Large area curved silicon modules for future trackers

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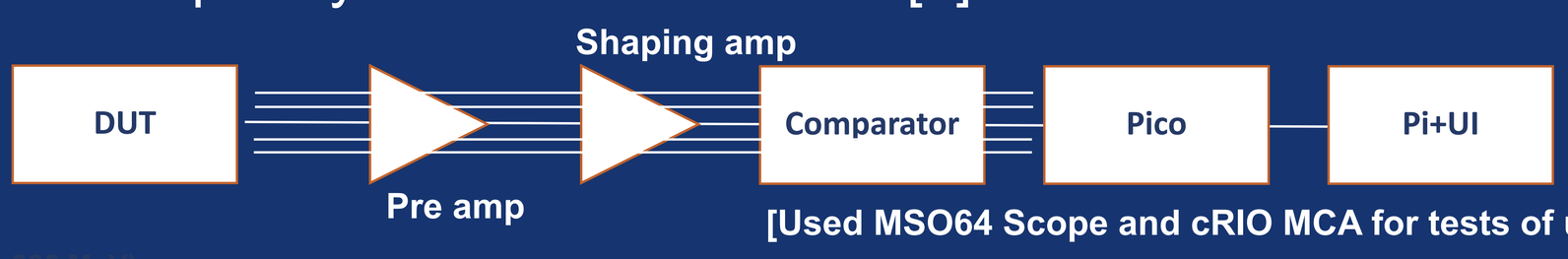
Abstract:

We present work on cylindrically curved detectors, covering the longevity of samples, low mass large area modules as a demonstrator for future detectors and exploration of the change in dark current for sensors on applying stress that we show to be consistent with the well-known piezo resistance effect. This work focuses on 50 μm thick variants of the TTT10 sensor from Micron Semiconductor Ltd. and on thin ATLAS Pix 3.1 chips.

Detectors:

Our aim is making large area curved modules to explore how to harness the sensor as part of the rigid structure of the detector.

- TTT10 is a 10x10cm sensor
- Modified to be only 50 μm thick
- 32 channel DC coupled strip sensor array
- Targeted 15 cm radius of curvature
- Only 2mm overlap of silicon with carbon fibre frame
- Tested with ^{241}Am in the lab
- 32 channel Raspberry Pi readout available [1]



[Used MSO64 Scope and cRIO MCA for tests of up to 3 channels]

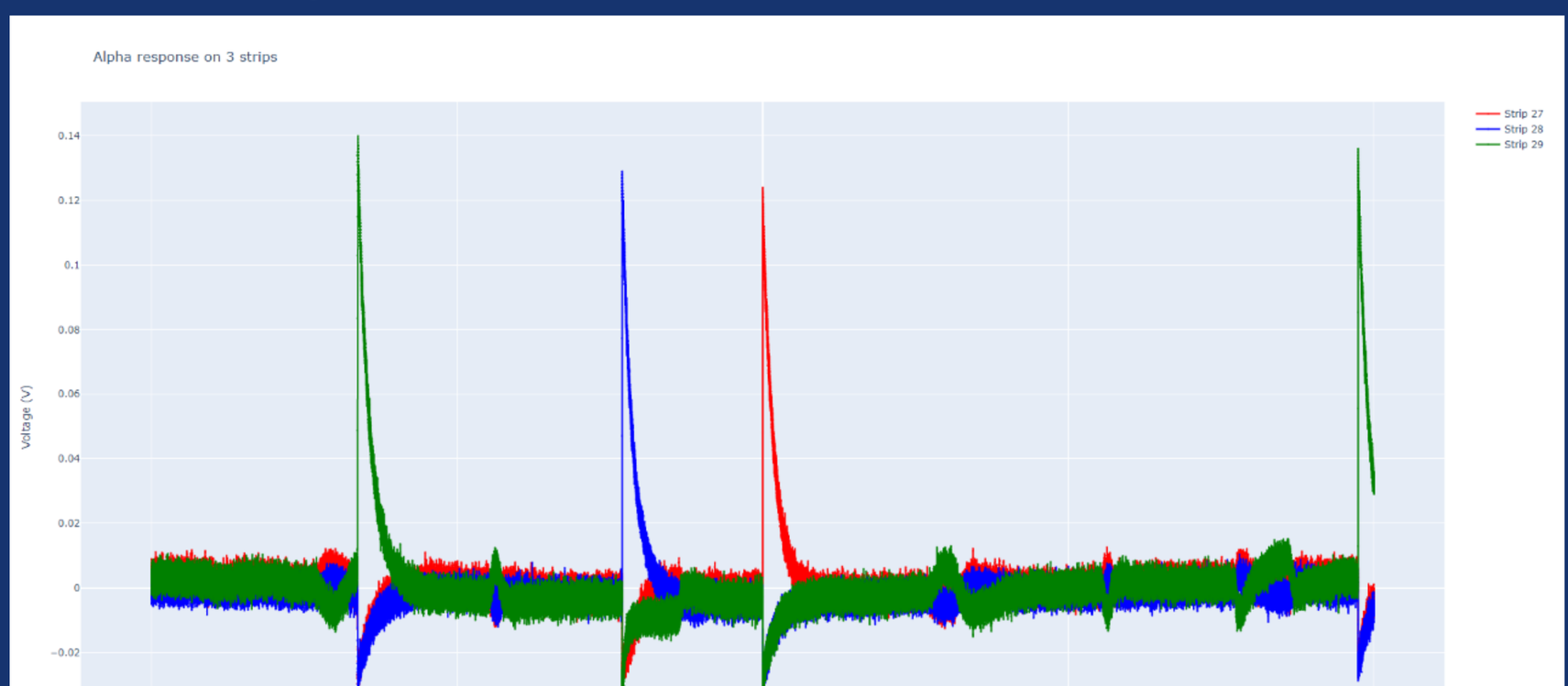
(Dominates at 0.565 MeV)

We have made mock ups with 1.2 to 15cm radius of curvature. The first curved tokens were fabricated in 2012 (check) and remain intact today, validating thin film theory expectations that structures would remain stable as defects get locked in on the surface of the thin film.

Response to radiation:

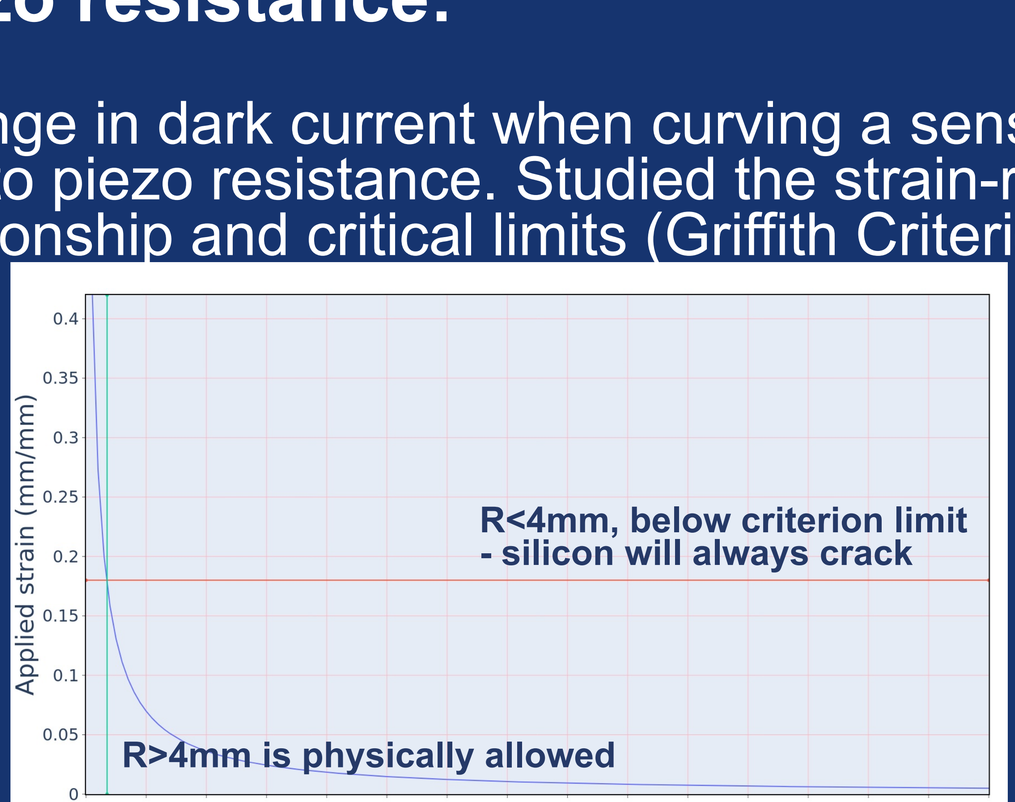
Able to readout signals from ^{241}Am with a high signal to noise ratio.

Consistent results using a Python MCA to interpret data from an MSO Scope and from a Compact RIO based MCA developed for this project.



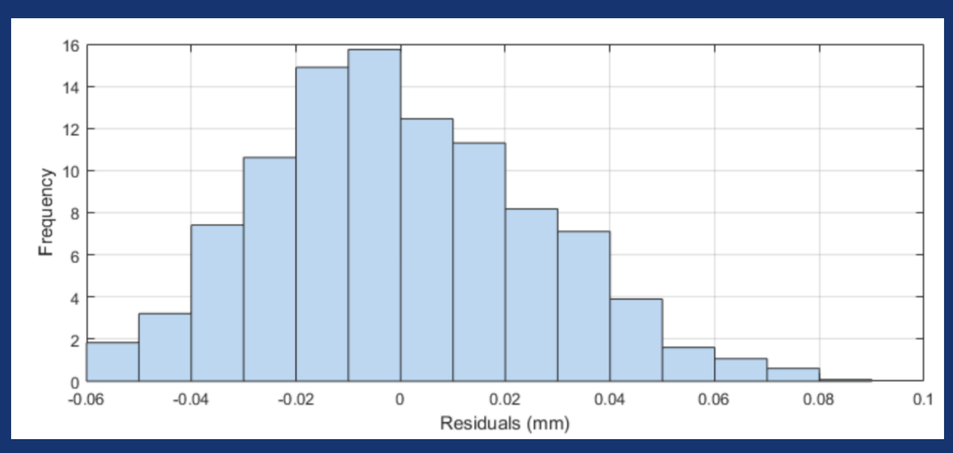
Piezo resistance:

Change in dark current when curving a sensor is due to piezo resistance. Studied the strain-radius relationship and critical limits (Griffith Criterion [3]).



Metrology:

Used an OGP SmartScope to scan the surface profile. Using the Legendre polynomial based model developed for CMS tracking [2] we find acceptable residuals (<100μm deviation from form).



Prospects:

This work demonstrates that curved large area silicon modules that use the silicon crystal as part of the structure can be fabricated. With a web-frame structure this approach could be used to make large low mass tracking detectors that do not require active cooling. We have also explored the effect of pixel resistance on the change in dark current when curving samples.

[1] L. Vozdecky and A. Bevan, Cost Effective DAQ System, NuSec Annual Conference, October 2023, London (link).
[2] G. Flucke, Alignment of the CMS silicon tracker, J. Phys.: Conf. Series 368 012036 (2012).
[3] A. A. Griffith, "The phenomena of rupture and flow in solids", *Philosophical Transactions of the Royal Society of London*, 221 (582–593) (1921).

https://www.qmul.ac.uk/spcs/collaborative-research-centres/detector-development/