Spark Monitoring System for sPHENIX TPC GEMs

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Goals of Studying GEM Sparks

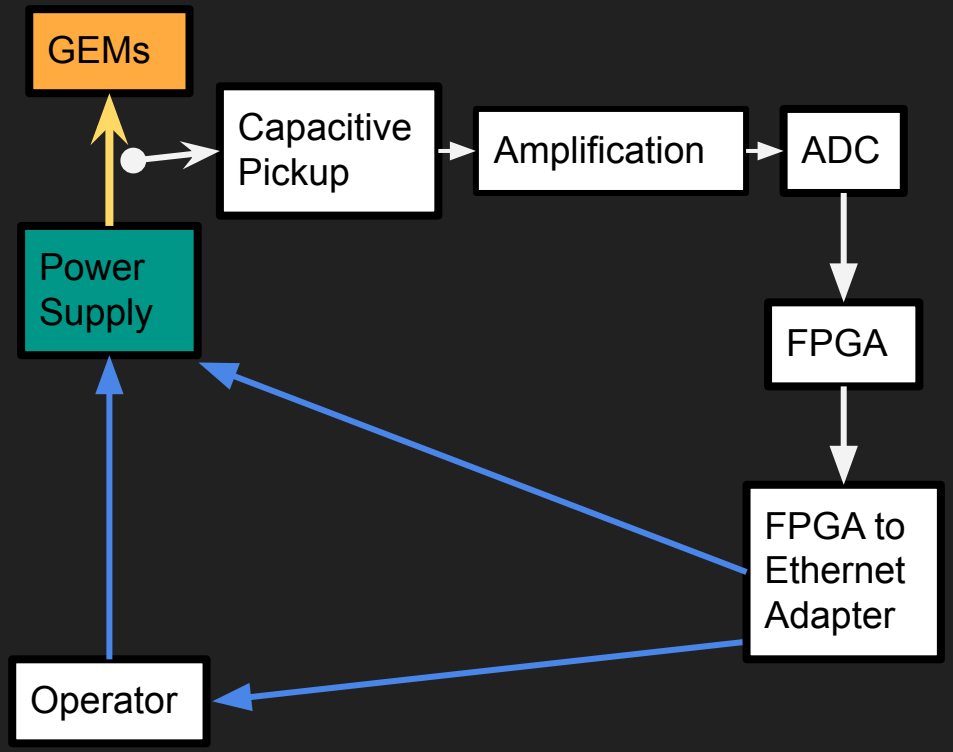
- It is important to prevent sparks to preserve the health of GEMS
- A module that sparks is likely to spark again
- The goal of this project is to characterise sparks so that a system could be developed to detect them in order to adjust voltages to prevent future sparks

GEMS installed in the sPHENIX TPC

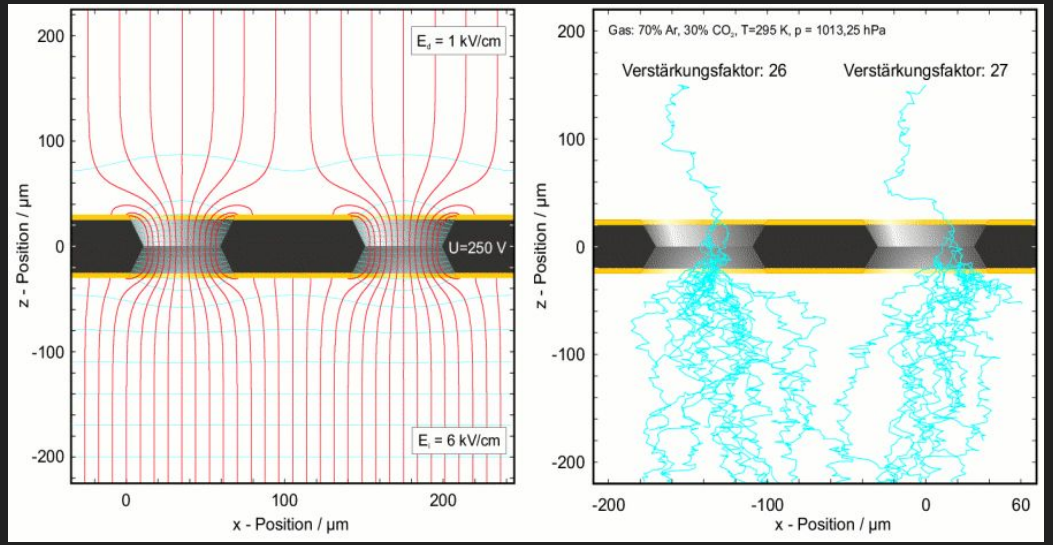
Overview

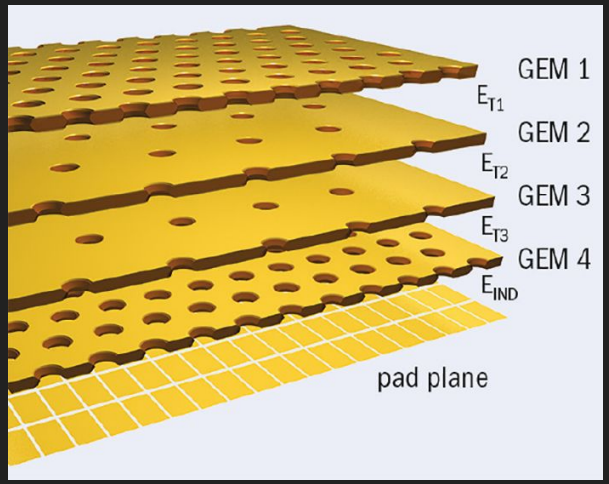
In this presentation we will discuss:

- The apparatus for characterizing sparks
- The results of the characterization
- The choice of pickoff circuitry
- Testing of amplifier designs



Gas Electron Multiplier (GEM)



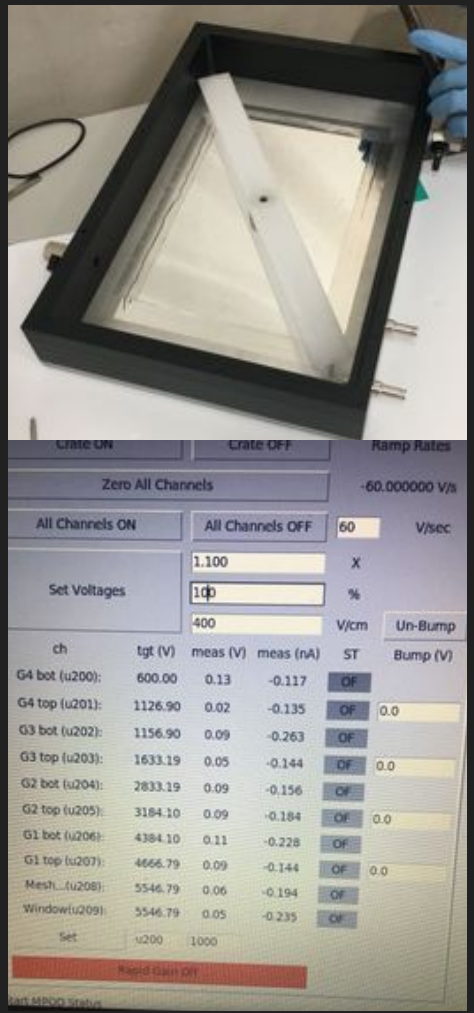


LCTPC Collaboration

CERN Courier

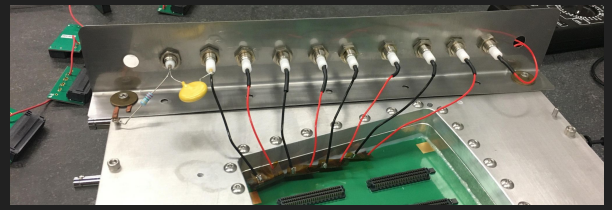
Inducing Sparks

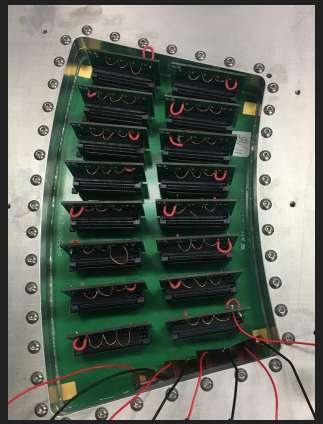
- Initially an Am-241 source was mounted in the chamber
  - primary discharge from the alpha signal was expected to induce secondary discharge
- Voltage had to be raised to produce sparks
- The alpha signals obscured spark signals
- The source was removed, instead sparks were created by raising the ΔV across a GEM while keeping transfer gaps the same
- This allowed for control of which GEM produced sparks

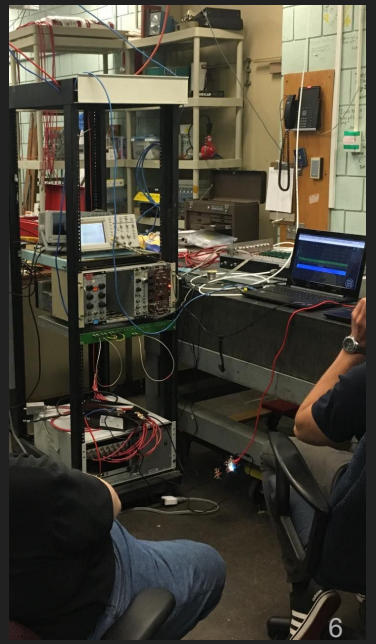


Set Up

- Pre-Production GEMs were used
  - Differ from production by tail length
- Each side of a GEM connects to an SHV cable which leads to an independently controlled HV module
  - This differs from the real GEM stacks which will receive 1 high voltage signal which will be broken down by resistor chains to provide GEM voltages
- Dummy connectors were prepared and attached to ground the pad-plane
- A gas line was run from a gas mixing unit
  - Some tests done using Ne/CF_4 , some using Ar/CF_4
- Pick-off capacitor on bottom of the bottom GEM

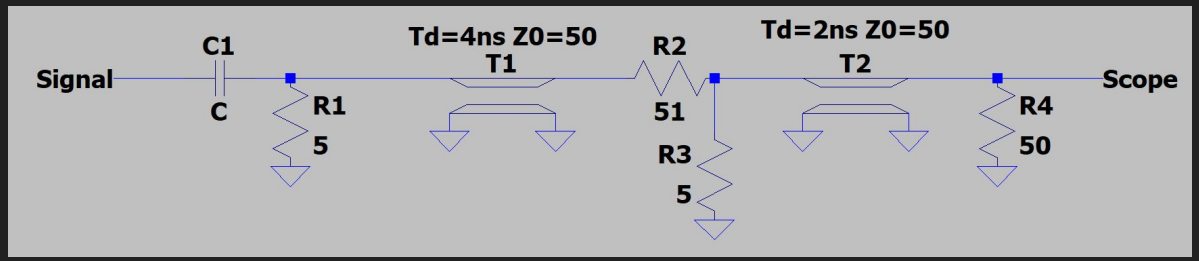


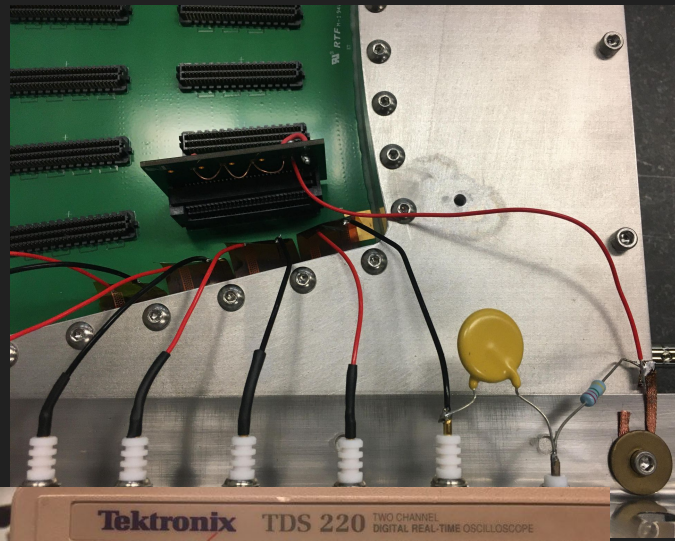


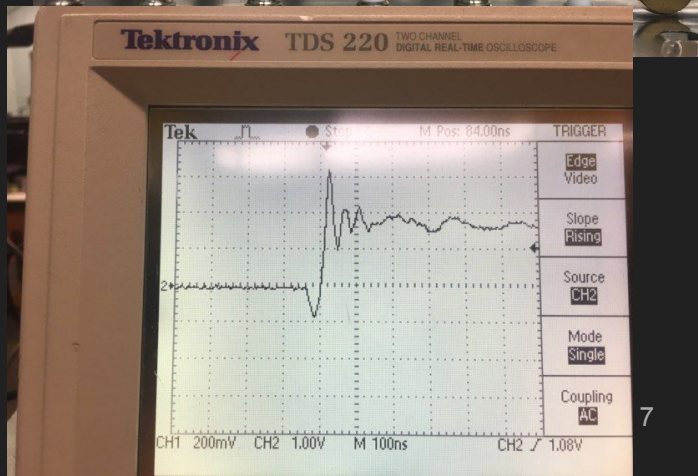


Original Pickoff Made Signal too Large

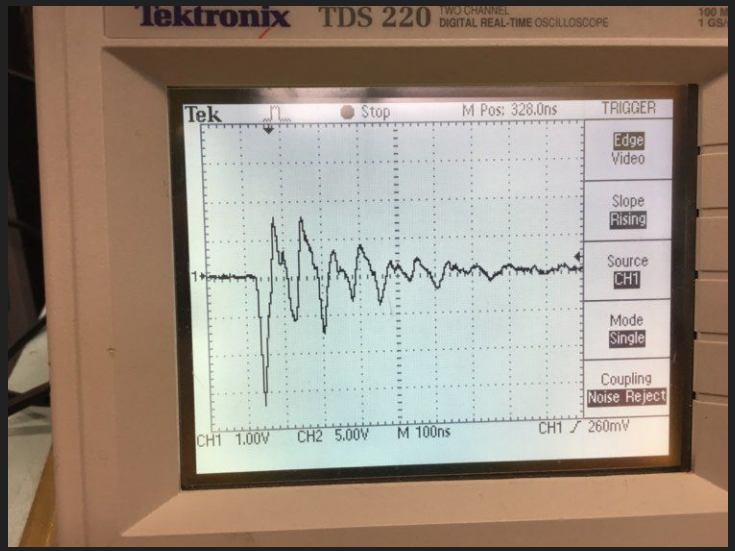
- Originally there was a 1 Meg Ohm resistor to ground
- This resulted in saturation of the pre-amp
- Instead a 5 Ohm resistor was used, as well as an additional attenuator
  - This signal was measured without a pre-amp

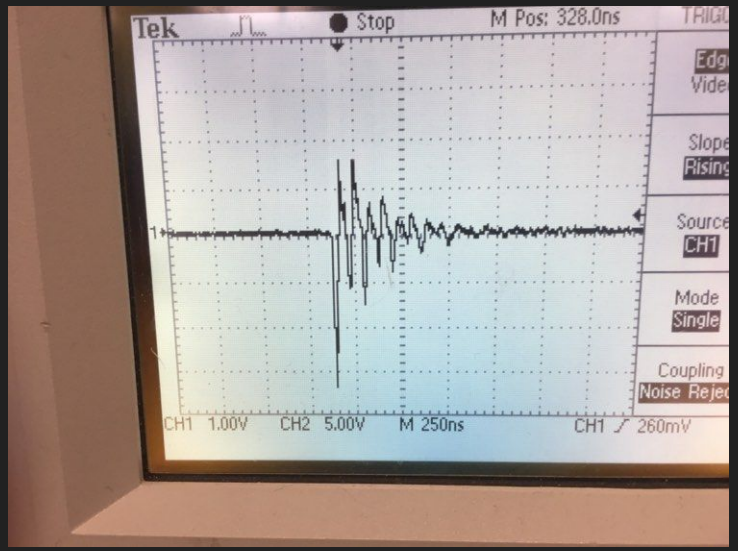






Attenuated Signal Straight from Chamber

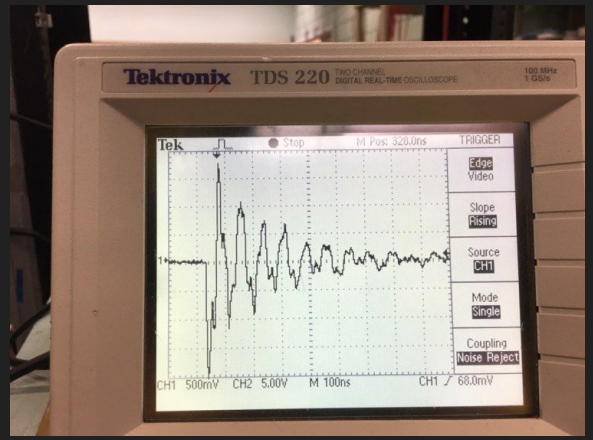




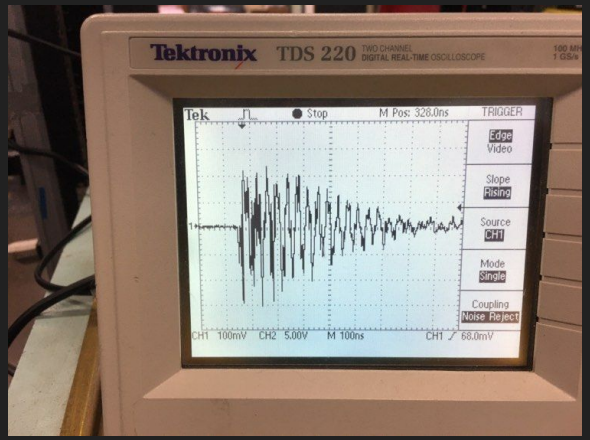
Same event at different time scales

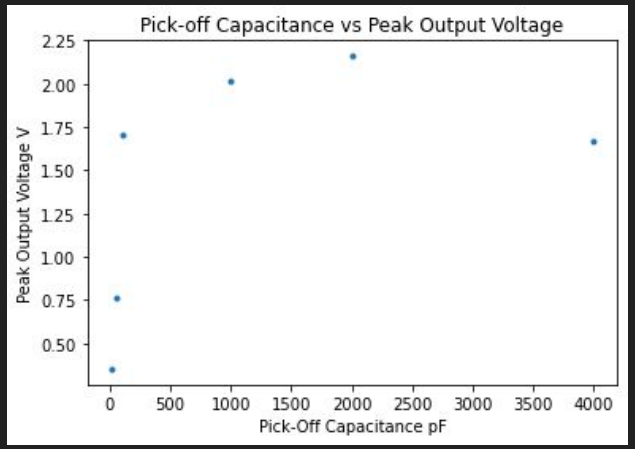
Effects of Pick-Off Capacitor Value

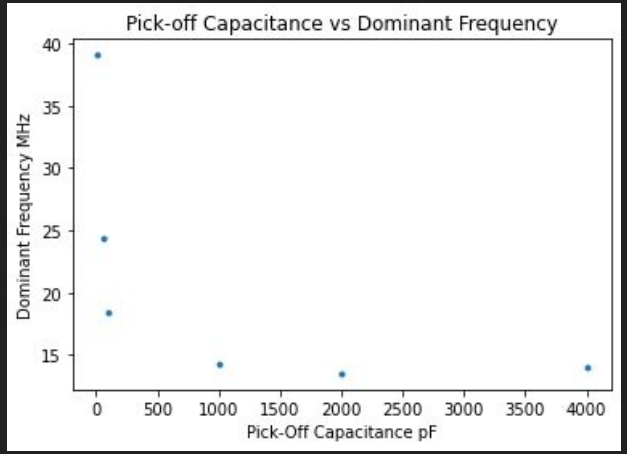
4000 pF

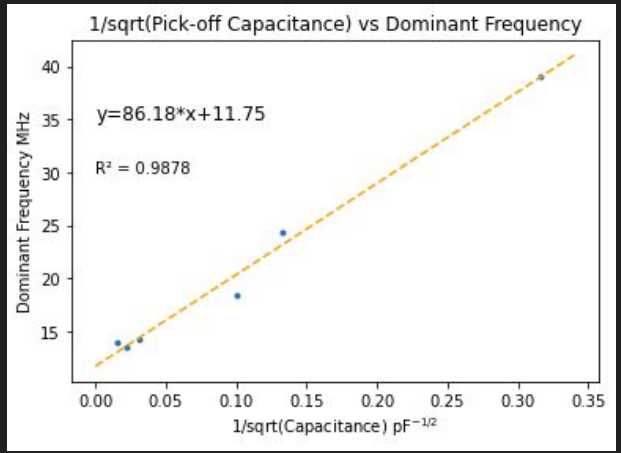


10 pF







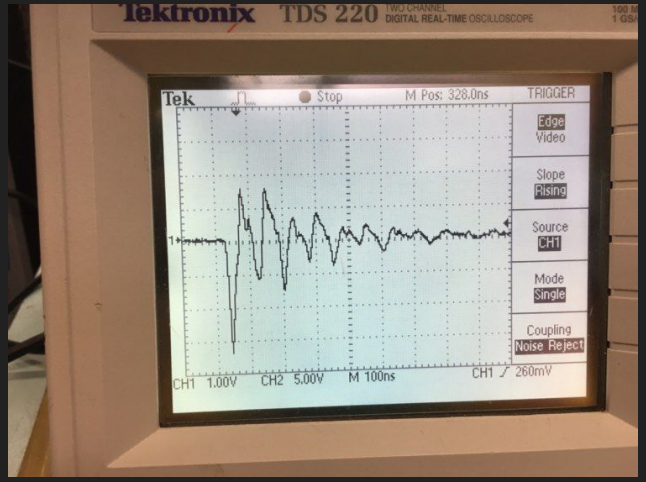


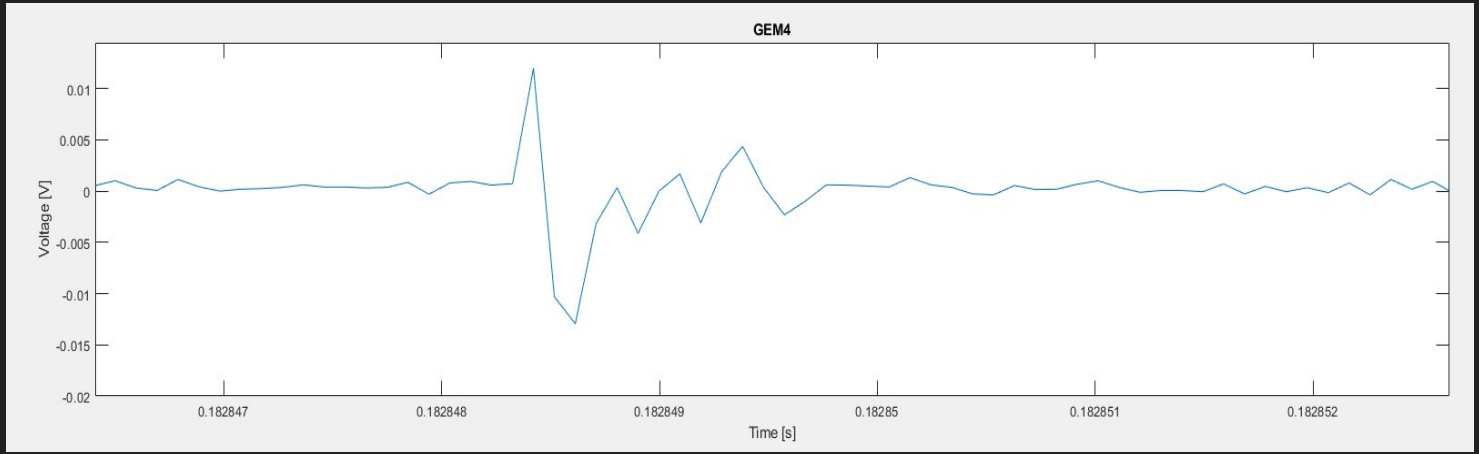
For an LC circuit: f=k/Sqrt(C), k=1/(2π*Sqrt(L))

10 MHz Digitization is too slow

10 MHz means 1 sample per 100 ns which is about the spark period

A faster oscilloscope is needed to digitize than the Red Pitaya





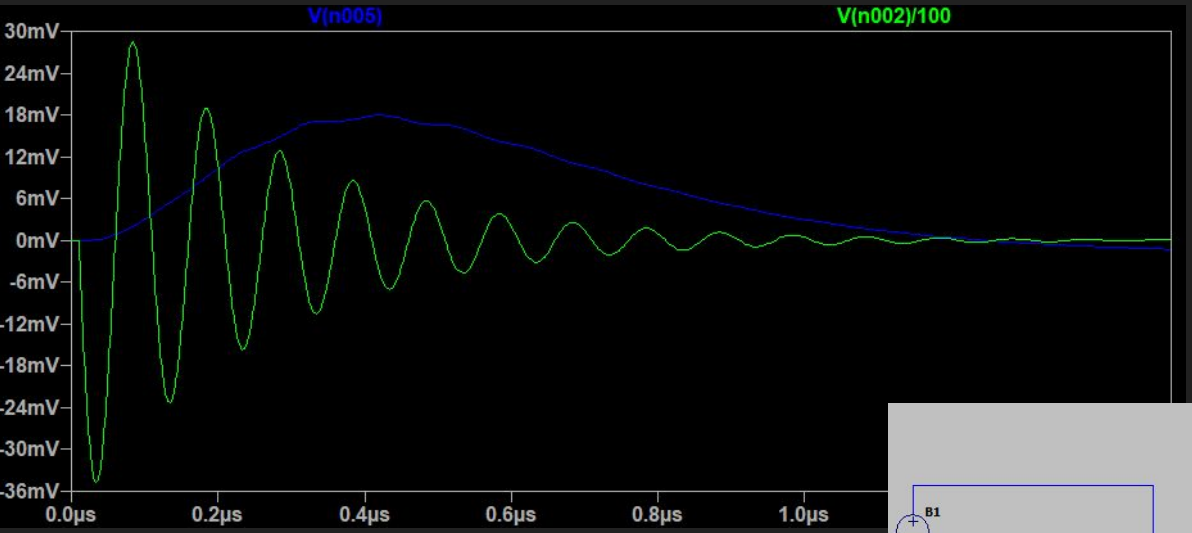
Average Amplitude After Delay Line

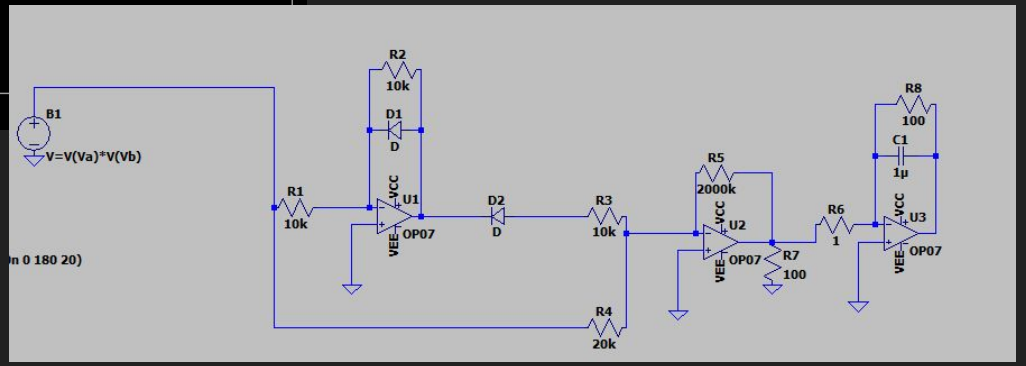
From 10 samples

	GEM1	GEM2	GEM3	GEM4
0 ns	5.7 V	2.6 V	2.2 V	1.8 V
50 ns	4.4 V	3.5 V	2.4 V	1 V
75 ns	4.1 V	3.1 V	2.6 V	1.1 V
100 ns	3.8 V	2.4 V	2.6 V	1.4 V

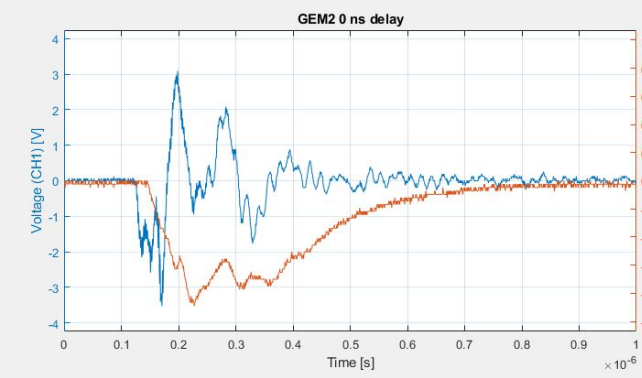
- Decreases as expected down the stack
- Increase with longer delay lines for G3, G4 could be from low statistics or not triggering on smaller events
- Regardless, the signal after the delay line

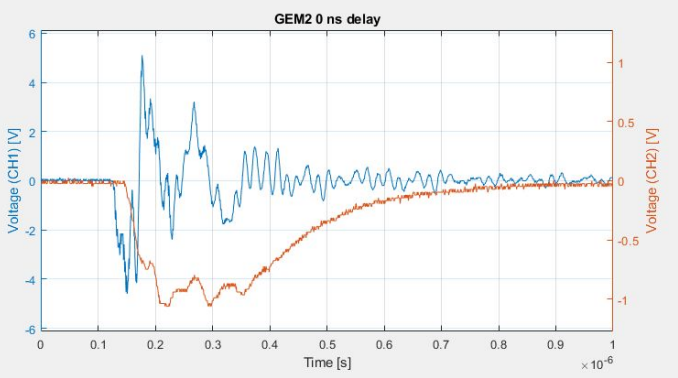
Amplifier Concept:Integrate an Absolute Value



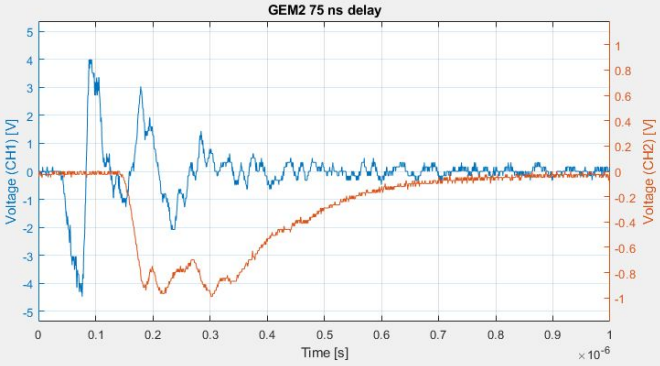


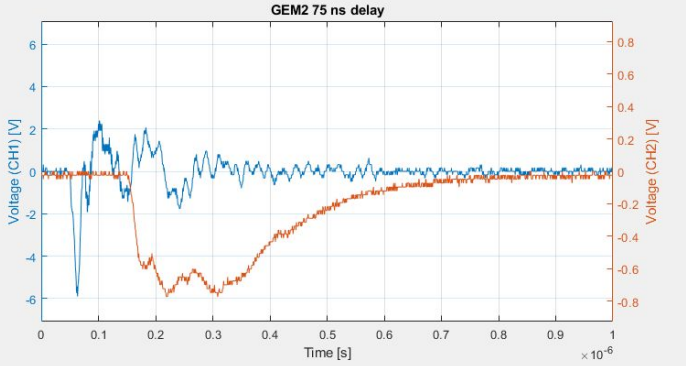
Successful Performance of Integrated Absolute Value





After Delay Line





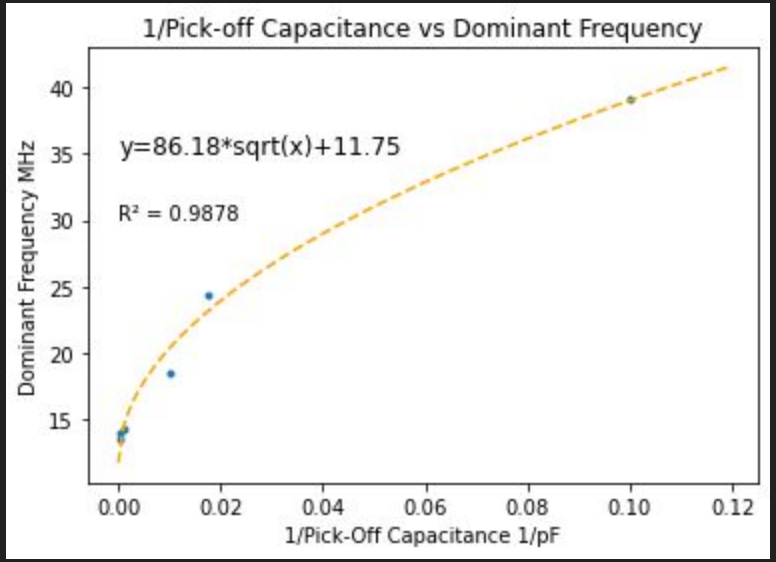
Acknowledgements

- This work was done in collaboration with Tamas Majoros of the University of Debrecen and Tom Hemmick and Prakhar Garg from Stony Brook University
- I would also like to thank Ujvari Balazs, Gabor David, Evgeny Shulga and Klaus Dehmelt for their discusion and input

Conclusion

- Sparks were larger and faster than expected, but a pre-amp sufficient for digitising signals at 10 MHz has been demonstrated
- Tamas is working on the FPGA for processing the signals, which will be installed in sPHENIX

Backup


1/Pick-off Capacitance vs Dominant Frequency
y=86.18*sqrt(x)+11.75
R² = 0.9878
Dominant Frequency MHz
1/Pick-Off Capacitance 1/pF
40
35
30
25
20
15
0.00
0.02
0.04
0.06
0.08
0.10
0.12

FPGA Flow Chart