

# An EC-branch in the decay of 27-s $^{263}\text{Db}$ : Evidence for the new isotope $^{263}\text{Rf}$

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The first hint for  $^{263}\text{Rf}$  was reported by Czerwinski et al. who detected 7 spontaneous fission (SF) events with a half life of  $500^{+300}_{-200}$  s in rutherfordium fractions separated by manual TTA extractions from the  $^{248}\text{Cm}(^{18}\text{O}, 3n)$  reaction at 92.5 MeV [1]. No  $\alpha$  events could be attributed to  $^{263}\text{Rf}$ .

In 1990, we discovered the new isotope 27-s  $^{263}\text{Db}$  in the  $^{249}\text{Bk}(^{18}\text{O}, 4n)$  reaction at 93 MeV by eluting element 105 from cation exchange columns in unbuffered 0.05 M  $\alpha$ -HiB [2].

In 1993, a rutherfordium fraction was milked from  $^{263}\text{Db}$ , and 22 SF events were registered in that fraction. Of these, 8.8 events had to be assigned to a contamination by  $^{256}\text{Fm}$ . A two-component decay curve with the  $^{256}\text{Fm}$  fixed gave a half life of  $10^{+5}_{-3}$  min for the isotope  $^{263}\text{Rf}$  [3]. Based on the effective production cross section, an EC-branch in  $^{263}\text{Db}$  on the order of 5% was deduced [3]. Two  $\alpha$  particles at 7.9 MeV were discussed as possibly being associated with the decay of  $^{263}\text{Rf}$  giving an upper limit for the  $\alpha$ -decay branch of 30%.

A search for  $^{263}\text{Rf}$  in the  $^{248}\text{Cm}(^{22}\text{Ne}, \alpha 3n)$  reaction at 122 MeV by Dressler et al. [4] involving a chemical separation of Rf as the volatile tetrachloride yielded two  $\alpha$  particles at 7.8 and 7.9 MeV and four SF events with very long life times. Another search using the same reaction and aqueous chemistry with fluoride complexes of Rf [5] yielded two  $\alpha$  events near 7.9 MeV with unusually long life times. This was not considered to present conclusive evidence for  $^{263}\text{Rf}$  [4],[5].

We have attempted to add further evidence for an EC-branch in the decay of  $^{263}\text{Db}$  and for  $^{263}\text{Rf}$  in an experiment at the Paul Scherrer Institute (PSI), Switzerland, producing again  $^{263}\text{Db}$  in the  $^{249}\text{Bk}(^{18}\text{O}, 4n)$  reaction at 93 MeV. The activity was transported by a He/KCl jet and collected for 15 min on a Ta disc. It was dissolved in 2 x 20  $\mu\text{l}$  of unbuffered 0.5 M  $\alpha$ -HiB and added on top of a 3 x 50 mm cation-exchange column (AG 50Wx8). The  $\alpha$ -HiB solution contained  $^{88}\text{Zr}$  tracer for the determination of the chemical yield for group-4 elements. These were eluted from the column with 1 ml 0.5 M  $\alpha$ -HiB. The eluate was mixed with 3 ml 12 M HCl yielding a solution being 9 M in HCl. This was subject to liquid-liquid extraction with 200  $\mu\text{l}$  of 20 vol% TBP/Cyclohexane which, after phase separation, was evaporated to dryness on a Ta disc. The Ta discs were assayed for  $\alpha$  and SF activity starting about 8 min after the end of collection. The He/KCl jet efficiency was about 50%, the chemical yields were 70% on the average. The decontamination factor for Fm was on the order of  $10^4$ .

In some 200 experiments, a total of 9 SF events was registered of which 2 have to be considered a long-lived background. The life times are consistent with a half life of  $^{263}\text{Rf}$  of about 22 min with an uncertainty of  $\pm 5$  min. Relative to the measured cross section for production of  $^{263}\text{Db}$  in the  $^{249}\text{Bk}(^{18}\text{O}, 4n)$  reaction at 93 MeV,  $10 \pm 6$  nb [2], the new experiments give an EC-branch in the decay of  $^{263}\text{Db}$  of

$$3^{+4}_{-1}\%$$

and provide additional evidence for the new isotope  $^{263}\text{Rf}$ . The latter decays predominantly by spontaneous fission with a long half life of tens of minutes. In principle, the observation of  $\alpha$  particles from the  $\alpha$ -decay daughter of  $^{263}\text{Rf}$ ,  $^{259}\text{No}$  (7.472 – 7.689 MeV), could help to fix the  $\alpha$ -decay branch in the decay of  $^{263}\text{Rf}$ . However, this part of the spectrum is masked by a contamination with the naturally occurring  $^{214}\text{Po}$  (7.687 MeV). The picture that consistently emerges from [3] and the present work is shown in Fig.1.

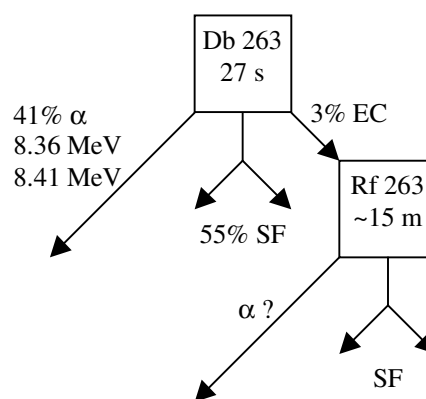


Fig.1 Decay scheme for  $^{263}\text{Db}$  and  $^{263}\text{Rf}$

## References

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