Upgrade of the gas-filled recoil separator TASCA and first search experiment for the new element 120 in the reaction ^{50}Ti + ^{249}Cf

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The heaviest elements were discovered in ^{48}Ca-induced fusion reactions with actinide targets [1]. The observation of the hitherto heaviest element 118 was claimed from irradiations of targets of ^{249}Cf, which is the highest-Z nucleus that is available in sufficient quantities. Hence, to search for elements beyond Z=118, reactions induced by projectiles with Z>20 are required. Previously, ^{64}Ni+^{238}U [2], ^{58}Fe+^{244}Pu [3], and recently ^{54}Cr+^{248}Cm [4] were studied, but element 120 is yet to be discovered. Theoretical predictions [5-8] agree on the ^{50}Ti+^{249}Cf reaction to have the highest cross section. Accordingly, the TASCA collaboration selected this reaction to search for element 120. Maximum predicted cross sections range from 0.04 pb [5] to 0.75 pb [6, 8]. For comparison, the ^{48}Ca+^{249}Cf $\rightarrow$ Z=118 experimental cross section is $0.5^{+1.6}_{-0.3}$ pb [9].

On the way to a first search experiment for element 120 at TASCA, upgrades of several key components were performed, compared to the setup as used for the ^{244}Pu(^{48}Ca,3-4n)^{288,289}114 reaction [10, 11]. These include the implementation of a larger-area target wheel with 100 mm diameter comprising four targets [12]. The heat of each 5-ms long UNILAC macropulse is now dissipated over a four times larger area (6 cm^2) than in the old system (1.4 cm^2) used for element 114.

The separation from unwanted nuclear reaction products was increased by a factor of ~10 [13] by (i) implementing a carbon stripper foil in front of the target to increase the beam charge state, (ii) a fixed scraper mounted in the center of the first quadrupole magnet, and (iii) a second, moveable scraper mounted behind the second quadrupole. Both scraper positions were chosen based on ion-optical simulations, which predicted significant background suppression without loss in EVR efficiency due to the scrapers. Measurements, e.g., of the ^{48}Ca+^{208}Pb reaction, confirmed the expectations (see also [14]). The efficiency of TASCA for element 120 produced in the reaction ^{50}Ti+^{249}Cf was calculated to be (62±6)%. Discrimination between various event types was enhanced by improving the multi-wire proportional counter veto detector efficiency compared to the element 114 experiment. Several predictions of decay properties of isotopes produced in the ^{50}Ti+^{249}Cf reaction suggest their half-lives, $T_{1/2}$, to be on the order of μs. This is shorter than the dead-time of the data acquisition (DAQ) system used in 2009 [11]. Therefore, a fast digital sampling pulse processing system was built and integrated into the DAQ system [15]. This allowed registering events with $T_{1/2}$ as short as 100 ns, as confirmed in a study of the reaction ^{50}Ti+^{176}Yb, which yields decay chains with very short-lived members [16].

Old ^{249}Cf samples were chemically reprocessed and electrodeposited on ~2.2-μm thick Ti backings by molecular plating [17], yielding ~0.5-mg/cm^2 thick targets.

In August-October 2011, a first experiment to search for element 120 was conducted. Intense beams (0.5-1.0 μA_{part}) were applied on the Cf targets during 39 days of beamtime. The data analysis is in progress.

Acknowledgments: We thank the ion source and accelerator staff for providing stable and intense ^{50}Ti beams, and the experimental electronics department for making the digital DAQ system available on a short time-scale.

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