Exploring New Ways to Produce Heavy and Superheavy Nuclei with Bigsol

T. Materna, Z. Chen, K. Hagel, J. Natowitz, L. Qin,
P.K. Sahu, R. Wada, D. Fabris,[1] M. Lunardon,[1] M. Morando,[1] S. Moretto,[1]
G. Nebbia,[1] S. Pesente,[1] V. Rizzi,[1] G. Viesti,[1] V. Bocci,[2] M. Barbui,[3]
A. Andrighetto,[3] M. Cinausero,[3] G. Prete,[3] Z. Majka,[4] A. Wieloch,[4] and S. Kowalski[5]
[1]*Dipartamento di Fisica dell'Universitá di Padova and INFN Sezione di Padova, Italy*
[2]*Dipartimento di Fisica dell'Università di Brescia and INFN, Italy*
[3]*INFN Laboratori Nazionali di Legnaro, Italy*
[4]*Smoluchowski Institute of Physics, Jagiellonian University, Krakow, Poland*
[5]*Institute of Physics, Silesia University, Katowice, Poland*

The synthesis of superheavy elements (SHE) has been an important field in both theoretical and experimental nuclear physics for many years. Fusion of the doubly-magic neutron-rich ^{48}Ca projectiles with transuranium target nuclei has led during the past 6 years to the synthesis of elements with Z = 113-116 and 118 [1]. The cross-sections involved are at the limit of the sensitivity achievable with the current technology. Our aim is to investigate possible alternative reactions to produce such elements. For example, one of the reactions might be one in which the fissile target nucleus (e.g. ^{238}U and ^{232}Th) would fission as the projectile approaches and where one of the fragments would fuse with the projectile nucleus. The fission fragments being neutron-rich and close to shell closure, they should enhance the fusion and survival probabilities of the formed superheavy nucleus [2].

Experiments have been performed in 2003 and 2004 in collaboration with the Instituto Nazionale di Fisica Nucleare (INFN, Italy). The superconducting solenoid BigSol was used to collect the reaction products and to focus them towards a Bragg chamber, with a back plane covered with scintillators, at about 4 meters from the magnet. Two position-sensitive PPACs were placed before the Bragg chamber, allowing time of flight measurement and trajectory reconstruction.

The reactions studied in 2004 were projectiles of ^{172}Yb (15, 10 and 7.5 A.MeV), ^{197}Au (7.5 A.MeV), ^{136}Xe (7.5 A.MeV) and ^{84}Kr (25, 15 and 7.5A.MeV) on a ^{232}Th target and with ^{238}U (7.5 A.MeV) projectiles on ^{nat}Ti, ^{64}Zn, ^{90}Zr and ^{232}Th targets. The analysis of the collected data is complete. A few tens of events are consistent with the expected signature of superheavy ions. These events have passed all the rejection tests we could implement with our current setup. The setup was optimized to make a survey and needs to be improved significantly before a possible synthesis of superheavy elements can be claimed. In particular, a better separation of the candidates from the high cross-section products (elastics, deep-inelastics,…) must be achieved to allow for the use of Silicon detectors capable of measuring alpha-decay chains to identify the produced elements

The SHE candidates appear mostly in systems at lower energy (7.5 A.MeV), in the reactions ^{197}Au + ^{232}Th and ^{238}U + ^{64}Zn. Our group plans to investigate in more details these reactions in August of this year with a further improved experimental setup. Our goal is to confirm the existence of these candidates and to characterize them better in order to build a more discriminating setup in the future.

[1] Yu. Ts. Oganessian *et al.*, Phys. Rev. C **69**, R021601 (2004); Yu. Ts. Oganessian *et al.*,Nature **400**, 242 (1999); Yu. Ts. Oganessian *et al.*, Scientific American **282**, 45 (2000); Yu. Ts. Oganessian *et al.*, Phys. Rev. C **63**, R011301 (2001); Yu. Ts. Oganessian, "JINR Preprint and Communications", D7-202-287, Dubna, 2002.

[2] Y. Aritomo, T. Wada, M. Ohta, and Y. Abe, Phys. Rev. C **59**, 796 (1999).