The Chandrayaan-2 Large Area Soft X-ray Spectrometer (CLASS)

Conference or Workshop Item

THE CHANDRAYAAN-2 LARGE AREA SOFT X-RAY SPECTROMETER (CLASS). V.Radhakrishna[1], S. Narendranath[1], A. Tyagi[1], M. Bug[1], U. Unnikrishnan[1,2], R. Kulkarni[1], C.V. Sreekantha[1], Kumar[1], G. Balaji[1], P.S. Athiray[1], M. Sudhakar[1], R. Manoj[1], S. V. Chetty[1], M. R. Thyagaraj[1], C. Howe[3], J. Gow[4], P. Sreekumar[1], (email: rkrish@isac.gov.in) [1]ISRO Satellite Centre, [2]University of Calicut, [3]Rutherford Appleton Laboratory, UK, [4]Open University, UK.

Introduction: The CLASS experiment on Chandrayaan-2, the second Indian lunar mission, aims to map the abundance of the major rock forming elements on the lunar surface using the technique of X-ray fluorescence during solar flare events. CLASS is a continuation of the successful C1XS [1] XRF experiment on Chandrayaan-1. CLASS is designed to provide lunar mapping of elemental abundances with a nominal spatial resolution of 25 km (FWHM) from a 200 km polar, circular orbit of Chandrayaan-2.

C1XS was developed at Rutherford Appleton Laboratory, UK, in collaboration with ISRO and operated for ~ 9 months in orbit. Although the instrument performed very well [2], the lack of adequate solar activity and a reduced mission life, prevented global coverage. However, there are several observations that have yielded good XRF data from C1XS.

Science objectives: The science objectives of CLASS are to make global studies on the diversity and distribution of lunar lithologies, quantitative estimate of Mg abundance, essential for determining the distribution of Mg suite rocks, bulk composition of the crust, abundance patterns in the major crustal provinces and mare basalt diversity. In addition to this regional studies on the composition of central peaks of craters, composition of large scale ejecta around basins, and to study dark halo craters and possible associated cryptomare.

Results from C1XS indicate that the lunar highland composition may contain more sodic plagioclase than previously thought [3]. CLASS is hence designed to operate down to 0.8 keV in order to also measure the possible XRF signals from Na in addition to the majpr elements Mg, Al and Si. Measurement of Ca, Ti and Fe at the proposed spatial resolution can be achieved only during strong flares; CLASS is expected to provide the first distribution maps from direct chemical abundance studies.

CLASS has a geometric area three times that of C1XS which would enable it to measure lunar XRF signals down to B flares promising better coverage even if solar activity remains low.

CLASS Instrument: Our experience with C1XS has proven swept charge devices as good choice for experiments which demand large area (without imaging) and require good spectral resolution even at temperatures of -20°C (hence passive cooling is adequate). SCDs of 1cm^2 area, CCD-54, manufactured by e2V technologies, were used in C1XS. In CLASS, we propose to use large area SCDs (~20 x 20 mm^2), sixteen of which providing a total geometric area of 64 mm^2. From an orbital height of 200 kms, the collimators placed over the detectors define a field of view of 14° x 14° (25 km FWHM) at the lunar surface. The collimators over approximately one-fourth of the array are designed to have a smaller field of view which would yield a spatial resolution of 12 km on the lunar surface. This would enable high resolution mapping during strong solar flares. The CLASS payload is designed to be operated in the range of -15°C to -25°C in the lunar orbit using only passive cooling. A door is provided in front of the detectors for protection of the SCDs from high energy particles during transit through the radiation belts. Thin aluminium foils were used as visible light shields on C1XS. To prevent any contribution from Particle Induced X-ray Emission (PIXE) from the Al foil, we plan to use Be foils in CLASS. The schematic of the CLASS payload is shown in Fig.1.

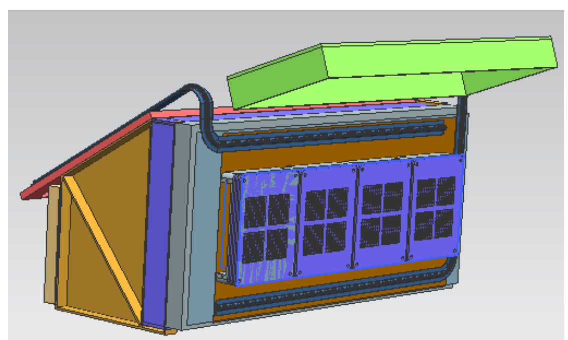

Figure 1. CLASS instrument showing the four quadrants with four SCDs each. The electronics is housed in the box behind the detector units. An aluminum door protects the detectors from radiation damage en-route to the Moon. Passive radiators connected to heat pipes provide the required low-temperature environment for the detectors.

Large area SCDs, with larger pixel size and two phase clocking are expected to give good spectral resolution (< 200 eV @ 6 keV) and low energy threshold (~ 0.8 keV). This has already been demostrated in the laboratory with a CCD-236 device manufactured by e2V Technologies. A comparison of spectra recorded for CCD-54 used in C1XS and that from a large area SCD, is shown in Fig.3. It is seen that the large number of partially absorbed (split) events recorded for CCD-54, is significantly reduced in the large area SCD. The reduced fraction of split events in the large area SCD is due to its larger pixel size. This is significant and one can expect improved resolution and higher sensitivity in CLASS.

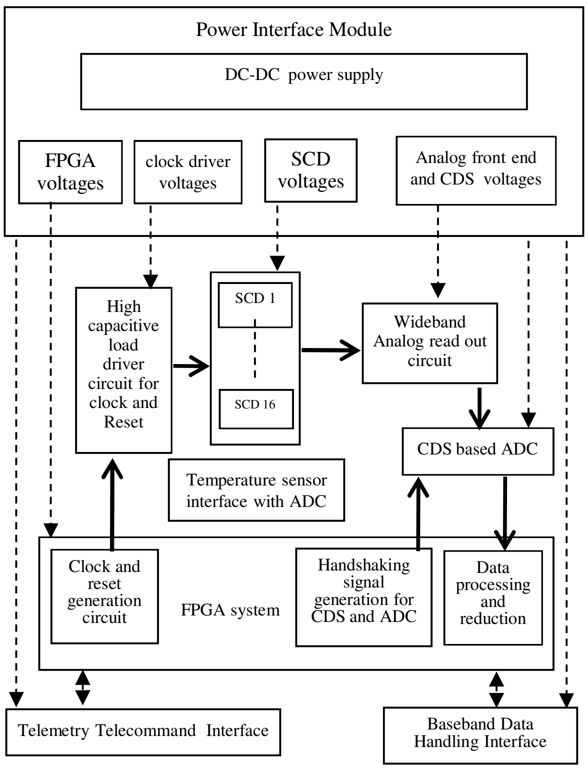

Figure 2. CLASS electronics block diagram

Electronics: The electronics is packed behind the detector unit into four PCB cards. The large area SCD, is a single output, diagonally-read x-ray CCD with 2 phase clocks and is non-imaging. Charge generated by an event is continuously clocked (~ 100 kHz) and transported along the buried channels towards a node to generate a voltage pulse. The output from an SCD is similar to a conventional CCD and a correlated double sampling (CDS) circuit is used for noise reduction before feeding the signal into ADC. The signal generation and data processing is done using Actel's RTAX-1000S FPGA based system. The temperature interface provides the continuous monitor of the SCD temperature for operation in favorable temperature range using onboard logic. While spacecraft telecommand interface provides different commands for ON / OFF and mode of operation Telemetry interface is used to monitor critical parameters of the payload. Base band data handling interface is used to transfer the science data from the spacecraft Solid State Recorder.

Performance: The large area SCDs on CLASS are an improved version of that on C1XS. They operate with 2 phase clocking and have larger pixels thus reducing split events. Figure 3 shows spectra obtained with C1XS SCDs compared to that with CLASS SCDs. The fraction of events outside the photopeak is considerably reduced and detection efficiency at the photopeak increased. Photopeak fraction for the recored spectra increased by a factor of two for the large area SCD compared to CCD-54.

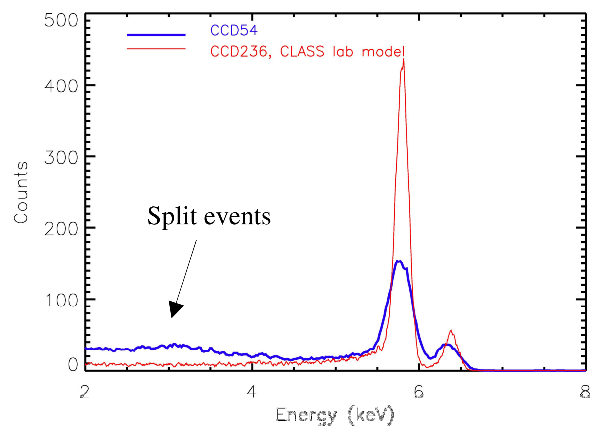

Figure 3. Large area SCD(CCD-236) spectrum along with C1XS SCD (CCD-54) spectrum showing lesser contribution from split events to the photopeak.

Conclusions and future work: CLASS is currently under development at the Space Astronomy Group, ISRO Satellite Centre, India. It is expected to provide the first moderate resolution (25 km or better) global map of lunar chemistry.

References:

[1] Grande, M. et al. (2007) *PSS*, 55, 494-502. [2] Howe et al (2009) *PSS*, 753. [3] Narendranath et al (2010) submitted to *Icarus.* [4] Tyagi, A. et al (2010) Nat. Symp. Nucl.Instrum Proceedings, 593-595.