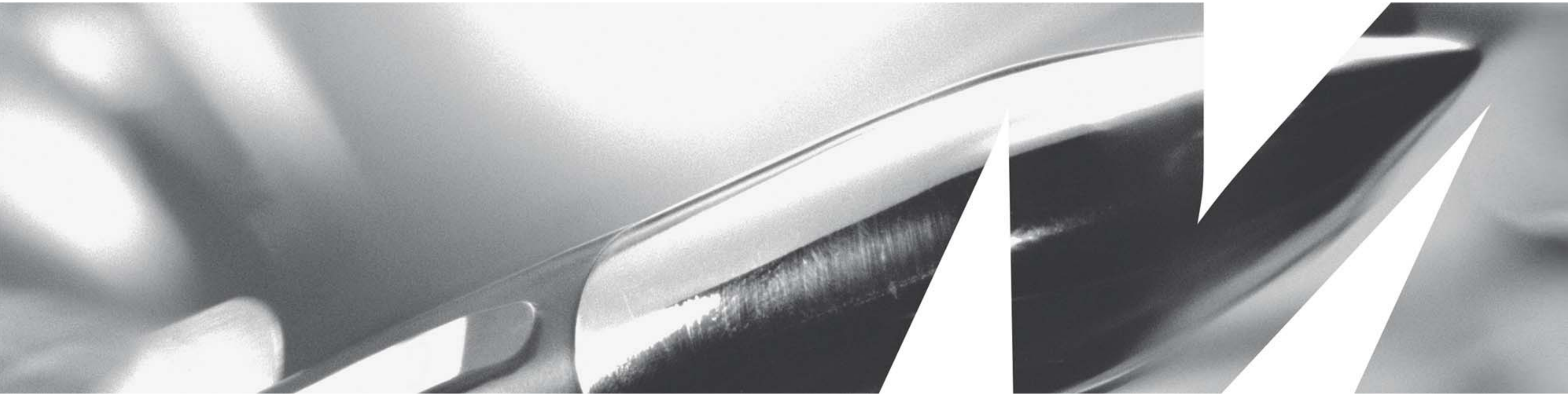


Laser Single Event Effects Studies Phase IV: Latchup Investigations of SRAM's Selected for the TDM

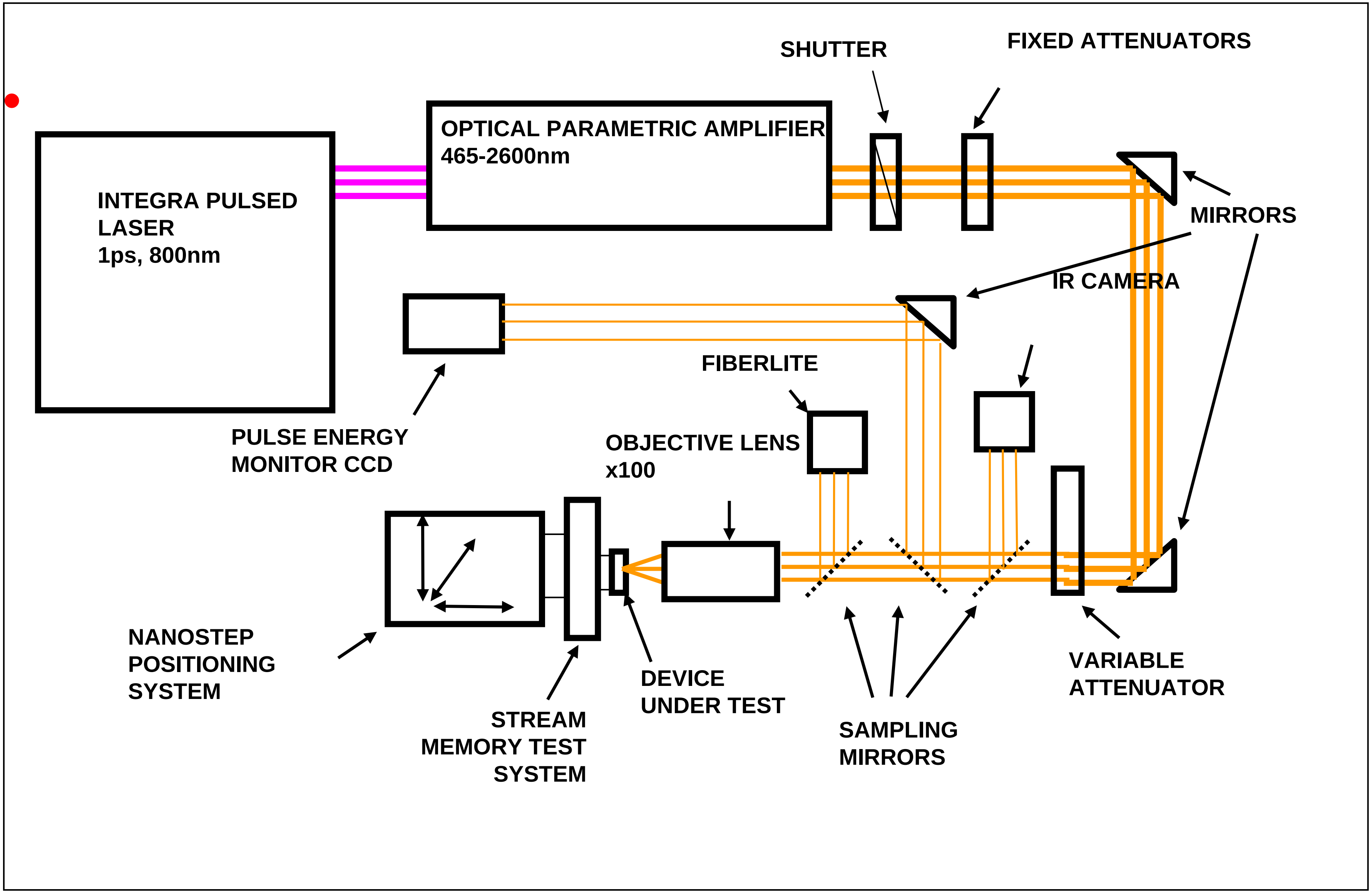
Prepared by Roger English
Presented by Andrew Chugg

Introduction & Objectives

- **Single Event Latchup sensitivity**
- Characterisation of the Single Event Latchup (SEL) sensitive volumes in close detail and broad die wide view.

- **Memory Mapping/Unscrambling**
- identify physical area patterns of the logical memory address lines on a large memory device.

SEREEL 2 System Layout



SHUTTER

FIXED ATTENUATORS

OPTICAL PARAMETRIC AMPLIFIER
465-2600nm

INTEGRA PULSED
LASER
1ps, 800nm

MIRRORS

IR CAMERA

FIBERLITE

PULSE ENERGY
MONITOR CCD

OBJECTIVE LENS
x100

NANOSTEP
POSITIONING
SYSTEM

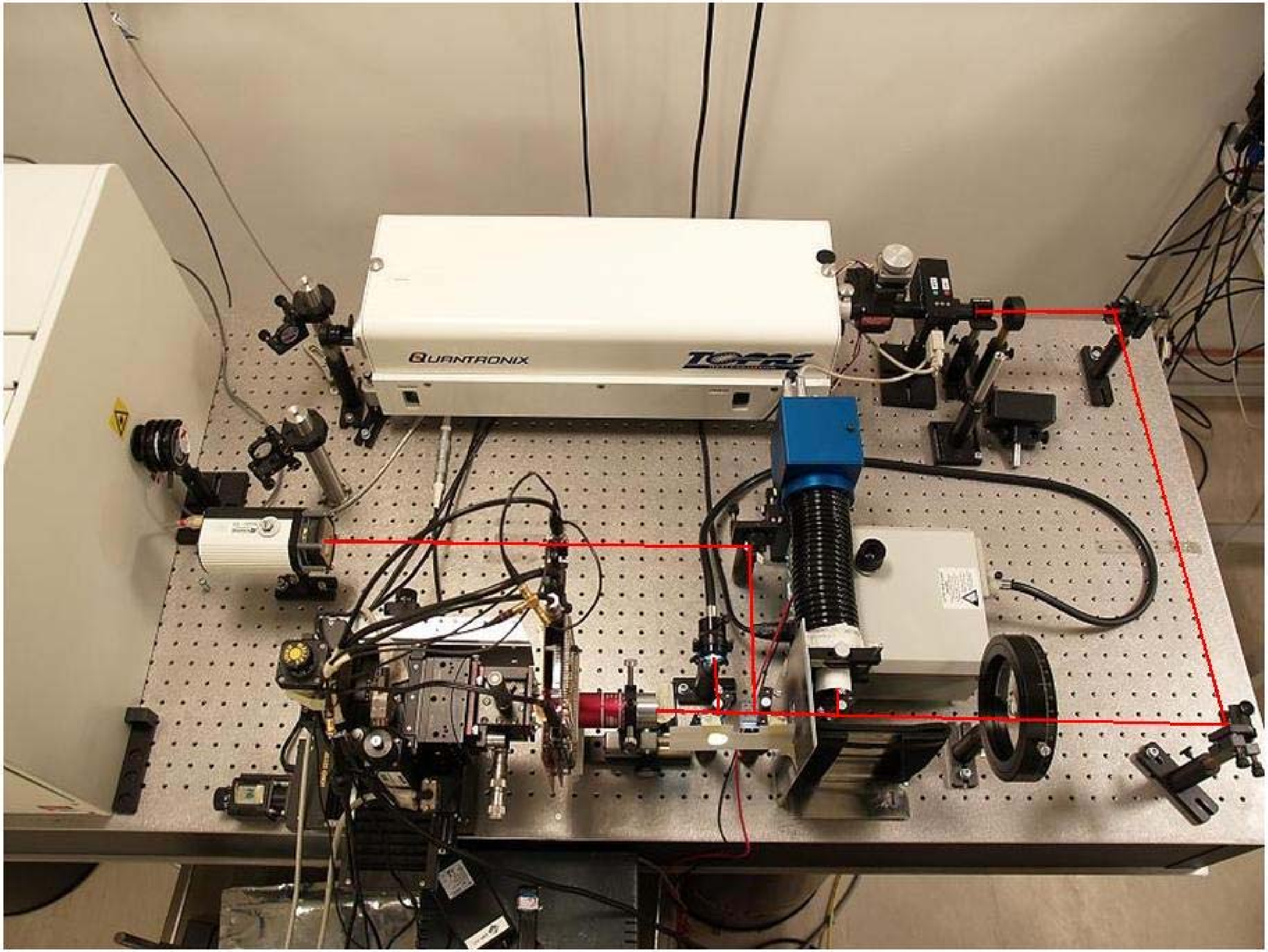
STREAM
MEMORY TEST
SYSTEM

DEVICE
UNDER TEST

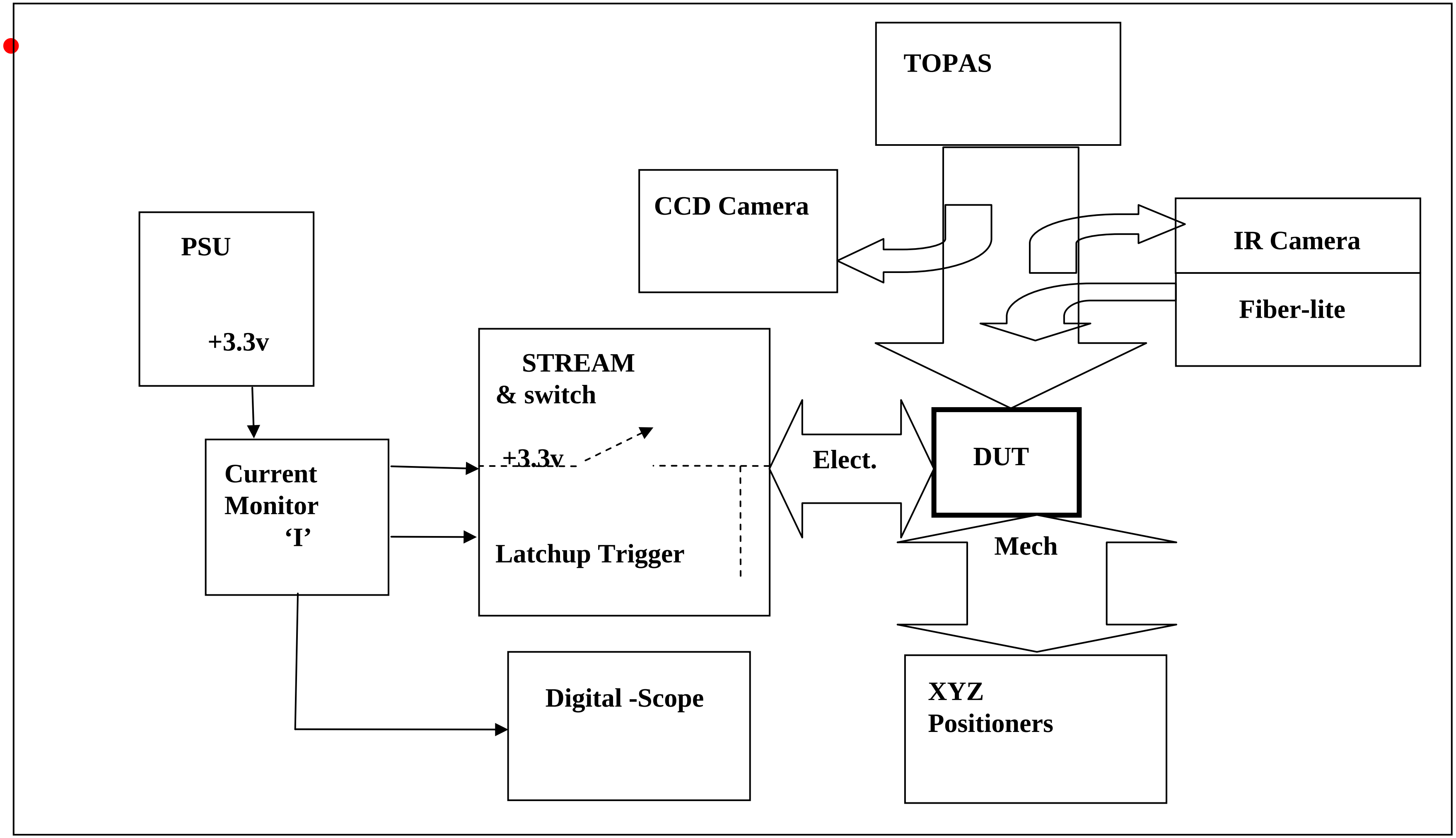
SAMPLING
MIRRORS

VARIABLE
ATTENUATOR

Optical Bench from above - showing beam positions



Simplified Test System Block diagram



Backside polished device sample

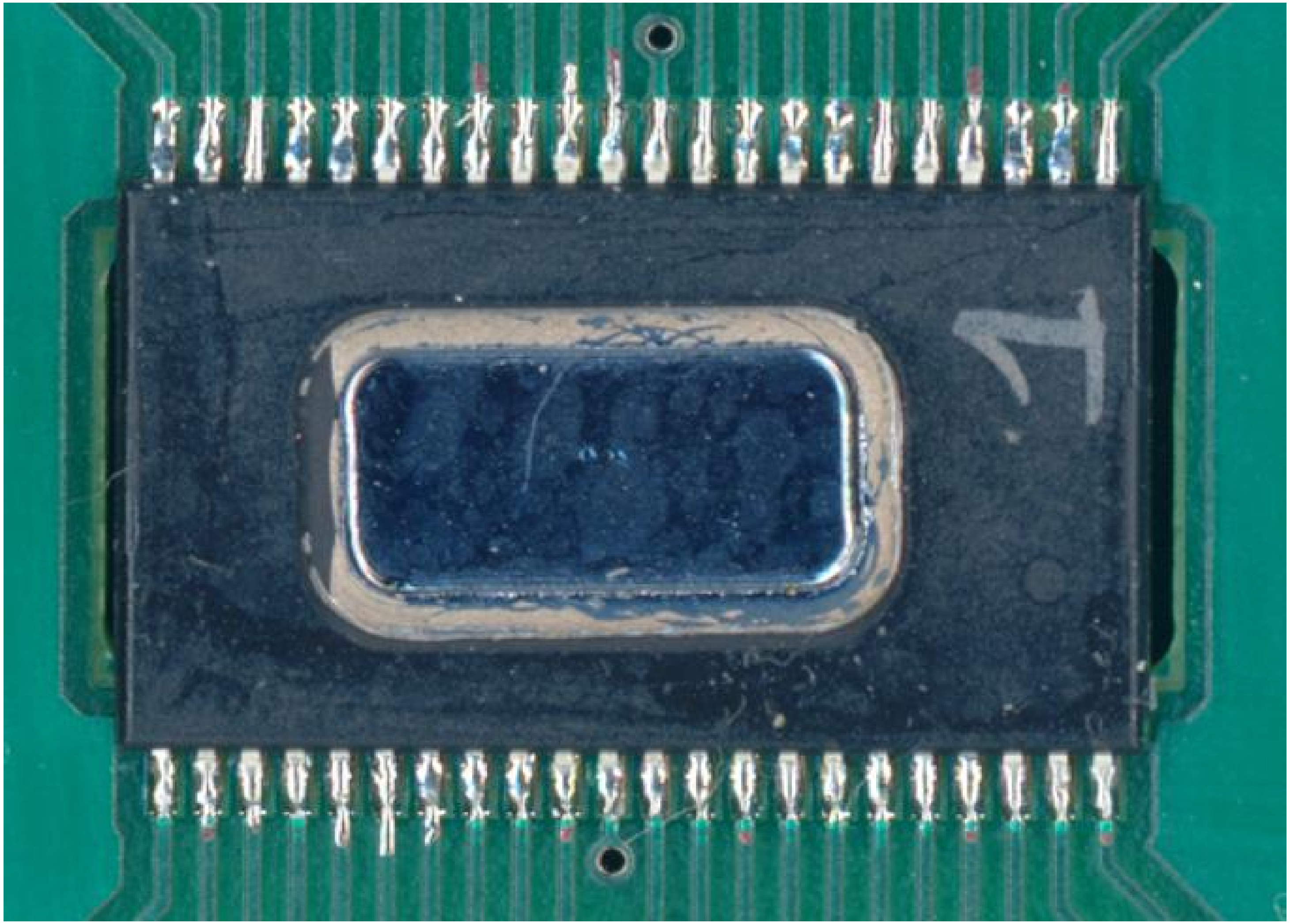
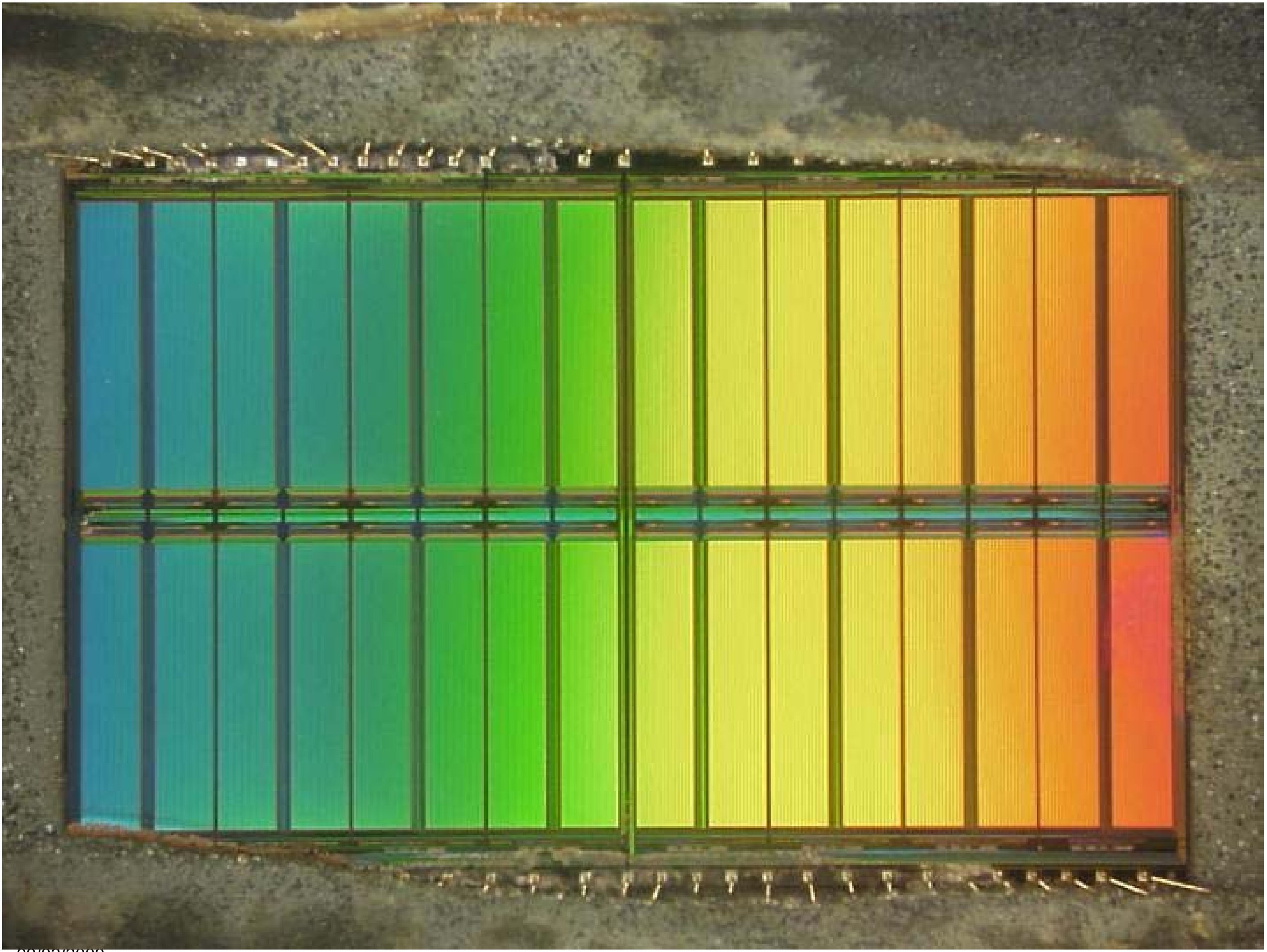
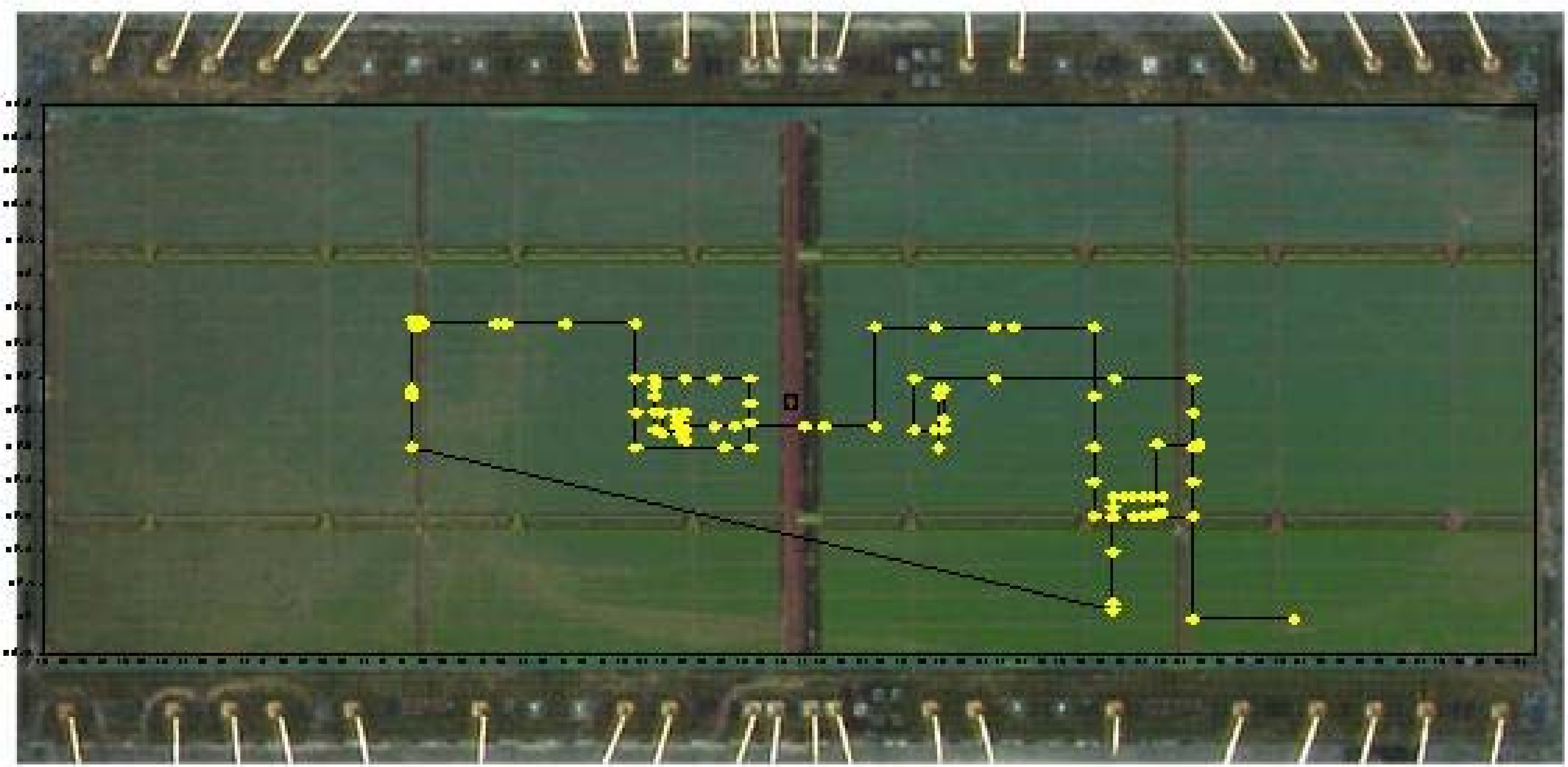


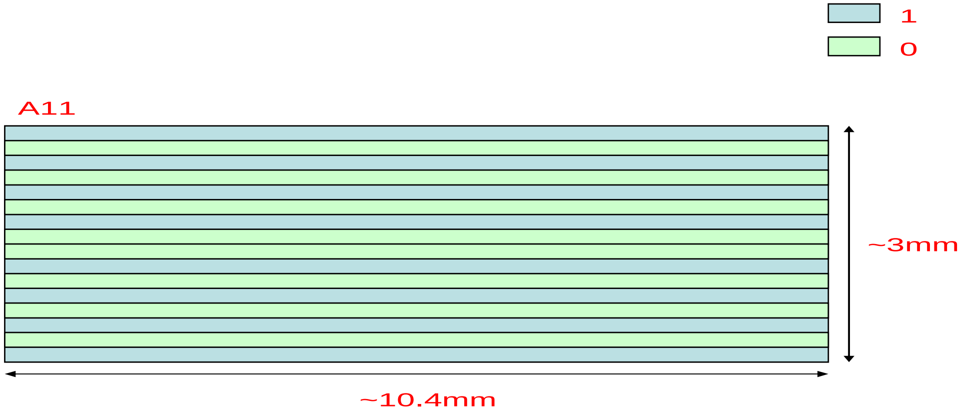
Photo of Brilliance device topside

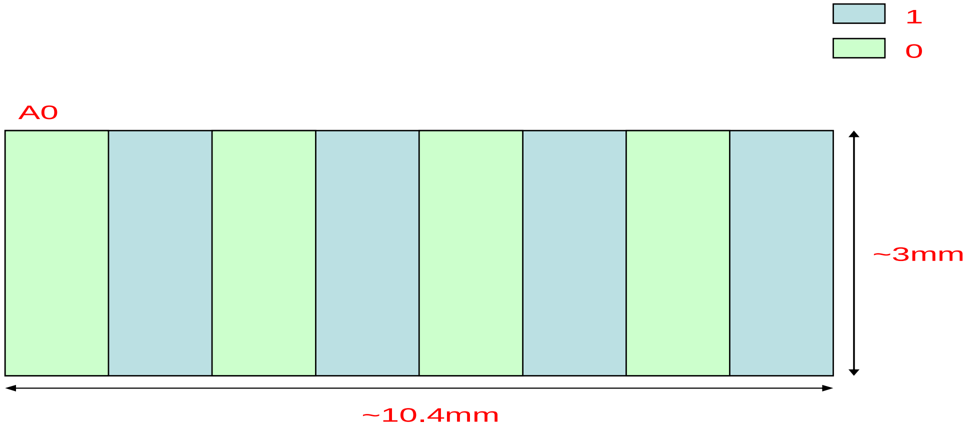


Alliance device, topside, with memory mapping scan pattern overlaid



Derived Address–Bit Layout Patterns for the Brilliance SRAM





SEL background

- Transistors in IC’s use adjacent **p-type** and **n-type** regions of silicon.
- **4 layer paths,** potential **parasitic** Silicon Controlled Rectifiers **(SCRs**).
- Not normally activated, transient high energy cosmic ray may activate.
- SCR Action is to **turn ON**. Must reduce **current to zero to turn OFF**
- Continues until current path fuses, or the power to it is cycled.
- With energetic (charged) particle, or focused laser pulse it is called **Single Event Latchup**.

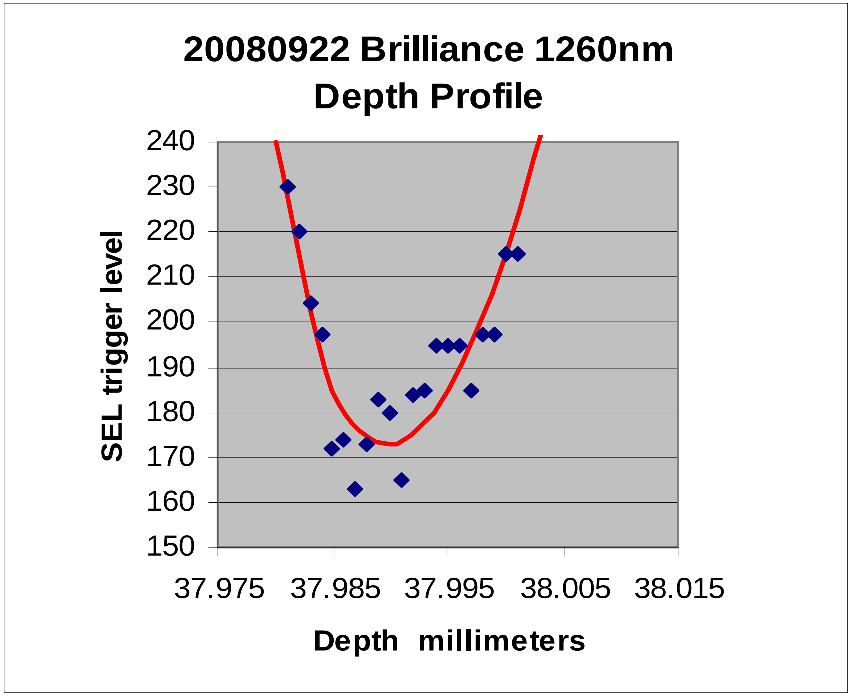
Single Event Latchup - Overview

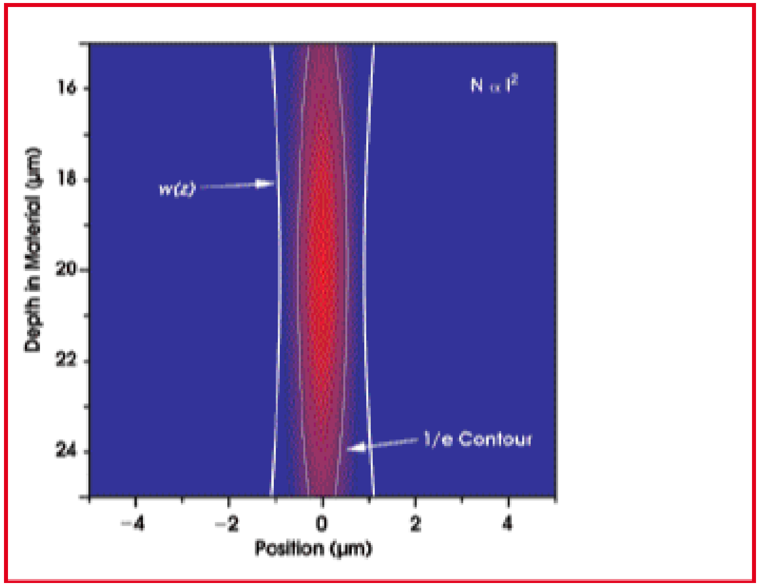
- Where an integrated circuit is susceptible to SEE it is expected that the sensitivity to **latchup will vary across the device**.
- This experiment was designed to show that we can plot out these variations at the **resolution of our equipment**, 1 micrometre.
- Hence we can **map the SEL** sensitive regions with high resolution.
- For each position in an array it was necessary only to know relative intensity to cause SEL and the position of the laser pulse.

Method Summary

- **Fix a physical reference point** corresponding to control logic using wideband lamp & IR camera to focus objective lens onto the die.
- **Memory cells** moved into view (vast array of identical rectangles) and check laser.
- **SEREEL2 XYZ positioning system** manoeuvres DUT around the laser spot in small regular pattern.
- **STREAM** is continuously testing whole memory. Approx 1 test/second
- **Set next point** in the regular scan pattern; increase laser pulse intensity until latchup. Record level on spreadsheet for charts and analysis.
- **300** is a useful number of spots

SEL Depthwise Sensitivity Profiles



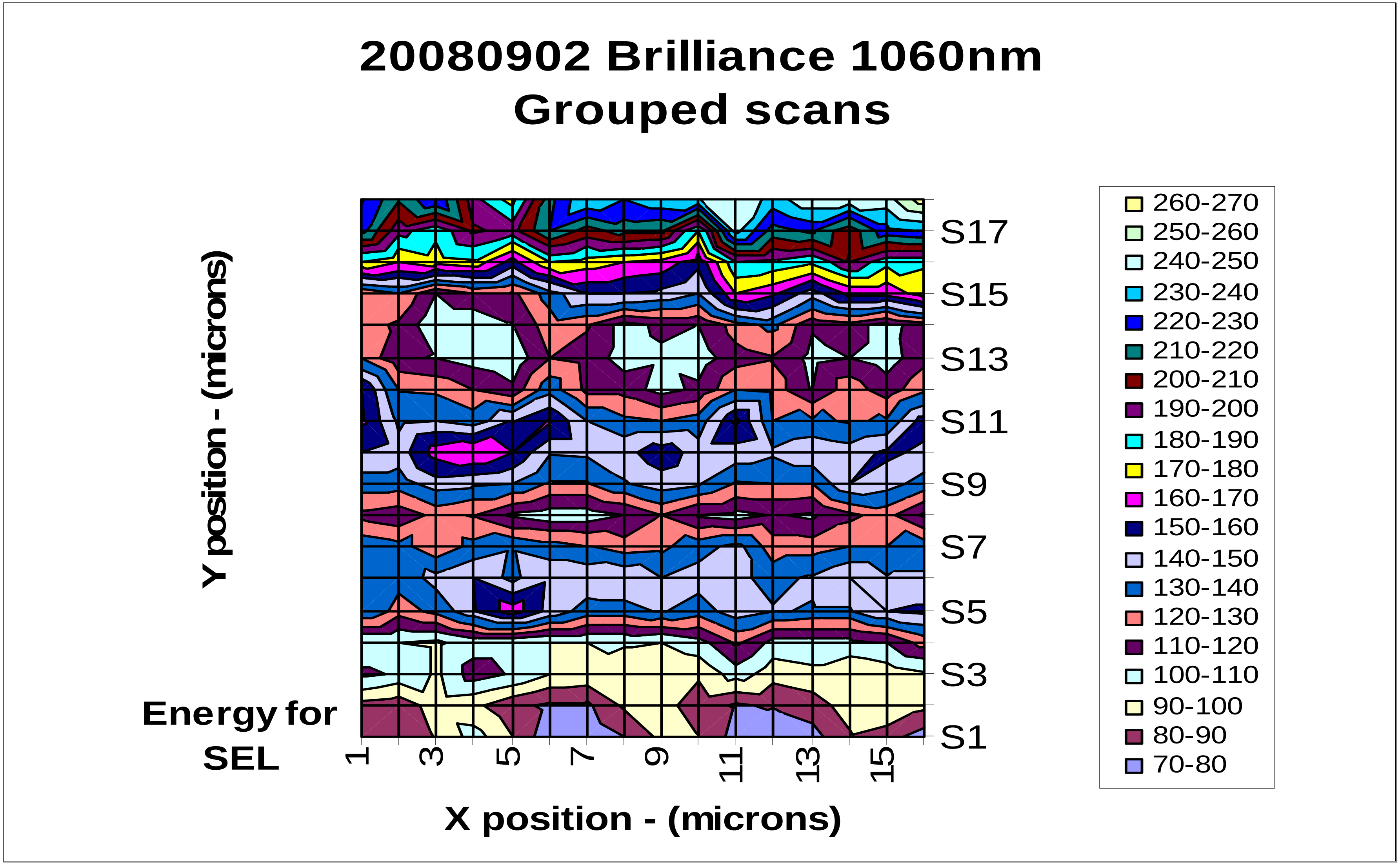


The depth width of the SEL sensitive region was generally ~10-20μm, suggesting that the real thickness of the SEL sensitive layer is smaller than the length of the lenticular 2-photon absorption maximum

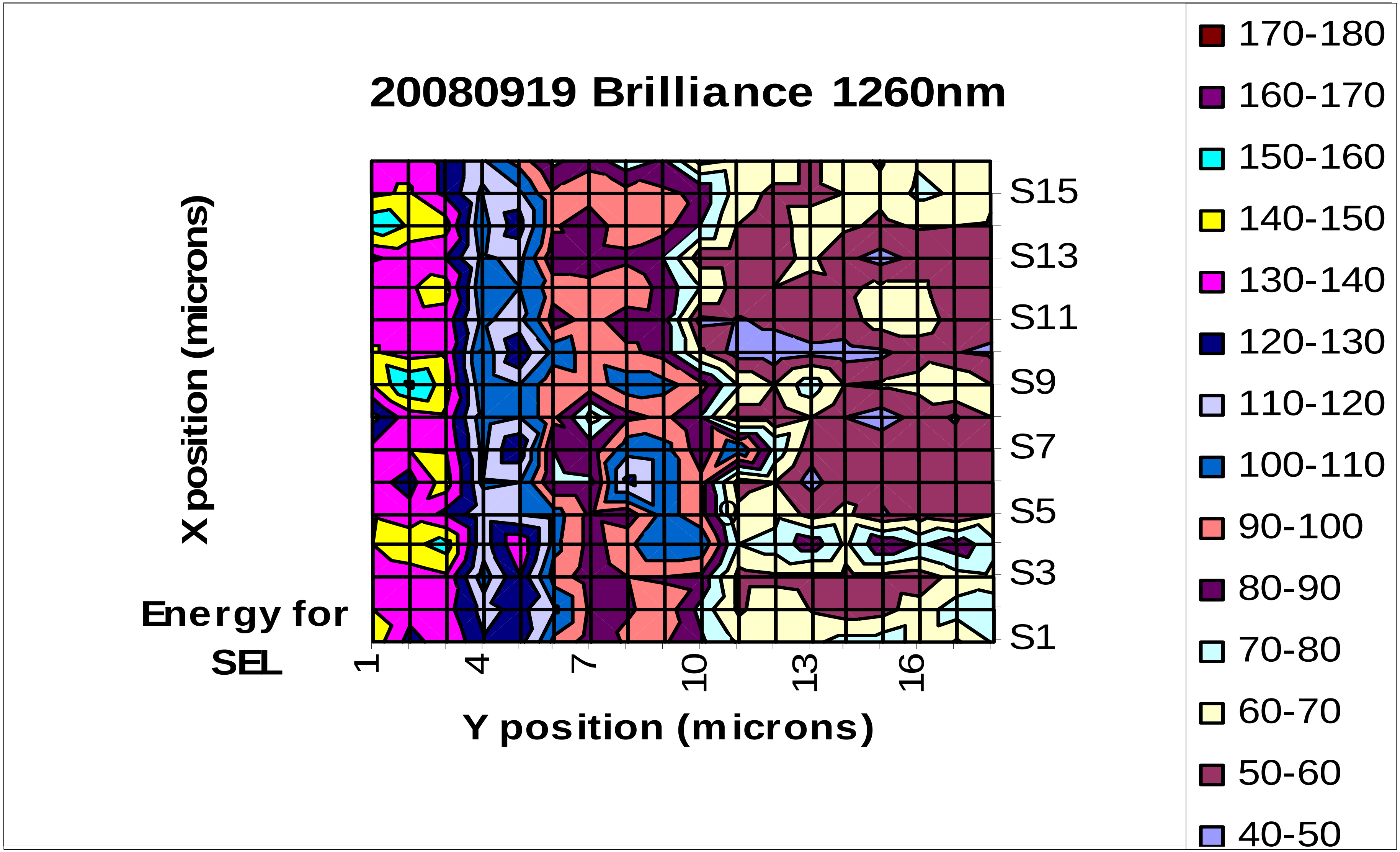
Results – Charts, Tables and Images

- **2D ‘surface’ chart with coloured contours.** Features approximate to twice size of the cells with a regularly repeating nature in the patterns. Features reflect real SEL sensitivity variations within the cell arrays.
- **Graphs of depth scans** are included to show variation of thresholds with focus depth, going into the surface of the device, Z-axis, at two X-Y locations on each device.
- **Tables** show variation of thresholds across each die.
- **IR** images collected on the IR camera and recorded as digital ‘pictures’. This shows detail of device topology, cells and control logic and position of laser pulse on device.
- **3D charts** are presented to illustrate a particular point.
- **Measured energy levels** of the laser pulses are relative within each test & not absolutely calibrated. They may not be related between tests.
- **Pulse energy** was estimated to be of the order of picojoules

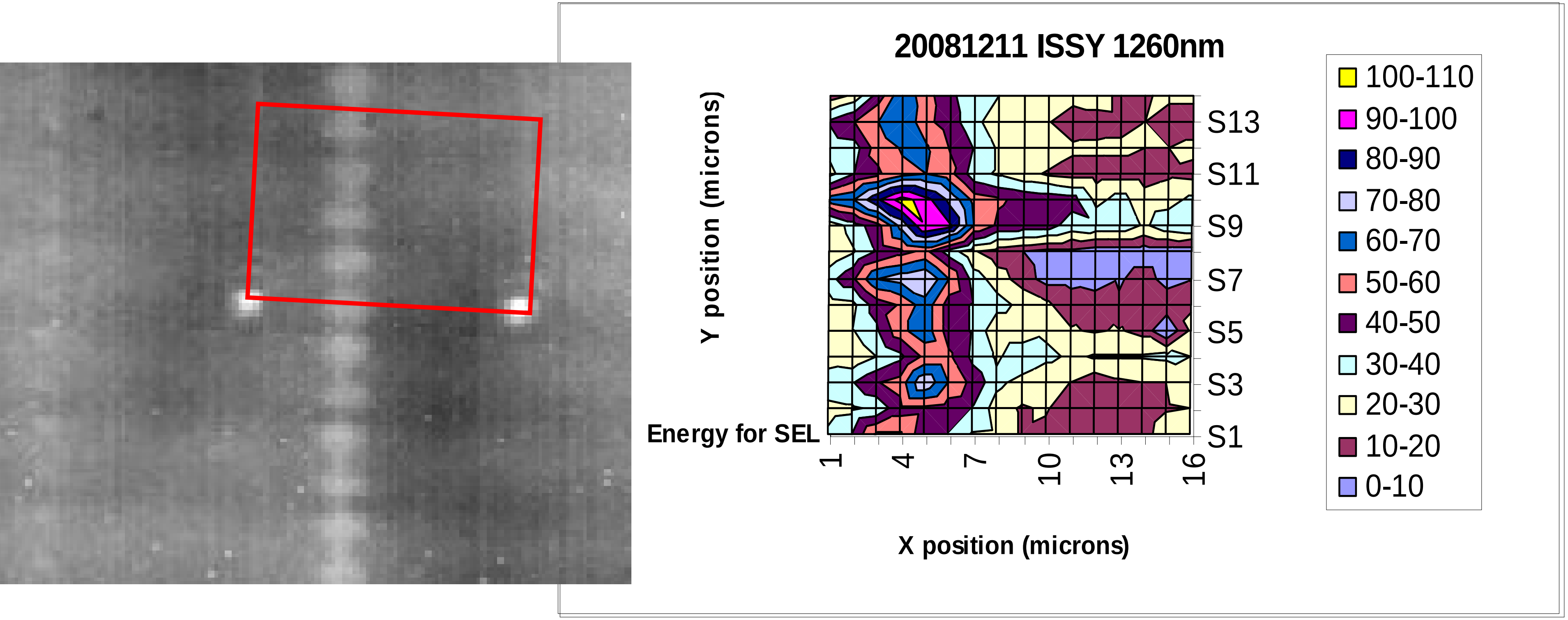
Chart combines three runs performed at intervals on one day



Contours of levels of sensitivity to SEL for one continuous run of 288 measurements



Correlation of less sensitive region on chart with features on the IR Image.



Whole Die scan

- **ISSI & Alliance** SEL data was collected from a number of locations spread across the devices. It was not viable to have a complete regular fine scan pattern.
- **Chosen locations** were viewed during laser illumination using the IR camera enabling the locations to be identified as memory cells or control logic.
- **Control logic** was not sensitive to laser pulses when subject to minimum attenuation.
- **Focus** depth affects sensitivity to latching. Die was not accurately aligned normal to the laser beam. It was necessary to reset the focus at each location. Focus value settings were correlated across the device to ensure consistency.
- **Result** The SEL threshold of the memory cells varied in a range which is compatible with ranges encountered in detail small area scans illustrating that the general sensitivity across these die does not vary dramatically.

Die Wide Scan

Die Wide Scan **20081215 ISSI**

Attenuator angle for latchup

🟩 cells

🟪 control

Y pos'n \ X pos'n	3.800	4.200	4.600	5.000	5.400	5.800	6.200	6.600
20.750	🟩 206.000	🟩 198.000	🟩 222.000	🟪 300.000	🟪 255.000	🟩 212.000	🟩 218.000	🟩 179.000
19.750	🟩 219.000	🟩 215.000	🟩 168.000	🟪 300.000	🟩 220.000	🟩 198.000	🟩 198.000	🟩 210.000
18.750						🟩 194.000	🟩 191.000	🟩 169.000
17.750				🟪 300.000	🟪 300.000	🟪 300.000		
16.750	🟩 231.000	🟩 192.000	🟪 300.000	🟩 200.000	🟩 152.000	🟩 210.000	🟩 199.000	🟩 150.000
15.750	🟩 190.000	🟩 217.000					🟩 194.000	

SYSTEM IMPROVEMENTS – Some of the items considered

- **Q/ TOPAS output varies pulse by pulse**…..A/ Measure level on rising and falling attenuator setting
- **Q/ Attenuator value determined ‘on the move’**…… A**/** as above
- **Q/ Temperature**…..A/ The room is air conditioned. Keep white light on throughout experiment. SEL is highly temperature dependant
- **Q/ Beam alignment drift…..**A/ This challenge is ongoing
- **Q/ XYZ errors due to cable strain**…..A/ Strain relief provided
- **Corner mirrors are mechanically vulnerable**…..A/ protection fitted

CONCLUSIONS

- **Laser illumination** of large and complex devices, stimulate SEE on single cells.
- **Avoid obscuration** of metallisation & illuminate at IR through back of the silicon.
- **Powerful, precision & speed** enables test of large memories for SEE.
- **Memory mapping** ‘decoded’ the die areas covered by memory address bits.
- **Sensitivity patterns** at the micron scale. Cell area is congruent with chart patterns .
- **Correlation** between sensitivity and visible features.
- **Scope for development** in speed & accuracy & remove the human element.
- **Accuracy** has been improved & we have seen less apparent system drift.