

Search for Element 113

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Element 113 was still unknown in summer 2003. From the systematic trend of cross-sections shown in Fig. 1 we expected a value of 0.1 to 0.3 pb for the synthesis of element 113 using the cold fusion reaction $^{70}\text{Zn} + ^{209}\text{Bi} \rightarrow ^{278}113 + 1n$. The upper value of 0.3 pb could be reached within a beam time of 15 days, assuming a projectile current of 700 pA, 400 $\mu\text{g}/\text{cm}^2$ thick targets and a total efficiency of 50 %. The expected decay chain should be similar to that of $^{277}112$. The first three nuclei of the α -decay chain, $^{278}113$, $^{274}111$ and ^{270}Bh , are unknown, however, the subsequently produced nuclei are known. The α -decay chain could end at ^{262}Db ($b_{\text{sf}} = 33\%$) or at ^{254}Md (100 % EC).

A search experiment for element 113 was already performed in 1998 [1]. The data are given in Tab. 1. The new experiment took place from September 11 to October 17, 2003. The ^{70}Zn beam was prepared in the ECR-ion source from ZnO which had an isotopic enrichment of 95 %. A maximum current of 700 pA was reached, the average current was 380 pA. The accelerator duty factor was 27.5 % at 5.5 ms wide beam pulses.

Table 1: Data of search experiments for element 113.

Year	Days	E_p/MeV	E^*/MeV	$N_p/10^{18}$	$\sigma_{\text{lim}}/\text{pb}$
1998	25	347.9	9.85	4.5	<0.9
1998	21	350.0	11.57	3.0	<1.4
2003	36	351.4	12.20	7.4	<0.4
mean ¹	57	351.0	12.02	10.4	<0.3

¹The mean values are calculated from the two experiments at 350.0 and 351.4 MeV beam energy, weighted by the beam dose.

The target layer was prepared from Bi_2O_3 (462 $\mu\text{g}/\text{cm}^2$) which was evaporated on a (not heated) carbon foil of 39 $\mu\text{m}/\text{cm}^2$ thickness and covered by 10 $\mu\text{g}/\text{cm}^2$ carbon. We used our standard wheel technique [2,3]. Seven wheels were irradiated during the 36 days of beam time.

The target was controlled using the scattering of 20 keV electrons by the target material [4].

During the experiment we collected a number of 7.4×10^{18} beam particles. No decay chain was measured, which could be assigned to element 113. Taking into account a total efficiency of 50 %, we calculate a cross-section limit of 0.4 pb on a probability level of 68 %, which means that 1 event would have had a cross-section of 0.2 pb.

The excitation energy of the compound nucleus in the new experiment and in that of the second part of the 1998 one differ by only 0.63 MeV. This is small compared to the expected width (FWHM) of the excitation function of about 4 to 5 MeV. Therefore we calculated the weighted mean of

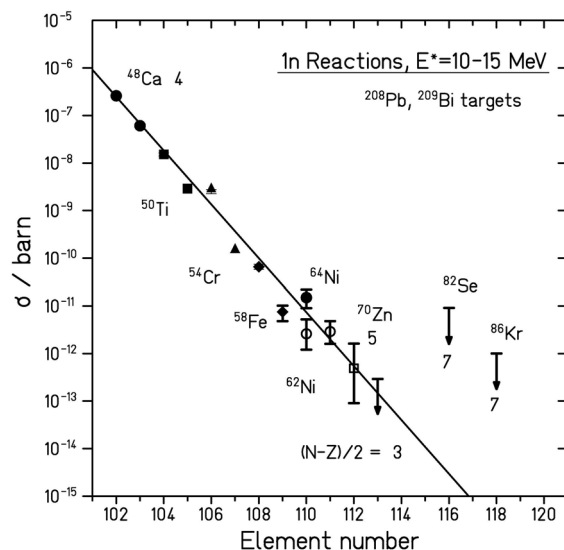


Figure 1: Measured cross-sections and limits for cold fusion reactions based on ^{208}Pb and ^{209}Bi targets.

these two parts, which is given in the last row of Tab. 1. The obtained cross-section limit of 0.3 pb is shown in Fig. 1.

The measured limit is not in contradiction to the systematic trend of cold fusion cross-sections. We conclude that a three times longer irradiation time or a three times higher beam intensity is needed to reach the expected lower cross-section limit of 0.1 pb. However, both can not be realized within the next three years. Therefore we plan to use the time to further upgrade the experimental set-up. Under discussion is a second ECR ion source of 28 GHz in addition to the existing 14 GHz source and an upgrade of the 25 % duty factor RFQ accelerator to 50 % duty factor [5]. Both improvements will result in a higher beam current by a factor of 5 to 10.

For the near future we also plan to perform experiments using actinide targets. In recent years these hot fusion reactions were successfully studied in Dubna, where element 113 was observed as daughter product after α -decay of $^{287}115$ and $^{288}115$ [6]. The goals at SHIP are to synthesize the elements 113 and 115 with beams of ^{45}Sc and ^{51}V and targets of ^{238}U .

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