Highly precise mass measurements of neutron-rich nuclei at $A = 82$–92 at ZeroDegree-MRTOF(ZD-MRTOF)

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A state-of-art multi-reflection time-of-flight (TOF) mass spectrograph (MRTOF-MS) coupling to a cryogenic helium filled gas catcher (gas cell) was developed and prepared for on-line tests prior to the launch of the HiCARI campaign 2020[1)] for γ-ray spectroscopy. For the first time, the ZD-MRTOF system was operated on-line running as parasitic experiment downstream of the ZeroDegree (ZD) spectrometer. Produced by in-flight fission of ^{238}U primary beam with ^{9}Be target, radioactive ions were selected, identified, and guided by BigRIPS to the focal plane F8, where the exotic ions reacted with a secondary target for in-beam γ-ray research. Reaction products were then analyzed using the ZD spectrometer before they were finally entrapped by the gas cell and measured by the MRTOF-MS.

Abundant stable molecules contribute to strong peaks with long tails in a TOF spectrum, which causes difficulties identifying the much weaker peaks of the ions of interest. Benefiting from the introduction of a new mass filter method,[2)] we obtained low-contaminant-background with high resolution isobaric TOF spectrums, as shown in Fig. 1. In this spectrum, in addition to isobaric ions from the on-line beam, stable molecules from background contaminations in the gas were also observed in the same measurement as several species can be measured simultaneously. Stable molecules provided isobaric references for extracting masses of ion of interest. On the other hand, the stable molecules also served as benchmarks for the evaluation of the systematic uncertainties.

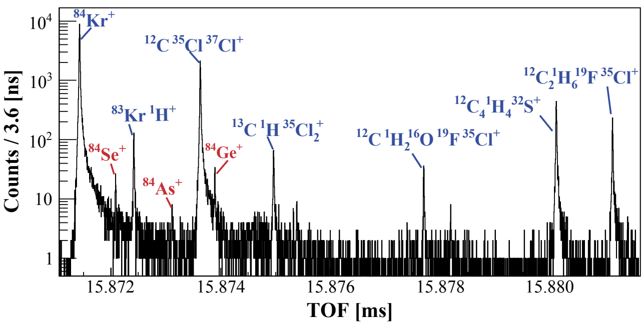

Fig. 1. TOF spectrum at $A = 84$ with radioactive ions (red) and stable molecules (blue).

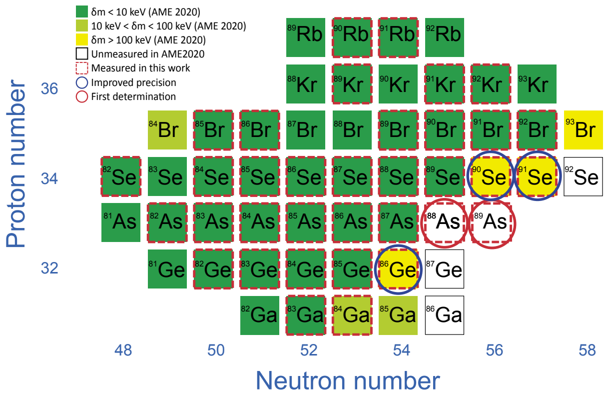

Fig. 2. Meassured isotopes ($A = 82$–92) in on-line tests.

In total, the HiCARI campaign 2020 had five separate experiments, covering four different regions. The results introduced in this report were from the data acquired during NP1912-RIBF196 and NP1912-RIBF190. Among other mass regions, abundant species of isotopes have been observed in the mass range $A = 82$–92. In total, 35 nuclides were measured in a neutron-rich region of Ga, Ge, As, Se, Br, Kr, and Rb in which ^{84}Ga, ^{86}Ge, ^{89}As, ^{91}Se, and ^{92}Br are the most exotic isotopes (see Fig. 2). Among those isotopes, mass uncertainties of ^{86}Ge, ^{90}Se, and ^{91}Se, could be reduced significantly to less than 5 keV. Moreover, for the first time, the masses of ^{88,89}As were unveiled. In addition to radioactive ions, at least one stable atomic or molecular ion was found for each mass number, *e.g.*, ^{82}Kr^{1}H^{+}, ^{83}Kr^{1}H^{+}, ^{12}C^{37}Cl$_2^{+}$, *etc.* The mass deviations of these ions from AME2020 enable an evaluation of system accuracy of the new ZD-MRTOF system. The weighted mean deviation of the measured masses from the precisely known values was found to be approximately only 2 keV, which proves a very high accuracy for future measurements.

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