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Determination of Emitted X-Ray Tube Spectra by Means of a Calibrated Instrumental Setup

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The accurate calculation of element concentration by means of standardless X-ray fluorescence (XRF) analysis requires besides accurate atomic and instrumental parameters the accurate knowledge of the excitation X-ray spectrum [1]. This paper deals with the determination of X-ray spectra emitted by side-window tubes in photons eV^{-1} msr^{-1} nA^{-1} s^{-1} by means of a calibrated instrumental setup.

Various algorithms for the calculation of the X-ray tube spectrum exist in the literature. For XRF the algorithms of (i) Pella et al. [2], (ii) Ebel [3] and (iii) Finkelshtein & Pavlova [4] based on the so-called fundamental parameters and semi-empirical approaches are conventionally employed. A recent model based on accurate knowledge of a SEM/EDS (scanning electron microscope / energy dispersive X-ray spectrometer) instrumentation, especially of the spectrometer efficiency has been also referred to [5]. As an example X-ray spectra emitted by a Mo tube have been calculated with the four models and are shown together in Fig. 1. The calibrated SEM/EDS system enables to experimentally simulate the side-window X-ray tube. This is possible by tilting the sample in SEM as the target in the X-ray tube and by placing the EDS onto the horizontal port of the SEM. The corresponding Mo X-ray spectrum is included also into Fig. 1.

The results show that the various algorithms differ significantly in the spectral distribution and in the intensities as well. Therefore, in order to determine the real emitted X-ray tube spectrum a special setup consisting on an extremely long distance of 16 m between the X-ray tube and the X-ray spectrometer was built (Fig. 2). Otherwise, a conventional X-ray spectrometer would attain the saturation due to the very high photon fluxes (up to 10^9 photons s^{-1}) emitted by such side-window X-ray tubes.
The efficiency of the X-ray spectrometer was calibrated up to 50 keV. For this purpose an X-ray spectrum of a reference material (RM) measured by the spectrometer belonging to the setup was related to the emitted spectrum of the same RM measured with a calibrated X-ray spectrometer [6]. In order to enable the certification of X-ray tube spectra as an automated tool in the quality assurance for the X-ray tube manufacturers, a software package was developed, see. Fig. 3.

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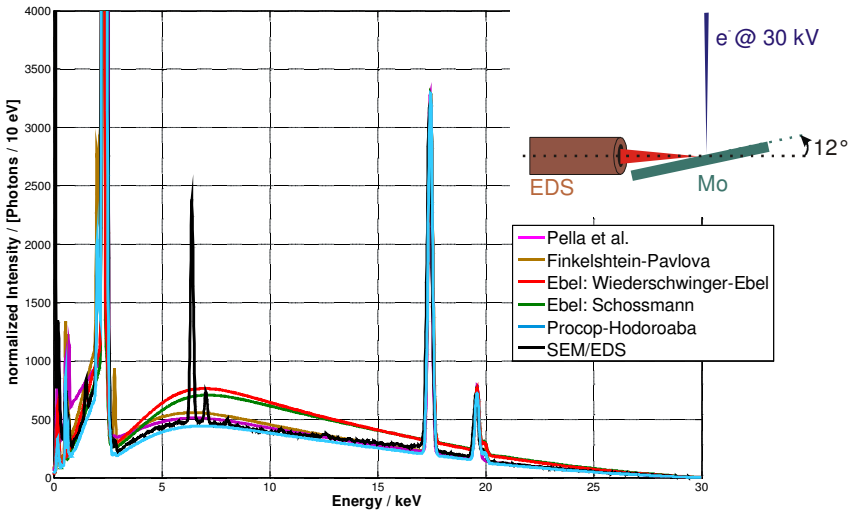

FIG. 1. 30 kV Mo X-ray tube spectra calculated with the models [2] – [5] and the spectrum measured with a calibrated SEM/EDS system (spectra are normalized to Mo Kα intensity).

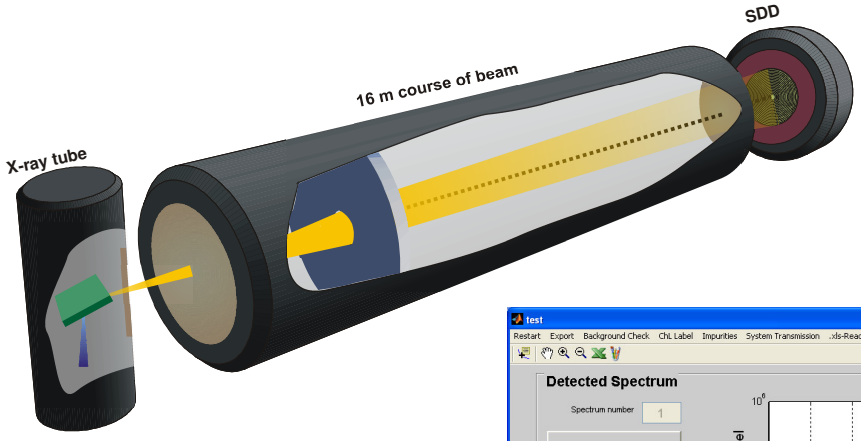

FIG. 2. Instrumental setup specially developed for the measurement of the emitted X-ray tube spectrum.

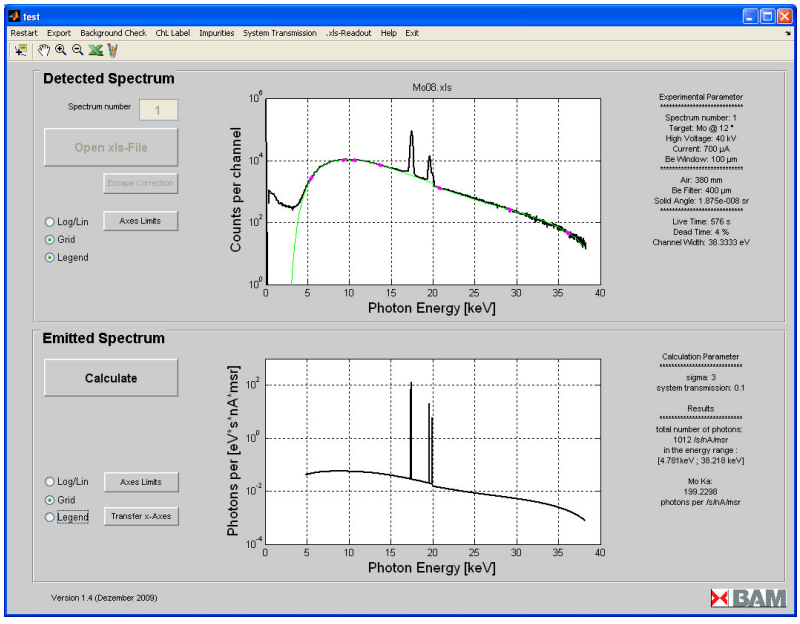

FIG. 3. Graphical user interface of the software package for the calculation of the emitted X-ray tube spectrum from the spectrum measured with the instrumental setup.

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