XMM Optical Monitor

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MICROCHANNEL PLATE LIFETIME CONCERNS

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1 Detector lifetimes

Following the presentations at the OEG-1 meeting, I have had the opportunity to discuss the ^{XMM}OM detector designs with George Fraser, who visited PSU recently I am prompted to summarise the concerns about detector lifetime and other related issues, and hope they can be a useful focus for the detector test programs.

Firstly, I note that in the proposal, a number of specifications and parameters were rather loosely quoted. For example, the mean count rates across the field of view are given variously as '200kHz', 'up to 1×10^5/sec', and as a background light level of 5.4×10^4/sec in the white band, or 7×10^3/sec in the blue band.

There is no clear derivation of a real averaged count rate seen by the detectors. Echoing the thoughts of the SG-1 meeting, some thought should be given to the likely observing plans, particularly concerning the mix between narrow band filter observations, and broad band white light: most of the simulations Cheng has performed so far have been restricted to white light data, where the maximum S:N ratio of timing data is obtained, yet this mode would be very onerous in its requirements of the micro-channel plate lifetime.

Suppose, for example that in a 6×10^4 sec EPIC observation, the observer requested 20% of OM time in white light and 20% time in each of 4 colour filters, a typical average zodiacal light background count rate would be $\sim 1.6 \times 10^4$ cts/sec based on the proposal tables (cf. Section 4.2.1.8 of the proposal $\sim 5 \times 10^3$ cts/sec) For 300 observations per year over 10 years, such rates would meet the charge extraction lifetime limits of 0.01C/sq mm specified in the proposal. With an identical detector format, but an expanded field of view (eg. 16arcmin dia), the lifetime would be correspondingly reduced to ~ 2.5 years.

Actually to perform this sort of lifetest may be very difficult - to expose the detector to a much higher photon count rate causes the gain to drop, and therefore the rate of total abstracted charge does not increase - 10 year lifetime cannot be demonstrated in a convenient laboratory timescale, yet the previous arguments show this is one of the most critical points to be considered in the Resolution/Field of View trade-off studies.

It may be possible to test the plates in a current mode instead of a pulse mode and although this may allow the abstracted charge levels to be reached, it is in a non-representative mode. It may also be important to establish if the nominal plate gain can be set lower than 1×10^7 to give more margin on lifetime (this of course also facilitates the use of a filmless detector, and possibly extends the life of the phosphors or photocathodes).

The necessary changes in detector HV to sustain the mean gain levels will inevitably be associated with a deteriorating pulse height distribution. For example in the UK ROSAT WFC test program, whilst comparable lifetime was established, the detection efficiency fell 50% due to a fraction of previously valid events falling outside the nominal gain threshold settings.

Further complications arising from gain variations occur at the *beginning* of life, and will be exacerbated by the life-limiting effects: serious differential non-linearities occur at the hexagonal multifibre bundle boundaries. These are attributed to gain variations, which cause systemmatic shifts in the apparent position of individual photon events, as the 'foot-print' of the charge cloud radial distribution changes with gain, and hence in charge partitioning readout systems of the 'wedge & strip' variety a 'chicken wire' appearance is produced in flat fields.

This would call into question the accuracy of the tracking algorithms: we had discussed the necessity of using a global look-up table to flatten out the gross non-linearities due to the SPAN readout system, or the MIC optical fibre taper effects. However, this finer scale non-linearity could not be removed by a look-up table, and will presumably also vary as the plate gain decays with time. MIC may not be as susceptible to this problem due to the different readout technique.

An additional point here is that the flat-fielding calibration plan envisaged for the EUVE experiment entails $\sim 1 \times 10^9 - 1 \times 10^{10}$ calibration data points, and that further in-orbit flat fields will be necessary if the inevitable gain changes are to be accounted for. The present ^{XMM}OM calibration plans should note the requirement to examine differential non-linearity effects at small spatial scales, but widely sampled across the detector. Also, no provision has been made for in-orbit flat field calibrations, only point source sensitivity checks

2 Summary

The baseline design lifetime must be re-assessed in the light of realistic observing scenarios.

Even with the baseline design, the subtle effects of gain and pulse height distribution degradation caused by HV adjustments may cause flat field and non-linearity response that impairs the ability to perform tracking and image re-registration.

Demonstration of the required lifetime is difficult to achieve and required test must be initiated as soon as possible to allow a realistic assessment of the implications for instrument design to be accommodated. This is particularly true if we are to examine the extension to wider fields of view.