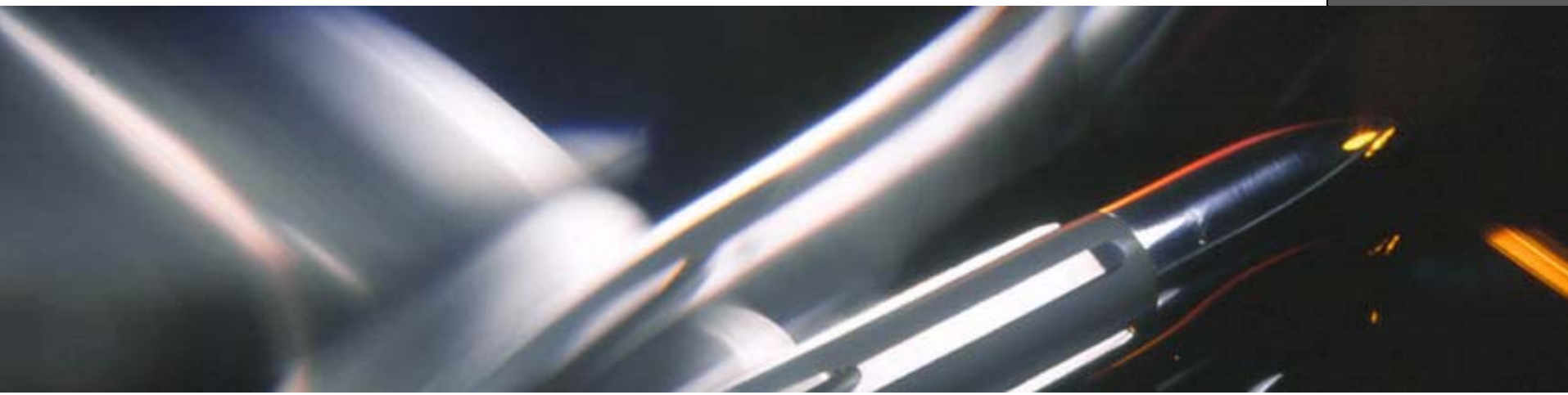

Laser Single Event Effects Studies - Phase 3

ESA ESTEC QCA 8

Andrew Chugg, Senior Technical Expert, Radiation Physics & EMC

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MBDA MISSILE SYSTEMS

Introduction

- The new 2nd generation SEREEL2 facility replaces SEREEL1
- Laser SEE research in 2006
  - Multi-wavelength sensing of SEE sensitivity versus depth
  - Sensitivity mapping of memory cells in Maxwell devices
  - Reconstructing SEE cross-sections from sensitivity maps
  - New MBU results from SEREEL2 testing
- Other recent research & future plans

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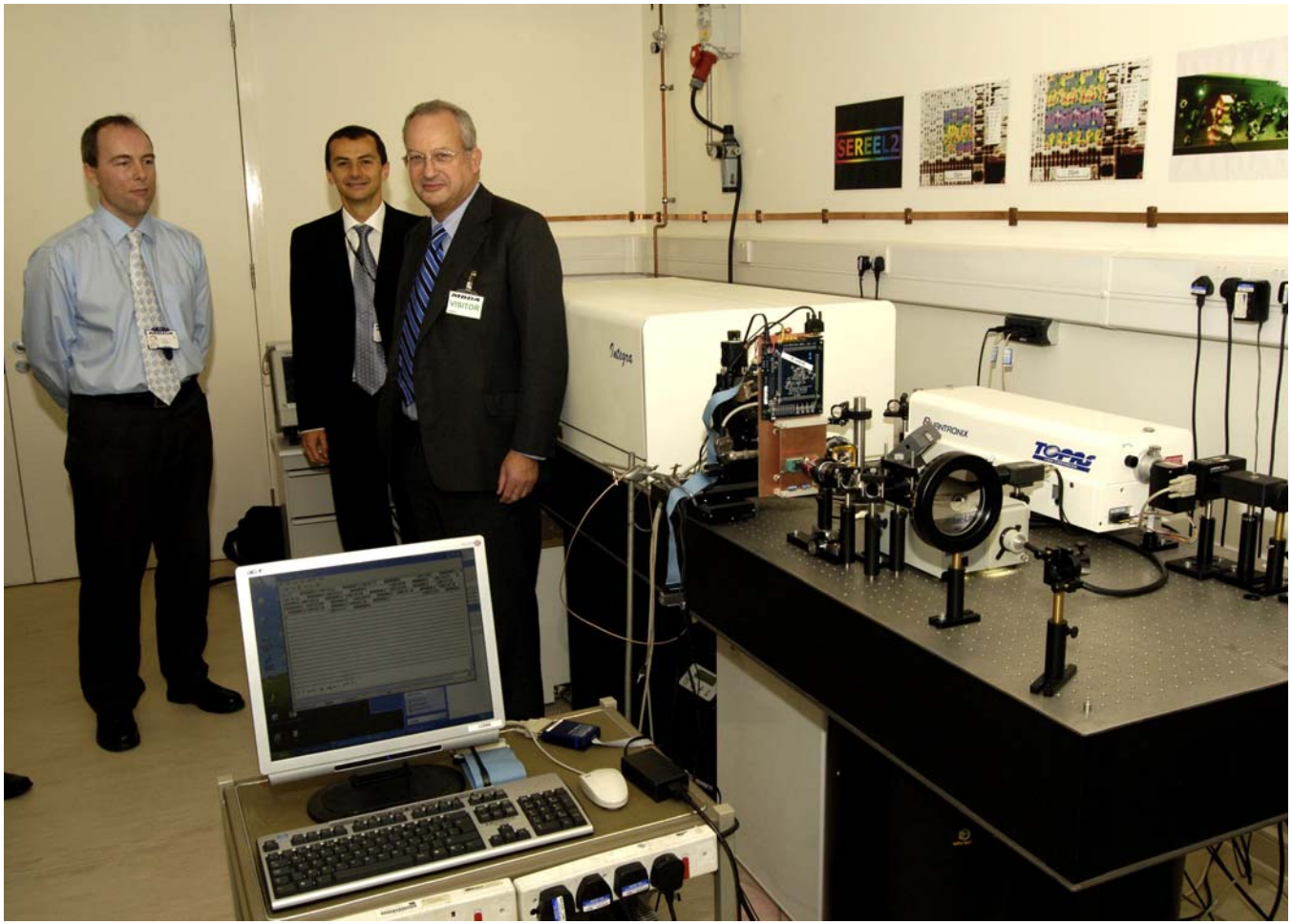
Visit of Lord Sainsbury to SEREEL2 on 6th October 2006
UK Minister of State for Science & Technology (includes Space Research)



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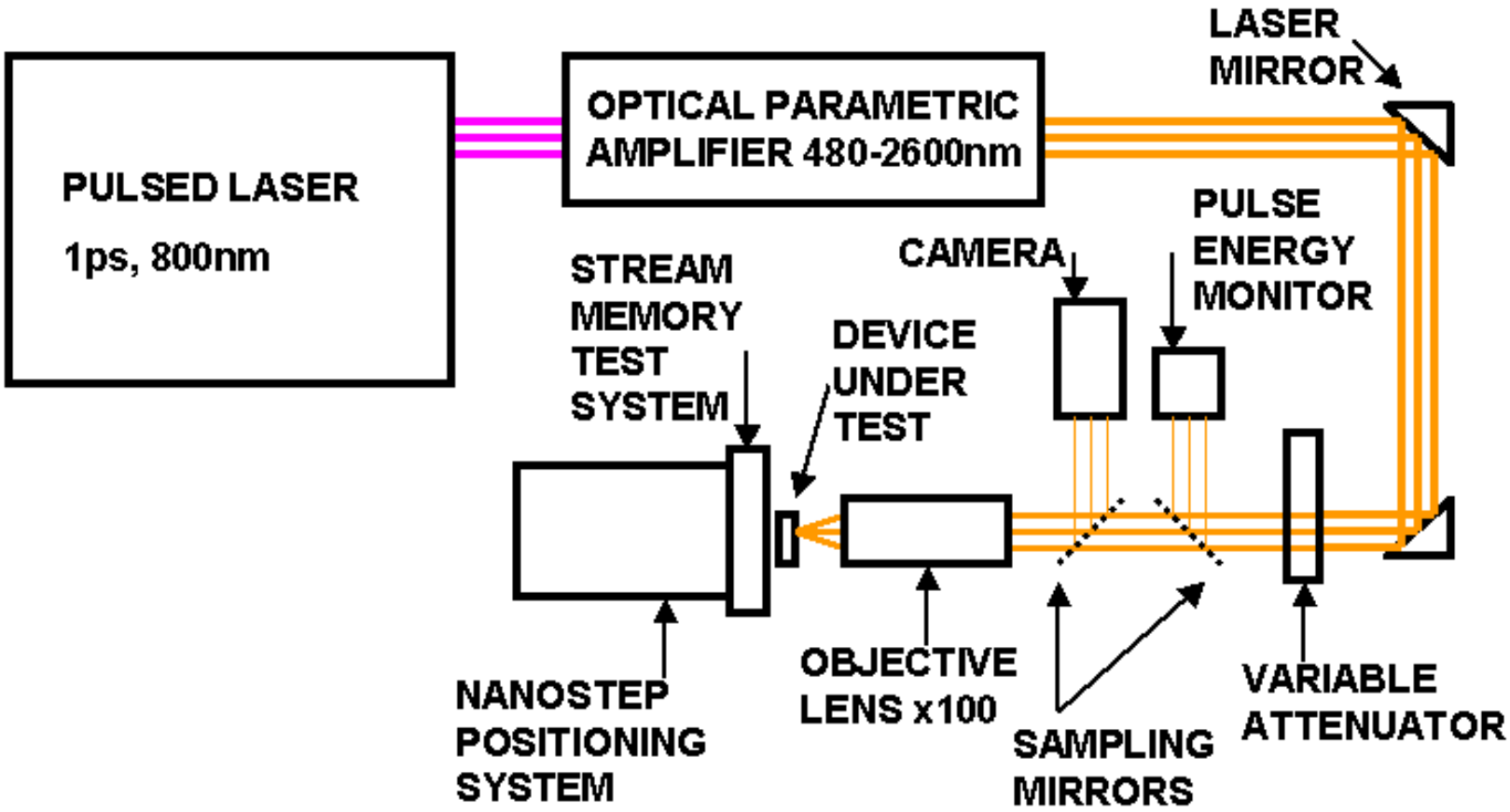
SEREEL2 Laser SEE Simulation Facility – conceptual plan



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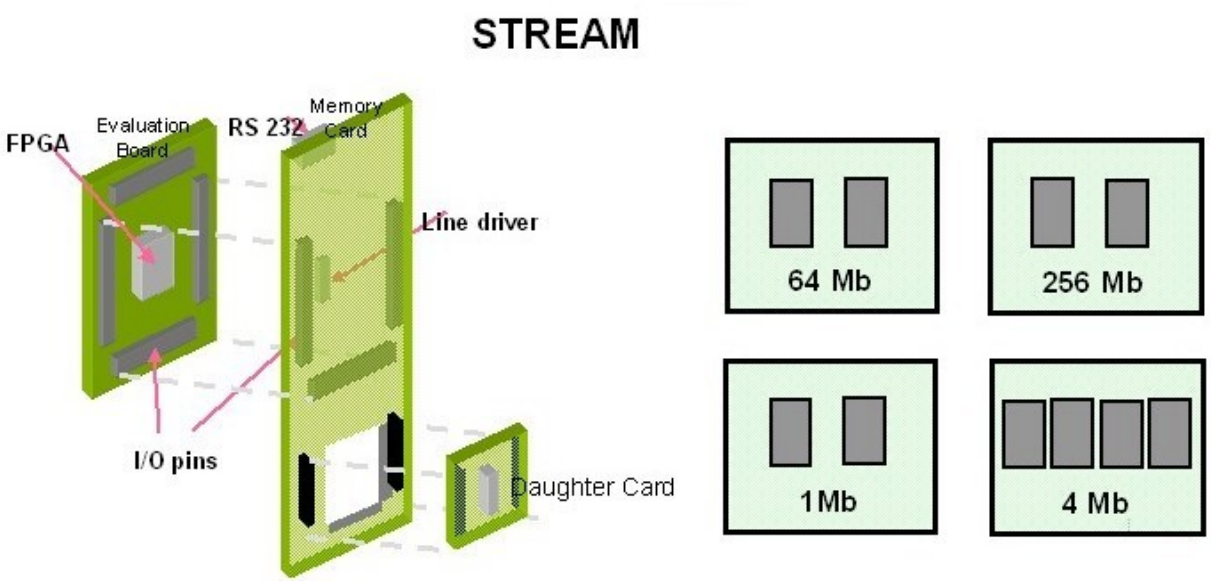
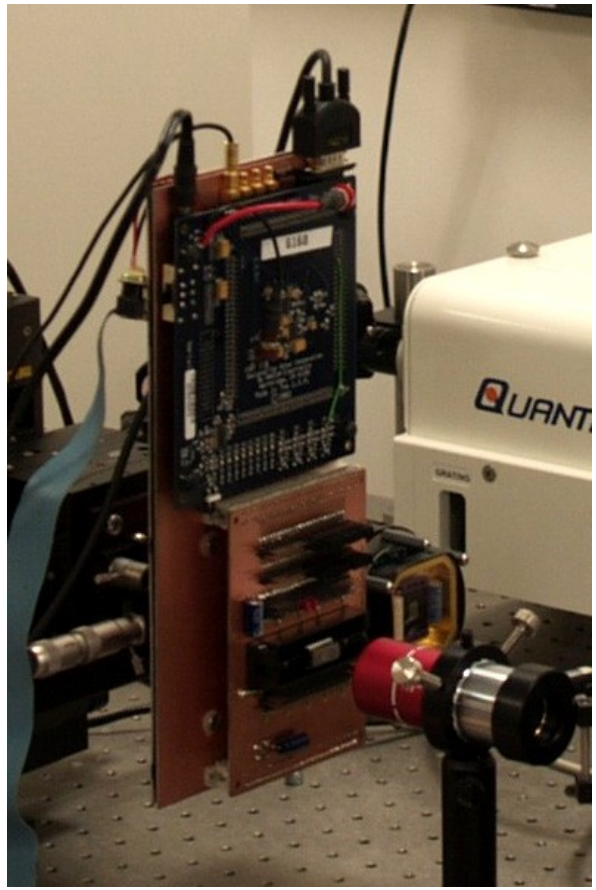
STREAM FPGA test set for cycling memories during SEE testing





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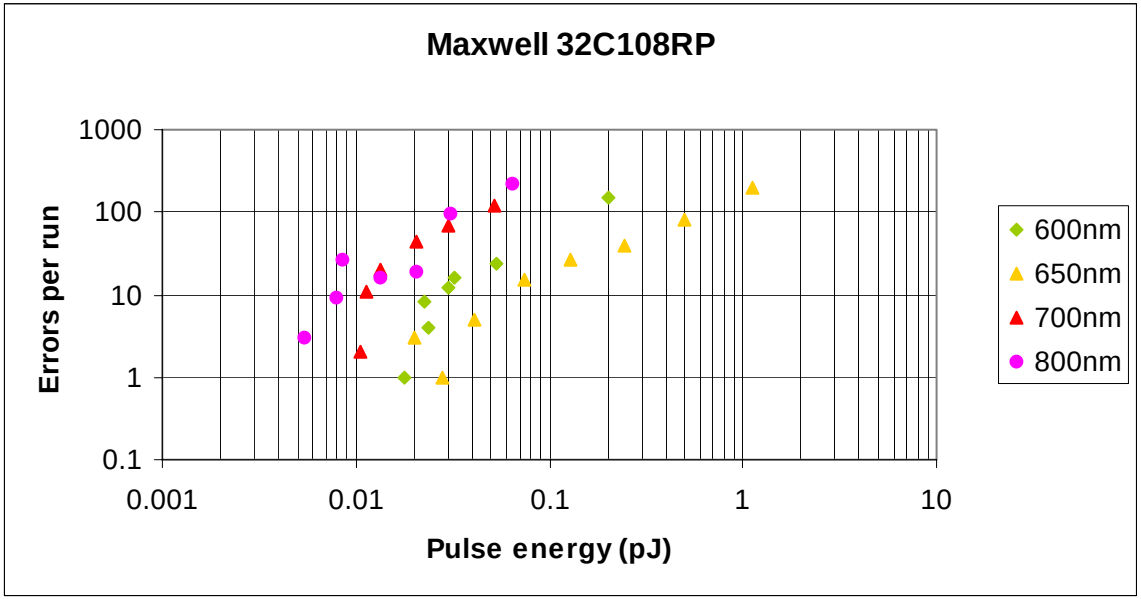
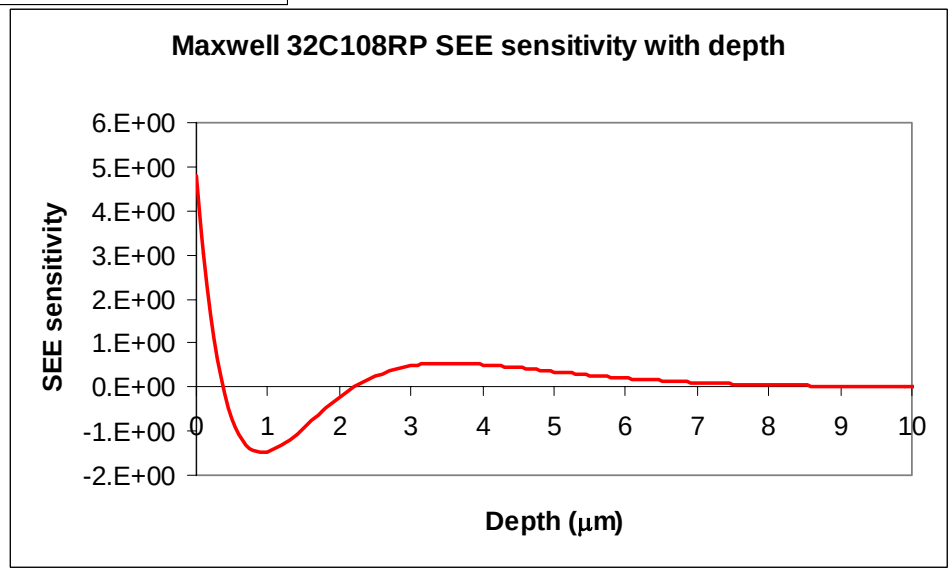
Laser cross-sections at a range of wavelengths using SEREEL2



SEREEL2 provides higher laser pulse frequencies and better light concentration near the focus, so laser SEE cross-sections are better defined and have lower thresholds than for SEREEL1

We can use our Inverse Laplace Transform method (IEEE TNS Dec 2002) to extract the SEE sensitivity with depth into the silicon from the ratios of the SEE thresholds at different wavelengths



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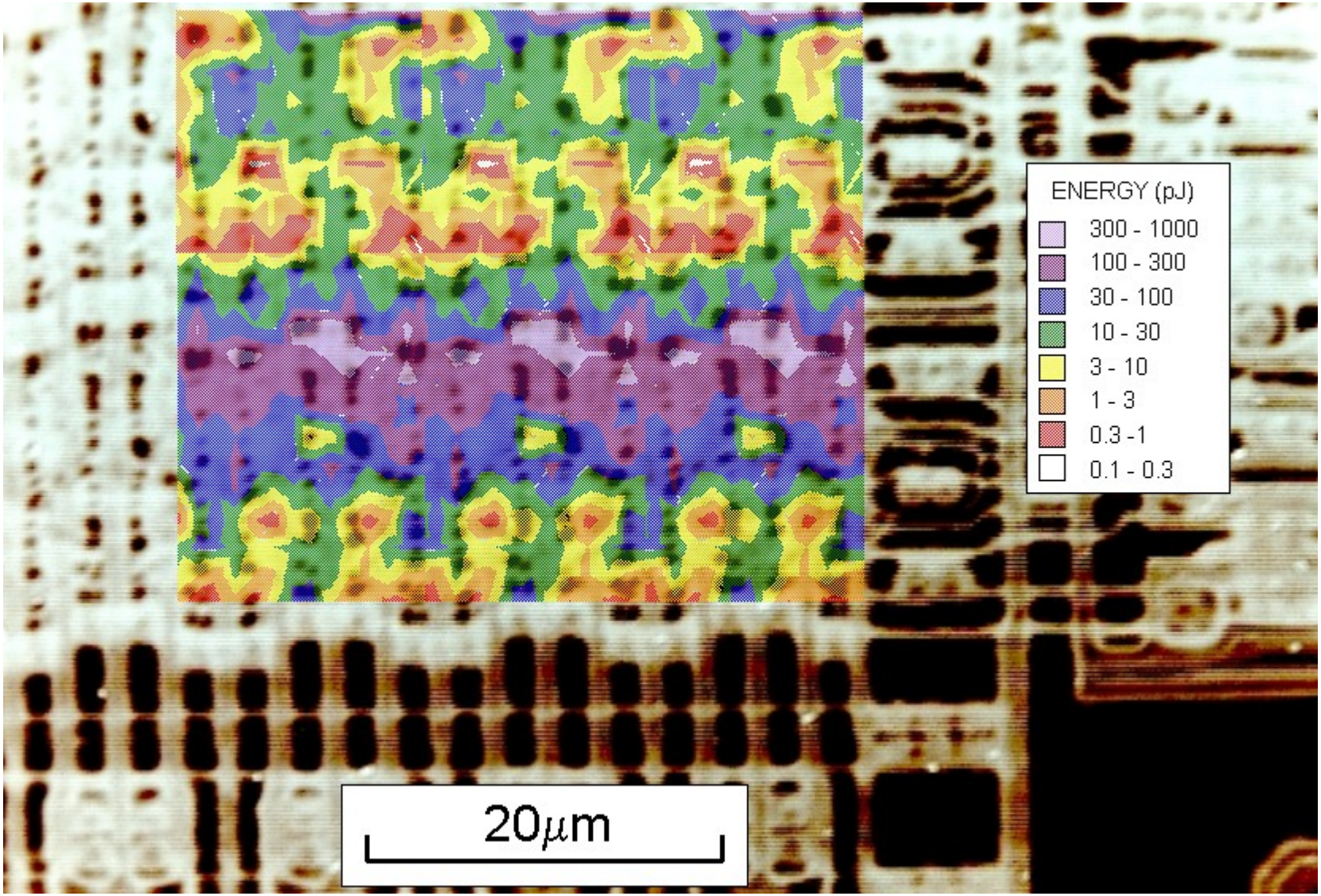
Laser pulse energy threshold map for bit-flips with a 5A Data Pattern (01011010) in the Maxwell 32C108R SRAM



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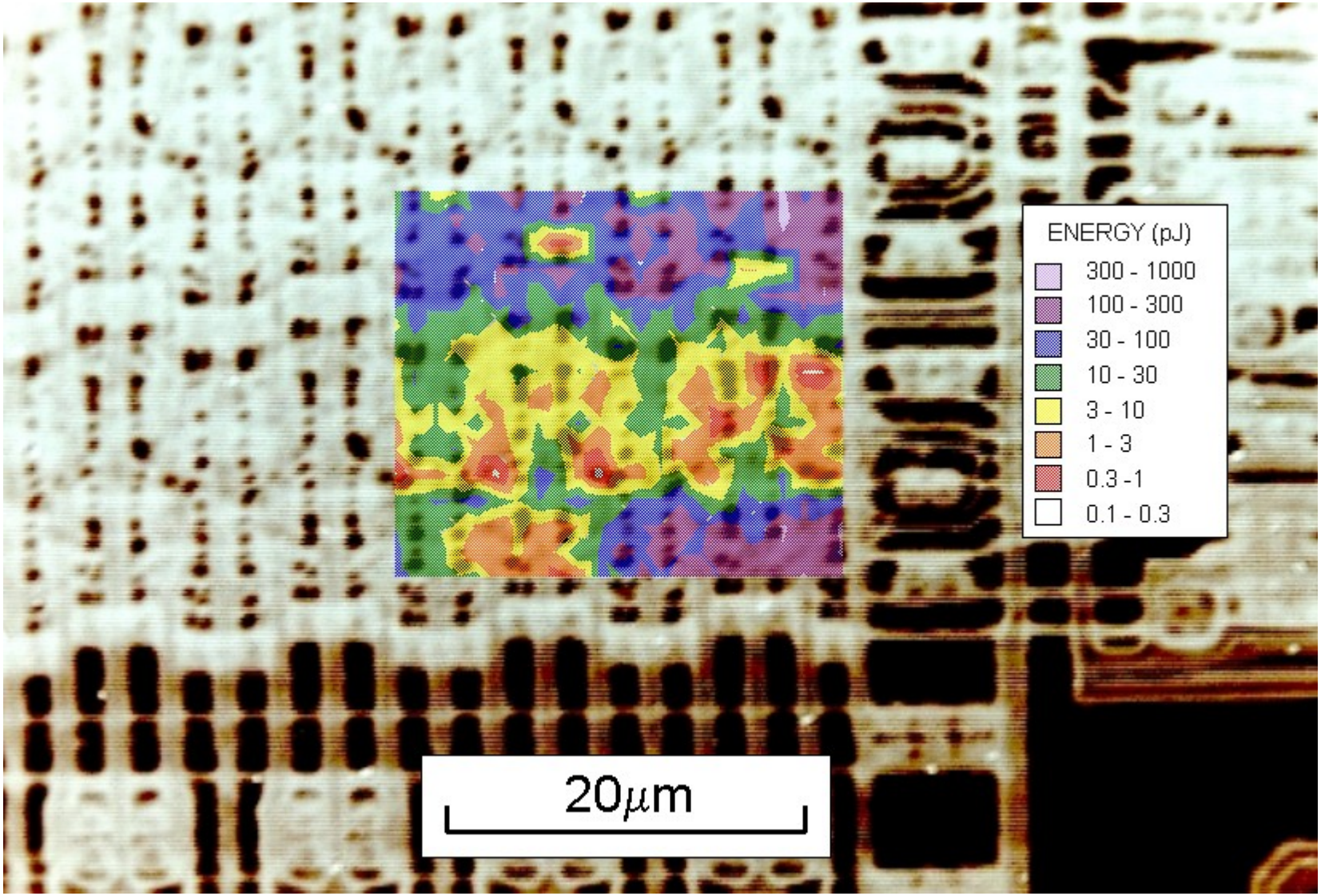
Laser pulse energy threshold map for bit-flips with an A5 Data Pattern (10100101) in the Maxwell 32C108R SRAM



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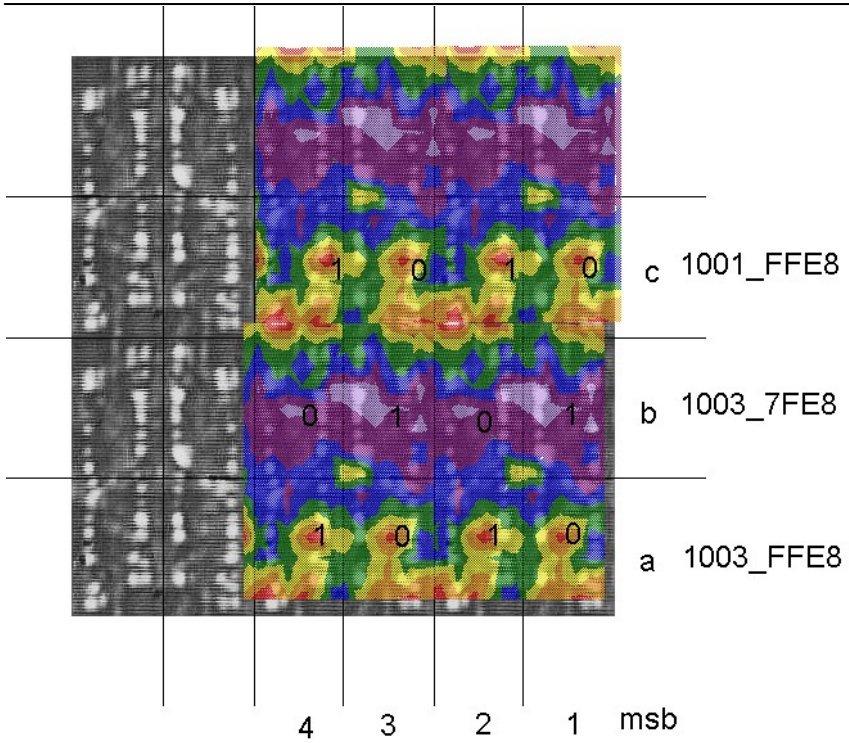
5A data pattern: relationship between laser pulse location and upset bit location(s)



Bridges of SEE sensitivity between cells are found to correspond to MBU sensitive sites

Observed errors may be in an adjoining cell to the pulsed cell, especially when pulsing insensitive cells

Laser Node	Error	Binary	Address	Node Upset
1a	DA	1101	3FFE8	1a
2a	1A	0001	3FFE8	2a
3a	3A	0011	3FFE8	2a & 3a
3a	7A	0111	3FFE8	3a
4a	4A	0100	3FFE8	4a
1b	DA	1101	3FFE8	1a
1b	9A	1001	3FFE8	1a & 2a
2b	DA	1101	3FFE8	1a
2b	1A	0001	3FFE8	2a
3b	7A	0111	3FFE8	3a
4b	7A	0111	37FE8	3b

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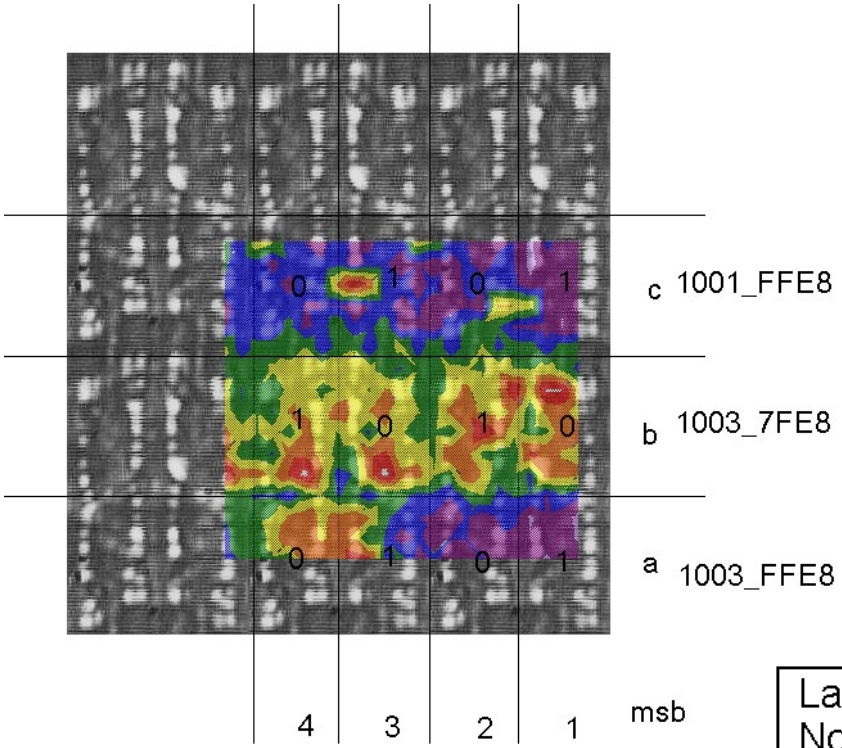
A5 data pattern: relationship between laser pulse location and upset bit location(s)



Note that it would be possible to choose a data pattern for which the device would be almost SEE insensitive on the basis of these results

Conversely, there appears to be a data pattern for which the sensitivity would be twice that observed

Laser Node	Error	Binary	Address	Node upset
2a	E5	1**1**10	37FE8	2b
3a	85	10**0**0	37FE8	3b
4a	B5	101**1**	3FFE8	4a
1b	25	**0**010	37FE8	1b
2b	E5	1**1**10	37FE8	2b
3b	85	10**0**0	37FE8	3b
4b	B5	101**1**	37FE8	4b

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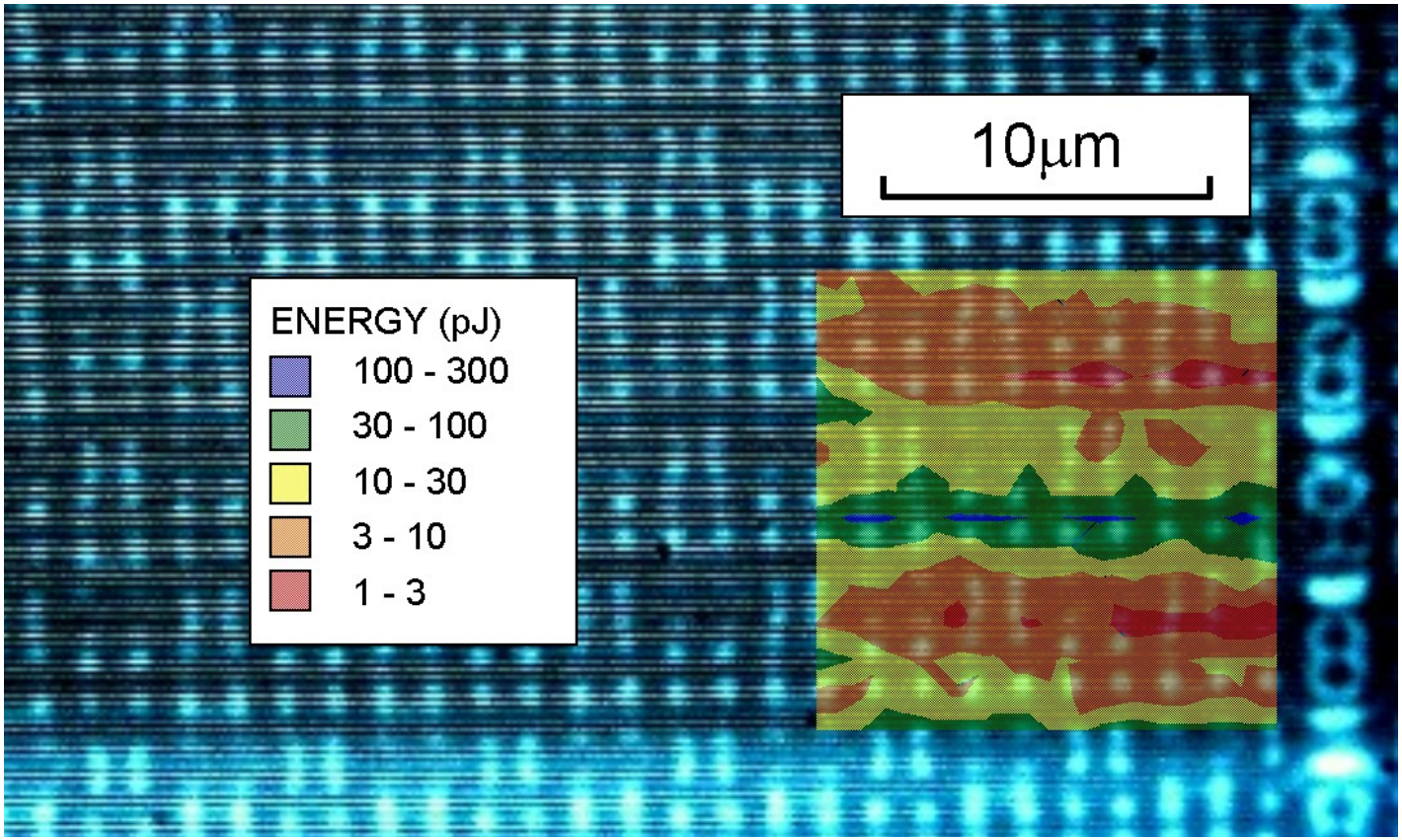
Laser pulse energy threshold map for bit-flips with an A5 Data Pattern (01011010) in the Maxwell 32C408R (4 Mbit Hitachi) SRAM



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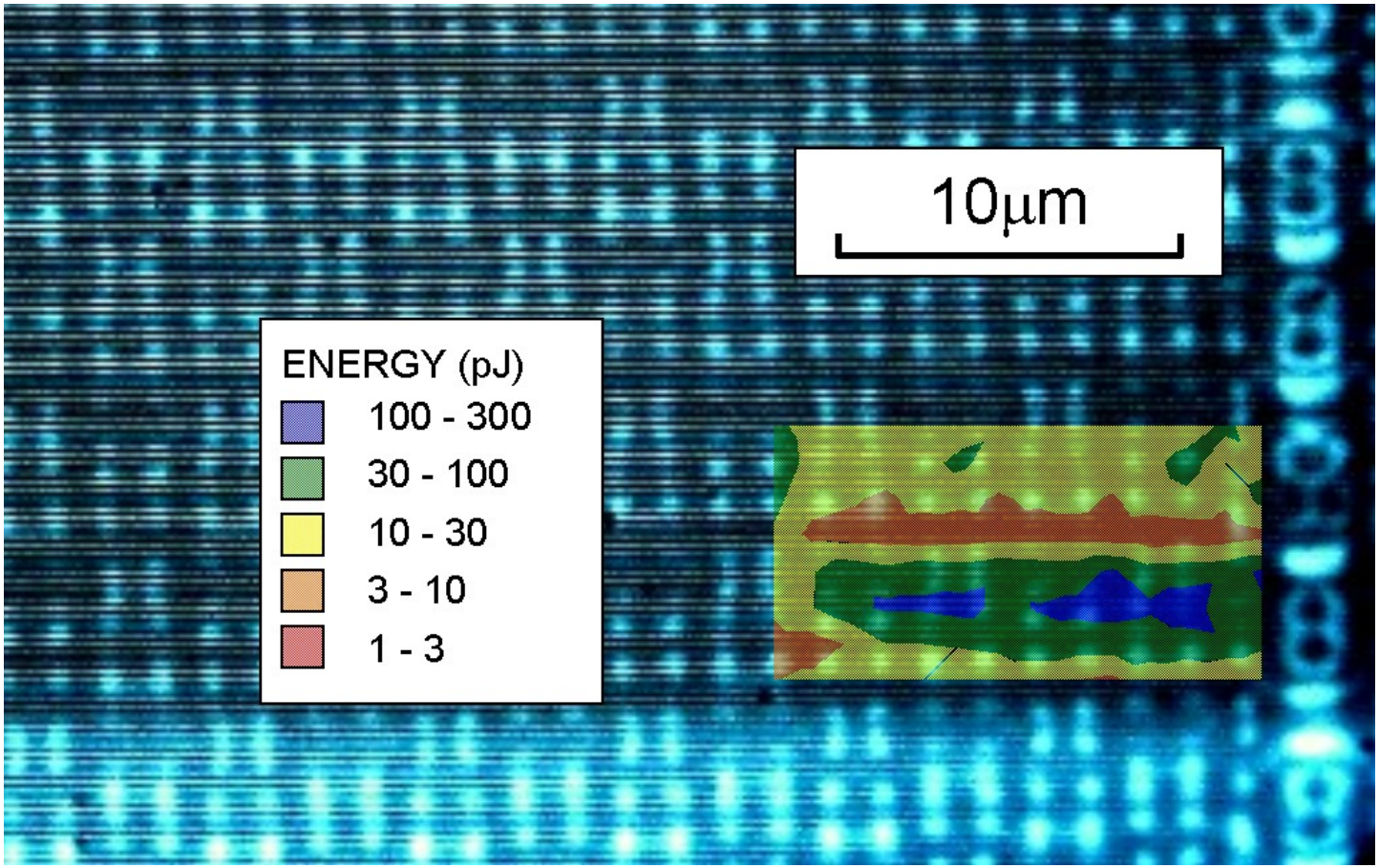
Laser pulse energy threshold map for bit-flips with a 5A Data Pattern (01011010) in the Maxwell 32C408R (4 Mbit Hitachi) SRAM



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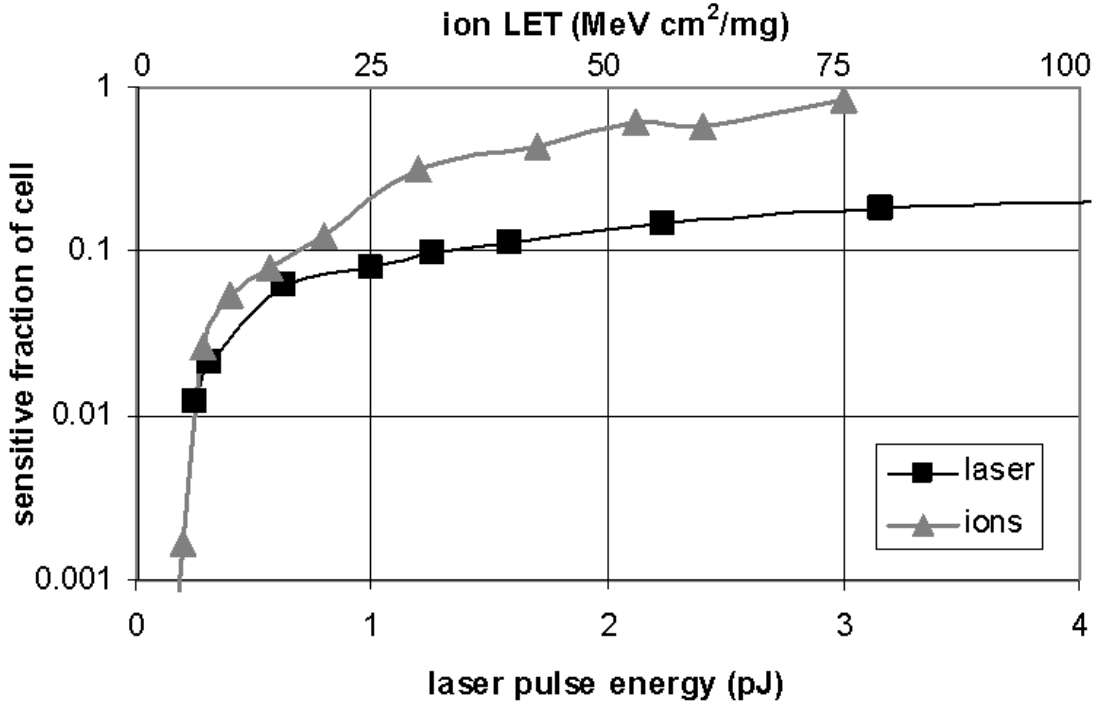
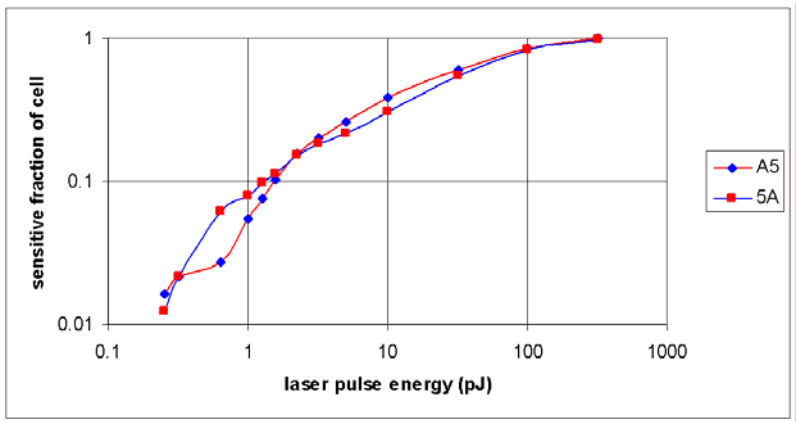
Reconstructed cross-sections on log-linear & log-log axes for the Maxwell 32C108R SRAM – comparison with ion beam data

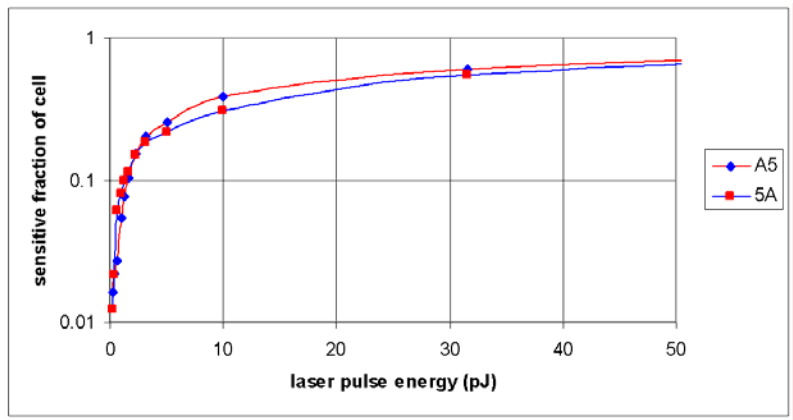


Reasons for discrepancy:

1) Metallisation reduces laser cross-section

2) Only MBU's scaled out of ion results: MCU's remain at higher LET's





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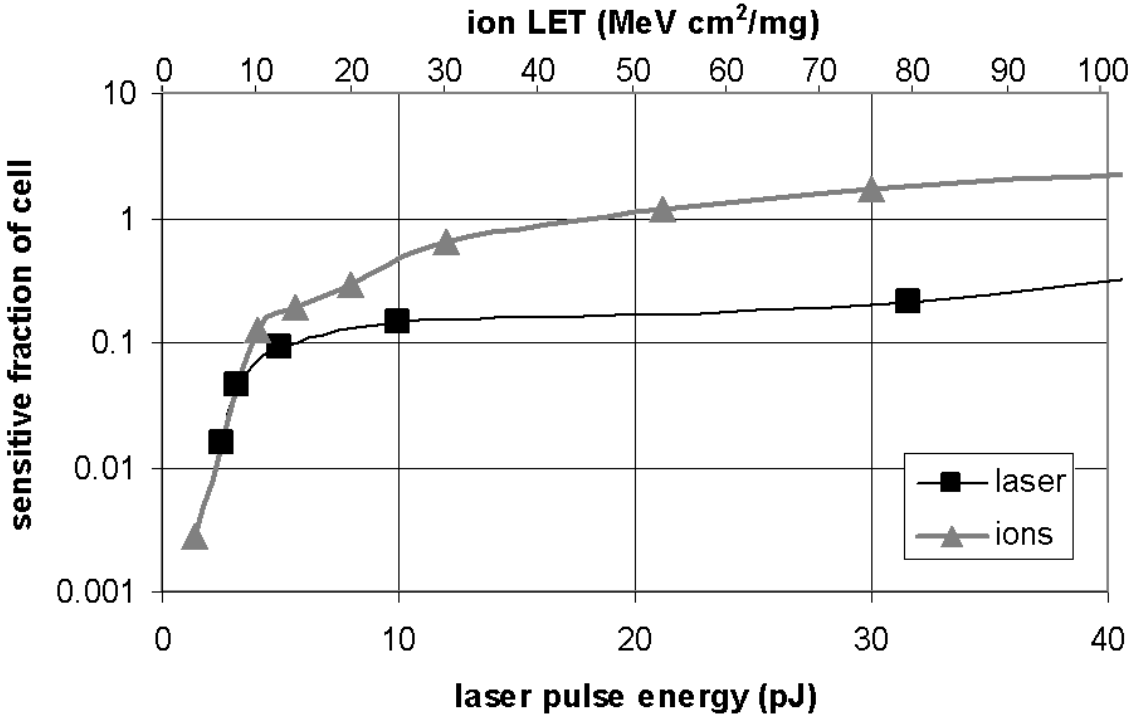
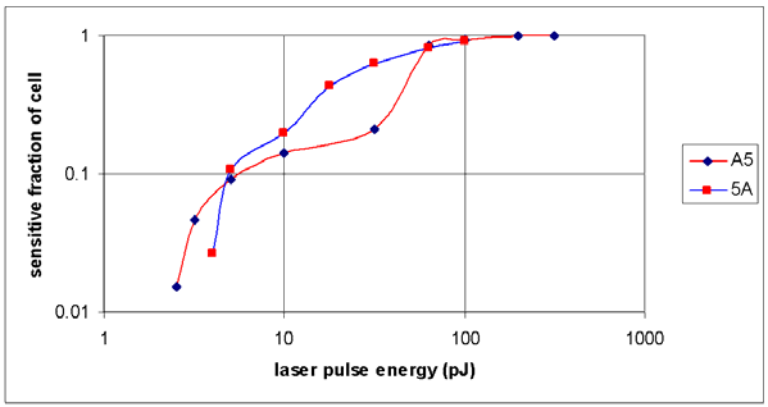
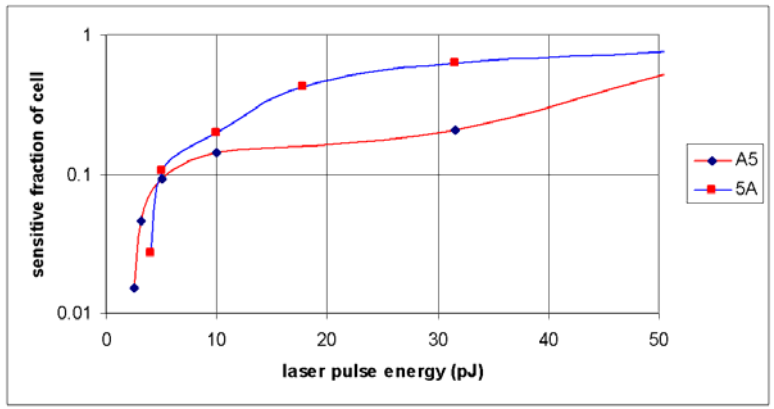
Reconstructed cross-sections on log-linear & log-log axes for the Maxwell 32C408R (4Mbit Hitachi) SRAM







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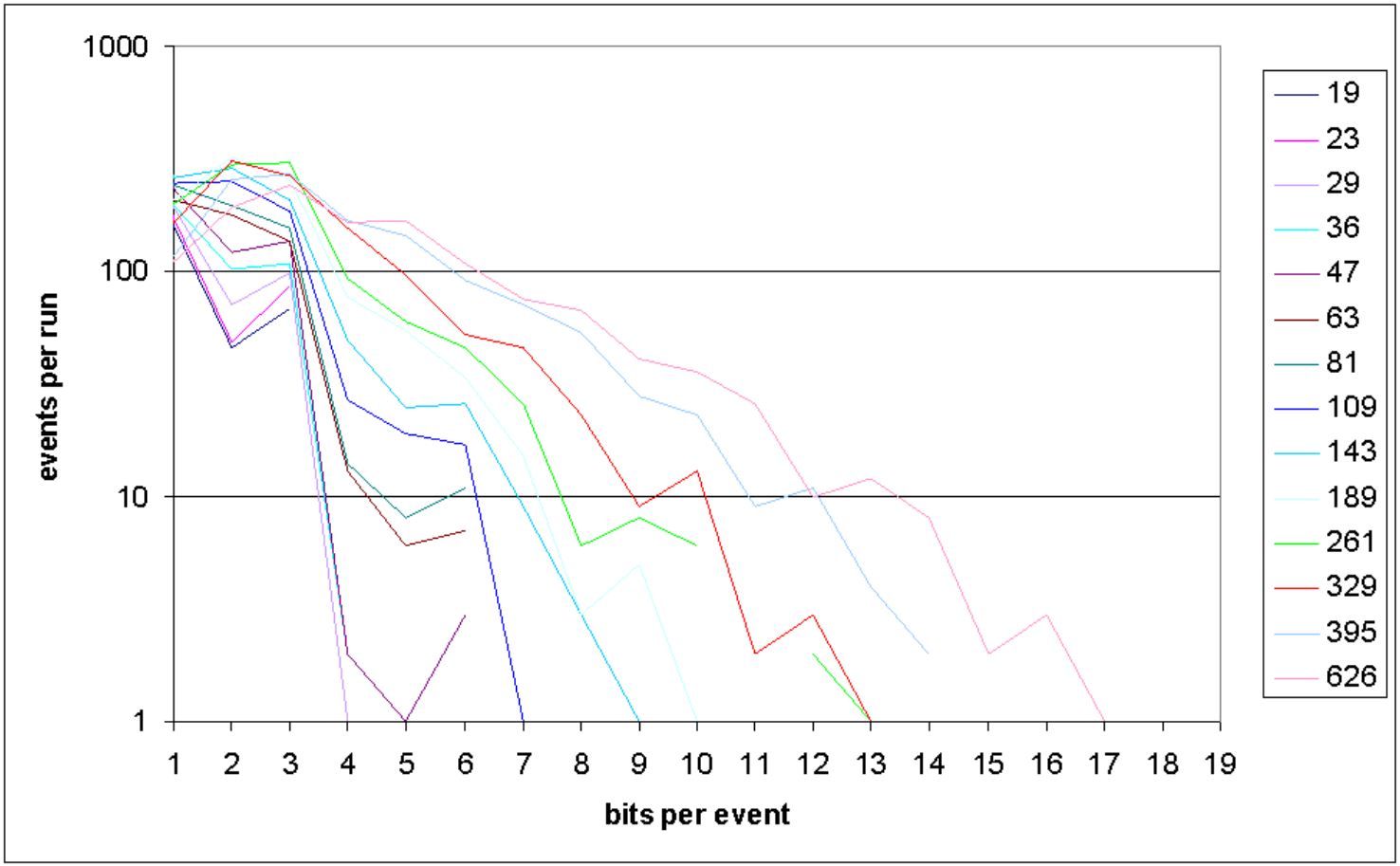
Bits per event distributions for the Maxwell 32C108R SRAM (the laser pulse energy in the key is in pJ)



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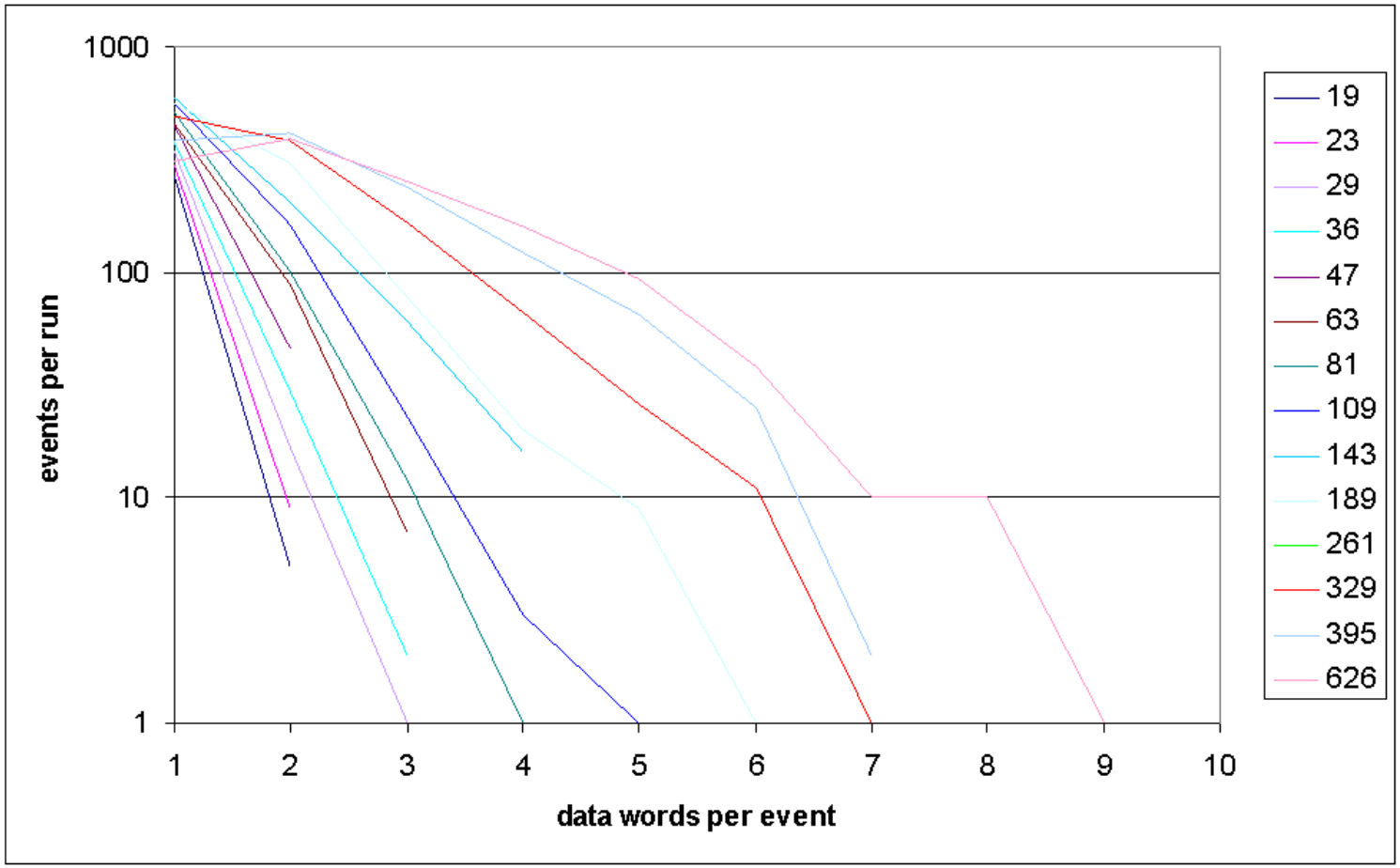
Word upsets per event distributions for the Maxwell 32C108R SRAM (the laser pulse energy in the key is in pJ)



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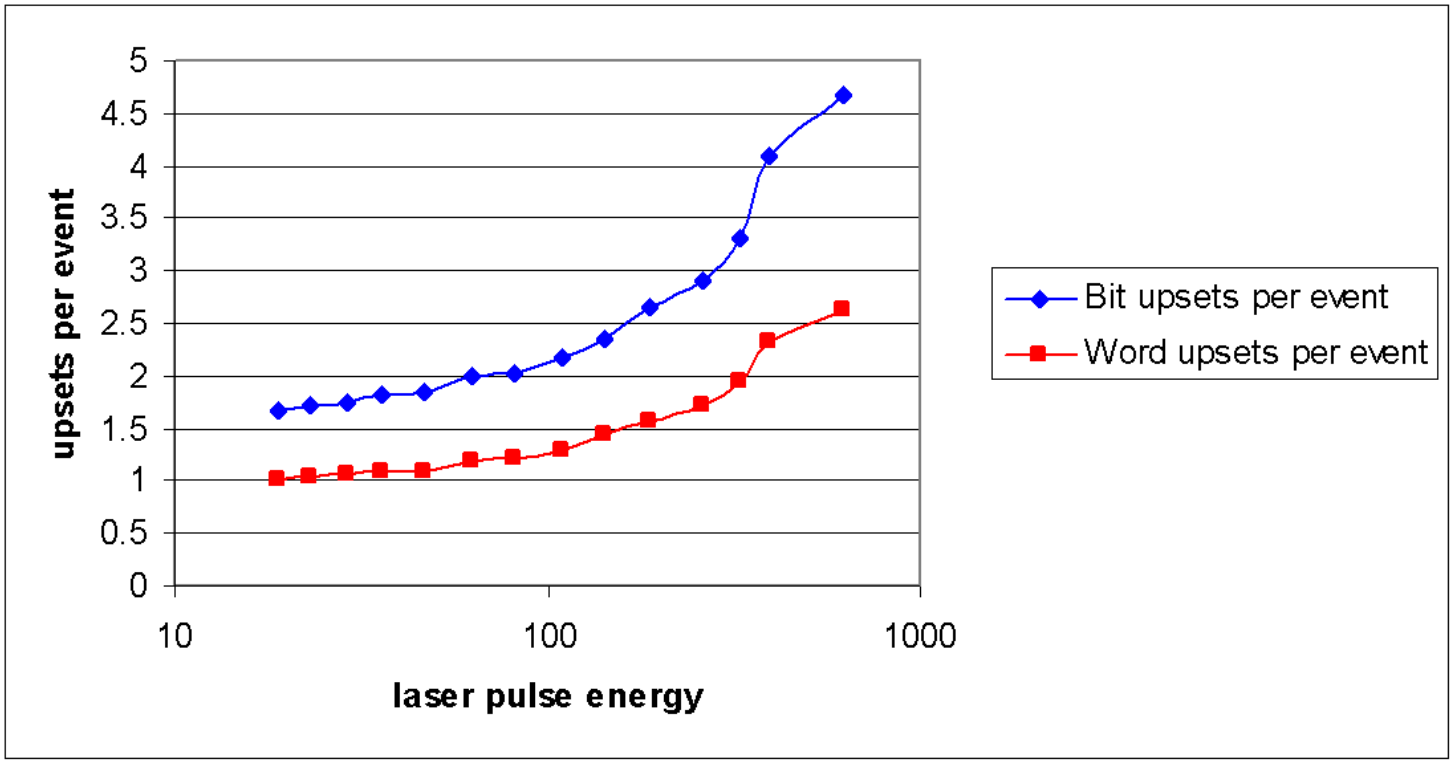
Trends in the mean bits per event and the mean words per even for the Maxwell 32C108R SRAM with increasing laser pulse energy

Note that for this device bits of the same word are physically adjacent



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SEREEL2 determination of SEE derating for power discrete devices

- Recent SPAESRANE results have shown
  - SEE breakdown voltage thresholds can be established with SEREEL2
  - SEREEL2 breakdown voltages have been shown to be within 5% of breakdown voltages with neutron/proton radiation
  - Laser can therefore establish derating of transistors/diodes for SEE environments

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Conclusions

- SEREEL2 has been shown to provide significantly enhanced performance relative to SEREEL1
- Fruitful results from memory cell SEE sensitivity threshold mapping
  - Reconstruction of cross-sections looks promising
  - Insights into origins of MBU sensitivity
- The laser is an excellent tool for studying MBU and MCU events
- New applications of SEE lasers are emerging
  - E.g. derivation of SEE derating voltages for discretes
- Backside pulsing with SEREEL2 is about to commence
  - To maintain and improve testability of perpetually-evolving components
  - Plan to SEE laser test the Atmel AT60142F SRAM used for the ESA Reference SEE Monitor
    - samples currently being backside polished
- This research demonstrates that the MBDA SEREEL2 facility delivers a wide range of SEE testing capabilities of value for spacecraft components

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