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Nuclear Structure Physics with advanced Gamma-Detector arrays  
10-12 June 2013  
Palazzo del Bo', Padova, Italy

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# High-spin Yrast Isomers in $^{204}\text{Hg}$

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Po

Pb

Hg

Pt

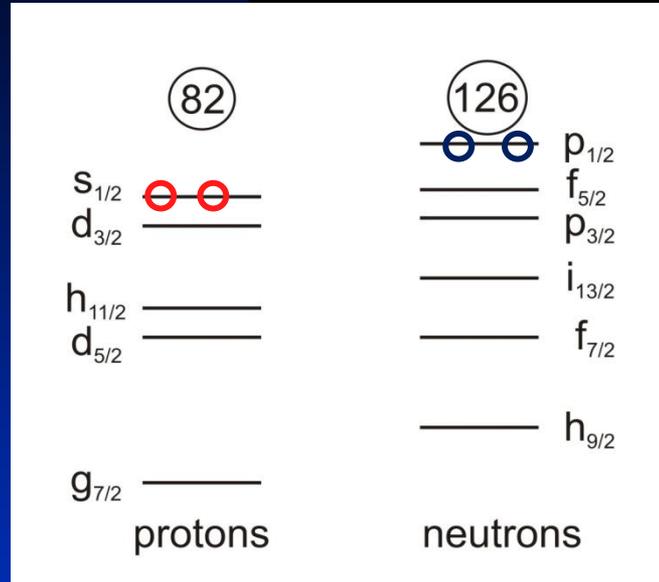
|                  |   |                          |                           |                                   |                   |  |                    |   |                                     |                                |                   |
|------------------|---|--------------------------|---------------------------|-----------------------------------|-------------------|--|--------------------|---|-------------------------------------|--------------------------------|-------------------|
| At 204<br>9,2 m  | At 205<br>26,2 m                            | At 206<br>29,4 m         | At 207<br>1,8 h           | At 208<br>1,63 h                  | At 209<br>5,4 h   | At 210<br>8,3 h                          | At 211<br>7,22 h   | At 212<br>119 ms / 314 ms                   | At 213<br>0,11 μs                   | At 214<br>8,2 μs / 0,16 μs     | At 215<br>0,1 ms  |
| Po 203<br>45 s   | Po 204<br>3,53 h                            | Po 205<br>1,66 h         | Po 206<br>8,8 d           | Po 207<br>2,8 s / 5,84 h          | Po 208<br>2,898 a | Po 209<br>102 a                          | Po 210<br>138,38 d | Po 211<br>25,2 s / 0,616 s                  | Po 212<br>45,1 s / 17,1 ns / 0,3 μs | Po 213<br>4,2 μs               | Po 214<br>164 μs  |
| Bi 202<br>1,72 h | Bi 203<br>11,76 h                           | Bi 204<br>11,22 h        | Bi 205<br>15,31 d         | Bi 206<br>6,24 d                  | Bi 207<br>31,55 a | Bi 208<br>3,68 · 10 <sup>5</sup> a       | Pb 209<br>100      | Bi 210<br>3,0 · 10 <sup>6</sup> h / 5,018 d | Bi 211<br>2,17 m                    | Bi 212<br>3 m / 25 m / 60,10 m | Bi 213<br>45,59 m |
| Pb 201<br>61 s   | Pb 202<br>3,62 h / 5,25 · 10 <sup>4</sup> a | Pb 203<br>6,2 s / 51,9 h | Pb 204<br>67,2 m / 1,4    | Pb 205<br>1,5 · 10 <sup>7</sup> a | Pb 206<br>24,4    | Pb 207<br>22,3                           | Pb 208<br>253 h    | Pb 209<br>22,3 a                            | Pb 210<br>22,3 a                    | Pb 211<br>36,1 m               | Pb 212<br>10,64 h |
| Tl 200<br>26,1 h | Tl 201<br>73,1 h                            | Tl 202<br>12,23 d        | Tl 203<br>29,524          | Tl 204<br>3,78 a                  | Tl 205<br>70,476  | Tl 206<br>3,7 m / 4,20 m / 1,3 s / 4,7 m | Tl 208<br>3,053 m  | Tl 209<br>2,16 m                            | Tl 210<br>1,30 m                    | Tl 211                         |                   |
| Hg 199<br>42,6 m | Hg 200<br>16,87                             | Hg 201<br>23,10          | Hg 202<br>10,18           | Hg 203<br>29,86                   | Hg 204<br>46,59 d | Hg 205<br>6,87                           | Hg 206<br>5,2 m    | Hg 207<br>115 m                             | Hg 208<br>2,9 m                     | Hg 209<br>~ 42 m               | Hg 210<br>35 s    |
| Au 198<br>2,30 d | Au 199<br>2,6943 d                          | Au 200<br>3,139 d        | Au 201<br>18,7 h / 48,4 m | Au 202<br>26,4 m                  | Au 203<br>28 s    | Au 204<br>60 s                           | Au 205<br>39,8 s   | Au 206<br>31 s                              |                                     |                                |                   |
| Pt 197<br>94,4 m | Pt 198<br>18,3 h                            | Pt 199<br>7,2            | Pt 200<br>13,6 s / 39,8 m | Pt 201<br>12,5 h                  | Pt 202<br>2,5 m   | Pt 203<br>~ 43,6 h                       |                    |   |                                     |                                |                   |

208 Pb

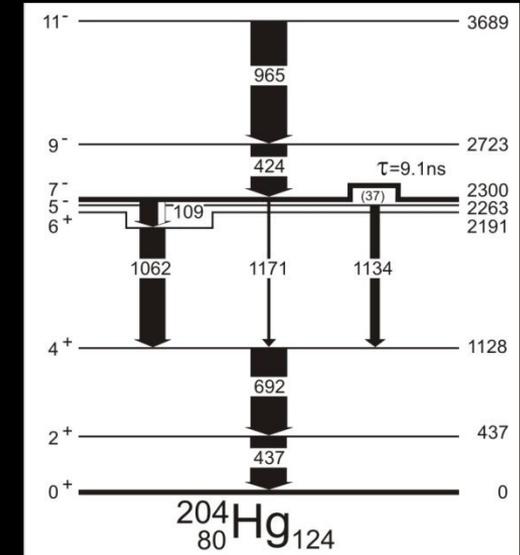


tion

# HIGH-SPIN STATES BEFORE PRESENT STUDY



tentative (8+)



Valance hole configurations

Incomplete – fusion reaction  
A.R. Poletti *et al.*, A473 (1987) 595

## EXPERIMENTS:

### *Deep-inelastic reactions*

*successful application for spectroscopic study around  $^{208}\text{Pb}$*

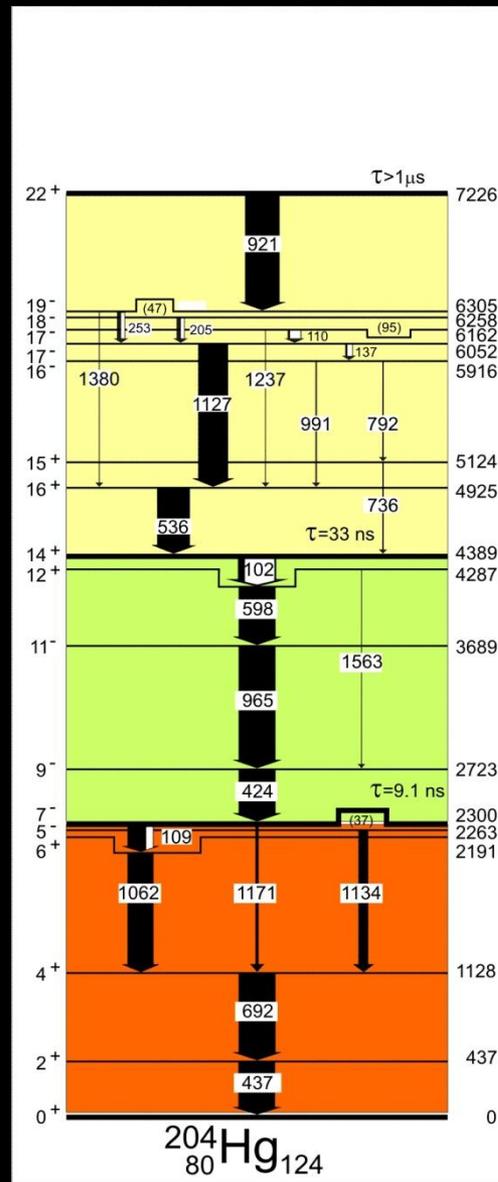
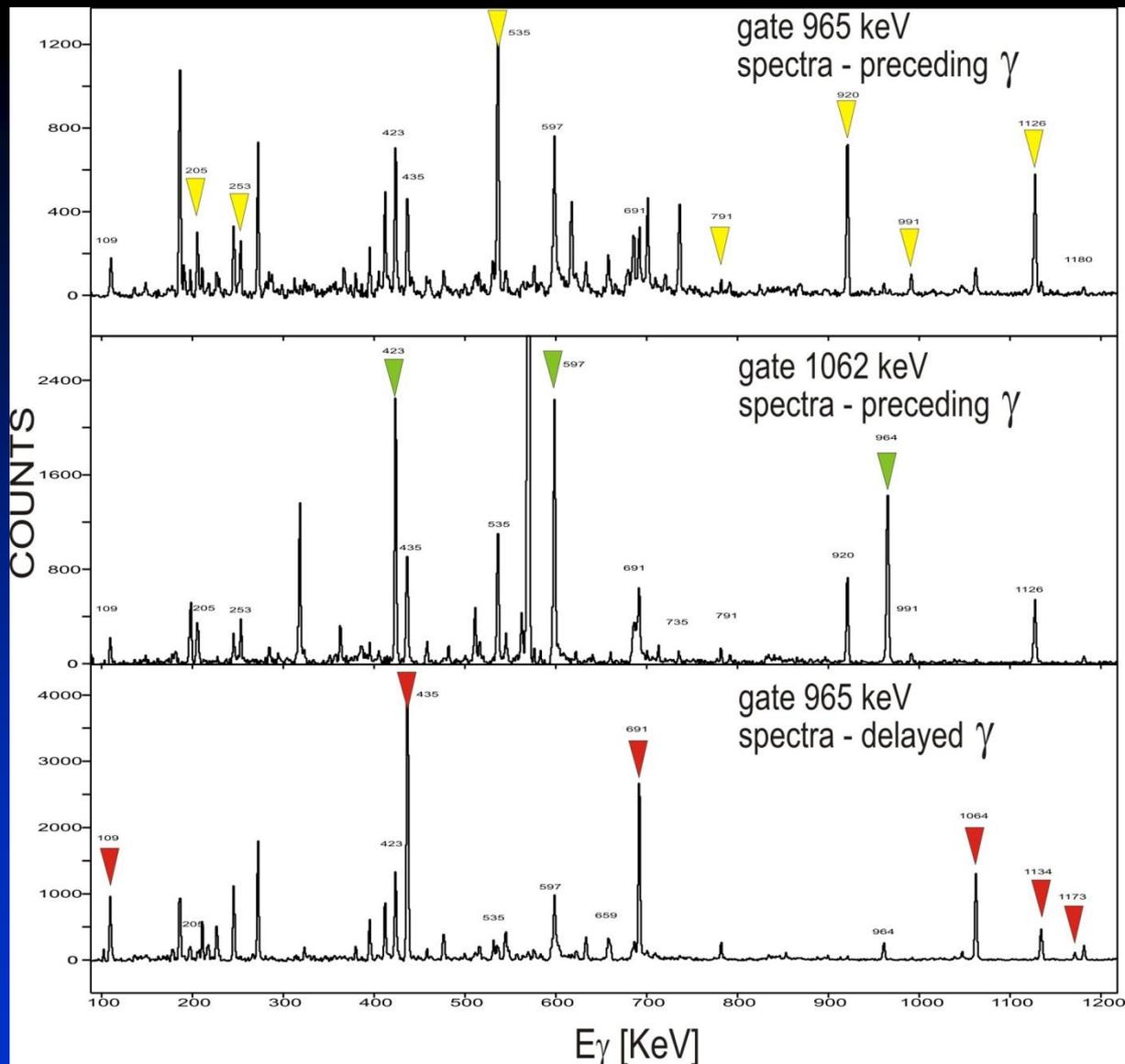
ANL Argonne -

- GAMMASPHER Array 101 detectors,
- Atlas accelerator

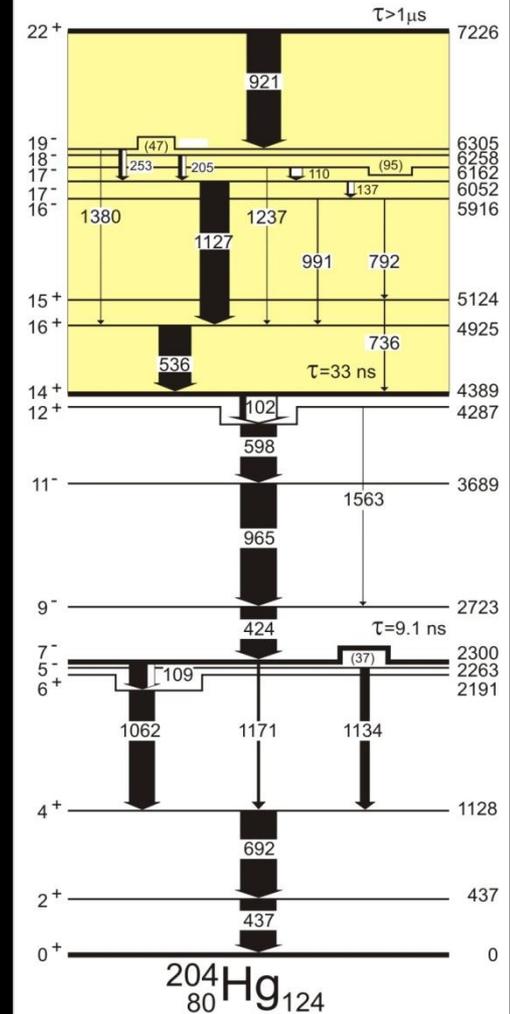
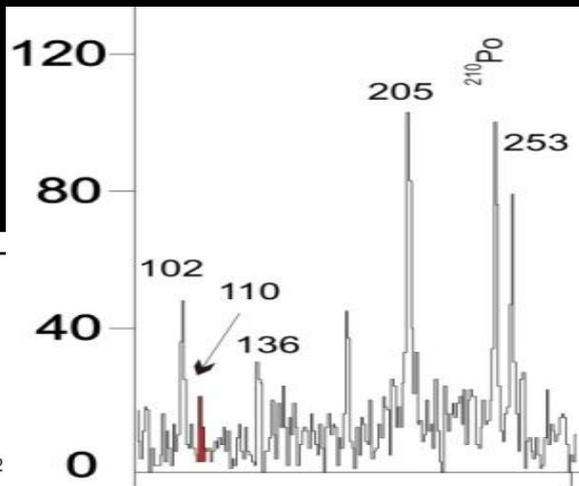
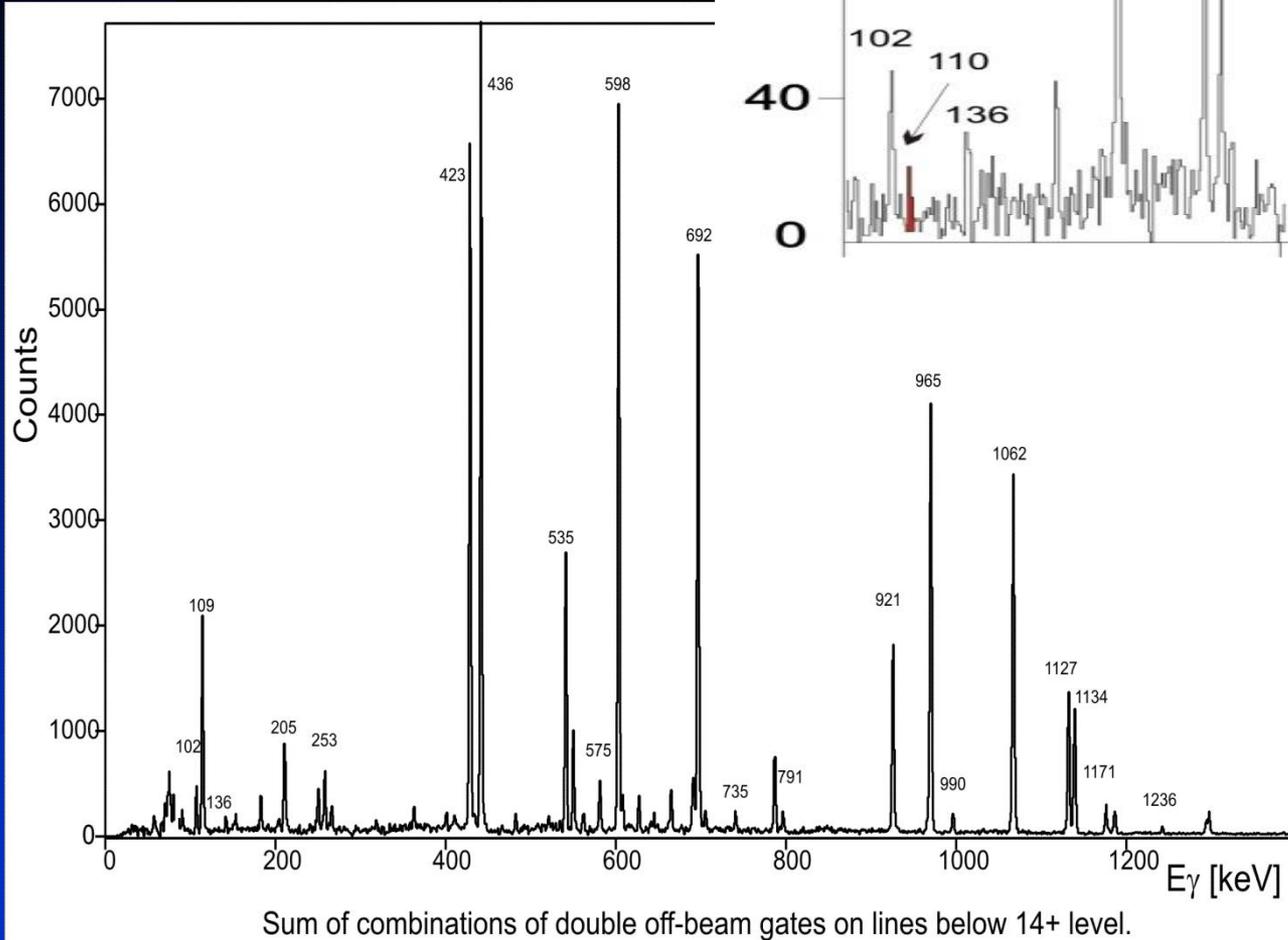
- $^{208}\text{Pb}$  (1360 MeV) +  $^{238}\text{U}$   
thick target  $50\text{mg}/\text{cm}^2$   
pulsed beam  $1.65\ \mu\text{s}$  repetition time  
events:  $\sim 2.3 \times 10^9$

- $^{48}\text{Ca}$  ( 330 MeV) +  $^{238}\text{U}$

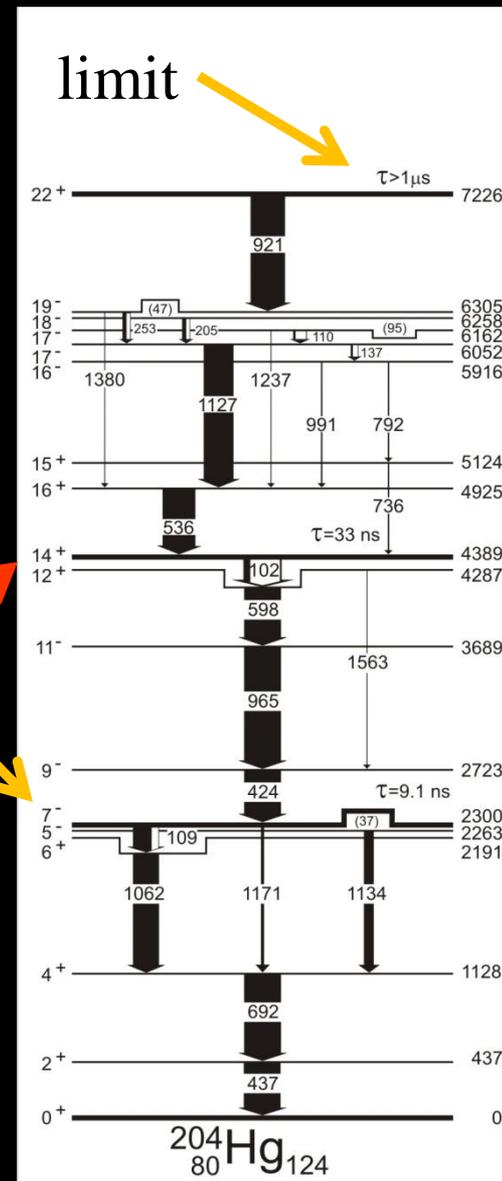
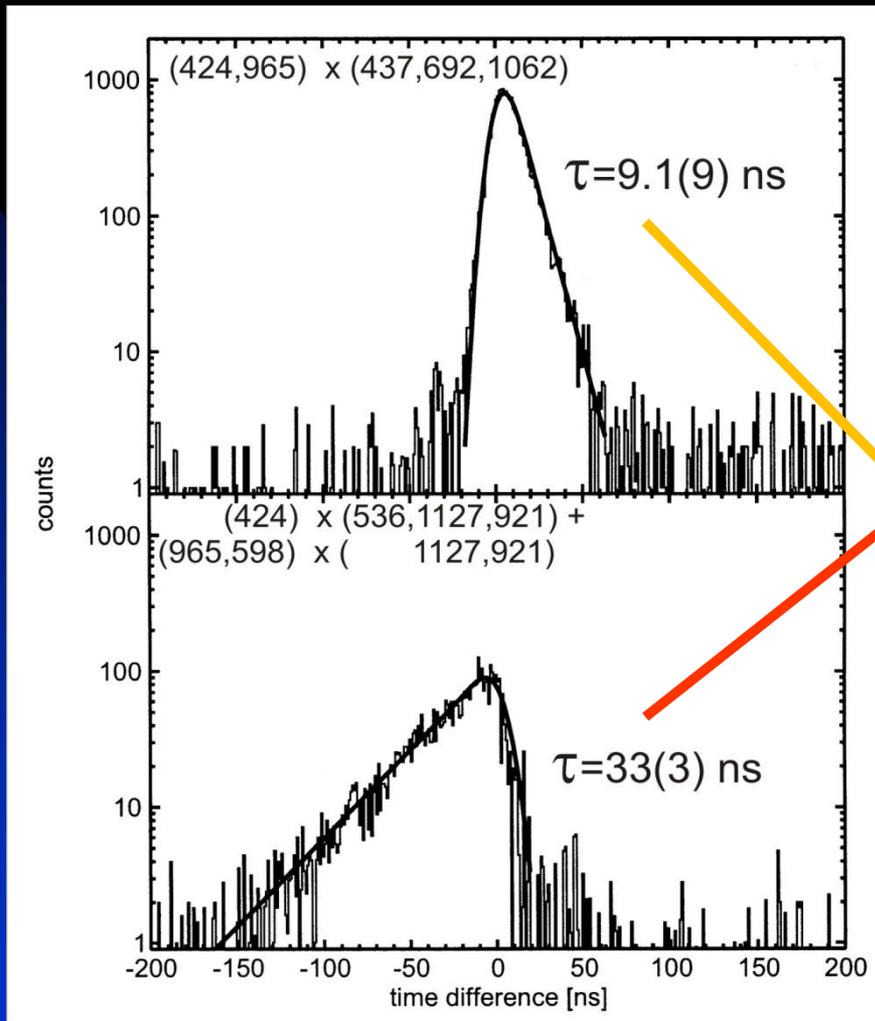
# $\gamma$ - $\gamma$ TIME CORRELATIONS



# LEVEL SCHEME

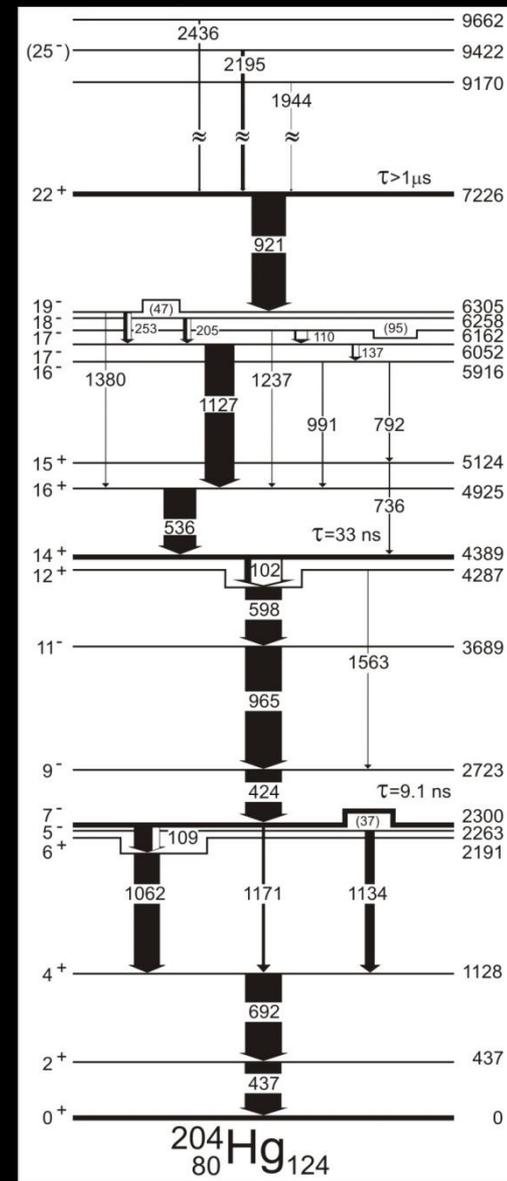


# LIFE-TIME DETERMINATION



# LEVEL SCHEME

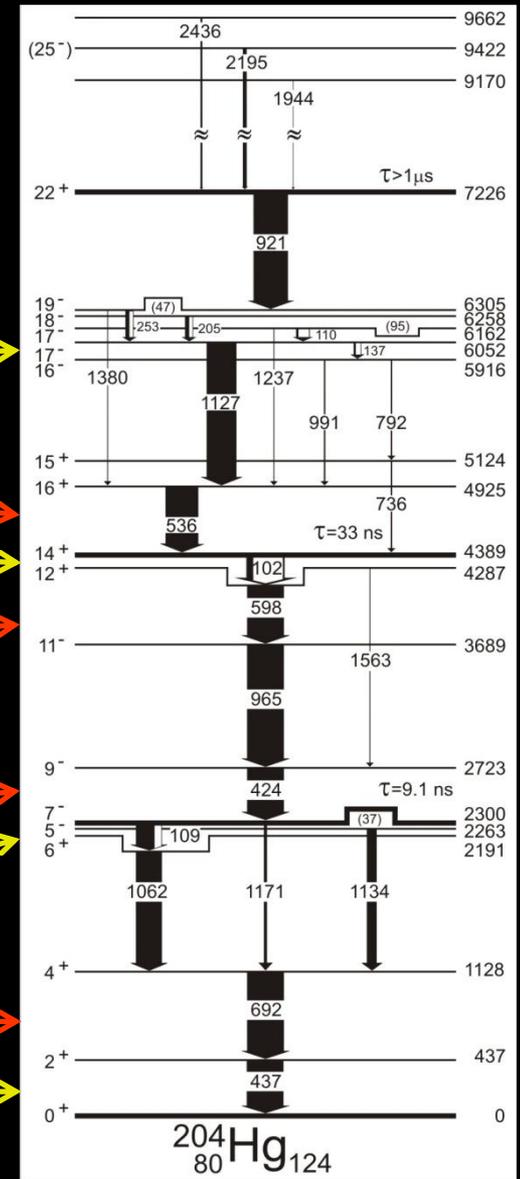
Observed prompt gamma transitions



# SPIN & PARITY ASSIGNMENT

Electron conversion coefficients  
Decay pattern

|                                     |          |   |
|-------------------------------------|----------|---|
| $\alpha_{\text{total}} = 2.7(3)$    | M1       | → |
| $\alpha_{\text{total}} = 0.051(15)$ | E2       | → |
| $\alpha_{\text{total}} = 5.5(6)$    | E2       | → |
| $\alpha_{\text{total}} = -0.01(2)$  | E1, (E2) | → |
| $\alpha_{\text{total}} = 0.030(26)$ | E2       | → |
| $\alpha_{\text{total}} = 0.030(26)$ | E1       | → |
| $\alpha_{\text{total}} = 0.015(20)$ | E2       | → |
| $\alpha_{\text{total}} = 0.057(25)$ | E2       | → |

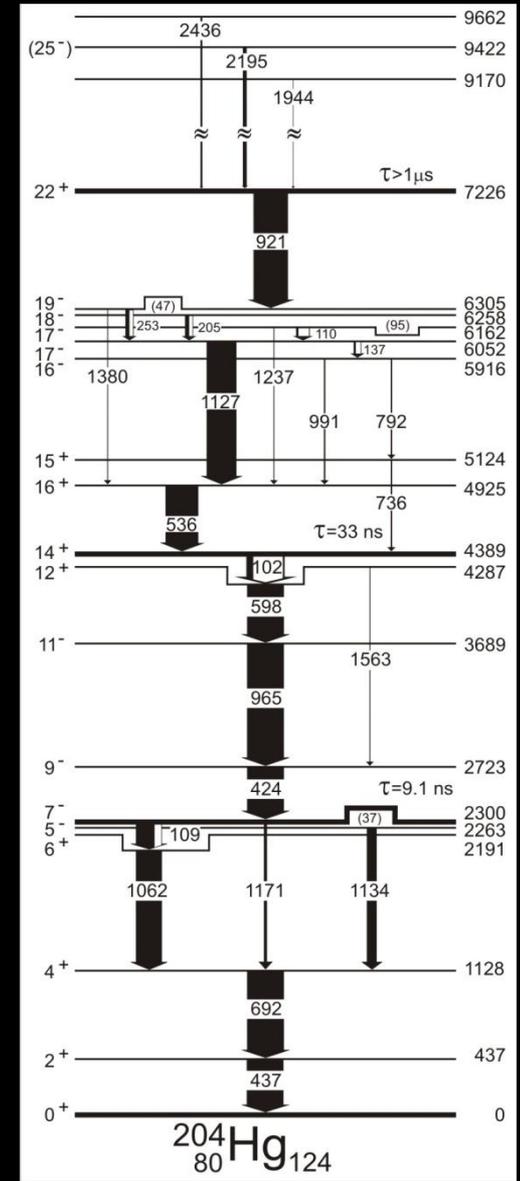
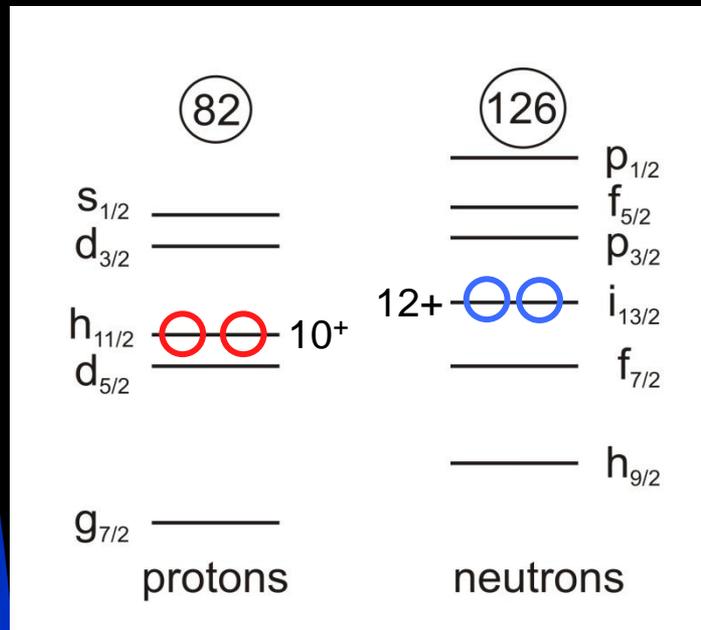


# SPIN & PARITY ASSIGNMENT

$^{208}\text{Pb}$ :  $3^-$  2615 keV  
 $^{206}\text{Hg}$ :  $3^- \times [\pi h_{11/2}^{-2}] 10^+$  -271 keV  
 $^{206}\text{Pb}$ :  $3^- \times [v i_{13/2}^{-2}] 12^+$  -212 keV  
 R. Broda et al., Eur.Phys.J. A20 (2004) 145

$[3^- \times \pi h_{11/2}^{-2} v i_{13/2}^{-2}] 25^-$   
 $E(E3): 2615 - 271 - 212 = 2132 \text{ keV}$   
 $E_{\text{exp}} = 2195 \text{ keV}$

$[\pi h_{11/2}^{-2} v i_{13/2}^{-2}] 22^+$

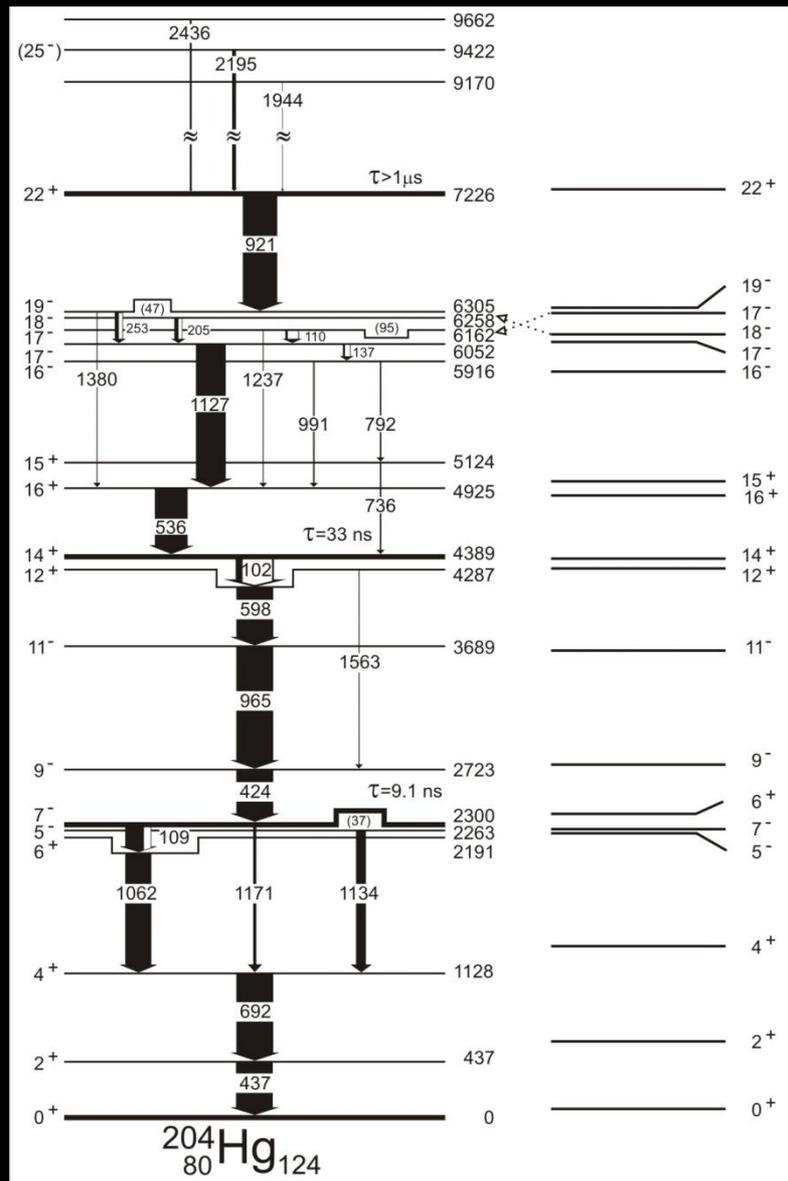


# SHELL MODEL CALCULATION

$B(E3, 22^+ \rightarrow 19^-) < 0.86 \text{ W.u.}$   
 $B(E2, 14^+ \rightarrow 12^+) = 5.1(5) \text{ W.u.}$   
 $B(E3, 7^- \rightarrow 4^+) = 1.4(2) \text{ W.u.}$

## OXBASH CODE

Configuration space between  $^{132}\text{Sn}$  and  $^{208}\text{Pb}$   
 based on Kuo-Herling interactions  
 proton-proton & proton-neutron interactions:  
 L.Rydstroem, J. Blomqvist et al., Nucl. Phys. A512 (1990) 217  
 J.B. Mcgrory and T.T.S. Kuo, Nucl. Phys. A274 (1975) 283



$$\pi h_{11/2}^{-2} \nu i_{13/2}^{-2}$$

$$\left\{ \begin{array}{l} \pi h_{11/2}^{-2} \nu i_{13/2}^{-1} f_{5/2}^{-1} \\ \pi h_{11/2}^{-1} d_{3/2}^{-1} \nu i_{13/2}^{-2} \end{array} \right.$$

$$10^+ \rightarrow 7^- \text{ } ^{206}\text{Hg}$$

$$\pi h_{11/2}^{-1} d_{5/2}^{-1}$$

$$12^+ \rightarrow 9^- \text{ } ^{206}\text{Pb}$$

$$\nu i_{13/2}^{-1} f_{7/2}^{-1}$$

B.Fornal et al.,  
 Phys.Let. 87 (2001) 212501-1

## SUMMARY

Deep-inelastic reaction of a  $\sim 1.4$  GeV  $^{208}\text{Pb}$  beam on a thick  $^{238}\text{U}$  target successfully used to populate high-spin states in  $^{204}\text{Hg}$  up to  $25^-$ .

New high-spin isomer with  $\tau > 1$   $\mu\text{s}$  found with pure configuration arising from the maximum spin coupling of the valence holes to  $22^+$ .

The observed  $\gamma$ -ray decay established the yrast states below long isomer, including another isomer with  $\tau = 33(3)$  ns.

Spin and parity assignments based on total conversion coefficients deduced from intensity balance and on the observed  $\gamma$ -decay patterns.

Observed good agreement of established level scheme with shell model calculations that include four holes in the entire configuration space between  $^{132}\text{Sn}$  and  $^{208}\text{Pb}$  supports spin-parity assignment.