Mass measurement by track reconstruction with the LEB spectrometer

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The large-acceptance spectrometer in the LEB cave will be used for experiments with intermediate or low energy radioactive beams from the Super-FRS. Gamma and charged-particle spectroscopy will be performed around a typically low-mass secondary target. Forward-focussed fragments are transported to the spectrometer's focal plane, where they are identified or "tagged" to complete the reaction analysis. The large beam emittance at the target means that event-by-event tracking is essential (position, angle, time-of-flight as well as the magnetic rigidity in the Super-FRS).

The simulations discussed here involve fragments in the mass 200 region, which are assumed to come from reactions at about 180 MeV/u. The goal is to resolve the different neighbouring-mass isotopes.

The Monte Carlo program MOCADI [1] was used for the simulations in which the secondary beam starts from the end focal plane of the Super-FRS. The secondary reaction target is a 500 mg/cm^2 beryllium foil, followed by a 300 μm silicon double-sided strip detector (DSSD, P2) for the beam spot correction and a 1-mm thick plastic scintillator. A TPC tracking detector P1, is located 0.5 m before the target. P1 and P2 would be used to correct the fragment angle during the data analysis. However, only the uncorrected angle is needed for the mass reconstruction. This is obtained event-by-event from P2 and P3, another position detector 30 cm downstream from the target

The Lund-York-Cologne calorimeter LYCCA [2] is used for the measurements at the focal plane. This consists of a 2-mm thick plastic (stop ToF), a 0.3-mm Si DSSD ($\Delta E, x, y$: P4) and a 2.5-cm CsI(Tl) crystal (E_{res}).The achieved resolutions during the commissioning of Pre-SPEC [3] are $\sigma_x, \sigma_y = 0.5$ mm, $\Delta Z = 1/100$, $\Delta E = 1/100$ and ToF = 27 ps.

The following reconstruction equations are used:

- δ is calculated from

$$\delta = [x_f - \mathrm{R}_{11}x_i - \mathrm{R}_{12}a_i]/\mathrm{R}_{16}. \qquad (1)$$

  where x_i is taken from P2, a_i is calculated from P2 and P3, and x_f is taken from P4.

- The corrected $B\rho$ is calculated as $B\rho_n = B\rho_0(1+\delta)$, where $B\rho_0$ is the magnetic rigidity of the reference particle, ^{201}Pt^{78+}, before the spectrometer.

- The path length of the reference particle is corrected for the initial coordinates by

$$l_n = l_0 + \mathrm{R}_{51}x_i + \mathrm{R}_{52}a_i + \mathrm{R}_{56}\delta$$

  where the subscript 5 is the length parameter.

- β is calculated from the corrected path length:

$$\beta = l_n/c(t_2 - t_1)$$

- Finally, the mass A divided by charge Q is:

$$\frac{A}{Q} = \frac{B\rho_n}{\gamma\beta}\frac{c}{m_u} \qquad (2)$$

  where m_u = 931.494061 MeV/c^2.

A similar reconstruction scheme is made at BigRIPS [4]. The exact matrix elements are known from the ion-optics, but rather than putting these back into the equations, "empirical" first order matrix elements are used from a simulated test experiment with a well-focused primary beam. As seen in the cross-hatched peak for ^{201}Pt in Fig. 1, one

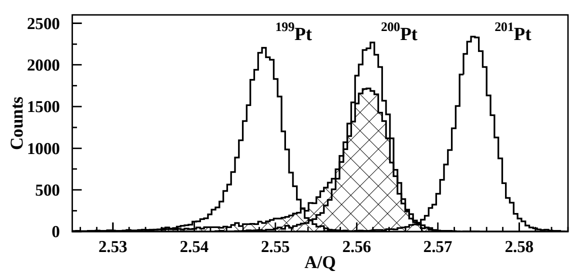

Figure 1: Simulated mass reconstruction for $A \sim 200$. Cross-hatched histogram is for 1^{st}-order matrix elements only. The finite resolution of the detectors is included.

could obtain reasonably resolved masses up to $A \sim 200$; however, there is a tail on the peak at the low A/Q side. The resolution can be improved by the inclusion of selected 2^{nd} and 3^{rd} order matrix elements, with appropriate modification of Eq. (1). Following the procedure used at BigRIPS, the Newton-Raphson iterative method is used to solve for delta. There is a clear improvement in the shape and width of the (unshaded) peaks of of Fig. 1 compared with the 1^{st}-order calculation. The FWHM of the ^{201}Pt peak corresponds to 0.53 mass units.

References

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