Optimal operation of a 4-element injection lens in a hemispherical spectrograph: FDM/BEM simulation and experimental demonstration

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Synopsis We have investigated the voltage settings for the 4-element injection lens of a biased paracentric hemispherical deflection analyzer (HDA) with virtual entry aperture using numerical methods. The two lens electrode voltages were varied as free parameters while the electron optical properties of the analyzer were calculated from trajectories with test initial distributions for different pre-retardation factors in an effort to obtain improved energy resolution. The resulting lens voltages were then also tested on the existing HDA spectrometer at the Tandem Accelerator Laboratory, while simulated and measured line profile characteristics were compared, particularly at the best resolution working points.

The biased paracentric hemispherical deflection analyzers represent a novel class of HDAs, which use the lensing action of the strong fringing fields at its entry, to restore the first order focus characteristics of ideal HDAs in a controlled way [1,2]. Here, we extend previous investigations to the study of the electron optical properties of such an HDA as a function of lens voltages, and compare our results to experimental measurements taken with the HDA at the Tandem Accelerator Laboratory [3].

Figure 1(a) shows the schematic of the biased paracentric HDA equipped with a 4-element injection lens and position sensitive detector (PSD). The lens system plays a particularly important role in regulating the energy resolution of the analyzer since it defines the size of the virtual entry aperture. The two lens voltage combinations, V_{L4} and V_{L5}, were found to belong to the families of elliptical-like contours, as shown in Figure 1(b), and were investigated for different pre-retardation factors, $F = E_{s0}/qV_p$, where E_{s0} is the electron source energy, and V_p is the HDA plate voltage ($F = 1$ for no pre-retardation). The correlation between F and the energy resolution was evaluated by means of both experimental measurements and computer simulations of the entire trajectories including the injection lens system. Two numerical methods, the finite difference method (FDM) and boundary element method (BEM) [4], were employed in the solution of the electrostatic problem.

All four combinations of positive and negative voltages gave rise to energy resolution minima from which only the subset with the most practical values were further investigated in more detail.

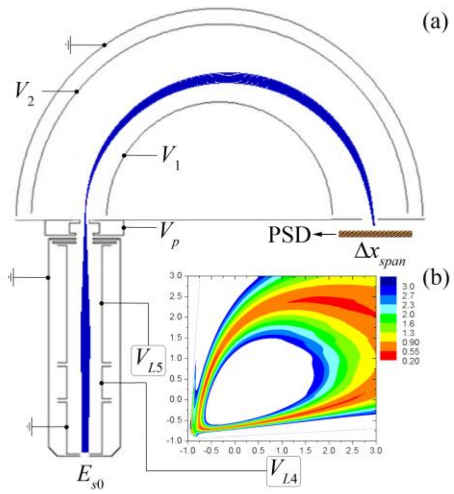

Figure 1. (a) Schematic view of the complete analyzer system. (b) 2-D contour map of the beam trace width Δx_{span} versus V_{L4} and V_{L5} (in kV) for $F = 1$.

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References

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