INSTRUMENT RESPONSE OF THE CHANDRYAAN-1 X-RAY SPECTROMETER (C1XS).

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Introduction: The C1XS experiment on Chandrayaan-1 [1] is designed to map the abundance of elements such as Mg, Al, Si, Ca, Ti and Fe on the lunar surface. A complementary experiment alongside C1XS, the X-ray solar monitor [2], provides simultaneous observation of the solar X-rays using a solid state detector.

C1XS is expected to provide lunar mapping of elemental abundances with a nominal spatial resolution of 25 km (FWHM) from the100 km polar, circular orbit of Chandrayaan-1. The instrument consists of 24 Swept Charge Devices [3] mounted below a passive collimator and coupled to visible light filters, yielding an X-ray spectrometer that operates with adequate resolution in the energy range of 1 to 10 keV without the need for active cooling.

A detailed description of the instrument (Grande et al.) and the scientific arguments for C1XS (Joy et al.) are available within these LPSC 2008 proceedings. Here we summarize the calibrations necessary to derive the instrument's response function.

Calibration measurements: The RESIK [5] X-ray beam facility at Rutherford Appleton Laboratory, UK, is designed to provide a controlled X-ray beam (continuum + lines) using a variety of targets.

The facility (Fig.1, Fig.2.) permits placement of the primary detector and associated reference detector, all mounted on computer-controlled translation and rotation stages along with temperature monitoring and control within the vacuum chamber. The 24 SCDs on C1XS are undergoing calibration measurements to address individual spectral response, absolute detection efficiency and angular response of the collimator. In addition, the dependence of these parameters on temperature will also be studied. A Si-PIN detector calibrated at the Synchrotron facility, PTB, BESSY II [4] is used as the reference for absolute calibration.

The following instrument characteristics can be derived from the analysis of calibration data:

1. Spectral redistribution function
2. Detection efficiency
3. Collimator response

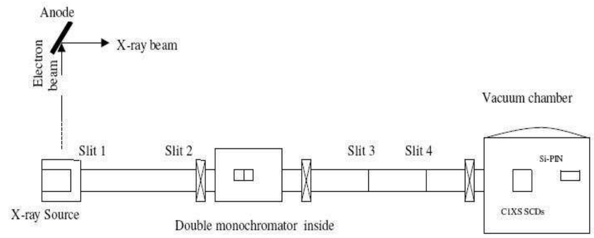

Figure 1: Schematic diagram of the RESIK X-ray beam set up.

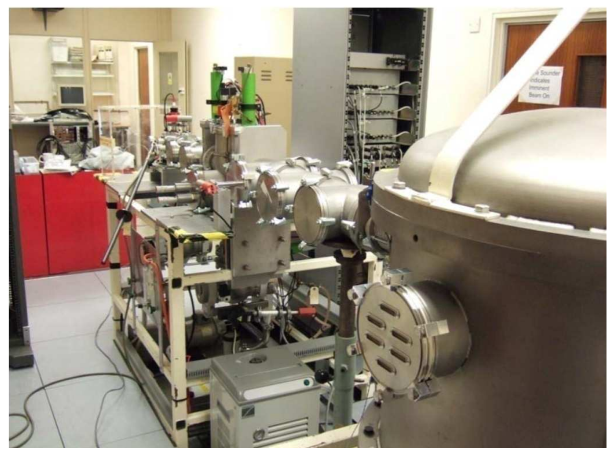

Figure 2: The RESIK X-ray beam facility at RAL. Image taken from [5].

Spectral redistribution function (SRF): The redistribution of a single energy photon in pulse height space (photons of the same energy are spread across many channels), termed SRF, has been modeled as a 'Hypermet' function (Fig.3)[4].

The parameters of the SRF are derived by fitting the spectra at single energies (this is done at RESIK using a double crystal monochromator to separate out a narrow energy band of interest). The SRF consists of a Main energy peak, a low energy tail, a low energy shelf, an escape peak and fluorescent peak (if present). Incomplete charge collection in the detector and photoelectrons produced in the surface dead layers contribute to the 'tail' and 'shelf' features in the spectra.

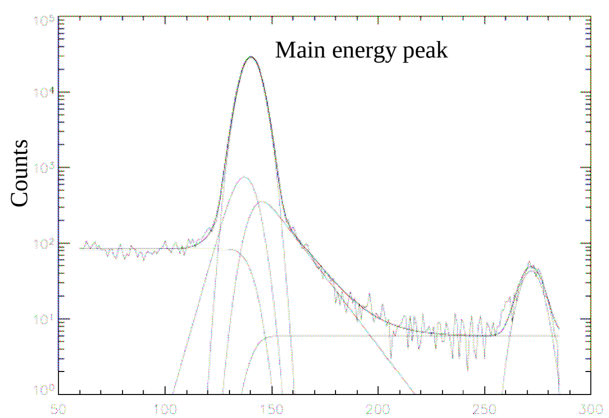

Figure 3: The SRF for the SiPIN reference detector at 1.5 keV; the individual components of the SRF are shown separately. In addition to the SRF, features above the main energy peak are modelled. The secondary peak is the second harmonic from the synchrotron beam.

The accurate modeling of the SRF is highly essential for absolute flux measurements under the X-ray fluorescence line of interest. The SCDs also exhibit 'split events', where the charge cloud generated due to a single photon occasionally spreads across adjacent pixels and appears as a lower energy event in the spectrum which will also be modeled as part of the SRF. The dependency of each of these parameters on temperature is also addressed.

Absolute detection efficiency: The absolute efficiency of the SCDs will be derived relative to the radiometrically calibrated Si-PIN detector.

Instrument Response: The derived C1XS instrument response is modeled as two parts

1. *Redistribution matrix file (RMF) [7]:* Consists of the spectral redistribution function expressed as a matrix. This includes parameters that are expected to change during the lifetime of the mission.
2. *Ancillary response file (ARF) [7]:* Consists of detection efficiency, active area of the detector and collimator response. This has parameters that do not normally change during the mission lifetime.

In addition, a Geometry Response File (GRF) will be created which will provide the 'correction factor' to account for variations in X-ray line flux with angle of incidence solar aspect angle. The X-ray line flux derived using response matrix will be corrected for the geometrical factors to enable co-adding of adjacent ground pixels when required.

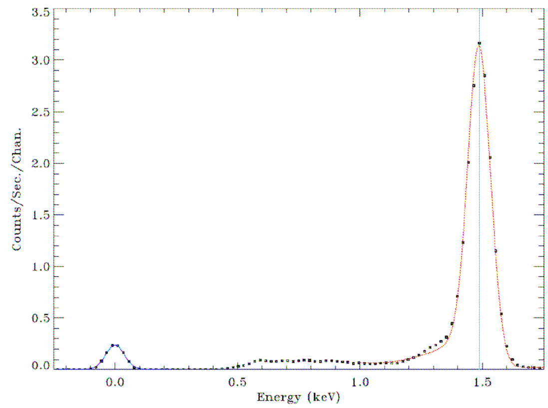

Figure 4: Spectrum obtained at RESIK using a flight SCD. The Al line at 1.49 keV has an energy resolution of ~110 eV

A response matrix consisting of RMF and ARF will be generated for each of the 24 individual SCDs for various temperature ranges.

Conclusions: C1XS on Chandrayaan-1 is expected to yield global elemental maps of the lunar surface. In addition to the refinements in the system from its precursor on SMART-1 (DCIXS [8]), extensive calibration measurements and generation of a more detailed instrument response should provide the most accurate results on the major fluorescent X-ray line flux from the lunar surface.

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