



The application of laser SEE testing as a new radiation effects validation and screening technique for COTS components

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- Our Harwell, UK office provides services in:
 - Radiation testing for space, nuclear and medical applications
 - Electronic component and materials testing
 - Total integrated dose (TID) testing (ESCC 22900, Mil-Std-750/883)
 - Single event effects (SEE) testing (ESCC 25100, JESD57)
 - Irradiation with gamma rays, electrons, protons, neutrons, alpha particles and heavy ions
 - SEREEL2 laser single-event effect test systems
- We have our own, walk-in cobalt cell for gamma irradiations
- ISO 9001:2015 accredited
- We are the only test house outside the US to have full DLA laboratory suitability for total dose testing over all test conditions

Current practice for space radiation testing



	Traditional GEO	Traditional LEO	New LEO
TID	✓	✓	x
SEE - heavy ions	✓	(✓)	x
SEE - protons	(✓)	✓	(x)

Current practice for space radiation testing

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Risk	😊😊😊	😊😊	😞😞

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Cost	😞😞	😞	😊😊

- Single Event Effects (SEE) are prevalent in space, for aerospace applications and even at ground level
- Transistor dimensions have been scaled sufficiently that most digital devices are now sensitive to SEE unless mitigated
- The cost of testing at accelerators is high and availability is poor
- The confluence of these factors now makes laser SEE testing attractive

What is laser SEE testing?

- Single Event Effects (SEE) are prevalent in space, for aerospace applications and even at ground level
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-
- Pulsed lasers enable charge to be injected into semiconductor structures to mimic an ion strike
 - Excellent temporal and spatial information is available
 - Testing is quick and low cost
 - Ideal for screening and product development

- Pros

- 24/7 availability in your lab
- Low cost
- SEE response can be related temporally and spatially to the sample
- No radiation damage is imparted to the sample

- Cons

- No general quantitative correlation with ion beam testing
- The laser beam cannot penetrate metal layers
- Only complementary to radiation testing

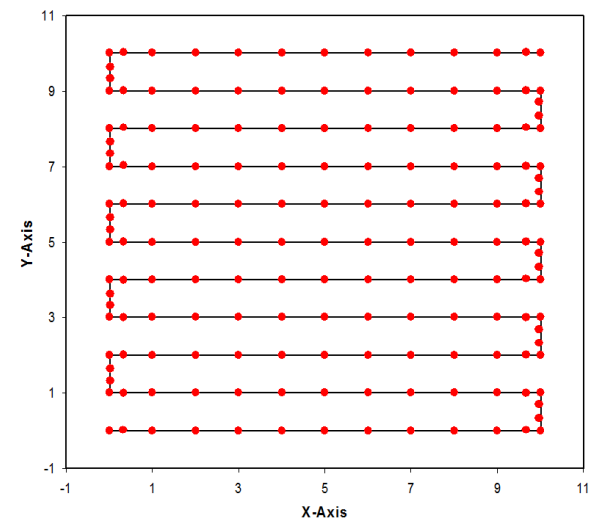
What can I do?	Ion beam	Laser (SPA)	Laser (TPA)
Bulk screening of devices	X	✓✓	✓
Accurate cross-section v. LET	✓	X	X
Mapping SEE sensitivity	X	✓	✓✓
Rad hard product development	✓	✓✓	✓
Investigate deep charge collection phenomena	✓	✓	✓✓
Study rare events, e.g. SEFIs		✓✓	✓✓
Understand sensitive volumes in three dimensions			✓✓
Rapid SEL screening	X	✓✓	✓✓

- Stability of the laser (users want no adjustments)
- Friendly user interface
- SPA and TPA capability in one machine
- Easy set-up (auto-levelling, autofocus, automatic die registration)
- Flexibility to accept a wide range of DUT board size and mass
- Spiral scanning to maximise the speed, efficiency and accuracy of the system

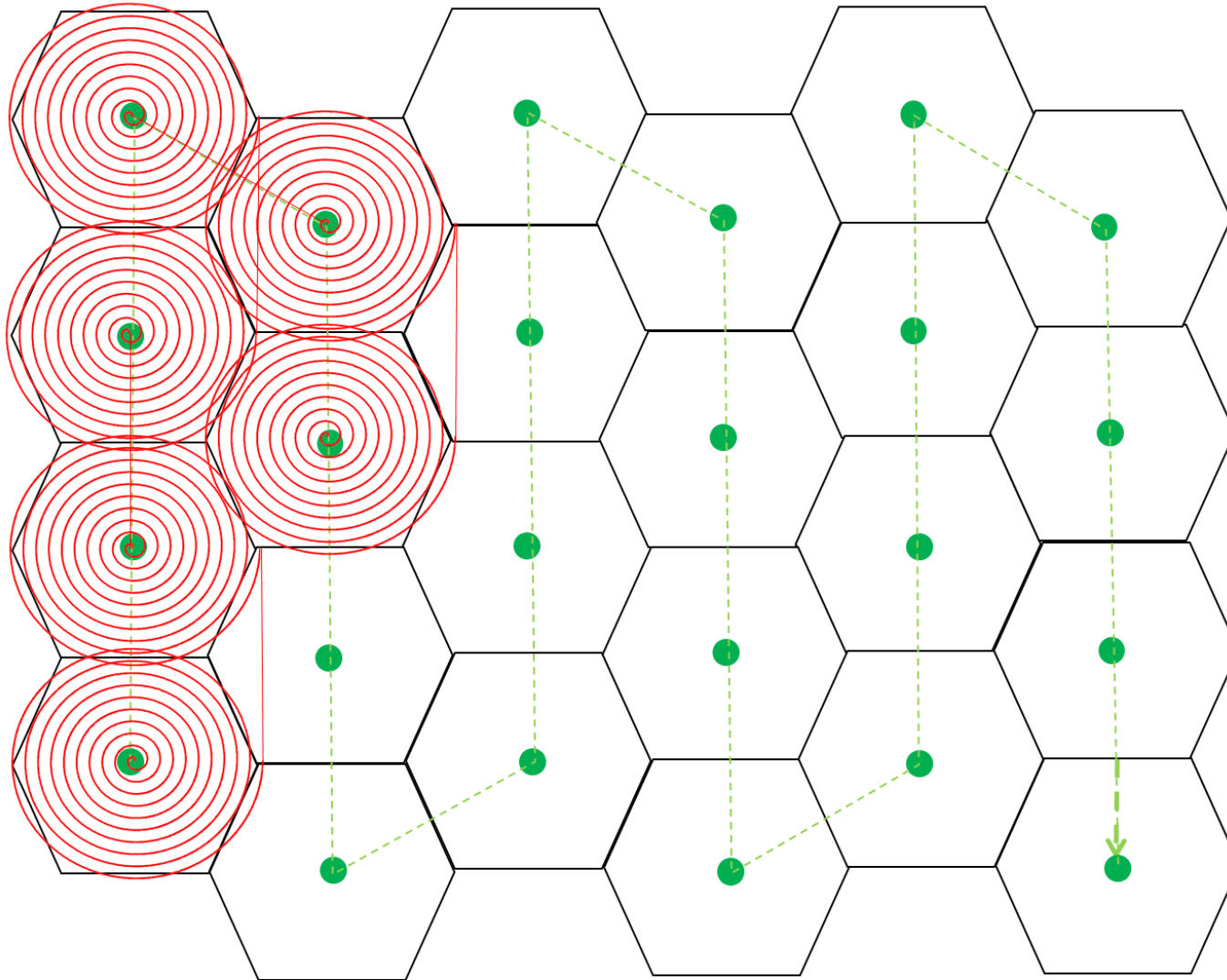
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Desirable criteria:

1. constant scanning speed
2. smooth trajectory with minimal acceleration
3. even distribution of laser pulse sites



Tessellating spirals



SEE testing examples

Instrumented Levelling 9.vi Front Panel

File Edit View Project Operate Tools Window Help

15pt Application Font

Search

Calibration File Selected Execute

Camera Calibration Filename
C:\User...\XC-(21-03-2019)-1000us_12398.xca

Zstep (um) 5 ZY (um) 20381.4
Max Inclination (deg) 10 X-Axis Rotation (DEGREES) ZX (um) 20200.8
Z0 (um) 20291 X-Axis Rotation (DEGREES) -5.14262
DY (um) 1000 Y-Axis Rotation (DEGREES)
DX (um) 1000 Y-Axis Rotation (DEGREES) 5.15247

stepper error in status code source
Y Motor Index 1 status code 0
X Motor Index 0 source

Enumerate 444013960 Yname Xname
xi-com:\\ xi-com:\\

Device Count 2 Y stepper error out status code source
X stepper error out status code source

Camera Integration Time (us) 10000 Frame delay (ms) 1000 Image Sample Pixel Radius 70 width (pixels) 320 height (pixels) 256 Xenics error out status code source

gonio VISA resource name COM6 Initial gonio X direction and steps -0 Initial gonio Y direction and steps +0
gonio baud rate 9600 gonio data bits 8 gonio bytes read 12
parity None gonio read string LX-16091
stop bits 1.0 flow control OK
None

Mercury_GCS_Configuration_Setup.vi is running
Conn. axis Mercury 2 Initial Mercury Move (mm) 0
Mercury PI System Number 2 Mercury Z0 (um) 20291 Mercury Z0 Out-of-Range
Identification Mercury controller
(c)2018 Physik Instrumente (PI) GmbH & Co. KG, C-663.12, 019550124, 00.048

Mercury error in status code source
no error 0
Mercury error out status code source
no error 0

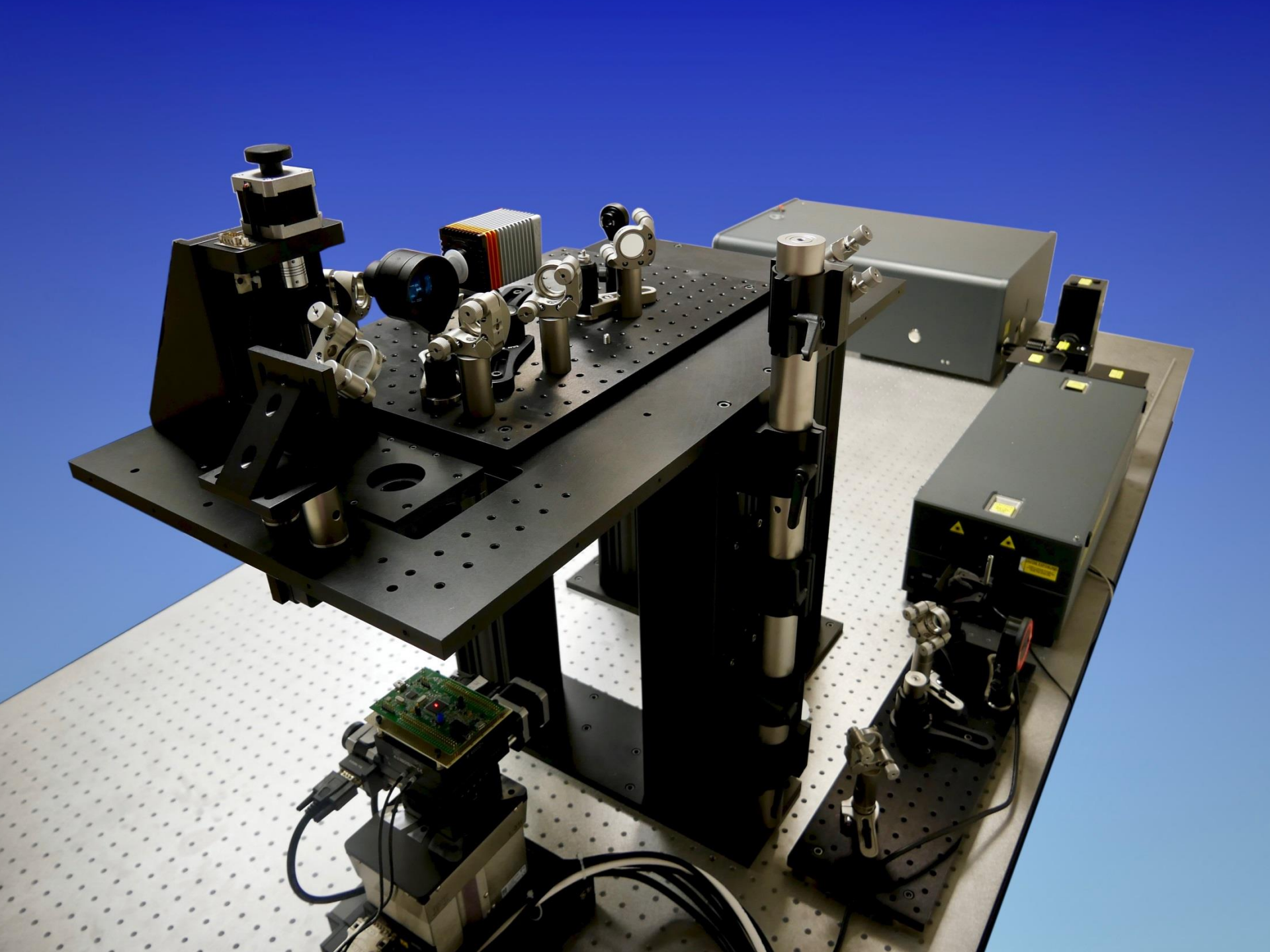
Focus ZY variances
Variance Score vs Z-displacement (um)

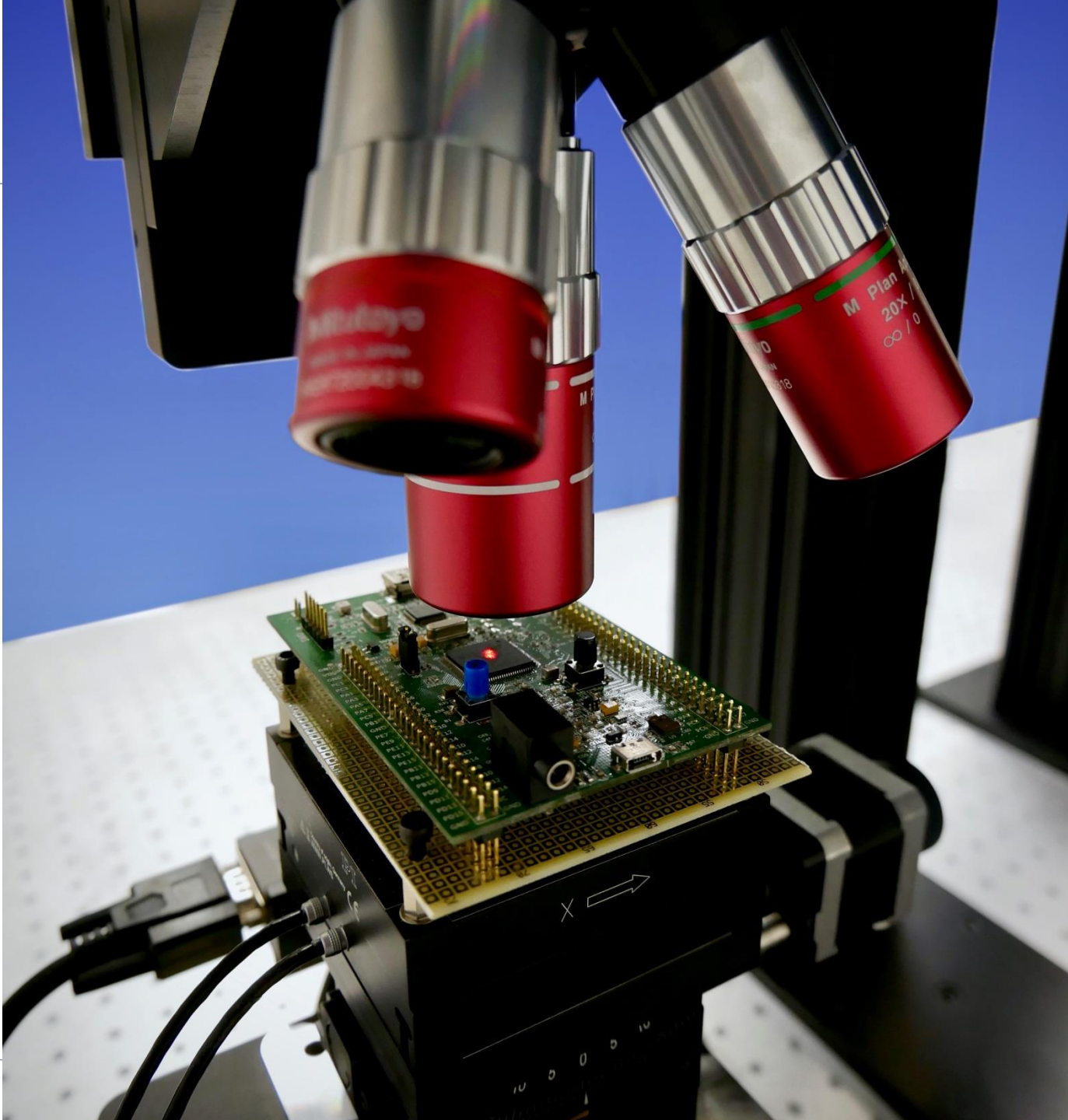
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Camera framegrabs

Intensity Distribution histogram count

count vs amplitude





- Any approach to obtaining radiation performance data on COTS components is better than doing nothing
- The aim is to reduce risk significantly without increasing costs (much)
- Standard SEE testing cannot achieve this but laser SEE testing can
- Using lasers makes SEE testing available and affordable for everyone

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