INFLUENCE OF ENVIRONMENTAL PARAMETERS VARIATIONS ON X-RAY BEAM INTENSITIES - A TIME-DEPENDENT ABSORPTION CORRECTION

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MOTIVATION
Essential for high precision X-ray diffraction or spectrometry analysis is a constant primary beam intensity. Besides electronically induced variations on X-ray primary intensity (X-ray generator electrical stability of 0.1 to 0.005 % [1]), ambient conditions are particularly important. This is barometric pressure, humidity and temperature, as well as cooling water, that affect the primary beam intensity. Changes of these parameters can influence the air density and thus the transmission of X-rays. This is important for long-term analysis, e.g. in situ investigation or high-precision structure data determination.

EXPERIMENTAL DATA

STANDARD ANALYSIS

The correlation of T and T reflects day and night cycle. T shows no time-dependence. T has small day and night fluctuations, whereas a small time-dependence in the time structure of T and T is recognizable.

Correlations were calculated with the statistical program: r [4]

Auto-Correlation shows the time-dependent correlation of particular parameters

Cross-Correlation shows the correlation between the parameters

Analysis of Variance (ANOVA) used to indicate influence of daily and weekly cycles

Changes of week and weekend have significant but small influence: during week I decreases, at weekends I increases

12 hour periodic cycles influence the intensity, but less than weekly cycles

EXPERIMENTAL DETAILS

X-ray source: water cooled sealed tube (Cu-Kα-radiation)

Detectors: scintillation counter

Air conditioning supplied by a central facility

Monitoring time: 28 days (664 hours)

External data from weather station

THEORETICAL CONSIDERATIONS

- Density of dry air calculated with ideal gas equation \( \rho = \frac{m}{V} \)
- Humid air, the equation must be extended with the water content \( \rho = 1 + \frac{\rho_{\text{water}}}{m_{\text{water}}} \) \[2\]
- Transmission can be calculated by \( T_{\text{meas}} = \frac{1}{1 + \frac{\rho_{\text{water}}}{m_{\text{water}}}} \)
- Attenuation coefficient \( \mu(E)_{\text{air}} \) is expressed by \( \mu(E)_{\text{air}} = \rho \sum_{i} \mu_{\text{water}}(E) \) \[1\]

CONCLUSION

- \( \frac{\Delta I}{I} = 1.153 \% \) induced by \( \Delta T_{\text{meas}} = \pm 1.37 \% \) due to \( \Delta \rho/\rho = 3.7 \% \)
- Main impact on intensity variations has \( \rho \)
- Air conditioning system damped influence of \( T_{l} \) and \( rH \)
- Small attenuations of \( \mu(E)_{\text{water}} \) are small
- Weekly and 12 hour periodic cycles have small but significant influence on I
- Recording of ambient conditions can be used for time-dependent absorption correction of measured I, reduce variation due to 25 %