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Noise and reproducible (non EXAFS) artefacts of an EXAFS station

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ABSTRACT

In 1989 and 1990 noise measurements on the electronics and optics of EXAFS Station 8.1 of the Daresbury Laboratory showed that non statistical "noise"in the photon beam determined the total noise in the absorption spectrum in transmission-mode.

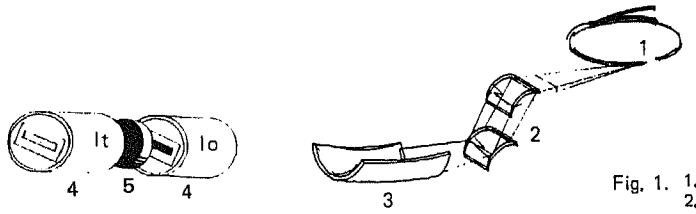

Fig. 1. 1. Electron beam
2. Monochromator
3. Mirror
4. Ionization chambers
5. Sample

The monochromator-position dependent reproducible artefacts are intensity fluctuations (with Energy) due to the monochromator and enhanced by the mirror, which break through in the absorptionspectrum. (In figure 1 a set up of Station 8.1 is shown) These reproducible artefacts can be a factor of ten larger than the statistical photon noise.
Increased counting times per datapoint or taking an average of a multiple scans will not improve the signal to noise ratio.

INTRODUCTION

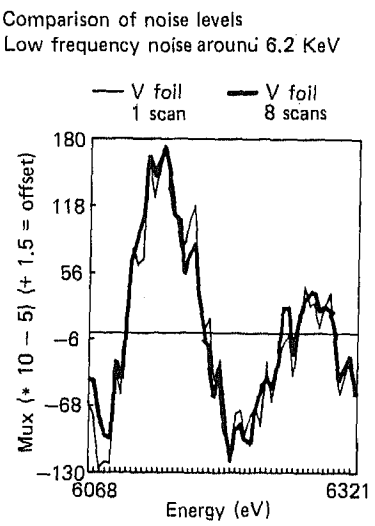

Fig. 2. Vanadium K EXAFS–scan
Recorded at 8.1 D.L. An average of 8 scans does not improve the Signal to 'noise'. The artefacts are reproducible.

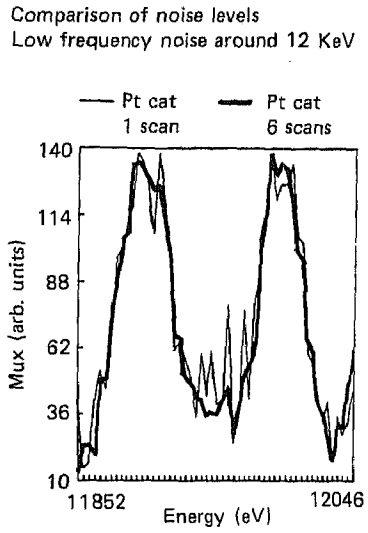

Fig. 3. Platinum L_{III} EXAFS–scan
Recorded at 9.2 D.L. An average of 6 scans improves the S/N (as expected with $\sqrt{6}$.

Figure 2 clearly shows a close resemblance in the absorption spectrum between one scan and the average of eight scans (Station 8.1)
At another EXAFS Station (9.2), six successive scans show a decrease of the noise to signal with the squareroot of six, as expected for statistical noise (See figure 3).
In order to find out the cause(s) of these reproducible artefacts an investigation was started.

THE ELECTRONICS

The noise contributions of the electronic components after the ionisation chambers were statistical and appeared to be much smaller than the total "noise" (=statistical noise and non-statistical "noise"). The Current_to_Voltage converters contributed significantly to the statistical noise.
In the case of ideal ion chambers, i.e. without space charge effects, and a perfect steady beam at the sample, no changes in intensity of whatever cause will break through in the absorption spectrum.
In practice however, ion chambers, though responding very much in the same way, cannot prevent this because of space charge effects.

THE OPTICS

The signal to noise ratio is limited by the mechanical inaccuracies of the double crystal monochromator used at Station 8.1. The mechanical inaccuracies are due to, firstly, the roller bearings used to translate the second crystal and, secondly, due to a non-responsive D.C. powered motor used to servo the angle of the second crystal.
To improve the signal to noise ratio, with respect to the mechanical inaccuracies, it is suggested that the D.C. powered motor be replaced with a piezo electric actuator.
Piezo electric actuators, in conjunction with an appropriate feed back system, should provide the precision and response required for EXAFS data aquisition.

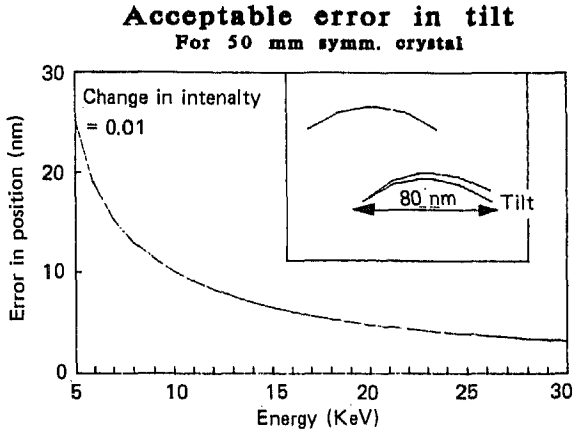

Fig. 4. Required accuracy of tilt (2nd crystal).

Figure 4 gives an impression of the requirements of the accuracy. Most likely the tilt mechanisms of the monochromators of Station 8.1 are not functioning as they should and though introducing changes in intensity.
(Rocking over the rocking curve)