Decay study of ^{258}Db at SHIP

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History

1981: first synthesis and identification in the reaction $^{209}Bi(^{50}Ti,n)^{258}Db$ at SHIP; α-decay and sf observed; sf attributed to ^{258}Rf formed by EC –decay of ^{258}Db

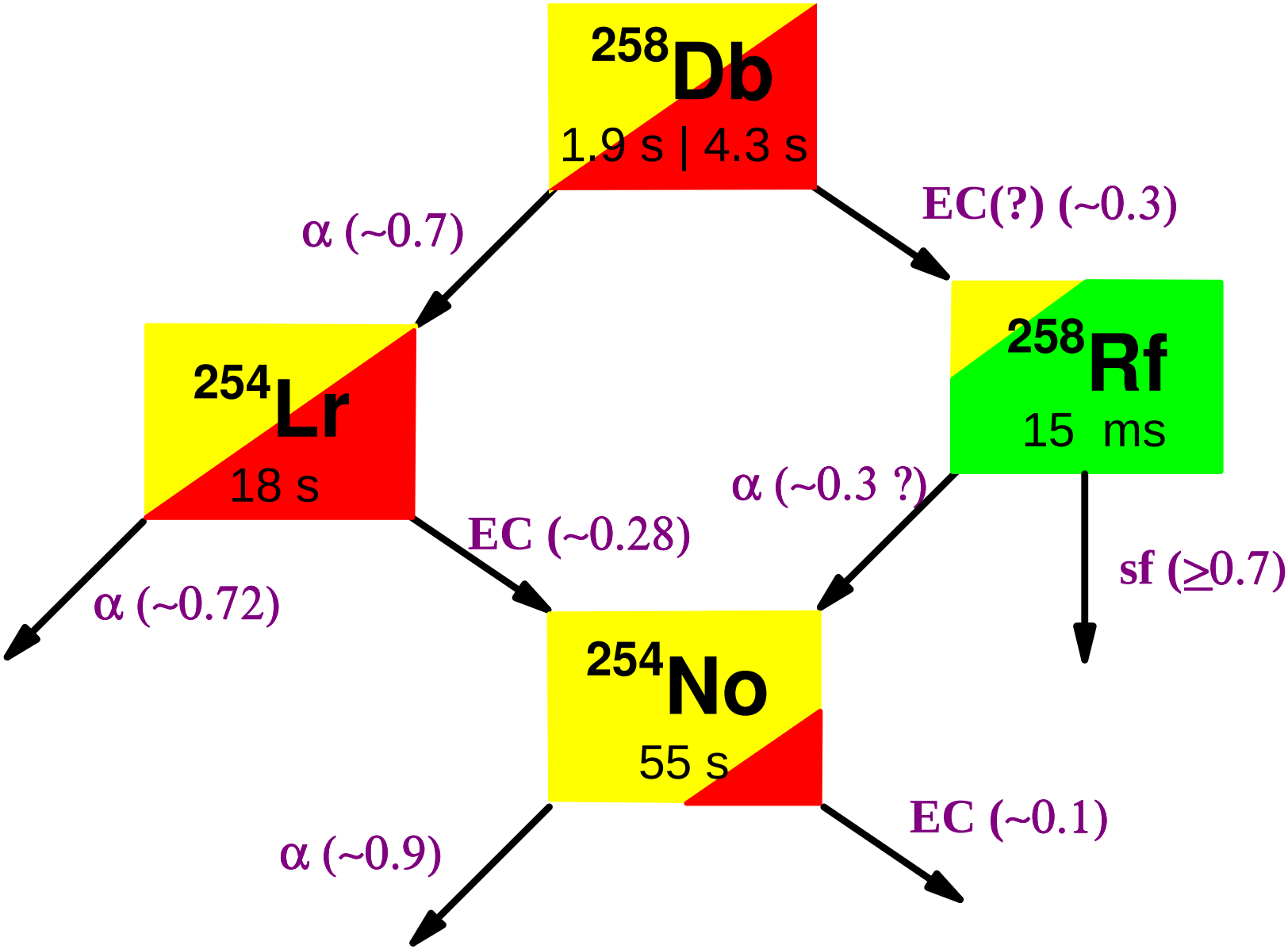
1982: first attempt to prove EC decay by measuring delayed coincidences between K-X-rays and sf of the EC – daughter ^{258}Rf at SHIP

1997: ‚complete' excitation function measured for $^{209}Bi(^{50}Ti,n)^{258}Db$ at SHIP; indication for differences in α-spectra when followed by α-decay of ^{254}Lr or ^{254}No

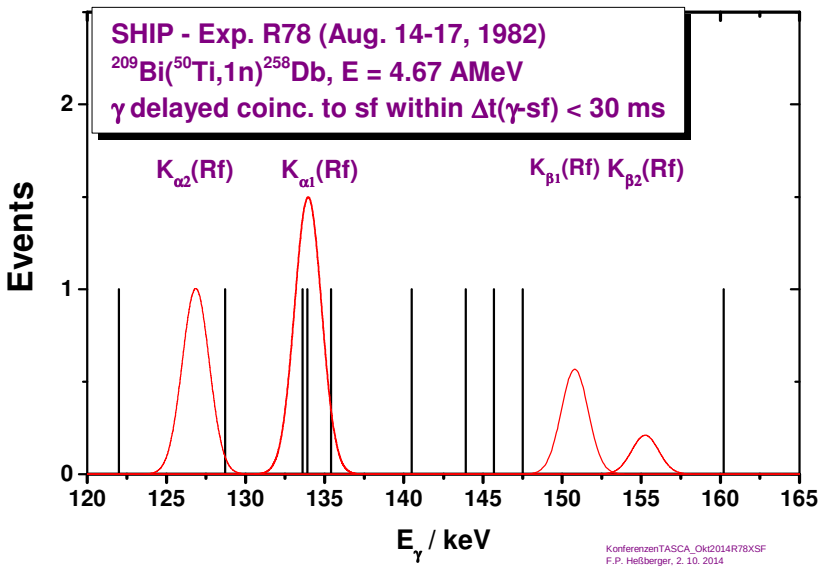
2004: more detailed decay study of ^{258}Db; first observation of α-γ – coincidences; indication of two states decaying by α – emission; unsuccessful attempt to measure delayed K-X-ray – sf - coincidences

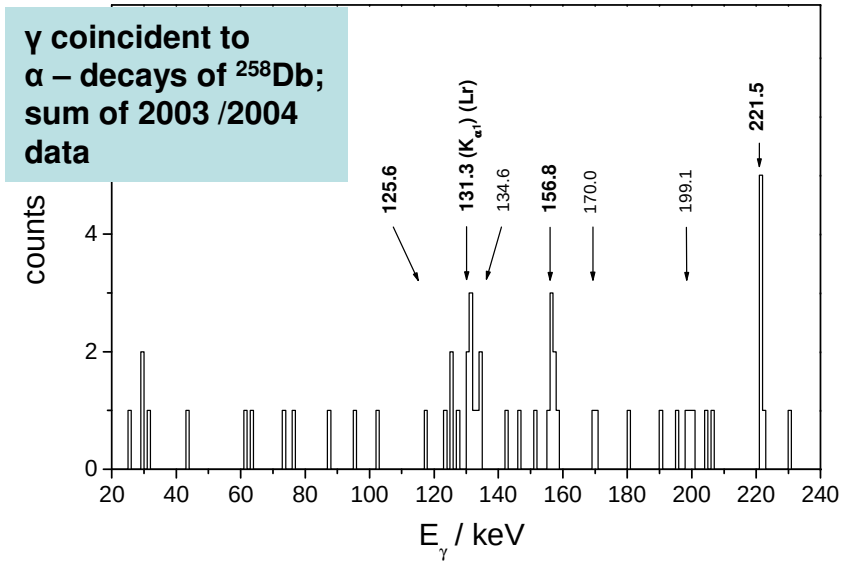
2012 / 2014: new detailed decay study of ^{258}Db

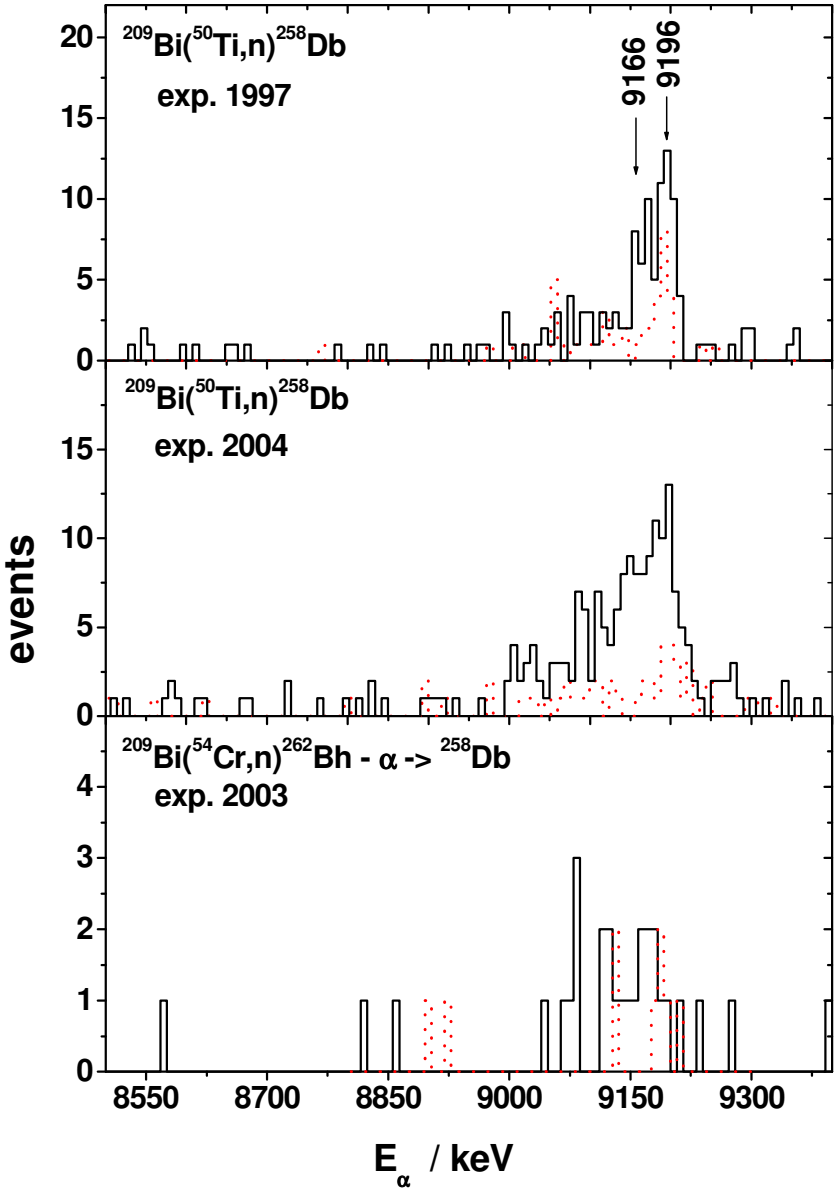
Decay Scheme of ^{258}Db



Status of Decay Studies







Status of Decay Studies

Table 4. Half-lives of ^{258}Db analyzed under various conditions.

Production by decay of ^{262}Bh	Σev.	$T_{1/2}$/s
SF following α-decay of ^{262}Bh(1)	16	$2.8^{+1.3}_{-0.7}$
SF following α-decay of ^{262}Bh(2)	9	$4.8^{+2.6}_{-1.3}$
E_α((9150–9220) keV) following α-decay of ^{262}Bh(1)	9	$1.9^{+1.3}_{-0.6}$
E_α(9196 keV) following α-decay of ^{262}Bh(2)	15	$2.6^{+1.1}_{-0.6}$
E_α (outside 9196 keV line) following α-decay of ^{262}Bh(2)	9	$4.1^{+1.4}_{-0.8}$
Production by ^{209}Bi(^{50}Ti,n)^{258}Db	**Σev.**	**$T_{1/2}$/s**
E_α(9196 keV) followed by α-dec. of ^{254}No	18[a]	$1.8^{+0.6}_{-0.4}$
E_α(9196 keV) followed by α-dec. of ^{254}Lr	41[a]	$2.0^{+0.6}_{-0.5}$
E_α(9166 keV) followed by α-dec. of ^{254}Lr	28[a]	$4.2^{+1.4}_{-0.8}$
α-decays coincident with $E_\gamma = 221.5$ keV	6[b]	$4.7^{+3.8}_{-1.5}$
α-decays coincident with K X-rays of Lr	7[b]	$4.4^{+2.2}_{-1.1}$
α-decays $E_\alpha > 9225$ keV	45	$4.7^{+0.9}_{-0.6}$
SF events (correlated to ER)	244	3.6 ± 0.3

(a) Numbers from exp. 1 only.
(b) Numbers from exp. 2 only.

(F.P. Heßberger et al. EPJ A 41, 145 (2009))

Summary:

- evidence for two states of 1.9 s and 4.3 s decaying by α – emission and/or EC
- α-decays at 9196 keV correlated to ^{254}Lr or ^{254}No exhibit a half-life of 1.9 s
- all other α-days and sf exhibit a half-life of 4.3 s

Motivation for the new study of ^{258}Db

→ disantangle the ‚puzzling' α-decay spectrum of ^{258}Db observed in previous experiments

→ prove or disprove isomeric state decaying by α – emission

→ establish a first partial level scheme of ^{254}Lr

→ prove directly EC – branch of ^{258}Db by measuring delayed coincidence between X-rays and sf

→ prove α-decay branch of ^{258}Rf (from LNBL)

→ measure <TKE> - sf of ^{255,256}Rf using <TKE> of ^{258}Rf as reference

Experiment

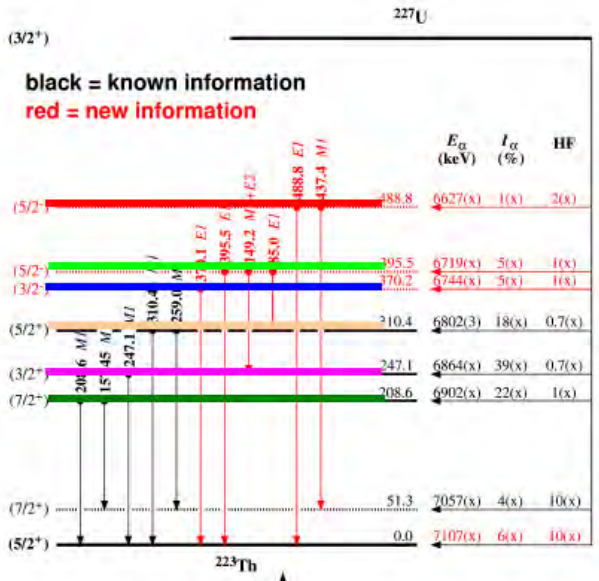
SHIP – Run 288: April, 9 – 15, 2012
^{50}Ti (4.72 AMeV) + ^{209}Bi
i ≈ 250 pnA (25 Hz), Penning source, Ti-nat
Σ(proj) = 3.8 x 10^{17}

SHIP – Run 291: April, 5 – 9, 2014
^{22}Ne(4.7 – 5.9 AMeV) + ^{197}Au, ^{208}Pb, ^{209}Bi
‚set-up test' after two years of break
→ enhanced dacay data for ^{227}U
→ few nucleon transfer mechanisms, indication for velocity dependence of production ratio σ(^{211m}Po(25/2+)) / σ(^{211g}Po(9/2+))

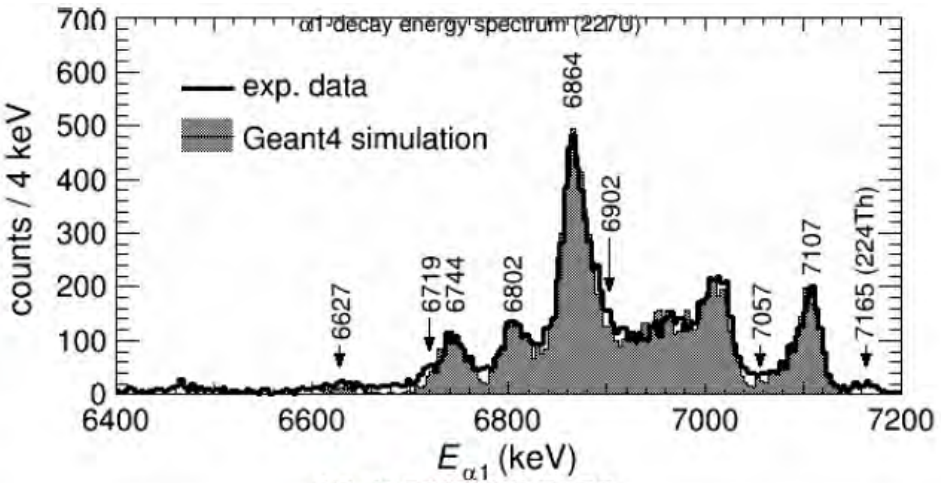
SHIP – Run 292: May, 5 (3) – 19, 2014
^{50}Ti beam from ECR source; first time at GSI; i ≈ 500 pnA (38 Hz),
^{50}Ti (4.72 AMeV) + ^{209}Bi, ≈200 h, Σ(proj) = 2.3 x 10^{18}
^{50}Ti (4.62 - 4.83 AMeV) + ^{208}Pb, ≈35 h, Σ(proj) = 2.4 x 10^{17}
^{50}Ti (4.86 AMeV) + ^{207}Pb, ≈45 h, Σ(proj) = 5.0 x 10^{17}

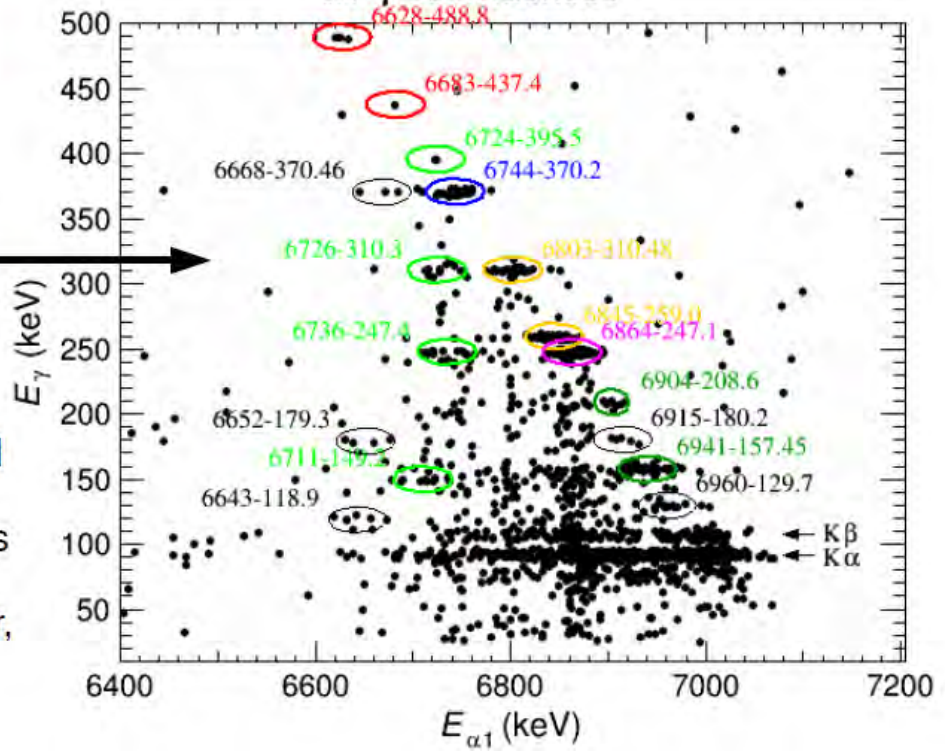
New Decay Data for ^{227}U

Data evaluated by Z. Kalaninova



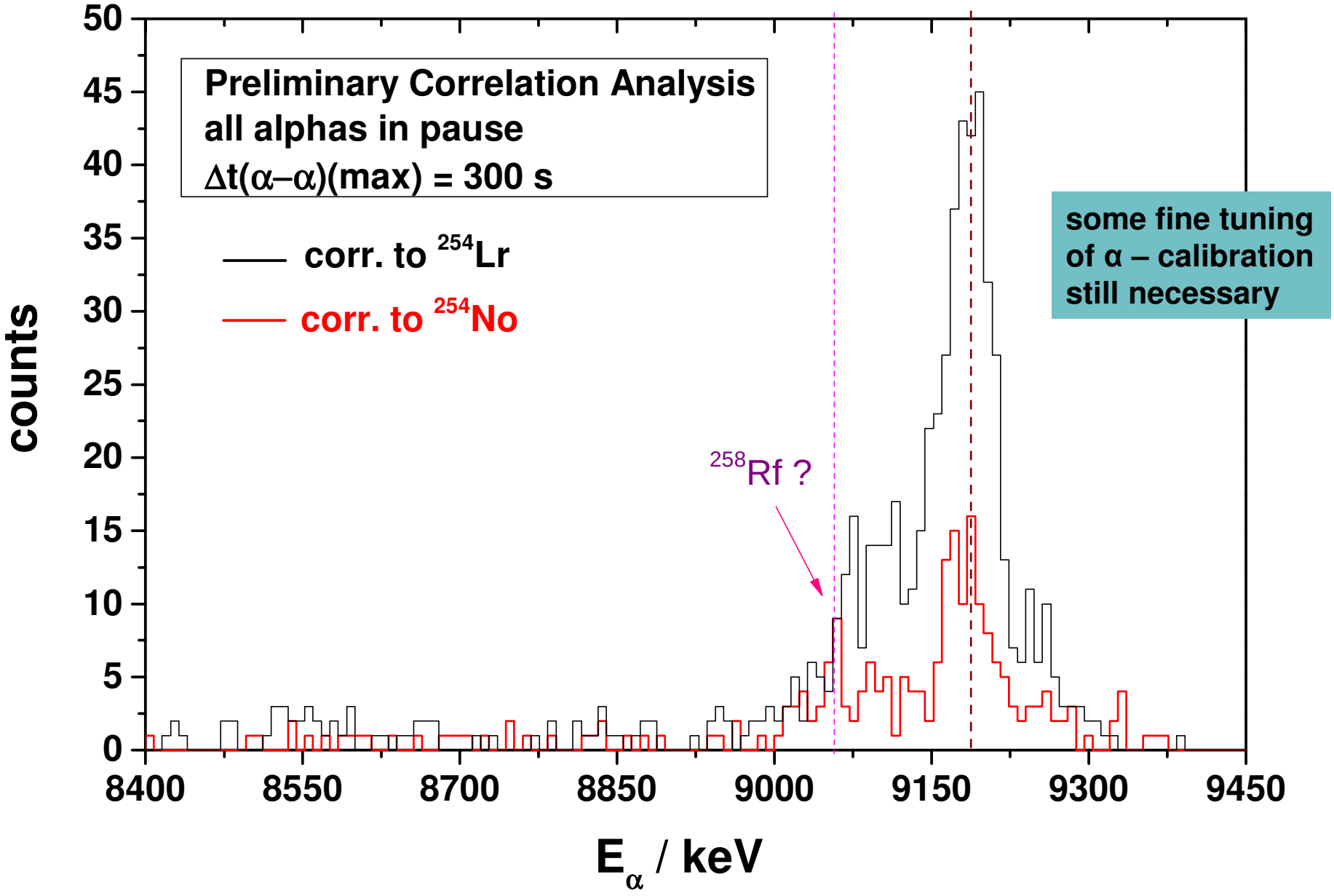
The same colors correspond to the decay of the same levels



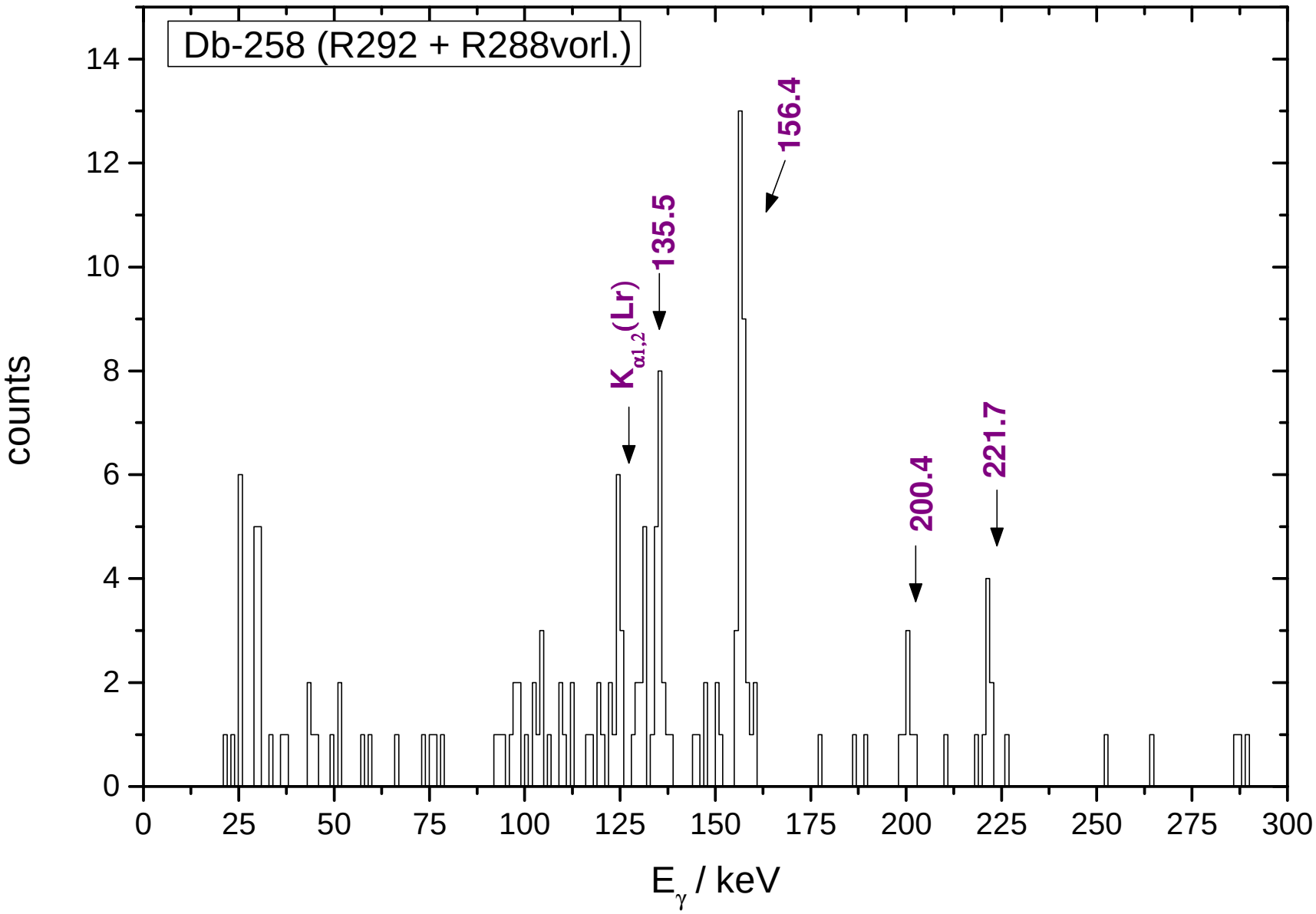


Points in black ellipses are not placed in the decay scheme up to now. However, the transitions with energies 119 and 129 keV were seen in the in-beam measurements [M. Dahlinger, NPA **484**, 337 (1998)].

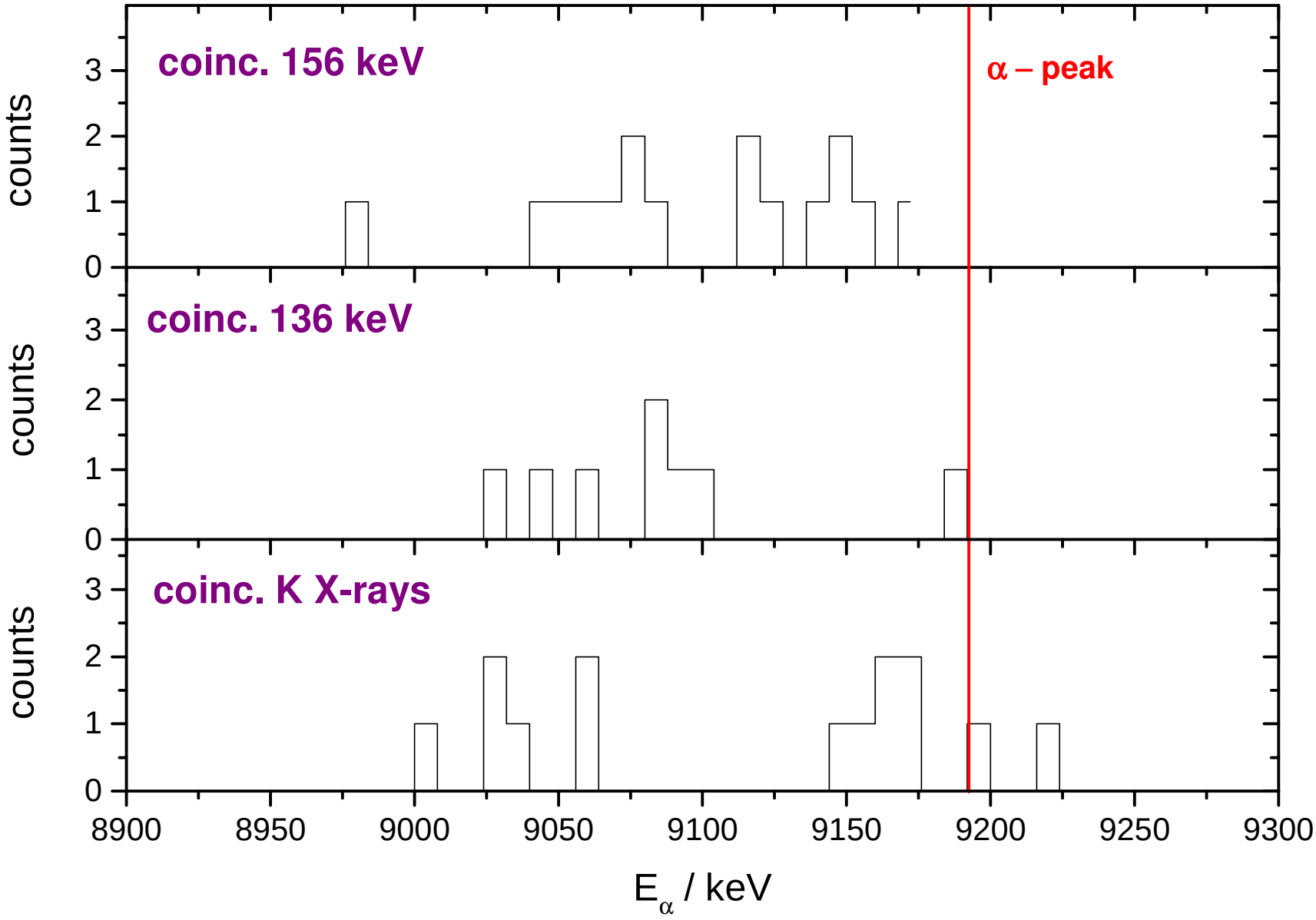
Status of Decay Studies – α - decay



Status of Decay Studies – α–γ – measurement



Status of Decay Studies – α–γ – measurement

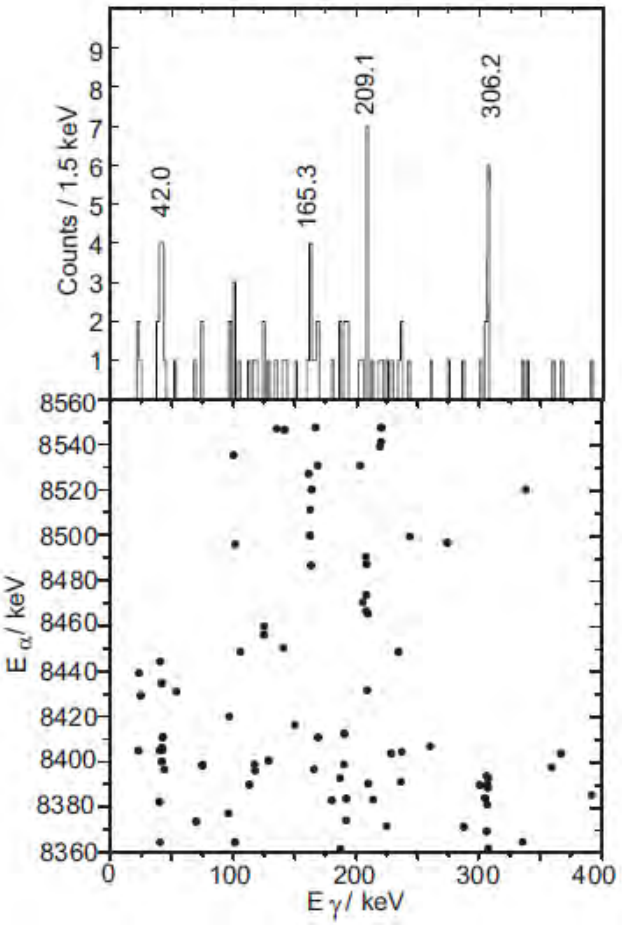


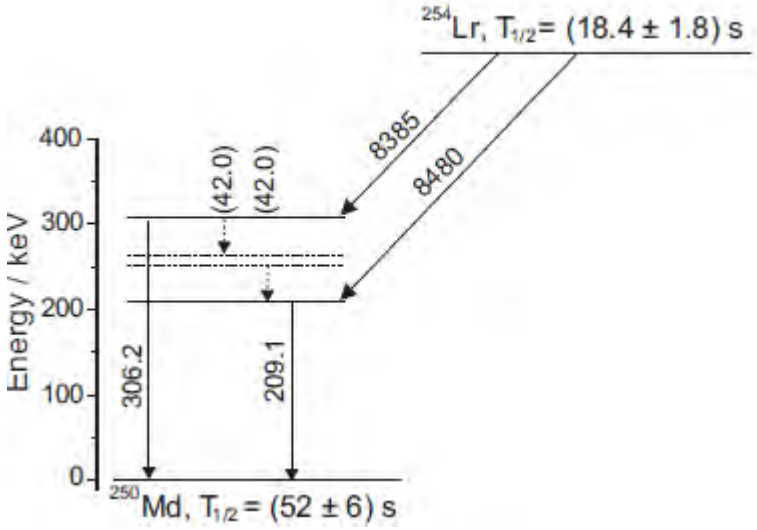
α – γ – coincidences ^{254}Lr

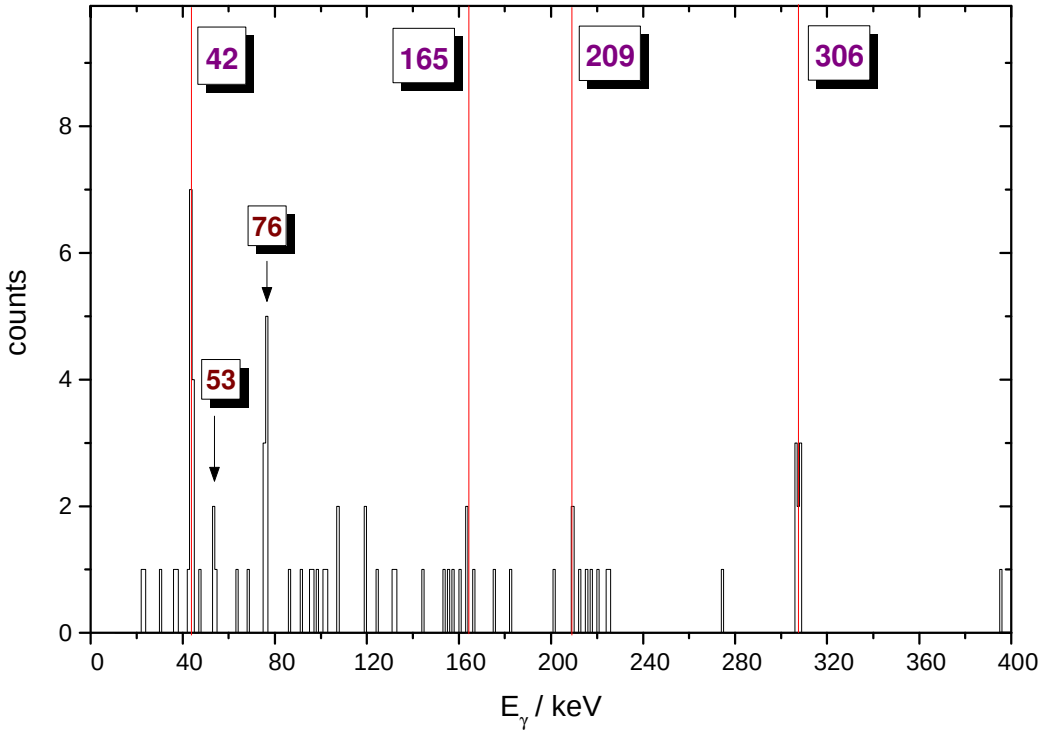
S. Antalic et al. EPJ A 38, 219 (2008)

decay of ^{258}Db +

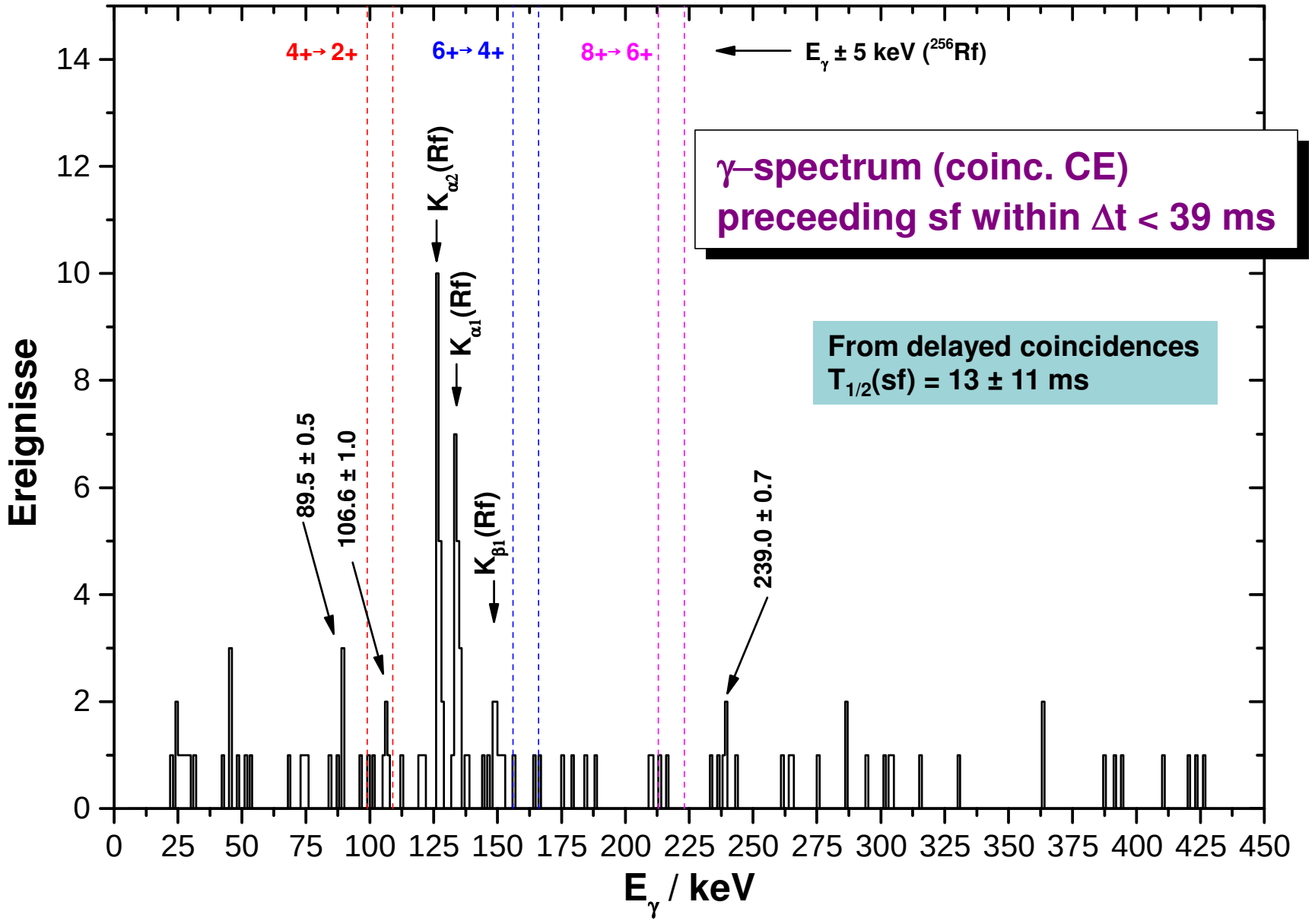
^{209}Bi(^{48}Ca,3n)^{254}Lr







Direct Prove of EC of ^{258}Db



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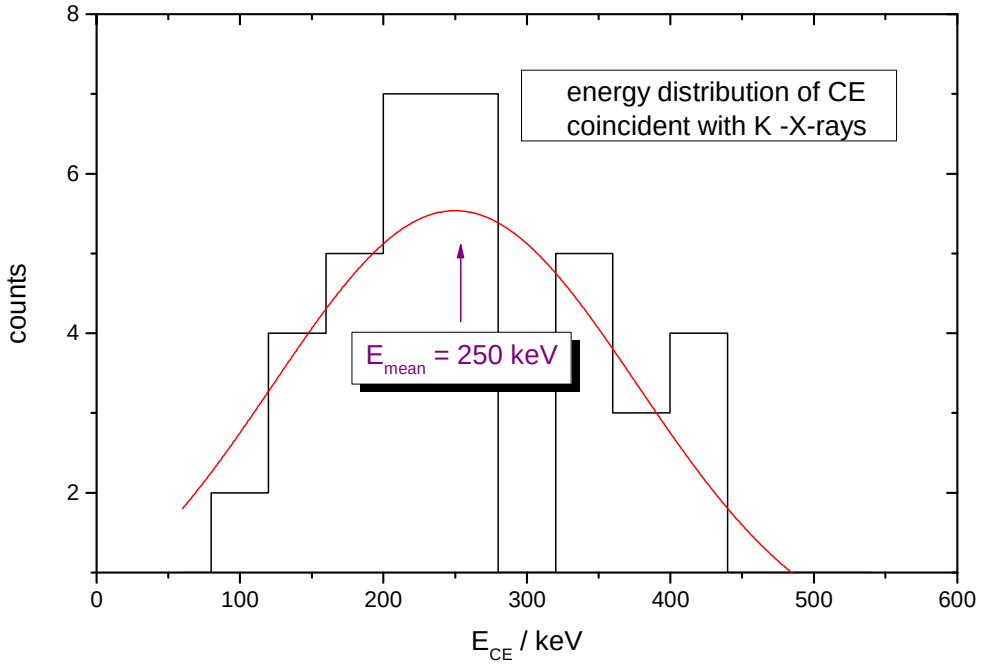
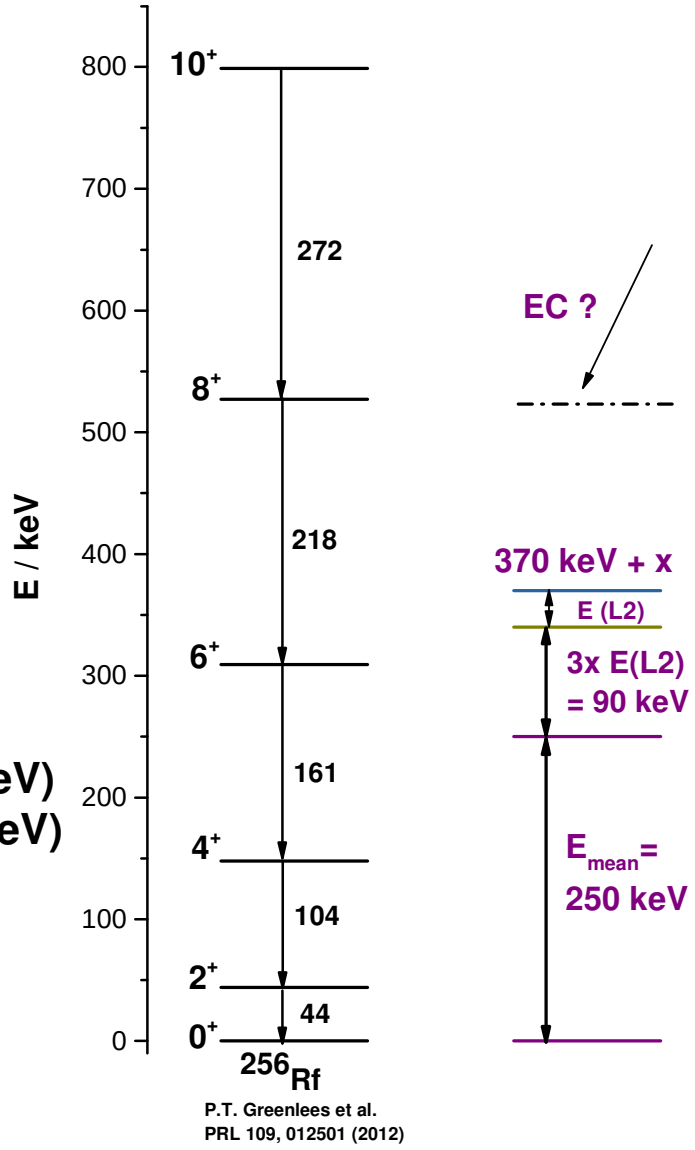




P.T. Greenlees et al.
PRL 109, 012501 (2012)

Levels in neighbouring odd-mass nuclei

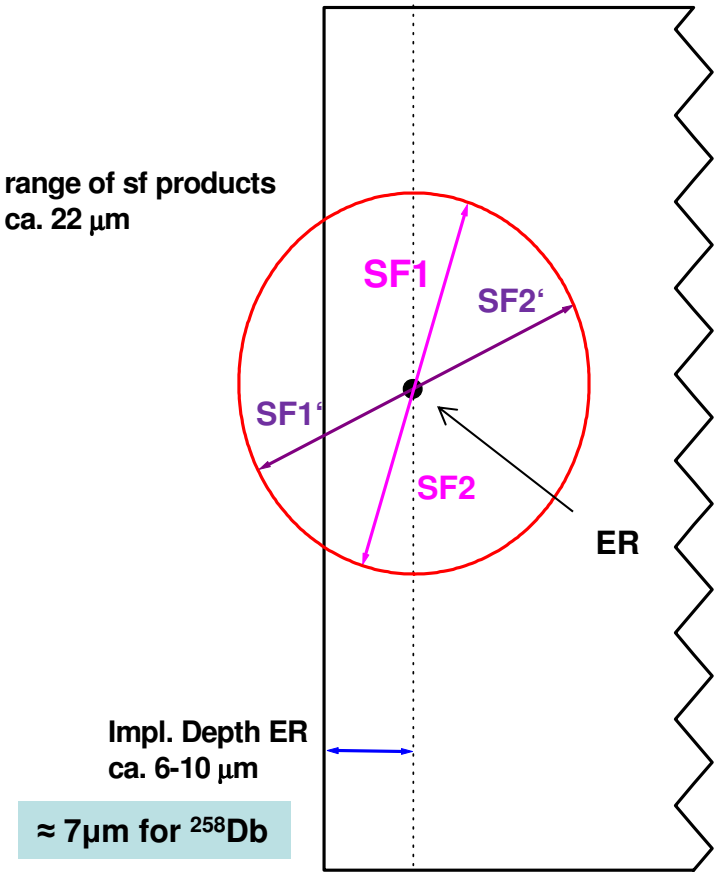
^{257}Rf (N=153): 1/2+[620] (gs), 11/2-[725] (E* = 70 keV)
^{257}Db (Z=105): 9/2+[624] (gs), 1/2-[521] (E* ≈ 100 keV)

possible low lying states in ^{258}Db: 1-, 4+, 5+, 9-
CE energy hints to high spin state
Σ(X-rays) / Σ(sf) ≈ 0.05 → ε(clover) ≈ 0.12

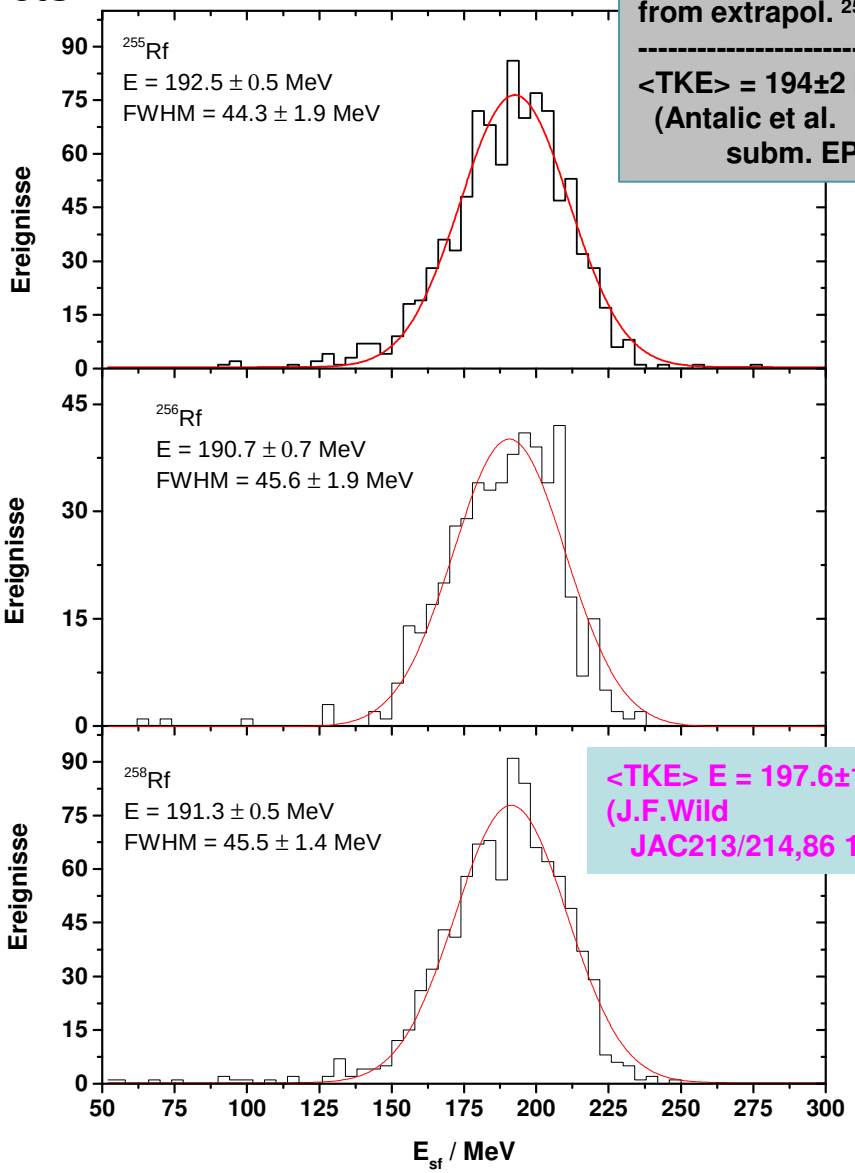
EC transitions with low E_{CE} ??
Has to be checked !!

<TKE> Measurement of ^{255,256,258}Rf

Implantation depth of ER < range of SF products
p(sf1+sf2) ≈ 40%
large PHD due to high ionisation density



≈ 7µm for ^{258}Db



<TKE> = 199 ±1 MeV
from extrapol. ^{258}Rf

<TKE> = 194±2 MeV
(Antalic et al.
subm. EPJA)

<TKE> E = 197.6±1.1 MeV
(J.F.Wild
JAC213/214,86 1994)

Conclusions

will be drawn when data are thoroughly evaluated

Collaboration

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