



### **B176 A Comparison of the Multivariate Likelihood Ratio (LR) Method and the Confidence Interval Method in Practice: Forensic Glass Analysis Using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS)**

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After attending this presentation, attendees will learn about the application of likelihood ratios in multivariate comparisons.

This presentation will impact the forensic science community by determining the evidential value by a Bayesian approach.

For the forensic analysis of float-glass a method using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) is in use at the NFI. The concentrations of ten elements in small glass fragments are measured with this method. Previously the method was validated<sup>[1, 2]</sup> and accredited by the Dutch accreditation council. An important question is how to evaluate the results as evidence that glass samples originate from the same or from different sources.

Currently the comparison of glass particles is done by using confidence intervals. Overlaps in confidence intervals for each of the ten elements are evaluated. The number of overlaps is used as a measure of similarity or difference between the samples. Based on a validation with known float-glass samples matching criteria have been defined to conclude whether glass fragments originate from the same source. However, this method has some disadvantages. First of all, the comparisons are univariate and therefore possible correlations between the concentrations of some elements are not taken into account. Secondly, small differences in the confidence intervals can result in a match or non-match, the well-known 'fall-off-the-cliff' effect. Finally, population data i.e., the relative frequency of occurrence of the glass composition could not be incorporated.

An alternative method which does not have these disadvantages is based on a Bayesian approach. In this study the use of multivariate Likelihood Ratio's (LR) as proposed by Aitken & Lucy<sup>[3]</sup> is evaluated. For the calculations a program written in R, based on Lucy's work, was applied. The underlying database consisted of 203 known float glass samples measured by LA-ICP-MS (10 elements). A multivariate kernel density estimate was used for the between-source variability and a multivariate normal distribution for the within-source variability.

To investigate the Likelihood Ratio method a series of simulations and validations have been undertaken. The results of the multivariate LR calculations are compared with the conclusions obtained from the confidence interval method. It appears that both type I errors (false negatives) as well as type II errors (false positives) are lower for the LR method. For glass fragments originating from a single source often very large likelihood ratio's are calculated. This reflects the high evidential value that potentially can be obtained from LA-ICP-MS measurements on glass.

For the time being both the Bayesian approach as well as the confidence interval method will be run in parallel to gain more experience. Also the glass database will be expanded to improve the accuracy of the calculations.

#### **Reference:**

- <sup>1</sup> S. Berends-Montero, W. Wiarda, P. de Joode and G.J.Q. van der Peijl, *J. Anal. At. Spectrom.*, 2006, 21, 1185.
- <sup>2</sup> S. Montero, Forensic float-glass analysis using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), method validation, NFI scientific report (2005), at <http://www.forensischinstituut.nl/>.
- <sup>3</sup> C.G.G. Aitken and D. Lucy (2004), Evaluation of trace evidence in the form of multivariate data, *Applied Statistics*, Vol. 53, part 1, pp. 109-122 (2004).

#### **Likelihood Ratio, Glass, LA-ICP-MS**