VOLTAGE OPTIMIZATION OF A 4-ELEMENT INJECTION LENS ON A HEMISPHERICAL SPECTROGRAPH WITH VIRTUAL ENTRY APERTURE

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Abstract

We present results on the simulation procedure for finding the optimal lens voltages of a biased paracentric hemispherical deflector analyzer (HDA) with a 4-element injection lens and a 2-D position sensitive detector (PSD) used for high resolution Auger projectile electron spectroscopy at the new atomic physics experimental station used in our APAPES collaboration [1]. The spectrometer is shown in Fig. 1.

The optimization was carried out by simulations using the SIMION 8.1 package [2]. SIMION solved the Laplace equation in the lens and HDA for the given geometry of the experimental setup utilizing the finite difference method. Simple initial electron distributions were flown through the lens entry aperture, through the HDA and on to the PSD. The two lens voltages V_{L4} and V_{L5} were varied as free parameters while various criteria were used to select the optimal voltages [3] such as minimization of the beam spot at the 2-D PSD, minimization of the lens magnification and beam angle at the lens image plane etc. in an effort to obtain improved energy resolution. The beam trace width x_{span} along the dispersion direction at the PSD was recorded for each fly. The simulations were carried out for various lens pre-retardation factors F. SIMION results were also crossed checked using the boundary-element method (BEM) [4] and found in good agreement.

The lens voltages obtained from simulations this way will be tested on the new electron spectrograph at the Demokritos 5 MV Tandem Accelerator Laboratory, with the expectation that they will provide improved energy resolution compared to the previously used empirically found lens voltages.

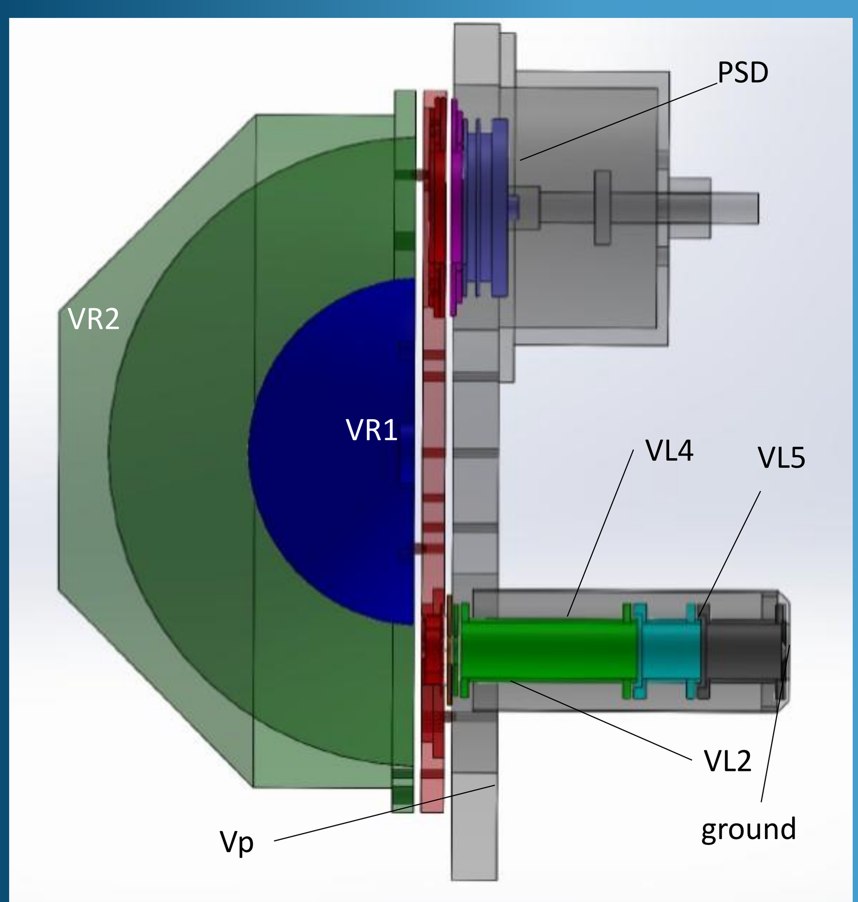

Fig. 1: Schematic representation of the spectrograph consisting of an input lens, the HDA and the PSD. All the important elements are shown. Each colour represents a different voltage. V_{L4} and V_{L5} are the lens voltages varied in the simulations. V_p is responsible for the final electron deceleration.

- Geometry files used in SIMION 8.1 utilized surface enhancement for highest accuracy conditions for system dimensions as well as the grid unit density
- Voltage parameters of each element of the injection lens as well as the initial conditions of the electron beam were controlled independently in SIMION with the use of Lua programming.
- The entire voltage space of both V_{L5},V_{L4} lens voltages was scanned in steps of ΔV=10V while the size of the resulting beam spot along the dispersion direction x_{span} and along the focusing direction y_{span} was recorded for each combination.
- Minimum beam spot size was found to be correlated with HDA optimal energy resolution.

Fig. 2: Panoramic view of the APAPES beam line

Results:

The results of the simulations are presented below for a test energy beam of 1000 eV. Beam trace widths x_{span} and y_{span} vs. V_{L4} and V_{L5} lens voltages 2-D contour plots are presented together with some 2-D beam spots determined on the PSD.

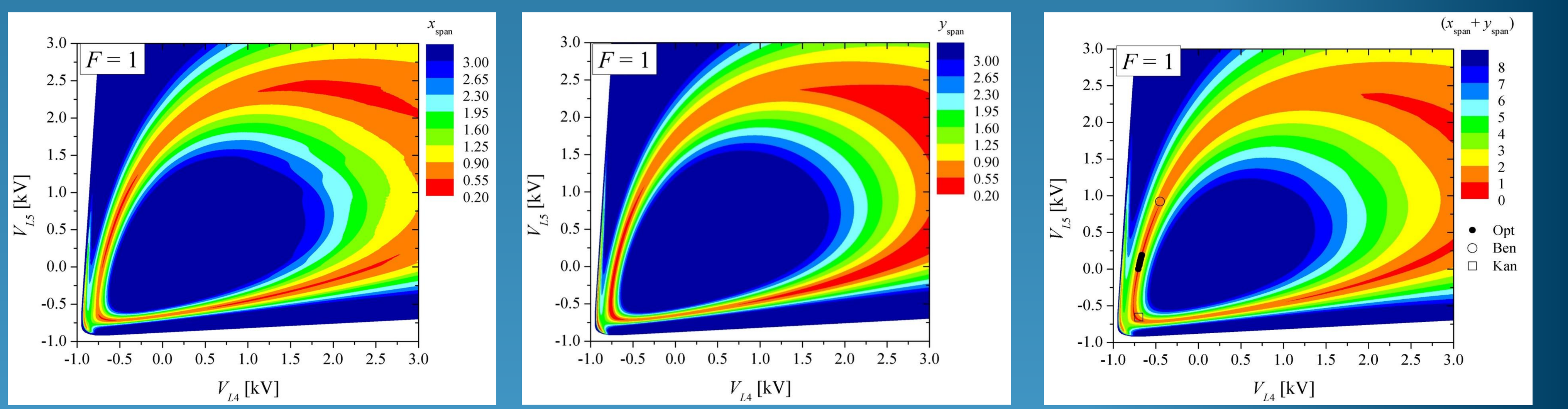

Figure 3: 2-D contour plots of the beam trace widths x_{span} and y_{span} (in mm) and their sum vs. V_{L4} and V_{L5} lens voltages for F=1. Ten values of optimal voltage sets of V_{L4} and V_{L5} are displayed with black dots . Empirically discovered len voltages using Auger lines are shown with white circles and squares.

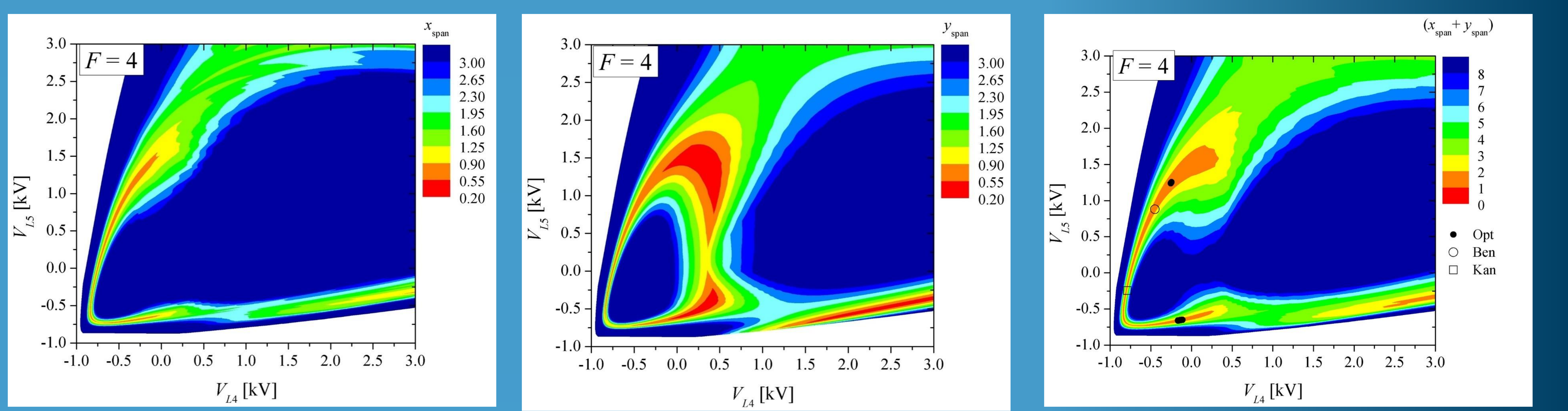

Figure 4: Same as Figure 3, but for F=4

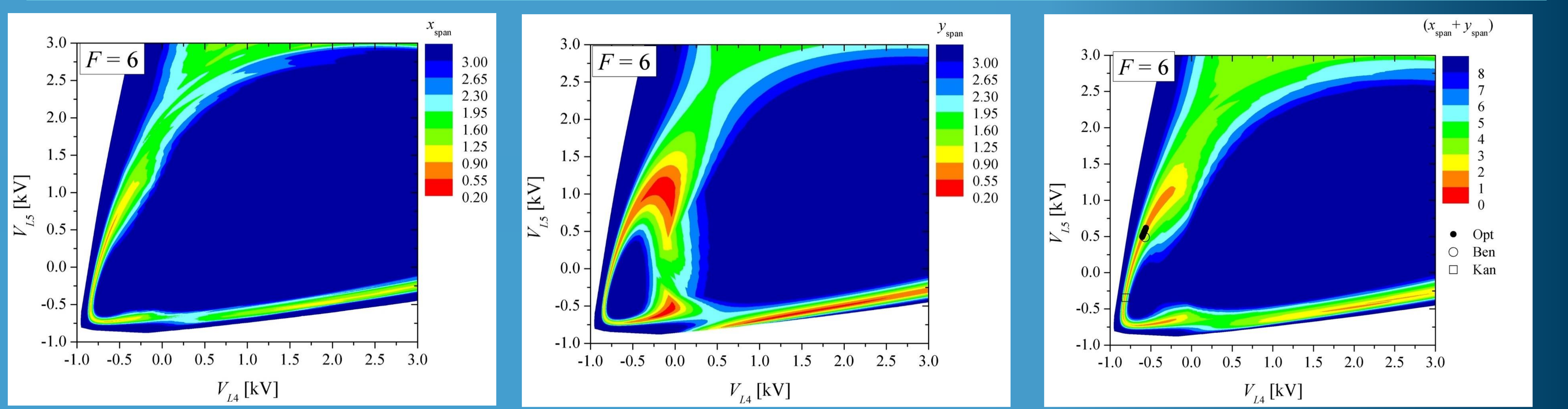

Figure 5: Same as Figure 3, but for F=6

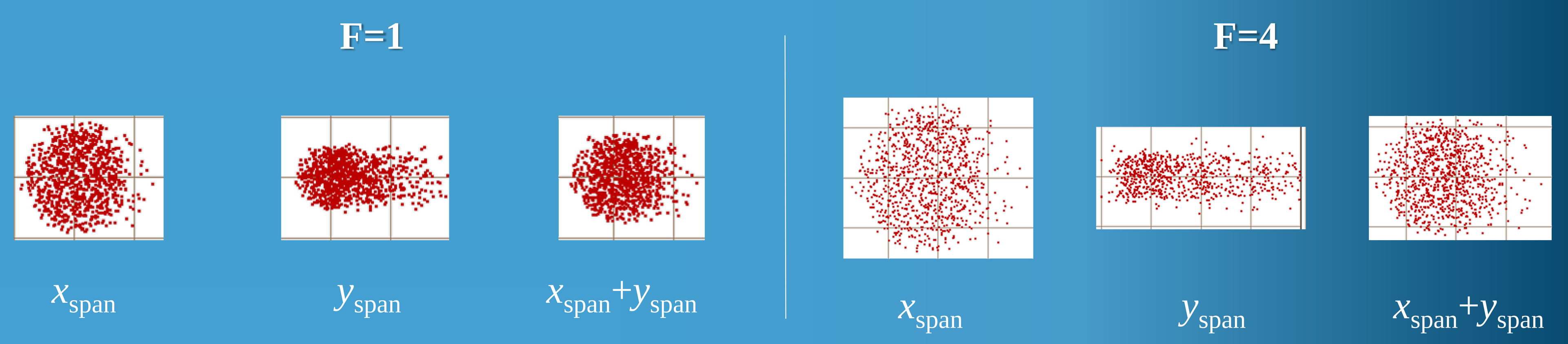

Figure 6: 2D beam spots for F=1 and F=4 – each square has a side of 0.254mm

Conclusions and Future

- Results for F=2, F=8 and F=10 will soon be available too
- The simulation results will be tested in the laboratory on the experimental apparatus with Auger lines from ion beam collisions with various gas targets.

References

1. I. Madesis *et al*, *JPCS* **583** (2015) 012014.
2. SIMION v.8.1, url: http://simion.com
3. T. J. M. Zouros and E. P. Benis, *Applied Physics Letters* **86** (2005) 094105.
4. G. Martínez and M. Sancho, in: P. Hawkes (Ed.), Advances in Electronics and Electron Physics 81, Academic Press, New York, 1991, pp.1-41.

Financed by the European Union (European Social Fund - ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) Research Funding Program: THALES. Investing in knowledge society through the European Social Fund (Grant No. MIS 377289)