NWTF

Testing of Single Photon Avalanche Diode Cameras for pressure-sensitive paint measurements

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National Wind Tunnel Facility Conference, 02-03 April 2025

The Exchange, University of Birmingham, UK

MANCHESTER 1824

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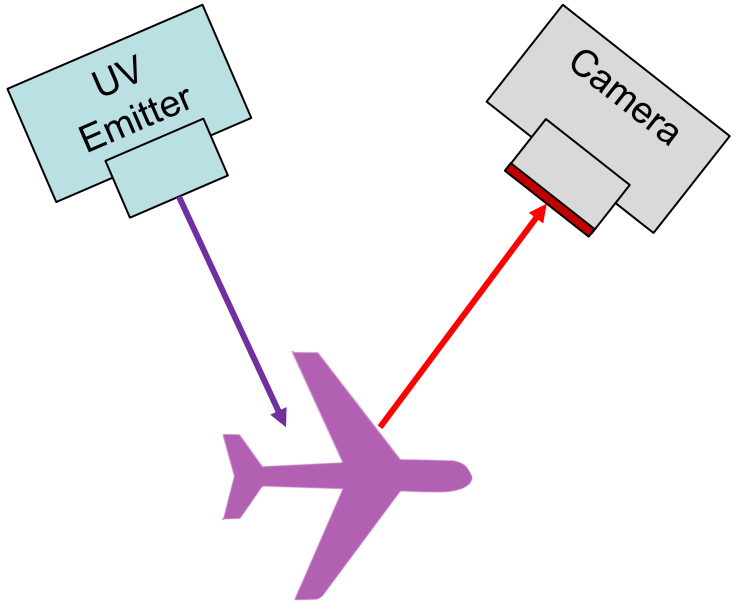
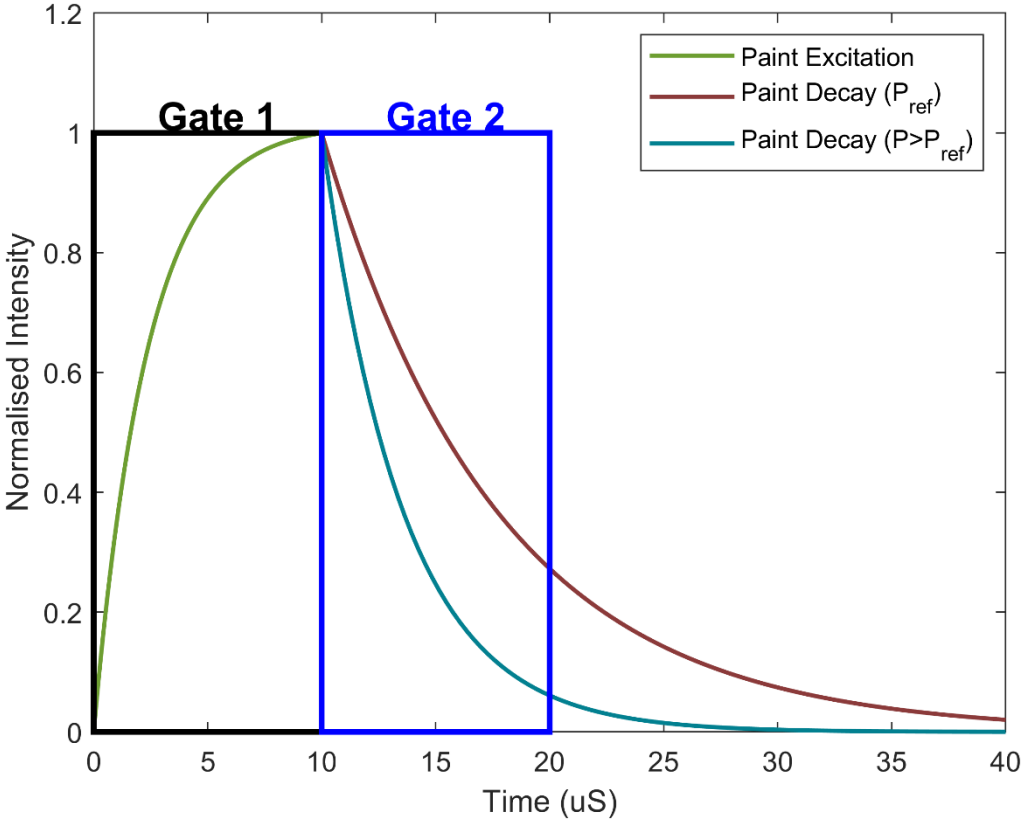
AIRBUS

What is PSP?

- A quantitative pressure measurement technique.
- Data gathered over a surface compared to point data of traditional pressure taps.
- Uses the principles of photo-luminescence and oxygen quenching.
  - The amount of light depends on the partial pressure of oxygen.



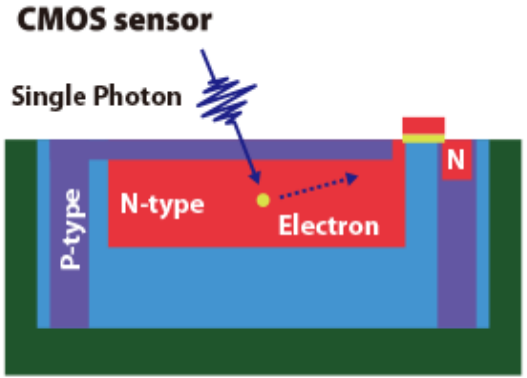
PSP methods


Gate 1
Gate 2
Paint Excitation
Paint Decay (P_ref)
Paint Decay (P>P_ref)
Normalised Intensity
Time (uS)
0
0.2
0.4
0.6
0.8
1
1.2
0
5
10
15
20
25
30
35
40

Traditional vs SPAD sensing

approx. 1X multiplication

Due to the impact of noise, may not be able to detect a single photon, leading to degraded accuracy.



approx. 1000000X multiplication

Correctly detect an incident of single photon. Detection of an individual photon without noise increases the accuracy of infomation.

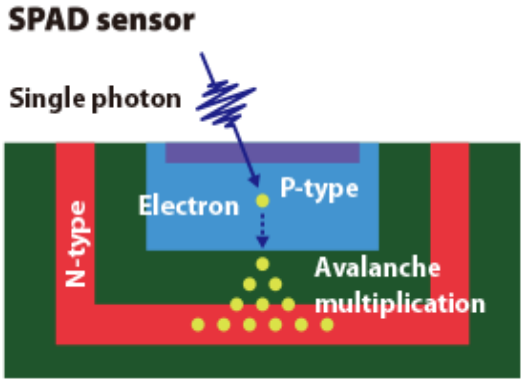
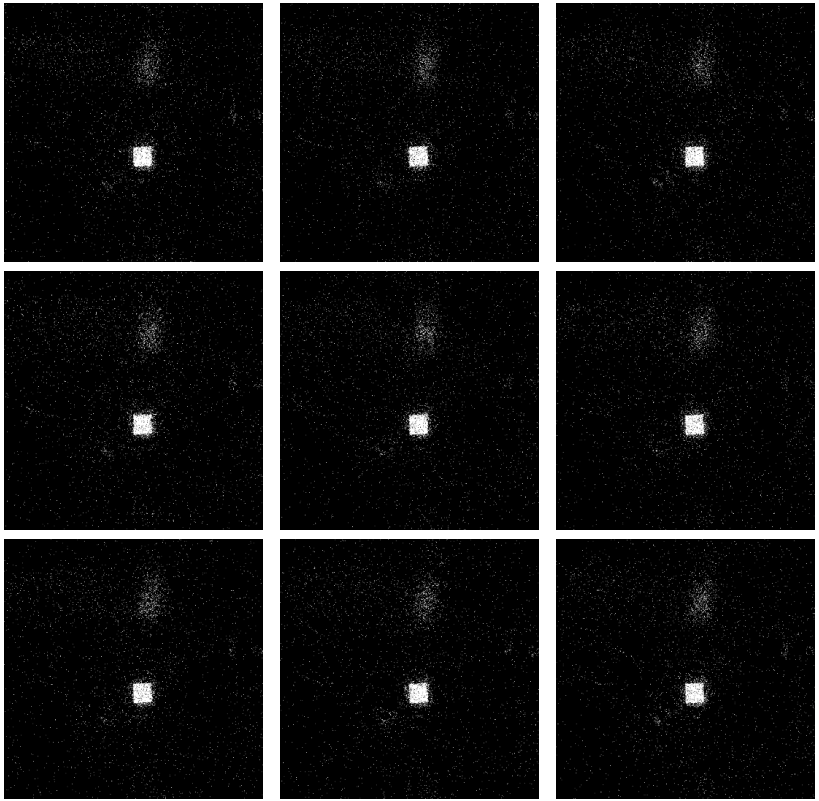
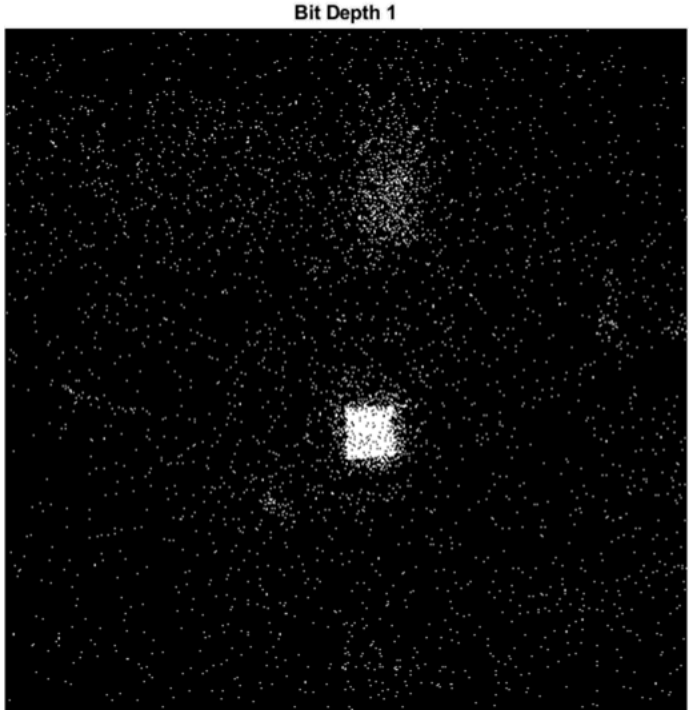


Image from Canon

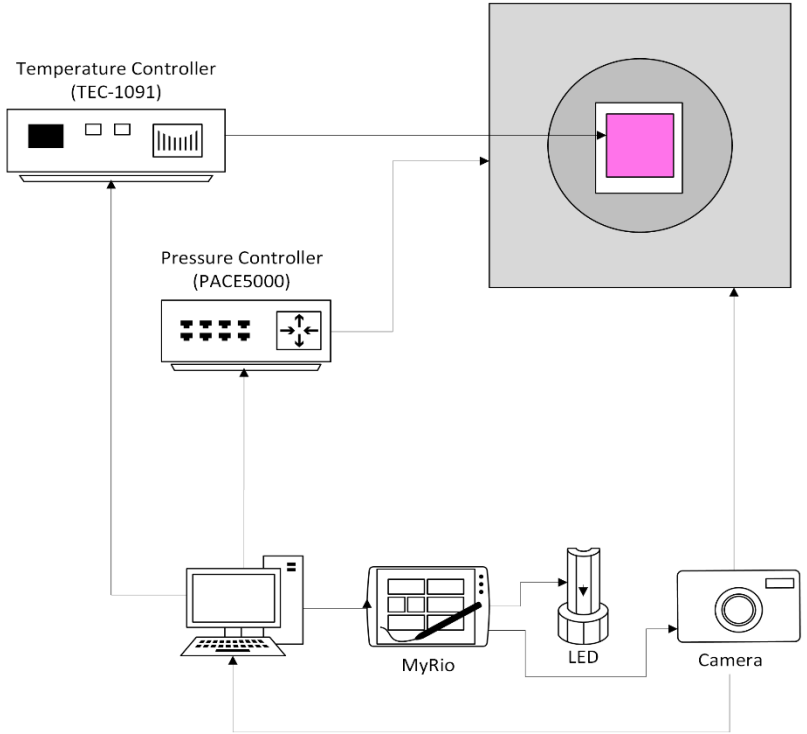
1-bit to n-bit images





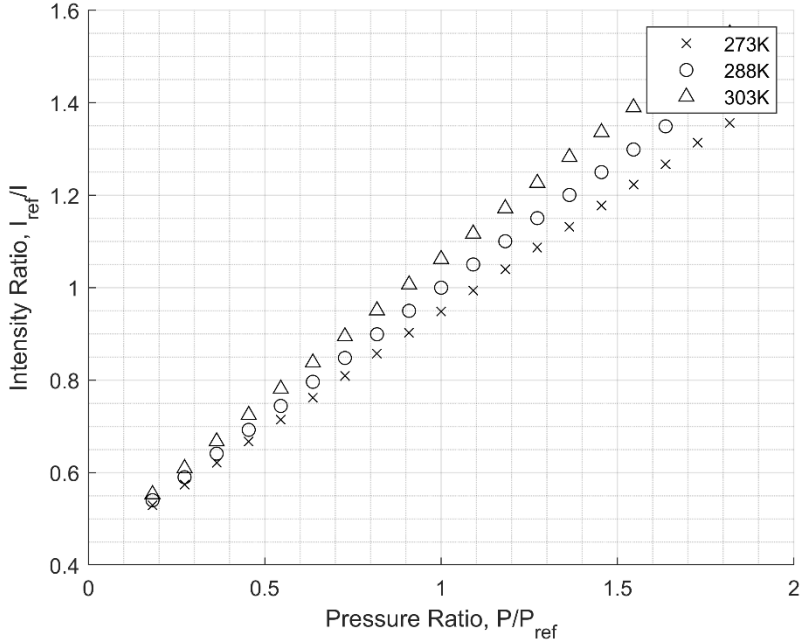
Experimental set-up

- In-house calibration chamber.
- TEC-1091 PID temperature controller.
- DRUCK PACE5000 pressure controller.
- PCO.2000 & SPAD 512^2 cameras.
- Luminus Devices CBM-120-UV with custom overdrive circuit for lifetime
- ISSI 2-Inch UV LED Lamp for intensity
- Temperature settings: 273K, 288K, 303K.
- Pressure range: 20-200kPa in 10kPa increments.

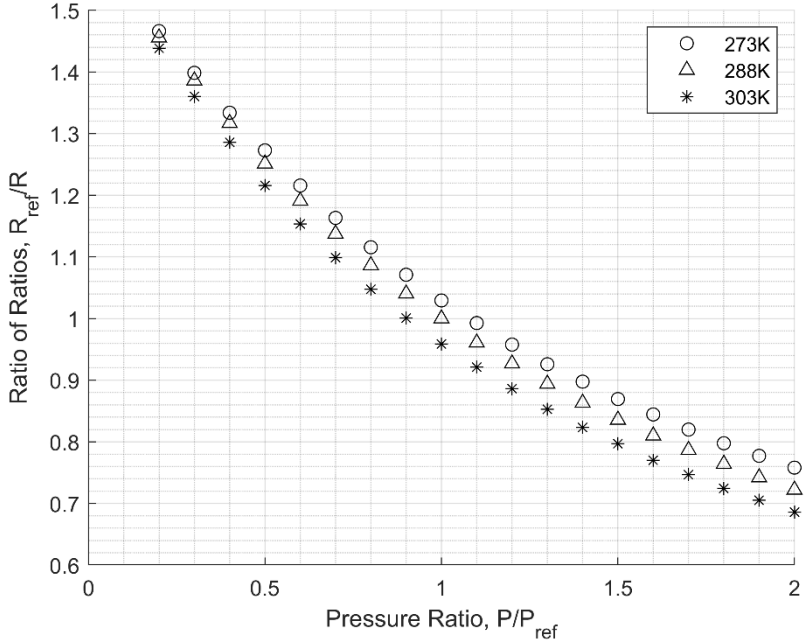


Calibration curves

Intensity

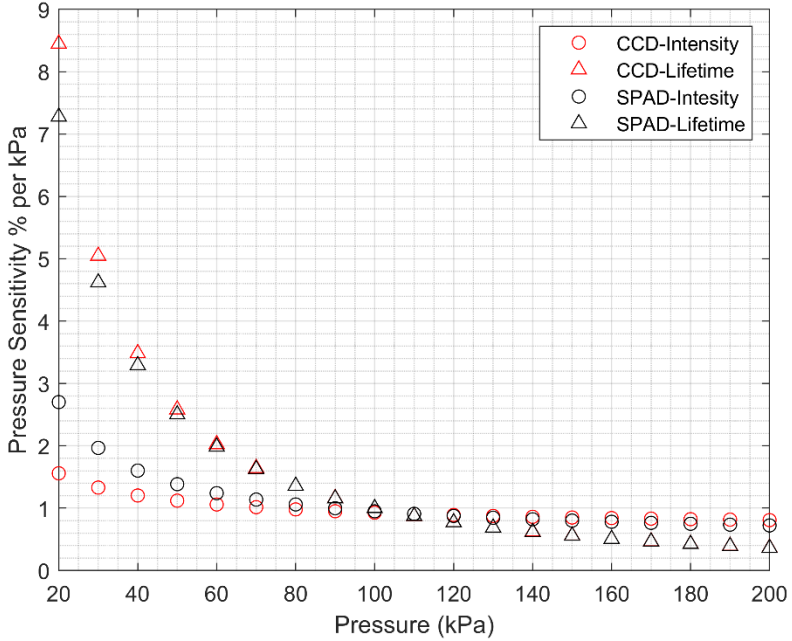


Lifetime

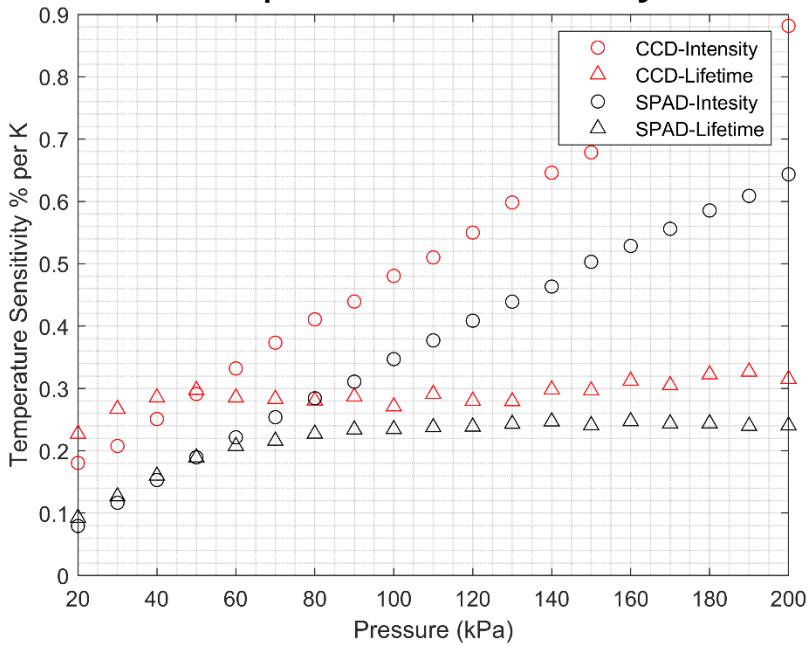


Pressure and temperature sensitivity

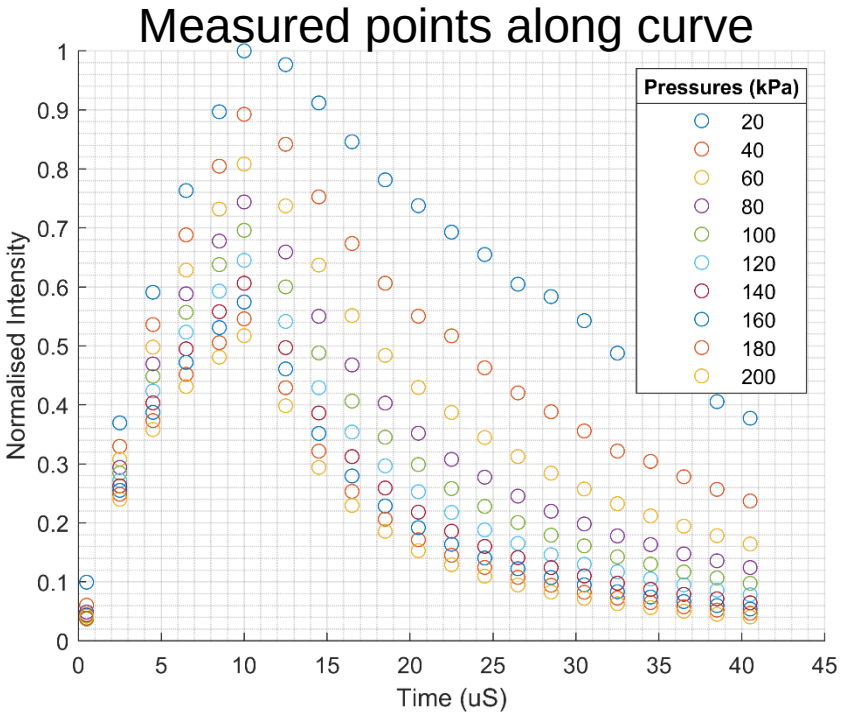
Pressure sensitivity

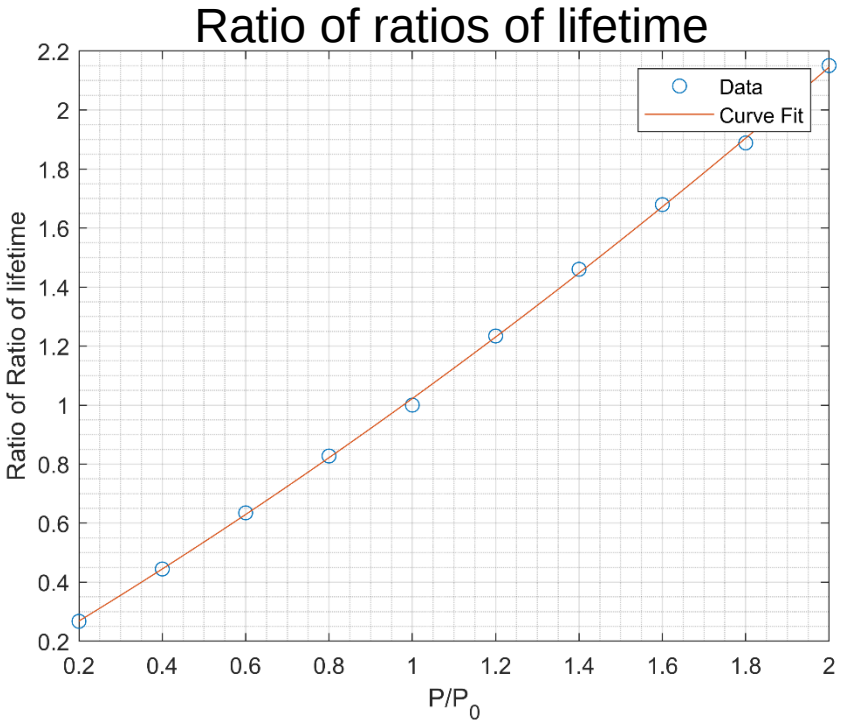


Temperature sensitivity

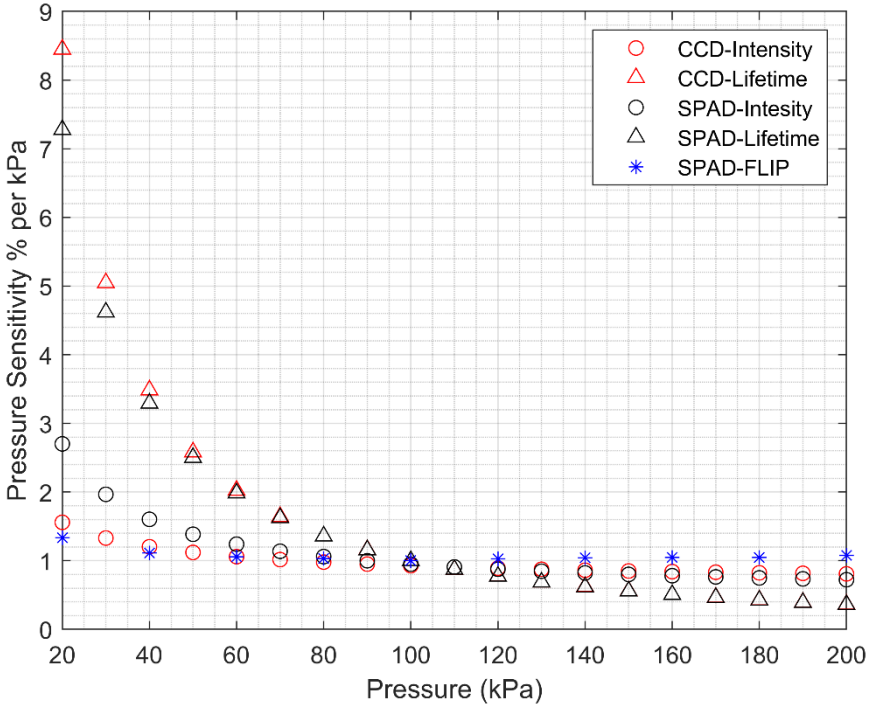


Fluorescent Lifetime Imaging PSP



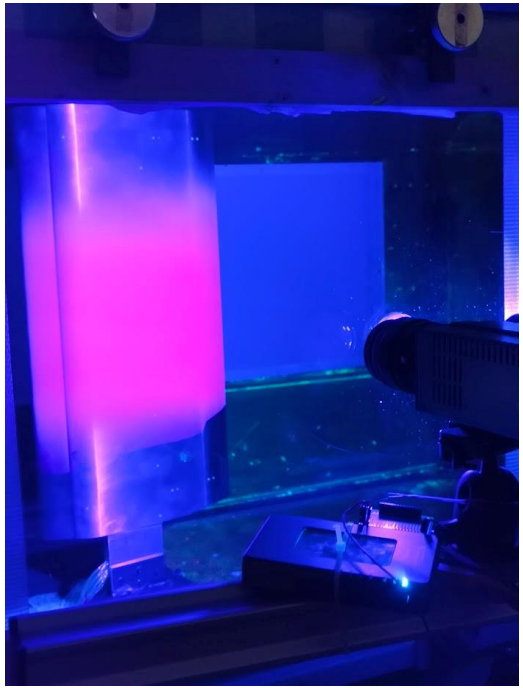


Pressure sensitivity of FLIP



Conclusions

- Preliminary calibrations show that the SPAD sensor is a suitable, modern replacement for PSP measurements.
- Future Work
  - Wind tunnel testing at Filton and at the University of Manchester.
  - Detailed FLI-PSP calibrations and uncertainty Analysis



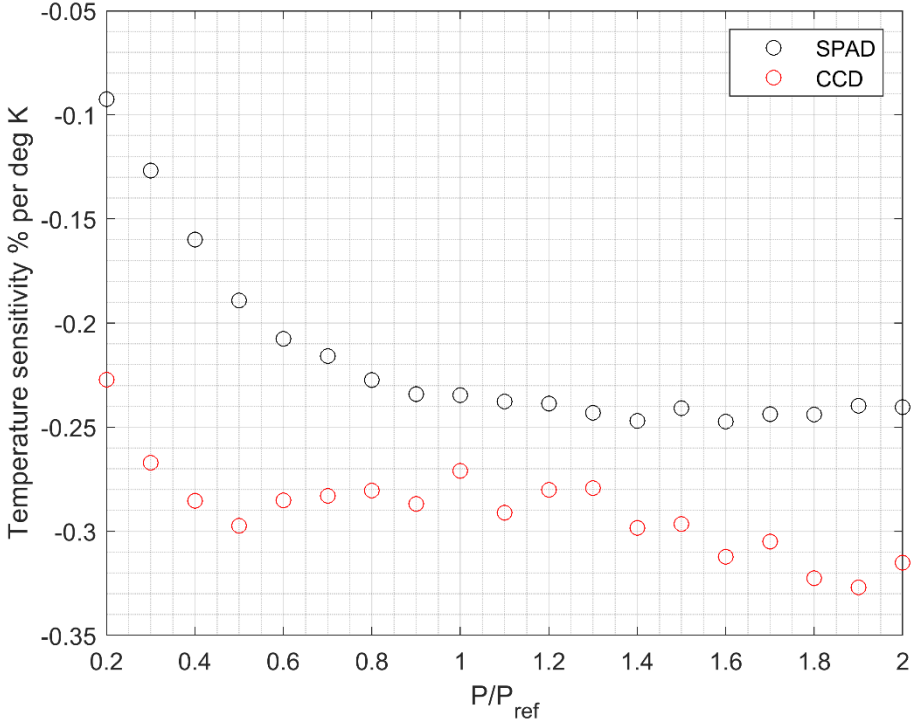
Closing remarks

- Thank you to Airbus Operations UK for their financial and technical support
- Thank you to the technical staff at the university of Manchester for their support.
- Thank you to Pi Imaging for their technical support.

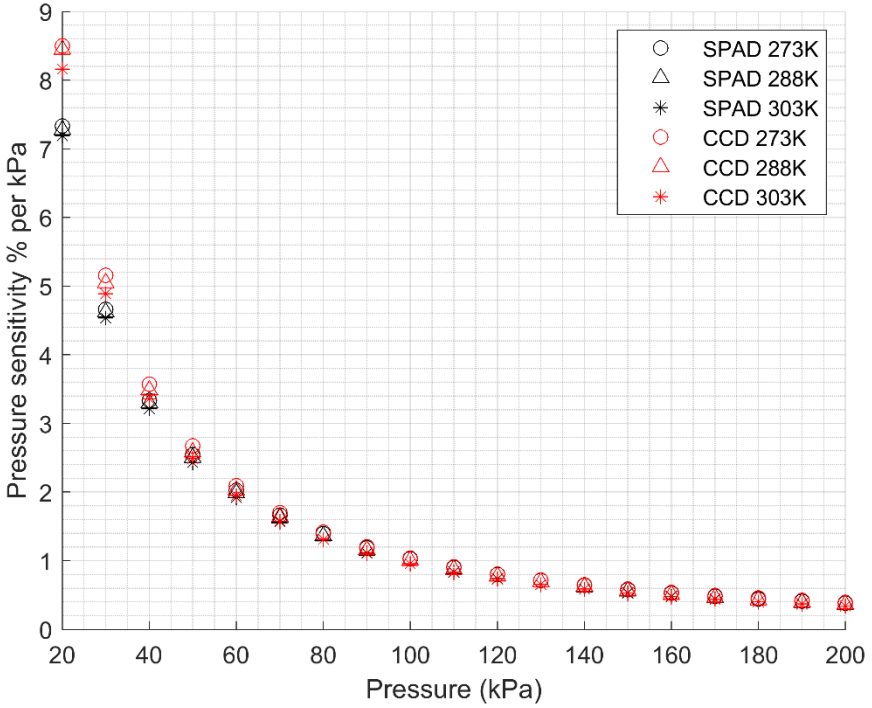
- Any Questions?

Full Lifetime-based calibration

Temperature Sensitivity

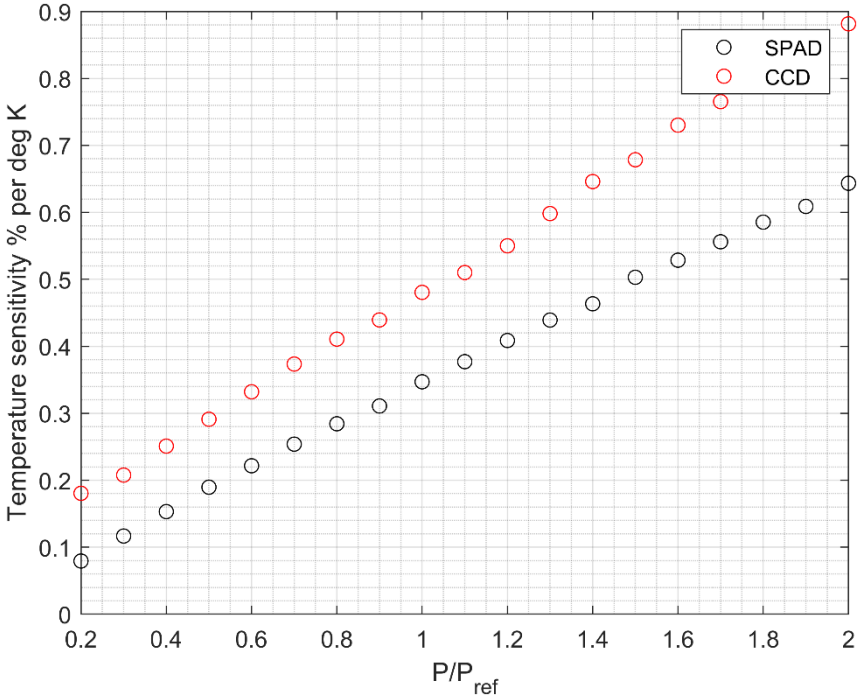


Pressure Sensitivity

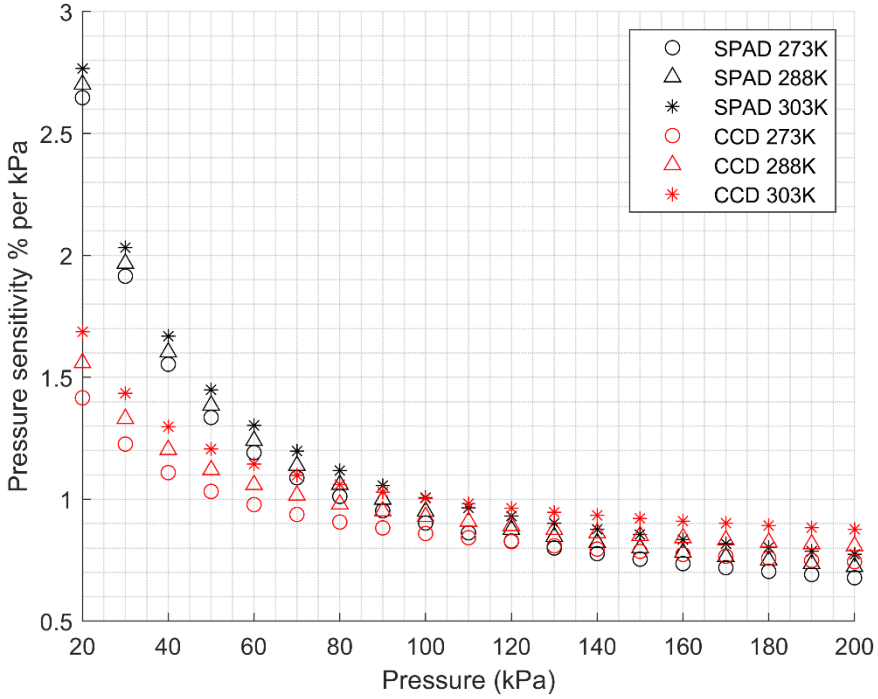


Full Intensity Results

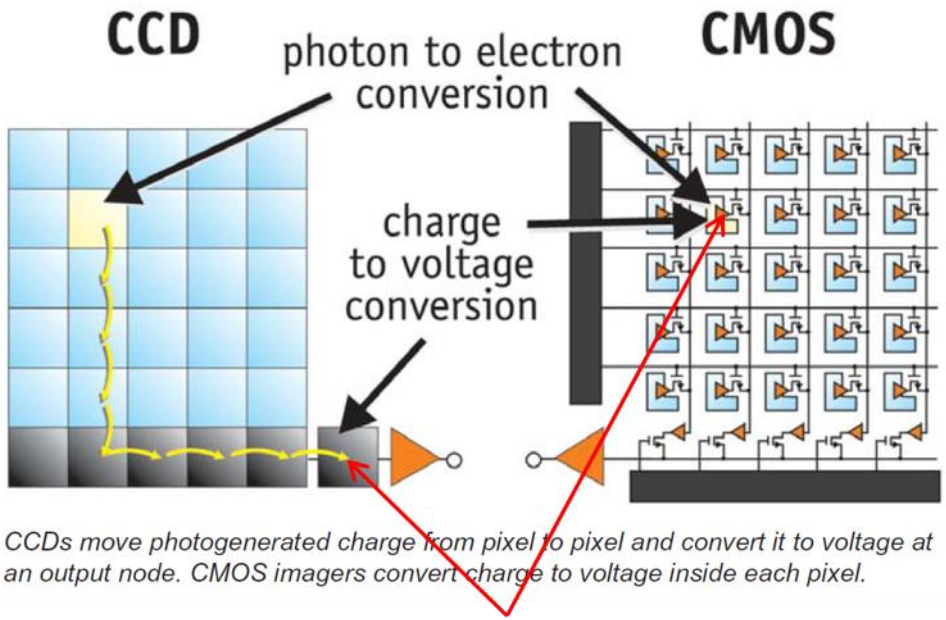
Temperature Sensitivity



Pressure Sensitivity



Typical imaging equipment



CCDs move photogenerated charge from pixel to pixel and convert it to voltage at an output node. CMOS imagers convert charge to voltage inside each pixel.

SPAD 512^2