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C1XS - The Chandrayaan-1 X-ray Spectrometer



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How C1XS works

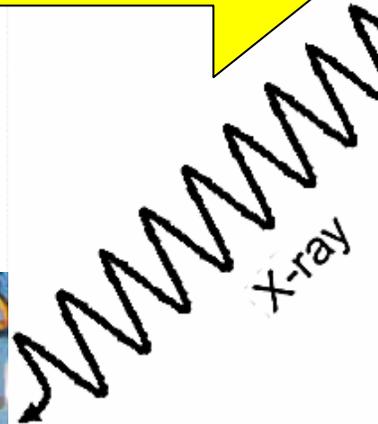
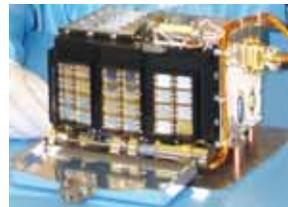
**1 The Sun shines on the Moon
(in X rays)**

2 The Moon fluoresces

**3 Each X-ray energy indicates
unambiguously the abundance
of a particular element**

4 C1XS detects these X-rays

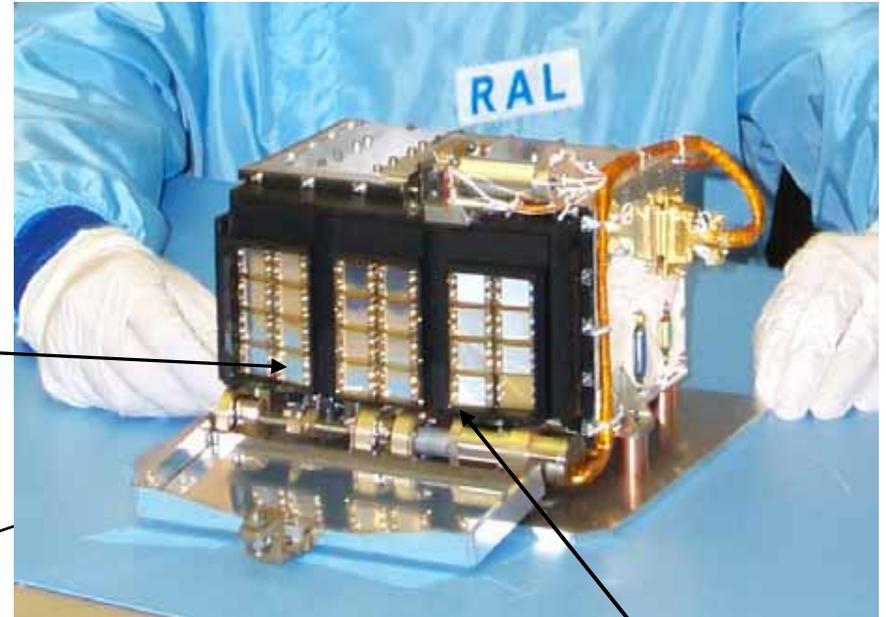
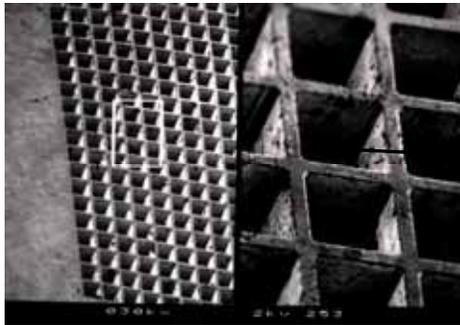
**5 Solar Monitor for Solar Input
required for absolute
abundances**



C1XS is based on SMART-1 D-CIXS

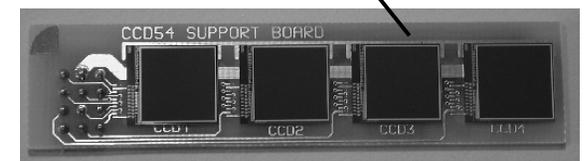
D-CIXS incorporated Two New Technologies

- Swept Charge Device (SCD) Detectors
- Advanced Microstructure Collimator

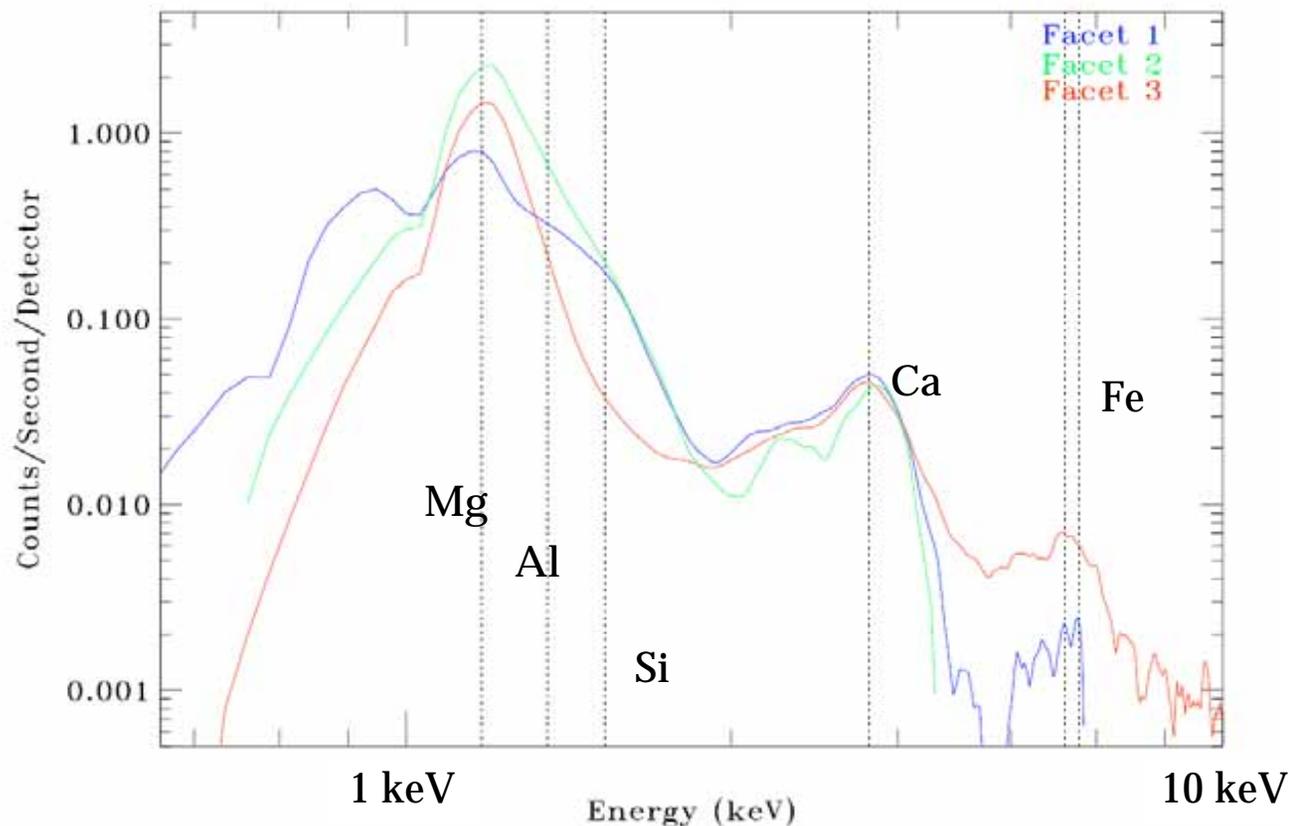


This enabled it to provide:

- High Throughput X-ray Spectrometer
- Compact, light design
- Near room temperature operation



D-CIXS Spectra Acquired from Crisium

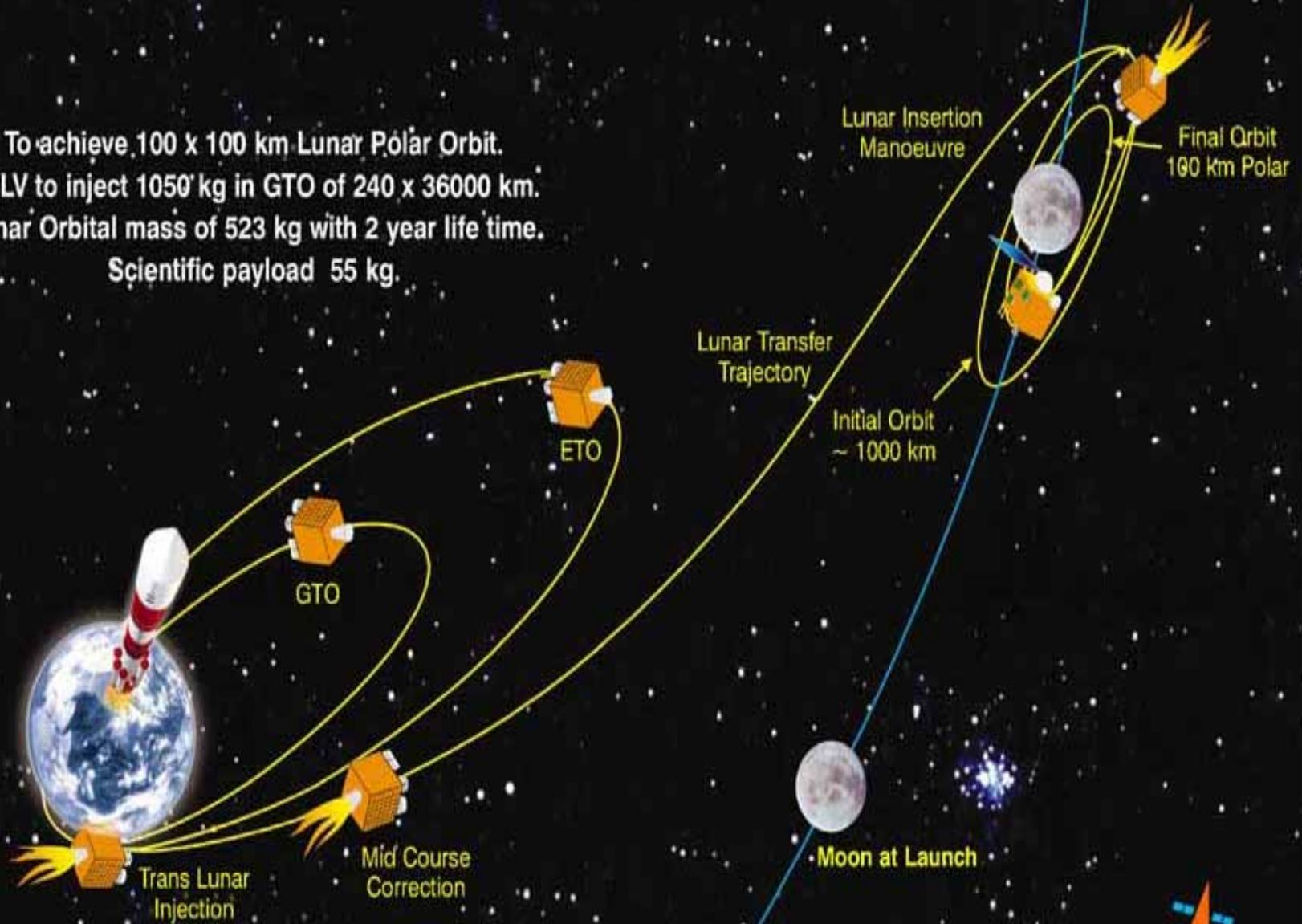


First ever direct remote sensing measurements of Ca at the Moon

INDIA'S FIRST MISSION TO MOON

CHANDRAYAAN-1

To achieve 100 x 100 km Lunar Polar Orbit.
PSLV to inject 1050 kg in GTO of 240 x 36000 km.
Lunar Orbital mass of 523 kg with 2 year life time.
Scientific payload 55 kg.



Expanding the scientific knowledge about the moon, upgrading India's technological capability



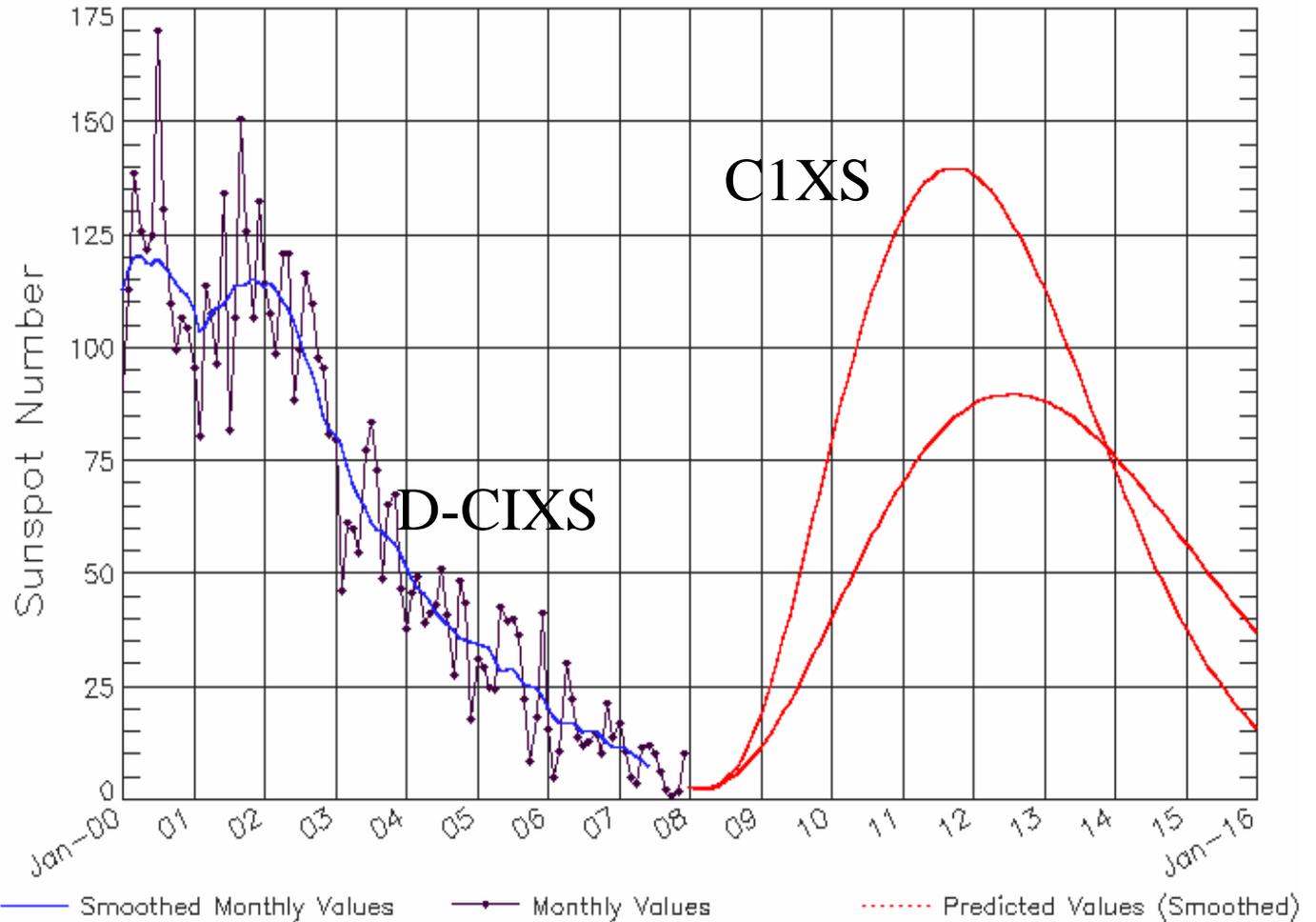


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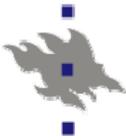
- **The Chandrayaan-1 mission, with its 100km constant altitude is ideal for C1XS.**
- **The main science drivers are for uniform global mapping of elemental abundances.**
- **The circular orbit means that we do not have to compromise with instrument field of view**
- **Hence we can push to higher spatial resolution, ~25 km, uniform over the whole Lunar Surface.**
- **In a one year mission, each pixel sees a far higher (x40) flux.**

ISES Solar Cycle Sunspot Number Progression
Data Through 31 Dec 07



Solar illumination during the last solar cycle.

The current cycle seems to be 11 years, but so far has been weak.



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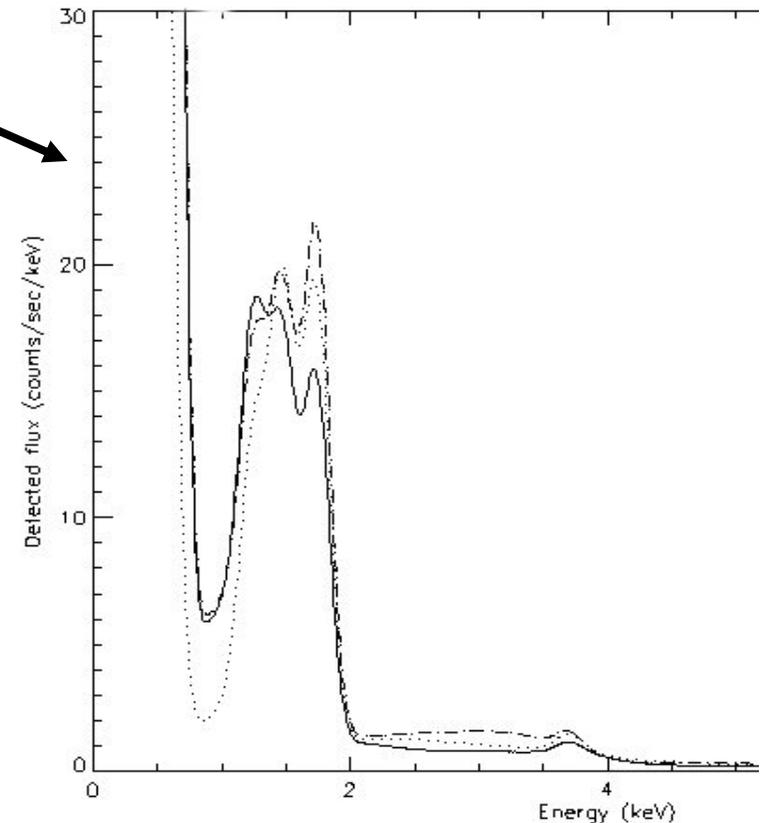
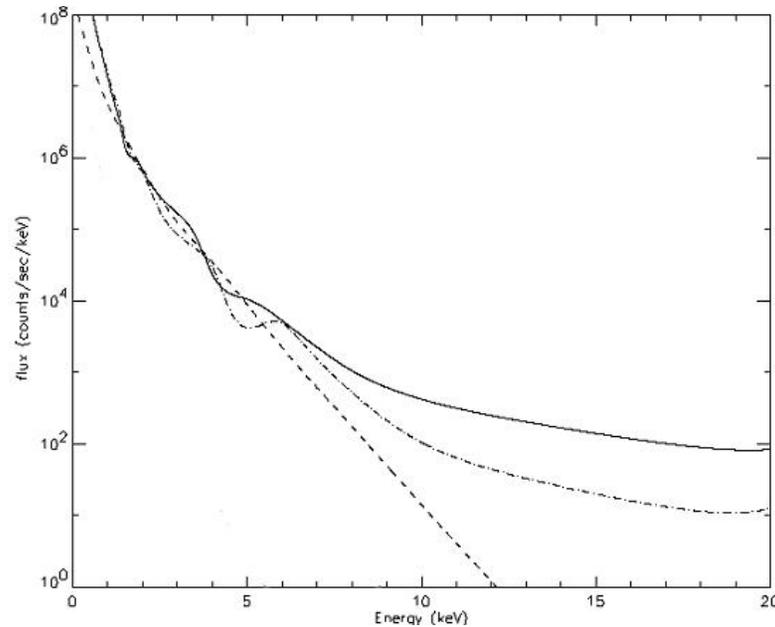
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X-RAY FLUORESCENCE

Importance of solar monitoring is now seen as critical for X-ray fluorescence data



Three different C-flare inputs produce three different fluorescence signals

XSM

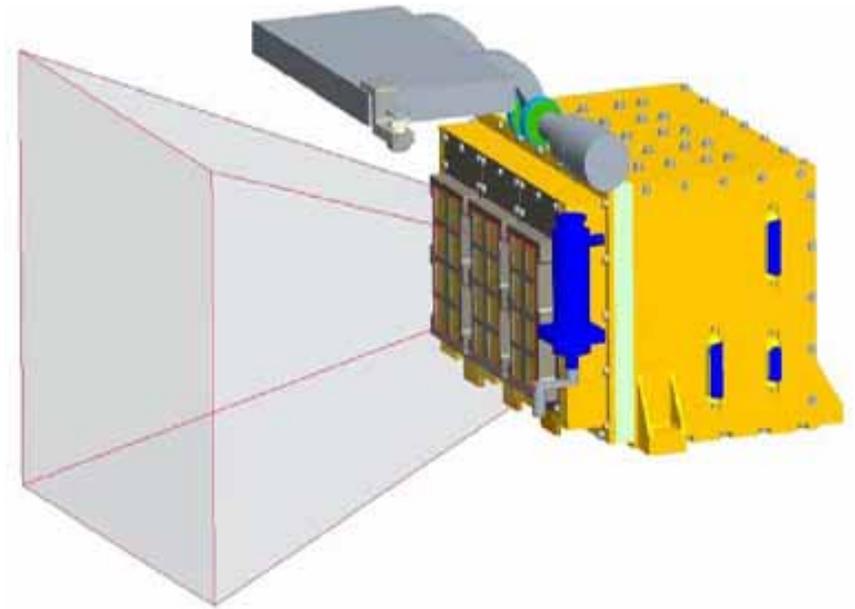
Solar Monitor

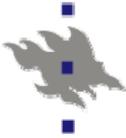


- Science return of both Chandrayaan-1 and Kaguya can be increased by sharing the Solar Monitor data from both to produce a more complete time series of Solar X-ray illumination
- Cross calibration important

Changes on C1XS

- **24 SCD X-ray sensors retained**
- **Field of view**
 - flat rather than 3 facets
 - all 14 deg FWHM (25km).
 - (Not variable as SMART-1)
 - All same filter
 - Fe55 cal source per detector
- **Improved FPGA modes**
- **Improved thermal stability**
- **Low energy threshold well defined**
- **Low radiation environment**
- **Approach to Solar Max**
- **Full ground calibration**





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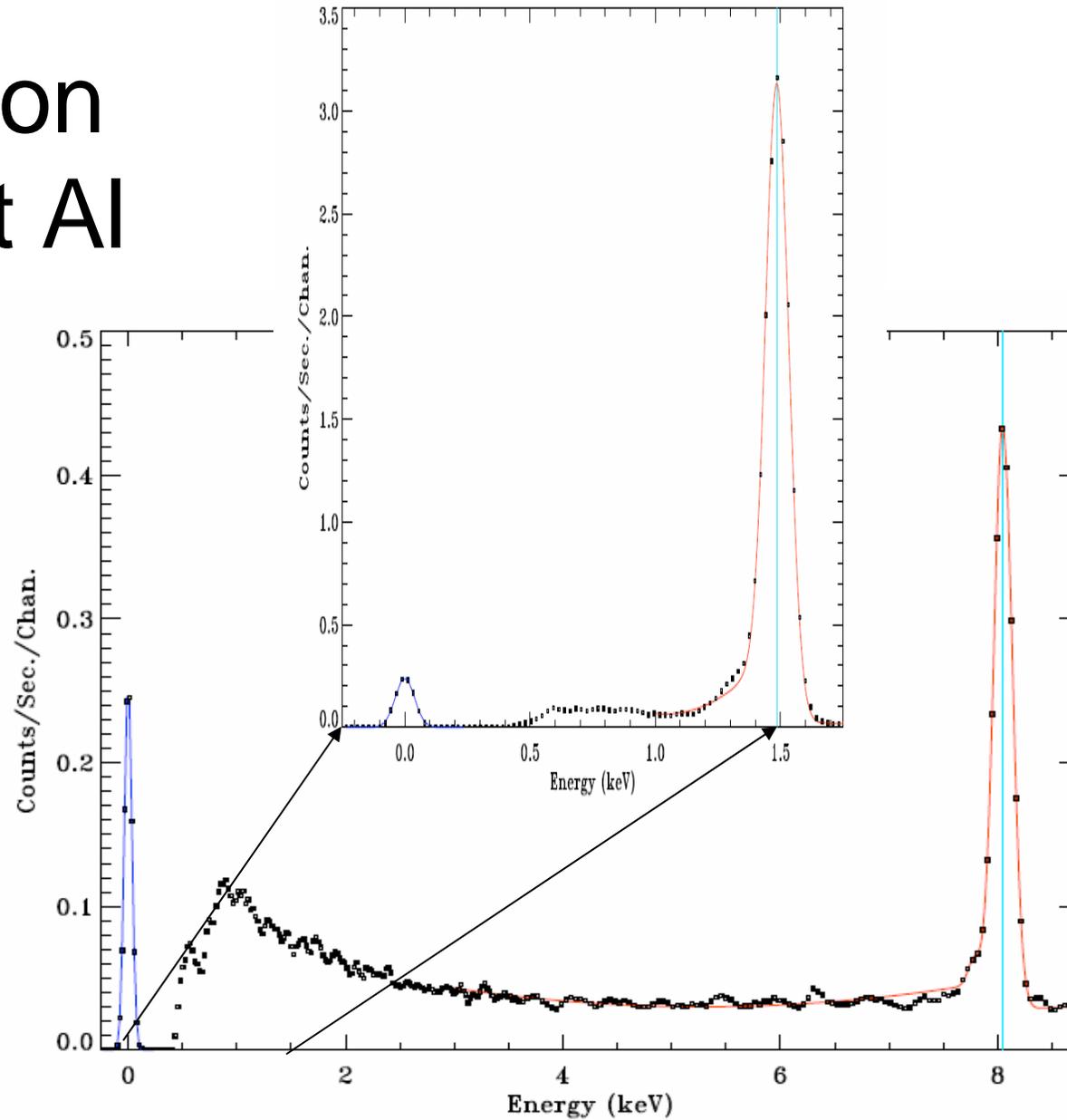


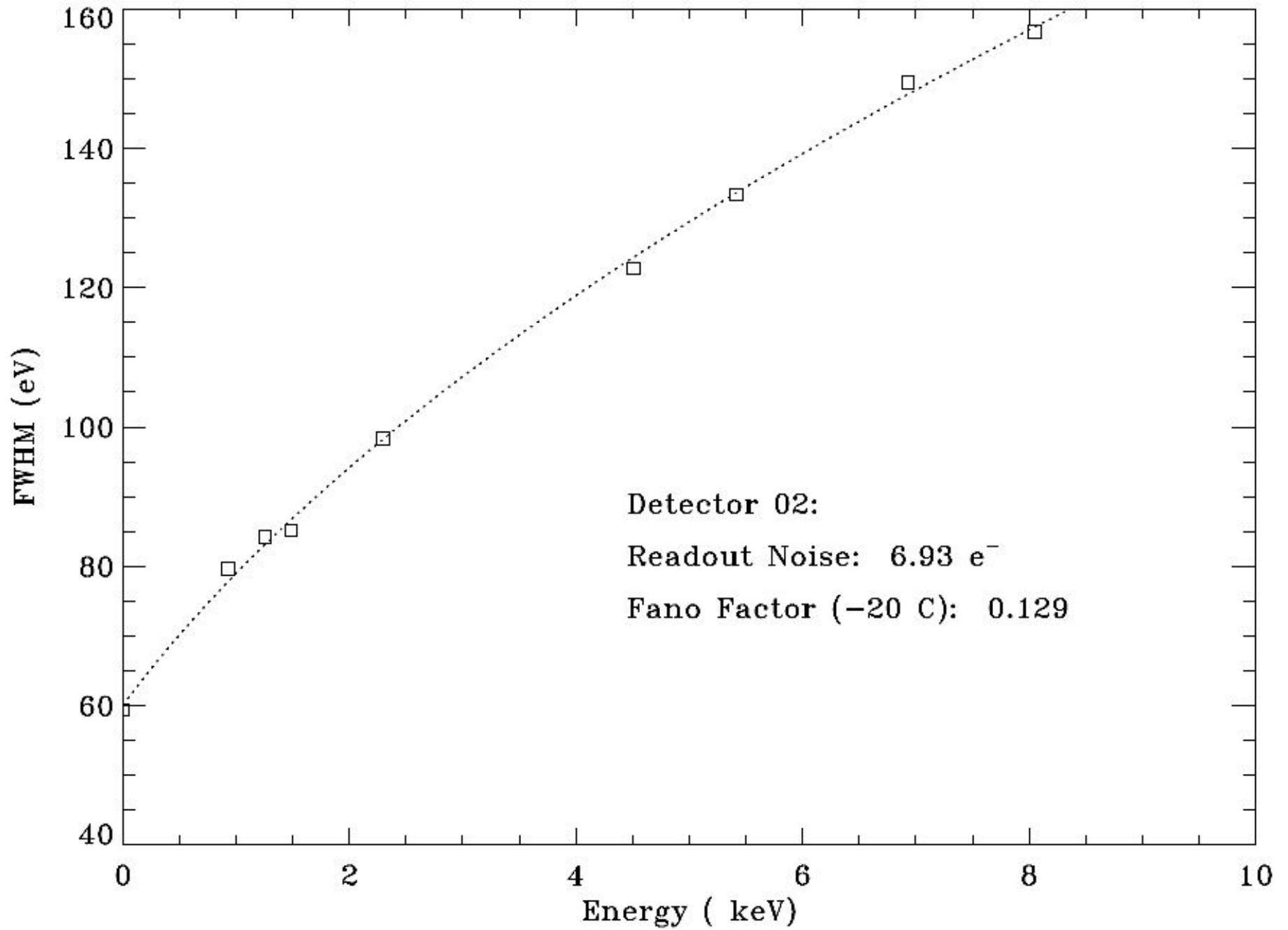
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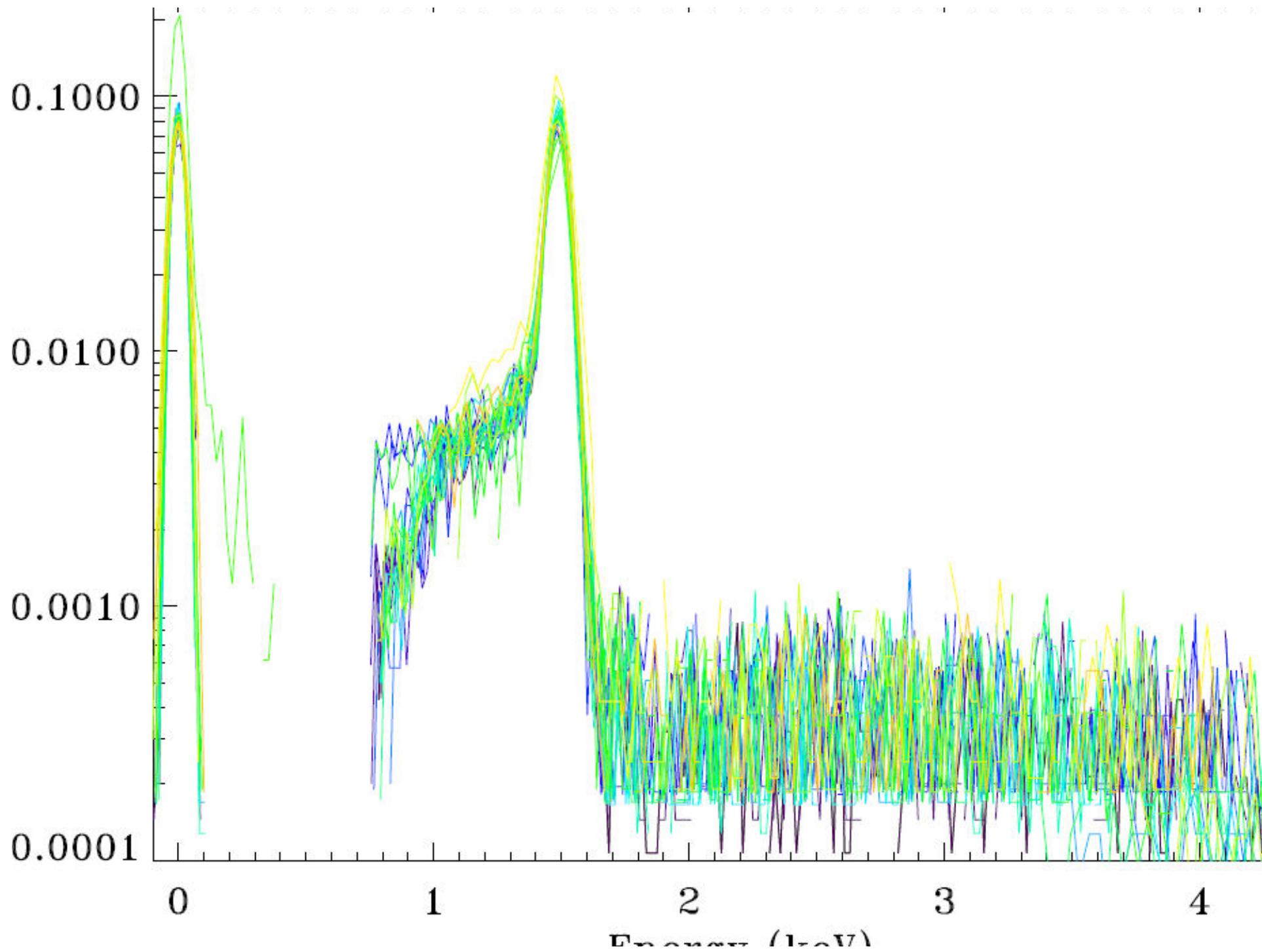
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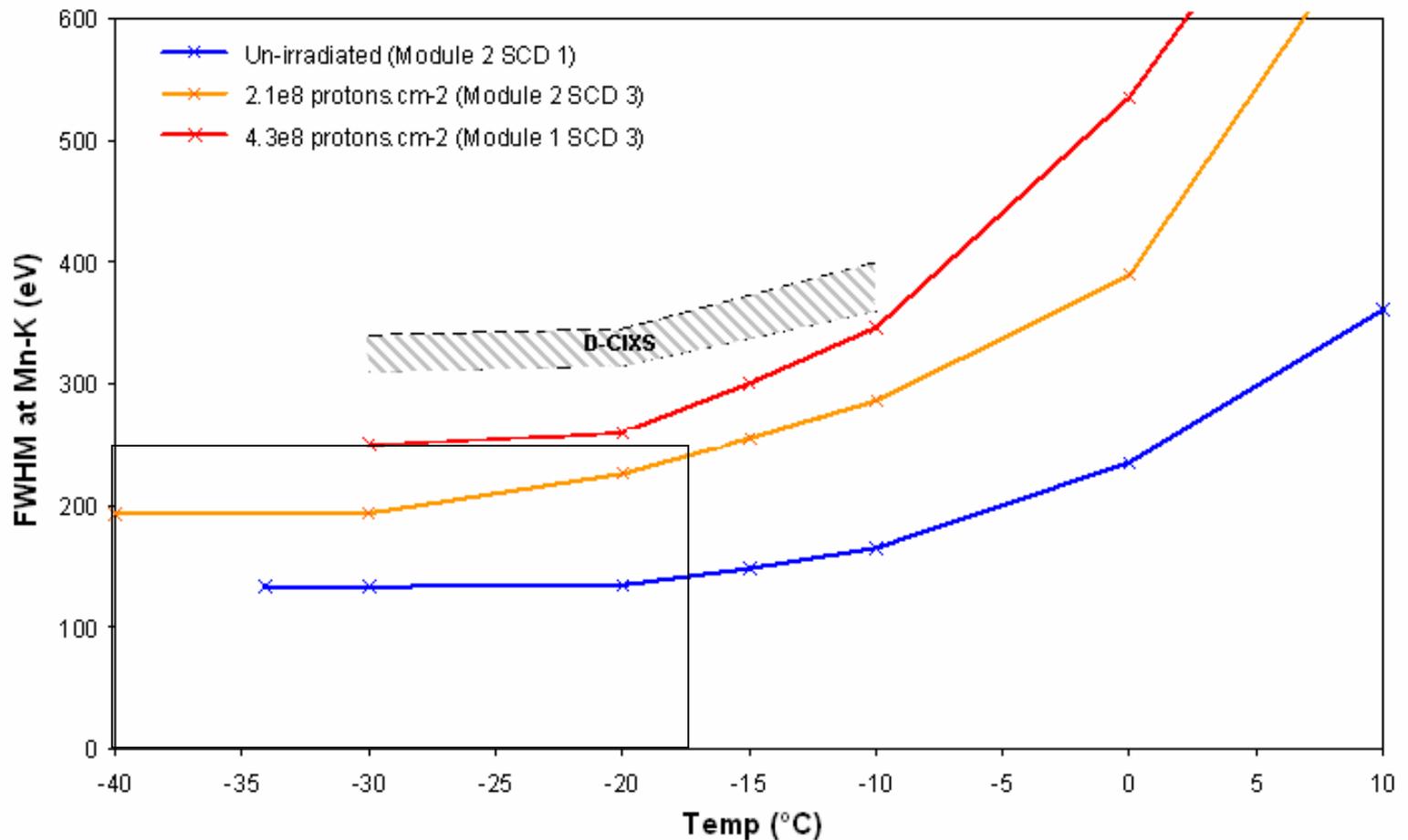
Resolution 110eV at Al

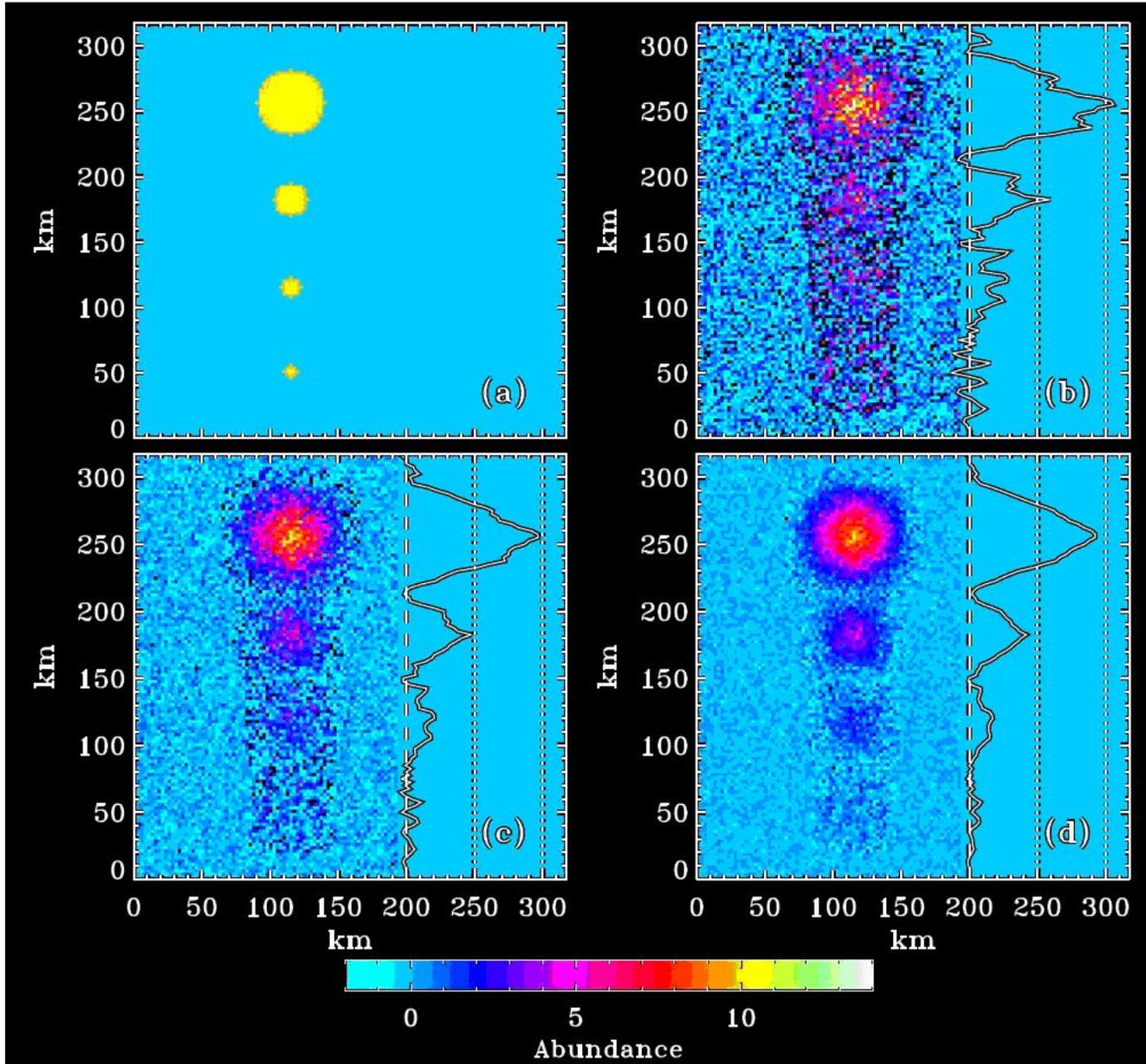




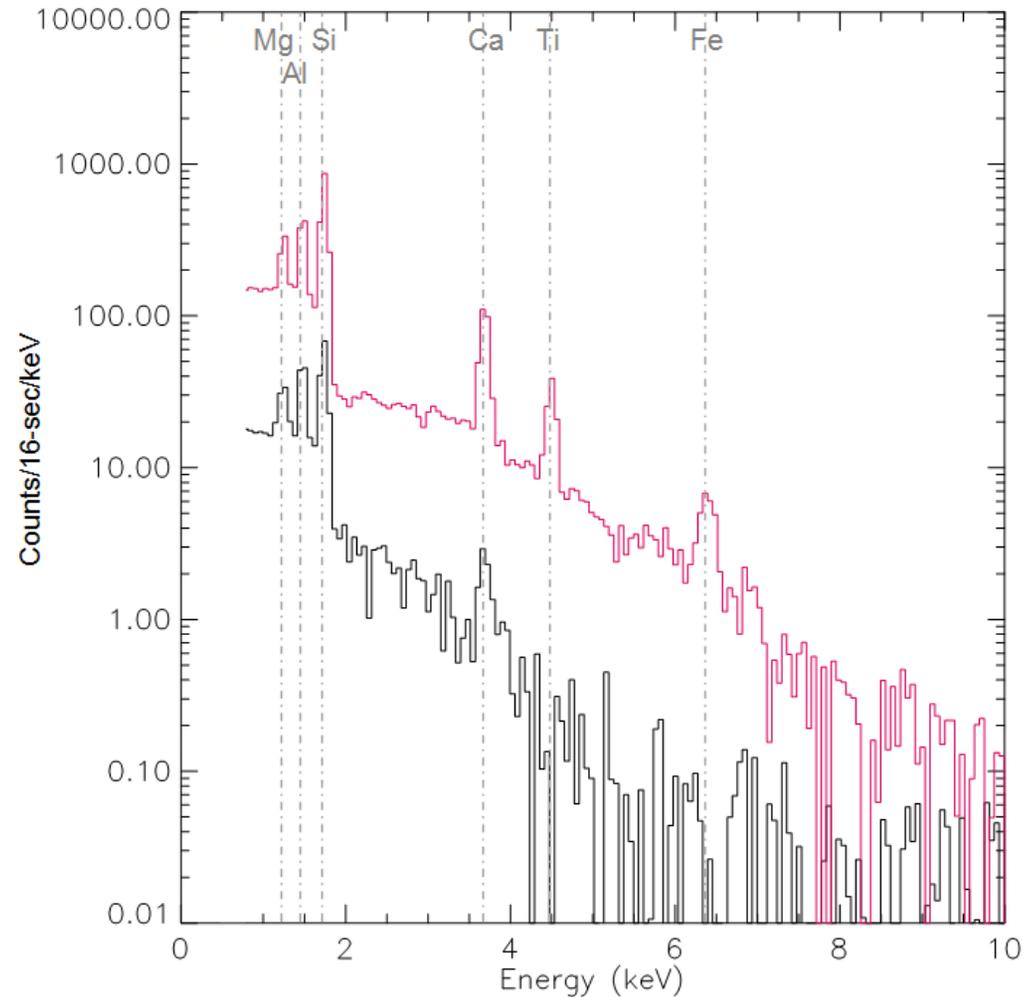


Swept charge device FWHM at at Mn-K α vs. temperature, before and after radiation testing. The specified maximum operating temperature is 17.5 O
 Note the favourable comparison with D-CIXS performance shown in between the dashed lines. (Brunel Univ.)





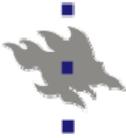
Simulated C1XS spectrum for the November 18 flare for the November 18 flare based on individual 16 second integrations. The lower line (black) shows the spectrum detected during the quiet period just before flare begins, while the upper line (red) shows the spectrum obtained at the peak of the flare. Note the greatly improved spectral resolution compared to D-CIXS,





Science Goals

- **Measure the major element geochemistry** (and especially Mg/Si and/or Mg/Fe) in the main lunar terrain types (i.e. Procellarum KREEP Terrain, South Pole-Aitken Basin, and the Farside Highlands).
- **Determine the large-scale stratigraphy of lower crust** (and possibly crust/mantle boundary region) by measuring the elemental abundances of the floor material of large basins not obscured by mare basalts (e.g. SPA and other farside basins)
- **Compare farside mare basalt composition to nearside compositions**, to inform models of mare basalt petrogenesis and mantle evolution.
- **Establish the geographical distribution of magnesian suite rocks.**
- **Aluminium abundance maps** will constrain models of the global melting event that produced the Al-rich crust
- Comparison of major element geochemistry of **stratigraphically distinct large-scale lava flows** in the same geographical region (e.g. Oceanus Procellarum, Imbrium Basin, etc) to study mantle evolution with time in specific regions.
- Obtain **depth information from basins and central peaks**
- Obtain major element abundances for regions where **ground truth** has been obtained (Apollo, Luna) to validate the calibration of C1XS measurements.



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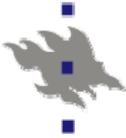
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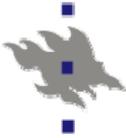


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