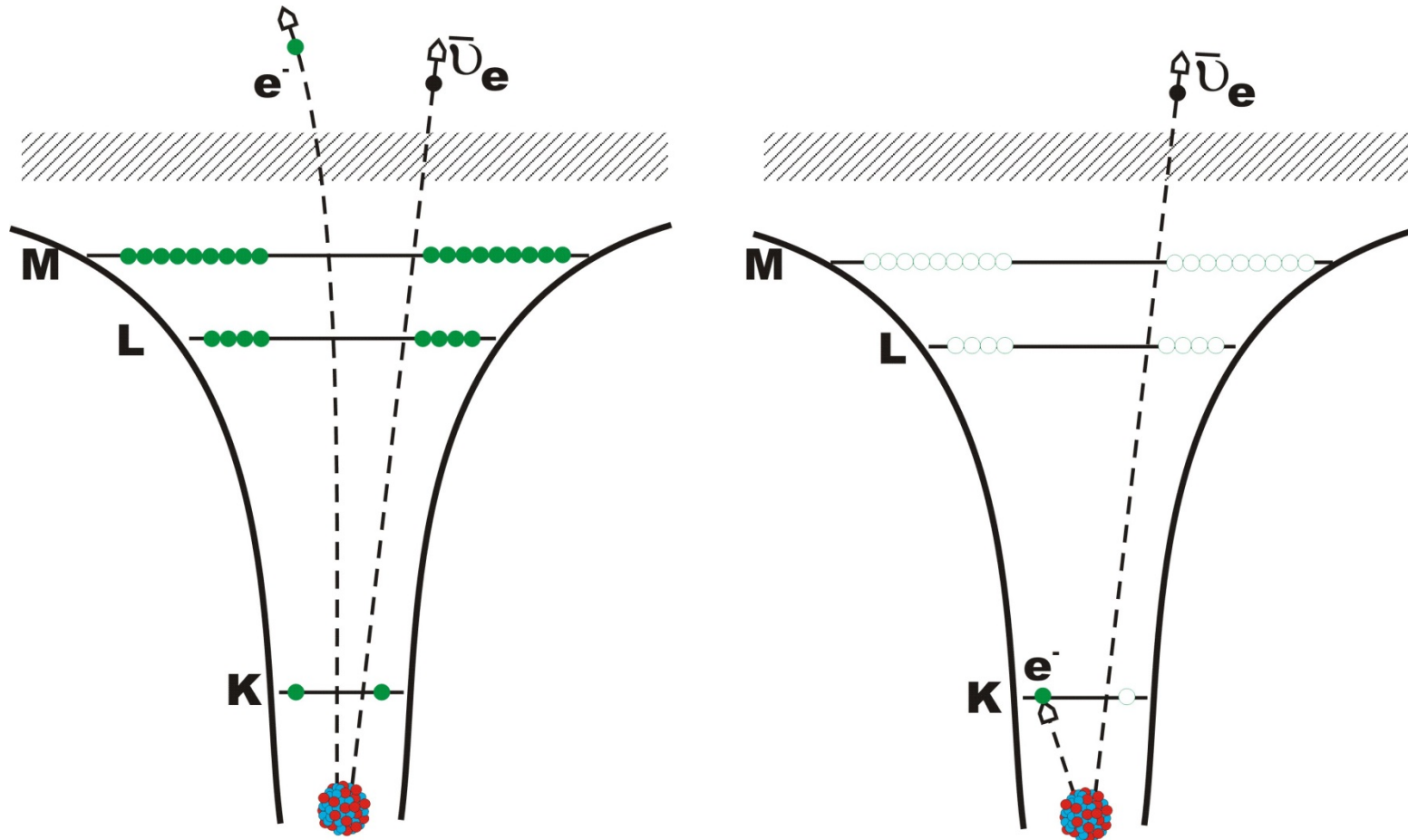


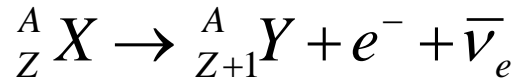
# Bound $\beta$ -decay

First observation at ESR ( $^{163}\text{Dy}$ ,  $^{187}\text{Re}$ ,  $^{206,207}\text{Tl}$ )



Time-mirrored process of orbital electron-capture decay; predicted by Jean, Daudel and Lecoine in 1947 and observed at the ESR in 1992

# $\beta$ -decay to bound states in the atomic cloud



## *Q-value for electric neutral atoms:*

from the mass difference of the atomic masses (mass of the nucleus + mass of the bound electrons)

$$Q_n = M(Z) - [M(Z+1) + BE_V + m_{\bar{\nu}_e}]$$

$BE_V$  = binding energy of the outer most valence electrons ( $<25$  eV),  $m_{\bar{\nu}_e}$  = mass of the antineutrinos ( $<2$  eV)

## *Q-value of the completely ionized atoms:*

$$\begin{aligned} Q_0 &= [M(Z) + BE_n(Z)] - [M(Z+1) + BE_n(Z+1) + m_{\bar{\nu}_e}] \\ &= Q_n - [BE_n(Z+1) - BE_n(Z)] \end{aligned}$$

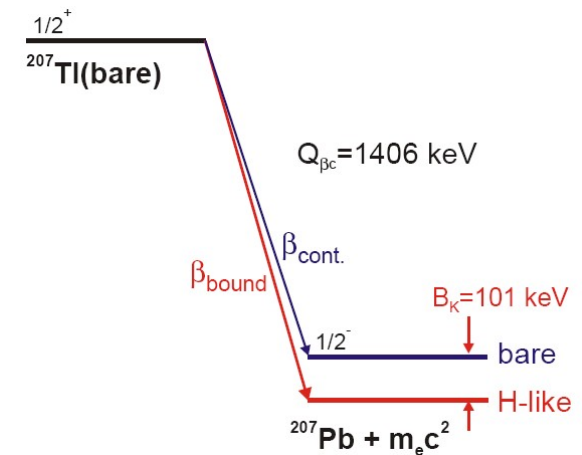
$BE_n$  = sum of the binding energies of all electrons

## *Q-value for the $\beta$ -decay in a bound state of the K-shell:*

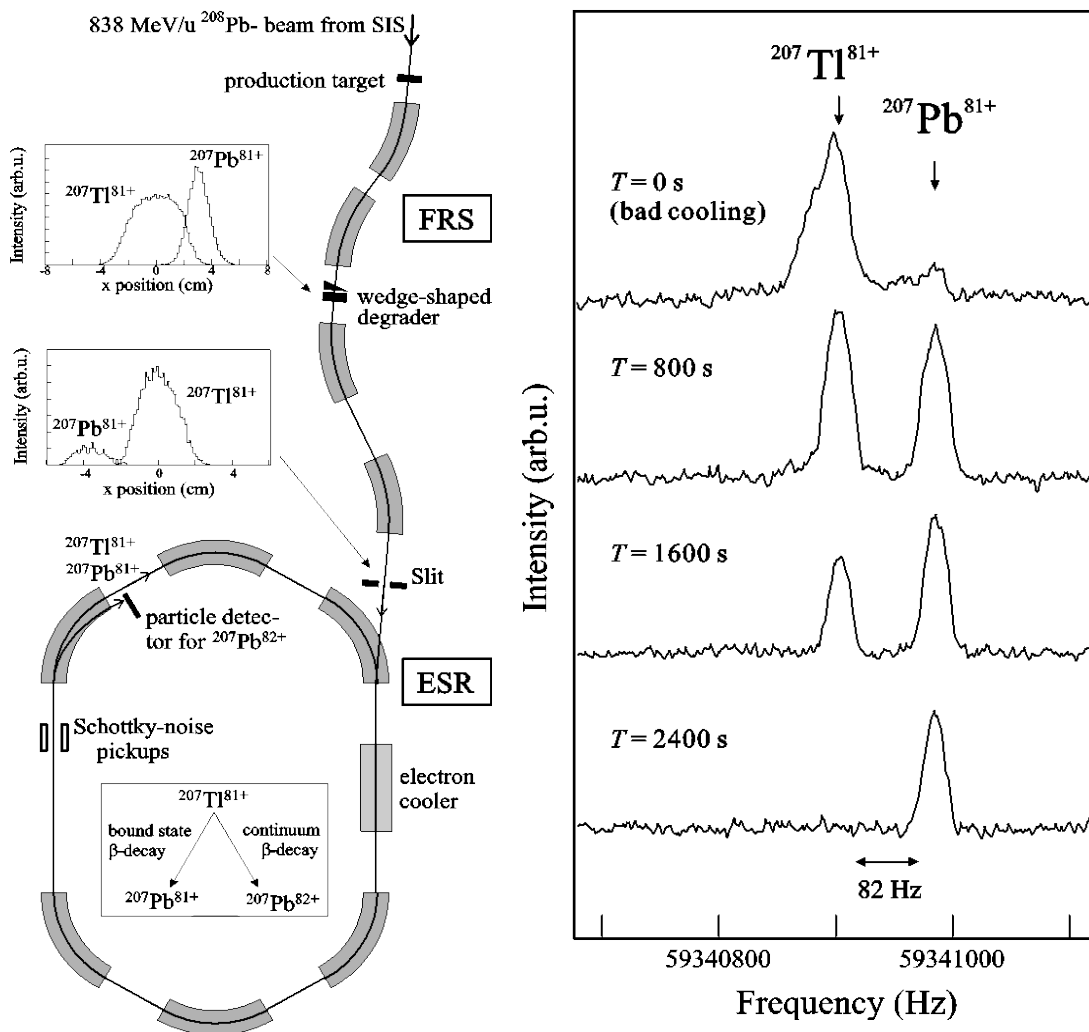
$$Q_K = Q_n - [BE_n(Z+1) - BE_n(Z)] + BE_K = Q_0 + BE_K$$

$BE_K$  = binding energy of the K-shell

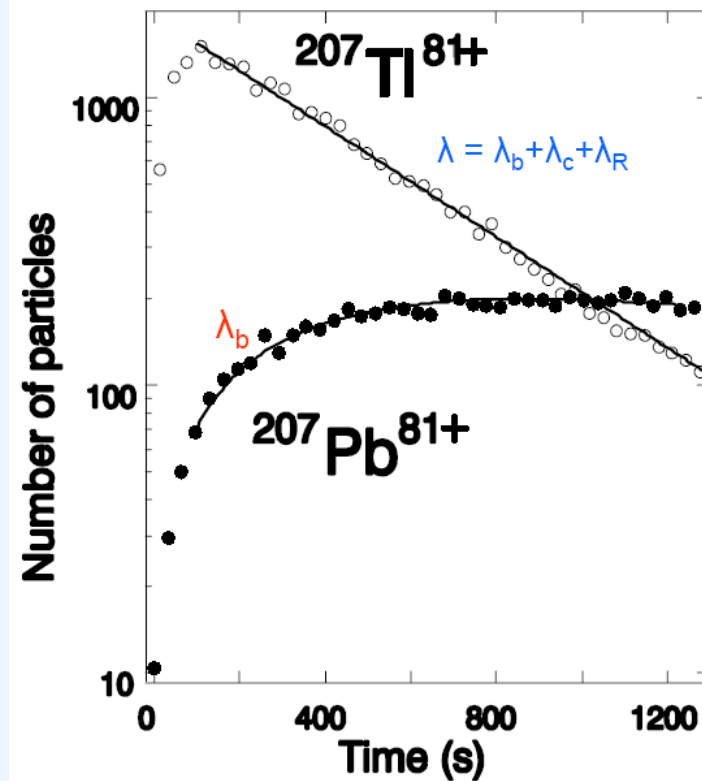
For  ${}^{187}\text{Re}$ ,  ${}^{241}\text{Pu}$ :  $Q_n < [BE_n(Z+1) - BE_n(Z)]$  is the  $\beta$ -decay into the continuum energetically not possible.



# First direct observation of bound-state $\beta$ -decay

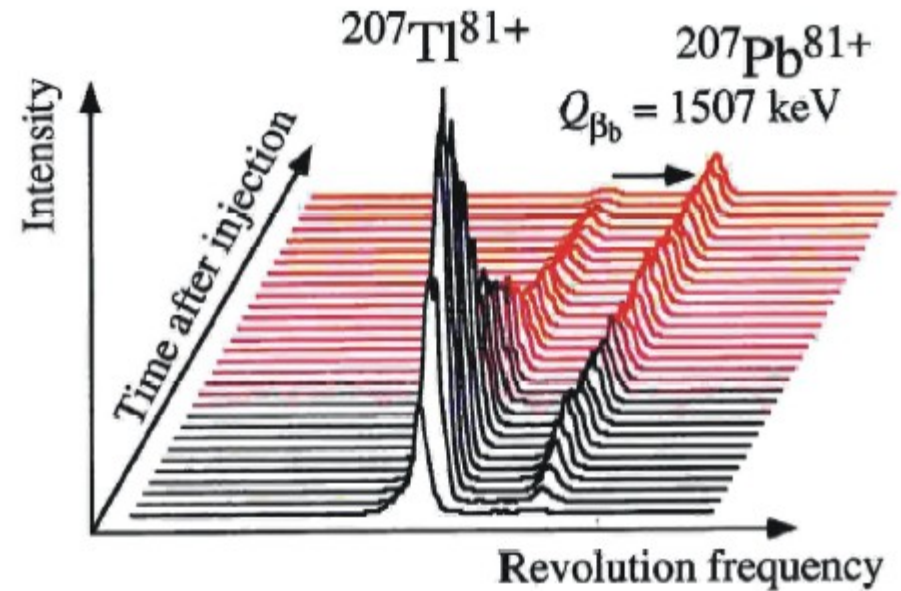
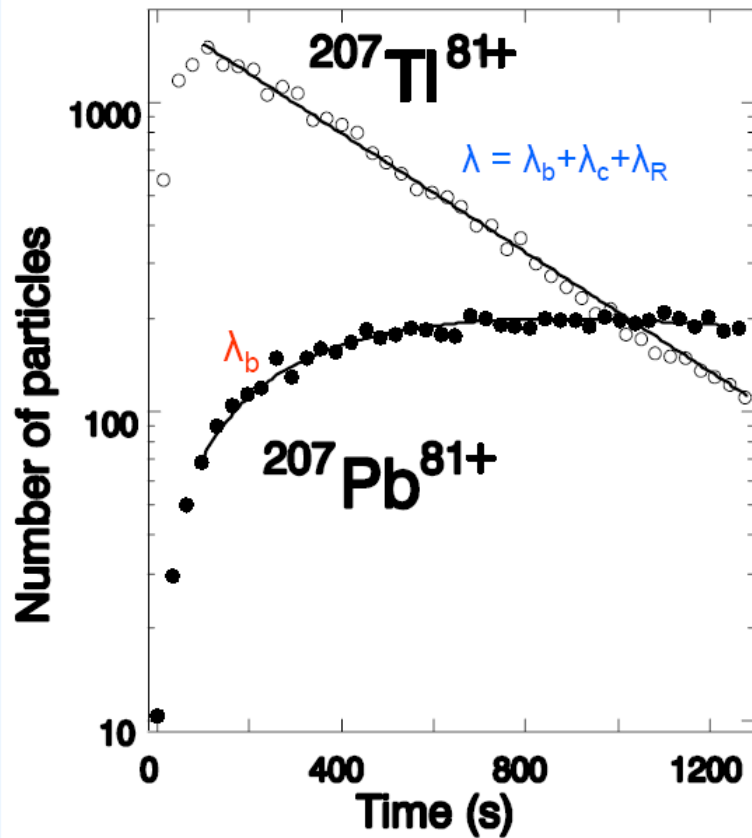


Parent and daughter ions are in the **same** spectrum



T. Ohtsubo et al., PRL **95** (2005) 052501

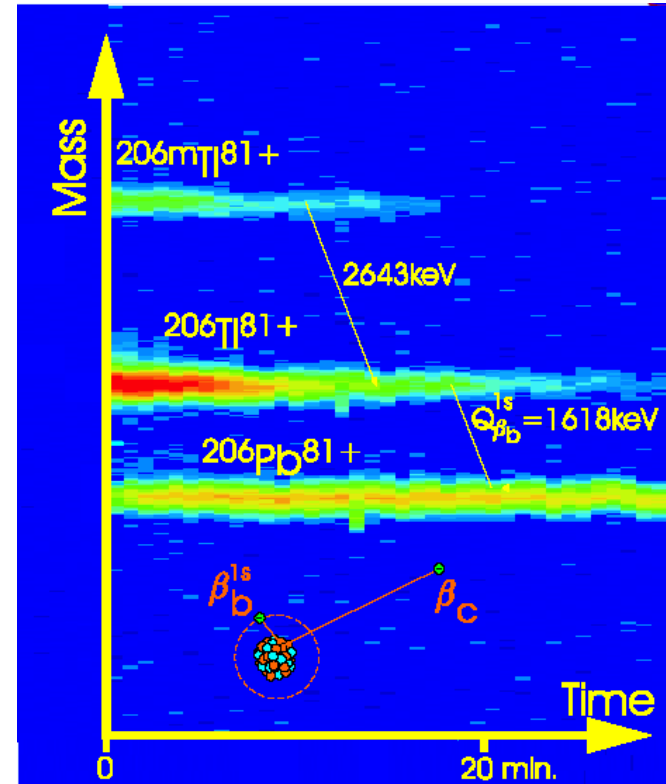
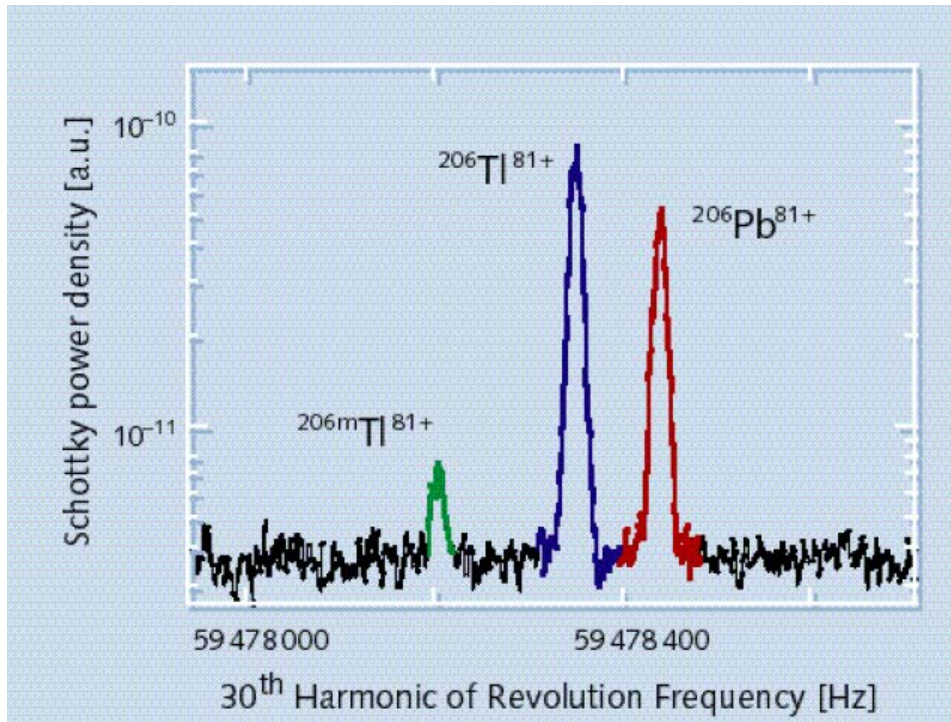
# Bound $\beta$ -decay: results



bound/continuum branching ratio  
→ Fermi function  $f(Z)$  of the  $\beta^-$  decay

direct Q-value determination

# Bound $\beta$ -decay: results



bound/continuum branching ratio: 10-20%

direct Q-value determination