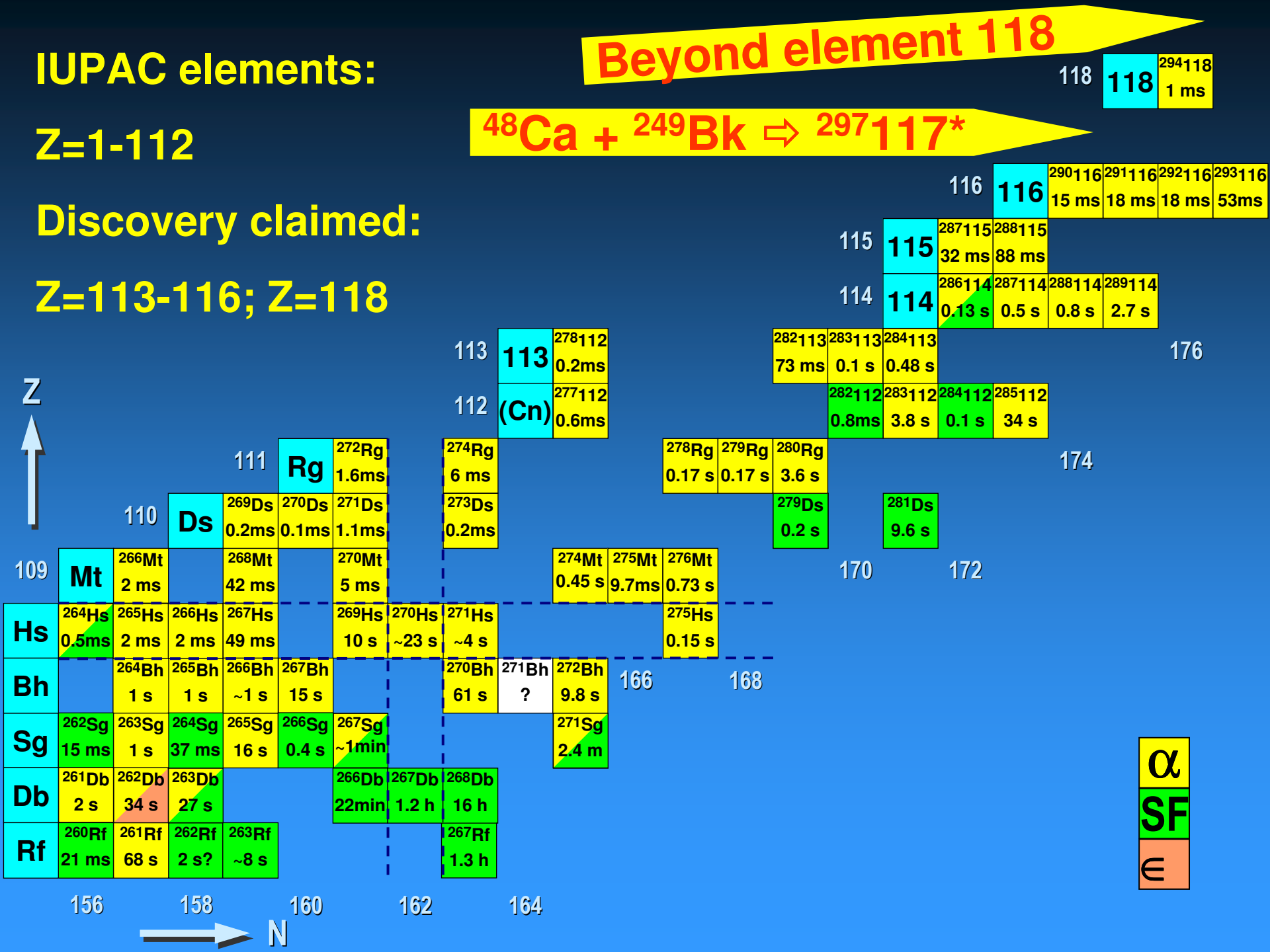

IUPAC elements:
Z=1-112
Discovery claimed:
Z=113-116; Z=118
Beyond element 118
48Ca + 249Bk ⇨ 297117*
118 118 294118 1 ms
116 116 290116 15 ms 291116 18 ms 292116 18 ms 293116 53ms
115 115 287115 32 ms 288115 88 ms
114 114 286114 0.13 s 287114 0.5 s 288114 0.8 s 289114 2.7 s
113 113 278112 0.2ms
112 (Cn) 277112 0.6ms
111 Rg 272Rg 1.6ms 274Rg 6 ms 278Rg 0.17 s 279Rg 0.17 s 280Rg 3.6 s
110 Ds 269Ds 0.2ms 270Ds 0.1ms 271Ds 1.1ms 273Ds 0.2ms 279Ds 0.2 s 281Ds 9.6 s
109 Mt 266Mt 2 ms 268Mt 42 ms 270Mt 5 ms 274Mt 0.45 s 275Mt 9.7ms 276Mt 0.73 s
Hs 264Hs 0.5ms 265Hs 2 ms 266Hs 2 ms 267Hs 49 ms 269Hs 10 s 270Hs ~23 s 271Hs ~4 s 275Hs 0.15 s
Bh 264Bh 1 s 265Bh 1 s 266Bh ~1 s 267Bh 15 s 270Bh 61 s 271Bh ? 272Bh 9.8 s
Sg 262Sg 15 ms 263Sg 1 s 264Sg 37 ms 265Sg 16 s 266Sg 0.4 s 267Sg ~1min 271Sg 2.4 m
Db 261Db 2 s 262Db 34 s 263Db 27 s 266Db 22min 267Db 1.2 h 268Db 16 h
Rf 260Rf 21 ms 261Rf 68 s 262Rf 2 s? 263Rf ~8 s 267Rf 1.3 h
Z
N
156 158 160 162 164
166 168 170 172 174 176
α
SF
∈

Making elements 119 and 120

Beam	Target	CN	Zp x Zt	E*@Bb*	eff. fiss.
^{45}Sc	^{249}Cf	^{294}119	2058	41.7	0.904
^{50}Ti	^{249}Bk	^{299}119	2134	32.4	0.911
^{51}V	^{248}Cm	^{299}119	2208	36.8	0.913
^{54}Cr	^{243}Am	^{297}119	2280	31.5	0.923
^{55}Mn	^{244}Pu	^{299}119	2350	37.7	0.922
^{58}Fe	^{237}Np	^{295}119	2418	29.9	0.934
^{59}Co	^{238}U	^{297}119	2484	36.7	0.933

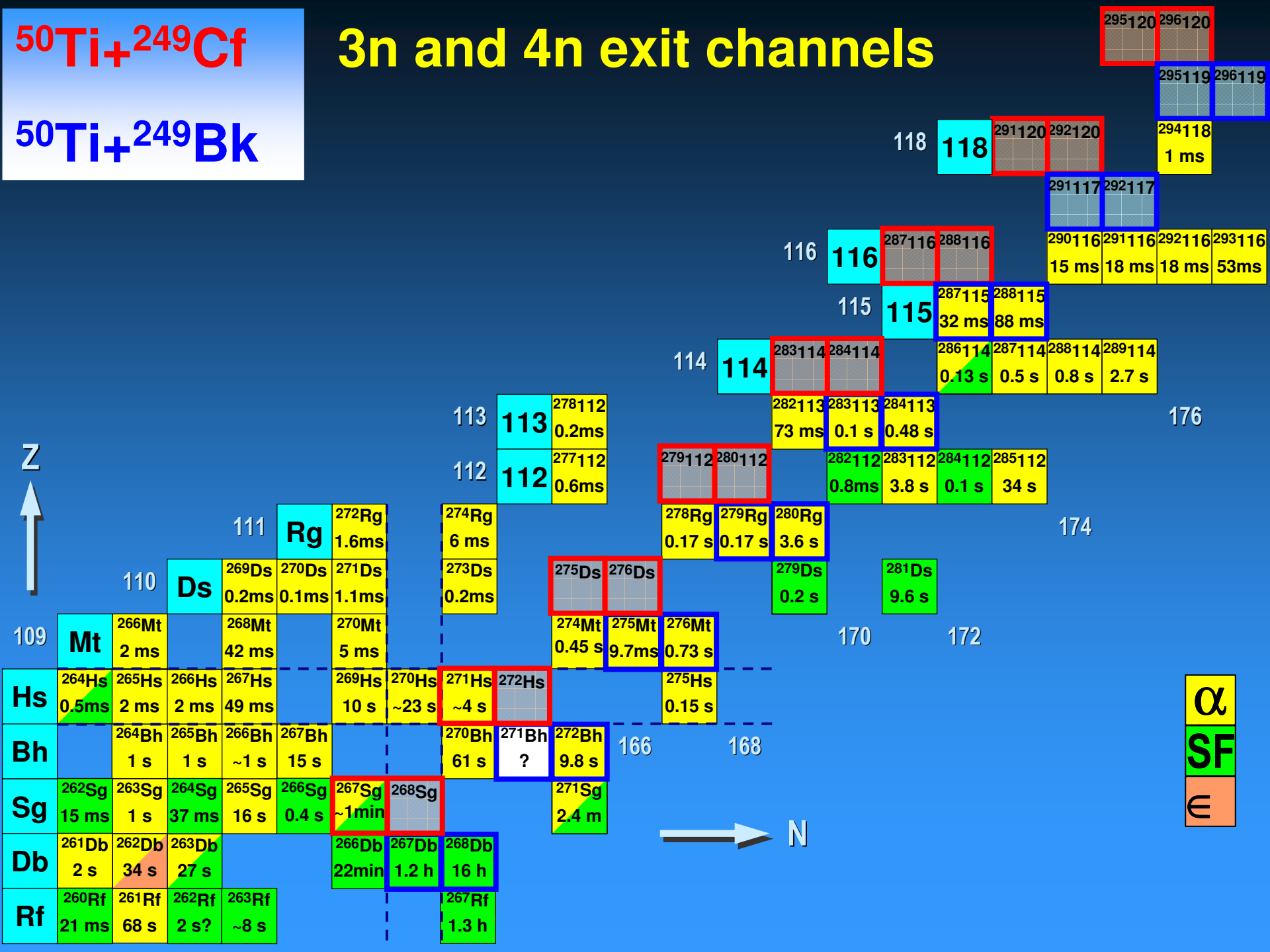
Beam	Target	CN	Zp x Zt	E*@Bb*	eff. fiss.
^{50}Ti	^{249}Cf	^{299}120	2156	31.7	0.919
^{51}V	^{249}Bk	^{300}120	2231	35.9	0.923
^{54}Cr	^{248}Cm	^{302}120	2304	33.0	0.926
^{55}Mn	^{243}Am	^{298}120	2375	34.5	0.934
^{58}Fe	^{244}Pu	^{302}120	2444	33.9	0.934
^{59}Co	^{237}Np	^{296}120	2511	32.9	0.945
^{64}Ni	^{238}U	^{302}120	2576	27.3	0.945

*Myers+Swiatecki Masses 1996

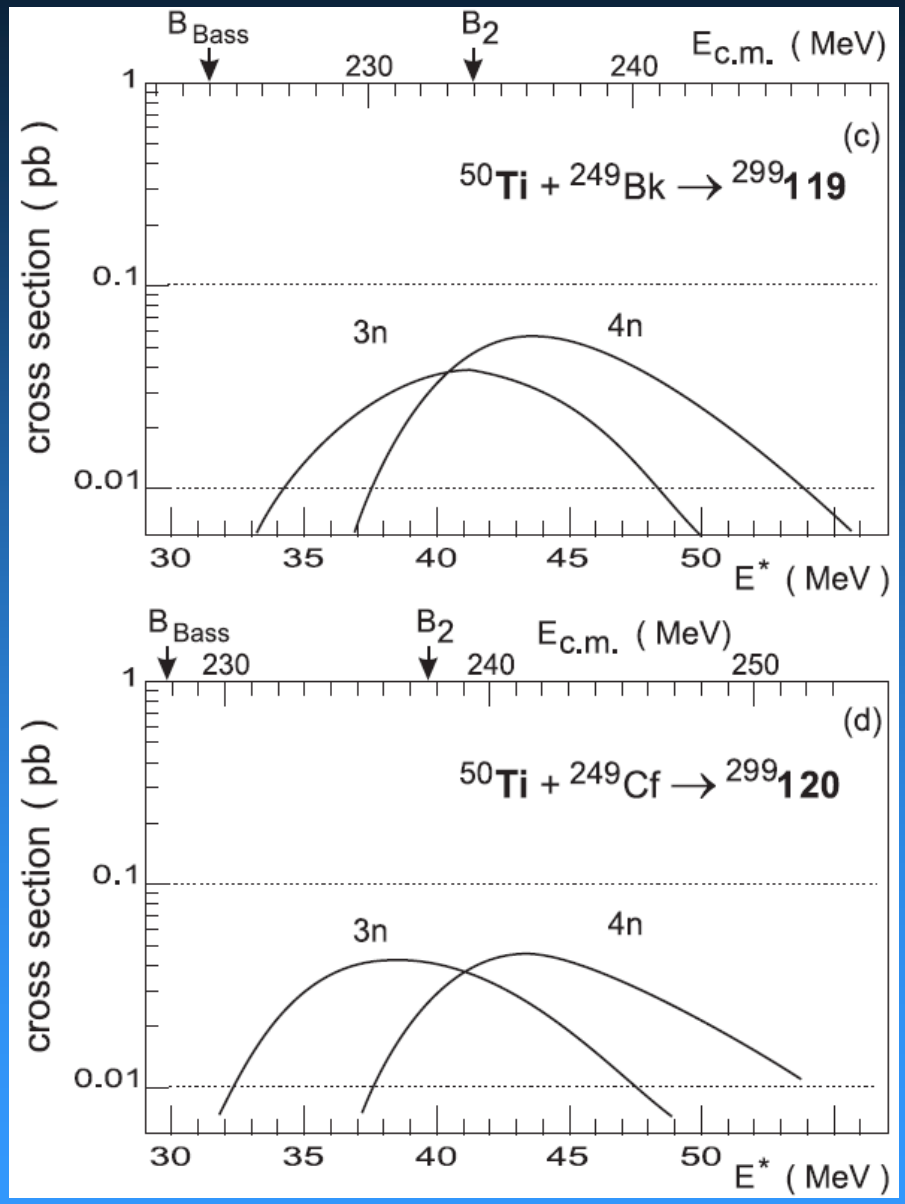
$^{50}Ti+^{249}Cf$

$^{50}Ti+^{249}Bk$

3n and 4n exit channels



Predicted cross sections



Element 119:

$^{50}Ti+^{249}Bk$: **55 fb**

Element 120:

$^{50}Ti+^{249}Cf$: **40 fb**

$^{54}Cr+^{248}Cm$: **25 fb**

$^{58}Fe+^{244}Pu$ / $^{64}Ni+^{238}U$: **5 fb**

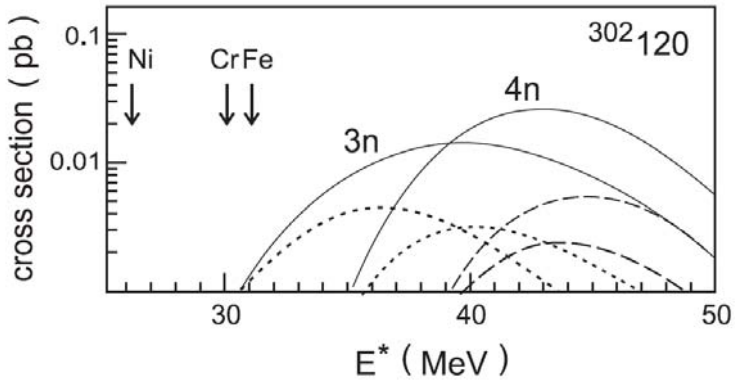


FIG. 10. Excitation functions for production of the $Z = 120$ element in $3n$ and $4n$ evaporation channels of the $^{54}Cr + ^{248}Cm$ (solid curves), $^{58}Fe + ^{244}Pu$ (dashed), and $^{64}Ni + ^{238}U$ (dotted) fusion reactions. The corresponding Bass barriers are shown by the arrows.

V.I. Zagrebaev & W. Greiner
Phys. Rev. C 78 (2008) 034610

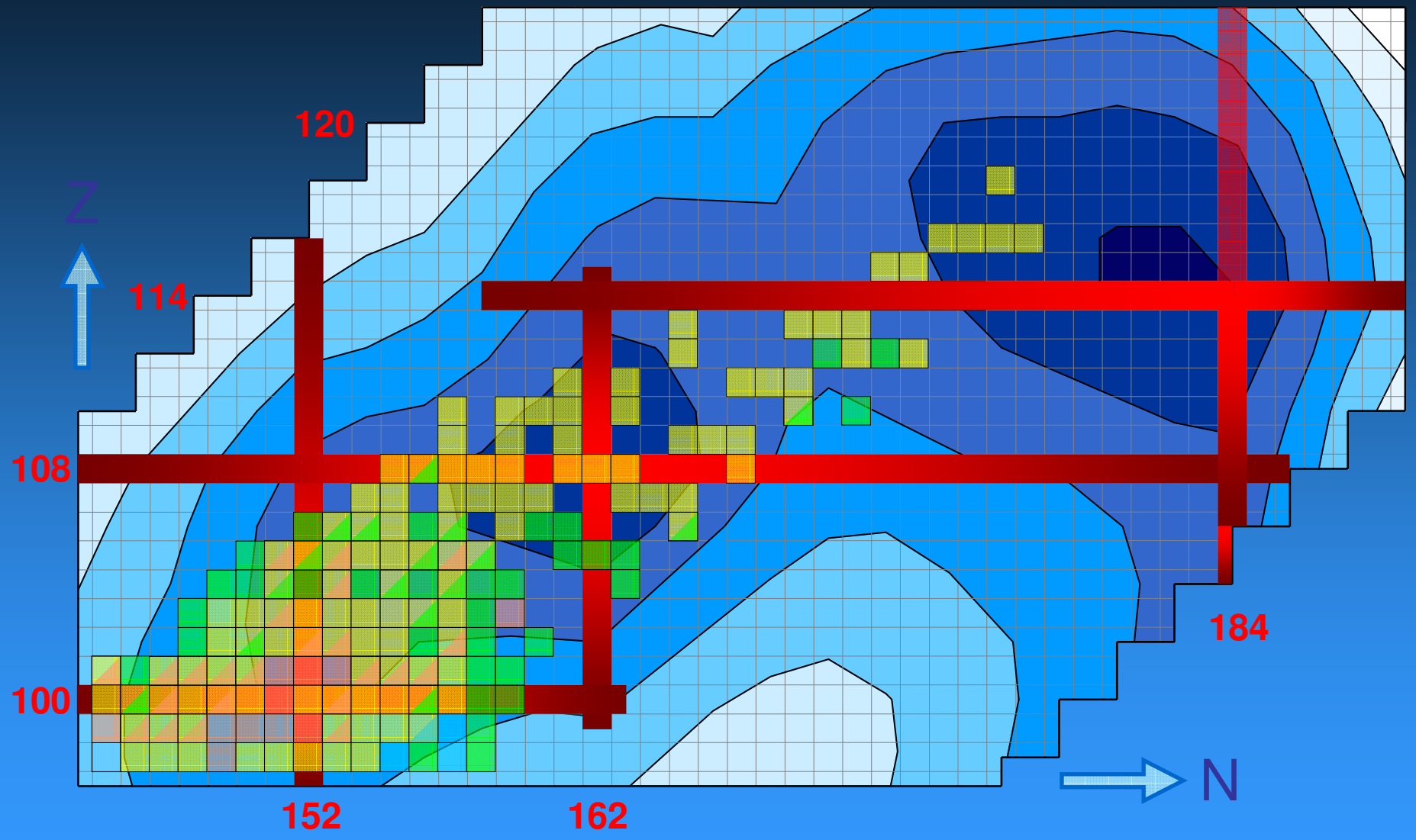
Expected half-lives of E119/120 isotopes

Depends on location of next spherical proton shell closure

Various approaches:

- **Macroscopic-microscopic (Mic-Mac)**
- **Skyrme-Hartree-Fock (SHF)**
- **Relativistic Mean Field (RMF)**
- **Rel. Continuum Hartree Bogoliubov (RHFB)**
- **Exp. / IBA-guided (P. Armbruster)**

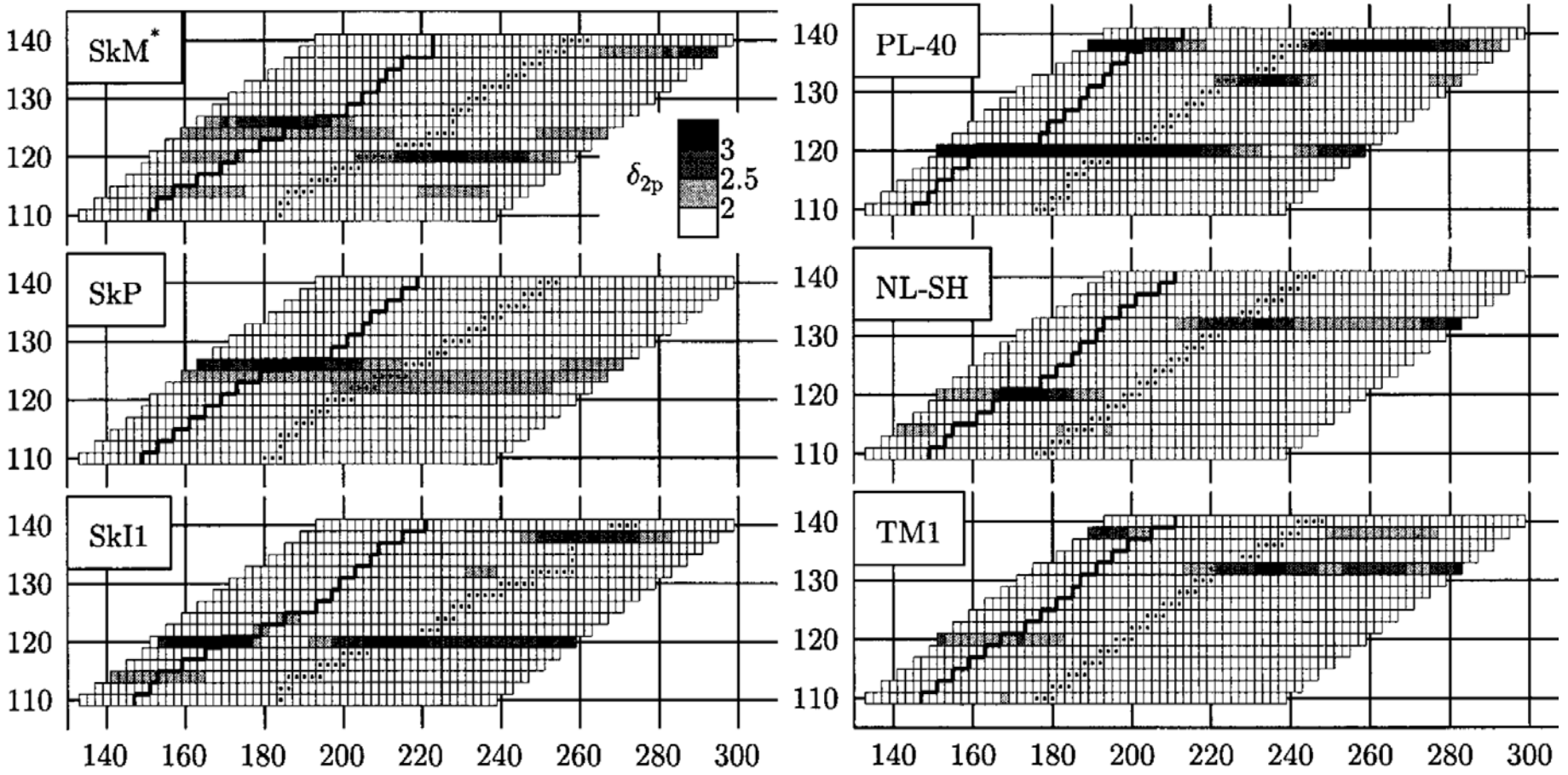
Macroscopic / Microscopic Model: Z=114



A. Sobiczewski

Proton gaps in self-consistent models: SHF and RMF
Z=120 / 126 / 132 / 138

Skyrme Hartree Fock **Rel. Mean Field**



K. Rutz et al., PRC 56 (1997) 238

Microscopic theories: RCHB. Z=120 (126, 132)

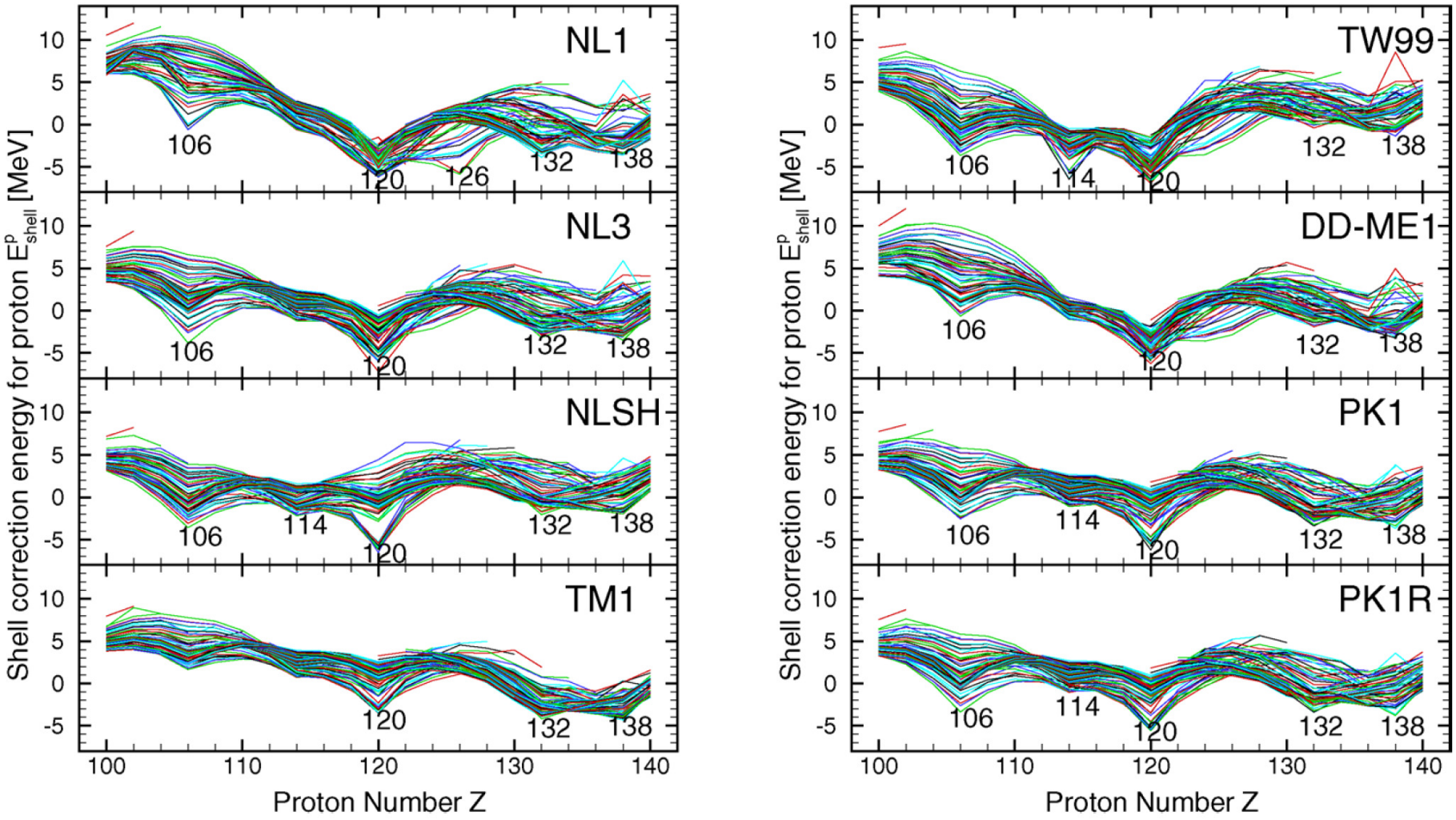
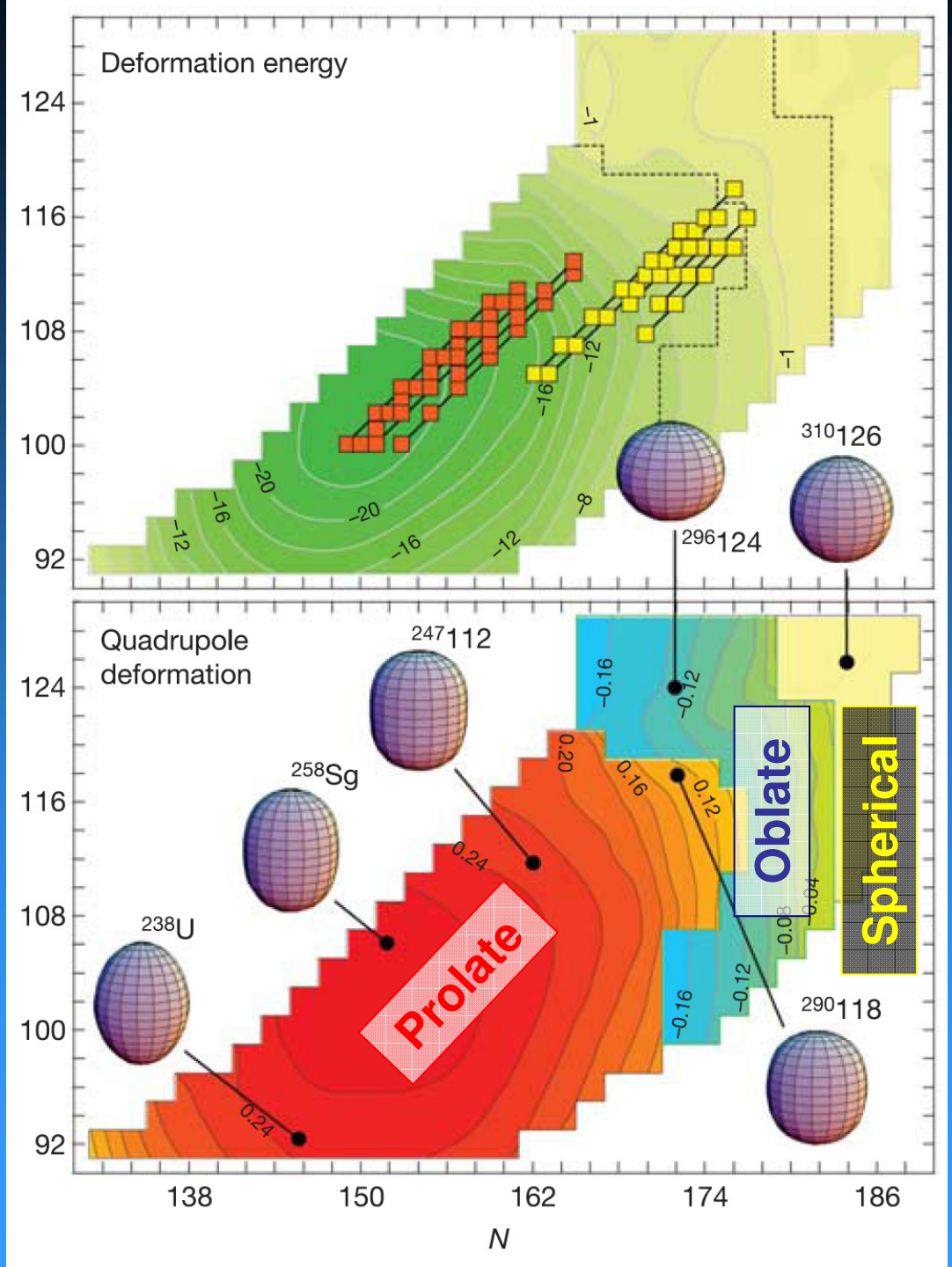


Fig. 6. The shell correction energies for proton E^p_{shell} as a function of proton number in RCHB.

Zhang et al., NPA 753 (2006) 106



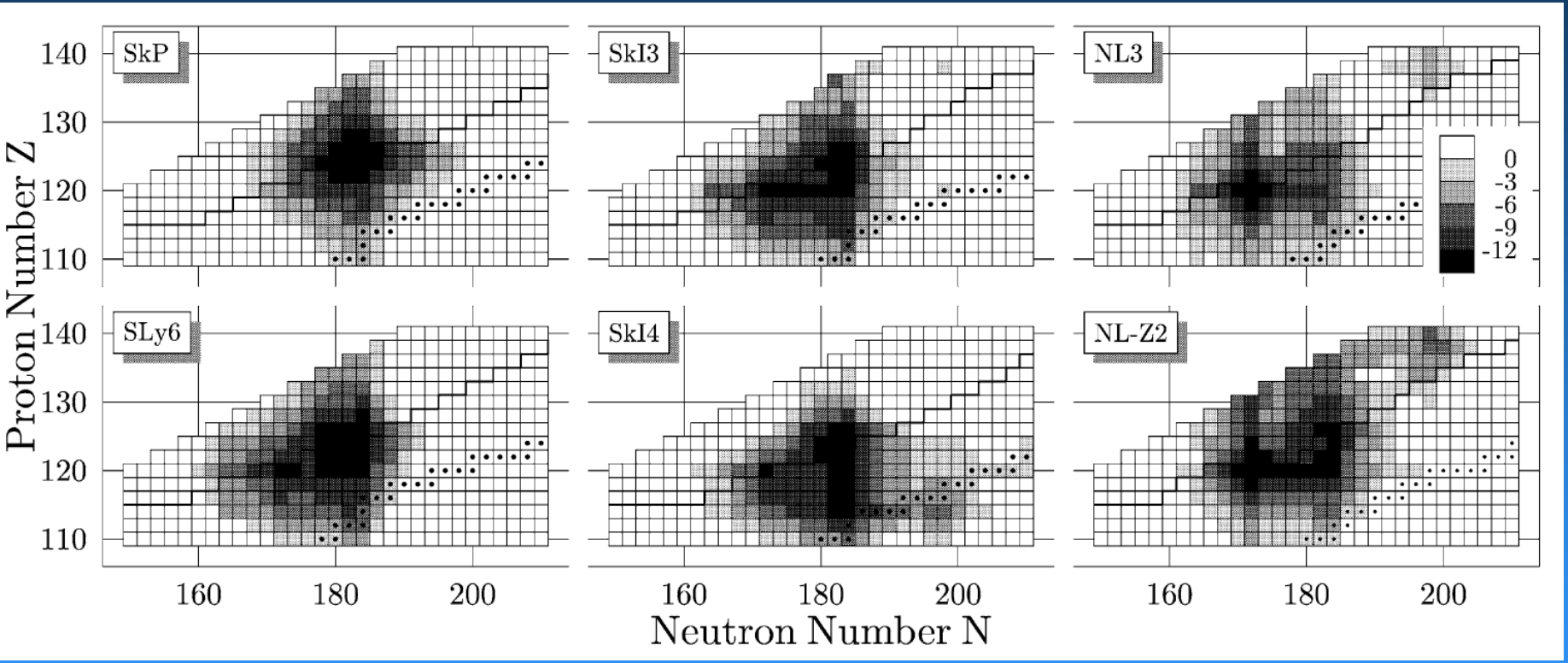
SHF (SLy4): Z=126

Shape evolution

Cwiok et al., Nature 433(2005) 705

Magic regions, not magic numbers?

Total (=neutron + proton) shell correction energy



Bender et al., Phys. Lett. B 515 (2001) 42

Eur. Phys. J. A **37**, 159–167 (2008)
DOI 10.1140/epja/i2008-10607-5

THE EUROPEAN PHYSICAL JOURNAL A

Regular Article – Experimental Physics

Shifting the closed proton shell to $Z = 122$ —A possible scenario to understand the production of superheavy elements $Z = 112$–118

P. Armbruster[a]

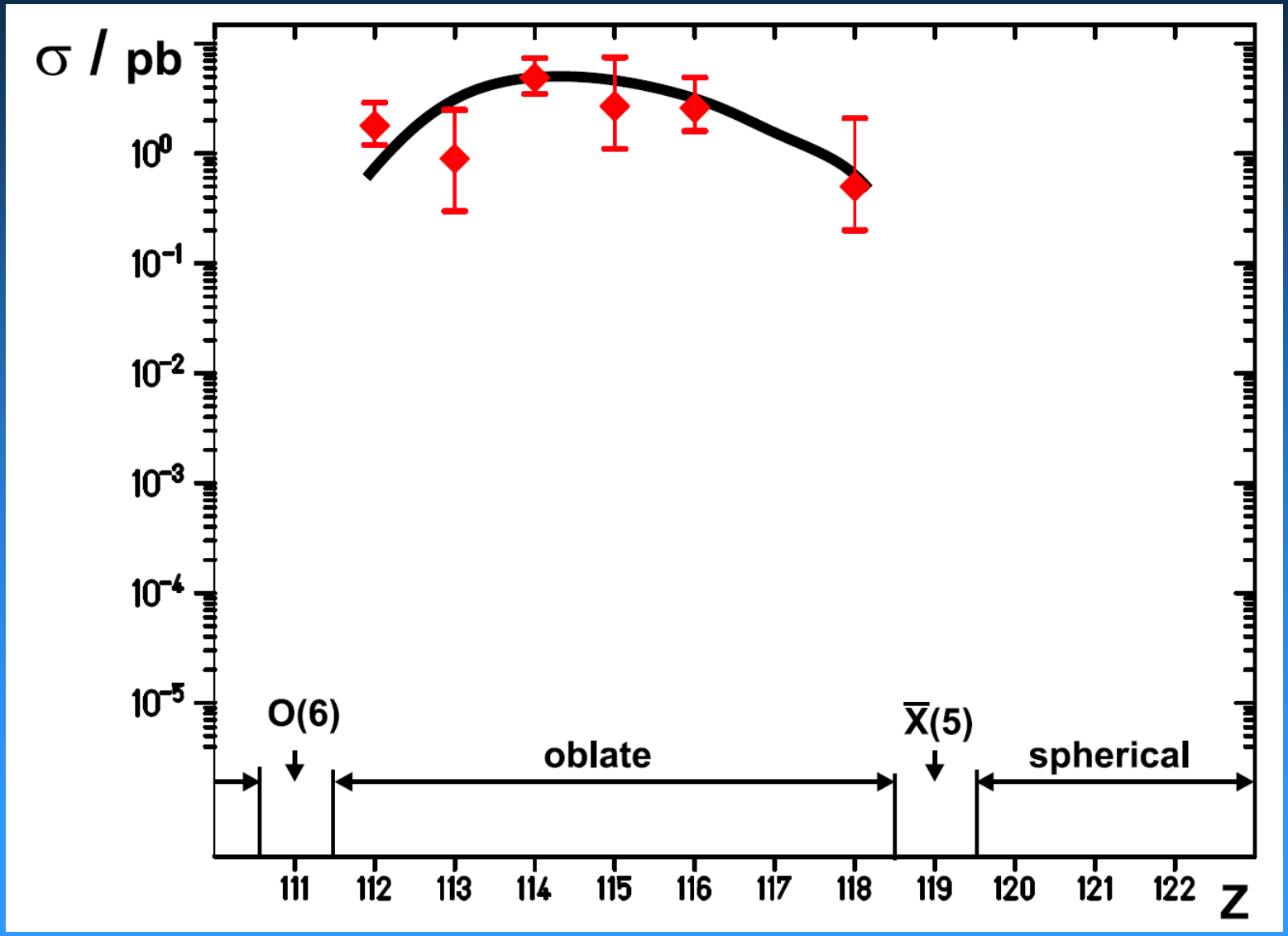
GSI Darmstadt, Planckstr. 1, D-64291 Darmstadt, Germany

Analysis of exp. $Q_\alpha \rightarrow$ Z=114 not magic at Z=172-176

Periodicities over the whole chart of nuclides interpreted with "interacting boson approx." suggest Z=122

Observed SHE are NOT spherical but oblate! $B_f > S_n$ enhances survival $\rightarrow$large and constant σ, as observed

Armbruster's model: theory vs. experiment



P. Armbruster, Eur. Phys. J. A 37 (2008) 159

Conclusion

Most promising reactions for E119 and E120:

^{50}Ti+^{249}Bk,^{249}Cf. Cross sections << 1 pb.

Crucial: $T_{1/2}(\alpha)$ and $T_{1/2}$(SF) to ensure survival of flight through separator

These depend on location of next spherical shell closures.

N=184 in most models.

Z: No agreement