JEM-X gain correction user requirements

Notes by S. Brandt, Oct 7, 2005

The gain of JEM-X detector varies in time due to several factors:

- High voltage setting
- Electrostatic settling (polarization) effects, which are a function of the history of applied high voltage (overshoot at start-up, ageing effect of the micro strip plate)
- Temperature effects
- Level of charged particle background

The time scale for temporal gain variations are typically on the following scales:

- Instantaneous (few seconds) when the high voltage setting is changed by command (12-14% gain change per high voltage step)
- A few minutes to a few hours for electrostatic settling effects when the high voltage has been off for a few hours (up to 50% overshoot)
- Several hours in response to externally induced temperature variations, which have this typical time scale (1% gain change per degree, most pronounced temperature variations are seen in the eclipse season)
- Up to more than 12 hours when the high voltage has been off for several days and the detector has accumulated more than a year of total service (up to 50% gain change)
- A general steady, slow gain drift is observed as a result of detector ageing (up to 1% per orbit)

The gain of the JEM-X detector varies as function of position on the detector plate. The spatial gain variation is quasi-constant and may be considered constant over periods of months.

The JEM-X temporal gain variation is derived from calibration spectra collected onboard with an integration time of 256 seconds. The reference spectra are derived from 4 radioactive sources and samples 4 individual locations on the micro strip plate. The calibration spectra are affected by the general grey filter mechanism, and the effective integration time of the spectra will vary accordingly. Normally the lines in the calibration spectra may be fitted for each 256 s integration period. However, in periods of grey filtering several spectra may be needed.
Heavy charged particles (cosmic rays) may locally deposit a large charge, which depresses the local gain in the area of impact on time scales of tens of minutes (gain glitches). When this effect is observed in the area of the calibration sources it is a local effect and does not reflect the average gain of the full detector and must be ignored by an appropriate algorithm (smoothing, fitting or other).

In light of the time scales of the temporal gain variations, the spacecraft and instrument operations, gain glitches etc., and grey filter effects, the data set required to determine the

temporal gain correction function for a particular observation **is the calibration spectra for one full revolution**.

The temporal gain correction function includes the temporal corrections. The gain correction function is based on the calibration spectra collected onboard, but processed by an automated routine (default) or “by hand” (optional) to reflect the best estimate of the actual gain on the micro strip plate.
(note: “by hand” in this context means any other routine, algorithm, or actual manual editing to derive a suitable gain correction function table.)

- The results of the fitting of the individual calibration spectra shall be given in tabular form for each revolution.

- The temporal gain correction function shall be in the form of a tabulated function suitable for determining the gain correction at a given time by linear interpolation for each revolution (note: the time resolution of the table may vary, and is not bound to be 256 s).

- The temporal gain correction function is applied together with the spatial gain map to correct the recorded pulse height (PHA) of an event or a spectrum to an energy scale (PI).

- The results of the fitting of the calibration spectra and the temporal gain correction function shall be available for comparison for each revolution in order to verify the performance of the automated derivation of the function.

- In cases, where the gain function is not found to represent the true performance of the detector (based on failure of the automated routine or knowledge about operations or detector performance not built in to the automated routine), the table of the gain function may be substituted by an another table of similar format.

- A mechanism shall exist to identify and determine the status of a gain function table (automatic, overwritten, final approval from instrument team, etc.).

- Software using the gain function shall propagate the information of the status of the gain function to the data product to indicate which version of the gain correction has been used.

Verification requirements

It is important that the instrument team, as well as the user, has tools to verify that the applied gain corrections make sense. This requires following to be available for a given observation:

- The result of the fitting of the individual calibration spectra for the full orbit (position of the main peak in the spectra of the calibration sources in PHA).
- The table of the temporal gain function used to correct the data, expressing the conversion from linearised PHA channel to energy (note: unit is keV/channel). The table must be available for the full orbit in which the observation takes place.
- Energy spectra of the full detector for each orbit to verify the position and resolution of the Xe background line at 29.6 keV. Preferably, spectra for each science window should also be available in order to verify performance on shorter time scale by adding up the appropriate number of spectra.