Handheld X-ray fluorescence spectrometer for the analysis of outdoor bronze monuments

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\textbf{Abstract}

A handheld XRF spectrometer was designed under the framework of the Educational and Initial Vocational Training Program – Archimedes for the study of characteristic corrosion products found on outdoor bronze monuments. The spectrometer consists of a low power (3W), cool cathode, transmission anode (Ag) X-ray tube, and a Si-PIN detector. The appropriate selection of materials, their careful integration and the optimal choice of apertures in the optical paths enabled finally a well-collimated exciting beam of high spectral purity, as seen in Fig. 1. The optimal conditions with respect to the operational voltage and filtering materials were deduced after measuring a variety of reference materials including mostly metal alloys, and corroded metallic coupons. A characteristic spectrum obtained from the standard BCR-D bronze sample is shown in Fig. 2. Typical detection limits, for the elements of interest, such as Sn were found to be at the order of 1% for a measuring time of 200 – 300 sec. A first attempt towards a quantification scheme resulted to a relatively good accuracy in the case of homogeneous, well certified metal alloys.

\textbf{Fig 1.} Profile of the exciting X-ray beam, obtained at 30 kV after scattering of the primary tube radiation onto a high purity amorphous SiO\textsubscript{2}. 
Fig 2. Spectrum of a standard bronze sample (BCR-D, Cu: 80.3%, Pb: 9.2%, Sn: 10.1%, As: 0.29%) obtained at 30 kV with direct filtered tube excitation. With the symbol DP, diffraction peaks are indicated.