Low energy noise on the MOS CCDs

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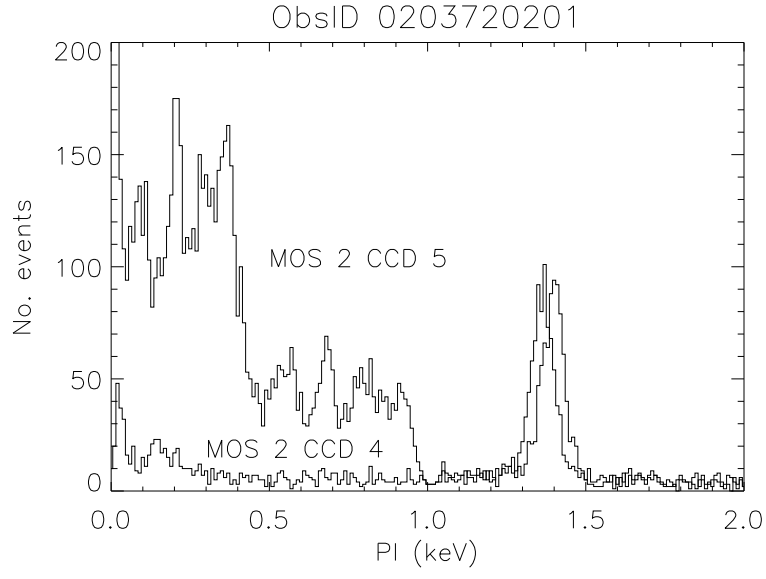
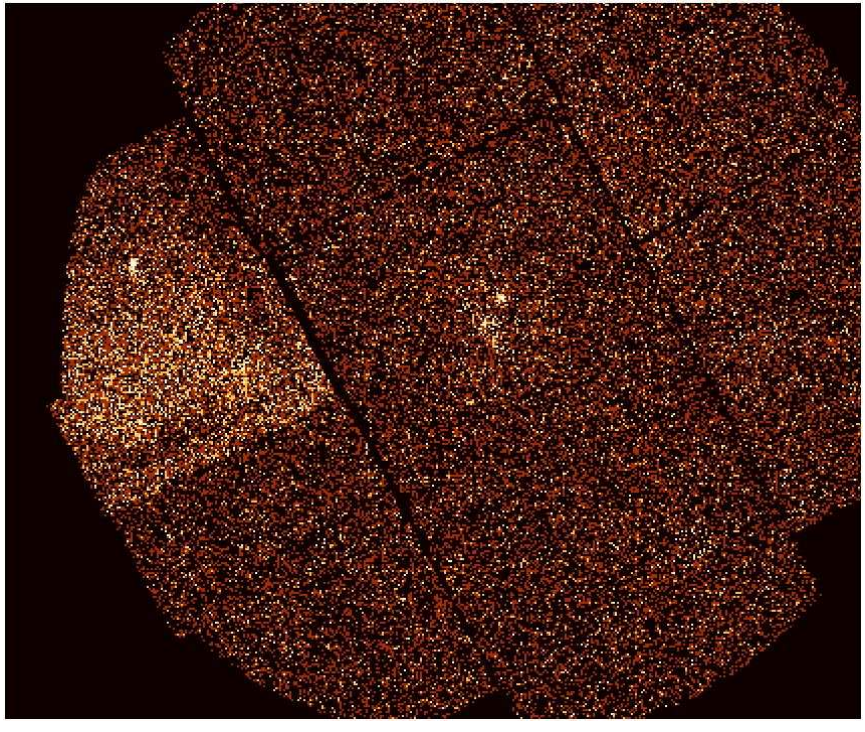
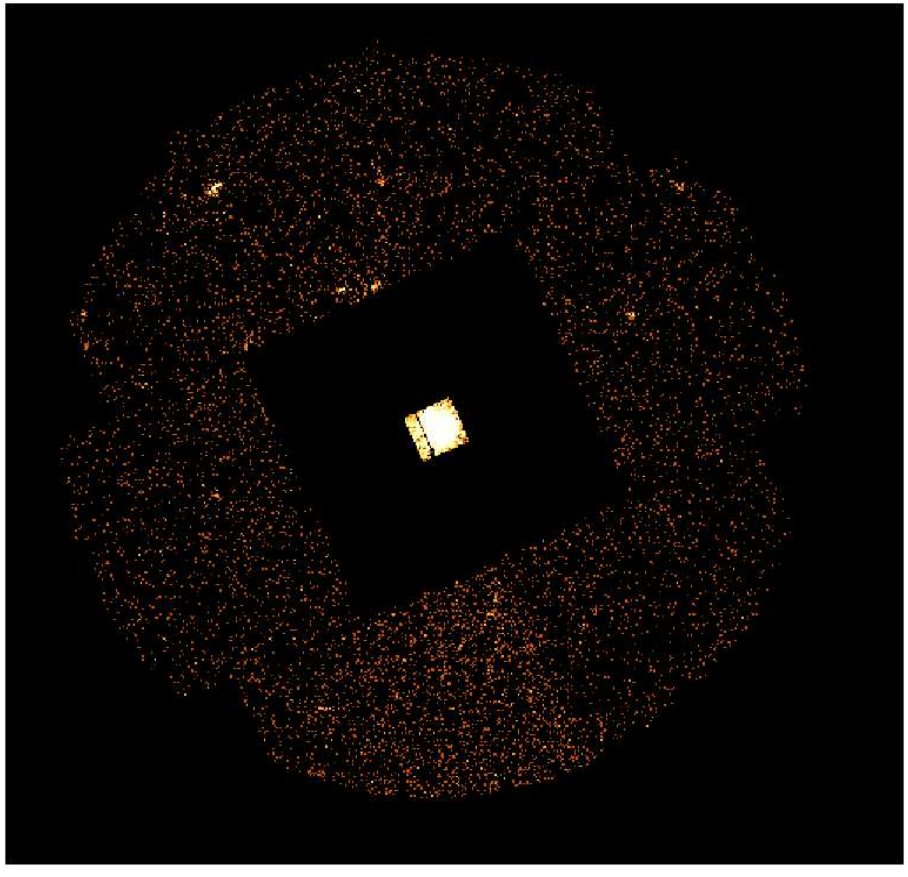
- A.k.a. the MOS2CCD5 effect (Stuhlinger 2008) or ‘anomalous states’ (Kuntz and Snowden 2008).
- Appears as plateaux in spectra below 1 keV.
- Present in multiple CCDs in both MOS 1 and 2.
- No switch on/off detected within observation.
- No correlation with radiation monitors.
- Excess in Patterns 0, 2 and 4.



Symptoms of the noise in images

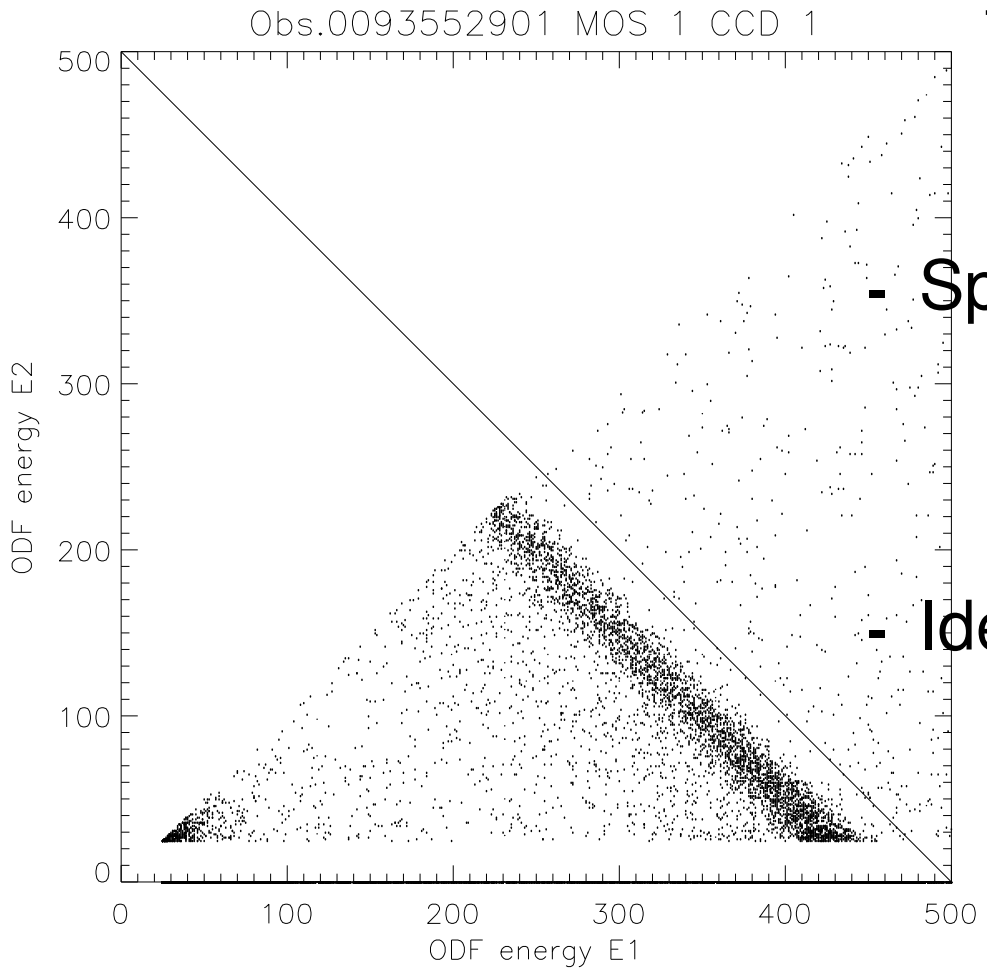


MOS1 CCD2

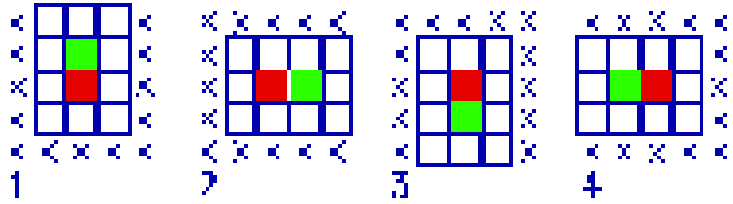


MOS2 CCD5

Event patterns 1 to 4

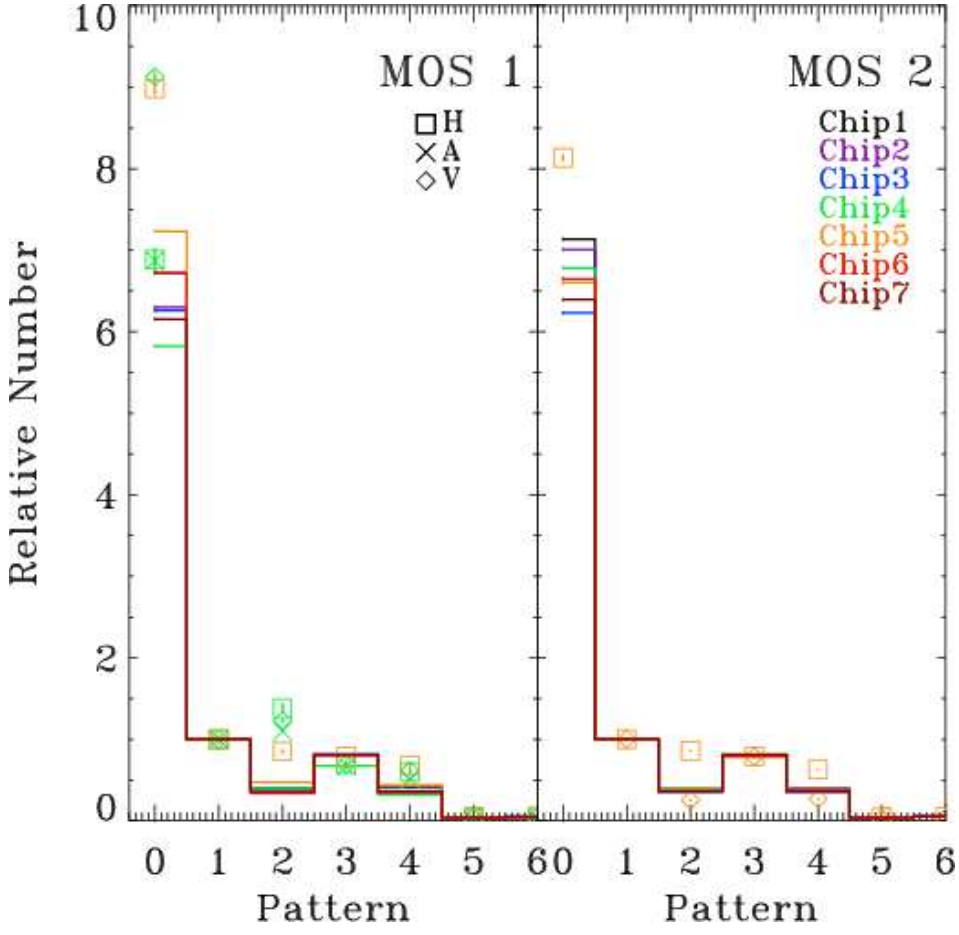


- Charge sharing between two adjacent pixels produces patterns 1–4.
- Spectral line at E_0 appears as diagonal line $E2 = -E1 + E_0$ in the ODF.
- Identity of Pixel 2 depends on orientation: ie, pattern value:



Excess of patterns 2, 4 is abnormal

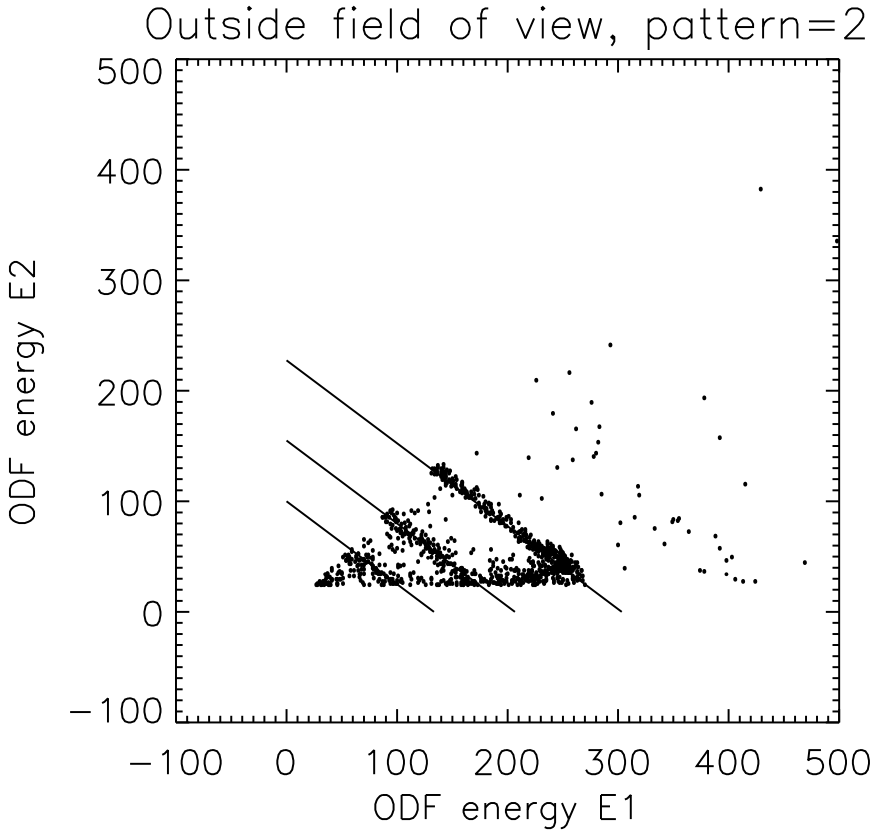
Kuntz and Snowden (2008):

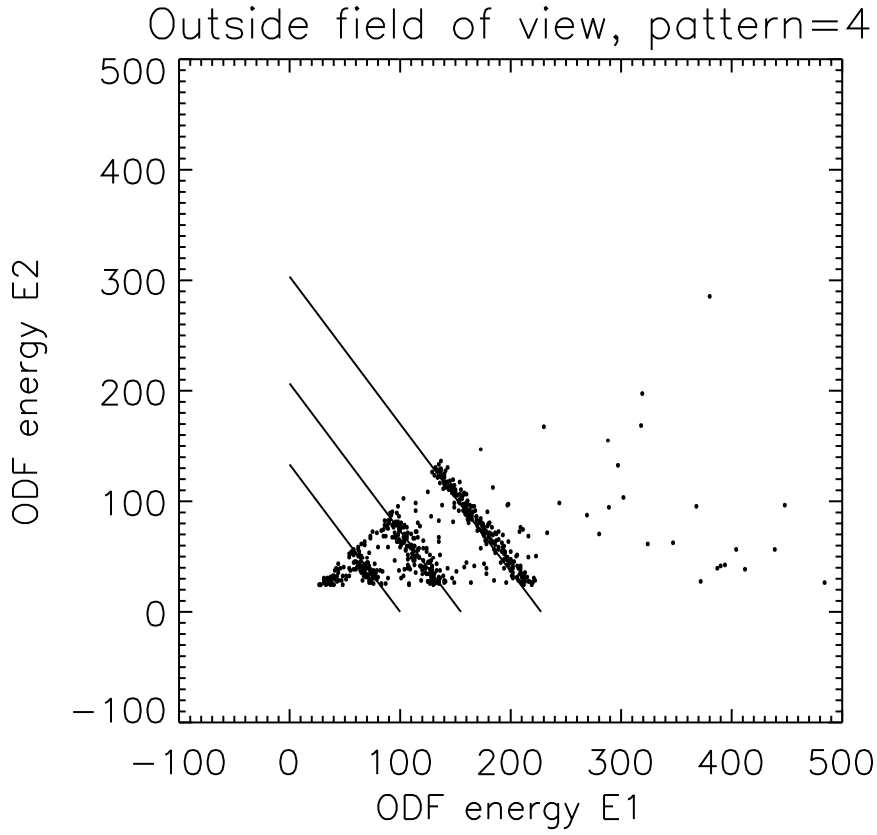


Lines: no noise
symbols: noisy

Pixels with patterns 2 or 4 are in *different* potential wells, so charge-sharing rates should be lower, but they are not.

Noise has correlation in ODF E1,E2 !





Pattern 2: Slope = −3/4

Pattern 4: Slope = −4/3

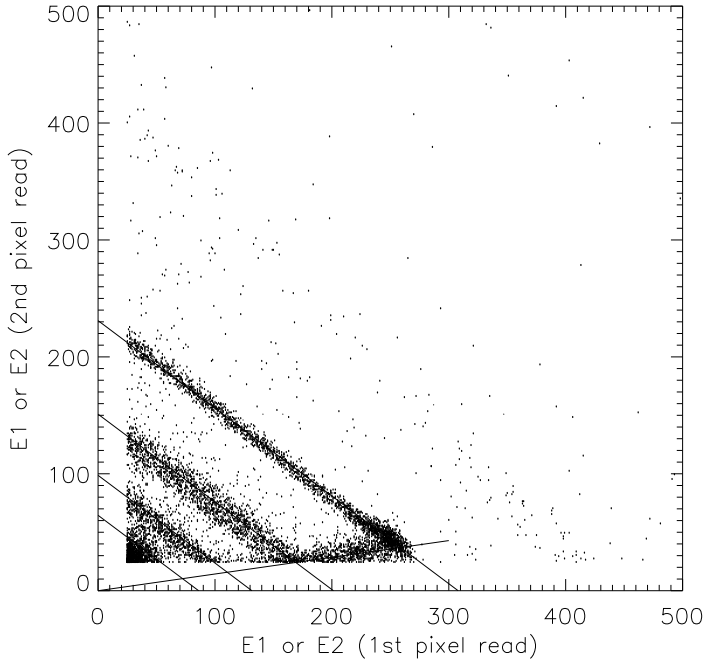
Key: Pixels w/ patterns 2 and 4 are read out consecutively, but in opposite order:

Pixel 1 *precedes* Pixel 2

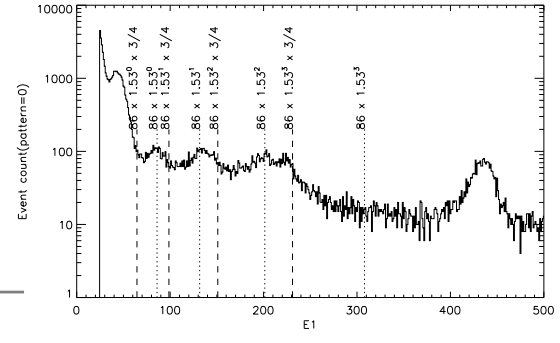
Pixel 1 *follows* Pixel 2

A unified view in $(E1, E2)$-space

Patterns 2 + 4 ($E1 \leftrightarrow E2$):



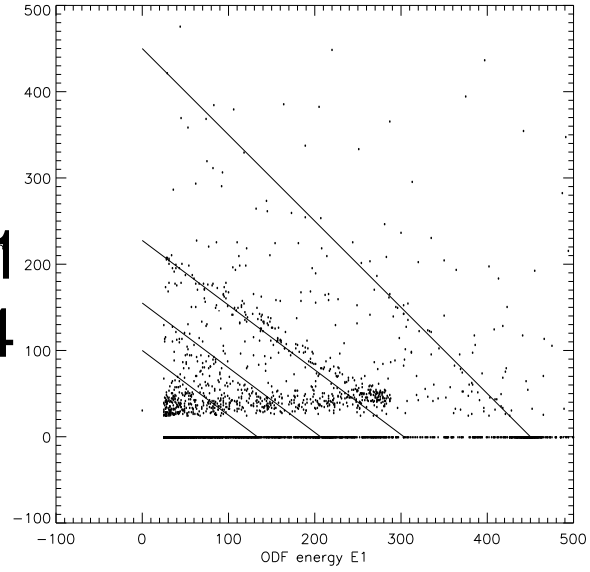
Pattern-0 spectrum:

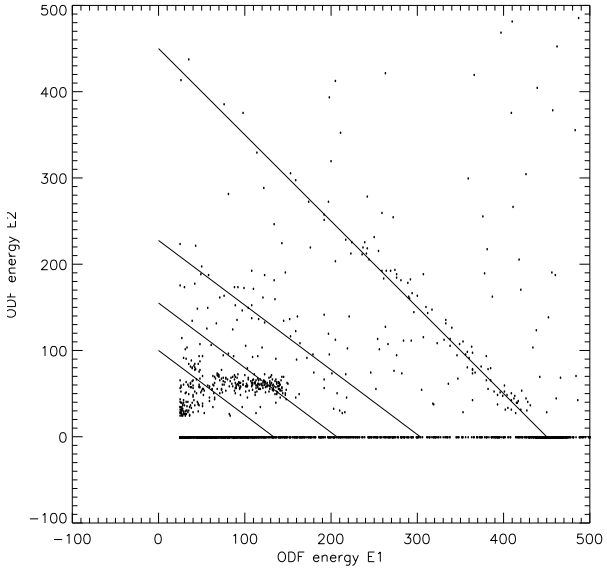


- Energies $E1$ and $E2$ in ODF are correlated for noise events.
- Slope = $-3/4$ instead of -1.
- Noise energy is actually discrete, and in multiples of 1.53; plateau formed by smearing due to $-3/4$ slope.
- Patterns 0, 2, 4 only: problem is in read-out.

Correlation is different in different CCDs

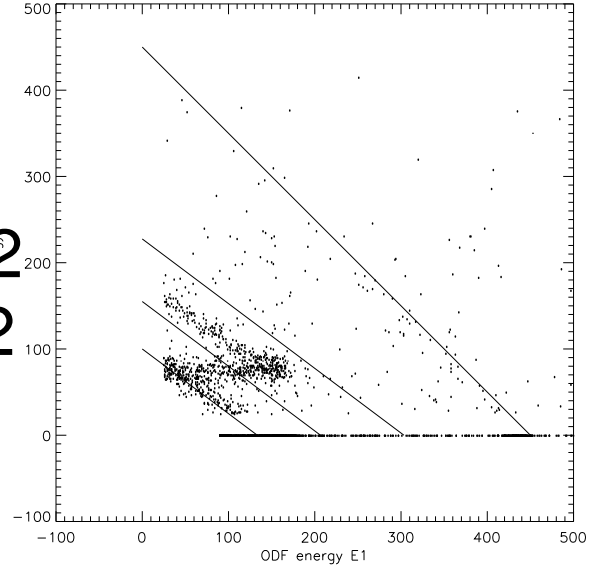
MOS 1
CCD 4

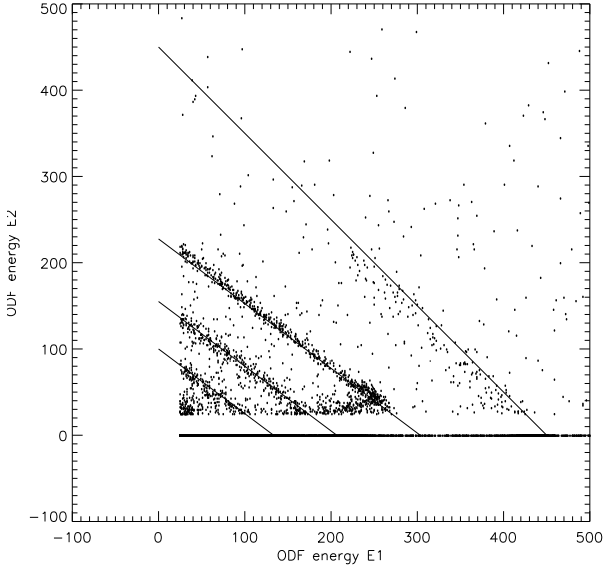




MOS 1
CCD 5

MOS 2
CCD 2

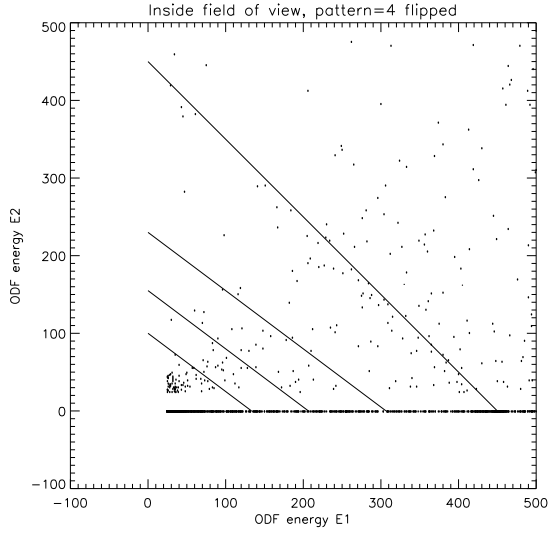




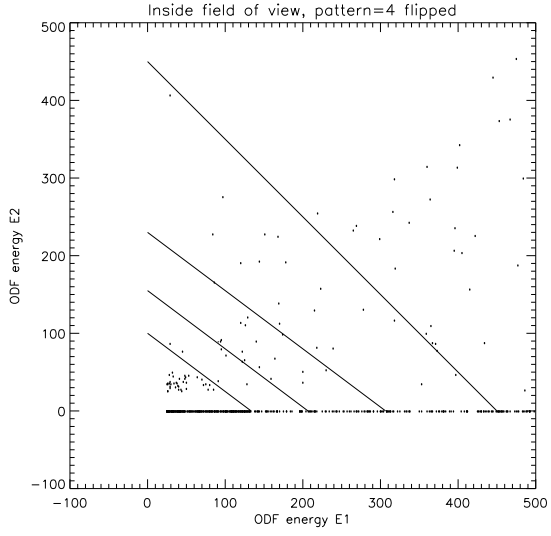
MOS 2
CCD 5

Application: Are the central CCDs noisy?

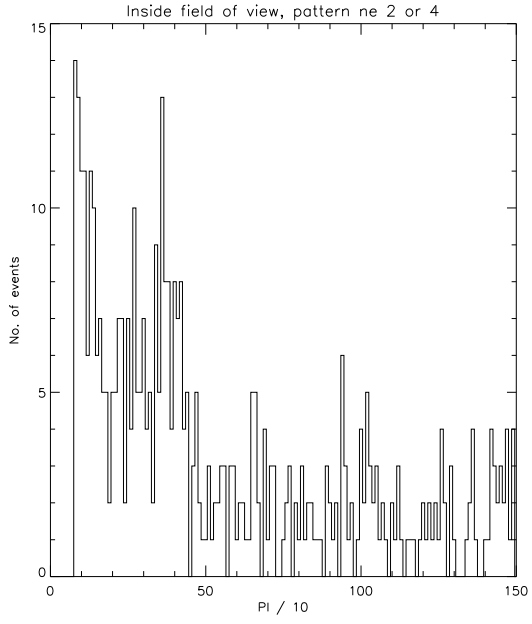
MOS 1 CCD 1



MOS 2 CCD 1



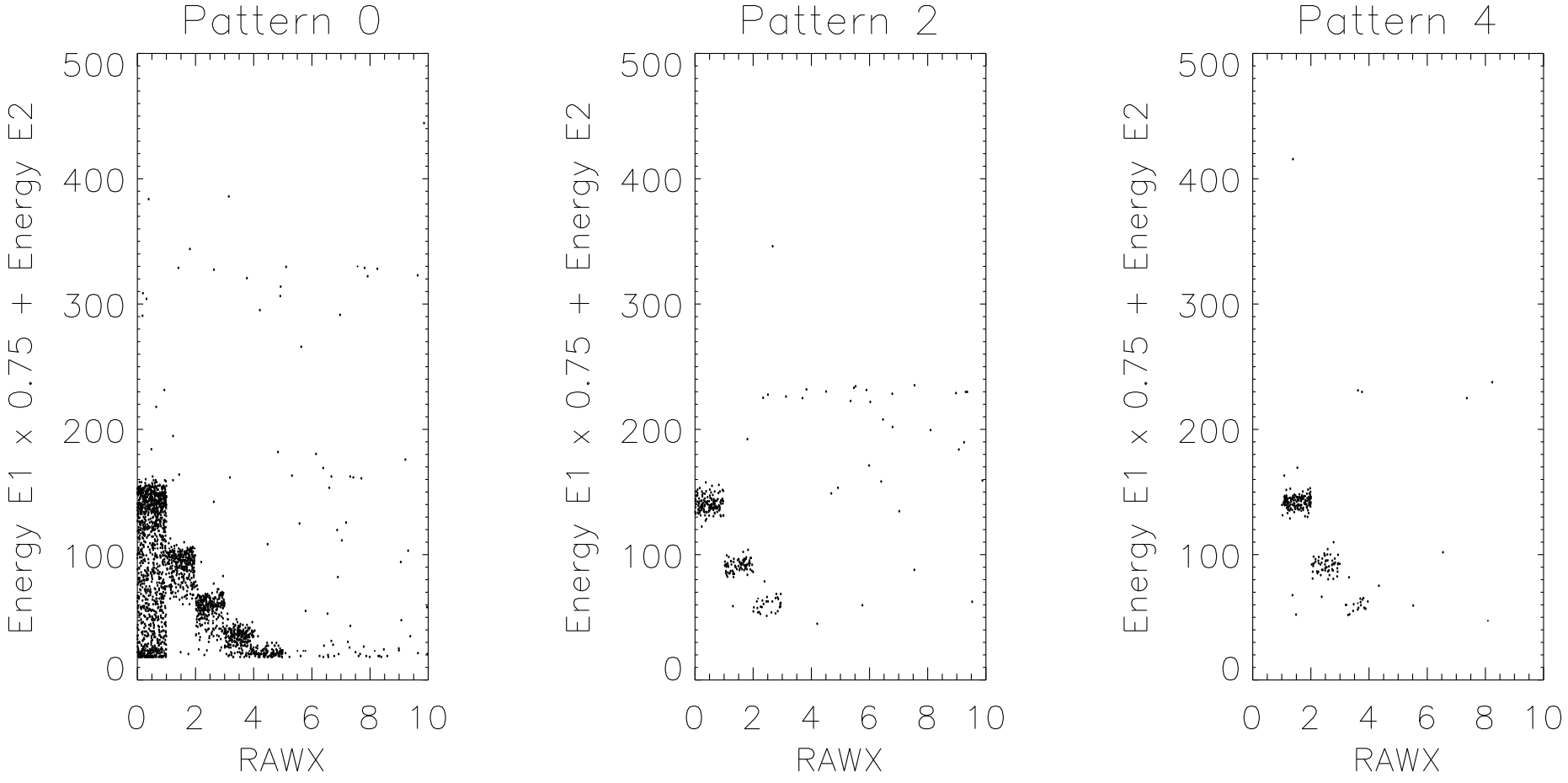
MOS 2 CCD 1
Pattern-0 spectrum



(E1,E2)-space shows little sign of noise, but some spectra from MOS 2 CCD 1 appear to have (small) plateaux.

Correlates w/ RAWX, iff RAWX < 4

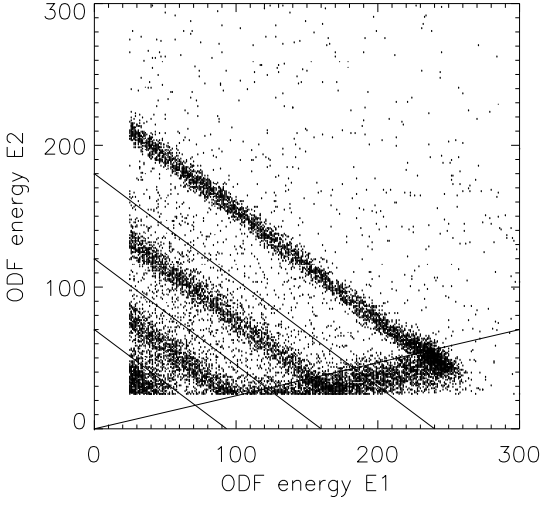
Unique (E1,E2)-track in each of the columns RAWX=0,1,2.

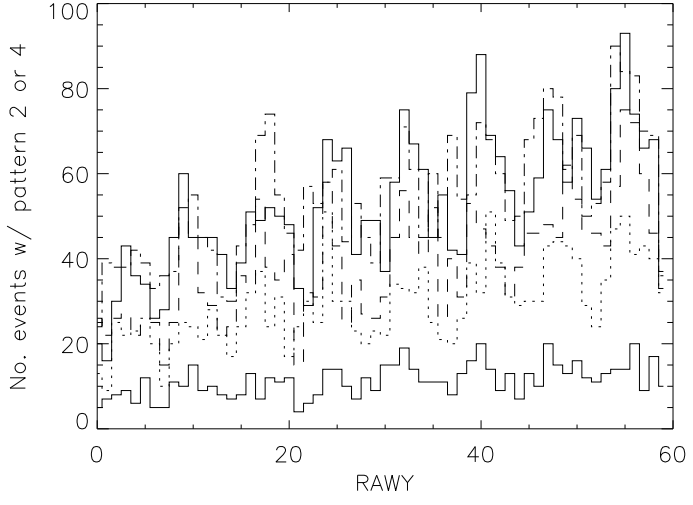


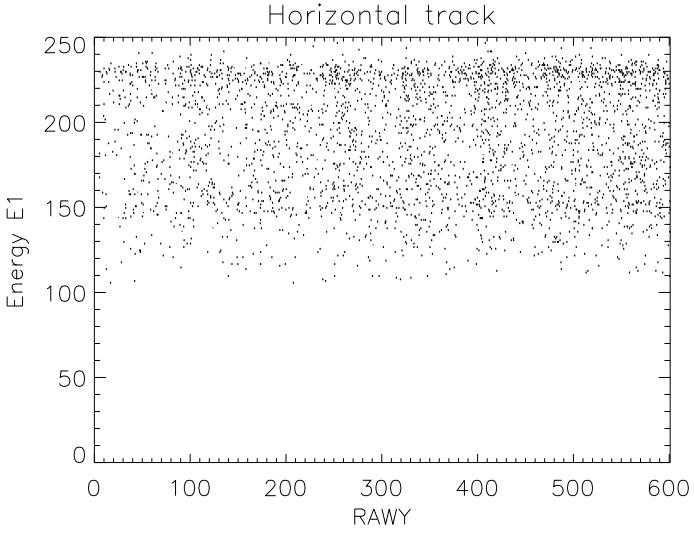
Pattern-0 data hints at more noise tracks below threshold.

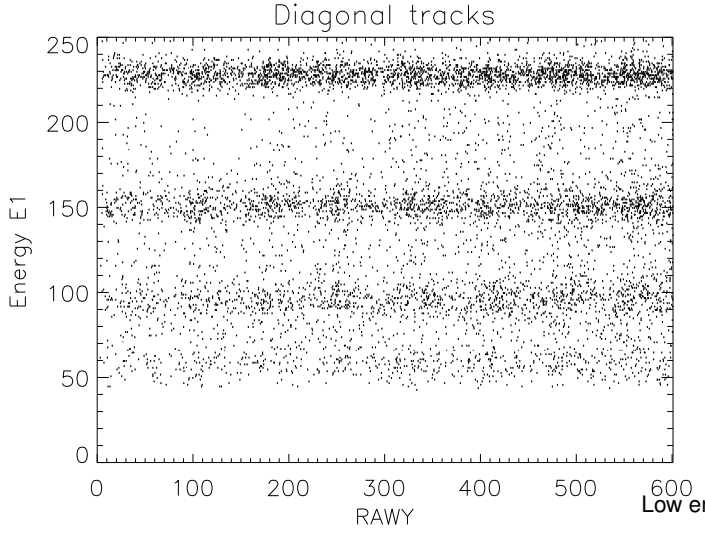
No correlation w/ RAWY periodicity

Noise appears as dark/bright rows (same RAWY), but all noise tracks brighten/darken together.

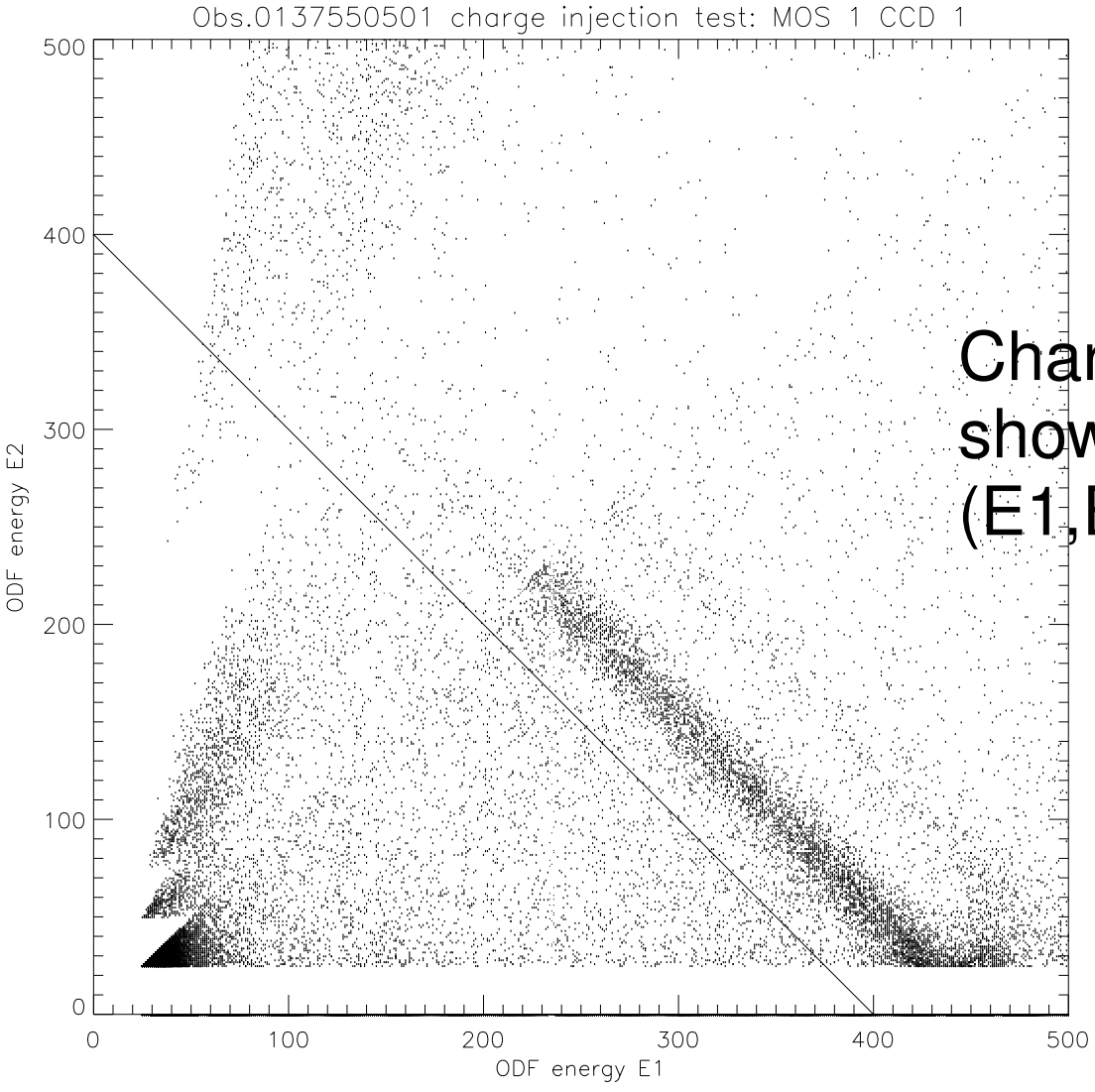






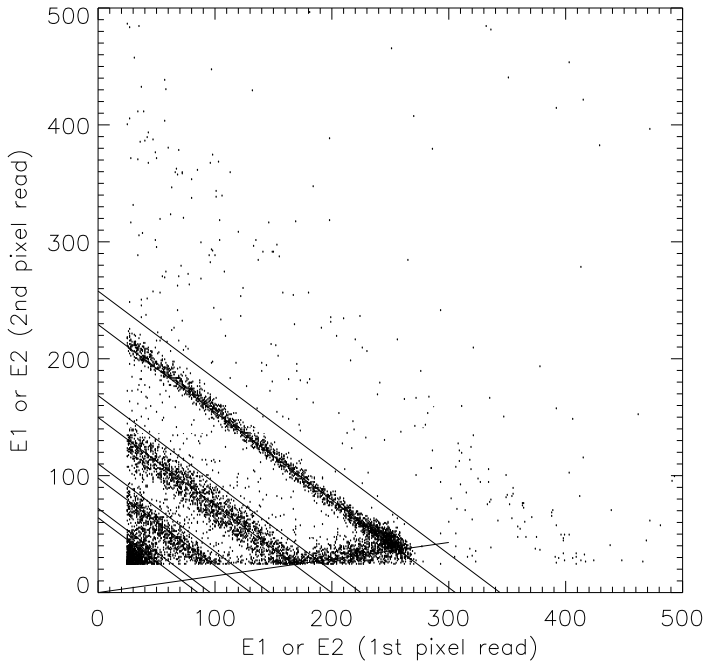


Charge injection is not the cause



Charge injection test shows no track in (E1,E2)-space.

Summary



- Energies $E1$ and $E2$ in ODF are correlated for low-energy noise in MOS.
- Problem lies in read-out amplifier circuit, not in pixels.
- Interference w/ column/row-select lines possible.
- True cause and mechanism still not understood.