On-line commissioning of the new SLOWRI/ZD-MRTOF system

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The new combined gas cell and MRTOF spectrograph developed for high-precision atomic mass measurements at BigRIPS has been finalized and transported to the F11 position behind the ZeroDegree spectrometer of RIBF. The combination of the new cryogenic gas cell[1] with the MRTOF system was initially tested in October 2020, where stable $^{39}K^{+}$ ions were extracted from the gas cell and detected at the system's downstream TOF detector. The system was ready to operate on-line just before the start of the 2020 HiCARI campaign, which enabled the first on-line commissioning of the new setup. The commissioning run took place in parasitic on-line operation during the HiCARI experiments (see HiCARI APR publications in this volume). After passing the HiCARI target and detectors, the reaction products were transported through the ZeroDegree spectrometer and stopped in the new cryogenic gas cell. Energy degraders were used to reduce the beam energy to match the He gas cell's stopping power. The stopped reaction products were extracted mostly as singly-charged ions and transported to the MRTOF setup[2] where their masses were determined with high precision and accuracy. The 2020 HiCARI campaign lasted throughout the month of November with five separate experiments, and another two experiments took place in December. During our commissioning, mass measurements covering four different regions in the nuclide chart have been carried out (see Fig. 1). Total system efficiencies, determined by comparing the incoming rate from F11 at the PID system with the detected rate after MRTOF, varied according to the presence of contaminants in the helium gas. While some of the radioactive species were dispersed across molecular sidebands (*e.g.* $^{55}ScOH^{+}$), very reasonable ion transport could be reached for many other species, *e.g.* $^{85}As^{+}$ with 0.16% and $^{137}Te^{+}$ with 1.3% total efficiency. In sum, the commissioning campaign was highly successful with more than 70 atomic masses measured during the HiCARI campaign. Notable results have been achieved in four different regions. Around neutron-rich Ti and V isotopes, our results include isotopes from Ca to Fe with ^{55}Sc, ^{58}Ti, and ^{59}V being the most exotic, which improve nuclear masses very recently measured using the TOF-Bρ method at NSCL[3] and RIBF[4] denoting the front line of nuclear mass studies in this region. In the neutron-rich region above Ni, nuclides have been studied reaching from Ga to Kr with ^{84}Ga, ^{86}Ge, ^{89}As, and ^{91}Se as most exotic isotopes. In this group the isotopes $^{88,89}As$ have been measured for the first time while three other isotopes provide a significant improvement of the previously performed measurements. Another region addressed with success is from Mo to Rh isotopes including the first mass measurement of ^{112}Mo. In the fourth region addressed, *i.e.* near ^{132}Sn, we have demonstrated the isomeric mass separtion of $^{134g,m}Sb$ (W. Xian, APR same volume). In total, three isotope masses have been measured for the first time and eleven other isotope masses improve the present uncertainty significantly. By performing this first on-line commissioning of a gas stopper connected to BigRIPS in a parasitic mode, we were able to efficiently identify and resolve issues that could not be studied offline. This will allow for a very rapid improvement in performance going forward. In March 2021, the next commissioning run takes place, wherein the neutron-rich Ni region will be addressed by HiCARI group. Furthermore, two different beam times with the ZD-MRTOF system as main experiment have been approved for 2021.

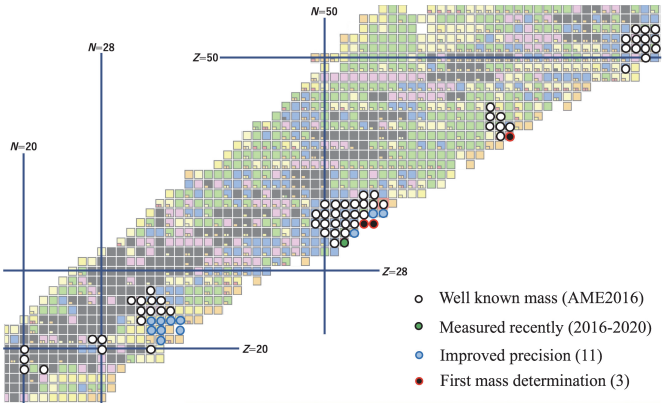

Fig. 1. Nuclear mass measurements during the HiCARI campaign and the results by the ZD-MRTOF system. Background color code illustrates the measured precision from AME2016 (see Nucleus-win for reference).

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