Improvements in the performance of the KISS MRTOF

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The KISS facility uses mutinucleon transfer reactions to produce nuclides which are difficult to produce by fusion or by in-flight fission and fragmentation reactions. Many of these nuclides are close to stability, and typically the more stable isobars are produced with orders of magnitude greater rates. This has made it difficult to access some desirable nuclides, such as ^{188}W, ^{198,199}Ir, and ^{238,239}Pa, as resolving such nuclides from the next stabler isobar requires a high mass resolving power not only in terms of full-width at half-maximum but in terms of full-width at 1%—*i.e.* minimal tails.

Until recently, the MRTOF at KISS has achieved a maximum mass resolving power of $\Delta m/m \sim 200{,}000$ and the peak shape had a strong asymmetry, with the relative amplitude at $\Delta m \approx +20$ ppm being ≈1% of maximum. This was not sufficient to the task of resolving interesting nuclides nearer stability. However, in the past year the performance of the MRTOF installed at the KISS facility has improved. The mass resolving power has increased to $\Delta m/m \sim 400{,}000$ while the peak shape has been made significantly more Gaussian. The improvement is shown in the top panel of Fig. 1. The lower panel of Fig. 1 demonstrates how the new peak shape will allow for discernment of ^{199}Ir which was previously not possible.

By carefully adjusting the biasing of the MRTOF optical elements, it was possible to both improve the peak shape and the resolving power. This effort was made reasonable by the use of purpose-built high-voltage power supplies[1)] which achieve a high-stability without requiring long time-constant capacitive filtering. As these power supplies settle in under one minute, it was possible to efficiently perform multi-parameter optimizations. With further tuning we anticipate that $\Delta m/m > 500{,}000$ with a Gaussian profile can be achieved, which will greatly improve our ability to resolve isobars near stability

In future experiments, we plan to use the MRTOF as a very high-resolution isobar purifier to deliver isobarically (and possibly isomerically) pure beam of radioactive ions for *e.g.* decay studies. This will require a high stability in the peak position. We have found that the power supplies contribute a temperature dependent drift of $\Delta m/\Delta T = 2.36(4)$ ppm/K while thermal expansion of the MRTOF itself results in $\Delta m/\Delta T = 20.4(6)$ ppm/K. In the past we observed very large shifts in the MRTOF peak position as the room warmed due to the presence of numerous experimenters during online measurements. To try to reduce this effect, we gently heated the MRTOF chamber using a PID regulated baking system. The result is shown in Fig. 2. In the future we will try improving the thermal regulation.

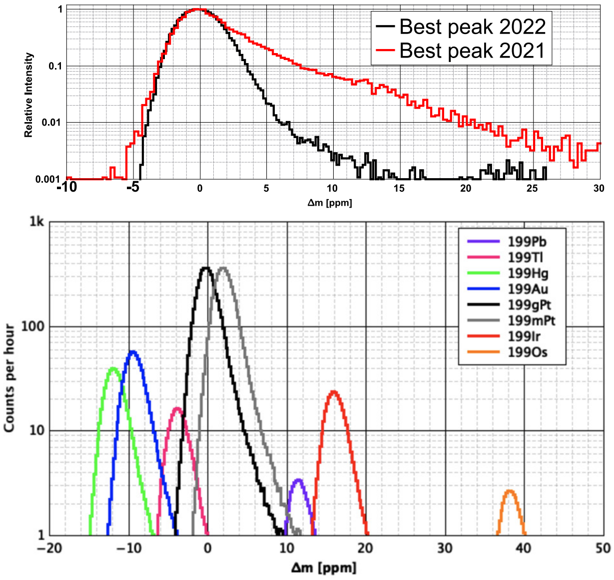

Fig. 1. (top) Comparison of MRTOF peak shape from 2021 with the improved peak shape achieved in 2022. (bottom) Simulated spectrum for $A = 199$ isobars based on measured MRTOF peak shape and calculated production yields. Prior to improving the peak shape it was very difficult to observe ^{199}Ir ions as they produced only a small fluctuation in the tail of the ^{199}Pt ion peak.

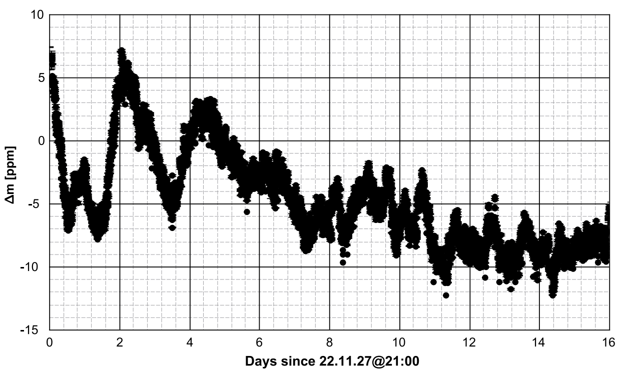

Fig. 2. Drift of the peak position over 16 days of measurement while roughly regulating the MRTOF chamber at 38°C. The maximum fluctuation is consistent with a thermal fluctuation of $\Delta T_{pk-pk} \approx 0.75$ K.

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Reference
1) P. Schury, *et al.*, Rev. Sci. Instrum. **91**, 014702 (2020).