Some Thoughts About Readout

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DRD3 WG6 SiC LGAD Meeting
January 17 2025

Preamble

- We’re just starting to think about this at SCIPP for the first time
- Some of this may be naïve
- That’s one of the points for presenting it

Two types of readout we're considering

Optimized for fast timing

➔ Typically $\tau_{amp} \approx \tau_{rise}$

➔ 0.5 – 1.5 GHz

Optimized for feature extraction

➔ The faster the better (if you can tolerate ~ $\sqrt{BW}$ increase in noise)

➔ A bit of a focus at SCIPP recently

Fast Timing Readout Scaling Laws (?)

Readout designed to optimize

$$\sigma_t = \frac{\sigma_V}{dV/_{dt}}$$

	Si	SiC
e/h energy	3.6 eV	7.8 eV
density	2.3 g/cm^3	3.2 g/cm^3
V_{drift} (saturated)	100 um/ns	200 um/ns

- Per um of bulk, SiC pair creation rate is roughly $(3.2/7.8)\ /\ (2.3/3.6) = 64\%$ of Si
- But SiC is twice as fast
- So dV/dt would be ~25% larger?
- SCIPP board OK for SiC LGAD?
- Gain = 1 signal would be difficult though

Feature Extraction Readout (multi GHz)

A fast readout system may be able to

- Extract features in pulse
- Be sensitive to v_{drift} and τ_{impact} as a function of local field

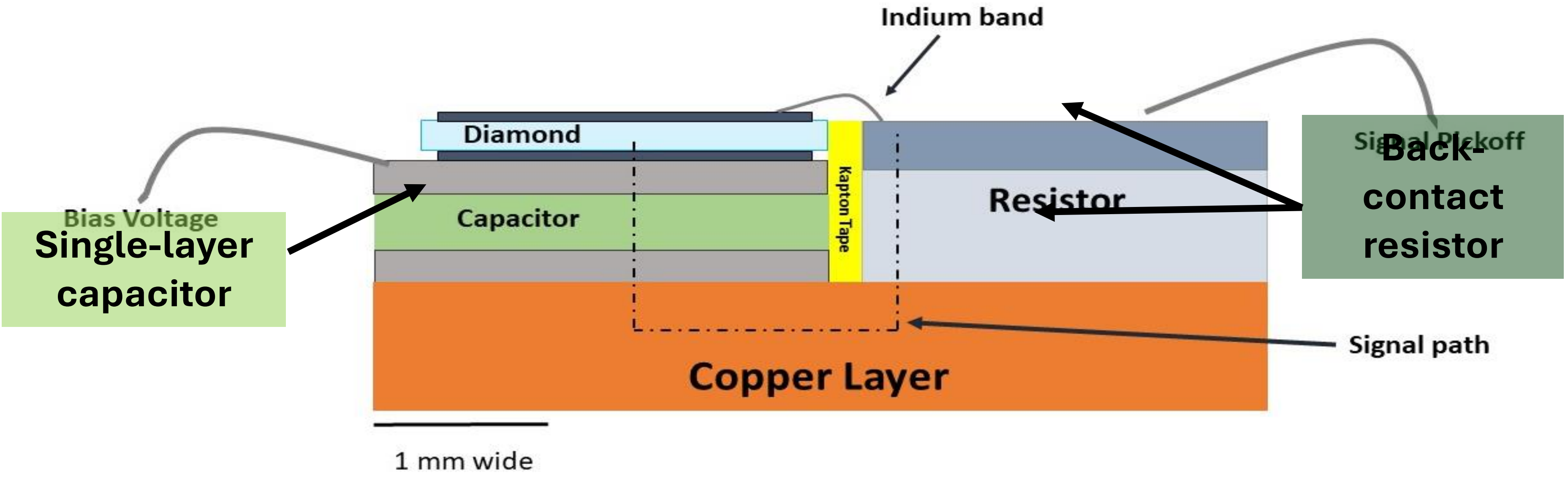
Best geared towards large depositions due to readout noise (alpha particle)

Under study at SCIPP

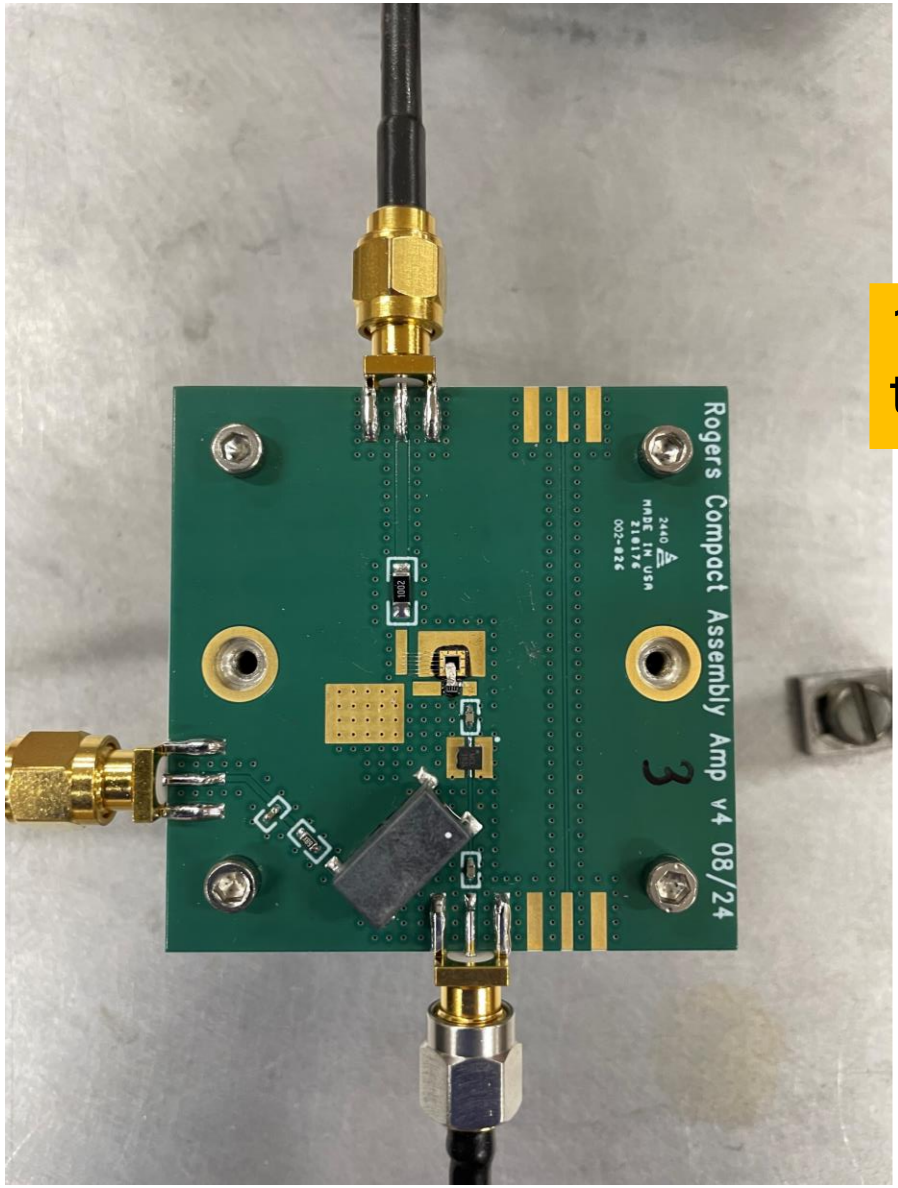
"Chain only as strong as weakest link" (charge collection, signal path, signal transport, readout...)

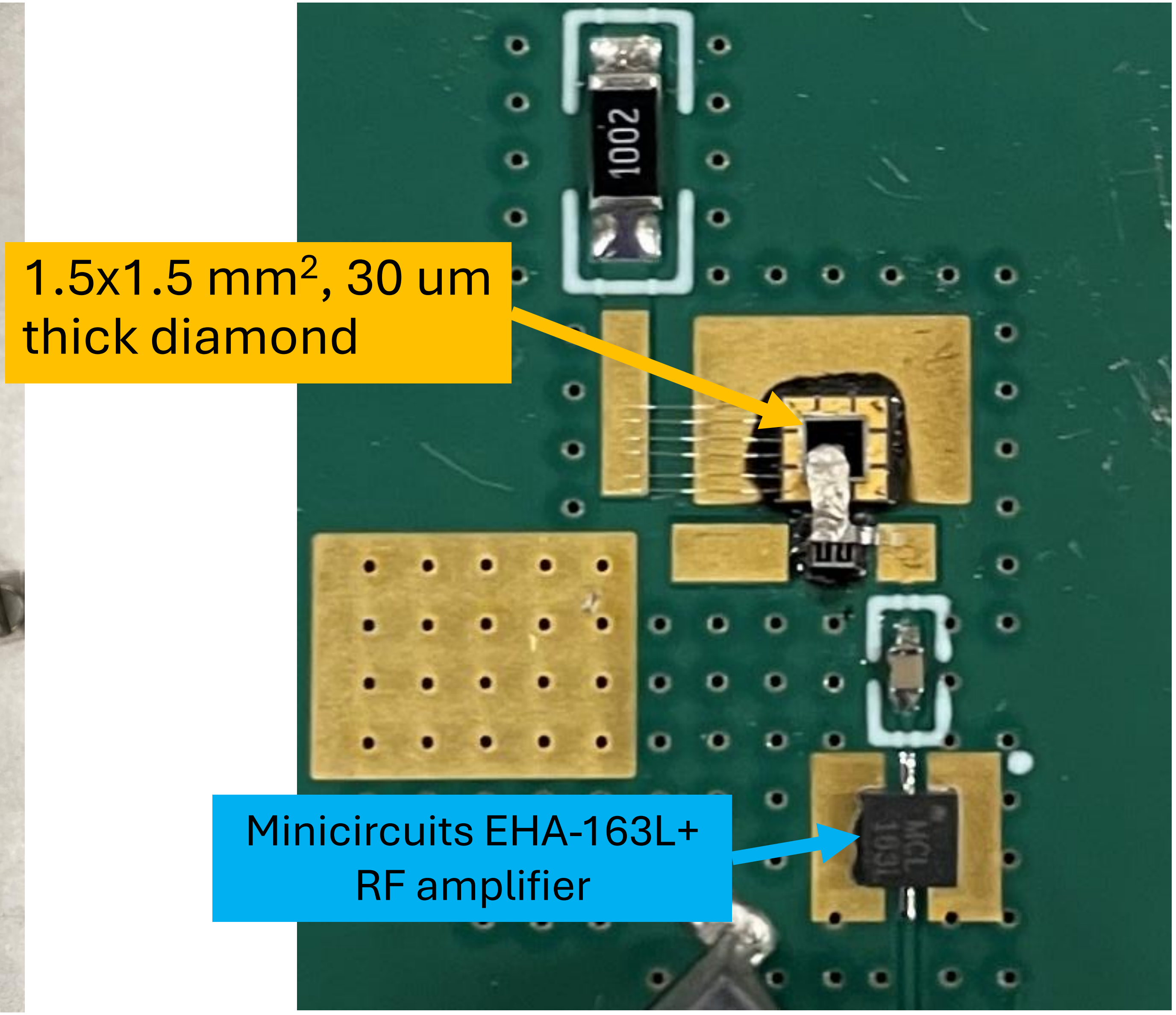
SCIPP Compact Signal Path Approach

- Make use of RF industry components to develop mm-scale signal path
- Limit inductance, capacitance to push LC resonance above 10 GHz



Integrate with localized readout to eliminate signal transport degradation


Rogers Compact Assembly Amp v4 08/24
3

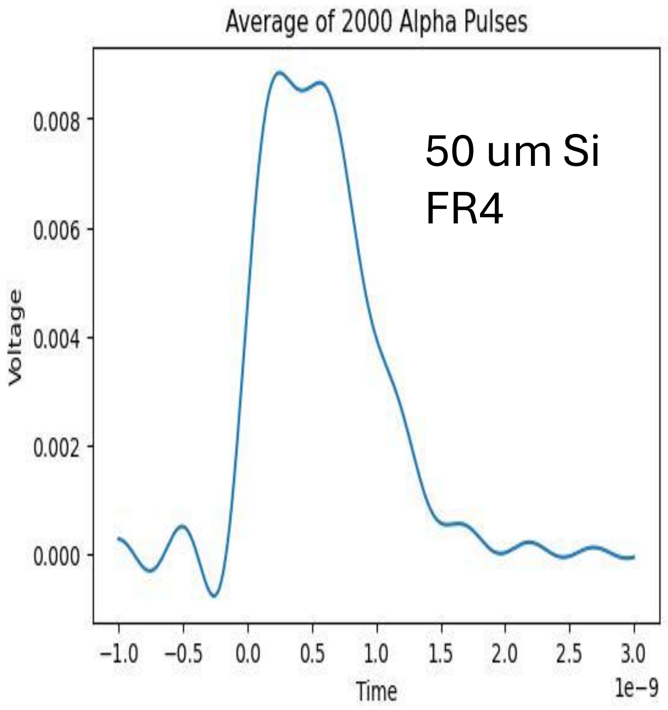

1.5x1.5 mm², 30 um thick diamond
Minicircuits EHA-163L+ RF amplifier
1002

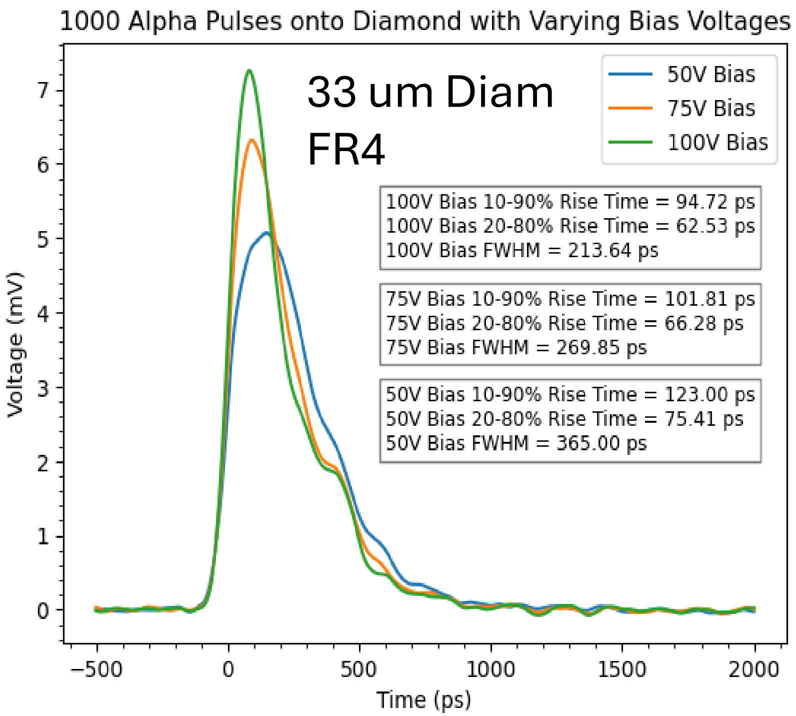
We've studied so far

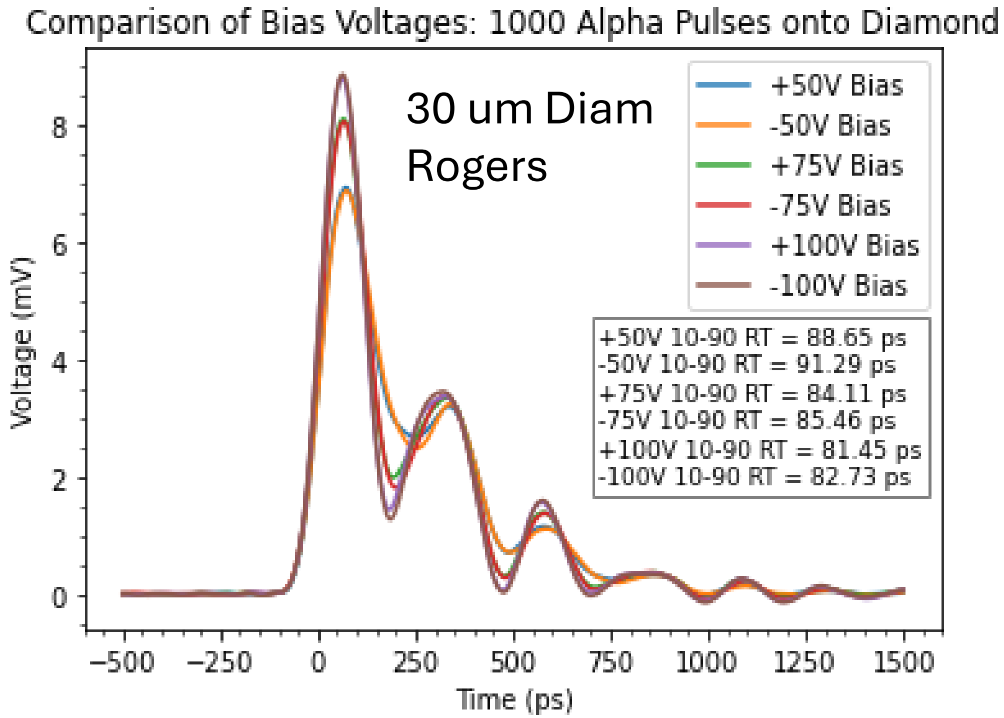
- Board with (slow) FR4 dielectric
- Board with (fast) Rogers 4350b dielectric

And on these, excited with an alpha source (~ 5 MeV)

- Silicon PiN on FR4
- 33 um, 2x2 mm^2 diamond on FR4
- 30 um, 1.5x1.5 mm^2 diamond on Rogers 4350b (results 5 days old)







- Rogers assembly fast, but develops ringing
- Taking into account 13 GHz scope BW, τ_{rise} = 81 ps is ~ 4.8 GHz
- Si PiN pulse features (~500 ps collection time) appear visible
- Systematic difference for +/- voltage (Rogers assembly) suggests possible sensitivity to hole vs. electron drift in diamond
- Studies underway in ANSYS HFSS to identify source of limitations