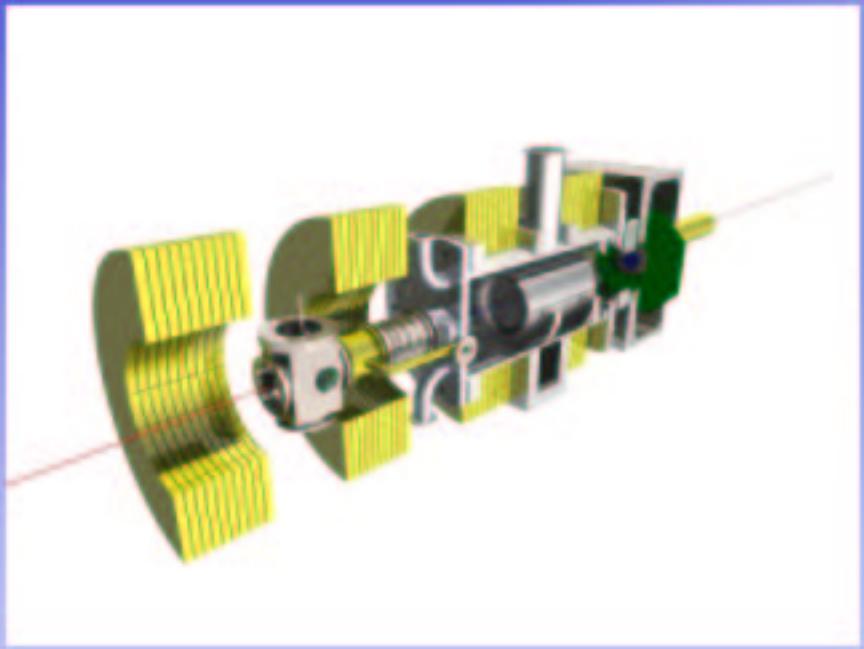
Lifetime measurements using the combined RDT and Recoil-Shadow methods



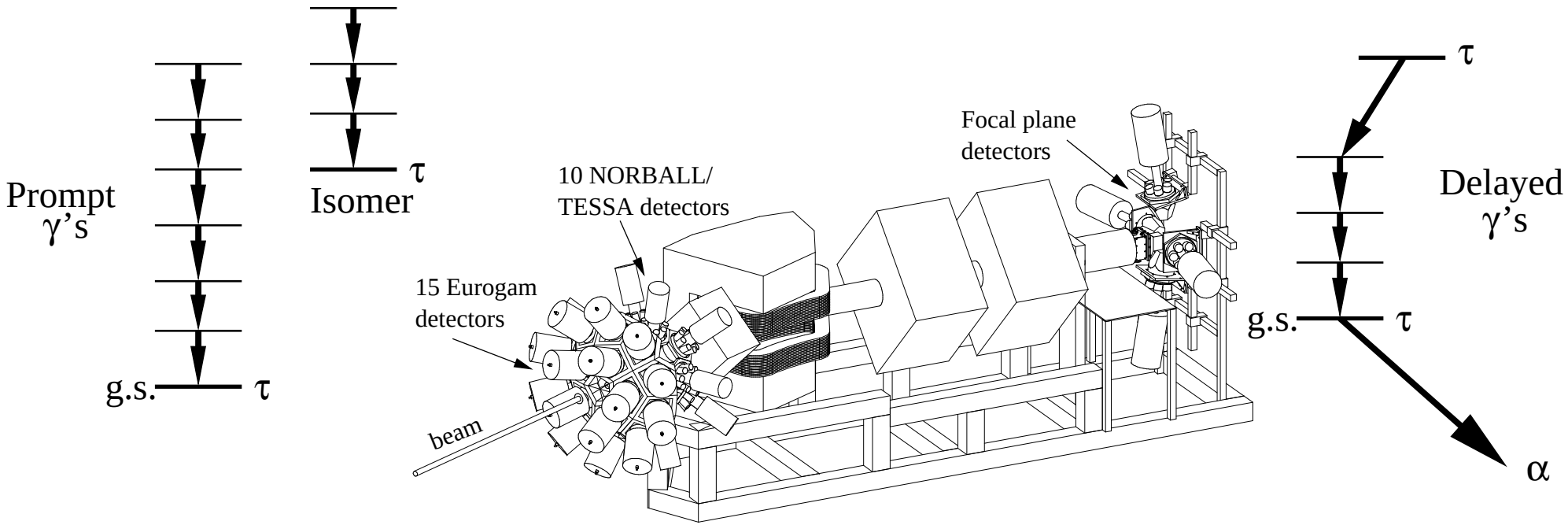
- Introduction – Techniques
- Pb region E0's
- Simulations
- First tests

Paul Greenlees

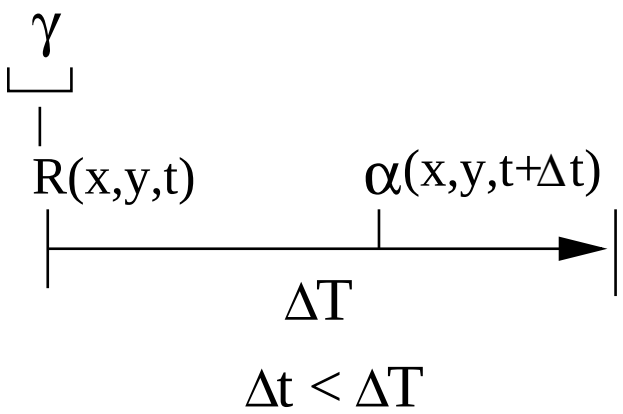
University of Jyväskylä

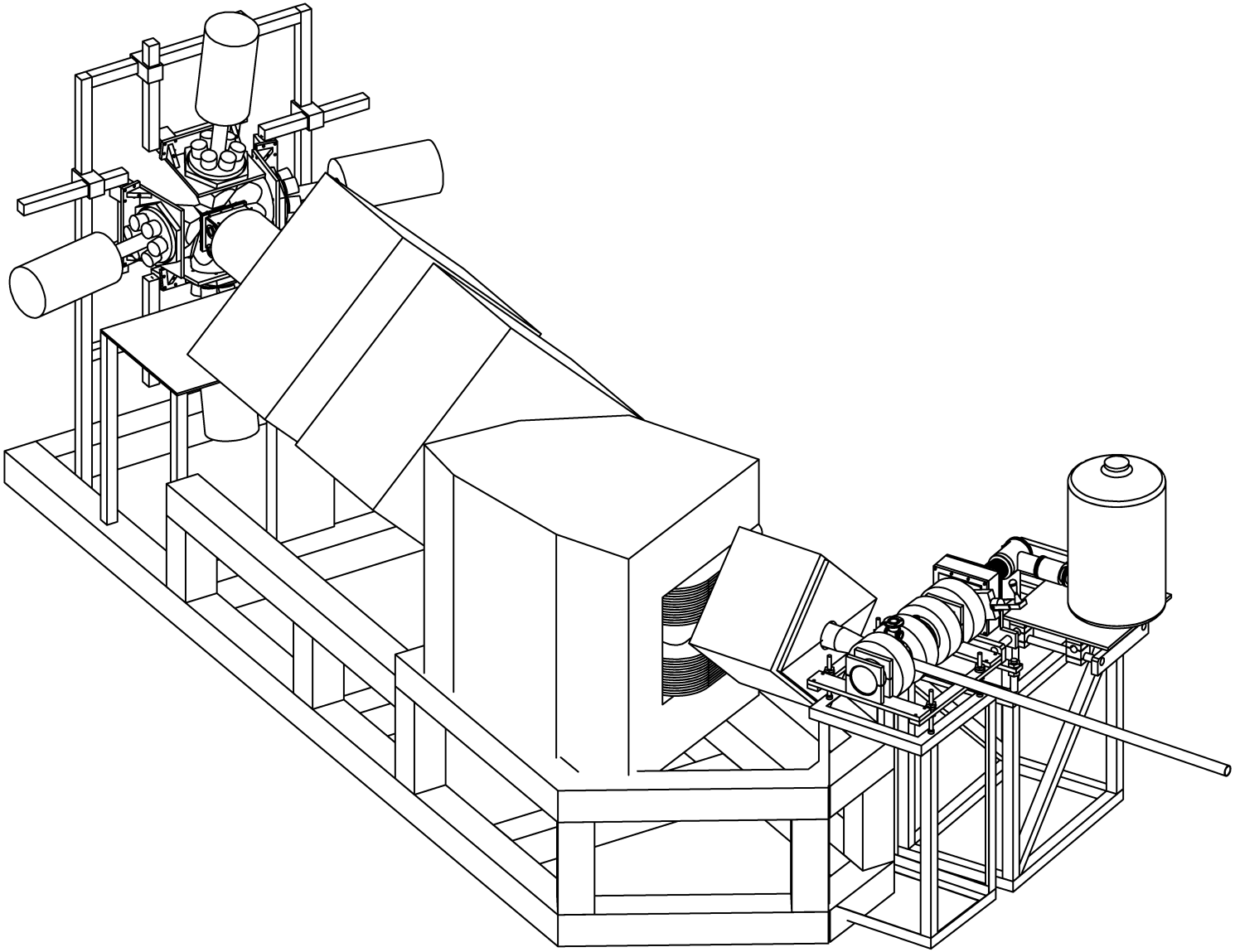
Tagging Techniques

Recoil, Recoil−Decay, Isomer



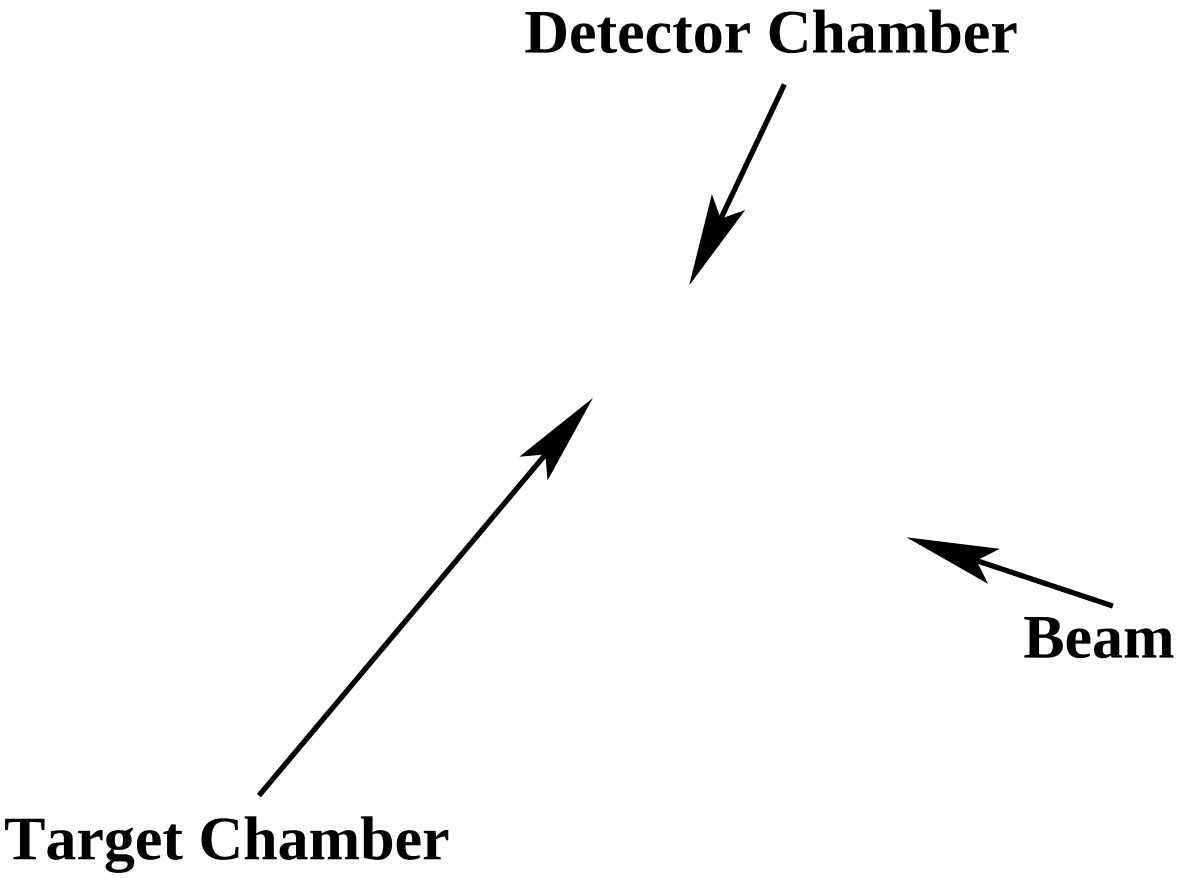
Time Line:

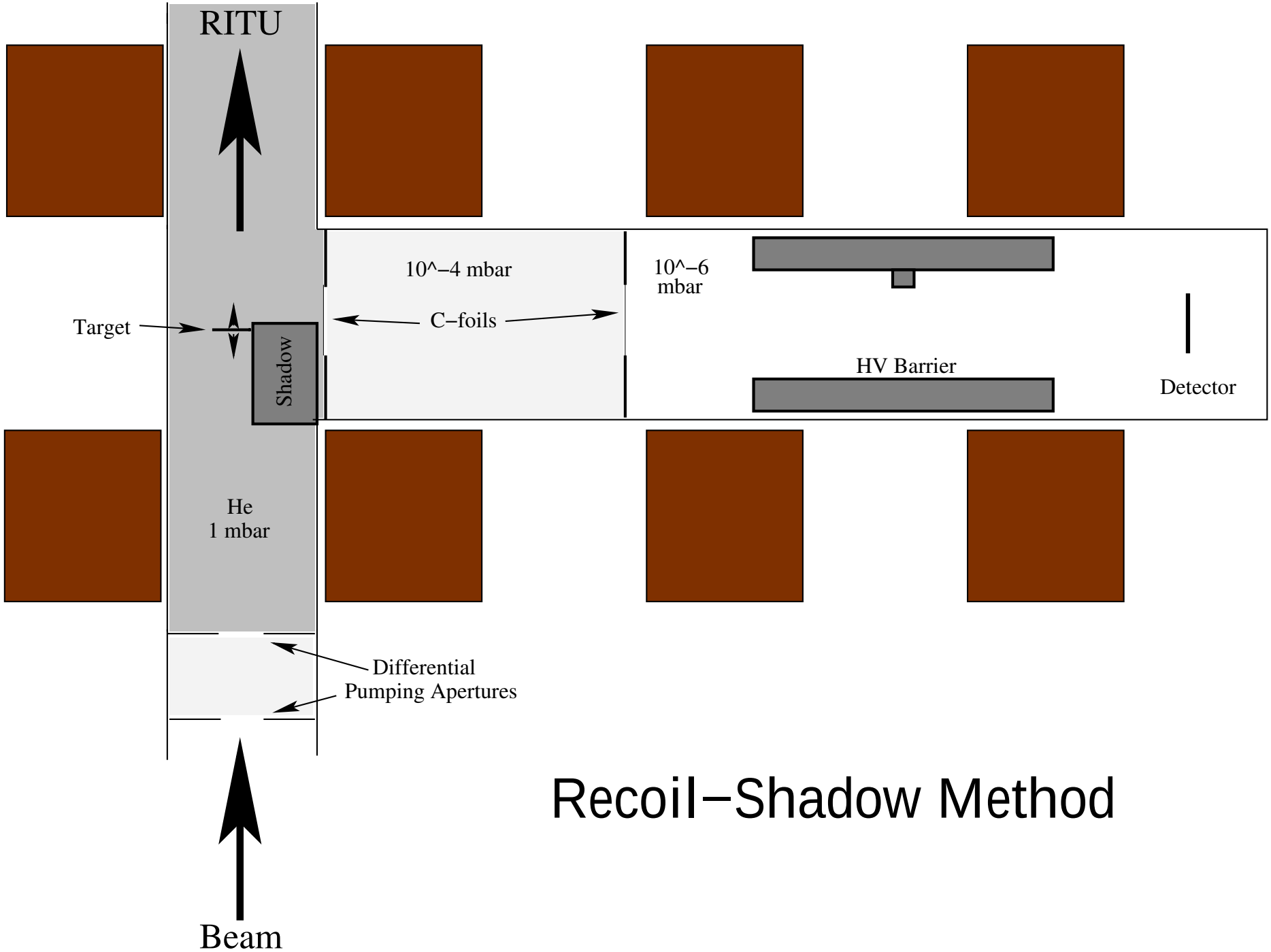




SACRED @ RITU

Transverse Geometry





Recoil−Shadow Method

0^+ States and E0 Transitions

Goals:

- Locate 0^+ states
- Measure $T_{1/2}$
- Extract monopole strength parameter, ρ^2

(need also branching ratios)

In case of K conversion:

$$\rho^2 = \frac{\ln 2}{(T_{1/2})_K \times \Omega_K}$$

Ω_K – electronic factor – analogous to ICC

ρ^2 given in "milli-units" = 0.001 ρ^2
Fast transitions ~few hundred milli-units
Typical ~10 milli-units

Two Level Model

Two mixed 0^+ states, containing components of two shapes e.g. sph-def

Wave functions:

$$\left|0_i^+\right\rangle = a\left|sph\right\rangle + b\left|def\right\rangle$$

$$\left|0_f^+\right\rangle = -b\left|sph\right\rangle + a\left|def\right\rangle$$

Monopole matrix element:

$$\left\langle 0_f^+\left|m(E0)\right|0_i^+\right\rangle \approx abk\beta^2$$

$$k = \frac{3}{4\pi} ZeR^2\left[1 + \frac{4\pi^2}{3}\left(\frac{a_0}{R}\right)^2\right]$$

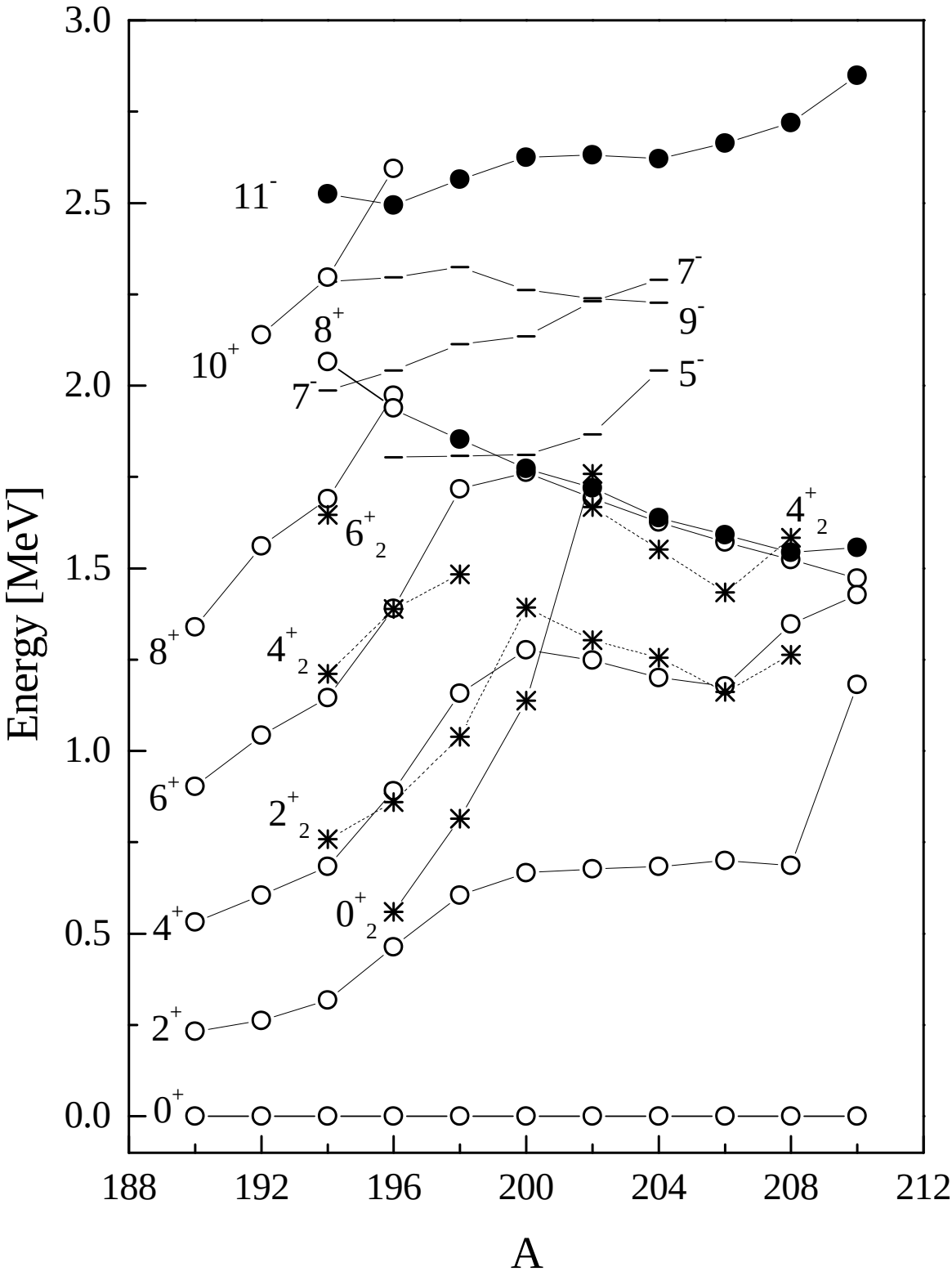
Monopole Strength:

$$\rho^2 \propto a^2\left(1 - a^2\right)\beta^4$$

N.B. Mixing: 50-50 – 100
60-40 – 96
80-20 – 64
90-10 – 36

Kantele, Handbook of Nuclear Spectroscopy:
"... large values of ρ^2 imply the presence of sizeable deformation, as well as mixing of components with different $\langle r^2 \rangle$."

Level Sytematics for Even−Even Po Isotopes



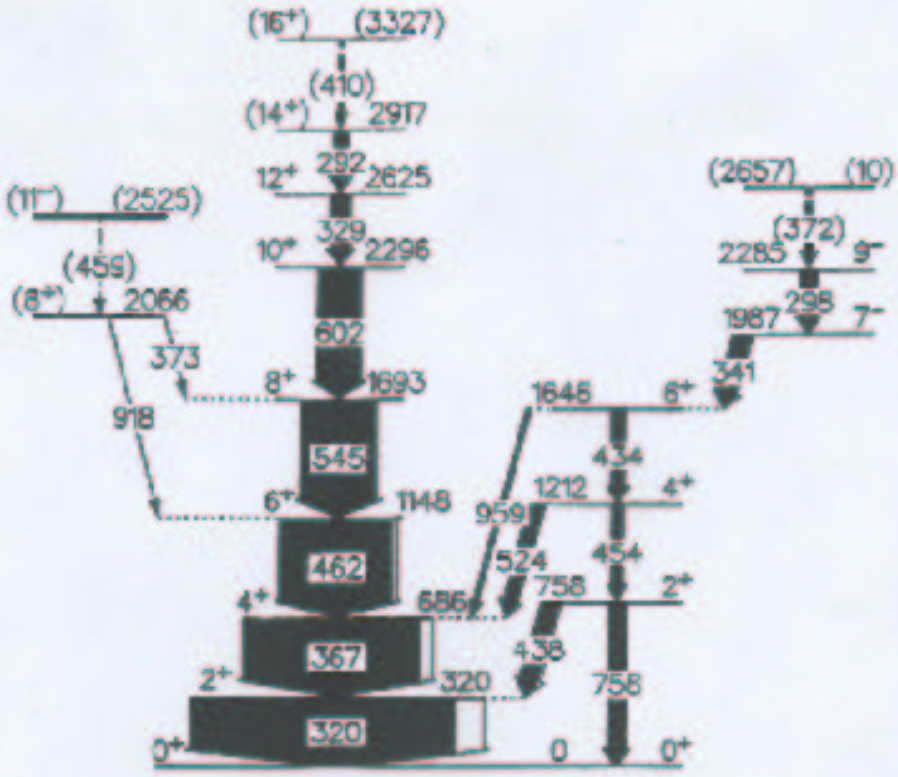
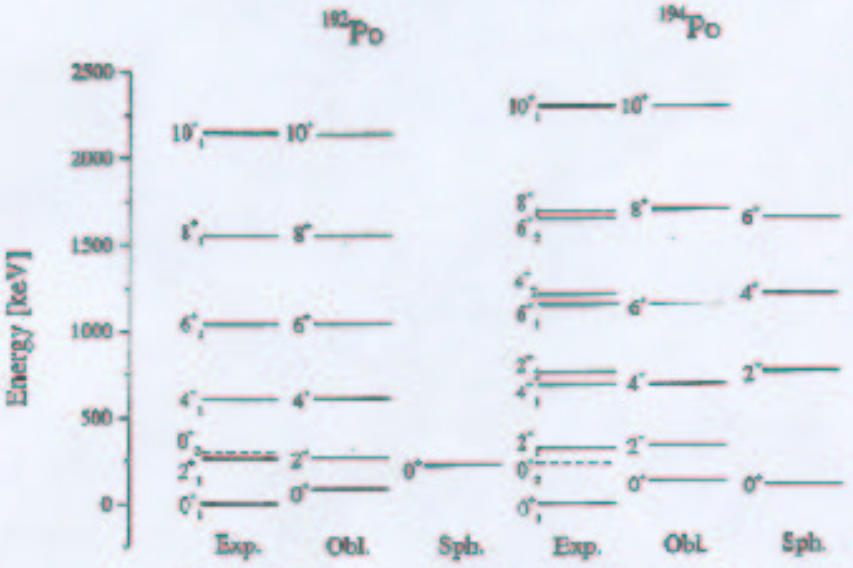


Figure 4.6. Level scheme of ^{194}Po.



0_1^+ 73% obl. 0_1^+ 45% obl

Figure 4.12. Experimental and unperturbed spherical and oblate deformed level energies for ^{192}Po and ^{194}Po. The energies are normalized with respect to the experimental 0^+_1 states.

K. HEURIUTTA THESIS (1999)

PERTURBED 0^+ STATES FROM THEORY, OROS ET AL NPA 645, 107 (1999)

$Z \approx 82$ $E \approx 200$ keV $T_{1/2}(E0) \sim 800$ ps

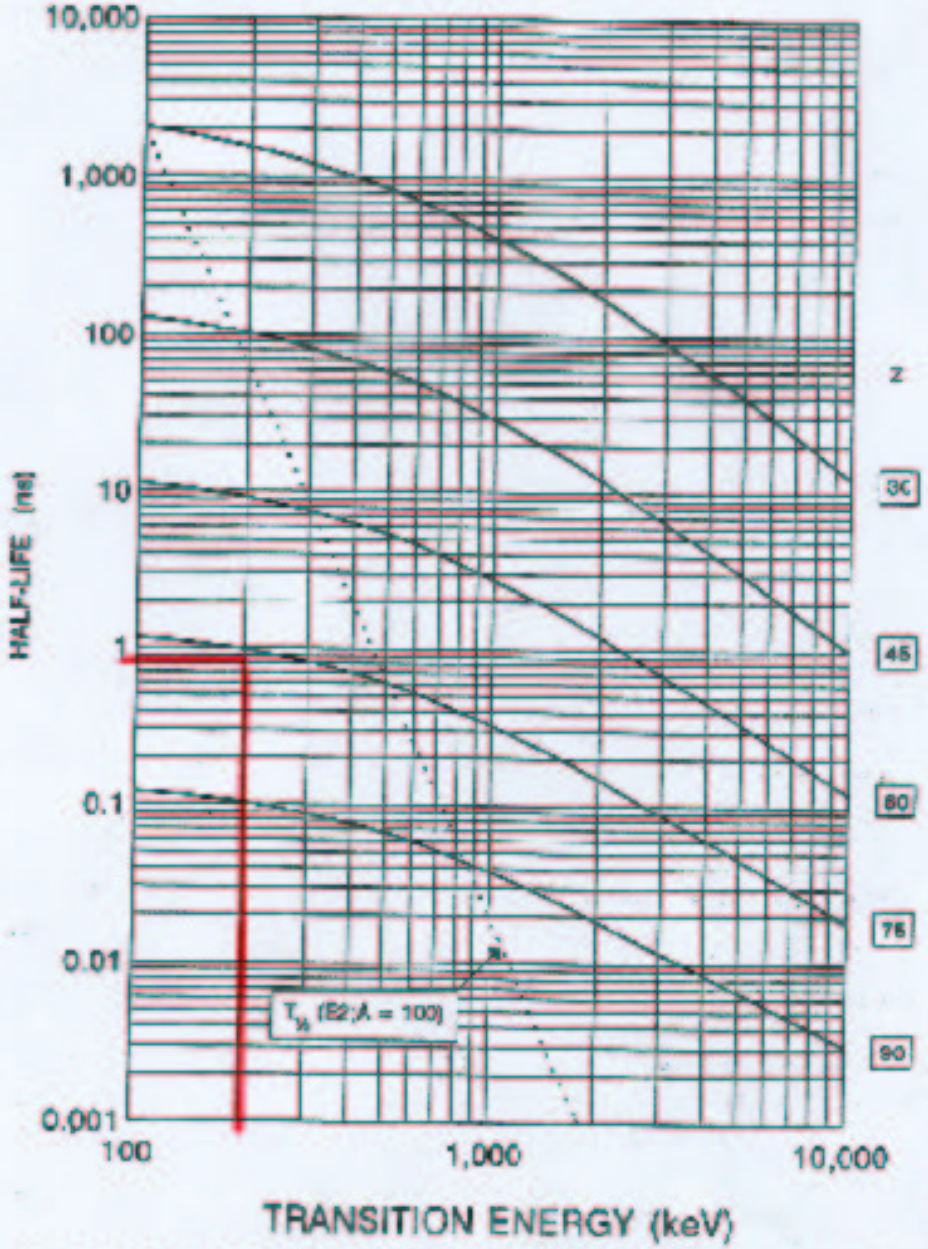
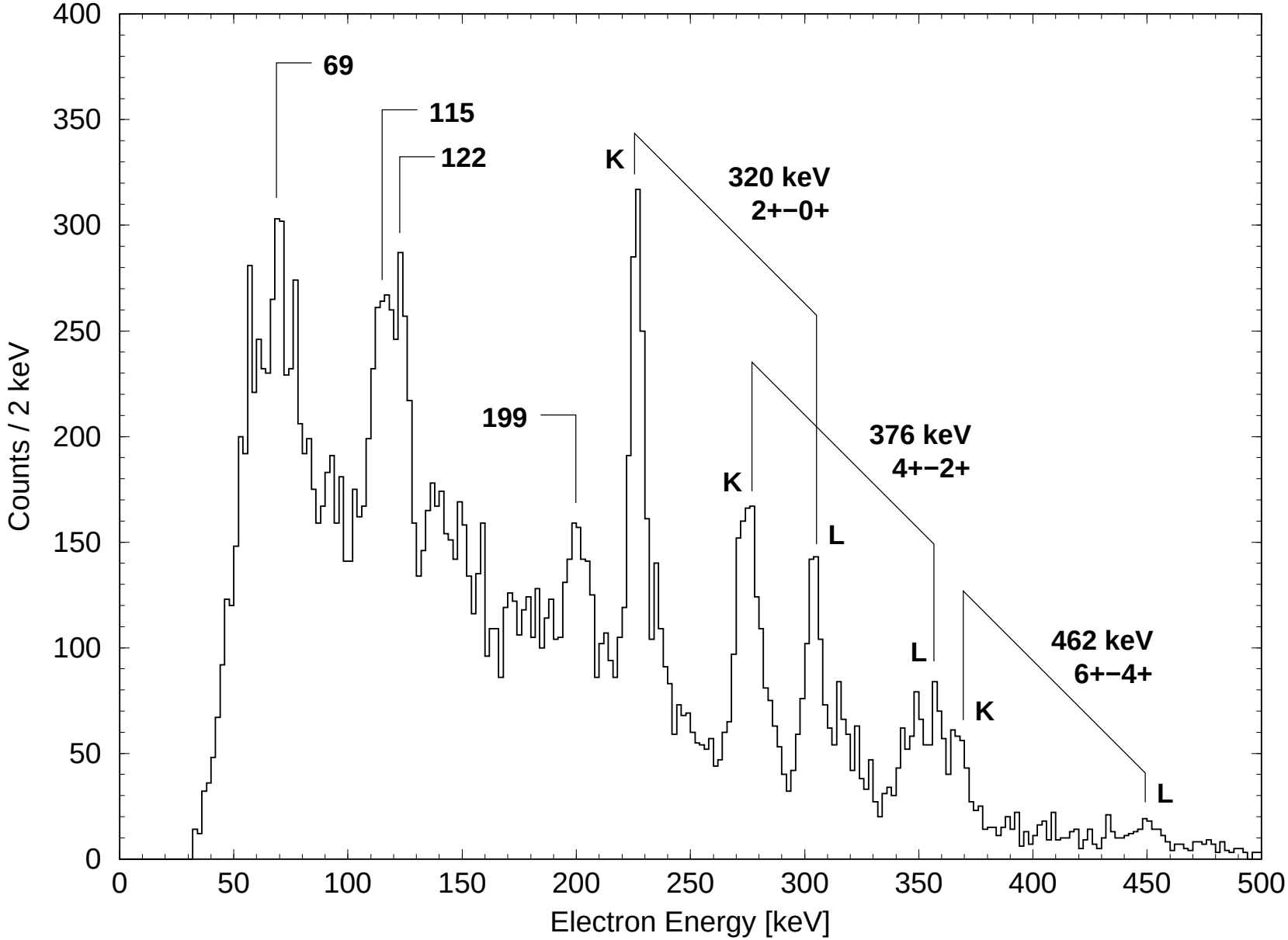


Figure 6-8 Speeds of E0 transitions with $\rho^2 = 0.010$. For comparison, the Weisskopf estimate half-life for E2 ($A = 100$) is also shown.

194Po a−tagged electrons

from 28Si+170Yb @ 143MeV



P.Rahkila 12.3.2001

$Z \approx 82 \quad E \approx 200$ keV $\quad K/L \sim 5.5-6$

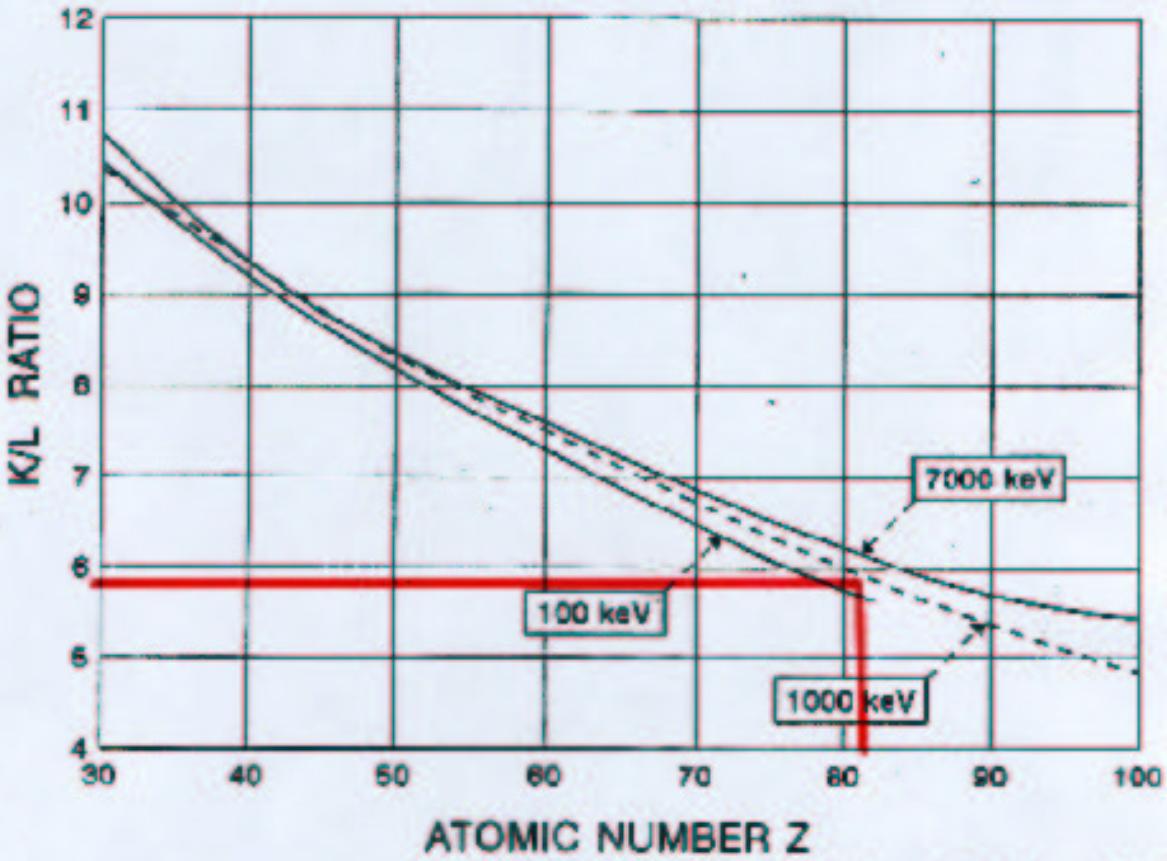
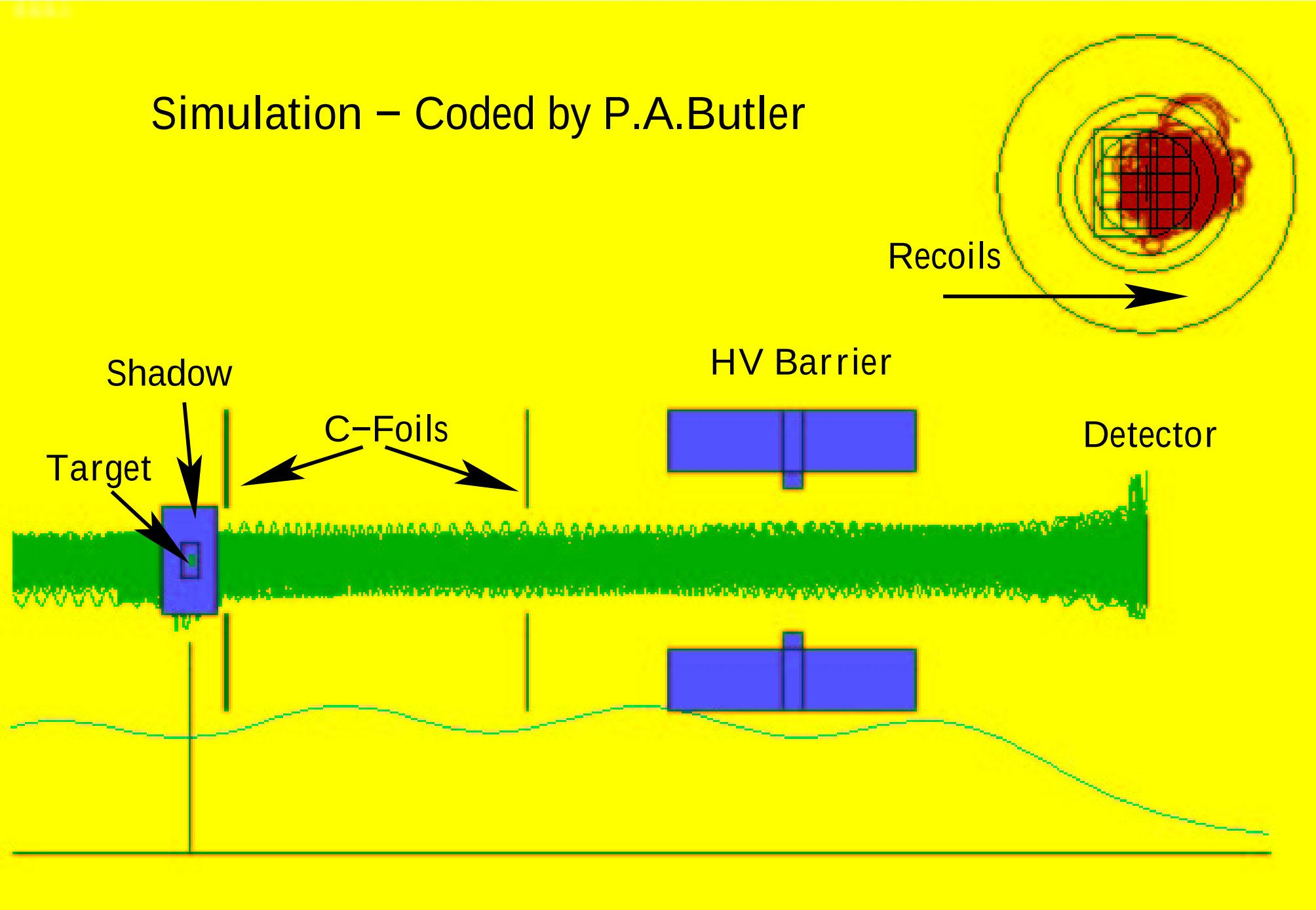
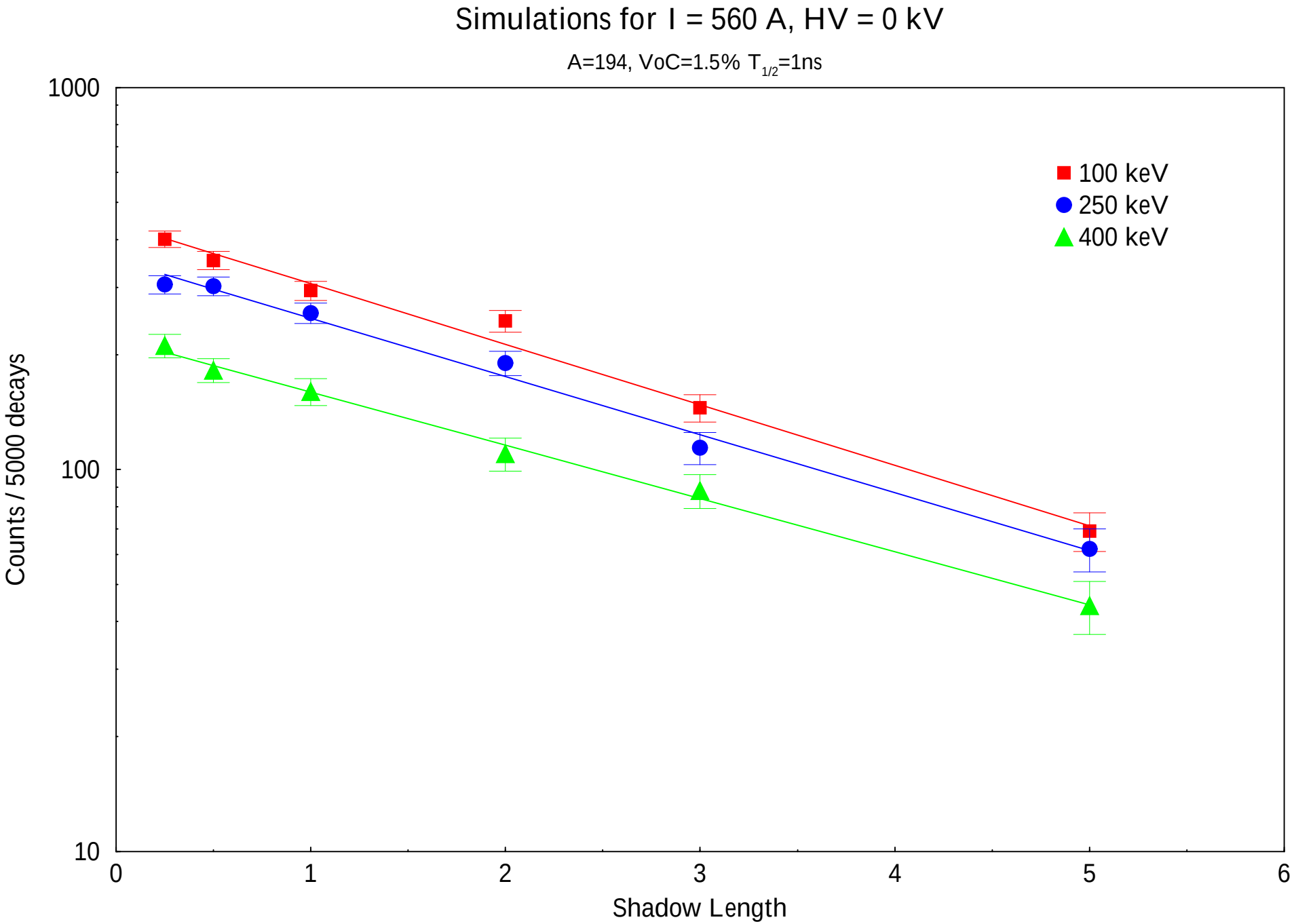
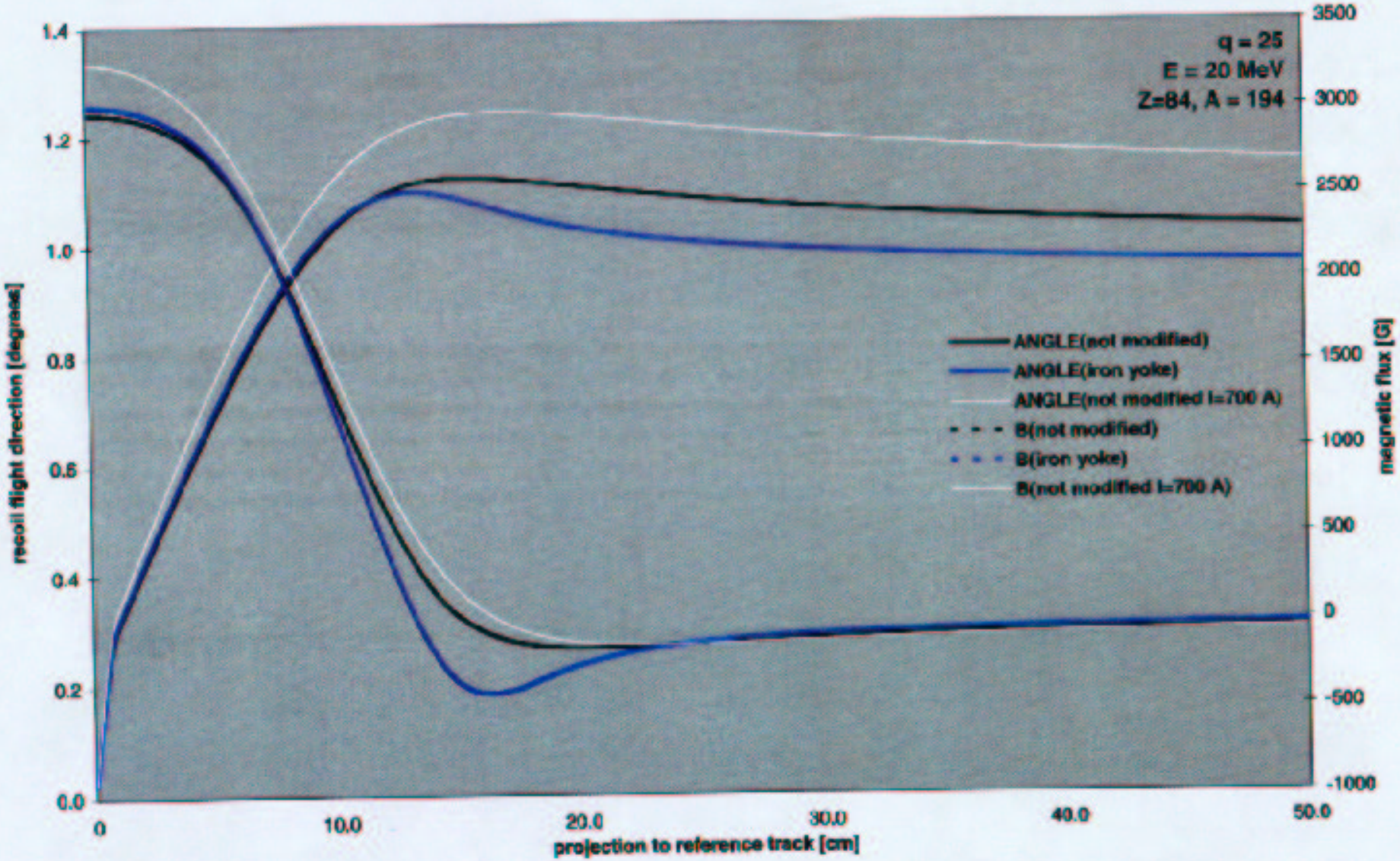


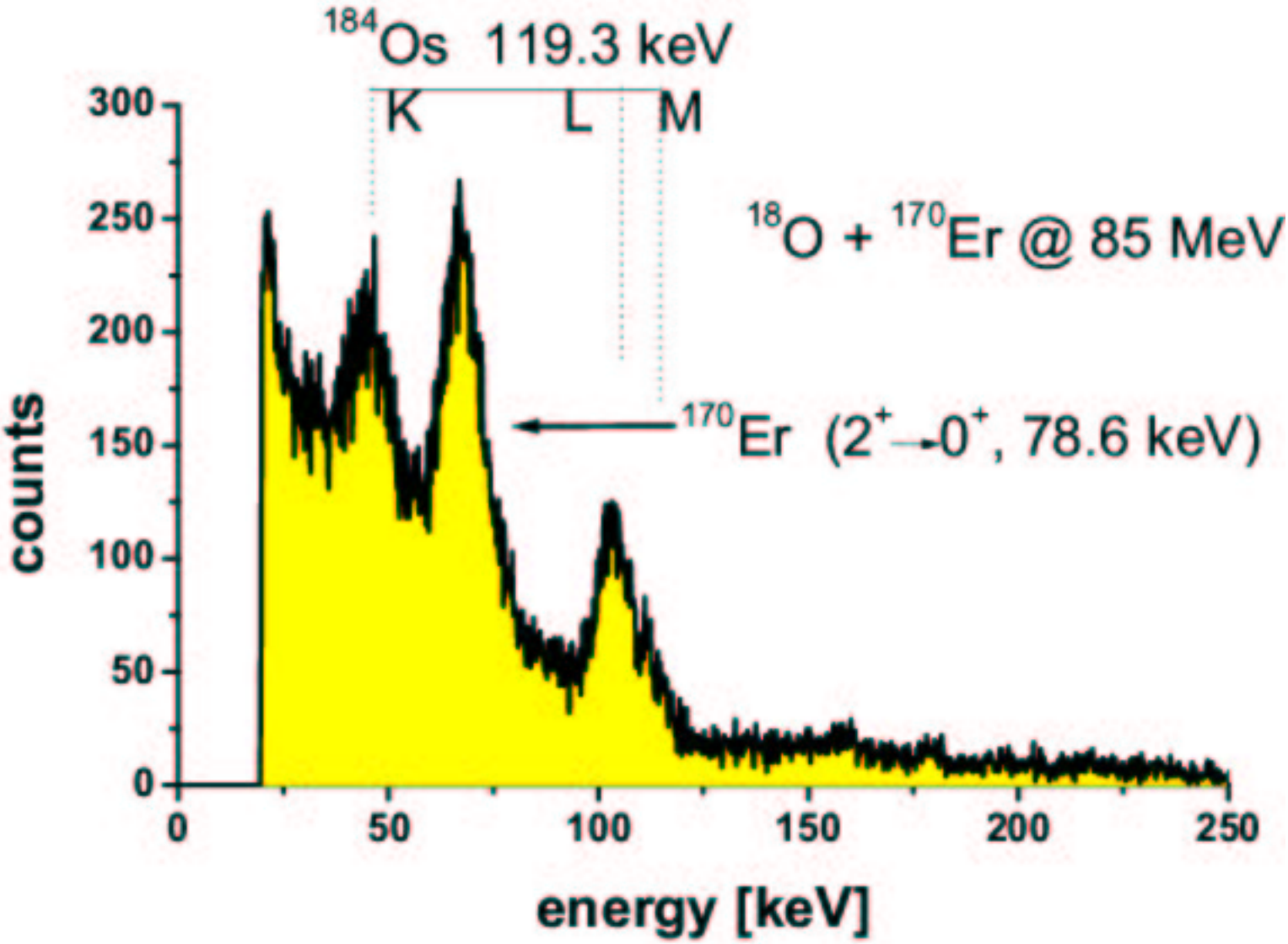
Figure 6-7 Behaviour of K/L conversion ratios of E0 transitions as functions of Z for some energies. Except for very high-Z elements,, the energy dependence is rather weak.

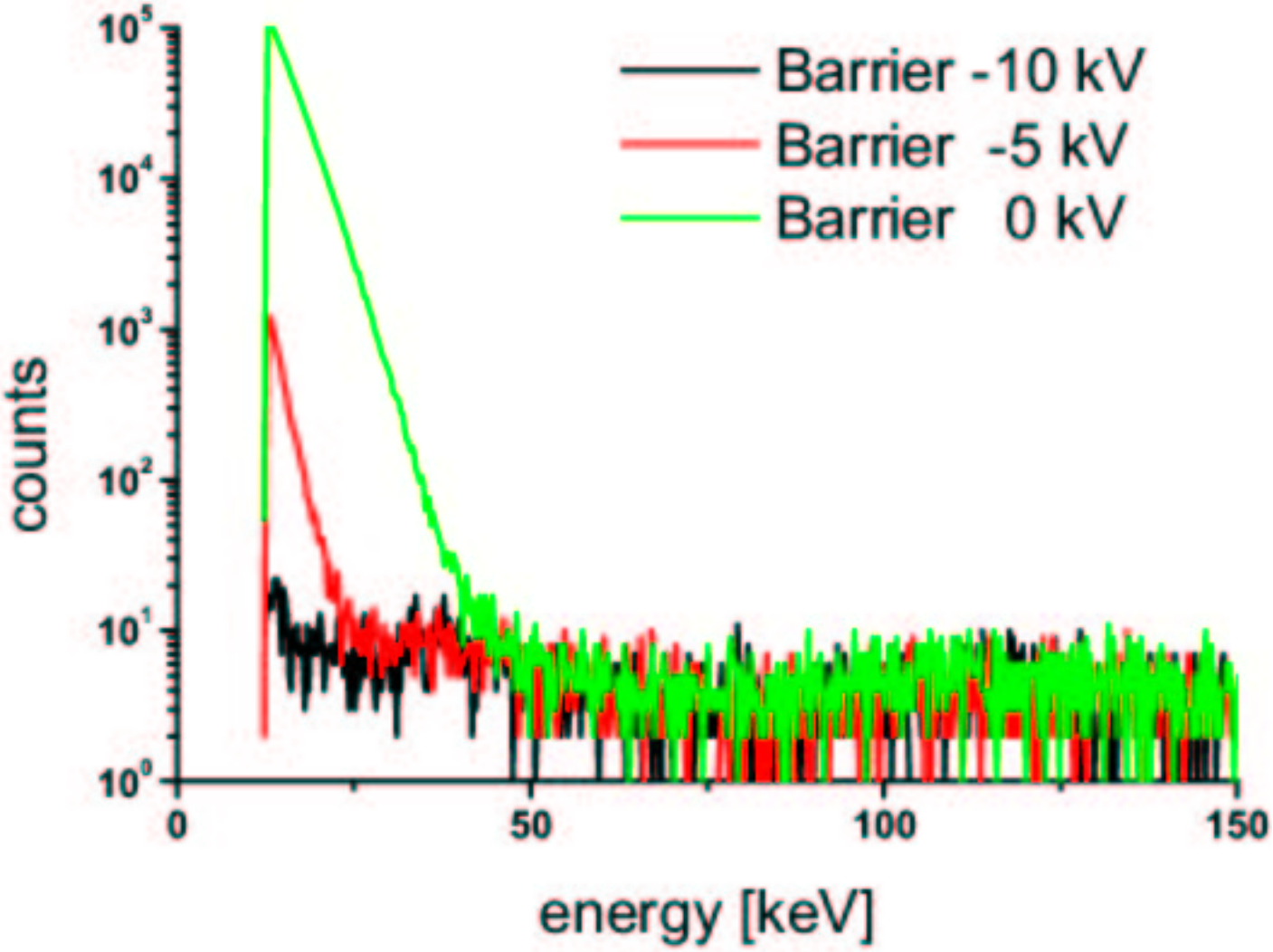

Simulation − Coded by P.A.Butler
Recoils
Shadow
HV Barrier
C−Foils
Detector
Target


Simulations for I = 560 A, HV = 0 kV
A=194, VoC=1.5% T1/2=1ns
100 keV
250 keV
400 keV
Counts / 5000 decays
Shadow Length
1000
100
10
0
1
2
3
4
5
6

J. PAKARINEN


q = 25
E = 20 MeV
Z=84, A = 194
ANGLE(not modified)
ANGLE(iron yoke)
ANGLE(not modified I=700 A)
B(not modified)
B(iron yoke)
B(not modified I=700 A)
recoil flight direction [degrees]
magnetic flux [G]
projection to reference track [cm]
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
3500
3000
2500
2000
1500
1000
500
0
-500
-1000
0
10.0
20.0
30.0
40.0
50.0


184Os 119.3 keV
K
L
M
18O + 170Er @ 85 MeV
170Er (2+→0+, 78.6 keV)
counts
energy [keV]
0
50
100
150
200
250
300


Barrier -10 kV
Barrier -5 kV
Barrier 0 kV
counts
energy [keV]
10^5
10^4
10^3
10^2
10^1
10^0
0
50
100
150