Investigation of the dependence of the energy resolution of a hemispherical deflector analyser on the distance of the position sensitive detector from its focal plane

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Synopsis

We are investigating the energy resolution and line shape of a biased paracentric hemispherical deflector analyzer considering the distance between the exit focal plane and the detection plane. Equipped with a piezo-electrically controlled location of a 2-D position sensitive detector we were able to accurately determine the optimum conditions for best energy resolution.

General principles

Modern hemispherical deflector analyzers (HDAs) are equipped with an electrostatic injection zoom lens at their entrance and a Position Sensitive Detector (PSD) for the collection of the energy analyzed electrons at their exit. Practical geometrical constraints (fringing field correctors, grids etc) rarely allow the PSD placement at the optimal position, i.e. the first-order focal plane following 180° deflection. The only study to date by Page *et al* [1] has shown in simulations that an optimal choice on the distance *h* might exist for which non-linearities in the energy of the electrons across the PSD become minimized.
Our goal is to study the *h*-dependence of the energy resolution and line shape of our biased paracentric HDA. Our HDA is equipped with a 4-element focusing/retardation lens at the entry and a 2-D PSD in operation with a doubly-differentially pumped gas target. The whole setup is displayed in Fig.3. This apparatus is part of the experimental station developed for the research initiative APAPES [2], funded by THALES and located at the 5MV TANDEM of the NCSR "Demokritos" in Athens. The setup is primarily dedicated to zero-degree Auger projectile spectroscopy, performing high resolution studies of electrons emitted from highly charged ions excited in collisions with gas targets.

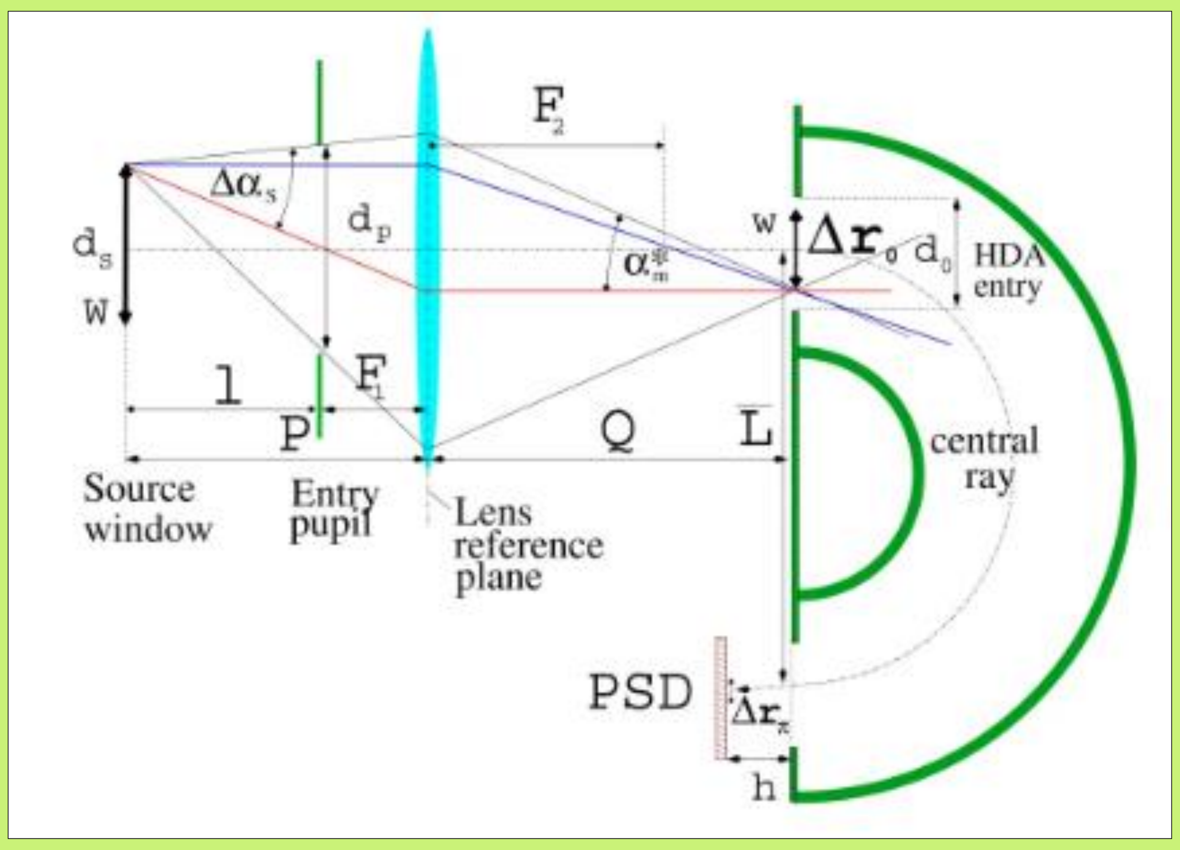

Fig. 1: Schematic geometry of typical lens-HDA spectrometer [3]. The object diameter d_s is focused by the lens and imaged onto the HDA entry plane as Δr_0. After the 180^0 travel of the electrons through the HDA they are imaged at the PSD with a radial width of Δr_π. Δr_π will depend on the distance *h* between the PSD and the analyzer. The drawing has been simplified by approximating the real dimensions of the lens as a thin lens.

Installation

Recently, we have installed a piezo-electric motor on the shaft on which the PSD is supported (see Fig. 3 left). This allows us to electronically control the location distance *h* of the PSD with respect to the HDA exit focal plane thus enabling an experimental study of its effect on the measured line shape and position. Moreover, at different values of *h* the injection lens voltages will be set through a brute force method to their most resolution-efficient voltages, in order to have consistent results on the *h*-dependence.[4].
The installed stepping motor has a travel range of A_{max}=12mm. The *h* distance is given by $h=h_{min}+A$, where h_{min}=23.08 mm is the minimum distance between the MCP surface and the exit plane of the HDA (Fig. 3 right). A hot cathode electron gun beam was mostly utilized, while electrons resulting from ion-atom collisions at zero-degrees with respect to the ionic beam complemented the study (Fig. 2). The SIMION 8.1 ion optics simulation package will also be used and compared to the experimental results.

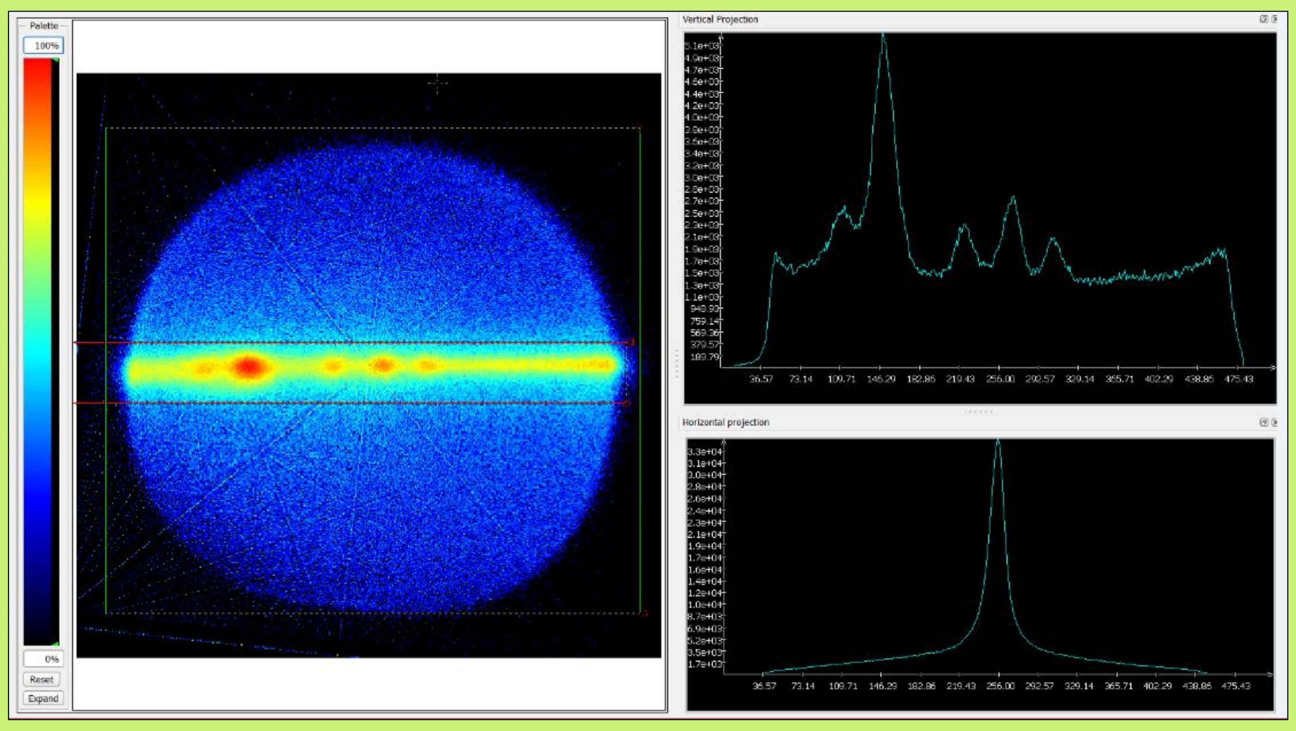

Fig. 2: A typical projectile Auger electron spectrum obtained by APAPES as seen on the 2-D PSD image (left) and projections (right) along the *x*-axis (energy spectrum – top) and the *y*-axis (bottom).

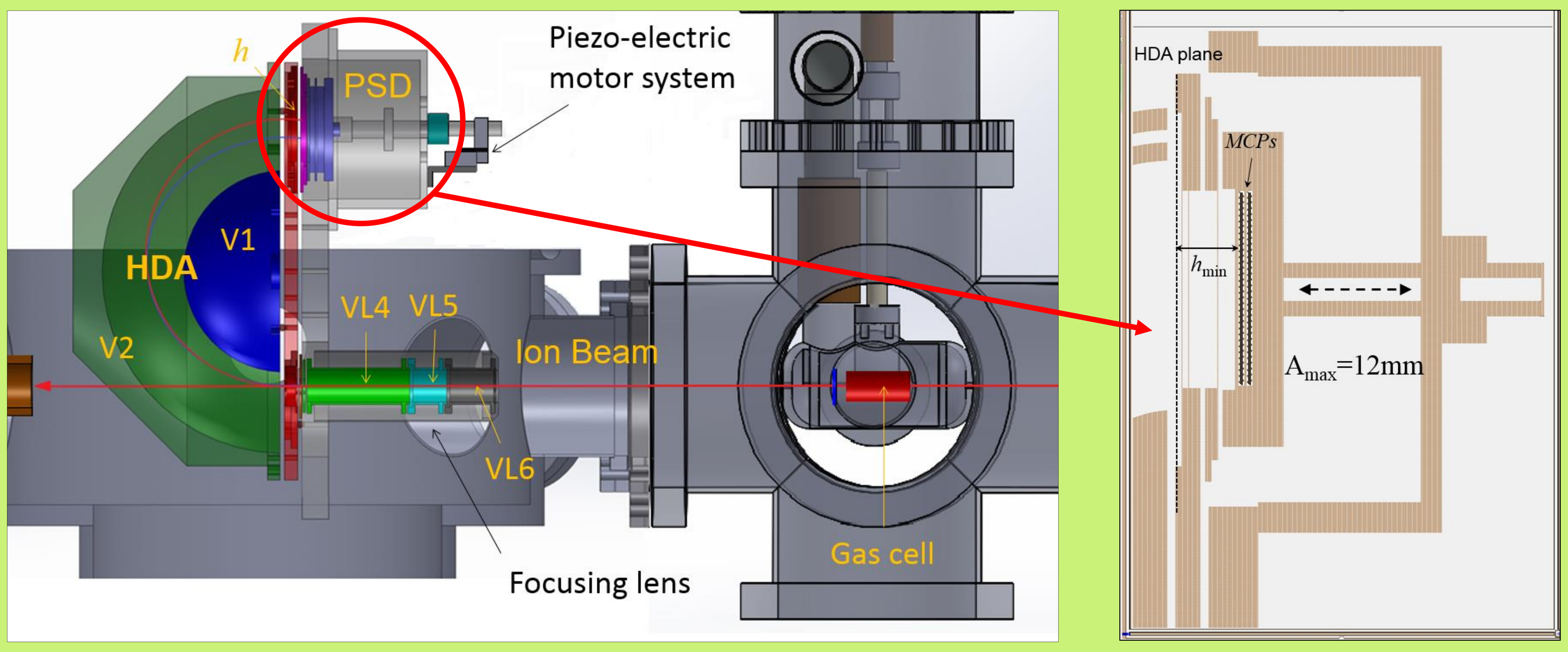

Fig. 3: (Left) Schematic view of the HDA spectrometer showing the position of the piezoelectric motor (PM). The Multichannel plates (MCPs) of the PSD are at a distance *h* from the focusing plane of the HDA. **(Right)** SIMION schematic view of PSD with piezoelectric motor in higher detail. The distance *h* is given by $h=h_{min}+A$, where A_{max} is the travel range of the PM (12mm).

Measurements from hot-cathode electrons

FWHM resolution measurements with respect to the distance *h* for various pre-retardation factors $F=E_{s0}/E_0$, where E_{s0} is the electron source energy and E_0, is the pass energy on the spectrometer (F=1 for no pre-retardation, and F>1 when $E_0<E_{s0}$).

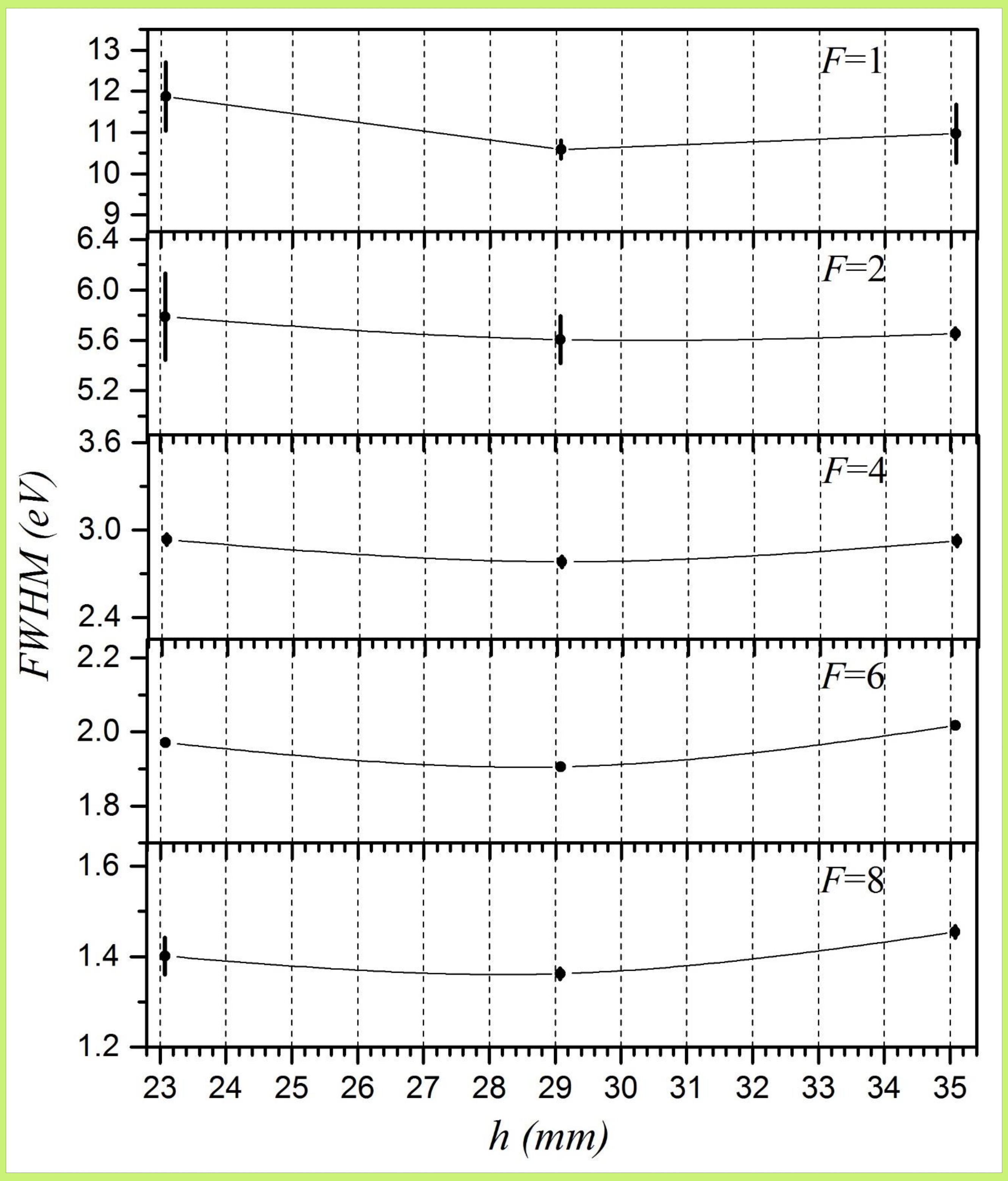

Fig. 4: FWHM as a function of the distance *h* for retardation factors *F*=1 - 8.

Concluding points and Future Prospects

- First results displayed on Fig. 4 show variations of FWHM with respect to the distance *h* (approx. 3 – 10 % depending on the value of *F*).
- Collection of data in progress. In the near future more results will be available for a wider variety of values of *h*, within the travel limits of the PM.
- An extended investigation before the next experiment with Auger electrons in an effort to have the best possible resolution.
- A real-time investigation of the effect of *h* on the resolution will also be possible during measurements .
- The paracentric HDA properties will be further investigated on a larger scale.
- Investigation of non-linearities in the energy calibration of the PSD will also be investigated as a function of *h*.
- Complete simulations with SIMION 8.1 and comparison to real measurements.

References

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