Measurements of $^{260-262}$Rf produced in ^{22}Ne + ^{244}Pu fusion reaction at TASCA*

A. Gorshkov[1#], R. Graeger[1], A. Türler[1], A. Yakushev[1], D. Ackermann[2], W. Brüchle[2], Ch. E. Düllmann[2], E. Jäger[2], F. Heßberger[2], J. Khuyagbaatar[2], J. Krier[2], M. Schädel[2], B. Schausten[2], E. Schimpf[2], L.-L. Andersson[3], D. Rudolph[3], K. Eberhardt[4], J. Even[4], J.V. Kratz[4], D. Liebe[4], P. Thörle[4], N. Wiehl[4], I. Dragojević[5], J.M. Gates[5], L. Stavsetra[5], J.P. Omtvedt[6], A. Sabelnikov[6], F. Samadani[6], J. Uusitalo[7]

[1]TU München, 85748 Garching, Germany; [2] GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany; [3]Lund University, 22100 Lund, Sweden; [4]Mainz University, 55128 Mainz, Germany; [5]LBNL, Berkeley, CA 94720, USA; [6]Oslo University, 0315 Oslo, Norway; [7] University of Jyväskylä, 40014 Jyväskylä, Finland

As a final experiment in the commissioning phase of TASCA the transactinides ($Z \geq 104$) were reached. Production and decay of ^{260}Rf, ^{261a,b}Rf and ^{262}Rf [1,2,3], produced in the asymmetric nuclear fusion reaction ^{244}Pu(^{22}Ne,xn) was studied. Separated reaction products were guided to a Focal Plane Detector (FPD) or into a Recoil Transfer Chamber (RTC), where they were available for transport to either the Rotating wheel On-line Multidetector Analyzer (ROMA) or to the Automated Rapid Chemistry Apparatus (ARCA) for chemical experiments [4].

TASCA was operated in the High Transmission Mode (HTM) [5]. The ^{22}Ne ion beam (average intensity: 0.8 μA_{part}) impinged on a rotating target wheel with 0.4 mg/cm^2 ^{244}PuO2 targets on 2.2 µm Ti backings. Three beam energies in the center of the target, $E_{c.o.t.}$, of 109 MeV, 116 MeV and 125 MeV, were used for the production of ^{262}Rf, ^{261}Rf and ^{260}Rf, respectively. The transmission of Rf has been optimized in He filling gas. The optimal pressure was 0.4 mbar. The magnetic rigidity, Bρ, was determined to be 1.99 T·m. To increase suppression of unwanted products, a He/H_2 (2:1) filling gas at a pressure of 1.5 mbar was used in experiments with the FPDs. Evaporation residues were implanted into a (80 x 36) mm^2 16-strip Position-Sensitive silicon Detector (PSD) or a (58 x 58) mm^2 Double-Sided Silicon Strip Detector (DSSSD). In other experiments, ^{261a,b}Rf passed a 1.2 µm thick (140 x 40) mm^2 Mylar window and was thermalized in 1.2 bar He in the RTC (depth: 17 mm). Rf atoms were then transported to ROMA by an He/KCl jet (gas flow rate: 3.45 L/min) through a 4 m long polyethylene capillary (inner diameter: 2 mm).

The measurement of ^{260}Rf, produced in the 6n evaporation channel at $E_{c.o.t.}$= 125 MeV yielded 15 time ($\Delta t \leq 200$ ms) correlated EVR-SF events in the PSD. The correlation time analysis yielded a half-life of $21^{+7.3}_{-4.3}$ ms (errors are within the 68% confidence interval). A search for ^{262}Rf decays at $E_{c.o.t.}$ = 109 MeV 7 position and time correlated EVR-SF events observed in the DSSSD, with EVR energies of 0.8 to 3.3 MeV and SF fragment energies of > 100 MeV. The measured $T_{1/2}$ for ^{262}Rf is 210^{+128}_{-58} ms (Fig. 1a), in contradiction with values from [1,2]. In addition, 9 short EVR-SF correlations were registered with $\Delta t \leq 1.5$ ms and EVR energies of 7.5 ± 5.0 MeV. They were attributed to the decay of ^{244mf}Am ($T_{1/2}$ = 0.9 ms). Because of a relatively high counting rate of EVR-like events in the DSSSD a random event analysis was performed for EVR-SF correlations within a Δt of 1 s. The random event number, n_b, was calculated individually for each observed event. It varies between 0.035 and 0.11 and depends on the event position in the DSSSD.

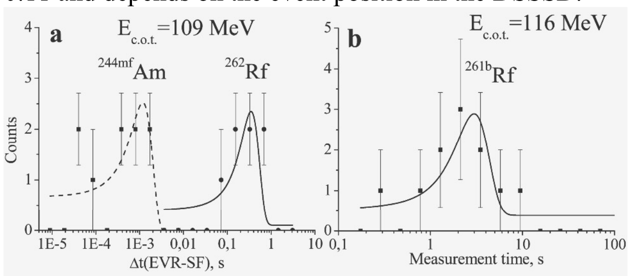

Figure 1: Time distributions of a) EVR-SF correlations from the DSSSD and b) SF decays from ROMA.

^{261}Rf was produced in the 5n channel at $E_{c.o.t}$ = 116 MeV and was detected in ROMA. Stepping time of 35 s (for ^{261a}Rf) were used. 149 single α-particles (E_α = 7.8 – 8.5 MeV) from ^{261a}Rf and ^{257}No were registered; among these 28 α-α correlations. Also, 11 SF-events were registered and are attributed to ^{261b}Rf based on the measured $T_{1/2}$ of $2.2^{+0.9}_{-0.5}$ s. The SF activity assigned in [2] to ^{262}Rf likely originated from then unknown ^{261b}Rf.

From our results and cross section of 4.4 nb [6], a transmission of Rf through TASCA to a 140 x 40 mm^2 large area in the focal plane of 10% follows. For ^{261b}Rf, a cross section of $1.8^{+0.8}_{-0.4}$ nb was calculated, respecting decay during transport. With an estimated transmission of 6% to the area of the FPDs, preliminary cross sections for ^{260}Rf and ^{262}Rf of ≈ 1.2 nb and ≈ 250 pb, respectively, follows ^{261b}Rf was observed for the first time as an EVR. The production ratio of ^{261a}Rf to ^{261b}Rf is about 2.5:1. The data analysis is still in progress.

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# Alexander.Gorshkov@radiochemie.de