

# Interim Report on EPIC MOS CCD Low Energy Proton Tests

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These tests were performed 29 Jan – 1 Feb 2001 in a beam line of the 3MeV Van-der-Graaff at the Physics Institute of the University of Tübingen with M Brandt & W Rochow from that institute and the help of T Claus & E Kendziorra at al from the Institute for Astronomy and Astrophysics.

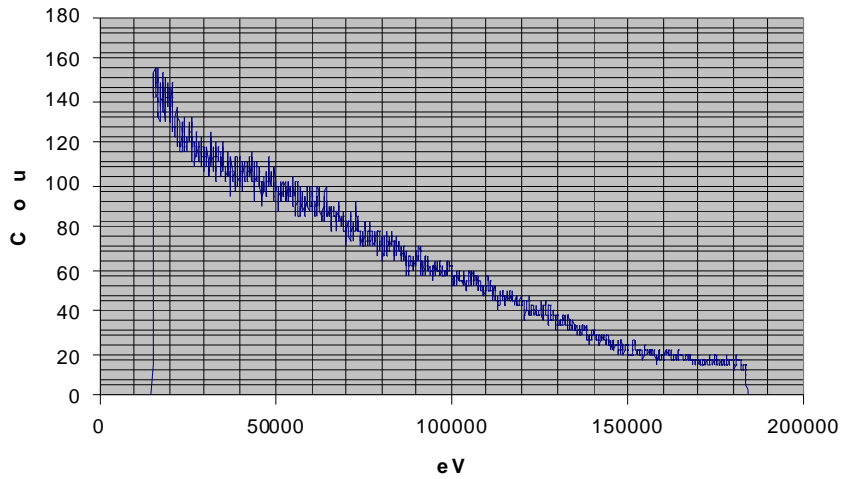
Two MOS CCDs from EEV (now Marconi Applied Technologies) from the batch #5 used in many positions in the EPIC MOS cameras of the ESA XMM-Newton X-ray satellite were irradiated with a beam of 900keV Protons through Al filters of 14, 13, 12 and 10 $\mu$ m to levels consistent with the dose expected after up to 10 years of soft protons in orbit.

## Irradiation Plan

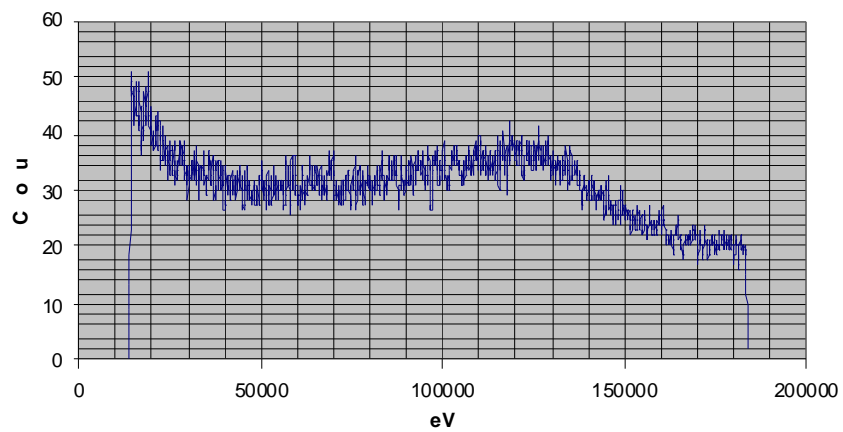
- CCD Batch 5 - #21
- At a low count rate, evaluate the beams energy spectra
- Irradiate top half of CCD
- with 1E6/cm<sup>2</sup> 12 $\mu$  Protons (P+)
- also 1E6/cm<sup>2</sup> 10 $\mu$  P+ in same area
- Lower right quarter with 1E7/cm<sup>2</sup> 13 $\mu$  P+
- CCD Batch 5 - #19
- Irradiated bottom RH quarter of CCD
- With 2.5E5/cm<sup>2</sup> 14 $\mu$  P+
- Top RH quarter with 5E6 12 $\mu$  P+

CCD #21 was used to evaluate the beam energy at fairly low fluxes. The following three graphs show the spectra from single and multi-pixel events for the 13, 12 and 10  $\mu$ m filters.

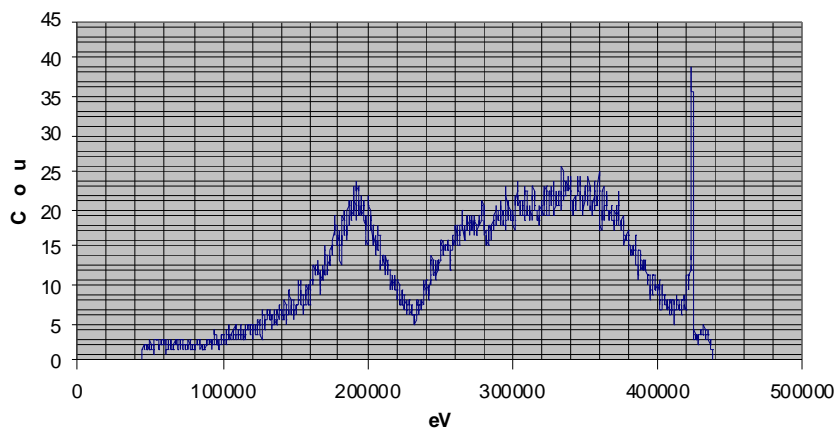
**Proton Spectrum with 13 micron filter**



**Proton Spectrum with 12 micron filter**



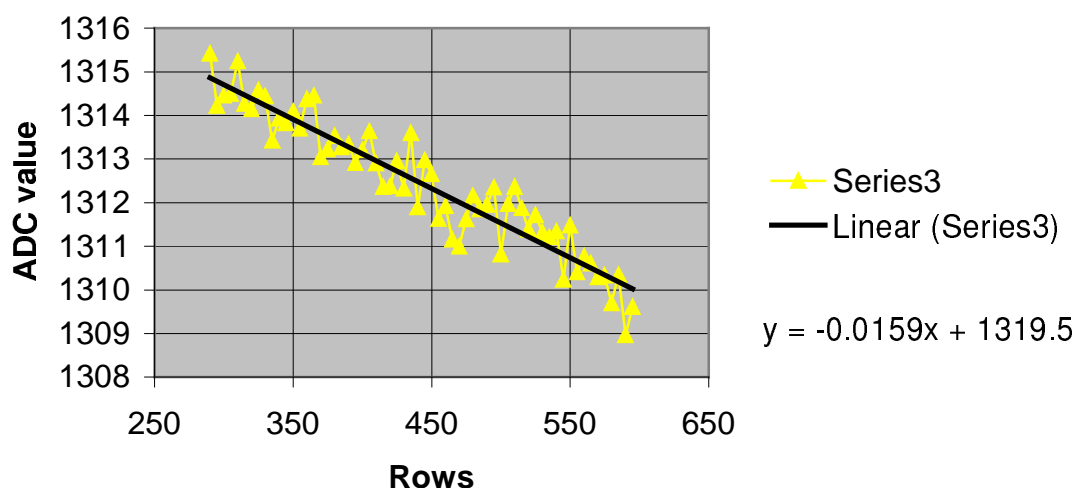
**Proton Spectrum with 10 micron filter**



## Results

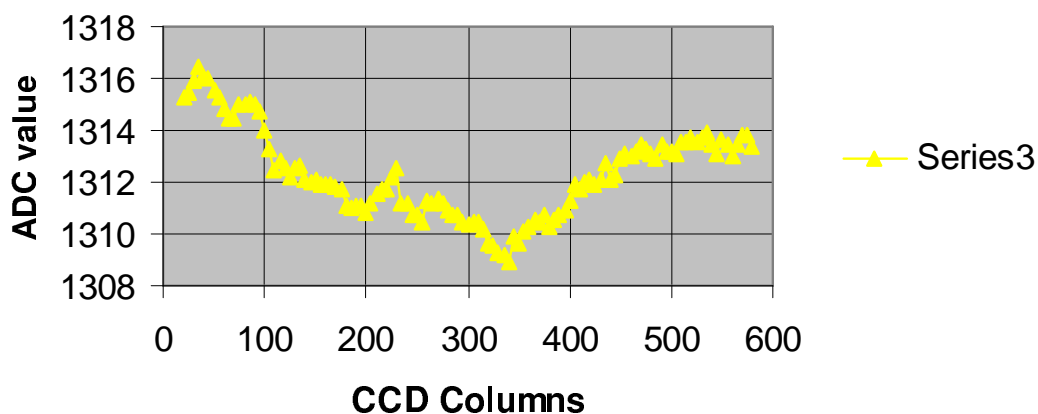
After the beam evaluation and the first  $1\text{E}6/\text{cm}^2$   $12\mu$  irradiation. Note that later it was realised that the Fe55 source was a bit too strong and therefore was slightly suppressing CTE degradation due to keeping the traps filled.

### 12u 1E6 Parallel CTI (Fe55 high rate)



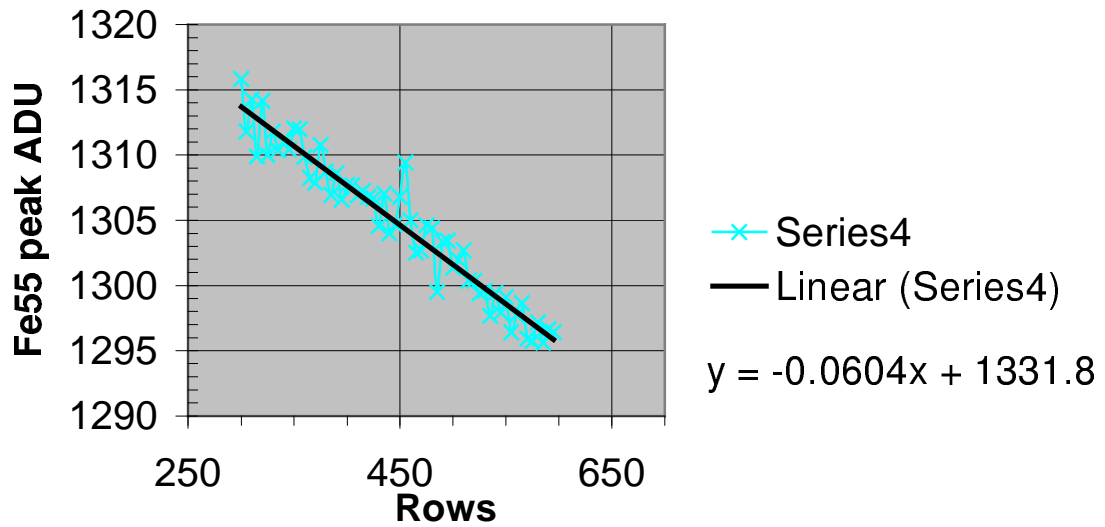
The following result shows that the beam intensity was not even across the device, being more intense in the middle. A plot along the X axis after  $1\text{E}6$   $12\mu$  P shows a dip in the peak energy in the middle.

### 12u 1E6 "Pseudo" serial CTE (Fe55 high rate) (25 column smoothing)

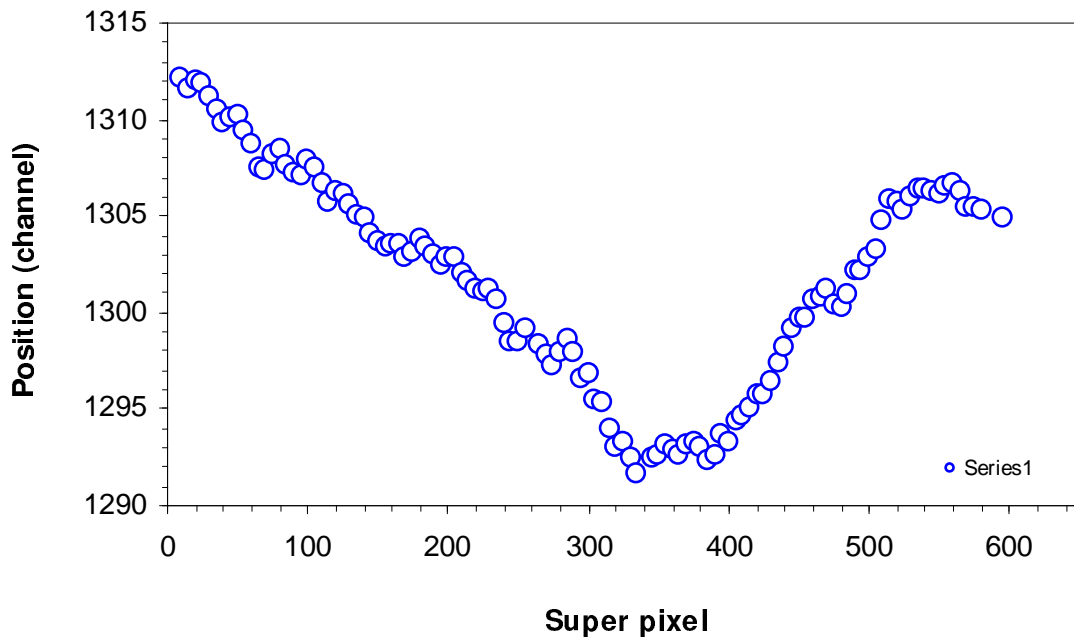


After 1E6/cm<sup>2</sup> protons through the 10μ filter there was considerably more CTE degradation – nearly 4 times as much as the 12μ protons.

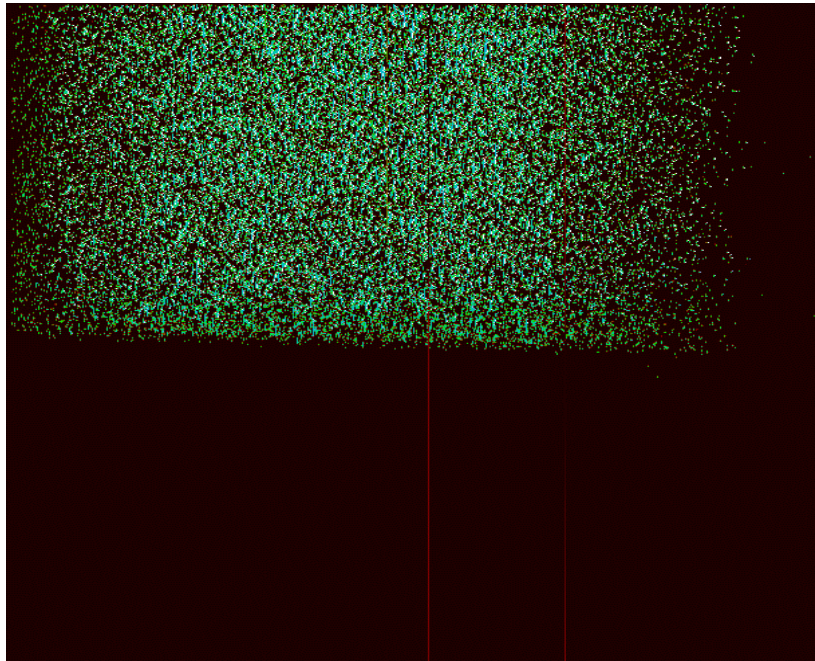
### Parallel CTE after 1E6 protons through each of 12 & 10u filters



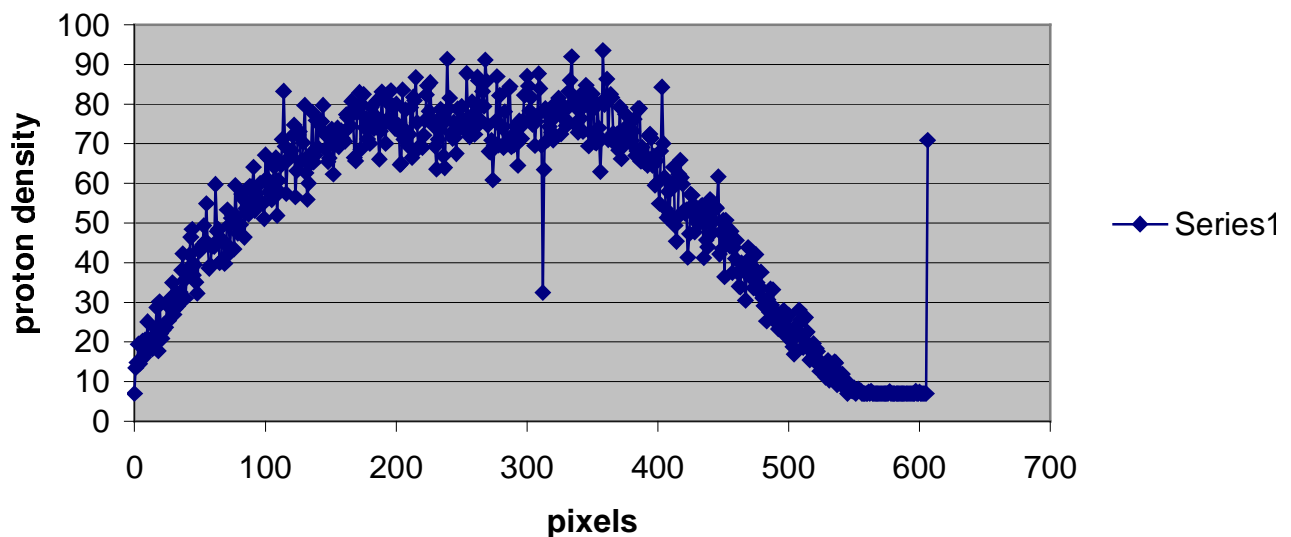
The corresponding plot in the X direction shows an asymmetry yet to be understood:



## 10 $\mu$ filter Proton Image and its profile in X

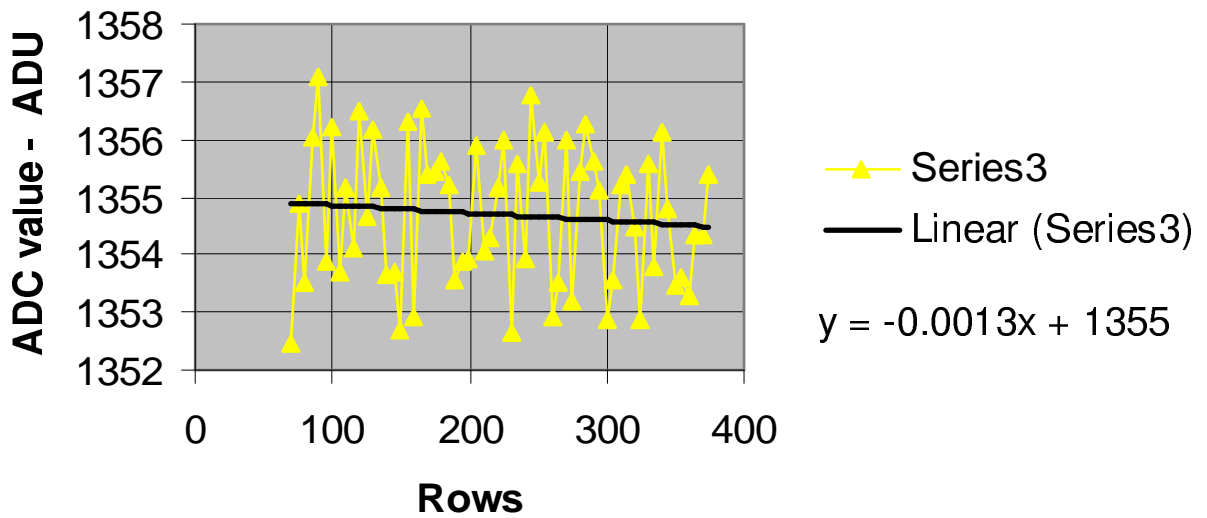


10 micron beam profile



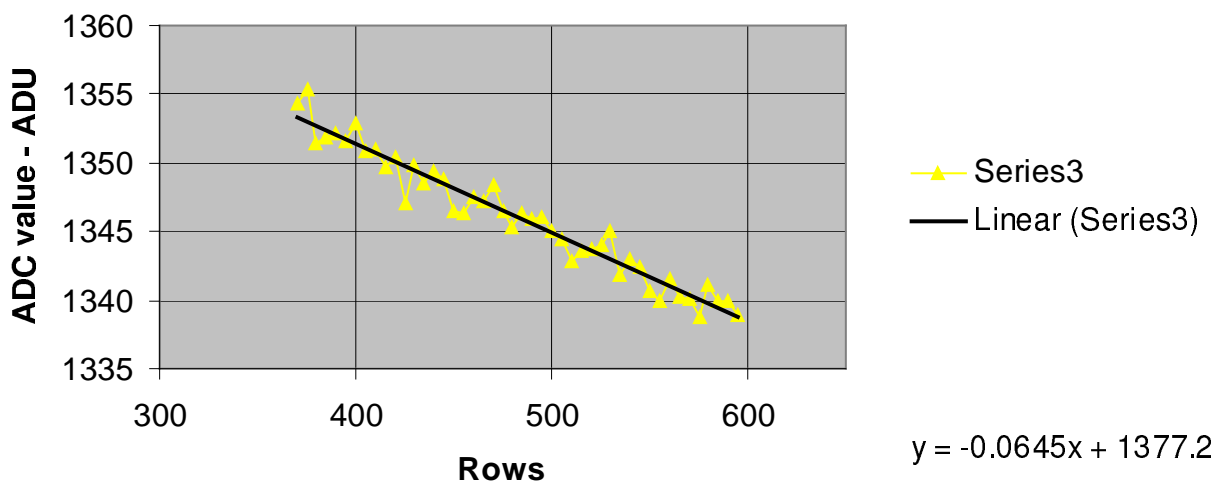
Then the second CCD (B5/19) was mounted and cooled, and the bottom RH quadrant irradiated with  $2.5E5/cm^2$  of  $14\mu$  protons. Later measurements at Leicester will establish whether the low energy response has been changed by this. However, the following plot shows no significant damage for Fe55 Xrays.

### 14u 2.5E5 Parallel CTE



Finally, as an independent measurement (rather than the mixed 12μ and 10μ on B5/21) the upper RH quadrant was irradiated with 5E6/cm<sup>2</sup> 12μ protons - results below show a CTE change approximately 4 times the effect of 1E6 on CCD B5/21.

### 12u 5E6 Parallel CTE



## Results summary

- Some intermediate results still in preparation
- No bright pixels detected (TBC)
- No surprises (yet)
- Follow-up lab work to determine if low energy X-ray response is affected