**Motivation**

Mass measurements play an important role in most of the calculations for nuclear astrophysics. Model calculations in the neutron-rich area for the r-process and problems in Q\(_d\) determinations, etc. The TOF-B\(_p\) mass measurements overcome all the complications and offer an access to new mass values.

**Experimental Method**

At the NSCL, a primary beam is accelerated in the coupled superconducting cyclotrons K500 and K1200. A fast radioactive beam is then produced by fragmentation reactions in the A1900 fragment separator [1]. For this experiment, the 58 m long time-of-flight line is used. It starts at the A1900 extended focal plane and ends at the focal plane of the spectrometer S800 [2]. Fast scintillation detectors provide a timing resolution of about 30 ps, the relative magnetic rigidity B\(_ρ\) is measured at the momentum dispersive plane, so that the B\(_ρ\) can be considered to be constant.

The method is based on the relation between nuclide's mass-to-charge ratio, magnetic rigidity B\(_ρ\) and time-of-flight t over a distance l:

\[
\frac{m}{q} = B\rho t^2.
\]

\( (1) \)

**TOF-Corrections**

For the mass measurements, the spectrometer S800 is set in the dispersion-matched mode so that the position y on the micro-channel plate detector corresponds to particle's magnetic rigidity B\(_ρ\).

The time-of-flight of one nuclide depends directly on the particle's magnetic rigidity, see Fig. 2. The time-of-flight value can be corrected to the B\(_ρ\) on the dispersive plane of the S800 spectrometer by position sensitive micro-channel plate detector [3].

Figure 4 shows the time-of-flight corrected to the B\(_ρ\) position (at the dispersive plane), compared with the uncorrected one in Fig.3. Ideally, the flight distance \( l \) can be considered to be constant for all particles. However, there are small differences in the path due to angles and positions at the focal planes. Therefore, we monitor positions and angles by a couple of CRDC's at the S800 focal plane. Figure 2 shows there is a small dependence on the angle that could improve a resolution by 10 ps, see Fig. 5.

**Mass Measurement of \(^{86}\text{Kr}\) Fragmentation Products**

In February 2006 the TOF-B\(_p\) mass measurement experiment was for the first time performed at NSCL, MSU. The primary beam \(^{160}\text{Kr}\) at 160 AMeV was used to produce neutron-rich exotic nuclei by fragmentation in the target. The target thickness was regularly changed between 45mg/cm\(^2\) and 94 mg/cm\(^2\) to cover a large area of nuclides. The magnetic optics setting was the same for both target thicknesses so that data can be combined.

The combination of the energy loss measurement in the standard S800 ion chamber detector with the time-of-flight offers the possibility of particle identification as shown in the figure.

**Time-of-Flight Spectra**

The mass value of a nuclide is determined from its time-of-flight with respect to the time-of-flight of a nuclide with well-known mass, the so-called reference mass (or reference nuclide [4]).

The nuclides with mass uncertainties lower than 10keV (shown as blue in the figure [4]) are used for the calibration of the relation between the mass-to-charge ratio and the time-of-flight.

This relation can be used to determine the new mass values for the nuclides with unknown mass or mass with large uncertainty (shown as red in the figure [4]) from its measured time-of-flight.

The nuclides with masses previously measured with higher uncertainties can be used to estimate the systematic errors.

The preliminary time-of-flight resolution achieved in the online analysis is better than 100ps.

**References:**


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